# 2021 Descriptive Report of Seafloor Mapping: Vicinity of Casco Bay

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Maine Coastal Mapping Initiative, July 2022

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## Acknowledgements

The Maine Coastal Mapping Initiative would like to acknowledge the efforts of the University of Maine sediment laboratory personnel, Hodgdon Vessel Services, and Maine Coastal Mapping Initiative team for contributing to the success of the 2021 survey season. The individual contributions made by many were an integral part of sampling, analysis, and synthesis of data collected for this project. Funding for this study was provided by provided by the National Oceanic and Atmospheric Administration Office of Coastal Management (award numbers NA18NOS4190097, NA20NOS4190064, and Project of Special Merit Program NA20NOS4190107), The Nature Conservancy, and the Maine Outdoor Heritage Fund.

Maine Coastal Mapping Initiative Maine Coastal Program Department of Marine Resources				
	DESCRIPTIVE REPORT			
Type of Survey:	Navigable Area			
Registry Number:				
	LOCALITY			
State(s):	Maine			
General Locality:	Gulf of Maine			
Sub-Localities:	Vicinity of Casco Bay			
	2021			
CHIEF OF PARTY				
Peyton Benson, Hydrographer, Contractor to the State of Maine				
	LIBRARY & ARCHIVES			
Date:				

	REGISTRY NUMBER:					
	MAINE COASTAL PROGRAM					
HYDR						
INSTRUCTIONS: The h	INSTRUCTIONS: The hydrographic sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.					
State(s):	Maine					
General Locality:	Gulf of Maine					
Sub-Locality:	Vicinity of Casco Bay					
Scale:						
Dates of Survey:	04/15/2021 to 05/02/2022					
Instructions Dated:						
Project Number:						
Field Unit:	Amy Gale					
Chief of Party:	Peyton Benson, Hydrographer, Contractor to	) the State of Maine				
Soundings by:	Kongsberg EM2040C (MBES)					
Imagery by:	Kongsberg EM2040C (MBES Backscatter)					
Verification by:						
Soundings in:	meters at Mean Lower Low Water					
Remarks:						

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#### Suggested citation:

Benson, P.T., 2022. 2021 Descriptive report of seafloor mapping: Vicinity of Casco Bay. 91 p.

## ABSTRACT

During April-August 2021, the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveying using a multibeam echosounder (MBES) in marine waters in the vicinity of the Gulf of Maine, sub-locality Casco Bay, Maine. The surveying efforts were conducted to support efforts 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 data collected for the survey season. During the scope of the season, approximately 37 mi<sup>2</sup> (95.8 km<sup>2</sup>) of high-resolution multibeam data were collected in the surveyed area. Throughout the survey period, MCMI also collected sediment samples, water column data, and video at 38 locations in the mainscheme survey area.

## 1.0 Area Surveyed

The mainscheme survey area mapped during the 2021 season (April 15-August 16) was located in and off Casco Bay in the Gulf of Maine, as shown in Figure 1. The approximately 37 mi<sup>2</sup> mainscheme survey area adjoins the southwestern extent of the area mapped by MCMI in 2016 (NOAA survey registry number W00448) and the northeastern extent of the area mapped by MCMI in 2020 (currently being reviewed for acceptance by NOAA) (Figure 2). 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.

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

Table 1 – 202	1 mainscheme su	rvey limits
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Southeast Limit	Northwest Limit
43° 33' 55.831" N	43° 35' 34.004'' N
69° 49' 07.272'' W	70° 00' 32.193" W



Figure 1 – General locality of 2021 mainscheme survey coverage in Casco Bay, Maine.



Figure 2 – General locality of 2021 MCMI mainscheme coverage relative to overlapping datasets in the region.



Figure 3 – Shaded relief image of 2021 mainscheme bathymetry data gridded at 4-meter resolution and colored by depth. Data is overlain on NOAA nautical chart 13288.

## **1.1 Survey Purpose**

This survey was conducted by the Maine Coastal Program's Maine Coastal Mapping Initiative (MCMI) as part of a multi-agency cooperative agreement partially funded by the National Oceanic and Atmospheric Administration (NOAA) Office of Coastal Management, The Nature Conservancy (TNC), and the Maine Outdoor Heritage Fund. The purpose of this project is to help inform policy decision-making related to Maine's coastal waters by increasing the volume of available high-quality bathymetric, benthic habitat, geochemical, and geologic data in the mainscheme Casco Bay vicinity area. This project also coincides with state and federal efforts to update coastal data sets for Maine's coastal waters and provides new data in the areas covered by National Oceanic and Atmospheric Administration (NOAA) nautical charts 13286, 13288, and 13290 in the vicinity of Casco Bay. These data were acquired and processed to meet Office of Coast Survey bathymetry standards as best as possible and are shared with the NOAA Office of Coast Survey for review.

## **1.2 Survey Quality**

The entire survey should be adequate to supersede previous data.

## **1.3 Survey Coverage**

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

## 2.0 Data Acquisition

The following sub-sections contain a summary of the systems, software, and general operations used for acquisition and preliminary processing during the 2021 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 South 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, Kongsberg EM2040C multibeam sonar, 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 2021 surveys are outlined in Table 2. Data acquisition was performed using the Quality Positioning Services (QPS) Qinsy (Quality Integrated

Navigation System; v.9.2.2) acquisition software. The modules within Qinsy integrated all systems and were used for real-time navigation, survey line planning, data time tagging, data logging, and visualization.

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

Sub-system	Components		
Multibeam Sonar	Kongsberg EM2040C and processing unit		
Position, Attitude, and Heading Sensor	Seapath 330 processing unit, HMI unit, dual GPS/GLONASS antennas, MRU 5-V motion reference unit (subsea bottle), Fugro 3610 Receiver and AD-341 antenna		
Acquisition Software and Workstation	Qinsy software v.9.2.2 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		

## **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 5 and 6). 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 8), 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 2021 survey season. See appendices for specific settings as entered in the Seapath 330 Navigation Engine (Appendix B) and for the template database (Appendix C) used during data acquisition while online in Qinsy. Configuration settings of the EM2040C were assigned in the EM Controller module of Qinsy (Appendix D).

Table 3 – 2017 equipment reference frame measurements for Seapath 330

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



Figure 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 time tag for GPS). Next, the desired Qinsy project (e.g. mainscheme, inshore, etc.) 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, a sound speed cast was taken and imported into the 'imports' folder of the current project. After confirming a close match between the upcast and downcast data, the profile was applied to the sonar (EM2040C) in the Qinsy Controller module. 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 6<sup>th</sup> Edition Order 1a survey (International Hydrographic Organization, 2020 & NOAA Office of Coast Survey, 2021). In the mainscheme area, parallel lines were mostly planned several days prior to surveying and run in a NE-SW or E-W pattern, depending on the location. Lines were spaced at consistent intervals to obtain a minimum of 20% overlap between full swaths. Soundings from beam angles outside of  $\pm 60$  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

Several patch tests were conducted aboard the F/V Amy Gale at the beginning of the 2021 survey season to correct for alignment offsets. After an initial application of patch test values data not tide-corrected, a second patch test was applied once verified tide data was available from NOAA. During the 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.2.4.0) 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. Full built-in self-tests (BIST) were performed at semi-regular intervals throughout the season to determine if any significant deviations in background noise were present at the chosen survey frequency of 300KHz.

