Data Acquisition and Processing Report

NOAA S3003

OPR-L430-NRT6-12

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Introduction

This Data Acquisition and Processing Report (DAPR) details all Navigation Response Team 6 (NRT6) survey equipment and methods used to acquire and process survey data. Systems were selected for use during this project based on instructions from the Field Procedures Manual, Project Instructions, and Hydrographic Survey Specifications and Deliverables. Survey systems and methods used during this project were also chosen based on the water depth, sea and weather conditions, and the ability of the vessel to safely navigate the area.

This report often references the 2012 Hydrographic Systems Readiness Review (HSRR), as most of the survey hardware, software, equipment, and personnel have been documented in that report. This DAPR will primarily discuss information differing from or not included in the HSRR.

A. Equipment

A.1 Survey Launch S3003

Survey Lunch S3003 is a 27-ft SeaArk Commander, and was used to acquire side scan sonar data, multibeam echosounder data, and sound velocity profiles. The 4.5 ton launch is 8 feet wide, has a static draft of 0.5 meters, and is powered by twin 150hp Honda outboards. Vessel descriptions and offset measurements are detailed in Chapter 1.1 and Appendix 1 of the HSRR.

Vessel Information

Hull Number:	**S3003**
Builder:	**SeaArk**
Built:	**2003**

Length Overall:	**33 ft.**
Beam:	**8 ft.**
Draft:	**1.6 ft.**
Cruising Speed	**28kts**
Min/Max Survey Speed:	**4-8kts.**
Primary Echosounder:	**Hull-mounted Simrad EM3002 MBES**
Secondary Echosounder:	**Hull-mounted ODOM Echotrac CV VBES**
Imagery System	**Towed Klein 3000 Side Scan Sonar system**
Sound Velocity Profiler:	**Sea-Bird SeaCat SBE 19+ CTD Profiler**
Surface Sound Velocity Probe:	**ODOM Digibar Pro**

A.2 Sounding Equipment

A.2.1 Shallow Water Multibeam Sonar

S3003 is equipped with a Kongsberg Simrad EM3002 multibeam echosounder. The EM3002 collects sounding and backscatter data at 300 kHz with 254 receive beams, which provide an optimal swath of 130°.
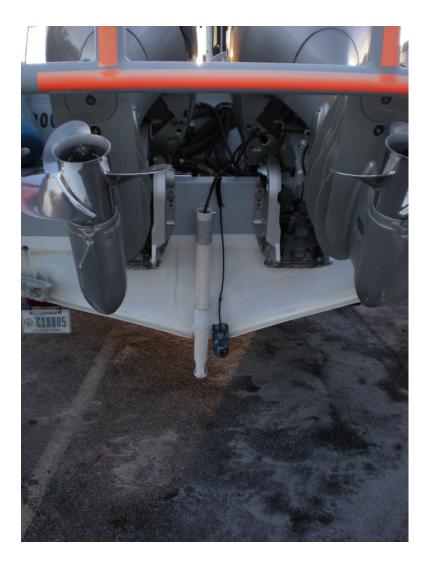
The sonar head contains a flat-face transducer (Mills Cross configuration) and all transmitter and receiver elements encased in an acoustically transparent medium. The transmit beam is steerable to compensate for mounting angle and vessel pitch.

The processing unit performs the beam-forming, bottom detection and controls the sonar head with respect to gain, ping rate and transmit angle. It also contains the interfaces for all time-critical external sensors such as attitude data, position, and the 1 PPS (pulse per second) signal.

EM3002 SIS (Seafloor Information System) software operates on the Hypack computer and communicates via Ethernet connection, is used to control adjustable parameters. The controller software also transmits real time sound velocity measurements (from a Digibar Pro velocimeter mounted near the sonar head) to the processing unit for initial beamforming and steering.

The sonar head is hull mounted aft of the vessel cabin, centered on the keel line. The POS/MV IMU is centered above the sonar head. Please see the CARIS HVF for offset values.

The sound velocity probe is mounted on the transom, between the outboard engines. The probe is housed in a PVC tube, which is then inserted into two brackets attached to the transom. This removable configuration allows for higher transit speeds between survey areas, while keeping the probe protected.

A problem with this configuration is the tendency for air bubbles (turbulence) and debris, mostly floating eel grass, to become trapped in the PVC tube, leading to large errors in the sound velocity. This in turn causes the multibeam to incorrectly steer the incoming pings, seen as large "frowns" in the bathymetry. Data exhibiting this problem are noted, and data are re-acquired over the problem areas.

