U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

# Data Acquisition & Processing Report

*Type of Survey* Navigable Area

*Project No.* OPR-K354-KR-13

*Time Frame* August 2013 to July 2014

## LOCALITY

*State* Louisiana

*General Locality* Louisiana Coast, LA

2014

CHIEF OF PARTY
Tara Levy

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TABLE OF CONTENTS

LIST OF FIGURES



**LIST OF TABLES**

# A. EQUIPMENT

## A.1. MAJOR OPERATIONAL SYSTEMS

The major operational systems used to acquire hydrographic data were Kongsberg EM 2040C and EM3002 multibeam echo sounders (MBES) and Klein 5000 V2 and GeoAcoustics side scan sonars (SSS). A list of the survey equipment is shown in Tables 1 and 2 for each vessel used in operations.

**Table 1. Survey Equipment R/V *SEA SCOUT***

| System | Manufacturer | Model | Serial Number |
|---|---|---|---|
| Multibeam Echo Sounder (Port) | Kongsberg | EM2040C | Transducer: 0131<br>Topside: 528 |
| Multibeam Echo Sounder (Starboard) | Kongsberg | EM2040C | Transducer: 0133<br>Topside: 529 |
| Side Scan Sonar (Primary) | Klein | 5000 V2 | Side Scan: 377<br>Topside: 792 |
| Side Scan Sonar (Back –up) | Klein | 5000 V2 | Side Scan: 376<br>Topside: 790 |
| Single Beam Echo Sounder (Port) | ODOM | Echotrac MK III | Transducer: TR7212<br>Topside:21646 |
| Single Beam Echo Sounder (Starboard) | ODOM | Echotrac MK III | Transducer: TR7211<br>Topside: 21646 |
| Attitude and Positioning System | CodaOctopus | F180 | F0407061 |
| Attitude and Positioning System (spare) | Coda Octopus | F180 | F0104012 |
| Positioning System | CNAV | 3050 | CNAV Receiver:13769 |
| Positioning System | CNAV | 3050 | CNAV Receiver: 13752 |
| Sound Speed at Transducer | YSI Electronics | 600R-BCR-C-T | 99B0559, 04M1615 |
| CTD | Sea-Bird Electronics, Inc | SBE 19 | 2791,1174, 2645 |
| CTD | Sea-Bird Electronics, Inc | SBE 19 Plus | 5221, 5222 |
| Cable Payout Indicator | Subsea Systems | PI-5600 | 234, 235 |

**Table 2. Survey Equipment R/V *C-Wolf***

| System | Manufacturer | Model | Serial Number |
|---|---|---|---|
| Multibeam Echo Sounder (Port) | Kongsberg | EM3002 | Transducer: 561<br>Topside: 1010 |
| Side Scan Sonar (Primary) | GeoAcoustics | 159D<br>SS981 | Side Scan: 362<br>Top Side: 438 |
| Side Scan Sonar (Back –up) | GeoAcoustics | 159D<br>SS981 | Side Scan: 593<br>Top Side: 441 |
| Single Beam Echo Sounder | ODOM | Hydrotrac | Transducer:<br>Topside: 11062 |
| Attitude and Positioning System | CodaOctopus | F180 | F0803009 |
| Positioning System | CNAV | 2050 | CNAV Receiver: 5329 |
| Positioning System | CNAV | 2050 | CNAV Receiver: 5399 |
| Sound Speed at Transducer | YSI Electronics | 600R-BCR-C-T | 12H100794 |
| CTD | Sea-Bird Electronics, Inc | SBE 19 | 1174, 2645 |

## A.2. SURVEY VESSELS

The majority of survey operations were conducted aboard the R/V *Sea Scout*, owned and operated by C & C Technologies. The R/V *Sea Scout* is a 134 foot (40.8432 meter) catamaran survey vessel based out of New Iberia, Louisiana. Vessel profile and vessel specification information is shown in Table 3. A portion of the survey operations were conducted with the R/V *C-Wolf*, a 30 foot (9.144 meter) aluminum vessel owned and operated by C & C Technologies. Vessel profile and vessel specification information is shown in Table 4. Vessel diagrams with all measured offsets from the central reference point (CRP) of each vessel are shown in Appendix 1: Vessel Reports – Vessel Offset Reports.

**Table 3. R/V *Sea Scout* Vessel Profile and Specifications**

| | |
|---|---|
| Owner/Operator | C & C Technologies, Inc. |
| Home Port / Flag | Lafayette, 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 Feet |
| Beam | 37' 4" |
| Draft | 6' 6" |
| Freeboard | 7' 7.5" |

**Table 4. R/V *C-Wolf* Vessel Profile and Specifications**

| | |
|---|---|
| Owner/Operator | C & C Technologies, Inc. |
| Home Port / Flag | Lafayette, Louisiana / USA |
| Hull ID | JQN00027J708 |
| LA Registration Number | LA-2935-FS |
| Year Built | 2008 |
| Builder | Razerhead Boats Inc. |
| Intended Service | Oceanographic Research Vessel |
| Operational Area | Shallow Water, USA |
| Length | 30' |
| Beam | 8.5' |
| Draft | 3' |
| Freeboard | 2.5 |

## A.3. MULTIBEAM ECHOSOUNDER OPERATIONS

Two hundred percent (200%) side scan sonar coverage with concurrent set line spacing MBES coverage was acquired, as outlined in the Project Instructions. Multibeam crossline data was acquired along transects perpendicular to the mainscheme lines. Crossline mileage consisted of at least 8% of the mainscheme mileage, in accordance with Section 5.2.4.3 of the HSSD (2013). Refer to section B.1.3.1 for details on crossline comparisons. Full bathymetric coverage was also obtained within the radii of all AWOIS (Automated Wreck and Obstruction Information System) items assigned for full investigation in the Project

Reference File (PRF). Operations specific to each vessel are outlined in the following sections.

### A.3.1. R/V *Sea Scout*

Multibeam survey operations aboard the R/V *Sea Scout* were conducted using a single head configuration comprised of one Kongsberg EM2040C multibeam echo sounder. The transducer was mounted on a retractable ram located in the port pod of the catamaran. The transducer is not mounted with any intended angular offsets. The ram operates such that the transducer can be lowered and raised as needed for survey operations and transit. The port transducer (serial number 0131) was operated at a frequency of 300 kHz. The multibeam sonar was operated in normal detection mode and equidistant beam spacing. Pertinent operational specifications of the EM2040C multibeam system are shown in Table 5. These specifications were obtained from the EM2040C product specification documentation.

**Table 5. EM2040C Operational 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.3.2. R/V *C-Wolf*

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

The transducer (serial number 561) was operated at a frequency of 300 kHz and the angular coverage of the sonar was typically set at 64 degrees from nadir. The multibeam sonar was operated in high-density equidistant beam spacing mode. The high density mode increased the number of soundings to 254 per ping.

**Table 6. EM3002 Operational Specifications**

| | |
|---|---|
| Frequencies | 292, 300, 307 kHz |
| Number of soundings per ping Dual Sonar Heads | Max 508 |
| Maximum Ping Rate | 40 Hz |
| Maximum Angular Coverage Dual Sonar Heads | 200 degrees |
| Pitch and Roll stabilization | Yes |
| Heave compensation | Yes |
| Pulse Length | 150 µs |

## A.4. SIDE SCAN SONAR OPERATIONS

A hanging sheave mounted to a retractable A-frame at the stern of the R/V *Sea Scout* was used as the tow point for the side scan sonar. The side scan sonar was also towed from a sheave mounted to the stern of the vessel aboard the R/V *C-Wolf*. Cable out values were recorded in the logs.

