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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-M328-FA-19
Time Frame:	August - August 2019

LOCALITY

State(s):	California Oregon
General Locality:	Offshore California and Oregon

2019

CHIEF OF PARTY
CDR Marc Moser, NOAA

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Data Acquisition and Processing Report

NOAAS Fairweather S220
Chief of Party: CDR Marc Moser, NOAA
Year: 2019
Version: 1
Publish Date: 2019-08-23

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 NOAAS Fairweather

<table>
<tr><td><i>Vessel Name</i></td><td colspan="2">NOAAS Fairweather</td></tr>
<tr><td><i>Hull Number</i></td><td colspan="2">S220</td></tr>
<tr><td><i>Description</i></td><td colspan="2">NOAAS Fairweather (S220) is a 70.4 meter oceanographic research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). It has a welded steel and ice strengthened hull for an ABS classification of #A1, #AMS.</td></tr>
<tr><td rowspan="3"><i>Dimensions</i></td><td><i>LOA</i></td><td>70.4 meters</td></tr>
<tr><td><i>Beam</i></td><td>12.8 meters</td></tr>
<tr><td><i>Max Draft</i></td><td>4.8 meters</td></tr>
<tr><td rowspan="2"><i>Most Recent Full Static Survey</i></td><td><i>Date</i></td><td>2015-01-07</td></tr>
<tr><td><i>Performed By</i></td><td>The IMTEC Group, Ltd.</td></tr>
</table>

Figure 1: NOAA Ship Fairweather S220

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM 710

S220 has a hull-mounted Kongsberg EM 710 multibeam echosounder (MBES), which operates at sonar frequencies in the 70 to 100 kHz range. The maximum utilized across-track swath coverage is 140° with a published maximum depth of >2500 meters. The along track beam width configuration is ½° with a receive beam width of 1°. The system forms 400 soundings per swath with an equidistant beam spacing and dynamic focusing employed in the near field. The transmit beams are divided into three sectors which transmit sequentially within each ping, using distinct frequencies to maximize range capability and to suppress interference from multiples of strong bottom echoes. The typical operational depth range of the EM 710 is 10 to 2500 meters.

Manufacturer	Kongsberg					
Model	EM 710					
Inventory	*S220*	*Component*	HWS	Transceiver Unit (TRU)	Transmit Array	Receive Array
		Model Number	MP 8300	EM 710	EM 710	EM 710
		Serial Number	CZC3407GZ9	232	232	232
		Frequency	N/A	70-100 kHz	70-100 kHz	70-100 kHz
		Calibration	2019-05-17	2019-05-17	2019-05-17	2019-05-17
		Accuracy Check	2019-05-18	2019-05-18	2019-05-18	2019-05-18

Figure 2: EM 710 gondola during transducer installation

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

No side scan sonars 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

Field units maintain calibrated lead lines for use in occasional direct water measurements, particularly during shoreline investigation. Fairweather maintains two calibrated lead lines on board.

Manufacturer	FA Personnel			
Model	Traditional			
Inventory	*S220*	*Component*	Lead Line	Lead Line
		Model Number	Traditional	Traditional
		Serial Number	10-05-09	10-06-09
		Calibration	2019-03-18	2019-03-18

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix POS MV 320 V5

The POS MV V5 calculates position, heading, attitude, and vertical displacement (heave) of a vessel. It consists of a rack mounted POS Computer System (PCS), a bolt down IMU-200 Inertial Measurement Unit (IMU), and two GNSS antennas corresponding to GNSS receivers in the PCS.

