Data Acquisition and Certification Report

Cruise Number NF-04-06-VI

W00123, W00124, and W00125

NOAA Ship Nancy Foster

St. Croix, St. John, and St. Thomas, U.S. Virgin Islands

Cruise Instructions dated January 2004

Chief Scientist: Mark E. Monaco

Lead Hydrographer: Sean C. Rooney

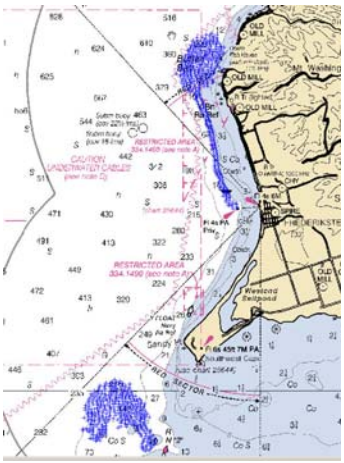
I. Background:

The purpose of this cruise was to support the National Oceanic and Atmospheric Administration's research on the characterization of near shore and deepwater habitats (<1000m) of Buck Island Reef and Virgin Islands National Coral Reef Monuments. Data from the mission will be used to produce maps of the seafloor topography, delineate the various seafloor habitats, and collect data to assist in the development of models to predict fish species utilization and populations. In addition the data collected will be used to update nautical charts covering the U.S. Virgin Islands.

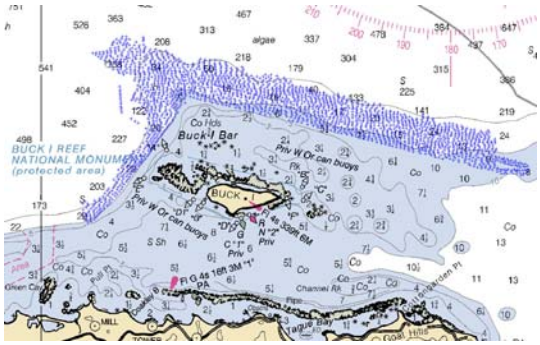
II. Area surveyed:

This project took place from February 18 through March 5, 2004 in the waters surrounding the U.S. Virgin Islands. One hundred percent shallow-water multibeam (SWMB) coverage was obtained within the survey area. In addition, backscatter data in "Snippets" and standard sidescan formats were collected for these areas. Underwater video, visual dive observations and fish trapping were conducted in portions of the survey areas to provide ground truthing of bottom characteristics, as well as to provide estimates of fish population in these areas.

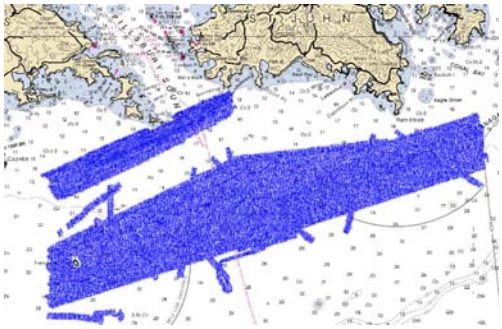
The project encompassed three main survey areas, as well as several smaller survey sites in response to on site requests. The patch tests and on site request surveys were located off the western extent of St. Croix (17°42'58.85" N 064°53'49.96" W; (298807.56, 1959817.74)). The first survey site was located in the vicinity of Buck Island, on the northwest side of St. Croix (17°47'47.45" N, 064°38'01.53" W; (326829.6, 1968427.73)). The two other survey sites were located in the waters between St. Thomas (18°17'04.26" N 064°49'23.01" W; (306180.88 , 2021790.14)) and St. John (18°15'18.07" N, 064°45'46.63" W; (312840.43 , 2019020.33)), on their south sides.



Patch test and onsite request sites



Buck Island



St. Thomas and St. John

III. Submitted Data and Reports:

The following documentation and data will accompany this survey upon completion:

Data:

- Raw multibeam sonar sounding files in XTF format
- Processed multibeam sounding files in CARIS HDCS format
- Raw and processed sound velocity data files
- Predicted tides correctors (created from NOAA NWLON Gauges Charlotte Amalie (975-1639) and Lime Tree Bay (975-1401)
- Verified tide correctors (created from NOAA NWLON Gauges Charlotte Amalie (975-1639) and Lime Tree Bay (975-1401)
- Tidal zoning prepared by NOAA CO-OPS
- Mosaics of side scan and backscatter
- XYZ files
- CARIS Vessel Configuration File (VCF)

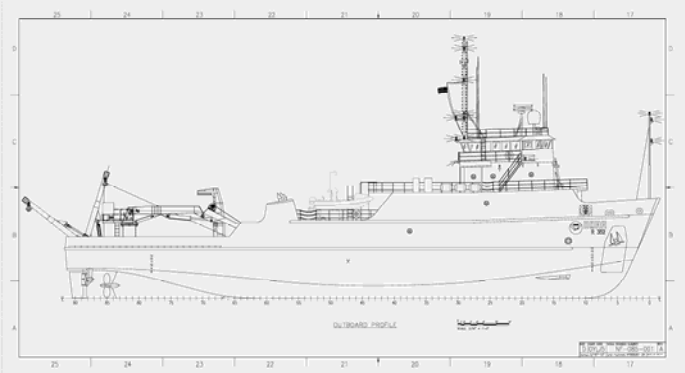
Documentation:

- A copy of Cruise Instructions for cruise NF-04-06-VI
- E-mail correspondence
- Report of data processing by NCCOS contractor
- Offset measurements and diagrams
- Data Acquisition and Certification report
- Copies of data acquisition and processing logs
- Digital photos

IV. Description of survey systems

Platform

The NOAA Ship Nancy Foster was the only vessel used during this survey. The vessel is 56.8 meters long, 12 meters wide and has a draft of 3.2 meters. The vessel was used to acquire shallow-water multibeam (SWMB) bathymetry and back scatter data. Sound velocity profiles were collected in support of hydrographic survey operations. A towed sled collected video for ground truth the multibeam backscatter. Fish traps were deployed and recovered from the vessel for population and species composition estimates. Scuba dives to measure habitat health, species composition and population estimates, were conducted from the ships two skiffs.



NOAA Ship Nancy Foster

Sonar system

For this project the ship was equipped with a pole-mounted RESON SeaBat 8101 ER (extended range). The pole-mount was secured to the starboard side of the NOAA Ship Nancy Foster, roughly 2/3 of the way aft on the vessel. The RESON 8101 ER (extended range) was equipped with two upgrades. Option 033, where both the transducer and processor are upgraded to measure, process, and output multibeam backscatter imagery in "standard" and "Snippets" formats. The system was also upgraded with option 040, extending the range of the projector. The SeaBat 8101 ER is a 240 kHz multibeam system that measures relative water depths across a 150^{o} swath, consisting of 101 individual 1.5^{o} x 1.5^{o} beams. This system was used to obtain full-bottom coverage in depths generally from 20 meters to 300 meters, with range scale values dependent upon the depth of water and across-track slope.

