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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	S-E904-BH2-18
Time Frame:	June - July 2018

LOCALITY

State(s):	Maryland
General Locality:	Chesapeake Bay

2018

CHIEF OF PARTY
LTJG Sarah L. Chappel

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Date:

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Data Acquisition and Processing Report

R/V Bay Hydro II
Chief of Party: LTJG Sarah L. Chappel
Year: 2018
Version: 1
Publish Date: 2019-10-28

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 R/V Bay Hydro II

Vessel Name	R/V Bay Hydro II	
Hull Number	S5401	
Description	R/V Bay Hydro II was used for the acquisition of sound velocity profiles (SVP) and the post- processing of Multi-Beam echo sounder (MBES) and Side Scan Sonar (SSS) data unless otherwise noted in the Descriptive Report.	
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

Figure 1: R/V Bay Hydro II

A.1.2 EchoBoat

<table>
<tr><td>Vessel Name</td><td>EchoBoat</td></tr>
<tr><td>Hull Number</td><td>ASV007</td></tr>
<tr><td>Description</td><td>The EchoBoat is a remotely controlled and autonomous surface vehicle that can be used to perform multibeam or side scan surveys in very shallow water or in remote areas where it is difficult to launch conventional survey boats. The ASV was used for hydrographic data acquisition, with an assisting vessel as a launching/hosting platform. The vessel was used for acquisition of MBES and SSS as noted in the DR. Vessel configuration and offset measurements are included in the appendix of this report.</td></tr>
<tr><td>Dimensions</td><td><table><tr><td>LOA</td><td>1.68 meters</td></tr><tr><td>Beam</td><td>0.79 meters</td></tr><tr><td>Max Draft</td><td>0.258 meters</td></tr></table></td></tr>
</table>

Most Recent Full Static Survey	*Date*	2017-10-02
	Performed By	Seafloor Systems, Inc.

Figure 2: EchoBoat ASV007

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Picotech, LTD PicoMBES-120SF

The PicoMBES-120SF is a miniature CHIRP FM multibeam echo sounder (MBES) manufactured by Picotech Ltd, customized to fit inside the transducer well of the ASV007. All beam forming and digital signal processing are performed within the sonar, allowing a direct connection from the sonar to a control computer via WiFi. The PicoMBES-120SF interfaces directly with the EchoBoat's onboard industrial PC.

From a shore laptop using Remote Desktop Connection, the user accesses the onboard PC via a WiFi bridge to control the sonar settings, data logging, as well as the ASV's AutoNav™ autonomous mission planner.

<table>
<tr><td>Manufacturer</td><td colspan="3">Picotech, LTD</td></tr>
<tr><td>Model</td><td colspan="3">PicoMBES-120SF</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">ASV007</td><td>Component</td><td>MBES</td></tr>
<tr><td>Model Number</td><td>120SF</td></tr>
<tr><td>Serial Number</td><td>389</td></tr>
<tr><td>Frequency</td><td>300-400kHz</td></tr>
<tr><td>Calibration</td><td>2018-04-20</td></tr>
<tr><td>Accuracy Check</td><td>2018-04-20</td></tr>
</table>

