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# Data Acquisition and Processing Report

**R/V Bay Hydro II**
Chief of Party: LTJG Bart O. Buesseler, NOAA
Year: 2014
Version: 1
Publish Date: 2015-05-13

## A Equipment

## A.1 Survey Vessels

### A.1.1 R/V Bay Hydro II

<table>
<tr><td>Name</td><td>R/V Bay Hydro II</td></tr>
<tr><td>Hull Number</td><td>S5401</td></tr>
<tr><td>Description</td><td>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.</td></tr>
<tr><td>Utilization</td><td>Bathymetric data were acquired a with one MBES this field season. The hydrographer determined the methods and systems to meet full-coverage of the survey in accordance within the Hydrographic Survey Project Instructions, NOAA's Hydrographic Surveys Specifications & Deliverables (2014 HSSD) and NOAA's Field Procedures Manual (2014 FPM).</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><td>LOA</td><td>17.3 meters</td></tr>
<tr><td>Beam</td><td>6.33 meters</td></tr>
<tr><td>Max Draft</td><td>1.8 meters</td></tr>
</table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table>
<tr><td>Date</td><td>2009-03-23</td></tr>
<tr><td>Performed By</td><td>H. Stewart Kuper Jr., NGS</td></tr>
<tr><td>Discussion</td><td>An NGS survey of R/V Bay Hydro II was performed on 23 March 2009 using optical levels.</td></tr>
</table></td></tr>
<tr><td>Most Recent Partial Static Survey</td><td>Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td>Full offset verification was not performed.</td></tr>
</table>

| | | |
|---|---|---|
| *Most Recent Partial Offset Verification* | Partial offset verification was not performed. | |
| *Most Recent Static Draft Determination* | *Date* | 2014-06-03 |
| | *Method Used* | Steel Measuring Tape and Lead Line |
| | *Discussion* | An initial static draft measured was determined on 03-June 2014 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 result is the distance from the reference point, to the water line. |
| *Most Recent Dynamic Draft Determination* | *Date* | 2014-06-03 |
| | *Method Used* | Post-Processed Kinematic (PPK) GPS |
| | *Discussion* | Dynamic draft values were determined on 03-June 2014, using the echo sounder method outline in the Field Procedures Manual Section 1.4.2.1.2.1. See Appendix 3 for the full report. |


*Figure : R/V Bay Hydro 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 rowspan="1">Description</td><td colspan="4">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 230 kHz 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 along with the rest of the data at the end of the survey at The National Geophysical Data Center (NGDC). The integrated system includes an EdgeTech 4200 light weight towfish, a tow cable telemetry system, and a Topside Processing Unit.<br><br>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 3.3.1. 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 6.3.1 See Section B.1.2.1).<br><br>This system 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 speed. Each distinct mode uses the transducer arrays in a different configuration. R/V Bay Hydro II uses Mode 3, multipulse mode/high speed. The use of multipulse allows for operational speeds up to 9.6 kts, while adhering to density specs from HSSD.</td></tr>
<tr><td rowspan="3">Serial Numbers</td><td>Vessel Installed On</td><td colspan="3">S5401</td></tr>
<tr><td>TPU s/n</td><td colspan="3">42646</td></tr>
<tr><td>Towfish s/n</td><td colspan="3">40728</td></tr>
<tr><td rowspan="6">Specifications</td><td>Frequency</td><td>230 kilohertz</td><td>540 kilohertz</td></tr>
<tr><td rowspan="3">Along Track Resolution</td><td>Resolution: 0.122 meters</td><td>Resolution: 0.061 meters</td></tr>
<tr><td>Min Range: 0 meters</td><td>Min Range: 0 meters</td></tr>
<tr><td>Max Range: 150 meters</td><td>Max Range: 100 meters</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>
<tr><td>Manufacturer Calibrations</td><td colspan="4">Manufacturer calibration was not performed.</td></tr>
</table>

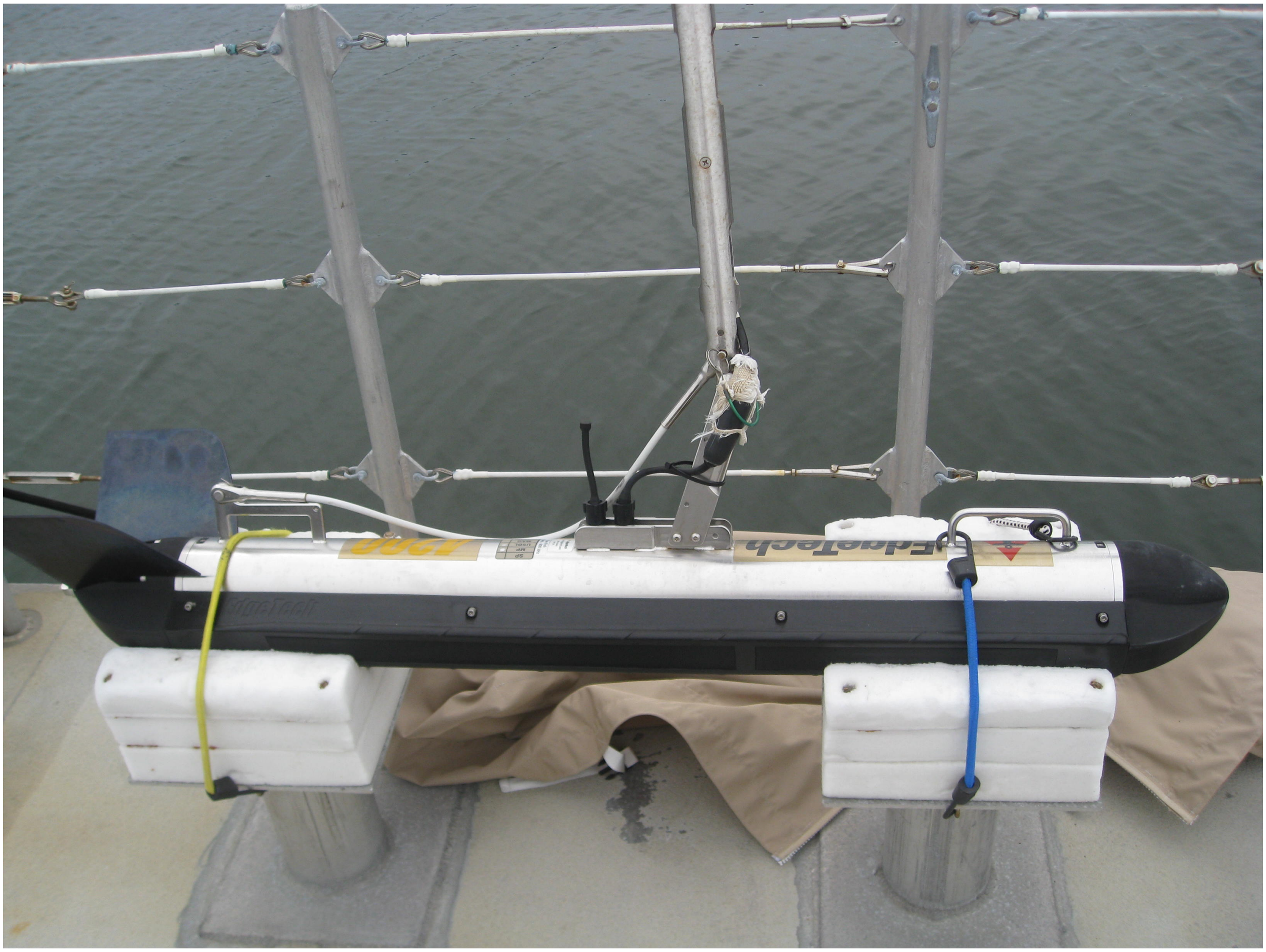


*Figure : EdgeTech 4200 side scan sonar.*

## 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 retractable sonar strut, a Hydrographic Work Station (HWS), and a Processor |

