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Data Acquisition and Processing Report

NRT1
Chief of Party: Mark McMann
Year: 2015
Version: 1
Publish Date: 2015-08-12

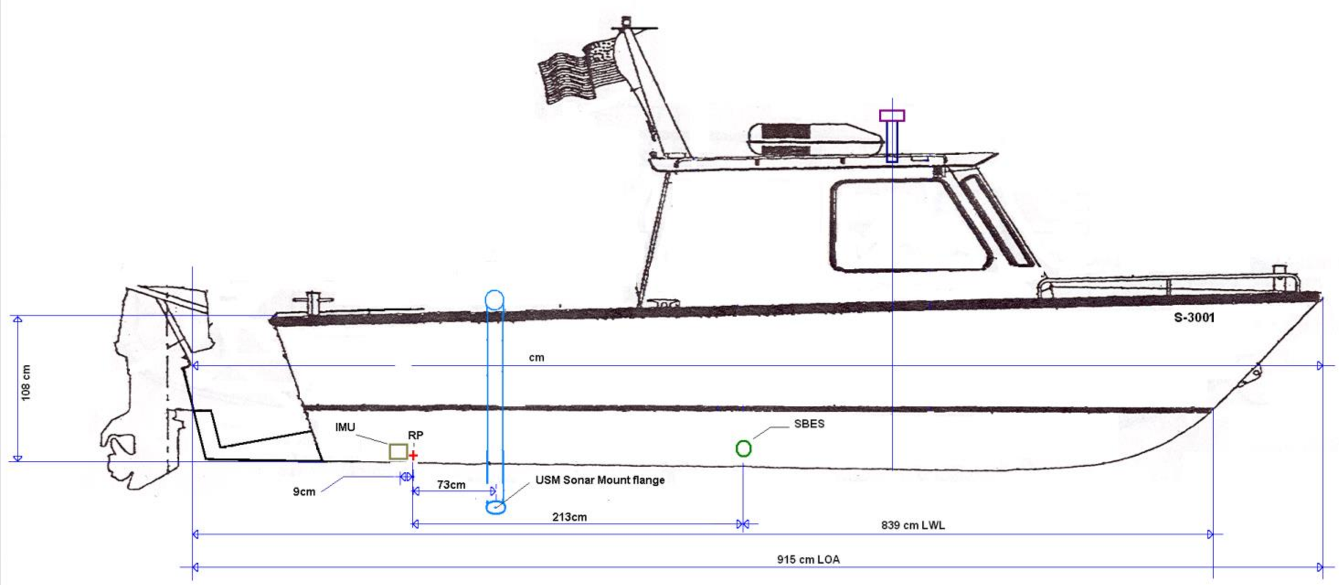
A Equipment

A.1 Survey Vessels

A.1.1 S3001

<table>
<tr><td>Name</td><td>S3001</td></tr>
<tr><td>Hull Number</td><td>S3001</td></tr>
<tr><td>Description</td><td>Sea Ark Commander 30'</td></tr>
<tr><td>Utilization</td><td>Survey vessel</td></tr>
<tr><td>Dimensions</td><td><table><tr><td>LOA</td><td>9.15 meters</td></tr><tr><td>Beam</td><td>2.45 meters</td></tr><tr><td>Max Draft</td><td>0.5 meters</td></tr></table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table><tr><td>Date</td><td>2013-03-19</td></tr><tr><td>Performed By</td><td>Buchanan and Harper, Surveyors, Panama City, FL.</td></tr><tr><td>Discussion</td><td>Offset survey values entered in Caris</td></tr></table></td></tr>
<tr><td>Most Recent Partial Static Survey</td><td>Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td><table><tr><td>Date</td><td>2013-03-19</td></tr><tr><td>Method Used</td><td>Total Station</td></tr><tr><td>Discussion</td><td>by Buchanan and Harper, Surveyors, Panama City, FL.</td></tr></table></td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td>Partial offset verification was not performed.</td></tr>
</table>

Most Recent Static Draft Determination	*Date*	2013-05-20
	Method Used	Lead Line Method
	Discussion	by NRT1 personnel
Most Recent Dynamic Draft Determination	*Date*	2014-04-21
	Method Used	Multibeam sonar surface comparison method
	Discussion	by NRT1 personnel