The problem of turbulence and eel grass has subsequently been mitigated for the most part by installing a 6 inch longer PVC tube so as to extend the velocity probe deeper below the water surface. Since this installation, we have seen fewer beam steering sound velocity errors. However, during times of calmer seas and/or cleaner water, free of floating eel grass we still prefer to use the shallower PVC tube as it is less likely to suffer debris damage and interference from the engines in the "up" position during transit between survey areas.

A.2.2 Side Scan Sonar

S3003 is equipped with a Klein System 3000 sonar system. The system includes:

• Dual frequency (100 kHz, 500 kHz) towfish with 300 PSI pressure sensor
• Transceiver Processing Unit (TPU)
• Acquisition Workstation
• Fifty meter Kevlar reinforced tow cable
• SonarPro software and VX Works TPU operating system

The horizontal beam widths for the low and high frequencies are 1° and 2° respectively. The vertical beam width is 40°. Maximum range scale is 150 meters at the high frequency, and 500 meters using the low frequency.

All SSS data collection is controlled using the SonarPro software operating in a Microsoft Windows XP environment on the Acquisition Workstation. Control signals are sent to the towfish and data is received from the towfish via the TPU. Data is recorded digitally and stored on the Acquisition Workstation in Klein SDF format.

Side scan sonar lines are spaced according to the range scale appropriate for the water depth. Lines are planned with a minimum of 25 meters of overlap with adjacent swaths. Vessel speed is adjusted to ensure that an object one meter square in size would be detected and clearly imaged across the sonar swath. Typical SSS collection speed is five knots. Confidence checks are performed by observing operation of the SSS along pier faces, buoy blocks, and in areas with known targets.

High frequency of 500 KHz is utilized as the primary frequency for data collection, with low frequency observed, but not logged. The maximum range scale used is 100 meters, with operation on the 50 to 75 meter range scales more typical. Fish height is kept at eight to twenty percent of the range scale, except in very shallow areas (< 6 meters).

S3003 is equipped with a Dynapar cable counter used to measures the length of towfish cable deployed by counting revolutions of the towing block on the J-frame. The length of cable deployed is computed automatically and output directly to the Acquisition Workstation where it is used by the SonarPro software and logged in the SDF data format.

A.2.3 Vertical Beam Echosounder

S3003 is equipped with an Odom Echotrac CV Vertical Beam Echosounder (VBES). It was not used during this project. For more information on the VBES, see HSRR section 2.4.

A.2.4 Lead line

NRT6 uses a lead line for echosounder calibration tests. It is a non-stretching synthetic line, marked every half-meter, with a lead weight attached at the bottom. See HSRR Appendix 7, the Sounding System Comparison, for details.

A.3 Positioning Equipment

A.3.1 POS MV Positioning and Orientation System

S3003 is equipped with an Applanix Model 320 Version 4 POS/MV, interfaced with controller software installed on the Hypack computer. A Trimble DSM 132 provides differential correctors to the POS/MV, and is also interfaced on the Hypack computer via Trimble TSIP talker software. The Inertial Measurement Unit (IMU) is located in a hatch aft of the cabin, directly over the multibeam transducer. The antennae are located on the top of the cabin, on mounts that raise them off of the deck. The antenna for the Trimble receiver is located on the top of the mast.

A.3.2 Trimble DSM212

Survey launch S3003 is equipped with a Trimble DSM212L integrated 12-channel GPS receiver and dual-channel DGPS beacon receiver. The beacon receiver can simultaneously monitor two independent U.S. Coast Guard (USCG) DGPS beacons. There are three modes: Auto-Range, which locks onto the beacon nearest the vessel, Auto-Power, which locks onto the beacon with the greatest signal strength, and Manual, which allows the user to select the desired beacon. Additionally, the DSM212L can accept differential correctors (RTCM messages) from an external source such as a user established DGPS reference station.

The following parameters can be monitored in real-time through Trimble's TSIP Talker software to ensure position data quality: number of satellites used in the solution, horizontal dilution of precision (HDOP), latency of correctors and beacon signal strength. The DSM212L is configured in the auto-range mode to only use correctors from the nearest USCG beacon, to go off-line if the age of DGPS correctors exceeded 20 seconds, and to exclude satellites with an altitude below 8∘. The DSM212L is used to supply differential correctors (RTCM) to the POS MV primary GPS receiver through the DIFF port on the POS MV PCS.

A.3.3 Trimble GeoXH Handheld GPS

NRT6 recently acquired a new handheld GPS unit to replace the older Trimble backpack-based units. The GeoXH is used to position AtoNs and assist with shoreline. Fixed Aids to Navigation (AtoNs) are occupied for a minute or longer, which allows for a horizontal precision of .1m or less after post processing.

NRT6 uses the standard data dictionary given in Appendix 5 of the Field Procedures Manual.

