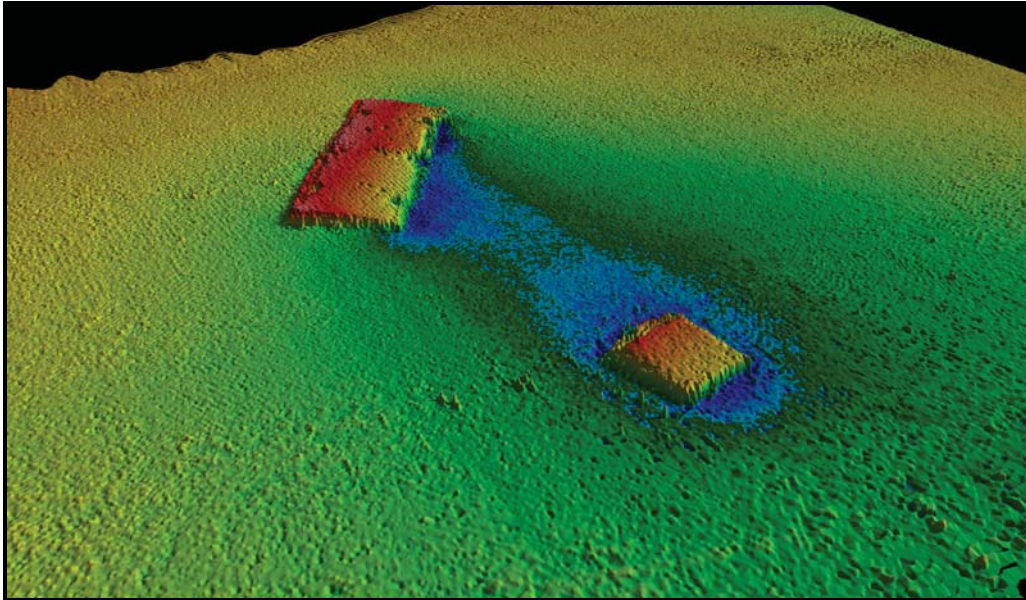


Data Acquisition and Processing Report

S-J977-KR-TE

Alabama, Louisiana, Mississippi: Gulf of Mexico



H11626

H11627

H11629

Royal Fish and Bella Marie

State: Alabama, Louisiana, Mississippi

Locality: Gulf of Mexico

Year: 2006-2007

Lead Hydrographer: Scott Cholmondeley

TERRASOND

A. EQUIPMENT

Vessels

Soundings for this survey were acquired using the hydrographic survey vessels *Royal Fish* and *Bella Marie*.

Royal Fish

Soundings for H-11629 were acquired using the hydrographic survey vessel *Royal Fish*.

The *Royal Fish* is an aluminum hull vessel, 7.62 meters length overall with a 2.43 meter beam and a 0.40 meter draft. During the survey it was equipped with a Odom Hydrotrac single beam sonar system and a bow-mounted pole Benthos C3D side scan towfish. The *Royal Fish* was powered by one 460ci Ford Kodiak inboard turbo drive and had a cruising speed of 30 knots. Vessel electrical power was provided by 300 AH deep cycle batteries and a 1.8 KW Trace inverter. Vessel drawings are included in Section C. of this report.



Figure 1- The *Royal Fish* underway.

Equipment Overview

The equipment on the *Royal Fish* performed well and within required specifications.

Major Operational Systems

Table 1- *Royal Fish* Survey Equipment

Description	Manufacturer	Model / Part	Serial Number
Sidescan Sonar Top Side	Teledyne Benthos	C3d Sonar System D298-0490	40010
Side Scan Sonar Head	Teledyne Benthos	D298-0470	40009
Single Beam Transducer	Odom	200 SW	N/A
Single Beam Sounder	Odom	Hydrotrac HT97001	10899
Positioning System	CodaOctopus	F180 Attitude and Positioning System	F1104018
Motion Platform	CodaOctopus	F180 Attitude and Positioning System	F1104018
SV Probe	Odom	Digibar	98440
SV Probe Controller	Odom	Digibar Pro DB1200	98440
SV Probe (Surface Velocity)	Applied Microsystems	Smart	4425

Sounding Equipment

An Odom Hydrotrac HT97001 Single Beam sounder was used on board the *Royal Fish* during this survey.

Singlebeam echosounder calibration checks were conducted several times per week. The calibration checks were performed by measuring the depth under the ship with a calibrated sounding lead line and comparing the value with the depths recorded by the singlebeam echosounder. All measurements were corrected to the survey vessel's 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 singlebeam echosounder values agreed consistently throughout the survey.

Table 2 – Odom Hydrotrac Technical Specifications

Odom Hydrotrac HT97001	
Sonar Operating Frequency	24,33,40,200,210, 340 KHz
Depth Range	20 cm to 600m
Depth Resolution	0.01m
Communication	2 RS232 or RS422 Serial Ports

Sonar Equipment

A Teledyne Benthos C3d D298-0490 side scan sonar system was utilized aboard the *Royal Fish* in a forward, pole-mounted configuration.

Table 3 – Teledyne Benthos Technical Specifications

Teledyne Benthos C3d D298-0490 Side Scan Sonar	
Frequency	100/ 200 kHz dual
Operating Range (max)	25 to 600 meters per side
Resolution Across Track	4.5 cm
Pulse Length	25 usec to 1msec (depending on range)
Beam Width	1°
Diameter	27.3 cm
Length	203.2 cm
Tow Cable Type	100 meter Cat-5

Bella Marie

Multibeam echosounder, singlebeam echosounder and side scan sonar data for surveys H-11626 and H11627 were acquired using the survey vessel *Bella Marie*.

