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

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey: __Navigable Area __

Time Frame: __2005 Field Season__

2005

CHIEF OF PARTY

LCDR Todd A. Haupt, NOAA

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Data Acquisition and Processing Report to Accompany 2005 Hydrographic Surveys

NOAA Ship RUDE (S590) LCDR Todd A. Haupt, NOAA, Commanding

A. EQUIPMENT

A.1 Platforms

All data are acquired from NOAA Ship RUDE (S590, EDP #9040) and NOAA Survey Launch 1419. RUDE and 1419 are equipped with multibeam, vertical beam echosounders, and side scan sonar. RUDE is a Class V Hydrographic Survey Ship, 90 feet in length overall, with a 22-foot beam and 7-foot draft. Launch 1419 is a 25-foot SeaArk aluminum launch, with an 8.5 foot beam, and 1.5 foot draft. Refer to Appendix III for more detailed vessel descriptions and equipment positioning diagrams.

A.2 Sounding Instruments

Vertical Beam Echo Sounder

RUDE and Launch 1419 are equipped with Odom Echotrac DF3200 MKII Dual Frequency Vertical-Beam Echosounders (VBES) configured for 24 and 200 kHz operation. Both frequencies are digitized and recorded at 5 Hz. Actual ping rates are dependent on the depth of water. Aboard RUDE, the VBES is the primary bathymetric sounding source during side scan sonar operations and quality control for the ship's multibeam echosounder system. VBES also provides bathymetry during side scan sonar operations on Launch 1419; however, the high frequency VBES and the multibeam echosounder system on 1419 operate at the same sonic frequency. Therefore, during Launch multibeam acquisition, only the low frequency VBES transducer is logged.

On each platform, VBES data is logged by the Hypack software package (see section A.5 below), but paper records are acquired and retained for comparison with digitized depths during processing whenever the VBES is the primary sounding instrument.

The VBES data are acquired in conjunction with side scan sonar or multibeam echo sounder acquisition. Side Scan Sonar line spacing is dictated by the acquisition requirements of the survey and the range scale used for a survey. Multibeam sonar system is used for shoal developments and item investigations with a typical line spacing of 10 meters.

Shallow Water Multibeam Echosounder
RUDE is equipped with a RESON Seabat 8125 Shallow Water Multibeam Sonar System (SWMB). The SWMB is a 455 kHz multibeam sonar that is efficient for water depths of 60 meters or less. For depths greater than 60 meters, the swath width decreases significantly as the depths increase. The 8125 utilizes an integrated transmit/receive head, which is pole mounted on the port side of the vessel. The 8125 projects a single transmit pulse and listens for the return echo using beam forming. There 240 beams, each 0.5° (across track) by 1.0° (along track). The 8125 is capable of ping rates from 3.02 Hz to 40.05 Hz, depending on range scale. However, to avoid extraneous amounts of sound in shallow water areas, the maximum ping rate is set to 20 Hz. The 8125 transmit power level and Time Varied Gain (TVG) receiver gain controls are adjusted to minimize returns from water column clutter and surface reflection. The 8125 Depth filters are adjusted to remove aberrant shallow and deep returns during acquisition. During SWMB data acquisition, the ship is operated at speeds resulting in a minimum of 3.2 pings / 3 meters along track bottom coverage. The 8125 multibeam sonar generates digital sounding data, backscatter, and snippets data that is logged by the ISIS software package (see section A.5 below).

Launch 1419 is equipped with a RESON Seabat 8124 Shallow Water Multibeam System (SWMB). The SWMB operates at a frequency of 200 KHZ and is designed for water depths of up to 650 m. The RESON Seabat 8124 is pole mounted on the port side of the launch. The 8124 transducer transmits a single pulse and receives using 80 beams. Each beam is 1.5° in the along track direction and 1.5° in the across track direction. The 8124 is capable of ping rates from 0.95 Hz to 39.89 Hz, depending on range scale. However, to avoid extraneous sound in shallow water areas, the maximum ping rate is set at 20 Hz. The 8124 transmit power level and Time Varied Gain (TVG) receiver gain controls are adjusted to minimize returns from water column clutter and surface reflection. The 8124 Depth filters are adjusted to remove aberrant shallow and deep returns during acquisition. During SWMB data acquisition, the ship is operated at speeds resulting in a minimum of 3.2 pings / 3 meters along track bottom coverage. The 8124 multibeam sonar generates digital sounding data and backscatter that is logged by the ISIS software package (see section A.5 below).

