NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey **Hydrographic**

Field No. **David Evans and Associates, Inc.**

Registry No. **H12356**

LOCALITY

State **Mississippi**

General Locality **Approaches to Mississippi Sound**

Sublocality **SE of Horn Island**

2011

CHIEF OF PARTY

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

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NOAA FORM 77-28
(11-72)

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

HYDROGRAPHIC TITLE SHEET

REGISTRY No

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 Horn Island**

Scale **1:20,000** Date of Survey **July 12 to November 11, 2011**

Instructions dated **June 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**

Graphic record scaled by **N/A**

Graphic record checked by **N/A** Automated Plot **N/A**

Verification by **Atlantic Hydrographic Branch Personnel**

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

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charts. All separates are filed with the hydrographic data. Revisions and Red notes were generated during office processing. The processing branch concurs with all information and recommendations in the DR unless otherwise noted. Page numbering may be interrupted or non-sequential. All pertinent records for this survey, including the Descriptive Report, are archived at the National Geophysical Data Center (NGDC) and can be retrieved via http://www.ngdc.noaa.gov/.

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Acronyms and Abbreviations

AHB - Atlantic Hydrographic Branch
AML - Applied Microsystems, Ltd
ASCII - American Standard Code for Information Interchange
AtoN - Aids to Navigation
AWOIS - Automated Wreck and Obstruction Information System
BAG - Bathymetric Attributed Grid
CO-OPS - Center for Operational Oceanographic Products and Services
CUBE - Combined Uncertainty and Bathymetry Estimator
DAPR - Data Acquisition and Processing Report
DEA - David Evans and Associates, Inc.
DGPS - Differential GPS
DN - Day Number
DtoN - Danger to Navigation
ENC - Electronic Navigational Charts
ERS - Ellipsoidal Referenced Survey
GPS - Global Positioning System
HIPS - Hydrographic Information Processing System
HSD - Hydrographic Surveys Division
HSSD - Hydrographic Surveys Specifications and Deliverables
IHO - International Hydrographic Organization
kHz - kilo Hertz
LNM - Local Notice to Mariners
MCD - Marine Chart Division
MLLW - Mean Lower-Low Water
MVP - Moving Vessel Profiler
NAD 83 (CORS96) (Epoch 2002.00) - North American Datum of 1983 CORS96 realization, 2002 Epoch
NOAA - National Oceanic and Atmospheric Administration
NOS - National Ocean Service
NPS - National Park Service
POS/MV - Position and Orientation System for Marine Vessels
RNC - Raster Nautical Chart
R/V - Research Vessel
SBET - Smooth Best Estimate and Trajectory
StdDev - Standard Deviation
SVP - Sound Velocity Profiler
TPU - Total Propagated Uncertainty
USCG - United States Coast Guard

Descriptive Report to Accompany Hydrographic Survey H12356
Project OPR-J348-KR-11 Approaches to Mississippi Sound, Mississippi
SE of Horn Island
Scale 1:20,000
July 2011 – November 2011
David Evans and Associates, Inc.
Lead Hydrographer: Jonathan L. Dasler

A. AREA SURVEYED

David Evans and Associates, Inc. (DEA) conducted hydrographic survey operations in the Approaches to Mississippi Sound, MS. The survey area extends from Horn Island southward 5 nautical miles and eastward to the safety fairway at the approaches to Horn Pass.

Survey H12356 was conducted in accordance with the *Statement of Work* (June 23, 2011) and *Hydrographic Survey Project Instructions* (June 22, 2011) for OPR-J348-KR-11. On December 13, 2011, DEA was directed to use Ellipsoidally Referenced Survey (ERS) methods for the reduction of survey data to chart datum via a signed memo from the Chief, Hydrographic Surveys Division (HSD). Approval of these methods was granted based on recommendations included with DEA's interim deliverables (submitted November 1, 2011) for the ERS/VDatum components of OPR-J348-KR-11, specified in the *Hydrographic Survey Project Instructions* (June 22, 2011). A copy of this memo is included in *OPR-J348-KR-11 Project Correspondence* of each survey's *Descriptive Report*.

The survey (Figure 1) consisted of 200% side scan sonar coverage with concurrent multibeam in waters 18 feet and deeper. 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. The survey was conducted over 80-meter and 130-meter set line spacing per 100% coverage (50 meters and 75 meters side scan sonar ranges, respectively). Automated Wreck and Obstruction Information System (AWOIS) items and significant side scan contact investigations were acquired to meet object detection coverage requirements for multibeam surveys. The coverage area totaled 30.7 square nautical miles using a combination of side scan and multibeam survey methods.

Parts of the OPR-J348-KR-11 survey area, including H12356, fell within the Gulf Islands National Seashore. Scientific Research and Collecting Permit GUIS-2011-SCI-0055 was issued by the National Park Service (NPS) on July 5, 2011 which permitted bathymetric data collection and bottom sampling in the waters managed by the NPS. The permit also allowed for tide gauge installation on Ship Island and GPS base station installation on Ship and Horn Islands. A copy of the Scientific Research and Collecting Permit is included in the *OPR-J348-KR-11 Project Correspondence*.

Nine (9) bottom samples were acquired on July 12, 2011 (Day Number 193). Predetermined sample locations were included in the file *BottomSamples_point.shp* provided by HSD. Six (6) AWOIS items were assigned to this survey. Of the six assigned items, two items were assigned as full investigation and four items were assigned as information only.

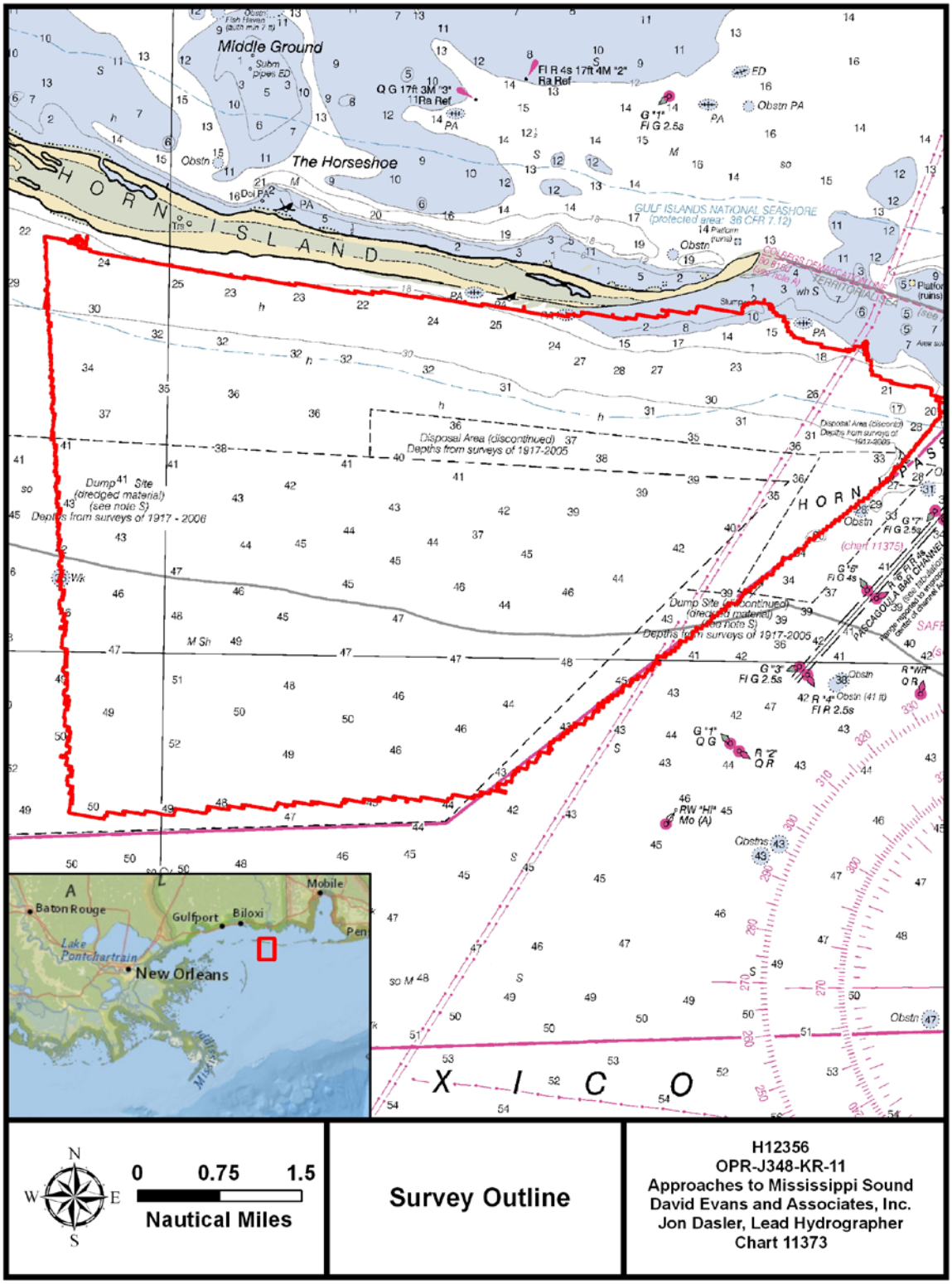


Figure 1. H12356 Survey Area

Data acquisition was conducted from July 12, 2011 (DN 193) to November 11, 2011 (DN 315). Table 1 lists specific dates of acquisition of survey data. In addition, dates of patch test data acquisition used to determine system biases in support of the survey are also shown and included in the digital deliverable, though survey data was not necessarily collected on those days.

Table 1. H12356 Days of Acquisition

Dates of Acquisition	
Month	**Dates**
July	12, 20, 24, 31
August	27-29, 31
September	7-18, 21, 24-27, 29
October	4, 5, 14-17
November	5, 8, 9, 11
Dates of Patch Test Acquisition	
July	13, 17
August	14- 15, 26
September	7- 8, 15, 20
November	11

Detailed survey statistics of H12356 are provided in Table 2.

Table 2. H12356 Survey Statistics

Survey Statistics	Research Vessel (R/V) *Chinook*	Research Vessel (R/V) *Westerly*	Combination MBES/SSS main scheme
MBES/SSS main scheme (nm)	641.7	402.3	1044.0
Crosslines (MBES nm)	21.2	85.6	106.8
Additional Full Coverage MBES (nm)	-	132.4	132.4
Additional Full Coverage MBES Crosslines (nm)	-	11.7	11.7
Number of Item Investigations that required additional survey effort	0	0	0
Total number of square nautical miles	-	-	30.7

B. DATA ACQUISITION AND PROCESSING

B1. Equipment

Equipment and vessels used for data acquisition and survey operations during this survey are listed below in Tables 3 and 4.

Table 3. R/V *Westerly* Equipment and Vessel Specifications

R/V *Westerly*	
	
IMO Number	1AR38CATK011
Official Number (O/N)	1231991
Builder	Armstrong Marine
Design	Catamaran
Year Built	2011
Weight	13 gross tons, 10 net tons
Length Overall	38’
Beam	16.5’
Draft, Maximum	4.6’
Cruising Speed	26 knots
Max Survey Speed	9 knots
Primary Echosounder	RESON 7125-SV2
Side Scan Sonar	Edgetech 4200-HFL
Sound Velocity Equipment	AML Micro SV (Sonar head) Brooke Ocean MVP-30 with AML Smart SVP+ (Primary) Sea-Bird SEACAT SBE-19 CTD Profiler
Positioning & Attitude	Applanix POS/MV 320 v4

Table 4. R/V *Chinook* Equipment and Vessel Specification

R/V *Chinook*	
	
IMO Number	IAR28CATJ607
Official Number (O/N)	AK-8018-AG
Builder	Armstrong Marine
Design	Catamaran
Year Built	2007
Length Overall	28’
Beam	10.5’
Draft, Maximum	2’
Cruising Speed	27 knots
Max Survey Speed	9 knots
Primary Multibeam Echosounder	Reson 7125-SV2
Primary Single Beam Echosounder	ODOM CV 100
Side Scan Sonar	Edgetech 4200-HFL
Sound Velocity Equipment	AML Micro SV (Sonar head) AML SVPlus V2 (Primary) Sea-Bird SEACAT SB-19 CTD Profiler
Positioning & Attitude	Applanix POS/MV 320 v4

There were no vessel or equipment configurations used during data acquisition that deviated from those described in the OPR-J348-KR-11 *Data Acquisition and Processing Report* (DAPR), submitted under separate cover.

B2. Quality Control

Survey data show good internal consistency. On average weekly bar checks agreed better than 0.02 meters, with a maximum uncertainty of 0.04 meters at 95%, as shown in Appendix II of the DAPR. Results from both crossline analysis and final Combined Uncertainty and Bathymetry Estimator (CUBE) surface uncertainty both indicate good internal consistency of the multibeam data. A sheet wide surface comparison of multibeam data between both survey vessels, which is inclusive of water level reduction, showed a mean difference between data collected by each vessel of 0.01 meters with an uncertainty of 0.09 meters at 95%.

B2.a Crosslines

A total of 106.8 nautical miles of crosslines, or 10.2% of all survey lines, were run for analysis of survey accuracy. Crosslines were run in a direction perpendicular to main scheme lines across the entire surveyed area, providing a good representation for analysis of consistency. All crosslines were used for crossline comparisons.

Crossline analysis was performed using the CARIS Hydrographic Information Processing System (HIPS) QC Report tool, which compares crossline data to a gridded surface and reports results by beam number. Crosslines from both vessels were compared to a 1 meter CUBE surface encompassing mainscheme data for the entire survey area. The QC Report tabular outputs and plots are included in Separate II *Digital Data*. The results of the analysis meet the requirements as stated in the 2011 National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables (HSSD).

Additional crossline analysis was performed on swath filtered multibeam data collected concurrently with side scan sonar data and on full swath multibeam data collected over multiple significant shoals and mounds. This analysis was performed by computing a 1 meter CUBE surface from the crossline data from both survey vessels. The surface was then differenced from a 1 meter CUBE surface comprised of all main scheme, fill, and investigation data. The resultant difference surfaces were exported using the Base Surface to ASCII function and statistics were compiled on the American Standard Code for Information Interchange (ASCII) data. The swath filtered crossline analysis included over 2,081,890 node comparisons and an average difference of 0.01 meters across all depths between the crossline surface and the main scheme surface, with 0.09 meters of uncertainty at 95% confidence. The full swath crossline analysis included over 807,164 node comparisons and an average difference of 0.01 meters across all depths between the crossline surface and the main scheme surface, with 0.06 meters of uncertainty at 95% confidence.

B2.b Uncertainty

During HIPS processing, the "greater of the two” option was selected, where the calculated uncertainty from total propagated uncertainty (TPU) is compared to the standard deviation (StdDev) of the soundings influencing the node and where the greater value is assigned as the final uncertainty of the node. The uncertainty of the finalized surface increased for nodes where the StdDev of the node was greater than the total propagated uncertainty. The resulting calculated uncertainty values of all nodes in the finalized surface range from 0.33 meters to 0.62 meters.

To determine if surface grid nodes met International Hydrographic Organization (IHO) Order 1 specification, a ratio of the final node uncertainty to the allowable uncertainty at that depth was determined. As a percentage, this value represents the amount of error budget utilized by the uncertainty value at each node. Values over 100% fail to meet specification.

As shown in Table 5, both uncertainty and the allowable error utilized have low average values and a tight StdDev. The maximum values, however, are outliers that fail to meet specification. For the 1 meter CUBE surface, 65 nodes out of 50,181,509 failed to meet specification.

Table 5. CUBE Uncertainty

CUBE Finalized Uncertainty Statistics						
	Uncertainty (m)			Allowable error utilized		
	Average	StdDev	Maximum	Average	StdDev	Maximum
1m CUBE	0.33	0.002	0.62	64%	1%	118%

Sixty-three (63) of the 65 nodes that failed to meet specification were located within a charted *Dump Site (dredged material)* where active dumping occurred over the course of the survey. The two remaining nodes were located on an insignificant feature located in a scour hole. The high standard deviation, which resulted in the nodes being reported as out of specification, is considered an artifact of gridding data over steeply sloping features or over areas where the bottom changed during the survey. As a result, all depth nodes are considered within specification and no area within the survey exceeds IHO Order 1 specifications for depth accuracy.

B2.c Junctions

Survey H12356 junctions with OPR-J348-KR-11 surveys H12354 and H12355 to the west. It also junctions with prior National Oceanic and Atmospheric Administration (NOAA) surveys H11512 to the east, H11545 to the south, and H11546 to the southeast.

One (1) meter finalized surfaces from surveys H12354 and H12355 were compared to the H12356 surface using CARIS Bathy DataBASE. The resultant difference surfaces were exported to ASCII and statistics were compiled on the ASCII data. The junction analysis between sheets H12355 and H12356 showed differences up to 16 centimeters and the junction analysis between sheets H12354 and H12356 showed differences of up to 36 centimeters. Upon further inspection it was determined that these anomalies were the result of sediment movement during Tropical Storm Lee which passed through the area between September 1 through 4, 2011 (DN244 to DN247). The majority of the other junctions agreed well with a mean difference of 0.01 meters. Statistics for each junction comparison are listed below in Table 6.

Bathymetric Attributed Grids (BAG) for surveys H11512, H11545 and H11546 were downloaded from NOAA's Nation Geophysical Data Center. The 1 meter finalized H12356 surface was compared to the prior surveys using the same methodology used to generate statistics. All junctions agreed well, with a mean difference of 0.06 meters or less. Statistics of the prior junction comparisons are listed below in Table 6. A qualitative review of the junction showed no anomalous areas. The -2.51 meter maximum difference occurring in the junction

comparison with H11512 is the result of a single node flyer in the H11512 survey. It should be noted that H11512, H11545 and H11546 were compiled using traditional discrete tidal zoning while H12356 was compiled using ERS methods.

Table 6. Results of Junction Analysis with H12356

Survey Junction Sheet	Junction Direction	Number of Nodes Compared	Minimum Depth Difference (m)	Maximum Depth Difference (m)	Mean Depth Difference of Nodes (m)	Standard Deviation of Nodes (m)
H12354	West	102894	-0.36	0.19	-0.01	0.04
H12355	West	320932	-0.16	0.16	-0.01	0.04
H11512	East	150988	-2.51	0.95	-0.06	0.17
H11545	South	80083	-0.25	0.52	0.04	0.12
H11546	Southeast	35484	-0.22	0.16	0.02	0.06

B2.d Sonar System Quality Checks

Quality control is discussed in detail in Section B of the DAPR. The results from the positioning system comparison and bar-to-multibeam comparison are included in Separate I *Processing Logs.* The sound velocity profile (SVP) sensor weekly evaluation table can be found in Separate II *Sound Speed Data* of this report. Multibeam data were reviewed at multiple levels of data processing including: CARIS HIPS conversion, subset editing, and analysis of anomalies revealed in CUBE surfaces. Submerged significant features identified during survey operations were noted in the acquisition logs, saved to Isis cursor log files, and then displayed during HIPS editing to act as a check during feature compilation. In addition to the field interpretation of side scan contacts, two independent post-processing reviews of the side-scan data were conducted, and all significant contacts or potentially significant contacts tracked in a custom database.

B2.e Unusual Conditions or Data Degradation

Occasional loss of bottom tracking was observed in the multibeam sonar onboard the R/V *Westerly*, possibly due to sheet cavitation sporadically blanking the sonar's transmit array. The resulting erroneous depths were manually removed during multibeam data processing. This error seldom resulted in a CUBE surface node of low density, and no full swath three node holidays exist.

