2019-2023 Combined Descriptive Report of Seafloor Mapping: Casco Bay, Maine

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Maine Coastal Mapping Initiative, June 2023

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For an overview of the Maine Coastal Mapping Initiative (MCMI) information products, including maps, data, imagery, and reports visit: https://www.maine.gov/dmr/mcp/planning/mcmi/index.htm.

Acknowledgements

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Maine Coastal Mapping Initiative
Maine Coastal Program
Department of Marine Resources

DESCRIPTIVE REPORT

Type of Survey:	Navigable Area
Registry Number:	W00648

LOCALITY

State(s):	Maine
General Locality:	Gulf of Maine
Sub-Localities:	Casco Bay

2023

CHIEF OF PARTY
Peyton Benson, Hydrographer, Contractor to the State of Maine

LIBRARY & ARCHIVES

Date:

MAINE COASTAL MAPPING INITIATIVE MAINE COASTAL PROGRAM	REGISTRY NUMBER:
HYDROGRAPHIC TITLE SHEET	W00648

INSTRUCTIONS: The hydrographic sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

State(s):	**Maine**
General Locality:	**Gulf of Maine**
Sub-Locality:	**Casco Bay**
Scale:	
Dates of Survey:	**07/15/2019 to 04/12/2023**
Instructions Dated:	
Project Number:	
Field Unit:	***Amy Gale***
Chief of Party:	**Peyton Benson, Hydrographer, Contractor to the State of Maine**
Soundings by:	**Kongsberg EM2040C (MBES)**
Imagery by:	**Kongsberg EM2040C (MBES Backscatter)**
Verification by:	
Soundings in:	**meters at Mean Lower Low Water**

Remarks:

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ABSTRACT

Across multiple survey seasons, spanning from July of 2019 through to April of 2023, the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveys using a multibeam echosounder (MBES) in state marine waters of Casco Bay, Maine. The surveying efforts were conducted to support endeavors to enhance coastal resiliency through identification and characterization of seafloor habitat to provide information necessary to managing the marine environment and economy. The survey also coincides with state and federal efforts to update coastal data sets and increase high resolution bathymetric coverage for Maine's coastal and marine waters. This report serves as a comprehensive summary of multiple combined survey efforts conducted by MCMI in Casco Bay, Maine. The combined efforts of these surveys collected approximately 35.15 mi^2 (91 km^2) of high-resolution multibeam data in the surveyed area and conducted sediment sampling at 71 sites to aid in seafloor characterization. Throughout the survey period, MCMI also collected water column data and video at all sample locations across the survey area which will contribute to improved classification of substrate and modeling of benthic communities.

1.0 Area Surveyed

The survey area collected across the span of the 2019 season, as well as through winter of 2021-2022 and the winter of 2022-2023, was located within Casco Bay, Gulf of Maine, as shown in Figure 1. The approximately 35.15 mi^2 survey area consists of all navigable waters to a minimum depth of 5 meters, from Ram Island in the southwest extent, to Moshier Island in the northeast extent.

These data were not collected in direct accordance with the *NOS Hydrographic Surveys Specifications and Deliverables* and the *Field Procedures Manual* requirements; however, both documents were referenced during acquisition for guidance.

Prior to completion of data collection, this area was registered with NOAA ESD under pre-registry ID W00648.

Casco Bay survey limits are listed in Table 1 by season of acquisition and as a merged single surface. Specific dates of data acquisition for the survey area are listed in Appendix A.

Table 1 – Casco Bay Survey Limits

2019 Survey Limits

Southwest Limit	**Northeast Limit**
43° 46’ 08.30” N 70° 03’ 59.69” W	43° 37’ 53.16” N 70° 11’ 31.97” W

2021-2022 Survey Limits

Southwest Limit	**Northeast Limit**
43° 41’ 28.49” N 70° 11’ 04.39” W	43° 47’ 17.98” N 70° 02’ 35.79” W

2022-2023 Survey Limits

Southwest Limit	**Northeast Limit**
43° 38’ 46.75” N 70° 12’ 10.90” W	43° 46’ 08.30” N 70° 03’ 59.69” W

Full Survey Extent

Southwest Limit	**Northeast Limit**
43° 46’ 08.30” N 70° 03’ 59.69” W	43° 47’ 17.98” N 70° 02’ 35.79” W

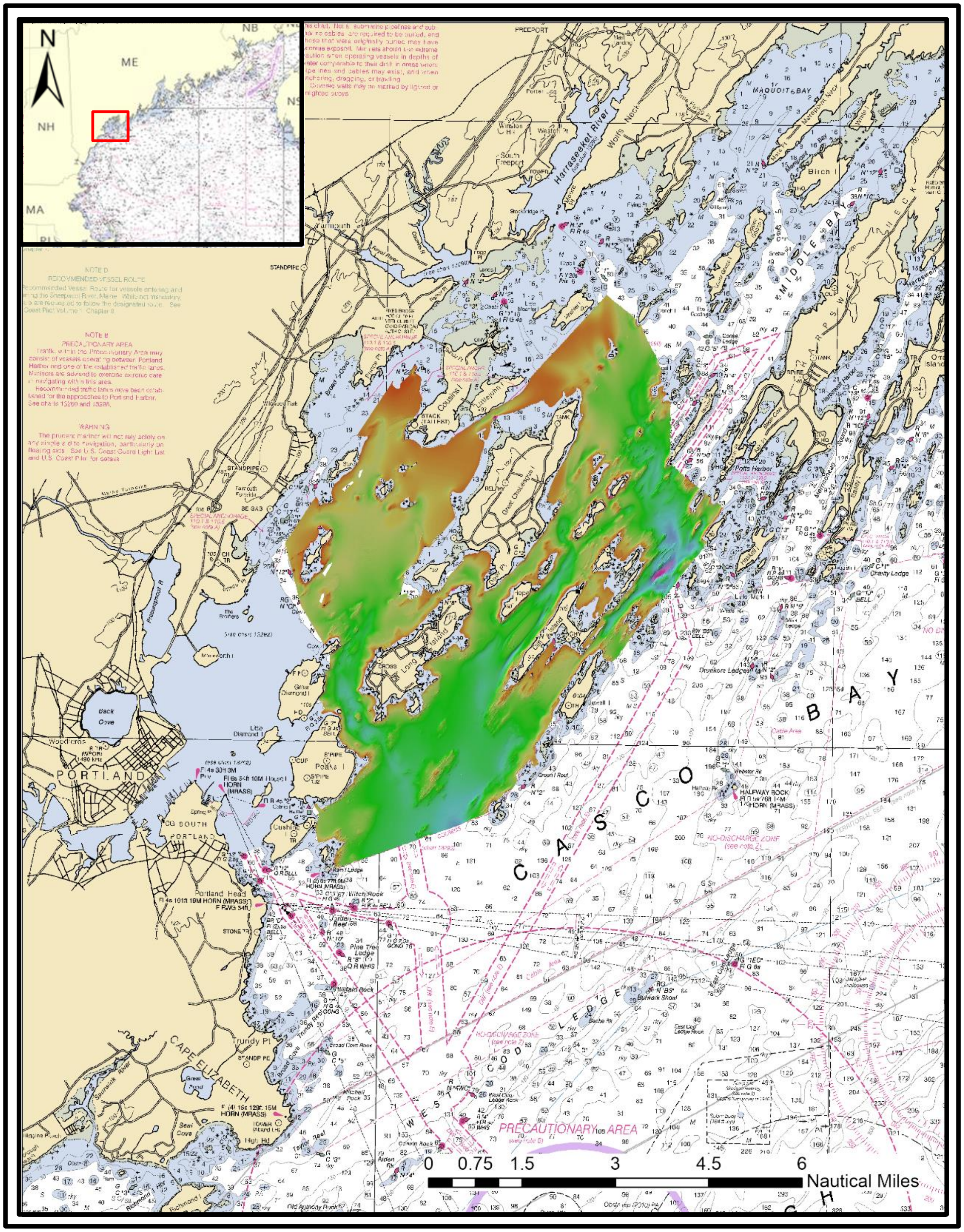


Figure 1 – General locality of Casco Bay survey coverage, plotted over NOAA chart 13288.

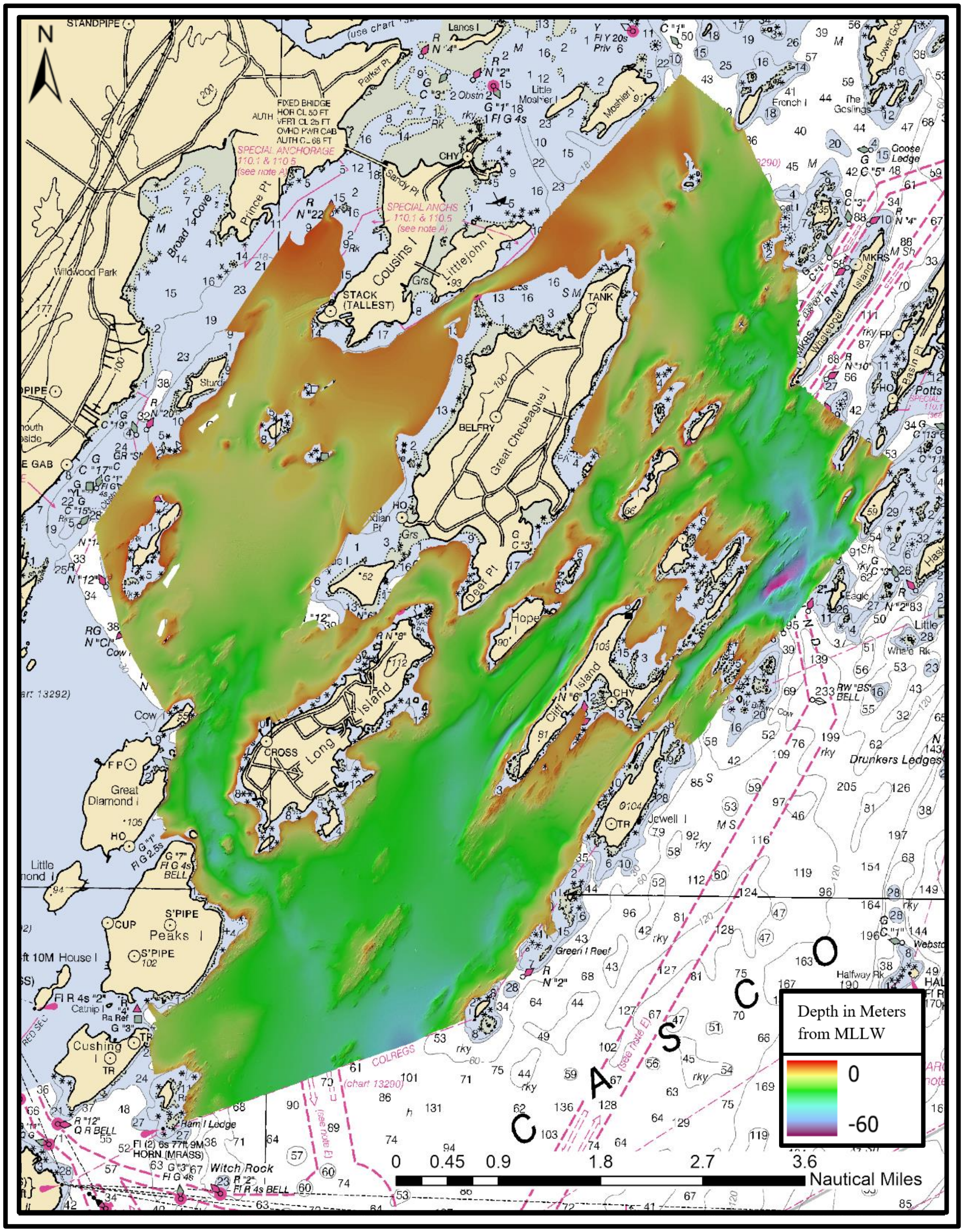


Figure 2 – Shaded relief image of Casco Bay bathymetry data gridded at 1-meter resolution and colored by depth. Data is overlain on NOAA chart 13288.

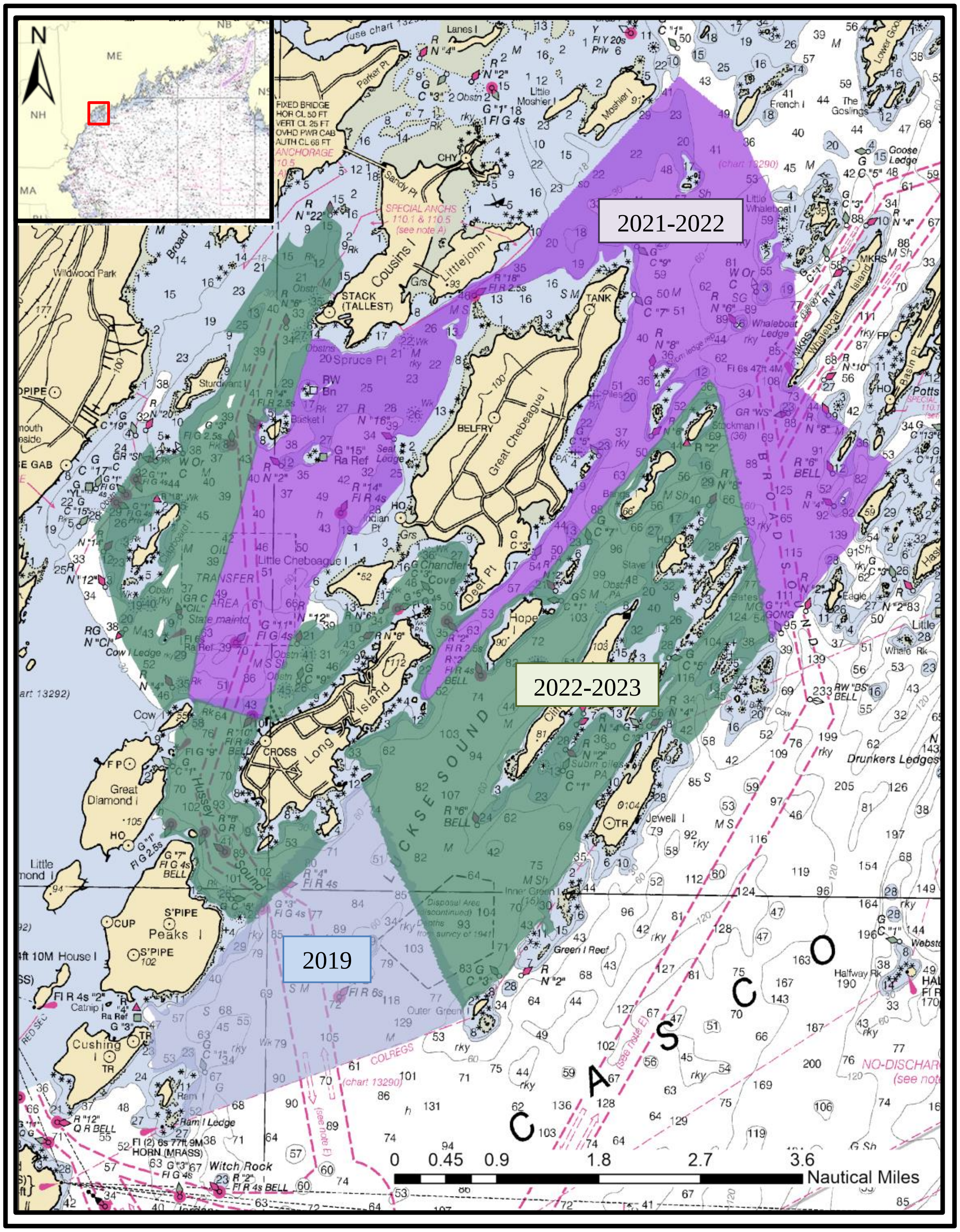


Figure 3 – Casco Bay survey coverage shown by season of acquisition, plotted over NOAA chart 13288

1.1 Survey Purpose

This survey was conducted by the Maine Coastal Program's Maine Coastal Mapping Initiative (MCMI) as part of a multi-agency cooperative agreement partially funded by the National Oceanic and Atmospheric Administration (NOAA) Office of Coastal Management, The Nature Conservancy (TNC), and the Maine Outdoor Heritage Fund. The purpose of this project is to help inform policy decision-making related to Maine's coastal waters by increasing the volume of available high-quality bathymetric, benthic habitat, geochemical, and geologic data in the Casco Bay area. This project also coincides with state and federal efforts to update coastal data sets for Maine's coastal waters and provides new data in the areas covered by National Oceanic and Atmospheric Administration (NOAA) nautical charts 13288, 13290, and 13292 in Casco Bay. These data were acquired and processed to meet Office of Coast Survey bathymetry standards as best as possible and are shared with the NOAA Office of Coast Survey for review.

1.2 Survey Quality

The entire survey should be adequate to supersede previous data.

1.3 Survey Coverage

Select few small holidays (gaps in MBES coverage) exist within the surveyed area, and normally occurred as sonic shadows in areas of locally high relief and/or highly irregular bathymetry. Analyses of bathymetric data show that the least depths were achieved over all features, and that holidays have not compromised data integrity.

Throughout the survey area, eight aquaculture arrays were encountered which prevented complete ensonification within their bounds. Survey lines were run as close as possible to the borders of the arrays, but holidays are present in the survey area due to these obstacles. These arrays are highlighted in Figure 4 below.

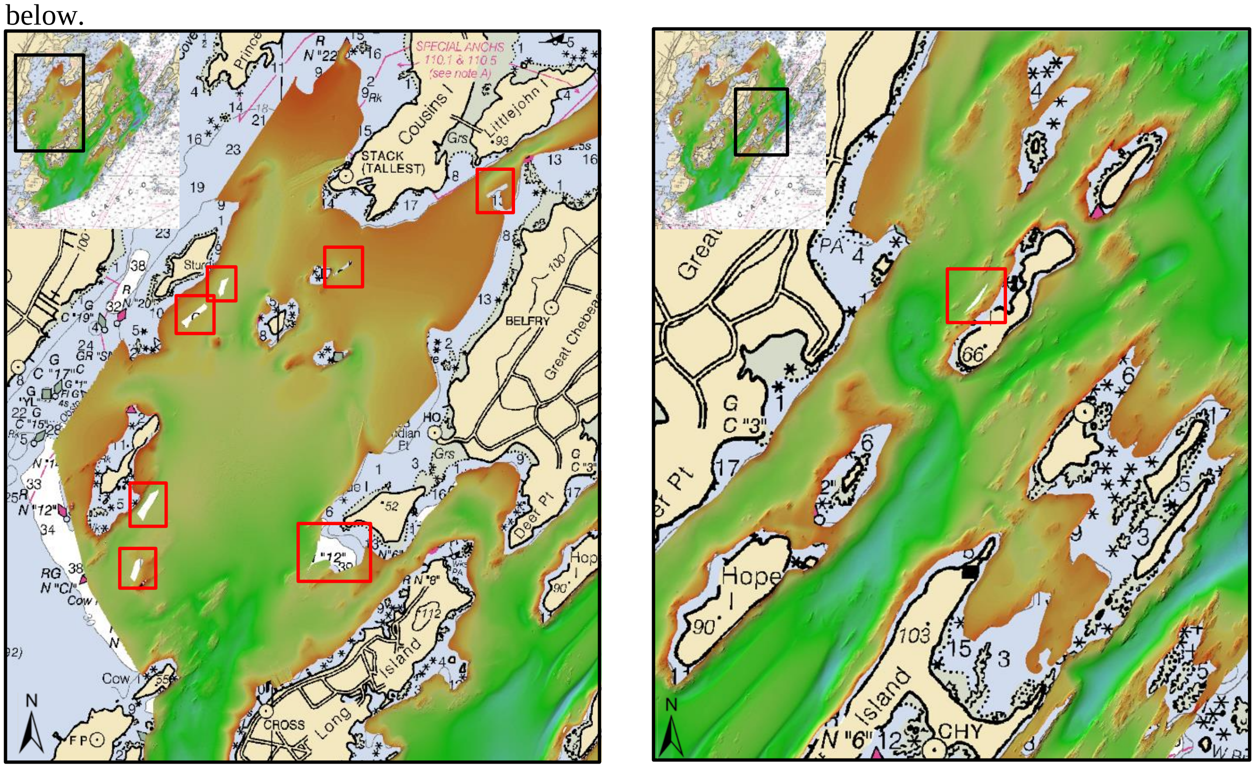


Figure 4: Aquaculture array-induced holidays in survey coverage

2.0 Data Acquisition

The following sub-sections contain a summary of the systems, software, and general operations used for acquisition and preliminary processing throughout the 2019, winter 2021-2022, and winter 2022-2023 Casco Bay survey efforts.

2.1 Survey Vessel

All data were collected aboard the Fishing Vessel (F/V) Amy Gale (length = 10.95 m, width = 3.81 m, draft = 0.93 m) (Figures 5, 6, and 7), a former lobster boat converted to a survey vessel and contracted to the MCMI. The vessel was captained by Caleb Hodgdon of Hodgdon Vessel Services. Surveys were based out of ports in Boothbay Harbor and Portland, ME. The EM2040C transducer, motion reference unit (MRU), AML MicroX surface sound speed probe, and dual GNSS antennas were pole-mounted to the bow; pole raised (for transit) and lowered (for survey) via a pivot point at the edge of the bow. The main cabin of the vessel served as the data collection center and was outfitted with four display monitors for real time visualization of data during acquisition.

Figure 5 – F/V Amy Gale shown with pole-mounted dual GPS antennas, Fugro AD-341 antenna, Kongsberg EM2040C multibeam sonar (not visible), MRU (not visible), and surface sound speed probe (not visible) in acquisition mode.

2.2 Acquisition Systems

The real-time acquisition systems used aboard the F/V Amy Gale during the reported surveys are outlined in Table 2. Data acquisition was performed using the Quality Positioning Services (QPS) Qinsy (Quality Integrated Navigation System; v.9.2.2 through v.9.5.4) acquisition software. The modules within Qinsy integrated all systems and were used for real-time navigation, survey line planning, data time tagging, data logging, and visualization.

Table 2 – Major systems used aboard F/V Amy Gale

Sub-system	Components
Multibeam Sonar	Kongsberg EM2040C and processing unit
Position, Attitude, and Heading Sensor	Seapath 330 processing unit, HMI unit, dual GPS/GLONASS antennas, MRU 5-V motion reference unit (subsea bottle), Fugro 3610 Receiver and AD-341 antenna
Acquisition Software and Workstation	Qinsy software v.9.2.2-9.5.4 and 64-bit Windows 10 PC console
Surface Sound Velocity (SV) Probe	AML Micro X with SV Xchange
Sound Velocity Profiler (SVP)	Teledyne Odom Digibar-S sound speed profiler
Ground-truthing/Sediment Sampling Platform	Ponar grab sampler, GoPro Hero 3+ video camera, GoPro Hero 5 Black video camera, dive light, dive lasers, YSI Exo I sonde

* See Appendix B for a diagram overview of survey systems aboard the Amy Gale.

2.3 Vessel Configuration Parameters

In 2017, the MCMI contracted Doucet Survey, Inc. to perform high-definition (precision ±5mm) 3D laser scanning of the Amy Gale and all external MBES system components (e.g. MRU, GPS antennas, and EM2040C) (Figures 6 and 7). The purpose of the laser scan survey was to refine and or verify the precision of hand-made vessel reference frame measurements for future surveys. All points were referenced to the center point of the base of the MRU (mounted inside the pole and directly atop the EM2040C transducer) (Figure 7), which served as the origin (e.g. 0,0,0), where ‘x’ was positive forward, ‘y’ was positive starboard, and ‘z’ was positive down. The laser scan survey results only differed from hand-made measurements by ≤ 3mm for all nodes of interest. Reference measurements for each component were entered into the Seapath 330 Navigation Engine (Table 3) and converted so all outgoing datagrams would be relative to the location of the EM2040C transducer (e.g. EM2040C was used as the monitoring point for all outgoing datagrams being received by Qinsy during acquisition). Additional configuration and interfacing of all systems were established during the creation of a template database in the Qinsy console.

These offset values were not changed for the reported survey seasons. See appendices for a diagram of survey systems aboard the Amy Gale. specific settings as entered in the Seapath 330 Navigation Engine (Appendix C), for the template database (Appendix D), and the computation settings (Appendix F) used during data acquisition while online in Qinsy. Configuration settings of the EM2040C were assigned in the EM Controller module of Qinsy (Appendix E).

Table 3 – 2017 equipment reference frame measurements for Seapath 330

Equipment	**x (m)**	**y (m)**	**z (m)**
MRU	0.000	0.000	0.00
Antenna 1 (port)	0.158	-1.245	-3.000
Antenna 2 (starboard)	0.158	1.252	-3.035
EM2040C	0.036	0.000	0.133

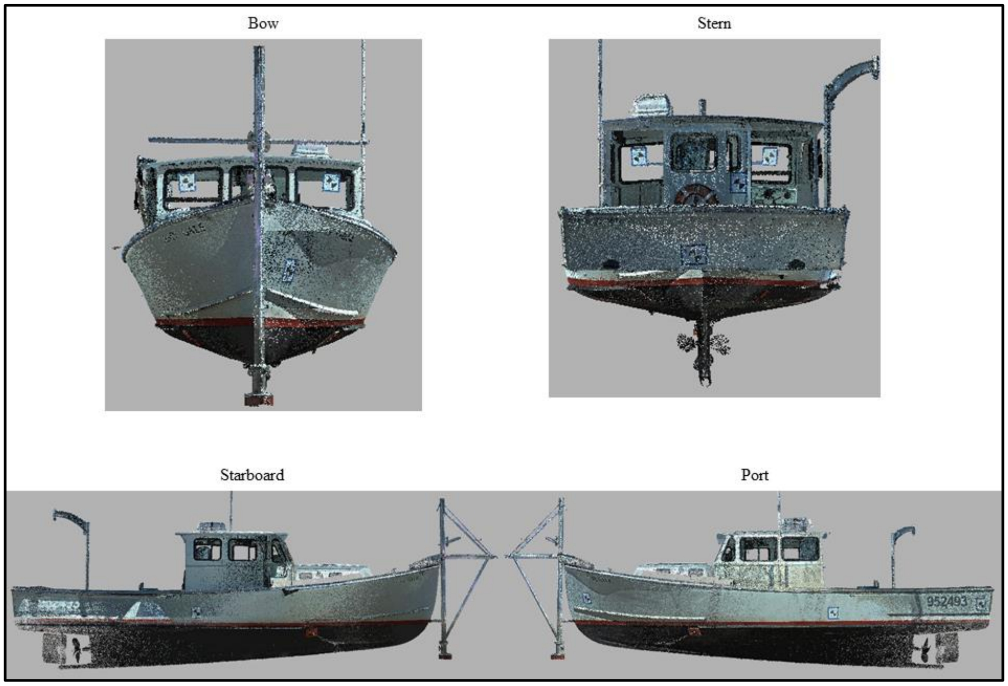


Figure 6 – Amy Gale RGB color images generated from 3D laser scan survey (GPS antennas and external cabling not included in survey) data (.pts file converted to .las for visualization)

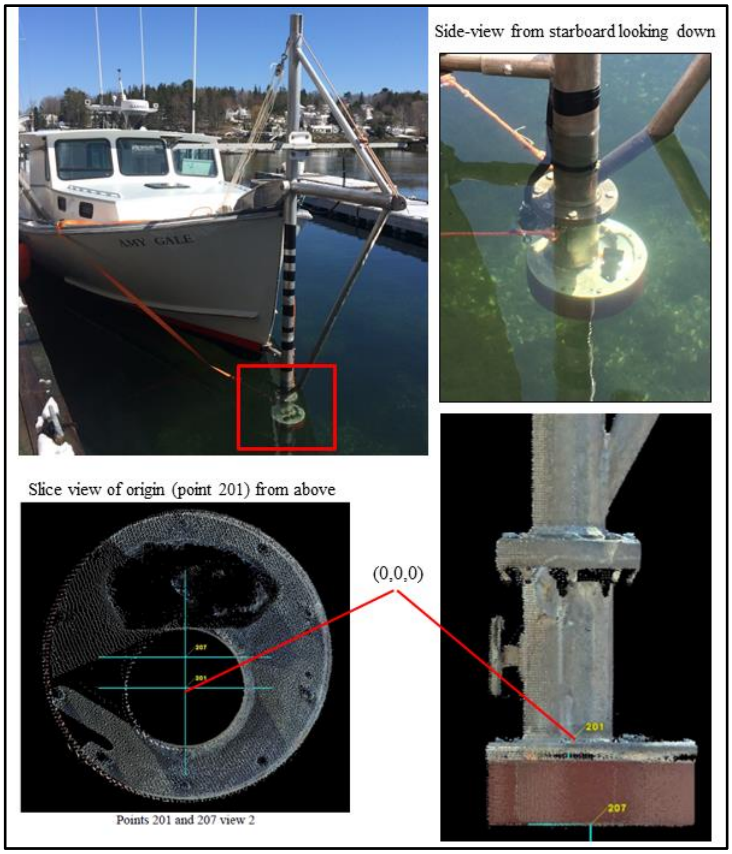


Figure 7 – Amy Gale origin (point 201 in RGB images) for vessel reference frame(s); origin is center point within the base of the pole (center point of base within internally-mounted motion reference unit (MRU) point 201 in images above)

2.4 Survey Operations

The following is a general summary of daily survey operations. Once the survey destination was reached, the sonar pole mount was lowered into survey position and its bracing rods were fastened securely to the hull of the ship via heavy-duty ratchet straps. Electric power to all systems was provided by a 2000-watt Honda *eu2000i* generator. Occasionally two *eu2000i* generators were simultaneously used if any auxiliary equipment needed additional electricity. Immediately following power-up, all interfacing instruments were given time to stabilize (e.g. approximately 30-45 minutes for Seapath to acquire accurate positioning). Next, the desired Qinsy project was selected for data acquisition. All files (e.g. raw sonar files, sound speed profiles, grid files, etc.) were recorded and stored within their respective project subfolders on a local drive. Prior to surveying each day, a sound speed cast was taken and imported into the 'imports' folder of the current project. After confirming agreement between the surface probe reading and the downcast data and inspecting cast values for abnormal profile/readings, the profile was applied to the sonar (EM2040C) in the Qinsy Controller module. Regular sound speed casts were collected throughout the survey day when necessitated by changing tide, location, or upon disagreement with the surface probe measurement (exceeding +/-2.0 m/s difference). Data were gridded at 0.5 to 4 meters for real-time visualization, depending on expected water depth range. Raw sonar files were logged in the Qinsy Controller module in .db format and saved directly onto the hydrographic workstation computer. All data were backed up daily on an external hard drive. At the end of each day's survey, sonar and navigation systems were powered down and the pole mount was raised and fastened for transit back to port. Upon arriving at the dock, all external instruments/hardware were visually inspected and rinsed with freshwater to prevent corrosion.

2.5 Survey Planning

Line planning and coverage requirements were designed to meet requirements for NOAA hydrographic standards and in accordance with IHO S-44 6th Edition Order 1a survey (International Hydrographic Organization, 2020 & NOAA Office of Coast Survey, 2021). Throughout the survey area, parallel lines were planned several days prior to surveying and generally run in an along-channel orientation, but variation was necessary for highly dynamic areas such as coves, ledges, and mooring fields. Lines were spaced at consistent intervals to obtain a minimum of 30% overlap between full swaths. Soundings from beam angles outside of ±60 degrees from the nadir were blocked from visualization during acquisition, thus increasing the true minimum full-swath overlap. This online blocking filter was recommended by QPS field engineers with the intent of eliminating noisy outer beams from the final product, thereby increasing the overall contribution of higher quality soundings. All data were acquired at approximately 6.5-7 knots, although some areas required slower speeds to ensure safe operation of the vessel around obstructions, fishing operations, or in especially rough conditions. When in shallow waters, survey lines were run parallel to the shoreline and moved landward until outer swath depths reached soundings of 5 meters for navigational safety throughout the entire survey area. Any depths not reaching the minimum value of 5 meters are the result of areas where attempting to do so would endanger the vessel and/or her crew.

2.6 Calibrations

Patch tests were conducted aboard the F/V Amy Gale at the beginning of each survey effort as well as throughout data collection periods to correct for alignment offsets. For each patch test, a series of lines were run to determine the latency, pitch, roll, and heading offset following standard protocol (NOAA Office of Coast Survey, 2021). The patch test data were processed using the Qimera (v.2.0.0 through v.2.5.3) patch test tool. After calibration was complete, offsets (Table 4) were entered into the template database in Qinsy. Additional patch tests were conducted any time a system was removed or reinstalled throughout the survey season or if data disagreements were noticed between lines. Full built-in self-tests (BIST) were performed at semi-regular intervals throughout the season to determine if any significant deviations in background noise were present at the chosen survey frequency of 300KHz.

Table 4 – Casco Bay Patch test calibration offsets for EM2040C

Type	Offsets 07/15/19	Offsets 07/28/21	Offsets 12/07/21	Offsets 06/21/22	Offsets 02/14/23
Roll (degrees)	-0.430	0.363	0.049	-0.039	-0.060
Pitch (degrees)	2.270	-1.582	2.480	0.474	0.609
Heading (degrees)	-0.300	2.388	1.494	1.254	0.695

3.0 Quality Control

3.1 Crosslines

Due to high priority offshore efforts conducted concurrently by the survey team, crosslines were collected significantly delayed from survey area acquisition. Crosslines were collected for winter 2021-2022 data on 05/11/2022, 02/01/2023, and 04/12/2023. Crosslines for winter 2022-2023 data were collected on 04/12/2023. No crosslines were collected by the survey team during the 2019 acquisition period due to time constraints and the team was unable to allocate time to revisit this region after collection. As a result, crosslines were not acquired for this 2019 area at time of data delivery. If the team is able to return to this locus to complete crosslines, the results will be appended to this report. However, due to the strong agreement across the 2021-2022 and 2022-2023 survey areas which overlap this coverage, the belief of the survey team is that results would be similar to those collected for the remainder of the Casco Bay coverage (Figures 9 & 10, Tables 5 & 6).

Throughout the survey area, crosslines were run at no greater than 900m spacing and intersected with all survey lines between 60° and 90° in accordance with BOEM and NOAA requirements (Figure 8) (U.S. Department of the Interior, 2014 & NOAA Office of Coast Survey, 2021). Crosslines were filtered during post-processing to remove soundings outside 45 degrees from the nadir. After filtering, the two-dimensional surface area totaled approximately 6.5% of survey area coverage. Crossline sounding agreement with survey data was evaluated by using the crosscheck tool in Qimera version 2.5.3, which performs beam-by-beam statistical analysis. Due to the very large file size of the survey effort, the Qimera projects and, consequently, the crossline comparison was split into two separate analyses: one for 2021-2022 data and one for 2022-2023 data (see Figure 3 for coverage).

For 2021-2022 data, the mean difference between soundings was 0.016 meters with a standard deviation of 0.221 meters; 95% of all differences were less than 0.458 meters from the mean (Figure 9).

For 2022-2023 data, the mean difference between soundings was 0.023 meters with a standard deviation of 0.055 meters; 95% of all differences were less than 0.139 meters from the mean (Figure 10).

Summary statistics for these analyses are shown in Tables 5 & 6, respectively. Additional statistical plots are reported in Appendix G. Raw difference data, reference surfaces, and sonar files used for this analysis were submitted with the data in this survey package.

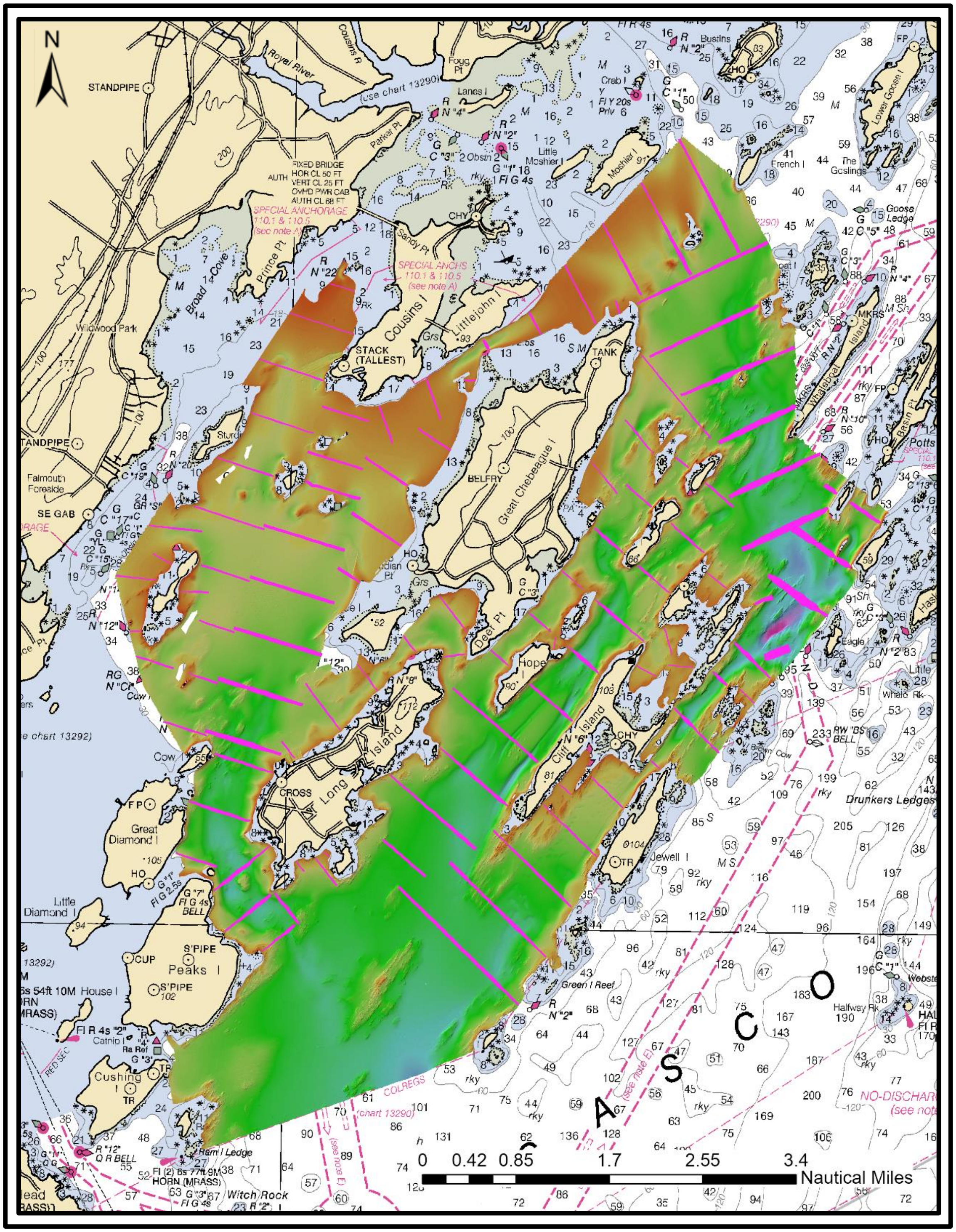


Figure 8 – Location of crosslines (depicted in magenta, with beams filtered outside ±45°) atop bathymetry data

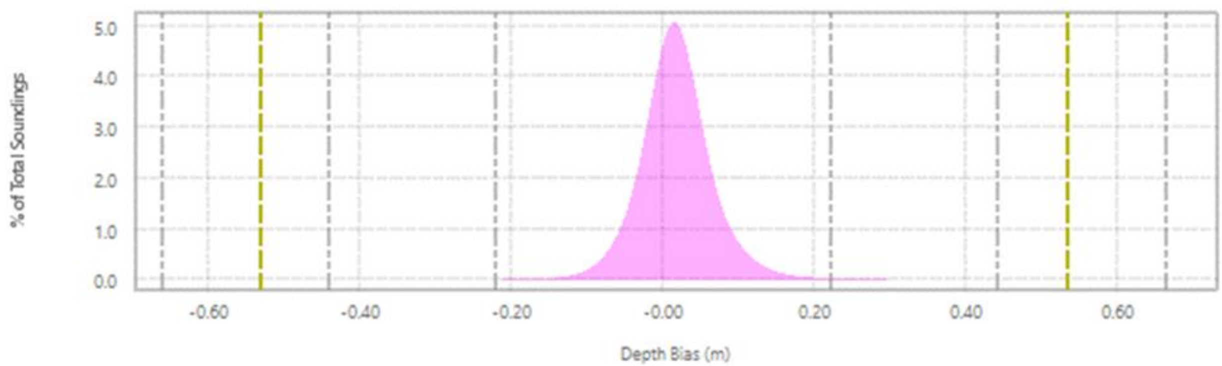


Figure 9 – 2021-2022 crosslines difference histogram; pink areas represent the 95% confidence interval based on normal distribution; yellow dashed lines represent limit of IHO Order 1 test vertical tolerance; gray dashed lines on histogram represent ±sigma 1, 2, and 3

Table 5 – 2021-2022 Crossline difference (Qimera crosscheck) summary statistics

# of Points of Comparison	36843319
Data Mean	-14.073442 m
Reference Mean	-14.090392 m
Difference Mean	0.016949 m
Difference Median	0.016949 m
Std. Deviation	0.220901 m
Data Z - Range	-51.25 m to -1.62 m
Ref. Z - Range	-48.29 m to -4.27 m
Diff Z - Range	-22.67 m to 5.86 m
Mean + 2*stddev	0.458752 m
Median + 2*stddev	0.458752 m
Order 1a Error Limit	0.532497 m
Order 1a P-Statistic	0.000411
Order 1a - # Rejected	15161
Order 1a Survey	ACCEPTED

*Order 1a parameters: a = 0.25 and b = 0.013

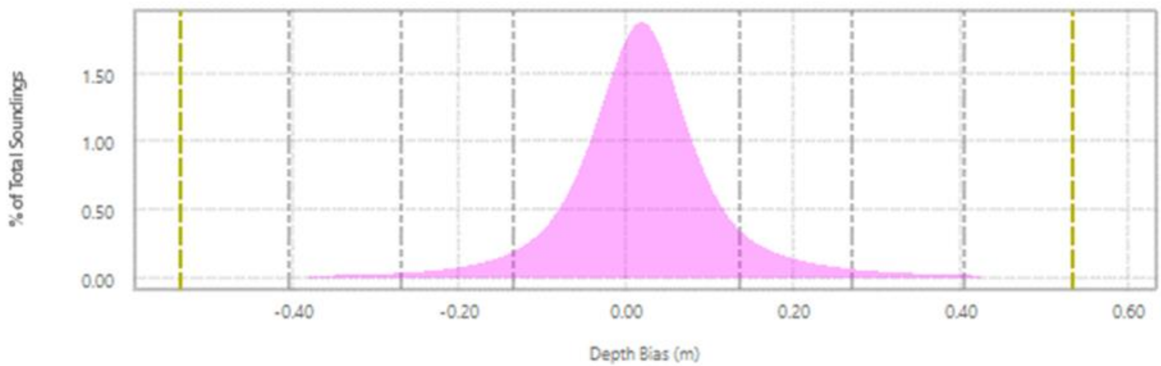


Figure 10 – 2022-2023 crosslines difference histogram; pink areas represent the 95% confidence interval based on normal distribution; yellow dashed lines represent limit of IHO Order 1 test vertical tolerance; gray dashed lines on histogram represent ±sigma 1, 2, and 3

Table 6 – 2022-2023 Crossline difference (Qimera crosscheck) summary statistics

# of Points of Comparison	41453232
Data Mean	-14.584082 m
Reference Mean	-14.607001 m
Difference Mean	0.022919 m
Difference Median	0.022919 m
Std. Deviation	0.055444 m
Data Z - Range	-40.19 m to -3.36 m
Ref. Z - Range	-39.08 m to -3.43 m
Diff Z - Range	-4.08 m to 2.25 m
Mean + 2*stddev	0.133807 m
Median + 2*stddev	0.133807 m
Order 1a Error Limit	0.534844 m
Order 1a P-Statistic	0.000213
Order 1a - # Rejected	8840
Order 1a Survey	ACCEPTED

*Order 1a parameters: a = 0.25 and b = 0.013

3.2 Junctions

Junctions were not computed for the surveys described in this report due to the inability to access data of existing survey areas by the time of writing. The strong agreement of MCMI survey data across the collection effort spanning 4 calendar years and several remobilizations of the survey vessel, as well as the consistency shown by crossline analysis, lead this survey team to believe that these data would agree with the highest quality datasets that exist within the region. Junction analysis may be completed by the survey team and have the results appended to this report should they become available following submission.

3.3 Uncertainty

HydrOffice QC Tools v.3.9.0 Grid QA feature was used to analyze the highest resolution surfaces for compliance with NOAA allowable uncertainty standards. 99.74%, 99.81%, and 99.94% of all nodes met uncertainty specifications for W00648_1, W00648_2, and W00648_3, respectively. These results are sufficient to pass allowable TVU for the survey areas. Detailed results from the analyses are shown in Figures 11, 12, and 13 below. Uncertainty surface layers are provided with all BAG files submitted with this report.

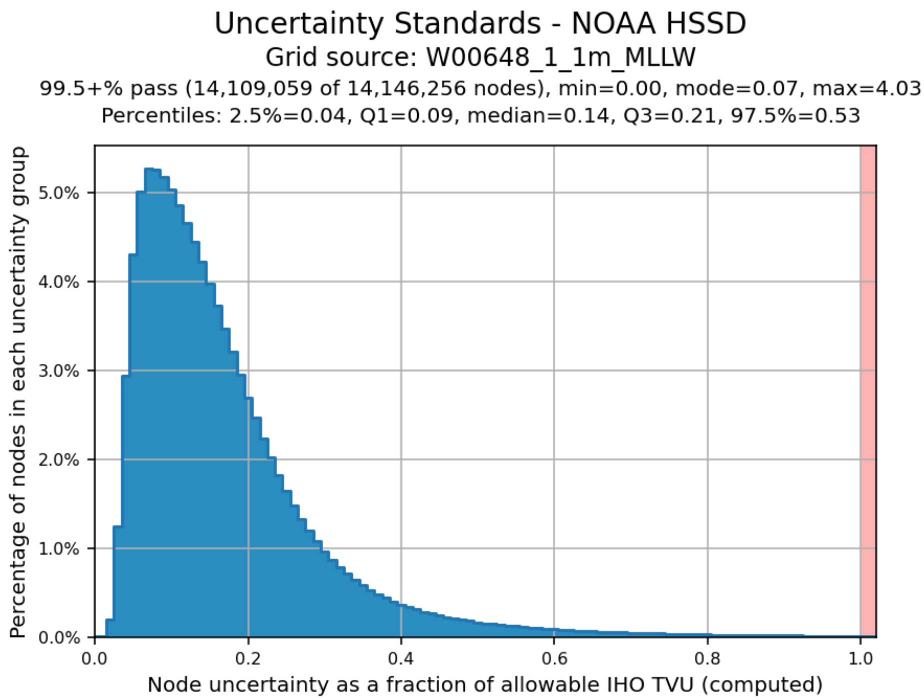


Figure 11: Allowable uncertainty statistics for 2019 Casco Bay coverage (W00648_1)

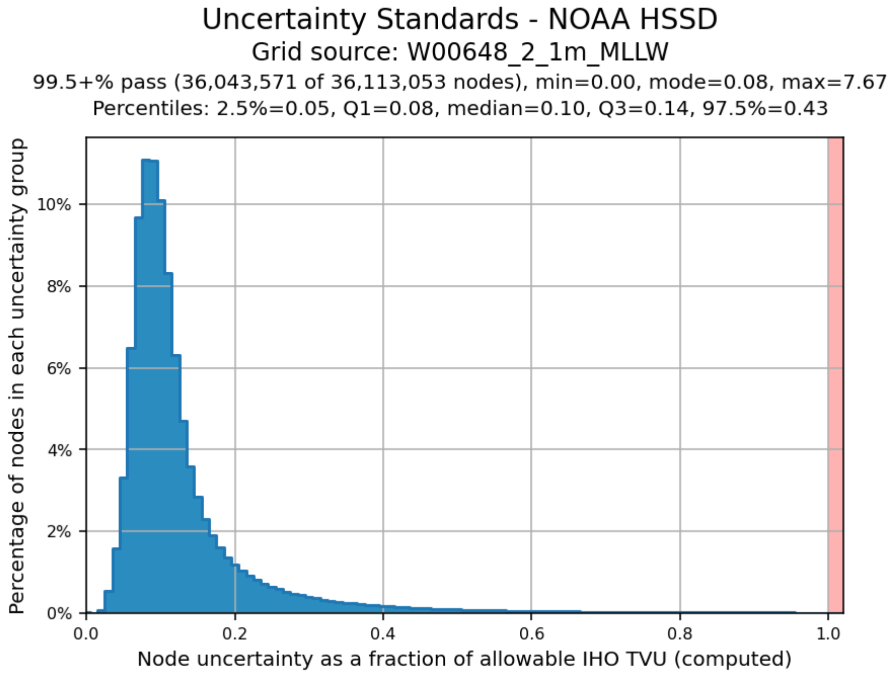


Figure 12: Allowable uncertainty statistics for 2021-2022 Casco Bay coverage (W00648_2)

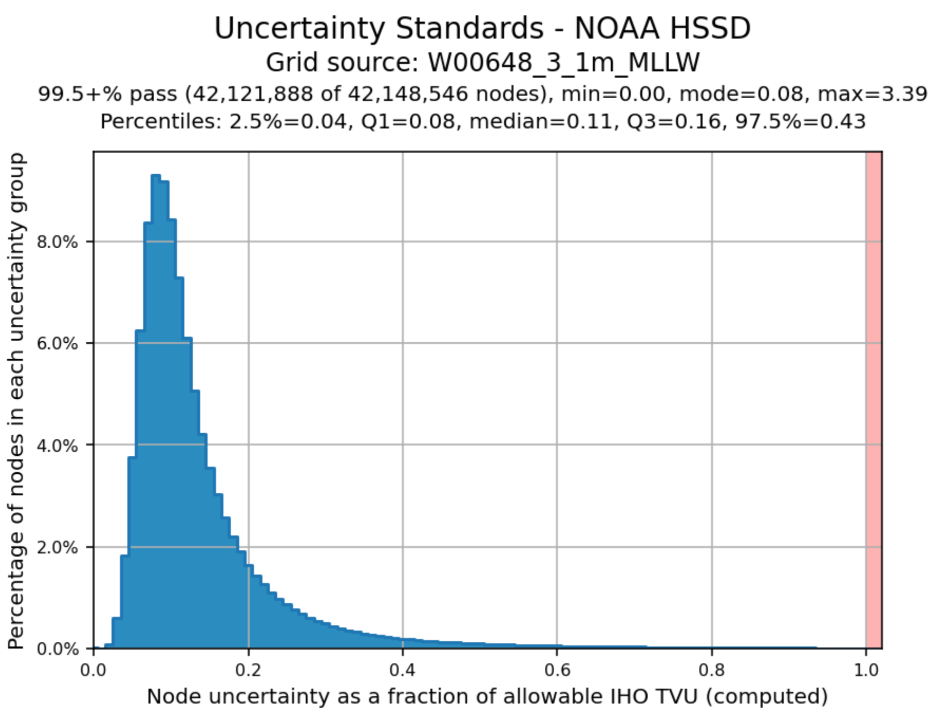


Figure 13: Allowable uncertainty statistics for 2022-2023 Casco Bay coverage (W00648_3)

3.4 Equipment Effectiveness

Sonar

Sonar data were acquired with a Kongsberg EM2040C set to a survey frequency of 300 kHz, high-density beam forming, with 400 beams per ping. Although the EM2040C allowed full swath widths at this frequency, lines from previous years' survey run at comparable depths contained considerable noise in outer beams (> ±60 degrees from the nadir as identified by QPS engineers). As a result (and as per QPS recommendation), soundings greater than ±60 degrees from the nadir were not included in final bathymetric surfaces.

Wobble

Prior to November 11, 2022, significant wobble can be observed in the outer swaths of bathymetry data collected by MCMI when mapping in rougher sea states, including select data in this submission. This wobble was investigated throughout the 2021 and 2022 seasons. Following several cooperative investigations with QPS and Kongsberg engineers, the following changes were implemented: 1.) Motion latency offset of +0.018s was applied 2.) RTK configuration changed in Qinsy computation setup (seen in Appendix F) 3.) Datagram output for attitude and velocity from Seapath to Qinsy was increased from 10 Hz to 50 Hz. These changes resulted in a dramatic decrease in motion artifacts noted in outer swaths in rougher sea states, but some artifacts may still be observed. Not all artifacts could be removed retroactively through these adjustments, but the hydrographer attempted to improve all data possible through these means. These artifacts should not significantly impact the confidence in sounding data and all products submitted should still supersede previous data in the area.

Lambert's Law for Intensity

Prior to January 25, 2023, the setting in EM Controller for Lambert's Law was set to OFF (Default). Following discussions with Kongsberg engineers regarding the mechanics of this setting and after a test comparing data in an area when OFF versus when ON, the setting was changed permanently to ON (Appendix E). This has allowed for more accurate backscatter returns which enables better substrate modeling and more refined sediment characterization efforts. Datasets after changing the setting maintain agreement with older data collected by the program but show improved definition of substrate transitions and throughout regions of uniform substrate.

3.5 Sound Speed Methods

Sound speed cast frequency: A total of 362 sound speed casts were taken within the boundaries of the W00648 survey area. All sound speed cast measurements were collected using the Teledyne Odom Digibar-S profiler. Sound speed casts were taken as needed throughout the survey, which was generally when the observed surface sound speed (monitored and visualized in real-time using the AML Micro X SV sensor) differed from the surface sound speed in the active profile by more than 2 meters per second. In certain instances, supplemental casts were taken when there was reason to suspect significant changes in the water column (e.g. change in tide, abrupt changes in seafloor relief, etc.). During the collection of sound speed casts, logging was stopped to download and apply the new cast and was resumed when the boat circled around and came back on the survey line. Throughout the duration of the survey, the surface sound speed was observed in real-time (by the AML Micro X SV probe). Sound speed data are recorded and included in raw sonar files submitted with this data package.

A quality comparison between the AML Micro X SV sensor and the Teledyne Odom Digibar-S profiler was not performed. However, real-time comparisons between surface sound speed observed by the AML Micro X SV and the surface sound speed entry in the Digibar-S profile suggested these instruments agreed. Annual calibrations were conducted for both sensors by original manufacturers to ensure performance within manufacturer defined standards.

4.0 Data Post-processing

The following is a summary of the procedures used for post-processing and analysis of survey data using Qimera (v.2.0.0 through v.2.5.3, 64-bit edition) and Fledermaus (v.8.4.0 through v.8.5.1, 64-bit edition) software.

4.1 Horizontal Datum

The horizontal datum for these data is WGS 84 projected in UTM zone 19N (meters) (EPSG 32619).

4.2 Vertical Datum and Water Level Corrections

The vertical datum for these data is mean lower-low water (MLLW) level in meters. A tidal zoning file ("Maine_Tide_Zoning_modified.zdf") containing time and range corrections for verified tide station data was provided by NOAA OCS to MCMI in May 2020. This file was used to apply time corrections, tide height offsets, and tide scale (range) for collected data in each zone listed in Table 7 and shown in Figure 14.

Table 7 – Tide zones and corrections referenced to verified Portland, ME (8418150) tide station data

Survey Area	Tide Station	Zone ID	Time Correction (mins.)	Tide Offset (m)	Tide Scale
Casco Bay	8418150	ME20	0	0	1.00
Casco Bay	8418150	ME78	0	0	0.99
Casco Bay	8418150	ME55	0	0	0.98
Casco Bay	8418150	ME91	-6	0	0.97
Casco Bay	8418150	ME69	0	0	0.98
Casco Bay	8418150	ME81	0	0	0.99

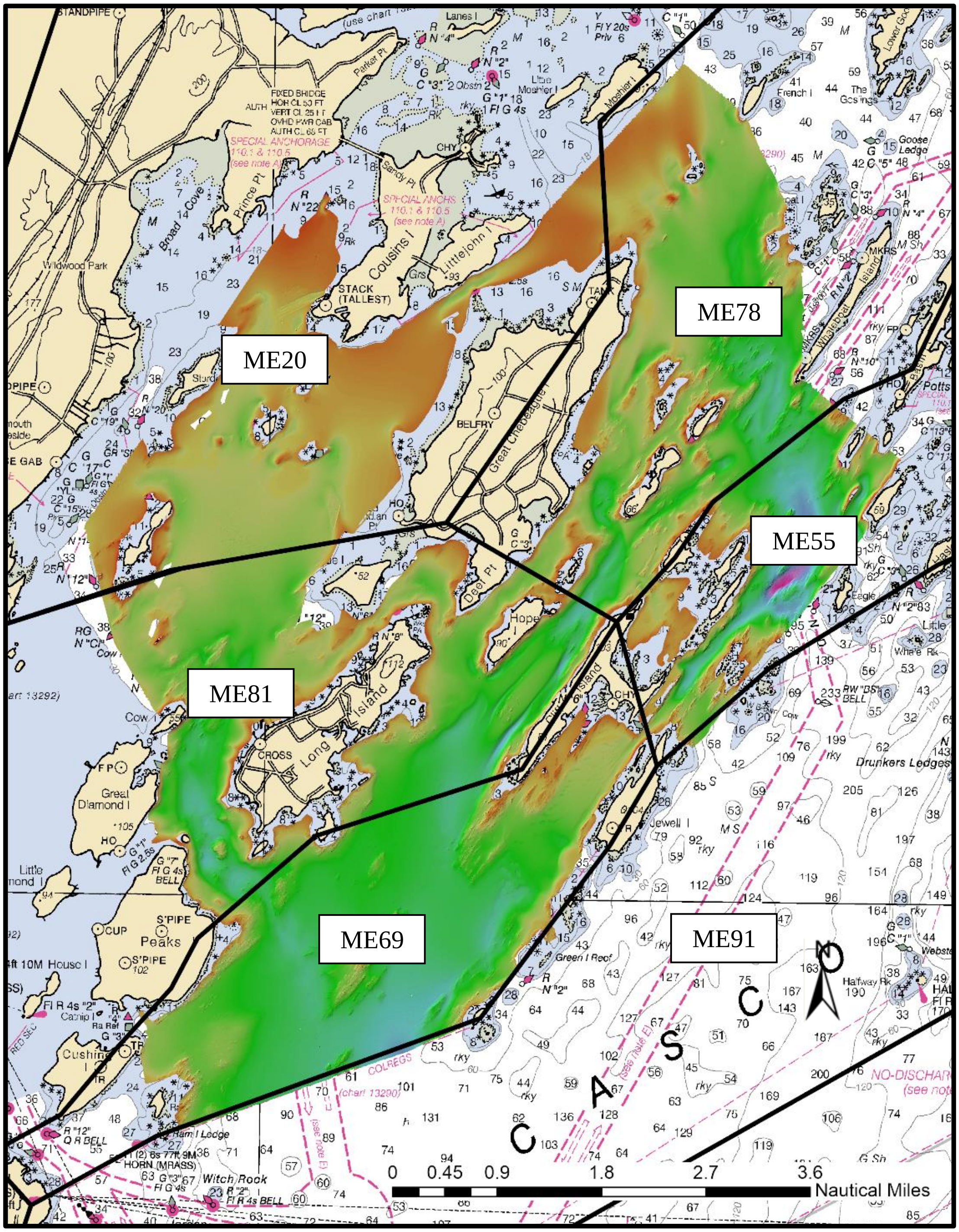


Figure 14 - Tide zones (outlined in black) relative to survey extent

4.3 Processing Workflow

The general post-processing workflow in Qimera was as follows:

1. Create project
2. Add raw sonar files (e.g. metadata extracted and processed bathymetry data converted to .qpd, including vessel configuration and sound velocity)
3. Apply sound velocity profiles via real-time scheduling or by distance/time, contingent upon region surveyed and local conditions
4. Add tide zoning file (.zdf) and associated tide data and integrate into raw files
5. Create dynamic surface with NOAA CUBE settings enabled for desired resolution (e.g. 2-meter, 4 meter)
6. Review and edit soundings/clean surface with slice editor tool, 3D editor tool, and available filters
7. Duplicate surfaces at other grid sizes, if desired
8. Export final surface to .BAG surface
9. Export processed data in .GSF format for backscatter processing

<u>CUBE</u>

A CUBE (Combined Uncertainty and Bathymetry Estimator) surface was created for editing and as a starting point for final products. The corresponding NOAA cube setting (e.g. "NOAA_4m" configuration, Figure 15) was selected for each surface depending on the grid size of the surface.

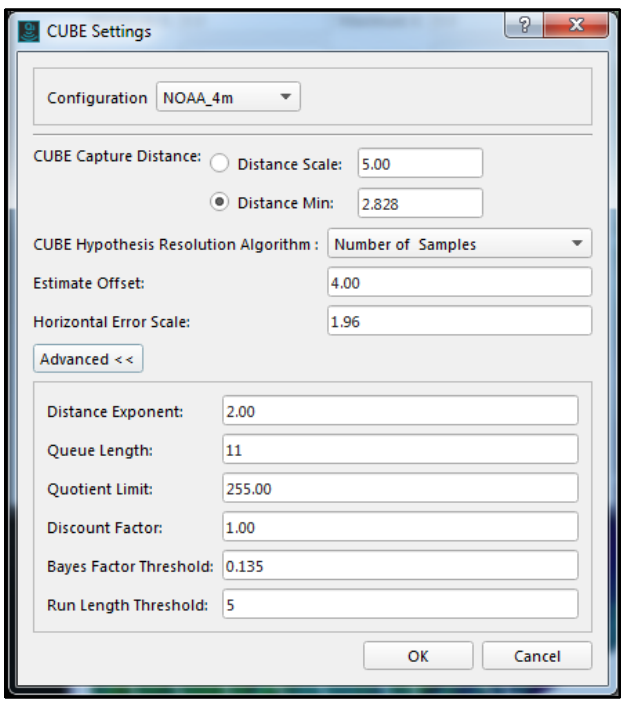


Figure 15 – CUBE settings parameters window shown with settings for NOAA 4-meter grid resolution

4.4 Final Surfaces

The following surfaces were submitted with the survey data. Each BAG file contains the CUBE-processed sounding surface layer and an uncertainty layer. The data submission package is split into three different sections due to the large size of each project and significant temporal difference in acquisition period. W00648_1 surfaces correspond to data collected in the 2019 survey effort, W00648_2 surfaces correspond to data collected in the 2021-2022 survey effort, and W00648_3 surfaces correspond to data collected in the 2022-2023 survey effort (Figure 3).

Table 8 – Bathymetry surfaces submitted for Casco Bay survey data

Surface Name	Resolution (m)	Depth Range (m)	Surface Parameter
W00648_1_1m_MLLW	1	2 - 47	N/A
W00648_1_2m_MLLW	2	2 - 47	N/A
W00648_1_4m_MLLW	4	2 - 47	N/A
W00648_2_1m_MLLW	1	1 - 59	N/A
W00648_2_2m_MLLW	2	1 - 59	N/A
W00648_2_4m_MLLW	4	1 - 59	N/A
W00648_3_1m_MLLW	1	1 - 57	N/A
W00648_3_2m_MLLW	2	1 - 57	N/A
W00648_3_4m_MLLW	4	1 - 57	N/A

4.5 Backscatter

Backscatter data was logged in raw .db files during acquisition. The .db files also hold the navigation record and bottom detections for all lines of surveys. Processed sonar files containing multibeam backscatter data (snippets and beam-average) were exported from Qimera in .GSF format. QPS Fledermaus Geocoder Toolbox (FMGT; v.7.8.6 through v.7.10.2, 64-bit edition) was used to import, process, and mosaic time-series backscatter data. Default backscatter processing settings were used to create the mosaic, except for the Angle Varied Gain (AVG) filter and AVG window size, which were set to 'Adaptive' and '100', respectively. Backscatter mosaics of the data were gridded at 1-meter, 2-meter, and 4-meter resolutions. Survey data were split by season of acquisition and delivered as separate files for file management purposes, as well as to keep discrepancies across datasets contained within acquisition timeframes. Mosaics were exported in floating-point GeoTIFF format. The mosaics are shown in Table 9 and Figure 16.

