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Data Acquisition and Processing Report

NOAA Ship *Fairweather*
Chief of Party: CDR David J. Zezula
Year: 2015
Version: 4
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A Equipment

A.1 Survey Vessels

A.1.1 Fairweather

<table>
<tr><td>Name</td><td>Fairweather</td></tr>
<tr><td>Hull Number</td><td>S220</td></tr>
<tr><td>Description</td><td>Welded steel hull-ice strengthened vessel</td></tr>
<tr><td>Utilization</td><td>Acquisition of mid-water multibeam and Side Scan Sonar.</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><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>5.0292 meters</td></tr>
</table></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 and delivery of final report. 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*	2015-04-19
	Method Used	Direct measurement from benchmarks.
	Discussion	The static drafts (Waterline Height in the HVF) for Fairweather S-220 was calculated based on laser range finder measurements of the distance from the punch mark/benchmarks on top of the Port and starboard Gunwales of the vessel to the waterline. Initial measurements were conducted during March of 2015 in Lake Washington, Seattle, WA, and were entered in to the Kongsberg Seafloor Information System as a reference point. Static drafts were taken periodically throughout the season and entered in the ship's HVF.
Most Recent Dynamic Draft Determination	*Date*	2015-04-21
	Method Used	The ellipsoidally referenced method.
	Discussion	The dynamic draft data was acquired for Fairweather S-220 in Lake Washington, Seattle. 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 and then processing the data with local reference stations in Applanix POSPac MMS software. The resulting Smoothed Best Estimate of Trajectory (SBET) was exported from POSPac and the 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 Pydro. The polynomial curve was used to derive the table used in the CARIS HVF, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement.

Figure 1: NOAA Ship Fairweather

A.1.2 Launch 2805

<table>
<tr><td>Name</td><td>Launch 2805</td></tr>
<tr><td>Hull Number</td><td>2805</td></tr>
<tr><td>Description</td><td>Hydrographic Survey Launch 2805 is a 28 foot aluminum launch vessel of the NOAA Ship Fairweather, S-220. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).</td></tr>
<tr><td>Utilization</td><td>Hydrographic Survey Launch for NOAA Ship Fairweather</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><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>
</table></td></tr>
</table>

<table>
<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>National Geodetic Survey, Geodetic Services Division.</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 2805.</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>2015-01-20</td></tr>
<tr><td>Method Used</td><td>Total Station</td></tr>
<tr><td>Discussion</td><td>During the 2015 Fairweather dry-dock period, four of her launches were removed from the water and placed on stilts at the NOAA facility at Sand Point. As part of the 2015 HSRR, the offsets of Fairweather's four hydro survey launches were surveyed to verify the 2010 full survey results are still valid. This verification survey was necessary due to significant work on the boats over the winter. The survey was conducted with the launches out of the water on blocks using a Sokkia NET05 total station, Tesla data collector, and prism for each shot. 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. See below for results:
2805: 0.0090 meters</td></tr>
</table>

Most Recent Static Draft Determination	*Date*	2015-03-12
	Method Used	Direct Measurement from benchmarks.
	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 March of 2015 in Lake Washington, Seattle, WA. 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*	2015-02-24
	Method Used	The ellipsoidally referenced method.
	Discussion	The dynamic draft data was acquired for Fairweather Launch 2805 in Lake Washington, Seattle. 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 and then processing the data with local reference stations in Applanix POSPac MMS software. The resulting Smoothed Best Estimate of Trajectory (SBET) was exported from POSPac and the 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 Pydro. The polynomial curve was used to derive the table used in the CARIS HVF, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement. The resulting values were averaged with historical data since 2011 from the NOAA Ships Fairweather and Rainier. This historical average was used to update the HVF.

Figure 2: Launch 2805 Taken During Survey of 2010

A.1.3 Launch 2806

Name	Launch 2806
Hull Number	2806

<table>
<tr><td>Description</td><td colspan="2">Hydrographic Survey Launch 2806 is a 28 foot aluminum launch vessel of the NOAA Ship Fairweather, S-220. Fairweather is a scientific research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).</td></tr>
<tr><td>Utilization</td><td colspan="2">Hydrographic Survey Launch for NOAA Ship Fairweather</td></tr>
<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>2010-01-25</td></tr>
<tr><td>Performed By</td><td>National Geodetic Survey, Geodetic Services Division.</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 2806.</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>
</table>

Most Recent Partial Offset Verification	*Date*	2015-01-20
	Method Used	Total Station
	Discussion	During the 2015 Fairweather dry-dock period, four of her launches were removed from the water and placed on stilts at the NOAA facility at Sand Point. As part of the 2015 HSRR, the offsets of Fairweather's four hydro survey launches were surveyed to verify the 2010 full survey results are still valid. This verification survey was necessary due to significant work on the boats over the winter. The survey was conducted with the launches out of the water on blocks using a Sokkia NET05 total station, Tesla data collector, and prism for each shot. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence the 2010 full survey results. See below for results: 2806: 0.0031 meters
Most Recent Static Draft Determination	*Date*	2014-03-11
	Method Used	Direct measurement from benchmarks.
	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 March of 2015 in Lake Washington, Seattle, WA. 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*	2015-02-26
	Method Used	The ellipoidally referenced method
	Discussion	The dynamic draft data was acquired for Fairweather launch 2806 in Lake Washington, Seattle. 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 and then processing the data with local reference stations in Applanix POSPac MMS software. The resulting Smoothed Best Estimate of Trajectory (SBET) was exported from POSPac and the 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 Pydro. The polynomial curve was used to derive the table used in the CARIS HVF, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement. The resulting values were averaged with historical data since 2011 from the NOAA Ships Fairweather and Rainier. This historical average was used to update the HVF.

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 28 foot aluminum launch vessel of the NOAA Ship Fairweather, S-220. 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/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 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*	2015-01-20
	Method Used	Total Station
	Discussion	During the 2015 Fairweather dry-dock period, four of her launches were removed from the water and placed on stilts at the NOAA facility at Sand Point. As part of the 2015 HSRR, the offsets of Fairweather's four hydro survey launches were surveyed to verify the 2010 full survey results are still valid. This verification survey was necessary due to significant work on the boats over the winter. The survey was conducted with the launches out of the water on blocks using a Sokkia NET05 total station, Tesla data collector, and prism for each shot. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence the 2010 full survey results. See below for results: 2807: 0.0038 meters
Most Recent Static Draft Determination	*Date*	2014-03-12
	Method Used	Direct measurement from benchmarks.
	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 March of 2015 in Lake Washington, Seattle, WA. 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*	2015-03-01
	Method Used	Ellipsoidally Referenced Dynamic Draft
	Discussion	The dynamic draft data was acquired for Fairweather launch 2807 in Lake Washington, Seattle. 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 and then processing the data with local reference stations in Applanix POSPac MMS software. The resulting Smoothed Best Estimate of Trajectory (SBET) was exported from POSPac and the 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 Pydro. The polynomial curve was used to derive the table used in the CARIS HVF, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement. The resulting values were averaged with historical data since 2011 from the NOAA Ships Fairweather and Rainier. This historical average was used to update the HVF.

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 28 foot aluminum launch vessel of the NOAA Ship Fairweather, S-220. 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	NGS/GSD
	Discussion	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.
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*	2015-01-20
	Method Used	Total Station
	Discussion	During the 2015 Fairweather dry-dock period, four of her launches were removed from the water and placed on stilts at the NOAA facility at Sand Point. As part of the 2015 HSRR, the offsets of Fairweather's four hydro survey launches were surveyed to verify the 2010 full survey results are still valid. This verification survey was necessary due to significant work on the boats over the winter. The survey was conducted with the launches out of the water on blocks using a Sokkia NET05 total station, Tesla data collector, and prism for each shot. The average difference between the results from this survey and the full survey conducted in 2010 are within acceptable tolerances to maintain confidence the 2010 full survey results. See below for results: 2808: 0.0057 meters.
Most Recent Static Draft Determination	*Date*	2014-03-11
	Method Used	Direct measurement from benchmarks
	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 March of 2015 in Lake Washington, Seattle, WA. 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*	2015-02-25
	Method Used	Ellipsoidally Referenced Dynamic Draft
	Discussion	The dynamic draft data was acquired for Fairweather S-220 in Lake Washington, Seattle. 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 and then processing the data with local reference stations in Applanix POSPac MMS software. The resulting Smoothed Best Estimate of Trajectory (SBET) was exported from POSPac and the 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 Pydro. The polynomial curve was used to derive the table used in the CARIS HVF, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement. The resulting values were averaged with historical data since 2011 from the NOAA Ships Fairweather and Rainier. This historical average was used to update the HVF.

