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

Data Acquisition & Processing Report

Type of Survey HYDROGRAPHIC

Project Number OPR-B370-NRT5-14

Time Frame AUGUST - NOVEMBER

LOCALITY

State: CONNECTICUT

General Locality Long Island Sound

2014

CHIEF OF PARTY

LTJG ANDREW CLOS, NOAA

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DATE

NOAA FORM 77-28 U.S. DEPARTMENT OF COMMERCE
(11-72) NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HYDROGRAPHIC TITLE SHEET

PROJECT NUMBER:

OPR-B370-NRT5-14

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: **Connecticut**

General Locality: **Eastern Long Island Sound, NY**

Sub-Locality: **Long Rock to Duck Island**

Scale: **1:10,000**

Date of Survey:
Instructions Dated: **4/24/2014**

Project Number: **OPR-B370-NRT5-14**

Vessel: **NOAA NRT5, S3002**

Chief of Party : **LTJG Andrew Clos, NOAA**

Surveyed by: **NOAA Navigation Response Team 5 Personnel**

Soundings by: **Kongsberg Simrad EM 3002 Multibeam Echosounder**

Verification by: **Pacific Hydrographic Branch Personnel**

Soundings in: **Meters at MLLW**

Remarks:
1) All Times are UTC.
2) Projection is UTM Zone 18.

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DATA ACQUISITION & PROCESSING REPORT

OPR-B370-NRT5-14
NOAA Navigation Response Team 5
LTJG Andrew Clos, Team Lead, Processing and Submittal

A. EQUIPMENT

A.1. Vessels

A.1.1. S3002

NRT5 operated a single vessel, S3002 (see Fig. 1), a 30-foot (overall), gray, aluminum-hull SeaArk Commander. NOAA Survey Vessel S3002 is powered by dual 200-horse power Honda outboards. A Kohler 7.5 kw generator supplied AC power. An APC Smart-UPS (uninterruptable power supply) provided battery backup for the survey-system electronics.

Figure 1: NOAA S3002 (NRT5)

A.1.1.1. Calibration & Configuration

See section C.1.1 for a description of the full vessel survey.

A.2. Depth Measurement Equipment

A.2.1. Kongsberg Simrad EM3002 Multibeam Echosounder

S3002 is equipped with a hull-mounted Kongsberg EM3002 multibeam, which is located directly beneath the IMU. The EM3002 is a 300 kHz (nominal) system with a characteristic operating depth range of 1 to 150 meters water depth. Under ideal, cold water conditions, the range may extend to 200 meters. The swath width is 130°, and the nadir beam is 1.5° x 1.5°. The system has a maximum ping rate of 40 Hz. The processing unit (PU) performs beam forming and bottom detection and automatically controls transmit power, gain, and ping rate. The sonar processor incorporates real time surface sound speed measurements for initial beam forming and steering. SVP correction is also performed in real time. The Seafloor Information System (SIS) application, designed to run under Microsoft Windows, provides control and monitoring of the EM3002.

A.2.1.1. Calibration & Configuration

The installation and runtime parameter configuration files are included in Appendix IV (Electronic Appendix). See section C.1.3 for a description of the calibration patch test.

A.3. Vessel Position and Orientation Equipment

A.3.1. POS/MV Position & Orientation Sensor

S3002 is equipped with an Applanix POS/MV 320 version 5. The POS/MV consists of dual Trimble BD960 GPS receivers (with corresponding Zephyr antennas), an inertial motion unit (IMU), and a POS computer system (PCS). The two antennas are mounted approximately 1.5 meters apart atop the launch cabin (see Fig. 2). The primary receiver (on the port side) is used for position and velocity, and the secondary receiver is used to provide heading information as part of the GPS azimuthal measurement sub-system (GAMS).

Figure 2: POS/MV Antenna Installation

The IMU contains three solid-state linear accelerometers and three gyros, which together provide a full position and orientation solution. The IMU is mounted on the top of the sonar housing, beneath a removable deck plate (see Fig. 3).

Figure 3: IMU Installation, POS M/V 320 V4 IMU shown. 2014 season utilized POS M/V 320 V5 IMU.

A.3.1.1. Calibration & Configuration

A GAMS calibration was performed on 6/11/2014, prior to data acquisition. The GAMS calibration report is included in Appendix II.

The POS/MV is configured, operated, and monitored via the POS/MV controller software, which is installed on the S3002 acquisition computer. The primary GPS-to-reference point lever arm was accounted for in the POS/MV controller. A POS/MV configuration file detailing lever arms, input/output settings, and operational settings is contained in Appendix IV (Electronic Appendix).

For the 2014 field season, the POS M/V IMU and TPU were upgraded to version five. The version 5 IMU is physically shorter than the version 4 model. Although the X and Y positions remained unchanged, a mounting bracket was used and the Z offset value was hand measured. This resulted in a change in Z-value from 0.539 meters to 0.508 meters. This change in Z value can be seen in the 2014-162 (Day number 162) entry in the NRT5_S3002_EM3002.hvf and supersedes the NGS values from 2009 found in Appendix II of this report.

A.3.2. Trimble SPS361 DGPS Receiver

The POS/MV receives differential (RTCM) correctors from a Trimble SPS361 GPS receiver that includes a dual-channel low-noise MSK beacon receiver, capable of receiving U.S. Coast Guard (USCG) differential correctors. The SPS361 can also accept RTCM messages from an external source such as a user-established DGPS reference station, however, no such stations were established for S-B904-NRT5-14.

