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

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project	**OPR-J348-KR-11**
Contract No	**DG133C08CQ0006**
Task Order No	**T0006**
Time Frame	**July 2011 - November 2011**

LOCALITY

State	**Mississippi**
General Locality	**Approaches to Mississippi Sound**

2011

CHIEF OF PARTY

Jonathan L. Dasler, PE (OR), PLS (OR,CA)

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DATE

NOAA FORM 77-28
(11-72)

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

HYDROGRAPHIC TITLE SHEET

REGISTRY No

H12353
H12354
H12355
H12356

INSTRUCTIONS – The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

FIELD No

David Evans and Associates, Inc.

State: **Mississippi**

General Locality: **Approaches to Mississippi Sound**

Sub-Locality: **SE of Ship Island Harbor to SE of Horn Island**

Scale: **1:20,000**

Date of Survey: **July 12 to November 11, 2011**

Instructions dated: **June 22, 2011**

Project No.: **OPR-J348-KR-11**

Vessel: **R/V Westerly, R/V Chinook**

Chief of party: **Jonathan L. Dasler, PE (OR) , PLS (OR,CA)**

Surveyed by: **David Evans and Associates, Inc.**

Soundings by echo sounder, hand lead, pole: **RESON 7125, EdgeTech 4200-HFL, Odom Echotrac CV-100**

Graphic record scaled by: **N/A**

Graphic record checked by: **N/A**

Automated Plot: **N/A**

Verification by:

Soundings in: **Meters at MLLW**

REMARKS: **NAD 83, UTM Zone 16, Meters, Times are UTC.**

The purpose of this contract is to provide NOAA with modern, accurate hydrographic survey data with which to update nautical charts of the assigned area.

SUBCONSULTANTS: **John Oswald & Associates, LLC, 2000 E Dowling Rd, Anchorage, AK, 99507**

Zephyr Marine, 1575 Spinnaker Dr., Suite 105B, Ventura, CA 93001

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Acronyms and Abbreviations

AML	Applied Microsystems, Ltd
AWOIS	Automated Wreck and Obstruction Information System
BAG	Bathymetric Attributed Grid
BIN	Binary Format
CORS	Continuously Operating Reference Systems
CTD	Condictivity, Temperature, Depth
CUBE	Combined Uncertainty and Bathymetry Estimator
DEA	David Evans and Associates, Inc.
DGPS	Differential Global Positioning System
DN	Day Number
DTON	Danger to Navigation
DXF	Drawing Exchange Format
ERS	Ellipsoidal Referenced Survey
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HSD	Hydrographic Surveys Division
HSSD	Hydrographic Survey Specifications and Deliverables
HSX	Hypack Hysweep File Format
HVF	HIPS Vessel File
IAKAR	Inertially-Aided Kinematic Ambiguity Resolution
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
MVP	Moving Vessel Profiler
MP	Multi Pulse
NAD83	North American Datum of 1983
NGS	National Geodetic Survey
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OPUS	On-line Positioning User Service
POS/MV	Position and Orientation System for Marine Vessels
PPS	Pulse per Second
R/V	Research Vessel
RMS	Root Mean Square
RPM	Revolutions per Minute
SBET	Smooth Best Estimate and Trajectory
SSS	Side Scan Sonar
SVP	Sound Velocity Profiler
TWF	TIF World File
TIF	Tagged Image File Format
TPE	Total Propagated Error

UTC	Universal Time Coordinated
XTF	Extended Triton Format
ZDA	Global Positioning System Timing Message

Data Acquisition and Processing Report
Project OPR-J348-KR-11 Approaches to Mississippi Sound
July 2011 – November 2011
R/V *Westerly*, R/V *Chinook*
David Evans and Associates, Inc.
Lead Hydrographer, Jon L. Dasler, P.E., P.L.S.
ACSM/THSOA Certified Inshore Hydrographer

INTRODUCTION

This report applies to surveys H12353, H12354, H12355, and H12356 located at the approaches to Mississippi Sound. These contract surveys were performed under OPR-J348-KR-11 as specified in the *Statement of Work* (June 23, 2011) and *Hydrographic Survey Project Instructions* (June 22, 2011). All survey methods meet or exceed requirements as defined in the National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables* (HSSD) (April 2011). The survey consisted of 200 percent side scan sonar coverage with concurrent multibeam in waters 18 feet and deeper. In addition, single beam data at 100-meter line spacing were acquired within the H12354 survey area in water depths between 6 feet and 18 feet. Single beam split lines were run as needed to define shoals and disprove charted soundings. Additional guidance on single beam disproval of charted soundings was provided by the Hydrographic Surveys Division (HSD) via email (*RE: Guidance on Sounding disproval by SBES*) on September 14, 2011. The survey polygon *OPR-J348-11_Sheets_Feb_region.shp,* which was included with the *Hydrographic Survey Project Instructions* (June 22, 2011) was used to define the limits for each survey. Significant side scan contacts and Automated Wreck and Obstruction Information System (AWOIS) investigations were acquired to meet object detection coverage requirements for multibeam surveys. Thirty-four (34) bottom samples were acquired as depicted by the *BottomSamples_point.shp* file provided HSD.

On December 13, 2011 David Evans and Associates, Inc. (DEA) was directed to use Ellipsoidal Referenced Survey (ERS) methods for the reduction of survey data to chart datum via a signed memo from the Chief, HSD. Approval of these methods was granted based on recommendations included with DEA's interim deliverables (submitted November 1, 2011) for the ERS / VDatum Validation components of OPR-J348-KR-11 specified in the *Hydrographic Survey Project Instructions (*June 22, 2011*)*. A copy of this memo is included in Appendix V *Supplemental Survey Records and Correspondence* of each survey's *Descriptive Report*.

All references to equipment, software, or data acquisition and processing methods were valid at the time of document preparation. Any deviations from these data acquisition and processing methods will be specifically addressed in the Descriptive Reports of the project surveys.

A. EQUIPMENT

For this project DEA implemented state-of-the-art data acquisition systems aboard the Research Vessels (R/V) Westerly and Chinook, in accordance with National Oceanic and Atmospheric Association (NOAA) standards and modern remote sensing techniques. Operational systems used to acquire survey data and redundant systems that provided confidence checks are described in detail in this section and are listed in Tables 1, 2, and 3 on the following pages.

Table 1. R/V Westerly Hardware

Instrument	Manufacturer	Model	Serial No.	Function
Side Scan Sonar				
Deck Unit	**EdgeTech**	701-DL	35324	Topside interface SSS and digital sensors.
Towfish	**EdgeTech**	4200 HFL	37844 38461*	600 kHz Digital SSS imagery with towfish heading and depth sensors. *Swapped towfish on DN272
Side Scan Sonar Cable Counter				
Cable Counter	**Measurement Technology Northwest**	LCI-90	636	Continuous digital output of deployed side scan tow cable length for layback calculations.
Multibeam Echosounder				
	RESON	SeaBat 7125-SV2 multibeam sonar		Dual frequency multibeam sonar
Deck Unit	**RESON**	7-P Processor Unit	18200511035	7-P processor running Feature Pack 1 (FP1)
Receiver	**RESON**	EM 7200	4010143 4010043*	*Swapped with Chinook receiver on DN237
Projector	**RESON**	TC 2160	3310053	400kHz Transmitter
Sound Speed				
Surface Sound Speed	**RESON**	AML Micro X, Sensor	7561, 200264 7561, 201077*	Beam formation and steering. *Swapped on DN263 with new sensor only.
Sound Speed Profiler	**Brooke Ocean Technology, Ltd.**	AML MVP 30 Smart SVP+	5110	Primary SV profiler
Sound Speed Profiler	**Applied Microsystems**	AML SVP+ V2	3592	Secondary SV profiler
Sound Speed Profiler	**Sea-Bird Electronics, Inc.**	SBE 19 SEACAT Profiler CTD	2691	Secondary SV profiler
Navigation				
Deck Unit	**Applanix**	POS MV 320 V4	3083	Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll and pitch data.
IMU	**Applanix**	POS MV V4	750	
Starboard Antenna	**Trimble**	Zephyr	60186994	
Port Antenna	**Trimble**	Zephyr	12354270	
Receiver	**Trimble**	DSM 132	02204094182	Secondary positioning system with integrated DGPS radio.
Antenna	**Trimble**	DSM ANT	0220360503	
POS/MV Beacon Receiver	**CSI Wireless**	MBX-3S	0647-32351-0026	Differential radio for primary position system.
POS/MV Beacon Antenna	**CSI Wireless**	MD MGL-3	0716-3582-0006	