S3001 Schematics- Side View

Figure : S3001 Schematics, Side View

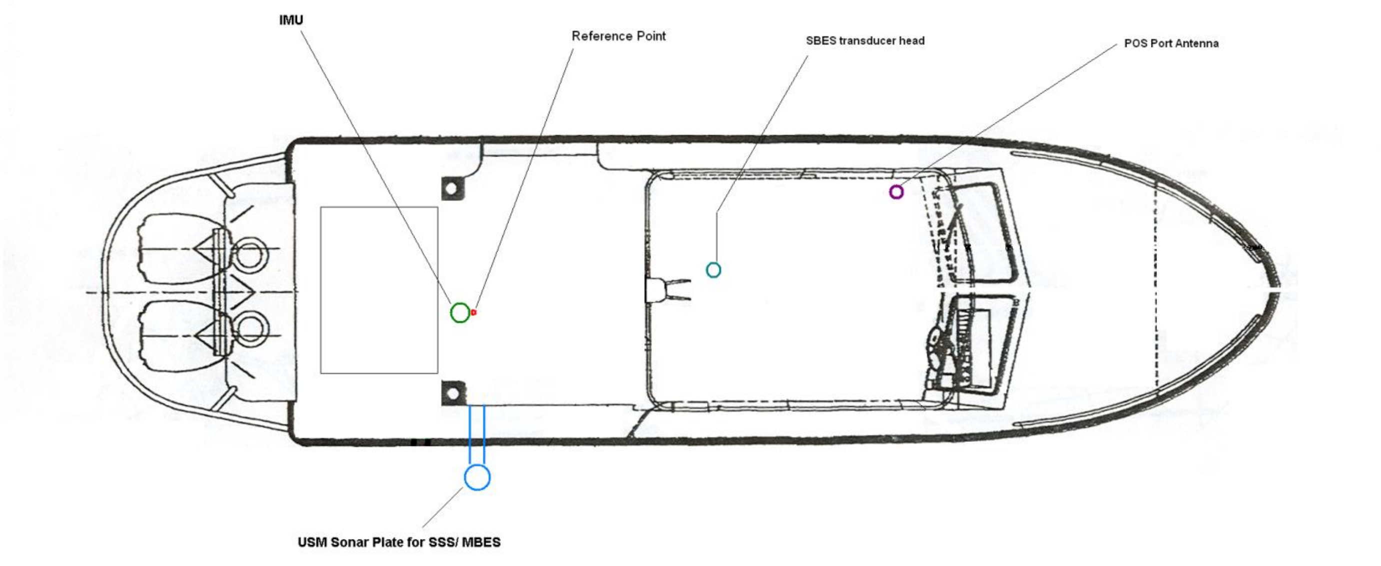


Figure : S3001 Schematics, Top View

Additional Discussion

All data collected on board survey vessel S3001.

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Edgetech 4125

Manufacturer	Edgetech
Model	4125
Description	pole mounted SSS

Serial Numbers	*Vessel Installed On*	S3001	SAMA1355E202 (S3001)
	TPU s/n	Edgetech TPU	SN#40259
	Towfish s/n	Model 4125	SN# 40424
Specifications	*Frequency*	900 kilohertz	
	Along Track Resolution	*Resolution*	27 centimeters
		Min Range	35 meters
		Max Range	150 meters
	Across Track Resolution	1.5 centimeters	
	Max Range Scale	150 meters	
Manufacturer Calibrations	Manufacturer calibration was not performed.		

Figure : Edgetech 4125 SSS

A.2.2 Multibeam Echosounders

A.2.2.1 Reson 8125 Seabat

Manufacturer	Reson		
Model	8125 Seabat		
Description	Pole mounted MBES		
Serial Numbers	*Vessel Installed On*	SAMA1355E202 (S3001)	
	Processor s/n	SN# 31546	
	Transceiver s/n	N/A	
	Transducer s/n	SN# 0802092	
	Receiver s/n	N/A	
	Projector 1 s/n	None	
	Projector 2 s/n	None	
Specifications	*Frequency*	455 kilohertz	
	Beamwidth	*Along Track*	1 degrees
		Across Track	0.5 degrees
	Max Ping Rate	40 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant
		Number of Beams	240
	Max Swath Width	120 degrees	
	Depth Resolution	6 millimeters	
	Depth Rating	*Manufacturer Specified*	400 meters
		Ship Usage	0.6 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.		
System Accuracy Tests	*Vessel Installed On*	S3001	
	Methods	Calibration Patch Test	
	Results	accepted	
Snippets	Sonar does not have snippets logging capability.		

Figure : Reson 8125 MBES

A.2.3 Single Beam Echosounders

A.2.3.1 Odom Echotrac CV200

Manufacturer	Odom		
Model	Echotrac CV200		
Description	Single Beam Echo Sounder		
Serial Numbers	*Vessel*	S3001	
	Processor s/n	SN#23019	
	Transducer s/n	N/A	
Specifications	*Frequency*	100 kilohertz	
	Beamwidth	*Along Track*	3 degrees
		Across Track	3 degrees
	Max Ping Rate	20 hertz	
	Depth Resolution	0.01 meters	
	Depth Rating	*Manufacturer Specified*	15 meters
		Ship Usage	0.5 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.		
System Accuracy Tests	*Vessel Installed On*	S3001	
	Methods	Sounding Systems Comparison	
	Results	accepted	

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

<table>
<tr><td>Manufacturer</td><td>unknown</td></tr>
<tr><td>Model</td><td>unknown</td></tr>
<tr><td>Description</td><td></td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>NRT1-LL</td></tr></table></td></tr>
<tr><td>Calibrations</td><td><table><tr><td>Serial Number</td><td>NRT1-LL</td></tr><tr><td>Date</td><td>2014-04-22</td></tr><tr><td>Procedures</td><td>manual calibration</td></tr></table></td></tr>
<tr><td>Accuracy Checks</td><td>No accuracy checks were performed.</td></tr>
<tr><td>Correctors</td><td>Correctors were not determined.</td></tr>
<tr><td>Non-Standard Procedures</td><td>Non-standard procedures were not utilized.</td></tr>
</table>

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>Trimble Applanix</td></tr>
<tr><td>Model</td><td>POS MV 5</td></tr>
<tr><td>Description</td><td></td></tr>
<tr><td>PCS</td><td><table>
<tr><td>Manufacturer</td><td>Trimble Applanix</td></tr>
<tr><td>Model</td><td>POS MV 5</td></tr>
<tr><td>Description</td><td></td></tr>
<tr><td>Firmware Version</td><td>unknown</td></tr>
<tr><td>Software Version</td><td>7.60</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S3001</td></tr>
<tr><td>PCS s/n</td><td>SN#5847</td></tr>
</table></td></tr>
</table></td></tr>
<tr><td>IMU</td><td><table>
<tr><td>Manufacturer</td><td>Trimble Applanix</td></tr>
<tr><td>Model</td><td>POS MV 5</td></tr>
<tr><td>Description</td><td>IMU</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>S3001</td></tr>
<tr><td>IMU s/n</td><td>SN#2425</td></tr>
</table></td></tr>
<tr><td>Certification</td><td>IMU certification report was not produced.</td></tr>
</table></td></tr>
</table>

Antennas	*Manufacturer*	Trimble		
	Model	Zephyr model 2		
	Description			
	Serial Numbers	*Vessel Installed On*	S3001	S3001
		Antenna s/n	SN#144132423	SN#1441132146
		Port or Starboard	Port	Starboard
		Primary or Secondary	Primary	Secondary
GAMS Calibration	*Vessel*	S3001		
	Calibration Date	2014-04-21		
Configuration Reports	*Vessel*	S3001, Please see NVM file in Z:\S-J924-NRT1-14\H12724\Data \Processed\Multimedia\Reports_Support_Files\Image Support Files \2014_111_pos_config.nvm		
	Report Date	2014-04-21		