The *Bella Marie*, shown underway in Figure 2, is an aluminum hulled catamaran hydrographic survey vessel 11.9 meters in length with a 4.3 meter beam and a 0.75 meter draft. During the survey it was equipped with a Reson SeaBat 8124 multibeam echosounder 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 *Bella 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 multibeam 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. On 2007-076 the *Bella Marie* was equipped with a hull-mounted Odom Hydrotrac single beam sonar system. This was necessary to collect bathymetry in areas of the survey too shallow to deploy the pole-mounted multibeam transducer. Detailed vessel drawings showing the location of 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
Singlebeam Sonar	Odom	Hydrotrac	N/A
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

An Odom Hydrotrac HT97001 Single Beam sounder was used on board the *Bella Marie* during this survey.

Singlebeam echosounder calibration checks were conducted several times per week. The calibration checks were performed by measuring the depth under the ship with a calibrated sounding lead line and comparing the value with the depths recorded by the single beam echosounder. All measurements were corrected to the survey vessel's 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.

Table 5 - Odom Hydrotrac Technical Specifications

Odom Hydrotrac HT97001	
Sonar Operating Frequency	24,33,40,200,210, 340 KHz
Depth Range	20 cm to 600m
Depth Resolution	0.01m
Communication	2 RS232 or RS422 Serial Ports

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.

Table 6 – Reson SeaBat 8124 technical specifications.

Reson SeaBat 8124	
Sonar Operating Frequency	200 kHz
Beam Width, Across Track at Nadir	1.75° @center beam
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

Total sounding error limits were determined using the following equation:

$$\pm\sqrt{[a^2+(b*d)^2]} \quad \text{where: } \underline{\text{for } d < 100 \text{ meters}}$$

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 each survey.

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

Sonar Equipment

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

Table 7 – 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°, 410 kHz – 0.3°
Horizontal Beam Width (HSM)	120 kHz – 1.26°, 410 kHz – 0.4°
Vertical Beam Width	50°
Diameter	11.4 cm
Length	125.6 cm
Tow Cable Type	Co-axial

Tide Gauges

NOAA tide station Dauphin Island, AL (873-5180/5181) provided initial and final tide processing for this project. Verified data from the Dauphin Island gauge was downloaded from the NOAA internet Hydro Hot list (<http://coops.nos.noaa.gov/hydro.shtml>). TerraSond, Ltd. with John Oswald & Associates, LLC (JOA), installed gauges at historic NOAA tide station Millview, AL (872-9905). The Horizontal and Vertical Control Report contains detailed information regarding installation and data processing procedures for this station.

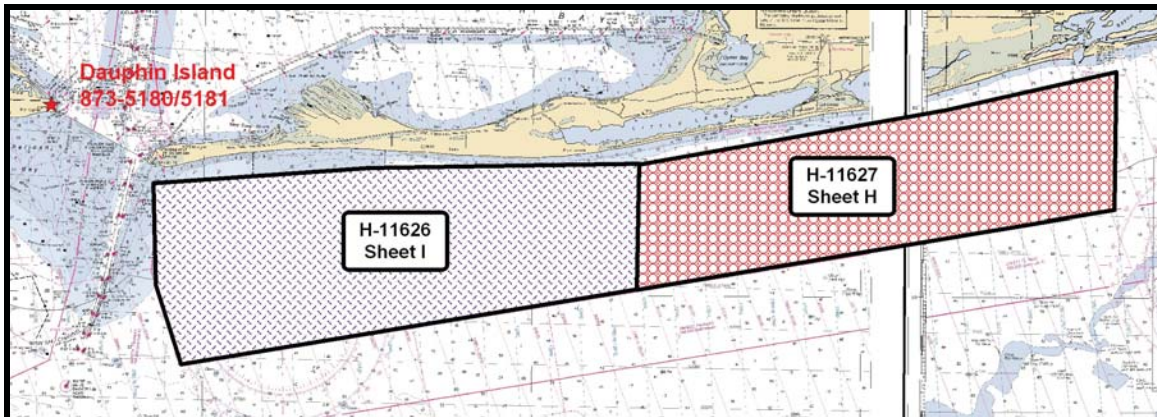


Figure 2- Overview of surveys H-11626 and H-11627 with tide station Dauphin Island, AL (873-5180/5181).

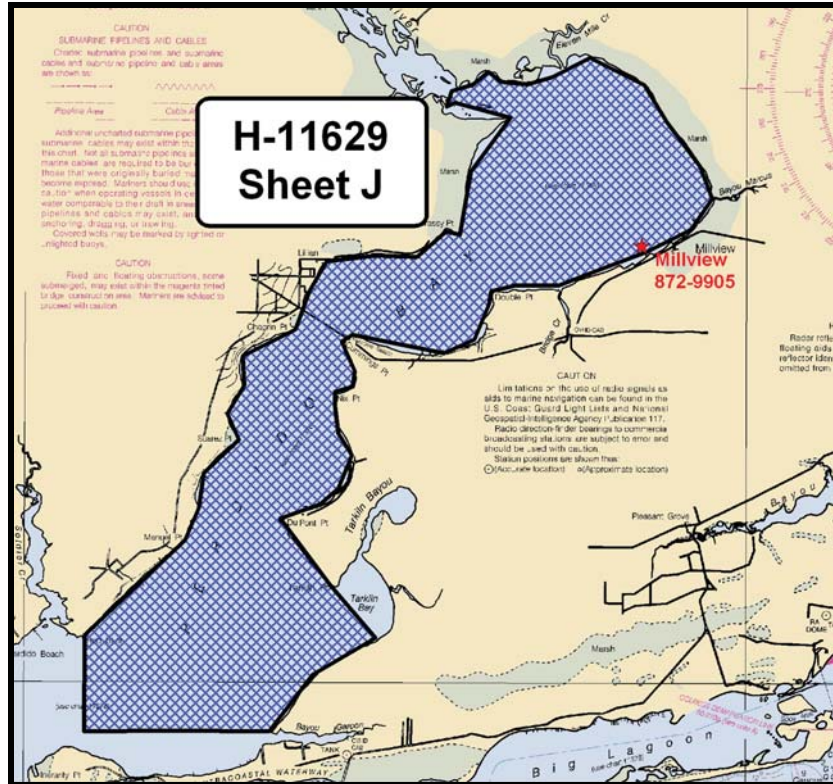


Figure 3- Overview of survey H-11629 with tide station Millview (872-9905).

