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

# Data Acquisition & Processing Report

| | |
|---|---|
| Type of Survey: | Navigable Area |
| Project Number: | OPR-K354-KR-19 |
| Time Frame: | September - March 2020 |

## LOCALITY

| | |
|---|---|
| State(s): | Louisiana |
| General Locality: | Gulf of Mexico |

## 2020

CHIEF OF PARTY
John R. Bean

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# Data Acquisition and Processing Report

**Ocean Surveys, Inc.**
Chief of Party: John R. Bean
Year: 2020
Version: 1.0
Publish Date: 2020-04-16

# A. System Equipment and Software

## A.1 Survey Vessels

### A.1.1 R/V Ocean Explorer

| | |
|---|---|
| *Vessel Name* | R/V Ocean Explorer |
| *Hull Number* | Official No. 905425 |
| *Description* | R/V Ocean Explorer is an 18-meter aluminum vessel powered by two 1,000 HP Iveco diesel engines. The R/V Ocean Explorer was modified by Ocean Surveys, Inc. (OSI) for hydrographic survey operations as follows:<br><br>-Survey system control modules (processors) and computer systems were installed at purpose-built work stations in the main cabin of the vessel.<br>-A measured and indexed Inertial Measurement Unit (IMU) mounting plate was installed on the vessel's fore-aft (roll) centerline at the approximate pitch center of rotation.<br>-A retractable multibeam transducer pole, constructed of thick-wall aluminum pipe, was attached to the starboard side of the vessel at the approximate pitch centerline. The pole was attached at two points: a substantial, positive locking swivel near the deck of the vessel and a "receiver plate" at the chine of the vessel. To prevent pole movement, the transducer pole was forced into the V-notch receiver plate with non-stretch line and a hand-crank winch. The transducer pole was fitted with fairings on the trailing edge to minimize cavitation.<br>-To support towed side scan sonar (SSS) operations, a custom-built, hydraulically-actuated A-frame was installed on the stern of the vessel.<br>-A moving vessel profiler (MVP) was installed on the port quarter of the vessel.<br><br>The R/V Ocean Explorer conducted 24 hour operations primarily offshore of Freshwater Bayou Lock. |

| | | |
|---|---|---|
| *Dimensions* | *LOA* | 18m |
| | *Beam* | 5.1m |
| | *Max Draft* | 2m |
| *Most Recent Full Static Survey* | *Date* | 2015-05-06 |
| | *Performed By* | A full survey of the R/V Ocean Explorer was conducted on May 6, 2015 by OSI. The survey established permanent shipboard benchmarks within the fixed vessel reference frame to include: vessel reference point (RP), draft measurement locations and sensor mounting locations. The points were surveyed using a precision total station while the vessel was hauled and blocked on land. |
| *Most Recent Partial Offset Verification* | *Date* | 2019-05-13 |
| | *Method* | Relevant offsets established by the 2015 total-station survey were confirmed during the 2019 vessel mobilization with a steel tape measure. |

*Figure 1: R/V Ocean Explorer configured for hydrographic survey operations.*

### A.1.2 R/V H.F. Stout

<table>
<tr><td>Vessel Name</td><td colspan="2">R/V H.F. Stout</td></tr>
<tr><td>Hull Number</td><td colspan="2">Registration No. CT 5054 BJ</td></tr>
<tr><td>Description</td><td colspan="2">R/V H.F. Stout is a 30 ft aluminum landing craft built by Life Tyme Boats and powered by twin 150HP Yamaha outboard engines. The R/V H.F. Stout was modified by OSI for hydrographic survey operations as follows:<br><br>-A measured and indexed Inertial Measurement Unit (IMU) mounting plate was installed near the vessel’s fore-aft (roll) centerline at the approximate pitch center of rotation.<br>-A retractable multibeam transducer pole, constructed of stainless steel pipe, was attached to the port side of the vessel at the approximate pitch centerline. The pole was attached at two points: a dual pillow-block swivel assembly on the gunwale and a “receiver plate” at the chine.<br>-To support fixed-mount SSS operations, a custom mount was added to the transducer pole to receive the SSS transducers.<br>-Reinforced davit to support towed SSS operations.<br><br>The R/V H.F. Stout conducted daily operations primarily offshore of Freshwater Bayou Lock.</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>9.1m</td></tr>
<tr><td>Beam</td><td>3m</td></tr>
<tr><td>Max Draft</td><td>0.76m</td></tr>
<tr><td rowspan="2">Most Recent Full Static Survey</td><td>Date</td><td>2019-03-29</td></tr>
<tr><td>Performed By</td><td>A full survey of the R/V H. F. Stout was conducted on March 29, 2019 by OSI. The survey established permanent onboard benchmarks within the fixed vessel reference frame to include: vessel reference point (RP), draft measurement locations and sensor mounting locations. The points were surveyed using a precision total station while the vessel was hauled out on land.</td></tr>
<tr><td rowspan="2">Most Recent Partial Offset Verification</td><td>Date</td><td>2019-04-28</td></tr>
<tr><td>Method</td><td>Relevant offsets established by the 2019 total-station survey were confirmed during the 2019 vessel mobilization with a steel tape measure.</td></tr>
</table>

*Figure 2: R/V H.F. Stout configured for hydrographic survey operations.*

## A.2 Echo Sounding Equipment

### A.2.1 Multibeam Echosounders

#### A.2.1.1 Teledyne-Reson SeaBat 7125 SV2

Both vessels used Teledyne Reson SeaBat 7125 SV2 multibeam echosounders. The SeaBat 7125 SV2 is a shallow-water dual-frequency Multibeam Echosounder (MBES) System with operational frequencies of 200 kHz or 400 kHz. The system is roll-stabilized and has multiple options for beam spacing (equidistant or equiangle), swath angle, and range. The manufacturer's stated depth resolution is 6mm. For this project, both boats operated at 400 kHz and at a maximum swath angle of 140 deg. Both vessels used the 512-equidistant beam configuration exclusively.

<table>
<tr><td>Manufacturer</td><td colspan="5">Teledyne-Reson</td></tr>
<tr><td>Model</td><td colspan="5">SeaBat 7125 SV2</td></tr>
<tr><td rowspan="12">Inventory</td><td rowspan="6">R/V Ocean Explorer</td><td>Component</td><td>Processor</td><td>Receiver</td><td>Projector</td></tr>
<tr><td>Model Number</td><td>7125 SV2</td><td>7125 SV2</td><td>7125 SV2</td></tr>
<tr><td>Serial Number</td><td>18342213063</td><td>213063</td><td>4712049</td></tr>
<tr><td>Frequency</td><td>400 kHz</td><td>400 kHz</td><td>400 kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2019-09-05</td><td>2019-09-05</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>2019-09-05</td><td>2019-09-05</td></tr>
<tr><td rowspan="6">R/V H.F. Stout</td><td>Component</td><td>Processor</td><td>Receiver</td><td>Projector</td></tr>
<tr><td>Model Number</td><td>7125 SV2</td><td>7125 SV2</td><td>7125 SV2</td></tr>
<tr><td>Serial Number</td><td>18341315183</td><td>2614057</td><td>1214102</td></tr>
<tr><td>Frequency</td><td>400 kHz</td><td>400 kHz</td><td>400 kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2019-09-05</td><td>2019-09-05</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>2019-09-05</td><td>2019-09-05</td></tr>
</table>

*Figure 3: Seabat 7125 SV2 transducer mounted on the R.V. Ocean Explorer transducer pole.*

*Figure 4: Seabat 7125 SV2 transducer mounted on the R.V. H.F. Stout transducer pole.*

**A.2.2 Single Beam Echosounders**

No single beam echosounders were utilized for data acquisition.

**A.2.3 Side Scan Sonars**

**A.2.3.1 Edgetech 4200-MP dual-frequency 300/600 with winch**

The towed SSS system used on the R/V Ocean Explorer was an EdgeTech 4200-MP dual-frequency sonar capable of operating at 300 kHz and/or 600 kHz. For this survey, the system was operated in high-frequency mode employing the "high speed" mode exclusively. Of the available range scales, only the 75 range was used. The system consists of a Topside Processor Unit (TPU), coaxial double-armored steel tow cable, electric powered slip ring winch, digital cable payout meter, and sonar towfish. The towfish was equipped with a pressure sensor which was used to measure towfish depth. System components were interfaced to the acquisition computer with ethernet (to a dedicated network card) and DB 9 serial connection.

| | | | | | |
|---|---|---|---|---|---|
| *Manufacturer* | Edgetech | | | | |
| *Model* | 4200-MP dual-frequency 300/600 with winch | | | | |
| *Inventory* | *R/V Ocean Explorer* | *Component* | Topside | Towfish | AGO Electric Winch |
| | | *Model Number* | 4200 | 4200 | CSW-7 |
| | | *Serial Number* | 48629 | 48742 | 1111061 |
| | | *Frequency* | 600 kHz | 600 kHz | N/A |
| | | *Calibration* | 2019-04-17 | 2019-04-17 | N/A |
| | | *Accuracy Check* | 2019-04-17 | 2019-04-17 | N/A |

*Figure 5: Edgetech 4200 MP SSS towfish aboard the R/V Ocean Explorer*


*Figure 6: Electric SSS winch and cable-counting sheave aboard the R/V Ocean Explorer*

**A.2.3.2 Edgetech 4125 dual-frequency 400/900 (fixed-mounted)**

The fixed-mount SSS used on the R/V H.F. Stout was an EdgeTech 4125 dual-frequency CHIRP system. The 4125 SSS consists of a portable Topside Processing Unit (TPU) and sonar towfish. The towfish and TPU were connected by a kevlar reinforced coaxial cable. The towfish was equipped with standard sensors for pitch, roll, heading, and depth (pressure). However, given that the system was fixed-mounted, none of the data from these sensors were used during data processing. The TPU was connected to the SSS acquisition computer through Ethernet to a dedicated network card. The fixed-mount SSS was operated at the 50m range scale. The 400 kHz frequency was not used because it interfered with the MBES.

<table>
<tr><td>Manufacturer</td><td colspan="4">Edgetech</td></tr>
<tr><td>Model</td><td colspan="4">4125 dual-frequency 400/900 (fixed-mounted)</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">R/V H.F. Stout</td><td>Component</td><td>Topside</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>4125</td><td>4125</td></tr>
<tr><td>Serial Number</td><td>50472</td><td>54084</td></tr>
<tr><td>Frequency</td><td>900 kHz</td><td>900 kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td></tr>
</table>

*Figure 7: Edgetech 4125 SSS towfish mounted on the transducer pole of the R/V H.F. Stout*

### A.2.3.3 Edgetech 4200-MP dual-frequency 300/600 with tow cable

The towed SSS system used on the R/V H.F. Stout was an EdgeTech 4200-MP dual-frequency sonar capable of operating at 300 kHz and/or 600 kHz. For this survey, the system was operated in high-frequency mode employing the “high speed” mode exclusively. Of the available range scales, only the 75 range was used. The towfish and TPU were connected by a kevlar-reinforced coaxial tow cable. A reinforced davit on the starboard side of the vessel served as the tow point and the tow cable was adjusted to achieve desired fish altitude. The cable-out value was noted and entered into the data acquisition program (HYPACK).

<table>
<tr><td>Manufacturer</td><td colspan="4">Edgetech</td></tr>
<tr><td>Model</td><td colspan="4">4200-MP dual-frequency 300/600 with tow cable</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">R/V H.F. Stout</td><td>Component</td><td>Topside</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>4200</td><td>4200</td></tr>
<tr><td>Serial Number</td><td>48825</td><td>48869</td></tr>
<tr><td>Frequency</td><td>600 kHz</td><td>600 kHz</td></tr>
<tr><td>Calibration</td><td>2020-02-27</td><td>2020-02-27</td></tr>
<tr><td>Accuracy Check</td><td>2020-02-27</td><td>2020-02-27</td></tr>
</table>


*Figure 8: Edgetech 4200 SSS Towpoint on R/V H.F. Stout*

### A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

### A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

## A.3 Manual Sounding Equipment

### A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

### A.3.2 Lead Lines

Each vessel was equipped with a lead line for spot-soundings and echosounder verification checks (bar checks). Lead lines were constructed by OSI using a 9 kilogram metal disk with a diameter of 0.3m. The metal disk was attached to a stainless steel cable with permanent index markers established at 1m intervals. The lead lines were calibrated prior to survey operations using a steel tape measure to verify index mark accuracy (see DAPR Appendix V for results).

<table>
<tr><td>Manufacturer</td><td colspan="3">OSI</td></tr>
<tr><td>Model</td><td colspan="3">Lead Line/Bar Check</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">R/V Ocean Explorer</td><td>Component</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>NOAA-1</td></tr>
<tr><td>Calibration</td><td>2019-04-01</td></tr>
<tr><td rowspan="4">R/V HF Stout</td><td>Component</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>2018-75-1</td></tr>
<tr><td>Calibration</td><td>2019-04-17</td></tr>
</table>

*Figure 9: OSI-built lead line*

#### A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

#### A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

## A.4 Horizontal and Vertical Control Equipment

### A.4.1 Base Station Equipment

#### A.4.1.1 Trimble NetR9

OSI supplemented the local CORS network with a temporary GNSS station at the U.S. Army Corps of Engineers Freshwater Bayou Lock. A Trimble NetR9 GNSS receiver with a Zephyr 3 Geodetic Antenna was configured to record GNSS observables continuously throughout the survey and parse data observables into daily files for each 24-hour period. The configuration of the receiver was based on UNAVCO standard settings for this device.

GNSS observables were recorded on removable media as well as on the receiver's internal storage. Data were delivered to OSI's home-office processing center by regular automated FTP and e-mail "pushes" over a network connection that was established on site for this purpose. The Trimble NetR9 data was included in IAPPK processing and designated as Ocean Surveys Freshwater Lock or "OSFL." The coordinates of OSFL were determined using OPUS. A discussion of OPUS data processing and the determination of final coordinates is included in the HVCR.

