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

Data Acquisition & Processing Report

Type of Survey HYDROGRAPHIC

Project Number S-E932-BH2-16

Time Frame DECEMBER

LOCALITY

State: MARYLAND

General Locality Severn River

2016

CHIEF OF PARTY

LTJG SARAH L CHAPPEL, NOAA

LIBRARY & ARCHIVES

DATE

NOAA FORM 77-28 U.S. DEPARTMENT OF COMMERCE (11-72) NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION **HYDROGRAPHIC TITLE SHEET**	PROJECT NUMBER: **S-E932-BH2-16**

INSTRUCTIONS: The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

State: **Maryland**

General Locality: **Severn River, MD**

Sub-Locality: **Severn River**

Scale: **1:5000**

Date of Survey:
Instructions Dated: **10/24/2016**

Project Number: **OPR-E932-BH2-16**

Vessel: **NOAA *R/V Bay Hydro II***

Chief of Party : **LTJG Sarah L Chappel, NOAA**

Surveyed by: **NOAA R/V *Bay Hydro II* Personnel**

Soundings by: **Kongsberg EM 2040 Multibeam Echosounder**

Verification by: **Pacific Hydrographic Branch Personnel**

Soundings in: **Feet at MLLW**

Remarks:
1) All Times are UTC.
2) Projection is UTM Zone 18.

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R/V BAY HYDRO II
Chief of Party: LTJG Sarah L Chappel
Year: 2016
Version: 1
Publish Date: 2017-01-12

A Equipment

A.1 Survey Vessels

A.1.1 R/V Bay Hydro II

Name	R/V Bay Hydro II
Hull Number	S5401
Description	R/V Bay Hydro II was used for the acquisition and post-processing of all side scan sonar (SSS) data, single beam echo sounder data (MBES), multibeam echo sounder (MBES) data, sound velocity profiles (SVP) and detached positions (DP'S) unless otherwise noted in the Descriptive Report. Vessel configuration and offset measurements are included in Appendix 1 of this report.
Utilization	Bathymetric data were acquired with one MBES this field season. The hydrographer determined the methods and systems to meet full-coverage of the survey in accordance with the Hydrographic Survey Project Instructions, NOAA's Hydrographic Surveys Specifications & Deliverables (2016 HSSD) and NOAA's Field Procedures Manual (2014 FPM).
Dimensions	*LOA*: 17.3 meters *Beam*: 6.33 meters *Max Draft*: 1.8 meters
Most Recent Full Static Survey	*Date*: 2009-03-23 *Performed By*: H. Stewart Kuper Jr., NGS *Discussion*: An NGS survey of R/V Bay Hydro II was performed on 23 March 2009 using optical levels.
Most Recent Partial Static Survey	Partial static survey was not performed.
Most Recent Full Offset Verification	Full offset verification was not performed.

<table>
<tr><td>Most Recent Partial Offset Verification</td><td colspan="2">Partial offset verification was not performed.</td></tr>
<tr><td rowspan="3">Most Recent Static Draft Determination</td><td>Date</td><td>2016-04-27</td></tr>
<tr><td>Method Used</td><td>Steel Measuring Tape and Lead Line</td></tr>
<tr><td>Discussion</td><td>An initial static draft measured was determined on 27-April-2016 during the HSRR. However, since this measurement changes with the vessel's fuel load, this measurement is retaken daily during MBES data acquisition. The value was calculated by: 1) measuring the Z-Axis distance from the benchmark on top of the multibeam strut, down to the waterline, then 2) subtracting the fixed distance from the benchmark to the reference point. The resulting value is the distance from the reference point to the water line.</td></tr>
<tr><td rowspan="3">Most Recent Dynamic Draft Determination</td><td>Date</td><td>2016-04-27</td></tr>
<tr><td>Method Used</td><td>Elipsoid Referenced Dynamic Draft Measurement (ERDDM)</td></tr>
<tr><td>Discussion</td><td>Dynamic draft values were determined on 27-April-2016, using the ERDDM method outlined in the Field Procedures Manual Section 1.4.2.1.2.1. See Appendix 3 for the full report.</td></tr>
</table>

Figure 1: R/V BAY HYRDO II

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 EdgeTech 4200

Manufacturer	EdgeTech
Model	4200

<table>
<tr><td>Description</td><td>The EdgeTech High Speed, High Resolution side scan sonar system is a beam-forming acoustic imagery device that is towed behind R/V BAY HYDRO II via an armored cable and a hydraulic A-frame. The EdgeTech 4200 towfish is a dual frequency system that operates at 230kHz and 540kHz with a vertical beam width of 50°. Even though the system is dual frequency and both frequencies are logged, only the high frequency data is converted and processed in CARIS. The low frequency is available to the hydrographer as a quality control tool and is archived at The National Centers For Environmental Information (NCEI) upon completion of the survey. The integrated system includes an EdgeTech 4200 lightweight towfish, a tow cable telemetry system, and a Topside Processing Unit.

Positioning of the towfish is calculated using CARIS SIPS and is derived from the amount of cable out, the towfish depth (from the towfish's pressure gage), and the vessel's Course Made Good (CMG). Towfish altitude is maintained between 8% and 20% of the range scale, in accordance with the FPM Section 2.5.3.1.2. The length of cable out is adjusted during SSS acquisition to ensure that the towfish stays in the required range to maximize sonar grazing angles. Confidence checks are performed daily in accordance with the HSSD Section 6.1.3.1. More information can be found in Section B.1.2.1 of this document.

The EdgeTech 4200 is capable of operation in three distinct modes; Mode 1 is single pulse/high definition, Mode 2 is multipulse/high speed, and Mode 3 is multipulse/high resolution. Each distinct mode uses the transducer arrays in a different configuration. R/V BAY HYDRO II uses Mode 3. The use of multipulse mode coupled with the high resolution mode allows for operational speeds up to 9.6 kts, while providing quality imagery and density that meet the standards in HSSD 6.1.2.2.

In May of 2016 an annual SSS calibration test was performed in accordance with FPM 1.5.7.1.2. For a full report see Appendix 2.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S5401</td></tr>
<tr><td>TPU s/n</td><td>42646</td></tr>
<tr><td>Towfish s/n</td><td>40728</td></tr>
</table></td></tr>
<tr><td>Specifications</td><td><table>
<tr><td>Frequency</td><td>230 kilohertz</td><td>540 kilohertz</td></tr>
<tr><td>Along Track Resolution</td><td><table><tr><td>Resolution</td><td>0.122 meters</td></tr><tr><td>Min Range</td><td>0 meters</td></tr><tr><td>Max Range</td><td>150 meters</td></tr></table></td><td><table><tr><td>Resolution</td><td>0.061 meters</td></tr><tr><td>Min Range</td><td>0 meters</td></tr><tr><td>Max Range</td><td>100 meters</td></tr></table></td></tr>
<tr><td>Across Track Resolution</td><td>0.03 meters</td><td>0.015 meters</td></tr>
<tr><td>Max Range Scale</td><td>500 meters</td><td>500 meters</td></tr>
</table></td></tr>
<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
</table>

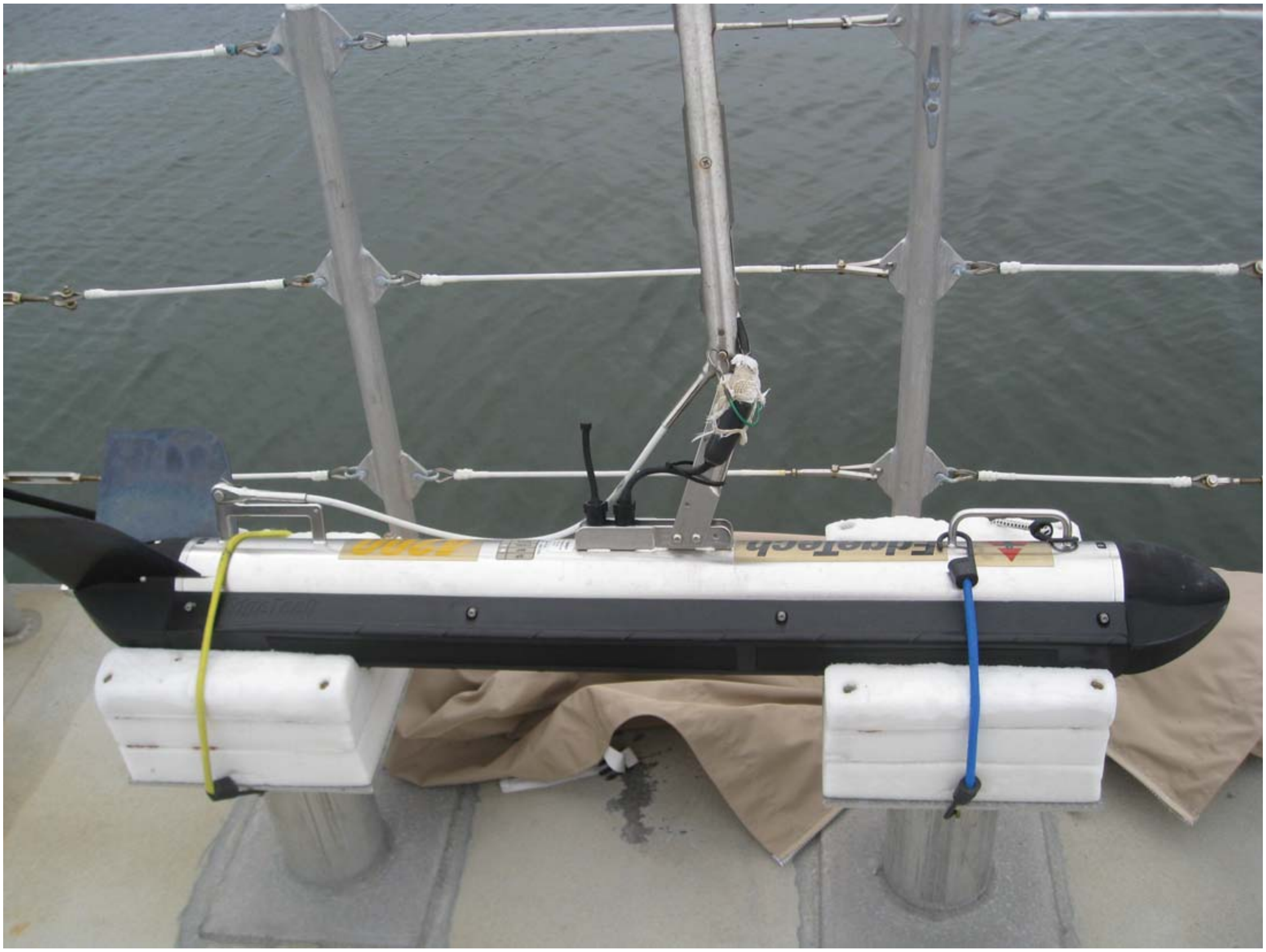

Figure 2: EdgeTech 4200 side scan sonar.

A.2.2 Multibeam Echosounders

A.2.2.1 Kongsberg EM2040

Manufacturer	Kongsberg
Model	EM2040
Description	The Kongsberg EM2040 system is a digital recording multibeam echo sounder which is capable of operating at 200kHz, 300kHz, 400kHz, or in a Frequency Modulation (FM) Chirp. The system is comprised of a receiver unit that is mounted on a sliding sonar strut, a Hydrographic Work Station (HWS), and a Processor Unit (PU). The

projector and receiver are set up in a Mills Cross configuration, and deployed through a retractable door located on the center line of the vessel. The EM2040 is operated through Seafloor Information System (SIS) software; version 4.1.5.

The EM2040 is used to acquire full and partial bottom bathymetric coverage throughout a survey area to determine least depths over critical items such as wrecks, obstructions, dangers-to-navigation, and general object detection. While operating in partial coverage, the EM2040 collects data concurrently with the EdgeTech 4200 without acoustic interference, commonly referred to as "skunk striping".

R/V BAY HYDRO II operates the EM2040 at a frequency of 300kHz for normal operations, as specified in the Kongsberg operator's manual. This configuration provides an ideal mix of resolution and range for surveying within R/V BAY HYDRO II's operational area. The specifications below reflect this mode of operation.

