2022 Descriptive Report of Seafloor Mapping: Vicinity of Monhegan Island

Chief of Party – Peyton Benson, Project Hydrographer, Contractor to the Maine Coastal Program

Program Manager – Claire Enterline, Research Coordinator, Maine Coastal Program



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: <u>https://www.maine.gov/dmr/mcp/planning/mcmi/index.htm</u>.

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Maine Coastal Mapping Initiative Maine Coastal Program Department of Marine Resources			
]	DESCRIPTIVE REPORT		
Type of Survey:	Navigable Area		
Registry Number:	W00649		
	LOCALITY		
State(s):	Maine		
General Locality:	Gulf of Maine		
Sub-Localities:	Vicinity of Monhegan Island		
2023			
CHIEF OF PARTY			
Peyton Benson, Hydrographer, Contractor to the State of Maine			
LIBRARY & ARCHIVES			
Date:			

	REGISTRY NUMBER:			
HYDR				
	W00649			
INSTRUCTIONS: The hy	ydrographic sheet should be accompanied by this form, filled in as completely as possible, v	when the sheet is forwarded to the Office.		
State(s):	Maine			
General Locality:	Gulf of Maine			
Sub-Locality:	Vicinity of Monhegan Island			
Scale:				
Dates of Survey:	06/14/2022 to 04/14/2023			
Instructions Dated:				
Project Number:				
Field Unit:	Amy Gale			
Chief of Party:	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

From June 14, 2022 through April 14, 2023, the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveys using a multibeam echosounder (MBES) in federal marine waters off mid-coast Maine, southwest of Monhegan Island. 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 the mainscheme survey efforts conducted by MCMI throughout the 2022 survey season. In total, this survey effort collected approximately 76.18 mi² (197.31 km²) of high-resolution multibeam data in the target area and conducted sediment sampling at 60 sites to aid in seafloor characterization. Throughout the survey area which will contribute to improved classification of substrate and modeling of benthic communities.

1.0 Area Surveyed

The survey area collected throughout the span of the 2022 season is situated in the vicinity of Monhegan Island, Gulf of Maine, as shown in Figure 1. The approximately 76.18 mi² survey area consists of all navigable waters from adjoining W00450 and MCMI 2018-2019 Monhegan surveys to the north down to NOAA survey H11347 in the south.

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 data collection, this area was registered with NOAA ESD under pre-registry ID W00649.

Mainscheme survey limits are listed in Table 1. Specific dates of data acquisition for the mainscheme survey are listed in Appendix A.

Table 1 – Survey Limits

2022 Mainscheme Survey Limits

Southwest Limit	Northeast Limit	
43° 31' 38.59" N	43° 43' 03.13" N	
69° 33' 31.54" W	69° 19' 30.86" W	



Figure 1 – General locality of mainscheme survey coverage, plotted over NOAA chart 13288. 3-mile, 8mile, and 12-mile lines shown in magenta



Figure 2 – General locality of mainscheme survey coverage relative to overlapping datasets in the region



Figure 3 – Shaded relief image of mainscheme bathymetry data gridded at 4-meter resolution and colored by depth. Data is overlain on 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 (OCM) and The Nature Conservancy (TNC). 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 Gulf of Maine. 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, 13260, and 13009 in the vicinity of Monhegan Island. 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.

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 2022 survey season.

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 4, 5, and 6), 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 4 - 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.9.5.4) 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.

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		

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

* 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 \pm 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 \leq 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).

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

Table 3 – 2017 equipment reference frame measurements for Seapath 330



Figure 5 – 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 6 – 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 east-west orientation, but variation was necessary for highly dynamic areas such as over ledges and scours. 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.

2.6 Calibrations

Patch tests were conducted aboard the F/V Amy Gale at the beginning of the survey season 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.2.5.3) 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.

Туре	Offsets 06/14/22	Offsets 02/07/23
Roll (degrees)	0.081	-0.060
Pitch (degrees)	0.474	0.609
Heading (degrees)	1.254	0.695

Table 4 – 2022 Mainscheme Patch test calibration offsets for EM2040C

3.0 Quality Control

3.1 Crosslines

The majority of crosslines for this region were conducted immediately following completion of the region in August and September of 2022. Due to the decision to append a subset of the survey area to these products some time following initial acquisition, final crosslines were delayed until the beginning of the 2023 survey season for the westernmost portion of the dataset. Final crosslines were collected in April 2023.

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 7) (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 29% of survey area coverage. Crossline sounding agreement with mainscheme data was evaluated by using the crosscheck tool in Qimera version 2.5.3, which performs beam-by-beam statistical analysis.

Results of the statistical analysis showed the mean difference between soundings was 0.051 meters with a standard deviation of 0.389 meters; 95% of all differences were less than 0.829 meters from the mean (Figure 8). Summary statistics for this analysis are shown in Table 5. 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 7 – Location of crosslines (depicted in magenta, with beams filtered outside $\pm 45^{\circ}$) atop bathymetry data



Figure 8 – 2022 mainscheme 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 \pm sigma 1, 2, and 3

Table 5 – 2022 Mainscheme crossline difference (Qimera crosscheck) summary statistics

# of Points of Comparison	40541686
Data Mean	-128.340857 m
Reference Mean	-128.289705 m
Difference Mean	0.051152 m
Difference Median	0.051152 m
Std. Deviation	0.388986 m
Data Z - Range	-194.99 m to -68.08 m
Ref. Z - Range	-193.84 m to -68.89 m
Diff Z - Range	-48.25 m to 48.02 m
Mean + 2*stddev	0.829124 m
Median + 2*stddev	0.829124 m
Order 1a Error Limit	1.741104 m
Order 1a P-Statistic	0.004026
Order 1a - # Rejected	163201
Order 1a Survey	ACCEPTED
Order 1a parameters: $a = 0.25$ ar	hdh = 0.013

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

3.2 Junctions

2022 mainscheme survey coverage was planned such that data would sufficiently overlap to the north and to the south with existing surveys in the region. The junctions shown in Table 6 are the result of overlap between the 2022 mainscheme survey and these existing surveys. The areas of overlap between the 2022 mainscheme survey and the junction surfaces (H13347, W00450, and MCMI 2018-2019 Monhegan survey) were evaluated for sounding agreement by performing surface difference tests in Fledermaus (v.8.5.1), where existing surfaces were subtracted from the newly collected 2022 surface. A summary of surface difference test results is shown in Table 6. The extent of overlap between the 2022 base surface and the existing survey areas are illustrated in Figure 9. Detailed junction surfaces can be seen in Figure 10. The surfaces used for these tests are submitted with the data package accompanying this report.

Table 6 – 2022 Main	scheme survey junctions
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Registry Number	Resolution (m)	Year	Field Unit	Relative Location(s)
H13347	VR	2020	Ferdinand R. Hassler	S
W00450	4	2017	Amy Gale	NW
Pending	4	2018-2019	Amy Gale	NE

Table 7 – Summary of surface difference test results for overlapping (junction) surveys

Junction Surface ID	New Surface ID	Mean (m)	Median (m)	Std. Dev. (m)
H13347_MB_VR_MLLW	W00649_4m_MLLW	0.03	-0.04	0.78
W00450_4m_MLLW	W00649_4m_MLLW	0.07	0.00	0.54
MCMI_2018_2019_Monhe gan_4m_MLLW	W00649_4m_MLLW	0.03	-0.02	0.37

Notable differences between overlapping surveys are likely attributable to poor agreement in rocky areas and motion artifacts resulting from rough survey conditions during acquisition. The greatest disagreement between surfaces is seen in areas of steep, rocky relief where dynamic features and dramatic changes in depth and substrate are present. Additionally, significant wobble caused by excessive motion of the survey vessel are noted throughout both the W00450 and MCMI 2018-2019 Monhegan surveys, which causes greater variability in soundings and slightly lower confidence.

Across all overlapping surfaces, average height agrees by less than 10 centimeters. 95% confidence for all nodes falls within +/- 0.54 meters across both MCMI surveys (W00450 and MCMI 2018-2019), and within +/- 0.78 meters for the extent of overlap with the H13347 survey. These results indicate strong agreement given the depths of survey and verify system accuracy to within desired survey parameters in accordance with Order 1a and NOAA HSSD for this region (International Hydrographic Organization, 2020 & NOAA, 2021).



Figure 9 – Overview of resulting junction surfaces atop 2022 mainscheme survey



Figure 10 – Junction surfaces created from surface differencing in Fledermaus for A) W00649 with W00450, B) W00649 with MCMI 2018-2019 Monhegan survey, and C) W00649 with H13347

3.3 Uncertainty

HydrOffice QC Tools v.3.9.0 Grid QA feature was used to analyze the highest resolution surface for compliance with NOAA allowable uncertainty standards. 99.97% of all nodes in the surface met uncertainty specifications which passes allowable TVU for the given survey. Detailed results from the analysis are shown in Figure 11 below. Uncertainty surface layers are provided with all BAG files submitted with this report.



Figure 11 – Allowable uncertainty statistics for 2022 Mainscheme data (W00649)

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 (> \pm 60 degrees from the nadir as identified by QPS engineers). As a result (and as per QPS recommendation), soundings greater than \pm 60 degrees from the nadir were not included in final bathymetric surfaces.

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. In this data package, only crosslines collected on April 14, 2023 are affected by this change.

All systems performed normally throughout the survey season and no significant failures are worthy of note for the duration of this survey.

3.5 Sound Speed Methods

Sound speed cast frequency: A total of 93 sound speed casts were taken within the boundaries of the W00649 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.2.5.3, 64-bit edition) and Fledermaus (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 12.

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
Mainscheme (W00649)	8418150	NA95	-12	0	0.95



Figure 12 - 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 13) was selected for each surface depending on the grid size of the surface.

CUBE Settings	? ×			
Configuration NOAA_4m				
CUBE Capture Distance: O Distance Scale: 5.00				
Distance Min: 2.828				
CUBE Hypothesis Resolution Algorithm : Number of Samples				
Estimate Offset:	4.00			
Horizontal Error Scale: 1.96				
Advanced <<				
Distance Exponent: 2.00				
Queue Length:	11			
Quotient Limit:	255.00			
Discount Factor:	ount Factor: 1.00			
Bayes Factor Threshold:	: 0.135			
Run Length Threshold:	5			
	OK Cancel			

Figure 13 - 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.

Surface Name	Resolution (m)	Depth Range (m)	Surface Parameter
W00649_4m_MLLW	4	57 - 198	N/A
W00649_8m_MLLW	8	57 - 198	N/A
W00649_16m_MLLW	16	57 – 198	N/A

Table 8 - Bathymetry surfaces submitted for 2022 mainscheme survey data

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.7.10.2, 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 4-meter, 8-meter, and 16-meter resolutions. Mosaics were exported in floating-point GeoTIFF format. The mosaics are shown in Table 9 and Figure 14.

