U.S. Department of Commerce National Oceanic and Atmospheric Administration National Ocean Service			
Ι	DESCRIPTIVE REPORT		
Type of Survey:	Navigable Area		
Registry Number:	W00676		
	LOCALITY		
State(s):	Maine		
General Locality:	Gulf of Maine		
Sub-locality:	Vicinity of Casco Bay		
	2021		
	CHIEF OF PARTY Peyton Benson		
	LIBRARY & ARCHIVES		
Date:			

U.S. DEPARTMENT OF COMMERCE REGISTRY NUMBER: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION				
HYDROGRAP	W00676			
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:	20000			
Dates of Survey:	04/15/2021 to 05/02/2022			
Instructions Dated:	05/09/2023			
Project Number:	ESD-AHB-23			
Field Unit:	State of Maine			
Chief of Party:	Peyton Benson			
Soundings by:	Kongsberg Maritime EM 2040C (MB	ES)		
Imagery by:	N/A			
Verification by:	Atlantic Hydrographic Branch			
Soundings Acquired in:	meters at Mean Lower Low Water			

Remarks:

Any revisions to the Descriptive Report (DR) applied during office processing are shown in red italic text. The DR is maintained as a field unit product, therefore all information and recommendations within this report are considered preliminary unless otherwise noted. The final disposition of survey data is represented in the NOAA nautical chart products. All pertinent records for this survey are archived at the National Centers for Environmental Information (NCEI) and can be retrieved via https://www.ncei.noaa.gov/. Products created during office processing were generated in WGS84 UTM 19N, MLLW. All references to other horizontal or vertical datums in this report are applicable to the processed hydrographic data provided by the field unit.

DESCRIPTIVE REPORT MEMO

May 09, 2023

MEMORANDUM FOR:	Atlantic Hydrographic Branch
FROM:	Report prepared by AHB on behalf of field unit Claire Enterline Maine Coastal Mapping Initiative Program Coordinator, State of Maine
SUBJECT:	Submission of Survey W00676

This survey was a part of a large data set provided by the State of Maine Coastal Mapping Initiative.

Survey products were created by the Atlantic Hydrographic Branch.

All soundings were reduced to Mean Lower Low Water using Discrete Zoning. The horizontal datum for this project is World Geodetic System (WGS) 1984. The projection used for this project is Universal Transverse Mercator (UTM) Zone 19.

This survey does not include a data acquisition and processing report.

All data were reviewed for DTONs and none were identified in this survey.

The State of Maine Coastal Mapping Initiative acquired the data outlined in this report. Data are available at https://www.maine.gov/dmr/programs/maine-coastal-program/coastal-science-and-research/maine-coastal-mapping-initiative/. Additional documentation from the data provider may be attached to this report.

This survey does meet charting specifications and is adequate to supersede prior data. This survey will be used to update NOAA navigational products.

2021 Descriptive Report of Seafloor Mapping: Vicinity of Casco Bay

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, July 2022

Disclaimer

These data and information published herein are accurate to the best of our knowledge. Data synthesis, summaries and related conclusions may be subject to change as additional data are collected and evaluated. While the Maine Coastal Program makes every effort to provide useful and accurate information, investigations are site-specific and (where relevant) results and/or conclusions do not necessarily apply to other regions. The Maine Coastal Program does not endorse conclusions based on subsequent use of the data by individuals not under their employment. The Maine Coastal Program disclaims any liability, incurred as a consequence, directly or indirectly, resulting from the use and application of any of the data and reports produced by staff. Any use of trade names is for descriptive purposes only and does not imply endorsement by The State of Maine.

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>.

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:				
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Sub-Localities:	Vicinity of Casco Bay			
	2021			
CHIEF OF PARTY				
Peyton Benson, Hydrographer, Contractor to the State of Maine				
	LIBRARY & ARCHIVES			
Date:				

	REGISTRY NUMBER:			
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~				
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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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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 mi² (95.8 km²) 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 mi² 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.