Figure 5: Launch 2808 Taken During Survey of 2010

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Klein Associates Inc Klein System 5000

<table>
<tr><td>Manufacturer</td><td>Klein Associates Inc</td></tr>
<tr><td>Model</td><td>Klein System 5000</td></tr>
<tr><td>Description</td><td>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 a computer for user interface. 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 weight of the towfish: the standard, and a lightweight variant. 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. 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.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S220</td><td>2807</td><td>2808</td></tr>
<tr><td>TPU s/n</td><td>166</td><td>176</td><td>177</td></tr>
<tr><td>Towfish s/n</td><td>292</td><td>321</td><td>260</td></tr>
</table></td></tr>
<tr><td>Specifications</td><td><table>
<tr><td>Frequency</td><td>455 kilohertz</td></tr>
<tr><td>Along Track Resolution</td><td><table>
<tr><td>Resolution</td><td>10 centimeters</td><td>20 centimeters</td><td>36 centimeters</td></tr>
<tr><td>Min Range</td><td>0 centimeters</td><td>39 centimeters</td><td>76 centimeters</td></tr>
<tr><td>Max Range</td><td>28 meters</td><td>75 meters</td><td>150 meters</td></tr>
</table></td></tr>
<tr><td>Across Track Resolution</td><td>3.75 centimeters</td></tr>
<tr><td>Max Range Scale</td><td>150 meters</td></tr>
</table></td></tr>
<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
</table>

Figure 6: Hull-Mounted Light Weight Klein 5000 Side Scan Sonar

Figure 7: Hull-Mounted Heavy Weight Klein 5000 Side Scan Sonar

Figure 8: Towed Heavy Weight Klein 5000 Side Scan Sonar

A.2.2 Multibeam Echosounders

A.2.2.1 Teledyne Reson SeaBat 7125 SV 1

Manufacturer	Teledyne Reson
Model	SeaBat 7125 SV 1
Description	Survey launches 2805, 2806, 2807, and 2808 are each equipped with a dual frequency Reson 7125 SV MBES. The Reson 7125 SV has both a low frequency (200kHz) and high frequency (400kHz) transmit array with swath coverage of 128°. The swath is made up of 256 discrete beams for 200 kHz and either 256 or 512 discrete beams for 400 kHz. The typical operational depth ranges for the Reson 7125 SV operating at 200 kHz is 3 to 400 meters and 3 to 100 meters operating with the 400 kHz system. Each system is hull mounted along the centerline and includes a single topside unit.
Serial Numbers	(see below)

Vessel Installed On	2805	2806	2807	2808
Processor s/n	1812027	1812020	1812023	1812028
Transceiver s/n	n/a	n/a	n/a	n/a
Transducer s/n	n/a	n/a	n/a	n/a
Receiver s/n	3008265	0309012	0309019	0309014
Projector 1 s/n	4408358	2409098	4408351	85000327
Projector 2 s/n	4008071	2208007	2308110	1908209

Specifications	*Frequency*	200 hertz		400 hertz	
	Beamwidth	*Along Track*	2.2 degrees	*Along Track*	1 degrees
		Across Track	1.1 degrees	*Across Track*	0.54 degrees
	Max Ping Rate	50 hertz		50 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equidistant
		Number of Beams	256	*Number of Beams*	512
	Max Swath Width	128 degrees		128 degrees	
	Depth Resolution	6 millimeters		6 millimeters	
	Depth Rating	*Manufacturer Specified*	400 meters	*Manufacturer Specified*	200 meters
		Ship Usage	250 meters	*Ship Usage*	100 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.				

System Accuracy Tests	*Vessel Installed On*	2805	2806	2807	2808
	Methods	NOAA Ship Fairweather was visited on 8 – 9 Apr 2015 to review the health and configuration of her onboard Teledyne-Reson systems. The following systems were reviewed with this document describing the health of Launch 2805: • Launch 2805 7125-SV1 FP 1.3.2 The review included: • Assessment of receiver health at both frequencies: o Accomplished by a review of IQ behavior at each frequency with active transmit, ambient environment, and caltone • 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 • Discussions with surveyors of recent experiences and issues • Attempted to install FP 2.2, but after tests, it was agreed upon to continue with the current version base on data quality performance	NOAA Ship Fairweather was visited on 8 – 9 Apr 2015 to review the health and configuration of her onboard Teledyne-Reson systems. The following systems were reviewed with this document describing the health of Launch 2806: • Launch 2806 7125-SV1 FP 1.3.2 The review included: • Assessment of receiver health at both frequencies: o Accomplished by a review of IQ behavior at each frequency with active transmit, ambient environment, and caltone • 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 • Discussions with surveyors of recent experiences and issues • Attempted to install FP 2.2, but after tests, it was agreed upon to continue with the current version base on data quality performance	NOAA Ship Fairweather was visited on 8 – 9 Apr 2015 to review the health and configuration of her onboard Teledyne-Reson systems. The following systems were reviewed with this document describing the health of Launch 2807: • Launch 2807 7125-SV1 FP 1.3.2 The review included: • Assessment of receiver health at both frequencies: o Accomplished by a review of IQ behavior at each frequency with active transmit, ambient environment, and caltone • 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 • Discussions with surveyors of recent experiences and issues • Attempted to install FP 2.2, but after tests, it was agreed upon to continue with the current version base on data quality performance	NOAA Ship Fairweather was visited on 8 – 9 Apr 2015 to review the health and configuration of her on board Teledyne-Reson systems. The following systems were reviewed with this document describing the health of Launch 2808: • Launch 2808 7125-SV1 FP 1.3.2 The review included: • Assessment of receiver health at both frequencies: o Accomplished by a review of IQ behavior at each frequency with active transmit, ambient environment, and caltone • 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 • Discussions with surveyors of recent experiences and issues • Attempted to install FP 2.2, but after tests, it was agreed upon to continue with the current version base on data quality performance

Snippets	Sonar does not have snippets logging capability.

Figure 9: Reson 7125 SV topside processing unit

Figure 10: Reson 7125 SV 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 m. The alongtrack beamwidth configuration is ½° with a receive beamwidth of 1°. The number of beams is 256 or 128 respectively, with dynamic focusing employed in the near field. A high density beam processing mode provides up to 400 or 200 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 does not have snippets logging capability.		

Figure 11: EM 710 Gondola during transducer installation.

A.2.3 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

Manufacturer	FA Personnel
Model	Traditional
Description	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.”
Serial Numbers	10_01_05 10_02_04 20_02_05 20_03_05 30_01_05 10_05_09 10_06_09

Calibrations	<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><td>10_02_04</td></tr><tr><td>*Date*</td><td>2014-12-17</td><td>2014-12-17</td><td>2014-12-17</td><td>2014-12-17</td><td>2014-12-17</td><td>2014-12-17</td><td>2014-12-17</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><td>Steel Tape</td></tr></table>
Accuracy Checks	<table><tr><td>*Serial Number*</td><td>30_01_05</td><td>30_01_05</td><td>30_01_05</td><td>30_01_05</td><td>30_01_05</td></tr><tr><td>*Date*</td><td>2015-03-04</td><td>2015-03-04</td><td>2015-03-04</td><td>2015-03-18</td><td>2015-02-19</td></tr><tr><td>*Procedures*</td><td>Lead line to 7125 MBES Comparison on Launch 2805</td><td>Lead line to 7125 MBES Comparison on Launch 2806</td><td>Lead line to 7125 MBES Comparison on Launch 2807</td><td>Lead line to 7125 MBES Comparison on Launch 2808</td><td>Lead line to SIMRAD EM710 MBES Comparison on S220</td></tr></table>
Correctors	Correctors were not determined.
Non-Standard Procedures	Non-standard procedures were not utilized.

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

Manufacturer	Applanix
Model	System: POS MV 320 V4
Description	The POS MV 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.

PCS

Manufacturer	Applanix
Model	System: POS MV 320 V4
Description	Position and Attitude POS Computer System. A rack-mounted computer system contains the core POS processor and IMU interface electronics, plus two GPS receivers and an optional removable PC-card disk drive. The PCS provides system timing, position and velocity aiding, together with GPS raw observables for use with GAMS.
Firmware Version	BD960 V4.21
Software Version	POS View 5.8.0.0

Serial Numbers

Vessel Installed On	2805	2806	2807	2808	S220
PCS s/n	2411	2560	3628	2564	3627

Figure 12: POS MV 320 V4 Computer System

IMU

Manufacturer	Applanix
Model	LN 200
Description	Positioning and Attitude Inertial Measurement Unit. The system's primary sensor allows for the continuous output of position and orientation data.

Serial Numbers

Vessel Installed On	2805	2806	2807	2808	S220
IMU s/n	294	991	995	324	292

Certification	IMU certification report was not produced.

Figure 13: IMU LN 200 Unit

Antennas

Manufacturer	Applanix
Model	Zephyr II
Description	GNSS Equipment. A dual frequency antenna for use with GAMS.

Serial Numbers

Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
2805	311717272	Port	Primary

Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
2805	5000100665	Starboard	Secondary
2806	5000101101	Starboard	Secondary
2806	5000101022	Port	Primary
2807	1440925095	Port	Primary
2807	1440912566	Starboard	Secondary
2808	1440904832	Port	Primary
2808	31177272	Starboard	Secondary
S220	31180200	Starboard	Secondary
S220	1440904133	Port	Primary

Figure 14: Zephyr II diagram

Figure 15: ZephyrII POS Antennas on Launch Boat

GAMS Calibration

Vessel	2805	2806	2807	2808	S220
Calibration Date	2015-02-24	2015-02-26	2015-02-27	2015-02-24	2015-02-09

Configuration Reports

Vessel	2805	2806	2807	2808	S220
Report Date	2015-02-24	2015-02-26	2015-02-27	2015-02-24	2015-02-09

Figure 16: POS MV 320 V4 Entire System

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	0923-9416-0007	0923-9416-0005	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	Complete backpack units with batteries, cables, antennas, and laptops.