<table>
<tr><td></td><td>Unit (PU). The projector and receiver are set up in a Mills Cross configuration, and deployed through a bomb bay door located on the center line of the vessel. The EM2040 is operated through Seafloor Information System (SIS) software; version 3.9.2<br><br>Bathymetric data from the EM2040 is used to provide least depths over features, and to provide object detection in areas of Complete Multibeam. The EM2040 can collect data concurrently with the EdgeTech 4200 without acoustic interference, commonly referred to as "skunk striping".<br><br>R/V Bay Hydro II operates in the 400 kHz mode. The specifications below reflect this mode of operation.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S5401</td></tr>
<tr><td>Processor s/n</td><td>274</td></tr>
<tr><td>Transceiver s/n</td><td>None</td></tr>
<tr><td>Transducer s/n</td><td>150</td></tr>
<tr><td>Receiver s/n</td><td>191</td></tr>
<tr><td>Projector 1 s/n</td><td>150</td></tr>
<tr><td>Projector 2 s/n</td><td>None</td></tr>
</table>
</td></tr>
<tr><td>Specifications</td><td>
<table>
<tr><td>Frequency</td><td colspan="2">400 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>0.4 degrees</td></tr>
<tr><td>Across Track</td><td>0.3 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>400</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">140 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">26 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>600 meters</td></tr>
<tr><td>Ship Usage</td><td>40 meters</td></tr>
</table>
</td></tr>
<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
<tr><td>System Accuracy Tests</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S5401</td></tr>
<tr><td>Methods</td><td>Sonar Acceptance Test</td></tr>
<tr><td>Results</td><td>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).</td></tr>
</table>
</td></tr>
</table>

| | |
|---|---|
| *Snippets* | Sonar has snippets logging capability. |

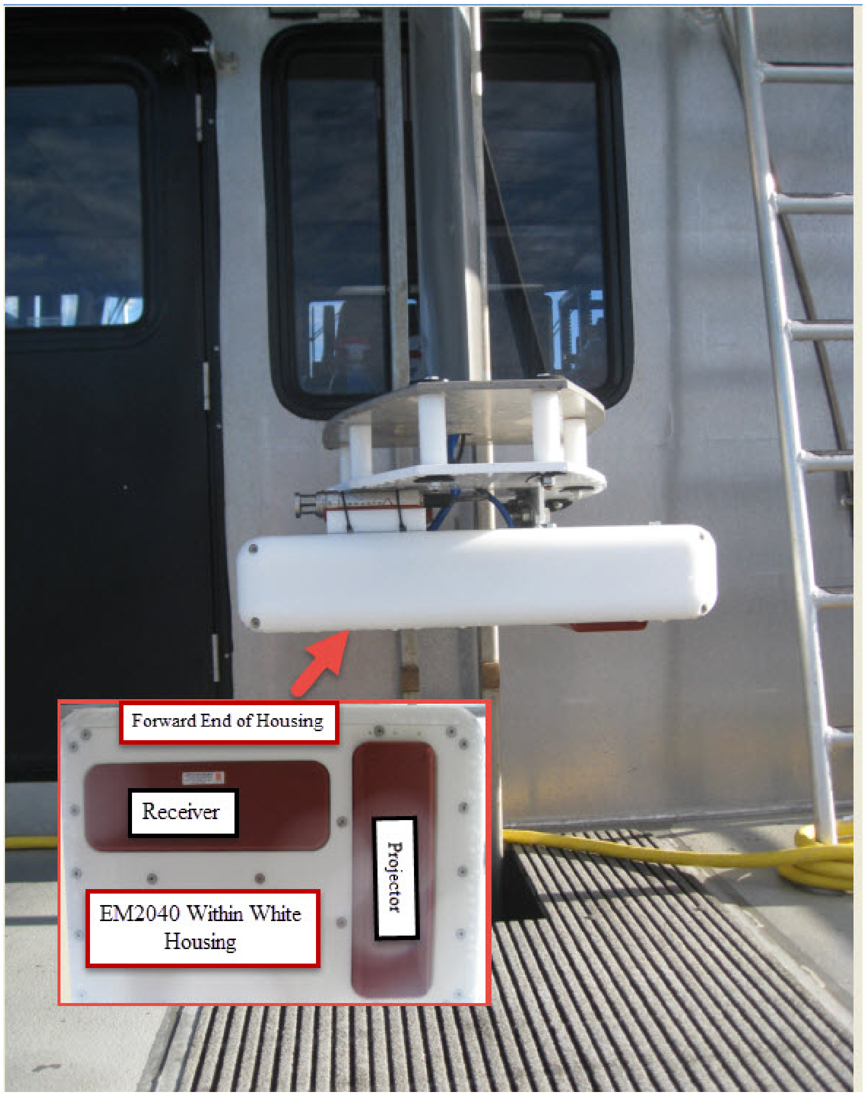


*Figure : Kongsberg EM2040 housing and sonar, in the retracted position.*

*Figure : 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, mounted to the starboard pontoon of R/V Bay Hydro II. This unit is used to collect depth data.</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>10 degrees</td><td>Along Track</td><td>10 degrees</td></tr>
<tr><td>Across Track</td><td>12 degrees</td><td>Across Track</td><td>12 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>Manufacturer Calibrations</td><td colspan="5">Manufacturer calibration was not performed.</td></tr>
<tr><td rowspan="3">System Accuracy Tests</td><td>Vessel Installed On</td><td colspan="4">S5401</td></tr>
<tr><td>Methods</td><td colspan="4">Comparison to Lead Line</td></tr>
<tr><td>Results</td><td colspan="4">On 27-January 2014, soundings from the ODOM Single Beam Echo sounder were compared to soundings read off a lead line. The average difference between depths was 3.5cm (See Appendix 2 for full report).</td></tr>
</table>

*Figure : 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

| | | |
|---|---|---|
| *Manufacturer* | N/A | |
| *Model* | N/A | |
| *Description* | 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 newly fabricated on 16-June 2009 by LT Michael C. Davidson. | |
| *Serial Numbers* | N/A | |
| *Calibrations* | *Serial Number* | N/A |
| | *Date* | 2014-01-13 |
| | *Procedures* | The 8 lb mushroom anchor was removed, and replaced with an in-line scale. The line was then pulled taunt until a force of 8 lb registered on the in line scale. The graduations were then checked using a steel measuring tape. Performed 13-Jan 2014. See Appendix 2 for the full report. |
| *Accuracy Checks* | *Serial Number* | none |
| | *Date* | 2014-01-27 |
| | *Procedures* | On 27-Jan 2013, soundings from the leadline was compared to soundings from the ODOM Single Beam Echo Sounder. The average difference between depths was 1 cm. See Appendix 2 for the full report. |
| *Correctors* | Correctors were not determined. | |
| *Non-Standard Procedures* | Non-standard procedures were not utilized. | |

*Figure : 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, and 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, with 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 located as close to the vessel's central reference point as possible , and is secured to the vessel. 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<br>*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 an extremely accurate heading solution. |
| | *Serial Numbers* | see below |

Antenna 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* | 2014-04-07 |
| *Configuration Reports* | *Vessel* | S5401 |
| | *Report Date* | 2012-03-27 |


*Figure : 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 an 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 external antenna allows for 10 centimeter accuracy, while the internal antenna allows for 30 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 : 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-a-lone range finding tool. The TruPulse has been used both ways by R/V Bay Hydro II |
| *Serial Numbers* | 044670 |
| *DQA Tests* | DQA test was not performed. |


*Figure : TruPulse 360B laser range finder.*

*Figure : TruPulse 360B laster 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 uses a Sea-Bird Electronics SeaCat SBE 19plus Conductivity, Temperature, and Depth (CTD) profiler. 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 profile.<br><br>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 II of this report. |
| *Serial Numbers* | *Vessel Installed On*: S5401<br>*CTD s/n*: 19P37217-4677 |
| *Calibrations* | *CTD s/n*: 19P37217-4677<br>*Date*: 2014-01-09<br>*Procedures*: Calibration performed by Sea-Bird Electronics |