A.3.2.1. Calibration & Configuration

Trimble's Web Interface was used to configure the SPS361. The DGPS receiver was manually set to receive corrections from Moriches, NY (293 kHz). The SPS361 is configured to go off-line if the age of DGPS correctors exceeds 20 seconds, and to exclude satellites with an altitude below fifteen degrees.

A.4. Side Scanning Imagery Sonar

A.4.1. Edgetech 4125

The Edgetech 4125 system consists of : A dual frequency towfish (400kHz/900kHz) with an onboard pressure, attitude, and heading sensor; tow cable; TPU; and an acquisition laptop running Edgetech's Discover II software.

Figure 4: Edgetech 4125

The SSS towfish is deployed from a davit arm located on starboard quarter using a Dayton electric winch spooled with approximately 30 meters of cable. Tow cable is lead from the winch upward along the davit arm. The tow cable at the winch is connected electro-mechanically to a deck cable through a slip ring assembly. Cable out is controlled manually and is computed by the Dynapar cable counter by the number of revolutions of the cable drum sheave. The cable counter data is transmitted to the Discover II acquisition computer via serial connection.

Line spacing for side scan sonar (SSS) operations is determined by range scale. A towfish altitude of 8-20% of the range scale is maintained during data acquisition. Altitude is adjusted by cable out, and vessel speed. The range scales of the Edgetech 4125s high and low frequencies can be set independently.

Confidence checks are performed daily by observing changes in linear bottom features extending to the outer edges of the digital side scan image, features on the bottom in survey area, and by passing aids to navigation. Daily rub tests are also conducted.

A.5. Sound Speed Equipment

S3002 is equipped with an AML MicroX surface sound speed sensor to measure surface sound speed, which is used in beam forming computations by the Kongsberg flat-face multibeam transducer head. For water column sound speed profiles NRT5 a Seabird SBE19+ CTD profiler. Speed of sound through water is determined by a minimum of one cast every four hours, in accordance with the NOS Specifications and Deliverables for Hydrographic Surveys. For quality assurance, the surface sound speed measurement is constantly compared to the surface measurement of the most recent cast in SIS. Full cast comparisons are also performed periodically.

A.5.1. AML Micro X

AML Micro X serial number 10313 provided surface sound speed data to the flat-face EM3002 for beam steering and beam forming. The unit is mounted in a removable pole that is inserted into a bracket mounted on the transom between the two motors (see Fig. 5). The unit is configured to output an AML datagram to SIS, which is installed on the acquisition computer (see wiring diagram in Appendix II).

Figure 5: Surface Sound Speed Digibar Installation

A.5.2. Odom Digibar Pro – Profile Sound speed

Odom Digibar Pro serial #98212, which has 25 meters of cable, can be used to obtain sound speed profiles in water depths of up to 25 meters. First, the Digibar profile data file is uploaded to the acquisition computer using Digibar software and processed using NOAA Velocipy software. The processing creates a series of files, including an *.asvp file, which is loaded into SIS for real-time sound speed ray tracing, and an *.svp file which is used for post processing in Caris.

A.5.3. Seabird SBE19+ CTD Profiler

Seabird SBE19+ serial #4835 can be used to obtain sound speed profiles in waters up to 600 meters. The raw profile data file is uploaded and processed with the acquisition computer using the NOAA Velocipy software. Velocipy generates an *.asvp file, which is loaded into SIS for real-time ray tracing, and an *.svp file which is used for post processing in Caris.

On August 16th, 2014, NRT5's CTD (#4835) was compared to one of NOAA Ship Thomas Jefferson's CTDs (#4487). The CTD's were shackled together and cast simultaneously to a depth of 12 meters. The two casts were downloaded and compared using NOAA's Velocipy software. They were compared at launch angles from 0 to 90 degrees in 15 degree increments. Each angle passed the comparison.

A.5.4. Calibration & Configuration

Calibration reports for all three sound speed sensors are included in Appendix III.

A.6. Data Acquisition Software

A complete list of software and versions is included in Appendix I.

A.6.1. Hypack Hysweep

Hypack Hysweep was used for real-time data display, and navigation.

A.6.2. Applanix PosView

The Applanix POSView software was used to configure and monitor the Applanix PosMV, and to log PosPac files for post processing. The PosMV configuration file, which is created using POSView, is located in Appendix IV (Electronic Appendix).

A.6.3. Kongsberg SIS-Seafloor Information System

SIS was used to control the EM3002 MBES, and for acquisition of .all files.

A.6.4. Discover II

Edgetech's Discover II software was used to control the Edgetech 4125, and to log side scan data, including cable out, position, and towfish depth.

A.7. Data Processing Software

A.7.1. Caris HIPS

Caris HIPS was used to process all MBES data including tide correction, SVC correction, merging with navigation data, TPU calculation, data cleaning, and CUBE BASE surface creation. The Caris HVF file, which contains offsets and correctors applied in Caris, is located in Appendix IV (Electronic Appendix).

In 2011, the vessel began recording its MBES data in the Kongsberg .all file format. This change caused the Multibeam transducer level arms to be accounted for in Kongsberg SIS software and carried through in the .all file. Although the IMU is still utilized as the reference point, the CARIS HVF file's "Transducer 1" entries were set to zero for X, Y and Z. The entry from 2011-172 (2011, day number 172) reflects this change.