Reson 8101 ER transducer unit

Pole mount for Reson 8101 ER unit

Auxiliary Sensors

Heave, roll, pitch, and heading

An Ixsea Octans gyrocompass & integrated motion sensor was used to provide true heading in addition to heave, pitch and roll correctors in NEMA and TSS HDT formats. The Octans generates attitude data in three axes (roll, pitch and heading). The manufactures specifications state that the dynamic heading accuracy was ∀0.2E and the dynamic accuracy for roll and pitch was ∀0.01E. Heave measurements supplied by the OCTANS maintained an accuracy of 5 cm or 5% of the measured vertical displacement. The heave period was automatically compensated for by the firm ware for periods between 0.03 and 40 seconds. Heave, roll, pitch, and navigation latency biases were determined in accordance with NOS Hydrographic Surveys Specifications and Deliverables Manual (HSSDM).

Sound speed

Sound velocity profiles were acquired with a SeaBird Electronics SeaCat SBE19 Conductivity, Temperature, and Depth (CTD) profiler.

Positioning

Survey vessel positions were obtained using a Trimble DSM212L GPS receiver. DGPS correctors were received via VHF radio modem from U.S. Coast Guard beacon Isabel, PR at a frequency of 295 kHz. The following parameters were 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), and beacon signal strength. When an HDOP of 2.5 was exceeded or the number of satellites available dropped below four, survey operations were halted.

The receiver was set up in the DGPS mode in Auto-Power mode (which locks onto the beacon with the greatest signal strength). On February 28, 2004 (1000 Atlantic Time) the receiver was reconfigured to manual search mode (accepting correctors from only the frequency of 295 kHz).

This reduced the number of "GPS fliers" initially noted during data processing.

V. Statement of accuracy and suitability for charting

Assessment of horizontal control

A complete assessment of the horizontal and vertical control errors was not possible for this survey. Possible sources for error include unmeasured system biases and unmeasured vertical measurement accuracy.

Positioning equipment and methods

The horizontal datum for this project is the North American Datum of 1983 (NAD83). Differential GPS (DGPS) was the sole method of positioning. Differential corrections from U.S. Coast Guard beacon Isabel, PR. While the survey areas were approximately 150 LNM from the corrector beacon site, no degradation of the signal was observed once the receiver search mode was set to manual search mode.

Quality control

No formal calibrations of the receivers operating in the DGPS mode were conducted during this survey; however internal precision of the system was monitored by the HYPACK-MAX system (HDOP, PDOP, number of satellites).

While no formal systems checks or comparisons were conducted on the Trimble receiver during the survey. A visual comparison was conducted between the ships receiver and a second Trimble unit (model 33302-51, SN 02240198210). The results agreed within 1-2 meters.

Statement of accuracy and compliance with HSSDM
While the horizontal accuracy could not be demonstrated through independent means, good positional agreement was seen in features observed in overlapping line. The Lead Hydrographer feels that the Horizontal Control should be considered adequate for the purposes of this survey.

Assessment of vertical control

Water level measuring equipment and methods
The Vertical Datum for this survey was Mean Lower-Low Water (MLLW). The National Water Level Observation Network (NWLON) primary tide stations at, Charlotte Amalie, VI (9751639) and Lime Tree Bay, VI (9751401) served as the primary sources for water level reducers for this survey. Six-minute predicted tides were obtained from the internet at the CO-OPS home page www.co-ops.nos.noaa.gov.

All data were reduced to MLLW with Six-minute predicted tides from stations Charlotte Amalie and Lime Tree Bay, VI using the tide file Charlotte Amalie 9751639.tid and Lime Tree Bay 9751401.tid. A corrupt zoned tides file prevented zoned tides to be applied during data

acquisition. Preliminary cleaning was conducted using predicted tides. Verified Observed tides were downloaded after completion of the survey and were applied to the data with time and height correctors using the zone corrector file NF0406VICORP.zdf.

Tides Zoning

Tidal zoning was provided by NOAA CO-OPS (refer to **APPENDIX VI**).
The Pacific Hydrographic Branch will apply final approved (smooth) tides to the survey data prior to final processing of the data. A request for delivery of final approved (smooth) tides for the survey was forwarded to N/OPS1 on April 19, 2004 in accordance with FPM 4.8. A copy of the request is included in **Appendix VI**.

Statement of accuracy and compliance with HSSDM

The Lead Hydrographer recommends that a complete error assessment for the tides and tidal zoning should be completed prior to the final assessment of this survey for charting purposes.

Assessment of sensors

Ancillary sensors
Sound velocity profiles were acquired using a SeaBird Electronics SeaCat SBE19 Conductivity, Temperature, and Depth (CTD) profiler (S/N 192472-0285). Raw conductivity, temperature, and pressure data were processed using VelocWin version 8.40, which generated sound velocity profiles for CARIS. Casts were extended using the most probable slope algorithm. Calibration reports and dates of the SeaCat profilers are included in **Appendix IV**.

The speed of sound through the water was determined by a minimum of one cast every four hours during SWMB acquisition. In general the CTD casts showed the water column to be well mixed (both spatially and temporally). When side-by-side cast comparisons were conducted using VelocWin software, differences were within the HSSDM specified tolerances.

While no independent check was conducted for this instrument, the Lead Hydrographer feels that due to the instruments recent factory calibration, and the acquired data falling within historic parameters, the CTD systems calibration should be considered adequate for the purposes of this survey.

Assessment of patch test and results

See **Appendix VII**

Assessment of draft (static and dynamic) application

The squat and settlement values for the Nancy Foster were not measured or corrected for during this survey. Review of other vessels of similar size showed the settlement and squat errors to be as follows: NAVO T-AGOS class vessels .09 meters (at the 95% confidence level), NOAA Ship Thomas Jefferson .2 M at speeds up to 8 knots, NOAA Ship Rainier .3 meters at speeds up to 8

knots. This gives confidence to the Lead Hydrographer that the error associated with the NOAA Ship Nancy Foster can be estimated to be .3 meters or less. The Lead Hydrographer also feels that due to the combination of vessel design (wide, flat bottom) and slow speed run during survey operations (4-7 knots), that squat and settlement did not significantly affect accuracy of the survey.