Serial Numbers	0224090101	
	0224078543	
Antennas	No antennas were installed.	
Receivers	No receivers were installed.	
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	8HKSB80630
		3ITSB60268
		3ITSB60210
		8HKSB80631
	Figure 17: Panasonic Toughbook	
DQA Tests	*Date*	2015-02-18
	Serial Number	0224090101 & 0224090101
	Methods	During February 2015, horizontal control hardware was tested on benchmark TIDAL 1987 at NOAA Facility Sandpoint. For the Trimble Backpacks, data were collected over the benchmark for data for 5 minutes in both differential and non-differential modes. Base Stations were also tested.
	Results	The largest error seen with differential corrected Trimble Backpack data was 0.269m. The largest error seen with non-differential corrected Trimble Backpack data was 3.373 m.

Figure 18: Trimble Backpack

A.4.4 Laser Rangefinders

Manufacturer	Laser Tech
Model	Impulse LR
Description	The Impulse Laser Range finder and TruPulse 200 Laser Range finder are 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. The Impulse LR and TruPulse 200 Laser Range finders do not function properly in low light or in choppy seas when a feature is not distinguishable from surroundings.
Serial Numbers	i09290
DQA Tests	*Date*: 2014-12-17 *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 with values only varying within +/- 0.1m.

Figure 19: Impulse LR

Manufacturer	Laser Tech
Model	TruPulse 200
Description	
Serial Numbers	000676 041169 041156 001481
DQA Tests	DQA test was not performed.

Figure 20: TruPulse 200 Laser Range finder

A.4.5 Other Positioning and Attitude Equipment

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

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profiles

A.5.1.1 CTD Profilers

A.5.1.1.1 Sea-Bird Electronics, Inc. SBE 19plus SEACAT Profiler

Manufacturer	Sea-Bird Electronics, Inc.
Model	SBE 19plus SEACAT Profiler
Description	Fairweather is equipped with one SBE 19plus and three SBE 19plusV2 SEACAT sound speed profilers used to acquire conductivity, temperature, and depth (CTD) data in the water column to determine the speed of sound through water at the start of the 2015 field season. The titanium cased SBE 19plus profiler has a pressure sensor rated to 3,500 meters. The three SBE 19plusV2 profilers have pressure sensors and units rated to 600 meters. All SEACAT sound speed profilers were calibrated by the manufacturer during the 2014-2015 winter repair period. Periodic quality assurance checks are conducted regularly and include comparison casts between CTD instruments. Data quality assurance (DQA) checks are conducted during each survey leg include comparison casts between two instruments as per section 1.5.2.2.2 of the FPM for each survey. Records of the DQA tests performed are kept aboard the ship and are included with the digital Separates II – Sound Speed Data for each survey. To ensure that the CTDs continue to function properly a stringent maintenance schedule is followed using guidelines from the manufacturer's recommendations.

Serial Numbers	*Vessel Installed On*	2808	2805	2807	2806
	CTD s/n	19P36026-4585	19P75459-7370	19P50959-6121	19P50959-6122
Calibrations	*CTD s/n*	19P36026-4585	19P75459-7370	19P50959-6121	19P50959-6122
	Date	2014-12-03	2014-12-02	2014-12-04	2014-12-06
	Procedures	Calibration Documents	Calibration Documents	Calibration Documents	Calibration Documents

Figure 21: 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 DU

Manufacturer	Rolls-Royce Canada Limited Naval Marine / Brooke Ocean Technologies				
Model	MVP 200 DU				
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, towing boom and a remotely located user interface controller. Fairweather's MVP fish is equiped with an AML Oceanographic MVP-X (X•Series instruments and Xchange sensors) 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 multi-beam sounder system.				
Serial Numbers	*Vessel Installed On*	S220	S220	S220	S220
	Sound Speed Profiler s/n	8680	8681	8705	8706

Calibrations	*Sound Speed Profiler s/n*	8680	8681	8705	8706
	Date	2014-12-17	2015-07-15	2015-07-15	2015-07-15
	Procedures	Calibration Documents	Calibration Documents	Calibration Documents	Calibration Documents

Figure 22: MVP 200 System

Figure 23: Single Sensor Free Fall Fish

Figure 24: MVP-X AML Oceanographic X•Series instruments and Xchange sensors

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 velocity 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 launches multibeam transducers 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	2008017	2008027	2008016	2008038

Calibrations	*Sound Speed Sensor s/n*	2008038	2008027	2008017	2008016
	Date	2009-07-13	2009-11-03	2009-06-10	2009-10-07
	Procedures	Functionality Test: Temperature Calibration, Pressure Calibration	Functionality Test: Temperature Calibration, Pressure Calibration	Functionality Test: Temperature Calibration, Pressure Calibration	Functionality Test: Temperature Calibration, Pressure Calibration

Figure 25: SVP-71 Pictured on Bottom of Launch

Figure 26: SVP-71

A.5.2.2 Reson SVP 70

Manufacturer	Reson		
Model	SVP 70		
Description	The SVP 70 is a direct reading sound velocity 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 each ship's multibeam transducers and provides real time surface sound speed values for refraction corrections.		
Serial Numbers	*Vessel Installed On*	S220	S220
	Sound Speed Sensor s/n	0614171	0614172
Calibrations	*Sound Speed Sensor s/n*	0614171	0614172
	Date	2015-07-15	2015-07-15
	Procedures	Functionality Test: Temperature Calibration, Pressure Calibration	Functionality Test: Temperature Calibration, Pressure Calibration

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. Base station sites are chosen for both clear lines of site to either survey launches or the ship for easy data downloads in addition to a clear horizon to maximize the number of GPS satellites observed. At the recommendation of HSTP, 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 all sealed in a watertight Pelican plastic case. A Zephyr Goedetic 2 GPS antenna is secured atop a Seco fixed-height GPS 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.
GPS Antennas	*Manufacturer*: Trimble Navigation Ltd. *Model*: Zephyr Geodetic 2 *Description*: The Trimble Zephyr Geodetic 2 antenna is an ideal design for horizontal control work. This antenna incorporates a large proprietary ground plane to “burn up” multipath energy. The Zephyr Geodetic 2 antenna is extremely rugged with a low profile design constructed of weather resistant materials. This antenna is compatible with GNSS signals, including GPS L2C and L5, GLONASS, and Galileo. *Serial Numbers*: 1441031361

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 is capable of tracking signals from GPS, GLONASS, Galileo, Compass, and QZSS constellations. This receiver contains 8 GB of internal storage and an integrated RJ45 port with full-duplex, auto-negotiate 100Base-T compatible with HTTP and FTP protocols. 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	n/a
	Serial Numbers	5034K69677 5034K69698
	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. 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
	Serial Numbers	4910K61054
UHF Antennas	No UHF antennas were installed.	

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 on FA 2805 885-8156 on FA 2806 885-8689 on FA 2807 884-9301 on FA 2808 884-9190 on S220
Solar Panels	*Manufacturer*	Uni-Solar (United Solar Systems Corp)
	Model	MBC-525
	Description	The Uni-Solar MBC-525 is a flexible 51" X 16" solar panel rated at 22watts.
	Serial Numbers	N/A.
Solar Chargers	*Manufacturer*	Morning Star
	Model	Sun Saver 10 SS-10L-12V
	Description	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.
	Serial Numbers	N/A
DQA Tests	No DQA tests were performed.	

A.6.1.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.6.2 Vertical Control Equipment

A.6.2.1 Water Level Gauges

Manufacturer	CO-OPS Seattle Instrument Laboratory.
Model	Portable Tide Gauge (PTG) system, 9210B data collection platform.
Description	The Portable Tide Gauge (PTG) is used for temporary installations in locations without the infrastructure to support a typical full installation. The PTG is a standalone water level station housed in a ruggedized weatherproof housing and includes all components necessary to measure, record, and transmit near real-time water levels from anywhere within the GOES footprint. The PTG utilizes an air pump as opposed to compressed nitrogen for its bubbler system thus reducing the overall weight and complexity of the system. The gauge components are housed within a Pelican weatherproof hard plastic housing. Inside the Pelican case is mounted a Sutron 9210B Data Collection Platform (DCP), a WaterLog H-355 Pump, and a Paroscientific 6000-30G pressure sensor. There are five external connections on the outside of the waterproof housing; the orifice quick connect, the GOES antenna connection (Type-N), a GPS antenna connection (SMA), a solar panel connection (2 pins), and finally the battery connection (4 pins). A complete PTG kit includes the gauge itself, GOES and GPS antennae, 40W solar panel, 40Ah battery, tripod, orifice, bubbler tubing and necessary cables. Additionally, a computer with an available serial port and a DB-9 serial cable are required to configure the DCP and/or manually download data.
Serial Numbers	PTG 1 PTG 2
Calibrations	No calibrations were performed.

Figure 27: The Portable Tide Gauge (PTG) system

A.6.2.2 Leveling Equipment

Manufacturer	LEICA
Model	NA2 100
Description	Leica's optical quality gives the NA2 a bright high contrast image. Push button compensator check Endless horizontal drive for left and right handed users Coarse and fine focusing knob Play-free footscrews Optional eyepieces available Top-class optics
Serial Numbers	5332739 5332747

Calibrations

Level s/n	5332739	5332747
Date	2015-02-03	2015-02-03
Procedures	The levels were taken in to PPI Group. for annual cleaning, inspection, adjustment, and calibration.	The levels were taken in to PPI Group. for annual cleaning, inspection, adjustment, and calibration.