A.4.2 DGPS

Description	Trimble DGPS Antenna			
Antennas	*Manufacturer*	Trimble		
	Model	33580-00		
	Description			
	Serial Numbers	*Vessel Installed On*	S3004	S3001
		Antenna s/n	SN#0220342684	SN#0220342684

<table>
<tr><td rowspan="6">Receivers</td><td>Manufacturer</td><td colspan="2">Trimble</td></tr>
<tr><td>Model</td><td colspan="2">DSM232</td></tr>
<tr><td>Description</td><td colspan="2"></td></tr>
<tr><td>Firmware Version</td><td colspan="2">3.59</td></tr>
<tr><td rowspan="2">Serial Numbers</td><td>Vessel Installed On</td><td>S3001</td></tr>
<tr><td>Antenna s/n</td><td>SN# 0225116712</td></tr>
</table>

Figure : Trimble DGPS Receiver DSM 232

A.4.3 Trimble Backpacks

Trimble backpack equipment was not utilized for data acquisition.

A.4.4 Laser Rangefinders

No laser rangefinders were utilized for data acquisition.

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 Castaway CTD 400100

<table>
<tr><td>Manufacturer</td><td colspan="2">Castaway CTD</td></tr>
<tr><td>Model</td><td colspan="2">400100</td></tr>
<tr><td>Description</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Serial Numbers</td><td>Vessel Installed On</td><td>S3001</td></tr>
<tr><td>CTD s/n</td><td>SN#CC1433005</td></tr>
<tr><td rowspan="3">Calibrations</td><td>CTD s/n</td><td>SN#CC1433005</td></tr>
<tr><td>Date</td><td>2014-09-08</td></tr>
<tr><td>Procedures</td><td>Manufacturer calibration</td></tr>
</table>

Figure : Castaway CTD

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 Odom Digibar

Manufacturer	Odom
Model	Digibar
Description	

Serial Numbers			
Vessel Installed On	S3001	S3001	S3001
Sound Speed Profiler s/n	SN#98294	SN#98527	SN#98376

Calibrations			
Sound Speed Profiler s/n	SN#98294	SN#98527	SN#98376
Date	2015-01-23	2014-03-05	2015-03-05
Procedures	Manufacturer calibration	Manufacturer calibration	Manufacturer calibration

Figure : Odom Digibar Sound Speed Profiler

A.5.2 Surface Sound Speed

No surface sound speed sensors were utilized for data acquisition.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

No horizontal control 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

<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>T5500</td></tr>
<tr><td>Description</td><td>desktop</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Computer s/n</td><td>Service Tag #D0W78U</td></tr>
<tr><td>Operating System</td><td>W7</td></tr>
<tr><td>Use</td><td>Acquisition</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>Manufacturer</td><td>Dell</td></tr>
<tr><td>Model</td><td>T5500</td></tr>
<tr><td>Description</td><td>desktop</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Computer s/n</td><td>Service tag #D1J78V1</td></tr>
<tr><td>Operating System</td><td>W7</td></tr>
<tr><td>Use</td><td>Processing</td></tr>
</table></td></tr>
</table>

Manufacturer	Dell
Model	T3400
Description	desktop

Serial Numbers	*Computer s/n*	Service tag#JH1J2H1
	Operating System	XP
	Use	Processing

Manufacturer	Dell		
Model	Latitude E6530		
Description	laptop		
Serial Numbers	*Computer s/n*	Service tag#B4CKFX1	
	Operating System	W7	
	Use	Processing	

A.7.2 Computer Software

Manufacturer	Hypack
Software Name	Hypack
Version	2014
Service Pack	
Hotfix	
Installation Date	2014-08-01
Use	Acquisition
Description	Acquisition Software

Manufacturer	Odom
Software Name	Echart
Version	
Service Pack	
Hotfix	
Installation Date	2012-01-07
Use	Acquisition
Description	Acquisition Software

Manufacturer	Edgetech
Software Name	DiscoverII
Version	06 26 13
Service Pack	

Hotfix	
Installation Date	2013-06-26
Use	Acquisition
Description	Acquisition Software

Manufacturer	Applanix
Software Name	PosView
Version	5
Service Pack	
Hotfix	
Installation Date	2013-07-01
Use	Acquisition
Description	Acquisition Software

Manufacturer	Caris
Software Name	HIPS & SIPS
Version	8
Service Pack	1
Hotfix	10
Installation Date	2013-09-02
Use	Processing
Description	Processing Software

Manufacturer	NOAA
Software Name	Pydro
Version	13.2
Service Pack	r4326
Hotfix	
Installation Date	2013-09-27
Use	Processing
Description	Processing Software

Manufacturer	Pitney Bowes
Software Name	Mapinfo
Version	11

Service Pack	0
Hotfix	4
Installation Date	2013-10-30
Use	Processing
Description	Processing Software

Manufacturer	Odom
Software Name	Digibar Pro
Version	3
Service Pack	0
Hotfix	
Installation Date	2008-01-07
Use	Processing
Description	Processing Software

Manufacturer	ESRI
Software Name	ArcMap
Version	10
Service Pack	2
Hotfix	
Installation Date	2015-06-29
Use	Acquisition and Processing
Description	Acquisition and processing software

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 unknown unknown

Manufacturer	unknown
Model	unknown

Description	no SN#

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

B.1.1.2 Single Beam Echosounder

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

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

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure 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

