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

Data Acquisition & Processing Report

Type of Survey: *Multibeam*

Project No: *OPR-BG380-TJ-15*

Time Frame: *April – June 2015*

LOCALITY

State: *South Carolina*

General Locality: *Charleston, SC*

2015

CHIEF OF PARTY

CAPT Shepard M. Smith
National Oceanic and Atmospheric Administration

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DATE: *June 10, 2015*

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Data Acquisition and Processing Report

NOAA Ship Thomas Jefferson
Chief of Party: Shepard M. Smith, CAPT/NOAA
Year: 2015
Version: 1
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A Equipment

A.1 Survey Vessels

A.1.1 NOAA Ship Thomas Jefferson (WTEA)

Name	NOAA Ship Thomas Jefferson (WTEA)		
Hull Number	S-222		
Description	NOAA Ship Thomas Jefferson is a steel hulled hydrographic survey ship built by Halter Marine, Inc, Moss Point, MS.		
Utilization	The primary mission of “NOAA Ship Thomas Jefferson” is to acquire hydrographic survey data to update NOAA nautical charts. Based on current draft and sonar configuration, the ship can operate in waters between 30 feet and 656 feet deep.		
Dimensions	*LOA*	208 feet	
	Beam	45 feet	
	Max Draft	17 feet	
Most Recent Full Static Survey	Full static survey was not performed.		

Most Recent Partial Static Survey	*Date*	2014-02-14
	Performed By	National Geodetic Survey
	Discussion	The Thomas Jefferson has never had a full static survey that includes all current antennas, inertial motion units, sonars and towpoints. Instead a series of partial surveys have been conducted across several years. In 2001 a survey of the (then named) USNS Littlehales was conducted by National Aeronautics and Space Agency. The survey measured offsets to several antennas and sonars, and established several benchmarks. Though the antennae and sonars are now defunct,the benchmarks are still in use. In 2003 a survey was conducted by the ship's force to establish the location of the DGPS antennae and the side scan sonar towpoint. In 2005 a survey was conducted by NOAA's National Geodetic Services Division (NGS). This survey verified the placement of the POS M/V IMU and antennas. Several additional permanent benchmarks were also established. In 2006 NGS conducted a survey to include the new RESON 7125 Multibeam Echosounder into the vessel's reference frame. In 2014, a new Reson 7125-SV2 and Sutron bubbler (for ship's static draft) were mounted to the hull of the ship. NGS conducted a partial offset survey to bring the new equipment into the vessel's reference frame.
Most Recent Full Offset Verification	Full offset verification was not performed.	

Most Recent Partial Offset Verification	*Date*	2015-04-20
	Method Used	Shipboard Analysis
	Discussion	A verification of the ships offsets was performed by HSTP personnel. The analysis used up to date rotational software for each of the axis orientations required by the major components of sensor software, specifically Caris, Applanix, and Reson. The data was from the last survey of the ship in 2014. The new rotations produce some small changes in offsets.
Most Recent Static Draft Determination	*Date*	2015-04-18
	Method Used	Bubbler and Ellipsoid
	Discussion	Static draft was performed by use of a Sutron bubbler gauge installed in the proximity of the IMU. Recent adjustments to the Sutron field calibrations were performed so that waterline can be directly measured by the sensor. An ERS ellipsoid static draft was also performed to confirm these values.
Most Recent Dynamic Draft Determination	*Date*	2015-04-27
	Method Used	Ellipsoidally Referenced Dynamic Draft
	Discussion	Dynamic draft was determined using the Ellipsoidally Referenced Dynamic Draft Model (ERDDM). Acquisition and processing was done in accordance with FPM Section 1.4.2.1.2.1 via the Pydro macro ProcSBETDynamicDraft.py. Ellipsoid heights were obtained via the 5P method, described in Section B.2.4.

Figure : NOAA Ship Thomas Jefferson (WTEA)

A.1.2 Hydrographic Survey Launch 3101 (TJ3101)

<table>
<tr><td>Name</td><td colspan="2">Hydrographic Survey Launch 3101 (TJ3101)</td></tr>
<tr><td>Hull Number</td><td colspan="2">3101</td></tr>
<tr><td>Description</td><td colspan="2">TJ3101 is an aluminum hulled hydrographic survey launch.</td></tr>
<tr><td>Utilization</td><td colspan="2">TJ3101 is equipped to collect bathymetric data, side scan imagery, and water column profiles. It can operate in waters between 12 feet and 656 feet deep.</td></tr>
<tr><td rowspan="3">Dimensions</td><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>

Most Recent Full Static Survey	*Date*	2015-04-02
	Performed By	National Geodetic Survey personnel
	Discussion	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.
Most Recent Partial Static Survey	Partial static survey was not performed.	
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*	2015-04-28
	Method Used	Site 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	*Date*	2015-05-28
	Method Used	Ellipsoidally Referenced Dynamic Draft
	Discussion	Dynamic draft was determined using the Ellipsoidally Referenced Dynamic Draft Model (ERDDM). Acquisition and processing was done in accordance with FPM Section 1.4.2.1.2.1 via the Pydro macro ProcSBETDynamicDraft.py. Ellipsoid heights were obtained via the 5P method, described in Section B.2.4.

A.1.3 Hydrographic Survey Launch 3102 (TJ3102)

Name	Hydrographic Survey Launch 3102 (TJ3102)
Hull Number	3102

Description	TJ3102 is an aluminum hulled hydrographic survey launch.
Utilization	TJ3102 is equipped to collect bathymetric data, side scan imagery, and water column profiles. It can operate in waters between 12 feet and 656 feet deep.
Dimensions	*LOA*: 31 feet *Beam*: 10.6 feet *Max Draft*: 5.16 feet
Most Recent Full Static Survey	*Date*: 2015-04-02 *Performed By*: National Geodetic Survey personnel *Discussion*: 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.
Most Recent Partial Static Survey	Partial static survey was not performed.
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*: 2015-04-28 *Method Used*: Site 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	*Date*	2015-04-28
	Method Used	Ellipsoidally Referenced Dynamic Draft
	Discussion	Dynamic draft was determined using the Ellipsoidally Referenced Dynamic Draft Model (ERDDM). Acquisition and processing was done in accordance with FPM Section 1.4.2.1.2.1 via the Pydro macro ProcSBETDynamicDraft.py. Ellipsoid heights were obtained via the 5P method, described in Section B.2.4.

