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

Data Acquisition & Processing Report

Type of Survey: *Multibeam,Verticalbeam & Side Scan Sonar*

Project No: *OPR-E350-TJ-16*

Time Frame: *March – August 2016*

LOCALITY

State: *Virginia*

General Locality: *Southern Chesapeake Bay*

2016

CHIEF OF PARTY

CDR Christiaan van Westendorp
National Oceanic and Atmospheric Administration

LIBRARY & ARCHIVES

DATE:

Table of Contents

List of Figures

Data Acquisition and Processing Report

NOAA Ship Thomas Jefferson
Chief of Party: Chris Van Westendorp, CDR/NOAA
Year: 2016
Version: 1
Publish Date: 2016-08-22

A Equipment

A.1 Survey Vessels

A.1.1 Hydrographic Survey Launch 3101 (TJ3101)

<table>
<tr><td>Name</td><td>Hydrographic Survey Launch 3101 (TJ3101)</td></tr>
<tr><td>Hull Number</td><td>3101</td></tr>
<tr><td>Description</td><td>TJ3101 is an aluminum hulled hydrographic survey launch.</td></tr>
<tr><td>Utilization</td><td>TJ3101 is equipped to collect bathymetric data, side scan imagery, and water column profiles. It can operate safely in waters as shallow as 4 meters with a max depth of 175m at 400kHz, 450m at 200kHz.</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><td>LOA</td><td>31 feet</td></tr>
<tr><td>Beam</td><td>10.6 feet</td></tr>
<tr><td>Max Draft</td><td>5.16 feet</td></tr>
</table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td>Full static survey was not performed.</td></tr>
<tr><td>Most Recent Partial Static Survey</td><td><table>
<tr><td>Date</td><td>2014-04-02</td></tr>
<tr><td>Performed By</td><td>National Geodetic Survey</td></tr>
<tr><td>Discussion</td><td>A full survey of launch offsets was performed in April 2014 by NGS personnel while acquiring POSPac data. Side scan sonar offsets were not measured at the same time, as the SSS can only be mounted when the launch is in the davits, not on jacks. Receiver to projector offsets were obtained by hand and entered into the Reson units' hardware menu.</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>Most Recent Full Offset Verification</td><td colspan="2">Full offset verification was not performed.</td></tr>
<tr><td rowspan="3">Most Recent Partial Offset Verification</td><td>Date</td><td>2016-03-08</td></tr>
<tr><td>Method Used</td><td>Shipboard Analysis</td></tr>
<tr><td>Discussion</td><td>Receiver to projector offsets were obtained by hand and entered into the Reson units’ hardware menu.</td></tr>
<tr><td rowspan="3">Most Recent Static Draft Determination</td><td>Date</td><td>2016-03-24</td></tr>
<tr><td>Method Used</td><td>Site tube</td></tr>
<tr><td>Discussion</td><td>Static draft is measured on a daily basis via a sight tube located near the IMU. Measurements were conducted using a steel ruler.</td></tr>
<tr><td>Most Recent Dynamic Draft Determination</td><td colspan="2">Dynamic draft determination was not performed.</td></tr>
</table>

Figure 1: Launch 3101.

A.1.2 Hydrographic Survey Launch 3102 (TJ3102)

<table>
<tr><td>Name</td><td>Hydrographic Survey Launch 3102 (TJ3102)</td></tr>
<tr><td>Hull Number</td><td>3102</td></tr>
<tr><td>Description</td><td>TJ3102 is an aluminum hulled hydrographic survey launch.</td></tr>
<tr><td>Utilization</td><td>TJ3101 is equipped to collect bathymetric data, side scan imagery, and water column profiles. It can operate safely in waters as shallow as 4 meters with a max depth of 175m at 400kHz, 450m at 200kHz.</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><td>LOA</td><td>31 feet</td></tr>
<tr><td>Beam</td><td>10.6 feet</td></tr>
<tr><td>Max Draft</td><td>5.16 feet</td></tr>
</table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table>
<tr><td>Date</td><td>2015-04-02</td></tr>
<tr><td>Performed By</td><td>National Geodetic Survey personnel</td></tr>
<tr><td>Discussion</td><td>A full survey of launch offsets was performed in April 2014 by NGS personnel while acquiring POSPac data. Side scan sonar offsets were not measured at the same time, as the SSS can only be mounted when the launch is in the davits, not on jacks. Receiver to projector offsets were obtained by hand and entered into the Reson units' hardware menu.</td></tr>
</table></td></tr>
<tr><td>Most Recent Partial Static Survey</td><td>Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td>Full offset verification was not performed.</td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td><table>
<tr><td>Date</td><td>2016-03-08</td></tr>
<tr><td>Method Used</td><td>Ship Personnel</td></tr>
<tr><td>Discussion</td><td>Receiver to projector offsets were obtained by hand and entered into the Reson units' hardware menu.</td></tr>
</table></td></tr>
</table>

Most Recent Static Draft Determination	*Date*	2016-03-23
	Method Used	Sight Tube
	Discussion	Static draft is measured on a daily basis via a sight tube located near the IMU. Measurements were conducted using a steel ruler.
Most Recent Dynamic Draft Determination	Dynamic draft determination was not performed.	

Figure 2: Launch 3102

A.1.3 Z-Boat 1

Name	Z-Boat 1
Hull Number	Z-1
Description	Z-1 is a 5.5' polyurethane autonomous survey vessel.
Utilization	The vessel is used to conduct Vertical Beam Echo Sounder (VBES) soundings in shallow areas,

Dimensions	*LOA*	5.5 feet
	Beam	2 feet
	Max Draft	1 feet
Most Recent Full Static Survey	Full static survey was not performed.	
Most Recent Partial Static Survey	*Date*	2016-03-08
	Performed By	Ship's Personnel
	Discussion	Measurements were conducted using a steel tape and laser rangefinder to determine the distance from the primary GPS antenna to the sounder face.
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	*Date*	2016-03-14
	Method Used	Direct Observation
	Discussion	The boat was placed in the water with a full operational load. Waterline readings were then taken using marks made on the side of the hull indicating a distance above the transducer zero point.
Most Recent Dynamic Draft Determination	*Date*	2016-03-24
	Method Used	Comparitive
	Discussion	Dynamic Draft for the Z-Boats was measured by acquiring VBES data over the same area twice on reciprocal courses at the following speed intervals: Hove To (0 knots) 1 knot 2 knots 3 knots 3.5 knots 4 knots 4.5 knots 5 knots 6 knots The purpose for the stated speed intervals was to capture draft at various expected survey speeds.

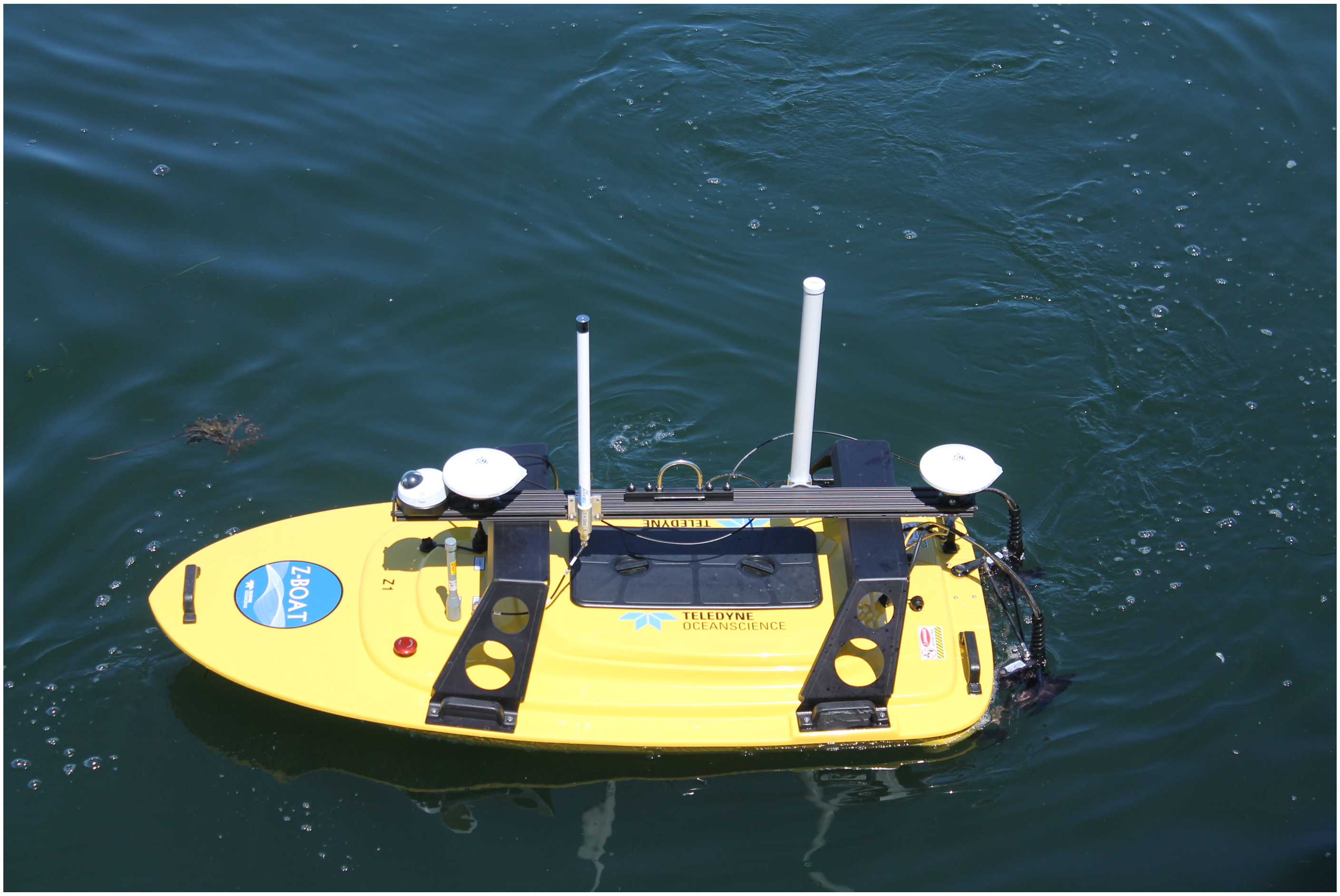


Figure 3: Z-Boat 1 (Z-1)

A.1.4 Z-Boat 2

Name	Z-Boat 2
Hull Number	Z-2
Description	Z-2 is a 5.5' polyurethane autonomous survey vessel.
Utilization	The vessel is used to conduct Vertical Beam Echo Sounder (VBES) soundings in shallow areas, as well as to conduct shoreline verification.
Dimensions	*LOA*: 5.5 feet *Beam*: 2 feet *Max Draft*: 1 feet
Most Recent Full Static Survey	Full static survey was not performed.