Table 2. R/V Chinook Hardware

Instrument	Manufacturer	Model	Serial No.	Function
Side Scan Sonar				
Deck Unit	**EdgeTech**	701-DL	35323	Topside interface SSS and digital sensors.
Towfish	**EdgeTech**	4200 HFL	38461	600 kHz Digital SSS imagery with towfish heading and depth sensors
Side Scan Sonar Cable Counter				
Cable Counter	**Measurement Technology Northwest**	LCI-90	350	Continuous digital output of deployed side scan tow cable length for layback calculations.
Multibeam Echosounder				
	Reson	SeaBat 7125-SV2 multibeam sonar		Dual frequency multibeam sonar
Deck Unit	**Reson**	7-P Processor unit	18200911041 18202410001*	7P processor running Feature Pack 1 (FP1) *DN258 to end of project
Receiver	**Reson**	EM7200	4010043 4010143*	*Swapped to Westerly receiver on DN237
Projector	**Reson**	TC2160	3310053	400 kHz transmitter
Single beam Echosounder				
Deck Unit	**ODOM**	Echotrac CV-100	26003	200 kHz 4 degree single beam echosounder
Transducer	**ODOM**	SMSW200-4a		
Sound Speed				
Surface Sound Speed	**Applied Microsystems**	AML Micro X	8083, 200790	Beam formation and steering
Sound Speed Profiler	**Applied Microsystems**	AML SVPlusV2	3592	Primary SV profiler
Sound Speed Profiler	**Brooke Ocean Technology, Ltd.**	AML MVP 30 Smart SVP+	5110	Secondary SV profiler
Sound Speed Profiler	**Sea-Bird Electronics, Inc.**	SBE 19 SEACAT Profiler CTD	2691	Secondary SV profiler
Navigation				
Deck Unit	**Applanix**	POS MV 320 V4	2357	Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll and pitch data.
IMU	**Applanix**	POS MV V4	477	
Starboard Antenna	**Trimble**	Zephyr	60073610	
PORT Antenna	**Trimble**	Zephyr	60080633	
Receiver	**Trimble**	DSM132	0224093932	Secondary positioning system with integrated DGPS radio.
Antenna	**Trimble**	Zephyr	0220415991	
Receiver	**CSI Wireless**	MBX-3S	0716-1600-0009	Differential radio for primary position system.
Antenna	**CSI Wireless**	MD MGL-3	0716-3582-0008	

Table 3. GPS Base Station Hardware

RTK Base Station Equipment						
Item/ Manufacturer	**Model**	**P/N**	**S/N**	**Antenna Type**	**Firmware Version**	**Comments**
Receiver						Dual Frequency/ data logging capable
Trimble	**NetR5**	62800-10	4750K11594		4.19	
Trimble	**NetR5**	62800-10	4750K11589		4.19	
Antenna						
Trimble	**Zephyr-Geodetic**	41249-00	12338039	TRM41249.00		
Trimble	**Zephyr-Geodetic**	41249-00	12337025	TRM41249.00		

A1. Survey Vessels

A1.a R/V *Westerly*

The R/V *Westerly*, which is owned and operated by Zephyr Marine (Figure 1), was used as the primary survey vessel for the project.

Figure 1. R/V *Westerly*

The R/V *Westerly*, hull registration number 1231991 is a 38-foot, 13-gross ton, aluminum catamaran with 16.5-foot beam and a draft of 4.6 feet. The vessel is equipped with twin Hamilton jets, centerline moon pool hydraulic multibeam mount, stern mounted A-frame, air-cushioned server station, and acquisition station. No unusual sensor configurations were used aboard R/V *Westerly*.

A1.b R/V *Chinook*

The R/V *Chinook*, which is also owned and operated by Zephyr Marine (Figure 2), was the second survey vessel configured for acquisition.

Figure 2. R/V *Chinook*

The R/V *Chinook*, hull registration number IAR28CATJ607, is a 28-foot, aluminum catamaran with 10.5-foot beam and a maximum draft of 2 feet. The vessel is equipped with twin 225 HP outboard motors, 12-foot pilot house, a starboard side custom multibeam pole mount, hull mounted single beam, stern mounted A-frame, air-cushioned server station and acquisition station. No unusual sensor configurations were used aboard R/V *Chinook*.

A2. Multibeam Systems

Each vessel was equipped with a Reson SeaBat 7125-SV2 multibeam sonar with dual frequency configuration and integrated AML Micro X SV sound velocity sensor. The multibeam deployment on the R/V *Westerly* was a center lift-mount through a moon pool; the multibeam deployment on the R/V *Chinook* was a pole mount on the starboard side. The Reson 7125-SV2, which is designed specifically for installation aboard surface vessels, produces a 128° swath at either 400 kHz or 200 kHz producing a beam width of 0.5° x 1.0° and 1.0° x 2.0° respectively. The 400 kHz comes with a choice between 256 and 512 equiangular or equidistant beams. The 200 kHz only operates with 256 equiangular or equidistant beams.

For this survey all multibeam data were acquired using equiangle beam spacing (256 beams) at the frequency of 400 kHz with the 400 kHz SV2 Bracket (PN85160026C02) selected in the hardware configuration. All multibeam data were output using the 7006 datagram, which references all soundings with respect to the 7125 sonar reference point. Range adjustments were made during acquisition as dictated by changes in water depth. Hypack HYSWEEP was used to acquire multibeam data in Hypack Hysweep File Format (HSX).

A3. Single beam Sonar Systems

The R/V *Chinook* was equipped with an Odom Echotrac CV-100 single beam echosounder with a hull mounted 200 kHz Odom SMSW200-4a four-degree transducer. Range adjustments were made during acquisition and dictated by changes in depth via the 'Auto' setting. Hypack MAX was used to acquire single beam data in Hypack RAW and Binary (BIN) formats.

A4. Side Scan Sonar Systems

Side scan sonar imagery was acquired with two Edgetech 4200-HFL (300/600 kHz) side scan sonars. Each sonar was operated in High Frequency, High Speed mode at 600 kHz. For water depths less than approximately 30 feet the sonar was set to 50-meter range with 40-meter line spacing. For water depths greater than approximately 30 feet the sonar was set to 75-meter range with 65-meter line spacing. The 40-meter and 65-meter line spacing allowed for 10 meters of outer range overlap between passes. Odd numbered lines were used to make up the 100 percent coverage while the even numbered lines made up the 200 percent coverage. Side scan sonar imagery was logged as Triton eXtended Triton Format (XTF) (16 bit, 2048 pixels/channel) in Triton Isis SS-Logger. In addition to the imagery, vessel heading, pitch, roll, position, towfish depth and altitude, and computed towfish position from layback calculations was also recorded to the XTF. The side scan sonar was primarily deployed from the stern A-frame of each vessel when water depth allowed it and was towed using a close-to-stern setup for shallow water. For stern tow a LCI-90 Cable Payout Meter along with measured tow point offsets and sss depth was used by SS-Logger for layback calculations. For the close-to-stern shallow water tow, a fixed layback distance was entered into SS-Logger manually.

To confirm adequate target resolution at the outer limits of the selected range, confidence checks were conducted on a daily basis during acquisition and noted in the acquisition logs. In deteriorating conditions, confidence checks were performed more frequently to confirm detection of features at the outer range limits.

A5. Position, Heading and Motion Reference Systems

The survey vessels were outfitted with an Applanix Position and Orientation System for Marine Vessels (POS/MV) 320 version 4 with Differential Global Positioning System (DGPS) and inertial reference system, which was used to measure attitude, heading, heights, and position. Each system was comprised of an Inertial Motion Unit (IMU), dual frequency (L1/L2) Global Positioning System (GPS) antennas, and a data processor.

CSI Wireless MBX-3S differential beacon receivers, which were installed onboard the R/V *Westerly* and R/V *Chinook*, acquired corrections from the U.S. Coast Guard beacon located at English Turn, Louisiana (293 kHz) and provided differential corrections to each POS M/V. In addition, Trimble DSM 132 DGPS receivers were used as redundant positioning systems to provide secondary DGPS corrected positions for quality control purposes. These redundant systems both used intergraded beacon receivers and acquired differential corrections from the U.S. Coast Guard beacon at Eglin, Florida (295 kHz). Positions from all systems were displayed in real-time using Hypack and continuously compared during survey operations.

A weekly position comparison between the POS/MV and DSM132 positioning systems was observed and documented while the vessel was secured and relatively motionless in the marina. Logged position data was extracted from the Hypack RAW file and entered into an Excel file for differencing. Position Check Reports can be found in Separate I *Acquisition and Processing Logs* of each survey's *Descriptive Report*.

Position, timing, heading and motion data were output to the Hypack acquisition system using the POS/MV real-time ethernet option at 25 Hz.

The POS/MV provided time synchronization of sonar instruments and data acquisition computers using a combination of outputs. The Reson processors and Hypack acquisition computers were provided a Pulse Per Second (PPS) and National Marine Electronics Association (NMEA) ZDA date and time message to achieve synchronization with the POS/MV. The Isis SS-Logger accquisition computers synchronized their time using the proprietary Trimble Universal Time Coordinated (UTC) message provided by the POS/MV. All messages contained time strings that enabled the acquisition computers and sonars to synchronize to the time contained within the message. Time offsets between the instruments and computers, relative to the times contained in POS/MV network packets, were typically sub-millisecond.

