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

HORIZONTAL & VERTICAL CONTROL REPORT

Type of Survey: Navigable Area

Project Number: OPR-B315-KR-22

Time Frame: July – August 2022

LOCALITY

State(s): Rhode Island
Massachusetts

General Locality: Approaches to Newport, RI

2022

CHIEF OF PARTY

John R. Bean

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Date:

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A. TIME BASIS

Coordinated Universal Time (UTC) was used to annotate the tide records and all other data obtained for this project.

B. VERTICAL CONTROL

All soundings are referenced to Mean Lower Low Water (MLLW) using Ellipsoidally Referenced Survey (ERS) methods per the Project Instructions. All baring features are reported in Mean High Water (MHW).

B.1 ERS Tide Source Data

Inertially Aided Post Processed Kinematic (IAPPK) ellipsoid heights were computed using POSPac MMS, Applanix SmartBase (ASB) processing. The ellipsoid heights in the resulting Smoothed Best Estimate Trajectory (SBET) data were used as the basis for the development of ERS Tide.

ASB processing was organized into POSPac projects by vessel and day. Figure 1 illustrates the location of Continuously Operating Reference Stations (CORS) stations (including OSI's locally installed base station OSSB) which contributed to ASB processing. The total number of stations occasionally varied from one POSPac project to the next (i.e. vessel-day) based on CORS data availability and solution quality. The table inset in Figure 1 shows the POSPac IAPPK project count for each station. The final coordinates of OSSB were determined using the NGS' Online Positioning User Service (OPUS).

ERS water levels ("GPS Tide") were derived from SBET altitude. SBET altitude corrected for heave, dynamic draft, and static draft were reviewed graphically in MATLAB and compared to the local NOAA tide gauge water levels. When apparent invalid altitude was present in the daily SBET, additional CORS stations were added to the ASB network. For any remaining daily SBETs with invalid altitude data, NOAA's POSPacAutoQC application was used to interpolate through and replace the invalid data.

B.2 VDatum Separation Model (SEP)

Two VDatum Separation Models (SEP), one for MHW and one for MLLW, were provided by NOAA with the original project files and described in the Project Instructions (Table 1).

Table 1

MHW VDATUM Model				
VDatum Version	Geoid	Area	Area Version	Separation Uncertainty
3.9	2012	RICTbis22_8301 and MENHMAgome13_8301	1	9.9 centimeters
MLLW VDATUM Model				
VDatum Version	Geoid	Area	Area Version	Separation Uncertainty
3.9	2012	RICTbis22_8301 and MENHMAgome13_8301	1	10.4 centimeters