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, a Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. 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. There are two configurations for data acquisition using the Klein 5000 system: stern-towed and hull-mounted. “Thomas Jefferson” uses exclusively stern towed SSS. TJ3101 uses a hull-mount configuration. TJ3102 can be converted from hull-mounted to towed as required. There are also two options for the weight of the towfish: the standard, and a lightweight variant. The hull mounts on both survey launches can accommodate both standard or lightweight towfish. “Thomas Jefferson” can only use the standard weight. Positioning of the Towfish is calculated using Caris SIPS, and is derived from the amount of cable out, the towfish depth (from the towfish pressure gauge), the vessel's Course Made Good (CMG), and the vessel's heading. 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

<table>
<tr><td></td><td>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>"Thomas Jefferson"</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>TPU s/n</td><td>137</td><td>136</td><td>135</td></tr>
<tr><td>Towfish s/n</td><td>280</td><td>322</td><td>319</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>3.75 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>

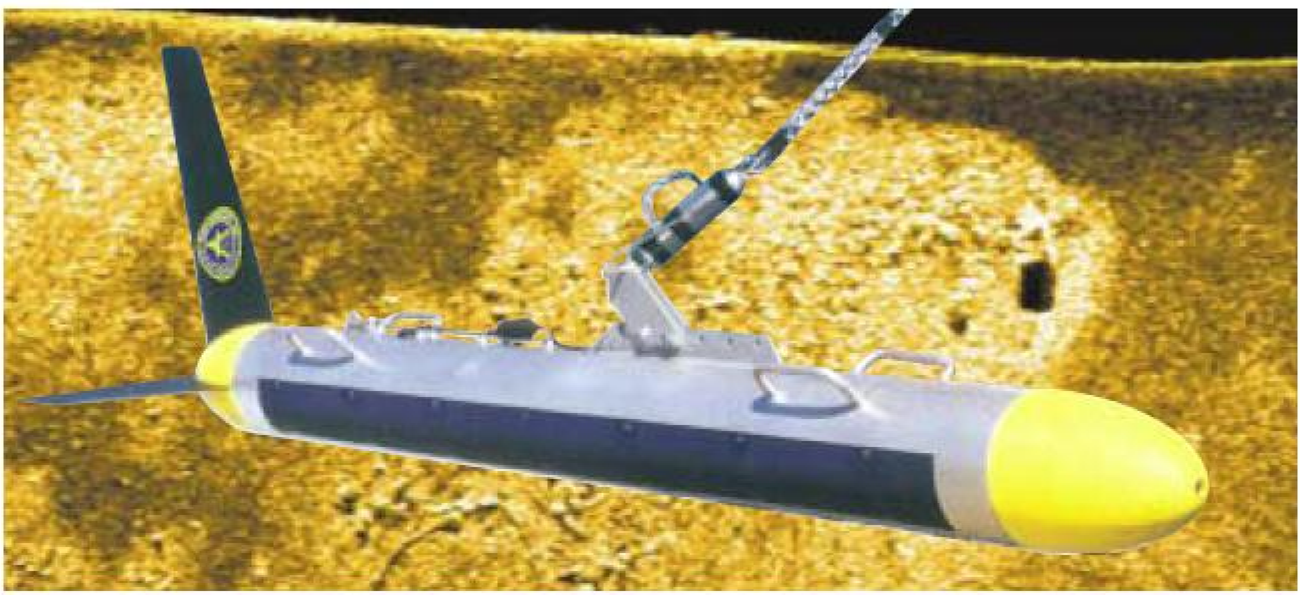

Figure : Klein 5000 Side Scan Sonar towfish

A.2.1.2 Klein 5000 V2

Manufacturer	Klein
Model	5000 V2
Description	The Klein High Speed, High Resolution Multi-Beam Side Scan Sonar (SSS) system is a beam-forming acoustic imagery device. The integrated system includes a Klein 5000 towfish, a Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. The towfish operates at a frequency of 455kHz and a vertical beam angle of 40°, and can resolve up to 5 discrete received beams per transducer stave. The system is capable of ranges up to 250 meters, however “Thomas Jefferson” does not use the 150m or the 250m reconnaissance mode. In addition, the Klein 5000 V2 model can collect bathymetric information using phase differencing. Each side scan transducer stave contains 3 bathymetry staves. The bathymetry staves operate at 455kHz, with an along track resolution of 0.4°, and can resolve one discrete beam per side. “Thomas Jefferson” operates the Klein 5000 as a stern-towed unit, and does not process or use the collected bathymetric data. Positioning of the Towfish is calculated using Caris SIPS, and is derived from the amount of cable out, the towfish depth (from the towfish pressure gauge), the vessel's Course Made Good (CMG), and the vessel's heading. 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.
Serial Numbers	*Vessel Installed On*: "Thomas Jefferson" *TPU s/n*: 778 *Towfish s/n*: 385
Specifications	*Frequency*: 455 kilohertz
	Along Track Resolution:
	Across Track Resolution: 3.75 centimeters
	Max Range Scale: 150 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.