The static draft of the sonar system (apparent water line) was measured on three occasions prior to starting main scheme data acquisition. The draft of the sonar system was determined by measuring the physical distance from the transducer head along the pole to the reference point mounted on the deck. The initial reading was taken prior to the first day of the patch test, when the vessel was riding very high due to low water and fuel levels. After the initial day of patch testing the vessel was fueled and potable water tanks were filled. The two measurements taken post fueling showed a 5 inches increase in the echosounder draft. The revised draft values were entered in the VCF as changes in the water line. The Lead Hydrographer feels that this should be considered adequate for the purposes of the survey.

Assessment of horizontal and vertical offsets

A high order survey was not undertaken to determine the offsets of the vessel. Offsets were acquired using a steel tape, where possible. These measurements should be considered accurate within 2-3 inches. See **Appendix III** of this report for additional information on vessel offsets. The corrector values were entered into the CARIS Vessel Configuration File, and applied to the SWMB data during post processing.

Assessment of sensor calibrations

The Reson 8101 ER, Ixsea OCTANS gyrocompass, and SBE19 Sea Cat, all received factory calibration prior to the survey. See section (**Appendix IV**) for attached certificates. No documentation existed for the calibration of the Trimble DSM212L. After conversations with Dave Pritchard of NOAA's Hydrographic Systems and Technology program it is the opinion of the Lead Hydrographer that all systems should be considered adequately calibrated for the purposes of this survey.

Assessment of object detection

NOAA accepted best practices were utilized during this survey (vessel speed was less than 8 knots, and reduced to 5 knots in deeper waters). While outer beams may not necessarily meet IHO order 1 specification, the general practice of having overlapping coverage from adjoining lines should help to mitigate the effects.

Bottom Coverage and Line Spacing

Multibeam sounding lines were run parallel to the general contours of the survey area. Line spacing was typically three times the water depth, however due to helm/OOD inexperience, and improper line spacing due to inadequate site knowledge a significant number of holidays lines were necessary in some areas. Data was retained out to 70 degrees from nadir on both port and

starboard. While this differed from NOS standard operational procedures, it was deemed acceptable to ensured significant overlap between adjoining lines, while still maintaining data quality. Preliminary review of the data by the Lead Hydrographer, determined that the bottom coverage and line spacing were considered adequate for the purposes of this survey. Final evaluation of the coverage will be conducted after final data processing is completed.

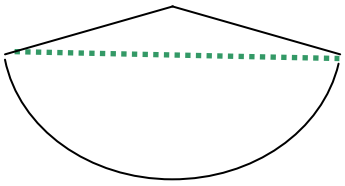
Vessel speed

Survey operations were conduced at a vessel speed of between 4.0 and 7.0 knots. Speeds were reduced to 4.0-5.0 knots for the offshore portion of Buck Island survey area, due to the water depths. In addition induced heave may have resulted through out portions of the survey due to not allowing adequate time for the vessel to steady up prior to coming on line steadying coming on line and due to the sinuous vessel track during data acquisition. The Lead Hydrographer considers vessel speed to be adequate for the purposes of this survey.

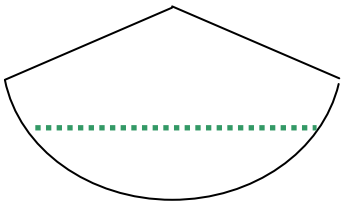
Range scale and ping rate

Range scales were adjusted to maximize data quality, dependant on depth of the water and across-track slope. The pulse length was adjusted throughout the Buck Island and patch testing portions of the survey due to the great variability of water depths. On DN 56 the pulse length was set at 33 us, for the remainder of the survey. The maximum ping rate was set at 20.0 Hz for the entire survey. Sounding density varied based on water depth and vessel speed. In general vessel speed was reduced to 4-5 knots in deeper waters surveyed.

On days DN 49-54 the Nancy Foster conducted hydrographic survey operations in the vicinity of Buck Island, St. Croix. Data was acquired in depths of up to 300 meters of water. While the Reson 8101 ER system was upgraded with the extended range option, significant degradation of the data was observed in depths of 275 meters and greater. The range scale was set at the maximize range scale (400 meter), however at times the system limitations resulted in the loss of outer beams. This was most readily observable when the widest part of the wedge on the Reson computer screen dipped below the optimal position. The Lead Hydrographer considers this to be of minimal impact due to the practice of only retaining 70Efrom nadir, and the depths not being critical to surface navigation



Good



Too Low – outer beams are lost

Item and/or least depth investigations

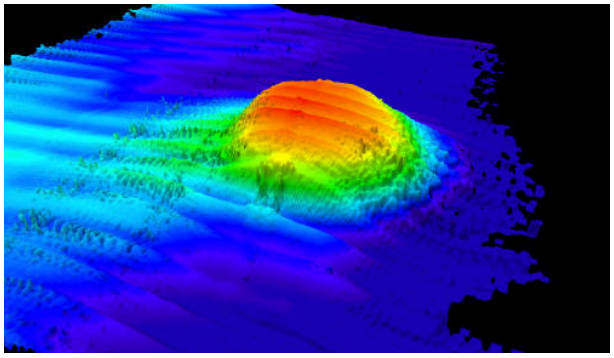
No least depth or item investigations were conducted during this survey.

Other items affecting data quality

A one meter artifact was observed during post processing of the multibeam data. This artifact manifested itself as a series of regularly spaced ridges along the vessels track. The Lead Hydrographer was unable to determine the source of this artifact during data acquisition. Upon the conclusion of the cruise a copy of the patch test data was sent to Gerd Glang, at the University of New Hampshire for review. In consultation with Gerd Glang and Jack Riley of NOAA's Hydrographic Surveys and Technologies Branch, the following adjustments were made to the Vessel Configuration File:

- All vessel offsets were adjusted to reference the vessels assumed center of motion.
- A value for the sound velocity sounding pole was defined at the same position as the sonar transducer.
- A corrector values were added to take into account difference in the vessels waterline pre and post fueling.
- The transducer roll offset was modified from +0.25 to -0.09 degrees.

Once these modifications were made to the VCF all lines were recorrected for sound velocity and remerged. The artifact while still observable was noticeably reduced to 0.5 meters. The Evaluator believes that the remaining artifacts are due to small errors in the measured lever arms. The Lead Hydrographer believes that this is acceptable given the purposes of the survey; however a full assessment of data quality should be conducted prior to final acceptance of the survey.



One meter artifact observed in the data

Assessment of internal data consistency

Crossline comparisons

Cross lines run for data quality evaluation purposes did not meet the NOS Hydrographic Survey Specifications and Deliverables required 5%, only 3.2% of total linear nautical miles were acquired. The Evaluator believes the lines which were run are representative of the survey are and should be considered adequate. A complete evaluation of the data quality will be conducted

upon completion of data processing.