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



Figure 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 6th 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 ± 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

# of Points of Comparison	22848609
Data Mean	-71.472299 m
Reference Mean	-71.443698 m
Difference Mean	-0.028601 m
Difference Median	-0.028601 m
Std. Deviation	0.477 m
Data Z - Range	-148.44 m to -28.74 m
Ref. Z - Range	-128.82 m to -29.19 m
Diff Z - Range	-51.878 m to 33.05 m
Mean + 2*stddev	0.982044 m
Median + 2*stddev	0.982044 m
Ord 1 Error Limit	1.054803 m
Ord 1 P-Statistic	0.031272
Ord 1 - # Rejected	714528
Order 1 Survey	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.

Table 6 - 2021	Mainscheme survey	junctions
----------------	-------------------	-----------

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 (± 65 degrees from the nadir), whereas the 2021 data were filtered to exclude soundings from beams > ± 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

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.

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 16th, 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 2nd, 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	Survey Area Tide Station		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 Scale: 5.00					
	Distance Mir	1: 2.828			
CUBE Hypothesis Resolution	on 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:	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	9/21/21	43.66597099	-70.01033069	52.2	gravelly muddy sand with shell hash	N/A

6.0 Summary

A total of 37 mi² (95.8 km²) 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.

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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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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

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- 🖲 Link					
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- 💍 Time Sync					
EM2040C Controller					
ASCII Logger					
⊢.¥ Fixed Node					
		1			
Qinsy 9	For Help, press F1				
		– 🗆 X			
--	--------------------------------------	--			
File Edit View Options Help					
Survey	Projection: Unive	ersal Transverse Mercator (North Hemisphere)			
Datums	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			
	UTM central meridian:	69:00:00.00000 W			
🚽 📩 Digital Terrain Models	Latitude of grid origin:	0:00:00.00000 N			
E Projections	Longitude of grid origin:	69:00:00 0000 W			
- 🔂 Universal Transverse Mercator (North Hemisphere)	Grid Easting at grid origin:	50,000 000 m			
一世 Local Construction Grid	Crid Northing at grid origin.	0000 m			
- © UTC to GPS Correction	Grid Northing at grid origin:	0.000 m			
Diect	Scale factor at longitude of origin:	0.99960000000			
in in System					
⊟ ¢ Gyro					
l ↓, ' Gyro					
-# Pitch Roll Heave Sensor					
L Position Navigation System					
⊨.¥ Variable Node					
• RX					
A Time Come					
- © Time Sync					
- Fixed Node					
	1				
Qinsy 9 For Help, press F1					

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program):);	×
File Edit View Options Help			
🖶 🏬 Survey	Local Grid: Local Construction Grid		
I General	Local Grid. Local Construction Grid		
e de detic	Construction grid type: Undefined		
e 🐨 Datums	2 December 2017 All All All All All All All All All Al		
- Gr WGS84			
E # Heights			
-# Chart Datum / Vertical Datum			
A Mean Water Level Model			
Projections			
Local Construction Grid			
- & UTC to GPS Correction			
C Sound Velocity Profile			
Diect			
🖨 🏧 Amy Gale			
🖨 🔚 System			
EM2040C			
ј⊨ Ø Gyro			
L-Jx' Gyro			
La Position Navigation System			
E 🖓 Variable Node			
® RX			
TX			
- S Link			
Auxiliary Systems			
EW2040C Controller			
× Eived Node			
Qinsy 9 For Help, press F1			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program		20 2	×
File Edit View Options Help			
Survey	UTC to GPS Correction		
- 1 General			
	UTC to GPS time correction: 18.000 s		
ar Chart Datum / Vertical Datum			
Mean Water Level Model			
Digital Terrain Models			
Projections			
Local Construction Grid			
- The second sec			
Sound Velocity Profile			
Diject			
🖻 🏧 Amy Gale			
🕀 📒 System			
- M EM2040C			
₽ \$P Gyro			
>* Gyro			
- 27 Pitch Roll Heave Sensor			
Variable Nede			
- ® RX			
L⊚ TX			
- 🖁 Link			
Auxiliary Systems			
- 💩 Time Sync			
M2040C Controller			
B ASCII Logger			
Fixed Node			
Qinsy 9 For Help, press F1	,		

