

# **Data Acquisition and Processing Report**

**NOAA S3003**

**OPR-M914-NRT6-08**





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## **Introduction**

This Data Acquisition and Processing Report (DAPR) describes 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 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 Launch 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 0.4 meters, and is powered by twin 130hp Honda outboards. Vessel descriptions and offset measurements are detailed in Chapter 1.1 and Appendixes 1,2 and 3 of the HSRR.

## Vessel Information

<b>Hull Number:</b>	<b>S3003</b>
<b>Builder:</b>	<b>SeaArk</b>
<b>Built:</b>	<b>2003</b>
<b>Length Overall:</b>	<b>33 ft.</b>
<b>Beam:</b>	<b>8 ft.</b>
<b>Draft:</b>	<b>1.6 ft.</b>
<b>Cruising Speed</b>	<b>28kts</b>
<b>Min/Max Survey Speed :</b>	<b>4-8kts.</b>
<b>Primary Echosounder:</b>	<b>Hull-mounted Simrad EM3000 MBES</b>
<b>Secondary Echosounder:</b>	<b>Hull-mounted ODOM Echotrac CV VBES</b>
<b>Imagery System</b>	<b>Towed Klein 3000 Side Scan Sonar system</b>
<b>Sound Velocity Profiler:</b>	<b>Sea-Bird SeaCat SBE 19+ CTD Profiler</b>
<b>Surface Sound Velocity Probe:</b>	<b>ODOM Digibar Pro</b>

## A.2 Sounding Equipment

### A.2.1 Shallow Water Multibeam Sonar

S3003 is equipped with a Kongsberg Simrad EM3000 shallow water multibeam echosounder. The Simrad EM3000 is a single-frequency echosounder with a central frequency of 300 kHz. The EM3000 has 127 beams, each of which has a 1.5° beam width. The maximum ping rate of this echosounder is 25 Hz. Soundings are acquired in meters.

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 beamforming, 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.

EM3000 controller software, operating on the Hypack computer and communicating via Ethernet connection, is used to control adjustable parameters such as range scale, power, gain and pulse width. 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.

OPR-M914-NRT6-08 is the first multibeam project following the retrofitting of the multibeam head. The sonar head was relocated to a hull mount, aft of the vessel cabin, centered on the keel line. The POS/MV IMU was also relocated so that it is centered

above the sonar head. Following the installation, a new patch test and settlement and squat test were conducted, offset measurements were taken to the sonar head, and the CARIS HVF was changed to include the new offset values. The new distance from the IMU to the primary GPS antenna was entered into the POS/MV controller. Please see the additional reports included in the DAPR folder for further information on the retrofitting of the EM3000 transducer, and the subsequent patch and settlement and squat tests. Please see the CARIS HVF for new offset values.

The removal of the pole mount also necessitated the relocation of the Odom Digibar, which is used to determine the speed of sound at the face of the multibeam transducer. The best solution thus far has been to mount the probe 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 and large debris (particularly seaweed during outgoing tides) 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. These areas were noted during survey operations, and were later re-surveyed. The post-processing of data may result in the rejection of additional areas with sound velocity areas that weren’t immediately distinguished during survey operations.

It was noted while examining data with CARIS subset editor that the echosounder skipped pings when the ping rate rose above 14 Hz. The EM 3000 automatically adjusts its ping rate according to depth, increasing the rate as the depth decreases. As a result, this problem was seen in depths approximately 6 meters or less. This problem has also occurred with NRT5’s survey system. A simple work-around is to set the ping rate at a maximum of 12 or 13 Hz (When set at 13 Hz, the ping rate may occasionally rise to the point where pings are skipped, so 12 may be a “safe” value) in the Simrad Controller window. At this ping rate, the sounding density in the along-track will remain well above the required 3.2 soundings/3m<sup>3</sup>, (HSSD section 5.2.2), at typical survey speeds.

A problem noted during this survey is the random skipping of attitude data, for periods of up to three seconds. The problem is observed as a short, isolated roll artifact in the DTM. CARIS interpolates across these attitude gaps, but usually misses one or more periods of roll. This problem was been noted on other NRT teams with similar survey systems. This is a newly observed problem, and is being discussed with the sonar and acquisition software manufacturers.

### **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)
- Workstation Display and Control Unit (WDCU)
- 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 NT environment on the WDCU. 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 WDCU 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 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 measure 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 WDCU 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 2.3.2

### **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 8, 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 the hatch just forward of the door, a protected location that is spatially close to the vessel's center of motion. 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.