Line 2011CH2531229 contained erroneous GPS tide data from 12:31:45 to 13:36:03. The HIPS GPS tide was interpolated between these times in order to remove the impact of the erroneous GPS tide.

B2.f Object Detection and Coverage Requirements

Survey speeds were maintained to meet or exceed object detection requirements throughout the survey.

Demonstration of 200% side scan sonar coverage was achieved by producing two separate 100% 1 meter resolution mosaics. Mosaics were thoroughly reviewed for holidays and areas of poor quality coverage due to biomass, vessel wakes, or other factors. A fill plan was created for holidays and poor quality coverage areas in water depths greater than 18 feet.

Multibeam data were acquired in conjunction with side scan sonar collection. A fill plan was created for all holidays greater than three nodes long that extended across the entire multibeam track line.

The sounding density requirement of 95% of all nodes, populated with at least five soundings per node, was verified by exporting the density child layer of each CUBE surface to an ASCII text file and compiling statistics on the density values. More than 98.8% of all final CUBE surface nodes contained five or more soundings. Density statistics of individual item investigation surfaces using Complete Coverage requirements were reviewed and all surpassed the 95% requirement.

B3. Corrections to Echo Soundings

Data reduction procedures for survey H12356 are detailed in the DAPR. For detailed information pertaining to applied filters, refer to the multibeam processing logs in Separate I *Processing Logs.*

B3.a Deviations from DAPR

Full coverage multibeam areas were acquired to address least depth concerns over shoal areas and two dredge material disposal areas. Data acquired in these areas were filtered using 0 and 1 quality flags. A swath filter was not applied to this data in order to maximize coverage. As previously discussed, a separate crossline analysis was completed to verify the use of the full multibeam swath. Crossline results are submitted in Separate II *Digital Data*.

The patch test calibration log submitted in the *Data Acquisition and Processing Report* Appendix II *Echosounder Reports* incorrectly lists a patch test for the R/V *Westerly* on August 17, 2011. The patch test occurred on August 14, 2011.

The CUBE Surface H12356_1m_MLLW_1of2 was created and finalized using CARIS HIPS version 7.1 Service Pack 1, Hotfix 1.

B3.b Additional Calibration Tests

No additional calibration tests were conducted beyond those discussed in the OPR-J348-KR-11 DAPR.

B4. Data Processing (Data Representation)

B4.a Multibeam

Bathymetric grids were created relative to Mean Lower Low Water (MLLW) in CUBE format using complete coverage and object detection resolutions described in the NOS HSSD (April 2011).

Since the entire survey was contained within a single depth range as defined in the NOS HSSD (April 2011), no depth thresholds were applied during surface finalization.

Duplicate bathymetric grids relative to the North American Datum of 1983 CORS96 realization, 2002 Epoch (NAD83) (CORS96) (2002) were generated by subtracting the VDatum derived separation model used during tide correction from the bathymetric grids.

Table 7 lists the CUBE surfaces submitted with this survey. The surface named *"_INV,"* is a combined surface comprised of all investigation data and full swath coverage of shoals and active dumping grounds at object detection resolution. In addition, two field sheets and surfaces were submitted for significant individual investigations as well field sheets for the dredge material disposal area and two significant shoals. The name of the investigation field sheets corresponds to the primary side scan sonar contact name. When reviewing the CUBE surface for the entire survey, one additional sounding was designated over an object that was not significant in order to have the final CUBE surface accurately represent the seafloor in accordance with NOS HSSD.

Table 7. H12356 Multibeam Surfaces

Surface Name	Resolution
H12356_1m_MLLW_1of2	1.0m
H12356_50cm_MLLW_INV_2of2	0.5m
H12356_1m_NAD83CORS96_1of2	1.0m
H12356_50cm_NAD83CORS96_INV_2of2	0.5m

B4.b Side Scan

Side scan sonar mosaics were created for each 100% coverage at 1 meter resolution. Mosaics submitted with this survey are listed in Table 8.

Table 8. H12356 Side Scan Mosaics

Mosaic Name	Resolution
H12356_SSS_100	1.0m
H12356_SSS_200	1.0m

C. HORIZONTAL AND VERTICAL CONTROL

A complete description of the horizontal and vertical control for survey H12356 can be found under the OPR-J348-KR-11 *Horizontal and Vertical Control Report*, submitted with this survey. A complete description of Global Positioning System (GPS) post-processing methodology for survey H12356 can be found in the DAPR. A summary of horizontal and vertical control for this survey follows.

Real-time differential GPS navigation logged during acquisition was overwritten with a post-processed navigation solution, created from Applanix POSPac MMS using the SingleBase option. A GPS base station with a dual frequency (L1/L2) receiver was established on Horn Island, Mississippi to enable post-processing using Single Base solutions. The base station was strategically located near the project site in order to meet the 20-kilometer maximum baseline length for single base post-processing defined in the NOS HSSD (April 2011). NAD83 (CORS96) coordinates of the base station are included in the OPR-J348-KR-11 *Horizontal and Vertical Control Report*.

C1. Vertical Control

The vertical datum for this project is MLLW. Soundings were reduced to MLLW using post-processed GPS derived water levels. The VDatum derived separation model, *MS_Sound.bin*, was used to reduce NAD83 ellipsoid heights to MLLW as described in the DAPR. The separation model has been included in the digital deliverables.

Traditional discrete tidal zoning from water level stations was not used for sounding reduction in this survey, though zoning provided by the Center for Operational Oceanographic Products and Services (CO-OPS) and verified water level files for the survey have been included with the digital deliverables.

C2. Horizontal Control

The horizontal datum for this project is NAD83 projected in UTM Zone 16. All of the real-time navigation data were collected in Differential GPS (DGPS) mode. DGPS corrections were received from the U.S. Coast Guard (USCG) beacon at English Turn, Louisiana (293 kHz) or from the secondary beacon at Eglin, Florida (295 kHz). During survey operations, some DGPS outages from the primary beacon occurred. The system was set up to automatically switch to the secondary beacon when the primary signal was lost. Real-time navigation data were overwritten by post-processed Smoothed Best Estimate of Trajectory (SBET) data referenced to NAD83 (CORS96) (2002).

D. RESULTS AND RECOMMENDATIONS

D1. Chart Comparison

D1.a Survey Agreement with Chart

During the course of data acquisition and processing, H12356 was compared to the largest scale raster navigation charts (RNCs) and electronic navigation charts (ENCs). Table 9 lists the charts and edition dates used for the chart comparison. The results of these comparisons are throughout this section.

Table 9. Charts Compared to H12356

Chart	Scale	Edition	Edition Date	Issue Date	Latest LNM	LNM Clear Date
11373	1:80,000	49	09/01/2010	---	07/12	02/14/2012
11374	1:40,000	36	02/01/2012	---	03/12	02/01/2012
US4MS12M	---	19	07/27/2011	02/10/2012	---	02/21/2012
US5MS21M	---	26	07/15/2011	02/10/2012	---	02/21/2012
US5MS22M	---	31	08/08/2011	01/25/2012	---	02/07/2012

The latest electronic and raster versions of the relevant charts were reviewed to ensure that all USCG Local Notice to Mariners (LNM) issued during survey acquisition, impacting the survey area, were applied and addressed by this survey. A 50-meter product surface was generated from ENCs of the largest scale charts covering the entire project area using the sounding layer, contour layer, and depth features. An additional, a 50-meter HIPS product surface of the entire survey area was generated from the finalized 1 meter CUBE surface. The chart comparison was conducted by creating and reviewing the resultant difference surface.

Contours and soundings generated from combined HIPS product surface were used to aid in the chart comparison. The product surfaces, contours, and soundings were created solely for the chart comparison and have not been submitted as a final deliverable.

Surveyed H12356 depths generally agree with charted depths within 2 feet throughout most of the survey area (Figure 2); however there are noteworthy areas of significant change.

1. There has been significant deepening of up to 14 feet at the eastern end of the survey area along the southern edge of Horn Island.
2. There has been significant shoaling of 5 feet to 10 feet along the southern edge of Horn Island at the northwestern corner of the survey area.

Danger to Navigation (DtoN 1) was submitted to the Atlantic Hydrographic Branch (AHB) as a large grouping of soundings over uncharted shoals and mounds of dredged material within the charted *Dump Site (dredged material*). AHB staff selected the most significant of these soundings at chart scale and passed them on in *H12356 Danger to Navigation Report #1* though the soundings included in the report did not fully capture all of the significantly shoaler soundings in the area. As a result, some areas within the charted *Dump Site (dredged material)* and in the vicinity of northeast corner of the survey are 5 feet to 10 feet shoaler than charted.

There are also differences shown in Figure 2 which are an artifact of comparing a dense dataset to a surface produced from a triangulated irregular network (TIN), of the largest scale ENC of the area composed of sparse soundings and contours. This includes areas in the vicinity of DtoN 1 which has been added to the charts and depicts shoals and dredged material within the charted *Dump Site* with a few sparse soundings. When compared to the denser survey dataset these artifacts appear as areas of significant deepening.

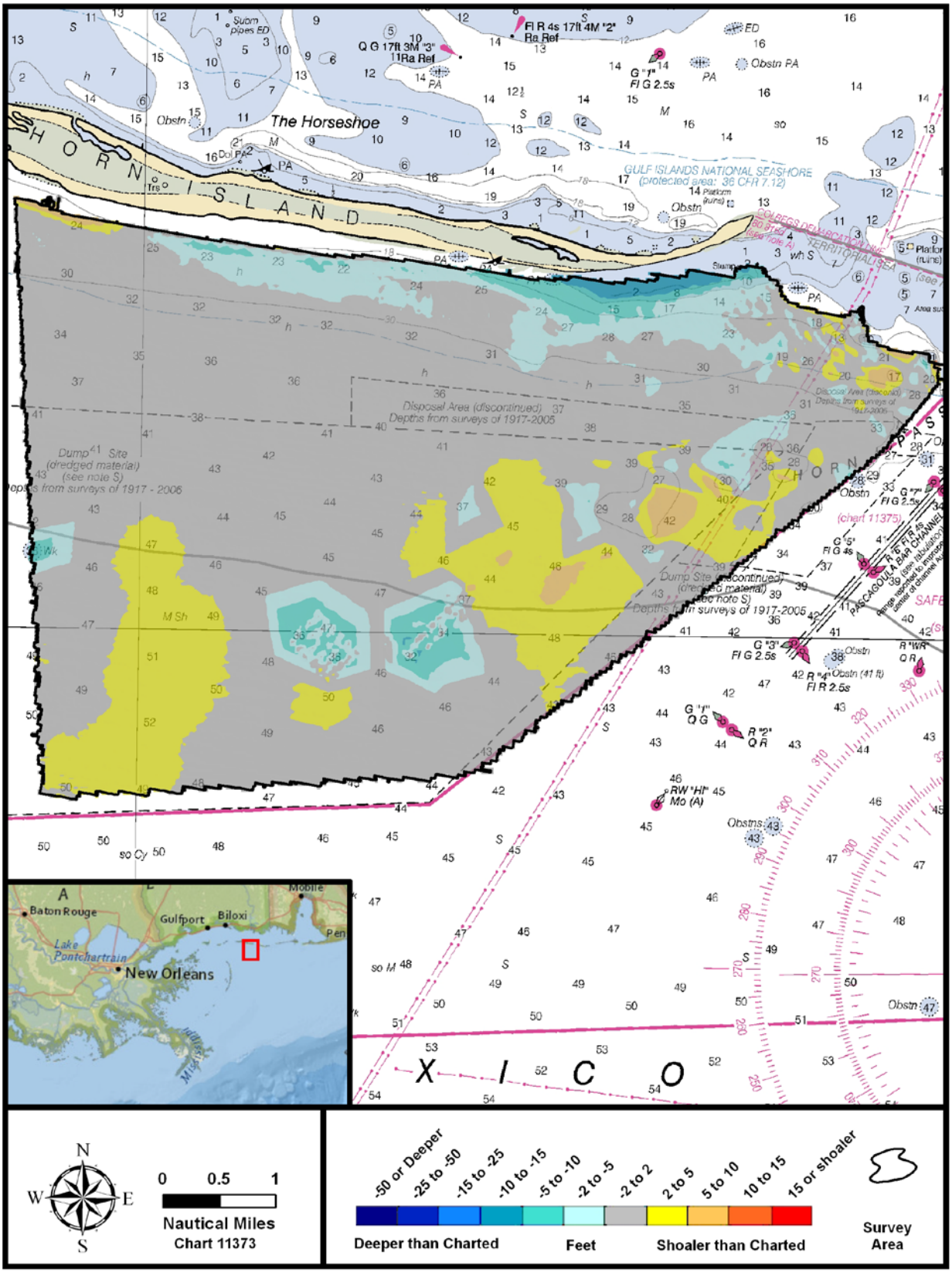


Figure 2. Depth Difference Between H12356 and Combined ENCs

D1.b Comparison to Significant Shoals

The H12356 survey area contains several previously uncharted significant shoals portrayed by DtoN 1. These include natural shoals in the vicinity of Horn Island Pass and shoals within the charted *Dump Site*. Full multibeam coverage was acquired as needed to adequately define the shoals and determine least depths.

D1.c Comparison to Charted Features

Two (2) AWOIS items were assigned for full investigation within survey H12356. Four (4) AWOIS items were assigned for information only. A complete description of these investigations is available in Appendix II *Survey Feature Report*. One of assigned AWOIS item overlaps the H12355 survey area and is addressed in both H12355 and H12356 Appendix II *Survey Feature Report*.

All charted features are listed by field charting action in Appendix II *Survey Feature Report* and included in the S-57 feature file. Charted features that were included in the assigned feature file that are outside of the survey coverage were not addressed by the survey and have been omitted from the final feature file.

D1.d Comparison of Soundings in Designated Anchorages and Along Channels

H12356 survey area does not contain any anchorage areas, maintained navigation channels or channel lines.

D1.e New Submerged Features

New submerged features are listed in tabular format in Appendix II *Survey Feature Report* and in the S-57 feature file.

D1.f Dangers to Navigation (DtoN)

One (1) DtoN was located during survey H12356 and submitted to AHB. This DtoN included seventeen soundings depicting highpoints of uncharted shoals and mounds of dredged material within a charted *Dump Site*. The seafloor features depicted by DtoN 1.1 are accurately portrayed in the CUBE surface and not included in the S-57 feature file. The charting status of the DtoN at the time of the Descriptive Report submission is included in Table 10. The DtoN report and related correspondence are located in Appendix I *Danger to Navigation Reports*.

Table 10. H12356 DtoN Charting Status

DtoN	Feature	Applied to Raster Chart	Applied to ENC	AHB Submitted to MCD
1	Soundings	Yes	Yes	Yes

D2. Additional Results

D2.a Shoreline Investigations

Shoreline investigation was not required for OPR-J348-KR-11.

D2.b Comparison with Prior Surveys

No comparison with prior survey was conducted.

D2.c Aids to Navigation (AtoN)

No Aids to Navigation (AtoNs) were charted within the H12356 survey area.

D2.d Overhead Clearance

There were no overhead bridges, cables, or other structures which would impact overhead clearance in the survey area.

D2.e Cables, Pipelines and Offshore Structures

There were no charted or observed drilling structures, production platforms, or well heads within the survey area. Two charted pipelines run through the eastern side of the survey area. Evidence of shifted sediment near the area of the charted pipeline was seen in the northeast corner of the survey area; however the actual pipeline was not seen in the multibeam or side scan data.

D2.f Environmental Conditions Impacting the Quality of the Survey

From September 1 through 4, 2011 (DN244 to DN247) Tropical Storm Lee impacted the survey area. When comparing survey data collected following the tropical storm to data collected before the storm, differences in depth of up to 35 centimeters were observed (Figure 3). However, full coverage multibeam acquired over several of the shoals up to 70 days after Tropical Storm Lee indicated that the seafloor is this area was dynamic and sediment disturbed by the storm had been disbursed (Figure 4).

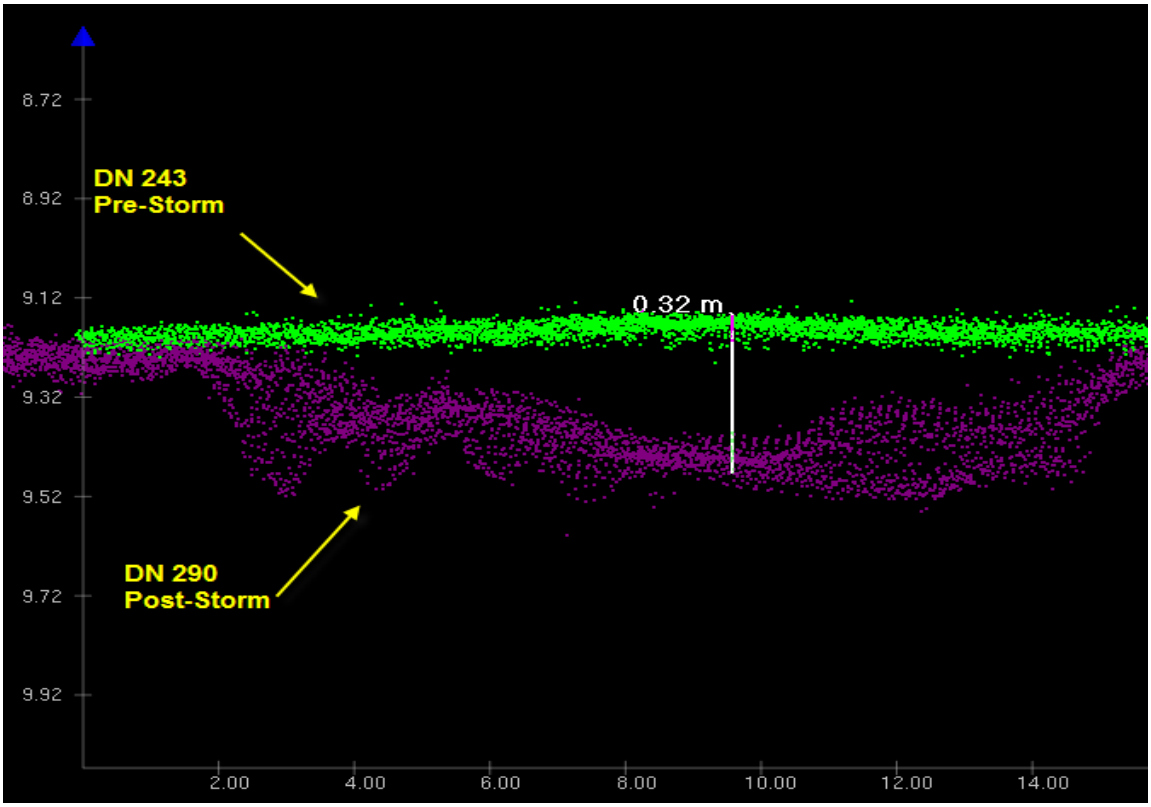


Figure 3. Example of pre- and post-storm differences

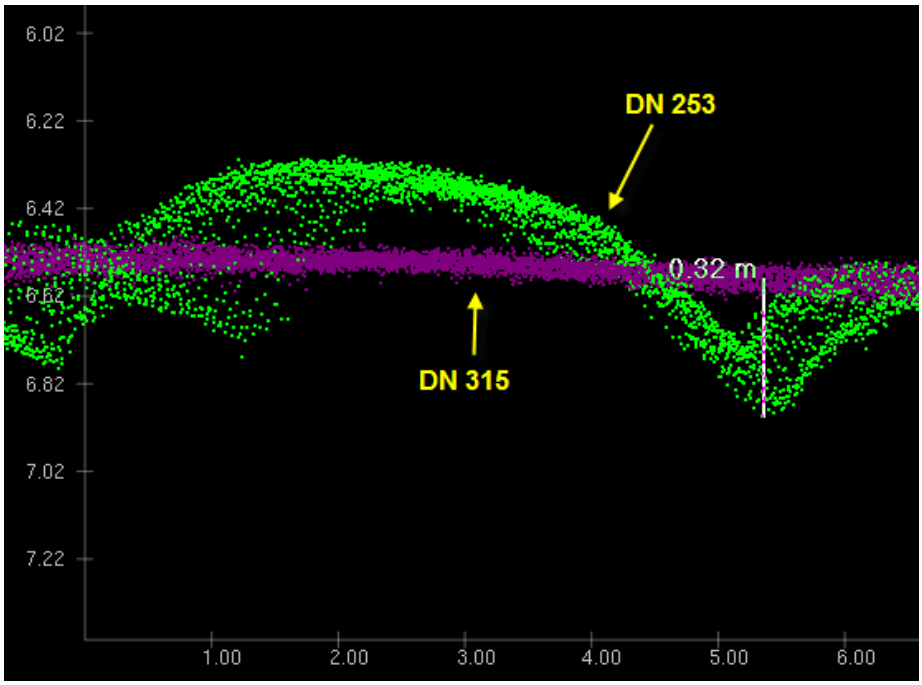


Figure 4. Example of sediment migration

D2.g Construction Projects

Active dumping of dredged material within the charted *Dump Site* was observed in the H12356 survey area on October 4 and November 11, 2011 (DN 277 and 315) as noted in the acquisition logs. In order to adequately portray the dredged material in the depth surface full multibeam coverage was obtained over the area. Multibeam coverage of the dredged material is shown in Figure 5 and an example of changes in bottom depth due to active dredged material disposal during survey operations between day number 259 and 289 is shown in Figure 6.