😝 AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program		ko th	×
File Edit View Options Help			
E ½ 📕 🙏 💿 🖉 🛛 🔢 📟 🛃 🔛 🔒 🕦 😵			
Survey	Sound Velocity Profile		
Survey General General General WGS84 Heights Chart Datum / Vertical Datum Mean Water Level Model Digital Terrain Models Digital Terrain Models Digital Terrain Models Local Construction Grid Otic GPS Correction Local Construction Grid Otic to GPS Correction Local Construction Grid Mean Mean Mean Mean Mean Mean Mean Mean Mean Mean Mean Mean Mean Mean Mean	Sound Velocity Profile Profile ID: 1383 Profile latitude: 433156.02287 N Profile tongitude: 702008.58092 W Profile time: 1307 Depth unit: Meters Velocity unit: Meters / Second SD depth data: 0.100 m SD velocity data: 0.050 m/s Number of entries: 17		
Qinsy 9 For Help, press F1			

Geraphy AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program			10-0	×
File Edit View Options Help				
🖶 🏬 Survey	Object: Amy Cale			
- 🕜 General	Object: Amy Gale			
😑 🕉 Geodetic	Object reference number:	1		
🖻 🎱 Datums	Object type:	Vessel		
U WGS84	Description of reference point:	Amy Gale MRU		
	Height above draft reference:	0.000 m		
Chart Datum / Vertical Datum	Constant del	Net Defend		
Digital Tarrain Models	Squat model:	Not Defined		
	SD draft:	0.050 m		
Universal Transverse Mercator (North Hemisphere)	SD squat:	0.050 m		
	SD load:	0.050 m		
- Ö UTC to GPS Correction	SD tide:	0.100 m		
Sound Velocity Profile	Time latency navigation:	0.025 s		
다 남 Object	Time correction to GMT (UTC):	0.000 h		
🗄 🏧 Amy Gale	Time correction to master vessel's time:	0.000 s		
🖨 🔚 System				 _
⇒ \$P Gyro				
Linda Gyro				
A Prici Novi neave Sensor A Decition Navigation System				
Amy Gale MRU				
– ● RX				
L. ⊚ TX				
Link				
🖨 🔚 Auxiliary Systems				
- Ö Time Sync				
EM2040C Controller				
- 🖙 ASCII Logger				
Qinsy 9 For Help, press F1				

