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-Z394-KR-21
Time Frame:	July - August 2021

LOCALITY

State(s):	Michigan
General Locality:	Vicinity of Whitefish Point

2021

CHIEF OF PARTY
John R. Bean

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Data Acquisition and Processing Report

Ocean Surveys
Chief of Party: John R. Bean
Year: 2021
Version: 1.0
Publish Date: 2021-12-16

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 MV Northstar Challenger

<table>
<tr><td>Vessel Name</td><td>MV Northstar Challenger</td></tr>
<tr><td>Hull Number</td><td>Official No. 1043939</td></tr>
<tr><td>Description</td><td>MV Northstar Challenger is a 28 m commercial utility vessel owned by North Star Marine. In preparation for this survey, the MV Northstar Challenger was modified by OSI and North Star Marine for hydrographic survey operations. The MV Northstar Challenger conducted 24-hour survey operations with port calls at approximately 9- to 10-day intervals for provisioning at Sault Ste. Marie.</td></tr>
<tr><td>Dimensions</td><td><table><tr><td>LOA</td><td>28.0 m</td></tr><tr><td>Beam</td><td>7.9 m</td></tr><tr><td>Max Draft</td><td>2.6 m</td></tr></table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table><tr><td>Date</td><td>2021-06-30</td></tr><tr><td>Performed By</td><td>OSI</td></tr></table></td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td><table><tr><td>Date</td><td>2021-07-22</td></tr><tr><td>Method</td><td>Relevant offsets established by the 2021 total station survey were confirmed during final on-site setup with a steel tape measure.</td></tr></table></td></tr>
</table>

Figure 1: MV Northstar Challenger configured for hydrographic survey operations.

A.1.2 RV North Cove

Vessel Name	RV North Cove	
Hull Number	Registration No. CT 9011 BM	
Description	RV North Cove is an 11.1 m aluminum forward cabin power boat designed by Specmar, Inc. and powered by twin 250 HP Yamaha outboard engines. The RV North Cove was customized by OSI for hydrographic surveying and conducted daily survey operations out of Whitefish Point State Dock.	
Dimensions	*LOA*	11.1 m
	Beam	3.4 m
	Max Draft	0.8 m

Most Recent Full Static Survey	*Date*	2021-03-08
	Performed By	OSI
Most Recent Partial Offset Verification	*Date*	2021-07-31
	Method	Relevant offsets established by the 2021 total station survey were confirmed during vessel mobilization with a steel tape measure.

Figure 2: RV North Cove configured for hydrographic survey operations.

A.1.3 RV H.F. Stout

Vessel Name	RV H.F. Stout	
Hull Number	Registration No. CT 5054 BJ	
Description	RV H.F. Stout is a 9.1 m aluminum landing craft built by Life Tyme Boats and powered by twin 150 HP Yamaha outboard engines. The RV H.F. Stout was modified by OSI for hydrographic surveying and conducted daily survey operations out of Whitefish Point State Dock.	
Dimensions	*LOA*	9.1 m
	Beam	3.0 m
	Max Draft	0.76 m
Most Recent Full Static Survey	*Date*	2020-09-27
	Performed By	OSI
Most Recent Partial Offset Verification	*Date*	2021-07-18
	Method	Relevant offsets established by the 2020 total station survey were confirmed during the 2021 vessel mobilization with a steel tape measure.

Figure 3: RV H.F. Stout 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 6 mm. For this survey, all vessels operated at 200 kHz, at a maximum swath angle of 140 degrees and used the 512-equidistant beam configuration. In addition to sounding data, the SeaBat T50-R systems collected and recorded "normalized" backscatter data (the 7058 datagram).

Manufacturer	Teledyne RESON				
Model	SeaBat T50-R				
Inventory	*MV Northstar Challenger*	*Component*	Processor	Receiver	Projector
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08940820102	1320183	320028
		Frequency	200 kHz	200 kHz	200 kHz
		Calibration	N/A	2021-07-23	2021-07-23
		Accuracy Check	N/A	N/A	N/A
	RV North Cove	*Component*	Processor	Receiver	Projector
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08940620100	1320182	0320020
		Frequency	200 kHz	200 kHz	200 kHz
		Calibration	N/A	2021-08-01	2021-08-01
		Accuracy Check	N/A	N/A	N/A
	RV H.F. Stout	*Component*	Processor	Receiver	Projector
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08943519090	0220014	4319043
		Frequency	200 kHz	200 kHz	200 kHz
		Calibration	N/A	2021-07-19	2021-07-19
		Accuracy Check	N/A	N/A	N/A

Figure 4: SeaBat T50-R transducer mounted on the MV Northstar Challenger transducer pole.

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

Figure 6: SeaBat T50-R transducer mounted on the RV H.F. Stout transducer pole.

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

A.2.3.1 EdgeTech 4200-MP dual-frequency 300/600 kHz with winch

The towed SSS systems used on the MV Northstar Challenger and RV North Cove were an EdgeTech 4200-MP dual-frequency sonar capable of operating at 300 kHz and/or 600 kHz. For this survey, both low- and high-frequency data were collected employing the "high speed" mode with only the high-frequency data being processed. Of the available range scales, only the 75 m range was used on the MV Northstar Challenger, and the 50 m and 75 m range scales were used on the RV North Cove. The system consists of a topside processor unit, coaxial double armored steel tow cable, electric powered slip ring winch, cable pay-out indicator, and sonar towfish. The towfish was equipped with a pressure sensor which was used to measure towfish depth. System components were interfaced to the acquisition computer via Ethernet cable (to a dedicated network card) and serial connections.

<table>
<tr><td>Manufacturer</td><td colspan="5">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="5">4200-MP dual-frequency 300/600 kHz with winch</td></tr>
<tr><td rowspan="12">Inventory</td><td rowspan="6">MV Northstar Challenger</td><td>Component</td><td>Topside</td><td>Towfish</td><td>AGO Electric Winch</td></tr>
<tr><td>Model Number</td><td>4200</td><td>4200</td><td>CSW-7</td></tr>
<tr><td>Serial Number</td><td>48629</td><td>48869</td><td>0807036-R</td></tr>
<tr><td>Frequency</td><td>600 kHz</td><td>600 kHz</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-07-24</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="6">RV North Cove</td><td>Component</td><td>Topside</td><td>Towfish</td><td>AGO Electric Winch</td></tr>
<tr><td>Model Number</td><td>4200</td><td>4200</td><td>CSW-6</td></tr>
<tr><td>Serial Number</td><td>48825</td><td>48742</td><td>0809061</td></tr>
<tr><td>Frequency</td><td>600 kHz</td><td>600 kHz</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-08-01</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

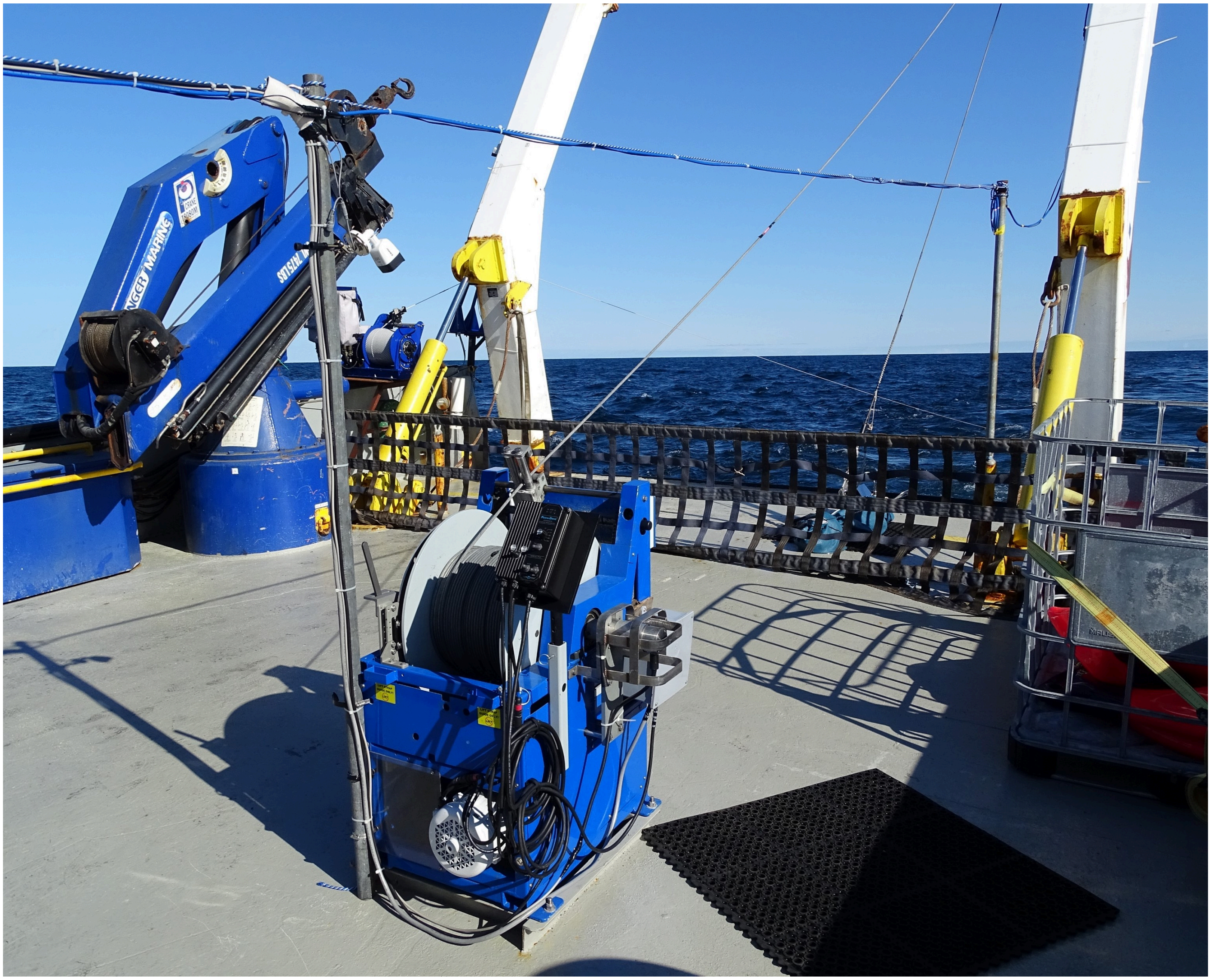

Figure 7: Electric SSS winch aboard the MV Northstar Challenger.

Figure 8: EdgeTech 4200-MP SSS towfish aboard the MV Northstar Challenger.