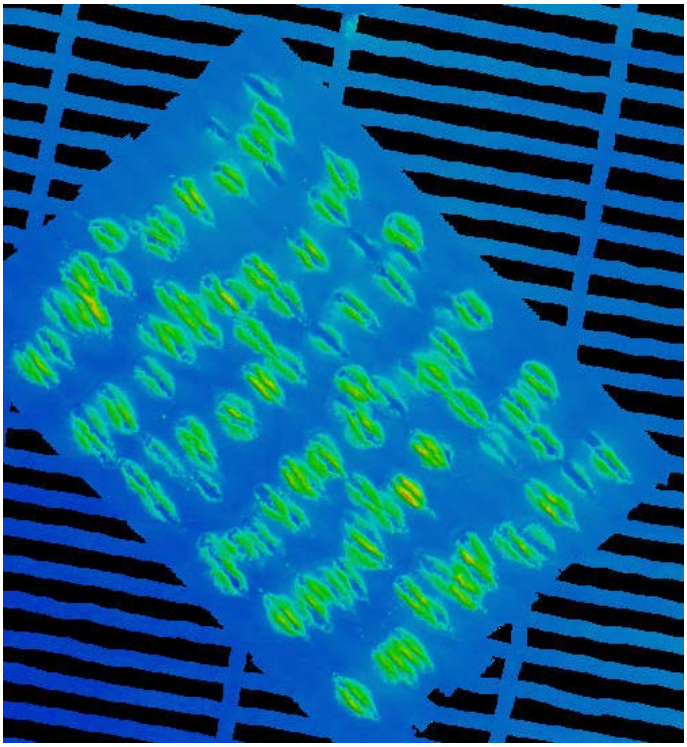


Figure 5. Active dredged material disposal within charted *Dump Site*

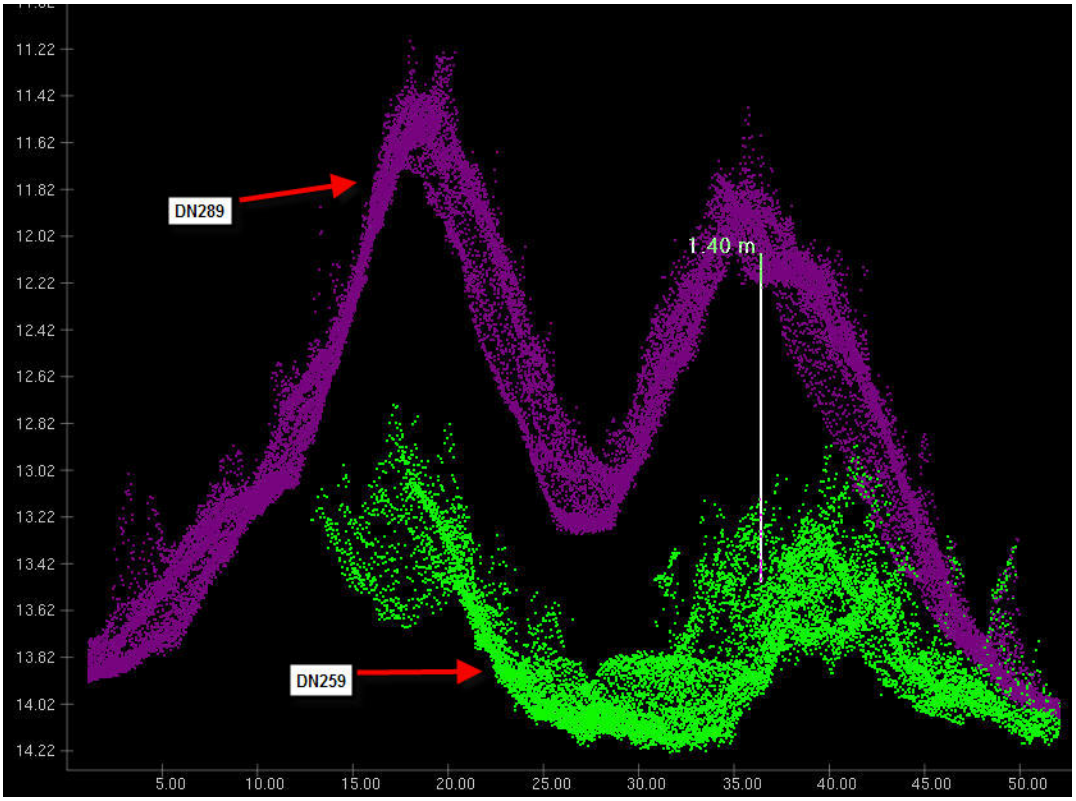


Figure 6. Multibeam data depicting dredged material disposal between DN 259 & 289

D2.h Bottom Characteristics

Nine (9) bottom samples were acquired within the survey H12356 limits per the locations indicated in the *BottomSamples_point.shp* file provided by NOAA. Results are in Appendix V *Supplemental Survey Records and Correspondence.*

DAVID EVANS
AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-J348-KR-11
REGISTRY NO. H12356

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of survey H12356 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 Statement* (June 2011) and *Hydrographic Survey Project Instructions* dated June 22, 2011.

Digitally signed by Jon Dasler
DN: cn=Jon Dasler, email=jld@deainc.com, o=David Evans and Associates, Inc., c=US
Date: 2012.03.30 10:20:54 -07'00'

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

Digitally signed by Jason Creech
DN: cn=Jason Creech, o=David Evans and Associates, Inc., ou, email=jasc@deainc.com, c=US
Date: 2012.03.30 10:21:14 -07'00'

Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
November 2011

2801 SE Columbia Way, Ste. 130, Vancouver, WA 98661 Telephone: 360.314.3200 Facsimile: 360.314.3250

APPENDIX I

TIDES AND WATER LEVELS

Project: OPR-J348-KR-11 Registry No: H12356
Contractor Name: David Evans and Associates, Inc.
Date: November 2011
Sheet Number: 4
Inclusive Dates: July 20, 2011- November 11, 2011

Time (UTC)

Day Number	Date	Start Time	End Time
201	07/20/2011	21:34:28	22:18:31
205	07/24/2011	14:48:16	17:12:24
212	07/31/2011	13:50:27	16:10:10
239	08/27/2011	16:32:11	20:27:04
240	08/28/2011	11:54:27	21:22:05
241	08/29/2011	11:46:15	19:09:30
243	08/31/2011	11:52:28	20:20:08
250	09/07/2011	13:19:38	21:15:09
251	09/08/2011	13:12:04	21:00:09
252	09/09/2011	12:05:36	21:04:22
253	09/10/2011	12:29:04	21:02:15
254	09/11/2011	12:31:45	21:35:27
255	09/12/2011	12:12:18	21:19:01
256	09/13/2011	12:38:06	20:00:11
257	09/14/2011	12:29:10	21:12:40
258	09/15/2011	14:08:33	20:50:48
259	09/16/2011	12:05:46	17:03:22
260	09/17/2011	12:27:08	21:07:00
261	09/18/2011	12:24:15	14:37:29
264	09/21/2011	15:44:04	21:27:19
267	09/24/2011	12:51:49	21:23:12
268	09/25/2011	12:07:33	21:18:49
269	09/26/2011	12:10:55	15:43:34
270	09/27/2011	12:06:39	17:24:45
272	09/29/2011	13:06:33	21:12:33
277	10/04/2011	19:06:24	21:22:46
278	10/05/2011	18:24:05	20:58:13
287	10/14/2011	13:50:57	21:21:33
288	10/15/2011	20:33:31	21:15:33
289	10/16/2011	11:43:52	21:14:39
290	10/17/2011	12:05:08	20:57:29
309	11/05/2011	14:47:18	16:04:33
312	11/08/2011	16:48:09	20:32:35
313	11/09/2011	18:17:47	21:16:30
315	11/11/2011	12:51:50	17:36:13

H12356

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: November 12, 2011

HYDROGRAPHIC BRANCH: Atlantic

HYDROGRAPHIC PROJECT: OPR-J348-KR-11

HYDROGRAPHIC SHEET: H12356

LOCALITY Approaches to Mississippi Sound, Mississippi

SUB-LOCALITY: SE of Horn Island

TIME PERIOD:

July	20, 24, 31
August	27-29, 31
September	7-18, 21, 24-27, 29
October	4, 5, 14-17
November	5, 8, 9, 11

TIDE STATIONS USED: 8741533, Pascagoula NOAA Lab, MS
Lat. 30° 22.0 N, Lon. 88° 33.7' W

PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters

HEIGHT OF MEAN HIGH WATER (8741533) ABOVE PLANE OF REFERENCE: 0.439 meters [1]

---

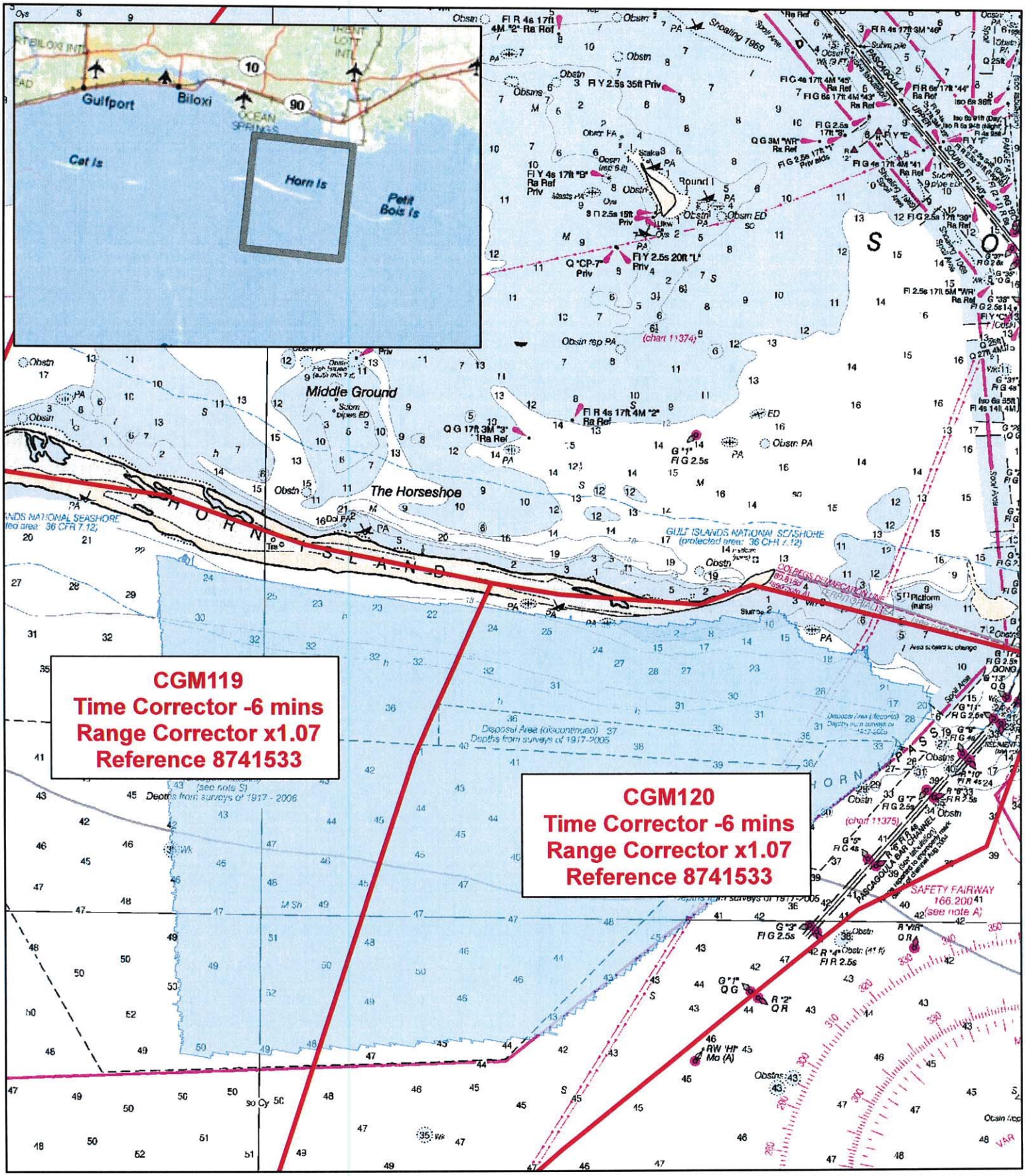
[1] MLLW 6.672m Mean Lower-Low Water
MHW 7.111m Mean High Water

http://tidesandcurrents.noaa.gov/data_menu.shtml?unit=0&format=Apply+Change&stn=8741533+Pascagoula+Noaa+Lab%2C+MS&type=Datums

FINAL TIDE ZONING
H12356
OPR-J348-KR-11

Zone	Time Corrector (Mins)	Range Ratio	Reference Station
CGM119	-6	1.07	8741533
CGM120	-6	1.07	8741533

NOTE: Final soundings were reduced to chart datum using Global Positioning System (GPS) water levels acquired directly at the vessel. The preliminary version of the zoning scheme provided with the project instructions was revised by David Evans and Associates, Inc. during analysis of ellipsoidally referenced survey transformation techniques for OPR-J348-KR-11. The revised tide zoning parameters referenced in this document are provided for information only.



N
W E
S

0 0.5 1
Nautical Miles

H12356
Final Tide Zoning
Reference Only

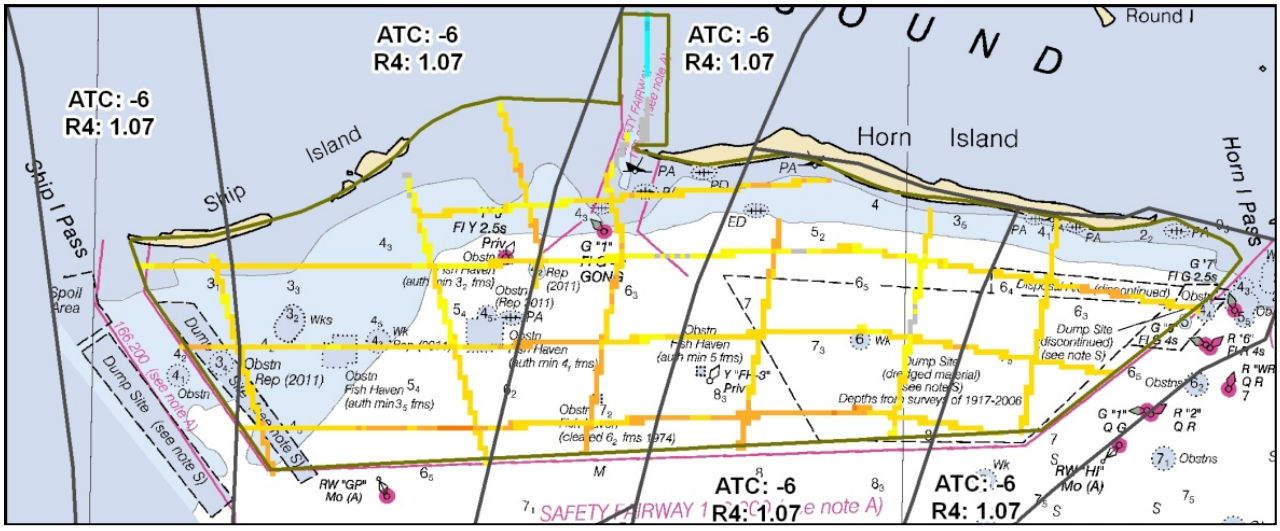
OPR-J348-KR-11
Approaches to Mississippi Sound, MS
David Evans and Associates, Inc.
Jon Dasler, Lead Hydrographer
Chart 11373_1

APPENDIX II

SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

OPR-J348-KR-11 Approaches to Mississippi Sound
Interim VDatum Report

November 2011



Prepared For:

US Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

Prepared By:

David Evans and Associates, Inc.
2801 SE Columbia Way, Suite 130
Vancouver, WA 98661
(360) 314-3200

OPR-J348-KR-11 Approaches to Mississippi Sound
Interim VDatum Report

November 2011

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 for an interim deliverable as per the OPR-J348-KR-11 *Project Instructions* (June 2011).

_____

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

_____

Jason Creech
Lead Hydrographer

_____

Ben Hocker
Lead Hydrographer
Tides and Water Levels Specialist

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Acronyms and Abbreviations

ARP	Antenna Reference Point
ASCII	American Standard Code for Information Interchange
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station
CUBE	Combined Uncertainty and Bathymetry Estimator
DAA	Design Analysis and Associates, Inc.
DEA	David Evans and Associates, Inc.
DN	Day Number
ERS	Ellipsoidal Referenced Survey
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HVF	HIPS Vessel Files
HSSD	Hydrographic Surveys Specifications and Deliverables
IAKAR	Inertially Aided Kinematic Ambiguity Resolution
JOA	John Oswald and Associates
LMSL	Local Mean Sea Level
MHHW	Mean Higher High Water
MHW	Mean High Water
MLLW	Mean Lower Low Water
MN	Mean Range
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NTDE	National Tidal Datum Epoch
NWLON	National Water Level Observation Network
OPUS	Online Positioning User Service
PPK	Post-Processed Kinematic
RMS	Root Mean Square
SBET	Smoothed Best Estimate Trajectory
STND	Station Datum
TPVU	Total Propagated Vertical Uncertainty
UTC	Universal Time Coordinated
VDATUM	Vertical Datum
ZDF	Zone Definition File

1.0 Executive Summary

This document is an interim report describing preliminary methods and results of an ongoing Vertical Datum (VDatum) analysis component of project OPR-J348-KR-11. The project, which is being performed by David Evans and Associates, Inc. (DEA), is located in the vicinity of the Approaches to Mississippi Sound and encompasses hydrographic surveys H12353, H12354, H12355, and H12356. DEA was contracted to perform an analysis of the reliability of Mean Lower Low Water (MLLW) estimates from the current Louisiana/Mississippi VDatum release and the ability to use those estimates to compute a North American Datum of 1983 (NAD83) ellipsoid to MLLW separation model for use with Global Positioning System (GPS) water levels following guidelines for ERS/Zoned Hydrography Comparisons set in the 2011 National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables. This interim report and supporting data will be used by National Oceanic and Atmospheric Administration (NOAA) to support a decision on whether to use (ERS) (Ellipsoidal Referenced Survey) methods in lieu of traditional tides for final water level correctors for the OPR-J348-KR-11 surveys.