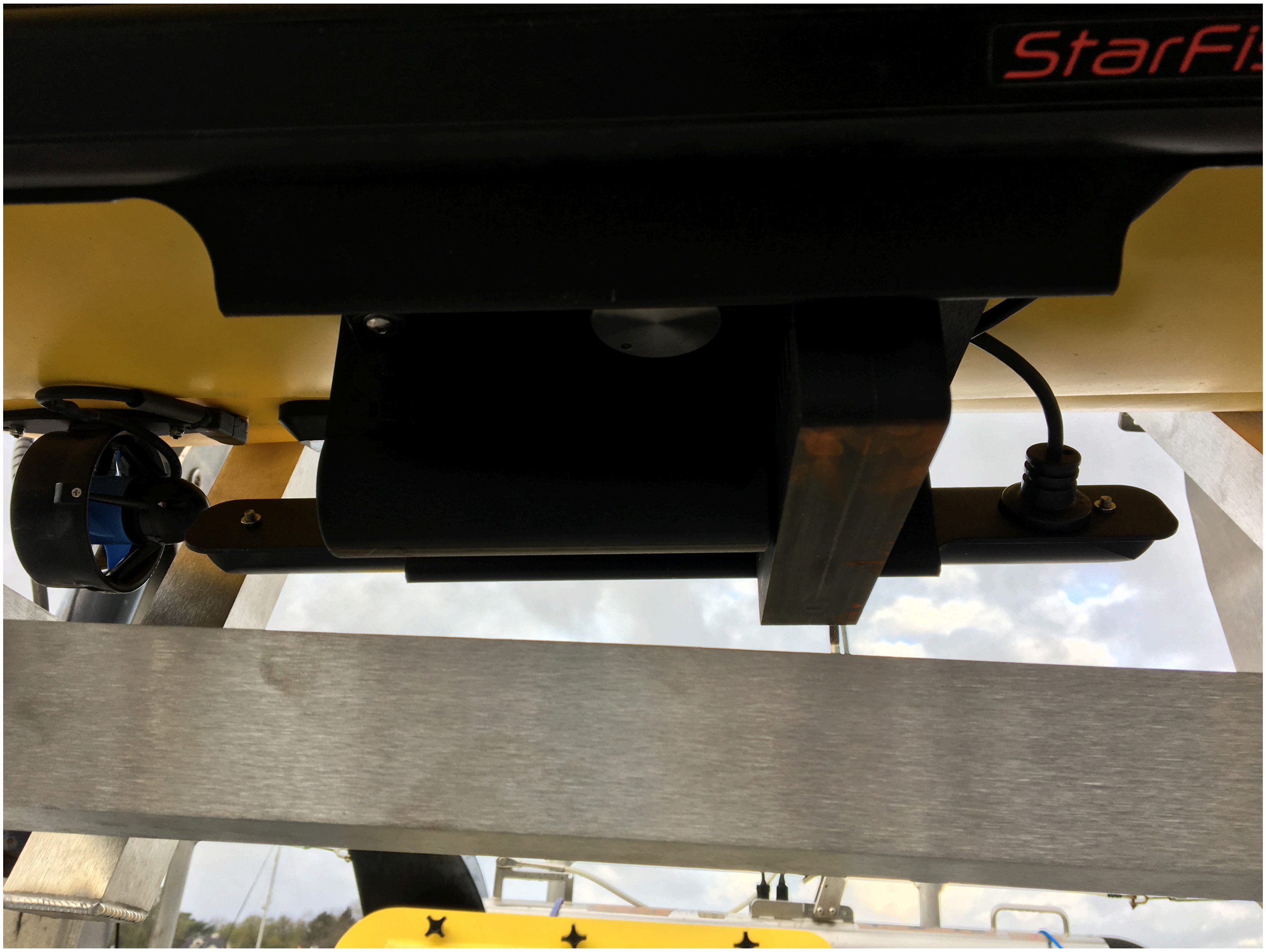

Figure 3: PicoMBES installed on ASV007.

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

A.2.3.1 Tritech StarFish 453

The Tritech StarFish 453 side scan sonar system is an acoustic imagery device that is mounted to the hull of ASV007. The Tritech StarFish has an operational frequency of 450kHz CHIRP with a vertical beam width of 60°. The integrated system includes two mounted transducers and a power control unit. Acquisition is controlled via WiFi interface between the ASV internal PC and a shore side lap top.

Positioning of the towfish is calculated using CARIS SIPS and found using the POS MV IMU, GPS locations, and the measured offsets of the Tritech. Altitude is maintained between 8% and 20% of the range scale, in accordance with the FPM Section 2.5.3.1.2. Confidence checks are performed daily in accordance with the HSSD Section 6.1.3.1. More information can be found in Section C.2.2 of this document.

