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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-B300-KR-20
Time Frame:	July - December 2020

LOCALITY

State(s):	Connecticut New York
General Locality:	Long Island Sound

2020

CHIEF OF PARTY
John R. Bean

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Data Acquisition and Processing Report

Ocean Surveys
Chief of Party: John R. Bean
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A. System Equipment and Software

A.1 Survey Vessels

A.1.1 RV Able 2

Vessel Name	RV Able 2
Hull Number	Registration No. CT 4788 BB
Description	RV Able 2 is a 7.6-meter fiberglass vessel powered by twin 150 HP outboard engines. The RV Able 2 was modified by Ocean Surveys, Inc. (OSI) for hydrographic survey operations: -Survey system control modules (processors) and computer systems were installed at purpose-built work stations in the main cabin of the vessel. -An indexed Inertial Measurement Unit (IMU) mounting plate is permanently installed on the starboard side of the vessel at the approximate pitch center of rotation. The POS MV IMU was installed on this plate and was related to the approximate center of rotation with offsets entered into the POS MV controller software (POSView). -A retractable multibeam transducer pole, constructed of thick-wall stainless steel pipe, was attached to the starboard side of the vessel at the approximate pitch centerline. The pole was attached at two points: a substantial, positive locking swivel on the gunwale of the vessel, and a “stiff arm” protruding from an aluminum H-beam integrated into the roof of the vessel. When deployed, the top of the transducer pole is bolted to a point on the stiff arm attachment point and clamped tight at the gunwale swivel point thereby eliminating pole movement. This configuration allows for repeatable deployment of the transducer during data acquisition and ease of retrieval for transit. -A custom-built 45-degree angled mount for the Velodyne VLP-16 LiDAR was installed on the top of the cabin roof and forward of the multibeam transducer pole.

Dimensions	*LOA*	7.6m
	Beam	2.9m
	Max Draft	0.8m
Most Recent Full Static Survey	*Date*	2008-11-25
	Performed By	A full static survey of the RV Able 2 was conducted on November 25, 2008 by OSI. The survey established permanent shipboard benchmarks within the fixed vessel reference frame to include: vessel reference point (RP), draft measurement locations and sensor mounting locations. The points were surveyed using a precision total station while the vessel was hauled out on land.
Most Recent Partial Offset Verification	*Date*	2020-07-15
	Method	Relevant offsets established by the 2008 total-station survey were confirmed during the 2020 vessel mobilization with a steel tape measure.

Figure 1: RV Able 2 configured for hydrographic survey operations.

A.1.2 RV Osprey

Vessel Name	RV Osprey	
Hull Number	Registration No. CT 7934 BC	
Description	RV Osprey is a 7.9 meter fiberglass vessel powered by twin 150 HP outboard engines. The RV Osprey was modified by OSI for hydrographic survey operations: -Survey system control modules (processors) and computer systems were installed at purpose-built work stations in the main cabin of the vessel. -An indexed Inertial Measurement Unit (IMU) mounting plate is permanently installed on the vessel's fore-aft (roll) centerline at the approximate pitch center of rotation. The POS MV IMU was installed on this plate. -A retractable multibeam transducer pole, constructed of thick-wall stainless steel pipe, was attached to the starboard side of the vessel at the approximate pitch centerline. The pole was attached at two points: a substantial, positive locking swivel on the gunwale of the vessel, and a "stiff arm" protruding from an aluminum H-beam integrated into the roof of the vessel. When deployed, the top of the transducer pole is bolted to a point on the stiff arm attachment point and clamped tight at the gunwale swivel point thereby eliminating pole movement. This configuration allows for repeatable deployment of the transducer during data acquisition and ease of retrieval for transit. -A custom-built 45-degree angled mount for the Velodyne VLP-16 LiDAR was installed on the top of the cabin roof and forward of the multibeam transducer pole.	
Dimensions	*LOA*	7.9m
	Beam	2.6m
	Max Draft	0.6m
Most Recent Full Static Survey	*Date*	2017-07-27
	Performed By	A full static survey of the RV Osprey was conducted on July 27, 2017 by OSI. The survey established permanent onboard benchmarks within the fixed vessel reference frame to include: vessel reference point (RP), draft measurement locations and sensor mounting locations. The points were surveyed using a precision total station while the vessel was hauled out on land.
Most Recent Partial Offset Verification	*Date*	2020-07-17
	Method	Relevant offsets established by the 2017 total-station survey were confirmed during the 2020 vessel mobilization with a steel tape measure.

Figure 2: RV Osprey configured for hydrographic survey operations.

A.1.3 RV Ready 2

<table>
<tr><td>Vessel Name</td><td colspan="2">RV Ready 2</td></tr>
<tr><td>Hull Number</td><td colspan="2">Registration No. CT 8934 AX</td></tr>
<tr><td>Description</td><td colspan="2">RV Ready 2 is a 7.6-meter fiberglass vessel powered by twin 150 HP outboard engines. The RV Ready 2 was modified by Ocean Surveys, Inc. (OSI) for hydrographic survey operations:

-Survey system control modules (processors) and computer systems were installed at purpose-built work stations in the main cabin of the vessel.
-An indexed Inertial Measurement Unit (IMU) mounting plate is permanently installed on the starboard side of the vessel forward of the approximate pitch center of rotation inside the cabin. The POS MV IMU was installed on this plate and was related to the approximate center of rotation with offsets entered into the POS MV controller software (POSView).
-A retractable multibeam transducer pole, constructed of thick-wall stainless steel pipe, was attached to the starboard side of the vessel at the approximate pitch centerline. The pole was attached at two points: a substantial, positive locking swivel on the gunwale of the vessel, and a “stiff arm” protruding from an aluminum H-beam integrated into the roof of the vessel. When deployed, the top of the transducer pole is bolted to a point on the stiff arm attachment point and clamped tight at the gunwale swivel point thereby eliminating pole movement. This configuration allows for repeatable deployment of the transducer during data acquisition and ease of retrieval for transit.
-A custom-built 45-degree angled mount for the Velodyne VLP-16 LiDAR was installed on the top of the cabin roof and forward of the multibeam transducer pole.</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>7.6m</td></tr>
<tr><td>Beam</td><td>2.9m</td></tr>
<tr><td>Max Draft</td><td>0.8m</td></tr>
<tr><td rowspan="2">Most Recent Full Static Survey</td><td>Date</td><td>2020-07-20</td></tr>
<tr><td>Performed By</td><td>A full static survey of the RV Ready 2 was conducted on July 20, 2020 by OSI. The survey established permanent onboard benchmarks within the fixed vessel reference frame to include: vessel reference point (RP), draft measurement locations and sensor mounting locations. The points were surveyed using a precision total station while the vessel was hauled out on land.</td></tr>
<tr><td rowspan="2">Most Recent Partial Offset Verification</td><td>Date</td><td>2020-07-21</td></tr>
<tr><td>Method</td><td>Relevant offsets established by the 2020 total-station survey were confirmed during the 2020 vessel mobilization with a steel tape measure.</td></tr>
</table>

Figure 3: RV Ready 2 configured for hydrographic survey operations.

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Teledyne-Reson SeaBat T50-R

All vessels used Teledyne Reson SeaBat T50-R multibeam echosounders (MBES). The SeaBat T50-R is a shallow-water MBES system with available operational frequencies of 190 kHz to 420 kHz. The system is roll-stabilized and has multiple options for beam spacing (equidistant or equiangle), swath angle, and range. The manufacturer's stated depth resolution is 6mm. For this project, all vessels operated at 400 kHz and at a maximum swath angle of 140 degrees. For the majority of the survey, vessels used the 512-equidistant beam configuration. However, when approaching some potentially shallow or hazardous areas or features, the system was switched to equiangle beam mode with 15 degree beam steering to starboard. This provided an added measure of safety as the vessel mapped towards the hazard. In addition to sounding data, the SeaBat T-50R systems collected and recorded "normalized" backscatter data (the 7058 datagram).

Manufacturer	Teledyne-Reson				
Model	SeaBat T50-R				
Inventory	*RV Able 2*	*Component*	Processor	Receiver	Projector
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08943519090	0220014	4319043
		Frequency	400 kHz	400 kHz	400 kHz
		Calibration	N/A	2020-07-21	2020-07-21
		Accuracy Check	N/A	N/A	N/A
	RV Osprey	*Component*	Processor	Receiver	Projector
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08940820103	1320184	0320026
		Frequency	400 kHz	400 kHz	400 kHz
		Calibration	N/A	2020-07-26	2020-07-26
		Accuracy Check	N/A	N/A	N/A
	RV Ready 2	*Component*	Processor	Receiver	Projector
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08940820102	1320183	0320028
		Frequency	400 kHz	400 kHz	400 kHz
		Calibration	N/A	2020-07-31	2020-07-31
		Accuracy Check	N/A	N/A	N/A

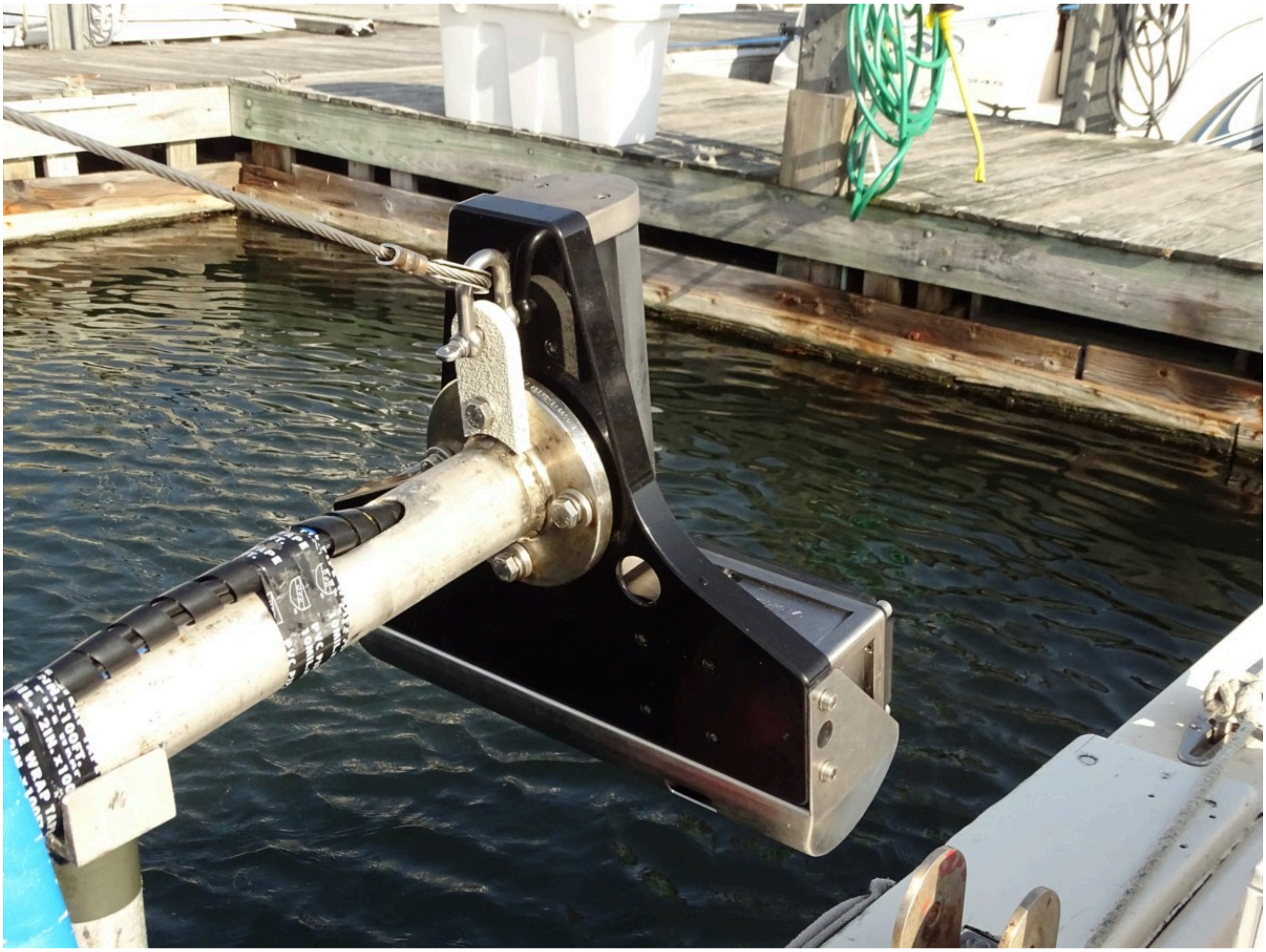

Figure 4: SeaBat T50-R transducer mounted on the RV Able 2 transducer pole.

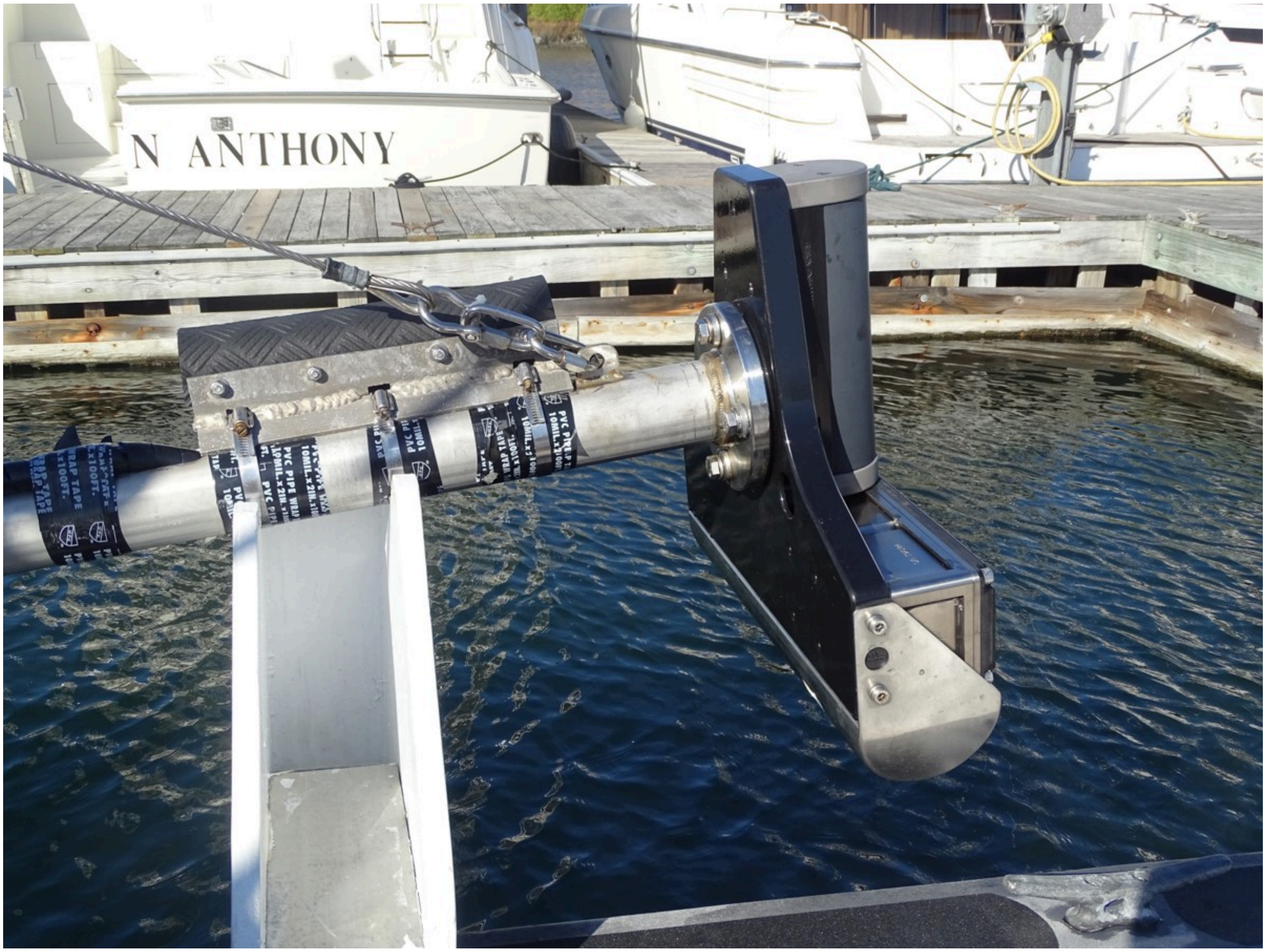

Figure 5: SeaBat T50-R transducer mounted on the RV Osprey transducer pole.

