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Data Acquisition and Processing Report

NOAA Ship *Fairweather*
Chief of Party: CDR Mark Van Waes, NOAA
Year: 2017
Version: 3
Publish Date: 2018-01-30

A Equipment

A.1 Survey Vessels

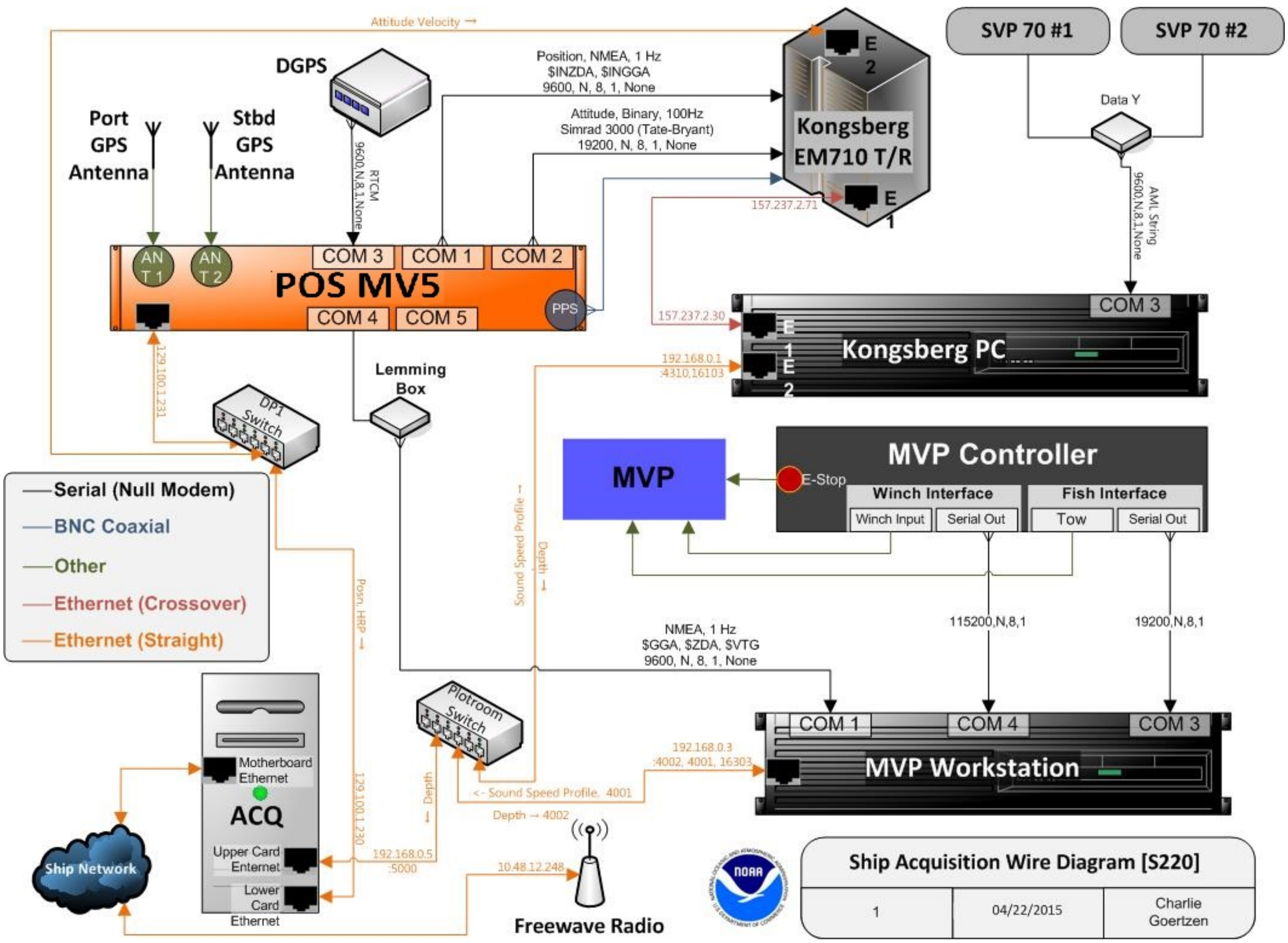
A.1.1 Fairweather

<table>
<tr><td>Name</td><td colspan="2">Fairweather</td></tr>
<tr><td>Hull Number</td><td colspan="2">S220</td></tr>
<tr><td>Description</td><td colspan="2">The Fairweather is an ice strengthened, welded steel hulled oceanographic research vessel operated by the National Oceanic and Atmospheric Administration (NOAA)</td></tr>
<tr><td>Utilization</td><td colspan="2">Acquisition of mid-water multibeam and side scan sonar data</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>70.4 meters</td></tr>
<tr><td>Beam</td><td>12.8 meters</td></tr>
<tr><td>Max Draft</td><td>4.8 meters</td></tr>
</table>

<table>
<tr><td rowspan="3">Most Recent Full Static Survey</td><td>Date</td><td>2014-11-24</td></tr>
<tr><td>Performed By</td><td>The IMTEC Group, Ltd.</td></tr>
<tr><td>Discussion</td><td>During the Fairweather 2014-2015 dry-dock period in conjunction with the installation of the new Kongsberg EM 710 multibeam system, The IMTEC Group, Ltd. was contracted to conduct a sensor alignment and orthogonal coordinate survey. The survey was conducted relative to a temporary three dimensional network of control points fixed to the ship and dry-dock and did not reference the gravity level. The three dimensional offsets were translated and rotated into three distinct (but fully equivalent) reference frames by the surveyor. These coordinate systems are: 1. A reference frame centered on the granite block, aligned with the keel in azimuth and pitch and aligned with the 12 foot draft marks for roll. 2. A reference frame centered on the granite block and aligned with the granite block in heading, pitch, and roll. 3. A reference frame centered on the EM710 transmit array and aligned with the transmit array in heading, pitch, and roll.</td></tr>
<tr><td>Most Recent Partial Static Survey</td><td colspan="2">Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td colspan="2">Full offset verification was not performed.</td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td colspan="2">Partial offset verification was not performed.</td></tr>
</table>

Most Recent Static Draft Determination	*Date*	2017-05-17
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	The static draft (Waterline Height in the HVF) for S220 was calculated based on laser range finder measurements of the distance from the benchmarks on the port and starboard gunwales of the vessel to the waterline. Initial measurements were conducted during May of 2017 in Puget Sound, WA. Static drafts were taken periodically throughout the season and entered in the ship's HVF.
Most Recent Dynamic Draft Determination	*Date*	2017-05-02
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement.
	Discussion	See section C.2.2.2

Figure 1: NOAA Ship Fairweather



A.1.2 Launch 2805

Name	Launch 2805
Hull Number	2805
Description	Hydrographic Survey Launch 2805 is a 8.53 meter aluminum launch vessel of the NOAA Ship Fairweather. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).
Utilization	Hydrographic Survey Launch for NOAA Ship Fairweather
Dimensions	*LOA*: 8.64 meters *Beam*: 3.48 meters *Max Draft*: 1.12 meters

Most Recent Full Static Survey	*Date*	2010-01-26
	Performed By	National Geodetic Survey, Geodetic Services Division
	Discussion	In January of 2010 a full static survey was performed by NGS/ GSD. The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks, and the components of a POS MV navigation system aboard the NOAA survey vessel 2805.
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	*Date*	2017-04-03
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	As part of the 2017 HSRR, the offsets of Fairweather's four survey launches were surveyed to verify the validity of the 2010 full survey results. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence in the 2010 full survey results. The values for the different measurements are listed in the respective offset verification spreadsheets included in this report.

Most Recent Static Draft Determination	*Date*	2017-04-03
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	The static draft (Waterline Height in the HVF) for launch 2805 was calculated based on steel tape and plumb bob measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline. Measurements were conducted during April of 2017 in Yaquina Bay, Newport, OR. The values and calculations for static draft of the various launches are listed in the respective Waterline Measurement spreadsheets included in this report.
Most Recent Dynamic Draft Determination	*Date*	2016-03-10
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement.
	Discussion	See section C.2.2.2

Figure 2: Launch 2805 Taken During Survey of 2010

A.1.3 Launch 2806

Name	Launch 2806
Hull Number	2806
Description	Hydrographic Survey Launch 2806 is a 8.53 meter aluminum launch vessel of the NOAA Ship Fairweather. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).
Utilization	Hydrographic Survey Launch for NOAA Ship Fairweather

Dimensions	*LOA*	8.64 meters
	Beam	3.48 meters
	Max Draft	1.12 meters
Most Recent Full Static Survey	*Date*	2010-01-25
	Performed By	National Geodetic Survey, Geodetic Services Division.
	Discussion	In January of 2010 a full static survey was performed by NGS/ GSD. The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2806.
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	*Date*	2017-04-06
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	As part of the 2017 HSRR, the offsets of Fairweather's four survey launches were surveyed to verify the validity of the 2010 full survey results. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence in the 2010 full survey results. The values for the different measurements are listed in the respective offset verification spreadsheets included in this report.

Most Recent Static Draft Determination	*Date*	2017-04-06
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	The static draft (Waterline Height in the HVF) for launch 2806 was calculated based on steel tape and plumb bob measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline. Measurements were conducted during April of 2017 in Yaquina Bay, Newport, OR. The values and calculations for static draft of the various launches are listed in the respective Waterline Measurement spreadsheets included in this report.
Most Recent Dynamic Draft Determination	*Date*	2016-04-13
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement
	Discussion	See section C.2.2.2

Figure 3: Launch 2806 Taken During Survey of 2010

A.1.4 Launch 2807

Name	Launch 2807
Hull Number	2807
Description	Hydrographic Survey Launch 2807 is a 8.53 meter aluminum launch vessel of the NOAA Ship Fairweather. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).
Utilization	Hydrographic Survey Launch for NOAA Ship Fairweather

Dimensions	*LOA*	8.64 meters
	Beam	3.48 meters
	Max Draft	1.12 meters
Most Recent Full Static Survey	*Date*	2010-01-26
	Performed By	National Geodetic Survey, Geodetic Services Division.
	Discussion	In January of 2010 a full static survey was performed by NGS/ GSD. The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2807.
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	*Date*	2017-04-03
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	As part of the 2017 HSRR, the offsets of Fairweather's four survey launches were surveyed to verify the validity of the 2010 full survey results. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence in the 2010 full survey results. The values for the different measurements are listed in the respective offset verification spreadsheets included in this report.

Most Recent Static Draft Determination	*Date*	2017-04-03
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	The static draft (Waterline Height in the HVF) for launch 2807 was calculated based on steel tape and plumb bob measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline. Measurements were conducted during April of 2017 in Yaquina Bay, Newport, OR. The values and calculations for static draft of the various launches are listed in the respective Waterline Measurement spreadsheets included in this report.
Most Recent Dynamic Draft Determination	*Date*	2016-04-08
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement
	Discussion	See section C.2.2.2

Figure 4: Launch 2807 Taken During Survey of 2010

A.1.5 Launch 2808

Name	Launch 2808
Hull Number	2808
Description	Hydrographic Survey Launch 2808 is a 8.53 meter aluminum launch vessel of the NOAA Ship Fairweather. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).
Utilization	Hydrographic Survey Launch for NOAA Ship Fairweather

<table>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>8.64 meters</td></tr>
<tr><td>Beam</td><td>3.48 meters</td></tr>
<tr><td>Max Draft</td><td>1.12 meters</td></tr>
<tr><td rowspan="3">Most Recent Full Static Survey</td><td>Date</td><td>2010-01-26</td></tr>
<tr><td>Performed By</td><td>NGS/GSD</td></tr>
<tr><td>Discussion</td><td>In January of 2010 a full static survey was performed by NGS/GSV. The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2808.</td></tr>
<tr><td>Most Recent Partial Static Survey</td><td colspan="2">Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td colspan="2">Full offset verification was not performed.</td></tr>
<tr><td rowspan="3">Most Recent Partial Offset Verification</td><td>Date</td><td>2017-04-03</td></tr>
<tr><td>Method Used</td><td>Direct measurement from benchmarks by the field unit</td></tr>
<tr><td>Discussion</td><td>As part of the 2017 HSRR, the offsets of Fairweather's four survey launches were surveyed to verify the validity of the 2010 full survey results. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence in the 2010 full survey results. The values for the different measurements are listed in the respective offset verification spreadsheets included in this report.</td></tr>
</table>

Most Recent Static Draft Determination	*Date*	2017-04-03
	Method Used	Direct measurement from benchmarks by the field unit
	Discussion	The static draft (Waterline Height in the HVF) for launch 2808 was calculated based on steel tape and plumb bob measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline. Measurements were conducted during April of 2017 in Yaquina Bay, Newport, OR. The values and calculations for static draft of the various launches are listed in the respective Waterline Measurement spreadsheets included in this report.
Most Recent Dynamic Draft Determination	*Date*	2016-04-13
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement
	Discussion	See section C.2.2.2

Figure 5: Launch 2808 Taken During Survey of 2010

A.1.6 AMBAR 2302

Name	AMBAR 2302
Hull Number	2302
Description	AMBAR 2302 is a 7 meter aluminum work boat of the NOAA Ship Fairweather. It has jet drive propulsion and a small cabin for the operator. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).
Utilization	This vessel performs shoreline investigation and nearshore reconnaissance. It is also used for shallow water data collection with a single beam sonar.

<table>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>7.0 meters</td></tr>
<tr><td>Beam</td><td>2.8 meters</td></tr>
<tr><td>Max Draft</td><td>0.55 meters</td></tr>
<tr><td>Most Recent Full Static Survey</td><td colspan="2">Full static survey was not performed.</td></tr>
<tr><td>Most Recent Partial Static Survey</td><td colspan="2">Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td colspan="2">Full offset verification was not performed.</td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td colspan="2">Partial offset verification was not performed.</td></tr>
<tr><td rowspan="3">Most Recent Static Draft Determination</td><td>Date</td><td>2017-08-24</td></tr>
<tr><td>Method Used</td><td>Direct measurement</td></tr>
<tr><td>Discussion</td><td>A steel tape was used to measure from the sonar head to the waterline when the sonar was deployed.</td></tr>
<tr><td>Most Recent Dynamic Draft Determination</td><td colspan="2">Dynamic draft determination was not performed.</td></tr>
</table>

Figure 6: AMBAR 2302

A.1.7 Skiff 1810

Name	Skiff 1810
Hull Number	1810
Description	Skiff 1810 is a 5.5 meter aluminum work boat of the NOAA Ship Fairweather. It has inboard/outboard propulsion and an open deck. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).
Utilization	This vessel conducts shoreline investigation activities.

Dimensions	*LOA*	5.5 meters
	Beam	2.6 meters
	Max Draft	0.36 meters
Most Recent Full Static Survey	Full static survey was not performed.	
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	Static draft determination was not performed.	
Most Recent Dynamic Draft Determination	Dynamic draft determination was not performed.	

Figure 7: Skiff 1810

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Klein Associates Inc Klein System 5000

Manufacturer	Klein Associates Inc
Model	Klein System 5000
Description	The Klein High Speed, High Resolution Side Scan (SSS) Sonar system is a beam-forming acoustic imagery device. The integrated system includes a KLEIN 5500 towfish, a Transceiver/Processing Unit (TPU), and interfaces to a computer for control and monitoring. Stern-towed units also include a tow cable telemetry assembly. The towfish operates at frequency of 455 kHz and a vertical beam angle of 40°, and can resolve up to 5 discreet received beams per transducer stave. There are two configurations for data acquisition using the KLEIN 5000 system: stern-towed and hull-mounted. S-220 uses exclusively stern towed SSS. Fairweather Launch 2807 and 2808 use a hull-mount configuration. There are also two options for the type of the towfish: the standard, and a lightweight variant. For the acquisition of data for project OPR-R365-FA-17, Launch 2807 was hull mounted with the lightweight variant, and Launch 2808 was hull-mounted with the standard variant towfish. The hull mounts on both survey launches can accommodate both standard or a light-weight towfish. Positioning of the Towfish is calculated using CARIS SIPS, and is derived from the amount of cable out, the towfish depth (from the towfish pressure gage), the vessel's Course Made Good (CMG), and the vessel's heading. For hull mounted systems, the position is derived using a static offset from the vessel reference point. Towfish altitude is maintained between 8% and 20% of the range scale unless specifically noted in the Descriptive Report. Vessel speed is adjusted during SSS acquisition to ensure that object detection density is met. Confidence checks are performed by noting changes in linear bottom features extending to the outer edges of the digital side scan image, and by verifying aids to navigation or other known features on the side scan record. The resolution of the system is: Along Track: 10cm out to 38 meters; 20cm out to 75 meters; 36 cm out to 150 meters; Across Track: 3.75 cm.

Serial Numbers

Vessel Installed On	S220	2807	2808
TPU s/n	166	176	177
Towfish s/n	292	321	260

Specifications	*Frequency*	455 hertz	
	Along Track Resolution	*Resolution*	10 centimeters
		Min Range	0 centimeters
		Max Range	28 meters
	Across Track Resolution	3.75 centimeters	
	Max Range Scale	150 meters	
Manufacturer Calibrations	Manufacturer calibration was not performed.		

Figure 8: Towed Heavy Weight Klein 5000 Side Scan Sonar

Figure 9: Hull- Mounted Heavy Weight Klein 5000 Side Scan Sonar and Kongsberg EM2040

Figure 10: Hull-Mounted Light Weight Klein 5000 Side Scan Sonar

A.2.2 Multibeam Echosounders

A.2.2.1 Kongsberg EM 2040

Manufacturer	Kongsberg
Model	EM 2040
Description	Survey launches 2805, 2806, 2807, and 2808 are each equipped with a Kongsberg EM2040 MBES. The EM2040 has a low frequency (200kHz), intermediate frequency (300 kHz), and high frequency (400kHz) transmit array with swath coverage of 140°. The typical operational depth range for the EM 2040 is 0.5 to 600 meters. Each system is hull mounted along the centerline and includes a topside processing unit and a topside control and monitoring unit.

Serial Numbers

Vessel Installed On	2805	2806	2807	2808
Processor s/n	1065	CZC3410KPV	CZC4310KMV	CZC4310KNO
Transceiver s/n	40122	40111	40109	40117
Transducer s/n	N/A	N/A	N/A	N/A
Receiver s/n	364	356	355	351
Projector 1 s/n	255	251	249	247
Projector 2 s/n	N/A	N/A	N/A	N/A

Specifications

Frequency		200 kilohertz		300 kilohertz		400 hertz	
Beamwidth		*Along Track*	1.5 degrees	*Along Track*	1 degrees	*Along Track*	0.7 degrees
		Across Track	1.51 degrees	*Across Track*	1 degrees	*Across Track*	0.7 degrees
Max Ping Rate		50 kilohertz		58.8 kilohertz		58.8 kilohertz	
Beam Spacing		*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equiangular
		Number of Beams	256	*Number of Beams*	256	*Number of Beams*	256
Max Swath Width		140 degrees		140 degrees		120 degrees	
Depth Resolution		20 millimeters		20 millimeters		20 millimeters	
Depth Rating		*Manufacturer Specified*	600 meters	*Manufacturer Specified*	465 meters	*Manufacturer Specified*	300 meters
		Ship Usage	600 meters	*Ship Usage*	465 meters	*Ship Usage*	300 meters

Manufacturer Calibrations	Manufacturer calibration was not performed.

System Accuracy Tests

Vessel Installed On	2805 / 2806 / 2807 / 2808
Methods	The reference surface used in Shilshole Bay, Seattle is a grid of 7 lines over known wreck. Each line is approximately 60 meters apart, providing generous overlap of soundings between lines. Reference surfaces were run for each launch's EM 2040 system in high (400 kHz), intermediate (300 kHz), and low (200 kHz) frequency, with equidistant beam spacing. Reference surfaces of 1 meter CUBE surfaces were created for each system and frequency. All surfaces were referenced to MLLW. NOAA Ship Fairweather was visited on May 22-26 2017 to perform system accuracy tests and review configuration of her onboard Kongsberg EM 2040 systems. The following systems were reviewed to assess the health of all Fairweather Launches: The review included: • Assessment of receiver health at all frequencies: o Accomplished by a review of water column data at each frequency with active transmit, ambient environment • Assessment of receiver stability by review of normalization history • Data analysis and performance of both bathymetry and backscatter • Review of sonar system settings • Review of sonar configuration with POSMV and Acquisition system
Results	See attached reports for details.

Snippets	Sonar has snippets logging capability.

Figure 11: Kongsberg EM 2040 topside processing unit

Figure 12: Kongsberg EM 2040 projector and receiver arrays

A.2.2.2 Kongsberg EM 710

Manufacturer	Kongsberg
Model	EM 710
Description	S220 is equipped with a hull-mounted Kongsberg EM 710, which operates at sonar frequencies in the 70 to 100 kHz range. The across-track swath width is up to 5.5 times water depth with a published maximum depth of more than 2000 meters. The alongtrack beamwidth configuration is ½° with a receive beamwidth of 1°. The number of beams is 256, with dynamic focusing employed in the near field. A high density beam processing mode provides up to 400 soundings per swath by using a limited range window for the detections. The beam spacing may be set to be either equiangular or equidistant. Fairweather typically collects 400 beams per

	ping in equidistant mode. The transmit fan is divided into three sectors to maximize range capability but also to suppress interference from multiples of strong bottom echoes. The sectors are transmitted sequentially within each ping, and use distinct frequencies or waveforms.		
Serial Numbers	*Vessel Installed On*		S220
	Processor s/n		CZC34076Z9
	Transceiver s/n		232
	Transducer s/n		232
	Receiver s/n		232
	Projector 1 s/n		None
	Projector 2 s/n		None
Specifications	*Frequency*		100 kilohertz
	Beamwidth	*Along Track*	0.5 degrees
		Across Track	1 degrees
	Max Ping Rate		30 hertz
	Beam Spacing	*Beam Spacing Mode*	Equidistant
		Number of Beams	256
	Max Swath Width		140 degrees
	Depth Resolution		1 centimeters
	Depth Rating	*Manufacturer Specified*	2000 meters
		Ship Usage	2000 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.		
System Accuracy Tests	*Vessel Installed On*		S220
	Methods		Sonar Acceptance Trial
	Results		Relative to the internal noise of the system, the installation has low flow noise and imperceptible direct path propulsion noise. The radiated, bottom bounce propulsion noise is noticeable in shallow water, but is not speed dependent and can be minimized with shaft speed and pitch combinations. The swath width as a function of depth meets or exceeds specifications. The system bathymetry meets or exceeds specifications in all modes tested.
Snippets	Sonar has snippets logging capability.		

Figure 13: EM 710 Gondola during transducer installation.

