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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

HORIZONTAL AND VERTICAL CONTROL REPORT

Type of Survey

Hydrographic

Project Number

OPR-J348-KR-17

Contract Number

EA-133C-14-CQ-0037

Task Order Number

T0004

Time Frame

August 2017 - April 2018

LOCALITY

State

Mississippi, Alabama and Texas

General Locality

Mississippi Sound and Vicinity

2017

CHIEF OF PARTY

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

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Horizontal and Vertical Control Report
Project OPR-J348-KR-17

Locality: Mississippi Sound and Vicinity
August 2017 – April 2018

S/V *Blake* and R/V *John B. Preston*

David Evans and Associates, Inc.

Chief of Party: Jonathan L. Dasler, PE, PLS, CH

INTRODUCTION

This report applies to surveys H13059, H13060, H13061, H13062, H13063, H13064, H13065, H13066, H13067, H13068, F00698 and F00699. Surveys H13059 through H13068 are located within the OPR-J348-KR-17 Project area in Mississippi Sound. Surveys F00698 and F00699 were Hurricane Harvey response surveys assigned to David Evans and Associates, Inc. (DEA) after OPR-J348-KR-17 began. Surveys H13059 through H13064 cover parts of the Mississippi Sound north of Ship, Horn, and Petit Bois Islands. Surveys H13065 through H13068 cover areas in the Gulf of Mexico south of Petit Bois and Dauphin Islands. These surveys meet requirements defined in the *Statement of Work (SOW)* (July 21, 2017), *Hydrographic Survey Project Instructions Mod2* (November 3, 2017), and National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables (HSSD)* (April 2017).

Hurricane Harvey response surveys F00698 and F00699 cover portions of the Houston-Galveston Ship Channel and Sabine Pass. Two revisions to the Project Instructions were required to address the addition of these surveys to the OPR-J348-KR-17 Project with specific instructions relating to these surveys such as a Descriptive Report memo and other deviations from the original instructions to expedite the survey and data turn around. These surveys were conducted as an emergency response to open shipping lanes following Hurricane Harvey. Data acquisition and products were time critical for the safety of maritime commerce. The response surveys were acquired in accordance with the requirements defined in the OPR-J348-KR-17 *Statement of Work* (July 21, 2017), *Hydrographic Survey Project Instructions Mod2* (November 3, 2017), and NOS HSSD (April 2017), as well as guidance provided by National Oceanic Atmospheric Administration (NOAA) Hydrographic Survey Division (HSD) Operations (OPS) branch staff during emergency survey operations.

The project's survey purpose for the H surveys, which was defined in the Project Instructions and consisted of the following, "The purpose of this project is to provide contemporary surveys to update National Ocean Service nautical charts and products. This hydrographic survey will support the dense vessel traffic transiting the Intracoastal Waterway extending from Biloxi to Pascagoula, Mississippi as well as the local fishing vessels and recreational boaters transiting further inshore. This area has been inundated by eight major tropical storms and hurricanes since it was last surveyed, including Hurricane Katrina. This survey will update the regional bathymetry and address over 50 chart discrepancies. In addition, this survey data will support the State of Mississippi and United States Army Corps of Engineers Mobile District as they plan a large barrier island restoration project in the vicinity of Ship Island. Survey data from this project is intended to supersede all prior survey data in the common area."

A. HORIZONTAL CONTROL

The horizontal datum for this project is the North American Datum of 1983 (NAD83). Position data consists of both geographic coordinates and projected coordinates. Projected coordinates are in meters using the Universal Transverse Mercator (UTM) Zone 16 projection for all H surveys and Zone 15 for the emergency response F surveys. All horizontal positioning for soundings followed requirements set forth in the SOW and the HSSD.