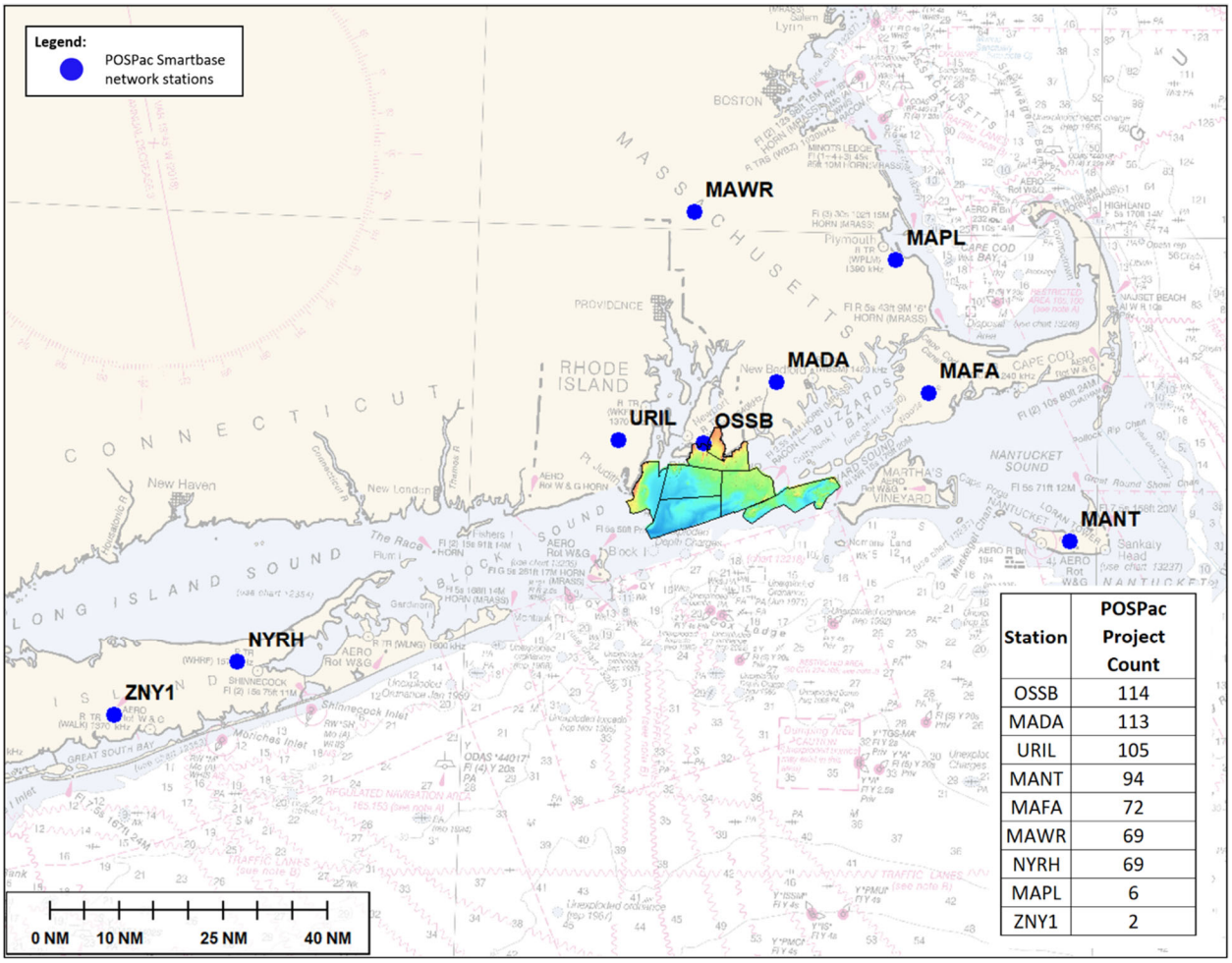

Figure 1. Local CORS network and "OSSB" in relation to the project site with corresponding CORS station POSPac project counts.

B.3 ERS Tide Smoothing

ASB derived ERS tides were smoothed prior to inclusion in the data reduction process.

I. ERS Tide Smoothing Steps:

1) Create and export final SBETs
2) Interpolate invalid altitude spikes with POSPacAutoQC
3) Smooth resultant SBETs using MATLAB
    - Convert SBET altitude to an isolated NAVD88 tide by removing the following components of the SBET altitude:
        - Static draft based on time
        - Dynamic draft based on speed
        - Delayed heave based on time
        - SEP based on position
    - Smooth NAVD88 tide with a 4th order Butterworth low-pass filter
    - Export smoothed SBETs after re-applying the above components
4) Import smoothed SBETs in CARIS HIPS
5) Run CARIS HIPS "Compute GPS Tides" with the NOAA-provided SEP to create tide correctors.

II. ERS Smoothed Tide Curve QA/QC:

Graphical analysis was the primary QA/QC tool used during the development phase of the ERS smoothing routine described above. MATLAB graphs were generated for all conversion and correction steps to identify erroneous source data or MATLAB program code.

III. Choice of Smoothing Parameters:

Combined SBETs were smoothed with a 4th order Butterworth low-pass filter using MATLAB's "filtfilt" function, which runs the filter in forward and reverse, resulting in a zero-lag solution.

OSI has demonstrated the effectiveness of this smoothing method on prior NOAA contract surveys (see OPR-K354-KR-18, OPR-K379-KR-19, OPR-K354-KR-19, and OPR-B300-KR-20).

To determine the best smoothing parameter settings for this survey site, the final SBETs were smoothed, converted to ERS tides and applied to the soundings using each of the following smoothing methods:

- 0.5, 1, 2, 3, 4-hour low pass filters

Statistical comparisons were made of crossline and main scheme difference data generated by CARIS HIPS. Standard deviation surfaces at intersections were reviewed, and the smoothed ERS tide was compared to local NOAA tide gauges and evaluated for trends and general agreement.

As a result of this iterative comparative analysis, a 4th order Butterworth low pass filter with the following settings were selected to smooth ERS tides:

- 1-hour cutoff frequency: *RV North Cove* and *RV South Cove*
- 2-hour cutoff frequency: *MV Northstar Challenger*

B.4 Final Application of ERS Tides

For the final application of ERS tides, the final tide-smoothed SBET ellipsoid record was imported to CARIS. The CARIS "Compute GPS Tides" function was used in conjunction with the NOAA-provided SEP to apply MLLW tide correctors to the soundings and MHW heights to baring features:

OPR-B315-KR-22_VDATUM_Coverage_100m_NAD83-MLLW_geoid12b.csar
OPR-B315-KR-22_VDATUM_Coverage_100m_NAD83-MHW_geoid12b.csar

Qualitative and quantitative crossline analysis, as well as junction analysis, indicated that the final ERS correctors applied to reduce soundings and heights to MLLW and MHW, respectively, were adequate for the purpose. The results of crossline and junction analysis are presented in the Descriptive Report (DR) for each survey.