Table 4 – 2021 patch test calibration offsets for EM2040C					
	Offsets	Offsets	Offsets	Offsets	Offsets
Туре	04/15/21	05/07/21	05/14/21	05/18/21	06/16/21
Roll (degrees)	0.318	0.317	0.314	0.330	0.363
Pitch (degrees)	0.541	-1.859	-1.159	-1.859	-1.582
Heading (degrees)	2.508	2.388	1.479	2.388	2.388

## **3.0 Quality Control**

## **3.1 Crosslines**

Due to systems failures noted in section 3.3, survey acquisition was delayed significantly in the 2021 season and crosslines were acquired in April and May of 2022. Crosslines were run at 900m spacing and intersected with all mainscheme lines between 60° and 90° in accordance with BOEM requirements (U.S. Department of the Interior, 2014). Crosslines were filtered during post-processing to remove soundings outside 45 degrees from the nadir. After filtering, the two-dimensional surface area totaled approximately 17% of mainscheme acquisition. Crossline sounding agreement with mainscheme data was evaluated by using the crosscheck tool in Qimera 2.4.0, which performs beam-by-beam statistical analysis. The mean difference between soundings was -0.029 meters with a standard deviation of 0.477 meters; 95% of all differences were less than 0.96 meters from the mean (Figure 8). Summary statistics for this analysis are shown in Table 5. Additional statistical plots

are reported in Appendix F. 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 mainscheme data



Figure 8 – 2021 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 – Crossline difference (Qimera crosscheck) summary statistics

22848609
-71.472299 m
-71.443698 m
-0.028601 m
-0.028601 m
0.477 m
-148.44 m to -28.74 m
-128.82 m to -29.19 m
-51.878 m to 33.05 m
0.982044 m
0.982044 m
1.054803 m
0.031272
714528
ACCEPTED

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

#### **3.2 Junctions**

The junctions shown in Table 6 were the result of overlap between the 2021 mainscheme survey season and existing surveys in the region. The areas of overlap between the 2021 survey and the junction surveys (NOAA survey ID W00448 and MCMI 2020 mainscheme) were evaluated for sounding agreement by performing surface (4-meter resolution) difference tests in Fledermaus (v.8.4.0, 64-bit), where the existing surfaces were subtracted from the newly collected 2021 surface (re-projected in NAD83). A summary of surface difference test results is shown in Table 7. The extent of overlap between the 2021 base surface and the corresponding

2016 and 2020 junction surfaces are illustrated in Figure 9. The surfaces used for these tests are submitted with the data in these surveys.

Registry Number	Scale	Year	Field Unit	Relative Location(s)
W00448	1:10,000	2016	Amy Gale	E and N
Pending	1:10,000	2020	Amy Gale	S

Table 7 – Summary of surface difference test results for overlapping (junction) surveys (Fledermaus 8.4.0)

Junction Surface ID	New Surface ID	Mean (m)	Std. Dev. (m)
W00448_MB_8m_MLLW _Combined	AG_MCMI_2021_01_4m_MLLW	0.25	0.39
MCMI_2020_CascoBay_4 m_mllw	AG_MCMI_2021_01_4m_MLLW	0.19	0.24

Relatively high standard deviation between overlapping mainscheme surveys is likely attributable to poor agreement in rocky areas, differences in filtering procedures, and survey conditions during acquisition. The most disagreement between surfaces were in areas with a steep, rocky seabed. In addition, the W00448 data included soundings from all beam angles ( $\pm 65$  degrees from the nadir), whereas the 2021 data were filtered to exclude soundings from beams >  $\pm 60$  degrees from the nadir. The larger accepted range of data from previous surveys as in W00448 would have potential to induce greater uncertainty in soundings due to greater side-lobe interference from outer beams, possibly resulting in a larger departure from recorded values from the 2021 mainscheme (see better agreement with MCMI 2020 where beam filtering was also applied). Furthermore, when compared in Fledermaus, wobble was discerned in older datasets (W00448 and MCMI 2020) that were not as dramatic in the 2021 mainscheme dataset. This wobble is likely the result of excessive motion induced by heavy seas during collection and would also attribute to a difference in surface agreement.

Overlapping surfaces agree on height by an average of less than 1 foot and 95% of data agrees within 2 feet across both junctions, indicating strong agreement and verifies 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 – Junctioning areas between W00448/MCMI 2020 and 2021 mainscheme survey area at scale of 1:50,000

## **3.3 Equipment Effectiveness**

#### <u>Sonar</u>

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.

#### Wobble

Early in the survey season, the interim hydrographer noticed wobble in data collected offshore. These visualizations were alleviated in real-time acquisition by patch tests and newly applied offsets. Once data were post-processed, however, the wobble issue was still apparent. Consultations with QPS engineers discovered an issue with the database setup, where tide and RTK application needed reconfiguring seen in Appendix E. This resolved a great deal of the data issues, but future analysis revealed that an additional latency issue existed between the Seapath 330+ system and delivery to Qinsy on the Hydrographic Workstation PC. The latency was found to be due to the presence of a null-modem adapter which induced roughly +0.016-0.018s of delay to the delivery of motion and positioning data. Unfortunately, this was not discovered until after data collection for the season had been completed and was not applied to the database in Qinsy for acquisition in time. Thus, these offsets were retroactively applied to select lines where wobble was especially noticed, via the Qimera wobble analysis tool in version 2.4.0.

#### Seapath 330+

Several failures of components of the Seapath 330+ occurred throughout the survey season, which required addressing before data collection could continue. Several months were spent coordinating with Kongsberg repair technicians and engineers, who ultimately discovered critical failures in the Seapath HMI motherboard, RAM, and internal battery. As such, the survey season was greatly reduced for 2021, and mainscheme acquisition was not continued after August 16<sup>th</sup>, 2021. Troubleshooting of these issues did not affect the quality of data collected throughout the survey season, and all data were acquired only when all systems were functioning properly.

#### Uninterruptible Power Supply

On August 2<sup>nd</sup>, 2021, the uninterruptible power supply (UPS) failed during acquisition and corrupted line 20210802\_131219. All systems simultaneously lost power and a reboot was attempted thereafter. Data collection continued until a second power failure, which occurred between collected lines. The corrupted file has not been included in this data package, and area ensonified was collected again after the replacement of the power supply.

## **3.4 Sound Speed Methods**

Sound speed cast frequency: A total of 64 sound speed casts were taken within the boundaries of the 2021 mainscheme survey. 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 MicroX 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 in addition to .bvsp files for reference.

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.

## 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.2.4.0, 64-bit edition) and Fledermaus (v.8.4.0, 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.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. An exception to note in this zoning scheme is that zone NA7 references the Wells, Maine tide station, which has not published water level data since December 2020. In lieu of this reference station, Portland station 8418150 was applied to this zone with the time correction and scale used for the same locus in NOAA surveys W00448 and W00450.

Table 8 - Tide zones and corrections referenced to verified Portland, ME (8418150) tide station data

Survey Area	Tide Station	Zone ID	Time Correction (mins.)	Tide Scale
Mainscheme	8418150	NA7	-6	0.95

## 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. Add tide zoning file (.zdf) and associated tide data and integrate into raw files
- 4. Create dynamic surface with NOAA CUBE settings enabled for desired resolution (e.g. 2-meter, 4 meter)
- 5. Review and edit soundings/clean surface with slice editor tool, 3D editor tool, and available filters
- 6. Duplicate surfaces at other grid sizes, if desired
- 7. Export final surface to .BAG file and CUBE surface
- 8. 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 10) was selected for each surface depending on the grid size of the surface.

CUBE Settings		-	? ×			
Configuration NOAA_4m						
CUBE Capture Distance:	Distance Sca	ile: 5.00				
٩	Distance Mir	n: 2.828				
CUBE Hypothesis Resolution	on Algorithm :	Number of Samples	•			
Estimate Offset:		4.00				
Horizontal Error Scale: 1.96						
Advanced <<	Advanced <<					
Distance Exponent:	2.00					
Queue Length:	11					
Quotient Limit:	255.00					
Discount Factor:	1.00					
Bayes Factor Threshold:	0.135					
Run Length Threshold:	5					
		ОК	Cancel			



#### 4.4 Final Surfaces

The following surfaces and BAGs were submitted with the survey data.

Table 9 - Surfaces submitted with 2021 survey data

Surface Name	Resolution (m)	Depth Range (m)	Surface Paramete r
AG_MCMI_21_01_2m_MLLW	2	27 – 135	N/A
AG_MCMI_21_01_4m_MLLW	4	27 – 135	N/A
AG_MCMI_21_01_Crosslines_4m	4	29 - 134	N/A
AG_MCMI_21_01_Junction_W00448	4	N/A	N/A
AG_MCMI_21_01_Junction_MCMI2020	4	N/A	N/A

#### 4.5 Backscatter

Backscatter was logged in the raw .db files. 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 v.2.4.0. in .GSF format. QPS Fledermaus Geocoder Toolbox (FMGT; v.7.8.6, 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 2-meter and 4-meter resolution. Mosaics were exported in greyscale and floating-point GeoTIFF format. The mosaics are shown in Table 10 and Figure 11.