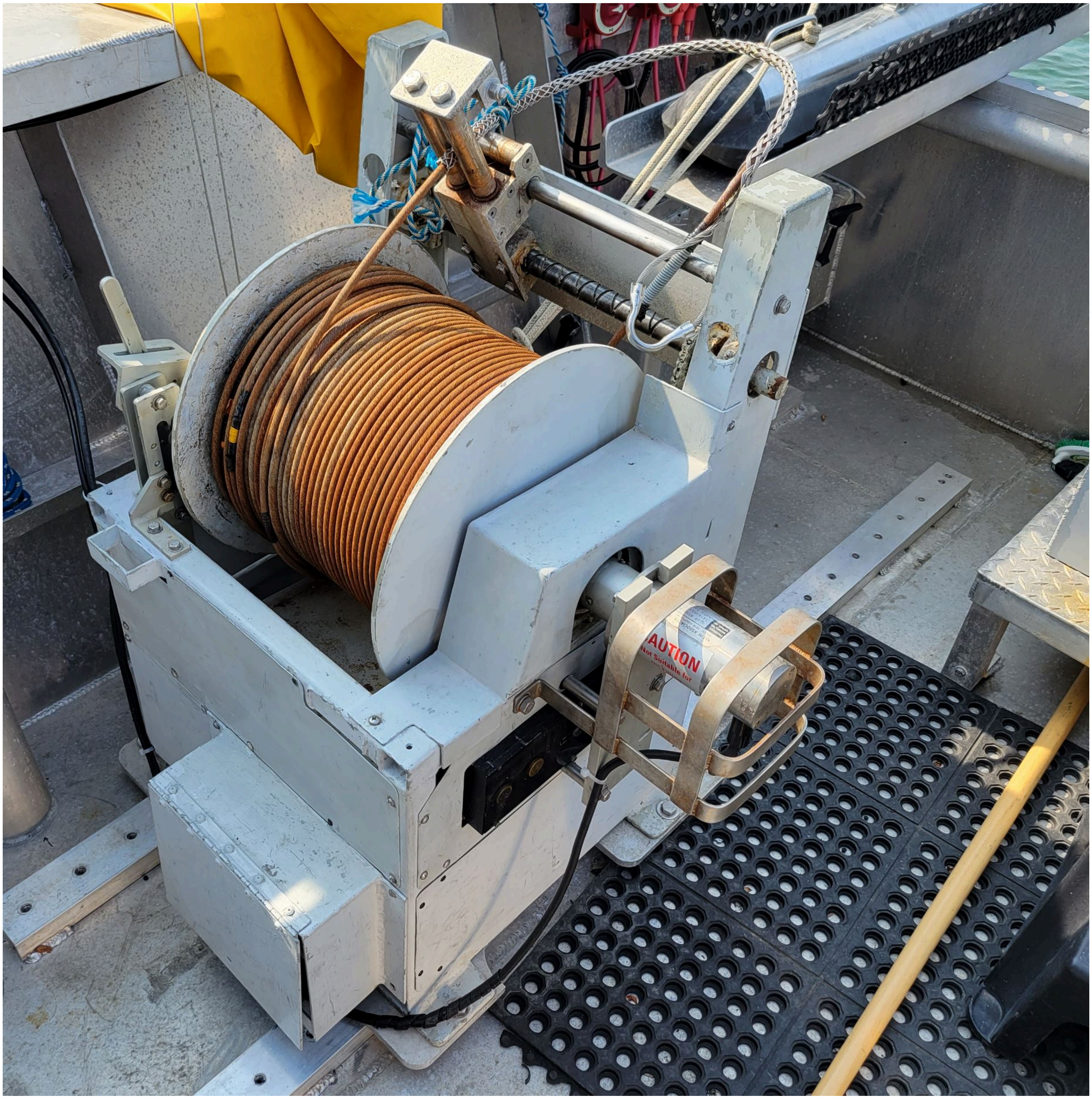

Figure 9: Electric SSS winch aboard the RV North Cove.

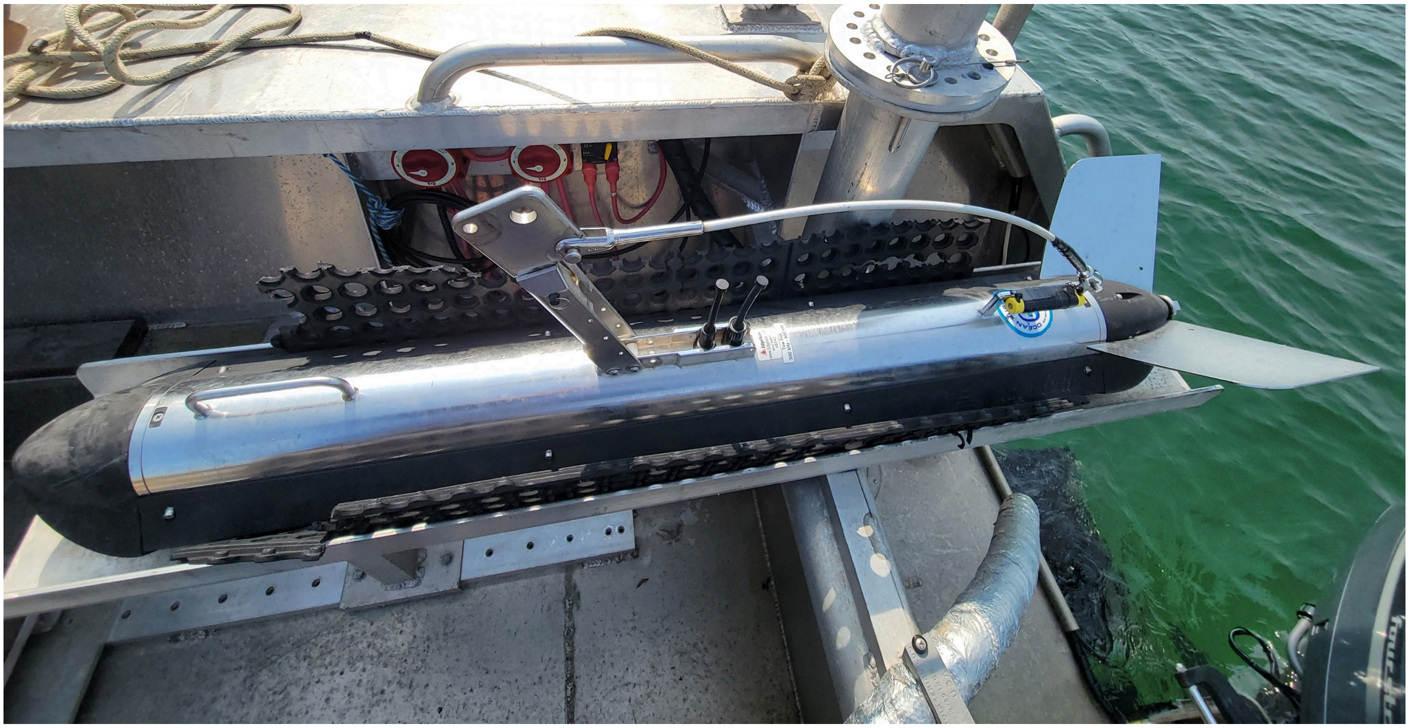

Figure 10: EdgeTech 4200-MP SSS towfish aboard the RV North Cove.

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

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 kg metal disk with a diameter of 0.3 m. The metal disk was attached to a stainless steel cable with permanent index markers established at 1 m 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).

<table>
<tr><td>Manufacturer</td><td colspan="3">OSI</td></tr>
<tr><td>Model</td><td colspan="3">Lead Line/Bar Check</td></tr>
<tr><td rowspan="12">Inventory</td><td rowspan="4">MV Northstar Challenger</td><td>Component</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>NOAA-1</td></tr>
<tr><td>Calibration</td><td>2021-07-12</td></tr>
<tr><td rowspan="4">RV North Cove</td><td>Component</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>2010 B</td></tr>
<tr><td>Calibration</td><td>2021-07-22</td></tr>
<tr><td rowspan="4">RV H.F. Stout</td><td>Component</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>75-1</td></tr>
<tr><td>Calibration</td><td>2021-07-12</td></tr>
</table>

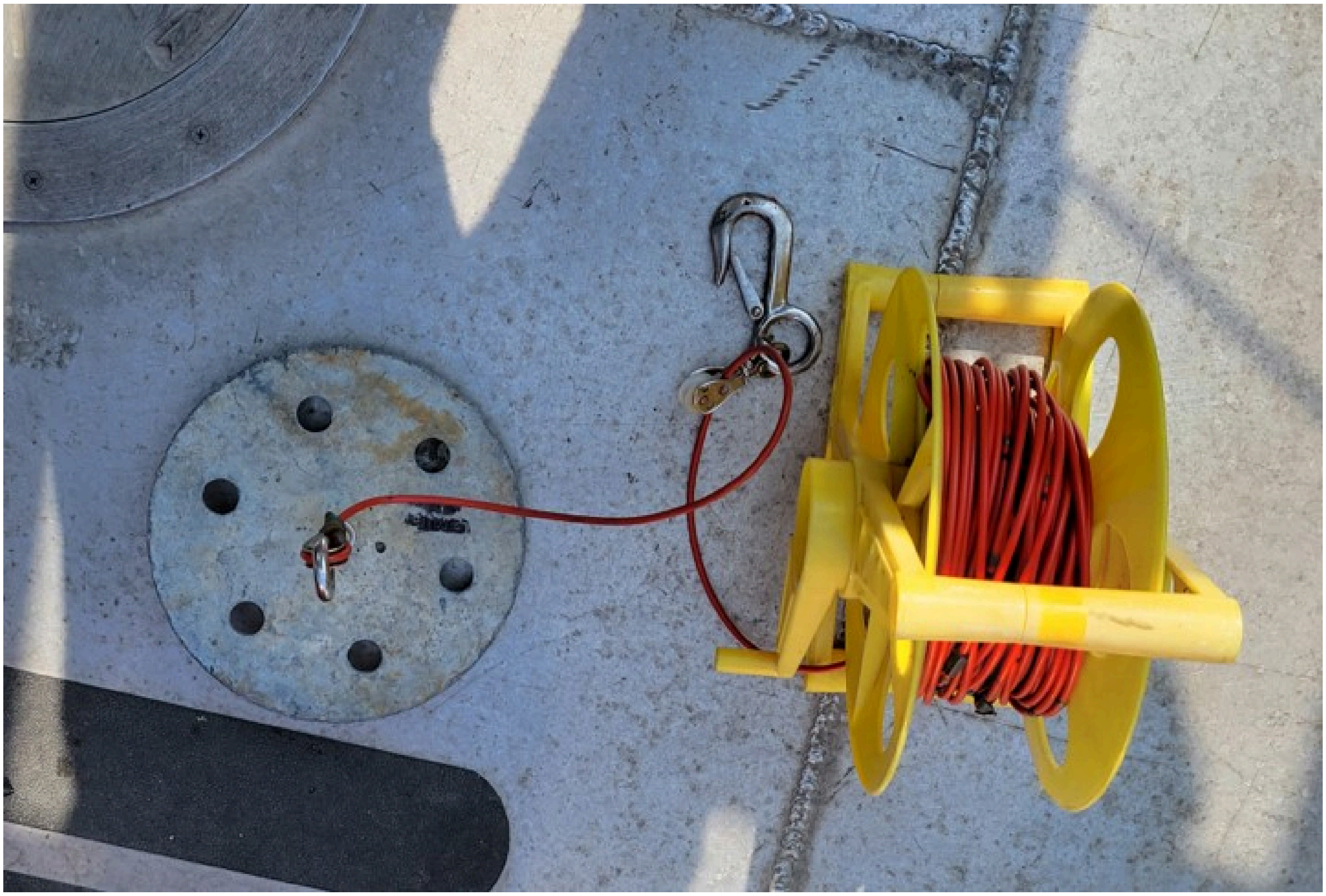

Figure 11: OSI-built lead line.

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 the Great Lakes Shipwreck Museum in Paradise, Michigan. 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.