B.4 GNSS Base Station "OSSB"

To supplement IAPPK SBET processing, OSI installed a temporary GNSS base station on a structure roof at Sachuest Beach, locally known as Second Beach, in Middletown, RI (Figure 2). The installed station was designated "OSSB" [Ocean Surveys Sachuest (Second) Beach] and consisted of a Trimble NetR9 GNSS receiver equipped with a Zephyr 3 Geodetic antenna (Model: TRM115000.00 None). OSSB also supplied real-time CMR+ RTK correctors to the nearshore survey vessels (when in cell service range) via a cellular based NTRIP stream. Real-time correctors provided precise horizontal positioning and allowed for real-time water level monitoring, which aided the survey vessels in mapping the Navigable Area Limit Line (NALL).

Figure 2. Ortho imagery and setup images of OSI's user-installed base station "OSSB" on top of a building at Sachuest Beach in Middletown, RI.

The configuration of the NetR9 was based on UNAVCO standard configuration settings for this device. The NetR9 was configured to record GNSS observables continuously throughout the period of the survey and parse data observables into daily files for each 24-hour period. Data were delivered to OSI's home office processing center via regular automated FTP and e-mail "pushes." Pushes were transmitted over a network connection that was established on site for this purpose. Data were also saved to the receiver's internal storage as a backup.

The HSSD requires that: "*The integrity of the geodetic tie of non-NOAA CORS installations to the NSRS shall be verified at least once per week while the site is utilized for survey operations. Verification may be achieved by repeated OPUS sessions to demonstrate that the difference between adopted and check positions are within the error budget allotted per THU (Section 3.2).*" OSI submitted all individual days of dual frequency GNSS observables (Rinex files) from OSSB to OPUS. Data were submitted with an ARP height of 0m. OSI used OPUS Projects (https://www.ngs.noaa.gov/OPUS-Projects/OpusProjects.shtml) for OPUS solution management, quality control, and to compute the final network-adjusted coordinates, which were then incorporated into ASB processing (Table 2). Processing steps and parameter selection were in accordance with the NGS-provided OPUS Projects Managers Training (required to obtain access to OPUS projects).

Table 2
OPUS Projects Network Adjusted Positions of OSSB

Time period	Latitude (NAD83-2011)	Longitude (NAD83-2011)	Ellipsoid Height (GRS80)
DN 194-241	41° 29' 17.34796" N	71° 15' 22.87933" W	-19.454 m

Figure 3 shows a summary of the residuals for each of the daily OPUS solutions, and the improved residuals obtained with OPUS Projects session processing. The residuals are relative to the final network-adjusted position computed by OPUS Projects using all the solutions. The error bars on each point indicate the 1-sigma peak-to-peak root mean square (RMS) error estimate of the 3D position components, namely east, north, and ellipsoid height. The apparent offset in the mean position of the daily residuals and the final network-adjusted position is due to plate velocities as handled in OPUS Projects for the time span of the project. All processing was done in ITRF 2014; however, final network-adjusted coordinates are also provided by OPUS Projects in NAD 83 (2011) @ 2010.00 (i.e. Table 2).

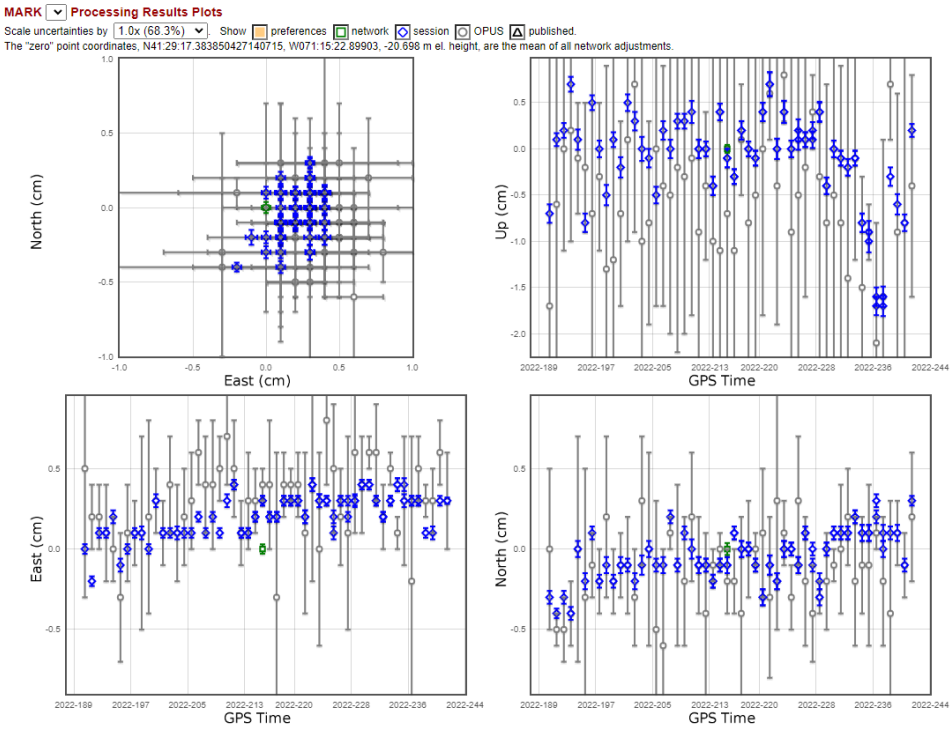

Figure 3. OPUS project coordinate residuals for GNSS observables at OSSB. OPUS solutions are in grey, improved OPUS Project session solutions are in blue. Error bars represent 1-sigma. Residuals are relative to the final network-adjusted and velocity corrected position (green) from OPUS Projects.

