

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

Horizontal and Vertical Control Report

Type of Survey: Navigable Area
Habitat Mapping

Project Number: OPR-H355-KR-21

Time Frame: April - November 2021

LOCALITY

State(s): Florida

General Locality: Key West

2021

CHIEF OF PARTY
David J. Bernstein, CH, PLS, GISP

LIBRARY & ARCHIVES

Date:

HYDROGRAPHIC TITLE SHEET

H13427
H13428
H13429
H13430
H13431
H13432

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

Geodynamics LLC

State	<u>Florida</u>		
General Locality	<u>Key West</u>		
Sub-Locality	<u>Eastern Outer Band, Western Outer Band, East of Key West, West of Key West, Seven Mile Bridge, South of Marquesas</u>		
Scale	<u>1:5,000</u>	<u>1:10,000</u>	<u>1:20,000</u>
Date of Survey	<u>April - June 2021</u>		
Instructions Dated	<u>February 17, 2021</u>	Project No.	<u>OPR-H355-KR-21</u>
Vessel	<u>R/V Benthos, R/V Chinook, R/V Substantial</u>		
Chief of Party	<u>David J. Bernstein, CH, PLS, GISP</u>		
Surveyed by	<u>Geodynamics LLC</u>		
Soundings by echo sounder	<u>Kongsberg 2040C</u>		
Graphic record scaled by	<u>N/A</u>		
Graphic record checked by	<u>N/A</u>	Automated Plot	<u>N/A</u>
Verification by	<u>Atlantic Hydrographic Branch</u>		
Soundings in	<u>Meters at Mean Lower Low Water (MLLW)</u>		

REMARKS: NAD83 (2011), UTM Zone 17 North

Times are in UTC

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

SUBCONSULTANTS: eTrac Inc., 637 Lindero, Suite 100, San Rafael, CA 94901

Ocean Operators LLC, 848 N. Rainbow Blvd. #4755, Las Vegas, NV, 89107



Table of Contents

A. Introduction	1
B. Horizontal Control	1
B.1 Horizontal Datum	1
B.2 SBAS Corrections	1
B.3 Post-Processed Horizontal Control	1
C. Vertical Control	1
C.1 Vertical Datum	1
C.2 VDatum Separation Model (SEP)	2
C.3 SBAS Corrections	2
C.4 Post-Processed Vertical Control	2
C.5 Vertical Control Confidence Check	2
D. Approval Sheet.....	1
E. List of Acronyms.....	2

List of Figures

Figure 1. Graphic documenting the vertical control confidence check performed at NOS water level station 8724580 – Key West, FL.....	3
--	---

A. Introduction

This Horizontal and Vertical Control Report (HVCR) is applicable to all surveys for OPR-H355-KR-21 (Key West, FL). Surveys H13427, H13428, H13429, H13430, H13431, and H13432 were acquired in the vicinity of Key West, Florida and within the Florida Keys National Marine Sanctuary. As defined in the Project Instructions (PI), “Conducting a modern bathymetric survey with concurrent backscatter data in this area will provide critical data for the updating of National Ocean Service (NOS) nautical charting products and services to increase maritime safety near the waters of the Florida Keys, and help classify the habitat of the reefs. Survey data from this project is intended to supersede all prior survey data in the common area.” These surveys meet the requirements defined in the Statement of Work (SOW), Hydrographic Survey PI, April 2021 Hydrographic Survey Specifications and Deliverables (HSSD), and correspondence with the National Oceanographic and Atmospheric Administration (NOAA) Hydrographic Survey Division (HSD) Operations (OPS) branch throughout the project.

B. Horizontal Control

B.1 Horizontal Datum

The horizontal datum for this project is North American Datum of 1983 (NAD83) (2011). Surveys were projected to Universal Transverse Mercator (UTM) Zone 17 North (N), Meters (m).

B.2 SBAS Corrections

Horizontal control for surveys H13427-H13432 utilized G2+ Global Navigation Satellite System (GNSS) satellite corrections provided by the Fugro Marinestar Satellite-Based Augmentation System (SBAS). Each vessel’s POS MV received the G2+ corrections, providing decimeter-level real-time horizontal control. Real-time corrections received by the POS MV were referenced to the ITRF14 realization.

B.3 Post-Processed Horizontal Control

All positioning data were post-processed using the Applanix POSPac Mobile Mapping Solution (MMS) software. Post-processed corrections were implemented with Trimble’s CenterPoint RTX service. Horizontal accuracy (RMS) was improved with sub-decimeter positioning in the Smoothed Best Estimate of Trajectory (SBET) file, that was applied to the survey data in CARIS HIPS. Real-time positioning referenced to ITRF14 was transformed to NAD83 (2011) upon export of the POSPac SBET files.

C. Vertical Control

C.1 Vertical Datum

The vertical datum for this project is Mean Lower Low Water (MLLW).



C.2 VDatum Separation Model (SEP)

NOAA’s HSD OPS provided a VDatum SEP model package with the initial project files. As described in the PI, the following metadata accompanies the SEP model.

VDatum Separation Model				
<i>OPR-H355-KR-21 NAD83 VDatum MLLW</i>				
VDatum Version	Geoid	Area	Area Version	Separation Uncertainty
3.9	2012	Florida South	8301	0.0893 m

C.3 SBAS Corrections

Vertical control for surveys H13427-H13432 utilized G2+ GNSS satellite corrections provided by the Fugro Marinestar SBAS. Each vessel’s POS MV received the G2+ corrections, providing decimeter-level real-time vertical control. Real-time corrections received by the POS MV were referenced to the ITRF14 realization. Ellipsoid heights of the water surface and soundings were reduced to MLLW in real-time on each vessel by incorporating the *OPR-H355-KR-21_1_100m_ITRF2014-MLLW_geoid12b* SEP model in QPS Qinsy. It should be noted this ITRF2014-MLLW SEP model was an additional SEP model requested by Geodynamics (initial only provided NAD83 SEP models). This ITRF2014-MLLW SEP model was only used in real-time and is not utilized by any delivered, processed data.

