H12502

NOAA Form 76-35A

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

DESCRIPTIVE REPORT

Type of Survey:	Navigable Area
Registry Number:	H12502

LOCALITY

State:	Virginia
General Locality:	Approaches to Chesapeake Bay, VA
Sub-locality:	30 NM East of Cape Henry, VA

2012

CHIEF OF PARTY
LCDR Benjamin K. Evans, NOAA

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Date:

NOAA FORM 77-28 (11-72)	U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NUMBER:
HYDROGRAPHIC TITLE SHEET		**H12502**

INSTRUCTIONS: The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

State:	**Virginia**
General Locality:	**Approaches to Chesapeake Bay, VA**
Sub-Locality:	**30 NM East of Cape Henry, VA**
Scale:	**40000**
Dates of Survey:	**09/07/2012 to 09/28/2012**
Instructions Dated:	**03/02/2012**
Project Number:	**OPR-D304-FH-12**
Field Unit:	**NOAA Ship *Ferdinand R. Hassler***
Chief of Party:	**LCDR Benjamin K. Evans, NOAA**
Soundings by:	**Multibeam Echo Sounder**
Imagery by:	**Multibeam Echo Sounder Backscatter**
Verification by:	**Atlantic Hydrographic Branch**
Soundings Acquired in:	**meters at Mean Lower Low Water**
H-Cell Compilation Units:	***meters at Mean Lower Low Water***

Remarks:

The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charts. All separates are filed with the hydrographic data. Any revisions to the Descriptive Report (DR) generated during office processing are shown in bold red italic text. The processing branch maintains the DR as a field unit product, therefore, all information and recommendations within the DR are considered preliminary unless otherwise noted. The final disposition of surveyed features is represented in the OCS nautical chart update products. All pertinent records for this survey, including the DR, are archived at the National Geophysical Data Center (NGDC) and can be retrieved via http://www.ngdc.noaa.gov/.

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Descriptive Report to Accompany Survey H12502

Project: OPR-D304-FH-12

Locality: Approaches to Chesapeake Bay, VA

Sublocality: 30 NM East of Cape Henry, VA

Scale: 1:40000

September 2012 - September 2012

NOAA Ship *Ferdinand R. Hassler*

Chief of Party: LCDR Benjamin K. Evans, NOAA

A. Area Surveyed

A.1 Survey Limits

Data was acquired within the following survey limits:

Northeast Limit	Southwest Limit
37.0127472222 N 75.1673083333 W	36.8151944444 N 75.3156388889 W

Table 1: Survey Limits

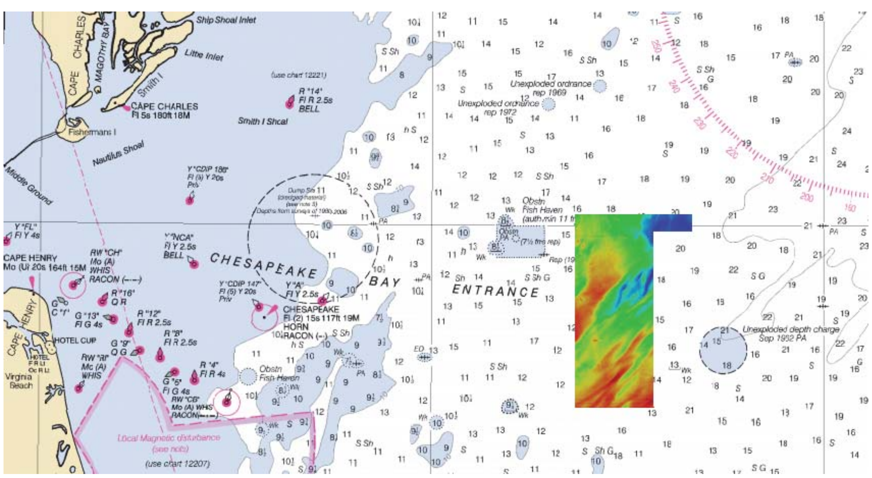


Figure 1: General locality of survey H12502

Survey coverage does not reach the eastern and western extents of the survey limits. This error was most likely caused by the hydrographer's failure to properly adjust display scale during line planning in MapInfo. The result was a line plan which visually appeared to extend to the sheet limits, but in fact went only as far as the interior edge of the sheet limit line work as displayed on the hydrographer's monitor.

Unfortunately, this error went unnoticed until review of junctions with contemporary surveys after the conclusion of the 2012 field season. There is no contemporary junction on the east side of H12502 , though coverage ends approximately 50-100 meters short of the sheet limit (figure 2). On the west edge of H12502, there is a gap approximately 50-90 meters wide to the east extent of H12503 (figure 3). As survey lines were run on an east-west axis, the extent of coverage on the northern and souther sides was unaffected.

The Chief of Party informed the Chief, Operations Branch (N/CS31) of this issue immediately following its discovery. Operations concurred with the hydrographer's recommendation to submit the survey as-is rather than hold it for completion in 2013.

The survey department aboard is aware of the issue and is adjusting the sheet planning SOP for 2013 surveying operations.

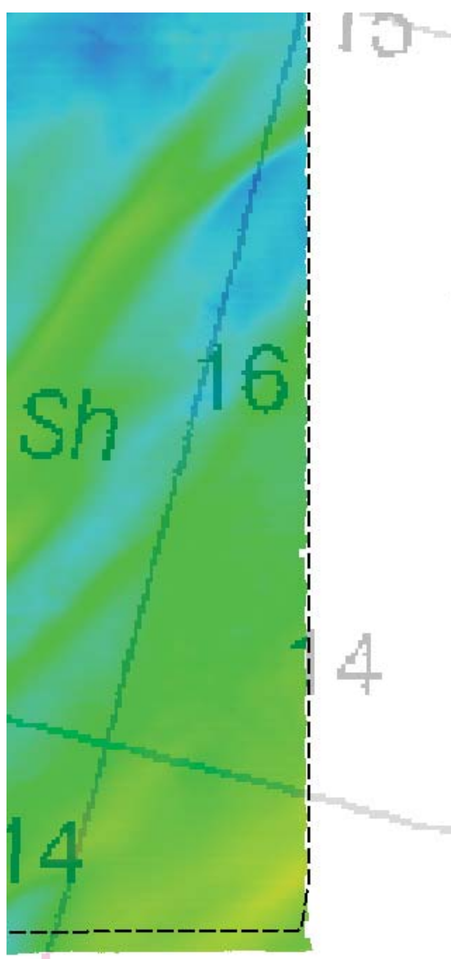


Figure 2: Gap on east side of sheet

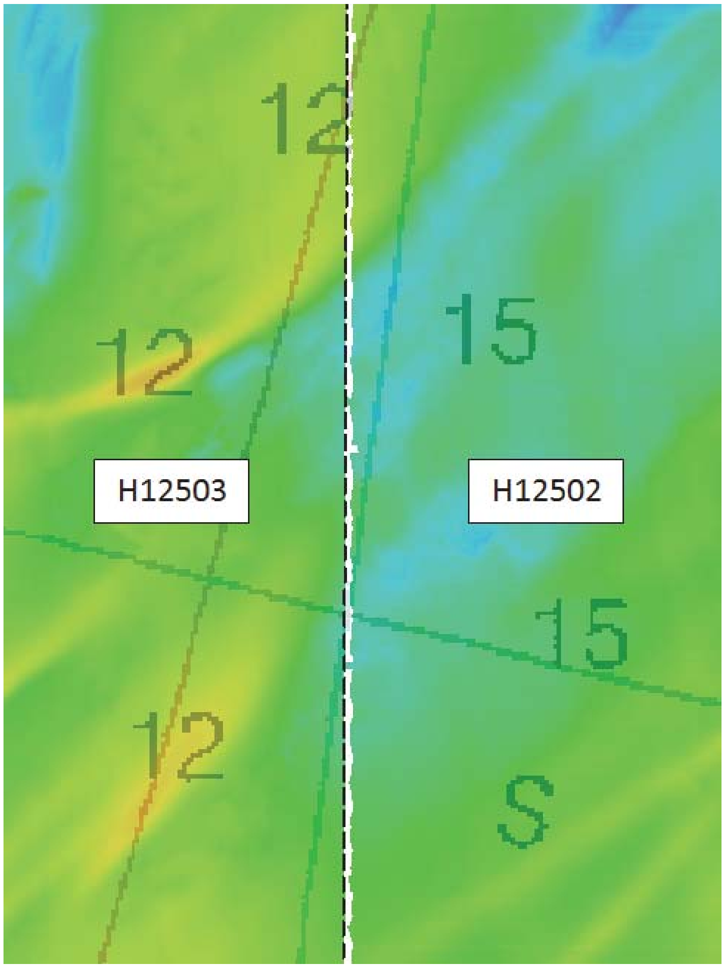


Figure 3: Gap on west side of sheet, junctioning with H12503

A.2 Survey Purpose

The primary purpose of H12502 is to support safe navigation through the acquisition and processing of hydrographic data for updating the National Ocean Service's (NOS) nautical charting products.

A.3 Survey Quality

The entire survey is adequate to supersede previous data.

A.4 Survey Coverage

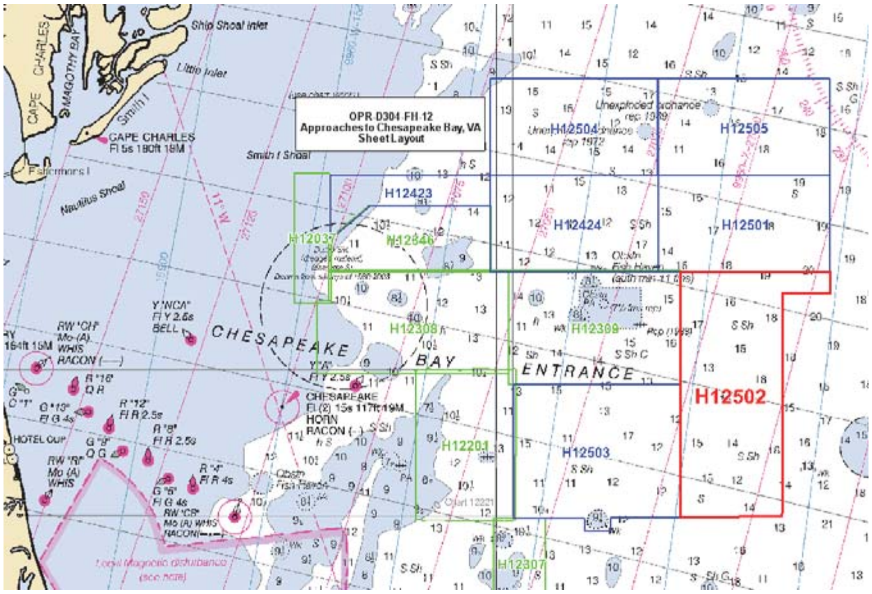


Figure 4: Project OPR-D304-FH-12 Sheet Layout

100% Object Detection multibeam was used as the primary method for satisfying the coverage requirement with the exception of the following discrepancy.

There are numerous small coverage holidays located throughout sheet H12502. For additional information refer to section B.2.8 of this report.

A.5 Survey Statistics

The following table lists the mainscheme and crossline acquisition mileage for this survey:

	HULL ID	***S250***	***Total***
LNM	**SBES Mainscheme**	0.00	0.00
	MBES Mainscheme	990.47	990.47
	Lidar Mainscheme	0.00	0.00
	SSS Mainscheme	0.00	0.00
	SBES/MBES Combo Mainscheme	0.00	0.00
	SBES/SSS Combo Mainscheme	0.00	0.00
	MBES/SSS Combo Mainscheme	0.00	0.00
	SBES/MBES Combo Crosslines	34.83	34.83
	Lidar Crosslines	0.00	0.00
Number of Bottom Samples			9
Number of DPs			0
Number of Items Items Investigated by Dive Ops			0
Total Number of SNM			59.83

Table 2: Hydrographic Survey Statistics

The following table lists the specific dates of data acquisition for this survey:

Survey Dates
09/07/2012
09/08/2012
09/09/2012
09/10/2012
09/11/2012
09/12/2012
09/13/2012
09/14/2012
09/22/2012
09/23/2012
09/27/2012
09/28/2012

Table 3: Dates of Hydrography

Survey lines were run with a dual-head multibeam echo sounder. LNM for the dual-head system was calculated using statistics from the starboard head.

A.6 Shoreline

The survey area is offshore and no shoreline investigation was required in the project instructions.

A.7 Bottom Samples

Bottom samples were taken to adequately sample the different bottom types apparent in the backscatter mosaic. Nine bottom samples were acquired within the limits of H12502. All bottom samples received S-57 attribution and are included in the submitted final feature file (FFF).

B. Data Acquisition and Processing

B.1 Equipment and Vessels

Refer to the Data Acquisition and Processing Report (DAPR) for a complete description of data acquisition and processing systems, survey vessels, quality control procedures and data processing methods. Additional information to supplement sounding and survey data, and any deviations from the DAPR are discussed in the following sections.

B.1.1 Vessels

The following vessels were used for data acquisition during this survey:

Hull ID	***S250***
LOA	37.7 meters
Draft	3.85 meters

Table 4: Vessels Used

NOAA Ship FERDINAND R. HASSLER (S250) acquired all data within the limits of H12502.