Figure 6: SeaBat T50-R transducer mounted on the RV Ready 2 transducer pole.

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

No side scan sonars were utilized for data acquisition.

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

A.2.5.1 Velodyne LiDAR PUCK VLP-16

The Velodyne VLP-16 is a real-time 3D LiDAR sensor with 16 beams. According to the manufacturer it has a range of 100 m, a 30 degree vertical field of view, and a 360 degree horizontal field of view. System accuracy is reported as 3cm at the maximum range. Rotation speed can be set between 300 RPM and 1200 RPM. The LiDAR is capable of collecting approximately 300,000 points/second. For this survey the LiDAR mounting approach and configuration was the same for all three vessels. The LiDAR was installed on a custom 45 degree mount on the starboard side just forward of the multibeam transducer pole. Of the 16 beams, only the outer two and the inner two were enabled during data collection. An angle filter and a minimum range filter of 2-5 meters were applied to filter out the physical parts of the vessel and its wake. Rotation speed was set at 600 RPM at which the manufacturer states the horizontal angular (azimuth) resolution is 0.2 degrees. A DJI OSMO action camera was mounted below the LiDAR mount to capture digital photographs when the LiDAR was collecting data. Photographs were collected in 4K with a 16:9 aspect ratio at a 2Hz rate. The camera was interfaced via Bluetooth to an Amazon Fire Tablet. Using the camera application installed on the tablet, field crews were able to start and stop recording and see a real time camera field of view from the inside of the cabin.

Manufacturer	Velodyne		
Model	LiDAR PUCK VLP-16		
Inventory	*RV Able 2*	*Component*	Laser Scanner
		Model Number	VLP-16
		Serial Number	11002200826135
		Frequency	N/A
		Calibration	2020-07-22
		Accuracy Check	N/A
	RV Osprey	*Component*	Laser Scanner
		Model Number	VLP-16
		Serial Number	11002200823328
		Frequency	N/A
		Calibration	2020-07-23
		Accuracy Check	N/A
	RV Ready 2	*Component*	Laser Scanner
		Model Number	VLP-16
		Serial Number	11002200869916
		Frequency	N/A
		Calibration	2020-07-31
		Accuracy Check	N/A

Figure 7: Velodyne VLP-16 LiDAR mounted on the RV Able 2.

Figure 8: Velodyne VLP-16 LiDAR mounted on the RV Osprey.

Figure 9: Velodyne VLP-16 LiDAR mounted on the RV Ready 2.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

Each vessel was equipped with a lead line for spot-soundings and echosounder verification checks. Lead lines were constructed by OSI using a 9 kilogram metal disk with a diameter of 0.3m. The metal disk was attached to a stainless steel cable with permanent index markers established at 1m intervals. The lead lines were calibrated prior to survey operations using a steel tape measure to verify index mark accuracy (see DAPR Appendix V for results).

Manufacturer	OSI		
Model	Lead Line/Bar Check		
Inventory	*RV Able 2*	*Component*	Lead Line
		Model Number	N/A
		Serial Number	NOAA 1
		Calibration	2020-07-13
	RV Osprey	*Component*	Lead Line
		Model Number	N/A
		Serial Number	BM 2020
		Calibration	2020-07-13
	RV Ready 2	*Component*	Lead Line
		Model Number	N/A
		Serial Number	75-1
		Calibration	2020-07-13

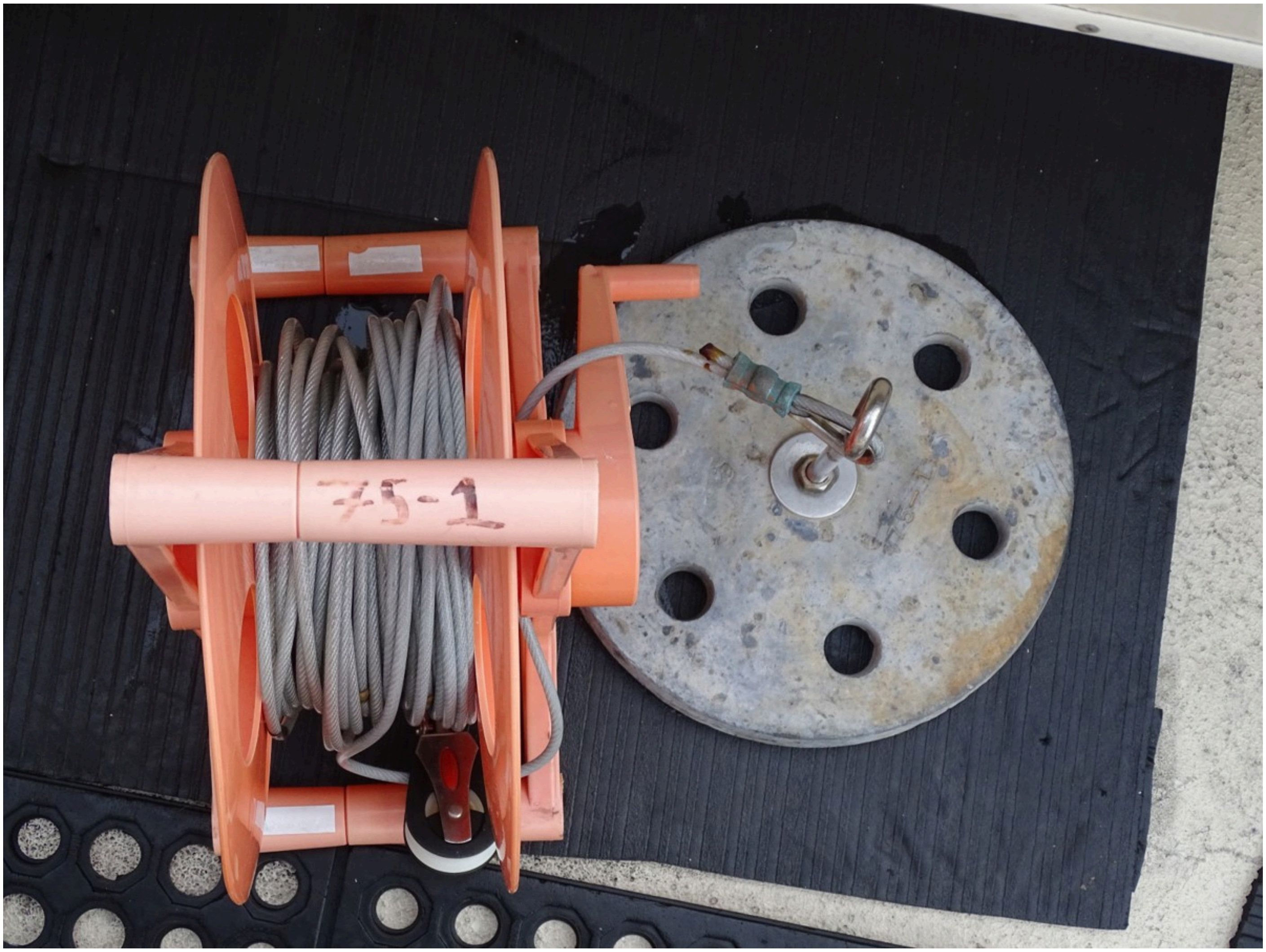

Figure 10: OSI-built lead line

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

A.4.1.1 Trimble NetR9

OSI supplemented the local CORS network with a temporary GNSS base station at Imperial Yacht Club in New Rochelle, New York. A Trimble NetR9 GNSS receiver with a Zephyr 3 Geodetic Antenna 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. The configuration of the receiver was based on UNAVCO standard configuration settings for this device. In addition to recording GNSS observables, OSNR was also configured to transmit CMR+ RTK correctors to all vessels for realtime water level measurement and monitoring.

GNSS observables were recorded on removable media as well as on the receiver's internal storage. Data were delivered to OSI’s home-office processing center by regular automated FTP and e-mail “pushes” over a network connection that was established on site for this purpose. The Trimble NetR9 data was included in IAPPK processing and designated as Ocean Surveys New Rochelle or “OSNR.” The coordinates of OSNR were determined using OPUS. A discussion of OPUS data processing and the determination of final coordinates is included in the HVCR.

On October 2, 2020 (DN276), the GNSS antenna of OSNR was temporarily removed and then re-installed by an Imperial Yacht Club electrician performing maintenance on the roof. When it was re-installed, the antenna was shifted to a new location approximately 0.5m away from the original installation. Additional details regarding this event including post-event OPUS processing and confirmation are included in the HVCR.

<table>
<tr><td>Manufacturer</td><td colspan="3">Trimble</td></tr>
<tr><td>Model</td><td colspan="3">NetR9</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>Receiver</td><td>Zephyr 3 Geodetic GNSS Antenna</td></tr>
<tr><td>Model Number</td><td>NetR9</td><td>115000-00</td></tr>
<tr><td>Serial Number</td><td>5811R52419</td><td>6122223813</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
</table>

Figure 11: GNSS Base Station OSNR. Left image is original installation. Right image is the new location after 10/2/20.

A.4.2 Rover Equipment

A.4.2.1 Trimble R8 GNSS Rover with TSC3 data collector

The Trimble R8 GNSS is an integrated receiver/antenna combination unit. The rover was used to install temporay navigation confidence checks for each vessel at their respective docks. See the HVCR for a discussion of these points.

<table>
<tr><td><i>Manufacturer</i></td><td>Trimble</td></tr>
<tr><td><i>Model</i></td><td>R8 GNSS Rover with TSC3 data collector</td></tr>
<tr><td><i>Inventory</i></td><td>
<table>
<tr><td><i>Component</i></td><td>GNSS Rover</td><td>Data Collector</td></tr>
<tr><td><i>Model Number</i></td><td>R8 Model 3</td><td>TSC3</td></tr>
<tr><td><i>Serial Number</i></td><td>5114465197</td><td>RG1F223827</td></tr>
<tr><td><i>Calibration</i></td><td>N/A</td><td>N/A</td></tr>
</table>
</td></tr>
</table>

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix POS MV 320 V5

The POS MV is a GNSS inertial navigation and attitude system made up of 2 GNSS antennas and an inertial measurement unit (IMU) interfaced with a topside processor. The POS MV combines the IMU and GNSS sensor data into an integrated and blended navigation solution. Per manufacturer’s literature there are two navigation algorithms incorporated into the system, namely a tightly coupled and a loosely coupled inertial/GNSS integration. Tightly coupled inertial/GNSS integration involves the processing of GNSS pseudo range, phase and Doppler observables. In this case, the GNSS receiver is strictly a sensor of the GNSS observables and the navigation functions in the GNSS receiver are not used. With loosely coupled inertial/GNSS integration, the GNSS position and velocity solution are processed to aid the inertial navigator.

The POS MV generates attitude data in three axes (roll, pitch, and heading). Roll and pitch measurements are made within an accuracy of 0.02°. Heave measurements supplied by the POS MV maintain an accuracy of 0.05 m or 5% of the measured vertical displacement for movements that have a period of up to 20 seconds.

The GNSS Azimuth Measurement Subsystem (GAMS) allows the POS MV system to achieve high-accuracy heading measurement. The GAMS subsystem uses two GNSS receivers and antennas to determine a GNSS-enhanced heading that is accurate to 0.02° or better (using an antenna baseline greater than or equal to 2m) when blended with the inertial navigation solution. The system uses this heading information together with the position, velocity and raw observations supplied by the primary GNSS receiver. GAMS heading was employed for all survey data acquisition, and GAMS status was monitored continuously during survey operations using POSView, the POS MV's controller software.

On the vessel RV Ready 2, the field crew noticed intermittent position and GAMS heading accuracies above the stated manufacturer's accuracies. On 8/24/20 (DN237), the port (secondary) GNSS antenna was replaced. Intermittent higher than normal accuracies were still observed after the swap. On 8/31/20

(DN244) the starboard (primary) GNSS antenna was replaced. Normal position and GAMS heading accuracies were observed thereafter.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="2">Applanix</td></tr>
<tr><td><i>Model</i></td><td colspan="2">POS MV 320 V5</td></tr>
<tr><td rowspan="3"><i>Inventory</i></td><td><i>RV Able 2</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Topside</td><td>IMU</td><td>GPS Antenna (Stbd.)</td><td>GPS Antenna (Port)</td></tr>
<tr><td><i>Model Number</i></td><td>POS MV V5</td><td>LN 200</td><td>GA830</td><td>GA830</td></tr>
<tr><td><i>Serial Number</i></td><td>6415</td><td>390</td><td>12189</td><td>9435</td></tr>
<tr><td><i>Calibration</i></td><td>2020-07-16</td><td>2020-07-16</td><td>2020-07-16</td><td>2020-07-16</td></tr>
</table>
</td></tr>
<tr><td><i>RV Osprey</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Topside</td><td>IMU</td><td>GPS Antenna (Stbd.)</td><td>GPS Antenna (Port)</td></tr>
<tr><td><i>Model Number</i></td><td>POS MV V5</td><td>64</td><td>GA830</td><td>GA830</td></tr>
<tr><td><i>Serial Number</i></td><td>10351</td><td>518</td><td>8360</td><td>8367</td></tr>
<tr><td><i>Calibration</i></td><td>2020-07-26</td><td>2020-07-26</td><td>2020-07-26</td><td>2020-07-26</td></tr>
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</td></tr>
<tr><td><i>RV Ready 2</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Topside</td><td>IMU</td><td>GPS Antenna (Stbd.)</td><td>GPS Antenna (Port)</td><td>GPS Antenna (Port)</td><td>GPS Antenna (Stbd.)</td></tr>
<tr><td><i>Model Number</i></td><td>POS MV V5</td><td>LN 200</td><td>GA830</td><td>GA830</td><td>GA830</td><td>GA830</td></tr>
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</table>
</td></tr>
</table>

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

A.5.3.1 Trimble SPS850 Extreme GNSS

On all vessels, a Trimble SPS850 Extreme (operating in RTK mode), served as an independent position check of the POS MV, and as a tool to map realtime water levels.