A.2.3 Single Beam Echosounders

A.2.3.1 CEE HydroSystems CEEPulse

Manufacturer	CEE HydroSystems
Model	CEEPulse
Description	The CEEPulse is a self contained single beam system designed for mobile applications that includes a transducer and processing unit and can interface with a computer using an RS232 or Bluetooth connection. The system operates at a 200 kHz frequency, with a ping rate of up to 10 Hz, and has an operational depth range of 0.25-100 meters. The CEEPulse was pole mounted and used to survey waters too shallow for the launches with a 1.1 meter draft.
Serial Numbers	*Vessel*: 2302 *Processor s/n*: 1428202 *Transducer s/n*: 1428202

<table>
<tr><td rowspan="7">Specifications</td><td>Frequency</td><td colspan="2">200 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>9 degrees</td></tr>
<tr><td>Across Track</td><td>9 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">10 hertz</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">1 centimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>100 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="3">Manufacturer calibration was not performed.</td></tr>
<tr><td rowspan="3">System Accuracy Tests</td><td>Vessel Installed On</td><td colspan="2">2302</td></tr>
<tr><td>Methods</td><td colspan="2">A comparison between data from the CEEPulse and calibrated MBES systems from 2807 and 2808 was performed after processing in CARIS. Using a difference surface between the MBES data and the SBES data gridded at 4 m, statistics were generated and verified with fall within allowable total vertical uncertainty in the relevant depths.</td></tr>
<tr><td>Results</td><td colspan="2">The mean difference between the MBES and SBES surfaces was 0.09 m with 95% of the differences falling within 0.33 m. This falls within the allowable vertical uncertainty of greater than 0.5 m as defined in HSSD 5.1.3. Due to the consistency of the mean difference between two survey areas and multiple days, the static draft was shifted by this amount as an estimate for the dynamic draft as described in Section C.2.1.</td></tr>
</table>

Figure 14: CEEPulse on a pole mount attached to FA 2303

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

<table>
<tr><td>Manufacturer</td><td>FA Personnel</td></tr>
<tr><td>Model</td><td>Traditional</td></tr>
<tr><td>Description</td><td>Despite the tremendous advances in hydrographic sonar technology, the hydrographer may occasionally require a direct measurement of water depth. To this end, a calibrated lead line is still essential for field parties. The Field Procedures Manual (FPM) states: “All field units engaged in hydrographic surveys where general depths are less than 40 meters shall have one or more lead lines marked and calibrated.” The Fairweather maintains seven lead lines on board.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>10_01_05</td></tr>
<tr><td>10_02_04</td></tr>
<tr><td>20_02_05</td></tr>
<tr><td>20_03_05</td></tr>
<tr><td>30_01_05</td></tr>
<tr><td>10_05_09</td></tr>
<tr><td>10_06_09</td></tr>
</table></td></tr>
<tr><td>Calibrations</td><td><table>
<tr><td>Serial Number</td><td>10_01_05</td><td>20_02_05</td><td>20_03_05</td><td>30_01_05</td><td>10_05_09</td><td>10_06_09</td></tr>
<tr><td>Date</td><td>2017-02-06</td><td>2017-02-06</td><td>2017-02-06</td><td>2017-02-06</td><td>2017-02-06</td><td>2017-02-06</td></tr>
<tr><td>Procedures</td><td>Steel Tape</td><td>Steel Tape</td><td>Steel Tape</td><td>Steel Tape</td><td>Steel Tape</td><td>Steel Tape</td></tr>
</table></td></tr>
<tr><td>Accuracy Checks</td><td>No accuracy checks were performed.</td></tr>
<tr><td>Correctors</td><td>Correctors were not determined.</td></tr>
<tr><td>Non-Standard Procedures</td><td>Non-standard procedures were not utilized.</td></tr>
</table>

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</td></tr>
<tr><td>Model</td><td>POS MV V5</td></tr>
<tr><td>Description</td><td>The POS MV V5 calculates position, heading, attitude, and vertical displacement (heave) of a vessel. It consists of a rack mounted POS Computer System (PCS), a bolt down IMU-200 Inertial Measurement Unit (IMU), and two GNSS antennas corresponding to GNSS receivers in the PCS.</td></tr>
<tr><td>PCS</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS MV5</td></tr>
<tr><td>Description</td><td>Position and Attitude POS Computer System. A rack-mounted computer system contains the core POS processor and IMU interface electronics, plus two GPS receivers. The PCS couples system timing, position, and velocity aiding with GPS raw observables for use with GAMS.</td></tr>
<tr><td>Firmware Version</td><td>9.13</td></tr>
<tr><td>Software Version</td><td>POS View 9.12</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>2805</td><td>2806</td><td>2807</td><td>2808</td><td>S220</td></tr>
<tr><td>PCS s/n</td><td>8198</td><td>8197</td><td>8195</td><td>8196</td><td>8194</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td rowspan="5">IMU</td><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>LN 200</td></tr>
<tr><td>Description</td><td>The LN 200 inertial measurement unit allows for the continuous output of position and orientation data.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>2805</td><td>2806</td><td>2807</td><td>2808</td><td>S220</td></tr><tr><td>IMU s/n</td><td>294</td><td>991</td><td>995</td><td>324</td><td>292</td></tr></table></td></tr>
<tr><td>Certification</td><td>IMU certification report was not produced.</td></tr>
<tr><td></td><td colspan="2">

Figure 15: IMU LN 200 Unit</td></tr>
<tr><td rowspan="2">Antennas</td><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>GA830</td></tr>
</table>

Description	The Trimble GA830 is a dual frequency GNSS antenna.

Serial Numbers

Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
2805	9962	Port	Primary
2805	9961	Starboard	Secondary
2806	9964	Port	Primary
2806	9963	Starboard	Secondary
2807	9966	Port	Primary
2807	9965	Starboard	Secondary
2808	9968	Port	Primary
2808	9967	Starboard	Secondary

Figure 16: GA830 POS Antennas on Launch Vessels

Figure 17: GA830 POS Antennas

Manufacturer	Trimble
Model	Zephyr Geodetic
Description	The Zephyr Geodetic is a dual frequency GNSS antenna for use with survey grade receivers

Serial Numbers

Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
S220	0224078543	Port	Primary
S220	0224090101	Starboard	Secondary

GAMS Calibration	*Vessel*	2805	2806	2807	2808	S220
	Calibration Date	2017-05-09	2017-05-09	2017-05-09	2017-05-09	2017-05-20
Configuration Reports	*Vessel*	2805	2806	2807	2808	S220
	Report Date	2017-05-09	2017-05-09	2017-05-09	2017-05-09	2017-05-20

Figure 18: POS MV5 components (note actual IMU and antennas are shown in separate images)

A.4.2 DGPS

Description	Fairweather and launches are equipped with beacon receivers. These receivers are tuned to the closest available US Coast Guard maintained beacon transmitter with a reliable signal. The USCG beacon selected may change throughout the survey day depending on the received signal strength and position of the survey platform. GPS correctors are fed to the Applanix POS/MVs to produce real time differentially corrected positions.

Antennas

Manufacturer	Hemisphere
Model	MA40
Description	DGPS Equipment
Serial Numbers	

Vessel Installed On	2805	2806	2807	2808
Antenna s/n	0924-9488-0040	0919-9231-0193	0919-9231-0191	0924-9488-0040

Manufacturer	CSI Wireless
Model	MGL3
Description	DGPS Equipment
Serial Numbers	

Vessel Installed On	S220
Antenna s/n	0328-12352-0002

Receivers

Manufacturer	Hemisphere
Model	MBX-4
Description	DGPS Equipment. Dual-channel Coast Guard beacon receiver
Firmware Version	n/a
Serial Numbers	

Vessel Installed On	2805	2806	2807	2808
Antenna s/n	0927-9567-0001	0923-9416-0005	0923-9416-0007	0924-9498-0007

Manufacturer	CSI Wireless
Model	MBX-3S
Description	DGPS Equipment. Dual-channel Coast Guard beacon receiver
Firmware Version	n/a
Serial Numbers	

Vessel Installed On	S220
Antenna s/n	0324-11969-0002

A.4.3 Trimble Backpacks

Manufacturer	Trimble
Model	Pathfinder Pro XRS
Description	Fairweather personnel use the Trimble "backpack" GPS system to obtain positions of selected shoreline features. They are also useful in positioning linear features on the

	shore such as finger piers or roads where the user can simply go ashore and walk the boundary of the object in question while wearing the backpack. The system consists of a Pathfinder Pro XRS, a 12-channel GPS receiver that provides real-time 1-2 meter accuracy with built-in Coast Guard differential beacon reception capability. This GPS receiver is connected to a Toughbook all-weather laptop computer running Caris Notebook. Due to both the portable and weather resistant attributes of this setup, it can be used in an open skiff to augment traditional shoreline verification in a survey launch.
Serial Numbers	N/A
Antennas	*Manufacturer*: Trimble *Model*: GPS Pathfinder Pro XRS Antenna (part number 33580-50) *Description*: Integrated L1 GPS/Beacon/Satellite differential antenna *Serial Numbers*: 0220321062; 0220321059
Receivers	*Manufacturer*: Trimble *Model*: Pathfinder Pro XRS *Description*: GPS receiver with built-in USCG beacon capabilities. *Firmware Version*: unknown *Serial Numbers*: 0224090101; 0224078543

Field Computers

Manufacturer	Panasonic
Model	Toughbook 31
Description	The Panasonic Toughbook CF-30 comes standard with a 1.66 GHz Intel Core Duo processor in a sealed all-weather design magnesium alloy case. The screen consists of a 13.3” sunlight-viewable display. Other design elements include a shock-mounted 160GB hard drive, a moisture and dust-resistant LCD, keyboard and touchpad. This laptop also has no cooling fan and instead dissipates heat "evenly" through the chassis. Having no fan ensures a better seal against dust and moisture. All external connection ports are also protected with waterproof flaps and covers.
Operating System	Windows 7
Serial Numbers	3ITSB60210 3ITSB60208

Figure 19: Panasonic Toughbook

Manufacturer	Panasonic
Model	Toughbook 54
Description	The Panasonic Toughbook CF-54 comes standard with a 2.3 GHz Intel Core ™ I5-5300U processor in a sealed all-weather design magnesium alloy case. The screen consists of 14" HD; Intel® graphics. It features a spill-resistant, 906 GB hard drive with heater, backlit keyboard.
Operating System	Windows 7

DQA Tests	*Date*	2017-03-28
	Serial Number	0224090101 & 0224090101
	Methods	On March 28th, 2017 horizontal control hardware was tested on benchmark BBCN88 at NOAA Facility MOC-P. For the Trimble Backpacks, data were collected over the benchmark for 1 minute using differential corrections from USCG DGPS station Fort Stevens (287.0 kHz).
	Results	The largest error seen with differential corrected Trimble Backpack data was 1.0 meter.

Figure 21: Trimble Backpack

A.4.4 Laser Rangefinders

Manufacturer	Laser Tech
Model	Impulse LR
Description	The Impulse laser range finder is used in conjunction with the Trimble Backpack GPS unit to acquire distances and heights during shoreline verification. These data

	are entered directly into the shoreline acquisition software and annotated on the detached position forms.		
Serial Numbers	i09290		
DQA Tests	*Date*	2017-04-26	
	Serial Number	i09290	
	Methods	Data quality assurance testing was conducted by Fairweather personnel during the HSRR period. Vertical and horizontal readings were taken with the laser range finders and compared to measurements taken with a steel tape. The laser range finder was set up on a tripod, and a staff of known height was measured at distances of 10, 20, 50, and 100 meters.	
	Results	Three horizontal and three vertical readings were taken at each interval. All measurements were within 0.15 meters.	

Figure 22: Impulse LR

Manufacturer	Laser Tech
Model	TruPulse 200
Description	The TruPulse 200 laser range finders are used in conjunction with the Trimble Backpack GPS units to acquire distances and heights during shoreline verification. These data are entered directly into the shoreline acquisition software and annotated on the detached position forms. The TruPulse 200 laser rangefingers are also used to measure the static draft of S220.
Serial Numbers	041169
	041156
	001481

DQA Tests	*Date*	2017-04-26
	Serial Number	041169/ 041156/ 001481
	Methods	Data quality assurance testing was conducted by Fairweather personnel during the HSRR period. Vertical and horizontal readings were taken with the laser range finders and compared to measurements taken with a steel tape. The laser range finder was set up on a tripod, and a staff of known height was measured at distances of 10, 20, 50, and 100 meters.
	Results	Three horizontal and three vertical readings were taken at each interval. All measurements were within 0.08 meters.

Figure 23: TruPulse 200 Laser Range finder

A.4.5 Other Positioning and Attitude Equipment

<table>
<tr><td>Manufacturer</td><td>Velodyne LiDAR</td></tr>
<tr><td>Model</td><td>VLP-16</td></tr>
<tr><td>Description</td><td>The Velodyne VLP-16 laser scanner provides a 360° 3D image utilizing 16 laser detector pairs spinning at 5 to 20 rotations per second. It can acquire data at ranges up to 100m with a maximum point density of 300,000 points per second. VLP-16 system were mounted to a fixed arm extending from the cabin atop FA 2806 and FA 2808. The sensor mount included a GPS antenna for timing.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel</td><td>2806</td><td>2808</td></tr>
<tr><td>Serial Number</td><td>AF29414259</td><td>AF29614375</td></tr>
</table>
</td></tr>
<tr><td>DQA Tests</td><td>
<table>
<tr><td>Date</td><td>2017-06-08</td></tr>
<tr><td>Serial Number</td><td>AF29414259</td></tr>
<tr><td>Methods</td><td>The Hydrographic Systems and Technology Branch (HSTB), with field support and participation of Fairweather personnel and laboratory analysis by UNH-CCOM, have completed an evaluation of the Velodyne VLP-16 laser scanner for shoreline acquisition. In addition, standard operating and processing procedures have developed and validated. The Velodyne VLP-16 Acceptance Report it is included in the support folder of this submission. The current schema (2017_01) does not support laser scanner metadata inputs; the XmlDR team has been notified of the changes needed to allow the documentation of the laser scanner in the DAPR. A patch test was performed with the Velodyne VLP-16 in Port Madison, WA on 06/08/2017. A fixed piling was surveyed with the laser from all four directions, creating a box around the object. The patch test analysis was performed in Hypack 2017 MBMAX. Values yielded from the patch test analysis are entered into Hypack Hysweep configuration for acquisition.</td></tr>
<tr><td>Results</td><td>Please see Velodyne VLP-16 Acceptance report in the support folder of this submission.</td></tr>
<tr><td>Date</td><td>2017-06-08</td></tr>
<tr><td>Serial Number</td><td>AF29614375</td></tr>
<tr><td>Methods</td><td>The Hydrographic Systems and Technology Branch (HSTB), with field support and participation of Fairweather personnel and laboratory analysis by UNH-CCOM, have completed an evaluation of the Velodyne VLP-16 laser scanner for shoreline acquisition. In addition, standard operating and processing procedures have developed and validated. The Velodyne VLP-16 Acceptance Report it is included in the support folder of this submission. The current schema (2017_01) does not support laser scanner metadata inputs; the XmlDR team has been notified of the changes needed to allow the documentation of the laser scanner in the DAPR. A patch test was performed with the Velodyne VLP-16 in Port Madison, WA on 06/08/2017. A fixed piling was surveyed with the laser from all four directions, creating a box around the object. The patch test analysis was performed in Hypack 2017 MBMAX. Values yielded from the patch test analysis are entered into Hypack Hysweep configuration for acquisition.</td></tr>
<tr><td>Results</td><td>Please see Velodyne VLP-16 Acceptance report in the support folder of this submission.</td></tr>
</table>
</td></tr>
</table>

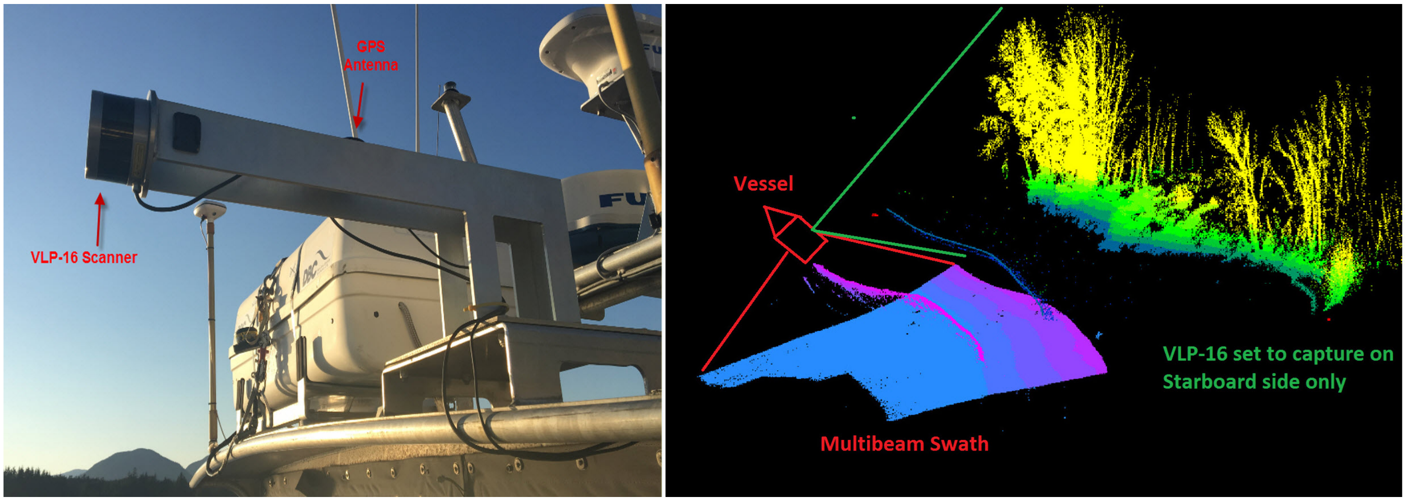
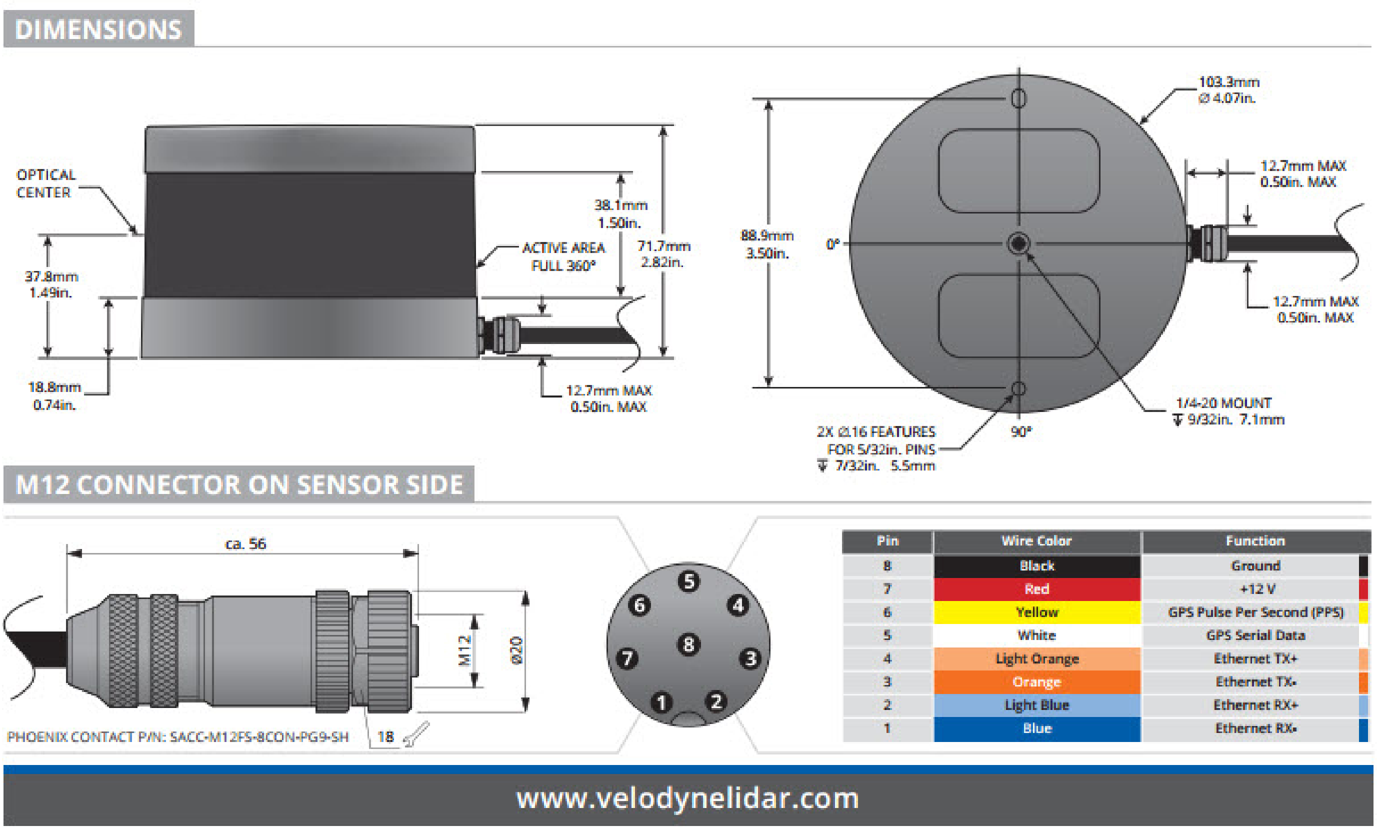


Figure 24: Velodyne VLP-16 Mount and Configuration



Pin	Wire Color	Function
8	Black	Ground
7	Red	+12 V
6	Yellow	GPS Pulse Per Second (PPS)
5	White	GPS Serial Data
4	Light Orange	Ethernet TX+
3	Orange	Ethernet TX-
2	Light Blue	Ethernet RX+
1	Blue	Ethernet RX-

Figure 25: Velodyne VLP-16 Dimensions

Manufacturer	Garmin
Model	GLO
Description	The Garmin GLO is a compact GNSS receiver that transmits data over a Bluetooth connection to a computer or handheld device. Its small size and internal battery allow for versatile applications. While this receiver is not currently listed in HTD 2017-03 (Configuration Management), it met the 5 m horizontal positional accuracy standard in static testing.
Serial Numbers	*Vessel*: N/A *Serial Number*: 2NV066394
DQA Tests	DQA test was not performed.

Figure 26: Garmin GLO GNSS Receiver

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profiles

A.5.1.1 CTD Profilers

A.5.1.1.1 Sea-Bird Scientific SBE 19plus SEACAT Profiler

<table>
<tr><td>Manufacturer</td><td>Sea-Bird Scientific</td></tr>
<tr><td>Model</td><td>SBE 19plus SEACAT Profiler</td></tr>
<tr><td>Description</td><td>Fairweather is equipped with one SBE 19plus and four SBE 19plusV2 SEACAT sound speed profilers used to acquire conductivity, temperature, and depth (CTD) data throughout the water column. The titanium cased SBE 19plus profiler has a pressure sensor rated to 3,500 meters. The four SBE 19plusV2 profilers have pressure sensors and units rated to 600 meters. All SEACAT sound speed profilers were calibrated by the manufacturer during the 2016-2017 winter repair period. Quality checks, including comparison casts, are performed if instruments are suspected to fall out of calibration. To ensure that the CTDs continue to function properly a stringent maintenance schedule is followed using guidelines from the manufacturer's recommendations.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S220</td><td>2805</td><td>2807</td><td>2806</td><td>2808</td></tr>
<tr><td>CTD s/n</td><td>19P36026-4585</td><td>19P75459-7370</td><td>19P50959-6121</td><td>19P50959-6122</td><td>19P-7634</td></tr>
</table></td></tr>
<tr><td>Calibrations</td><td><table>
<tr><td>CTD s/n</td><td>19-7634</td><td>19P75459-7370</td><td>19P50959-6121</td><td>19P50959-6122</td></tr>
<tr><td>Date</td><td>2017-02-28</td><td>2017-02-28</td><td>2017-02-28</td><td>2017-02-28</td></tr>
<tr><td>Procedures</td><td>Calibration Documents</td><td>Calibration Documents</td><td>Calibration Documents</td><td>Calibration Documents</td></tr>
</table></td></tr>
</table>

Figure 27: SBE 19plus V2

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 Rolls-Royce Canada Limited Naval Marine / Brooke Ocean Technologies MVP-200

Manufacturer	Rolls-Royce Canada Limited Naval Marine / Brooke Ocean Technologies
Model	MVP-200
Description	The MVP-200 system is a self-contained profiling system capable of sampling water column profiles to 200m depth from a vessel moving at up to 12 knots, and deeper depths at slower speeds. The MVP-200 is completely autonomous and can be controlled by computer without the requirement for personnel on deck. The system consists of a Single Sensor Free Fall Fish, an integrated winch and hydraulic power unit, a towing boom, and a remotely located user interface controller.