In April 2018 an annual SSS calibration test was performed in accordance with FPM 1.5.7.1.2. For a full report see the Appendix.

Manufacturer	Tritech		
Model	StarFish 453		
Inventory	*ASV007*	*Component*	SSS
		Model Number	453
		Serial Number	ASV007
		Frequency	450kHZ CHIRP
		Calibration	2018-04-20
		Accuracy Check	2018-04-20

Figure 4: Tritech StarFish 453

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

No lead lines were utilized for data acquisition.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix (a Trimble company) POS MV

The POS MV SURFMASTER ONE system used on the EchoBoat is a user friendly, turn-key system designed and built to provide accurate attitude, heading, heave, position, and velocity data of the marine vessel and onboard sensors. POS MV blends GNSS data with angular rate and acceleration data from an IMU and heading from the GPS Azimuth Measurement System (GAMS) to produce a robust and accurate full six degrees-of- freedom position and orientation solution. The SURFMASTER on ASV007 is set to use WAAS for real-time positioning.

<table>
<tr><td>Manufacturer</td><td colspan="5">Applanix (a Trimble company)</td></tr>
<tr><td>Model</td><td colspan="5">POS MV</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">ASV007</td><td>Component</td><td>IMU/POS</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>MV-120</td><td>AT1675-540TS</td><td>AT1675-540TS</td></tr>
<tr><td>Serial Number</td><td>9025</td><td>11859</td><td>11862</td></tr>
<tr><td>Calibration</td><td>2018-04-20</td><td>2018-04-20</td><td>2018-04-20</td></tr>
</table>

Figure 5: POS MV SURFMASTER ONE unit, as used on ASV007.

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

A.6.2.1 SonTek (a Xylem brand) Castaway

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 calculate 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 the Appendix of this report.

<table>
<tr><td>Manufacturer</td><td colspan="2">SonTek (a Xylem brand)</td></tr>
<tr><td>Model</td><td colspan="2">Castaway</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>CTD</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>CC1332002</td></tr>
<tr><td>Calibration</td><td>2018-02-07</td></tr>
</table>

Figure 6: SonTek CastAway CTD.

A.6.3 Sound Speed Sensors

A.6.3.1 Valeport miniSVS

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 alongside the PicoMBES on the EchoBoat. As part of the annual HSRR, the miniSVS is sent to the manufacturer for factory calibration, however, a calibration report is not available.

<table>
<tr><td>Manufacturer</td><td colspan="3">Valeport</td></tr>
<tr><td>Model</td><td colspan="3">miniSVS</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">ASV007</td><td>Component</td><td>miniSVS</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2018-04-20</td></tr>
</table>

Figure 7: Valeport MiniSVS

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
HYPACK, Inc	HYPACK 2017/2018	2017+	Acquisition
Applanix	POSView	8.15	Acquisition
Applanix	POSPac MMS	8.4	Processing
Teledyne Caris	HIPS and SIPS	11.1.4	Processing
NOAA OCS HSTB	PydroExplorer	19.4	Processing
Teledyne Caris	BASE Editor	5.3	Processing
Hydroffice	Sound Speed Manager	2018.0	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

No bottom sampling equipment was utilized for data acquisition.

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

A survey of the Echoboat was completed by SeaFloor Systems and provided to the user. The survey established a vessel Reference Point (RP), then found the X, Y, and Z distances for the GNSS antennas and multibeam sonar. These offsets were verified by NOAA representatives at the vessel acceptance testing. All physical offsets are located in the Caris HVF because the reference point is at the MRU. The MRU and Nav to Transducer offsets are shown in the tables below. It should be noted that the sonars and IMU are mounted on a rigid frame with precise manufacturing. This keeps the lever arms very small and the roll, pitch, and yaw measurements near zero.