Manufacturer	Trimble			
Model	SPS850 Extreme GNSS			
Inventory	*RV Able 2*	*Component*	Receiver	Antenna
		Model Number	58805-66	Zephyr Model 2
		Serial Number	5023K67948	30572582
		Calibration	N/A	N/A
	RV Osprey	*Component*	Receiver	Antenna
		Model Number	58805-64	Zephyr Model 2
		Serial Number	4726K06460	30572609
		Calibration	N/A	N/A
	RV Ready 2	*Component*	Receiver	Antenna
		Model Number	58805-90	Zephyr Model 2
		Serial Number	4708K04800	4611118555
		Calibration	N/A	N/A

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

No additional positioning and attitude equipment was utilized for data acquisition.

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

No CTD profilers were utilized for data acquisition.

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic Micro-X Sound Speed Sensor

On all vessels, an AML Micro-X was mounted within the forward faring of the MBES and supplied real-time surface sound speed data to the MBES for beam forming and to the HYPACK acquisition computer via the Reson interface. The Micro-X uses a direct read sound speed “exchange” sensor.

Manufacturer	AML Oceanographic			
Model	Micro-X Sound Speed Sensor			
Inventory	*RV Able 2*	*Component*	Sonde	Sound Speed Sensor
		Model Number	Micro-X	SV-Exchange
		Serial Number	10817	201521
		Calibration	N/A	2020-02-28
	RV Osprey	*Component*	Sonde	Sound Speed Sensor
		Model Number	Micro-X	SV-Exchange
		Serial Number	12737	209651
		Calibration	N/A	2020-07-11
	RV Ready 2	*Component*	Sonde	Sound Speed Sensor
		Model Number	Micro-X	SV-Exchange
		Serial Number	12739	209669
		Calibration	N/A	2020-07-11

A.6.3.2 AML Oceanographic Base X and Base X2 Sound Speed Profilers

On all vessels, sound speed profiles were acquired using an AML Oceanographic Base-X or Base-X2 logging profiler. This instrument collects high-precision direct sound speed and pressure measurements. The instrument was configured to take measurements at a rate of 5 Hz. The data was stored internally and downloaded via a serial connection to the SeaCast software program on the logging laptop computer.

On the RV Osprey, the field crew was unable to download the data off the profiler on 10/17/20 (DN291). The internal memory of the profiler was full and the field crew could not clear the previously collected data. It was replaced with a fully calibrated spare Base X2 profiler.

<table>
<tr><td><i>Manufacturer</i></td><td>AML Oceanographic</td></tr>
<tr><td><i>Model</i></td><td>Base X and Base X2 Sound Speed Profilers</td></tr>
<tr><td><i>Inventory</i></td><td>
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<tr><td><i>RV Able 2</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Sonde</td><td>Sound Speed Sensor</td><td>Pressure Sensor</td></tr>
<tr><td><i>Model Number</i></td><td>Base-X2</td><td>SV-Exchange</td><td>P-Exchange</td></tr>
<tr><td><i>Serial Number</i></td><td>25846</td><td>201525</td><td>304351</td></tr>
<tr><td><i>Calibration</i></td><td>N/A</td><td>2020-06-06</td><td>2020-06-06</td></tr>
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<tr><td><i>RV Osprey</i></td><td>
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<tr><td><i>Model Number</i></td><td>Base-X2</td><td>SV-Exchange</td><td>P-Exchange</td><td>Base-X2</td><td>SV-Exchange</td><td>P-Exchange</td></tr>
<tr><td><i>Serial Number</i></td><td>25838</td><td>203516</td><td>306268</td><td>26280</td><td>209454</td><td>307082</td></tr>
<tr><td><i>Calibration</i></td><td>N/A</td><td>2020-05-24</td><td>2020-05-24</td><td>N/A</td><td>2020-08-03</td><td>2020-06-25</td></tr>
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</td></tr>
<tr><td><i>RV Ready 2</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Sonde</td><td>Sound Speed Sensor</td><td>Pressure Sensor</td></tr>
<tr><td><i>Model Number</i></td><td>Base-X</td><td>SV-Exchange</td><td>P-Exchange</td></tr>
<tr><td><i>Serial Number</i></td><td>25028</td><td>208179</td><td>306256</td></tr>
<tr><td><i>Calibration</i></td><td>N/A</td><td>2020-05-24</td><td>2020-05-24</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
HYPACK	Hypack Survey	20.2.0.0	Navigation and data collection
HYPACK	Hysweep Survey	20.2.0.0	MBES, backscatter and LiDAR collection
HYPACK	MB Max 64	20.2.7	Field processing for data QC and calibrations of MBES
Applanix	POSPac MMS	8.3 SP1	IAPPK proscessing to final SBETs and ERS Tides
Applanix	MV POS View	10.3	Monitoring and logging of POS MV data aboard the RV Osprey and RV Ready 2
Applanix	MV POS View	8.46	Monitoring and logging of POS MV data aboard the RV Able 2
Teledyne CARIS	HIPS/SIPS	10.4.3	Processing of MBES and Features
Teledyne CARIS	Notebook	3.1.1	Feature Management and Review
Global Mapper Software, LLC	Global Mapper	19.1	Data review and reporting
AML Oceanographic	SeaCast	4.4.0	Configuring and downloading sound speed profiles
Microsoft	Office Suite	14.0.7229.5	Survey logs, notes and processing sound speed profiles
Mathworks	MATLAB	R2010b	ERS tide smoothing and processing
UNH-CCOM/NOAA	HydroOffice QC Tools	2	Automated QC of project deliverables (surfaces, feature attribution, grid statistics, grid holidays, designated soundings, directory structure of deliverables).
NOAA HSTP	XMLDR	19.4 (r10456)	Compilation and printing (PDF) of project reports (DAPR, DR).
National Geodetic Survey	OPUS Projects	4.2	QC and processing of OSI-Installed GNSS base station data.

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 WILDCO Ponar Dredge

The WILDCO Ponar Dredge is a stainless steel bottom sampler with 9 inch scoops. The bottom sampler was deployed from with a davit on the port side of the vessel. During deployment, the sampler is held in the open position by a spring-loaded catch pin. Once the sampler hits bottom and the line slacks, the catch pin is released. Hauling on the retrieval line causes the scoops to close and capture the bottom sample which is then brought to the surface for description and documentation.

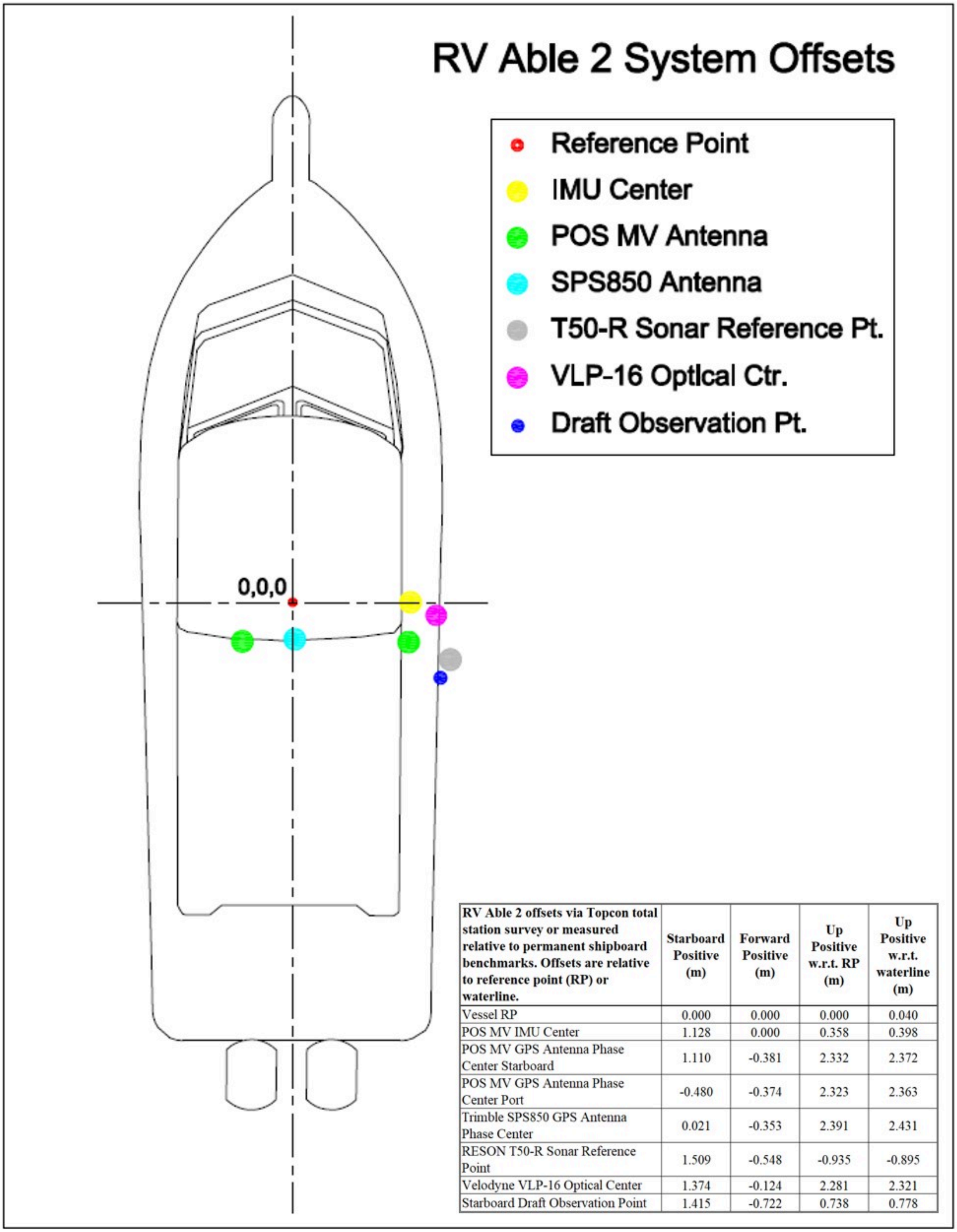
Figure 12: WILDCO Ponar Dredge Bottom Sampler used on the RV Osprey

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

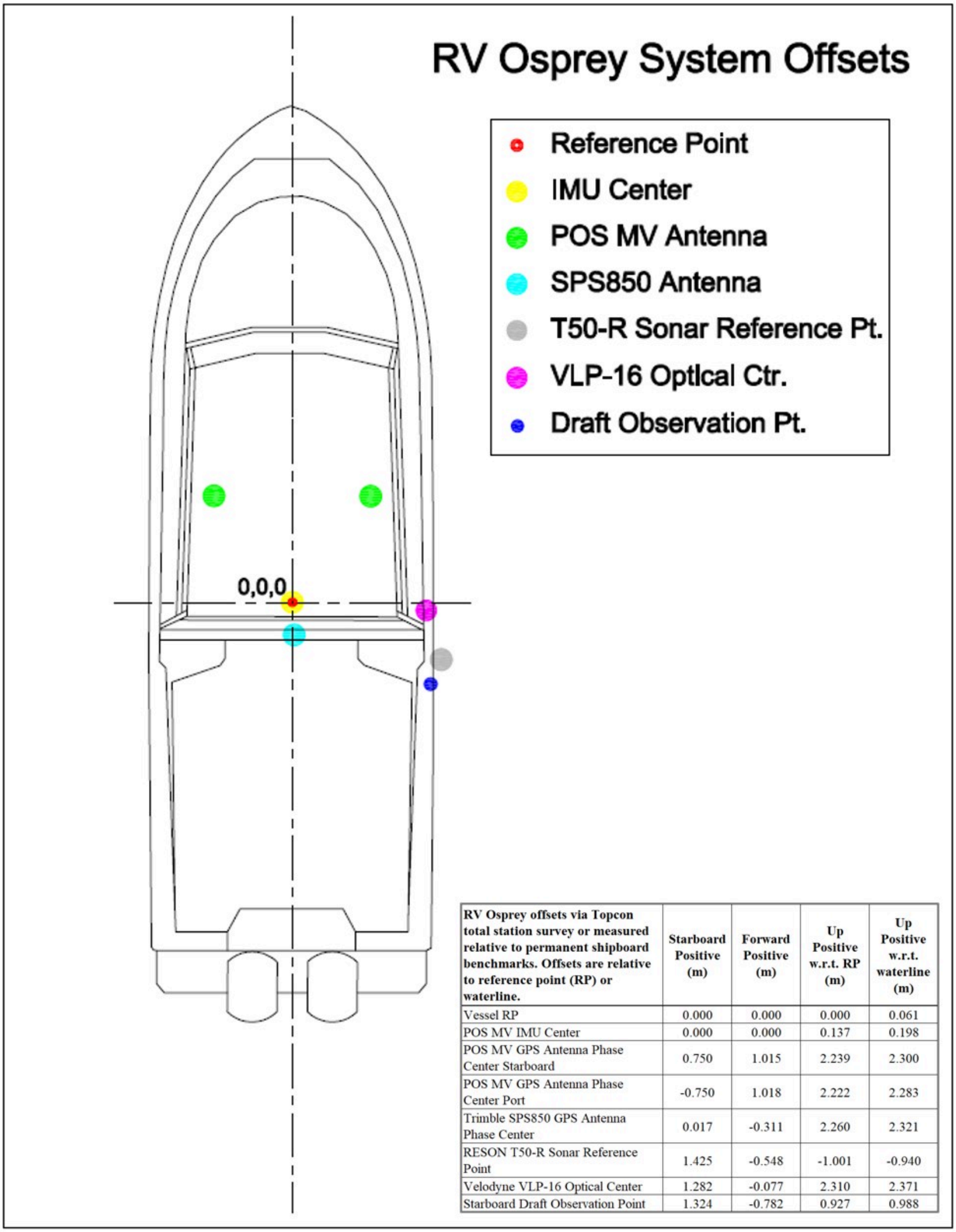
B.1.1 Vessel Offsets

Sensor offsets for each vessel were measured relative to their respective reference point (RP). Offsets and on-board benchmarks were established in the vessel reference frame during full static surveys (on land) and confirmed in the field using a steel tape measure. On the RV Able 2, the RP is located on the deck just forward of the cabin entrance along the centerline of the vessel and at the approximate pitch center of rotation. The POS MV IMU is located 1.128m starboard of RP, on the approximate pitch center of rotation and the IMU "bullseye" target is 0.358m above the RP. On the RV Osprey, the RP is located on the center of the IMU mounting plate just forward and port of the cabin entrance along the centerline of the vessel and at the approximate pitch center of rotation. The POS MV IMU is mounted directly over the RP with the IMU "bullseye" target 0.137m above the RP. On the RV Ready 2, the RP is located on the deck just aft of the cabin entrance along the centerline of the vessel and at the approximate pitch center of rotation. The POS MV IMU is located inside the cabin 0.919m starboard and 0.433m forward of the RP. The IMU "bullseye" target is 0.059m below the RP. For all vessels, the RP to IMU and RP to primary GNSS antenna lever arm offsets are applied in the POS MV configuration. Multibeam transducer and LiDAR offsets were measured and applied relative to each vessel's RP and did not change during the survey. All sensor offsets and estimated measurement accuracies were incorporated into the CARIS vessel configuration file (HVF) for each vessel.