Individual OSSB OPUS Project results (OPUS solutions, sessions, and final network adjustment) are included in the HVCR digital deliverables.

C. HORIZONTAL CONTROL

C.1 Horizontal Datum

The horizontal datum for this project is the North American Datum of 1983 (NAD83). Horizontal coordinates are referenced to Latitude/Longitude and Universal Transverse Mercator (UTM) Zone 19N, in meters. The assigned project boundary falls entirely within UTM Zone 19N. However, calibrations were conducted in Long Island Sound and Connecticut River near OSI's headquarters in Old Saybrook, CT, thus, calibration data are referenced to Latitude/Longitude and UTM Zone 18N, in meters.

C.2 Horizontal Control

During the survey, the POSMV on the *RV North Cove and RV South Cove* received real-time CMR+ RTK correctors from "OSSB" base station via a cellular NTRIP stream, while the *MV Northstar Challenger* was configured to receive SBAS (FAA WAAS) correctors for real-time positioning.

Real-time vessel navigation was replaced during post processing with ASB-derived SBET positioning and attitude. Final SBET positioning is referenced to NAD83 (2011).

Positioning system confidence checks for each vessel were accomplished at the start of survey and periodically thereafter. In practice, the distance between the vessel's reference point (RP) and the dockside horizontal control point as computed by the navigation system was compared to the tape-measured distance between the vessel RP and the horizontal control point.

A temporary navigation confidence check point was installed near OSI's headquarters of Old Saybrook, CT in the Connecticut River prior to calibrations (Figure 4). The sole purpose of this control point was to ensure that *MV Northstar Challenger* positioning system was functioning properly before transiting to the survey site. The vessel did not dock at its project site berth before commencing data collection and accomplished it's start of survey positioning system confidence check in Old Saybrook, CT. The temporary point was established in UTM Zone 18, meters using a single OPUS observation with a duration of approximately 4 hours. It was then converted to UTM Zone 19, meters for the "start of the job" positioning system confidence check to be done in project datum.

Five other temporary points were established upon arrival to each vessel's respective dock and were used for frequent positioning checks (Figures 5 - 9). Temporary point "95rd" in Tiverton, RI was established first using a single OPUS observation with a duration of approximately 4.5 hours. Field crews then performed a rover navigation check to temporary point "95rd" with a Trimble R8 GNSS interfaced with a TSC3 data collector programmed to receive real-time CMR+ RTK corrections from the base station "OSSB." Once the rover system's accuracy was confirmed, it was used to install the other temporary points at the remaining docks. A minimum of three observations of 10 seconds each were collected by the rover system for each point. These observations were averaged to get the X,Y coordinate for each point.

The X,Y coordinates for all temporary navigation confidence check points are presented in Table 3. The OPUS reports for each installation are included in the HVCR digital deliverables.

In all cases, dockside navigation system accuracy checks demonstrated an accuracy that was substantially better than 1.0 meter.

Table 3
Temporary Navigation Confidence Check Points

Designation	Easting UTM 19N, NAD83 (meters)	Northing UTM 19N, NAD83 (meters)	Locale	For Survey Vessel
UTM 19 Harbor One PI 2022	219556.86	4575408.24	Old Saybrook, CT	*MV Northstar Challenger*
PJ-XDock-01	289982.56	4584029.10	Point Judith, RI	*MV Northstar Challenger*
PJ-BBDock-01	289950.05	4584110.21	Point Judith, RI	*MV Northstar Challenger*
PJ-CCDock-01	289926.04	4584130.48	Point Judith, RI	*MV Northstar Challenger*
SHNP1	309551.39	4606681.83	Portsmouth, RI	*RV North Cove*
95rd	315733.18	4611703.69	Tiverton, RI	*RV North Cove, RV South Cove*

Figure 4. "UTM 19 Harbor One PI 2022" is a deck screw backed with yellow tape on pier decking at north half of Plum Island Crew Boat pier in Old Saybrook, CT.

Figure 5. "PJ-XDock-01" is a pink backed PK nail in pier decking on the west side of X-Dock at Point Judith State Docks in Point Judith, RI.

Figure 6. "PJ-BBDock-01" is the northwest bolt head on a bulkhead cleat below a pile indicated with pink survey tape located on BB Dock at Point Judith State Docks in Point Judith, RI.