Line spacing was generally set to 40 meters in water depths of 0 to 25 feet (7.62 m), 60 meters in depths between 25 and 35 feet (7.62 – 10.67 m), and 90 meters in depths greater than 35 feet (10.67 m). The side scan sonar was operated at range scales of 50, 75, or 100 meters for line spacing of 40, 60, and 90 meters respectively. The criteria of acquiring 200% SSS coverage for object detection was accomplished using the aforementioned parameters and Technique 1 as set forth in Section 6.1 of the HSSD (2013). In this technique a single survey was conducted with the tracklines separated by about half the distance required for 100-percent coverage. Coverage mosaics were developed using an east/west system to ensure that 200% coverage was obtained.

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 was occasionally towed at heights of less than the required range scale. Confidence checks were observed and recorded in the logs.

Refer to the following sections, section C.2: Vessel Offset Measurements and Configuration and Appendix I: Vessel Reports – Vessel Layback Report for additional side scan sonar offset, layback information and vessel-specific operations.

### A.4.1. R/V *Sea Scout*

The Klein 5000 V2 side scan sonar was operated in a towed configuration. A hanging sheave mounted to a retractable A-frame at the stern of the vessel was used as the tow point for the side scan sonar. 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. The side scan sonar range scale did not exceed 100 m, in accordance with Section 6.1.2.4 of the HSSD (2013). 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. The survey speed did not reach the limits as stated in the product specifications (Table 7), and survey operations were conducted at speeds between 4 and 8.5 knots. The side scan sonar data was continuously monitored during acquisition to ensure quality and coverage.

**Table 7. Klein 5000 V2 Product Specifications**

| | |
|---|---|
| Number of Beams | 5 port and 5 starboard |
| Frequency | 455 kHz |
| Resolution (along track) | 10 cm at 38 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 at 150 m,<br>200 m and 250 m reconnaissance mode |

### A.4.2. R/V *C-Wolf*

The GeoAcoustics side scan sonar was operated in a towed configuration off the stern of the vessel. The cable out values were either recorded within the software and added to the XTF file directly, or recorded in the acquisition logs, and later used for layback calculations. The side scan sonar range scale did not exceed 100 m, in accordance with Section 6.1.2.4 of the HSSD (2013).

## A.5. ADDITIONAL SURVEY OPERATIONS

### A.5.1. Singlebeam Operations

An Odom Echotrac MK III was used to collect single beam data aboard the R/V *Sea Scout* and an Odom Hydrotrac used aboard the R/V *C-Wolf*. This data was continuously recorded and monitored in real-time as an independent check of the nadir beam (bottom-detect) of the multibeam sonar system.

### A.5.2. Sound Speed Operations

Sea Bird Electronics SBE19 and SBE19 Plus CTDs were used to calculate the speed of sound through the water column. Casts were performed at least twice daily aboard the R/V *Sea Scout* and more often as needed. In general, 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. Dual Endeco YSI 600R sondes were used to calculate the sound speed at the transducer. Refer to Section C.7 for additional information.

### A.5.3. Bottom Samples

Bottom samples were acquired with a Wildco® Petite Ponat® grab sampler deployed from a winch aboard the R/V *Sea Scout*; no grab sample operations were conducted from the R/V *C-Wolf*. The samples were described and photographed in the field; the samples were not retained. The bottom samples are fully attributed in the S-57 Final Feature File.

### A.5.4. Backscatter

Backscatter was acquired and logged within each raw EM2040C and EM3002 file. The backscatter data was imported during CARIS conversion and reviewed when necessary.

## A.6. ACQUISITION AND PROCESSING SOFTWARE

A list of data acquisition and processing software systems are shown in Table 8 and 9. All systems on the network are synced using 1PPS strings from GPS. Processing software updates are shown in Table 10.

**Table 8. Data Acquisition and Processing Software – R/V *Sea Scout***

| Purpose | Software | Version | Date of Installation |
|---|---|---|---|
| Multibeam data recording and monitoring | Hydromap | n/a | 11-20-2013 |
| Multibeam control Software | Seafloor Information System (SIS) | 4.0.2 | 11-20-2013 |
| Multibeam control Software | Seafloor Information System (SIS) | 4.1.3 | 03-17-2014 |
| Side Scan Collection | SonarWiz5 | V.5.06.0031 | 11-20-2013 |
| Side Scan Processing | SonarWiz5 | V.5.06.0031 | 11-20-2013 |
| Multibeam Processing | CARIS HIPS/SIPS | 8.1 | 11-20-2013 |
| Multibeam Processing | Notebook | 3.1 with SP1 | 11-20-2013 |
| CTD Conversion Tool | Seabird Electronics Sea Term | 1.59 | 11-20-2013 |
| CTD Conversion Tool | Seabird Electronics Data Conversion | 7.22.5 | 11-20-2013 |
| CTD Conversion Tool | SVTool | 1.2 | 11-20-2013 |
| IMU control software | F180 Series | 3.04.0004 | 11-20-2013 |

**Table 9. Data Acquisition and Processing Software – R/V *C-Wolf***

| Purpose | Software | Version | Date of Installation |
|---|---|---|---|
| Multibeam data recording and monitoring | Hydromap | n/a | 08-01-2013 |
| Multibeam control Software | Seafloor Information System (SIS) | 3.4.3 | 08-01-2013 |
| Side Scan Collection | SonarWiz5 | V.5.06.0024 | 08-01-2013 |
| Side Scan Processing | SonarWiz5 | V.5.06.0024 | 07-11-2013 |
| Multibeam Processing | CARIS HIPS/SIPS | 8.1.0 | 08-14-2013 |
| Multibeam Processing | Notebook | 3.1 with SP1 | 08-01-2013 |
| CTD Conversion Tool | Seabird Electronics Sea Term | 1.59 | 08-01-2013 |
| CTD Conversion Tool | Seabird Electronics Data Conversion | 7.23.1 | 08-01-2013 |
| CTD Conversion Tool | SVTool | 1.2 | 08-01-2013 |
| IMU control software | F180 Series | 3.04.0002 | 08-01-2013 |

**Table 10. Data Processing Software Updates**

| Purpose | Software | Version | Date of Installation |
|---|---|---|---|
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0021 | 06/12/2013 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0024 | 07/11/2013 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0026 | 07/22/2013 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0032 | 09/05/2013 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0037 | 11/01/2013 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0040 | 12/04/2013 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.06.0049 | 03/25/2014 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.07.0009 | 09/26/2014 |
| Side Scan Processing (Office) | SonarWiz5 | V.5.07.0011 | 10/21/2014 |
| Multibeam Processing (Field/Office) | CARIS HIPS/SIPS | 8.1.0 | 08/14/2013 |
| Multibeam Processing (Office) | CARIS HIPS/SIPS | 8.1.2 | 11/19/2013 |
| Multibeam Processing (Office) | CARIS HIPS/SIPS | 8.1.4 | 01/13/2014 |
| Multibeam Processing (Office) | CARIS HIPS/SIPS | 8.1.7 | 03/10/2014 |
| Multibeam Processing (Office) | CARIS HIPS/SIPS | 8.1.8 | 07/09/2014 |
| Multibeam Processing (Office) | CARIS HIPS/SIPS | 8.1.9 | 10/01/2014 |

Kongsberg's Seafloor Information System (SIS) software was used as the control software for the multibeam. This software allowed sound speed, attitude and position to be applied to the data in real time. Data were sent from SIS to C & C Technologies' proprietary software, Hydromap, to be recorded. Hydromap software was used for multibeam data collection, quality assurance, and quality control. 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 or due to lack of coverage, this was logged and additional data collected. Hydromap software was also used to monitor the survey line plan and maintain on-line control.