Table 9 – Backscatter mosaics submitted for Casco Bay survey data

Mosaic Name	Pixel Size (m)
W00648_1_1m_MLLW	1
W00648_1_2m_MLLW	2
W00648_1_4m_MLLW	4
W00648_2_1m_MLLW	1
W00648_2_2m_MLLW	2
W00648_2_4m_MLLW	4
W00648_3_1m_MLLW	1
W00648_3_2m_MLLW	2
W00648_3_4m_MLLW	4

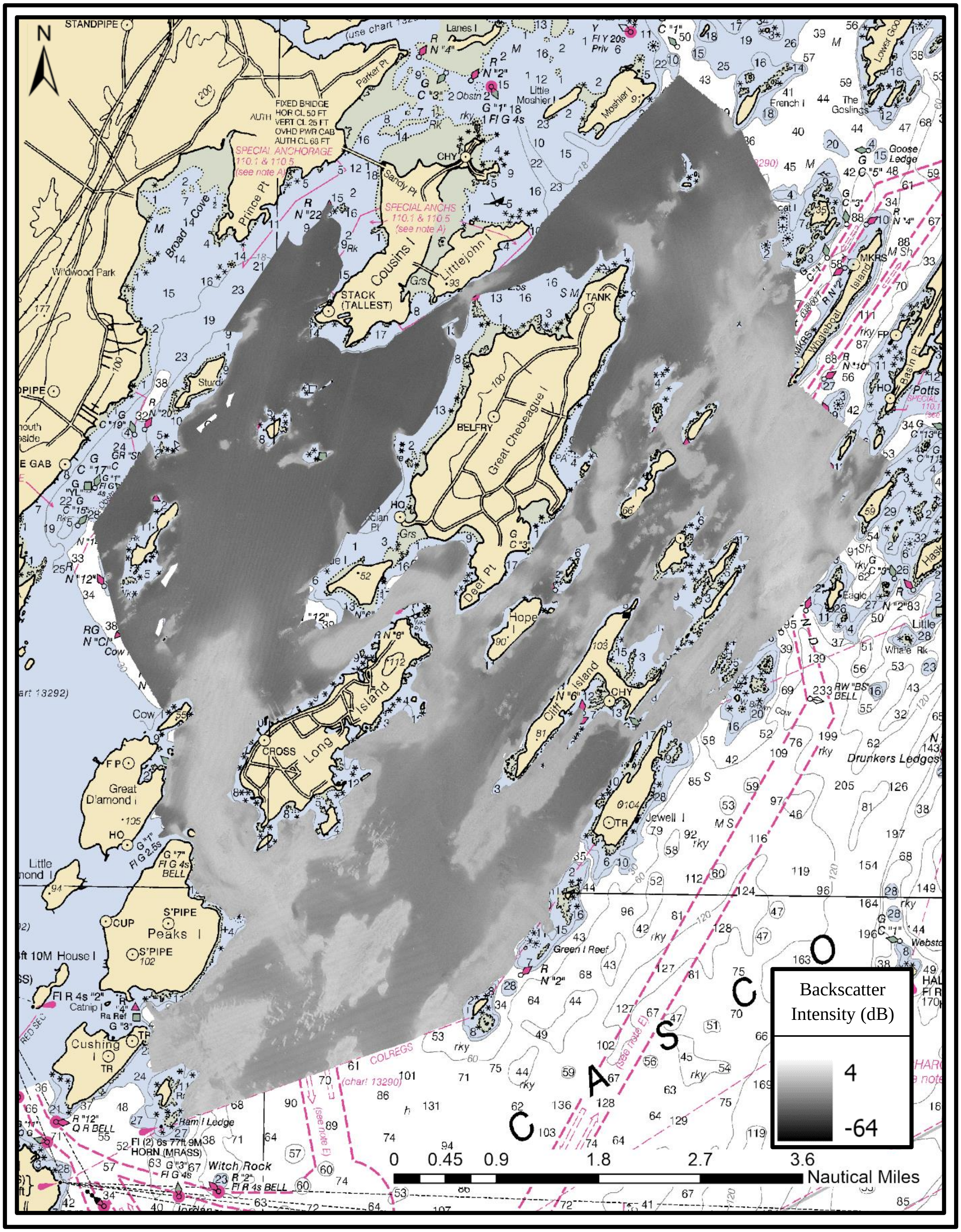


Figure 16 – Backscatter mosaic (1-meter pixel size) of Casco Bay coverage atop NOAA chart 13288

5.0 Results

5.1 Charts Comparison

The hydrographer conducted a qualitative comparison of reclassified bathymetry data and depth contours from the surveyed area to the charted soundings and contours. The largest scale raster navigational charts which cover the survey areas are listed in Table 10. Prior hydrographic surveys in the vicinity were conducted by NOAA in 1941, 1998, and 2000. These data were not compared with data collected by the MCMI. Chart comparisons shown in figures are provided at the largest scale available. Charts at coarser resolution will show similar differences as seen in the largest scale charts.

Table 10 – Largest scale raster charts in survey area

Chart	Scale	Source Edition	Source Date	NTM Date
13288	1:80,000	44	02/2016	5/30/2023
13290	1:40,000	41	10/2019	5/30/2023
13292	1:20,000	42	06/2018	5/30/2023

<u>Chart 13288</u>

Surveyed depths have good overall agreement with charted apart from a notable deep region northwest of Eagle Island where the channel reaches 57 meters and extends at depth further to the west than charted, with values exceeding 50 meters where charts indicate 37-38 meters (Figure 26). This disagreement is most likely due to a changing topology from strong bottom boundary layer dynamics since the last survey, which was over 80 years prior to the efforts described in this report. All other depths show strong agreement with contours showing only minor discrepancies in placement throughout the survey area. It is recommended that contours showing disagreement in this area be revised based on the findings of this report.

<u>Chart 13290</u>

Surveyed depths have good overall agreement with charted contours apart from a deep region northwest of Eagle Island where the channel reaches 57 meters and extends at depth further to the west than charted, with values exceeding 50 meters where charts indicate 37-38 meters (Figure 26). This disagreement is most likely due to a changing topology from strong bottom boundary layer dynamics since the last survey, which was over 80 years prior to the efforts described in this report. All other depths show strong agreement with contours showing only minor discrepancies in placement throughout the survey area. It is recommended that contours showing disagreement in this area be revised based on the findings of this report.

<u>Chart 13292</u>

Surveyed depths have good overall agreement with charted contours, but minor discrepancies in placement exist throughout the survey area. It is recommended that contours showing disagreement in this area be revised based on the findings of this report.

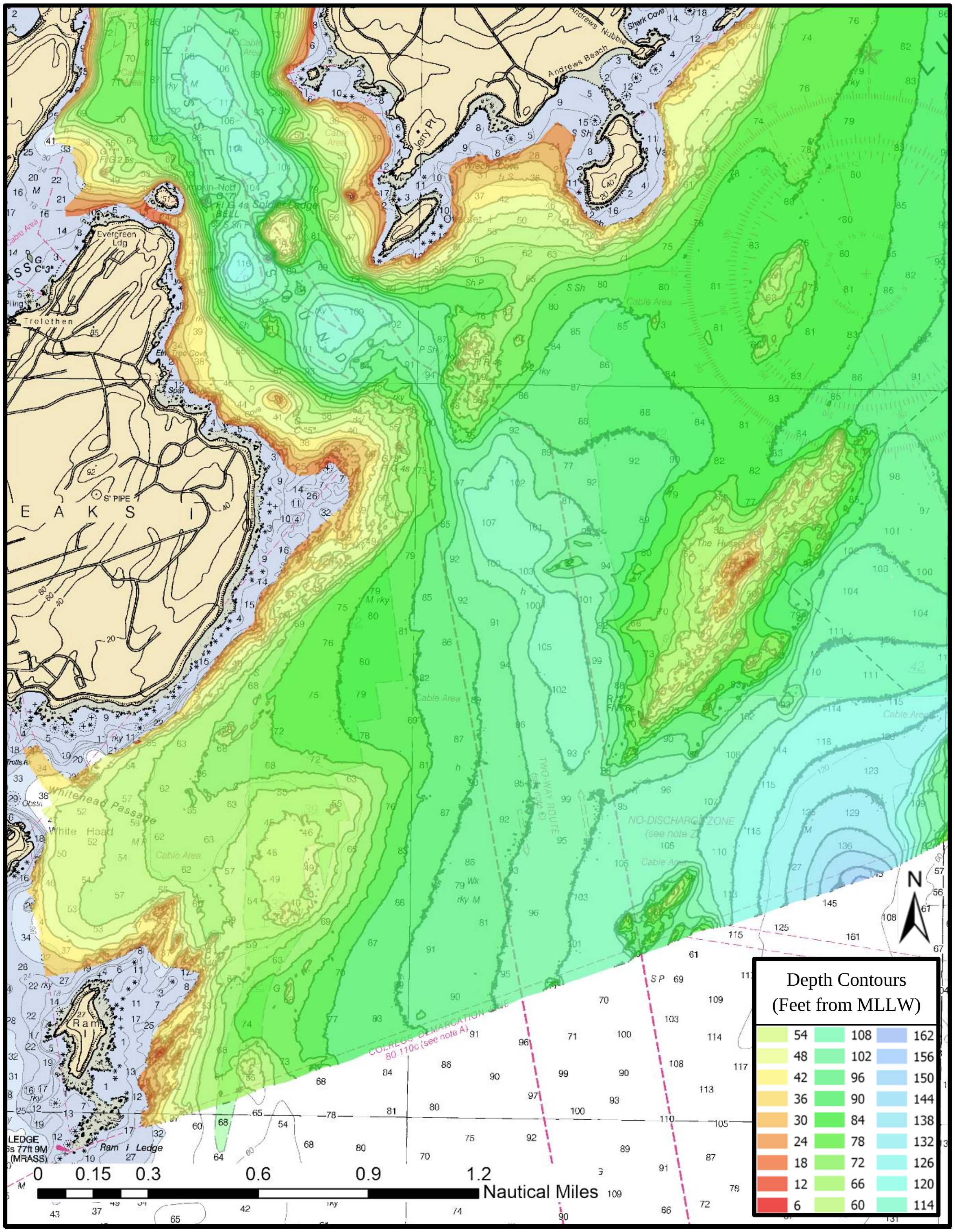


Figure 17 – South of Hussey Sound comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

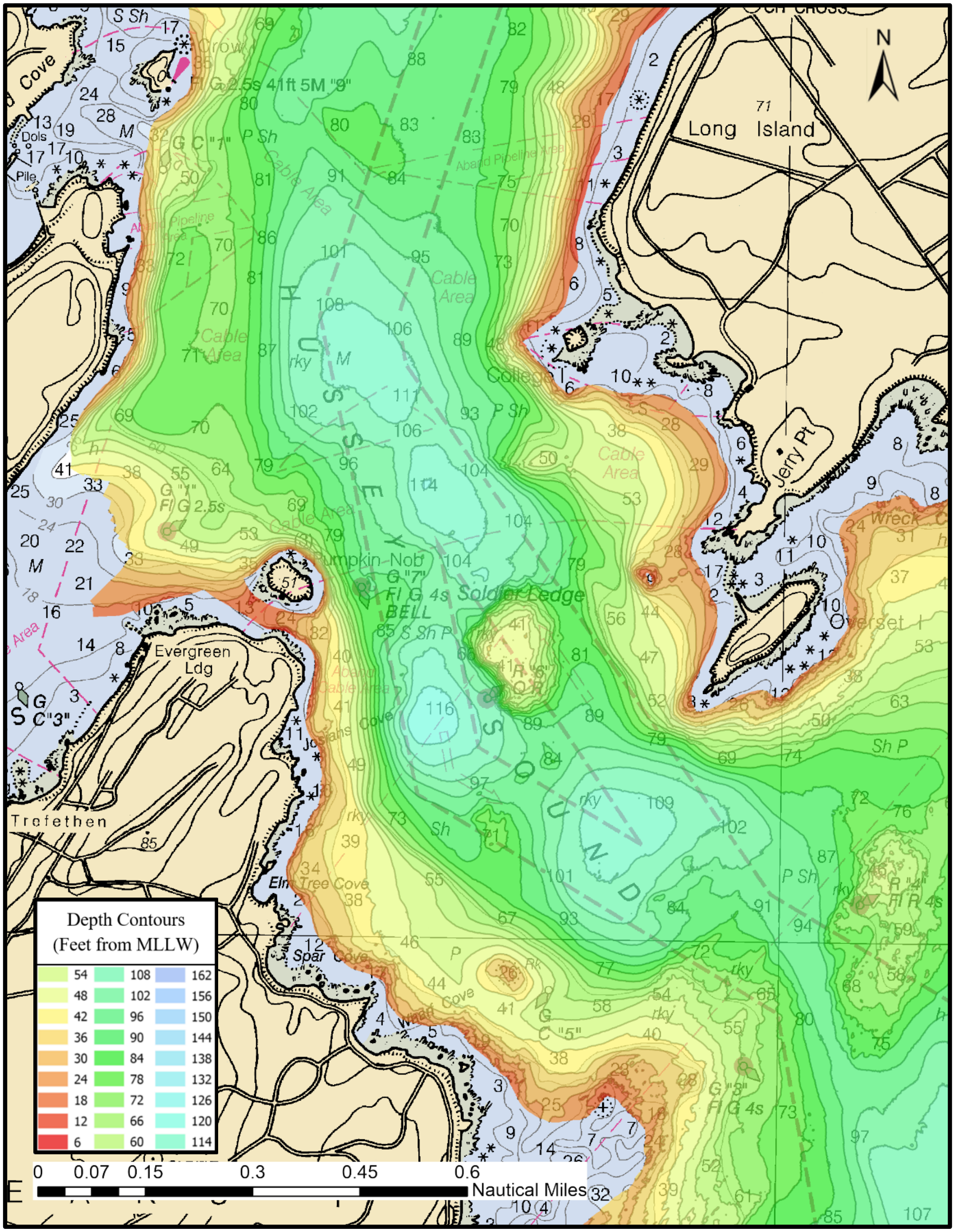


Figure 18 – Hussey Sound comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

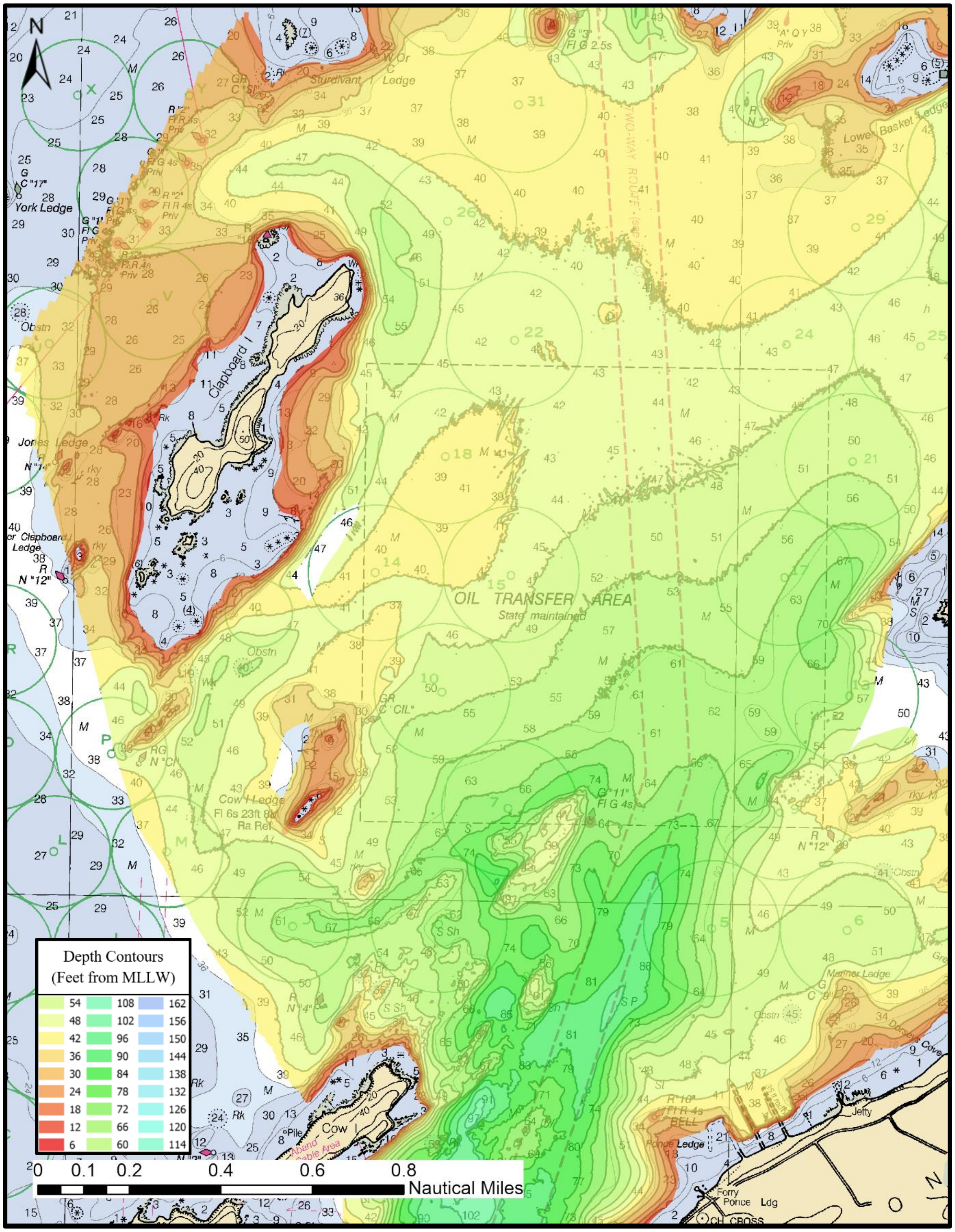


Figure 19 – North of Hussey Sound comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

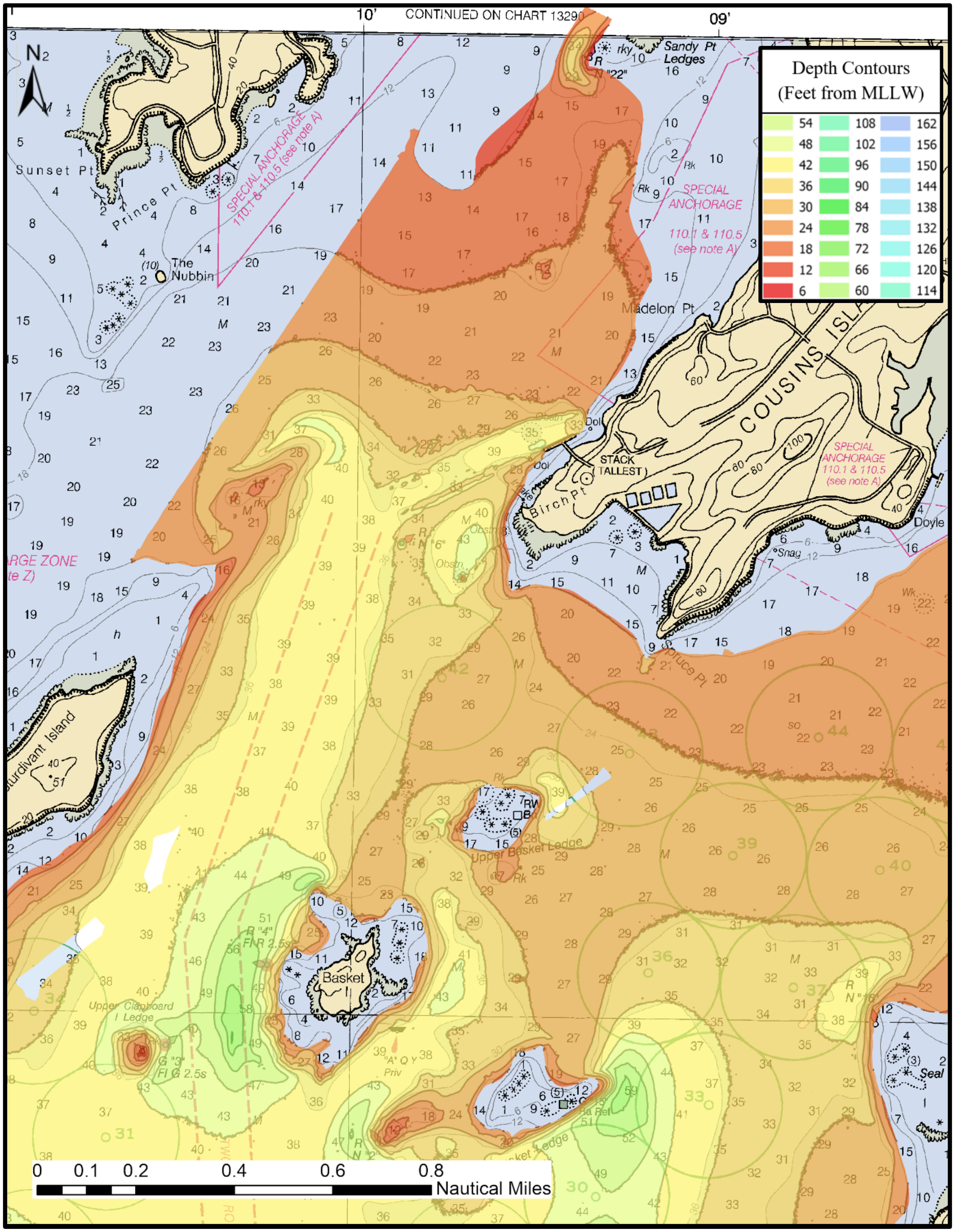


Figure 20 – South of Cousins Island comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

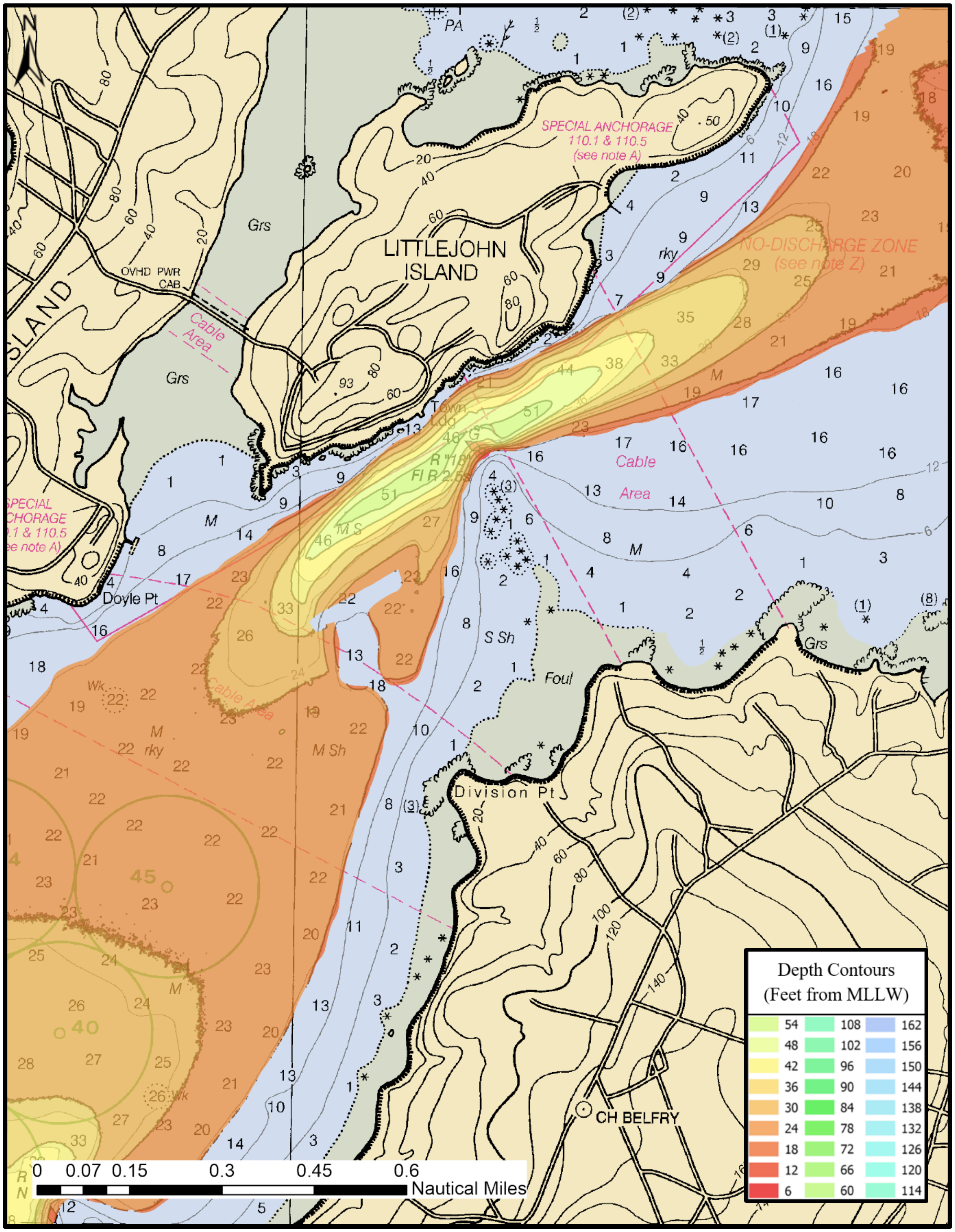


Figure 21 – Littlejohn Island channel comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

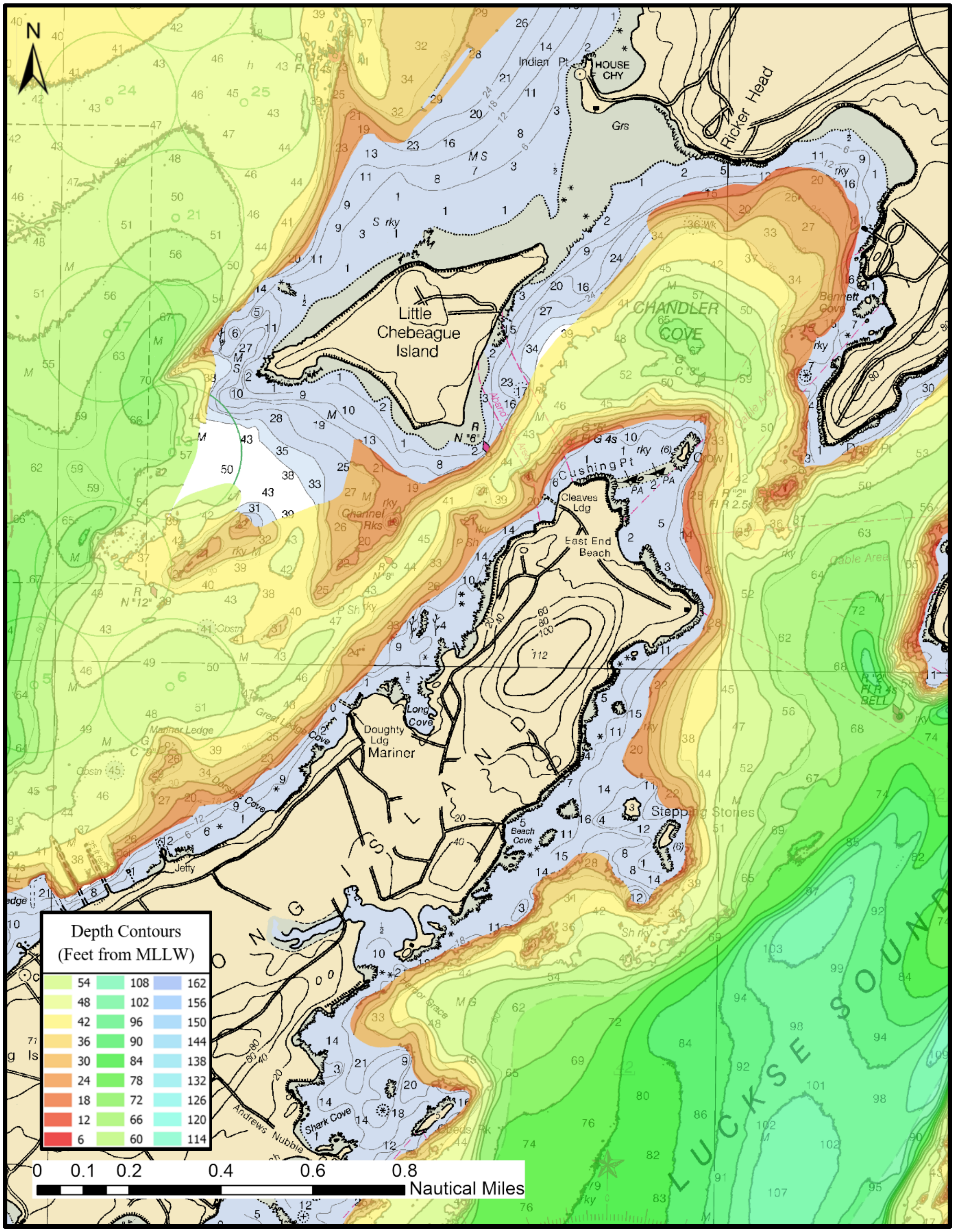


Figure 22 – Chandler Cove comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

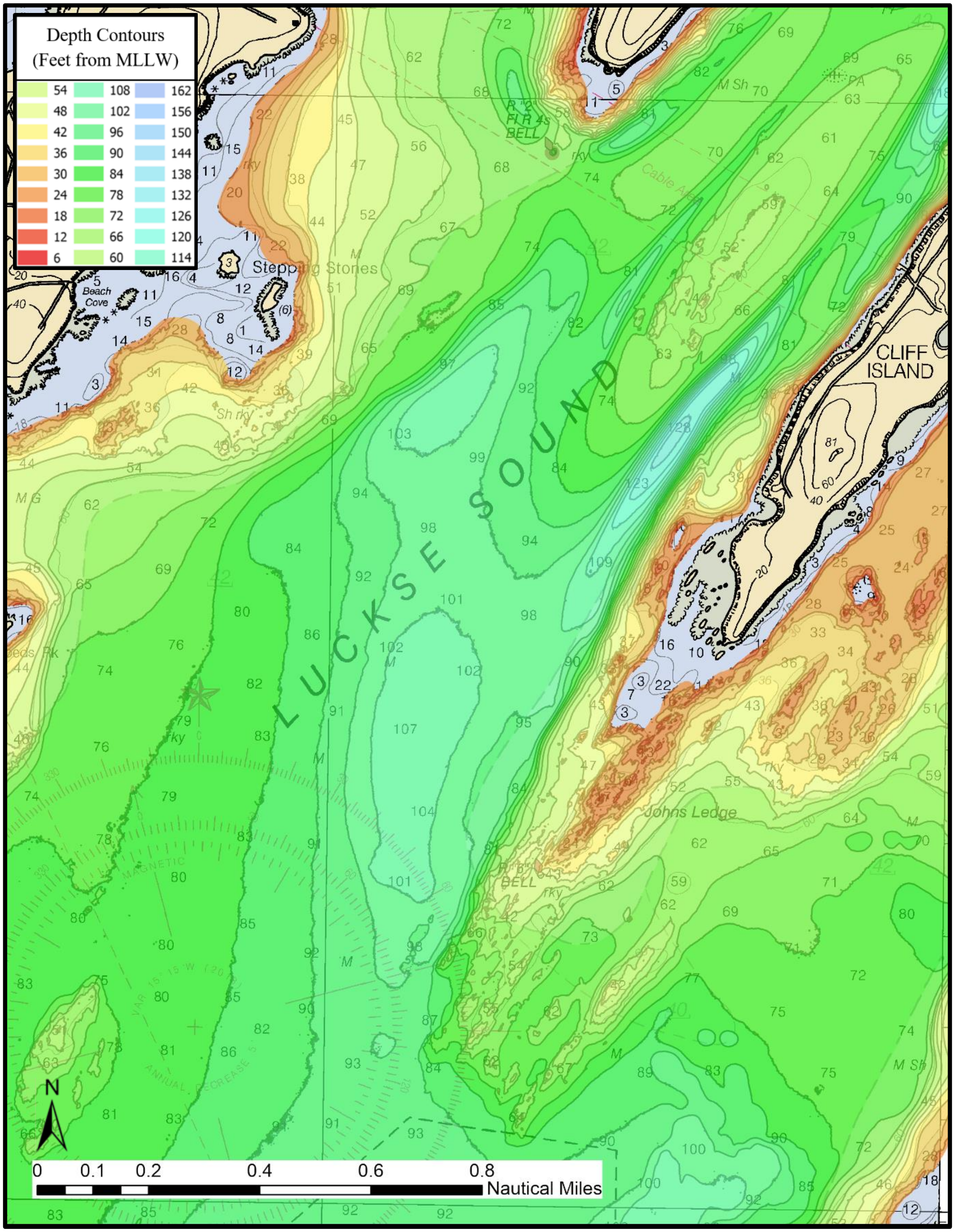


Figure 23 – Luckse Sound SW comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

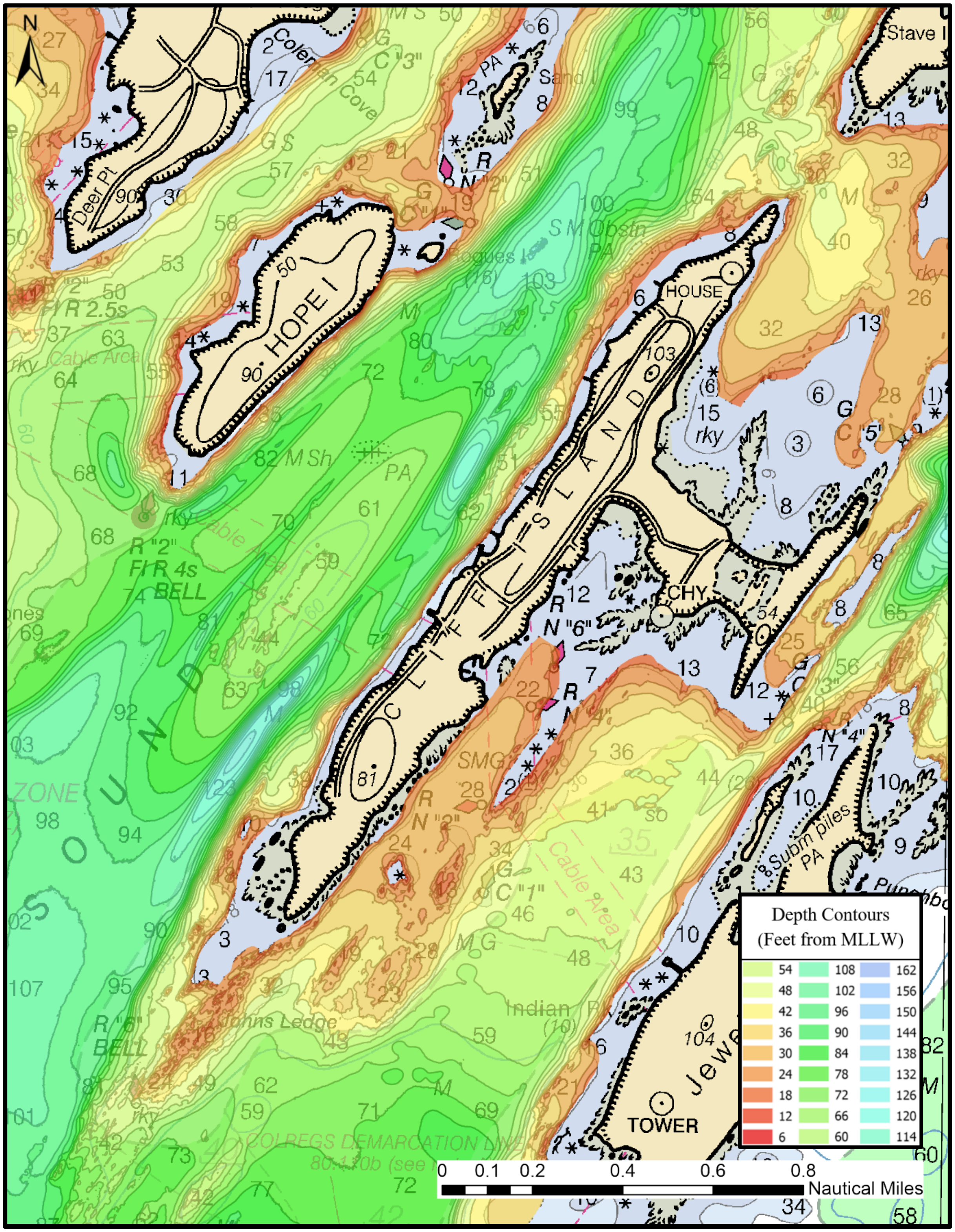


Figure 24 – Luckse Sound SW comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

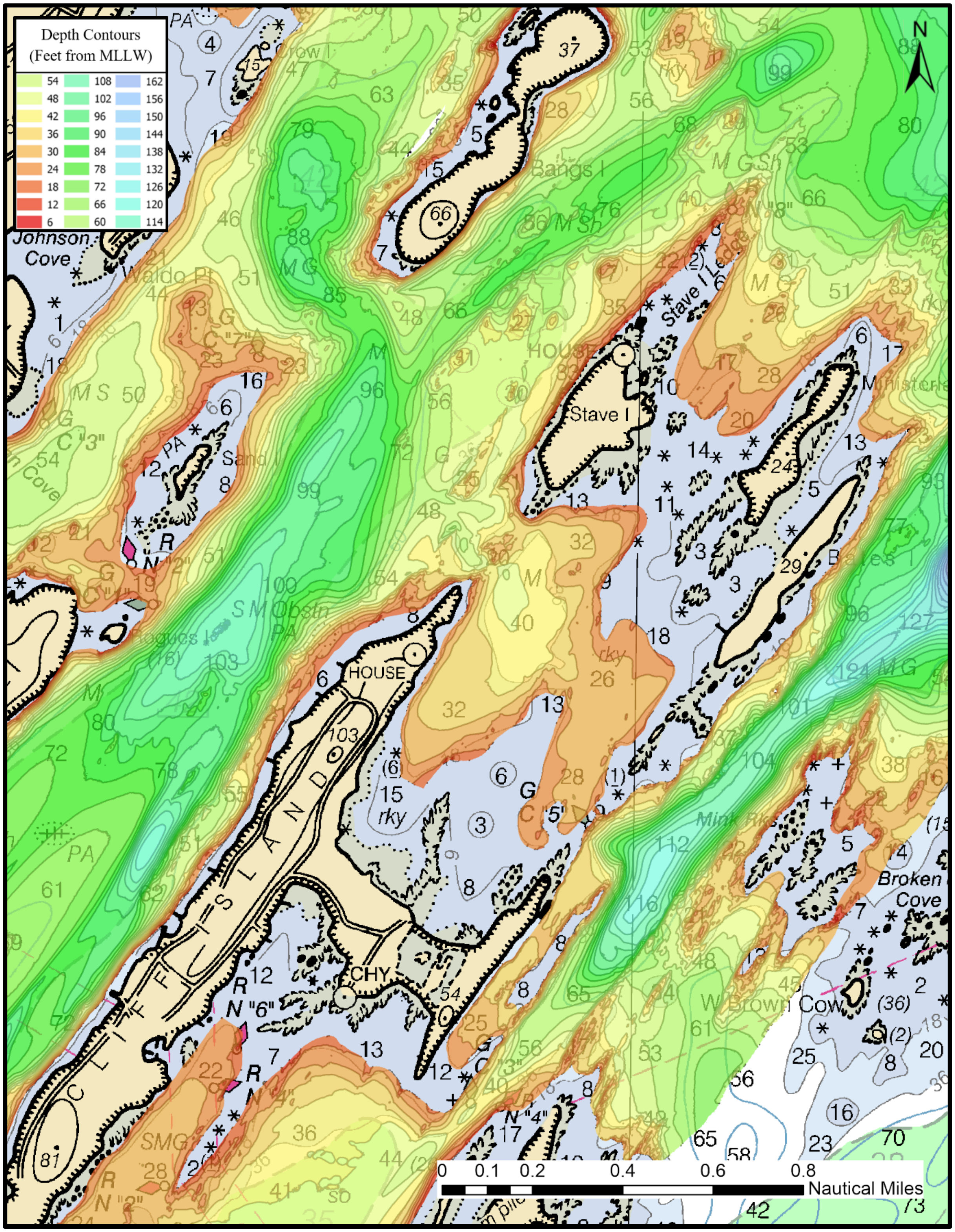


Figure 25 – Luckse Sound and Cliff Island comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

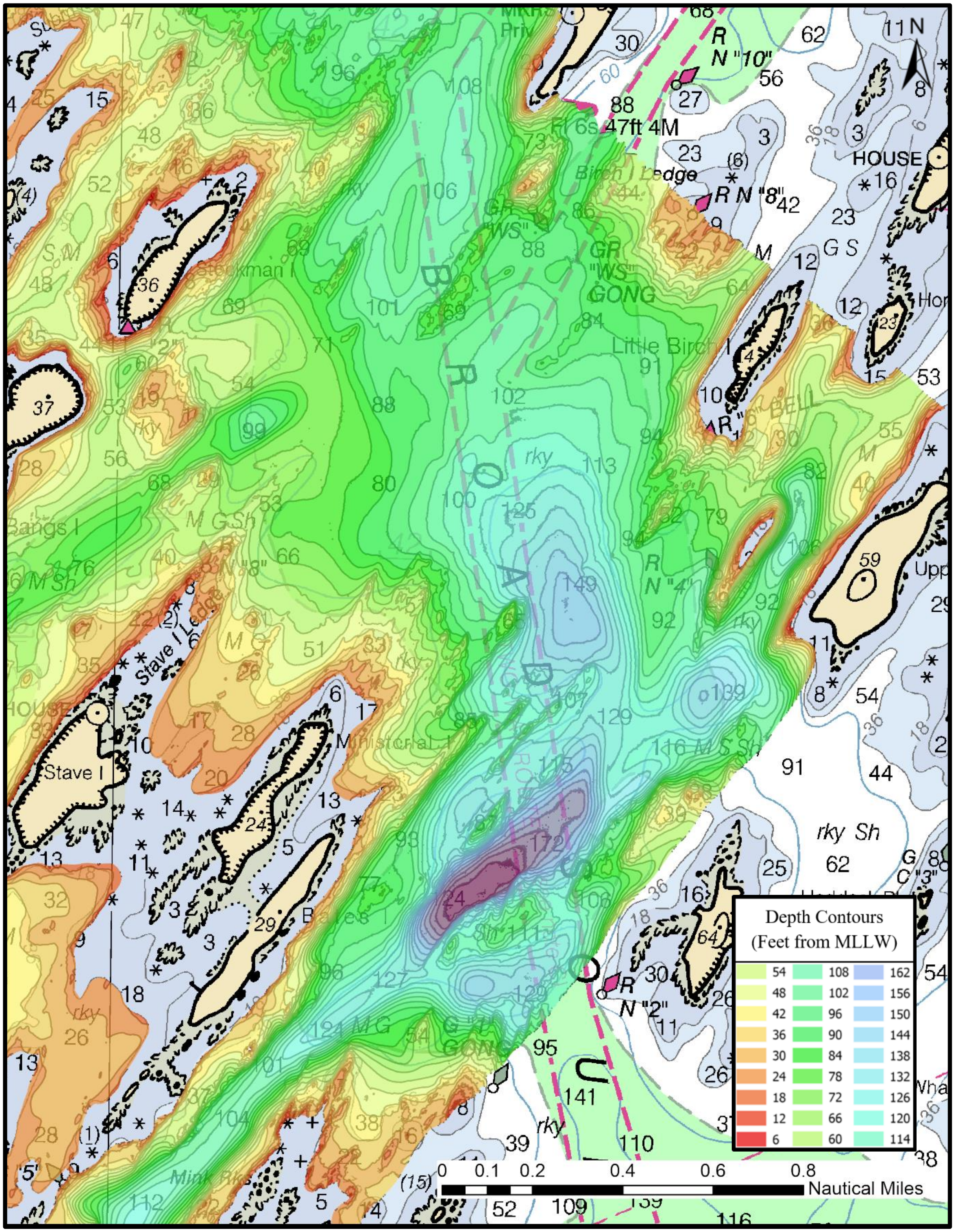


Figure 26 – Broad Sound to Eagle Island comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

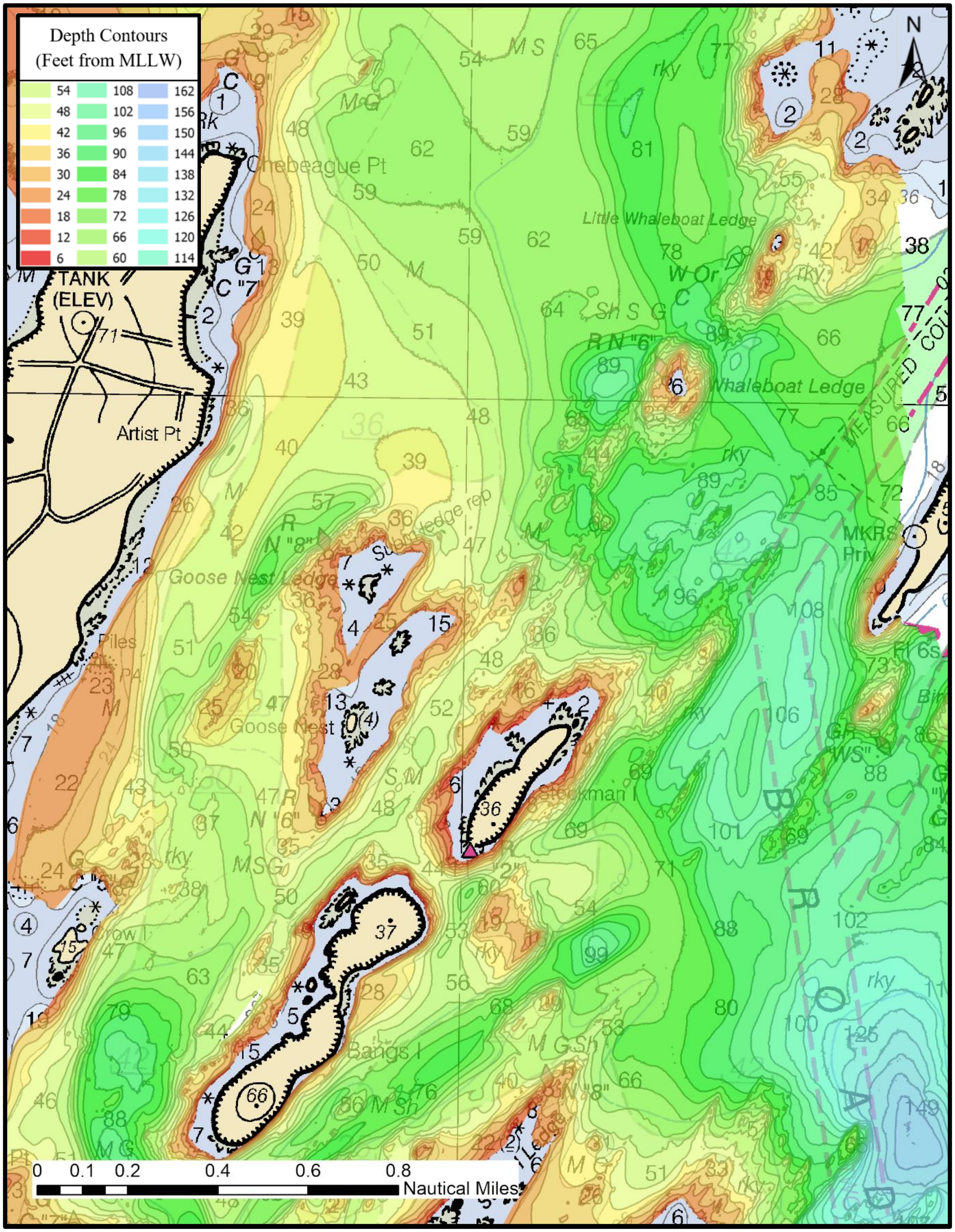


Figure 27 – Luckse Sound meets Broad Sound comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

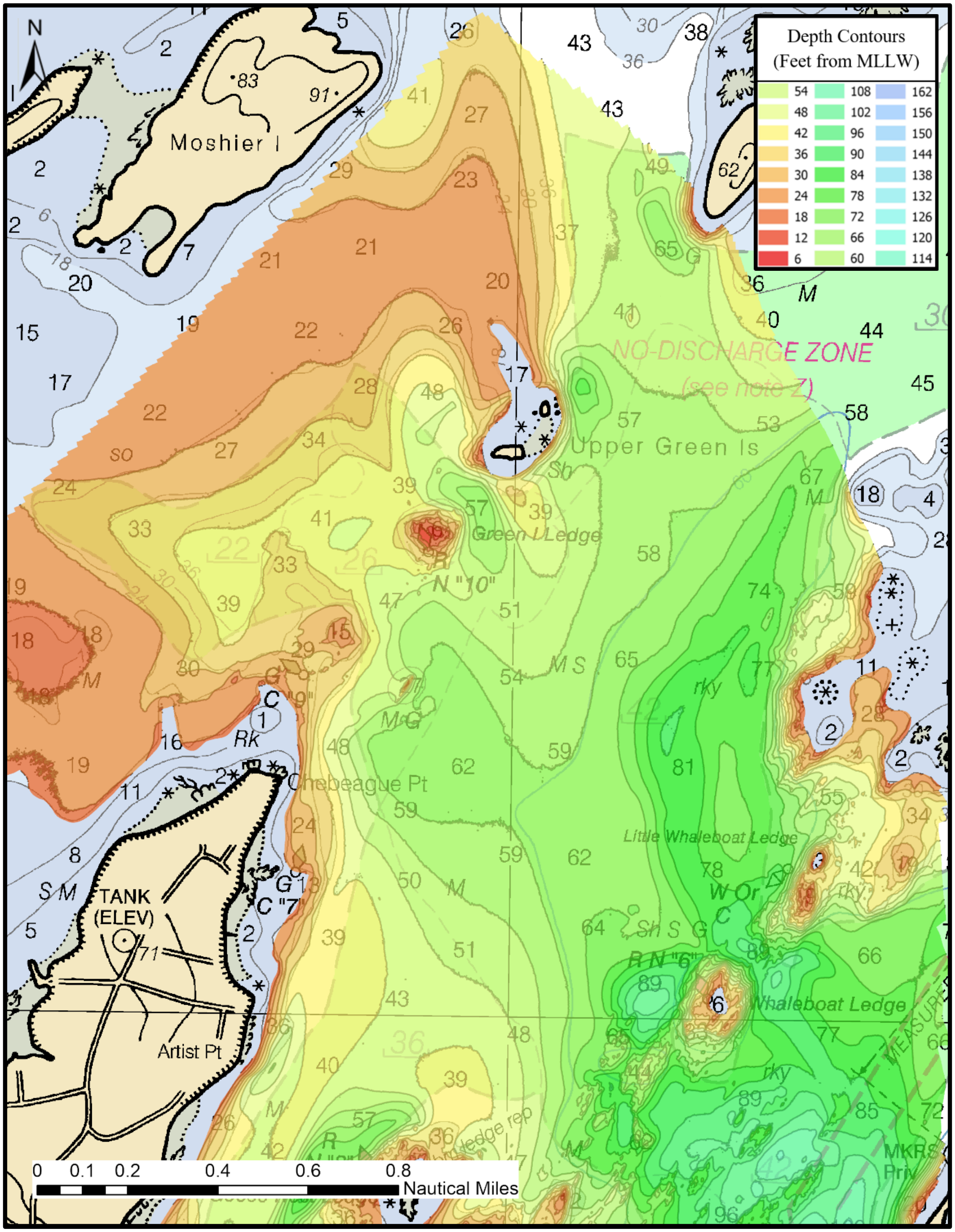


Figure 28 – Broad Sound to Whaleboat Ledge comparison between surveyed depth (reclassified at 6-feet intervals) and chart 13292 contours (6-feet interval in shoals)

5.2 Bottom Samples

A total of 71 bottom sampling sites were planned for collection throughout the course of the acquisition effort in state and federal waters to supplement existing sediment data collected previously by other agencies (Maine Geological Survey and University of Maine) in and surrounding the survey area (Figure 29). A total of 69 sites were successfully completed, with 54 retrieving sediment samples for analysis. The results of grain-size and video analyses will be used to calibrate, refine, and digitize interpretations of seafloor substrate. These data are also used to investigate how these data relate to benthic infauna in the survey area.

Additional details on the bottom samples are provided in Table 11. More detailed analysis of grain size composition of these samples and benthic fauna composition will be determined after laboratory processing is complete for the collected samples. Metadata sheets for all bottom samples are provided as part of the submitted data package accompanying this report.

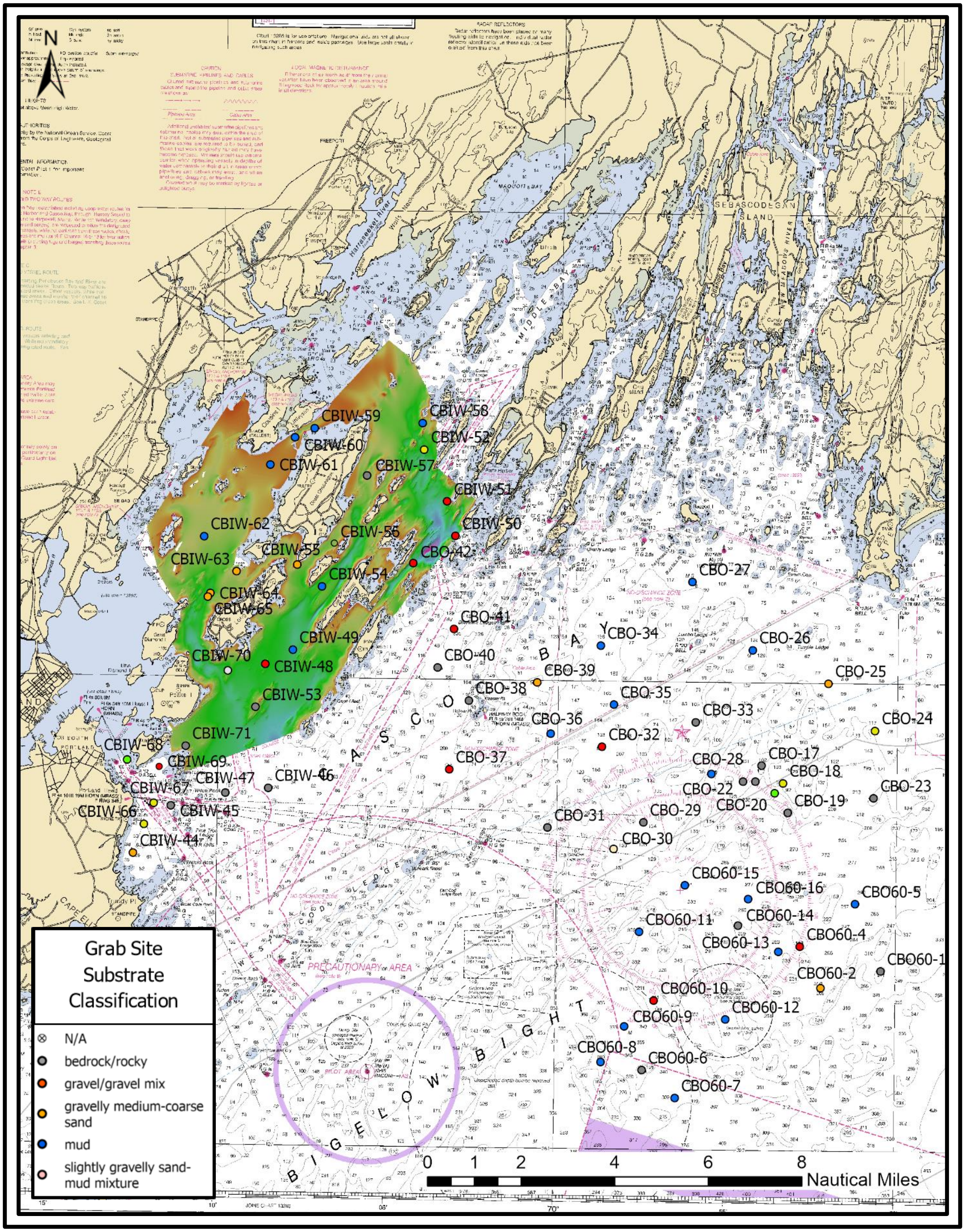


Figure 29 – Bottom sample locations collected over the course of the MCMI 2021 survey season in Casco Bay. Sites classified via the modified CMECS 7-class scheme from field observations (Appendix H).

Table 11 – Grab Sample Information

Site Name	Date	Latitude (decimal degrees N)	Longitude (decimal degrees W)	Depth (m)	Grain size (field observation)	Backscatter Intensity (dB)
CBO60-1	07/14/2021	43.56434874	-69.84043317	86.7	rock	-8.91
CBO60-2	07/14/2021	43.55819487	-69.86976905	80	gravelly muddy sand	-10.16
CBO60-4	07/14/2021	43.57289778	-69.88005763	66.2	muddy gravel	-5.75
CBO60-5	07/14/2021	43.58825363	-69.8532413	89.3	mud with shell hash	-23.39
CBO60-6	07/27/2021	43.5282881	-69.95701022	83.1	rock	-8.59
CBO60-7	07/27/2021	43.51850195	-69.94063984	103	silty mud with trace sand	-15.2
CBO60-8	07/27/2021	43.53101614	-69.97704435	89.2	clayey sandy mud with trace sand and gravel	-13.63
CBO60-9	07/27/2021	43.54387055	-69.96571119	105	silty mud with trace sand	-17.41
CBO60-10	07/27/2021	43.5531374	-69.95139053	69.8	sandy gravel with mud, assumed atop rock due to low yield	-7.64
CBO60-11	07/27/2021	43.57756521	-69.95907309	93.6	silty mud with trace sand	-20.56
CBO60-12	08/04/2021	43.54665962	-69.91629933	95.8	silty mud with trace sand	-20.87
CBO60-13	08/04/2021	43.57100557	-69.89058881	85.7	clayey silty mud with trace sand	-18.98
CBO60-14	08/04/2021	43.58018277	-69.91054073	70.2	rock	-5.44
CBO60-15	08/04/2021	43.59433163	-69.93672223	88.3	clayey mud with trace sand	-22.76
CBO60-16	08/04/2021	43.58970106	-69.90562112	89.6	clayey silty mud with trace sand	-20.56
CBO-17	08/10/2021	43.63726057	-69.89973456	39	rock	-9.22
CBO-18	08/10/2021	43.63104394	-69.88925266	45.4	sand with shell hash and trace gravel	-8.27
CBO-19	08/10/2021	43.62049572	-69.88679743	42	rock	3.07
CBO-20	08/10/2021	43.62743115	-69.89315061	60	clayey muddy sand	-13.31
CBO-21	08/10/2021	43.63160203	-69.902709	48	rock	-4.49
CBO-22	08/10/2021	43.63144262	-69.90886332	38	surficial gravel atop rock	-11.11
CBO-23	09/01/2021	43.62601626	-69.84461578	52.7	rock	Unavailable
CBO-24	09/01/2021	43.65006997	-69.84423635	37.2	sand	Unavailable
CBO-25	09/01/2021	43.66673057	-69.86737224	31.7	gravelly sand with shell hash	Unavailable
CBO-26	09/01/2021	43.67838093	-69.90477437	42.3	silty clayey mud	Unavailable
CBO-27	09/01/2021	43.70244163	-69.93472201	36.3	clayey mud	Unavailable
CBO-28	09/14/2021	43.634098	-69.92430233	60.9	clayey mud with trace sand and gravel	-16.15
CBO-29	09/14/2021	43.6165869	-69.95750871	40.4	rock	-12.05
CBO-30	09/14/2021	43.60703578	-69.97187846	52.6	gravelly sandy mud with shell hash	-9.22
CBO-31	09/14/2021	43.61436553	-70.00449403	43.7	rock	Unavailable
CBO-32	09/14/2021	43.6433754	-69.97824097	41	muddy gravel with shell hash	Unavailable
CBO-33	09/14/2021	43.65246427	-69.9322708	41.9	surficial mud and shell hash atop rock	Unavailable
CBO-34	09/21/2021	43.6794123	-69.9794058	49.8	clayey mud with trace fine sand	Unavailable
CBO-35	09/21/2021	43.65844131	-69.97264017	55.6	clayey mud with trace fine sand	Unavailable
CBO-36	09/21/2021	43.64777554	-70.00341145	55.1	clayey mud with trace coarse grain sand and gravel	Unavailable
CBO-37	09/21/2021	43.63466854	-70.05312236	42.3	muddy gravel with coarse sand	Unavailable
CBO-38	09/21/2021	43.65930149	-70.04387337	39.3	surficial shell hash atop rock	Unavailable
CBO-39	09/21/2021	43.66597099	-70.01033069	52.2	gravelly muddy sand with shell hash	Unavailable
CBO-40	10/07/2021	43.6709336	-70.05945749	35.7	rock	Unavailable
CBO-41	10/07/2021	43.68471829	-70.05166945	60.3	muddy gravel	Unavailable
CBO-42	10/07/2021	43.707942	-70.072079	39.5	muddy gravel	Unavailable
CBIW-44	10/13/2021	43.60346	-70.207592	17.4	gravelly sand	Unavailable
CBIW-45	10/13/2021	43.620469	-70.18952	18.8	rock	Unavailable
CBIW-46	10/13/2021	43.627253	-70.141778	21.8	rock	Unavailable
CBIW-47	10/13/2021	43.625266	-70.162846	25.7	rock	Unavailable
CBIW-48	10/13/2021	43.67142	-70.144092	19.8	muddy gravel composed primarily of shell hash-pebble mix	Unavailable
CBIW-49	10/13/2021	43.676552	-70.130639	30.8	clayey mud with trace sand	Unavailable
CBIW-50	10/07/2021	43.71786	-70.05139	27.7	gravel	Unavailable
CBIW-51	10/07/2021	43.73013	-70.055711	29.9	muddy gravel with shell hash; large cobbles present	Unavailable
CBIW-52	10/07/2021	43.748517	-70.067306	29	medium to coarse grain sand with trace gravel	Unavailable
CBIW-53	10/19/2021	43.655987	-70.148463	14	rock	Unavailable
CBIW-54	10/19/2021	43.69927	-70.116656	22.6	silty mud with trace sand	Unavailable
CBIW-55	10/19/2021	43.706947	-70.12905	10.3	gravelly sand with shell hash	Unavailable
CBIW-56	10/19/2021	43.714675	-70.110828	17.5	N/A	Unavailable
CBIW-57	10/19/2021	43.739052	-70.095317	11.2	rock	Unavailable
CBIW-58	10/19/2021	43.757935	-70.068187	19.1	sandy mud with shell hash	Unavailable
CBIW-59	10/19/2021	43.755613	-70.121337	8.8	silty mud with trace sand	Unavailable
CBIW-60	11/03/2021	43.752286	-70.130831	13.8	silty clayey mud with trace sand	Unavailable
CBIW-61	11/03/2021	43.74242596	-70.14284794	9.7	clayey silty mud with trace sand	Unavailable
CBIW-62	11/03/2021	43.716613	-70.174988	15.3	silty mud	-35.98
CBIW-63	11/03/2021	43.70421848	-70.158677	12.7	muddy sand with gravel; large cobbles present	Unavailable
CBIW-64	11/03/2021	43.69636432	-70.171422	29	muddy sand with gravel	-14.57
CBIW-65	11/03/2021	43.69512988	-70.172774	26.8	muddy sand with gravel	-10.79
CBIW-66	11/09/2021	43.61377584	-70.202542	18.7	fine sand	Unavailable
CBIW-67	11/09/2021	43.62130717	-70.197911	15.3	fine sand	Unavailable
CBIW-68	11/09/2021	43.63655605	-70.211089	11.9	muddy sand with trace shell hash	Unavailable
CBIW-69	11/09/2021	43.63436966	-70.19546	15.4	sandy gravel with shall hash; many large cobbles present	Unavailable
CBIW-70	11/09/2021	43.66881435	-70.162386	17.8	shell hash; no mud visible in sample at all	Unavailable
CBIW-71	11/09/2021	43.64186621	-70.182566	10.3	rock	Unavailable

Note: Backscatter values were unavailable for several grab sites at time of deployment and are shown above.

5.3 Wrecks and Obstructions

Throughout the course of survey acquisition, three charted wrecks and one uncharted wreck were mapped by the survey team. The wrecks are referred to in this report by geographic location and are identified as follows: Clapboard Island wreck, Great Chebeague wreck, Chandler Cove wreck, and Stave Island wreck. Positions for Clapboard Island wreck, Great Chebeague wreck, and Chandler Cove wreck were previously charted, but the Stave Island wreck is believed to be a new finding.

The position of the Clapboard Island wreck, which was identified by previous surveys as a barge, was surveyed to be in the exact position indicated by charts 13290 and 13292 (Figure 30). Additionally, the obstruction identified to the east of this wreck was also found to be in the exact charted position. Depth soundings are in agreement with the charted figures.

The Great Chebeague and Chandler Cove wrecks were surveyed to be a significant distance from their charted positions (Figures 31 & 32). The Great Chebeague wreck is charted to be at 43.739973°N 70.101859°W and the surveyed position was recorded at 43.740378°N 70.099658°W. Least depths were unknown for this wreck and were ensonified to be 9.5 meters from MLLW. The Chandler Cove wreck is charted at 43.716221°N 70.135071°W and the surveyed position was recorded at 43.717276°N 70.129735°W. The soundings obtained from this survey found the least depths of this Chandler cove wreck were 2.55 meters below MLLW versus the charted 10.9 meters. Is it believed these discrepancies are due to potential drifting of the wrecks since first being observed. It is recommended by this survey team that relevant charts be updated with the new positions and depths following review by NOAA.

The Stave Island wreck was identified at 43.717884°N 70.081335°W and measured roughly 7 meters long by 2.5 meters wide (Figure 33). The wreck was found to be laying on her starboard side and the least depth was found to be roughly 4.6 meters from MLLW. It is recommended by this survey team that relevant charts be updated with the new wreck following review by NOAA.