B.1.1.1 Vessel Offset Correctors

Vessel	ASV007			
Echosounder	Picotech, LTD. PicoMBES-120SF			
Date	2018-04-20			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.000 meters	0.020 meters
		y	-0.033 meters	0.020 meters
		z	0.258 meters	0.020 meters
	Nav to Transducer	*x*	0.000 meters	0.020 meters
		y	0.360 meters	0.020 meters
		z	0.578 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

B.1.2 Layback

Layback correctors were not applied to Echoboat data because the side scan is a hull mounted system.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft for EchoBoat was calculated using manufacturer provided measurements. The calculated value is entered directly into the HVF for use by Charlene for processing.

B.2.1.1 Static Draft Correctors

Vessel		ASV007
Date		2018-04-20
Loading		0.001 meters
Static Draft	*Measurement*	0.003 meters
	Uncertainty	0.001 meters

B.2.2 Dynamic Draft

Dynamic draft for ASV007 was measured using the Post Processed Kinematic GPS method outlined in section 1.4.2.1.2.1 of NOAA's FPM. To reduce the effect of any potential current, reciprocal lines were run at each RPM step in order to get an average speed over ground for each RPM. This average speed was used to estimate the vessel’s speed through the water. Dynamic draft and vessel offsets corrector values are stored in the HVF.

In ERS surveys, those that use recorded GPS heights corrected via a VDatum SEP model to achieve tidal datum, the dynamic draft correction is not applied to the soundings.

B.2.2.1 Dynamic Draft Correctors

Vessel	ASV007	
Date	2018-04-20	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	0.50	0.30
	1.00	0.36
	1.50	0.38
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.40	0.01

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

The 2018 field season patch test was conducted as part of the HSRR (see the Appendix 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 ASV 007 crew members. The results of the trials are averaged and the result is recorded in the Caris HVF. The standard deviation of several calibration iterations for pitch and roll are averaged to produce the HVF associated value.

B.3.1.1 System Alignment Correctors

Vessel	ASV007
Echosounder	Picotech, LTD PicoMBES
Date	2018-04-20

Patch Test Values

	Corrector	Uncertainty
Transducer Time Correction	0.000 seconds	0.010 seconds
Navigation Time Correction	0.000 seconds	0.010 seconds
Pitch	3.550 degrees	2.000 degrees
Roll	0.000 degrees	2.000 degrees
Yaw	0.000 degrees	2.000 degrees
Pitch Time Correction	0.000 seconds	0.010 seconds
Roll Time Correction	0.000 seconds	0.010 seconds
Yaw Time Correction	0.000 seconds	0.010 seconds
Heave Time Correction	0.000 seconds	0.010 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

PicoMB multibeam data is logged using HYPACK and HYSWEEP in the ".HSX" and ".RAW" formats. The hydrographer scans the real time data for system wide errors, anomalies, and dropouts. Display windows such as Intensity Waterfall, Matrix Maps, and Beam Profile aid in this task. This system is controlled via remote desktop over Wifi connection. Using this Wifi interface, data is viewed real-time from the parent platform but is collected on the ASV internal computer. 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.

Data Processing Methods and Procedures

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. These conversions, corrections, and offsets are performed via the automated processing and data transfer tool, Charlene.

The process starts by converting the Hypack .HSX 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 C.6.1).