😝 AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pr	ogram		- 🗆 X
File Edit View Options Help			
E 🕺 🛄 🙏 💿 🖉 🛛 🔢 📟 🖉 🗟 📖 🔒			
Survey	System: EM2040C		
General F Constant	System. Emizo40e		
	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	
E Projections	Update rate:	0.000 s	
	Acquired by:	[Directly into Oinsy] (No additional time tags)	
Local Construction Grid	Observation time from:		
- O UTC to GPS Correction	Number of data	1	
Sound velocity Prome	Number of slots:		
Amy Gale	Manufacturer:	Kongsberg	
System	Model:	EM2040C	
	Object location:	Amy Gale	
🖨 🕸 Gyro	Node name:	RX	
Line Gyro	X (Stbd = Positive)::	0.000 m	
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	
	Heading offset:	-0.181	
Auxiliary Systems	Linit is roll stabilized:	No	
- Ö Time Sync	Unit is nitch stabilized:	No	
EM2040C Controller	Unit is beave compensated:	No	
- D+ ASCII Logger	Beam steering (flat transducer):	No	
└─↓¥ Fixed Node	Beam angle width along	1 500 m	
	Beam angle width along.	1.500 m	
	Beam angle width across:	1.500 m	
	Maximum number of beams per ping:	800	
	Use sound velocity from unit:	Yes	
	Slot:	1	
	SD type:	Pulse, Sampling	
	SD pulse length:	0.150 ms	
	SD sampling length:	0.050 m	
Qinsy 9 For Help, press F1			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		- 0	×
File Edit View Options Help				
E 🕺 E 🕹 🖉 🛛 🗄 📟 🔒	1 3			
Survey	Update rate:	0.000 s		
- 🖪 General	Acquired by:	[Directly into Qinsy] (No additional time tags)		
🖶 🖝 Geodetic	Observation time from:	N/A		
🗎 🚯 Datums	Number of slots:	1		
Heights	Manufacturer	Kongcherg		
The chart Datum / Vertical Datum	Madal	EM2040C		
Mean Water Level Model	Model.			
📩 Digital Terrain Models	Object location:	Amy Gale		
🖻 🖫 Projections	Node name:	RX		
	X (Stbd = Positive)::	0.000 m		
🖳 🔂 Local Construction Grid	Y (Bow = Positive)::	-0.045 m		
- 💩 UTC to GPS Correction	Z (Up = Positive)::	0.006 m		
Sound Velocity Profile	A-priori SD:	0.010 m		
Diect	Roll offset:	0.332		
🖻 🏧 Amy Gale	Pitch offset:	0.279		
System	Heading offset:	-0.181		
	Unit is roll stabilized:	No		
	Unit is not stabilized:	No		
→ the Pitch Boll Heave Sensor	Unit is prich stabilized.	No		
L Position Navigation System	Description (flat transference)	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		
	Maximum number of beams per ping:	800		
Link	Use sound velocity from unit:	Yes		
End Auxiliary Systems	Slot:	1		
FM2040C Controller	SD type:	Pulse, Sampling		
ASCILLogger	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		
Qinsy 9 For Help, press F1	1			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Progra	im		– 🗆 X
File Edit View Options Help			
	3		
😑 🌉 Survey	System: Gyr	0	
 Geodetic Datums WGS84 Heights Hean Water Level Model Digital Terrain Models Se Projections Oniversal Transverse Mercator (North Hemisphere) 	Description: Type: Driver: Executable and Cmdline: Port: Update rate: Latency: Acquired by:	Gyro Gyro Compass Network - Seapath Binary Format 11 (Hdg) (With UTC) DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS 13001 0.000 s 0.000 s Directly into Qinsyl (No additional time tags)	
- B Local Construction Grid	Observation time from:	N/A	
Sound Velocity Profile	Number of slots:	0	-
Image: System Image: System <t< td=""><td></td><td></td><td></td></t<>			
Qinsy 9 For Help, press F1	ре. 		

🖶 AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program				
File Edit View Options Help				
	8			
Survey Image: General Image: Geodetic Image: Geodetic	Observation description: Observation type: 'At' node: Measurement unit code: System description: (C-O) option: Scale factor:	n: Gyro Bearing (True) Amy Gale MRU Degrees Gyro (C-O) offsets applied first 1.0000000000		
Universal Transverse Mercator (North Hemisphere) El Local Construction Grid O UTC to GPS Correction E Sound Velocity Profile Object	Fixed system (C-O): Variable (C-O): A-priori SD:	0.000000000 0.00000000 0.5000		
Amy Gale Gyro Position Navigation System Variable Node Amy Gale MRU RX TX Link Milliary Systems AT Ime Sync EM2040C Controller Position Logger Fixed Node Controller				
Qinsy 9 For Help, press F1				

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E 🏒 📕 🙏 💿 🖉 🚽 📴 📰 📰 🗟 💷 🔒	1 1		
W Survey	System: Pitch Roll	Heave Sensor	
Geodetic Geodet	Description: Type: Driver:	Pitch Roll Heave Sensor Pitch Roll Heave Sensor Network - Seapath MRU Binary Format 11 (With UTC)	
- ★ Chart Datum / Vertical Datum → Mean Water Level Model → Digital Terrain Models	Executable and Cmdline: Port:	DrvQPSCountedUDP.exe SEAPATH_FMT11 PPS 13001	
Projections Supersonal Transverse Mercator (North Hemisphere)	Latency: Acquired by:	0.000 s 0.000 s [Directly into Qinsy] (No additional time tags)	
- [™] © UTC to GPS Correction	Observation time from: Number of slots:	N/A 0	
Object Amy Gale System	Object: PRH sensor reference number: Rotation convention pitch:	Amy Gale 1 Positive bow up	
	Rotation convention roll: Angular variable measured:	Positive heeling to starboard HPR (roll first)	
Prich Roll Heave Sensor L Position Navigation System ✓ Variable Node G Amy Gale MRU	Angular measurement units: Sign convention heave: Measurement unit heave: Conversion factor to degrees decimal:	Degrees Positive upwards Meters N/A	
→ © RX → © TX → © Link ■ Auxiliary Systems	Conversion factor to metres: Quality indicator type pitch and roll: Quality indicator type heave:	N/A No quality info recorded No quality info recorded	
 – Õ Time Sync →● EM2040C Controller 	Description of quality indicator type: Object location:	N/A Amy Gale	
└─▶ ASCII Logger ¥ Fixed Node	Node name: X (Stbd = Positive)::	Amy Gale MRU 0.000 m	
	Y (Bow = Positive):: Z (Up = Positive):: A-priori SD:	0.000 m 0.000 m 0.000 m	
	(C-O) roll offset: (C-O) pitch offset:	0.000 ° 0.000 °	
	(C-O) heave offset: Heave time delay:	0.000 m 0.000 s	