Table 10 – Backscatter mosaics submitted with 2021 survey data

Mosaic Name	Pixel Size (m)
AG_MCMI_21_01_2m_gs_backscatter.tiff	2
AG_MCMI_21_01_4m_gs_backscatter.tiff	4
AG_MCMI_21_01_2m_backscatter.tiff	2
AG_MCMI_21_01_4m_backscatter.tiff	4



Figure 11 – Backscatter mosaic (4-meter pixel size) of 2021 mainscheme area

## 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 11. Prior hydrographic surveys in the vicinity were conducted by NOAA between 1867 and 1946 and consisted only of partial bottom coverage. These data were not compared with data collected by the MCMI. In addition to the below listed figures, .pdf exports of overlaid contoured bathymetry have been included in this data package for reference.

Chart	Scale	Source Edition	Source Date	NTM Date
13286	1:80,000	34	3/19/2019	4/2/2020
13288	1:80,000	44	3/1/2016	4/30/2020
13290	1:40,000	41	10/9/2019	3/18/2021

Table 11 – Largest scale raster charts in survey area

#### Chart 13286

Surveyed depths have good overall agreement with charted contours (Figure 12) apart from a deep area roughly 300m by 75m in the southeastern portion of the dataset which was found to exceed 420 ft. This location has a nearest sounding of 326 ft which disagrees with the findings of this survey. This disagreement is most likely due to lack of full bottom coverage during prior surveys rather than over-generalization. All other depths show strong agreement with contours showing only minor discrepancies in placement. It is recommended that contours showing disagreement in this area be revised.

#### Chart 13288

Surveyed depths have good overall agreement with charted contours (Figure 13) apart from a deep area roughly 300m by 75m in the southeastern portion of the dataset which was found to exceed 420 ft. This location has a nearest sounding of 326 ft which disagrees with the findings of this survey. This disagreement is most likely due to lack of full bottom coverage during prior surveys rather than over-generalization. All other depths show strong agreement with contours showing only minor discrepancies in placement. It is recommended that contours showing disagreement in this area be revised.

#### Chart 13290

Surveyed depths have good overall agreement with charted contours (Figure 14), although individual soundings may disagree at any given location.



Figure 12 – Comparison between surveyed depth (reclassified at 60-feet intervals) and chart 13286 contours (60-feet interval)



Figure 13 – Comparison between surveyed depth (reclassified at 60-feet intervals) and chart 13288 contours (60-feet interval)



Figure 14 – Comparison between surveyed depth (reclassified at 60-feet intervals) and chart 13290 contours (60-feet interval)

## **5.2 Bottom Samples**

A total of 38 bottom samples were collected throughout the course of the survey season in state and federal waters to supplement existing sediment data collected previously by other agencies (Maine Geological Survey and University of Maine) in the mainscheme area (Figure 15). 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 12. 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.



Figure 15 – Bottom sample locations collected over the course of the MCMI 2021 survey season

## Table 12 – Grab Sample Information

Site Name	Date	Latitude (decimal degrees N)	Longitude (decimal degrees W)	Depth (m)	Grain Size (field observation)	Backscatter Intensity (dB)
CBO60-1	7/13/21	43.564349	-69.840433	86.7	rock	-8.91
CBO60-2	7/13/21	43.558195	-69.869769	80.0	gravelly muddy sand	-10.16
CBO60-4	7/13/21	43.572898	-69.880058	66.2	muddy gravel	-5.75
CBO60-5	7/13/21	43.588254	-69.853241	89.3	mud with shell hash	-23.39
CBO60-6	7/28/21	43.528288	-69.957010	83.1	rock	-8.59
CBO60-7	7/28/21	43.518502	-69.940640	103.0	silty mud with trace sand	-15.20
CBO60-8	7/28/21	43.531016	-69.977044	89.2	clayey sandy mud with trace sand and gravel	-13.63
CBO60-9	7/28/21	43.543871	-69.965711	105.0	silty mud with trace sand	-17.41
CBO60-10	7/28/21	43.553137	-69.951391	69.8	sandy gravel with mud, assumed atop rock due to low yield	-7.64
CBO60-11	7/28/21	43.577565	-69.959073	93.6	silty mud with trace sand	-20.56
CBO60-12	8/4/21	43.546660	-69.916299	95.8	silty mud with trace sand	-20.87
CBO60-13	8/4/21	43.571006	-69.890589	85.7	clayey silty mud with trace sand	-18.98
CBO60-14	8/4/21	43.580183	-69.910541	70.2	rock	-5.44
CBO60-15	8/4/21	43.594332	-69.936722	88.3	clayey mud with trace sand	-22.76
CBO60-16	8/4/21	43.589701	-69.905621	89.6	clayey silty mud with trace sand	-20.56
CBO-17	8/10/21	43.637261	-69.899735	39.0	rock	-9.22
CBO-18	8/10/21	43.631044	-69.889253	45.4	sand with shell hash and trace gravel	-8.27
CBO-19	8/10/21	43.620496	-69.886797	42.0	rock	3.07
CBO-20	8/10/21	43.627431	-69.893151	60.0	clayey muddy sand	-13.31
CBO-21	8/10/21	43.631602	-69.902709	48.0	rock	-4.49
CBO-22	8/10/21	43.631443	-69.908863	38.0	surficial gravel atop rock	-11.11
CBO-23	9/1/21	43.626016	-69.844616	52.7	rock	N/A
CBO-24	9/1/21	43.650070	-69.844236	37.2	sand	N/A
CBO-25	9/1/21	43.666731	-69.867372	31.7	gravel with shell hash, some mud	N/A
CBO-26	9/1/21	43.678381	-69.904774	42.3	silty clayey mud	N/A
CBO-27	9/1/21	43.702442	-69.934722	36.3	clayey mud	N/A
CBO-28	9/14/21	43.634098	-69.924302	60.9	clayey mud with trace sand and gravel	-16.15
CBO-29	9/14/21	43.616587	-69.957509	40.4	rock	-12.05
CBO-30	9/14/21	43.607036	-69.971878	52.6	gravelly sandy mud with shell hash	-9.22
CBO-31	9/14/21	43.614366	-70.004494	43.7	rock	N/A
CBO-32	9/14/21	43.6433754	-69.97824097	41	muddy gravel with shell hash	N/A
CBO-33	9/14/21	43.65246427	-69.9322708	41.9	surficial mud and shell hash atop rock	N/A
CBO-34	9/21/21	43.6794123	-69.9794058	49.8	clayey mud with trace fine sand	N/A
CBO-35	9/21/21	43.65844131	-69.97264017	55.6	clayey mud with trace fine sand	N/A
CBO-36	9/21/21	43.64777554	-70.00341145	55.1	clayey mud with trace coarse grain sand and gravel	N/A
CBO-37	9/21/21	43.63466854	-70.05312236	42.3	muddy gravel with coarse sand	N/A
CBO-38	9/21/21	43.65930149	-70.04387337	39.3	surficial shell hash atop rock	N/A
CBO-39			-70.01033069	52.2	gravelly muddy sand with shell hash	N/A

## 6.0 Summary

A total of 37 mi<sup>2</sup> (95.8 km<sup>2</sup>) of high-resolution multibeam data were collected in the mainscheme survey area from April to August of 2021. 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 were processed with 4-meter grid resolution, although 2-meter surfaces were produced for the respective surfaces in submission of this report. The bathymetry and backscatter information for the mainscheme survey area are supplemented by seafloor surficial sediment samples, water column data, video, and benthic fauna collection in 38 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 1 foot (0.25 meters) and within specifications for Order 1a survey accuracy 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*). Comparisons between mainscheme survey data and the largest scale nautical charts in the vicinity show good agreement in most cases apart from a 300m by 75m deep portion exceeding 420 ft in depth in the southeastern most extent of the survey area. It is recommended that the corresponding charts be updated in this area to reflect this data.