A1. Differential Correctors

A Differential Global Positioning System (DGPS) was used for real-time survey navigation aboard the survey vessels *S/V Blake* and *R/V John B. Preston*. The primary positioning system was an Applanix Position and Orientation System for Marine Vessels (POS/MV) 320 Version 5 receiving DGPS corrections from a CSI Wireless MBX-3S beacon receiver and a Trimble Pro Beacon, respectively. Both systems received corrections from the United States Coast Guard (USCG) DGPS beacon located at English Turn, Louisiana (293 kHz) during Mississippi Sound operations. During emergency response operations in Texas, the *S/V Blake* received corrections from the USCG DGPS beacon located at Angleton, Texas (301 kHz). DGPS was selected as the primary positioning system due to reliability in receiving correctors offshore.

A2. Real-time Kinematic Correctors

Real-time kinematic (RTK) receivers were equipped on both vessels to provide vertical positioning and a redundant system in case of DGPS outages. RTK correctors were received from state Real Time Networks (RTNs) via cellular modem and Networked Transport of RTCM via Internet Protocol (NTRIP). RTK heights were reduced in real-time to Mean Lower Low Water (MLLW) in Hypack by use of VDatum. The addition of the redundant RTK Global Navigation Satellite System (GNSS) system gave the hydrographer the ability to compare the positions of the two systems during acquisition and allowed for real-time monitoring of the limits of hydrography when the limits are based on depth requirements.

The RTNs used for this project were managed by the Texas Department of Transportation (DOT), Louisiana State University's (LSU) Center for GeoInformatics (C4G), and Mississippi's Gulf Coast Geospatial Center (GCGC). All RTN data were provided relative to NAD83 (2011).

Due to faults with the DGPS beacon located at English Turn, the primary positioning system on the *R/V John B. Preston* was reconfigured on January 19, 2018 to accept RTK corrections from the Trimble SPS851 receiver via LSU's C4G network. This configuration remained for the duration of the project.

A3. Positioning Systems Confidence Checks

On both vessels a weekly comparison between positions from the primary DGPS and secondary RTK systems was documented. The mean computed difference for all position checks was 0.25 meters with a standard deviation of 0.20 meters for all H and F surveys. The maximum differences during the position checks were 0.59 meters for the *S/V Blake* and 0.64 meters for the *R/V John B. Preston*. These values are well within the NOS specification of hydrographic positioning.

A4. DEA Operated Reference Stations

One GNSS reference station was installed by DEA prior to OPR-J348-KR-17 operations and utilized in a limited capacity during project acquisition. The GNSS reference station was established by DEA for the U.S. Army Corps of Engineers, Mobile District, Mississippi Coastal Improvement Program, Ship Island Restoration Project with an operational permit from the National Park Service (Figure 1).