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		- 🗆 ×
File Edit View Options Help			
□	Latency:	0.000 s	
- III General	Acquired by:	[Directly into Qinsy] (No additional time tags)	
	Observation time from:	N/A	
WGS84	Number of slots:	0	
	Object.	Anna Cala	
A Chart Datum / Vertical Datum	Object:	Amy Gale	
👍 Mean Water Level Model	PKH sensor reference number:	1	
🚽 🚽 Digital Terrain Models	Rotation convention pitch:	Positive bow up	
🖨 随 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	
Sound Velocity Profile	Measurement unit heave:	Meters	
e di Object	Conversion factor to degrees decimal:	N/A	
Amy Gale	Conversion factor to metres:	N/A	
	Quality indicator type pitch and roll:	No quality info recorded	
A di Guro	Quality indicator type heave:	No quality info recorded	
	Description of quality indicator type:	N/A	
Heave Sensor	Object location:	Amy Gale	
L Position Navigation System	Node name:	Amy Gale MPL	
⊨ 💥 Variable Node	X (Sthd - Bositivo)		
	X (Stod = Positive)	0.000 m	
— • RX	Y (Bow = Positive)::	0.000 m	
L ⊚ TX	Z (Up = Positive)::	0.000 m	
Link	A-priori SD:	0.000 m	
Auxiliary Systems	(C-O) roll offset:	0.000 °	
→ © Time Sync	(C-O) pitch offset:	0.000 °	
EM2040C Controller	(C-O) heave offset:	0.000 m	
Y Eived Node	Heave time delay:	0.000 s	
met riked 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 nitch offset:	0.050 °	
	SD heave offset	0.050 m	
		0000 11	
Qinsy 9 For Help, press F1			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		- 🗆 X
File Edit View Options Help			
E In Survey	System: Pos	ition Navigation System	
- III General	System. TOS	nion navigation system	
	Description:	Position Navigation System	
	Туре:	Position Navigation System	
	Driver:	Network - Seapath 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	Undate rate:	0.000 s	
Projections	Latencir	0.000 s	
	Latency.		
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	
e 🔁 Object	Satellite system name:	WGS84	
🖻 🛄 Amy Gale	Horizontal datum:	WGS84	
System	Vertical datum:	WGS84	
m EM2040C	Height file	Ν/Δ	
	Height level	No Level Correction	
Pitch Boll Heave Sensor	Height files	N/A	
1 Position Navigation System	Height file.	N/A	
□ ¥ Variable Node	Height offset:	0.000 m	
- Amy Gale MRU	SD latitude:	0.250 m	
• RX	SD longitude:	0.250 m	
TX ®	SD height:	0.250 m	
Link	Measurement unit:	Meters	
🚍 🚟 Auxiliary Systems	Receiver description:	Position Navigation System	
- Time Sync	Receiver number:	0	
EM2040C Controller	Object location:	Amy Gale	
ASCII Logger	Node name:	Amy Gale MRU	
The node	Y (Sthd = Positive)"	0.000 m	
	X (Stou = Positive).	0.000 m	
	T (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	27-48	×
File Edit View Options Help			
	Neder Amy Cole MDU		
General	Node: Amy Gale MKO		
🖨 😽 Geodetic	Object location: Amy Gale		
🖨 🔮 Datums	Node name: Amy Gale MRI		
WGS84	V (chaile) - 000 m		
🛱 🚖 Heights			
🚽 Chart Datum / Vertical Datum	Y (BOW = POSITIVE):: 0.000 m		
Mean Water Level Model	Z (Up = Positive):: 0.000 m		
🚽 Digital Terrain Models	A-priori SD: 0.000 m		
Projections			
Universal Transverse Mercator (North Hemisphere)			
回 Local Construction Grid			
Cound Valacity Profile			
Chiert			
System			
⊜ \$ Gyro			
Gyro			
Pitch Roll Heave Sensor			
Position Navigation System			
⊨ Xariable Node			
- G Amy Gale MRU			
e RX			
u			
Link			
Auxiliary Systems			
- Ime Sync			
EM2040C Controller			
ASCII Logger			
Tixed Node			
Qinsy 9 For Help, press F1			

