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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project	**OPR-J348-KR-13**
Contract No	**DG133C-08-CQ-0006**
Task Order No	**T0008**
Time Frame	**March 2013**

LOCALITY

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

2013

CHIEF OF PARTY

Jonathan L. Dasler, David Evans and Associates, Inc.

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March 2013
R/V *Westerly*

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INTRODUCTION

This report applies to surveys H12528, H12529, and H12530 located in the approaches to Mississippi Sound. These contract surveys were performed under OPR-J348-KR-13 as specified in the *Statement of Work* (April 29, 2013) and *Hydrographic Survey Project Instructions* (revised) (March 25, 2013). All survey methods meet or exceed requirements as defined in the National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables* (HSSD) (April 2013).

The *Hydrographic Survey Project Instructions* reference the 2012 HSSD, however the OPR-J348-KR-13 surveys were performed using the 2013 HSSD. The only exception is with the holiday specification for Set Line Spacing Surveys (Section 5.2.2.3), which uses the 2012 specification of no gaps in the entire multibeam swath greater than 3 nodes along track. This modification was approved by Hydrographic Surveys Division (HSD) staff.

The survey consisted of 200 percent side scan sonar coverage with concurrent multibeam within the survey polygon depicted in the Project Reference File (PRF) *OPR-J348-KR-13_PRF.000* which was included with the *Hydrographic Survey Project Instructions*. Automated Wreck and Obstruction Information System (AWOIS) items identified by side scan sonar and significant side scan sonar contacts were acquired to meet object detection coverage requirements for multibeam surveys. The locations of bottom samples have been determined by using the side scan sonar mosaics as directed by the OPR-J348-KR-13 *Hydrographic Survey Project Instructions*.

A. EQUIPMENT

For this project David Evans and Associates, Inc. (DEA) implemented state-of-the-art data acquisition systems aboard the Research Vessels (R/V) *Westerly* in accordance with National Oceanic and Atmospheric Administration (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 Table 1.

Table 1. R/V *Westerly* 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 FS	43188	300/600 kHz side scan towfish for seafloor imaging
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, using 400kHz.
Deck Unit	**RESON**	7-P Processor Unit	18202410001	Feature Pack 1 (FP2.1)
Receiver	**RESON**	EM 7200	3310053	Receiver
Projector	**RESON**	TC 2160	4010162	Transmitter
Sound Speed				
Surface Sound Speed	**AML**	Micro X / SV Xchange	7561/ 200790	Sonar head SV for beam formation and steering.
Sound Speed Profiler	**Brooke Ocean Technology, Ltd.**	AML Micro SVPT	7710/ 201529	Primary SV profiler
Sound Speed Profiler	**Sea-Bird Electronics, Inc.**	SBE 19Plus	19P42715-4962	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 Model 1	60186994	
Port Antenna	**Trimble**	Zephyr Model 1	60154234	
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. 293.0 mHz
POS/MV Beacon Antenna	**CSI Wireless**	MD MGL-3	0716-3582-0006	

A1. Survey Vessel

The R/V *Westerly*, which is owned and operated by Zephyr Marine (Figure 1), was the 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.

A2. Multibeam System

The R/V *Westerly* was equipped with a Reson SeaBat 7125-SV2 dual frequency multibeam sonar capable of operating at 200 kHz or 400 kHz, and integrated Applied Microsystems, Ltd. (AML) Micro X SV sound velocity sensor. The multibeam was deployed with a center lift-mount through a moon pool. The Reson 7125-SV2 was operated with Feature Pack (FP) 2.1 at 400 kHz in Minimum Beam mode which produced a 140-degree swath of 240 equiangular beams.

For this survey all multibeam data were acquired 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) and multibeam backscatter in Hypack 7K format.

A3. Side Scan Sonar Systems

Side scan sonar imagery was acquired with an Edgetech 4200-FS (300/600 kHz) side scan sonar operated in Low Frequency, High Speed mode at 300 kHz. The sonar was operated in Low Frequency, High Speed mode at 300 kHz to allow for 100-meter range operations from the start of the project through October 1, 2013. After this point the sonar was operated in Dual Frequency, High Speed mode at 300 kHz and 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 60 feet, the sonar was set to 100-meter range with 90-meter line spacing. For depths between 30 and 60 feet, the sonar was operated at the 75-meter range with 60-meter line spacing. These operational scenarios allowed for 10 meters of outer range overlap between passes when the full effective sonar range was in specification. Odd numbered preplanned Hypack survey 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 were also recorded to the XTF. The side scan sonar was deployed from the stern A-frame where an LCI-90 Cable Payout Meter along with measured tow point offsets and towfish depth were used by SS-Logger to compute layback.