Kukkamaki

Level s/n	5332739	5332747
Date	2015-02-18	2015-02-18
Procedures	The Kukkamaki procedure used follows that outlined in the User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987.	The Kukkamaki procedure used follows that outlined in the User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987.

Manufacturer	Carl Zeiss
Model	Zeiss Ni2
Description	The Zeiss Ni2 is the first automatic level based on suspended prisms that levels the light path. When set close to level, the internal compensator mechanism (a swinging prism) automatically removes any remaining variation from level. This reduces the need to set the instrument truly level since small inclination deviations are automatically corrected for. The telescope has a magnification power of 32 times and an objective diameter of 40 millimeters. It is 270 millimeters in length and produces an erect image. The cross hairs form a straight cross with stadia hairs on the vertical hair. In contrast to most

	other geodetic instruments the cross-hairs only occupy the central 50% of the field of view.		
Serial Numbers	103267		
	100056		
Calibrations	*Level s/n*	103267	100056
	Date	2015-02-10	2015-02-10
	Procedures	The levels were taken in to PPI Group. for annual cleaning, inspection, adjustment, and calibration.	The levels were taken in to PPI Group. for annual cleaning, inspection, adjustment, and calibration.
Kukkamaki	*Level s/n*	103267	100056
	Date	2014-11-23	2015-07-16
	Procedures	The Kukkamaki procedure used follows that outlined in the User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987.	The Kukkamaki procedure used follows that outlined in the User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987.

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

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

Manufacturer	HP		
Model	Z620		
Description	Ship Acquisition Computer		
Serial Numbers	*Computer s/n*	*Operating System*	*Use*
	2UA4041PPC	Windows 7	Acquisition

Manufacturer	Dell		
Model	Precision T3500		
Description	FA Processor 1, 2, 3, 8 and 9		
Serial Numbers	*Computer s/n*	*Operating System*	*Use*
	GV1ZSR1	Windows 7	Processing
	GV1SSR1	Windows 7	Processing
	GV1VSR1	Windows 7	Processing
	GV1YSR1	Windows 7	Processing
	GV23TR1	Windows 7	Processing

Manufacturer	Dell		
Model	Precision T5600		
Description	FA Processor 4, 5, 6 and 7		
Serial Numbers	*Computer s/n*	*Operating System*	*Use*
	9TOMFX1	Windows 7	Processing
	9SZJFX1	Windows 7	Processing
	9SYLFX1	Windows 7	Processing
	9T0LFX1	Windows 7	Processing

A.7.2 Computer Software

Manufacturer	Applanix
Software Name	MV-POSView
Version	5.8.0.0
Service Pack	n/a

Hotfix	n/a
Installation Date	2014-11-23
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	7.1
Service Pack	1
Hotfix	n/a
Installation Date	2015-03-06
Use	Processing
Description	The Applanix POSPac Mobile Mapping Suite (MMS) is 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 is also loaded once it receives an OPUS solution. If there is 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. General highlights for this release are listed below to give a brief summary of the changes: Improvement of navigation performance and robustness. Added support for Smart Select Single Base in manual mode. This was previously only supported in batch mode. Added support for T0x base in batch. Updated GNSS QC display design to provide more information and in a more organized manner. Updated the GUI for the Find Base Station window. Improved diagnostic logs for T0x rover and base files. Added unrepairable inertial data gap detection along with a GUI for time interval selection. Fixed an issue where IN#Fusion Single Base and IN#Fusion SmartBase may not process in corner cases. Fixed an issue where incorrect update notification window is shown. Fixed an issue where using illegal characters in the project name in batch caused an exception. Appropriate warning window is now shown. Fixed an issue where OLG high#rate data cannot be downloaded. Fixed an issue where incorrect handling of the GPS week occurred in T0x data. Various warning dialogs/windows are automatically bypassed during batch processing to avoid requiring user's input. Fixed an issue where downloading FLEPOS data did not provide download progress. Updated Trimble Antenna Config CalQC fixes and enhancements Fixed an issue where

	CalQC can crash if the photoID file is selected under “Project Files” and if the focal length is zero. Fixed an issue where GCP report is missing some GCPs.

Manufacturer	Applanix
Software Name	POSPac MMS
Version	7.1
Service Pack	2
Hotfix	n/a
Installation Date	2015-07-05
Use	Processing
Description	The Applanix POSPac Mobile Mapping Suite (MMS) is 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 is also loaded once it receives an OPUS solution. If there is 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. General highlights for this release are listed below to give a brief summary of the changes: Added support for Beidou and QZSS satellite systems for GNSS#Inertial and GNSS QC processing in Single Base mode. This includes the updates of satellite observable and QC data plots as well as the relevant message logs and statistics to include Beidou and QZSS. Same with GPS and GLONASS, Beidou and QZSS satellites can be disabled under Project Settings. Improved PPK performance. Added support for IMU69 and POS MV SurfMaster IP68 (IMU70). Fixed an issue where certain plots cannot be viewed simultaneously. Increased batch manager ‘batch name’ and ‘project name’ character limit for better legibility. Fixed an issue where datasets cannot be processed fully in some corner cases. Users may activate and deactivate a node lock license without having to contact customer support.

Manufacturer	Caris
Software Name	Base Editor
Version	4.1.10
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-04-06
Use	Processing

Description	CARIS Bathy DataBASE BASE editor allows the user to open all sources of data from historical BASE surfaces, S-57 shoreline files, raster charts 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 area ease junction and crossline comparisons. In addition the 3D fly-through offers an easy way to catch data fliers.

Manufacturer	Caris
Software Name	Base Editor
Version	4.1.16
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-12-08
Use	Processing
Description	CARIS Bathy DataBASE BASE editor allows the user to open all sources of data from historical BASE surfaces, S-57 shoreline files, raster charts 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 area 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	9.1.14
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-06-08
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	HIPS/SIPS
Version	9.1.17
Service Pack	n/a
Hotfix	n/a

Installation Date	2015-08-15
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	HIPS/SIPS
Version	9.1.19
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-09-22
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	HIPS/SIPS
Version	9.1.21
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-12-08
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 2015
Version	2015
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-06-08
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 (HSTP)
Software Name	Pydro
Version	14.6 r5115
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-07-09
Use	Processing
Description	Pydro is a special—purpose hydrographic GIS written by HSTP that provides important functionality for the quality control of NOAA hydrographic survey data. Pydro assists the hydrographer and cartographer in managing feature/object data in the context of other supporting/correlating data ("other" vector data, bathymetry, and raster data).

Manufacturer	NOAA (HSTP)
Software Name	Pydro
Version	15.1 r5469

Service Pack	n/a
Hotfix	n/a
Installation Date	2015-11-18
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 (HSTP)
Software Name	Velocipy
Version	14.6 r5115
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-07-09
Use	Acquisition
Description	Velocipy is a special purpose program written by HSTP to communicate with Sea-Bird sound velocity 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	UNH/CCOM/NOAA HSTP
Software Name	Cast Time
Version	14.6 r5115
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-07-09
Use	Acquisition
Description	CastTime is an application that bridges the gap between sound speed profiling instrumentation and multibeam echosounder acquisition systems. It is designed to assist the hydrographer in deciding when he/she should make a sound speed cast and at what times the casts should be executed. Too few profiles can lead to poor data quality and too many can lead to unnecessary wear and tear on the MVP tow-fish cable and possibly loss of the instrument. CastTime starts with user input seed times for the minimum and maximum allowable times between casts. Using available cast information, surface sound speed, and water depth, CastTime calculates a real time predicted error for the outer beams of the sonar system and recommends a new cast

	only when the error threshold is surpassed. This allows for the maximum allowable time between casts without adversely affecting data quality.

Manufacturer	NOAA (HSTP)
Software Name	POSPac Automated QC
Version	15.1 r5469
Service Pack	n/a
Hotfix	n/a
Installation Date	2015-11-18
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 density of information on a given tab may at first seem a bit excessive, but such an arrangement allows you to quickly evaluate the ERS data via correlatation to important parameters on the same view. Most of the QC work can be accomplished on the single tab labeled SBET QC. On this tab you can replace the unresolvable errors in the GNSS height and uncertainty time series data with an intepolated 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	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.

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Kahlsico International Corp Mud Snapper 214WA110

Manufacturer	Kahlsico International Corp
Model	Mud Snapper 214WA110
Description	Mud snapper is a foot-trip model, capable of fitting through a 15 cm (6") diameter ice-hole, and fabricated from sturdy bronze and stainless steel materials to assure long-time, trouble-free service. The Snapper has a long threaded post with a strong compression spring surrounding it which presses against the jaws at one end and is seated inside a cap at its upper end. By turning the threaded cap, spring-tension adjustment is effected on the closing jaws which are easily cocked open by the attached foot-trip assembly. The post may be fastened to a long, hand-held rod for shallow-water use, to a sounding weight for intermediate-water sampling or to a lowering line for free-fall to the bed of a lake, estuary, reservoir, etc. Upon impact with the bottom, the foot-trip is pushed up, disengaging the pivoted locking arm and allowing the spring-tensioned, hinged jaws to snap shut.

Figure 28: Mud Snapper

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. It is not considered a complete flow through sampler and should not be used where the water-bottom interface is important to sample. The whole body is made of stainless steel.

	A simple flap valve allows water to flow through the sampler during descent and close tightly for retrieval, minimizing sample loss.