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Prog	jram	- 🗆 X
File Edit View Options Help		
Survey	Node: RX	
⊟- & Geodetic	Object location: Amy Gale	
🖨 🌀 Datums	Nada asses	
	Node name: KX	
🖶 🚖 Heights	X (Stbd = Positive):: 0.000 m	
🚽 🛣 Chart Datum / Vertical Datum	Y (Bow = Positive):: -0.045 m	
📥 Mean Water Level Model	Z (Up = Positive):: 0.006 m	
☐	A-priori SD: 0.010 m	
🔄 Universal Transverse Mercator (North Hemisphere)		
Local Construction Grid		
- O UTC to GPS Correction		
Sound Velocity Profile		
Diject		
Amy Gale		
System		
The fill Guro		
Pitch Roll Heave Sensor		
1 Position Navigation System		
→ Y Variable Node		
Amy Gale MRU		
TX III		
B Link		
🖃 🚟 Auxiliary Systems		
- Ö Time Sync		
- EM2040C Controller		
ASCII Logger		
└─☆ Fixed Node		
Qinsy 9 For Help, press F1	1	

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program			
File Edit View Options Help			
Survey	Node: TX		
General			
☐ 중 Geodetic	Object location: Amy Gale		
Datums	Node name: TX		
	X (Stbd = Positive): 0.040 m		
A Chart Datum (Vertical Datum	Y (Bow = Positive)* 0.004 m		
Chart Datum / Vertical Datum			
Digital Terrain Models			
Universal Transverse Mercator (North Hemisphere)			
Local Construction Grid			
- 💩 UTC to GPS Correction			
Sound Velocity Profile			
😑 🔁 Object			
🖨 🔤 Amy Gale			
🖨 🔚 System			
i≘- \$ [#] Gyro			
- # Pitch Roll Heave Sensor			
Position Navigation System			
B link			
Auxiliary Systems			
Time Sync			
- EM2040C Controller			
- CHASCII Logger			
Fixed Node			
Qinsy 9 For Help, press F1	1		

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Progra	m	8			×		
File Edit View Options Help							
E 🎾 🔜 🙏 💿 🖉 🔢 🗟 💷 🙆 🔞 🕮	8						
E W Survey	System: Time Sync						
General	System. This Sync						
Geodetic	Description: Time Sync						
Datums	Type:	Time Synchronization System					
WGS84	Driver:	NMFA ZDA					
E # Heights	Executable and Cmdline:	DryPositionNMEA exe					
Moan Water Level Model	Dert						
Digital Terrain Models	Port	2					
	Baud rate:	9600					
Universal Transverse Mercator (North Hemisphere)	Data bits:	8					
Local Construction Grid	Stop bits:	1					
- Ö UTC to GPS Correction	Parity:	None					
Sound Velocity Profile	Byte frame length (time):	10 bits (1.042 ms)					
🖨 🔁 Object	Maximum data transfer rate:	960 bytes / second					
🖨 🏧 Amy Gale	Update rate:	0.000 s			14		
🖨 🔚 System	Latency:	0.000 s					
- The EM2040C	Acquired by:	[Directly into Qinsy] (No additional time tags)					
☐ \$ ^p Gyro	Observation time from:	N/A					
Gyro		0					
Position Navigation System	Number of slots:	0					
→ ✓ Variable Node	Use QPS PPS Adapter:	On COM1					
Amy Gale MRU	PPS time tag pulse matching:	Automatic Matching					
- • RX	Windows System Time Synchronization:	Synchronization is enabled					
● TX	e vor						
8 Link							
🕂 🔚 Auxiliary Systems							
-ð Time Sync							
ASCII Logger							
└─ _v ¥ Fixed Node							
Qinsy 9 For Help, press F1	1				80 810 810		