Summery of data acquisition procedures

Triton-Elics' ISIS software version 6.20 was used to acquire shallow-water multibeam (SWMB) echosounder data in Extended Triton Format (XTF). The Isis Seabat controller version 1.08 was used to interface with the Reson sonar system. The XTF data was sampled at 16 bits, RI-Theta data was logged and the side scan settings were Full (new). Isis Real time Bathy Pro (version 1.5.0.0) was run during data acquisition, to assist in obtaining adequate coverage. Gyro, heave, pitch and roll correctors were acquired using an Ixsea Octans gyrocompass. Additionally, vessel speed was adjusted as necessary, and in accordance with the NOS Specifications and Deliverables and Draft Standing Project Instructions, to ensure the required along-track coverage for object detection. Coastal Oceanographic's HYPACK MAX version 2.12A Gold was used for vessel navigation and line tracking during acquisition. The Hypack data was not processed.

XTF files are logged onto the Isis machines local drive. At the completion of a day, a copy of the data was copied over to a Maxor 5000 portable hard drive for data transfer and archival purposes. An additional copy of the raw data was placed on a laptop for data conversion and processing.

Sound velocity profiles were computed from raw pressure, temperature, and conductivity measurements using Velocwin 8.40 supplied by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP). CTD casts were extended, and CARIS readable corrector files were created using the above software. Corrector files were transferred to the local processing machine and concatenated into a single SVP corrector file.

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

Summary of data processing and quality control procedures

SWMB data were processed using the CARIS Hydrographic Information Processing System (HIPS/SIPS) software for NT, version 5.3. The XTF data was converted to HDCS data using CARIS HIPS and SIPS Conversion Wizard. The following parameters were used during data conversion in CARIS: the Navigation Correctors were Geographic, Ship Navigation came from the Sensor, Bathymetry Gyro came from the Ship, soundings with a data quality flag of 0 were rejected, Side Scan Navigation came from the Sensor, Side Scan Gyro came from the Ship, the data was 16 bit, and 16 bit sensor data was preserved.

Navigation data was reviewed on a line-by-line basis for both time and horizontal consistency using CARIS navigation editor. Positions exceeding the expected horizontal offset or speed (.5 knots) and time (.2 seconds) jumps were manually edited or interpreted for short periods between data points.

Heave, pitch, roll and heading were reviewed on a line-by-line basis using Caris HIPS Attitude Editor. Fliers or gaps in positioning and attitude data were rejected and interpolated for small periods in time and outright rejected for larger periods in time in which the characteristic of the

curve was ambiguous. On DN 52, line 052_1400 was observed to be corrupted and did not have the draft applied. All attempts to reconvert, and correct for this error failed. This line should not be included in the final data set. Otherwise all data appeared to be consistent with the survey environment, vessel dynamics and track line characteristics.

After review and cleaning of position and attitude data were merged with sound velocity, tide, and vessel offset, to compute the corrected depth and position of each sounding. Sound velocity correctors were applied with option for previous in time being selected. Predicted tides from NOAA National Water Level Observation Network (NWLON) tide gauges (975-1639 and 975-1401) were applied for preliminary processing. Zoned Observed tides were applied prior to final data cleaning.

Preliminary bathymetry data cleaning was conducted in Caris HIPS, on a line-by-line basis (swath editor) and in 3-dimensional mode (subset). All soundings beyond a maximum angle of 70^{o} off-nadir were filtered to reduce the noise and refraction errors possible in these outer beams. Soundings with poor quality flags, 0 were also rejected. Gross flyers, system noise and water-column artifacts were flagged and excluded from the final sounding selection. Data were compared with adjacent lines and crosslines, for systematic errors such as tide or sound velocity errors. Questionable soundings were also compared with adjacent or overlapping data for confirmation or further rejection. Complete processing of the data was not completed by the end of the survey. The data will be processed through subset mode by a contractor prior to final review and acceptance by a NOAA Hydrographer. A complete report of cleaning procedures will accompany the final processed data.

Data decimation

A full description of final data reduction procedures will accompany the final evaluation report accompanying this data.

Adequacy of processes for charting

Data acquired during this survey did not follow all NOAA specified data acquisition procedures and standards, including lack of settlement squat, and adequate measurement of vessel offsets. Due to the incomplete nature of the survey data at this time a full evaluation could not be conducted. A full assessment will be conducted prior to final acceptance of the data.

Additional processing required by evaluator

It is anticipated that Smooth Tides will need to be applied to the data prior to final application of this data to the chart. No additional processing of this data is anticipated at this time.

Recommendations and Requests

Sufficient time or documentation provided to determine system installation parameter and settings, prior to the start of survey operations

Adequate time allocated to acquire and process the patch test, again prior to the start of data acquisition

Time allocated prior to data collection to familiarize the crew and science party in hydrographic data collection procedures.

APPROVAL

As Lead Hydrographer, I have ensured that standard field surveying and processing procedures were followed during this project in accordance with the Hydrographic Manual, Fourth Edition; Hydrographic Survey Guidelines; Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables Manual, as updated for 2003.

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

Approved and Forwarded: _____

Sean C. Rooney
Physical Scientist

APPENDIX I

Software Versions and Hardware Serial Numbers

Software	Version
Acquisition	
Hypack Max	2.12a
Isis	6.20 81XX
BathyPro	1.5.0.0
DelphMap GIS	2.9.5.0
Processing	
Pydro	3.71
KapConv	1.2
MapInfo	6.5
Vertical Mapper	2.0.0
CARIS HIPS/SIPS (NT)	5.3 service pack 3 hotfix 24
CARIS GIS (NT)	4.4a service pack 3 hotfix 28
Horizontal Control	
TSIP Talker	2.0
Vertical Control (Sound Velocity)	
VelocWin	8.40
SBE SeaTerm	1.30

Equipment:

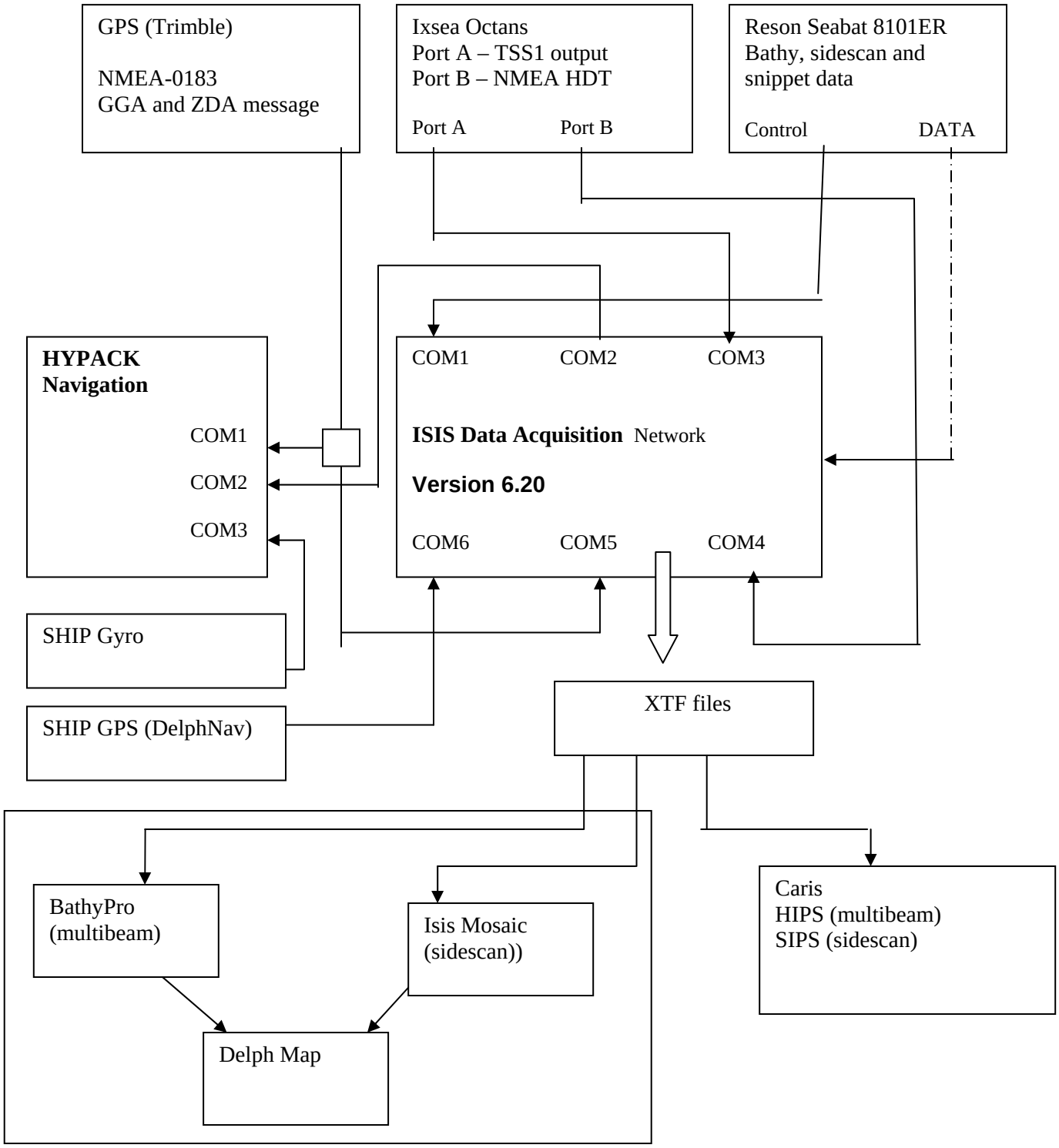
Description	Firmware	Serial Number
Abyss IES-10Echosounder		
RESON 8101 SONAR Processor (deck unit)	(dry) firmware version 8101-2.09-E34D	35737
Processor (deck unit)	(dry) firmware version 8101-2.09-E34D	34497
RESON 8101 ER SONAR (transducer)		3102027
Trimble DSM212L		0220159721
Ixsea Octans Gyrocompass	For DN 49 Firmware V.3.2 was used. For the remainder of the project Firmware V.4.6 was used	3453-118
SeaCat SBE19		192472-0285-285

APPENDIX II

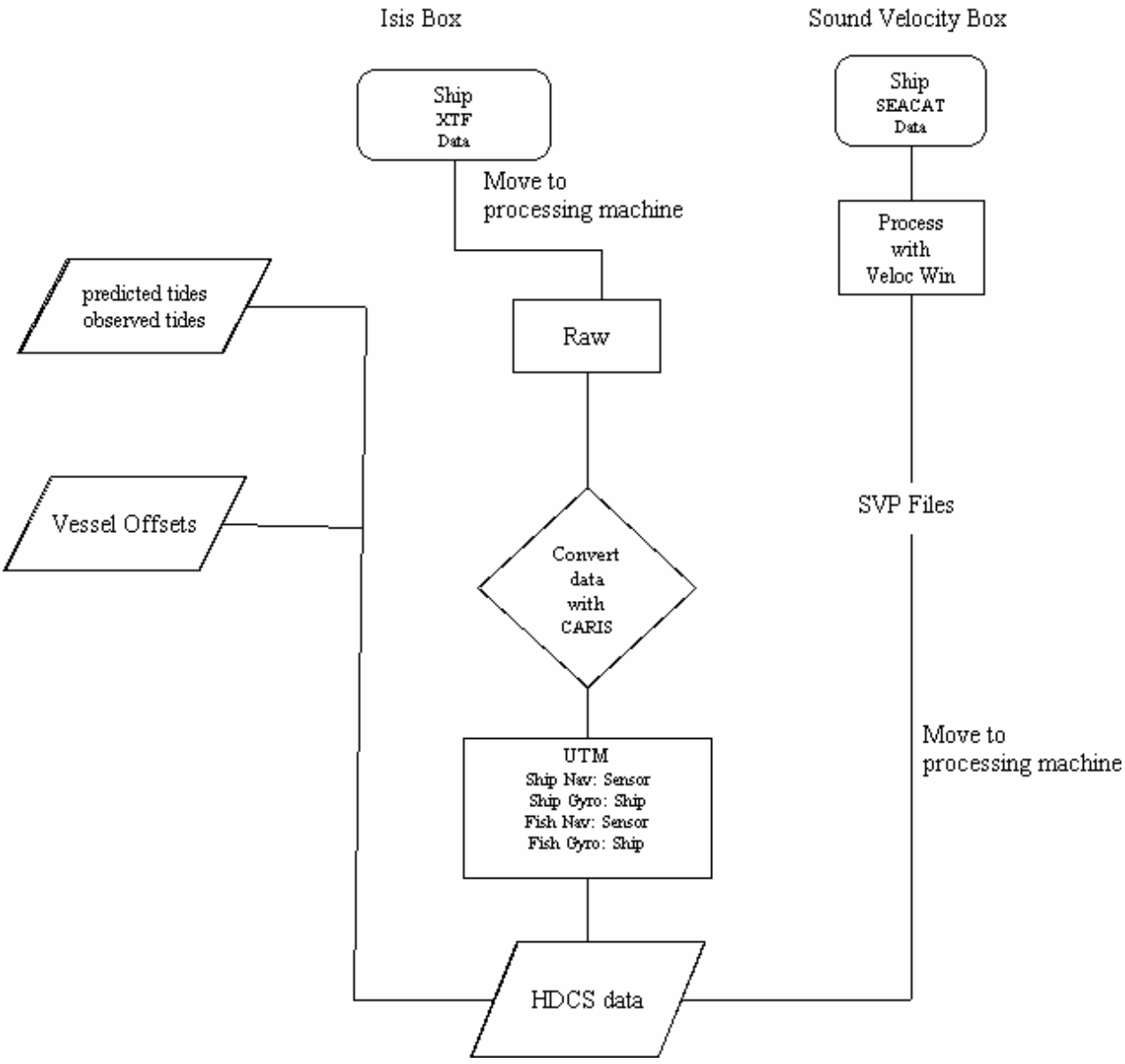
Data Processing Flow Diagrams

- **Sensor setup and data flow**
- **Hydro acquisition to HDCS**
- **HDCS to Subset**
- **DTM and QC Report Creation**