A reference surface test with NOAA Ship Rude was conducted in March 2005 to assess the precision of the SWMB system. This test showed that under the prevailing conditions at that time and location, RUDE's sonar systems exceeded the International Hydrographic Organization "Special Order" specification for vertical soundings. Ship's equipment meet IHO "Special Order" specifications but can not achieve "Special Order" due to tide zones. See the report attached in System Certification 2005 for complete results.

To achieve 100% MultiBeam Echosounder (MBES) coverage, lines are run parallel to bottom contours at spacing of approximately 2 ½ times the water depth. After initial acquisition, coverage plots are generated and reviewed using

BASE Surface plot data at a resolution of no more than 5 meters depending on depth, and additional lines are planned to fill any gaps.

Side Scan Sonar
RUDE and Launch 1419 carry a Klein 5500 High Speed High Resolution Side Scan Sonar (HSHRSSS) towfish and a Klein 3200 dual frequency towfish, respectively. Klein side-scan sonar data from both platforms are recorded digitally from the Transceiver and Processing Unit (TPU) using the ISIS software and archived in the Extended Triton Format (*.XTF) files (see section A.5). The Klein 5500 towfish transmits at 455 kHz. The Klein 3000 towfish transmits at 100 kHz and 500 kHz.

RUDE's ship wake turbulence limits SSS acquisition by RUDE to depths greater than approximately 8 meters. SSS from Launch 1419 is similarly limited to depths greater than roughly 4 meters.

Side scan sonar lines are planned to run parallel to bottom contours, spaced in accordance with the Side Scan Sonar Manual. Lines are planned with at least 15m of overlap with adjacent swaths on either side. Range scales are determined primarily by water depth.

Vessel speed is adjusted to ensure that an object one meter in characteristic size would be detected and clearly imaged across the sonar swath. Confidence checks are performed and noted frequently to ensure this standard of resolution is met.

Lead Line
A lead line test on NOAA Ship Rude was conducted in March 2005 to confirm the calibration of RUDE's VBES and SWMB. This test showed that under the prevailing conditions at that time and location, RUDE's sonar systems exceeded the International Hydrographic Organization "Special Order" specification for vertical soundings. See the report attached in System Certification 2005 for complete results.

Diver Least Depth Gauge
RUDE divers are equipped with a diver least depth gauge for item investigations. The calibration report is included in System Certification 2005. The accuracy of RUDE's diver least depth gauge was also assessed as part of the Lead Line comparison test mentioned above.

A.3 Positioning and Attitude Instruments

RUDE

POS/MV 320

RUDE's primary positioning and attitude sensor is a POS/MV Model 320 Ver. 3. This system combines data from an inertial attitude sensor and carrier-phase GPS receivers to compute position, heading, heave, pitch, and roll to the accuracy required for shallow water multibeam sonar surveys. The three major components of the POS/MV are: an Inertial Measurement Unit (IMU) mounted close to the ship's center of motion; two GPS antennas on the ship's mast mounted perpendicular to the line of the ship; and a Pos Computer System (PCS) processing unit on the bridge.

Differential GPS corrector input from an external source is required. These correctors are brought in with GPS data from the Trimble GPS system. A GPS receiver is directly connected to the POS/MV processor computer. RUDE's position and heading is calculated by measuring the phase difference of the GPS signals arriving at the two antennas and computing the vector between them. The resulting GPS position is corrected for the lever arm from the antennas to the center of motion. The GPS heading data and linear and angular acceleration values from the IMU are processed through a Kalman filter.

Heave is computed by double integration of acceleration in the vertical axis as measured by the IMU. Since this measurement is subject to long term drift, the data is high pass filtered with a rolloff frequency and damping coefficient selected to stabilize the measurement while preserving the phase and amplitude of the ship's vertical position in sea states anticipated in RUDE's area of operations.