Using the ethernet logging controls, each POS/MV was configured to log all of the raw observable groups needed to post process the real-time sensor data. The POS/MV logged 64 megabyte (MB) .000 files each, which resulted in multiple files created per day. The TrueHeave™ data group was also logged to these files.

A6. Sound Speed Measurement Systems

Sound speed sensors were calibrated prior to the start of acquisition. Factory calibration results are included in Appendix IV *Sound Speed Sensor Report*. All sound speed calculations from the Sea-Bird Conductivity, Temperature, and Depth (CTD) profiler used the Chen-Millero equation. Checks between surface sound speed sensors and sound speed profilers were periodically monitored. The Seabird SBE 19 was used as the secondary sound speed sensor for both vessels.

A6.a R/V *Westerly*

An AML Micro X SV sensor mounted on the Reson 7125 sonar head was input into the Reson 7-P processor and speeds from the sensor were used in real-time during acquisition for beam forming on the 7125's flat array. A Brooke Ocean Technology Moving Vessel Profiler (MVP) 30 with an AML Smart Sound Velocity Profiler (SVP)+ was mounted on the stern of the R/V *Westerly* and used as the primary sound speed sensor during multibeam acquisition.

A6.b R/V *Chinook*

An AML Micro X SV sensor mounted on the Reson 7125 sonar head was input into the Reson 7-P processor and speeds from the sensor were used in real-time during acquisition for beam forming on the 7125's flat array. An Applied Microsystems, Ltd (AML) SV Plus V2 was used to acquire sound speed profiles collected onboard the R/V *Chinook* .

When possible the R/V *Chinook* worked in tandem with the R/V *Westerly* in order to increase operational efficiency by using the sound speed profiles acquired by the R/V *Westerly's* MVP-30. These instances are noted in the R/V *Chinook's* survey acquisition logs.

A7. Acquisition and Processing System

Acquisition stations were custom-installed and integrated on the R/V *Westerly* and R/V *Chinook* by DEA and consisted of a Triton Isis SS-Logger side scan sonar data acquisition computer, Hypack Hysweep multibeam acquisition and navigation computer, and an additional computer for digital logs and general adminsitration. In addition, an MVP computer was installed aboard the R/V *Westerly*. During acquisition, data were logged locally on each individual acquisition computer and then transferred to the field office in Biloxi, MS using a USB hard drive at the completion of each survey day. Data were archived in the field office and prepared for shipment to DEA's Vancouver, WA office, where additional archiving, processing and creation of deliverables was performed. The software and version numbers used throughout the survey are listed in Table 4.

Table 4. Acquisition and Processing Software

Description	Manufacturer	Version
Acquisition		
HYPACK	Hypack, Inc.	10.0.0.34
Survey	Hypack, Inc.	10.0.6.10
Hysweep Survey	Hypack, Inc.	10.0.12.0
Isis SS-Logger	Triton Imaging, Inc.	7.3.623.51
Discover 4200-MP	Edgetech	7.02
LineLog	David Evans and Associates	1.0.6
MV-POSView	Applanix Corporation	5.1.0.2
POS MV V4 Firmware	Applanix Corporation	5.01
Smart Talk	Applied Microsystems Ltd.	2.27
Reson 7125	Reson	FP1.2
ODIM MVP Control	Brooke Ocean Technology, Ltd.	2.430
SeaTerm	Sea-Bird Electronics, Inc.	1.59
SBE Processing	Sea-Bird Electronics, Inc.	5.37e
Processing		
HIPS	CARIS	7.1 HF2
Notebook	CARIS	3.1 SP1 HF1
Bathy DataBASE	CARIS	3.2 HF1
HYPACK	Hypack, Inc.	10.0.0.34
ArcMap	ESRI	10.0 SP2
POSPac MMS	Applanix Corporation	5.4.4183.20673 SP1
Isis SS-Logger	Triton Imaging, Inc.	7.2.118.331
TargetPro	Triton Imaging, Inc.	2.8.118.331
SonarWiz	Chesapeake Technology, Inc	4.04.0054
Photoshop	Adobe	10.0.1
Convert to Rinex	Trimble	2.1.1.0
Velocwin	NOAA	8.96
Other		
Microsoft Office Suite	Microsoft	2007
Beyond Compare	Beyond Compare	3.0.13

A8. GPS Reference Station Network

Prior to the start of hydrographic survey operations, GPS base stations were established by DEA on Ship and Horn Islands. This was done in order to log raw dual frequency observables necessary for GPS post-processing of survey vessel navigation data using the single base mode within Applanix POSPac MMS. GPS base stations were installed no greater than 20 kilometers from the survey areas in order to keep the maximum possible range from survey vessel to base station within the published limits for post-processing using POSPac MMS in single base mode. Table 5 shows the positions for the two GPS base stations established for the project.

Table 5. GPS Base Station Positions

Station Name	Latitude (DMS North)	Longitude (DMS West)	NAD 83 Ellipsoid Height (m)
SHIP	30 12 50.79097	88 58 17.34520	-21.222
HORN	30 14 17.35884	88 40 01.67123	-21.122
HORN (adjusted)	30 14 17.35884	88 40 01.67123	-21.095

GPS Base station antennas were mounted on 5/8" bolts that were temporally fixed to stable structures. Clear sky was found at both base stations 10° above the horizon.

A North American Datum of 1983 (NAD83) (CORS96) (Epoch 2002.00) position of each base station was determined by acquiring and submitting a 24-hour observation with 1 second epoch data to the On-line Positioning User Service (OPUS) operated by the National Geodetic Survey (NGS). Due to the time delay in the availability of precise orbits (up to 19 days); base station positions were computed using rapid orbits. Once precise orbits were posted base station positions were recomputed in order to validate the rapid orbit positions and to evaluate the need for using positions computed with precise orbits rather than with rapid orbits. Differences between the positions were negligible with a maximum horizontal deviation of 4 millimeters and a maximum vertical difference of -1 millimeter. The positions for base stations SHIP and HORN computed using rapid orbits (Table 5) were used during all GPS post-processing sessions.

Upon several OPUS submissions, it became apparent that the z-value for the first precise emphemeris for the HORN base station submittal was inaccurate. The differences in z-values between the first submittal and subsequent submittals averaged 0.027 meters. A z-value adjustment of 0.027 meters was made to surveys H12354, H12355 and H12356 to account for the discrepancy. This value was applied as a static height adjustment during the computation of GPS tides in CARIS HIPS for survey lines, which used correctors from the HORN base station.

More information on the GPS base stations, including site reports, and positions, are included in the OPR-J348-KR-11 *Horizontal and Vertical Control Report*.

A9. Survey Methodology

A9.a Mobilizations

Mobilization, sensor installation, and calibration of the R/V *Westerly* and R/V *Chinook* occurred at Point Cadet Marina in Biloxi, Mississippi from July 6, 2011 (DN 187) to July 17, 2011 (DN 198). Vessel offsets and associated measurement uncertainties for the R/V *Westerly* were calculated from a vessel survey using a terrestrial land survey total station on June 27, 2011. All survey points were positioned from a minimum of two locations, which allowed a position uncertainty to be determined. A similar vessel survey of the R/V *Chinook* was performed on July 20, 2009 prior to the start of OPR-E349-KR-09. New offsets for the multibeam sonar acoustic center were calculated for R/V *Chinook* prior to the start of OPR-J348-KR-11 after the multibeam pole was lowered and a new sonar make and model was installed. Vessel offsets and uncertainties were used in the Hydrographic Information Processing System (HIPS) vessel files (HVF).

Once installations were completed and the hydrographer was confident that all sensors were operational, the survey vessels underwent system calibration tests, including settlement and squat and patch tests.

A9.b Survey Coverage

The project area (OPR-J348-KR-11) was surveyed with line orientation appropriate for the charted depth contours and prevailing winds with respect to the survey boundaries. The side scan sonars were operated at 50-meter and 75-meter range scales with 40-meter and 65-meter survey line spacing, to achieve 200 percent side scan coverage and allow for a 10-meter offline tolerance. Multibeam echosounder data was acquired concurrently with side scan sonar operations. Additional multibeam coverage was acquired over significant features found in the side scan data record to obtain a least depth at object detection requirement. Single beam coverage was acquired between the 6-foot and 18-foot depth curves over shoal areas and pre-existing charted soundings for survey H12354 only.

Survey coverage was based on the survey limits depicted by the file *OPR-J348-11_Sheets_Feb_region.shp*, which was provided with the *Hydrographic Survey Project Instructions* (June 22, 2011). For surveys H12353, H12355, and H12356 side scan sonar with concurrent multibeam survey coverage extends to either the polygon limit or the surveyed 18-foot depth curve. For survey H12354 side scan sonar with concurrent multibeam coverage extends to the polygon limit or the surveyed 18-foot depth curve and single beam coverage extends from the 18-foot depth curve to the 6-foot depth curve over shoal areas. The *OPR-J348-11_Survey_Limits.shp* file is included with the digital deliverables of each survey.