A.7.2. Caris SIPS

Caris SIPS was used to process all SSS data, including towfish height, slant range correction, recomputing towfish navigation, and selecting contacts. The Caris HVF file, which contains offsets and correctors applied in Caris, is located in Appendix IV (Electronic Appendix).

A.7.3. Caris Bathy Database

Caris Bathy Database(BDB) was used for feature management and quality assurance.

A.7.4. Velocipy

Velocipy was used to process SVP casts, and for DQA tests. The .asvp files created by Velocipy were applied to the MBES data in real-time using SIS software.

A.7.5. Pydro

Pydro was used for feature management, DTON report generation, and tides requests.

B. QUALITY CONTROL

B.1. Multibeam Echosounder Data

B.1.1. Acquisition Operations

Mainscheme multibeam data were acquired using either planned lines, or a “paint-the-bottom,” or adaptive-line-steering approach, whereby the coxswain viewed a real-time coverage map in Hysweep and accordingly adjusted line steering to ensure adequate overlap. When gaps in coverage were found, holiday line plans were created using Mapinfo and exported as Hypack line files. Sound speed casts were acquired as per HSSD section 5.2.3.3.

B.1.2. MBES Processing Workflow

Multibeam processing for S-B904-NRT5-14 was based on the BASE surface/directed-editing paradigm described in FPM section 5.2, Bathymetry Processing. The multibeam processing workflow had four main components: conversion, preliminary processing, surface generation, and surface review/data cleaning (see Fig. 6). Note that the surface generation and surface review/data cleaning steps are iterative.

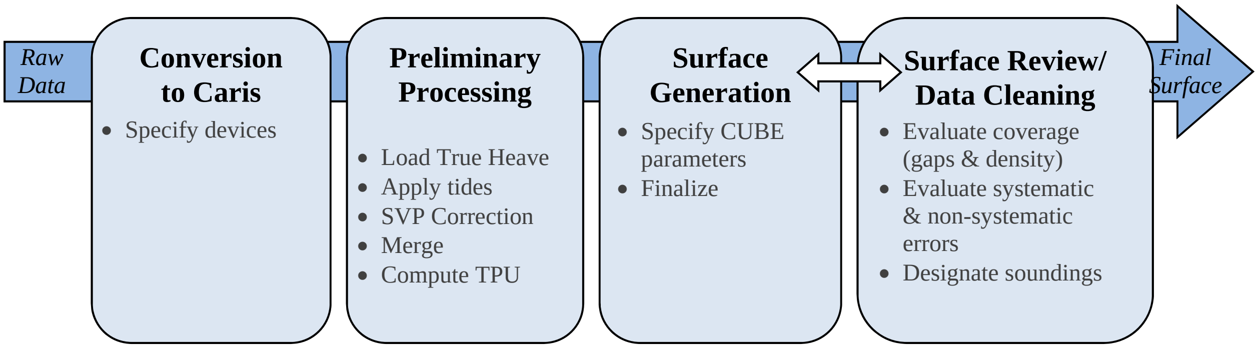

Figure 6: Multibeam Processing Workflow

B.1.2.1. Conversion

Raw multibeam .ALL data were converted to HDCS format in Caris HIPS. Device conversion parameters are shown in Figure 7.

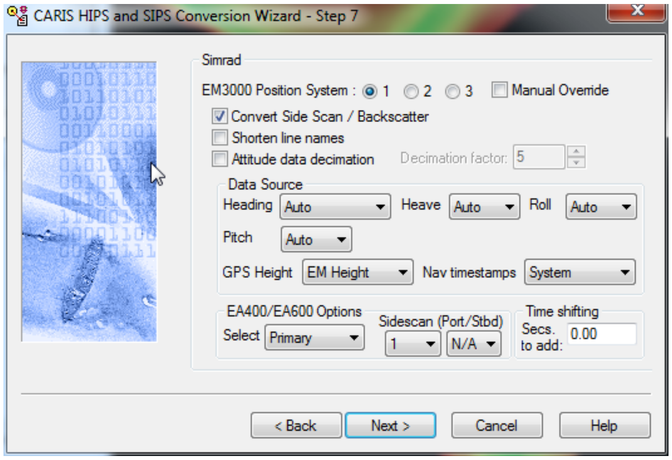

Figure 7: Device Conversion Parameters

B.1.2.2. Preliminary Processing

After conversion, preliminary processing consisted of applying True Heave, tide, SVP Correction, merging, and computing total propagated uncertainty (TPU).

Loading True Heave

True Heave was loaded for each day of data. Occasionally the True Heave files need to be fixed using the Fix-True-Heave utility.

Applying Tides

A TCARI grid was provided for this project. TCARI water level correctors were applied using the Pydro TCARI tide tool. The TCARI grid file used for this project was B904NRT52014_Rev.tc. See section C.3 for a detailed description of the tide correctors for S-B904-NRT5-14.

SVP Correction

SVP post processing was performed in Caris using the Simrad “intersection of cones” algorithm. Typically, the “Nearest in distance within time” option was used, with a time limit of 4 hours, unless a different method was warranted. True Heave was applied during this correction.