Table 9 - Backscatter mosaics submitted for 2022 mainscheme survey data

Mosaic Name	Pixel Size (m)
W00649_4m_BS	4
W00649_8m_BS	8
W00649_16m_BS	16



Figure 14 – Backscatter mosaic (4-meter pixel size) of 2022 mainscheme 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 1888, but only covered a portion of the region and consisted only of partial bottom coverage. These data were not compared with data collected by the MCMI. No existing surveys with digital sounding data was available for reference for much of the survey area.

Chart	Scale	Source Edition	Source Date	NTM Date
 13288	1:80,000	44	02/2016	5/30/2023
13260	1:378,838	44	10/2019	5/30/2023
13009	1:500,000	38	10/2018	6/14/2023

Table 10 – Largest scale raster charts in survey area

Chart 13288

Surveyed depths show coarse agreement with charted contours in portions of the survey area but much of the data disagrees, especially where contours are absent (Figure 15). Throughout much of the southern portion of the survey area, depths do not agree with marked soundings and show values sometimes exceeding 200 feet deeper than charted. Agreement between surveyed values and charted values were found to be stronger in the northern portion of the dataset, with disagreements becoming more apparent moving south. It is likely this is due to a lack of sounding data and/or outdated data sources within the surveyed region. It is recommended that contours showing disagreement in this area be revised based on the findings of this report. Furthermore, it is recommended that the new data provided by this survey be incorporated into drawing new contours where no sounding data previously existed.

Chart 13260

Surveyed depths show coarse agreement with charted contours in portions of the survey area but much of the data disagrees, especially where contours are absent (Figure 16). Throughout much of the southern portion of the survey area, depths do not agree with marked soundings and show values sometimes exceeding 200 feet deeper than charted. Agreement between surveyed values and charted values were found to be stronger in the northern portion of the dataset, with disagreements becoming more apparent moving south. It is likely this is due to a lack of sounding data and/or outdated data sources within the surveyed region. It is recommended that contours showing disagreement in this area be revised based on the findings of this report. Furthermore, it is recommended that the new data provided by this survey be incorporated into drawing new contours where no sounding data previously existed.

Chart 13009

Surveyed depths show coarse agreement with charted contours in portions of the survey area but much of the data disagrees, especially where contours are absent (Figure 17). Throughout much of the southern portion of the survey area, depths do not agree with marked soundings and show values sometimes exceeding 200 feet deeper than charted. Agreement between surveyed values and charted values were found to be stronger in the northern portion of the dataset, with disagreements becoming more apparent moving south. It is likely this is due to a lack of sounding data and/or outdated data sources within the surveyed region. It is recommended that contours showing disagreement in this area be revised based on the findings of this report. Furthermore, it is recommended that the new data provided by this survey be incorporated into drawing new contours where no sounding data previously existed.



Figure 15 - 2022 Mainscheme data comparison between surveyed depth (re-classified at 60-feet intervals) and chart 13288 contours (60-feet intervals)



Figure 16 – 2022 Mainscheme data comparison between surveyed depth (re-classified at 60-feet intervals) and chart 13260 contours (60-feet intervals)



Figure 17 – 2022 Mainscheme data comparison between surveyed depth (re-classified at 60-feet intervals) and chart 13009 contours (60-feet intervals)

5.2 Bottom Samples

A total of 60 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 26). A total of 52 sites were successfully completed, with 36 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 18 – Bottom sample locations collected over the course of the 2022 season in and around the survey area. Sites classified via modified CMECS 7-class scheme from field observations (Appendix H).

Site Name	Date	Latitude (decimal degrees N)	Longitude (decimal degrees W)	Depth (m)	Grain Size (field observation)	Backscatter Intensity (dE
TRI-1	07/05/2022	43.5995	-69.84725	-87.4	N/A	-32.21
TRI-2	07/05/2022	43.59851667	-69.81718333	-54.9	rock	-13
TRI-3	07/05/2022	43.59288333	-69.79306667	-67.4	rock	-17.09
TRI-4	07/05/2022	43.6065	-69.75398333	-72.9	muddy sandy gravel with large cobbles	-10.48
TRI-5	07/05/2022	43.59986667	-69.71921667	-99.5	N/A	-29.38
TRI-6	07/05/2022	43.58505	-69.72093333	-97.8	silty clayey mud with sand / sandy silty clay	-26.86
TRI-7	07/05/2022	43.59478333	-69.70046667	-50.2	rock	-18.04
TRI-8	07/05/2022	43.61791667	-69.70073333	-90.3	sandy clayey mud	-28.43
TRI-9	07/05/2022	43.60291667	-69.66205	-85.1	rock	-15.2
TRI-10	07/05/2022	43.62623333	-69.63643333	-92.7	gravelly mud with trace sand	-22.45
TRI-11	07/05/2022	43.63035	-69.62381667	-65.7	rock	-13.94
TRI-12	07/05/2022	43.6446	-69.57801667	-99.1	silty mud with trace fine sand	-22.45
TRI-13	07/20/2022	43.53897	-69.8648	-80.5	rock	Unavailabl
TRI-14	07/20/2022	43.536	-69.8479	-90	rock	Unavailable
TRI-15	07/20/2022	43.53266667	-69.80288333	-118.1	silty clayey mud with trace sand and gravel	1.65*
TRI-16	07/20/2022	43.56613333	-69.80735	-110	clayey mud with trace sand	-25.91
TRI-17	07/20/2022	43.55521667	-69.77433333	-119	silty clayey mud with trace sand	Unavailabl
TRI-17 TRI-18	07/20/2022	43.5589	-69.74896667	-117	rock	Unavailabl
TRI-18 TRI-19	07/20/2022	43.5445	-69.74831667	-107		Unavailabl
TRI-19 TRI-20	07/20/2022	43.54111667	-69.69725	-107	slightly gravelly sandy mud silty clayey mud with trace sand	Unavailabl
TRI-21	07/20/2022	43.55323333	-69.68403333	-125	silty clayey mud with trace sand and shell hash	Unavailabl
TRI-22	07/20/2022	43.56058333	-69.64288333	-135	silty clayey mud with trace sand	Unavailabl
TRI-23	07/20/2022	43.57155	-69.6887	-110	clayey mud with trace sand	Unavailabl
TRI-24	07/20/2022	43.58635	-69.64941667	-89.6	rock	Unavailabl
TRI-25	07/26/2022	43.62946667	-69.45856667	-142	clayey mud with trace sand	-19.93
TRI-26	07/26/2022	43.61393333	-69.41156667	-161	clayey silty mud with trace fine sand	Unavailabl
TRI-27	07/26/2022	43.62281667	-69.40556667	-156	clayey silty mud with trace sand	Unavailabl
TRI-28	07/26/2022	43.62825	-69.38288333	-121	clayey mud with trace sand	Unavailabl
TRI-29	07/26/2022	43.64876667	-69.38405	-110	gravelly sandy mud	-16.15
TRI-30	07/26/2022	43.66521667	-69.38356667	-117	clayey mud with trace sand	-18.67
TRI-31	07/26/2022	43.65901667	-69.40758333	-123	clayey mud with trace sand	-18.04
TRI-32	07/26/2022	43.6636	-69.44328333	-121	clayey mud with trace sand	-15.52
TRI-33	07/26/2022	43.6657	-69.48828333	-113	clayey mud with trace sand	-27.17
TRI-34	07/26/2022	43.65653333	-69.49051667	-87.8	rock	Unavailabl
TRI-35	07/26/2022	43.64965	-69.51498333	-120	N/A	Unavailabl
TRI-36	07/26/2022	43.64646667	-69.53255	-96.9	rock	-20.56
TRI-37	08/11/2022	43.60641667	-69.35831667	-103	N/A	Unavailabl
TRI-38	08/11/2022	43.6003	-69.3445	-106	rock	Unavailabl
TRI-39	08/11/2022	43.57283333	-69.343	-130	clayey mud with trace sand	Unavailabl
TRI-40	08/11/2022	43.5471	-69.33345	-135	gravel with large cobbles; consolidated clay chunks present	
TRI-41	08/11/2022	43.53983333	-69.356	-157	N/A	14.88*
TRI-42	08/11/2022	43.55921667	-69.38738333	-128	rock	Unavailabl
TRI-43	08/11/2022	43.53998333	-69.42053333	-146	gravelly mud with trace sand; pebbles present	17.63*
TRI-44	08/11/2022	43.54561667	-69.45748333	-155	silty clayey mud with trace fine sand	7.71*
TRI-45	08/11/2022	43.54703333	-69.42691667	-153	muddy sandy gravel with cobbles	24.8*
TRI-46	08/11/2022	43.56608333	-69.44546667	-149	silty clayey mud with trace sand	Unavailabl
TRI-47	08/11/2022	43.57983333	-69.45785	-155	clayey mud with trace sand	Unavailabl
TRI-48	08/11/2022	43.58231667	-69.38973333	-114	rock	Unavailabl
TRI-49	08/16/2022	43.60338333	-69.47555	-134	N/A	Unavailabl
TRI-50	08/16/2022	43.60598333	-69.50658333	-103	rock	Unavailabl
TRI-51	08/16/2022	43.57826667	-69.5167	-140	silty mud	Unavailabl
TRI-51 TRI-52	08/16/2022	43.55543333	-69.49663333	-140	N/A	Unavailabl
TRI-52 TRI-53	08/16/2022	43.5445	-69.55398333	-132	gravelly sandy mud; large pebbles present	15.98*
TRI-55	08/16/2022	43.53856667	-69.61198333	-137	silty clayey mud with trace sand	7.16*
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TRI-55	08/16/2022		-69.5601	-143	clayey mud with trace sand and gravel	
TRI-56	08/16/2022	43.58401667	-69.56791667	-136	clayey silty mud with trace sand	Unavailabl
	08/16/2022	43.58268333	-69.61311667	-126	slightly sandy mud	Unavailabl
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TRI-57 TRI-58 TRI-59	08/16/2022 08/16/2022	43.61085 43.61548333	-69.59086667 -69.55416667	-131 -134	N/A silty clayey mud with trace sand	Unavailable Unavailable

Table 11 – Grab Sample Information

TRI-6008/16/202243.62176667-69.54516667-89rockUnavailableNote: Backscatter values were unavailable for several grab sites at time of deployment and are shown above.Backscatter values marked with an asterisk were obtained by an EM2040 and are not of the same profile as theEM2040C.

6.0 Summary

A total of 76.18 mi² (197.31 km²) of high-resolution multibeam data were collected throughout the 2022 mainscheme area, located in the vicinity of Monhegan Island, Maine from June of 2022 to April of 2023. Except for select few small holidays due to seafloor elevation-induced sonic shadows, multibeam coverage was 100% in all areas surveyed.

