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

Data Acquisition & Processing Report

Type of Survey **Navigable Area**

Project No. **OPR-B307-FH-15**

Registry No. **H12802, H12811**

Time Frame **18 June 2015 - 26 July 2015**

LOCALITY

State **Rhode Island**

General Locality **Rhode Island Sound and Approaches**

2015

CHIEF OF PARTY

LCDR Marc S. Moser, NOAA; LCDR Briana Welton, NOAA

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NOAA Ship *Ferdinand R. Hassler*
Chief of Party: LCDR Briana J. Welton, NOAA
Year: 2015
Version: 2.1
Publish Date: 2016-02-15

A Equipment

A.1 Survey Vessels

A.1.1 NOAA Ship FERDINAND R. HASSLER

<table>
<tr><td>Name</td><td colspan="2">NOAA Ship FERDINAND R. HASSLER</td></tr>
<tr><td>Hull Number</td><td colspan="2">S250</td></tr>
<tr><td>Description</td><td colspan="2">FERDINAND R. HASSLER is a Small Waterplane Area, Twin-Hull (SWATH) coastal mapping vessel.</td></tr>
<tr><td>Utilization</td><td colspan="2">Survey</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>37.7 meters</td></tr>
<tr><td>Beam</td><td>18.5 meters</td></tr>
<tr><td>Max Draft</td><td>3.85 meters</td></tr>
<tr><td rowspan="3">Most Recent Full Static Survey</td><td>Date</td><td>2009-11-04</td></tr>
<tr><td>Performed By</td><td>Raymond C. Impastato, Professional Land Surveyor</td></tr>
<tr><td>Discussion</td><td>This survey was provided by the shipbuilder, V.T. Halter Marine, and performed in the shipyard prior to delivery.</td></tr>
<tr><td rowspan="3">Most Recent Partial Static Survey</td><td>Date</td><td>2012-06-12</td></tr>
<tr><td>Performed By</td><td>Kevin Jordan, NGS</td></tr>
<tr><td>Discussion</td><td>This survey was performed after the POS/MV antenna mounts were reconfigured to newly fabricated mounts and ties the POS antennae into benchmarks on the 03 deck.</td></tr>
</table>

Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	*Date*	2013-04-07
	Method Used	Optical level run while ship was out of the water in drydock
	Discussion	A level loop was run from the POS antenna to each sensor mounted on the ship's hull. In addition, measurements were made to both IMU base plates through the 7125 cable passage. The resulting offsets from this survey were used to verify and update Z offsets between all sensors.
Most Recent Static Draft Determination	*Date*	2011-07-12
	Method Used	Calculation from design waterline and measured offsets
	Discussion	Assumed design waterline of 3.8 meters and measured offsets to IMU were used to determine static draft of the reference point. The ship's draft is operationally managed with daily ballast to achieve a true waterline of 3.77 meters. Draft uncertainty is estimated at 0.05 meters. See Section C.2.1.1 for additional discussion.
Most Recent Dynamic Draft Determination	*Date*	2015-05-12
	Method Used	Ellipsoid referenced dynamic draft measurement (ERDDM)
	Discussion	Data were acquired with canards at zero trim angle. During all survey operations, the canards are set to zero trim angle. Averages are being calculated from all ERDDM tests since the installation of the buoyancy appendages in 2013. This will help filter out errors located in individual tests.

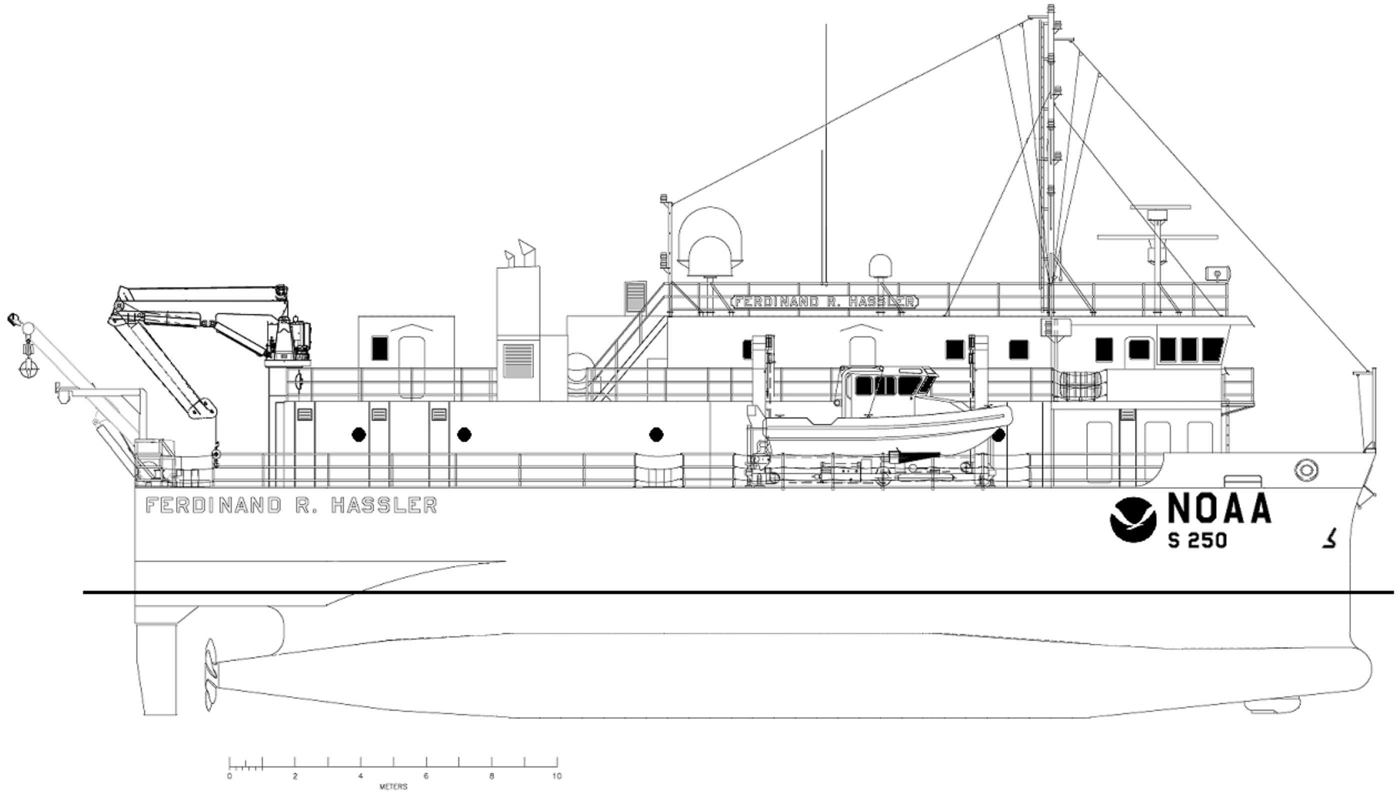


Figure 1: NOAA Ship FERDINAND R. HASSLER, Starboard View

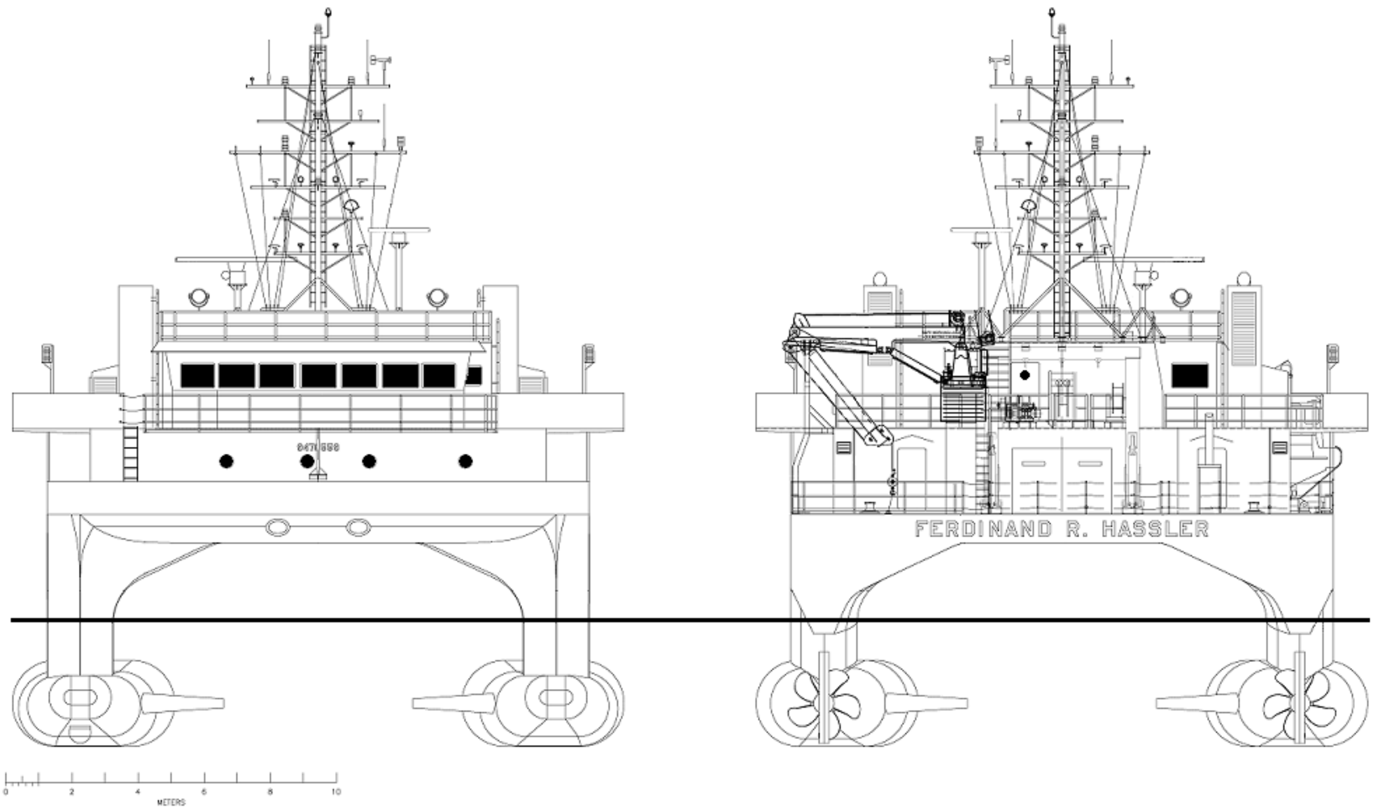
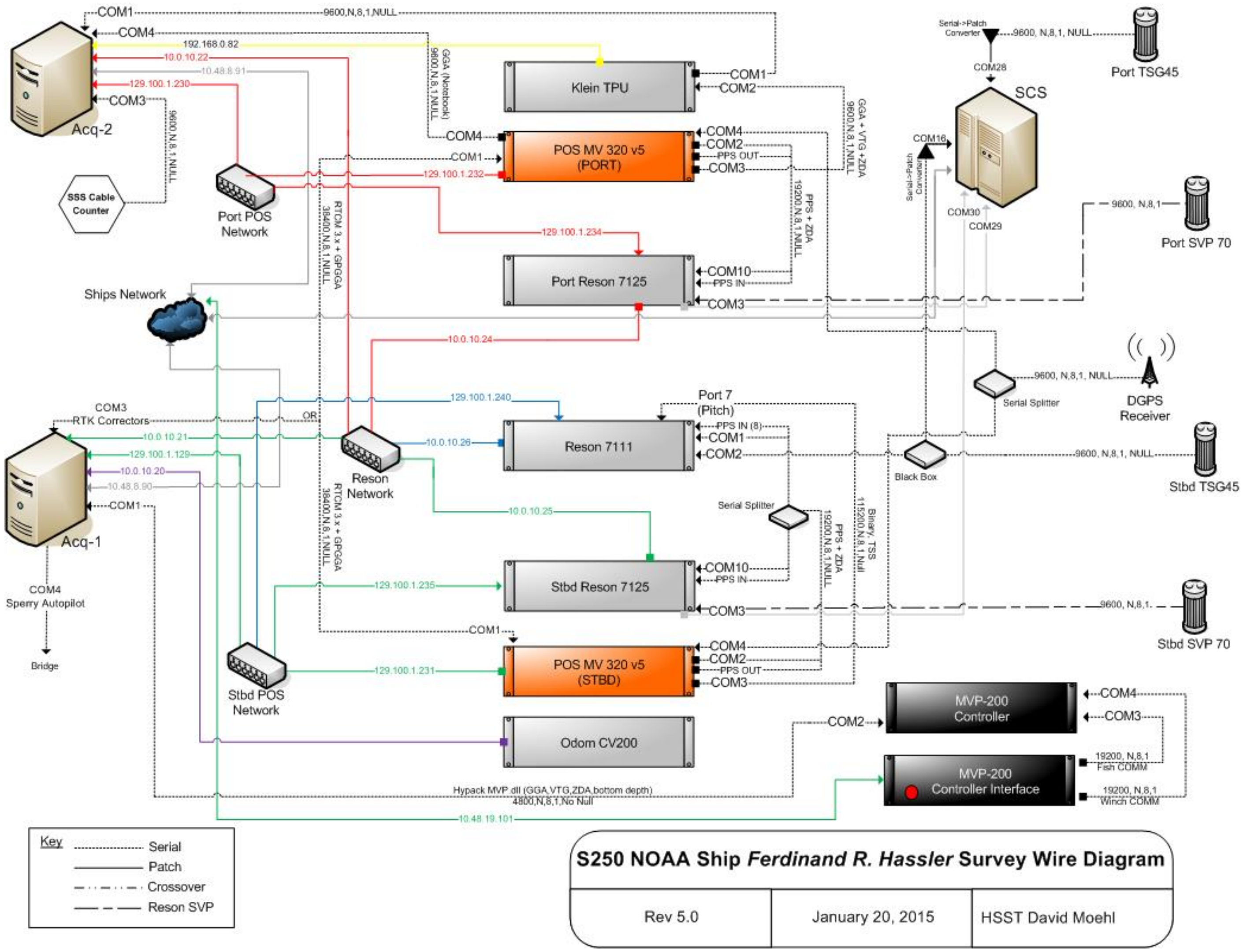