Merging

The merge process in Caris combines the observed depths (created during conversion) with the loaded tide file, the navigation data, the HVF draft sensor (containing dynamic draft values), and the HVF swath1 sensor (containing patch test biases) to compute the final processed depths. No smoothed sensors were applied during the merge process.

Computing TPU

The TPU computation process assigns each sounding a horizontal and vertical uncertainty, or estimate of error, based on the uncertainties of the various data components, such as position, sound speed, and loading conditions. Table 1 lists the HVF TPU values used for S-B904-NRT5-14.

Table 1: TPU Values

Data Component	*TPU Value*	*Data Component*	*TPU Values*
Motion Gyro	0.02°	X, Y, & Z Offsets	0.01 m
Heave % Amplitude	5%	Vessel Speed	0.03 m/s
Heave	0.05 m	Loading	0.01 m
Roll	0.02°	Draft	0.03 m
Pitch	0.02°	Delta Draft	0.03 m
Position Nav	1 m	MRU Align StdDev gryo	0.2°
Timing Transducer	0.01 s	MRU Align StdDev Roll/Pitch	0.2°
Nav Timing	0.01 s	Sound Speed Surface	0.5 m/s
Gyro Timing	0.01 s	Sound Speed Profile	2.0 m/s
Heave Timing	0.01 s	Tide measured	.0*
Pitch Timing	0.01 s	Tide zoning	.0*
Roll Timing	0.01 s		

*Note: Applying TCARI tides loads tidal uncertainty information into the HDCS directory.

B.1.2.3. Surface Generation

The multibeam sounding data were modeled using the CUBE BASE surface algorithm implemented in Caris HIPS. CUBE BASE surfaces were generated using the parameters outlined in Hydrographic Surveys Technical Directive 2009-02 (CUBE Parameters). The resolutions of the finalized surfaces were based on the resolution requirements specified in the Specs and Deliverables (5.2.2.2).

B.1.2.4. Surface Review/Data Cleaning

Rather than a traditional line-by-line review and a full subset-cleaning, the data cleaning/quality review process for S-B904-NRT5-14 consisted of a combination of the directed-editing approach described in FPM section 4.2.4.3, and a full subset-review (not full subset-cleaning). All the sounding data were viewed in subset, but unlike in the traditional workflow, where every sounding deemed to be “noise” is rejected, only the soundings that negatively impacted the CUBE surface were rejected. Surface review also consisted of evaluating achieved coverage and sounding density, checking for systematic errors, and designating soundings. Sounding designation was in accordance with Specs and Deliverable section 5.2.1.2.

B.2. Sidescan Sonar Data

B.2.1. SSS Processing Workflow

SSS processing for S-B904-NRT5-14 was performed using Caris SIPS.

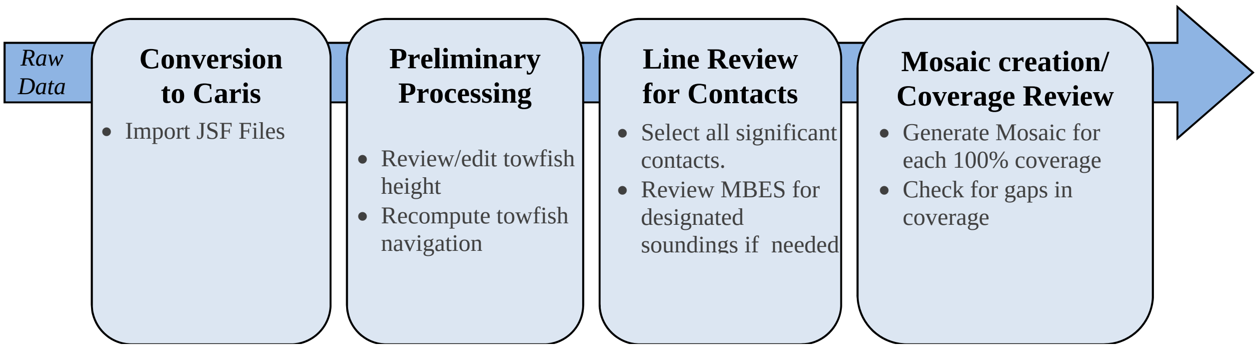

Figure 8: SSS Processing Workflow

B.2.1.1. Data Conversion

The JSF lines logged by Discover II were brought into Caris SIPs using the Conversion wizard. Parameters selected are shown in the figure below.