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 Whitefish Point or "OSWP." The coordinates of OSWP were determined using OPUS. A discussion of OPUS data processing and the determination of final coordinates is included in the HVCR.

Manufacturer	Trimble		
Model	NetR9		
Inventory	*Component*	Receiver	Zephyr 3 Geodetic GNSS Antenna
	Model Number	NetR9	115000-00
	Serial Number	5811R52419	6122223813
	Calibration	N/A	N/A

Figure 12: GNSS Base Station OSWP.

A.4.2 Rover Equipment

A.4.2.1 Trimble R10 GNSS Rover with TSC3 data collector

The Trimble R10 GNSS is an integrated receiver/antenna combination unit. The rover was used to install temporary navigation confidence checks for each vessel at their respective docks. See the HVCR for a discussion of these points.

<table>
<tr><td>Manufacturer</td><td colspan="3">Trimble</td></tr>
<tr><td>Model</td><td colspan="3">R10 GNSS Rover with TSC3 data collector</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>GNSS Rover</td><td>Data Collector</td></tr>
<tr><td>Model Number</td><td>R10</td><td>TSC3</td></tr>
<tr><td>Serial Number</td><td>5433475655</td><td>RSOFC08146</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</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 2 m) 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 all vessels, the POS MV's integrated DGPS was activated from the controller sofware utilizing SBAS (FAA WAAS) corrections to improve real-time positioning.

Manufacturer	Applanix					
Model	POS MV 320 V5					
Inventory	*MV Northstar Challenger*	*Component*	Topside	IMU	GPS Antenna (Stbd.)	GPS Antenna (Port)
		Model Number	POS MV V5	LN 200	GA830	GA830
		Serial Number	11273	497	15853	12189
		Calibration	2021-07-23	2021-07-23	2021-07-23	2021-07-23
	RV North Cove	*Component*	Topside	IMU	GPS Antenna (Stbd.)	GPS Antenna (Port)
		Model Number	POS MV V5-1	82	GA830	GA830
		Serial Number	12016	5487	17027	15406
		Calibration	2021-08-01	2021-08-01	2021-08-01	2021-08-01
	RV H.F. Stout	*Component*	Topside	IMU	GPS Antenna (Stbd.)	GPS Antenna (Port)
		Model Number	POS MV V5	64	GA830	GA830
		Serial Number	11495	5690	17460	16001
		Calibration	2021-07-19	2021-07-19	2021-07-19	2021-07-19

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

A.5.3.1 Trimble SPS850 Extreme GPS

On the MV Northstar Challenger and RV H.F. Stout, a Trimble SPS850 Extreme GPS was configured to operate using SBAS (FAA WAAS) positioning, and served as an independent position check of the POS MV.

<table>
<tr><td>Manufacturer</td><td colspan="4">Trimble</td></tr>
<tr><td>Model</td><td colspan="4">SPS850 Extreme GPS</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">MV Northstar Challenger</td><td>Component</td><td>Receiver</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>58805-66</td><td>Zephyr 2</td></tr>
<tr><td>Serial Number</td><td>4605K00522</td><td>4611118555</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="4">RV H.F. Stout</td><td>Component</td><td>Receiver</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>58805-66</td><td>Zephyr 2</td></tr>
<tr><td>Serial Number</td><td>5023K67948</td><td>30572582</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
</table>

A.5.3.2 Trimble SPS461 GPS

On the RV North Cove, a Trimble SPS461 GPS was configured to operate using SBAS (FAA WAAS) positioning, and served as an independent position check of the POS MV.

<table>
<tr><td>Manufacturer</td><td colspan="4">Trimble</td></tr>
<tr><td>Model</td><td colspan="4">SPS461 GPS</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">RV North Cove</td><td>Component</td><td>Receiver</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>SPS461</td><td>GA830</td></tr>
<tr><td>Serial Number</td><td>5622R80094</td><td>17024</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
</table>

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

A.5.5.1 Hydrographic Survey Products, Inc. Smart Sensor Cable Pay-Out Indicator

A Hydrographic Survey Products, Inc. Smart Sensor Cable Pay-Out Indicator was used to measure cable out values for towed SSS positioning on the MV Northstar Challenger and RV North Cove. The cable pay-out indicator consists of a topside display/controller, deck cable, and a 0.4 m diameter sheave fitted with a magnetically triggered counting sensor. The cable pay-out indicator was calibrated according to manufacturer specifications before data acquisition by measuring the sheave circumference and entering a calibration value into the topside controller software. The accuracy of the system was checked repeatedly during towed SSS operations by comparing sensor display values to calibration marks on the tow cable. These checks were performed frequently during each survey day. The system was recalibrated as needed to account for minor cable slippage. Cable pay-out data were transmitted to HYPACK on the main acquisition computer by a serial data connection.

<table>
<tr><td>Manufacturer</td><td colspan="3">Hydrographic Survey Products, Inc.</td></tr>
<tr><td>Model</td><td colspan="3">Smart Sensor Cable Pay-Out Indicator</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">MV Northstar Challenger</td><td>Component</td><td>Cable Counter</td></tr>
<tr><td>Model Number</td><td>ver4</td></tr>
<tr><td>Serial Number</td><td>1794</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
<tr><td rowspan="4">RV North Cove</td><td>Component</td><td>Cable Counter</td></tr>
<tr><td>Model Number</td><td>ver3</td></tr>
<tr><td>Serial Number</td><td>1737</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
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A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 AML Oceanographic MVP30-350

Sound speed profiles were acquired using an AML Oceanographic MVP30-350 on the MV Northstar Challenger. This instrument consists of towfish-mounted sensors, an electro-mechanical conducting cable, and an electric winch. The MVP may be deployed manually using the winch controls or remotely using the MVP Controller Software. When operated in "FreeWheel" mode, the MVP falls near-vertically to a preset depth off the bottom, collecting sound speed, temperature, and pressure (depth) measurements at a rate of 10 Hz. Profiles were acquired at intervals of approximately 20 minutes on the MV Northstar Challenger.

Manufacturer	AML Oceanographic					
Model	MVP30-350					
Inventory	*MV Northstar Challenger*	*Component*	MVP			
		Model Number	30-350			
		Serial Number	M12730			
		Calibration	N/A			
	MV Northstar Challenger	*Component*	Sonde	Sound Speed Sensor	Pressure Sensor	Temperature Sensor
		Model Number	MVP-X	SV Xchange	P Xchange	T Xchange
		Serial Number	9108	209496	307135	404611
		Calibration	N/A	2021-05-18	2021-06-11	2021-06-10

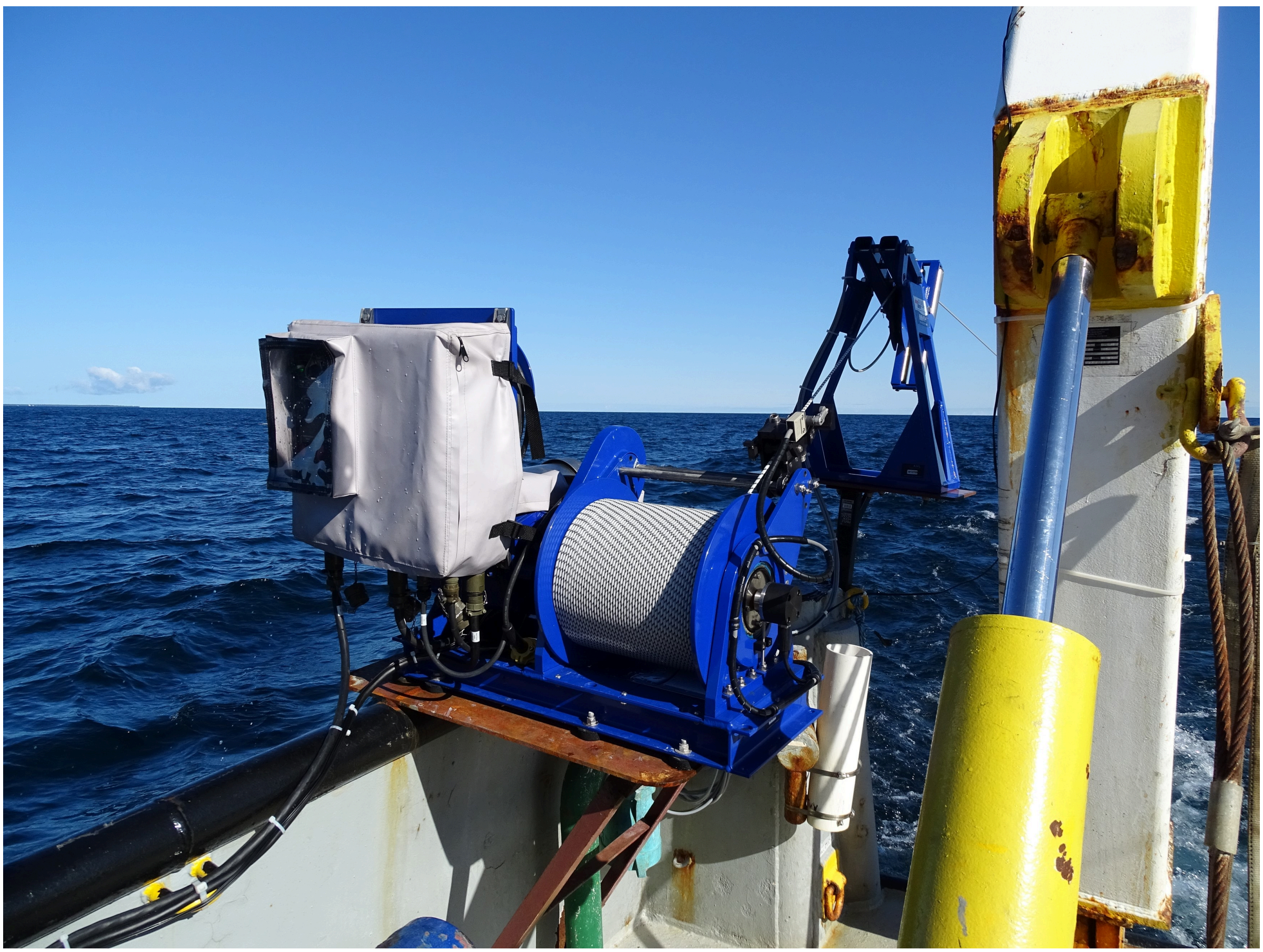

Figure 13: MVP30-350 Moving Vessel Profiler mounted on the starboard quarter of the MV Northstar Challenger.

A.6.1.2 AML Oceanographic MVP30

Sound speed profiles were acquired using an AML Oceanographic MVP30 on the RV North Cove. This instrument consists of towfish-mounted sensors, an electro-mechanical conducting cable, and an electric winch. The MVP may be deployed manually using the winch controls or remotely using the MVP Controller Software. When operated in "FreeWheel" mode, the MVP falls near-vertically to a preset depth off the bottom, collecting sound speed, temperature, and pressure (depth) measurements at a rate of 10 Hz. Profiles were acquired at intervals of approximately 30 minutes on the RV North Cove.