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Program				×
File Edit View Options Help				
E % 📕 🙏 💿 🖉 📗 🗄 📼 🖉 🗟 💷 🔒 ())			
두	System: EM	2040C Controllor		
- 🖪 General	System: Elviz	2040C Controller		
Geodetic	Description:	EM2040C Controller		
Datums	Type:	Miscellaneous System		
WGS84	Driver	Kongsberg FM2040 Compact (Single) Multibeam Controller		
# Heights	Executable and Cmdline:	Drukongsberg EM/2010 compact (Single) Mattibeam controller		
Chart Datum / Vertical Datum	Executable and ciridinie.			
Tigital Tarrain Medels	Update rate:	0.000 s		
	Latency:	0.000 s		
Injuercal Transverse Mercator (North Hemisphere)	Acquired by:	[Directly into Qinsy] (No additional time tags)		
	Observation time from:	N/A		
UTC to GPS Correction	Number of slots:	0		
Sound Velocity Profile				
Diject				
📥 🔤 Amy Gale				
🖕 🔚 System				
🛱 🕫 Gyro				
-Ja ² Gyro				
Pitch Roll Heave Sensor				
La Position Navigation System				
□ ↓ Variable Node				
@ RX				
FM2040C Controller				
Qinsy 9 For Help, press F1				

AmyGale_2020_Patch1_nonverified_tides_2.db - Database Setup Pro	ogram		- 🗆 X
E W Survey	System: ASC	Cll Logger	
General Geodetic Geodet	Description: Type: Driver: Executable and Cmdline: Update rate: Latency: Data output setting: Acquired by: Observation time from: Number of slots:	ASCII Logger Output System Generic ASCII Data Logger (Controller) DrvGenericLogger.exe 1.000 s 0.000 s Enabled [Directly into Qinsy] (No additional time tags) N/A 0	
Qinsy 9 For Help, press F1			

Appendix D – Configuration settings for Qinsy EM controller

EM Controller - EM2040C Controller					
-PU Status					
Status Active			Stop		
Pinaina 15308 @ 2.90 H	nging 15308 @ 2.90 Hz				
Clock Status Ok			<u>P</u> u Info 🔻		
Errors All Ok					
			Options		
Settings					
Head1 Port Angle	65		~		
Head1 Starboard Angle	65				
Max. Port Coverage	300				
Max. Starboard Coverage	300				
Angular Coverage	Auto		-		
Beam Spacing	High Density		•		
Pitch Stabilization	On		•		
Max. Ping Freq.(Hz)	50.00				
Transmit Angle (deg)	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 intensity	Off		-		
Ping Mode	300 KHz				
Pulse Type	Auto				
Transmit Power Level	Maximum		▼		
FM Enable	FM Enabled		<u> </u>		
13D Scanning - Scan Sten	10.0		Ţ		
Apply Settings	Force 🔽 Log Events				
Events					
10:00:53.105 PU Clock is sync	hronized		~		
10:00:53.963 Connection to P 10:00:53.963 Set Initial Setting	U (157.237.20.40) Established				
10:00:55.073 Command Accep	ited				
1			*		