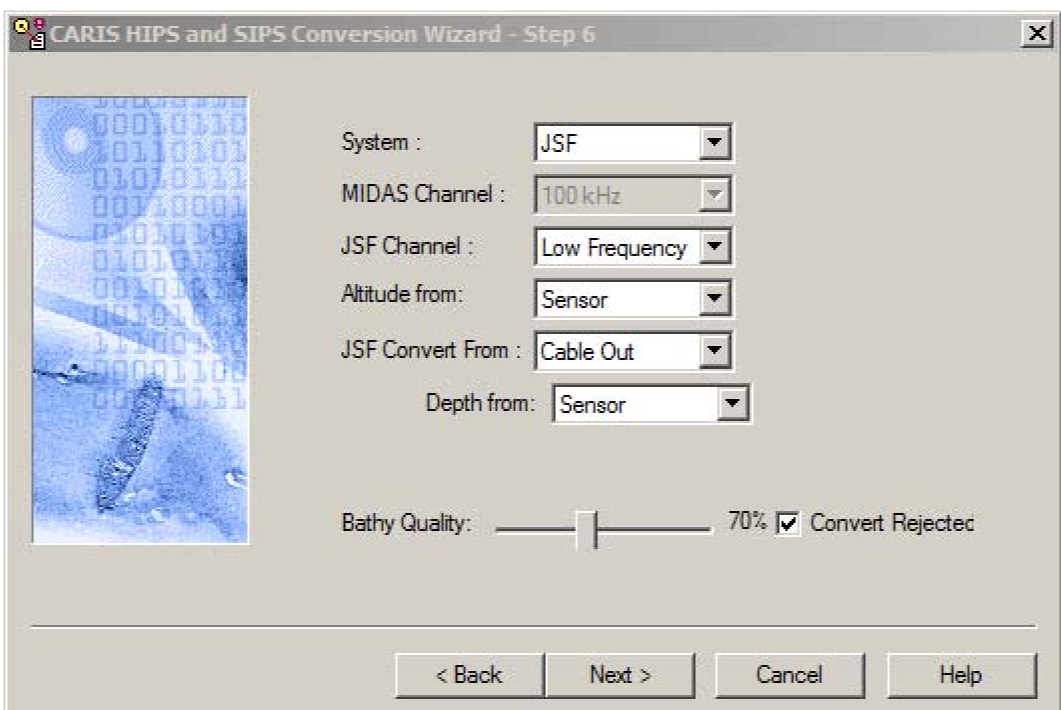

Figure 9: Caris Conversion Wizard

B.2.1.2. Towfish height Digitization

The towfish bottom tracking was reviewed for each line, and redigitized where needed.

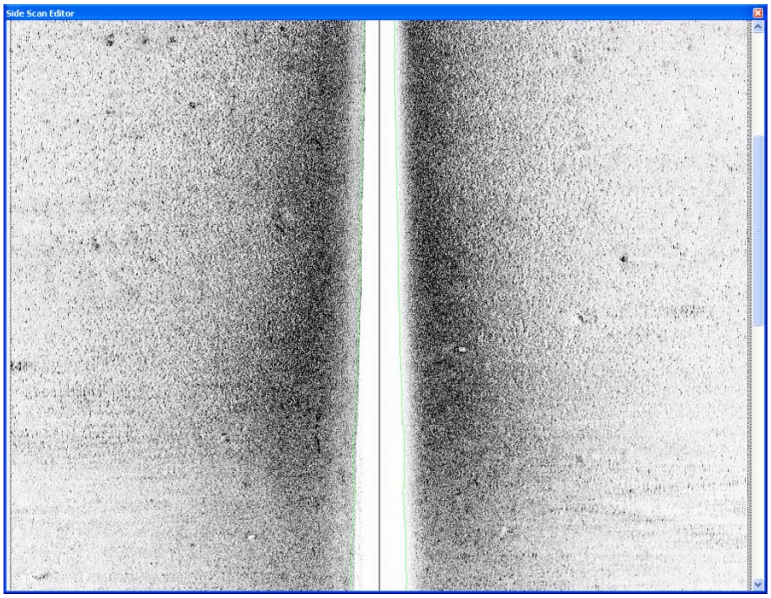

Figure 10: Digitizing Towfish Height

B.2.1.3. Recompute Towfish Navigation

Along with the sidescan imagery, Discover II logs ship's navigation, cable-out, and towfish depth data. Recompute towfish navigation combines these three sensors to compute the position of the towfish in relation to the vessel. The process is needed for accurate positioning of contacts, and georeferencing of mosaics.

B.2.1.4. Slant Range Correction

Caris SIPS 8.1 now slant range corrects on the fly, so no separate process is needed.

B.2.1.5. Line Review and Contact Selection

Each line of SSS data was reviewed for possible contacts. Significant contacts were selected and exported to Pydro for correlation with MBES data.

B.2.1.6. Creation of Mosaics

Mosaics were created for each 100% of SSS data to allow any gaps in coverage to be identified.

B.3. Feature Data

Feature management consisted of one main workflow depicted in Figure 12. Bottom Samples, Designated Soundings and SSS contacts from Caris, and Detached Positions from Hypack were all inserted into Pydro as Features. Once in Pydro, each feature was evaluated, correlated with other features if appropriate, and given S-57 attribution. All features were exported from Pydro in the s57 .000 format, and imported into Bathy Database. In BDB, the features exported from Pydro were combined with the CSF file. After all correlation, digitization, and S-57 attribution are finalized, the Final Features File (FFF), and the SSS contacts file are produced as the final deliverables.