<table>
<tr><td></td><td>Fairweather's MVP fish is equipped with an AML Oceanographic Micro-CTD sensor capable of acquiring conductivity, temperature, and depth (CTD) data in the water column to determine the speed of sound through water, primarily to correct bathymetry data acquired with the EM 710 MBES.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S220</td></tr><tr><td>Sound Speed Profiler s/n</td><td>8808</td></tr></table></td></tr>
<tr><td>Calibrations</td><td><table><tr><td>Sound Speed Profiler s/n</td><td>8808</td></tr><tr><td>Date</td><td>2017-02-22</td></tr><tr><td>Procedures</td><td>Calibration Documents</td></tr></table></td></tr>
</table>

Figure 28: MVP 200 System

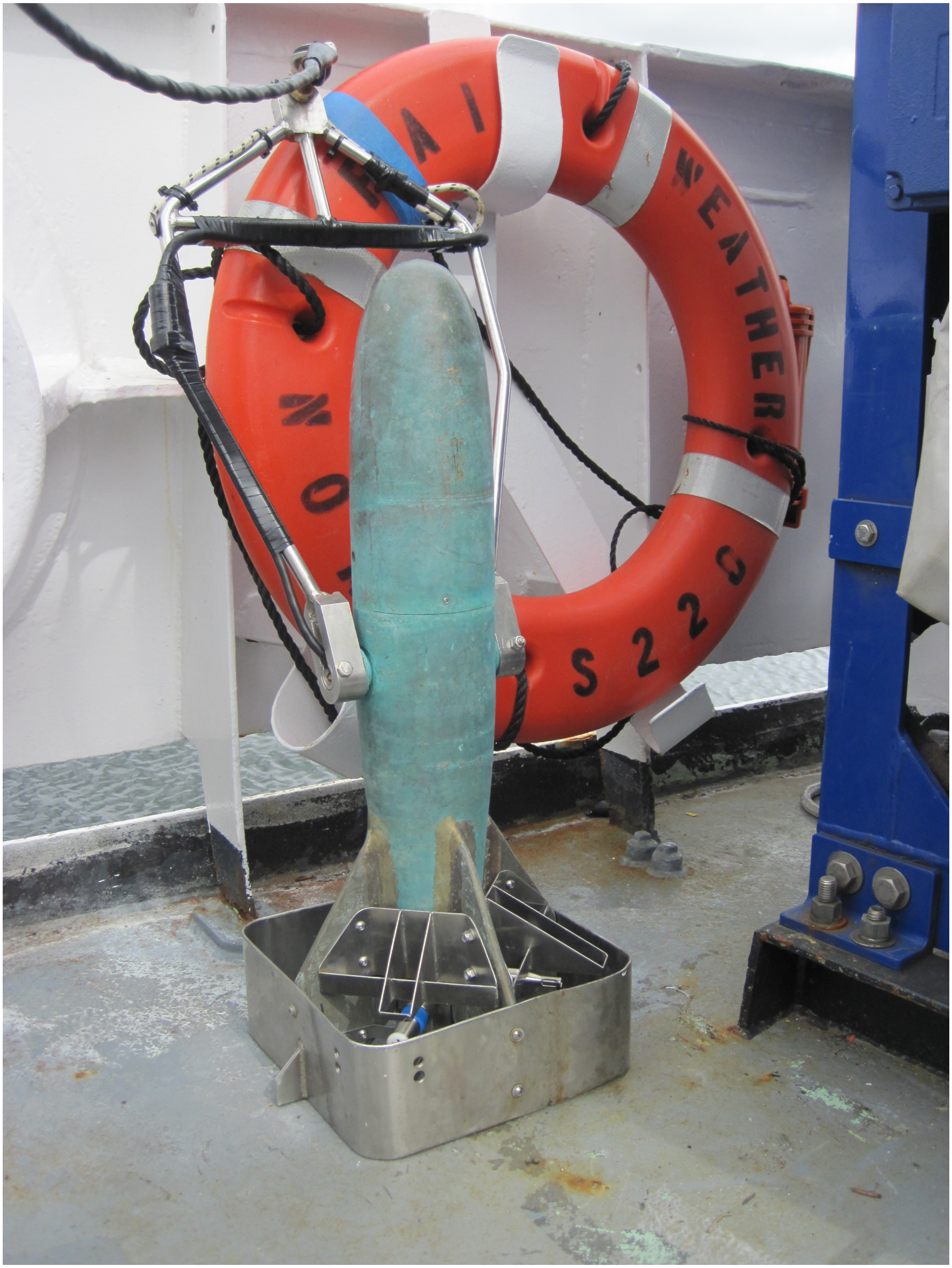


Figure 29: Single Sensor Free Fall Fish

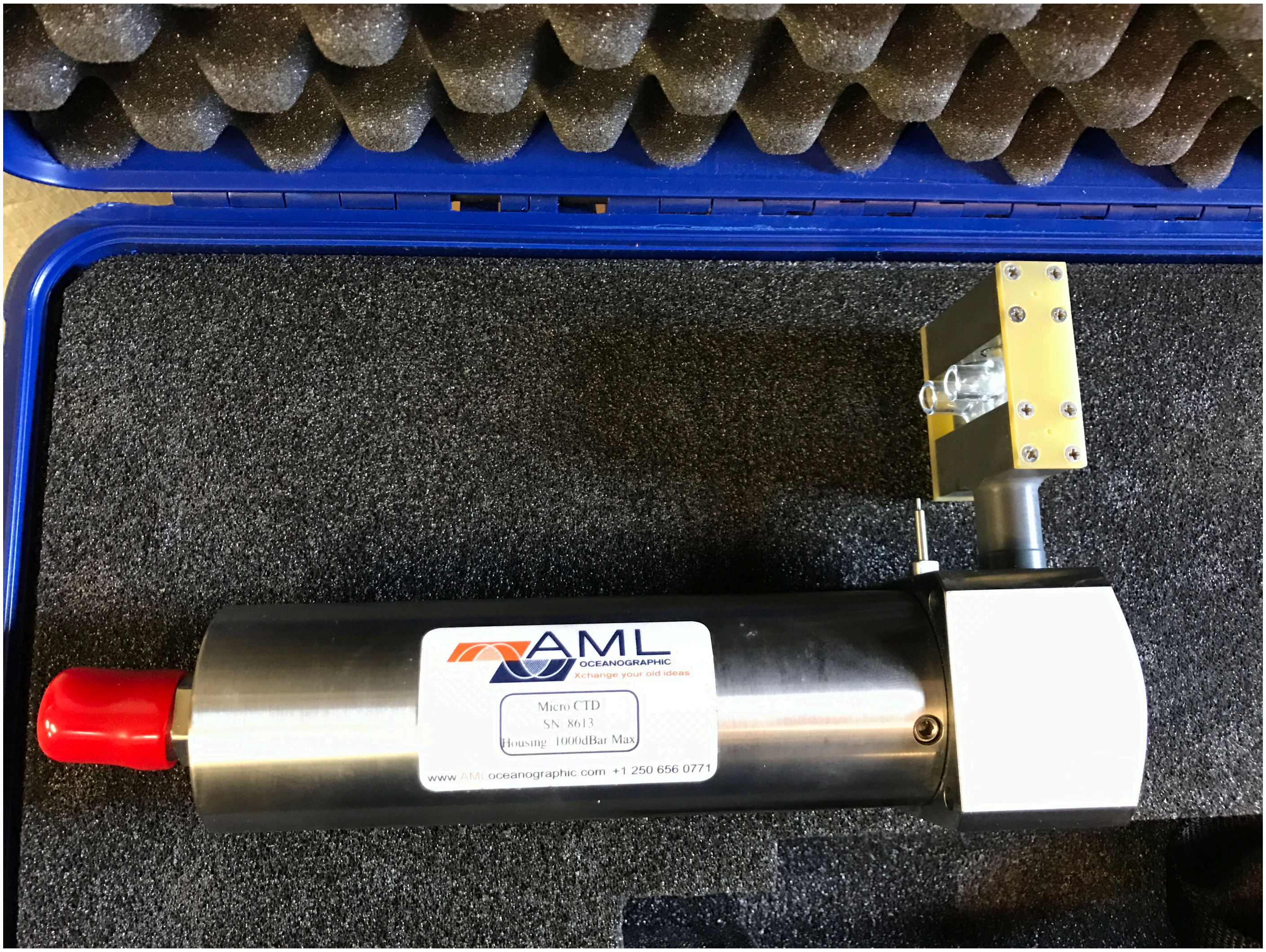


Figure 30: AML Micro-CTD Sensor

A.5.2 Surface Sound Speed

A.5.2.1 Teledyne Reson SVP-71

Manufacturer	Teledyne Reson
Model	SVP-71
Description	The SVP-71 is a direct reading sound speed probe with a sound transmission path of 125mm. The unit's housing is constructed of a hard, anodized, sea water resistant aluminum and is recommended for a semi-permanent mounting where regular

	maintenance is possible. This sensor is mounted in close proximity to each launch's multibeam transducer, and provides real time surface sound speed values for refraction corrections.				
Serial Numbers	*Vessel Installed On*	2808	2807	2806	2805
	Sound Speed Sensor s/n	3511352	3511355	1213046	1713034
Calibrations	*Sound Speed Sensor s/n*	3511355			
	Date	2015-01-27			
	Procedures	Functionality Test: Temperature Calibration, Pressure Calibration			

Figure 31: SVP-71 Pictured on Bottom of Launch in Kongsberg Array

Figure 32: SVP-71

A.5.2.2 Reson SVP 70

<table>
<tr><td>Manufacturer</td><td>Reson</td></tr>
<tr><td>Model</td><td>SVP 70</td></tr>
<tr><td>Description</td><td>The SVP 70 is a direct reading sound speed probe with a sound transmission path of 125mm. The unit’s housing is constructed of a robust titanium that eases cleaning in environments with high levels of marine growth and is recommended for permanent installations. This sensor is mounted in close proximity to ship’s multibeam transducer and provides real time surface sound speed values for refraction corrections.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S220</td><td>S220</td></tr>
<tr><td>Sound Speed Sensor s/n</td><td>0614171</td><td>0614172</td></tr>
</table></td></tr>
<tr><td>Calibrations</td><td><table>
<tr><td>Sound Speed Sensor s/n</td><td>0614171</td><td>0614172</td></tr>
<tr><td>Date</td><td>2015-07-15</td><td>2015-07-15</td></tr>
<tr><td>Procedures</td><td>Functionality Test: Temperature Calibration, Pressure Calibration</td><td>Functionality Test: Temperature Calibration, Pressure Calibration</td></tr>
</table></td></tr>
</table>

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

Description	In the absence of a local Continuously Operating Reference Station (CORS) network, Fairweather maintains at least one GPS base station during hydrographic operations in the project area. Following the HSSD 2017, base station sites are selected to fall within 40 kilometers of all data within the project area. Each station consists of either a Trimble NetR5 or Trimble NetR9 GNSS reference receiver interfaced with a FreeWave HTP-900RE 900 MHz Ethernet radio, with all components sealed in a watertight Pelican plastic case. A Zephyr Geodetic 2 GNSS antenna is secured atop a Seco fixed-height GNSS antenna tripod and connected to the Trimble receiver through a watertight connection fitted in the side of the Pelican case. A UHF antenna on top of an extending pole supported by a standard survey tripod is connected to the FreeWave Ethernet radio and provides for remote daily download of the Trimble data. Batteries and solar panels provide power.

<table>
<tr>
<td>GPS Antennas</td>
<td>
<table>
<tr><td>Manufacturer</td><td>Trimble Navigation Ltd.</td></tr>
<tr><td>Model</td><td>Zephyr Geodetic 2</td></tr>
<tr><td>Description</td><td>The Trimble Zephyr Geodetic 2 antenna is a survey grade GNSS antenna with a large ground plane for reduction of multipath. This antenna is compatible with GNSS signals, including GPS L2C and L5, GLONASS, and Galileo.</td></tr>
<tr><td>Serial Numbers</td><td>1441031361
1441027807
6127560651
30767996</td></tr>
</table>


Figure 33: Zephyr Geodetic 2 Antenna
</td>
</tr>
</table>

GPS Receivers

Manufacturer	Trimble Navigation Limited
Model	NetR9
Description	The Trimble NetR9 reference station is a multi-channel, multi-frequency GNSS (Global Navigation Satellite System) receiver designed for use as a stand-alone reference station or as part of a GNSS infrastructure solution. With 440 channels it is capable of tracking signals from GPS, GLONASS, Galileo, Compass, and QZSS constellations. Power is provided through Power over Ethernet (PoE) or a 9.5 V to 28 V DC input on a Lemo port, while an internal 15 hour battery operates as a UPS in the event of power source outage.
Firmware Version	4.3
Serial Numbers	5034K69677
	5034K69698
	5439R49375
	5439R49375

Figure 34: Trimble NetR9 Receiver

Manufacturer	Trimble Navigation Ltd.
Model	NetR5
Description	The Trimble NetR5 reference station is a multi-channel, multi-frequency GNSS (Global Navigation Satellite System) receiver designed for use as a stand-alone reference station or as part of a GNSS infrastructure solution. With 76 channels it can track all GPS signals (L1/L2/L5) as well as GLONASS (L1/L2). This receiver contains 56 MB of internal storage and has Ethernet ports compatible with HTTP and FTP protocols, also has an USB port used for extending the storage capability. Power is provided through a 9.5 V to 28 V DC input on 26 pin D sub connector, while an internal 15 hour battery operates as a UPS in the event of power source outage.
Firmware Version	n/a

UHF Antennas

Manufacturer	Hyperlink Technology
Model	HGV-906U
Description	The HyperLink HGV-906U is a high performance 6 dBi gain omnidirectional antenna designed for the 800 MHz / 900 MHz ISM band. It is suited for applications where high gain and wide coverage is desired.
Serial Numbers	N/A

Figure 36: 800/900 MHz 6 dBi Omnidirectional Antenna

UHF Radios	*Manufacturer*	FreeWave
	Model	HTP-900RE
	Description	The FreeWave Technologies HTplus Industrial 900 MHz Radio is an industrial grade high speed Ethernet radio that operates in harsh environments and noisy RF conditions. It features high speed (867 Kbps) over-the-air throughput with strong signal performance, maintaining high sensitivity even in marginal conditions. This radio has a point-to-point range of 15 miles with clear line of sight.
	Firmware Version	n/a
	Serial Numbers	885-8740 885-8156 885-8689 884-9301 886-0745 884-9511 886-0744 884-9190
Solar Panels	*Manufacturer*	Solar Tech Power, Inc.
	Model	SPM080P
	Description	The Solar Tech SPM080P is a 20.7" X 42.2" polycrystalline solar panel rated at 80 watts.
	Serial Numbers	110810050446 110810050448 110810050443 110810050444 110810050447 110810050445

<table>
<tr><td>Solar Chargers</td><td>
<table>
<tr><td>Manufacturer</td><td>Morning Star</td></tr>
<tr><td>Model</td><td>Sun Saver 10 SS-10L-12V</td></tr>
<tr><td>Description</td><td>The Morning star SunSaver SS-10L-12V is a small solar controller that regulates how much power goes into the storage batteries connected to a solar panel. The amount of power passed to the battery is dependent on the current level of the battery. This power regulation helps to increase longterm battery life. The Sunsaver also includes Low Voltage Disconnect (LVD) which automatically shuts off the load when batteries get to low, also saving on long-term battery life.</td></tr>
<tr><td>Serial Numbers</td><td>N/A</td></tr>
</table>
</td></tr>
<tr><td>DQA Tests</td><td>No DQA tests were performed.</td></tr>
</table>

A.6.1.2 Rover Equipment

<table>
<tr><td>Description</td><td>No description was provided.</td></tr>
<tr><td>UHF Radios</td><td>
<table>
<tr><td>Manufacturer</td><td>FreeWave Technologies</td></tr>
<tr><td>Model</td><td>HTP-900RE</td></tr>
<tr><td>Description</td><td>The FreeWave Technologies HTplus Industrial 900 MHz Radio is an industrial grade high speed Ethernet radio that operates in harsh environments and noisy RF conditions. It features high speed (867 Kbps) over-the-air throughput with strong signal performance, maintaining high sensitivity even in marginal conditions. This radio has a point-to-point range of 15 miles with clear line of sight.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>2805</td><td>2806</td><td>2807</td><td>2808</td><td>S220</td></tr>
<tr><td>UHF Radio s/n</td><td>885-8740</td><td>885-8156</td><td>885-8689</td><td>884-9301</td><td>884-9190</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

UHF Antennas	*Manufacturer*	Hyperlink Technology
	Model	HGV-906U
	Description	The HyperLink HGV-906U is a high performance omnidirectional antenna designed for the 800 MHz / 900 MHz ISM band. It is ideally suited for multipoint, Non Line of Sight (NLOS) and mobile applications where high gain and wide coverage is desired.
	Serial Numbers	

Vessel Installed On	2805	2806	2807	2808	S220
UHF Antenna s/n	N/A	N/A	N/A	N/A	N/A

A.6.2 Vertical Control Equipment

No vertical control equipment was utilized for data acquisition.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

Manufacturer	HP
Model	Z620
Description	Acquisition Computers on Launch 2805 & 2807
Serial Numbers	

Computer s/n	*Operating System*	*Use*
2UA4041PPB	Windows 7	Acquisition
2UA4041PPH	Windows 7	Acquisition

Manufacturer	DELL
Model	CybertronPC
Description	Acquisition Computer on Launch 2806 & 2808
Serial Numbers	

Computer s/n	*Operating System*	*Use*
454320	Windows 7	Acquisition
454317	Windows 7	Acquisition

<table>
<tr><td>Manufacturer</td><td>HP</td></tr>
<tr><td>Model</td><td>Z620</td></tr>
<tr><td>Description</td><td>FA Processor 1</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>2UA4041PPL</td><td>Windows 7</td><td>Processing</td></tr></table></td></tr>
</table>

<table>
<tr><td>Manufacturer</td><td>HP</td></tr>
<tr><td>Model</td><td>Z620</td></tr>
<tr><td>Description</td><td>Ship Acquisition Computer</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>2UA4041PPC</td><td>Windows 7</td><td>Acquisition</td></tr></table></td></tr>
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<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>Precision T5810</td></tr>
<tr><td>Description</td><td>FA Processor 2, 8 and 9</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>GTFPS52</td><td>Windows 7</td><td>Processing</td></tr><tr><td>GTFQS52</td><td>Windows 7</td><td>Processing</td></tr><tr><td>GTDVS52</td><td>Windows 7</td><td>Processing</td></tr></table></td></tr>
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<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>Optiplex 9020</td></tr>
<tr><td>Description</td><td>FA Processor 3, 4, 5, 6 and 7</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>228H282</td><td>Windows 7</td><td>Processing</td></tr><tr><td>2295282</td><td>Windows 7</td><td>Processing</td></tr><tr><td>228F282</td><td>Windows 7</td><td>Processing</td></tr><tr><td>2294282</td><td>Windows 7</td><td>Processing</td></tr><tr><td>228G282</td><td>Windows 7</td><td>Processing</td></tr></table></td></tr>
</table>

A.7.2 Computer Software

Manufacturer	Applanix

Software Name	MV-POSView
Version	9.1.2
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-03-23
Use	Acquisition
Description	The MV-POSView controller program is used to configure and operate the POS/MV attitude and positioning system. This program is also used to record the POS/MV .000 files used to produce the SBET files post-applied in CARIS to improve attitude and navigation.

Manufacturer	Applanix
Software Name	POSPac MMS
Version	8.1
Service Pack	0
Hotfix	n/a
Installation Date	2017-07-01
Use	Processing
Description	The Applanix POSPac Mobile Mapping Suite (MMS) is a post-processing software designed to maximize the accuracy potential of the POS/MV (Position and Orientation System Marine Vessels) system. Highly accurate position and orientation solutions from the GNSS and Inertial data logged to a POS/MV system may be obtained despite periods of GNSS outages. Logged POS/MV files are imported into POSPac MMS for automatic analysis and quality checks. When available, data from installed base stations are also loaded upon receiving an OPUS solution. If there are no user installed base stations to reference the acquired POS data to, reference station and precise ephemeris data may be imported from the internet. This produces a SBET (Smoothed Best Estimate of Trajectory) file that may be applied in CARIS to produce superior position and attitude data. Version 7.4 was used for OPR-O190-FA-17, and 8.1 for all other 2017 projects

Manufacturer	CARIS
Software Name	BASE Editor
Version	4.4
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-08-01
Use	Processing

Description	CARIS BASE Editor allows the user to open all sources of data from historical BASE surfaces, S-57 shoreline files, raster charts, and ENCs to the latest high density multibeam survey in a single space. Once opened, these data can easily be simultaneously examined for consistency. Analysis tools to compare BASE surfaces in their common areas ease junction and crossline comparisons. In addition the 3D fly-through offers an easy way to catch data fliers.

Manufacturer	Caris
Software Name	HIPS/SIPS
Version	10.3.3
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-09-01
Use	Processing
Description	CARIS HIPS and SIPS is a comprehensive bathymetric, seafloor imagery, and water column data processing software. HIPS & SIPS allows the user to convert raw hydrographic data into a usable format and then compute and apply all correctors. Data may then be visualized and manipulated by the user for analysis and cleaning. Automated data cleaning filters and algorithms assist the user in this process.

Manufacturer	Caris
Software Name	Notebook
Version	3.1.1
Service Pack	1
Hotfix	2
Installation Date	2014-03-01
Use	Acquisition and Processing
Description	Notebook allows for the quick collection of geo-referenced hydrographic object data and notes in the field. Both NMEA and Trimble formats are supported in CARIS Notebook which allows the user to obtain data directly from a GPS receiver. New S-57 objects can be added and proper S-57 attributes attached during collection. Field note descriptions can be attached to new marker objects as attributes. The newly digitized S-57 hydrographic objects can easily be brought directly into ENC production software.

Manufacturer	HYPACK, Inc.
Software Name	Hypack
Version	2017
Service Pack	n/a

Hotfix	n/a
Installation Date	2017-06-01
Use	Acquisition
Description	Hypack and the associated Hysweep software is the primary multibeam data acquisition software aboard Fairweather. Data from sonar, GPS and attitude sensors are logged to the hard drive while real time displays of launch position and sonar coverage are displayed on a digital chart.

Manufacturer	NOAA (HSTB)
Software Name	Pydro
Version	17.06
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-05-01
Use	Processing
Description	Pydro means Python + Hydrography. Pydro represents a framework to create, distribute, and update field software tools built on a reusable code base that makes use of an exhaustive set of Python modules and libraries. The inaugural application of Pydro was (released circa 2001) a specialized GIS designed for survey feature management: the PydroGIS.

Manufacturer	NOAA (HSTB)
Software Name	Velocipy
Version	17.06
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-05-01
Use	Acquisition
Description	Velocipy is a special purpose program written by HSTP to communicate with Sea-Bird sound speed profiling equipment. With this software, CTD profilers can be initialized and after deployment have the raw conductivity, temperature and pressure data downloaded. These data are then processed into a form usable by CARIS in addition to an archival NODC format.

Manufacturer	NOAA (HSTB)
Software Name	POSPac Automated QC
Version	17.06
Service Pack	n/a

Hotfix	n/a
Installation Date	2017-05-01
Use	Processing
Description	The POSPac Automated QC application concentrates the most important information from the POSPac MMS Message Logs and Plots into a set of windowed tabs to focus the contextual review of your ERS vessel positioning.The SBET editing is performed on the SBET QC tab. On this tab you can replace the unresolvable errors in the GNSS height and uncertainty time series data with an interpolated signal derived from (known) differential heave, dynamic draft, and water level data. The ability to discern anomalous ellipsoidal heights for editing is established in this tool via comparisons to the smooth in situ water level and tidal datum. Hence, it is important to include as input for each analysis run - as available: (1) a valid dynamic draft model in the HVF, (2) optional tide zoning data and (3) VDatum.

Manufacturer	NOAA (HSTB)
Software Name	QC Tools
Version	1.9.3+ and 2.0.0+
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-05-01
Use	Processing
Description	QC Tools assist in the review of various types of data occurring all throughout the ping-to-chart process. Data is input as a bathymetric grid and/or feature file, and the output is a GIS file that alerts to the user various parts of their data that might require more attention.

Manufacturer	Kongsberg Maritime AS
Software Name	SIS
Version	4.1.5
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-07-16
Use	Acquisition
Description	Seafloor Information System (SIS) is produced by Kongsberg Maritime and is supplied as part of the EM710 multi-beam sonar system. This real time software is designed to be the user interface and real time data processing system for the EM710. All necessary sensor interfaces, data displays for quality control and sensor calibration, seabed visualization, data logging, and integrated seabed acoustical imaging capability (sidescan) are standard parts of the software. It operates under the

	Windows operating system in a rack mounted computer dedicated to control of the EM710.