Along Track Resolution:

Resolution	10 centimeters	20 centimeters	36 centimeters
Min Range	0 meters	39 meters	76 meters
Max Range	38 meters	75 meters	150 meters

Figure : Klein 5000 V2

A.2.2 Multibeam Echosounders

A.2.2.1 Reson SeaBat 7125-ROV

Manufacturer	Reson
Model	SeaBat 7125-ROV
Description	The Reson SeaBat 7125-ROV system is a single-frequency multibeam echo sounder. It is hull mounted on "Thomas Jefferson." The integrated system includes a 400 kHz Projector unit, a Receiver unit, a Link Control Unit (LCU), and a topside 7-P Sonar Processor Unit (TPU). The projector and receiver are set up in a Mills Cross configuration. The 7125-ROV produces a 128° across track swath that is resolved into 512 discrete beams by the receive array. Each beam has a resolution of 1.0° across track, and 0.5° along track. Sound velocity at the face of the transducer is provided by an integrated Reson SV-70 sound velocimeter. The 7-P Sonar Processor

<table>
<tr><td></td><td>Unit has the following software versions installed: 7K Center Version 3.7.11.11, 7K UI Version 3.12.7.3, and 7K IO Version 3.4.1.11. Bathymetric data from the 7125-ROV is used to provide object detection and complete coverage in shallow water.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>"Thomas Jefferson"</td></tr>
<tr><td>Processor s/n</td><td>50357</td></tr>
<tr><td>Transceiver s/n</td><td>50872 (LCU Bottle)</td></tr>
<tr><td>Transducer s/n</td><td>n/a</td></tr>
<tr><td>Receiver s/n</td><td>808042</td></tr>
<tr><td>Projector 1 s/n</td><td>19082203</td></tr>
<tr><td>Projector 2 s/n</td><td>n/a</td></tr>
</table>
</td></tr>
<tr><td>Specifications</td><td>
<table>
<tr><td>Frequency</td><td colspan="2">400 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>1 degrees</td></tr>
<tr><td>Across Track</td><td>0.5 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>512</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">128 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">5 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>200 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td></tr>
</table>
</td></tr>
<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
<tr><td>System Accuracy Tests</td><td>
<table>
<tr><td>Vessel Installed On</td><td>"Thomas Jefferson"</td><td>"Thomas Jefferson"</td></tr>
<tr><td>Methods</td><td>Reference Surface</td><td>Lead line comparison</td></tr>
<tr><td>Results</td><td>Over the course of DN118 and DN119, all MBES systems on "Thomas Jefferson" and both launches were run over the same reference surface near Cape Charles in Chesapeake Bay. All systems were tidally reduced using a provided TCARI grid and compared against the 7125-ROV1 installed on "Thomas Jefferson." The mean difference was 0.050m with a standard deviation of 0.052m.</td><td>On June 4, 2015, a lead line comparison was conducted between the ship multibeam sonars and a lead line lowered over the side while dead in the water. The Reson 7125 ROV system differed from the lead line by -0.09m.</td></tr>
</table>
</td></tr>
<tr><td>Snippets</td><td>Sonar has snippets logging capability.</td></tr>
</table>

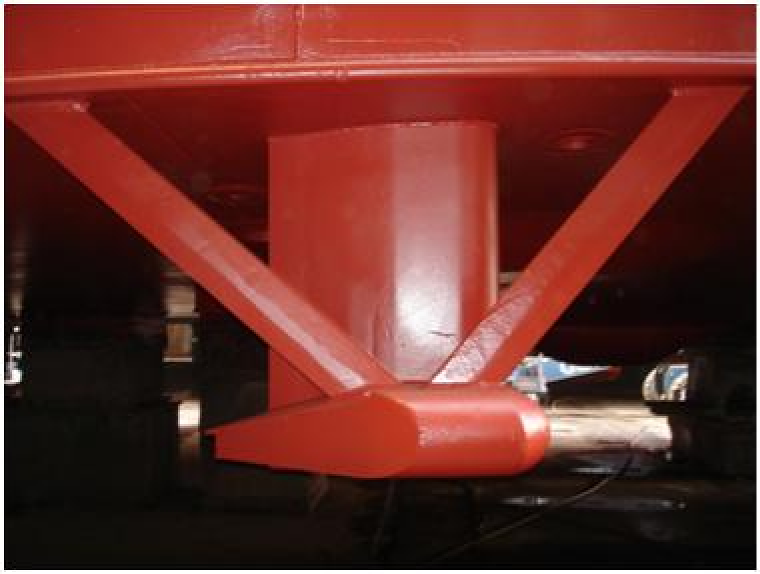

Figure : Housing for ship mounted RESON 7125-ROV

A.2.2.2 Reson SeaBat 7125-SV1

Manufacturer	Reson
Model	SeaBat 7125-SV1
Description	The Reson SeaBat 7125-SV1 is a dual frequency (200/400kHz), high-resolution multibeam echo sounder system for shallow water depths. The recommended maximum range at 200kHz is 500m resulting in a 220 m depth limit for full swath coverage on a flat bottom. The 400kHz setting maximum range is 200m 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 two projectors, one for each frequency. The system is installed on TJ3102 using a Reson sled mount which is attached to a retractable arm. The integrated system includes a 200 kHz Projector unit, a 400 kHz Projector unit, a Receiver unit, and a topside 7-P Sonar Processor Unit (TPU). The projectors and receiver are set up in a Mills Cross configuration. The 7125-SV1 produces a 128° across track swath. The 400 kHz frequency has a 0.54° across-track resolution and 1° along-track resolution, and is resolved into 512 discrete beams. The 200 kHz frequency has a 1.1° across-track resolution and 2.2° along-track resolution, and is resolved into 256 discrete beams. Sound velocity at the face of the transducer is provided by an integrated Reson SV-71 sound velocimeter. The Reson 7125-SV1 can be configured for roll stabilization. In roll-stabilized mode, the sonar can operate in environments with up to +/- 10 degrees