Most Recent Partial Static Survey	*Date*	2016-03-18
	Performed By	Ship's Personnel
	Discussion	Measurements were conducted using a steel tape and laser rangefinder to determine the distance from the primary GPS antenna to the sounder face.
Most Recent Full Offset Verification	*Date*	2016-03-18
	Method Used	Direct measurement
	Discussion	Measurements were conducted using a steel tape and laser rangefinder to determine the distance from the primary GPS antenna to the sounder face.
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	*Date*	2016-03-24
	Method Used	Direct observation
	Discussion	The boat was placed in the water with a full operational load. Waterline readings were then taken using marks made on the side of the hull indicating a distance above the transducer zero point.
Most Recent Dynamic Draft Determination	*Date*	2016-04-08
	Method Used	Comparitive
	Discussion	Dynamic Draft for the Z-Boats was measured by acquiring VBES data over the same area twice on reciprocal courses at the following speed intervals: Hove To (0 knots) 1 knot 2 knots 3 knots 3.5 knots 4 knots 4.5 knots 5 knots 6 knots The purpose for the stated speed intervals was to capture draft at various expected survey speeds.

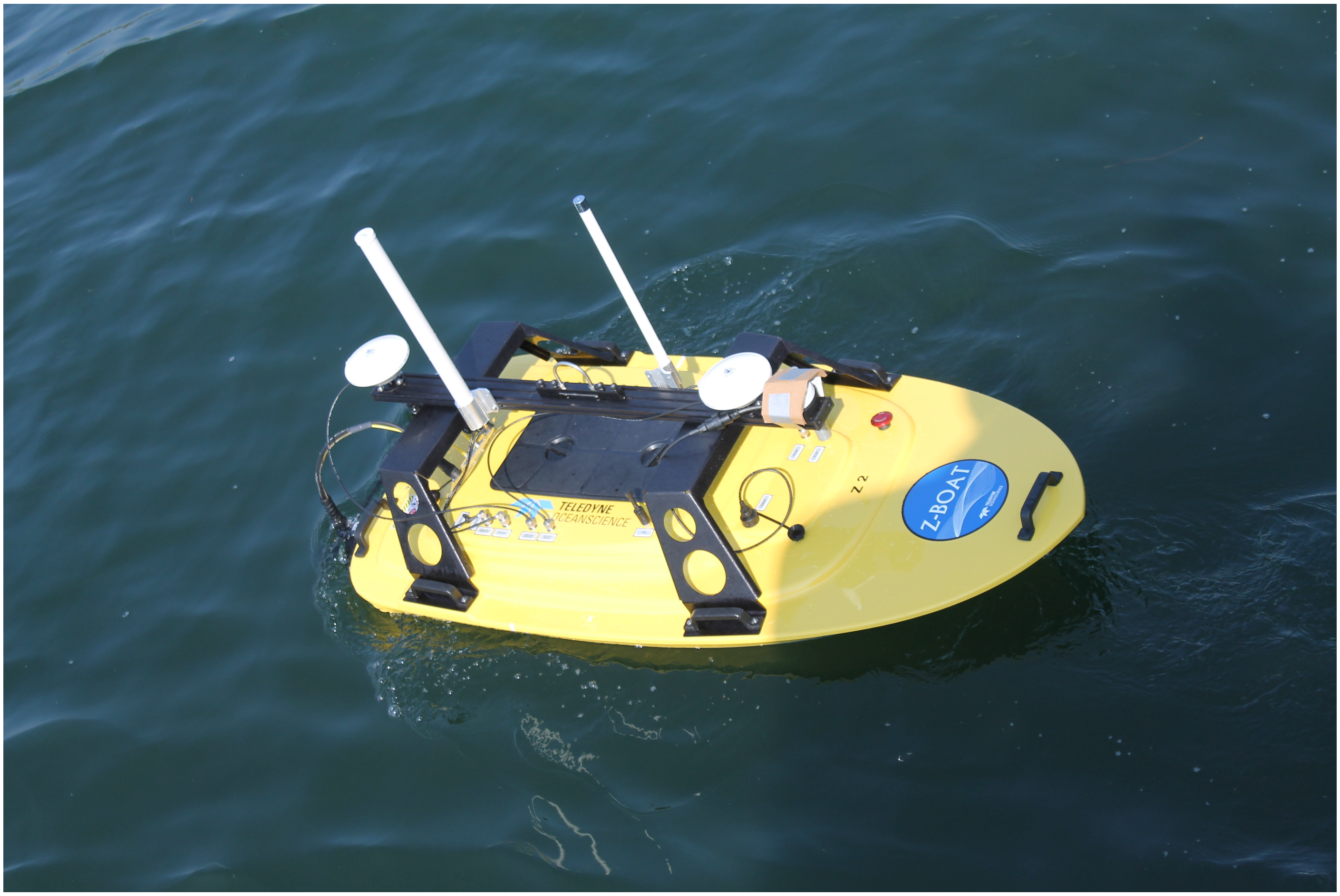


Figure 4: Z-Boat 2

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Klein 5000

Manufacturer	Klein
Model	5000
Description	The Klein High Speed, High Resolution Side Scan Sonar (SSS) system is a beam-forming acoustic imagery device. The integrated system includes a Klein 5000 towfish mounted to

<table>
<tr><td></td><td>the launch hull, a Transceiver/Processing Unit (TPU), and a computer for user interface. The towfish operates at frequency of 455kHz and a vertical beam angle of 40°, and can resolve up to 5 discrete received beams per transducer stave. TJ3101 and TJ3102 use a light-weight hull-mount configuration. The hull mounts on both survey launches can accommodate both standard or lightweight towfish.
Positioning of the Towfish is calculated using Caris SIPS, the vessel's heading, the vessel's Course Made Good (CMG),the towfish depth (from the towfish pressure gauge). Towfish altitude is maintained between 8% and 20% of the range scale unless specifically noted in the Descriptive Report. Vessel speed is adjusted during SSS acquisition to ensure that object detection density is met. Confidence checks are performed by noting changes in linear bottom features extending to the outer edges of the digital side scan image, and by verifying aids to navigation or other known features on the side scan record.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>TPU s/n</td><td>139</td><td>137</td></tr>
<tr><td>Towfish s/n</td><td>319</td><td>320</td></tr>
</table></td></tr>
<tr><td>Specifications</td><td><table>
<tr><td>Frequency</td><td>455 kilohertz</td></tr>
<tr><td>Along Track Resolution</td><td><table>
<tr><td>Resolution</td><td>10 centimeters</td><td>20 centimeters</td><td>36 centimeters</td></tr>
<tr><td>Min Range</td><td>0 meters</td><td>39 meters</td><td>75 meters</td></tr>
<tr><td>Max Range</td><td>38 meters</td><td>76 meters</td><td>150 meters</td></tr>
</table></td></tr>
<tr><td>Across Track Resolution</td><td>7.5 centimeters</td></tr>
<tr><td>Max Range Scale</td><td>150 meters</td></tr>
</table></td></tr>
<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
</table>

Figure 5: Klein 5000 Side Scan Sonar towfish

A.2.2 Multibeam Echosounders

A.2.2.1 Reson SeaBat 7125-SV2

Manufacturer	Reson
Model	SeaBat 7125-SV2
Description	The Reson SeaBat 7125-SV2 is a dual frequency (200/400kHz), high-resolution multibeam echo sounder system for shallow-water depths. The recommended maximum range at 200kHz is 450m resulting in a 225 m depth limit for full swath coverage on a flat bottom. The 400kHz setting maximum range is 175m resulting in a 87m depth limit for full swath coverage on a flat bottom. The transducer assembly consists of single flat-faced receiver array and one curved projector, which can transmit at either 200kHz or 400kHz. Bathymetric data from the 7125 SV2 is used to provide object detection and complete coverage in shallow water.

The system is installed on TJ3101 and TJ3102 using a Reson sled mount which is attached to a retractable arm. The integrated system includes a dual 200kHz & 400 kHz Projector unit, a Receiver unit, and a topside 7-P Sonar Processor Unit (TPU). The projector and receiver are set up in a Mills Cross configuration. The 7125-SV2 produces a across track swath of 140° in equidistant mode and 165° in equi-angle mode. At 200kHz the across track transmit swath is resolved into 256 discrete beams by the receive array. Each beam is has a resolution of 2° across track and 1° along track. At 400kHz the across track swath is resolved into 512 discrete beams by the receive array. Each beam has a resolution of 1° across track and 0.5° along track. The Reson 7125-SV2 can be configured for roll stabilization. In roll-stabilized mode, the sonar can operate in environments with up to +/- 10 degrees of roll without degrading system performance. Sound velocity at the face of the transducer is provided by an integrated Reson SVP-70 sound velocimeter. The 7-P Sonar Processor Unit has the following software versions installed: 7K Center: 7K Center Version # 6.1.0.3, 7K UI Version 6.1.0.3, 7K IO Version 4.2.0.5.