Figure 29: 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.

All multibeam data are acquired in Hypack's Hysweep® SURVEY extension (.hsx) format and monitored in real-time using the 2-D and 3-D data display windows and the on-screen displays for the Reson 7125 SV. Adjustable parameters that are used to control the Reson include range scale, power, gain, pulse width, absorption, and spreading. These parameters are adjusted as necessary to acquire the highest quality of bathymetry and backscatter. At this time, Satmon for backscatter monitoring is still being configured and calibrated aboard Fairweather. Vessel speed for acquisition is predominantly between 6-8 knots for acquisition with launch 7125 SV systems. Speeds are reduced as needed to eliminate noise from the data and to ensure the required along-track coverage for object detection in accordance with the HSSD.

For the Kongsberg EM 710 all multibeam data is acquired in SIS (Seafloor Information System) extension (.all) format. Data were monitored in 2D, 3D and backscatter realtime display windows. A survey template is created to define its parameters. The parameters established in the template are storage location of raw data and gridded (survey) data as well as file naming convention. The New survey (sheet H#####) frame is then used to define current survey, based upon parameters given by the survey template. Basic parameters will determine projection, naming convention for mainschime (H####_M) and crossline (H#####_X). Adjustable parameters that are used to control the EM-710 include Sector Coverage, Depth Settings and Transmit Control.

Survey personnel follow standard operating procedures documented aboard Fairweather while setting and utilizing the Reson systems and Hypack for data acquisition. The sensor offsets and mounting biases are entered into the Hysweep® Hardware Reson device. This information is recorded in the Hypack hsx file header for corrected backscatter mosaics created with Hypack Geocoder. These offsets do not have any effect on CARIS HIPS HDCS sounding corrections.

For the Kongsberg EM 710 seafloor backscatter was acquired for all data during the 2015 field season. The EM710 has 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 HSTP, 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®.

During launch acquisition main scheme MBES lines using the Reson 7125 SV are generally run parallel to the 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. If coverage is not adequate, additional lines are run while still in the area.

For ship acquisition, real-time coverage is adopted. Main scheme 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.

For areas where shoreline verification is not conducted before multibeam, 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 ever being in un-surveyed waters. Survey launch crews in the field survey to the Navigable Area Limit Line (NALL) line as defined by section 1.1.2 of the HSSD.

B.1.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

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;

- Adjusts towfish height, in accordance with Field Procedures Manual.

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

B.1.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

B.1.3 Sound Speed

B.1.3.1 Sound Speed Profiles

Sound speed casts are taken at least once every 1–4 hours during multibeam survey operations in accordance with section 3.5.1 of the FPM. Fairweather's launches collect sound speed casts approximately every 2 hrs utilizing the SBE 19plus and 19plus V2 SEACAT sound speed profilers. These casts are then compared once daily to the SVP 71 surface sound speed (SSP) 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 at rest 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, during processing of later casts, the deep end of such a stationary cast can be tacked on to the end of shallower casts obtained while the ship is moving.

The fish can either be user-deployed or deployed automatically by the computer at a user defined time interval. Fairweather uses the user-deployed method due to the danger of an automatic deployment taking place during a turn. Casts with the MVP are taken as often as every 15 minutes. This high frequency is due to the ease of collecting casts while losing no survey time stopping for a SEACAT cast. In addition there is also a need to better define the SV profile over larger horizontal distances covered since it is preferable to minimize turns while the MVP is deployed.

B.1.3.2 Surface Sound Speed

Surface sound speed values are measured by a SVP 70 on Fairweather and SVP 71 probes on all survey launches. These sound speed values are applied in real-time to all MBES systems to provide refraction corrections to flat-faced transducers.

B.1.4 Horizontal and Vertical Control

B.1.4.1 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.

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. 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.

When possible, real time DGPS positioning may later be 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. With either Single Base or SmartBase 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.1.4.2 Vertical Control

All Fairweather installed tide gauges conform to the data collection and transmission requirements as stated in section 4.2 of the Hydrographic Surveys Specifications and Deliverables (HSSD). Installation and documentation of the tide staff, benchmarks, bubbler orifice in addition to leveling requirements also conform to the HSSD as well as the User's Guide for GPS Observations At Tide and Water Level Station Bench Marks, Updated December 2009.

Requirements for the acquisition of water level data from subordinate tide gauge(s) is spelled out in the Hydrographic Survey Project Instructions. Most tide gauges assigned are subordinate “30-day” stations. As the name implies, data acquisition must be continuous for a 30-day minimum. Tidal data collection must begin at least 4 hours before the start of the hydrographic survey operations and continue 4 hours after the end of survey operations.

Each gauge installation at its most basic level includes the tide gauge that is attached to a GOES antenna and a bubble orifice, a tide staff, and five benchmarks. For tide gauges, Fairweather employs the CO-OPS supplied Portable Tide Gauge (PTG) system 9210B water level gauge as described in section A.6 of this report. Tide staffs consist of 2.5 meter long 2 x 4s with attached vitrified plastic scale and stainless steel staff stops. Benchmarks are standard sized NOS benchmarks made of red brass for superior weathering resistance. Tide gauge sites assigned are either historic or new. If a historic gauge site is assigned, the Project Instructions package will include a written report of the gauge site and benchmark descriptions. Although there is no requirement to install the tide gauge and staff at their exact historic locations, every effort is made to recover as many benchmarks as possible. All historic benchmarks are reused for the tide station installation although replacement benchmarks were needed to be installed to replace those missing. Some historic gauges have only three benchmarks installed, so two new marks were needed to be installed to bring the total up to the required five.

Instructions for new gauges include a proposed installation site, but this is not set in stone. Prior to actual installation, it is standard procedure to recon the immediate area and select the best potential site. After consultation with CO-OPS and if the new location is approved, the gauge is assigned a new seven-digit station identifier number.

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 features to be verified. 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 and reconnaissance at times near predicted negative tides within the survey limits when possible, 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 and 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 instruction for a given project area.

Detached positions (DPs) acquired during shoreline verification 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.

B.1.6 Bottom Sampling

Bottom samples are acquired according to section 7.1 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 C - 2.2 of this report. Bottom sample results are included in the Notebook/BDB .hob deliverable layer, H#####_Final_Feature_File and are descriptively attributed as New.

B.1.7 Backscatter

Current guidance from the Field Procedures Manual and Project Instructions call for field units to acquire and submit multibeam backscatter data in snippet mode whenever feasible. Reson “snippets” imagery are recorded at acquisition and are present in the raw data, but not processed or analyzed. Snippet data contains the amplitude data of each individual sonar beam in a swath, but there are problems, well-documented in the hydrographic literature, that reduces the efficacy of processing these data.

When tuned to collect the optimal bathymetric data, Reson sonar systems tend to over-saturate the return signal and thus limit its value in terms of backscatter. In an attempt to alleviate this problem Saturation Monitor (SatMon) was developed by Glen Rice based on thesis work by Sam Greenaway with the goal of producing consistent and high quality backscatter data without adversely affecting the collection of bathymetric data. SatMon is a bundle of python code developed in-house as part of the Pydro software suite and is intended to aid the sonar operator in estimating the saturation state of the receiver of a Reson 7k series multibeam sonar.

Backscatter data are collected by default with the Fairweather's EM710.

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 .HSX files in Hypack, for launch acquisition and as .all for ship acquisition. This data is then converted to CARIS HIPS HDCS format using established and internally documented settings. After TrueHeave™, sound speed, and water level correctors are applied to all lines, the lines are merged. Once lines are merged, Total Propagated Uncertainty (TPU) is computed.

Bathymetric surfaces are created and analyzed using the resolution, depth range, and CUBE parameters outlined in 5.2.2.2 of the HSSD. If these depth range values for specific resolutions require adjustment for analysis and submission of individual surveys then a waiver from HSD Operations is required and would be requested. A detailed listing of the resolutions and the actual depth ranges used during the processing of each survey, along with the corresponding field sheet(s), will be provided in the Descriptive Report of each survey.

BASE surfaces are created using the Density & Locale function of the CUBE algorithm and parameters contained in the NOAA CUBEParams_NOAA.xml. The CUBEParams_NOAA.xml will be included with the HIPS Vessel Files with the individual survey data. The NOAA parameter configurations for resolutions 50 centimeters-32 meters are used.

Multibeam data are revied and analysed in HIPS subset mode and in swath editor as necessary. The finalized BASE surfaces and CUBE hypotheses are used for directed data editing at the appropriate depth range in subset editor. The surfaces and subset editor view 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 BASE surface does not depict the desired depth for the given area, a designated sounding is selected. Designated soundings are selected as outlined in section 5.2.1.2 of the HSSD.

Layers determining “IHOness” are added to the CUBE surfaces allowing the Hydrographer to see where and if the surfaces meet IHO Order. The process is easily performed in HIPS and allows the Hydrographer to identify areas of high uncertainty with respect to depth. This is a spatial quality control check rather than just a statistical list of nodes and allows for specific areas with problems to be isolated and addressed. The following logic equation is used to create “IHO_1” child layers in the 1 through 8 meter finalized surfaces:

IHO-1: -Uncertainty/((0.5^2 +((Depth*0.013)^2))^0.5), and an “IHO_2” child layer is created in the 8, 16 meter, and greater finalized surfaces using IHO-2: -Uncertainty/((1.0^2 +((Depth*0.023)^2))^0.5).