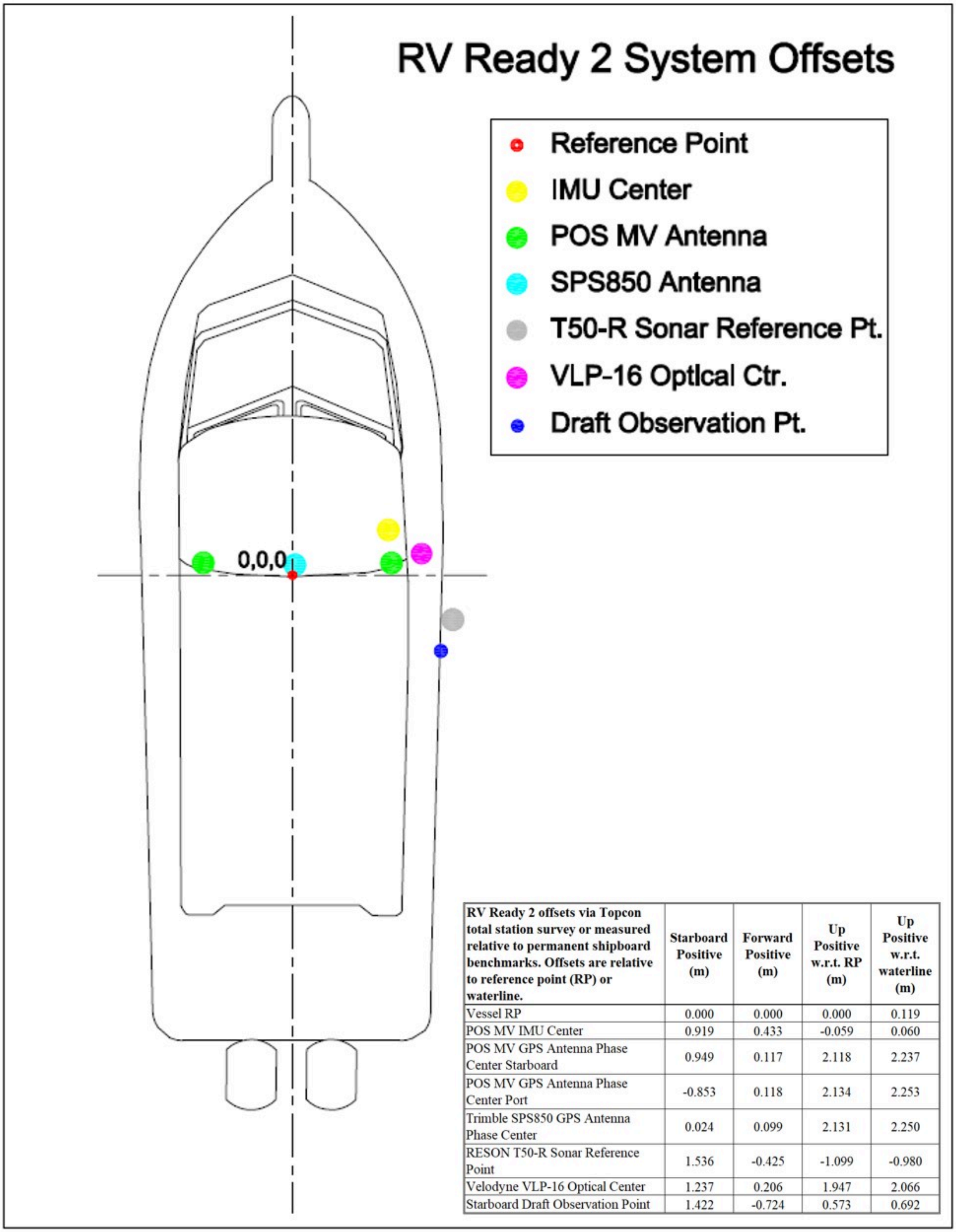
RV Able 2 offsets via Topcon total station survey or measured relative to permanent shipboard benchmarks. Offsets are relative to reference point (RP) or waterline.	Starboard Positive (m)	Forward Positive (m)	Up Positive w.r.t. RP (m)	Up Positive w.r.t. waterline (m)
Vessel RP	0.000	0.000	0.000	0.040
POS MV IMU Center	1.128	0.000	0.358	0.398
POS MV GPS Antenna Phase Center Starboard	1.110	-0.381	2.332	2.372
POS MV GPS Antenna Phase Center Port	-0.480	-0.374	2.323	2.363
Trimble SPS850 GPS Antenna Phase Center	0.021	-0.353	2.391	2.431
RESON T50-R Sonar Reference Point	1.509	-0.548	-0.935	-0.895
Velodyne VLP-16 Optical Center	1.374	-0.124	2.281	2.321
Starboard Draft Observation Point	1.415	-0.722	0.738	0.778

Figure 13: RV Able 2 Systems Layout



RV Osprey offsets via Topcon total station survey or measured relative to permanent shipboard benchmarks. Offsets are relative to reference point (RP) or waterline.	Starboard Positive (m)	Forward Positive (m)	Up Positive w.r.t. RP (m)	Up Positive w.r.t. waterline (m)
Vessel RP	0.000	0.000	0.000	0.061
POS MV IMU Center	0.000	0.000	0.137	0.198
POS MV GPS Antenna Phase Center Starboard	0.750	1.015	2.239	2.300
POS MV GPS Antenna Phase Center Port	-0.750	1.018	2.222	2.283
Trimble SPS850 GPS Antenna Phase Center	0.017	-0.311	2.260	2.321
RESON T50-R Sonar Reference Point	1.425	-0.548	-1.001	-0.940
Velodyne VLP-16 Optical Center	1.282	-0.077	2.310	2.371
Starboard Draft Observation Point	1.324	-0.782	0.927	0.988

Figure 14: RV Osprey Systems Layout



RV Ready 2 offsets via Topcon total station survey or measured relative to permanent shipboard benchmarks. Offsets are relative to reference point (RP) or waterline.	Starboard Positive (m)	Forward Positive (m)	Up Positive w.r.t. RP (m)	Up Positive w.r.t. waterline (m)
Vessel RP	0.000	0.000	0.000	0.119
POS MV IMU Center	0.919	0.433	-0.059	0.060
POS MV GPS Antenna Phase Center Starboard	0.949	0.117	2.118	2.237
POS MV GPS Antenna Phase Center Port	-0.853	0.118	2.134	2.253
Trimble SPS850 GPS Antenna Phase Center	0.024	0.099	2.131	2.250
RESON T50-R Sonar Reference Point	1.536	-0.425	-1.099	-0.980
Velodyne VLP-16 Optical Center	1.237	0.206	1.947	2.066
Starboard Draft Observation Point	1.422	-0.724	0.573	0.692

Figure 15: RV Ready 2 Systems Layout

B.1.1.1 Vessel Offset Correctors

Vessel	RV Able 2			
Echosounder	Teledyne-Reson SeaBat T50-R Multibeam Echosounder			
Date	2020-07-21			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	1.509 meters	0.020 meters
		y	-0.548 meters	0.020 meters
		z	-0.935 meters	0.020 meters
	Nav to Transducer	*x*	1.509 meters	0.020 meters
		y	-0.548 meters	0.020 meters
		z	-0.935 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	RV Osprey			
Echosounder	Teledyne-Reson Seabat T50-R Multibeam Echosounder			
Date	2020-07-26			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	1.425 meters	0.020 meters
		y	-0.548 meters	0.020 meters
		z	-1.001 meters	0.020 meters
	Nav to Transducer	*x*	1.425 meters	0.020 meters
		y	-0.548 meters	0.020 meters
		z	-1.001 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	RV Ready 2			
Echosounder	Teledyne-Reson SeaBat T50-R Multibeam Echosounder			
Date	2020-07-31			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	1.536 meters	0.020 meters
		y	-0.425 meters	0.020 meters
		z	-1.099 meters	0.020 meters
	Nav to Transducer	*x*	1.536 meters	0.020 meters
		y	-0.425 meters	0.020 meters
		z	-1.099 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	RV Able 2			
Echosounder	Velodyne VLP-16 LiDAR			
Date	2020-07-22			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	1.374 meters	0.020 meters
		y	-0.124 meters	0.020 meters
		z	2.281 meters	0.020 meters
	Nav to Transducer	*x*	1.374 meters	0.020 meters
		y	-0.124 meters	0.020 meters
		z	2.281 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	RV Osprey			
Echosounder	Velodyne VLP-16 LiDAR			
Date	2020-07-23			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	1.282 meters	0.020 meters
		y	-0.077 meters	0.020 meters
		z	2.310 meters	0.020 meters
	Nav to Transducer	*x*	1.282 meters	0.020 meters
		y	-0.077 meters	0.020 meters
		z	2.310 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

<table>
<tr><td><i>Vessel</i></td><td colspan="4">RV Ready 2</td></tr>
<tr><td><i>Echosounder</i></td><td colspan="4">Velodyne VLP-16 LiDAR</td></tr>
<tr><td><i>Date</i></td><td colspan="4">2020-07-31</td></tr>
<tr><td rowspan="8"><i>Offsets</i></td><td rowspan="4"><i>MRU to Transducer</i></td><td></td><td><i>Measurement</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>x</i></td><td>1.237 meters</td><td>0.020 meters</td></tr>
<tr><td><i>y</i></td><td>0.206 meters</td><td>0.020 meters</td></tr>
<tr><td><i>z</i></td><td>1.947 meters</td><td>0.020 meters</td></tr>
<tr><td rowspan="3"><i>Nav to Transducer</i></td><td><i>x</i></td><td>1.237 meters</td><td>0.020 meters</td></tr>
<tr><td><i>y</i></td><td>0.206 meters</td><td>0.020 meters</td></tr>
<tr><td><i>z</i></td><td>1.947 meters</td><td>0.020 meters</td></tr>
<tr><td><i>Transducer Roll</i></td><td><i>Roll</i></td><td>0.000 degrees</td><td></td></tr>
</table>

B.1.2 Layback

All sensors were rigidly mounted. No towed sensors were employed during this project.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft is the vertical distance of the echosounder transducer phase center below the water line with the vessel at rest. It is added to the observed sounding during data processing in CARIS HIPS. On all vessels, a draft observation point (stamped "X") was established on the starboard gunwale and aft of the echosounder transducer. During the full static survey, the vertical offset between the transducer phase center and RP and the vertical offset between the draft observation point and RP were recorded. The vertical offset between the transducer phase center and the RP was entered into the HVF Swath 1, Z-value field in CARIS for each vessel. On all vessels, during mobilization and prior to the start of the survey, direct measurements were made from a calm water surface to the draft observation point using a steel tape. These initial measure-downs were performed with the vessel at normal load and full of fuel and while keeping the roll of the boat as close to zero as possible. Starting static waterline height was then calculated by difference. Over the course of the survey, daily measure-downs were performed at dock to account for changes in waterline height due to fuel consumption and loading. These time-stamped updates were entered into CARIS under the Waterline Height field in the HVF.

B.2.1.1 Static Draft Correctors

Vessel		RV Able 2	RV Osprey	RV Ready 2
Date		2020-07-21	2020-07-26	2020-07-31
Loading		0.030 meters	0.030 meters	0.030 meters
Static Draft	*Measurement*	-0.895 meters	-0.940 meters	-0.980 meters
	Uncertainty	0.030 meters	0.030 meters	0.030 meters

B.2.2 Dynamic Draft

Dynamic draft correctors account for the vertical displacement of the transducer when a vessel is underway in relation to its position at rest.

The dynamic draft (settlement) for each vessel was measured using IAPPK SBET height measurements at average load and trim and configured for survey operations. Pairs of reciprocal lines were run at increasing speed intervals in order to mitigate the effect of current. “Drift lines” were recorded with the vessel at rest between reciprocal test runs in order to account for tidal variations. The sea-state was calm during collection.

The dynamic draft test for each vessel was performed in Long Island Sound near OSI's headquarters in Old Saybrook, CT. The tables below summarize the as-measured test results for all vessels. To populate the CARIS HVF draft table, the as-measured values shown were smoothed and densified using a 3rd order (RV Osprey and RV Ready 2) or 5th order (RV Able 2) polynomial curve fit. Settlement values entered into the CARIS HVFs were taken from the smooth curve at regular speed intervals. The fitted curves and the HVF dynamic draft correctors for all vessels are included in DAPR Appendix III.