Manufacturer	Applanix					
Model	POS MV 320 V5					
Inventory	*S220*	*Component*	PCS	IMU	GNSS Antenna	GNSS Antenna
		Model Number	320 V5	LN200	GA830	GA830
		Serial Number	8194	292	9959	9960
		Calibration	2019-05-17	2019-05-17	2019-05-17	2019-05-17

Figure 3: POS MV 320 V5 System

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

A.5.4.1 Laser Tech TruPulse 200

The TruPulse laser rangefinders are used to measure the static draft of S220

<table>
<tr><td><i>Manufacturer</i></td><td>Laser Tech</td></tr>
<tr><td><i>Model</i></td><td>TruPulse 200</td></tr>
<tr><td><i>Inventory</i></td><td><table><tr><td><i>S220</i></td><td><table>
<tr><td><i>Component</i></td><td>Laser Range Finder</td><td>Laser Range Finder</td></tr>
<tr><td><i>Model Number</i></td><td>TruPulse 200 Laser Rangefinder</td><td>TruPulse 200 Laser Rangefinder</td></tr>
<tr><td><i>Serial Number</i></td><td>LR 041156</td><td>LR 041169</td></tr>
<tr><td><i>Calibration</i></td><td>2019-03-22</td><td>2019-03-22</td></tr>
</table></td></tr></table></td></tr>
</table>

Figure 4: TruPulse 200 Laser Rangefinder

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

No CTD profilers were utilized for data acquisition.

A.6.3 Sound Speed Sensors

A.6.3.1 Teledyne RESON SVP-70

The SVP-70 is a direct-reading sound speed probe with a 125mm sound transmission path. The unit’s housing is composed of robust titanium, which reduces marine growth on these continually submerged sensors. S220 has two sensors in close proximity to the ship’s multibeam transducer.

<table>
<tr><td><i>Manufacturer</i></td><td>Teledyne RESON</td></tr>
<tr><td><i>Model</i></td><td>SVP-70</td></tr>
<tr><td><i>Inventory</i></td><td><table><tr><td><i>S220</i></td><td><table>
<tr><td><i>Component</i></td><td>Surface Sound Speed Sensor</td><td>Surface Sound Speed Sensor</td></tr>
<tr><td><i>Model Number</i></td><td>SVP-70</td><td>SVP-70</td></tr>
<tr><td><i>Serial Number</i></td><td>0614171</td><td>0614172</td></tr>
<tr><td><i>Calibration</i></td><td>2019-04-01</td><td>2019-03-29</td></tr>
</table></td></tr></table></td></tr>
</table>

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

A.6.5.1 Lockheed Martin Deep Blue Expendable Bathythermograph (XBT)

The XBT system consists of an expendable probe, a data processing/recording system, and a launcher. An electrical connection between the probe and the processor/recorder is made when the canister containing the probe is placed within the launcher and the launcher breech door is closed. Communications between the probe and the surface is maintained through a pair of fine copper wires which pay out from both a spool retained in the launcher and one dropped with the instrument. The XBT Deep Blue includes enough wire to cast a maximum depth of 760m (2500 ft).

The XBT Deep Blue is designed to be used while the ship maintains course and speed. The maximum rate ship speed for deployment is 20 knots.

The XBT contains a precision thermistor located in the nose of the probe. Changes in water temperature are recorded by changes in the resistance of the thermistor as the XBT falls through the water. The XBT is capable of temperature accuracies of ±0.1 ºC.

The nose of each expendable probe is precisely weighted and the unit is spin-stabilized to assure a predictable rate of descent. From this rate of descent, probe depth is determined to an accuracy of ±2% and a vertical resolution of 65cm. When the probe reaches its maximum depth (a function of ship speed and the quantity of wire contained within the shipboard spool) the profile is completed and the system is ready for another launch.

XBTs are deployed using the LM-3A hand launcher interfaced with a MK21 Oceanographic Data Acquisition System by a 100’ cable. Data collection is controlled by the MK21 and the buffered I/O stores all the data until it can be read in by the operating system. Every data point is time stamped by an independent clock on the MK21 to ensure no data is lost or skipped. The MK21 is controlled by either a laptop or desktop PC computer via USB.

The operator uses the computer to select the type of probe to be launched along with other parameters to be stored such as date, time and latitude/longitude (by manual input or NMEA string). The computer performs system diagnostics and prelaunch tests and then indicates the probe is ready for launch. The computer then receives probe data during the descent and displays and stores the information. The XBT data is easily translated to an ASCII text format (.edf file) that Sound Speed Manager can process into CARIS SVP format files. Since the XBT data itself contains no salinity data, Sound Speed Manager creates CARIS SVP files using the depth-temperature data from the XBT augmented with salinity data from the World Ocean Atlas.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="4">Lockheed Martin</td></tr>
<tr><td><i>Model</i></td><td colspan="4">Deep Blue Expendable Bathythermograph (XBT)</td></tr>
<tr><td rowspan="4"><i>Inventory</i></td><td rowspan="4"><i>S220</i></td><td><i>Component</i></td><td>XBT Launcher</td><td>Topside Unit</td></tr>
<tr><td><i>Model Number</i></td><td>LM-3A</td><td>MK21</td></tr>
<tr><td><i>Serial Number</i></td><td>N/A</td><td>N/A</td></tr>
<tr><td><i>Calibration</i></td><td>N/A</td><td>N/A</td></tr>
</table>

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
Teledyne CARIS	HIPS and SIPS	11.1.3	Processing
Teledyne CARIS	BASE Editor	5.3.0	Processing
Applanix	MV POSView	9.91	Acquisition
Applanix	POSPac MMS	8.3.3	Processing
HYPACK, Inc.	HYPACK 2018	2018	Acquisition
Quality Positioning Services BV (QPS)	Fledermaus Geocoder Toolbox	7.7	Processing
Kongsberg Maritime AS	Seafloor Information System (SIS)	4.3.2	Acquisition
NOAA Hydrographic Systems and Technology Branch (HSTB)	Pydro Explorer	19.4	Acquisition and Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

No bottom sampling equipment was utilized for data acquisition.

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

The reference point for the positioning, attitude, and sonar system maintained by Fairweather is co-located at the phase center of the sonar transmitter and rotated to the face of the transducer for the EM 710 installed on S220. A single reference point simplifies downstream processing and eliminates errors due to incorrect offset application in CARIS HIPS. This was achieved for position and attitude by entering the surveyed translational and rotational offsets of the IMU and GNSS antennae into the POS configuration, ensuring that the position and attitude reported by the POS, including heave and delayed heave, are valid at the transmit array. Furthermore, this reference point is the center of rotation in POS for the purposes of applying the heave filter, as the reference to center of rotation field is zero.

Rotational and translational offsets for the EM 710 system on Fairweather were determined by IMTEC Group during drydock in 2014, and a reference frame was delivered which centered on the EM 710 transmit array and aligned with the array in heading, pitch, and roll. This allows for direct entry of these values since they were already in the desired reference frame.

Transducer and navigation offsets and alignments were entered in SIS according to the EM 710 transmitter reference frame. The translational and angular offsets of the receiver array (labeled “RX Transducer”) relative to the transmit array were entered into SIS. Since the transmit array is at the reference point and was aligned with the reference frame by definition, the translational and angular offsets of the transmit array (labeled “TX Transducer”) are all zero. Since the reference point of the POS was configured to be located 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 EM 710 and the IMU discovered in a patch test (see Section B.3.1) was added to the IMU alignment with respect to the reference frame in the POS configuration, maintaining the transmit array as aligned with the reference frame.

Entries in the CARIS HVF account for the offset between the transmit and receive array for the EM 710, entered under the SVP 2 section so processing of raw range-angle data is correct after sound speed profile corrections are applied. All other vessel offset values have been set to zero and apply to “No” to avoid double-correction. Offsets to the IMU and primary GNSS antenna are also entered under the TPU section, but this is only used for estimates of uncertainty and not positioning of soundings.

B.1.1.1 Vessel Offset Correctors

Vessel	FA_S220_EM710			
Echosounder	Kongsberg Simrad EM710			
Date	2015-02-06			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	1.728 meters	0.002 meters
		y	8.427 meters	0.002 meters
		z	4.677 meters	0.002 meters
		x2	1.838 meters	N/A
		y2	7.204 meters	N/A
		z2	4.675 meters	N/A
	Nav to Transducer	*x*	1.728 meters	0.002 meters
		y	8.427 meters	0.002 meters
		z	4.677 meters	0.002 meters
		x2	1.838 meters	N/A
		y2	7.204 meters	N/A
		z2	4.675 meters	N/A
	Transducer Roll	*Roll*	0.000 degrees	
		Roll2	0.000 degrees	

B.1.2 Layback

No towed arrays were utilized for this project.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft for Fairweather is determined by using a laser rangefinder to measure the vertical distance to the water from benchmarks on the port and starboard E-Deck breezeway below the bridge wings. The measurements are translated to the transmitter reference frame using surveyed offsets to the benchmarks. These measurements are taken while the vessel is at anchor or hove to.

Static draft corrector values are entered in the Kongsberg SIS Installation Parameters window. In addition, waterline values are entered in the CARIS HVF. For S220, only the HVF is updated with the measurements taken throughout the field season, as this will override the SIS waterline during processing. The waterline value in CARIS will only be used during Sound Speed Correction. The Apply switch is set to “No” to avoid double application of the waterline value during HIPS merge.

B.2.1.1 Static Draft Correctors

Vessel		FA_S220_EM710
Date		2019-05-20
Loading		0.116000 meters
Static Draft	*Measurement*	-4.6600000 meters
	Uncertainty	0.128000 meters

B.2.2 Dynamic Draft

The method employed to determine dynamic draft calculates the vessel's ellipsoid height change while transiting at different speeds in a straight line. The ellipsoid heights were determined using a Post Processed Kinematic (PPK) trajectory through processing the recorded POS MV data with SmartBase correctors in Applanix POSPac MMS software. A third order polynomial curve was fit to the speed versus ellipsoid height data using a least squares fit through a script implemented in the POSPac AutoQC tool.

The 2016 polynomial curve was used to derive the table used in the CARIS HVF as this value has historically remained consistent, and the 2016 data were collected in an environment free from currents and swell.

B.2.2.1 Dynamic Draft Correctors

Vessel	FA_S220_EM710	
Date	2016-05-02	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	1.50	0.01
	2.00	0.03
	2.50	0.06
	3.00	0.08
	3.50	0.11
	4.00	0.14
	4.50	0.17
	5.00	0.20
	5.50	0.23
	6.00	0.25
	6.50	0.27
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.03	0.10

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

Patch test data were collected in Seattle, WA along a slope with two parallel lines surveyed in both directions for determination of pitch and yaw correctors. An additional line was surveyed in a flat area in reciprocal directions for determination of the roll corrector.

Data were converted in CARIS HIPS using an HVF file with heave, pitch, roll, and timing values set to zero. Delayed heave, SBETs, SBET RMS, the most recent dynamic draft, sound speed correctors, and GPS tides via a VDATUM separation model were applied and the data were georeferenced before cleaning via Subset Editor. Bias values were determined in the following order; pitch, roll, yaw. A minimum of five individual testers determined alignment test biases in CARIS. Additionally, a reviewer examined these results for outlier elimination, after which the remaining results were averaged. The averaged values were entered as opposite sign rotations into the POS MV angular offsets in “IMU Frame w.r.t. Ref Frame" within the Lever Arms & Mounting Angles setup. The values for roll, pitch, and yaw correctors were entered as X, Y, and Z, respectively. These rotations are therefore applied to all raw orientation data output from the POS.

An additional examination of the correlation between a bathymetric roll artifact and the motion time series is used to solve for timing errors that are difficult to detect in the traditional patch test methodology. From these results, a constant timing delay is applied to all motion data in Kongsberg SIS. A value of 14 milliseconds was used for S220.

The values listed below are those entered into the POS MV, as the alignment values in the HVF are all set to zero.

B.3.1.1 System Alignment Correctors

Vessel	FA_S220_EM710		
Echosounder	Kongsberg Simrad EM710		
Date	2019-05-18		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.005 seconds
	Navigation Time Correction	0.000 seconds	0.005 seconds
	Pitch	0.000 degrees	0.040 degrees
	Roll	0.080 degrees	0.040 degrees
	Yaw	0.090 degrees	0.060 degrees
	Pitch Time Correction	0.000 seconds	0.005 seconds
	Roll Time Correction	0.000 seconds	0.005 seconds
	Yaw Time Correction	0.000 seconds	0.005 seconds
	Heave Time Correction	0.000 seconds	0.005 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Acquisition methods employed are determined based on consideration of sonar system specifications, seafloor topography, water depth, and the capabilities of the acquisition platform. They are also dictated by the coverage method specified in the Project Instructions for a survey area. For the Kongsberg EM 710, all multibeam data were acquired in the .all format within the SIS (Seafloor Information System) software. Data were monitored in 2D, 3D, and backscatter imagery real-time display windows. A survey template defined the storage location of raw and gridded (survey) data, and the file naming convention for mainscheme (Filename_M.all) and crossline (Filename_X.all) data. During acquisition, the hydrographers often adjusted parameters of the Kongsberg system to improve data quality. The following are parameters that are commonly adjusted: the port and starboard beam angle, the force depth fields, ping mode, and yaw stabilization. Settings and specialized filters are found in the Runtime Parameters tear off window within SIS.

During ship acquisition, mainscheme MBES lines are generally run parallel to depth contours with appropriate overlap to ensure the data density requirements for the proper finalized CUBE surfaces are met. The 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.

Seafloor backscatter data were acquired for all lines during the 2019 field season, logged in the .all files. The Kongsberg EM 710 system has an internal file, BsCorr, used to correct for beam pattern effects to equalize backscatter returns between swaths, sectors, and modes. A default file is populated at the factory, however a modified BsCorr file was provided by HSTB following the sonar acceptance to optimize the quality of the backscatter data. This HSTB version was used for all backscatter acquisition for the EM 710.

Navigation and motion data are acquired and monitored in POSView and logged to a POS MV file with a .### extension, starting with .000. Data are logged on a USB flash drive inserted into the PCS and automatically split into 12 MB files. Various position and heading accuracies, as well as satellite constellations, are monitored real-time both in POSView and in Hypack Hysweep to ensure the collection of quality data. 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.

Data Processing Methods and Procedures

Initial processing is typically completed the same day as acquisition, and employs Charlene to transfer the external hard drive data to the S220 network and process it to a daily QC product, which is typically a bathymetric surface with data from that acquisition platform. Charlene automates the following tasks between raw data collection and the final daily product:

1. Perform verification of raw data
2. Build a deliverable directory structure
3. Transfer and verify raw data
4. Convert the Kongsberg .all file to CARIS HIPS HDCS format
5. Apply delayed heave from the POS files
6. Generate and apply SBET and SBET RMS files
7. Apply sound speed correctors
8. Apply a GPS Tide via a separation model (VDATUM or ERTDM)
9. Compute the Total Propagated Uncertainty
10. Generate a CARIS CSAR bathymetric surface from the data

Once Charlene has completed, night processors inspect the data in CARIS HIPS to ensure all correctors have been properly applied, and that the final products reflect observed conditions to the standards set by the relevant OCS guidance. Bathymetric surfaces are reviewed to ensure that all data quality problems are identified and resolved if possible, and all submerged features are accurately represented.

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

The field unit's final deliverable bathymetric surface is a variable resolution (VR) Combined Uncertainty and Bathymetric Estimator (CUBE) surface for complete coverage surveys. The CUBE surface's resolution, depth range, and parameters follow HSSD section 5.2.2. The bathymetric surfaces are generated following the application of all correctors highlighted above in Section C.1.1.

C.1.4.2 Depth Derivation

Multibeam data were reviewed and analyzed in CARIS HIPS Subset Editor, utilizing the generated CUBE surfaces for directed data editing to reject data that led to fliers in the surface. The surfaces were also used to demonstrate coverage and to check for errors due to tides, sound speed, attitude, and timing.

Vessel heading, attitude, and navigation data were 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 were manually rejected or interpolated for small periods of time. Any editing of this nature is outlined in the Descriptive Report for the particular survey.

Hydrographers may designate soundings if the bathymetric surface fails to represent navigationally significant depths and features. Designated soundings are selected following the criteria in section 5.2.1.2.3 of the HSSD.

C.1.4.3 Surface Computation Algorithm

All VR surfaces are generated via the Ranges estimation method within CARIS HIPS and SIPS. This algorithm grids data based on the resolution requirements for each depth range, adhering to the specifications in the HSSD. The following options are selected for the Ranges Estimation Method:

- Range/Resolution File: NOAA_DepthRanges_ObjectDetection.txt (for object detection surveys) or NOAA_DepthRanges_CompleteCoverage.txt (for complete coverage surveys)

- Range Estimation Method: Percentile

- Input Band: Depth

- Output Vertical Coordinate System: Unknown

- Keep Partial Bins: Checked

- Maximum Grid Size: 64

- Minimum Grid Size: 4

The population method utilized for the generation of the Ranges surfaces was CUBE. The following options were selected for the generation of each surface:

- Disambiguation Method: Density and Locale

- IHO Order: S44 Order 1a

- Display Bias: Highest

- CUBE Configuration: NOAA_VR

The CUBE Configuration utilized comes from the CUBE_Parameters_NOAA_2019.xml file included within the Caris_Support_Files_2019v0. This file contains the parameters necessary to create CUBE surfaces meeting the requirements as stated in the HSSD.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

The Kongsberg EM 710 system logs backscatter to the .all file concurrently with all multibeam data. The HIC monitors the “Seabed Image” tear-off to ensure adequate backscatter imagery is obtained during survey acquisition.

Data Processing Methods and Procedures

Backscatter data are processed with the Fledermaus Geocoder Toolkit (FMGT) software using the subsequent steps:

- Lines were imported into FMGT, combining the .all files with the HDCS files created in CARIS, resulting in the generation of GSF files.

- A mosaic in floating point GeoTIFF format was created for each project from the imported GSF files. The backscatter mosaic’s minimum resolution depends on the acquisition frequency, using the equation provided in HTD 2018-3. The minimum resolution utilized was 6 meters for 100 kHz.

C.2.2 Side Scan Sonar

Side scan sonar imagery was not acquired.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Water level data was not acquired.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

Vessel attitude is measured by the Applanix POS MV and recorded in both SIS .all files (for real-time correctors) and POS MV .000 files (for delayed heave data). The POS MV continuously logs data to a USB drive throughout the survey day. A five minute buffer period of POS MV data is acquired preceding and following any sonar data acquisition to permit proper initialization of filters for delayed heave and PPK solutions.

Data Processing Methods and Procedures

Attitude correctors applied after initial CARIS HIPS conversion use the raw POS MV attitude data recorded in the Kongsberg data files (.all). The .000 delayed heave file logged by the POS MV is separately loaded into HIPS, replacing the real-time heave values recorded in the raw data.

This .000 file is then post processed in Applanix POSPac to generate a Smoothed Best Estimate of Trajectory (SBET), adjusting the integrated positioning and inertial measurements with Trimble CenterPoint Real-Time Extended (RTX) differential correctors. Trimble RTX uses a network of globally distributed high-performance GNSS receivers that generate the precise orbit, clock, and observation biases for any location on Earth, eliminating the need to establish local reference stations. Post processed RTX corrections are available an hour after data acquisition. The SBET file is exported from WGS84 to NAD83, and then run through the POSPac AutoQC tool in Pydro to evaluate the quality of the ERS vessel positioning. Any short-term unresolvable errors in the GNSS height and uncertainty time series data are manually replaced with an interpolated signal derived from differential heave, dynamic draft, and water level data. Once this quality assessment has been completed, the SBET and corresponding RMS uncertainty file containing the recomputed vessel navigation and ellipsoidal height are applied to the data in CARIS HIPS.

Once SBETs have been applied to the data a GPS vertical adjustment is computed in CARIS HIPS, utilizing a VDATUM seperation model to reduce the data from the ellipse to MLLW. The data are then reviewed for consistency, ensuring that no vertical offsets due to artifacts in the SBET or improper application exist.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

Sound speed casts are conducted at least once every four hours during multibeam survey operations in accordance with section 5.2.3.3 of the HSSD. S220 collects sound speed casts according to observed variations in the water column and any changes in survey location that would influence sound speed differences in excess of the accepted 2 m/s range. Changes are monitored through the real-time surface sound speed view in Sound Speed Manager (SSM) and the data view in SIS. SSM provides a geographic view of changes in surface sound speed which assists in the targeting of casts for zoning water masses. The CastTime algorithm is also employed in SSM to guide cast frequency. In SIS, the user is 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.

Data Processing Methods and Procedures

Sound speed cast processing is performed via the HydrOffice Sound Speed Manager (SSM) application. S220 casts are transferred from the XBT processing computer as .edf files and loaded into Sound Speed Manager. Salinity values are downloaded from the World Ocean Atlas and applied to each cast. Once the profiles have been loaded and filtered, they are transmitted by SSM over the network to the Kongsberg HWS for application in SIS. SSM confirms reception, or the hydrographer may inspect the updated file name in the “Runtime Parameters” tear-off upon network errors.

All sound speed casts saved to the SSM database are exported into a .svp file that is readable in CARIS HIPS. Casts are progressively concatenated per sheet, including all casts taken within the sheet limits. This concatenated file is applied to all HDCS data using the “Nearest in distance within time” algorithm, using the time interval suggested by the Hydrographer in Charge during acquisition. This time interval is generally four hours, but may be reduced if necessitated by environmental conditions.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

S220 measures surface sound speed values with a SVP 70 probe. The SVP probe supplies the MBES with real-time values, which applies a median filter and corrects for the flat-faced transducer’s refraction. During acquisition, the HIC adjusts this filter’s length to capture variability while suppressing bubble sweep-down errors. HICs monitor the surface sound speed for a > 2 m/s change, which requires a new cast using the methods described in C.5.1.

Data Processing Methods and Procedures

Surface sound speed data are not post-processed.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

The final uncertainty for soundings is calculated within CARIS HIPS using the Compute TPU tool. CARIS HIPS computes the TPU based on the vessel's static and dynamic measurements, project specific tidal referencing, ERS positioning, and sound speed values. The TPU section of the HVF captures fixed estimates of uncertainty. Uncertainty values for the multibeam and positioning systems are compiled from manufacturer specification sheets for each sensor, and from those set forth in Section 4.2.3.8 of the 2014 FPM. CARIS HIPS also applies a sonar device model for uncertainty values associated with the sounding detections.

Sound speed uncertainty is estimated based on cast frequency and distribution, with a typical value of 4 m/s employed unless otherwise specified in the DR. Real-time sonar uncertainties are provided via EM 710 MBES data, and positioning errors are provided via the Applanix Delayed Heave RMS. Following post-processing of the real-time vessel motion, recomputed uncertainties of navigation and ellipsoidal height are applied in CARIS HIPS via a Smoothed Best Estimate of Trajectory (SBET) RMS file generated in Applanix POSPac.

C.6.2 Uncertainty Components

A Priori Uncertainty

Vessel		FA_S220_EM710
Motion Sensor	*Gyro*	0.02 degrees
	Heave	5.00% 0.05 meters
	Roll	0.02 degrees
	Pitch	0.02 degrees
Navigation Sensor		0.50 meters

Real-Time Uncertainty

Vessel	*Description*
S220	Real-time sonar uncertainties are provided via EM710 MBES data, and positioning errors via Applanix Delayed Heave RMS.

C.7 Shoreline and Feature Data

Shoreline and feature data was not acquired.

C.8 Bottom Sample Data

Bottom sample data was not acquired.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Preliminary data cleaning is performed daily during night processing following acquisition, addressing the most blatant fliers and blowouts. Cleaning is primarily done in Subset Editor, rejecting data that cause fliers in the CUBE grid. Following this gross cleaning, Flier Finder, part of the QC Tools package of HydrOffice, is used to assist the search for spurious soundings. Flier Finder is run iteratively until all remaining flagged fliers are deemed to be valid aspects of the steep slopes and dynamic nature of the seafloor. Additionally, the uncertainty, hypothesis count, hypothesis strength, and node standard deviation child layers of the surface in CARIS HIPS are utilized to identify potential problem areas.