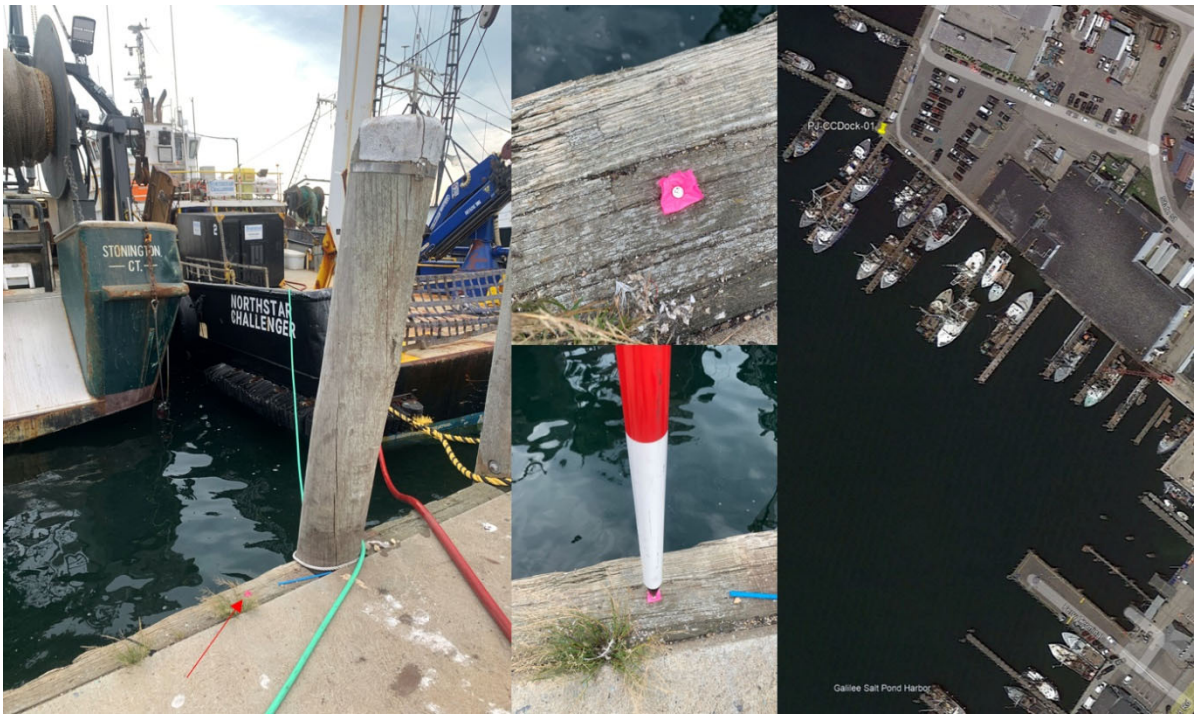

Figure 7. "PJ-CCDock-01" is a pink backed PK nail near a bulkhead corner next to CC Dock at Point Judith State Docks in Point Judith, RI.