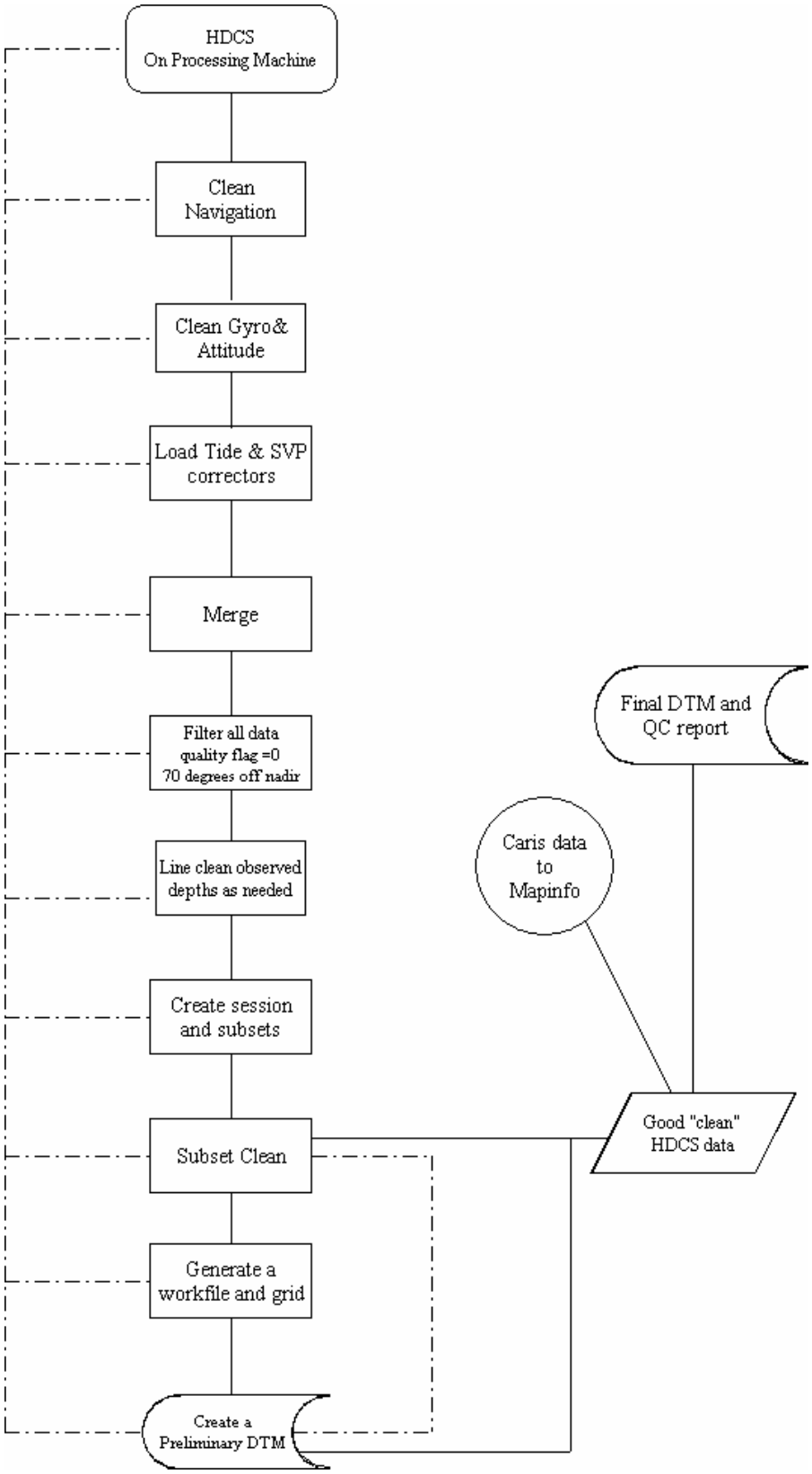
Sensor set-up and data flow



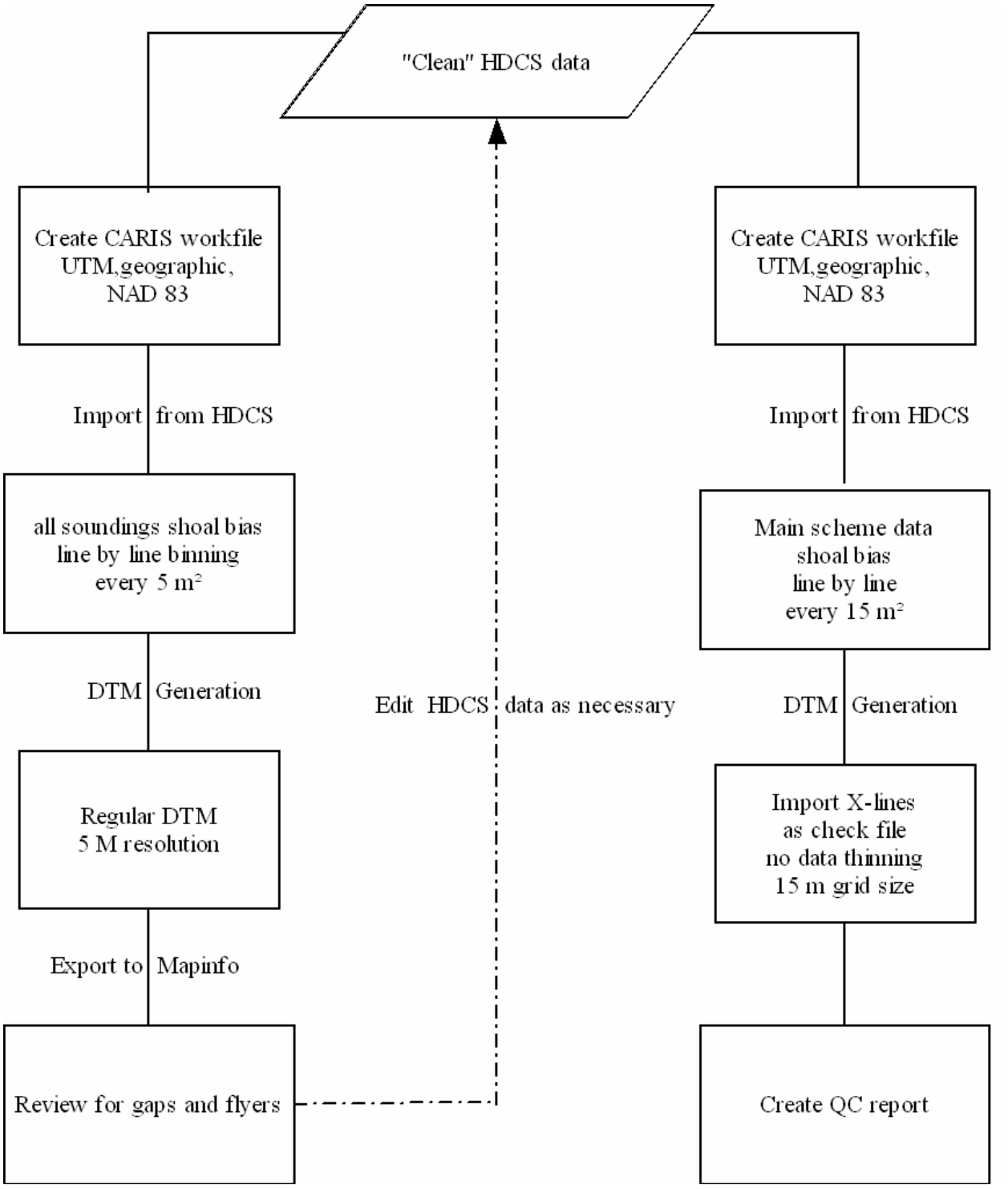