B.1.2 Equipment

The following major systems were used for data acquisition during this survey:

Manufacturer	Model	Type
Reson	7125	MBES
Applanix	POS M/V 320 V4	Vessel Attitude and Positioning System
Hemisphere	MBX-4	Positioning System
Brooke Ocean	MVP-30	Sound Speed System
AML	Smart SV&P	Sound Speed System
Sea-Bird	MicroTSG 45	Sound Speed System

Table 5: Major Systems Used

B.2 Quality Control

B.2.1 Crosslines

A geographic plot of crosslines is shown in Figure 5. 34.8 linear nautical miles of crosslines were acquired. Excluding holiday lines, this accounts for 3.8% of mainscheme distance. While this percentage fails to satisfy Hydrographic Surveys Specifications and Deliverables (2012), all mainscheme lines are intersected by a crossline and the comparison analysis yielded favorable results (see discussion below). In light of this, the hydrographer suggests that the crosslines acquired are adequate for this survey.

Crosslines were filtered to remove soundings greater than 45 degrees from nadir. To evaluate crossline agreement, two 1-meter surfaces were created: one from the crossline soundings, the other from mainscheme soundings. The crossline surface was differenced from the mainscheme surface using CARIS HIPS and SIPS. The statistical analysis of the difference between the mainscheme and crossline surfaces are shown in Figure 6. The average difference between the surfaces is 0.07 meters; 95% of all differences were less than 0.15 meters.

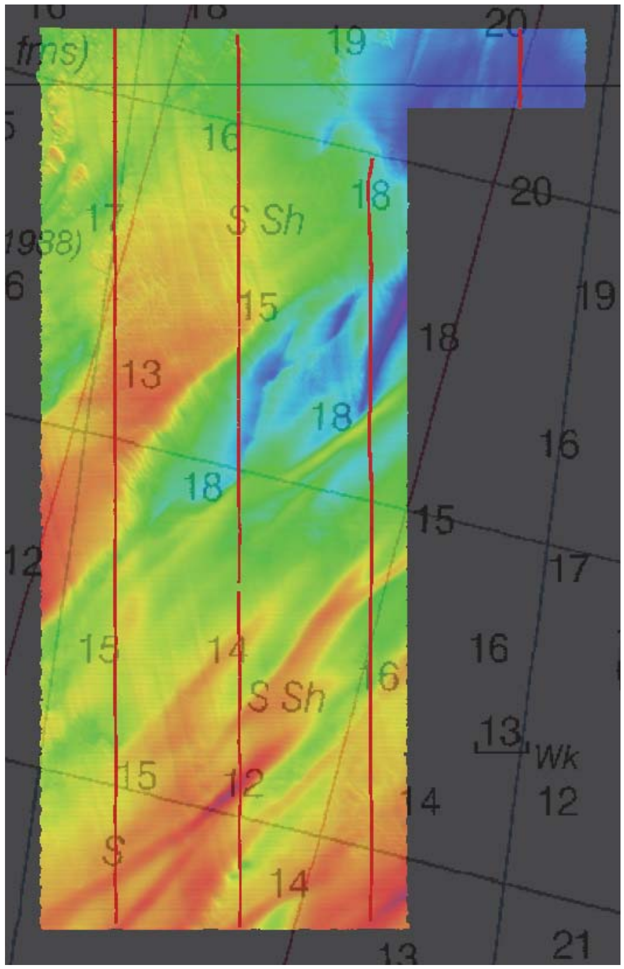


Figure 5: Crosslines (shown in red) and mainscheme data

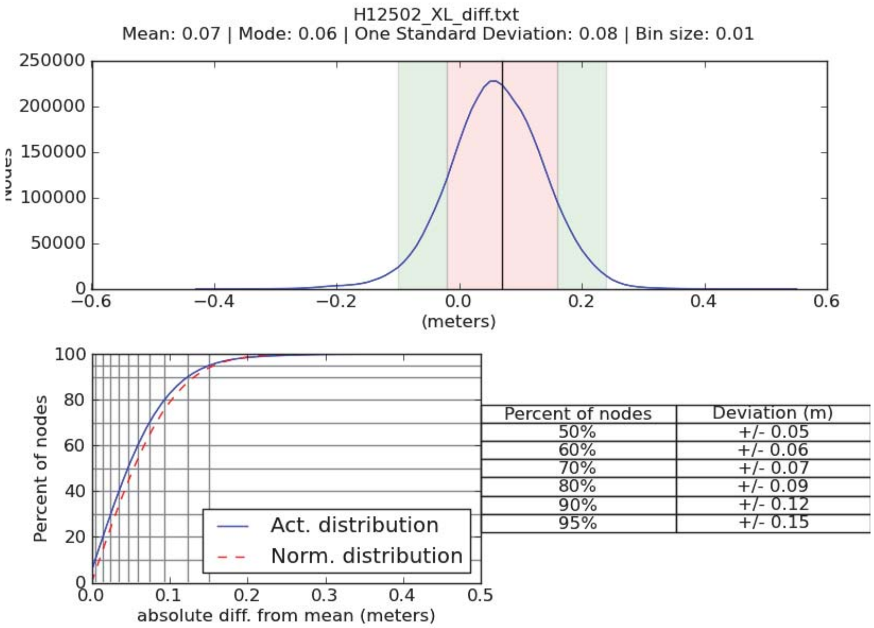


Figure 6: H12502 Crossline Difference Statistics - Mainscheme minus Crossline

B.2.2 Uncertainty

The following survey specific parameters were used for this survey:

Measured	Zoning
0.01meters	0.09meters
0.01meters	0.081meters

Table 6: Survey Specific Tide TPU Values

Hull ID	Measured - CTD	Measured - MVP	Surface
S250	1.0meters/second	1.0meters/second	0.5meters/second

Table 7: Survey Specific Sound Speed TPU Values

CO-OPS did not provide a tidal uncertainty in the Project Instructions due to lack of available water level time series data. Tide uncertainties provided by CO-OPS for the adjoining sheets in the 2011 project OPR-D304-FH-11 were used for this project. Only those soundings for which it was not possible to compute GPS heights were corrected with zoned tides. See Section C for details.

The 0.081 meter zoning uncertainty was provided by HSD, and is based on VDatum uncertainty in the area. Only lines which were brought to MLLW via VDatum techniques received these uncertainty values.

B.2.3 Junctions

The areas of overlap between sheet H12502 and its junction sheets were reviewed in CARIS Subset Editor for sounding consistency. The H12502 surface was differenced with junction surfaces to assess agreement.

The following junctions were made with this survey:

Registry Number	Scale	Year	Field Unit	Relative Location
H12309	1:40000	2011	NOAA Ship THOMAS JEFFERSON	W
H12501	1:40000	2012	NOAA Ship FERDINAND R. HASSLER	N
H12503	1:40000	2012	NOAA Ship FERDINAND R. HASSLER	W

Table 8: Junctioning Surveys

H12309

This survey is from project OPR-D304-TJ-11. At the time of this report, H12309 was in the survey acceptance process at Atlantic Hydrographic Branch and was not available for comparison.

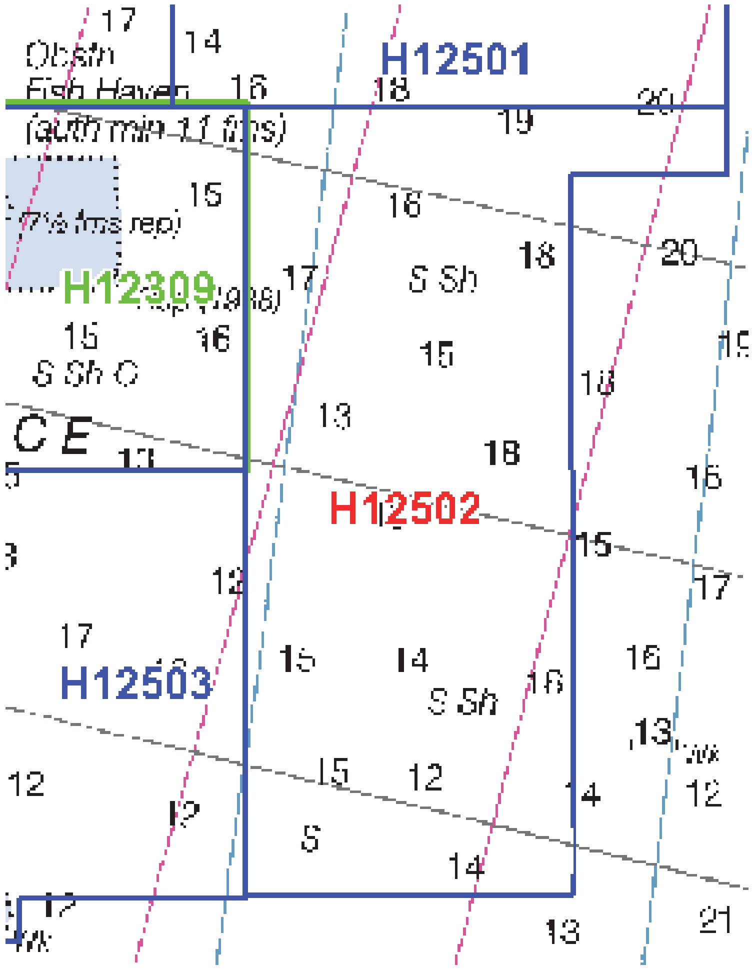


Figure 7: H12502 Junctions

<u>H12501</u>

Survey H12501 is within project OPR-D304-FH-12 as is H12502. Survey dates for H12501 are from 08/29/2012 to 09/11/2012. A difference surface shows that survey H12501 agrees with H12502 within -0.74 to 0.78 meters. The average difference is 0.05 meters with a standard deviation of 0.08 meters. 95% of all the differenced surface nodes are in the range of -0.10 to 0.20 meters.

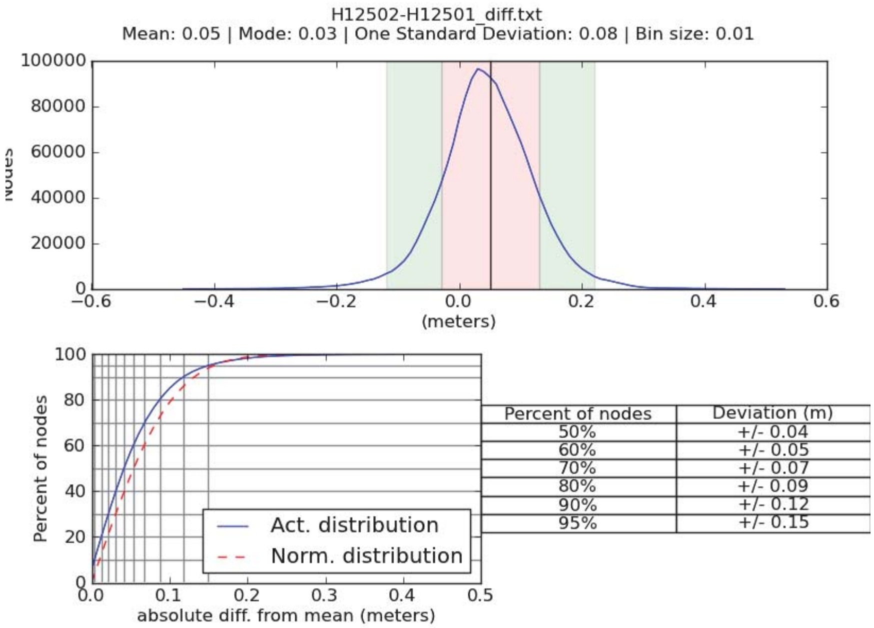


Figure 8: Difference Surface Statistics - H12502 minus H12501

<u>H12503</u>

Due to poor line planning during the preparation of project OPR-D304-FH-12 the areas of overlap between survey H12502 and H12503 was very small. As discussed in section A.1 of this report, this was an oversight by the field unit which was not noticed until after the conclusion of the 2012 field season. Figure 9 shows the small area of overlap between the surveys and highlights the data coverage gap.

Survey H12503 is within project OPR-D304-FH-12 as is H12502. Survey dates for H12503 are from 09/24/2012 to 12/13/2012. A difference surface of the overlapping areas shows that survey H12503 agrees with H12502 within -0.25 to 0.27 meters. The majority if H12503 agrees with H12502 on average of 0.01 meters with a standard deviation of 0.06 meters. 95% of all the differenced surface nodes are in the range of -0.10 to 0.12 meters.