Figure 2: NOAA Ship FERDINAND R. HASSLER, Bow and Stern View



A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

No side scan sonars were utilized for data acquisition.

A.2.2 Multibeam Echosounders

A.2.2.1 RESON 7125

Manufacturer	RESON
Model	7125
Description	The RESON 7125 is a dual head, dual multibeam system configured to work as a unit. While the particulars of the port system are specified in this section and the starboard head in the following section, this description and following quality control address the two heads as an integrated system. The port and starboard sonars are mounted in their respective hulls with a 4.5 degree outboard tilt. The sonars can be operated independently, but are typically operated together as a dual-head system using frequency modulated (FM) pulses combined with center frequency separation to enable simultaneous pinging between the heads. When operated as a dual head system, the starboard system acts as the master and the port system the slave. The range scale, ping rate, surface sound speed, and time varied gain (TVG) parameters are controlled by the master. Patch Tests - A patch test for the Port 400kHz and 200kHz modes was conducted on May 13, 2015 (Dn133) in the vicinity of Isles of Shoals, NH. A patch test for the Starboard 400kHz and 200kHz modes was conducted on June 5, 2015 (Dn156) in the southern approaches of Rhode Island Sound. Reference Surfaces - A reference surface for both Port and Starboard, in both 400kHz and 200kHz modes was conducted on June 9, 2015 (Dn160) in the southern approaches of Rhode Island Sound.

Serial Numbers

Vessel Installed On	S250	same
Processor s/n	18210412051	same
Transceiver s/n	212036	same
Transducer s/n	n/a	n/a
Receiver s/n	2411045	same
Projector 1 s/n	2611093	same
Projector 2 s/n	n/a	n/a

<table>
<tr><td rowspan="12">Specifications</td><td>Frequency</td><td colspan="2">400 kilohertz</td><td colspan="2">200 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>1.0 degrees</td><td>Along Track</td><td>2 degrees</td></tr>
<tr><td>Across Track</td><td>0.5 degrees</td><td>Across Track</td><td>1 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">50 hertz</td><td colspan="2">50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equidistant</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>512</td><td>Number of Beams</td><td>512</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">140 degrees</td><td colspan="2">140 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">6 millimeters</td><td colspan="2">6 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>150 meters</td><td>Manufacturer Specified</td><td>400 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td><td>Ship Usage</td><td>250 meters</td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="5">Manufacturer calibration was not performed.</td></tr>
</table>

System Accuracy Tests	*Vessel Installed On*	S250	S250
	Methods	Reference surface comparison	Ellipsoidal Referenced Lead Line and Water Line
	Results	Reference surfaces were performed in the vicinity of Rhode Island Sound on June 8 & 9, 2015 (Dn159 & Dn160). The 7125 400kHz sonars were operated in dual head FM and single head FM. For 400kHz, the starboard head was on average 0.10 meters deeper than the port head with a standard deviation of 0.10 meters.	On March 5, 2014 a static lead line comparison was performed relative to the ellipsoid for the port 7125 system. Ellipsoid height was obtained on a fixed mark ashore using static GPS observations. While the ship was pierside at Judd Gregg Marine Research Complex, a lead-line was lowered to the sea floor in the port 7125 field of view while logging sounding data. Observed ellipsoid height was transferred to the suspended lead-line using differential leveling, and the distance from the lead to the mark measured with a steel survey tape. Logged sonar data was processed through CARIS using standard ERS methods to yield an ellipsoid referenced measurement. Results of this test show the sonar measured depth to be 0.03 meters shallower than the lead-line derived depths with a propagated uncertainty of 0.03 meters. In addition to the ellipsoid measurement, the lead-line was marked at the waterline and the distance from the lead to the mark measured with a steel survey tape. Logged sonar data was processed through CARIS using a zero-tide file to yield a waterline referenced measurement. Sonar depths were an average of 0.04 meters deeper than lead-line derived depths with a propagated error of 0.06 meters. The uncertainty of the measurement is dominated by the uncertainty in reading ship draft marks. This test was repeated for the starboard 7125 system. Results show the sonar depth 0.01 meters deeper than the lead-line derived depths with a propagated uncertainty of 0.03 meters. For the waterline; sonar measured depths were an average of 0.15 meters shallower than the lead-line derived depths with a propagated error of 0.06 meters. There is still uncertainty of the measurement, mainly dominated by the uncertainty in reading ship draft marks.

Snippets	Sonar has snippets logging capability.

Figure 3: 7125 Housing flush-mounted on hull.

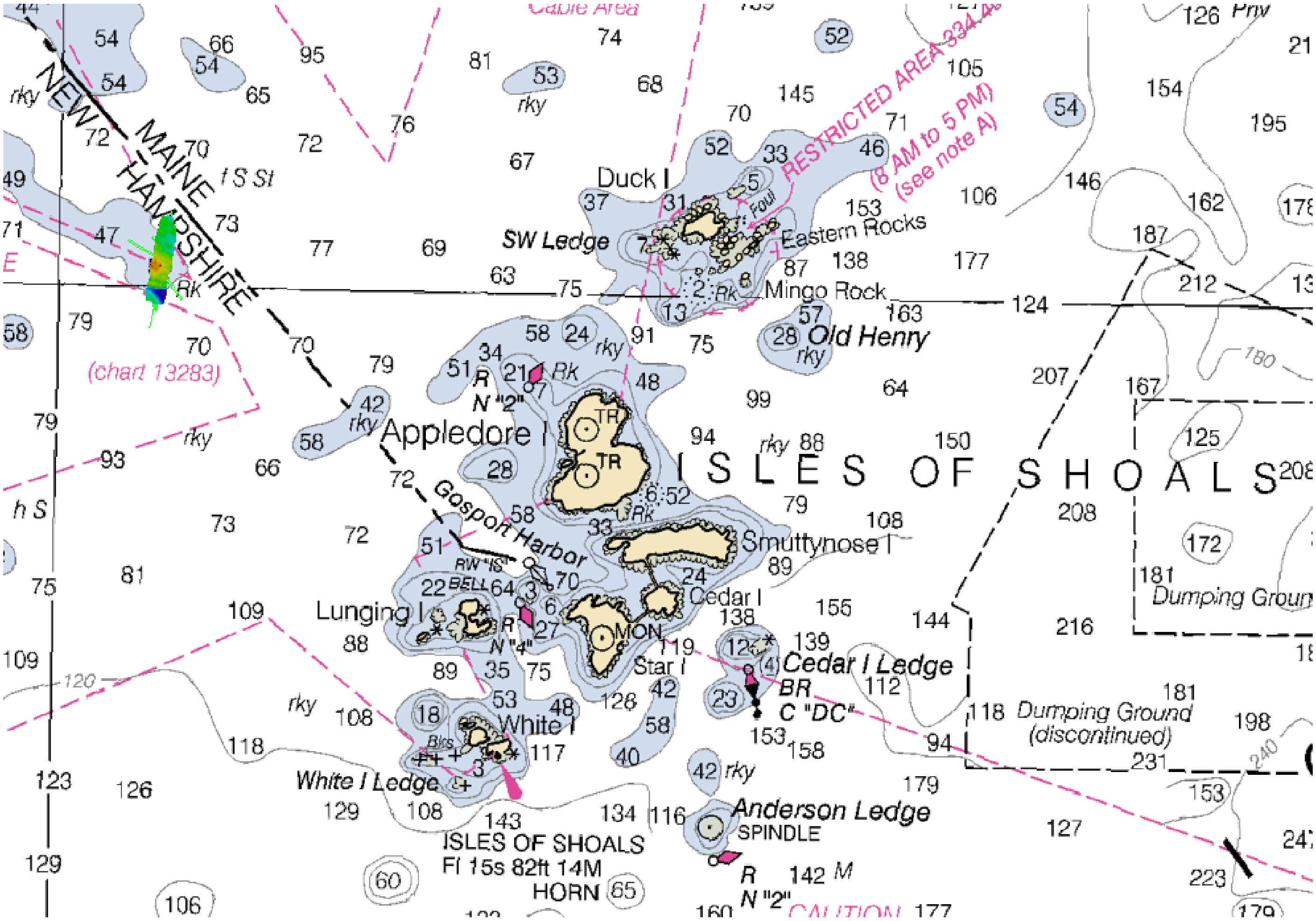


Figure 4: General location of Dn133 patch test in the vicinity of Isles of Shoals, NH. Charted depths are in feet.