Speed of Sound

The *Bella Marie* collected speed of sound data using an Applied Microsystems Sound Velocity & Pressure (SV&P) Smart Sensor from JD 2007-006 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. All data was collected by vertical casts.

The *Royal Fish* collected speed of sound data using an Odom Digibar Pro for the entirety of the survey. All data was collected by vertical casts.

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 extend to 95% of the anticipated water depth and are representative of local and diurnal variability. There were no data issues related to speed of sound measurements.

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 *Royal Fish* and *Bella Marie*.

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	98014/98440
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 *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.

The *Royal Fish* used the Coda Octopus F-180 positioning system with a DSM 212 GPS receiver. Positional differences were analyzed in real time and using Microsoft Excel to ensure position quality.

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

Attitude Sensors

On the *Bella Marie*, 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. On the *Royal Fish*, a Coda Octopus F-180 was used. Detailed descriptions of all attitude corrections are provided in Section C: Corrections to Echo Soundings.

Data Collection

The survey was conducted using shallow-water multibeam, singlebeam and side scan sonar techniques. The *Royal Fish* and *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 (100%) was obtained seaward of the 4-meter curve for surveys H-11626 and H-11627. Survey lines were spaced 75 meters apart. For survey H-11629, full bottom side scan sonar coverage (100%) was obtained to the edge of the survey limits.

Line Planning

Pre-planned processing blocks for each assigned sheet were developed prior to the survey to aid in processing organization. The survey lines were run the length of the sheet parallel to the shore for H-11626 and H-11627. Survey lines for H-11629 were run the length of the sheet.

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:

$$3.2 \text{ pings per 3 meters} = 1.1 \text{ pings per 1 meter}$$

$$1.1 * \text{Speed over Ground (meters per second)} = \text{ping rate}$$

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 were collected at a frequency of 410 kHz.

Software and Hardware Summary

Bella Marie

Multibeam and side scan data were 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 were 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.

Royal Fish

Singlebeam and side scan data were collected on an Intel Pentium IV PC using Hypack/hysweep data collection software operating in a Microsoft Windows 2000 environment. During acquisition, Hypack generates a depth matrix, similar to a DTM, which tracks real-time, uncorrected depths during each survey line. The Hypack matrix file was used in the field to determine whether the survey had been completed with adequate bottom coverage. The matrix file 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 Hypack native .raw (singlebeam) and .hsx (sidescan) 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, singlebeam 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 tables list the software used on the *Royal Fish* and *Bella Marie* during the survey and in the office during pre-survey planning and post-survey processing:

Table 8 – Software used aboard the *Royal Fish* and *Bella Marie*.

Program Name	Version	Date	Primary Function
Hypack/Hysweep	SP1 6.2.0.25	2006	Singlebeam and Sidescan data collection
F180 Control	3.1.4.4.	2006	Positioning and Attitude
C3D Control Panel	3.0.0.0	2006	Benthos Control
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
Corpcon	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	5.0.2195.2 722	2001	TerraSond Ltd. proprietary software for logging of GPS data for Quality Control

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) was used for the majority of the data processing tasks on this project. HIPS and SIPS is 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. The TerraSond, Ltd. Multibeam Suite (MBS) software also adheres to this protocol of strict traceability of the origins of and adjustments made to each sounding throughout the data reduction process.

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.

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 and Hypack. 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. Conventional bar-check procedures were used to verify the function of the MBES.