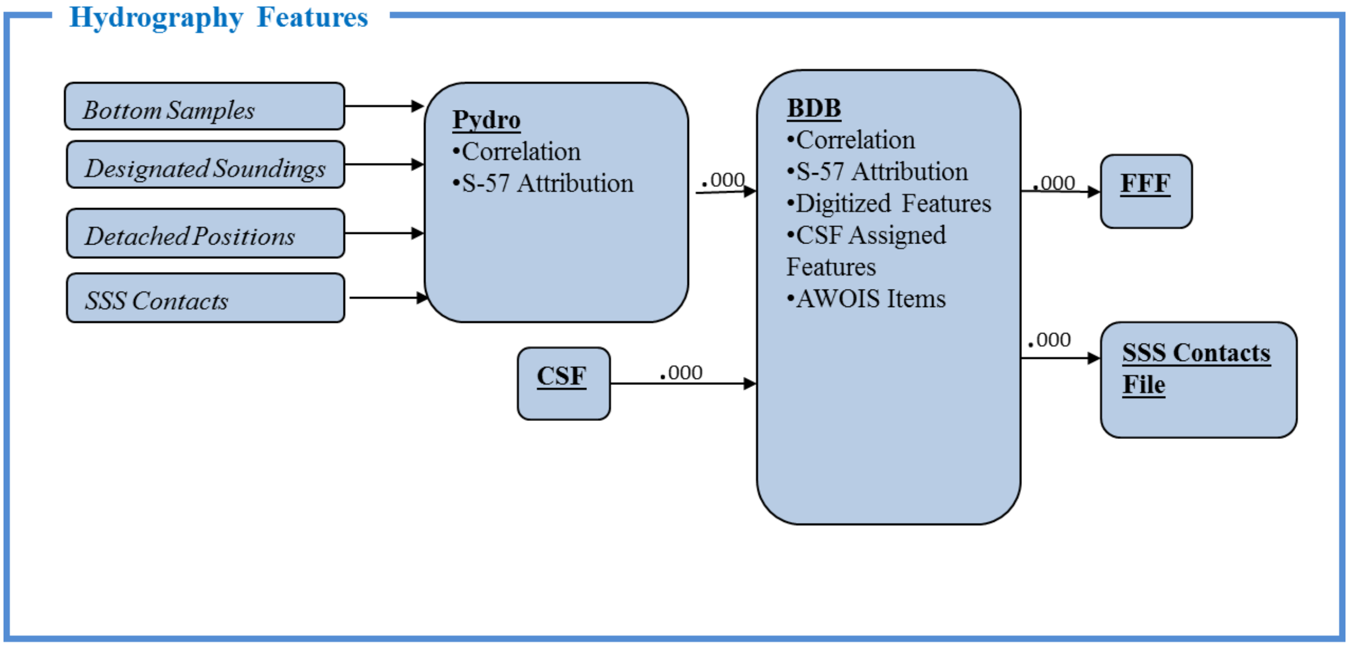

Figure 11: Feature Management Workflow.

B.3.1. <u>Hydrography Features</u>

B.3.1.1. Bottom Samples

Bottom sample positions and attributes were acquired as Targets in Hypack, and then imported into Pydro as Features.

B.3.1.2. Designated Soundings

The least depth of charted features and significant uncharted features were flagged “designated” in Caris HIPS to ensure that the depth was portrayed in the final BASE surface. Soundings that were flagged designated were then imported into PYDRO as bathymetric features. Once in PYDRO, these bathymetric features were given the appropriate S-57 attribution.

B.3.1.3. Detached Positions (DPs)

Features for which the least depth or position could not be derived from the bathymetry data were defined based on a range and bearing, or detached position (DP), relative to the vessel position. DPs were created as Hypack targets and then imported into Pydro.

B.3.1.4. Digitized Features

New or modified area features were digitized in Caris Base Editor, and combined with the Final Features File (FFF).

B.3.1.5. SSS Contacts

Significant SSS contacts imported into Pydro from Caris SIPS are typically correlated with a MBES least depth designated sounding. All SSS contacts are placed in a SSS contacts file in a .000 as a final deliverable.

B.3.2. <u>Shoreline Features</u>

Shoreline point features were acquired as Hypack DPs, and inserted into Pydro.

C. CORRECTIONS TO ECHO SOUNDINGS

The following section describes the determination and evaluation of the three main categories of corrections to echosoundings: vessel, sound speed, and water level correctors.

C.1. Vessel Correctors

Vessel correctors include static offsets, dynamic offsets, and patch test biases. The various correctors are applied to echo soundings at different points throughout the data pipeline, which is detailed in the sections below.

C.1.1. <u>Static Offsets</u>

C.1.1.1. Vessel Lever-Arms

The National Geodetic Survey conducted a full vessel survey on 8/4-8/5/09 in Middletown, RI (see Appendix II for the NGS report). The primary-GPS-to-Reference-Point lever arm is accounted for in the POS/MV controller. The Reference-Point-to-Multibeam-Transducer lever arm is accounted for in Caris.

The coordinate systems are different between CARIS and NGS. Therefore, careful attention was given when entering the NGS offsets in to the appropriate fields of the CARIS HVF, particularly with respect to X and Y and the sign of Z.

Table 2: Coordinate system differences.

CARIS Coordinate System	NGS Coordinate System
Y: Positive Forward	Y: Positive Starboard
X: Positive Starboard	X: Positive Forward
Z: Positive Down	Z: Positive Up

C.1.1.2. Static Draft

A static draft measurement was performed on May 27th, 2014 in Long Island Sound, off Westbrook, CT. To determine the static draft (i.e., the height of the waterline above/below the reference point), a straight rod long enough to overhang the boat on each side was laid across the gunwales directly above the IMU. Measurements were taken with a tape measure from the rod to the water line on each side of the boat, and from the rod to the top of the IMU (RP). The port and starboard water line measurements were averaged, and then subtracted from the rod-to-IMU measurement to determine the separation between the reference point and water line.