Hydro acquisition to HDCS:



HDCS to subset:



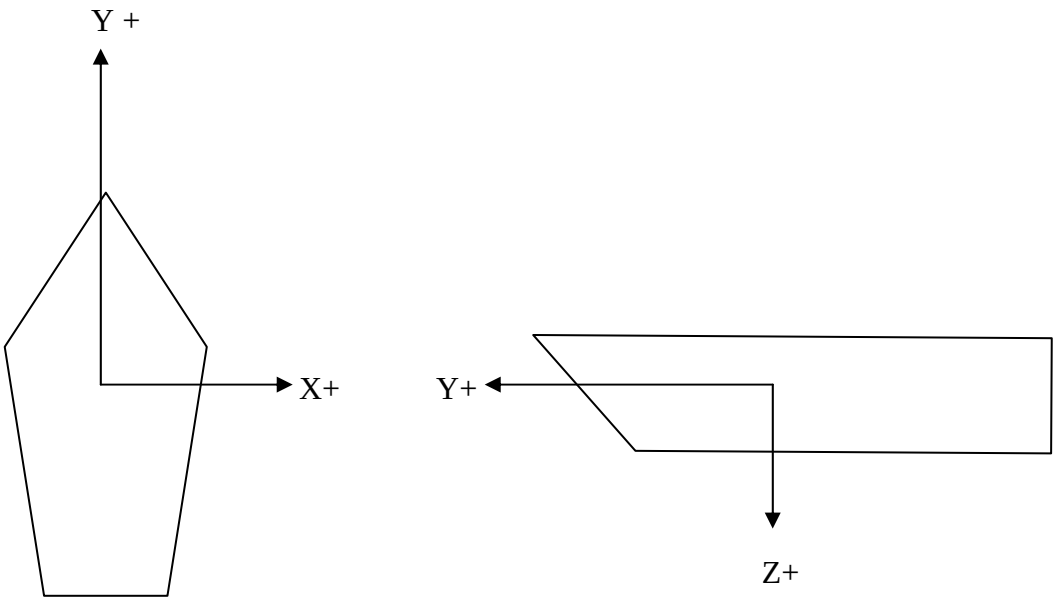
DTM and QC report Creation:



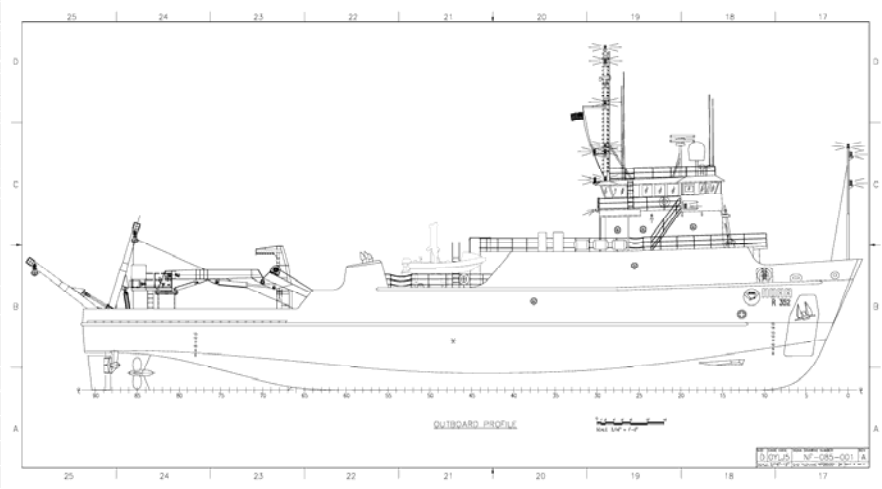
APPENDIX III

Vessel Offset Diagrams

CARIS Offset Sign Conventions

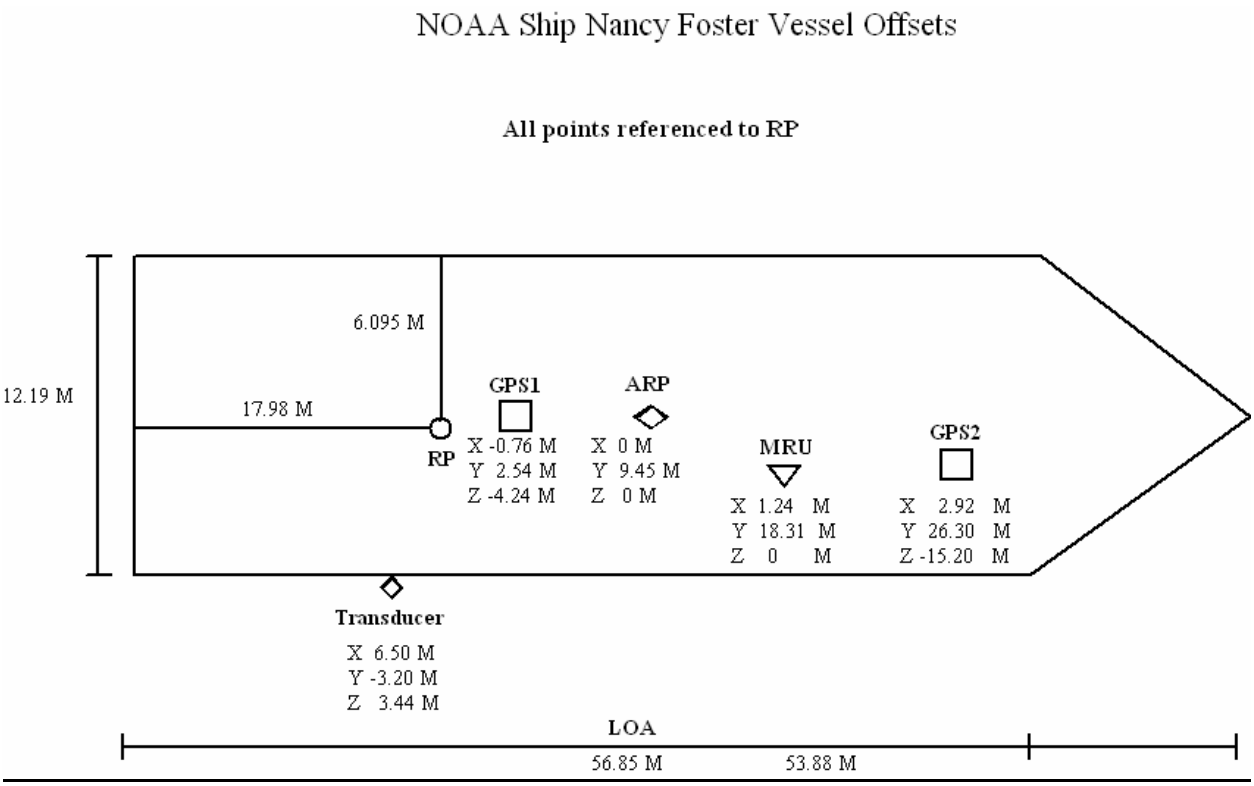


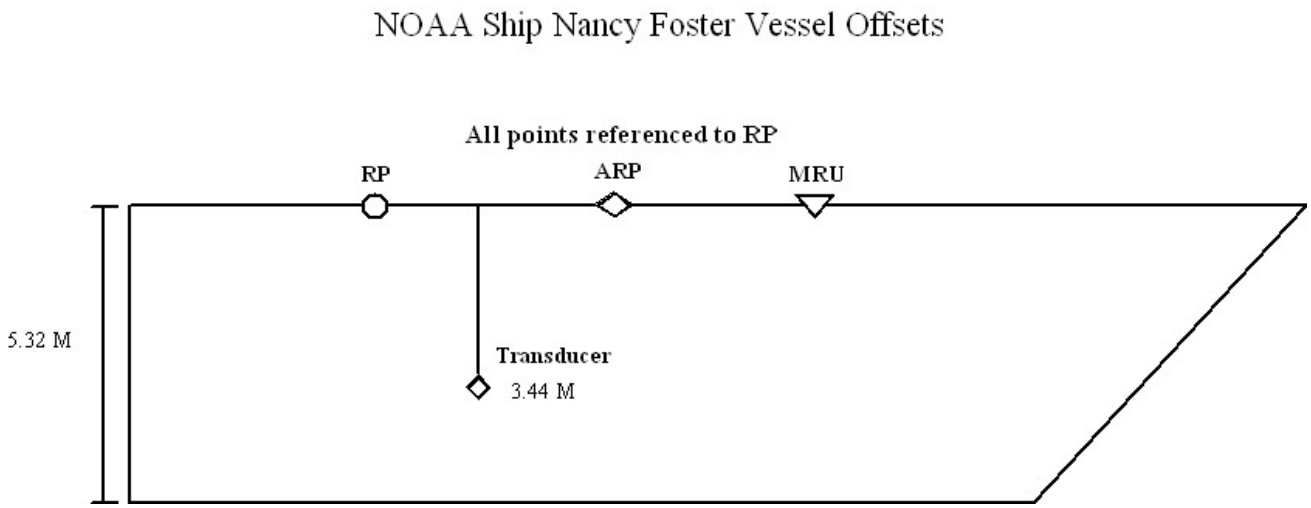
Nancy Foster (hull 352) Vessel Offset Measurements



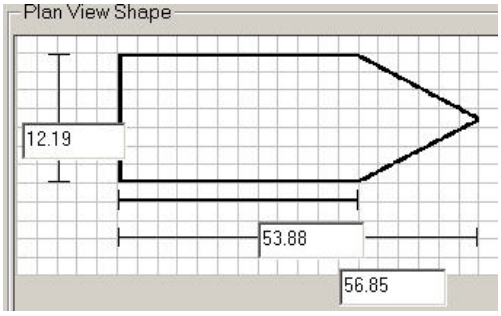
Description: Coastal oceanographic research ship, twin 300 hp Z-drives, with 42-inch diameter propeller
LOA: 187 ft. (57 m) Weight: 894 Tons

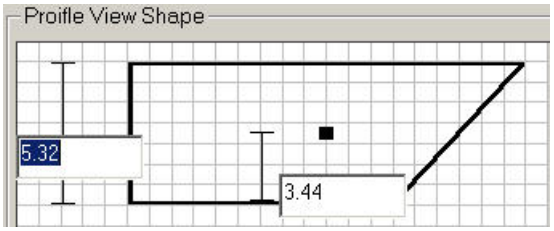
CARIS Vessel Configuration File (VCF) Parameters: Nancy Foster

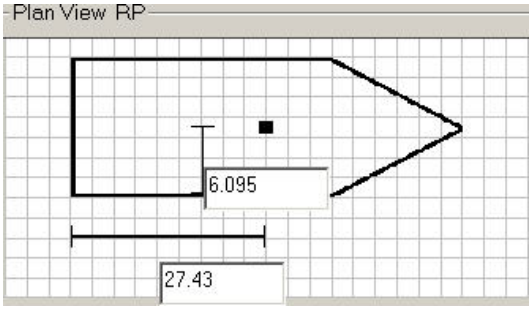




CARIS Vessel Configuration File offsets for the Nancy Foster







Appendix IV

Calibration Reports

- **Sound Velocity Profiler**
- **Reson 8101 ER**
- **Ixsea Octans Gyrocompass**

Appendix V

Patch Test Report

Appendix VI

Tides

- Smooth Tides Request
- Tide Error Estimation Report
- Tidal Zoning