Based on preliminary tidal datum computations at Ship Island, Mississippi Sound, MS (874-4756), computed MLLW relative to heights determined using GPS is approximately 3.9 centimeters lower when compared to the NAD83 ellipsoid height of MLLW using VDatum. Vessel float observations at Ship Island supported this finding (gauge observations reduced to MLLW were 2.2 centimeters lower than MLLW determined from vessel floats using VDatum).

The results of the test line analysis show no significant difference between crossline ties with mainscheme data when using either GPS or traditional tidal correctors. As shown by the lowest standard deviation of crossing differences, the use of GPS water levels does offer a general improvement in the agreement of the VDatum test lines. It should be noted that these test lines were run under near optimum conditions for using traditional tidal zoning (calm seas, light winds, relatively low tide ranges, etc.). One would expect comparable results when using GPS methods as sea and weather patterns degrade while the traditional tidal zoning would not perform nearly as well. Further, the application of zoned tides does not adequately correct multibeam data for large kinematic waves, wind driven water level changes and other small scale transient water levels typical to the survey area. Last, ERS eliminates errors resulting from vessel loading and inadequate compensation for vessel squat by using speed over ground lookup tables. For this project, the implementation of ERS will result in the application of slightly lower water levels that more accurately reflect dynamic water levels in the survey area. The resultant soundings will be slightly deeper than soundings corrected through the application of zoned tides.

Based on the analysis performed to date, DEA recommends moving forward with ERS deliverables for this project.

2.0 GPS Base Stations

Two temporary GPS base stations were installed by DEA to post-process GPS and inertial data collected on the survey vessels by the Applanix POS/MV. Each station was strategically located near the project site in order to meet the 20-kilometer maximum baseline length for single base post-processed kinematic (PPK) mode using Applanix POSPac MMS software. The stations were designated SHIP and HORN and were installed on existing piers at Ship and Horn Islands respectively. Both GPS stations were located within the boundaries of the Gulf Islands National Seashore and as such, a permit was required from the National Park Service. The base station HORN was located along the east side of the project area while SHIP was located on the west at the tertiary tide station (Figure 1).

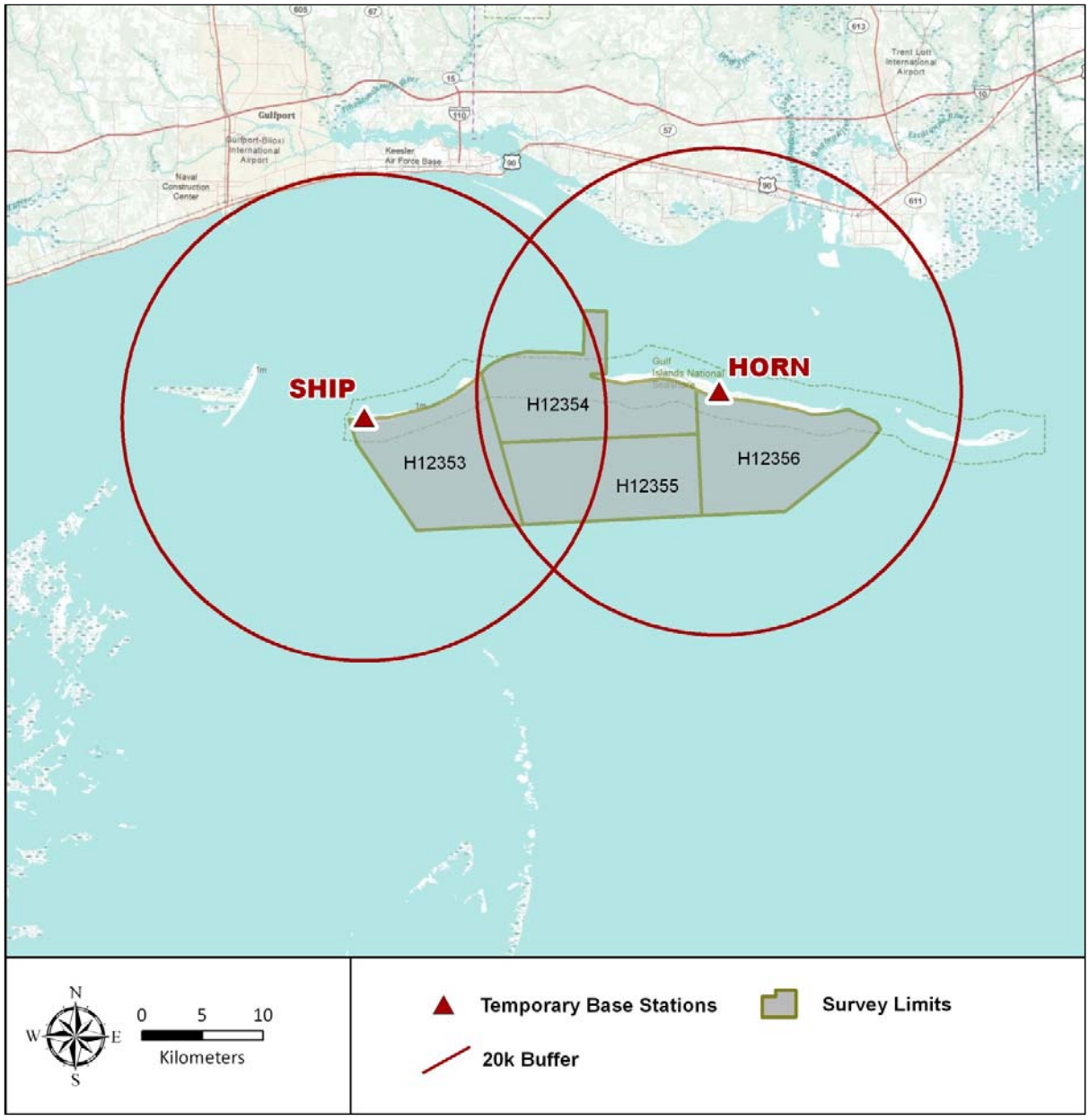

Figure 1: Temporary GPS Base Stations used for OPR-E349-KR-11

Data from existing Continually Operating Reference Station (CORS) sites could not be used in a multi-base solution in POSPac MMS due to the geometry of the network. The distances between the existing stations forming the southern baseline (needed to capture the offshore sides of the project area) exceeded the maximum length of 100 km specified in Section 9.1.1.1 of the NOS Hydrographic Surveys Specifications and Deliverables (HSSD) dated April 2011.

Each temporary GPS base station consists of a Trimble Net-R5 GPS dual frequency (L1/L2) receiver with Trimble Zephyr Geodetic GPS antenna. The station location was selected to provide clear satellite visibility with the GPS antennas installed on a rigid steel pole securely attached to a stable structure. The receivers were configured to log raw GPS observables at 1 Hz. Data logged included: L1 phase, C/A code, L2 phase, P(Y) code and L2C (CM+CL). Internally logged data were stored in Trimble T01 format and segmented into 24-hour files that were automatically uploaded to the DEA FTP site daily. The network connection was provided by a cellular modem with a directional antenna to increase signal strength. Files were manually downloaded from the FTP site and quality controlled daily. Table 1 lists the GPS equipment used on the project.

Table 1: GPS Base Station Equipment

GPS Base Station Equipment					
Item/ Manufacturer	**Model**	**P/N**	**S/N**	**Firmware Version**	**Location**
Receiver					
Trimble	NetR5	62800-10	4750K11594	4.19	SHIP
Trimble	NetR5	62800-10	4750K11589	4.19	HORN
Antenna					
Trimble	Zephyr-Geodetic	41249-00	12338039	N/A	SHIP
Trimble	Zephyr-Geodetic	41249-00	60201334	N/A	HORN

The coordinates were derived at each site from the GPS receiver logging one second epochs for a 24-hour static occupation. The data files recorded at each site were submitted to the Online Positioning User Service (OPUS), operated by the National Geodetic Survey (NGS). The solutions derived from OPUS were processed using a rapid GPS ephemeris and later checked against a precise orbit. This was done to expedite processing and meet the interim deliverables deadline. All solutions were in accordance with the passing criteria for the solution statistics established in the NOAA publication *User's Guide for GPS Observations (March 2007).* The coordinates for each site were derived at the Antenna Reference Point (ARP) of the Trimble Zephyr Geodetic antennas. The coordinates derived from the OPUS solutions at the temporary base stations are shown in Table 2, referenced to NAD83 (CORS96, Epoch 2002).

Table 2: Antenna Reference Point (ARP) Station Coordinates

Coordinates NAD83(CORS96, Epoch 2002) ARP (24 Hour OPUS Solution)			
Temporary Station	Latitude	Longitude	Ellipsoid Height (m)
SHIP	30° 12' 50.79097" N	088° 58' 17.34520" W	-21.222
HORN	30° 14' 17.35884" N	088° 40' 01.67123" W	-21.095[1]

[1] Adjusted height using OPUS 10-day average. The height used during POSPac processing was -21.122 meters.

Weekly OPUS solutions were obtained and compared to the initial base station position to verify the stability of the base station over the course of the project. Similar to the technique used to establish the base station coordinates, these weekly solutions were computed using a rapid GPS ephemeris. A total of 13 weekly comparisons were made between July 24, 2011 and October 16, 2011. For the base station on Ship Island, the average vertical deviation between the weekly check position and the original reference position was 0.004 meters, with a standard deviation of 0.012 meters. Horizontal deviation was also on average 0.004 meters or less, indicating the base station was stable over the course of the project. For the base station on Horn Island, the average vertical deviation between the weekly check position and the original reference position was 0.026 meters, with a standard deviation of 0.005 meters. Similar to the Ship island station, the average horizontal deviation was 0.004 meters or less. The 0.026-meter vertical deviation between the weekly check positions and initial base position, which was well in excess of the corresponding standard deviation, suggested that either the Horn island station had moved vertically since the initial derived position, or the initial derived position was in error.

To further evaluate base station stability for the station on Horn Island, OPUS solutions using final ephemeris were derived for a 24-hour period prior to and another following the day used to derive the initial position. Both of these solutions deviated from the derived initial position in the same direction, with the prior day 0.042 meters higher, and the following day 0.034 meters higher. This suggests that the observed deviation was attributable to error in the estimation of the original base station position, not to a physical change in the vertical location of the base station. To derive a more reliable estimate of the vertical position of the Horn Island base station, additional OPUS solutions using final ephemeris were derived for 10 days and averaged. The majority of the days used to compute the 10-day average did not coincide with days used for weekly checks, and included days prior to and following the day used to derive the initial position. The resulting position was 0.027 meters higher than the original base station position, with a standard deviation of 0.009 meters. Comparing the weekly check vertical positions to this new Horn Island vertical position yields an average difference of 0.001 meters, with a standard deviation of 0.005 meters. These results indicated that the rapid ephemeris OPUS solution used to compute the initial base position was in error by approximately 0.027 meters. The 0.027 meter shift in the vertical position of the Horn Island base station was applied to the bathymetric data as a static offset during the computation of GPS Tide in Caris Hydrographic Information Processing System (HIPS) rather than reprocessing all of the POSPac sessions using the Horn Island base station.

To tie the GPS observations to MLLW, optical leveling was performed between the GPS base station ARP and the tidal bench marks. Optical levels were run between the Horn Island GPS station HORN and bench mark 8742221 J in order to tie the NAD83 antenna reference position (ARP) height of HORN to Center for Operational Oceanographic Products and Services (CO-OPS) published MLLW; and to verify the historic NAD83 height of the tidal bench mark 8742221 H (PID: BBBG92) obtained by NGS in 2009 (Table 3). It was not possible to occupy tidal bench mark 8742221 H or any other bench marks due to access restrictions mandated by the National Park Service. GPS observation were collected on 8742221 H by the NGS on February 12, 2009 and published by OPUS-DB. CO-OPS provided station datum elevations of 8742221 H and 8742221 J which were adjusted to MLLW using published values for (874-2221). The Horn Island GPS observations when comparing the ten-day average height for HORN ARP to the NGS GPS observations do not agree by 0.028 meters. This is most likely the result of a questionable OPUS solution from 8742221 H acquired on February 12, 2009 which has a published height accuracy of ±0.078 meters. Vertical peak-to-peak errors of this magnitude typically signify a questionable OPUS solution from the 2009 GPS observation by NGS.

Table 3: Horn Island, MS (874-2221) VDatum Check

Horn Island, Mississippi Sound, MS (874-2221)	
Bench Mark	**HORN ARP**
MLLW (CO-OPS Published / transferred from 8742221 H)	6.779 m
MLLW (VDatum GEOID09)	6.691 m
MLLW Difference	**-0.088 m**
NAD83 OPUS (CORS96, 2002 Epoch) / 10 day average	-21.095 m
NAD83 Published (CORS96, 2002 Epoch) transferred from 8742221 H	-21.123 m
NAD83 Difference	**-0.028 m**

The SHIP GPS station included optical leveling from the GPS ARP to tidal bench marks during the installation of the tertiary gauge at Ship Island (874-4756). Results comparing observations to VDatum are listed in Table 4.

Table 4: Ship Island, MS (874-4756) VDatum Check

Ship Island, Mississippi Sound, MS (874-4756)	
Bench Mark	**SHIP ARP**
MLLW (CO-OPS Published / transferred from 8744756 F)	1.425 m
MLLW (VDatum GEOID09)	1.310 m
MLLW Difference	**-0.115 m**
NAD83 OPUS (CORS96, 2002 Epoch)	-21.222 m
NAD83 (CORS96, 2002 Epoch) transferred from 8744756 F	-21.228 m
NAD83 Difference	**-0.006 m**

3.0 Ship Island Tertiary Gauge

A tertiary gauge was established at the historic CO-OPS site at Ship Island, Mississippi Sound, MS (874-4756). This station was last occupied by CO-OPS in 1980. DEA incorporated this station in the permit acquired from the National Park Service and worked jointly with John Oswald and Associates, Inc. (JOA) to install two bubbler gauges to collect data for datum determination and possible sounding reduction. The primary gauge was based on a ParoScientific pressure sensor while the backup gauge consisted of a Design Analysis and Associates (DAA) H-350XL. Complete details of the installation, which was established to CO-OPS specifications as required by the Tides and Water Levels component of the project instructions, were submitted to CO-OPS in the Installation Report dated September 1, 2011. The location of the Ship Island tertiary station relative to the project area is shown in Figure 2.

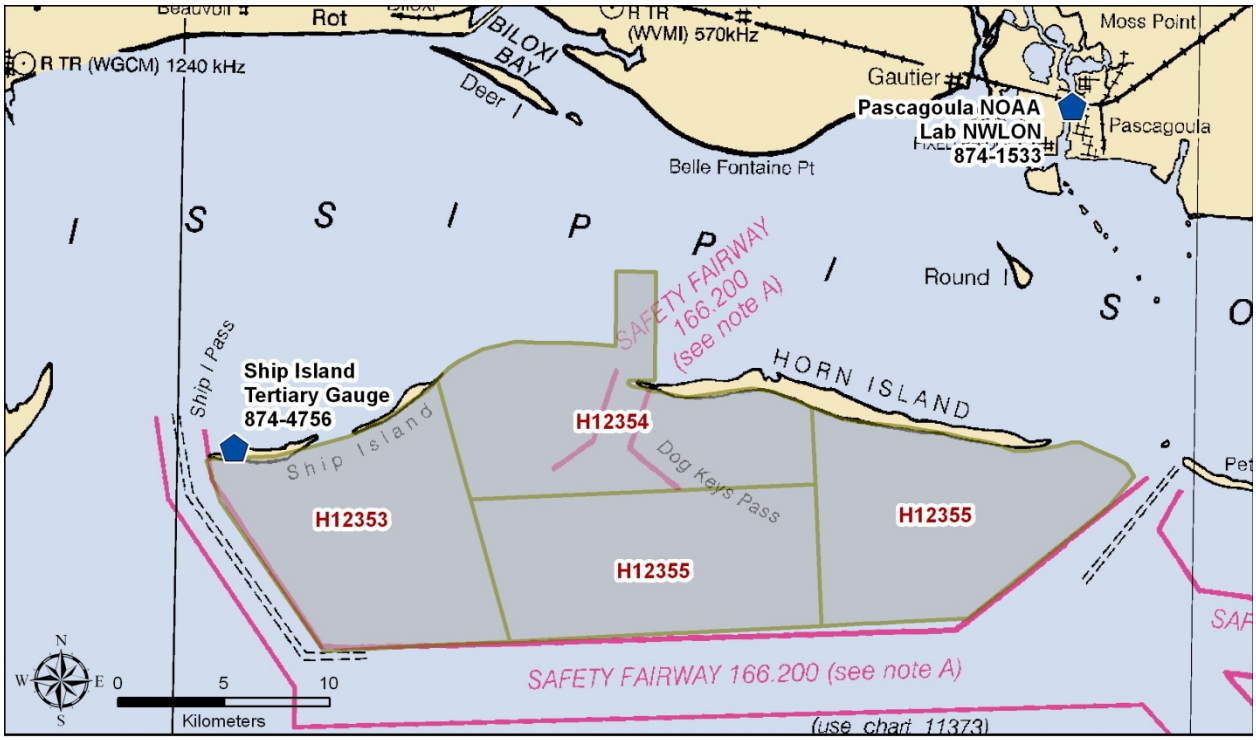

Figure 2: Water level gauging sites for OPR-E349-KR-11

3.1 Preliminary Tidal Datum at Ship Island

A preliminary datum was computed from the first set of data using the modified range ratio method. One calendar month of data was used from August, 2011 with Pascagoula NOAA Lab, MS (874-1533) as the control station. The modified range ratio method was used to correct the datums to the current National Tidal Datum Epoch (NTDE). By using this method, the Mean Higher High Water (MHHW) datum computes to a value lower than Mean High Water (MHW). Using the other computation methods this is not the case; however the modified range ratio method is the recommended method for the Gulf Coast. Datum planes are presented in Table 4

while the tabulations are given in *Appendix A. Ship Island, Mississippi Sound, MS Datum Computation Results*.

To compare the results to the published historic datum and VDatum values, the elevation of MLLW on station datum (STND) was used. The results from this preliminary datum computation are 7.6 centimeters higher than the published CO-OPS datum from 1980 that was based on four months of data (Table 5).

Table 5: Ship Island, Mississippi Sound, MS (874-4756) Datum Planes

	Preliminary Datum Planes Relative to STND (m)	Historic Datum Planes Relative to STND (m)
MHHW	1.631	1.582
MHW	1.638	1.545
DTL	1.388	1.326
MTL	1.398	1.325
MSL	1.386	1.326
MLW	1.157	1.104
MLLW	1.145	1.069
GT	0.486	0.512
MN	0.481	0.441
DHQ	-0.008	0.037
DLQ	0.012	0.035

The Computational Techniques for Tidal Datums Handbook estimates the uncertainty of a tidal datum computed from one month of data collected on the Gulf Coast is 5.49 centimeters while a datum computed from four months of data has an associated uncertainty of 4.57 centimeters at 1 sigma. Thus, in general, the differences between the 1980 published datums and the computed 2011 preliminary datums are within the estimated uncertainties, particularly when sea level trends and subsidence are taken into account.