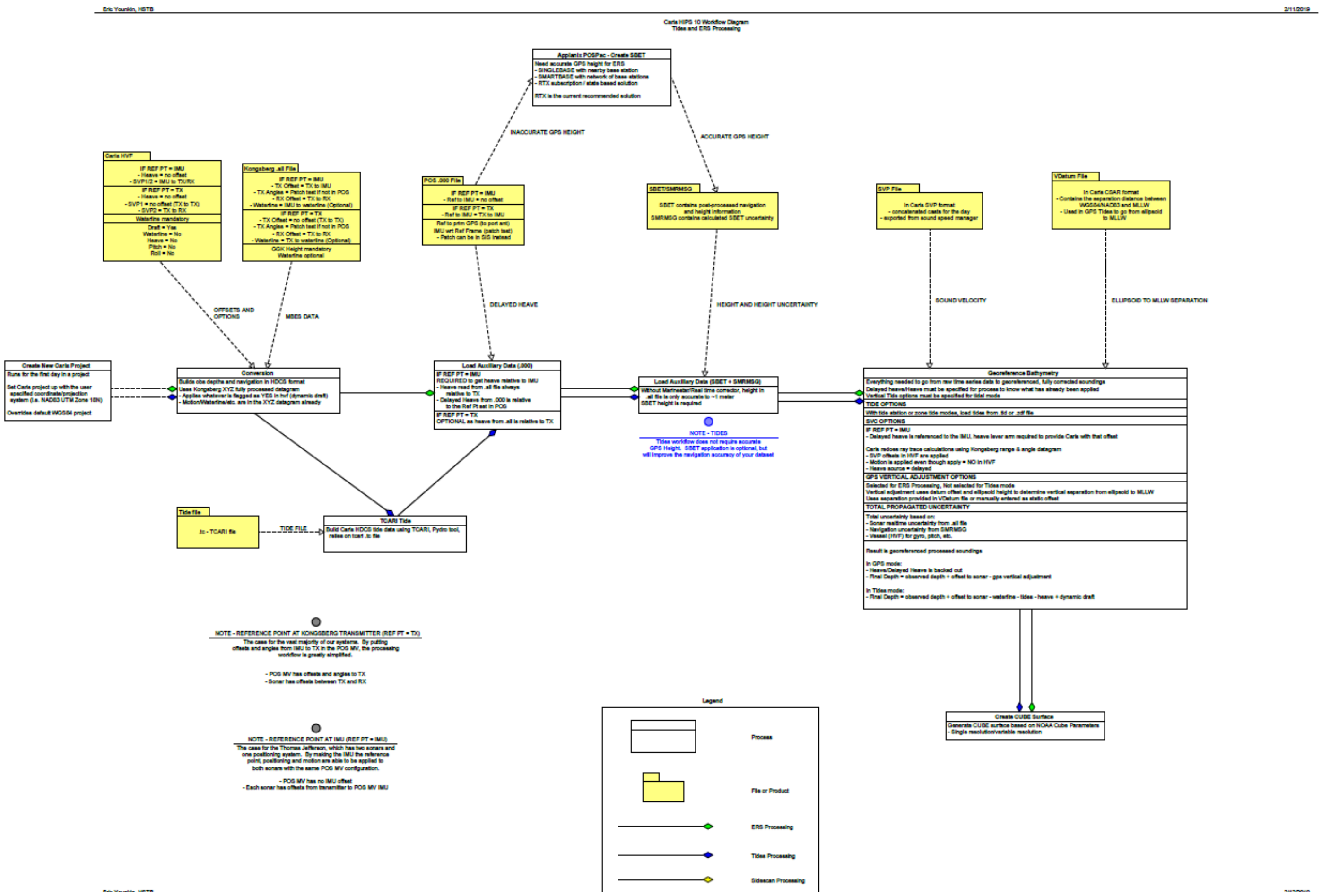

Figure 8: MBES Data Processing Workflow

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

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, using methods described above in Section C.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 in accordance with HSSD Section 5.2.1.2.3.

C.1.4.2 Depth Derivation

See above

C.1.4.3 Surface Computation Algorithm

See above

C.2 Imagery

C.2.1 Multibeam Backscatter Data

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

Backscatter data is not collected during acquisition with the PicoMB.

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

Backscatter data were not processed.