It should be noted that both IHO order 1 (~80 to 100) and order 2 (100 to 176) child layers are created for the 8 meter surface since it overlaps the order 1 and order 2 boundary (order1<100 meters, order 2>100 meters). IHO surfaces are used during processing to indicate potential problem areas requiring attention or documentation. Observed grid node uncertainty values are compared to IHO order 1 and Order 2 uncertainty standards. The percentage of nodes meeting or exceeding these standards is calculated for each HIPS CUBE surface with a NOAA supported and distributed script, and then reported in the Descriptive Report. For surveyed areas that do not meet IHO standards, images of affected areas may be included.

The individual finalized surface are loaded in the Pydro Contribution/ Finalized CSAR QA application to allow the Hydrographer to see the full data distribution rather than just the minimum and maximum values in the surface. These data distribution are used to assess the quality of the survey, to ensure one hundred percent of the data meets the appropriate IHO order as specified in section 5.1.3 of the HSSD 2015.

Additionally, a combined surface is reviewed in 3-D mode using one of the following programs, CARIS HIPS, CARIS Base Editor, or IVS Fledermaus, to ensure that the data are sufficiently cleaned for submission.

Figure 30: Coverage and Resolution.

B.2.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not processed.

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 generated for final submission. The exact behavior of CUBE is determined by the values set in the CUBE parameters file, a 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.xml) with new 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

- Convert raw .sdf data using CARIS SIPS;
- Scan Navigation and Attitude data, flagging erroneous data as rejected;
- Re-compute towfish navigation. This is when towpoint offsets and horizontal layback is applied to the data;
- Slant range correct is done automatically in CARIS HIPS and SIPS;
- A primary reviewer scans each line for significant contacts;
- A secondary reviewer makes an independent check-scan of all lines, verifying contacts and checking for missed contacts;
- Create mosaics for 100% coverage. Examine for coverage and refraction present in the data;
- When necessary, create a holiday line plan.

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

Daily confidence checks were completed to ensure integrity of data. These checks were completed by ensonifing a target in the outer limits of the range scale on either side of towfish. When this target was seen on the trace within ten meters of the target's actual position (the positional accuracy of a towed system), it was understood that data integrity was maintained. Additionally, integrity is controlled through the use of acquisition and processing logs.

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

Object detection from side-scan imagery is obtained by acquiring the entire survey area two times, with survey lines in the second coverage offset halfway between the lines from the first coverage. These results in 200% Side-Scan Coverage with line spacing based on 80% of the range scale.

For object detection in Kotzebue Sound due to the nature of the area, SSS data was collected once, 100% Side Scan Coverage with line spacing based on 80% of the range scale. All significant contacts were verified with MBES.

To ensure positional accuracy, a side-scan certification test is performed. Multiple passes are made on a discrete feature (1m cube when possible) that ensonifies the feature with each transducer at a distance approximately 15%, 50%, and 80% of the range scale in use. A total of 12 passes are made and the feature must be detected in at least 10 of the 12 pass. All survey lines are then processed and a contact created for the feature. Contact positions are plotted and compared to the actual position of the feature. The contacts must be within 5m of the actual position for hull-mounted systems and 10m for towed systems.

B.2.2.3.3 Methods Used to Verify Swath Coverage

Side-scan sonar coverage is determined by creating mosaics using Mosaic Editor in CARIS SIPS. The 100% of coverage is evaluated for gaps in coverage. Any holidays noted in the mosaics must be re-acquired in manners that will ensonify the area from the same incidence angle as originally intended.

B.2.2.3.4 Criteria Used for Contact Selection

For water depths less than 20m, contact heights of 1m or greater are considered significant. For water depths 20m or greater, contact heights of 10% of the water depth are considered significant.

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 HSTP supplied Pydro program suite. Raw SV files are retained and archived for later submission to NGDC. Processed SVP files are archived and submitted to the hydrographic branch as well as the National Oceanographic Data Center (NODC) as part of the sheet submission package.

For Seacats:

- After a cast, the SBE Seacat 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 meta data. Empty slots for Project, Survey, NOAA Unit, Instrument, User name, Process Date, Draft, and Latitude and Longitude are given. The meta data is written into the NODC output files.
- After entering meta data, the sound velocity, 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.
- 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 Velocity, 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.

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 beacons. 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. When possible, real time DGPS positioning may later be 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. With either Single Base or SmartBase 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, current guidelines are to delete current feature and create a new feature 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. The status of Primary or Secondary may be attributed to aid in de-conflicting multiple positions or instances of the same feature.

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 CARIS/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 CARIS Notebook files 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 CARIS Notebook 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 from Notebook, the H##### Original Composite Source and the H##### Final Feature File, included with the processed data.

B.2.6 Backscatter

Although no formal processing of backscatter data were performed, backscatter data were periodically converted solely to spot check and ensure that it was being properly logged. No processed backscatter data is included with the data submission but all raw backscatter data are submitted directly to NGDC for archival purposes.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Final review of the “QC” field sheet 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.

On occasion, the resolution of the CUBE 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 CUBE 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, (i.e. 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.

At the time of this report, Coast Survey has not approved multiple resolution BASE surfaces as a final deliverable. Although these surfaces are acceptable for field use, the algorithm produces artifacts at the resolution steps that are unsuitable for a final product. To circumvent this problem, single resolution CUBE surfaces were generated to be “cookie cut” and then reassembled to create the final CUBE surface from which depths are derived. Multiple CUBE surfaces are gridded using different resolutions for different depth ranges as defined in section 5.2.2.2 of the HSSD.

Under ideal circumstances, gridding should be done at the finest resolution that the data density will support. 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 5.2.2.2) states that 95% of the nodes in a CUBE surface shall contain at least 5 soundings per node. This minimum density of 5 soundings per node 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. These resolutions are also 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)

Once the collection of CUBE surfaces accurately represent the surveyed bottom and it is certain that no further edits will be made, each CUBE surface is finalized using the resolution as defined in section 5.2.2.2 of the HSSD. All finalized CUBE surfaces are then combined at the coarsest resolution created for the data set to produce the final combined CUBE surface. The final combined CUBE surface is named by the following convention; H#####_MB_Xm_MLLW_Combined.

The final CUBE surfaces are sun-illuminated from different angles and examined for coverage and as a final check for systematic errors such as tide, sound velocity, or attitude and/or timing errors. The final CUBE surface submitted to demonstrate that both SWMB coverage requirements are met and that systematic errors have been examined for quality-assurance purposes.

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. Dynamic/ERS and sound speed uncertainties are entered 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.

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 tide/ERS and sound speed are entered and used over the duration of the project.

B.4.1.2 Source of TPU Values

Error 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.

B.4.1.3 TPU Values

Vessel	FA_2805_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.500 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*	0.006 meters
		y	0.006 meters
		z	0.006 meters

	MRU Alignment	*Gyro*	0 degrees
		Pitch	0.09 degrees
		Roll	0.09 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.018 meters
		Draft	0.019 meters
		Delta Draft	0.1 meters
Vessel	FA_2805_400kHz_7125_512bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 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*	0.006 meters
		y	0.006 meters
		z	0.006 meters
	MRU Alignment	*Gyro*	0.010 degrees
		Pitch	0.040 degrees
		Roll	0.040 degrees
	Vessel	*Speed*	0.03 meters/second
		Loading	0.018 meters
		Draft	0.019 meters
		Delta Draft	0.1 meters
Vessel	FA_2806_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 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*	0.004 meters
		y	0.004 meters
		z	0.004 meters
	MRU Alignment	*Gyro*	0.070 degrees
		Pitch	0.06 degrees
		Roll	0.06 degrees
	Vessel	*Speed*	0.03 meters/second
		Loading	0.051 meters
		Draft	0.051 meters
		Delta Draft	0.1 meters
Vessel	FA_2806_400kHz_7125_512bms_2015		
Echosounder	Teledyne reson SeaBat 7125 SV 1 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.040 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*	0.004 meters
		y	0.004 meters
		z	0.004 meters
	MRU Alignment	*Gyro*	0.05 degrees
		Pitch	0.09 degrees
		Roll	0.09 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.051 meters
		Draft	0.051 meters
		Delta Draft	0.1 meters
Vessel	FA_2807_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 degrees
		Heave	5 % Amplitude 0.05 meters
		Pitch	0.020 degrees
		Roll	0.020 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*	0.007 meters
		y	0.007 meters
		z	0.007 meters

	MRU Alignment	*Gyro*	0.08 degrees
		Pitch	0.07 degrees
		Roll	0.07 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.044 meters
		Draft	0.044 meters
		Delta Draft	0.050 meters
Vessel	FA_2807_400kHz_7125_512bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 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*	0.007 meters
		y	0.007 meters
		z	0.007 meters
	MRU Alignment	*Gyro*	0.170 degrees
		Pitch	0.08 degrees
		Roll	0.08 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.044 meters
		Draft	0.044 meters
		Delta Draft	0.050 meters
Vessel	FA_2808_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 degrees
		Heave	5 % Amplitude 0.05 meters
		Pitch	0.020 degrees
		Roll	0.020 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*	0.006 meters
		y	0.006 meters
		z	0.006 meters
	MRU Alignment	*Gyro*	0.02 degrees
		Pitch	0.06 degrees
		Roll	0.06 degrees
	Vessel	*Speed*	0.03 meters/second
		Loading	0.032 meters
		Draft	0.032 meters
		Delta Draft	0.075 meters
Vessel	FA_2808_400kHz_7125_512bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.04 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*	0.006 meters
		y	0.006 meters
		z	0.006 meters
	MRU Alignment	*Gyro*	0.08 degrees
		Pitch	0.03 degrees
		Roll	0.03 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.032 meters
		Draft	0.032 meters
		Delta Draft	0.075 meters
Vessel	FA_S220_EM710_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 100 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

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 needed to compute sensor lever arms needed to correct for vessel orientation and ultimately produce the final geographic position for every sounding collected.

