U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project No.	**M-I907-NF-15**
Registry No.	**H12756, H12757**

LOCALITY

State	**USVI**
General Locality	**Caribbean Sea**

2015

CHIEF OF PARTY

Timothy Battista, Mike Stecher

LIBRARY & ARCHIVES

DATE **April 2015**

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

H12756
H12757

HYDROGRAPHIC STYLE SHEET

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

FIELD No
NOAA Ship Nancy Foster

State	USVI
General Locality	Caribbean Sea
Sub-Locality	12 NM North of St. Thomas, Southern Approaches to St. Croix
Scale	1:40,000
Date of Survey	March 28, 2015 to April 7, 2015
Instructions dated	March 04, 2015 Project No. M-I907-NF-15
Vessel	NOAA Ship Nancy Foster
Chief of party	Timothy Battista
Surveyed by	NOAA Center for Coastal Monitoring and Assessment
Soundings by	Reson 7125-SV2, Kongsberg EM710
Graphic record scaled by	N/A
Graphic record checked by	N/A
Automated Plot	N/A
Verification by	N/A
Soundings in	Meters at MLLW
Remarks	All times are UTC

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ACRONYMS AND ABBREVIATIONS

BAG	Bathymetric Attributed Grid
BASE	Bathymetry Associated with Statistical Error
CCMA	Center for Coastal Monitoring and Assessment
CO-OPS	Center for Operational Oceanographic Products and Services
CTD	Conductivity Temperature Depth
CUBE	Combined Uncertainty and Bathymetry Estimator
DGPS	Differential Global Positioning System
FPM	Field Procedures Manual (April 2014)
GAMS	GPS Azimuth Measurement Subsystem
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HSSD	Hydrographic Survey Specifications and Deliverables Manual (April 2012)
HSTP	Hydrographic Systems Technology Programs
HSX	Hypack Hysweep File Format
HTD	Hydrographic Surveys Technical Directives
HVF	HIPS Vessel File
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
MLLW	Mean Lower Low Water
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OMAO	Office of Marine and Aviation Operations (NOAA)
POS/MV	Position and Orientation System for Marine Vessels
PPS	Pulse per second
ROV	Remotely Operated Vehicle
R/V	Research Vessel
SAT	Sea Acceptance Test
SBE	Smooth Best Estimate
SBET	Smooth Best Estimate and Trajectory
SVP	Sound Velocity Profiler
TPE	Total Propagated Error
TPU	Total Propagated Uncertainty
TSG	Thermosalinograph
USCRTF	U.S. Coral Reef Task Force
ZDA	Global Positioning System timing message
ZDF	Tide Zone Definition File

Data Acquisition and Processing Report
M-I907-NF-15 Caribbean Sea, USVI
March 2015
NOAA Ship Nancy Foster
Center for Coastal Monitoring & Assessment, Biogeography Branch
Lead Scientist, Timothy Battista

INTRODUCTION

In June 1998, the U.S. Coral Reef Task Force (USCRTF) was established by Presidential Executive Order 13089. The USCRTF mission is to lead, coordinate, and strengthen U.S. government actions to better preserve and protect coral reef ecosystems. The National Oceanic and Atmospheric Administration's (NOAA) Center for Coastal Monitoring and Assessment (CCMA) Biogeography Team is supporting the USCRTF mandate. The Biogeography Team completed its twelfth year of an ongoing scientific research mission on board the NOAA Ship *Nancy Foster* from March 28th to April 7th, 2015.

This report applies to surveys H12756 and H12757 located in the Caribbean Sea near St. Croix and St. Thomas. These surveys were performed under M-I907-NF-15 as specified in the Hydrographic Survey Project Instructions signed on March 4th, 2015. The objective of this project was to collect a bathymetric dataset in waters greater than 10 meters with complete multibeam coverage, along with backscatter suitable for seafloor characterization in high-priority conservation areas. The delineation and identification of seafloor habitats within areas mapped during the mission was assisted by the use of an ROV with video and camera capabilities.

All references to equipment, software, and data acquisition and processing methods were valid at the time this document was prepared. Any deviations from these methods will be specifically addressed in the Descriptive Reports (DR) of the project surveys.

A. EQUIPMENT

Detailed descriptions of the equipment and systems, including hardware and software, used for bathymetric data acquisition and processing are listed in the table below.

Table 1. NOAA Ship Nancy Foster Hardware

Hydrographic Systems Hardware Inventory M-I907-NF-15				
Equipment type	Manufacturer	Model	Serial #	Firmware
MBE Kongsberg	Kongsberg	EM710	240	N/A
Kongsberg TX Unit	Kongsberg	EM710	233/234	N/A
Kongsberg RX Unit	Kongsberg	EM710	173	N/A
MBE Reson	Reson	7125-SV2	18341313044	MR 7.1.1
Reson TX Unit	Reson	7125-SV2	2710007	N/A
Reson RX Unit	Reson	7125-SV2	2011032	N/A
Inertial GPS PCS	Applanix	POS/MV 320 V4	2249	5.03
IMU	Applanix	LN 200	447	N/A
DGPS	Trimble	DSM 132	224096283	3.0
SVP	Oceanscience	UCTD	PA-0188	N/A

SVP	SBE	19*Plus*	0355	N/A
SVP	Reson	SVP 71	0614160	N/A

A1. SURVEY VESSEL

The NOAA Ship *Nancy Foster* (R352) is fifty-seven meters in length, has a beam of twelve meters, and draws approximately three meters of water. During the past 12 years numerous hydrographic surveying hardware and software installations have been implemented by NOAA's Office of Marine and Aviation Operations (OMAO) to make multibeam data acquisition a more integral component of the ship's research support.

Figure 1. NOAA Ship *Nancy Foster*

A2. MULTIBEAM SYSTEMS

The *Nancy Foster* is equipped with a Reson SeaBat 7125-SV2 dual frequency multibeam echosounder (MBE) capable of operating at 200 or 400 kHz and is integrated with a Reson SVP 71 sound velocity sensor. The 7125-SV2 MBE is mounted on the hull, and is located port of the keel, and forward of the reference point of the vessel. The 7125-SV2 was operated at 400 kHz for the duration of the M-I907-NF-15 cruise. The 7125-SV2 produced a 128-degree swath of 512 equiangular beams with an along-track beam width of 1.0 degrees and across-track beam width of 0.5 degrees. Previous to this cruise the Reson MBE system had been malfunctioning and was sent back to the manufacturer for testing and repair. The malfunctioning parts were replaced with a new receiver, topside processor and SVP-71 prior to this cruise.