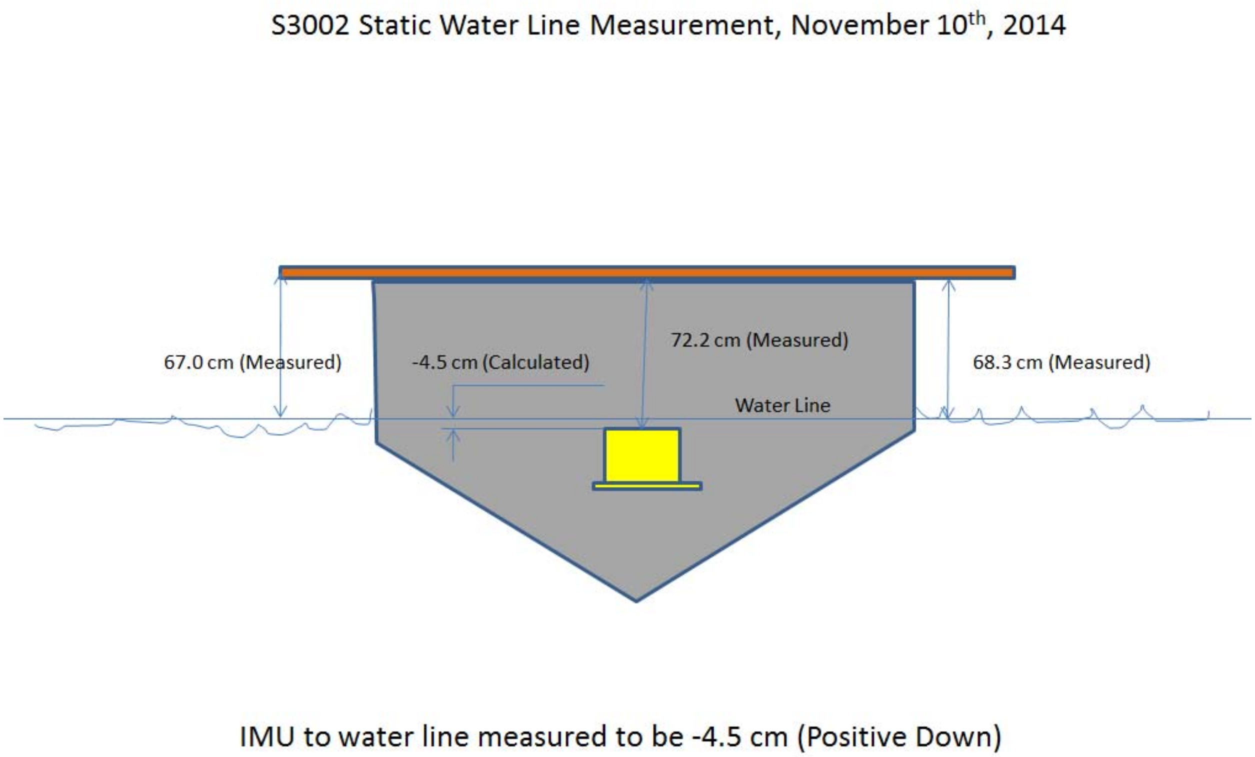

Figure 12: Static Draft Measurement

C.1.2. <u>Dynamic Offsets</u>

The dynamic draft values were obtained on 6/12/2014. The dynamic draft measurements were obtained with an optical level positioned on shore using the methods described in section 1.4.2.1.2.1 of the NOAA Field Procedures Manual. Two independent tests conducted with different observers. The two tests showed excellent correlation, and the average of the two tests were taken as the final values. The dynamic correctors are summarized in Table 2. A positive draft corrector implies that the boat moved down.

Table 3: 2014 Dynamic Draft Values

Speed (m/s)	Draft Correction (m)
0	0.000
1.080	0.010
1.530	0.009
2.392	0.016
2.855	0.026
3.370	0.033
3.807	0.049
4.154	0.060
4.604	0.078
5.042	0.050
6.276	-0.010
7.639	-0.056

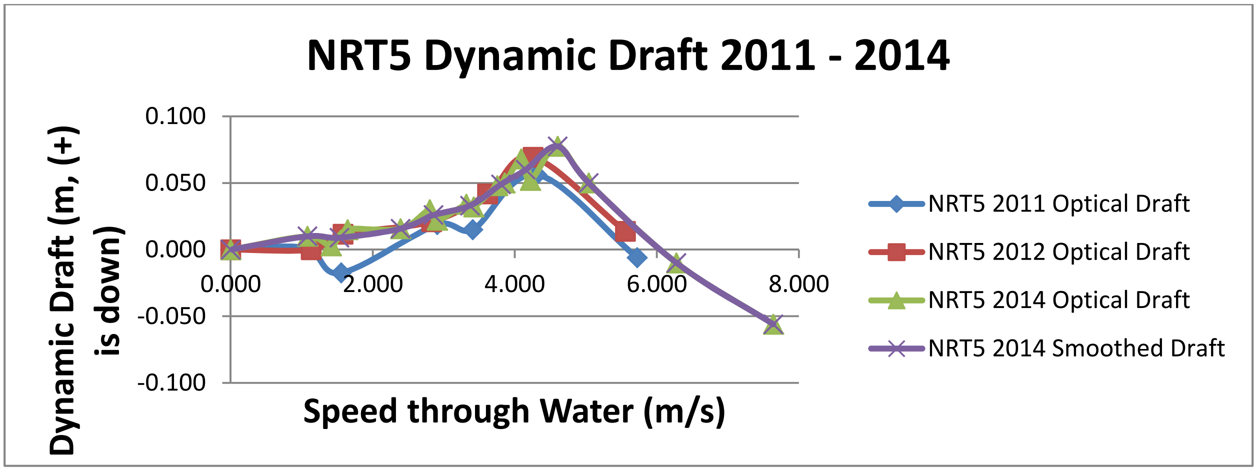

Figure 13: Dynamic Draft Plot showing results from 2011 through 2014.