*Figure : 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 uses a SonTek CastAway Conductivity, Temperature, and Depth (CTD) profiler. 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 profile.<br><br>As part of the annual HSRR, the CTD profiler is sent to the manufacturer for factory calibration. A Calibration Report can be found in Separate 2 of this report. |

| | |
|---|---|
| *Serial Numbers* | *Vessel Installed On*: S5401<br>*CTD s/n*: CC1332002 |
| *Calibrations* | No CTD profiler calibrations were performed. |


*Figure : 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 |

<table>
<tr><td></td><td>unit was used to determine the speed of sound at the head of the Kongsberg EM2040 MBES.<br><br>As part of the annual HSRR, the Valeport is sent to the manufacturer for factory calibration. A Calibration Report can be found in Separate 2 of this report.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S5401</td></tr><tr><td>Sound Speed Sensor s/n</td><td>22882</td></tr></table></td></tr>
<tr><td>Calibrations</td><td><table><tr><td>Sound Speed Sensor s/n</td><td>22882</td></tr><tr><td>Date</td><td>2014-03-26</td></tr><tr><td>Procedures</td><td>Performed by Valeport Limited</td></tr></table></td></tr>
</table>

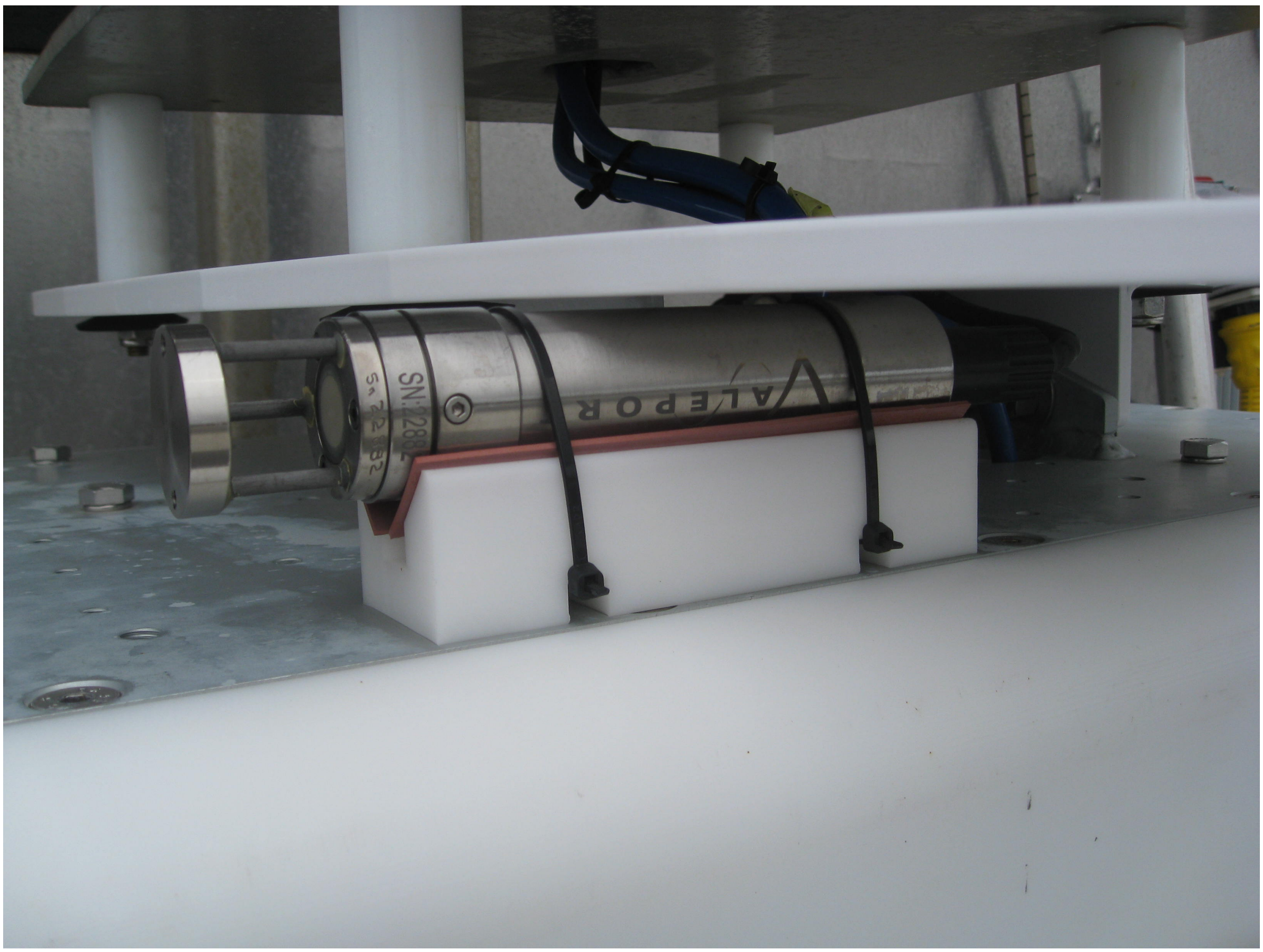

*Figure : Valeport MiniSVP mounted to the MBES case.*

## 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

<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>Precision T5500</td></tr>
<tr><td>Description</td><td>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.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Computer s/n</td><td>Operating System</td><td>Use</td></tr><tr><td>D1K78V1</td><td>Microsoft Windows 7 Enterprise, Version 2009 Service Pack 1</td><td>Acquisition</td></tr></table></td></tr>
</table>

<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>Optiplex 990</td></tr>
<tr><td>Description</td><td>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.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Computer s/n</td><td>Operating System</td><td>Use</td></tr><tr><td>5K158V1</td><td>Microsoft Windows 7 Professional, Version 2009 Service Pack 1</td><td>Acquisition</td></tr></table></td></tr>
</table>

| | |
|---|---|
| *Manufacturer* | Dell |
| *Model* | Precision T1650 |

<table>
<tr><td>Description</td><td>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 Bathy DataBASE , Pydro, Velocipy, and the full Microsoft Office Suite.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Computer s/n</td><td>Operating System</td><td>Use</td></tr><tr><td>G8Y78Y1</td><td>Microsoft Windows 7, Service Pack 1</td><td>Processing</td></tr></table></td></tr>
</table>

<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>Precision T3500</td></tr>
<tr><td>Description</td><td>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 Bathy DataBASE, Pydro, Velocipy, and the full Microsoft Office Suite.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Computer s/n</td><td>Operating System</td><td>Use</td></tr><tr><td>C3SMZQ1</td><td>Microsoft Windows 7, Service Pack 1</td><td>Processing</td></tr></table></td></tr>
</table>

### A.7.2 Computer Software

| | |
|---|---|
| *Manufacturer* | HYPACK, Inc |
| *Software Name* | HYPACK 2014 |
| *Version* | 14.0.0.1 |
| *Service Pack* | none |
| *Hotfix* | none |
| *Installation Date* | 2014-02-20 |
| *Use* | Acquisition |
| *Description* | HYPACK is used to acquire SBES data in a *.raw format MBES data in a *.hsx format and detached positions, in a *.tgt format. It is also used for vessel navigation during SBES, MBES and SSS data acquisition. HYPACK was updated multiple times during the field season to take advantages of software improvements. |

| | |
|---|---|
| *Manufacturer* | HYPACK, Inc |
| *Software Name* | HYPACK 2015 |
| *Version* | 15.0.0.1 |
| *Service Pack* | none |
| *Hotfix* | none |

| | |
|---|---|
| *Installation Date* | 2015-02-09 |
| *Use* | Acquisition |
| *Description* | HYPACK is used to acquire SBES data in a *.raw format MBES data in a *.hsx format and detached positions, in a *.tgt format. It is also used for vessel navigation during SBES, MBES and SSS data acquisition. HYPACK was updated multiple times during the field season to take advantages of software improvements. |

| | |
|---|---|
| *Manufacturer* | Applanix |
| *Software Name* | POSVIEW |
| *Version* | 8.15 |
| *Service Pack* | none |
| *Hotfix* | none |
| *Installation Date* | 2014-01-01 |
| *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* | MMS |
| *Version* | 6.14553.15282 |
| *Service Pack* | |
| *Hotfix* | none |
| *Installation Date* | 2014-01-01 |
| *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* | 8.1.10 |
| *Service Pack* | |
| *Hotfix* | |
| *Installation Date* | 2014-01-01 |
| *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 during the field season to take advantage of software improvements. |