Serial Numbers

Vessel Installed On	S5401
Processor s/n	274
Transceiver s/n	None
Transducer s/n	150
Receiver s/n	191
Projector 1 s/n	150
Projector 2 s/n	None

Specifications

Frequency	300 kilohertz	
Beamwidth	*Along Track*	0.4 degrees
	Across Track	0.3 degrees
Max Ping Rate	50 hertz	
Beam Spacing	*Beam Spacing Mode*	Equidistant
	Number of Beams	400
Max Swath Width	140 degrees	
Depth Resolution	26 millimeters	
Depth Rating	*Manufacturer Specified*	600 meters
	Ship Usage	40 meters

Manufacturer Calibrations

Manufacturer calibration was not performed.

System Accuracy Tests

Vessel Installed On	S5401
Methods	Sonar Acceptance Test
Results	In July 2013, the EM2040 was installed on R/V BAY HYDRO II and the Sea Acceptance Test verified the sonar system was fully functional (See full report in Appendix 2).

Snippets	Sonar has snippets logging capability.

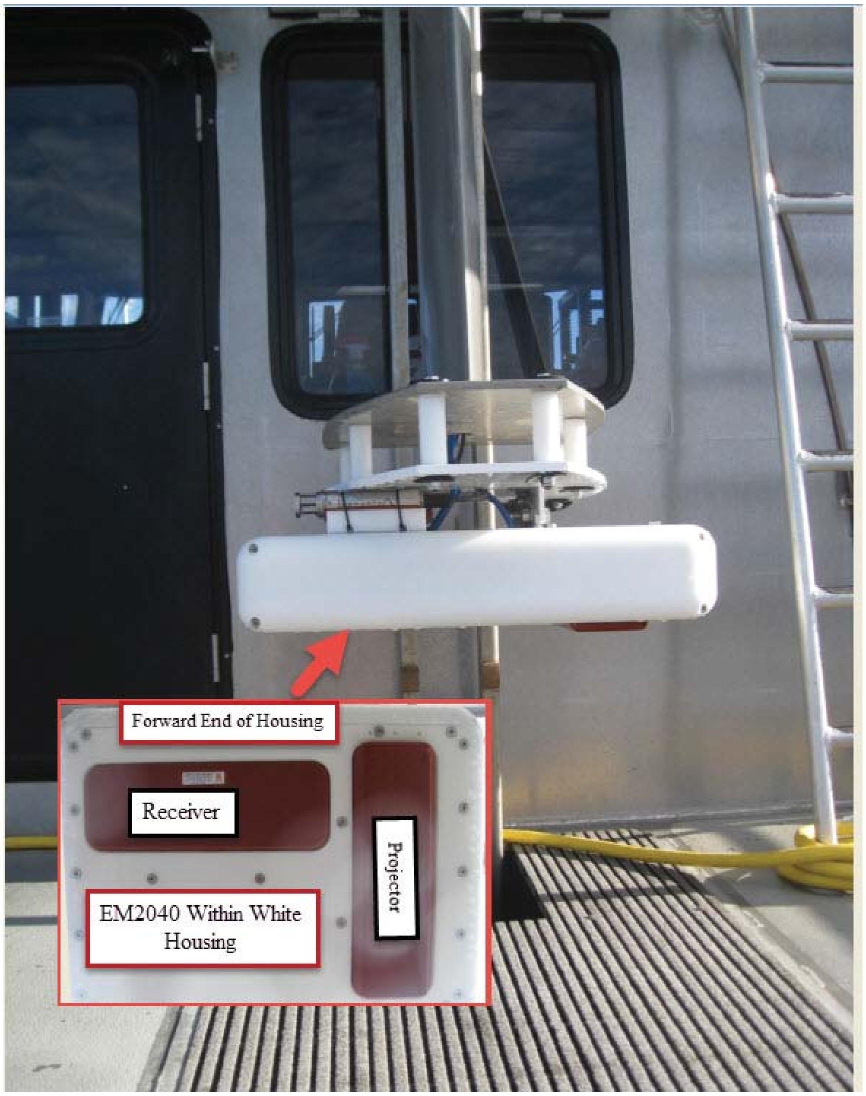

Figure 3: Kongsberg EM2040 housing and sonar, in the retracted position.

Figure 4: Kongsberg EM2040 housing and sonar in the deployed position.

A.2.3 Single Beam Echosounders

A.2.3.1 ODOM Echotrac CV 200 Single Beam Echo Sounder CV-200

<table>
<tr><td>Manufacturer</td><td colspan="5">ODOM Echotrac CV 200 Single Beam Echo Sounder</td></tr>
<tr><td>Model</td><td colspan="5">CV-200</td></tr>
<tr><td>Description</td><td colspan="5">The Odom Echotrac CV-200 is a dual frequency digital recording echo sounder which operates at 24 kHz and 200 kHz simultaneously. The system is comprised of the CV-200 hydrographic echo sounder and one M42 dual frequency transducer mounted on the outboard side of the starboard hull. The system is used for water depth measurements and to confirm depths measured by other systems through the annual Hydrographic Systems Readiness Review (HSRR) comparison testing procedures. The system can be used for SBES surveys and concurrent SBES/SSS acquisition surveys.</td></tr>
<tr><td rowspan="3">Serial Numbers</td><td>Vessel</td><td colspan="4">S5401</td></tr>
<tr><td>Processor s/n</td><td colspan="4">003071</td></tr>
<tr><td>Transducer s/n</td><td colspan="4">TR5444</td></tr>
<tr><td rowspan="8">Specifications</td><td>Frequency</td><td colspan="2">200 kilohertz</td><td colspan="2">24 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>4 degrees</td><td>Along Track</td><td>20 degrees</td></tr>
<tr><td>Across Track</td><td>4 degrees</td><td>Across Track</td><td>20 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">20 hertz</td><td colspan="2">20 hertz</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">0.01 meters</td><td colspan="2">0.01 meters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>200 meters</td><td>Manufacturer Specified</td><td>1500 meters</td></tr>
<tr><td>Ship Usage</td><td>38 meters</td><td>Ship Usage</td><td>38 meters</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="5">Manufacturer calibration was not performed.</td></tr>
</table>

System Accuracy Tests	*Vessel Installed On*	S5401	S5401
	Methods	Comparison to Lead Line	Comparison to MBES
	Results	On 22-April-2016, soundings from the Odom Single Beam Echo Sounder were compared to lead line soundings. The average difference between depths was 6.8cm (See Appendix 2 for full report).	On 21-May-2015, soundings from the Odom Single Beam Echo Sounder were compared to soundings from the Kongsberg EM2040 MBES. This comparison was conducted by running both systems over the same nine lines, creating a CUBE surface for each data set, and differencing the two surfaces. A statistical analysis of the resulting difference surface showed the sounding from both systems to be in good agreement, having a mean difference of 8cm, with the multibeam soundings being shoaler, and a standard deviation of 41cm (See Appendix 2 for full report).

Figure 5: R/V Bay Hydro II's hull mounted starboard SBES sonar.

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

<table>
<tr><td>Manufacturer</td><td colspan="2">N/A</td></tr>
<tr><td>Model</td><td colspan="2">N/A</td></tr>
<tr><td>Description</td><td colspan="2">R/V BAY HYDRO II is equipped with a non-traditional lead line fabricated from Amsteel® brand line and an eight inch tall mushroom anchor. This lead line was fabricated on 16-June-2009.</td></tr>
<tr><td>Serial Numbers</td><td colspan="2">N/A</td></tr>
<tr><td rowspan="3">Calibrations</td><td>Serial Number</td><td>N/A</td></tr>
<tr><td>Date</td><td>2016-02-02</td></tr>
<tr><td>Procedures</td><td>The lead line was laid out on the dock with the mushroom anchor on its side, the line was pulled tight, and the lead line graduations were compared to the graduations on a fabric measuring tape. Performed 02-February-2016. See Appendix 2 for the full report.</td></tr>
<tr><td rowspan="3">Accuracy Checks</td><td>Serial Number</td><td>none</td></tr>
<tr><td>Date</td><td>2016-04-22</td></tr>
<tr><td>Procedures</td><td>On 22-April-2016, soundings from the leadline were compared to soundings from the ODOM Single Beam Echo Sounder. The average difference between depths was 3.23 cm. See Appendix 2 for the full report.</td></tr>
<tr><td>Correctors</td><td colspan="2">Correctors were not determined.</td></tr>
<tr><td>Non-Standard Procedures</td><td colspan="2">Non-standard procedures were not utilized.</td></tr>
</table>

Figure 6: Bay Hydro II's non-traditional lead-line with orange meter incrementation.

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 Positioning and Attitude Equipment

A.4.1 Applanix POS/MV

<table>
<tr><td>Manufacturer</td><td>Applanix (a Trimble company)</td></tr>
<tr><td>Model</td><td>v.5</td></tr>
<tr><td>Description</td><td>The POS/MV is a GPS-aided inertial positioning system that provides position and orientation data to external equipment. The system is comprised of an Inertial Measurement Unit (IMU), two GNSS receivers, and a POS Computing System (PCS) unit. Roll, pitch, and heave values are measured by the IMU, while position is derived from the tightly-coupled GPS/IMU integration. The system determines vessel heading by integrating data from the GNSS antennas and heading estimates by the IMU.</td></tr>
<tr><td>PCS</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix (a Trimble company)</td></tr>
<tr><td>Model</td><td>v.5</td></tr>
<tr><td>Description</td><td>The PCS blends raw acceleration measurements from the IMU with positional information from the GNSS antennas and RTCM beacon, creating a tightly-coupled position and orientation solution. The PCS also provides the one Pulse Per Second (PPS) signal used by integrated systems to accurately time-stamp data.</td></tr>
<tr><td>Firmware Version</td><td>4.1-7</td></tr>
<tr><td>Software Version</td><td>3.4.0.0</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>5401</td></tr>
<tr><td>PCS s/n</td><td>3954</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

IMU

Manufacturer	Applanix (a Trimble company)
Model	v.5
Description	The POS/MV IMU is used to record the amount of motion experienced by the vessel. The IMU is secured to the vessel as close to the vessel's central reference point as possible. The motion experienced by the IMU is, by definition, the same motion experienced by the vessel. The IMU housing contains three orthogonally placed accelerometers, which sense acceleration in the x, y, and z directions. It also contains three orthogonally placed gyros, which sense angular rate of motion around the three axes. The measured amount of acceleration and rate of rotation is then used to find the degree of motion experienced by the vessel. In the event of GNSS dropouts due to overhead obstructions, the IMU data can be used to provide a dead reckoned position.
Serial Numbers	*Vessel Installed On*: 5401 *IMU s/n*: 1023
Certification	IMU certification report was not produced.

Antennas

Manufacturer	Applanix (A Trimble Company)
Model	Zephyr Model 2
Description	The POS/MV system includes two GNSS antennas, each of which provides carrier phase level positioning information. In addition to providing robust positional information, the antenna's level of accuracy is also used to improve the system's heading accuracy. The two antennas have at a fixed spacing interval and a known position relative to the reference point. The POS has enough resolution to position one antenna relative to the other using carrier phase level positioning. The positions are then used to calculate the North-East-Down vector between the primary and the secondary antennas. Combining the North-East-Down vector with the measured distance between antennas allows the system to resolve the IMU's heading. These heading estimates are blended with those made by the IMU, providing accurate heading solution (0.02 degrees).

Serial Numbers

Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
S5401	1440911819	Port	Primary
S5401	1440918106	Starboard	Secondary

GAMS Calibration

Vessel	S5401
Calibration Date	2016-04-27

Configuration Reports	*Vessel*	S5401
	Report Date	2015-09-08

Figure 7: POS/MV computing system unit (orange) rack mounted aboard R/V BAY HYDRO II.