<table>
<tr><td rowspan="7">Serial Numbers</td><td>Vessel Installed On</td><td colspan="2">3101</td><td colspan="2">3102</td></tr>
<tr><td>Processor s/n</td><td colspan="2">18341313046</td><td colspan="2">18340713036</td></tr>
<tr><td>Transceiver s/n</td><td colspan="2">N/A</td><td colspan="2">N/A</td></tr>
<tr><td>Transducer s/n</td><td colspan="2">N/A</td><td colspan="2">N/A</td></tr>
<tr><td>Receiver s/n</td><td colspan="2">1513550</td><td colspan="2">1409071</td></tr>
<tr><td>Projector 1 s/n</td><td colspan="2">1513528</td><td colspan="2">1214104</td></tr>
<tr><td>Projector 2 s/n</td><td colspan="2">n/a</td><td colspan="2">n/a</td></tr>
<tr><td rowspan="11">Specifications</td><td>Frequency</td><td colspan="2">400 kilohertz</td><td colspan="2">200 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>1 degrees</td><td>Along Track</td><td>2 degrees</td></tr>
<tr><td>Across Track</td><td>0.5 degrees</td><td>Across Track</td><td>1 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">50 hertz</td><td colspan="2">50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equidistant</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>512</td><td>Number of Beams</td><td>256</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">140 degrees</td><td colspan="2">140 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">6 millimeters</td><td colspan="2">6 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>175 meters</td><td>Manufacturer Specified</td><td>450 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td><td>Ship Usage</td><td>200 meters</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="2">Manufacturer Calibrations</td><td>Vessel Installed On</td><td colspan="2">3101</td><td colspan="2">3102</td></tr>
<tr><td>Calibration Date</td><td colspan="2">2016-03-09</td><td colspan="2">2016-03-10</td></tr>
</table>

System Accuracy Tests	*Vessel Installed On*	TJ3101	TJ3102	TJ 3101, TJ3102, Z1 and Z2
	Methods	Lead line comparison	Lead line comparison	Comparison of processed depths between vessels
	Results	On March 23, 2016, a lead line comparison was conducted between the launches multibeam sonars and a lead line lowered over the side while dead in the water. The Reson 7125 SV2 system differed from the lead line by 0.068m.	On March 23, 2016, a lead line comparison was conducted between the launches multibeam sonars and a lead line lowered over the side while dead in the water. The Reson 7125 SV2 system differed from the lead line by -.034m.	The results when comparing 99.98% of all nodes,were found to be within 15 centimeters of each other.
Snippets	Sonar has snippets logging capability.			

Figure 6: RESON SV2 mounted on the retractable arm.

A.2.3 Single Beam Echosounders

A.2.3.1 ODOM Echotrac CV-200

<table>
<tr><td>Manufacturer</td><td colspan="5">ODOM</td></tr>
<tr><td>Model</td><td colspan="5">Echotrac CV-200</td></tr>
<tr><td>Description</td><td colspan="5">The Odom Echotrac CV-200 is a dual frequency, digital recording echo sounder. Identical systems are hull mounted on TJ3101 and TJ3102.</td></tr>
<tr><td rowspan="3">Serial Numbers</td><td>Vessel</td><td colspan="2">TJ3101</td><td colspan="2">TJ3102</td></tr>
<tr><td>Processor s/n</td><td colspan="2">3260</td><td colspan="2">2917</td></tr>
<tr><td>Transducer s/n</td><td colspan="2">TR2160</td><td colspan="2">TR7698</td></tr>
<tr><td rowspan="7">Specifications</td><td>Frequency</td><td colspan="2">24 kilohertz</td><td colspan="2">200 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>20 degrees</td><td>Along Track</td><td>4 degrees</td></tr>
<tr><td>Across Track</td><td>20 degrees</td><td>Across Track</td><td>4 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">20 hertz</td><td colspan="2">20 hertz</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">0.01 meters</td><td colspan="2">0.01 meters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>1500 meters</td><td>Manufacturer Specified</td><td>200 meters</td></tr>
<tr><td>Ship Usage</td><td>1000 meters</td><td>Ship Usage</td><td>150 meters</td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="5">Manufacturer calibration was not performed.</td></tr>
<tr><td rowspan="3">System Accuracy Tests</td><td>Vessel Installed On</td><td colspan="4">TJ3101 and TJ3102</td></tr>
<tr><td>Methods</td><td colspan="4">HSRR Timing and Latency</td></tr>
<tr><td>Results</td><td colspan="4">The ODOM Echotrac systems aboard TJ3101 and TJ3102 are considered backup echo sounders, to be used if the multibeam systems fail. System accuracy tests will be preformed if the systems are activated.</td></tr>
</table>

A.2.3.2 ODOM Echotrac CV100

Manufacturer	ODOM
Model	Echotrac CV100
Description	The Odom Echotrac CV100 is a dual frequency, digital recording echosounder.

Serial Numbers	*Vessel*	Z-Boat 1		Z-Boat 2	
	Processor s/n	005997		Unknown	
	Transducer s/n	N/A		N/A	
Specifications	*Frequency*	24 kilohertz		200 kilohertz	
	Beamwidth	*Along Track*	20 degrees	*Along Track*	4 degrees
		Across Track	20 degrees	*Across Track*	4 degrees
	Max Ping Rate	20 hertz		20 hertz	
	Depth Resolution	0.01 meters		0.01 meters	
	Depth Rating	*Manufacturer Specified*	100 meters	*Manufacturer Specified*	100 meters
		Ship Usage	10 meters	*Ship Usage*	10 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.				
System Accuracy Tests	*Vessel Installed On*	Z-Boat 1 and Z-boat 2			
	Methods	Reference Surface			
	Results	A comparison between data acquired between Launch 3101's Reson 7125 and the Odom CV100 on Z-1 yielded a mean difference of 0.135m, the difference between Z-2 and 3101 is 0.006m. Comparison between Z-1 and Z-2 yielded a difference of 0.129 meters.			

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

No lead lines were utilized for data acquisition.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Positioning and Attitude Equipment

A.4.1 Applanix POS/MV

Manufacturer	Applanix (a Trimble company)
Model	320 v.4
Description	TJ3101 and TJ3102 are equipped with Applanix POS/MV 320 Position and Orientation Sensors version 4 to measure and calculate position and attitude. The POS/MV is a GPS-aided inertial navigation system, which provides a blended position solution derived from both an Inertial Motion Unit (IMU) and an integrated GPS receiver. The IMU and GPS receiver are complementary sensors, and data from one are used to filter and constrain errors from the other. Position accuracy is displayed in real time by the POS/MV software and was monitored to ensure that positioning accuracy requirements as outlined in the NOS Hydrographic Surveys Specifications and Deliverables (HSSD) were not exceeded. In addition, the POS/MV software displays HDOP and the number of satellites used in position computation. Data acquisition was generally halted when an HDOP of 2.5 was exceeded or the number of satellites available dropped below four. However, because positional accuracy can be maintained by the POS/MV through short GPS outages with the help of the IMU, data acquisition was not halted during short periods of time when the HDOP and number of satellites used exceeded stated parameters. It has yet to be identified if this practice needs to be modified when using the MarineStar service or what the new operational constraints may be.

<table>
<tr><td></td><td>In addition to position, the Applanix POS/MV also provides accurate navigation and attitude data to correct for the effects of heave, pitch, roll and heading. The POS/MV generates attitude data in three axes (roll, pitch and heading) to an accuracy of 0.02° or better. Heave measurements supplied by the POS/MV maintain an accuracy of 5% of the measured vertical displacement for movements that have a period of up to 20 seconds. The Heave Bandwidth filter was configured with a damping coefficient of 0.707. The cutoff period of the high pass filter was determined by estimating the swell period encountered on the survey grounds. These values ranged from 8 seconds (flat water) to 20 seconds (long period ocean swell), with values of 8 or 12 seconds typically. Currently the launches are set to 8 seconds. Intermittent problems with the heading accuracy climbing above the ideal cutoff of 0.05° are observed. Heading accuracy is monitored by the launch crew and survey operations are temporarily suspended in the event that the error exceeds 0.08°. Applanix “TrueHeave” values are also recorded. The TrueHeave algorithm uses a delayed filtering technique to eliminate many of the artifacts present in real time heave data. The TrueHeave data were applied to Reson bathymetry in Caris HIPS post processing. Full POSPac data are recorded on both survey launches. This data is used to post process POS/MV data to produce superior position and attitude data in the form of a Smoothed Best Estimate of Trajectory (SBET) which is then applied in Caris.</td></tr>
<tr><td>PCS</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>320 v.4</td></tr>
<tr><td>Description</td><td>The PCS blends raw acceleration measurements from the IMU, with position information from the GPS antennas and RTCM correctors received via 4G network, creating a tightly-coupled centimeter position and orientation solution. The PCS outputs a one Pulse Per Second (PPS) signal to integrated systems to accurately time-stamp data.</td></tr>
<tr><td>Firmware Version</td><td>5.08</td></tr>
<tr><td>Software Version</td><td>5.8.0.0</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>PCS s/n</td><td>3245</td><td>3954</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td rowspan="5">IMU</td><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>LN 200</td></tr>
<tr><td>Description</td><td>The POS M/V Inertial Measurement Unit (IMU) is used to record the amount of heave, pitch, and roll experienced by the vessel. The IMU is located at the vessel's central reference point, and is strapped down to the vessel. Since the IMU is fixed to the vessel, the motion experienced by the IMU is, by definition, the same motion experienced by the vessel. The IMU housing contains three orthogonally placed accelerometers, which sense acceleration in the x, y, and z directions. It also contains three orthogonally placed gyros, which sense angular rate of motion around the three axes. The measured amount of acceleration and rate of rotation is then used to find the degree of pitch, roll, and heave experienced by the vessel. Data from the IMU is also combined with data from the GNSS antennas to calculate vessel heading.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>TJ3101</td><td>TJ3102</td></tr><tr><td>IMU s/n</td><td>131</td><td>356</td></tr></table></td></tr>
<tr><td>Certification</td><td><table><tr><td>IMU s/n</td><td>356</td></tr><tr><td>Certification Date</td><td>2014-01-21</td></tr></table></td></tr>
<tr><td rowspan="8">Antennas</td><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>GA830</td></tr>
<tr><td>Description</td><td>High Gain GNSS/MSS antenna</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>Antenna s/n</td><td>Port or Starboard</td><td>Primary or Secondary</td></tr><tr><td>3102</td><td>5389</td><td>Port</td><td>Primary</td></tr><tr><td>3102</td><td>9999</td><td>Starboard</td><td>Secondary</td></tr></table></td></tr>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>GA830</td></tr>
<tr><td>Description</td><td>High gain GNSS/MSS antenna.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>Antenna s/n</td><td>Port or Starboard</td><td>Primary or Secondary</td></tr><tr><td>3101</td><td>8240</td><td>Port</td><td>Primary</td></tr><tr><td>3101</td><td>7991</td><td>Starboard</td><td>Secondary</td></tr></table></td></tr>
</table>