<table>
<tr><td>Manufacturer</td><td colspan="6">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="6">MVP30</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">RV North Cove</td><td>Component</td><td colspan="4">MVP</td></tr>
<tr><td>Model Number</td><td colspan="4">30</td></tr>
<tr><td>Serial Number</td><td colspan="4">10646</td></tr>
<tr><td>Calibration</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="4">RV North Cove</td><td>Component</td><td>Sonde</td><td>Sound Speed Sensor</td><td>Pressure Sensor</td><td>Temperature Sensor</td></tr>
<tr><td>Model Number</td><td>MVP-X</td><td>SV Xchange</td><td>P Xchange</td><td>T Xchange</td></tr>
<tr><td>Serial Number</td><td>9062</td><td>208339</td><td>307286</td><td>404470</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-03-15</td><td>2021-06-01</td><td>2021-03-16</td></tr>
</table>

Figure 14: MVP30 Moving Vessel Profiler mounted on the port quarter of the RV North Cove.

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 AML-3 LGR Sound Speed Profiler

On the RV North Cove and RV H.F. Stout, sound speed profiles were acquired using an AML Oceanographic AML-3 LGR logging profiler. This instrument collects high-precision direct sound speed and pressure measurements. It also has the capability to be configured with a third sensor which measures both temperature and conductivity. The instruments were configured to take measurements at a rate of 5 Hz. Data were stored internally and downloaded via Bluetooth connection to the Sailfish software program on the vessel's logging laptop (RV North Cove) or acquisition computer (RV H.F. Stout).

<table>
<tr><td>Manufacturer</td><td>AML Oceanographic</td></tr>
<tr><td>Model</td><td>AML-3 LGR Sound Speed Profiler</td></tr>
<tr><td>Inventory</td><td>
<table>
<tr><td>RV North Cove</td><td>
<table>
<tr><td>Component</td><td>Sonde</td><td>Sound Speed Sensor</td><td>Pressure Sensor</td></tr>
<tr><td>Model Number</td><td>AML-3 LGR</td><td>SV X2change</td><td>P X2change</td></tr>
<tr><td>Serial Number</td><td>A30204</td><td>210966</td><td>307638</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-07-14</td><td>2021-07-07</td></tr>
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</td></tr>
<tr><td>RV H.F. Stout</td><td>
<table>
<tr><td>Component</td><td>Sonde</td><td>Sound Speed Sensor</td><td>Pressure Sensor</td><td>Temperature Sensor</td><td>Conductivity Sensor</td></tr>
<tr><td>Model Number</td><td>AML-3 LGR</td><td>SV X2change</td><td>P X2change</td><td>T X2change</td><td>C X2change</td></tr>
<tr><td>Serial Number</td><td>A30011</td><td>210009</td><td>307211</td><td>450931</td><td>450931</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2020-11-22</td><td>2020-12-09</td><td>2020-12-13</td><td>2020-12-14</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

A.6.3.2 AML Oceanographic Micro-X Sound Speed Sensor

An AML Micro-X was mounted within the forward faring of each 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.

<table>
<tr><td>Manufacturer</td><td colspan="4">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="4">Micro-X Sound Speed Sensor</td></tr>
<tr><td rowspan="12">Inventory</td><td rowspan="4">MV Northstar Challenger</td><td>Component</td><td>Sonde</td><td>Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>Micro-X</td><td>SV Xchange</td></tr>
<tr><td>Serial Number</td><td>12814</td><td>209651</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-04-14</td></tr>
<tr><td rowspan="4">RV North Cove</td><td>Component</td><td>Sonde</td><td>Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>Micro-X</td><td>SV Xchange</td></tr>
<tr><td>Serial Number</td><td>10315</td><td>201525</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-04-14</td></tr>
<tr><td rowspan="4">RV H.F. Stout</td><td>Component</td><td>Sonde</td><td>Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>Micro-X</td><td>SV Xchange</td></tr>
<tr><td>Serial Number</td><td>10817</td><td>203108</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2021-03-15</td></tr>
</table>

A.6.4 TSG Sensors

No TSG sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No other surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
HYPACK	HYPACK Survey	20.3.2.0	Acquisition
HYPACK	HYSWEEP Survey	20.3.6.0	Acquisition
HYPACK	MB Max 64	20.3.2.0	Acquisition and Processing
Applanix	POSPac MMS	8.7	Processing
Applanix	MV POS View	10.5	Acquisition
EdgeTech	Discover 4200	Ver 8.0 (37.0.1.111)	Acquisition
Teledyne RESON	Teledyne Sonar UI	5.0.0.17	Acquisition
AML Oceanographic	MVP Controller	2.48	Acquisition
AML Oceanographic	MVP Controller	2.45	Acquisition
AML Oceanographic	Sailfish	1.3.0.10	Acquisition
Teledyne CARIS	HIPS/SIPS	11.3	Processing
Chesapeake Technology	SonarWiz 7	7.07.05	Processing
Global Mapper Software, LLC	Global Mapper	19.1	Processing
Microsoft	Office Suite	14.0.7229.5	Acquisition and Processing
National Geodetic Survey	OPUS Projects	4.2	Processing
NOAA	Pydro Programs (Sound Speed Manager, QC Tools, CA Tools, Compare Grids, XMLDR)	v19.4 (r12484)	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

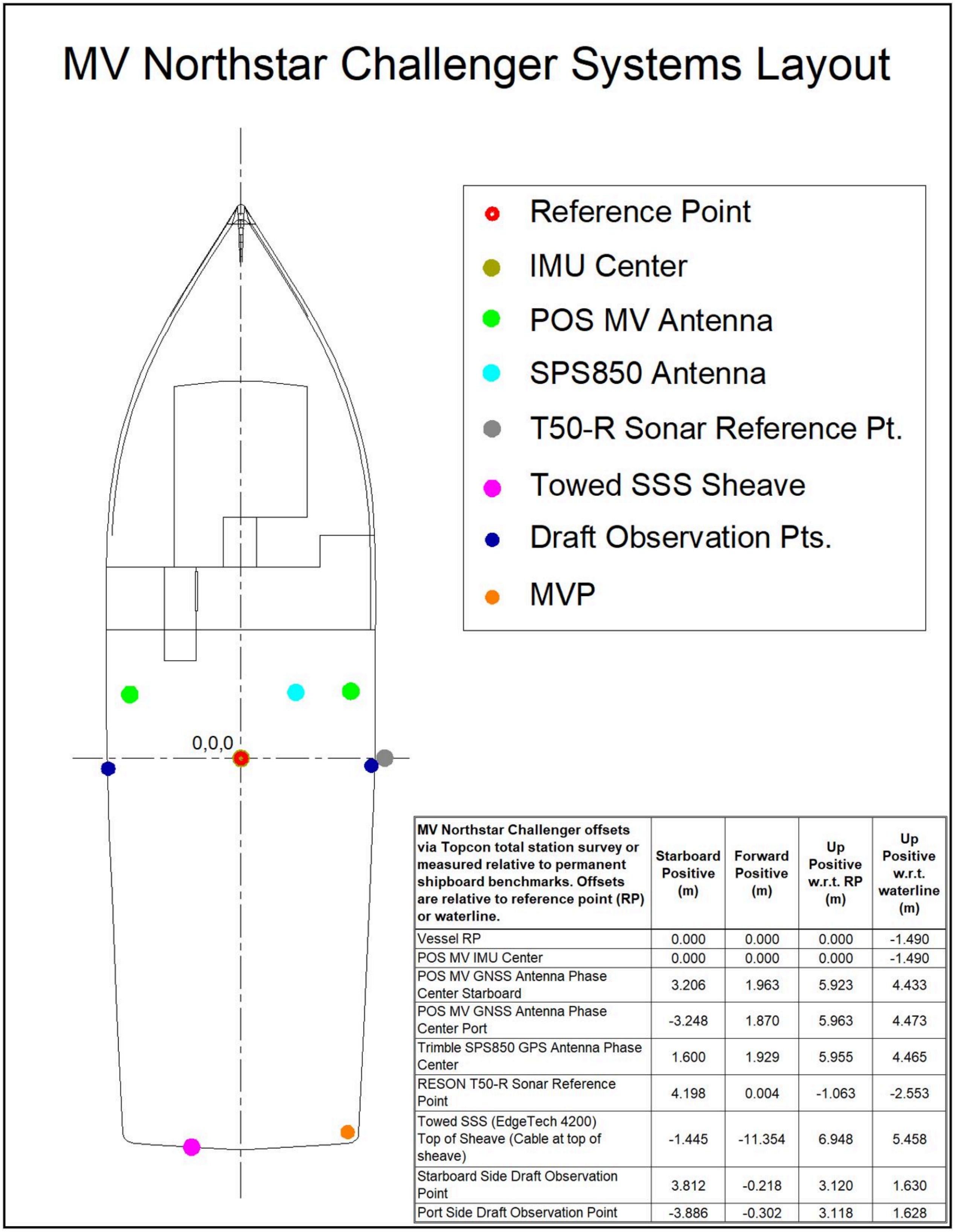
No bottom sampling equipment was utilized for data acquisition.

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

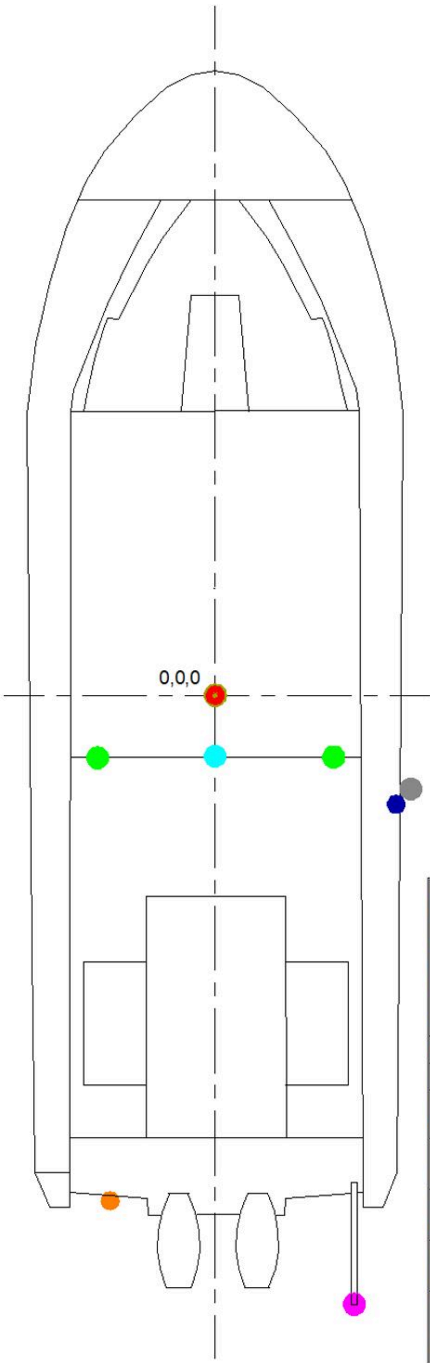
Sensor offsets for each vessel were measured relative to their respective reference point (RP) and are depicted in the vessel layout figures below. Offsets and on-board benchmarks were established in the vessel reference frame during full static surveys when the vessels were on land or in dry dock and confirmed in the field using a steel tape measure. For all vessels, the RP to IMU and RP to primary GNSS antenna lever arm offsets are applied in the POS MV's controller software, POSView. Multibeam transducer and SSS sheave offsets were measured and applied relative to each vessel's RP in HYPACK 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 for data processing.