For these surveys all 7125-SV2 data were acquired with the custom bracket selected in the hardware configuration with offsets values entered from the vessel survey. Range adjustments were made during acquisition as dictated by changes in water depth. Other sonar parameters were kept a constant to maximize backscatter quality. Hypack HYSWEEP was used to acquire all Reson MBE data in the HSX file format and backscatter in the 7K file format.

The *Nancy Foster* is also equipped with a deep water Kongsberg EM710 MBE system. The EM710 MBE is permanently hull-mounted between two fiberglass hydrodynamic fittings starboard of the keel line. The EM710 replaces the obsolete EM1002, and was installed during a drydock period in February of 2015. A Sea Acceptance Test (SAT) was performed and passed on the EM710 by Kongsberg and NOAA representatives on March 13, 2015. The EM710 is a 40-100 kHz system with a 140° swath consisting of 200 individually formed, electronically roll-stabilized 2° beams, with a maximum ping rate of 10Hz, depending on water depth. A combination of phase and amplitude detection was used, resulting in measurement accuracy practically independent of beam angle. The system is compensated in real-time for sound velocity changes at the transducer array, to assist the electronic beam steering capabilities with an additional hull mounted SVP-71.

All EM710 MBE data were acquired with Kongsberg's Seafloor Information System (SIS) software and logged in the .all format. Range adjustments and other sonar settings were made automatically by SIS during acquisition as dictated by changes in water depth.

A3. POSITION, HEADING and MOTION REFERENCE SYSTEMS

The *Nancy Foster* is outfitted with an Applanix Position and Orientation System for Marine Vessels (POS/MV) 320 Version 4, Global Positioning System (GPS) inertial system. The POS/MV was used to measure attitude, heading, heave, and position for the MBE system. The POS/MV is comprised of an Inertial Motion Unit (IMU), two dual frequency (L1/L2) Global GPS antennas, and a topside control unit.

A Trimble DSM132 differential beacon receiver acquired corrections from a U.S. Coast Guard transmission station located at Isabel, Puerto Rico (295 kHz). The DSM132 provided DGPS corrections to the POS M/V to increase accuracy and precision.

Position, timing, heading and motion data were output to the Hypack and SIS acquisition systems using the POS/MV real-time ethernet option at 25 Hz. Additionally, using the ethernet logging controls, the POS/MV was configured to log TrueHeave™ and all of the raw observable groups needed to post process real-time navigation data if required. The POS/MV logged 13 megabyte files, which resulted in multiple files created per day. Position and orientation data from the POS/MV were displayed in real-time using Hypack and POSView software and continuously monitored during survey operations.

The POS/MV also provided time synchronization of MBE systems and data acquisition computers using a combination of serial and ethernet outputs. The Reson, SIS and Hypack acquisition computers were provided a Pulse Per Second (PPS) and National Marine Electronics Association (NMEA) ZDA date and time message to achieve synchronization with the POS/MV.

A position check between the POS/MV and DSM132 positioning system was performed while the vessel was secured and relatively motionless while tied up at the Crown Bay pier in St. Thomas on March 27th, 2015. Logged position data from the POS/MV and DSM132 were compared to the vessel survey with satisfactory results.

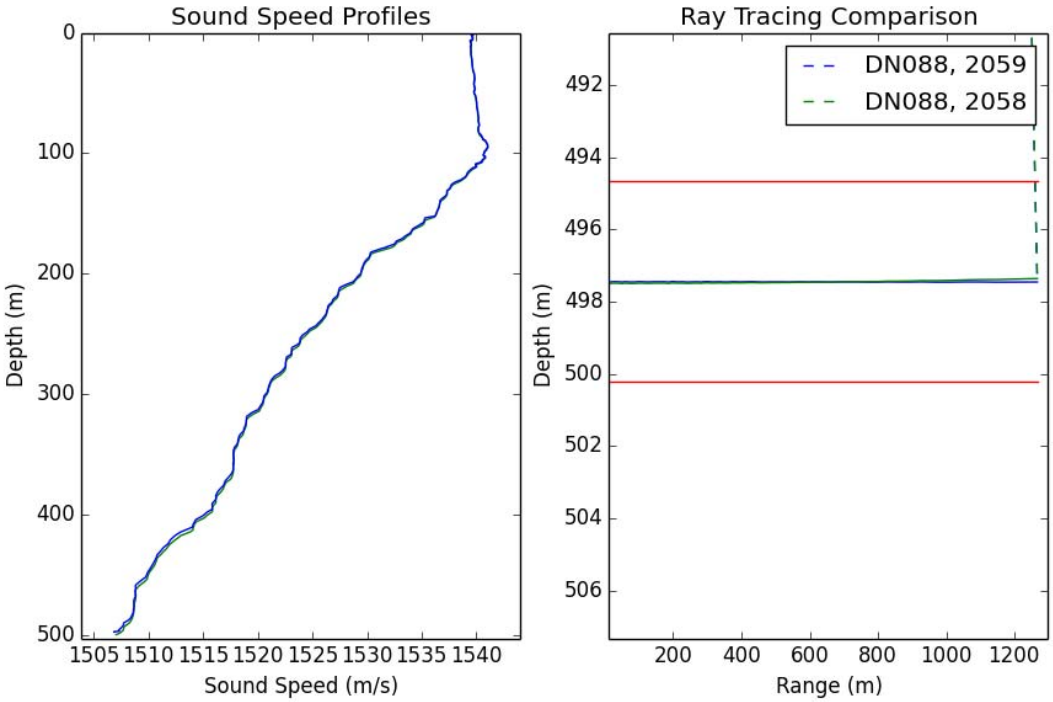
A4. SOUND SPEED MEASURMENT SYSTEMS

A4.a UCTD

An OceanScience UnderWay CTD (UCTD) was the primary sound speed measurement instrument for this cruise. The UCTD provided CTD profiles while the vessel was underway off the aft deck with a tethered freefall CTD probe which is then retrieved with a powered level winding winch. After the UCTD was downloaded, the data was processed with UCast version 1.2 and converted and concatenated with Velocipy version 14.6.