Bathymetry and backscatter data products were produced at 4-meter, 8-meter, and 16-meter grid resolution. 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 52 locations.

Consistency of hydrographic data collected aboard the F/V Amy Gale was reflected in the results of the surface difference tests between crosslines and junction survey data, where mean vertical differences across all tests were less than 10 centimeters, 95% of all nodes having maximum deviation of +/- 0.83 meters, and within allowable tolerances for IHO 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 and NOAA specifications at all depths, where 99.97% of all nodes fell within the allowable range.

Comparisons between survey data and the largest scale nautical charts in the vicinity show coarse agreement with charted contours in portions of the survey area but much of the data disagrees, especially where contours are absent. Throughout much of the southern portion of the survey area, depths do not agree with marked soundings and show values sometimes exceeding 200 feet deeper than charted. Agreement between surveyed values and charted values were found to be stronger in the northern portion of the dataset, with disagreements becoming more apparent moving south. 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

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Appendix A – Specific dates of data acquisition for surveys

Dates (mm/dd/yy) of Data Acquisition for 2022 Mainscheme Surveys*

*Dates of surveys not summarized in this report not listed









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- Processing	TelegramOut3 Ethernet			
- Altitude Processing	TelegramOut4 Serial	Out COM2 9600 n 8 1	POSITION and TIME to OINSv	Disabled OK OK From Control C
E- DGNSS				Disabled OK Ok Ok From
- HP/G2/G4	Configuration details			
BTK	Interface TelegramOut3	Description		
G- MRU	relegramous	Description		
Geometry	Type Ethernet	-		
- Heave config				
Monitoring points Geometry	Cable ID			
Communication interface	▼ I/O properties			
- Input/Output	● Broadcast ○ Unicast ○ M	ulticast		
- Serial port extender	Local interface LAN3 (192.168.)	2.10)		
Data Pool	Edda Interface	2.10)		
- Network	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 O Event driven Time 	her driven	
Connected to Seanath 330				

Apply Breview ■ Vessel Input/Output list ■ Geometry Description ■ Geometry Interface ■ Geometry TelegramOut2 ■ For Configuration details Interface ■ HRU Interface ■ Geometry TelegramOut4 ■ Configuration details Interface Interface TelegramOut4 ■ Hasve config Cable ID ■ Manuterface Telegram Out4 ■ Geometry Heave config ■ Communication interface Folgram Out4 ■ Pool CoM2 ■ Advanced ■ Communication interface ■ Interface ■ Geometry ■ Leigram out properties ■ Format		
Geometry Description B-Seniots C-SNS B-Seniots C-SNS C-Processing Athude Processing B-DGNSS C-SNS B-PG2524 HRU B-Seniotis C-SNS C-SNS B-DGNS C-SNS C-SNS <td>P-Vessel</td> <td></td>	P-Vessel	
Sensors Geometry	Geometry	
Athlude Processing Configuration details Athlude Processing Configuration Con	Sensors Interface Type Direction I/0 Properties I/0 Proper	32 SIMRAD EM3000 to EM2040C CAST ATTITUDE VELOCITY TO EM2
NMEA selection Options NMEA talker ID IN □ Log to file Time precision 2 ÷ Telegram timing Interval (s) 0.100 ○ Event driven ⊙ Timer driven	Geometry Description B-Sensors B-Sensors B-Geometry Processing Athude Processing B-DGNSS B-SBAS HP/G2/G4 B-MRU Geometry Heave config B-MRU Geometry Heave config Communication interface Imput/Dutput Serial point extender Data Pool Network	32 SIMRAD EM3000 to EM2040C DCAST ATTITUDE VELOCITY TO EM2 POSITION and TIME to OINSy ODCAST ATTITUDE VELOCITY to OINSy O Disabled O OK Warning Error 2 Ors-422

Apply	Preview	Revert		
Apply	Input/Output list Interface Type Toppe TelegramOut3 Ethernet Toppe TelegramOut4 Serial TelegramOut5 Ethernet	Direction I/O Properties Out UDP LAN3 3001 BROADCAST Out COM2 9600 n 8 1	Description ATTITUDE VELOCITY TO EM2 POSITION and TIME to QINSy ATTITUDE VELOCITY to QINSy continue or consy	
E - DGNSS - HP/G2/G4 - RTK B - MRU - Geometry - Geometry - Geometry - Communication interface - Ingui/Uniput - Serial port extender - Data Pool - Network	✓ Configuration details Interface TelegramOut5 Type Ethernet Cable ID ✓ I/O properties ④ Broadcast ○ Unicast ○ Mult Local interface LAN4 (192.168.3.1 Remote port 13001 ✓ Telegram out properties Format Seapath binary 1 Options Log to file ✓ Telegram timing	Description	Monitoring point EM2040C •	Disabled OK Warning Error

Address Directory P Vend Decodors Address 122:16:11:50 Open configuration D =	→ Vessel Address 192.168.1.150 Open configuration → Description Type Disabled Image: Configuration ⊖ GNSS → Geometry → Processing Image: Configuration → Athdode Processing → Athdode Processing Image: Configuration ⊕ DINSS → SRAS → HP/G2/G4 RTK → HRU → Geometry → Geometry → Geometry → Here exercising → Geometry → Geometry → Geometry → Here exercising → Geometry → Geometry → Geometry → Here exercising → Geometry → Geometry → Geometry → Horitoring points → Geometry → Geometry → Geometry → Communication interfacee → Input/Output → Geometry → Geometry → Communication interface → Input/Output → Geometry → Geometry → Communication interface → Input/Output → Geometry → Geometry → Communication interface → Input/Output → Geometry → Geometry → Communication interface → Input/Output → Geometry → Geometry → Communication interface <t< th=""><th>NAV Engine Configuration</th><th></th><th></th><th></th></t<>	NAV Engine Configuration			
Geometry Geometry	Important Type Important Type </th <th>Apply</th> <th>Preview</th> <th>Revert</th> <th></th>	Apply	Preview	Revert	
		Vessel Geometry Ge	Address 192.168.1.150 Open confi		

Apply	Preview		Revert		
E-Vessel	Data pool parameters	1			
Geometry	Processing unit name	Unit#1			
- Description - Sensors	Network interface name	LAN2 (192.168.1.10) •			
E GNSS					
- Geometry - Processing	UDP address	239.255.0 .3			
- Attitude Processing	UDP port	31000			
E- DGNSS	L				
- HP/G2/G4					
- Geometry					
- Heave config					
Geometry					
Communication interface Input/Dutput					
 Serial port extender 					
Data Pool Network					
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			1	
Apply	Preview	<u>R</u> evert		
Connected to Seapath 330	Interface settings Interface AN1 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 Apply Restore			

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

	Information: General
- III General - 🖉 Geodetic	
Datums	Line name: No line name
G WGS84	Line sequence number: 1
⊟ <u>≭</u> Heights	Line description: N/A
🖉 🖄 🖉 🖉 🖉	
Mean Water Level Model	
🛣 Digital Terrain Models	
🖻 🐻 Projections	
🕞 Local Construction Grid	
- O UTC to GPS Correction	
C Sound Velocity Profile	
Object	
- Amy Gale	
🕞 🏭 System	
id-∯ Gyro ↓ ↓ Gyro	
- 2 Position Navigation System	
□ ¥ Variable Node	
Amy Gale MRU	
B Link	
Auxiliary Systems	
ð Time Sync	
EM2040C Controller	
D+ ASCII Logger	
Fixed Node	

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- ∰ General - ∰ Geodetic		
Datums	Predefined system:	Not Defined
WGS84	Survey unit name:	Meters
🛱 🛣 Heights	Conversion factor to metres:	1.0000000000000
🛣 Chart Datum / Vertical Datum	WKT blob:	2
Mean Water Level Model	WKT string:	PROJCS["Universal Transverse Mercator (North
🚽 🖄 Digital Terrain Models		Hemisphere)",
Projections _ _ _ Universal Transverse Mercator (North Hemisphere)		GEOGCS["WGS84", DATUM["WGS84",
		SPHEROID["WGS 1984", 6378137, 298.2572235
Ø UTC to GPS Correction		UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]]],
C Sound Velocity Profile		PRIMEM["Greenwich", 0, AUTHORITY["EPSG",
Object		"8901"]],
📲 Amy Gale		UNIT["degree", 0.0174532925199433, AUTHORITY["EPSG", "9102"]]],
🖨 🔚 System		PROJECTION_NAME["Universal Transverse Mercator
		(North Hemisphere)", AUTHORITY["EPSG", "9807"]],
ן לא Gyro		PROJECTION["Transverse Mercator",
-↓s″ Gyro		AUTHORITY["EPSG", "9807"]],
→ → → → → → → → → →		PARAMETER["latitude_of_origin", 0, UNIT["degree", 0.0174532925199433, AUTHORITY["EPSG", "9102"]]],
└─┴ Position Navigation System		PARAMETER["central_meridian", -69, UNIT["degree"
Amy Gale MRU		0.0174532925199433, AUTHORITY["EPSG", "9102"]]],
		PARAMETER["false_easting", 500000, UNIT["meter",
● TX		AUTHORITY["EPSG", "9001"]]],
B Link		PARAMETER["false_northing", 0, UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]],
Auxiliary Systems		PARAMETER["scale_factor", 0.9996, UNIT["unity", 1,
🗝 🕉 Time Sync		AUTHORITY["EPSG", "9201"]]],
EM2040C Controller		UNIT["meter", 1, AUTHORITY["EPSG", "9001"]]],
		METADATA["WGS84",
Fixed Node		PARAMETER["version", 2], PARAMETER["timestamp",
		"20210225T035001.424000"]]

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⊇ III Survey	Datums: Datums	
- 🕅 General	Datams. Datams	
Geodetic	Survey datum: WGS84	
WGS84	Chart datum: WGS84	
e	Height file: N/A	
L → A heights	Height level: No Level Correction	
America Mean Water Level Model	Height file: N/A	
Z Digital Terrain Models	Height offset: 0.000 m	
Projections		
- Marcator (North Hemisphere)		
Local Construction Grid		
- 💩 UTC to GPS Correction		
Sound Velocity Profile		
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🖨 🏧 Amy Gale		
🖨 🔚 System		
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-# Pitch Roll Heave Sensor		
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Auxiliary Systems		
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EM2040C Controller		
ASCII Logger		
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General	Datum: WGS84
- 🕉 Geodetic	Datum name: WGS84
🖨 🥵 Datums	Spheroid name: WGS 1984
GS84 WGS84	Prime meridian: Greenwich
in	
—	Prime meridian: 0;00;00.000 E
2 Digital Terrain Models	Conversion factor to metres: 1.0000000000000
	Semi-major axis (a): 6378137.000 m
- Superior Content of	Semi-minor axis (b): 6356752.314 m
Local Construction Grid	Inverse flattening (1/f): 298.257223563000
💩 UTC to GPS Correction	Flattening (f): 0.003352810664747
-	First eccentricity (e): 0.081819190842621
d Object	First eccentricity squared (e**2): 0.006694379990141
Amy Gale	Second eccentricity (e'): 0.082094437949696
🖃 🔚 System	Second eccentricity squared (e'**2): 0.006739496742276
- MEM2040C	
白 夕 Gyro 一 上, Gyro	
→ Gyro	
L Position Navigation System	
⊨ Y Variable Node	
• Amy Gale MRU	
— ◎ RX	
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Auxiliary Systems	
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EM2040C Controller	
✓ Fixed Node	