MV Northstar Challenger 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	-1.490
POS MV IMU Center	0.000	0.000	0.000	-1.490
POS MV GNSS Antenna Phase Center Starboard	3.206	1.963	5.923	4.433
POS MV GNSS Antenna Phase Center Port	-3.248	1.870	5.963	4.473
Trimble SPS850 GPS Antenna Phase Center	1.600	1.929	5.955	4.465
RESON T50-R Sonar Reference Point	4.198	0.004	-1.063	-2.553
Towed SSS (EdgeTech 4200) Top of Sheave (Cable at top of sheave)	-1.445	-11.354	6.948	5.458
Starboard Side Draft Observation Point	3.812	-0.218	3.120	1.630
Port Side Draft Observation Point	-3.886	-0.302	3.118	1.628

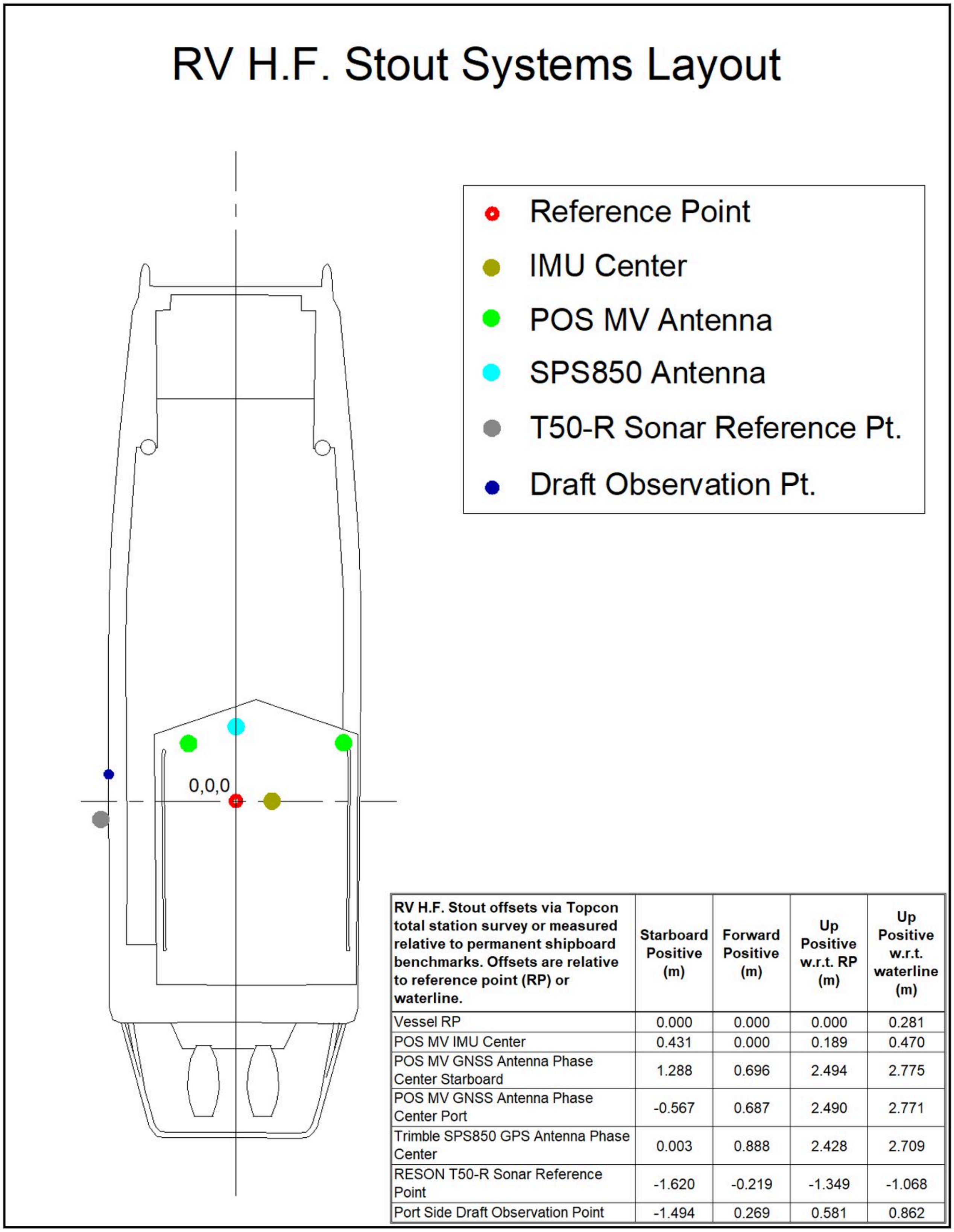
Figure 15: MV Northstar Challenger Systems Layout.

RV North Cove



RV North Cove 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	-0.312
POS MV IMU Center	0.000	0.000	0.119	-0.193
POS MV GNSS Antenna Phase Center Starboard	1.067	-0.558	2.937	2.625
POS MV GNSS Antenna Phase Center Port	-1.063	-0.565	2.939	2.627
Trimble SPS461 GPS Antenna Phase Center	-0.002	-0.552	2.935	2.623
RESON T50-R Sonar Reference Point	1.762	-0.847	-0.551	-0.863
Towed SSS (EdgeTech 4200) Top of Sheave (Cable at top of sheave)	1.254	-5.497	2.512	2.200
Starboard Side Draft Observation Point	1.629	-0.985	1.382	1.070

Figure 16: RV North Cove Systems Layout.



RV H.F. Stout 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	0.281
POS MV IMU Center	0.431	0.000	0.189	0.470
POS MV GNSS Antenna Phase Center Starboard	1.288	0.696	2.494	2.775
POS MV GNSS Antenna Phase Center Port	-0.567	0.687	2.490	2.771
Trimble SPS850 GPS Antenna Phase Center	0.003	0.888	2.428	2.709
RESON T50-R Sonar Reference Point	-1.620	-0.219	-1.349	-1.068
Port Side Draft Observation Point	-1.494	0.269	0.581	0.862

Figure 17: RV H.F. Stout Systems Layout.

B.1.1.1 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="4">MV Northstar Challenger</td></tr>
<tr><td>Echosounder</td><td colspan="4">Teledyne RESON SeaBat T50-R Multibeam Echosounder</td></tr>
<tr><td>Date</td><td colspan="4">2021-07-23</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>4.198 meters</td><td>0.020 meters</td></tr>
<tr><td>y</td><td>0.004 meters</td><td>0.020 meters</td></tr>
<tr><td>z</td><td>1.063 meters</td><td>0.020 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>0.992 meters</td><td>0.020 meters</td></tr>
<tr><td>y</td><td>-1.959 meters</td><td>0.020 meters</td></tr>
<tr><td>z</td><td>6.986 meters</td><td>0.020 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="4">RV North Cove</td></tr>
<tr><td>Echosounder</td><td colspan="4">Teledyne RESON SeaBat T50-R Multibeam Echosounder</td></tr>
<tr><td>Date</td><td colspan="4">2021-08-01</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>1.762 meters</td><td>0.020 meters</td></tr>
<tr><td>y</td><td>-0.847 meters</td><td>0.020 meters</td></tr>
<tr><td>z</td><td>0.670 meters</td><td>0.020 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>0.695 meters</td><td>0.020 meters</td></tr>
<tr><td>y</td><td>-0.289 meters</td><td>0.020 meters</td></tr>
<tr><td>z</td><td>3.488 meters</td><td>0.020 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

Vessel	RV H.F. Stout			
Echosounder	Teledyne RESON SeaBat T50-R Multibeam Echosounder			
Date	2021-07-19			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-2.051 meters	0.020 meters
		y	-0.219 meters	0.020 meters
		z	1.538 meters	0.020 meters
	Nav to Transducer	*x*	-1.053 meters	0.020 meters
		y	-0.906 meters	0.020 meters
		z	3.839 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

B.1.2 Layback

On the vessels that collected SSS, MV Northstar Challenger and RV North Cove, HYPACK SURVEY (towfish.dll) calculated and transmitted fish positions to the EdgeTech 4200-MP SSS system. The towfish device calculates fish position based on fixed tow-point offsets relative to the RP, real-time ship position, cable out value, and towfish depth. The real-time calculation incorporates the Pythagorean Theorem and a multi-segmented cable discretization approach to predict how the towfish follows the main vessel. The layback calculation can be empirically fine-tuned by adjusting the number of cable segments and modifying the catenary factor. Field testing conducted prior to this survey indicated a 5-segmented cable model and a catenary factor of 1.0 were appropriate for this particular setup. The Hydrographic Survey Products, Inc. Smart Sensor Cable Pay-Out Indicator, consisting of a topside display/controller, deck cable, and a 0.4 m diameter sheave fitted with a magnetically triggered counting sensor, was used to measure cable out values.

An evaluation of SSS positioning accuracy and an estimate of positioning error was performed for each vessel. A discrete feature was identified and mapped with MBES. That same feature was then mapped on sets of reciprocal lines at 50 m and 75 m range scales. This was done in a way that the target was detected in both channels of the sonar from a distance of 15%, 50% and 85% of the sonar range scale. The SSS data were processed and contacts were picked for each pass of the feature. The SSS-derived positions were then compared to the MBES reference position of feature. Results of the comparison are reported in DAPR Appendix V. SSS positioning accuracy on both vessels was also verified regularly during the course of the survey by observing adjacent and/or reciprocal data.

B.1.2.1 Layback Correctors

<table>
<tr><td>Vessel</td><td colspan="3">MV Northstar Challenger</td></tr>
<tr><td>Echosounder</td><td colspan="3">EdgeTech 4200-MP Dual Frequency SSS</td></tr>
<tr><td>Frequency</td><td colspan="3">600 kHz</td></tr>
<tr><td>Date</td><td colspan="3">2021-07-24</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>-1.445 meters</td></tr>
<tr><td>y</td><td>-11.354 meters</td></tr>
<tr><td>z</td><td>6.948 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">1.000 meters</td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="3">RV North Cove</td></tr>
<tr><td>Echosounder</td><td colspan="3">EdgeTech 4200-MP Dual Frequency SSS</td></tr>
<tr><td>Frequency</td><td colspan="3">600 kHz</td></tr>
<tr><td>Date</td><td colspan="3">2021-08-01</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>1.254 meters</td></tr>
<tr><td>y</td><td>-5.497 meters</td></tr>
<tr><td>z</td><td>2.512 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">1.000 meters</td></tr>
</table>

B.2 Static and Dynamic Draft

B.2.1 Static Draft

On all vessels, a draft observation point was established so that a direct measurement could be made to the surface of the water. Refer to the figures in section B.1.1 Vessel Offsets for the location of the draft observation point for each boat. 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 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, measure-downs were performed at dock to account for changes in waterline height due to fuel consumption and loading. Since ERS tides were applied, the time-stamped updated waterline heights were not needed, but were entered into CARIS under the Waterline Height field in the vessels' calibration HVFs only for recording purposes.

B.2.1.1 Static Draft Correctors

Vessel	*Date*	*Loading*	*Static Draft*	
			Measurement	*Uncertainty*
MV Northstar Challenger	2021-07-23	0.030 meters	-2.553 meters	0.030 meters
RV North Cove	2021-07-31	0.030 meters	-0.863 meters	0.030 meters
RV H.F. Stout	2021-07-19	0.030 meters	-1.068 meters	0.030 meters

B.2.2 Dynamic Draft

Dynamic draft 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. For the vessels, RV North Cove and RV H.F. Stout, dynamic draft measurements were made near OSI's home office in Old Saybrook, CT prior to the survey. Pydro's POSPac Auto QC Dynamic Draft tool was used to confirm the values once the vessels were on-site. For the MV Northstar Challenger, dynamic draft values were calculated using Pydro's Auto QC Dynamic Draft tool on the patch test data collected in the St. Mary's River.