| | |
|---|---|
| *Manufacturer* | NOAA OCS HSTP |
| *Software Name* | PYDRO |
| *Version* | v14.6 |
| *Service Pack* | r4990 |
| *Hotfix* | |
| *Installation Date* | 2014-01-01 |
| *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 updated multiple times during the field season to take advantage of software improvements. |

| | |
|---|---|
| *Manufacturer* | NOAA OCS HSTP |
| *Software Name* | VELOCIPY |
| *Version* | v13.8 |
| *Service Pack* | r4328 |
| *Hotfix* | |
| *Installation Date* | 2014-01-01 |
| *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 VELOCIPY was updated multiple times during the field season to take advantage of software improvements |

| | |
|---|---|
| *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* | 3.9.2 |
| *Service Pack* | N/A |
| *Hotfix* | N/A |
| *Installation Date* | 2014-07-08 |
| *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* | 4.1.2 |
| *Service Pack* | N/A |
| *Hotfix* | N/A |
| *Installation Date* | 2014-08-01 |
| *Use* | Processing |
| *Description* | CARIS Bathy BataBASE is a processing software that is used to analyze sonar data, apply S-57 attributes to objects found or known objects that were "re-found", 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 |

# 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. |

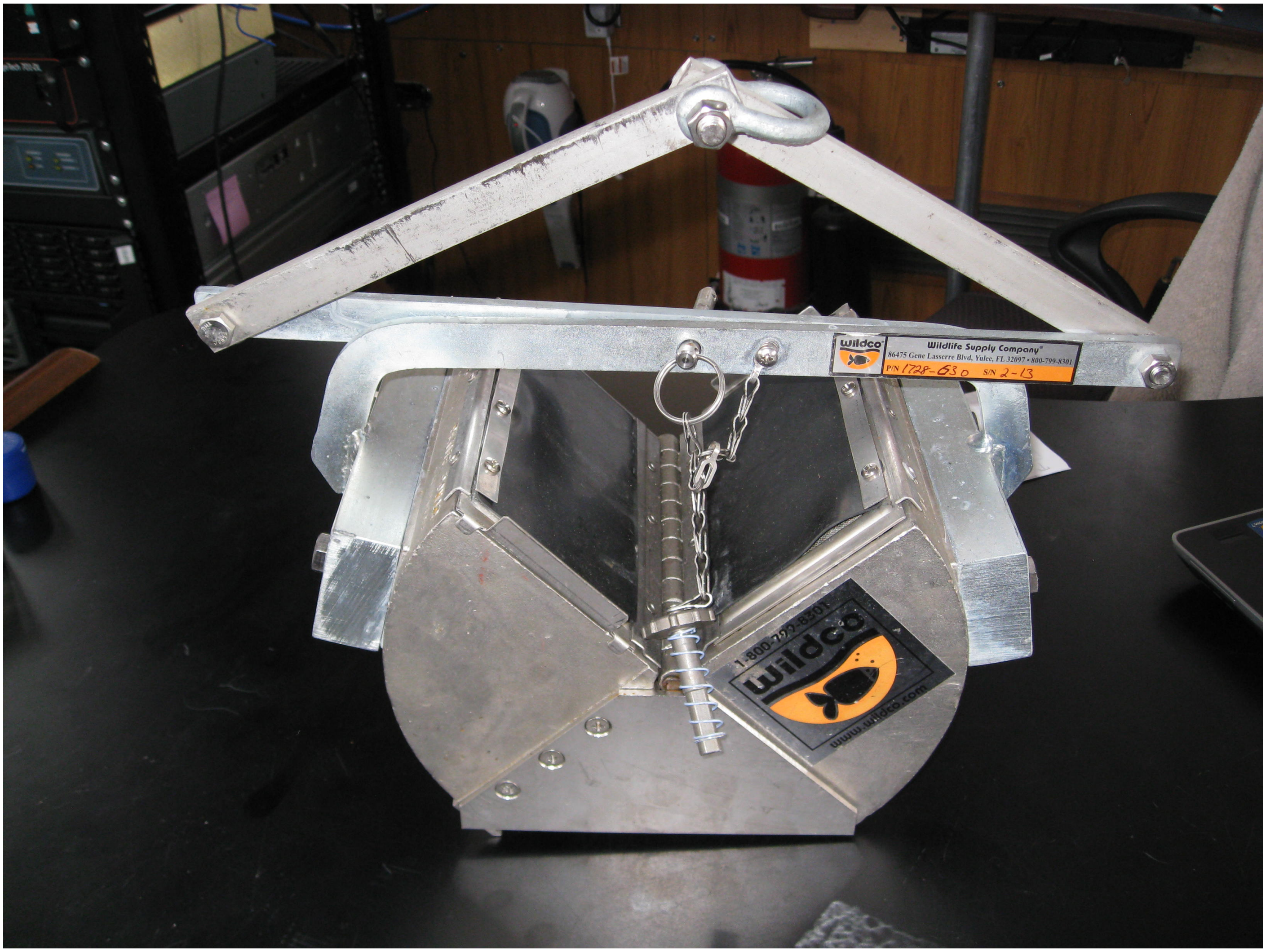


*Figure : R/V Bay Hydro II's Petite Ponar grab sampler.*

# 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 HYPCKS's HYSWEEP for the coxswain's display. This secondary interface acts as another monitoring tool to aid data quality. During acquisition the hydrographer adjusts sonar settings and provides feedback to the coxswain in order to ensure acquired data will meet coverage requirements set forth in the Project Instructions and HSSD.

#### B.1.1.2 Single Beam Echosounder

All Single Beam Data is logged using HYPACK. Two file types are logged. First, the ".raw" file, contains all the seafloor data and second, the .bin file which 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 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 Simrad's Discover II, in the ".jsf" format. The hydrographer sets the range scale to maximize imagery resolution and makes the identification of contacts easier in post processing. During acquisition, the hydrographer makes sure 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. Whenever there is a change in cable out, the measurement is manually entered into the Discover II software and the new value is automatically recorded in the .jsf file. R/V Bay Hydro II is not equipped with a cable counter, therefore these values have to be manually entered. The hydrographer monitors the towfish's health and function via real time data displays of heading, pitch, roll, internal pressure, and temperature. The hydrographer also monitors the towfish's position and speed, making sure that they correspond with data coming from the vessel's positioning software.

The hydrographic team conducts daily confidence checks to ensure the SSS system by passing by known objects. If the known object (such as a crab pot or navigation buoy) is seen in the appropriate channel, at an appropriate distance, the system is confirmed to be in good working order. This type of check is performed for both towfish channels prior to data acquisition.

#### 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 : The SonTeck CastAway CTD used for all sound speed profiles.*

#### B.1.3.2 Surface Sound Speed

Surface sound speed data is a direct measurement collected 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 either automatically selected based on the strongest DGPS signal for the area or manually defined via the web interface or front panel of the SPS. 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.

#### 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).

### B.1.5 Feature Verification

All potentially significant features are converted to a shape file for use in HYPACK.  The development line plan is created in HYPACK with a line spacing planed set for MBES to ensonify all features.  MBES data is collected over all significant SSS contacts, SBES designated soundings, and all possible shoaling.  The quality of data is controlled through real time monitoring during acquisition and post processing inspection (See  Section B.2.5).

### B.1.6 Bottom Sampling

Bottom samples are collected according to the designated sites provided by the Project Instructions.  Samples are obtained with a ponar type grabs 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 the branches along with associated surveys as well as provided to NOAA's Chesapeake Bay Office. No processing was 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. The converted file is saved in the CARIS HCDS file format. The navigation and attitude data are are visually inspected for gross errors. The data file is corrected for delayed heave, tides, sound velocity profile, and then merged. After the merge, the Total Propagated Uncertainty (TPU) is computed (See Section B.4.1).