C.2.2 Side Scan Sonar

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

All side scan sonar data is logged using HYPACK, in the ".hsx" and ".RAW" formats. 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 range scale meets the HSSD specifications based on the depth of the water set forth in Section 6.1.2.3. This is accomplished by adjusting the range scale settings in HYPACK realtime. The hydrographer monitors the sonar's health and function via realtime data displays of the Side Scan Intensity Waterfall as well as the ASV'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. An example is using a navigation buoy and its associated buoy block on the seafloor to verify. 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.

Data Processing Methods and Procedures

SSS processing work flow begins with converting Tritech SSS .hsx file using CARIS SIPS via Charlene. 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 the gaps are acquired by either SSS or MBES.

The hydrographer reviews each SSS line for contacts by visually inspecting the imagery record for 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. An additional hydrographer reviews the data using the same processes, 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 hydrographers, all identified contacts are treated as features and fully investigated with MBES, as explained in section C.7.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

Data Acquisition Methods and Procedures

For WAAS surveys, the POS MV is optionally configured to receive correctors from the Wide Area Augmentation System (WAAS). The WAAS is a Satellite Based Augmentation System (SBAS) for North America, developed by the Federal Aviation Administration and the Department of Transportation as an aid to air navigation. Usable by any WAAS-enabled GPS receiver, WAAS corrects for GPS signal errors caused by ionospheric disturbances, timing and satellite orbit errors, and it provides vital integrity information regarding the health of each GPS satellite.

WAAS consists of multiple widely-spaced Wide Area Reference Stations (WRS) sites that monitor GPS satellite data. The WRS locations are precisely surveyed so that any errors in the received GPS signals can be detected. Two master stations, located on either coast, collect data from the reference stations via a terrestrial communications network and create a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through geostationary satellites with a fixed position over the equator. The information is compatible with the basic GPS signal structure, which means any WAAS-enabled GPS receiver can read the signal.

The WAAS specification requires it to provide a position accuracy of 7.6 meters (25 ft) or better (for both horizontal and vertical measurements), at least 95% of the time. Actual performance measurements of the system at specific locations have shown it typically provides better than 1.0 meter horizontally and 1.5 meters vertically throughout most of the contiguous United States and large parts of Canada and Alaska. In more remote regions of Alaska, values range between 2 and 6 meters horizontally.

Data Processing Methods and Procedures

Position accuracy and quality were monitored using the POSView Controller software to ensure positioning accuracy requirements in the HSSD Section 3.2 were met.