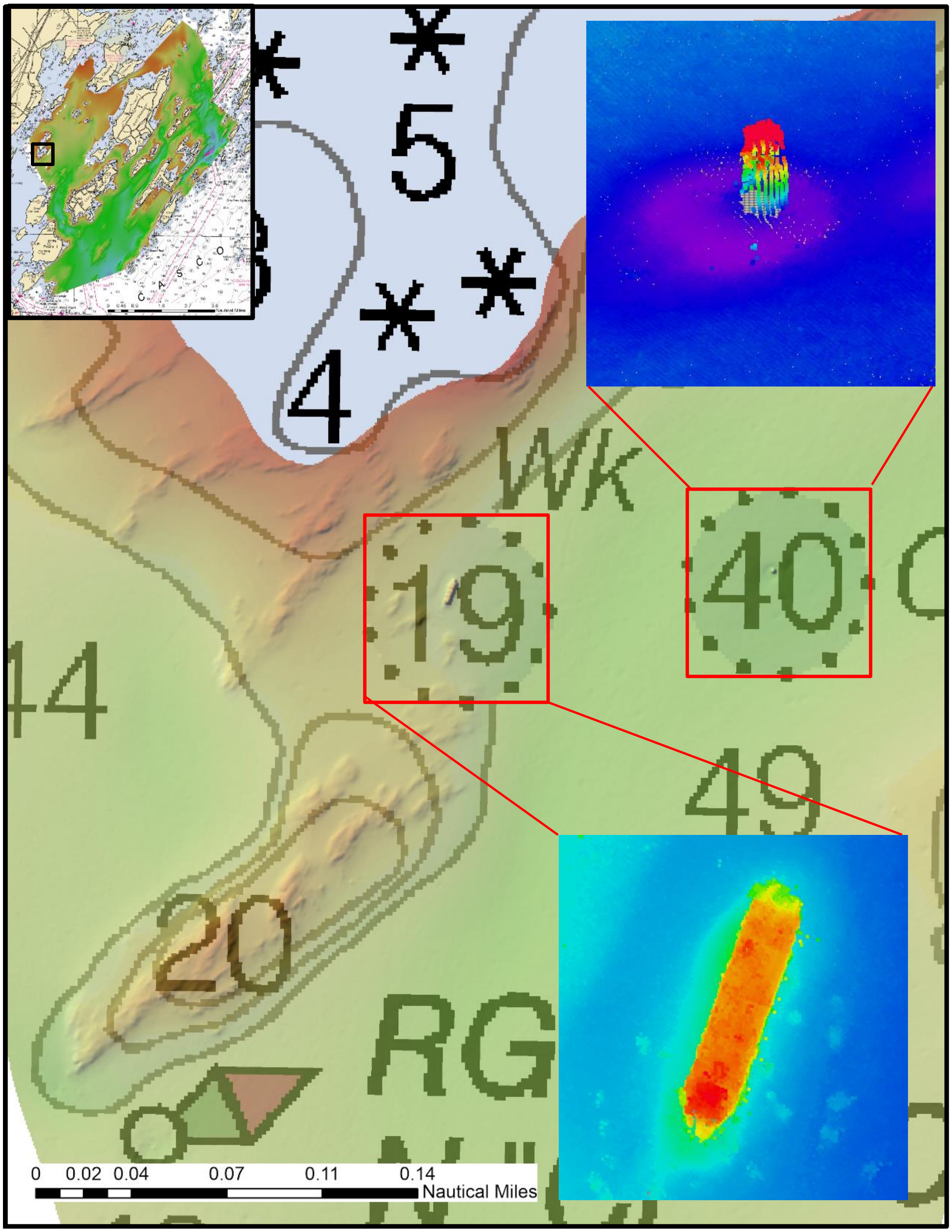


Figure 30 - Clapboard Island wreck and object mapped positions shown atop charted positions

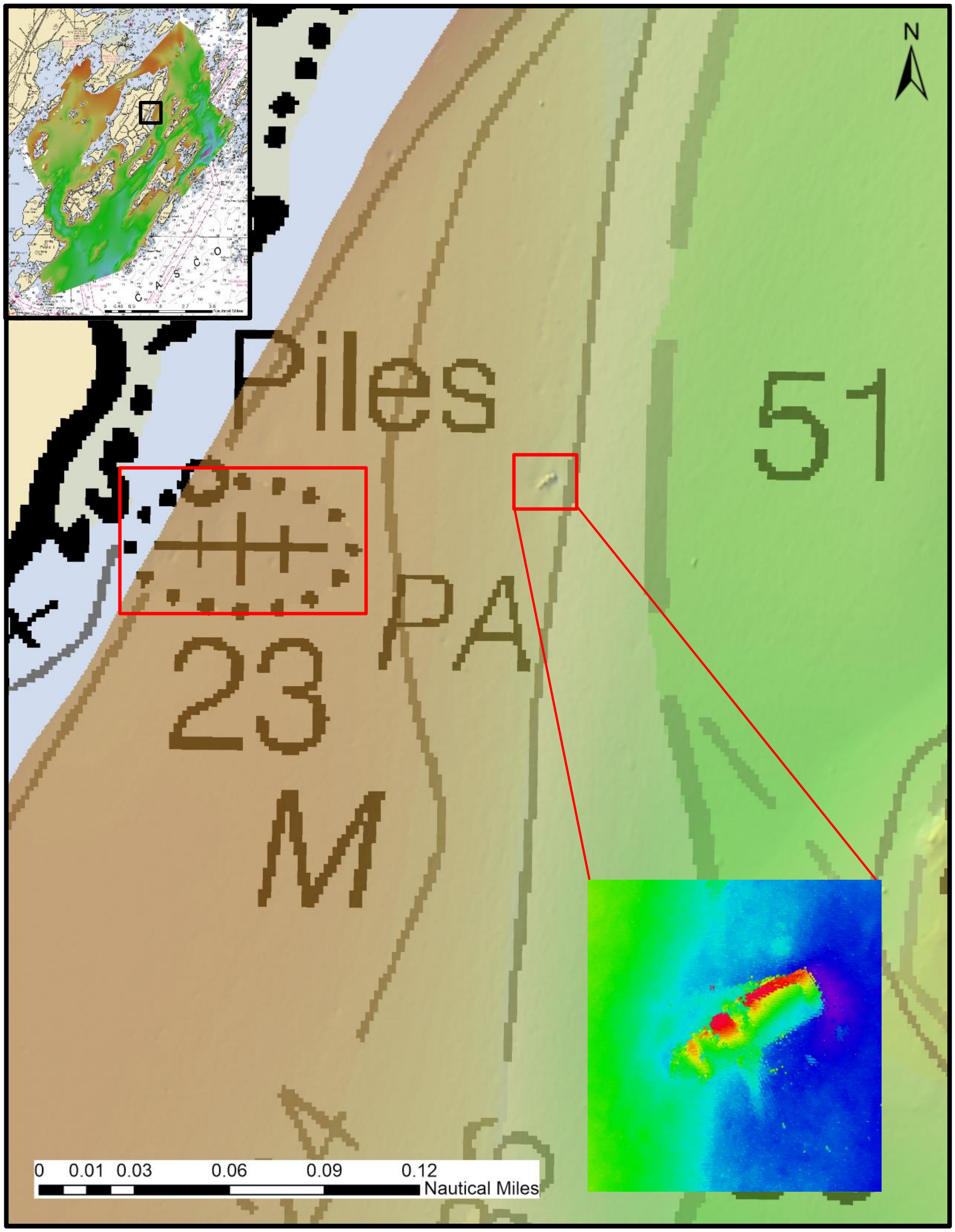


Figure 31 - Great Chebeague wreck mapped position shown atop charted position

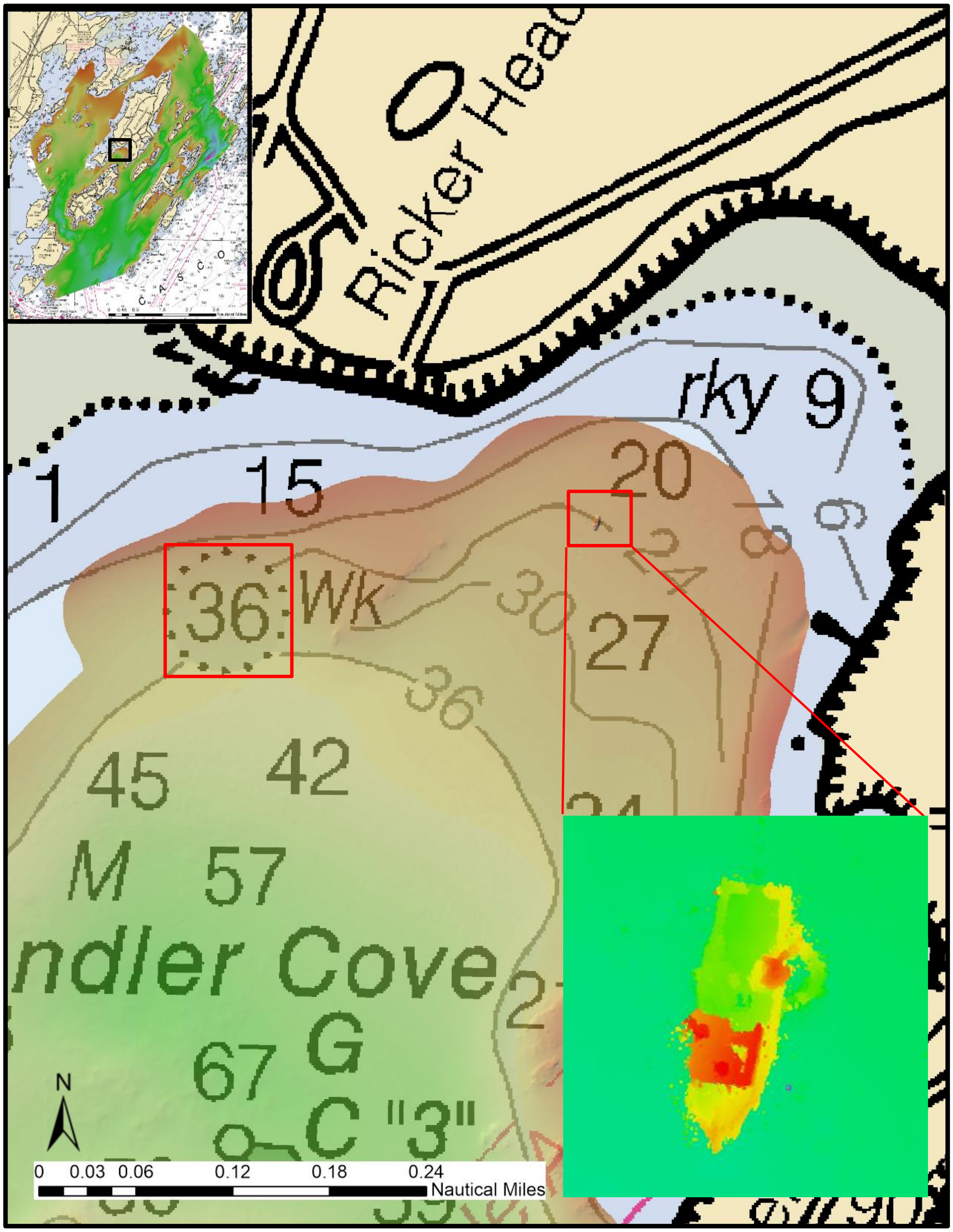


Figure 32 - Chandler Cove wreck mapped position shown atop charted position

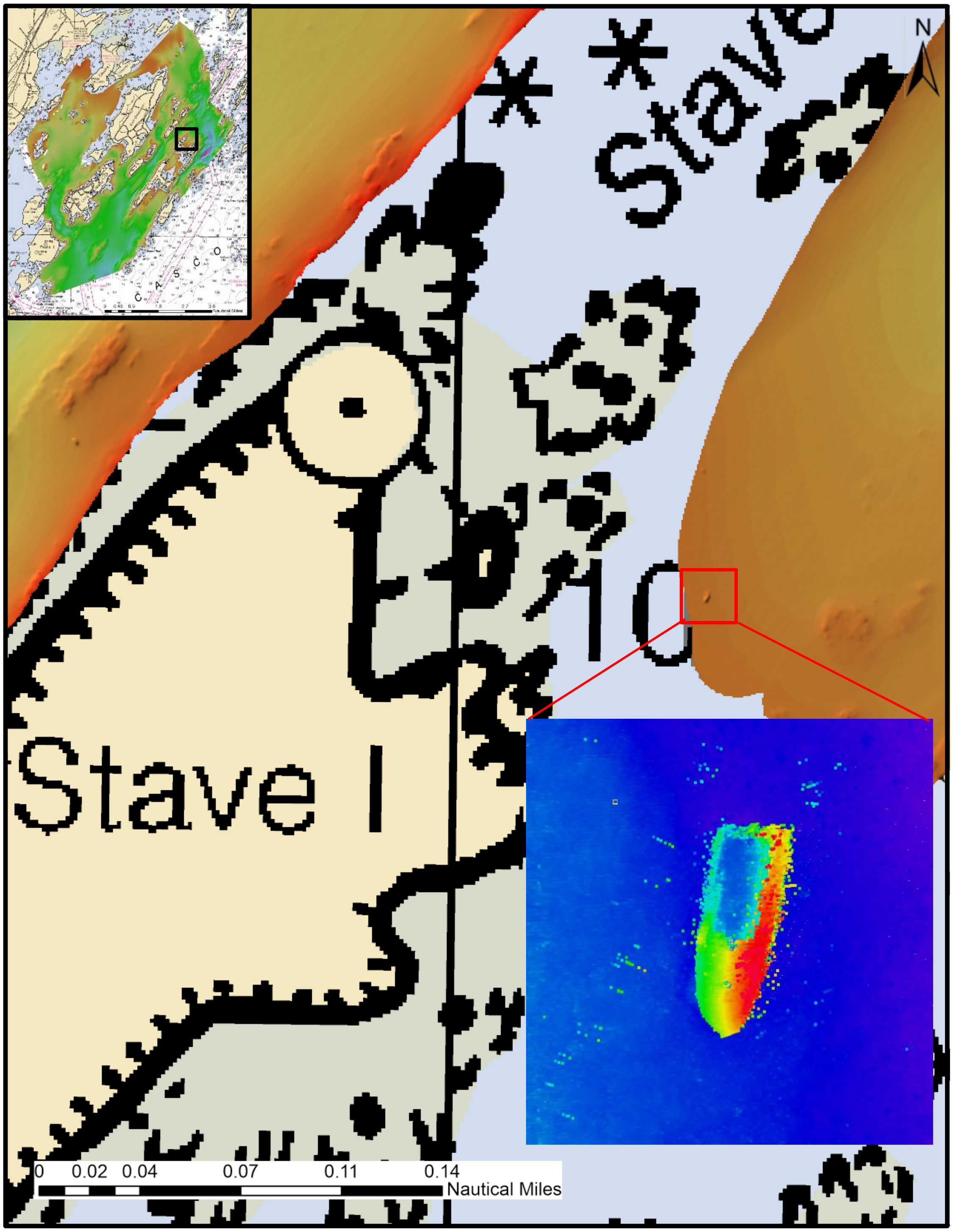


Figure 33 - Stave Island wreck mapped position

6.0 Summary

A total of 35.15 mi^2 (91 km^2) of high-resolution multibeam data were collected throughout Casco Bay from July of 2019 to April of 2023. Except for select few small holidays due to seafloor elevation-induced sonic shadows and non-navigable areas throughout the survey area, multibeam coverage was 100% in all areas surveyed to the shallowest sounding of 5 meters wherever possible.

Bathymetry and backscatter data products were produced at 1-meter, 2-meter, and 4-meter grid resolution for the extent of the survey area. The bathymetry and backscatter information for the survey area are supplemented by seafloor surficial sediment samples, water column data, video, and benthic fauna collection in 69 locations.

Consistency of hydrographic data collected aboard the F/V Amy Gale was reflected in the results of the surface difference tests for crosslines, where mean vertical differences across tests were less than 0.025 meters, 95% of all nodes having maximum deviation of +/- 0.055 meters, and within allowable tolerances for IHO Order 1a and NOAA specifications at the depths ensonified. Standard deviations of all tests were relatively low and comparable to those achieved by small vessels in similar surveys of the area (e.g. *Ferdinand R. Hassler* and previous submissions by *Amy Gale*). Total vertical uncertainties for all areas surveyed were within tolerances for IHO Order 1a and NOAA specifications at all depths, where 99.74%, 99.81%, and 99.94% of all nodes fell within the allowable range for respective surfaces of W00648_1, W600648_2, and W00648_3.

Comparisons between survey data and the largest scale nautical charts in the vicinity show good agreement in most cases apart from a notable deep region northwest of Eagle Island where the channel reaches 57 meters and extends at depth further to the west than charted, with values exceeding 50 meters where charts indicate 37-38 meters. It is recommended that the corresponding charts be updated in this area to reflect these data, and that contours be adjusted throughout the survey area to the refined values delivered in these updated datasets.

These data were acquired and processed to meet Office of Coast Survey bathymetry standards as best as possible and were shared with the NOAA Office of Coast Survey for review.

Please contact the Maine Coastal Program’s Research Coordinator for additional information or data requests.

References

International Hydrographic Organization (2020) IHO Standards for Hydrographic Surveys, Edition 6.0.0, September 2020. Monaco, International Hydrographic Organization, 41pp. (International Hydrographic Organization Special Publication, S-44). DOI: https://doi.org/10.25607/OBP-1354.2

NOAA. (2021). NOS hydrographic surveys specifications and deliverables: U.S Department of Commerce National Oceanic and Atmospheric Administration. 162pp.

NOAA, Office of Coast Survey (2021). Field Procedures Manual, February 2021. Silver Spring, MD, National Oceanic and Atmospheric Administration, Office of Coast Survey, 165pp. DOI: http://dx.doi.org/10.25607/OBP-153.3

U.S. Department of the Interior (2014). Proposed geophysical and geological activities in the Atlantic OCS to identify sand resources and borrow areas north Atlantic, mid-Atlantic, and south Atlantic-Straits of Florida planning areas, *final environmental assessment.* OCS EIS/EA BOEM 2013-219 U.S. Department of the Interior Bureau of Ocean Energy Management Division of Environmental Assessment Herndon, VA, January 2014.

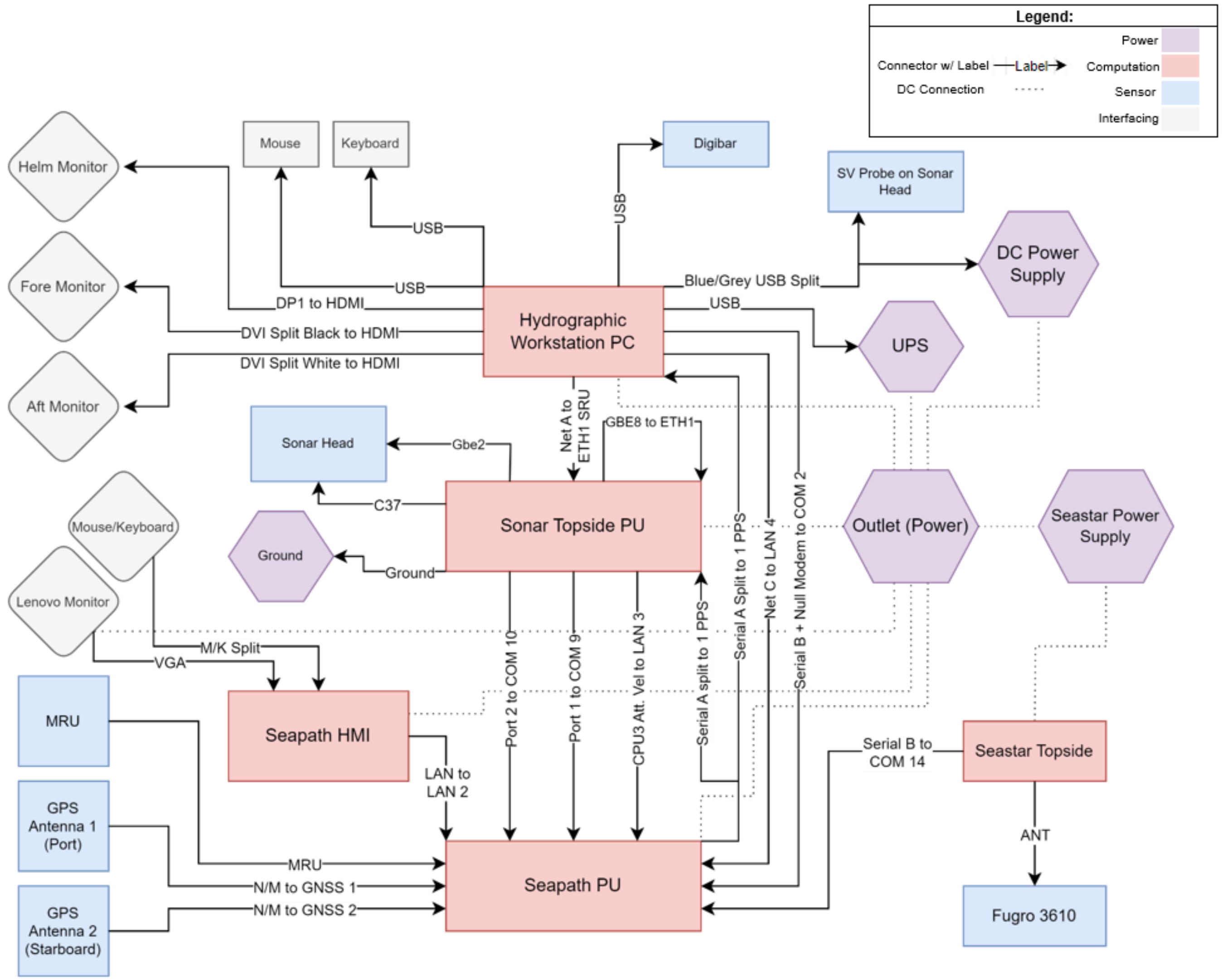
Appendix A – Specific dates of data acquisition for surveys

Dates (mm/dd/yy) of Data Acquisition for Casco Bay Surveys*

	W00648	
07/15/2019	04/12/2022	01/09/2023
07/16/2019	04/15/2022	01/10/2023
07/24/2019	04/21/2022	01/11/2023
08/06/2019	05/03/2022	01/25/2023
08/07/2019	05/11/2022 (Crosslines)	01/27/2023
08/16/2019	05/12/2022	01/30/2023
08/23/2019	05/13/2022	02/01/2023 (Crosslines)
07/28/2021	05/19/2022	02/06/2023
07/29/2021	05/20/2022	02/08/2023
08/12/2021	05/23/2022	02/09/2023
12/08/2021	06/01/2022	02/14/2023
01/24/2022	06/02/2022	02/21/2023
01/26/2022	10/27/2022	03/13/2023
01/28/2022	11/01/2022	03/17/2023
02/16/2022	11/02/2022	03/21/2023
02/24/2022	11/03/2022	03/22/2023
03/01/2022	11/09/2022	03/23/2023
03/07/2022	11/22/2022	03/28/2023
03/09/2022	11/28/2022	04/03/2023
03/10/2022	12/02/2022	04/04/2023
03/11/2022	12/06/2022	04/06/2023
03/15/2022	12/07/2022	04/10/2023
03/23/2022	12/21/2022	04/11/2023
03/31/2022	01/03/2023	04/12/2023 (Crosslines)
04/11/2022	01/06/2023	

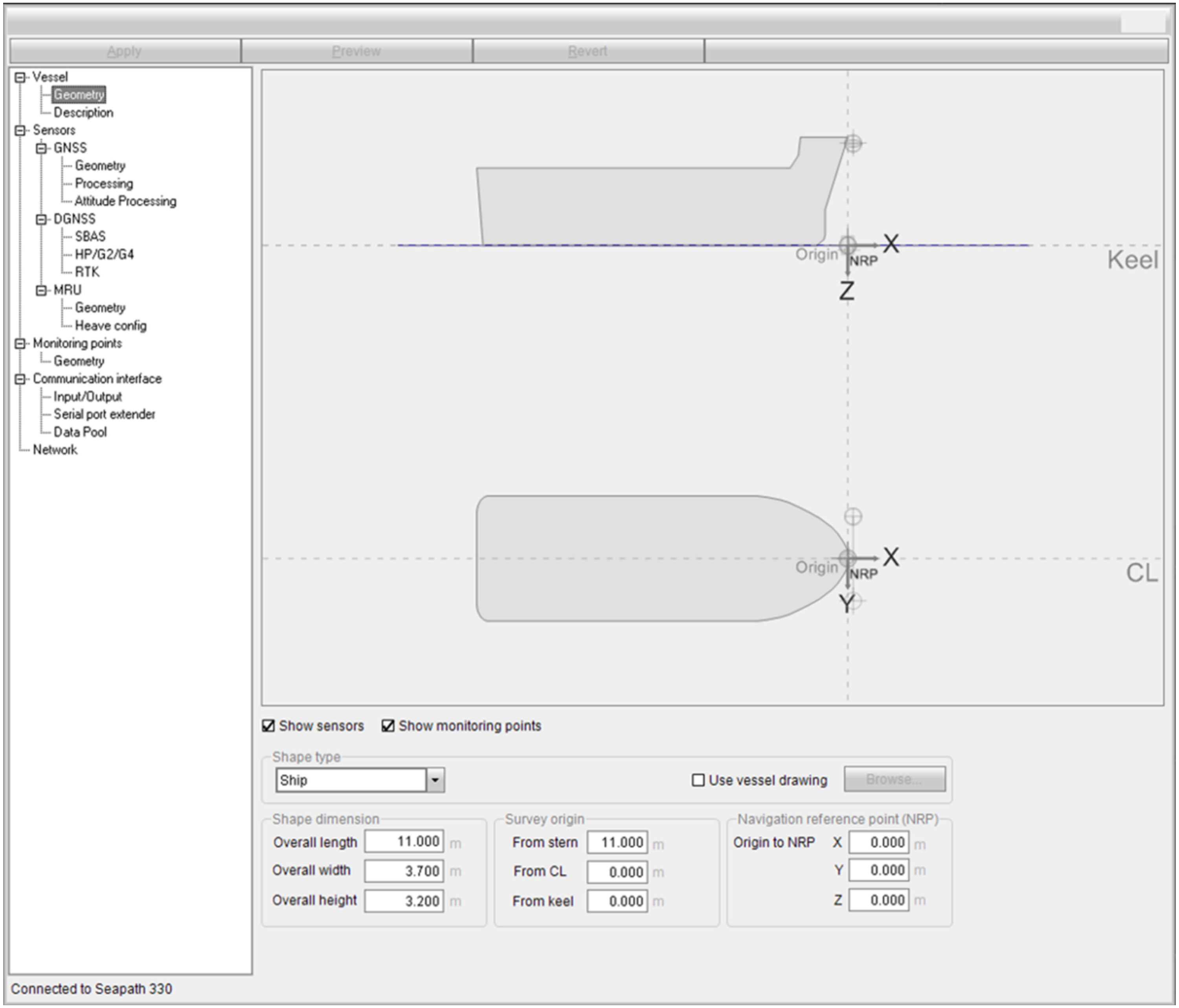
*Dates of surveys not summarized in this report not listed

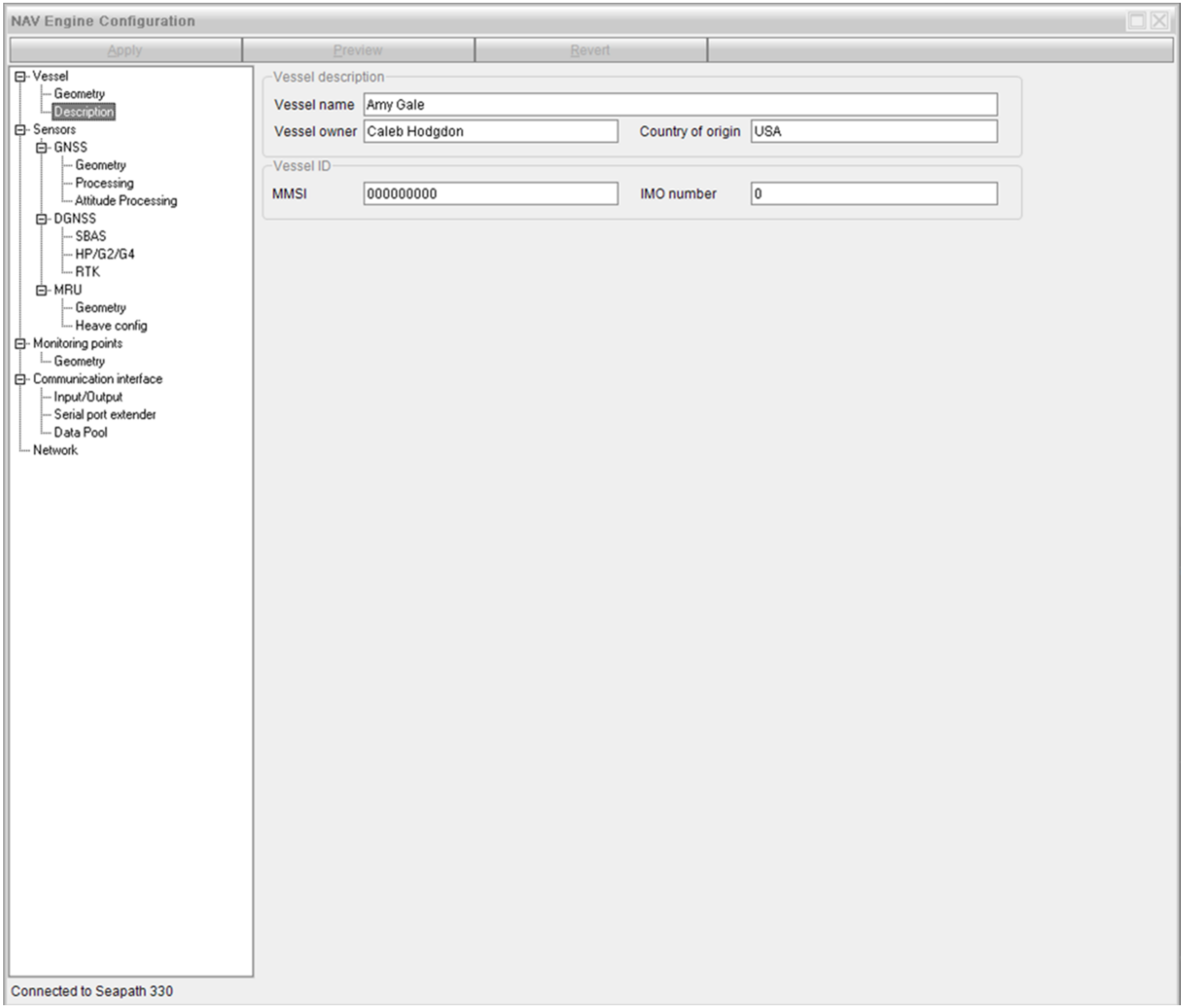
Appendix B – 2023 MCMI Survey Systems Diagram for the F/V Amy Gale

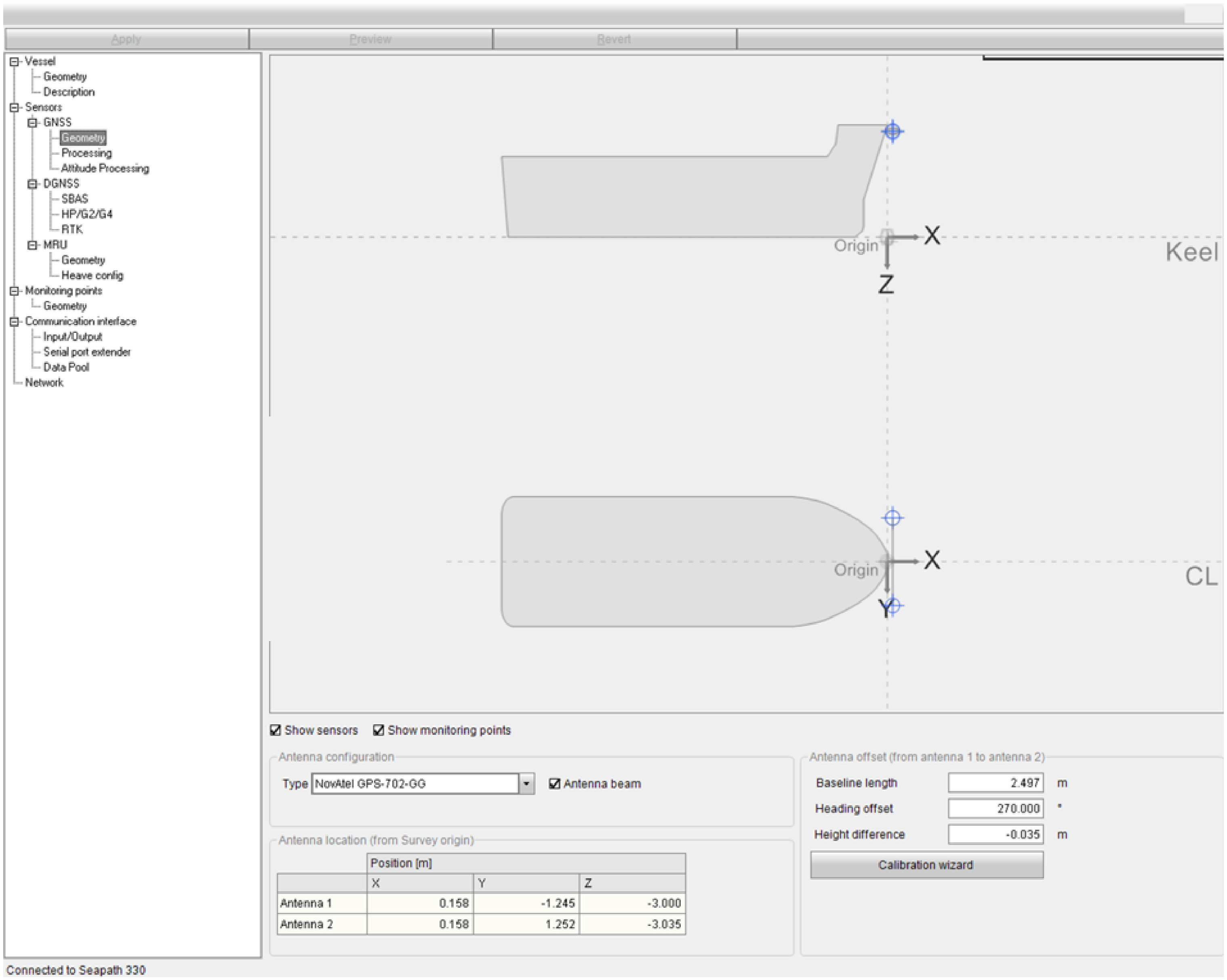


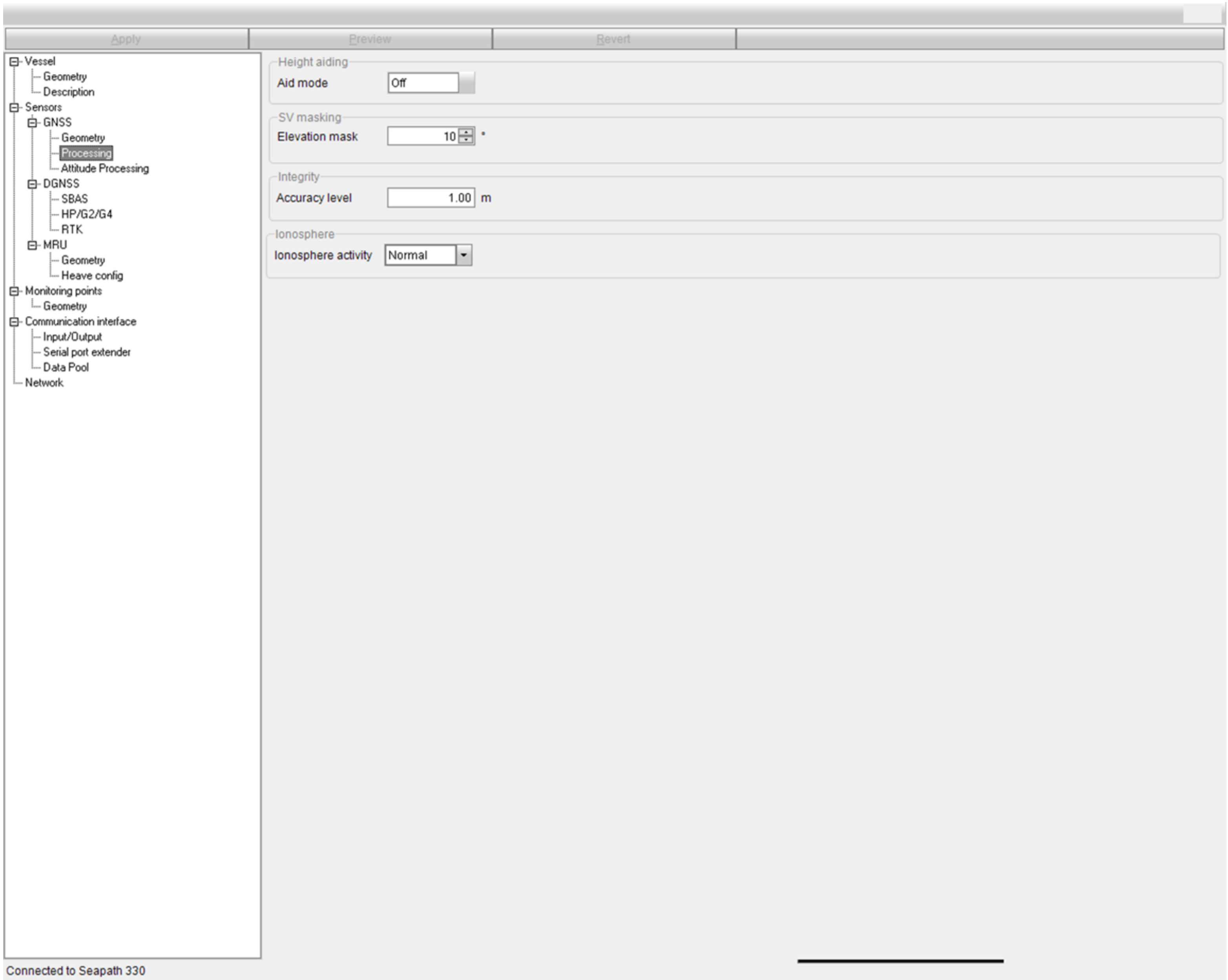
Appendix C – 2023 Configuration settings for Seapath 330

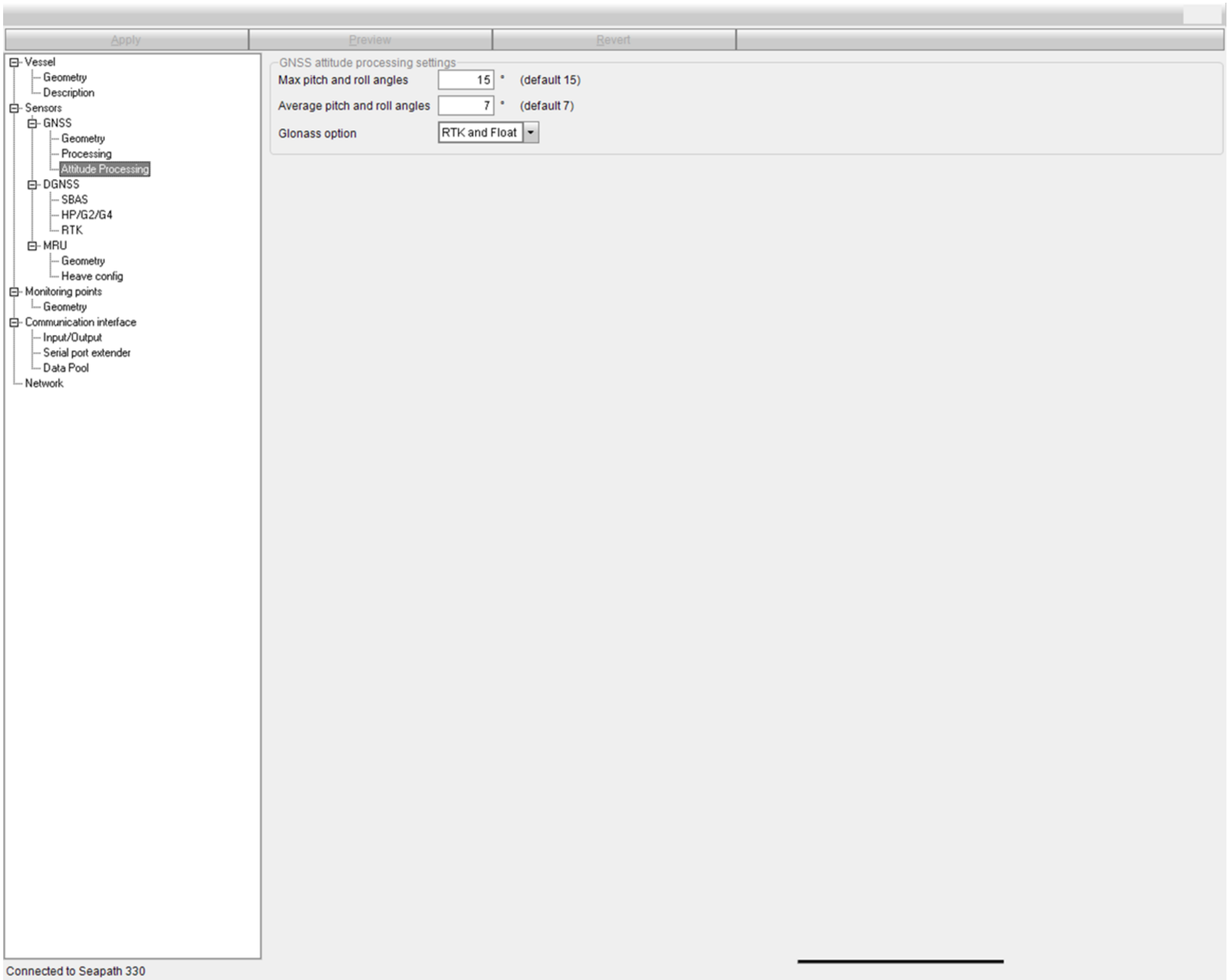
Note: Adjustments mentioned in this report are reflected in the following configuration. Prior to the adjustments, attitude and velocity values were sent to Qinsy at 10Hz. This and the addition of the 135 WAAS satellite are the only settings that are different in Seapath across the span of the surveys of this report.

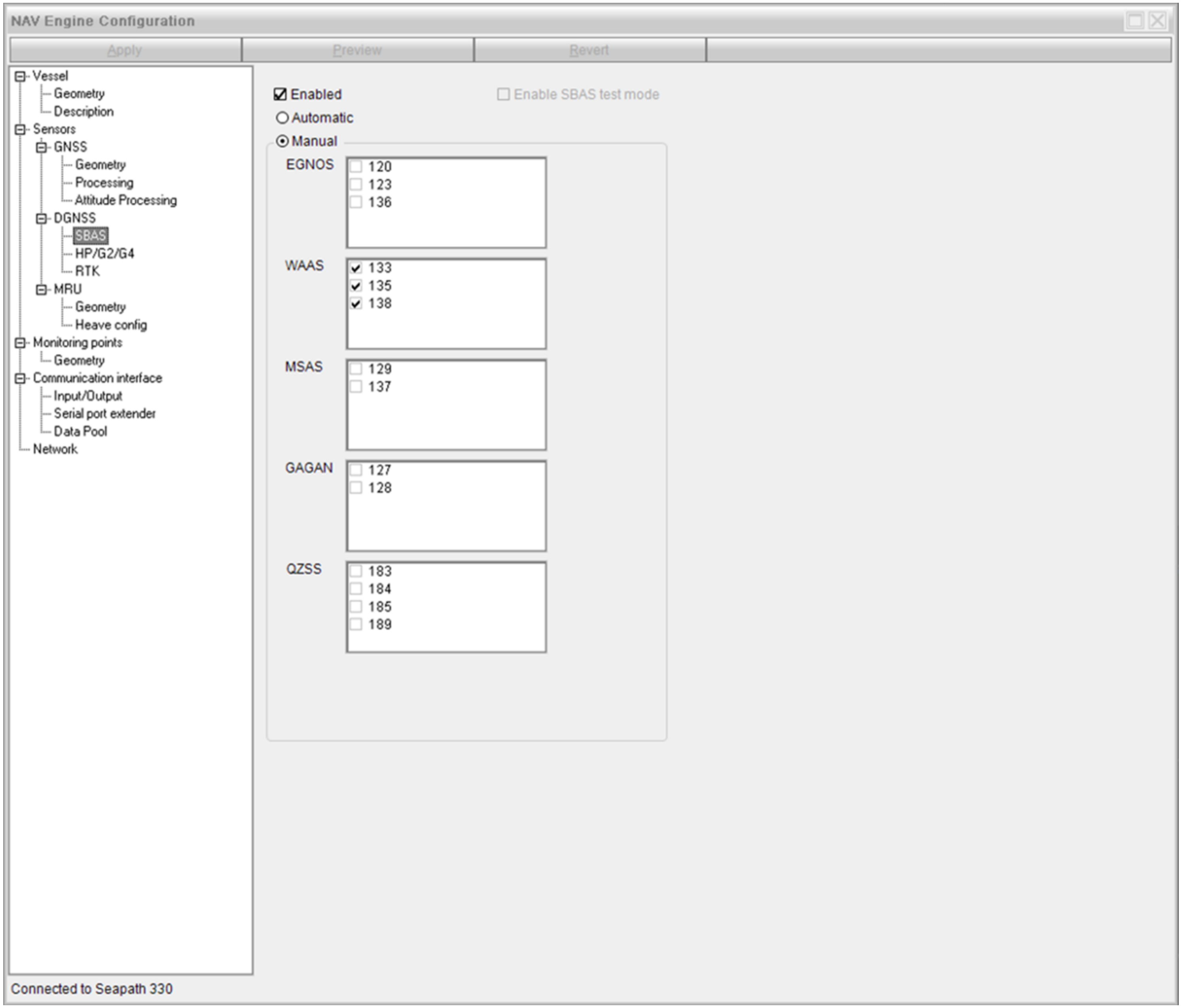

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Origin
NRP
X
Z
Keel
Origin
NRP
X
Y
CL
Show sensors
Show monitoring points
Shape type
Ship
Use vessel drawing
Browse...
Shape dimension
Overall length 11.000 m
Overall width 3.700 m
Overall height 3.200 m
Survey origin
From stern 11.000 m
From CL 0.000 m
From keel 0.000 m
Navigation reference point (NRP)
Origin to NRP X 0.000 m
Y 0.000 m
Z 0.000 m
Connected to Seapath 330

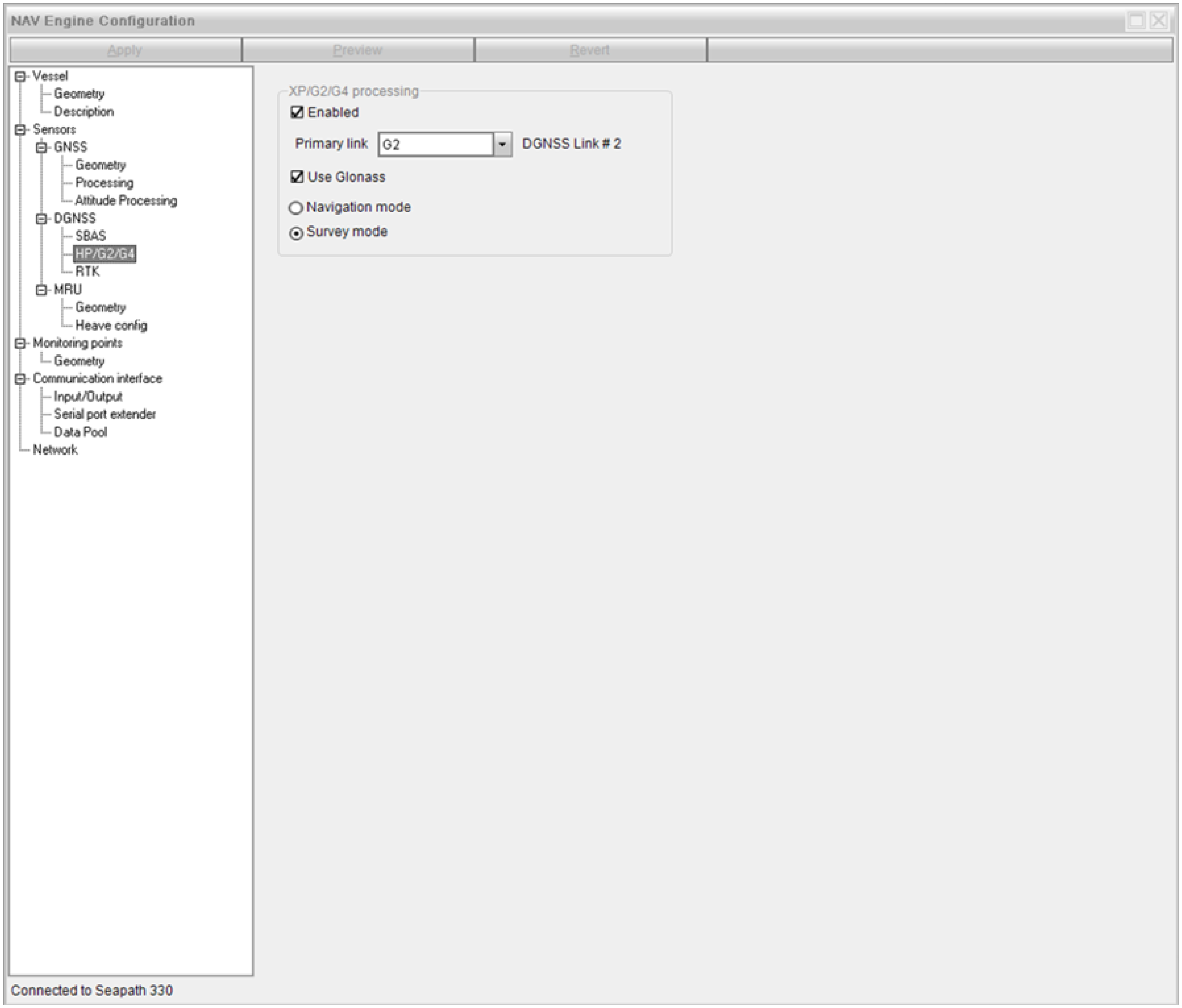

NAV Engine Configuration
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Vessel description
Vessel name
Amy Gale
Vessel owner
Caleb Hodgdon
Country of origin
USA
Vessel ID
MMSI
000000000
IMO number
0
Connected to Seapath 330

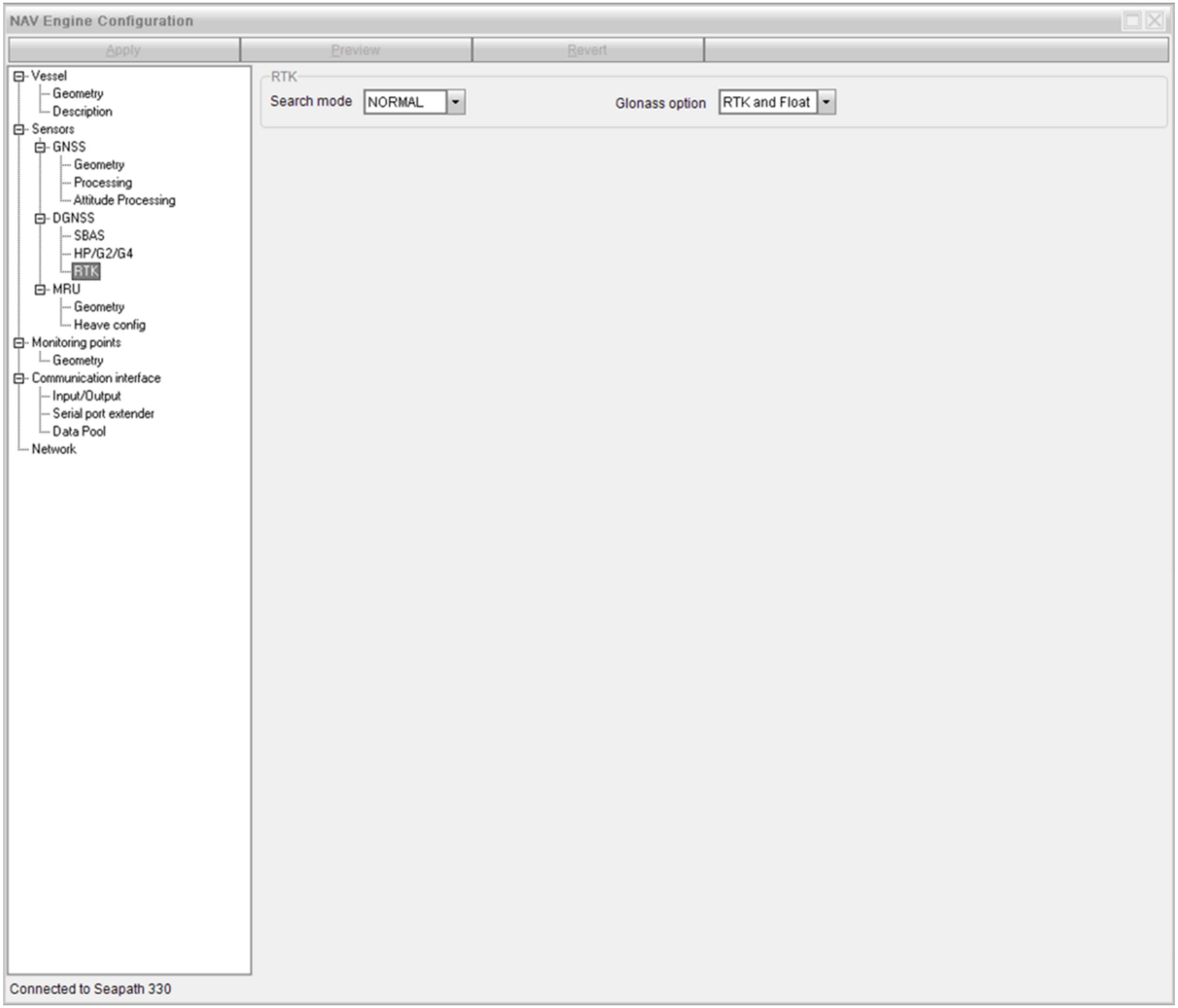

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Origin
X
Z
Keel
Origin
X
Y
CL
Show sensors
Show monitoring points
Antenna configuration
Type NovAtel GPS-702-GG
Antenna beam
Antenna offset (from antenna 1 to antenna 2)
Baseline length 2.497 m
Heading offset 270.000 °
Height difference -0.035 m
Calibration wizard
Antenna location (from Survey origin)
Position [m]
X Y Z
Antenna 1 0.158 -1.245 -3.000
Antenna 2 0.158 1.252 -3.035
Connected to Seapath 330

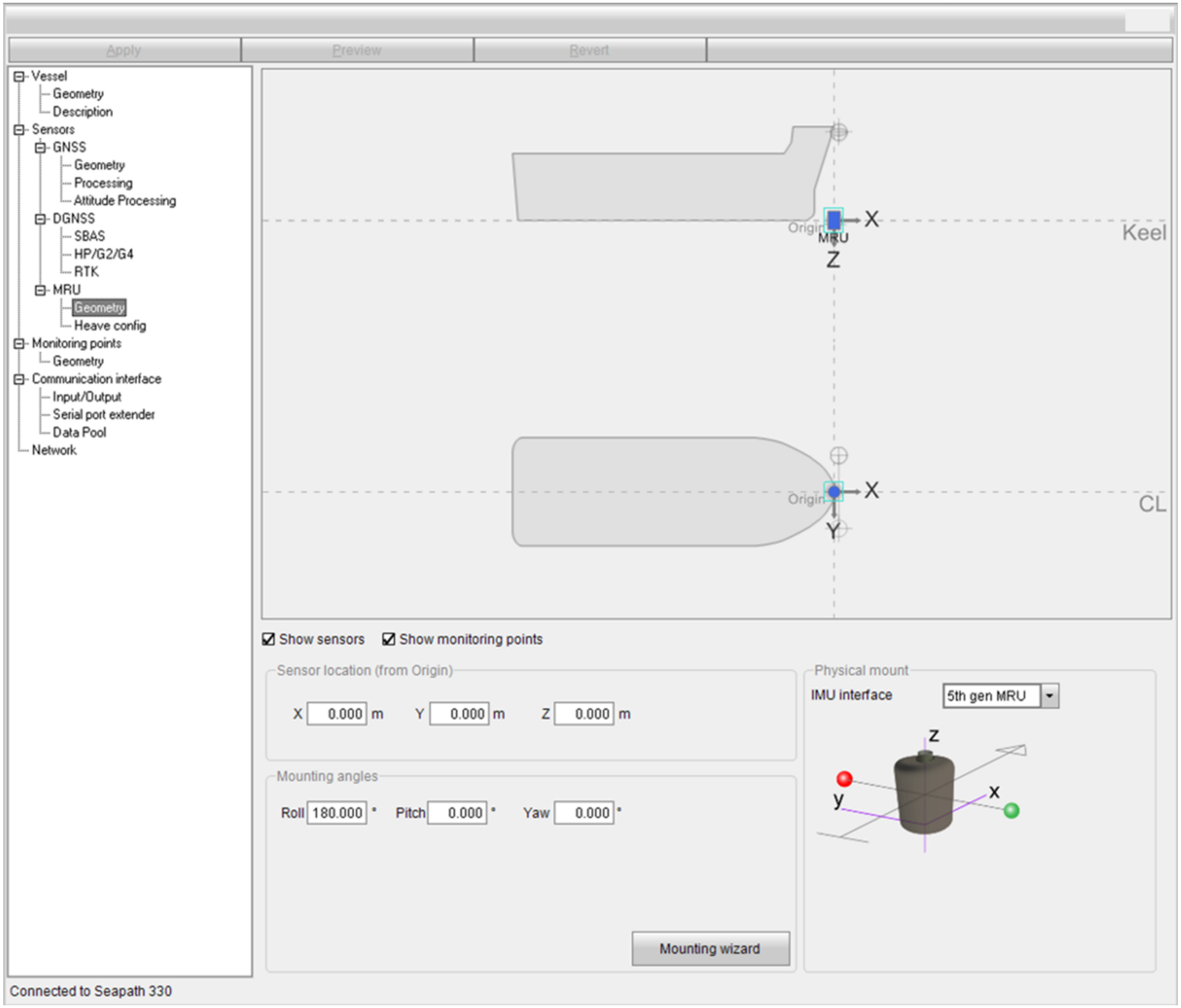

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Height aiding
Aid mode
Off
SV masking
Elevation mask
10
°
Integrity
Accuracy level
1.00
m
Ionosphere
Ionosphere activity
Normal
Connected to Seapath 330


Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
GNSS attitude processing settings
Max pitch and roll angles 15 ° (default 15)
Average pitch and roll angles 7 ° (default 7)
Glonass option RTK and Float
Connected to Seapath 330

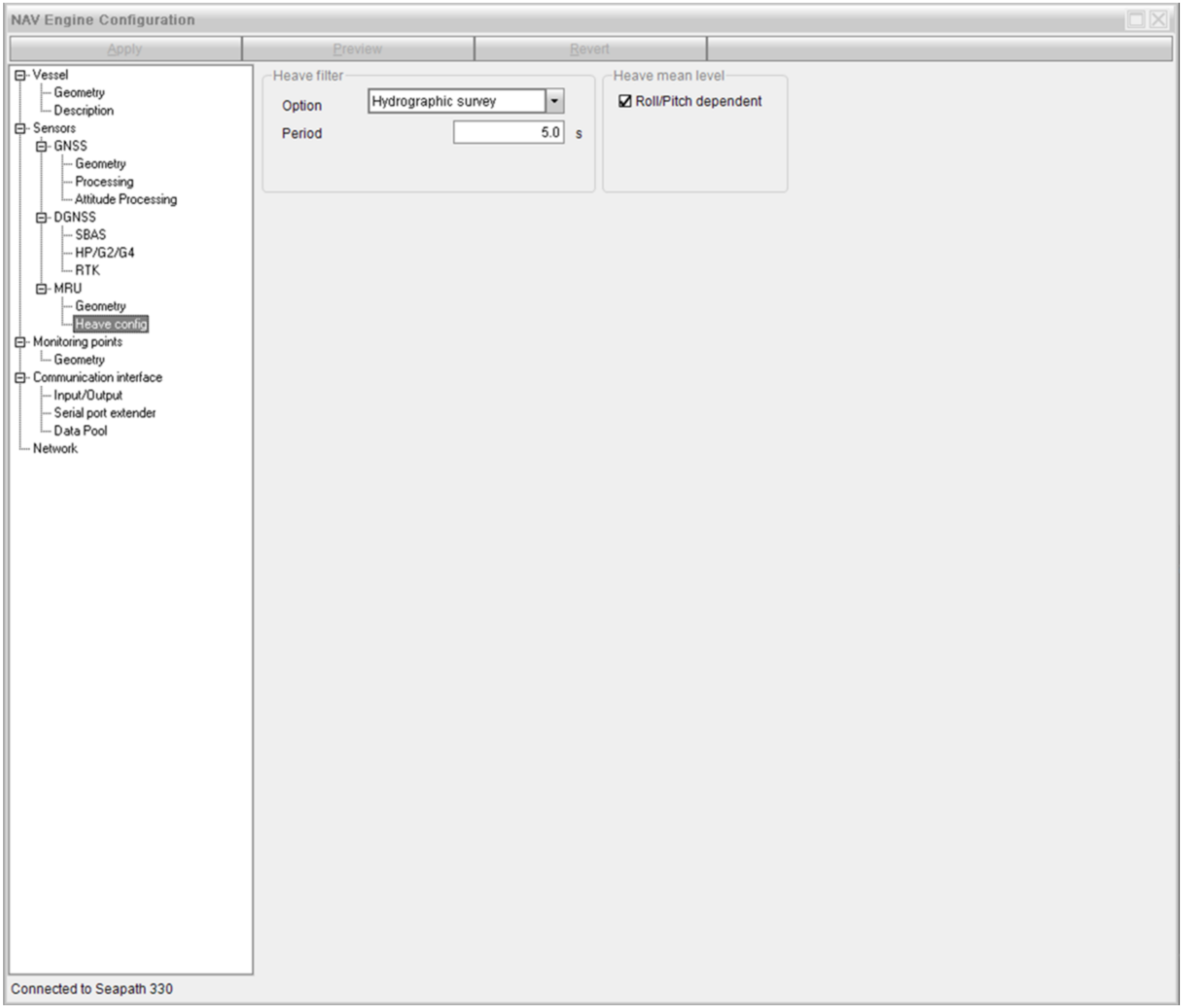

NAV Engine Configuration
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Enabled
Enable SBAS test mode
Automatic
Manual
EGNOS
120
123
136
WAAS
133
135
138
MSAS
129
137
GAGAN
127
128
QZSS
183
184
185
189
Connected to Seapath 330

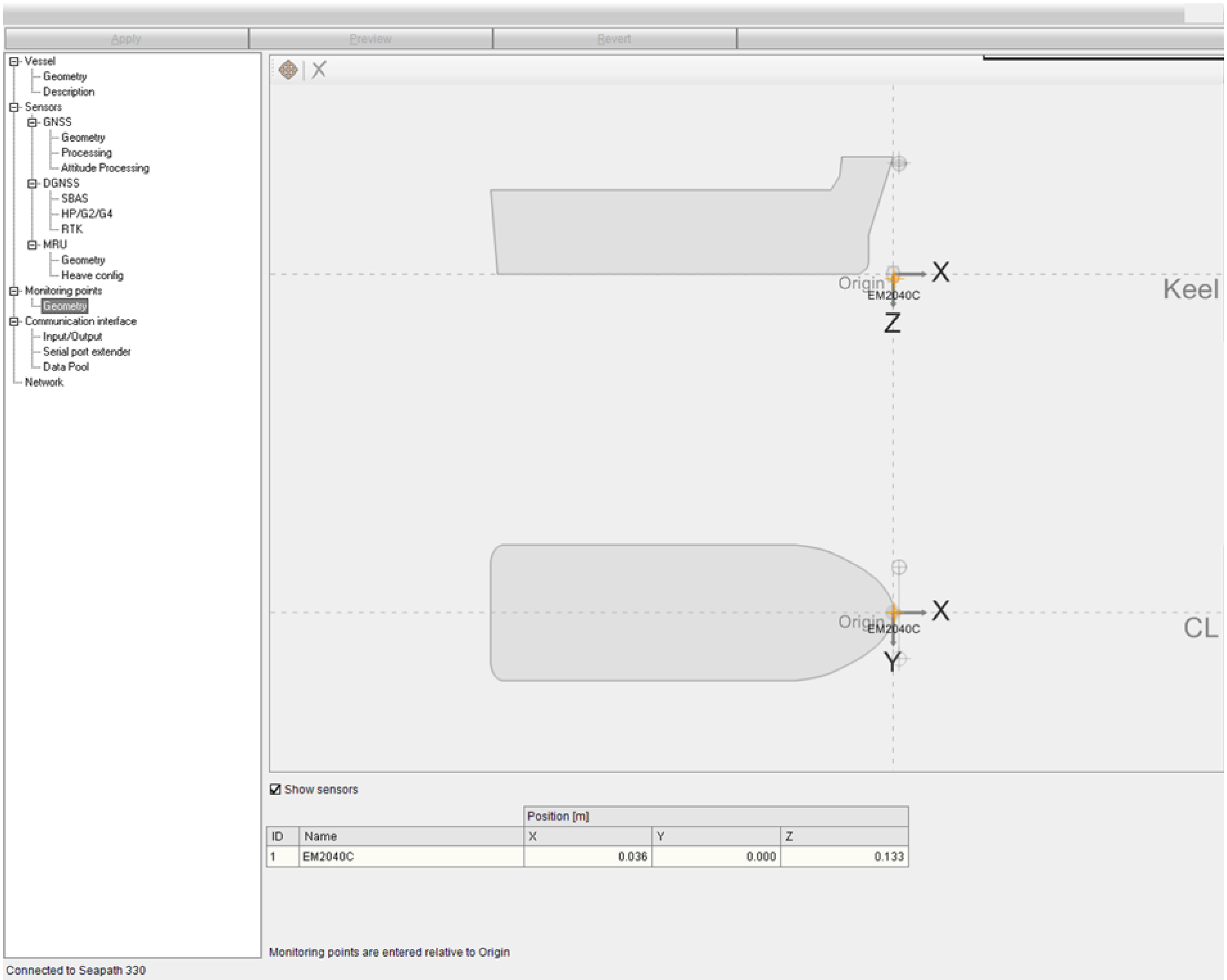

NAV Engine Configuration
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
XP/G2/G4 processing
Enabled
Primary link
G2
DGNSS Link # 2
Use Glonass
Navigation mode
Survey mode
Connected to Seapath 330