Manufacturer	Kongsberg Maritime AS
Software Name	SIS
Version	4.1.7
Service Pack	n/a
Hotfix	n/a
Installation Date	2017-04-01
Use	Acquisition
Description	Seafloor Information System (SIS) is produced by Kongsberg Maritime and is supplied as part of the EM2040 multi-beam sonar system. This real time software is designed to be the user interface and real time data processing system for the EM710. All necessary sensor interfaces, data displays for quality control and sensor calibration, seabed visualization, data logging, and integrated seabed acoustical imaging capability (sidescan) are standard parts of the software. It operates under the Windows operating system in a rack mounted computer dedicated to control of the EM2040.

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Kahlsico International Corp Small Clam Shell

Manufacturer	Kahlsico International Corp
Model	Small Clam Shell
Description	The clam shell bottom sampler has a post attached to a strong compression spring that presses against the jaws of the device. To open the clam shell mouth, the two halves of the clam shell are pried apart, and the lever that connects the two clam shell halves is pulled upwards to lock the clam shell jaws in the "open" position. Upon impact with the bottom, the lever is released, allowing the spring-tensioned and hinged jaws to snap shut.

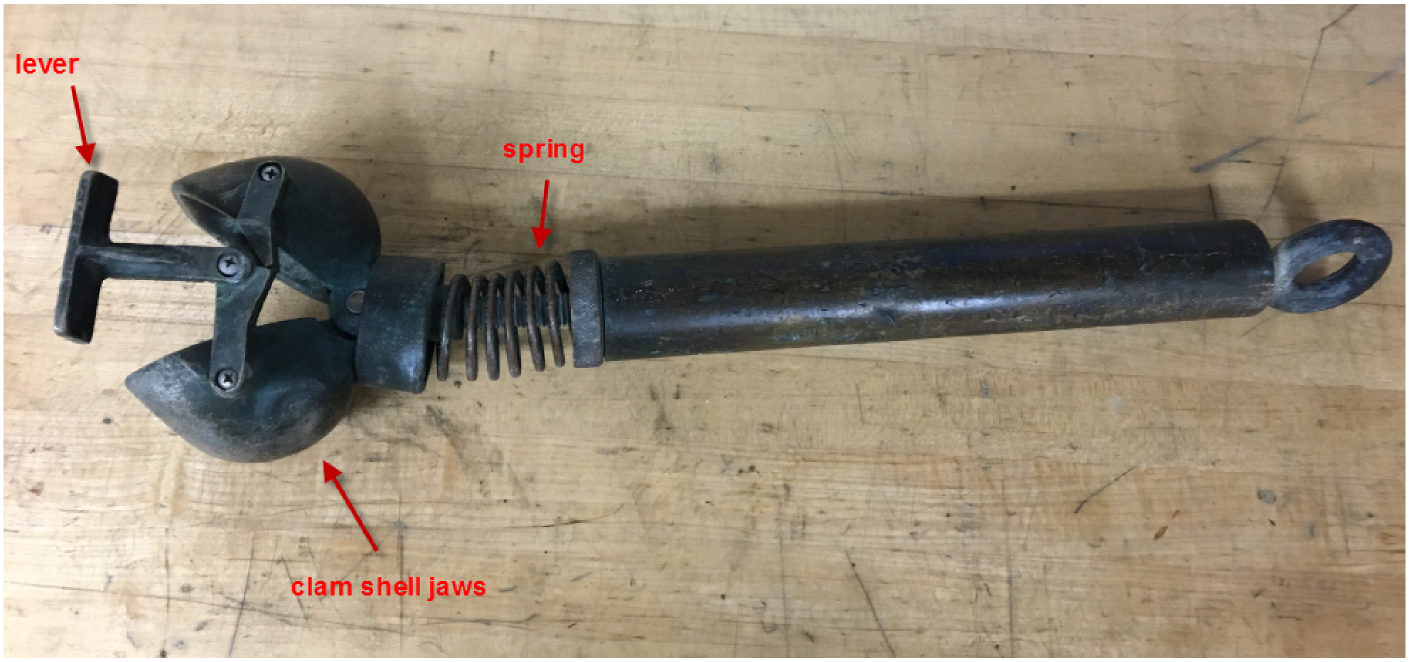


Figure 37: Small Clam Shell Sampler

A.8.1.2 Kahlsico International Corp Hard sediment core sampler

Manufacturer	Kahlsico International Corp
Model	Hard sediment core sampler
Description	The core sampler allows for both shallow and deep water core sampling applications. It is a gravity type sampler that comes with a stabilizing fin. The sampler comes standard with a 2" diameter, 4" long stainless steel sampling tube. A simple flap valve allows water to flow through the sampler during descent and close tightly for retrieval, minimizing sample loss.

Figure 38: Hard sediment core sampler

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

Acquisition methods and platforms used are determined based on consideration of sonar system specifications, seafloor topography, water depth, and the capability of the acquisition platforms.

For the Kongsberg EM 710 and EM 2040 all multibeam data is acquired in SIS (Seafloor Information System) .all format. Data were monitored in 2D, 3D and backscatter real-time display windows. A survey template define the storage location of raw and gridded (survey) data and the file naming convention. Basic parameters will determine projection, naming convention for mainscheme (H####_M) and crossline (H#####_X). During acquisition, the hydrographer often adjust parameters of the Kongsberg systems to improve data quality. Common parameters that are adjusted are the port and starboard beam angle, the force depth fields, ping mode, and yaw stabilization. Settings and specialized filters are found in the Runtime parameters tear off window of Seafloor Information Systems (SIS).

During launch acquisition mainscheme MBES lines using the Kongsberg EM2040 are generally run parallel to depth contours with appropriate overlap to ensure data density requirements for finalized BASE surface resolutions are met. For discrete item developments, 200 percent coverage is acquired to ensure least-depth determination by multibeam near-nadir beams. Hypack Hysweep realtime coverage display is used in lieu of pre-planned line files. Hysweep displays the acquired multibeam swath during acquisition and is monitored to ensure overlap and full bottom coverage.

For ship acquisition, real-time coverage is also adopted. Mainscheme MBES lines are run parallel to the contours with appropriate overlap to ensure data density requirements for finalized BASE surface resolutions are met. Hypack Hysweep realtime coverage display is used in lieu of pre-planned line files. If coverage is not adequate, additional lines are run while still in the area.

For areas where shoreline verification is not conducted before multibeam and hazards are suspected to exist, extra caution is taken by “half stepping” shoreward when operating near shore. Half stepping is done by driving along the edge of real time coverage to prevent the survey vessel from working in un-surveyed waters. Survey launch crews in the field survey to the Navigable Area Limit Line (NALL) line as defined by section 1.3.2 of the HSSD.

Seafloor backscatter data were acquired for all data during the 2017 field season, logged in the .all files. The Kongsberg systems have an internal file, BsCorr, used to correct for beam pattern and other effects to equalize backscatter between swaths, sectors, and modes. This file is populated at the factory. A modified BsCorr file was provided by HSTB for the EM 710 system, following the sonar acceptance, to optimize the quality of the backscatter data.

Navigation and motion data are acquired and monitored in POSView and logged into a POS MV file with a .000 extension. Various position and heading accuracies, as well as satellite constellations, are monitored real-time both in POSView and Hypack Hysweep. It is standard procedure not to log the POS/MV data through UTC midnight on Saturdays. At this time the GPS seconds of the week reset.

B.1.1.2 Single Beam Echosounder

The CEEPulse transducer was installed on FA 2302 using a custom built bracket that mounted to the jet guard. The transducer was mounted to a pole that submerged the transducer to a depth of approximately 50 cm below surface. The processing unit was installed in FA 2302 and powered by a 12 volt battery. The transducer was interfaced with Hypack for data acquisition on a Toughbook laptop in the cabin via RS 232 for configuration and monitoring of data collection. During acquisition, the vessel position was monitored on Hypack, and planned lines or tracks were followed. Vessel speed was limited to 6 knots to minimize bubble sweepdown and vibration of the mounting bracket. Data acquisition was only conducted in wave heights of less than 30 cm and negligible swell to minimize the uncertainty from the lack of a vertical motion sensor for the system.

Figure 39: CEEPulse with submerged transducer on its pole mount

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 Klein SonarPro, in the .SDF format. During acquisition the hydrographer:

- Monitors range, towfish height, heading, pitch, roll, latitude, longitude, speed, pressure, and temperature
- If towed, the hydrographer adjusts towfish height in accordance with Field Procedures Manual
- Monitors imagery for any real-time contacts, flagging contacts as necessary

During hull mounted acquisition, the bottom depth was monitored and range scale selected such that the towfish height would be between 8-20% of the range scale above the bottom as per HSSD 6.1.2.3. In some areas, waivers were requested for increased range scales, which are included with applicable survey submissions. At all times during acquisition, the outer portion of the range scale was continuously evaluated for signs that data may not be capable of meeting required object detection standards.

The hydrographic team conducts confidence checks on survey days to ensure the SSS system is functioning properly by surveying over a known object within the survey area. Confidence checks were usually performed on the S220 anchor and anchor chain. 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 outer edge of the range scale for both port and starboard channels, the confidence check is complete.

B.1.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

B.1.3 Sound Speed

B.1.3.1 Sound Speed Profiles

Sound speed casts were taken at least once every 4 hours during multibeam survey operations in accordance with section 5.2.3.3 of the HSSD. Fairweather’s launches collected sound speed casts according to changes in the water column and any changes in survey location that would influence sound speed differences in excess of the accepted 2 m/s range. The launches use the SBE 19plus and 19plus V2 SEACAT sound speed profilers, which in conjunction with Velocipy or Sound Speed Manager software, are transferred to SIS for realtime application and sonar tuning. The user is then warned for the need of a new cast by highlighting both the “SV Profile” and “SV Used” numerical displays in yellow with a difference greater than 3 m/s and red for a difference greater than 5 m/s. These casts were then compared once daily to the SVP 71 surface sound speed sensors to verify their accuracy in lieu of annual SVP 71 calibration. The results of the daily SSP sensor comparisons are logged in the Microsoft Excel acquisition log to track instrument health. Deviations from this procedure will be outlined in the individual Descriptive Report for the survey.

The Moving Vessel Profiler (MVP) is an automated winch system that deploys a fish containing a sound speed sensor by free fall. The fish is towed behind the survey vessel in a ready position that is marked by messengers attached to the tow cable. Ideally at survey speeds the fish is “flying” just above the depth of the sonar transducers. The specified depth deployed is selected by specifying a distance off the bottom (typically 10 meters). Once at the depth limit, the winch freefall is automatically stopped and the drag forces on the fish cause it to rise toward the surface due to the ship's forward motion. The cable slack is then pulled in by the winch to the towing position.

In the event of a particularly deep survey area or prior to the entire survey system being brought on-line, the MVP fish can be manually deployed while the ship is stationary using the hand-operated control box located on the winch. This method ensures that the maximum possible depth is obtained since the cable is deployed vertically. If necessary, the deep end of such a stationary cast can be added to the end of shallower casts obtained while the ship is underway.

B.1.3.2 Surface Sound Speed

Surface sound speed values are measured by an SVP 70 probe on Fairweather and SVP 71 probes on all survey launches. These sound speed values are supplied in real-time to all MBES systems to provide refraction corrections to flat-faced transducers. SIS applies a median filter to the surface sound speed values, the length of which is adjusted during acquisition to capture variability while eliminating errors due to bubble sweepdown. Surface sound speed is monitored for > 3 m/s changes to indicate when casts should be taken. SIS automatically monitors sound speed changes > 3 m/s and prompts the user when the MVP fish needs to be deployed.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

A complete description of horizontal control activities is included in the project's Horizontal and Vertical Control Report (HVCR), submitted under separate cover as outlined in Section 8.1.5.2 of the HSSD and Section 5.2.3.2.3 of the FPM.

The horizontal datum for all projects is the North American Datum of 1983 (NAD83) unless otherwise noted in the individual Descriptive Reports.

Multibeam and shoreline data are differentially corrected in real time using correctors provided by Coast Guard DGPS beacons when available, or WAAS when no beacons are available. The specific beacons used for a given survey will be included in the Horizontal Control section of the survey's descriptive report. If loss of the differential beacon resulted in any data being recorded with C/A GPS positions it will be noted in the Descriptive Report for the specific survey.

B.1.4.2 Vertical Control

The Fairweather uses Mean Lower Low Water as the vertical datum and TCARI zoned tidal method for vertical control. National Water Level Observation Network (NWLON) stations provide the data that serve as datum control.

Initial reduction of acquired data to MLLW is accomplished via traditional tidal means using the Tidal Constituent And Residual Interpolation (TCARI) grid provided by HSD-OPS. Following the successful application of SBETs and computation of an Ellipsoidally Referenced Zone Tide (ERZT) separation model, ERS methods are used for reducing data to MLLW. After final tides are received, the final TCARI grids are applied to the data and used for reducing features to MLLW.

B.1.5 Feature Verification

The composite source file (CSF) in S-57/.000 format provided with the Project Instructions is the primary source for shoreline feature verification. The original project file is imported into CARIS BASE Editor, converted to a .hob file, clipped to the sheet limits for the specific survey, and named H#####_Original_Composite_Source.hob to be included with the deliverables. This file is then copied and named H#####_Feature_File.hob to be utilized during field verification. Additionally, all features to be investigated are provided to the field in the project reference file (PRF). All hob files are re-exported to S-57/.000 format for data submission.

Fairweather personnel conduct limited shoreline verification during periods when the tide is less than 0.5m above Mean Lower-Low Water (MLLW) as directed by section 3.5.5.3 of the FPM. Detached positions (DPs) are acquired and edits to the daily field feature files are recorded in CARIS Notebook and on paper DP forms and boat sheets. An inshore limit buffer line, defined by the distance seaward from the Mean High Water (MHW) line at the scale of the largest chart in the area, is provided with the Project Instructions. This inshore limit buffer line is used in the shoreline acquisition software and on the boat sheet as a reference, and utilized as described in section 1.1.2 of the HSSD. The NALL is determined in the field as the farthest off-shore of one of the following; the MHW inshore limit buffer specified above, the 4-meter depth contour, or the inshore limit of safe navigation as defined by the HSSD. All shoreline features from the CSF seaward of the NALL are verified (including an update to depth and/or position as necessary) or disproved during operations. Features in-shore of the NALL are not addressed, or features of an ambiguous nature include remarks for further clarification. Specifically assigned features may be investigated that are inshore of the NALL in accordance with the associated instructions for a given project area.

Detached positions (DPs) acquired during shoreline verification utilizing backpacks and Laser Range Finders indicate new features, revisions to source features, or source features not found in the field. They are recorded in the shoreline acquisition software and on DP forms.

The NOAA Ship Fairweather has two vessel mounted Velodyne VLP-16 laser scanners. These Lidar systems were integrated and tested by the Hydrographic Systems and Technology Branch (HSTB) and the NOAA Ship Fairweather in January 2016. Some shoreline verification is performed used the vessel mounted Lidar systems. The laser scanners provide the position and height on features that survey launches are able to safely approach, with a maximum distance of 100 meters.

HYPACK has developed a device driver that allows for the simultaneous acquisition of shoreline Lidar data with MBES coverage. Data are logged through HYPACK in a HSX format with TOP or RMB messages and exported as a target file or an S57 file. A CSV is exported that contains the height and position for each feature that was acquired. After acquisition, a script is run in Pydro Explorer that merges the S57 file with the CSV file to produce an attributed S57 file that contains heights and positions of all new features.

The Velodyne workflow replaces the backpacks and Laser Range Finders with the VLP-16 scanner, and the DP forms with HYPACK target metadata.

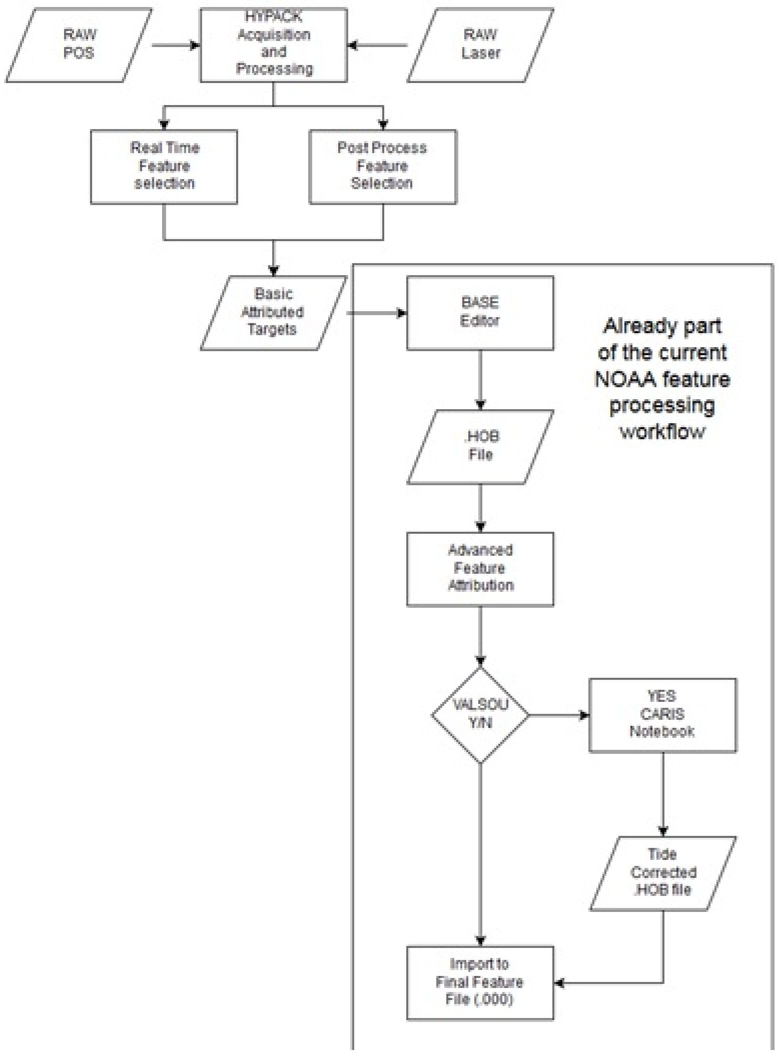


Figure 40: VLP-16 Laser Scanner work Flow

B.1.6 Bottom Sampling

Bottom samples are acquired according to section 7.2.3 of the HSSD. Any deviations from this protocol will be outlined in the individual Descriptive Report for the survey. Samples are acquired using CARIS Notebook, HYPACK target files (.tgt), or by logging the latitude, longitude, and bottom characteristics manually. All samples are processed similarly to other shoreline features as outlined below in section B.2.5 of this report. Bottom sample results are included in the Final Feature File and are descriptively attributed as New.

B.1.7 Backscatter

Backscatter data are collected by with the Fairweather's Kongsberg system, and stored in the .all file.

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Bathymetry is processed following section 4.2 of the FPM unless otherwise noted.

Raw multibeam data is recorded as .all for ship and launch acquisition. Data is stored in a file structure created by the HSTB tool Charlene. Section 5.2.7 of this report contains a complete description of Charlene and its implementation on the Fairweather. Charlene automates night processing, which includes the creation of a data directory, file transfer, data conversion and processing in CARIS HIPS and SIPS. For the 2017 field season, Charlene was used to store, transfer, and process data. If a crew member encountered a problem while running Charlene, MBES data was then manually processed according to the procedures described below.

Data is converted to CARIS HIPS HDCS format using established and internally documented settings. After Delayed Heave, sound speed, and water level (Zoned Tides or TCARI tides) correctors are applied to all lines, the lines are merged. Once lines are merged, Total Propagated Uncertainty (TPU) is computed.

As of 2017, the final deliverable bathymetric surface for the field units is a variable resolution (VR) surface. A detailed explanation for the use of any single resolution CUBE surfaces used for the processing of each survey will be provided in the Descriptive Report for each survey. The resolution, depth range, and CUBE parameters of any single resolution CUBE surface follow the specifications outlined in 5.2.2.2 and 5.2.2.3 of the HSSD.

VR surfaces are created using the Calder-Rice Density for Estimation method, and the parameters contained in the NOAA CUBEParams2017.xml. BASE surfaces are created using the Density & Locale function of the CUBE algorithm and parameters contained in the NOAA CUBEParams_NOAA_2017.xml. The CUBEParams_NOAA.xml will be included with the HIPS Vessel Files with the individual survey data. The NOAA parameter configurations for resolutions ranging from 50 centimeters to 32 meters are used.

Multibeam data are reviewed and analyzed in CARIS HIPS subset mode and in swath editor as necessary. The CUBE surfaces are used for directed data editing at the appropriate depth range in subset editor. The surfaces and subset editor are also used to demonstrate coverage and to check for errors due to tides, sound speed, attitude, and timing.

Vessel heading, attitude, and navigation data are reviewed in HIPS navigation editor and attitude editor if deemed necessary upon review of surfaces. Where necessary, data spikes (fliers) or gaps in heading, attitude, or navigation data are manually rejected or interpolated for small periods of time. Any editing of this nature will be outlined in the Descriptive Report for the particular survey.

In depths less than 20 meters and in areas of navigational significance where the bathymetric surface does not depict the desired depth for the given area, a designated sounding may be selected. Designated soundings are selected as outlined in section 5.2.1.2.3 of the HSSD.

To check that surface junctions meet the HSD specifications that 95% or greater of grid-node comparisons are within the IHO-allowable error, the hydrographer runs the Compare Grids tool within the Pydro Explorer suite. The Compare Grids tool uses the CARIS BASE Editor batch processing engine to compute the gridded difference and IHO-allowable error between two gridded Depth/Elevation layers in surfaces. Two coverage files are loaded into the Compare Grids dialogue window and the user selects an output folder and file output names. The tool computes the simple depth difference between the two gridded layers and the allowable error fraction of surface nodes according to IHO- based HSD maximum allowable error for the Total Vertical Uncertainty of the soundings. The results automatically address the TVUmax 100-m depth switchover point using IHO Order 1a (0-100m) and IHO Order 2a (100m+). The Compare Grids tool outputs a .csar and .csar0 files for the fraction of allowable error, a plot of Node Depth vs. Allowable Error Fraction with summary statistics, a histogram showing the Comparison Distribution of the magnitude of the fractional allowable errors with summary statistics, a .csar and a .csar0 for the CSAR Difference output surface, and a distribution summary plot with statistics for the Difference CSAR layer.

NOAA allowable uncertainty surfaces are used during processing to indicate potential problem areas requiring attention on single resolution CUBE surfaces. Historically, the field unit has reported the percentage of nodes meeting or exceeding uncertainty standards in the Descriptive Report, including images of areas that failed to meet uncertainty standards. The field units are submitting a single Variable Resolution surface for the 2017 field season and may shift to only reporting the total vertical uncertainty as calculated by Pydro QC Tools in the Descriptive Report, using uncertainty layers as a tool used solely to identify "problem areas" while data processing.

The variable resolution surface is loaded in the Pydro QC Tools 2 Grid QA application to allow the Hydrographer to see the full data distributions rather than just the minimum and maximum values in the surface. The QC Tools 2 Grid QA function that calculates statistics for uncertainty, density, total vertical uncertainty, depth vs. density, and depth vs. total vertical uncertainty. These data distributions are used to assess the quality of the survey, to ensure 95% of the data meets the appropriate IHO order as specified in section 5.1.3 of the HSSD 2017.