Multibeam data processing was conducted using CARIS HIPS and SIPS 8.1. CARIS Notebook 3.1 was used for contact correlation purposes and feature verification using the Composite Source File (CSF). All features in this file were updated based on the results of the survey and submitted as the Final Feature File. The NOAA Extended Attribute File V5_3_2 was used. The multibeam processing workflow is detailed in Section B.1.3.

The side scan sonar data were collected, processed, evaluated and contacts identified using Chesapeake Technologies' SonarWiz software. Details on the side scan sonar processing workflow are outlined in section B.2.

# B. QUALITY CONTROL

## B.1. MULTIBEAM

All multibeam data collected for OPR-K354-KR-13 was processed using CARIS HIPS. One CARIS project was created for each sheet. CARIS project directory structures were created according to the format required by CARIS. Prior to importing any sounding 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 Data\Processed\HDCS\VesselConfig folder for each sheet.

CARIS HIPS was used to apply tides, merge, compute TPU, apply SVC when necessary, and create BASE surfaces. CARIS HIPS was also used for multibeam data cleaning, quality control, crossline comparison, chart comparisons and side scan sonar contact correlation.

### B.1.1. CARIS Vessel Files

B.1.1.1. R/V *Sea Scout*

The R/V *Sea Scout* vessel file contains the following active sensors: Transducer 1, Navigation, Gyro, Heave, Pitch, Roll, Draft, TPU, SVP1 and Waterline Height.

Transducer 1: The X/Y/Z fields (the location of the transducer from the reference point) are zero (0) 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 (0) because the data is corrected for these during data acquisition using the SIS control software.

Navigation: The Navigation X and Y fields (location of the navigation source from the reference point) are set to 3.230 m and 1.860 m, respectively. These values are the inverse offset between the CRP and the transducer. Refer to the SVP section and Project Correspondence for additional information.

Gyro: No Gyro fields are edited because no offset was applied and the F180 IMU is aligned to the ship coordinate reference frame.

Heave/Pitch/Roll: Heave, Pitch, and Roll are compensated for by the F180 IMU and 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 during data acquisition.

Draft: A squat and settlement test was performed in order to correct for the dynamic draft of the vessel. The values input into the CARIS vessel file are shown in Table 11. Refer to Section C.3: Static and Dynamic Draft Corrections for additional information.

**Table 11. Vertical displacement of R/V *Sea Scout* with speed**

| Vertical Correction (m) | Speed (m/s) |
|---|---|
| 0.00 | 0.00 |
| 0.01 | 1.91 |
| 0.01 | 2.49 |
| 0.01 | 2.88 |
| 0.03 | 3.40 |
| 0.04 | 3.88 |
| 0.05 | 4.36 |

TPU Offsets: The offsets (Tables 12 and 13) were calculated from known locations of the equipment from the CRP (refer to Appendix 1: Vessel Reports – Vessel Offsets Report for additional information).

**Table 12. MRU to Transducer offsets**

| MRU to Trans X (m) | MRU to Trans Y (m) | MRU to Trans Z (m) |
|---|---|---|
| -2.93 | -1.54 | 7.231 |

**Table 13. NAV to Transducer offsets**

| NAV to Trans X (m) | NAV to Trans Y (m) | NAV to Trans Z (m) |
|---|---|---|
| -3.075 | 3.839 | 12.553 |

According to CARIS correspondence (refer to Project Reports\Project 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 Trans Roll (deg) is equal to the offset angle entered in the SIS control software (Table 14). Several patch tests were conducted during survey operations, and the roll values were updated to reflect any changes.

**Table 14. Values entered in the Transducer Roll fields of the TPU Offsets section**

| Date | Trans Roll (deg) |
|---|---|
| 11/26/2013 | 0.390° |
| 01/26/2014 | 0.362° |
| 03/19/2014 | 0.332° |

TPU Standard Deviation:

The values entered for the Standard Deviation are shown in Table 15. Explanation and reasoning are further explained in the following text.

**Table 15. Values entered for the TPU Standard Deviation section of the HVF**

| Field | Value |
|---|---|
| Motion Gyro: | 0.05° |
| Heave % Amplitude: | 5% |
| Heave (m): | 0.05 m |
| Roll: | 0.025° |
| Pitch: | 0.025° |
| Position Nav: | 0.05 m |
| Timing Trans: | 0.01 s |
| Nav Timing: | 0.01 s |
| Gyro Timing: | 0.01 s |
| Heave Timing: | 0.01 s |
| Pitch Timing: | 0.01 s |
| Roll Timing: | 0.01 s |
| Offset X: | 0.0017 m |
| Offset Y: | 0.0037 m |
| Offset Z: | 0.0009 m |
| Vessel Speed: | 0.8 m/s |
| Loading: | 0.14 m |
| Draft: | 0.027 m |
| Delta Draft: | 0.02 m |
| MRU Align StdDev Gyro: | 0.15° |
| MRU Align StdDev Roll/Pitch: | 0.05° |

The motion Gyro, Heave % Amplitude, Heave (m), Roll (deg) and Pitch (deg) values are based upon manufacturers' specifications as listed within the TPU resource link provided on the CARIS web page http://www.caris.com/tpu/navigation_tbl.cfm, which match the specifications in the F180 user's manual.

The Position NAV (m) was 0.05 m for survey operations conducted using the C-Nav 3050 as the primary navigation.

The Timing Trans and Nav, Gyro, Heave, Pitch and Roll Timing values were set to 0.01 s as they are serial connections, and 0.01 s is an appropriate value according to the Chapter 4 Appendix – CARIS HVF Uncertainty Values of the 2013 NOAA Field Procedures Manual.

The survey of the vessel was carried out with a Leica TPS 1200+ total station. This instrument has a 1" (1-second) angular accuracy and a range accuracy of 1mm + 1.5ppm. The errors of the measured vessel offsets were estimated by comparing the relative geometry of the offsets measured during nine (9) independent total station setups (Table 16).

**Table 16. Errors of measured vessel offsets.**

| | |
|---|---|
| No of reference points | 47 |
| Smallest misclosure | 0 mm |
| Largest misclosure | 9 mm |
| Standard deviation (X-offsets) | 1.7 mm |
| Standard deviation (Y-offsets) | 3.7 mm |
| Standard deviation (Z-offsets) | 0.9 mm |

Vessel Speed: According to according to the Chapter 4 Appendix – CARIS HVF Uncertainty Values of the 2013 NOAA Field Procedures Manual, this value is 0.03 plus the average current in the area; a value of 1.5 knots (0.77 m/s) was used for the average current.

Loading: Difference between the maximum and minimum draft measured for the duration of the survey.

Draft: The standard deviation was calculated for the draft measurements taken for the duration of survey operations.

Delta Draft: The dynamic draft data consists of 6 sets of lines run at varying speeds and the squat of the vessel at each speed. The standard deviation of the set of squat values for a specific speed setting was calculated and then averaged together for a final value.

According to the 2013 Field Procedures Manual, both the MRU Align. StdDev gyro and MRU Align StdDev Roll/Pitch can be estimated by calculating the standard deviation of a large sample of angular bias values resolved with a patch test.