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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04/13/22 (Crosslines)	
04/27/22 (Crosslines)	
05/02/22 (Crosslines)	

# Appendix A – Specific dates of data acquisition for surveys

Dates (mm/dd/yy) of Data Acquisition for 2021 Surveys\*

\*Dates of surveys not summarized in this report not listed

Appendix B – 2021 Configuration settings for Seapath 330


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- Geometry - Description	Interface	LAN2			
- Sensors					
- GNSS	IP address	192.168.1 .11			
Geometry Processing		A Design of the second s			
L. Attitude Processing	Subnet mask	255.255.255.0			
DGNSS	Gateway				
HP/XP/G2	Gateway interface	1 AN2			
E-MRU					
Geometry	Default gateway	<u></u>			
└ Heave config ⊒-Monitoring points					
∃- Monitoring points					
∃- Communication interface					
- Input/Output					
- Serial port extender					
- Network					
Network					
Data Pool					

	Breview	Bevort	
⊇-Vessel	Data pool parameters		
Geometry	Processing unit name	Unit#1	
- Description E- Sensors			
GNSS	Network interface name	LAN2 (192.168.1.11)	
Geometry	UDP address	239.255.0 .3	
- Processing - Attitude Processing	UDP port	31000	
DGNSS			
- SBAS			
- HP/XP/G2 BTK			
- Geometry			
- Heave config - Monitoring points			
Geometry			
Communication interface			
Input/Output Serial port extender			
- Network			
Data Pool			
Connected to Seapath 330			

## **Appendix C – 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 2021 season 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	
General	information: General	
日春 Geodetic 中 Datums	Line name: No line name	
G WGS84	Line sequence number: 1	
⊖ ± WG384	Line description: N/A	
🖉 Chart Datum / Vertical Datum		
A Mean Water Level Model		
🕱 Digital Terrain Models		
E B Projections		
🕼 Local Construction Grid		
- 💩 UTC to GPS Correction		
🗠 Sound Velocity Profile		
d Object		
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8 Link		
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- ∰ General - <b>∰ Geodetic</b>		
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"]],
→ → → Pitch Roll Heave Sensor		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"]]

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program		- 🗆 X
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WGS84	Chart datum: WGS84	
⊟ ☆ Heights	Height file: N/A	
🛓 Tregins	Height level: No Level Correction	
- A Mean Water Level Model	Height file: N/A	
🚽 Digital Terrain Models	Height offset: 0.000 m	
🖨 🐻 Projections	Treight onset	
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L Sound Velocity Profile		
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-# Pitch Roll Heave Sensor		
Position Navigation System		
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Fixed Node		
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General	Datum: WGS84
<b>a</b> Geodetic	Datum name: WGS84
B Datums	Spheroid name: WGS 1984
	Prime meridian: Greenwich
自査 Heights ☆ Chart Datum / Vertical Datum	Prime meridian: 0:00:00.000 E
A Mean Water Level Model	
Ž Digital Terrain Models	Conversion factor to metres: 1.0000000000000
	Semi-major axis (a): 6378137.000 m
Universal Transverse Mercator (North Hemisphere)	Semi-minor axis (b): 6356752.314 m
Local Construction Grid	Inverse flattening (1/f): 298.257223563000
💩 UTC to GPS Correction	Flattening (f): 0.003352810664747
Sound Velocity Profile	First eccentricity (e): 0.081819190842621
Object	First eccentricity squared (e**2): 0.006694379990141
Amy Gale	Second eccentricity (e'): 0.082094437949696
<mark>白 語</mark> System → 添 EM2040C	Second eccentricity squared (e**2): 0.006739496742276
⊟ ∯ Gyro	
L ↓ Gyro	
- # Pitch Roll Heave Sensor	
L. Position Navigation System	
⊨ ¥ Variable Node	
- 🗣 Amy Gale MRU	
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Link Auxiliary Systems	
- Time Sync	
<ul> <li>EM2040C Controller</li> </ul>	
ASCII Logger	
Fixed Node	

<ul> <li>Survey</li> <li>General</li> <li>Geodetic</li> <li>Datums</li> <li>WGS84</li> <li>Chart Datum / Vertical Datum</li> <li>Mean Water Level Model</li> <li>Digital Terrain Models</li> <li>Projections</li> <li>Universal Transverse Mercator (North Hemisphere)</li> <li>Local Construction Grid</li> <li>Object</li> <li>Object</li> <li>Sound Velocity Profile</li> <li>Object</li> <li>Mamy Gale</li> <li>System</li> <li>KeM2040C</li> <li>Ø Gyro</li> <li>Y Fitch Roll Heave Sensor</li> <li>Position Navigation System</li> <li>Variable Node</li> <li>Many Gale MRU</li> </ul>	Height Chart datum: Height file: Height level: Height offset: MWL model: MWL file: MWL file: MWL offset: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level: DTM file:	ks: Heights WGS84 N/A No Level Correction N/A 0.000 m Horizontal Datum N/A No Level Correction N/A 0.000 m 0.000 m 0.000 m Absolute DTMs WGS84 N/A No Level Correction
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<ul> <li>WGS84</li> <li>Chart Datum / Vertical Datum</li> <li>Mean Water Level Model</li> <li>Digital Terrain Models</li> <li>Projections</li> <li>Universal Transverse Mercator (North Hemisphere)</li> <li>Local Construction Grid</li> <li>Outro GPS Correction</li> <li>Sound Velocity Profile</li> <li>Object</li> <li>Mary Gale</li> <li>System</li> <li>Kem2040C</li> <li>Ø Gyro</li> <li>Gyro</li> <li>Yor Gyro</li> <li>Yor Gyro</li> <li>Yor Dick Construction System</li> <li>Yor Variable Node</li> </ul>	Height file: Height level: Height offset: MWL model: MWL file: MWL file: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	N/A No Level Correction N/A 0.000 m Horizontal Datum N/A No Level Correction N/A 0.000 m 0.000 m 0.000 m Absolute DTMs WGS84 N/A
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<ul> <li>Chart Datum / Vertical Datum</li> <li>Mean Water Level Model</li> <li>Digital Terrain Models</li> <li>Projections</li> <li>Universal Transverse Mercator (North Hemisphere)</li> <li>Local Construction Grid</li> <li>Outro to GPS Correction</li> <li>Sound Velocity Profile</li> <li>Object</li> <li>Army Gale</li> <li>System</li> <li>EM2040C</li> <li>Ø Gyro</li> <li>Gyro</li> <li>Yorgyro</li> <li>Projection Navigation System</li> <li>Yoriable Node</li> </ul>	Height file: Height offset: MWL model: MWL file: MWL level: MWL offset: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	N/A 0.000 m Horizontal Datum N/A No Level Correction N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A
Mean Water Level Model     Digital Terrain Models     Digital Terrain Models     Digital Terrain Models     Diversal Transverse Mercator (North Hemisphere)     Diversal Transverse Mercator (North Hemisphere)     Diversal Construction Grid     Diversal Construction Grid     Object     Object     Many Gale     System     ME2040C     Sy Gyro     J-' Gyro     J-' Pitch Roll Heave Sensor     Position Navigation System     Y Variable Node	Height offset: MWL model: MWL file: MWL level: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	0.000 m Horizontal Datum N/A No Level Correction N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A
Digital Terrain Models     Projections     Diversal Transverse Mercator (North Hemisphere)     Local Construction Grid     Outro to GPS Correction     Sound Velocity Profile     Object     Mary Gale     System     Mary Gale     System     Mary EM2040C     Ar Gyro     Jacobia Grid     Projection Navigation System     Yosition Navigation System     Yosition Navigation System     Yosition Navigation System	MWL model: MWL file: MWL level: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	Horizontal Datum N/A No Level Correction N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A
<ul> <li>Projections</li> <li>Universal Transverse Mercator (North Hemisphere)</li> <li>Local Construction Grid</li> <li>UTC to GPS Correction</li> <li>Sound Velocity Profile</li> <li>Object</li> <li>Many Gale</li> <li>System</li> <li>EM2040C</li> <li>Ø Gyro</li> <li>Gyro</li> <li>Y Gyro</li> <li>Y Dich Roll Heave Sensor</li> <li>Position Navigation System</li> <li>Y Variable Node</li> </ul>	MWL file: MWL level: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	N/A No Level Correction N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A
Image: System         Image: System <t< td=""><td>MWL level: MWL file: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:</td><td>No Level Correction N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A</td></t<>	MWL level: MWL file: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	No Level Correction N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A
Local Construction Grid → UTC to GPS Correction Cobject → Amy Gale → System → EM2040C → Ø Gyro → Ó Gyro → Position Navigation System → ✓ Variable Node	MWL file: MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	N/A 0.000 m 0.000 m Absolute DTMs WGS84 N/A
→ O       UTC to GPS Correction         → C       Sound Velocity Profile         → Object       →         → My Gale       →         → M       EM2040C         → ♥       Gyro         → ✓       Position Navigation System         → ✓       Variable Node	MWL offset: MWL st.dev.: DTM mode: DTM datum: DTM file: DTM level:	0.000 m 0.000 m Absolute DTMs WGS84 N/A
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Object     Amy Gale     System     FM2040C     F Ø Gyro     Fy Gyro     Fy Fitch Roll Heave Sensor     Fy Poitton Navigation System     Fy Variable Node	DTM mode: DTM datum: DTM file: DTM level:	Absolute DTMs WGS84 N/A
EM2040C	DTM datum: DTM file: DTM level:	WGS84 N/A
← EM2040C ⊕ & Gyro ↓ ´ Gyro ↓ ´ Pitch Roll Heave Sensor ↓ Position Navigation System ⊕ ↓ Yariable Node	DTM file: DTM level:	N/A
	DTM level:	
Gyro → Pitch Roll Heave Sensor → Position Navigation System → Variable Node	and an	No Level Correction
- # Pitch Roll Heave Sensor _ ▲ Position Navigation System □ ↓ Variable Node	DTM file:	
☐ I Position Navigation System □ ↓ Variable Node		N/A
$\mapsto$ ${\leftarrow}$ Variable Node	DTM offset:	0.000 m
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Auxiliary Systems		
<ul> <li>− ⊗ Time Sync</li> <li>■ EM2040C Controller</li> </ul>		
- ASCII Logger		
Fixed Node		
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🕀 🕎 Survey	Height Detune Chart Detune (Vertical Detune
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Qinsy 9 For Help, press F1	1