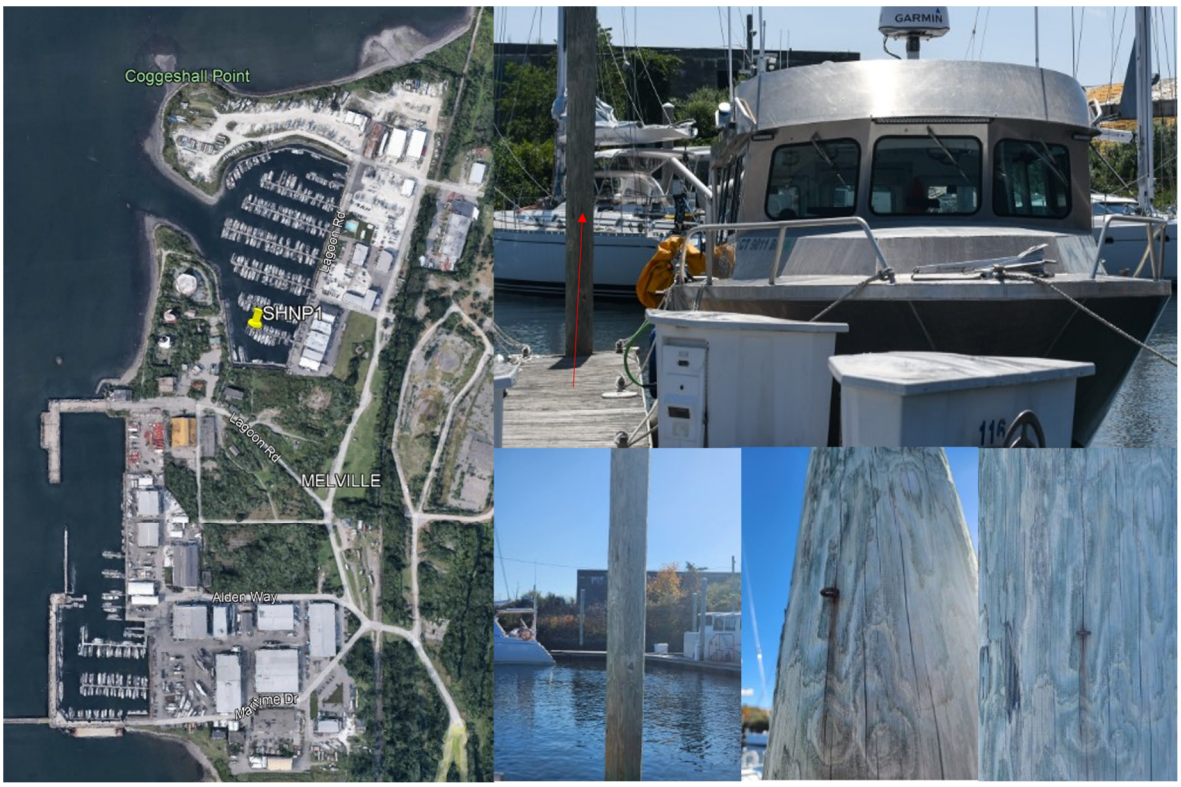

Figure 8. "SHNP1" is an eye hook located approximately halfway up a piling at the end the southernmost dock at New England Boat Works Marina in Portsmouth, RI.

Figure 9. "95rd" is a PK nail set in the northern section of the fixed wooden dock overhanging the water at Anthony Point on 95 Riverside Drive in Tiverton, RI

Navigation system confidence checks for each vessel are included below in Table 4 through Table 6.

Table 4
***MV Northstar Challenger* Tabulation of Navigation System Confidence Checks**

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
07/18/2022 (199)	02:01	UTM 19 HARBOR ONE PI 2022	WAAS	219,556.99	4,575,425.15	13.46	13.46	0.00
07/19/2022 (200)	21:01	UTM 19 PJ-XDock-01	WAAS	289,976.72	4,584,029.53	5.86	5.5	0.36
08/08/2022 (220)	12:13	UTM 19 PJ-BBDock-01	WAAS	289,940.37	4,584,102.30	12.50	12.4	0.10
08/26/2022 (238)	22:45	UTM 19 PJ-CCDock-01	WAAS	289,911.17	4,584,124.99	15.85	15.89	0.04

Table 5
***RV North Cove* Tabulation of Navigation System Confidence Checks**

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
07/13/2022 (194)	09:46	SHNP1	OSSB CMR + RTK	309,550.40	4,606,685.97	4.26	4.27	0.01
07/13/2022 (194)	20:54	SHNP1	OSSB CMR + RTK	309,550.58	4,606,685.62	3.87	3.85	0.02
07/14/2022 (195)	09:49	SHNP1	OSSB CMR + RTK	309,549.62	4,606,685.62	4.18	4.2	0.02
07/14/2022 (195)	20:42	SHNP1	OSSB CMR + RTK	309,550.43	4,606,686.00	4.28	4.27	0.01
07/15/2022 (196)	09:46	SHNP1	OSSB CMR + RTK	309,550.42	4,606,686.62	4.89	4.9	0.01
07/15/2022 (196)	21:36	SHNP1	OSSB CMR + RTK	309,550.02	4,606,685.76	4.16	4.17	0.01
07/16/2022 (197)	09:54	SHNP1	OSSB CMR + RTK	309,551.45	4,606,686.46	4.63	4.62	0.01
07/16/2022 (197)	21:25	SHNP1	OSSB CMR + RTK	309,550.37	4,606,685.57	3.88	3.87	0.01
07/17/2022 (198)	21:05	SHNP1	OSSB CMR + RTK	309,550.33	4,606,685.59	3.91	3.92	0.01
07/18/2022 (199)	10:01	SHNP1	OSSB CMR + RTK	309,550.28	4,606,685.51	3.84	3.85	0.01
07/18/2022 (199)	20:56	SHNP1	OSSB CMR + RTK	309,550.25	4,606,685.47	3.81	3.84	0.03
07/19/2022 (200)	11:25	SHNP1	OSSB CMR + RTK	309,550.41	4,606,685.56	3.86	3.85	0.01
07/20/2022 (201)	09:42	SHNP1	OSSB CMR + RTK	309,550.35	4,606,685.58	3.89	3.89	0.00
07/20/2022 (201)	20:57	SHNP1	OSSB CMR + RTK	309,550.37	4,606,685.73	4.03	4.02	0.01
07/21/2022 (202)	09:48	SHNP1	OSSB CMR + RTK	309,548.55	4,606,684.42	3.84	3.84	0.00
07/21/2022 (202)	21:05	SHNP1	OSSB CMR + RTK	309,550.26	4,606,685.62	3.95	3.96	0.01
07/22/2022 (203)	09:49	SHNP1	OSSB CMR + RTK	309,549.45	4,606,685.75	4.37	4.36	0.01
07/22/2022 (203)	20:40	SHNP1	OSSB CMR + RTK	309,550.42	4,606,685.96	4.24	4.32	0.08
07/23/2022 (204)	10:03	SHNP1	OSSB CMR + RTK	309,550.42	4,606,685.91	4.19	4.2	0.01
07/26/2022 (207)	17:19	SHNP1	OSSB CMR + RTK	309,550.36	4,606,685.84	4.14	4.12	0.02
07/27/2022 (208)	09:33	SHNP1	OSSB CMR + RTK	309,550.39	4,606,685.72	4.02	4.06	0.04
07/28/2022 (209)	09:23	SHNP1	OSSB CMR + RTK	309,550.19	4,606,685.32	3.69	3.665	0.03