SVP: An improper Z-offset for the multibeam transducer was used from November 22, 2013 through March 19, 2014. In order to correct the Z-offset, SVP 1 was added to the vessel files as needed. CARIS provided extensive support on this issue. The final vessel file was set-up with the transducer acting as the CRP because the HIPS SVC reads the data as being corrected to the transducer. The vessel file has zero offsets in the SVP section, but the patch test values are added. The inverse offset between CRP and the transducer was added to the Navigation section. Only the lines that needed to be re-processed were selected and processed with the CARIS Sound Velocity Correction (SVC) tool. Refer to Project Correspondence for additional information.

Waterline Height: The waterline value was also adjusted to reflect the transducer acting as CRP and the modified transducer Z offset (7.111 m) was subtracted from the original waterline offset. Although the apply flag is set to 'No', the SVC (Sound Velocity Correction) uses the values for processing Kongsberg data.

B.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, SVP and Waterline.

Transducer 1: The X/Y/Z fields (the location of the transducer from the reference point) are zero (0) 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 (0) for because the data is 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 (0) because the locations of the navigation sources are entered in the SIS control software during data acquisition.

Gyro: No Gyro fields are edited because no offset was applied and the F180 IMU is aligned to the ship coordinate reference frame.

Heave/Pitch/Roll: Heave, Pitch, and Roll are compensated for by the F180 IMU and 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 during data acquisition.

Draft: A squat and settlement test was performed in order to correct for the dynamic draft of the vessel. The values input into the CARIS vessel file are shown in Table 17. Refer to Section C.3: Static and Dynamic Draft Corrections for additional information.

**Table 17. Vertical displacement of the R/V *C-Wolf* with speed.**

| Vertical Correction (m) | Speed (m/s) |
|---|---|
| 0.00 | 0.00 |
| -0.01 | 1.54 |
| -0.02 | 1.80 |
| -0.03 | 2.06 |
| -0.04 | 2.57 |
| -0.09 | 3.60 |

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

TPU Offsets:

The offsets (Tables 18 and 19) were calculated from known locations of the equipment from CRP (refer to Appendix 1: Vessel Reports – Vessel Offsets Report for additional information).

**Table 18. MRU to Transducer offsets.**

| MRU to Trans X (m) | MRU to Trans Y (m) | MRU to Trans Z (m) |
|---|---|---|
| 0 | -4.275 | 0.64 |

**Table 19. NAV to Transducer offsets**

| NAV to Trans X (m) | NAV to Trans Y (m) | NAV to Trans Z (m) |
|---|---|---|
| 0.435 | -1.158 | 3.11 |

According to CARIS correspondence (refer to Project Reports\Project 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 Trans Roll is equal to the offset angle entered in the SIS control software (Table 20). An additional roll calibration was conducted on August 31, 2013 because of a roll offset visible in the multibeam data, possibly due to a spare generator onboard. In September, the value was reverted back to the original.

**Table 20. Values entered in the Transducer Roll fields of the TPU Offsets section.**

| Date | Trans Roll (deg) |
|---|---|
| 08/08/2013 | -0.08 |
| 08/31/2013 | -0.25 |
| 09/24/2013 | -0.08 |

TPU Standard Deviation:

The values entered for the Standard Deviation are shown in Table 21. Explanation and reasoning are further detailed in the following text.

**Table 21. Values entered for the TPU Standard Deviation section of the HVF.**

| Field | Value |
|---|---|
| Motion Gyro: | 0.05° |
| Heave % Amplitude: | 5% |
| Heave (m): | 0.05 m |
| Roll: | 0.025° |
| Pitch: | 0.025° |
| Position Nav: | 0.1 m |
| Timing Trans: | 0.01 s |
| Nav Timing: | 0.01 s |
| Gyro Timing: | 0.01 s |
| Heave Timing: | 0.01 s |
| Pitch Timing: | 0.01 s |
| Roll Timing: | 0.01 s |
| Offset X: | 0.02 m |
| Offset Y: | 0.02 m |
| Offset Z: | 0.02m |
| Vessel Speed: | 0.8 m/s |
| Loading: | 0.033 m |
| Draft: | 0.008 m |
| Delta Draft: | 0.016 m |
| MRU Align StdDev Gyro: | 0.16° |
| MRU Align StdDev Roll/Pitch: | 0.09° |

The motion Gyro, Heave % Amplitude, Heave (m), Roll (deg) and Pitch (deg) values are based upon manufacturers' specifications as listed within the TPU resource link provided on the CARIS web page http://www.caris.com/tpu/navigation_tbl.cfm, which match the specifications in the F180 user's manual.

The Position NAV (m) was 0.1 m for survey operations conducted using the C-Nav 2050 as the primary navigation.

The Timing Trans and Nav, Gyro, Heave, Pitch and Roll Timing values were set to 0.01 s as they are serial connections, and 0.01 s is an appropriate value according to the Chapter 4 Appendix – CARIS HVF Uncertainty Values of the 2013 NOAA Field Procedures Manual.

The X/Y/Z Offset values: The survey of the equipment offsets on the R/V *C-Wolf* was carried out using a total station. Typical accuracies are between 2 and 3 cm.

Vessel Speed: According to the Chapter 4 Appendix – CARIS HVF Uncertainty Values of the 2013 NOAA Field Procedures Manual, this value is 0.03 plus the average current in the area; a value of 1.5 knots (0.77 m/s) was used for the average current.

Loading: Difference between the maximum and minimum draft measured for the duration of the survey.

Draft: The standard deviation was calculated for the draft measurements taken for the duration of survey operations.

Delta Draft: The dynamic draft data consists of 5 sets of lines run at varying speeds and the squat of the vessel at each speed. The standard deviation of the set of squat values for a specific speed setting was calculated and then averaged together for a final value.

According to the 2013 Field Procedures Manual, both the MRU Align. StdDev gyro and MRU Align StdDev Roll/Pitch can be estimated by calculating the standard deviation of a large sample of angular bias values resolved with a patch test. Although no yaw offset was calculated, a historical value was used.

SVP: The multibeam Z-offset was not applied in SIS for data collected on August 8 through August 12, 2013. An additional roll calibration was conducted on August 31, 2013 because of a roll offset visible in the multibeam data, possibly due to a spare generator onboard, and August 30$^{th}$ was corrected using the SVP tool. In order to correct the data, SVP 1 was added to the vessel file and the transducer offsets and patch test values added. Only the lines that need to be re-processed were selected and processed with the CARIS Sound Velocity Correction (SVC) tool.

Waterline: The correct waterline height values were added to the vessel file for August 8 – 12 and 30, 2013. Although the apply flag is set to ‘No’, the SVC uses the values for processing Kongsberg data.

### B.1.2. Total Propagated Uncertainty (TPU)

CARIS HIPS was used to compute the Total Propagated Uncertainty (TPU) for each sounding using the parameters shown in Figure 1.