<table>
<tr><td>Manufacturer</td><td colspan="3">Trimble</td></tr>
<tr><td>Model</td><td colspan="3">NetR9</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>Topside</td><td>Zephyr 3 Geodetic GNSS Antenna</td></tr>
<tr><td>Model Number</td><td>NetR9</td><td>115000-00</td></tr>
<tr><td>Serial Number</td><td>5811R52419</td><td>6122223813</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
</table>

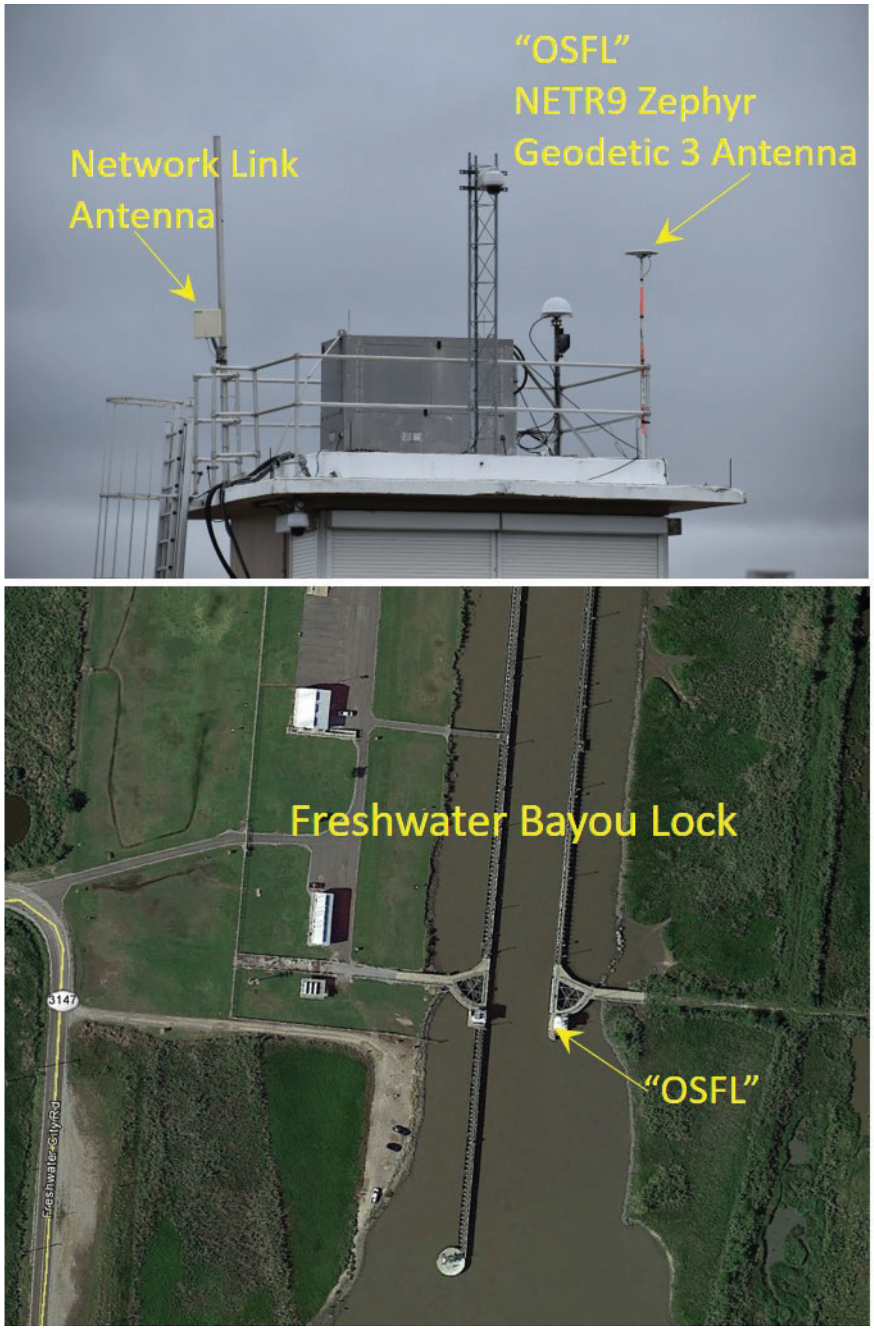



*Figure 10: GNSS Base Station "OSFL"*

### A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

### A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

#### A.4.4 Levels

No levels were utilized for data acquisition.

### A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

## A.5 Positioning and Attitude Equipment

### A.5.1 Positioning and Attitude Systems

#### A.5.1.1 Applanix POS MV 320 V5

The POS MV is a GNSS inertial navigation and attitude system made up of 2 GNSS antennas and an inertial measurement unit (IMU) interfaced with a topside processor. The POS MV combines the IMU and GNSS sensor data into an integrated and blended navigation solution. Per manufacturer's literature there are two navigation algorithms incorporated into the system, both a tightly coupled and a loosely coupled inertial/GNSS integration. Tightly coupled inertial/GNSS integration involves the processing of GNSS pseudo range, phase and doppler observables. In this case, the GNSS receiver is strictly a sensor of the GNSS observables and the navigation functions in the GNSS receiver are not used. With loosely coupled inertial/GNSS integration, the GNSS position and velocity solution are processed to aid the inertial navigator.

The POS MV generates attitude data in three axes (roll, pitch, and heading). Roll and pitch measurements are made within an accuracy of 0.02°. Heave measurements supplied by the POS MV maintain an accuracy of 0.05m or 5% of the measured vertical displacement for movements that have a period of up to 20 seconds.

The GNSS Azimuth Measurement Subsystem (GAMS) allows the POS MV system to achieve high-accuracy heading measurement. The GAMS subsystem uses two GNSS receivers and antennas to determine a GNSS-enhanced heading that is accurate to 0.02° or better (using an antenna baseline greater than or equal to 2m) when blended with the inertial navigation solution. The system uses this heading information together with the position, velocity and raw observations supplied by the primary GNSS receiver. GAMS heading was employed for all survey data acquisition, and GAMS status was monitored continuously during survey operations using the MV POSView controller software.

On the R/V Ocean Explorer, the GNSS antennas were mounted port and starboard on the forward part of the wheelhouse roof. The IMU was installed below the waterline in the engine room, along the approximate pitch and roll center of the vessel, and the IMU "bullseye" was co-located with the vessel reference point. The POS MV was enabled with Fugro's Marine Star GNSS Correction service for real-time positioning.

| | | | | | | |
|---|---|---|---|---|---|---|
| *Manufacturer* | Applanix | | | | | |
| *Model* | POS MV 320 V5 | | | | | |
| *Inventory* | *R/V Ocean Explorer* | *Component* | Topside | IMU | GPS Antenna (Port) | GPS Antenna (Stbd.) |
| | | *Model Number* | MV-320 V5 | 200 | GA830 | GA830 |
| | | *Serial Number* | 6415 | 861 | 12189 | 9435 |
| | | *Calibration* | N/A | N/A | N/A | N/A |

### A.5.1.2 Applanix POS MV 320 V5 Ocean Master

On the R/V H.F. Stout, the POS MV IMU was installed above the waterline inside the cabin, offset to starboard from the vessel reference point. The 2 GNSS antennas were mounted port and starboard on the forward part of the cabin roof. For real-time postioning, the POS MV's intergrated DPGS Wide Area Augmentation System (WAAS) correctors were enabled.

| | | | | | | |
|---|---|---|---|---|---|---|
| *Manufacturer* | Applanix | | | | | |
| *Model* | POS MV 320 V5 Ocean Master | | | | | |
| *Inventory* | *R/V HF Stout* | *Component* | Topside | IMU | GPS Antenna | GPS Antenna |
| | | *Model Number* | MV-320 V5 | 64 | GA830 | GA830 |
| | | *Serial Number* | 10351 | 5018 | 12310 | 14060 |
| | | *Calibration* | N/A | N/A | N/A | N/A |

### A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

### A.5.3 GPS

### A.5.3.1 Trimble MS-750

Onboard the R/V Ocean Explorer, a secondary GPS was installed as an independent offshore position check on the POS MV and was used to trigger “position integrity alarms” within HYPACK as necessary. The secondary GPS was configured to receive Wide Area Augmentation System (WAAS) correctors.

<table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>MS-750</td></tr>
<tr><td>Inventory</td><td><table><tr><td>R/V Ocean Explorer</td><td><table>
<tr><td>Component</td><td>Receiver</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>MS-750</td><td>Micro-centered L1/L2</td></tr>
<tr><td>Serial Number</td><td>220330606</td><td>220067576</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
</table></td></tr></table></td></tr>
</table>

#### A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

## A.5.5 Other Positioning and Attitude Equipment

### A.5.5.1 Hydrographic Consultant, Ltd. SCC Smart Sensor Cable Payout Indicator

A Hydrographic Consultant, Ltd. SCC Smart Sensor Cable Payout Indicator was used to measure cable-out values for towed SSS positioning. The payout indicator consists of a topside display/controller, deck cable, and a 0.4m diameter block fitted with a magnetically triggered counting sensor. The cable-out indicator was calibrated according to manufacturer specifications before data acquisition by measuring the sheave circumference and entering a calibration value into the topside controller software. The accuracy of the system was checked repeatedly during towed SSS operations by comparing sensor display values to calibration marks on the tow cable. These checks were performed frequently during each survey day. The counter system was recalibrated as needed to account for minor cable slippage. Cable-out data were transmitted to HYPACK on the main acquisition computer by a DB9 serial data connection.

<table>
<tr><td>Manufacturer</td><td>Hydrographic Consultant, Ltd.</td></tr>
<tr><td>Model</td><td>SCC Smart Sensor Cable Payout Indicator</td></tr>
<tr><td>Inventory</td><td><table><tr><td>R/V Ocean Explorer</td><td><table>
<tr><td>Component</td><td>Cable Counter</td></tr>
<tr><td>Model Number</td><td>ver2</td></tr>
<tr><td>Serial Number</td><td>2027</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
</table></td></tr></table></td></tr>
</table>

# A.6 Sound Speed Equipment

## A.6.1 Moving Vessel Profilers

### A.6.1.1 AML Oceanographic MVP-30

The MVP-30 was the primary sound speed profiler employed on the R/V Ocean Explorer during this survey.  The  MVP-30 Moving Vessel Profiler allows sound speed profiles to be collected while the vessel is underway.  It consists of towfish-mounted sensors (AML sound speed, temperature, and depth "micro SVPT" or MVP-X with exchange sensors), an electro-mechanical conducting cable, and an electric winch. The MVP may be deployed manually using the winch controls or remotely using the MVP Controller Software.  When operated in "FreeWheel" mode, the MVP falls near-vertically to a preset depth off the bottom, collecting sound speed and temperature/depth measurements at a rate of 10 Hz.  During data acquisition on the R/V Ocean Explorer, MVP casts were performed at approximately 15-minute intervals. Calibration certificates for all Sound Speed Sensor equipment are included in DAPR Appendix I.

| | | | | | | |
|---|---|---|---|---|---|---|
| *Manufacturer* | AML Oceanographic | | | | | |
| *Model* | MVP-30 | | | | | |
| *Inventory* | *R/V Ocean Explorer* | *Component* | MVP | | | |
| | | *Model Number* | 30 | | | |
| | | *Serial Number* | 10646 | | | |
| | | *Calibration* | N/A | | | |
| | *R/V Ocean Explorer* | *Component* | Sonde | Sound Speed Sensor | Pressure Sensor | Temperature Sensor |
| | | *Model Number* | MVP-X | SV Exchange | P Exchange | T Exchange |
| | | *Serial Number* | 9062 | 208339 | 306277 | 404501 |
| | | *Calibration* | N/A | 2019-08-12 | 2019-08-14 | 2019-08-14 |

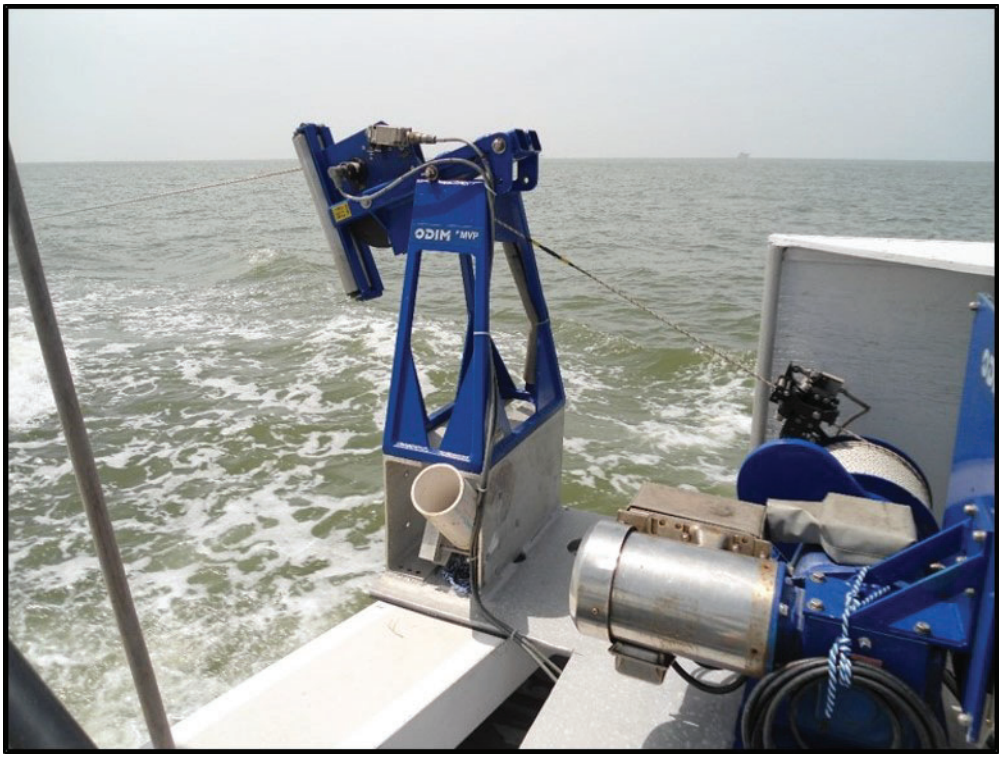



*Figure 11: MVP-30 Moving Vessel Profiler mounted on the port quarter of the R/V Ocean Explorer*

**A.6.2 CTD Profilers**

No CTD profilers were utilized for data acquisition.

**A.6.3 Sound Speed Sensors**

**A.6.3.1 AML Oceanographic Micro-X Sound Speed Sensor**

The AML Micro-X is a high-accuracy sound speed sensor capable of measuring and transmitting sound speed data directly to the MBES via a manufacturer-supplied data cable. The Micro-X, mounted within the forward faring of the MBES transducer, transmitted real-time surface sound speed data to the Reson 7125 multibeam system for beam forming and to the HYPACK acquisition computer via the Reson interface. The Micro-X, like the AML MVP-X sensor, uses a sound speed "exchange" sensor.

| | | | | | |
|---|---|---|---|---|---|
| *Manufacturer* | AML Oceanographic | | | | |
| *Model* | Micro-X Sound Speed Sensor | | | | |
| *Inventory* | *R/V Ocean Explorer* | *Component* | Sonde | Sound Speed Sensor | Sound Speed Sensor |
| | | *Model Number* | Micro-X | SV-Exchange | SV-Exchange |
| | | *Serial Number* | 12013 | 207470 | 201527 |
| | | *Calibration* | N/A | 2019-01-03 | 2019-03-14 |
| | *R/V H.F. Stout* | *Component* | Sonde | Sound Speed Sensor | |
| | | *Model Number* | Micro-X | SV-Exchange | |
| | | *Serial Number* | 10817 | 203516 | |
| | | *Calibration* | N/A | 2019-03-14 | |

### A.6.3.2 AML Oceanographic Base X and Base X2 Sound Speed Profilers

On the R/V Ocean Explorer, sound speed comparison profiles were acquired using an AML Oceanographic Base-X logging profiler. This instrument collects high-precision direct sound speed and pressure measurements. The instrument was configured to take measurements at a rate of 5 Hz. These data were stored internally and downloaded via a serial connection using the field logging computer.