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.

A4. Position, Heading and Motion Reference Systems

The survey vessel was 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, heave, and position. The system was comprised of an Inertial Motion Unit (IMU), dual frequency (L1/L2) Global Positioning System (GPS) antennas, and a data processor.

A CSI Wireless MBX-3S differential beacon receiver acquired corrections from the U.S. Coast Guard (USCG) beacon located at English Turn, Louisiana (293 kHz) and provided differential corrections to the POS M/V. In addition, a Trimble DSM 132 DGPS receiver was used as a redundant positioning system to provide secondary DGPS corrected positions for quality control purposes. The redundant system used an intergraded beacon receiver and acquired differential corrections from the USCG 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 system was observed and documented while the vessel was secured and relatively motionless in the marina. Logged position data were extracted from the Hypack RAW file and entered into an Excel file for comparison. 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 (Global Positioning System Timing Message) to achieve synchronization with the POS/MV. The Isis SS-Logger acquisition 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, the 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, which resulted in multiple files created per day. The TrueHeave™ data group was also logged to these files.

A5. 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 sensor and sound speed profilers were periodically monitored. The Seabird SBE 19 was used as a secondary sound speed sensor.

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 Micro SVPT was mounted on the stern of the R/V *Westerly* and used as the primary sound speed sensor during multibeam acquisition. This sensor was repaired several times during the survey at which time it was replaced with an AML Smart SV&P. Dates of use are included in Table 1.

A6. Acquisition and Processing System

An acquisition station was custom-installed and integrated on the R/V *Westerly* by DEA and consisted of a Triton Isis SS-Logger side scan sonar data acquisition computer, Hypack Hysweep multibeam acquisition and navigation computer, a computer to run the MVP system, and an additional computer for digital logs and general administration. During acquisition, data were logged locally on each acquisition computer and then transferred to the field office in Biloxi, MS using an external hard drive at the completion of each survey day. Preliminary processing and backup of the multibeam and side scan data was performed in the field office prior to 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 2.

Table 2. Acquisition and Processing Software

Name	Manufacturer	Version	Installation Date
Acquisition			
HYPACK	Hypack, Inc.	12.0.1.8	03/15/2013
Survey	Hypack, Inc.	12.0.1.8	03/15/2013
Hysweep Survey	Hypack, Inc.	12.0.7.0	03/15/2013
Isis SS-Logger	Triton Imaging, Inc.	7.3.623.51	03/15/2013
Discover 4200-MP	Edgetech	8.05	03/15/2013
LineLog	David Evans and Associates	1.0.6	03/15/2013
MV-POSView	Applanix Corporation	5.1.0.2	03/15/2013
POS MV V4 Firmware	Applanix Corporation	5.03	03/15/2013
Reson 7125	Reson	FP2.1	03/15/2013
ODIM MVP Control	Brooke Ocean Technology, Ltd.	2.430	03/15/2013
SeaTerm	Sea-Bird Electronics, Inc.	1.59	03/15/2013
SBE Processing	Sea-Bird Electronics, Inc.	7.21g	03/15/2013
Processing			
HIPS	CARIS 64-bit	7.1.1 SP1 HF1	03/15/2013
Notebook	CARIS 64-bit	3.1 SP1 HF1	03/15/2013
Bathy DataBASE	CARIS 64-bit	4.0	03/15/2013
ArcGlobe	ESRI	10.1 SP1	03/15/2013
Isis	Triton Imaging, Inc.	7.2.118.331	03/15/2013
TargetPro	Triton Imaging, Inc.	2.8.118.331	03/15/2013
SonarWiz5	Chesapeake Technology, Inc	5.006.0027	03/15/2013
SonarWiz5	Chesapeake Technology, Inc	5.006.0034	10/02/2013
Photoshop	Adobe	10.0	03/15/2013
SVP Convert	David Evans and Associates	0.2.4	03/15/2013
Other			
Microsoft Office Suite	Microsoft	2007	03/15/2013
Beyond Compare	Beyond Compare	3.3.1	03/15/2013