A CUBE surface is then 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 that 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.

The surface’s other child layers are reviewed to ensure the surface meets NOAA standards as set forth in the HSSD, and is free from systematic errors. If holidays are identified in any of the child layers, a holiday line plan is created and executed (See Section B.2.2.3.3).

*Figure : 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 also goes through corrections and inspections 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 HCDS. At this point, offsets, draft, and dynamic draft sensor entries are applied to the HDCS file. The navigation and attitude data are 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, the 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.

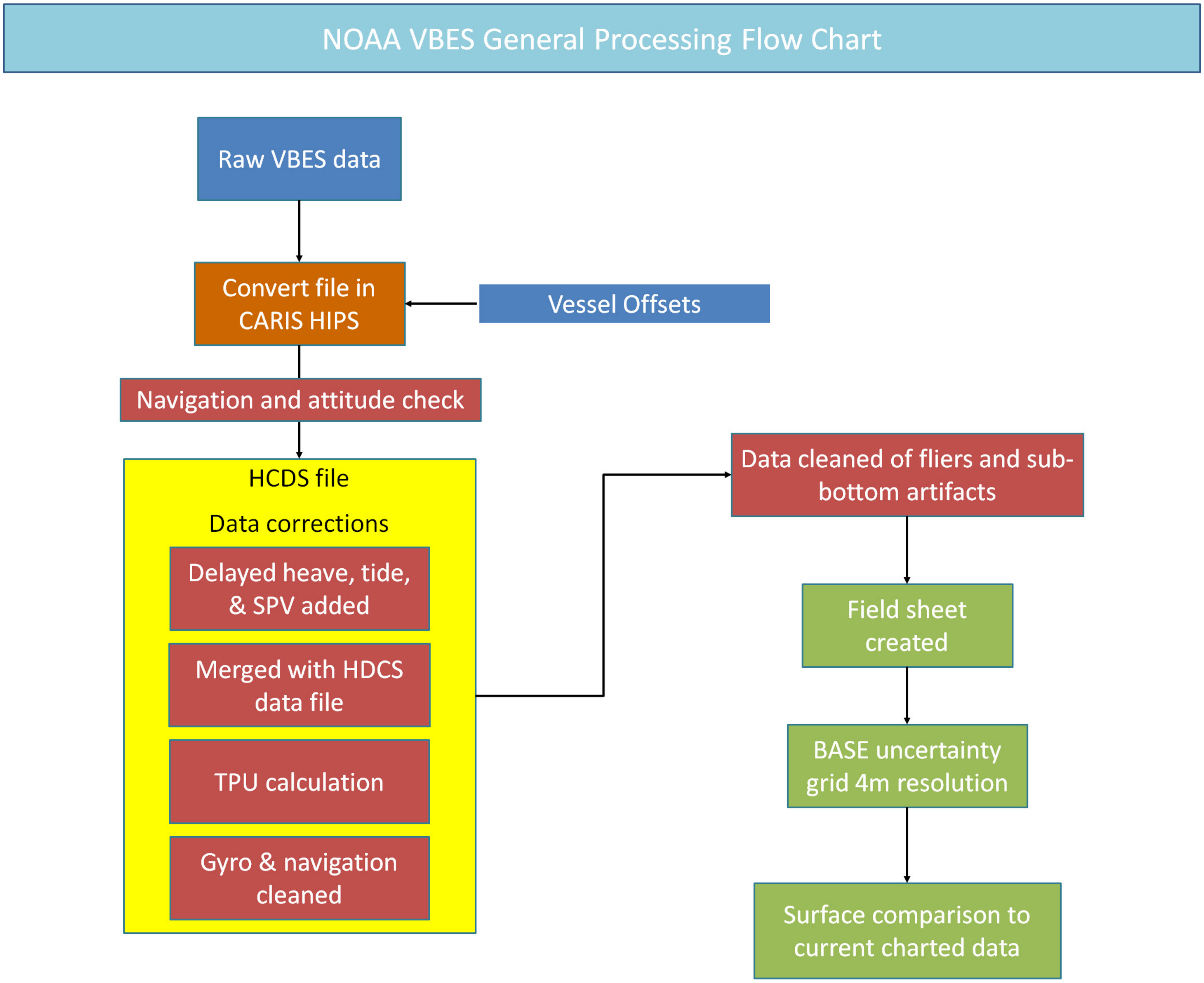


*Figure : SBES data processing flow chart.*

### 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 line by line 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 the bathymetric data is gridded into BASE surfaces.

SBES and 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. These grids meet the HSSD specifications set forth in Section 5.2.1.

After creation, Uncertainty and CUBE grids go through a quality control process. During this process, the Depth, Uncertainty, and Density child layers are examined for compliance with NOAA specifications. After the grids passes quality control, they are finalized. Uncertainty values for finalized surface come from the greater of either Uncertainty, or Standard Deviation.

#### B.2.1.4.3 Methods Used to Derive Final Depths

| | |
|---|---|
| *Methods Used* | Gridding Parameters<br>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 SSS .jsf file using CARIS SIPS. The vessels offset and draft entries are then loaded to the CARIS SIPS file. The towfish navigation and gyro are examined for gross errors, and the towfish height is inspected and digitized as needed so that it accurately tracks the seafloor.

The individual lines are stitched together to create a mosaic of the SSS data. As per the project requirements, 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 to exist, a holiday line plan is created and executed as per Section B.2.2.3.3.

The primary hydrographer reviews each SSS line for contacts. A secondary hydrographer reviews all of the data, verifies contacts, and inspects all lines to ensure nothing was missed. The contacts are imported to CARIS BDB and a .000 file is exported for a contact development plan with MBES.