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
07/29/2022 (210)	09:10	SHNP1	OSSB CMR + RTK	309,550.24	4,606,685.41	3.76	3.79	0.03
07/30/2022 (211)	09:40	SHNP1	OSSB CMR + RTK	309,550.28	4,606,685.60	3.93	3.95	0.02
07/31/2022 (212)	09:51	SHNP1	OSSB CMR + RTK	309,550.29	4,606,685.66	3.98	3.99	0.01
08/01/2022 (213)	09:50	SHNP1	OSSB CMR + RTK	309,550.26	4,606,685.76	4.09	4.072	0.02
08/02/2022 (214)	09:44	SHNP1	OSSB CMR + RTK	309,550.34	4,606,685.70	4.01	4.005	0.00
08/03/2022 (215)	10:22	SHNP1	OSSB CMR + RTK	309,550.32	4,606,685.60	3.92	3.926	0.01
08/04/2022 (216)	09:41	SHNP1	OSSB CMR + RTK	309,550.32	4,606,685.73	4.04	4.05	0.01
08/05/2022 (217)	09:43	SHNP1	OSSB CMR + RTK	309,550.38	4,606,685.82	4.12	4.01	0.11
08/06/2022 (218)	09:43	SHNP1	OSSB CMR + RTK	309,550.30	4,606,685.74	4.06	4.07	0.01
08/09/2022 (221)	16:45	SHNP1	OSSB CMR + RTK	309,550.14	4,606,686.04	4.39	4.35	0.04
08/10/2022 (222)	11:18	SHNP1	OSSB CMR + RTK	309,550.19	4,606,685.36	3.73	3.735	0.01
08/13/2022 (225)	10:30	SHNP1	OSSB CMR + RTK	309,550.24	4,606,685.51	3.86	3.83	0.03
08/14/2022 (226)	10:25	SHNP1	OSSB CMR + RTK	309,550.31	4,606,685.70	4.02	4.018	0.00
08/15/2022 (227)	10:32	SHNP1	OSSB CMR + RTK	309,550.27	4,606,685.68	4.01	4.015	0.01
08/16/2022 (228)	10:12	SHNP1	OSSB CMR + RTK	309,550.27	4,606,685.62	3.95	4.012	0.06
08/17/2022 (229)	21:37	95rd	OSSB CMR + RTK	315,733.72	4,611,721.60	17.92	17.92	0.00
08/18/2022 (230)	19:05	95rd	OSSB CMR + RTK	315,733.51	4,611,720.51	16.82	16.755	0.07
08/19/2022 (231)	09:44	95rd	OSSB CMR + RTK	315,733.48	4,611,720.02	16.33	16.235	0.10
08/20/2022 (232)	10:13	95rd	OSSB CMR + RTK	315,733.69	4,611,720.82	17.14	17.076	0.06
08/21/2022 (233)	10:02	95rd	OSSB CMR + RTK	315,732.79	4,611,718.36	14.67	14.582	0.09
08/22/2022 (234)	10:11	95rd	OSSB CMR + RTK	315,732.79	4,611,718.43	14.74	14.692	0.05
08/23/2022 (235)	10:04	95rd	OSSB CMR + RTK	315,732.68	4,611,717.96	14.28	14.216	0.06
08/24/2022 (236)	09:49	95rd	OSSB CMR + RTK	315,733.44	4,611,720.19	16.50	16.454	0.05
08/25/2022 (237)	09:49	95rd	OSSB CMR + RTK	315,732.63	4,611,717.87	14.19	14.086	0.10

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
08/26/2022 (238)	09:46	95rd	OSSB CMR + RTK	315,733.41	4,611,720.12	16.43	16.402	0.03
08/27/2022 (239)	10:15	95rd	OSSB CMR + RTK	315,732.76	4,611,718.03	14.34	14.34	0.00
08/28/2022 (240)	11:17	95rd	OSSB CMR + RTK	315,731.11	4,611,717.72	14.18	13.965	0.21