A.4.2 DGPS

Description	Trimble		
Antennas	*Manufacturer*	Trimble	
	Model	27207-00	
	Description	The Trimble utilizes a L1 GPS antenna and a Beacon H-Field Loop antenna. These two antennas are held in one combined antenna housing that is secured to the vessel. The L1 GPS antenna is an active antenna element that filters out unwanted signals and amplifies the L1 signal. The Beacon H-field Loop antenna works as a preamplifier for filtering out interference and amplifies the Beacon signal.	
	Serial Numbers	*Vessel Installed On*	S5401
		Antenna s/n	0220172421
Receivers	*Manufacturer*	Trimble	
	Model	SPS361	
	Description	The Differential GPS (DGPS) receiver allows for submeter vessel positioning during hydrographic survey.	
	Firmware Version	4.70	
	Serial Numbers	*Vessel Installed On*	5401
		Antenna s/n	530K63695

A.4.3 Trimble Backpacks

<table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>GeoExplorer 2008 Series GeoXH</td></tr>
<tr><td>Description</td><td>The Trimble backpack is used to collect geographic positions on shoreline features. The unit can use either an internal GPS antenna, or an external Zephyr 2 GNSS antenna; the internal antenna allows for 30 centimeter accuracy and the external antenna allows for 10 centimeter accuracy. Both antennas receive GPS positions and carrier code data to give the user a raw GPS position.</td></tr>
<tr><td>Serial Numbers</td><td>4713435892</td></tr>
<tr><td>Antennas</td><td><table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>Zephyr Model 2</td></tr>
<tr><td>Description</td><td>The Zephyr is the optional external antenna.</td></tr>
<tr><td>Serial Numbers</td><td>1441132114</td></tr>
</table></td></tr>
<tr><td>Receivers</td><td>No receivers were installed.</td></tr>
<tr><td>Field Computers</td><td>No field computers were utilized for data acquisition.</td></tr>
<tr><td>DQA Tests</td><td>DQA test was not performed.</td></tr>
</table>

Figure 8: Handheld GeoXH.

A.4.4 Laser Rangefinders

Manufacturer	Laser Technology, Inc.
Model	TruPulse 360B
Description	The TruPulse uses sensors to measure distances, vertical angles, and menu-driven software to convert sensor readings to meaningful measurements. This unit can be attached to a Ricoh G700SE GPS camera to give the user images of targets with the "range to target" measurement in the picture, or it can be used as a stand-alone range finding tool. R/V BAY HYDRO II utilizes both methods available.
Serial Numbers	044670
DQA Tests	DQA test was not performed.

Figure 9: TruPulse 360B laser range finder.

Figure 10: TruPulse 360B laser range finder configuration with Ricoh G700SE GPS camera.

A.4.5 Other Positioning and Attitude Equipment

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

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profiles

A.5.1.1 CTD Profilers

A.5.1.1.1 Sea-Bird Electronics CTD SBE 19plus 05M

Manufacturer	Sea-Bird Electronics CTD
Model	SBE 19plus 05M
Description	R/V BAY HYDRO II is equipped with a Sea-Bird Electronics SeaCat SBE 19plus Conductivity, Temperature, and Depth (CTD) profiler. This unit serves as a backup to the CastAway CTD, however, it is fully functional and capable of being used as the primary CTD if needed. Temperature and electrical conductivity (to determine salinity) are measured directly, while depth is calculated from strain gauge pressure. Using the Chen-Millero Equations, CTD data is used to calculate sound velocity profiles. As part of the annual HSRR, the CTD profiler is sent to the manufacturer for factory calibration. A Calibration Report can be found in Appendix 4 of this report.
Serial Numbers	*Vessel Installed On*: S5401 *CTD s/n*: 19P37217-4677
Calibrations	*CTD s/n*: 19P37217-4677 *Date*: 2016-03-14 *Procedures*: Calibration performed by Sea-Bird Electronics

Figure 11: R/V BAY HYDRO II's SeaBird 19plus CTD.

A.5.1.1.2 SonTeck (a Xylem brand) CastAway-CTD

Manufacturer	SonTeck (a Xylem brand)
Model	CastAway-CTD
Description	R/V BAY HYDRO II is equipped with a SonTek CastAway CTD profiler and uses it as the primary CTD device. Temperature and electrical conductivity (to determine salinity) are measured directly, while depth is calculated from strain gauge pressure. Using the Chen-Millero Equations, CTD data is used to calculate sound velocity profiles. As part of the annual HSRR, the CTD profiler is sent to the manufacturer for factory calibration. A Calibration Report can be found in Appendix 4 of this report.

Serial Numbers	*Vessel Installed On*	S5401
	CTD s/n	CC1332002
Calibrations	*CTD s/n*	CC1332002
	Date	2016-01-26
	Procedures	Calibration performed by SonTek

Figure 12: SonTeck CastAway CTD.

A.5.1.2 Sound Speed Profilers

No sound speed profilers were utilized for data acquisition.

A.5.2 Surface Sound Speed

A.5.2.1 Valeport miniSVS

Manufacturer	Valeport
Model	miniSVS

Description	The Valeport miniSVS is a sing-around transducer that determines the sound velocity by measuring the time needed for a ping of sound to travel a known distance . This unit was used to determine the speed of sound at the head of the Kongsberg EM2040 MBES. As part of the annual HSRR, the Valeport is sent to the manufacturer for factory calibration. A Calibration Report can be found in Appendix 4 of this report.	
Serial Numbers	*Vessel Installed On*	S5401
	Sound Speed Sensor s/n	22882
Calibrations	*Sound Speed Sensor s/n*	22882
	Date	2016-01-22
	Procedures	Performed by Valeport Limited

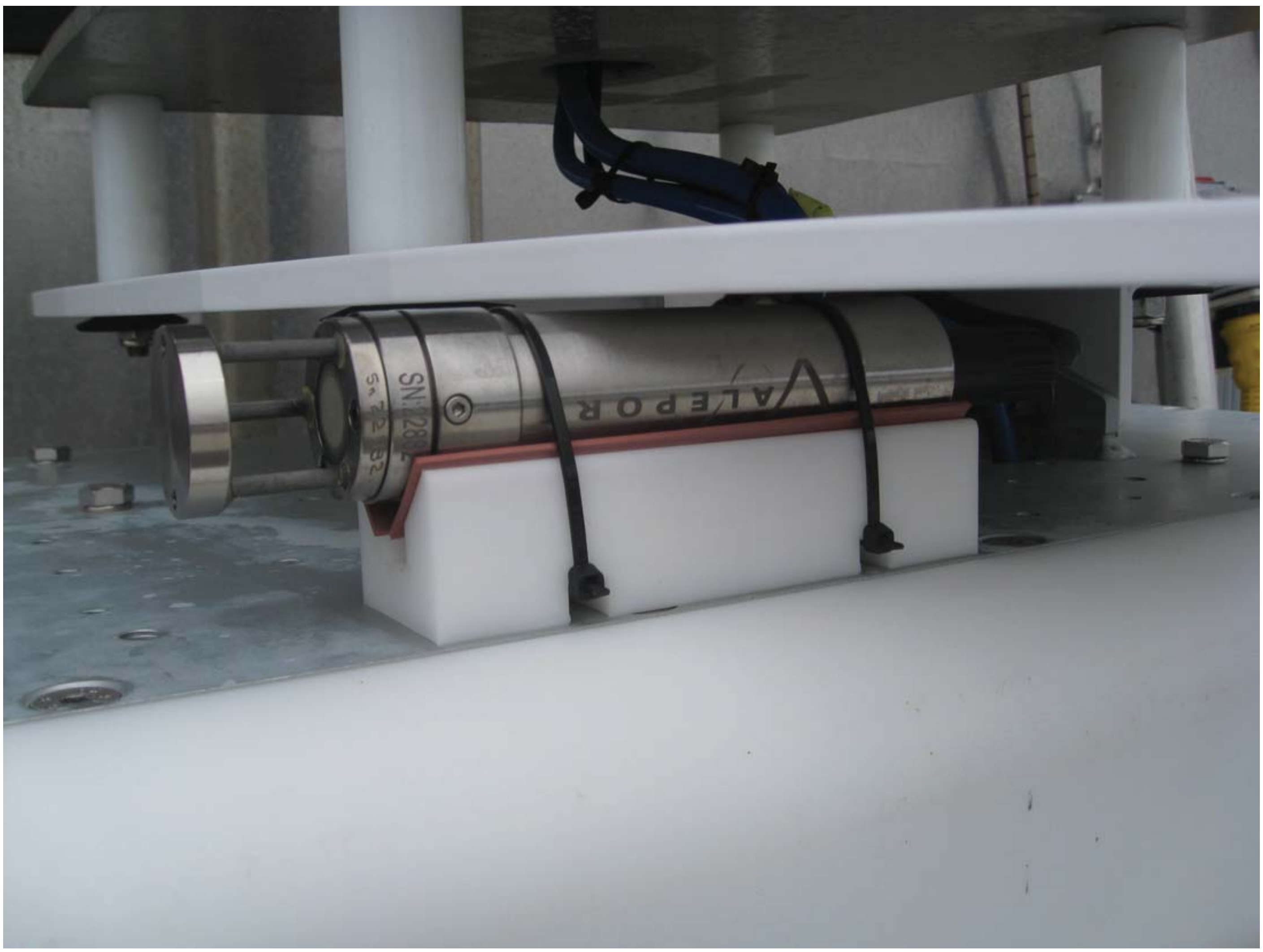

Figure 13: Valeport MiniSVP mounted to the MBES case.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

No horizontal control equipment was utilized for data acquisition.

A.6.2 Vertical Control Equipment

No vertical control equipment was utilized for data acquisition.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

Manufacturer	Dell
Model	Precision T5500
Description	HYPACK Computer using dual Intel Xenon CPU E5620 that processes at 2.40 GHz and 2.39 GHz and has 12 GB of RAM. This computer is used to operate the HYPACK/HYSWEEP interface, as well as to view the POS/MV interface during acquisition.
Serial Numbers	*Computer s/n*: D1K78V1; *Operating System*: Microsoft Windows 7 Enterprise, Version 2009 Service Pack 1; *Use*: Acquisition

Manufacturer	Dell
Model	Optiplex 990
Description	Sonar Pro Computer uses an Intel Core i7-2600 that processes at 3.24 GHz and has 4.00 GB of RAM. This computer is used for the Discover II interface.
Serial Numbers	*Computer s/n*: 5K158V1; *Operating System*: Microsoft Windows 7 Professional, Version 2009 Service Pack 1; *Use*: Acquisition

Manufacturer	Dell
Model	Precision T1650
Description	OCS-W-004101902 uses an Intel Xeon CPU that processes at 3.40 GHz and has 16.00 GB of RAM. This computer is used for post-processing and development of deliverables, using the following programs: CARIS HIPS/SIPS, CARIS BathyDataBASE, Pydro, Velocipy, and the full Microsoft Office Suite.
Serial Numbers	*Computer s/n*: G8Y78Y1; *Operating System*: Microsoft Windows 7, Service Pack 1; *Use*: Processing

Manufacturer	Dell
Model	Precision T3500
Description	OCS-W-001670305 uses an Intel Xeon CPU that processes at 3.07 GHz and has 6.00 GB of RAM. This computer is used for post-processing and development of deliverables only, using the following programs: CARIS HIPS/SIPS, CARIS BathyDataBASE, Pydro, Velocipy, and the full Microsoft Office Suite.
Serial Numbers	*Computer s/n*: C3SMZQ1; *Operating System*: Microsoft Windows 7, Service Pack 1; *Use*: Processing

Manufacturer	Dell
Model	PowerEdge M520
Description	OCS-S-VRTXBH01 is a blade type processing unit that is part of R/V BAY HYDRO II's DELL PowerEgde VRTX server. This blade unit uses an Intel Xeon E5-2430L v2 CPU that processes at 2.46 GHz and has 32.0 GB of RAM, and is used for post-processing in CARIS HIPS/SIPS.
Serial Numbers	*Computer s/n*: 9N2PZ12; *Operating System*: Windows Server 2012; *Use*: Processing

Manufacturer	Dell
Model	PowerEdge M520
Description	OCS-S-VRTXBH02 is a blade type processing unit that is part of R/V BAY HYDRO II's DELL PowerEgde VRTX server. This blade unit uses an Intel Xeon E5-2430L v2 CPU that processes at 2.46 GHz and has 32.0 GB of RAM, and is used for post-processing in CARIS HIPS/SIPS.
Serial Numbers	*Computer s/n*: 9N2PZ12; *Operating System*: Windows Server 2012; *Use*: Processing

A.7.2 Computer Software

Manufacturer	HYPACK, Inc
Software Name	HYPACK 2015
Version	15.0.2.2
Service Pack	none
Hotfix	none
Installation Date	2016-02-09
Use	Acquisition
Description	HYPACK is used to acquire SBES data in a *.raw format, MBES data in a *.hsx format, and detached position, in a *.tgt format. It is also used for vessel navigation during SBES, MBES, and SSS data acquisition. HYPACK was updated to the latest version in January 2015.