Data Collection

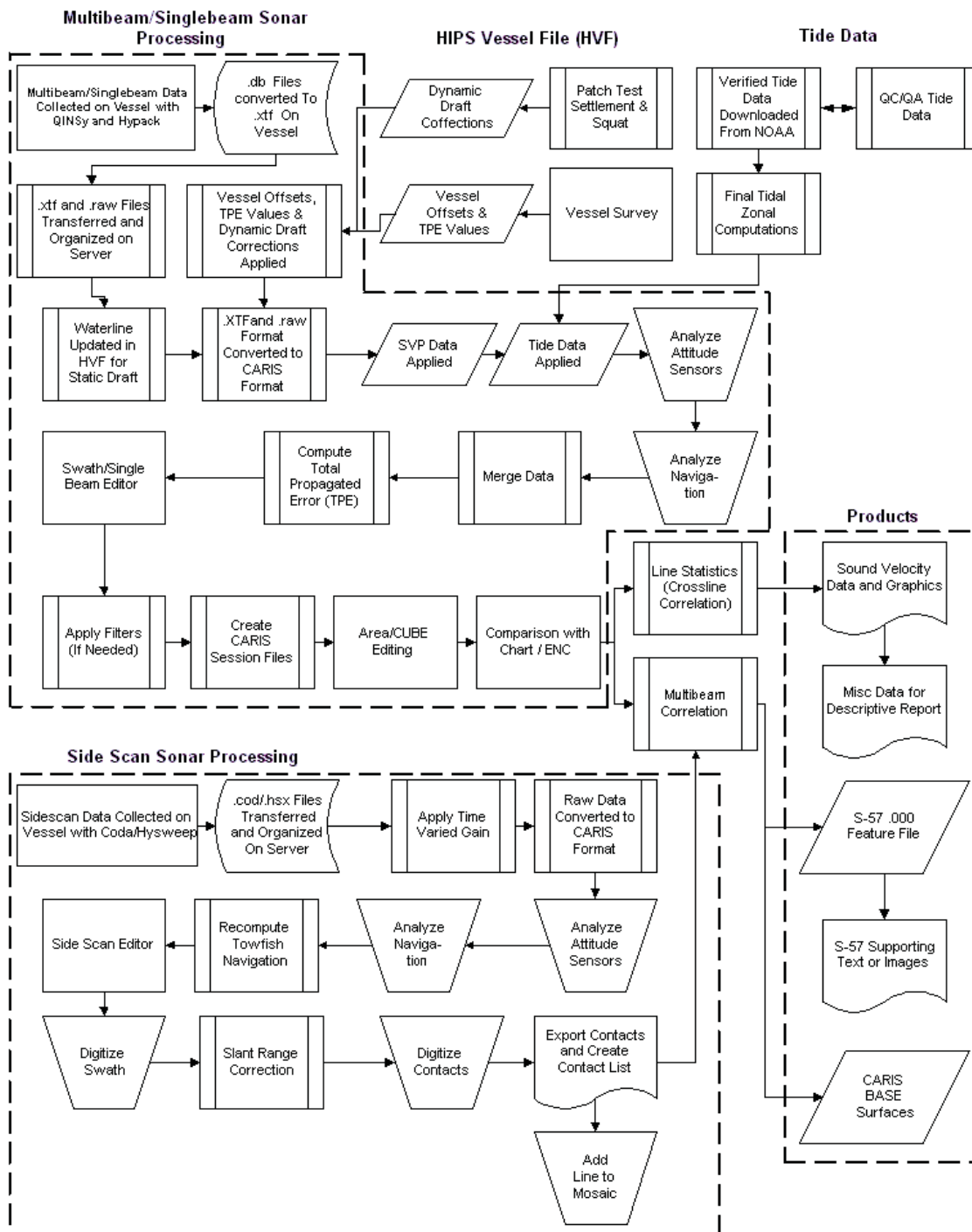
Multibeam sounding data collection on the *Bella Marie* was performed using QPS QINSy Multibeam data-collection software. File naming conventions were established to ensure that individual survey lines had unique names. Lines were assigned consecutive numbers with a letter designator corresponding to 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 on the *Bella Marie* 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.

Singlebeam and side scan sounding data collection on the *Royal Fish* was performed using Hypack data-collection software. File naming conventions were established to ensure that individual survey lines had unique names. Lines were assigned consecutive numbers followed by the time (hhmm) at which the line began. Hypack software generated individual line files using associated filenames, with the extension “.raw” (singlebeam) and .hsx (side scan), which contained survey data and equipment settings specific to each line.

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 and cable out.

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.



Initial Data Processing

Multibeam/Singlebeam

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. Singlebeam raw data (.raw) files were also converted to CARIS format using the CARIS conversion wizard. The wizard was used to create a directory for each line and separate the “.xtf” and “.raw” files into sub-files which contained individual sensor information. All data entries were time-referenced using the time associated with the “.xtf” and “.raw” file to relate the navigation, azimuth, heave, pitch, roll and slant range depths sensor files.

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

Preliminary soundings were tide adjusted using data from the National Water Level Observation Network (NWLON) stations at Dauphin Island, AL (873-8150/8151) and Millview (872-9905) through March 25, 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.

All sound speed casts made by the *Bella Marie* and *Royal Fish* were performed using an AML SV&P Smart Sensor or Odom Digibar Pro following conventional vertical cast procedures. Sound speed cast locations were selected to ensure spatial variety and casts were made more frequently in areas of variable sound velocity. Minimum and maximum depth limits were set as specified in NOAA Hydrographic Surveys Specifications and Deliverables, Section 5.4.3.

Sound speed raw data was converted to a CARIS compatible format using TerraSond’s proprietary SVP software and Microsoft Excel. 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 used slant range data, applied motion correctors to determine launch angles, and adjusted for range and ray-bending, resulting in a 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.

Multibeam and singlebeam navigation data were 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 were rejected with interpolation using a loose Bezier curve. Data was queried for time, position, delta time, speed, and status. If necessary, the status of the data was changed from accepted to rejected. Azimuth, heave, pitch and roll data were viewed in the CARIS Attitude Editor which displayed 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 inverted time-domain data into geographically referenced, soundings.

CARIS Swath Editor was used to review the merged multibeam 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 artifacts.

Singlebeam data were examined and cleaned using CARIS Single Beam Editor. Single Beam Editor displays a 2-dimensional profile view of survey data where soundings can be queried or flagged as accepted or rejected. Processors simultaneously reviewed the digital data and the analog paper trace, allowing acceptance or rejection of data based on field observations recorded in the acquisition notes or on the analog paper trace.

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 jumps in speed, distance and course made good. 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 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

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.

Area Editing

Following the individual line (swath and single beam) editing and quality assurance of draft and tide applications, several area-based editing processes in CARIS HIPS and SIPS Subset Editor were performed during 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. 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. Vertical exaggeration was increased as required to amplify trends or features. Soundings were flagged as accepted, rejected or designated.

In the first phase of area editing, processors examined the entire survey area in CARIS HIPS and SIPS Subset Editor and rejected outlying soundings. 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) for multibeam data collected by the *Bella Marie*. 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 (Table 10). 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 and squat).

Table 10 – *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: **for d < 100 meters**
a=0.5 m
b=0.013 m
d=depth (m)

CUBE

For H-11626 and H-11627 where multibeam data was collected, a Combined Uncertainty and Bathymetry Estimator (CUBE) surface was created using CARIS HIPS and SIPS BASE surface wizard. This was used to locate areas requiring further investigation and, potential 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. However, after correlating features resolved in side scan sonar data with multibeam data, remaining areas of high hypothesis counts often aided in the identification of locations 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.