The closest station to Ship Island with published sea level trends is Dauphin Island, AL (873-5180). Dauphin Island is approximately 86 kilometers (46 nautical miles) east of Ship Island and likely experiences similar sea level trends. The published long term trend, with regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures and ocean currents removed, is 2.98 millimeters per year with an uncertainty of 0.87 millimeters at 2 sigma. Projecting this out 31 years, yields a corrected historic MLLW datum of 1.161 meters relative to STND with a sea level correction uncertainty of 0.027 meters at 2 sigma. This compares very well to the preliminary MLLW datum relative to STND (1.145 meters) with a difference of 0.016 meters.

3.2 Preliminary VDatum Comparison at Ship Island

To compare the VDatum model to the preliminary datum, the ellipsoid height of bench mark 8744756 F determined by static GPS observations during the station installation was input to the VDatum software and the MLLW elevation was computed. It was found that the VDatum determined MLLW elevation was 3.9 centimeters below the preliminary MLLW datum computed from the observed water levels (Table 6).

Table 6: Ship Island, Mississippi Sound, MS MLLW Datum Plane Comparison

Ship Island, Mississippi Sound, MS (874-4756)	
Bench Mark	**8744756 F (GPS bench mark)**
MLLW (Preliminary)	1.349 m
MLLW (CO-OPS Published, installation levels)	1.425 m
MLLW Difference between Preliminary & CO-OPS	**0.076 m**
MLLW (VDatum GEOID09)	1.310 m
MLLW Difference between Preliminary & VDatum	**-0.039 m**
NAD83 (CORS96, 2002 Epoch)	-26.321 m

The adjusted VDatum model file for Louisiana/Mississippi - Eastern Louisiana to Mississippi Sound, released August 10, 2011 was used for the conversion.

3.3 Vessel Float Observation at Ship Island

To compare the gauge results with GPS water levels, a one-hour vessel float observation was acquired adjacent to the tertiary gauge at Ship Island during a maintenance visit. GPS data acquired during the vessel float observation was logged and processed using the combined separation model generated from the VDatum model and GEOID09. The resulting water elevations on MLLW were then compared to the tertiary gauge measured values, which were also adjusted to MLLW using a preliminary datum computed from the first month of data. The vessel measurements were averaged using the same interval as the gauge (three minutes centered on the six-minute interval). The average difference between the two methodologies was 2.2 centimeters with a standard deviation of 1.2 centimeters (Table 7 and Figure 9).

Table 7: Ship Island, Mississippi Sound, MS (874-4756) GPS to Tertiary Water Levels Comparison

Ship Island, Mississippi Sound, MS (874-4756), September 6, 2011			
Time (UTC)	GPS Water Level (VDATUM MLLW m)	Gauge Water Level (Preliminary MLLW m)	Difference (m)
19:42	0.259	0.268	-0.009
19:48	0.247	0.260	-0.013
19:54	0.256	0.258	-0.002
20:00	0.234	0.253	-0.019
20:06	0.225	0.243	-0.018
20:12	0.226	0.238	-0.012
20:18	0.217	0.238	-0.021
20:24	0.192	0.228	-0.036
20:30	0.185	0.220	-0.035
20:36	0.191	0.217	-0.026
20:42	0.167	0.205	-0.038
20:48	0.164	0.201	-0.037
		Mean	-0.022
		Standard Deviation	0.012

The direction of the difference is consistent with the differences observed by static GPS discussed in section 3.2.

4.0 Analysis of VDatum Test Lines

A series of VDatum test lines have been processed and reduced to MLLW using both ERS methods and traditional discrete zoning. The intent of these lines, which are required by the Project Instructions, is to provide a baseline in which to compare results of the two sounding reduction techniques. The VDatum test lines (Figure 3) consist of a subset of preplanned mainscheme and crosslines which run perpendicular to the maximum slopes of both the Geoid and the zoning range correctors. These lines were approved for use by NOAA Hydrographic Surveys Division by email on June 29, 2011.

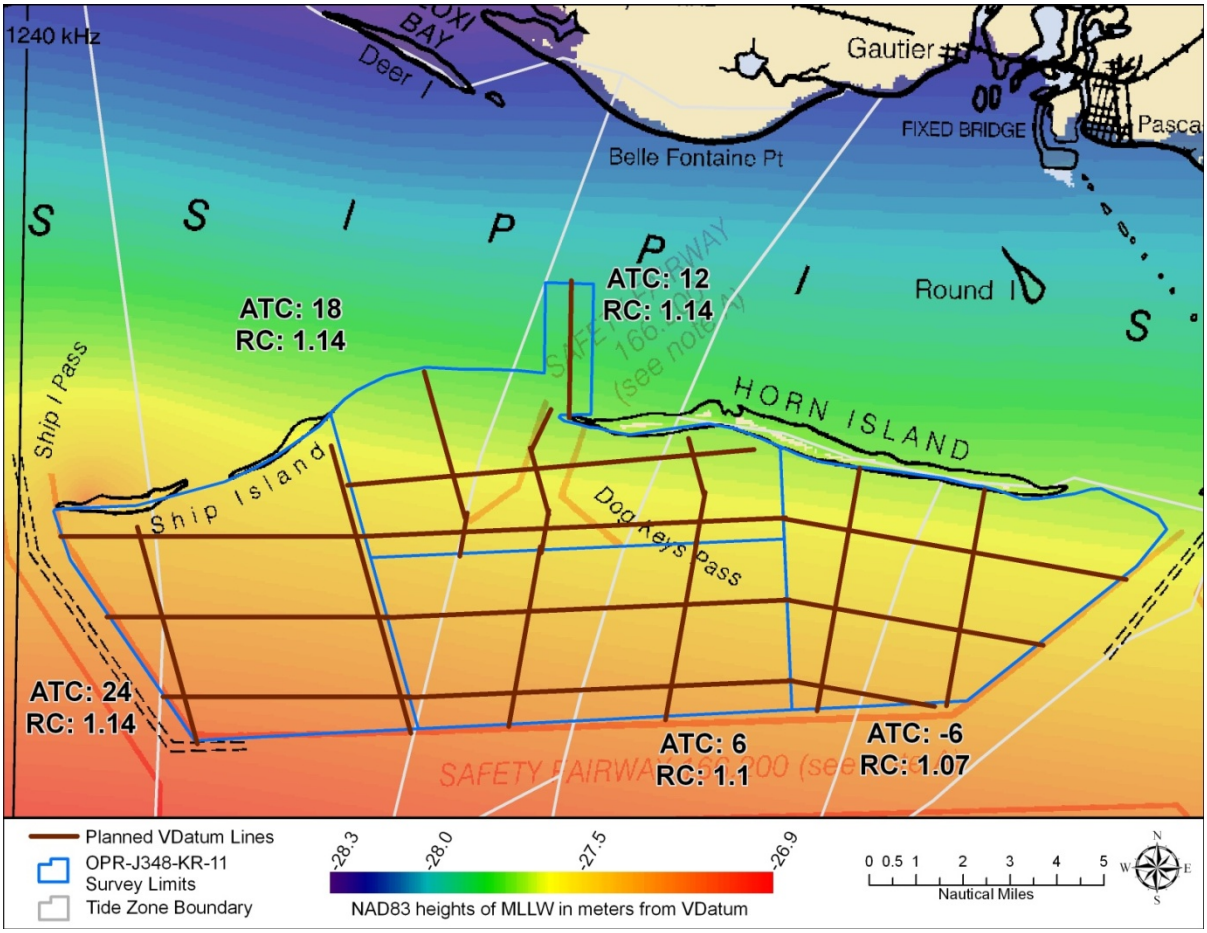

Figure 3: VDatum test lines for OPR-E349-KR-11 and preliminary zoning correctors

4.1 Processing Methods

The VDatum test lines approved for this project required the collection of 29 individual survey lines that were converted into Caris HIPS for processing and analysis. Integrated vessel attitude and Global Satellite Navigation System (GNSS) data were post-processed using the Applanix POSPac MMS Single Base option. DEA installed two base stations, SHIP and HORN, on Ship and Horn Islands to support the post processing effort. Post-processing using a SmartBase network was not possible for this project due to the inability to create a network from existing

and new GPS infrastructure without exceeding the 100 kilometer tolerance for adjacent base stations as defined in the 2011 NOS HSSD.

For both datasets (ERS and discrete zoning) data processing followed the typical Caris HIPS (CUBE) Combined Uncertainty Bathymetric Estimator workflow with integration of Smoothed Best Estimate Trajectory (SBET) data through the HIPS load Attitude and Navigation tool. Applanix POSPac MMS was used to produce an Inertially Aided Kinematic Ambiguity Resolution (IAKAR) navigation solution relative to NAD83 (CORS96, Epoch 2002) and well as real time error estimates. All available post-processed navigation, attitude, and error parameters (Navigation/Position, Gyro, Pitch, Roll, and GPS Height/Down) were applied to the ERS versions of the survey lines. All parameters except Down Root Mean Square (RMS) were applied to the zoned version of the survey lines. Down RMS was excluded in order to facilitate the proper computation of total propagated vertical uncertainty (TPVU).

The file name convention of all delivered HIPS survey lines follows the Hypack CHS format which uses a thirteen character structure incorporating year, the first two letters of the survey vessel name, Julian day number, and year (e.g. 2011WE1971724_XL_VD_ERS). Several suffixes have been appended to each survey line to indicate they are Vdatum test lines (_VD), they are also crosslines in the original survey dataset (_XL), and the method of datum reduction. The suffix _ERS indicates that the survey line uses ERS methods with SingleBase post-processing while the suffix _Zoned indicated that the survey line uses discrete zoning with NOS verified water levels.

GPS water levels from the POSPac SBET solutions were computed for the ERS version using the HIPS Compute GPS Tide dialogue. During this step the NAD83 to MLLW model file (MS_Sound.bin) created by DEA was selected as well as options necessary to apply HIPS water line offsets and to remove heave and dynamic draft from the GPS signal. The bin file was created with the aid of VDatum using GEOID09 and the Eastern Louisiana to Mississippi Sound, Version 01 transformation grids (LAMobile01_8301). During the HIPS Merge process GPS Tides are applied and the waterline, heave, and dynamic draft correctors applied during the GPS tide computation are backed out. With all correctors applied, depths were reduced to MLLW. Figure 4 shows the basic ERS processing workflow. This same methodology will be used for all project OPR-J348-KR-11 survey deliverables if permission is granted to use ERS methods in place of traditional discrete zoning.

The adjustment of the Horn Island GPS base station height previously discussed in Section 2.0 was performed with the Caris HIPS Compute GPS Tide dialogue using the Apply Height Correction option. This adjustment was not performed for survey lines collected within the H12353 survey area since they used the Ship Island base during post-processing.

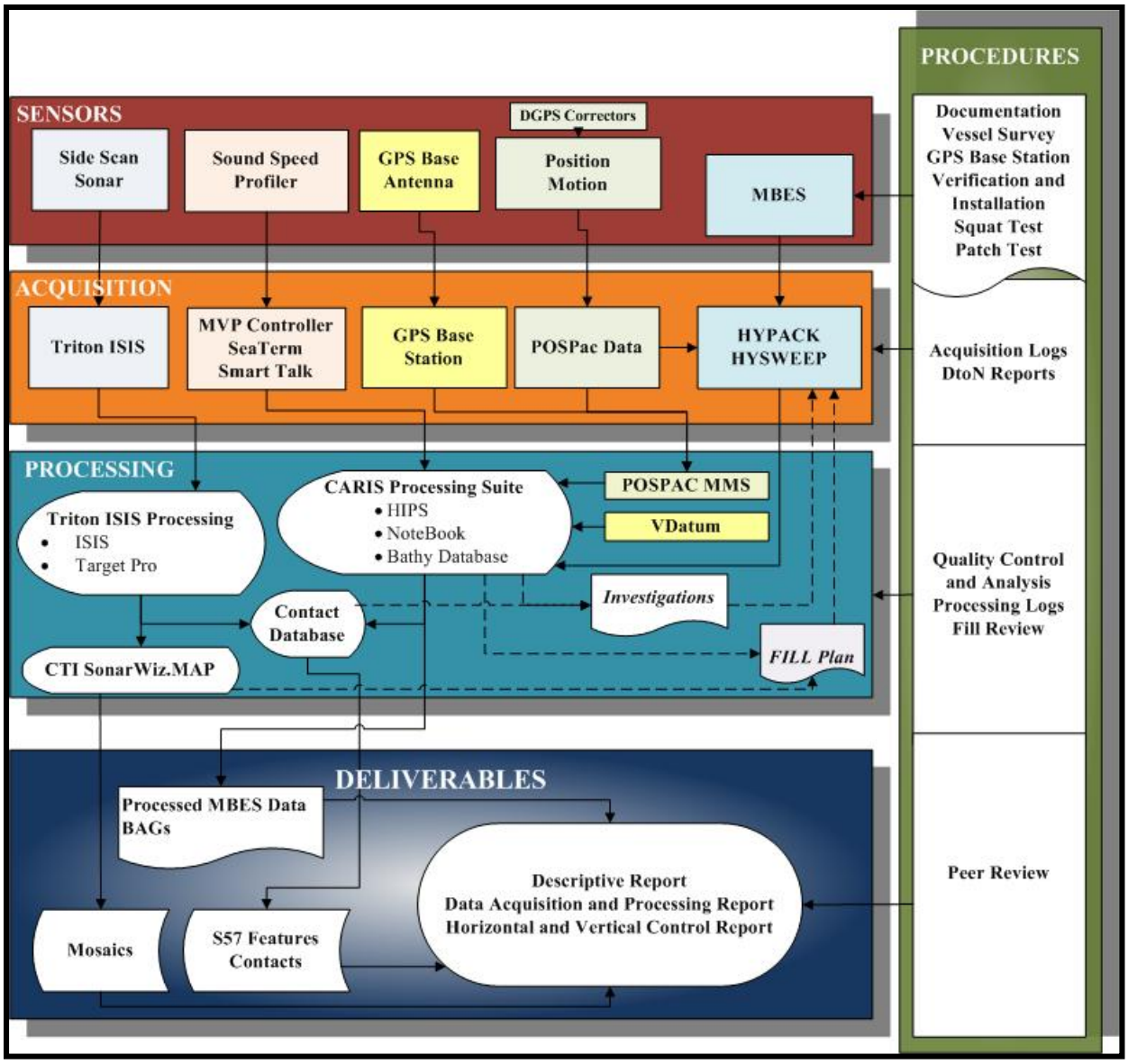

Figure 4: Workflow for GPS Water Levels

The zoned version of the survey lines followed a similar workflow. Data were reduced to MLLW using a HIPS Zone Definition File (ZDF) rather than the VDatum model file. The zoning schemes used to correct the data for this analysis are a modified version of the scheme supplied with the project instructions (J348KR2011CORP_Rev). The modified files used a HIPS Interval value of one second rather than the default value of 360 seconds which was used in the file received by DEA. The interval value controls the frequency of tide zoning interpolation. The default value of 360 seconds is too infrequent to properly correct for the assigned zoning boundaries where it would be possible for the survey vessel to pass through a zone without a zoned tide corrector being applied if the vessel was not within the zone boundary for longer than 359 seconds. Using a 1 second interval value is also more appropriate when evaluating the

performance of zoning correctors since the longer default interval has the potential to mask zoning artifacts at zone boundaries.

Table 8 lists the inputs entered into the Caris HIPS Compute Total Propagated Error (TPE) dialogue for each version of the data.

Table 8: Differences between GPS Water Levels and Zoned Tide Uncertainties

Parameter	ERS	Zoned
Tide Value Measured (m)	0.000	0.000
Tide Value Zoning (m)	0.170[1]	0.070[2]
Sound Speed Measured (m/s)	1.000	1.000
Surface Sound Speed (m/s)	0.500	0.500

[1] Computed from published values (http://vdatum.noaa.gov/docs/est_uncertainties.html)

[2] Computed from values supplied by CO-OPS and conditionally approved by HSD for use in this report

4.2 Analysis Methods

Difference surfaces of the VDatum test lines were created over the project area in order to quantify the differences between the two tide correction methods and to evaluate the effectiveness of each method. These quality control checks follow the ERS / Zoned Hydrography Comparisons guidelines set in the 2012 NOS Hydrographic Specification and Deliverables. VDatum test line mainscheme to crossline differences statistics were computed for ERS methods as well as several different zoning schemes in order to determine the most effective tide correction method for the project.

The preliminary version of the zoning scheme (noted as "Zoned" during the analysis) provided with the project instructions was evaluated alongside several new schemes created by DEA using analytical methods as well as unempirical interpretation of the local tidal dynamics. Two other zoning schemes were created after discovering that the time correction for the Ship Island (874-4756) short term datum computed specifically for the Interim Deliverables differs from the preliminary zoning value by 24 minutes. Both of these schemes were based on assumptions about the tidal dynamics for the area and held the zoning parameters from zone CGM120 for the entire project area. The first of these zones ("CGM120") used Pascagoula, NOAA Lab, MS (874-1533) water levels and the preliminary time and range correctors for CMG120 for all zones. The other ("SHIP_CGM120") used Ship Island water levels and preliminary zoning CGM120 back zoned from Ship Island.

In addition, a completely new zoning scheme was created after generating new co-phase and co-range lines for the area. New zoning parameters were created for multiple stations in the vicinity of the survey area, including the Ship Island (874-4756) subordinate gauge. Predictions were made for each of these sites using published tidal harmonics for Pascagoula, NOAA Lab, MS (874-1533) and then fitting these predictions to observed data using least squares techniques.

Revised co-range and co-phase lines were generated from the results of the analysis and used to create a new zoning scheme for the project area. This scheme was tagged as "DEA_Mod" during the analysis.

Difference surfaces were created using one meter HIPS swath angle surfaces. HIPS swath angle surfaces were generated using the 1x1 maximum footprint setting to prevent depth interpolation beyond the boundary of each one meter node. The surface differencing analysis used swath angle surfaces in lieu of CUBE surfaces to remove the impact of uncertainty weighting on the final depth estimates of each node. Total propagated uncertainty was computed for both datasets using the appropriate a priori and real-time uncertainties to enable the comparison of both depth and uncertainly differences resulting from the two tide correction techniques. This required the use of two HIPS Vessel Files (HVF) which used the same sensor offset information, but with standard deviation values specific to the water level correction technique. Loading, draft, and dynamic draft error estimates were used in the Zoned version of the vessel files while these parameters were zeroed out in the ERS version.

Difference surfaces between crossings of the VDatum test lines were created to evaluate the performance of each tide correction method. VDatum test lines included both mainscheme and crosslines from the OPR-J348-KR-11 data set. This analysis excluded VDatum lines run on September 13, 2011 (DN 256) because water levels reduced to MLLW at the Ship Island subordinate gauge were not available when the analysis was performed. The difference surfaces were created in HIPS 7.1 using the GPS water levels version of a surface as Input Surface 1 and the zoned version as Input Surface 2. The output grid was then exported to American Standard Code for Information Interchange (ASCII) to enable computation of descriptive statistics (Table 9). Positive differences indicate that the zoned tide was greater than the GPS water level.