The table below summarizes the dynamic draft results for all vessels and are included in DAPR Appendix III. Since ERS tides were applied, dynamic draft corrections were not needed, but were entered into CARIS in the vessels' calibration HVFs only for recording purposes.

B.2.2.1 Dynamic Draft Correctors

Vessel	MV Northstar Challenger		RV North Cove		RV H.F. Stout	
Date	2021-07-23		2021-08-01		2021-07-19	
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
	1.00	-0.03	1.00	0.01	1.00	0.01
	2.00	-0.06	2.00	0.02	2.00	0.01
	3.00	-0.08	3.00	0.01	3.00	0.02
	4.00	-0.09	4.00	0.01	4.00	0.03
	5.00	-0.11	5.00	-0.01	5.00	0.04
	6.00	-0.13	6.00	-0.03	6.00	0.05
	7.00	-0.14	7.00	-0.05	7.00	0.05
	8.00	-0.16	8.00	-0.07	8.00	0.04
	9.00	-0.17	9.00	-0.09	9.00	0.04
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 before data collection commenced. The patch test for the MV Northstar Challenger was performed in the St. Mary's River near Sault Ste. Marie. The patch tests for the RV North Cove and RV H.F. Stout were performed in Whitefish Bay near the Whitefish Point State Docks. Final patch values for the CARIS HVF for each vessel were determined using final SBETs. Each vessel developed a reference surface near its patch test area 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 day 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 on board. If small changes in alignment (typically roll) were observed, the HVF was updated with a time-stamped entry of the new value.

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

B.3.1.1 System Alignment Correctors

Vessel	MV Northstar Challenger
Echosounder	Teledyne RESON SeaBat T50-R Multibeam Echosounder
Date	2021-07-23

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.001 seconds
Navigation Time Correction	0.000 seconds	0.001 seconds
Pitch	-0.800 degrees	0.020 degrees
Roll	1.340 degrees	0.020 degrees
Yaw	1.650 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 North Cove
Echosounder	Teledyne RESON SeaBat T50-R Multibeam Echosounder
Date	2021-08-01

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.001 seconds
Navigation Time Correction	0.000 seconds	0.001 seconds
Pitch	1.000 degrees	0.020 degrees
Roll	1.100 degrees	0.020 degrees
Yaw	2.300 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 H.F. Stout		
Echosounder	Teledyne RESON SeaBat T50-R Multibeam Echosounder		
Date	2021-07-19		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.300 degrees	0.020 degrees
	Roll	-0.300 degrees	0.020 degrees
	Yaw	0.700 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

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

<u>Data Acquisition Methods and Procedures</u>

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, 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, absorption, and spreading settings. "Tracker" mode was employed at the beginning of each day or area, which automatically adjusts settings in trying to achieve optimal bottom detection. Once settings were steady, Tracker mode for the above mentioned settings was turned off. Additional minor manual adjustments were made over the course of the survey day to fine tune the system for optimal bottom detection and also to prevent saturation. Tracker mode for range was kept on for the majority of the survey. Tracker mode automatically adjusted the range with changes to depth in order 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 feature investigations.

The RESON T50-R was operated in equidistant mode at 200 kHz using 512 return beams and a maximum swath width of 140° depending on water depth. 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 and investigations were organized by sub areas within each sheet. Sub area designations were carried through the processing workflow as well, and were used to manage feature tracking and coverage checks.

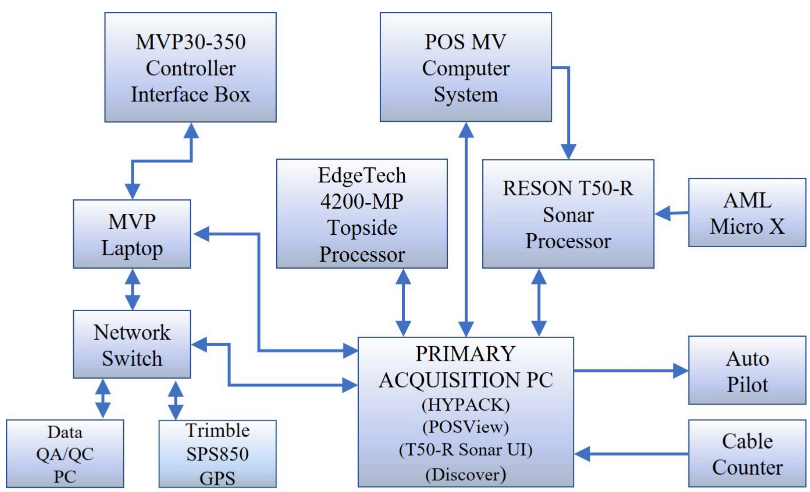


Figure 18: MV Northstar Challenger Acquisition Wiring Diagram.

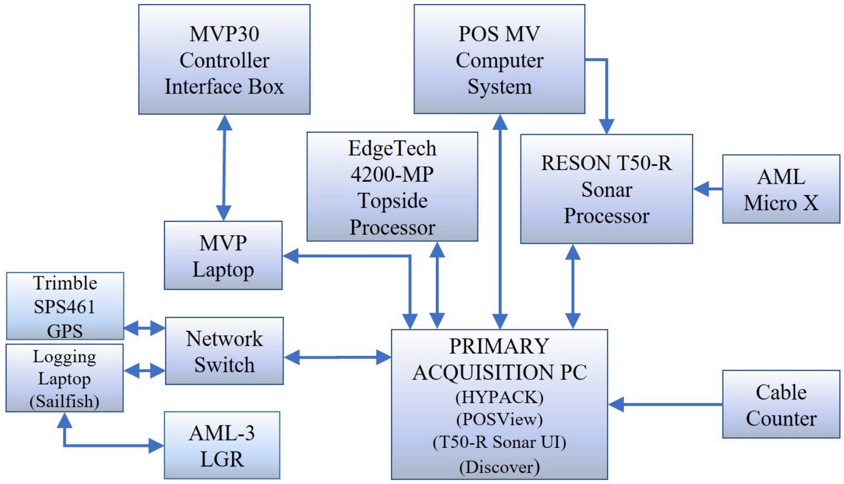


Figure 19: RV North Cove Acquisition Wiring Diagram.

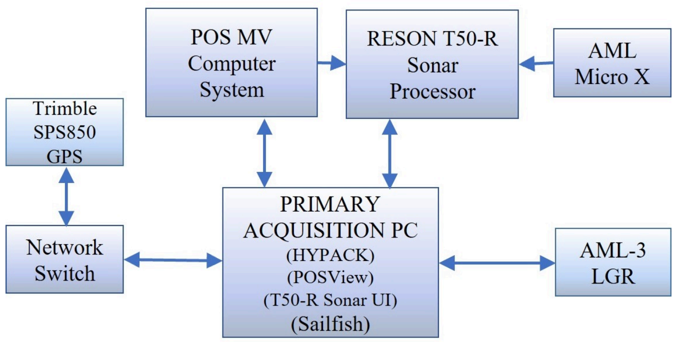


Figure 20: RV H.F. Stout Acquisition Wiring Diagram.

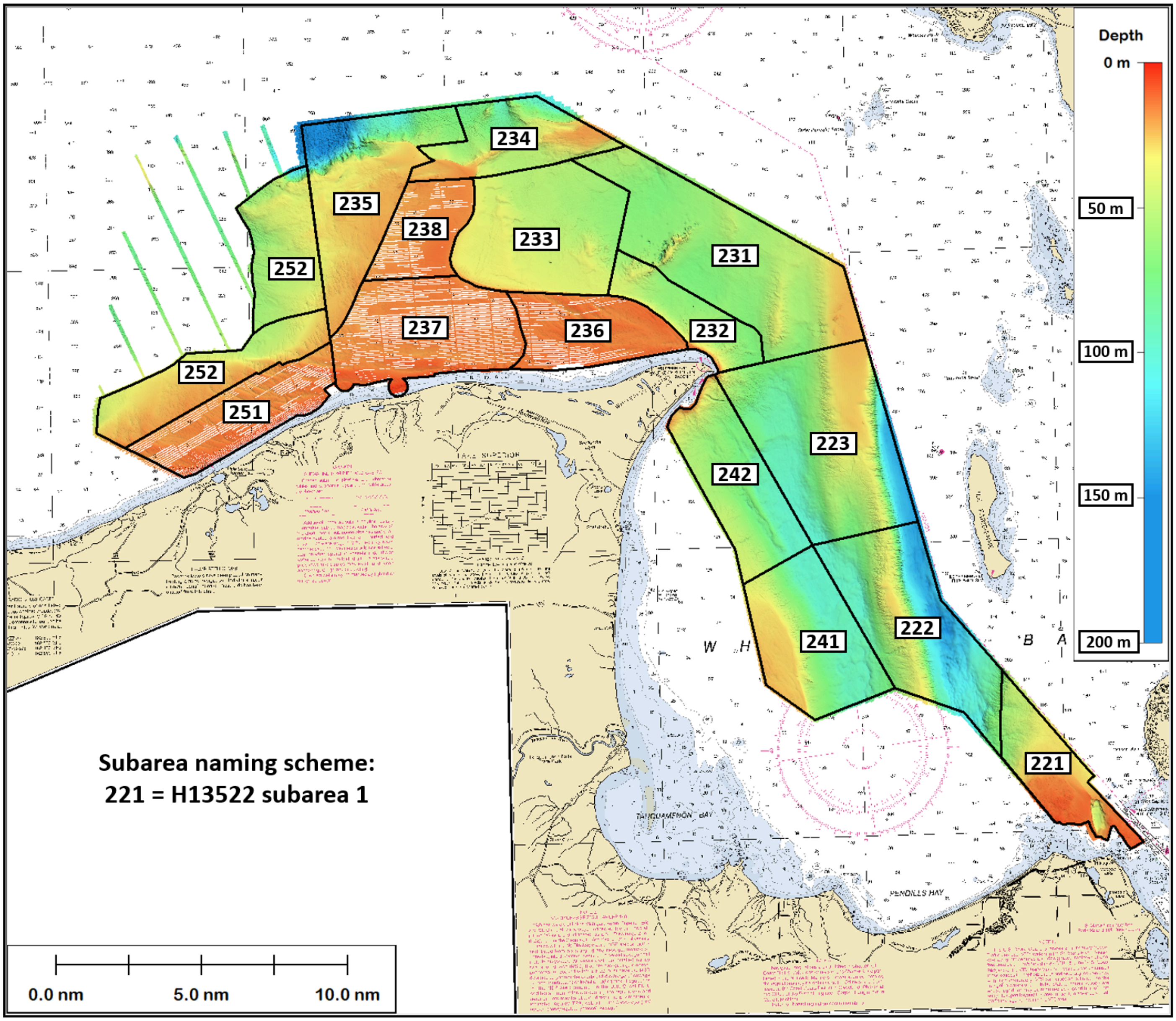


Figure 21: Subarea designations for Sheets H13522 (22X), H13523 (23X), H13524 (24X) and H13525 (25X).