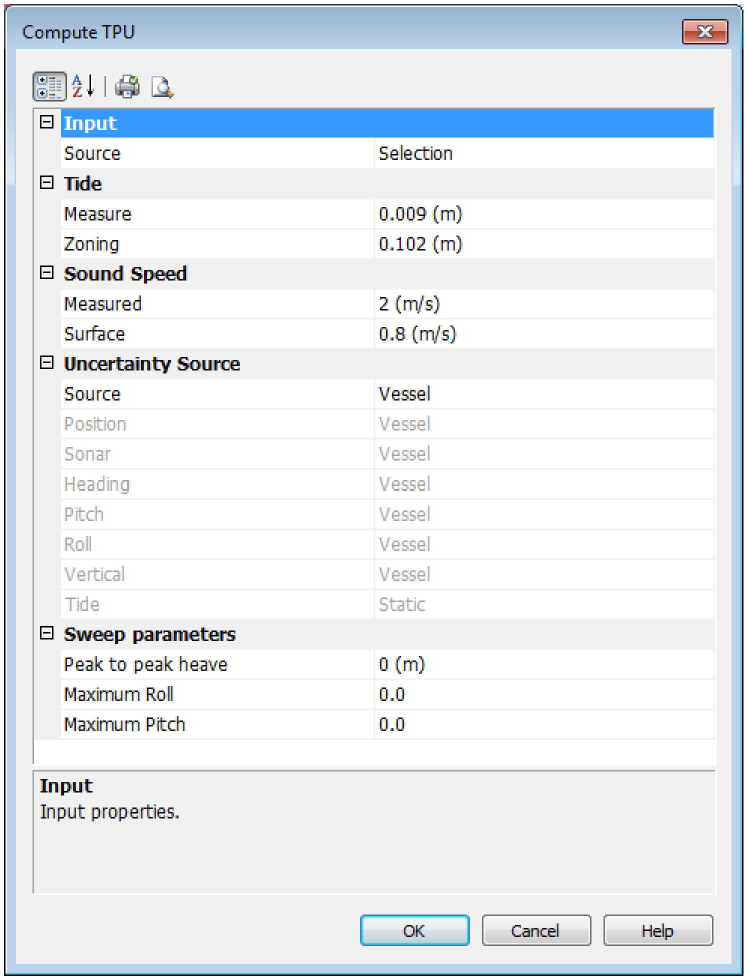

**Figure 1. Total Propagated Uncertainty (TPU) values.**

#### B.1.2.1. Tide Component

According to the NOAA Tides and Currents home page for water level station 8764227 (LAWMA), the sensor type is an A1 (Aquatrak acoustic sensor). According to CO-OPs (from the 2011 field season – refer to Project Correspondence for additional information) understood uncertainty for these sensors is 0.009 m, which was used as the measured tide TPU value. Also according to CO-OPS, the tidal zoning error is not expected to exceed the 0.45 m tolerance (at the 95% confidence level) as listed in Section 4.1.6 of the HSSD (2013). However, this section also states that typical errors associated with tidal zoning are 0.20 m at the 95% confidence level and this is the zoning error used for this survey. All error values entered in CARIS for the TPU calculation are assumed to be at the 1 sigma level, and the value provided by CO-OPS should be divided by 1.96, according to the Field Procedures Manual Section 4.2.3.8. Therefore, a final value of 0.102 m was entered as the zoning tide value for the CARIS TPU calculation.

B.1.2.2. 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 (http://www.ysi.com/productsdetail.php?600R-9) are shown in Table No. 20 and the known amount by which a certain change in salinity and temperature affect sound speed are shown in Table No. 21.

**Table 22. 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 23. 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 (using values in Table 22) 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 (Table No. 16) and the amount that this value would change the sound speed is:

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

The total uncertainty of the sound speed measurement is determined by calculating the square root of the quadratic sum of the individual uncertainty sources.

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

This value of approximately $0.8\frac{m}{s}$ is within the range of values provided in the CARIS HVF Uncertainty Values document in Appendix 4 of the Field Procedures Manual, which is 0.2 to 2 m/s.

B.1.2.3. Horizontal and Vertical Uncertainty Components

The CARIS TPU command applies both a horizontal TPU (HzTPU) and depth TPU (DpTPU). According to section 3.1.1 of the HSSD (2013), 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 (2013) the Total Vertical (or depth) Uncertainty (TVU) is calculated using the following formula:

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

For IHO Order 1 surveys, in depths less than 100 meters, a = 0.5 m and b = 0.013. Several values are shown in Table 24.

**Table 24. Maximum IHO Order 1 TVU values for water depths of 1 – 25 m in increments of 5 m.**

| a | b | Water Depth (m) | Maximum (TVU) |
|---|---|---|---|
| 0.5 | 0.013 | 1 | 0.500 |
| | | 5 | 0.504 |
| | | 10 | 0.517 |
| | | 15 | 0.537 |
| | | 20 | 0.564 |
| | | 25 | 0.596 |

The TPU was evaluated to ensure that the values are within the specifications above. In accordance with section 5.1.2 of the HSSD (2013), all depths reported in the deliverables are accompanied by the estimate of TPU.

### B.1.3. Multibeam Processing

Upon commencement data acquisition for a Sheet, a CARIS project was created for the Sheet and multibeam lines converted by the processor on shift. All lines converted were assigned a project, vessel, and day. Preliminary tidal data from the 8764227 (LAWMA, LA) water level station was downloaded from the CO-OPS website: http://opendap.co-ops.nos.noaa.gov/axis//text.html or the NOAA Tides and Currents website and applied to all data in CARIS using the tidal zoning file supplied by CO-OPS (Refer to Section C.6 for detailed tide correction information). The lines were merged, TPU was computed and a BASE surface created.

Multibeam data were reviewed using the CARIS HIPS swath editor with the BASE surface and pertinent background data open. Background data included the chart(s) and the line files, as well as the PRF and CSF provided by NOAA. For areas where both multibeam and side scan sonar data were collected, the preferred multibeam review method involves the ability to simultaneously review the side scan sonar data. When this was not possible, potential contacts were noted in multibeam processing log for future review with the side scan sonar data. In swath editor, erroneous and noisy data was rejected from the project.

In addition, if applicable, a contact S-57 file (Refer to section B.2.4 for additional information) was evaluated in the CARIS map window with BASE surfaces of the mainscheme lines and completed investigations to ensure complete coverage over significant targets. Object Detection Coverage (investigation data) was obtained over all potentially significant features. All contact investigation data were incorporated into BASE surfaces and then cleaned in swath editor and subset editor. The BASE surfaces were created as uncertainty surfaces with a single resolution of 0.5 m to ensure that a 1 x 1 x 1 m object would appear in the grid. The investigation data were reviewed with respect to mainscheme multibeam lines, charted data and, if available, side scan sonar contact information. If necessary, a designated sounding was assigned to the least depth sounding of an identified contact and the contact submitted in a Danger to Navigation Report.

Once all multibeam data had been cleaned and incorporated into a BASE surface, the surface underwent additional quality control. The standard deviation layer of the BASE surfaces was evaluated and areas of high standard deviation were investigated by all means appropriate, including subset editor, swath editor, comparison to charts, side scan sonar and backscatter data and side scan sonar contacts imported from SonarWiz. If data were found to misrepresent the seafloor, it was rejected. In addition, the BASE surface was evaluated using the CARIS 3D window with increased vertical exaggeration that can highlight outliers as well as potential contacts.

BASE surfaces were named as <Survey registry number>_<Sounding Type>_units of resolution_<Vertical Datum>, as specified in section 8.4.2 of the HSSD (2013). All BASE surfaces were created as uncertainty surfaces based upon IHO Order 1a standards. BASE surface resolution varied depending on depth and acquisition method, and is detailed in each descriptive report.

Crossline comparisons were generated on a regular basis as a quality control tool, which is explained further in the following section.

#### B.1.3.1. Crossline Comparisons

Crosslines were run perpendicular to mainscheme survey lines and comprised at least 8% of mainscheme line mileage for set line spacing coverage, in accordance with Section 5.2.4.3 of the HSSD (2013). Crossline comparisons were performed as a quality control tool to identify systematic errors and blunders in the survey data.