C.4 Post-Processed Vertical Control

All ellipsoid data were post-processed using the Applanix POSPac MMS software. Post-processed corrections were implemented with Trimble’s CenterPoint RTX service. Vertical accuracy (RMS) was improved to sub-decimeter in the SBET file that was applied to the survey data in CARIS HIPS. Real-time corrections referenced to ITRF14 were transformed to NAD83 (2011) upon export of the POSPac SBET files. The *OPR-H355-KR-21_NAD83_VDatum_MLLW* SEP model was then utilized in CARIS HIPS to reduce the sonar data to MLLW.

C.5 Vertical Control Confidence Check

Following pre-survey calibrations and still utilizing SBAS corrections, a “float test” was performed with the R/V Benthos to ensure the quality of the GNSS corrections, SEP model, and survey systems integrations. The vessel remained stationary while nearby NOS Water Level Station 8724580 – Key West and recorded the MLLW elevation of the water surface. This information was then compared to the near real-time water level data collected by the Key West tide gauge for the same time period and showed good agreement (Figure 1).


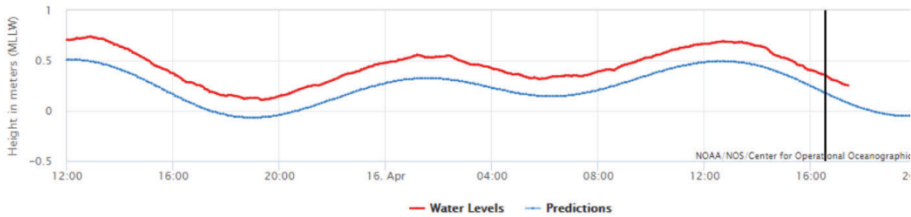
OPR-H355-KR-21 Key West, Florida Float Test - R/V Benthos		FLOAT TEST R/V Benthos		 Geodynamics 310 A Greenfield Dr. Newport, NC 28570 252-247-5785 www.GeodynamicsGroup.com	
General Calibration Information					
Vessel	R/V Benthos		Personnel:	Dave Bernstein Sam Bradtke	
Date (s):	4/16/2021			Josh Savage	
Julian Day:	106				
Water Level Station Information					
Station ID:	8724580		NOAA Chart:	11447_1	
Station Name:	Key West, FL		Established:	01/18/1913	
Latitude	24° 33.0 N				
Longitude:	81° 48.5 W				
Time (UTC)	Tide Gauge (MLLW, m)	Vessel Waterline Reading (MLLW, m)		Difference (m)	
17:24	0.253	0.203		0.05	
Mean Difference:	0.050		Summary: The vessel was held as close to the water level gauge as possible for this comparison (~0.27 nmi from the station due to restricted access). The vessel utilized a provided SEP Model. Using SBAS Marinestar G2+, POS MV vertical RMS was ~0.05 m.		
Std Dev:	N/A				
Photos					
Water Level Readings from Vessel (Qinsy Node):					
0.20					
0.22					
0.24					
0.17					
0.19					
0.20					
Image of Water Level from Tide Gauge:					
<div style="display: flex; justify-content: space-between;"> <div style="width: 25%;"> <p>Water Levels 0.253 m MLLW as of 04/16/2021 17:24 LST/LDT</p> </div> <div style="width: 70%; text-align: center;"> <p>NOAA/NOS/CO-OPS Observed Water Levels at 8724580, Key West FL From 2021/04/15 12:00 LST_LDT to 2021/04/16 23:59 LST_LDT</p>  <p style="text-align: right; font-size: small;">NOAA/NOS/Center for Operational Oceanographic</p> </div> </div>					

Figure 1. Graphic documenting the vertical control confidence check performed at NOS water level station 8724580 – Key West, FL.

D. Approval Sheet



LETTER OF APPROVAL

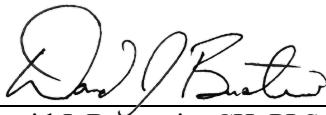
Registry Nos.

H13427, H13428, H13429, H13430, H13431, H13432

OPR-H355-KR-21 – Key West, FL
HORIZONTAL AND VERTICAL CONTROL REPORT

This report and the accompanying data are respectfully submitted.

As Chief of Party, field operations contributing to the accomplishment of Surveys H13427, H13428, H13429, H13430, H13431, and H13432 were conducted under my direct supervision, with frequent personal checks of progress and adequacy. This report and accompanying data deliverable have been closely reviewed and are considered complete and adequate as per the Statement of Work (February 16, 2021).



David J. Bernstein, CH, PLS, GISP | Geodynamics LLC | Chief of Party | September 30, 2021

E. List of Acronyms

GNSS	Global Navigation Satellite System
HSD	Hydrographic Survey Division
HSSD	Hydrographic Surveys Specifications and Deliverables
HVCR	Horizontal and Vertical Control Report
ITRF14	International Terrestrial Reference System 2014
m	Meter
MLLW	Mean Lower Low Water
MMS	Mobile Mapping Solution
N	North
NAD83	North American Datum of 1983
NOAA	National Oceanographic and Atmospheric Administration
NOS	National Ocean Service
OPS	Operations
PI	Project Instructions
RMS	Root Mean Square
SBAS	Satellite-Based Augmentation System
SBET	Smoothed Best Estimate of Trajectory
SEP	Separation
SOW	Statement of Work
UTM	Universal Transverse Mercator