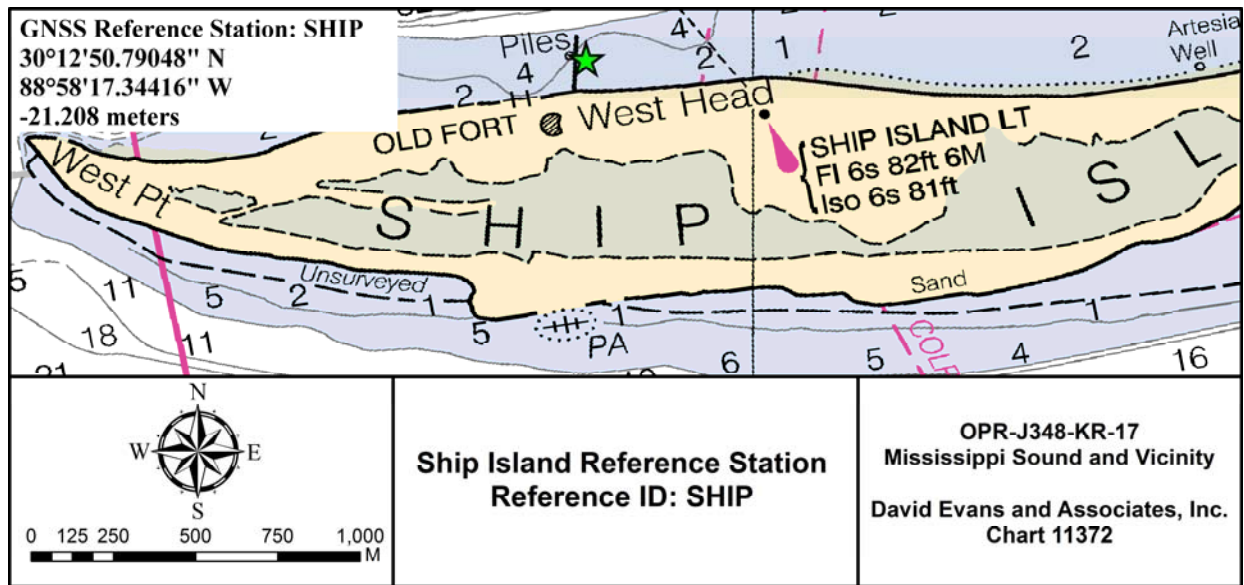


Figure 1. Ship Island Reference Station Locality

The station operated almost continuously throughout the project, with small outages occurring during large storms. The station is located within survey H13063 on the northern shore of Ship Island on the roof of the boathouse serving the National Park Service's pier and received the designation SHIP (Figure 2). SHIP was used for post-processing of all patch tests, except for the R/V *John B. Preston* patch test acquired on January 4, 2018, which was corrected using publicly available Continuously Operating Reference Station (CORS) data from Dauphin Island, Alabama (ALDI). The station was also used to correct select data collected on November 7, 2017 (DN311) for survey H13063 because of DGPS dropouts. The Online Positioning User Service (OPUS) reports for the original coordinates, as well as for DN311, are included in the Base Station Data folder found in Digital B-Horizontal Control Data supplementing this report.

In addition, this station was being used as a reference station by LSU's C4G network which constantly monitors position data and automatically conducts quality assurance testing.



Figure 2. Ship Island Reference Station Setup

B. VERTICAL CONTROL

The chart datum for this project is MLLW for depths and Mean High Water (MHW) for heights. All soundings are referenced to MLLW. All data (tidal, position, attitude, sonar, survey logs, etc.) were time tagged using Coordinated Universal Time (UTC).

B1. Tide and Water Level Corrections

In accordance with the *Hydrographic Survey Project Instructions*, the active National Water Level Observation Network (NWLON) stations at Dauphin Island, Alabama (8735180), Pascagoula NOAA Lab, Mississippi (8741533), and Bay Waveland (8747437) were the primary reference stations for all Mississippi Sound and vicinity surveys.

NOAA's HSD provided the Tidal Constituents and Residual Interpolation (TCARI) grid (J348KR2017Rev.tc) used to apply tides to all the bathymetric data for the H surveys. Figure 3 depicts the extents of the TCARI grid and location of the supporting NWLON stations for Project OPR-J348-KR-17.