A9.c Side Scan Sonar Operations

Side scan sonar imagery was collected using the sonar's high frequency setting (600 kHz) in the multi-pulse high-speed mode at a range of 75 meters for deep areas or 50 meters for shoal areas (Figure 3).

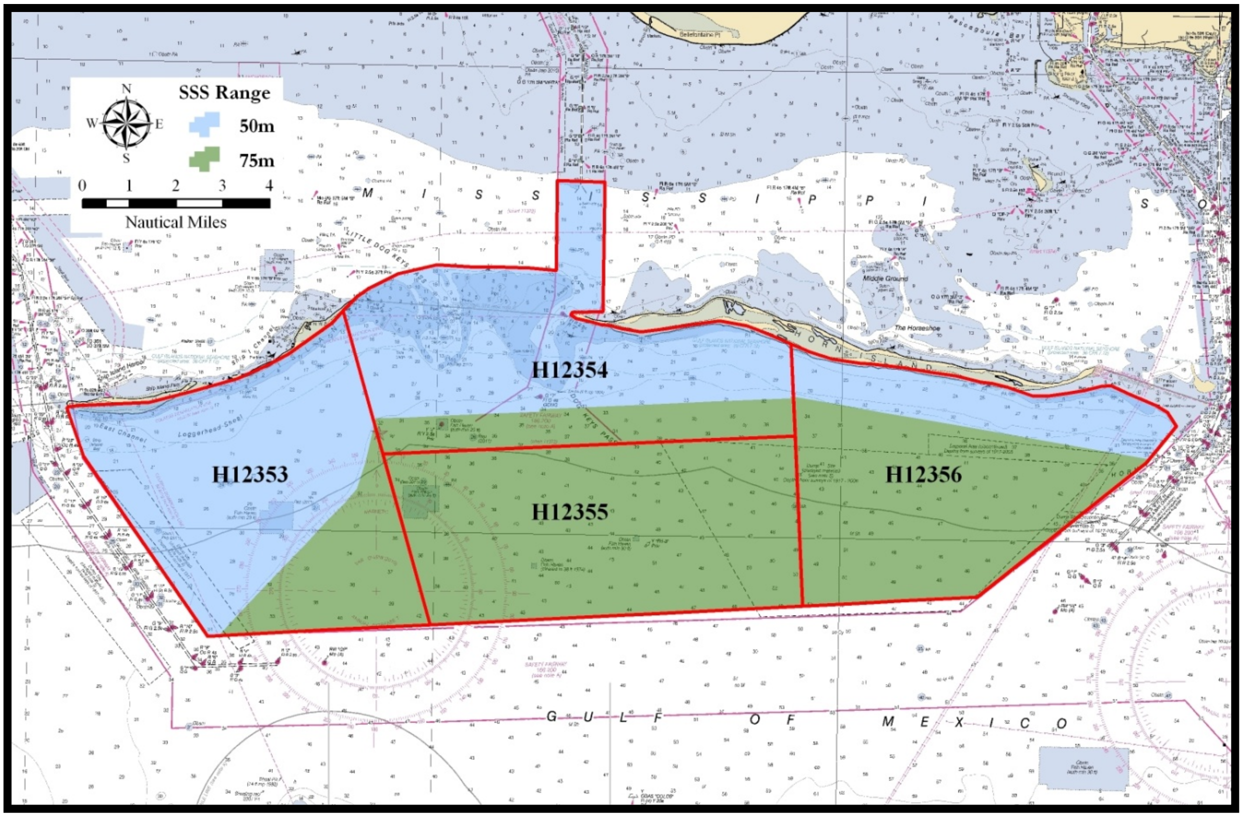

Figure 3. Side Scan Sonar Range Scale Use by Survey

The EdgeTech 4200-HFL series sonar has a ping rate of 20 Hz at 75-meter range and 30 Hz at 50-meter range, while operating in the high speed mode. High speed mode makes use of the optional Multi-Pulse (MP) technology, which places two sound pulses in the water at a time rather than the traditional one pulse, and allows for tow speeds upwards of 10 knots. In accordance with the NOS HSSD (April 2011), vessel speed was monitored to allow for the acquisition of a minimum of three pings per meter. The side scan was towed from the stern of the vessels during acquisition.

The side scan sonar operator was assigned the task of analyzing the digital sonogram and keeping the towfish height within specification by adjusting cable out. The operator also called out contacts and daily confidence checks, which were entered into the digital acquisition log by the multibeam operator/log keeper. When weather or sea conditions degraded side scan sonar imagery, operations were suspended. All acquisition occurred during daylight hours with the vessel leaving port in the morning and returning in the evening.

Side scan sonar coverage was obtained by using Technique 2 listed under Section 6.1 of the NOS HSSD (April 2011). This technique allows for two separate 100 percent coverages by running splits between the first coverage to obtain the second coverage. The sonar acquisition operator monitored the vessel speed to maintain a speed over ground that allowed for a minimum of three pings per meter for the range scale being used. In addition, the side scan sonar operator monitored both towfish height and coverage displays in order to maintain an altitude of 8 percent to 20 percent of the range above the bottom and to acheive the desired coverage.

A9.d Multibeam Sonar Operations

Multibeam operations occurred concurrently with side scan sonar acquisition using the Set Line Spacing coverage technique as stated in the OPR-J348-KR-11 *Hydrographic Survey Project Instructions*, (June 2011) and defined by the NOS HSSD (April 2011). Full multibeam coverage was not a requirement for this survey. The multibeam sonar was operated at different range scales throughout the survey by adjusting the depth range to obtain the best coverage in varying depths of water.

Table 6 lists the typical sonar settings for the survey.

Table 6. Reson 7125 Sonar Settings

7125 Parameter	Value
Range	Variable, depth dependent
Gain	15-65 dB
Power	208-220 dB
Spreading	30 dB
Absorption	100 dB/km
Ping Rate	20-30 p/s
Pulse Width	31-60 µs

A9.e Bottom Sampling

Thirty-four (34) bottom samples were acquired as specified in the *Hydrographic Survey Project Instructions* (June 22, 2011) in accordance with section 7.1 of the HSSD. Bottom sample locations were provided by NOAA in the file *BottomSamples_point.shp*, which is included on the delivery drive.

A9.f GPS Base Stations

GPS Base stations logged one second epoch GPS observables in the Trimble .T00 format with one file created every 24 hours. The Trimble Convert to RINEX version 2.1.1.0 utility was used to convert Trimble .T00 files to RINEX format in order to be imported into Applanix POSPac post-processing software.

A10. Quality Assurance

Acquisition and processing methods followed systematic and standardized workflows established by DEA. These systems include, but are not limited to staff training and mentoring, a formalized project management program, record and log keeping standards, software version management, and a multilevel review process.

MBES survey data were converted and processed in Caris HIPS version 7.1 Hotfix 2. Processing methodology followed the standard Caris HIPS CUBE (Combined Uncertainty Bathymetric Estimator) workflow with integration of post-processed sensor data through the HIPS Load Attitude and Navigation Tool.

The default *CUBE Parameters.XML* was replaced with a file issued by NOAA Hydrographic Surveys Technical Directive 2009-2. This updated XML file uses the resolution dependent maximum propagation distance values required in the NOS HSSD (April 2011).

All side scan contacts that were determined to be significant were investigated with multibeam according to object detection specifications. Investigations were conducted even if the object was covered in the initial set-line multibeam mainscheme. This technique is shown in Figure 4.