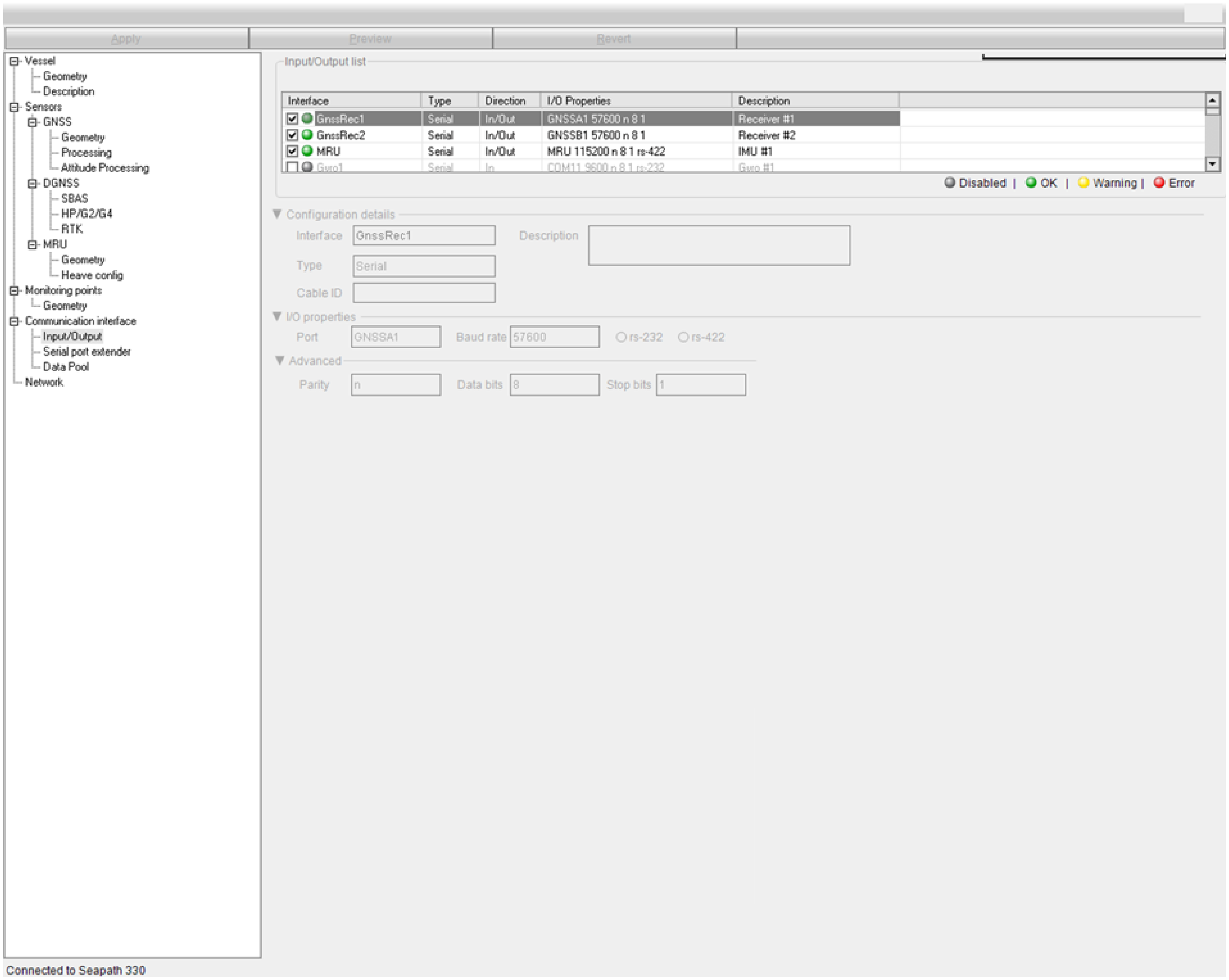

NAV Engine Configuration
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
RTK
Search mode
NORMAL
Glonass option
RTK and Float
Connected to Seapath 330



Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Origin
MRU
X
Z
Keel
Origin
X
Y
CL
Show sensors
Show monitoring points
Sensor location (from Origin)
X 0.000 m
Y 0.000 m
Z 0.000 m
Mounting angles
Roll 180.000 °
Pitch 0.000 °
Yaw 0.000 °
Mounting wizard
Physical mount
IMU interface
5th gen MRU
z
x
y
Connected to Seapath 330


NAV Engine Configuration
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Heave filter
Option
Hydrographic survey
Period
5.0
s
Heave mean level
Roll/Pitch dependent
Connected to Seapath 330


Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
X
Origin
EM2040C
Z
Keel
X
Origin
EM2040C
Y
CL
Show sensors
Position [m]
ID
Name
X
Y
Z
1
EM2040C
0.036
0.000
0.133
Monitoring points are entered relative to Origin
Connected to Seapath 330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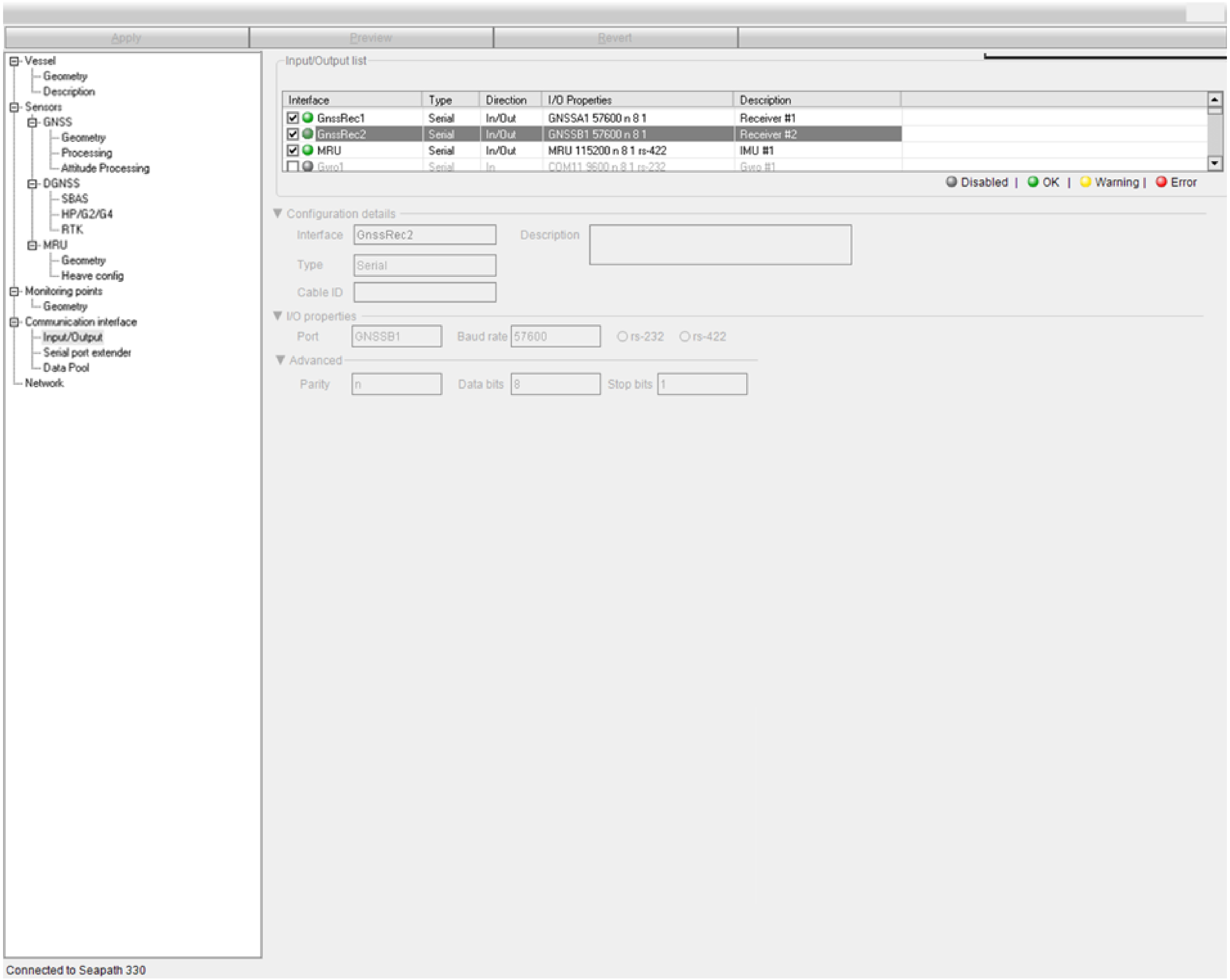
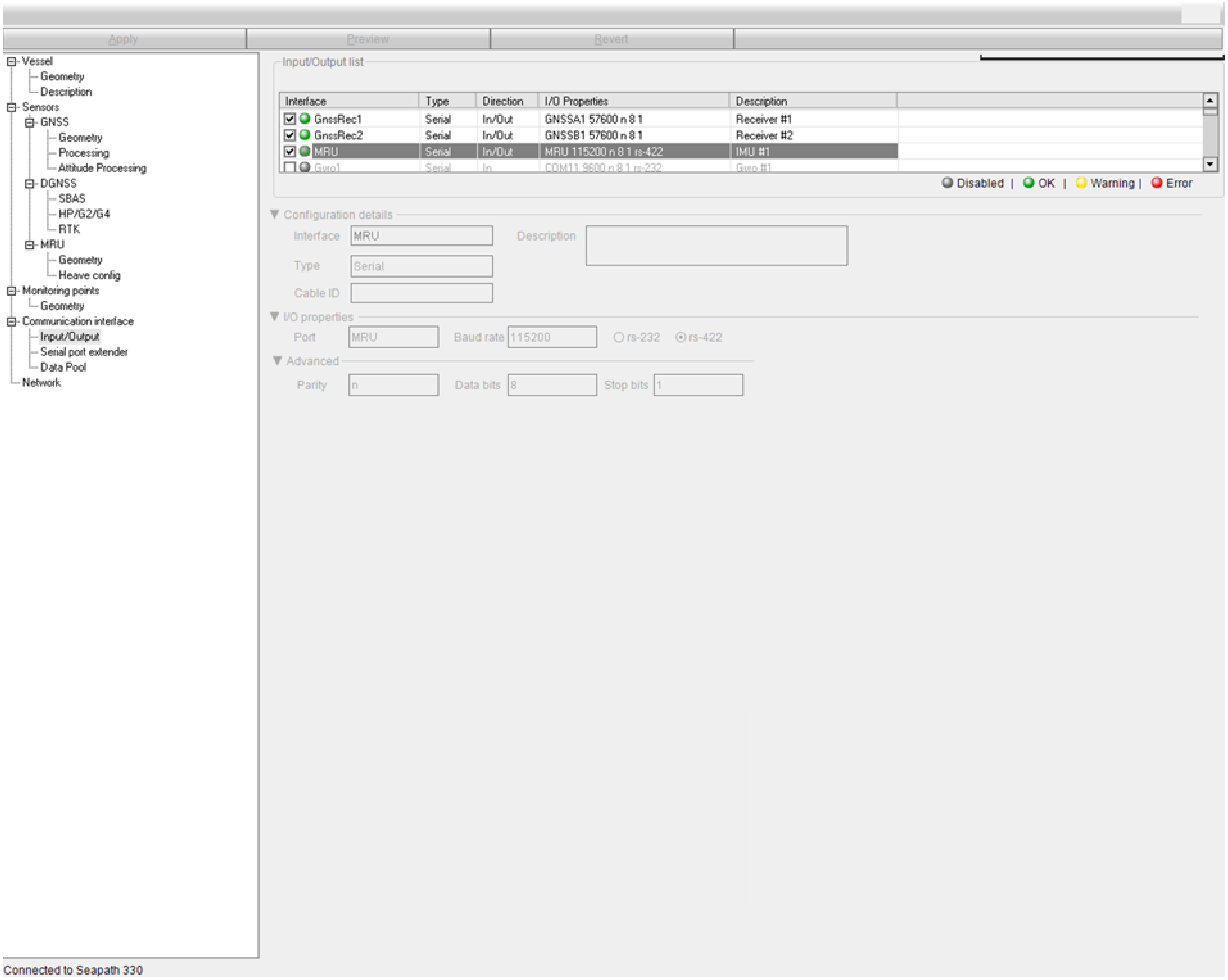
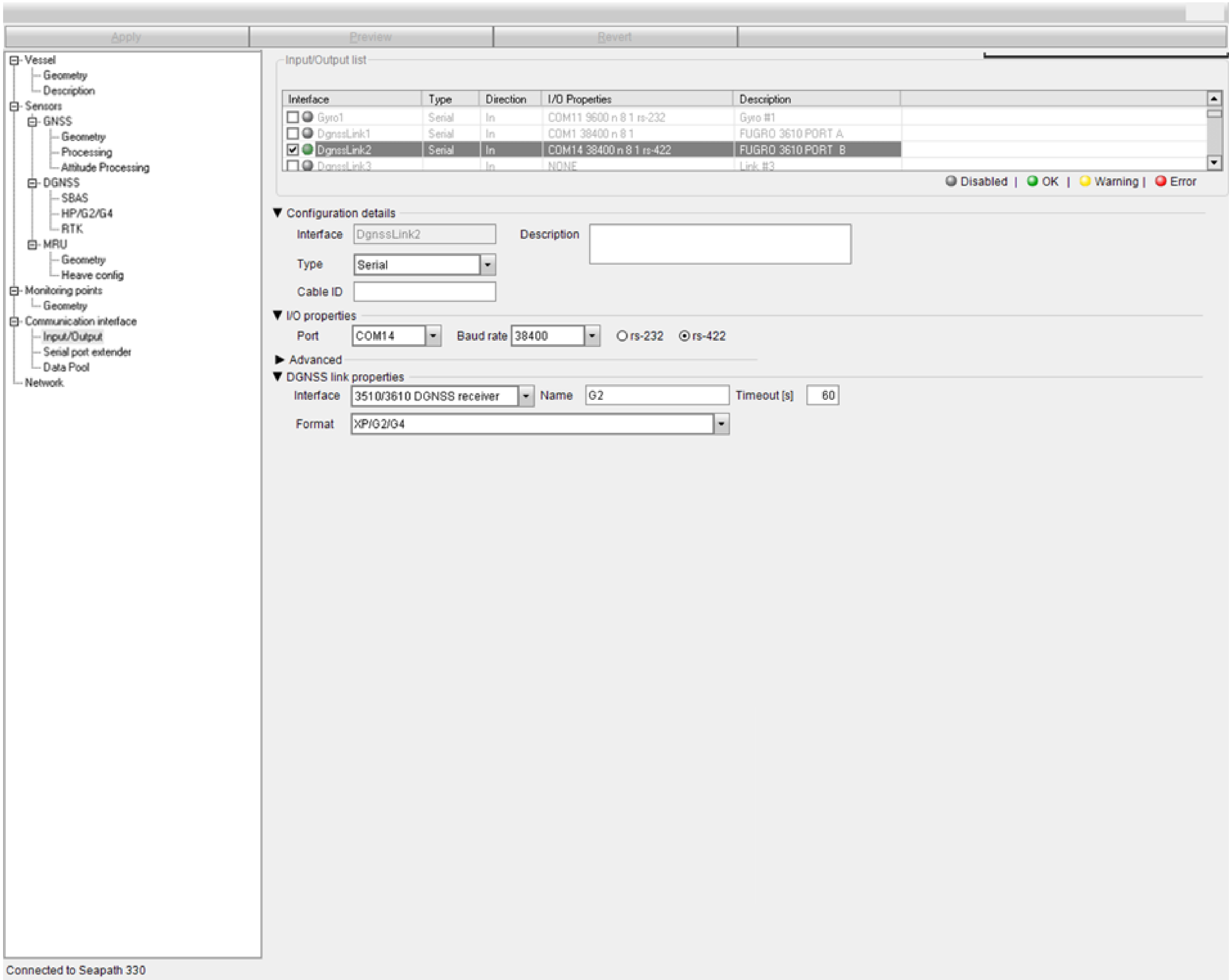
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface
Type
Direction
I/O Properties
Description
GnssRec1 Serial In/Out GNSSA1 57600 n 8 1 Receiver #1
GnssRec2 Serial In/Out GNSSB1 57600 n 8 1 Receiver #2
MRU Serial In/Out MRU 115200 n 8 1 rs-422 IMU #1
Disabled | OK | Warning | Error
Configuration details
Interface GnssRec1
Description
Type Serial
Cable ID
I/O properties
Port GNSSA1
Baud rate 57600
rs-232
rs-422
Advanced
Parity n
Data bits 8
Stop bits 1
Connected to Seapath 330

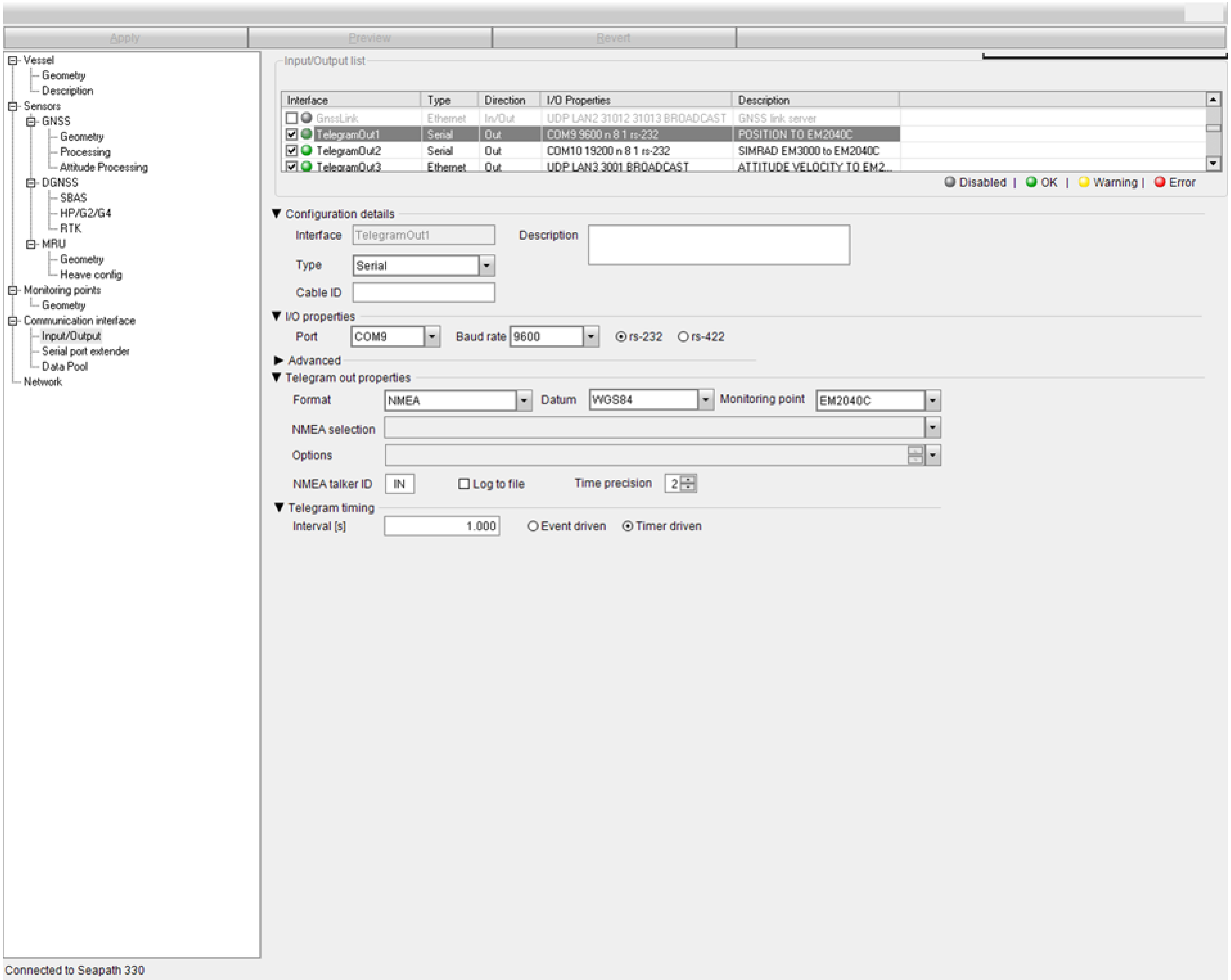


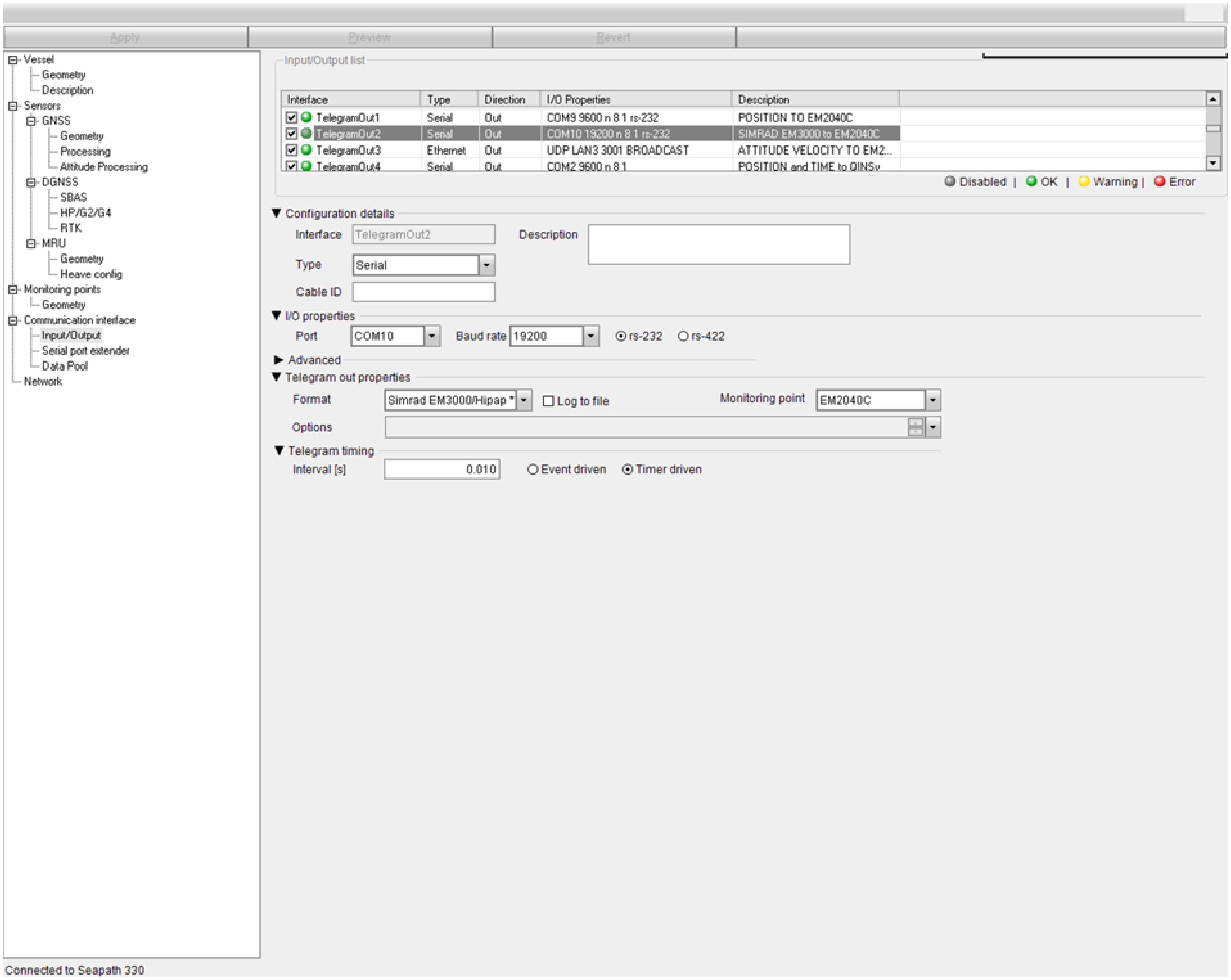
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface
Type
Direction
I/O Properties
Description
GnssRec1
Serial
In/Out
GNSSA1 57600 n 8 1
Receiver #1
GnssRec2
Serial
In/Out
GNSSB1 57600 n 8 1
Receiver #2
MRU
Serial
In/Out
MRU 115200 n 8 1 rs-422
IMU #1
Disabled | OK | Warning | Error
Configuration details
Interface
GnssRec2
Description
Type
Serial
Cable ID
I/O properties
Port
GNSSB1
Baud rate
57600
rs-232
rs-422
Advanced
Parity
n
Data bits
8
Stop bits
1
Connected to Seapath 330

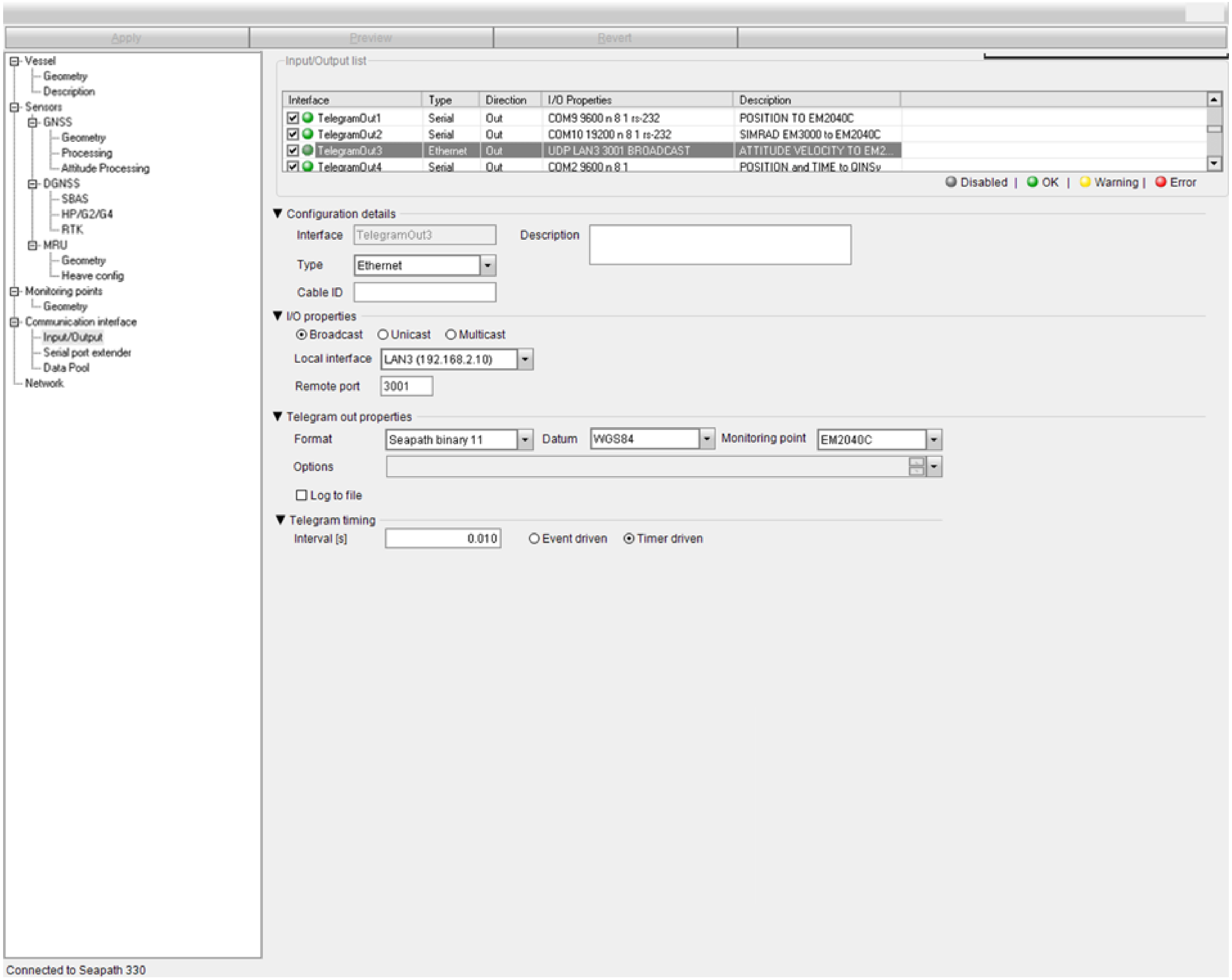

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface
Type
Direction
I/O Properties
Description
GnssRec1
Serial
In/Out
GNSSA1 57600 n 8 1
Receiver #1
GnssRec2
Serial
In/Out
GNSSB1 57600 n 8 1
Receiver #2
MRU
Serial
In/Out
MRU 115200 n 8 1 rs-422
IMU #1
Gyro1
Serial
In
COM11 9600 n 8 1 rs-232
Gyro #1
Disabled | OK | Warning | Error
Configuration details
Interface
MRU
Description
Type
Serial
Cable ID
I/O properties
Port
MRU
Baud rate
115200
rs-232
rs-422
Advanced
Parity
n
Data bits
8
Stop bits
1
Connected to Seapath 330

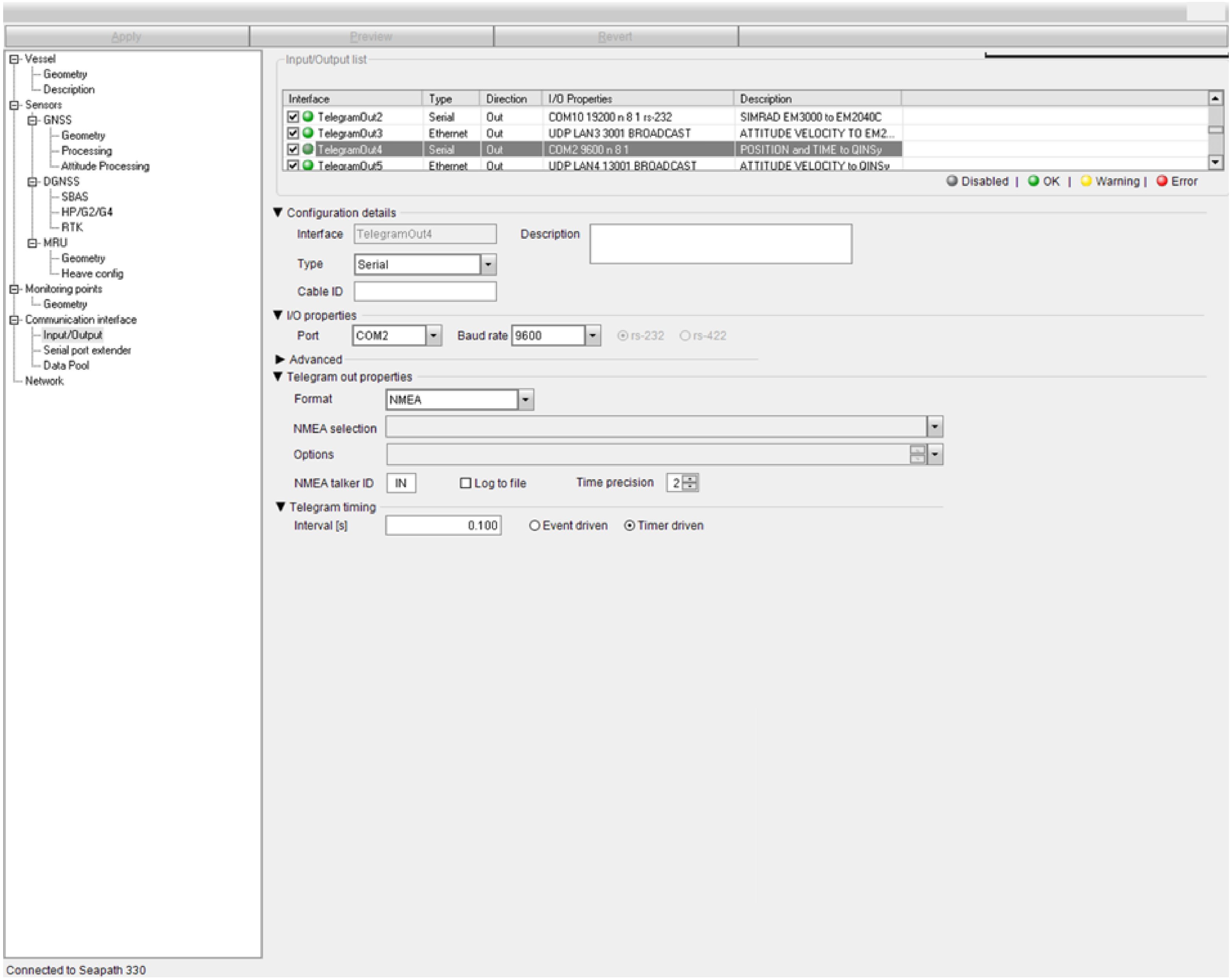


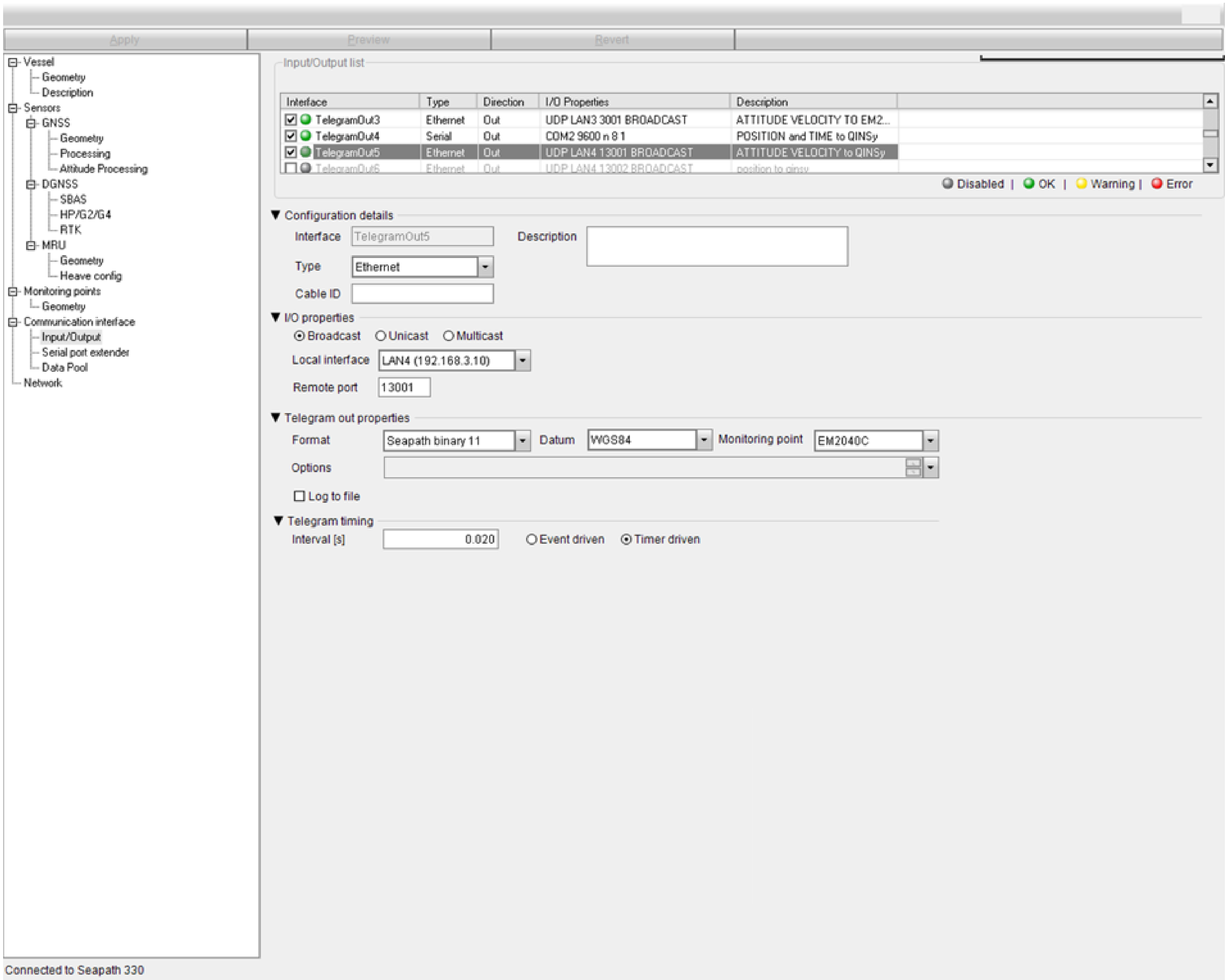
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface Type Direction I/O Properties Description
Gyro1 Serial In COM11 9600 n 8 1 rs-232 Gyro #1
DgnssLink1 Serial In COM1 38400 n 8 1 FUGRO 3610 PORT A
DgnssLink2 Serial In COM14 38400 n 8 1 rs-422 FUGRO 3610 PORT B
DgnssLink3 In NONE Link #3
Disabled | OK | Warning | Error
Configuration details
Interface DgnssLink2
Description
Type Serial
Cable ID
I/O properties
Port COM14
Baud rate 38400
rs-232
rs-422
Advanced
DGNSS link properties
Interface 3510/3610 DGNSS receiver
Name G2
Timeout [s] 60
Format XP/G2/G4
Connected to Seapath 330

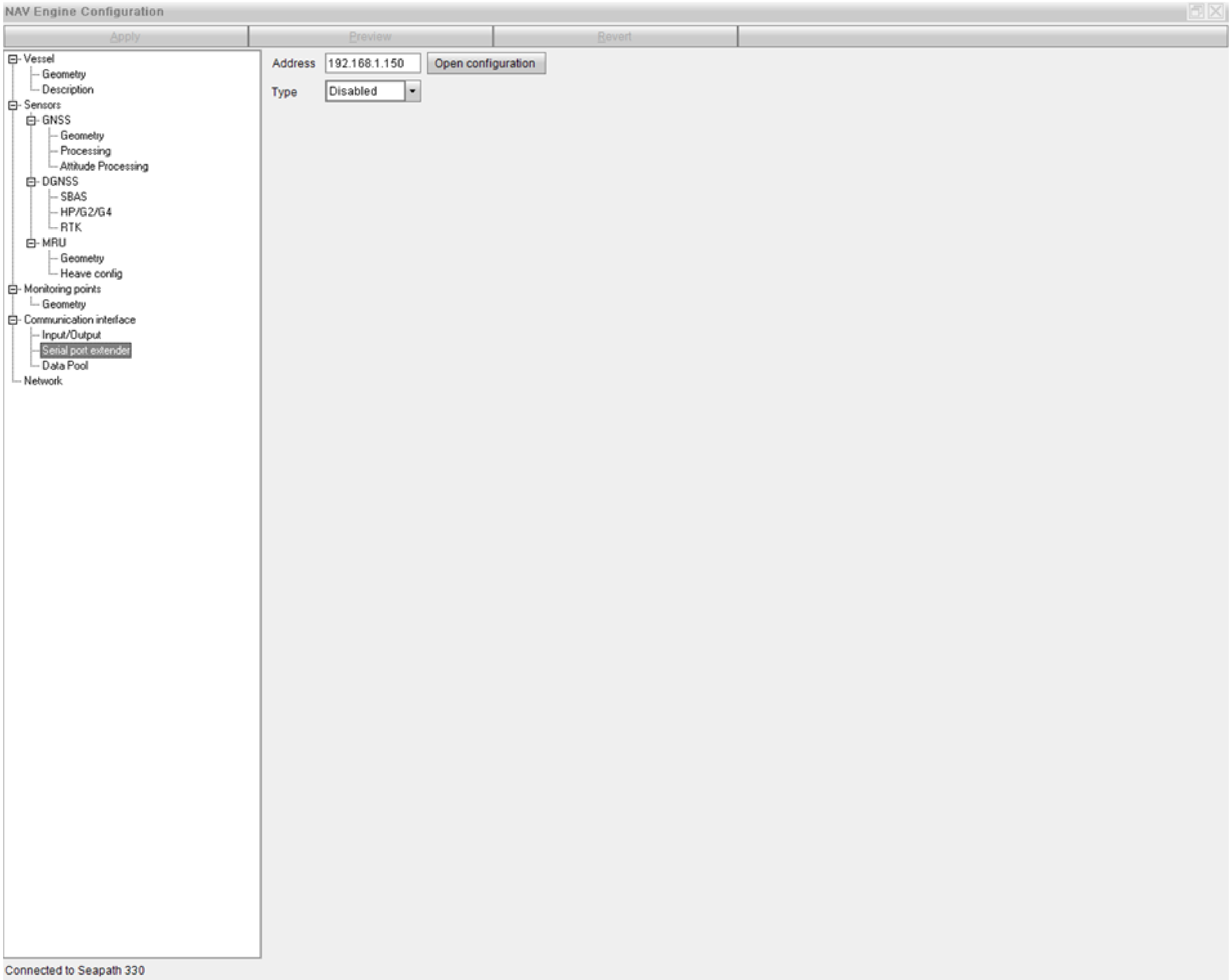

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface
Type
Direction
I/O Properties
Description
GnssLink
Ethernet
In/Out
UDP LAN2 31012 31013 BROADCAST
GNSS link server
TelegramOut1
Serial
Out
COM9 9600 n 8 1 rs-232
POSITION TO EM2040C
TelegramOut2
Serial
Out
COM10 19200 n 8 1 rs-232
SIMRAD EM3000 to EM2040C
TelegramOut3
Ethernet
Out
UDP LAN3 3001 BROADCAST
ATTITUDE VELOCITY TO EM2...
Disabled | OK | Warning | Error
Configuration details
Interface
TelegramOut1
Description
Type
Serial
Cable ID
I/O properties
Port
COM9
Baud rate
9600
rs-232
rs-422
Advanced
Telegram out properties
Format
NMEA
Datum
WGS84
Monitoring point
EM2040C
NMEA selection
Options
NMEA talker ID
IN
Log to file
Time precision
2
Telegram timing
Interval [s]
1.000
Event driven
Timer driven
Connected to Seapath 330

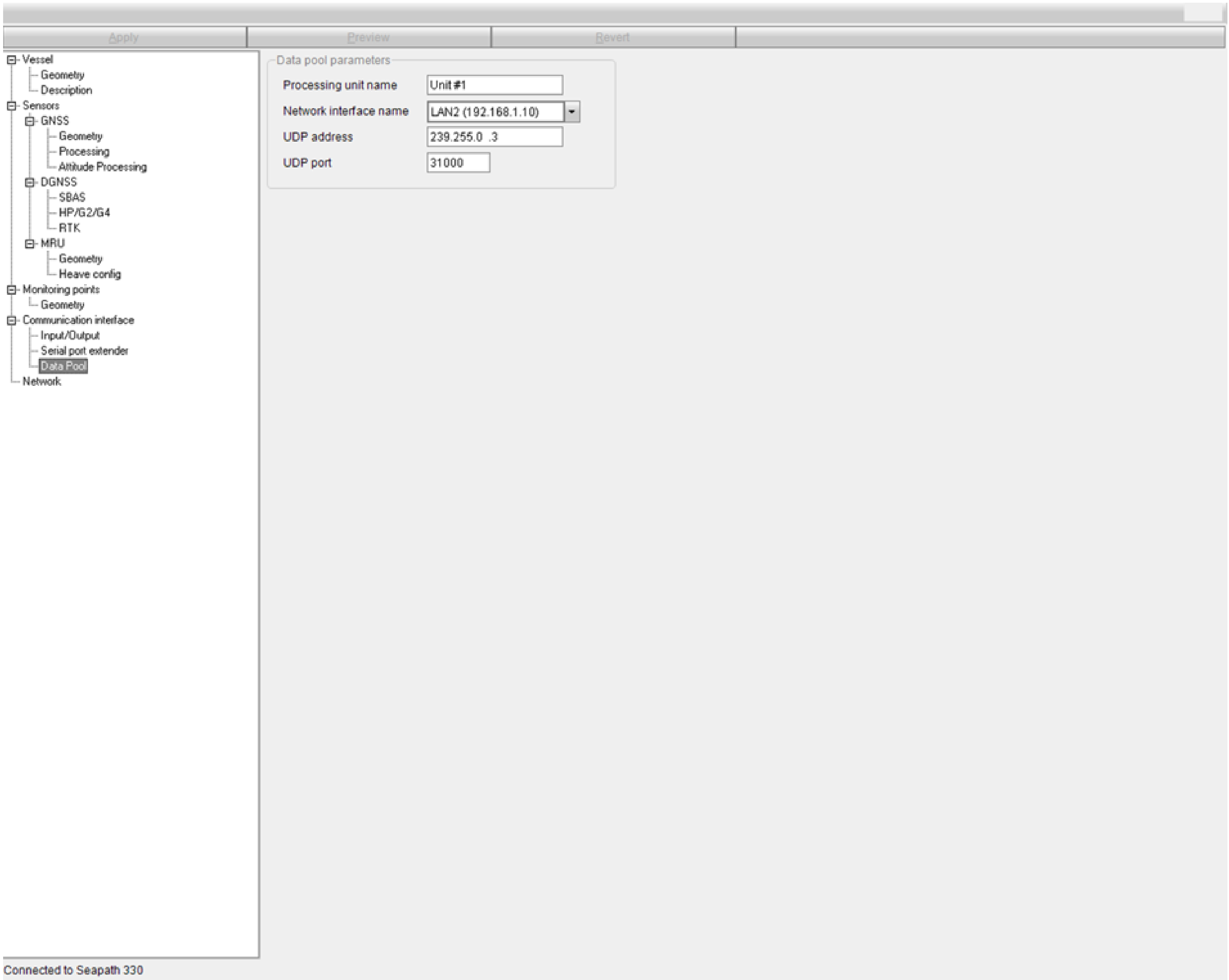

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface Type Direction I/O Properties Description
TelegramOut1 Serial Out COM9 9600 n 8 1 rs-232 POSITION TO EM2040C
TelegramOut2 Serial Out COM10 19200 n 8 1 rs-232 SIMRAD EM3000 to EM2040C
TelegramOut3 Ethernet Out UDP LAN3 3001 BROADCAST ATTITUDE VELOCITY TO EM2...
TelegramOut4 Serial Out COM2 9600 n 8 1 POSITION and TIME to QINSy
Disabled | OK | Warning | Error
Configuration details
Interface TelegramOut2
Description
Type Serial
Cable ID
I/O properties
Port COM10
Baud rate 19200
rs-232
rs-422
Advanced
Telegram out properties
Format Simrad EM3000/Hipap
Log to file
Monitoring point EM2040C
Options
Telegram timing
Interval [s] 0.010
Event driven
Timer driven
Connected to Seapath 330

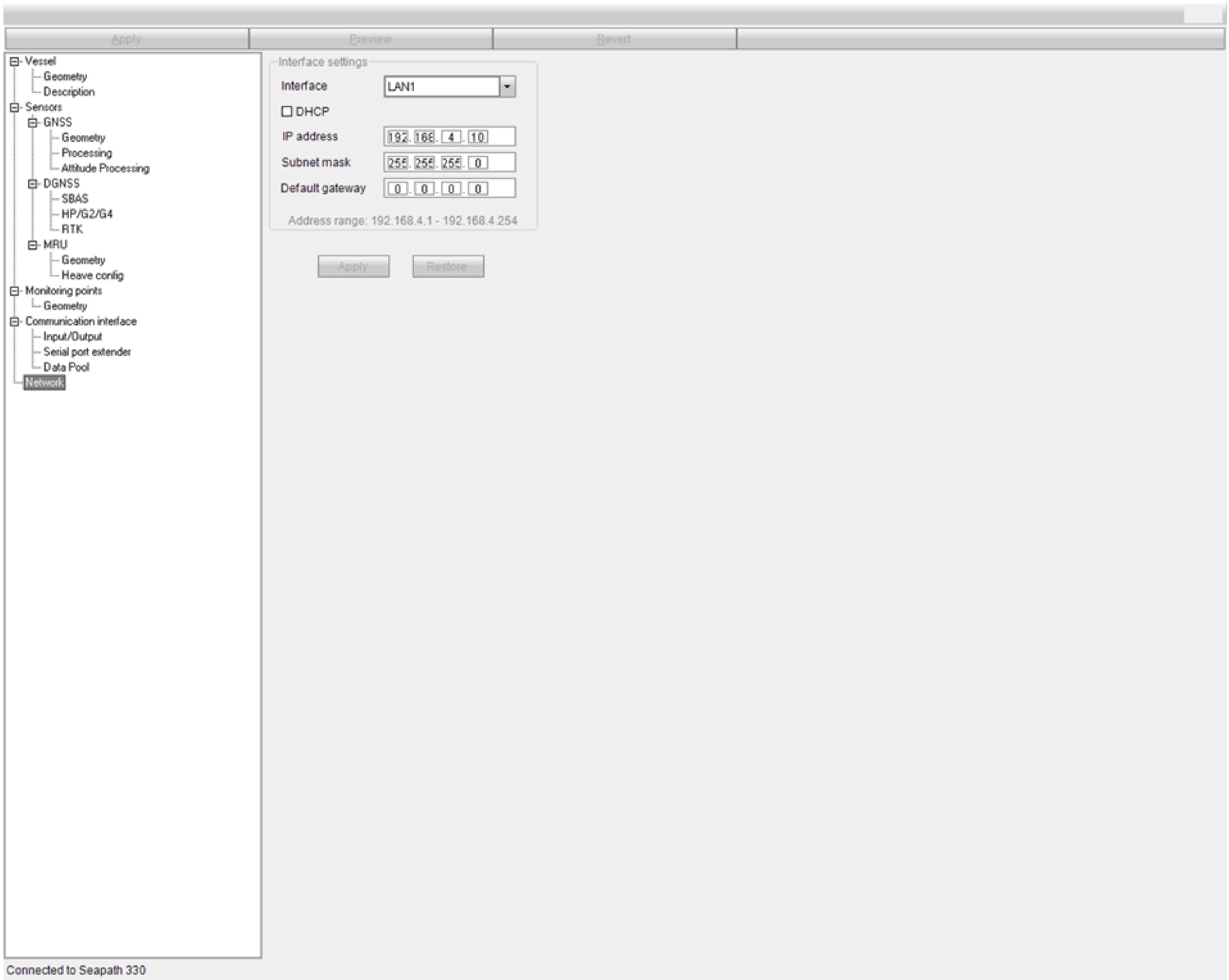

Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface | Type | Direction | I/O Properties | Description
TelegramOut1 | Serial | Out | COM9 9600 n 8 1 rs-232 | POSITION TO EM2040C
TelegramOut2 | Serial | Out | COM10 19200 n 8 1 rs-232 | SIMRAD EM3000 to EM2040C
TelegramOut3 | Ethernet | Out | UDP LAN3 3001 BROADCAST | ATTITUDE VELOCITY TO EM2...
TelegramOut4 | Serial | Out | COM2 9600 n 8 1 | POSITION and TIME to QINSy
Disabled | OK | Warning | Error
Configuration details
Interface
TelegramOut3
Description
Type
Ethernet
Cable ID
I/O properties
Broadcast
Unicast
Multicast
Local interface
LAN3 (192.168.2.10)
Remote port
3001
Telegram out properties
Format
Seapath binary 11
Datum
WGS84
Monitoring point
EM2040C
Options
Log to file
Telegram timing
Interval [s]
0.010
Event driven
Timer driven
Connected to Seapath 330


Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface | Type | Direction | I/O Properties | Description
TelegramOut2 | Serial | Out | COM10 19200 n 8 1 rs-232 | SIMRAD EM3000 to EM2040C
TelegramOut3 | Ethernet | Out | UDP LAN3 3001 BROADCAST | ATTITUDE VELOCITY TO EM2...
TelegramOut4 | Serial | Out | COM2 9600 n 8 1 | POSITION and TIME to QINSy
TelegramOut5 | Ethernet | Out | UDP LAN4 13001 BROADCAST | ATTITUDE VELOCITY to QINSy
Disabled | OK | Warning | Error
Configuration details
Interface TelegramOut4
Description
Type Serial
Cable ID
I/O properties
Port COM2
Baud rate 9600
rs-232
rs-422
Advanced
Telegram out properties
Format NMEA
NMEA selection
Options
NMEA talker ID IN
Log to file
Time precision 2
Telegram timing
Interval [s] 0.100
Event driven
Timer driven
Connected to Seapath 330


Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Input/Output list
Interface
Type
Direction
I/O Properties
Description
TelegramOut3 Ethernet Out UDP LAN3 3001 BROADCAST ATTITUDE VELOCITY TO EM2...
TelegramOut4 Serial Out COM2 9600 n 8 1 POSITION and TIME to QINSy
TelegramOut5 Ethernet Out UDP LAN4 13001 BROADCAST ATTITUDE VELOCITY to QINSy
TelegramOut6 Ethernet Out UDP LAN4 13002 BROADCAST position to qinsy
Disabled | OK | Warning | Error
Configuration details
Interface
TelegramOut5
Description
Type
Ethernet
Cable ID
I/O properties
Broadcast
Unicast
Multicast
Local interface
LAN4 (192.168.3.10)
Remote port
13001
Telegram out properties
Format
Seapath binary 11
Datum
WGS84
Monitoring point
EM2040C
Options
Log to file
Telegram timing
Interval [s]
0.020
Event driven
Timer driven
Connected to Seapath 330


NAV Engine Configuration
Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Address
192.168.1.150
Open configuration
Type
Disabled
Connected to Seapath 330


Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Data pool parameters
Processing unit name
Unit #1
Network interface name
LAN2 (192.168.1.10)
UDP address
239.255.0 .3
UDP port
31000
Connected to Seapath 330


Apply
Preview
Revert
Vessel
Geometry
Description
Sensors
GNSS
Geometry
Processing
Attitude Processing
DGNSS
SBAS
HP/G2/G4
RTK
MRU
Geometry
Heave config
Monitoring points
Geometry
Communication interface
Input/Output
Serial port extender
Data Pool
Network
Interface settings
Interface
LAN1
DHCP
IP address
192 . 168 . 4 . 10
Subnet mask
255 . 255 . 255 . 0
Default gateway
0 . 0 . 0 . 0
Address range: 192.168.4.1 - 192.168.4.254
Apply
Restore
Connected to Seapath 330

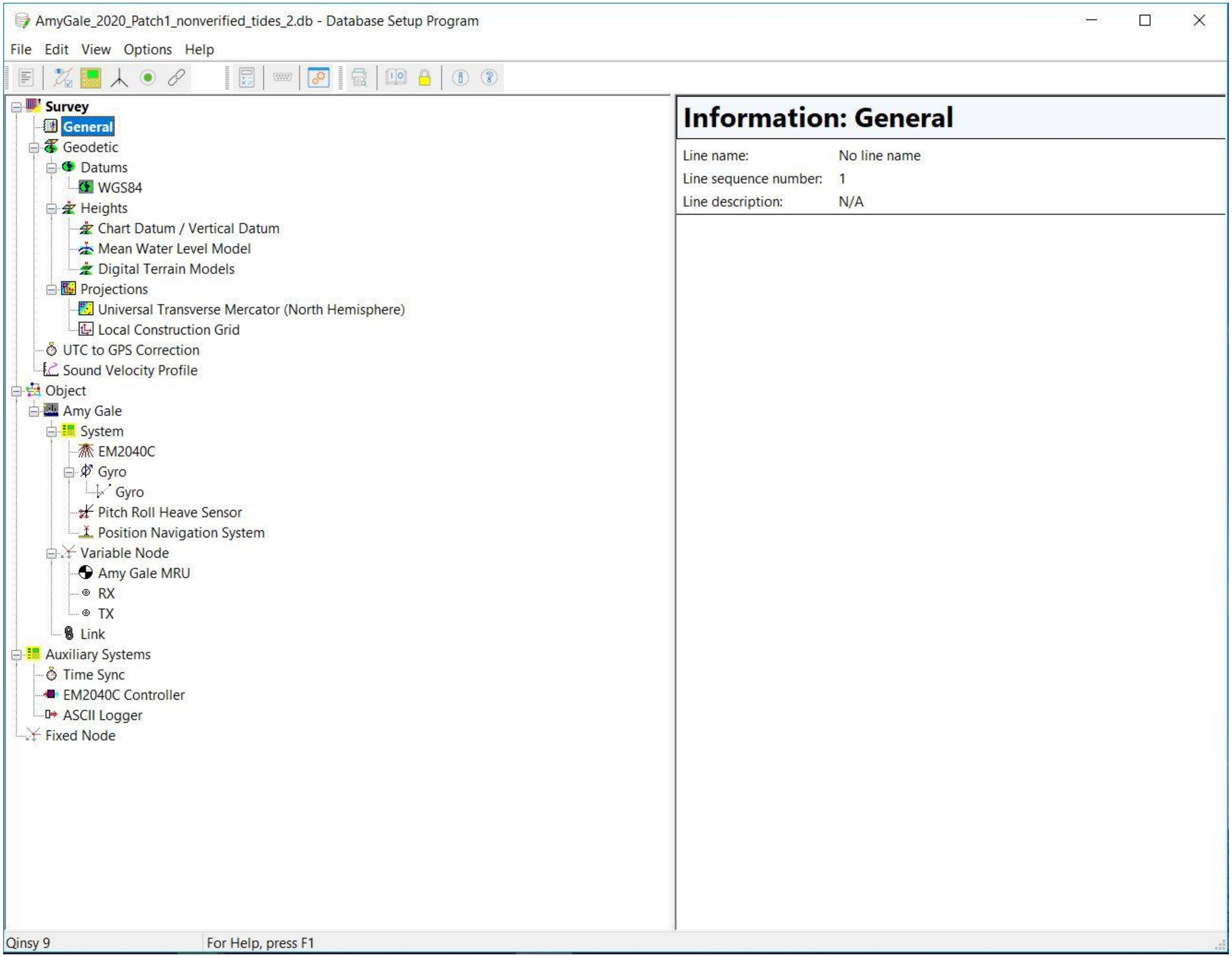
Appendix D – Template database settings in Qinsy (for acquisition)

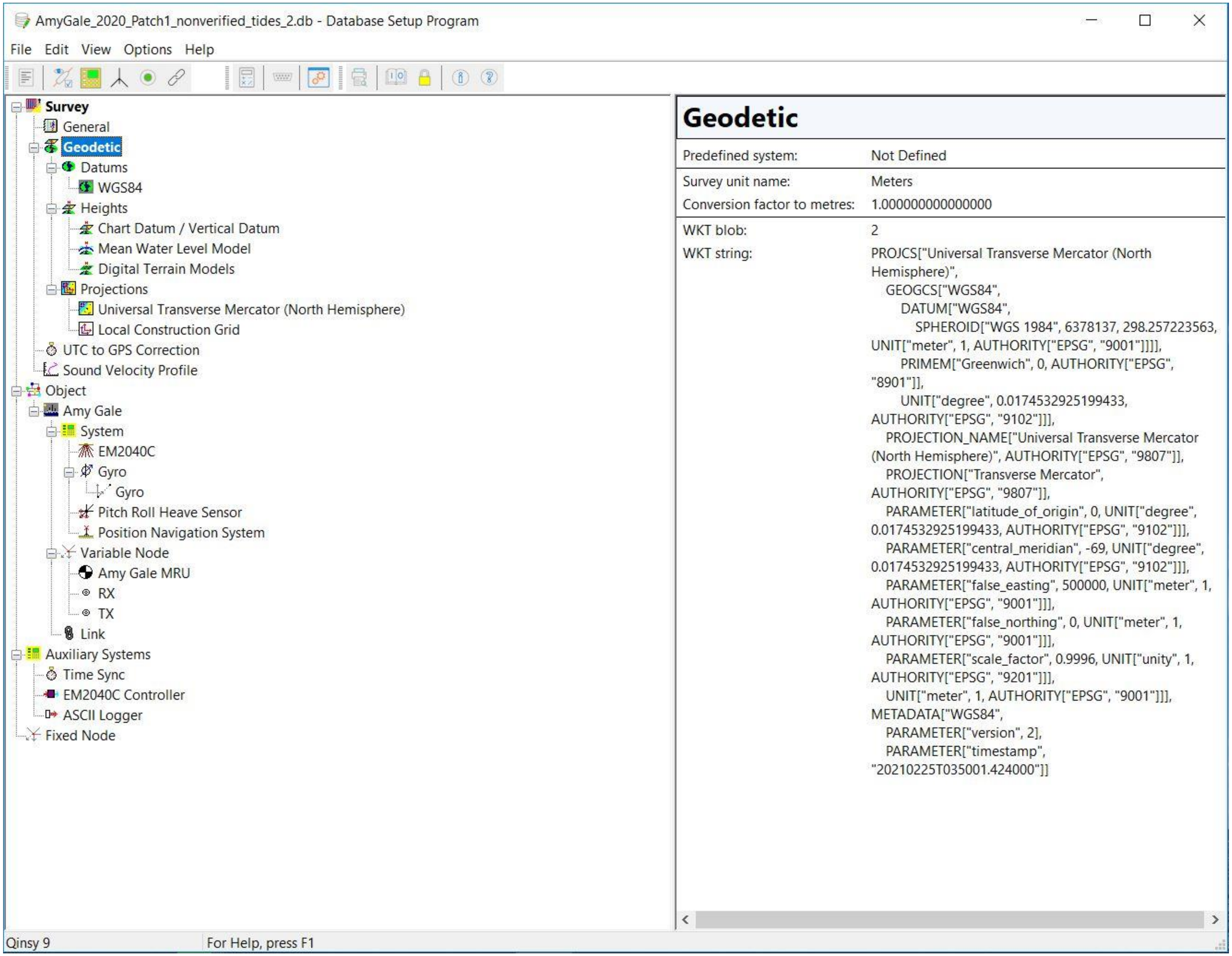
Note: Depicted Qinsy template settings show configuration from a 2020 survey project. All settings remain the same for the seasons described in this report apart from changes to pitch, roll, heading for EM2040C from patch test results (Table 4), as well as latency offsets applied to Position Navigation Systems and Motion Reference output values.