GAMS Calibration	*Vessel*	TJ3101	TJ3102
	Calibration Date	2016-03-14	2016-03-14
Configuration Reports	*Vessel*	TJ3101	TJ3102
	Report Date	2016-03-14	2016-03-14

A.4.2 DGPS

Description	Fugro MarineStar is a commercial service that provides real-time GPS correctors via satellite. The correctors are derived using a Precise Point Positioning (PPP) approach and are based on a state estimation of the GPS system rather than a differential correction. The state estimation includes real-time estimate of satellite orbits, clock errors, and atmospheric delays. The specified accuracy advertised by MarineStar are generally less than 10cm in the horizontal and 15cm in the vertical at 95% confidence interval. The MarineStar corrector signal is received on the L1 channel of the primary POS antenna and is logged directly into the POS PCS. As such, no additional antenna or receiver equipment is necessary.			
Antennas	*Manufacturer*	Trimble		
	Model	GA530		
	Description	RTCM DGPS antenna that is designed to be placed on a rover unit. The antenna receives L1, L2, Beacon, MarineStar, and SBAS signals.		
	Serial Numbers	*Vessel Installed On*	TJ3101	Tj3102
		Antenna s/n	13008	12987
Receivers	*Manufacturer*	Trimble		
	Model	SPS-461		
	Description	The Trimble SPS-461 GPS is used for horizontal and vertical positioning of TJ's two Z-Boats. Connected to two antennae, the receiver also provides a heading value. The GPS is also used to apply the Real Time Kinematic corrector discussed in section A.6 of this report.		
	Firmware Version	5		
	Serial Numbers	*Vessel Installed On*	Z-1	Z-2
		Antenna s/n	5551R80002	5551R80011

A.4.3 Trimble Backpacks

Trimble backpack equipment was not utilized for data acquisition.

A.4.4 Laser Rangefinders

Manufacturer	Laser Technology Inc.
Model	TruPulse 360 R
Description	LTI TruPluse 360 R is a hand held laser range finder. The device can be operated in 5 modes: horizontal distance, vertical distance, slope distance and inclination (or percent slope), 3-point flexible height routine with auto sequencing, and 2-shot missing line routine. There are also 5 target modes which are standard, closest, farthest, continuous, and filter. The Measurement range is 0 to 3280ft typical and 6560ft max to reflective target, inclination range of +/- 90 degrees and an azimuth range 0 to 359.9 degrees. The range finder is accurate in distance +/- 0.30 meters to high quality targets and +/-1 meter to low quality targets, inclination accuracy of +/-0.25 degrees and azimuth accuracy of +/- 1 degree.
Serial Numbers	000172
DQA Tests	DQA test was not performed.

Figure 7: TruPulse 360 R

A.4.5 Other Positioning and Attitude Equipment

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

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profiles

A.5.1.1 CTD Profilers

A.5.1.1.1 Sea-Bird Electronics SBE19+

<table>
<tr><td>Manufacturer</td><td>Sea-Bird Electronics</td></tr>
<tr><td>Model</td><td>SBE19+</td></tr>
<tr><td>Description</td><td>TJ3101, and TJ3102 all use Sea-Bird Electronics SeaCat SBE19+ Conductivity, Temperature, and Depth (CTD) Profilers to collect vertical sound speed profiles. The speed of sound is calculated from temperature, salinity, and pressure measurements. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated via strain gauge pressure. The system is configured for a sampling rate of 0.5 seconds. Aboard the launches, the profiler is deployed by hand.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>TJ3102</td><td>TJ3101</td></tr>
<tr><td>CTD s/n</td><td>19P33589-4486</td><td>19P33589-4487</td></tr>
</table></td></tr>
<tr><td>Calibrations</td><td><table>
<tr><td>CTD s/n</td><td>19P60744-6667</td><td>19P33589-4486</td><td>19P33589-4487</td></tr>
<tr><td>Date</td><td>2016-01-12</td><td>2015-05-19</td><td>2016-01-25</td></tr>
<tr><td>Procedures</td><td>Calibrations performed by Sea-Bird Electronics</td><td>Calibrations performed by Sea-Bird Electronics</td><td>Calibrations performed by Sea-Bird Electronics</td></tr>
</table></td></tr>
</table>

Figure 8: Sea-Bird 19+ CTD used aboard Thomas Jefferson S-222 and her survey launches.

A.5.1.2 Sound Speed Profilers

No sound speed profilers were utilized for data acquisition.

A.5.2 Surface Sound Speed

A.5.2.1 Reson SVP-71

<table>
<tr><td>Manufacturer</td><td colspan="3">Reson</td></tr>
<tr><td>Model</td><td colspan="3">SVP-71</td></tr>
<tr><td>Description</td><td colspan="3">TJ3101 and TJ3102 us a Reson SVP-71 to collect the speed of sound at the face of the Reson 7125-SV2 transducers. The sensor is bolted to the mounting sled, near the face of the transducer. The speed of sound is measured directly using a 'time-of-flight' sensor, and integrated directly into the Reson processing unit.</td></tr>
<tr><td rowspan="2">Serial Numbers</td><td>Vessel Installed On</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>Sound Speed Sensor s/n</td><td>4211067</td><td>0810065</td></tr>
<tr><td rowspan="3">Calibrations</td><td>Sound Speed Sensor s/n</td><td>4211067</td><td>0810065</td></tr>
<tr><td>Date</td><td>2016-02-17</td><td>2016-02-17</td></tr>
<tr><td>Procedures</td><td>Calibration was performed by Teledyne RESON, Inc</td><td>Calibration was performed by Teledyne RESON, Inc</td></tr>
</table>

Figure 9: Reson SV-71 Sound Velocity Probe used for surface sound speed aboard TJ3101 & TJ3102

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.6.1.2 Rover Equipment

No rover equipment was utilized for data acquisition.

Additional Discussion

The Horizontal Datum for all projects is the World Geodetic system 1984 (WGS 84) zone 18 north. During data acquisition and initial processing, horizontal control for all survey data is derived from either Real Time Kinematic (RTK) correctors or from the MarineStar realtime satellite corrector service.

If RTK is used,there is no post processing to create a Smooth Best Estimate Trajectory (SBET) positioning. In the case of MarineStar, SBETs are used to transform the reference frame from ITRF00 to WGS 84. A more detailed discussion of the processing pipeline is included in Section C.4.

A.6.2 Vertical Control Equipment

A.6.2.1 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.6.2.2 Leveling Equipment

No water level gauges were utilized for data acquisition.

Additional Discussion

Vertical control for this survey will be managed via the ellipse, (e.g. RTK, PPK, PPP). All survey lines are reduced to MLLW via the VDatum SEP model provided with the project instructions. Unless otherwise stated in the specific Descriptive Report, see Section C.5 for more details on the different methods used to reduce data to tidal datum.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

Manufacturer	Individual computers utilized are not discussed in this report.
Model	See Additional Discussion for more information.
Description	N/A
Serial Numbers	<table><tr><td>*Computer s/n*</td><td>*Operating System*</td><td>*Use*</td></tr><tr><td>N/A</td><td>N/A</td><td>Acquisition and Processing</td></tr></table>

A.7.2 Computer Software

Manufacturer	Caris
Software Name	HIPS/SIPS
Version	9.1
Service Pack	
Hotfix	
Installation Date	2016-05-04
Use	Processing
Description	Caris HIPS (Hydrographic Information Processing System) is used for all initial processing of multibeam and vertical beam echo sounder bathymetry data. The program applies vessel offsets to the raw sonar data, corrects for tide and sound velocity, and calculates a Total Propagated Uncertainty (TPU) for each sounding. Individual soundings are then processed into a CUBE (Combined Uncertainty and Bathymetry Estimator) surface. These surfaces are then reviewed in HIPS or BDB (see below) for depth fliers, systematic errors, and agreement with adjoining and prior surveys. Caris SIPS (Side Scan Information Processing System) is used for all processing of side scan sonar imagery, including cable layback correction, slant range correction, contact selection, towpoint entry, and mosaic generation.