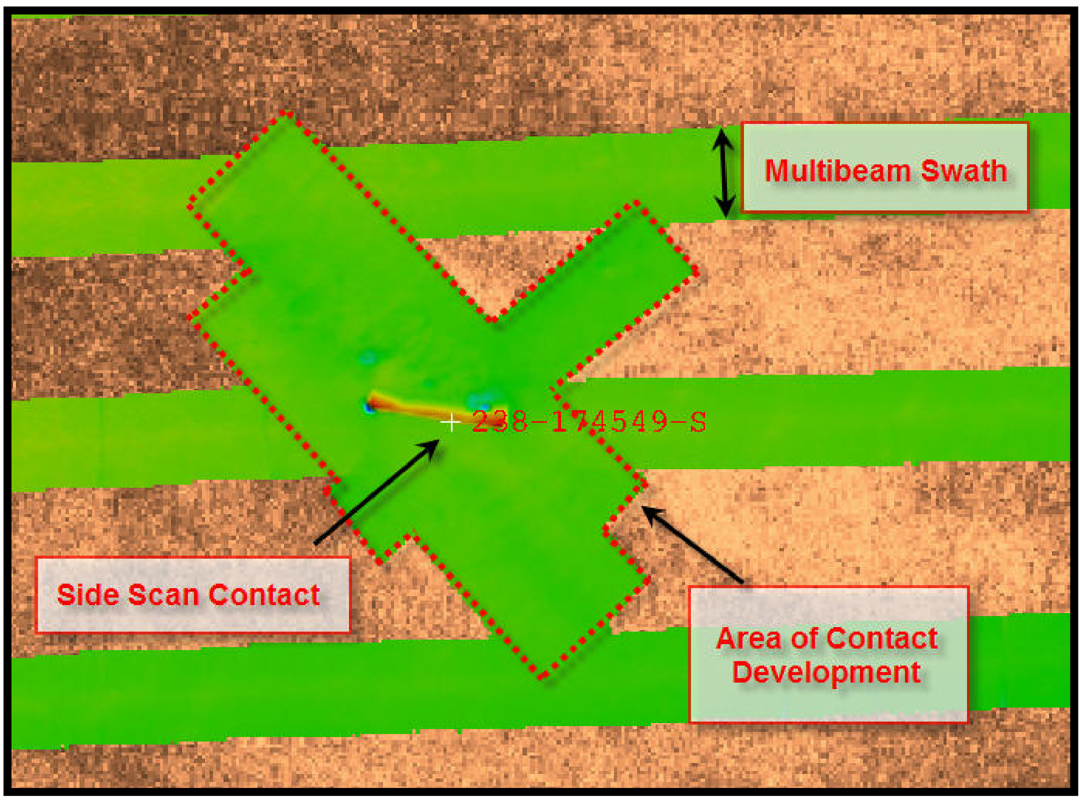

Figure 4. Side scan sonar mosaic overlaid with side scan sonar contacts

B. QUALITY CONTROL

B1. Data Acquisition

B1.a Side Scan Sonar

Triton Isis SS-Logger acquisition software was used to record side scan sonar data in XTF format. Adjustments to towfish height were made during data acquisition as necessary, and logged in Isis SS-Logger to meet specifications and provide the best image quality possible. Layback values and changes were recorded in the daily acquisition log. Typical windows for monitoring raw sensor information included a waterfall display for the sonar imagery, tow fish motions, sonar signal voltage display and I/O port monitor. Data were displayed on a 30-inch LCD flat panel monitor mounted vertically at the acquisition station. The large format display allowed for increased time to analyze online contacts. Contacts were selected in real-time and during post-processing. Additionally, vessel speed was adjusted in accordance with the NOS HSSD (April 2011) to meet the required along track coverage requirements.

To aid in the consistency of contact identification, a table was posted listing slant range and towfish altitude to determine minimum shadow heights for 1 meter contacts at 75-meter and 50-meter ranges. Contacts were classified as significant if their estimated height was 1 meter or more. Maintaining towfish altitude at 8 percent to 20 percent of the range (6 meters to 15 meters height above the bottom at 75-meter range and 4 meters to 10 meters height above bottom at 50-meter range.) was tasked to the side scan operator who also controlled the winch operation. The operator could view the towfish altitude above the seafloor on the Isis SS-Logger display and adjust cable out accordingly to fly the towfish at the required height. Digital cable out values were confirmed by stopping pay out of the tow cable when 10-meter marks on the cable were at the top of the the block sheave. Using this method, the cable-out meter was calibrated each day prior to deployment and continousouly during tow operations.

B1.b Multibeam

Multibeam data were acquired in HYPACK Hysweep HSX format. Adjustments to the sonar, including changes in range and gain were made as necessary, in order to acquire the best bathymetric data quality. Additionally, vessel speed was adjusted in accordance with the NOS HSSD (April 2011) to meet the required along track coverage. Typical windows for monitoring raw sensor information included timing synchronization, surface sound velocity, vessel motion, number of satellites, HDOP and PDOP. Raw attitude and nadir depth is also recorded in HYPACK (RAW) format, as a supplementary backup.

The HYPACK acquisition station operator monitored and tuned the multibeam sonar, examined surface sound velocity to determine the frequency of sound velocity casts, tracked vessel navigation and maintained the digital line log. Operators monitored primary and secondary navigation systems to verify quality position data were acquired at all times.

B2. Methodology Used to Maintain Data Integrity

The acquisition systems and survey protocols were designed with some redundancy to demonstrate that the required accuracy was being achieved during the survey and provide a backup to primary systems. Data integrity was monitored throughout the survey through system comparisons. Two positioning systems were used to provide real-time monitoring of position data. Position confidence checks and multibeam bar checks were conducted weekly to confirm required accuracy was being maintained. Weekly comparison checks were performed simultaneously lowering the R/V *Chinook's* AML or SeaBird SEACAT and R/V *Westerly's* MVP. Sound speed profiles were computed for each of the sensors and compared to confirm instrumentation was functioning within survey tolerances.

A flow diagram of the data acquisition and processing pipeline is presented in Figure 5 on the following page. This diagram graphically illustrates the data pipeline and processing workflow from acquisition to delivery.

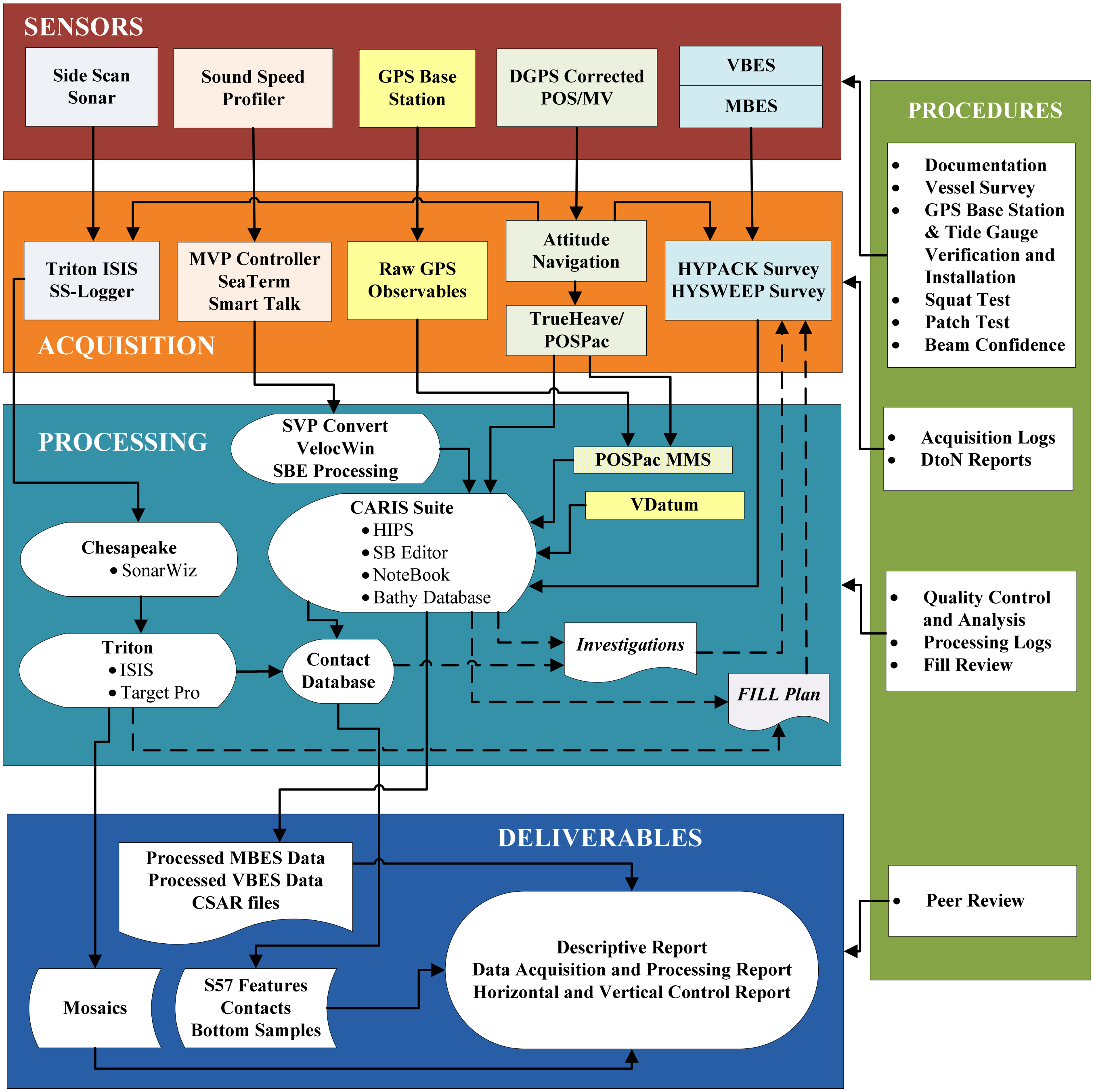

Figure 5. Flowchart of data acquisition and processing pipeline

B2.a HIPS Conversion

Multibeam data were converted from HSX format to Caris HDCS format using the HYPACK conversion wizard. HIPS ground coordinates (UTM NAD 83 16N) were selected in the Conversion Wizard dialogue and the device numbers fields were left blank since there were no duplicate sensors logged in the HSX files. No data were rejected based on quality flags during conversion.

The Caris output window was reviewed for failures during conversion.

B2.b Vessel Files

Two (2) HIPS vessel files (Table 7) were created to correspond to each survey vessel configuration used during the survey. The vessel file contains all offsets and system biases for the survey vessels and its systems, as well as error estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements.