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

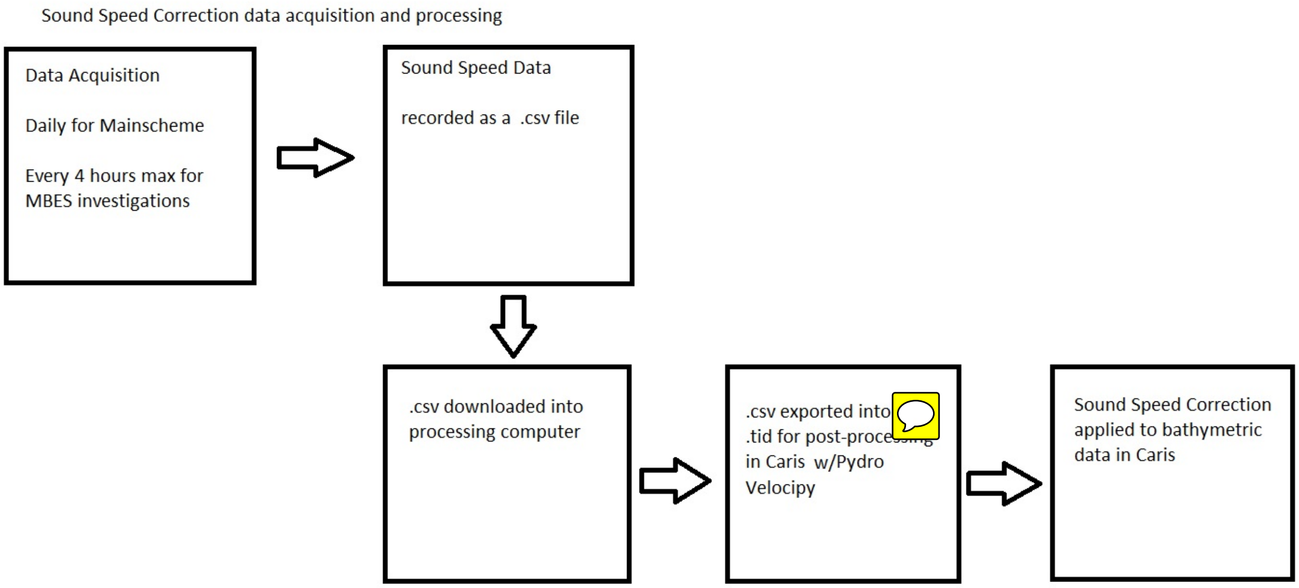


Figure : Sound Speed Corrections Process

B.1.3.2 Surface Sound Speed

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

B.1.4.2 Vertical Control

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

B.1.5 Feature Verification

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

B.1.6 Bottom Sampling

Data acquisition was done in agreement with the current Specifications and Deliverables as well as the current Field Procedure Manual.

B.1.7 Backscatter

Backscatter data were not acquired.

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

NOAA hydrographic field units typically acquire bathymetric data using VBES, MBES, or a combination of both.
VBES depths are processed using the CARIS HIPS Single Beam Editor tool to review and edit data anomalies.
MBES data may be edited in two different ways: using CARIS HIPS Swath Editor tool to edit data in a time-series
mode, or using the CARIS HIPS Subset Editor tool to edit data in a spatial mode. In both instances, Bathymetry
Associated with Statistical Error (BASE) methods are used to generate, using one or more different algorithms, a

digital seafloor model that contains depth and uncertainty information at each model node. In addition to the basic bathymetric layer, auxiliary information layers such as standard deviation of soundings, sounding density,
shoal depth, source identification, hypothesis count, and hypothesis strength will be generated depending upon
the algorithm used to construct the BASE surface. These BASE surface layers are used to guide the hydrographer
to areas that require further examination and/or editing.

Figure : Multibeam Echosounder

B.2.1.2 Single Beam Echosounder

NOAA hydrographic field units typically acquire bathymetric data using VBES, MBES, or a combination of both.
VBES depths are processed using the CARIS HIPS Single Beam Editor tool to review and edit data anomalies.
MBES data may be edited in two different ways: using CARIS HIPS Swath Editor tool to edit data in a time-series
mode, or using the CARIS HIPS Subset Editor tool to edit data in a spatial mode. In both instances, Bathymetry
Associated with Statistical Error (BASE) methods are used to generate, using one or more different algorithms, a
digital seafloor model that contains depth and uncertainty information at each model node. In addition to the basic bathymetric layer, auxiliary information layers such as standard deviation of soundings, sounding density,
shoal depth, source identification, hypothesis count, and hypothesis strength will be generated depending upon
the algorithm used to construct the BASE surface. These BASE surface layers are used to guide the hydrographer
to areas that require further examination and/or editing.

Figure : Vertical Echosounder

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

NOAA hydrographic field units typically acquire bathymetric data using VBES, MBES, or a combination of both.
VBES depths are processed using the CARIS HIPS Single Beam Editor tool to review and edit data anomalies.
MBES data may be edited in two different ways: using CARIS HIPS Swath Editor tool to edit data in a time-series
mode, or using the CARIS HIPS Subset Editor tool to edit data in a spatial mode. In both instances, Bathymetry

Associated with Statistical Error (BASE) methods are used to generate, using one or more different algorithms, a
digital seafloor model that contains depth and uncertainty information at each model node. In addition to the basic bathymetric layer, auxiliary information layers such as standard deviation of soundings, sounding density,
shoal depth, source identification, hypothesis count, and hypothesis strength will be generated depending upon
the algorithm used to construct the BASE surface. These BASE surface layers are used to guide the hydrographer
to areas that require further examination and/or editing.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

Combined Uncertainty and Bathymetric Estimator (CUBE)
CUBE is a gridding algorithm developed at the University of New Hampshire (UNH)/NOAA Center for Coastal
and Ocean Mapping Joint Hydrographic Center by Dr. Brian Calder. Its primary advantage over uncertainty weighted grids is that it is less susceptible to noise. CUBE works in two stages:
Integration of Soundings into Hypotheses - During the first stage, all soundings in the area are grouped into internally consistent depth hypotheses, using the uncertainty of the soundings as a threshold.
Disambiguation - After all soundings are integrated, a second stage determines which hypothesis at each node is
the most likely to be the seafloor. There are four disambiguation methods available:
(a) The density option selects the hypothesis with the greatest number of sounding samples.
(b) The locale option selects the hypothesis that is most consistent with its surrounding nodes that has only one hypothesis.
(c) The density and locale option selects the hypothesis with the greatest number of soundings and is consistent with neighboring nodes.
(d) The initialization option selects the hypothesis that is closest to an initialization surface created previously.
The CARIS HIPS integration of CUBE is well documented in the CARIS HIPS and SIPS User's Manual. This
manual should be referenced for details on the workings of the algorithm and explanations of the user interface.
When editing a CUBE surface, the user may opt to edit soundings or to edit hypotheses. For NOAA hydrographic
survey data, it is critical that only sounding edits be used to correct gridding problems. This is primarily because
hypothesis edits exist only in the context of a single grid, and will be lost if that grid is recomputed.
CUBE Parameters
There is a small parameter file called "CUBEParams.xml" in the HIPS system directory that is referenced in the
HIPS environment. The values in this file control the behavior of the CUBE gridding and disambiguation processes.
The default CUBE parameters are not authorized for NOAA surveys. Instead, field units shall use the CubeParams_