##### B.1.3.1.1 Hydromap Statistical Comparisons

Hydromap contains a tool that compares data from a main line with data from crosslines. The comparison calculates the mean difference and noise level as a function of cross-track position. The measurements are used for quantitative quality assurance of system accuracy and ray-bending analysis. In general, crosslines are used to produce reference data. The reference data is considered to be an accurate representation of the bottom. Since the data is taken from an orthogonal direction, the errors should at least be independent.

The crosslines are processed to produce the best possible data. Sound velocity profiles are taken to minimize any possible ray bending, and the multibeam swath angle is filtered to five degrees, which ensures that there are no measurable ray bending or roll errors. The data is binned and thinned using a median filter. The crossline swath data is then merged into a single file, and edited to ensure that there are no remaining outliers.

The line to be evaluated is processed to produce a trace file. Trace files are binned soundings that have not been thinned. The files contain x, y, and z data, as well as information on ping and beam numbers that is used for analysis. Processing parameters are set to use all beams with no filtering, and tidal affects are removed using predicted tides generated from Micronautics world tide software.

The effects of ray-bending can be measured by observing the values of the mean difference curve. Ray-bending produces a mean difference which curves upward or downward at the outer edges of the swath in a symmetric pattern around nadir. The value of the difference at a given across-track distance indicates the amount of vertical error being introduced by incorrect ray-bending corrections.

The accumulated statistics of all main line soundings compared to all crosslines is processed to produce four across-track profiles. The profiles represent the mean difference, standard deviation, root-mean-square difference, and percentile confidence interval. Select data is provided in graphical form in a separate pdf document for the main lines. These pdf's are found in Separates II of the reports.

B.1.3.1.2 CARIS Comparisons

Crossline comparisons were performed in CARIS HIPS 8.1 using the surface difference tool. Separate BASE surfaces were generated for the mainscheme lines and crosslines and a difference surface between the mainscheme and crossline BASE 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 outline in Section 5.2.4.3 of the HSSD (2013); refer to section B.1.2.3 for sample TVU values for certain depths. 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.

Crossline comparisons were also generated using the CARIS QC report utility. Each crossline was compared to the depth layer of the BASE surface of the mainscheme lines (the reference surface). The crossline sounding data were grouped by beam number. Survey statistic outputs include the total soundings in the range, the maximum distance of soundings above the reference surface, the maximum distance of soundings below the reference surface, the mean of the differences between the crossline soundings and the surface, the standard deviation of the mean differences, and the percentage of soundings that fall within the depth standards for a selected IHO Order. Although statistics were generated for all IHO Orders (Special Order, Order 1a, Order 1b and Order2), the percentage of crossline soundings that are within Order 1a specification is of primary interest for this project. The quality control statistics were evaluated for extreme values and are shown in Separates II: Digital Data.

The crossline and mainline BASE surfaces have been retained and submitted in the Fieldsheet directory.

### B.1.3.2. Reporting and Products and Finalization

Junction analysis was performed between adjoining contemporary and historical surveys using the CARIS differencing tool. Difference surfaces were generated with the survey of interest as Surface 1 and the adjoining survey as Surface 2.

Chart comparisons were performed in CARIS HIPS using cleaned BASE surfaces of mainscheme and investigation lines, colored depth ranges, and sounding layers. The data were compared to the largest scale charts in this area, summarized in Table No. 25 and 26. Data was compared to the most recent nautical charts, and updates to the below charts are specified in each Descriptive Report.

**Table 25. Raster Nautical Charts**

| Chart Number | Scale | Edition Number | Edition Date | LNM Date | NM Date |
|---|---|---|---|---|---|
| 11356 | 80000 | 39 | 06/2012 | 05/22/2012 | 06/02/2012 |
| 11351 | 80000 | 43 | 03/2012 | 03/06/2012 | 03/17/2012 |
| 11340 | 80000 | 76 | 08/2012 | 05/01/2012 | 05/05/2012 |

**Table 26. Electronic Nautical Charts**

| ENC Name | Scale | Edition | Update Application Date | Issue Date | Preliminary |
|---|---|---|---|---|---|
| US4LA25M | 80000 | 16 | 08/24/2012 | 03/25/2013 | NO |
| US4LA21M | 80000 | 25 | 11/18/2011 | 03/22/2013 | NO |
| US3GC03M | 458596 | 43 | 11/01/2012 | 11/01/2012 | NO |

The sounding layer to which charted soundings were compared was generated from the BASE surface created for each Sheet. The shoal biased radius option was always selected and the radius was selected as distance on the ground (in m). 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 Descriptive Report.

After all data had been cleaned, and all least depths on significant contacts had been designated, the BASE surfaces were finalized for submission. The final BASE 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 BASE surface (Figure 2). Any depth threshold applied is detailed in the Descriptive Reports.

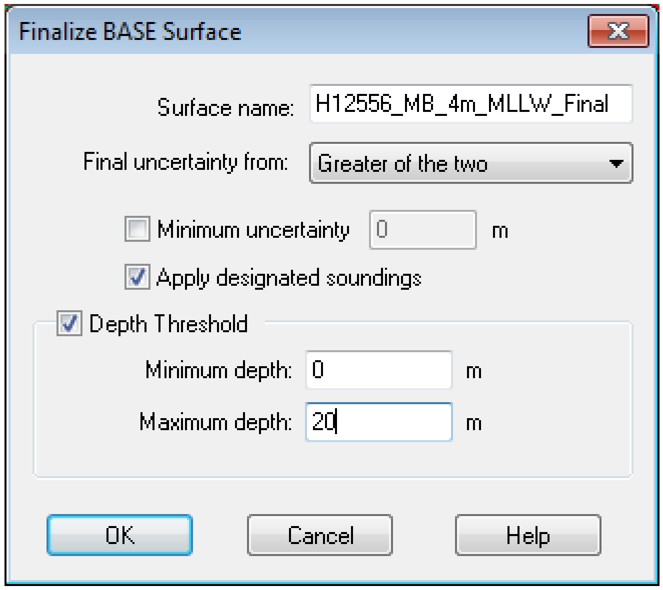


**Figure 2. Sample BASE surface finalization parameters.**

## B.2. SIDE SCAN SONAR

### B.2.1. Image Processing

Side scan sonar data were processed using Chesapeake Technologies' SonarWiz5. The water column was auto tracked in the field and the data slant range corrected after the data was imported into SonarWiz5. The bottom track was also reviewed during post-processing. The side scan sonar files were subsequently layback corrected and gains applied when necessary. The side scan sonar data were evaluated and contacts identified, always selected from slant-range corrected data. Bottom tracked and layback corrected files were exported from SonarWiz for the final deliverables.

### B.2.2. Data Review and Proof of Coverage

The side scan operator reviewed all data during data acquisition and noted in the survey logs any significant features or surface/water column effects. All side scan data were also reviewed at least twice during post processing. Any lines or portions of lines that did not meet quality standards due to noise, thermals, etc. were re-run. During review, a coverage map was produced. 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.

A mosaic for each 100% side scan sonar coverage of the Sheet was created and submitted for the requirement of the final deliverables. The coverage mosaics were generated from lines that were run east to west and those that were run west to east; the direction was generally differentiated by an even/odd numbering system These mosaics served as an additional quality control tool and were not only used for coverage but were used to correlate contacts seen on adjacent lines. The mosaics can be found in the Data\Processed\Fieldsheets directory.

### B.2.3. Contact Selection

Sonar contacts were identified and recorded as each line was reviewed. All contacts with shadows were recorded when possible. In areas where a high density of contacts exists in close proximity, the hydrographer retained the ability to select the area as a region, ensuring that the contact with the greatest height off bottom was selected and/or the least depth examined in the bathymetry. All existing infrastructure, such as pipelines, wells, platforms, and buoys was also documented.