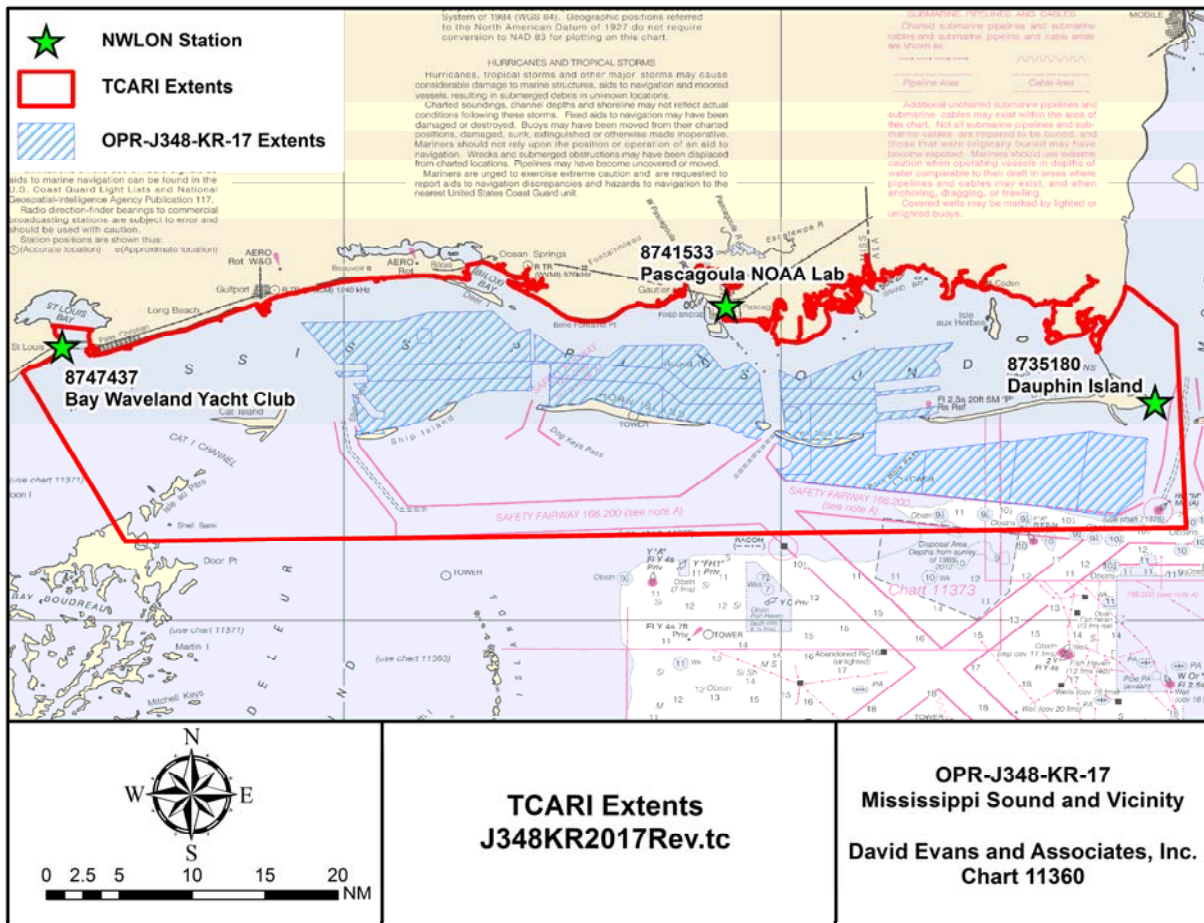


Figure 3. Mississippi Sound TCARI Grid Extents

All processed data and bathymetric grids submitted for the H surveys for Project OPR-J348-KR-17 utilize TCARI methods for vertical control and reduction to MLLW.

For the emergency response surveys in Galveston – Port Arthur, Texas, RTK correctors were acquired during acquisition via the Texas Department of Transportation’s (TX DOT) Real Time Network (RTN) to allow for instantaneous MLLW water level values for soundings using NOAA’s VDatum model toolset. TX DOT granted DEA a temporary emergency RTN license to support the survey effort. RTK correctors from TX DOT were input into a secondary GPS receiver installed directly over the vessel reference point. This receiver provided vertical control and allowed for real time corrections in Hypack when using Geoid12b and the NOAA VDatum model. This method is referred to as Ellipsoid Referenced Surveys (ERS) by NOAA.

HSD also provided the TCARI grid (Galveston_Response.tc) that was used on a portion of the data offshore of Galveston but did not cover the Port Arthur or Sabine Pass survey area. The active NWLON stations at Galveston Pier 21 (8771450), Galveston Bay Entrance, North Jetty (8771341), Eagle Point (8771013), Manchester (8770777), and Morgans Point (8770613) were the primary reference stations for the TCARI grid provided. Figure 4 depicts the extents of the TCARI grid and supporting NWLON stations.