NOAA.xml file, which is included in Appendix 4. Each of the following grid resolutions has its own CUBE parameter set: 0.5m, 1m, 2m, 4m, 8m, 16m, and 32m. Field units shall use the parameter set corresponding to the appropriate resolution(s) and depth ranges of their survey data as specified in section 5.2.2 of the HSSD. A description of each parameter and its default value and allowable range of values can be found in the header of the XML file.

Three parameters have been modified from the CARIS default values: Capture Distance Scale, Capture Distance Minimum, and Horizontal Error Scalar.

The Capture Distance Scale value is a percentage of depth used to limit the radius of influence a sounding may have on the grid. The system default value is 5.0. However, for all grid resolutions in the NOAA parameters file, the value has been set to 0.5. Setting the value this low disables the function and forces the Capture Distance Minimum to be used instead over the range of applicable grid resolutions. This fixes the Capture Distance to the grid resolution.

A value of 0.5 was determined to be low enough for all grid resolutions, since they grow with depth.

The Horizontal Error Scaler value is used to scale the horizontal error of each sounding when used in the radius of influence computation. It effects the propagated uncertainty of each sounding and how it is combined into each hypothesis. The system default value is 2.95. However, based on discussions with Dr. Calder, the value has been set to 1.96, for all grid resolutions in the NOAA parameters file.

The Capture Distance Minimum value is minimum distance that the CUBE algorithm will search for soundings to contribute to a node. It is used in conjunction with the Capture Distance Scale to limit the radius or influence of a sounding. The system default value is 0.5. The Capture Distance Minimum is the only parameter that varies between the grid resolutions in the NOAA parameters file.

The minimum capture distance radius is specified in sections 5.2.2.1 and 5.2.2.2 of the HSSD and is limited to (0.707*grid resolution), or

This value defines the capture distance to ensure that the radius of influence touches the outer corners of the grid resolution but not farther. With this capture distance, no sounding is ever “lost” to the algorithm, but there is not an oversampling of data from areas significantly further than the grid resolution. Because all of the soundings are in close proximity to the node, the grid most accurately depicts the seafloor in that area without losing any soundings.

Uncertainty Weighted Grids

In order to generate uncertainty-weighted BASE surfaces, TPU. TPU accounts for the a priori horizontal and vertical

components of uncertainty associated with each
sounding measurement. TPU is formulated from the summation of the modeled uncertainties for all sub-systems
included in the overall hydrographic survey system (e.g., water levels, tide zoning, attitude sensor error, navigation
sensor horizontal position error, sound velocity profile error, sonar bottom detection method, etc.). The sources of
uncertainty values include (or may be combination of) manufacturer specifications, theoretical values, and empirical observations from the field. These values are entered into the HVF.
The uncertainty values described in the appendix are provided as guidance for use in standard NOAA hydrographic surveys. These values do not cover the breadth of operations encountered by all field parties, nor do
they cover the range of equipment configurations possible for any particular vessel. As such, these values should
serve a starting point in developing a vessel's error model. Any deviation from the attached values should be completely described in the applicable Descriptive Reports and DAPR.
In general, soundings (observation points) do not coincide with grid nodes (BASE surface estimation points). To
account for this, the vertical component of a sounding's TPU is propagated to a grid node according to a power law
that models the increase in uncertainty as a function of three variables: distance between sounding and node, the
sounding's horizontal component of TPU, and grid node resolution. The amount of weight an observation exerts
on a given BASE estimation point is inversely proportional to the propagated vertical uncertainty of the observation.
Where V and H are the vertical and horizontal components of TPU (resp.), SH is a scale factor representing the
worst case error that horizontal TPU can contribute, xi and nj are the location of the sounding and estimation node (resp.), x and y are the two-dimensional spacing of grid nodes, and the exponent is a heuristic to control overall growth of propagated uncertainty, P . The HIPS BASE surface algorithm uses a value of 1.0 (HIPS has
already scaled H by 1.96, for a 95% confidence interval) and an value of 2.0.
Theoretically, every sounding can affect every node in a BASE surface encompassing a survey area. For computational
efficiency, HIPS limits a sounding's radius of influence on surrounding nodes through the following "spreading
conditions." (1) At a minimum, each sounding affects all nodes within a radius of 0.707 times the grid resolution
of its position; i.e., within half the distance of the diagonal on a regular (square) grid. Hence, a given sounding will
affect at least two to four nodes, depending on where it is situated with respect to the nodes. (2) Each sounding will
propagate at most a distance determined by a user-specified threshold of propagated vertical uncertainty. The uncertainty threshold is expressed in HIPS according to an IHO sounding error model (see Figure 4.2); that is, an

estimate of all constant errors (a) and depth-dependent errors (b times d) are summed in quadrature as shown in
OCS requirements for the accuracy of measured depths, as set forth in the HSSD, are adapted from IHO S-44,
Standards for Hydrographic Surveys, 5th Edition, which defines Special Order (a=0.25 meters, b=0.0075), Order
1 (a=0.5 meters, b=0.013 or 1.3% of depth), and Order 2 (a=1.0 meters, b=0.023 or 2.3% of depth) standards. OCS
specifies that the total sounding error in a measured depth at the 95 percent confidence level, after systematic and
system specific errors have been removed, shall not exceed the IHO Order 1 standard in depths up to 100 meters
and shall not exceed the IHO Order 2 standard in deeper waters.