A7. Survey Methodology

A7.a Mobilization

Mobilization, sensor installation, and calibration of the R/V *Westerly* occurred at Point Cadet Marina in Biloxi, Mississippi from March 13, 2013 (DN 072) to March 14, 2013 (DN 073). Vessel offsets and associated measurement uncertainties for the R/V *Westerly* were calculated from a vessel offset survey performed on June 27, 2011 prior to the start of project OPR-J349-KR-11. All survey points were positioned using a terrestrial land survey total station from a minimum of two locations, which allowed a position uncertainty to be determined. Vessel offsets and uncertainties were used in the Hydrographic Information Processing System (HIPS) vessel files (HVF). A settlement and squat test using post-processed GPS heights was performed on May 27, 2011, also in support of OPR-J348-KR-11. No modifications to the survey vessel or sensor installation points have occurred since the close of OPR-J348-KR-11 that would impact offsets or dynamic draft tables. Once installation was complete and the hydrographer was confident that all sensors were operational, the survey vessel underwent system calibration tests and patch tests.

A7.b Survey Coverage

The project area (OPR-J348-KR-13) was surveyed with line orientation appropriate for the charted depth contours and prevailing winds with respect to the survey boundaries. The side scan sonar was operated at 50-meter, 75-meter and 100-meter range scales with 40-meter, 65-meter and 90-meter survey line spacing, to achieve 200 percent side scan coverage and allow for a 10-meter offline tolerance. When towfish altitude was less than 8 percent of the side scan sonar range the SonarWiz processing software was used to reduce the side scan sonar effective range to 12.5 times the altitude. Multibeam echosounder data were 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 meeting NOS HSSD (April 2013) object detection coverage requirements.

Survey coverage was based on the survey polygon depicted in the PRF *OPR-J348-KR-13_PRF.000* which was included with the *Hydrographic Survey Project Instructions* (March 25, 2013).

A7.c Side Scan Sonar Operations

From the start of the project through October 1, 2013 the side scan sonar was operated at 300 kHz in the multi-pulse high-speed mode at a range of 100 and 75 meters for deep areas and a range of 50 meters for shallower inshore areas. After October 1, 2013 the side scan sonar was operated at both 300 kHz and 600 kHz in the multi-pulse high-speed mode. The switch was made to Dual Frequency mode to provide a high frequency view of the seafloor to aid in contact review and to reduce the impacts of sea clutter on the outer ranges of the return. Only the 300 kHz data was bottom tracked during processing and included in the final mosaics. The geographic distribution of side scan sonar range scale used for project OPR-J348-KR-13 is depicted in Figure 2.