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I General	Heights: Heights
a Geodetic	Chart datum: WGS84
Datums	Height file: N/A
WGS84	Height level: No Level Correction
A Heights A Chart Datum / Vertical Datum	Height file: N/A
A Mean Water Level Model	Height offset: 0.000 m
Digital Terrain Models	
	MWL model: Horizontal Datum
Universal Transverse Mercator (North Hemisphere)	MWL file: N/A MWL level: No Level Correction
Local Construction Grid	MWL file: N/A
💩 UTC to GPS Correction	MWL offset: 0.000 m
C Sound Velocity Profile	MWL st.dev.: 0.000 m
Object Amy Gale	
📥 Any Gale	DTM mode: Absolute DTMs
EM2040C	DTM datum: WGS84
⊕ Ø Gyro	DTM file: N/A
Lip" Gyro	DTM level: No Level Correction
	DTM file: N/A
L Position Navigation System	DTM offset: 0.000 m
È-X Variable Node │	
o TX	
B Link	
Auxiliary Systems	
💩 Time Sync	
EM2040C Controller	
- D+ ASCII Logger	
Fixed Node	

Survey	Height Datum: Chart Datum / Vertical Datum	
Geodetic	Chart datum: WGS84	
🖨 🗣 Datums	Height file: N/A	
WGS84	Height level: No Level Correction	
🕂 🛣 Heights	Height file: N/A	
🚽 Chart Datum / Vertical Datum		
Amean Water Level Model	Height offset: 0.000 m	
E Projections		
- 10 Universal Transverse Mercator (North Hemisphere)		
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Sound Velocity Profile		
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Auxiliary Systems		
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₩ <mark>' Survey</mark> -	MWL Model: Mean Water Level Model	
Geodetic	MWL model: Horizontal Datum	
LG WGS84	MWL file: N/A	
⊖ Ż Heights	MWL level: No Level Correction	
🚽 🛓 Chart Datum / Vertical Datum	MWL file: N/A	
📥 Mean Water Level Model	MWL offset: 0.000 m	
🚽 👷 Digital Terrain Models	MWL st.dev.: 0.000 m	
🗄 🌆 Projections		
-🔣 Universal Transverse Mercator (North Hemisphere)		
Local Construction Grid		
- Ö UTC to GPS Correction		
上 Sound Velocity Profile		
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ian Any Gale		
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Gyro		
🚽 Pitch Roll Heave Sensor		
Position Navigation System		
🛱 💥 Variable Node		
- 🗣 Amy Gale MRU		
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🔲 🖁 Link Standard Systems		
Time Sync		
EM2040C Controller		
ASCII Logger		
Fixed Node		
8		

⇒ III Survey	DTM Mode: Digital Terrain Models
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Survey	Projections: P	Projections: Projections		
🖶 🕈 Geodetic	Projection type:	0001		
🖨 🗣 Datums	Projection name:	Universal Transverse Mercator (North Hemisphere)		
- 3 WGS84				
会社 Heights 一変 Chart Datum / Vertical Datum				
→ Chart Datum / Vertical Datum → Mean Water Level Model	Construction grid type:	Undefined		
🚽 Digital Terrain Models				
Universal Transverse Mercator (North Hemisphere)				
Local Construction Grid				
- 💩 UTC to GPS Correction				
LC Sound Velocity Profile				
B Object				
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EM2040C ⊟-Ø [°] Gyro				
Gyro				
₩ Pitch Roll Heave Sensor				
L Position Navigation System				
□.¥ Variable Node				
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Auxiliary Systems				
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arrow Geodetic brain the second sec	Projection type:	0001
WGS84	Projection name:	Universal Transverse Mercator (North Hemisphere)
🖻 🛣 Heights	Conversion factor to metres:	1.0000000000000
🚽 🖄 Chart Datum / Vertical Datum	UTM zone number:	19
- 📩 Mean Water Level Model	UTM central meridian:	69;00;00.00000 W
🚽 💆 Digital Terrain Models	Latitude of grid origin:	0;00;00.00000 N
Fojections Juniversal Transverse Mercator (North Hemisphere)	Longitude of grid origin:	69:00:00.00000 W
	Grid Easting at grid origin:	50000.000 m
− [®] UTC to GPS Correction	Grid Northing at grid origin:	0.000 m
Sound Velocity Profile	Scale factor at longitude of origin:	
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📥 🏧 Amy Gale		
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🕀 🐺 Survey	Local Grid: Local Construction Grid		
- I General □ - & Geodetic			
Batums	Construction grid type: Undefined		
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🚽 Digital Terrain Models			
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G WGS84 ⊖-∰ Heights		
→ → Preignts → → ☆ Chart Datum / Vertical Datum		
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上ご Sound Velocity Profile 語 Object		
🗄 🏧 Amy Gale		
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→ Pitch Roll Heave Sensor		
└─┴ Position Navigation System □-┴ Variable Node		
-• Amy Gale MRU		
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EM2040C Controller De ASCII Logger		
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Survey	Object: Amy Gale				
General General General General Geodetic Datums Quiversal Transverse Mercator (North Hemisphere) Quiverse Transverse Me	Object: Amy Gale Object reference number: Object type: Description of reference point: Height above draft reference: Squat model: SD draft: SD squat: SD load: SD tide: Time latency navigation: Time correction to GMT (UTC): Time correction to master vessel's time:	1 Vessel Amy Gale MRU 0.000 m Not Defined 0.050 m 0.050 m 0.050 m 0.050 m 0.050 m 0.050 m 0.000 m 0.025 s 0.000 h 0.000 s			

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General	System: EM2040C				
Geodetic	Description:	EM2040C			_
🛱 🌗 Datums		Multibeam Echosounder			
G WGS84	Type:				
🖨 🚖 Heights	Driver:	Kongsberg EM2040/EM710/EM302/EM122			
🚽 🛣 Chart Datum / Vertical Datum	Executable and Cmdline:	DrvKongsbergEM.exe			
📥 Mean Water Level Model	Driver specific settings:	MANUFACTURER=2;MODEL=2045;RAW_BATHY=1;RAW_SNIP=1;RAW_WCD=1;			_
🚽 📩 Digital Terrain Models	Port:	2001			
E Projections	Update rate:	0.000 s			
题 Universal Transverse Mercator (North Hemisphere) 	Acquired by:	[Directly into Qinsy] (No additional time tags)			-
-@ UTC to GPS Correction	Observation time from:	N/A			
Sound Velocity Profile	Number of slots:	1			-
Object					
Amy Gale	Manufacturer:	Kongsberg			
🛓 🔚 System	Model:	EM2040C			_
EM2040C	Object location:	Amy Gale			
⊨ Ø Gyro	Node name:	RX			
La Gyro	X (Stbd = Positive)::	0.000 m			
-# Pitch Roll Heave Sensor	Y (Bow = Positive)::	-0.045 m			
La Position Navigation System	Z (Up = Positive)::	0.006 m			
□ ¥ Variable Node	A-priori SD:	0.010 m			
	Roll offset:	0.332			-
	Pitch offset:	0.279			
© TX ■S Link	Heading offset:	-0.181			
Auxiliary Systems	-				_
- Time Sync	Unit is roll stabilized:	No			
EM2040C Controller	Unit is pitch stabilized:	No			
- ASCII Logger	Unit is heave compensated:	No			
Fixed Node	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	<i>.</i>	-	
	Slot:	1			-
	SD type:	Pulse, Sampling			-
	SD pulse length:	0.150 ms			
	SD puise length: SD sampling length:	0.050 m			

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📮 🌉 Survey	Update rate:	0.000 s
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E & Geodetic	Observation time from:	N/A
Datums	Number of slots:	1
Heights	Manufacturer:	Kongsberg
A Chart Datum / Vertical Datum	Model:	EM2040C
📥 Mean Water Level Model	Object location:	Amy Gale
🚽 📩 Digital Terrain Models	Node name:	RX
E Projections	X (Stbd = Positive)::	0.000 m
- SUniversal Transverse Mercator (North Hemisphere)	Y (Bow = Positive)::	-0.045 m
Local Construction Grid O	Z (Up = Positive)::	-0.045 m 0.006 m
Sound Velocity Profile	A-priori SD:	0.010 m
Big Object	Contraction and	
🖨 🏧 Amy Gale	Roll offset:	0.332
🖨 📒 System	Pitch offset:	0.279
- <u>M</u> EM2040C	Heading offset:	-0.181
⊜ \$° Gyro	Unit is roll stabilized:	No
L, [™] Gyro	Unit is pitch stabilized:	No
	Unit is heave compensated:	No
a → Variable Node	Beam steering (flat transducer):	No
Amy Gale MRU	Beam angle width along:	1.500 m
- • RX	Beam angle width across:	1.500 m
	Maximum number of beams per ping:	800
S Link	Use sound velocity from unit:	Yes
E-III Auxiliary Systems	Slot:	1
— Ö Time Sync — EM2040C Controller	SD type:	Pulse, Sampling
- D ASCII Logger	SD pulse length:	0.150 ms
- Fixed Node	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
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Survey	Sustam: Gur						
- 🕜 General	System: Gyro						
🚍 🖝 Geodetic	Description:	Gyro					
🖻 🧐 Datums	Type:	Gyro Compass					
- 3 WGS84	Driver:	Network - Seapath Binary Format 11 (Hdg) (With UTC)					
i in the second		DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS					
					-		
- Z Digital Terrain Models	Port:	13001					
	Update rate:	0.000 s					
- Universal Transverse Mercator (North Hemisphere)	Latency:	0.000 s					
- Local Construction Grid	Acquired by:	[Directly into Qinsy] (No additional time tags)					
- 💩 UTC to GPS Correction	Observation time from:	N/A					
Sound Velocity Profile	Number of slots:	0					
e 😫 Object							
are Amy Gale							
ー ← EM2040C ⊕ ゆ Gyro ↓ ↓ Gyro ↓ Pitch Roll Heave Sensor ↓ Position Navigation System							
 ➡ Variable Node ➡ Amy Gale MRU ■ RX ■ TX ■ Link 							
→ ▲uxiliary Systems → ▲ Time Sync → ■ EM2040C Controller → ASCII Logger							
→ Fixed Node							
Qinsy 9 For Help, press F1	1						