C.1.1.2 Methods and Procedures

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 top, center of the POS MV IMU. The offset values from the reference point to the primary GNSS antenna are entered into Applanix's POSView POS MV monitoring software so that all raw position data are centered at the vessel's reference point. The CARIS HVF contains the offset from the vessel's reference point to the multibeam sonar reference point.

Additionally, the Reson 7125 sonar mounting offsets measured from the center of each projector to the center of the transceiver are entered in the Reson 7125 hardware configuration with the 7K Center for both the 400 kHz and 200 kHz projectors. The measured values are used instead of Reson's default values because Fairweather's mounts are slightly different than of Reson's standard sonar mount.

Permanent control points were established on launches 2805, 2806, 2807, and 2808 during construction at All American Marine in 2009.

For Fairweather ship's 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 in 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. Because 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. Because 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.

With this approach, any residual misalignment between the EM710 and 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 receiver but is entered only in SVP 2 so that SV files are properly applied. The CARIS HVF is maintained for Fairweather, required for application of SV and dynamic draft correctors. For this HVF, all vessel offset values have been set to 0,0,0 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.

Figure 31: Vessel Reference Point (Top of POS MV IMU) & Primary GNSS Antenna (port side).

Figure 32: Reson 7125 sonar mounting with 400k Hz and 200 kHz offsets respectively.

C.1.1.3 Vessel Offset Correctors

Vessel	FA_2805_200kHz_7125_256bms_2015
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz
Date	2015-02-23

Offsets	*MRU to Transducer*	*x*	0.004 meters
		y	0.245 meters
		z	0.482 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.686 meters
		y	1.051 meters
		z	3.656 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2805_400kHz_7125_512bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz		
Date	2015-02-22		
Offsets	*MRU to Transducer*	*x*	0.004 meters
		y	0.245 meters
		z	0.482 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.686 meters
		y	1.051 meters
		z	3.656 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2806_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		
Date	2015-02-22		

Offsets	*MRU to Transducer*	*x*	-0.013 meters
		y	0.254 meters
		z	0.481 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.624 meters
		y	1.087 meters
		z	3.603 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2806_400kHz_7125_512bms_2015		
Echosounder	SeaBat 7125 SV 1 Teledyne Reson 400 kilohertz		
Date	2015-02-22		
Offsets	*MRU to Transducer*	*x*	-0.013 meters
		y	0.254 meters
		z	0.481 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.624 meters
		y	1.087 meters
		z	3.603 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2807_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		
Date	2015-02-22		

Offsets	*MRU to Transducer*	*x*	0.019 meters
		y	0.244 meters
		z	0.481 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.804 meters
		y	1.056 meters
		z	3.628 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2807_400kHz_7125_512bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz		
Date	2015-02-23		
Offsets	*MRU to Transducer*	*x*	0.019 meters
		y	0.244 meters
		z	0.481 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.804 meters
		y	1.056 meters
		z	3.628 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2808_200kHz_7125_256bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz		
Date	2015-02-26		

Offsets	*MRU to Transducer*	*x*	0.004 meters
		y	0.250 meters
		z	0.477 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.685 meters
		y	1.086 meters
		z	3.637 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_2808_400kHz_7125_512bms_2015		
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz		
Date	2015-02-26		
Offsets	*MRU to Transducer*	*x*	0.004 meters
		y	0.250 meters
		z	0.477 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.685 meters
		y	1.086 meters
		z	3.637 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	FA_S220_EM710_2015		
Echosounder	Kongsberg EM-710 100 kilohertz		
Date	2015-02-06		

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 degrees
		Roll2	0 degrees

C.1.2 Layback

C.1.2.1 Description of Correctors

Towfish positioning is provided to CARIS HIPS using cable-out values registered by the cable counter and recorded in the Sonar Pro SDF files. SonarPro uses Payout and Towfish Depth to compute towfish positions. The towfish position is calculated from the position of the tow point using the cable-out value received by SonarPro from the cable payout meter, the towfish pressure depth (sent via a serial interface from the KLEIN 5000 TPU to the SonarPro software), and the Course Made Good (CMG) of the vessel. This method assumes that the cable is in a straight line. Therefore, no catenary algorithm is applied at the time of acquisition, but in processing, CARIS SIPS applies a 0.9 coefficient to account for the catenary.

C.1.2.2 Methods and Procedures

Layback error is calculated by running a side-scan certification test. This test consists of running parallel to a known feature at varying ranges from nadir to ensonify the target in the near-field (approx 15% of range scale in use), mid-field (approx 50 % of range scale in use), and far-field (approx 85% of the range scale in use). The test requires that each side of the sonar ensonify the feature at each of these areas in the swath. Then the test is repeated in a direction that is orthogonal to the original set of lines such that the feature is ensonified a total of 12 times. A successful test will detect the feature in at least 10 of the 12 passes. For hull-mounted systems, the selected contact positions must be within 5m; for towed systems, the contact positions must be within 10m. Layback error is the amount of correction that must be applied to minimize the distance between contact positions.

C.1.2.3 Layback Correctors

Vessel	S220		
Echosounder	Klein Associates Inc Klein 5000 455 kilohertz		
Date	2015-07-27		
Layback	*Towpoint*	*x*	0.269 meters
		y	-51.060 meters
		z	-7.460 meters
	Layback Error	0 meters	
Vessel	2807		
Echosounder	Klein Associates Inc Klein 5000 455 kilohertz		
Date	2015-03-19		
Layback	*Towpoint*	*x*	-0.619 meters
		y	0.655 meters
		z	0.774 meters
	Layback Error	0 meters	
Vessel	2808		
Echosounder	Klein Associates Inc Klein 5000 455 hertz		
Date	2015-03-20		
Layback	*Towpoint*	*x*	-0.564 meters
		y	0.666 meters
		z	0.730 meters
	Layback Error	0 meters	

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. Since the distance between the reference point and transducers is known, it is elementary to derive the difference between the water line and the transducer. 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 during February- March of 2015 in Seattle, WA. The values and calculations for static draft of the various launches are listed in the respective Waterline Measurement spreadsheets included in this report.

For Fairweather ship sonar system, static draft corrector values are entered in the Kongsberg SIS Installation Parameters window. Unlike survey launches, loading conditions on the ship, particularly fuel and launches, does have a significant influence on static draft. To compensate, during the Kongsberg start up procedure static draft values are measured. In addition to being entered into the SIS Installation Parameters window, waterline values are also entered in the CARIS HVF. This Waterline value in CARIS will only be used during Sound Velocity Correction. The Apply switch is also set to “No”. If it is set to “Yes”, the waterline value will be applied twice, once in SIS and again in Merge.

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 (typically chosen to be coincident with Inertial Measurement Unit, IMU). 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 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. The resulting Smoothed Best Estimate of Trajectory (SBET) was exported from POSPac and the 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 Pydro. For the ship, the polynomial curve was used to derive the table used in the CARIS HVF. We used the 2015 values to contribute to the Historical average, which was entered into the HVF for the launches. The standard deviation of the residuals was used to determine the associated uncertainty in the measurement. Written reports for each platform including initial measurement notes, graphs, and finalized values are provided in report. The polynomial best fit curve of the ellipsoidal height differences from all platforms are compared with each other and previous years. The dynamic draft offset values and standard deviations were then entered into the CARIS HVFs.

C.2.2.3 Dynamic Draft Correctors

Vessel	2805
Date	2015-02-24
Dynamic Draft Table	

Speed	*Draft*
0	0
0.5	-0.01
1	0
1.5	0.01
2	0.02
2.5	0.04
3	0.05
3.5	0.05
4	0.05
4.5	0.03
5	0
5.5	-0.05
6	-0.09
6.5	-0.14
7	-0.2

Vessel	2806
Date	2015-02-24
Dynamic Draft Table	

Speed	*Draft*
0	0
0.5	-0.01
1	0
1.5	0.01
2	0.02
2.5	0.04
3	0.05
3.5	0.05
4	0.05
4.5	0.03
5	0
5.5	-0.05
6	-0.09

Speed	*Draft*
6.5	-0.140
7	-0.2

Vessel	2807
Date	2015-02-24

Dynamic Draft Table

Speed	*Draft*
0	0
0.5	-0.1
1	0
1.5	0.01
2	0.02
2.5	0.04
3	0.05
3.5	0.05
4	0.05
4.5	0.03
5	0
5.5	-0.05
6	-0.09
6.5	-0.140
7	-0.2

Vessel	2808
Date	2015-02-24

Dynamic Draft Table

Speed	*Draft*
0	0
0.5	-0.1
1	0
1.5	0.01
2	0.02
2.5	0.04
3	0.05
3.5	0.05
4	0.05
4.5	0.03

	Speed / *Draft*: 5 / 0; 5.5 / -0.05; 6 / -0.09; 6.5 / -0.14; 7 / -0.2
Vessel	S220
Date	2015-04-21
Dynamic Draft Table	see below

Speed	*Draft*
5	0
5.5	-0.05
6	-0.09
6.5	-0.14
7	-0.2

Vessel	S220
Date	2015-04-21

Dynamic Draft Table

Speed	*Draft*
0	0
0.5	0
1	0.01
1.5	0.02
2	0.03
2.5	0.05
3	0.07
3.5	0.09
4	0.11
4.5	0.14
5	0.16
5.5	0.2
6	0.23
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. The Sea Bat 7125 SV1 multibeam system is a dual frequency system utilizing a separate transducer for each frequency and thus requiring an individual test for each frequency. 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.