∃ <b>₩' Survey</b> - ⓓ General	MWL Model: Mean Water Level Model	
Geodetic Geodet	MWL model:       Horizontal Datum         MWL level:       No Level Correction         MWL file:       N/A         MWL offset:       0.000 m         MWL st.dev:       0.000 m	

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Polatums     Projection type:     0001       WGS04     Projection name:     Universal Transverse Mercator (North Hemisphere)       ▲ Z Heights     Conversion factor to metre:     1000000000000       ▲ Z hart Datum / Vertical Datum     Conversion factor to metre:     1000000000000       ▲ Z hart Datum / Vertical Datum     Conversion factor to metre:     1000000000000       ▲ Straights     Conversion factor to metre:     1000000000000       ▲ Universal Transverse Mercator (North Hemisphere)     □     0       ■ Digital Terrain Models	Projection type:       0001         ■ WGS84       Projection name:       Universal Transverse Mercator (North Hemisphere)         ■ Atter Level Model       Conversion factor to metres:       1.0000000000000         ■ Mean Water Level Model       Construction grid type:       Undefined         ■ Models       Construction grid type:       Undefined         ■ Projections       Construction grid type:       Undefined         ■ Object       System       System         ■ Attrack       System       System         ■ York Coll Heave Sensor       Projection system       Projection system         ■ York Variable Node       ● Xorabel MRU       Projection factor to metres:       Invigoal MRU         ● TX       Variable Node       ● TX       Projection factor to metres:       Invigoal Notes
	- Image: Auxiliary Systems - Ö Time Sync - Image: EM2040C Controller

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Survey	Projection: Unive	ersal Transverse Mercator (North Hemisphere
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<b>Geodetic</b>	Construction grid type: Undefined	
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E W Survey	System: EM2040C			
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Geodetic	Description:	EM2040C		
WGS84	Type:	Multibeam Echosounder		
⊟ ★ 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		
🖨 🐻 Projections	Update rate:	0.000 s		
- 🔁 Universal Transverse Mercator (North Hemisphere)		[Directly into Qinsy] (No additional time tags)		
Local Construction Grid	Acquired by:			
UTC to GPS Correction	Observation time from:	N/A		
Sound Velocity Profile	Number of slots:	1		
금 불 Object	Manufacturer:	Kongsberg		
	Model:	EM2040C		
EM2040C	Object location:	Amy Gale		
<i>⊟ \$</i> <sup>#</sup> Gyro	Node name:	RX		
Gyro	X (Stbd = Positive)::	0.000 m		
H Pitch Roll Heave Sensor	Y (Bow = Positive)::	-0.045 m		
Position Navigation System	Z (Up = Positive)::	0.006 m		
🖨 💥 Variable Node	A-priori SD:	0.010 m		
- Amy Gale MRU	Roll offset:	0.332	 	
	Pitch offset:	0.279		
S Link	16-17) 16-90 (FER 10)	-0.181		
⊢ ™ Link ⊟-3■ Auxiliary Systems	Heading offset:			
-Ö Time Sync	Unit is roll stabilized:	No		
EM2040C Controller	Unit is pitch stabilized:	No		
-D+ 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		
	Slot:	1		
	SD type:	Pulse, Sampling	 	
	SD pulse length:	0.150 ms		
	SD sampling length:	0.050 m		

24 📕 🙏 💿 🖉 📲 🕎 📟 😰 🔛 🔒	1 1		
Survey	Update rate:	0.000 s	
III General	Acquired by:	[Directly into Qinsy] (No additional time tags)	
T Geodetic	Observation time from:	N/A	
Datums     WGS84	Number of slots:	1	
⊟ ★ Heights	Manufacturer:	Kongsberg	
🖉 🛣 Chart Datum / Vertical Datum	Model:	EM2040C	
📥 Mean Water Level Model	Object location:	Amy Gale	
🚽 🛣 Digital Terrain Models	Node name:	RX	
E Brojections	X (Stbd = Positive)::	0.000 m	
- Universal Transverse Mercator (North Hemisphere)	Y (Bow = Positive)::	-0.045 m	
Les Local Construction Grid	Z (Up = Positive)::	0.006 m	
Sound Velocity Profile	A-priori SD:	0.010 m	
Object	Roll offset:	0.332	
Amy Gale	Pitch offset:	0.279	
🖨 🔚 System	Heading offset:	-0.181	
		Characterized in the second	
i ⊕ Φ' Gyro ↓ ↓ ΄ Gyro	Unit is roll stabilized:	No	
→ Gyro	Unit is pitch stabilized:	No	
1. Position Navigation System	Unit is heave compensated:	No	
🗄 💥 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	
Le TX	Maximum number of beams per ping:		
Link Auxiliary Systems	Use sound velocity from unit:	Yes	
Time Sync	Slot:	1	
<ul> <li>EM2040C Controller</li> </ul>	SD type:	Pulse, Sampling	
🗠 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	

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	gram		39 <del>-3</del> 8	×
File Edit View Options Help				
E 🕺 📕 🙏 💿 🔗 🛛 🔢 📟 🛃 🔛 🔒	(1) (2)			
Survey	System: Gyr			
- 🕜 General	System: Gyr	U C		
🚍 🖝 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				
<ul> <li>➡ Variable Node</li> <li>➡ Amy Gale MRU</li> <li>■ RX</li> <li>■ TX</li> <li>■ Link</li> </ul>				
→ ▲uxiliary Systems  → ▲ Time Sync  → ■ EM2040C Controller  → ASCII Logger				
→ Fixed Node				
Qinsy 9 For Help, press F1	1			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		27 <del>-1</del> 8	×
File Edit View Options Help				
E W Survey	Observation	: Evro		
- 🖪 General	Observation	. dylo		
Geodetic	Observation description:	Gyro		
G WGS84	Observation type:	Bearing (True)		
e # Heights	'At' node:	Amy Gale MRU		
Chart Datum / Vertical Datum	Measurement unit code:	Degrees		
A Mean Water Level Model	System description:	Gyro		
🛓 Digital Terrain Models	(C-O) option:	(C-O) offsets applied first		 
Projections	Scale factor:	1.0000000000		
Local Construction Grid	Fixed system (C-O):	0.00000000		
- 💩 UTC to GPS Correction	Variable (C-O):	0.0000000		
Sound Velocity Profile	A-priori SD:	0.5000		
Big Object				
🗄 🔤 Amy Gale				
EM2040C				
⊖ Ø Gyro				
Gyro				
☆ Pitch Roll Heave Sensor				
🕺 Ž. Position Navigation System				
⊨ 🖓 Variable Node				
- C Amy Gale MRU				
- • RX				
L © TX				
□ 🖗 Link				
Auxiliary Systems				
—				
-X Fixed Node				
)insy 9 For Help, press F1				