Surface Resolutions, Cube Parameters, and Naming for Complete Multibeam Coverage

Surface Resolutions		Cube Parameters and Naming Convention		
Default Ranges	Grid Resolution	Cube Parameters	Surface Naming	Finalize Naming
0-20	1m	NOAA_1m	H#####_MB_1m_MLLW	H#####_MB_1m_MLLW_Final
18-40	2m	NOAA_2m	H#####_MB_2m_MLLW	H#####_MB_2m_MLLW_Final
36-80	4m	NOAA_4m	H#####_MB_4m_MLLW	H#####_MB_4m_MLLW_Final
72-160	8m	NOAA_8m	H#####_MB_8m_MLLW	H#####_MB_8m_MLLW_Final
144-320	16m	NOAA_16m	H#####_MB_16m_MLLW	H#####_MB_16m_MLLW_Final
288-640	32m	NOAA_32m	H#####_MB_32m_MLLW	H#####_MB_32m_MLLW_Final
0-depth limit	VR	NOAA_VR	H#####_MB_VR_MLLW	N/A

Object Detection Coverage				
Depth Ranges	Resolution	Cube Parameters	Surface Naming	Finalize Naming
0-20	0.5	NOAA_50cm	H#####_MB_1m_MLLW	H#####_MB_1m_MLLW_Final
18-40	1	NOAA_1m	H#####_MB_2m_MLLW	H#####_MB_2m_MLLW_Final
36-80	4	NOAA_4m	H#####_MB_4m_MLLW	H#####_MB_4m_MLLW_Final
72-160	8	NOAA_8m	H#####_MB_8m_MLLW	H#####_MB_8m_MLLW_Final
144-320	16	NOAA_16m	H#####_MB_16m_MLLW	H#####_MB_16m_MLLW_Final
0-depth limit	VR	NOAA_VR	H#####_MB_VR_MLLW	N/A

Figure 41: Coverage and Resolution.

B.2.1.2 Single Beam Echosounder

The acquired Hypack HSX files are imported into CARIS HIPS and SIPS, converted using default settings with an HVF that incorporated the waterline offset of the sonar. Once converted to HDCS format, the data was edited using single beam editor to remove spikes and otherwise erroneous data. The final data was gridded at a 4 m resolution for analysis and data comparison.

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

see section B.2.1.1

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

see section B.2.1.1

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Surface Computation Algorithms
Description	Fairweather uses the CARIS CUBE BASE surface algorithms for the generation of all surfaces for final submission. The exact behavior of CUBE is determined by the values set in the CUBE parameters file, an xml file which can be selected by the user in the CARIS Tools --> Options --> Environment tab. The Hydrographic Surveys Division (HSD) has created and provided a customized CUBE parameters file (CubeParams_NOAA_2017.xml) with specific CUBE parameters that are required for each grid resolution. During the creation of CUBE surfaces, the user is given the option to select parameter configurations based upon surface resolution which have been tuned to optimize the performance of the CUBE algorithm. The advanced options configuration is manipulated based on the grid resolution of the CUBE surface being generated.

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Raw .sdf data was converted using CARIS SIPS. Navigation and Attitude data were scanned, erroneous data was rejected and interpolated as needed. Navigation was computed in CARIS HIPS and SIPS to apply offsets and horizontal layback to the data. CARIS HIPS and SIPS automatically corrects for the slant range. Night processors scan each line of data for significant contacts. A sheet manager or secondary reviewer makes another check scan of all lines, verifying contacts and checking for missed contacts. Contacts that meet the specification as put forth by the HSSD 2017 are exported into a Final Feature File for development by MBES. Mosaics were created at a 1 m resolution for 100% coverage and inspected for any gaps larger than 2 m x 2 m. When such gaps were found, the corresponding area was marked for re-acquisition.

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

The NetApps server maintains continuous duplication and makes periodic full backups to mitigate any technological failures in addition to user error.

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

To verify object detection requirements, and approximately 1 m x 1 m target was constructed and placed on the seafloor. This target was then observed in processed data from all range scales to confirm visibility. Raw data was examined to ensure that the target was ensonified a minimum of three times. The 95% confidence radius of detections on the target was calculated and verified to meet the 5 m specification in FPM Section 1.5.7.1.2. Certification reports are attached in an appendix. The daily confidence checks described in B.1.2.1 assured that object detection continue to meet requirements.

During data acquisition, SSS acquisition lines were spaced at 80% of the range scale to ensure 100% coverage meeting complete coverage specifications. If refraction artifacts were observed in either acquisition or processing, the areas were re-acquired at a closer line spacing or shorter range scale.

B.2.2.3.3 Methods Used to Verify Swath Coverage

Swath coverage is verified using mosaics created by CARIS SIPS. Any gap in coverage larger than 2 m x 2 m is considered a holiday and re-acquired.

B.2.2.3.4 Criteria Used for Contact Selection

For water depths less than 20 m, any notable shadow or anomalous return of 1 m or greater in height are selected as contacts for further investigation by MBES. For water depths 20m or greater, contact heights of 10% of the water depth are considered significant. At least two reviewers inspect all data for contacts using the swath view in CARIS SIPS.

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

Downloading and processing of sound speed data is performed using Velocipy, a part of the HSTB supplied Pydro program suite. Raw and Processed SV files are retained and archived for later submission to the Pacific Hydrographic Branch (PHB).

A separate submission of sound speed data is sent to the National Center for Environmental Information (NCEI) following the NetCDF template format. Velocipy is used to export a NetCDF file by selecting the NODC box upon export and specifying the export directory. Files are submitted to NCEI via email attachment to NODC.submissions@noaa.gov with a courtesy copy to the HSD Project Manager.
For Seacats:
• After a cast, the SBE Seacat CTD is connected to the download computer with a serial cable.
• After starting Velocipy, “File/ Download from SBE/Download Selected” is selected from the dropdown menu. A window showing available casts is then displayed with check boxes to select cast(s) for download.
• After download the user is then required to enter cast metadata. Empty slots for Project, Survey, NOAA Unit, Instrument, User name, Process Date, Draft, and Latitude and Longitude are given. The metadata is written into the NODC output files.
• After entering metadata, the sound speed, Temperature, Salinity graphs and the table with data points are reviewed for QA. The user can change the sound speed/depth units (X and Y buttons), zoom in (Magnifier tool), and take a look/edit cast points (+ button).
• Casts are exported into CARIS SVP and NODC format files by selecting File/Export Selected or All Profiles. A File Export Settings window will pop up, allowing the user to point to the Caris HIPS SVP and NODC folder. The Caris HIPS SVP files are appended by checking the corresponding option in the export window. After clicking OK, the Log Window should read ‘exported sound speed profile successfully’.
• To prepare for the next cast, SEACAT PreCast Setup is selected to clear all memory and initialize the profiler for the next cast.
For MVP:
• For the MVP, casts are typically processed continuously during acquisition.
• After starting Velocipy, “File/ Load Profiles” is selected from the dropdown menu. Navigate to the *.s12 file produced by the MVP and select file/s to process.
• In Velocipy right click on the loaded file to send the cast to SIS.
• After the files are loaded, the user is then required to enter cast Meta data. Empty slots for Project, Survey, NOAA Unit, Instrument, User name, Process Date, and Draft are given. Unlike the SBE Seacat, Latitude and Longitude are already populated.The Meta data is written into the NODC output files.
• After entering Meta data, the Sound Speed, Temperature, Salinity graphs and the table with data points are reviewed for QA. The user can change the sound speed/depth units (X and Y buttons), zoom in (Magnifier tool), and take a look/edit cast points (+ button).
• Casts are exported into CARIS SVP and NODC format files by selecting File/Export Selected or All Profiles. A File Export Settings window will pop up, allowing the user to point to the Caris HIPS SVP and NODC folder. The Caris HIPS SVP files are appended by checking the corresponding option in the export window. After clicking OK, the Log Window should read ‘Exported sound speed profile successfully’.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

Daily sound speed profiles from the AML Micro CTD, SBE 19plus and SBE 19plusV2 profilers are processed with Velocipy and concatenated into single .svp files for each vessel per survey. Individual .svp files and the concatenated vessel files for the survey are submitted with each survey.

The concatenated sound speed files are applied to multibeam data in CARIS HIPS during data processing. CARIS HIPS uses one of four different methods to automatically apply a sound speed profile stored in a concatenated sound speed file. They are: “previous in time,” “nearest in time,” “nearest in distance” and “nearest in distance within time.” The method of applying sound speed for a specific day of data collection is listed in the daily logs included as Separates submitted with the individual survey data.

B.2.3.2 Surface Sound Speed

Surface sound speed data were not processed.

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

A complete description of horizontal control will be included in the project’s Horizontal and Vertical Control Report (HVCR), submitted for each project under separate cover when necessary as outlined in section 8.1.5.2 of the HSSD and section 5.2.3.2.3 of the FPM.

Real time DGPS positioning is later replaced with a Post Processed Kinematic (PPK) Smoothed Best Estimate of Trajectory (SBET). The PPK solution is usually dependent on a local base station supported by the ship and processed in Applanix POSPac MMS software using Single Base mode. However, in areas with an adequate network of Continuously Operating Reference Stations (CORS) or public third-party base stations, Applanix POSPac SmartBase™ mode may be used. Additionally, Applanix has integrated PP-RTX technology into POSPac MMS 8.1 to provide post-processed positioning accuracies without the use of a local reference station. A global network of stations tracking GPS, GLONASS, BDS, QZSS, and Galileo provide raw data for processing to produce the PP-RTX correction, which are made available via the internet within one hour of real-time. With Single Base, SmartBase, or RTX processing, the resulting navigation from PPK is an improvement over C/A and DGPS navigation. The details of PPK use and application for a given survey will be included in the Horizontal Control section of the project’s HVCR or the survey’s Descriptive Report.

B.2.4.2 Vertical Control

All tide data is processed off of the ship by the Center for Operational Oceanographic Products and Services (CO-OPS). Although Fairweather does not process any of the tidal water level data that she collects, preliminary and final data packages are submitted to CO-OPS. All Tide & Water Level Data Packages submitted conform to the requirements of section 5.2.2.4 of the FPM and section 4 of the HSSD.

To receive final water level correctors to apply to an individual hydrographic sheet, a Request for Approved Tides/Water Levels must be submitted to the Chief of Products and Services Branch, N/OPS3. This package includes an Abstract of Times of Hydrography and digital MID MIF files of the track lines from Pydro. Once this request has been received, CO-OPS has agreed to provide final water level correctors relative to the appropriate chart datum and final tidal zoning, as soon as possible. Final approved water levels are applied to applicable data of all hydrographic surveys before data submission to PHB.

B.2.5 Feature Verification

During shoreline verification, field detached positions (DP) are acquired with CARIS Notebook or Hypack .tgt files. Tide application for features requiring tide correction is applied in CARIS Notebook when using discrete zoning.

New features and any updates to the composite source shoreline, such as ledges or reefs, are acquired or digitized with S-57 attribution and compiled from the field daily files into the H#####_Final_Feature_File.hob. Updates to source shoreline features primarily include a change in depth/height, position, or S-57 classification. If the position of a feature changes, the existing feature is deleted and a new feature created in the new location. Any changes to depth/height or S-57 classification are done so as an update to the S-57 object with the inclusion of NOAA's object attributes.

The SORIND and SORDAT S-57 attribute fields for new features or modified source features are updated to reflect the information for the associated survey number and date (US,US,graph,H#####). All new or modified features are S-57 attributed as applicable and descriptively attributed as New or Update respectively. All unmodified source features retain their original SORIND and SORDAT values. Assigned features that are addressed but not updated are descriptively attributed as Retain and unaddressed assigned features are attributed as Not Addressed. Short descriptive comments taken from the boat sheets or DP forms along with investigation or survey methods are listed under the Remarks field.

For significant features that deserve additional discussion, the Hydrographer may include a recommendation to the cartographer in the Recommendations field, along with the Hydrographer notes and investigation methods provided in the Remarks field. Features that are disproved or that do not adequately portray the shoreline are descriptively attributed as Delete in the H#####_Final_Feature_File.hob layer. Features with the attribution of Delete retain their original SORIND and SORDAT values and include a recommendation from the Hydrographer along with an informative remark.

Investigation items are received in the Project Reference File and investigated as necessary. Investigation items are included in the H#####_Final_Feature_File.hob layer and labeled appropriately and include a remark detailing the search methods and a recommendation from the Hydrographer. Any features that are submitted as dangers to navigation (DTON) will be attributed accordingly for reporting purposes.

Images are labeled and associated with a DP/userid number or other descriptive/unique name. They are included with the survey data and stored in the Multimedia folder with the deliverables. References to the images are listed with file extension and comma delimited in the Images attribute for the specific feature.

The H#####_Final_Feature_File.hob along with CARIS HIPS BASE surface(s) are viewed to compare MBES coverage and features simultaneously. The current NOAA object catalog will be used for all CARIS software for processing and the version of such will be documented in the individual Descriptive Reports, along with any deviations in shoreline processing from those listed above. Final shoreline deliverables are two S-57 (*.000) files exported CARIS HIPS and SIPS or Base Editor, the H##### Feature File and the H##### Final Feature File, included with the processed data.

B.2.6 Backscatter

Backscatter is logged within the Kongsberg .all file and processed using Fledermaus Geocoder Toolbox Version 7.7.4. Backscatter was processed and analyzed for any discrepancies as a quality check each day after acquisition, then compiled into master mosaics once acquisition completed. For OPR-R365-FA-17 and OPR-O346-FA-17, both processed GSF files and mosaics are submitted. Additionally, any perceived changes in bottom type from the processed backscatter mosaics can be used to modify the location of assigned bottom samples to more accurately capture changes in bottom type across the survey area. Sheet managers changed bottom sample locations as necessary.

B.2.7 Other

Initial data processing at the end of each survey day is the responsibility of a few crew members that are assigned to "night processing". Daily processing produces a preliminary product in which all gross data problems have been identified and/or removed, and thus can be used by the sheet manager and the FOO to plan the next day’s operations.

New to night processing for the 2017 field season is Charlene, the automated data processor. Initial testing of the Charlene was conducted during the Sonar Acceptance Trials in May of 2017 in Seattle, WA. Charlene was integrated into the Fairweather workflow before the start of the first project for the 2017 field season and used for the entirety of the 2017 field season.

Charlene is an automated night processing and data transfer tool developed by NOAA’s Office of Coast Survey in early 2017 to reduce user interaction, user error, and processing time. Night processing includes all of those tasks in between raw data collection and a final daily product, which is usually a surface that includes all up-to-date data. Charlene allows the user to:

1. Perform verification of raw data
2. Build deliverable directory structure
3. Transfer and verify raw data
4. Process MBES and SSS data with Caris Batch Processor
5. Generate SBETs with POSPac Batch
6. Use NOAA Pydro tools like AutoQC, QCTools, and TCARI

The development of Charlene was made possible when recent versions of Caris and Applanix (10.2 and 8.1 respectively) opened up machine access to the processes in these packages. This now allowed the ability to run these software packages outside of the graphical interface. Charlene leverages this to become the universal night processing tool. Charlene works across software platforms; it can transfer raw data to the appropriate submission folders, process SBETs, convert survey lines into Caris, apply sound velocity profiles, water levels, and SBETs, run in-house QC reports, and generate logs. In practice, Fairweather has set up Charlene to largely follow the current processing pipeline with the exception of now adopting the official file submission structure for data storage instead of creating it just for the data submission. Manual data processing procedures are used when the survey team runs into technical difficulties while running Charlene.

Final data processing and analysis is the responsibility of the Survey Team. While “ping-by-ping” data editing is not required, the Team will review the survey in its entirety to ensure that the final products reflect observed conditions to the standards set by the relevant OCS guidance. Bathymetric surfaces are reviewed with the best available correctors applied to ensure that all data quality problems are identified and resolved if possible, and all submerged features are accurately represented. Shoreline verification (if applicable) and feature data are reviewed in the context of this bathymetry. Survey documentation (including the Descriptive Report) is generated in conjunction with this review process.

B.3 Quality Management

Final review of the CUBE Surface is left to the Mentor or experienced Survey Manager who inspects areas with questionable shaded depth models and/or high standard deviation to ensure that no actual features were cleaned out. The use of large subset tiles is encouraged to track coverage of problems areas. Flier Finder v3, part of the QC Tools package within Pydro, is currently used to assist the search for spurious soundings following gross cleaning. Flier Finder is run multiple times for each surface, reducing the flier height value for each consecutive run. This allowed Flier Finder to very accurately and quickly identify gross fliers.

Variable resolution (VR) surfaces grid data at the resolution that corresponds to the appropriate depth range as specified by 5.2.2.2 of the HSSD. On occasion, the resolution of the surface may not be sufficient to capture the high point of a feature. In less than 20m of water, any feature where the most probable accurate sounding was shoaler than the surface by greater than one half the allowable error under IHO S-44 Order 1 was considered inadequately captured by the CUBE surface. In greater than 20m of water, this allowable error was expanded to the full Order 1 error allowance at that depth. Although this may occur on irregular shoals or rock pinnacles, man-made features such as piles and wrecks are of particular concern. These features have very slender high points that extend far above the surrounding seafloor as well as the CUBE surface. To ensure that these features are properly represented, the shoalest point is flagged “designated” in CARIS.

During the “finalization” process, the CUBE surface is forced to honor all soundings which have been flagged “designated.” In the case of a survey where the high points of many features are not being captured by the CUBE surface, (e.g. a boulder field), the hydrographer may decide to produce higher resolution CUBE surfaces to ensure that these features are being honored. Any such deviations from standard procedures will be noted in that survey’s Descriptive Report.

Under ideal circumstances VR surfaces grid data at the finest resolution the data density will support, allowing the production a single BASE surface as the final deliverable. This theoretical maximum resolution was historically defined as three times the beam footprint size for a particular echo sounder and depth combination. Current guidance (HSSD 5.2.2.3) states that 95% of the nodes in a CUBE surface shall contain at least 5 soundings per node, which has experimentally been shown to be adequate to represent the depth of the seafloor while not being strongly influenced by a single erroneous sounding. To meet the required sounding density, Fairweather adheres to the table of resolutions and depth ranges as defined in HSSD which are based on practical experience in typical survey areas, and a working knowledge of bottom coverage capabilities of each echo sounding system currently in use throughout the fleet.

Although we have transitioned to VR surfaces, the Fairweather may occasionally use single resolution CUBE surfaces to address problem areas within surveys or meet particular needs that may arise on a sheet to sheet basis. The following text describes procedures for single resolution gridded surfaces.

Single resolution CUBE surfaces are based on assumed sonar system selections for each depth regime and practical data processing limitations. Deeper areas are gridded at a coarser resolution than shoaler areas with the advent of the CARIS CSAR framework and multi-threaded CUBE processing implemented in CARIS HIPS and SIPS. The CUBE surface resolutions are described for each survey in the Descriptive Report.

Each resolution-specific CUBE surface is named according to the following convention:

<Survey registry number>_<Sounding Type>_<units of resolution>_<Vertical Datum>

(EX: “H12780_MB_2m_MLLW” is the two-meter resolution surface of survey H12780 referenced to MLLW. VR will replace 2m for VR surfaces)

Once the VR surface or the collection of CUBE surfaces accurately represent the surveyed bottom and it is certain that no further edits will be made, surfaces are finalized using the resolution as defined in section 5.2.2.2 or 5.2.2.3 of the HSSD depending on whether coverage meet object detection or complete coverage specifications. The final CUBE surfaces are examined by reviewing all layers for coverage and as a final check for systematic errors such as tide, sound speed, or attitude and/or timing errors.

B.4 Uncertainty and Error Management

CARIS computes TPU based on both the static and dynamic measurements of the vessel and survey-specific information including tidal zoning uncertainty estimates and sound speed measurement uncertainties. Static offset values are entered into the CARIS *.hvf file. Real-time uncertainties provided via EM2040 MBES data, positioning errors via Applanix Delayed Heave RMS, and sound speed uncertainties are applied using the CARIS Compute TPU tool. Where TCARI tides are used, uncertainty is calculated and applied during application of TCARI tidal correctors to HDCS data. Following post-processing of the real-time vessel motion, recomputed uncertainties of vessel roll, pitch, gyro, and navigation were applied in CARIS HIPS and SIPS via a Smoothed Best Estimate of Trajectory (SBET) RMS file generated in Applanix POSPac.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

TPU is calculated in CARIS HIPS using the Compute TPU tool. Project specific values for tidal referencing, ERS positioning and sound speed are entered and used over the duration of the project.

B.4.1.2 Source of TPU Values

Uncertainty values for the multibeam and positioning systems were compiled from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 and Appendix 4 - CARIS HVF Uncertainty Values of the 2014 FPM. The values listed below for Kongsberg MBES systems are attributed to the 300 kHz frequency but apply to the 200 and 400 kHz frequencies of the Fairweather's Kongsberg EM2040 sonars, all three frequencies are produced from a single transducer head.

Uncertainty values for the SBES system were derived from manufacturer specifications and observation of environmental conditions. As the positioning system is not capable of recording heave, the estimated uncertainty due to heave and wave action has been included in the HVF.

B.4.1.3 TPU Values

Vessel	FA_2805_EM2040		
Echosounder	Kongsberg Simrad EM 2040 300 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.500 meters	
	Timing	*Transducer*	0.001 seconds
		Navigation	0.001 seconds
		Gyro	0.001 seconds
		Heave	0.001 seconds
		Pitch	0.001 seconds
		Roll	0.001 seconds
	Offsets	*x*	0.006 meters
		y	0.006 meters
		z	0.006 meters

	MRU Alignment	*Gyro*	0.10 degrees
		Pitch	0.07 degrees
		Roll	0.07 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.018 meters
		Draft	0.017 meters
		Delta Draft	0.04 meters
Vessel	FA_2806_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.05 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.5 meters	
	Timing	*Transducer*	0.001 seconds
		Navigation	0.001 seconds
		Gyro	0.001 seconds
		Heave	0.001 seconds
		Pitch	0.001 seconds
		Roll	0.001 seconds
	Offsets	*x*	0.006 meters
		y	0.006 meters
		z	0.006 meters
	MRU Alignment	*Gyro*	0.10 degrees
		Pitch	0.07 degrees
		Roll	0.07 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.018 meters
		Draft	0.006 meters
		Delta Draft	0.04 meters
Vessel	FA_2807_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude
			0.05 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position		0.5 meters
	Timing	*Transducer*	0.001 seconds
		Navigation	0.001 seconds
		Gyro	0.001 seconds
		Heave	0.001 seconds
		Pitch	0.001 seconds
		Roll	0.001 seconds
	Offsets	*x*	0.006 meters
		y	0.006 meters
		z	0.006 meters
	MRU Alignment	*Gyro*	0.1 degrees
		Pitch	0.07 degrees
		Roll	0.07 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.018 meters
		Draft	0.012 meters
		Delta Draft	0.040 meters
Vessel	FA_2808_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude
			0.05 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position		0.5 meters

	Timing	*Transducer*	0.001 seconds
		Navigation	0.001 seconds
		Gyro	0.001 seconds
		Heave	0.001 seconds
		Pitch	0.001 seconds
		Roll	0.001 seconds
	Offsets	*x*	0.006 meters
		y	0.006 meters
		z	0.006 meters
	MRU Alignment	*Gyro*	0.1 degrees
		Pitch	0.07 degrees
		Roll	0.07 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.018 meters
		Draft	0.018 meters
		Delta Draft	0.04 meters
Vessel	FA_S220_EM710		
Echosounder	Kongsberg Simrad EM710 100 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude 0.05 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.5 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*	0.06 degrees
		Pitch	0.04 degrees
		Roll	0.04 degrees
	Vessel	*Speed*	0.03 meters/second
		Loading	0.116 meters
		Draft	0.128 meters
		Delta Draft	0.1 meters
Vessel	FA_2302_CEEPulse_SB		
Echosounder	CEE HydroSystems, Inc. CEEPulse 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.00 degrees
		Heave	0.00 % Amplitude 0.20 meters
		Pitch	0.00 degrees
		Roll	0.00 degrees
	Navigation Position	1.53 meters	
	Timing	*Transducer*	0.01 seconds
		Navigation	0.001 seconds
		Gyro	0.00 seconds
		Heave	0.00 seconds
		Pitch	0.00 seconds
		Roll	0.00 seconds
	Offsets	*x*	0.02 meters
		y	0.02 meters
		z	0.01 meters
	MRU Alignment	*Gyro*	0.00 degrees
		Pitch	0.00 degrees
		Roll	0.00 degrees
	Vessel	*Speed*	0.10 meters/second
		Loading	0.03 meters
		Draft	0.05 meters
		Delta Draft	0 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

Vessel offset correctors are the values used to describe the location of all hydrographic sensors in relation to a defined reference point. These values are necessary to compute sensor lever arms to correct for vessel orientation and ultimately produce the final geographic position for each sounding collected.