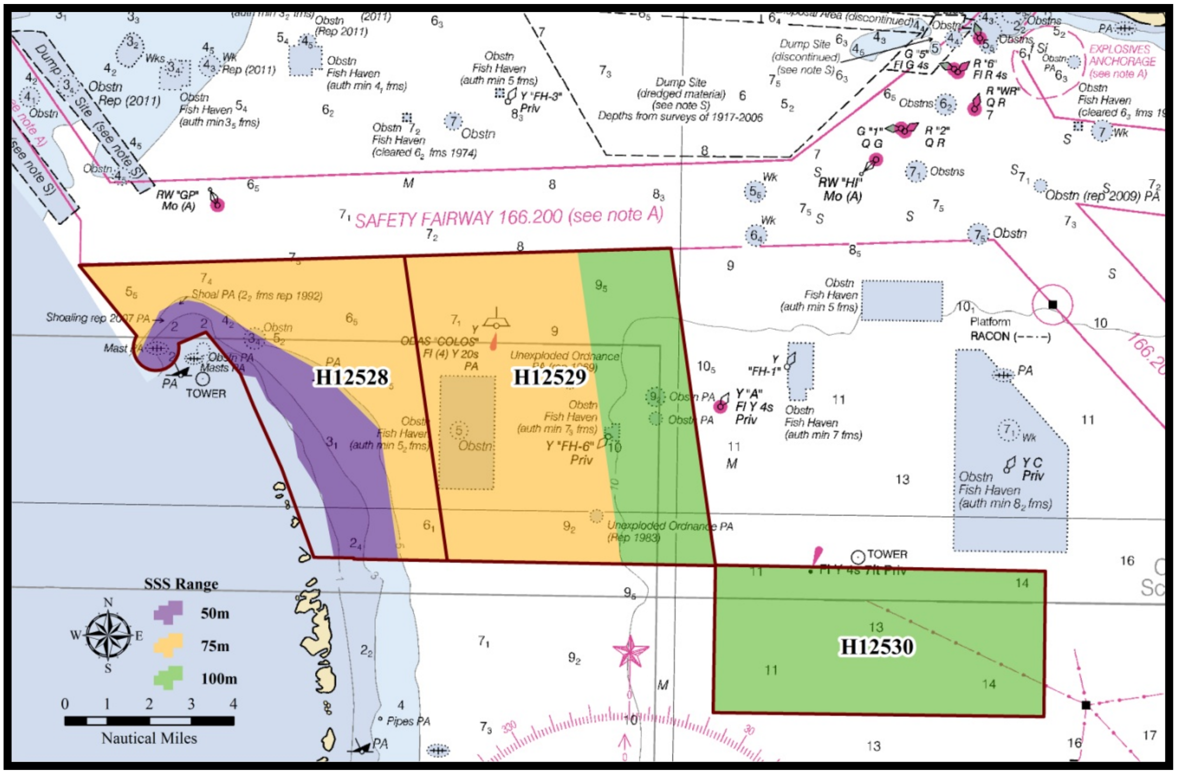

Figure 2. Side Scan Sonar Range Scale Use by Survey

The EdgeTech 4200 series sonar has a ping rate of 20 Hz at 75-meter range and 15 Hz at 100-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 9 knots. In accordance with the NOS HSSD (April 2013), 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 R/V *Westerly* 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 6.1.1 of the NOS HSSD (April 2013). 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 a concerted effort to maintain an altitude of 8 percent to 20 percent of the range above the bottom and to achieve the desired coverage. In extreme shallow water this was not always possible and the effective range was reduced when the towfish altitude dropped below 8 percent of the side scan sonar range.

A7.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-13 *Hydrographic Survey Project Instructions* (March 25, 2013) and defined by the NOS HSSD (April 2013 and April 2012). As previously stated HSD staff permitted the use the 2012 specification for holidays requiring no gaps in the multibeam gridded surface greater than 3 nodes along track. 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 3 lists the typical sonar settings for the survey.

Table 3. Reson 7125 Sonar Settings

7125 Parameter	Value
Range	Variable, depth dependent
Gain	33 dB
Power	200-220 dB
Spreading	30 dB
Absorption	110 dB/km
Ping Rate	13-25 p/s
Pulse Width	33 µs

A7.e Bottom Sampling

Seventeen (17) bottom samples were acquired as specified in the *Hydrographic Survey Project Instructions* (March 25, 2013) in accordance with section 7.1 of the HSSD. Approximate bottom sample locations were provided by NOAA in the file *OPR-J348-KR-13 Project Preference File (OPR-J348-KR-13_PRF.000).* The final sampling plan used these locations with some modification of position to better characterize bottom types as seen in the side scan imagery and to avoid sampling in the vicinity of submerged infrastructure such as pipelines or platforms.

A8. 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 initially converted and processed in Caris HIPS version 7.1 Service Pack 1 Hotfix 1. Processing methodology followed the standard Caris HIPS CUBE (Combined Uncertainty Bathymetric Estimator) workflow.

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 2013).

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 3.