Independent cast comparisons are a required survey deliverable, thus a cast comparison was performed via ray tracing uncertainty analysis between the UCTD and the SBE 19*Plus* on March 29th, 2015. The sound speed profiles derived from each CTD measurement are nearly identical. In this case, maximum outer beam refraction was estimated at a negligible 10cm at 500m of water depth. Current specification would allow for 2.8m in these depths (red bounds), less than 4% of the allowable refraction error was consumed in this comparison.

Figure 2. UCTD vs SBE 19Plus Comparison Analysis



A4.b SBE 19*Plus*

A SBE 19*Plus* Conductivity Temperature Depth (CTD) instrument for determining sound velocity throughout the water column was used to QA/QC the UCTD and was available for backup if the primary UCTD failed. The vessel's hydraulic winch was rigged through the block of the port J-Frame davit, which provided a consistent rate of descent for acquisition of the SBE 19*Plus* data.

A4.c Reson SVP-71

A Reson SVP-71 sensor is mounted at each MBE transducer, real time values are input into both the 7125 SV-2 and EM710 topsides through serial communications. Sound speed values from the sensors were used in real-time during acquisition for beam steering and were also used to QC the sound speed values derived at the surface from the UCTD.

A5. ACQUISITION AND PROCESSING SYSTEMS

All acquisition and processing workstations are located in the Dry Lab of the *Nancy Foster* and are networked as a workgroup, and are interfaced with the ship's backup system. Coastal Oceanographics Hypack/Hysweep 2015 was used for 7125-SV2 bathymetric data acquisition and vessel navigation. The system provided precise time tagging of the sensor data and real-time data displays for quality control. Data was acquired in three formats: .RAW, .HSX and .7K. Kongsberg Seafloor Information System (SIS) software was used to acquire the EM710 bathymetric data in the .all format. A combination of the Geocoder implementation included with Hypack and Fledermaus were used to process the backscatter acquired by the 7125-SV2 and EM710.

Bathymetric survey data was converted and processed in Caris HIPS with modifications to the default Combined Uncertainty Bathymetric Estimator (CUBE) Parameters XML file. The default CUBE Parameters XML was replaced with the XML file issued to all NOAA hydrographic field units included with the Field Procedures Manual (FPM, 5/14). This updated XML file uses the resolution dependent maximum propagation distance values required in the Hydrographic Survey Specifications and Deliverables Manual (HSSD, 4/14). Processing methodology followed the standard Caris HIPS CUBE workflow. These steps include data conversion, filtering, sound velocity correction, tide correction, Total Propagated Uncertainty (TPU) calculation, TrueHeave application, merging, and editing.

Table 2. Acquisition and Processing Software

Hydrographic Systems Inventory	**Cruise# M-I907-NF-15**		**SOFTWARE**
Equipment type	**Manufacturer**	**Model**	**Software Version**
Inertial GPS PCS	Applanix	MV POSView	5.1.0.2
Navigation	Coastal Oceanographics	Survey	2015
Acquisition	Kongsberg	SIS	4.1.8
Acquisition	Coastal Oceanographics	Hysweep	2015
Processing	NOAA	Velocipy	14.6
Processing	CARIS	HIPS & SIPS	7.1.2 SP2, 9.0.19
Processing	Fledermaus	FMGT	7.4.4
7k Control Center 7125	Reson	7125 SV2	FP 4
7k Control Center 7125	Reson	7K UI	6.1.0.3
7k Control Center 7125	Reson	7K Center	6.1.0.3
7k Control Center 7125	Reson	7K IO	4.2.0.5

A6. SURVEY METHODOLOGY

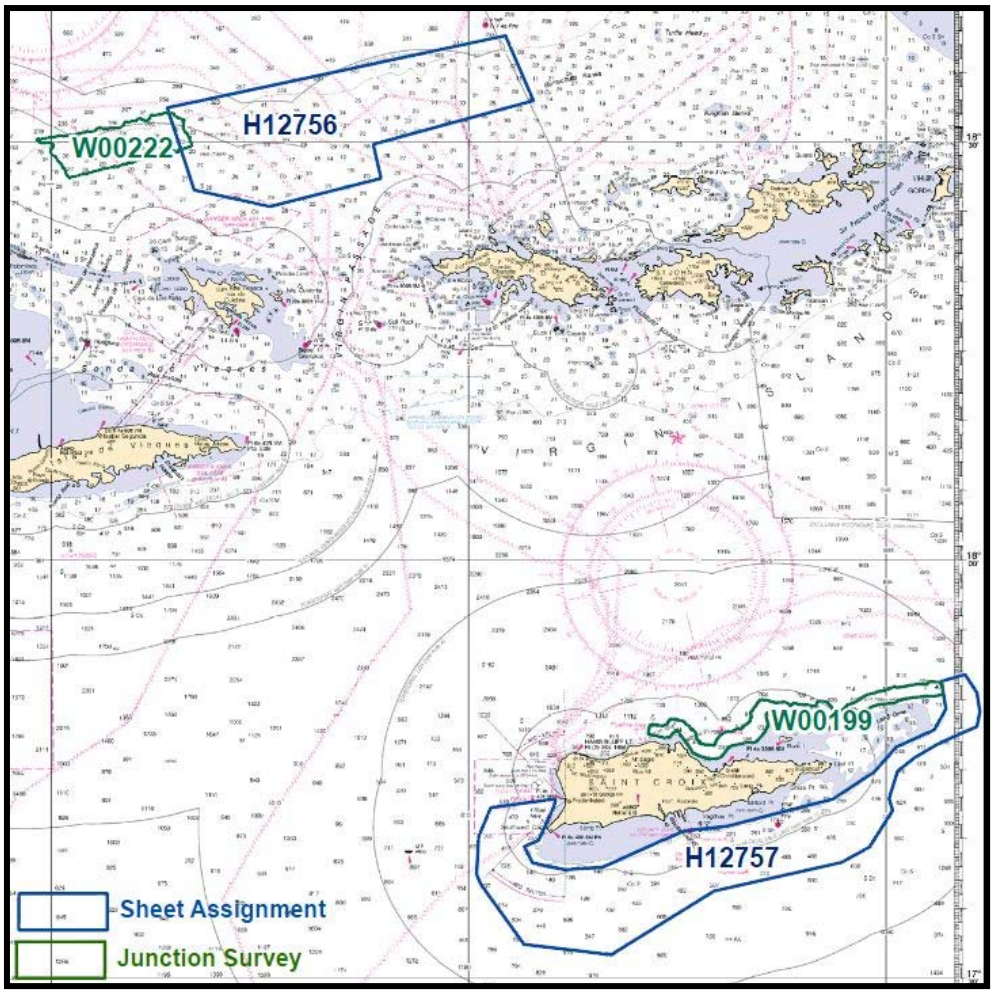
A6.a Mobilization

Mobilization of the *Nancy Foster* occurred in St Thomas, at the Crown Bay Pier on March 28th, 2015. Vessel offsets and TPU values used in the HIPS Vessel Files (HVF) were confirmed from the various vessel surveys performed on 2/06, 2/11 and 3/15. These vessel offsets and uncertainties are used in the HVF's for the 7125-SV2 and EM710.