C.1.1.2 Methods and Procedures

Permanent control points were established on launches 2805, 2806, 2807, and 2808 during construction at All American Marine in 2009. Sensor offsets are measured with respect to each vessel's reference point. The reference point for Fairweather's survey launches 2805, 2806, 2807, and 2808 is the phase center of the Kongsberg EM2040 transmitter. The offset values from the reference point to the primary GNSS antenna and reference point to IMU are entered into the POS MV configuration so that all raw position data are centered at the vessel's reference point. These offsets are included in the attached "280X_Offset_HVF" reports.

For Fairweather's ship sonar system the reference point for the positioning and attitude system was placed at the EM710 transmit array by entering the surveyed translational and rotational offsets of the IMU and antennae into the POS configuration. Thus the position and attitude reported by the POS, including heave and delayed heave, are valid at the transmit array. Furthermore, it is this reference point that is assigned as the "center of rotation" in POS for the purposes of applying the heave filter (the reference to center of rotation field is zero).

Transducer and navigation offsets and alignments in SIS were also entered according to the EM710 transmitter reference frame. The surveyed translational and angular offsets of the EM710 receiver array (labeled "RX Transducer") relative to the transmit array were entered into SIS. Since the transmit array is at the reference point and is aligned with the reference frame by definition, the translational and angular offsets of the transmit array (labeled "TX Transducer") are all zero. Since the reference point of the POS was configured to be at and aligned with the transmit array centered frame, the offsets for the position and attitude data from the POS are also zero in SIS. This is also true for our EM240 systems, except that the offsets were derived from the engineering drawings of the sonar mount rather than being surveyed.

With this approach, any residual misalignment between the EM710 or EM2040 and the IMU discovered in a patch test would be added to the IMU alignment with respect to the reference frame in the POS configuration.

Offsets in the CARIS HVF also account for the offset between the EM710 transmitter and EM2040 receivers, but is entered only in SVP 2 so that SV files are properly applied. The CARIS HVF is maintained for Fairweather, and is required for application of SV and dynamic draft correctors. For this HVF, all vessel offset values have been set to zero to avoid double-correction. The only exceptions to this are the SVP 2 offset values (and waterline discussed in section C.2.1) that are required for SV application.

Offsets for the hull mounted Klein 5000 sonar systems on 2807 and 2808 were measured directly from the center of the EM2040 transmitter and entered into a separate HVF from the MBES ones for each vessel. These offsets are included in the attached "280X_Offset_HVF" reports.

Offsets for the CEEPulse SBES installed on 2302 were determined by direct measurement of the mounting hardware. The GPS antenna was positioned directly over the transducer, so there are no horizontal offsets required for positioning. The vertical offset for sounding correction is the static draft, as discussed in C.2.1.2.

Values for CARIS HVF

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

HVF

Transducer 1

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Manufacturer	Model
2017-090	0:00	0	0	0	0	0	0	0	Kongsberg	EM2040

Transducer 2

Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Start Beam num
0	0	0	0	0	0	0	1,000

TPU Values - Offsets

MRU to Trans X (m)	MRU to Trans2 X (m)	MRU to Trans Y (m)	MRU to Trans2 Y (m)	MRU to Trans Z (m)	MRU to Trans2 Z (m)	Nav to Trans X (m)	Nav to Trans2 X (m)	Nav to Trans Y (m)	Nav to Trans2 Y (m)	Nav to Trans Z (m)	Nav to Trans2 Z (m)	Trans Roll (deg)	Trans Roll 2 (deg)
0.195	-0.110	0.148	0.048	0.534	0.518	0.877	0.572	0.954	0.854	3.624	3.608	0.000	0.000

TPU Values - StdDev

Motion Gyro (deg)	Heave % Amp	Heave (m)	Roll (deg)	Pitch (deg)	Position Nav (m)	Timing Trans (s)	Nav Timing (s)	Gyro Timing (s)	Heave Timing (s)	Pitch Timing (s)	Roll Timing (s)
0.020	5.000	0.050	0.020	0.020	0.500	0.001	0.001	0.001	0.001	0.001	0.001
From POS Specs						*Per POS Manual (v5, Appendix H-3), errors are in order of tenths of microsecond up to a "few". One seems reasonable.*					

Offset X (m)	Offset Y (m)	Offset Z (m)	Vessel Speed (m/s)	Loading (m)	Draft (m)	Delta Draft (m)	MRU Align StdDev gyro	MRU Align StdDev Roll/Pitch	Comments
0.006	0.006	0.006	0.030	0.018	0.017	0.040	0.100	0.070	2017 HSRR
Last vessel survey was to 1mm, 6 is conservative.			*POS Specs*	*Half of est. diff in draft from empty to full fuel & 4 people*	*STDEV of 2017 WL measure ments*	*STDEV from dynamic draft spreadsheet*	*From Sonar Acceptance Patch Tests*		

SVP 1

Date	Time	Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth	Comments
2017-090	0:00	0	0	0	0	0	0	Tx; ref. point

SVP 2

Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth
-0.305	-0.100	-0.016	0	0	0

Waterline Height

Date	Time	Apply?	Waterline (m)	Comments
2017-090	0:00	Yes	-0.619	2017 HSRR

Figure 42: 2805 MBES HVF values

Values for CARIS HVF

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

HVF

Transducer 1

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Manufacturer	Model
2017-090	0:00	0	0	0	0	0	0	0	Kongsberg	EM2040

Transducer 2

Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Start Beam num
0	0	0	0	0	0	0	1,000

TPU Values - Offsets

MRU to Trans X (m)	MRU to Trans2 X (m)	MRU to Trans Y (m)	MRU to Trans2 Y (m)	MRU to Trans Z (m)	MRU to Trans2 Z (m)	Nav to Trans X (m)	Nav to Trans2 X (m)	Nav to Trans Y (m)	Nav to Trans2 Y (m)	Nav to Trans Z (m)	Nav to Trans2 Z (m)	Trans Roll (deg)	Trans Roll 2 (deg)
0.205	-0.100	0.134	0.034	0.532	0.516	0.842	0.537	0.966	0.866	3.608	3.592	0.000	0.000

TPU Values - StdDev

Motion Gyro (deg)	Heave % Amp	Heave (m)	Roll (deg)	Pitch (deg)	Position Nav (m)	Timing Trans (s)	Nav Timing (s)	Gyro Timing (s)	Heave Timing (s)	Pitch Timing (s)	Roll Timing (s)
0.020	5.000	0.050	0.020	0.020	0.500	0.001	0.001	0.001	0.001	0.001	0.001
From POS Specs						*Per POS Manual (v5, Appendix H-3), errors are in order of tenths of microsecond up to a "few". One seems reasonable.*					

Offset X (m)	Offset Y (m)	Offset Z (m)	Vessel Speed (m/s)	Loading (m)	Draft (m)	Delta Draft (m)	MRU Align StdDev gyro	MRU Align StdDev Roll/Pitch	Comments
0.006	0.006	0.006	0.030	0.018	0.006	0.040	0.100	0.070	2017 HSRR
Last vessel survey was to 1mm, 6 is conservative.			*POS Specs*	*Half of est. diff in draft from empty to full fuel & 4 people*	*STDEV of 2017 WL measure ments*	*STDEV from dynamic draft spreadsheet*	*From Sonar Acceptance Patch Tests*		

SVP 1

Date	Time	Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth	Comments
2017-090	0:00	0	0	0	0	0	0	Tx; ref. point

SVP 2

Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth
-0.304	-0.100	-0.016	0	0	0

Waterline Height

Date	Time	Apply?	Waterline (m)	Comments
2017-090	0:00	Yes	-0.640	2017 HSRR

Figure 43: 2806 MBES HVF values

Values for CARIS HVF

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

HVF

Transducer 1

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Manufacturer	Model
2017-090	0:00	0	0	0	0	0	0	0	Kongsberg	EM2040

Transducer 2

Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Start Beam num
0	0	0	0	0	0	0	1,000

TPU Values - Offsets

MRU to Trans X (m)	MRU to Trans2 X (m)	MRU to Trans Y (m)	MRU to Trans2 Y (m)	MRU to Trans Z (m)	MRU to Trans2 Z (m)	Nav to Trans X (m)	Nav to Trans2 X (m)	Nav to Trans Y (m)	Nav to Trans2 Y (m)	Nav to Trans Z (m)	Nav to Trans2 Z (m)	Trans Roll (deg)	Trans Roll 2 (deg)
0.207	-0.098	0.130	0.030	0.540	0.523	0.992	0.688	0.941	0.841	3.602	3.586	0.000	0.000

TPU Values - StdDev

Motion Gyro (deg)	Heave % Amp	Heave (m)	Roll (deg)	Pitch (deg)	Position Nav (m)	Timing Trans (s)	Nav Timing (s)	Gyro Timing (s)	Heave Timing (s)	Pitch Timing (s)	Roll Timing (s)
0.020	5.000	0.050	0.020	0.020	0.500	0.001	0.001	0.001	0.001	0.001	0.001
From POS Specs						*Per POS Manual (v5, Appendix H-3), errors are in order of tenths of microsecond up to a "few". One seems reasonable.*					

Offset X (m)	Offset Y (m)	Offset Z (m)	Vessel Speed (m/s)	Loading (m)	Draft (m)	Delta Draft (m)	MRU Align StdDev gyro	MRU Align StdDev Roll/Pitch	Comments
0.006	0.006	0.006	0.030	0.018	0.012	0.040	0.100	0.070	2017 HSRR
Last vessel survey was to 1mm, 6 is conservative.			*POS Specs*	*Half of est. diff in draft from empty to full fuel & 4 people*	*STDEV of 2017 WL measure ments*	*STDEV from dynamic draft spreadsheet*	*From Sonar Acceptance Patch Tests*		

SVP 1

Date	Time	Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth	Comments
2017-090	0:00	0	0	0	0	0	0	Tx; ref. point

SVP 2

Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth
-0.305	-0.100	-0.016	0	0	0

Waterline Height

Date	Time	Apply?	Waterline (m)	Comments
2017-090	0:00	No	-0.639	2017 HSRR

Figure 44: 2807 MBES HVF values

Values of CARIS HVF; Hull Mount

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

Navigation

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Ellipsoid	Manufacturer	Model	Serial Number	Comments
2015-061	0:00	0	0	0	0	NAD83	(null)	(null)	(null)	(null)

Tow Point

Date	Time	Delta X (m)	Delta Y (m)	Delta Z (m)	Layback Error (m)	Manufacturer	Serial Number	Comments
2017-121	0:00	0.342	0.491	0.181	0	Klein		Measured from 2040 Tx 2017

Waterline Height

Date	Time	Apply	Waterline (m)	Comments
2017-121	0:00	No	-0.639	2017 HSRR

Figure 45: 2807 SSS HVF values

Values for CARIS HVF

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

HVF

Transducer 1

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Manufacturer	Model
2017-090	00:00	0	0	0	0	0	0	0	Kongsberg	EM2040

Transducer 2

Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Start Beam num
0	0	0	0	0	0	0	1,000

TPU Values - Offsets

MRU to Trans X (m)	MRU to Trans2 X (m)	MRU to Trans Y (m)	MRU to Trans2 Y (m)	MRU to Trans Z (m)	MRU to Trans2 Z (m)	Nav to Trans X (m)	Nav to Trans2 X (m)	Nav to Trans Y (m)	Nav to Trans2 Y (m)	Nav to Trans Z (m)	Nav to Trans2 Z (m)	Trans Roll (deg)	Trans Roll 2 (deg)
0.205	-0.100	0.140	0.040	0.534	0.518	0.886	0.582	0.977	0.877	3.610	3.593	0.000	0.000

TPU Values - StdDev

Motion Gyro (deg)	Heave % Amp	Heave (m)	Roll (deg)	Pitch (deg)	Position Nav (m)	Timing Trans (s)	Nav Timing (s)	Gyro Timing (s)	Heave Timing (s)	Pitch Timing (s)	Roll Timing (s)
0.020	5.000	0.050	0.020	0.020	0.500	0.001	0.001	0.001	0.001	0.001	0.001
From POS Specs						*Per POS Manual (v5, Appendix H-3), errors are in order of tenths of microsecond up to a "few". One seems reasonable.*					

Offset X (m)	Offset Y (m)	Offset Z (m)	Vessel Speed (m/s)	Loading (m)	Draft (m)	Delta Draft (m)	MRU Align StdDev gyro	MRU Align StdDev Roll/Pitch	Comments
0.006	0.006	0.006	0.030	0.018	0.018	0.040	0.100	0.070	YYYY HSRR
Last vessel survey was to 1mm, 6 is conservative.			*POS Specs*	*Half of est. diff in draft from empty to full fuel & 4 people*	*STDEV of 2017 WL measure ments*	*STDEV from dynamic draft spreadsheet*	*From Sonar Acceptance Patch Tests*		

SVP 1

Date	Time	Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth	Comments
2017-090	00:00	0	0	0	0	0	0	Tx; ref. point

SVP 2

Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth
-0.305	-0.100	-0.016	0.000	0.000	0.000

Waterline Height

Date	Time	Apply?	Waterline (m)	Comments
2017-090	00:00	No	-0.646	20XX HSRR

Figure 46: 2808 MBES HVF values

Values of CARIS HVF; Hull Mount

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

Navigation

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Ellipsoid	Manufacturer	Model	Serial Number	Comments
2015-060	0:00	0	0	0	0	NAD83	Applanix	POS MV	(null)	(null)

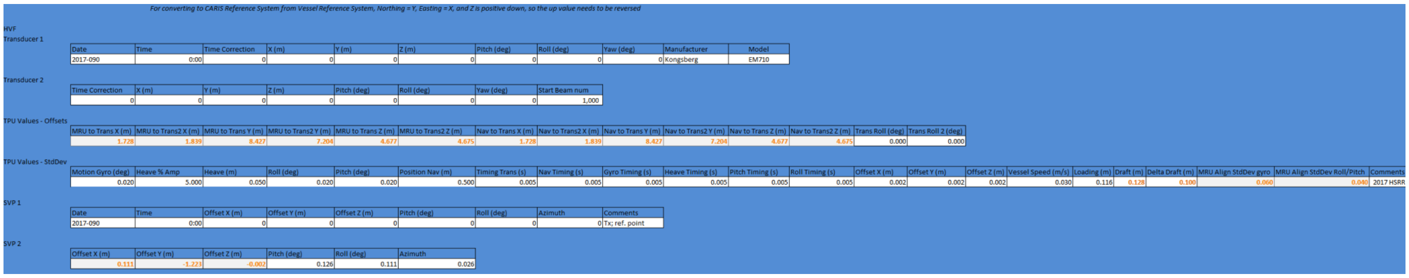
Tow Point

Date	Time	Delta X (m)	Delta Y (m)	Delta Z (m)	Layback Error (m)	Manufacturer	Serial Number	Comments
2017-121	0:00	-0.755	0.509	0.175	0	Klein		2017 Measured from 2040 Tx

Waterline Height

Date	Time	Apply	Waterline (m)	Comments
2017-121	0:00	No	-0.646	2017 HSRR

Figure 47: 2808 SSS HVF values



For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

HVF
Transducer 1

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Manufacturer	Model
2017-090	0:00	0	0	0	0	0	0	0	Kongsberg	EM710

Transducer 2

Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Start Beam num
0	0	0	0	0	0	0	1,000

TPU Values - Offsets

MRU to Trans X (m)	MRU to Trans2 X (m)	MRU to Trans Y (m)	MRU to Trans2 Y (m)	MRU to Trans Z (m)	MRU to Trans2 Z (m)	Nav to Trans X (m)	Nav to Trans2 X (m)	Nav to Trans Y (m)	Nav to Trans2 Y (m)	Nav to Trans Z (m)	Nav to Trans2 Z (m)	Trans Roll (deg)	Trans Roll 2 (deg)
1.728	1.839	8.427	7.204	4.677	4.675	1.728	1.839	8.427	7.204	4.677	4.675	0.000	0.000

TPU Values - StdDev

Motion Gyro (deg)	Heave % Amp	Heave (m)	Roll (deg)	Pitch (deg)	Position Nav (m)	Timing Trans (s)	Nav Timing (s)	Gyro Timing (s)	Heave Timing (s)	Pitch Timing (s)	Roll Timing (s)	Offset X (m)	Offset Y (m)	Offset Z (m)	Vessel Speed (m/s)	Loading (m)	Draft (m)	Delta Draft (m)	MRU Align StdDev gyro	MRU Align StdDev Roll/Pitch	Comments
0.020	5.000	0.050	0.020	0.020	0.500	0.005	0.005	0.005	0.005	0.005	0.005	0.002	0.002	0.002	0.030	0.116	0.128	0.100	0.060	0.040	2017 HSRR

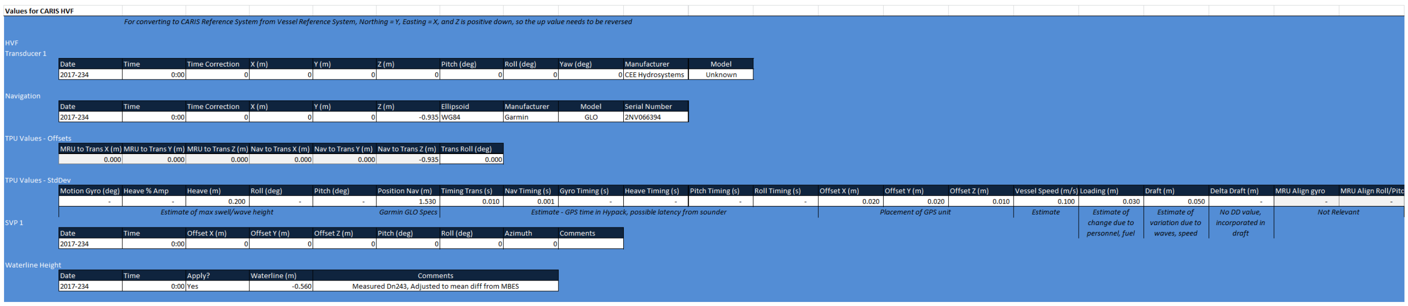
SVP 1

Date	Time	Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth	Comments
2017-090	0:00	0	0	0	0	0	0	Tx; ref. point

SVP 2

Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth
0.111	-1.223	-0.002	0.126	0.111	0.026

Figure 48: S220 MBES HVF values



Values for CARIS HVF

For converting to CARIS Reference System from Vessel Reference System, Northing = Y, Easting = X, and Z is positive down, so the up value needs to be reversed

HVF
Transducer 1

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Pitch (deg)	Roll (deg)	Yaw (deg)	Manufacturer	Model
2017-234	0:00	0	0	0	0	0	0	0	CEE Hydrosystems	Unknown

Navigation

Date	Time	Time Correction	X (m)	Y (m)	Z (m)	Ellipsoid	Manufacturer	Model	Serial Number
2017-234	0:00	0	0	0	-0.935	WG84	Garmin	GLO	2NV066394

TPU Values - Offsets

MRU to Trans X (m)	MRU to Trans Y (m)	MRU to Trans Z (m)	Nav to Trans X (m)	Nav to Trans Y (m)	Nav to Trans Z (m)	Trans Roll (deg)
0.000	0.000	0.000	0.000	0.000	-0.935	0.000

TPU Values - StdDev

Motion Gyro (deg)	Heave % Amp	Heave (m)	Roll (deg)	Pitch (deg)	Position Nav (m)	Timing Trans (s)	Nav Timing (s)	Gyro Timing (s)	Heave Timing (s)	Pitch Timing (s)	Roll Timing (s)	Offset X (m)	Offset Y (m)	Offset Z (m)	Vessel Speed (m/s)	Loading (m)	Draft (m)	Delta Draft (m)	MRU Align gyro	MRU Align Roll/Pitch
-	-	0.200	-	-	1.530	0.010	0.001	-	-	-	-	0.020	0.020	0.010	0.100	0.030	0.050	-	-	-
Estimate of max swell/wave height					*Garmin GLO Specs*	*Estimate - GPS time in Hypack, possible latency from sounder*						*Placement of GPS unit*			*Estimate*	*Estimate of change due to personnel, fuel*	*Estimate of variation due to waves, speed*	*No DD value, incorporated in draft*	*Not Relevant*	

SVP 1

Date	Time	Offset X (m)	Offset Y (m)	Offset Z (m)	Pitch (deg)	Roll (deg)	Azimuth	Comments
2017-234	0:00	0	0	0	0	0	0	

Waterline Height

Date	Time	Apply?	Waterline (m)	Comments
2017-234	0:00	Yes	-0.560	Measured Dn243, Adjusted to mean diff from MBES

Figure 49: 2302 SBES HVF Values

C.1.1.3 Vessel Offset Correctors

Vessel	FA_2805_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		
Date	2017-04-27		
Offsets	*MRU to Transducer*	*x*	0.195 meters
		y	0.148 meters
		z	0.534 meters
		x2	-0.110 meters
		y2	0.048 meters
		z2	0.518 meters
	Nav to Transducer	*x*	0.877 meters
		y	0.954 meters
		z	3.624 meters
		x2	0.572 meters
		y2	0.854 meters
		z2	3.608 meters
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees

Vessel	FA_2806_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		
Date	2017-04-27		
Offsets	*MRU to Transducer*	*x*	0.205 meters
		y	0.134 meters
		z	0.532 meters
		x2	-0.100 meters
		y2	0.034 meters
		z2	0.516 meters
	Nav to Transducer	*x*	0.842 meters
		y	0.966 meters
		z	3.608 meters
		x2	0.537 meters
		y2	0.866 meters
		z2	3.592 meters
	Transducer Roll	*Roll*	0.00 degrees
		Roll2	0.00 degrees
Vessel	FA_2807_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		
Date	2017-04-27		
Offsets	*MRU to Transducer*	*x*	0.207 meters
		y	0.130 meters
		z	0.540 meters
		x2	-0.098 meters
		y2	0.030 meters
		z2	0.523 meters
	Nav to Transducer	*x*	0.992 meters
		y	0.941 meters
		z	3.602 meters
		x2	0.688 meters
		y2	0.841 meters
		z2	3.586 meters
	Transducer Roll	*Roll*	0.00 degrees
		Roll2	0.00 degrees
Vessel	FA_2808_EM2040		
Echosounder	Kongsberg Simrad EM2040 300 kilohertz		

Date	2017-04-27		
Offsets	*MRU to Transducer*	*x*	0.205 meters
		y	0.140 meters
		z	0.534 meters
		x2	-0.100 meters
		y2	0.040 meters
		z2	0.518 meters
	Nav to Transducer	*x*	0.886 meters
		y	0.977 meters
		z	3.610 meters
		x2	0.582 meters
		y2	0.877 meters
		z2	3.593 meters
	Transducer Roll	*Roll*	0.00 degrees
		Roll2	0.00 degrees
Vessel	FA_S220_EM710_2015		
Echosounder	Kongsberg EM-710 100 kilohertz		
Date	2017-04-27		
Offsets	*MRU to Transducer*	*x*	1.728 meters
		y	8.427 meters
		z	4.677 meters
		x2	1.839 meters
		y2	7.204 meters
		z2	4.675 meters
	Nav to Transducer	*x*	1.728 meters
		y	8.427 meters
		z	4.677 meters
		x2	1.839 meters
		y2	7.204 meters
		z2	4.675 meters
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees

C.1.2 Layback

Layback correctors were not applied.

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Static draft correctors are the z-values used to describe the difference between the measured waterline on the hull and the reference point while the vessel is at rest. This value is required to correct for the draft of the transducer when computing the corrected water depths.

C.2.1.2 Methods and Procedures

The static drafts (Waterline Height in the HVF) for launches 2805, 2806, 2807, and 2808 were calculated based on steel tape and plumb bob measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline. Measurements were conducted between February and April of 2017 in Yaquina Bay, Newport, OR. The values and calculations for static draft of the various launches are listed in the respective Waterline Measurement spreadsheets included in this report.

For both the S220 and launch sonar systems, static draft corrector values are entered in the Kongsberg SIS Installation Parameters window. The loading condition of the ship, particularly fuel and launches, has a significant influence on static draft in comparison to the launches. To compensate and monitor for static draft changes, static draft values are measured on S220 after any changes in fuel levels and at the start of each leg throughout the season. In addition to being entered into the SIS Installation Parameters window, waterline values for S220 and the launches are entered in the CARIS HVF. This waterline value in CARIS will only be used during Sound Speed Correction. The Apply switch is also set to “No” to avoid double application of the waterline value during HIPS merge.