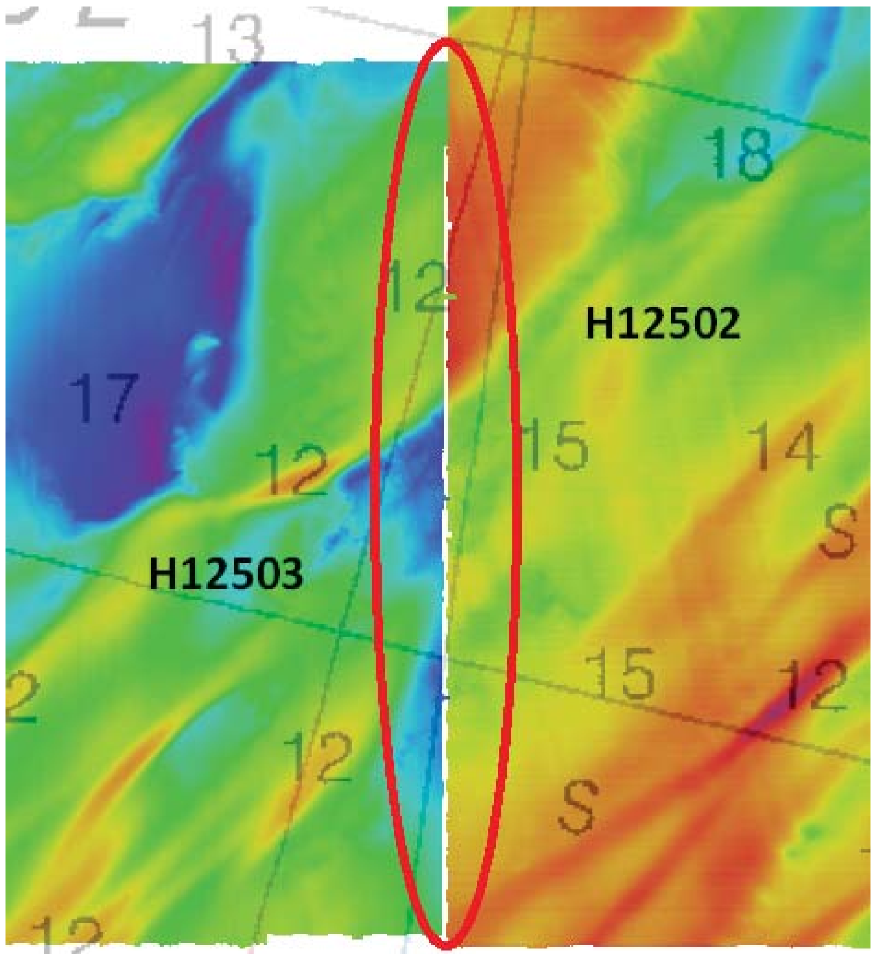
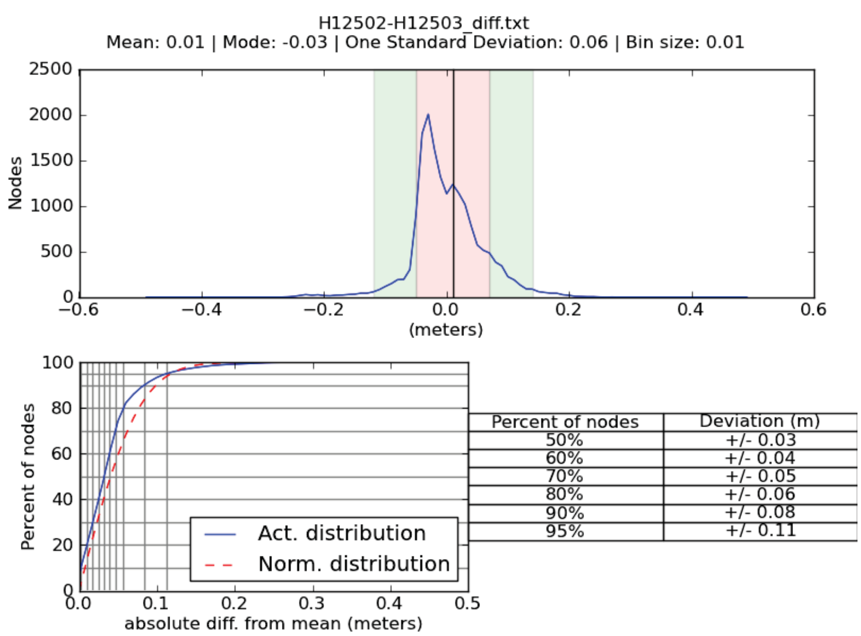


Figure 9: Areas of overlap and data gap between two OPR-D304-FH-12 surveys; H12502 and H12503.



Percent of nodes	Deviation (m)
50%	+/- 0.03
60%	+/- 0.04
70%	+/- 0.05
80%	+/- 0.06
90%	+/- 0.08
95%	+/- 0.11

Figure 10: Difference Surface Statistics - H12502 minus H12503

B.2.4 Sonar QC Checks

Sonar system quality control checks were conducted as detailed in the quality control section of the DAPR.

B.2.5 Equipment Effectiveness

B.2.5.1Outer Beam Errors

Survey H12502 contains suspect data on the outer beams. This could be attributed to data being not collected at the appropriate range scale. To free the survey watchstander for data processing, it is common practice to set appropriate range scales and not monitor them from one survey line to the next. In this case, the range scale was possibly set too low. Another possible source is that when running at full swath for Reson 7125 v2 (140 degrees) and with the permanent 4.5 degree outboard tilt, the outboard most beams have low signal to noise and the bottom detection quality deteriorates. Figure 11 shows a section of the 1-meter CUBE surface which has obvious striping caused by these outer beam errors.

Attempts were made to remove these fliers where the surface exceeds the maximum allowable TVU. Filters were applied as described in section B.5.4 of this report as well as manually rejecting soundings in CARIS Subset Editor. While the submitted surfaces may still honor some of these spurious soundings, they are within the maximum allowable vertical uncertainty at that depth. Figures 12 and 13 show specific examples of these surface spikes approaching the allowable vertical uncertainty for their depths.

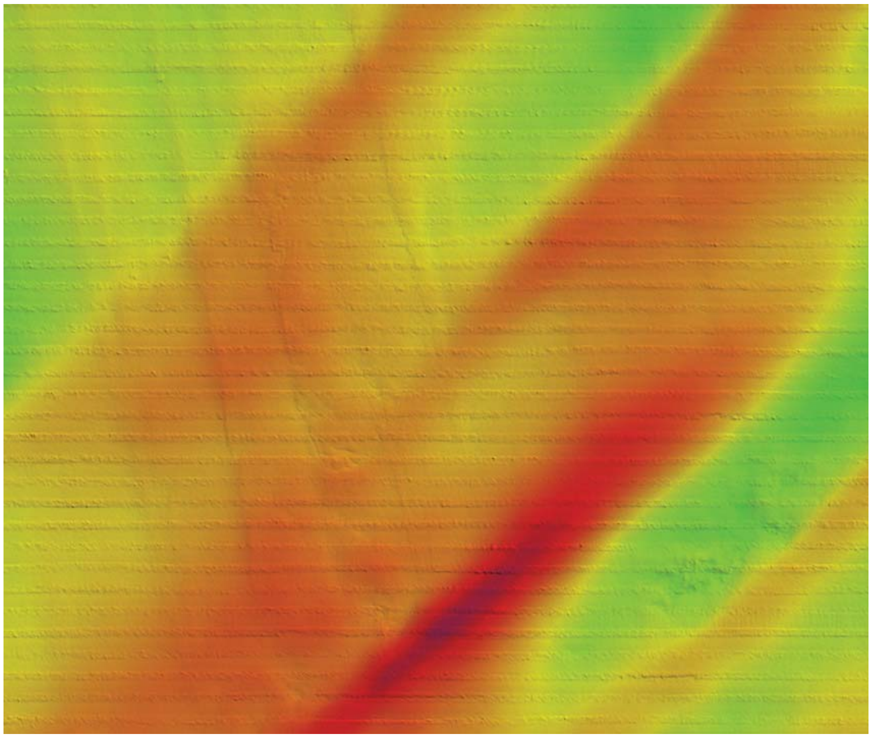


Figure 11: Horizontal striping evident in 1-meter CUBE surface at a 15 x exaggeration

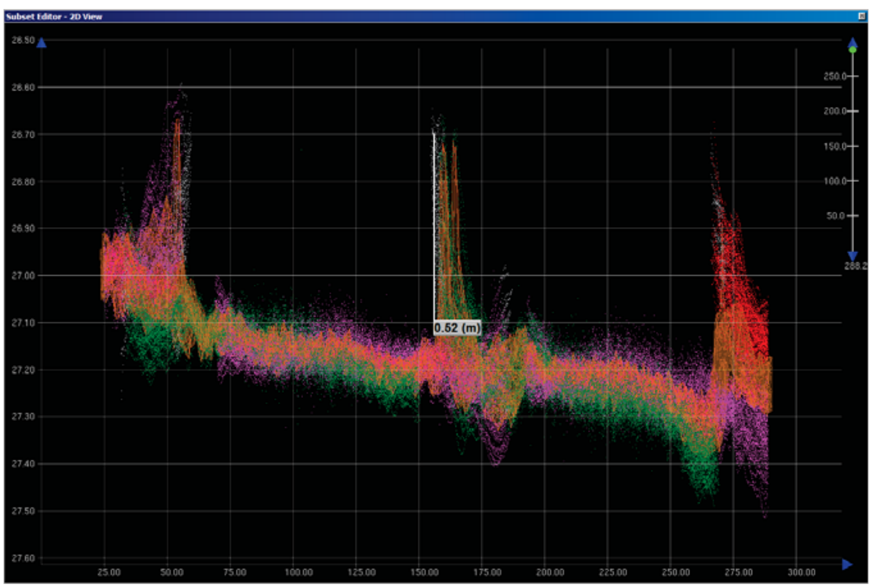


Figure 12: Example of outer beams viewed in CARIS Subset Editor causing surface to approach vertical uncertainty limits

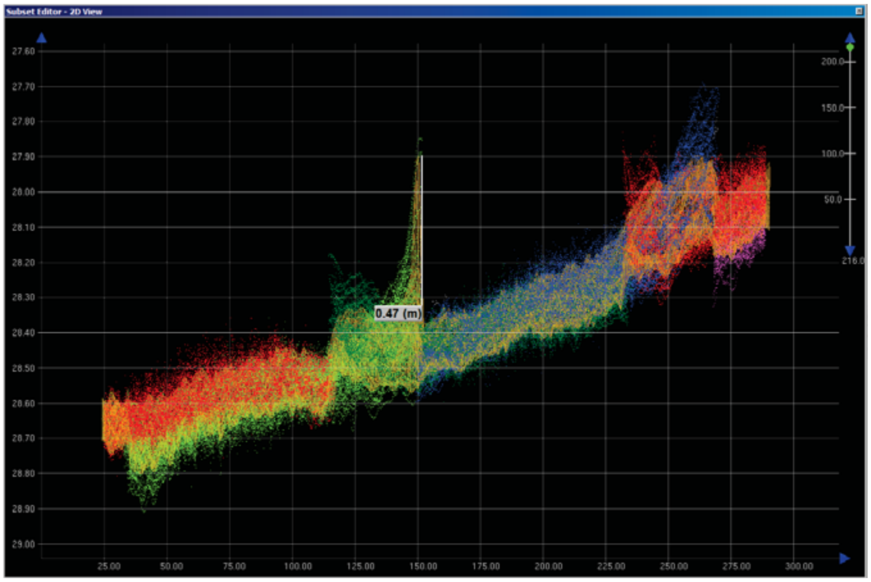


Figure 13: Example of outer beams viewed in CARIS Subset Editor causing surface to approach vertical uncertainty limits

B.2.5.1Cast-by-Vast Field Calibration of MVP Sound Speed Sensor

During acquisition on H12502, the MVP sound speed sensor (SN: 5466) was examined and found to be in need of repair. The base of the three rods supporting the sound speed chamber of the sing-around system were rusted and two of the three screws holding the reflector to the rods were loose. The assembly was disassembled, cleaned of rust, and reassembled with new screws and thread-lock compound.

On Dn270 the sound speed sensor was again loose, and the sensor was disassembled, cleaned and reassembled.

While these in-house repairs improved the stability of the sensor, the length of the rod was changed, and unknown. The sensitivity of the instrument is such that a difference in length of less than 0.10 mm will cause a sound speed change of over 1 m/s. Therefore, the instrument was considered out of calibration.

The repaired sensor was used for acquisition on Dn271 and verified against the ship's hull-mounted thermosalinograph (TSG) for each cast. A correction coefficient was calculated by dividing the average sound speed value computed from one minute of TSG data at the time of each MVP cast by the average value of the MVP sound speed sensor within 1m of the TSG intake. The full MVP cast was multiplied by the correction coefficient to correct for any length change in the sound speed chamber.

The Python scripts used for this analysis and a table of the correction coefficient for each cast are included in Separates II. The sound speed values used for this field calibration are shown in Figure 15 and the correction coefficient is shown in Figure 16. SV data on this sheet was within specification with these corrections applied.

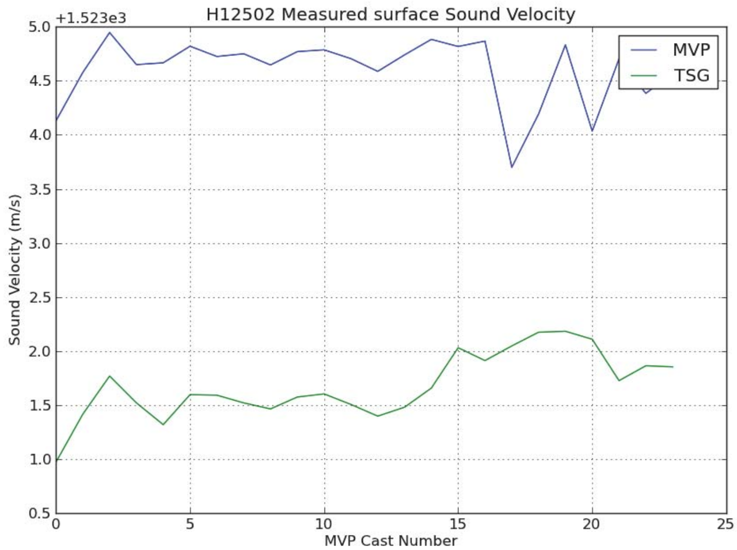


Figure 14: Sound speed at 4 meters depth from MVP and TSG at each MVP cast.