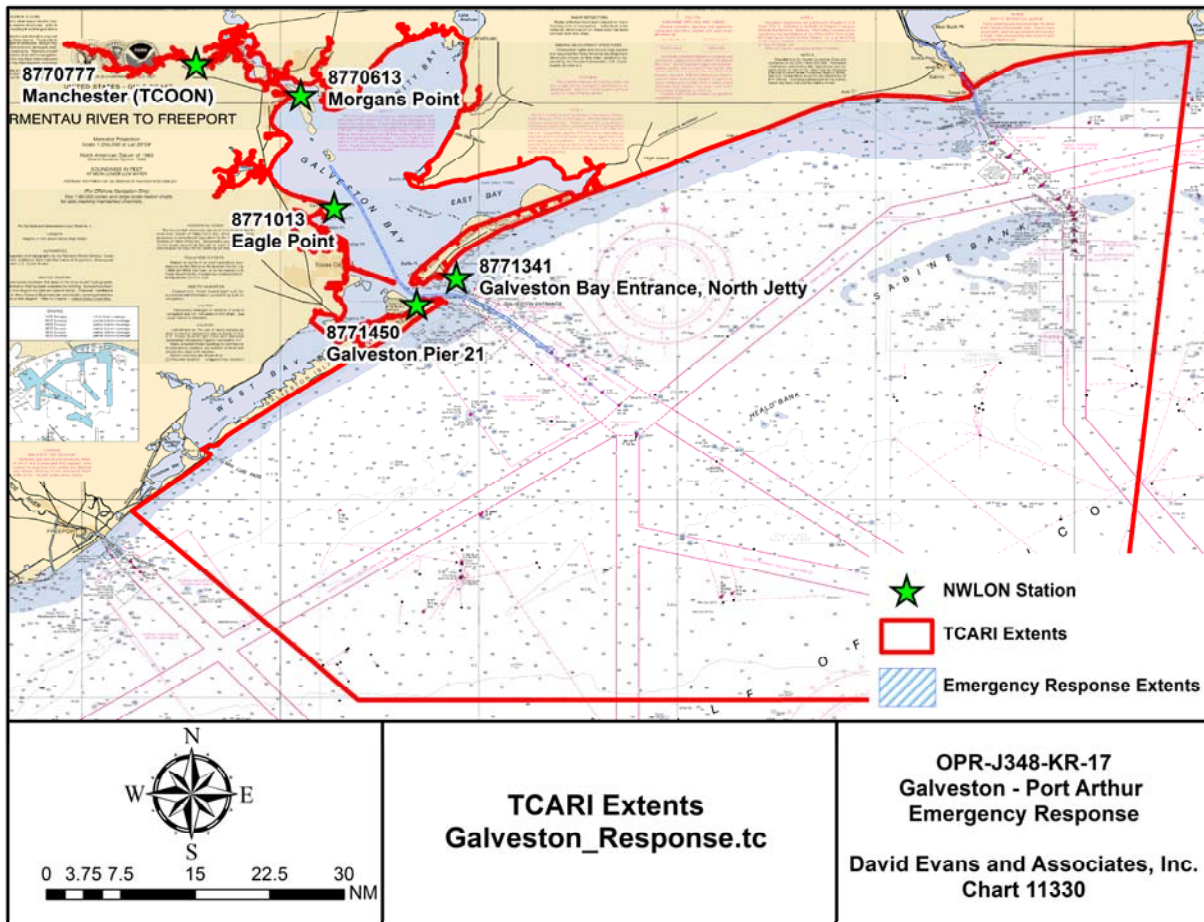


Figure 4. Galveston TCARI Grid Extents

Detailed information regarding vertical control for the response surveys is included in the Descriptive Report summaries for surveys F00698 and F00699. The majority of the surveys' bathymetric data were processed using ERS methods (RTK NAD83 (2011) ellipsoid heights and the VDatum separation model). This method provided greater internal consistency than using TCARI exclusively. The VDatum grids, TXlaggal01_8301 and LATXwest01_8301, were exported as an XYZ file using a Hypack tool and included in the deliverables to meet separation model submission requirements.

Unfortunately, cell service outages and VDatum zoning issues offshore of Galveston limited the use of ERS in this area. In the end a split method was used with TCARI used offshore of

Galveston and all other areas using ERS methods. A detailed discussion and difference between the methods is further documented in the Descriptive Report summary for survey F00698.