Static draft for the CEEPulse single beam sonar installed on 2302 was measured directly between the sonar head and waterline with a tape measure while the system was in the deployed configuration. This value was entered into the HVF for initial application in HIPS and SIPS. After data collection, comparison was made to MBES data from overlapping areas and the waterline in the HVF shifted to result in zero mean difference. This value for the draft at survey speed is -0.56 m, which was used for the submitted data corrector. This was used as a replacement for the lack of systematically measured dynamic draft since all data was acquired at approximately the same speed.

2805 Waterline Measurements

Background Info

Date:	3/4/2017	Notes:
Launch Fuel Level:	1/2 tank	sunny, calm seas
Persons Onboard:	Murphy, Gassett, Wozumi	

Raw Measurements

Name:	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.981)	(0.986)	(0.990)	(0.988)	(1.000)	(0.992)
Stbd Benchmark to Waterline	(0.956)	(0.956)	(0.955)	(0.968)	(0.960)	(0.962)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
Avg (m)	(0.986)	(0.956)	(0.993)	(0.963)
Stdev (m)	0.005	0.001	0.006	0.004

	Measurer A			Measurer B		
	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	0.032	(0.030)	0.062	0.032	(0.030)	0.062

Waterline Value

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
BM Z-Value (m)*	1.075	1.043	1.075	1.043
RP to WL (m)	0.089	0.087	0.082	0.080

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.085**	*This value is used in the 2805 vessel offset workbook*
Global STDEV (m)	**0.017**	*This value is used in the 2805 vessel TPU workbook*

Value for HVF (m) -0.619

Figure 50: 2805 Waterline Measurement

2806 Waterline Measurements

Background Info

		Notes:
Date:	6/4/2017	
Launch Fuel Level:	1/2 tank	
Persons Onboard:	Murphy, Sharr, Wozumi	overcast, calm seas

Raw Measurements

Name:	Murphy			Wozumi		
	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.949)	(0.955)	(0.952)	(0.957)	(0.945)	(0.949)
Stbd Benchmark to Waterline	(0.947)	(0.934)	(0.945)	(0.954)	(0.955)	(0.952)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
Avg (m)	(0.952)	(0.942)	(0.950)	(0.954)
Stdev (m)	0.003	0.007	0.006	0.002

	Measurer A			Measurer B		
	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	0.078	(0.010)	0.088	0.078	0.003	0.075

Waterline Value

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
BM Z-Value (m)*	1.096	1.018	1.096	1.018
RP to WL (m)	0.144	0.076	0.146	0.064

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.108**	*This value is used in the 2806 vessel offset workbook*
Global STDEV (m)	**0.006**	*This value is used in the 2806 vessel TPU workbook*

Value for HVF (m) **-0.640**

Figure 51: 2806 Waterline Measurement

2807 Waterline Measurements

Background Info

Date:	**3/4/2017**	Notes:
Launch Fuel Level:	**1/2 tank**	**sunny,calm seas**
Persons Onboard:	**Murphy, Gassett, Wozumi**	

Raw Measurements

Name:	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.966)	(0.970)	(0.966)	(0.982)	(0.962)	(0.972)
Stbd Benchmark to Waterline	(0.942)	(0.946)	(0.944)	(0.966)	(0.954)	(0.968)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	**STBD**	**Port**	**STBD**
Avg (m)	(0.967)	(0.944)	(0.972)	(0.963)
Stdev (m)	0.002	0.002	0.010	0.008

	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	(0.055)	(0.023)	0.032	(0.055)	(0.009)	0.046

Waterline Value

	Measurer A		Measurer B	
	Port	**STBD**	**Port**	**STBD**
BM Z-Value (m)*	1.033	1.088	1.033	1.088
RP to WL (m)	0.066	0.144	0.061	0.125

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.099**	*This value is used in the 2807 vessel offset workbook*
Global STDEV (m)	**0.012**	*This value is used in the 2807 vessel TPU workbook*

Value for HVF (m) **-0.639**

Figure 52: 2807 Waterline Measurement

2808 Waterline Measurements

Background Info

Date:	3/4/2017
Launch Fuel Level:	half
Persons Onboard:	3

Notes:
sunny calm seas

Raw Measurements

Name:	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.962)	(0.960)	(0.960)	(0.972)	(0.962)	(0.970)
Stbd Benchmark to Waterline	(0.928)	(0.928)	(0.928)	(0.940)	(0.936)	(0.928)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
Avg (m)	(0.961)	(0.928)	(0.968)	(0.935)
Stdev (m)	0.001	-	0.005	0.006

	Measurer A			Measurer B		
	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	0.032	(0.033)	0.065	0.032	(0.033)	0.065

Waterline Value

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
BM Z-Value (m)*	1.076	1.044	1.076	1.044
RP to WL (m)	0.115	0.116	0.108	0.109

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.112**	*This value is used in the 2808 vessel offset workbook*
Global STDEV (m)	**0.018**	*This value is used in the 2808 vessel TPU workbook*

Value for HVF (m) -0.646

Figure 53: 2808 Waterline Measurement

Historical AVG Static Draft: 4.63

Date	Port measurement #1	Port measurement #2	STBD Measurement #1	STBD measurement #2	Average	Translation (enter "-" # in CARIS HVF)	Notes:
5/17/2017	5.80	6.00	6.00	6.00	5.95	4.73	All launches aboard, moored port side 98,247gl fuel
6/5/2017	5.90	5.90	6.00	6.00	5.95	4.73	All launches aboard, moored starboard side fuel tanks 130,003 gl
7/12/2017	6.10	6.10	5.90	6.30	6.10	4.58	All launches aboard,
8/1/2017	6.10	6.10	6.20	6.20	6.15	4.53	All launches aboard
8/9/2017	6.00	6.00	6.10	6.10	6.05	4.63	all launches aboard, 96,600, gal
8/17/2017	5.95	6.00	5.80	6.10	5.96	4.72	All launches aboard, potable water 1/4, 93,200 gal
9/4/2017	5.70	6.10	6.10	6.40	6.08	4.61	All launches aboard, 77000 gal
9/20/2017	6.20		6.30		6.25	4.43	Launches aboard, 59000 gal
10/27/2017	5.90	6.00	6.00	6.00	5.98	4.71	2 launches out, 67000 gal

Figure 54: S220 Waterline Measurement

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

The purpose of the dynamic draft and settlement & squat measurements (DDSSM) is to correlate a vessel's speed through the water with the vertical rise/fall of the vessel's Inertial Navigation System (INS) reference point (the sonar transmitter for all Fairweather systems). Since Fairweather's launches lack a method of accurately logging speed through the water, the GPS-based speed over ground (SOG) is used as a proxy. Consequently, the presence of currents introduce errors into the DDSSM that must be mitigated by careful planning of data acquisition methods. Ideally, this test would be conducted in an area with no current, chop, or swell.

C.2.2.2 Methods and Procedures

The dynamic draft data were acquired for all Fairweather MBES platforms in Lake Washington, WA. The measurements were made using the change in ellipsoid height while the vessels were transiting at different speeds in their respective locations. The ellipsoid heights were determined using Post Processed Kinematics (PPK) by recording POSPac data on each vessel and then processing the data with local reference stations in Applanix POSPac MMS software. Speed versus ellipsoid height was fit to a third order polynomial curve using a least squares fit method in a Python Script written by NOAA personnel and implemented within the POSPac AutoQC tool. For the ship, the 2016 polynomial curve was used to derive the table used in the CARIS HVF. The values obtained during 2016 did not significantly differ from those obtained in 2015. Since all launches are of essentially identical construction, in order to reduce uncertainty introduced by wave action noise, an historical average for all launches using data from 2011-2016 was used to populate the CARIS HVF. Outliers with multiple values more than two standard deviations from the mean were removed after initial averaging. The standard deviation of the residuals was used to determine the associated uncertainty in the measurement. Due to low uncertainty in the historically averaged measurement, a new DDSSM was not processed for 2017, thus, the figures below display ERDDM results from 2016.

Due to limited time and operational constraints, a systematic dynamic draft measurement was not performed for the CEEPulse single beam sonar installed on 2302. During data collection, 2302 was consistently driven at the same speed through the water. Therefore, the mean offset between the single beam data from H12798 and F00694 and MBES data in the same region was used as an estimate of the dynamic draft and incorporated in the static draft for the HVF.

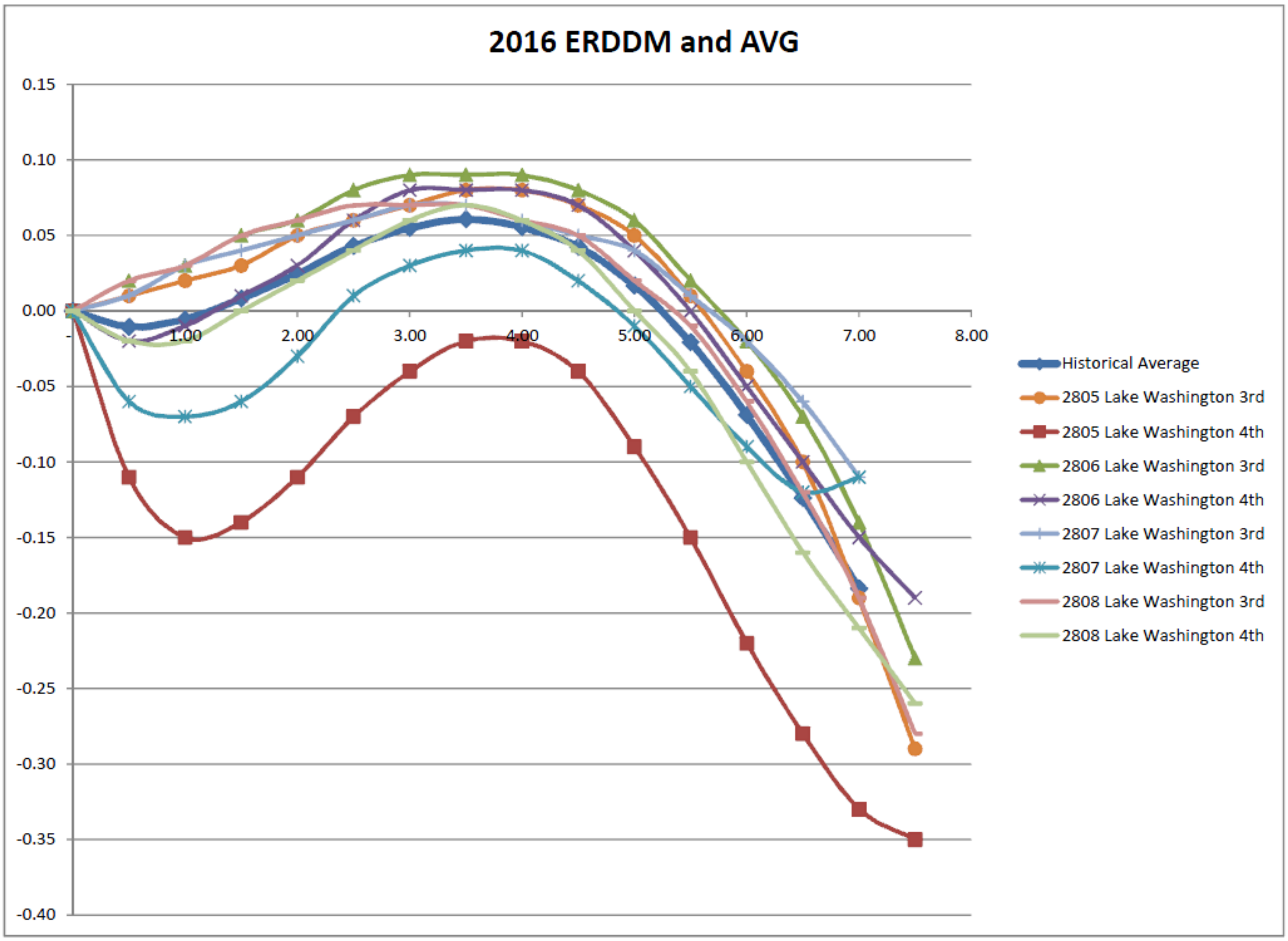
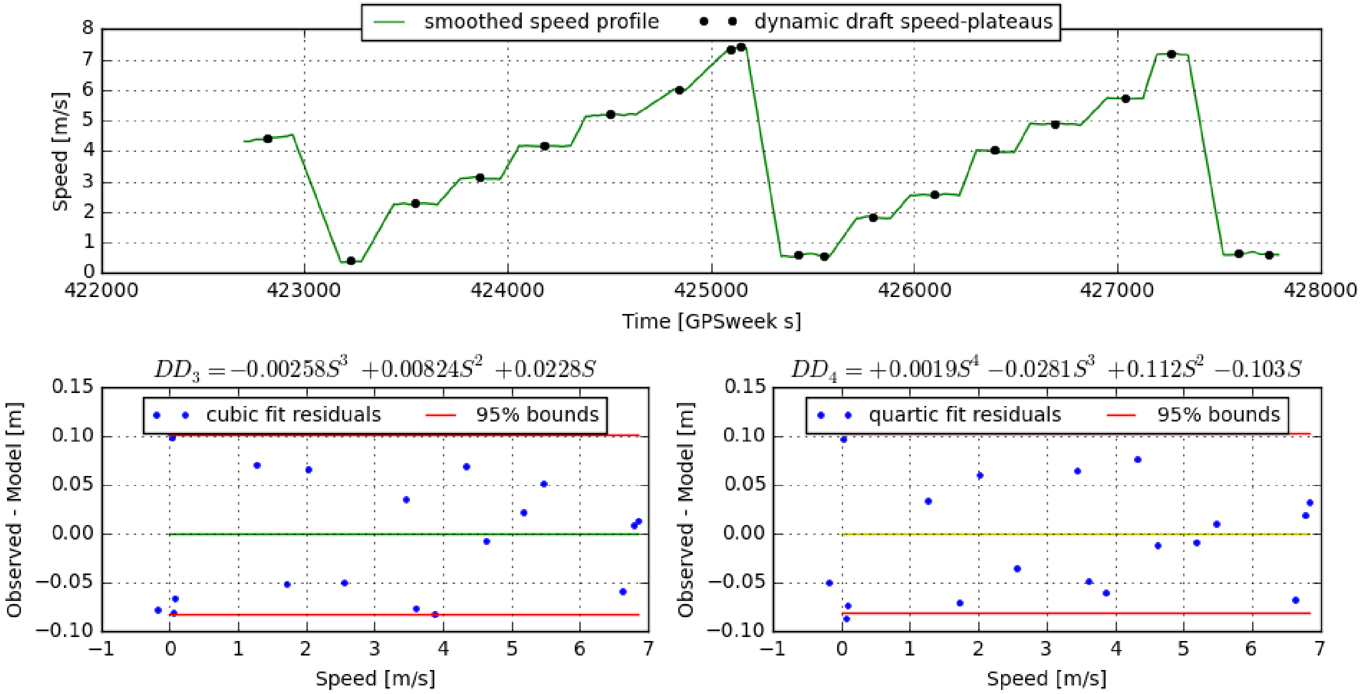


Figure 55: Chart displaying the historical averages for the ERDDM results



Speed [m/s]	Current HVF Model [m]	Cubic Model [m]	Quartic Model [m]
0.00	0.00	0.00	0.00
0.50	-0.01	0.01	-0.03
1.00	0.00	0.03	-0.02
1.50	0.01	0.04	0.01
2.00	0.02	0.06	0.05
2.50	0.04	0.07	0.08
3.00	0.05	0.07	0.10
3.50	0.05	0.07	0.10
4.00	0.05	0.06	0.07
4.50	0.03	0.03	0.03
5.00	-0.00	-0.00	-0.03
5.50	-0.05	-0.06	-0.10
6.00	-0.09	-0.12	-0.17
6.50	-0.14	-0.21	-0.24
7.00	-0.20	-0.32	-0.28

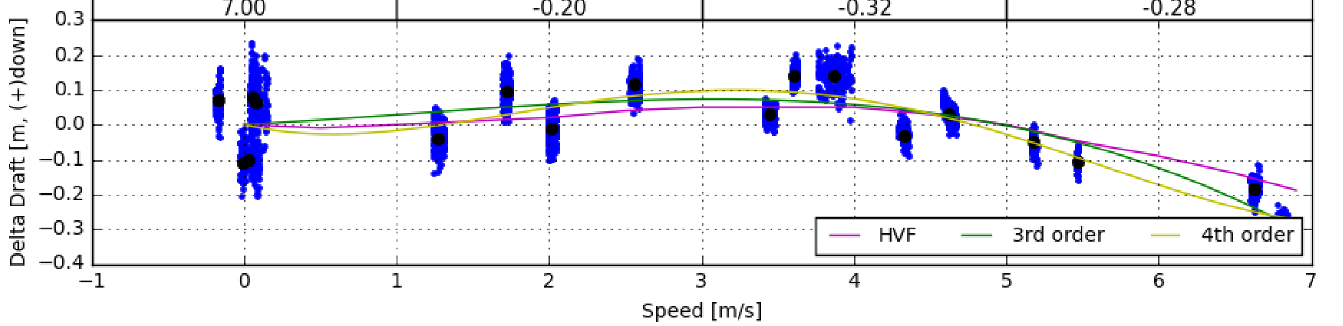
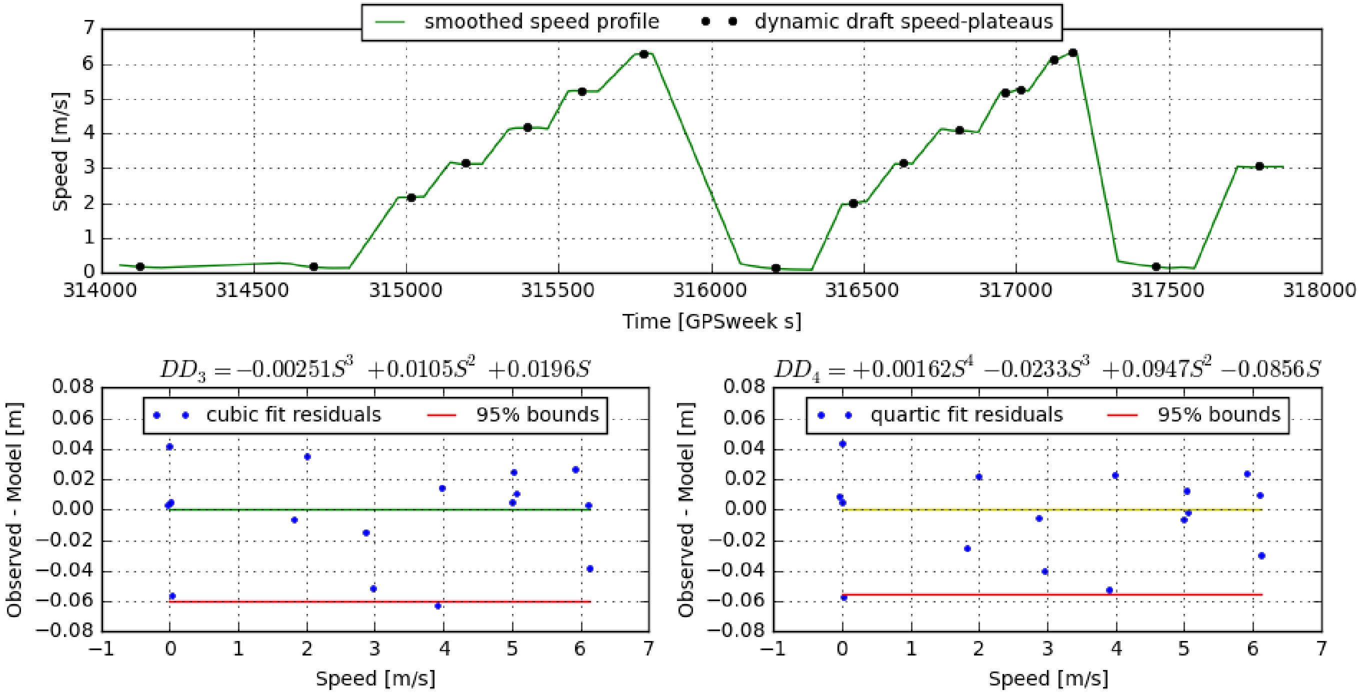


Figure 56: 2805 ERDDM 2016



Speed [m/s]	Current HVF Model [m]	Cubic Model [m]	Quartic Model [m]
0.00	0.00	0.00	0.00
0.50	-0.01	0.01	-0.02
1.00	0.00	0.03	-0.01
1.50	0.01	0.04	0.01
2.00	0.02	0.06	0.05
2.50	0.04	0.08	0.08
3.00	0.05	0.09	0.10
3.50	0.05	0.09	0.10
4.00	0.05	0.09	0.09
4.50	0.03	0.07	0.07
5.00	-0.00	0.05	0.03
5.50	-0.05	0.01	-0.01
6.00	-0.09	-0.04	-0.05
6.50	-0.14	-0.12	-0.07

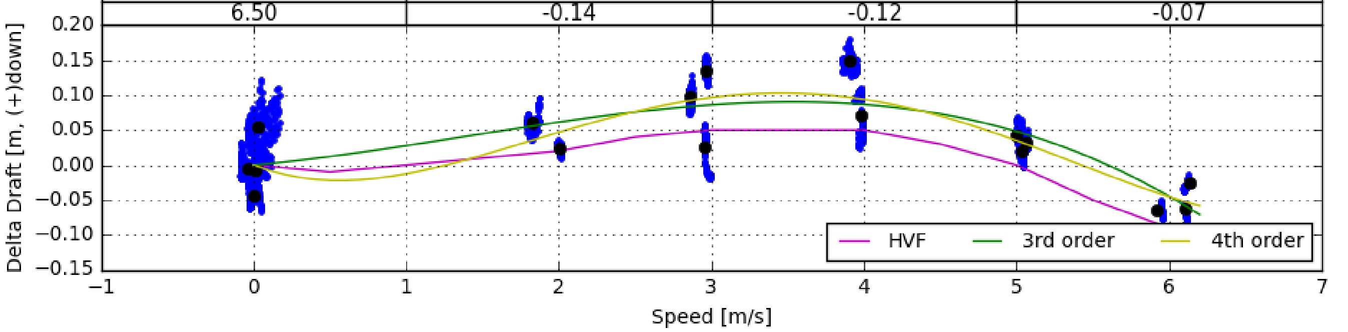
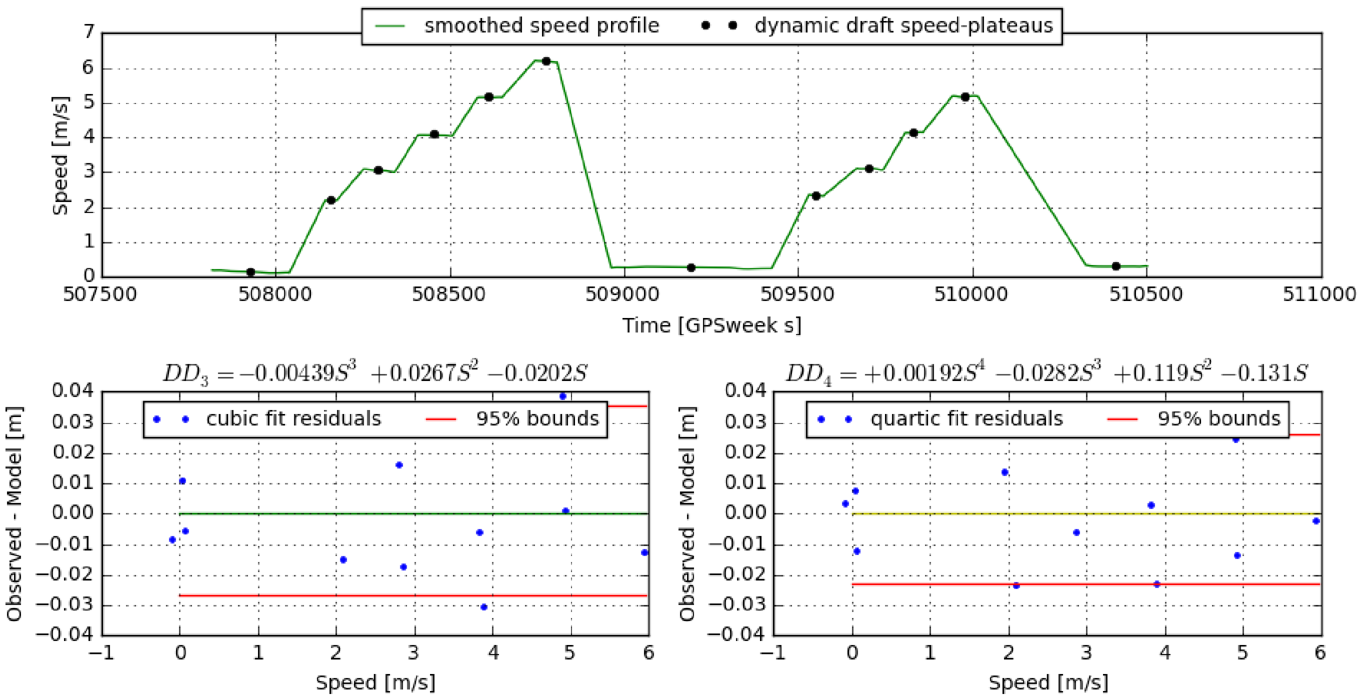