On the R/V H.F. Stout, an AML Base X2 was used as the primary sound speed profiler. The Base X2 is an updated version of the AML Base X that has wireless capability for automatically transferring profile data off the sonde after each cast. An AML Base X was used on the H.F. Stout for sound speed comparison casts.

| | | | | | |
|---|---|---|---|---|---|
| *Manufacturer* | AML Oceanographic | | | | |
| *Model* | Base X and Base X2 Sound Speed Profilers | | | | |
| *Inventory* | *R/V Ocean Explorer* | *Component* | Sonde | Sound Speed Sensor | Pressure Sensor |
| | | *Model Number* | Base-X | SV-Exchange | P-Exchange |
| | | *Serial Number* | 25028 | 203524 | 304060 |
| | | *Calibration* | N/A | 2019-03-14 | 2019-03-15 |
| | *R/V HF Stout* | *Component* | Sonde | Sound Speed Sensor | Pressure Sensor |
| | | *Model Number* | Base X | SV Exchange | P Exchange |
| | | *Serial Number* | 25016 | 208179 | 306268 |
| | | *Calibration* | N/A | 2019-06-12 | 2019-06-12 |
| | *R/V HF Stout* | *Component* | Sonde | Sound Speed Sensor | Pressure Sensor |
| | | *Model Number* | Base X2 | SV Exchange | P Exchange |
| | | *Serial Number* | 25838 | 203108 | 304351 |
| | | *Calibration* | N/A | 2019-03-14 | 2019-03-15 |

#### A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

#### A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

### A.7 Computer Software

| *Manufacturer* | *Software Name* | *Version* | *Use* |
|---|---|---|---|
| HYPACK | Hypack Survey | 18.2.1.0 | Navigation and data collection, SSS towfish positioning |
| HYPACK | Hysweep Survey | 18.2.5.0 | MBES collection |
| HYPACK | MB Max 64 | 18.2.7 | Field processing for data QC and calibrations of MBES |
| Applanix | POSPac MMS | 8.4 SP2 | IAPPK proscessing to final SBETs and ERS Tides |
| Applanix | MV POS View | 9.9.1 | Monitoring and logging of POS MV data on the R/V H.F. Stout |
| Applanix | MV POS View | 7.92 | Monitoring and logging of POS MV data on the R/V Ocean Explorer |
| Edgetech | Discover | 10.0 (38.0.1.107) | Control and collection of SSS |
| Teledyne CARIS | HIPS/SIPS | 10.4.17 | Processing of MBES, SSS, and Features |
| Teledyne CARIS | Notebook | 3.1.1 | Feature Management and Review |
| Global Mapper Software, LLC | Global Mapper | 19.1 | Data review and reporting |
| ODIM Brooke Ocean | MVP Controller | 2.430 | MVP 30 operation and sound speed data acquisition |
| AML Oceanographic | SeaCast | 4.4.0 | Configuring and downloading sound speed profiles |
| UNH-CCOM/NOAA | HydroOffice-Sound Speed Manager | 2019.2.5 | Processing and QC of sound speed profiles |
| Microsoft | Office Suite | 16.0 | Survey Log, Notes |
| Mathworks | MATLAB | R2020a | ERS tide smoothing and processing |
| Chesapeake Technology | SonarWiz 7 | 7.04.01 | SSS data processing |
| UNH-CCOM/NOAA | HydroOffice QC Tools | 3.1.6 | Automated QC of project deliverables (surfaces, feature attribution, grid statistics, grid holidays, designated soundings, directory structure of deliverables). |
| NOAA HSTP | XMLDR | 19.4 (r10456) | Compilation and printing (PDF) of project reports (DAPR, DR, HVCR). |
| National Geodetic Survey | OPUS Projects | 4.8 | QC and processing of OSI-Installed GNSS base station data. |

## A.8 Bottom Sampling Equipment

### A.8.1 Bottom Samplers

#### A.8.1.1 OSI Pipe Dredge

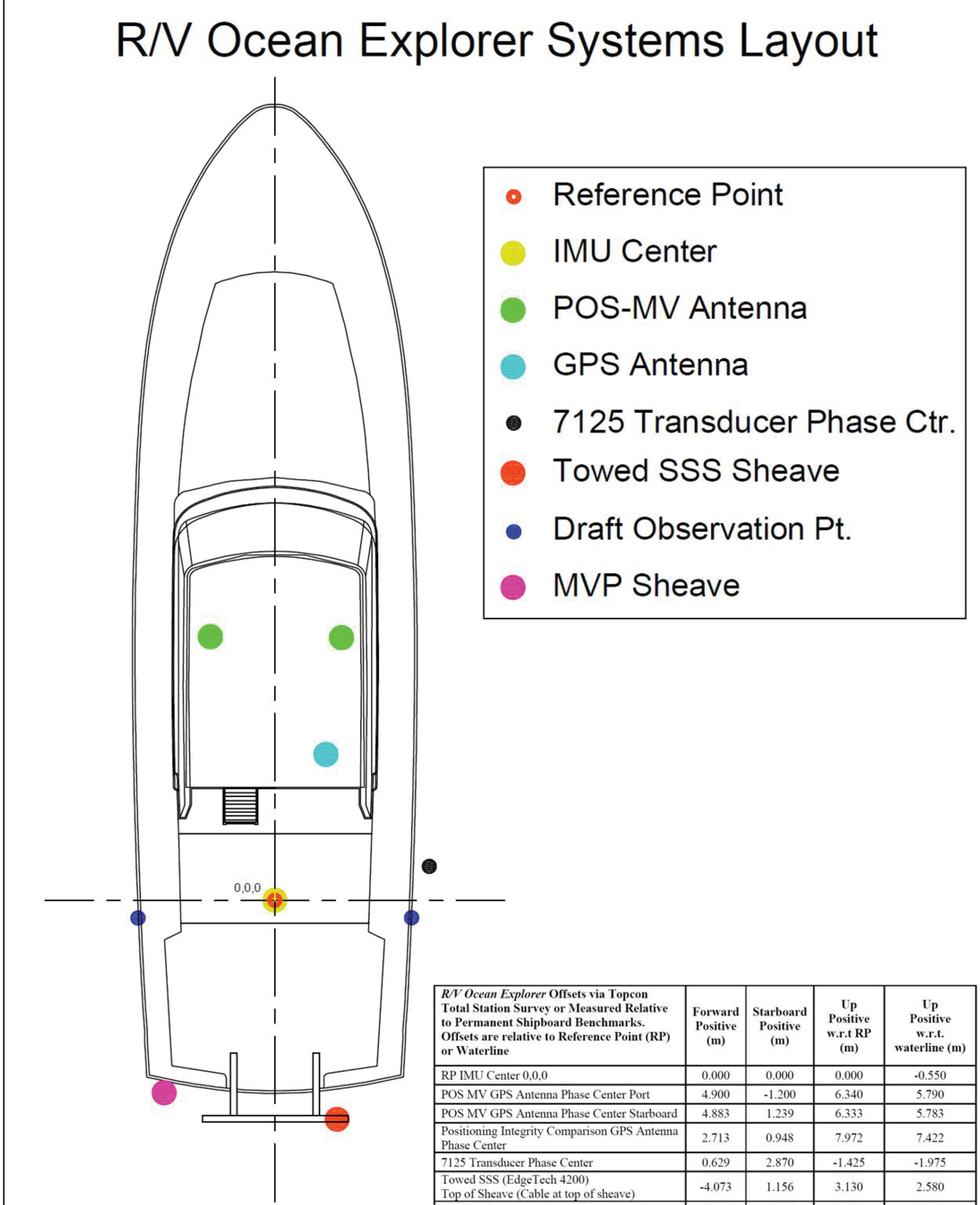
A pipe dredge measuring 0.3m long and 0.1m in diameter was used to acquire bottom samples.

# B. System Alignment and Accuracy

## B.1 Vessel Offsets and Layback

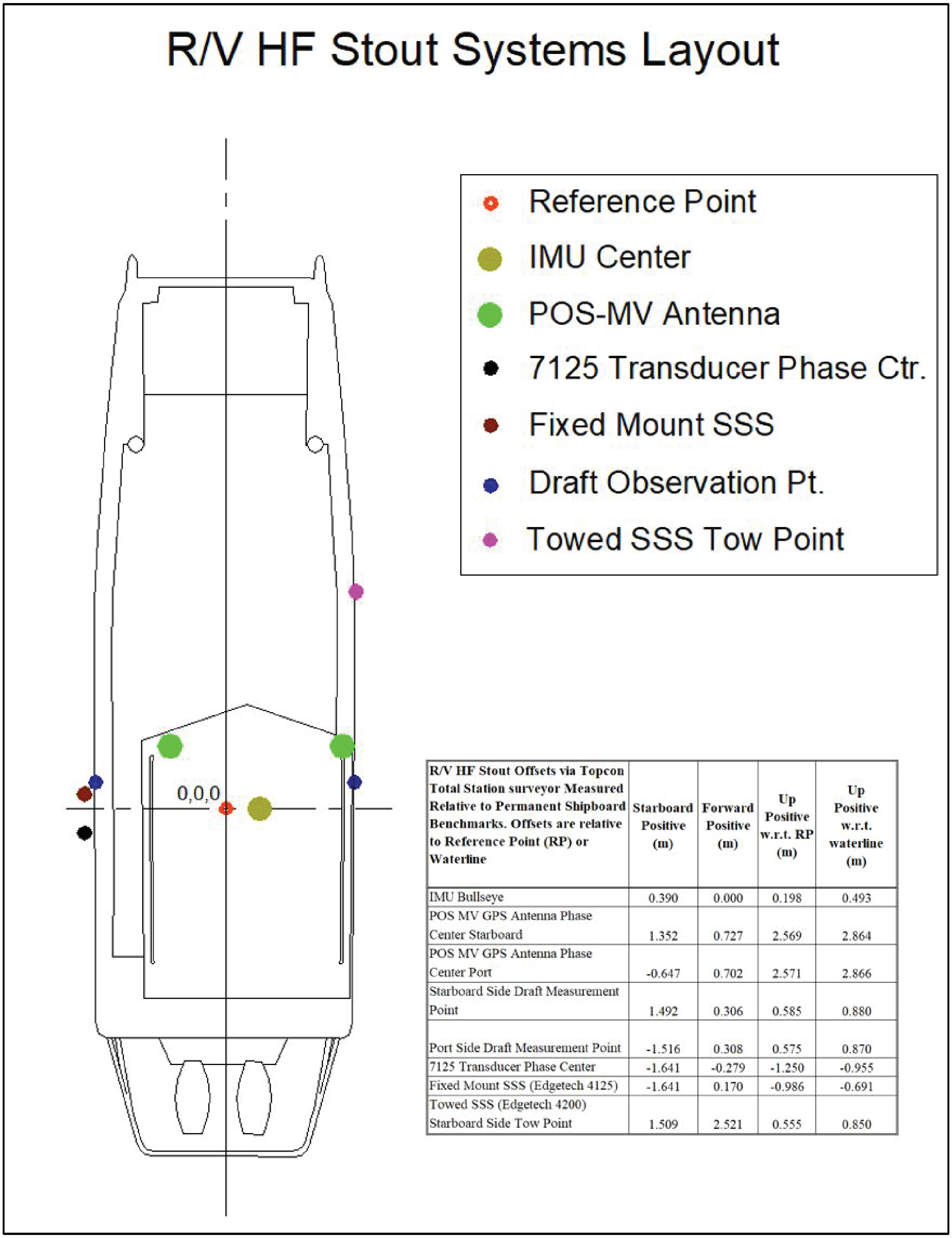
### B.1.1 Vessel Offsets

Sensor offsets for each vessel were measured with respect to their RP. Offsets and on-board benchmarks were established in the vessel reference frame during full static surveys (on land) and confirmed in the field using a steel tape measure. On the Ocean Explorer, the POS MV IMU "bullseye" target serves as the RP. On the H.F. Stout, the RP is located on the deck, along the centerline of the vessel, at the approximate pitch center of rotation. The POS MV IMU is located 0.390m starboard of RP. IMU to RP lever arm offsets are applied in the POS MV configuration. The multibeam transducer pole of each vessel is capable of multiple draft settings. During the 2019 mobilization, the initial transducer phase center-to-RP offsets were established relative to on-board benchmarks using a steel tape measure. The relative distance between transducer phase center and vessel RP did not change during the survey. Survey offsets and estimated measurement accuracies were incorporated into the CARIS vessel configuration file for each vessel.




| ***R/V Ocean Explorer*** **Offsets via Topcon Total Station Survey or Measured Relative to Permanent Shipboard Benchmarks. Offsets are relative to Reference Point (RP) or Waterline** | **Forward Positive (m)** | **Starboard Positive (m)** | **Up Positive w.r.t RP (m)** | **Up Positive w.r.t. waterline (m)** |
|---|---|---|---|---|
| RP IMU Center 0,0,0 | 0.000 | 0.000 | 0.000 | -0.550 |
| POS MV GPS Antenna Phase Center Port | 4.900 | -1.200 | 6.340 | 5.790 |
| POS MV GPS Antenna Phase Center Starboard | 4.883 | 1.239 | 6.333 | 5.783 |
| Positioning Integrity Comparison GPS Antenna Phase Center | 2.713 | 0.948 | 7.972 | 7.422 |
| 7125 Transducer Phase Center | 0.629 | 2.870 | -1.425 | -1.975 |
| Towed SSS (EdgeTech 4200) Top of Sheave (Cable at top of sheave) | -4.073 | 1.156 | 3.130 | 2.580 |
| Starboard Side Draft Measurement Point | -0.325 | 2.542 | 1.975 | 1.425 |
| Port Side Draft Measurement Point | -0.329 | -2.494 | 1.979 | 1.429 |

*Figure 12: R/V Ocean Explorer Systems Layout*




| R/V HF Stout Offsets via Topcon Total Station surveyor Measured Relative to Permanent Shipboard Benchmarks. Offsets are relative to Reference Point (RP) or Waterline | Starboard Positive (m) | Forward Positive (m) | Up Positive w.r.t. RP (m) | Up Positive w.r.t. waterline (m) |
|---|---|---|---|---|
| IMU Bullseye | 0.390 | 0.000 | 0.198 | 0.493 |
| POS MV GPS Antenna Phase Center Starboard | 1.352 | 0.727 | 2.569 | 2.864 |
| POS MV GPS Antenna Phase Center Port | -0.647 | 0.702 | 2.571 | 2.866 |
| Starboard Side Draft Measurement Point | 1.492 | 0.306 | 0.585 | 0.880 |
| Port Side Draft Measurement Point | -1.516 | 0.308 | 0.575 | 0.870 |
| 7125 Transducer Phase Center | -1.641 | -0.279 | -1.250 | -0.955 |
| Fixed Mount SSS (Edgetech 4125) | -1.641 | 0.170 | -0.986 | -0.691 |
| Towed SSS (Edgetech 4200) Starboard Side Tow Point | 1.509 | 2.521 | 0.555 | 0.850 |