Surface-Based Editing

Several BASE surfaces of varying resolutions were created and the 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.

Finally, a tile layer was created for each survey area. The 10m tiles were created twice, once populated with the shoalest soundings and once populated with the deepest sounding, in order to clean any remaining flyers from the data set. Tiles with depth values differing from their neighbors were investigated and edited when necessary.

Singlebeam & Multibeam Correlation / S-57

The next processing task involved correlating side scan sonar contacts with singlebeam/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 singlebeam/multibeam data in locations corresponding to each side scan sonar contact. The side scan sonar contacts were either disproved (only 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 T0002.

Verified contacts were determined to be significant or insignificant. 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 associated with multibeam data 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. Significant contact heights associated with Singlebeam data were recorded using the measure shadow tool in CARIS Side Scan Editor.

In accordance with Task Order T0002, it was necessary to record currently charted depths associated with significant contacts. However, the position of soundings from the largest scale ENC's covering the survey area and significant contacts from the 2007 survey rarely coincided. Therefore, it was necessary to interpolate the charted depth of a significant contact from the ENC soundings closest to it. This was accomplished by creating CARIS BASE surfaces from ENC sounding values. The charted depths of all significant contacts were determined by displaying the interpolated ENC sounding value from the BASE surface.

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-to-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 and referenced the same physical object. 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 the digital deliverables.

Sounding Reduction / Final QC

Since final, processed singlebeam/multibeam depths are no longer delivered as a fixed-scale smooth sheet of selected, shoal-biased soundings, it was not necessary to decimate the 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 largest scale current editions of the 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 included in each Descriptive Report Section D.1 Chart Compare.

Gridded Surfaces

The final depth information for this survey was submitted as CARIS BASE surfaces which best represent 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 surfaces.

In accordance with the statement of work, shallow water multibeam (SWMB) line spacing was set to achieve the desired side scan sonar coverage. This was not optimal for SWMB coverage and resulted in SWMB coverage gaps as the outer beams of adjacent lines did not meet.

The submittal of several grids of varying resolution was unnecessary due to the shallow depths and relatively flat bottom throughout the survey area.

2007 multibeam survey depths were submitted as a 2 meter resolution 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. 2007 singlebeam survey depths are submitted as a 5-meter resolution, swath angle-dependent, shoal-biased CARIS BASE surface. Additionally, one sun-illuminated, geographically referenced, DTM image depicting the coverage of elevation surface is submitted. The resolution of the DTM matches the resolution of the BASE surface from which they were generated. All grids are projected to UTM Zone 16 North, NAD 1983. Naming conventions for each grid are as follows:

CARIS BASE Uncertainty Surface: H11xxx_1_OF_1.hns

CARIS BASE Swath Angle Surface: H11xxx_1_OF_1.hns

Sun-Illuminated Elevation DTM: H11xxx_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 2007 survey deliverables. The base cell contains information on objects not represented in the depth grids, 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 geographically referenced files (.tif) are included in the data set, referenced as PICREP (Pictorial Representation attributes).

SIPS Final Processing

A side scan sonar mosaic was created for each survey in CARIS HIPS and SIPS using a 1m grid size for each multiple of 100% coverage specified in Task Order T0002. The mosaics were used to verify side scan sonar coverage. 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:

File Name: H11xxx_Resolution(m)

Example: H11627_1_0.tif

Crossline Analysis

For H-11626 and H-11627 where multibeam data was collected, crossline analysis was performed using CARIS HIPS and SIPS, in conjunction with Microsoft Excel. A BASE 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 and SIPS. 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 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 for 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 Section B2 Quality Control and 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 on the *Bella Marie* 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 the *Bella Marie* 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. For the *Royal Fish*, motion data were measured by the Octopus F-180 and output as a binary data string via RS-232 serial line to QPS QINSy acquisition software at 20Hz. Heave, roll and pitch corrections were applied during the sound velocity correction process in CARIS HIPS and SIPS.

Patch Test Data

Patch tests were performed on 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 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, 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 2007 survey and whenever there was a configuration change involving the position of the multibeam transducer. A listing of the patch tests performed for the 2007 survey is provided in Table 11.

Table 11 – Patch tests performed for instrument calibration during S-J977-KR-TE.

Vessel	Julian Date	Longitude (DMS)	Latitude (DMS)	Reason
<i>Bella Marie</i>	2006-314	088° 37' 59.156" W	30° 07' 35.861" N	Initial calibration
<i>Bella Marie</i>	2007-013	087° 33' 51.731" W	30° 15' 13.218" N	MBES / Side scan sensor switch

Speed of Sound through Water

An Applied Microsystems Ltd. Sound Velocity & Pressure (SV&P) Smart Sensors (*Bella Marie*) and an Odom Digibar Pro (*Bella Marie* and *Royal Fish*) velocimeters were used to collect sound speed data for S-J977-KR-TE. 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 SVP sensor data and provide graphs and statistics for each cast. The SVP 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 collected by the *Bella Marie*. The most temporally adjacent sound speed data was applied to the soundings collected by the *Royal Fish*.

The Descriptive Report SEPARATE II: SOUND SPEED DATA contains a detailed listing of the sound speed profiles and applicable cast dates used during the 2007 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 *Bella Marie* vessel survey log and once daily in the *Royal Fish* 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

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 on the engine RPM set to zero. Measurements continued as the RPM was slowly increased to the desired RPM. Once the vessel was at the desired speed, measurements were logged for several minutes. For the December 16, 2006 measurement, power was then removed and the vessel was brought to a drift, where data was logged for several more minutes. 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.