The results from the project-wide crossline analysis are presented in Table 9 and Figure 5.

Table 9: Crossline Differences at VDatum Test Line Crossings

	ERS	Zoned (CO-OPS preliminary)	Zoned (CGM120)	Ship Island (DEA mod)	Zoned (SHIP_CGM120)
Mean (m)	-0.022	-0.004	-0.002	0.010	0.010
Median (m)	-0.022	-0.005	-0.002	0.008	0.011
Standard Deviation (m)	0.030	0.048	0.039	0.041	0.041
Range (m)	0.279	0.269	0.238	0.250	0.247
Minimum (m)	-0.190	-0.133	-0.115	-0.103	-0.114
Maximum (m)	0.089	0.137	0.124	0.148	0.134

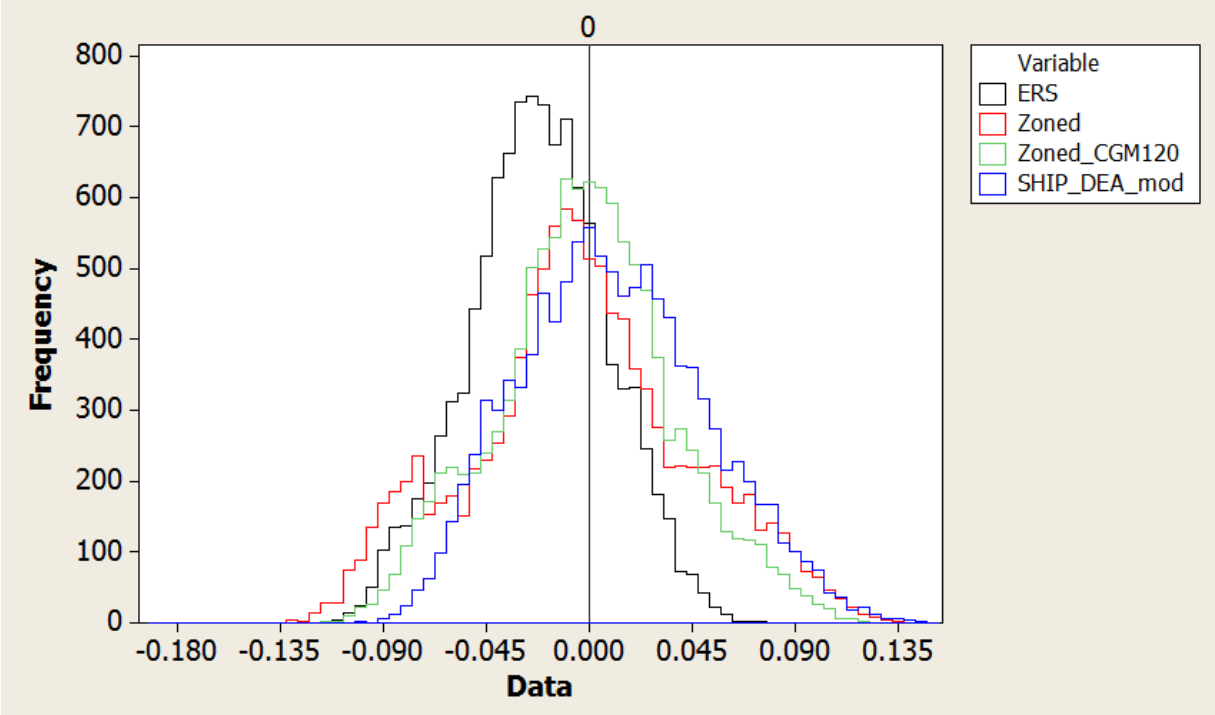

Figure 5: Histogram of difference results from crossing analysis

Outliers in the difference statistics, including those represented by the minimum and maximum statistics result from errors in water level correction techniques, other contributors to vertical errors such as refraction, actual changes in the seafloor, and gridding errors.

The best performing zoning scheme was the scheme "CGM120" which used Pascagoula, NOAA Lab, MS (874-1533) water levels and the preliminary time and range correctors for CMG120 for all zones. After this determination was made difference surfaces were generated using the ERS VDatum test lines and the duplicate version corrected with zoned water levels using "CGM120". As with the crossing analysis the GPS water levels version of a surface was used as Input Surface 1 and the zoned version entered as Input Surface 2. Input surfaces included survey lines for the entire project area. Statistics for individual survey areas were created by spatially selecting differences within each survey area polygon.

Table 10: Depth Differences between GPS Water Levels and Zoned Tides (CMG_120)

Survey	Minimum (m)	Maximum (m)	Mean (m)	Standard Deviation (m)
H12353	0.005	0.172	0.076	0.029
H12354	-0.166	0.176	0.053	0.040
H12355	0.007	0.158	0.093	0.027
H12356	-0.003	0.137	0.069	0.022

Figures 6 and 7 display difference surfaces for each of the four survey sheets overlaid on the zoning scheme and the GEOID09 model. A standard difference color map was applied to all of the surfaces in order to aid in the visual comparison of differences. Areas where soundings corrected with zoned water levels are deeper than those corrected with ERS water levels are depicted in yellows and reds and areas where soundings corrected with ERS water levels are deeper than those corrected with zoned water levels are depicted in shades of blues. Conversely, yellow and red shadings also indicate areas where zoned tide values were greater than GPS water level values and areas shaded with blue indicate areas where the zoned tide values were less than the GPS water level values.

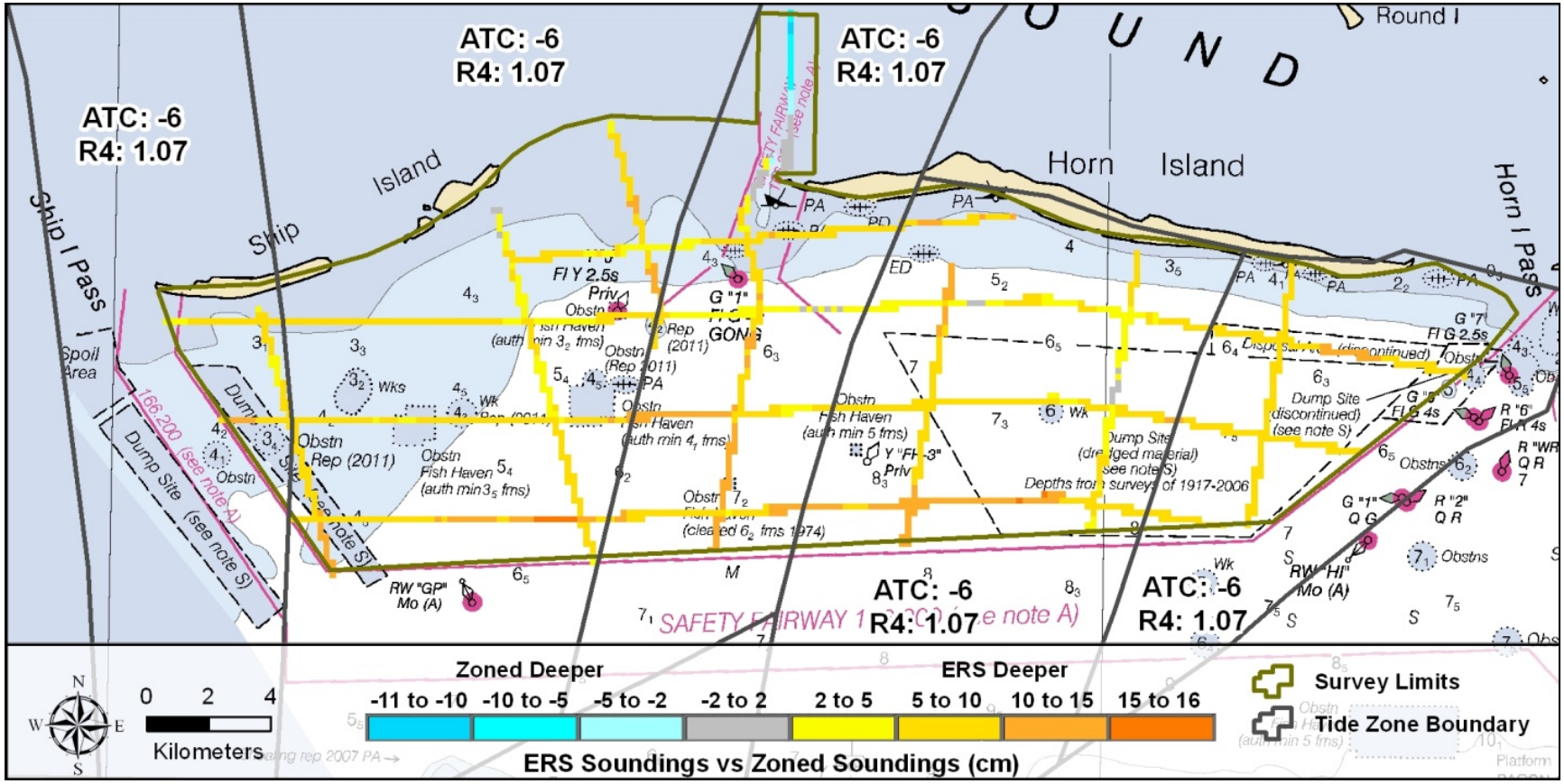

Figure 6: Depth Difference Surface between GPS Water Levels and Zoned Tides with Zoning Scheme Overlay

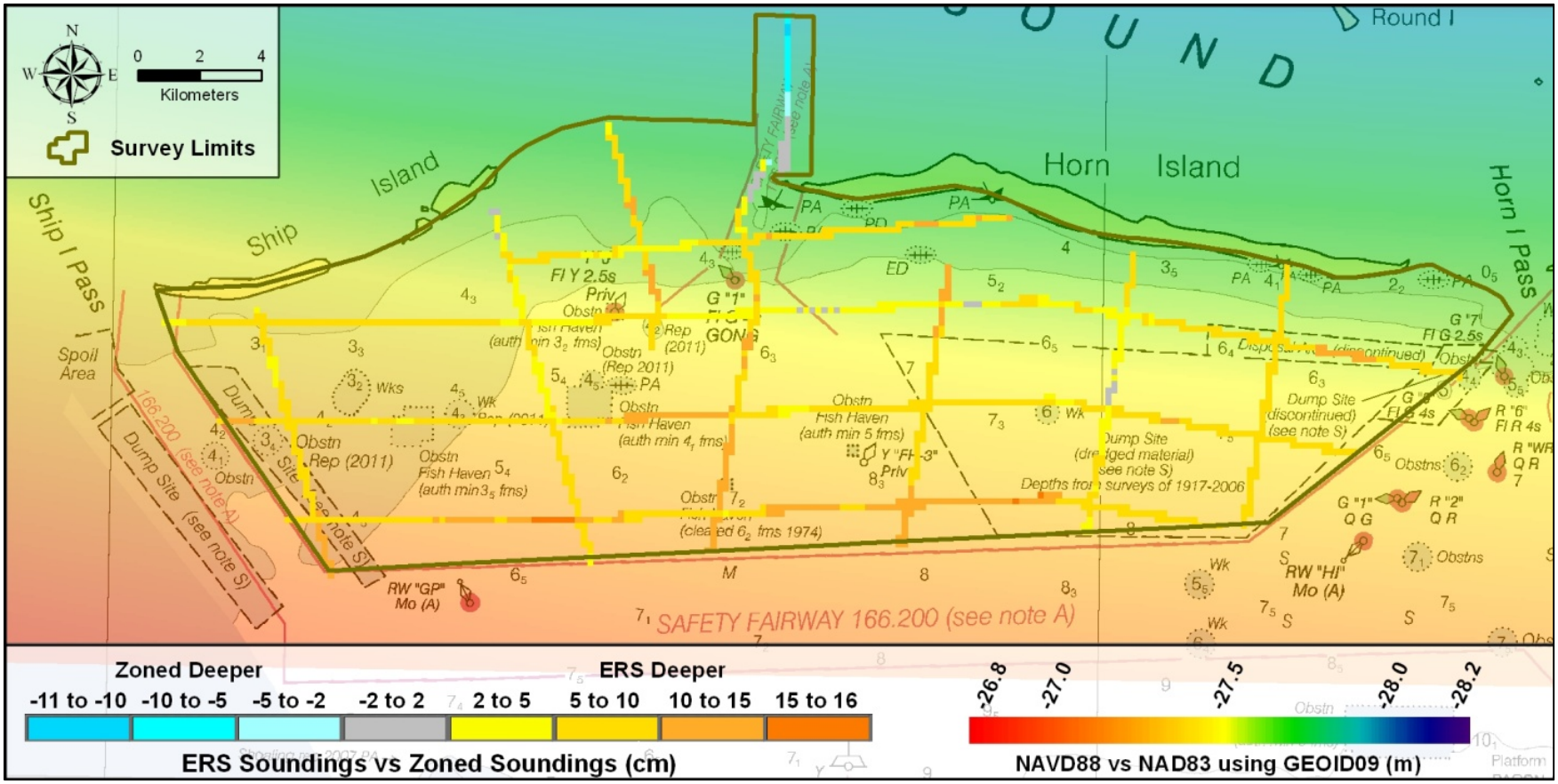

Figure 7: Depth Difference Surface between GPS Water Levels and Zoned Tides with GEOID09 Overlay

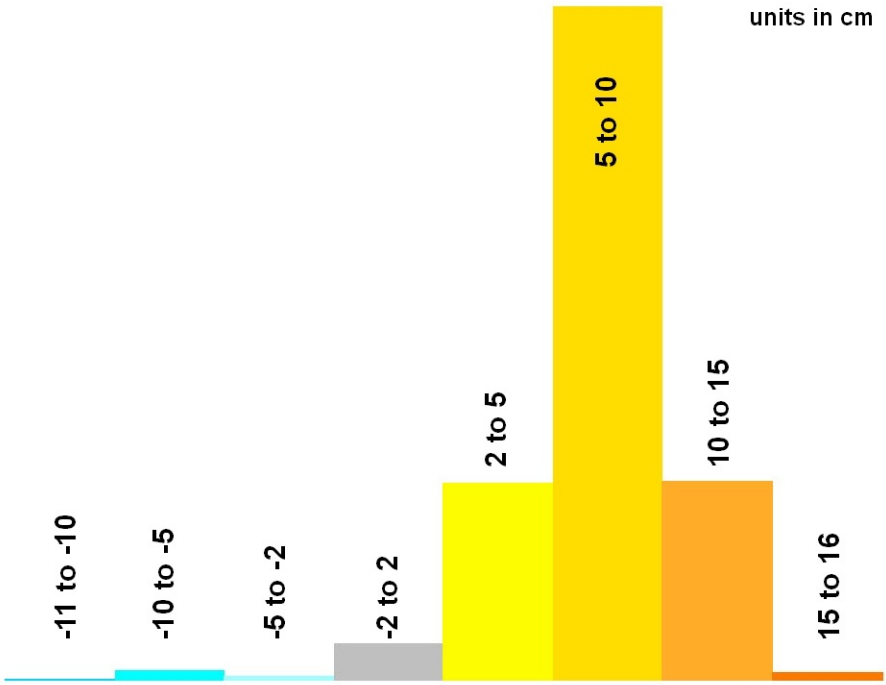

Figure 8: Histogram of GPS Water Levels and Zoned Tides Depth Difference Surface

4.3 Ship Island Comparisons to Zone CGM69

The Ship Island tertiary gauge (874-4756) lies within zone CGM69 of the preliminary zoning scheme provided by CO-OPS as part of the project instructions. The primary gauge for this zone is the National Water Level Observation Network (NWLON) station at Pascagoula NOAA Lab (874-1533), located approximately 44 kilometers (24 nautical miles) from the tertiary gauge.

Water level data from the tertiary gauge was used with zoned data from the primary gauge at Pascagoula NOAA Lab (874-153) to analyze the uncertainty of the zone time and range correctors. Water levels for the tertiary gauge were corrected to MLLW using the preliminary datum planes. An iterative least squares approach was used to correlate the time and range differences between the two stations. The results from this computation should approximate the zoning parameters for this location. The comparison between the preliminary zoning parameters and least squares determined fit factors are presented in Table 11.

Table 11: Zoning correctors for CGM69

	CGM69	
	Time Corrector	Range Corrector
Preliminary CO-OPS Tidal Zoning Scheme	00:24:00	x1.14
Least Squares Computation Results	00:00:00	x1.07

The least squares results were verified during the tide float done by the survey vessel at the Ship Island gauge on September 9, 2011. The average difference between the observed water level by the tertiary gauge and the GPS determined water levels on MLLW was -2.2 centimeters (Table 6). The average difference between the tertiary gauge and the CO-OPS zoned Pascagoula NOAA Lab data was 6.6 centimeters during the same time period. When the least squares determined zoning values were applied, this difference drops to 2.0 centimeters (Figure 9).

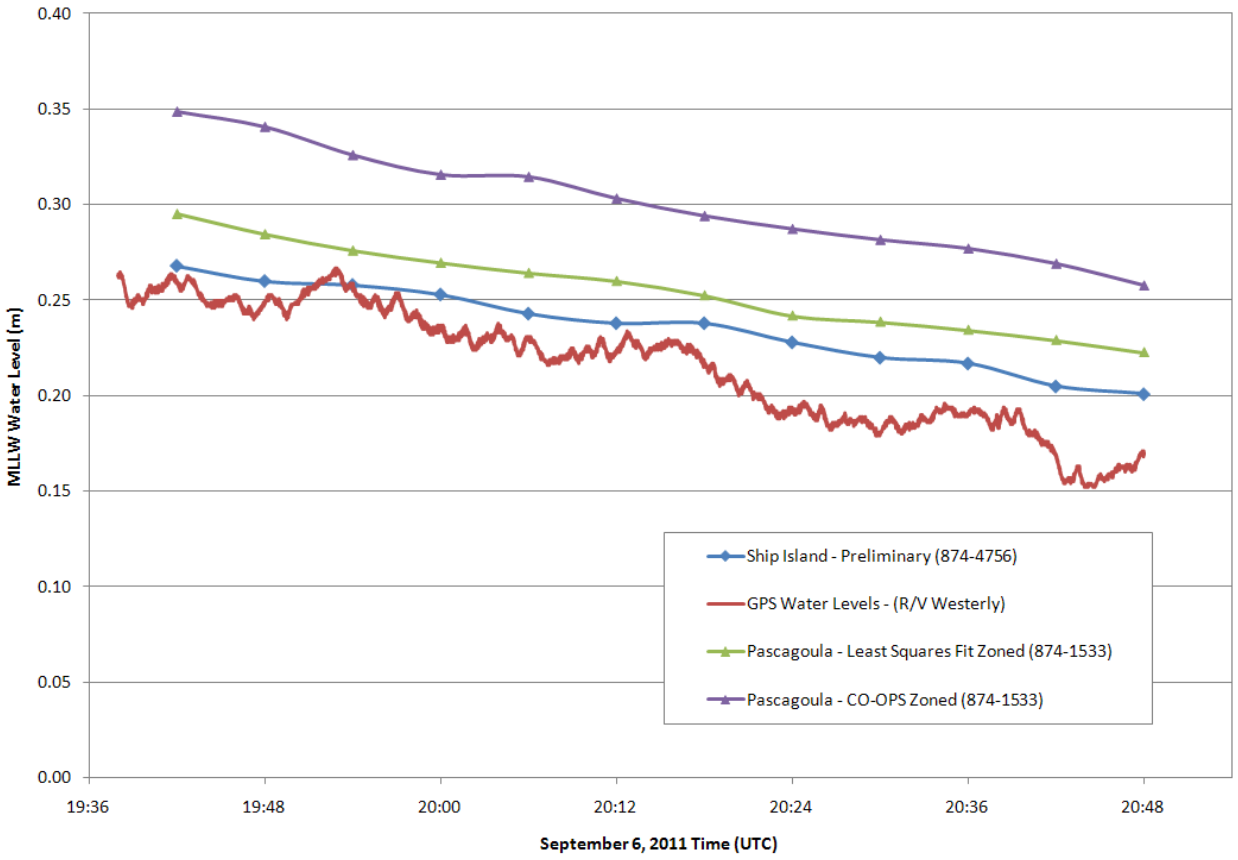

Figure 9: Zoned, observed and GPS water levels at Ship Island on September 6, 2011

Larger differences were observed during weather events as strong winds drive the Gulf coast water levels. During the approach of tropical storm Lee, differences between the zoned and measured water levels at Ship Island approached 30 centimeters, as shown in Figure 10.