A6.b Survey Coverage

Survey coverage was based on the survey limits depicted by the M-I907-NF-15 USVI Mapping Project Instructions from the Atlantic Hydrographic Branch signed March 4, 2015. Sheets H12756 (Sheet 1) and H12757 (Sheet 2) were surveyed with line orientation appropriate for each of the survey boundaries, approximately parallel to contour or the adjusted orientations for encountered sea states. The survey project boundaries for H12757 were completed. Sheet H12756 was not completely surveyed due to time constraints.

Figure 3. M-I907-NF-15 Sheet Layout



A6.c Multibeam Sonar Operations

Complete multibeam coverage was a requirement for this survey and MBE survey operations utilized the techniques defined by the HSSD. The 7125-SV2 was tuned to simultaneously maximize bathymetric and backscatter data quality by not over-saturating sonar returns by using Pydo's SATMON utility. The MBE was operated at different range scales throughout the survey by adjusting the depth range to obtain the best coverage in varying depths of water. Other parameters were left at a constant to maintain backscatter consistency.

Table 3. Typical Reson 7125-SV2 Sonar Settings

7125-SV2 Parameter	Value
Range	Variable, depth dependent
Gain	20 dB
Power	220 dB
Spreading	30 dB
Absorption	110 dB/km
Ping Rate	9-30 p/s
Pulse Width	33 µs

The EM710 is configured by Kongsberg to be a MBE system that is basically automatically tuned by the SIS acquisition system depending on water depths. The few operator selectable options included sector coverage (generally 55/55 except along steep slopes) swath mode (dynamic) and ping mode (auto).

A7. QUALITY ASSURANCE

Acquisition and processing methods followed systematic and standardized workflows as defined by the FPM. These procedures include, but are not limited to record and log keeping standards, software version management, and a multi-level review process. Due to Caris software inconsistencies onboard the *Nancy Foster*, two versions of Caris were used for conversion and processing of the bathymetric data during field operations. Final MBE bathymetric data were processed in Caris HIPS version 7.1.2SP2 for H12756, and version 9.0.19 for H12757.

B. QUALITY CONTROL

B1. Data Acquisition

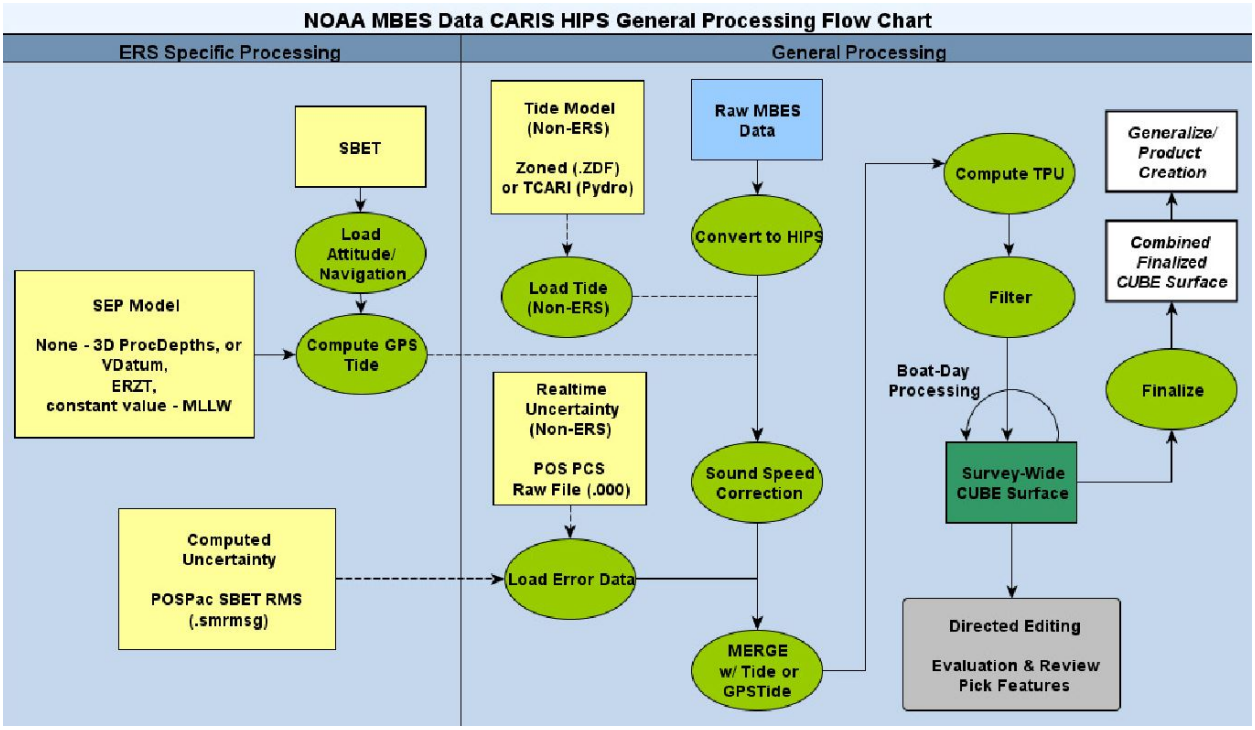
B1.a Multibeam

The only incremental adjustments made during acquisition with the 7125-SV2 system was the sonar range to ensure quality bathymetric and backscatter data. The EM710 system was closely monitored for optimized resolution while continuing to operate in autonomous mode. Vessel speeds were adjusted in accordance with the HSSD to ensure required along-track sounding density occurred with both sonar systems. Typical windows for monitoring raw sensor information included timing synchronization, surface-sound velocity, vessel motion, GPS quality, intensity, and satellite coverage.