C.1.3. Patch Test Biases

A patch test was performed on 6/16/14 (DN 172), in Long Island Sound, 3 NM SSW of Cornfield Point, Old Saybrook, CT (see Fig. 16). A charted wreck in 80 ft of water was located and used as the calibration target. A pair of roll bias lines was collected in a flat area 200 meters to the northwest. Timing offset was tested for using the conventional method, rather than the "precise timing" method. The derived biases (summarized in Table 3), were entered into the Swath1 sensor of the Caris HVF and therefore were applied to the data during the merge step of post-processing.

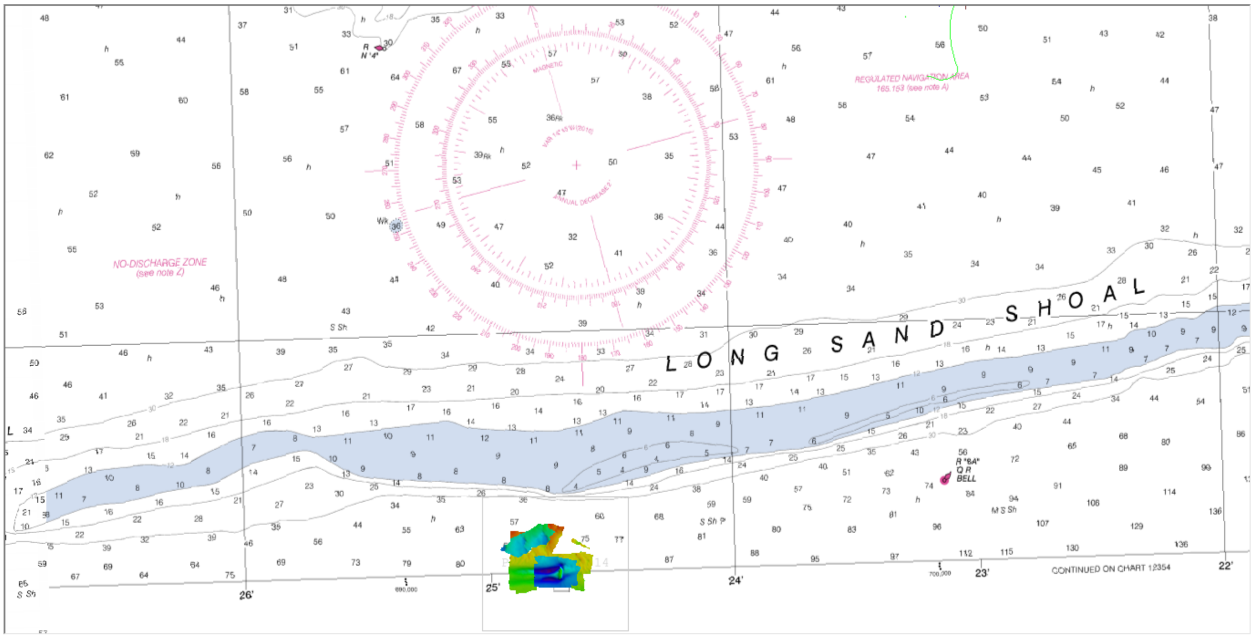

Figure 14: Patch Test Location (Charted depths are in feet)

Table 4: Patch Test Values

Bias	Estimate
Navigation Timing	0.000
Pitch	-0.160
Roll	-0.042
Heading (Yaw)	-1.060

C.2. Sound Speed

Sound speed corrections were performed in real-time by the EM3002 controller software, SIS. Casts were taken, at a minimum, every four hours as per NOS Specifications and Deliverables for Hydrographic Surveys. Sound velocity corrections were then post processed in Caris.

C.3. Water Level Corrections

Tide corrections for OPR-B370-NRT5-14 were applied using a TCARI grid file B370NRT52014.tc in Pydro.

APPROVAL SHEET

Data Acquisition & Processing Report
Navigation Response Team 5

As Chief of Party, I have ensured that surveying and processing procedures were conducted in accordance with the Field Procedures Manual and that the submitted data meet the standards contained in the 2014 Hydrographic Surveys Specifications and Deliverables.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Respectfully,

LTJG Andrew Clos
Team Lead, NOAA NRT-5

Appendices

Appendix I – System Tracking

See the Appendix I folder submitted with this document.

Appendix II - Vessel Reports, Offsets, and Diagrams

See the Appendix II folder submitted with this document.

Appendix III – Calibration

See the Appendix III folder submitted with this document.

Appendix IV – Electronic Appendix

The Electronic Appendix contains digital files meant to accompany the report body. It is submitted as a .zip file located in the *Appendix IV - Electronic* folder.