*Figure 13: R/V H.F. Stout Systems Layout*

**B.1.1.1 Vessel Offset Correctors**

| | | | | |
|---|---|---|---|---|
| *Vessel* | R/V Ocean Explorer | | | |
| *Echosounder* | Teledyne-Reson Seabat 7125 SV2 Multibeam Echosounder | | | |
| *Date* | 2019-05-13 | | | |
| *Offsets* | *MRU to Transducer* | | *Measurement* | *Uncertainty* |
| | | *x* | 2.870 meters | 0.015 meters |
| | | *y* | 0.629 meters | 0.015 meters |
| | | *z* | 7.972 meters | 0.015 meters |
| | *Nav to Transducer* | *x* | 2.870 meters | 0.015 meters |
| | | *y* | 0.629 meters | 0.015 meters |
| | | *z* | 7.972 meters | 0.015 meters |
| | *Transducer Roll* | *Roll* | 0.000 degrees | |

| | | | | |
|---|---|---|---|---|
| *Vessel* | R/V H.F. Stout | | | |
| *Echosounder* | Teledyne-Reson Seabat 7125 SV2 Multibeam Echosounder | | | |
| *Date* | 2019-04-28 | | | |
| *Offsets* | *MRU to Transducer* | | *Measurement* | *Uncertainty* |
| | | *x* | -1.641 meters | 0.015 meters |
| | | *y* | -0.279 meters | 0.015 meters |
| | | *z* | -1.250 meters | 0.015 meters |
| | *Nav to Transducer* | *x* | -1.641 meters | 0.015 meters |
| | | *y* | -0.279 meters | 0.015 meters |
| | | *z* | -1.250 meters | 0.015 meters |
| | *Transducer Roll* | *Roll* | 0.000 degrees | |

**B.1.2 Layback**

On both vessels, HYPACK SURVEY (towfish.dll) calculated and transmitted fish position to the 4200 SSS system. The Towfish device calculates fish position based on fixed tow-point offsets relative to the RP, real-time ship position, cable out value, and towfish depth. The real-time calculation incorporates the Pythagorean Theorem and a multi-segmented cable discretization approach to predict how the towfish follows the main vessel. The layback calculation can be empirically fine-tuned by adjusting the number of cable segments and modifying the catenary factor. Field testing conducted prior to this survey indicated a 5-segmented cable model and a catenary factor of 1.0 were appropriate for this particular setup. A cable counting sheave was used to determine cable-out on the R/V Ocean Explorer. On the R/V H.F. Stout, the cable-out value was measured and adjusted manually using pre-set markings on the cable.

On the H.F. Stout, positioning of the fix-mounted 4125 SSS was determined via sensor offsets from vessel RP as applied in the CARIS HVF.

An evaluation of SSS postioning accuracy and an estimate of positioning error was perfomed for each vessel. A discrete feature was identified and mapped with MBES. That same feature was then mapped on sets of reciprocal lines at 50m and 75m range scales. This was done in a way that the target was detected in both channels of the sonar from a distance of 15%, 50% and 85% of the sonar range scale. The SSS data were processed and contacts were picked for each pass of the feature. The SSS-derived positions were then compared to the MBE reference position of feature. Results of the comparison are reported in DAPR Appendix V. SSS positioning accuracy on both vessels was also verified regularly during the course of the survey by observing adjacent and/or reciprocal data.

### B.1.2.1 Layback Correctors

| | | | |
|---|---|---|---|
| *Vessel* | R/V Ocean Explorer | | |
| *Echosounder* | Edgetech 4200-MP Dual Frequency SSS (towed) | | |
| *Frequency* | 600 kHz | | |
| *Date* | 2019-04-17 | | |
| *Layback* | *Towpoint* | *x* | 1.156 meters |
| | | *y* | -4.073 meters |
| | | *z* | 3.130 meters |
| | *Layback Error* | 1.000 meters | |

| | | | |
|---|---|---|---|
| *Vessel* | R/V H.F. Stout | | |
| *Echosounder* | Edgetech 4125 Dual Frequency SSS (fixed mount) | | |
| *Frequency* | 900 kHz | | |
| *Date* | 2019-04-29 | | |
| *Layback* | *Towpoint* | *x* | -1.641 meters |
| | | *y* | 0.170 meters |
| | | *z* | -0.986 meters |
| | *Layback Error* | 0.015 meters | |

<table>
<tr><td>Vessel</td><td colspan="3">R/V H.F. Stout</td></tr>
<tr><td>Echosounder</td><td colspan="3">Edgetech 4200-MP Dual Frequency SSS (towed)</td></tr>
<tr><td>Frequency</td><td colspan="3">600 kHz</td></tr>
<tr><td>Date</td><td colspan="3">2019-04-29</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>1.509 meters</td></tr>
<tr><td>y</td><td>2.521 meters</td></tr>
<tr><td>z</td><td>0.555 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">1.000 meters</td></tr>
</table>

## B.2 Static and Dynamic Draft

### B.2.1 Static Draft

Static draft is the vertical distance of the echosounder transducer below the water line and is added to the observed soundings during data processing in CARIS HIPS. The vertical offset between the transducer phase center and the RP was entered into the HVF Swath 1, Z-value field. The vertical offset to account for the distance from the RP to the water surface was updated nearly once per day (as conditions allowed). Updates were entered into the Waterline Height field in the HVF. The Z-value and the waterline corrector added together equaled the static draft of the echosounder transducer phase center.

On both vessels, static draft measurements were taken during mobilization, prior to the start of the survey and periodically throughout the term of the survey. Direct measurements or “measure downs” from a calm water surface to both the port and starboard draft observation point “benchmarks” were made using a steel tape. The waterline height above the RP was determined by averaging the measure downs. Minor variations in vessel attitude were negated as the final measured waterline height value is an average of the port and starboard measured values. In CARIS HIPS, the time stamped waterline height correctors were added to the Z-value vertical offset between the RP and the transducer phase center to obtain the vessel’s echosounder static draft.

On the R/V Ocean Explorer an Onset HOBO pressure sensor (vented water level gauge) was installed within the transducer pole as an alternate method for monitoring the change in static draft due to changes in vessel loading. The pressure sensor was installed at a fixed elevation within the transducer pole. The transducer mounting flange at the bottom of the transducer pole was fitted with a small diameter copper orifice making the transducer pole, in effect, a stilling well. The pressure sensor depth below the water surface was calibrated prior to the start of survey to determine a vertical offset constant relative to the RP. When the vessel was at a full stop for the daily “UTC midnight” changeover, 1 Hz pressure sensor water level data were logged for 5-10 minutes. The water level values were processed and averaged to obtain the depth of the pressure sensor below the water line. The waterline height was calculated by subtracting the vertical offset between the pressure sensor and the RP from the pressure sensor average depth. The pressure sensor gauge water level determination method was used exclusively for static draft measurements offshore, as the sea state made measure downs impractical.

### B.2.1.1 Static Draft Correctors

| *Vessel* | | R/V Ocean Explorer | R/V H.F. Stout |
|---|---|---|---|
| *Date* | | 2019-05-13 | 2020-01-12 |
| *Loading* | | 0.030 meters | 0.030 meters |
| *Static Draft* | *Measurement* | -1.975 meters | -0.955 meters |
| | *Uncertainty* | 0.030 meters | 0.030 meters |

### B.2.2 Dynamic Draft

Dynamic draft correctors account for the vertical displacement of the transducer when a vessel is underway in relation to its position at rest.

The dynamic draft (settlement) for each vessel was measured using IAPPK SBET height measurements at average load and trim for survey operations. Pairs of reciprocal lines were run at increasing speed intervals in order to mitigate the effect of current. “Drift lines” were recorded with the vessel at rest between reciprocal test runs in order to account for tidal variations. The sea-state was calm during collection.

The R/V Ocean Explorer dynamic draft test was performed near its homeport of Noank, CT. The R/V H.F. Stout test was performed in Corpus Christi Bay during on-site calibrations of previous NOAA Survey OPR-K379-KR-19. The table below summarizes the as-measured test results for both vessels. To populate the CARIS HVF draft table, the as-measured values shown were smoothed and densified using a 4th Order polynomial curve fit. Settlement values entered into the CARIS HVFs were taken from the smooth curve at regular speed intervals. The fitted curves and the HVF dynamic draft correctors for both vessels are included in DAPR Appendix III.