Figure 57: 2806 ERDDM 2016



Speed [m/s]	Current HVF Model [m]	Cubic Model [m]	Quartic Model [m]
0.00	0.00	0.00	0.00
0.50	-0.01	-0.00	-0.04
1.00	0.00	0.00	-0.04
1.50	0.01	0.01	-0.01
2.00	0.02	0.03	0.02
2.50	0.04	0.05	0.05
3.00	0.05	0.06	0.07
3.50	0.05	0.07	0.08
4.00	0.05	0.07	0.07
4.50	0.03	0.05	0.04
5.00	-0.00	0.02	0.00
5.50	-0.05	-0.03	-0.05
6.00	-0.09	-0.11	-0.09

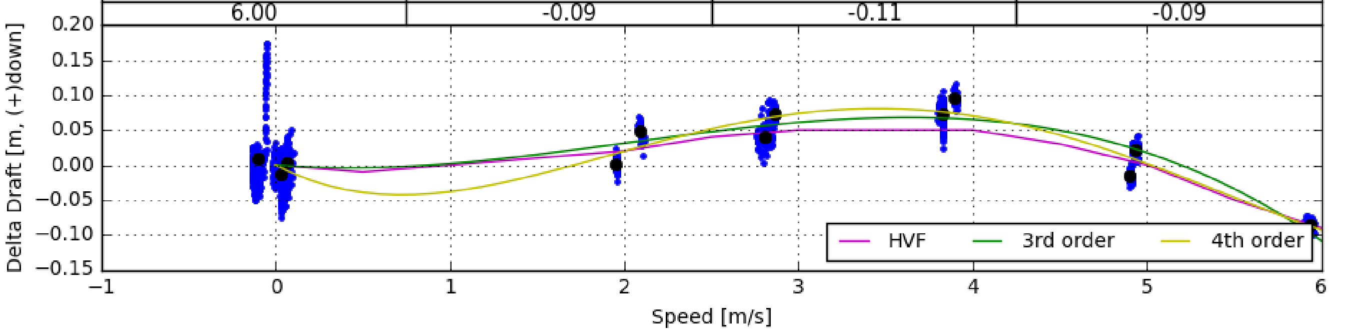
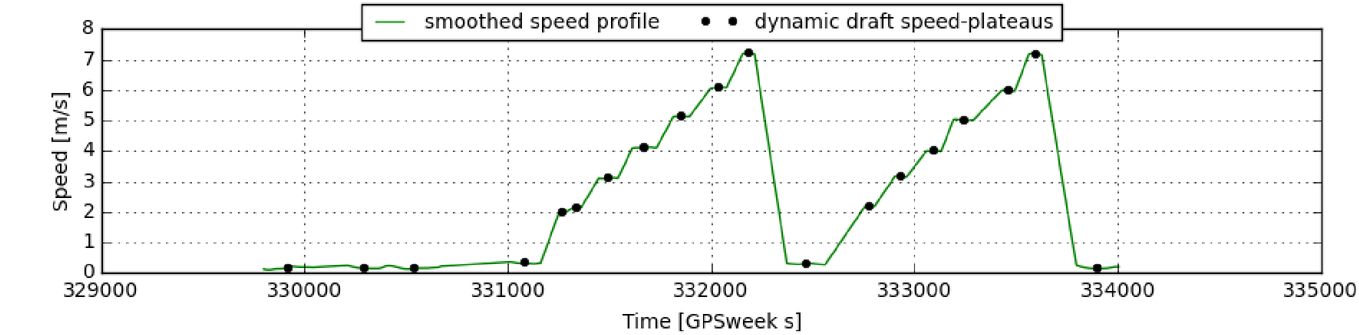
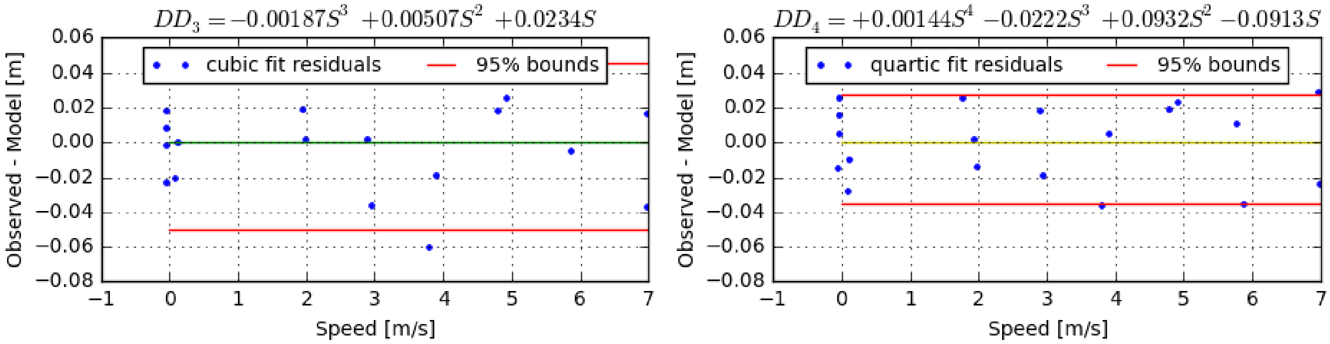


Figure 58: 2807 ERDDM 2016





Speed [m/s]	Current HVF Model [m]	Cubic Model [m]	Quartic Model [m]
0.00	0.00	0.00	0.00
0.50	-0.01	0.01	-0.03
1.00	0.00	0.03	-0.02
1.50	0.01	0.04	0.01
2.00	0.02	0.05	0.04
2.50	0.04	0.06	0.06
3.00	0.05	0.07	0.08
3.50	0.05	0.06	0.09
4.00	0.05	0.05	0.08
4.50	0.03	0.04	0.05
5.00	-0.00	0.01	0.00
5.50	-0.05	-0.03	-0.05
6.00	-0.09	-0.08	-0.11
6.50	-0.14	-0.15	-0.17
7.00	-0.20	-0.23	-0.22

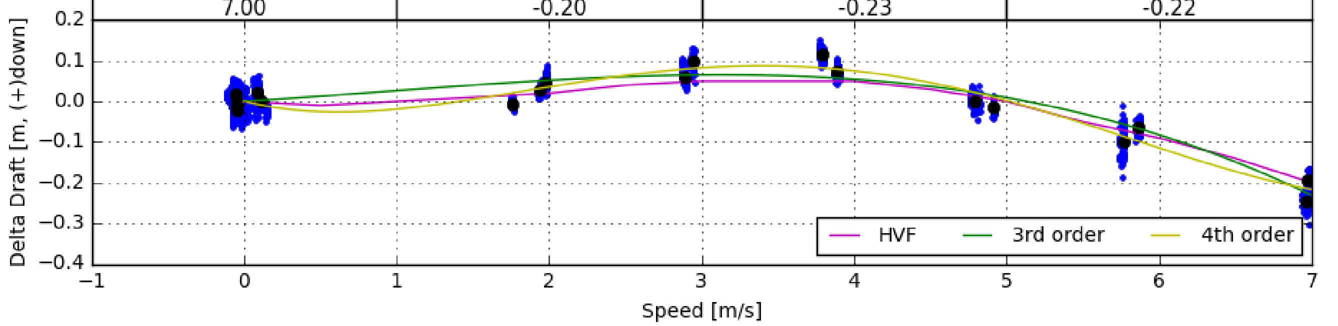
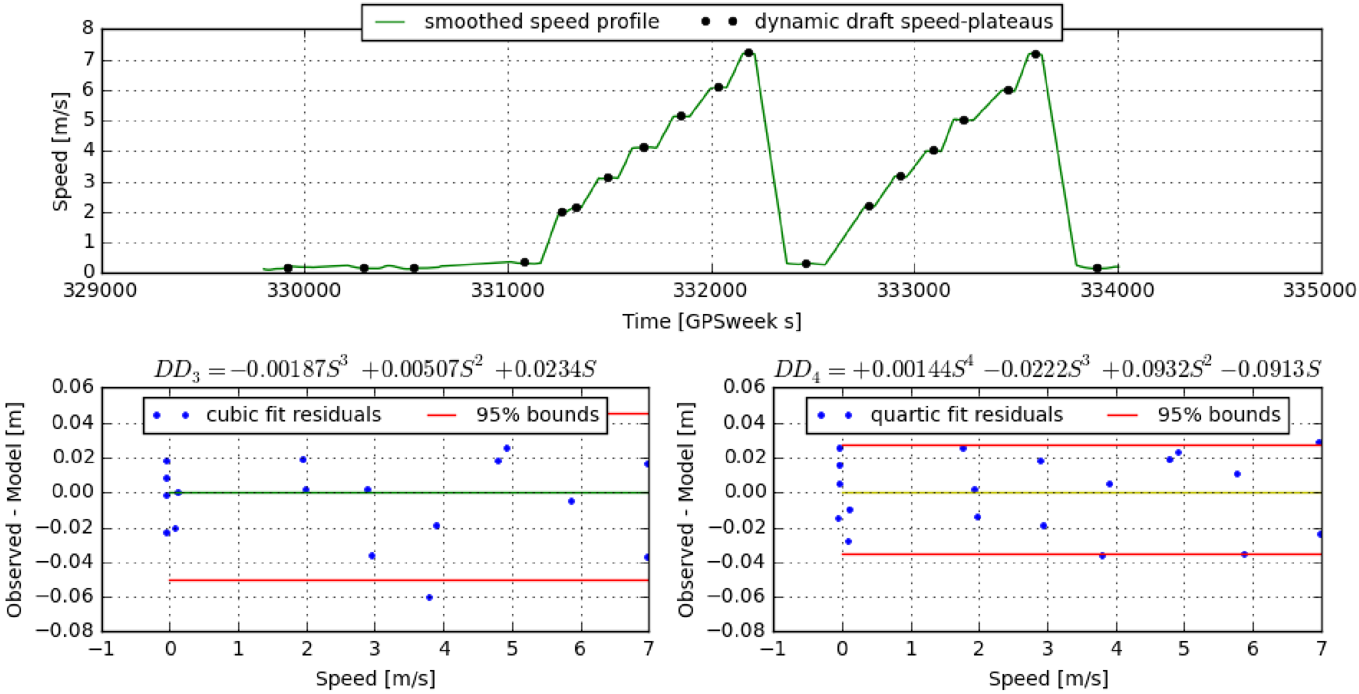


Figure 59: 2808 ERDDM 2016



Speed [m/s]	Current HVF Model [m]	Cubic Model [m]	Quartic Model [m]
0.00	0.00	0.00	0.00
0.50	-0.01	0.01	-0.03
1.00	0.00	0.03	-0.02
1.50	0.01	0.04	0.01
2.00	0.02	0.05	0.04
2.50	0.04	0.06	0.06
3.00	0.05	0.07	0.08
3.50	0.05	0.06	0.09
4.00	0.05	0.05	0.08
4.50	0.03	0.04	0.05
5.00	-0.00	0.01	0.00
5.50	-0.05	-0.03	-0.05
6.00	-0.09	-0.08	-0.11
6.50	-0.14	-0.15	-0.17
7.00	-0.20	-0.23	-0.22

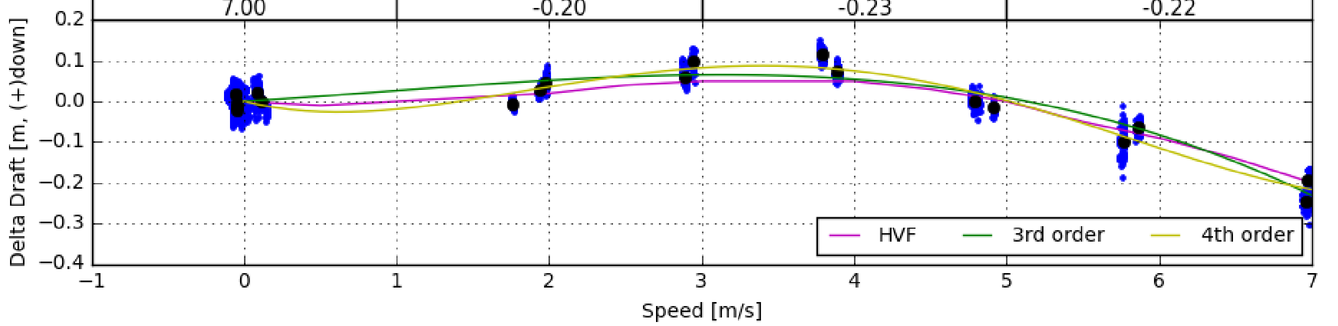


Figure 60: S220 ERDDM 2016

C.2.2.3 Dynamic Draft Correctors

Vessel	2805

Date	2017-03-30	
Dynamic Draft Table	*Speed*	*Draft*
	0	0
	0.5	-0.01
	1	-0.01
	1.5	0.01
	2	0.02
	2.5	0.04
	3	0.06
	3.5	0.06
	4	0.06
	4.5	0.04
	5	0.02
	5.5	-0.02
	6	-0.07
	6.5	-0.12
	7	-0.18
	7.5	-0.25
Vessel	2806	
Date	2017-03-30	
Dynamic Draft Table	*Speed*	*Draft*
	0	0
	0.5	-0.01
	1	-0.01
	1.5	0.01
	2	0.02
	2.5	0.04
	3	0.06
	3.5	0.06
	4	0.06
	4.5	0.04
	5	0.02
	5.5	-0.02
	6	-0.07

Speed	*Draft*
6.5	-0.12
7	-0.18
7.5	-0.25

Vessel	2807
Date	2017-03-30

Dynamic Draft Table

Speed	*Draft*
0	0
0.5	-0.01
1	-0.01
1.5	0.01
2	0.02
2.5	0.04
3	0.06
3.5	0.06
4	0.06
4.5	0.04
5	0.02
5.5	-0.02
6	-0.07
6.5	-0.12
7	-0.18
7.5	-0.25

Vessel	2808
Date	2017-03-30

Dynamic Draft Table

Speed	*Draft*
0	0
0.5	-0.01
1	-0.01
1.5	0.01
2	0.02
2.5	0.04
3	0.06
3.5	0.06

	Speed	*Draft*
	4	0.06
	4.5	0.04
	5	0.02
	5.5	-0.02
	6	-0.07
	6.5	-0.12
	7	-0.18
	7.5	-0.25
Vessel	S220	
Date	2017-05-02	
Dynamic Draft Table	*Speed*	*Draft*
	0	0
	1.5	0.01
	2	0.03
	2.5	0.06
	3	0.08
	3.5	0.11
	4	0.14
	4.5	0.17
	5	0.20
	5.5	0.23
	6.0	0.25
	6.5	0.27

C.3 System Alignment

C.3.1 Description of Correctors

As part of the annual HSRR, Fairweather conducted MBES calibration tests for each individual multibeam system on all survey launches and S220. The procedure used follows that outline in section 1.5.5.1 of the Field Procedures Manual. Timing bias was determined using the induced roll method. Pitch and yaw bias was determined using a target on the seafloor. And finally, roll bias was determined using the standard flat bottom method. Patch tests were processed in CARIS, SIS, and QPS Qimera.

C.3.2 Methods and Procedures

Data were converted in CARIS HIPS version using an HVF file with heave, pitch, roll and timing values set to zero. True heave, water levels, the most recent dynamic draft, and sound speed were applied and the data merged before cleaning via Swath Editor. Biases were determined by individual testers in SIS and QPS Qimera, with an average between at least two methods was used for the final value. Obvious outliers were eliminated and the patch test lines re-run where necessary. The averaged values were entered as opposite sign rotations into the POS MV angular offset settings. Each offset was sequentially entered after determination and before data collection for the next bias. The multiple values determined for each bias by individual testers were examined by a reviewer, and obvious outliers rejected before an average was determined. Bias values were determined in the following order; timing, pitch, roll, and finally yaw. The rotations are entered into the POS MV and are applied to the raw sonar data.

C.3.3 System Alignment Correctors

<table>
<tr><td>Vessel</td><td>FA_2805_EM2040</td></tr>
<tr><td>Echosounder</td><td>Kongsberg EM2040 300 kilohertz</td></tr>
<tr><td>Date</td><td>2017-05-22</td></tr>
<tr><td>Patch Test Values</td><td><table>
<tr><td>Navigation Time Correction</td><td>0 seconds</td></tr>
<tr><td>Pitch</td><td>0.051 degrees</td></tr>
<tr><td>Roll</td><td>0.214 degrees</td></tr>
<tr><td>Yaw</td><td>0.100 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0 seconds</td></tr>
</table></td></tr>
<tr><td>Vessel</td><td>FA_2806_EM2040</td></tr>
<tr><td>Echosounder</td><td>Kongsberg EM2040 300 kilohertz</td></tr>
<tr><td>Date</td><td>2017-05-24</td></tr>
<tr><td>Patch Test Values</td><td><table>
<tr><td>Navigation Time Correction</td><td>0 seconds</td></tr>
<tr><td>Pitch</td><td>-0.160 degrees</td></tr>
<tr><td>Roll</td><td>-0.180 degrees</td></tr>
<tr><td>Yaw</td><td>0.400 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0 seconds</td></tr>
</table></td></tr>
<tr><td>Vessel</td><td>FA_2807_EM2040</td></tr>
<tr><td>Echosounder</td><td>Kongsberg EM2040 300 kilohertz</td></tr>
</table>

Date	2017-05-23	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-0.125 degrees
	Roll	-0.195 degrees
	Yaw	0.596 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	FA_2808_EM2040	
Echosounder	Kongsberg EM2040 300 hertz	
Date	2017-05-24	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-0.400 degrees
	Roll	-0.800 degrees
	Yaw	0.280 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	FA_S220_EM710_2015	
Echosounder	Kongsberg EM-710 100 kilohertz	
Date	2017-05-24	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-0.077 degrees
	Roll	0.000 degrees
	Yaw	0.309 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds

C.4 Positioning and Attitude

C.4.1 Description of Correctors

Heave, pitch, roll and heading, including attitude biases and navigation timing errors.

C.4.2 Methods and Procedures

Vessel attitude is measured by the Applanix POS MV and recorded in SIS .all files and POS MV .000 files.

Attitude correctors are applied during CARIS HIPS conversion using the raw POS MV attitude data recorded in the raw data (.all). The TrueHeave file is separately loaded into HIPS, replacing the real-time heave values recorded in the raw data. Post processed kinematic (PPK) data from the POS MV .000 file are applied to MBES data in CARIS HIPS in the form of SBET files once data acquisition is complete.

The POS MV TrueHeave™ (CARIS Delayed Heave) data is logged within the POS MV *.000 files and applied in CARIS HIPS during post processing using the “Apply Delayed Heave” function during sound speed correction. TrueHeave™ is a forward-backward filtered heave corrector providing additional robustness to the solution. To ensure proper application in CARIS HIPS, POS MV files are logged for at least five minutes before and after all MBES files are logged. The filter that produces the true heave values needs only 3 minutes of data before and after the acquisition of bathymetric data to create a baseline for the data series, but SBET processing which uses the same .000 file requires a 5 minute buffer period before and after bathymetric acquisition.

In cases where TrueHeave™ cannot be applied, real time heave correctors are used. Real time heave data are recorded and stored in the raw data file and are applied as the heave corrector for MBES data if TrueHeave™ files are unavailable. Data that do not have TrueHeave™ applied will be listed in the individual Descriptive Report for the survey.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

Different methods to reference soundings to MLLW.

C.5.2 Methods and Procedures

Unless otherwise noted in the survey Descriptive Report, the vertical datum for all soundings and heights is Mean Lower Low Water (MLLW). Predicted, preliminary, and/or verified water level correctors from the primary tide station(s) listed in the Project Instructions may be downloaded from the CO-OPS website and used for water level corrections during the course of the project. These tide station files are collated to include the appropriate days of acquisition and then converted to CARIS .tid file format using FetchTides.

Water level data in the .tid files are applied to HDCS data in CARIS HIPS using the zone definition file (.zdf) or a Tidal Constituent and Residual Interpolation (TCARI) model supplied by CO-OPS. Upon receiving final approved water level data, all data are reduced to MLLW using the final approved water levels as noted in the individual survey’s Descriptive Report.

If a V Datum Separation Model is provided, a comparison might be requested by Office of Coast Survey, Operations Branch. If accepted, CARIS HIPS data may be reduced to MLLW per supplied separation model instead of through traditional water level application. See the individual survey's Descriptive Report for further information.

In Alaska, which lacks of a published VDatum Separation Model, an Ellipsoidally-Referenced Zoned Tides (ERZT) evaluation will be requested by Office of Coast Survey, Operations Branch. ERZT is done by measuring the height of the GPS antenna to the water line. Then a Separation Model is created in CARIS HIPS by adding this ellipsoidally-referenced water line measurement to the zoned water level "corrector." If the preliminary analysis is accepted, the Separation Model is differenced from the Poor Man's VDatum and the difference surface is analyzed for any discrepancies that might have resulted from a problematic Smoothed Best Estimate of Trajectory (SBET). The mean difference value is applied to the PMVD through a vertical shift, a process referred to as "de-biasing"the PMVD. The PMVD is then applied to the data to reference it to chart datum.

A complete description of vertical control utilized for a given project can be found in the project specific Horizontal and Vertical Control Report (HVCR), submitted for each project under separate cover when necessary as outlined in section 5.2.3.2 of the FPM.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

Sound speed profiles for Fairweather survey launches were acquired with SeaBird Electronics SeaCat SBE19 and SBE 19Plus Conductivity, Temperature, and Depth (CTD) profilers. For ship acquisition, sound speed profiles were acquired with the Rolls Royce Moving Vessel Profiler MVP200 micro CTD. Static casts for S220 were taken using an SBE19Plus during periods where the MVP200 was non-operational. All Fairweather launches are equipped with 24-volt electric winches attached to small swing-arm davits to deploy and recover SV CTD profilers while the vessel is at rest.

C.6.1.2 Methods and Procedures

See section B.1.3.1 and B.2.3.1

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

Sound speed profiles are applied in real-time during MBES acquisition through Velocipy by sending the sound speed cast to SIS via the SIS data distribution window. Sound speed profiles are applied again in CARIS HIPS and SIPS during post-processing via the Nearest In Distance Within Time option.

C.6.2.2 Methods and Procedures

The Kongsberg EM 2040 systems on all launches require a sound speed probe to be interfaced with the sonar acquisition unit for use in projector beam steering computations. A Reson SVP 71 surface sound speed probe is utilized to feed real time SV values directly into the Kongsberg EM2040 acquisition computer.

The Kongsberg EM 710 multibeam systems utilized aboard requires a sound speed probe to be interfaced with the sonar acquisition unit for use in projector steering computations. A Reson SVP 70 surface sound speed probe is utilized to feed real time SV values directly into the acquisition computer for use in beam steering calculations. The MVP is also interfaced to send cast information directly to the SIS acquisition computer. SIS monitors changes in the surface sound speed vs. the value obtained with the last cast in realtime and highlights both the “SV Profile” and “SV Used” numerical displays in yellow when sound speed differences are greater than 3 m/s and red for differences greater than 5 m/s.