In addition to measuring the dimensions of each contact in SonarWiz, contacts were assigned two attributes to aid in the processing workflow. The first attribute is related to the nature of the contact and one of several descriptors was chosen for each contact. These included, but may not be limited to: insignificant contact (INSCON), significant contact (SIGCON), linear contact not clearly a pipeline (LINEAR), offshore platform (OFSPLF), submerged pipeline (PIPSOL), jetty or groin (JETTY), submerged cable (CBLSUB), fish contact (FSHGRD), seabed area (SBAREA), unknown contacts (UNKCON) and buoys (BUOY). Most of these descriptors fulfill the requirement of updating the NINFOM for the customized attributes for the side scan sonar list as outlined in 8.2 of the HSSD (2013). However, the hydrographer may elect to retain LINEAR, INSCON and SIGCON if unsure of the exact nature of the feature. The second attribute is related to the significance of the contact and might include descriptors such as INSCON, SIGCON, OBSTRN and DTON.

All contacts that displayed a height of 1 meter or greater, calculated from the shadow length in SonarWiz, were considered significant within water depths of 20 meters or less, in accordance with Section 6.1.3.2 of the HSSD (2013). These contacts were always given the attribute ‘SIGCON’ during processing. Other contacts may have been deemed significant based on their characteristics (dimensions, strength of return, location etc.).

Large schools of fish were identified by shape, detached shadows and observations recorded in the acquisition logs. These contacts were noted as FSHGRD; however, fish were not generally picked as contacts. The second 100% SSS was evaluated to confirm the fish contact and to make sure no other contacts were obscured. The label seabed area (SBAREA) was used to include seabed change and features such drag scars. The unknown (UNKCON) label was used only if no shadow could be measured and no other descriptor could be used to identify the feature. The majority of the UNKCON contacts are picked generally because of possible correlation to either a significant or insignificant feature found on an adjacent line based on factors such as proximity, shape and size.

### B.2.4. Contact Correlation

Once all contacts were recorded and assigned the aforementioned attributes and dimensions, the contacts were exported from SonarWiz as a Comma Delimited File (csv). Contacts were brought into Notebook 3.1 using the Object Import Utility as points under the LNDMRK class with several attributes assigned. The contacts were exported as an S-57 file and opened in CARIS.

The S-57 file of contacts was evaluated in the CARIS map window with BASE surfaces of the mainscheme 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, if necessary.

After the multibeam BASE 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 CARIS HIPS map window with respect to BASE surfaces and charted features. The attributes of each contact were examined in the CARIS selection window 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 of the HSSD (2013).

### B.3. DATA DIRECTORY STRUCTURE

During data processing separate directories were created for CARIS projects, CARIS Notebook files, SonarWiz projects and Report Deliverables. Upon submission, these were combined into a directory structure that was generated to closely match the structure specified in Appendix 12 of the 2013 HSSD (Figure 3).

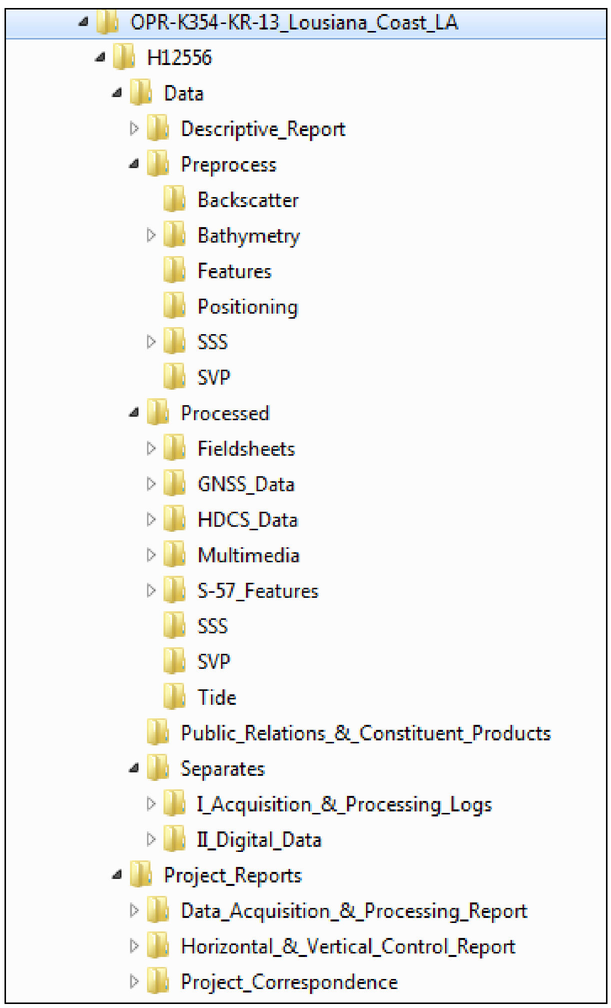


**Figure 3. Overview of data directory structure.**

A <Field Sheets> folder and an <HDCS Data> folder were added to the directory structure to remain consistent with the CARIS processing directories. An additional SSS folder in the <Processed> directory was added and populated with fully corrected SSS files exported from SonarWiz. No folders were removed from the directory structure as listed in Appendix 12; if no data exists for that particular folder, a text file explanation is included.

# C. CORRECTIONS TO ECHOSOUNDINGS

## C.1. INSTRUMENT CORRECTIONS

In order to ensure that the multibeam system was functioning properly, the single beam was monitored in real-time as an independent check of the nadir beam of the multibeam sonar system.

## C.2. VESSEL OFFSET MEASUREMENTS AND CONFIGURATION

### C.2.1. VESSEL CONFIGURATION PARAMETERS AND OFFSETS

#### C.2.1.1. R/V *Sea Scout*

During construction of the R/V *Sea Scout* (Figure 4) a full survey was conducted in dry dock using a Leica TPS 1200+ total station to measure offsets from the Central Reference Point (CRP) to all survey equipment on the vessel. Figure 4 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 4. R/V *Sea Scout*.**

#### C.2.1.2. R/V *C-Wolf*

The offsets for the R/V *C-Wolf* were measured with a total station while the vessel was trailered. Figure 5 shows a picture of the R/V *C-Wolf* and a vessel diagram with all measured offsets from the central reference point is shown in Appendix 1: Vessel Reports – Vessel Offset Reports.

**Figure 5. R/V *C-Wolf***

### C.2.2. Layback

Layback could be applied to side scan XTF files during acquisition using SonarWiz5, during post-processing using SonarWiz 5, or during post-processing using C & C Technologies' Hydromap software. Refer to Appendix I: Vessel Reports – Vessel Layback Report for additional information.

## C.3. STATIC AND DYNAMIC DRAFT

### C.3.1. R/V *Sea Scout*

Static draft measurements were read at least once daily during survey operations. The R/V *Sea Scout* is equipped with two draft tubes on the port and starboard sides, near the MB rams. Each draft tube is marked 1.2 meters up from the hull. The distance from CRP to the 1.2 m mark is 5.14 m and 5.27 m on the port and starboard sides, respectively. Therefore, an addition of 1.2 m to each of these values (6.34 m and 6.47 m for port and starboard, respectively) provides the distance from CRP to the base of the draft tubes (the hull). The draft values observed from the draft tubes are subtracted from the 6.34 m and 6.47 m values to provide a waterline to CRP measurement for the port and starboard sides. These two values were averaged and input into the SIS software system as the waterline to CRP value; if only one head is in use, the one relevant draft measurement is used.