<table>
<tr><td></td><td colspan="5">of roll without degrading system performance. The 7-P Sonar Processor Unit has the following software versions installed: 7K Center: IO Version 3.12.7.3, 7K UI Version 3.1.2.7.3. Bathymetric data from the 7125-SV1 is used to provide object detection and complete coverage in shallow water.</td></tr>
<tr><td rowspan="7">Serial Numbers</td><td>Vessel Installed On</td><td colspan="4">TJ3102</td></tr>
<tr><td>Processor s/n</td><td colspan="4">1812018</td></tr>
<tr><td>Transceiver s/n</td><td colspan="4">n/a</td></tr>
<tr><td>Transducer s/n</td><td colspan="4">n/a</td></tr>
<tr><td>Receiver s/n</td><td colspan="4">0309006</td></tr>
<tr><td>Projector 1 s/n</td><td colspan="4">2909185</td></tr>
<tr><td>Projector 2 s/n</td><td colspan="4">2208005</td></tr>
<tr><td rowspan="11">Specifications</td><td>Frequency</td><td colspan="2">200 kilohertz</td><td colspan="2">400 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>2.2 degrees</td><td>Along Track</td><td>1.0 degrees</td></tr>
<tr><td>Across Track</td><td>1.1 degrees</td><td>Across Track</td><td>0.54 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>256</td><td>Number of Beams</td><td>512</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">128 degrees</td><td colspan="2">128 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>220 kilometers</td><td>Manufacturer Specified</td><td>87 meters</td></tr>
<tr><td>Ship Usage</td><td>200 meters</td><td>Ship Usage</td><td>50 meters</td></tr>
<tr><td colspan="5"></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">TJ3102</td></tr>
<tr><td>Methods</td><td colspan="4">Reference Surface</td></tr>
<tr><td>Results</td><td colspan="4">Over the course of DN118 and DN119, all MBES systems on "Thomas Jefferson" and both launches were run over the same reference surface near Cape Charles in Chesapeake Bay. All systems were tidally reduced using a provided TCARI grid and compared against the 7125-ROV1 installed on "Thomas Jefferson." The mean difference was 0.050m with a standard deviation of 0.052m.</td></tr>
<tr><td>Snippets</td><td colspan="5">Sonar has snippets logging capability.</td></tr>
</table>

A.2.2.3 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 500m resulting in a 220 m depth limit for full swath coverage on a flat bottom. The 400kHz setting maximum range is 200m 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. It is hull mounted on “Thomas Jefferson,” on the portside transducer pod. The system is also installed on 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 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. Sound velocity at the face of the transducer is provided by an integrated Reson SV-70 sound velocimeter. The 7-P Sonar Processor Unit has the following software versions installed: 7K Center: 7K Center Version # 6.0.0.11, 7K UI Version 4.1.0.7, 7K IO Version 4.1.0.1. Bathymetric data from the 7125 SV2 is used to provide object detection and complete coverage in shallow water.
Serial Numbers	see below

Serial Numbers

Vessel Installed On	S222	TJ3101
Processor s/n	18340713036	18341313046
Transceiver s/n	n/a	n/a
Transducer s/n	n/a	n/a
Receiver s/n	unknown	1513550
Projector 1 s/n	unknown	1513528
Projector 2 s/n	n/a	n/a

Specifications	*Frequency*	200 kilohertz		400 kilohertz	
	Beamwidth	*Along Track*	2 degrees	*Along Track*	1 degrees
		Across Track	1 degrees	*Across Track*	0.5 degrees
	Max Ping Rate	50 hertz		50 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equidistant
		Number of Beams	256	*Number of Beams*	512
	Max Swath Width	140 degrees		140 degrees	
	Depth Resolution	6 millimeters		6 millimeters	
	Depth Rating	*Manufacturer Specified*	220 meters	*Manufacturer Specified*	87 meters
		Ship Usage	200 meters	*Ship Usage*	50 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.				
System Accuracy Tests	*Vessel Installed On*	"Thomas Jefferson" and TJ3101		"Thomas Jefferson"	
	Methods	Reference Surface		Lead line comparison	
	Results	Over the course of DN118 and DN119, all MBES systems on "Thomas Jefferson" and both launches were run over the same reference surface near Cape Charles in Chesapeake Bay. All systems were tidally reduced using a provided TCARI grid and compared against the 7125-ROV1 installed on "Thomas Jefferson." The mean difference was 0.050m with a standard deviation of 0.052m.		On June 4, 2015, a lead line comparison was conducted between the ship 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 -0.13m.	
Snippets	Sonar has snippets logging capability.				

A.2.3 Single Beam Echosounders

A.2.3.1 ODOM Echotrac CV-200

Manufacturer	ODOM
Model	Echotrac CV-200

<table>
<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="8">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 colspan="5"></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">None</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.2.4 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.

Additional Discussion

The Klein 5000 V2 is a Phase Measuring Bathymetric Sonar, but it is not used in that capacity so it is documented above as a SSS, which is how it is used aboard "Thomas Jefferson."

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

<table>
<tr><td>Manufacturer</td><td colspan="4">Ship's Force</td></tr>
<tr><td>Model</td><td colspan="4">n/a</td></tr>
<tr><td>Description</td><td colspan="4">The lead lines aboard “Thomas Jefferson” are standard lead lines, constructed and calibrated in accordance with Appendix 1 of NOAA's Field Procedures Manual (2013 ed).</td></tr>
<tr><td rowspan="3">Serial Numbers</td><td colspan="4">TJ A 16m</td></tr>
<tr><td colspan="4">TJ S222 23m</td></tr>
<tr><td colspan="4">TJ 07 2012</td></tr>
<tr><td rowspan="3">Calibrations</td><td>Serial Number</td><td>TJ A 16m</td><td>TJ S222 23m</td><td>TJ 07 2012</td></tr>
<tr><td>Date</td><td>2015-04-15</td><td>2015-04-15</td><td>2015-04-15</td></tr>
<tr><td>Procedures</td><td>The lead line was calibrated against a steel measuring tape.</td><td>The lead line was calibrated against a steel measuring tape.</td><td>The lead line was calibrated against a steel measuring tape.</td></tr>
<tr><td>Accuracy Checks</td><td colspan="4">No accuracy checks were performed.</td></tr>
<tr><td>Correctors</td><td colspan="4">None of the lead lines required correctors.</td></tr>
<tr><td>Non-Standard Procedures</td><td colspan="4">Non-standard procedures were not utilized.</td></tr>
</table>