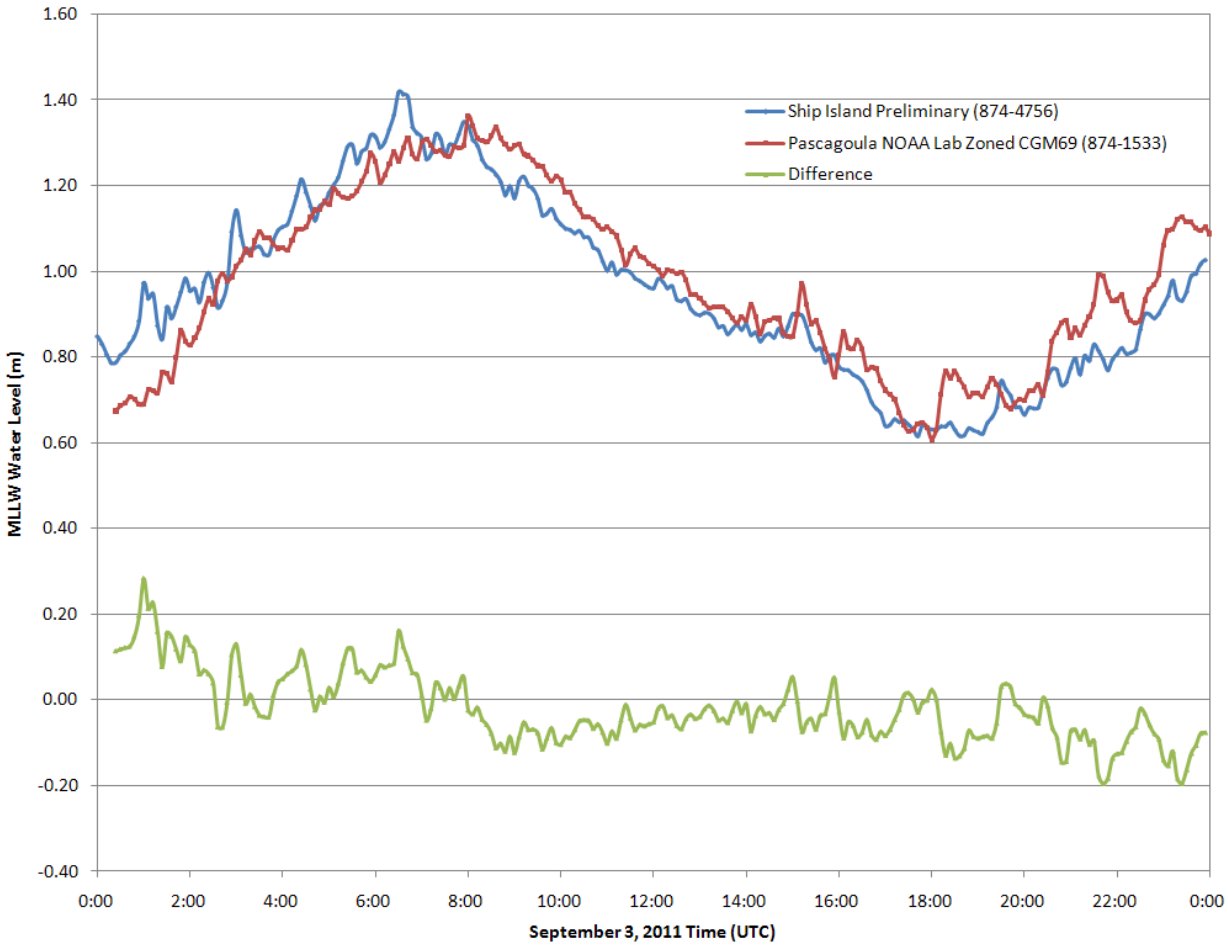

Figure 10: Zoned and observed water levels at Ship Island on September 3, 2011

The tertiary station at Ship Island is the only active water level station in the zoning scheme. No water level observations were available in other zones to conduct comparisons.

5.0 VDatum Grid Analysis

Prior to the start of the project DEA reviewed the VDatam transformation grids (LAmobile01_8301_03) in order to evaluate VDatum suitability for use in supporting ERS for the OPR-J348-KR-11 project. During this pre-analysis DEA gridded and contoured all component transformation grids required to convert a NAD83 ellipsoid height to MLLW and discovered significant artifacts in the North American Vertical Datum of 1988 (NAVD88) to Local Mean sea level transformation surface. These artifacts were brought to the attention of NOAA HSD and they were later removed prior to the release of updated VDatum surfaces on August 10, 2011. The previously discussed VDatum test line analysis used the revised VDatum products.

As shown is Figure 11, bulls-eye artifacts discovered during the VDatum pre-analysis were centered on historic CO-OPS tide gauge sites on Cat and Ship Islands. DEA discovered that the artifacts were caused by the use of inaccurate NAVD88 heights on tidal bench marks when creating the VDatum model of the area. The published NAVD88 heights of the Cat Island bench mark (ARMY 1966 RM 2) and the Ship Island bench mark (SIGNAL AZ MK) were computed by using VERTCON to shift superseded National Geodetic Vertical Datum of 1929 (NGVD29) orthometric heights computed from vertical angle observations out to the islands and rounded to zero decimal places.

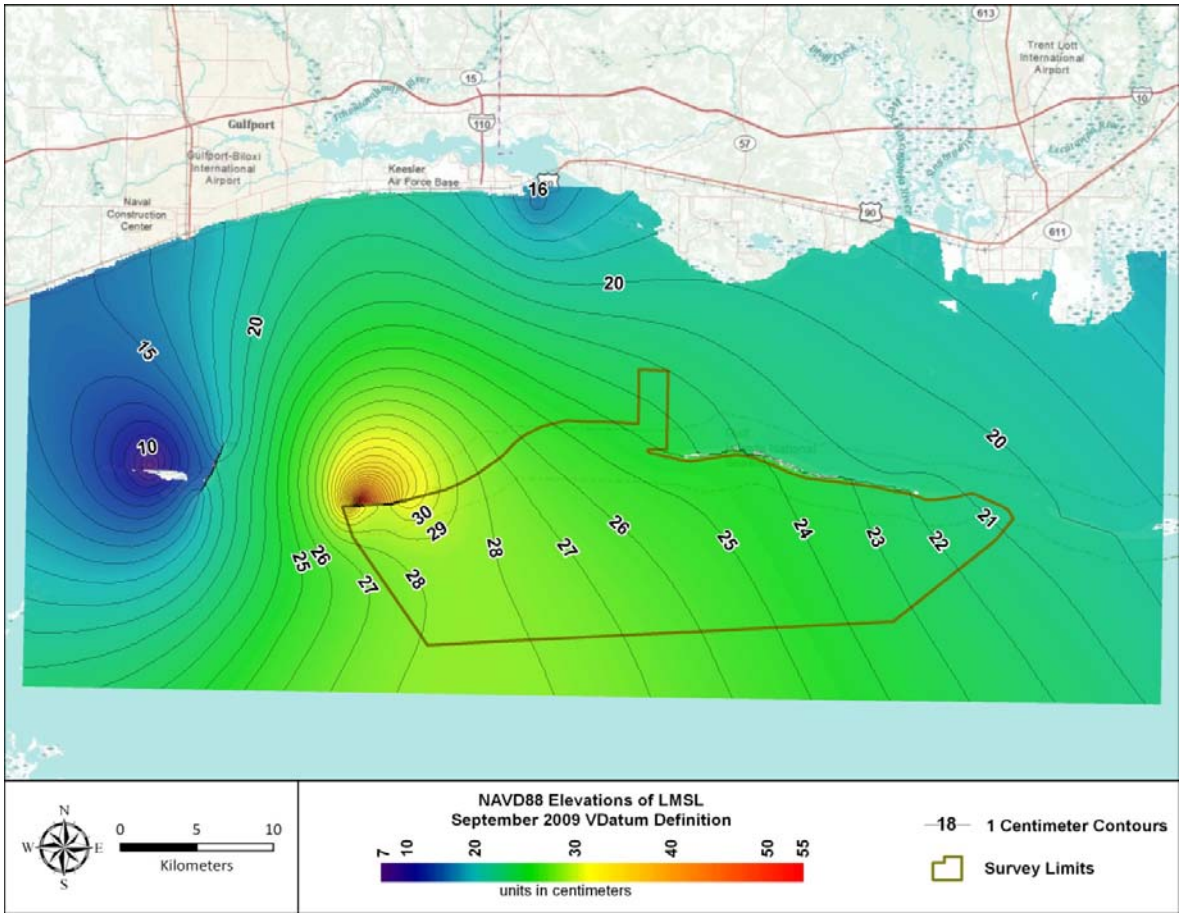

Figure 11: NAVD88 to Local Mean sea level transformation surface, Version 01

During additional investigation of the bulls-eye artifacts DEA discovered that a 2009 GPS occupation of SIGNAL AZ MK by the National Geodetic Survey was posted on the OPUS website. The NAVD88 height on the OPUS site was 1.531 meters while the published height of the mark, which was used in VDatum, was 2.0 meters. These differences confirmed that the published height of SIGNAL AZ MK was incorrect.

Since notifying HSD about the anomalies in the LAmobile01_8301_03 transformation grids NOAA has released a revision. According to documentation included with its release, the Version 02 grids were generated with updated tidal datums and in some cases entirely different tidal stations. Visual interpretation of a grid and contours of the revised NAVD88 to Local Mean sea level transformation surface (Figure 12) leads one to believe that the Ship Island station was removed from the revised grid, that the Cat Island Station was retained, and that a Horn Island station was added. It is also apparent from Figures 11 and 12, which use the same color ramp to display differences between Local Mean Sea Level (LMSL) to NAVD88, that differences up to 20 centimeters have been incorporated in the vicinity of the OPR-J348-KR-11 project area as a result of this revision.

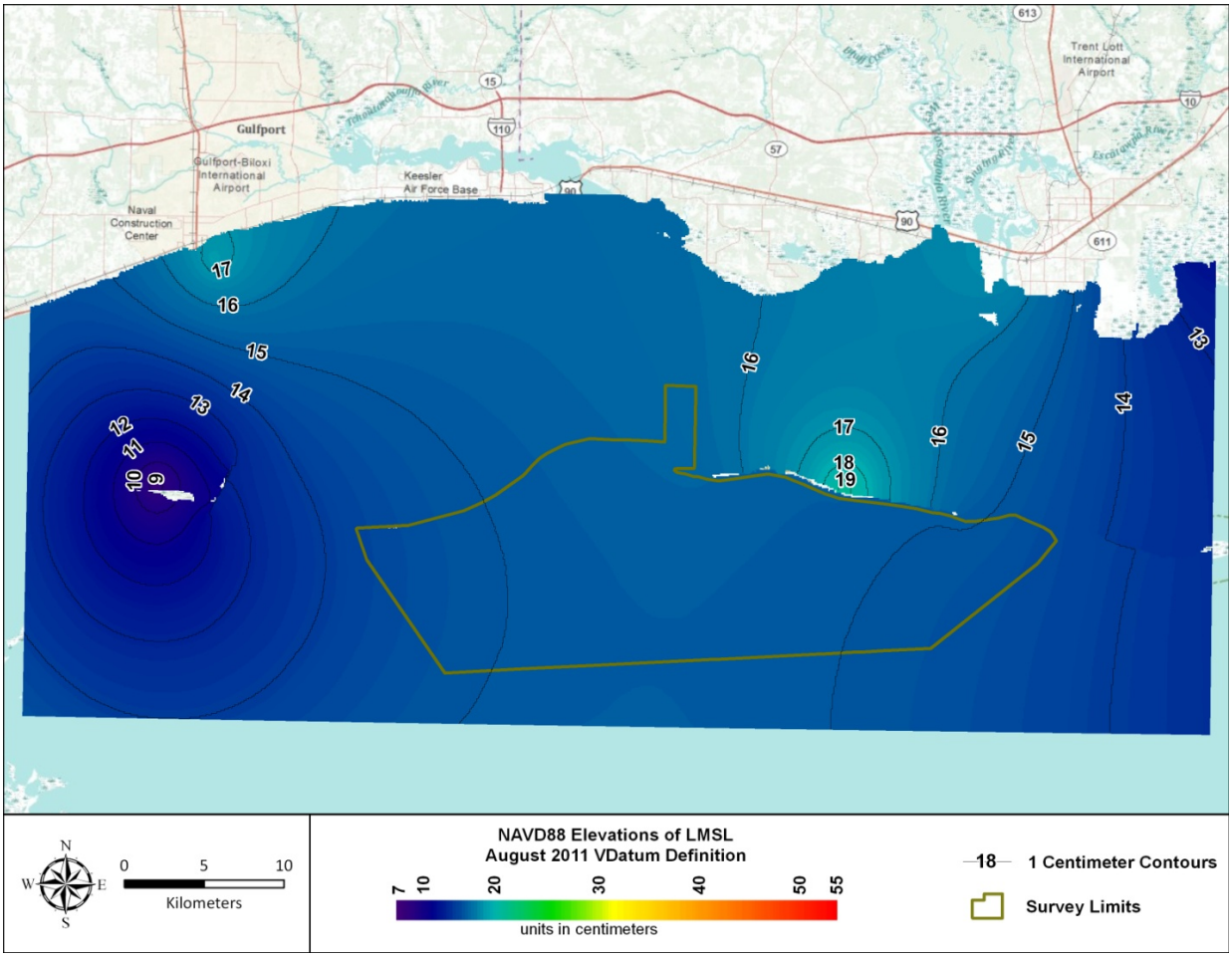

Figure 12: NAVD88 to Local Mean sea level transformation surface, Version 02

6.0 Recommendations

Based on the analysis performed to date DEA recommends moving forward with ERS deliverables for this project. The results of the test line analysis show no significant difference between crossline ties with mainscheme data when using either GPS or traditional tidal correctors. It should be noted that these test lines were run under near optimum conditions for using traditional tidal zoning (calm seas, light winds, relatively low tide ranges, etc.). One would expect comparable results when using GPS methods as sea and weather patterns degrade while the traditional tidal zoning would not perform nearly as well. Further, the application of zoned tides does not adequately correct multibeam data for wind driven water level changes and other small scale transient water levels typical to the survey area. Last, ERS eliminates errors resulting from vessel loading and inadequate compensation for vessel squat by using speed over ground lookup tables. For this project, the implementation of ERS will result in the application of slightly lower water levels that more accurately reflect dynamic water levels in the survey area. The resultant soundings will be slightly deeper than soundings corrected through the application of zoned tides.

APPENDIX A

Ship Island, Mississippi Sound, MS
Datum Computation Result

COMPARISON OF MONTHLY MEANS (Aug 2011 - Aug 2011)
1983-2001 TIDAL EPOCH

File Created: Sep 08 2011 00:47

Sub Contractor: JOA Surveys, LLC
Prime Contractor: David Evans & Associates
Processor: N. Wardwell

Subordinate Station: Ship Island, MS
Control Station: Pascagoula Noaa Lab, MS

		MTL			MSL			DTL	
MONTH	(A)	(B)	(A-B)	(A)	(B)	(A-B)	(A)	(B)	(A-B)
		Meter			Meter			Meter	
Aug	1.450	6.958	-5.508	1.446	6.961	-5.515	1.449	6.967	-5.518
Sums			-5.508			-5.515			-5.518
Count			1			1			1
Means			-5.508			-5.515			-5.518
Accepted(B)			6.906			6.901			6.906
Corrected(A)			1.398			1.386			1.388

		MN			DHQ			DLQ			GT	
MONTH	(A)	(B)	(A/B)	(A)	(B)	(A/B)	(A)	(B)	(A/B)	(A)	(B)	(A/B)
		Meter			Meter			Meter			Meter	
Aug	0.383	0.327	1.170	0.021	0.050	0.410	0.022	0.033	0.678	0.425	0.410	1.038
Sums			1.170			0.410			0.678			1.038
Count			1			1			1			1
Means			1.170			0.410			0.678			1.038
Accepted(B)			0.411			0.029			0.028			0.468
Corrected(A)			0.481			0.012			0.019			0.486

MODIFIED

1.631 = MHHW(A) = MLLW(A) + GT(A)
1.638 = MHW(A) = MLW(A) + MN(A)
1.157 = MLW(A) = MTL(A) - 0.5*MN(A)
1.145 = MLLW(A) = DTL(A) - 0.5*GT(A)

STANDARD

1.650 = MHHW(A) = MHW(A) + DHQ(A)
1.638 = MHW(A) = MLW(A) + MN(A)
1.157 = MLW(A) = MTL(A) + 0.5*MN(A)
1.138 = MLLW(A) = MLW(A) - DLQ(A)
1.394 = DTL(A) = 0.5*(MHHW(A) + MLLW(A))
0.512 = GT(A) = MHHW(A) - MLLW(A)

FINAL DATUMS (modified)

1.631 = MHHW = MLLW(A) + GT(A)
1.638 = MHW = MLW(A) + MN(A)
1.388 = DTL = Corrected for (A)
1.398 = MTL = Corrected for (A)
1.386 = MSL = Corrected for (A)
1.157 = MLW = MTL(A) - 0.5*MN(A)
1.145 = MLLW = DTL(A) - 0.5*GT
0.486 = GT = Corrected for (A)
0.481 = MN = Corrected for (A)
-0.008 = DHQ = MHHW(A) - MHW(A)
0.012 = DLQ = MLW(A) - MLLW(A)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

December 13, 2011

MEMORANDUM FOR: Jonathon L. Dasler, PE (OR), PLS (OR, CA)
David Evans and Associates, Inc.
2100 SW River Parkway
Portland, OR 97201

FROM: Jeffrey Ferguson
Chief, Hydrographic Surveys Division

SUBJECT: Vertical Datum Transformation Technique,
OPR-J348-KR-11, Approaches to Mississippi Sound, MS

Hydrographic surveys H12353, H12354, H12355, and H12356 are approved for vertical reduction to chart datum, Mean Lower Low Water (MLLW), using the NOAA Vertical Datum Transformation (VDatum) (http://vdatum.noaa.gov) However, this approval does not remove the requirement to submit all water level data for subordinate gauges as required by the Statement of Work and Chapter 4 of the NOS Hydrographic Surveys Specifications and Deliverables.

Approval of VDatum, in lieu of the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) preliminary discrete zoning package as per the Statement of Work, is based on review of David Evans and Associates (DEA) recommendations in their Interim VDatum Report (see OPR-J348-KR-11_Interim_VDatum_Report_20111101.pdf) and results from an internal review of DEA submitted data indicating agreement within acceptable limits.