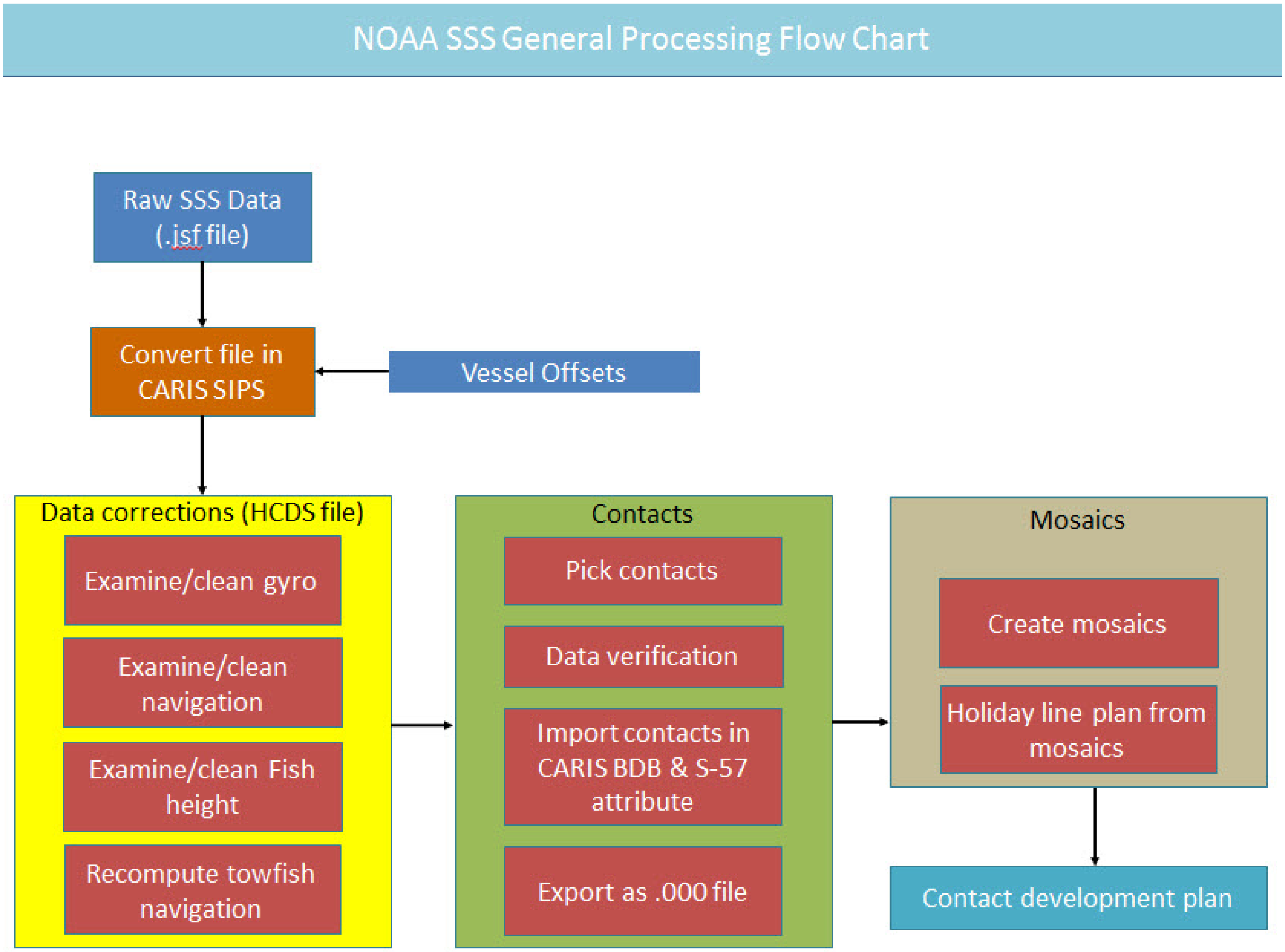


*Figure : SSS data processing flow chart.*

### 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 line by line 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

Although SSS system object detection and accuracy are mostly verified on the acquisition side of survey by conducting daily confidence checks (See Section B.1.2.1) and a yearly calibration test as part of the HSRR (procedures outlined in FPM 1.5.7.1.2), there are a few things that can be investigated on the processing side. First, a comparison of the contact position as seen in adjacent lines to make sure the contacts are within a ten meters radius (as stated in FPM 1.5.7.1.2). Second, a comparison of the SSS contact position to the MBES position for the same contact. Lastly, SSS lines are inspected by the primary hydrographer and reviewed by a secondary hydrographer to ensure significant contacts are not overlooked.

#### B.2.2.3.3 Methods Used to Verify Swath Coverage

Once the SSS Mosaic or the MBES CUBE Surface is created, it is set over a brightly colored background and scanned for any areas of missing data, or holidays. If a holiday is identified in SSS mosaic or MBES surfaces, a .hob file is created to digitize the ares that need further investigation. This exported as a .000 or shape file into Hypack and a holiday line plan is created. Once the holiday line plan is collected, it is processed and added to the corresponding surface or mosaic.

#### 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.

#### 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, unless stated in the DR, to acquire sound velocity profiles. 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 SPV file for the specific survey.

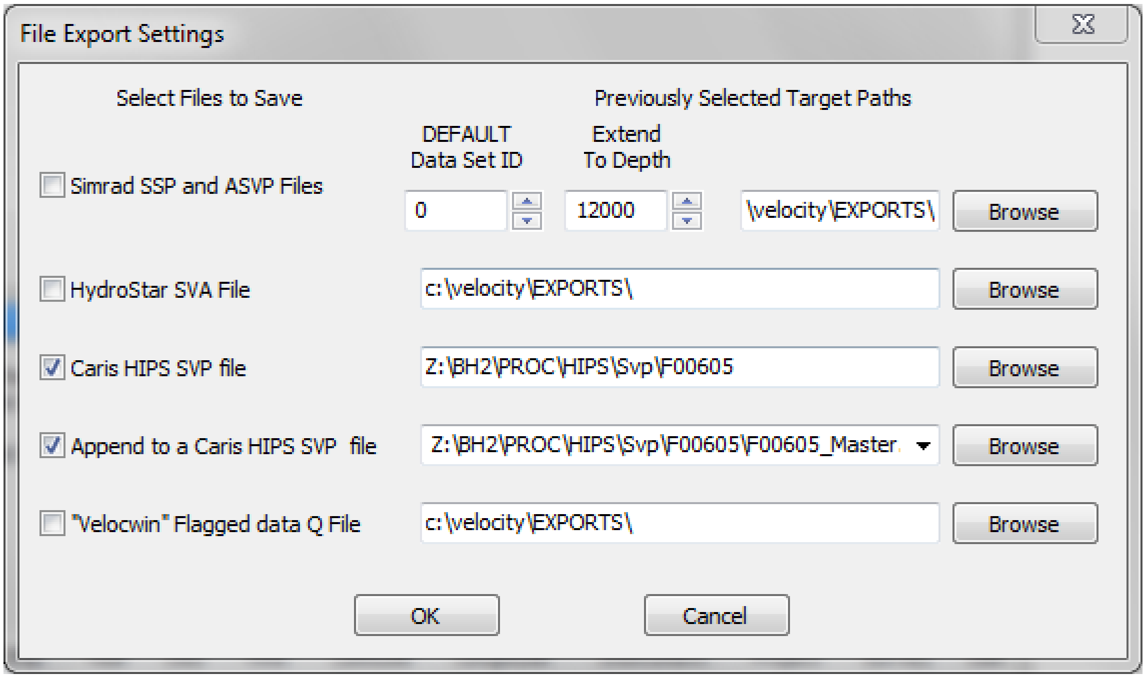


*Figure : Velocipy GUI.*

### B.2.3.2 Surface Sound Speed

Surface sound speed data is a direct measurement collected by the Valeport miniSVS for use by the MBES during acquisition, see Section C.6.2.