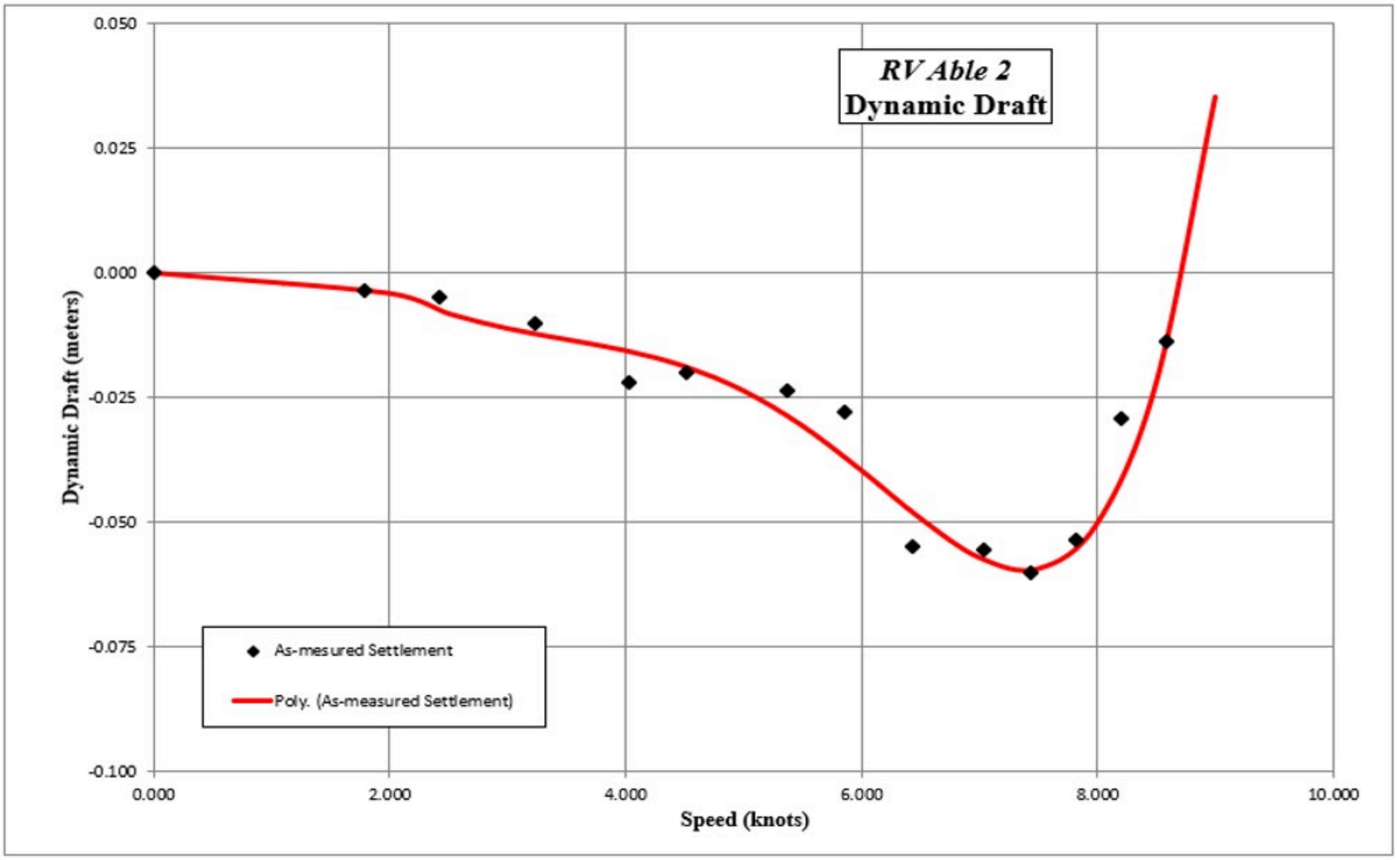


Figure 16: RV Able 2 Dynamic Draft Curve

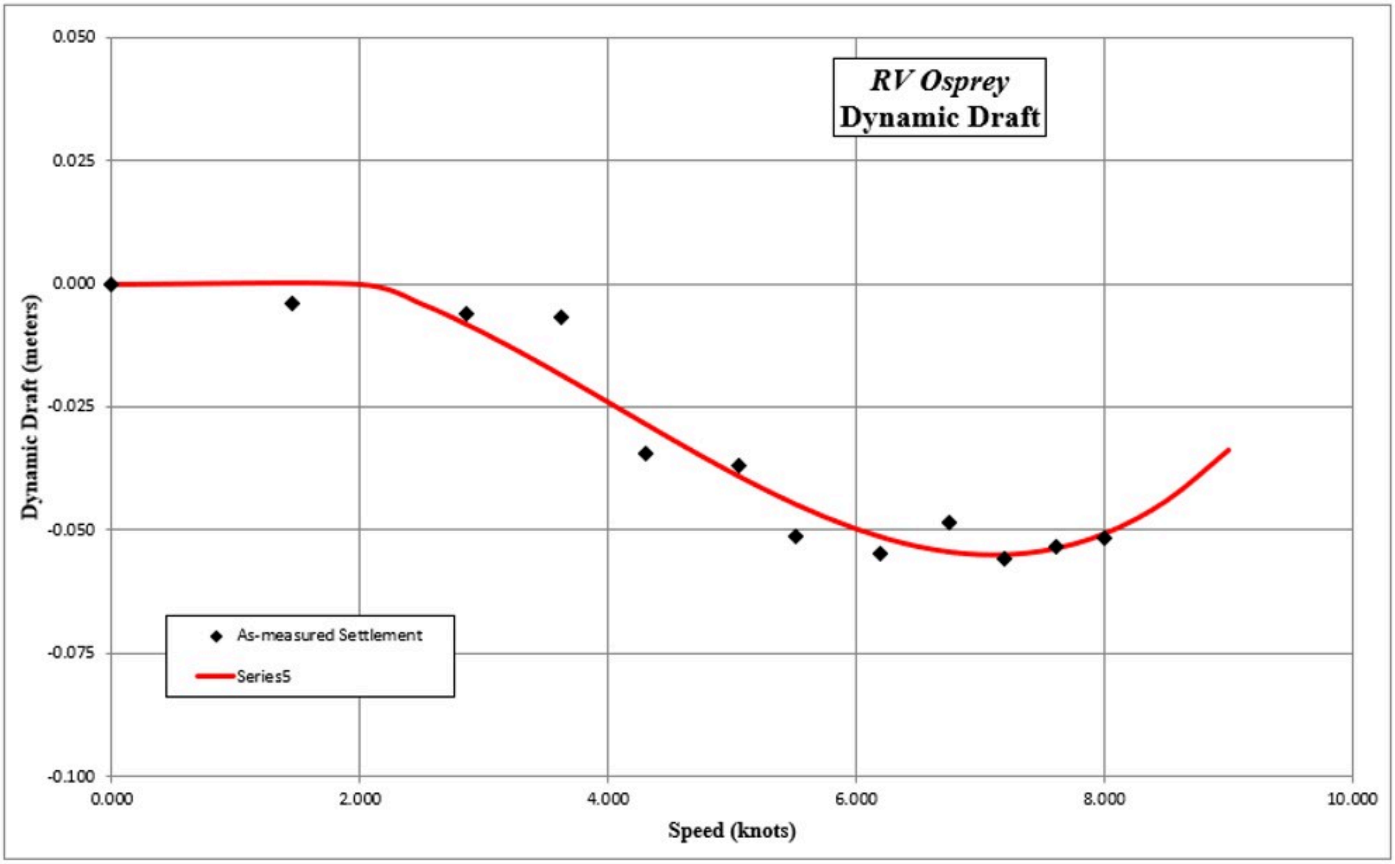


Figure 17: RV Osprey Dynamic Draft Curve

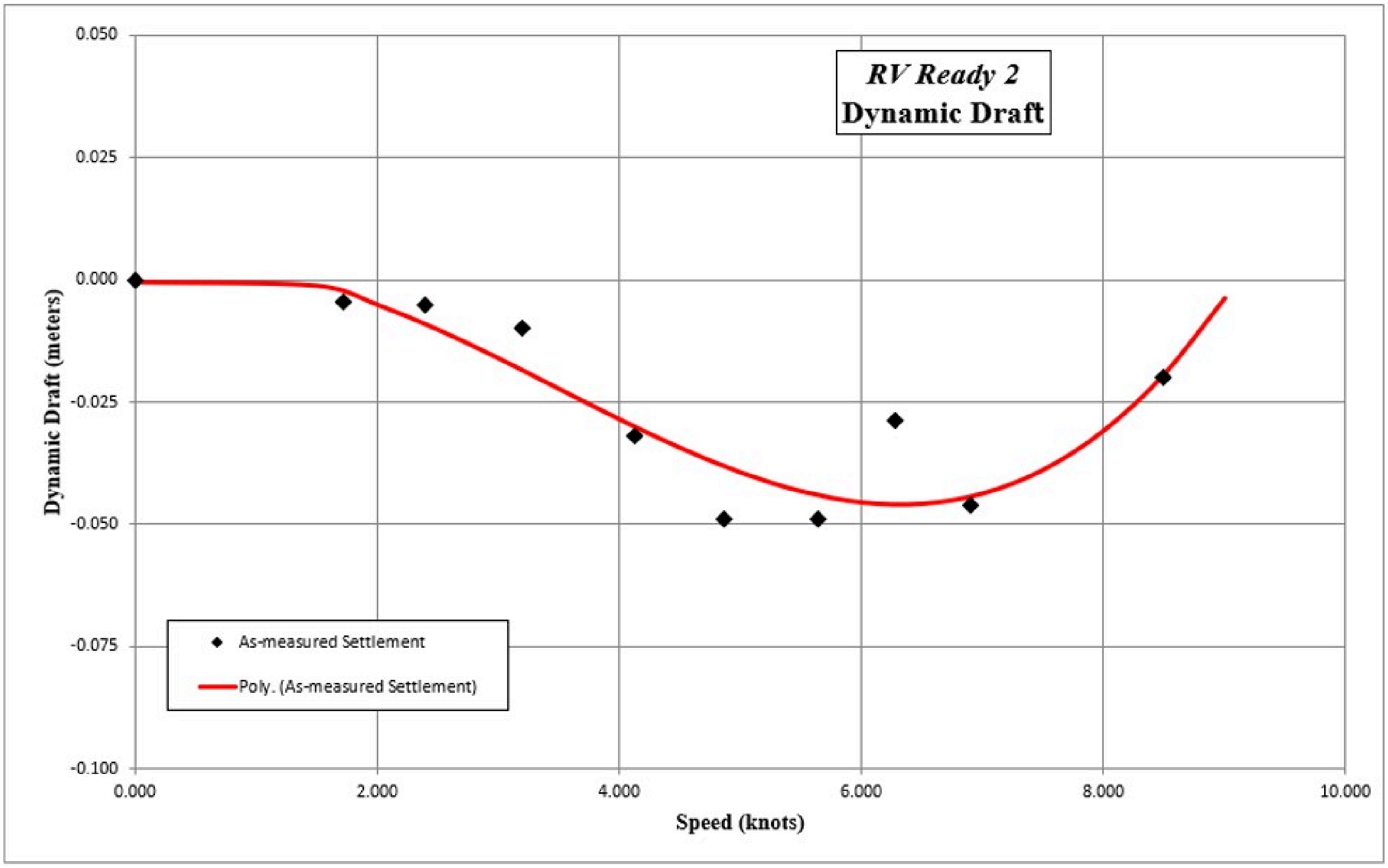


Figure 18: RV Ready 2 Dynamic Draft Curve

B.2.2.1 Dynamic Draft Correctors

Vessel	RV Able 2		RV Osprey		RV Ready 2	
Date	2020-07-21		2020-07-23		2020-07-31	
Dynamic Draft	*Speed (kt)*	*Draft (m)*	*Speed (kt)*	*Draft (m)*	*Speed (kt)*	*Draft (m)*
	0.00	0.00	0.00	0.00	0.00	0.00
	1.78	-0.00	1.46	-0.00	1.72	-0.00
	2.42	-0.00	2.86	-0.01	2.39	-0.00
	3.23	-0.01	3.62	-0.01	3.19	-0.01
	4.04	-0.02	4.30	-0.04	4.13	-0.03
	4.51	-0.02	5.06	-0.04	4.87	-0.05
	5.37	-0.02	5.51	-0.05	5.64	-0.05
	5.85	-0.03	6.19	-0.06	6.27	-0.03
	6.43	-0.06	6.74	-0.05	6.90	-0.05
	7.04	-0.06	7.19	-0.06	8.49	-0.02
	7.44	-0.06	7.61	-0.05		
	7.82	-0.05	8.00	-0.05		
	8.19	-0.03				
	8.59	-0.01				
Uncertainty	*Vessel Speed (kt)*	*Delta Draft (m)*	*Vessel Speed (kt)*	*Delta Draft (m)*	*Vessel Speed (kt)*	*Delta Draft (m)*
	0.97	0.01	0.97	0.01	0.97	0.01

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

A multibeam sonar calibration was completed for each vessel in order to determine residual navigation timing error and angular biases in roll, pitch, and heading (yaw) in the echosounder transducer alignment. Standard patch tests were conducted by each boat near OSI's headquarters of Old Saybrook, CT before data collection commenced. CMR+ corrections from a GNSS base station installed at OSI's home office were used for real-time navigation during the patch test and for field processing of patch values. Final patch values for the CARIS HVF for each vessel were determined using final SBETs. A reference surface was developed nearby in order to evaluate outer beam performance.

All vessels were equipped with retractable MBES pole mounts. To monitor any potential variability resulting from multiple pole deployments during the survey, each vessel performed abbreviated "interim" patch tests once per operating or after each deployment. For the interim patch tests, reciprocal multibeam data were collected on a short set of lines at a convenient time each day and processed onboard. If small changes in alignment (typically roll) were observed, the HVF was updated with a time-stamped entry of the new value.

A LiDAR calibration was also completed for each vessel in order to determine the angular biases of the LiDAR sensor. A mooring dolphin and a set of pilings were selected near OSI headquarters and multiple LiDAR lines were collected from multiple angles and approach distances alongside thes features. These lines were processed in both Hypack and CARIS to iteratively determine angular offsets. Final LiDAR patch values for the CARIS HVF for each vessel were determined using final SBETs.

Calibration reports and statistics for initial calibrations are included in DAPR Appendix V.

B.3.1.1 System Alignment Correctors

<table>
<tr><td><i>Vessel</i></td><td>RV Ready 2</td></tr>
<tr><td><i>Echosounder</i></td><td>Teledyne-Reson SeaBat T50-R Multibeam Echosounder</td></tr>
<tr><td><i>Date</i></td><td>2020-07-21</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
<table>
<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>-0.750 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Roll</i></td><td>0.100 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>-0.500 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td><i>Vessel</i></td><td>RV Osprey</td></tr>
<tr><td><i>Echosounder</i></td><td>Teledyne-Reson SeaBat T50-R Multibeam Echosounder</td></tr>
<tr><td><i>Date</i></td><td>2020-07-26</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
<table>
<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Roll</i></td><td>-0.660 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>1.800 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
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</td></tr>
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<table>
<tr><td><i>Vessel</i></td><td>RV Ready 2</td></tr>
<tr><td><i>Echosounder</i></td><td>Teledyne-Reson SeaBat T50-R Multibeam Echosounder</td></tr>
<tr><td><i>Date</i></td><td>2020-07-31</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
<table>
<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>-0.800 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Roll</i></td><td>0.560 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>4.400 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
</table>
</td></tr>
</table>

Vessel	RV Able 2		
Echosounder	Velodyne VLP-16 LiDAR		
Date	2020-07-22		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	44.340 degrees	0.020 degrees
	Roll	1.000 degrees	0.020 degrees
	Yaw	-0.450 degrees	0.020 degrees
	Pitch Time Correction	0.000 seconds	0.001 seconds
	Roll Time Correction	0.000 seconds	0.001 seconds
	Yaw Time Correction	0.000 seconds	0.001 seconds
	Heave Time Correction	0.000 seconds	0.001 seconds

Vessel	RV Osprey		
Echosounder	Velodyne VLP-16 LiDAR		
Date	2020-07-23		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	44.950 degrees	0.020 degrees
	Roll	-1.350 degrees	0.020 degrees
	Yaw	2.500 degrees	0.020 degrees
	Pitch Time Correction	0.000 seconds	0.001 seconds
	Roll Time Correction	0.000 seconds	0.001 seconds
	Yaw Time Correction	0.000 seconds	0.001 seconds
	Heave Time Correction	0.000 seconds	0.001 seconds

<table>
<tr><td><i>Vessel</i></td><td>RV Ready 2</td></tr>
<tr><td><i>Echosounder</i></td><td>Velodyne VLP-16 LiDAR</td></tr>
<tr><td><i>Date</i></td><td>2020-07-31</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
<table>
<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>42.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Roll</i></td><td>-2.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>1.500 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
</table>
</td></tr>
</table>

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Unless specifically noted, the acquisition steps and settings described in this section apply to all vessels.