Figure : Lead line used aboard Thomas Jefferson and her survey launches

A.3.3 Sounding Poles

Manufacturer	Ship's Force
Model	n/a
Description	"Thomas Jefferson" has two non-traditional sounding poles. Both poles are round steel with a plastic covering, capped by a weighted metal shoe. Each pole is 4 meters in length, with graduations at 0.25m.
Serial Numbers	TJ-SP-1 TJ-SP-2

Calibrations	*Serial Number*	TJ-SP-1	TJ-SP-2
	Date	2015-04-29	2015-04-29
	Procedures	The sounding pole was calibrated using a steel tape.	The sounding pole was calibrated using a steel tape.
Accuracy Checks	No accuracy checks were performed.		
Correctors	No correctors were required.		
Non-Standard Procedures	Non-standard procedures were not utilized.		

Figure : Sounding pole used aboard Thomas Jefferson and her survey launches.

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 & 320 v.5
Description	"Thomas Jefferson" and both of her launches are equipped with Applanix POS/MV 320 Position and Orientation Sensors (version 5 on "Thomas Jefferson," version 4 on TJ3101 and TJ3102) 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. 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 ship system is set to 9 seconds and the launches are set to 8 seconds. Intermittent problems with the heading

<table>
<tr><td></td><td>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 also recorded on "Thomas Jefferson" and both of her 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 beacon, creating a tightly-coupled 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>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>320 v.5</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 beacon, creating a tightly-coupled 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>8.23</td></tr>
<tr><td>Software Version</td><td>7.92</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S222</td></tr>
<tr><td>PCS s/n</td><td>6497</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>S222</td><td>TJ3101</td><td>TJ3102</td></tr><tr><td>IMU s/n</td><td>1074</td><td>352</td><td>356</td></tr></table></td></tr>
<tr><td>Certification</td><td><table><tr><td>IMU s/n</td><td>1074</td><td>352</td><td>356</td></tr><tr><td>Certification Date</td><td>2014-09-25</td><td>2014-01-03</td><td>2014-01-21</td></tr></table></td></tr>
<tr><td rowspan="4">Antennas</td><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>Zephyr 2</td></tr>
<tr><td>Description</td><td>A high gain GNSS 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>S222</td><td>6948</td><td>Port</td><td>Primary</td></tr><tr><td>S222</td><td>6950</td><td>Starboard</td><td>Secondary</td></tr></table></td></tr>
<tr><td>GAMS Calibration</td><td colspan="2"><table><tr><td>Vessel</td><td>S222</td><td>TJ3101</td><td>TJ3102</td></tr><tr><td>Calibration Date</td><td>2015-04-17</td><td>2015-05-19</td><td>2015-05-19</td></tr></table></td></tr>
<tr><td>Configuration Reports</td><td colspan="2"><table><tr><td>Vessel</td><td>S222</td><td>TJ3101</td><td>TJ3102</td></tr><tr><td>Report Date</td><td>2015-04-17</td><td>2015-05-19</td><td>2015-05-19</td></tr></table></td></tr>
</table>

A.4.2 DGPS

<table>
<tr><td>Description</td><td>The Trimble SPS351 receiver uses RTCM DGPS corrections either broadcast free by IALA Beacon stations, from SBAS (Satellite Based Augmentation Systems) or via an external radio or Internet connection from a DGPS reference station. GPS correctors are fed to the Applanix POS/MVs to produce real time differentially corrected positions.</td></tr>
<tr><td>Antennas</td><td>
<table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>GA530</td></tr>
<tr><td>Description</td><td>RTCM DGPS antenna that is designed to be placed on a rover unit. The antenna receives L1, L2, Beacon, OmniSTAR (now called MarineStar), and SBAS signals.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S222</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>Antenna s/n</td><td>13019</td><td>13008</td><td>12987</td></tr>
</table>
</td></tr>
</table>
</td></tr>
<tr><td>Receivers</td><td>
<table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>SPS351</td></tr>
<tr><td>Description</td><td>The Trimble SPS351 receiver uses RTCM DGPS corrections either broadcast free by IALA Beacon stations, from SBAS (Satellite Based Augmentation Systems) or via an external radio or Internet connection from a DGPS reference station.</td></tr>
<tr><td>Firmware Version</td><td>4.70</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S222</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>Antenna s/n</td><td>5229D53057</td><td>5229D53050</td><td>5229D53059</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>Description</td><td>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.</td></tr>
</table>

Antennas	No DGPS antennas were installed.
Receivers	No DGPS receivers were installed.

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 : 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

Manufacturer	Sea-Bird Electronics
Model	SBE19
Description	"Thomas Jefferson" uses a Sea-Bird Electronics SeaCat SBE19 Conductivity, Temperature, and Depth (CTD) Profiler 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 from strain gauge pressure. The system is configured for a sampling rate of 0.5 seconds. Depending on the depth of water, the profiler is either deployed by hand, or using a winch.
Serial Numbers	*Vessel Installed On*: S222 *CTD s/n*: 192472-0285
Calibrations	*CTD s/n*: 192472-0285 *Date*: 2015-04-17 *Procedures*: Calibrations performed by Sea-Bird Electronics

Figure : Sea-Bird 19 CTD used aboard Thomas Jefferson S222

A.5.1.1.2 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>“Thomas Jefferson,” 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. Aboard “Thomas Jefferson,” the profiler is either hand deployed, or deployed via a winch, depending on the depth of water.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S222</td><td>TJ3101</td><td>TJ3102</td></tr>
<tr><td>CTD s/n</td><td>19P60744-6667</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>2015-05-19</td><td>2015-05-19</td><td>2015-05-19</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 : Sea-Bird 19+ CTD used aboard Thomas Jefferson S-222 and her survey launches.