All data is corrected to the position of the IMU. The final position, heave, and attitude data is outputed to the Hypack and Isis data acquisition systems via RS-232 serial and Ethernet connections. This correction data is stored within the Hypack and Isis output data files. The POS/MV system is configured for 20 Hz output of the "TSS" Heave / Roll / Pitch message and 5 Hz output of the NMEA-0183 GGA and HDT messages. (See the report attached in System Certification 2005 for POS/MV settings).

Trimble DSM-212L

RUDE's auxiliary positioning system is a Trimble DSM-212L DGPS receiver. The DSM-212L is an integrated unit combining a 12 channel L1 C/A code receiver with a 2 channel Differential Beacon receiver. This unit is used primarily to receive USCG Differential Beacon messages, which are passed with GPS data to the POS/MV auxiliary input. Although the DSM-212L has the ability to automatically select stations based on signal strength or geographic proximity, the receiver is manually tuned to avoid unexpected and undocumented changes in the differential beacon in use.

Position, time, and velocity data from the Trimble is available in a 1 Hz NMEA message as an auxiliary input to the POS/MV. The DSM-212L is configured using the “TSIP Talker” software to suspend output in the event NOS Hydrographic Position Control specifications are not met.

Furuno GP-90

RUDE also carries a Furuno GP- 90 DGPS positioning system. The system is capable of accepting either USCG Differential Beacon messages or Wide Area Augmentation System (WAAS) messages. This unit is not currently used for survey acquisition, but serves as a back-up navigation system.

Yokogawa CMZ700S Gyrocompass
RUDE is equipped with a Yokogawa CMZ700S gyrocompass. This instrument serves primarily as a heading reference for navigation.

LAUNCH 1419

Launch 1419 is undergoing a POS/MV installation. An amendment to the DAPR and System Certification will follow upon completion of the installation.

A.4 Ancillary Instruments

Sound Velocity
Conductivity, temperature, and depth profiles are acquired using two Seabird Seacat SBE-19 Conductivity, Temperature, and Depth (CTD) profilers. The SBE-19 is a self-contained, battery-powered unit with a serial interface for configuration and data download. RUDE’s SBE-19’s are equipped with a 300 psi pressure gauge to provide high resolution data in the relatively shallow water typical of RUDE’s areas of operations. Sound velocity files in CARIS format are computed using the “Velociwin” software described in section A.5.

During MBES data acquisition, CTD casts are conducted when starting work in an area and every 4 hours thereafter, or when the surface sound velocity is observed to have drifted outside accepted limits as discussed below. For VBES data, casts are conducted weekly or when survey personnel suspect a significant change in the properties of the water column. The calibration records are included in the Appendix of System Calibration 2005.

Surface sound velocity is continuously monitored during multibeam acquisition with an Odom Hydrographic Digibar Pro sound velocimeter. The velocimeter is mounted just above the multibeam transducer head. During MBES data acquisition, a new CTD cast is taken if the surface sound velocity is observed to have changed more than +/-5 m/s from its value at the last CTD cast. The calibration records for this instrument are included in the Appendix of System Calibration 2005.

Comparisons between the two CTDs and the Digibar Pro are conducted on a regular basis to ensure data quality.

Cable Counter
RUDE is equipped with a MD Totco Cable counter that measures the side scan towfish tow cable by counting revolutions of the towing block on the A-frame. The length of cable deployed is computed automatically and output to Hypack.

Cable out on Launch 1419 is manually inputed by survey personnel and read from calibrated taped markings on the SSS cable.

Bottom Sampler
Where required by project instructions, RUDE personnel acquire sediment samples from the sea floor in the survey area. The primary tool for this operation is a “clamshell” style gravity-closed sediment sampler, which penetrates approximately 0.05m into the bottom.

A.5 Data Acquisition and Processing Software

Coastal Oceanographics Hypack Max is used for survey navigation, Detached Positioning (DP), and VBES data logging. Hypack is also used for overall data acquisition control, and passes file names, line start and end messages, and fix numbers to ISIS via a serial link. In addition, during side scan sonar operations, Hypack collects cable out data and computes towfish position, which, along with raw water depth from the VBES, is also passed to ISIS.