-

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		20 <del></del> 0	×
File Edit View Options Help				
E   🌿 🔜 🙏 💿 🖉 🛛 📃 📟   📴 🛛 🤮   💷 🔒	( <b>b</b> ) ( <b>b</b> )			
<b>□</b> III Survey	System: Pitch Roll	Heave Sensor		
General	System: Then Ron	Theave Sensor		
Geodetic     Datums	Description:	Pitch Roll Heave Sensor		
	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		
	Latency:	0.000 s		
- 🔄 Universal Transverse Mercator (North Hemisphere)	Acquired by:	[Directly into Qinsy] (No additional time tags)		
Local Construction Grid	Observation time from:	N/A		
Sound Velocity Profile	Number of slots:	0		
B Bobject				
🖨 🏧 Amy Gale	Object:	Amy Gale		
System	PRH sensor reference number:	1		
	Rotation convention pitch:	Positive bow up		
⊨ 𝗚 Gyro	Rotation convention roll:	Positive heeling to starboard		
-l⇒′ Gyro	Angular variable measured:	HPR (roll first)		
☆ Pitch Roll Heave Sensor	Angular measurement units:	Degrees		
Position Navigation System	Sign convention heave:	Positive upwards		
	Measurement unit heave:	Meters		
	Conversion factor to degrees decimal:	N/A		
I I I I I I I I I I I I I I I I I I I	Conversion factor to metres:	N/A		
Link	Quality indicator type pitch and roll:	No quality info recorded		
Auxiliary Systems	Quality indicator type heave:	No quality info recorded		
-Ö Time Sync	Description of quality indicator type:	N/A		
EM2040C Controller	Object location:	Amy Gale		
- D• ASCII Logger	Node name:	Amy Gale MRU		
	X (Stbd = Positive)::	0.000 m		
	Y (Bow = Positive)::	0.000 m		
	Z (Up = Positive)::	0.000 m		
	A-priori SD:	0.000 m		
	(C-O) roll offset:	0.000 °		 
	(C-O) pitch offset:	0.000 °		
	(C-O) heave offset:	0.000 m		
	Heave time delay:	0.000 s		 
Qinsy 9 For Help, press F1				

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Survey	Latency:	0.000 s	
General	Acquired by:	[Directly into Qinsy] (No additional time tags)	
Ceodetic	Observation time from:	N/A	
⊖	Number of slots:	0	
E ★ Heights	The Data Me		
🖉 🛣 Chart Datum / Vertical Datum	Object:	Amy Gale	
👍 Mean Water Level Model	PRH sensor reference number:	1	
🛓 🛓 Digital Terrain Models	Rotation convention pitch:	Positive bow up	
Projections	Rotation convention roll:	Positive heeling to starboard	
🔣 Universal Transverse Mercator (North Hemisphere)	Angular variable measured:	HPR (roll first)	
Local Construction Grid	Angular measurement units:	Degrees	
O UTC to GPS Correction	Sign convention heave:	Positive upwards	
C Sound Velocity Profile	Measurement unit heave:	Meters	
Object	Conversion factor to degrees decimal:	N/A	
Amy Gale	Conversion factor to metres:	N/A	
自 <mark>譜 System</mark> │	Quality indicator type pitch and roll:	No quality info recorded	
EM2040C ⊟ Ø Gyro	Quality indicator type heave:	No quality info recorded	
L L Gyro	Description of quality indicator type:	N/A	
- Hitch Roll Heave Sensor	Object location:	Amy Gale	
L Position Navigation System	Node name:	Amy Gale MRU	
□ 🕂 Variable Node	X (Stbd = Positive)::	0.000 m	
Amy Gale MRU	Y (Bow = Positive)::	0.000 m	
- • RX			
L @ TX	Z (Up = Positive)::	0.000 m	
Eink	A-priori SD:	0.000 m	
Auxiliary Systems	(C-O) roll offset:	0.000 °	
Õ Time Sync ■ EM2040C Controller	(C-O) pitch offset:	0.000 °	
ASCII Logger	(C-O) heave offset:	0.000 m	
Fixed Node	Heave time delay:	0.000 s	
	Heave filter length:	N/A	
	SD roll and pitch:	0.050 °	
	SD heave (fixed):	0.050 m	
	SD heave (variable):	5.000 %	
	SD roll offset:	0.050 °	
	SD pitch offset:	0.050 °	
	SD heave offset:	0.050 m	

Survey       System: Position Navigation System         General       General         General       Paturus         Microsoft       Posciption:         Posciption:       Postion Navigation System         Type:       Postion Navigation System         Driver:       Network-Seapeth Binage Format 11 (With UTC)         Description:       Postion Navigation System         Driver:       Network-Seapeth Binage Format 11 (With UTC)         Description:       Postic Transmother         Driver:       Network-Seapeth Binage Format 11 (With UTC)         Description:       Postic Transmother         Driver:       Difference         Driver:       Namber of slots:         Drescription:       Namber of slot	🏂 📕 🙏 💿 🖉 🔢 🔢   📟   🖉   🗟   💷 🔒   (	8		
■ Geodetic       Description:       Position Navigation System         ■ WidS84       Type:       Position Navigation System         ■ Keinghis       Ministry System       Type:       Position Navigation System         ■ Keinghis       Ministry System       Diver:       Navigation System         ■ Keinghis       Ministry System       Diver:       Navigation System         ■ Konstry       Ministry       Diver:       Spatian         ■ Konstry       Ministry       Diver:       Diver:         ■ Konstry       Diver:       Diver: </th <th></th> <th>System: Pos</th> <th>sition Navigation System</th> <th></th>		System: Pos	sition Navigation System	
<ul> <li>Time Sync</li> <li>EM2040C Controller</li> <li>ASCII Logger</li> </ul> <ul> <li>Ascil Logger</li> <li>Fixed Node</li> </ul> Amy Gale MRU             X (Stbd = Positive):: 0.000 m             Y (Bow = Positive): 0.000 m             Y (Bow = P	General     General     General     Geodetic     Datums     Geodetic     Datums     Geodetic     Datums     Geodetic     WGS84     Chart Datum / Vertical Datum     Mean Water Level Model     Digital Terrain Models     Digital Terrain Models     Digital Terrain Models     Projections     Clocal Construction Grid     OUTC to GPS Correction     Sound Velocity Profile     Object     Many Gale     System     Fostion Navigation System     Variable Node     Amy Gale MRU     RX     TX     Kinck	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 file: Height offset: SD latitude: SD longitude: SD height:	Position Navigation System         Position Navigation System         Network - Seapath Binary Format 11 (With UTC)         2:       DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS         13001       0.000 s         0.000 s	
Z (Up = Positive):: 0.000 m A-priori SD: 0.000 m	- EM2040C Controller D= ASCII Logger	Object location: Node name: X (Stbd = Positive):: Y (Bow = Positive):: Z (Up = Positive)::	0 Amy Gale Amy Gale MRU 0.000 m	

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	gram	12-30	×
File Edit View Options Help			 
E   🔏 🔜 🙏 💿 🖉 🛛 🗄   🔤   📟   🖉   🗟   🕮 🔒			
E W Survey	Node: Amy Gale MRU		
Geodetic Geodet	Object location:       Amy Gale         Node name:       Amy Gale MRU         X (Stbd = Positive):       0.000 m         Z (Up = Positive):       0.000 m         A-priori SD:       0.000 m		
Qinsy 9 For Help, press F1			1