B2. TCARI vs RTK/VDatum Mississippi Sound Comparison

The initial plan for the project was to compute water levels relative to MLLW from RTK/VDatum. Equipment on the vessels and the SHIP reference station were configured to support the ellipsoid reference survey (ERS) with the GCGC and C4G real-time networks. However, the decision was made to switch over to TCARI after a float at Pascagoula raised questions on the validity of the VDatum model for the area. Two issues were discovered when conducting the float observation. The extents of the Louisiana/Mississippi - Eastern Louisiana to Mississippi Sound VDatum grids (LAMobile02_8301) do not extend to the Pascagoula gauge (Figure 5.) The other is the Pascagoula gauge was not used during the creation of the VDatum model, resulting in model discrepancies at Pascagoula.



Figure 5. VDatum Tide Float Locality

On September 29, 2017 (DN272) the R/V *John B. Preston* conducted a tide float near the NOAA tide gauge located in Pascagoula, MS (8741533). The VDatum coverage did not fully extend to the gauge so the survey vessel moved south to a point just inside the VDatum coverage. For thirty minutes the R/V *John B. Preston* limited vessel movements while collecting RTK derived waterline elevations using VDatum. The average value of the 30-minute observation was then compared to the average six-minute tide gauge value over the same period. When compared, the NOAA tide gauge was approximately 0.15 meters higher than the water levels derived with RTK/VDatum. This difference is greater than anticipated in the uncertainty models and may be subject to a number of factors such as: some unaccounted-for errors in modeling, the Pascagoula gauge reporting water levels slightly different than tidal benchmarks, or orthometric heights from the RTN system relative to orthometric heights published on tidal benchmarks. When comparing

published values for bench mark “Z 192 Reset 2000” at the NOAA lab between the North American Vertical Datum of 1988 (NAVD88) orthometric value of 5.903 meters to the MLLW value of 6.076 meters, the difference was found to be 0.173 meters, or NAVD88 is 0.173 meters above MLLW (which does not match the CO-OPS value of NAVD88 at 0.191 meters above MLLW). The VDatum model separation value between NAVD88 and MLLW nearby at the edge of VDatum coverage is 0.069 meters, or NAVD88 is 0.069 meters above MLLW, a 0.104-meter difference from the NGS data sheet and a 0.122-meter difference from the separation listed on the CO-OPS datum sheet for Pascagoula.

Because of these discrepancies, the more conservative decision to correct all bathymetric data with TCARI tides was made. RTK heights continued to be collected for the duration of the project but mainly for the real-time making decisions it allowed when determining coverage limits requirements from water depths.

C. LETTER OF APPROVAL

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



DAVID EVANS
AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-J348-KR-17 HORIZONTAL AND VERTICAL CONTROL REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-J348-KR-17 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-17 *Statement of Work* (July 21, 2017) and *Hydrographic Survey Project Instructions* (November 3, 2017).

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David Evans and Associates, Inc.
April 2018

D. TABLE OF ACRONYMS

C4G	Center for GeoInformatics
CH	Certified Hydrographer
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station
DEA	David Evans and Associates, Inc.
DGPS	Differential Global Positioning System
DOT	Department of Transportation
GCGC	Gulf Coast Geospatial Center
GNSS	Global Navigation Satellite System
HSD	Hydrographic Surveys Division
HSSD	Hydrographic Surveys Specifications and Deliverables
kHz	kilo Hertz
LSU	Louisiana State University
MHW	Mean High Water
MLLW	Mean Lower Low Water
NAD83	North American Datum of 1983
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSPS	National Society of Professional Surveyors
NTRIP	Networked Transport of RTCM via Internet Protocol
NWLON	National Water Level Observation Network
OPS	HSD Operations Branch
PE	Professional Engineer
PLS	Professional Land Surveyor
POS/MV	Position and Orientation System for Marine Vessels
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-time Kinematic
R/V	Research Vessel
S/V	Survey Vessel
SOW	Statement of Work
TCARI	Tidal Constituents and Residual Interpolation
THSOA	The Hydrographic Society of America
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator