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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Data Acquisition & Processing Report

Type of Survey Navigable Area

Project Number OPR-J317-KR-18

Time Frame August 2018 to February 2019

LOCALITY

State Florida

General Locality Approaches to Tampa Bay, FL

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Abbreviations

ATON	Aid to Navigation
CO-OPS	Center for Operational Oceanographic Products and Services
CRP	Central Reference Point
CSF	Composite Source File
CTD	Conductivity, Temperature, Depth (sound speed sensor)
CUBE	Combined Uncertainty and Bathymetric Estimator
DAPR	Data Acquisition and Processing Report
DR	Descriptive Report
DTON	Danger to Navigation
FFF	Final Feature File
GPS	Global Positioning System
GMT	Generic Mapping Tools
GNSS	Global Navigation Satellite System
HSSD	Hydrographic Surveys Specifications and Deliverables document
HVCR	Horizontal and Vertical Control Report
IHO	International Hydrographic Organization
ITRF	International Terrestrial Reference Frame
MCU	Maximum Combined Uncertainty
MBES	Multibeam Echosounder
MLLW	Mean Lower Low Water
NOAA	National Oceanic and Atmospheric Administration
NWLON	National Water Level Observation Network
OII	Oceaneering International, Inc.
PPP	Precise Point Positioning
PRF	Project Reference File
SEP	Ellipsoid to chart datum separation
SIS	Seafloor Information System (Kongsberg)
SSS	Side Scan Sonar
THU	Total Horizontal Uncertainty
TPU	Total Propagated Uncertainty
TVU	Total Vertical Uncertainty
UTC	Coordinated Universal Time (Universal Time Coordinated)
VDATUM	Vertical Datum Transformations Tool
WL	Waterline
1-sigma	Within 1 Standard Deviation of the Mean
2-sigma	Within 2 Standard Deviations of the Mean

A. EQUIPMENT

A.1. SURVEY VESSELS

Survey operations were conducted aboard two vessels owned and operated by Oceaneering International, Inc. (OII): the R/V *Sea Scout* and R/V *C-Wolf*. The R/V *Sea Scout* is a 134-foot (40.842-meter) catamaran survey vessel and the R/V *C-Wolf* is a 30-foot (9.144-meter) aluminum survey vessel. Vessel profile and specification information is shown in Table 1 and Table 2. Vessel diagrams with measured offsets from the central reference point (CRP) of each vessel are included in Appendix 1: Vessel Reports.

Table 1. R/V *Sea Scout* Vessel Profile and Specifications

Vessel Specifications	
Owner/Operator	Oceaneering International, Inc.
Home Port / Flag	New Iberia, Louisiana / USA
United States Coast Guard Official Number	1237094
Year Built	2011
Place Built	Bellingham, Washington
Builder	All American Marine
Intended Service	Oceanographic Research
Operational Area	Gulf of Mexico
Length	134’
Beam	37’ 4”
Draft	6’ 6”
Freeboard	7’ 7.5”

Table 2. R/V *C-Wolf* Vessel Profile and Specifications

Vessel Specifications	
Owner/Operator	Oceaneering International, Inc.
Home Port / Flag	Lafayette, Louisiana / USA
Hull ID	JQN00027J708
LA Registration Number	LA-2935-FS
Year Built	2008
Builder	Razorhead Boats Inc.
Intended Service	Oceanographic Research
Operational Area	Shallow Water, USA
Length	30’
Beam	8.5’
Draft	2.5’
Freeboard	2.5’

A.2. MAJOR OPERATIONAL SYSTEMS

The major operational systems used to acquire hydrographic data were Kongsberg EM2040C and EM3002 multibeam echosounder (MBES) systems and EdgeTech 4200 and Klein 5000 V2 side scan sonar (SSS) systems. The survey equipment for each vessel used during survey operations is shown in Table 3 and Table 4.

Table 3. Survey equipment aboard the R/V *Sea Scout*

System	Manufacturer	Model	Serial Number
Multibeam Echosounder	Kongsberg	EM2040C	Transducer: 1163 Topside: 20017
Side Scan Sonar	Klein	5000 V2	376
Single Beam Echosounder (Port)	Odom	Echotrac MK III	Transducer: TR7212 Topside: 003477
Motion Sensor	Teledyne TSS	DMS05	40050
Gyrocompass	Teledyne TSS	Meridian Surveyor	4393
Positioning System	CNAV	3050	CNAV Receiver: 13769
Positioning System	CNAV	3050	CNAV Receiver: 15006
Sound Speed at Transducer	YSI Electronics	600R-BCR-C-T	12M100701
CTD	Sea-Bird Electronics, Inc	SBE 19 Plus	1174, 2645
Cable Payout Indicator	Subsea Systems	PI-5600	0210

Table 4. Survey equipment aboard the R/V *C-Wolf*

System	Manufacturer	Model	Serial Number
Multibeam Echosounder	Kongsberg	EM3002	Transducer: 665 Topside: 1009
Side Scan Sonar	EdgeTech 4200	300/600 kHz Portable	Side Scan: 38216 Topside: 38162
Single Beam Echosounder	Odom	Echotrac CV-100	26034
Attitude and Positioning System	Coda Octopus	F180	F0407061
Positioning System	CNAV	3050	C-Nav® Receiver: 22179
Positioning System	CNAV	3050	CNAV® Receiver: 23107
Sound Speed at Transducer	YSI Electronics	600R-BCR-C-T	13H101931 13L100270
CTD	Sea-Bird Electronics, Inc.	SBE 19 Plus	2872, 5222

A.3. SURVEY OPERATIONS OVERVIEW

Complete Coverage was required in all waters in the survey area except Sheet 4, in which Object Detection Coverage was required. 100% side scan sonar coverage with concurrent multibeam data acquisition acquired to fulfil the Complete Coverage requirement and 100% multibeam data coverage was acquired to fulfil the Object Detection Coverage requirement outlined in Sections 5.2.2.2 and 5.2.2.3 of the 2018 Hydrographic Surveys Specifications and Deliverables (HSSD) document. The R/V *C-Wolf* conducted survey operations in the shallower, nearshore areas.

A.4. MULTIBEAM ECHOSOUNDER OPERATIONS

Multibeam data coverage was collected as either object detection or concurrently with 100% side scan sonar coverage to fulfill complete coverage requirements, as specified in the Project Instructions. The multibeam data were continuously monitored during acquisition to ensure quality and coverage.

A.4.1. Calibrations and Accuracy Checks

To ensure the proper operation of the MBES system, a patch test was conducted prior to starting survey operations. Refer to section C.7 for additional information. In addition, confidence checks, also called system accuracy checks, were conducted periodically throughout the survey. These confidence checks were in the form of lead lines and single beam/multibeam comparisons.

A.4.1.1. Single Beam Operations

The R/V *Sea Scout* and R/V *C-Wolf* are equipped with Odom Echotrac MK III and Odom EchoTrac CV-100 single beam echosounder systems, respectively. These data were continuously recorded and monitored in real-time as an independent check of the nadir beam (bottom-detect) of the multibeam sonar system.

A.4.1.2. Lead Line Operations

Lead line comparisons were conducted during survey operations as an independent check on the multibeam bottom-detect. To avoid misreading values, lead lines were generally taken during calm sea conditions and in water depths less than 15 meters.

A.4.1.3. Crossline Comparisons

Crossline data were acquired along transects perpendicular to the main scheme lines. Crossline mileage consisted of approximately 5% of the mainscheme line mileage, in accordance with Section 5.2.4.2 of the HSSD (2018). Refer to section B.2.5 for details on crossline comparisons.

A.4.2. Multibeam Operations - R/V Sea Scout

The R/V *Sea Scout* is equipped with a single head Kongsberg EM2040C multibeam echosounder system (serial number 1163). The transducer is mounted on a retractable ram and not mounted with any intended offsets. The ram operates such that the transducer can be lowered and raised as needed for survey operations and transit. The system was operated at 350 kHz in normal detection mode and equidistant beam spacing. Pertinent operational specifications of the EM2040C multibeam system, obtained from the EM2040C product specification documentation, are shown in Table 5.

Table 5. Kongsberg EM2040C Product Specifications

Equipment Specifications	
Frequencies	200-400 kHz in steps of 10 kHz
No. of soundings per ping Single Head, Single Swath	400
No. of soundings per ping Single Head, Dual Swath	800
No. of soundings per ping Dual Head, Dual Swath	1600
Maximum Ping Rate	50 Hz
Maximum Angular Coverage Single Sonar Head	130 degrees
Maximum Angular Coverage Dual Sonar Heads	200 degrees
Pitch and Roll stabilization	Yes
Heave compensation	Yes
Pulse Length	25 µs to 12 µs

A.4.3. Multibeam Operations - R/V *C-Wolf*

Multibeam survey operations aboard the R/V *C-Wolf* were conducted with a single Kongsberg EM3002 MBES system. The transducer is mounted on a ram that extends through a moon pool in the center of the vessel. The ram can be raised and lowered as needed for transit and survey operations.

The multibeam echosounder (serial number 665) was operated in high-density equidistant beam spacing mode at a frequency of 300 kHz. The high-density mode increased the number of soundings to 254 per ping. Pertinent operational specifications of the EM3002 multibeam system obtained from Kongsberg's Seafloor Information System (SIS) multibeam control software and the EM3002 product specification documentation are shown in Table 6. The actual angular coverage during data acquisition varied depending on application and data quality; this is specified in the project logs.

Table 6. Kongsberg EM3002 Product Specifications

Equipment Specifications	
Frequencies	293, 300, 307 kHz
No. of soundings per ping Single Head, Single Swath	254
Maximum Ping Rate	40 Hz
Maximum Angular Coverage Single Sonar Head	120 degrees
Pitch and Roll stabilization	Yes
Heave compensation	Yes

Equipment Specifications	
Pulse Length	150 µs

A.5. SIDE SCAN SONAR OPERATIONS

Side scan sonar (SSS) operations were conducted in order to obtain Complete Coverage defined as 100% side scan sonar coverage with concurrent multibeam data acquisition (Section 5.2.2.3 – 2018 HSSD) and/or to provide 200% SSS coverage for feature disprovals. The line spacing for SSS operations allowed for overlapping coverage of 40% of the range scale and 20% of the entire swath with the sonar range scale not to exceed 100 m (Table 7).

Table 7. Side Scan Sonar Operational Parameters

Depth Min (m)	Depth Max (m)	Sonar Range (m)	Line Spacing (m)
0	6	25	40
6	10	50	80
10	13	75	120
>13	n/a	100	160

A.5.1. R/V *Sea Scout*

A Klein 5000 V2 side scan sonar was operated in a towed configuration and a hanging sheave, mounted to a retractable A-frame at the stern of the vessel, was used as the tow point. A Subsea Systems Cable Payout Indicator was used to digitally record the tow cable length from the sheave. The cable out values were recorded in the acquisition logs and also digitally in the side scan XTF files, and later used for layback calculations. In general, the survey speed of the towed side scan sonar would be limited by the range scale. However, according to the Klein 5000 V2 product specifications, the sonar fish can be towed at higher speeds with no loss of bottom coverage (Table 8). Survey operations were generally conducted at speeds between 4 and 8.5 knots. The side scan sonar data were continuously monitored during acquisition to ensure quality and coverage.

Table 8. Klein 5000 V2 Product specifications

Equipment Specifications	
Number of beams	5 port and 5 starboard
Frequency	45 5kHz
Resolution (along track)	10 cm at 50 m, 20 cm at 75 m, 36 cm at 150 m
Resolution (across track)	3.75 cm at all pulse lengths
Operating Speed Envelope	2 to 10 knots

A.5.2. R/V *C-Wolf*

An EdgeTech 4200 side scan sonar was operated aboard the R/V *C-Wolf* in a towed configuration either off the stern or bow of the vessel, depending on the water depth. A hanging sheave mounted to a fixed A-frame was used as the tow point for towed operations off the stern of the vessel. The cable out values were recorded in the acquisition logs and used for layback calculations during post-processing.

The EdgeTech 4200 side scan sonar was operated in High Definition Mode (HDM) at a frequency of 545 kHz. The fish was towed at a speed that ensured an object 1 m x 1 m x 1 m would be independently ensonified a minimum of three times per pass (Table 9). The vessel generally operated at 8.5 knots or less. The side scan sonar data were continuously monitored during acquisition to ensure quality and coverage. Operational specifications are shown in Table 10.

Table 9. Maximum Vessel Speed at Side Scan Sonar Operational Ranges

Side Scan Range (m)	Max Ping Rate (Hz)	Max Speed (m/s)	Max Speed (kts)
25	27	9	17.5
50	14	4.67	9.1

Table 10. EdgeTech 4200 Product Specifications

Equipment Specifications	
Frequency	300/600 kHz
Resolution (along track)	600 kHz: 0.45m @ 100m
Resolution (across track)	1.5 cm at 600 kHz
Operating Speed Envelope	4 to 12 kts

The side scan sonar was generally towed at heights in accordance with the required 8 to 20 percent of the range scale, although due to factors such as water depth and data quality, the side scan sonar may occasionally be towed at heights less than the required height. Confidence checks were conducted to ensure that the sonar was operating appropriately and that contacts were visible within the range used.

A.6. ADDITIONAL SURVEY OPERATIONS

A.6.1. Sound Speed Operations

Sea Bird Electronics SBE19 Conductivity, Temperature, Depth (CTD) sensors were used to calculate the speed of sound through the water column. Generally, casts were performed at least twice daily aboard the R/V *Sea Scout* and more often as needed. Two CTDs were simultaneously lowered within a cage structure during each cast. Casts were performed at least once daily aboard the R/V *C-Wolf* and more often as needed;

comparisons were conducted between two CTD systems periodically. YSI 600R sondes were used to calculate the sound speed at the transducer on both vessels.

A.6.2. Backscatter

Backscatter data were acquired and logged within each raw Kongsberg multibeam .all file.

A.6.3. Bottom Samples

Bottom samples were acquired in accordance with the Project Reference File and attributed in the Final Feature File (FFF) for each Sheet.

A.7. ACQUISTION AND PROCESSING SOFTWARE

Software systems used for data acquisition and processing aboard each survey vessel used operations as well as processing software used after completion of data collection are listed in Table 11 and Table 12.

Table 11. Data Acquisition and Processing Software – R/V *Sea Scout*

Purpose	Software	Version	Date of Installation
Multibeam Data Recording and Monitoring	Hydromap®	170817	08-17-2018
Multibeam Control Software	Seafloor Information System (SIS)	4.3.2	04-16-2018
Side Scan Collection	SonarWiz5	V.5.06.0046	08-17-2018
Side Scan Collection	SonarWiz6	V.6.01.0031	10-17-2018
CTD Conversion Tool	Seabird Electronics Sea Term	1.5.9	04-16-2018
CTD Conversion Tool	Seabird Electronics Data Conversion	7.22.2	04-16-2018
CTD Conversion Tool	SVTool	1.2	04-16-2018
C-Nav® Data Control and Logging Tool	C-Navigator	03.05.08	06-03-2015
Side Scan Processing	SonarWiz	V6.01.0031	09-29-2018
Side Scan Processing	SonarWiz	V6005.0025	11-20-2018
Multibeam Processing	CARIS HIPS/SIPS	10.4	09-29-2018
Multibeam QC	HydrOffice QCTools	2.2.6.5	08-08-2018
Water Column QC	Qimera	1.7.4	11-21-2018
GNSS Data Processing	GMT	5.4.4	10-05-2018
GNSS Data Datum Conversion	VDATUM	3.9	10-05-2018

Table 12. Data Acquisition and Processing Software – R/V *C-Wolf*

Purpose	Software	Version	Date of Installation
Multibeam Data Recording and Monitoring	Hydromap®	V170817	08-03-2018
Multibeam Control Software	Seafloor Information System (SIS)	3.9.2	05-05-2017
Side Scan Collection	SonarWiz	V.5.06.0031	07-25-2018
CTD Conversion Tool	Seabird Electronics Sea Term	1.59	04-25-2014
CTD Conversion Tool	Seabird Electronics Data Conversion	7.23.1	04-25-2014
CTD Conversion Tool	SV Tool	1.2	04-25-2014
IMU control software	F180 Series	3.04.0004	04-25-2014
C-Nav® Data Control and Data Logging Tool	C-Monitor	2007-03-07	08-2018
Side Scan Processing	SonarWiz	V6.01.0031	03-13-2018
Side Scan Processing	SonarWiz	V6005.0025	11-20-2018
Multibeam Processing	CARIS HIPS	10.4	12-04-2017
Multibeam QC	HydrOffice QCTools	2.2.6.2	08-28-2018
GNSS Data Processing	GMT	5.4.4	10-05-2018
GNSS Data Datum Conversion	VDATUM	3.9	08-02-2018

A.7.1. Multibeam Acquisition Software

Kongsberg's Seafloor Information System (SIS) software was used as the control software for the multibeam sonar systems. This software allowed sound speed, attitude, and position to be applied to the data in real time. Data were directed from SIS to Oceaneering's proprietary software, Hydromap®, to be recorded. Hydromap® software was used for multibeam data collection, quality assurance, and quality control. Hydromap® was also used to monitor the survey line plan and to allow the boat operator(s) to maintain on-line control for all vessels in the field. The Hydromap® display includes a coverage map, bathymetric and backscatter display waterfalls, and other parameter displays. These tools allow the operator to monitor coverage, compare between single beam and multibeam depths, monitor the various positioning systems, and identify any ray-bending effects in real time. Corrective measures were made whenever necessary, ensuring that only high-quality data were collected. In cases where re-runs were necessary due to degraded quality of data during acquisition or due to lack of coverage, the aforementioned difficulties were logged in the field. Additional data were collected for quality and coverage assurance as needed. Multibeam data were acquired in .all format and imported into separate software for processing. If applicable, multibeam water column data was collected within Kongsberg's Seafloor Information System (SIS) software.

A.7.2. Side Scan Sonar Acquisition Software

Chesapeake Technology's SonarWiz software was used for side scan sonar data acquisition. SonarWiz software allows users to, in real-time, view data in waterfall view, adjust gain variance settings, verify data quality assurance and quality control, track the towfish position compared to the planned pre-plot tracklines, control sonar range, and modulate frequencies. The sonar data were acquired in eXtended Triton Format (XTF), which were then imported in a separate SonarWiz project for data processing.

B. QUALITY CONTROL

B.1. GNSS Data Processing

In order to import ASCII navigation and Global Navigation Satellite System (GNSS) height data into the multibeam processing software (specifically CARIS), the GNSS data file must be reformatted, filtered, and converted to NAD83(2011) via VDATUM. C-Navigator software logged a GNSS data file in Comma Separated Value (CSV) format once per day. Unix timestamp, latitude, longitude and height were extracted, and headers, if present, were removed.

A 30-second median filter in GMT (Generic Mapping Tools) was used to smooth the data and reduce the high frequency noise in the GNSS data. The 'filter1d' command generates a filtered value for every input timestamp and if 1 Hz data is input, 1 Hz data is output. GMT performs the filter centered on each timestamp. For a median filter it will advance to a timestamp, gather the data from the specified window (i.e. 30 seconds ±15 seconds centered on current timestamp), perform a median sort on the collected values, then replace the current value with the selected median, after which it advances to the next timestamp and starts again.

Prior to importing into VDATUM, the Unix timestamp was converted to Coordinated Universal Time (UTC). The GNSS data were collected referenced to an International Terrestrial Reference Frame (ITRF). In VDATUM the input Reference Frame (horizontal and vertical) was chosen to be ITRF2008. The output Reference Frame (horizontal and vertical) was chosen to be NAD83(2011). The output from VDATUM with time, latitude, longitude and ellipsoid height was further processed to remove duplicate positions. This is the final ASCII navigation file.

Processing the GNSS data was similar for importation into QPS' Qimera, but it was not necessary for the data to be filtered. The raw GNSS data files were formatted and the datum conversion conducted in VDATUM.

B.2. MULTIBEAM

B.2.1. Multibeam Processing

The multibeam data were processed using CARIS HIPS (CARIS) software. One CARIS project was created for each sheet and the CARIS project directory structures were created according to the format required by CARIS. Prior to importing multibeam data into CARIS, a HIPS vessel file (.hvf) was created. This vessel file includes uncertainty estimate values for all major equipment integral to data collection. Uncertainty estimates assigned are further described in the following sections. The vessel files used for this project are included in the following directory for each sheet: Data\Processed\Sonar_Data\HDCS_Data\VesselConfig.

CARIS was used to apply tides, merge, compute Total Propagated Uncertainy (TPU), and create surfaces. CARIS was also used for multibeam data cleaning, quality control, crossline comparison and chart comparisons as well as for contact correlation purposes and feature verification using the Composite Source Files (CSF). All features in the CSF file were updated based on the results of the survey and submitted in the Final Feature File. The NOAA Extended Attribute File V5_8 was used.

B.2.1.1. CARIS Vessel Files

The vessel files are named according to the vessel, system used, frequency and head used (if applicable):

- SeaScout_EM2040C_350kHz_C
- CWolf_EM3002_300kHz

B.2.1.1.1. R/V Sea Scout

The vessel file used for the R/V *Sea Scout* contains the following active sensors: Transducer 1, Navigation, Gyro, Heave, Pitch, Roll, Draft, SVP, and TPU.

<u>Transducer 1</u>: The X/Y/Z fields (the location of the transducer from the reference point) are zero because the location of the transducer is entered in the SIS control software prior to data acquisition. The Roll/Pitch/Yaw fields (mounting misalignments resolved with the patch test) are zero because the data were corrected for these during data acquisition using the SIS control software.

<u>Navigation</u>: The Navigation X/Y/Z fields (location of the navigation source from the reference point) are set to zero because the locations of the navigation sources are entered in the SIS control software during data acquisition. CARIS correspondence indicates that the Ellipsoid should be set to match that of the Separation model used. In this case the coordinate system of the Separation Model is NAD83(2011) which uses the GRS80 ellipsoid. The Ellipsoid in the vessel file was set to GR80.

Gyro: No Gyro fields are edited because no offset was applied.

Heave/Pitch/Roll: Heave, Pitch, and Roll are compensated for by the DMS05. The respective X/Y/Z fields are set to zero and the Apply Switches are set to 'No' because the dynamic values are applied in real-time during data acquisition.

Draft: A draft table was not applied. This is accounted for during the post-processing and reducing the data to Mean Lower Low Water (MLLW) via ellipsoid referencing.

TPU Offsets: The offsets were calculated from known locations of the equipment from the CRP, which are presented in Table 13 and

Table 14. (Refer to Appendix 1: Vessel Reports – Vessel Offsets Report for additional information).

Table 13. R/V *Sea Scout* MRU to Transducer offsets

Transducer	MRU to Trans X (m)	MRU to Trans Y (m)	MRU to Trans Z (m)
Transducer 1	0.00	0.223	0.575

Table 14. R/V *Sea Scout* NAV to Transducer offsets

Transducer	NAV to Trans X (m)	NAV to Trans Y (m)	NAV to Trans Z (m)
Transducer 1	0.257	-0.502	12.926

According to CARIS correspondence, the Transducer Roll is the mounting angle of the Receive Array + Roll Calibration. The transducers aboard the R/V *Sea Scout* are mounted flat; therefore, the Transducer Roll (deg) is equal to the offset angle entered in the SIS control software (Table 15).

Table 15. Transducer Roll value for TPU Offsets section for the R/V *Sea Scout*.

Date	Transducer Roll (deg)
September 28, 2018	-0.04
October 12, 2018	0.03

TPU Standard Deviation:

The values entered for the Standard Deviation are shown in Table 16 and Table 17.

Table 16. Values entered for the TPU Standard Deviation section of the HVF for the R/V *Sea Scout*.

Field	Value	Reasoning
Motion Gyro:	0.23	Based on the TSS Surveyor Meridian this is 0.2 x Secant(latitude) (latitude used 27.5 degrees)
Heave % Amplitude:	0%	ellipsoid processing - value taken into account in GNSS height

Field	Value	Reasoning
Heave (m):	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
Roll:	0.05°	based on the DMS05 product datasheet
Pitch:	0.05°	based on the DMS05 product datasheet
Position Nav:	0.1 m	The C-Nav® 3050 GNSS units underwent internal testing and it was found that they were within 0.2 m of a known position at the 95% confidence level. 1-sigma value here is 0.2 m divided by 1.96.
Timing Trans:	0.01 s	serial connection
Nav Timing:	0.01 s	serial connection
Gyro Timing:	0.01 s	serial connection
Heave Timing:	0.01 s	serial connection
Pitch Timing:	0.01 s	serial connection
Roll Timing:	0.01 s	serial connection
Offset X:	0.003 m	standard deviation of the control point residuals from the Sea Scout dimensional control survey
Offset Y:	0.002 m	standard deviation of the control point residuals from the Sea Scout dimensional control survey
Offset Z:	0.001 m	standard deviation of the control point residuals from the Sea Scout dimensional control survey
Vessel Speed:	0.0 m/s	ellipsoid processing – dynamic draft not needed - value taken into account in ellipsoid height
Loading:	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
Draft:	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
Delta Draft:	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
MRU Align StdDev Gyro:	See table 17	standard deviation of several patch test iterations
MRU Align StdDev Roll/Pitch:	See table 17	standard deviation of several patch test iterations

Table 17. Standard deviation of patch test iterations.

Date	Julien Day	MRU Align StdDev Gyro:	MRU Align StdDev Roll/Pitch:
September 28, 2018	2018-271	0.089°	0.039°
October 12, 2018	2018-285	0.19°	0.059°

Corrections to Vessel File:

Between September 28, 2018 and October 12, 2018 it was recognized that incorrect CRP > MRU (Motion Reference Unit) offsets were entered into the SIS control software. According to CARIS correspondence the following updates were made to the vessel file: the correct MRU offsets (Table 18) were entered in the Heave section and the SVP1 section filled out with the X, Y, and Z offsets of the Transducer together with the Calibration values (Pitch, Roll and Azimuth). The Waterline (WL) was updated with the apply switch set to 'No'. These offsets were corrected in the field prior to data collection of October 13, 2018.

Table 18. CRP to MRU offsets (R/V *Sea Scout*)

X (+starboard) m	Y (+forward) m	Z (+down) m
0.067	-6.460	6.871

Between October 12 and October 15, 2018 it was recognized that incorrect patch test values were applied to the data. A new SVP section was created and the X, Y, and Z offsets of the Transducer together with the correct Calibration values (Pitch, Roll and Azimuth). These offsets were corrected in the field prior to data collection of October 16, 2018. The WL was updated with the apply switch set to 'No'.

B.2.1.1.2. **R/V C-Wolf**

The R/V *C-Wolf* vessel file contains the following active sensors: Transducer 1, Navigation, Gyro, Heave, Pitch, Roll, Draft, TPU.

Transducer 1: The X/Y/Z fields (the location of the transducer from the reference point) are zero for Transducer 1 because the location of the transducer is entered in the SIS control software prior to data acquisition. The Roll/Pitch/Yaw fields (mounting misalignments resolved with the patch test) are zero because the data were corrected for these during data acquisition using the SIS control software.

Navigation: The Navigation X/Y/Z fields (location of the navigation source from the reference point) are set to zero because the locations of the navigation sources are entered in the SIS control software during data acquisition. CARIS correspondence indicates that the Ellipsoid should be set to match that of the Separation model used. In this case the coordinate system of the Separation Model is NAD83(2011) which uses the GRS80 ellipsoid. The Ellipsoid in the vessel file was set to GR80.

Gyro: No Gyro fields are edited because no offset was applied and the F180 Inertial Measurement Unit (IMU) is aligned to the ship's coordinate reference frame.

Heave/Pitch/Roll: Heave, Pitch, and Roll are compensated for by the F180 IMU. The respective X/Y/Z fields are set to zero (0) and the 'Apply' switches are set to 'No' because the dynamic values are applied in real-time during data acquisition.

Draft: A draft table was not applied. This is accounted for during the post-processing and reducing the data to MLLW via ellipsoid referencing.

TPU Offsets: The offsets (
Table 19 and Table 20) were calculated from known locations of the equipment from CRP (refer to Appendix 1: Vessel Reports – Vessel Offsets Report for additional information).

Table 19. MRU to EM3002 Transducer offsets for the R/V *C-Wolf*.

MRU to Trans X (m)	MRU to Trans Y (m)	MRU to Trans Z (m)
-0.02	-4.185	0.833

Table 20. NAV to EM3002 Transducer offsets for the R/V *C-Wolf*

NAV to Trans X (m)	NAV to Trans Y (m)	NAV to Trans Z (m)
0.365	-0.959	3.103

According to CARIS correspondence, the Transducer Roll is the mounting angle of the Receive Array + Roll Calibration. The transducer aboard the R/V *C-Wolf* is mounted flat; therefore the value entered in the Transducer Roll is equal to the offset angle entered in the SIS control software (Table 21).

Table 21. Transducer Roll for the R/V *C-Wolf*

Date	Trans Roll (deg)
August 18, 2018	1.34°

TPU Standard Deviation:

The values entered for the Standard Deviation are shown in Table 22.

Table 22. Values entered for the TPU Standard Deviation section of the HVF for the R/V *C-Wolf*.

Field	Value	Reasoning
Motion Gyro:	0.1°	based on the F180 manual system performance at a 1 m antenna baseline
Heave % Amplitude:	0%	ellipsoid processing - value taken into account in ellipsoid height
Heave (m):	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
Roll:	0.025°	based on the F180 manual system performance
Pitch:	0.025°	based on the F180 manual system performance
Position Nav:	0.1 m	The C-Nav® 3050 GNSS units underwent internal testing and it was found that they were within 0.2 m of a known position at the 95% confidence level. 1-sigma value here is 0.2 m divided by 1.96.
Timing Trans:	0.01 s	serial connection
Nav Timing:	0.01 s	serial connection
Gyro Timing:	0.01 s	serial connection
Heave Timing:	0.01 s	serial connection
Pitch Timing:	0.01 s	serial connection
Roll Timing:	0.01 s	serial connection
Offset X:	0.03 m	standard deviation of the control point residuals from the Cwolf dimensional control survey
Offset Y:	0.02 m	standard deviation of the control point residuals from the Cwolf dimensional control survey

Field	Value	Reasoning
Offset Z:	0.01 m	standard deviation of the control point residuals from the Cwolf dimensional control survey
Vessel Speed:	0.0 m/s	ellipsoid processing – dynamic draft not needed - value taken into account in ellipsoid height
Loading:	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
Draft:	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
Delta Draft:	0.0 m	ellipsoid processing - value taken into account in ellipsoid height
MRU Align StdDev Gyro	0.03	standard deviation of several patch test iterations
MRU Align StdDev Roll/Pitch:	0.03	standard deviation of several patch test iterations

B.2.1.2. Multibeam Processing Workflow

B.2.1.2.1. Field Processing

B.2.1.2.1.1. R/V Sea Scout

An individual CARIS project was created for each Sheet and multibeam lines converted by the processor on shift. All lines converted were assigned a project, vessel, and day. ASCII navigation (outlined in B.1) was imported and applied on a day by day basis with an appropriate .info file. GPS Tide was computed in which the ellipsoid separation model was applied with an appropriate .info file. The lines were merged, TPU was computed and a Combined Uncertainty and Bathymetric Estimator (CUBE) surface created. The HydrOffice QCTools flier finder tool was utilized to identify potential erroneous data and clean the data if necessary.

B.2.1.2.1.2. R/V C-Wolf

The field unit performed preliminary quality control review on a daily basis of the multibeam data. A CARIS project was created for each Sheet and multibeam lines converted. These lines were assigned a project, vessel, and day. Preliminary tidal data from the 8726384 (Port Manatee, FL) water level station were downloaded from the National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) Tides and Currents website and applied to all MBES data in CARIS. The lines were merged and a preliminary surface created. These surfaces were provided to the office on a regular basis for additional quality control purposes.

B.2.1.2.2. Office Processing

The office processing of the data collected by the R/V *C-Wolf* involved first following the procedures outlined in B.2.1.2.1.1 with a couple differences. The data were filtered using a surface filter (3 standard deviations) and also filtered by beam angle to decrease the amount of edge fliers present in the data.
The surfaces were examined systematically using several methods, including review of the standard deviation, deep, shoal and depth layers with all pertinent background data open. Background data included the chart(s) and the line files; the Project Reference File (PRF); Composite Source File (CSF); SSS mosaics and SSS contact locations. Areas of high standard deviation and/or anomalous depths were investigated by all means appropriate, including, subset editor and swath editor and comparison to SSS data and charted information. If data were found to misrepresent the seafloor, the data were rejected. The hydrographer would review the navigation, attitude and raw swath data as necessary.

The side scan sonar contacts were reviewed in the map window to ensure complete coverage over all significant targets. The least depths of features and contacts were designated as appropriate using the criteria in section 5.2.1.2.3 of the HSSD (2018) Designated Soundings and Danger to Navigation (DtoN) reports submitted, as necessary.

B.2.1.2.3. Multibeam Water Column Review via Qimera

For a period of time it was recognized that the water column data, when processed in CARIS, was not added in the correct depth. It was decided to review the water column data in Qimera. Qimera projects were created, source data added, ASCII navigation processed and loaded, and the ellipsoid separation model loaded. Water column data was reviewed on a line by line basis in order to determine whether contacts showed features shallower than determined by the bathymetry alone. The issue with CARIS (a zero entry in the SVC section) was fixed and water column additional bathymetry was added in CARIS as necessary.

B.2.1.2.4. Fixed File Path

During post-processing, ASCII navigation files (time, lat, lon, ellipsoid height) were imported into CARIS with an associated .info file, which contains information on the contents and formatting of the ASCII navigation files. When projects processed in the above manner were copied from a network location to external or internal drives or from internal drives to external drives it was observed that the path of the info file remained fixed to the original path name. CARIS asked to update the navigation folder, but not the info file. Keeping the info file in with the ASCII navigation did not appear to change this. Certain editors such as navigation editor or swath editor could not be opened within CARIS and the lines became locked.

The workaround is to recreate the exact folder structure of the original project on the internal or external drive. However, it is recognized that this is an issue for submission because files are placed in the appropriate submission folders without regard for how the projects were originally set up.

A request was logged with CARIS support and the information sent to the development team. Information from CARIS supports indicates that the Check Project process was not checking for an *.info file when using an ASCII file for auxiliary navigation. CARIS correspondence indicates that this has been fixed so that the check process will look for *.info missing files, enabling users to update their location using the Reset Raw Data Location dialog box. This fix should be available in both versions 10.4.10 (tentatively early-January) and 11.1.0 (tentatively mid-January). Due to licensing limitations this has not been tested in-house and the workaround to maintain original path names and drive letters was used. These path names are further described in the Descriptive Reports (DR).

B.2.2. **Total Propagated Uncertainty**

Total propagated uncertainty (TPU) is computed from a combination of all individual error sources and is used as an estimate of the uncertainty associated with individual hydrographic measurements, such as soundings. There is a horizontal component and a vertical component of uncertainty. TPU must be computed to create bathymetric products using the CUBE algorithms.

According to section 3.2 of the HSSD (2018), the Total Horizontal Uncertainty (THU) in the position of the soundings will not exceed 5 m + 5% of the depth. According to section 5.1.3 of the HSSD (2018) the maximum allowable Total Vertical (or depth) Uncertainty (TVU) is calculated using the below formula; in depths less than 100 meters, a = 0.5 m and b = 0.013.

$$\pm\sqrt{a^2 + (b * d)^2}$$

The TPU was evaluated to ensure that the values are within the specifications above. In accordance with section 5.1.2 of the HSSD (2018), all depths reported in the deliverables are accompanied by the estimate of TPU.

B.2.2.1. TPU Calculation via CARIS HIPS

CARIS HIPS was used to compute the Total Propagated Uncertainty (TPU) for each sounding. There are two places within CARIS to enter uncertainty estimates:

1. In the vessel file
2. In the Compute TPU dialog box.

The vessel file stores static values of the estimated uncertainties associated with each individual sensor. In the Compute TPU dialog box the user can specify tidal and sound speed uncertainty, as well as if the sources of uncertainty are static (come from the vessel file) or were collected in real-time. CARIS also incorporates the above uncertainty estimates with a DeviceModels.xml that contains individual sonar model characteristics to calculate the total TPU. Refer to section B.2.1.1 for information regarding the vessel file TPU values and Figure 1 for the Compute TPU dialog values.

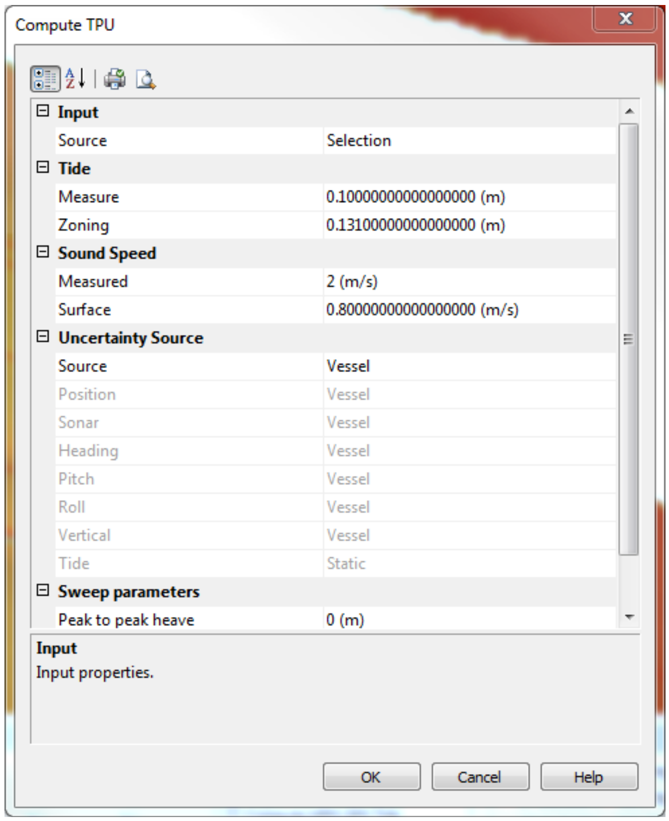

Figure 1. Total Propagated Uncertainty (TPU) values.

B.2.2.1.1. **Tide Component**

Currently in CARIS there is no entry for static vertical uncertainty associated with a positioning system or separation model. The workaround is to put these values in the Tide Measured and Zoning entry locations. This was confirmed with CARIS as an appropriate method.

The C-Nav® 3050 GNSS units underwent internal testing and the observations were found to be within 0.2 m of a known vertical position at the 95% confidence level. The 95% confidence level is expressed as 1.96 standard deviations from the mean. Because CARIS entries of uncertainty are assumed to be 1-sigma, this value is divided by 1.96 for entry into the CARIS Tide Measure location (10 cm).

The 1-sigma VDATUM maximum combined uncertainty value is provided in the project instructions (13.1 cm) and was entered in the Tide Zoning location in the CARIS Compute TPU dialog.

B.2.2.1.2. Sound Speed Component

The measured sound speed TPU value is 2 m/s. The sound speed calculated at the transducer is compared to the sound speed calculated by the previous CTD cast. If the difference is 2 m/s or greater, it is necessary to obtain a new sound speed cast.

The surface sound speed value was set at 0.8 m/s with the following reasoning. The YSI 600R sonde is used to calculate the sound speed at the multibeam transducer. The resultant sound speed is a function of temperature and salinity (ignoring the effects of depth/pressure because the sensor is near the sea surface). The Law of the Propagation of Variances states that the uncertainty associated with an unknown (sound speed) can be calculated if the variance associated with a series of known variables (salinity and temperature) are known.

The specifications for the 600R are shown in Table 23 and the known amount by which a certain change in salinity and temperature affect sound speed are shown in Table 24.

Table 23. Accuracies associated with salinity and temperature measured by the YSI 600R sonde.

Parameter	Accuracy
Salinity	± 1% of reading or 0.1 ppt (whichever is greater)
Temperature	± 0.15 °C

Table 24. The amount that sound speed changes with changes in salinity and temperature.

Parameter	Change in parameter	Change in Sound Speed
Salinity	1 ppt	1.3 m/s
Temperature	1 °C	4.5 m/s

A value of 30 ppt is used as a general surface salinity value. The uncertainty surrounding this measurement is: 30 * .01 = ± 0.30 ppt; this value is used in the following calculations because it is greater than 0.1 ppt. The amount that 0.3 ppt salinity would change sound speed is:

$$0.3\,ppt * \left(\frac{1.3\,\frac{m}{s}}{1ppt}\right) = 0.39\,\frac{m}{s}$$

The accuracy associated with the temperature measurement is ± 0.15 °C and the amount that this value would change the sound speed is:

$$0.15℃ * \left(\frac{4.5\frac{m}{s}}{1℃} \right) = 0.675\frac{m}{s}$$

The total uncertainty of the sound speed measurement is determined by calculating the square root of the quadratic sum of the individual uncertainty sources. The final value used was $0.8\frac{m}{s}$.

$$\sigma_{ss}^2 = \sigma_{sal}^2 + \sigma_{temp}^2$$
$$\sigma_{ss}^2 = (0.39\frac{m}{s})^2 + (0.675\frac{m}{s})^2$$
$$\sigma_{ss}^2 = (0.607735\frac{m}{s})^2$$
$$\sigma_{ss} = 0.7795\frac{m}{s}$$

B.2.3. **Surfaces**

Surfaces were named as follows: <Survey registry number>_<Sounding Type>_<units of resolution>_<Vertical Datum>, as specified in section 8.3.2 of the HSSD (2018). All surfaces were created as CUBE surfaces based upon the respective NOAA parameters. Complete coverage surfaces were created with a single resolution of 1.0 m. Object detection surfaces were created with a single resolution of 0.5 m.

B.2.4. **HydroOffice QCTools**

The HydroOffice QCTools utility was used as additional quality control check to search the surfaces for fliers. The 'flier finder' utility used to check for fliers using the default parameters. HydrOffice QCTools was also used to analyze Uncertainty, Density, determine if holidays exist and review the Final Feature File.

B.2.5. **Crossline Comparison**

Crosslines were run perpendicular to the main scheme survey lines. Crossline mileage consisted of approximately 4% of the main scheme mileage, in accordance with Section 5.2.4.2 of the HSSD (2018). Crossline comparisons were performed as a quality control tool to identify systematic errors and blunders in the survey data.

B.2.5.1. Crossline Comparison via CARIS HIPS

Crossline comparisons were performed in CARIS HIPS 10.4 using the surface difference tool. Separate surfaces were generated for the main scheme lines and crosslines and a difference surface between the main scheme and crossline surfaces computed. The difference surface was used as a data cleaning tool as well as a quality control tool. It was noted if the depth difference values differed by more than the maximum allowable Total Vertical Uncertainty (TVU), as outlined in Section 5.2.4.2 of the HSSD (2018). Areas were further evaluated where the depth values for the two datasets differed by more than the maximum allowable TVU and the source of error identified and explained. The crossline and mainline surfaces have been retained and submitted in the Processed\Reports\Survey\Separates\II_Digital_Data\Crossline_Comparison directory.

B.2.6. Reporting, Products and Finalization

B.2.6.1. Junctions

Junction analysis was performed between adjoining contemporary and historical surveys using a surface difference tool. Junctions were evaluated for agreement in depth.

B.2.6.2. Chart Comparisons

Chart comparisons were performed using cleaned surfaces and a variety of methods including colored depth ranges, contours and. sounding layers. The data were compared to the most recent, largest scale Electronic Navigational Charts (ENC) in the area, as specified in each Descriptive Report (DR).

In CARIS, a sounding layer was generated from the surface created for each Sheet and compared to charted depths. The shoal biased radius option was always selected and the radius was selected as distance on the ground (in meters). A single-defined radius was chosen that generated a sufficient amount of soundings, which potentially varied from sheet to sheet and is detailed in each DR.

B.2.6.3. Finalized Surfaces

The surfaces were finalized in CARIS for submission after all data had been cleaned and all least depths on the contacts either examined or designated. The final surfaces were generated from the higher of the standard deviation or uncertainty values in order to preserve a conservative uncertainty estimate. The designated soundings were applied in order to maintain the shallowest soundings within the final surface (Figure 2). Any depth threshold applied is detailed in the DR.

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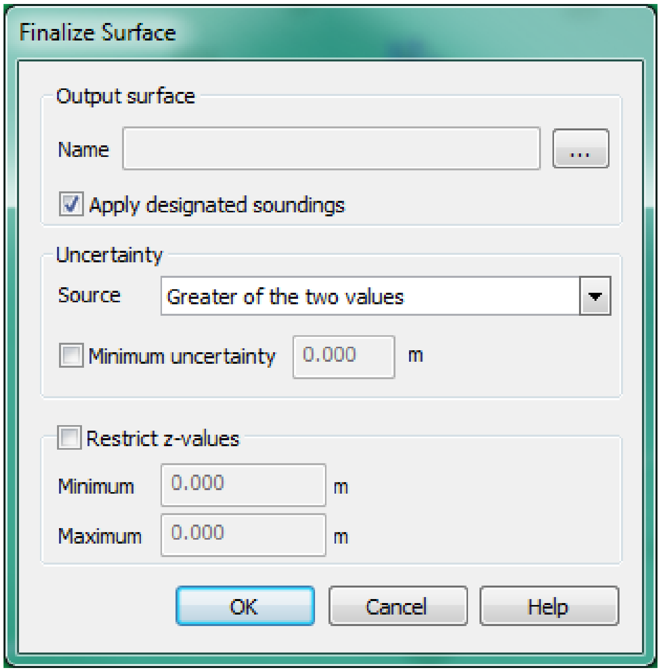

Figure 2. Sample surface finalization parameters.

B.2.6.4. Feature Management and Final Feature File

Survey data were reviewed for contacts and features. All features identified as anthropogenic and measured greater than the appropriate minimum required feature size for the coverage requirement (Table 25) were given a final status of Designated in the final CARIS project to aid in feature management, as outlined in Section 7.4 of the HSSD (2018). In addition, notable features less than a meter in height but with other distinguishing characteristics could also be designated and included in the Final Feature File (FFF).

Table 25. Minimum Required Feature Size for Inclusion in the Final Feature File.

Sheet	Coverage Requirement	Grid Resolution	Minimum Required Feature Size
1	Object Detection	0.5 m	1 x 1 x 1 m
2	Complete Coverage	1.0 m	2 x 2 x 1 m

Features could also be designated, but not necessarily added to the FFF, if the grid does not recognize a least depth. Determination of whether the grid honored the least depth was determined in accordance with the HSSD (2017) section 5.2.1.2.3. Features that were greater than 1 meter in height could be designated if the difference between the gridded surface and the potential designated sounding was greater than the allowable TVU at that depth.

All assigned features in the CSF file were addressed appropriately. If a feature was disproven, the feature retained the original attribution in the FFF with Remarks, Description and Recommendations updated. If blank in the CSF file the Technique of Sounding Measurement was updated to reflect the method of disproval.

As per the HSSD (2018) a feature with any horizontal dimension greater than 1 mm at survey scale (i.e. 10-meters for a survey scale of 1:10,000) were treated as area features and delineated appropriately.

B.3. SIDE SCAN SONAR

B.3.1. Image Processing

Chesapeake Technologies' SonarWiz software was used to process side scan sonar data. During processing the XTF files were imported; the bottom track of each line was reviewed and manually corrected if needed; sheave offsets were applied; cable out values were added depending on the collection method; and layback and gains were applied. Fully position-corrected XTF files were exported from SonarWiz for the final deliverables.

B.3.2. Data Review and Proof of Coverage

The side scan processor reviewed all data during data acquisition and noted in the survey logs any significant features or surface/water column effects. Any lines or portions of lines that did not meet quality standards including, but not limited to noise, thermoclines, and biologic interference were re-run.

A coverage map was produced during review. Any gaps in coverage were noted, logged in the re-run log, and brought to the attention of the party chief and the operators on shift; gaps were filled when possible. ArcGIS was also utilized to identify gaps using a combination of the 'reclassify' and 'raster to polygon' tools. The polygon(s) generated were also used to create the final survey outline of sheets surveyed with 100% SSS.

The main survey lines were submitted as the first 100% coverage mosaic. When the side scan sonar was used within a specified radius for a feature disproval, the second 100% disproval lines were submitted as a separate mosaic.

B.3.3. Contact Selection

Each side scan sonar file was evaluated individually and contacts identified. Contacts were always selected from slant-range corrected data. According to section 6.1.3.3 of the HSSD (2018), contacts shall be picked that have computed target heights of at least one meter in water depths less than or equal to 20 m and heights of at least 5% of the depth in water depths greater than 20 m. In some instances contacts where retained whether the shadows measured a meter or more or not depending on factors such as size, shape and notability.

In areas where a high density of contacts exists in close proximity, it was at the hydrographer's discretion to create an area feature around the contacts, for example, in a Fish Haven area. In CARIS, the hydrographer would ensure that the contact with the shallowest least depth was selected and/or the least depth examined/designated in the bathymetry. All existing infrastructure, such as pipelines, wells, platforms, and Aids to Navigation were also documented.

B.3.4. Contact Correlation

The contacts were exported from SonarWiz as a Comma Separated Value (csv) file. Contacts were brought into the multibeam processing software. In CARIS the Object Import Utility was used to import the contacts as points. The S-57 file of contacts was evaluated in the CARIS map window with the surfaces of the main scheme lines and completed investigations to ensure complete coverage over significant targets. All significant contacts not fully developed with multibeam data were further investigated. Danger to Navigation (DtoN) reports were submitted for uncharted significant contacts and structures.

B.3.5. Side Scan Sonar Contact List

After the multibeam surfaces had been reviewed for anomalous data points in conjunction with charts and the side scan sonar contacts, the contacts were systematically reviewed in the multibeam processing software map window with respect to surfaces and charted features. The attributes of each contact were examined and the Description field updated in SonarWiz, which would become the 'Remarks' field in the final S-57 deliverable. This final S-57 file of all the contacts was generated in accordance with section 8.2.2 of the HSSD (2018).

B.4. DATA DIRECTORY STRUCTURE

During data processing, separate directories were created for multibeam processing projects, SonarWiz projects, and Report Deliverables. Upon submission, these were combined into the directory structure as supplied by NOAA. No folders were removed. If a folder is to remain empty, a readme file was added for explanation purposes. Prior to data submission, the data directory structure was checked using HydrOffice QCTools and a checksum file created in FileVerifier

C. CORRECTIONS TO ECHOSOUNDING

C.1. INSTRUMENT CORRECTIONS

In order to ensure that the multibeam systems aboard the R/V *Sea Scout* and R/V *C-Wolf* were functioning properly, single beam echo sounders were monitored in real-time as an independent check of the multibeam nadir. Lead lines were performed periodically as a secondary independent check of the multibeam sonar systems aboard all vessels.

C.2. VESSEL OFFSET MEASUREMENTS AND CONFIGURATION

C.2.1. R/V Sea Scout

During construction of the R/V *Sea Scout* a full dimensional control survey was conducted in dry dock using a Leica TPS 1201+ total station to measure offsets from the Central Reference Point (CRP) to all survey equipment on the vessel. Additional dimensional control surveys have been conducted periodically thereafter to verify the offsets. The most recent dimensional control survey was conducted in May, 2018. Figure 3 shows a picture of the R/V *Sea Scout* and a vessel diagram with all measured offsets from the central reference point is shown in Appendix 1: Vessel Reports – Vessel Offset Reports.