B2. DATA PROCESSING

Data processing methodology followed the standard Caris HIPS CUBE workflow. A general flow diagram of the data processing pipeline is presented in Figure 5. This diagram graphically illustrates the general processing workflow from acquisition to delivery.

Figure 4. Flowchart of Data Acquisition and Processing Pipeline



B2.a Methodology Used to Maintain Data Integrity

The acquisition systems and survey protocols were designed with some redundancy to demonstrate that the required accuracy and precision was being achieved during the survey. Data integrity confirmation was performed through system comparisons and checks. A position confidence check was performed between the POSMV and DGPS system to confirm horizontal control. An SVP comparison check was performed by simultaneous deployment of the UCTD and SBE 19*Plus*. Sound speed profiles were computed for each of the sensors and compared to the hull mounted SVP-71 sensors. Frequent horizontal and vertical comparisons of mapped seafloor features with Caris between the 7125-SV2 and EM710 also promoted confidence between the two MBE systems and HVF configurations.

B2.b HIPS Conversion

MBE data were converted from HSX and ALL formats to Caris HDCS format using the Caris Conversion Wizard. Bathymetric data was organized in the typical Project Name, Vessel and Day of Year (DOY) format. During conversion ground coordinates (UTM NAD 83 20N) were selected with no data rejected or filtered during the conversion process. The Caris output window was monitored for failures during data conversion and none were observed.

B2.c Vessel Files

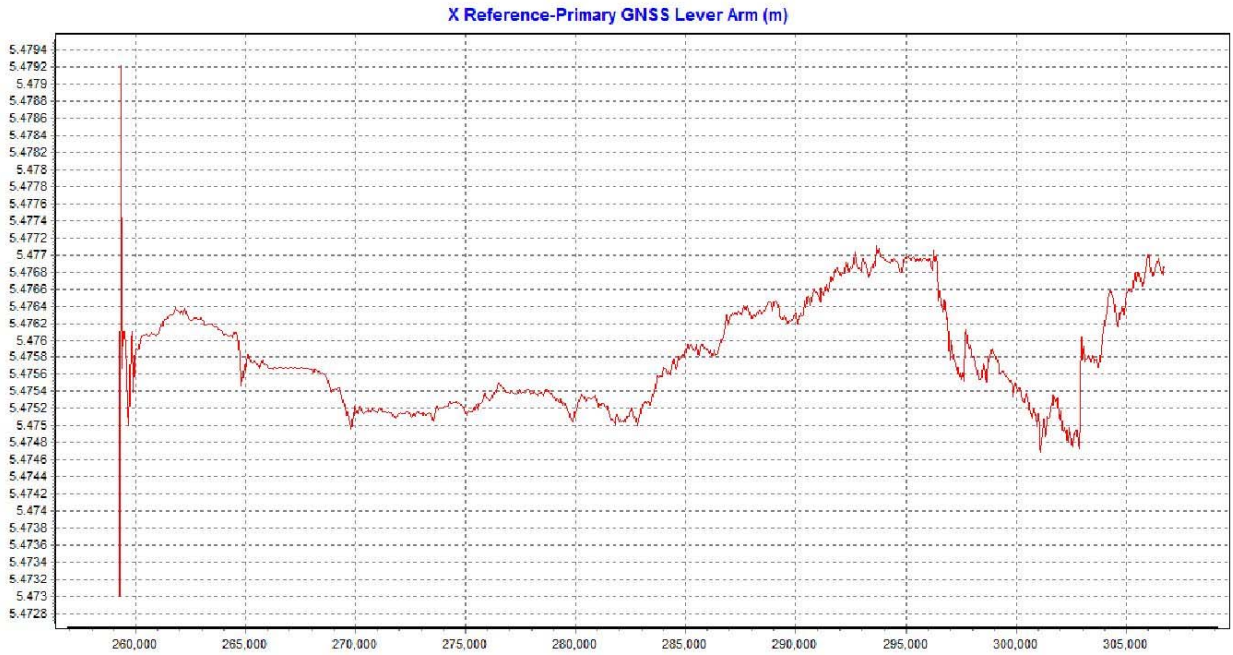
The reference point, as defined by the settings in the POSMV, is the EM710 transmit array, thus the motion and position data is output at the EM710. All offsets and patch values for the EM710 are compensated for in real-time with the POSMV, therefore the HVF EM710 offsets and patch values are zero. All offset and patch values for the 7125-SV2 HVF are in relation to the EM710 reference point. The HVF's in Table 4 contains all offsets and system biases for the 7125-SV2, as well as error estimates for TPU and waterline measurements for both the 7125-SV2 and EM710.