Table 6
***RV South Cove* Tabulation of Navigation System Confidence Checks**

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
07/13/2022 (194)	20:33	95rd	OSSB CMR + RTK	315,727.62	4,611,700.93	6.21	6.25	0.04
07/14/2022 (195)	09:52	95rd	OSSB CMR + RTK	315,727.52	4,611,700.70	6.40	6.48	0.08
07/14/2022 (195)	20:42	95rd	OSSB CMR + RTK	315,727.87	4,611,701.72	5.66	5.62	0.04
07/15/2022 (196)	09:19	95rd	OSSB CMR + RTK	315,727.77	4,611,701.63	5.79	5.71	0.08
07/15/2022 (196)	20:31	95rd	OSSB CMR + RTK	315,733.71	4,611,719.71	16.03	16.1	0.07
07/16/2022 (197)	10:22	95rd	OSSB CMR + RTK	315,733.60	4,611,719.68	15.99	15.92	0.07
07/17/2022 (198)	09:23	95rd	OSSB CMR + RTK	315,733.58	4,611,719.59	15.90	15.885	0.02
07/18/2022 (199)	09:44	95rd	OSSB CMR + RTK	315,731.98	4,611,714.34	10.72	10.723	0.01
07/19/2022 (200)	10:56	95rd	OSSB CMR + RTK	315,733.79	4,611,719.91	16.23	16.213	0.02
07/20/2022 (201)	09:44	95rd	OSSB CMR + RTK	315,733.79	4,611,719.74	16.06	15.994	0.07
07/21/2022 (202)	09:42	95rd	OSSB CMR + RTK	315,733.56	4,611,719.49	15.80	15.657	0.15

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
07/22/2022 (203)	08:52	95rd	OSSB CMR + RTK	315,733.84	4,611,719.88	16.20	16.365	0.16
07/23/2022 (204)	09:14	95rd	OSSB CMR + RTK	315,733.75	4,611,719.92	16.24	16.353	0.11
07/24/2022 (205)	09:13	95rd	OSSB CMR + RTK	315,733.53	4,611,719.90	16.21	16.252	0.04
07/27/2022 (208)	09:15	95rd	OSSB CMR + RTK	315,735.10	4,611,724.07	20.47	20.546	0.08
07/28/2022 (209)	09:13	95rd	OSSB CMR + RTK	315,733.82	4,611,720.01	16.33	16.322	0.01
07/29/2022 (210)	09:09	95rd	OSSB CMR + RTK	315,733.70	4,611,719.83	16.15	16.127	0.02
07/30/2022 (211)	09:34	95rd	OSSB CMR + RTK	315,733.73	4,611,719.81	16.13	16.123	0.00
07/31/2022 (212)	09:12	95rd	OSSB CMR + RTK	315,733.62	4,611,719.60	15.91	15.895	0.02
08/01/2022 (213)	20:50	95rd	OSSB CMR + RTK	315,733.75	4,611,719.67	15.99	15.942	0.05
08/02/2022 (214)	09:43	95rd	OSSB CMR + RTK	315,733.78	4,611,719.81	16.13	16.127	0.00
08/03/2022 (215)	09:47	95rd	OSSB CMR + RTK	315,733.64	4,611,719.44	15.75	15.727	0.03
08/04/2022 (216)	09:24	95rd	OSSB CMR + RTK	315,733.70	4,611,719.72	16.04	16.004	0.03
08/05/2022 (217)	10:03	95rd	OSSB CMR + RTK	315,733.81	4,611,719.91	16.23	16.207	0.02
08/06/2022 (218)	09:38	95rd	OSSB CMR + RTK	315,733.78	4,611,719.78	16.10	16.107	0.01
08/10/2022 (222)	10:56	95rd	OSSB CMR + RTK	315,733.63	4,611,719.60	15.91	15.968	0.05
08/11/2022 (223)	09:47	95rd	OSSB CMR + RTK	315,733.37	4,611,719.41	15.72	15.743	0.02
08/12/2022 (224)	09:41	95rd	OSSB CMR + RTK	315,734.48	4,611,722.03	18.38	18.353	0.03

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 19N, NAD83 (meters)	Observed Northing UTM 19N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
08/13/2022 (225)	10:38	95rd	OSSB CMR + RTK	315,734.35	4,611,722.12	18.47	18.464	0.00
08/14/2022 (226)	10:10	95rd	OSSB CMR + RTK	315,734.45	4,611,722.09	18.44	18.433	0.01
08/15/2022 (227)	09:43	95rd	OSSB CMR + RTK	315,734.52	4,611,722.10	18.46	18.493	0.04
08/16/2022 (228)	09:44	95rd	OSSB CMR + RTK	315,734.45	4,611,722.21	18.56	18.547	0.01

D. APPROVAL SHEET

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of Surveys H13657, H13658, H13659, H13660, H13661, H13662, and H13663 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 Statement of Work.

Approver Name	Approver Title	Approval Date	Signature
John R. Bean	Chief of Party	02/23/2023	John R. Bean 2023.02.23 15:38:03 -05'00'
David T. Somers	Data Processing Manager	02/23/2023	David T. Somers 2023.02.23 15:38:20 -05'00'