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 AML Oceanographic AML Smart/Micro SV&P Probe

Manufacturer	AML Oceanographic
Model	AML Smart/Micro SV&P Probe
Description	“Thomas Jefferson” uses an AML Micro SV&P Probe to collect speed of sound profiles via the Brooks Ocean Technology MVP. The speed of sound is measured directly using a 'time-of-flight' sensor. Depth is calculated via strain gauge pressure. The currently installed probe is the Micro SV&P, serial number 7591. Any changes to the installed probe will be noted in the Descriptive Report of the effected survey.
Serial Numbers	*Vessel Installed On*: S222 / S222 / S222 *Sound Speed Profiler s/n*: Smart SV&P 4988 / Smart SV&P 5340 / Smart SV&P 7591
Calibrations	*Sound Speed Profiler s/n*: 4988 / 5340 / 7591 *Date*: 2015-04-17 / 2015-05-19 / 2015-05-19 *Procedures*: Calibrations performed by AML Oceanographic. / Calibrations performed by AML Oceanographic. / Calibrations performed by AML Oceanographic.

Serial Numbers

Vessel Installed On	S222	S222	S222
Sound Speed Profiler s/n	Smart SV&P 4988	Smart SV&P 5340	Smart SV&P 7591

Calibrations

Sound Speed Profiler s/n	4988	5340	7591
Date	2015-04-17	2015-05-19	2015-05-19
Procedures	Calibrations performed by AML Oceanographic.	Calibrations performed by AML Oceanographic.	Calibrations performed by AML Oceanographic.

Figure : AML Smart SV&P Probe used in the MVP free-fall fish.

A.5.2 Surface Sound Speed

A.5.2.1 AML Oceanographic AML Smart SV&T Probe

Manufacturer	AML Oceanographic
Model	AML Smart SV&T Probe
Description	"Thomas Jefferson" uses either an AML Smart SV&T Probe, or a Reson SV-70 Probe to measure sound velocity at the face of the Reson-ROV and -SV2 transducers. The sensor is mounted in an insulated sea chest, and a pump is used

	to collect water from near the transducer. The speed of sound is measured directly using a 'time-of-flight' sensor. The AML probe can also acquire temperature with a thermistor, however this measurement is not used by the Reson transducers. Sound speed values are output in real time to the Reson systems. The currently installed probe is the Reson SV-70, serial number 5011603. Any changes to the installed probe will be noted in the Descriptive Report of the effected survey.
Serial Numbers	*Vessel Installed On*: S222 / S222 *Sound Speed Sensor s/n*: Smart SV&T 4823 / Smart SV&T 5649
Calibrations	*Sound Speed Sensor s/n*: 4823 / 5649 *Date*: 2015-04-17 / 2015-05-19 *Procedures*: Calibration was performed by AML Oceanographic. / Calibration was performed by AML Oceanographic.

A.5.2.2 Reson SV-70

Manufacturer	Reson
Model	SV-70
Description	“Thomas Jefferson” uses either an AML Smart SV&T Probe, or a Reson SV-70 Probe to measure sound velocity at the face of the Reson-ROV and -SV2 transducers. The sensor is mounted in an insulated sea chest, and a pump is used to collect water from near the transducer. The speed of sound is measured directly using a 'time-of-flight' sensor. Sound speed values are output in real time to the Reson systems. The currently installed probe is the Reson SV-70, serial number 5011603. Any changes to the installed probe will be noted in the Descriptive Report of the effected survey.
Serial Numbers	*Vessel Installed On*: S222 *Sound Speed Sensor s/n*: 5011603
Calibrations	*Sound Speed Sensor s/n*: 5011603 *Date*: 2015-05-19 *Procedures*: Calibration was performed by Teledyne RESON, Inc

A.5.2.3 Reson SV-71

<table>
<tr><td>Manufacturer</td><td colspan="3">Reson</td></tr>
<tr><td>Model</td><td colspan="3">SV-71</td></tr>
<tr><td>Description</td><td colspan="3">TJ3101 and TJ3102 us a Reson SV-71 to collect the speed of sound at the face of the Reson 7125-SV1 and -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>0810064</td></tr>
<tr><td rowspan="3">Calibrations</td><td>Sound Speed Sensor s/n</td><td>4211067</td><td>0810064</td></tr>
<tr><td>Date</td><td>2015-05-19</td><td>2015-05-19</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 : Reson SV-71 Sound Velocity Probe used for surface sound speed aboard TJ3101 & TJ3102

Additional Discussion

“Thomas Jefferson” primarily uses a Brooke Ocean Moving Vessel Profiler (MVP) installed on the port quarter to collect sound speed profiles. The integrated system consists of a computer controlled high-speed winch with cable metering, a conductor cable, and a free-fall fish (FFF). Housed in the FFF is an Applied Microsystems SV&P Smart Sensor (see above). The profiler is deployed at survey speed via the winch. A traditional winch on the port side can collect stationary casts with the SeaBird SBE19 or SBE19+ as a backup to the MVP system.

Figure : MVP winch aboard NOAA Ship Thomas Jefferson

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 North American Datum of 1983 (NAD83). During data acquisition and initial processing, horizontal control for all survey data is derived from either differentially corrected GPS using USCG differential beacons or from the MarineStar realtime satellite corrector service. If DGPS is used, differential beacons are chosen based on their proximity to the survey grounds and the signal-to-noise ratio of the beacons if more than one beacon is near the survey grounds.