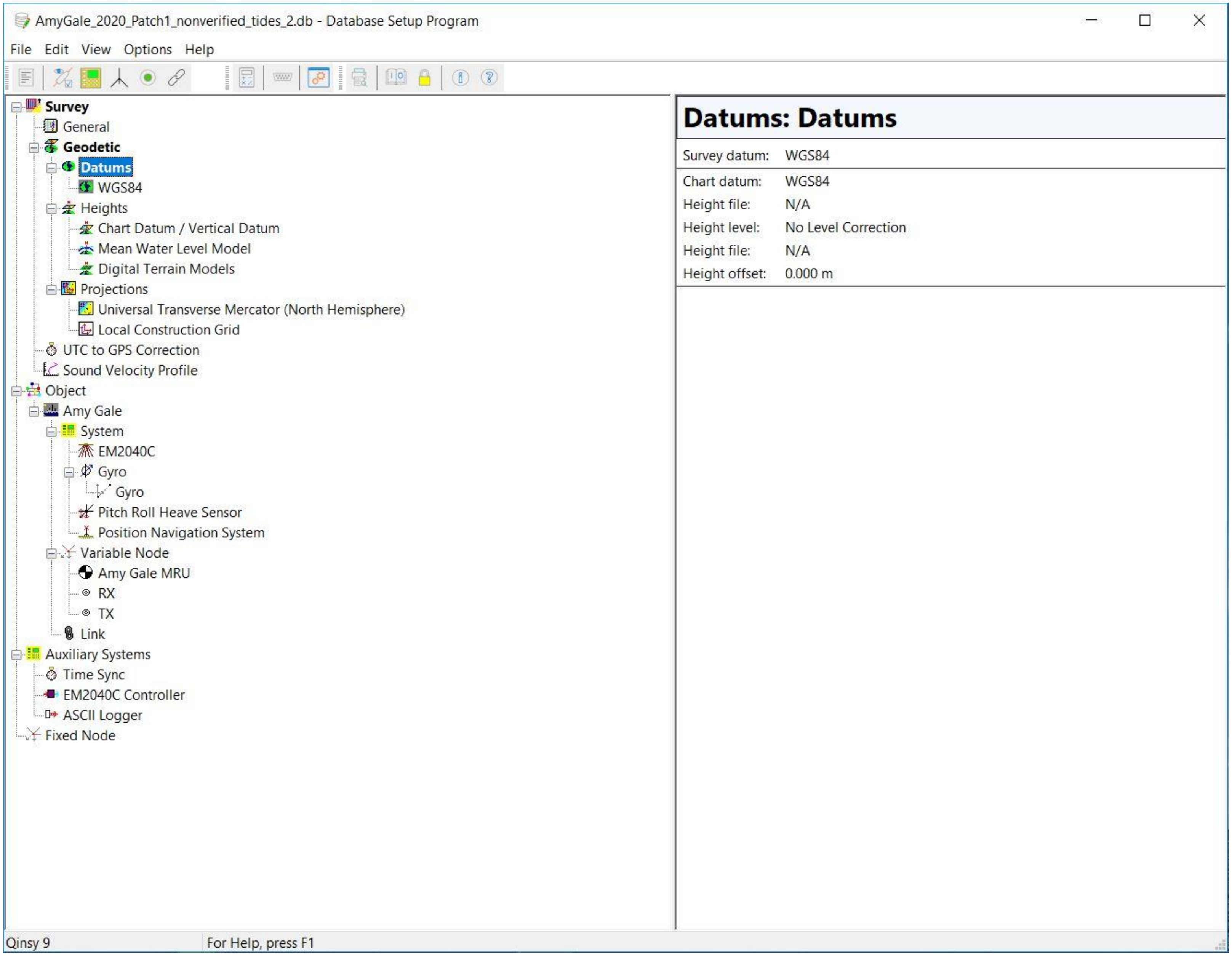
Qinsy uses the following reference frame conventions (these differ from those used by Seapath 330):

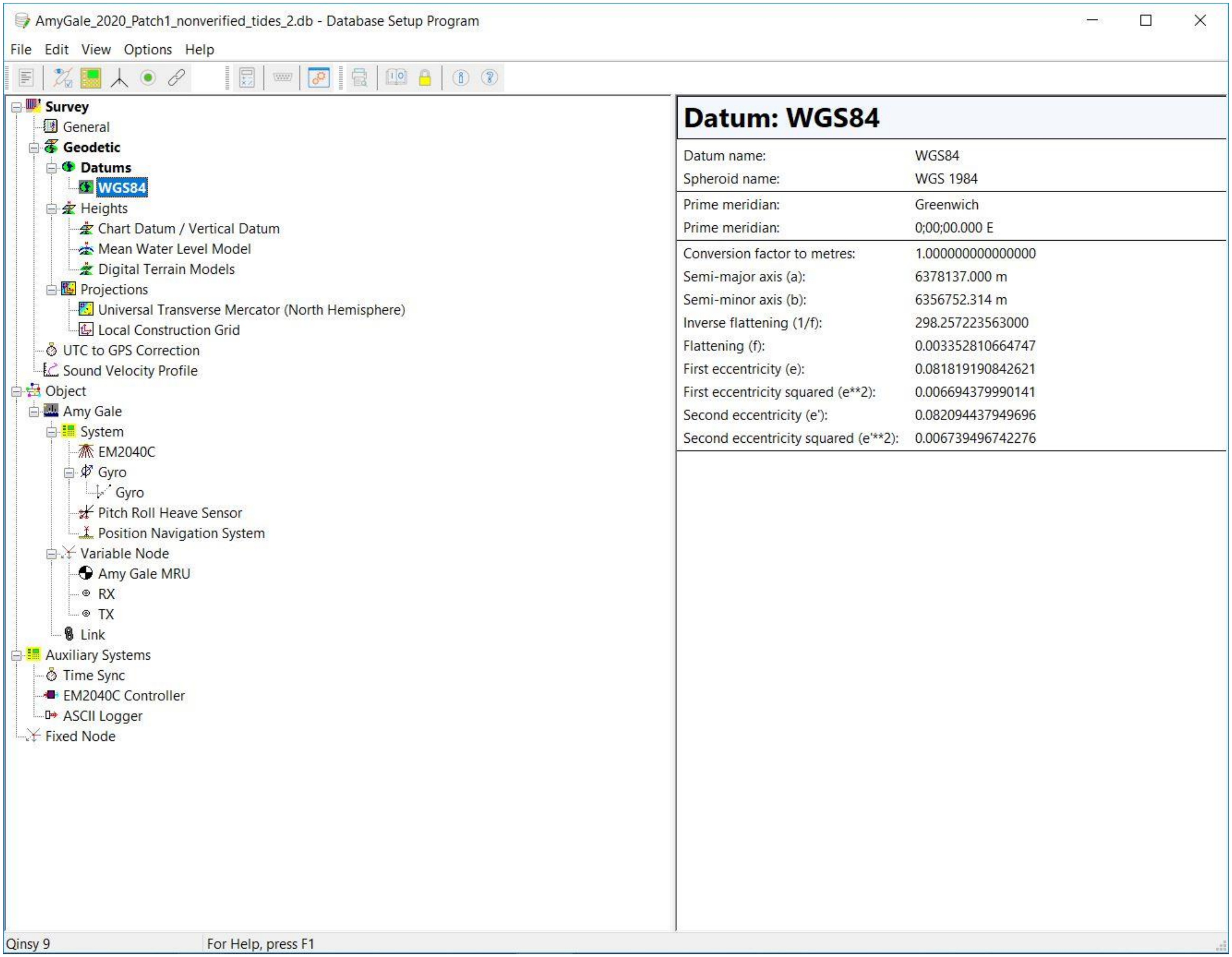
Pitch rotation: + bow up
Roll rotation: + heeling to starboard
Heave: + upwards

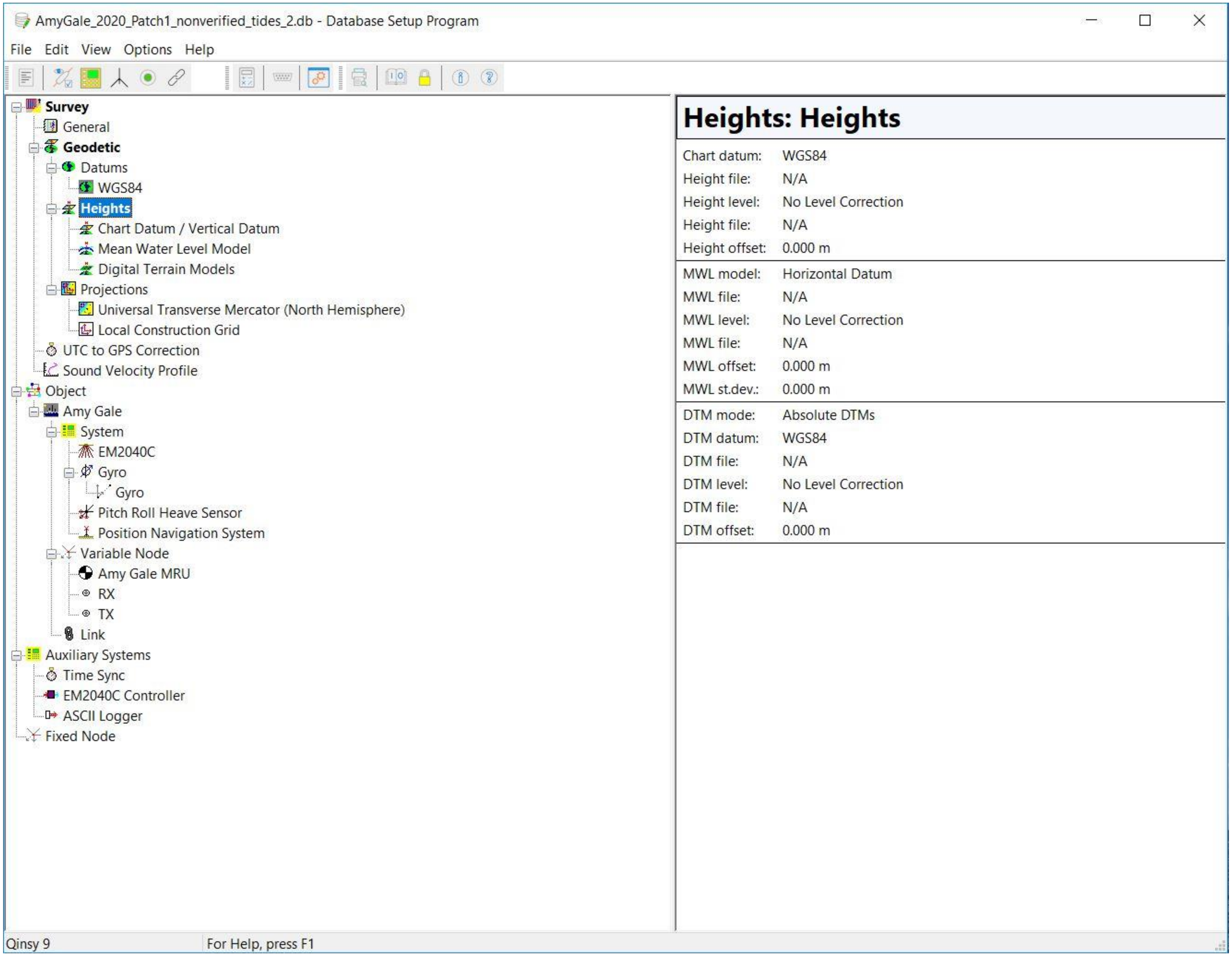
X: + to starboard
Y: + towards bow
Z: + up

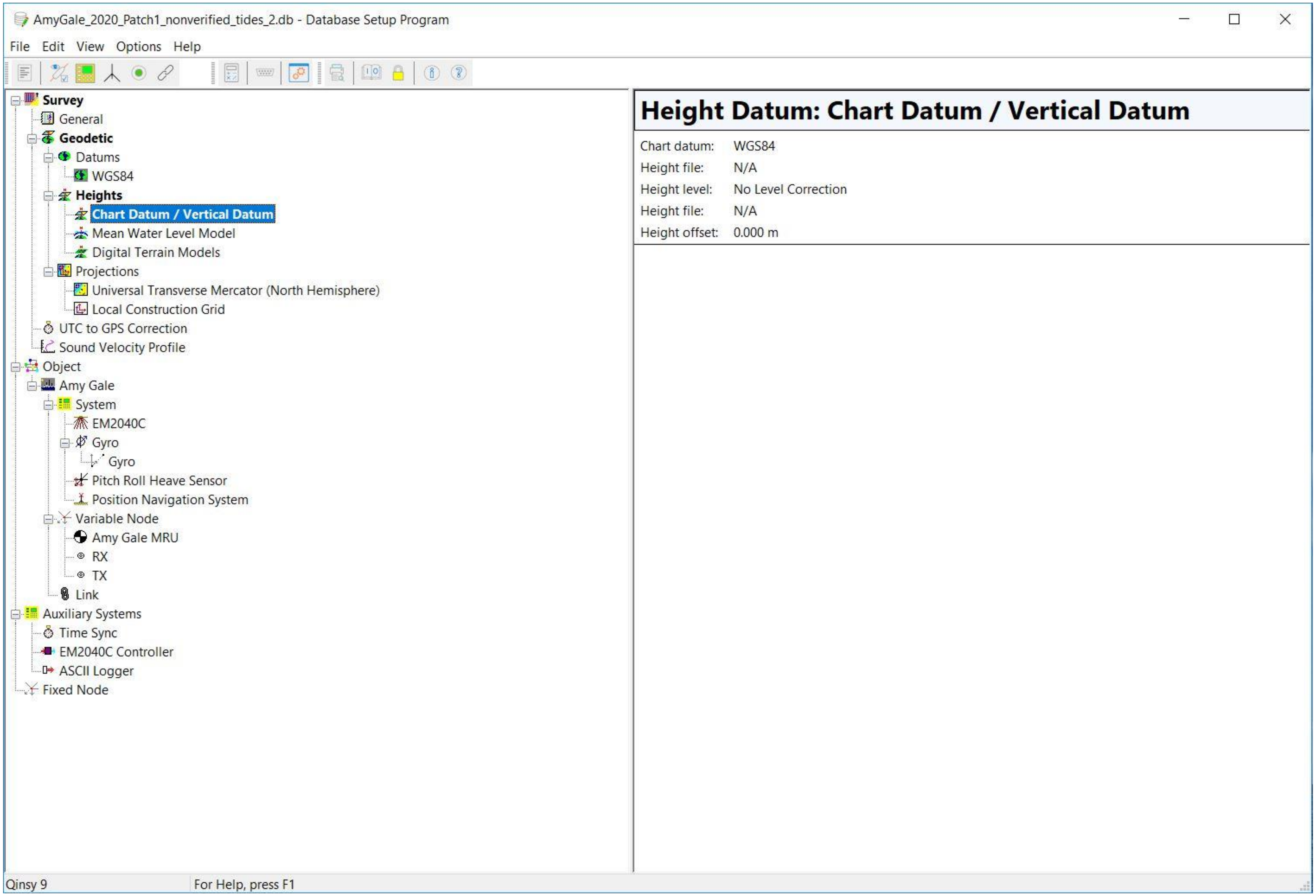

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Information: General
Line name: No line name
Line sequence number: 1
Line description: N/A
Qinsy 9
For Help, press F1

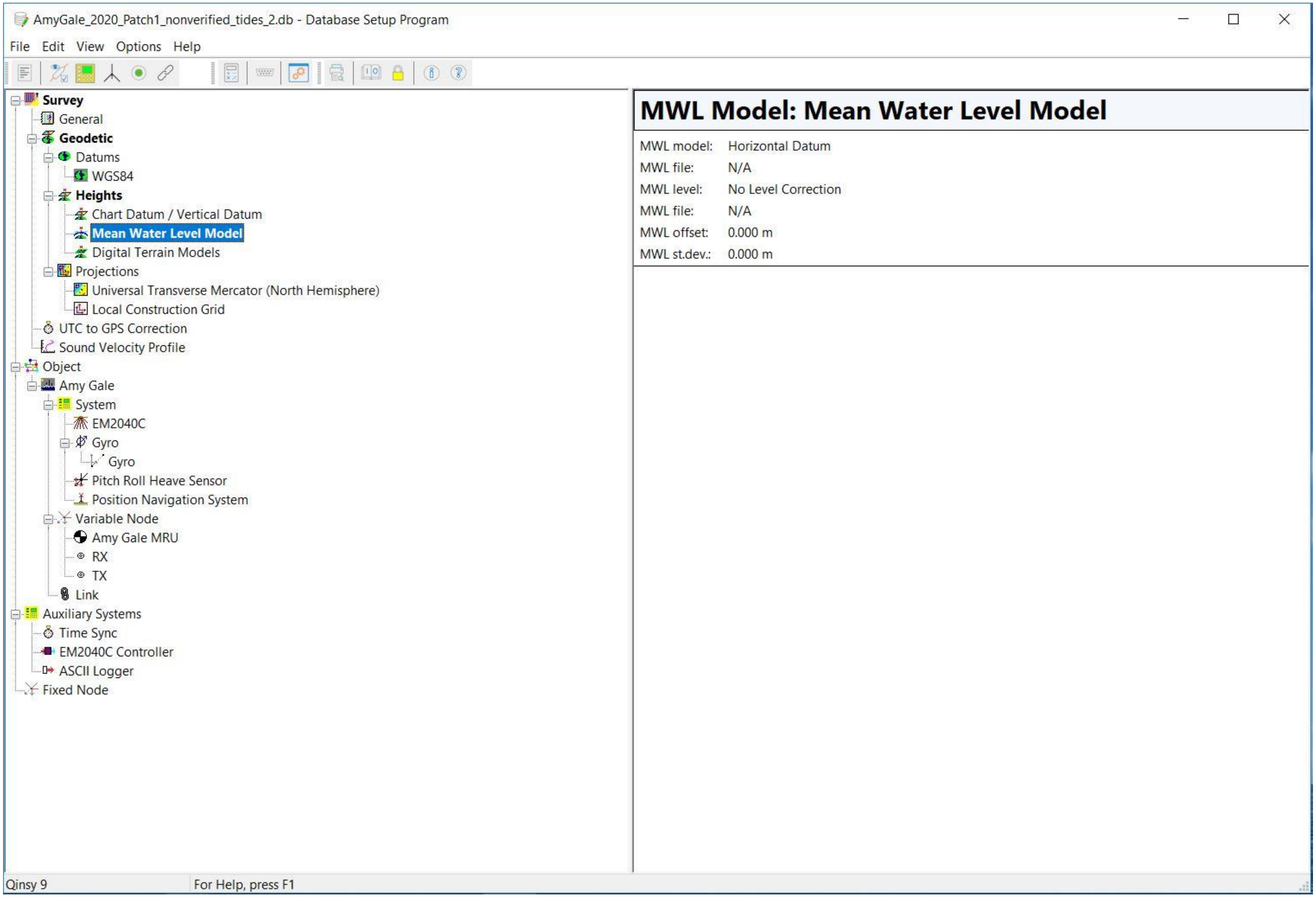

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Geodetic
Predefined system: Not Defined
Survey unit name: Meters
Conversion factor to metres: 1.000000000000000
WKT blob: 2
WKT string: PROJCS["Universal Transverse Mercator (North Hemisphere)",
GEOGCS["WGS84",
DATUM["WGS84",
SPHEROID["WGS 1984", 6378137, 298.257223563,
UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]]],
PRIMEM["Greenwich", 0, AUTHORITY["EPSG", "8901"]],
UNIT["degree", 0.0174532925199433, AUTHORITY["EPSG", "9102"]]],
PROJECTION_NAME["Universal Transverse Mercator (North Hemisphere)", AUTHORITY["EPSG", "9807"]],
PROJECTION["Transverse Mercator", AUTHORITY["EPSG", "9807"]],
PARAMETER["latitude_of_origin", 0, UNIT["degree", 0.0174532925199433, AUTHORITY["EPSG", "9102"]]],
PARAMETER["central_meridian", -69, UNIT["degree", 0.0174532925199433, AUTHORITY["EPSG", "9102"]]],
PARAMETER["false_easting", 500000, UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]],
PARAMETER["false_northing", 0, UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]],
PARAMETER["scale_factor", 0.9996, UNIT["unity", 1, AUTHORITY["EPSG", "9201"]]],
UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]],
METADATA["WGS84",
PARAMETER["version", 2],
PARAMETER["timestamp", "20210225T035001.424000"]]
Qinsy 9
For Help, press F1

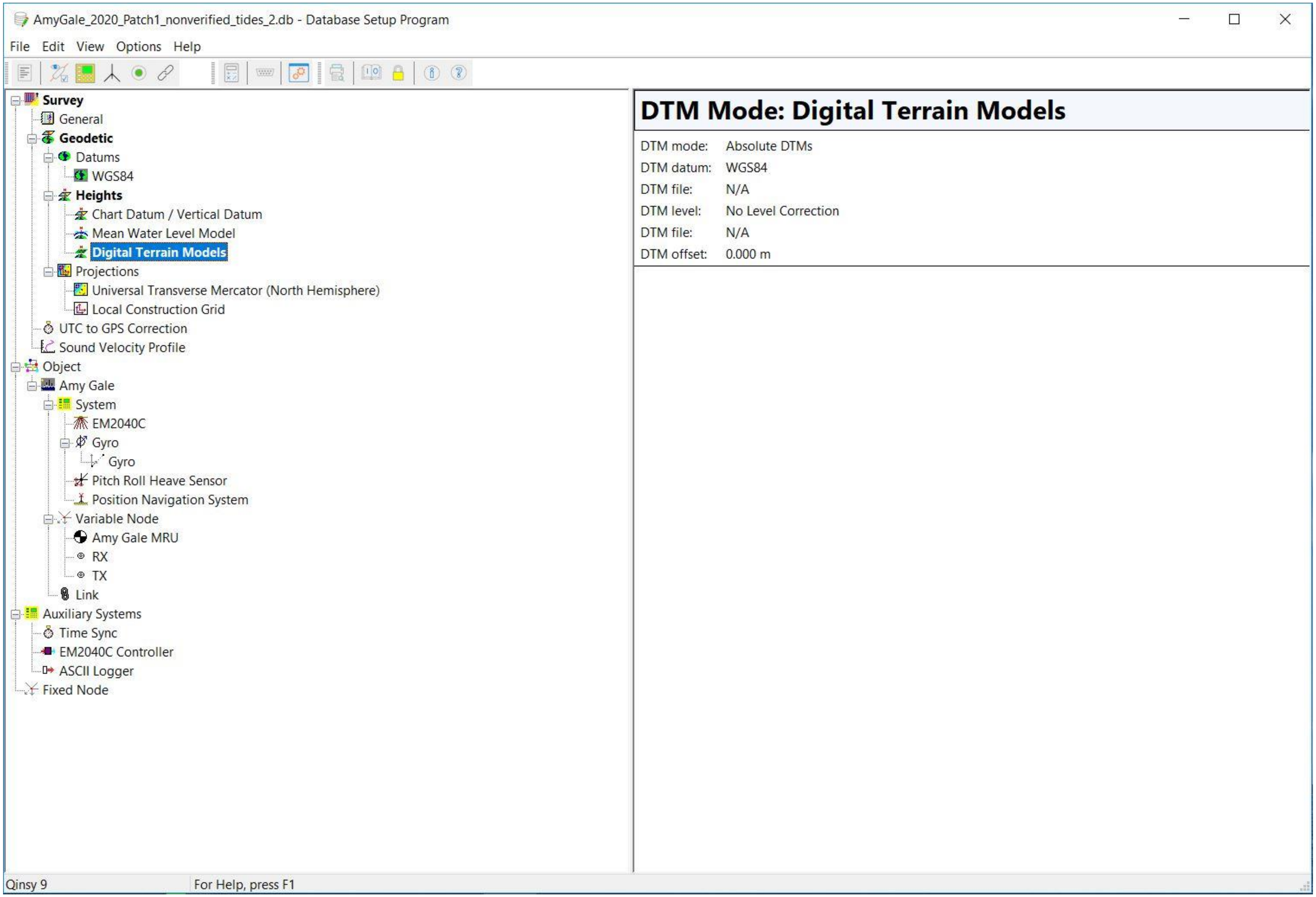

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Datums: Datums
Survey datum: WGS84
Chart datum: WGS84
Height file: N/A
Height level: No Level Correction
Height file: N/A
Height offset: 0.000 m
Qinsy 9
For Help, press F1

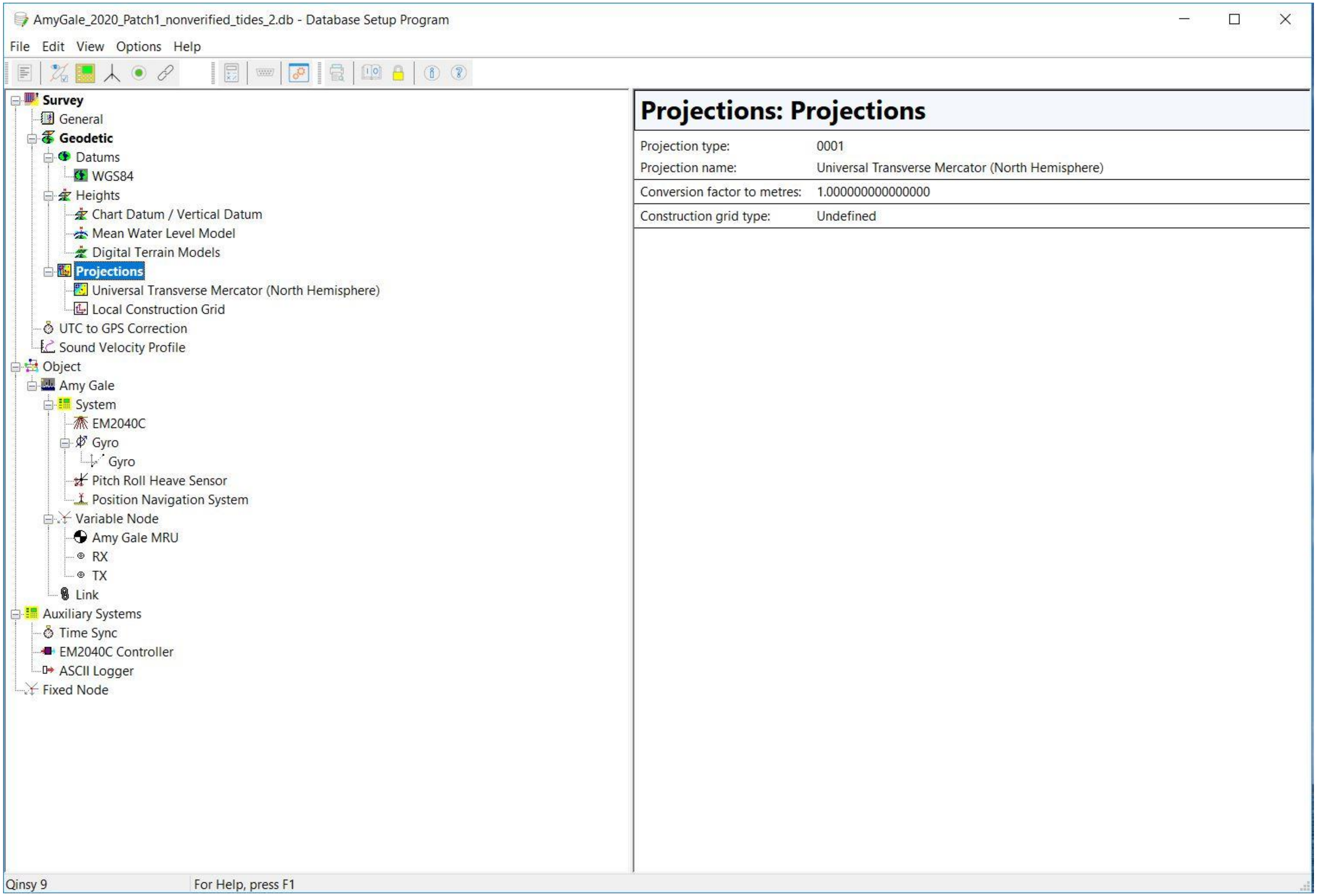

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Datum: WGS84
Datum name: WGS84
Spheroid name: WGS 1984
Prime meridian: Greenwich
Prime meridian: 0;00;00.000 E
Conversion factor to metres: 1.000000000000000
Semi-major axis (a): 6378137.000 m
Semi-minor axis (b): 6356752.314 m
Inverse flattening (1/f): 298.257223563000
Flattening (f): 0.003352810664747
First eccentricity (e): 0.081819190842621
First eccentricity squared (e**2): 0.006694379990141
Second eccentricity (e'): 0.082094437949696
Second eccentricity squared (e'**2): 0.006739496742276
Qinsy 9
For Help, press F1

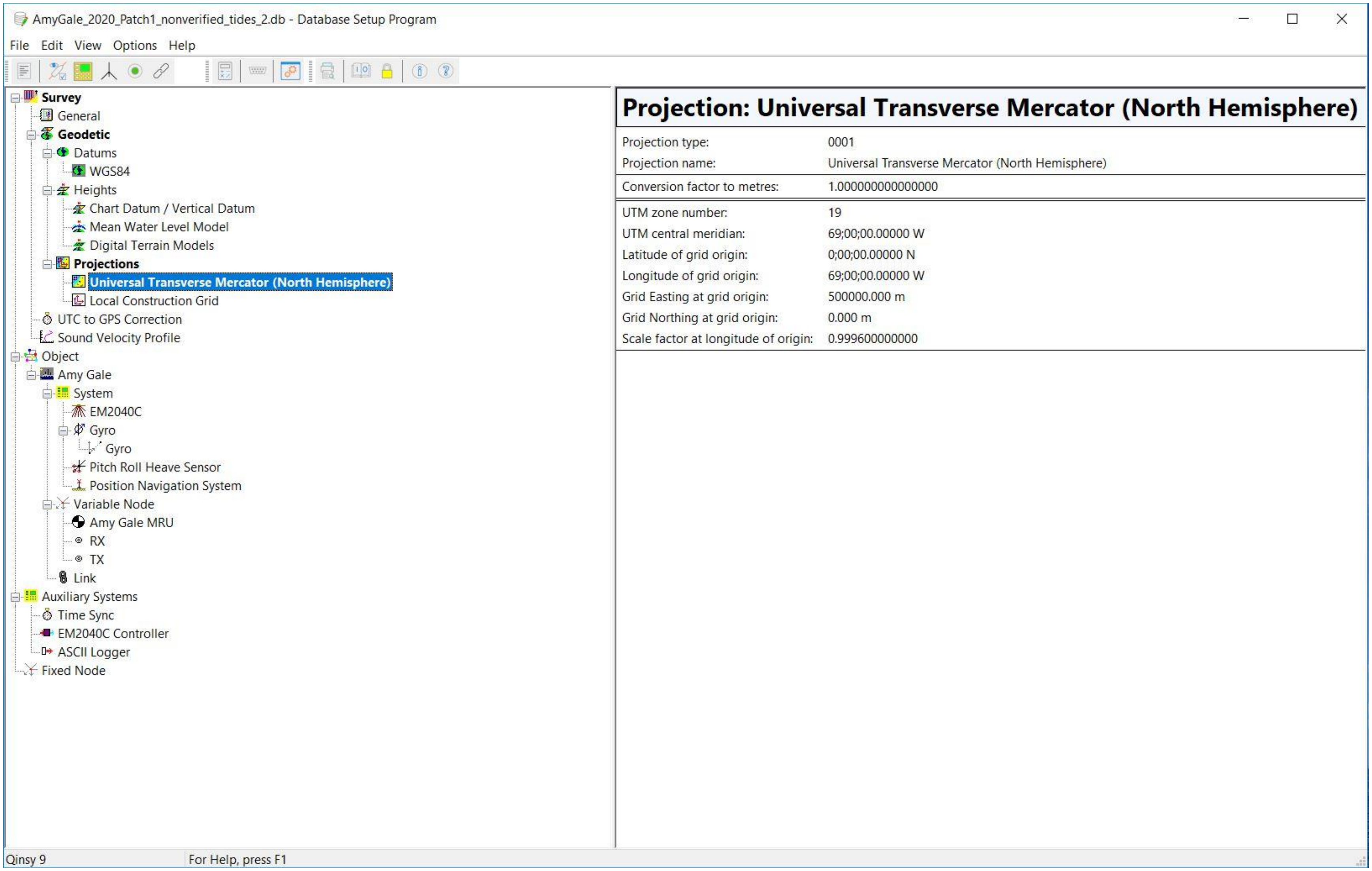

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Heights: Heights
Chart datum: WGS84
Height file: N/A
Height level: No Level Correction
Height file: N/A
Height offset: 0.000 m
MWL model: Horizontal Datum
MWL file: N/A
MWL level: No Level Correction
MWL file: N/A
MWL offset: 0.000 m
MWL st.dev.: 0.000 m
DTM mode: Absolute DTMs
DTM datum: WGS84
DTM file: N/A
DTM level: No Level Correction
DTM file: N/A
DTM offset: 0.000 m
Qinsy 9
For Help, press F1

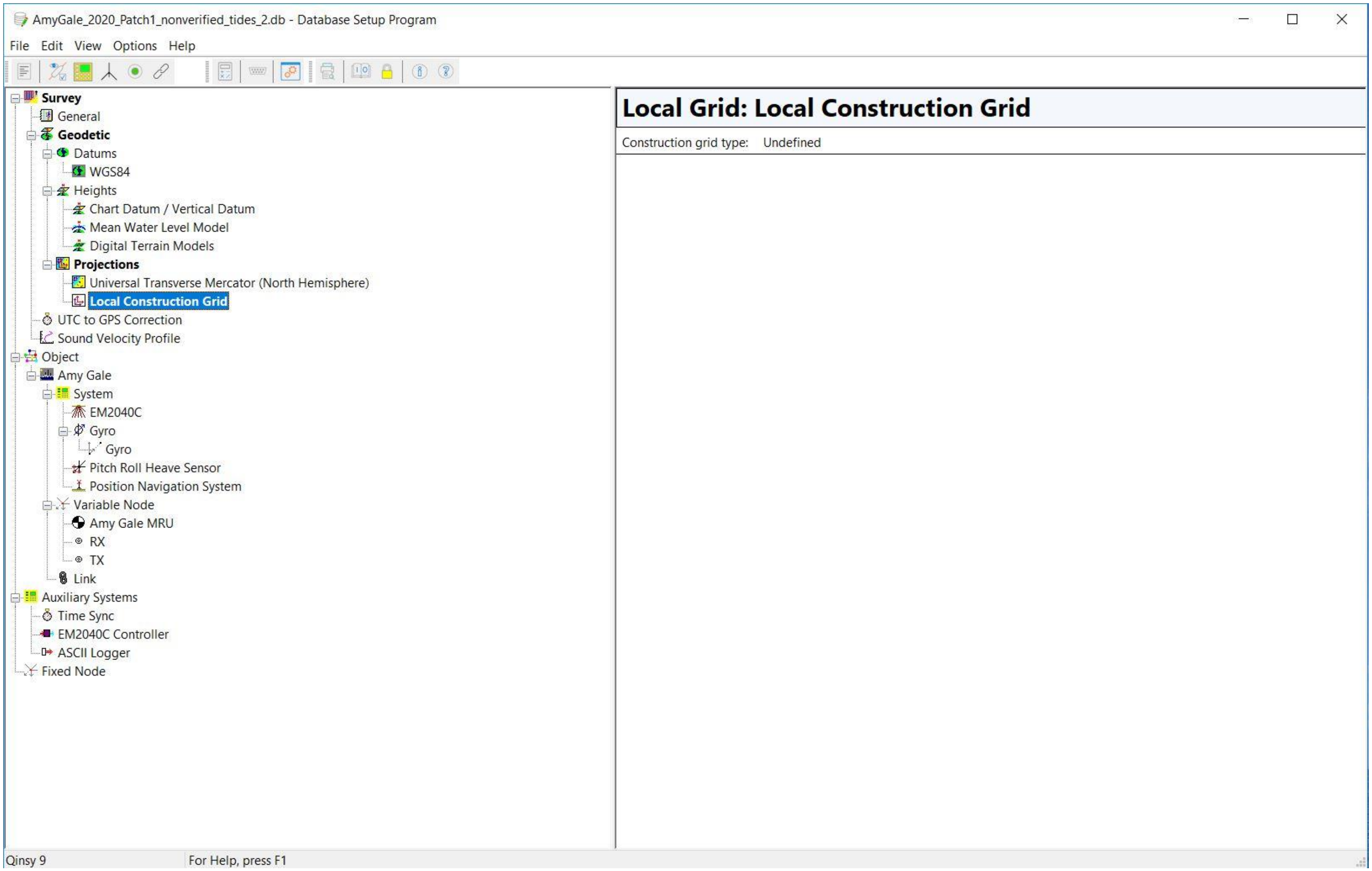

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Height Datum: Chart Datum / Vertical Datum
Chart datum: WGS84
Height file: N/A
Height level: No Level Correction
Height file: N/A
Height offset: 0.000 m
Qinsy 9
For Help, press F1

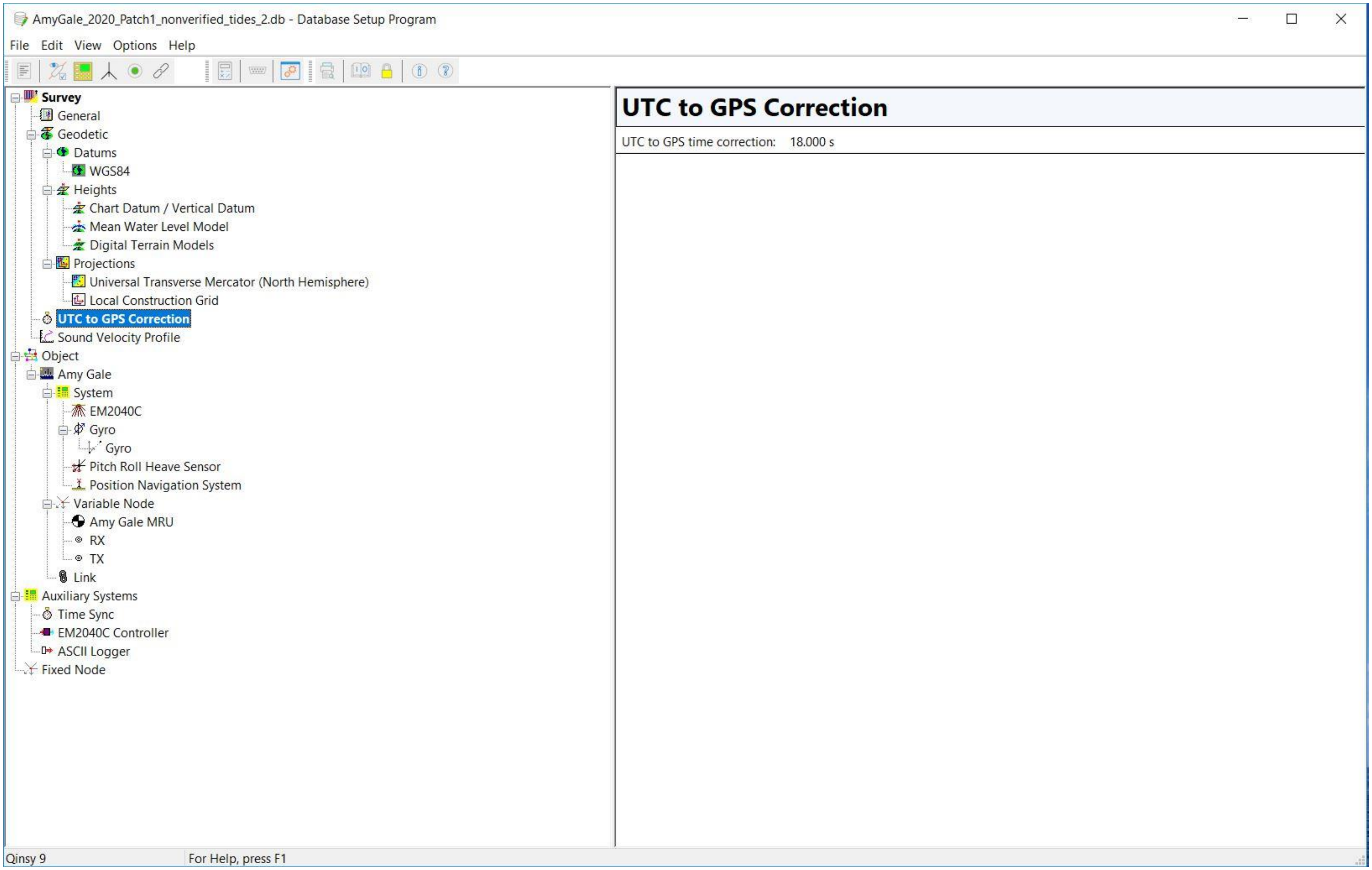

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
MWL Model: Mean Water Level Model
MWL model: Horizontal Datum
MWL file: N/A
MWL level: No Level Correction
MWL file: N/A
MWL offset: 0.000 m
MWL st.dev.: 0.000 m
Qinsy 9
For Help, press F1

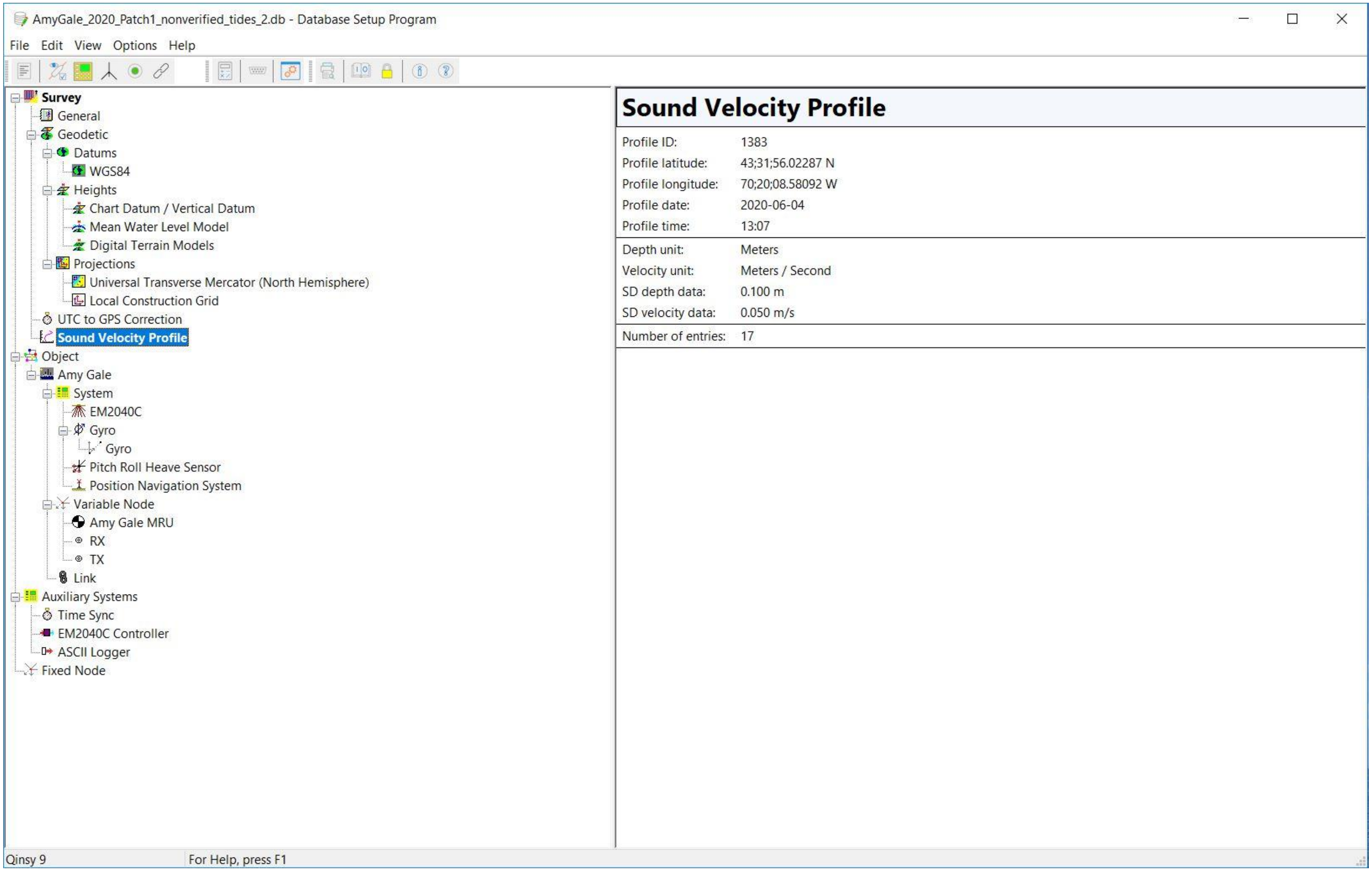

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
DTM Mode: Digital Terrain Models
DTM mode: Absolute DTMs
DTM datum: WGS84
DTM file: N/A
DTM level: No Level Correction
DTM file: N/A
DTM offset: 0.000 m
Qinsy 9
For Help, press F1

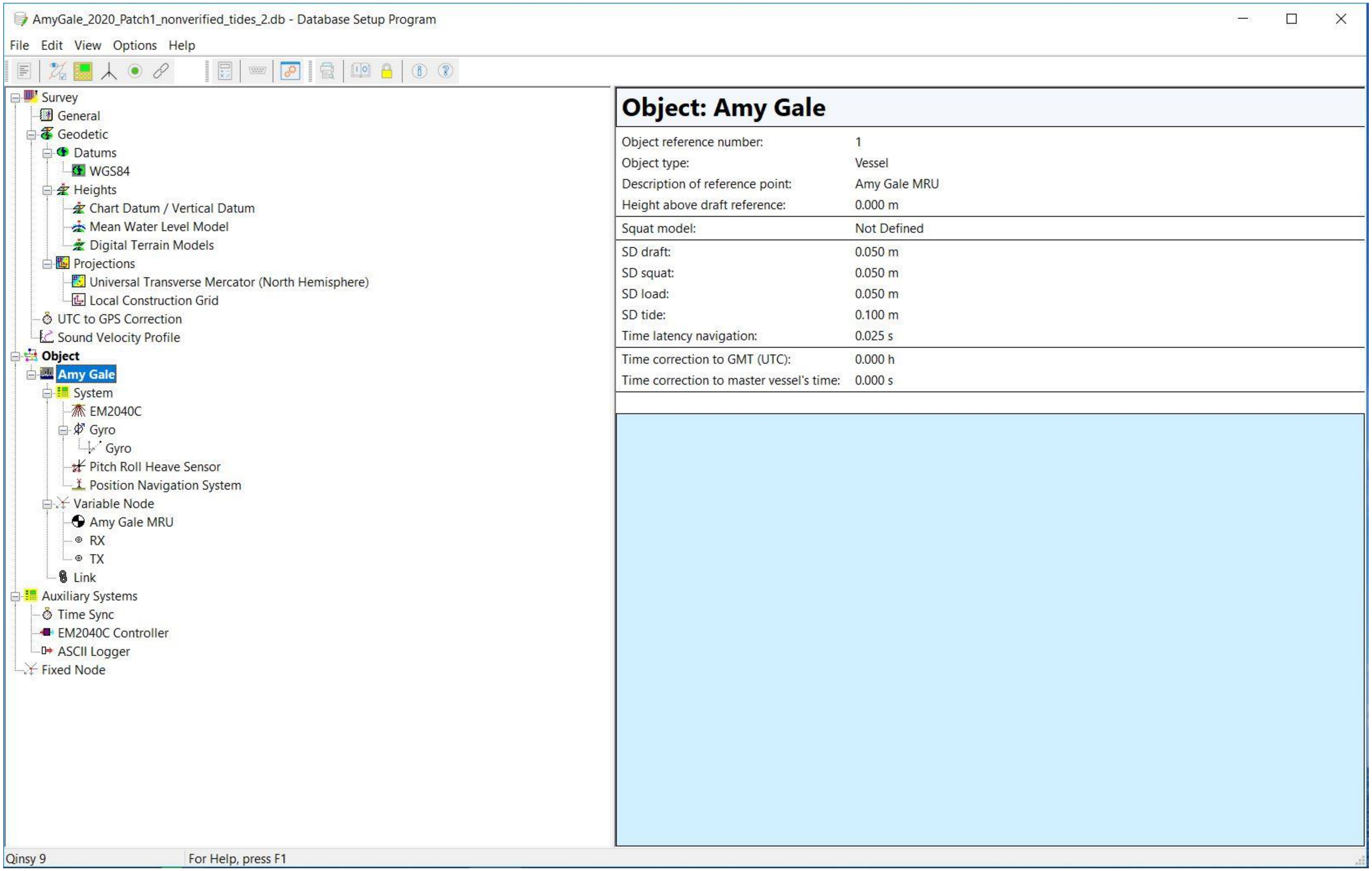

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Projections: Projections
Projection type: 0001
Projection name: Universal Transverse Mercator (North Hemisphere)
Conversion factor to metres: 1.000000000000000
Construction grid type: Undefined
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Projection: Universal Transverse Mercator (North Hemisphere)
Projection type: 0001
Projection name: Universal Transverse Mercator (North Hemisphere)
Conversion factor to metres: 1.000000000000000
UTM zone number: 19
UTM central meridian: 69;00;00.00000 W
Latitude of grid origin: 0;00;00.00000 N
Longitude of grid origin: 69;00;00.00000 W
Grid Easting at grid origin: 500000.000 m
Grid Northing at grid origin: 0.000 m
Scale factor at longitude of origin: 0.999600000000
Qinsy 9
For Help, press F1

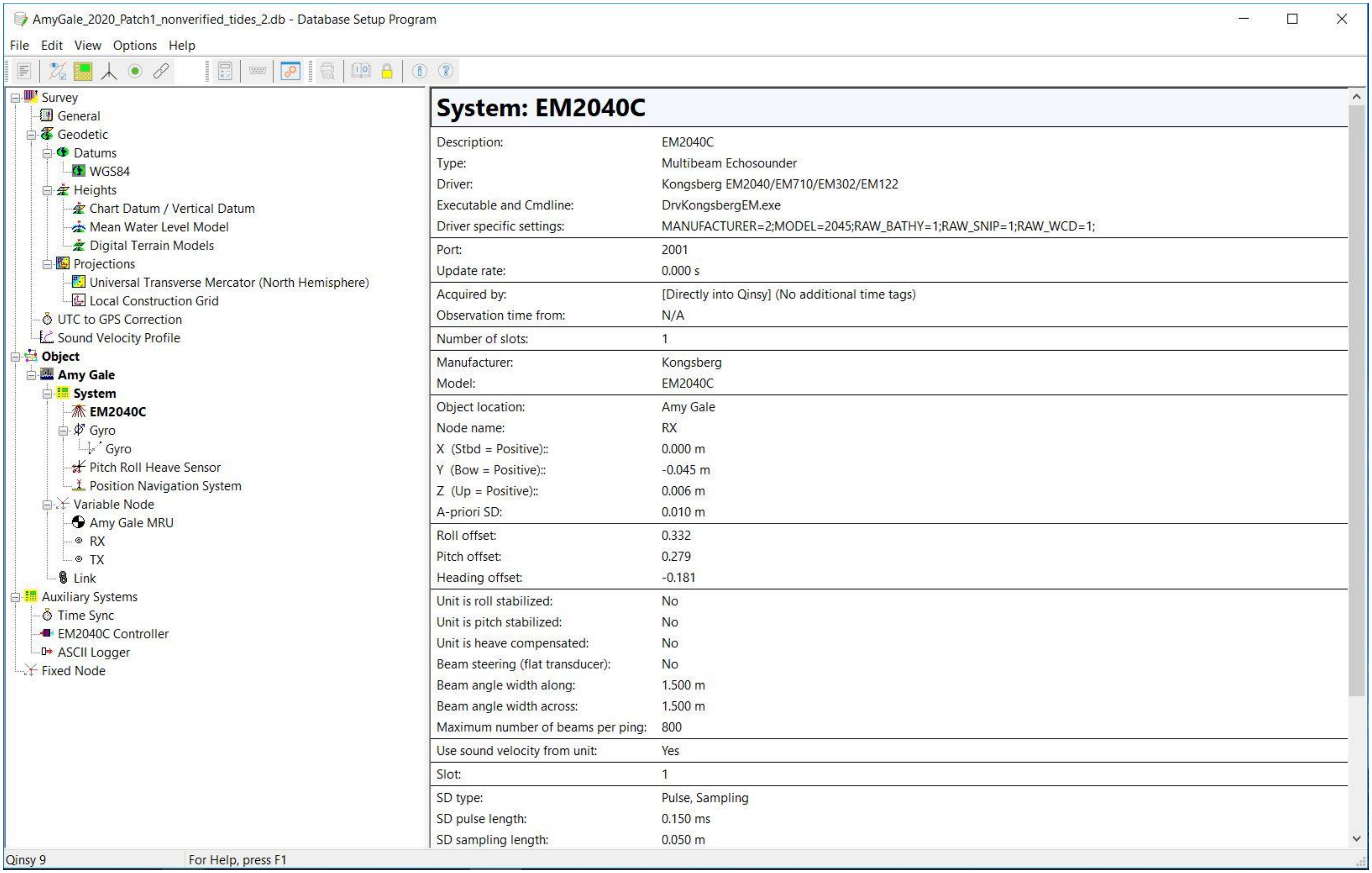

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Local Grid: Local Construction Grid
Construction grid type: Undefined
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
UTC to GPS Correction
UTC to GPS time correction: 18.000 s
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Sound Velocity Profile
Profile ID: 1383
Profile latitude: 43;31;56.02287 N
Profile longitude: 70;20;08.58092 W
Profile date: 2020-06-04
Profile time: 13:07
Depth unit: Meters
Velocity unit: Meters / Second
SD depth data: 0.100 m
SD velocity data: 0.050 m/s
Number of entries: 17
Qinsy 9
For Help, press F1



AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
Survey
General
Geodetic
Datums
WGS84
Heights
Chart Datum / Vertical Datum
Mean Water Level Model
Digital Terrain Models
Projections
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Object: Amy Gale
Object reference number: 1
Object type: Vessel
Description of reference point: Amy Gale MRU
Height above draft reference: 0.000 m
Squat model: Not Defined
SD draft: 0.050 m
SD squat: 0.050 m
SD load: 0.050 m
SD tide: 0.100 m
Time latency navigation: 0.025 s
Time correction to GMT (UTC): 0.000 h
Time correction to master vessel's time: 0.000 s
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
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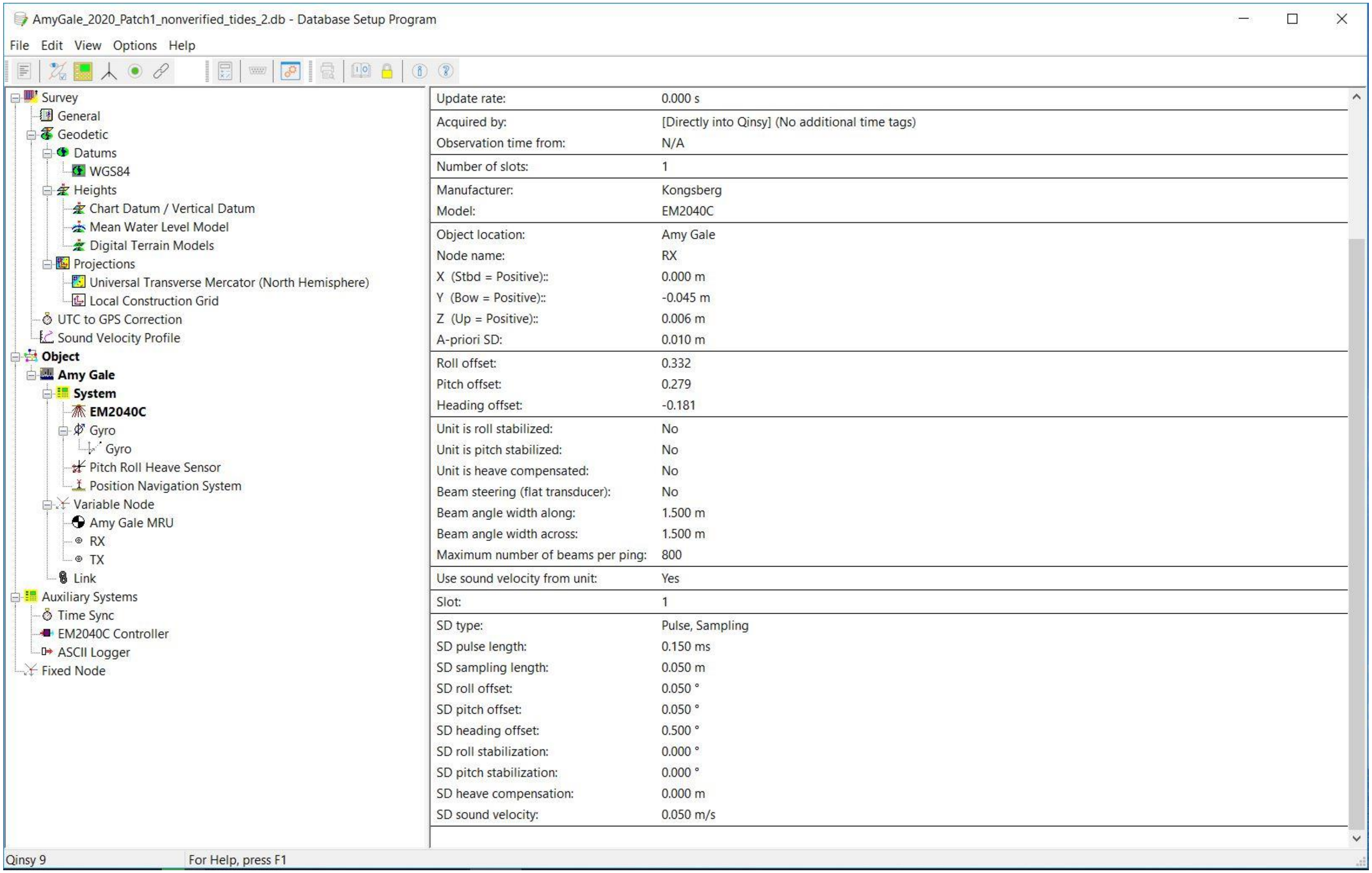
Universal Transverse Mercator (North Hemisphere)
Local Construction Grid
UTC to GPS Correction
Sound Velocity Profile
Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: EM2040C
Description: EM2040C
Type: Multibeam Echosounder
Driver: Kongsberg EM2040/EM710/EM302/EM122
Executable and Cmdline: DrvKongsbergEM.exe
Driver specific settings: MANUFACTURER=2;MODEL=2045;RAW_BATHY=1;RAW_SNIP=1;RAW_WCD=1;
Port: 2001
Update rate: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 1
Manufacturer: Kongsberg
Model: EM2040C
Object location: Amy Gale
Node name: RX
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: -0.045 m
Z (Up = Positive):: 0.006 m
A-priori SD: 0.010 m
Roll offset: 0.332
Pitch offset: 0.279
Heading offset: -0.181
Unit is roll stabilized: No
Unit is pitch stabilized: No
Unit is heave compensated: No
Beam steering (flat transducer): No
Beam angle width along: 1.500 m
Beam angle width across: 1.500 m
Maximum number of beams per ping: 800
Use sound velocity from unit: Yes
Slot: 1
SD type: Pulse, Sampling
SD pulse length: 0.150 ms
SD sampling length: 0.050 m
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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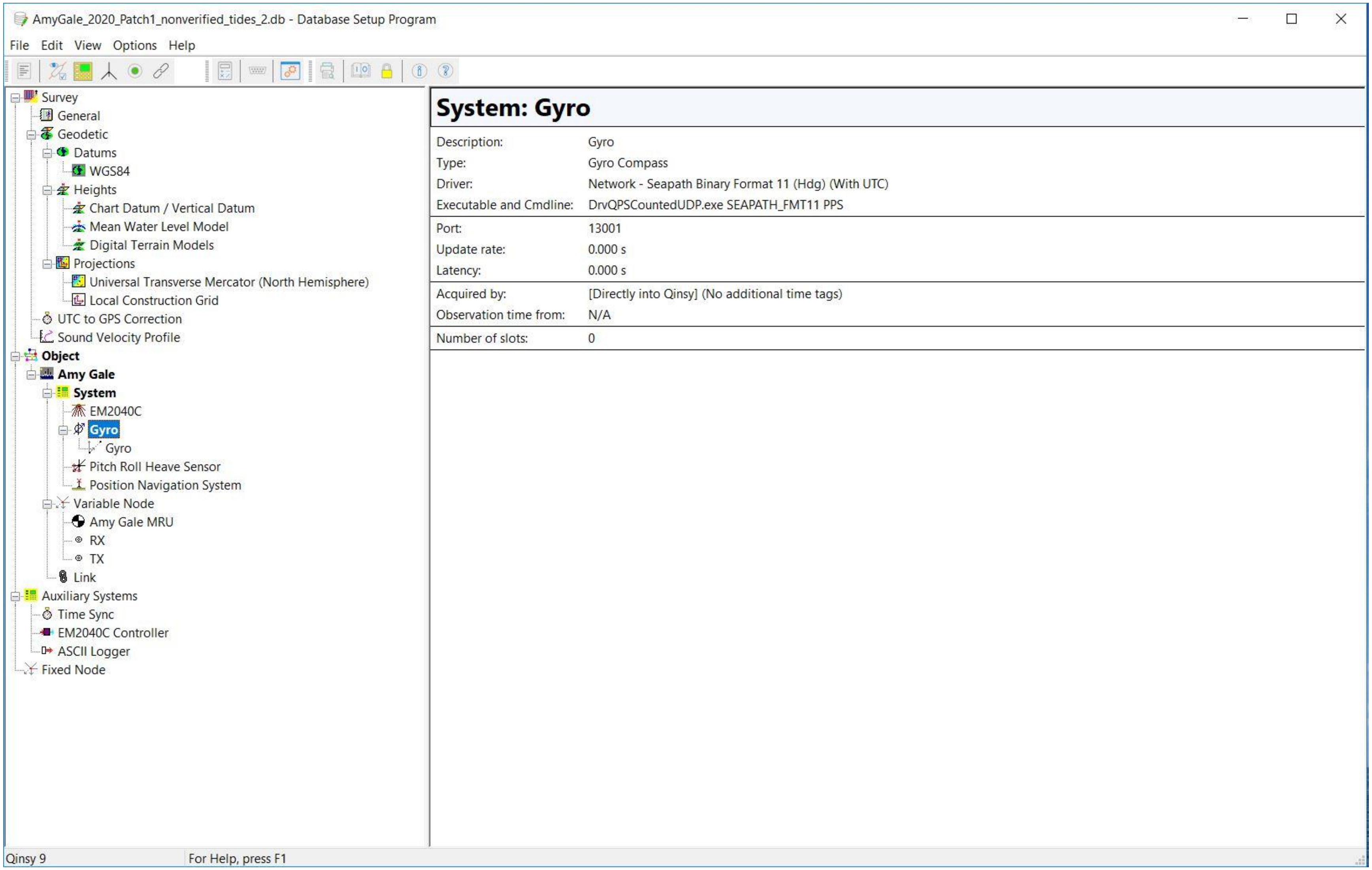
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Update rate: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 1
Manufacturer: Kongsberg
Model: EM2040C
Object location: Amy Gale
Node name: RX
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: -0.045 m
Z (Up = Positive):: 0.006 m
A-priori SD: 0.010 m
Roll offset: 0.332
Pitch offset: 0.279
Heading offset: -0.181
Unit is roll stabilized: No
Unit is pitch stabilized: No
Unit is heave compensated: No
Beam steering (flat transducer): No
Beam angle width along: 1.500 m
Beam angle width across: 1.500 m
Maximum number of beams per ping: 800
Use sound velocity from unit: Yes
Slot: 1
SD type: Pulse, Sampling
SD pulse length: 0.150 ms
SD sampling length: 0.050 m
SD roll offset: 0.050 °
SD pitch offset: 0.050 °
SD heading offset: 0.500 °
SD roll stabilization: 0.000 °
SD pitch stabilization: 0.000 °
SD heave compensation: 0.000 m
SD sound velocity: 0.050 m/s
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
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Gyro
Gyro
Pitch Roll Heave Sensor
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Variable Node
Amy Gale MRU
RX
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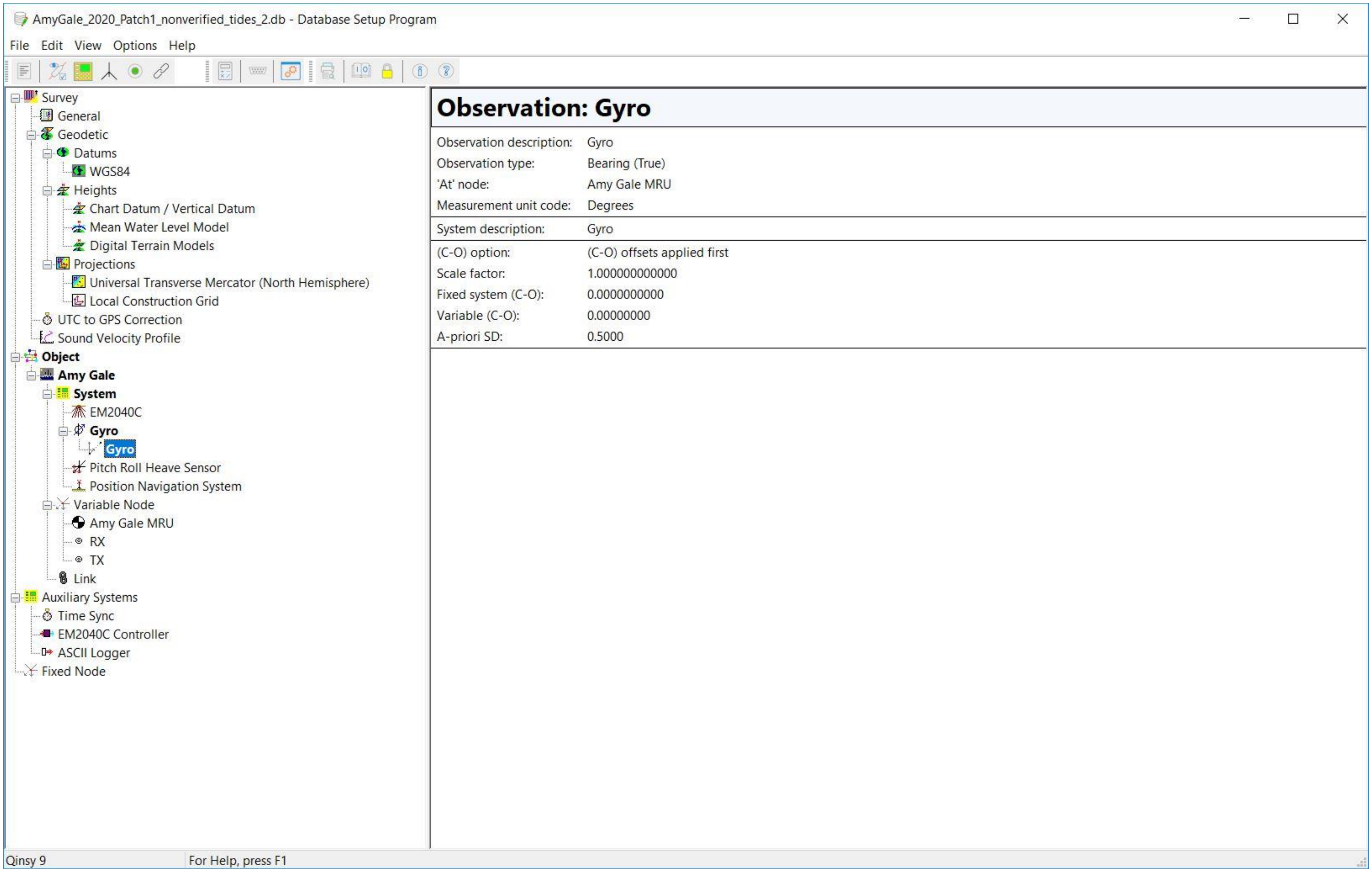
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: Gyro
Description: Gyro
Type: Gyro Compass
Driver: Network - Seapath Binary Format 11 (Hdg) (With UTC)
Executable and Cmdline: DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS
Port: 13001
Update rate: 0.000 s
Latency: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Gyro
Gyro
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Variable Node
Amy Gale MRU
RX
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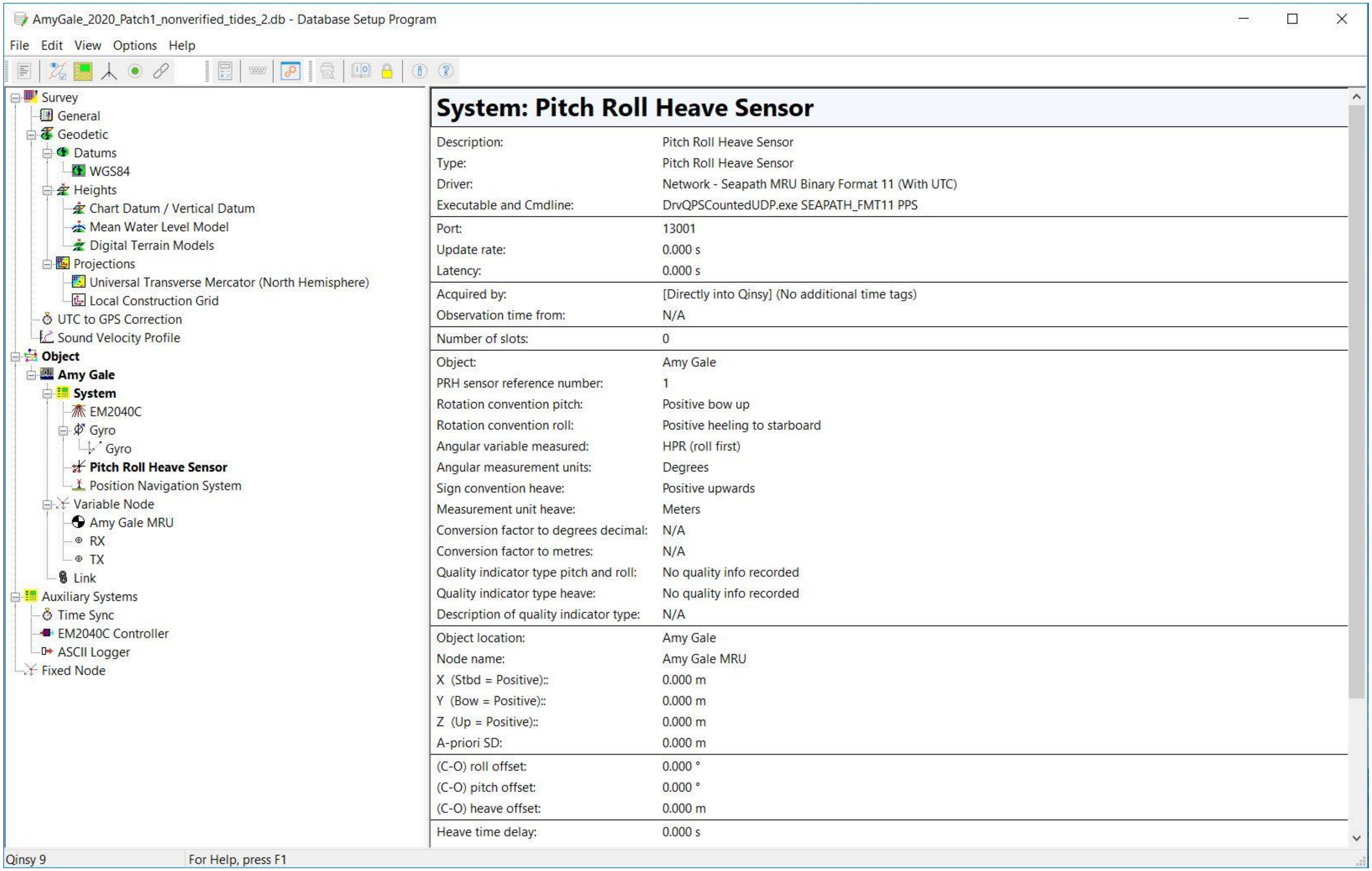
EM2040C Controller
ASCII Logger
Fixed Node
Observation: Gyro
Observation description: Gyro
Observation type: Bearing (True)
'At' node: Amy Gale MRU
Measurement unit code: Degrees
System description: Gyro
(C-O) option: (C-O) offsets applied first
Scale factor: 1.000000000000
Fixed system (C-O): 0.0000000000
Variable (C-O): 0.00000000
A-priori SD: 0.5000
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
File Edit View Options Help
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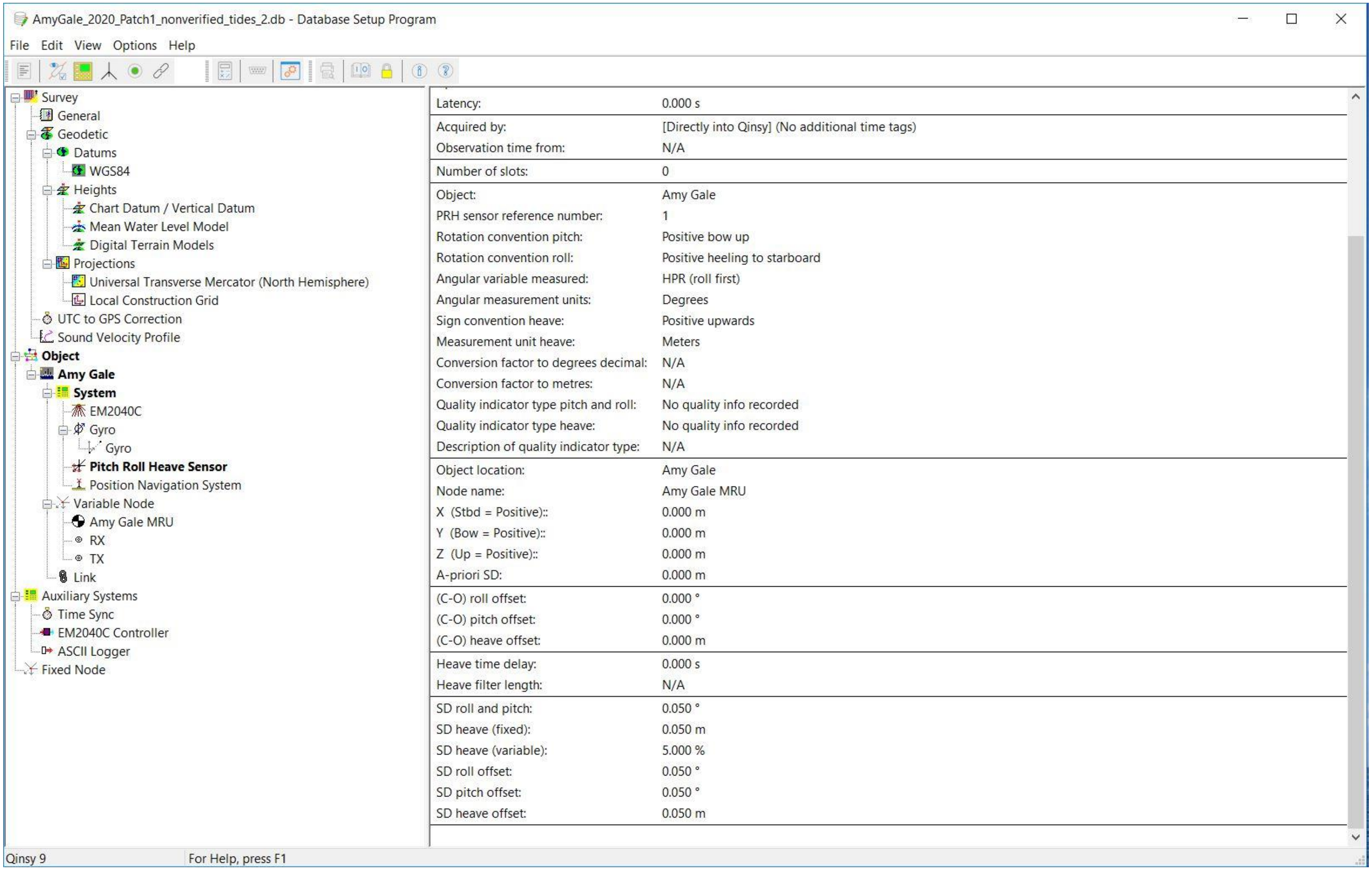
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: Pitch Roll Heave Sensor
Description: Pitch Roll Heave Sensor
Type: Pitch Roll Heave Sensor
Driver: Network - Seapath MRU Binary Format 11 (With UTC)
Executable and Cmdline: DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS
Port: 13001
Update rate: 0.000 s
Latency: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Object: Amy Gale
PRH sensor reference number: 1
Rotation convention pitch: Positive bow up
Rotation convention roll: Positive heeling to starboard
Angular variable measured: HPR (roll first)
Angular measurement units: Degrees
Sign convention heave: Positive upwards
Measurement unit heave: Meters
Conversion factor to degrees decimal: N/A
Conversion factor to metres: N/A
Quality indicator type pitch and roll: No quality info recorded
Quality indicator type heave: No quality info recorded
Description of quality indicator type: N/A
Object location: Amy Gale
Node name: Amy Gale MRU
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: 0.000 m
Z (Up = Positive):: 0.000 m
A-priori SD: 0.000 m
(C-O) roll offset: 0.000 °
(C-O) pitch offset: 0.000 °
(C-O) heave offset: 0.000 m
Heave time delay: 0.000 s
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Object
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Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
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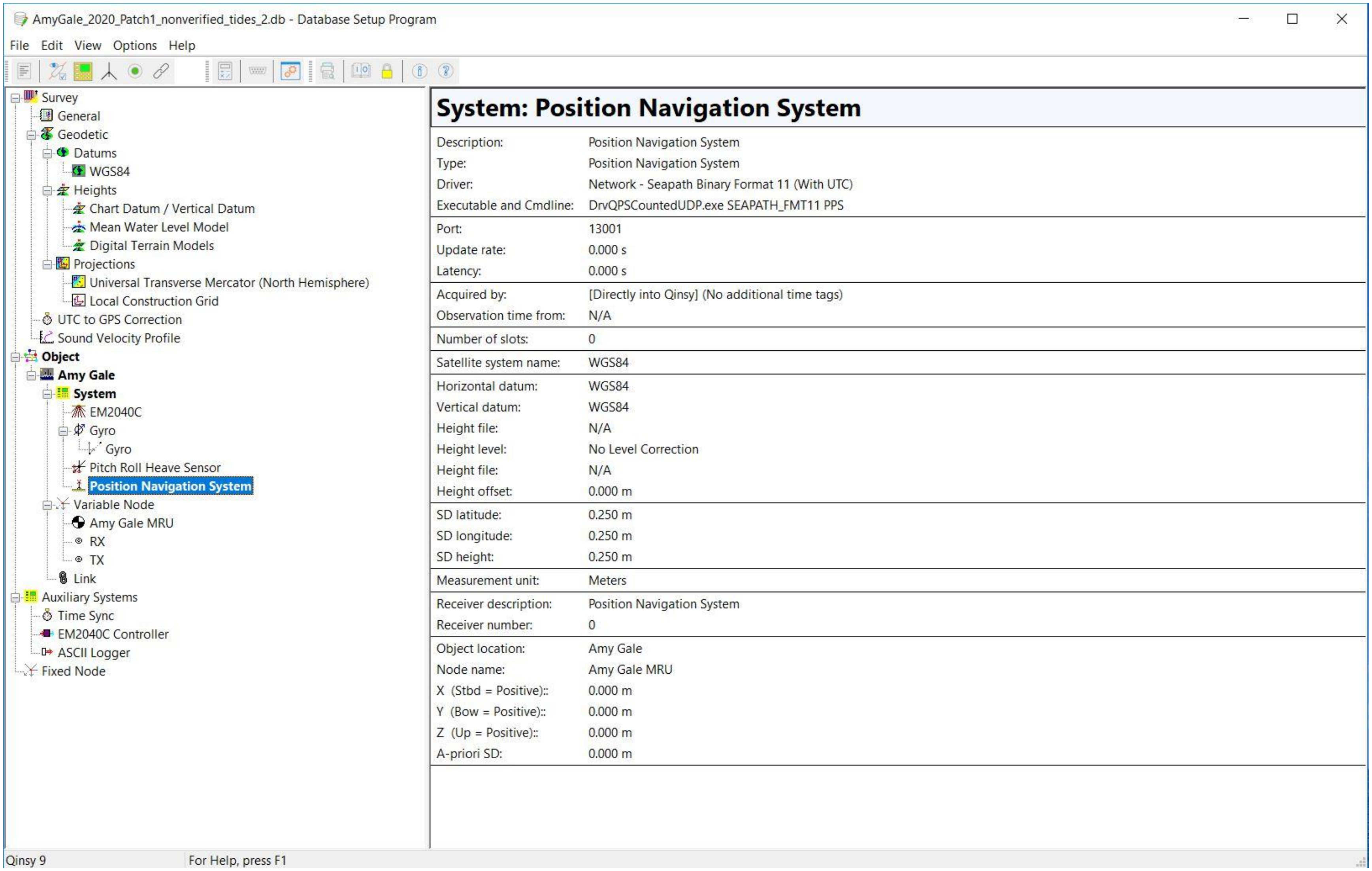
Fixed Node
Latency: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Object: Amy Gale
PRH sensor reference number: 1
Rotation convention pitch: Positive bow up
Rotation convention roll: Positive heeling to starboard
Angular variable measured: HPR (roll first)
Angular measurement units: Degrees
Sign convention heave: Positive upwards
Measurement unit heave: Meters
Conversion factor to degrees decimal: N/A
Conversion factor to metres: N/A
Quality indicator type pitch and roll: No quality info recorded
Quality indicator type heave: No quality info recorded
Description of quality indicator type: N/A
Object location: Amy Gale
Node name: Amy Gale MRU
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: 0.000 m
Z (Up = Positive):: 0.000 m
A-priori SD: 0.000 m
(C-O) roll offset: 0.000 °
(C-O) pitch offset: 0.000 °
(C-O) heave offset: 0.000 m
Heave time delay: 0.000 s
Heave filter length: N/A
SD roll and pitch: 0.050 °
SD heave (fixed): 0.050 m
SD heave (variable): 5.000 %
SD roll offset: 0.050 °
SD pitch offset: 0.050 °
SD heave offset: 0.050 m
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Object
Amy Gale
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
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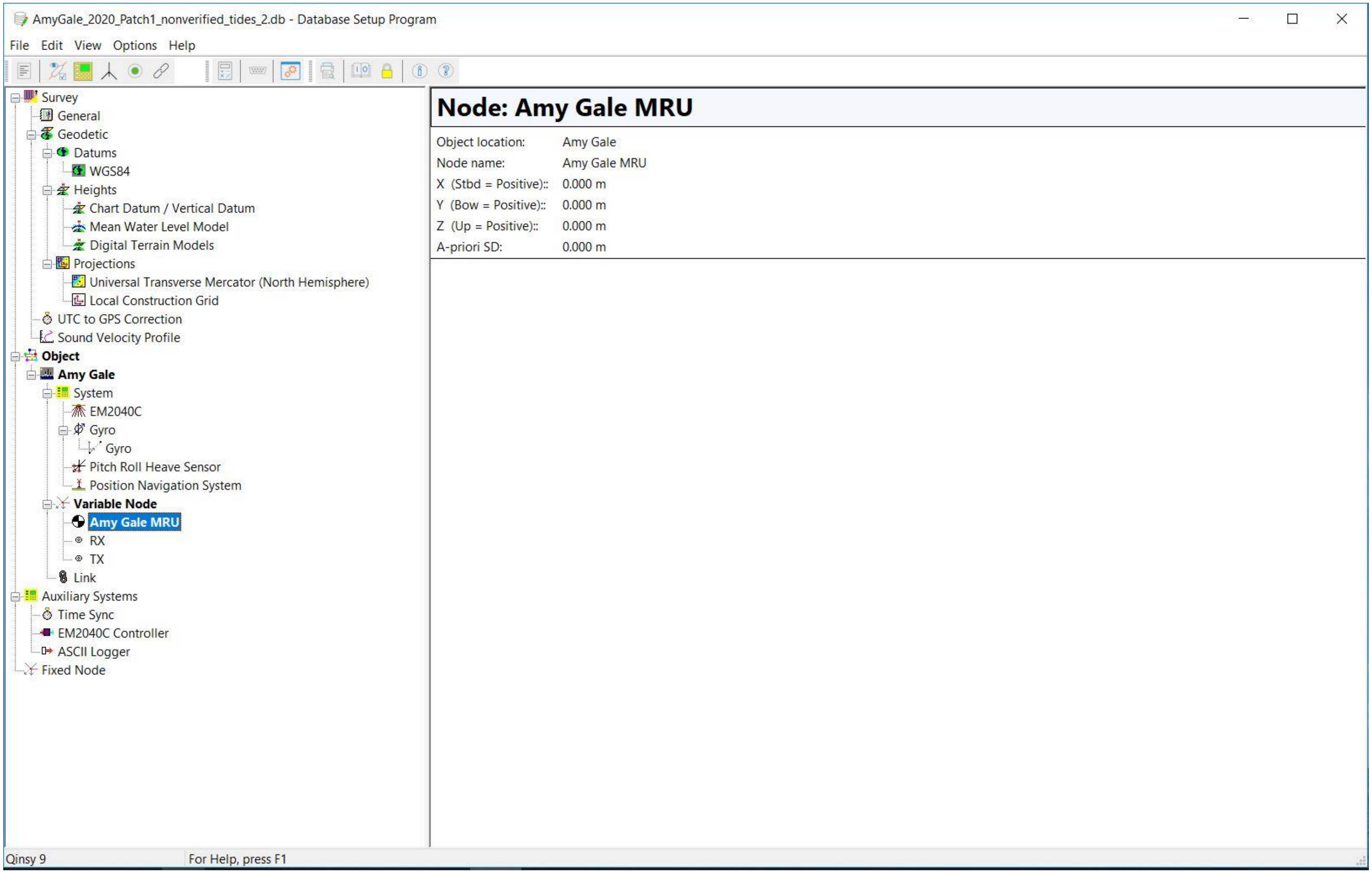
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: Position Navigation System
Description: Position Navigation System
Type: Position Navigation System
Driver: Network - Seapath Binary Format 11 (With UTC)
Executable and Cmdline: DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS
Port: 13001
Update rate: 0.000 s
Latency: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Satellite system name: WGS84
Horizontal datum: WGS84
Vertical datum: WGS84
Height file: N/A
Height level: No Level Correction
Height file: N/A
Height offset: 0.000 m
SD latitude: 0.250 m
SD longitude: 0.250 m
SD height: 0.250 m
Measurement unit: Meters
Receiver description: Position Navigation System
Receiver number: 0
Object location: Amy Gale
Node name: Amy Gale MRU
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: 0.000 m
Z (Up = Positive):: 0.000 m
A-priori SD: 0.000 m
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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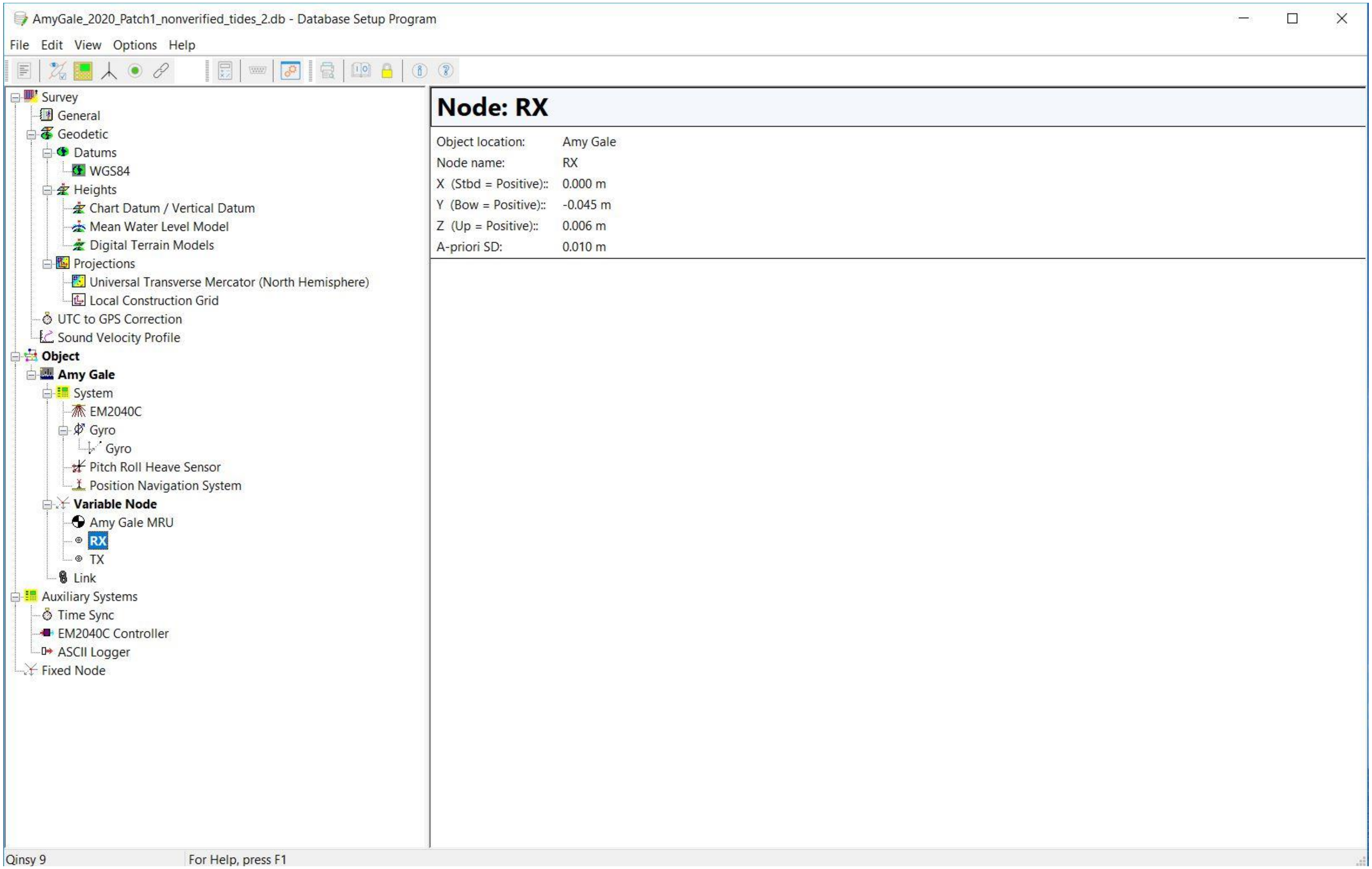
System
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Node: Amy Gale MRU
Object location: Amy Gale
Node name: Amy Gale MRU
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: 0.000 m
Z (Up = Positive):: 0.000 m
A-priori SD: 0.000 m
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Object
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Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
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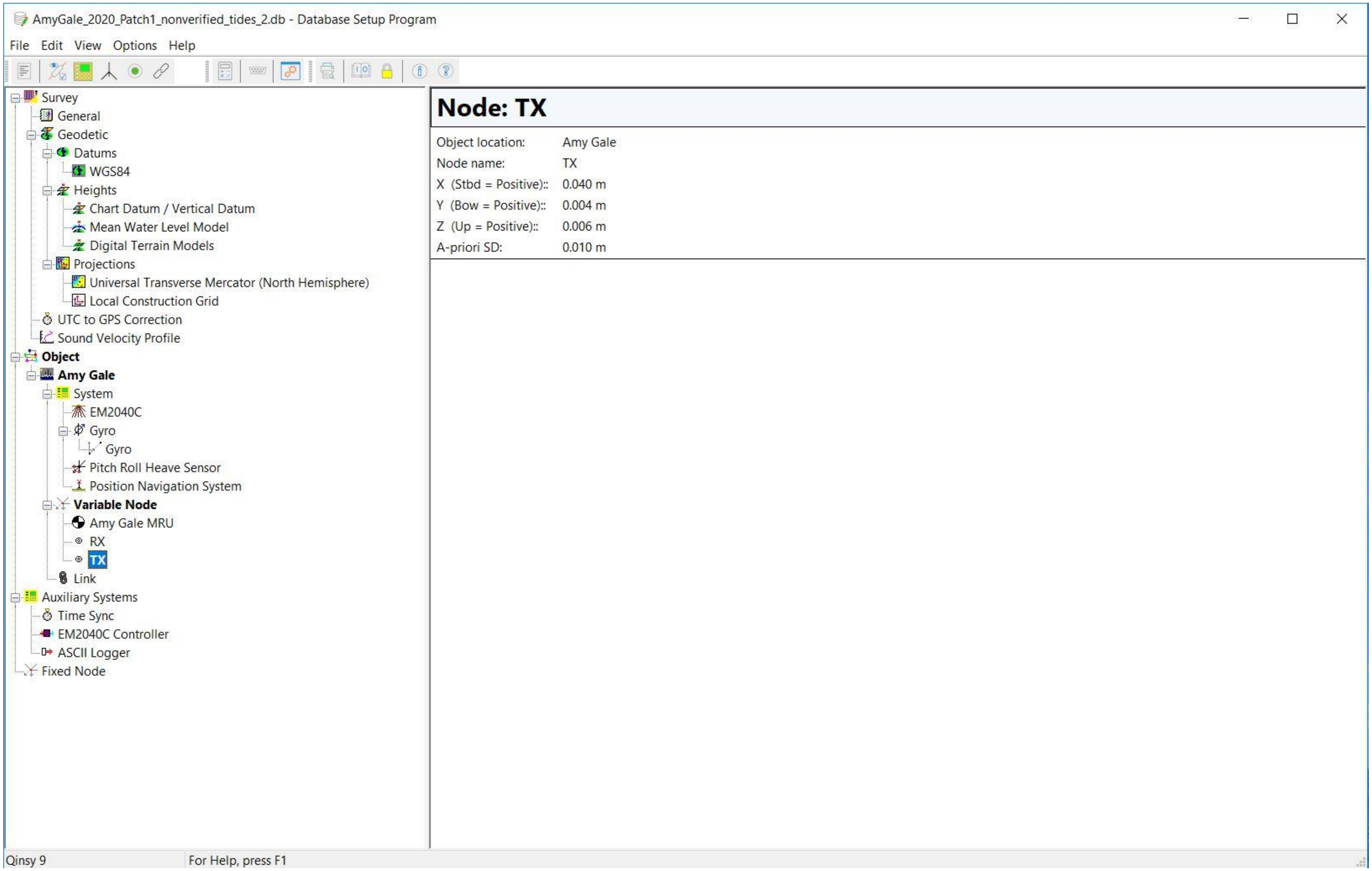
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
Node: RX
Object location: Amy Gale
Node name: RX
X (Stbd = Positive):: 0.000 m
Y (Bow = Positive):: -0.045 m
Z (Up = Positive):: 0.006 m
A-priori SD: 0.010 m
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Gyro
Pitch Roll Heave Sensor
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Amy Gale MRU
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TX
Link
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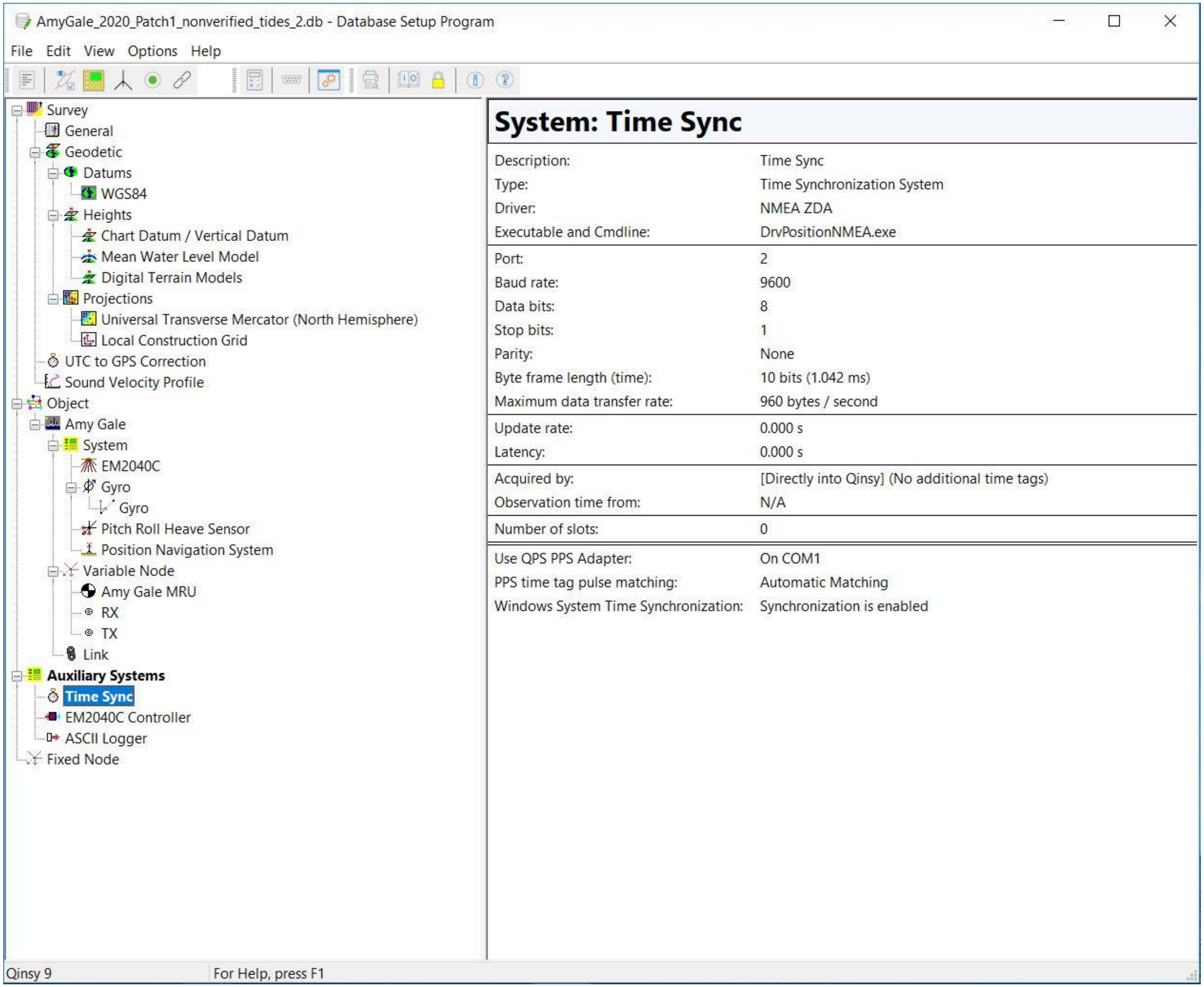
EM2040C Controller
ASCII Logger
Fixed Node
Node: TX
Object location: Amy Gale
Node name: TX
X (Stbd = Positive):: 0.040 m
Y (Bow = Positive):: 0.004 m
Z (Up = Positive):: 0.006 m
A-priori SD: 0.010 m
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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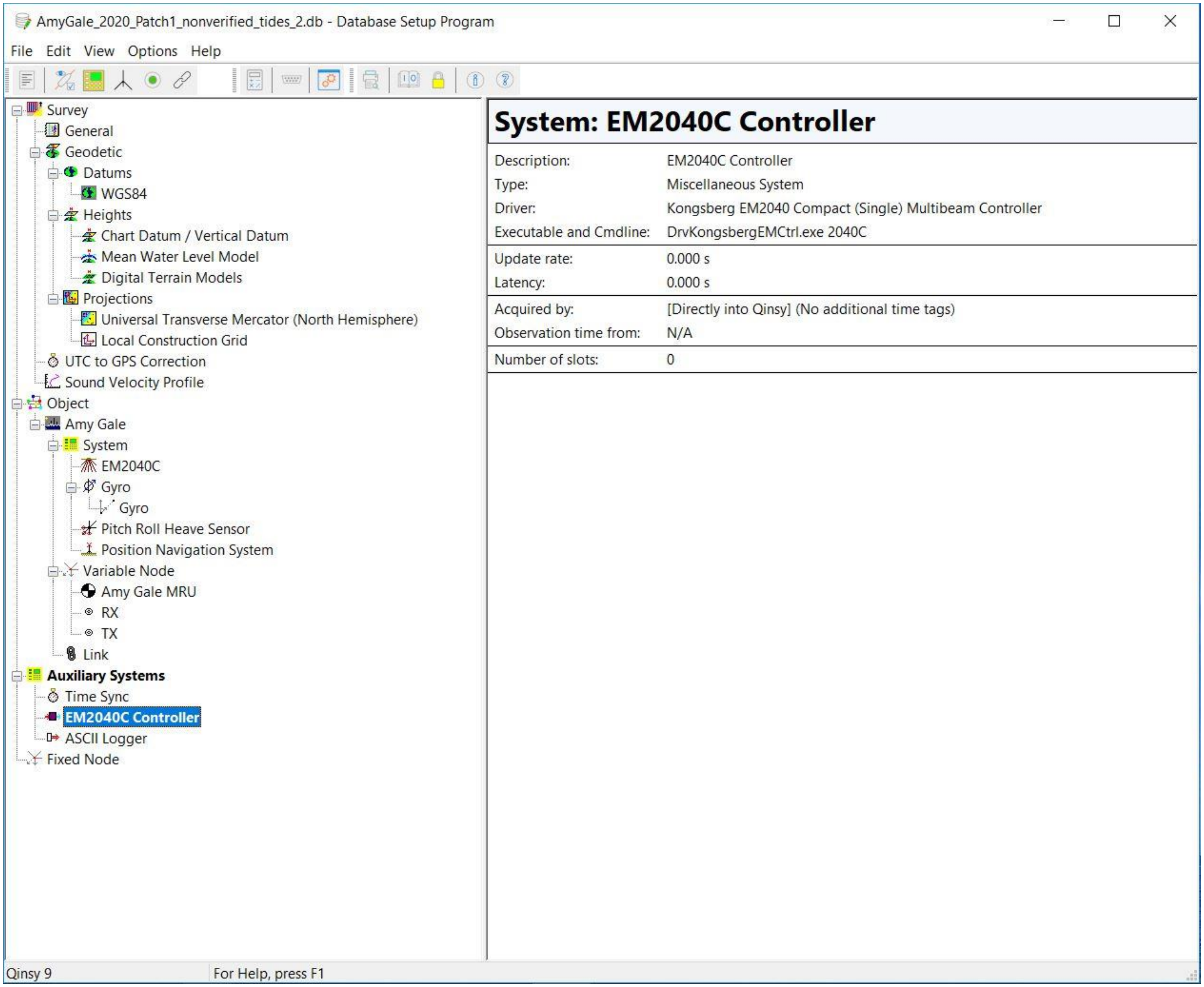
EM2040C
Gyro
Gyro
Pitch Roll Heave Sensor
Position Navigation System
Variable Node
Amy Gale MRU
RX
TX
Link
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: Time Sync
Description: Time Sync
Type: Time Synchronization System
Driver: NMEA ZDA
Executable and Cmdline: DrvPositionNMEA.exe
Port: 2
Baud rate: 9600
Data bits: 8
Stop bits: 1
Parity: None
Byte frame length (time): 10 bits (1.042 ms)
Maximum data transfer rate: 960 bytes / second
Update rate: 0.000 s
Latency: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Use QPS PPS Adapter: On COM1
PPS time tag pulse matching: Automatic Matching
Windows System Time Synchronization: Synchronization is enabled
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Gyro
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Variable Node
Amy Gale MRU
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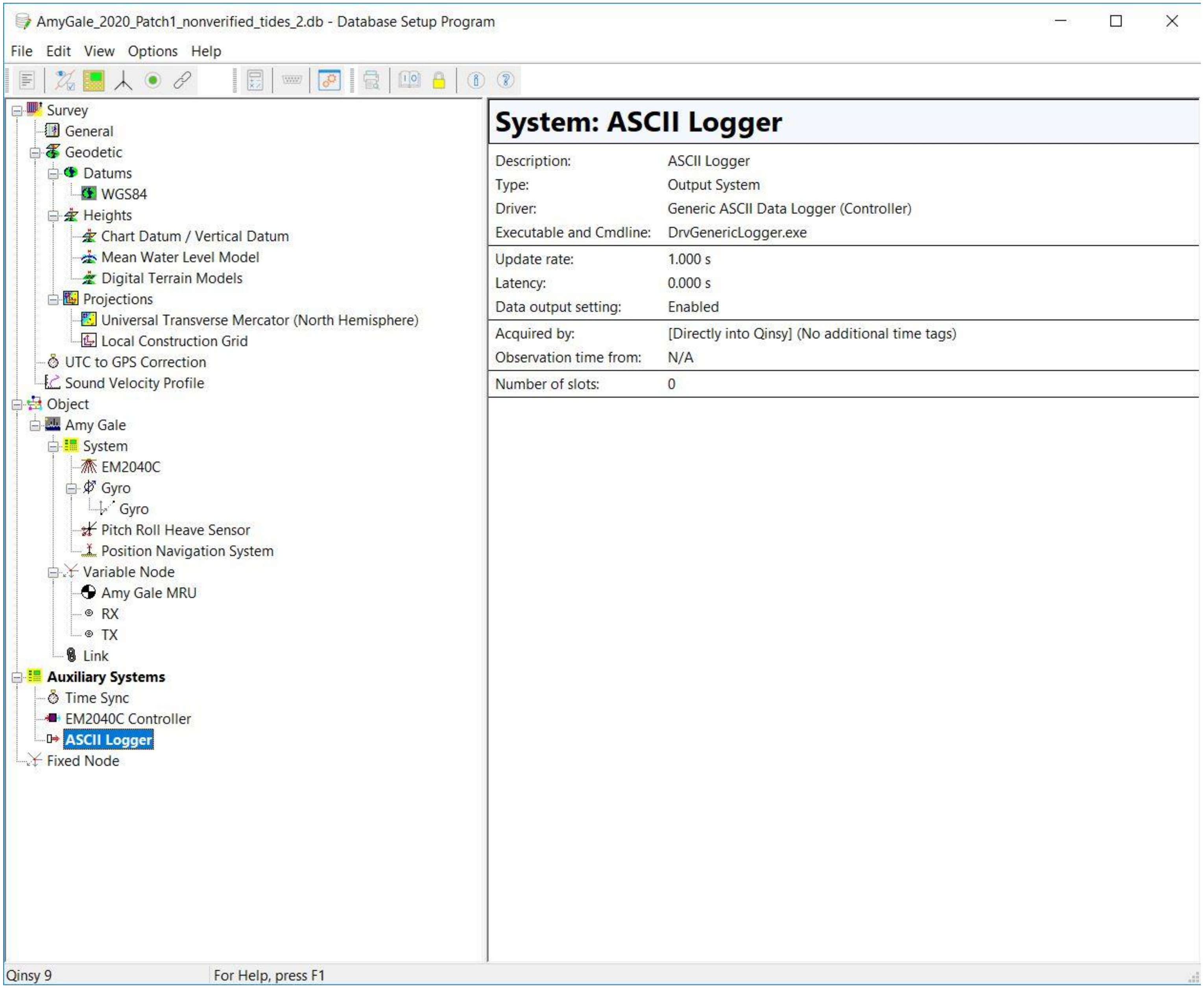
Auxiliary Systems
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: EM2040C Controller
Description: EM2040C Controller
Type: Miscellaneous System
Driver: Kongsberg EM2040 Compact (Single) Multibeam Controller
Executable and Cmdline: DrvKongsbergEMCtrl.exe 2040C
Update rate: 0.000 s
Latency: 0.000 s
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Qinsy 9
For Help, press F1


AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program
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Gyro
Pitch Roll Heave Sensor
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Variable Node
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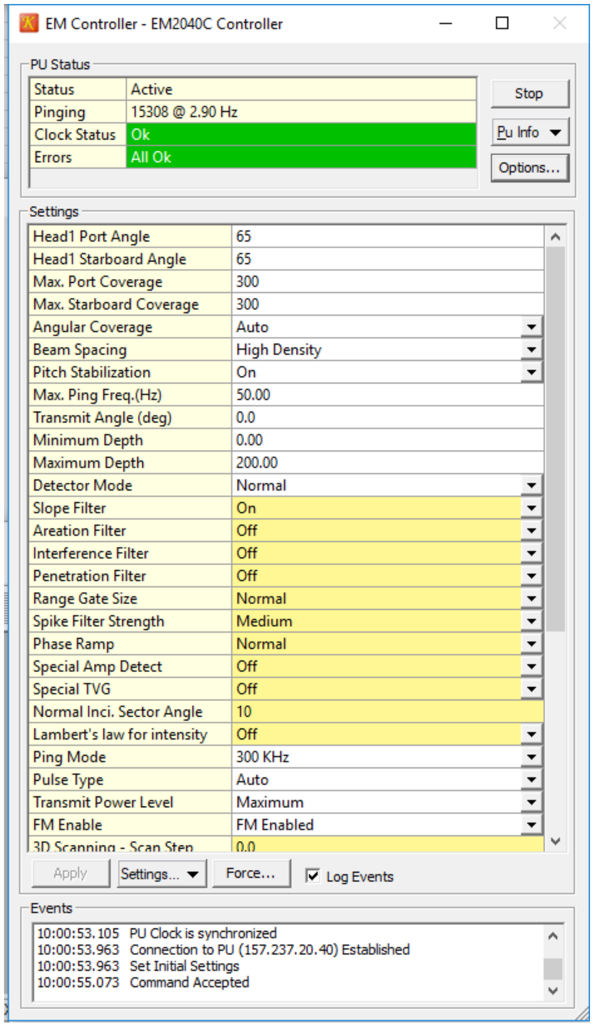
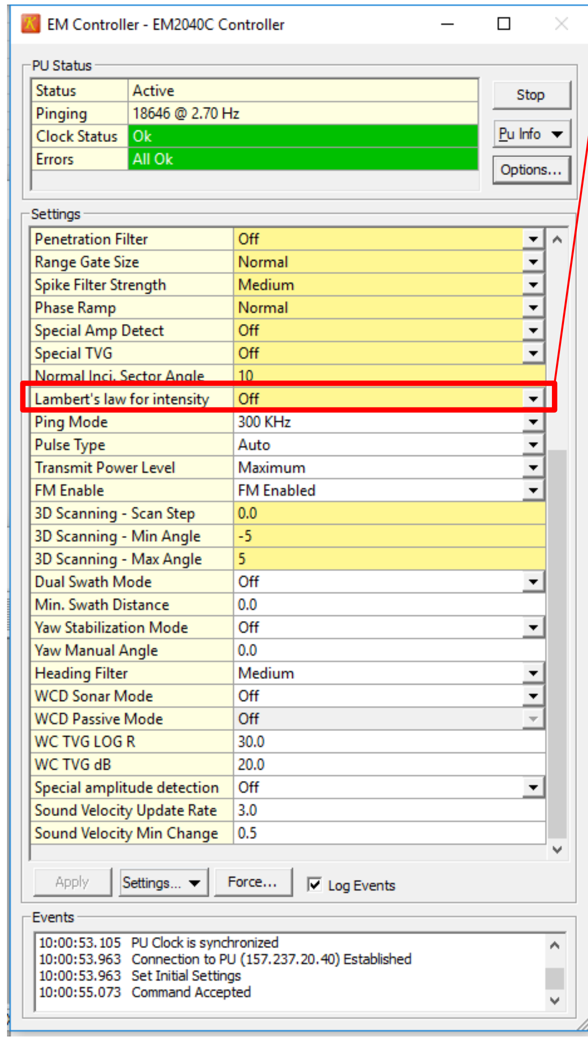
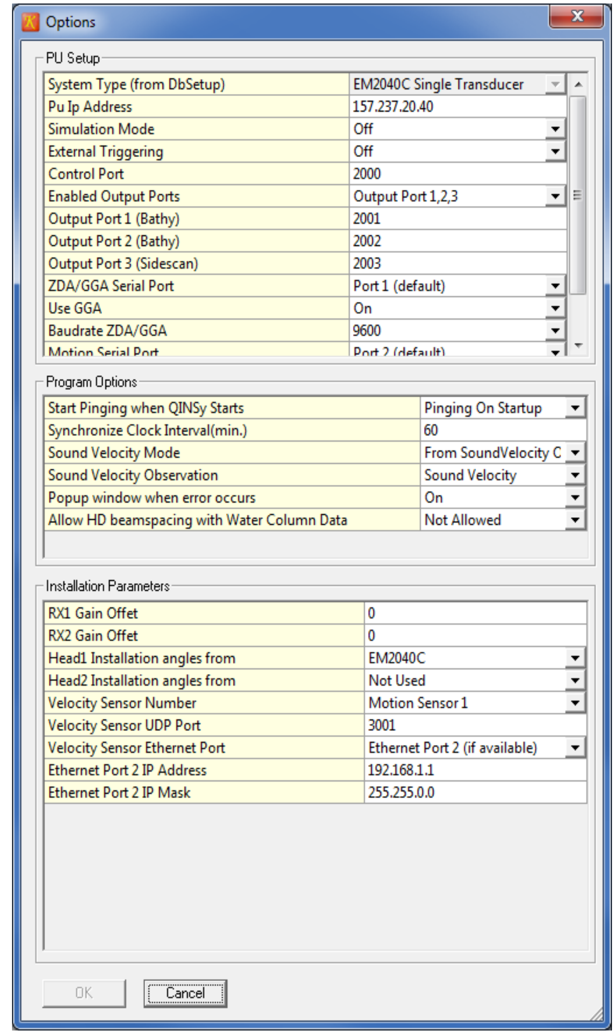
Time Sync
EM2040C Controller
ASCII Logger
Fixed Node
System: ASCII Logger
Description: ASCII Logger
Type: Output System
Driver: Generic ASCII Data Logger (Controller)
Executable and Cmdline: DrvGenericLogger.exe
Update rate: 1.000 s
Latency: 0.000 s
Data output setting: Enabled
Acquired by: [Directly into Qinsy] (No additional time tags)
Observation time from: N/A
Number of slots: 0
Qinsy 9
For Help, press F1

Appendix E – Configuration settings for Qinsy EM controller

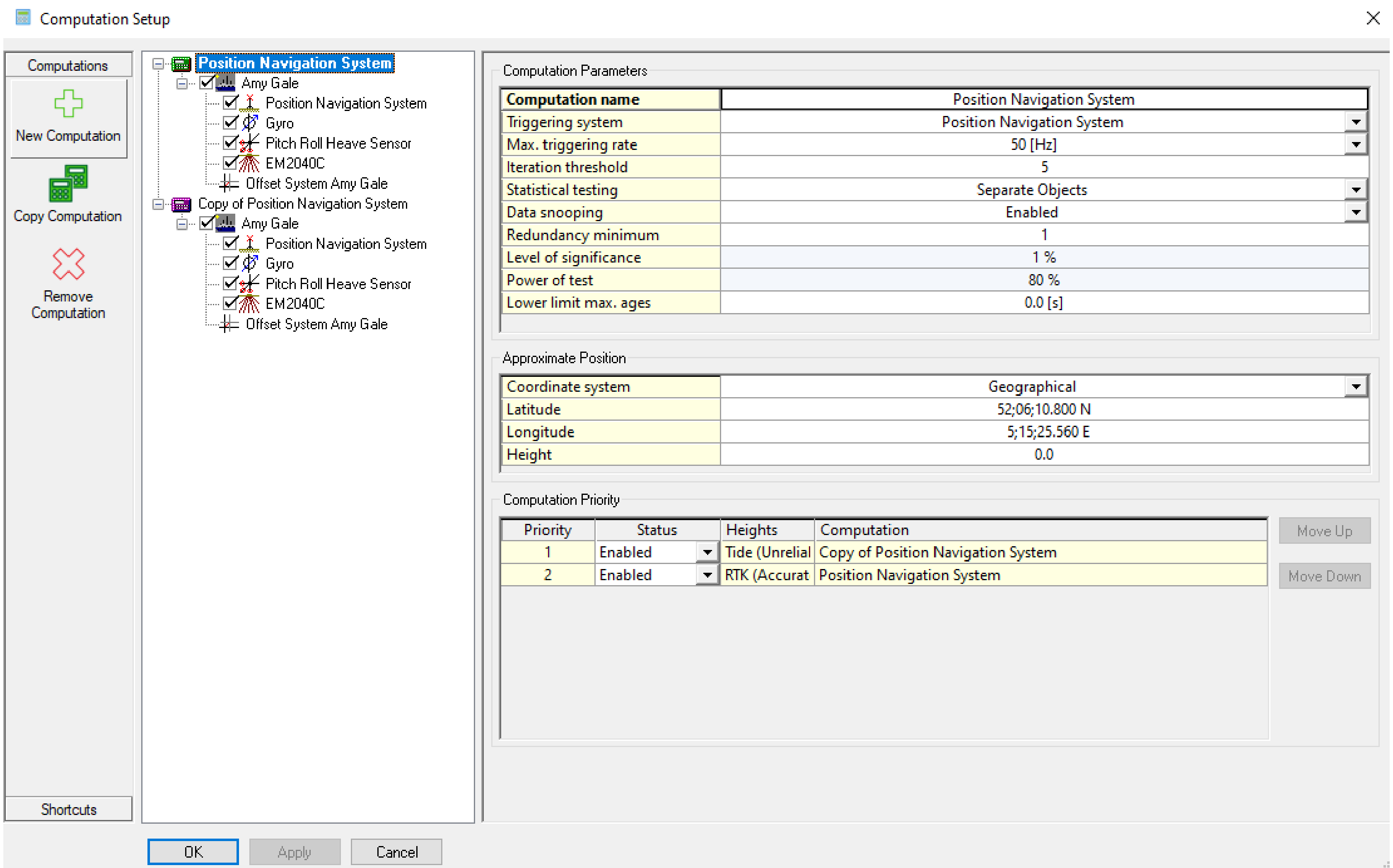
Lambert's law for intensity was turned ON starting 01/25/23. No notable disagreements were found across backscatter datasets collected before and after the change was implemented.

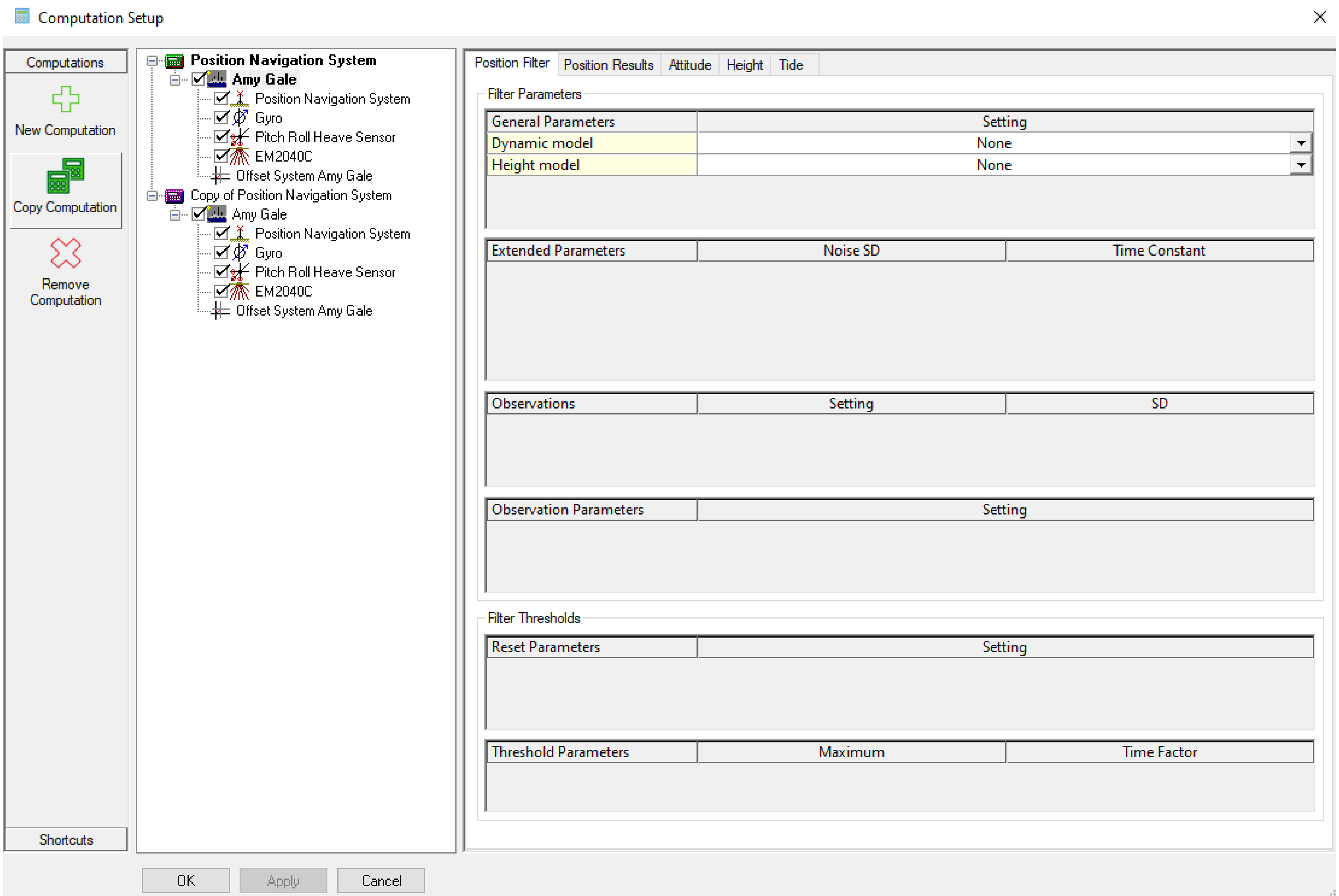


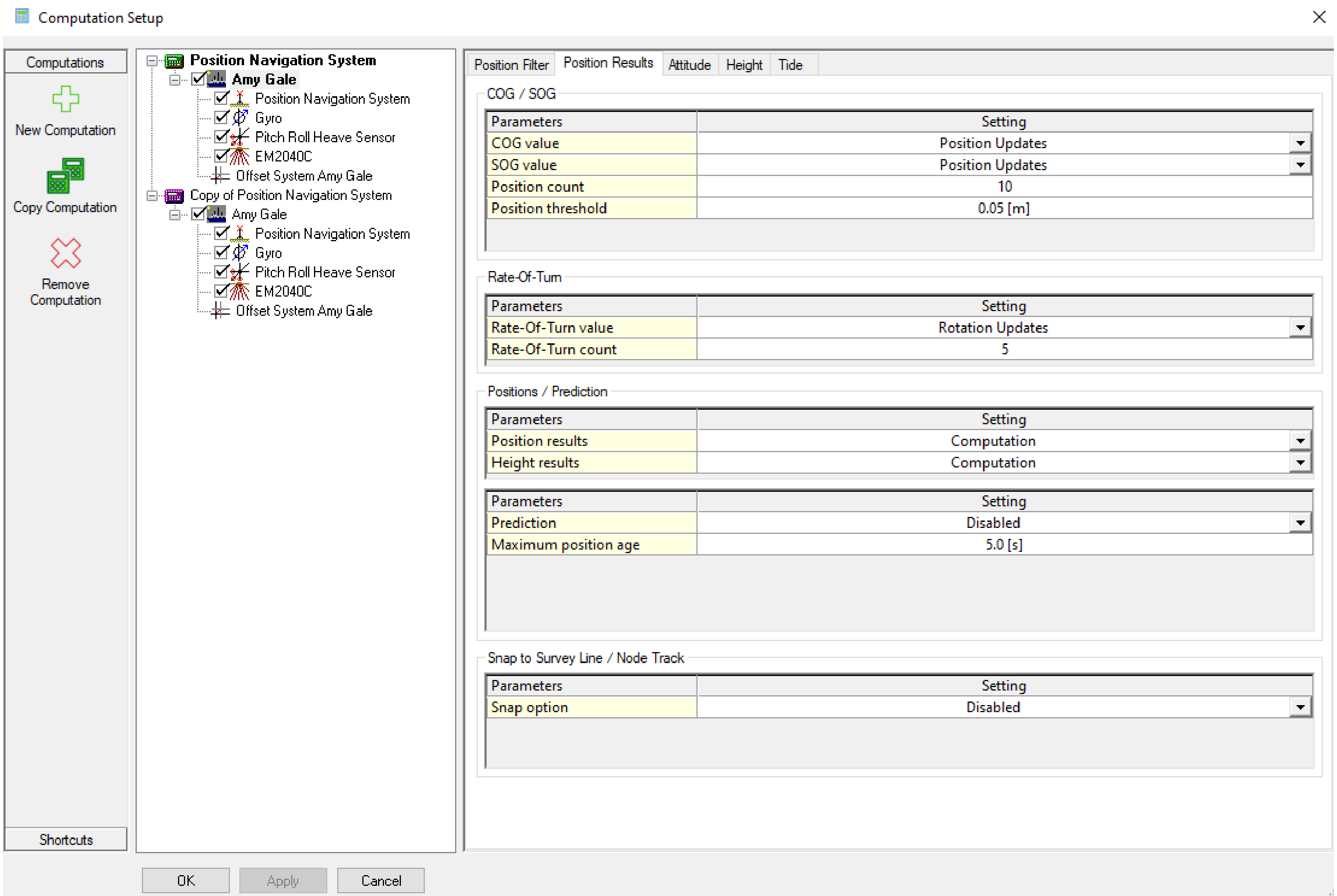


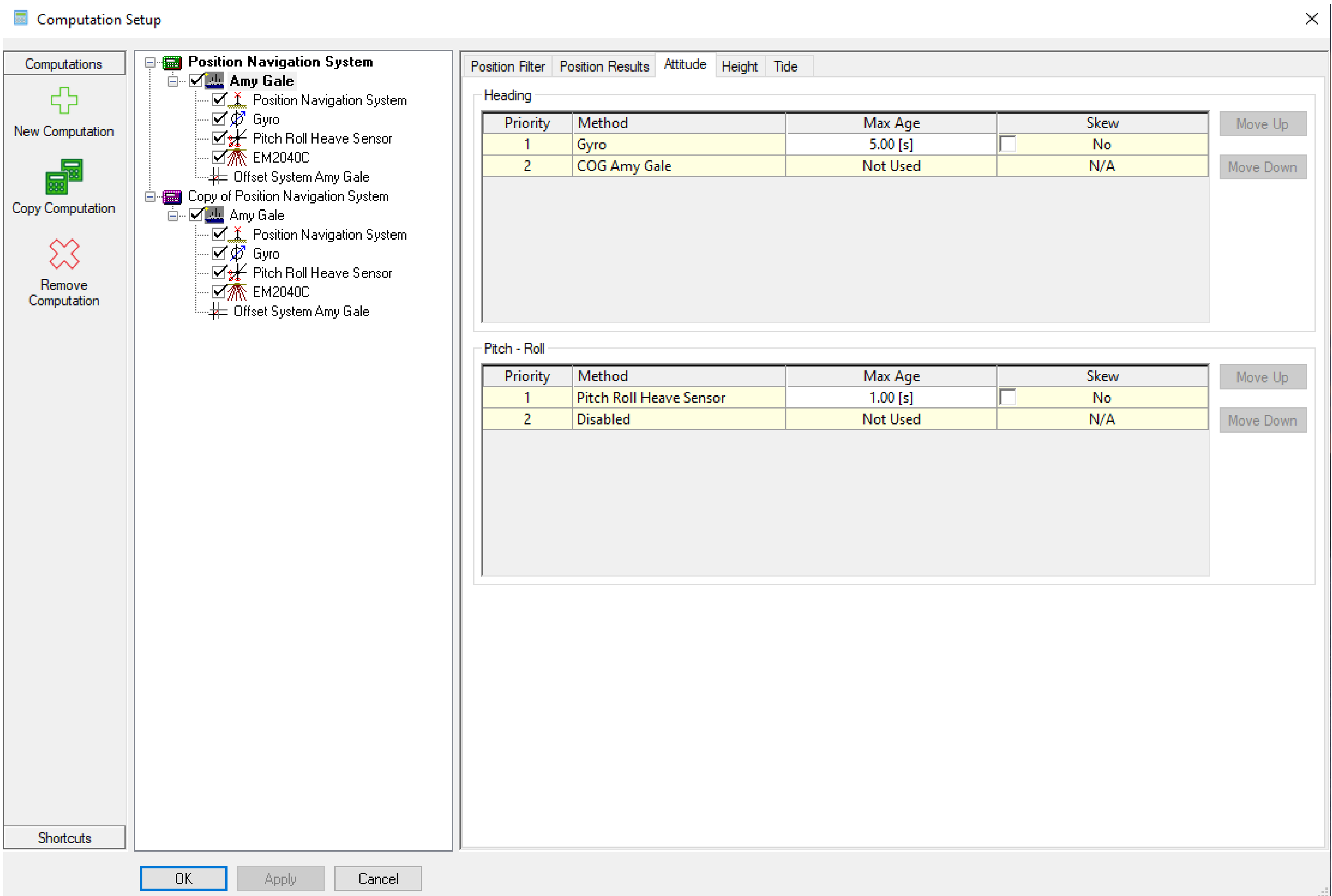


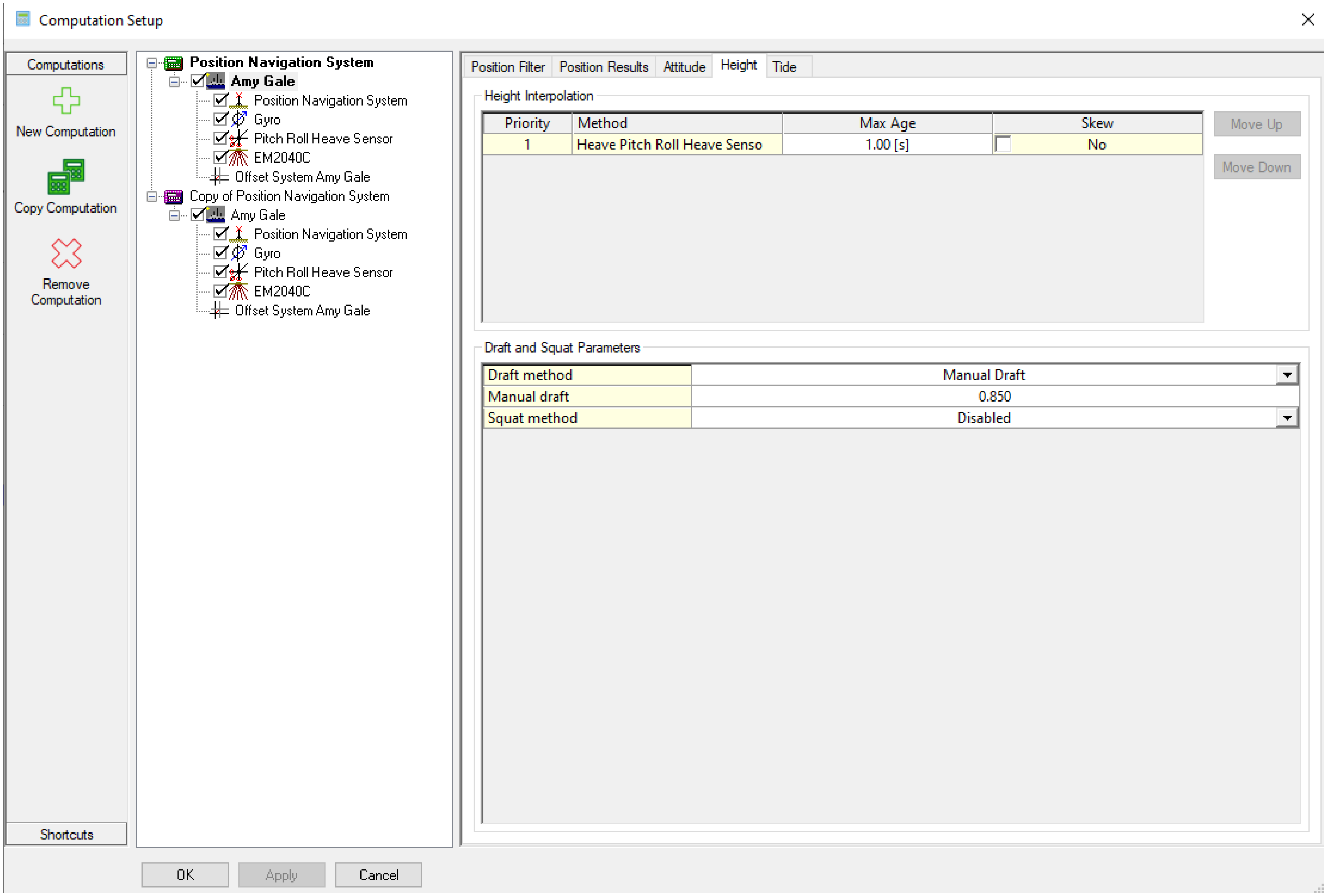
Appendix F – Computation Settings for Qinsy Online