In order to correct for the dynamic draft of the vessel, a squat and settlement test was performed in Calcasieu Pass, LA on March 25, 2014. Refer to Appendix I: Vessel Reports – Dynamic Draft Report for additional information.

### C.3.2. R/V *C-Wolf*

Static draft aboard the RV *C-Wolf* is measured using a rod that is placed through the top of the multibeam ram to the top of the mounting plate, which is then measured from the mounting plate end to the water mark on the rod. This value is put into the draft formula to obtain the draft.

In order to correct for the dynamic draft of the R/V *C-Wolf*, a squat and settlement test was performed in at Cypremort Point, LA on August 6, 2013. Refer to Appendix I: Vessel Reports – Dynamic Draft Report for additional information.

## C.4. POSITIONING AND ATTITUDE SYSTEMS

### C.4.1. R/V *Sea Scout*

The R/V *Sea Scout* is equipped with three (3) GPS systems: two (2) C-Nav 3050 receivers and one (1) CodaOctopus F180 attitude and positioning system. All three GPS systems feed their position strings via serial interface to a serial splitter box. The position strings are then sent to multiple systems for logging and use. The F180 GPS is used for the serial and 1PPS strings that are used to sync all systems on the network. The R/V *C-Wolf* has a similar set up except that the vessel is equipped with C-Nav 2050 receivers.

The C-Nav 3050 receivers use the C-Nav Subscription Services, which can achieve 5 cm horizontal accuracy and 10 cm vertical accuracy. The C-Nav 2050 receivers also use the C-Nav Subscription Services and can achieve decimeter accuracy. These systems are controlled and monitored with a C-Navigator system.

One (1) of the C-Nav receivers provides a DGPS correction via serial connection to the F180 system. The F180 is controlled and monitored using PC software via a network connection to the system. The F180 attitude and positioning system is integrated with the multibeam echo sounder to provide real-time heave, pitch, and roll corrections; heading is also obtained from the F180. The antenna baseline for the F180 is 2.160 m on the R/V *Sea Scout* and 1.485 m on the R/V *C-Wolf*. Manufacturer accuracies are shown in Table 25.

**Table 27. Manufacturer accuracies for the CodaOctopus F180 attitude and positioning system with an antenna baseline distance of 2 m.**

| Heading | Roll | Pitch | Heave |
|---|---|---|---|
| 0.05º | 0.025º | 0.025º | The greater of 5% of heave amplitude or 5 cm |

## C.5. EQUIPMENT OFFSETS

Equipment offsets from the CRP were entered directly into the Simrad SIS software. The Primary C-Nav GPS offsets were entered into POS, COM1 and the Secondary C-Nav offsets were entered into POS, COM3. The multibeam transducer offsets were entered in Sonar Head 1 and Sonar Head 2, if applicable. The F180 offsets were entered in POS, COM4, Attitude 1, COM2 and Attitude 2, COM 3.

## C.6. MULTIBEAM CALIBRATION

### C.6.1. R/V *Sea Scout*

Prior to commencement of survey operations, a standard patch test was performed on November 28, 2013 to determine corrections for pitch, roll, and heading. C & C Technologies' proprietary software Hydromap was used in the field to determine results from the patch test (Table 29). Due to concerns over the starboard transducer heading value, the port head only was used during survey operations. During the course of survey operations, two (2) additional patch tests were conducted. Refer to the patch test reports for additional information. The angular offsets from the patch tests were entered directly into the Simrad SIS software under Sensor Setup → Angular Offsets for correction of data in real-time.

**Table 28. Patch Test Results (R/V *Sea Scout* –September 19, 2013)**

| | Roll | Pitch | Heading |
|---|---|---|---|
| Port Transducer | 0.39° | 0.00° | 0.00° |
| Starboard Transducer | -0.381° | -0.89° | -12.225° |

### C.6.2. R/V *C-Wolf*

Prior to commencement of survey operations, a standard patch test was performed on August 8, 2013 near Cypremort Point, LA.  C & C Technologies' proprietary software Hydromap was used in the field to determine results from the patch test. The angular offsets from the patch tests were entered directly into the Simrad SIS software under Sensor Setup → Angular Offsets for correction of data in real-time.

**Table 29. Patch Test Results (R/V *C-Wolf* – August 8, 2013)**

| | Roll | Pitch | Heading |
|---|---|---|---|
| Multibeam Transducer | -0.818° | -2.14° | 0.00 |

## C.7. SOUND SPEED CORRECTIONS

Seabird Electronics SBE19 and SBE19 Plus CTDs were used to collect sound speed data through the water column. Simultaneous sound speed profiles were acquired aboard the R/V *Sea Scout* (Figure 16) and reviewed together as a quality control check; only one cast was typically conducted aboard the R/V *C-Wolf*.  The profile would be entered into the SIS control software and the multibeam data corrected for the water column sound speed in real-time. Prior to importation into SIS, the chosen sound speed cast was extended by at least 50 feet beyond the deepest reading of the CTD. The intent of the extended data is strictly to avoid error messages associated with bad multibeam pings that were deeper than the sound speed cast. Extending the profile was accomplished by averaging the last ten to twenty data points in the profile. The onboard processor of the cast determined how many points to average in order to create an extension that accurately reflected the downward trend of the data.  If water depths began to exceed the depth of the cast, another sound speed cast was taken. The mean water column sound speed generated from the chosen sound speed profile was applied to the single beam echo sounder data.


**Figure 6. 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 by the Endeco YSI 600R sondes was monitored in the SIS software. A difference of more than 2 m/s required a new cast to be taken.

The digital sound speed data and confidence checks can be found in: \Separates \II_Digital_Data\Sound_Speed_Data_Summary. In addition, a summary (.csv file) of the sound speed data acquired can be found in the Sound_Speed_List folder. This file was imported into Notebook 3.1 and exported as an S-57 file to be easily brought into CARIS. The .hob and .000 files along with a ReadMe.txt file of the attribute mapping used are also located in the Sound_Speed_List folder.

### C.8. TIDES AND WATER LEVEL CORRECTIONS

The operating National Water Level Observation Network (NWLON) station 8764227 (LAWMA, LA) provided water level reducers for this project.

During survey operations, preliminary 6-minute tidal data from 8764227 water level station were downloaded from the NOAA Tides and Currents website and incorporated into a .tid (ASCII) file consisting of date, time and tide values. These tide values were applied to all multibeam data in CARIS using the tidal zoning definition file supplied by NOAA/CO-OPS; Table 30 shows the tide zones and correctors.

**Table 30. LAWMA, LA (8764227) Tide Zones and Correctors.**

| Tide Zone | Reference Station | Time Corrector | Range Ratio |
|---|---|---|---|
| WGM265 | 8764227 | -18 | x0.96 |
| WGM264 | 8764227 | -24 | x0.96 |
| WGM278 | 8764227 | -30 | x1.06 |
| WGM263 | 8764227 | -30 | x0.96 |
| WGM279 | 8764227 | -36 | x1.06 |
| WGM289 | 8764227 | -36 | x0.99 |
| WGM280 | 8764227 | -42 | x1.09 |
| WGM281 | 8764227 | -54 | x1.09 |

Tidal zoning correctors were applied to verified data from the 8764227 (LAWMA, LA) water level station for final processing, as outlined in section 1.5 of the Tides and Water Levels Statement of Work. The verified tidal data was downloaded from the NOAA Tides and Currents website.

## D. LETTER OF APPROVAL

Data Acquisition and Processing Report

OPR-K354-KR-13

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.

Tara Levy
Chief of Party
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October 2014

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October 2014