In addition vessel files were created to facilitate the review of side scan sonar data by the processing branch. The side scan sonar vessel files were not used during data processing. Instructions for conversion of side scan data into Caris HIPS using these vessel files are included in Appendix V *CARIS SIPS Side Scan Processing Guidance* of this document.

Table 7. HIPS Vessel Files

HIPS Vessel File	HIPS Converter	Sonar Type
OPR-J348-KR-11_MBES_CH	Hypack 7.1.0.0	Multibeam
OPR-J348-KR-11_MBES_WE	Hypack 7.1.0.0	Multibeam
OPR-J348-KR-11_VBES_Chinook	Hypack 7.1.0.0	Single beam
OPR-J348-KR-11_SSS_CH	N/A	Side scan
OPR-J348-KR-11_SSS_WE	N/A	Side scan

Sensor offsets values were calculated from the vessel surveys, which were conducted prior to the start of field operations. Draft (water line) was measured and entered daily from draft marks on the port and starboard side of each vessel’s hull. Morning and evening, port and starboard draft readings were averaged to obtain the vessel draft. Draft changes relative to the vessel reference point were entered into the multibeam vessel configuration files. Dynamic draft (settlement and squat) values were calculated through the use of post-processed GPS observations. These offsets are listed in tabular format in Section C of this document. Both dynamic draft and waterline values were used to properly position the multibeam in the water column for the sound velocity correction. GPS Tides were computed using the “apply dynamic draft” and “apply waterline offset” options, which subtract the waterline height and dynamic draft values from the final signal. Therefore, the dynamic draft and waterline values are not used as correctors in the sounding reduction, other than their role in the sound velocity correction.

Best estimates for total propagated error (TPE) values were entered into the vessel file based on current knowledge of the TPE/CUBE processing model. The manufacturers’ published values were entered into the static sensor accuracy fields. Other values were either calculated or estimated. Real-time error values created during the POSPac post-processing sessions were loaded for position, heading, height, and attitude and used during TPE computation. Navigation and transducer separation distances from the motion sensor were computed relative to the phase center, vice the top hat, of the motion sensor therefore the vessel file standard deviation offsets will not exactly match the sensor offset values. No error values were entered for draft and loading since the use of GPS referenced tides includes those error sources in the vertical uncertainty. Table 8 represents HVF TPE values for each vessel.

Table 8. Hydrographic Vessel File TPE Values

Manufacturer Accuracy Values for Total Propagation Error Computation		
HIPS Vessel File (HVF)*		
Vessel	***R/V Westerly***	***R/V Chinook***
Motion Sensor	POS/MV	POS/MV
Position System 1	POS/MV Model 320 V 4	POS/MV Model 320 V 4
Position System 2	DSM132	DSM132
Gyro - Heading		
Gyro (°)	0.020	0.020
Heave		
Heave % Amplitude	5	5
Heave (m)	0.050	0.050
Roll and Pitch		
Roll (°)	0.020	0.020
Pitch (°)	0.020	0.020
Navigation		
Position Navigation (m)	1.00	1.00
Latency		
Timing Trans (s)	0.005	0.005
Nav Timing (s)	0.005	0.005
Gyro Timing (s)	0.005	0.005
Heave Timing (s)	0.005	0.005
Pitch Timing (s)	0.005	0.005
Roll Timing (s)	0.005	0.005
Measurement		
Offset X (m)	0.005	0.009
Offset Y (m)	0.005	0.005
Offset Z (m)	0.005	0.008
Speed		
Vessel Speed (m/s)	0.030	0.030
Draft and Loading		
Loading	0.000	0.000
Draft (m)	0.000	0.000
Delta Draft (m)	0.000	0.000
Physical Alignment Errors*		
Alignment		
MRU align Stdev gyro	0.099	0.175
MRU align roll/pitch	0.027	0.039
*All values given as 1 sigma.		

The estimated uncertainty of the ellipsoid to MLLW separation model was computed from values published on NOAA's VDatum website[1]. This estimate is the cumulative uncertainty of the source data and transformation uncertainties required to convert an ellipsoid height to MLLW in VDatum. The model uncertainty was introduced into the HIPS TPU computation by entering the 1 sigma uncertainty into the "Tide Zoning" field since HIPS does not currently allow for the application of a separation model uncertainty. Table 9 lists the published source and transformation uncertainties used to compute the separation model uncertainty. Sound speed and tide TPE values are listed in Table 10.

Table 9. Estimated VDatum Model Uncertainty

Louisiana/Mississippi – Eastern Louisiana to Mississippi Sound	
Transformation Uncertainty	**1-Sigma (cm)**
ITRF to NAD83	Does Not Apply
NAD83 to NAVD88	5.0
NAVD88 to LMSL	14.8
LMSL to MLLW	2.9
Total Transformation Uncertainty	*15.89*
Source Uncertainty	**1-Sigma (cm)**
NAD83	2.0
NAVD88	5.0
LMSL	1.9
MLLW	1.9
Total Source Uncertainty	*6.02*
MODEL Uncertainty	**17.0**
Maximum Cumulative Uncertainty[1]	**17.1**

Table 10. TPE Values for Tide and Sound Speed

Total Propagation Error Computation in CARIS HIPS	
Tide Values	**Uncertainty (m)**
Tide Value Measured	0.000
Tide Value Zoning	0.170
Sound Speed Values	**Uncertainty (m)**
Sound Speed Measured	1.000
Surface Sound Speed	0.500

*All values given as 1 sigma.

[1] http://vdatum.noaa.gov/docs/est_uncertainties.html

B2.c Static Draft

Static draft marks were surveyed and painted on the port and starboard sides of the R/V *Westerly* and R/V *Chinook* as well as on the multibeam pole mounts. Port and starboard draft readings were averaged to obtain the draft in relation to the reference point at the center of the vessel. During survey operations, vessel draft was observed at the beginning and end of daily survey operations to compute average draft for the day. This provided an accurate draft reading during survey operations with the majority of the fuel load change during the day being burned during transit to and from the survey area. The start and end of day draft values for port and starboard were calculated daily, averaged, and entered into the ”Waterline Height” field in the HVF.

B2.d Sound Velocity

Sound speed profiles were applied to each line using the nearest in distance within time (one hour) option in the Caris SVP correct routine. Profiles were taken at frequent intervals through the use of the MVP-30 or through manual deployment of the AML SVP Plus V2 or Sea-Bird SBE 19. In addition, periodic comparisons of sound velocity measurements were made between the AML Micro X mounted on the sonar head and the MVP-30 when being towed near the surface.

B3. Multibeam Data Processing

Multibeam data processing followed the standard HIPS workflow for CUBE editing except that the hypothesis surface was not edited. Instead, fliers influencing the CUBE surface were rejected and critical soundings not incorporated in the CUBE surface were designated. Baring point features, were rejected and flagged “Examined” at the shoalest and seaward-most point. The use of the “Examined” status flag enabled DEA hydrographers to denote baring items during processing and then resolve their charting status during review.

Below is the list of correctors and filters applied to the bathymetric data in HIPS. Several of the steps are interim processes (such as the water levels) and were re-applied as needed. The TPE was re-computed for the multibeam data as needed to reflect changes in the correctors.

1. Apply true heave
2. Load post-processed attitude, height, navigation, and heading
3. Load post-processed error for altitude, navigation, height and heading
4. Compute GPS Tide using VDatum-derived separation model
5. Apply sheet wide concatenated sound speed profiles
    - “Nearest in distance within time 1 hour”
6. Merge, apply GPS Tides
7. Compute TPE via values listed in Table 12
8. Filters applied based on the following criteria:
    - Reject soundings with poor quality flags (0 and 1)
    - Reject by swath width 45/45
9. Data reviewed and fliers removed in Swath Editor and/or Subset Editor
10. Add data to field sheet:
    - “CUBE” weighted surface of appropriate resolution for water depth
        - International Hydrographic Organization (IHO) S-44 Order 1

- Density & Local Disambiguation method
- Advanced configuration using the 2009 NOAA field unit parameters of the appropriate resolution surface

11. Review CUBE surface and child layers with tiles with reference surface on

Navigation, attitude, height, heading, and their corresponding error estimates were applied during post-processing in HIPS. Data were post-processed using POSPac MMS software. The POSPac SingleBase routine was used to generate a tightly coupled post-processed Inertial-Aided Kinematic Ambiguity Resolution (IAKAR) navigation and attitude solution using OPUS-derived control positions from either the SHIP or HORN GPS Base stations. The resulting Smooth Best Estimate and Trajectory (SBET) and POSPac smrmsg dynamic error files were applied in HIPS with the Load Attitude/Navigation data and Load Error data tools.