Raw sounding data were output directly from the Reson Seabat T50-R processor to the HYPACK acquisition computer via a dedicated network card. HYPACK SURVEY and HYSWEEP SURVEY were configured to record position, heading, attitude and depth to RAW and HSX data files. For the real-time display, system offsets for the IMU and for the transducer phase center were entered into the HYPACK configuration files. These offsets were subsequently incorporated into the CARIS data processing routine. During operations, the HYSWEEP real-time MBES sounding wedge and digital terrain model (DTM) waterfall displays were monitored. The sounding wedge, DTM waterfall, and plan view coverage displays were corrected for draft, motion, tide and sound speed. Survey coverage was tracked in the HYPACK SURVEY display window with a matrix file updating in real time.

The Reson T50-R processor was interfaced with the POS MV such that UTC date and time information from the POS MV were used to accurately time stamp the Reson output data string. The Reson T50-R processor received a pulse-per-second (PPS) signal and a serial $ZDA NMEA timing string from the POS MV. The POS MV also supplied a “TSS1” message to the Reson processor for real-time roll stabilization. Surface sound speed, measured at the transducer head with the AML Micro-X, was output to the Reson T50-R processor for beam-forming. The T50-R's “Normal” filter was used for sound speed filtering.

The user interface of the Reson T50-R processor was used to configure MBES settings, to monitor sounding acquisition, and to adjust system parameters in real time. Bottom detection was optimized by adjusting power, gain, pulse length, and “ocean” settings (absorption and spreading). Most of the adjustment occurred during calibration and intital testing. For the majority of the survey, all three vessels used the same power, gain, pulse length and "ocean" settings. Additional minor adjustments were made over the course of the survey, though these were rare. Range settings were monitored and adjusted to observed depths to maximize the ping rate. The “adaptive” depth gates were employed to reject fliers during mainscheme and crossline data acquisition. Depth gate filters were used sparingly or completely disabled during item investigations.

The Reson T50-R was operated in equidistant mode using 512 return beams and a maximum swath width of 140° depending on water depth. When approaching potentially hazardous shoals and features, equiangle beam mode with 15 degree beam steering to the starboard was employed. This helped to map potential hazards further away from the vessel giving more information to the crew as they mapped towards the hazard. The roll stabilization feature was activated throughout the term of the project.

To better track and organize operations, each sheet (registry number) was divided into sub areas. Line plans, feature ID's, investigations, etc., were all organized by subarea within each sheet. Subarea deisgnations were carried through the processing workflow as well, and were used to manage feature tracking and coverage checks.

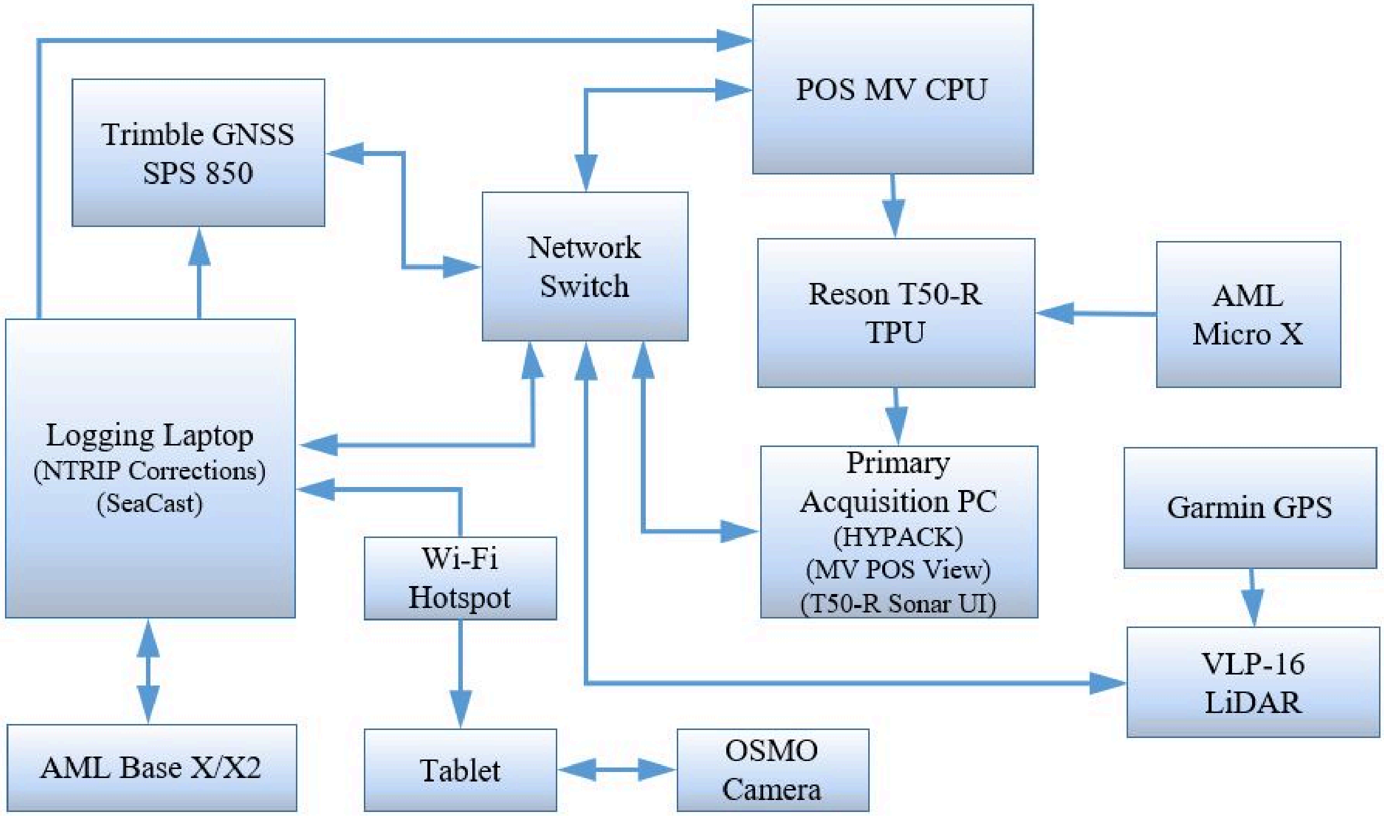


Figure 19: Acquisition Wiring Diagram for all vessels

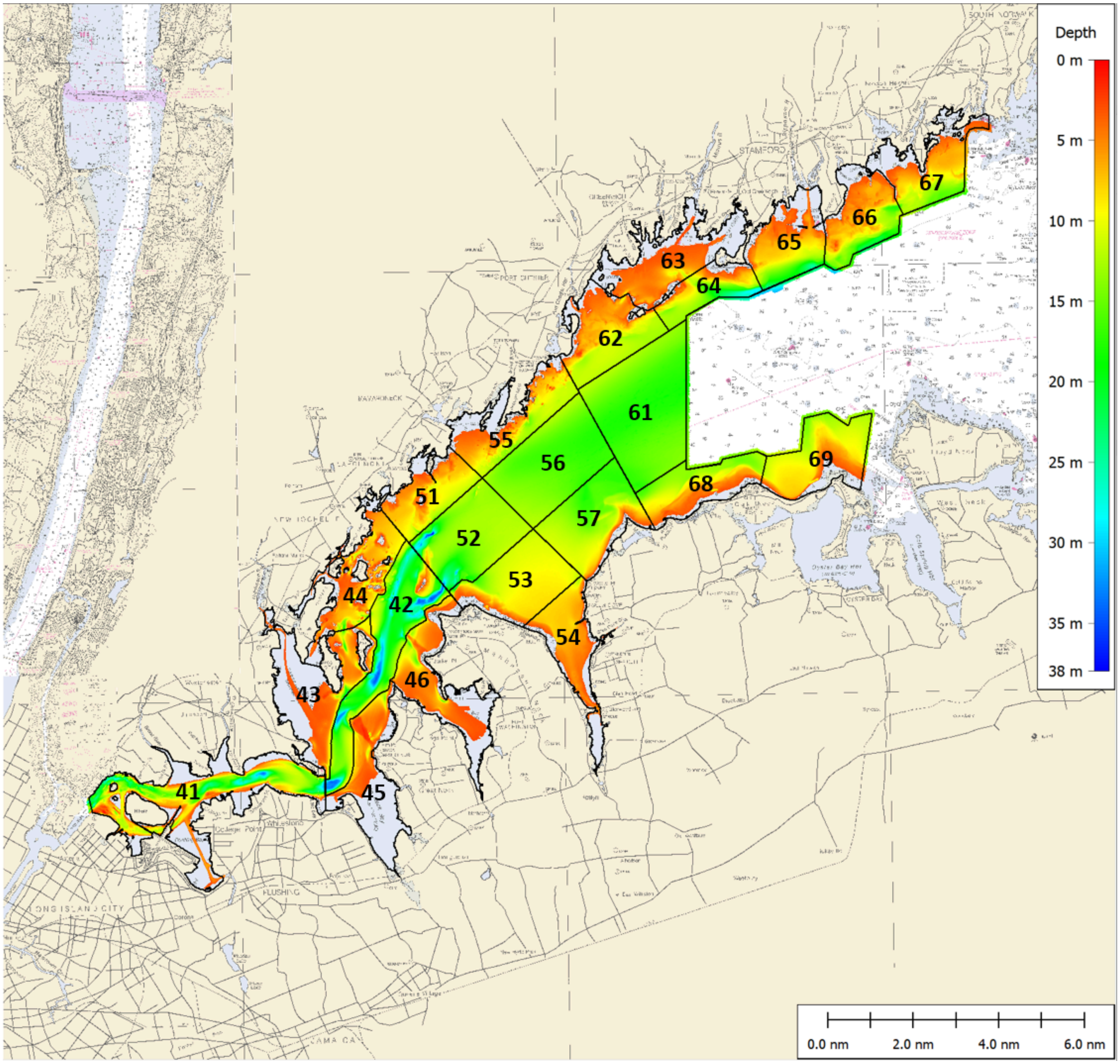


Figure 20: Subarea designations for Sheets H13384 (4X), H13385 (5X), and H13386 (6X).

Data Processing Methods and Procedures

QA/QC level processing was completed on board the survey vessels, however, all final data processing occurred at OSI's home office. For each vessel, field data was backed up daily to a portable data disk. Every night after data collection, data was uploaded from the portable data disk to OSI's S3 file server for the home office processing center to download. During field crew changes, back up data disks were also hand delivered to the office. The lag between acquisition and data check-in at the home office was about one day.

Upon receipt of nightly uploads and/or data disks, information contained in the daily acquisition log was compared to the data package to ensure that no files were lost or omitted. The acquisition log was consulted to verify line names and file size and to remove any aborted lines from the preprocess folder before converting the data in CARIS HIPS.

Multibeam sonar data conversion and the application of sounding correctors were completed using routines developed in CARIS' Process Designer. The Process Designer (model) runs a user-defined script which accomplished the following standard tasks in succession:

-Convert the HSX and RAW data to the HDCS data format, establish UTM grid.
-Enable all multibeam beams.
-Load daily TrueHeave (delayed heave) files.

After TrueHeave was loaded, the next step in CARIS' Process Designer is Georeference Bathymetry which includes these steps:

-Load and apply sound speed profile data. Sound speed profiles were loaded with the CARIS nearest in time correction method. During CARIS SVP Correction, the following correctors were applied: sound speed, heave, pitch, roll and waterline.
-Run "Compute GPS Tides" employing the provided VDatum ellipsoid separation model (SEP).
-Merge data to apply vessel offsets/alignment, position, gyro, tide, and dynamic draft correctors to bathymetry. CARIS HIPS computes the fully corrected depth and position of each sounding during the Merge process.
-Compute Total Propagated Uncertainty (TPU). TPU is calculated in CARIS HIPS from contributing uncertainties in the echosounder, positioning and motion sensor measurements as well as uncertainties associated with sound speed and water level correction.

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

Preliminary field sheets and Bathymetry Associated with Statistical Error (BASE) surfaces were created for reviewing and cleaning of full-density soundings using the Combined Uncertainty and Bathymetry Estimator (CUBE) process. BASE surfaces were "finalized" for each survey based on the coverage requirements outlined in the Project Instructions and the HSSD. Complete Coverage sheets were gridded to 0.5m resolution surfaces. Designated soundings were incorporated into the finalized BASE surfaces making certain that the least depth sounding was honored in the grid.

C.1.4.2 Depth Derivation

Attitude and navigation data were reviewed in their respective CARIS editors to ensure that there were no problems with the correctors, such as gaps in attitude data or navigation jumps.

Swath Editor was used to clean fish noise, multipath returns, and gross fliers. Soundings were colored by depth and reviewed in multi-directional profile and plan view displays. Tracklines and swath boundaries were viewed in the CARIS Map window in reference to BASE surfaces, charted data (RNC/ENC) and field annotations (HYPACK target files).

The CARIS Subset Editor was used to clean fully-corrected, geo-referenced soundings in 2-D and 3-D displays. Areas with multiple sounding coverages from adjacent survey lines were evaluated to increase confidence in outer beams and over significant features. Overlapping soundings were colored by line and reviewed to verify the validity of bathymetric features and to reject fish or water column noise. Subset boundaries were viewed in the CARIS Map window in reference to BASE surfaces and charted data (RNC/ENC).

C.1.4.3 Surface Computation Algorithm

After MBES sounding editing was complete, final BASE surfaces were created using the CUBE algorithm in CARIS HIPS/SIPS. The CUBE algorithm generates surface models from multiple hypotheses. Hypotheses with lower combined Total Propagated Uncertainty (TPU) are given higher significance for incorporation into the final surfaces. Also, soundings closest to a grid node have a greater weight on the node depth value than soundings that are further away.