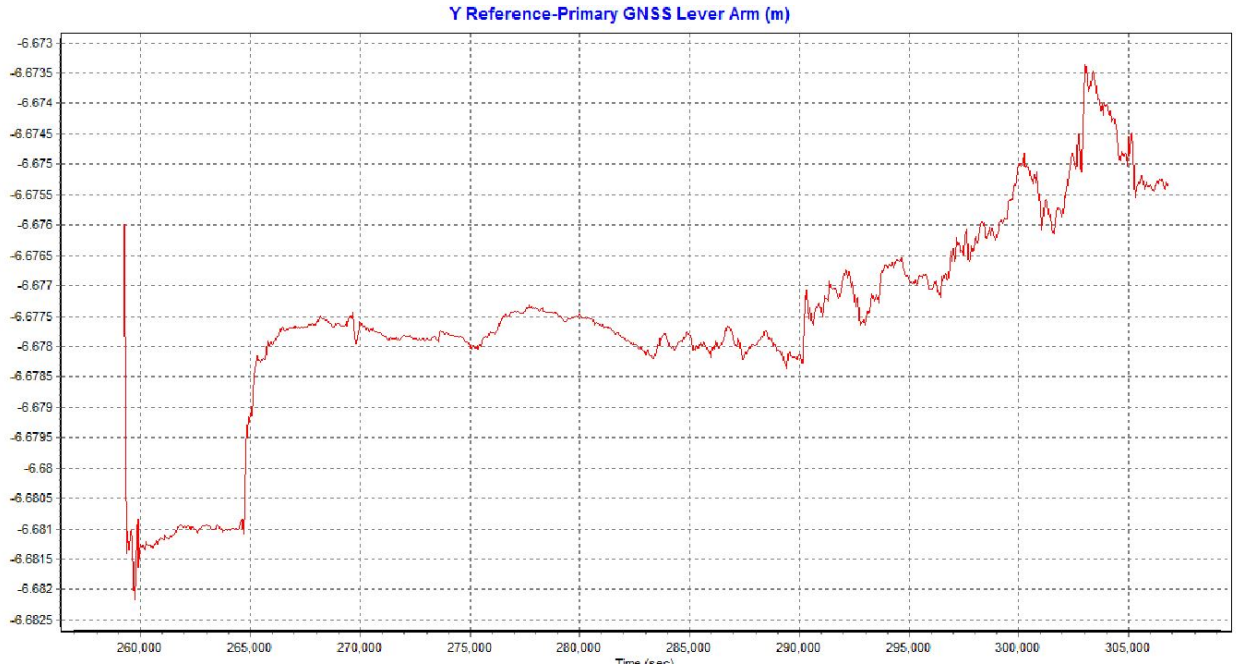
Table 4. HIPS Vessel Files

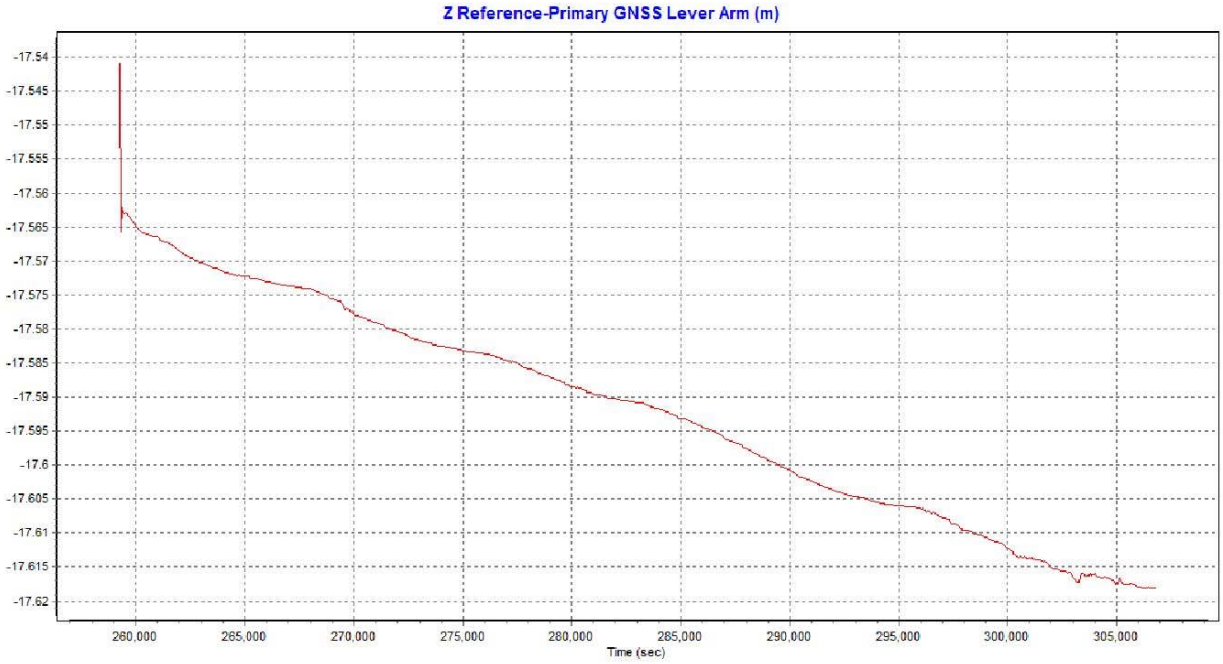
HIPS Vessel File	HIPS Converter	Sonar Type
NF7125-SV2_400khz_512_2015	Hypack	MBE
NF_EM710	Simrad	MBE

Sensor offset values were derived from various vessel offset surveys conducted by the IMTEC Group, Ltd.. The IMTEC primary GNSS lever arm to Reference Point offsets were compared to the Smoothed Best Estimate of Trajectory (SBET) data processed as part of the ellipsoid referenced waterline procedure discussed in section B2.d. The calibrated x,y,z values agree with the offsets currently entered into the POS/MV within reason for DGPS positioning accuracies. The reference point, as defined by the settings in the POS/MV, is the EM710 transmit array, thus the motion data entering the Reson 7125-SV2 are shifted by lever arm offsets from EM710 to Reson 7125-SV2. These x,y,z values (per the IMTEC Group report) were entered into the Reson 7125-SV2 HVFs.

Figure 6. SBET Installation Calibration XYZ Values







The TPU values were entered into the HVF were based on current knowledge of the TPU/CUBE processing model. The manufacturers' published values were entered into the static sensor accuracy fields. Other values were either obtained from HTD 2007-10, calculated or estimated. TPU values for the *Nancy Foster* are listed in Table 5.

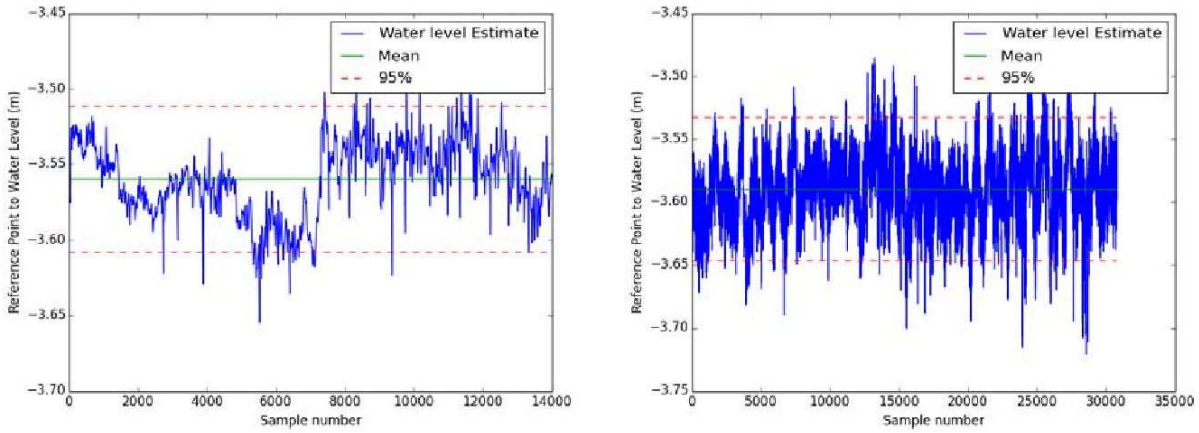
Table 5. Hydrographic Vessel File TPU Values