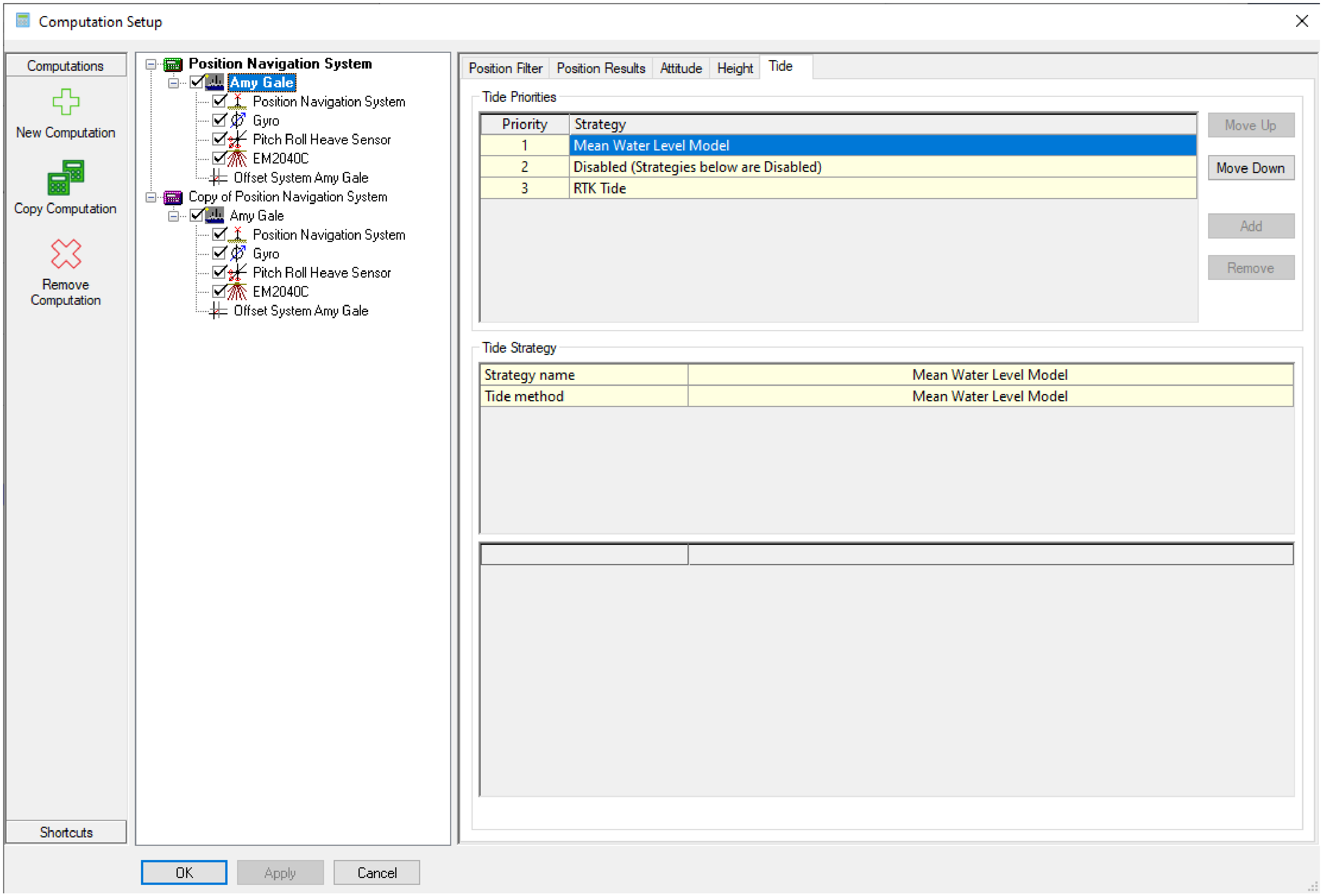


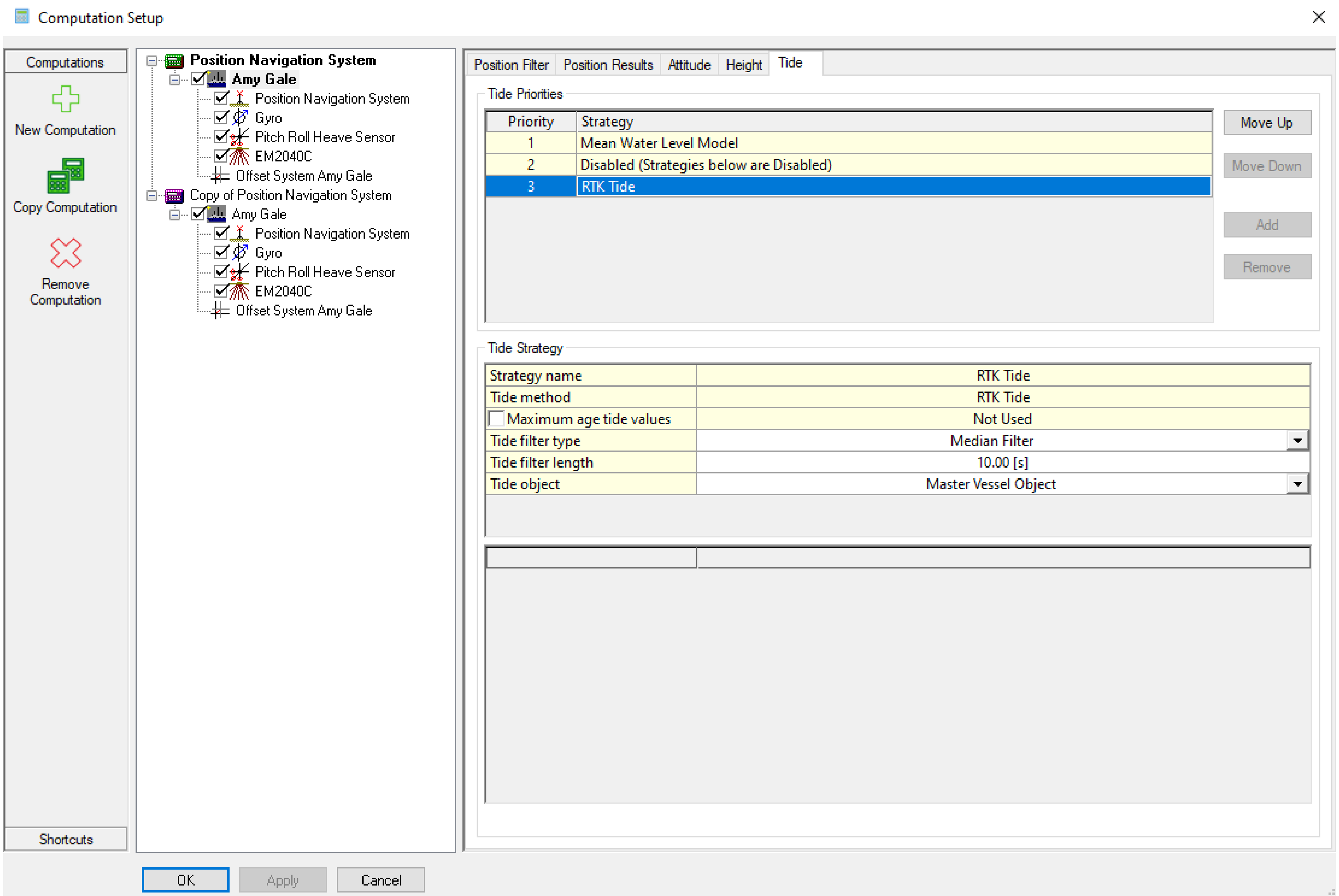

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Filter Parameters
General Parameters
Setting
Dynamic model
None
Height model
None
Extended Parameters
Noise SD
Time Constant
Observations
Setting
SD
Observation Parameters
Setting
Filter Thresholds
Reset Parameters
Setting
Threshold Parameters
Maximum
Time Factor
OK
Apply
Cancel

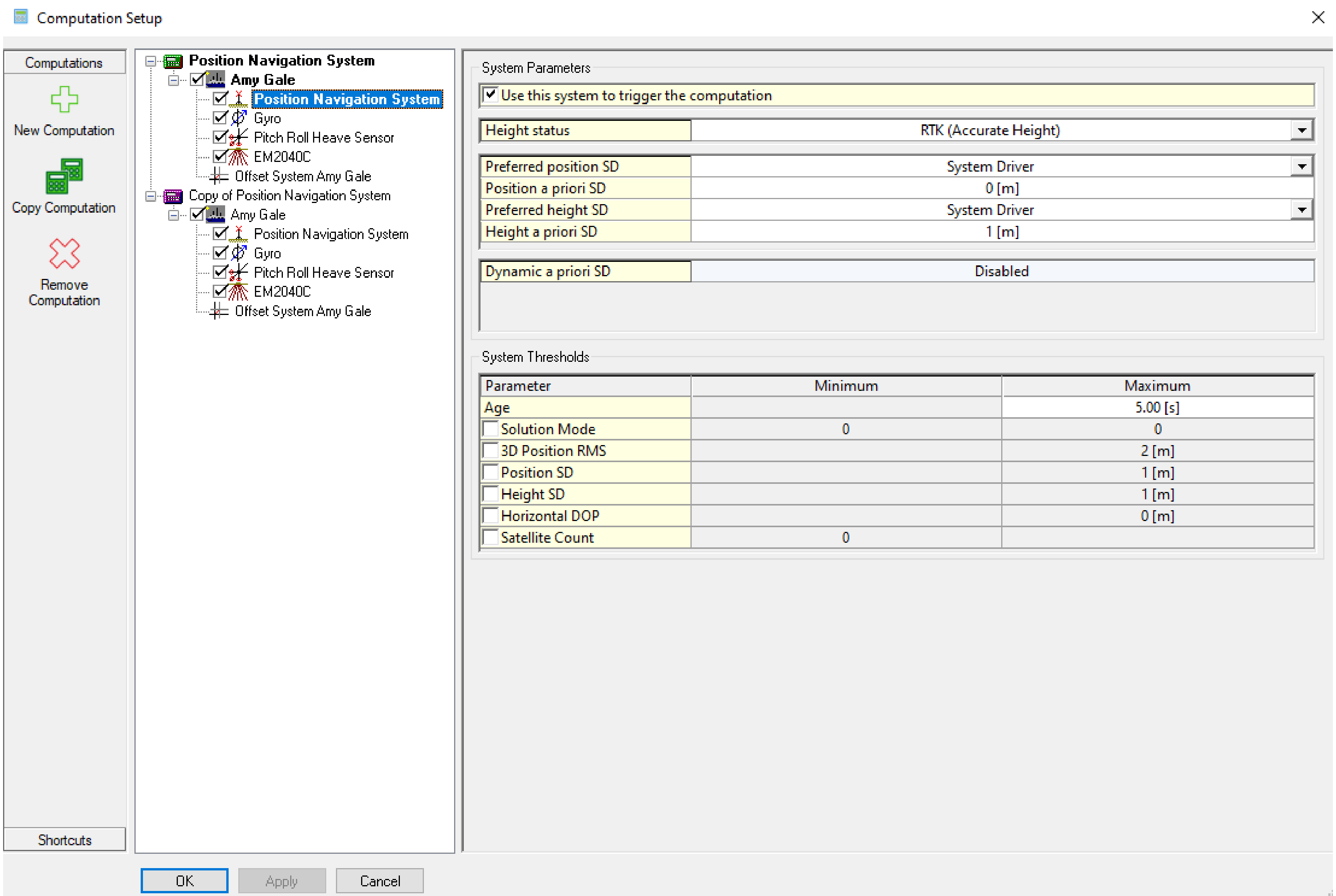

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
COG / SOG
Parameters
Setting
COG value
Position Updates
SOG value
Position Updates
Position count
10
Position threshold
0.05 [m]
Rate-Of-Turn
Parameters
Setting
Rate-Of-Turn value
Rotation Updates
Rate-Of-Turn count
5
Positions / Prediction
Parameters
Setting
Position results
Computation
Height results
Computation
Parameters
Setting
Prediction
Disabled
Maximum position age
5.0 [s]
Snap to Survey Line / Node Track
Parameters
Setting
Snap option
Disabled
OK
Apply
Cancel

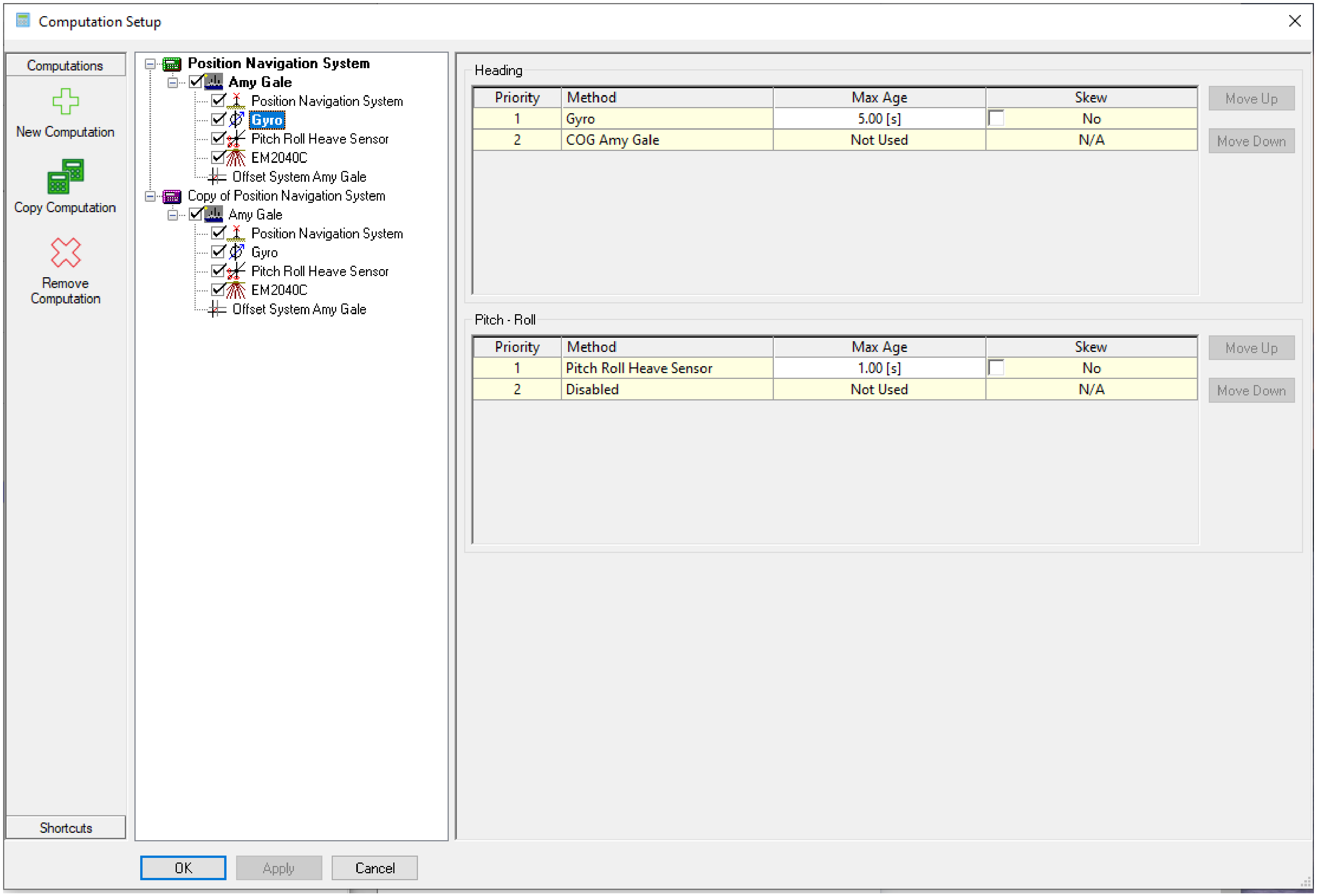

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Heading
Priority
Method
Max Age
Skew
1
Gyro
5.00 [s]
No
2
COG Amy Gale
Not Used
N/A
Move Up
Move Down
Pitch - Roll
Priority
Method
Max Age
Skew
1
Pitch Roll Heave Sensor
1.00 [s]
No
2
Disabled
Not Used
N/A
Move Up
Move Down
OK
Apply
Cancel

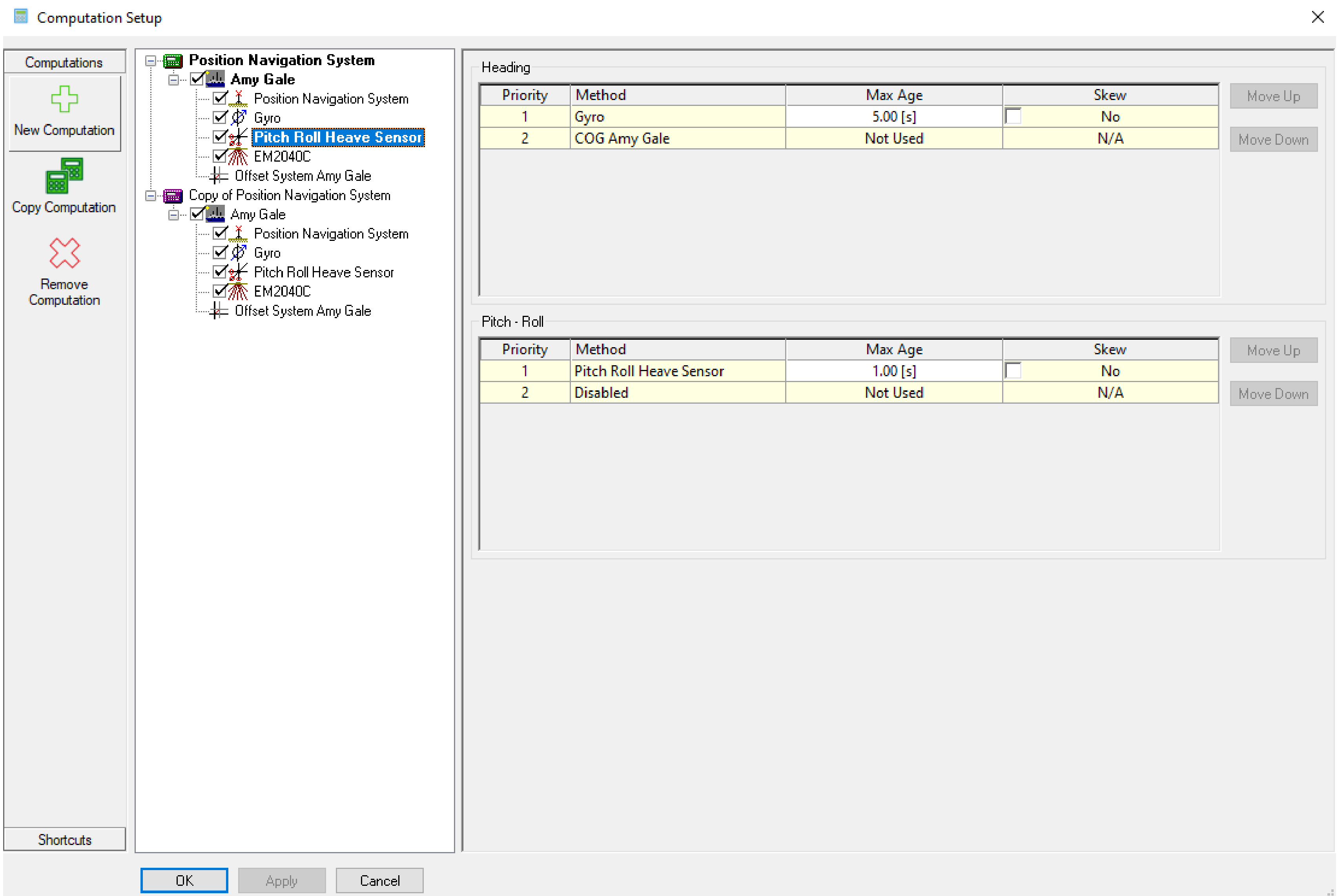

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Height Interpolation
Priority
Method
Max Age
Skew
1
Heave Pitch Roll Heave Senso
1.00 [s]
No
Move Up
Move Down
Draft and Squat Parameters
Draft method
Manual Draft
Manual draft
0.850
Squat method
Disabled
OK
Apply
Cancel

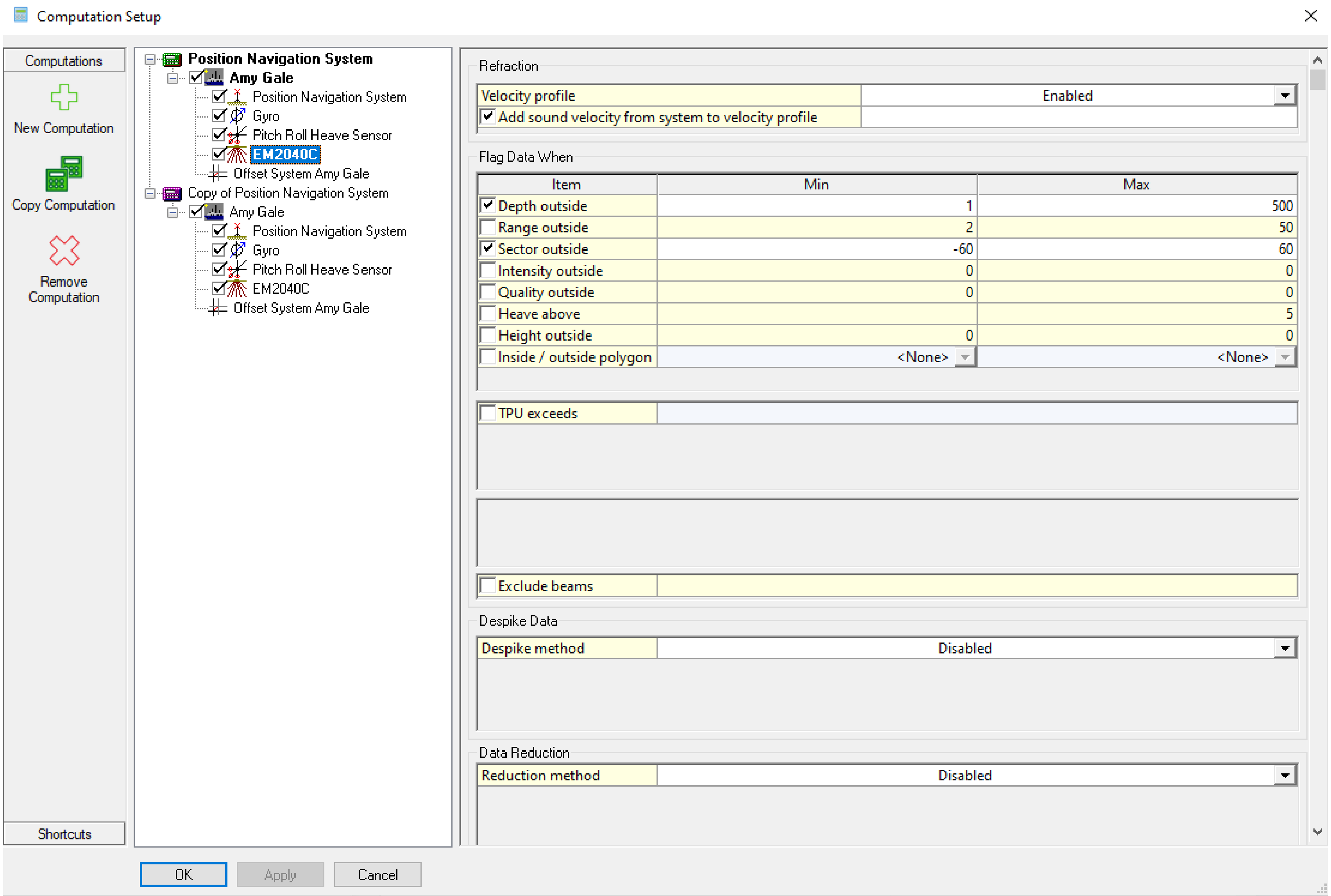

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Tide Priorities
Priority
Strategy
1
Mean Water Level Model
2
Disabled (Strategies below are Disabled)
3
RTK Tide
Move Up
Move Down
Add
Remove
Tide Strategy
Strategy name
Mean Water Level Model
Tide method
Mean Water Level Model
OK
Apply
Cancel

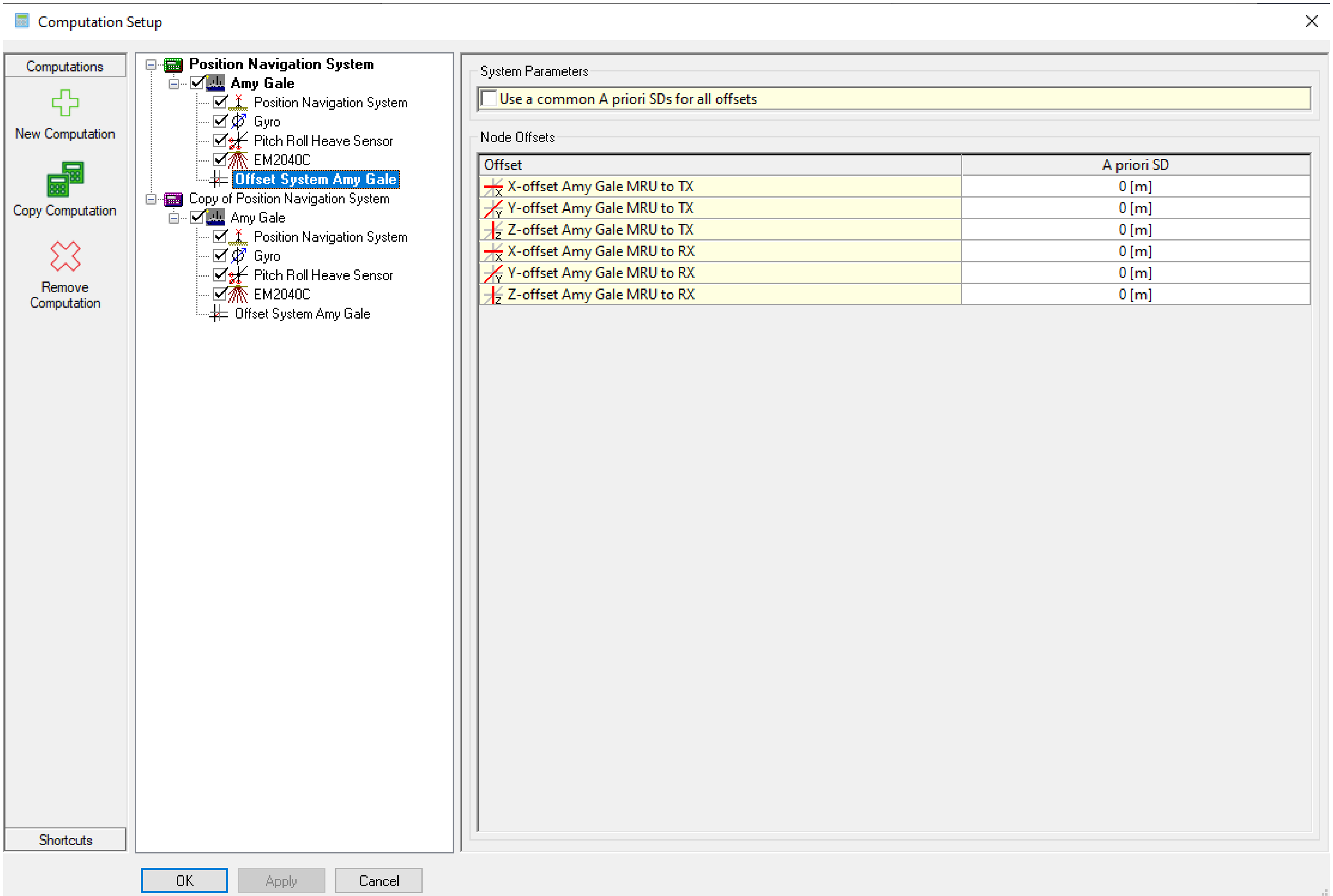

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Tide Priorities
Priority
Strategy
1
Mean Water Level Model
2
Disabled (Strategies below are Disabled)
3
RTK Tide
Move Up
Move Down
Add
Remove
Tide Strategy
Strategy name
RTK Tide
Tide method
RTK Tide
Maximum age tide values
Not Used
Tide filter type
Median Filter
Tide filter length
10.00 [s]
Tide object
Master Vessel Object
OK
Apply
Cancel

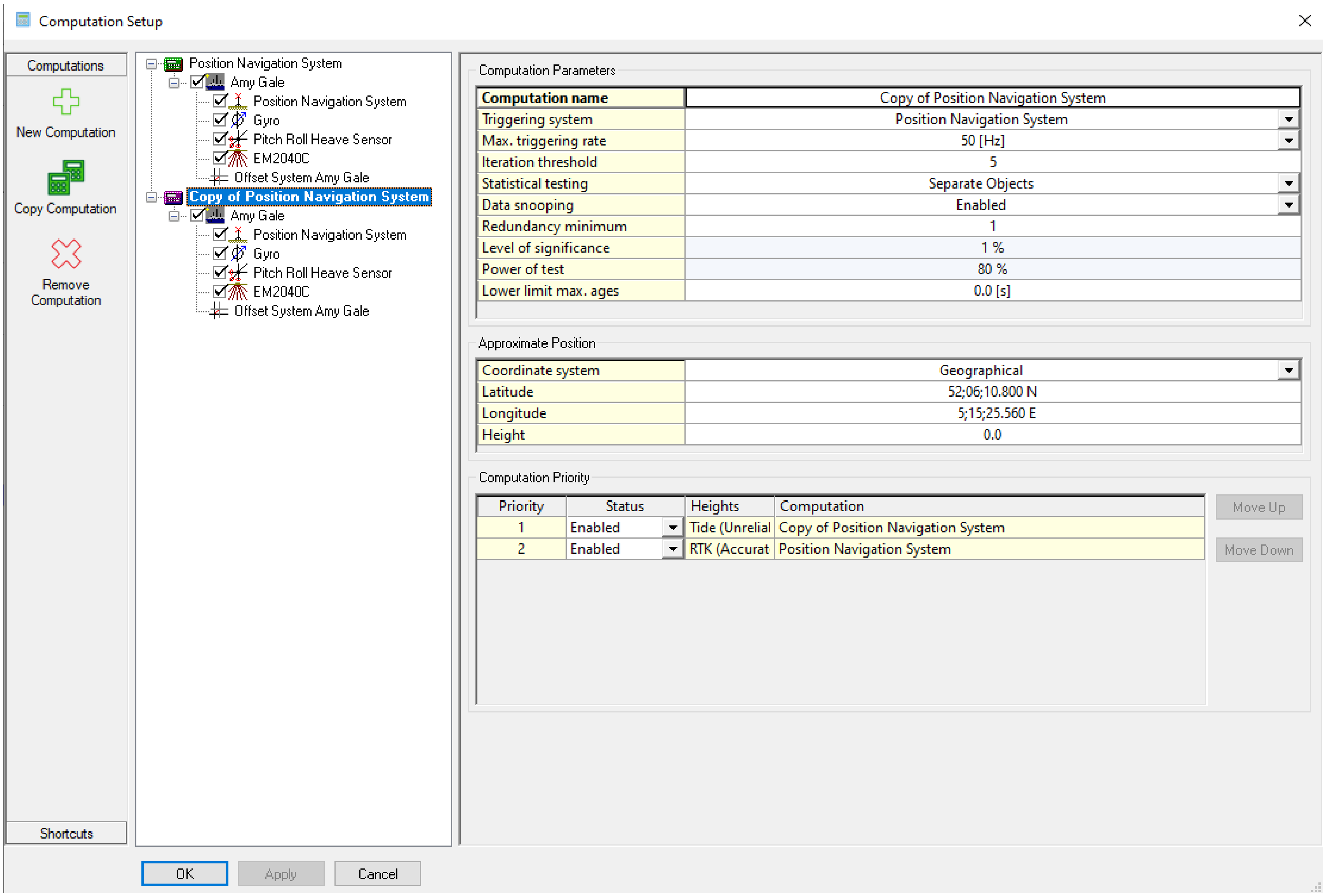

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
System Parameters
Use this system to trigger the computation
Height status
RTK (Accurate Height)
Preferred position SD
System Driver
Position a priori SD
0 [m]
Preferred height SD
System Driver
Height a priori SD
1 [m]
Dynamic a priori SD
Disabled
System Thresholds
Parameter
Minimum
Maximum
Age
5.00 [s]
Solution Mode
0
0
3D Position RMS
2 [m]
Position SD
1 [m]
Height SD
1 [m]
Horizontal DOP
0 [m]
Satellite Count
0
OK
Apply
Cancel

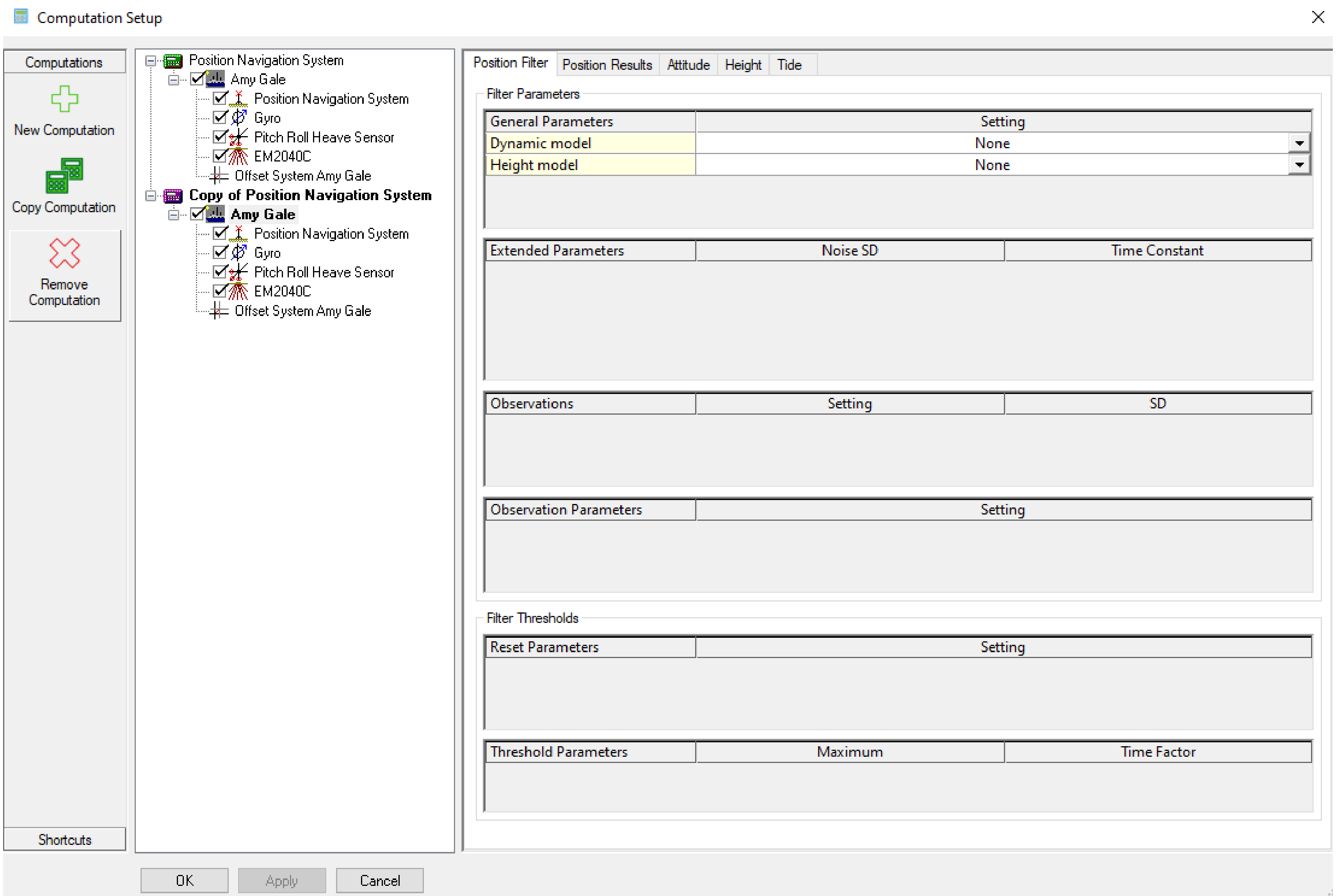

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Heading
Priority
Method
Max Age
Skew
1
Gyro
5.00 [s]
No
2
COG Amy Gale
Not Used
N/A
Move Up
Move Down
Pitch - Roll
Priority
Method
Max Age
Skew
1
Pitch Roll Heave Sensor
1.00 [s]
No
2
Disabled
Not Used
N/A
Move Up
Move Down
OK
Apply
Cancel

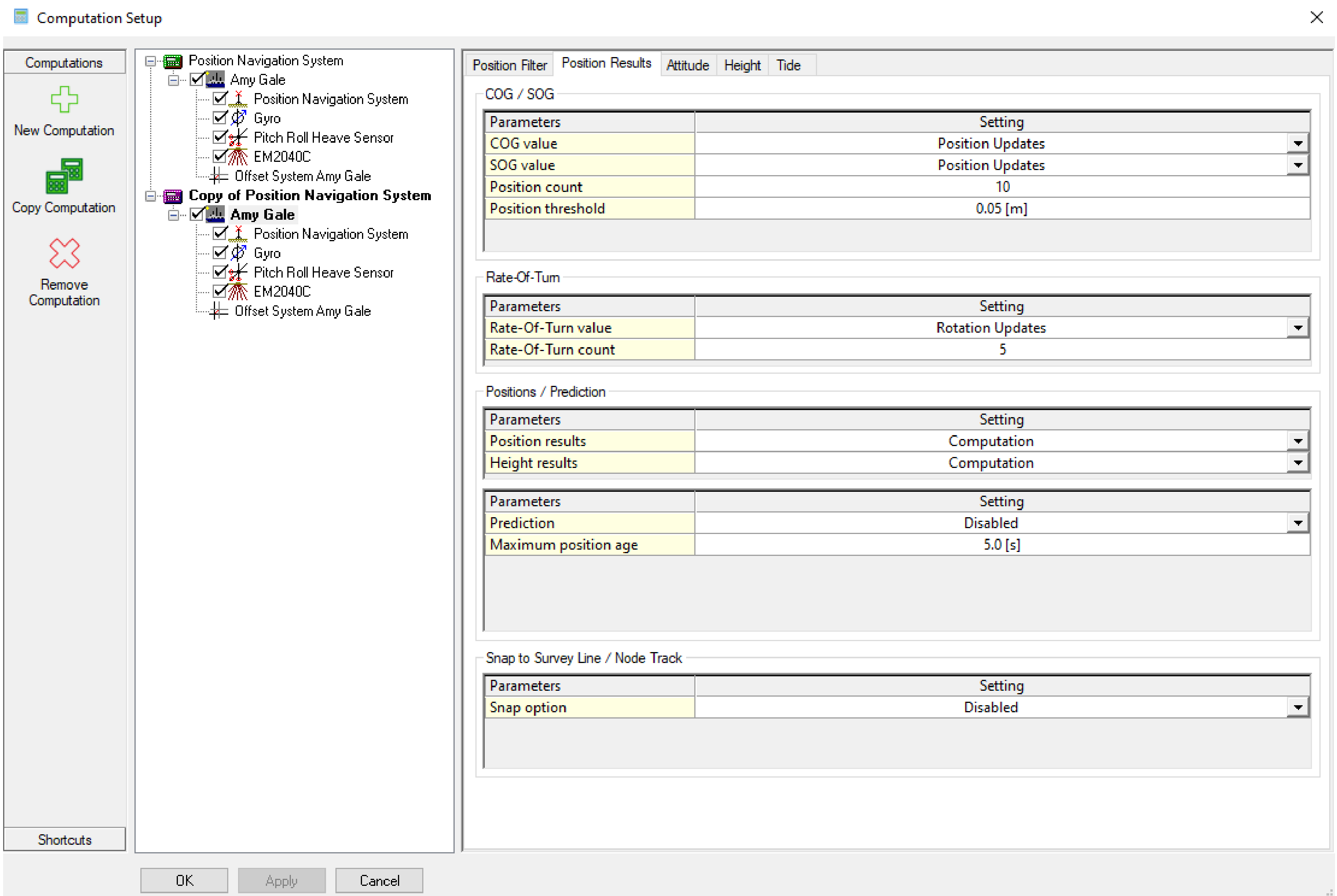

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Heading
Priority Method Max Age Skew
1 Gyro 5.00 [s] No
2 COG Amy Gale Not Used N/A
Move Up
Move Down
Pitch - Roll
Priority Method Max Age Skew
1 Pitch Roll Heave Sensor 1.00 [s] No
2 Disabled Not Used N/A
Move Up
Move Down
OK
Apply
Cancel

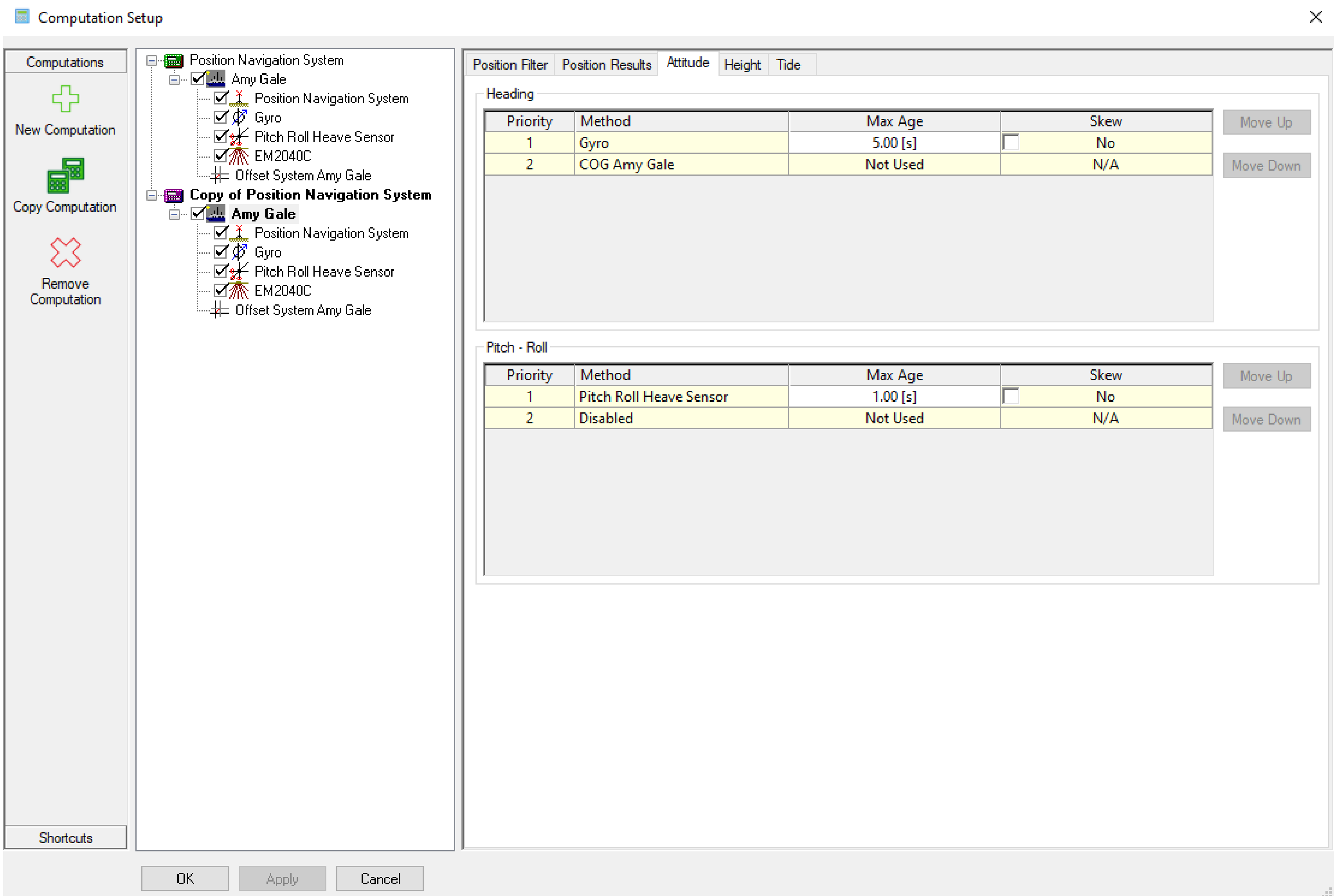

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Refraction
Velocity profile
Enabled
Add sound velocity from system to velocity profile
Flag Data When
Item
Min
Max
Depth outside
1
500
Range outside
2
50
Sector outside
-60
60
Intensity outside
0
0
Quality outside
0
0
Heave above
5
Height outside
0
0
Inside / outside polygon
<None>
<None>
TPU exceeds
Exclude beams
Despike Data
Despike method
Disabled
Data Reduction
Reduction method
Disabled
OK
Apply
Cancel

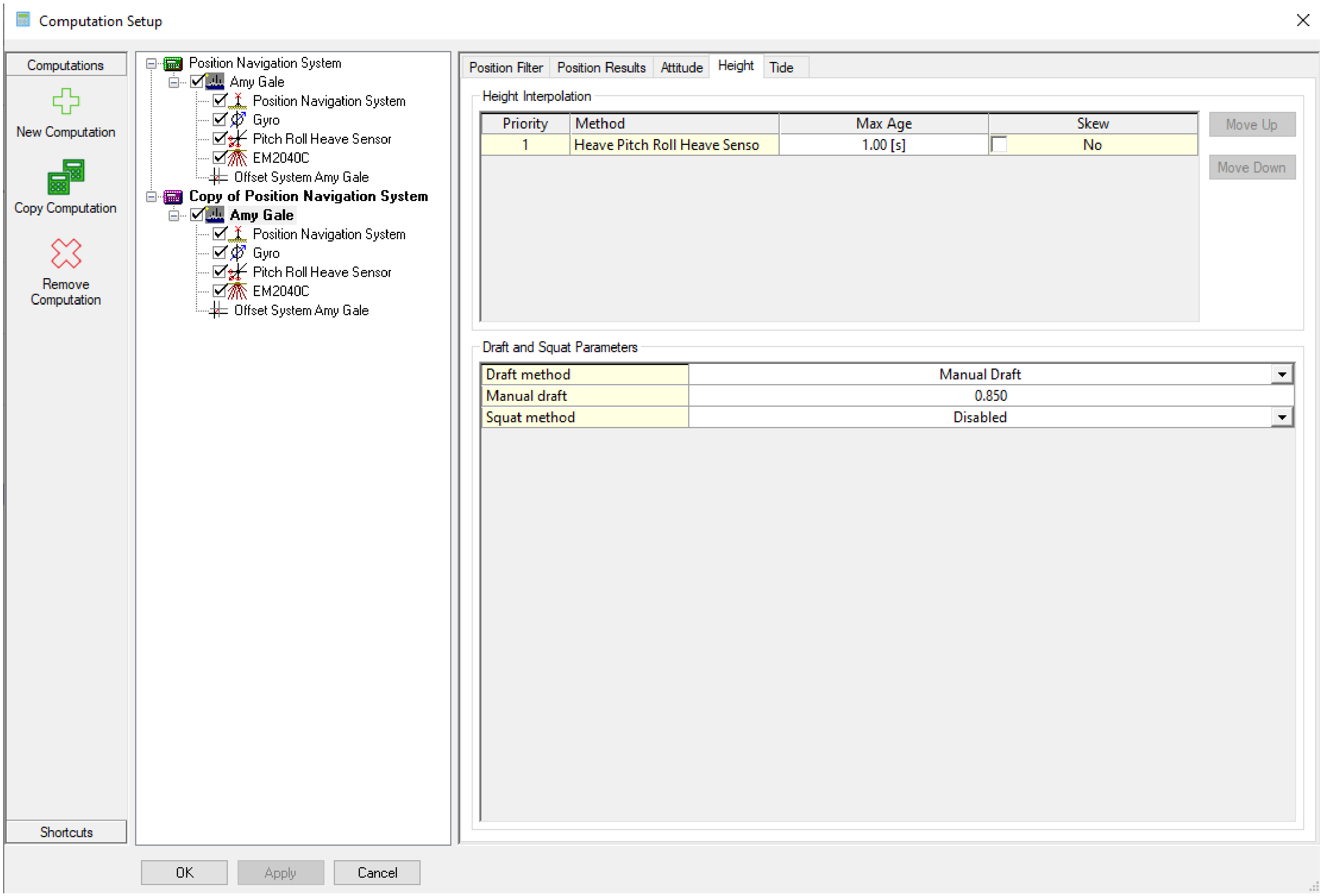

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
System Parameters
Use a common A priori SDs for all offsets
Node Offsets
Offset
A priori SD
X-offset Amy Gale MRU to TX
0 [m]
Y-offset Amy Gale MRU to TX
0 [m]
Z-offset Amy Gale MRU to TX
0 [m]
X-offset Amy Gale MRU to RX
0 [m]
Y-offset Amy Gale MRU to RX
0 [m]
Z-offset Amy Gale MRU to RX
0 [m]
OK
Apply
Cancel


Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Computation Parameters
Computation name: Copy of Position Navigation System
Triggering system: Position Navigation System
Max. triggering rate: 50 [Hz]
Iteration threshold: 5
Statistical testing: Separate Objects
Data snooping: Enabled
Redundancy minimum: 1
Level of significance: 1 %
Power of test: 80 %
Lower limit max. ages: 0.0 [s]
Approximate Position
Coordinate system: Geographical
Latitude: 52;06;10.800 N
Longitude: 5;15;25.560 E
Height: 0.0
Computation Priority
Priority | Status | Heights | Computation
1 | Enabled | Tide (Unrelial | Copy of Position Navigation System
2 | Enabled | RTK (Accurat | Position Navigation System
Move Up
Move Down
OK
Apply
Cancel

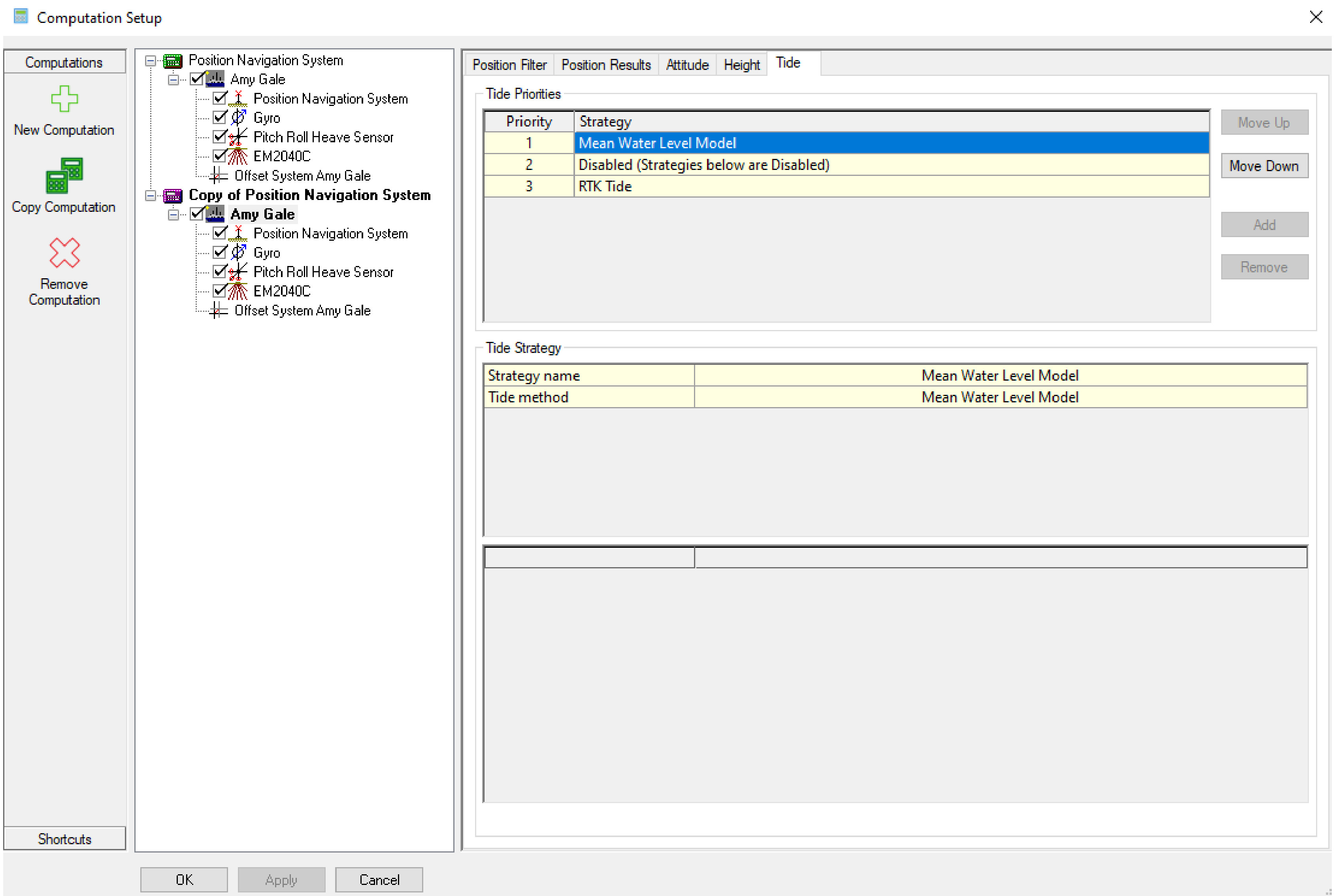

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Filter Parameters
General Parameters
Setting
Dynamic model
None
Height model
None
Extended Parameters
Noise SD
Time Constant
Observations
Setting
SD
Observation Parameters
Setting
Filter Thresholds
Reset Parameters
Setting
Threshold Parameters
Maximum
Time Factor
OK
Apply
Cancel


Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
COG / SOG
Parameters
Setting
COG value
Position Updates
SOG value
Position Updates
Position count
10
Position threshold
0.05 [m]
Rate-Of-Turn
Parameters
Setting
Rate-Of-Turn value
Rotation Updates
Rate-Of-Turn count
5
Positions / Prediction
Parameters
Setting
Position results
Computation
Height results
Computation
Parameters
Setting
Prediction
Disabled
Maximum position age
5.0 [s]
Snap to Survey Line / Node Track
Parameters
Setting
Snap option
Disabled
OK
Apply
Cancel

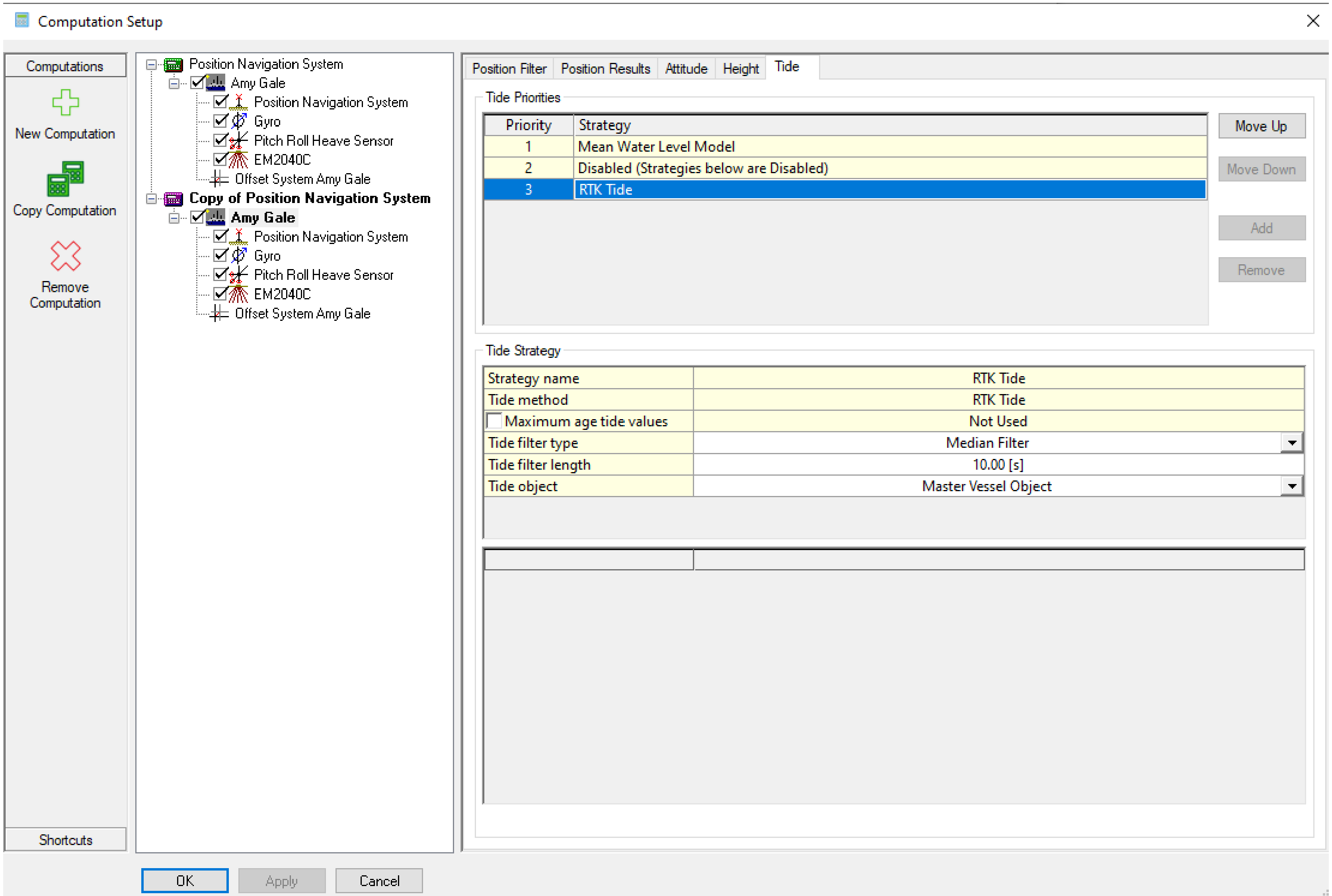

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Heading
Priority
Method
Max Age
Skew
1
Gyro
5.00 [s]
No
2
COG Amy Gale
Not Used
N/A
Move Up
Move Down
Pitch - Roll
Priority
Method
Max Age
Skew
1
Pitch Roll Heave Sensor
1.00 [s]
No
2
Disabled
Not Used
N/A
Move Up
Move Down
OK
Apply
Cancel

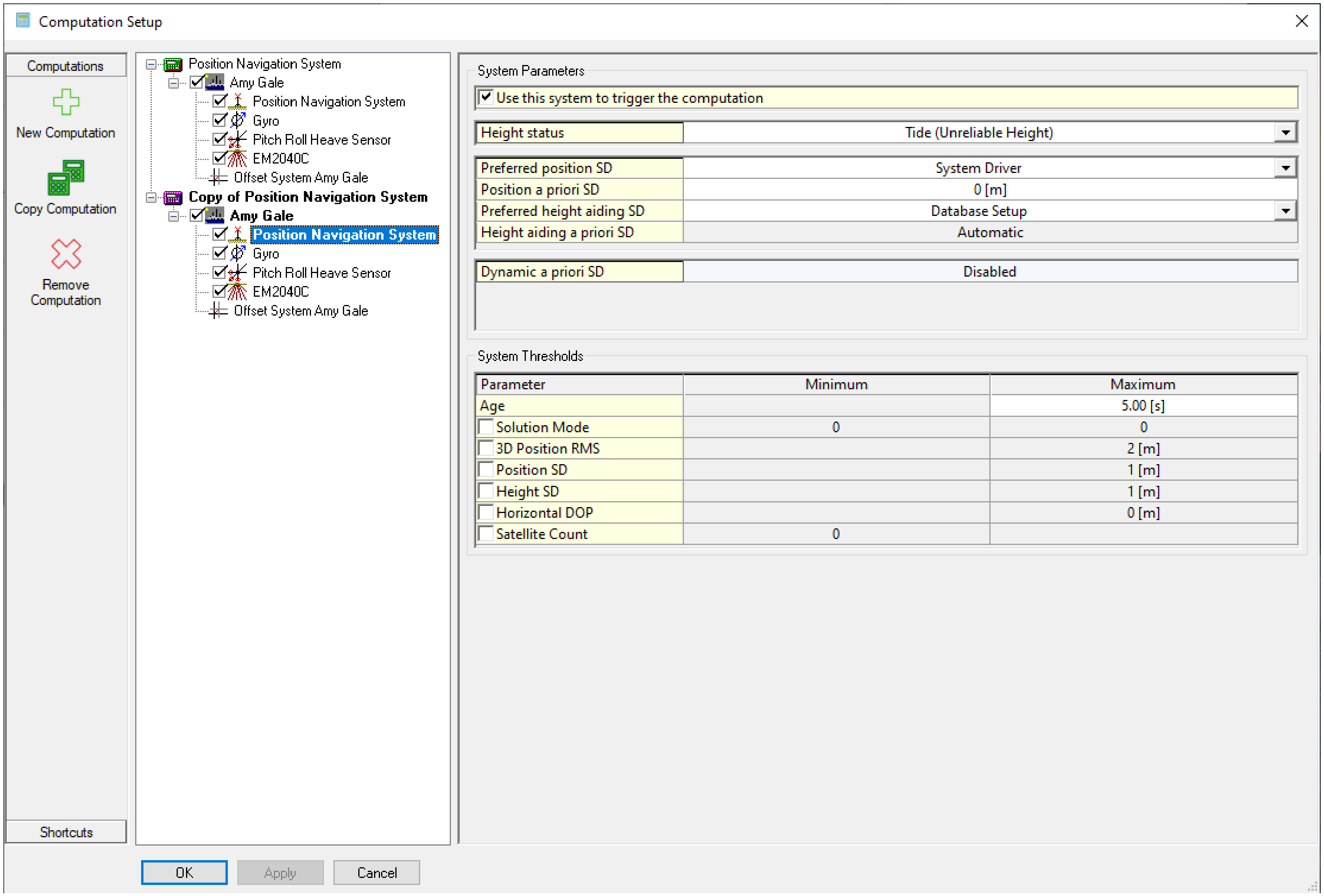


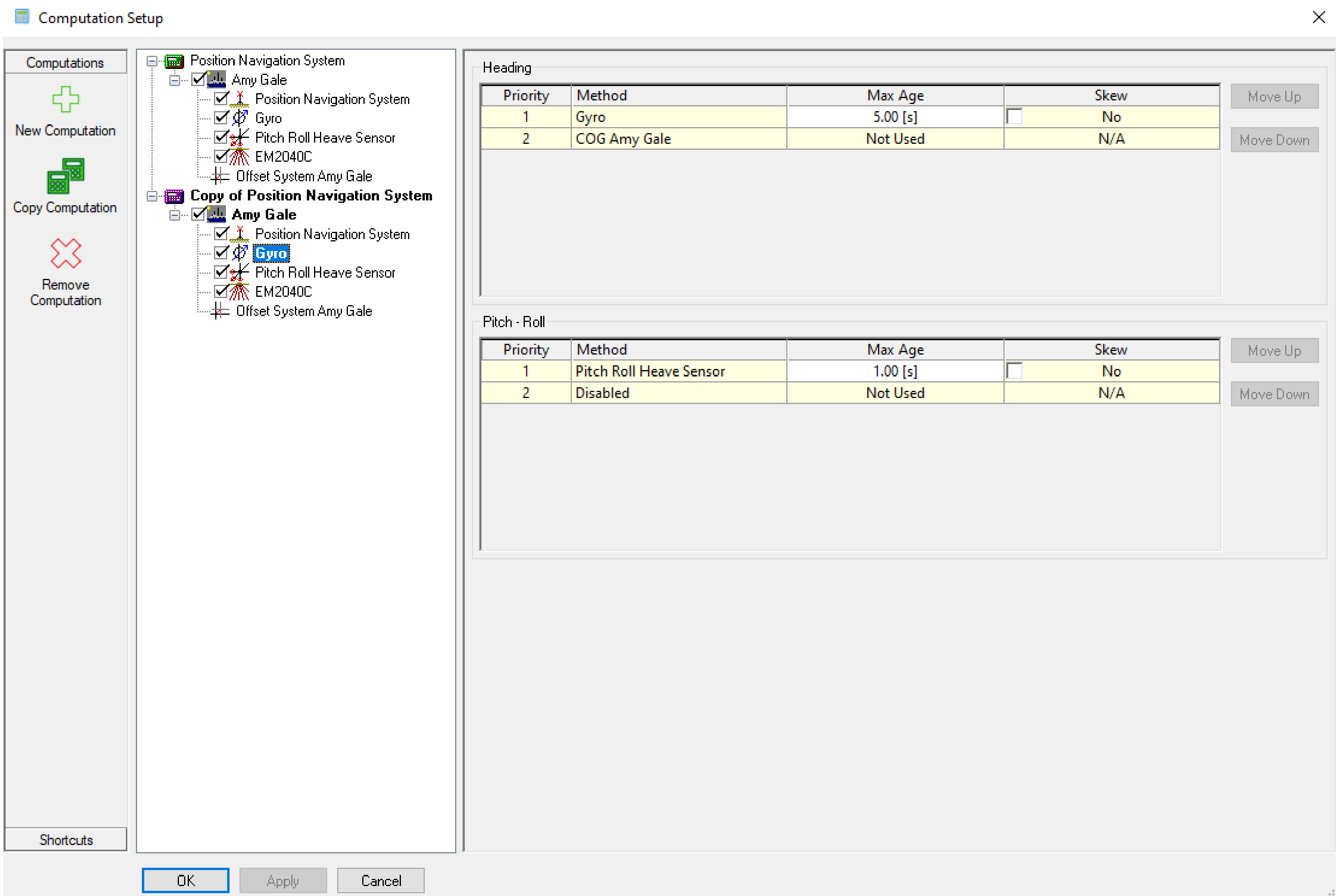
Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Height Interpolation
Priority
Method
Max Age
Skew
1
Heave Pitch Roll Heave Senso
1.00 [s]
No
Move Up
Move Down
Draft and Squat Parameters
Draft method
Manual Draft
Manual draft
0.850
Squat method
Disabled
OK
Apply
Cancel