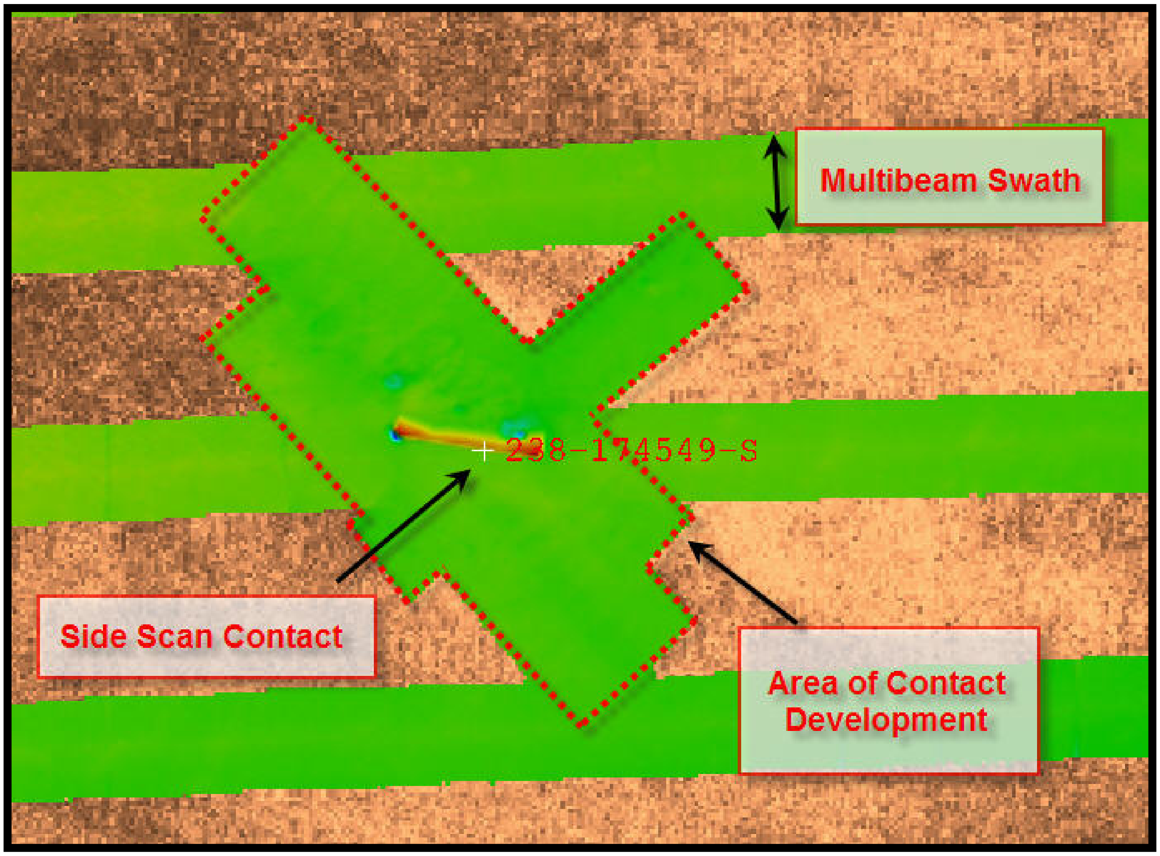

Figure 3. Side Scan Sonar Mosaic Overlaid with Multibeam and Sonar Contacts

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. Changes to cable out values, sensor settings, offset configurations, data quality and contacts 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, cable out and layback, 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 2013) to meet the required along track coverage requirements.

To aid in the consistency of contact identification, a table was posted at the side scan acquisition station listing slant range and towfish altitude to determine minimum shadow heights for 1 meter contacts at 50-meter, 75-meter and 100-meter ranges. Contacts were classified as significant if their estimated height was 1 meter or greater in waters shallower than 20 meters; and 10 percent of water depth in waters deeper than 20 meters. Efforts to maintain towfish altitude at 8 percent to 20 percent of the 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 maintain the towfish at the required height. At times environmental conditions and or shallow waters forced the operator to fly the fish under 8 percent of the side scan range scale. In these instances effective side scan sonar range was reduced to 12.5 times the towfish altitude. 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 block sheave. Using this method, the cable-out meter was calibrated each day prior to deployment and continuously 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 2013) 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. Multibeam backscatter was logged in Hypack 7K format. Data were processed periodically in CARIS HIPS to evaluate backscatter quality but the processed data is not included with the deliverables.

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 the 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 by simultaneous deployment of the SeaBird SEACAT and 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 4. This diagram graphically illustrates the data pipeline and processing workflow from acquisition to delivery.