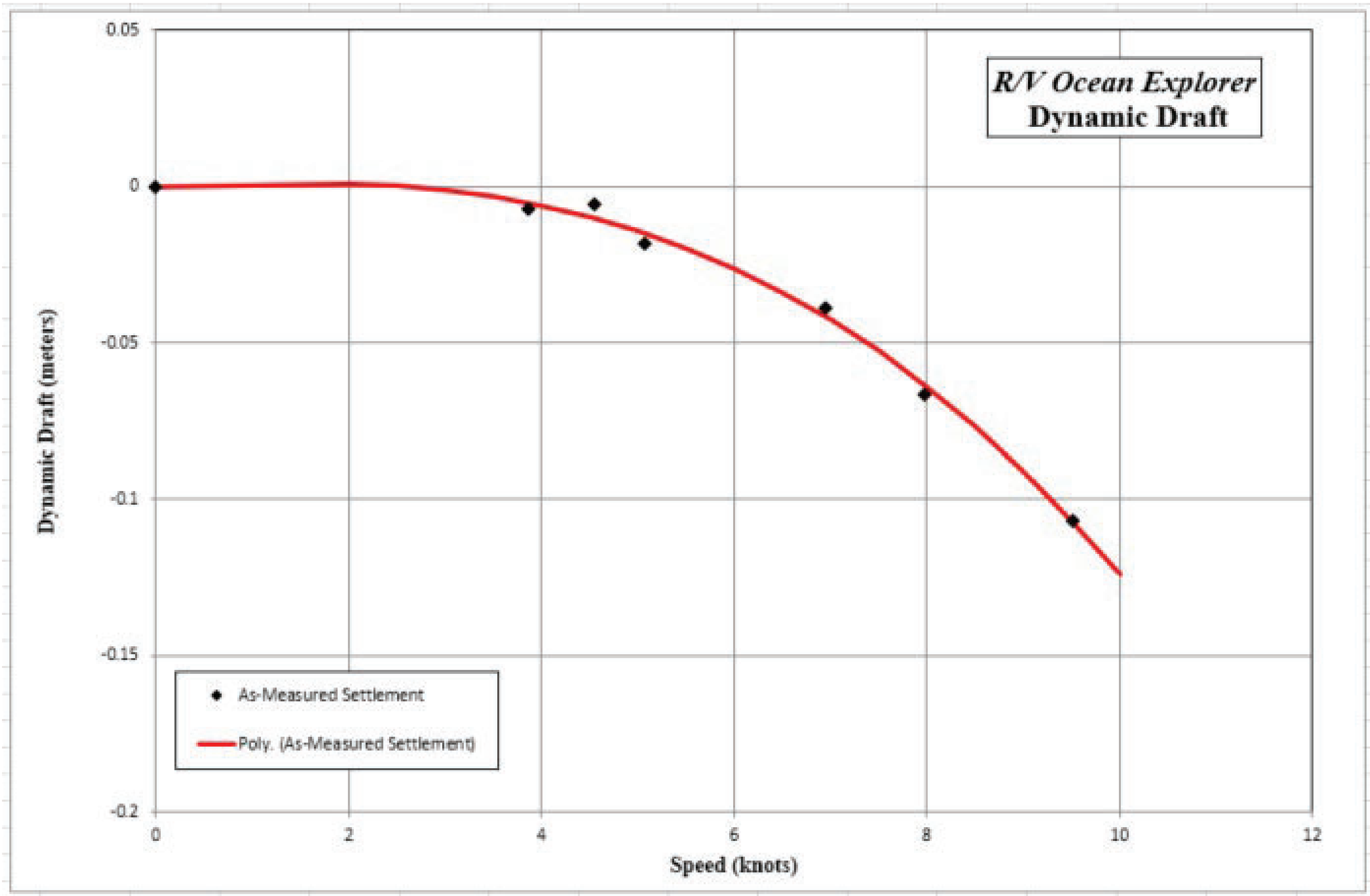



*Figure 14: R/V Ocean Explorer Dynamic Draft Curve*

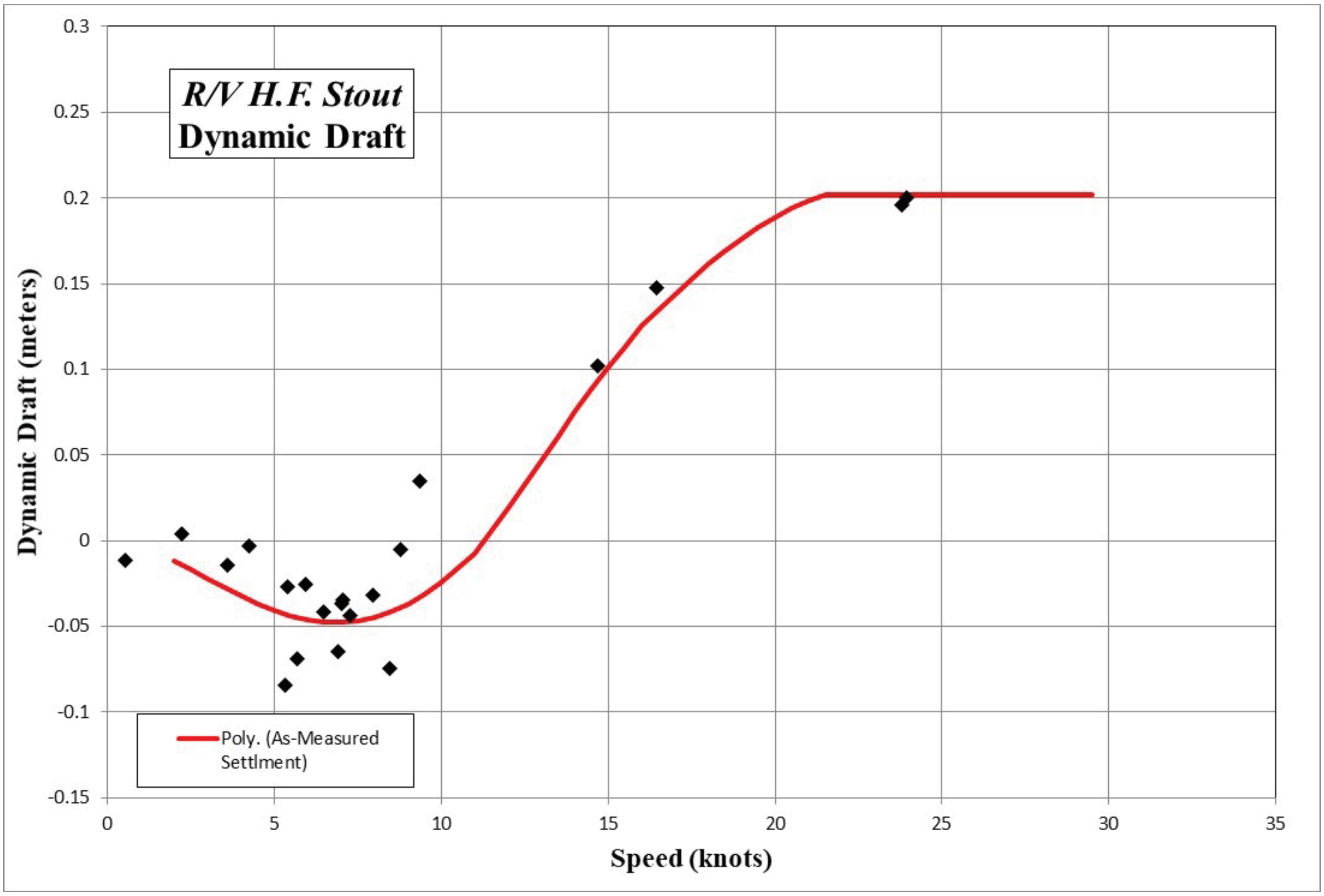



*Figure 15: R/V H.F. Stout Dynamic Draft Curve*

### B.2.2.1 Dynamic Draft Correctors

| *Vessel* | R/V Ocean Explorer | | R/V H.F. Stout | |
|---|---|---|---|---|
| *Date* | 2019-04-17 | | 2019-04-29 | |
| *Dynamic Draft* | *Speed (kt)* | *Draft (m)* | *Speed (kt)* | *Draft (m)* |
| | 0.00 | 0.00 | 0.53 | -0.01 |
| | 3.87 | -0.01 | 2.23 | 0.00 |
| | 4.56 | -0.01 | 3.58 | -0.02 |
| | 5.07 | -0.02 | 4.23 | -0.00 |
| | 6.95 | -0.04 | 5.32 | -0.04 |
| | 7.98 | -0.07 | 5.38 | -0.03 |
| | 9.51 | -0.11 | 5.67 | -0.05 |
| | | | 5.95 | -0.02 |
| | | | 6.48 | -0.04 |
| | | | 6.89 | -0.06 |
| | | | 7.04 | -0.04 |
| | | | 7.07 | -0.04 |
| | | | 7.28 | -0.04 |
| | | | 7.95 | -0.03 |
| | | | 8.46 | -0.08 |
| | | | 8.80 | -0.00 |
| | | | 9.35 | 0.04 |
| | | | 14.69 | 0.09 |
| | | | 16.45 | 0.14 |
| | | | 23.80 | 0.18 |
| | | | 23.95 | 0.18 |
| *Uncertainty* | *Vessel Speed (kt)* | *Delta Draft (m)* | *Vessel Speed (kt)* | *Delta Draft (m)* |
| | 1.03 | 0.01 | 1.03 | 0.01 |

## B.3 System Alignment

### B.3.1 System Alignment Methods and Procedures

A multibeam sonar calibration was completed for each vessel in order to determine residual navigation timing error and angular biases in roll, pitch, and heading in the echosounder transducer alignment. Standard patch tests were conducted by each boat offshore of Freshwater Bayou Canal Lock after on-site mobilization and before data collection commenced. Marine Star and WAAS correctors were used for real-time navigation during the patch test and for field processing of patch values. Final patch values for the CARIS HVF for each vessel were determined using final SBETs. A reference surface was developed in order to evaluate outer beam performance. Calibration reports and statistics for initial calibrations are included in DAPR Appendix V.

Both vessels were equipped with retractable MBES pole mounts. To monitor any potential variability resulting from multiple pole deployments, each vessel performed abbreviated "interim" patch tests once per operating day and after each pole deployment. For the interim patch tests, reciprocal multibeam data were collected on a short set of lines at a convenient time each day and processed onboard. If small changes in alignment (typically roll) were observed, the HVF was updated with a time-stamped entry of the new value.

At the end of the day on 11/13/2019 (DN 318), the MBES faired transducer mounting bracket on the R/V H.F. Stout allided with a piling during a docking maneuver causing damage to the mounting bracket. The mounting bracket was replaced and a second full system alignment test (patch test) was performed on 11/16/2019 (DN 320) before resuming data acquisition. The results of this second test are included in the HVF and in DAPR Appendix V.

### B.3.1.1 System Alignment Correctors

| | | | |
|---|---|---|---|
| *Vessel* | R/V Ocean Explorer | | |
| *Echosounder* | Teledyne-Reson SeaBat 7125 SV2 | | |
| *Date* | 2019-09-05 | | |
| *Patch Test Values* | | *Corrector* | *Uncertainty* |
| | *Transducer Time Correction* | 0.000 seconds | 0.010 seconds |
| | *Navigation Time Correction* | 0.000 seconds | 0.010 seconds |
| | *Pitch* | -0.190 degrees | 0.100 degrees |
| | *Roll* | -0.760 degrees | 0.100 degrees |
| | *Yaw* | 0.800 degrees | 0.100 degrees |
| | *Pitch Time Correction* | 0.000 seconds | 0.010 seconds |
| | *Roll Time Correction* | 0.000 seconds | 0.010 seconds |
| | *Yaw Time Correction* | 0.000 seconds | 0.010 seconds |
| | *Heave Time Correction* | 0.000 seconds | 0.010 seconds |

| | |
|---|---|
| *Vessel* | R/V H.F. Stout |
| *Echosounder* | Teledyne-Reson SeaBat 7125 SV2 |
| *Date* | 2019-09-05 |

*Patch Test Values*

| | *Corrector* | *Uncertainty* |
|---|---|---|
| *Transducer Time Correction* | 0.000 seconds | 0.010 seconds |
| *Navigation Time Correction* | 0.000 seconds | 0.010 seconds |
| *Pitch* | ~~-0.270~~ degrees -2.70 | 0.100 degrees |
| *Roll* | -0.570 degrees | 0.100 degrees |
| *Yaw* | 0.800 degrees | 0.100 degrees |
| *Pitch Time Correction* | 0.000 seconds | 0.010 seconds |
| *Roll Time Correction* | 0.000 seconds | 0.010 seconds |
| *Yaw Time Correction* | 0.000 seconds | 0.010 seconds |
| *Heave Time Correction* | 0.000 seconds | 0.010 seconds |

| | |
|---|---|
| *Vessel* | R/V H.F. Stout |
| *Echosounder* | Teledyne-Reson SeaBat 7125 SV2 |
| *Date* | 2019-11-16 |

*Patch Test Values*

| | *Corrector* | *Uncertainty* |
|---|---|---|
| *Transducer Time Correction* | 0.000 seconds | 0.010 seconds |
| *Navigation Time Correction* | 0.000 seconds | 0.010 seconds |
| *Pitch* | -2.450 degrees | 0.100 degrees |
| *Roll* | -0.280 degrees | 0.100 degrees |
| *Yaw* | 1.000 degrees | 0.100 degrees |
| *Pitch Time Correction* | 0.000 seconds | 0.010 seconds |
| *Roll Time Correction* | 0.000 seconds | 0.010 seconds |
| *Yaw Time Correction* | 0.000 seconds | 0.010 seconds |
| *Heave Time Correction* | 0.000 seconds | 0.010 seconds |

# C. Data Acquisition and Processing

## C.1 Bathymetry

### C.1.1 Multibeam Echosounder

<u>Data Acquisition Methods and Procedures</u>

Unless specifically noted, the acquisition steps and settings described in this section apply to both vessels.

Multibeam data were generally acquired on a set of parallel tracklines spaced appropriately to achieve the coverage requirements specified in the Project Instructions. Modifications to the line plan were made as needed to accomadate changing site conditions, and/or to perform cross-lines and bathymetric splits. Bathymetric splits were run to ensure features were adequately mapped between planned lines and to "disprove" charted soundings with depths more than 2 feet shoaler than surrounding survey data. The 2 foot criteria for sounding verifcation was based on correspondence with AHB and was a more conservative approach than required by AHB.

Raw sounding data were output directly from the Reson 7125 TPU to the HYPACK acquisition computer via a dedicated network card. HYPACK SURVEY and HYSWEEP SURVEY were configured to record position, heading, attitude and depth to RAW and HSX data files. For the real-time display, system offsets for the IMU and for the transducer phase center were entered into the HYPACK configuration files. These offsets were subsequently incorporated into the CARIS data processing routine. During operations, the HYSWEEP real-time MBES sounding wedge and digital terrain model (DTM) waterfall displays were monitored. The sounding wedge, DTM waterfall, and plan view coverage displays were corrected for draft, motion, predicted tides and sound speed. Survey coverage was tracked in the HYPACK SURVEY display window with a matrix file updated in real time.

The Reson Seabat 7125 processor was interfaced with the POS MV such that UTC date and time information from the POS MV were used to accurately time stamp the Reson output data string. The Reson 7125 processor received a pulse-per-second (PPS) signal and a serial $ZDA NMEA timing string from the POS MV. The POS MV also supplied a “TSS1” message to the Reson TPU for real-time roll stabilization. Surface sound speed, measured at the transducer head with the AML Micro-X, was output to the Reson 7125 processor for beam-forming. The 7125’s “Normal” filter was used for sound speed filtering.

The SeaBat user interface of the Reson 7125 TPU was used to configure MBES settings, to monitor sounding acquisition, and to adjust system parameters in real time. Bottom detection was optimized by adjusting gain, pulse length, and “ocean” settings (absorption and spreading). Most of the adjustment occurred during calibration and system acceptance. Additional minor adjustments were made over the course of the survey, though these were rare. Range settings were monitored and adjusted to observed depths to maximize the ping rate. The “absolute” depth gates were conservatively employed to reject fliers during mainscheme and crossline data acquisition. Depth gate filters were used sparingly or completely disabled during item investigations.

The Reson 7125 was operated in equidistant mode using 512 return beams and a maximum swath width of 140° depending on water depth. The roll stabilization feature was activated throughout the term of the project.