<u>Data Processing Methods and Procedures</u>

QA/QC level processing was completed on board the survey vessels, however, all final data processing occurred at OSI's home office. For the two small vessels working daytime operations, field data were backed up daily to a portable data disk. Every night after data collection, data were uploaded from the portable data disk to OSI's file share site for the home office processing center to download. During field crew changes, back up data disks were also hand delivered to the office. On the MV Northstar Challenger, which worked 24-hour operations, field data were backed up daily to a portable data disk, and when the vessel made a port call the disk was shipped to OSI's home office for processing. On one occasion (DN 228), the RV H.F. Stout met up with the MV Northstar Challenger on the water and collected the portable data disk for shipping to reduce the time between acquisition and data check-in.

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:

1) Convert the HSX data to the HDCS data format, establish UTM grid.
2) Enable all multibeam beams.
3) Load daily TrueHeave (delayed heave) files.
4) Run the CARIS process Georeference Bathymetry, which includes the following steps:
-Load and apply sound speed profile data. Sound speed profiles were loaded with the CARIS nearest in distance within time 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, attitude, heading, and horizontal/vertical position 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. 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 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, and field annotations (HYPACK target files).

The CARIS Subset Editor was used to clean fully-corrected, georeferenced 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.

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. 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 were collected as snippets with the SeaBat T50-R system. The T50-R backscatter data includes an optional "normalized" backscatter feature (the 7058 datagram) which generates an intensity magnitude data signal that is compensated for the effects of the sonar itself (beam pattern, source level, sensitivity and gain). Backscatter data were 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: 2021CH2151201_167.7K where “CH” stands for MV Northstar Challenger. During initial calibration, MBES system settings such as power, gain, pulse length, absorption, and spreading were optimized for acquisition of MBES sounding data and to ensure over saturation did not occur.

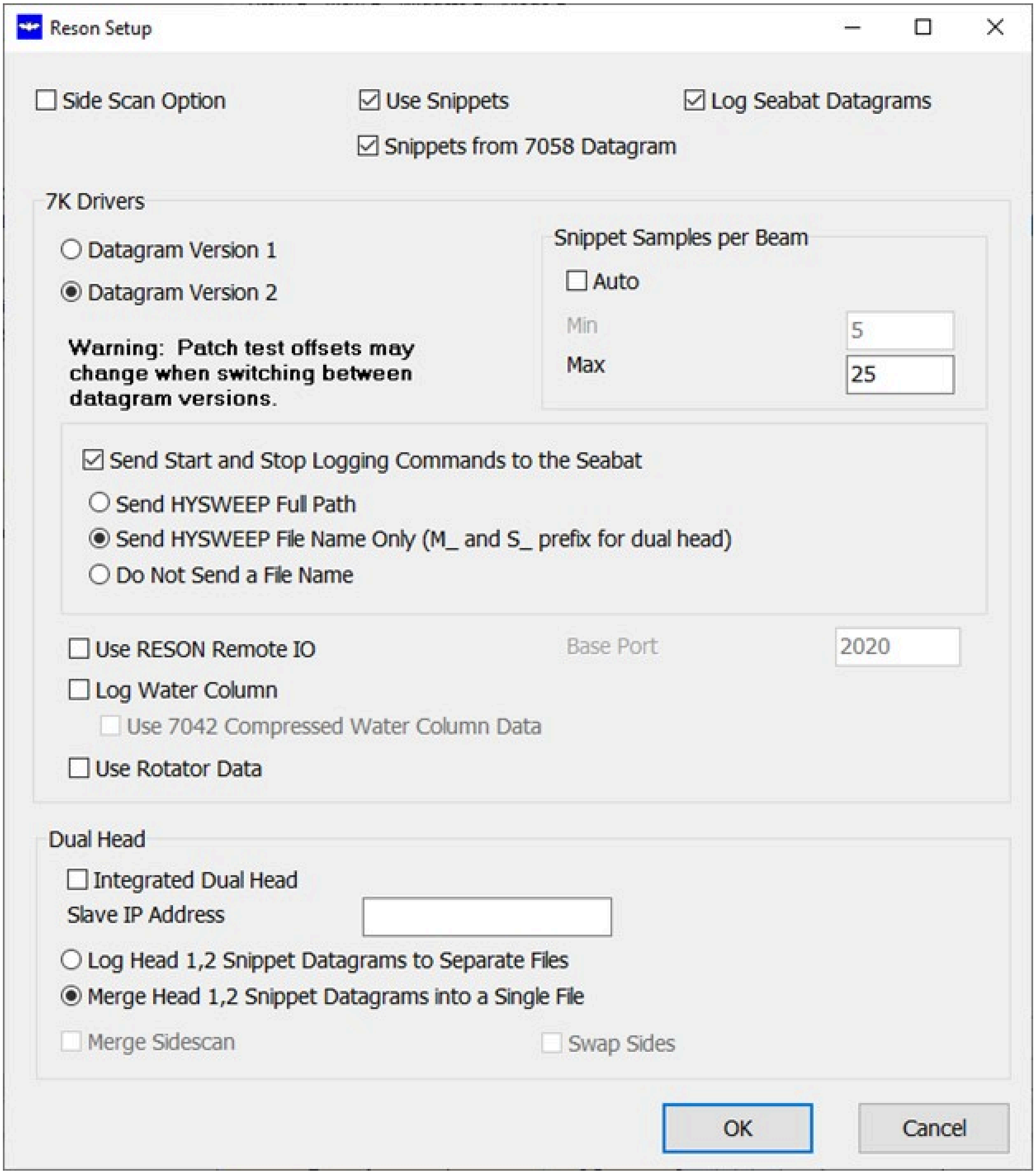


Figure 22: HYSWEEP Survey settings used for backscatter acquisition.

Data Processing Methods and Procedures

Backscatter data were collected but not processed for this project.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

Side scan sonar data were collected from two vessels, the MV Northstar Challenger and RV North Cove. SSS data were recorded in *.JSF format using EdgeTech Discover software, which was also used for system configuration and control. SSS data were transmitted via Ethernet from the SSS Topside Processor Unit to a dedicated network card on the main data acquisition computer. EdgeTech Discover file recording start and stop control was handled by HYPACK and HYSWEEP through a loop-back IP device connection. SSS fish depth was transmitted from Discover to HYPACK as a NMEA DPT serial message, which was needed to calculate fish position. Real-time navigation was transmitted to Discover from HYPACK as a NMEA RMC serial message at 2 Hz. A discussion on positioning and layback is included in section B.1.2 of this report. A ZDA timing message was transmitted at 1 Hz to Discover by direct serial connection to the POS MV.

On both vessels the EdgeTech 4200-MP SSS was operated at the 50 m or 75 m range scale collecting both 300 kHz and 600 kHz frequency data simultaneously, but only the 600 kHz (high) frequency was used for processing. Towed SSS altitude was monitored in real time and adjustments were made to maintain an altitude within the permissible range. The SSS waterfall was monitored for refraction, surface noise, excessive fish, and other factors that could affect data quality. Bottom texture changes and sand waves were noted in the survey log as daily confidence checks. Vessel speed ranged from 6-9 knots, which was well within the range needed to ensure SSS coverage of 3 pings per meter when the 4200-MP was operated in high speed mode. The depth pressure sensor on the towfish was zeroed out in air on a daily basis to account for changes in atmospheric pressure. As a QC check on towfish depth and altitude detection, the sum of the towfish altitude and depth were frequently compared to water depth from the MBES.

Data Processing Methods and Procedures

Preliminary QA/QC of the SSS data occurred simultaneously with data acquisition. However, all final data processing occurred at OSI’s home office. Once the data were received from the field, the data files and acquisition log were reviewed to verify line names and file size and to remove any aborted lines from the preprocess folder prior to converting the data in CARIS SIPS. All lines copied from the acquisition computer were entered into the survey processing log, which was used to track the processing progress of each line and to record all notes pertinent to individual lines or days.

Preliminary processing steps were conducted prior to the import of *.JSF SSS files into CARIS SIPS. Towed SSS *.JSF files were first passed through SonarWiz for initial bottom tracking and to smooth the navigation. A 100-point smoothing window was applied to the 2 Hz positions received from the HYPACK towfish.dll and recorded in the *.JSF. Bottom tracking and smooth navigation were exported from SonarWiz as *.CSV files.

CARIS HVFs were created to convert EdgeTech *.JSF data files. All preprocess EdgeTech *.JSF data were converted to the HDCS data format in the CARIS Conversion Wizard. Parameters developed during the preliminary processing steps described above were imported and applied with the CARIS Generic Data Parser. Navigation time stamp irregularities were edited, and navigation data were reviewed in the CARIS

Navigation Editor. Each side scan line was reviewed in CARIS Attitude Editor to ensure that the towfish attitude was properly represented and there were no gaps or problems with this parameter.

The CARIS Side Scan Editor was used to review the imported bottom track, apply slant range corrections, and apply image enhancement correction to the data. In order to ensure sufficient coverage, individual line mosaics were created with a resolution of 0.15 m. The line mosaics were then merged and saved as a 0.25 m resolution sheet mosaic. The sheet mosaics were reviewed for coverage gaps and poor-quality imagery that required SSS fill-in lines. Fill-in lines were assigned to the field team, as necessary, to supplement the existing coverage. After the completion of survey and processing operations, the final sheet mosaics were exported as individual GeoTiffs at 1 m resolution.

Once initial image processing was completed, contacts were selected in the Side Scan Editor waterfall. Objects were identified by the presence of sonar shadows. Contacts were positioned and created at the top (closest to nadir) of the shadow, and attributed with the following information: feature type, height, width & length (if significant per the HSSD), and processor remarks. Heights were measured with the shadow tool. Lengths and widths were measured with the distance tool.

SSS lines were reviewed a minimum of two times by more than one data analyst to make certain that all significant contacts were selected that may require investigation. The contacts selected in Side Scan Editor were visible in the HIPS/SIPS Display window. Senior processing personnel would identify the contacts that required additional investigation with consideration of supporting data such as field targets, notes in the survey log, and historical shipwreck information available online. An item investigation HOB layer was then created which included the positions of all side scan contacts and outstanding soundings to be developed with additional MBES coverage. Upon receipt of MBES investigation data, contacts were reviewed in CARIS Subset Editor.

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 base station at the Great Lakes Shipwreck Museum in Paradise, Michigan. Specifically, a Trimble NetR9 GNSS receiver with a Zephyr 3 Geodetic antenna was installed on the roof of the most northeast building of the Museum complex. 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.

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 Whitefish Point or "OSWP."

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. OSWP was used in all solutions and the final coordinates of OSWP were determined using OPUS. A discussion of OPUS data processing and the determination of final station coordinates are included in the HVCR.