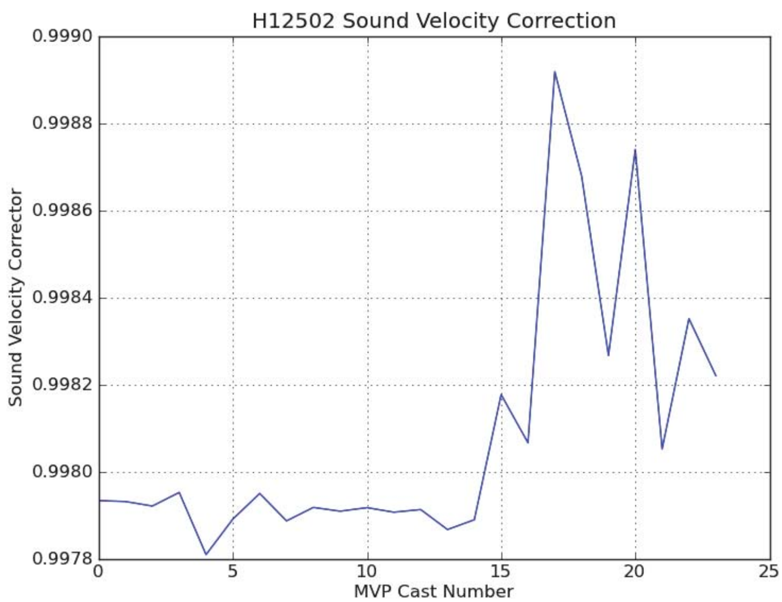


Figure 15: Correction coefficient calculated from the ratio of TSG sound speed to MVP sound speed.

B.2.5.1Applanix Trueheave dropouts

The internally logged POS file used for Trueheave had gaps in the IMU data for four lines. Because CARIS linearly interpolates across a gap in the data record, these data gaps resulted in large heave errors in the corrected soundings. An example of this interpolation across a data gap and the bathymetric effect is shown in Figure 16 and 17. These data gaps occurred during the acquisition of the following lines:

Port:	Starboard:
Dn256 _061131	Dn255 _085811
Dn257 _101504	
Dn252 _200733	

Trueheave dropouts were corrected by manually removing the Trueheave records from the HDCS folder and corrected with real-time heave only. Following these corrections, the large heave artifacts caused by these data gaps are eliminated.

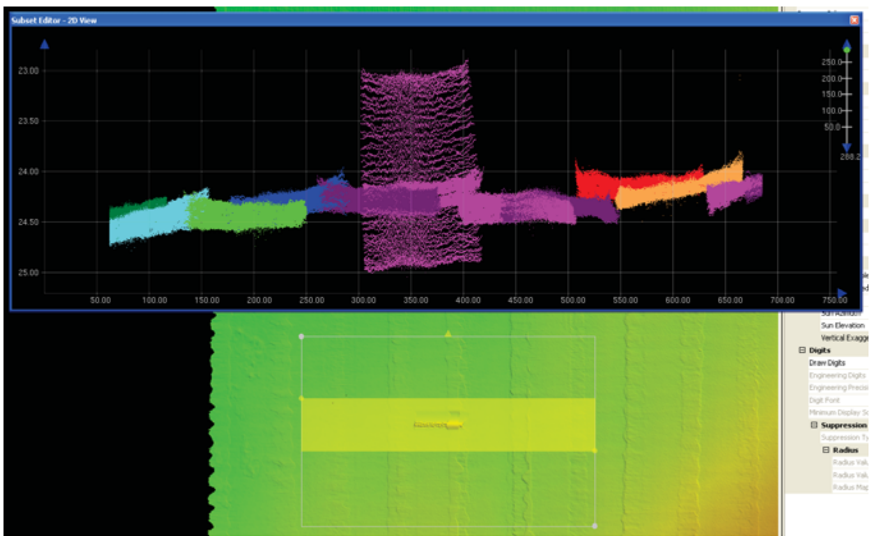


Figure 16: Example of Trueheave dropouts seen in BASE surfaces and Subset Editor before correction

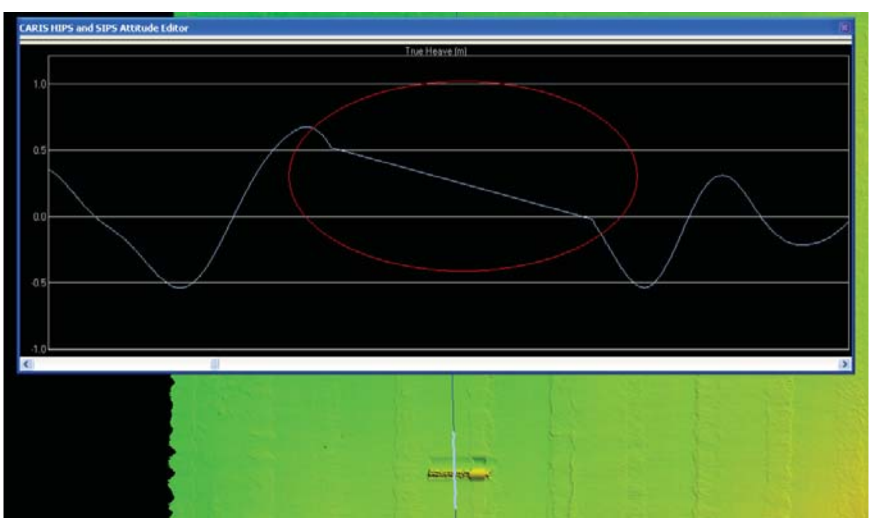


Figure 17: Example of Trueheave dropouts seen in BASE surfaces and Attitude Editor before correction - Interpolated section circled in red

B.2.6 Factors Affecting Soundings

B.2.6.1 None Exist

There were no other factors that affected corrections to soundings.

B.2.7 Sound Speed Methods

Sound Speed Cast Frequency: Sound speed casts were taken using the MVP approximately every 20 minutes.

The sound speed correction method of nearest in distance within time of one hour was used for the entire survey with the exception of port Dn266 line _231237 and port/starboard Dn271 lines _141412 through _160250 which were applied within three hours.

B.2.8 Coverage Equipment and Methods

A density analysis was run to calculate number of soundings per surface node. Five or more soundings per node were present in over 99% of the 1-meter surface. For additional detail refer to H12502_Standards_Compliance report submitted in Appendix II of this report. Due to limitations of the analysis script, the 1-meter surface was split into sections.

The density analysis only includes nodes which are at least populated by one sounding and do not account for holidays located within the surface. H12502 contained numerous small coverage holidays which were not discovered before the conclusion of the survey. Many of these holidays are the result of aggressive cleaning on the outer beams, previously mentioned in this report, but some are from the lack of adequate overlap. These holidays are mostly less than 20 meters in horizontal extent. Taking into account the flat topography of the surface, the hydrographer is confident that no shoaling is present at these locations.

Figure 18: Example of holidays located on sheet H12502

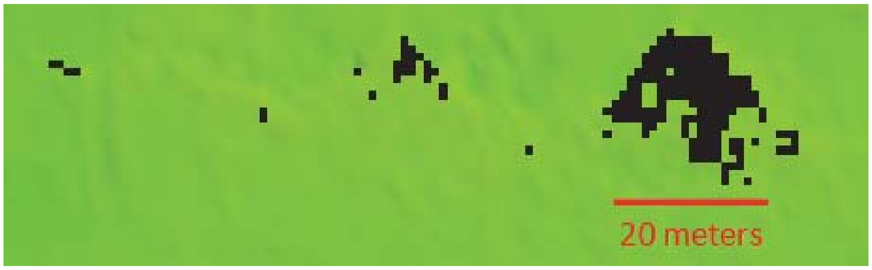


Figure 19: Example of holidays located on sheet H12502

Figure 20: Example of holidays located on sheet H12502

B.3 Echo Sounding Corrections

B.3.1 Corrections to Echo Soundings

All data reduction procedures conform to those detailed in the DAPR.

B.3.2 Calibrations

All sounding systems were calibrated as detailed in the DAPR.

B.3.3 Designated Soundings

One sounding was flagged as designated to preserve the shoal depth of an object on the sea floor.

B.4 Backscatter

Backscatter was logged in Reson datagram 7008 snippets record in the raw .s7k files. The .s7k file also holds the navigation and bottom detections for all lines of survey H12502. The files were paired with the CARIS HDCS data, imported and processed using Fledermaus Geocoder Toolbox, version 7.3.2b-beta, build 406, 64-bit version.

The GSF files containing the extracted backscatter are saved in the "Backscatter" folder under the processed data directory in accordance with instruction from HSD Ops dated 6/28/2012. The processed mosaic is saved as both a GeoTIFF and a scalar attached to the bathymetric Fledermaus .sd file and is also submitted.

B.5 Data Processing

B.5.1 Software Updates

The following software updates occurred after the submission of the DAPR:

Manufacturer	Name	Version	Service Pack	Hotfix	Installation Date	Use
Caris	Bathy DataBASE	4	0	3	02/05/2013	Processing
Caris	HIPS/SIPS	7.1	2	6	02/05/2013	Processing

Table 9: Software Updates

The following Feature Object Catalog was used: 5.2

B.5.2 Surfaces

The following CARIS surfaces were submitted to the Processing Branch:

Surface Name	**Surface Type**	**Resolution**	**Depth Range**	**Surface Parameter**	**Purpose**
H12502_1m	CUBE	1 meters	23.58 meters - 41.41 meters	NOAA_1m	Object Detection
H12502_1m_Final	CUBE	1 meters	23.59 meters - 41.40 meters	NOAA_1m	Object Detection

Table 10: CARIS Surfaces

The 1-meter resolution was chosen for the entire H12502 survey. While the depth range extends slightly deeper than the guidance put forth in the Hydrographic Surveys Specifications and Deliverables, the 1-meter was kept as it contains adequate density.

B.5.3 Interpolation of GPS Tide Errors using SBETs

In limited areas throughout the survey, errors in the GPS-derived vertical position solution led to vertical errors in the associated soundings. These altitude errors were located by examining the surface for areas of high standard deviation. Figure 22 shows an example of an area of high standard deviation caused by altitude errors before correction. CARIS Subset Editor and Attitude Editor were used to isolate the error in these cases to a GPS height error.

These errors are most apparent in the GPS Tide record generated in CARIS. This record is calculated during the "Calculate GPS Tide" process by removing the inertial generated heave record (Trueheave) from the post-processed GPS height solution (from the applied SBET) and applying the datum-ellipsoid transformation model. The resultant record should contain both the tidal signal and any loading or dynamic draft effects. In cases where there was both an apparent vertical error in the corrected soundings and the GPS Tide record had physically unreasonable jumps or anomalies, the GPS Tide anomalies were rejected in CARIS Attitude Editor and the resultant gap linearly interpolated. For short duration anomalies contained wholly within the line, this rejection and interpolation could be done simply in Attitude Editor. Sections of the following lines were handled in this way:

Port:	Starboard:
Dn256 _175640	Dn253 _064636
Dn257 _165620	Dn257 _165619

For lines were GPS tide anomalies extended beyond the end of the line, this simple interpolation approach was not feasible because the heave record, and thus the derived GPS height record, does not extend beyond the end of the line. In these cases, the SBET attitude was reapplied with a 30 minute buffer beyond each end of the line. The GPS height was smoothed through application of a 60 second moving average (effectively removing heave without reliance on the inertial data) and the GPS height re-calculated with the smoothed GPS height. These extended GPS Tide records were then interpolated in a similar fashion as described above. The following lines were corrected in this way:

Port:	Starboard:
Dn253 _052534	Dn252 _010824
Dn253 _060806	Dn256 _001107
Dn256 _183429	Dn256 _183429
Dn271 _114027	Dn257 _073154
Dn257 _140950	
Dn257 _145000	
Dn266 _183542	
Dn271 _114026	

Following corrections of the GPS tide records, the lines were re-merged. In all cases the vertical error in the soundings was substantially reduced or eliminated. The following figures are examples from adjoining sheet H12503. The detection and processing methods were the same for both of these surveys.

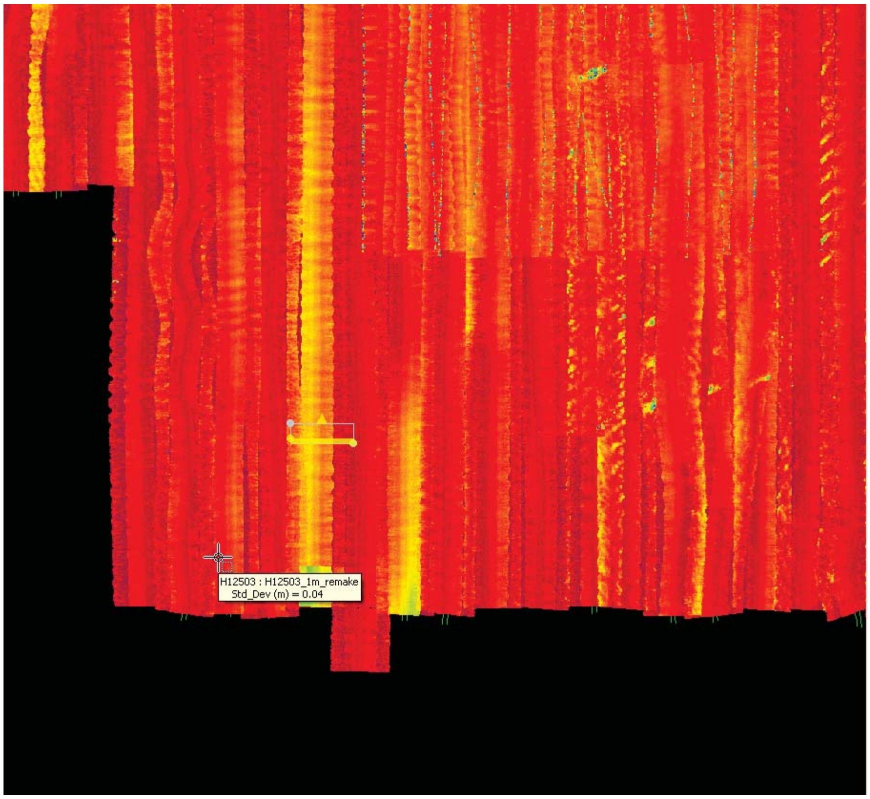


Figure 21: Example (from H12503) of an area of high standard deviation, caused by incorrect GPS altitude before correction.