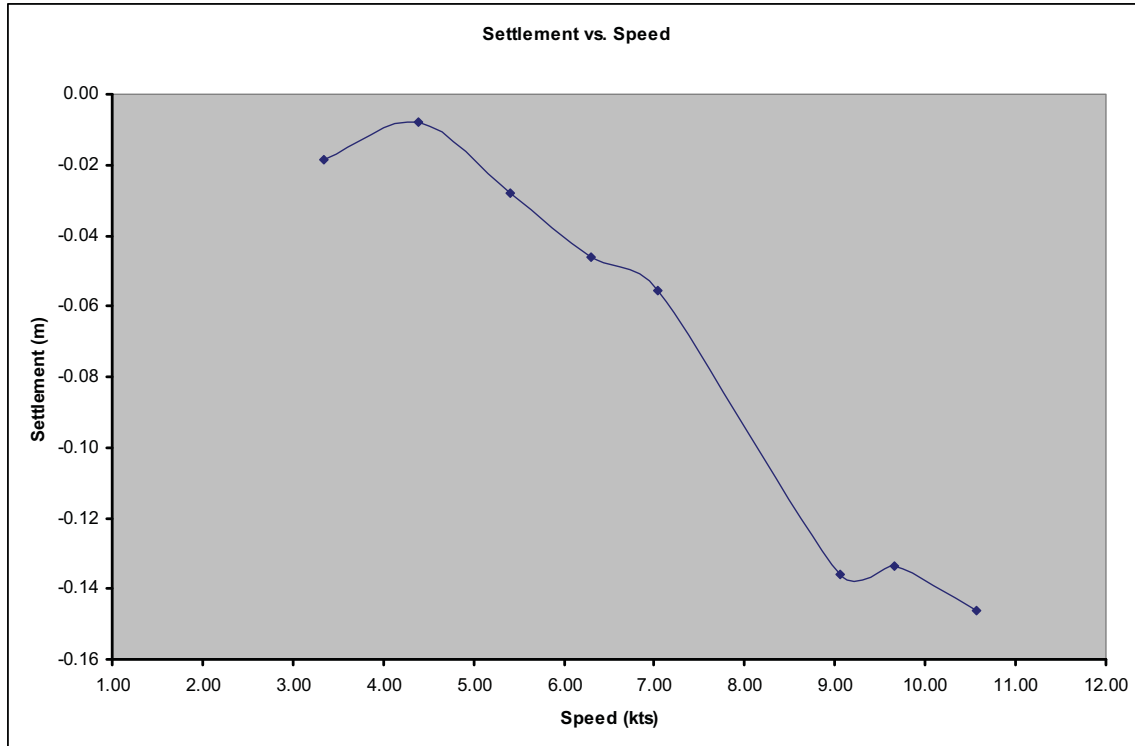


Figure 6 – *Bella Marie* Settlement and Squat Measurements.

Table 12 – *Bella Marie* average speed vs. settlement measured during Settlement and 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

Royal Fish

A settlement test was performed on the *Royal Fish* on 2006-356. The vessel was equipped with Coda F-180 Positioning configured to receive RTK corrections from a base station set up within 1km of the test area. The base station consisted of a Trimble 4000 SSE GPS receiver. The Trimble 4000 SSE was configured to broadcast its carrier phase measurements, using telemetry techniques, to the Coda F-180 once per second. Both the F-180 and the 4000 were configured with an elevation mask of 15 degrees, and a PDOP mask of 2.5 to reduce the DOP effects of low lying satellites. On board the *Royal Fish*, Hypack acquisition software was configured to log the necessary data. The relative height of the vessel’s reference point was monitored, along with, vessel speed, RPM, position, heave, pitch, and roll. Lines were run in 1000 RPM intervals. The test was performed at survey depth. Each RPM was run twice with 180 degree heading offsets to help reduce current effects on speed over water. Static observations of the RP height were also made before and after each line to eliminate the effects of tide. This test yielded values with an estimated accuracy $\pm 0.025\text{m}$.

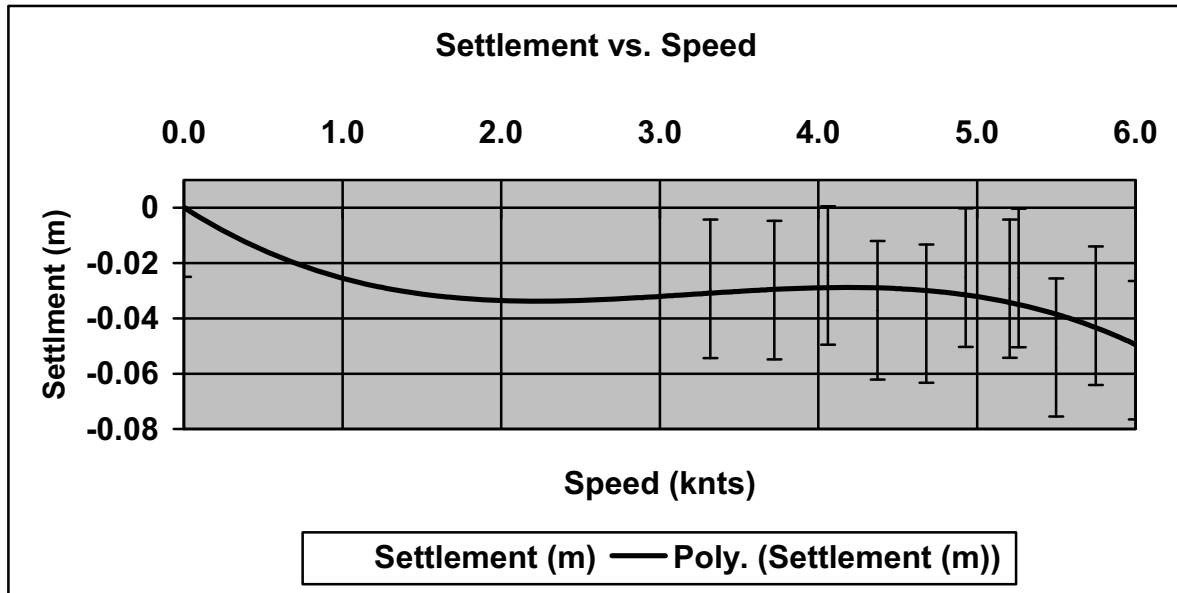


Figure 7 – *Royal Fish* Settlement and Squat Measurements.