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File Edit View Options Help	1		 	
E W Survey	Observation	Gyro		
- 🖪 General	Observation	aylo		
🖨 🔏 Geodetic	Observation description:	Gyro		
Datums	Observation type:	Bearing (True)		
GS84	'At' node:	Amy Gale MRU		
er Heights → ☆ Chart Datum / Vertical Datum	Measurement unit code:	 There is a state of the state o		
Mean Water Level Model	10 72 80	Gyro	 	
Digital Terrain Models	System description:		 	
	(C-O) option:	(C-O) offsets applied first		
- Superior States - S	Scale factor:	1.0000000000		
Local Construction Grid	Fixed system (C-O):	0.000000000		
- 💩 UTC to GPS Correction	Variable (C-O):	0.0000000		
Sound Velocity Profile	A-priori SD:	0.5000		
🕀 🚼 Object			 	 -
📥 🏧 Amy Gale				
🖨 🚟 System				
⊟ \$° Gyro				
L. Gyro				
-# Pitch Roll Heave Sensor				
L⊥ Position Navigation System				
Amy Gale MRU				
- • RX				
o TX				
S Link				
Auxiliary Systems				
- Time Sync				
EM2040C Controller				
→ ASCII Logger				
└────────────────────────────────────				
Qinsy 9 For Help, press F1				

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram			
				_
Survey	System: Pitch Roll	Heave Sensor		
- 🕼 General	System. Then non			_
Datums	Description:	Pitch Roll Heave Sensor		
WGS84	Туре:	Pitch Roll Heave Sensor		
⊟ ± Heights	Driver:	Network - Seapath MRU Binary Format 11 (With UTC)		
Chart Datum / Vertical Datum	Executable and Cmdline:	DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS		
Mean Water Level Model	Port:	13001		
🛓 🛓 Digital Terrain Models	Update rate:	0.000 s		
Projections	Latency:	0.000 s		
- 🔁 Universal Transverse Mercator (North Hemisphere)	Acquired by:	[Directly into Qinsy] (No additional time tags)		-
Local Construction Grid	and the second			
💩 UTC to GPS Correction	Observation time from:	N/A		_
Sound Velocity Profile	Number of slots:	0		
Object	Object:	Amy Gale		
🔤 Amy Gale	PRH sensor reference number:	1		
EM2040C	Rotation convention pitch:	Positive bow up		
B Ø Gyro	Rotation convention roll:	Positive heeling to starboard		
Gvro	Angular variable measured:	HPR (roll first)		
→ Hitch Roll Heave Sensor	Angular measurement units:	Degrees		
L Position Navigation System	Sign convention heave:	Positive upwards		
⊨ X Variable Node	Measurement unit heave:	Meters		
Amy Gale MRU	Conversion factor to degrees decimal:			
® RX	Conversion factor to metres:	N/A		
E © TX	A BARCATARY A CONTRACTOR OF A CONTRACT BARCATARY A CONTRACTOR	All the test of the second s		
Link	Quality indicator type pitch and roll:	No quality info recorded		
Auxiliary Systems	Quality indicator type heave:	No quality info recorded		
Time Sync	Description of quality indicator type:	N/A		_
 EM2040C Controller ASCII Logger 	Object location:	Amy Gale		
Fixed Node	Node name:	Amy Gale MRU		
HAEU NOUE	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		-
	ricave time delay.	0.000 3		

E 🎢 🔚 🙏 💿 🖉 🛛 📴 🔤 📟 🔒	89		
The second s			
- III General	Latency:	0.000 s	
eneral	Acquired by:	[Directly into Qinsy] (No additional time tags)	
Datums	Observation time from:	N/A	
WGS84	Number of slots:	0	
🖨 🚖 Heights	Object:	Amy Gale	
🚽 🛣 Chart Datum / Vertical Datum	PRH sensor reference number:	1	
📥 Mean Water Level Model	Rotation convention pitch:	Positive bow up	
🚽 🛓 Digital Terrain Models	Rotation convention roll:	Positive heeling to starboard	
Kernel Transmission (Neath Units Inc.)	Angular variable measured:	HPR (roll first)	
Universal Transverse Mercator (North Hemisphere) Local Construction Grid	Angular measurement units:	Degrees	
- O UTC to GPS Correction	Sign convention heave:	Positive upwards	
Sound Velocity Profile	Measurement unit heave:	Meters	
H Object	Conversion factor to degrees decimal:		
🗄 🛄 Amy Gale	Conversion factor to metres:	N/A N/A	
🖨 🔚 System			
	Quality indicator type pitch and roll:	No quality info recorded	
⊕ \$ [°] Gyro	Quality indicator type heave:	No quality info recorded	
Gyro →★ Pitch Roll Heave Sensor	Description of quality indicator type:	N/A	
- Position Navigation System	Object location:	Amy Gale	
Stein Variable Node	Node name:	Amy Gale MRU	
Amy Gale MRU	X (Stbd = Positive)::	0.000 m	
- • RX	Y (Bow = Positive)::	0.000 m	
	Z (Up = Positive)::	0.000 m	
Link	A-priori SD:	0.000 m	
Auxiliary Systems	(C-O) roll offset:	0.000 °	
Ö Time Sync	(C-O) pitch offset:	0.000 °	
EM2040C Controller	(C-O) heave offset:	0.000 m	
→ ASCII Logger → Fixed Node	Heave time delay:	0.000 s	 _
Pixed Node	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	

E 🎢 🔜 🙏 💿 🖉 🔢 🕎 🔤 🔤 🛛 🔒		
Survey	System: Pos	ition Navigation System
 Survey General Geodetic 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 Many Gale System Yeniable Node RX TX Kulliary Systems Time Sync EM2040C Controller ACCII Logger Fixed Node 	System: Posi Description: Type: Driver: Executable and Cmdline: Port: Update rate: Latency: Acquired by: Observation time from: Number of slots: Satellite system name: Horizontal datum: Vertical datum: Vertical datum: Height file: Height file: Height offset: SD latitude: SD longitude: SD height: Measurement unit: Receiver description: Receiver number: Object location: Node name: X (Stbd = Positive):: Y (Bow = Positive):: Z (Up = Positive):: Z (Up = Positive):: A-priori SD:	ition Navigation System Position Navigation System Position Navigation System Network - Seapath Binary Format 11 (With UTC) DrvQPSCounted/UDP.exe SEAPATH_EMT11 PPS 13001 0.000 s 0.000 m 0.00

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram	- 🗆 X
File Edit View Options Help ■ ½ ■ ↓ ● ∅ □		
Survey	Node: Amy Gale MRU	
Geodetic Geodetic Geodetic Geodetic WGS84 Chart Datum / Vertical Datum Mean Water Level Model Digital Terrain Models Digital Terrain Models Digital Terrain Models Digital Terrain Models Construction Grid Colocat Construction	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 Progr	am	– 🗆 X
File Edit View Options Help		
E W Survey	Node: RX	
	Node: KX Object location: Amy Gale Node name: RX X (Stbd = Positive):: 0.000 m Y (Bow = Positive):: 0.006 m A-priori SD: 0.010 m	
Qinsy 9 For Help, press F1		
consy s Torrieb, press ri		

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Progr	am	– 🗆 X
File Edit View Options Help		
Emeral	Node: TX	
⊟ a Geodetic		
Datums	Object location: Amy Gale	
- WGS84	Node name: TX	
⊖ ★ Heights	X (Stbd = Positive):: 0.040 m	
└ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	Y (Bow = Positive):: 0.004 m	
Mean Water Level Model	Z (Up = Positive):: 0.006 m	
🚖 Digital Terrain Models	A-priori SD: 0.010 m	
Projections		
Universal Transverse Mercator (North Hemisphere)		
Local Construction Grid		
- Ö UTC to GPS Correction		
Sound Velocity Profile		
e 🗄 Object		
🖻 🏧 Amy Gale		
System ▲ ▲ EM2040C		
⊢ ∰ Gyro		
l ↓ Gyro		
₩ Pitch Roll Heave Sensor		
L Position Navigation System		
Amy Gale MRU		
e RX		
Link		
🕀 🔚 Auxiliary Systems		
- 💩 Time Sync		
EM2040C Controller		
ASCII Logger		
→ Fixed Node		
Qinsy 9 For Help, press F1	*	

System: Time Sync		
Description: Type: Driver: Executable and Cmdline: Port: Baud rate: Data bits: Stop bits: Parity: Byte frame length (time): Maximum data transfer rate: Update rate: Latency: Acquired by: Observation time from: Number of slots: Use QPS PPS Adapter: PPS time tag pulse matching:	Time Sync Time Synchronization System NMEA ZDA DrvPositionNMEA.exe 2 9600 8 1 1 None 10 bits (1.042 ms) 960 bytes / second 0.000 s 0.000 s 0.000 s [Directly into Qinsy] (No additional time tags) N/A 0 On COM1 Automatic Matching Synchronization is enabled	
	System: Time SyncDescription:Type:Driver:Executable and Cmdline:Port:Baud rate:Data bits:Stop bits:Parity:Byte frame length (time):Maximum data transfer rate:Update rate:Latency:Acquired by:Observation time from:Number of slots:Use QPS PPS Adapter:PPS time tag pulse matching:	System: Time SyncDescription:Time SyncType:Time Synchronization SystemDriver:NMEA ZDAExecutable and Cmdline:DrvPositionNMEA.exePort:2Baud rate:9600Data bits:8Stop bits:1Parity:NoneByte frame length (time):10 bits (1.042 ms)Maximum data transfer rate:960 bytes / secondUpdate rate:0.000 sLatency:0.000 sAcquired by:[Directly into Qinsy] (No additional time tags)Observation time from:N/ANumber of slots:0Use QPS PPS Adapter:On COM1