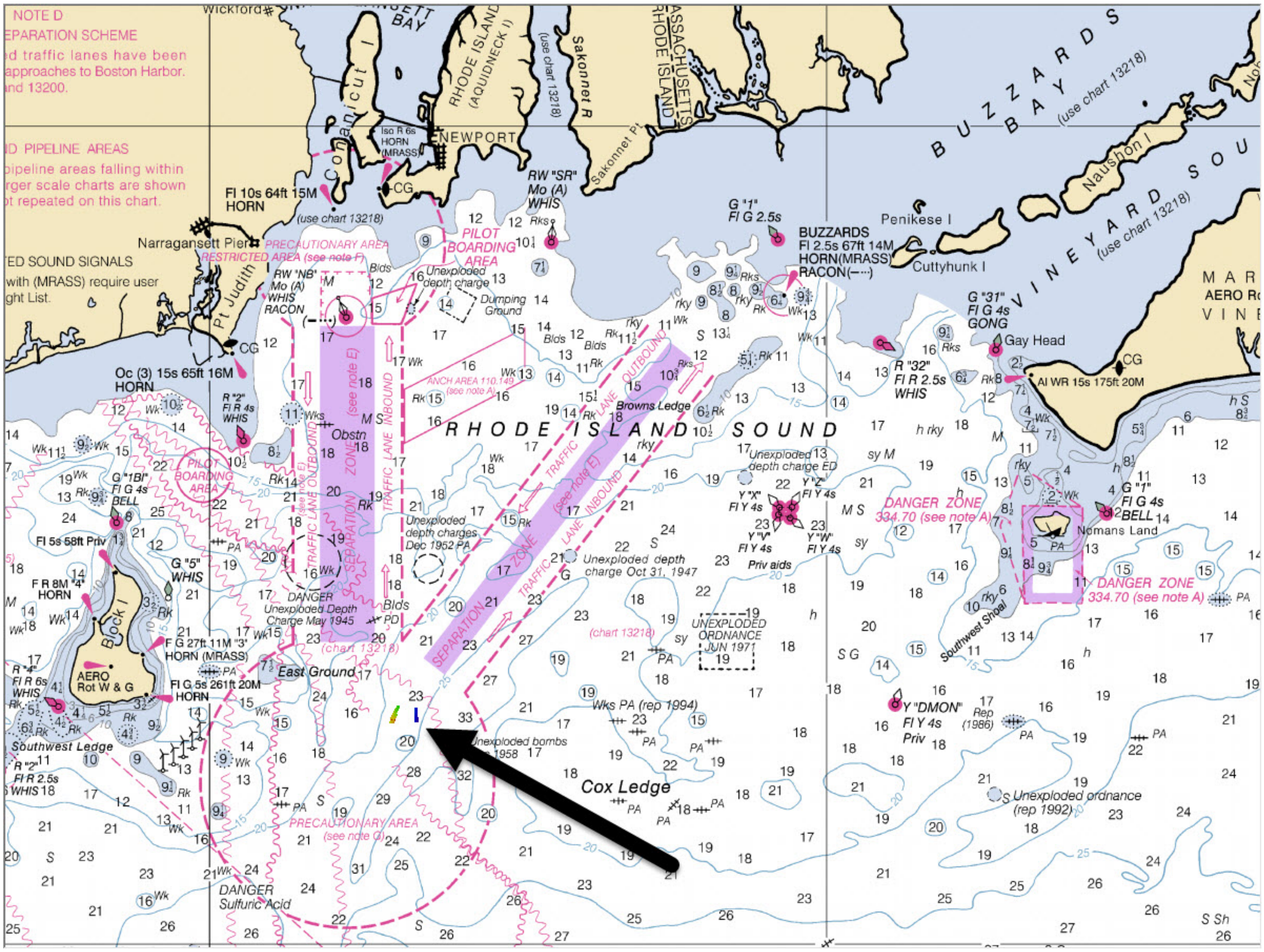


Figure 5: General location of Dn156 patch test in the vicinity of the entrances to Rhode Island Sound. Charted depths are in fathoms.

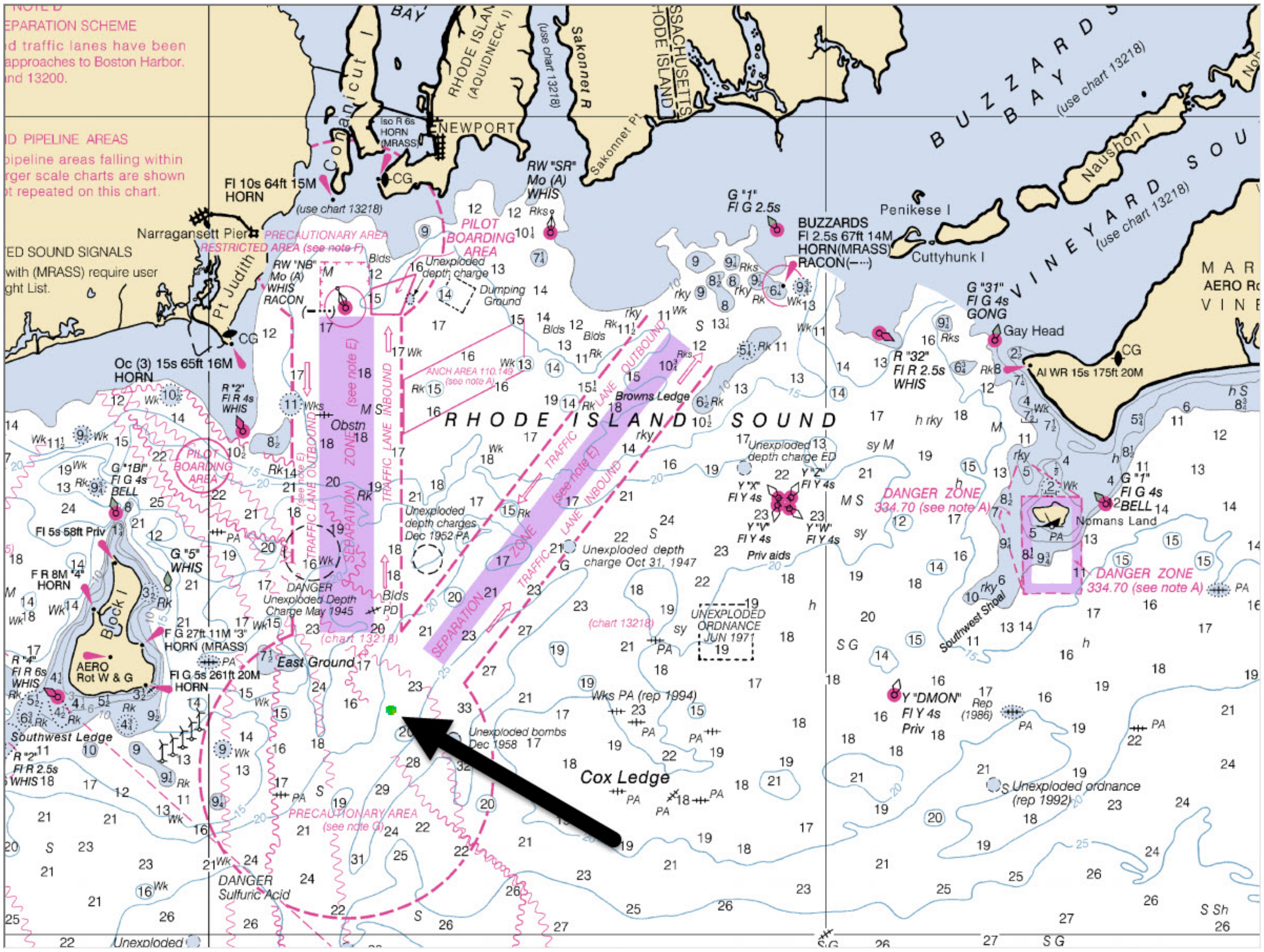


Figure 6: General location of Dn160 reference surface in the vicinity of the entrances to Rhode Island Sound. Charted depths are in fathoms.

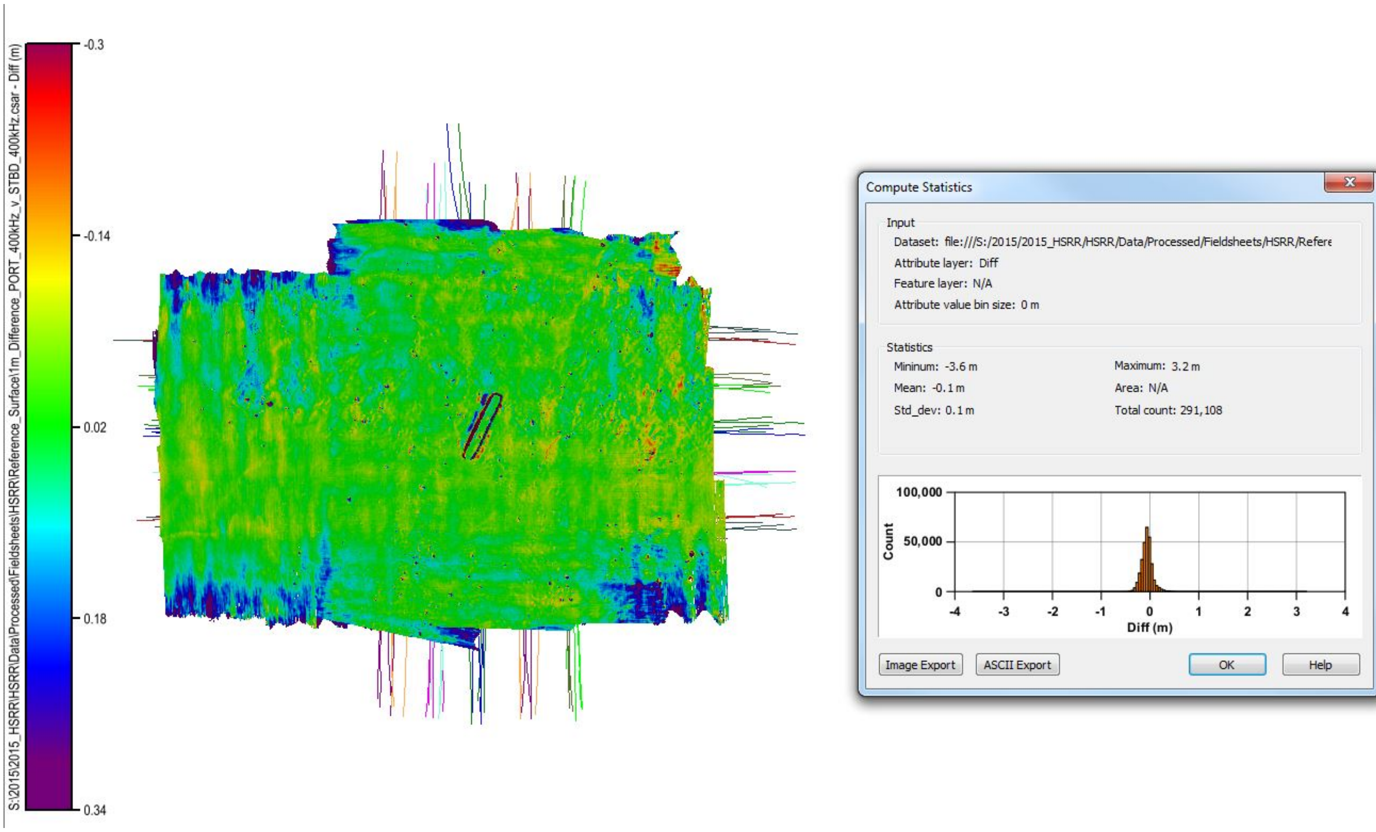


Figure 7: Distribution of depth differences, port minus starboard for Dn156 reference surface. Depths from starboard are on average 0.10 meters deeper than depths from port system with a standard deviation of 0.10 meters. Sonars configured in FM simultaneous pinging configuration.

A.2.2.2 RESON 7125

Manufacturer	RESON
Model	7125
Description	Starboard system of a dual head configuration. For a description of this system and associated quality control tests, see entry for port 7125. On Dn231, August 21, 2014, the receiver for the starboard 7125 was found to contain dead cards, causing an issue in the bottom detection to consistently prioritize data from specular reflection. The receiver was removed on Dn268, September 25, 2014, returned to RESON for repair and was not re-installed until Dn139, May 19,2015. While troubleshooting the 7125 receiver problems it was noted that several pins on the through-hull receiver cable were damaged. A new receiver cable was installed on Dn139, May 19,2015, replacing the damaged cable.

<table>
<tr><td rowspan="7">Serial Numbers</td><td>Vessel Installed On</td><td colspan="2">S250</td><td colspan="2">same</td></tr>
<tr><td>Processor s/n</td><td colspan="2">18215011048</td><td colspan="2">same</td></tr>
<tr><td>Transceiver s/n</td><td colspan="2">212035</td><td colspan="2">same</td></tr>
<tr><td>Transducer s/n</td><td colspan="2">n/a</td><td colspan="2">n/a</td></tr>
<tr><td>Receiver s/n</td><td colspan="2">3411050</td><td colspan="2">same</td></tr>
<tr><td>Projector 1 s/n</td><td colspan="2">1111236</td><td colspan="2">same</td></tr>
<tr><td>Projector 2 s/n</td><td colspan="2">n/a</td><td colspan="2">n/a</td></tr>
<tr><td rowspan="11">Specifications</td><td>Frequency</td><td colspan="2">400 kilohertz</td><td colspan="2">200 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>0.5 degrees</td><td>Along Track</td><td>2 degrees</td></tr>
<tr><td>Across Track</td><td>1 degrees</td><td>Across Track</td><td>1 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">50 hertz</td><td colspan="2">50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equidistant</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>512</td><td>Number of Beams</td><td>512</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">140 degrees</td><td colspan="2">140 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">6 millimeters</td><td colspan="2">6 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>150 meters</td><td>Manufacturer Specified</td><td>400 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td><td>Ship Usage</td><td>250 meters</td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="5">Manufacturer calibration was not performed.</td></tr>
<tr><td rowspan="3">System Accuracy Tests</td><td>Vessel Installed On</td><td colspan="4">S250</td></tr>
<tr><td>Methods</td><td colspan="4">Reference surface comparison</td></tr>
<tr><td>Results</td><td colspan="4">See section A 2.2.1</td></tr>
<tr><td>Snippets</td><td colspan="5">Sonar has snippets logging capability.</td></tr>
</table>

A.2.3 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

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

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

Manufacturer	In-Situ Inc.
Model	Rugged TROLL 100 / Rugged BaroTROLL
Description	The Rugged TROLL 100 is a non-vented (absolute) data logger that measures and records changes in water level, pressure, and temperature. When post-processed with an accompanying CTD cast and tide value, accurate least depths on submerged objects can be obtained. The Rugged BaroTROLL is a data logger used to measure and record barometric pressure, which is used to compensate for changes in water level due to barometric fluctuations. Typically the BaroTROLL is not used for dive operations but may prove to be beneficial for least depth investigations in the future.
Serial Numbers	349000 - Rugged TROLL 100 349047 - Rugged BaroTROLL
Calibrations	No calibrations were performed.
Accuracy Checks	*Serial Number*: 349000 *Date*: 2014-04-15 *Procedures*: Sounding System Comparison - The DLDG was taped to the leadline while recording and submerged to the seafloor for a measurement. A cast was taken during the comparison and the data gathered were processed using Velocipy. The DLDG results were 0.13 meters deeper than the leadline measurement, 0.13 and 0.23 meters shallower than the port and starboard 7125 values, respectively.
Correctors	Correctors were not determined.