Manufacturer	Applanix
Software Name	POSView
Version	8.15
Service Pack	none
Hotfix	none
Installation Date	2015-02-04
Use	Acquisition
Description	POSView is used to monitor positional accuracy and log positional and inertial data while displaying the attitude accuracy details.

Manufacturer	Applanix
Software Name	POSPac MMS
Version	7.2
Service Pack	1
Hotfix	none
Installation Date	2016-07-21
Use	Processing
Description	POSPac MMS is used to process POSPac files, which are recorded in a .000 format.

Manufacturer	CARIS
Software Name	HIPS and SIPS
Version	9.1
Service Pack	N/A

Hotfix	N/A
Installation Date	2016-02-06
Use	Processing
Description	CARIS HIPS (Hydrographic Information Processing System) is used for the initial processing of multibeam and singlebeam echo sounder data. The program applies vessel offsets to the raw sonar data, corrects for tide and sound velocity, and calculates a Total Propagated Uncertainty (TPU) for each sounding. Individual soundings are then processed into a CUBE (Combined Uncertainty and Bathymetry Estimator) surface. CARIS SIPS (Side Scan Information Processing System) is used for processing of SSS imagery, including cable layback correction, slant range correction, contact selection, tow point entry, and mosaic generation. CARIS was updated multiple times (9.1.X) during the field season to fix software bugs and to take advantage of software improvements.

Manufacturer	NOAA OCS HSTP
Software Name	PYDRO
Version	v15.13
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-10-20
Use	Processing
Description	HSTP PYDRO is a program used to generate the Request For Tides package that is sent to NOAA's Center for Operational Oceanographic Products and Services (CO-OPS), and Dangers To Navigation (DTON) reports that are sent to the Marine Chart Division's (MCD) Nautical Data Branch. PYDRO was automatically updated multiple times during the field season to take advantage of software improvements.

Manufacturer	NOAA OCS HSTP
Software Name	VELOCIPY
Version	v15.13
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-10-20
Use	Processing
Description	HSTP VELOCIPY is a program used for processing sound velocity casts. This program converts the hexadecimal SeaCat data into ASCII data, then converts the ASCII data into a depth-binned sound velocity file. The resulting .svp files are applied to MBES and SBES data during post processing to correct for sound velocity variation within the water column

Manufacturer	EdgeTech
Software Name	Discover II
Version	3_15_2012 Build
Service Pack	N/A
Hotfix	N/A
Installation Date	2013-06-12
Use	Acquisition
Description	Discover II is the software interface that allows the user to control data acquisition using the Edgetech 4200 side scan sonar.

Manufacturer	Kongsberg
Software Name	SIS
Version	4.1.5
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-03-24
Use	Acquisition
Description	Seafloor Information System (SIS) is the interface software that allows the user to control data acquisition using the Kongsberg EM2040 Multibeam Echo Sounder.

Manufacturer	CARIS
Software Name	Bathy DataBASE
Version	4.1.17
Service Pack	N/A
Hotfix	N/A
Installation Date	2016-01-05
Use	Processing
Description	CARIS Bathy DataBASE is a processing software that is used to analyze sonar data, apply S-57 attributes to features, and to create bathymetric and cartographic products for in-house and external customers.

Manufacturer	Teledyne Odom Hydrographic
Software Name	eChart
Version	1.4
Service Pack	N/A
Hotfix	N/A

Installation Date	2010-05-10
Use	Acquisition
Description	eChart is the interface software that allows the user to control data acquisition using the Odom Echtrac CV-200 Single Beam Echo Sounder

Manufacturer	Lefebure
Software Name	NTRIP Client
Version	2013.11.24
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-10-01
Use	Acquisition
Description	NTRIP (Network Transport of RTCM data over IP) is a protocol for RTK correction data from the base to the rover using the Internet.

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Wildco Petite Ponar Grabber

Manufacturer	Wildco
Model	Petite Ponar Grabber
Description	The Ponar-type grab sampler is used to collect sediment for seafloor bottom type classification/verification.

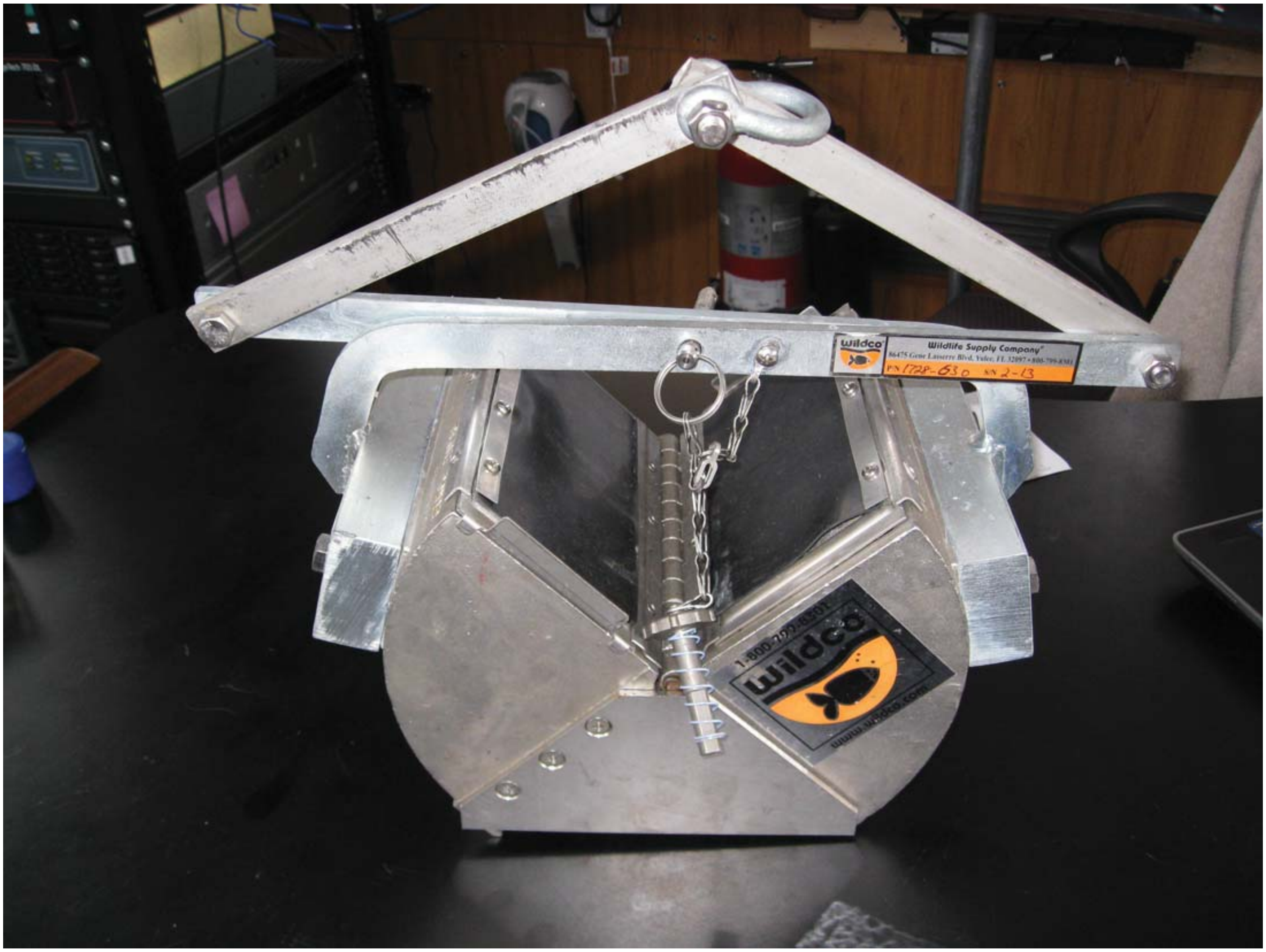

Figure 14: R/V BAY HYDRO II's Petite Ponar grab sampler.

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

Kongsberg multibeam data is logged using SIS in the ".all" format. The hydrographer scans the real time SIS data for system wide errors, anomalies, and dropouts. Display windows such as Sea Bed Image, Time Series, Water Fall, and Beam Intensity aid in this task. SIS data is also fed through HYPACKS's HYSWEEP for the coxswain's display. This secondary interface acts as another real time monitoring tool. During acquisition, the hydrographer reviews the real time data and provides feedback to the coxswain in order to ensure acquired data will meet coverage requirements set forth in the Project Instructions and HSSD Section 5.2.2.

B.1.1.2 Single Beam Echosounder

All Single Beam Data is logged using HYPACK. Two file types are logged. The ".raw" file, contains all the seafloor data and the .bin file contains all the water column data. This water column data can be used during post processing as a contact identification tool. During acquisition, the hydrographer monitors data in Odom's eChart interface, and makes any required changes to signal power and gain to ensure proper bottom tracking.

B.1.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

B.1.2 Imagery

B.1.2.1 Side Scan Sonar

All side scan sonar data is logged using Edgetech's Discover II, in the ".jsf" format. The hydrographer sets the range scale to maximize coverage while providing sufficient resolution to easily identify contacts in post processing. During acquisition, the hydrographer ensures the towfish's height off the bottom meets the HSSD specifications set forth in Section 6.1.2.3. This is accomplished by adjusting the length of cable out, increasing the speed of the vessel to increase the towfish height, or by decreasing the vessel speed to decrease the towfish height. Since the R/V BAY HYDRO II is not equipped with a cable counter, whenever there is a change in cable out, the measurement is manually entered into the Discover II software to be recorded with the .jsf file. The hydrographer monitors the towfish's health and function via real time data displays of the towfish's position, speed, course, and altitude, making sure that they correspond with data coming from the vessel's positioning software.

During acquisition of SSS data, lines are acquired so approximately 20%, of the swath will overlap the swath from an adjacent line. This overlap is used to ensure continuous coverage over the survey area without creating holidays.

The hydrographic team conducts confidence checks on survey days to ensure the SSS system is functioning properly by passing by a known object; this object is typically within the survey area and is visually conspicuous at the surface,for example a navigation buoy and its associated bouy block on the seafloor. Once the vessel passes the object, the hydrographer reviews the real time data for the object's presence in the appropriate channel and at the offset from nadir. Once the object is confirmed in the data, the confidence check is complete.

B.1.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

B.1.3 Sound Speed

B.1.3.1 Sound Speed Profiles

All sound velocity profiles are acquired using a SonTek CastAway CTD.

Figure 15: R/V BAY HYDRO II's primary CTD.

B.1.3.2 Surface Sound Speed

Surface sound speed data is directly measured by the Valeport miniSVS for use by the MBES (See Section C.6.2).

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

The beacon frequency is selected automatically one of two ways: either the strongest DGPS signal for the area, or manually defined via the web interface or front panel of the SPS361. R/V BAY HYDRO II is typically configured to automatically select the strongest signal.

During acquisition, differential correctors are sent to the Applanix POS/MV via serial connection. Total positional accuracy is then monitored inside the POSView window by the hydrographer.

RTK survey: R/V BAY HYDRO II is equipped with a Sierra Wireless cellular Internet Wi-Fi model that provides steady, always-on Internet connectivity to the acquisition laptop. The RTK corrections are sent to the POS MV v5 via serial cable. During survey acquisition, the Lefebure window shows the status of the incoming data stream. This window is monitored to ensure continuous reception of RTK corrections. In addition, the POS MV v5 window displays a Pri. Fixed (under Nav Status) indicating the RTK corrections are being logged. The horizontal and vertical accuracy while acquiring with RTK stream are between 2-5 centimeters, as reported by the POS MV v5.

The Lefebure software is a free-ware application that provides portal to access RTK corrections from network transport of RTCM data over IP. The availability of RTK correction data are dependent on the the locality of the RTK network service provider. Prior to using the Lefebure software, one must contact the local RTK network service provider and apply for network access to stream the RTK correctors.