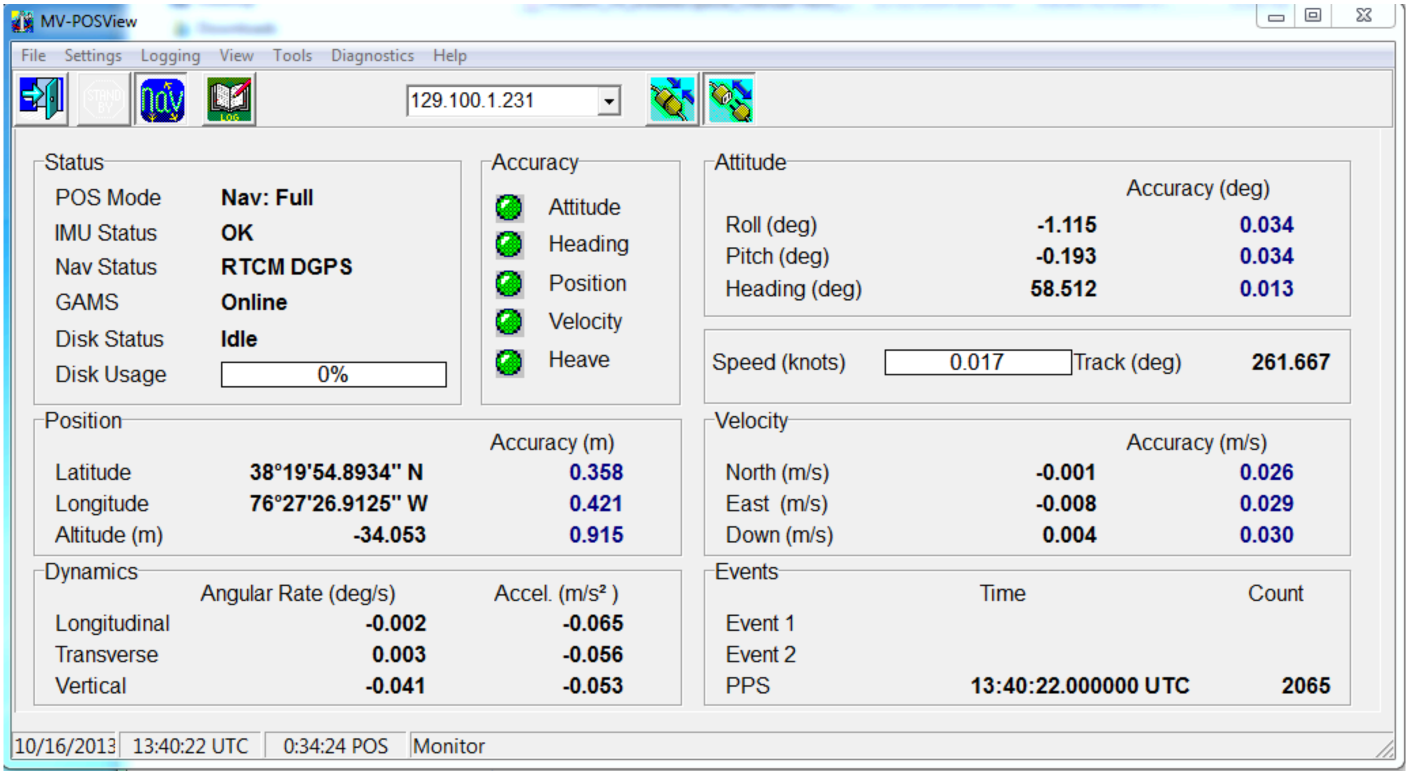

Figure 9: Real Time POS M/V monitoring interface.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

R/V BAY HYDRO II performs Ellipsoidally Referenced Surveys (ERS) or VDatum surveys.

Data Processing Methods and Procedures

The raw POSPac file is processed using reference stations (usually CORS Stations) and a Smooth Best Estimate of Trajectory (SBET) is produced via Charlene and POSPac MMS. This SBET is used in CARIS via "Input Auxiliary Data" to calculate the GPS tide, and then merged to generate a surface at the ellipsoid. The separation model provided by the Project Manager is applied to the data to reduce it to the local MLLW datum.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

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

Data Processing Methods and Procedures

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

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

The CastAway CTD is the primary instrument to acquire sound velocity profiles, unless otherwise stated in the Descriptive Report. CARIS HIPS then utilizes the concatenated sound velocity data as a corrector. Casts are acquired every 2-4 hours during MBES acquisition. Profiles are collected more frequently when current and weather conditions warrant.

Data Processing Methods and Procedures

All SVP casts are processed using HydrOffice's Sound Speed Manager. In CARIS, the "Nearest in Distance Within Time of Four Hours" option is used when correcting the data for sound speed unless otherwise noted in the DR.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed data is directly measured by the Valeport miniSVS for use by the MBES during acquisition.

Data Processing Methods and Procedures

The PicoMBES-120SF uses the surface sound speed for its beam forming equation and only depends on the CTD sound speed profile for post-processing. An accuracy check is performed by comparing the continuous reading from the surface sound speed profiler to a CTD reading at the same depth.The hydrographer monitors the surface sound speed readings and frequently preforms casts to ensure proper representation of the water column sound speed profile. All surface sound speed is internal to the PicoMBES and stored in the .HSX file.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation 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. Uncertainty standards are also confirmed using Pydro QC Tools.