Manufacturer Accuracy Values for Total Propagation Uncertainty Computation	
M-I907-NF-15 HVFs	
Motion Sensor	POS/MV
Position System 1	POS/MV Model 320 V 4
Position System 2	DSM132
Gyro - Heading	
Gyro (°)	0.020
Heave	
Heave % Amplitude	5
Heave (m)	0.050
Roll and Pitch	
Roll (°)	0.020
Pitch (°)	0.020
Navigation	
Position Navigation (m)	1.00
Latency	
Timing Trans (s)	0.010
Nav Timing (s)	0.010
Gyro Timing (s)	0.010
Heave Timing (s)	0.010
Pitch Timing (s)	0.010
Roll Timing (s)	0.010
Measurement	
Offset X (m)	0.002
Offset Y (m)	0.002
Offset Z (m)	0.002
Speed	
Vessel Speed (m/s)	0.015
Draft and Loading	
Loading	0.15
Draft (m)	0.15
Delta Draft (m)	0.030
Physical Alignment Errors	
Alignment	
MRU align Stdev gyro	0.0
MRU align roll/pitch	0.0
* *All values given as 1 sigma.	

B2.d Static Draft

Three independent measurements of the waterline were performed, two of them utilizing the ellipsoid referenced waterline technique (developed by Glen Rice in 2011) and one of them simply measuring the draft marks while in port and referencing the observation to the vessel offset survey. Records of POSMV data were logged, 3.9 hours on 3/18 while inport at Charleston, and 9.7 hours on 3/28, while inport at Crown Bay. The POSMV records were post processed in Applanix POSPac to obtain a SBET file which contains the vessel's NAD 83 ellipsoid heights. The correlating water levels from a nearby tide gauge were also obtained with water levels referenced to the NAD 83 ellipsoid. Then the time series are differenced to obtain a third time series of vertical offset from waterline to ship reference point, this procedure was provided by Mr. Rice in a python utility. The results of two ellipsoid referenced waterline measurements, performed in Charleston (left), and Crown Bay (right) are shown below.

Figure 6. ERS Waterline Measurement Results



The results are ‑ 3.56 +/ ‑ 0.05m (Charleston), ‑ 3.59 +/ ‑ 0.06m (Crown Bay), and ‑ 3.50 (draft mark observation referenced to EM710). For reference, the projector draft mark read on 3/18 in Charleston was 12.5 feet, and on 3/28 in Crown Bay was 12.4 feet. The waterline value utilized during mapping operations and currently entered into SIS, the EM710 HVF, and the 7125-SV2 HVF's is -3.56 m. This value is applied in real-time to the EM710 data via SIS, so therefore the waterline value in the EM710 HVF is set to not apply, and is only necessary for ray tracing if there is a need to reapply sound speed. The waterline value in the 7125-SV2 HVF is set to apply.

B2.e Sound Velocity

All sound speed profiles were concatenated and organized into one complete file for each sheet. Sound velocity casts were applied to each line using the nearest in distance within time (five hour) option in the Caris SVP correction routine. Velocity casts were taken at approximately four-hour frequency intervals with the UCTD throughout the survey sheets. The online surveyors made periodic comparisons and verifications of sound velocity measurements that were made during survey operations between the SVP-71 and UCTD.

B3. CARIS DATA PROCESSING

Below is a list of the general workflow for processing the MBE data. Several of the steps are interim processes, such as the water levels, SVP, merge and were re-applied as needed. The TPU was also re-computed as needed to reflect changes in the correctors.

1. Apply true heave
2. Load zoned tide
3. Apply daily concatenated sound speed profiles
   - "Nearest in distance within time 5 hour"
4. Merge
5. Compute TPU
6. Filters applied based on the following criteria:
   - Reject soundings with poor quality flags (0,1,2)
   - Reject by swath width 60/60
7. Add data to field sheet:
   - CUBE surface of appropriate resolution for water depth per HSSD
     - Density & Local Disambiguation method
     - Advanced configuration using the 2010 NOAA XML File
8. Review CUBE layers and edit accordingly
9. Data reviewed and fliers removed in Swath Editor and/or Subset Editor
10. Finalize surfaces with uncertainty from "Greater of the two"
    - Apply depth thresholds per HSSD requirements
11. Create TVU QC child layer and review for IHO compliance.

The CUBE surfaces were created using grid-resolution depth thresholds and resolution dependent maximum propagation distances for complete coverage surveys as specified in the HSSD. Multibeam data processing followed the standard HIPS workflow for CUBE editing except that the hypothesis surface was not edited; instead, fliers influencing the CUBE surface were rejected. Subset tiles were used to track the progress of processing activities. Surfaces were reviewed for excessive motion artifacts or systematic biases. All crosslines were manually reviewed for internal consistency between the datasets and comparison statistics were also computed using the HIPS QC Report tool.

Data were reviewed in HIPS 2D subset with the CUBE reference surface visible. Soundings rejected by quality filters were displayed during editing, and any feature removed by a filter was manually re-accepted. Fliers making the CUBE surface shoaler than expected by more than the allowable IHO vertical error were rejected.

The CUBE surfaces were reviewed to confirm where, and if, holidays greater than three nodes sharing adjacent sides in the surface, or data gaps over significant contacts may exist. The HIPS density layer of each grid was reviewed to confirm that the minimum sounding density of five soundings per node was achieved for 95 percent of nodes populated by mainscheme survey lines.

After finalizing the CUBE surfaces, TVU QC child layers were created and reviewed for final International Hydrographic Organization (IHO) compliance.

B4. Final Bathymetric Processing

The finalized CUBE surfaces were generated using the "greater of the two" option for the final uncertainty value. Surfaces were reviewed in the 3D graphics window with an extreme vertical exaggeration to verify that all fliers have been removed from the surfaces. Thorough analysis determined that the 1m resolution CUBE surface is an accurate representation of the seafloor in the shallow regions for each survey sheet. The 1m surface honors the shoalest reliable soundings within 1/2 of the allowable TVU, therefore no designated sounding were used on either sheet.

The Raster Product Export function was then used on each finalized CUBE Depth surface and exported as individual Bathymetry Attributed Grid (BAG) files.