Shallow Water Multibeam and Side Scan Sonar data is collected by the Triton Elics International ISIS software package and logged in the “eXtended Triton Format” (.xtf) file format. Because of improved timing precision, vessel position is logged to the “sensor” field of the XTF data structure, and towfish position, if present, is recorded in the “ship” position. Water depth, required for recomputation of towfish position, is stored in “Aux 1”. Cable count is recorded in the “cable out” field.

The PCs running Hypack and Isis are automatically synchronized to UTC time from the NMEA-0183 GPS messages. The time update occurs during the start and stop logging messages on the Hypack computer and during the start-logging message on the Isis computer.

CTD casts are downloaded and processed in the Velociwin program supplied by the Hydrographic Systems and Technology Program (HSTP). This software is also used to process diver’s least depth gauge readings.

Preliminary tide data is either directly collected from the Center for Operational Oceanographic Products and Services' web site, or sent to RUDE via the "Tidebot" automated tides email system. Verified tides are downloaded from the CO-OPS web site as they become available. All tide data is zone corrected using MapInfo's ZDF file creation utility software.

All sonar data is processed in the CARIS HIPS and SIPS system.

Processed soundings, side scan sonar contacts, dives, and DPs are inserted and analyzed in HSTP's "Pydro" software. This system is used for all feature assessment and bathymetry excessing.

Final sounding plots can be generated in the Mapinfo Professional GIS.

See the report attached in System Certification 2005 for listing for data acquisition and processing hardware serial numbers and software versions.

B. QUALITY CONTROL

Please refer to Appendix III for detailed Data Acquisition and Processing Flow Diagrams

B.1 Bathymetry Data

Vertical Beam Sonar Data
Vertical Beam sonar data is converted from Hypack format to CARIS format using the CARIS "Hypack" data converter (See Conversion Parameters Appendix II).

After conversion, the data is opened in CARIS Navigation Editor, Attitude Editor, and Single Beam Editor. Vessel navigation data is manually checked for speed jumps greater than 2 knots, which are rejected with interpolation. Attitude data (if present) are checked for errors or gaps. Sounding data are checked for irregular pings.

Survey personnel scan raw VBES soundings in CARIS Single Beam Editor. The digital data is compared with analog paper records to ensure no valid depths are missed by the bottom detection algorithm or irregular pings are accepted. Low frequency soundings found to be more shoal than the corresponding high frequency depths can be manually "selected". Once VBES soundings are scanned, the raw data is corrected for sound velocity and tides then the data is merged. Sound velocity corrections, tide corrections, and merging of raw VBES data is done with CARIS HIPS software package. Once all the raw VBES data is processed, a field sheet grid is created from all the processed data using a resolution of 25+ meters. A digital terrain model is generated from the gridded data, which is used as a quality control tool on a survey project.

Multibeam Sonar Data
Multibeam sonar data is converted from ISIS XTF format to CARIS HDCS format using the CARIS converter (See Conversion Parameters Appendix II)

After conversion, the converted multibeam data is examined in Caris Navigation Editor for gross navigational errors. The following tasks; sound velocity, appropriate tides, merge and compute Total Prorogated Error (TPE) can be performed individually or in a batch process to further progress the collected multibeam data. Occasionally, bottom type of the survey area or sea state during acquisition cause aberrant pings. These "fliers" are rejected. In main scheme areas, survey personnel employ the CARIS depth filter to facilitate cleaning. The filter is configured as a window with appropriate lateral, upper, and lower constraints chosen based on the expected mean depth and the variability of bathymetry and TPE which does not meet IHO criteria. After applying the filter, survey personnel review the data to ensure that only those soundings that are clearly incorrect are rejected (See Conversion Parameters Appendix II).

A daily fieldsheet is created to make a BASE surface of the daily collected data. The daily fieldsheet helps survey personnel keep a running track of the clean data versus uncleaned data using the tiles utility in CARIS. The BASE surface resolution is based on depth and the actual resolutions are annotated in the Field Procedures Manual. Upon completion of area cleaning of MBES data, the daily BASE surface is recomputed and added to the ongoing project's BASE surface.

Final Processing of Sounding Data

All single-beam and multibeam data are sound velocity corrected. The sound velocity profiles that are nearest in time are applied to the sounding data.