Non-Standard Procedures	Non-standard procedures were not utilized.

A.3.2 Lead Lines

Manufacturer	Unknown
Model	Traditional
Description	FERDINAND R. HASSLER is equipped with one lead line. Lead lines are used for measurements near shore over submerged shoals and for echosounder depth comparisons.
Serial Numbers	RA6S
Calibrations	No calibrations were performed.
Accuracy Checks	*Serial Number*: RA6S *Date*: 2014-03-03 *Procedures*: The wet lead line was stretched with an amount of force equal to the weight, on relatively flat ground and compared with a steel survey tape. Values were recorded of true measurements at lead line markings.
Correctors	From the table of values obtained during the accuracy checks a table of correctors was calculated. This table is stored locally aboard the FERDINAND R. HASSLER and referenced when appropriate.
Non-Standard Procedures	Non-standard procedures were not utilized.

Figure 8: Leadline fitted with custom mud-shoe to limit penetration of soft bottoms.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Positioning and Attitude Equipment

A.4.1 Applanix POS/MV

<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS/MV 320 V5</td></tr>
<tr><td>Description</td><td>Tightly coupled GPS and inertial positioning and attitude sensing system for port hull. Inertial motion unit (IMU) is located below water line close to the port side 7125 wet end. GPS antennae are located on flying bridge of S250. The V5 system was installed on July 29, 2013.</td></tr>
<tr><td>PCS</td><td><table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS/MV 320 V5</td></tr>
<tr><td>Description</td><td>Rack mounted POS control system located in charting lab.</td></tr>
<tr><td>Firmware Version</td><td>8.15</td></tr>
<tr><td>Software Version</td><td>8.15</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S250 Port</td></tr>
<tr><td>PCS s/n</td><td>5806</td></tr>
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</table></td></tr>
<tr><td>IMU</td><td><table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>Type 36</td></tr>
<tr><td>Description</td><td>Inertial measurement system consisting of three orthogonal accelerometers and three orthogonal fiber-optic gyroscopes. Located in port hull near 7125 wet end.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S250 Port hull</td></tr>
<tr><td>IMU s/n</td><td>2423</td></tr>
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<tr><td>Certification</td><td><table>
<tr><td>IMU s/n</td><td>2423</td></tr>
<tr><td>Certification Date</td><td>2013-06-26</td></tr>
</table></td></tr>
</table></td></tr>
<tr><td>Antennas</td><td><table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>382AP GNSS</td></tr>
<tr><td>Description</td><td>GNSS antennae are used for position input as well as aiding the heading solution. The antennae pair for the port system is the forward and aft pair on the port side. The separation distance between the antennae is approximately 2 meters.</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>S250 Port (forward)</td><td>8848</td><td>Port</td><td>Primary</td></tr>
</table></td></tr>
</table></td></tr>
</table>

	Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
	S250 Port (aft)	8839	Port	Secondary

GAMS Calibration	*Vessel*	S250
	Calibration Date	2015-05-12
Configuration Reports	POS/MV configuration reports were not produced.	

Manufacturer	Applanix
Model	POS/MV 320 V5
Description	Tightly coupled GPS and inertial positioning and attitude sensing system for starboard hull. Inertial motion unit (IMU) is located below water line close to the starboard side 7125 wet end. GPS antennae are located on flying bridge of S250. The V5 system was installed on July 29, 2013. On October 18, 2014, the starboard IMU suffered an 'IMU failure' during surveying operations. The starboard POS was not being used for data acquisition at the time, nor was it used for the remainder of the project. The IMU was shipped back to Applanix, where it was determined that the power supply was the cause of failure. The power supply and top hat was replaced under warranty and installed on November 10, 2014. The replaced IMU has a new serial number due to the replaced top hat, but retains all the original sensors. Since the sensors remained the same, no calibration certificate was supplied.

PCS	*Manufacturer*	Applanix	
	Model	POS/MV 320 V5	
	Description	Rack mounted POS control system located in charting lab.	
	Firmware Version	8.15	
	Software Version	8.15	
	Serial Numbers	*Vessel Installed On*	S250 Starboard
		PCS s/n	5807

<table>
<tr><td>IMU</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>Type 36</td></tr>
<tr><td>Description</td><td>Inertial measurement system consisting of three orthogonal accelerometers and three orthogonal fiber-optic gyroscopes. Located in starboard hull near 7125 wet end.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S250 Starboard hull</td><td>S250 Starboard hull new top hat</td></tr>
<tr><td>IMU s/n</td><td>2424</td><td>2672</td></tr>
</table>
</td></tr>
<tr><td>Certification</td><td>
<table>
<tr><td>IMU s/n</td><td>2424</td></tr>
<tr><td>Certification Date</td><td>2013-06-26</td></tr>
</table>
</td></tr>
</table>
</td></tr>
<tr><td>Antennas</td><td>
<table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>382AP GNSS</td></tr>
<tr><td>Description</td><td>GNSS antennae are used for position input as well as aiding the heading solution. The antennae pair for the starboard system is the forward and aft pair on the starboard side. The separation distance between the antennae is approximately 2 meters.</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>S250 Starboard (forward)</td><td>8840</td><td>Starboard</td><td>Primary</td></tr>
<tr><td>S250 Starboard (aft)</td><td>8838</td><td>Starboard</td><td>Secondary</td></tr>
</table>
</td></tr>
</table>
</td></tr>
<tr><td>GAMS Calibration</td><td>
<table>
<tr><td>Vessel</td><td>S250</td></tr>
<tr><td>Calibration Date</td><td>2015-05-12</td></tr>
</table>
</td></tr>
<tr><td>Configuration Reports</td><td>POS/MV configuration reports were not produced.</td></tr>
</table>

A.4.2 DGPS

Description	Hemisphere PGS MBX Kit

Antennas	*Manufacturer*	Hemisphere	
	Model	MBX-4	
	Description		
	Serial Numbers	*Vessel Installed On*	S250
		Antenna s/n	1113139440044
Receivers	*Manufacturer*	Hemisphere	
	Model	MBX-4	
	Description		
	Firmware Version	1.0	
	Serial Numbers	*Vessel Installed On*	S250
		Antenna s/n	1118144550001

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 360R
Description	Rugged and waterproof laser rangefinder which provides full measurement capabilities of distances, heights and azimuths.
Serial Numbers	2557
DQA Tests	DQA test was not performed.

Figure 9: TruPulse 360R Laser Rangefinder

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 SeaCat 19plus 350 meter and 3500 meter

<table>
<tr><td>Manufacturer</td><td colspan="4">Sea-Bird</td></tr>
<tr><td>Model</td><td colspan="4">SeaCat 19plus 350 meter and 3500 meter</td></tr>
<tr><td>Description</td><td colspan="4">Internal logging conductivity, temperature, and depth measuring devices.</td></tr>
<tr><td rowspan="2">Serial Numbers</td><td>Vessel Installed On</td><td>S250</td><td>S250</td><td>S250</td></tr>
<tr><td>CTD s/n</td><td>19P65591-6918</td><td>19P32914-4480</td><td>19P36399-4642</td></tr>
<tr><td rowspan="3">Calibrations</td><td>CTD s/n</td><td>6918</td><td>4480</td><td>4642</td></tr>
<tr><td>Date</td><td>2015-04-01</td><td>2015-03-23</td><td>2015-03-23</td></tr>
<tr><td>Procedures</td><td>Routine calibration service</td><td>Routine calibration service</td><td>Routine calibration service</td></tr>
</table>

Figure 10: Ferdinand R. Hassler CTD inventory

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 Rolls-Royce Brooke-Ocean MVP200

<table>
<tr><td>Manufacturer</td><td>Rolls-Royce Brooke-Ocean</td></tr>
<tr><td>Model</td><td>MVP200</td></tr>
<tr><td>Description</td><td>Moving vessel profiler equipped with an AML Micro-CTD in a single sensor free fall fish:
The towfish and cable were outfitted on August 18, 2014 using AML Micro-CTD sensor SN-8610, after returning from calibration and verified to be in working order by sound speed comparison cast. MVP brake adjustments were conducted on August 21, 2014, to meet manufacturer specifications of 500 lbs of force.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S250</td><td>S250</td></tr><tr><td>Sound Speed Profiler s/n</td><td>8609</td><td>8610</td></tr></table></td></tr>
<tr><td>Calibrations</td><td><table><tr><td>Sound Speed Profiler s/n</td><td>8609</td><td>8610</td></tr><tr><td>Date</td><td>2015-03-25</td><td>2015-03-20</td></tr><tr><td>Procedures</td><td>Routine calibration service</td><td>Routine calibration service</td></tr></table></td></tr>
</table>

Figure 11: MVP control station & winch

Figure 12: MVP single sensor free fall fish.

A.5.2 Surface Sound Speed

A.5.2.1 Sea-Bird 45 MicroTSG

Manufacturer	Sea-Bird

Model	45 MicroTSG
Description	Two SBE-45 thermosalinographs are installed to determine the sound velocity of the water at the sonar transducers. This data is used to aid beam steering of the multibeam 7111 sonar system, and as a backup sound speed input available for beam steering of the multibeam 7125 sonar systems. One is located in the starboard engine room, the other in the port. Both units draw sampling water from the main cooling water line of the respective main engine. The SBE-45s are configured to use their internal temperature sensors. Both units are insulated with foam to ensure accurate temperature readings. These devices calculate the sound speed from the measured salinity and temperature (using the Chen-Millero equation) of the sampled water. A serial broadcast device sends the sound speed message from the SBE-45 to the RESON 7111 and SCS acquisition server.
Serial Numbers	*Vessel Installed On*: S250 Port / S250 Starboard *Sound Speed Sensor s/n*: 4553332-0276 / 4553332-0277
Calibrations	*Sound Speed Sensor s/n*: 4553332-0276 / 4553332-0277 *Date*: 2015-04-02 / 2015-04-02 *Procedures*: Routine calibration service / Routine calibration service

A.5.2.2 RESON SVP-70

Manufacturer	RESON
Model	SVP-70
Description	Sound velocity probe developed for fixed-mount installation near RESON 7125 transducer heads which uses a direct path echosounding technique that instantly compensates for temperature and pressure with internal sensors, providing accurate surface sound velocity measurements for beam steering. SVP-70 probe 2011276, which would normally be on the port hull, was not installed for this project.
Serial Numbers	*Vessel Installed On*: S250 Starboard hull / S250 Port hull *Sound Speed Sensor s/n*: 2011278 / 2011276
Calibrations	*Sound Speed Sensor s/n*: 2011278 / 2011276 *Date*: 2014-03-12 / 2014-03-26 *Procedures*: Routine calibration service / Routine calibration service

Additional Discussion

When in the deployed and docked position, the MVP sensor is towed at approximately the same height as the surface sound speed sensor. As part of the system start up and watch turnover procedures as well as periodically through a survey watch, these values are verified to be in agreement. Comparison casts between a SeaCat 19+ and the MVP are conducted once a project or if any issues with the MVP sensor are suspected. The results of these tests are included in the Separates section of each survey. In addition, the two TSGs and two SVP-70 sensors are fed into NOAA SCS software for real-time monitoring and post-processing if warranted. Surface sound speed comparisons were performed each day between an MVP cast and the TSGs and Starboard SVP-70.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

Description	Trimble NetR5 receiver used for long-term GPS base observations and correctors.	
GPS Antennas	*Manufacturer*	Trimble
	Model	Zephyr Geodetic Model 2
	Description	The Zephyr Geodetic 2 is the antenna component for the NetR5 system which incorporates a large Trimble Stealth™ Ground Plane, which reduces multipath interference using technology similar to that used by Stealth aircraft to hide from radar. The antenna is made with weather-resistant materials and a low profile design, so the antenna can be used for many years of continuous operation on a permanent installation.
	Serial Numbers	1440921338
GPS Receivers	*Manufacturer*	Trimble
	Model	NetR5 GNSS
	Description	The Trimble NetR5 Reference Station is a multi-channel, multi-frequency GNSS receiver designed for use as a stand-alone reference station or as part of a GNSS infrastructure solution.
	Firmware Version	4.03
	Serial Numbers	4934K63376
UHF Antennas	No UHF antennas were installed.	
UHF Radios	No UHF antennas were installed.	