Geodetic □ Image: Datums □ Imag	
Geodetic Description: WGS84 Type: ★ Heights Driver: ★ Chart Datum / Vertical Datum Executable and Cmdline ★ Mean Water Level Model Update rate: ★ Digital Terrain Models Latency: ★ Digital Terrain Models Update rate: ▲ Digital Terrain Models Universal Transverse Mercator (North Hemisphere) ▲ Local Construction Grid Observation time from: Number of slots: Number of slots: Object Mary Gale ▲ Amy Gale System ★ Position Navigation System Yariable Node ▲ RX TX ● Link Maxiliary Systems ▲ Tx Time Sync ▲ EM2040C Controller ● ACIL Logger	2040C Controller
Image: Source Controller Type: Image: Source Controller Diver: Image: Source Controller Executable and Cmdline Image: Source Controller Digital Terrain Models Image: Source Control Control Control Update rate: Image: Source Control Control Latency: Image: Source Control Control Acquired by: Image: Source Control Control Distribution Grid Image: Source Control Control Control Number of slots: Image: Source Control Control Control Control Number of slots: Image: Source Control Control Control Control Control Number of slots: Image: Source Control Cont	
→ WigS84 Driver: ★ Heights Executable and Cmdline ★ Mean Water Level Model Update rate: ▲ Digital Terrain Models Update rate: ■ Projections Cost Construction Grid ▲ Utiversal Transverse Mercator (North Hemisphere) Observation time from: Number of slots: Number of slots: ▲ Object Amy Gale ■ Amy Gale System → Position Navigation System → Yoriable Node → Amy Gale MRU ● RX ● Time Sync ■ Tx ● Link Auxiliary Systems → ASCII Logger ■ Ascil Logger	EM2040C Controller
Arreights Action Ac	Miscellaneous System
↓ Chain Datanny Vertical Datanny ↓ Mean Water Level Model ↓ Digital Terrain Models ↓ Local Construction Grid ↓ Local Construction Grid ↓ Local Construction Grid ↓ Sound Velocity Profile ↓ Object ↓ Number of slots: ↓ System ↓ ↓ ↓ May Gale ↓ ↓ ↓ Yeitch Roll Heave Sensor ↓ ↓ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ ↓ ♥ <td>Kongsberg EM2040 Compact (Single) Multibeam Controller</td>	Kongsberg EM2040 Compact (Single) Multibeam Controller
Digital Terrain Models Digital Terrain Models Digital Terrain Models Latency: Latency: Acquired by: Observation time from: Number of slots: Diservation Navigation System Distion Navigation System Position Navigation System Position Navigation System TX Dink Auxiliary Systems Time Sync EM2040C Controller DASCII Logger	: DrvKongsbergEMCtrl.exe 2040C
 Projections Cuckery: Acquired by: Observation time from: Number of slots: Number of slots: Sound Velocity Profile Object Amy Gale System EM2040C \$ Gyro Y Prich Roll Heave Sensor Position Navigation System Y variable Node Amy Gale MRU RX TX Link Auxiliary Systems Time Sync EM2040C Controller ASCII Logger 	0.000 s
▲ Cquired by: Observation time from: ▲ Local Construction Grid Observation time from: ▲ UTC to GPS Correction Number of slots: ▲ Object Amy Gale ▲ May Gale ▲ EM2040C ▲ Pitch Roll Heave Sensor ▲ Position Navigation System ▲ Variable Node ▲ Amy Gale MRU ● TX ● Link ▲ Auxiliary Systems ● TX ● Link EM2040C Controller ● ASCII Logger ● ASCII Logger	0.000 s
Observation time from: Image: Sound Velocity Profile Object Image: System Image: Syst	[Directly into Qinsy] (No additional time tags)
→ B Local Construction Grid Number of slots: → C UTC to GPS Correction Number of slots: → Object → Margin Gale → Margin Gale → System → Margin Gale → System → Position Navigation System → Amy Gale MRU → RX ● TX ● TX ● TX ● Time Sync ● Margin Systems ● XSCII Logger ● ASCII Logger	N/A
Sound Velocity Profile Object Amy Gale System Controller Axio Tix Controller ASCII Logger Sound Velocity Profile Sou	
Object Amy Gale System Amy Gale System Amy Gale System Amy Gale System Amy Gale MRU System Amy Gale MRU Sk Tx Link Amy Gale MRU Sk Tx Sk Time Sync ASCIL Logger	0
Amy Gale System EM2040C Sy or System Position Navigation System Position Navigation System Amy Gale MRU Systems TX TX TX Success Time Sync EM2040C Controller PostIl Logger	
 System EM2040C P Gyro Formation System Position Navigation System Variable Node Amy Gale MRU RX TX Link Auxiliary Systems Time Sync EM2040C Controller ASCII Logger 	
 It has been been been been been been been bee	
Position Navigation System Amy Gale MRU Stress TX Time Sync Million Systems Million Systems Marcologer Solution System Solution	
Variable Node Amy Gale MRU O RX O TX O TX O TX O Time Sync EM2040C Controller D ASCII Logger	
Amy Gale MRU O RX O TX O TX O Time Sync EM2040C Controller DF ASCII Logger	
• RX • TX • TX • Time Sync • EM2040C Controller • ASCII Logger	
TX Stink Sinc Muxiliary Systems Muxiliary Systems Ascription of the sync Mathematical System of the sync Mathematical System of the sync Mathematical System of the synce of the	
Link Auxiliary Systems	
Auxiliary Systems O Time Sync EM2040C Controller ASCII Logger	
 ─Õ Time Sync ✓ EM2040C Controller □→ ASCII Logger 	
ASCII Logger	
ASCII Logger	
→ Fixed Node	

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Prog	ram		20 2	×
File Edit View Options Help				
E 26 🖪 🙏 💿 🖉 🛛 🔢 📟 😰 😫 💷 🔒 (8			
Emeral General	System: ASC	II Logger		
Geodetic	Description: Type:	ASCII Logger Output System		
日本 Heights 一立 Chart Datum / Vertical Datum	Driver: Executable and Cmdline:	33		
	Update rate: Latency: Data output setting:	1.000 s 0.000 s Enabled		
Universal Transverse Mercator (North Hemisphere) Local Construction Grid $-$ UTC to GPS Correction	Acquired by: Observation time from:	[Directly into Qinsy] (No additional time tags) N/A		
└─└ Sound Velocity Profile	Number of slots:	0		
Amy Gale System Amy Gale System Amy Gale System Amy Gale System Amy Gale MRU System Yariable Node Amy Gale MRU SRX TX Link Sinc Amy Gale MRU Systems Sinc Fixed Node				
Qinsy 9 For Help, press F1				

Appendix E – Configuration settings for Qinsy EM controller

EM Controller - El	V12040C C	ontroller		-		
PU Status						
Status Activ	/e				Stop	
Pinging 1530	8 @ 2.90 H	łz				-
Clock Status Ok					<u>P</u> u Info	•
Errors All O	k				Options	_
					Options	•••
Settings						_
Head1 Port Angle		65				~
Head1 Starboard Ar	ngle	65				
Max. Port Coverage	Ĩ	300				
Max. Starboard Cov	erage	300				
Angular Coverage		Auto			-	
Beam Spacing		High De	nsity		-	
Pitch Stabilization		On			-	
Max. Ping Freq.(Hz)		50.00				
Transmit Angle (de	g)	0.0				
Minimum Depth		0.00				
Maximum Depth		200.00				
Detector Mode		Normal			-	
Slope Filter		On			-	
Areation Filter		Off			-	
Interference Filter		Off			-	
Penetration Filter		Off			-	
Range Gate Size		Normal			-	
Spike Filter Strength		Medium			-	
Phase Ramp		Normal			-	
Special Amp Detect		Off			-	
Special TVG		Off			-	
Normal Inci. Sector	Angle	10				
Lambert's law for in	tensity	Off			-	
Ping Mode		300 KHz			-	
Pulse Type		Auto			-	
Transmit Power Lev	el	Maximu	m		• • •	
FM Enable		FM Enab	led		-	
3D Scanning - Scan	Sten	0.0				1
Apply Setting	s ▼	Force	Log Events			
Events						
10:00:53.105 PU Cl 10:00:53.963 Conn 10:00:53.963 Set Ir 10:00:55.073 Comn	ection to P nitial Settin	U (157.237 gs	.20.40) Established			^ ~

🔣 EM Controll	er - EM2040C C	ontroller	-		×
-PU Status					
Status	Active			Stop	
Pinging	18646 @ 2.70 H	z		3100	
Clock Status	Ok			<u>P</u> u Info	-
Errors	All Ok				31
				Options.	···
Settings					
Penetration Fi	lter	Off		-	^
Range Gate Siz	ze	Normal		-	
Spike Filter Str	ength	Medium			
Phase Ramp		Normal		-	
Special Amp D	Detect	Off		• • •	
Special TVG		Off		-	
Normal Inci, S		10			
Lambert's law	for intensity	Off		•	
Ping Mode		300 KHz		-	-
Pulse Type		Auto		-	- 1
Transmit Pow	er Level	Maximum		-	
FM Enable		FM Enabled		-	
3D Scanning -	Scan Step	0.0			
3D Scanning -	Min Angle	-5			
3D Scanning -		5			
Dual Swath M		Off		-	
Min. Swath Di	stance	0.0			
Yaw Stabilizati		Off		-	
Yaw Manual A	ngle	0.0			
Heading Filter		Medium		-	
WCD Sonar M		Off		-	
WCD Passive I		Off		T	
WC TVG LOG	R	30.0			
WC TVG dB		20.0			
Special amplit		Off		-	
Sound Velocity		3.0			
Sound Velocity	y Min Change	0.5			¥
Apply	Settings 🔻 🗌	Force 🔽 Log Events			
Events					
	PU Clock is sync	aronized		-	-
10:00:53.963 10:00:53.963	Connection to Pl Set Initial Setting	J (157.237.20.40) Established gs			
10:00:55.073	Command Accep	ted			~

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.

System Type (from DbSetup) Pu Ip Address Simulation Mode External Triggering Control Port Enabled Output Ports Output Port 1 (Bathy)	157.2 Off Off 2000	237.20.4) put Port	ngle Transducer 0	~
Simulation Mode External Triggering Control Port Enabled Output Ports Output Port 1 (Bathy)	Off Off 2000 Outp) put Port	0	
External Triggering Control Port Enabled Output Ports Output Port 1 (Bathy)	0ff 2000 Outp	put Port		
Control Port Enabled Output Ports Output Port 1 (Bathy)	2000 Outp	put Port		-
Enabled Output Ports Output Port 1 (Bathy)	Outp	put Port		-
Output Port 1 (Bathy)				
	2001		1,2,3	-
				_
Output Port 2 (Bathy)	2002			
Output Port 3 (Sidescan)	2003			_
ZDA/GGA Serial Port		1 (defa	ult)	-
Use GGA	On			-
Baudrate ZDA/GGA	9600			-
Motion Serial Port	Port	2 (defa	ul t)	τl
Program Options				
Start Pinging when QINSy Starts			Pinging On Startup	
			60	
Synchronize Clock Interval(min.)			From SoundVelocity	C C
Synchronize Clock Interval(min.) Sound Velocity Mode			From Soundvelocity	
			From Soundvelocity Sound Velocity	
Sound Velocity Mode	nn Data			
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs	nn Data		Sound Velocity On	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun	nn Data		Sound Velocity On	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters			Sound Velocity On	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters RX1 Gain Offet RX2 Gain Offet	0		Sound Velocity On Not Allowed	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters RXI Gain Offet RX2 Gain Offet HeadI Installation angles from	0 0 EN		Sound Velocity On Not Allowed	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters RXI Gain Offet RX2 Gain Offet Head1 Installation angles from Head2 Installation angles from	0 0 EN	м2040С	Sound Velocity On Not Allowed	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters RXI Gain Offet RX2 Gain Offet HeadI Installation angles from	0 0 EN No	M2040C ot Used	Sound Velocity On Not Allowed	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters RXI Gain Offet RX2 Gain Offet Head1 Installation angles from Head2 Installation angles from Velocity Sensor Number	0 0 EN No 30	M2040C ot Used lotion S 001	Sound Velocity On Not Allowed	
Sound Velocity Mode Sound Velocity Observation Popup window when error occurs Allow HD beamspacing with Water Colun Installation Parameters RXL Gain Offet RX2 Gain Offet Head1 Installation angles from Head2 Installation angles from Velocity Sensor Number Velocity Sensor UDP Port	0 0 EN No 30 Ett	M2040C ot Used lotion S 001	Sound Velocity On Not Allowed ensor 1 Port 2 (if available)	