D.1.2 Designated Sounding Selection

In depths less than 20 meters in areas of navigational significance where the bathymetric surface does not adequately depict the depth for the given area, a designated sounding may be selected. Designated soundings are selected in accordance with section 5.2.1.2.3 of the HSSD. Detailed designated sounding searches in Subset Editor are only performed in regions expected to contain variation not captured in the standard grid, or when searching for known features. Generation of higher resolution grids than required for the depth range may be used to guide the search for designated soundings.

D.1.3 Holiday Identification

Pydro's "Holiday Finder" tool scans the CUBE surfaces for any empty grid nodes that are surrounded by populated nodes, and flags holidays dependent on the criteria set by the coverage requirements. All flags are then visually inspected to determine the validity of each holiday, and all confirmed holidays are addressed either by acquiring additional data over the gaps, or explaining the cause and likelihood of hazards within each gap.

D.1.4 Uncertainty Assessment

Pydro’s “Grid QA v.5” function verifies that all surfaces meet HSSD’s uncertainty specifications. This tool plots node percentage histograms, which demonstrate surface compliance with the uncertainty standards set forth in the HSSD.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

As a quality control measure, approximately 4% (for complete coverage surveys) or 8% (for set line spacing surveys) of the linear nautical mile total of mainscheme multibeam lines are run on each survey as crosslines. Crosslines are run in accordance with Section 5.2.4.2 of the HSSD. Following acquisition, a surface containing strictly data from mainscheme lines and a surface containing strictly data from crosslines are generated and analyzed with the Compare Grids tool in Pydro. This tool analyzes the difference between the two grids and outputs a difference surface between the depths, as well as a second surface that contains the fraction of NOAA allowable error represented by that depth difference for each node. Additionally, statistics/ distribution summary plots of the difference surface and the fraction of allowable error are generated to provide easily interpretable analyses of the differences between the surfaces.

D.1.5.2 Junctions

Survey managers perform junction analyses between the current survey and all adjacent contemporary surveys. To ensure proper overlap between surveys, approximately one bathymetric swath of overlap is acquired at each junction. Surface based and statistical analysis of the junctions is performed through the Compare Grids tool as described in D.1.5.1.

D.1.5.3 Platform to Platform

Agreement and continuity of data collected between platforms is visually investigated by the survey manager to ensure consistency and highlight any potential biases in the data. To aid in the determination of potential biases, the depth child layer of the surfaces is inspected with an increased vertical exaggeration, generally between five and ten times greater.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Processed backscatter mosaics are inspected in CARIS HIPS to ensure that no data were omitted during processing, and that no errors occurred in mosaic generation.

D.2.2 Contact Selection Methodology

Not applicable.

E. Approval Sheet

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

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys Specifications and Deliverables, Field Procedures Manual, Letter Instructions, and all HSD Technical Directives. These data are adequate to supersede charted data in their common areas. This survey is complete and no additional work is required with the exception of deficiencies noted herein.

Approver Name	Approver Title	Date	Signature
CAPT Marc Moser, NOAA	Chief of Party	10/03/2019	MOSER.MARC.STANTON.1163193902 Digitally signed by MOSER.MARC.STANTON.1163193902 Date: 2019.10.03 14:24:56 -07'00'
HCST Sam Candio	Chief Survey Technician	10/03/2019	

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	S220 Wiring Diagram.pdf
Sound Speed Sensor Calibration	Sound_Speed_Sensor_Calibration_Reports.pdf
Vessel Offset	Static_Draft_Measurements_2019.pdf Dynamic_Draft_Table_2019.pdf
Position and Attitude Sensor Calibration	S220_POS_GAMS_Report_2019.pdf
Echosounder Confidence Check	2019_PatchTests.pdf HSRR_2019_Reference_Surfaces.pdf
Echosounder Acceptance Trial Results	N/A