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Prog	jram	- 🗆 X
File Edit View Options Help		
Emeral	Node: RX	
🖶 🖝 Geodetic	Object location: Amy Gale	
🖨 🥵 Datums	Node name: RX	
- 5 WGS84	X (Stbd = Positive):: 0.000 m	
🗎 🛣 Heights		
🚽 Chart Datum / Vertical Datum	Y (Bow = Positive):: -0.045 m	
Mean Water Level Model	Z (Up = Positive):: 0.006 m	
ーえ Digital Terrain Models 回覧 Projections	A-priori SD: 0.010 m	
🛐 Universal Transverse Mercator (North Hemisphere)		
Local Construction Grid		
-Ö UTC to GPS Correction		
Sound Velocity Profile		
금 윤 Object		
🖨 🔤 System		
EM2040C		
⊟ Ø Gyro		
L → Gyro		
Pitch Roll Heave Sensor		
L Position Navigation System		
□ 💥 Variable Node		
Amy Gale MRU		
® RX		
TX ®		
Link		
🖨 🔚 Auxiliary Systems		
- Ö Time Sync		
EM2040C Controller		
- D+ ASCII Logger		
└─☆ Fixed Node		
Qinsy 9 For Help, press F1	1	

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program	n	- 🗆 X
File Edit View Options Help		
Survey	Node: TX	
- III General		
E-& Geodetic	Object location: Amy Gale	
Datums	Node name: TX	
- 5 WGS84	X (Stbd = Positive):: 0.040 m	
⊨ 🚖 Heights	Y (Bow = Positive):: 0.004 m	
→ 🛣 Chart Datum / Vertical Datum	Z (Up = Positive):: 0.006 m	
2 Digital Terrain Models	A-priori SD: 0.010 m	
	A-prior SD: 0.010 m	
- Universal Transverse Mercator (North Hemisphere)		
Local Construction Grid		
- O UTC to GPS Correction		
Sound Velocity Profile		
🕀 🚼 Object		
🗄 🛄 Amy Gale		
🖨 🔚 System		
⊜ Ø Gyro		
Pitch Roll Heave Sensor		
L Position Navigation System		
la X Variable Node		
● RX		
- S Link		
Auxiliary Systems		
- Time Sync		
EM2040C Controller		
- D+ ASCII Logger		
-X Fixed Node		
10 <sup>-0</sup>		
Qinsy 9 For Help, press F1	1	

Survey       System: Time Sync         Image: General       Description:         Image: Geodetic       Description:	Time Sync Time Synchronization System NMEA ZDA DrvPositionNMEA.exe 2 9600 8 1 None 10 bits (1.042 ms) 960 bytes / second 0.000 s
Image: Description:       Description:         Image: WGS84       Type:         Image: WGS84       Driver:         Image: WGS84       Port:         Image: WGS84       Data bits:         Image: WGS84       Data bits:         Image: WGS84       Data bits:         Image: WGS84       Data bits:         Image: WGS84       Parity:         Image: WGS84       Byte frame length (time):         Image: WGS84       Wgdate rate:         Image: WGS84       Update rate:         Image: WGS84       Update rate:         Image: WGS84       May:         Imag	Time Synchronization System NMEA ZDA DrvPositionNMEA.exe 2 9600 8 1 1 None 10 bits (1.042 ms) 960 bytes / second 0.000 s
<ul> <li>Position Navigation System</li> <li>Position Navigation System</li> <li>Variable Node</li> <li>Amy Gale MRU</li> <li>RX</li> <li>TX</li> <li>Link</li> <li>Auxiliary Systems</li> <li>Time Sync</li> <li>EM2040C Controller</li> <li>ASCII Logger</li> <li>Fixed Node</li> </ul>	0.000 s [Directly into Qinsy] (No additional time tags) N/A 0 On COM1 Automatic Matching : Synchronization is enabled

	1 3		
Usurvey	System: EM2	2040C Controller	
Geodetic			
	Description:	EM2040C Controller	
WGS84	Type:	Miscellaneous System	
⊟ Ż Heights	Driver:	Kongsberg EM2040 Compact (Single) Multibeam Controller	
🛓 Chart Datum / Vertical Datum	Executable and Cmdline:	DrvKongsbergEMCtrl.exe 2040C	
📥 Mean Water Level Model	Update rate:	0.000 s	
🚽 📩 Digital Terrain Models	Latency:	0.000 s	
E Projections	Acquired by:	[Directly into Qinsy] (No additional time tags)	
Local Construction Grid	Observation time from:	N/A	
- 💩 UTC to GPS Correction	Number of slots:	0	
Sound Velocity Profile			
a Object			
Amy Gale			
System			
i ⊟ Ø Gyro			
└─↓ Gyro └─╁ Pitch Roll Heave Sensor			
Position Navigation System			
→ Y Variable Node			
Amy Gale MRU			
• RX			
● TX			
link			
Auxiliary Systems			
🖉 Time Sync			
EM2040C Controller			
ASCII Logger			
¥ Fixed Node			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		20 <del></del> 38		×		
File Edit View Options Help							
E   % 🛄 🙏 💿 🖉 🛛 🔢   📟   🖉   🗟   📖 🔒	8 3						
	Sustam ASC						
- 🔄 General	System: ASCII Logger						
🖨 🕉 Geodetic	Description:	ASCII Logger					
🖨 🎱 Datums	Type:	Output System					
WGS84	Driver:	Generic ASCII Data Logger (Controller)					
🗇 🛣 Heights	Executable and Cmdline:						
🚽 Chart Datum / Vertical Datum	2008 02						
→ Mean Water Level Model → Digital Terrain Models	Update rate:	1.000 s					
	Latency:	0.000 s					
- Universal Transverse Mercator (North Hemisphere)	Data output setting:	Enabled					
Local Construction Grid	Acquired by:	[Directly into Qinsy] (No additional time tags)					
-Ö UTC to GPS Correction	Observation time from:	N/A					
Sound Velocity Profile	Number of slots:	0					
□ 🗄 Object		-					
Amy Gale							
System							
j⊟ Ø Gyro							
–↓ Gyro							
-# Pitch Roll Heave Sensor							
Position Navigation System							
□ ¥ Variable Node							
- Amy Gale MRU							
® RX							
u link							
e Hauxiliary Systems							
-Ö Time Sync							
- EM2040C Controller							
-D+ ASCII Logger							
Fixed Node							
80							
Qinsy 9 For Help, press F1							

# **Appendix D – Configuration settings for Qinsy EM controller**

U Status				
Status	Active	Stop	,	
Pinging	15308 @ 2.90 H	Hz		
Clock Status	Ok		<u>P</u> u Info	•
Errors	All Ok		Options	s
			option	
ettings				
Head1 Port A	ngle	65		~
Head1 Starboard Angle		65		
Max. Port Coverage		300		-
Max. Starboar	-	300		1
Angular Cove	-	Auto	•	
Beam Spacing	-	High Density	•	
Pitch Stabiliza	tion	On	•	
Max. Ping Fre	q.(Hz)	50.00		1
Transmit Ang	le (deg)	0.0		1
Minimum De	oth	0.00		1
Maximum De	pth	200.00		
Detector Mod	e	Normal	•	
Slope Filter		On	-	
Areation Filter	r	Off	* * * * * * *	
nterference F	ilter	Off	-	
Penetration Fi	lter	Off	-	
Range Gate Si	ze	Normal	•	
Spike Filter Sti	rength	Medium	•	
Phase Ramp		Normal	•	
Special Amp [	Detect	Off	•	
Special TVG		Off	•	
Normal Inci. S	-	10		
Lambert's law	for intensity	Off	•	
Ping Mode		300 KHz	-	
Pulse Type		Auto	-	
Transmit Pow	er Level	Maximum	-	
FM Enable		FM Enabled		
3D Scanning -	Scan Step	0.0		Y
Apply	Settings 🔻	Force 🔽 Log Events		
Events				
10:00:53.105	PU Clock is sync	hronized		~
10:00:53.963	Connection to P	U (157.237.20.40) Established		
	Set Initial Settin Command Accep			