*Figure : Valport MiniSVS.*

## B.2.4 Horizontal and Vertical Control

### B.2.4.1 Horizontal Control

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

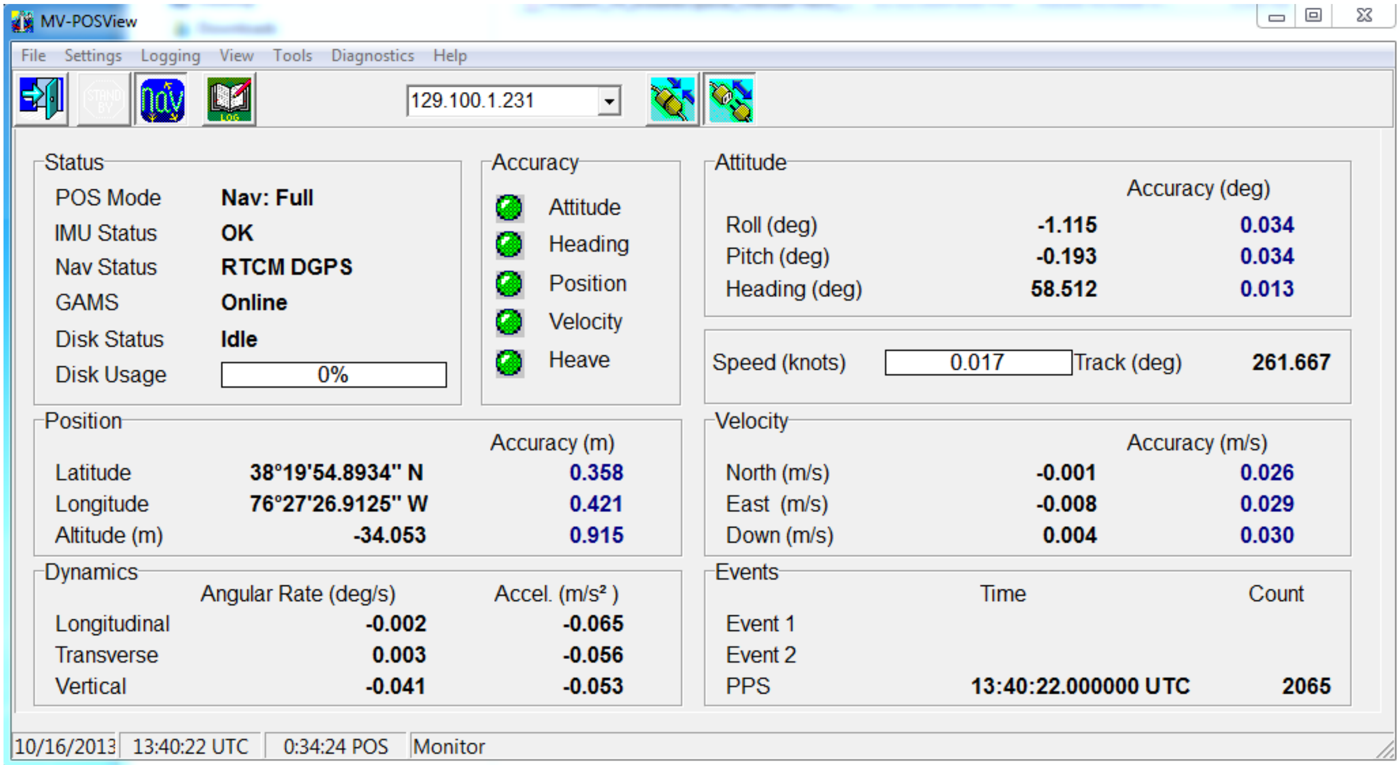


*Figure : Real Time POS M/V monitoring interface.*

### 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).

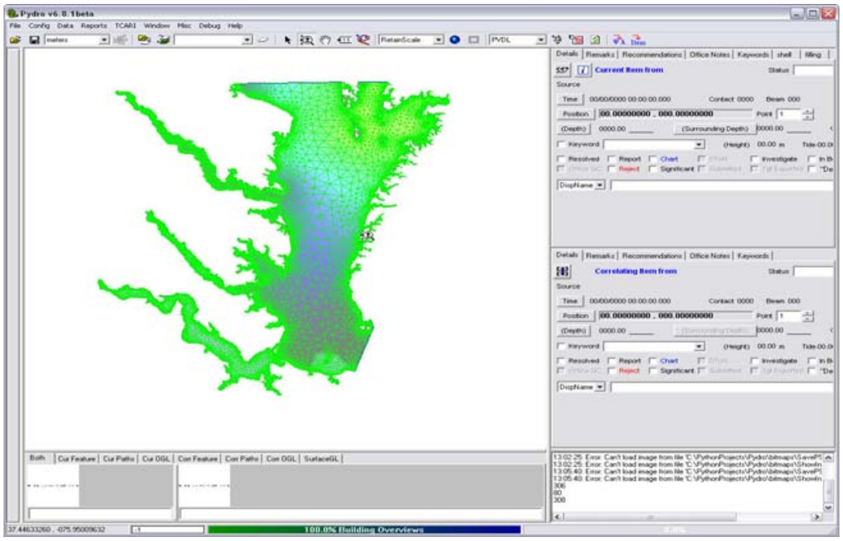

*Figure : TCARI Tide interface.*

## B.2.5 Feature Verification

There are three feature types, submerged, shoreline, or unsafe. Each are outlined and explained below. During any feature verification, R/V Bay Hydro II tries to take high resolution photographs of the feature (when it is safe to do so) to aid in identification and documentation of the feature.

Submerged features, that are safe to acquire data over, are verified by collecting MBES data over them. This data is then converted using the methodology described in Section B.2.1.1. The CUBE surface is imported into CARIS Bathy Database (BDB), features are created and assigned a "designated" sounding at highest point of a new feature, all BDB features are S-57 attributed.

In the event that shoreline verification is required, or a significant/assigned feature is accessible by shore, the Trimble GeoXH is used for position verification for features inaccessible form the vessel. This hand held unit is held on the highest point of 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. A shape file is imported into CARIS BDB, and a S-57 feature file is created.

In the event that a feature is unsafe to approach, a detached position is calculated. An azimuth and range (via compass and laser range finder, respectively) are taken along with a known vessel position. This allows the feature's position to be calculated with a high degree of accuracy. A feature is then created in BDB, it is assigned S-57 attributes, and described as being surveyed as a detached position.

*Figure : 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

Prior to each Field Season R/V Bay Hydro II performs a Hydrographic Systems Readiness Review (HSRR), during which all multibeam sonars, side scan sonars, lead lines, sound speed measuring devices, and positioning systems are calibrated. Additionally, a comparison is made between depths found by lead line, SBES, and the MBES.

During daily acquisition, a hydrographer monitors position and attitude data in the POS/MV interface, watches incoming data for errors, and compares the surface sound speed against the corresponding sound speed from the CTD cast.

For post processing quality management procedures (See Section B.2.1.1 for MBES, Section B.2.1.2 for SBES, and Section B.2.2.1 for SSS).

## B.4 Uncertainty and Error Management

R/V Bay Hydro's configured for the "Precise Timing" setup for MBES operations, in this method of minimizing timing errors, two data strings are being outputted from the POS/MV. The first is a Pulse Per Second (PPS) signal. This signal is fed directly into the the Kongsberg EM2040 SPU for synchronizing the MBES's internal clock with the POS/MV. The second signal is the National Marine Electronics Association (NMEA) ZDA string. The ZDA string is also fed directly into the the MBES system and into Hypack and is the NMEA string that states precise date and time. As a result of the raw data be precisely time stamped and compared to a precise time stamp in HYPACK's HYSWEEP, timing offset between the two systems are eliminated.

Total Propagated Uncertainty is an estimate of the uncertainty of any individual sounding, taking into account the error estimates of the component measurements (tide, sound speed, draft, range measurement, angle measurement, attitude, offsets, etc), and expressed as a separate value in horizontal and vertical planes. Only soundings that have an associated TPU can be combined into a Navigation Surface with depth and uncertainty attributes for each node.

### B.4.1 Total Propagated Uncertainty (TPU)

#### B.4.1.1 TPU Calculation Methods

TPU is computed using CARIS HIPS and applies the NOAA specified CubeParams_2010 values. Tides and Sound Speed estimates are dictated by Table 4-9 and 4-10, located in Appendix 4 of the Field Procedures Manual, and are set to 4 m/s for sound speed and 0.50 m/s for Surface. Uncertainty source values are another constituent of TPU and are collected in real time, during acquisition, from the individual sensors themselves, motion reference unit (MRU) alignment is the exception (see Section 4.2.3.8 of the FPM).

### B.4.1.2 Source of TPU Values

Field Procedures Manual: Table 4-9, Appendix 4

### B.4.1.3 TPU Values

| | | | |
|---|---|---|---|
| *Vessel* | R/V Bay Hydro II | | |
| *Echosounder* | Kongsberg EM2040 400 hertz | | |
| *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 |

## 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 MBES transducer head. The Kongsberg system records the attitude and navigation in the multibeam time and reference frame. Therefore the specific offsets are needed in the vessel HVF file for CARIS processing software to calculate the correct ping placement. The X,Y,Z distances are set to zero because the new reference point provides resolved depths and records attitude and navigation data at the head of the MBES, instead of recording the raw navigation and attitude data from the IMU. In addition, this configuration eliminates the need for additional HVF's in CARIS when surveying to the ellipsoid. The new offsets in the vessels HVF file are reflected in the Nav to Transducer, SVP 1, and SVP 2 sections of the HVF file.