C. CORRECTIONS TO ECHO SOUNDINGS

C1. Static Draft

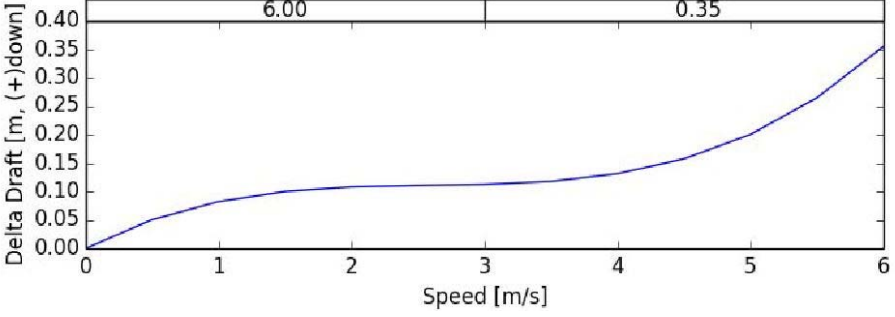
Please see section B2.d

C2. Dynamic Draft

An ellipsoid referenced dynamic draft procedure was conducted just south of St. Thomas, during calm seas on April 4th, 2015. This procedure requires POS/MV POSpac data while the ship is at rest and then at transitions of 2 knot increments up to top speed, moving for 2 minutes at each speed in a straight transect. Then the ship slows to rest, and repeats the procedure while moving back along the same transect. An SBET file was then created from the processed POS/MV data. The dynamic draft procedure, accessible via Pydro, incorporates the processed SBET and outputs adjustments of the vessel height as a function of speed. The results were entered into the dynamic draft entry for all HVF's onboard the ship and are shown in Figure 7.

Figure 7. ERS Dynamic Draft Results

Speed [m/s]	Delta Draft [m]
0.00	0.00
0.50	0.05
1.00	0.08
1.50	0.10
2.00	0.11
2.50	0.11
3.00	0.11
3.50	0.12
4.00	0.13
4.50	0.16
5.00	0.20
5.50	0.26
6.00	0.35



C3. LeadLine Comparisons

Unfortunately the Nancy Fosters leadline was found to be missing when the science crew arrived. Confidence in the vertical has been confirmed during previous cruises though with leadlines comparisons in agreement with the 7125-SV2. Confidence in the vertical is also confirmed with matching z values between the IMTEC vessel survey and the ERS waterline survey, SBET GNSS lever arm to Reference Point installation values, chart comparisons and vertical agreement between the 7125_SV2 and the EM710.

C4. Heave, Roll and Pitch Corrections

An Applanix POS/MV 320 v4 integrated dual frequency GPS and inertial reference system was used for the motion sensor for this survey. The POS/MV 320 is a 6-degree of freedom motion unit, with a stated accuracy of 0.05-meter or 5 percent for heave, 0.01 degrees for roll and pitch and heading. Real-time displays of the vessel motion accuracy were monitored throughout the survey with the MV POSView controller program. Manufacturer reported accuracies as published on the Caris HIPS TPU website (http://www.caris.com/tpu/) were entered into the HVF and used for TPU computations.

C5. Patch Test

A patch test was performed for the Reson 7125-SV2 sonar system on March 31st, 2015. The EM710 was patch tested prior to the cruise during the SAT with satisfactory results. The EM710 patch values are entered into the POSMV, whereas the 7125-SV2 values are applied within the HVF file. The purpose of the patch test was to measure alignment offsets between the IMU sensor and the multibeam transducer, while also determining time delays between the time-tagged sensor data. The patch test consisted of a series of lines run in a specific pattern, which were then used in pairs to analyze roll, pitch, and heading alignment bias angles.

Roll alignment was determined by evaluating the reciprocal lines run over a flat bottom. The pitch tests consisted of set of reciprocal lines located on a steep slope. The yaw error was determined by running parallel lines over the same slope separated by approximately four times water depth. Latency lines were ran at varying speeds over a changing slope in the same direction. The roll, pitch and yaw lines were collected at approximately 7 knots, whereas the latency lines were ran at 4 and 8 knots. The patch test was performed over a previously surveyed seafloor feature from approximately 24m to 50m of water.

Selected pairs of lines were then analyzed in HIPS Calibration editor to measure the angular sensor bias values. Visual inspection of the data confirmed each adjustment. Patch test values for the sonar system are listed in Table 7.

Table 7. Patch Test Values

M-I907-NF-15 Patch Test Values				
	Pitch	**Roll**	**Yaw**	**Latency**
EM710	-0.20	0.00	0.15	0.0
7125-SV2	0.90	-0.34	0.20	0.00

C6. Tide and Water Level Corrections

Existing water level stations were used in conjunction with height and time correctors in a Caris tide zone definition file (ZDF). Predicted tides, adjusted to Mean Lower Low Water (MLLW), and the ZDF were supplied by the Center for Operational Oceanographic Products and Services (CO-OPS) prior to the commencement of survey operations. Verified six-minute-interval water level and final tide-zone correctors were applied while post-processing the data. Survey-specific parameters including the estimated tidal errors were applied during the computation of the TPU. Further tidal information is located in the associated Descriptive Reports (DRs) for H12756 and H12757.

C7. Sound Velocity Correction

Sound velocity casts were generally performed at four hour intervals during survey operations. After each cast the sound speed data was reviewed for outliers or anomalies that could impact data quality. Additionally, the sound speed measured by the UCTD at the surface was compared to the Reson SVP-71 for surface sound velocity agreement.

The sound speed correction was applied to each line using the nearest in distance within time (five hour) option in the HIPS SVP correct routine. All casts were concatenated into a sheet specific HIPS SVP file for each survey sheet with the associated time, position, depth, and sound speed information for each cast.

D. LETTER OF APPROVAL

The letter of approval for this report follows on the next page.

LETTER OF APPROVAL

M-I907-NF-15 DATA ACQUISITION AND PROCESSING REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of M-I907-NF-15 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the M-I907-NF-15 Hydrographic Survey Project Instructions dated March 04, 2015.

Mike Stecher

Digitally signed by Mike Stecher
DN: cn=Mike Stecher, o, ou=Solmar Hydro Inc, email=solmarhydro@gmail.com, c=US
Date: 2015.11.12 09:55:45 -08'00'