DEA's discrete zoning analysis, based on a 30 datum computation at the Ship Island subordinate installation, indicate the preliminary zoning product provided by CO-OPS was inadequate. DEA performed their crossline evaluation of ERS against a number of different zoning schemes to ensure that the most thorough and accurate comparison was performed. DEA indicated the most favorable results and therefore the best zoning scheme was produced using zone CGM120's time and range ration correctors for the entire project area.

The results of the DEA's analysis show that ellipsoidally referenced survey (ERS) techniques with VDatum used as the vertical datum reducer to MLLW in this area show no significant difference relative to modified traditional zoned correctors (CGM120), produce better internal consistency of the survey data, and produce final sounding values that meet or exceed horizontal and vertical specifications for hydrographic surveys.

APPENDIX III

FEATURES REPORT

No DTONs or Maritime Boundaries

H12356_AWOIS Item

Registry Number: H12356

State: Mississippi

Locality: Approaches to Mississippi Sound

Sub-locality: SE of Horn Island

Project Number: OPR-J348-KR-11

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

Charts Affected

Number	Edition	Date	Scale (RNC)	RNC Correction(s)*
11375	36th	01/01/2005	1:20,000 (11375_1)	[L]NTM: ?
11374	34th	10/01/2007	1:40,000 (11374_1)	[L]NTM: ?
11373	47th	10/01/2008	1:80,000 (11373_1)	[L]NTM: ?
11366	11th	01/01/2008	1:250,000 (11366_1)	[L]NTM: ?
11360	43rd	11/01/2008	1:456,394 (11360_1)	[L]NTM: ?
1115A	43rd	11/01/2008	1:456,394 (1115A_1)	[L]NTM: ?
11006	32nd	08/01/2005	1:875,000 (11006_1)	[L]NTM: ?
411	52nd	09/01/2007	1:2,160,000 (411_1)	[L]NTM: ?

* Correction(s) - *source: last correction applied (last correction reviewed--"cleared date")*

Features

No.	Name	Feature Type	Survey Depth	Survey Latitude	Survey Longitude	AWOIS Item
1.1	AWOIS 14889 13 ft Wreck	Wreck	4.01 m	30° 13' 09.4" N	088° 35' 43.6" W	14889
1.2	AWOIS 4756 Uncharted OBSTRUCTION AWOIS			[no data]	[no data]	4765

1.1) AWOIS 14889 13 ft Wreck

Primary Feature for AWOIS Item #14889

Search Position: 30° 13' 09.2" N, 088° 35' 47.8" W
Historical Depth: [None]
Search Radius: 0
Search Technique: MB,S2,VI
Technique Notes: Investigate item only within limits of the survey.

History Notes:

CL 1400/76--USPS, WRECK, VISIBLE WRECK PA

Survey Summary

Survey Position: 30° 13' 09.4" N, 088° 35' 43.6" W
Least Depth: 4.01 m (= 13.14 ft = 2.191 fm = 2 fm 1.14 ft)
TPU (±1.96σ): **THU (TPEh)** [None] ; **TVU (TPEv)** [None]
Timestamp: 2011-315.00:00:00.000 (11/11/2011)
Dataset: H12356_AWOIS Items.000
FOID: US 0001245836 00001(02260013028C0001)
Charts Affected: 11375_1, 11374_1, 11373_1, 11366_1, 1115A_1, 11360_1, 11006_1, 411_1

Remarks:

WRECKS/remrks: FS 255-142040-S. Wreck rising approximately 0.9m above the natural bottom inside AWOIS radius 14889.

Feature Correlation

Source	Feature	Range	Azimuth	Status
H12356_AWOIS Items.000	US 0001245836 00001	0.00	000.0	Primary
AWOIS_EXPORT	AWOIS # 14889	111.62	086.9	Secondary (grouped)

Hydrographer Recommendations

Add wreck

Cartographically-Rounded Depth (Affected Charts):

13ft (11375_1, 11374_1, 11373_1)

2 ¼fm (1115A_1, 11360_1, 11006_1, 411_1)

2fm 1ft (11366_1)

S-57 Data

Geo object 1:	Wreck (WRECKS)
Attributes:	CATWRK - 2:dangerous wreck
	NINFOM - Add wreck
	QUASOU - 6:least depth known
	SORDAT - 20111111
	SORIND - US,US,graph,H12356
	TECSOU - 3:found by multi-beam
	VALSOU - 4.006 m
	WATLEV - 3:always under water/submerged

Office Notes

SAR: Wreck observed at 30-13-09.9393N, 088-35-43.6380W, 157 meters from AWOIS 14889. Wreck is positioned in AWOIS search radius for AWOIS 14889. Least depth of 4.006m.

COMPILATION: Concur. Delete charted dangerous wreck PA depth unknown, add dangerous wreck, least depth 13 feet in present survey location.

Feature Images

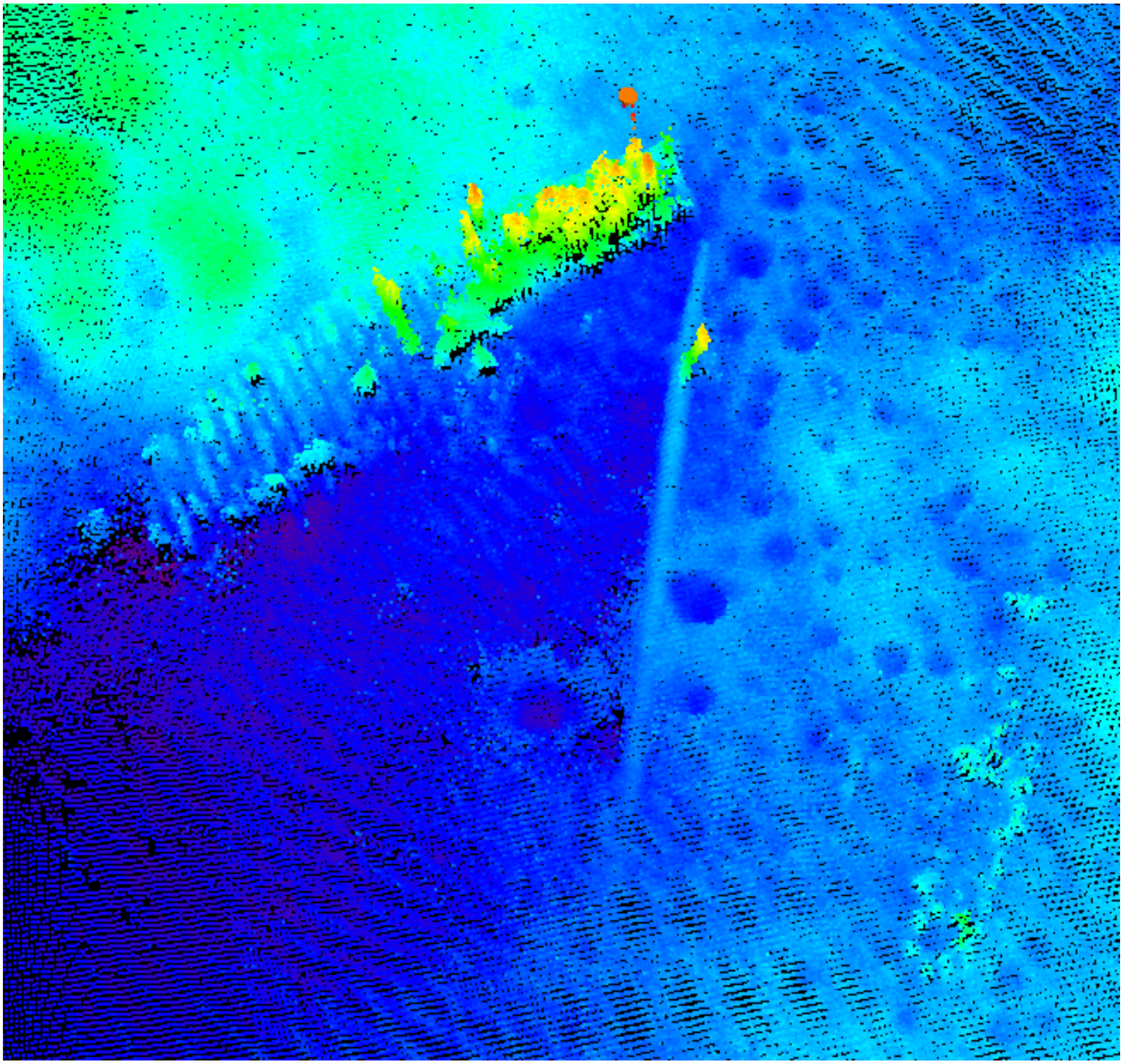

Figure 1.1.1

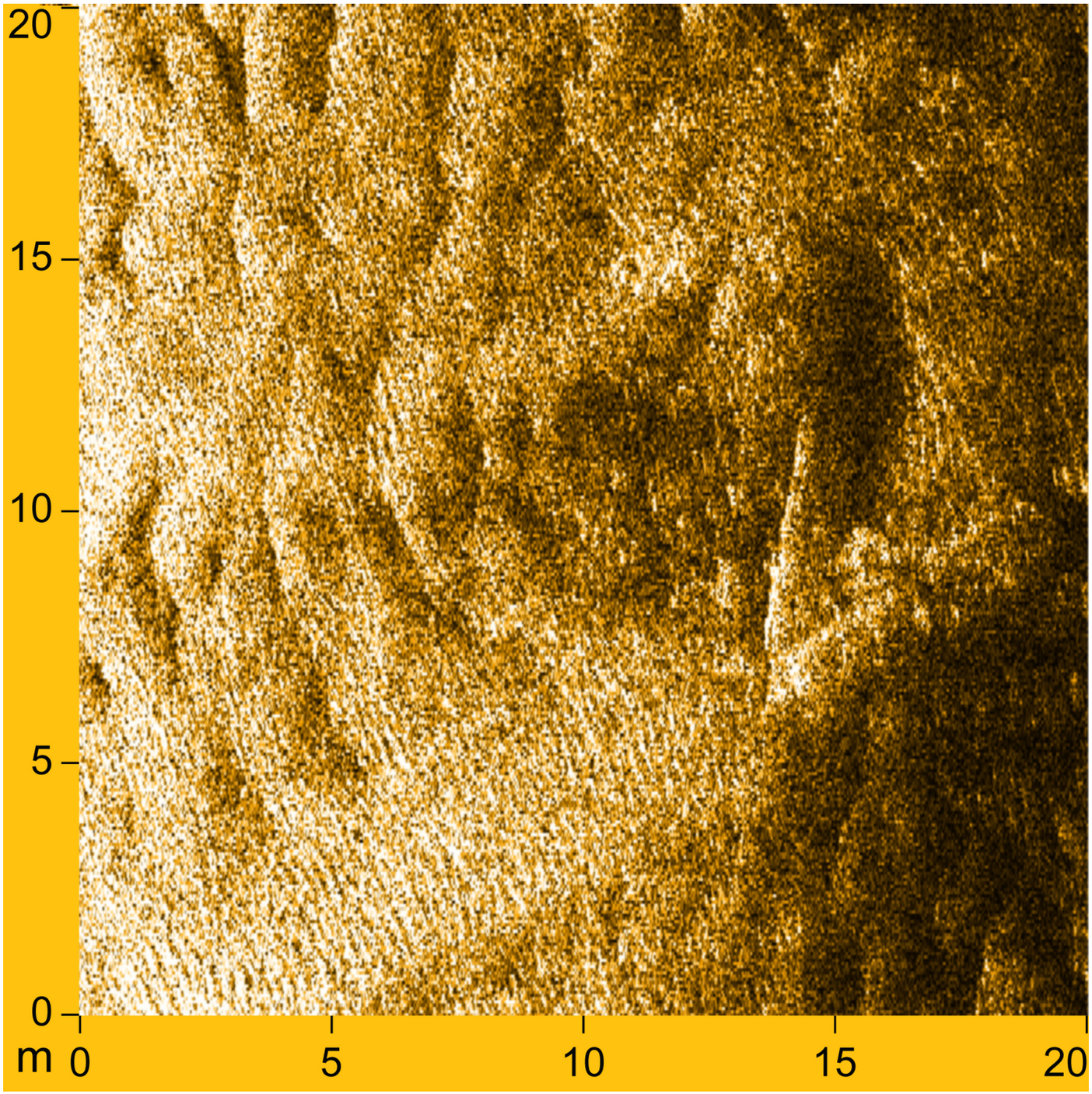

Figure 1.1.2

1.2) AWOIS #4756 - AWOIS 4756 Uncharted OBSTRUCTION

No Primary Survey Feature for this AWOIS Item

Search Position: 30° 10' 01.5" N, 088° 35' 16.1" W
Historical Depth: [None]
Search Radius: 200
Search Technique: MB,S2
Technique Notes: [None]

History Notes:

FE274WD/74--OPR-479-RU/HE-74; ESTIMATED HANG AT 40 FT. CLEARED BY 40 FT. IN
LAT. 30-10-00.80N, LONG. 88-35-16.10W. NOT INVESTIGATED BY DIVER.
LNM35/86--PUBLISHES ABOVE DATA.
FE313SS/88--OPR-J433-RU/HE-88; RESOLVED (PROCESSING INCOMPLETE,
2/17/89) (UP 2/17/89, SJV)
FE313SS/88--OPR-J433-RU/HE-88; 400% SIDE SCAN SONAR OF REQUIRED 500 METER
RADIUS NEGATIVE. PRIOR WIRE DRAG HANG AT 40FT. BELIEVED TO HAVE BEEN A
GROUNDING OR A VERY SLIGHT PROJECTION ABOVE BOTTOM. EVALUATOR RECOMMENDS
DELETING CHARTED OBSTN CLEARED 40FT. (UP 8/10/89 SJV)
FE309WD/74--OPR-479-RU/HE-74; MODIFIED EVALUATION REPORT; CLEARED IN ONE
DIRECTION ONLY BY 41 FEET. SEE FE313SS/88.
H11512/08-- FEATURE NEITHER RESOLVED NOR DISPROVED. RETAIN AS CHARTED AT POSITION 30/10/1.52N 88/35/16.15W. (ENTERED 10/29/08, EAN)

Survey Summary

Charts Affected: 11375_1, 11373_1, 11366_1, 1115A_1, 11360_1, 11006_1, 411_1

Remarks:

Nothing found during present survey

Feature Correlation

Source	Feature	Range	Azimuth	Status
AWOIS_EXPORT	AWOIS # 4756	0.00	000.0	Primary

Hydrographer Recommendations

Update feature in AWOIS database

S-57 Data

[None]

Office Notes

COMPILATION: AWOIS item obstruction hang at 40 ft cleared by 40 ft, is not charted and there is no indication on the present survey of its existance. The AWOIS history for this feature states that this feature was disproved and recommended for deletion by survey FE313SS/88. That is likely when the feature was removed from the charts. It is recommended the AWOIS database is updated and the history notes are put in the correct order with FE313SS/88 notes coming after FE309WD/74 history notes. The feature should be considered disproved.

Feature Images

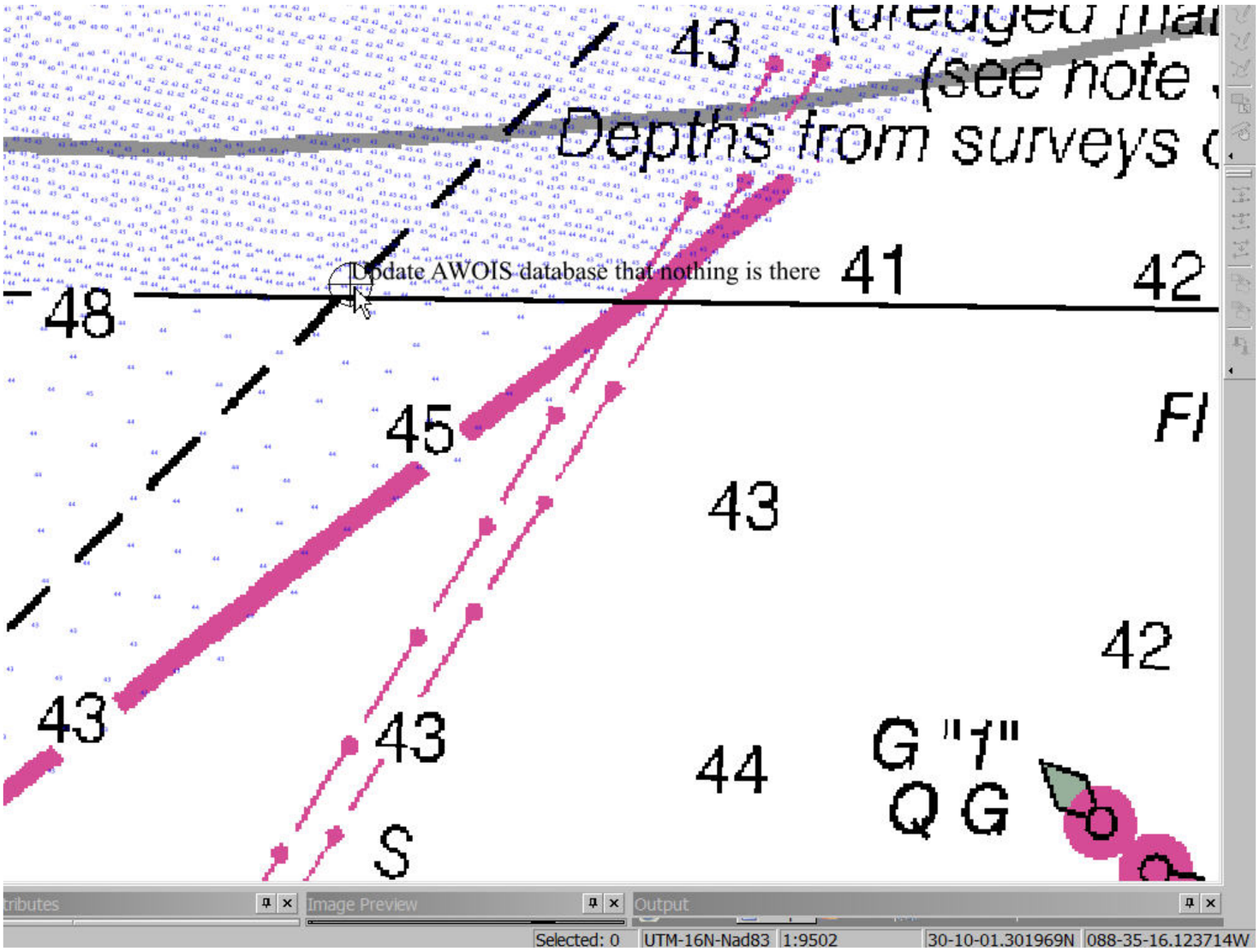

Figure 1.1.1

APPROVAL PAGE

H12356

Data meet or exceed current specifications as certified by the OCS survey acceptance review process. Descriptive Report and survey data except where noted are adequate to supersede prior surveys and nautical charts in the common area.

The following products will be sent to NGDC for archive

- H12356_DR.pdf
- Collection of depth varied resolution BAGS
- Processed survey data and records
- H12356_GeoImage.pdf

The survey evaluation and verification has been conducted according to current OCS Specifications, and the survey has been approved for dissemination and usage of updating NOAA's suite of nautical charts.

Approved: 

Digitally signed by
HIGGINS.ABIGAIL.SARAH.1267671750
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,
ou=NOAA, cn=HIGGINS.ABIGAIL.SARAH.1267671750
Date: 2012.11.30 17:26:06 -05'00'

LT Abigail Higgins
Chief, Atlantic Hydrographic Branch