Zoned tides are applied in the field to all bathymetry data. Preliminary observed water levels obtained from either the CO-OPS web site or through Tidebot email is used. The tide Zone Definition File (ZDF) is either supplied with the project information or created through MapInfo's export tide region to CARIS HIPS ZDF format utility supplied by HSTP. The resulting zone file and tide files are applied to the corresponding data in CARIS, and merged. When Verified Tides become available, this data is downloaded from the CO-OPS site and applied to the bathymetric data through a re-merge.

Once the daily multibeam data is cleaned and processed, the sheet manager performs multiple tasks to ensure quality assurance of the end product. First the sheet manager creates an ongoing fieldsheet to incorporate all cleaned multibeam data into a BASE surface. Again, the BASE surface resolution is dictated by the Field Procedures Manual. The BASE surface doesn't always accurately depict shoalest soundings. However, using designated soundings allows the BASE surface model to represent the shoal soundings. Using the standard deviation layer in BASE usually allows the sheet manager to zero-in at areas of interest and designate the shoalest sounding(s). Also, using SSS contact imagery along with multibeam data allows the sheet manager to search for shoal soundings to designate. The BASE surface is finalized to accurately depict shoal soundings in the BASE model. Finally, prior to submitting data to the processing branch, a coverage plot of multibeam data is generated at a resolution of no more than five meter to show 100% multibeam coverage.

In the case of areas covered with VBES only, grids are created at a much a lower resolution to facilitate digital terrain models that can be visually interpreted. These products are analyzed to assess coverage and highlight remaining data problems.

B.2 Side Scan Sonar Imagery

All side scan sonar imagery is converted from XTF formats to CARIS format using CARIS converters (See conversion parameters Appendix II).

After conversion, the data is opened in CARIS Navigation Editor, Attitude Editor, and Side Scan Editor. Survey personnel check vessel attitude (if present), cable out, Gyro, and sonar height. Vessel navigation data is manually checked for speed jumps greater than 2 kts. Data showing these speed jumps are rejected with interpolation.

After confirming the validity of the vessel navigation, cable out, and towfish depth values, survey personnel then use the "recompute towfish navigation" function to calculate towfish position. The CARIS towfish positioning is based on a smoothed course made good value from the towing vessel.

Side scan sonar data is scanned in CARIS Side Scan Editor. Survey personnel correct errors in bottom tracking, slant range correct the imagery at default resolution (0.1m), and scan the data for significant contacts. Contacts deemed "significant" include, but are not limited to, contacts with a shadow indicating a contact height of 1 m or greater in water depths of 20m or less or contact heights 10% of the water depth in water deeper than 20m. Other contacts considered significant by RUDE personnel include smaller contacts in particularly shoal areas or channels, cables and pipelines, large sand wave ridges, and contacts of possible historical significance.

Point feature contacts are picked using CARIS "single point contacts". Larger contacts and line features are picked using CARIS "multipoint contacts". All contacts are descriptively labeled and feature codes selected if conclusive identification is possible. TIF format images of all contacts are saved. After the initial SSS imagery scan, a check scan of all data is conducted.

Survey personnel assess SSS coverage by using CARIS to mosaic side scan data. These mosaics are drawn at 1 - 5m resolution, using the "autoseam" option.

B.3 Data Analysis

HSTP's Pydro software package is the primary tool for sounding and feature integration and assessment. Side scan contacts and detached positions are inserted into the Pydro Preliminary Smooth Sheet (PSS). Bathymetry is imported into Pydro at a 15m by 15m BASE surface grid at a three meter resolution. Survey sheet officers use Pydro to assess and categorize contacts, and suppress soundings to produce a BASE surface bathymetry data set at the scale of the survey.

Pydro provides five flags for categorizing features: “Significant”, “Chart”, “Report”, “Investigate”, and “DTON”. In addition, pydro provides “Primary” and ”Secondary” flags for grouping correlated features.

After insertion, SSS features are first categorized by significance. Contacts that meet the standard of significance described in section B.2. are marked as such; those contacts which are deemed insignificant are marked “Resolved” and not investigated further. Also, multiple contacts representing the same physical feature are grouped. The contact that the hydrographer believes best represents the feature (typically, the most clear SSS image) is selected as the “Primary” contact, while the rest are flagged as “Secondary.”