Photographs and calibration details of the POS/MV may be found in section 2 of the HSRR. A full calibration report is located in Appendix 7 of the HSRR.

### **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 GPS Backpack System**

The Trimble backpack unit is used to collect DGPS data on fixed aids to navigation and to update high water features and natural shoreline.

The Trimble backpack unit consists of the following:

- Pro XRS 12 channel DGPS receiver
- Combined L1 GPS/Beacon/Satellite Differential Antenna
- TSCe data logger with Windows CE operating system



*Trimble backpack unit*

The ProXRS receiver is set to collect data using the following restrictions:

- Minimum No. of satellites: 5
- Maximum PDOP: 6
- Minimum SNR: 6
- Minimum Satellite elevation: 15 degrees

Data collection rates and times are:

- Fixed aides to navigation: One second data collected for ten minutes.
- Other point features: One second data collected for one minute.

Line features: One second interval for length of line or single points collected at corners

Trimble's TerraSync software is used on the Trimble TSCe data logger to collect DGPS data in the field. A data dictionary created by NRT6 is used in the collection process to categorize and add metadata to features. Features are collected under one of three categories: fixed aids, structures or lines.

Line data is acquired on curved and/or complex structures where collecting discrete, multiple points would be confusing. In most cases, these DGPS line data positions are acquired by collecting a data point along the outside edge of a feature at an angle or intersection, then pausing data collection until the next angle or intersection is reached, at which point a new position is logged to the line. These steps would be repeated until the feature is completely defined. The Pathfinder software extrapolates between the points acquired to create a continuous line and clearly delineate the feature.

In some cases where shoreline changes are obvious, line data is collected while walking along the waterline to delineate the revised shoreline.

On bridges where walking is impractical, a line is obtained while driving a vehicle across the bridge (antenna positioned outside the passenger side window). An offset to the edge of the bridge is estimated and entered in the collection process to more accurately depict the structure.

All items are assigned position numbers based on the day number and order of collection in the format DDD.###, where DDD is the day number and ### is incremented with each data point, e.g., 301.001, 301.002, etc.

## **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 2008 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.

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 8 is used to monitor and log all side scan sonar data from the Klein 3000 sonar. Data is recorded in the Klein SDF format. Compatibility issues with the Klein boot file occurred during the upgrade to the latest version SonarPro, so version 8 is still being used.

### **A.4.2 Processing Software**

#### A.4.2.1 CARIS HIPS/SIPS

NRT6 uses CARIS HIPS/SIPS 6.1, SP1, updated with the most current hotfixes, to process all sonar data. See Appendix 11 of the HSRR for a copy of the current CARIS HVF file.

#### A.4.2.2 MapInfo

Mapinfo 9.0 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**

Velocwin 8.8 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 EM3000 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 Settings menu, the user is able to set a maximum ping rate, and a minimum and maximum depth.

Hypack Hysweep .HSX SWMB 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 Error (TPE) was then computed for each sounding, using the error values included in the CARIS HIPS Vessel File (HVF). TPE 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.

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. BASE surfaces were gridded at a resolution of 1m.

## **B.2. Side Scan Sonar Data**

Side Scan Sonar (SSS) data were collected and monitored with Klein Sonar Pro Version 8. 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.

## **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 Appendix 6 for serial numbers and calibration dates). Raw CTD data were processed using the program VelocWin version 8.8.

An Odom Digibar Pro sound velocimeter, mounted near the SWMB arm, measured the speed of sound at the face of the transducer. The Simrad EM3000 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 in March 2008. For a complete discussion of vessel offsets, see section 1.1, and Appendixes 1, 2 and 3 of the 2008 HSRR.

Dynamic draft measurements were taken in July 2008. Please see the Settlement and Squat Report included in the DAPR folder.

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. A patch test was conducted following the re-installation of the multibeam transducer. Please see the Patch Test Report included in the DAPR folder.

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 Hypack, which stored the data in the HSX 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. See Appendix 7, POS MV Calibration Report, in the 2008 HSRR for the user-determined accuracy 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 observed tides, taken from station 9415020, Point Reyes, Drake's Bay, CA. The Zone Definition File for this project was L927NRT62007CORP.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**

### **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 2008.

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

Approved and Forwarded: \_\_\_\_\_

Eric M. Moore  
Physical Scientist Technician  
Team Leader, NRT6