Other BASE Weighting Methods in HIPS

CARIS HIPS allows BASE surfaces to be generated using either swath-angle weighting, uncertainty weighting, or
CUBE discussed in the previous section. Swath-angle weighted BASE surface nodes do not incorporate TPU and,
hence, node "uncertainty" is not available therein. Unless specifically stated to the contrary,
use of the term "BASE surface" in conjunction with OCS hydrographic surveys refers to those surfaces generated
using the uncertainty weighting method or CUBE.

BASE Node Attributes

The depth at a given BASE surface grid node, n, is the mean depth (weighted by propagated depth uncertainty) of
the set of N soundings whose domain, Di, contains n. Likewise, the uncertainty at a given node is the mean
uncertainty (weighted by propagated depth uncertainty) of all the soundings contained in set N. See Figure 4.4
Note that the depth at grid node n is the weighted mean of soundings 1, 2, and 3. Sounding 4 is not included
because its radius of influence does not encompass grid node n.
In addition to depth and uncertainty, users can include five additional attributes in the BASE surface nodal data.
The definitions of the seven nodal attributes are summarized below. Note that all node statistics are computed
from the set of surrounding soundings whose propagated vertical uncertainty passes a user-supplied threshold
(IHO Order):

• Depth - weighted-mean depth of soundings that contribute to a node; weighting is inversely proportional to the propagated vertical uncertainty of the soundings.
• Uncertainty - weighted-mean vertical component of TPU (see section 4.2.3.8) of soundings that contribute to a node; weighting is inversely proportional to the propagated vertical uncertainty of the soundings.
• Density - number of soundings that contribute to a node.
• Std_Dev - sample standard deviation (not weighted) of soundings that contribute to a node; multiply Std_Dev by 1.96 to obtain the 95% confidence interval.
• Shoal - shoalest sounding from the set of soundings that contribute to a node.

• Mean - sample mean of the set of soundings that contribute to a node.
• Deep - deepest sounding from the set of soundings that contribute to a node.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Gridding Parameters Surface Computation Algorithms
Description	CUBE Algorithm used, gridding parameter per FPM guidance.

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Imagery Object Detection
Imagery data are acquired and processed with the purpose of detecting objects that may be of navigational significance. This determination is typically based on contact type, position, and height above the sea floor estimated from the item’s acoustic shadow on the SSS record. Imagery data acquired for OCS hydrographic surveys
are geographically referenced; thus, a position can be determined for each contact identified. The accuracy of this
position will vary depending on whether the sonar was towed or hull-mounted, but either method should be sufficient to locate the item for further investigation. If a contact is determined to be significant, a “development”
should be conducted to determine the item’s least depth and a more accurate position for charting.

Daily Batch Processing
Several processing tasks need to be performed on “raw” imagery data (i.e., unaltered data in the format generated
by the acquisition software) before any detailed analysis and evaluation can occur. Some of these daily tasks are
interdependent, and the specific sequence is critical. The recommended ordering of daily batch processing tasks is
as follows:
1. Conversion
2. Filter, if applicable
3. Recompute Towfish Navigation
4. Slant Range Correction
Most of the tasks above can be semi-automated in HIPS/SIPS using the “Batch Processor” tool. Data format determines how specific processing actions need to be configured; as such, a separate Batch Processing File (.hbp)
is needed for each raw data format type.

Figure : Side Scan Sonar

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

Imagery data should be reviewed twice using CARIS SIPS Side Scan Editor. The initial review process is referred to as “scanning” the data. The second review is performed by a different person and is called “check scanning.” The initial reviewer should identify any object that warrants further investigation, often referred to as a “significant contact”, and record these items into the digital data. The second review serves as a quality control, and should add any significant contacts that were overlooked during the initial check.

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

Imagery data are acquired and processed with the purpose of detecting objects that may be of navigational significance. This determination is typically based on contact type, position, and height above the sea floor estimated from the item’s acoustic shadow on the SSS record. Imagery data acquired for OCS hydrographic surveys are geographically referenced; thus, a position can be determined for each contact identified. The accuracy of this position will vary depending on whether the sonar was towed or hull-mounted, but either method should be sufficient to locate the item for further investigation. If a contact is determined to be significant, a “development” should be conducted to determine the item’s least depth and a more accurate position for charting.

B.2.2.3.3 Methods Used to Verify Swath Coverage

A survey-wide side scan mosaic should be created and maintained during Daily Batch Processing to evaluate data coverage, identify any gross systematic errors, and plan future data acquisition.
Note: If a 200% side scan survey is being conducted, a separate mosaic should be created to demonstrate coverage for each hundred percent.
In addition to planning future SSS acquisition, the first 100% mosaic can be used to delineate areas of high contact density where complete MBES coverage is more appropriate than 200% SSS. The hydrographer is reminded that AWOIS radii that extend beyond the basic survey limits must be entirely covered with 200% side scan, complete or object detection multibeam, or a combination thereof to be disproved by sonar data. These radii should be considered when evaluating survey coverage.
When creating a mosaic, the hydrographer will be prompted for several pieces of information. In accordance with section 6.2.1 of the HSSD, resolution shall be 1m by 1m or less. Maximum acrosstrack and altitude ratios can be used to systematically remove areas of poor quality data from the mosaic, such as when outer edges are affected by thermocline. Note: These features will not actually reject the imagery data, but they will remove portions indicated for all lines in the mosaic.
Options such as interpolation and shine-thru may be used at the hydrographer’s discretion. These features may enhance the overall mosaic and can be desirable for creating constituent products.

B.2.2.3.4 Criteria Used for Contact Selection

SIPS provides several tools to assist in determining if a contact is significant. Two of the most frequently used are “Measure Shadow” and “Measure Distance.”
“Measure Shadow” can be used to determine the height of an object by measuring its acoustic shadow and

calculating the object's approximate elevation off the seafloor. This tool can only be used when viewing data in slant range corrected mode. "Measure Distance" is used to measure the distance between two points. This tool is helpful in determining the overall size of contacts, which may determine significance. For example, a very large item, even if it does not protrude significantly from the seafloor, may be listed in the AWOIS database and should therefore be investigated. The Measure Distance tool can be used when viewing both "raw" (i.e., not slant range corrected) and slant range corrected data.