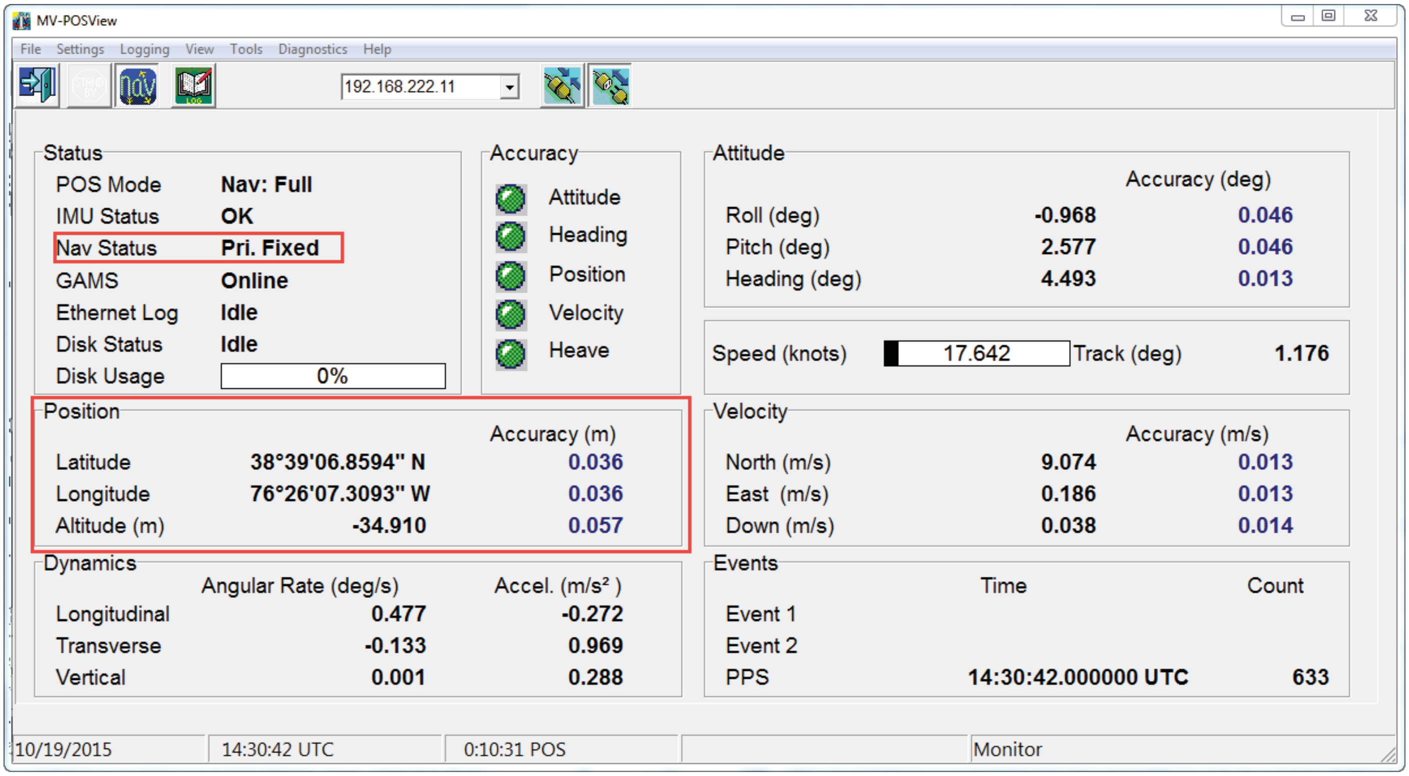

Figure 16: POSView window displaying the RTK stream.

B.1.4.2 Vertical Control

R/V BAY HYDRO II traditionally uses Tidal Constituent and Residual Interpolation (TCARI) tides, however Discrete Tide Zoning and Ellipsoidally Referenced Surveys (ERS) are viable options for vertical control (See Section C.5).

RTK referenced surveys follow the ERS vertical control workflow. The RTK processing workflow is located in section B2.1.1 of this document.

B.1.5 Feature Verification

All discussion regarding the acquisition and processing of features can be found in Section B.2.5.

B.1.6 Bottom Sampling

Bottom samples are collected at the designated sites by the Project Instructions. Samples are obtained with a Ponar type grab sampler (See Section A.8.1.1). All samples are photo logged and classified using the classification system in Chart 1, Section "J", Nature of the Seabed.

B.1.7 Backscatter

R/V BAY HYDRO II collected backscatter data during acquisition. This data is submitted to Pacific Hydrographic Branch along with associated surveys. The backscatter data is also shared with NOAA's Chesapeake Bay Office. No processing is performed on board.

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Once data acquisition is complete, raw MBES data is converted in CARIS HIPS to provide a visual examination of the data points collected. Corrections and offsets are then applied to the MBES data to produce high resolution depth profiles of the seafloor.

The process starts by converting the Kongsberg .all files using CARIS HIPS. Converted files are saved in the CARIS HDCS file format. Navigation and attitude data are are visually inspected for gross errors. Data files are corrected for delayed heave, tides, and sound velocity profiles, and then merged. After the merge, the Total Propagated Uncertainty (TPU) is computed (See Section B.4.1).

In the case of a RTK survey, standard tide files are not used, instead compute GPS tide is applied because the RTK corrections provide high resolution accuracy to an ellipsoid. This has the same outcome as applying SBETs and SBET RMS files during an ERS survey. In order to bring the data to MLLW, a separation model is applied. The separation model is provided to the field by CO-OPS.

MBES data are gridded using CARIS HIPS Combined Uncertainty and Bathymetric Estimator (CUBE) algorithm and is processed as described in FPM Section 4.2.1.1. The CUBE surface is also created using a grid resolution determined by coverage type and depth, as required by the Project Instructions and specified in the HSSD, Section 5.2.2. The "Depth" layer is reviewed for holidays (gaps in coverage) or erroneous soundings. Any erroneous soundings, known as fliers, are flagged as rejected and removed from the surface so the surface more accurately represents the seafloor. Any least depth on a feature that is not accurately reflected in the surface is flagged as "designated" in order to force the surface to reflect that shoaler depth.

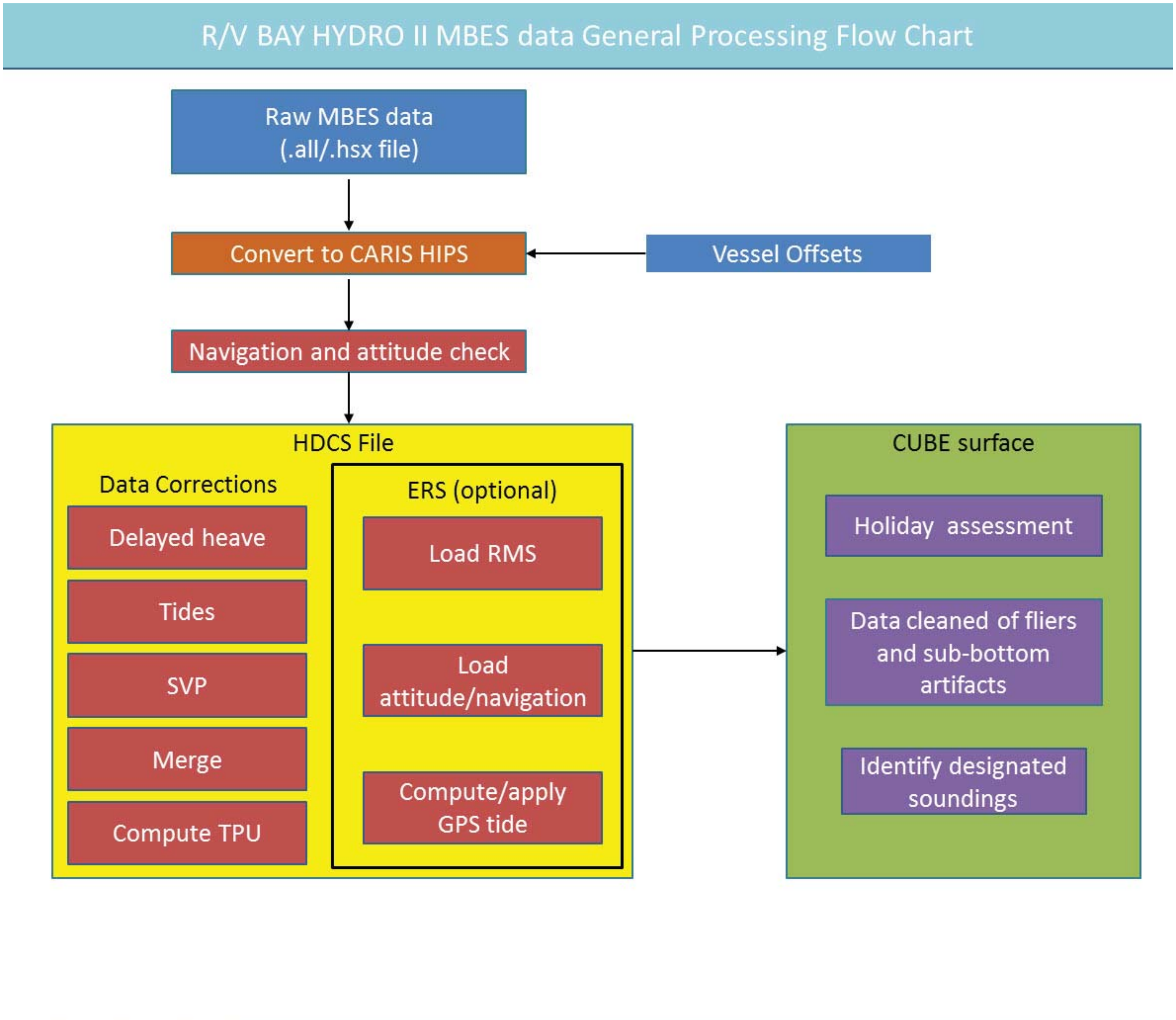

Figure 17: MBES data processing flow chart.

B.2.1.2 Single Beam Echosounder

Much like MBES data, SBES data is converted in CARIS HIPS for processing. It is also corrected and inspected prior to becoming a visual representation of the seafloor.

The SBES work flow starts by converting the raw files using CARIS HIPS. The converted file is saved in the CARIS software as HDCS data. At this point, offsets, draft, and dynamic draft sensor measurements are applied to the HDCS file. Navigation and attitude data are visually inspected for gross errors. The data file is corrected for delayed heave, tides, SVP, and then data and correctors are merged. After the merge, TPU is computed (See Section B.4.1).

The data is reviewed and cleaned using CARIS single beam editor. Any fliers or sub-bottom returns in the dataset are flagged as rejected. In the event that the definition of the true bottom is ambiguous, the full water column data can be inspected by viewing the HYPACK.bin file. After all correctors and data cleaning is complete, a CARIS BASE Uncertainty Weighted Grid is created as specified in the HSSD Section 5.2.2.3.