Manufacturer	Caris

Software Name	HIPS/SIPS
Version	9.0.20
Service Pack	
Hotfix	
Installation Date	2015-12-22
Use	Processing
Description	Caris HIPS (Hydrographic Information Processing System) is used for all initial processing of multibeam and vertical beam echo sounder bathymetry data. The program applies vessel offsets to the raw sonar data, corrects for tide and sound velocity, and calculates a Total Propagated Uncertainty (TPU) for each sounding. Individual soundings are then processed into a CUBE (Combined Uncertainty and Bathymetry Estimator) surface. These surfaces are then reviewed in HIPS or BDB (see below) for depth fliers, systematic errors, and agreement with adjoining and prior surveys. Caris SIPS (Side Scan Information Processing System) is used for all processing of side scan sonar imagery, including cable layback correction, slant range correction, contact selection, towpoint entry, and mosaic generation.

Manufacturer	Caris
Software Name	Base Editor
Version	4.1.3
Service Pack	
Hotfix	
Installation Date	2015-03-07
Use	Processing
Description	Caris Base Editor (BDB) is used for quality control of multibeam and vertical beam surfaces, and for management of survey features. CUBE and Uncertainty grids are imported, and then reviewed for depth fliers and systematic errors, and agreement with adjoining surveys. Multibeam contacts (designated soundings), side scan sonar contacts, and detached position contacts are analyzed, grouped, and assigned S-57 classification.

Manufacturer	NOAA OCS HSTP
Software Name	Pydro
Version	15.13
Service Pack	r5631
Hotfix	
Installation Date	2016-04-20
Use	Processing

Description	HSTP Pydro is a suite of programs used to process survey data, and to generate reports. FetchTides is used to create a .tid file from NWLON tide station data. Pydro can be used to classify side scan sonar and multibeam bathymetry contacts and manage survey features, however this functionality has largely been replaced by Caris BASE Editor. Pydro is still used for the generation of chartlets, the generation of Danger to Navigation reports, and to process TCARI tides. Velocipy is a program used for processing sound velocity casts. This program converts the hexadecimal SeaCat data to ASCII, and converts the ASCII data into a depth-binned sound velocity file. MVP data is recorded in a .txt format, and can be binned via Velocipy without conversion to ASCII. The resulting .svp files are applied to MBES and VBES data during post processing to correct for sound velocity variation within the water column. XmlDR is used to generate Descriptive Reports for each survey and the Data Acquisition Processing Report for each project.

Manufacturer	Hypack, Inc
Software Name	Hypack 2016
Version	
Service Pack	
Hotfix	
Installation Date	2016-05-04
Use	Acquisition
Description	Hypack is used to acquire VBES data in a .raw format, and detached positions, in .tgt format. It is also used for vessel navigation during MBES and SSS data acquisition. Hysweep is a module for Hypack used to acquire Reson 7125 MBES data in .HSX format. It receives input from the Reson 7125, the Reson SV-70 & SV-71 probes, and the Applanix POS/MV systems.

Manufacturer	HYPACK, Inc
Software Name	Hypack 2015
Version	
Service Pack	
Hotfix	
Installation Date	2015-03-19
Use	Acquisition
Description	Hypack is used to acquire VBES data in a .raw format, and detached positions, in .tgt format. It is also used for vessel navigation during MBES and SSS data acquisition. Hysweep is a module for Hypack used to acquire Reson 7125 MBES data in .HSX format. It receives input from the Reson 7125, the Reson SV-70 & SV-71 probes, and the Applanix POS/MV systems.

Manufacturer	Applanix
Software Name	POSPac MMS
Version	7.1
Service Pack	2
Hotfix	
Installation Date	2015-12-16
Use	Processing
Description	Applanix POSPac MMS is used to create SBETs, which provide horizontal and vertical control to bathymetric data.

Manufacturer	Applanix
Software Name	MV-POSView
Version	8.32
Service Pack	
Hotfix	
Installation Date	2015-10-16
Use	Acquisition
Description	The MV-POSView controller program is used on launches 3101 and 3102 to configure and operate the POS/MV attitude and positioning system. This program is also used to record the POS/MV .000 files used to produce the SBET files applied in Caris to improve attitude and navigation.

Manufacturer	QPS, Inc
Software Name	Fledermaus
Version	7.4.0d
Service Pack	
Hotfix	
Installation Date	2015-04-10
Use	Processing
Description	Fledermaus is used to process backscatter mosaics.

Manufacturer	ESRI, Inc
Software Name	ArcGIS
Version	10.3
Service Pack	
Hotfix	

Installation Date	2015-10-15
Use	Acquisition and Processing
Description	ArcGIS is used for initial survey planning, such as the creation of line plans for export into Hypack to guide the survey acquisition. ArcGIS is also used for data analysis, where a variety of tools and a high level of customization allow for detailed analysis of surfaces and data products.

Additional Discussion

Computer hardware that was a core component of a sensor is listed under the Echo Sounding section, referred to as the "Processor" for MBES systems or the "TPU" for the SSS systems. Computers used for processing of the data or controlling acquisition were completely interchangeable and the serial numbers used were not tracked.

A.8 Bottom Sampling Equipment

No bottom sampling equipment was utilized for data acquisition.

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

All multibeam data is logged using Hypack/Hysweep in the .HSX format. During acquisition, the hydrographer;
- Monitors the Reson SeaBat interface for errors and data quality;
- Adjusts range scale, power, gain, pulse width, swath width, absorption, spreading, and gates to ensure maximum data quality;
- Monitors the Hysweep interface;
- Monitors the vessel speed and adjusts as necessary to ensure density specifications are met.

TJ3101 and TJ3102 acquire complete coverage MBES data using polygons, with coverage being monitored via Hypack's matrix feature. 100% and 200% side scan sonar with concurrent MBES or VBES is acquired using preplanned lines, with a matrix in the background. Holidays are acquired as they occur, with a final quality control check for density rarefactions occurring near the completion of acquisition. The ship acquires all MBES data using preplanned lines, with a matrix in the background, with holidays being noted as they occur. Near the end of main scheme acquisition, a quality control check for density rarefactions is completed, and all gaps in coverage are acquired.

B.1.1.2 Single Beam Echosounder

All VBES data are logged using ODOM eChart and Hypack in .bin and .raw formats. The .raw contains the depth data, the .bin files contain water column data. During acquisition the hydrographer:
- Monitors real-time data in the ODOM eChart window;
- Adjusts gain and power as needed to ensure data quality.

B.1.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

B.1.2 Imagery

B.1.2.1 Side Scan Sonar

All side scan sonar data are logged using Klein SonarPro, in the .SDF format. During acquisition the hydrographer:
- Monitors range, towfish height, heading, pitch, roll, latitude, longitude, speed, pressure, and temperature;
- Adjusts towfish height, in accordance with Field Procedures Manual.

B.1.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

B.1.3 Sound Speed

B.1.3.1 Sound Speed Profiles

TJ3101 and TJ3102 both use a Sea-Bird SBE19+ CTD to collect sound speed profiles, generally at 2 - 4 hour intervals. Casts are also conducted when changing survey areas, or when a change of weather, tide, or current warrant. The launch crew also monitors the real time display of the Reson SVP-70 sound velocity probe for drastic changes in the surface sound velocity indicative of the need for a new cast.

Velocipy software is used for both data processing and setting up Sea-Bird SEACAT instruments. Prior to deployment the SEACAT voltage is checked. The SBE 19plus should have a minimum of 9.5 volts and the SBE 19 should have a minimum of 7 volts. In the event of lower voltage readings, the instrument batteries were changed.

The site selected should be in the deepest portion of the project area expected to be surveyed.

When conducting SEACAT casts with the SBE 19, the 3-2-1 rule of thumb is followed. The instrument should be turned on and allowed to sit on deck for 3 minutes while the sensors settle and form baseline. The instrument is then set to soak just below the surface for 2 minutes. Finally the instrument is lowered at a rate of 1 meter/second.

When conducting SEACAT casts with the SBE 19plus, the instrument should be lowered and held just below the water's surface for about 1 minute to allow air to escape the salinity cell. After soaking the instrument, it should be lowered at a rate of 1 meter/second through the water column. In areas with lenses of fresh water or other complex sound speed variation near the surface, the instrument should be lowered slowly (in some cases, much less than 1 meter/second) through the first 5-10 meters of water in order to accurately sample the sound speed. After this initial descent, the instrument should proceed to drop at a rate of 1 meter/second.

The hydrographer processes each cast immediately, then reviews it for erroneous data.

This image intentionally left blank

Figure 10: This image intentionally left blank

B.1.3.2 Surface Sound Speed

TJ3101 and TJ3102 use a Reson SVP-71 to acquire sound speed at the transducer face. These sound speed values are applied in real-time to all MBES systems to provide refraction corrections to flat-faced transducers.

The accuracy of each surface sound speed device is checked against the closest CTD data point after every CTD cast.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

Depending on Project Instructions and availability, TJ3101, TJ3102, Z1 and Z2 use one of the following methods for horizontal control:

Real-Time Kinematic:

The RTK corrector is derived from carrier phase measurements and integer ambiguity resolution at the base station. Delivering that corrector to the remote vessel's GPS receiver in real time allows for an RTK solution. Network Transport of RTCM via Internet Protocol (NTRIP) is used to transmit correctors in real time. The base station runs an NTRIP server that sends RTCM messages to a NTRIP caster located at the University of New Hampshire. A local computer runs a NTRIP client that receives the message from the caster and forwards it on to the POS MV over a serial connection to compute a float/fixed RTK solution. The computer is connected to a cellular internet connection in order to receive the corrector. Algorithms at this server generate carrier phase and pseudo-range observables for the approximate position using either atmospheric models or regional derived corrections. The corrections are then obtained through a Verizon wireless 4-G hot-spot on the vessels (TJ3101, TJ3102) via NTRIP fed directly into the Applanix POS M/V through a serial connection thus providing real-time corrections to the horizontal and vertical positioning to bathymetric data.