All significant contacts should be recorded in the digital data by creating a contact in SIPS. (Refer to the CARIS HIPS and SIPS Users Guide for detailed information on how to create a contact.) The general OCS practice for determining significance of an imagery contact is stated in the HSSD.

The hydrographer must always consider the location of a contact when determining significance. For example, in a major channel where vessels transit with minimal underkeel clearance, a contact less than one meter high could be significant.

When a contact is recorded in SIPS, the item is geo-coded and attributes are attached to it in the Side Scan Editor.

Each contact should be attributed as thoroughly as possible. A contact file is created for each survey line and is stored in the line folder within the Project directory structure.

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

Correcting sonar data for the speed of sound (through water) actually refers to performing a refraction correction based on a sound speed profile of the water column. Variations in the speed of sound (primarily due to water temperature variations, or thermocline) result in refraction (bending) of sonar beams. The speed of sound through water will decrease as water temperature lowers, causing a sonar beam to bend downward and creating depth and position errors in any measurement calculated based on travel time and an assumed linear travel path of the sonar beam. Figure 4.7 illustrates the effect of refraction. The sound wave striking the thermocline at point B slows down,

while point A on the same sound wave continues at the original speed until it strikes the thermocline at C. As a
result, the sonar beam bends downward.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

Through Pydro Velocipy software, concatenated in a project master file.

Figure : Odom Digibar

B.2.3.2 Surface Sound Speed

The DigibarPro Profiling Sound Velocimeter is a portable, user-deployed instrument. The DigibarPro system includes a high frequency “sing-around” transducer and a reflector precisely spaced to facilitate measuring the
speed of sound in water by continuously transmitting and receiving a signal across a known separation distance.
The sing-around frequency and associated depth information are recorded at a rate of 10 samples per second. In
many OCS applications, DigibarPro systems have been mounted to or near a MBES transducer to directly measure
sound speed at the sonar face.
Recorded DigibarPro sound speed profiles can be uploaded to a PC and processed using NOAA’s Velocipy software.

Figure : Odom Digibar

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Horizontal control data were not processed.

B.2.4.2 Vertical Control

Water Level Data Retrieval
Typically, predicted tides or preliminary water level data are applied to soundings during initial post-processing.
As verified or final water level data become available, the best quality data should be applied to bathymetry. Field
units can download six-minute preliminary water level data directly from the Products > Tides section of the COOPS
website http://www.tidesandcurrents.noaa.gov within hours of data acquisition. Verified water level data should be available from the CO-OPS website within seven days if the station has been placed on the Hydro Hot
List.

Figure : NOAA Tide Gauge #8729108

B.2.5 Feature Verification

Feature verification of assigned features were done through bathymetric investigations with MBES or VBES, or visually when these investigations were not possible or unnecessary.

Figure : N/A

B.2.6 Backscatter

Backscatter data were not processed.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Quality management is done on a daily basis. The team follows strict data acquisition and processing routines enunciated by the FPM and HSSD to ensure highest data quality.

B.4 Uncertainty and Error Management

TPU accounts for the a priori horizontal and vertical components of uncertainty associated with each sounding measurement. TPU is formulated from the summation of the modeled uncertainties for all sub-systems
included in the overall hydrographic survey system (e.g., water levels, tide zoning, attitude sensor error, navigation
sensor horizontal position error, sound velocity profile error, sonar bottom detection method, etc.). The sources of
uncertainty values include (or may be combination of) manufacturer specifications, theoretical values, and empirical observations from the field. These values are entered into the HVF.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

Prior to data processing, vessel offsets and total propagated uncertainty values based on uncertainty estimates for
survey equipment should have been entered into the corresponding HVF .
For the most part, uncertainty estimates entered into the HVF file are static over a field season or in the absence of
changes to the vessel configuration. Some HVF uncertainty estimate values may need to be adjusted on a case-bycase
basis to account for any un-modeled uncertainty in a given component of the sounding. For example, in areas with strong currents, uncertainty in vessel speed can be adjusted in the sensor TPU section of the HVF to compensate for appreciable differences between speed-over-ground and speed-through-water. Another critical
example of TPU values that may need to be updated in the CARIS HVF is depth uncertainty introduced by heave
in singlebeam data acquired on vessels without an attitude sensor. Survey days with substantial heave introduce a
larger depth uncertainty than calm days, and require a larger TPU value in the heave section of the HVF. An estimation of uncertainty introduced by heave can be calculated by multiplying the heave amplitude (1/2 the wave
height) by 0.707. (This formula is equal to 1 sigma of a sinusoidal wave).
Most of the uncertainty estimates that are entered into a CARIS HVF are straightforward and are based on direct
measurement techniques or manufacturer provided information. The estimation of the uncertainty value associated
with MRU alignment is an exception. There is no direct method to measure or estimate MRU alignment uncertainty.
One method to estimate these values is to calculate the standard deviation of a large sample of angular bias values

resolved with a patch test. The sample size can be created either by a number of people resolving the angular biases or a couple of people resolving the values numerous times. Angular bias values resolved in a patch test are actually a measurement of the angular bias that exists between the transducer reference frame and the MRU reference frame. Therefore, any uncertainty values derived from the patch test angular biases are based on the same relationship. As it is the angle between the MRU and the transducer that we are measuring, rather than the absolute alignments of both the MRU and the transducer to a vessel reference frame, we can assign this uncertainty to either the MRU alignment or the transducer alignment. CARIS expects this value to be entered into the MRU alignment uncertainty field.
Note: All changes made to HVFs used to process OCS hydrographic survey data shall be approved by the field unit’s Chief-of-Party and completely described in the Descriptive Report. Provided the TPU sensor values in the HVF do not require modification as noted above, TPU computation for specific survey lines is completed by selecting a set of survey lines and choosing the Compute TPU process in HIPS. Once the process has been selected, uncertainty values that change on a survey-by-survey basis, such as tide and sound speed, are entered into the Compute TPU dialog box (see below regarding Tide zoning uncertainty values for TCARI tides).
CARIS allows for only one sound speed and one tide value to be entered per survey area, on a survey-wide basis (at BASE surface creation) in the Compute TPU dialog box. HSTP is working with CARIS to adapt a statistical approach which will allow for multiple values per survey.