In the CARIS TPU calculation, real time uncertainty values are used, where possible. Real time calculated uncertainties found in the .HSX file are used for position, sonar, heading, pitch, and roll. The vertical real time uncertainty is from the SBET's RMS file and the tidal uncertainty is derived from the ERS Separation Model.

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.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		ASV007
Motion Sensor	*Gyro*	0.08 degrees
	Heave	5.00% 0.05 meters
	Roll	0.04 degrees
	Pitch	0.04 degrees
Navigation Sensor		0.50 meters

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
ASV007	The .HSX file contains many realtime uncertainty calculations, however, when processing in Caris, the a priori uncertainty values are used.

C.7 Shoreline and Feature Data

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

All potentially significant features are divided into three categories. The first, features that are not safe for ASV007 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 ASV007 to investigate. For features in this category, a file is created in CARIS HIPS and SIPS 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 operator during data collection. The MBES development lines are created over the suspected feature in a way that is safest for the vessel, ensonify all sides of the feature, and ensonify the feature with both the port and starboard channels of the MBES. The features are created in CARIS HIPS and SIPS, 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.

Data Processing Methods and Procedures

See previous section.

C.8 Bottom Sample Data

Bottom sample data was not acquired.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

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 depth layer is reviewed for 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.

D.1.2 Designated Sounding Selection

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 in accordance with HSSD Section 5.2.1.2.3.

D.1.3 Holiday Identification

The depth layer of each resolution grid is reviewed visually for gross holidays (gaps in coverage) by the hydrographer and then run through QC Tools "Holiday Finder" for a more thorough identification of holidays. All holidays are identified and data is later acquired to resolve the gap in data coverage to the best of the hydrographer's ability. In the unusual event that holidays are identified after the survey team has departed the survey area and are unable to return, holidays are digitized in a .HOB file and submitted with the data to the Branch.

D.1.4 Uncertainty Assessment

The uncertainty layer is viewed to ensure that the data has not exceeded specifications as set by the HSSD Section 5.2.3. Pydro's QC Tools are used to further investigate and produce statistics and graphs to whether or not the data meets uncertainty requirements.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Crosslines are collected, processed, and compared in accordance with Section 5.2.4.3 of the HSSD. A CUBE surface is created at the appropriate resolution for the survey area using only mainscheme lines and a second surface is created using only crosslines. Using the two surfaces, a difference surface (mainscheme - crosslines = difference surface) is generated. Statistics are calculated to show the mean difference between the depths derived from the mainscheme and crosslines and reported in the DR. The difference surface is also compared to the IHO allowable total vertical uncertainty (TVU) standards and reported in the DR.

D.1.5.2 Junctions

Junction surveys are performed in accordance with HSSD Section 7.2.2. The process is the same as the crossline to mainscheme review (see paragraph above). 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 event has caused a change in the sea floor. Analyses are documented in the DR.

D.1.5.3 Platform to Platform

In the event R/V BAY HYDRO II is assigned a survey with another vessel, data is consistently reviewed for differences and troubleshooting is performed, as necessary.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

See Section C.2.

D.2.2 Contact Selection Methodology

See Section C.2.

E. Approval Sheet

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

The entire survey is adequate to supersede previous data.

Approver Name	Approver Title	Date	Signature
LTJG Sarah Chappel	Chief of Party	12/03/2019	DEBROISSE.PATRICK.JOSEPH.1501248670

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	ASVWiringDiagram.pdf
Sound Speed Sensor Calibration	2018_Valport_Calibration_Report.pdf 2018 Cast-Away Calibration Report.pdf
Vessel Offset	2018_ASV007_ERDDM_Report.pdf
Position and Attitude Sensor Calibration	POS_MV_Cal_Report_ASV007_2018.pdf
Echosounder Confidence Check	ASV007_2018_Patch_Cal.pdf ASV007_2018_SSS_Cal.pdf 2018_Lead Line Calibration_Report.pdf
Echosounder Acceptance Trial Results	N/A