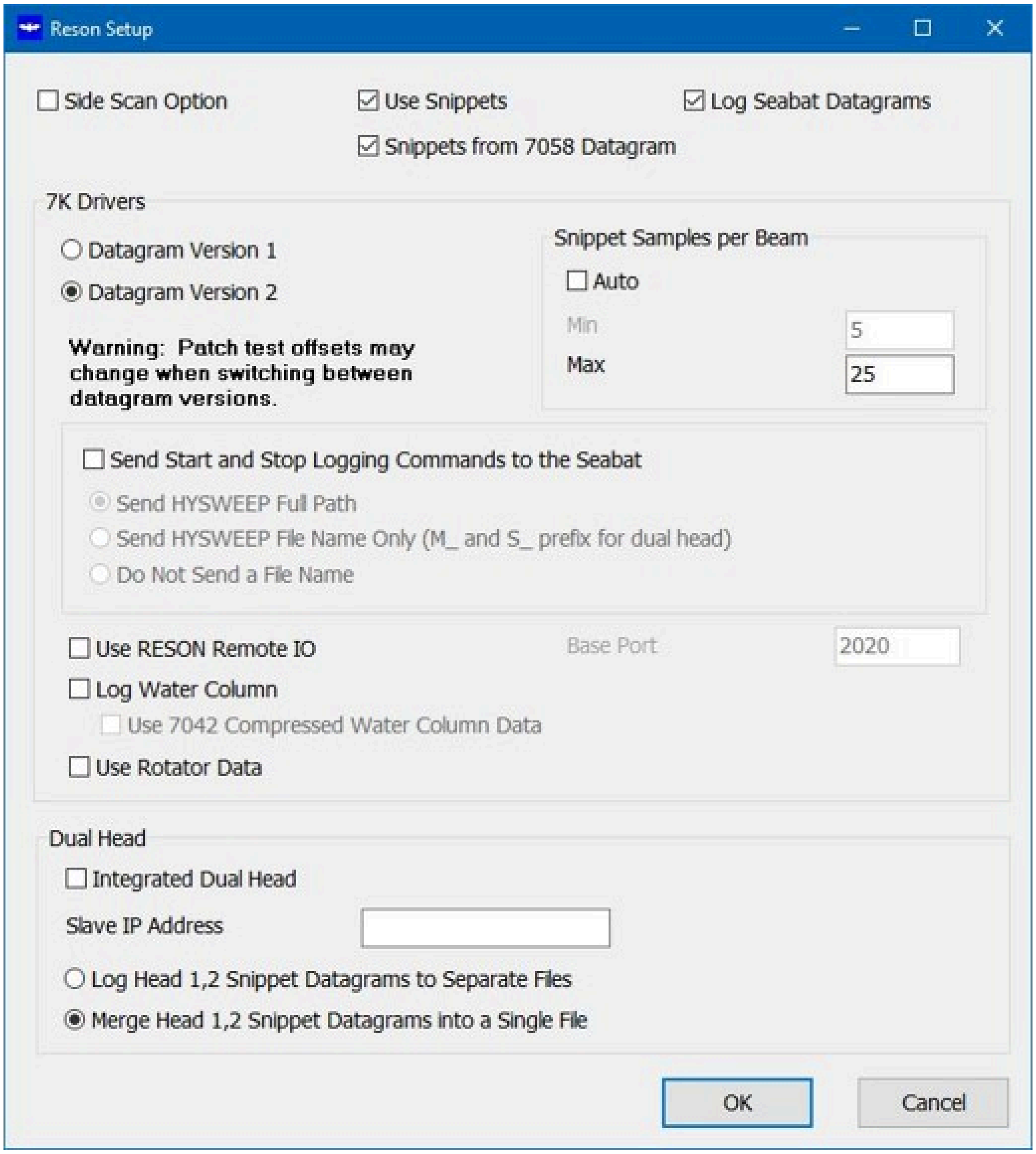
The CUBE algorithm and specific parameters used to create BASE surfaces were contained in the NOAA "CUBEParams_NOAA_2020.xml" file as included in the Pydro software suite.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

Coincident multibeam backscatter data was collected as snippets with Seabat T50-R system. The T50-R backscatter data includes an optional "normalized" backscatter feature (the 7058 datagram) which generates an intensity magnitude signal that is compensated for the effects of the sonar itself (beam pattern, source level, sensitivity and gain). It was logged in HYSWEEP SURVEY simultaneously with MBES soundings. The sonar was operated in Continuous Wave mode (CW), and snippet size was set to 25 samples. Backscatter file names were composed of the year, vessel, day number, UTC time and line number, for example: 2020AB2151201_167.7K where “AB” stands for RV Able 2. During initial calibration, MBES system settings such as power, gain, pulse length and "ocean" settings (absorption and spreading) were optimized for acquisition of MBES sounding data and to ensure over saturation did not occur. Spreading was based on expected salinity and manufacturer's recommendation as modified during testing and calibrations. Absorption was estimated based on expected salinity, temperature and average depth using 3 separate models for acoustic absorption in seawater: Fisher and Simmons 1977, Francois and Garrison 1982, and Ainslie and McColm 1998. Within the project area, a backscatter test bed was selected which contained many of the representative natural bottom types (mud, sand, and rock) for the project and a reasonable range of depths. All three vessels collected multiple reciprocal lines over this test bed. These data were used to determine and account for inter-vessel variation in backscatter intensity.



Reson Setup

☐ Side Scan Option
☑ Use Snippets
☑ Log Seabat Datagrams
☑ Snippets from 7058 Datagram

7K Drivers

○ Datagram Version 1
● Datagram Version 2

Warning: Patch test offsets may change when switching between datagram versions.

Snippet Samples per Beam

☐ Auto
Min 5
Max 25

☐ Send Start and Stop Logging Commands to the Seabat
● Send HYSWEEP Full Path
○ Send HYSWEEP File Name Only (M_ and S_ prefix for dual head)
○ Do Not Send a File Name

☐ Use RESON Remote IO
Base Port 2020
☐ Log Water Column
☐ Use 7042 Compressed Water Column Data
☐ Use Rotator Data

Dual Head

☐ Integrated Dual Head
Slave IP Address
○ Log Head 1,2 Snippet Datagrams to Separate Files
● Merge Head 1,2 Snippet Datagrams into a Single File

Figure 21: HYSWEEP Survey settings used for backscatter acquisition

Data Processing Methods and Procedures

After MBES data was converted and processed in CARIS HIPS, a Generic Sensor Format (GSF) file containing bathymetry data was output from CARIS HIPS and SIPS Data Export utility for each survey line. These GSF files were imported into Fledermaus Geocoder Toolbox (FMGT) software program, which created the backscatter mosaic, along with the corresponding RESON *.7k files. To create the mosaics, the pixel size was set to 2 meters and automatic processing was used with Beam Time Series selected as Backscatter Source. A GeoTIFF of each mosaic was exported from Export Surface in FMGT. When the mosaics were created, the software also created another GSF file of the combined RESON 7k file and the CARIS exported GSF file.

To determine inter-vessel variation in backscatter intensity, data from all three vessels were imported and mosaicked from the test bed area. The intensity of the overlapping data between vessels were examined. Using the Cascading Backscatter Normalization and Line Backscatter Adjustment tools, adjustments/offsets in the intensity can be applied to individual lines for overlapping data to match. For this survey, the RV Able 2 and RV Ready 2 had matching return intensities. The RV Osprey had an approximate 2 to 2.5 dB adjustment in its backscatter intensity to match the other two vessels. Therefore, for the RV Osprey, this adjustment was applied during the import of the CARIS exported GSF file and the RESON 7k file. The offset was entered in the Head 1 Bias field in the adjustment tab of the import settings.

C.2.2 Side Scan Sonar

Side scan sonar imagery was not acquired.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

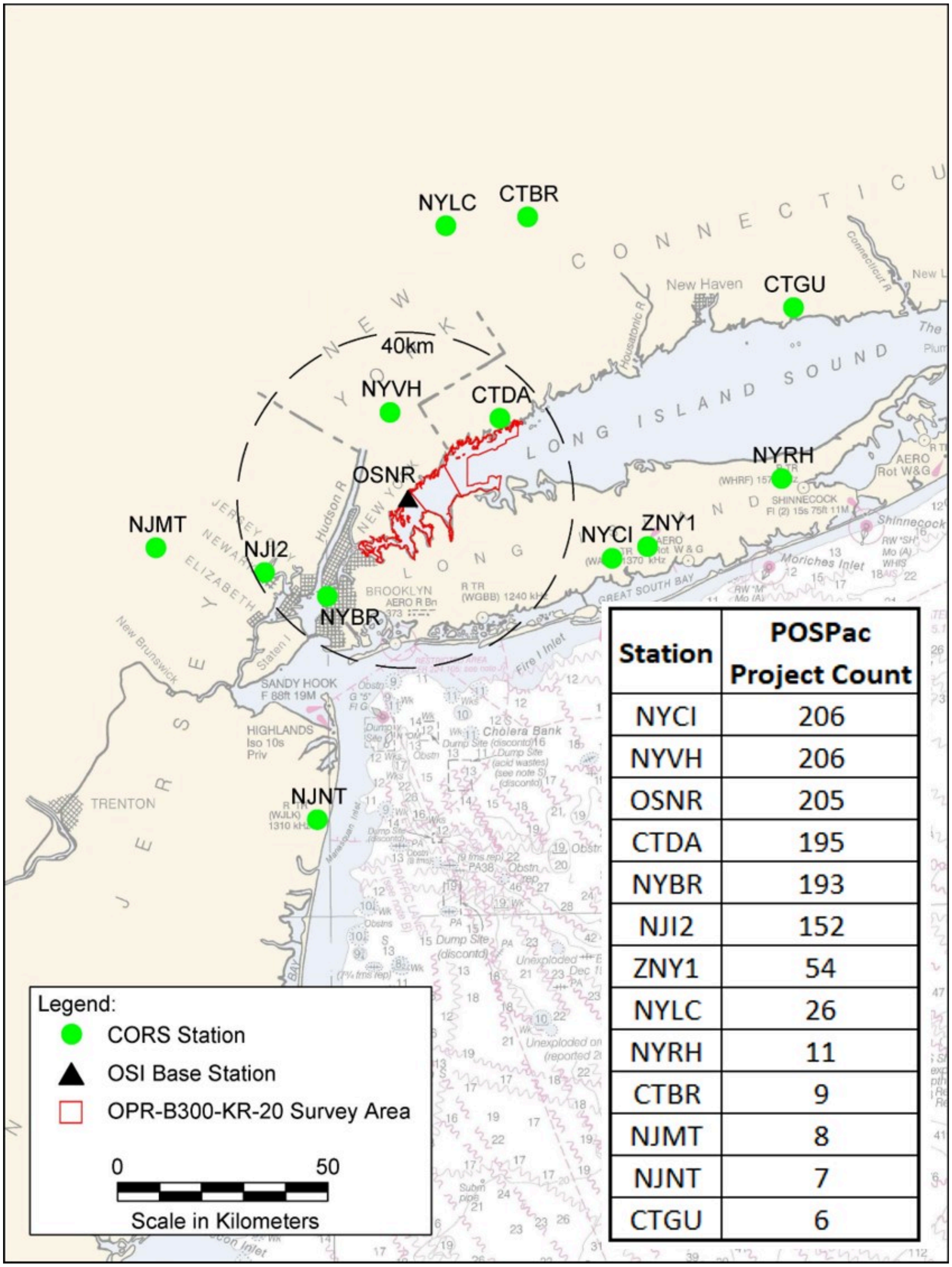
Data Acquisition Methods and Procedures

To supplement CORS-based IAPPK SBET processing, OSI installed a temporary GNSS station at Imperial Yacht Club in New Rochelle, New York. Specifically, a Trimble NetR9 GNSS receiver with a Zephyr 3 Geodetic Antenna was installed on the southwest corner of the maintenance building roof. 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. On October 2, 2020 (DN276), the GNSS base station was moved by Imperial Yacht Club staff by approximately 0.5m further away from the corner of the building without any notice to OSI. See the HVCR for details.

The configuration of the NetR9 was based on UNAVCO standard configuration settings for this device. GNSS observables were recorded on removable media as well as on the NetR9’s internal storage. 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. The Trimble NetR9 was included in IAPPK processing and designated as Ocean Surveys New Rochelle or “OSNR.”

Data Processing Methods and Procedures

For all vessels, real time positioning was replaced by Applanix SmartBase (ASB) derived SBET positioning in NAD83 during the processing workflow. On each vessel, POS *.000 files (for POSPac) were logged continuously each day on the main acquisition computer and directly to a USB drive on the POS MV topside processor. The POS *.000 files were imported into POSPac MMS for ASB processing , which was organized into POSPac projects by vessel and day. The total number of CORS stations included in ASB processing was occasionally varied from one POSPac project to the next (i.e. vessel-day) based on CORS data availability and solution quality. OSNR was used in all solutions except for the day when the base station was moved, as previously mentioned on DN276. The final coordinates of OSNR were determined using OPUS. There are two sets of final coordinates for OSNR; one for the original installation, and one for after the base station was moved. A discussion of OPUS data processing and the determination of final station coordinates are included in the HVCR.



Station	POSPac Project Count
NYCI	206
NYVH	206
OSNR	205
CTDA	195
NYBR	193
NJI2	152
ZNY1	54
NYLC	26
NYRH	11
CTBR	9
NJMT	8
NJNT	7
CTGU	6

Figure 22: Local CORS network used in Applanix Smart Base (ASB) IAPPK processing. The inset table lists the POSPac MMS project count for each station.

C.3.1.2 DGPS Data

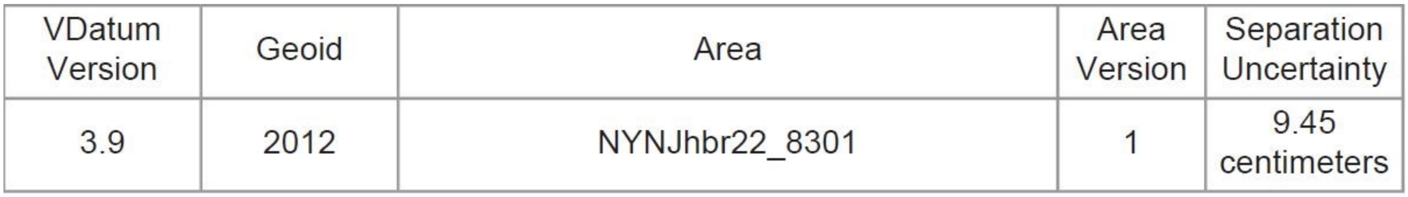
DGPS data was not acquired.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

Per the Project Instructions, the determination of MLLW water levels for sounding reduction was perfomed with Ellipsoidally Referenced Survey (ERS) methods. On each vessel, POS *.000 files (for POSPac) were logged continously each day on the main acquisition computer and directly to a USB drive on the POSMV topside processor. Inertially Aided Post Processed Kinematic (IAPPK) ellipsoid heights were computed by importing the POS *.000 files into POSPac MMS for 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. A VDatum Separation Model (SEP) was provided by NOAA with the original project files and described in the Project Instructions.



VDatum Version	Geoid	Area	Area Version	Separation Uncertainty
3.9	2012	NYNJhbr22_8301	1	9.45 centimeters

Figure 23: VDATUM Separation Model (SEP) Parameters as provided in the Project Instructions

Data Processing Methods and Procedures

ASB processing was organized into POSPac projects by vessel and by day using the steps described above to generate a set of preliminary SBETs. SBET altitude corrected for heave, dynamic draft, and static draft were reviewed graphically in MATLAB and compared to local NOAA tide gauge water levels for trend and general agreement. If invalid or poor-quality altitude data were contained in the preliminary SBET, additional CORS stations were added to the ASB network and reprocessed to create an improved SBET. As a final step, NOAA’s POSPacAutoQC application was used to interpolate through and replace any short time periods of poor-quality or invalid data that remained.