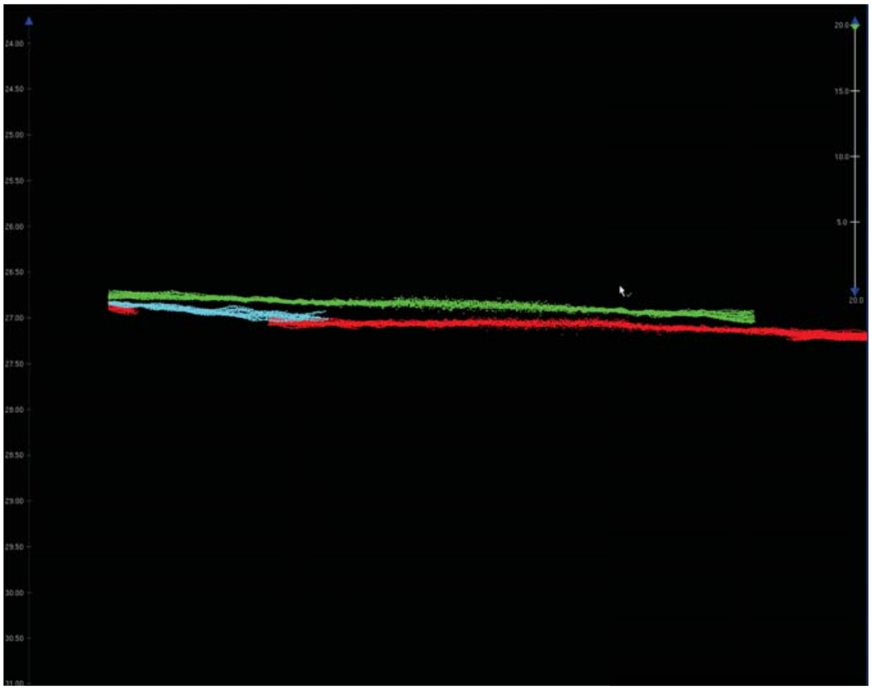


Figure 22: CARIS Subset Editor image. Green line is an example (from H12503) of a line with a vertical offset before correction.

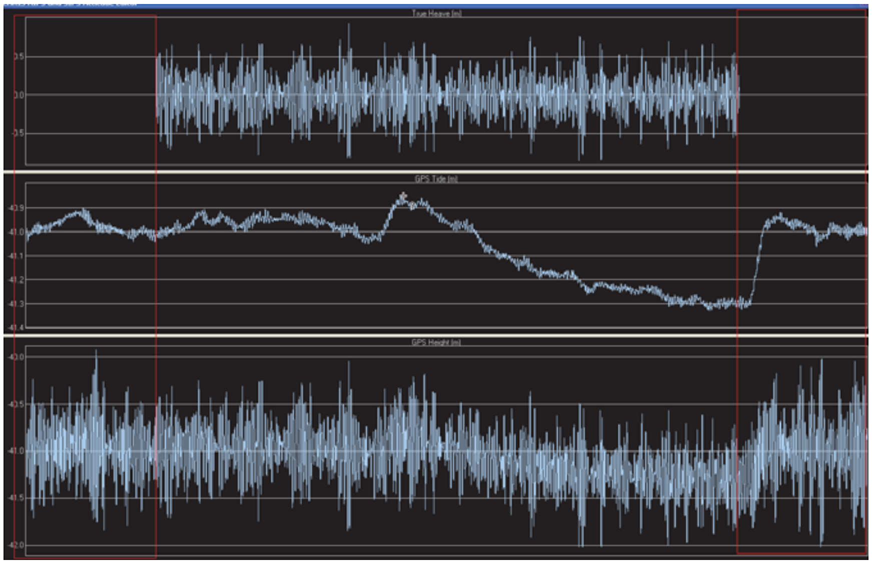


Figure 23: GPS Tide (middle box) of an example line (from H12503) before interpolation was made from SBETs. SBET data is indicated by red boxes. Top box is TrueHeave and bottom box is GPS Height which are both used to calculate GPS tide.

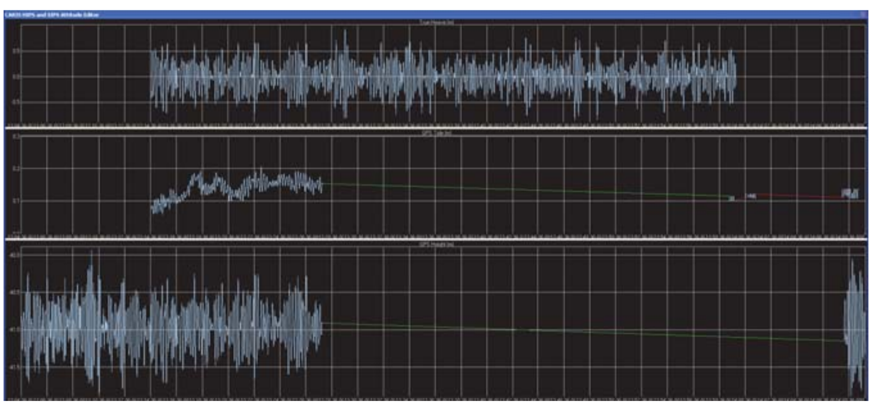


Figure 24: An example of an interpolate GPS tide line (from H12503) using SBETs. Top box is TrueHeave, bottom box is GPS Height and middle box is GPS Tide.

B.5.4 Outer Beam Filtering

To eliminate many low quality soundings on the outer beams which were causing physically unrealistic discontinuities in the modeled surface, all lines were filtered using CARIS filtering tool. This filter included port beams numbers 1-15 and starboard beams 498-512.

In certain cases these beams were reaccepted by the hydrographer if deemed to be valid.

B.5.5 Total Vertical Uncertainty Analysis

A custom layer was created on finalized surfaces showing the uncertainty of individual nodes in relation to the allowable uncertainty for their depths. This layer was exported and run through a custom Python script resulting in statistical analysis. 100% of nodes within survey H12502 met the vertical uncertainty standards of section 5.1.3 of the Hydrographic Surveys Specifications and Deliverables (2012 Edition). See H12502_Standards_Compliance report submitted in Appendix II of this report.

C. Vertical and Horizontal Control

Additional information discussing the vertical or horizontal control for this survey can be found in the accompanying HVCR. Ellipsoid referenced survey methods were used for most of this survey with the exception of three lines listed and discussed in section C.2. The VDatum Evaluation report submitted by the field unit and accompanying Approval Memo are submitted in Appendix II of this report.

C.1 Vertical Control

The vertical datum for this project is Mean Lower Low Water.

Standard Vertical Control Methods Used:

Discrete Zoning

The following National Water Level Observation Network (NWLON) stations served as datum control for this survey:

Station Name	Station ID
Duck, NC	8651370

Table 11: NWLON Tide Stations

File Name	Status
8651370.tid	Verified Observed

Table 12: Water Level Files (.tid)

File Name	Status
D304FH2012CORP.zdf	Final

Table 13: Tide Correctors (.zdf or .tc)

A request for final approved tides was sent to N/OPS1 on 10/29/2012. The final tide note was received on 11/02/2012.

Preliminary zoning is accepted as the final zoning for project OPR-D304-FH-12, H12502 during the time period between September 7 to 28, 2012 per Tide Note submitted in Appendix I of this report.

Non-Standard Vertical Control Methods Used:

VDatum

Ellipsoid to Chart Datum Separation File:

2012_D304_VDatum_Ellip_MLLW.xyz

All soundings being submitted as H12502 are referenced to MLLW reduced by Ellipsoidal methods using the aforementioned Ellipsoid to Chart Datum separation file except soundings from the lines that have no SBETs applied. These lines are listed in section C.2 of this report.

C.2 Horizontal Control

The horizontal datum for this project is North American Datum of 1983 (NAD83).

The following PPK methods were used for horizontal control:

Smart Base

All data submitted as H12502, with the exception of the following lines, has SBETs and SMRMSGs applied for post processed position/attitude and TPU values, respectively. Refer to the OPR-D304-FH-12 HVCR for specific values used while processing and applying these files.

The following lines do not have post-processed position and attitude due to post-processed solution gaps and are corrected using real-time DGPS positioning and discrete zoning tide methods.

Port:	Starboard:
Dn252 _200733	Dn255 _085811
Dn257 _121325	

The following CORS Stations were used for horizontal control:

HVCR Site ID	Base Station ID
Acushnet 5	ACU5
Chesapeake Light	COVX
Driver 5	DRV5
Driver 6	DRV6
Loyola 2	LOY2
Loyola W	LOYW
Loyola	LS03
Moriches 5	MOR5
Moriches 6	MOR6
Buxton	NCBX
Duck	NCDU
Elizabeth City	NCEL
R Stockton Coll	NJGT
Riverhead	NYRH
Wallops Island	VAWI

Table 14: CORS Base Stations

DGPS was used for real-time positioning.

The following DGPS Stations were used for horizontal control:

DGPS Stations
Driver, Virginia (289kHz)

Table 15: USCG DGPS Stations

D. Results and Recommendations

D.1 Chart Comparison

D.1.1 Raster Charts

The following are the largest scale raster charts, which cover the survey area:

Chart	Scale	Edition	Edition Date	LNM Date	NM Date
12220	1:419706	50	07/2011	06/28/2011	07/09/2011

Table 16: Largest Scale Raster Charts

12220

Survey soundings of H12502 agree within 1 fathom of charted depths on raster chart 12200.

D.1.2 Electronic Navigational Charts

The following are the largest scale ENCs, which cover the survey area:

ENC	Scale	Edition	Update Application Date	Issue Date	Preliminary?
US3DE01M	1:419706	13	08/02/2012	10/23/2012	NO

Table 17: Largest Scale ENCs

US3DE01M

ENC US3DE01M contains no soundings different than RNC 12200. See previous discussion for comparison with chart 12200.

D.1.3 AWOIS Items

No AWOIS items exist for this survey.

D.1.4 Charted Features

No charted features exist for this survey.

D.1.5 Uncharted Features

No uncharted features exist for this survey.

D.1.6 Dangers to Navigation

No Danger to Navigation Reports were submitted for this survey.

D.1.7 Shoal and Hazardous Features

No shoals or potentially hazardous features exist for this survey.

D.1.8 Channels

No channels exist for this survey. There are no designated anchorages, precautionary areas, safety fairways, traffic separation schemes, pilot boarding areas, or channel and range lines within the survey limits.

D.2 Additional Results

D.2.1 Shoreline

Shoreline was not assigned in the Hydrographic Survey Project Instructions or Statement of Work.

D.2.2 Prior Surveys

Prior survey comparisons exist for this survey, but were not investigated.

D.2.3 Aids to Navigation

Aids to navigation (ATONs) do not exist for this survey.

D.2.4 Overhead Features

Overhead features do not exist for this survey.

D.2.5 Submarine Features

Submarine features do not exist for this survey.

D.2.6 Ferry Routes and Terminals

No ferry routes or terminals exist for this survey.

D.2.7 Platforms

No platforms exist for this survey.

D.2.8 Significant Features

No significant features exist for this survey.

D.2 Construction and Dredging

H12502 is part of an area planned for possible future wind energy development.

E. Approval Sheet

As Chief of Party, field operations for this hydrographic survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports.

All field sheets, this Descriptive Report, and all accompanying records and data are approved. All records are forwarded for final review and processing to the Processing Branch.

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables Manual, Field Procedures Manual, Standing and Letter Instructions, and all HSD Technical Directives with the exception of the discrepencies noted in this report. These data are adequate to supersede charted data in their common areas. This survey is complete and no additional work is required with the exception of deficiencies noted in the Descriptive Report.