For Fairweather new Kongsberg EM-710 a patch test was conducted as part of the Sonar Acceptance Trial. The purpose of a patch test is to experimentally resolve any residual angular offset between the positioning system and the sonar reference frame. The patch test was independently processed in SIS as well as CARIS.

C.3.2 Methods and Procedures

For all Launches:

Data was 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 velocity were applied and the data merged before cleaning via Swath Editor. Biases were determined using the CARIS HIPS Calibration tool by at least 5 individual testers. The multiple values determined for each bias by individual testers were examined by a reviewer, and obvious outliers rejected before an average was determined. This average value was then applied to the bias in question and applied to the data before moving on to the next bias determination. Bias values were determined in the following order; timing, pitch, roll, and finally yaw. These averaged values were established as the final correctors and were added to the CARIS HVF.

For Ship System:

Please see NOAA Ship Fairweather Kongsberg EM710 Multibeam Echosounder Acceptance Trials document.

Figure 33: NOAA Ship Fairweather Kongsberg EM710 Multibeam Echosounder Acceptance Trials.

C.3.3 System Alignment Correctors

<table>
<tr><td>Vessel</td><td colspan="2">FA_2805_200kHz_7125_256bms_2015</td></tr>
<tr><td>Echosounder</td><td colspan="2">Teledyne Reson SeaBat 7125 SV 1 200 kilohertz</td></tr>
<tr><td>Date</td><td colspan="2">2015-02-22</td></tr>
<tr><td rowspan="8">Patch Test Values</td><td>Navigation Time Correction</td><td>0 seconds</td></tr>
<tr><td>Pitch</td><td>-1.450 degrees</td></tr>
<tr><td>Roll</td><td>-0.3 degrees</td></tr>
<tr><td>Yaw</td><td>0.450 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>
<tr><td>Vessel</td><td colspan="2">FA_2805_400kHz_7125_512bms_2015</td></tr>
</table>

Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz	
Date	2015-02-22	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-1.05 degrees
	Roll	-0.27 degrees
	Yaw	0.21 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	FA_2806_200kHz_7125_256bms_2015	
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz	
Date	2015-02-22	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-2.260 degrees
	Roll	-0.17 degrees
	Yaw	0.3 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	FA_2806_400kHz_7125_512bms_2015	
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 hertz	
Date	2015-02-22	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-1.840 degrees
	Roll	-0.22 degrees
	Yaw	0.350 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	FA_2807_200kHz_7125_256bms_2015	
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 kilohertz	
Date	2015-02-22	

Patch Test Values	*Navigation Time Correction*: 0 seconds *Pitch*: -2.31 degrees *Roll*: 0.03 degrees *Yaw*: 1.2 degrees *Pitch Time Correction*: 0 seconds *Roll Time Correction*: 0 seconds *Yaw Time Correction*: 0 seconds *Heave Time Correction*: 0 seconds
Vessel	FA_2807_400kHz_7125_512bms_2015
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz
Date	2015-02-22
Patch Test Values	*Navigation Time Correction*: 0 seconds *Pitch*: -2.37 degrees *Roll*: 0.04 degrees *Yaw*: 0.61 degrees *Pitch Time Correction*: 0 seconds *Roll Time Correction*: 0 seconds *Yaw Time Correction*: 0 seconds *Heave Time Correction*: 0 seconds
Vessel	FA_2808_200kHz_7125_256bms_2015
Echosounder	Teledyne Reson SeaBat 7125 SV 1 200 hertz
Date	2015-02-26
Patch Test Values	*Navigation Time Correction*: 0 seconds *Pitch*: -2.68 degrees *Roll*: 0.06 degrees *Yaw*: 0.21 degrees *Pitch Time Correction*: 0 seconds *Roll Time Correction*: 0 seconds *Yaw Time Correction*: 0 seconds *Heave Time Correction*: 0 seconds
Vessel	FA_2808_400kHz_7125_512bms_2015
Echosounder	Teledyne Reson SeaBat 7125 SV 1 400 kilohertz
Date	2015-02-26

Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-1.25 degrees
	Roll	0.1 degrees
	Yaw	0.87 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	2015-07-19	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	0 degrees
	Roll	0 degrees
	Yaw	0 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 the Hysweep .hsx and SIS .all files.

Attitude correctors are applied during CARIS HIPS conversion using the raw POS MV attitude data recorded in the raw data (.hsx, .all). The TrueHeave file is separately loaded into HIPS, replacing the unfiltered 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 all 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 as opposed to the real time heave corrector, and is fully described in Section 6 of the POS MV V4 User Guide 2009. 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. Although the filter that produces the true heave values by looking at a long series of data to create a baseline needs only 3 minutes before and after the acquisition of bathymetric data, SBET processing which uses the same .000 file requires logging for 5 minutes before and after bathymetric acquisition.

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.

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.

All Fairweather survey launch offsets, dynamic draft correctors, and system bias values are contained in CARIS HIPS Vessel Files (HVFs) and were created using the program Vessel Editor in CARIS. These offsets and biases are applied to the sounding data during processing in CARIS.

For the Fairweather Kongsberg EM-710 all offsets, offsets, dynamic draft correctors, and system bias values are spread out between the ship's HVF, SIS configuration and POS/MV configuration. These offsets and biases are applied to the sounding data during processing in CARIS.

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 by HSD OPS, 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 the Alaska area, which lacks of a published VDatum Separation Model, a 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 then applied to the ellipsodially-referenced hydrography to reference it to chart datum. ERS-ERZT data may be readjusted at a later date when VDatum coverage becomes available.

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 velocity 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 velocity profiles were acquired with the BrookeOcean Moving Vessel Profiler MVP200 micro CTD. All Fairweather launches are equipped with 24-volt electric winches attached to small swing-arm davits to deploy and recover SV profilers while the vessel is at rest.

C.6.1.2 Methods and Procedures

For both the individual SeaCat profilers and the ship's MVP-200, sound velocity profiles for CARIS were computed from raw pressure, temperature, and conductivity measurements using the program Velocipy. Velocipy was supplied by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP). Velocipy generated sound velocity profiles for CARIS in the .SVP format. For survey launches, the speed of sound through the water was determined by a minimum of one cast for every four hours of SWMB acquisition, as strongly recommended in the NOS Hydrographic Surveys Specifications and Deliverables manual. Casts were conducted more frequently when changing survey areas, or when it was felt that conditions, such as a change in weather, tide, or current, would warrant additional sound velocity profiles.

While conducting survey operations with the ship and the MVP200, the frequency of casts were determined with the aid of the program "CastTime" developed at the University of New Hampshire's Center for Coastal and Ocean Mapping / Joint Hydrographic Center. This tool monitors oceanographic variability inreal-time based on sound speed data acquired by the MVP200. From this information, CastTime provides recommendations for optimal water-column sampling intervals. As a result, ship personnel are no longer required to subjectivity take casts based on some arbitrary time interval. Rather an improvement in sounding accuracy is realized with a sampling interval based on constant monitoring of oceanographic variability.

In addition CastTime also prevent needless overworking of the underway profiler, saving on wear and tear maintenance costs for the MVP200 system.

SIS also monitors changes in the surface sound speed vs. the value obtained with the last cast in real-time. 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.Processed MVP casts sent directly to the Kongsberg EM710 are applied to all subsequent SWMB data. This method has the drawback that the MVP cast taken prior to the collection of the SWMB data will always be applied rather than the SV cast that is geographically closest. This shortcoming may be circumvented by post applying SV data to all EM710 data in CARIS HIPS/SIPS.

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

All multibeam systems utilized aboard require a sound velocity probe to be interfaced with the sonar acquisition unit for use in projector steering computations. During all survey operations, surface sound velocity probes are on at all times. In the event of a velocity probe failure, survey operations immediately cease until the failure is corrected.

C.6.2.2 Methods and Procedures

The Reson 7125 SV1 systems utilized on all launches require a sound velocity probe to be interfaced with the sonar acquisition unit for use in projector beam steering computations. A Reson SVP 71 surface sound velocity probe is utilized to feed real time SV values directly into the 7-P Sonar Processing Unit.

The Kongsberg EM 710 multibeam systems utilized aboard requires a sound velocity probe to be interfaced with the sonar acquisition unit for use in projector steering computations. A Reson SVP 70 surface sound velocity 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 real-time. 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.

Additional Discussion

Static Draft tables

Figure 34: S220 Draft error from directly measuring draft from e#deck handrail marks without correction for pitch.

Figure 35: 2805 Static Draft table

Figure 36: 2806 Static Draft table

Figure 37: 2807 Static Draft table

Figure 38: 2808 Static Draft table

Additional Discussion