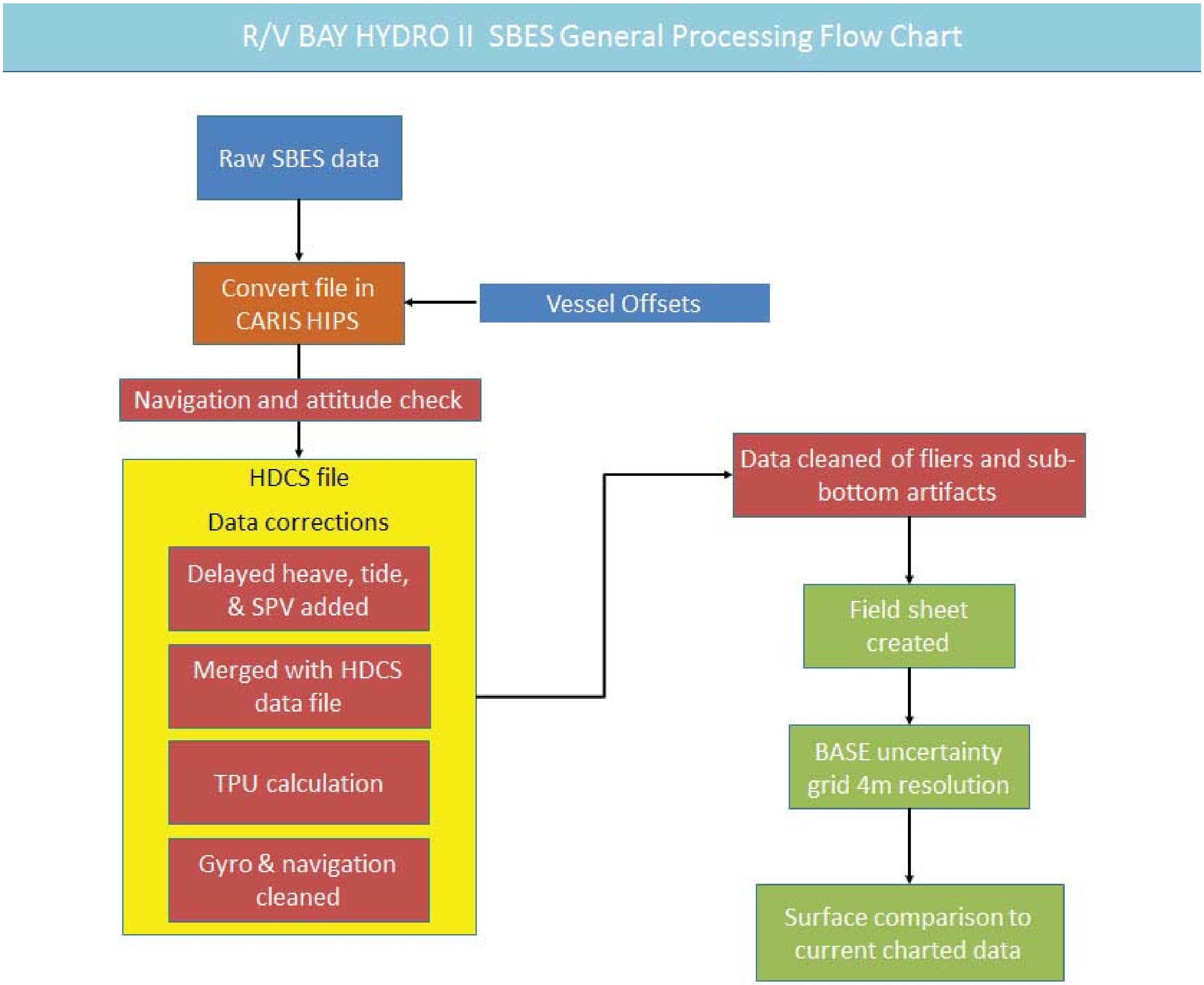

Figure 18: SBES data processing flow chart.

B.2.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not processed.

B.2.1.4 Specific Data Processing Methods

B.2.1.4.1 Methods Used to Maintain Data Integrity

Data integrity is maintained through the use of processing logs that track data from acquisition throughout the conversion and processing steps for MBES (See Section B.2.1.1), and SBES (See Section B.2.1.2).

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

After initial processing and the CUBE surface is created, data integrity is confirmed by reviewing the surface's child layers and by comparing the data set to crossline data and pre-existing data sets.

The surface's child layers are reviewed to ensure the surface meets NOAA standards as set forth in the HSSD, and is free from systematic errors. The Hypothesis Count and Hypothesis Strength child layers are reviewed to ensure that fliers are not causing confusion in determining the actual sea floor. The Density layer is reviewed to determine that all the data has the appropriate density as set by the HSSD Section 5.2.2.2. The Standard Deviation layer is reviewed to ensure that all the data lies within the 95% confidence level. The uncertainty layer is viewed to ensure that the data has not exceeded specifications as set by the HSSD Section 5.2.3.

Once the data set's child layers have been reviewed, the data is compared to a crossline data set that has been collected over the same area and to surveys of the same area (Junction Surveys). The crossline data set is a series of MBES data lines that are aquired on a different day than the data in the CUBE surface, surrounding the MBES mainscheme data, and in a manner to cross the mainscheme lines in as near a perpendicular manner as practical. Junctions surveys compare the two data sets that may be years apart and collected with different MBES systems. Regardless of the comparison, either junction surveys or crosslines, the process is the same. The two data set surfaces are differenced using the CARIS Differencing algorithm and difference surface statistics are generated. When the difference surface are in good agreement between the two data sets, the process is complete. If the data sets are found to be in poor agreement, the data will be reviewed to determine if a vessel bias has been introduced into the HVF, a processing error has occurred, or a significant weather event has change in the sea floor.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Gridding Parameters Surface Computation Algorithms
Description	Gridding parameters are dictated by section

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

SSS processing work flow begins with converting Edgetech SSS .jsf file using CARIS SIPS. The towfish navigation and gyro are examined for gross errors, and the towfish altitude is inspected and corrected as needed to accurately track the seafloor.

The individual lines are stitched together to create a mosaic of the SSS data. As per the Project Instructions, the hydrographer creates mosaics for each percentage of coverage required (i.e.: one mosaic for the first set of data and a second mosaic for the second set of data of the project area). If holidays are found, a holiday line plan is created and executed as per Section B.2.2.3.3 of this document.

The primary hydrographer reviews each SSS line for contacts (this is called a scan) by visually inspecting the imagery record contacts on the seafloor with a shadow height that meets or exceeds the specifications for a significant contact as stated in HSSD 6.1.3.2. The hydrographer has the ability to adjust the color histogram, zoom in and out on the image record, and switch between the processed and unprocessed view of the imagery to make locating contacts and measuring associated shadows easier. A secondary hydrographer reviews the data using the same processes (this is called a check scan), verifies contacts found by the first hydrographer, and inspects all lines to ensure no possible contacts were missed.

Once the data has been scanned by two independent hydrographers, all identified contacts are treated as features, as explained in section B.2.5.

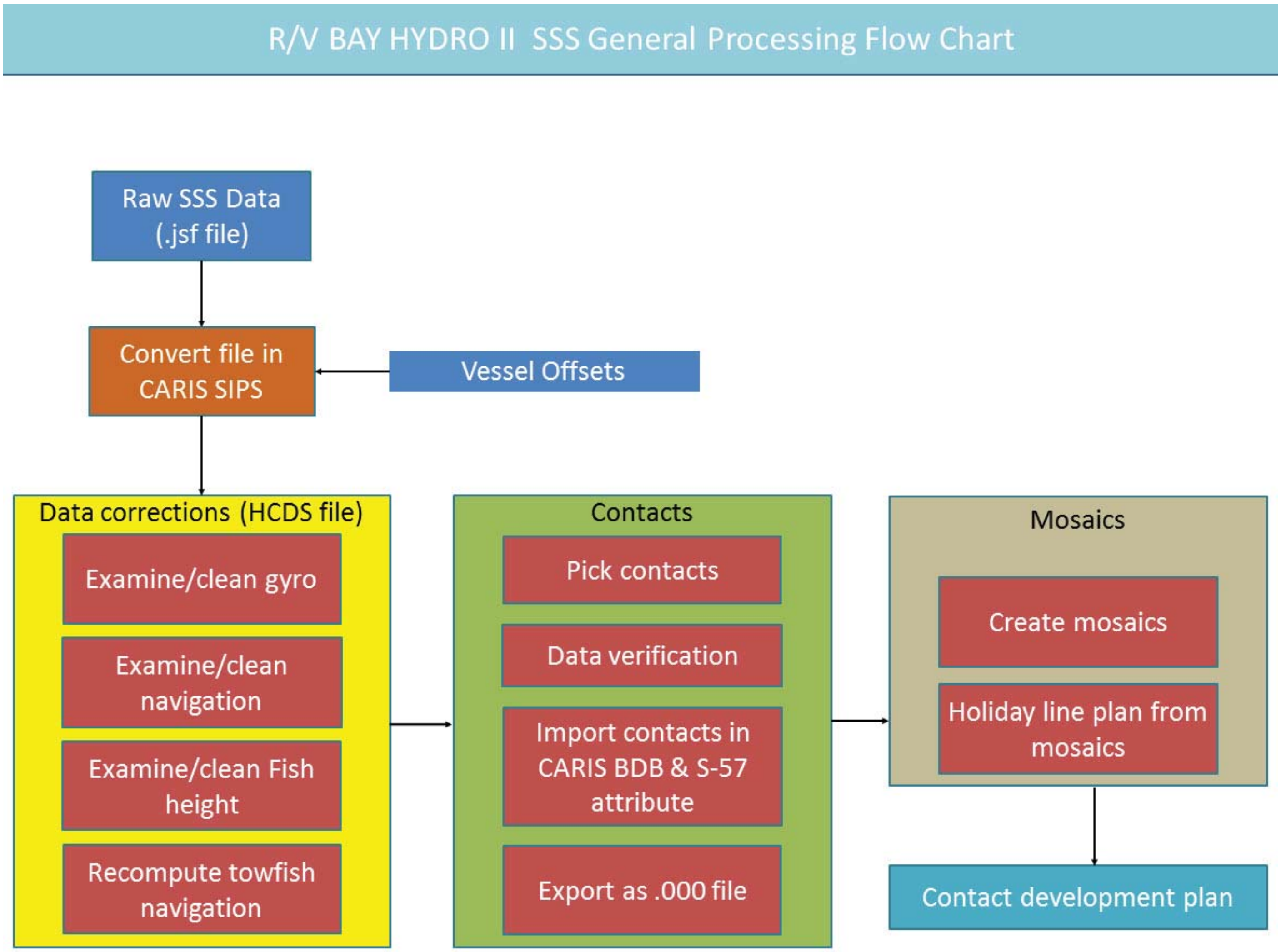

Figure 19: SSS data processing flow chart.

B.2.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not processed.

B.2.2.3 Specific Data Processing Methods

B.2.2.3.1 Methods Used to Maintain Data Integrity

All data is moved through the CARIS SIPS processing pipeline. Data integrity is maintained through the use of processing logs that track data from acquisition throughout the conversion and processing steps for SSS (see Section B.2.2.1).

B.2.2.3.2 Methods Used to Achieve Object Detection and Accuracy Requirements

SSS system object detection and accuracy are verified during the HSRR (see Section A.2.1.1). During processing, SSS contact positions are compared to corresponding SSS contacts (e.g. from 200% coverage) and MBES data where available. Any gross discrepancies in positioning are investigated and resolved prior to further acquisition.

B.2.2.3.3 Methods Used to Verify Swath Coverage

If holidays are created, they can easily be seen by overlaying the mosaic onto a brightly colored background. Once identified, a shape file is created in CARIS BDB identifying them, and exported into Hypack for re-acquisition.

B.2.2.3.4 Criteria Used for Contact Selection

R/V BAY HYDRO II followed the criteria set forth in the HSSD Section 6.1.3.2. It states that in water less than or equal to 20 m, a computed SSS target height, based on shadow lengths of 1m or greater, constitutes a significant contact. The hydrographer designates any contact they deem significant for further investigation.

B.2.2.3.5 Compression Methods Used for Reviewing Imagery

No compression methods were used for reviewing imagery.

B.2.3 Sound Speed

B.2.3.1 Sound Speed Profiles

The CastAway CTD is the primary instrument to acquire sound velocity profiles, unless otherwise stated in the Descriptive Report. CARIS HIPS then utilizes the sound velocity cast as a corrector(See Section C.6.1.2).

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

All SVP casts are processed using HSTP's Velocipy. Casts are concatenated into a master SVP file for the specific survey.

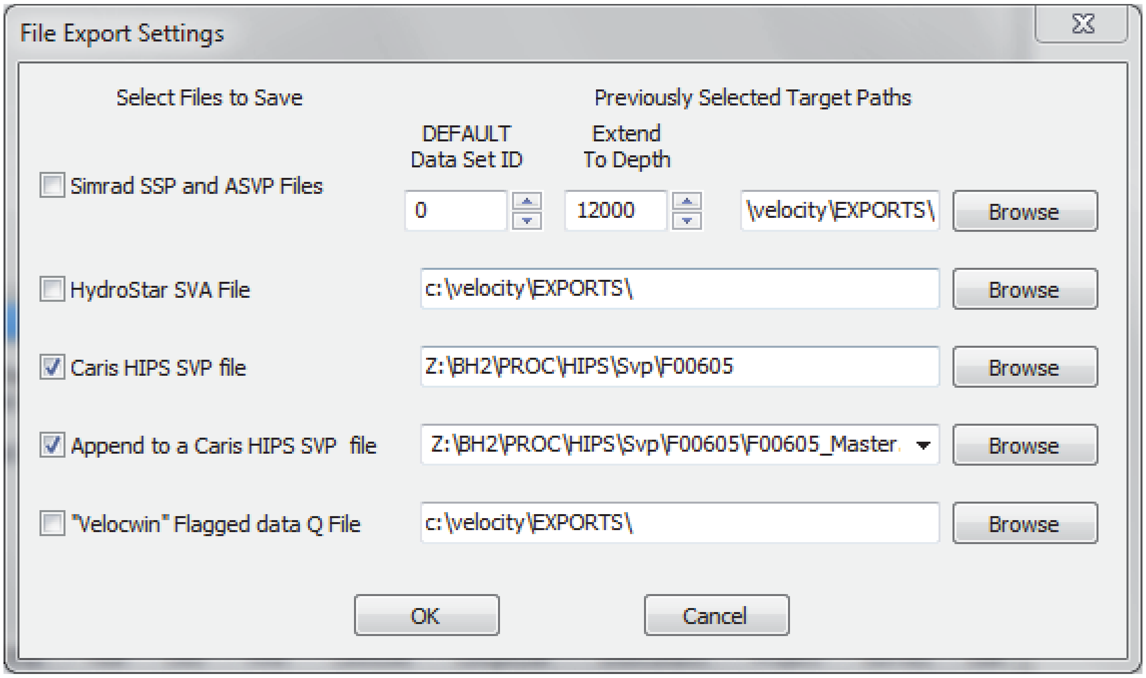

Figure 20: Velocipy GUI.