Autonomous Surface Vessels (ASV) Z1 and Z2 utilize RTK corrections similarly to TJ3101 and TJ3102 with the exception of the integration of a Trimble SPS461 connected to Verizon 4-G hot-spot receiving and applying real time correctors to bathymetric data via an on-board network managed by a Next Unit of Computing, (NUC) made by Intel.

MarineStar Realtime PPP Corrector Service:
TJ3101 and TJ3102 use the Fugro MarineStar satellite based corrector service to provide realtime correction to the horizontal position and ellipsoid height for all data acquisition and initial processing. The corrector signal is received on the L1 channel of the POS/MV primary GPS antenna and logged directly into the POS/MV. The POS files produced during acquisition are then processed through the POSPac MMS software to produce an SBET in the WGS84 reference frame and an RMS file containing the realtime uncertainty estimates of the position and attitude data.

During post-processing horizontal positioning can be shifted to an Inertially Aided Post-Processed Kinematic (IAPPK) solution. The solution is created by combining GPS/GNSS satellite ephemeris and clock data with position information downloaded from a network of Continually Operating Reference Stations (CORS). The resulting position data is corrected for the effects of atmospheric interference on the GPS signal. The corrected GPS position is then combined with the vessel's inertial data using the POSPac MMS program to create a Smoothed Best Estimate of Trajectory (SBET). The resulting position can be used to apply higher quality navigation information to the processed data.

B.1.4.2 Vertical Control

Vertical Control methods for each project are specified in the project instructions, and utilize one of three possible methods:

-GPS Tide: The RTK, IAPPK or5P solution described in the Horizontal Control section can also be used to provide vertical control. Using this method the bathymetric data is initially referenced to the ellipsoid using the high accuracy position data. It is later reduced to MLLW using a separation model called VDatum, which is provided to the field unit by NOAA's Hydrographic Services Division.

-Zoned Tides: when using zoned tides vertical control is based on one or more NWLON stations operated by CO-OPS. Co-range and co-phase measurements from the NWLON stations are used to break the project area into zones, each of which has a distinct time-of-tide and range-of-tide corrector. CO-OPS provides the field unit with a Caris compatible file which takes observed water levels from surrounding gauges, computes the time and range correctors for each zone, and uses the zoned data to reduce bathymetric soundings to MLLW. “Thomas Jefferson” does not install tertiary gauges in support of tidal modeling. After completion of a survey area, CO-OPS verifies all zoning and water level data.

-TCARI Tides: Tidal Constituent and Residual Interpretor is an alternative to discrete zoning. A TCARI grid is a triangulated network that uses two or more water level gauges to create a weighted network across the survey area. Each point on the grid has a discrete tidal interpolation that is based on the horizontal nearness of a water level gauge, the harmonic constants of the area, and the residual water levels. Bathymetric data is then reduced to MLLW using the TCARI tool in Pydro. Like zoned tides, CO-OPS verifies TCARI grids and observed water levels at the conclusion of each survey.

B.1.5 Feature Verification

The following work flow is used to develop and verify features:
- The location of all potentially significant features are opened in Caris BASE Editor (BDB). Any indication of shoaling found in VBES data is also noted, and the area outlined in BDB;
- A development area polygon is exported from BDB and a line plan is created using ArcMap, creating line spacing that will ensonify all features with near nadir beams;
- Object Detection level MBES data is collected over all SSS contacts, VBES designated soundings, and all possible shoals.

Quality of data is controlled through:
- Real time monitoring during acquisition to ensure that all features are covered by near nadir beams;
- Post processing inspection of the CUBE surface's Density, Standard Deviation, and Uncertainty layers;
- All developments are examined for significance. Objects found to be significant are flagged with a designated sounding, and become part of the Final Feature File.

B.1.6 Bottom Sampling

Bottom sampling data were not acquired.

B.1.7 Backscatter

MBES backscatter data are logged via Hypack in the .7k format. The ship processes these data on a daily basis for delivery to the Atlantic Hydrographic Branch. The workflow is as follows:

-Import .7K files into Fledermaus Geocoder Toolbox (FMGT)
-Correlate .7K files with CARIS-based HDCS bathymetry data
-Set horizontal coordinate system
-Adjust pre-set imagery resolution to allow a mosaic no larger than 20mb
-Create mosaic
-Export GeoTIFF of mosaic created
-Place GeoTIFF in deliverable folder

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Four workflows exist depending on whether a survey uses zoned tides, TCARI tides, MarineStar service and the Post-Processed Precise Point Positioning (5P) method, or Inertially Aided Post Processed Kinematic (IAPPK) method. A more detailed description of 5P and IAPPK SBET creation is covered below in Section B.2.4.

-RTK
1) Convert raw .HSX data to Caris HDCS format
2) Load Delayed Heave with special parameters
3) compute GPS tide
4) Apply sound speed correctors
5) Merge; use GPS tides
6) Compute Total Propagated Uncertainty (TPU)

-Zoned Tides:
1) Convert raw .HSX data to Caris HDCS format

2) Load Delayed Heave
3) Apply tide correctors
4) Apply sound speed correctors
5) Merge
6) Compute Total Propagated Uncertainty (TPU)

-TCARI Tides:
The TCARI Tides work flow is the same as Zoned Tides except that Step 3 applies the TCARI correctors via Pydro, and Step 6 applies "realtime" tidal uncertainty values instead of project specific static values.

-5P
1) Create SBET and RMS files in POSPac MMS.
2) Convert raw .HSX data to Caris HDCS format
3) Load Delayed Heave
4) Import ancillary data: SBET and RMS
5) Apply tide correctors. While unused, if available these are useful for a QC check in Subset Editor.
6) Compute GPS Tides using the provided VDatum SEP model.
7) Apply sound speed correctors
8) Merge; use GPS Tides.
9) Compute Total Propagated Uncertainty (TPU)

-IAPPK
IAPPK requires a delay of around 48 hours to produce the SBET and RMS files, due to reliance on updates of CORS station and ephemeris data. The need for fast QC of the data ("night processing") to allow planning of the next day's survey operations necessitates that initial processing must happen before the IAPPK solution is available. As a result, it initially follows the tidal scheme appropriate to that project area (Zoned Tides or TCARI). Once sufficient time has passed, SBETs and RMS files are produced and the data is reprocessed using the same work flow as 5P, skipping the conversion and Delayed Heave steps.

At this stage, all of the work flows merge into a common process.

1) Create CUBE surfaces. Surface resolution is dictated by the type of coverage required (Complete Coverage vs. Object Detection), and the depth of water. Disambiguation method is NOAA CUBE Parameters.
Compliance with HSSD gridding requirements is strictly observed;
2) Review the CUBE surface for holidays.
3) Create a holiday line plan.
4) Review the uncertainty and standard deviation layers and address areas where the standards set by the HSSD are exceeded.
5) Examine all surfaces for erroneous surface designation and evidence of systematic errors. Also identify features and look for evidence of shoaling.
6) Significant features are flagged 'designated', forcing the CUBE algorithm to honor the depth of the sounding. Designated soundings are reviewed to ensure compliance with guidance in the HSSD.
7) Create finalized grids. In finalization, the standard deviation for each node in the surface is multiplied by 1.96 to provide the 95% (2-sigma) confidence level. Standard deviation is then compared to the computed

Total Vertical Uncertainty (TVU) for each node. The larger of the two values is retained as the finalized Uncertainty for each node. Finalization is also when the surface is forced to honor designated soundings.

This image intentially left blank

Figure 11: This image intentionally left blank

B.2.1.2 Single Beam Echosounder

All VBES data is converted using Caris. The workflow is as follows:
- Convert raw .bin and .raw data using Caris HIPS;
- Scan Navigation and Attitude data, flagging erroneous data as rejected;
- compute GPS Tide,
- apply speed of sound correctors;
- Compute Total Propagated Uncertainty. Uncertainty values applied to the data follow recommendations of NOAA's FPM (ed 2014) Appendix 4. The exception is MRU alignment uncertainties,(TJ3101,TJ3102) which are set to zero.

Tidal zoning and sound speed error modeling is computed on a per-project basis, and is detailed in section B.2.2 of the Descriptive Report;
- Scan all data using the Caris Single Beam Editor tool, flagging data from the water column and the sub-bottom returns as rejected;
- When definition of the true bottom is ambiguous, the full water column Data can be inspected by viewing the Hypack created .bin files;
- Create Caris BASE Uncertainty weighted grids at 4-meter resolution;
- Analyze grids for features and for areas of shoaling, flagging them for development by a multibeam echo sounder.

This image intentially left blank

Figure 12: This image intentionally left blank

B.2.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not processed.

B.2.1.4 Specific Data Processing Methods

B.2.1.4.1 Methods Used to Maintain Data Integrity

All bathymetric data is moved through the Caris HIPS processing pipeline using a step-by-step method. Data integrity is maintained through the use of acquisition and processing logs, which track: acquisition of each line of data; conversion of the data; examination of ancillary sensor(navigation and attitude); and the application of heave, tides, SVP, and TPU. When processing an ERS survey, an additional log tracking the quality of SBETs is used.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

After initial processing the bathymetric data is gridded into BASE surfaces. VBES data is gridded using an Uncertainty Weighted algorithm. This type of surface calculates a horizontal and vertical uncertainty for each sounding, derived from the combined uncertainty from each of the sensors that contributes data to the sounding (e.g water levels, tide zoning, attitude sensor error, navigation sensor horizontal position error, and sound velocity profile error). Individual soundings are then propagated to grid nodes, which takes on a depth value as well as an uncertainty value based on all the soundings that contribute to the node. The influence of a sounding on a grid node is limited to 0.707 times the grid resolution.