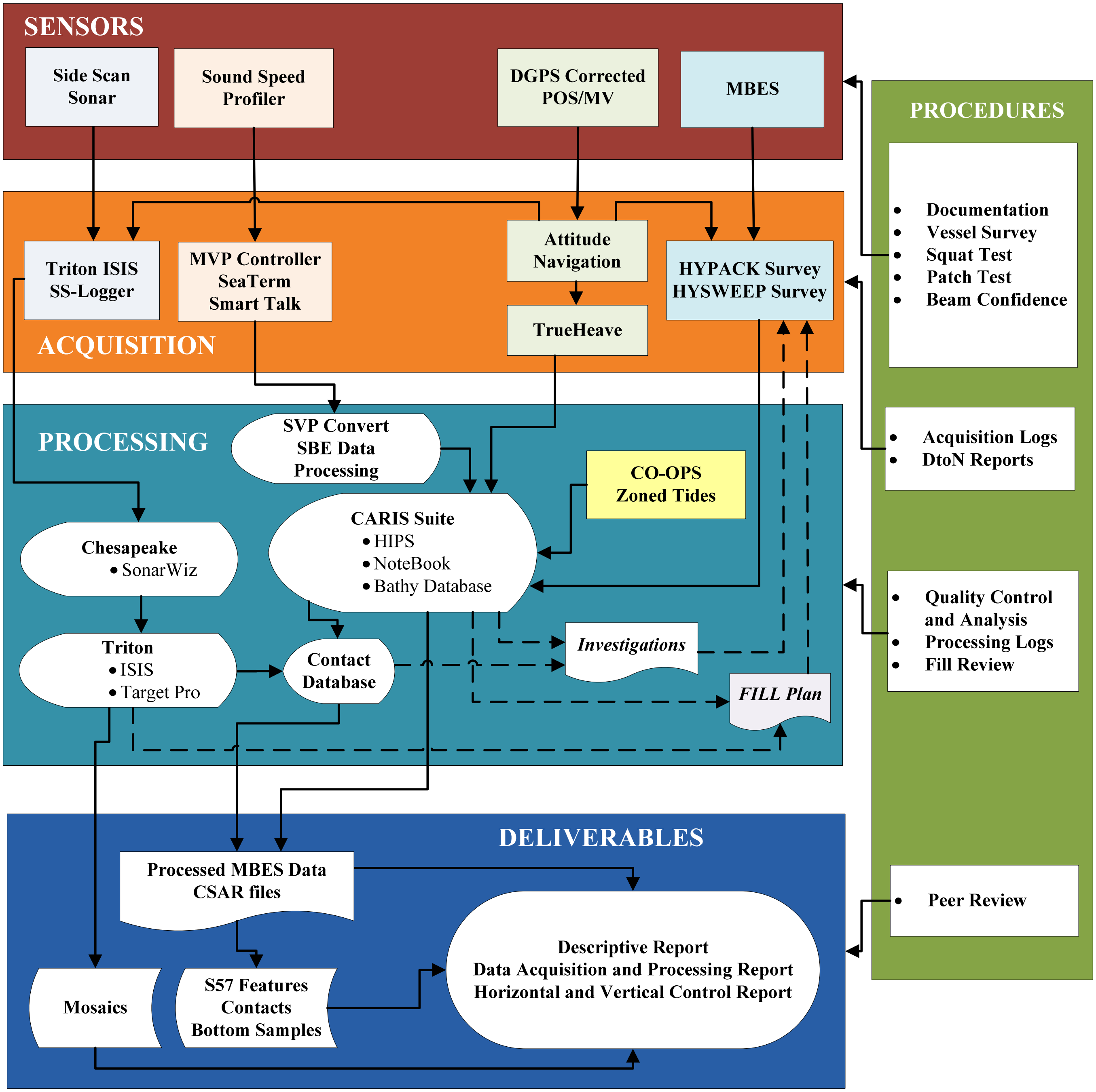

Figure 4. Flowchart of Data Acquisition and Processing Pipeline

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. 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

The HIPS vessel files listed in Table 4 contain all offsets and system biases for the survey vessel and its systems, as well as error estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements.

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

Table 4. HIPS Vessel Files

HIPS Vessel File	HIPS Converter	Sonar Type
OPR-J348-KR-13_MBES_WE	Hypack 7.1.1.0	Multibeam
OPR-J348-KR-13_MBES_WE_PATCH	Hypack 7.1.1.0	Multibeam
OPR-J348-KR-13_SSS_WE	N/A	Side scan

Sensor offsets and dynamic draft (settlement and squat) values were calculated prior to the start of project OPR-J348-KR-11. Sensor offsets were calculated from the vessel survey and dynamic draft values were calculated through the use of post-processed GPS observations. Draft (water line) was measured and entered daily from draft marks on the port and starboard side of the vessel's hull. In the 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 file. These corrections are listed in tabular and graphical format in Appendix I *Vessel Reports*.

Best estimates for total propagated uncertainty (TPU) values were entered into the vessel file based on current knowledge of the TPU/CUBE processing model. The manufacturers' published values were entered into the static sensor accuracy fields. Other values were either calculated or estimated. 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. TPU values for the R/V *Westerly* are listed in Table 5.