B.2.3.2 Surface Sound Speed

Surface sound speed data is directly measured by the Valeport miniSVS for use by the MBES during acquisition, see Section C.6.2.

Figure 21: Valport MiniSVS.

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Position accuracy and quality were monitored using the POSView Controller software to ensure positioning accuracy requirements in the HSSD Section 3.1.1 were met.

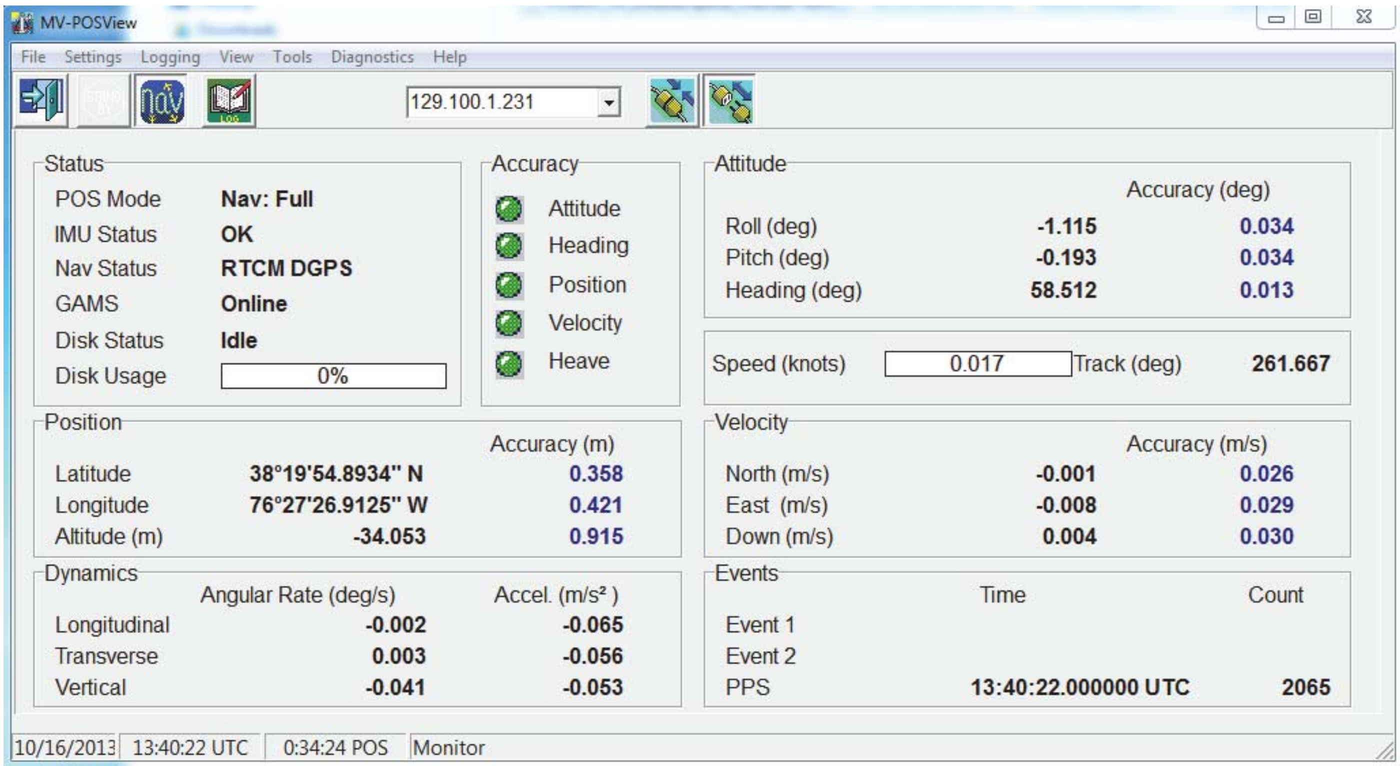

Figure 22: Real Time POS M/V monitoring interface.

B.2.4.2 Vertical Control

R/V BAY HYDRO II typically uses TCARI tides, however Discrete Tide Zoning and Ellipsoidally Referenced Surveys (ERS) are viable options for tides (See Section C.5).

RTK survey vertical control follows the ERS protocol.

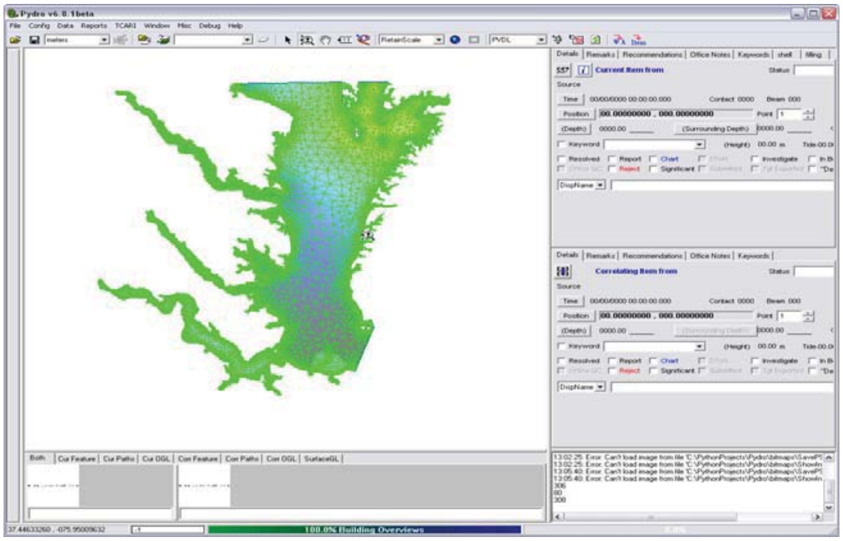

Figure 23: TCARI Tide interface.

B.2.5 Feature Verification

As stated in section B.1.5 of this document, the entire feature acquisition and processing process is as follows:

All potentially significant features are divided into three categories. The first, features that are not safe for R/V BAY HYDRO II to approach, are given a cursory visual inspection. If they are visible above the water line, a detached position is calculated. An azimuth and range (via compass and laser range finder, respectively) are measured along with a known vessel position, and photographed from a safe distance. This allows the feature's position to be calculated with a high degree of accuracy without placing the vessel or crew in danger. The features are imported into the Final Feature File (FFF) and S-57 attributed. For unsafe features, the feature is not addressed and referenced as such in the Descriptive Report.

The second category of features are those safe for R/V BAY HYDRO II to investigate. For features in this category, a file is created in CARIS Bathy DataBASE identifying the position of the feature and the area around the feature that is to be ensonified by MBES, called a shape file. This shape file is exported into HYPACK and used by the coxswain during data collection. The MBES development lines are created over the suspected feature in a way that is safest for the vessel and crew, ensonify all sides of the feature, and ensonify the feature with both the port and starboard channels of the MBES. This data is then converted using the methodology described in Section B.2.1.1. The CUBE surface is imported into CARIS Bathy DataBASE, features are created, are S-57 attributed and added to the FFF.

The third category is shoreline features. In the event that shoreline verification is required, or a significant/ assigned feature is only accessible by shore, the Trimble GeoXH is used and a high resolution photograph of the object is taken. This hand held unit is held as high on the object as possible, for a minimum of ten minutes to achieve a positional accuracy of one meter. The data collected with the Trimble is post-processed using the Trimble Pathfinder Office software package, exported to BDB, S-57 attributed, and added to the FFF.

The quality of data is controlled through real time monitoring during acquisition and in the post processing inspection.

Figure 24: Shoreline verification of the features with a Trimble GeoXH.

B.2.6 Backscatter

Backscatter data were not processed.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Before any project is submitted to a branch, a review is conducted with a physical scientist at NRB headquarters. During this review, MBES CUBE surfaces are spot-checked for any visually conspicuous gross errors and child layers are reviewed to ensure they meet HSSD specifications for accuracy and quality. The Final Feature File is reviewed to ensure no features were omitted and that they were S-57 attributed correctly. The Descriptive Report is reviewed and discussed to ensure that it accurately reflects the survey.

B.4 Uncertainty and Error Management

There are uncertainties associated with every depth and position measured. These uncertainties are associated with the hardware used to measure and log the data and in the means of collecting the measurements (tide, sound speed, draft, range measurement, angle measurement, attitude, offsets, etc). The uncertainty is expressed as a confidence level (in meters) based on the assumption that the uncertainty is a Gaussian distribution, these uncertainties are estimated at one sigma (95%), as stated in the CARIS HIPS/SIPS Help document, and inputted into the CARIS HVF. During processing, the real time or manufacturer supplied uncertainties are combined into a single weighted estimate of uncertainty, Total Propagated Uncertainty (TPU), for each sounding.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

TPU is computed using CARIS HIPS: Compute TPU and the CUBE surface Uncertainty child layer is reviewed to ensure all depth measurement uncertainties meet the uncertainty standard in HSSD Section 5.1.3.

B.4.1.2 Source of TPU Values

In the CARIS TPU calculation, real time uncertainty values are used where possible. Real time calculated uncertainties found in the .all file are used for position, sonar, heading, pitch, and roll. The TPU tidal constituent is calculated in Pydro while interpolating the water level, for TCARI tides, or they are provided by CO-OPS for discrete tidal zoning. The vertical real time uncertainty, for ERS surveys, are from the

SBET's RMS file, while vertical real time uncertainty for geoidally referenced surveys comes from the POS .000 file.

When real time uncertainty data is not available the uncertainty values recorded in the HVF are used. These uncertainties come directly from the manufacturers and are typically found in the systems operators manual's specification section.

B.4.1.3 TPU Values

Vessel	R/V BAY HYDRO II		
Echosounder	Kongsberg EM2040 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5.000 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.02 degrees
	Navigation Position	1.0 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.002 meters
		y	0.002 meters
		z	0.002 meters
	MRU Alignment	*Gyro*	0.28 degrees
		Pitch	0.035 degrees
		Roll	0.035 degrees
	Vessel	*Speed*	0.257 meters/second
		Loading	0.100 meters
		Draft	0.020 meters
		Delta Draft	0.020 meters
Vessel	R/V BAY HYDRO II		
Echosounder	Teledyne Odom CV-200 200 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5.0 % Amplitude 0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	0.020 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.002 meters
		y	0.002 meters
		z	0.002 meters
	MRU Alignment	*Gyro*	0.00 degrees
		Pitch	0.00 degrees
		Roll	0.00 degrees
	Vessel	*Speed*	0.257 meters/second
		Loading	0.100 meters
		Draft	0.020 meters
		Delta Draft	0.020 meters

B.4.2 Deviations

There were no deviations from the requirement to compute total propagated uncertainty.

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

An NGS survey of R/V BAY HYDRO II was performed on 23-March-2009 using optical levels. The survey established a vessel Reference Point (RP), then found the X, Y, and Z distances for the GNSS antennas and multibeam sonar. On 26-February-2010 the crew surveyed in the Tow Point for the side scan sonar. On 18-March 2010 the crew surveyed in the vessel's singlebeam transducers (See Offset Report in Appendix 1).