Solar Panels	No solar panels were installed.
Solar Chargers	No solar chargers were installed.
DQA Tests	No DQA tests were performed.

A.6.1.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.6.2 Vertical Control Equipment

No vertical control equipment was utilized for data acquisition.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

Manufacturer	Dell
Model	T5500
Description	Processing Computers
Serial Numbers	

Computer s/n	*Operating System*	*Use*
FH-PROC1 Service Tag # GFTQ8V1	Windows 7	Processing
FH-PROC2 Service Tag # GFTR8V1	Windows 7	Processing
FH-PROC3 Service Tag # GFTN8V1	Windows 7	Processing
FH-PROC4 Service Tag # GFTM8V1	Windows 7	Processing

Manufacturer	Dell
Model	T3400
Description	Acquisition Computers
Serial Numbers	

Computer s/n	*Operating System*	*Use*
FH-ACQ1 Service Tag # 101WTK1	Windows 7	Acquisition

	Computer s/n	*Operating System*	*Use*
	FH-ACQ2 Service Tag # 201WTK1	Windows 7	Acquisition
	FH-ACQ3 Service Tag # 6P5VTK1	Windows 7	Acquisition

Manufacturer	Cybertron PC		
Model	Generic		
Description	Processing Computer		
Serial Numbers	*Computer s/n*	*Operating System*	*Use*
	FH-PROC5 Service Tag # FQC-00765	Windows 7	Processing

A.7.2 Computer Software

Manufacturer	CARIS
Software Name	HIPS/SIPS
Version	9.0
Service Pack	12
Hotfix	
Installation Date	2015-04-14
Use	Processing
Description	Data Processing

Manufacturer	CARIS
Software Name	HIPS/SIPS
Version	8.1
Service Pack	10
Hotfix	
Installation Date	2014-10-29
Use	Processing
Description	Data Processing

Manufacturer	CARIS
Software Name	Bathy BASE Editor

Version	4.0
Service Pack	9
Hotfix	
Installation Date	2014-03-12
Use	Processing
Description	Data analysis and feature management

Manufacturer	CARIS
Software Name	Plot Composer
Version	5.3
Service Pack	
Hotfix	
Installation Date	2015-02-18
Use	Processing
Description	Mapping and plotting software

Manufacturer	Applanix
Software Name	POSPac
Version	7.1
Service Pack	1
Hotfix	
Installation Date	2015-04-30
Use	Processing
Description	Position and Attitude processing software

Manufacturer	NOAA
Software Name	Pydro
Version	14.6
Service Pack	r4773
Hotfix	
Installation Date	2014-08-13
Use	Processing
Description	Feature management, correlation, and report generator

Manufacturer	NOAA

Software Name	Pydro
Version	14.6
Service Pack	r4910
Hotfix	
Installation Date	2014-12-18
Use	Processing
Description	Feature management, correlation, and report generator, software update installed for bug fixes and schema changes

Manufacturer	NOAA
Software Name	Velocipy
Version	14.6
Service Pack	r4910
Hotfix	
Installation Date	2014-12-18
Use	Acquisition and Processing
Description	Sound velocity download and processing software, software update installed for bug fixes and schema changes

Manufacturer	IVS 3D
Software Name	Fledermaus
Version	7
Service Pack	4
Hotfix	3
Installation Date	2015-04-08
Use	Processing
Description	Data modeling

Manufacturer	Hypack
Software Name	Hypack/Hysweep
Version	2014
Service Pack	0
Hotfix	16
Installation Date	2014-02-18
Use	Acquisition
Description	Data logging

Manufacturer	Applanix
Software Name	POSView
Version	8.21
Service Pack	
Hotfix	
Installation Date	2015-04-29
Use	Acquisition
Description	Positioning

Manufacturer	Synergy
Software Name	Synergy
Version	1.4.14
Service Pack	
Hotfix	
Installation Date	2014-02-17
Use	Acquisition
Description	Shared mouse and keyboard between acquisition systems

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco 1728

Manufacturer	Ponar Wildco
Model	1728
Description	Grab sampler triggered by contact with sea floor. A custom mount equipped with camera and light was designed for the acquisition of video of the seafloor. This allows for the classification of bottom samples without successfully obtaining a sediment sample.

Figure 13: Ponar grab sampler

Figure 14: Camera with custom mount allowing for high quality video of the seafloor

A.8.1.2 Go Pro Hero 3

Manufacturer	Go Pro
Model	Hero 3
Description	Video camera rigged as a drop camera to function along with grab sampler. The camera contains a 12 MP sensor capable of 1440p at 48fps. This camera supplements the data gathered with the grab sampler, and allows the field unit to provide data from null samples from the sediment sampler.

Figure 15: Go Pro video camera.

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

Multibeam data are logged locally on the RESON topside machines in s7k format. Multibeam data are also acquired through Hypack/Hysweep in HSX format for bathymetry, though these files are only used in the event of errors in the s7k file and are otherwise discarded. The HSX format includes sounding solutions, navigation and attitude data. Ship navigation and survey line monitoring are performed with Hypack/Hysweep. The s7k format includes sounding solutions, navigation, attitude, and backscatter snippet data. This record is configured to include the following RESON datagrams: 1003: Position; 1012: Roll, Pitch, Heave; 1013: Heading; 7000: 7k Sonar Settings; 7004: 7k Beam Geometry; 7006: 7k Bathymetric Data;

7008: 7k Generic Watercolumn Data (used for snippets backscatter) and 7503: Remote Control Sonar Settings.

All multibeam sonars are configured in equidistant ("Best Coverage" in newest RESON version) beam steering mode. The opening angle of the 7125 systems is configured based on analysis of coverage, speed, and expected sound speed refraction errors for each survey. This angle typically varies between 120 and 140 degrees. Power, gain, and TVG parameters are typically set for a particular project and changes during acquisition are minimal.

The RESON units are interfaced with the acquisition machines through UDP LAN connections over a dedicated network switch (NetGear ProSafe Gigabit Switch). Position and attitude data is passed from the POS-MV to both the RESON machines and to the acquisition computers through dedicated network switches (NetGear ProSafe Gigabit Switch). There is a dedicated switch for the port and starboard POS systems. Time is passed from the POS to the RESON machines via an RS232 serial connection and a PPS pulse via a coaxial cable with BNC connectors. The starboard POS is interfaced with the starboard 7125 and the 7111, which is located in the starboard hull. The port POS is interfaced to the port 7125. A diagram of this configuration is included with the support files to this report and illustrated in Figure 20.

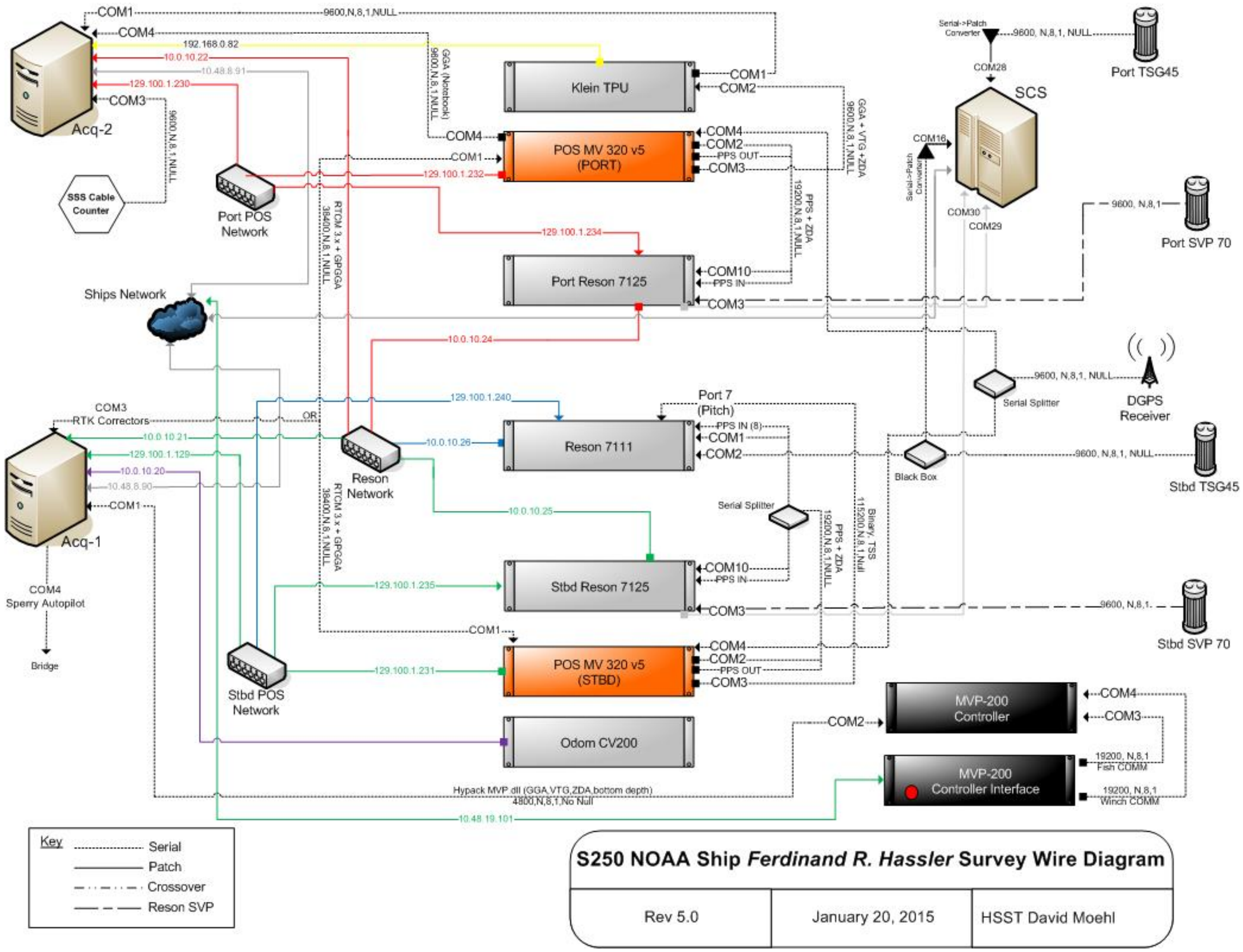

Figure 16: Ship survey systems wiring diagram

B.1.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

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

Side scan sonar imagery was not acquired.

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

Seabird SBE 19plus and MVP sound speed profilers are used regularly to collect sound speed data for ray tracing corrections for the multibeam sonar systems. The MVP is the primary method of sound speed profiling unless fishing gear or other potential dangers are deemed high enough risk that the MVP could be lost. To mitigate the risk of loss "running" casts are performed, where the ship recovers the MVP immediately upon a successful cast. If it is deemed that a "running" cast is too high risk a "static" cast will be performed, where the ship will stop all way and manually winch out to the desired depth before recovering the towfish. CTD casts are performed if there is not an MVP qualified operator available on watch. Data is retrieved from the Seabird CTDs with a serial connection to a processing computer. Data from both the Seabirds and MVP are processed through the NOAA in-house program Velocipy to give CARIS .svp formatted sound velocity profiles. All .svp profiles for a survey sheet are concatenated to one master file for a survey.