Appendix F – Computation Settings for Qinsy Online

Computation Setup

Position Navigation System Computations Computation Parameters 🖮 🗹 🛄 Amy Gale ÷ Computation name Position Navigation System 🗹 🧵 Position Navigation System 🗹 🗭 Gyro Position Navigation System • • Triggering system New Computation Pitch Roll Heave Sensor Max. triggering rate 50 [Hz] ☑ ★ EM2040C P Iteration threshold 5 📥 Offset System Amy Gale Statistical testing Separate Objects ▼ E Gopy of Position Navigation System Enabled • Copy Computation Data snooping 🖮 🗹 🛄 Amy Gale Redundancy minimum 1 🗹 🏌 Position Navigation System £3 Level of significance 1% 🗹 🗭 Gyro 80 % Pitch Roll Heave Sensor Power of test Remove ☑ ★ EM2040C Lower limit max. ages 0.0 [s] Computation 👍 Offset System Amy Gale Approximate Position Coordinate system Geographical • 52;06;10.800 N Latitude 5;15;25.560 E Longitude Height 0.0 **Computation Priority** Priority Status Heights Computation Move Up 1 Enabled Tide (Unrelial Copy of Position Navigation System 2 Enabled RTK (Accurat Position Navigation System) Move Down Shortcuts ΟK Apply Cancel

Computations	Position Navigation System	Position Filter Position Results Attitu	ude Height Tide			
- c	Amy Gale	Filter Parameters				
		General Parameters	C-#i-			
New Computation	Pitch Roll Heave Sensor					
		Dynamic model	None			
	Offset System Amy Gale	Height model	None	<u> </u>		
	🚊 🛲 Copy of Position Navigation System					
Copy Computation	🖮 🗹 🔐 Amy Gale					
	🔤 🗹 🁗 Position Navigation System		1			
23	— 🗹 🗭 Gуго	Extended Parameters	Noise SD	Time Constant		
Remove	Pitch Roll Heave Sensor					
Computation	☑ 🥂 EM2040C Offset System Amy Gale					
	Criset System Amy Gale					
		1				
		Observations	Setting	SD		
		Observation Parameters	Settir	ng		
		Filter Thresholds				
		Reset Parameters	Settir	na		
				<u></u>		
		Threshold Parameters	Maximum	Time Factor		
			,			
Shortcuts						
		11				
	OK Apply Cancel					

Computations	Position Navigation System	Position Filter Position Results Attitu	ude Height Tide	
-c-	ian ⊠ In Amy Gale In I Amy Gale System			
- ⁶ 0	Such avigation system		C-Min -	
New Computation	Pitch Roll Heave Sensor	Parameters COG value	Setting	
_	- ☑ EM2040C		Position Updates	
	Offset System Amy Gale	SOG value	Position Updates	-
	E- 🗃 Copy of Position Navigation System	Position count	10	
Copy Computation	🖮 🗹 🛄 Amy Gale	Position threshold	0.05 [m]	
83	✓ I Position Navigation System			
Remove		Rate-Of-Tum		
Computation		Parameters	Setting	
		Rate-Of-Turn value	Rotation Updates	-
		Rate-Of-Turn count	5	
		Positions / Prediction		
		Parameters	Setting	
		Position results	Computation	.
		Height 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	-
		1		
Shortcuts				
	OK Apply Cancel			

0	Position Navigation System			-		
Computations		Position Filter F	Position Results Attitude Height Tid	de		
	- Stein Navigation System	Heading				
	🗹 🗭 Gyro	Priority	Method	Max Age	Skew	Move Up
New Computation	Pitch Roll Heave Sensor	1	Gyro	5.00 [s]	No	
		2	COG Amy Gale	Not Used	N/A	Move Down
				·		
Copy Computation	in I in the state of the sta					
	Position Navigation System					
E S S						
Remove	Pitch Roll Heave Sensor					
Computation	EM2040C					
	Offset System Amy Gale					
		Pitch - Roll				
		Priority	Method	Max Age	Skew	Move Up
		1	Pitch Roll Heave Sensor	1.00 [s]	No	Move op
		2	Disabled	Not Used	N/A	Move Down
			bisbled	Hot obcu		MOVE DOWN
Shortcuts						
ononodia		1				
	OK Apply Cancel					

 \times

omputations	Position Navigation System	Position Filter Po	sition Results Attitude Heig	ght Tide				
¢	🖮 🗹 🛄 Amy Gale	Height Interpolat	tion					
_	🗹 🖉 Gyro		Method		Max Age		Skew	Move Up
w Computation			Heave Pitch Roll Heave Se	nso	1.00 [s]		No	
								Move Dov
	Copy of Position Navigation System							
Computation	🖮 🗹 🛄 Amy Gale							
\sim	Position Navigation System							
\mathfrak{s}	⊠∲ Gyro ⊠∰ Pitch Roll Heave Sensor							
Remove mputation	🗹 🎊 EM2040C							
mputation								
		Draft and Squat	Parameters					
		Draft method			Mar	nual Draft		
		Manual draft			ivid.	0.850		
		Squat method			D	isabled		
Shortcuts	OK Apply Cancel							





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Computation S	Setup					×
Computations		Heading				
- cp	V 🔤 Amy Gale	Priority	Method	Max Age	Skew	Move Up
_		1	Gyro	5.00 [s]	No	
New Computation	Pitch Roll Heave Sensor	2	COG Amy Gale	Not Used	N/A	Move Down
	- M M EM2040C		,			
	→ ↓ Offset System Amy Gale					
Copy Computation	E- ✓ May Gale					
~~						
EX I	— ☑ Ø ̈́ Gyro					
Remove	Pitch Roll Heave Sensor					
Computation	Offset System Amy Gale					
		Pitch - Roll				
		Priority	Method	Max Age	Skew	Move Up
		1	Pitch Roll Heave Sensor	1.00 [s]	No	
		2	Disabled	Not Used	N/A	Move Down
Shortcuts						
Shortcuts		1				
	OK Apply Cancel					