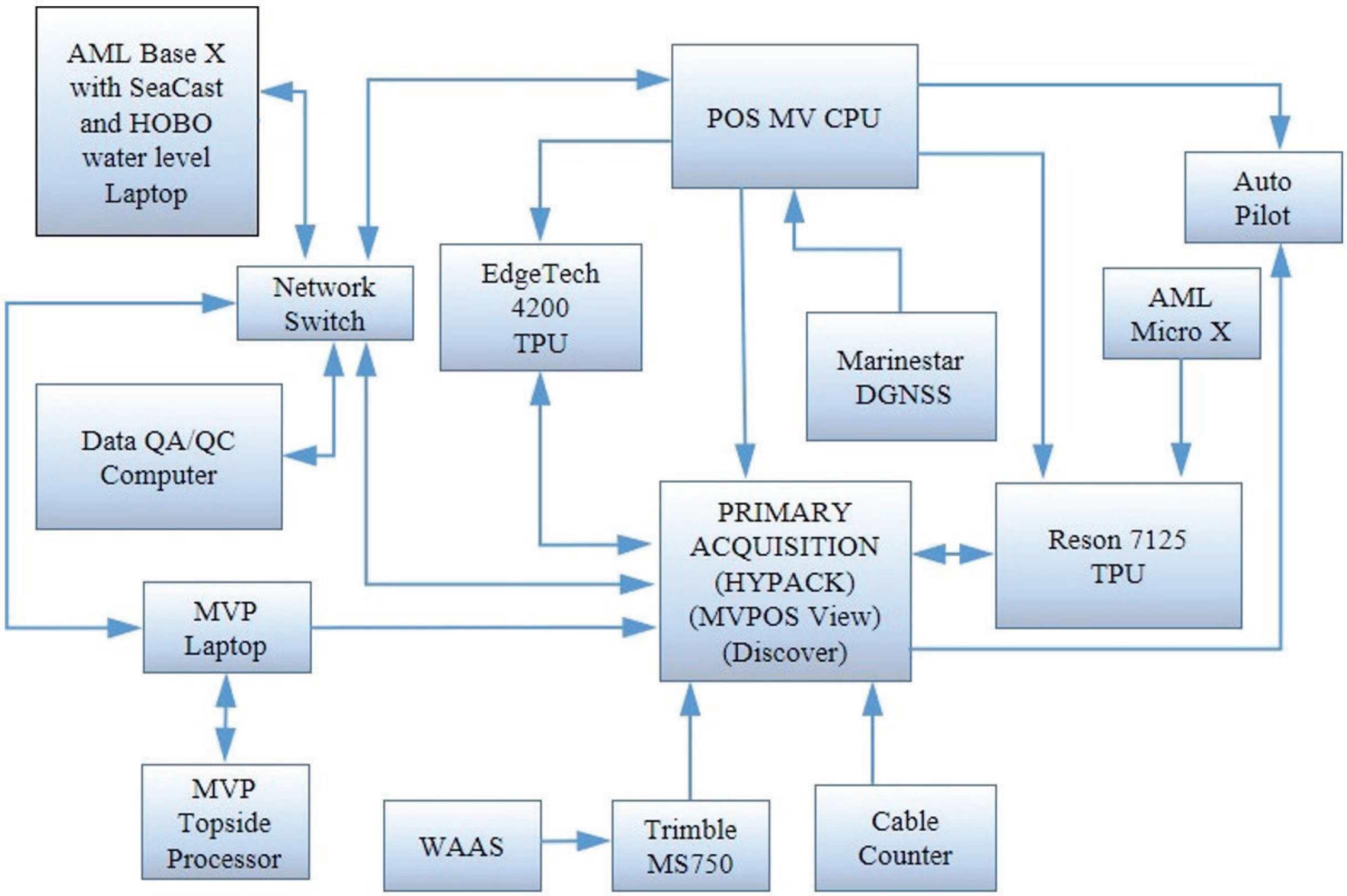



*Figure 16: R/V Ocean Explorer Acquisition Wiring Diagram*

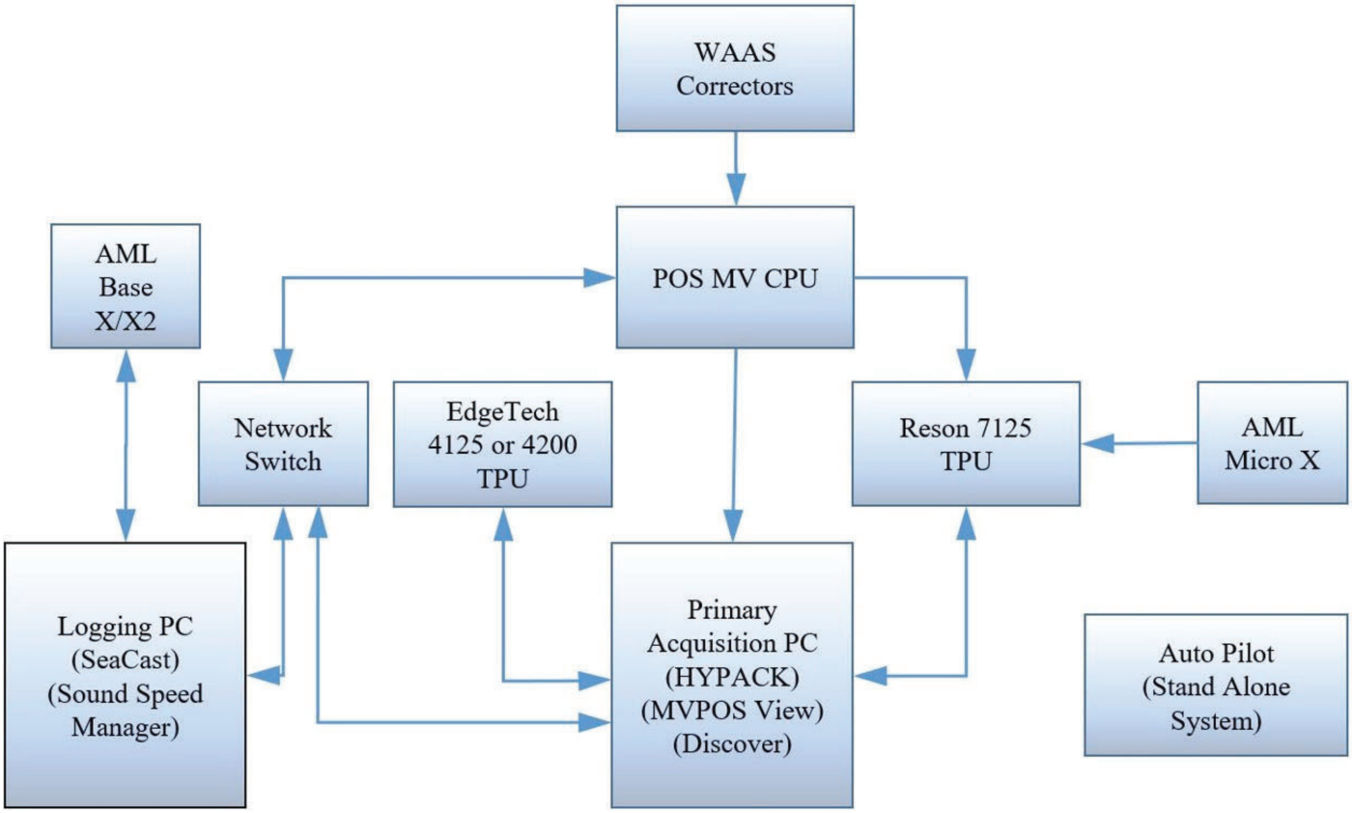



*Figure 17: R/V H.F. Stout Acquisition Wiring Diagram*

<u>Data Processing Methods and Procedures</u>

QA/QC level processing was completed onboard the survey vessel; however, all final data processing occurred at OSI's home office. Field data were shipped via express courier to the home office processing center during convenient in-ports. The lag between acquisition and data check-in at the home office was about one week.

Upon receipt of a data disk, information contained in the daily acquisition log was compared to the data package to ensure that no files were lost or omitted. Prior to data processing, the acquisition log was consulted to verify line names and file size and to remove any aborted lines from the preprocess folder before converting the data in CARIS HIPS.

Multibeam sonar data conversion and the application of sounding correctors were completed using routines developed in CARIS' Process Designer. The Process Designer (model) runs a user-defined script which accomplished the following standard tasks in succession:

-Convert the HSX and RAW data to the HDCS data format, establish UTM grid.
-Enable all multibeam beams.
-Load daily TrueHeave (delayed heave) files.

-Load and apply concatenated sound speed profile data. Sound speed profiles were loaded with the CARIS nearest in distance within time correction method. A time basis of 1 hour was used for the R/V Ocean Explorer and 2 hours for the H.F. Stout. During CARIS SVP Correction, the following correctors were applied: sound speed, heave, pitch, roll and waterline.
-Run "Compute GPS Tides" employing the provided VDatum ellipsoid separation model (SEP).
-Merge data to apply vessel offsets/alignment, position, gyro, tide, and dynamic draft correctors to bathymetry. CARIS HIPS computes the fully corrected depth and position of each sounding during the Merge process.
-Compute Total Propagated Uncertainty (TPU). TPU is calculated in CARIS HIPS from contributing uncertainties in the echosounder, positioning and motion sensor measurements as well as uncertainties associated with sound speed and water level correction.

### C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

### C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

### C.1.4 Gridding and Surface Generation

#### C.1.4.1 Surface Generation Overview

Preliminary field sheets and Bathymetry Associated with Statistical Error (BASE) surfaces were created for reviewing and cleaning of full-density soundings using the Combined Uncertainty and Bathymetry Estimator (CUBE) process. BASE surfaces were "finalized" for each survey based on the coverage requirements outlined in the Project Instructions and the HSSD. Complete Coverage sheets were gridded to 1m resolution surfaces. Designated soundings were incorporated into the finalized BASE surfaces making certain that the least depth sounding was honored in the grid.

#### C.1.4.2 Depth Derivation

Line attitude and navigation data were reviewed in their respective CARIS editors to ensure that there were no problems with the correctors, such as gaps in attitude data or navigation jumps.

CARIS surface filters were employed to clean the majority of fish, noise, multipath returns, and gross fliers. To avoid poor surface filter performance where survey lines intersect, 2-meter surfaces (with 4-meter CUBE parameters) were created such that no survey line overlapped another survey line. Due to the abundance of fish, shrimp, and other water column returns, surface filters were commonly run multiple times.

Swath Editor was used to review the surface filter results and further clean fliers or reaccept over-filtered soundings. Soundings were colored by depth and reviewed in multi-directional profile and plan view displays. Tracklines and swath boundaries were viewed in the CARIS Map window in reference to BASE surfaces, charted data (ENC), SSS contacts and field annotations (HYPACK target files).

The CARIS Subset Editor was used to clean fully-corrected, geo-referenced soundings in 2-D and 3-D displays. Areas with multiple sounding coverages from adjacent survey lines were evaluated to increase confidence in outer beams and over significant features. Overlapping soundings were colored by line and reviewed to verify the validity of bathymetric features or SSS contacts and to reject fish or water column noise. Subset boundaries were viewed in the CARIS Map window in reference to BASE surfaces, charted data (RNC/ENC), and SSS contacts.

### C.1.4.3 Surface Computation Algorithm

After MBES sounding editing was complete, final BASE surfaces were created using the CUBE algorithm in CARIS HIPS/SIPS. The CUBE algorithm generates surface models from multiple hypotheses. Hypotheses with lower combined Total Propagated Uncertainty (TPU) are given higher significance for incorporation into the final surfaces. Also, soundings closest to a grid node have a greater weight on the node depth value than soundings that are further away.

The CUBE algorithm and specific parameters used to create BASE surfaces were contained in the NOAA "CUBEParams_NOAA_2019.xml" file as included in the Pydro software suite.

## C.2 Imagery

### C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

Multibeam backscatter data were logged in HYSWEEP SURVEY simultaneously with MBES soundings. Snippet size was set to 25 samples. Backscatter file names were composed of the year, vessel, day number, UTC time and line number, for example: 2019OE1650133_2163.7K where “OE” stands for Ocean Explorer and "ST" for H.F. Stout. MBES system settings such as power, gain, and pulse length were optimized for acquisition of MBES sounding data.

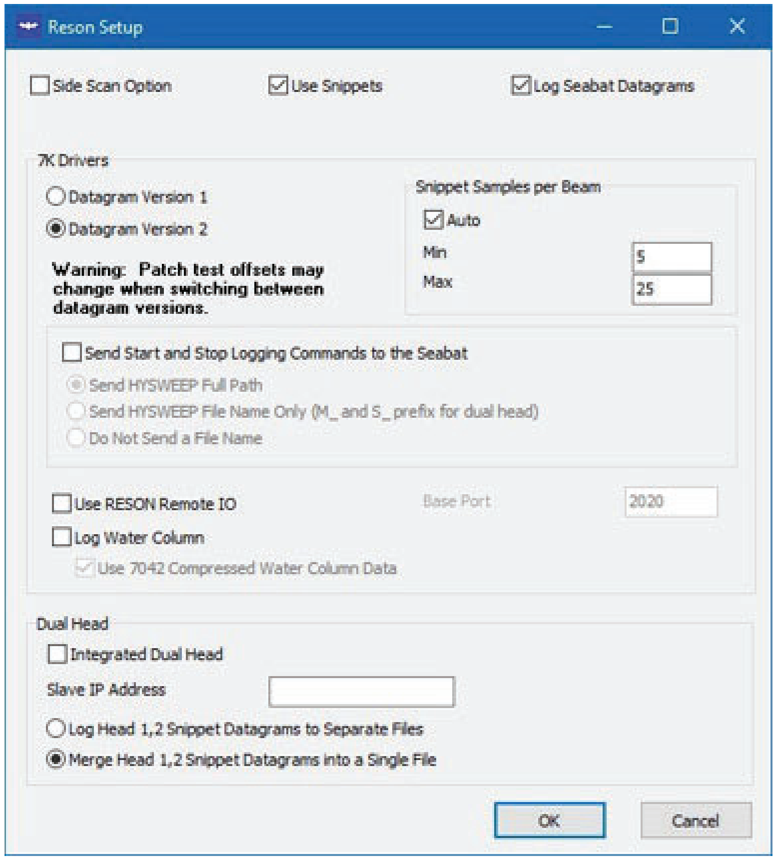



*Figure 18: HYSWEEP Survey settings used for backscatter acquisition*

Data Processing Methods and Procedures

Multibeam *.7k backscatter data files were reviewed for completeness and included as a deliverable with no additional specialized processing.

### C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

On both vessels, side scan sonar (SSS) data were recorded in *.jsf format using EdgeTech Discover software which was also used for system configuration and control. SSS data was transmitted via ethernet from the SSS TPU to a dedicated network card on the main data acquisition computer. Edgetech Discover file recording start and stop control was handled by HYPACK and HYSWEEP through a loop-back IP device connection. Realtime navigation was transmitted to Discover from HYPACK as a NMEA RMC serial message at 2Hz. A discussion on positioning and layback is included in section B.1.2 of this report. A ZDA timing message was transmitted at 1 Hz to Discover by direct serial connection to the POSMV.

On both vessels the Edgetech 4200 MP SSS was operated at the 75m range scale using the 600 kHz (high) frequency. Towed SSS altitude was monitored in real time and adjustments were made to maintain an altitude within the permissible range. The Project Instructions included an altitude waiver from the 8% to 20% of SSS range in the HSSD to 6% to 20% of SSS range when in depths less than 8 m. The SSS waterfall was monitored for refraction, surface noise, excessive fish, and other factors that could affect data quality. Outer-range features, or bottom texture changes and drag marks that spanned the entire record were noted in the survey log as daily confidence checks. Vessel speed ranged from 6-9 knots, which was well within the range needed to ensure SSS coverage of 3 pings per meter when the 4200 MP was operated in high speed mode. The depth pressure sensor on the towfish was zeroed out in air on a daily basis to account for changes in atmospheric pressure. As a QC check on towfish depth and altitude detection, the sum of the towfish altitude and depth were frequently compared to water depth from the MBES.

On the H.F. Stout, a 400/900 kHz Edgetech 4125 SSS was operated at the 50m range exclusively using the 900 kHz frequency. The 400 kHz frequency was not used because it interfered with the MBES. The 4125 SSS was fix-mounted so altitude was a function of water depth and not adjustable. HSSD altitude specification compliance was handled in post-processing.

Data Processing Methods and Procedures

Preliminary QA/QC of the SSS data occurred simultaneously with data acquisition. However, all final data processing occurred at OSI's home office. Once the data were received from the field, the data files and acquisition log were reviewed to verify line names and file size and to remove any aborted lines from the preprocess folder prior to converting the data in CARIS HIPS. All lines copied from the acquisition computer were entered into the survey processing log, which was used to track the processing progress of each line and to record all notes pertinent to individual lines or days.

Preliminary processing steps were conducted prior to the import of *.jsf SSS files into CARIS SIPS. Towed SSS *.jsf files were first passed through SonarWiz for initial bottom tracking and to smooth the navigation. A 100-point smoothing window was applied to the 2 Hz positions received from the HYPACK towfish.dll and recorded in the *.jsf. Bottom tracking and smooth navigation were exported from SonarWiz as *.csv files.

For the fix-mounted SSS, since the towfish was mounted directly above the MBES on the sounder pole, the altitude field was computed by appliying a vertical offset to the MBES nadir depth using HYPACK. During post processing, SBET position and heading data were substituted for realtime navigation. The fixed-mount SSS vessel file is not a "zero" configuration. The fixed-mount SSS vessel file includes forward and starboard towpoint offsets which allowed the fish position to be recomputed using IAPPK SBETs in CARIS SIPS. The fixed-mount configuration did not have a variable "cable out" field; therefore, this value is always shown as zero.

CARIS HVFs were created to convert EdgeTech JSF data files. All Preprocess EdgeTech JSF data were converted to the HDCS data format in the CARIS' Conversion Wizard. Parameters developed during the preliminary processing steps described above were imported and applied with the CARIS Generic Data Parser.

Navigation time stamp irregularities were edited, and navigation data were reviewed in the CARIS Navigation Editor. Each side scan line was reviewed in CARIS Attitude Editor to ensure that the towfish attitude was properly represented and there were no gaps or problems with this parameter.

The CARIS SIPS bottom tracking routine was then employed to format and review the imported bottom tracking solution and make the relatively few minor corrections/edits that were needed. The CARIS Side Scan Editor was used to bottom track, slant range correct, and apply image enhancement correction to the data.

Lines were beam-pattern corrected to normalize angular response across the swath. Average sound speed from each respective day was applied during mosaicking. The sound speed used in mosaicking each day's imagery is noted in the processing log.