Report Name	Report Date Sent
OPR-D304-FH-12 Data Acquisition and Processing Report	2013-01-07
Hydrographic Survey Readiness Review Memo	2012-07-03

Approver Name	Approver Title	Approval Date	Signature
LCDR Benjamin K. Evans, NOAA	Chief of Party	03/22/2013	Benjamin K. Evans 2013.03.21 09:00:07 -04'00'
LT Samuel F. Greenaway, NOAA	Field Operations Officer	03/22/2013	
David T. Moehl	Senior Survey Technician	03/22/2013	David Moehl 2013.03.21 09:29:53 -04'00'

F. Table of Acronyms

Acronym	Definition
AFF	Assigned Features File
AHB	Atlantic Hydrographic Branch
AST	Assistant Survey Technician
ATON	Aid to Navigation
AWOIS	Automated Wreck and Obstruction Information System
BAG	Bathymetric Attributed Grid
BASE	Bathymetry Associated with Statistical Error
CO	Commanding Officer
CO-OPS	Center for Operational Products and Services
CORS	Continually Operating Reference Staiton
CTD	Conductivity Temperature Depth
CEF	Chart Evaluation File
CSF	Composite Source File
CST	Chief Survey Technician
CUBE	Combined Uncertainty and Bathymetry Estimator
DAPR	Data Acquisition and Processing Report
DGPS	Differential Global Positioning System
DP	Detached Position
DR	Descriptive Report
DTON	Danger to Navigation
ENC	Electronic Navigational Chart
ERS	Ellipsoidal Referenced Survey
ERZT	Ellipsoidally Referenced Zoned Tides
FOO	Field Operations Officer
FPM	Field Procedures Manual
GAMS	GPS Azimuth Measurement Subsystem
GC	Geographic Cell
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HSD	Hydrographic Surveys Division
HSSDM	Hydrographic Survey Specifications and Deliverables Manual

Acronym	Definition
HSTP	Hydrographic Systems Technology Programs
HSX	Hypack Hysweep File Format
HTD	Hydrographic Surveys Technical Directive
HVCR	Horizontal and Vertical Control Report
HVF	HIPS Vessel File
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
ITRF	International Terrestrial Reference Frame
LNM	Local Notice to Mariners
LNM	Linear Nautical Miles
MCD	Marine Chart Division
MHW	Mean High Water
MLLW	Mean Lower Low Water
NAD 83	North American Datum of 1983
NAIP	National Agriculture and Imagery Program
NALL	Navigable Area Limit Line
NM	Notice to Mariners
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NRT	Navigation Response Team
NSD	Navigation Services Division
OCS	Office of Coast Survey
OMAO	Office of Marine and Aviation Operations (NOAA)
OPS	Operations Branch
MBES	Multibeam Echosounder
NWLON	National Water Level Observation Network
PDBS	Phase Differencing Bathymetric Sonar
PHB	Pacific Hydrographic Branch
POS/MV	Position and Orientation System for Marine Vessels
PPK	Post Processed Kinematic
PPP	Precise Point Positioning
PPS	Pulse per second

Acronym	Definition
PRF	Project Reference File
PS	Physical Scientist
PST	Physical Science Technician
RNC	Raster Navigational Chart
RTK	Real Time Kinematic
SBES	Singlebeam Echosounder
SBET	Smooth Best Estimate and Trajectory
SNM	Square Nautical Miles
SSS	Side Scan Sonar
ST	Survey Technician
SVP	Sound Velocity Profiler
TCARI	Tidal Constituent And Residual Interpolation
TPU	Total Porpagated Error
TPU	Topside Processing Unit
USACE	United States Army Corps of Engineers
USCG	United Stated Coast Guard
UTM	Universal Transverse Mercator
XO	Exectutive Officer
ZDA	Global Positiong System timing message
ZDF	Zone Definition File

Appendix I:
Tides & Water Levels

Request for Tides

Tide Note

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOAA Ship FERDINAND R. HASSLER (MOA-FH)
29 Wentworth Road
New Castle, NH 03854

October 29, 2012

MEMORANDUM FOR: Gerald Hovis, Chief, Products and Services Branch, N/OPS3

FROM: LCDR Benjamin K. Evans, NOAA, NOAA Ship FERDINAND R. HASSLER (MOA-FH)

SUBJECT: Request for Approved Tides/Water Levels

Please provide the following data:

1. Tide Note
2. Final zoning in MapInfo and .MIX format
3. Six Minute Water Level data (Co-ops web site)

Transmit data to the following:

Atlantic Hydrographic Branch (N/CS33)
439 West York St
Norfolk, VA 23510

NOAA Ship Ferdinand R. Hassler
439 West York St
Norfolk, VA 23510
ATTN: Operations Officer

These data are required for the processing of the following hydrographic survey:

Project No.:	OPR-D304-FH-12
Registry No.:	H12502
State:	Virginia
Locality:	Approaches to Chesapeake Bay, VA
Sublocality:	30 NM East of Cape Henry,VA

Attachments containing:

1) an Abstract of Times of Hydrography,
2) digital MID MIF files of the track lines from Pydro

cc: N/CS33

Generated by Pydro v12.9(r3952) on Mon Oct 29 14:39:44 2012 [UTC]

Year_DOY	Min Time	Max Time
2012_251	22:58:38	23:59:58
2012_252	00:00:03	23:55:24
2012_253	00:10:30	08:48:36
2012_254	00:25:39	13:13:53
2012_255	01:40:57	23:32:47
2012_256	00:11:09	23:56:08
2012_257	00:13:49	23:55:54
2012_258	00:15:20	05:13:12
2012_265	23:12:38	23:49:29
2012_266	00:00:47	23:53:09
2012_267	00:14:01	02:53:58
2012_271	08:33:57	23:59:58
2012_272	00:00:03	01:04:07

UNITED STATES DEPARMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Silver Spring, Maryland 20910

TIDE NOTE FOR HYDROGRAPHIC SURVEY

DATE : Novemeber 1, 2012

HYDROGRAPHIC BRANCH: Atlantic
HYDROGRAPHIC PROJECT: OPR-D304-FH-2012
HYDROGRAPHIC SHEET: H12502

LOCALITY: 30 NM East of Cape Henry, Approaches to Chesapeake Bay, VA
TIME PERIOD: September 7 - September 28, 2012

TIDE STATION USED: 8651370 Duck, NC
Lat. 36° 11.0'N Long. 75° 44.8' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 1.026 meters

REMARKS: RECOMMENDED ZONING

Preliminary zoning is accepted as the final zoning for project OPR-D304-FH-2012, H12502, during the time period between September 7 to 28, 2012.

Please use the zoning file D304FH2012CORP submitted with the project instructions for OPR-D304-FH-2012. Zones SA46 is the applicable zone for H12502.

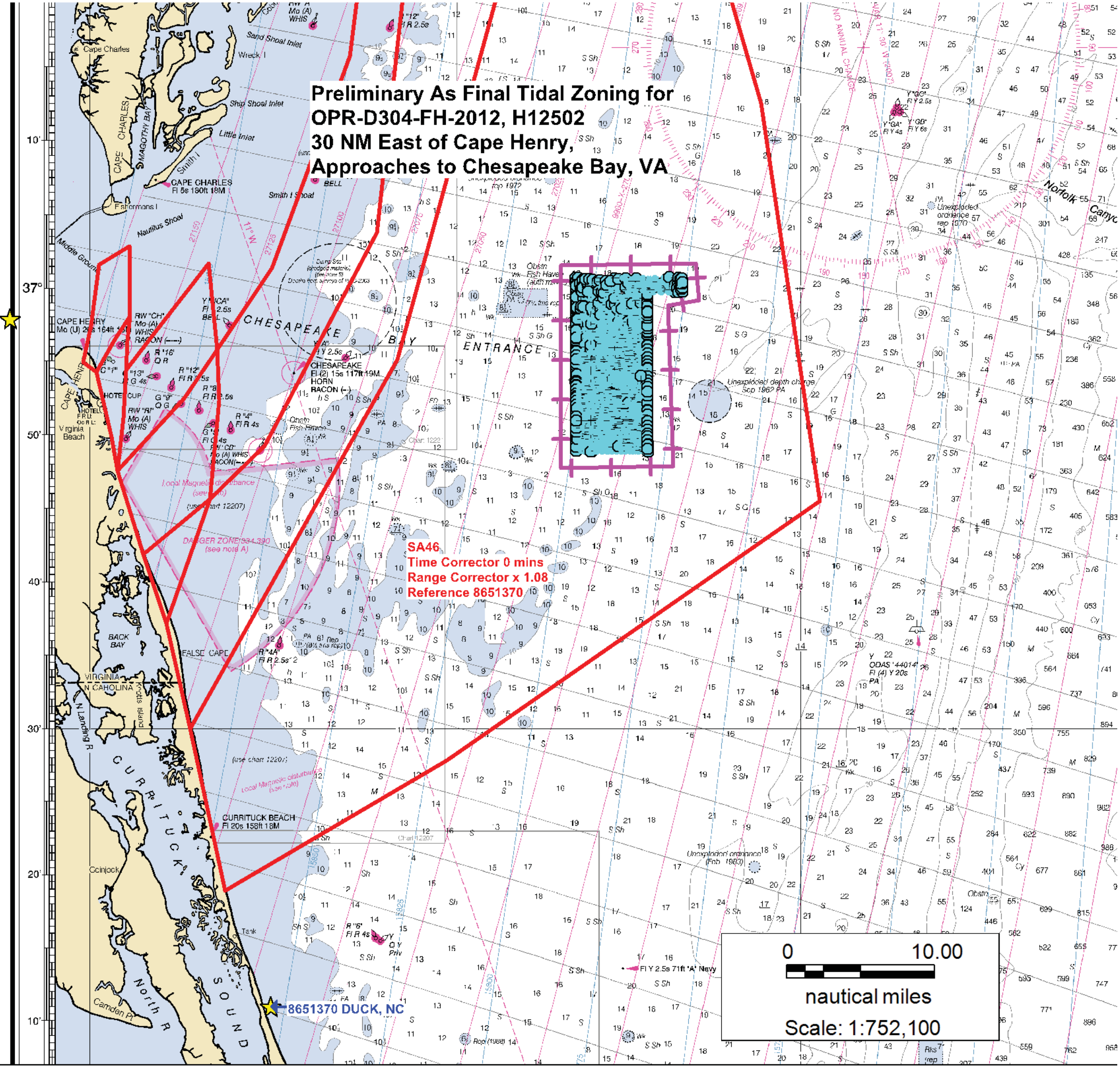
Refer to attachments for zoning information.

Note 1: Provided time series data are tabulated in metric units (meters), relative to MLLW and on Greenwich Mean Time on the 1983-2001 National Tidal Datum Epoch (NTDE).

HOVIS.GERALD.THOMAS.1365860250

Digitally signed by HOVIS.GERALD.THOMAS.1365860250
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=OTHER, cn=HOVIS.GERALD.THOMAS.1365860250
Date: 2012.11.02 15:16:22 -04'00'

CHIEF, PRODUCTS AND SERVICES BRANCH



Preliminary As Final Tidal Zoning for
OPR-D304-FH-2012, H12502
30 NM East of Cape Henry,
Approaches to Chesapeake Bay, VA
SA46
Time Corrector 0 mins
Range Corrector x 1.08
Reference 8651370
8651370 DUCK, NC
0
10.00
nautical miles
Scale: 1:752,100
CHESAPEAKE BAY
ENTRANCE
CAPE CHARLES
CAPE HENRY
FALSE CAPE
CURRITUCK BEACH
CURRITUCK SOUND
VIRGINIA
N CAROLINA

Appendix II:

Supplemental Survey Records and Correspondence

Subject: Final Tides Request: H12502 of OPR-D304-FH-12
From: OPS Hassler <samuel.greenaway@noaa.gov>
Date: 10/29/2012 2:50 PM
To: final.tides@noaa.gov
CC: "Paul.Turner" <Paul.Turner@noaa.gov>

Please find final tide request for sheet H12502 of project OPR-D304-FH-12 attached.

Best regards,

Sam

--
LT Sam Greenaway
Operations Officer
NOAA Ship Ferdinand R. Hassler

Attachments:

H12502_Final_Tides_Request.zip	27 bytes

Subject: Final Tide Notes for OPR-D304-FH-2012, Registry Nos. H12502 and H12503
From: Hua Yang <hua.yang@noaa.gov>
Date: 11/2/2012 7:44 PM
To: CO.Ferdinand.Hassler@noaa.gov, OPS.Ferdinand.Hassler@noaa.gov
CC: marc.s.moser@noaa.gov, corey.allen@noaa.gov, abigail.higgins@noaa.gov, nos.coops.hpt@noaa.gov

UNITED STATES DEPARMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Silver Spring, Maryland 20910

DATE: 11/02/2012

MEMORANDUM FOR: LCDR Benjamin K. Evans
Commanding Officer, NOAA Ship Ferdinand Hassler

FROM: Gerald Hovis
Chief, Products and Services Branch, N/OPS3

SUBJECT: Delivery of Tide Requirements for Hydrographic Surveys

This is notification that the preliminary zoning is accepted as the final zoning for survey project OPR-D304-FH-2012, Registry Nos. H12502 and H12503 during the time period of September 7 to October 15, 2012. The accepted reference station for them is Duck, NC (8651370).

Included with this memo are the Tide Notes in .PDF format, stating the preliminary zoning has been accepted as the final zoning.

Hua Yang

Hydrographic Planning Team
Oceanographic Division
NOAA/National Ocean Service
Center for Operational Oceanographic Products and Services
1305 East-West Highway
Silver Spring, MD 20910
Hua.Yang@noaa.gov
Phone (work):(301) 713-2890 x 210

Attachments:

H12502.pdf	479 KB
H12503.pdf	477 KB

OPS.Ferdinand Hassler - NOAA Service Account <ops.ferdinand.hassler@noaa.gov>

OPR-D304-FH-12; H12504 and H12505

4 messages

OPS.Ferdinand Hassler - NOAA Service Account <ops.ferdinand.hassler@noaa.gov> Thu, Dec 20, 2012 at 10:01 AM
To: _NOS OCS Survey Outlines <survey.outlines@noaa.gov>
Cc: David Moehl - NOAA Federal <david.t.moehl@noaa.gov>

Good Morning,
Attached, please find survey outlines for OPR-D304-FH-12; H12504 and H12505. Areas agree with the progress report and project instructions.
Very respectfully,
Madeleine

2 attachments

H12504_Survey_Outline.zip
6K

H12505_Survey_Outline.zip
4K

OPS.Ferdinand Hassler - NOAA Service Account <ops.ferdinand.hassler@noaa.gov> Wed, Mar 13, 2013 at 3:35 PM
To: _NOS OCS Survey Outlines <survey.outlines@noaa.gov>
Cc: "CO.Ferdinand Hassler - NOAA Service Account" <co.ferdinand.hassler@noaa.gov>, Marc Moser - NOAA Federal <Marc.S.Moser@noaa.gov>

Good Afternoon,
Attached, please find the survey outline for OPR-D304-FH-12; H12502
Thank you.
V/r,
Madeleine

--
Field Operations Officer, *NOAA Ship Ferdinand R. Hassler*
MOC-A, 439 West York Street
Norfolk, VA 23510

H12502_Survey_Outline.zip
2K

CO HASSLER <co.ferdinand.hassler@noaa.gov> Wed, Mar 13, 2013 at 3:42 PM
To: "OPS.Ferdinand Hassler - NOAA Service Account" <ops.ferdinand.hassler@noaa.gov>

Mud,

Thanks. Please double check that we have submitted survey outlines for all surveys completed last year.