B.4.1.2 Source of TPU Values

Project Instructions

B.4.1.3 TPU Values

<table>
<tr><td>Vessel</td><td colspan="3">S3001</td></tr>
<tr><td>Echosounder</td><td colspan="3">Odom CV200 100 kilohertz</td></tr>
<tr><td rowspan="6">TPU Standard Deviation Values</td><td rowspan="5">Motion</td><td>Gyro</td><td>0.02 degrees</td></tr>
<tr><td rowspan="2">Heave</td><td>5 % Amplitude</td></tr>
<tr><td>0.05 meters</td></tr>
<tr><td>Pitch</td><td>0.02 degrees</td></tr>
<tr><td>Roll</td><td>0.02 degrees</td></tr>
<tr><td>Navigation Position</td><td colspan="2">1 meters</td></tr>
</table>

	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.01 seconds
	Offsets	*x*	0 meters
		y	0 meters
		z	0 meters
	MRU Alignment	*Gyro*	0.5 degrees
		Pitch	0.5 degrees
		Roll	0.5 degrees
	Vessel	*Speed*	0.2 meters/second
		Loading	0.01 meters
		Draft	0.01 meters
		Delta Draft	0.081 meters

B.4.2 Deviations

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

Additional Discussion

Delta Draft TPU adjusted after 2014 Settlement & Squat procedure (MBES surface difference method)

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

S3001 Offsets

C.1.1.2 Methods and Procedures

Total Station Survey, Buchanan and Harper, surveyors, April 10, 2013

C.1.1.3 Vessel Offset Correctors

Vessel	S3001		
Echosounder	Odom CV200 100 kilohertz		
Date	2014-08-01		
Offsets	*MRU to Transducer*	*x*	0.252 meters
		y	2.144 meters
		z	0.304 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Nav to Transducer	*x*	-0.576 meters
		y	1.085 meters
		z	2.929 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Transducer Roll	*Roll*	0 degrees
		Roll2	0 radians
Vessel	S3001		
Echosounder	Reson 8125 455 kilohertz		
Date	2014-08-01		
Offsets	*MRU to Transducer*	*x*	1.556 meters
		y	0.747 meters
		z	1.125 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	2.383 meters
		y	2.482 meters
		z	3.750 meters
		x2	
		y2	
		z2	

	Transducer Roll	*Roll*	0 degrees
		Roll2	
Vessel	S3001		
Echosounder	Edgetech 4125 900 kilohertz		
Date	2014-04-21		
Offsets	*MRU to Transducer*	*x*	1.457 meters
		y	0.740 meters
		z	0.909 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0 meters
		y	0 meters
		z	0 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0 degrees
		Roll2	

C.1.2 Layback

Layback correctors were not applied.

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Static draft was calculated by using the WL (waterline) to RP (reference point) and Transducer head to RP offsets. The static draft of the transducer head is 0.899 m.

C.2.1.2 Methods and Procedures

Boat offset values from Buchanan and Harper, professional surveyors. Please refer to S3001 schematic in Equipment section for illustration of RP (reference point) in relation to all other offsets.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

April 21st, 2014 (S3001)

C.2.2.2 Methods and Procedures

MBES surface comparison method

C.2.2.3 Dynamic Draft Correctors

<table>
<tr><td>Vessel</td><td colspan="5">S3001</td></tr>
<tr><td>Date</td><td colspan="5">2014-04-21</td></tr>
<tr><td rowspan="2">Dynamic Draft Table</td><td>Speed</td><td>0.551 meters/second</td><td>1.196 meters/second</td><td>2.8 meters/second</td><td>4.107 meters/second</td></tr>
<tr><td>Draft</td><td>0 meters</td><td>-0.004 meters</td><td>-0.016 meters</td><td>0.024 meters</td></tr>
</table>

C.3 System Alignment

C.3.1 Description of Correctors

MBES calibration

C.3.2 Methods and Procedures

patch test method

C.3.3 System Alignment Correctors

Vessel	S3001
Echosounder	Reson 8125 455 kilohertz
Date	2014-06-17

<table>
<tr><td rowspan="8">Patch Test Values</td><td>Navigation Time Correction</td><td>0 seconds</td></tr>
<tr><td>Pitch</td><td>0.9375 degrees</td></tr>
<tr><td>Roll</td><td>1.9783 degrees</td></tr>
<tr><td>Yaw</td><td>0.725 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0 seconds</td></tr>
<tr><td>Vessel</td><td colspan="2">S3001</td></tr>
<tr><td>Echosounder</td><td colspan="2">Reson 8125 455 kilohertz</td></tr>
<tr><td>Date</td><td colspan="2">2015-04-27</td></tr>
<tr><td rowspan="8">Patch Test Values</td><td>Navigation Time Correction</td><td>0 seconds</td></tr>
<tr><td>Pitch</td><td>1.242 degrees</td></tr>
<tr><td>Roll</td><td>2.023 degrees</td></tr>
<tr><td>Yaw</td><td>0.701 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0 seconds</td></tr>
</table>

C.4 Positioning and Attitude

C.4.1 Description of Correctors

Applanix POS/MV positioning and attitude data correctors where recorded concurrently to sounding data.

C.4.2 Methods and Procedures

True Heave was applied to the data during post processing.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

A TCARI file was used as the water level corrector. MLLW was used as vertical Datum for all bathymetric data.

C.5.2 Methods and Procedures

Unique tide gauge assigned and used was #8741533 Pascagoula, MS

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

Daily sound speed profiles were done for mainscheme data acquisition. During MBES investigations, profiles were done every 4 hours maximum.

C.6.1.2 Methods and Procedures

Digibar pro and Velocipy are used as post processing softwares.

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

Surface sound speed profiles were acquired concurently to MBES data acquisition.

C.6.2.2 Methods and Procedures

Direct input in MBES TPU.