ASB derived ERS tides were smoothed before application to sounding data. After SBETs were exported, a MATLAB script was used to isolate the NAVD 88 tide component of SBET altitude by removing the following components: static draft based on time, dynamic draft based on speed, delayed heave based on time, and SEP based on position. The NAVD 88 tide was then smoothed with a 4th order Butterworth low-pass filter with a 0.5 hour cutoff frequency using MATLAB's "filtfit" function. Filtfit runs the filter in forward and reverse resulting in a zero-lag solution. Once the NAVD 88 tide was smoothed, new SBETs were exported after re-applying the SBET altitude components that were removed to isolate the NAVD88 tide.

Once a “smoothed” SBET was generated, it was imported to CARIS HIPS and the CARIS “Compute GPS Tides” function was used in conjunction with the NOAA-provided SEP to create MLLW tide correctors.

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. A discussion of the choice of smoothing parameters is included in the HVCR.

Qualitative and quantitative crossline analysis as well as junction analysis indicate that the final ERS correctors employed in reducing soundings to MLLW were adequate for the purpose. The results of crossline and junction analysis are presented in the Descriptive Report (DR) for each survey.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

The GNSS base station OSNR transmitted CMR+ satellite corrections using RTK2go NTRIP caster service. All vessels were equipped with a cellular service hotspot, enabling them to receive the CMR + satellite corrections via NTRIP Client software to a laptop computer. The corrections were sent from the laptop computer through a serial cable to the POS MV to improve realtime positioning and as a supplemental option for ERS tide development. Navigation system confidence checks were performed during mobilization before the start of the survey and periodically thereafter (see the HVCR and DAPR Appendix IV for results). The corrections were also sent to the GNSS Trimble SPS850 Extreme receiver via serial cable. The SPS850 was interfaced with HYPACK SURVEY on the acquisition computer to show its position and tide data in the survey windows for realtime comparison to the POS MV's position and tide data.

On all vessels, positioning, attitude and timing data from the POS MV were transmitted to the data acquisition computer via Ethernet through a network switch and were recorded in the HYSWEEP *.HSX files. POS *.000 files were also logged continuously each day on the main acquisition computer and directly to a USB drive on the POS MV topside processor. The POS *.000 files also contain True Heave data.

Data Processing Methods and Procedures

For all vessels, realtime positioning and attitude data were replaced with IAPPK SBET solutions using POSPac MMS and Applanix SmartBase (ASB) processing.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

All sound speed profiles (casts) were acquired inside the bounds of the survey area or within *XX* meters of the boundary. Sound speed profiles were acquired approximately every 1 to 2 hours using AML Base X or Base X2 hand-deployed sound speed profiler set to a 5Hz sampling rate. The profilers collected direct sound speed and depth readings with AML SV and pressure exchange sensors. Profiles were uploaded to a laptop computer on the vessel using AML SeaCast software which outputted a *.csv file per profile. Then, using Microsoft Excel with an OSI custom made macro, the *.csv files were converted to HYPACK *.vel format file for import to HYSWEEP survey.

The hydrographers acquired more frequent profiles if high variability was noted in the surface sound speed from the AML Micro-X installed on the head of the transducer, or when the surface sound speed comparison threshold was exceeded (> 2 meters/second change) between the profile reading at the draft of the transducer and the Micro-X

Data Processing Methods and Procedures

AML Base X and Base X2 profiles collected in *.csv format were converted to compatible CARIS SVP format using Microsoft Excel with an OSI custom made macro. Sound speed profiles were applied to the sounding data in CARIS HIPS using the "nearest in time" correction method. During CARIS SVP Correction, the following correctors were applied: sound speed, true heave, pitch, roll and waterline.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed, measured at the transducer head with the AML Micro-X equipped with a SV Exchange sensor, was outputted to the Reson T50-R processor for beam forming. The T-50 R's “Normal” filter was used for sound speed filtering. Raw surface sound speed data was recorded in the HYSWEEP *.HSX files during MBES logging.

Data Processing Methods and Procedures

No additional processing was performed on surface sound speed data, but the data were used as a QA/QC flag in MBES processing. Surface sound speed data were extracted from the HYSWEEP *.HSX files and plotted by vessel and by day. Sounding data collected during periods of high surface sound speed variability were carefully scrutinized for outer beam artifacts.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

Estimates for the uncertainty of all measurements associated with sounding collection were gathered from either reported manufacturer system accuracy or from calculated statistics.

The combined uncertainty value per sounding, or the Total Propagated Uncertainty (TPU), was calculated using CARIS HIPS. Standard deviation values for vessel offsets, motion, draft and alignment measurements were entered into the HVF “TPU values” section at the 1-sigma level. The HVF uncertainty values, along with uncertainties associated with tide and sound speed, were used in combination with the sonar model in the DeviceModels.xml file to assign a total horizontal uncertainty (THU) and total vertical uncertainty (TVU) for every sounding. For the Velodyne LIDAR, a custom "sonar" model was developed with a range sampling distance of 5 cm.

The POS MV 320 manufacturer-recommended uncertainty values for the heading, heave, roll, pitch and timing measurements were entered in the HVFs. However, the uncertainty of certain parameters (heave, pitch, roll, heading, and position) was superseded later using RMS error values from the ASB post-processed solution accuracy file "smrmsg.out" which contains the position, orientation and velocity RMS after smoothing at 1Hz intervals.

The standard deviation values for the XYZ Offset and static draft measurements were calculated from distances acquired with the steel tape, the coarsest tool used to verify vessel offsets.

The standard deviation for the loading measurement was calculated from the measure down values acquired on the port and starboard sides of each vessel.

The uncertainty for the delta draft was established by calculating the standard deviation of the differences between settlement values of reciprocal runs per each vessel speed tested. The settlement curve is included in DAPR Appendix III.

The MRU Alignment standard deviation values were calculated from the bias values estimated by multiple hydrographers who had individually processed the patch test data.

The Tide Measurement uncertainty is variable and is applied in CARIS HIPS based on post processed uncertainties from SBET RMS files generated in POSPac. Similarly, post processed uncertainties associated with vessel roll, pitch, heading and navigation are applied in CARIS HIPS.

Sound speed TPU values were estimated from sensor manufacturer-stated accuracy and from guidance in the OCS Field Procedures Manual (FPM), Appendix 4, CARIS HVF Uncertainty Values.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		RV Able 2	RV Osprey	RV Ready 2
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees	0.02 degrees
	Heave	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters
	Roll	0.02 degrees	0.02 degrees	0.02 degrees
	Pitch	0.02 degrees	0.02 degrees	0.02 degrees
Navigation Sensor		1.00 meters	1.00 meters	1.00 meters

C.6.2.2 Real-Time Uncertainty

Real-time uncertainty was not applied.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

The locations of the CSF assigned features and Aids to Navigation (ATONs) were imported into HYPACK's target database for each vessel enabling the field crews to see the locations of the CSF items in HYPACK SURVEY display window. Crews were able to anticipate that a potential feature was approaching, log if it was observed and take any notes to help data processors if necessary.

Each vessel was equipped with a Velodyne VLP-16 LiDAR and DJI OSMO camera for recording xyz data and imagery of near-NALL shoreline features and isolated baring features. A Garmin GPS was interfaced with the LiDAR system to provide timing. The data was sent to the acquisition computer via Ethernet through a network switch and interfaced with HYSWEEP survey. LiDAR data was recorded in the *.HSX HYSWEEP files, often while simultaneously recording MBES. HYSWEEP supplied the realtime controls of the LiDAR for beam enabling/disabling, angle and range filtering. Four of the 16 available beams were enabled, and angle and range filters were applied to mask the boat and the boat's wake from the recorded data. The LiDAR was monitored in realtime using the 3D Point Cloud Display in HYSWEEP SURVEY and realtime coverage matrix updates in HYPACK SURVEY. Simultaneously with LiDAR collection, a DJI OSMO camera recorded digital photographs of shoreline and above water features. Photographs were collected in 4K with 16:9 aspect ratio at a 2Hz rate.   The camera was mounted below the LiDAR with a view to starboard and interfaced with an Amazon Fire Tablet. The tablet was connected to the cellular hotspot to obtain accurate time which was then provided to the camera for accurate image UTC time-tagging.

Using the DJI software application installed on the tablet, field crews were able to start and stop recording, and see a realtime view of the camera from the inside of the cabin.

Prior to the conclusion of survey operations, the home office project manager reviewed the data to ensure the CSF assigned items, other unassigned features and ATONs were adequately addressed and photos were obtained of above-water features and ATONS.

Data Processing Methods and Procedures

Once data was converted and processed in CARIS HIPS and added to the CUBE surface, data density layers were reviewed to verify that the Multibeam Coverage requirement of 5 soundings per 1m grid node was met. Each CSF item location and its assigned search radius were examined in CARIS Subset Editor to see if feature was present and to check for nadir coverage or ensure the search radius was adequately covered. A designated sounding was selected from the nadir coverage if CSF feature was present. For features that are awash, exposed at low tide, or above the surface at high tide, the high point in the LiDAR data set was selected as the feature's height in MHW and designated. The data processing team also reviewed the data and CUBE surfaces for other features not assigned and selected a designated sounding for each feature.

Shoal and designated soundings were compared to the largest scale charts in the survey area to identify Dangers to Navigation (DTONs). Comparisons were achieved using Pydro's Chart Adequacy (CA) Tools and also by comparing the soundings (shoal and designated) to the ENC charts manually. CARIS BAG files and ENC charts were imported into CA Tools which exports soundings that are deemed to be DTONs. Processors would then manually review the exported soundings to decide which soundings were DTONs.

All DTONs were submitted to AHB as attributed S-57 .000 files per the specifications laid out for Contractors in the HSSD. Submitted DTONs, CSF assigned features, ATONs and unassigned features are included in the FFF.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Bottom samples were acquired by the RV Osprey at the locations specified in the Project Instructions, with one exception. One of the assigned bottom sample locations was within a charted cable area, so a new location was proposed to the COR and accepted. Correspondence with NOAA regarding this shift is provided in the Project Correspondence report folder. At each bottom sample location, a sample was collected using a Ponar Dredge and brought to the deck. Sample time and position were recorded and each sample was photographed and described.

Data Processing Methods and Procedures

Bottom sample descriptions and photographs were included in the FFF and attributed in accordance with HSSD Appendix G.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

After the lines were run through the appropriate Process Designer model, they were added to 0.5m cleaning/ coverage surfaces. Depth, standard deviation and shoal surface models were viewed with sun illumination and/or vertical exaggeration to highlight areas that would require immediate investigation. Standard deviation surfaces were reviewed to evaluate data for consistency between overlapping coverage and crosslines, and to detect any systematic position, motion, tide, or sound velocity errors. The highest standard deviation values were observed over obstruction features and sloping seafloors. Additional directed editing was performed using CARIS HIPS Swath Editor and Subset Editor to remove fliers and noise, while taking care to preserve features.

D.1.2 Designated Sounding Selection

Full-density soundings were reviewed for each significant MBES feature in the CARIS Subset Editor and a sounding was designated for the representative least depth.

“Outstanding” sounding flags were temporarily assigned to soundings on features, or possible features, which required further review. Occasionally, a request would be sent to the field crew for additional coverage on a feature for clarification. Before finalizing the survey, all "Outstanding" soundings were reviewed and resolved, then either marked as “Accepted” or “Designated” as appropriate. No soundings were left with an “Outstanding” flag.

The “Designated” flag was used to identify the least depth of a significant feature and ensure that the least depth would be represented in the finalized CUBE surfaces. When a designated sounding was assigned to a feature, it indicated that no further investigation was required. OSI followed Section 5.2.1.2.3 of the HSSD guidance on the criteria for choosing designated soundings. Near-nadir soundings were designated as least depths on features in lieu of outer-beam soundings whenever possible.

D.1.3 Holiday Identification

Coverage surfaces were checked for any data gaps meeting the criteria described in HSSD Section 5.2.2.3 (Complete Coverage). All surfaces were reviewed to ensure that the appropriate coverage was obtained over significant shoals and features. Density layers were reviewed and analyzed to verify that at least 95% of all nodes were populated with at least 5 soundings.

D.1.4 Uncertainty Assessment

The Total Vertical Uncertainty Quality Check (TVU QC) "Ratio Method" was used to evaluate IHO uncertainty for the finalized surface, which was generated using the "greater of the two" option in the CARIS "Finalize Base Surface" utility. The TVU QC "Ratio Method" is described in the Chapter 4 Appendices of the NOAA OCS Field Procedures Manual (FPM) dated April 2014. Per the FPM TVU QC section, "The hydrographer should use the finalized surface because this surface will identify areas where either the uncertainty or the standard deviation exceeded the maximum allowable error and the greater of these two values is used in addition to having the uncertainty scaled to a 95% CI, whereas unfinalized surface uncertainties are reported at the 68% CI". The FPM TVU QC section also states that, "[ratio] values which do not require further examination are from -1 to 0 and the values which do require further examination are from -100 to -1".

Results are reported and analyzed in each sheets' individual DR.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

To evaluate crossline to mainscheme line differences, separate 1m CUBE surfaces were created for crosslines and mainscheme lines in each sheet. Comparisons were made by computing the overlapping node to node differences. Histograms, basic statistics, and a discussion of the comparison are included in the DR for each sheet.

D.1.5.2 Junctions

Junction analysis between indivdual sheets in OPR-300-KR-20 and bordering sheets assigned in the Project Instructions were evaluated using the same method as Crossline to Mainscheme comparisons. Results are included in the DR for each sheet.

D.1.5.3 Platform to Platform

Vessel to vessel comparisons were made by computing the overlapping node to node differences in 1m CUBE surfaces for each vessel. A histogram and basic statistics of the vessel to vessel differences are included in DAPR Appendix V.

D.2 Imagery data Integrity and Quality Management

Imagery data integrity and quality management were not conducted for this survey.

E. Approval Sheet

Field operations contributing to the accomplishment of OPR-B300-KR-20 surveys H13384, H13385, and H13386, were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report, digital data and accompanying records have been closely reviewed, and are considered complete and adequate per the Statement of Work and Project Instructions.

This report and associated data are considered complete and adequate for its intended purpose.

Approver Name	Approver Title	Date	Signature
John R. Bean	Chief of Party	05/27/2020	John R. Bean 2021.05.27 14:55:32 -04'00'
David T. Somers	Data Processing Manager	05/27/2020	David T. Somers 2021.05.27 14:55:46 -04'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	OPR-B300-KR-20_DAPR_A-I.pdf
Sound Speed Sensor Calibration	OPR-B300-KR-20_DAPR_A-II.pdf
Vessel Offset	OPR-B300-KR-20_DAPR_A-III.pdf
Position and Attitude Sensor Calibration	OPR-B300-KR-20_DAPR_A-IV.pdf
Echosounder Confidence Check	OPR-B300-KR-20_DAPR_A-V.pdf
Echosounder Acceptance Trial Results	N/A