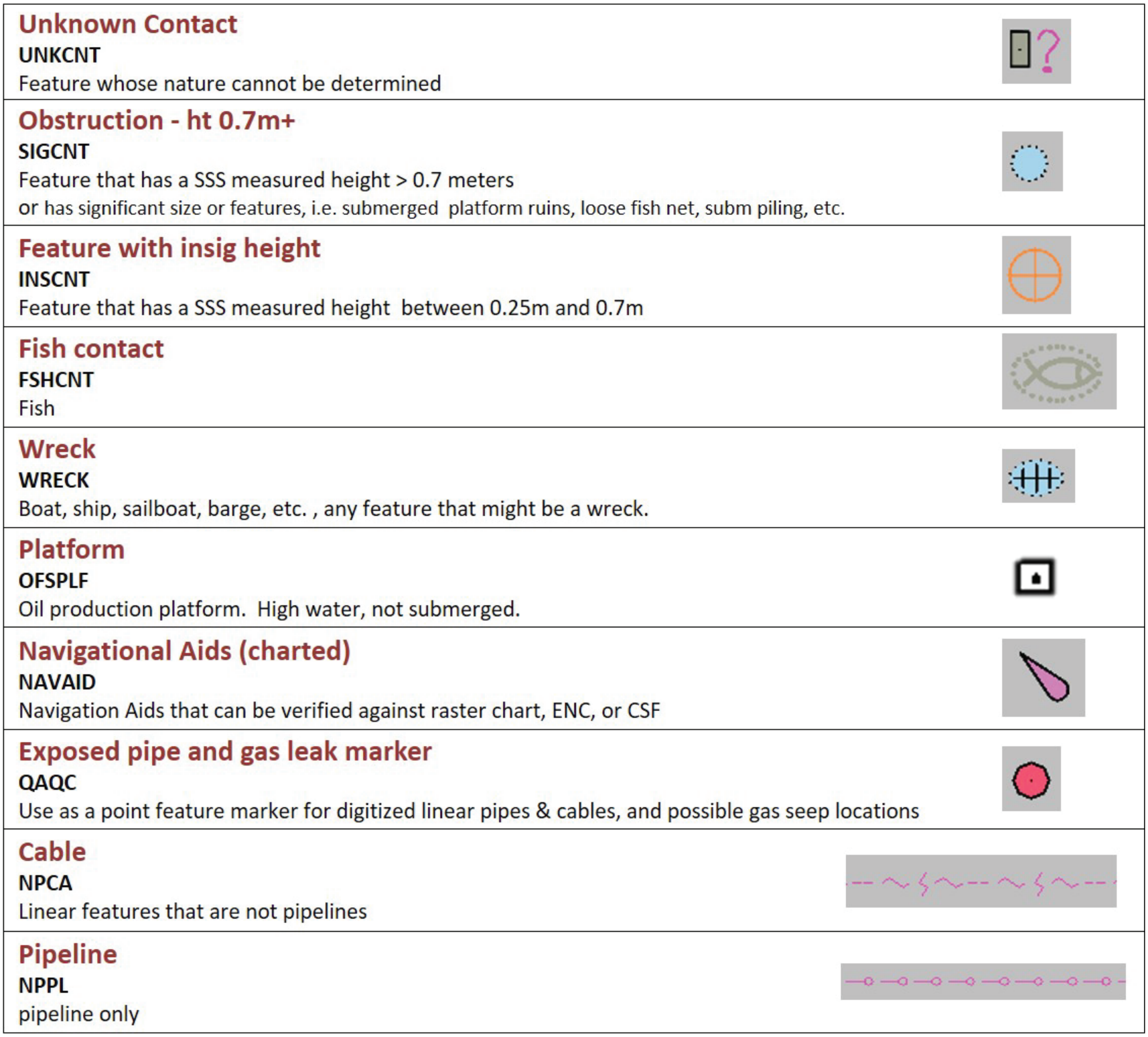
In order to ensure sufficient coverage, individual line mosaics were created with a resolution of 0.15m. The line mosaics were then merged and saved as 0.25m resolution sheet mosaic. The sheet mosaics were reviewed for coverage gaps and poor-quality imagery that required SSS fill-in lines. Fill-in lines were assigned to the field team, as necessary, to supplement the existing coverage. After the completion of survey and processing operations, the final sheet mosaics were exported as individual GeoTiffs at 1m resolution.

Once initial image processing was completed, contacts were selected in the Side Scan Editor waterfall. The CARIS HIPS/SIPS *.hips database files were modified by OSI to include additional Contact Feature types with which to classify contacts in Side Scan Editor. The additional contact types are included in Figure 19, along with their graphical display in CARIS HIPS and a brief description of the conditions under which the contact type is selected.

Objects were identified by the presence of sonar shadows. Contacts were positioned and created at the top (closest to nadir) of the shadow, and attributed with the following information: feature type (obstruction, platform, unknown, wreck), height, width & length (if significant per the HSSD), and processor remarks. Heights were measured with the shadow tool, lengths and widths were measured with the distance tool.

SSS lines were reviewed a minimum of two times by more than one data analyst to make certain that all significant contacts were selected that may require investigation. The contacts selected in Side Scan Editor were visible in the HIPS and SIPS Display window. Contacts were reviewed in CARIS Subset Editor using full sounding density while toggling views between visible and hidden rejected soundings.

Picked contacts were exported from HIPS and SIPS to an ASCII text file, which was reformatted and imported into a CARIS edit layer (.HOB file). Senior processing personnel would identify the contacts that required additional investigation from the contact HOB file and from supporting data such as geo-referenced photographs, boat targets and notes in the survey log. An item investigation HOB layer was then created which included the positions of all side scan contacts and outstanding soundings to be developed with additional MBES coverage. The Investigation HOB layer was exported to an S-57 (.000) file which could be opened as a background layer in HYPACK SURVEY during investigations.



| | |
|---|---|
| **Unknown Contact**<br>**UNKCNT**<br>Feature whose nature cannot be determined | |
| **Obstruction - ht 0.7m+**<br>**SIGCNT**<br>Feature that has a SSS measured height > 0.7 meters<br>or has significant size or features, i.e. submerged platform ruins, loose fish net, subm piling, etc. | |
| **Feature with insig height**<br>**INSCNT**<br>Feature that has a SSS measured height between 0.25m and 0.7m | |
| **Fish contact**<br>**FSHCNT**<br>Fish | |
| **Wreck**<br>**WRECK**<br>Boat, ship, sailboat, barge, etc. , any feature that might be a wreck. | |
| **Platform**<br>**OFSPLF**<br>Oil production platform. High water, not submerged. | |
| **Navigational Aids (charted)**<br>**NAVAID**<br>Navigation Aids that can be verified against raster chart, ENC, or CSF | |
| **Exposed pipe and gas leak marker**<br>**QAQC**<br>Use as a point feature marker for digitized linear pipes & cables, and possible gas seep locations | |
| **Cable**<br>**NPCA**<br>Linear features that are not pipelines | |
| **Pipeline**<br>**NPPL**<br>pipeline only | |

*Figure 19: Modified OSI Contact Types Selected in Side Scan Editor*

### C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

## C.3 Horizontal and Vertical Control

### C.3.1 Horizontal Control

#### C.3.1.1 GNSS Base Station Data

Data Acquisition Methods and Procedures

To supplement CORS-based IAPPK SBET processing, OSI installed a temporary GNSS station at the U.S. Army Corps of Engineers Freshwater Bayou Canal Lock. A Trimble NetR9 GNSS receiver with a Zephyr 3 Geodetic Antenna was installed on the roof of the lock house located at the southeastern corner of the lock. The NetR9 was configured to record GNSS observables continuously throughout the period of the survey and parse data observables into daily files for each 24-hour period. There were no outages of the base station record during survey operations.

The configuration of the NetR9 was based on UNAVCO standard configuration settings for this device. GNSS observables were recorded on removable media as well as on the NetR9's internal storage. Data were delivered to OSI's home office processing center via regular automated FTP and e-mail "pushes." Pushes were transmitted over a network connection that was established on site for this purpose. The Trimble NetR9 was included in IAPPK processing and designated as Ocean Surveys Freshwater Lock or "OSFL."

Data Processing Methods and Procedures

For both vessels, realtime positioning was replaced by Applanix SmartBase (ASB) derived SBET positioning in NAD83 during the processing workflow. ASB processing was organized into POSPac projects by vessel and day. The total number of CORS stations included in ASB processing was occasionally varied from one POSPac project to the next (i.e. vessel-day) based on CORS data availability and solution quality. OSFL was used in all solutions. The final coordinates of OSFL were determined using OPUS. A discussion of OPUS data processing and the determination of final station coordinates is included in the HVCR.

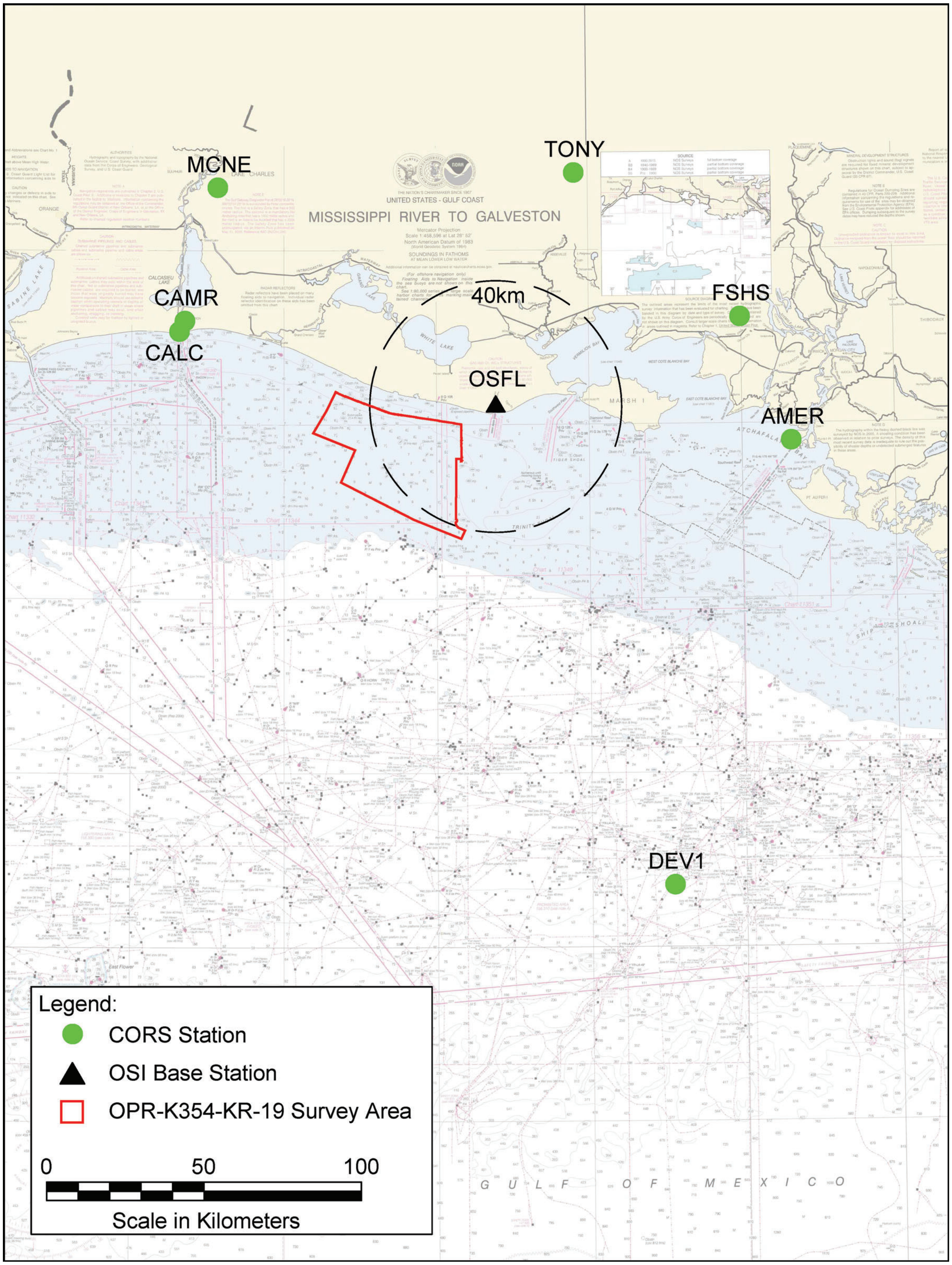



*Figure 20: Local CORS network used in Applanix Smart Base (ASB) IAPPK processing.*

#### C.3.1.2 DGPS Data

DGPS data was not acquired.

### C.3.2 Vertical Control

#### C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

Per the Project Instructions, the determination of MLLW water levels for sounding reduction was perfomed with Ellipsoidally Referenced Survey (ERS) methods. Inertially Aided Post Processed Kinematic (IAPPK) ellipsoid heights were computed using POSPac MMS, Applanix SmartBase (ASB) processing. The ellipsoid heights in the resulting Smoothed Best Estimate Trajectory (SBET) data were used as the basis for the development of ERS Tide. On each vessel, POS *.000 files (for POSPac) were logged continously each day on the main acquisition computer and directly to a USB drive on the POSMV topside processor. A VDatum Separation Model (SEP) was provided by NOAA with the original project files and described in the Project Instructions.

| VDATUM Version | Geoid | Area | Area Version | Separation Uncertainty |
|---|---|---|---|---|
| 3.6.1 | 2012 | LAmobile02 and LATXwest01 | 8301 | 14.1 centimeters |

*Figure 21: VDATUM Separation Model (SEP) Parameters as provided in the Project Instructions*

Data Processing Methods and Procedures

ASB processing was organized into POSPac projects by vessel and by day using the steps described above to generate a set of preliminary SBETs. SBET altitude corrected for heave, dynamic draft, and static draft were reviewed graphically in MATLAB and compared to local NOAA tide gauge water levels for trend and general agreement. If invalid or poor-quality altitude data were contained in the preliminary SBET, additional CORS stations were added to the ASB network and reprocessed to create an improved SBET. As a final step, NOAA's POSPacAutoQC application was used to interpolate through and replace any short time periods of poor-quality or invalid data that remained.

ASB derived ERS tides were smoothed before application to sounding data. After SBETs were exported, a MATLAB script was used to isolate the NAVD 88 tide component of SBET altitude by removing the following components: static draft based on time, dynamic draft based on speed, delayed heave based on time, SEP based on position. The NAVD 88 tide was then smoothed with a 4th order Butterworth low-pass filter with a 3 hour cutoff frequency using MATLAB's "filtfilt" function. Filtfilt runs the filter in forward and reverse resulting in a zero-lag solution. Once the NAVD 88 tide was smoothed, new SBETs were exported after re-applying the SBET altitude components that were removed to isolate the NAVD88 tide.

Once a “smoothed” SBET was generated, it was imported to CARIS HIPS and the CARIS “Compute GPS Tides” function was used in conjunction with the NOAA-provided SEP to create MLLW tide correctors.

Graphical analysis was the primary QA/QC tool used during the development phase of the ERS smoothing routine described above. MATLAB graphs were generated for all conversion and correction steps to identify erroneous source data or MATLAB program code. A discussion of the choice of smoothing parameters is included in the HVCR.

Qualitative and quantitative crossline analyses as well as junction analyses indicate that the final ERS correctors employed in reducing soundings to MLLW were adequate for the purpose. The results of crossline and junction analyses are presented in the Descriptive Report (DR) for each survey.

#### C.3.2.2 Optical Level Data

Optical level data was not acquired.

## C.4 Vessel Positioning

Data Acquisition Methods and Procedures

On the R/V Ocean Explorer, Fugro's SBAS correction service Marinestar was activated on the POS-MV to improve realtime positioning while offshore and as a supplemental option for ERS tide development. On the R/V H.F. Stout, the POS-MV's integrated DGPS was activated utilizing WAAS corrections to improve realtime positioning. Navigation system confidence checks were performed at the beginning of the survey and periodically thereafter (see the HVCR and in DAPR Appendix IV for results).