CO
[Quoted text hidden]

--
LCDR Ben Evans, NOAA
Commanding Officer
NOAA Ship FERDINAND R. HASSLER (S-250)
mobile: (240) 687-4602
ship's cell: (603) 812-8748

OPS.Ferdinand Hassler - NOAA Service Account <ops.ferdinand.hassler@noaa.gov> Wed, Mar 13, 2013 at 3:59 PM
To: CO HASSLER <co.ferdinand.hassler@noaa.gov>

Hi CO,
I went through the OPS email and saw that H12502 was never sent (from this account).

I sent H12504 and H12505 in December. This afternoon, I asked the XO if he sent anything from his personal account before I resubmit anything.

When I hear back, I will ensure anything remaining is sent in.

V/r,
Mud
[Quoted text hidden]

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

February 25, 2013

MEMORANDUM FOR: LCDR Benjamin K. Evans, NOAA
Commanding Officer, NOAA Ship *Ferdinand Hassler*

FROM: Jeffrey Ferguson
Chief, Hydrographic Surveys Division

SUBJECT: Vertical Datum Transformation Technique,
OPR-D304-FH-12, Long Island Sound, NY

Hydrographic surveys H12502, H12503, and H12504 are approved for vertical reduction to chart datum, Mean Lower Low Water (MLLW), using the NOAA Vertical Datum Transformation (VDatum) (http://vdatum.noaa.gov) derived separation (SEP) model provided on the project CD/DVD.

Approval of VDatum, in lieu of the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) TCARI package as per the Project Instructions, is based on your recommendation and the review of comparison results you included in your memos from January 4, 2013, Subject "OPR-D304-FH-12 VDatum Evaluation".

The results of the data analysis show that ellipsoidally referenced survey (ERS) techniques with VDatum used as the vertical datum reducer to MLLW in this area indicate a better internal consistency of the survey data and produces final sounding values that meet or exceed horizontal and vertical specifications for hydrographic surveys.

The comparison techniques are in line with the procedures that were developed and approved as part of the CSDL Ellipsoidally Referenced Survey (ERS) project. These procedures and deliverables were added to the April 2012 edition of the NOS Hydrographic Surveys Specifications and Deliverables Manual and Field Procedures Manual documents.

You shall include a description of your ERS processing procedures and the comparisons you conducted between ERS and traditional tides in the appropriate Descriptive Report (DR), Horizontal and Vertical Control Report and/or Data Acquisition and Processing Report.

This memo and your memo, shall be included in the supplemental correspondence Appendix of the DR.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOAA Marine and Aviation Operations
NOAA Ship *Ferdinand R. Hassler* S-250
326 West York Street
Norfolk, VA 23510

January 4, 2013

MEMORANDUM FOR: Jeffrey Ferguson
Chief, Hydrographic Survey Branch

FROM: LCDR Benjamin K. Evans, NOAA
Commanding Officer

TITLE: OPR-D304-FH-12 VDatum Evaluation and Deliverable Recommendation

Ferdinand R. Hassler personnel conducted a comparison of VDatum based Ellipsoid Referenced Survey (ERS) versus discrete tidal zoning vertical transformation techniques using crossline data per the Hydrographic Survey Project Instructions (PI). In addition we conducted comparisons using the difference between crosslines and mainscheme to give a better recommendation on internal consistency. While there are differences between the two data reduction methods, there is no justification to disprove or suspect the VDatum separation model. Results and analysis of the comparison are in the attached report.

When successful, ERS methods generally result in a more internally consistent sounding set. However, we experienced a number of problems in reliably processing the vessel trajectory relative to the ellipsoid. Due to these difficulties rather than any suspicion of the VDatum mode, we recommend that some sheets be submitted with zoned water level correctors and others with ERS. The sheet by sheet recommendation is tabulated below.

Sheet	Recommended Method	Reason
H12423	zoned	FM related vertical offsets
H12424	zoned	FM related vertical offsets
H12501	zoned	Data gaps, may be too far from network
H12502	ERS	No solution for three lines. Many small issues, but should be solvable
H12503	ERS	Good solutions. A few small issues
H12504	ERS	Good solutions. A few small issues
H12505	To be determined	May be too far from network.

Attachment

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Introduction

This document is an interim report describing methods and results of the vertical datum analysis component in the vertical control requirements of the Hydrographic Survey Project Instructions for *OPR-D304-FH-12 Approaches to Chesapeake Bay* (March 2, 2012). The project is located in the vicinity of the Approaches to Chesapeake Bay, Virginia and encompasses hydrographic surveys H12423, H12424, H12501, H12502, H12503, H12504 and H12505. According to the Project Instructions the field unit is to provide a recommendation on the vertical transformation technique after an analysis using crossline data. This interim report and supporting data constitutes the recommendation and will be used by Hydrographic Survey Division (HSD) to support a decision on whether to use Ellipsoidally-Referenced Survey (ERS) methods in lieu of traditional tides for final water level correctors for the OPR-D304-FH-12 surveys.

The basis of this analysis is a comparison of discrete tidal zoning and Vertical Datum Transformation (VDatum) as methods for vertical control. Because discrete tidal zoning is the conventional and accepted method, it is regarded as a baseline for this evaluation.

2.0 Procedure

The VDatum evaluation was conducted according to the instructions in Appendix 1 of the project instructions. Additional guidance found in the Pydro 12.9 distribution (Pydro\Lib\site-packages\HSTP\Pydro\ PostAcqTools_CompareTSeries.docx) was followed for the direct comparison of data.

Project crossline data was reduced to Mean Lower Low Water (MLLW) via conventional discrete tidal zoning and also via VDatum. Time series data for the nadir depth was extracted from both data sets and differenced using the Pydro PostAcq toolset.

In addition, CARIS surfaces of crosslines and mainscheme were analyzed in both discrete zoning and VDatum methods to evaluate the internal consistency of data as well as look for any spatial patterns in the difference that may have suggested problems with the VDatum model.

Sheets H12501, H12502, H12503 and H12504 were chosen for evaluation because these sheets contained higher quality POSPac solutions. In addition, these sheets span project OPR-D304-FH-12, as shown in Figure 1 below.

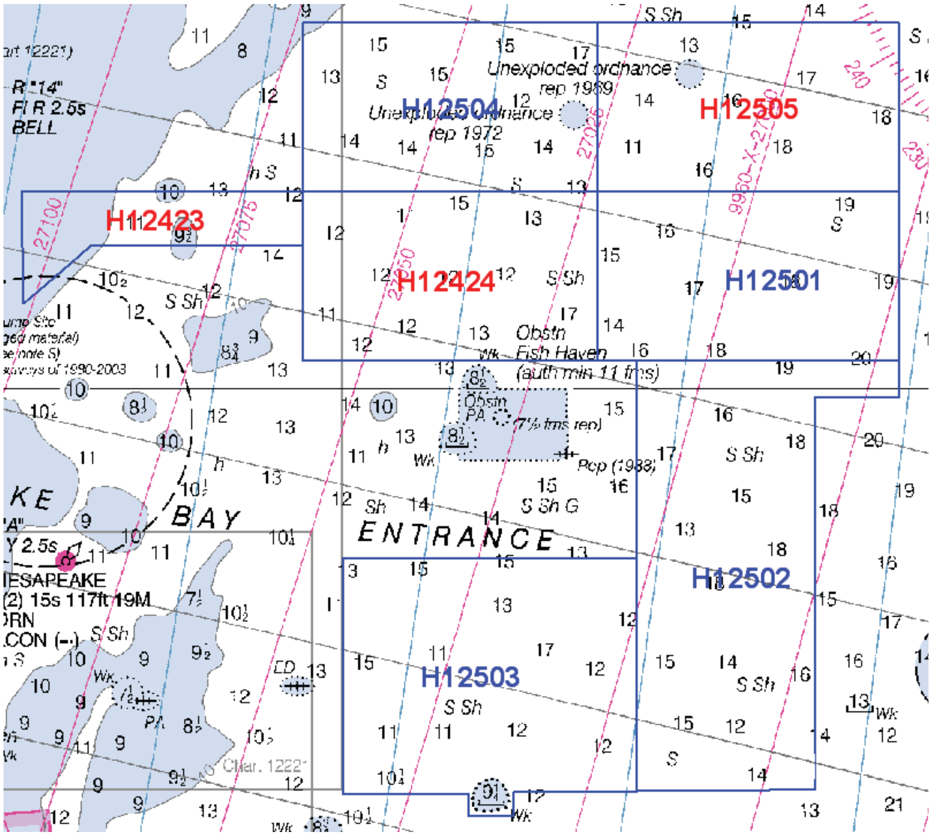


Figure 1: D304 sheets where VDatum Evaluation was performed shown in blue, sheets not evaluated shown in red.

3.0 Results and Discussion

This report addresses two questions:

1) Is the VDatum model correct in the geographic location of this project?
2) Is the internal consistency of the data improved from the use of ERS methods?

The following discussion will attempt to answer these questions.

3.1 VDatum Model Accuracies

To analyze the VDatum model, an approximately 100 meter surface was created using the ellipsoid to MLLW .xyz separation file provided by HSD Operations. The resulting surface was analyzed by looking for blunders in the model as well as an overall assessment of the change expected in the separation between MLLW and the ellipsoid. This surface is represented below in Figure 2.

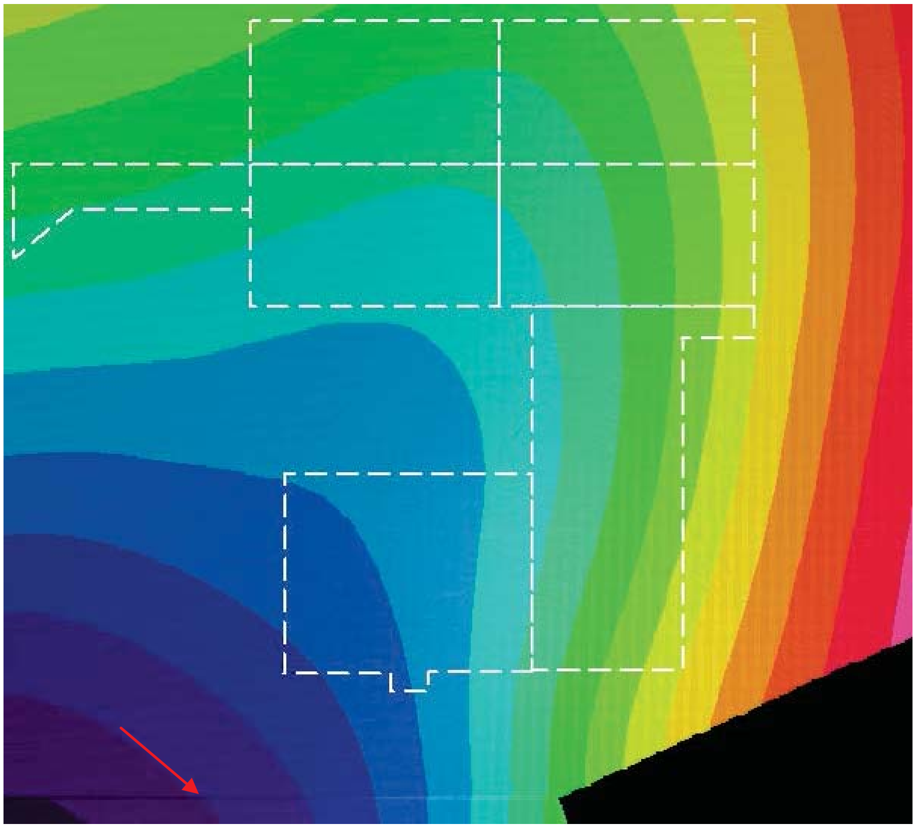


Figure 2: D304 sheets shown with gridded 2012_D304_VDatum_Ellip_MLLW_rev1.xyz VDatum Separation Model (colored bands correspond to 10 cm interval) NOTE: arrow pointing to model artifact outside of project area

As the above figure shows, the grid is absent of obvious blunders. One 0.01 meter discontinuity artifact in the VDatum model is apparent south of the project area which does not affect these results. There is a significant slope in the VDatum model across the project extents at approximately 1 meter overall. This is thought to be driven by close proximity of the continental shelf and the geoid slope that accompanies this geographic feature.

In accordance with Appendix I of the Project Instructions, Pydro was used to compare the nadir depths using both vertical models. As shown in Table 1, there are significant differences between zoned tides and VDatum, with values ranging from 0.02 to -0.23. These differences may arise from many different sources including: poor vertical GPS solutions, poor zoning model, errors in dynamic draft values and loading errors.