On 13-August-2014 the EM2040 reference point was moved from the vessel's Reference Point to the EM2040 transmit (Tx) transducer head by changing the configuration of the POS/MV. By referencing the Tx transducer rather than the RP, the associated HVF offset values are no longer needed and are zeroed out. This configuration eliminates the possibility for errors due to the lever arm between the RP and transducer, as well as removes the need for additional "ERS specific" HVFs in Caris for surveying to the ellipsoid.

The X, Y, Z offsets of the MBES between the transmit transducer head and the receiver transducer head are entered into the HVF in two locations. 1) For the SVP process in CARIS, the offset values are entered in the "SVP 2" section of the HVF. 2) the offsets are entered in the "Offsets" section of TPU under "Trans2" as x2 y2 z2 for MRU to Traducer and Nav to Transducer (See table below).

C.1.1.2 Methods and Procedures

This original Sensor Components Spatial Relationship Survey was conducted by NGS using the TOPCON GPT 3002LW Series Total Station, and a SECO 25mm Mini Prism System. The vessel's personnel surveyed the Tow Point and single beam transducer using a laser level and measuring tape.

C.1.1.3 Vessel Offset Correctors

Vessel	R/V BAY HYDRO II		
Echosounder	Teledyne Odom Hydrographic Odom Echotrac CV-200 200 kilohertz		
Date	2010-03-18		
Offsets	*MRU to Transducer*	*x*	2.294 meters
		y	3.406 meters
		z	2.414 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Nav to Transducer	*x*	2.143 meters
		y	3.253 meters
		z	2.249 meters
		x2	N/A
		y2	N/A
		z2	N/A

	Transducer Roll	*Roll*	0.000 degrees
		Roll2	N/A
Vessel	R/V BAY HYDRO II		
Echosounder	Kongsberg EM2040 300 kilohertz		
Date	2016-06-30		
Offsets	*MRU to Transducer*	*x*	0.309 meters
		y	-0.884 meters
		z	2.428 meters
		x2	-0.002 meters
		y2	-0.779 meters
		z2	2.411 meters
	Nav to Transducer	*x*	1.759 meters
		y	-6.374 meters
		z	5.440 meters
		x2	1.448 meters
		y2	-6.269 meters
		z2	5.423 meters
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees

C.1.2 Layback

C.1.2.1 Description of Correctors

Layback on R/V BAY HYDRO II is the position of the towfish based upon the vessel tow point (sheave at the top of the A-frame). The value for layback is calculated based on the vessel speed and the amount of cable deployed.

C.1.2.2 Methods and Procedures

During acquisition the amount of side scan cable out is monitored and the values are entered into the Discover II acquisition program and recorded into the .jsf file. The values from the .jsf file are used to calculate the towfish position (within 10 meters) during data processing with CARIS SIPS.

C.1.2.3 Layback Correctors

Vessel	R/V BAY HYDRO II

Echosounder	EdgeTech 4200 Towfish, 701-DL Transceiver Processing Unit 600 kilohertz		
Date	2015-04-06		
Layback	*Towpoint*	*x*	-0.163 meters
		y	-8.934 meters
		z	-6.314 meters
	Layback Error	0.00 meters	

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Static draft is measured daily, and entered into the HVF file.

C.2.1.2 Methods and Procedures

Once the multibeam has been deployed, the vessel's static draft is determined using the procedures described in Section A.1.1. The new measurement is inserted into the HVF file for the appropriate sonar under the respective Julian day in the Waterline Height section.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

Change in draft measurement are used on R/V BAY HYDRO II to account for the natural settlement and squat the vessel undergoes while changing speed while acquiring MBES data.

C.2.2.2 Methods and Procedures

On 27-April-2016 a new dynamic draft measurement was conducted. The Post-Processed Kinematic (PPK) GPS method was used to determine the dynamic draft for the R/V BAY HYDRO II. This technique uses the vessel’s POS/MV system and POSPac data acquisition and processing to measure vessel ellipsoidal heights at speeds relevant to survey operations. A Pydro macro reads POSPac Smoothed Best Estimate Trajectory (SBET) dynamic draft calibration data, adjusts for tidal water levels, and outputs graphs and tables per a 3rd or 4th order polynomial regression.

The Ellipsoidally Referenced Dynamic Draft measurement consisted of acquiring POS data over different speed values. The test started with a five minute rest period at the west end of the acquisition line. Then, R/V BAY HYDRO II transited east beginning with one engine at 550 RPMs for 30 seconds. Subsequently, the RPM’s were increased in the following increments: both engines at 550, 650, 750, 850, 950, 1050, and 1150. Once the RPM’s were increased, time was allowed for the vessel speed to steady prior to the 30 second measurement. At the east end of the line, the vessel rested for five minutes. On the way west, the vessel ran the same RPMs over the same distance as the transit north to have accurate comparisons. Finally, at the south end of the line the vessel rested for five minutes again.

The full Dynamic Draft Report is located in Appendix I.

C.2.2.3 Dynamic Draft Correctors

Vessel	R/V BAY HYDRO II	
Date	2016-04-06	
Dynamic Draft Table	*Speed*	*Draft*
	0.00	0.00
	0.50	-0.02
	1.00	-0.04
	1.50	-0.04
	2.00	-0.04
	2.50	-0.04
	3.00	-0.03
	3.50	-0.01
	4.00	0.00
	4.50	0.01
	5.00	0.03
	5.50	0.04
	6.00	0.04

C.3 System Alignment

C.3.1 Description of Correctors

Patch Tests are performed on all MBES systems as part of the Hydrographic Systems Readiness Review (HSRR). Patch tests are also performed throughout the year when there is physical change in the sonar layout that alters the offsets of the sonar. This test determines and accounts for any offsets in alignment between the vessel's reference frame and the MBES system's positional alignment.

C.3.2 Methods and Procedures

Only one patch test was needed throughout the 2016 field season, and was conducted as part of the HSRR (see Appendix II for full report). The patch test determined any roll, pitch, and yaw biases (X, Y, and Z axis) and the time offset between the MBES reference frame and the navigational reference frame. All patch tests are conducted in accordance with the HSSD Section 5.2.4.1. The lines are post-processed and the CARIS Calibration Utility is performed by all R/V BAY HYDRO II crew members. The results of the two trials are averaged and the result is recorded in the "IMU Frame w.r.t. Ref. Frame" inputs located in the POS Installation: Lever Arms & Mounting Angles window, after converting the values from the CARIS to the POS M/V coordinate system. It should also be stated that since the purpose of this exercise is to zero out the biases, the inverse of the patch test values are inputted into the POS M/V, so that the sum of the offset equals zero, eliminating the bias. As the POS M/V is outputting the position at the EM2040 transducer head, no offsets are needed in the CARIS HVF file to correct the position. Therefore the navigation offsets in the CARIS HVF file are all zero. Accidentally placing the offsets into the HVF would cause them to "double apply" and introduce significant biases.

C.3.3 System Alignment Correctors

Vessel	R/V BAY HYDRO II	
Echosounder	Kongsberg EM2040 300 kilohertz	
Date	2016-04-10	
Patch Test Values	*Navigation Time Correction*	0.0 seconds
	Pitch	-1.53 degrees
	Roll	0.08 degrees
	Yaw	1.325 degrees
	Pitch Time Correction	0.0 seconds
	Roll Time Correction	0.00 seconds
	Yaw Time Correction	0.00 seconds
	Heave Time Correction	0.00 seconds

C.4 Positioning and Attitude

C.4.1 Description of Correctors

POS/MV positioning and attitude data are logged and the ZDA (day, month, year, and local time zone offset), GGA (time, position, and fix), and attitude packets are applied in real time to the raw MBES and SBES data.

C.4.2 Methods and Procedures

The POS/MV file is recorded during acquisition and saved to the network RAW drive. The POS/MV file is loaded and merged with the raw MBES or SBES data file in CARIS SIPS using the "Import Auxiliary Data" utility as part of the standard processing flow.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

Sounding are reduced to Mean Lower-Low Water (MLLW) using the assigned TCARI grid, a zone definition file (.zdf) utilizing observed tidal data from assigned tide stations, or via ERS utilizing VDatum.

C.5.2 Methods and Procedures

All tide data are obtained from CO-OPS using either the HSTP programs Pydro for TCARI Tides or FetchTides for Discrete Tidal Zoning. Predicted, preliminary, and verified tides are downloaded and used as correctors in CARIS HIPS (See Section B.2.1). Once survey acquisition is complete, a Request for Final Tides note is completed in Pydro and emailed to CO-OPS (See FPM Section 5.2.2.3.3 for further information). CO-OPS either informs the hydrographer to use the original TCARI or .zdf tides from the Project Instructions, or provides a new final tides file to account for any changes that may have taken place during the survey.

R/V BAY HYDRO II uses either Tidal Constituent and Residual Interpolation (TCARI) or discrete tidal zoning, based on the project instructions. Both TCARI and discrete tidal zoning methods use the same six minute raw tide gauge data to reduce the data to MLLW, however, the manner in which the data is distributed throughout the survey area is different. TCARI tides are processed in Pydro and use a model that spatially interpolates the harmonic constants, tidal datums, and residual water levels using values at a combination of operational and historical stations for the entire survey area. Discrete Tidal Zoning tides are applied in CARIS using a model that divides the survey area into discrete zones based on reference water level stations, time correctors and range correctors, then applies the tidal correctors uniformly across the zones. Both the zone file and the TCARI file are provided by CO-OPS with the Project instructions.

R/V BAY HYDRO II is also capable of Ellipsoidally Referenced Surveys (ERS), or VDatum surveys when provided an appropriate separation model by HSD-OPS. For both types, the raw POSPac file is processed using reference stations (usually CORS Stations) and a Smooth Best Estimate of Trajectory (SBET) is produced. This SBET is inputted into CARIS via "Input Auxiliary Data" to calculate the GPS tide, and then merged to generate a surface at the ellipsoid. If HSD-OPS has provided a separation model, then this ERS surface can be reduced to the local MLLW datum.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

Sound speed was calculated using the Castaway CTD profiler. The sound speed profile created is applied to MBES and SBES data in CARIS HIPS using the Sound Velocity Corrections utility.

C.6.1.2 Methods and Procedures

Casts are acquired once per week for SBES acquisition, and every 2 - 4 hours for MBES. Profiles are collected more frequently when transiting more than 3 nautical mile between survey areas, if current and weather conditions warrant, when the hydrographer feels more casts are warranted, or when the Kongsberg indicates a new cast is needed.

Once the conductivity, temperature, and salinity data is collected, the data is processed by the HSTP program Velocipy using the Chen-Millero Equation and a speed of sound profile is created. Velocipy then exports the sound velocity profile into SIS to be used in real time beam pattern formation.

In CARIS, the "Nearest in Time" option is typically used when correcting the data for sound speed. This option has proven to provide the best representation of R/V BAY HYDRO II's standard operating area of the Chesapeake Bay where time is the primary driver of sound speed change. This is due to the limited freshwater inputs or nonuniform currents throughout a majority of the bay that would induce localized differences in sound speed. For these areas with freshwater inputs or nonuniform currents, the "Nearest in Distance within Time" option is used instead.

Anytime the speed of sound method used is different from the "Nearest in Time" method, the change is documented in the Descriptive Report .

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

The Valeport miniSVS measures the surface sound speed at the head of the Kongsberg EM2040.

C.6.2.2 Methods and Procedures

The Kongsberg EM2040 uses the sound velocity profile from the CTD profile for its beam forming equation and only depends on the surface sound speed as a comparison tool to ensure accuracy. This accuracy check is performed by comparing the continuous reading from the surface sound speed profiler to the CTD reading at the same depth. If the two measurements fall outside the range of 0 m/s to 2 m/s, then SIS indicates that a new cast is needed.

APPROVAL SHEET

Data Acquisition & Processing Report
R/V Bay Hydro II

As Chief of Party, I have ensured that surveying and processing procedures were conducted in accordance with the Field Procedures Manual and that the submitted data meet the standards contained in the 2016 Hydrographic Surveys Specifications and Deliverables.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Respectfully,

Digitally signed by CHAPPEL.SARAH.LYNN.1472631272
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=NOAA, cn=CHAPPEL.SARAH.LYNN.1472631272
Date: 2017.02.06 10:10:32 -05'00'

LTJG Sarah L. Chappel
Officer in Charge, NOAA *R/V Bay Hydro II*