Computations	Position Navigation System					
	🖮 🗹 🛄 Amy Gale	Heading				
- c - I	🔤 🗹 🁗 Position Navigation System	Priority	Method	Max Age	Skew	Move Up
New Computation	- ⊻ ♥ Gyro	1	Gyro	5.00 [s]	No	
	Pitch Roll Heave Sensor EM2040C	2	COG Amy Gale	Not Used	N/A	Move Down
	Offset System Amy Gale					
	💼 🔚 Copy of Position Navigation System					
Copy Computation	🖮 🗹 🔐 Amy Gale					
\sim	Position Navigation System					
~~~	⊡ ∯ Gyro ⊡r∰ Pitch Roll Heave Sensor					
Remove						
Computation						
		Pitch - Roll				
		Priority	Method	Max Age	Skew	Move Up
		1	Pitch Roll Heave Sensor	1.00 [s]	No	
		2	Disabled	Not Used	N/A	Move Down
Shortcuts						
	OK Apply Cancel					

Computations	Position Navigation System     My Gale	Refraction			^				
	- V Any Gale	Velocity profile		Enabled					
_	- ØØ Gyro		Add sound velocity from system to velocity profile						
New Computation									
	EM2040C     Gale     Gifset System Amy Gale	Flag Data When							
222	Copy of Position Navigation System	ltem	Min	Max					
Copy Computation	E ✓ May Gale	Depth outside	1	500					
	Position Navigation System	Range outside	2	50					
53	🗹 🖉 Gyro	Sector outside	-60	60					
~~		Intensity outside	0	0					
Remove Computation	🗹 🥂 EM2040C	Quality outside	0	0					
comparation	Offset System Amy Gale	Heave above		5					
		Height outside	0	0					
		Inside / outside polygon	<none> 👻</none>	<none> 👻</none>					
		TPU exceeds							
		<u>'</u>							
		Exclude beams							
		Despike Data							
		Despike method	Disabl	ed 🔹					
		Data Reduction							
		Reduction method	Disabl	ed 🔹					
			Disabi						
Shortcuts					~				
Chortouto		1.1							
	OK Apply Cancel								
					.:				

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

Computations	Enter Position Navigation System	Computation F	arameters			
c,	Amy Gale	Computatio	n name		Copy of Position Navigation System	
_			Triggering system		Position Navigation System	
ew Computation	- 🗹 👥 🕂 Pitch Roll Heave Sensor	Max. trigger			50 [Hz]	
	🗹 📶 EM2040C	Iteration thr			5	
	🕂 🕂 Offset System Amy Gale	Statistical te	sting		Separate Objects	
oy Computation	Copy of Position Navigation System	Data snoopi	ng		Enabled	
	Amy Gale	Redundancy	minimum		1	
$\sim$		Level of sigr			1 %	
$\sim$	Pitch Roll Heave Sensor	Power of tes	t		80 %	
Remove Computation	🗹 🥂 EM2040C	Lower limit	max. ages		0.0 [s]	
computation	🕂 🕂 Offset System Amy Gale					
		Approximate F	osition			
		Coordinate			Geographical	
		Latitude	system		52;06;10.800 N	
		Longitude			5;15;25.560 E	
		Height			0.0	
		Priority	Status Enabled	Heights	Computation	Move U
		1			Copy of Position Navigation System	
		2	Enabled	<ul> <li>RTK (Accurat)</li> </ul>	Position Navigation System	Move Dov

Computations	🖃 📾 Position Navigation System	Position Filter Position Results Attitu	ide Height Tide	
	🖮 🗹 🛄 Amy Gale	Filter Parameters		
÷	ー・ビ 👗 Position Navigation System ー・ビ 🛱 Gyro	General Parameters	C.uti	
New Computation	Pitch Roll Heave Sensor	Dynamic model	Settir None	-
	🗹 🥂 EM2040C	Height model		
	Offset System Amy Gale     Gale     Gopy of Position Navigation System		None	
Copy Computation	Amy Gale			
$\sim$		Extended Parameters	Nuiter CD	TracConstant
225	⊠Ø Gyro Ø☆ Pitch Roll Heave Sensor	Extended Parameters	Noise SD	Time Constant
Remove Computation	27 EM2040C			
Computation	🕂 Offset System Amy Gale			
		Observations	Setting	SD
			Setting	30
		, Observation Parameters	Settir	
			Setti	'Y
		Filter Thresholds		
		Reset Parameters	Settir	ng
		Threshold Parameters	Maximum	Time Factor
Shortcuts				
	OK Apply Cancel			

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Computations	Position Navigation System	Position Filter Position Results Attitu		
Computations	E ✓	Position Filter Position Results Attitu	ide Height lide	
		COG / SOG		
New Computation	⊡Ø Gyro	Parameters	Setting	
New Computation	Pitch Roll Heave Sensor	COG value	Position Updates	-
		SOG value	Position Updates	-
	Giffset System Amy Gale	Position count	10	
Copy Computation	Amy Gale	Position threshold	0.05 [m]	
• •				
EX I	🗹 🕉 Gyro	1		
Remove	🗹 🛃 Pitch Roll Heave Sensor 🗹 🎢 EM2040C	Rate-Of-Tum		
Computation		Parameters	Setting	
		Rate-Of-Turn value	Rotation Updates	-
		Rate-Of-Turn count	5	
		1		
		Positions / Prediction		
		Parameters	Setting	
		Position results	Computation	-
		Height results	Computation	-
		Parameters	Setting	
		Prediction	Disabled	-
		Maximum position age	5.0 [s]	
		1		
		Snap to Survey Line / Node Track		
		Parameters	Setting	
		Snap option	Disabled	•
			Disabled	
Shortcuts				
		1		
	OK Apply Cancel			



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Computations	Position Navigation System	Position Filter	Position Results Attitude H	eight Tide			
÷	Amy Gale	Height Interpo	blation				
	- 🗹 🖉 Gyro	Priority	Method	Max Age		Skew	Move Up
lew Computation	Pitch Roll Heave Sensor	1	Heave Pitch Roll Heave S			No	
	☑ 🥂 EM2040C 井 Offset System Amy Gale						Move Dov
2008	Copy of Position Navigation System						
opy Computation	🖮 🗹 🔐 Amy Gale						
$\sim$	Position Navigation System						
$\approx$	⊡ ∯ Gyro ⊡¥ Hitch Roll Heave Sensor						
Remove	EM2040C						
Computation	Offset System Amy Gale						
		Draft and Squ	lat Parameters				
		Draft metho	bd		Manual Draft		
		Manual dra	ft		0.850		
		Squat meth	od		Disabled		
Shortcuts							



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mputation	✓ Amy Gale ✓ Ý Position Navigation System ✓ ∜ Gyro ✓ Ý Pitch Roll Heave Sensor ✓ M EM2040C ↓ Offset System Amy Gale	Use this system to trigger the compute Height status		
	🗹 🖌 Pitch Roll Heave Sensor 🗹 🎊 EM2040C	Height status	<b>T</b> 1 (1) (1)	
	☑ 🥂 EM2040C		lide (Unreliabl	le Height)
8		Preferred position SD	System D	river
	Copy of Position Navigation System	Position a priori SD	0 [r	n]
utation	✓	Preferred height aiding SD	Database S	Setup
	- 🗹 👗 Position Navigation System	Height aiding a priori SD	Auton	natic
	⊡Ø Ø Gyro ⊡√y Pitch Roll Heave Sensor	Dynamic a priori SD	Disab	bled
	🗹 🎊 EM2040C			
ion	🛶 🕂 Offset System Amy Gale			
		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	



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Computation S	jetup					×
Computations		Heading				
¢		Priority	Method	Max Age	Skew	Move Up
_	🗹 🖉 Gyro	1	Gyro	5.00 [s]	No	
New Computation	Pitch Roll Heave Sensor	2	COG Amy Gale	Not Used	N/A	Move Down
	🗹 🎢 EM2040C 					
888	Copy of Position Navigation System					
Copy Computation	🖮 🗹 🛄 Amy Gale					
8						
Remove Computation						
	Offset System Amy Gale	Pitch - Roll				
		Priority	Method	Max Age	Skew	Move Up
		1	Pitch Roll Heave Sensor	1.00 [s]	No	
		2	Disabled	Not Used	N/A	Move Down
Shortcuts						
	OK Apply Cancel					

× _

	ı					
Computations	E- 📰 Position Navigation System È ☑ 🛄 Amy Gale	Refraction				^
4 <u>2</u>	- Supervision Navigation System	Velocity profile			Enabled	-
_		Add sound velocity from	system to velocity profile			
New Computation				1		
	☑ 🦟 EM2040C 🛱 Offset System Amy Gale	Flag Data When				_
	Copy of Position Navigation System	ltem	Min		Max	
Copy Computation	🖮 🗹 🛄 Amy Gale	Depth outside		1		00
~~		Range outside		2		i0
53	<b>⊡</b> Ø Gyro	Sector outside		-60		50
Remove		Intensity outside		0		0
Computation	- M EM2040C	Quality outside		0		0
		Heave above				5
		Height outside		0		0
		Inside / outside polygon		<none> 💌</none>	<none></none>	-
		TPU exceeds				
		in o exceeds				_
						_
		Exclude beams				
		Despike Data				_
		Despike method		Disable	d	-
		L				
		Data Reduction				_
		Reduction method		Disable	d	-
Shortcuts						~
	OK Apply Cancel					

Computations	Position Navigation System	System Parameters	
	🖶 🗹 🛄 Amy Gale	Use a common A priori SDs for all offsets	
÷			J
New Computation		Node Offsets	
	EM2040C	Offset	A priori SD
888		🕂 X-offset Amy Gale MRU to TX	0 [m]
Copy Computation	area copy of rosalon wavigation system	✓ Y-offset Amy Gale MRU to TX	0 [m]
	Constition Navigation System	Z-offset Amy Gale MRU to TX	0 [m]
<u> </u>	🗹 🗭 Gyro	X - offset Amy Gale MRU to RX	0 [m]
Remove		Y-offset Amy Gale MRU to RX	0 [m]
Computation		Z Z-offset Amy Gale MRU to RX	0 [m]
Shortcuts			
	OK Apply Cancel		

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¢		System Parameters		
52	✓ May Gale ✓ May Gale ✓ May Control	Use this system to trigger the co	mputation	
w Computation	⊠Ø Gyro ⊡¥ Pitch Roll Heave Se	Height status	RTK (Accurat	te Height)
_	EM2040C			-
	Gifset System Amy Gale	Preferred position SD	System	
	Copy of Position Navigation Sys	Position a priori SD		5 [m]
y Computation	Amy Gale	Preferred height SD	System	
$\sim$	Position Navigation !	Height a priori SD	0.50	)[m]
$\sim$	⊡Ø Gyro ⊡∰ Pitch Roll Heave Se	Dynamic a priori SD	Disz	abled
Remove Computation	EM2040C	by harme a prior ob		
		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	

putations Position Navigation System	System Parameters			
Amy Gale		putation		
Ø Gyro		Tide (Unreliab	le Height)	-
Pitch Roll Heave				
Difset System Amy G	ale Preferred position SD	System [		•
Copy of Position Navigal	io Position a priori SD		[m]	
Computation Amy Gale	Preferred height aiding SD	Database	•	•
Y Position Navigation Navigation	Height aiding a priori SD	Auto	matic	
Pitch Roll Heave	Ge Dynamic a priori SD	Disa	bled	
Remove EM2040C				
	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		

Computations	Position Navigation System	Computation Pa	arameters			
÷	Position Navigation !	Computation	name		Position Navigation System	
-	Gyro	Triggering sy			Position Navigation System	
omputation	Pitch Roll Heave Se	Max. triggerin			20 [Hz]	
-		Iteration thre	-		5	
	👘 🚈 Offset System Amy Gale	Statistical tes		Separate Objects		
Computation	Copy of Position Navigation Sys	Data snoopin		Enabled		
computation	Amy Gale	Redundancy	-		1	
$\sim$	Position Navigation ! $\nabla \phi$ Gyro	Level of signi			1 %	
$\sim$	- ₩ ₩ Gyro - ₩ ₩ Pitch Roll Heave Se	Power of test			80 %	
emove	EM2040C	Lower limit n			0.0 [s]	
outation	Gifset System Amy Gale		,		••	
		Approximate Po	osition			
		Coordinate s	ystem		Grid	
		Easting			4840352.1	
		Northing			8669036.1	
		Height			0.0	
		-				
		Computation Pr	-			
		Priority	Status	Heights	Computation	Move U
		1	Enabled • Enabled •		Copy of Position Navigation System Position Navigation System	Move Do
Shortcuts	<					

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# Appendix G – Crossline surface difference test statistical plots

## Plots (histogram, scatter, and uncertainty)

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











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

Scatter: Depth Bias (m) vs Beam Number









Uncertainty: Depth Bias (m) 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	
	Boulder			
Gravel	Cobble			
Giavei	Pebble	Consultaneouslavinus (complete		
	Granule	Gravel/gravel mixes (samples containing ≥ 30% gravel)		
	Sandy Gravel			
Gravel Mixes	Muddy Sandy Gravel		0 1/ 1 · / #/#.4	
	Muddy Gravel		Gravel/gravel mixes/gravelly/slightly gravelly	
	Gravelly Sand		Bravery	
Gravelly	Gravelly Muddy Sand	Gravelly medium-coarse sand		
	Gravelly Mud	(includes samples with 5-30% gravel and samples with >90% sand with a		
	Very Coarse Sand	mean phi size < 2, even if gravel		
	Coarse Sand	content is up to 5%)		
Sand	Medium Sand			
	Fine Sand	Fine sand (samples having 0-5%	Fine and (fine sand + muddy sand)	
	Very Fine Sand	gravel, ≥ 90% sand, and a mean phi size between 2 and 4)		
	Silty Sand			
Muddy Sand	Silty-Clayey Sand	Muddy sand (silty sand + clayey sand + muddy sand; Folk, 1974)		
	Clayey Sand	sand + muddy sand, Polk, 1974)		
	Sandy Silt			
Sandy Mud	Sandy Silt-Clay			
	Sandy Clay	Nord (can de med + cit+ class)	Mud	
	Silt	Mud (sandy mud + silt + clay)	Mud	
Mud	Silt-Clay			
	Clay			
	Slightly Gravelly Sand			
Slightly Gravelly	Slightly Gravelly Muddy Sand	Slightly gravelly sand-mud mixtures (0.01-5% gravel, excluding samples	Gravel/gravel mixes/gravelly/slightly	
Singinuy Gravelly	Slightly Gravelly Sandy Mud	(0.01-5%  graver, excluding samples) with > 90% sand)	gravelly	
	Slightly Gravelly Mud			