One field sheet was created to correspond to each survey sheet. CUBE surfaces were created over the entire survey area using grid-resolution thresholds and resolution dependent maximum propagation distances for complete coverage surveys as specified in the NOS HSSD (April 2011). CUBE surfaces using object detection resolution were created over each multibeam investigation of a significant side scan sonar contact. Survey coverage was specifically reviewed to confirm there were no holidays spanning the entire survey swath greater than three nodes or data gaps over significant contacts. The HIPS density layer of each grid was reviewed to confirm that the minimum sounding density of five soundings per node was achieved for 95 percent of nodes populated by mainscheme survey lines and that all multibeam investigations over significant features had either a designated sounding from a nadir beam or the node overlying the least depth had a density of at least five soundings.

All data were reviewed in HIPS 2D subset with the CUBE reference surface visible. Soundings rejected by quality filters were displayed during editing, and any feature removed by a filter was manually re-accepted. Fliers making the CUBE surface shoaler than expected by more than the allowable IHO Order one vertical error were rejected. Designated soundings were used as necessary in order to force the finalized depth surface through reliable shoaler soundings when the difference between the surface and sounding was more than one-half the maximum allowable IHO Order one vertical error. Subset tiles were used to track the progress of processing activities. In addition, data processors reviewed sounding data and CUBE surfaces for excessive motion artifacts or systematic biases. All crosslines were manually reviewed for high internal consistency between the datasets and comparison statistics were also computed using the HIPS crossline QC tool.

Contacts derived from the daily cursor logs were displayed in the background in HIPS as a drawing exchange format (DXF) file and reviewed for multibeam coverage and significance. Designated soundings were created to denote the least depth of each significant feature.

B4. GPS Post-processing

POSPac processing followed the workflow recommended by Applanix. The only deviation from standard procedures was the use of the NAD83 coordinate system which is required by NOS HSSD (April 2011). Since POSPac only works with real-time sensor navigation using the WGS-84 coordinate system, the software’s default settings for WGS-84 real-time input and post-processed output were used. NAD83 coordinates of the GPS reference stations were used during post-processing even though the software assumed the coordinates were relative to WGS-84. This processing configuration resulted in a post-processed navigation solution (SBET file) relative to NAD83 without the need of a transformation. Prior to the start of processing the NAD83 (CORS96) (epoch2002) coordinates of all base stations were imported into the POSPac coordinate manager on each processing computer.

Applanix POSPac MMS software was used to post-process the vessel navigation data through application of the Applanix SingleBase technique to generate a post-processed IAKAR navigation solution. During POSPAC processing, the NAD83 coordinates from the coordinate manager file was assigned to the primary base station.

A primary station was selected based on its proximity to the survey area. Prior to generating a post-processed navigation solution, all lever arms and offsets were manually reviewed and validated. With the relatively short lever arms on the survey vessels and high accuracy of the vessel surveys, lever arm uncertainty was set at 3 centimeters. Once the single base reference station was generated and all lever arms and settings were reviewed, the POSPAC GNSS processor was used to post-process a tightly coupled PPK navigation and attitude solution.

This post-processed solution included new position, height, heading and attitude measurements, which used reference station observables to resolve integer ambiguities. The software also used a forward and backward smoother to blend the inertial position and sensor data into a combined Smoothed Best Estimate Trajectory (SBET).

Processing review included graphical review of the vessel track, while color coded by position Root Mean Square (RMS) and the creation of a low-pass filtered GPS height signal as a proxy for a GPS Tide. The GPS Tide proxy was compared to a conventional zoned tide as an independent check on data quality. POSPac processing logs were kept for each survey sheet. The logs were used to record POSPac project information, vessel and base stations used, and major processing steps. These logs have been included in Separate I *Acquisition and Processing Logs* of the *Descriptive Reports*.

Once the SBET solution was loaded into CARIS, a GPS Tide was created by applying dynamic heave, dynamic draft, and the waterline offset to the GPS Height solution. The resulting GPS Tide was reviewed for accuracy. In reviewing the GPS Tide signal for each survey line, in several instances the GPS Tide signal showed an anomalous deviation from the general trend in the signal. These deviations were interpreted as errors in the GPS Tide solution and rejected with interpolation between the points on either side of the anomalous deviation. In some instances the GPS Tide deviation extended beyond the end of the survey line. In order to provide a good data point beyond the end of the survey line for the interpolation, an alternate approach was used for the computation of GPS Tide on those particular survey lines.
For lines where the Tide error extended beyond the end of the survey line, the SBET attitude and navigation data were loaded with an additional time buffer sufficient to include the good GPS height beyond the end of the survey line. Due to the limitations of the processing software, the tide could no longer be computed using a direct subtraction of dynamic heave from the extended GPS Height solution. To average out the effects of heave, a 60-second moving average was

applied to the GPS Height solution, and the GPS Tide was computed from the smoothed GPS Height without applying dynamic heave. The resulting extended GPS Tide solution included data on either side of the deviation, which was rejected and interpolated through.

B5. Final Bathymetric Processing

Upon the completion of editing multibeam data in HIPS, finalized CUBE grids were generated using the "greater of the two" option for the final uncertainty value. Depths and contours were generated from the surfaces and used for chart comparison purposes, but are not included with the deliverables. Finalized surfaces were reviewed in the HIPS 3D graphics window with an extreme vertical exaggeration to verify that all fliers have been removed from the surfaces. Bathymetric Attributed Grids (BAGs) for each CUBE surface were exported from HIPS for submittal.

Designated soundings were used as a starting point for S-57 feature creation. Designated soundings that were determined to be obstructions, rocks wrecks, or other significant features were imported into the S-57 feature files and attributed. S-57 objects were created for all new and incorrectly charted baring features. Many items included in the S-57 feature file have already been submitted as Dangers to Navigation (DtoNs).

All features were created using the NOAA Profile object cataloge which references the NOAA Extended Attributes defined in the 2011 HSSD. The NOAA extended attribute files were received by email from the Chief of HSD on July 19, 2011. All mandatory attributes of features have been populated. In addition, the pictures attribute has been used to provide multibeam and side scan screen shots of features. The feature file also includes meta-objects (M_COVR and M_QUAL).

B6. Side Scan Processing

After acquisition, the side scan bottom track was reviewed in Chesapeake Technologies SonarWiz and loss of bottom or incorrect bottom track areas were re-digitized. The newly bottom tracked files were exported to XTF and two independent reviews were performed in Triton TargetPro to identify significant contacts. Contacts in depths less than or equal to 20 meters were classified as significant, if their estimated height was at least one meter. In depths greater that 20 meters, contacts with heights greater than 10 percent of the depth were classified as significant. In most cases side scan contacts were determined to be significant if the measured height was within 25 centimeters of the significant height requirement to allow for contact measurement error. Also contacts with minimal shadow heights were classified as significant if there were areas deemed to be critical to navigation or if they appeared to be mounds or other geologic structures, which cast little or no shadow. Towfish altitude was reviewed to verify the height was maintained between 8 percent and 20 percent of the range.

Sonar contacts were processed using Triton TargetPro software. Management of the high volume of side scan sonar contacts was accomplished by utilizing an in-house created utility for contact tracking, meeting the requirements of the NOS HSSD (April 2011). The database was maintained and stored in Microsoft Access using the .MDB file format. Contacts were added into the database on a daily basis upon completion of the side scan review and contact identification.

The use of the .MDB format allowed direct geographic display of contacts and spatial queries within ESRI ArcGIS, where contacts were correlated and compared to the chart and other survey data.

Side scan mosaics were created using Chesapeake Technologies SonarWiz. Bottom track and layback from the previously processed XTF files were applied during generation of mosaics. Signal processing was performed during the mosaic creation in order to improve the overall appearance of the final images. An empirical gain normalization table was generated for each sonar from a subset of lines from each survey and then applied to all the appropriate survey lines. User defined gains were applied on a line by line basis in some cases. Minor adjustments were then made to the final empirical gain normalization intensity of individual survey lines to enhance the mosaic. Georeferenced mosaics were generated in Tagged Image File Format (TIF) with an associated world file (TWF) at one-meter resolution for each 100 percent survey coverage.

C. CORRECTIONS TO ECHO SOUNDINGS

C1. Static Draft

With the vessels out of the water, markings were surveyed and painted on the port and starboard sides of the hull providing a means to monitor vessel draft. Static draft readings from the port and starboard side were recorded at the start and end of each survey day. The start and end of day draft values for the sonar were calculated from the average of the port and starboard draft readings. The draft marks were directly abeam of the vessel reference point in the center of the vessel and the multibeam head pole mounted on the side or amidship of the vessel.

An average of the start and end of day draft values was calculated daily and entered into the waterline field in the Caris HVF. The average draft value best approximates the true draft value during acquisition due to loading changes from fuel consumption during transit to and from the survey area at the start and end of each day. Ultimately, the daily draft values were used to calculate daily draft relative the HIPS reference point which was entered into the waterline field in the Caris HVF files.

C2. Dynamic Draft

The settlement and squat test for the R/V *Westerly* occurred on May 27, 2011 (DN147) and for the R/V *Chinook* on September 16, 2011 (DN259). No modifications, which would impact the settlement and squat curves of these survey vessels, were made after the tests were performed. Results from these tests are displayed Appendix I *Vessel Reports*.