Significant contacts are then reassessed to determine if additional investigation (typically SWMB development) is required. Using the “bathymetry grid” feature of pydro, the hydrographer checks the bathymetry coverage of the contact in question. If additional bathymetry is required, the “investigate” flag is checked. This can then be queried in Mapinfo to select only those contacts requiring development for line planning.

After contacts are sufficiently investigated, they are further assessed to determine whether they require charting. Features that the hydrographer believes should be added or retained on the chart are marked as such. Features that will be reported in the survey Descriptive Report are flagged “Report.” Features that pose a special threat to vessel traffic have their shoal soundings marked as “DTONS”, and a Danger to Navigation Report is generated.

Each physical feature should have one Pydro contact as the “Primary” contact. This contact represents the best information (horizontal and vertical position) available at the time. Many contacts that represent the same physical feature may be marked “Secondary” and should be thought of as additional information only.

Contacts and bathymetry analyzed in Pydro maybe imported into Mapinfo for plotting and further contact development planning. Contact and sounding plots are printed at survey scale for final survey assessment.

C. CORRECTIONS TO ECHO SOUNDINGS

It is OCS and RUDE policy that all data be acquired and logged in raw format without application of any corrections for vessel offsets, sensor alignment, sound velocity profile, or tides. These factors are logged separately or contained in the CARIS “Vessel Configuration File” (VCF), and applied in post-acquisition data processing.

C.1 Vessel Offsets and Static Draft

RUDE
Please refer to 2005 Hydrographic System Certification for vessel offsets and static draft.

Application
Static transducer offsets are applied to all bathymetry data during the CARIS "SVP Correct" operation. Horizontal offsets are applied during CARIS "Merge".

C.2 Dynamic Draft

RUDE
Please refer to 2005 Hydrographic System Certification for dynamic draft information

Application
Dynamic Draft corrections are applied to all bathymetry data in the CARIS "SVP Correct" operation.

C.3 Attitude and Heave

Heave, pitch, and roll corrections are applied to SWMB and VBES bathymetry data in the CARIS "SVP Correct" operation. Yaw corrections are applied during CARIS "Merge".

C.4 Sound Velocity Profile

RUDE carries two Seabird SBE-19 Conductivity, Temperature, and Depth profilers. These instruments are returned to the manufacturer yearly for calibration. Records of the latest calibrations are included in Appendix IV.

RUDE personnel conduct CTD data quality assessments prior to a new sheet survey project by comparing CTD readings at the surface with Digibar Pro and a bucket thermometer. This information is processed using Velociwin "comparison cast" feature.

As described in Section A.4, A.5, and B.1, raw conductivity, temperature and depth data are processed to produce sound velocity files in CARIS format. These profiles are applied in CARIS "SVP Correct".

C.5 Water Levels

Soundings are corrected to Mean Lower Low Water using first Preliminary Unverified tides, and then Verified tides when available, according to the procedure described in Section B.1. All raw tide data is corrected according to the zoning provided with the relevant project instructions prior to application to bathymetry data.

During bathymetric data collection, subordinate gauges included in the project instructions are monitored via the CO-OPS web site, “Tidebot” email, and the CORMS Morning Report. When water level measurement problems are suspected, RUDE personnel bring them to the attention of CO-OPS staff before continuing bathymetric data acquisition.

Water level corrections are applied during CARIS “Merge”.

D. APPROVAL SHEET

LETTER OF APPROVAL

Data acquisition and processing is conducted under my direct supervision with frequent personal checks of progress and adequacy. All equipment is continuously monitored for proper operation during data acquisition and all supplemental and supporting records are reviewed in their entirety.

This Data Acquisition and Processing Report is adequate to accompany Descriptive Reports for surveys including data collected during NOAA Ship RUDE's 2005 Field Season.

Respectfully Submitted:

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Richard Edmundson
LTJG, NOAA
Field Operations Officer
NOAA Ship RUDE

Approved:

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Todd A. Haupt
LCDR, NOAA
Commanding Officer
NOAA Ship RUDE

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