MBES data is gridded using the CUBE algorithm. Resolution is dictated by the Project Instructions, as well as section 5.2.2 of the HSSD. The disambiguation method used is always Density and Local. The settings used for Capture Distance Scale, Horizontal Error Scale, and Capture Distance Minimum are those listed in section 4.2.1.1.1.1 of the FPM. After creation, Uncertainty and CUBE surfaces go through a quality control process. During this process, the Depth, Uncertainty, Standard Deviation, and Density child layers are examined for compliance with NOAA specifications. After the surfaces pass quality control, they are finalized. Uncertainty values for finalized surface come from the greater of either Uncertainty, or Standard Deviation.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Cleaning Filters Gridding Parameters Surface Computation Algorithms
Description	Filters are used on a case-by-case basis as determined by the hydrographer. Refer to the Descriptive Report for more information. Gridding parameters and surface computation algorithms comply with the HSSD and are described above.

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

1) Convert raw .sdf data using Caris SIPS;
2) Scan Navigation and Attitude data, flagging erroneous data as rejected;

3) Re-compute towfish navigation. This is when tow point offsets and horizontal layback is applied to the data;
4) Slant range correct each line of data;
5) A primary reviewer scans each line for significant contacts;
6) A secondary reviewer makes an independent check-scan of all lines, verifying contacts and checking for missed contacts;
7) If the Project Instructions call for 200% Side Scan coverage, the scanners check correlation of contacts between 100% and 200% coverage;
8) Correlation is also used to reveal systematic errors, particularly if a contact shows up on lines collected in opposite or orthogonal directions;
9) Create individual mosaics for 100% and 200% coverage. Examine for coverage;
10) If necessary, create a holiday line plan.

This image intentially left blank

Figure 13: This image intentionally left blank

B.2.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not processed.

B.2.2.3 Specific Data Processing Methods

B.2.2.3.1 Methods Used to Maintain Data Integrity

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

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

Object detection from side scan imagery is obtained by acquiring the entire survey area two times, with survey lines in the second coverage offset halfway between the lines from the first coverage. This results in 200% Side-Scan Coverage with line spacing based on 80% of the range scale. To ensure positional accuracy, a side scan certification test is performed. Multiple passes are made on a discrete feature (1m cube when possible) that ensonifies the feature with each transducer at a distance approximately 15%, 50%, and 80% of the range scale in use. A total of 12 passes are made and the feature must be detected in at least 10 of the 12 pass. All survey lines are then processed and a contact created for the feature. Contact positions are plotted and compared to the actual position of the feature. The contacts must be within 5m of the actual position for hull-mounted systems and 10m for towed systems.

B.2.2.3.3 Methods Used to Verify Swath Coverage

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

B.2.2.3.4 Criteria Used for Contact Selection

For water depths less than 20m, contact heights of 1m or greater are considered significant. For water depths 20m or greater, contact heights of 10% of the water depth are considered significant. A feature is created for each significant contact.

B.2.2.3.5 Compression Methods Used for Reviewing Imagery

No compression methods were used for reviewing imagery.

B.2.3 Sound Speed

B.2.3.1 Sound Speed Profiles

Sound speed profiles are acquired by two types of devices: CTD and MVP. Downloading and processing of all sound speed data is performed using Velocipy, a part of the HSTP supplied Pydro program suite.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

All sound speed profiles are concatenated into master files using Velocipy.

This image intentially left blank

Figure 14: This image intentionally left blank

B.2.3.2 Surface Sound Speed

Surface sound speed data were not processed.

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Realtime horizontal correctors are applied during acquisition from either the National Geodetic Survey (NGS) Continuously Operating Reference Stations (CORS) stations, or from the MarineStar satellite service. In all cases, the necessary data for post processing of the position is recorded by the POS PCS into .000 files (when automatically split for file size, the file suffix increments to .001, .002, etc). The post processing workflow varies based on using 5P (with the MarineStar service) or IAPPK

RTK workflow;
1) Load POS files into CARIS Hips/Sips.
2) Compute GPS Tides
3) Load water level data (if needed) TCARI or zoned.
4) Load Sound Velocity Profiles.
5) Merge
6)compute TPU.

MarineStar workflow:
1) Create a new project in POSPac MMS.
2) Drag all of the POS files into the new project window.
3) Wait for extraction and download of rapid ephemeris.
4) Run the GNSS-Inertial Processor.
5) Export SBET files.

IAPPK workflow:
1) Create a new project in POSPac MMS.
2) Drag all of the POS files into the new project window.
3) Wait for extraction and download of ephemeris and CORS data.
4) Run the GNSS-Inertial Processor.
5) Export SBET files.

RTK processing streamlines the amount of time needed to process as well as reduces the amount of uncertainty to a centimeter level. If there are drop outs of 4-G service where RTK fluctuates from "fixed" to "float" and the uncertainties for the effected data are high, then the requirement for running MarineStar through POSPac is to reducing the uncertainty of the solution by running the processing both forward and backward. For IAPPK, there is a time delay of around two days waiting on upload of the CORS data and availability of ephemeris. Slow satellite internet download rates can make the download of CORS data prohibitively slow and prone to failure. The reprocessing of the solution using the CORS data and recorded raw observables takes around two hours per 8 hour platform survey day, as compared to 10-15 minutes for the same processing via 5P. For “Thomas Jefferson,” with 24 hours of ship acquisition per day and two launch acquisition periods of 9 hours, the IAPPK processing typically takes 10 hours per day compared to about one hour for 5P processing.

This image intentionally left blank

Figure 15: This image intentionally left blank.

B.2.4.2 Vertical Control

Methods vary based on project assigned vertical control.

If Zoned Tides or TCARI are assigned, all tidal data processing is done by CO-OPS. Tides are then loaded in Caris or Pydro, respectively.

For ERS projects, a VDatum separation model (SEP) is provided with the Project Instructions. This SEP and the GPS heights in the SBET exported from POSPac are combined in Caris using the Compute GPS Tides command. Reduction to tidal datum is then completed by checking the "GPS Tides" option during the Merge step in Caris.

This image intentionally left blank

Figure 16: This image intentionally left blank.

B.2.5 Feature Verification

Feature verification begins during initial data processing. When conducting Side Scan surveys the data is converted and scanned for contacts using 2 independent reviewers. All significant contacts are then developed using a MBES. When conducting Multibeam surveys, or when reviewing MBES developments over side scan sonar contacts, the least depths over navigationally significant features are flagged as 'designated soundings', then imported into Caris BASE Editor. Inside BASE Editor, each significant contact is given an S-57 attribution, and the hydrographer recommends charting action. The final deliverable is a Final Feature File (FFF) in .000 format.

This image intentionally left blank

Figure 17: This image intentionally left blank.

B.2.6 Backscatter

All backscatter data is logged in Hypack's .7k format, using datagram version 2. All processing of backscatter is done using the FMGT module of the QPS Fledermaus software package.

This image intentionally left blank

Figure 18: This image intentionally left blank.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Prior to each field season, “Thomas Jefferson personnel" perform an annual Hydrographic Survey Readiness Review, during which all multibeam echo sounders, vertical beam echo sounders, side scan sonars, positioning systems, sound speed measuring devices, lead lines, and leveling equipment are calibrated.

Prior to acquisition, the hydrographer ensures that all charted features and AWOIS items are in the Composite Source File (CSF), and reviews the coverage requirements. During daily acquisition, a hydrographer monitors the cumulative uncertainties in position and attitude data, watches incoming data for errors, and compares the surface sound speed against full water column data for each CTD cast. During post-processing, navigation and attitude data is scanned using Caris HIPS and SIPS. Side Scan data is then examined for significant features by two separate individuals. Multibeam data is binned into a BASE surface using the CUBE algorithm, then undergoes directed editing using the Standard Deviation, Depth, Uncertainty, and Hypothesis Count child layers. The HSSD allowed uncertainty is also calculated for each surface node, and compared against the actual uncertainty. Any systematic errors, problems in density, or areas of high uncertainty are addressed in the Descriptive Report.

Before any data is to be submitted, it is reviewed by at least three experienced hydrographers who are signatories to the Descriptive Report.

B.4 Uncertainty and Error Management

Caris computes TPU based on both the static and dynamic measurements of the vessel and survey-specific information including tidal zoning uncertainty estimates and sound speed measurement uncertainties. Static offset values are entered into the Caris .hvf file. Dynamic (realtime) and sound speed uncertainties are entered using the Caris Compute TPU tool. Where TCARI tides are used, uncertainty is calculated and applied during application of TCARI tidal correctors to HDCS data.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

TPU is calculated in Caris HIPS using the Compute TPU tool. The uncertainty values for each input into the TPU model can come from one of three sources: Realtime, Static, or Vessel. Realtime values are provided from the sensor or processing package, such as POSPac RMS files. Static values are those entered manually into the Compute TPU dialog, such as tidal zoning uncertainty and sound speed measurement uncertainties. These Static values are documented in each sheet's Descriptive Report. Vessel values are taken from the HVF if no realtime or static values are available.