The settlement and squat values were obtained by computing a three minute GPS height average for transects run at different ship speeds and measured in both knots and revolutions per minute (RPM). Transects were run twice at each RPM interval; once at a northerly heading and once at a southerly heading.

Vessel speeds in increments of 200 RPMs were observed from just above each survey vessel’s idle RPM to just beyond the survey vessel’s maximum survey speed. GPS heights were recorded at 25 Hz. Observations were recorded between each RPM interval in order to have a baseline GPS height value not affected by tide changes during the test with the vessel at rest static GPS height. Three minute running averages of GPS height were calculated to remove any heave bias from the calculations. Each transect was run for approximately three minutes. The difference between the GPS height and an interpolated static GPS height (to account for changing tide) at the time of the average height value were used to calculate the dynamic draft for each transect. An average dynamic draft corrector was then calculated from the average of the two values for each RPM interval.

The settlement and squat profile of the R/V *Chinook* was modified to remove values at speeds where the vessel was on plane. Due to differences between speed over ground (used by HIPS) and speed over water it may be possible to achieve a higher speed over ground when running with currents, which would use settlement and squat correctors achievable only when the vessel was on plane. No survey data was acquired while the survey vessels were on plane. When vessel speeds exceed the maximum value in the HVF HIPS still uses the dynamic draft corrector for the maximum speed.

C3. Bar Check Comparisons

Weekly bar checks were performed to confirm that sonars were functioning properly and static drafts were accurately documented. A bar check device was constructed using a 6-inch diameter aluminum pipe. Chain was fixed to each side of the pipe and measured and marked on each side at 3 meters to the top of the bar. Marks were checked periodically with a measuring tape.

The bar check device was lowered to 3 meters-depth, a point above the natural bottom, where it could be clearly ensonified. The depths of the bar reported was compared to the depth of the bar reported by the sonar. Observations were recorded in a comparison log. Table 11 below details the average difference, standard deviation, and maximum deviations for each vessel. Tabulated bar check comparisons may be found in the Weekly Bar Check logs included in Separate I *Acquisition and Processing Logs* of the *Descriptive Reports*.

Table 11. Vessel Bar Check Summary

	R/V *Chinook* MBES	R/V *Chinook* SBES	R/V *Westerly* MBES
Mean Difference	-0.003	-0.014	0.000
Standard Deviation	0.023	0.017	0.010
Maximum Deviation	0.036	-0.039	0.020

C4. Heave, Roll and Pitch Corrections

An Applanix POS/MV 320 v4 integrated dual frequency GPS and inertial reference system was used for the motion sensor for this survey. The POS/MV 320 is a six-degree of freedom motion unit, with a stated accuracy of 0.05-meter or 5 percent for heave, 0.01° for roll and pitch and heading. Real-time displays of the vessel motion accuracy were monitored throughout the survey with the POS/MV controller program. If any of the vessel motion accuracy degraded to greater than 0.05° RMS, survey operations would be suspended until the inertial unit was able to regain the higher degree of accuracy. Manufacturer reported accuracies as published on the Caris HIPS TPE website (http://www.caris.com/tpu/) were entered into the HVF and used for TPU computations.

As previously discussed, attitude and heading were reapplied after post-processing navigation and inertial sensor data in POSPac. SBET files were applied in HIPS with the Load Attitude/Navigation data tool. Installation bias and patch test results were computed at the start of the survey. Additionally, patch tests were performed throughout the survey to monitor known values and account for changes due to sensor replacements. All values were stored in the Caris HVF files.

Schematics of the vessel and sensor set-up for the R/V *Westerly* and the R/V *Chinook* are located in Appendix I *Vessel Reports*.

C5. Patch Tests

Multibeam patch tests were conducted for the R/V *Westerly* and R/V *Chinook* to measure alignment offsets between the IMU sensor and the multibeam transducer and to determine time delays between the time-tagged sensor data. Multiple patch tests were performed throughout the project to verify the adequacy of the system biases. Patch tests were performed at the beginning of the project, at the end of each month, after any system replacement, and at the end of the project. Each patch test consisted of a series of lines run in a specific pattern, which were then used in pairs to analyze roll, pitch and heading alignment bias angles.

A precise timing latency test was performed by running a single line over a flat bottom with induced vessel motion. The line was then opened in the HIPS calibration editor (after applying tide and SVP corrections) and a small along-track slice of data was evaluated in the outer swath of the line for motion artifacts. Incremental changes to the roll time offset were made to evaluate the performance of the precise timing setup and to determine if a latency correction was needed. No latency was found in the system.

Roll alignment was determined by evaluating the reciprocal lines run over a flat bottom used for the latency test. The pitch tests consisted of set of reciprocal lines located on a steep slope or deep water charted wreck. The yaw error was determined by running parallel lines over the same area. All lines were run at approximately 3 knots to 6 knots. Patch tests were run in the local survey area. Selected pairs of lines were then analyzed in HIPS Calibration editor to measure the angular sensor bias values. Visual inspection of the data confirmed each adjustment. Two sets of lines were run and analyzed for each of the mounting biases with the second set used to confirm the results of the data.

Swath 1 offsets and average biases for both vessels were entered into the HVF and also documented in Table 12.

Table 12. Vessel Offsets and Average Biases

Vessel	Latency	Pitch	Yaw	Roll	X (m)	Y (m)	Z (m)
R/V Westerly	0.000	-0.441	-0.955	-0.190	0.010	-0.250	1.542
R/V Chinook	0.000	1.516	4.078	0.722	1.684	-1.164	1.158

C6. Tide and Water Level Corrections

The application of SBET navigation positioned soundings vertically on the NAD83 (CORS96) ellipsoid. VDatum version 2.3.3 and the region file Eastern Louisiana to Mississippi Sound (version 01) was used to reduce soundings from NAD83 to MLLW in CARIS using the model file MS_Sound.bin, which has been included with the survey's digital deliverables. To generate the model file, a three-second grid was created, which encompassed the entire survey area. The elevation value of the grid was populated with the NAD83 elevation of MLLW using GEOID09 and the VDatum model. The grid model was then converted to the same binary format as geoid grid models generated by NGS, which can be used by Hypack (using a GenGeo.exe utility provided by Hypack) and Caris HIPS to convert ellipsoid heights directly to a mapping datum. In order to provide a check to the grid values, at one point within the model the MLLW to NAD83 separation was computed by using VDatum to transfer from MLLW to NAVD88, and then CorpsCon to transfer from NAVD88 orthometric elevations to NAD83 ellipsoid heights. No elevation change in the check file was observed. The model file, *MS_Sound.bin*, has been included with the survey's digital deliverables.

As a confidence check on the GPS tide computation, GPS tide readings were recorded for one hour, while the survey vessel floated adjacent to the tertiary tide station installed at Ship Island (874-1533). GPS measurements were processed using techniques identical to processing for all collected survey data and then compared to verified tide data.

C7. Sound Velocity Correction

While underway during data acquisition the MVP-30 on the R/V *Westerly* was deployed as needed to obtain an adequate number of sound velocity profiles to properly correct the survey data during data processing. At the start of each survey day, a cast was taken right before coming online with additional casts taken on a periodic basis, usually every 20 minutes. At least one deep cast (extending to 95 percent of depth) was taken per day.

A sound speed cast using the Applied Microsystems, Ltd. SV Plus V2 sound velocity sensor was taken at approximately one hour intervals during R/V *Chinook* survey operations. Sound velocity profiles obtained from the MVP-30 were applied to multibeam data collected by the R/V *Chinook* when the vessel was operating in close proximity to the R/V *Westerly*.

After each cast the sound speed data was reviewed for outliers, which could impact data quality. The sound speed measured by the MVP at 1 meter depth was also compared to the Reson 7125 head velocity, for agreement to check that both systems were working properly. In addition to these periodic comparisons, weekly comparison checks were performed by lashing the SBE 19 or AML to the R/V *Westerly's* MVP and simultaneously lowering them to the bottom. These comparison sensors were both used by the R/V *Chinook.*

Weekly checks were completed to verify pressure sensor and SV instrument performance. Corrections for the speed of sound through the water column were computed for each sensor. Sound speed profiles were imported and overlaid for comparison into an Excel file. All comparisons were well within survey specification. Weekly check results are included in Separate II *Sound Speed Data* of the *Descriptive Reports*.

The sound speed correction was applied to each line using the nearest in distance within time (one hour) option in the HIPS SVP correct routine. All casts were concatenated into a daily HIPS SVP file for each survey day. Time, position, depth, and sound speed for each profile were included in the HIPS file.

D. APPROVAL SHEET

The letter of approval for this report follows on the next page.

DAVID EVANS AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-J348-KR-11
DATA ACQUISITION AND PROCESSING REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-J348-KR-11 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the OPR-J348-KR-11 *Statement of Work* (April 2011) and *Hydrographic Survey Project Instructions* (June 2011).

Digitally signed by Jon Dasler
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Jonathan L. Dasler, PE (OR), PLS (OR,CA)
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Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
November 2011