On both vessels, positioning, attitude and timing data from the POS-MV were transmitted to the data acquisition computer via ethernet through a network switch and recorded in the Hysweep HSX files. POS *.000 files (for POSPac) were also logged continuously each day on the main acquisition computer and directly to a USB drive on the POSMV topside processor.

Data Processing Methods and Procedures

For both vessels, realtime positioning and attitude data were replaced with IAPPK SBET solutions using POSPac MMS and Applanix SmartBase (ASB) processing.

## C.5 Sound Speed

### C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

All sound speed profiles (casts) were acquired either inside the bounds of the survey area or within 250 meters of the boundary. Profiles acquired outside the survey area (within 250 meters) were typically acquired on the approach to a given survey line.

On the R/V Ocean Explorer, sound speed profile data were acquired with the ODIM MVP30 approximately every 15 minutes to a depth approximately 0.8 meters off the bottom. The ODIM MVP Controller software was configured to receive navigation data from HYPACK via the MVP.dll. HYSWEEP survey was configured to receive MVP casts real time to correct the realtime waterfall and profile displays with the most recent sound speed profile. MVP cast position, sound speed and depth data were recorded in *.calc file format and saved to the designated MVP laptop computer. Profiles were named for day number and cast number, for example: MVP_DN254_0007.calc.

On the R/V H.F. Stout, sound speed profiles were acquired approximately every 2 hours using AML- Base X2 hand-deployed sound speed profiler. Profiles were uploaded to a laptop computer with AML-Seacast software and then processed using Sound Speed Manager to convert each *.csv format profile to HYPACK *.vel format for import to HYSWEEP survey.

The hydrographers acquired more frequent profiles if high variability was noted in the surface sound speed, or when the surface sound speed comparison threshold was exceeded (> 2 meters/second change).

Data Processing Methods and Procedures

AML Base X2 profiles collected in *.csv format and MVP 30 files in *.calc format were converted to compatible CARIS SVP format using Sound Speed Manager. Sound speed profiles were applied to the sounding data in CARIS HIPS using the "nearest in time" correction method on the R/V Ocean Explorer, and the "nearest in distance within time" correction method on the R/V H.F. Stout. A time basis of 2 hours was used for both vessels. During CARIS SVP Correction, the following correctors were applied: sound speed, heave, pitch, roll and waterline.

### C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed, measured at the transducer head with the AML Micro-X equipped with a SV Exchange sensor, was output to the Reson 7125 processor for beam forming. The 7125's "Normal" filter was used for sound speed filtering. Raw surface sound speed data was recorded in the HYSWEEP *.HSX files during MBES logging.

Data Processing Methods and Procedures

No additional processing was performed on surface sound speed data, but the data were used as a QA/QC flag in MBES processing. Surface sound speed data were extracted from the HYSWEEP *.HSX files and plotted by vessel and by day. Sounding data collected during periods of high surface sound speed variability were carefully scrutinized for outer beam artifacts.

## C.6 Uncertainty

### C.6.1 Total Propagated Uncertainty Computation Methods

Estimates for the uncertainty of all measurements associated with sounding collection were gathered from either reported manufacturer system accuracy or from calculated statistics.

The combined uncertainty value per sounding, or the Total Propagated Uncertainty (TPU), was calculated using CARIS HIPS. Standard deviation values for vessel offsets, motion, draft and alignment measurements were entered into the HVF “TPU values” section at the 1-sigma level. The HVF uncertainty values, along with uncertainties associated with tide and sound speed, were used in combination with the sonar model in the DeviceModels.xml file to assign a total horizontal uncertainty (THU) and total vertical uncertainty (TVU) for every sounding.

The POS MV 320 manufacturer recommended uncertainty values for the heading, heave, roll, pitch and timing measurements were entered in the HVFs. However, the uncertainty of certain parameters (heave, pitch, roll, heading, and position) was superseded later using RMS error values from the ASB post-processed solution accuracy file "smrmsg.out" which contains the position, orientation and velocity RMS after smoothing at 1Hz intervals.

The standard deviation values for the XYZ Offset and static draft measurements were calculated from distances acquired with the steel tape, the coarsest tool used to verify vessel offsets.

The standard deviation for the loading measurement was calculated from the measure down values acquired on the port and starboard sides of each vessel. Pressure gauge-derived static draft values measured on the R/V Ocean Explorer were also included in the calculation.

The uncertainty for the delta draft was established by calculating the standard deviation of the differences between settlement values of reciprocal runs per each vessel speed tested. The settlement curve is included in DAPR Appendix III.

The MRU Alignment standard deviation values were calculated from the bias values estimated by multiple hydrographers who had individually processed the patch test data.

The Tide Measurement uncertainty is variable and is applied in CARIS HIPS based on post processed uncertainties from SBET RMS files generated in POSPac. Similarly, post processed uncertainties associated with vessel roll, pitch, heading and navigation are applied in CARIS HIPS.

Sound speed TPU values were estimated from sensor manufacturer-stated accuracy and from guidance in the OCS Field Procedures Manual (FPM), Appendix 4, CARIS HVF Uncertainty Values.

### C.6.2 Uncertainty Components

#### C.6.2.1 A Priori Uncertainty

| *Vessel* | | R/V Ocean Explorer | R/V H.F. Stout |
|---|---|---|---|
| *Motion Sensor* | *Gyro* | 0.02 degrees | 0.02 degrees |
| | *Heave* | 5.00%<br>0.05 meters | 5.00%<br>0.05 meters |
| | *Roll* | 0.02 degrees | 0.02 degrees |
| | *Pitch* | 0.02 degrees | 0.02 degrees |
| *Navigation Sensor* | | 1.00 meters | 1.00 meters |

#### C.6.2.2 Real-Time Uncertainty

Real-time uncertainty was not applied.

## C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

Following the field team's completion of investigation and development tasks, feature verification and sonar coverage confirmation were accomplished through intensive review employing various data sources and software. Prior to the conclusion of survey operations, the home office project manager reviewed the data to ensure the following:

-The appropriate MBES coverage (by sheet) was obtained over significant SSS contacts.
-Charted soundings were verified or disproved with MBES coverage per guidance included in HSSD Section 5.2.2.1. Bathymetric Splits.
-CSF "assigned" items were adequately addressed.
-Photos were obtained of high-water features, e.g. platforms.

Data Processing Methods and Procedures

The item investigation and development lines were converted and processed in CARIS HIPS following the bathymetry processing procedures outlined above. CUBE surfaces with the appropriate grid resolution were created for each sheet over the investigated significant features. The density layers were reviewed to verify that the Multibeam Coverage requirement of 5 soundings per node was met.

Contacts were evaluated with correlating SSS, BASE surfaces, charted information, and designated soundings. Significant contacts were evaluated in full density sounding subsets to ensure that there was adequate MBES coverage.

Contacts, contact images, and designated soundings were exported from CARIS HIPS and SIPS. All contacts were imported into a HOB file which was the foundation of the S-57 SSS Contact File included with the project deliverables. The designated soundings were imported into a HOB file, and were also included in the production of the S-57 Final Feature File (FFF).

Shoal soundings, designated soundings and contacts were compared to the largest scale charts in the survey area to identify Dangers to Navigation (DTONs). All DTONs were submitted to AHB as attributed S-57 .000 files per the specifications laid out for Contractors in the HSSD. All features submitted as DTONs are included in the FFF.

### C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Bottom samples were acquired by the R/V H.F. Stout at the locations specified in the Project Instructions and accompanying data package. For each location, a sample was collected using a pipe dredge and brought to the deck. Sample time and position were recorded and each sample was photographed and described.

Data Processing Methods and Procedures

Bottom sample descriptions and photographs were included in the FFF and attributed in accordance with HSSD Appendix G.

## D. Data Quality Management

## D.1 Bathymetric Data Integrity and Quality Management

### D.1.1 Directed Editing

After the lines were run through the appropriate Process Designer model, they were added to 1m Cleaning/ Coverage surfaces. Depth, Standard Deviation and Shoal surface models were viewed with sun illumination and/or vertical exaggeration to highlight areas that would require immediate investigation. Standard deviation surfaces were reviewed to evaluate data for consistency between overlapping coverage and crosslines, and to detect any systematic position, motion, tide, or sound speed errors. The highest standard deviation values were observed over obstruction features, seafloor depressions, and in the vicinity of offshore platforms. Additional directed editing was performed using CARIS HIPS Swath Editor and Subset Editor to remove fliers and noise not handled during filtering, while taking care to preserve features. As a result of discussions with AHB, OSI rejected portions of outer range multibeam that displayed sound speed artifacts which could not be corrected sufficiently with frequent sound speed profiles. The cause of the artifacts was attrtibuted to a extraordinarily steep gradients in the sound speed profile at or near draft depth. See project correspondence and individual DRs for a more complete discussion.

### D.1.2 Designated Sounding Selection

Full-density soundings were reviewed for each SSS contact or significant MBES feature in the CARIS Subset Editor and a sounding was designated for the representative least depth of significant contacts.

“Outstanding” sounding flags were temporarily assigned to soundings on features, or possible features, which required further review. Occasionally, a request would be sent to the field crew for additional coverage on a feature for clarification. Before finalizing the survey, all Outstanding soundings were reviewed and resolved, then either marked as “Accepted” or “Designated” as appropriate. No soundings were left with an “Outstanding” flag.

The “Designated” flag was used to identify the least depth of a significant feature and ensure that the least depth would be represented in the finalized CUBE surfaces. When a designated sounding was assigned to a feature, it indicated that no further investigation was required. OSI followed Section 5.2.1.2.3 of the HSSD guidance on the criteria for choosing designated soundings. Near-nadir soundings were designated as least depths on features in lieu of outer-beam soundings whenever possible. In the instance that soundings from multiple MBES lines suggested different least depths, the contact heights measured in side scan editor were reviewed to assist with least depth designation and near nadir soundings were favored over outer beam soundings.

### D.1.3 Holiday Identification

Coverage surfaces were checked for any data gaps meeting the criteria described in HSSD Section 5.2.2.3 (Complete Coverage). All surfaces were reviewed to ensure that the appropriate coverage was obtained over significant shoals and features. Density layers were reviewed and analyzed to verify that at least 95% of all nodes were populated with at least 5 soundings.

#### D.1.4 Uncertainty Assessment

The HydrOffice "QC Tools" application was used to calculate TVU QC, determined by a ratio of uncertainty to the allowable error per NOAA and IHO specifications.

Results are reported and analyzed in the individual DR for each sheet.

#### D.1.5 Surface Difference Review

##### D.1.5.1 Crossline to Mainscheme

To evaluate crossline to mainscheme line differences, separate 1m CUBE surfaces were created for crosslines and maincsheme lines in each sheet. Comparisons were made by computing the overlapping node to node differences. Histograms, basic statistics, and a discussion of the comparison are included in the DR for each sheet.

##### D.1.5.2 Junctions

Junction analyses between indivdual sheets in OPR-354-KR-19 and bordering sheets assigned in the Project Instructions were evaluated using the same method as crossline to mainscheme comparisons. Results are included in the DR for each sheet.

##### D.1.5.3 Platform to Platform

A vessel to vessel comparison was made by computing the overlapping node-to-node differences in 1m CUBE surfaces for each vessel. A histogram and basic statistics of the vessel to vessel differences are included in DAPR Appendix V.

### D.2 Imagery data Integrity and Quality Management

#### D.2.1 Coverage Assessment

The Project Instructions for OPR-K354-KR-19 required Complete Coverage for all sheets. MBES coverage surfaces were first checked for any data gaps which met the criteria described in HSSD Section 5.2.2.3 (Complete Coverage). Then all surfaces were reviewed to ensure that the appropriate coverage was obtained over significant shoals and features. Density layers were reviewed and the HydrOffice "QC Tools" application was used to verify that at least 95% of all nodes were populated with at least 5 soundings. SSS coverages were reviewed to ensure that all included data met the specifications in the HSSD for along-track coverage and altitude, and were of sufficent quality to detect featurers.

Three separate image layers were generated and used to confirm that coverage requirements were met. These included the MBES CUBE surface, and SSS coverage mosaics divided into mainscheme and feature disproval coverages. The image layers were reviewed to confirm that gaps in MBES coverage were filled by the mainscheme SSS mosaic. For feature disprovals, gaps in MBES coverage were reviewed to ensure they were covered by both SSS coverage mosaics.

**D.2.2 Contact Selection Methodology**

The criteria used to select contacts was based on the guidance provided in the HSSD Section 6.1.3.3 Side Scan Sonar Contacts, which defines a contact as significant based on its measured shadow height within different depth ranges. In depths less than 20m, measured shadow heights of 1m or more are considered significant; in depths greater than 20m, shadow heights greater than 5% of the surrounding depth are considered significant.

OSI used a more conservative approach than required when selecting contacts to make certain that significant features would not be overlooked for further investigation or correlation in the MBES record. All contacts with a minimum height of 0.7m (based on shadow length) were selected. Features smaller than 0.7m were sometimes chosen if they appeared navigationally “significant” in relation to the charted depth.

At times there was an abundance of fish within the project area and visible in the data. Fish contacts were created when fish, fish schools, or dolphins created detectable shadows in the side scan record. Singular fish presented themselves in the record most often as hard returns with long detached shadows. Individual fish contacts having a well-defined detached shadow were not investigated further. Where the character of an interpreted individual fish shadow was not convincing, additional data were acquired to disprove the questionable fish feature.

Most side scan contacts were symbolized as point features; however, sections of exposed pipeline were digitized as linear contacts. At times, contacts without a shadow were selected if there was a noteworthy shape or size to the item, despite its insubstantial relief.

# E. Approval Sheet

Field operations contributing to the accomplishment of OPR-K354-KR-19 surveys H13312, H13313, H13314, H13315, H13316, H13317, H13318, and H13319 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report, digital data and accompanying records have been closely reviewed, and are considered complete and adequate per the Statement of Work and Project Instructions.

This report and associated data are considered complete and adequate for its intended purpose.

| Approver Name | Approver Title | Date | Signature |
|---|---|---|---|
| John R. Bean | Chief of Party | 04/14/2020 | John R. Bean<br>2020.04.14 17:15:35 -04'00' |
| David T. Somers | Data Processing Manager | 04/14/2020 | David T. Somers<br>2020.04.14 17:15:52 -04'00' |

# List of Appendices:

| ***Mandatory Report*** | ***File*** |
| --- | --- |
| *Vessel Wiring Diagram* | OPR-K354-KR-19_DAPR_A1.pdf |
| *Sound Speed Sensor Calibration* | OPR-K354-KR-19_DAPR_A2.pdf |
| *Vessel Offset* | OPR-K354-KR-19_DAPR_A3.pdf |
| *Position and Attitude Sensor Calibration* | OPR-K354-KR-19_DAPR_A4.pdf |
| *Echosounder Confidence Check* | OPR-K354-KR-19_DAPR_A5.pdf |
| *Echosounder Acceptance Trial Results* | N/A |