#### 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 |

<table>
<tr><td rowspan="14">Offsets</td><td rowspan="6">MRU to Transducer</td><td>x</td><td>2.294 meters</td></tr>
<tr><td>y</td><td>3.406 meters</td></tr>
<tr><td>z</td><td>2.143 meters</td></tr>
<tr><td>x2</td><td></td></tr>
<tr><td>y2</td><td></td></tr>
<tr><td>z2</td><td></td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.0 meters</td></tr>
<tr><td>y</td><td>0.0 meters</td></tr>
<tr><td>z</td><td>0.0 meters</td></tr>
<tr><td>x2</td><td></td></tr>
<tr><td>y2</td><td></td></tr>
<tr><td>z2</td><td></td></tr>
<tr><td rowspan="2">Transducer Roll</td><td>Roll</td><td>0.000 degrees</td></tr>
<tr><td>Roll2</td><td></td></tr>
<tr><td>Vessel</td><td colspan="3">R/V Bay Hydro II</td></tr>
<tr><td>Echosounder</td><td colspan="3">Kongsberg EM2040 400 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2010-03-02</td></tr>
<tr><td rowspan="14">Offsets</td><td rowspan="6">MRU to Transducer</td><td>x</td><td>0.305 meters</td></tr>
<tr><td>y</td><td>-0.894 meters</td></tr>
<tr><td>z</td><td>2.469 meters</td></tr>
<tr><td>x2</td><td>-0.006 meters</td></tr>
<tr><td>y2</td><td>-0.789 meters</td></tr>
<tr><td>z2</td><td>2.451 meters</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.152 meters</td></tr>
<tr><td>y</td><td>-1.045 meters</td></tr>
<tr><td>z</td><td>2.304 meters</td></tr>
<tr><td>x2</td><td>-0.159 meters</td></tr>
<tr><td>y2</td><td>-0.94 meters</td></tr>
<tr><td>z2</td><td>2.287 meters</td></tr>
<tr><td rowspan="2">Transducer Roll</td><td>Roll</td><td>0.000 degrees</td></tr>
<tr><td>Roll2</td><td>0.000 degrees</td></tr>
<tr><td>Vessel</td><td colspan="3">R/V/Bay Hydro II</td></tr>
<tr><td>Echosounder</td><td colspan="3">Kongsberg EM2040 400 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2014-08-13</td></tr>
</table>

<table>
<tr><td rowspan="14">Offsets</td><td rowspan="6">MRU to Transducer</td><td>x</td><td>0.305 meters</td></tr>
<tr><td>y</td><td>-0.894 meters</td></tr>
<tr><td>z</td><td>2.469 meters</td></tr>
<tr><td>x2</td><td>-0.006 meters</td></tr>
<tr><td>y2</td><td>-0.789 meters</td></tr>
<tr><td>z2</td><td>2.451 meters</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.152 meters</td></tr>
<tr><td>y</td><td>-1.045 meters</td></tr>
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<tr><td>y2</td><td>-0.94 meters</td></tr>
<tr><td>z2</td><td>2.287 meters</td></tr>
<tr><td rowspan="2">Transducer Roll</td><td>Roll</td><td>0.00 degrees</td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td></tr>
</table>

## 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

<table>
<tr><td>Vessel</td><td colspan="3">R/V Bay Hydro II</td></tr>
<tr><td>Echosounder</td><td colspan="3">EdgeTech 4200 Towfish,701-DL Transceiver Processing Unit 600 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2010-02-26</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>-0.011 meters</td></tr>
<tr><td>y</td><td>-9.979 meters</td></tr>
<tr><td>z</td><td>-4.01 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">0.00 meters</td></tr>
</table>

# 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, a 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 date 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 03-June 2014 a new dynamic draft measurement was conducted. A total of 18 2,000 m lines were run in opposite directions for each of eight different RPM's on the vessel's main engines. The initial two lines were run using a single engine, in order to maintain the slowest speed possible. The remaining fourteen lines were run using both engines. The evaluation was completed by acquiring six drift lines that ran orthogonal to the azimuth of the main lines.

The data was processed using the standard work flow in CARIS HIPS/SIPS version 8.1.4. A TCARI grid, E349BH22014_Rev.tc, was used for water levels. All MBES DDM data was filtered to +/- 5° of swath (10° total). This processes results in a near true nadir-to-nadir analysis of depth values.

Individual 1-meter resolution surfaces were made from the filtered data for all 24 MBES lines. Difference surfaces were generated from each DDM line compared to each of the six drift lines at 1-meter resolution.

In Excel the statistics from each reciprocal line pair was averaged together to account for any influence from current. Furthermore, the resulting averages for each reciprocal line pair at each drift line were averaged together to produce the dynamic draft for any given RPM setting.

The full Dynamic Draft Report is located in Appendix I.

### C.2.2.3 Dynamic Draft Correctors

<table>
<tr><td>Vessel</td><td>R/V Bay Hydro II</td></tr>
<tr><td>Date</td><td>2014-06-03</td></tr>
<tr><td>Dynamic Draft Table</td><td>
<table>
<tr><td>Speed</td><td>Draft</td></tr>
<tr><td>0.00</td><td>0.00</td></tr>
<tr><td>1.92</td><td>0.02</td></tr>
<tr><td>2.58</td><td>0.02</td></tr>
<tr><td>2.96</td><td>0.02</td></tr>
<tr><td>3.24</td><td>0.02</td></tr>
<tr><td>3.65</td><td>0.01</td></tr>
<tr><td>3.87</td><td>0.00</td></tr>
<tr><td>4.12</td><td>0.00</td></tr>
<tr><td>4.66</td><td>-0.02</td></tr>
<tr><td>5.18</td><td>-0.01</td></tr>
</table>
</td></tr>
</table>

## C.3 System Alignment

### C.3.1 Description of Correctors

Patch Tests are performed on all MBES systems used 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 is the hydrographers way of determining and accounting for any offsets in alignment between the vessel's reference frame and the MBES system's positional alignment.

### C.3.2 Methods and Procedures

Two patch tests were performed throughout the year because the multibeam sonar reference point was updated on 13-Aug-2014. The patch tests determine any roll, pitch, and yaw biases (X, Y, and Z axis) and the time offset between the MB reference frame and the navigational reference frame. The patch tests are conducted in accordance with the Hydrographic Specifications and Deliverables 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 three trials are averaged together and the average is recorded in the appropriate system's CARIS .HVF file under the appropriate columns in Swath 1 for the specific day number.

## C.3.3 System Alignment Correctors

| | |
|---|---|
| *Vessel* | R/V Bay Hydro II |
| *Echosounder* | Kongsberg EM2040 300 kilohertz |
| *Date* | 2014-05-21 |

| | | |
|---|---|---|
| *Patch Test Values* | *Navigation Time Correction* | 0.0 seconds |
| | *Pitch* | 0.067 degrees |
| | *Roll* | 0.113 degrees |
| | *Yaw* | 0.58 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 during survey and applied to the raw MBES and SBES data.

### C.4.2 Methods and Procedures

The POS/MV file is recorded the to the network RAW drive. The POS/MV file is merged with the raw MBES or SBES data file in CARIS SIPS using the "Load Delayed Heave" utility.

## 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 an ERS VDatum evaluation.

### 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 or preliminary 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.

Tidal Constituent and Residual Interpolation (TCARI), the 6-minute water level data (predicted, preliminary, or verified) is loaded into TCARI for all water level stations operating during the time of the survey. TCARI grid computes and interpolates the tidal influence for discrete points within the survey area. The TCARI data is referenced to MLLW and is used as a corrector in the final bathymetric soundings.

Discrete Tidal Zoning, tidal correctors are apply uniformly by dividing the survey area into discrete tidal zones based on a reference water level station, time corrector and rage corrector which are provided per the Project Instructions.

R/V Bay Hydro II is capable of ERS and VDatum reduction to MLLW when provided an appropriate separation model by HSD-OPS. Applanix POSPac is used to process GPS heights for ERS evaluation. Then the CARIS HIPS Compute GPS Tide function creates the HDCS GPSTide file using the SBET converted GPSHeight and the loaded Ellipsoid to chart datum Separation Model. Additional information about ERS VDatum methods and procedures are referenced in FPM Appendix 4 and HSSD Chapter 9.

# 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 once every 2 - 4 hours for MBES. Profiles are collected more frequently when transiting more than 1 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 data is collected, the data is processed by the HSTP program Velocipy using the Chen-Millero Equation. The Kongsberg EM2040 imports the the sound velocity profile into SIS as an aid for real time beam pattern formation.

In CARIS, the "Nearest in Time" option is applied for our sound velocity correction protocol as the survey area has limited outside influences that impact sound speed (depth, tides, currents, freshwater inputs). This provides the best representation of sound speed in the Chesapeake Bay.

## C.6.2 Surface Sound Speed

### C.6.2.1 Description of Correctors

The Valeport miniSVS measure the surface sound speed measurements 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.