Table 13 – *Royal Fish* average speed vs. settlement measured during Settlement and Squat survey on 2006-356.

Average Speed (kts)	Settlement (m)
0.00	0.00
3.3	-0.03
3.7	-0.03
4.1	-0.02

Average Speed (kts)	Settlement (m)
4.4	-0.04
4.7	-0.04
4.9	-0.03
5.2	0.03
5.3	-0.03
5.5	-0.05
5.7	-0.04
6.0	-0.05

Tide Correctors

The National Water Level Observation Network (NWLON) stations at Dauphin Island, AL (873-5180/5181) and Millview, AL (872-9905) 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 provided predicted tides and weekly verified tide data. Data for the Dauphin Island gauge were downloaded from the NOAA internet Hydro Hot list (<http://co-ops.nos.noaa.gov/hydro.shtml>) in ASCII format. Data from the Millview gauge were uploaded daily via GOES satellite by TerraSond, Ltd. and downloaded by JOA for analysis. JOA was responsible for the final tide zoning time and range corrections. Refer to Horizontal and Vertical Control Report tide gauge operations and zoning methods. Verified tide data from each gauge were 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 (873-8150/5181) and the Millview, AL (872-9905) were used as references stations for the zoning scheme. Tide Zone range and time correctors for the Millview (872-9905) gauge were provided by JOA. Refer to the Horizontal and Vertical Control Report for tide zone methods and operations.

Royal Fish

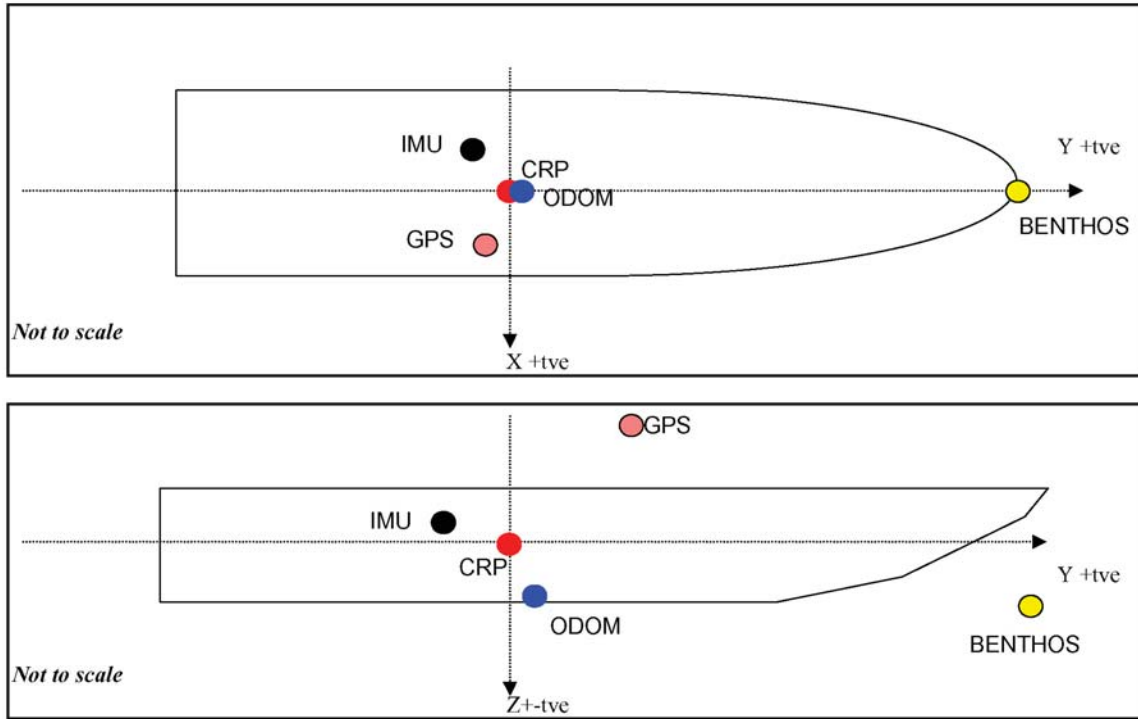


Figure 4 – *Royal Fish* vessel and equipment

Table 14 – *Royal Fish* 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	CodaOctopus F-180	-1.293	-0.53	-0.13
SB Sounder	Odom Hydrotrac	±0.000	+0.408	+0.496
GPS	CodaOctopus F-180	+1.158	-.463	-2.37
Side Scan Sonar Head	Bethos C3d	±0.000	+4.396	1.045