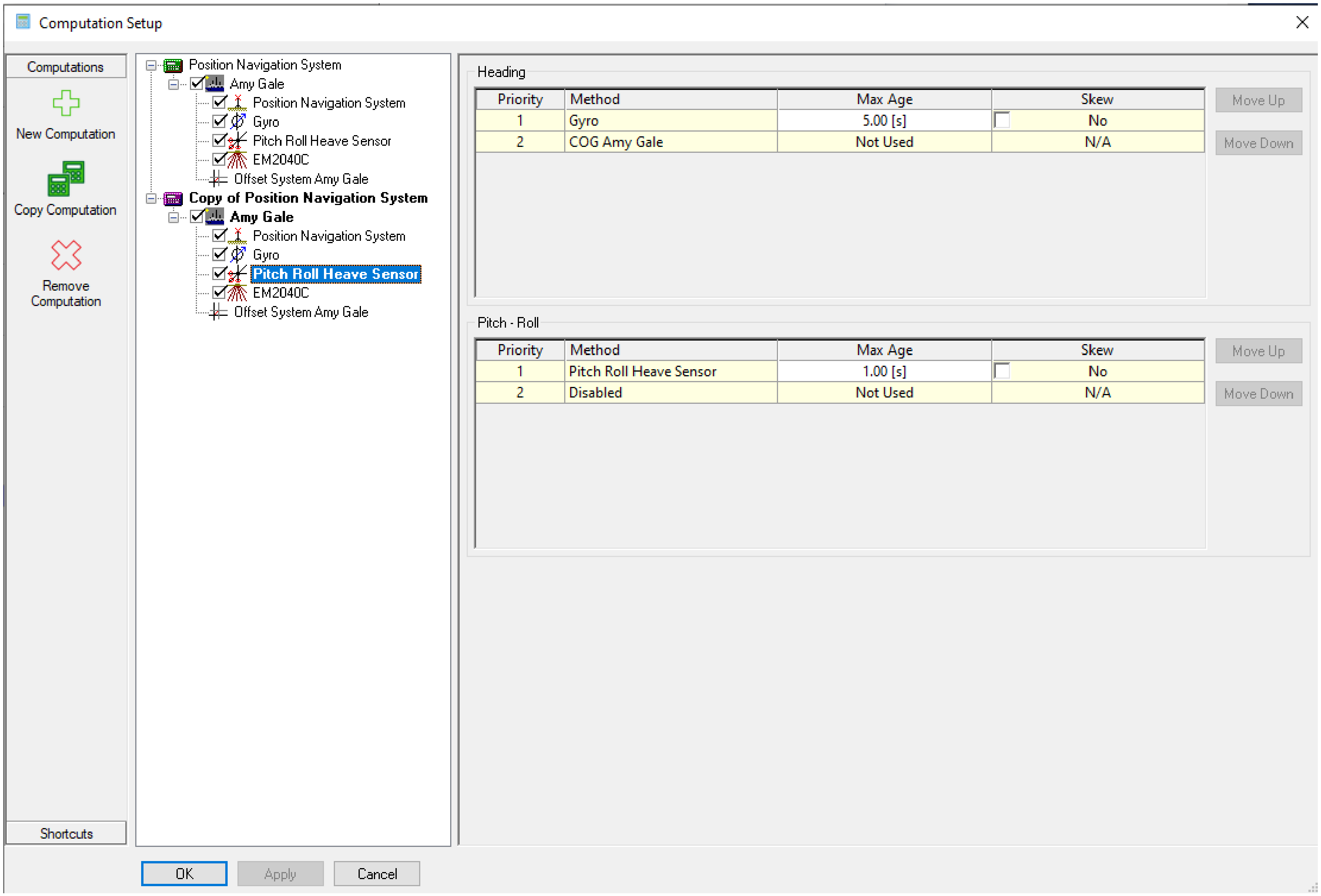


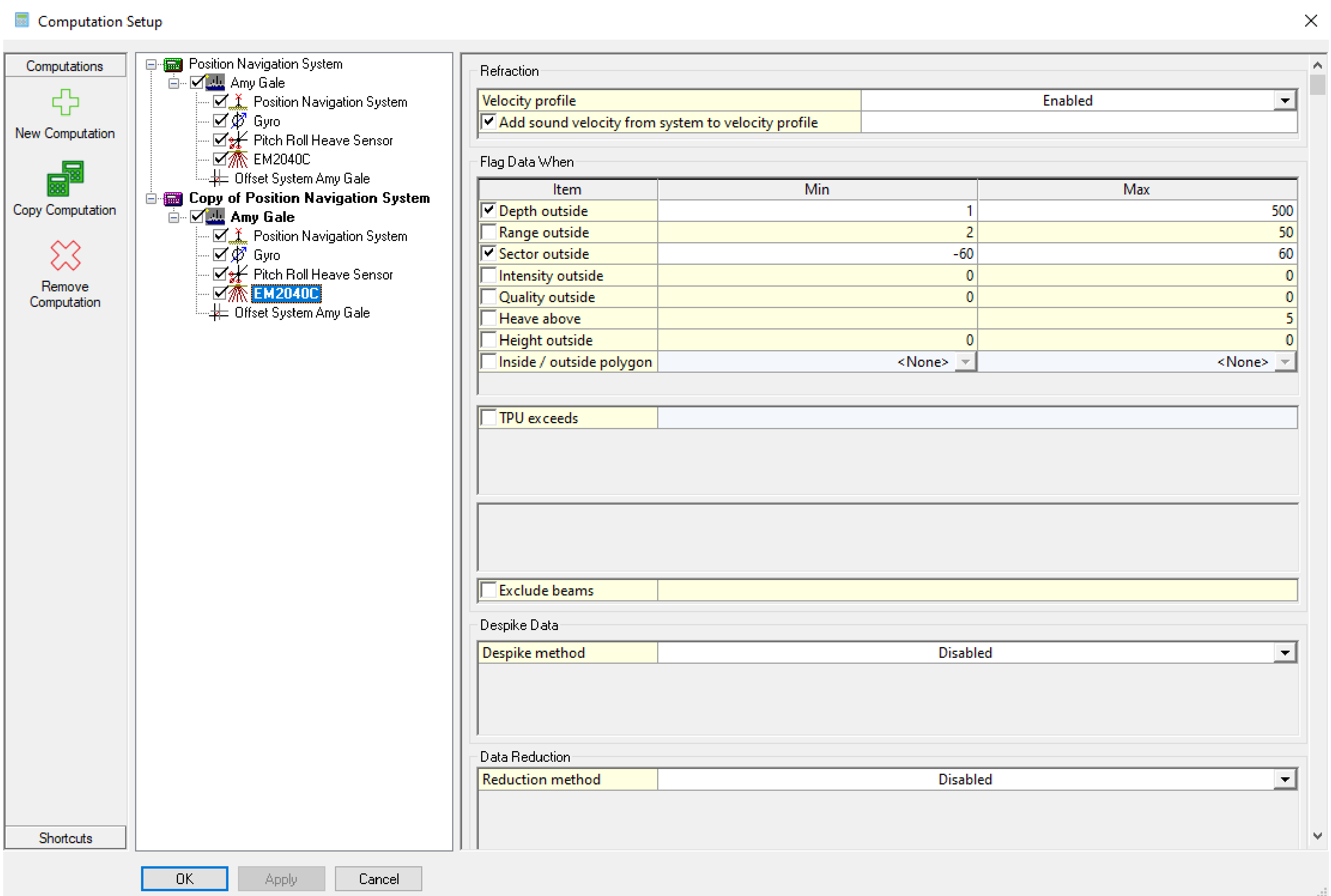
Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Tide Priorities
Priority
Strategy
1
Mean Water Level Model
2
Disabled (Strategies below are Disabled)
3
RTK Tide
Move Up
Move Down
Add
Remove
Tide Strategy
Strategy name
Mean Water Level Model
Tide method
Mean Water Level Model
OK
Apply
Cancel

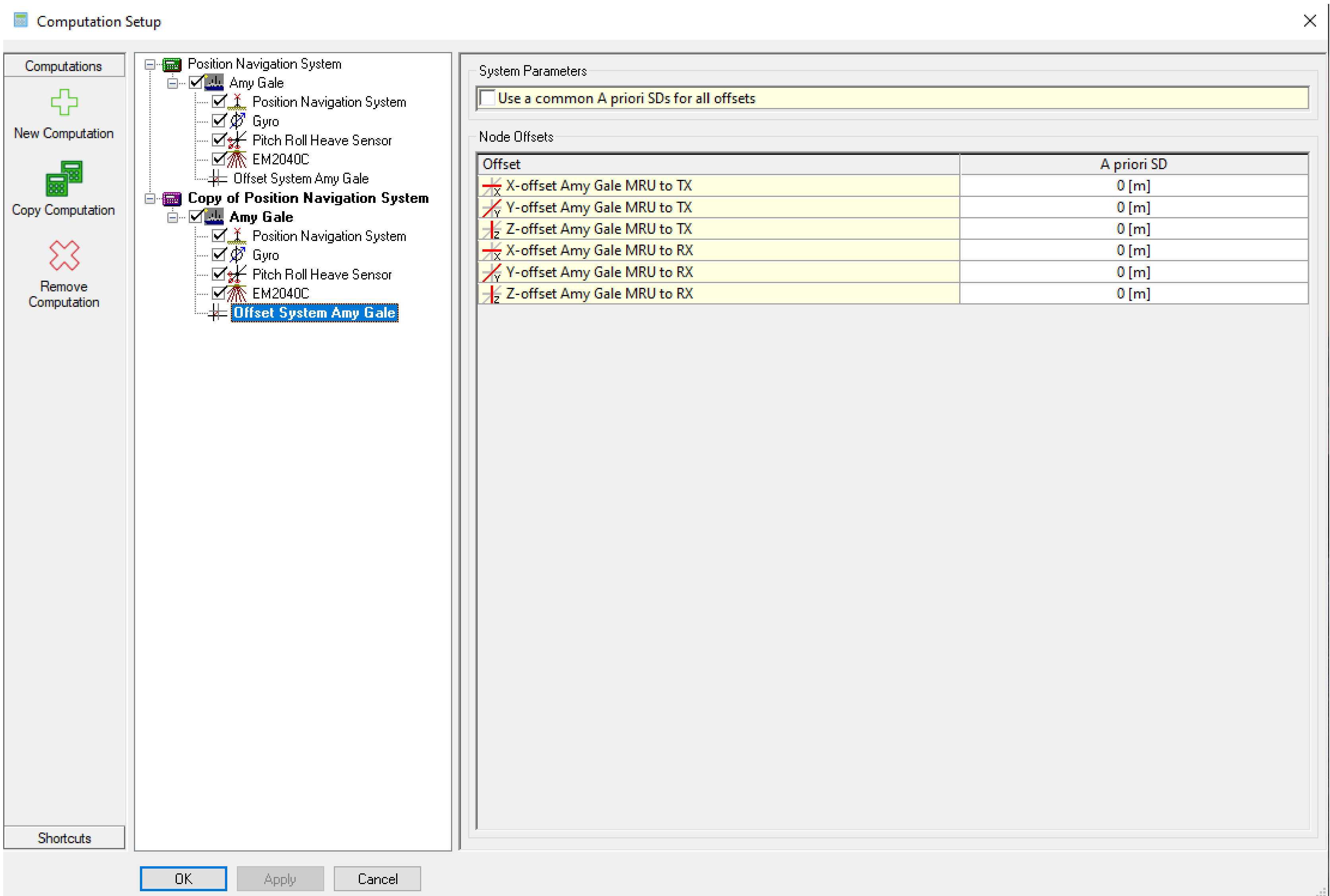

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Tide
Tide Priorities
Priority
Strategy
1
Mean Water Level Model
2
Disabled (Strategies below are Disabled)
3
RTK Tide
Move Up
Move Down
Add
Remove
Tide Strategy
Strategy name
RTK Tide
Tide method
RTK Tide
Maximum age tide values
Not Used
Tide filter type
Median Filter
Tide filter length
10.00 [s]
Tide object
Master Vessel Object
OK
Apply
Cancel

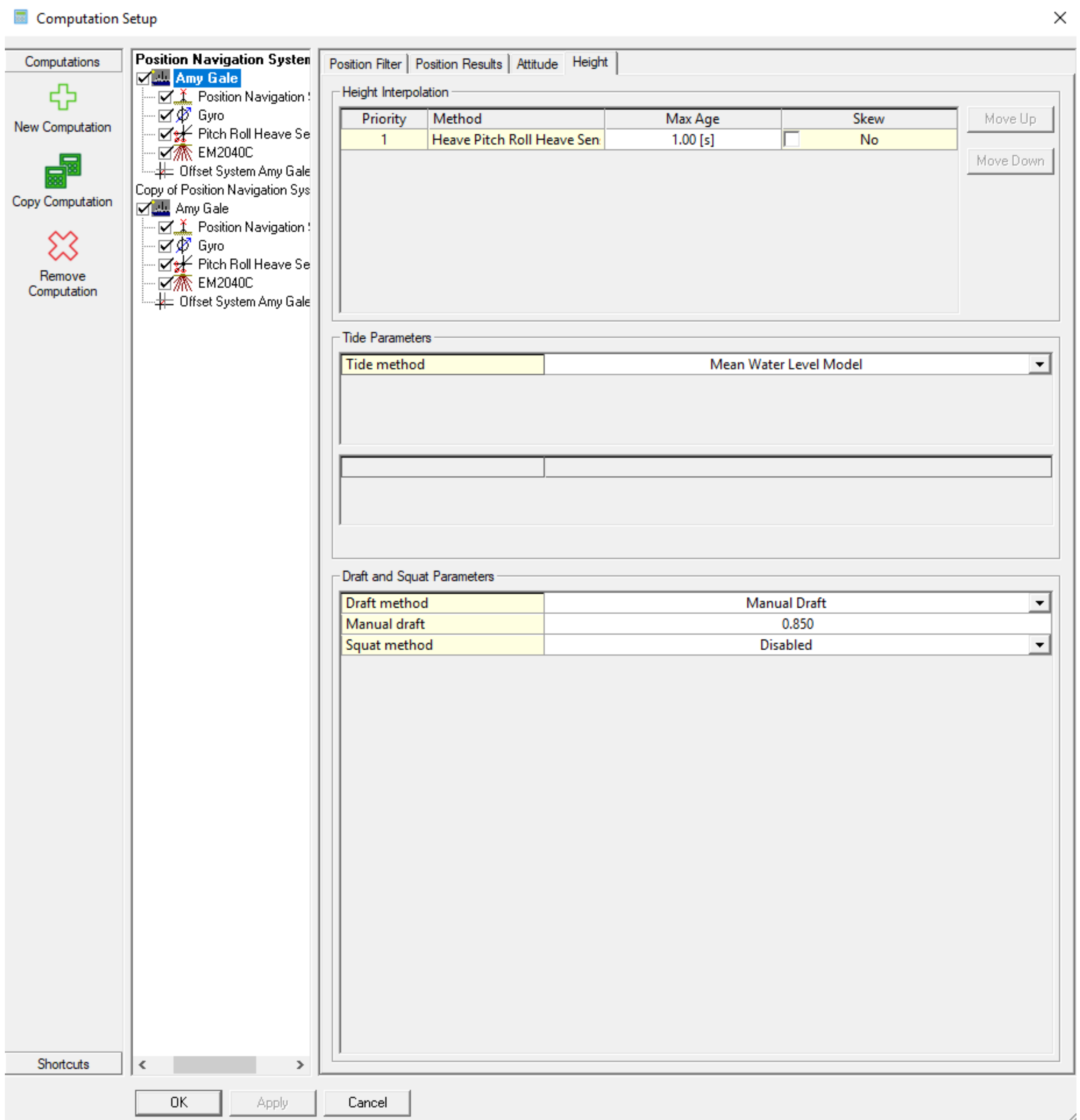

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
System Parameters
Use this system to trigger the computation
Height status
Tide (Unreliable Height)
Preferred position SD
System Driver
Position a priori SD
0 [m]
Preferred height aiding SD
Database Setup
Height aiding a priori SD
Automatic
Dynamic a priori SD
Disabled
System Thresholds
Parameter
Minimum
Maximum
Age
5.00 [s]
Solution Mode
0
0
3D Position RMS
2 [m]
Position SD
1 [m]
Height SD
1 [m]
Horizontal DOP
0 [m]
Satellite Count
0
OK
Apply
Cancel

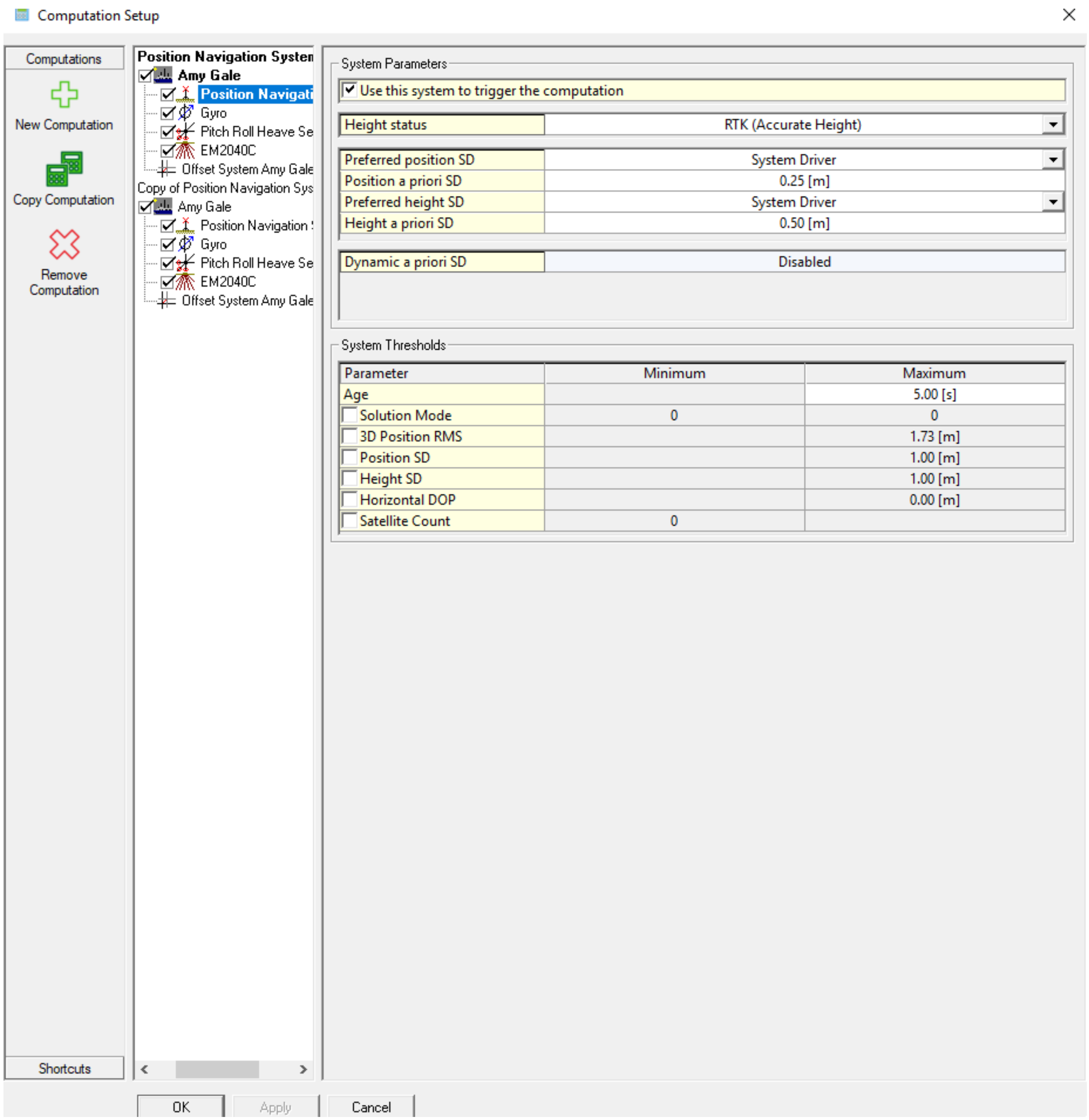

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Heading
Priority
Method
Max Age
Skew
1
Gyro
5.00 [s]
No
2
COG Amy Gale
Not Used
N/A
Move Up
Move Down
Pitch - Roll
Priority
Method
Max Age
Skew
1
Pitch Roll Heave Sensor
1.00 [s]
No
2
Disabled
Not Used
N/A
Move Up
Move Down
OK
Apply
Cancel

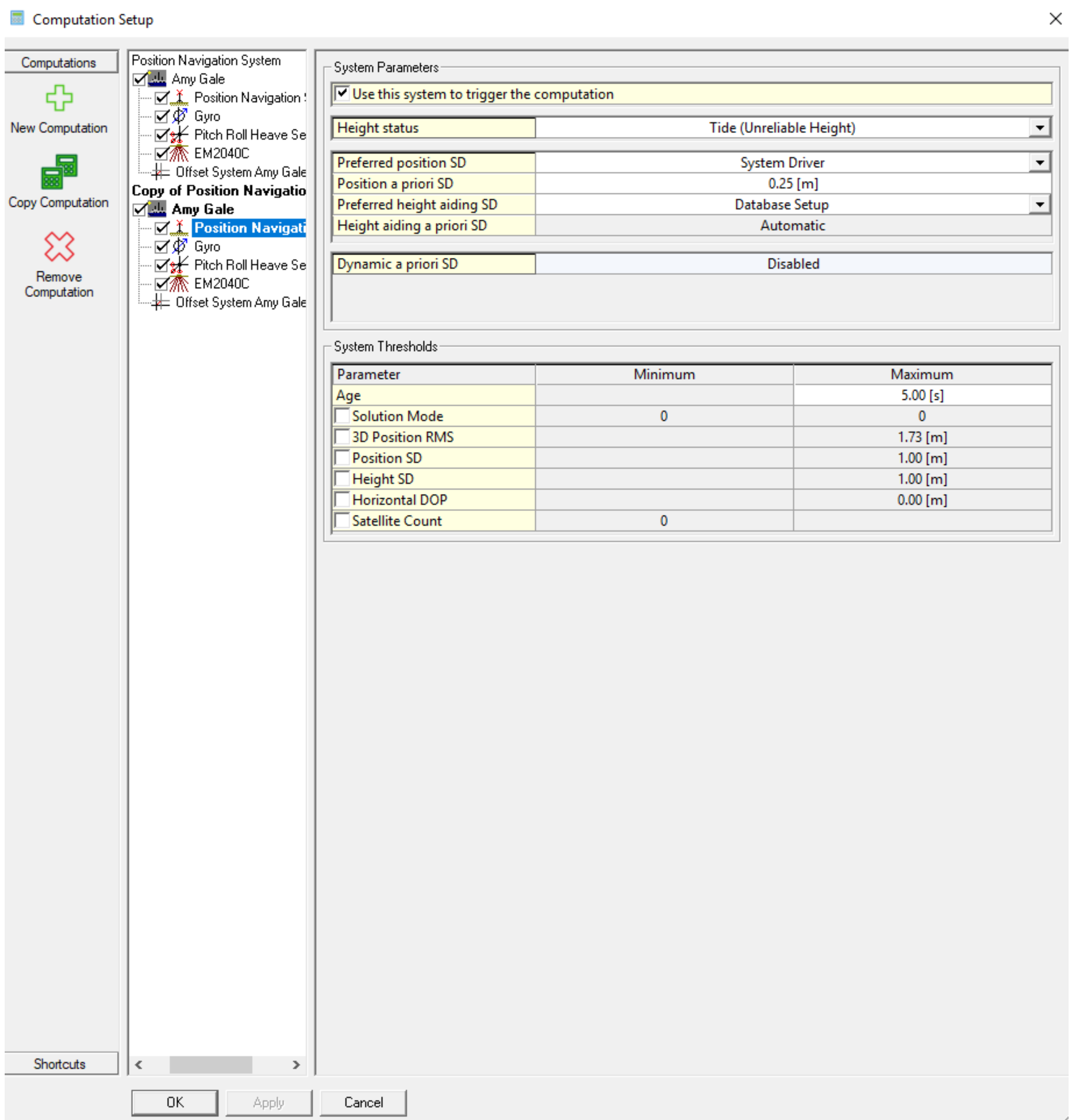

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Heading
Priority Method Max Age Skew
1 Gyro 5.00 [s] No
2 COG Amy Gale Not Used N/A
Move Up
Move Down
Pitch - Roll
Priority Method Max Age Skew
1 Pitch Roll Heave Sensor 1.00 [s] No
2 Disabled Not Used N/A
Move Up
Move Down
OK
Apply
Cancel

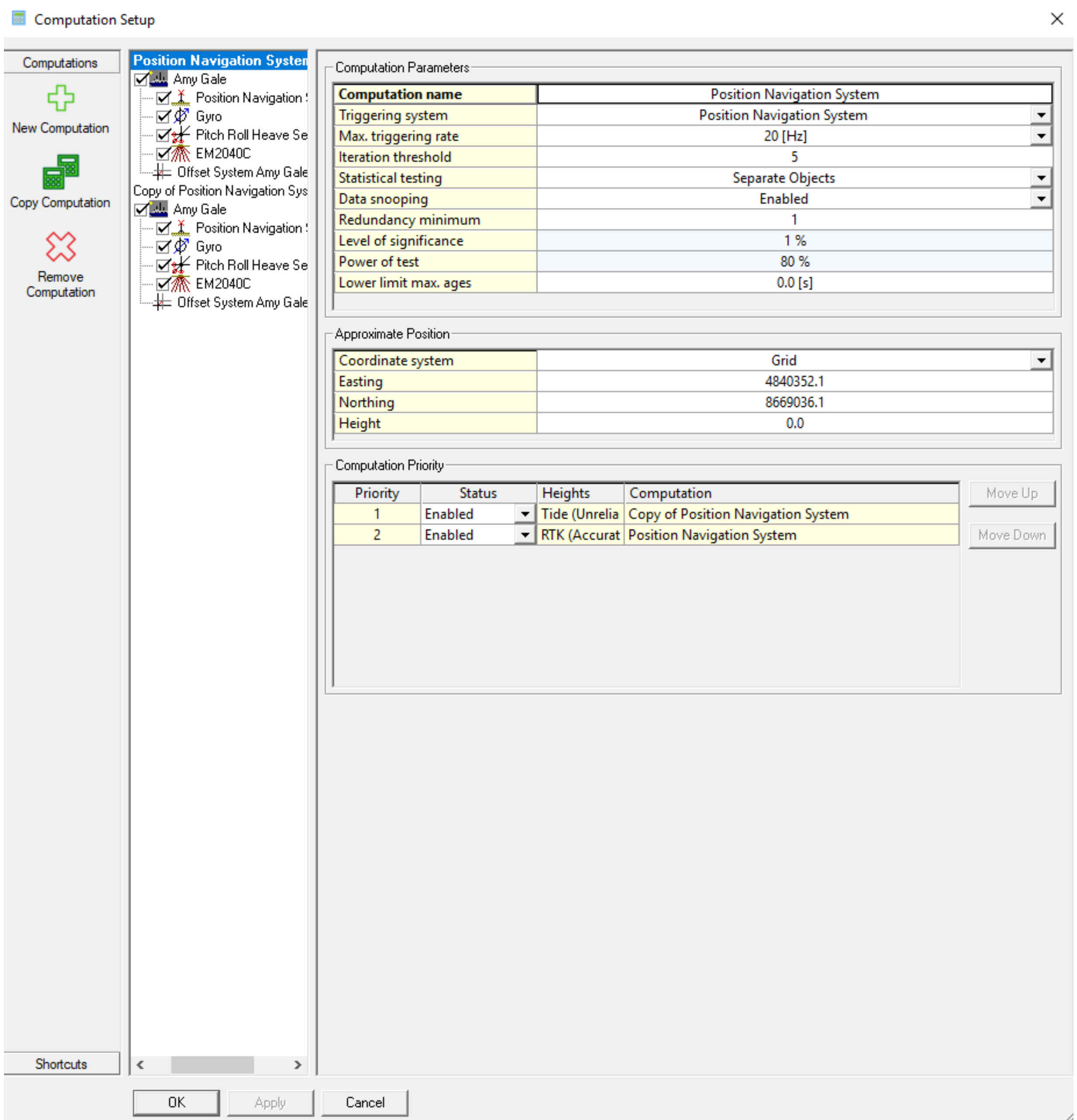

Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Refraction
Velocity profile
Enabled
Add sound velocity from system to velocity profile
Flag Data When
Item
Min
Max
Depth outside 1 500
Range outside 2 50
Sector outside -60 60
Intensity outside 0 0
Quality outside 0 0
Heave above 5
Height outside 0 0
Inside / outside polygon <None> <None>
TPU exceeds
Exclude beams
Despike Data
Despike method
Disabled
Data Reduction
Reduction method
Disabled
OK
Apply
Cancel


Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
Copy of Position Navigation System
Amy Gale
Position Navigation System
Gyro
Pitch Roll Heave Sensor
EM2040C
Offset System Amy Gale
System Parameters
Use a common A priori SDs for all offsets
Node Offsets
Offset
A priori SD
X-offset Amy Gale MRU to TX
0 [m]
Y-offset Amy Gale MRU to TX
0 [m]
Z-offset Amy Gale MRU to TX
0 [m]
X-offset Amy Gale MRU to RX
0 [m]
Y-offset Amy Gale MRU to RX
0 [m]
Z-offset Amy Gale MRU to RX
0 [m]
OK
Apply
Cancel


Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation Systen
Amy Gale
Position Navigation !
Gyro
Pitch Roll Heave Se
EM2040C
Offset System Amy Gale
Copy of Position Navigation Sys
Amy Gale
Position Navigation !
Gyro
Pitch Roll Heave Se
EM2040C
Offset System Amy Gale
Position Filter
Position Results
Attitude
Height
Height Interpolation
Priority
Method
Max Age
Skew
1
Heave Pitch Roll Heave Sen
1.00 [s]
No
Move Up
Move Down
Tide Parameters
Tide method
Mean Water Level Model
Draft and Squat Parameters
Draft method
Manual Draft
Manual draft
0.850
Squat method
Disabled
OK
Apply
Cancel


Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation Systen
Amy Gale
Position Navigati
Gyro
Pitch Roll Heave Se
EM2040C
Offset System Amy Gale
Copy of Position Navigation Sys
Amy Gale
Position Navigation !
Gyro
Pitch Roll Heave Se
EM2040C
Offset System Amy Gale
System Parameters
Use this system to trigger the computation
Height status
RTK (Accurate Height)
Preferred position SD
System Driver
Position a priori SD
0.25 [m]
Preferred height SD
System Driver
Height a priori SD
0.50 [m]
Dynamic a priori SD
Disabled
System Thresholds
Parameter
Minimum
Maximum
Age
5.00 [s]
Solution Mode
0
0
3D Position RMS
1.73 [m]
Position SD
1.00 [m]
Height SD
1.00 [m]
Horizontal DOP
0.00 [m]
Satellite Count
0
OK
Apply
Cancel


Computation Setup
Computations
New Computation
Copy Computation
Remove Computation
Shortcuts
Position Navigation System
Amy Gale
Gyro
EM2040C
Offset System Amy Gale
Copy of Position Navigatio
System Parameters
Use this system to trigger the computation
Height status
Tide (Unreliable Height)
Preferred position SD
System Driver
Position a priori SD
0.25 [m]
Preferred height aiding SD
Database Setup
Height aiding a priori SD
Automatic
Dynamic a priori SD
Disabled
System Thresholds
Parameter
Minimum
Maximum
Age
5.00 [s]
Solution Mode
3D Position RMS
1.73 [m]
Position SD
1.00 [m]
Height SD
Horizontal DOP
0.00 [m]
Satellite Count
OK
Apply
Cancel


Computation Setup
Computations
New Computation
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EM2040C
Offset System Amy Gale
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Position Navigation !
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Pitch Roll Heave Se
EM2040C
Offset System Amy Gale
Computation Parameters
Computation name
Position Navigation System
Triggering system
Position Navigation System
Max. triggering rate
20 [Hz]
Iteration threshold
5
Statistical testing
Separate Objects
Data snooping
Enabled
Redundancy minimum
1
Level of significance
1 %
Power of test
80 %
Lower limit max. ages
0.0 [s]
Approximate Position
Coordinate system
Grid
Easting
4840352.1
Northing
8669036.1
Height
0.0
Computation Priority
Priority
Status
Heights
Computation
1
Enabled
Tide (Unrelia
Copy of Position Navigation System
2
Enabled
RTK (Accurat
Position Navigation System
Move Up
Move Down
OK
Apply
Cancel

Appendix G – Crossline surface difference test statistical plots

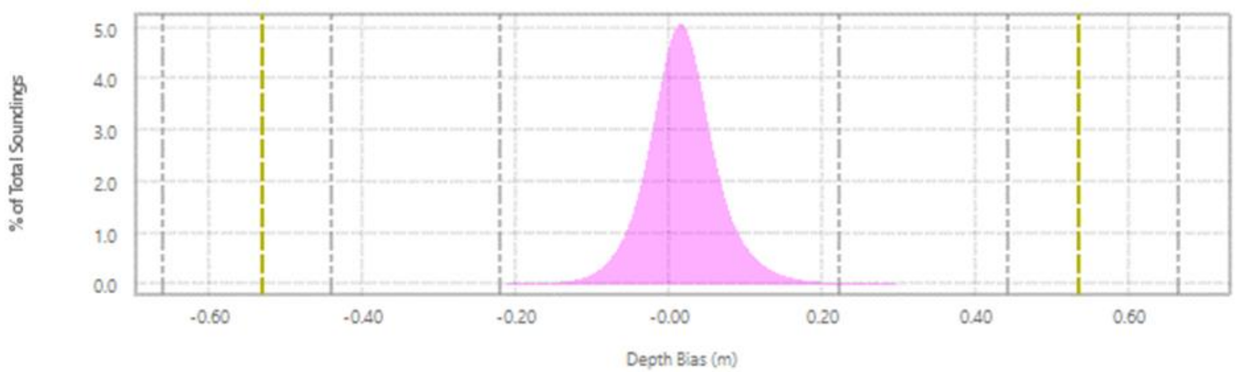
<u>Plots (histogram, scatter, and uncertainty)</u>

Key for plots:

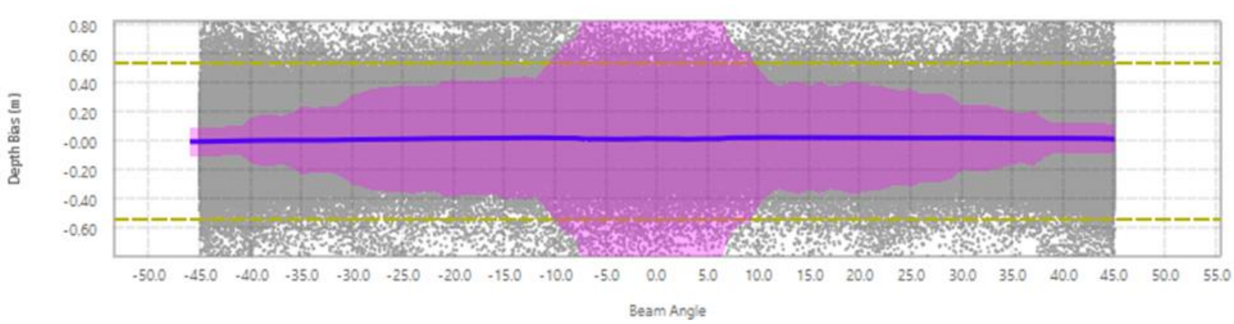
- Gray dots represent difference in depth between the crossline and the reference surface for individual beam angles or beam numbers
- Purple areas represent the 95% confidence interval (2 standard deviations) based on normal distribution (see histogram)
- Yellow dashed lines represent limit of IHO Order 1 test vertical tolerance
- Gray dashed lines on histogram represent ±sigma 1, 2, and 3
- Blue lines represent the mean value

SECTION 1: Crossline statistical plots for W00648_2 (2021-2022)

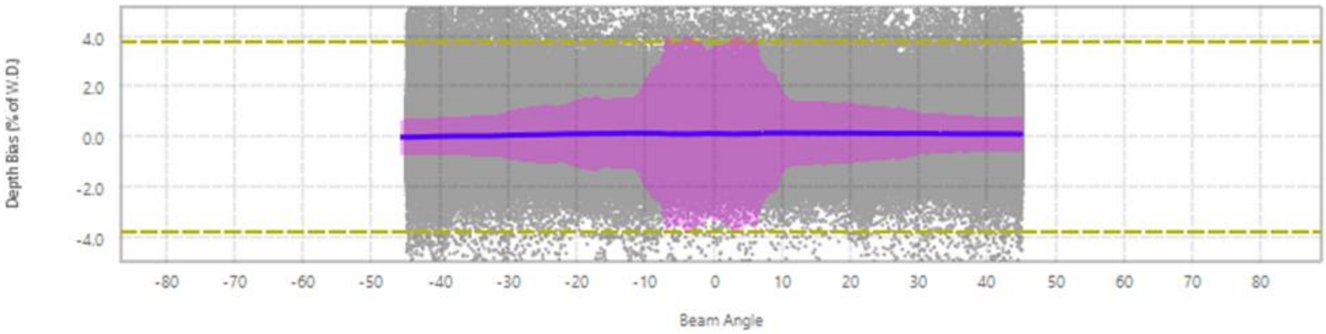
<u>Histogram</u>



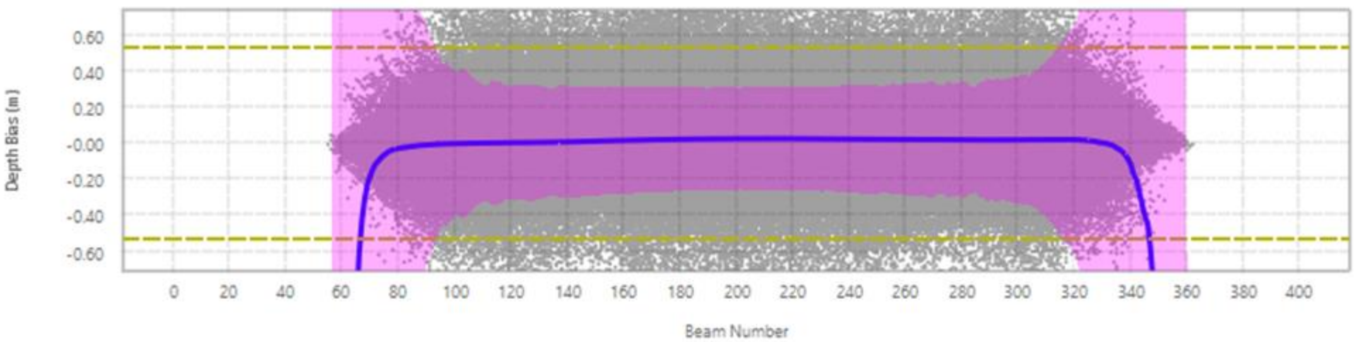
<u>Scatter: Depth Bias (m) vs. Beam Angle (Degrees from Nadir)</u>



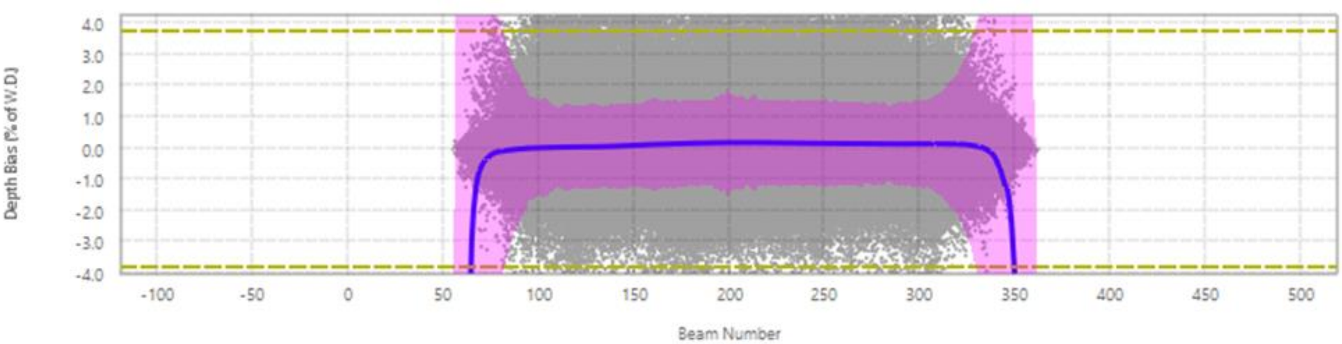
Scatter: Depth Bias (% Water Depth) vs Beam Angle (Degrees from Nadir)



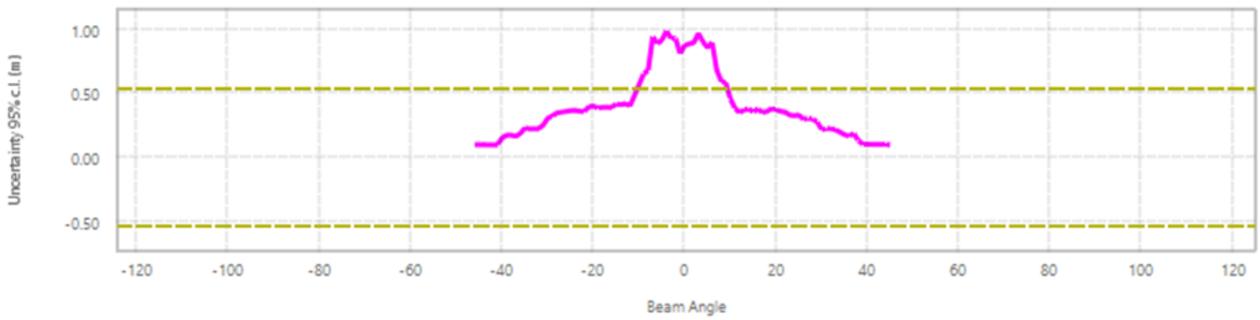
Scatter: Depth Bias (m) vs Beam Number



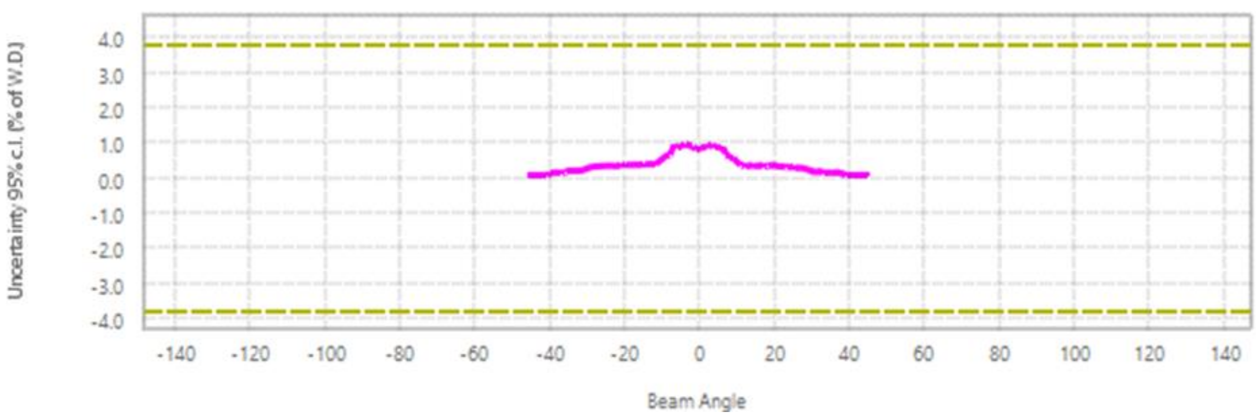
Scatter: Depth Bias (% Water Depth) vs Beam Number



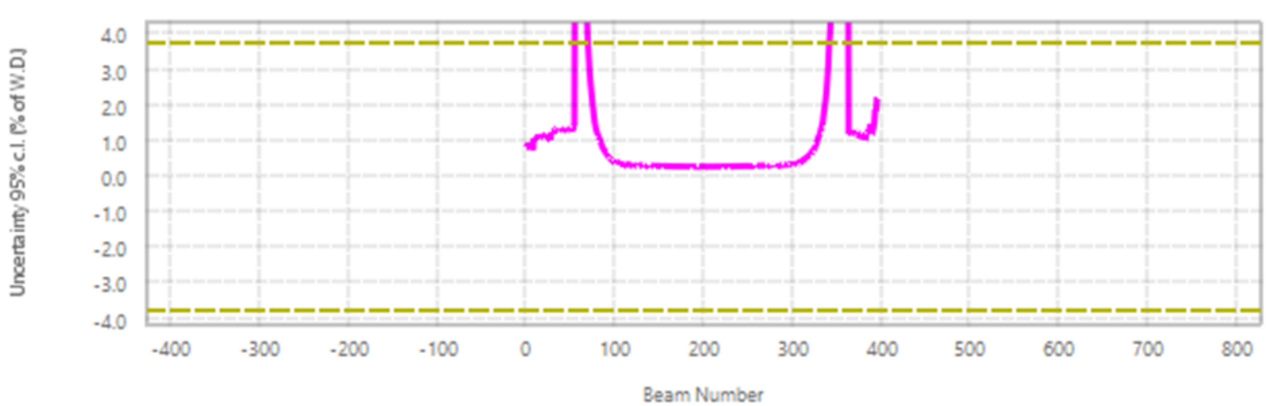
Uncertainty: Depth Bias (m) vs Beam Angle (Degrees from Nadir)



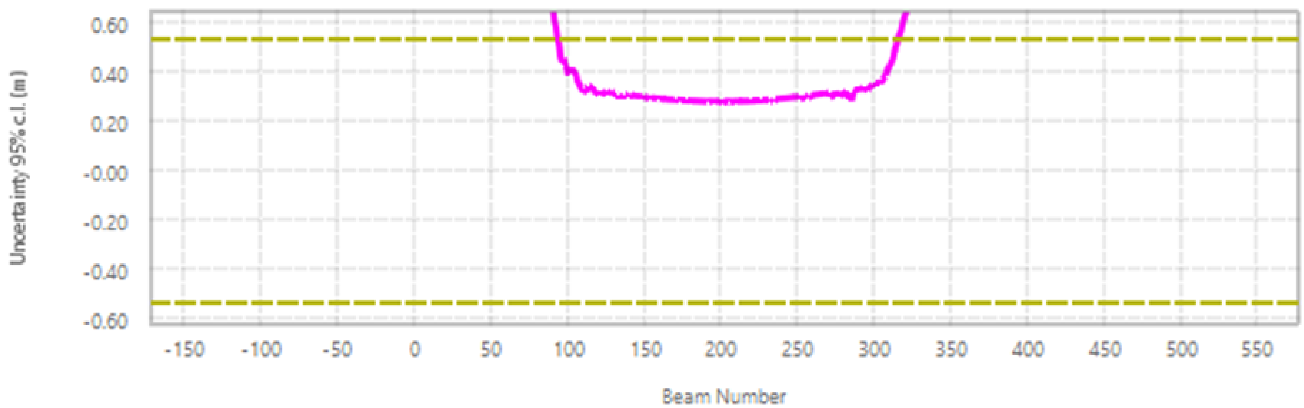
Uncertainty: Depth Bias (% Water Depth) vs Beam Angle (Degrees from Nadir)



Uncertainty: Depth Bias (% Water Depth) vs Beam Number

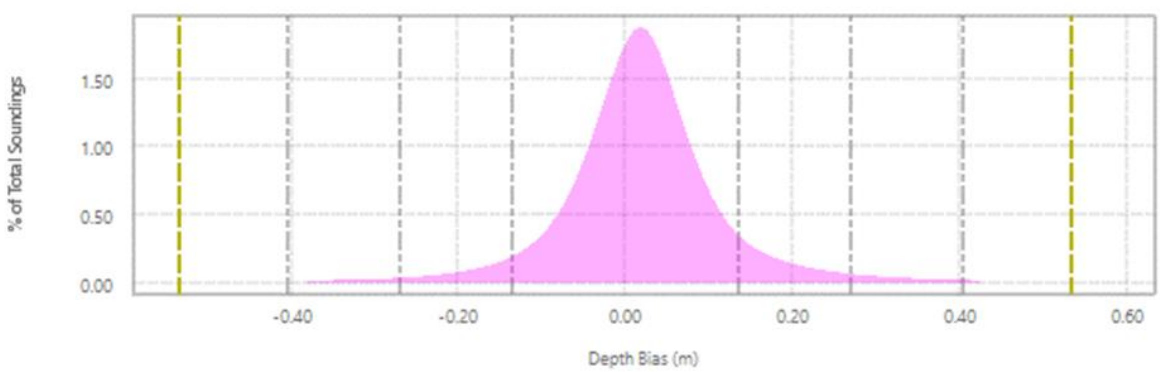


Uncertainty: Depth Bias (m) vs Beam Number

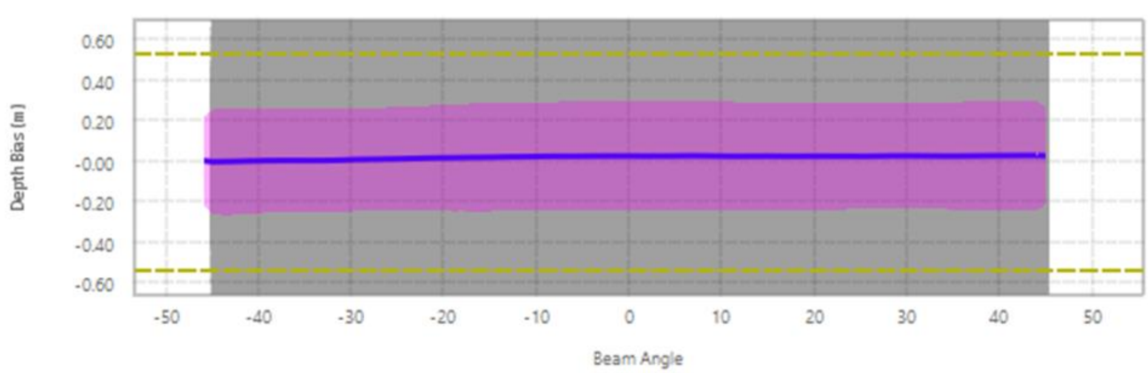


SECTION 2: Crossline statistical plots for W00648_3 (2022-2023)

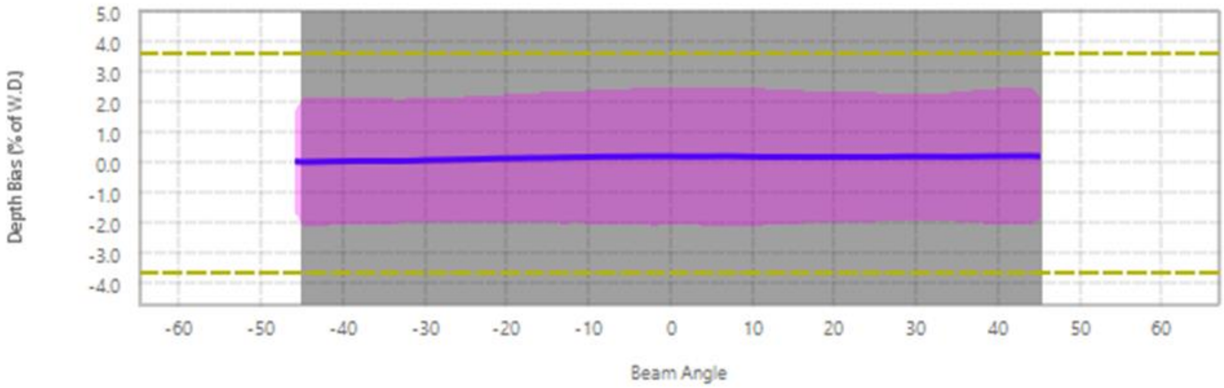
Histogram



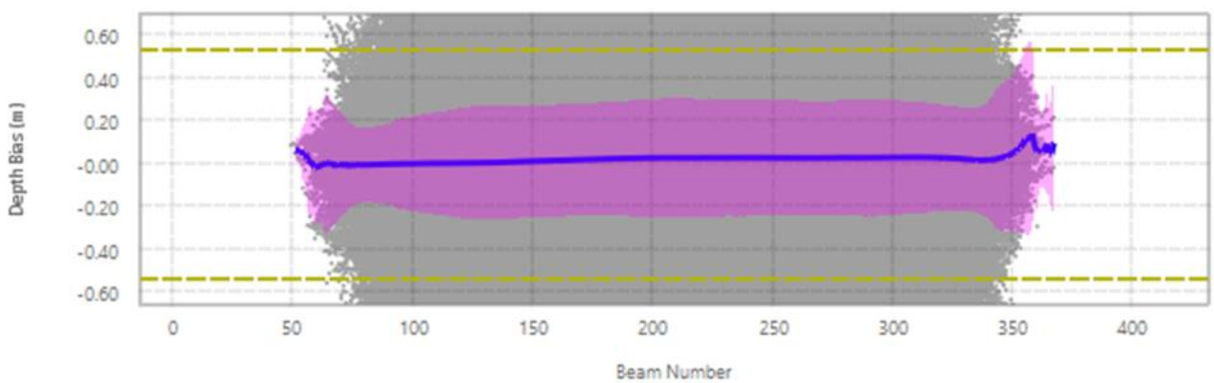
Scatter: Depth Bias (m) vs. Beam Angle (Degrees from Nadir)



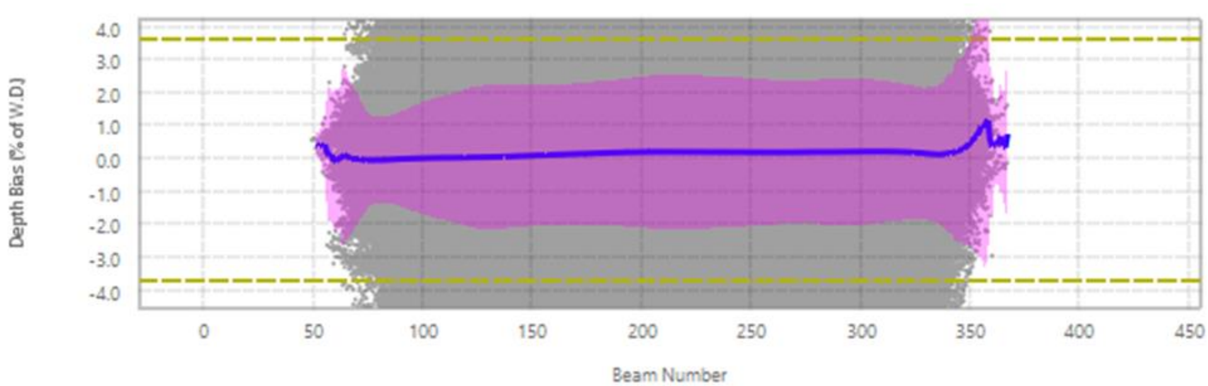
Scatter: Depth Bias (% Water Depth) vs Beam Angle (Degrees from Nadir)



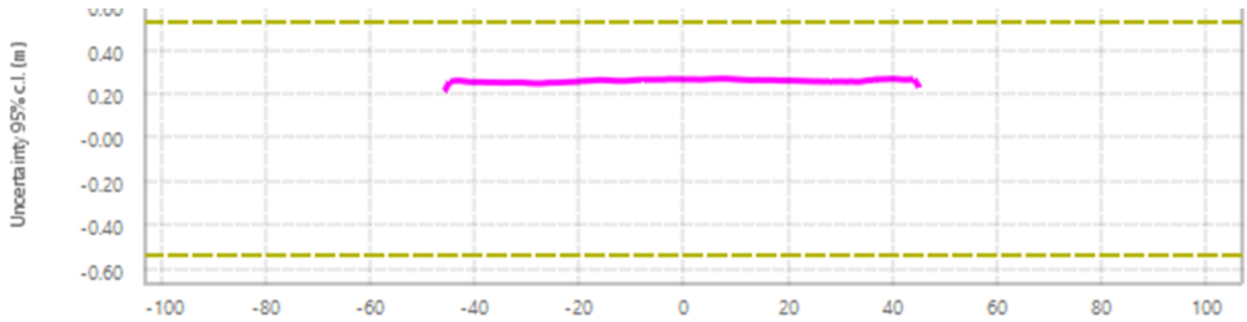
Scatter: Depth Bias (m) vs Beam Number



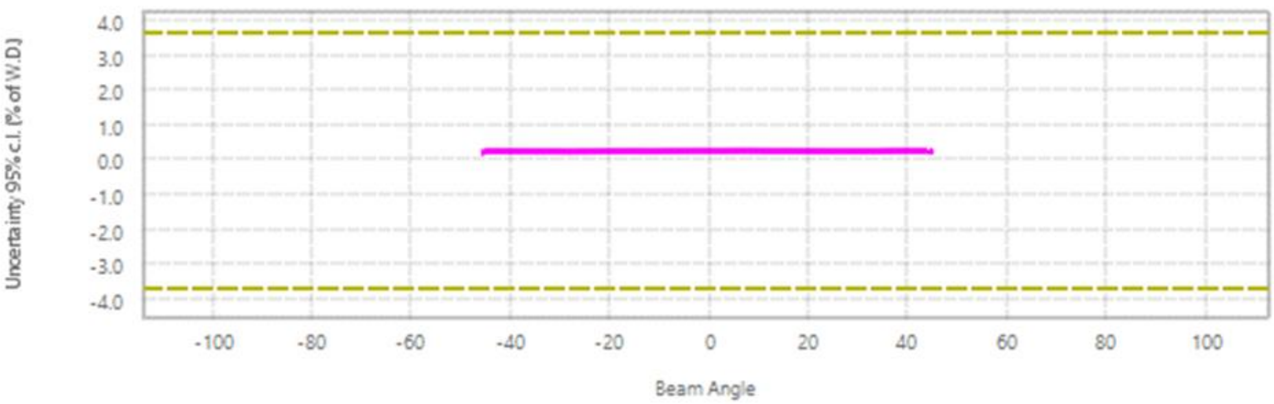
Scatter: Depth Bias (% Water Depth) vs Beam Number



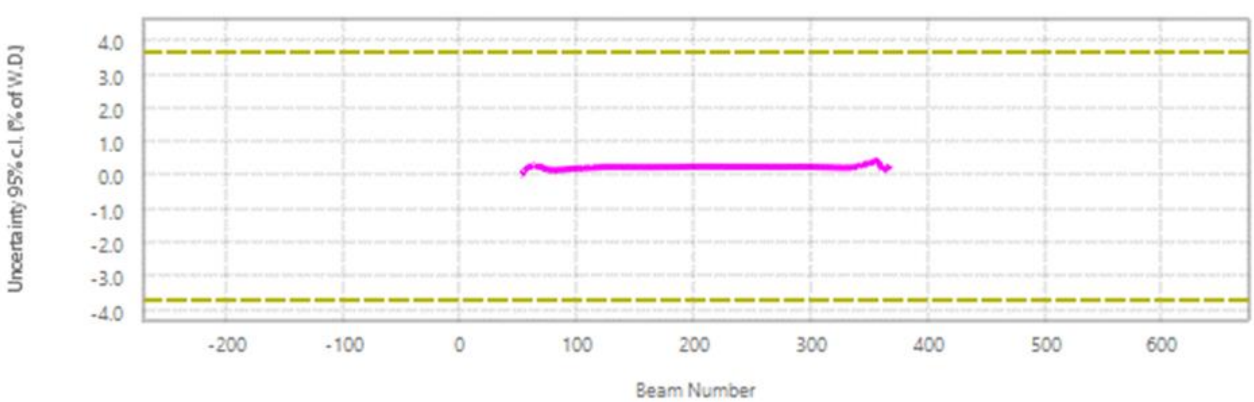
Uncertainty: Depth Bias (m) vs Beam Angle (Degrees from Nadir)



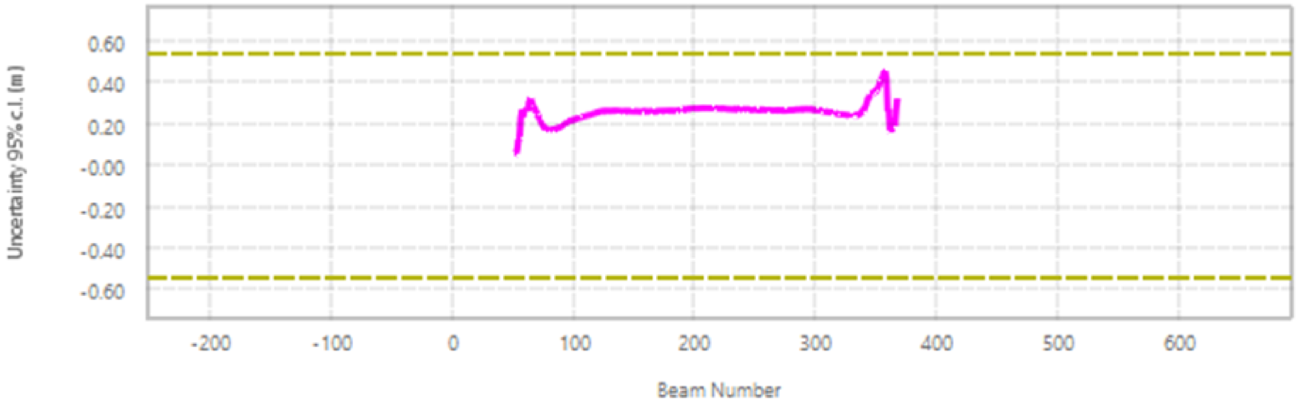
Uncertainty: Depth Bias (% Water Depth) vs Beam Angle (Degrees from Nadir)



Uncertainty: Depth Bias (% Water Depth) vs Beam Number



Uncertainty: Depth Bias (m) vs Beam Number



Appendix H – Modified CMECS Classification Scheme Used by MCMI

Modified CMECS Substrate Group	CMECS Substrate SubGroup	Modified CMECS Substrate Groups for 7-Class Textural Model	Modified CMECS Substrate Groups for 4-Class Textural Model
Bedrock/rocky		Bedrock/rocky (confirmed with video)	Bedrock/rocky
Gravel	Boulder	Gravel/gravel mixes (samples containing ≥ 30% gravel)	Gravel/gravel mixes/gravelly/slightly gravelly
	Cobble		
	Pebble		
	Granule		
Gravel Mixes	Sandy Gravel		
	Muddy Sandy Gravel		
	Muddy Gravel		
Gravelly	Gravelly Sand	Gravelly medium-coarse sand (includes samples with 5-30% gravel and samples with >90% sand with a mean phi size < 2, even if gravel content is up to 5%)	
	Gravelly Muddy Sand		
	Gravelly Mud		
Sand	Very Coarse Sand		
	Coarse Sand		
	Medium Sand		
	Fine Sand	Fine sand (samples having 0-5% gravel, ≥ 90% sand, and a mean phi size between 2 and 4)	Fine and (fine sand + muddy sand)
	Very Fine Sand		
Muddy Sand	Silty Sand	Muddy sand (silty sand + clayey sand + muddy sand; Folk, 1974)	
	Silty-Clayey Sand		
	Clayey Sand		
Sandy Mud	Sandy Silt	Mud (sandy mud + silt + clay)	Mud
	Sandy Silt-Clay		
	Sandy Clay		
Mud	Silt		
	Silt-Clay		
	Clay		
Slightly Gravelly	Slightly Gravelly Sand	Slightly gravelly sand-mud mixtures (0.01-5% gravel, excluding samples with > 90% sand)	Gravel/gravel mixes/gravelly/slightly gravelly
	Slightly Gravelly Muddy Sand		
	Slightly Gravelly Sandy Mud		
	Slightly Gravelly Mud		