B.4.1.2 Source of TPU Values

Uncertainty values entered into the HVF for the multibeam and positioning systems were compiled from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 and Appendix 4 - Caris HVF Uncertainty Values of the 2014 FPM. Sound speed static values are derived from the guidance in the FPM. Tidal uncertainty values are realtime if using TCARI, or static and provided with the Project Instructions for Zoned Tides or VDatum. Realtime values for the sonar are provided by the sonar. Realtime values for motion and navigation are output from POSPac via the RMS file.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.4.1.3 TPU Values

<table>
<tr><td>Vessel</td><td colspan="3">n/a</td></tr>
<tr><td>Echosounder</td><td colspan="3">n/a n/a 0 kilohertz</td></tr>
<tr><td rowspan="6">TPU Standard Deviation Values</td><td rowspan="5">Motion</td><td>Gyro</td><td>0 degrees</td></tr>
<tr><td rowspan="2">Heave</td><td>0 % Amplitude</td></tr>
<tr><td>0 meters</td></tr>
<tr><td>Pitch</td><td>0 degrees</td></tr>
<tr><td>Roll</td><td>0 degrees</td></tr>
<tr><td>Navigation Position</td><td colspan="2">0 meters</td></tr>
</table>

	Timing	*Transducer*	0 seconds
		Navigation	0 seconds
		Gyro	0 seconds
		Heave	0 seconds
		Pitch	0 seconds
		Roll	0 seconds
	Offsets	*x*	0 meters
		y	0 meters
		z	0 meters
	MRU Alignment	*Gyro*	0 degrees
		Pitch	0 degrees
		Roll	0 degrees
	Vessel	*Speed*	0 meters/second
		Loading	0 meters
		Draft	0 meters
		Delta Draft	0 meters

B.4.2 Deviations

There were no deviations from the requirement to compute total propagated uncertainty.

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

See included HVFs for information on applied correctors.

C.1.1.2 Methods and Procedures

See included HVFs for information on applied correctors.

C.1.1.3 Vessel Offset Correctors

Vessel	See included HVFs for information on applied correctors.		
Echosounder	See included HVFs for information on applied correctors. See included HVFs for information on applied correctors. 0 hertz		
Date	2015-11-13		
Offsets	*MRU to Transducer*	*x*	0 meters
		y	0 meters
		z	0 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Nav to Transducer	*x*	0 meters
		y	0 meters
		z	0 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Transducer Roll	*Roll*	0 degrees
		Roll2	0 radians

C.1.2 Layback

Layback correctors were not applied.

Additional Discussion

All offsets for "Thomas Jefferson" and her survey launches were derived from full or partial surveys performed by NGS personnel. All offsets are tracked and updated as needed.

The offsets for TJ3101 and TJ3102 are measured with respect to the vessel's IMU. Offset values are entered into each platform's Caris HIPS Hydrographic Vessel File (HVF), with the exception of the x,y,z offsets between the primary GPS antenna and the IMU. The distance between primary antenna and IMU is entered into POSView, which then feeds position relative to the IMU to all integrated sonars. All other offsets are applied to data during the SVP or Merge steps in processing of bathymetric data. Offsets are applied to side scan sonar data during the Recompute Towfish Navigation step.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

See Additional Discussion for information on static draft application.

C.2.1.2 Methods and Procedures

See Additional Discussion for information on static draft application.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

See Additional Discussion for information on dynamic draft application.

C.2.2.2 Methods and Procedures

See Additional Discussion for information on dynamic draft application.

C.2.2.3 Dynamic Draft Correctors

Vessel	0	
Date	2015-11-07	
Dynamic Draft Table	*Speed*	*Draft*
	0	0

Additional Discussion

Dynamic draft for TJ3101 TJ3102, Z-1 and Z-2 were measured using the Post Processed Kinematic GPS method outlined in section 1.4.2.1.2.1 of NOAA's FPM. To reduce the effect of any potential current, reciprocal lines were run at each RPM step in order to get an average speed over ground for each RPM. This average speed was used to estimate the vessel’s speed through the water. Dynamic draft and vessel offsets corrector values are stored in the HIPS Vessel Files (HVF).

In ERS surveys, those that use recorded GPS heights corrected via a VDatum SEP model to achieve tidal datum, the dynamic draft correction is not applied to the soundings.

Dynamic draft on the Z-Boats was measured using a comparative method outlined in section B.2.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

Additional Discussion

Static draft for each survey launch is measured via a sight tube. On TJ3101 & TJ3102, the waterline is measured by placing a steel ruler directly on the reference mark and measuring directly from the sight tube. The waterline is almost constant on the launches despite fuel levels or normal loading. The normal range for waterline on each launch is 22.5cm to 23.5cm above the reference point.

In ERS surveys, the Static Draft is not applied to the soundings.

Static draft on the Z-Boats was measured using a direct observation method outlined in section B.2.

Waterline measurements are recorded daily on TJ3101 and TJ3102. The values are kept in a static draft log and periodically updated in the HVF. Once applied in the HVF, all affected lines have SVP re-applied and are then merged so that the updated waterline measurements will be applied.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

C.3 System Alignment

System alignment correctors were not applied.

C.4 Positioning and Attitude

C.4.1 Description of Correctors

Real time Kinematic application

C.4.2 Methods and Procedures

Vessel navigation and attitude is measured by the POS/MV and recorded in the Hysweep .HSX file and .7k file. When the navigation and attitude measurements are not applied in real time via RTK, the correctors are applied during post processing in Caris HIPS using the attitude data recorded in the .HSX or .s7k file. The POS/MV TrueHeave data is logged within the POS/MV .000 files and applied in Caris HIPS during post processing using the Import Ancillary Data command. TrueHeave is a forward-backward filtered heave corrector as opposed to the real time heave corrector, and is fully described in section 6 of the POS/MV V4 User Guide 2009. In some cases, when the quality of the RTK solution is degraded, SBET files are applied to soundings to increase the accuracy of the kinematic vessel corrections and to allow the ability to reference soundings to the ellipsoid. Standard daily data processing procedures include post processing of POS/MV kinematic .000 files using Applanix POSPac MMS and POSGNSS software using either IN-Fusion SmartBase, IN-Fusion SingleBase or Omnistar Precise Point Positioning (a reference to the previous commercial name of Marinestar) processing modes. After processing and quality control analysis of the post-processed SBET files is complete, the SBET and RMS files are applied to the HDCS data in Caris HIPS using the Import Ancillary Data command.

Additional Discussion

As part of the annual HSRR, TJ3101 and TJ3102 multibeam systems with two frequencies required an individual test for each frequency. The procedure used follows that outlined in section 1.5.5.1 of the Field Procedures Manual dated April 2014. Timing bias was determined using the method of running the same line at different speeds. Pitch and yaw bias was determined using a target on the seafloor. Finally, roll bias was determined using the standard flat bottom method.

Data was converted in Caris HIPS version using an HVF file with heave, pitch, roll and timing values set to zero. True heave, water levels, the most recent dynamic draft, and sound velocity were applied and the data merged. Biases were determined using the Caris HIPS Calibration tool and an average was determined. Bias values were determined in the following order; timing, pitch, roll, and finally yaw. These averaged values were established as the final correctors and were added to the Caris HVF.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

All calibration reports can be found in the Appendix Folder, Patch Test Reports.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

Unless otherwise noted in the survey Descriptive Report (DR) or project Horizontal and Vertical Control Report (HVCR), the vertical datum for all soundings and heights is Mean Lower Low Water (MLLW).

C.5.2 Methods and Procedures

Reduction to MLLW is accomplished by a variety of means depending on the project.

Predicted, preliminary, and verified water level correctors from the primary tide station(s) listed in the Project Instructions may be downloaded from the CO-OPS website and used for water level corrections during the course of the project. These tide station files are collated to include the appropriate days of acquisition and then converted to Caris .tid file format using FetchTides. Water level data in the .tid files are applied to HDCS data in Caris HIPS using the zone definition file (.zdf) or, for TCARI, in Pydro using a TCARI model provided by CO-OPS. Upon receiving final approved water level data, all data are reduced to MLLW using the final approved water levels as noted in the individual survey's Descriptive Report.

ERS surveys are reduced to MLLW via the application of the CO-OPS provided VDatum SEP model using the Compute GPS Tides tool in Caris.

A complete description of vertical control utilized for a given project can be found in the project specific HVCR, submitted for each project under separate cover when necessary as outlined in section 5.2.3.2.3 of the FPM.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

Aboard TJ3101 and TJ3102, hand-deployed seabird CTD units are used to take sound of speed profiles.

C.6.1.2 Methods and Procedures

Seabird .cnv files are collected when necessary and converted to .svp files using NOAA's Pydro/Velocipy program. These .svp files are concatenated into one vessel specific master file per project which is then applied to HDCS data using a specified method. This method of applying sound speed to data is listed in the sheets processing log included in the Separates submitted with the individual survey.

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

TJ3101 and TJ3102 both use a Reson SV-71 probe mounted near the transducer face to measure the surface sound speed

C.6.2.2 Methods and Procedures

The speed of sound at the transducer face is fed directly to the Reson 7125-SV2 topside processing units. It is then passed to HYPACK/HYSWEEP, which records the value in the .HSX file.

D. APPROVAL SHEET

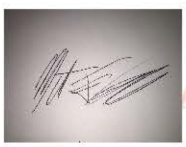
This Data Acquisition and Processing Report is respectfully submitted for the following projects:

OPR-E350-TJ-16 Southern Chesapeake Bay

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the Hydrographic Surveys Specifications and Deliverables (2016 ed), and the Field Procedures Manual for Hydrographic Surveying (2014 ed).

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

Approved and Forwarded:



Digitally signed by FORREST.MATTHEW.ROBERT.1362733100
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=NOAA, cn=FORREST.MATTHEW.ROBERT.1362733100
Date: 2016.12.05 21:24:19 Z

LT Matthew R. Forrest, NOAA

Operations Officer

VAN WESTENDORP.CHRISTIAAN.HENRY.1012828175
2016.11.29 17:40:58 -05'00'

CDR Chris Van Westendorp, NOAA

Commanding Officer