During post processing, horizontal control for MBES data is replaced with a Smooth Best Estimate Trajectory (SBET) positioning. In the case of DGPS, the SBET process overwrites the position solution with an improved IAPPK solution. In the case of MarineStar, SBETs are used to transform the reference frame from ITRF00 to NAD83. 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 Datum for all projects is Mean Lower Low Water (MLLW), 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. "Thomas Jefferson" typically does not install additional tide gauges on projects.

The form of Vertical Control used for each survey will be listed in section C.1 of the Descriptive Report.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

No computer hardware was utilized for data acquisition.

A.7.2 Computer Software

Manufacturer	Caris
Software Name	HIPS/SIPS
Version	9.0.12
Service Pack	
Hotfix	
Installation Date	2015-04-18

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	9.0.11
Service Pack	
Hotfix	
Installation Date	2015-04-10
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
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	Caris
Software Name	Base Editor
Version	4.0
Service Pack	
Hotfix	
Installation Date	2015-03-19
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	
Service Pack	
Hotfix	
Installation Date	2015-03-19
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 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	
Service Pack	
Hotfix	
Installation Date	2015-04-20
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	5.8
Service Pack	
Hotfix	
Installation Date	2015-04-10
Use	Acquisition
Description	The MV-POSView controller program is used on the ship's launches 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	Applanix
Software Name	MV-POSView
Version	7.92
Service Pack	

Hotfix	
Installation Date	2015-04-08
Use	Acquisition
Description	The MV-POSView controller program is used on the ship 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	Brooke Ocean
Software Name	MVP
Version	2.450
Service Pack	
Hotfix	
Installation Date	2007-02-01
Use	Acquisition and Processing
Description	The MVP program is used to control the MVP winch and fish.

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	2015-04-08
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

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco #1728

Manufacturer	Ponar Wildco
Model	#1728
Description	The Ponar Wildco is a winch-deployed bottom sampler used aboard “Thomas Jefferson.”

Figure : Ponar style grab sampler used aboard NOAA Ship Thomas Jefferson.

A.8.1.2 Kahlsico Mud Snapper 214WA100

Manufacturer	Kahlsico Mud Snapper
Model	214WA100
Description	The Kahlsico Mud Snapper is a hand held bottom sampler that is used aboard TJ3101 and TJ3102.

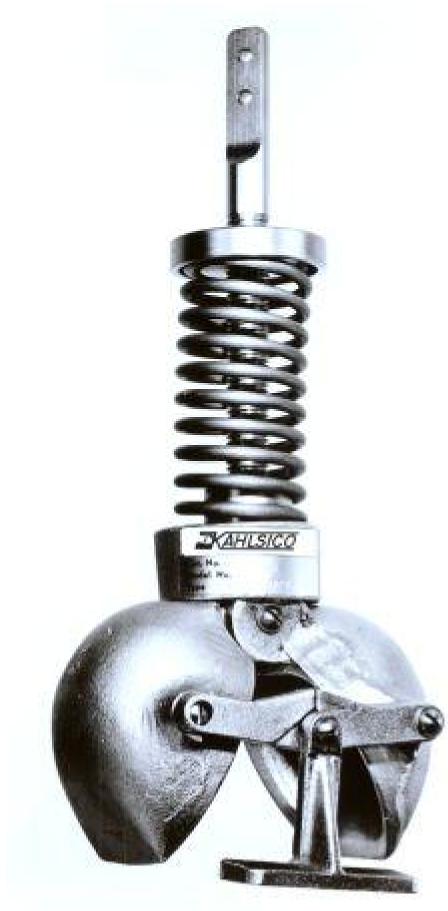

Figure : Snapper type grab sampler used aboard TJ3101 & TJ3102.

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 is logged using ODOM eChart in the .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 is 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

“Thomas Jefferson” uses an AML Micro SV&P Probe installed inside an MVP free-fall fish to acquire sound speed profiles. Profiles aboard the ship are acquired at 30 - 90 minute intervals. The interval between casts is monitored real-time using NOAA's CastTime program. CastTime compares successive casts using a ray-tracing uncertainty analysis that estimates the effect of the sound speed variability towards multibeam echo sounding. When the profile comparisons show redundancy, meaning that the effect of the sound speed variability towards echo sounding is negligible, then this provides justification to relax the sampling intervals towards the 90 minute bound. Conversely, when the comparisons show variability with a significant effect towards echo sounding, the MVP usage is increased accordingly. At any time, sampling intervals are adjusted on-the-fly at the discretion of the surveyor, to ensure spatial variability accounted for, or if there is suspicion of sudden changes in the water-column.

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 Moving Vessel Profiler (MVP) is an automated winch system that deploys a fish containing a sound speed sensor by free fall. The fish is towed behind the survey vessel in a ready position that is marked by messengers attached to the tow cable. Ideally, at survey speeds the fish is “flying” just above the depth of the sonar transducers. The specified depth deployed is selected by specifying a distance off the bottom. Once at the depth limit, the winch freefall is automatically stopped and the drag forces on the fish cause it to rise toward the surface due to the ship's forward motion. The cable slack is then pulled in by the winch to the towing position.

Aboard all platforms, the hydrographer processes each cast immediately, then reviews it for erroneous data.

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Figure : This image intentionally left blank

B.1.3.2 Surface Sound Speed

“Thomas Jefferson” uses an Reson SV-70 probe to find the speed of sound at the Reson transducer face. TJ3101 and TJ3102 use a Reson SV-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, "Thomas Jefferson" used one of the three following methods for horizontal control:

USCG Differential GPS Beacons:
“Thomas Jefferson” and her survey launches all use differentially-corrected GPS via a USCG DGPS beacon to establish horizontal position for all data acquisition and initial processing. The frequency of the assigned beacon is programmed into the Trimble DGPS receiver. The minimum number of satellites, their minimum elevation above the horizon, and the age of pseudorange correctors are also set via the Trimble software interface. During acquisition, differential correctors are sent to the Applanix POS M/V via serial connection. Total positional accuracy is monitored inside the MV-POSView window.