Bella Marie

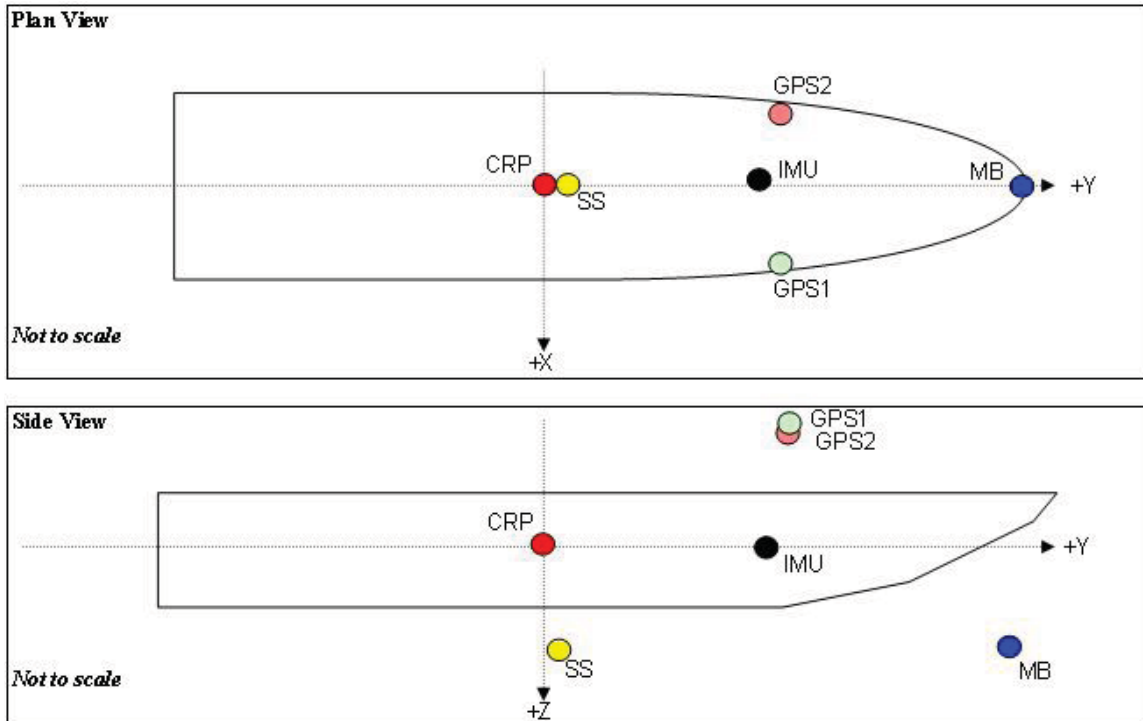


Figure 8 – *Bella Marie* vessel survey effective JD 2006-314 through JD 2007-012.

Table 15 – *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

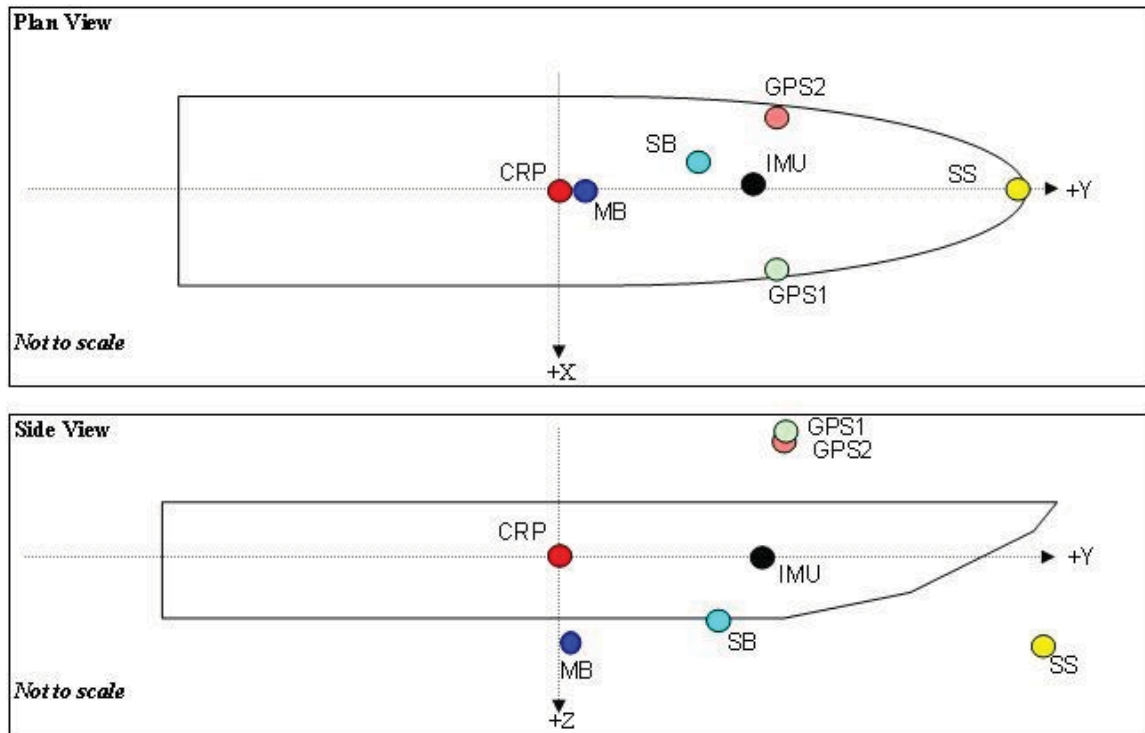
Bella Marie

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

Table 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	+0.005	+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

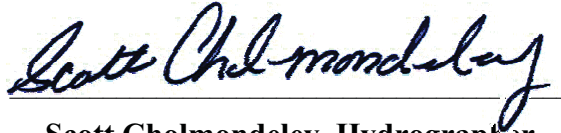
LETTER OF APPROVAL

S-J977-KR-TE

This report and the accompanying digital data are respectfully submitted.

Field operations contributing to the accomplishment of surveys H-11626, H11627 and H11629 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report, digital data, and accompanying records have been closely reviewed and are considered complete and adequate as per the Statement of Work. Other reports submitted with S-J977-KR-TE include the Descriptive Reports and the Horizontal and Vertical Control Report.

I believe this survey is complete and adequate for its intended purpose.



Scott Cholmondeley, Hydrographer
TerraSond Ltd.

Date 06/06/2007