Casts are taken at least every four hours, but typically far more frequently. The interval between casts is typically between ten minutes and four hours based on the observed variability between casts and is discussed in the Descriptive Report of each survey.

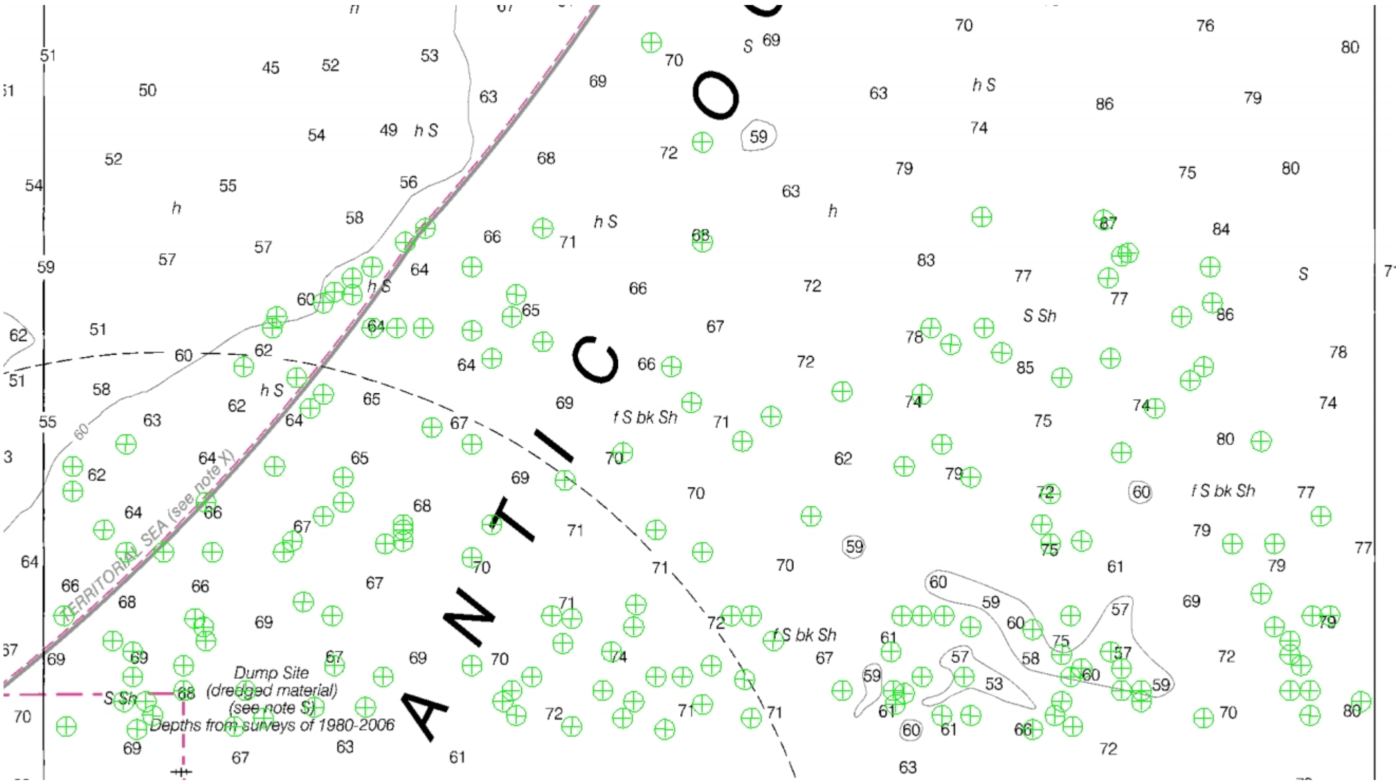

Figure 17: Example of sound speed samples taken in a survey area

B.1.3.2 Surface Sound Speed

Surface sound speed for both RESON 7125 systems is fed from individual SVP-70 sound velocity sensors mounted near each transducer. While operating in dual-head mode the starboard SVP-70 feeds both the master and slave. Seabird TSG 45 thermosalinograph measures sea surface conductivity and temperature and then calculates surface sound speed for the RESON 7111. Surface sound speed is typically compared daily between the real time MVP output and the starboard SVP-70 sensor by the acquisition watch. Data from all surface sound speed sensors can be fed into SCS for real time comparison and are recorded during MVP or CTD casts to perform surface sound speed DQAs.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

Applanix POS/MV files are logged using both the USB logging function and Ethernet logging function. Both files contain the same data records including attitude, heading, position, and velocity data as stated in section 3.4.1 of the FPM. During acquisition, the navigation solution status is constantly monitored by the acquisition watch stander.

The internal (USB) logged files are size limited, therefore files submitted typically start with the .000 extension and increment upwards (e.g. .001, .002, .003, ...). There are approximately 240 files generated during 24 hours of acquisition. The Ethernet logged files are typically broken at approximately UTC noon and midnight each day to yield two files per hull for a survey day.

Real-time USCG DGPS correctors are used for all acquisition. Specific DGPS stations are noted in the DR accompanying each survey.

B.1.4.2 Vertical Control

Preliminary, observed, and verified water levels are downloaded using FetchTides and applied to the data using CARIS HIPS Load Tide function. For data submission, depth data are reduced to MLLW either through application of Verified Water levels and Verified Tidal Zoning or using GPS derived vertical positions and the VDatum model. Refer to individual sheet DRs for detailed methods and additional information.

B.1.5 Feature Verification

Feature verification data were not acquired.

B.1.6 Bottom Sampling

Bottom Sampling followed guidelines set forth in sections 7.1 of the HSSD and 2.5.4.2.1 of the FPM. Unless specified otherwise in the DR, bottom sample locations are guided by analysis of the backscatter and bathymetry of the survey area. Refer to individual sheet DR for additional information.

B.1.7 Backscatter

Backscatter is acquired in the 7008 record logged in the .s7k files directly from the RESON 7125 processors. For the 7125 400kHz systems, snippet size is set to 25 samples in water depths less than 50 meters and to 50 samples in depth greater than 50 meters. The 7125 200kHz system has snippets size set to 100 in depths less than 100 meters and 200 in all depths greater than 100 meters. 7111 snippet size is set to 40 samples in depths less than 80 meters, 80 samples in depths between 150 and 300 meters, and 120 samples in deeper depths. All processing of backscatter is done using the FMGT module of the QPS Fledermaus package.

B.1.8 Other

No additional data were acquired.

Additional Discussion

FERDINAND R. HASSLER maintains a continuous manned survey watch during all survey acquisition. The watch stander is in constant communication with the bridge and monitors the performance of all systems. Thresholds set in Hypack/Hysweep, POSview, RESON, and SonarPro alert the watch stander by displaying alarm messages when error thresholds or tolerances are exceeded. Alarm conditions that may compromise survey data quality are corrected and then noted in acquisition log. Warning messages such as the temporary loss of differential GPS, excessive cross track error, or vessel speed approaching the maximum allowable survey speed are addressed by the watch stander and corrected before further data acquisition occurs.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Bathymetry processing followed section 4.2 of the FPM unless otherwise noted.

Raw .s7k multibeam data were converted to CARIS HIPS HDCS format using established and internally documented settings. After TrueHeave, sound speed, and water level correctors are applied to all lines, the lines are merged. Once lines are merged, Total Propagated Uncertainty (TPU) is computed using settings documented for each survey in the Descriptive Report. Default CARIS device models (C:\CARIS\HIPS\71\System\devicemodels.xml) are used during processing.

The general resolution, depth ranges, and Combined Uncertainty and Bathymetric Estimator (CUBE) parameter settings outlined in section 5.2.2.2 of the HSSD and section 4.2.1.1.1.1 of the FPM are used for surface creation and analysis. If these depth range values for specific resolutions require adjustment for analysis and submission of individual surveys then the required waiver from NOAA HSD Operations is requested. A detailed listing of the resolutions and the actual depth ranges used during the processing of each survey, along with the corresponding fieldsheet(s), is provided in the Descriptive Report of each survey.

BASE surfaces were created using the CUBE algorithm and parameters contained in the NOAA CUBEParams_NOAA.xml file as provided in Appendix 4 of the FPM. The CUBEParams_NOAA.xml file is included with the HIPS Vessel Files with the individual survey data. The NOAA parameter configurations for resolutions 0.5-16 meters are used.

Multibeam data were reviewed and edited in HIPS Subset Editor as necessary. The finalized BASE surfaces and CUBE hypotheses guided directed data editing at the appropriate depth range in subset editor. The surfaces and subset editor views were also used to demonstrate coverage and to check for errors due to tides, sound speed, attitude and timing.

Vessel heading, attitude, and navigation data were reviewed with the HIPS navigation editor and attitude editor as deemed necessary upon review of surfaces. Where necessary, fliers or gaps in heading, attitude, or navigation data were manually rejected or interpolated for small periods of time. Any editing of this nature is outlined in the Descriptive Report for the particular survey.

Either the Density or the Density & Locale method for hypothesis disambiguation is typically used. This follows section 4.2.1.1.1 of the FPM as available disambiguation methods. The disambiguation method can be seen in each individual layers properties and can be modified if desired.

The surface filtering function in CARIS HIPS is not utilized routinely. If utilized, the individual Descriptive Report lists the confidence level settings for standard deviation used and discuss the particular way the surface filter was applied.

Designated soundings were selected as outlined in section 5.2.1.2 of the HSSD.

IHO child layers were created using the following two formulas for IHO_1 and IHO_2, respectively; -Uncertainty/((0.5^2 +((Depth*0.013)^2))^0.5) and -Uncertainty/((1.0^2 +((Depth*0.023)^2))^0.5). IHO_1 is created for all soundings less than 100 meters while IHO_2 is for 100 meters and deeper. This layer is then exported and run through an application which computes statistics. The results are reported and analyzed in each sheets' individual DR, but the layers are not submitted with the survey.

Additionally, a combined resolutuin surface was created and reviewed in 3-D mode using one of the following programs; CARIS HIPS, CARIS Base Editor or IVS Fledermaus, to ensure that the data are sufficiently free of artifacts and is a reasonable model of the sea floor.

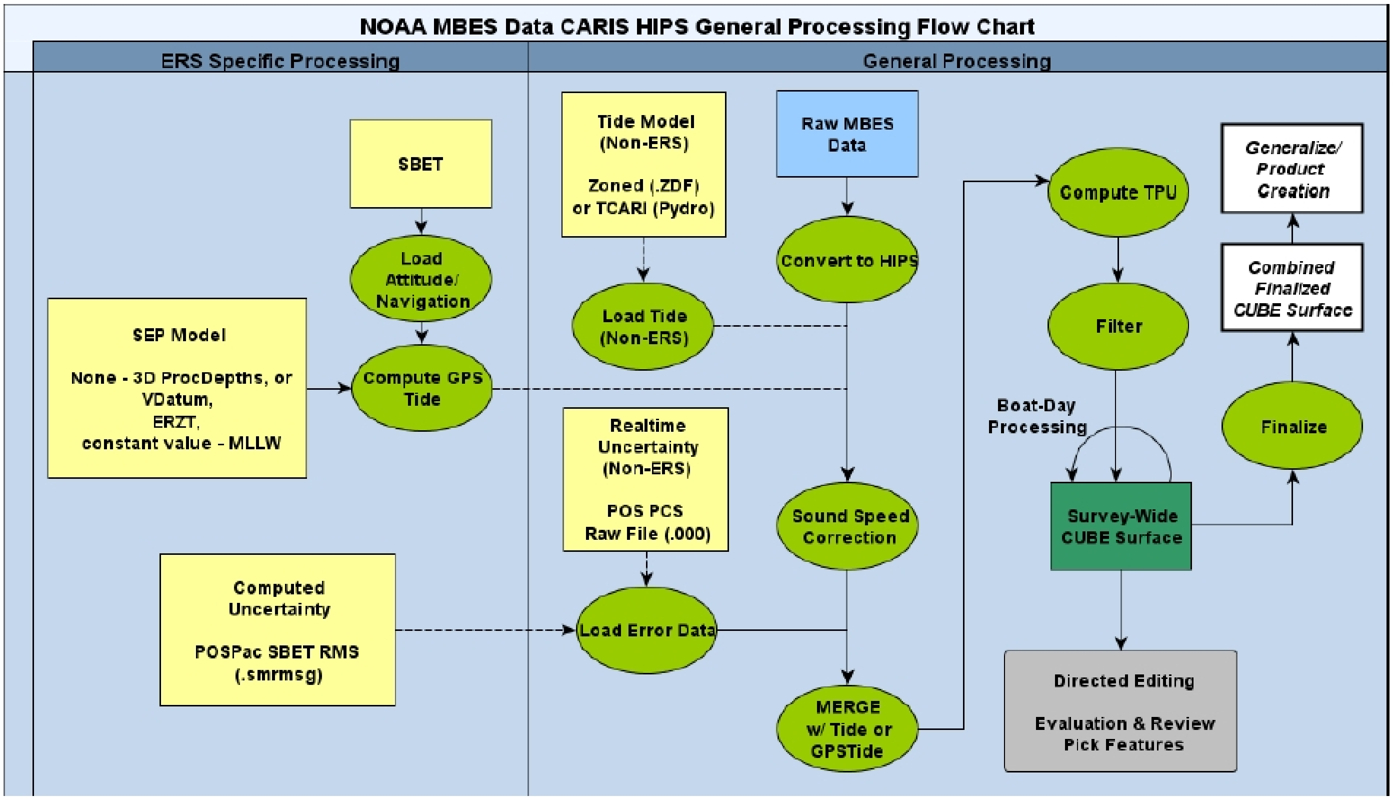

Figure 18: MBES flow diagram

B.2.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not processed.