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.

MarineStar Realtime PPP Corrector Service:
“Thomas Jefferson” and her survey launches all 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 NAD83 reference frame and an RMS file containing the realtime uncertainty estimates of the position and attitude 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:

-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.

-GPS Tide: The IAPPK or 5P 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.

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 samples are collected in accordance with the recommended bottom sample plan provided in each survey's Project Reference File (PRF). The potential sample sites are examined by the Command and potentially culled based on the actual depths found during survey operations. Additional sample sites may also be added.

Aboard TJ3101 and TJ3102 bottom samples are collected using the Kahlsico Mud Snapper, while “Thomas Jefferson” uses the winch-deployed Ponar Wildco. Once obtained, samples are analyzed for sediment type and classified with S-57 attribution using Caris BASE Editor. In the event that no sample is obtained after three attempts, the nature of the surface is characterized as "unknown". Samples are discarded after field analysis is complete.

B.1.7 Backscatter

As per the Field Procedures Manual, “Thomas Jefferson’s” current policy is to ensure quality by processing one line of backscatter per platform, per day.

All backscatter data is logged using Hypack/Hysweep in the .7k format.

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.

-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.

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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;
- Apply TrueHeave, tide, and 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, 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.

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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.

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Figure : 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.

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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 USCG DGPS 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 (with DGPS).

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.

While very similar, the two are very different in practice. The primary requirement for running MarineStar through POSPac is to change the reference system of the data to NAD83, with the added benefit of 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.

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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.

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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.

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B.2.6 Backscatter

All backscatter data is logged in Hypack's .7k format, using datagram version 2. In accordance with the FPM, “Thomas Jefferson’s” policy is to process one line per platform, per day in order to conduct quality control checks. All processing of backscatter is done using the FMGT module of the QPS Fledermaus software package.

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B.2.7 Other

No additional data were processed.

B.3 Quality Management

Prior to each field season, “Thomas Jefferson” and her survey launches 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

Vessel	n/a		
Echosounder	n/a n/a 0 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0 degrees
		Heave	0 % Amplitude
			0 meters
		Pitch	0 degrees
		Roll	0 degrees
	Navigation Position	0 meters	

	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

Vessel offset correctors were not applied.

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.

All sensor offsets for “Thomas Jefferson” were measured with respect to the vessel's reference point, then translated to the IMU. 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.

Additional Discussion

Towfish positioning is provided to Caris HIPS using cable-out values registered by the Totco cable counter and recorded in the SonarPro SDF files. SonarPro uses Payout and Towfish Depth to compute towfish positions. The towfish position is calculated from the position of the tow point using the cable-out value received by SonarPro from the cable payout meter, the towfish pressure depth (sent via a serial interface from the Klein 5000 TPU to the SonarPro software), and the Course Made Good (CMG) of the vessel. This method assumes that the cable is in a straight line. Therefore, no catenary algorithm is applied at the time of acquisition, but in processing, Caris SIPS applies a 0.9 coefficient to account for the catenary.

Layback error is calculated by running a side scan certification test. This test consists of running parallel to a known feature at varying ranges from nadir to ensonify the target in the near-field (approximately 15% of range scale in use), mid-field (approximately 50 % of range scale in use), and far-field (approximately 85% of the range scale in use). The test requires that each side of the sonar ensonify the feature at each of these areas in the swath. Then the test is repeated in a direction that is orthogonal to the original set of lines such that the feature is ensonified a total of 12 times. A successful test will detect the feature in at least 10 of the 12 passes. For hull-mounted systems, the selected contact positions must be within 5m; for towed systems, the contact positions must be within 10m. Layback error is the amount of correction that must be applied to minimize the distance between contact positions.

C.2 Static and Dynamic Draft

C.2.1 Static Draft

Static draft correctors were not applied.

C.2.2 Dynamic Draft

Dynamic draft correctors were not applied.

Additional Discussion

Dynamic draft for “Thomas Jefferson” and her survey launches 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.

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. For the ship, a Sutron Bubbler system is used to measure static draft. The orifice was surveyed into the IMU reference frame, and a waterline height was calculated. A common waterline for the ship when fully loaded with fuel and ballasted normally is approximately 35cm below the reference point of the ship, but the waterline may change by as much as +/- 30cm over the course of a field season. 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.

Waterline measurements are recorded daily on TJ3101 and TJ3102. The waterline for “Thomas Jefferson” is measured at least weekly. When feasible, waterline measurements are taken before and after fueling or ballasting of the ship. 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

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. Navigation and attitude measurements not applied in real time 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 most cases, 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, “Thomas Jefferson” conducted MBES calibration tests for each individual multibeam system on the ship and her launches. 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 “Thomas Jefferson,” the MVP free-fall fish is used to collect sound speed profiles. Aboard TJ3101 and TJ3102, and-deployed seabird CTD units are used to take sound of speed profiles.

C.6.1.2 Methods and Procedures

Seabird .cnv and MVP .bot 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

Aboard "Thomas Jefferson," surface sound speed is measured using a Reson SV-70 probe mounted inside a tank. The tank draws water from the approximate location of the face of the Reson 7125-ROV and Reson 7125-SV2 transducer faces. 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-ROV and 7125-SV 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-G380-TJ-15: Approaches to Charleston, SC

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 (2015 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 CARRIER.JOSEPH.KELSO.III.1155373152
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=NOAA, cn=CARRIER.JOSEPH.KELSO.III.1155373152
Date: 2015.06.10 14:37:01 Z

LT Joseph K. Carrier, NOAA	CAPT Shepard M. Smith, NOAA
Operations Officer	Commanding Officer