NRT6 processes rover data collected on the GeoXH using Pathfinder software. Data are post-processed using local CORS stations. Typical processing uses multiple CORS sites, as there are numerous sites in NRT6's operating area.

For AtoNs, the processed file is then exported as a SHP file, and formatted for submission to MCD, as outlined in Appendix 5 of the Field Procedures Manual.

A.4 Software

Basic descriptions of the various software used for acquisition, processing, and other tasks are listed below. For further information, including details about software versions and other information, please see the 2012 HSRR.

A.4.1 Acquisition Software

A.4.1.1 Hypack

Coastal Oceanographic's Hypack Max is used for vessel navigation and line tracking during data acquisition. NRT6 used HYPACK 2011 for this survey.

Hypack Max's Survey program is used to log SBES data and is used in conjunction with Hypack Max's Hysweep Survey program to log MBES data. SBES and MBES data are logged in the Hypack "raw" format, with SBES data using the day number as an extension and MBES data using the .hsx extension. Both are ASCII text files.

A.4.1.2 SonarPro

Klein SonarPro version 11.6 is used to monitor and log all side scan sonar data from the Klein 3000 sonar. Data is recorded in the Klein SDF format.

A.4.2 Processing Software

A.4.2.1 CARIS HIPS/SIPS

NRT6 uses CARIS HIPS/SIPS 7.1, updated with the most current hotfixes, to process all sonar data. See Appendixes 10 and 11 of the HSRR for a detailed discussion of the current CARIS HVF file.

A.4.2.2 MapInfo

Mapinfo 10.5 is used on all processing computers for project planning, and creating survey products. HydroMI, a NOAA in-house software application, is used with

MapInfo to convert planned lines for use with Hypack, create chartlets, and perform a number of other survey-related tasks.

A.4.2.3 Pydro

The latest version of Pydro is installed on the three main processing workstations. Pydro is used to organize survey feature data and bathymetry, to generate reports, and for a number of other survey-related tasks.

A.4.3 Other Software

Velocipy is used to process CTD casts into CARIS .SVP files, used to correct the sound velocity profile in CARIS.

B. Data Processing and Quality Control

B.1 Shallow-Water Multibeam Data

Shallow-water multibeam (SWMB) data were monitored in real-time using the 2-D and 3-D data display windows in Hypack Hysweep, and the Simrad controller window. As the Simrad EM3002 is a relatively "hands-off" system, few parameters are adjustable by the sonar operator. Ping rate, range scale, power, and gain are all automatically adjusted by the Simrad system. In the Runtime Parameters menu, under Sounder Main, the user is able to set a maximum ping rate, and a minimum and maximum depth.

Simrad SIS .ALL files were converted to CARIS HDCS files following acquisition. Tide, sound velocity (SVP), vessel offset, dynamic draft, and True Heave correctors were then applied and merged with depth, position and attitude data to compute the corrected depth and position of each sounding. The Total Propagated Uncertainty (TPU) was then computed for each sounding, using the error values included in the CARIS HIPS Vessel File (HVF). TPU values are used to create a Bathymetry Associated with Statistical Error (BASE) surface, a grid comprised of nodes that contain bathymetric and uncertainty information. NRT6 uses the Combined Uncertainty and Bathymetric Estimator (CUBE) algorithm to create BASE surfaces from SWMB data. The CUBE algorithm creates a BASE surface grid by first creating depth hypotheses at each grid node, and then using density, locale, or a combination of the two to choose the best hypothesis. NRT6 used the parameters (and the associated XML file) outlined in Hydrographic Technical Directive 2009-2 for the surfaces generated in this survey. Specifically, NRT6 used the NOAA_1m and NOAA_0.5m CUBE parameters. Please see the HVF Review, located in the HSRR, for updated information on the TPU values used in during this project.

The BASE surface is then used to conduct area-based editing in CARIS subset mode, which allows the processor to focus on specific areas with higher uncertainty values and also a high number of CUBE hypotheses. In addition to area-based editing, subset tiles

were also used to systematically review the entire project area in subset mode. Both of these review methods include removing fliers and or noise in the water column, as well as picking the least depth on significant contacts.   Filtering was also used to assist in cleaning noise and fliers. NRT6 used the IHO Order 1 filter in CARIS for this project.

B.2. Side Scan Sonar Data

Side Scan Sonar (SSS) data were collected and monitored with Klein Sonar Pro Version 11.6. Files were saved in .SDF format. Range scale, gain, and towfish height were all adjusted to ensure the collection of quality data, and that the imagery and towfish height met the requirements of the HSSD. Sonar imagery quality checks were performed on objects located within the survey area.