XL Discrete-Vdatum (Pydro)			
Sheet	**Head**	**Mean (m)**	**StDev (m)**
H12501	Port	0.02	0.05
H12502	Port	-0.07	0.07
	Starboard	0.01	0.14
H12503	Port	0.00	0.13
	Starboard	0.05	0.11
H12504	Port	-0.23	0.07
	Starboard	-0.22	0.07

Table 1: Results of D304 VDatum Evaluation (Pydro analysis)

Sheets H12501, H12502 and H12503 show average differences within the VDatum uncertainty of 0.08 meters. However, H12504 contains average differences in the twenty centimeter range, which exceeds the uncertainty model.

From these results (using Pydro as was recommended in Appendix I) it is difficult to form a recommendation for H12504. There is clearly a large difference between ERS and zoned tides for this sheet, but the nadir analysis alone is insufficient to understand why.

Comparison of the CARIS crossline difference surfaces referenced to discrete zoning or VDatum, rather than statistical analysis of just the nadir depths, was performed in order to see spatial trends in the data.

For the crossline surface comparisons, crossline surfaces contained data from both heads: the crosslines were not filtered, as is common practice amongst the fleet to eliminate erroneous outer beams. Before submission, the crosslines will be filtered, however for this evaluation SV errors on the outer beams would affect both discrete and VDatum equally and therefore cancel out. The results of the surface differences are shown in Table 2. As expected the average differences and standard deviation are similar to the Pydro nadir analysis shown in Table 1.

XL Discrete-Vdatum (CARIS)				
Sheet	Mean (m)	Mode (m)	StDev (m)	95% +/- (m)
H12501	0.02	0.00	0.05	0.08
H12502	-0.08	-0.05	0.12	0.22
H12503	0.02	0.11	0.12	0.23
H12504	-0.26	-0.31	0.08	0.15

Table 2: Additional results of D304 VDatum Evaluation (CARIS surface analysis)

In particular, H12504 shows the same large difference in the CARIS surfaces as the Pydro analysis. Figure 3 shows the Discrete – VDatum crossline surface over the separation model.

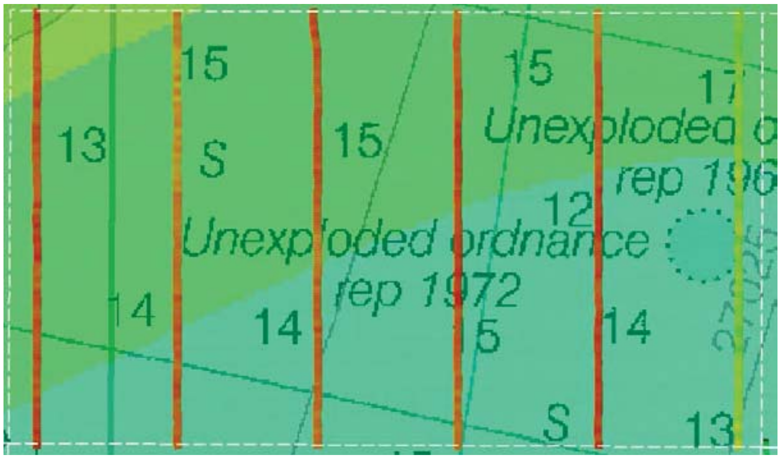


Figure 3: H12504 Discrete minus VDatum XL CUBE surface – average differences for green line on right are -0.14 m while average of red/orange lines are -0.31 m.

The tides were examined for the particular day of crosslines and are shown below in Figure 4. The dark green lines show the time period of the crosslines and the orange line marks the time period in between the first crossline (east line) and the subsequent lines. Take note of the high residual values recorded at the tide gauge. Because the gauge is 60 nautical miles from this sheet, water level residuals driven by local effects may not be well modeled in the zoned methods. The black dotted line represents when mainscheme acquisition was started.

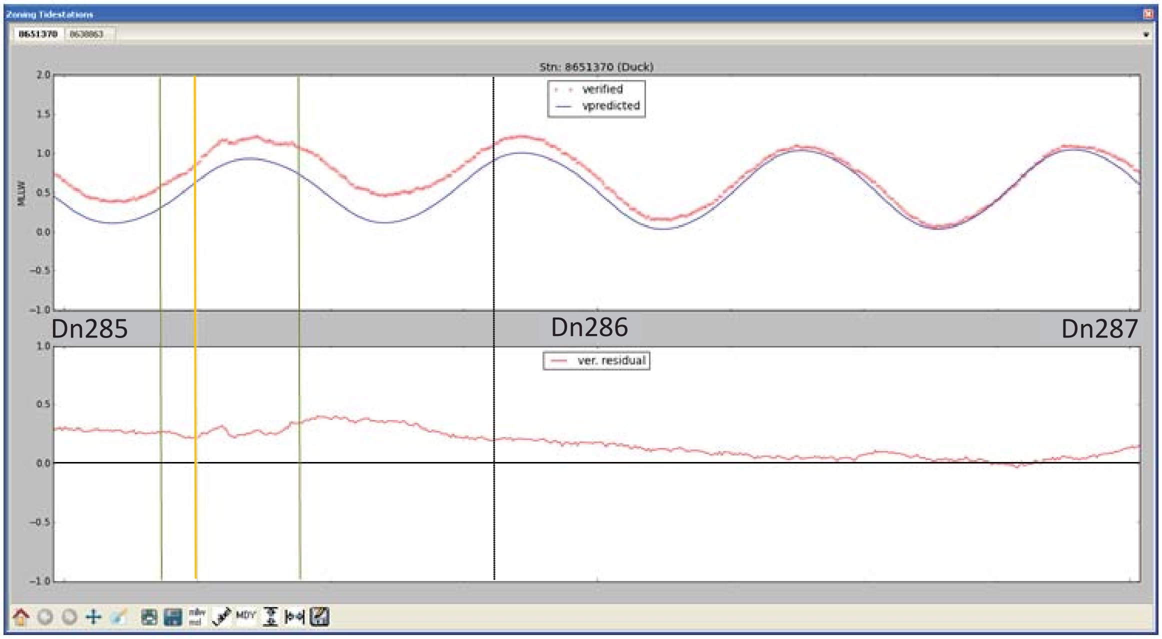


Figure 4: Verified tidal signature for Duck, NC and accompanying residual values.

Sheet H12504 was analyzed further to determine which vertical model is more likely to contain correct values. Results from this further analysis can be seen below in Table 3. A complete difference between an ERS and zoned approach was made with the mainscheme lines and again with the holiday and development lines, which were collected two months later. During the acquisition of multibeam, the water level residual at the controlling gauge varied from 0 to 0.25 meters. When waterline residuals were close to zero, ERS - zoned differences were approximately 0.15 meters. When waterline residuals were higher ERS - zoned differences were approximately 0.30 meters.

This result suggests that the large differences between ERS and zoned are the result of water level errors, not VDatum.

H12504 Analysis				
	Mean (m)	Mode (m)	StDev (m)	95% +/- (m)
Mainscheme Dn285-288 (Discrete - VDatum)	-0.24		0.07	
Development Dn345-348 (Discrete - Vdatum)	-0.14	-0.16	0.10	0.19

Table 3: Additional H12504 Statistics

After careful examination of all data it is our belief that on average H12504 discrete zoning contains a separation from VDatum of around 15 cm. This is most likely the result of a poor zoning model and is not the result of an erroneous VDatum model.

3.2 Data Internal Consistency

To analyze the internal consistency of ERS methods a crossline analysis was completed over the entire sheet for both discrete zoning and VDatum. The results of these differences are shown in Table 4.

	Discrete MS-XL Differences				VDatum MS-XL Differences			
Sheet	Mean (m)	Mode (m)	StDev (m)	95% +/- (m)	Mean (m)	Mode (m)	StDev (m)	95% +/- (m)
H12501	-0.07	-0.07	0.11	0.21	unsucessful			
H12502	-0.04	-0.10	0.14	0.26	0.05	0.05	0.10	0.19
H12503	-0.14	-0.28	0.15	0.24	0.01	0.00	0.06	0.12
H12504	0.06	0.09	0.11	0.24	0.02	0.01	0.12	0.17

Table 4: D304 Internal Consistency Comparison from CARIS Difference Surfaces

The results show that ERS generally improves the internal consistency of the data. As can be seen in the result of sheet H12503, averaged differences of -0.14 with a standard deviation of 0.15 under discrete zoning went to an average of 0.01 with standard deviation 0.06 with VDatum. For sheets H12502, and H12503 the standard deviation of the differences was significantly lowered with VDatum compared to discrete zoning. As seen in Figure 5; with VDatum, the distribution of differences is generally Gaussian, while the zoned distribution often shows multiple peaks and other anomalies.

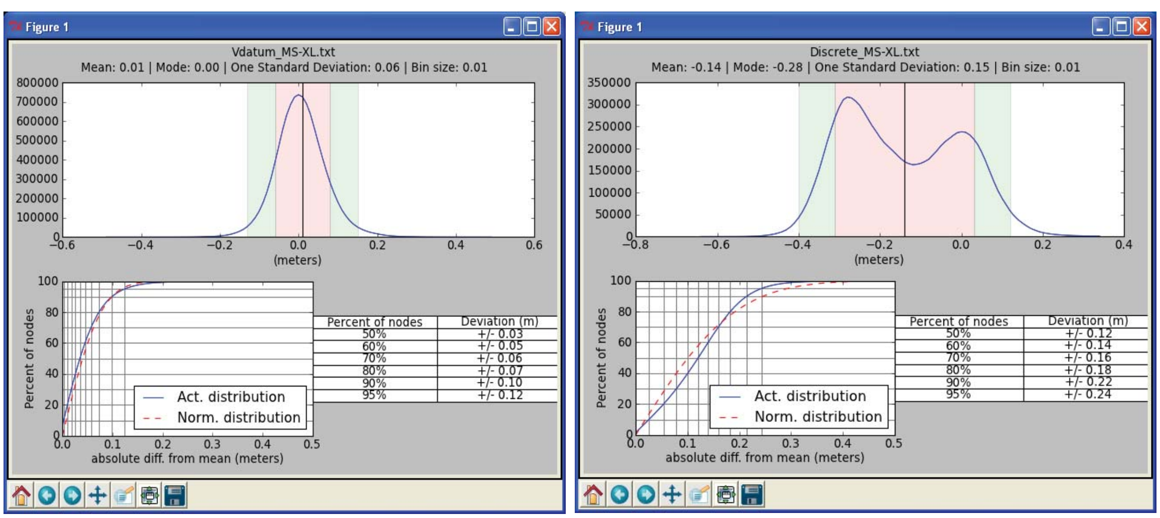


Figure 5: Surface Difference Distribution for Sheet H12503; VDatum on left and Discrete on right.

Sheet H12501 proved to be more troublesome. While the SBETs for the cross-lines were acceptable for this analysis, processing the SBETs for the main-scheme coverage was difficult, resulting in many split projects and incomplete SBETs for five lines. In addition to the troubles with processing, solutions derived in POSPac contained high RMS values as well as unexplainable vertical position jumps. This demonstrates the limits of an ERS approach; if poor or no vertical GPS solution exists, then there is an ERS holiday. To collect these holidays would take additional time at sea and therefore is not feasible in most cases.

4.0 Recommendation

ERS with VDatum is a tool to help us eliminate many vertical errors that can be attributed to traditional tide models and ship water line estimators. For D304, the difference between ERS and zoned were generally within the anticipated VDatum uncertainty. Where they were not (H12504) we have shown that this is likely the result of water level errors rather than an issue with VDatum. While this analysis does not rigorously verify the VDatum model, it gives us no reason to doubt it. Therefore, we believe the VDatum model is accurate in this area.

In addition, we have shown that ERS improves the internal consistency of the data when compared with traditional tide zoning methods, especially noticeable during times of increased wind and weather.

However, poor POSPac solutions can result in inferior data compared to the traditional methods and therefore should not be applied to all data on all sheets. It is our recommendation to use ERS on a sheet by sheet basis. We recommend an ERS approach when the majority of the sheet contains good solutions, i.e. free of data gaps and vertical jumps. Additionally H12423 and H12424 had vertical offsets related to newly implemented FM hardware that complicate application of ERS methods. This issue is discussed in detail in the Data Acquisition and Processing report submitted with this project. The sheet by sheet recommendation is tabulated below.

Sheet	Recommended Method	Reason
H12423	zoned	FM related vertical offsets
H12424	zoned	FM related vertical offsets
H12501	zoned	Data gaps, may be too far from network
H12502	ERS	No solution for three lines. Many small issues, but should be solvable
H12503	ERS	Good solutions. A few small issues
H12504	ERS	Good solutions. A few small issues
H12505	To be determined	May be too far from network.

In all cases the vertical data reduction method will be discussed in the individual sheet descriptive report and the D304 Horizontal and Vertical Control Report to avoid confusion in the quality control process that follows.

Appendix III: Feature Report

AWOIS: 0

DtoNs: 0

Maritime Boundary: 0

Wrecks: 0

APPROVAL PAGE

H12502

Data meet or exceed current specifications as certified by the OCS survey acceptance review process. Descriptive Report and survey data except where noted are adequate to supersede prior surveys and nautical charts in the common area.

The following products will be sent to NGDC for archive

- H12502_DR.pdf
- Collection of depth varied resolution BAGS
- Processed survey data and records
- H12502_GeoImage.pdf

The survey evaluation and verification has been conducted according to current OCS Specifications, and the survey has been approved for dissemination and usage of updating NOAA's suite of nautical charts.

Approved: ___________ ____________________________

LT Abigail Higgins, NOAA
Chief, Atlantic Hydrographic Branch