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

Quality control logs were used to track and communicate problems during processing.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

All methods used to generate final bathymetric grids are followed as put forth in section 4.2 and all relevant subsections of the FPM.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Cleaning Filters Gridding Parameters Surface Computation Algorithms
Description	Filters were used on a case by case basis as determined by the hydrographer, refer to individual sheet DRs for more information.

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Side scan sonar imagery was not processed.

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

Processing logs were used to record and communicate problems from acquisition to final processing.

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

Range of the SSS, XTE, speed of vessel collecting data, and repetitious processing examinations were all used
to ensure that object detection and accuracy requirements are met.

B.2.2.3.3 Methods Used to Verify Swath Coverage

Swath coverage is verified through construction of side scan mosaics. During acquisition, the outer portions of the swath are monitored for refraction artifacts. If an apparent refraction artifact impacts object detection ability and cannot be eliminated through adjustment of fish height, the range scale is reduced.

B.2.2.3.4 Criteria Used for Contact Selection

In CARIS SIPS, if an apparent shadow measures greater than 1.0 meters a contact is chosen for development by MBES.

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

Daily sound speed profiles from the SBE and MVP profilers were processed with Velocipy after acquisition.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

CTD profiles from the Seabird SBE 19-plus and AML Micro-CTD were processed using the NOAA developed program Velocipy. From each system, sound speed profiles are extracted and archived as both individual and concatenated CARIS SVP files.

Figure 19: no figure

B.2.3.2 Surface Sound Speed

The SBE-45s were configured to average four samples and report the result once a second. No additional filters are applied.

Figure 20: no figure

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Fixed USCG DGPS stations were used for all real-time horizontal control. If post-processed GPS techniques were used to improve horizontal and vertical control, specific information is included in the Descriptive Report and/or the project's Horizontal and Vertical Control Report.

If USB logged TrueHeave files contained IMU data gaps or other errors apparent during post processing, the Ethernet-logged files may be examined and used if free from gaps. If this is the case both files will be submitted with the GNSS data.

Figure 21: no figure

B.2.4.2 Vertical Control

CO-OPS zoned water levels utilizing water level observations from fixed, continuously operating NOAA tide gages are used for reduction of data to MLLW. Predicted water levels are applied during preliminary processing. Before submission, verified water levels are applied to all tidally corrected data. If post-processed GPS techniques are used to improve vertical control, specific information is included in the Descriptive Report and/or the project's Horizontal and Vertical Control Report.

Figure 22: no figure

B.2.5 Feature Verification

Features were processed using CARIS BASE Editor software and were included with submitted in the survey's final feature file (FFF) in S-57 .000 format. The FFF includes all features; buoys, rocks, wrecks, bottom samples, etc., addressed within the limits of each individual sheet.

Figure 23: no figure

B.2.6 Backscatter

All backscatter was processed from acquired RESON .s7k or Hypack .7k files. All backscatter processing was performed with QPS Fledermaus Geocoder Toolbox and a mosaic calculated with default processing parameters. RESON TVG plugins were used for all processing steps.

Figure 24: no figure

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Standard Operating Procedures (SOPs) and checklists are followed by personnel throughout the survey to ensure consistent high quality data and products.

Data are reviewed for artifacts and errors during daily processing, and also reviewed by the Field Operations Officer and/or Hydrographic Senior Survey Technician daily. Before any data is to be submitted it is reviewed independently by at least three experienced hydrographers who are signatories to the Descriptive Report.

B.4 Uncertainty and Error Management

TPU is processed using the following settings.

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. Project specific values for tide and sound speed are entered and used over the duration of each project.

B.4.1.2 Source of TPU Values

Error values 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 of the 2014 FPM.

B.4.1.3 TPU Values

Vessel	S250 (Port)		
Echosounder	RESON 7125 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	0.500 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.050 meters
		y	0.050 meters
		z	0.050 meters
	MRU Alignment	*Gyro*	0.100 degrees
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Port)		
Echosounder	RESON 7125 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5.000 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	0.500 meters	

	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.050 meters
		y	0.050 meters
		z	0.050 meters
	MRU Alignment	*Gyro*	0.027 degrees
		Pitch	0.04 degrees
		Roll	0.04 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Starboard)		
Echosounder	RESON 7111 100 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5.000 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	1.000 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.100 meters
		y	0.100 meters
		z	0.100 meters

	MRU Alignment	*Gyro*	0.130 degrees
		Pitch	0.030 degrees
		Roll	0.030 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.040 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Starboard)		
Echosounder	RESON 7125 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	1.000 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.050 meters
		y	0.050 meters
		z	0.050 meters
	MRU Alignment	*Gyro*	0.080 degrees
		Pitch	0.010 degrees
		Roll	0.010 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Starboard)		
Echosounder	RESON 7125 400 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude 0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	1.000 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.050 meters
		y	0.050 meters
		z	0.050 meters
	MRU Alignment	*Gyro*	0.090 degrees
		Pitch	0.030 degrees
		Roll	0.030 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters

B.4.2 Deviations

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

Additional Discussion

During the 2012 field season, the method of calculating the MRU alignment uncertainty was revised. The previous method estimated the alignment uncertainty by taking the standard deviation of each evaluators' best estimate. This method was modified to have each evaluator make five measurements of each offset (e.g. roll). The average of all these values was taken as the patch test value, the standard deviation of the mean (standard deviation of all the independent measurements divided by the square root of the number of measurements) was used as the MRU alignment error. This better models the expected error in the estimate of the true offset value rather than the uncertainty of any particular evaluator's estimate. This new method was utilized for calculating the MRU alignment uncertainty for the 2015 field season.

For the port 7125, the MRU gyro alignment uncertainty value is 0.06 degrees with the new method compared with 0.29 degrees with the previous method. The Roll/Pitch MRU alignment uncertainty is 0.02 degrees with the new method compared to 0.13 degrees with the previous method.

For the starboard 7125, the MRU gyro alignment uncertainty value is 0.05 degrees with the new method compared with 0.22 degrees with the previous method. The Roll/Pitch MRU alignment uncertainty is 0.02 degrees with the new method compared to 0.11 degrees with the previous method.

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

C.1.1.2 Methods and Procedures

Sensor offsets are measured with respect to the vessel's reference point. These offsets are derived from the full survey performed in the shipyard, a partial survey performed by NGS personnel and measurements/ verifications performed by FERDINAND R. HASSLER personnel. All offsets are tracked and updated as needed on a spreadsheet submitted with the appendices of this report.

The port IMU serves as the reference point for the port-only 7125 HSX configuration, the port 7125 s7k configuration and the side scan sonar. For all other vessel configurations the starboard IMU is the reference point.

POS GPS antennae pairs are mounted to a 2 meter length of channel extrusion in a fore and aft orientation.

C.1.1.3 Vessel Offset Correctors

Vessel	S250 Port
Echosounder	RESON 7125 400 kilohertz
Date	2013-07-01

Offsets	*MRU to Transducer*	*x*	-1.244 meters
		y	0.362 meters
		z	1.349 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	-2.246 meters
		y	-2.351 meters
		z	14.269 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	4.500 degrees
		Roll2	
Vessel	S250 Starboard		
Echosounder	RESON 7125 400 kilohertz		
Date	2013-07-01		
Offsets	*MRU to Transducer*	*x*	1.424 meters
		y	0.380 meters
		z	1.358 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	4.528 meters
		y	-2.320 meters
		z	14.278 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	-4.500 degrees
		Roll2	
Vessel	S250		
Echosounder	RESON 7111 100 kilohertz		
Date	2013-07-01		

Offsets	*MRU to Transducer*	*x*	1.203 meters
		y	11.608 meters
		z	0.977 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	4.307 meters
		y	8.908 meters
		z	13.897 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees
Vessel	S250		
Echosounder	Odom Echotrac CV200 - Transducer 1 = Starboard hull (200 kHz), Transducer 2 = Port hull (24 kHz) 24 kilohertz		
Date	2013-07-01		
Offsets	*MRU to Transducer*	*x*	-0.455 meters
		y	4.620 meters
		z	1.383 meters
		x2	-12.701 meters
		y2	4.620 meters
		z2	1.381 meters
	Nav to Transducer	*x*	2.649 meters
		y	1.920 meters
		z	14.303 meters
		x2	-9.597 meters
		y2	1.920 meters
		z2	14.301 meters
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees

C.1.2 Layback

C.1.2.1 Description of Correctors

Layback is calculated in CARIS from the cable-out and fish depth. Cable-out is output from a cable counter and recorded in the .sdf file. The side scan cable is marked at 12 meters and is deployed to this position on launching. The cable counter is reset to zero at this position and the 12 meter offset applied in SonarPro. Thus, the cable out value in the .sdf file is the correct value for the cable between the tow point and the towfish.

C.1.2.2 Methods and Procedures

No layback correctors are applied in the HVF

C.1.2.3 Layback Correctors

Vessel	S250		
Echosounder	Klein 5250 455 kilohertz		
Date	2013-07-01		
Layback	*Towpoint*	*x*	7.161 meters
		y	-26.032 meters
		z	-9.347 meters
	Layback Error	0.00 meters	

Additional Discussion

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Because of her SWATH design, FERDINAND R. HASSLER is particularly susceptible to loading and trim. While underway, the ballast is actively managed to maintain the draft at the design draft of 3.77 meters. During typical survey operations, HASSLER burns approximately 4,000 liters of diesel per day. At a density of 0.83 kilograms/liter this is approximately 3.3 metric tons of fuel per day. At design draft of 3.77 meters, 1.3 metric tons is required to submerge an additional 0.01 meters of the hull in salt water. The daily fuel burn would thus account for 0.03 meters of variation in the draft. Ballast is adjusted daily to account for fuel burn and the levels in other tanks. Uncertainty is estimated at 0.05 meters.

C.2.1.2 Methods and Procedures

The waterline to reference point is calculated from the vessel offset survey and the vessel draft marks.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

Dynamic draft is calculated as the dynamic height of the vessel reference point as a function of vessel speed compared to the height at rest. This correction is applied during CARIS processing.

C.2.2.2 Methods and Procedures

An ellipsoidally referenced dynamic draft measurement (ERDDM) was performed following guidelines in the 2014 FPM on June 14, 2015 (Dn165). An area was selected in Rhode Island Sound, 10-15 NM SE of Martha's Vineyard where the slope of the geoid was minimal. Speeds from 6 to 13 knots were run in one direction. The ship was then turned to the reciprocal heading, brought to a complete stop, and then the speeds from 6 to 13 knots were run in the opposite direction.