Table 5. Hydrographic Vessel File TPU Values

Manufacturer Accuracy Values for Total Propagation Uncertainty Computation	
HIPS Vessel File (HVF)*	
Motion Sensor	POS/MV
Position System 1	POS/MV Model 320 V 4
Position System 2	DSM132
Gyro - Heading	
Gyro (°)	0.020
Heave	
Heave % Amplitude	5
Heave (m)	0.050
Roll and Pitch	
Roll (°)	0.020
Pitch (°)	0.020
Navigation	
Position Navigation (m)	1.00
Latency	
Timing Trans (s)	0.005
Nav Timing (s)	0.005
Gyro Timing (s)	0.005
Heave Timing (s)	0.005
Pitch Timing (s)	0.005
Roll Timing (s)	0.005
Measurement	
Offset X (m)	0.005
Offset Y (m)	0.005
Offset Z (m)	0.005
Speed	
Vessel Speed (m/s)	0.030
Draft and Loading	
Loading	0.010
Draft (m)	0.010
Delta Draft (m)	0.030
Physical Alignment Errors*	
Alignment	
MRU align Stdev gyro	0.153
MRU align roll/pitch	0.084
*All values given as 1 sigma.	

A tide uncertainty consisting of both measurement and zoning errors was estimated by DEA and approved via email (*Re: Fwd: OPR-J348-KR-13 Tides TPU*) from CO-OPS and HSD staff on April 4, 2013. A copy of this email is included in OPR-J348-KR-13 *Project Correspondence*. The tide uncertainty estimate was computed by using the published Pascagoula Datum error (using Gulfport Harbor for Datum Control) and the published measurement and processing errors for National Water Level Observation Network (NWLON) stations. The total tide uncertainty was entered in the HIPS Tide Value Zoning field during TPU computation. Sound speed and tide TPU values are listed in Table 6.

Table 6. TPU Values for Tide and Sound Speed

Total Propagation Uncertainty Computation in CARIS HIPS	
Tide Values	**Uncertainty (m)**
Tide Value Measured	0.000
Tide Value Zoning	0.074
Sound Speed Values	**Uncertainty (m/s)**
Sound Speed Measured (SN 7710)	1.000
Surface Sound Speed	0.500

B2.c Static Draft

Static draft marks were surveyed and painted on the port and starboard sides of the R/V *Westerly*. 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 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 Sound Velocity Profiler (SVP) correct routine. Profiles were taken at frequent intervals through the use of the MVP-30 or through manual deployment of the 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.

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 TPU was re-computed for the multibeam data as needed to reflect changes in the correctors.

1. Apply true heave
2. Load zoned tide
3. Apply daily concatenated sound speed profiles
    - "Nearest in distance within time 1 hour"
4. Merge
5. Compute TPU via values listed in Tables 5 and 6
6. Filters applied based on the following criteria:
    - Reject soundings with poor quality flags (0)
    - Reject by swath width 60/60
7. Data reviewed and fliers removed in Swath Editor and/or Subset Editor
8. 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
9. Review CUBE surface and child layers with tiles with reference surface on

One field sheet was created to correspond to each survey. 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 2013). 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 three soundings per node was achieved for 95 percent of nodes populated by mainscheme survey lines; and to confirm 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.

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 QC Report 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

GPS Post-processing was used to aid in the determination of alignment offsets for some patch tests where the use of DGPS navigation made it difficult to accuracy resolve alignment angles.

Applanix POSPac MMS software was used to create a post-processed navigation solution included new position, height, heading and attitude measurements in Smoothed Best Estimate of Trajectory (SBET) format. The SBET file was applied to the patch test data using the HIPS Load Navigation/Attitude Data tool during patch test processing and analysis.

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. Selected soundings 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 or Bathy DataBASE 3D view with an extreme vertical exaggeration to verify that all fliers have been removed from the surfaces.

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.

All features were created using the NOAA Profile object catalogue which references the NOAA Extended Attributes defined in the 2013 HSSD. The NOAA extended attribute files were received by email from the Contracting Officer’s Representative (COR) on April 3, 2013. All mandatory feature attributes 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-object M_COVR.

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 Isis and 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 than 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.

Sonar contacts were processed using Triton TargetPro software. Management of side scan sonar contacts was accomplished by utilizing an in-house utility created for contact tracking and meeting the requirements of the NOS HSSD (April 2013). 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 Trition Imaging, Inc. Isis and DelphMap. Bottom track and layback were previously processed and reviewed in Chesapeake Technologies SonarWiz. Signal processing was performed during the mosaic creation in order to improve the overall appearance of the final images. User defined time varied gain curves were developed to enhance the mosaic. Georeferenced mosaics were generated in Tagged Image File Format (TIF) with an associated world file (TWF) at 50-centimeter resolution for each 100 percent survey coverage.