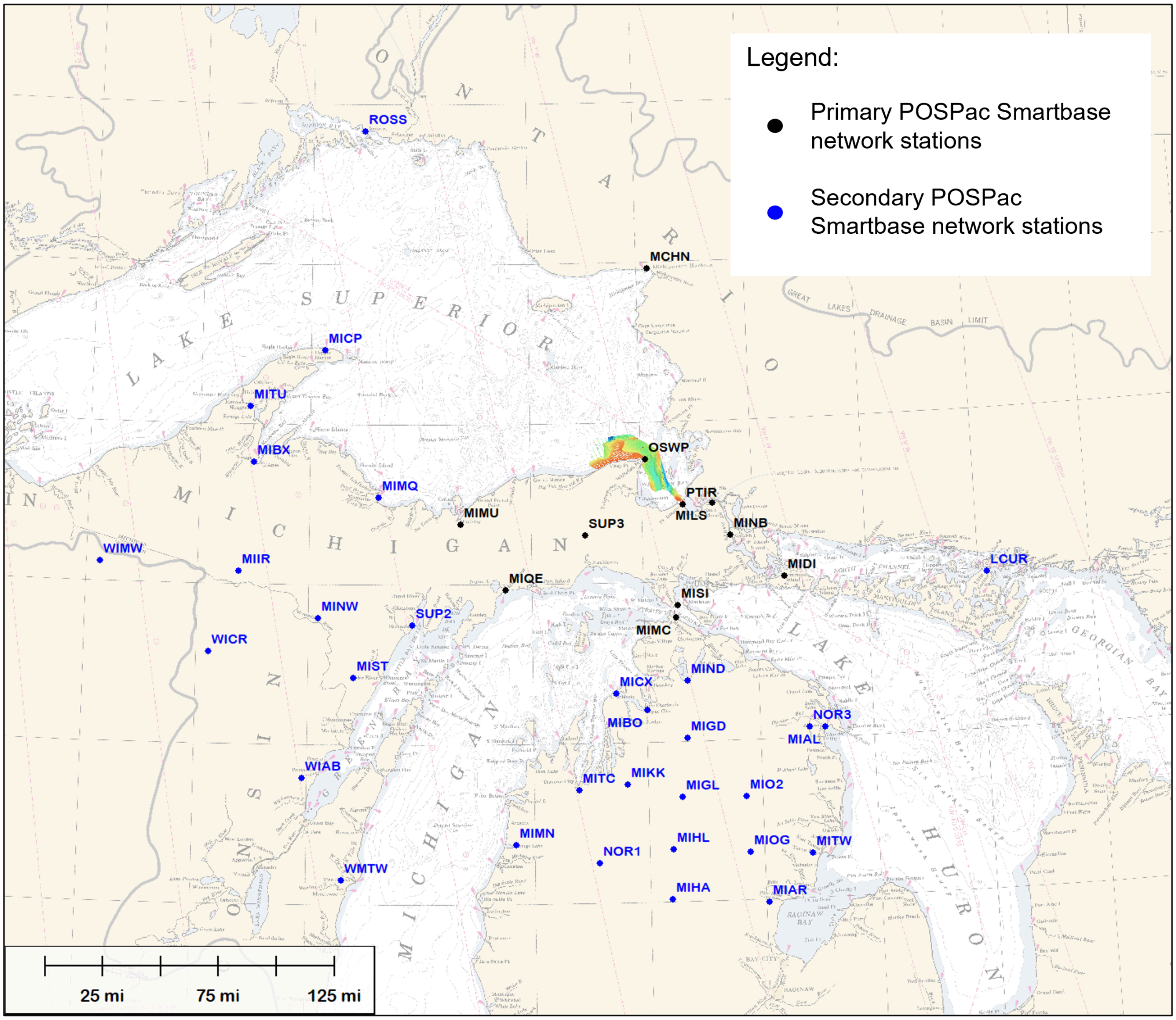


Figure 23: Local CORS network used in Applanix Smart Base (ASB) IAPPK processing.

Station	POSPac Project Count
OSWP	86
PTIR	80
SUP3	78
MILS	72
MCHN	66
MINB	58
MISI	43
MIMU	35
MIQE	23
MIMC	19
MIDI	15
WIAB	12
WICR	12
LCUR	11
MIMQ	8
ROSS	8
SUP2	7
MICX	7
MIBX	6
MICP	6
MIGD	6

Station	POSPac Project Count
MIGL	6
MIIR	6
MIKK	6
MIND	6
MINW	6
MIO2	6
MIST	6
MITC	6
NOR3	6
MIHL	5
MIMN	5
MIOG	5
MITW	5
NOR1	5
MIAR	4
MITU	4
WMTW	4
MIAL	3
MIBO	3
MIHA	2
WIMW	1

Figure 24: POSPac Project Count of Local CORS network used in Applanix Smart Base (ASB) IAPPK processing.

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 LWD IGLD85 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 POS MV 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 with the original project files and described in the Project Instructions.

VDATUM Model				
VDatum Version	Geoid	Area	Area Version	Separation Uncertainty
4.1.2	2018	Eastern Lake Superior	2021.2	0.045 meters

Figure 25: 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 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 periods of poor-quality or invalid data that remained.

Once an 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 LWD IGLD85 tide correctors.

Qualitative and quantitative crossline analysis as well as junction analysis indicate that the final ERS correctors employed in reducing soundings to LWD IGLD85 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

On all vessels, the POS MV's integrated DGPS was activated utilizing SBAS (FAA WAAS) corrections to improve real-time positioning. 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 secondary SPS850 Extreme GPS and SPS461 GPS also used SBAS (FAA WAAS) corrections to improve its real-time positioning. The secondary GPS receivers were interfaced with HYPACK Survey on the acquisition computers to show its positions in the survey windows for real-time comparison to the POS MV's positions.

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 contained True Heave data.

Data Processing Methods and Procedures

For all vessels, real-time 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

Sound speed profiles were acquired inside the bounds of the survey area, with few exceptions such as casts acquired on the approach to a survey line.

On the MV Northstar Challenger, sound speed profile data were acquired with the MVP30-350 system at approximately 20-minute intervals. On the RV North Cove, profiles were acquired with the MVP30 system at approximately 30-minute intervals. In deeper areas, the North Cove reduced survey speed or drifted in order to maximize the profile depth of the MVP30. In areas of fish nets/traps or where the depth was deeper than the amount of cable on the MVP30 system, the North Cove acquired profiles using a manually-deployed AML-3 LGR profiler. On the RV H.F. Stout, profiles were acquired by the AML-3 LGR profile exclusively. Profiles were acquired approximately every hour when using the hand-deployed AML-3 sound speed profiler. Interval times varied depending on transit, working location and depth, and conditions. 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.

MVP Controller software was configured to receive navigation data from HYPACK via the MVP.dll. HYSWEEP Survey was configured to receive MVP casts in real time to correct waterfall and profile displays with the most recent sound speed profile. MVP cast position, sound speed, and depth data were recorded in *.CALC file format and saved to the designated MVP laptop computer. Profiles were named for day number and cast number, i.e. MVP_DN207_005.calc.

AML-3 profiles were uploaded to the vessel's computer via Bluetooth using AML Oceanographic's Sailfish software. Sailfish output *.AML text files and using Microsoft Excel with an OSI custom made macro, the *.AML files were converted to HYPACK *.VEL file format for import to HYSWEEP Survey.

Data Processing Methods and Procedures

HydrOffice Sound Speed Manager was used to process and organize sound speed profiles for the project. Separate databases for each vessel within each survey sheet were created, and profiles were reviewed and added to the appropriate database on an ongoing basis at the OSI home office. MVP profiles were imported directly into Sound Speed Manager from the *.CALC files or the *.M1 files. AML-3 profiles collected in *.AML format were converted to CARIS SVP format using an OSI custom macro in Microsoft Excel. Individual cast *.SVP files were imported into Sound Speed Manager for organization into the master sound speed database for each vessel within each survey sheet.

Sound speed profiles were applied to the sounding data in CARIS HIPS using primarily the "nearest in distance within time" correction method with 1 to 6 hours as the time parameter. SVP application settings varied due to the complexity of the thermocline, which had an undulating transition zone and slope interactions affecting the depth of the layers. Details for each sheet are discussed in the DR.

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 an SV Xchange sensor, was transmitted to the RESON T50-R processor for beam forming. The T-50 R “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.

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 1 Hz 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).

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		MV Northstar Challenger	RV North Cove	RV H.F. Stout
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		0.25 meters	0.25 meters	0.25 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 were imported into HYPACK's target database for each vessel, enabling the field crews to see the locations of the CSF items in the 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.

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. If deemed necessary, investigation lines were run over features with the multi-detect and compressed water column turned on in the RESON T50-R sonar interface. This water column imagery was used to confirm least depth over the feature.

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 grid node was met. Each CSF item location and its assigned search radius were examined in CARIS Subset Editor to see if the 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 a feature was present. 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 locate potential Dangers to Navigation (DTONs); after review there were no DTONs identified in this survey. Chart comparisons were conducted 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 potential DTONs and those that have a high discrepancy from charted soundings. Processors manually reviewed the exported soundings with consideration for water depth and the magnitude of discrepancy from the chart.

All CSF assigned features, ATONs, and unassigned features are included in the FFF.

C.8 Bottom Sample Data

Bottom sample data was not acquired.

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 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, sloping seafloors, and areas with high thermocline variability. 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.

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

To assess uncertainty, the bathymetric surfaces were finalized in CARIS HIPS using the "greater of the two" option to set the uncertainty of each grid node to either the standard deviation or the uncertainty. Finalized surfaces were analyzed using the Grid QA function within the NOAA Pydro "QC Tools" application, which plots the node uncertainty as a fraction of allowable IHO TVU. Passing nodes are those with uncertainty fractions between 0 and 1. The uncertainty assessment is included in the DR for each sheet.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

To evaluate crossline to mainscheme line differences, separate CUBE surfaces were created for crosslines and mainscheme lines in each sheet. Comparisons were made by computing the overlapping node to node differences using the NOAA Pydro "Compare Grids" tool. 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 individual sheets in OPR-Z394-KR-21 and the bordering topobathy lidar survey 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 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

D.2.1 Coverage Assessment

Side scan sonar data was collected in areas north of Whitefish Point where the water depth was anticipated to be less than 20 m. To ensure complete coverage requirements were met within the side scan areas, the 100% side scan coverage mosaic was updated frequently and reviewed by the home office for gaps or poor-quality data. Splits, reruns, and fill-in lines were collected in the field to achieve high quality coverage in all areas using side scan sonar data. Contacts and features were developed with multibeam, and 200% side scan sonar was collected within an assigned feature disproval radius.

D.2.2 Contact Selection Methodology

Side scan sonar contacts were picked for objects with a computed height of 1 m, per HSSD 6.1.3.3 guidance for contact selection in water depths less than 20 m. Features smaller than 1m were sometimes chosen if they appeared potentially significant based on their horizontal dimensions or in relation to the charted depth. Contacts for features were selected on all lines where any portion of the feature was visible.

E. Approval Sheet

Field operations contributing to the accomplishment of OPR-Z394-KR-21 surveys H13522, H13523, H13524, and H13525 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	12/16/2021	John R. Bean 2021.12.16 14:40:43 -05'00'
David T. Somers	Data Processing Manager	12/16/2021	David T. Somers 2021.12.16 14:41:11 -05'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	OPR-Z394-KR-21_DAPR_A-I.pdf
Sound Speed Sensor Calibration	OPR-Z394-KR-21_DAPR_A-II.pdf
Vessel Offset	OPR-Z394-KR-21_DAPR_A-III.pdf
Position and Attitude Sensor Calibration	OPR-Z394-KR-21_DAPR_A-IV.pdf
Echosounder Confidence Check	OPR-Z394-KR-21_DAPR_A-V.pdf
Echosounder Acceptance Trial Results	N/A