The fourth order polynomial results for the dynamic draft curves from the port and starboard side were averaged. These results were marginally different from the 2011, 2012, 2013, and 2014 values, with a 0.05 meter difference at typical survey speeds from the prior year. The 2015 results and comparisons between 2011 - 2015 can be found included in the attached appendices. Results from the last three years were averaged for use as the dynamic draft corrector values for 2015.

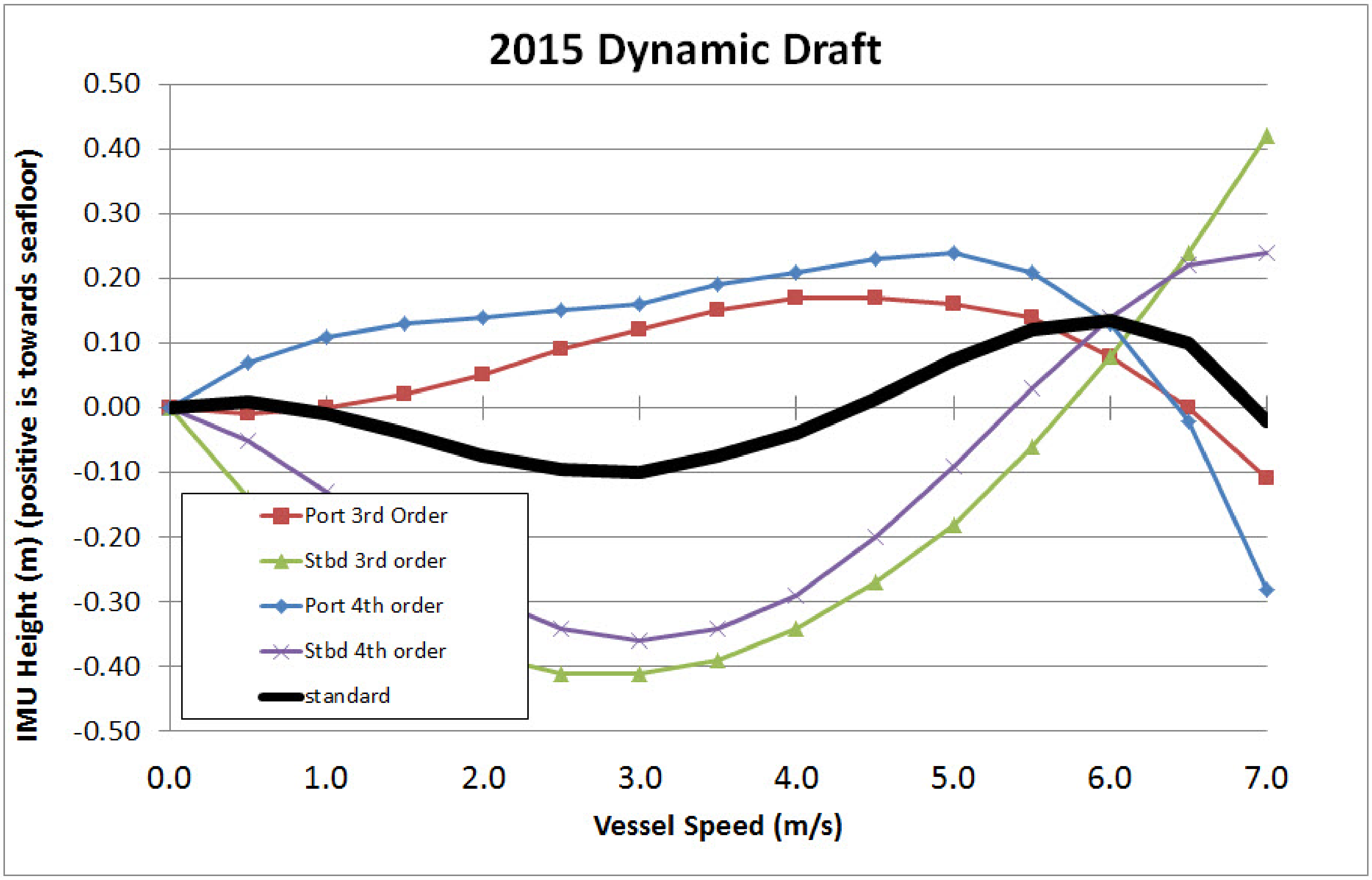

Figure 25: Dynamic draft derived from ERDDM methods. Positive values are displacements of the IMU towards the sea floor. Thin lines are results from port and starboard head for third and fourth order polynomial fits. Black bold line is dynamic draft value used for both hulls.

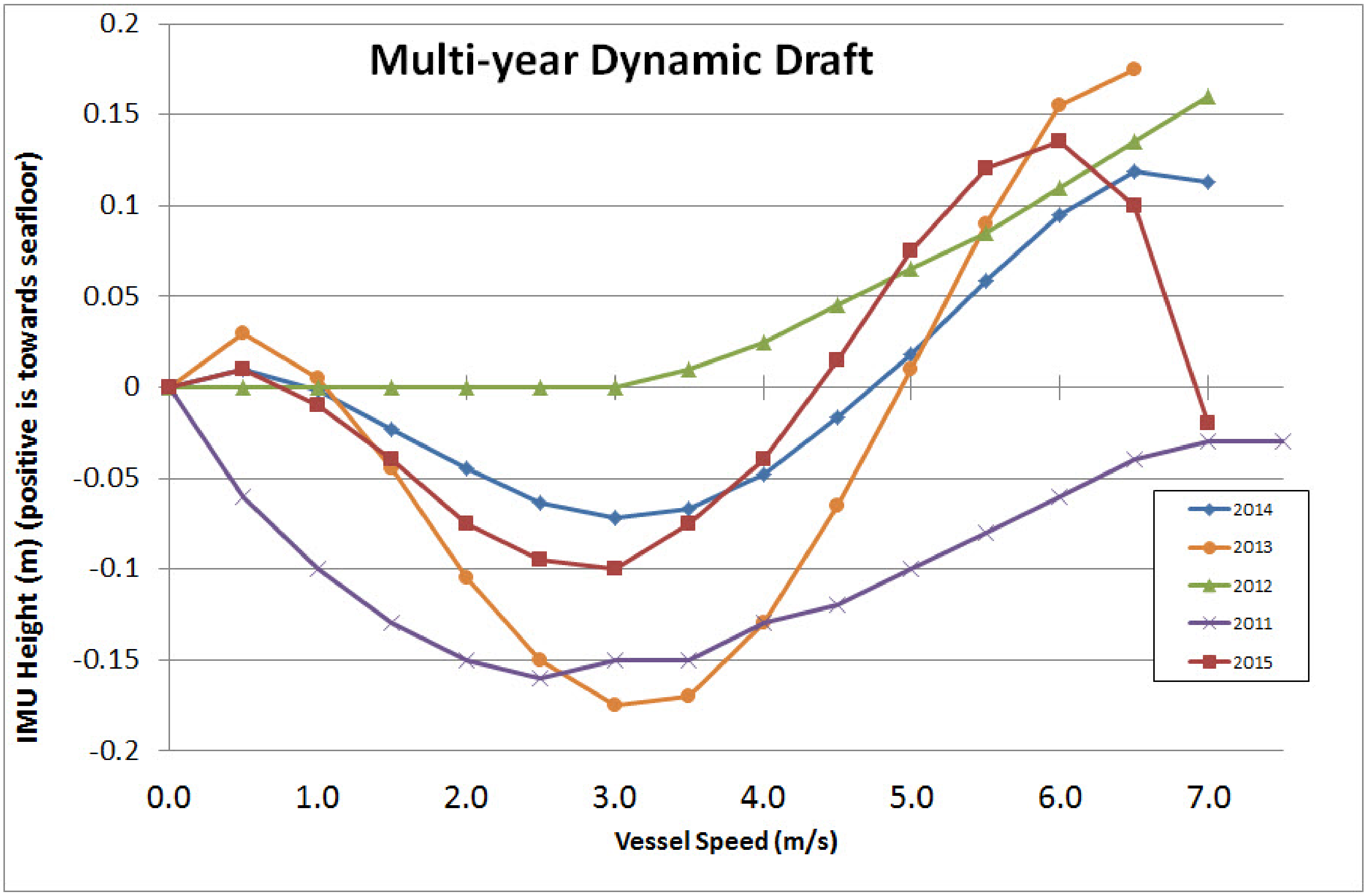

Figure 26: Dynamic draft derived from ERDDM methods comparison from years 2011 - 2015.

C.2.2.3 Dynamic Draft Correctors

Vessel	S250	
Date	2015-06-14	
Dynamic Draft Table	*Speed*	*Draft*
	0.0	0.000
	0.5	0.02
	1.0	0
	1.5	-0.04
	2.0	-0.08
	2.5	-0.10
	3.0	-0.12
	3.5	-0.10

<table>
<tr><td>Vessel</td><td>S250</td></tr>
<tr><td>Date</td><td>2015-06-14</td></tr>
<tr><td>Dynamic Draft Table</td><td><table>
<tr><td>Speed</td><td>Draft</td></tr>
<tr><td>4.0</td><td>-0.07</td></tr>
<tr><td>4.5</td><td>-0.02</td></tr>
<tr><td>5.0</td><td>0.03</td></tr>
<tr><td>5.5</td><td>0.09</td></tr>
<tr><td>6.0</td><td>0.13</td></tr>
<tr><td>6.5</td><td>0.13</td></tr>
<tr><td>7.0</td><td>0.05</td></tr>
</table></td></tr>
</table>

C.3 System Alignment

C.3.1 Description of Correctors

C.3.2 Methods and Procedures

Methods and Procedures used follow recommendations given in Section 1.5 of the 2014 FPM.

C.3.3 System Alignment Correctors

<table>
<tr><td>Vessel</td><td>S250</td></tr>
<tr><td>Echosounder</td><td>RESON 7125 Starboard 400 megahertz</td></tr>
<tr><td>Date</td><td>2015-06-14</td></tr>
<tr><td>Patch Test Values</td><td><table>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>-0.124 degrees</td></tr>
<tr><td>Roll</td><td>0.056 degrees</td></tr>
<tr><td>Yaw</td><td>0.518 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td></tr>
</table></td></tr>
<tr><td>Vessel</td><td>S250</td></tr>
<tr><td>Echosounder</td><td>RESON 7125 Starboard 200 kilohertz</td></tr>
<tr><td>Date</td><td>2015-06-14</td></tr>
</table>

Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	-0.042 degrees
	Roll	0.009 degrees
	Yaw	0.418 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7125 Port 400 kilohertz	
Date	2015-06-18	
Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	-0.031 degrees
	Roll	-0.079 degrees
	Yaw	-0.481 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7125 Port 200 kilohertz	
Date	2015-06-13	
Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	-0.938 degrees
	Roll	-0.559 degrees
	Yaw	-0.925 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7111 100 kilohertz	
Date	2014-04-16	

Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	-0.86 degrees
	Roll	0.010 degrees
	Yaw	1.170 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds

Additional Discussion

The RESON 7111 sonar was inoperable during the 2015 field season and was not calibrated during 2015. The 7111 patch test values are retained here from the 2014 calibration period for reference only.

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 the RESON .s7k file. Pitch is applied real-time to the RESON 7111. 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 "Apply Delayed Heave" function. 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, PPK data in the form of 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 Precise Point Positioning (PPP) processing modes. After processing and quality control analysis of the post-processed SBET files is complete, the SBET and SMRMSG files are applied to the HDCS data in CARIS HIPS using the "Load Attitude/Navigation Data" and "Load Error Data" processing tools, respectively.

The heave lever arms are configured to a point on the centerline of the vessel between the two POS IMUs. This was done to prevent long-term static roll angles from causing a steady state heave offset.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

C.5.2 Methods and Procedures

Unless otherwise noted in the survey Descriptive Report (DR) and/or project Horizontal and Vertical Control Report (HVCR), the vertical datum for all soundings and heights is Mean Lower Low Water (MLLW). Predicted, preliminary, and/or 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 a Tidal Constituent and Residual Interpolation (TCARI) model supplied 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 DR.

A Horizontal and Vertical Control Report (HVCR) was not created for this project.

Newer methods for handling vertical control are being developed and, if utilized, are explained in more detail in the survey DR.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

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 sheet 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 sheet's processing log included in the Separates submitted with the individual survey.

C.6.2 Surface Sound Speed

Surface sound speed correctors were not applied.