.SDF are converted to CARIS SIPS files, and reviewed for significant contacts using the Side Scan Editor. Contacts are then exported into Pydro, where they are then examined and categorized based on significance. Significant contacts are noted, and are later developed using SWMB. Mosaics of the data are created to ensure complete coverage of the survey area.

All SSS data were examined and re-acquired if motion artifacts, boat wakes, or refraction prevented the identification of targets while examining side scan data.

B.3. Composite Source File

A composite source file (CSF) was included with this project. The CSF items were imported into Pydro and clipped so that all objects outside the sheet extents were excluded. The items were then filtered in Pydro by object class to create a manageable workspace. Mandatory object classes were brought into Pydro and items that were deemed too shallow or dangerous to investigate were not marked "Investigate". The remaining items were selected to investigate, and Hypack targets were exported. Boat sheets with images of the CSF items located on the chart were created, and used for notes on the items while surveying. These sheets were scanned and are located under Acquisition Logs in the CSF folder.

In Pydro, all CSF items were marked with the keyword "CSF", and a separate "CSF Items" tab in the PSS was created.   The CSF items were then correlated to SSS and MB features. Items that were not found were classified "Chart-Delete". Items that were present, but differed from the CSF description were classified secondary to sonar features, and marked "Chart-Modify". Items that were investigated and found, but did not differ from the CSF items were classified "Chart-None". All S-57 attributes were assigned for each CSF item investigated. If the item was not found or investigated, the S-57 information from the original CSF was retained. CSF items on the chart that were picked to be modified or deleted will also be included in the Survey Feature Report located in Appendix II.

The Navigation Response Branch is in the process of streamlining the CSF process to guarantee that future submissions include all pertinent CSF items while taking out redundancies and extra work that clutters the survey area. The new assigned feature files (AFF) will supersede the original CSFs and are currently being compiled for the San Francisco Bay area.

C. Corrections to Echo Soundings

C.1. Sound Velocity

Sound velocity profiles were acquired with the SeaBird Electronic SeaCat SBE19Plus Conductivity, Temperature, and Depth (CTD) profiler (see HSRR Appendixes 5 and 6 for serial numbers and calibration dates). Raw CTD data were processed using the program Velocipy.

An Odom Digibar Pro sound velocimeter, mounted on the transom, measured the speed of sound near the face of the transducer. The Simrad EM3002 has a flat-faced transducer, necessitating corrections to the returning wave front based on the speed of sound.

C.2. Vessel Offsets and Dynamic Draft Corrections

Measurements to verify the vessel offsets currently used by NRT6 were taken by a survey team from the National Geodetic Survey in March 2009. New offset measurements from the reference point to the multibeam transducer and IMU were taken following the retrofitting of the multibeam transducer. Both were relocated to points aft of the cabin. For complete survey details, please see the NGS Offset measurement report in Appendix 1 of the HSRR.

An adjustment to the offsets to correct for the phase center of the POS/MV antenna may be seen in section 1.1.1 of the 2012 HSRR.

A new dynamic draft test was conducted on October 2nd, 2012, and the dynamic draft values calculated from this test are used during this survey. Please see Appendix 2 of the HSRR for dynamic draft test details.

Angular offsets and navigation timing errors of the multibeam system were determined using a patch test. A series of calibration lines are run and processed using the CARIS Calibration mode. The patch test report may be found in the 2012 HSRR, Appendix 8.

Static and dynamic offsets (settlement and squat values), angular offsets, and navigation timing errors are entered into the CARIS HIPS Vessel File (HVF), which is used to correct CARIS HDCS data.

C.3 Heave, Pitch, Roll, Heading, and Timing

The POS/MV 320 provided attitude data to SIS, which stored the data in the ALL multibeam file. Attitude data quality is monitored while surveying by monitoring the POS Controller window, which is installed on the Hypack workstation. Alarms are triggered when accuracy values fall below user-determined values.

As discussed in the previous section, navigation timing error is determined using the patch test, and applied to data using the CARIS HVF.

C.4 Water Level Correctors

Soundings were reduced to Mean Lower-Low Water (MLLW) using preliminary tides, taken from stations 9414750, Alameda, CA, 9414290, San Francisco, CA and 9414863 Richmond, CA. The Zone Definition File for this project was L430NRT62012CORP.zdf. The .zdf file breaks the survey area into polygons that take into account the magnitude and time differences from a primary tide gauge. Once available, the verified tide data is applied before submitting hydrographic survey data.

D. Approval

As Chief of Party, I have ensured that standard field surveying and processing procedures were used during this project in accordance with the Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables Manual, as updated for 2012.

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

Approved and Forwarded: _____

                      Laura Pagano
                      Physical Scientist Technician
                      Acting Team Leader, NRT6