🔣 EM Controller - EM	-		×		
-PU Status					
Status Active	:			Stop	
Pinging 18646	18646 @ 2.70 Hz				
Clock Status Ok	Ok				
Errors All Ok					-1
	Options	····			
, Settings					
Penetration Filter		Off		•	
Range Gate Size		Normal		-	
Spike Filter Strength		Medium		<b>•</b>	
Phase Ramp		Normal		•	
Special Amp Detect		Off		▼ ▼	
Special TVG		Off		-	
Normal Inci. Sector A	ngle	10			
Lambert's law for inte	-	Off		-	
Ping Mode		300 KHz		-	
Pulse Type		Auto		• •	
Transmit Power Level		Maximum		-	
FM Enable		FM Enabled		-	
3D Scanning - Scan S	tep	0.0			
3D Scanning - Min A	ngle	-5			
3D Scanning - Max A	ngle	5			
Dual Swath Mode		Off		•	
Min. Swath Distance		0.0			
Yaw Stabilization Mo	de	Off		-	
Yaw Manual Angle		0.0			
Heading Filter		Medium		-	
WCD Sonar Mode		Off		-	
WCD Passive Mode		Off		-	
WC TVG LOG R		30.0			
WC TVG dB		20.0			
Special amplitude de		Off		-	
Sound Velocity Updat		3.0			
Sound Velocity Min C	hange	0.5			~
Apply Settings.	🔻 🔤	Force 🔽 Log Events			
Events					
10:00:53.105 PU Cloo 10:00:53.963 Connec 10:00:53.963 Set Init	ction to Pl	J (157.237.20.40) Established			^
10:00:55.073 Comma					~

PU Setup System Type (from Pu Ip Address Simulation Mode External Triggering Control Port Enabled Output Por Output Port 1 (Bat		EM2040C			
Pu Ip Address Simulation Mode External Triggering Control Port Enabled Output Po		EM2040C			
Pu Ip Address Simulation Mode External Triggering Control Port Enabled Output Po			Single Transducer 🚽 👻		
Simulation Mode External Triggering Control Port Enabled Output Po		157.237.2		IT.	
Control Port Enabled Output Po		Off	•		
Enabled Output Po	4	Off	-	1	
		2000		1	
Output Port 1 (Bat	orts	Output P	Output Port 1,2,3 🔹		
	thy)	2001			
Output Port 2 (Bat	thy)	2002			
Output Port 3 (Sid	escan)	2003			
ZDA/GGA Serial Po	ort	Port 1 (de	fault) 💌		
Use GGA		On	-		
Baudrate ZDA/GG	A	9600	-		
Motion Serial Port		Port 2 (de	fault) 🔻	1 -	
Program Options					
Start Pinging when	n QINSy Starts		Pinging On Startup	-	
Synchronize Clock	Interval(min.)		60		
Sound Velocity Mo	ode		From SoundVelocity C	-	
Sound Velocity Observation			-		
	oservation		Sound Velocity	•	
			Sound Velocity On	-	
Sound Velocity Ob Popup window wh		n Data	-	•	
Sound Velocity Ob Popup window wh	hen error occurs acing with Water Columi	n Data	On		
Sound Velocity Ob Popup window wh Allow HD beamsp	hen error occurs acing with Water Columi	n Data	On		
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet	hen error occurs Pacing with Water Column Pro	0	On Not Allowed	• • •	
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet Head1 Installation	hen error occurs lacing with Water Column ars angles from	0 0 EM2040	On Not Allowed		
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet Head1 Installation Head2 Installation	hen error occurs acing with Water Column ars angles from angles from	0 0 EM2040 Not Us	On Not Allowed		
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet Head1 Installation Head2 Installation Velocity Sensor Nu	hen error occurs acing with Water Column ars angles from angles from umber	0 0 EM2040 Not Us Motior	On Not Allowed		
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet Head1 Installation Head2 Installation Velocity Sensor UD Velocity Sensor UD	hen error occurs acing with Water Column ars angles from angles from umber DP Port	0 0 EM2040 Not Us Motior 3001	On Not Allowed	•••	
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet Head1 Installation Head2 Installation Velocity Sensor Nu Velocity Sensor UE Velocity Sensor Eth	hen error occurs lacing with Water Column ass angles from angles from umber DP Port hernet Port	0 0 EM2040 Not Us Motior 3001 Etherne	On Not Allowed	•••	
Sound Velocity Ob Popup window wh Allow HD beamsp Installation Paramete RX1 Gain Offet RX2 Gain Offet Head1 Installation Head2 Installation Velocity Sensor Nu Velocity Sensor UE	hen error occurs lacing with Water Column angles from angles from umber DP Port hernet Port Address	0 0 EM2040 Not Us Motior 3001	On Not Allowed		

# **Appendix E – New Computation Settings for Qinsy Online**

tations	Position Navigation Sy	ysten   Position Filter   Position Res	ults Attitude Height			
L	Amy Gale		· ·			
}	- 🗹 🧎 Position Naviga		î			
nputation	Pitch Roll Heav	Priority Method		Max Age	Skew	Move U
_		1 Heave Pi	tch Roll Heave Sen:	1.00 [s]	<mark>∏ No</mark>	
	🔄 🛄 📥 Offset System Amy					Move Do
nputation	Copy of Position Navigation	in Sys				
nperation	Amy Gale	ation (				
2	Gyro	auon				
$\sim$	🗌 🖳 🗹 🕁 Pitch Roll Heav	veSe				
iove utation						
		y Gale				
		Tide Parameters				
		Tide method		Mean Wa	ter Level Model	
		Draft and Squat Paramete				
			rs			
		Draft method		Mar	nual Draft	
		Draft method Manual draft			0.850	
		Draft method				
		Draft method Manual draft			0.850	
		Draft method Manual draft			0.850	
		Draft method Manual draft			0.850	
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		Draft method Manual draft			0.850	
		Draft method Manual draft			0.850	
touts		Draft method Manual draft			0.850	

omputations	Position Navigation System	System Parameters		
÷	Position Navigati	Use this system to trigger the cor	nputation	
Computation	····· ☑ ∅ Gyro ····· ☑ ☆ Pitch Roll Heave Se	Height status	RTK (Accurat	te Height)
-		Preferred position SD	System	Driver
	🚽 🔤 Offset System Amy Gale	Position a priori SD	System I	i [m]
Computation	Copy of Position Navigation Sys	Preferred height SD	System I	
Comparation	Amy Gale	Height a priori SD		)[m]
52	Gyro		0.50	.[11]
$\sim$	Pitch Roll Heave Se	Dynamic a priori SD	Disa	bled
Remove omputation				
		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	
Shortcuts	< >>			

 $\times$ 

#### Computation Setup

	Position Navigation System	System Parameters		
<del>ረ</del>	Position Navigation !	Use this system to trigger the com	putation	
omputation	⊡Ø Gyro ⊡¥ Pitch Roll Heave Se	Height status	Tide (Unrelia	ole Height)
-	🗹 🥂 EM2040C	Professed a setting SD	Curtana I	Driver
	🖳 🚘 Offset System Amy Gale	Preferred position SD	System I	
	Copy of Position Navigatio	Position a priori SD Preferred height aiding SD	Database	[m] Setup
omparation	Amy Gale	Height aiding a priori SD		matic
$\sim$	— 🗹 👗 <mark>Position Navigati</mark> — 🗹 🛱 Gyro		Auto	matic
$\sim$	Pitch Roll Heave Se	Dynamic a priori SD	Disa	bled
emove nputation	ー 図 旅 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	Satellite Count	0	

Computations	Position Navigation System	Computation Parameters	
- cp	Amy Gale	Computation name	Position Navigation System
50°	Gyro	Triggering system	Position Navigation System
New Computation	Pitch Roll Heave Se	Max. triggering rate	20 [Hz]
_		Iteration threshold	5
	Offset System Amy Gale	Statistical testing	Separate Objects
	Copy of Position Navigation Sys	Data snooping	Enabled
Copy Computation	🗹 🔐 Amy Gale	Redundancy minimum	1
$\sim$	Position Navigation !	Level of significance	1 %
23	Gyro Ø	Power of test	80 %
Remove	Pitch Roll Heave Se		
Computation	EM2040C	Lower limit max. ages	0.0 [s]
		Approximate Position	
		Coordinate system	Grid
		Easting	4840352.1
		Northing	8669036.1
		Height	0.0
		Incigin	0.0
		Computation Priority	
		Priority Status	Heights Computation Move Up
			Tide (Unrelia Copy of Position Navigation System
			RTK (Accurat Position Navigation System Move Down
Shortcuts	< >>		
	OK Apply	Cancel	

# Appendix F – Mainscheme 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  $\pm$ sigma 1, 2, and 3
- Blue lines represent the mean value



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



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



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

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



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





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

Uncertainty: Depth Bias (m) vs Beam Number