Figure 3. R/V *Sea Scout*.

C.2.2. R/V C-Wolf

The offsets for the R/V *C-Wolf* are measured periodically with a total station while the vessel is trailered. The most recent dimensional control survey was conducted on July 25, 2018. Figure 4 shows a picture of the R/V *C-Wolf* and a vessel diagram with all measured offsets from the CRP is shown in Appendix 1: Vessel Reports – Vessel Offset Reports.

Figure 4. R/V *C-Wolf*

C.3. LAYBACK

Layback was applied to side scan XTF files during post-processing using SonarWiz. Refer to Appendix I: Vessel Reports – Vessel Layback Report for additional information.

C.4. STATIC AND DYNAMIC DRAFT

Static draft measurements aboard the R/V *Sea Scout* were read at least once every 36 hours during survey operations. The vessel has a draft tube in each hull and the reading from each draft tube is averaged together to provide a centerline draft value. This value is used to calculate the waterline to CRP measurement, which is entered into SIS.

Static draft aboard the R/V *C-Wolf* is measured using a rod that is placed down through a hole in the top of the multibeam ram. The rod measures the distance from the waterline to the top of the EM3002 mounting plate. This value is used to calculate the waterline to CRP measurement, which is entered into SIS.

In order to correct for the vertical displacement of the vessel while underway, a squat and settlement test is generally performed. However, this survey is processed with

GNSS ellipsoid heights and an ellipsoid separation model. Dynamic draft is included in the raw GNSS measurement and dynamic draft was not applied during post-processing.

C.5. POSITIONING AND ATTITUDE SYSTEMS

Both the R/V *Sea Scout* and the R/V *C-Wolf* are equipped with two (2) C-Nav® 3050 receivers. The C-Nav® 3050 receivers use the C-Nav® Subscription Services and deliver precise point positioning (PPP), which can achieve up to 5 cm horizontal accuracy and 15 cm vertical accuracy (1-sigma). These systems are controlled and monitored with either a C-Navigator system (R/V *Sea Scout)* or the C-Monitor control software (R/V *C-Wolf*).

Aboard the R/V *C-Wolf* one of the C-Nav® receivers provides a DGPS correction via serial connection to the F180 attitude and positioning system. The F180 is controlled and monitored using PC software via a network connection to the system. The F180 position string is used for the serial and 1PPS strings that are used to sync all systems on the network and is integrated with the multibeam echosounder to provide real-time heave, pitch, and roll corrections; heading is also obtained from the F180. The antenna baseline is 1.488 m. Manufacturer accuracies are shown in Table 26.

Table 26. Manufacturer accuracies for the Coda Octopus F180 attitude and positioning system.

Baseline	Heading	Roll	Pitch	Heave
1 meter	0.1º	0.025º	0.025º	The greater of 5% of heave amplitude or 5 cm

Aboard the R/V *Sea Scout* a DMS05 motion sensor is integrated with the multibeam echosounder to provide real-time heave, pitch, and roll corrections; heading is obtained from the TSS Meridian Surveyor. Manufacturer accuracies are shown in Table 27 and Table 28.

Table 27. Manufacturer accuracies for the DMS05 motion sensor.

Roll	Pitch	Heave
0.5º	0.5º	The greater of 5% of heave amplitude or 5 cm

Table 28. Manufacturer accuracy for the TSS Meridian Surveyor.

Dynamic Accuracy
0.2 * secant latitude

C.6. EQUIPMENT OFFSETS

Equipment offsets from the CRP were entered directly into the Kongsberg SIS software aboard the R/V *Sea Scout* and R/V *C-Wolf*.

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C.7. MULTIBEAM CALIBRATION

Prior to commencement of survey operations, a standard multibeam calibration (patch test) is performed to calculate the misalignment in the mounting of the multibeam transducer within the vessel reference frame. CARIS HIPS was used to resolve the angular offsets. The angular offsets from the patch tests were entered directly into the Kongsberg SIS software for correction of data in real-time. Refer to Table 29 and

Table 30 as well as the patch test reports for additional information.

Table 29. Patch Test Results (R/V *Sea Scout*)

Date	Pitch	Roll	Yaw
September 28, 2018	-0.46°	-0.04°	-1.43°
October 12, 2018	-0.02°	0.03°	2.27°

Table 30. Patch Test Results (R/V *C-Wolf*)

Date	Pitch	Roll	Yaw
August 18, 2018	0.09°	1.34°	-0.178°

C.8. SOUND SPEED CORRECTIONS

Seabird Electronics SBE19 Plus CTD sensors were used to collect sound speed data through the water column. Simultaneous sound speed profiles were acquired aboard the R/V *Sea Scout* (Figure 5) and reviewed together as a quality control check. Only one cast was typically conducted aboard the R/V *C-Wolf* unless specifically conducting a comparison. The data from the CTD sensor is uploaded via SeaTerm software and converted to a .cnv file using SBEDataProcessing software. The sound speed profile is filtered at 1-meter intervals, extended to 12,000-meters and saved in a format compatible with the multibeam control software (SIS) using SVTool software. The profile is then entered into SIS and the multibeam data corrected for the water column sound speed in real-time. The mean water column sound speed generated from the chosen sound speed profile was applied to the singlebeam echosounder data.

Figure 5. CTD set-up on the R/V *Sea Scout*.

Endeco YSI 600R sondes were used to calculate the sound speed at the transducers. The difference between the sound speed measured by the CTD and the sound speed calculated at the transducer was monitored in the SIS software. A difference of more than 2 m/s indicates a new cast should be taken.

The digital sound speed data and a summary (.csv file) of the sound speed data acquired can be found in Processed\Reports\Survey\Separates\II_Digital_Data\Sound_Speed_Data_Summary.

C.9. TIDES AND WATER LEVELS CORRECTIONS

Survey data were acquired vertically referenced to the waterline. In post processing, survey data were processed to the ellipsoid using the ellipsoid height from the primary C-Nav® 3050 GNSS unit. The GNSS data were converted to NAD83(2011) using VDATUM. An ellipsoid separation model provided by NOAA (Table 31 and Table 32) was used to reduce multibeam survey data to chart datum. The datum to which the soundings were reduced to for this survey is Mean Lower Low Water (MLLW).

Table 31. VDATUM Model as referenced in the Project Instructions.

VDatum Version	Geoid	Area	Area Version	Separation Uncertainty
3.6.1	2012	FLwest_01_8301 and FLapalach01_8301	1	13.1 cm

Table 32. Separation Model

Separation Model Used
TampaBay_EC_poly_xyNAD83-MLLW_geoid12b.txt

D. LETTER OF APPROVAL

DATA ACQUISITION AND PROCESSING REPORT

OPR-J317-KR-18

This report is respectfully submitted. Field operations contributing to the accomplishment of this survey were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report has been closely reviewed and is considered complete and adequate as per the Statement of Work.

Scott Melancon

Digitally signed by Scott Melancon
DN: cn=Scott Melancon, o, ou, email=smelancon@oceaneering.com, c=US
Date: 2019.03.08 08:50:30 -06'00'

Scott Melancon
Chief of Party
Oceaneering International, Inc.
February 2019

Nicole Galloway
Geoscientist
Oceaneering International, Inc.
February 2019

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