C. CORRECTIONS TO ECHO SOUNDINGS

C1. Static Draft

With the vessel 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 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 prior to the start of OPR-J348-KR-11 on May 27, 2011 (DN147). No modifications which would impact the settlement and squat curves were made after the tests were performed. Results from these tests are included in 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 the 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. 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.

C3. Bar Check Comparisons

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

The bar check device was lowered to 3 meters depth below the water surface, a point above the natural bottom, where it could be clearly ensonified. The depth of the bar was compared to the depth of the bar reported by the sonar. Observations were recorded in a comparison log. Tabulated bar check comparisons may be found in the Weekly Bar Check logs included in Appendix II *Echosounder Reports*.

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 6-degree of freedom motion unit, with a stated accuracy of 0.05-meter or 5 percent for heave, 0.01 degrees 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 degrees root mean square (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 TPU website (http://www.caris.com/tpu/) were entered into the HVF and used for TPU computations.

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

C5. Patch Tests

Multibeam patch tests were conducted for the R/V *Westerly* 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 periodically throughout the project including at the beginning of the project, 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 as the pitch tests. 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.

Sonar offsets and alignment angles computed during patch tests were entered into the HVF. Sonar roll and pitch values were entered in HVF SVP1 entry rather than the Swath1 in order for the HIPS Sound Velocity tool to work correctly. Routine roll test lines were acquired to monitor the stability of the multibeam mount. Roll test results were included in the project vessel file.

C6. Tide and Water Level Corrections

The primary water level station for this project was Pascagoula NOAA Lab, Mississippi (8741533). The HIPS Zone Definition File (ZDF) *OPSREVISED_J348KR2013CORP* used to apply zoned tides to the multibeam data was created by HSD Operation Branch staff is a revised version of by NOAA’s Center for Operational Oceanographic Products and Services (CO-OPS) was used to apply zoned tides to the multibeam data.

The primary station experienced no down time during periods of hydrographic survey.

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.

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 to the R/V *Westerly's* MVP and simultaneously lowering them to the bottom.

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 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-13
DATA ACQUISITION AND PROCESSING REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-J348-KR-13 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-13 *Statement of Work* (April 29, 2013) and *Hydrographic Survey Project Instructions* (revised) (March 25, 2013).

Digitally signed by Jon Dasler
DN: cn=Jon Dasler, o=David Evans and Associates, Inc., ou=Marine Services Division, email=jld@deainc.com, c=US
Date: 2013.12.11 13:51:07 -08'00'

Jonathan L. Dasler, PE (OR), PLS (OR,CA)
NSPS/THSOA Certified Hydrographer
Chief of Party

Digitally signed by Jason Creech
DN: cn=Jason Creech, o=David Evans and Associates, Inc., ou=Marine Services Division, email=jasc@deainc.com, c=US
Date: 2013.12.11 13:52:43 -08'00'

Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
March 2013

E. TABLE OF ACRONYMS

AML	Applied Microsystems, Ltd
AWOIS	Automated Wreck and Obstruction Information System
CO-OPS	Center for Operational Oceanographic Products and Services
COR	Contracting Officer's Representative
CTD	Conductivity, Temperature, Depth
CUBE	Combined Uncertainty and Bathymetry Estimator
DEA	David Evans and Associates, Inc.
DGPS	Differential Global Positioning System
DN	Day Number
DXF	Drawing Exchange Format
FP	Feature Pack
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
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
MB	Megabyte
MP	Multi Pulse
MVP	Moving Vessel Profiler
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWLON	National Water Level Observation Network
POS/MV	Position and Orientation System for Marine Vessels
PPS	Pulse per Second
PRF	Project Reference File
R/V	Research Vessel
RMS	Root Mean Square
RPM	Revolutions per Minute
SBET	Smoothed Best Estimate of Trajectory
SSS	Side Scan Sonar
SVP	Sound Velocity Profiler
TIF	Tagged Image File Format
TPU	Total Propagated Uncertainty
TWF	TIF World File
USCG	U.S. Coast Guard
UTC	Universal Time Coordinated
XTF	Extended Triton Format
ZDA	Global Positioning System Timing Message
ZDF	Zone Definition File