EM Controller - EM2040C Controller —					
-PU Status					
Status	Active		Stop		
Pinging	inging 18646 @ 2.70 Hz				
Clock Status	Ok		Pu Info ▼		
Errors	All Ok				
			Options		
Settings					
Penetration Filt	er	Off	- ^		
Range Gate Size	e	Normal	•		
Spike Filter Stre	nath	Medium	-		
Phase Ramp	5	Normal	-		
Special Amp De	etect	Off	-		
Special TVG		Off	-		
Normal Inci. Se	ctor Angle	10			
Lambert's law f	or intensity	Off	-		
Ping Mode		300 KHz	-		
Pulse Type		Auto	▼		
Transmit Powe	r Level	Maximum	-		
FM Enable		FM Enabled	-		
3D Scanning - S	Scan Step	0.0			
3D Scanning - I	Min Angle	-5			
3D Scanning - I	Max Angle	5			
Dual Swath Mo	de	Off	-		
Min. Swath Dist	tance	0.0			
Yaw Stabilizatio	on Mode	Off	-		
Yaw Manual Ar	ngle	0.0			
Heading Filter		Medium	-		
WCD Sonar Mo	de	Off	-		
WCD Passive N	lode	Off	T		
WC TVG LOG R		30.0			
WC TVG dB		20.0			
Special amplitu	ide detection	Off	-		
Sound Velocity	Update Rate	3.0			
Sound Velocity	Min Change	0.5			
Apply Se	ettings 🔻 F	Force 🔽 Log Events			
Events					
10:00:53.105 10:00:53.963 10:00:53.963	PU Clock is synch Connection to PL Set Initial Setting	rronized J (157.237.20.40) Established	^		
10:00:55.073	Command Accep	ted	~		

Options			x
PU Setup			
System Type (from DbSetup)	EM2040C	Single Transducer	
Pu Ip Address 157.23		57.237.20.40	
Simulation Mode Off			-
External Triggering	Off		-
Control Port	2000		
Enabled Output Ports	Output P	ort 1,2,3	▼ Ξ
Output Port 1 (Bathy)	2001		
Output Port 2 (Bathy)	2002		
Output Port 3 (Sidescan)	2003		
ZDA/GGA Serial Port	Port 1 (de	fault)	-
Use GGA	On		-
Baudrate ZDA/GGA	9600		-
Motion Serial Port	Port 2 (de	fault)	- ⁻
Program Options			
Start Pinging when QINSy Starts		Pinging On Startup	-
Synchronize Clock Interval(min.)		60	
Sound Velocity Mode		From SoundVelocity	C -
Sound Velocity Observation		Sound Velocity	-
Popup window when error occurs		On	-
Allow HD beamspacing with Water Column Da	ata	Not Allowed	-
Installation Parameters	0		
RXI Gain Offet	0		
RAZ Gain Offet	0		_
Head1 Installation angles from	EIVI2040		
Head2 Installation angles from	Not Us	ed Several	
Velocity Sensor Number	2001	Sensor 1	_ <u> </u>
Velocity Sensor Ethernet Dort	Ethern	t Dort 2 (if available)	
Ethernet Dort 2 ID Address	102.169		_ <u> </u>
Ethernet Port 2 IP Mark	255 255	0.0	
OK Cancel			

Appendix E – New Computation Settings for Qinsy Online

Itations	Position Navigation Syst	en Position Filter Position Results At	titude Height		
r.	Amy Gale				
<u>ل</u>	Position Navigatio				
mputation		Se Priority Method	Max Age	Skew	Move U
_	✓ ▲ EM2040C	Heave Pitch Rol	Heave Sen: 1.00 [s]		No. Do
	🚽 🖳 🗰 Offset System Amy G	ale			Move Do
annu totion	Copy of Position Navigation S	iys			
Inputation	Amy Gale				
2	Position Navigatio	on :			
\sim		Se			
nove	EM2040C				
utation	Offset System Amy G	ale			
		,			
		Tide Parameters			
		Tide method	Me	an Water Level Model	
		Draft and Squat Parameters			
		Draft and Squat Parameters		Manual Draft	
		Draft and Squat Parameters Draft method Manual draft		Manual Draft 0.850	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	
		Draft and Squat Parameters Draft method Manual draft Squat method		Manual Draft 0.850 Disabled	

Computations	Position Navigation System	System Parameters				
പ	Amy Gale	Use this system to trigger the	✓ Use this system to trigger the computation			
New Computation	🗹 🖗 Gyro	Height status	PTK (Accurate	a Height)		
New Computation	Pitch Roll Heave Se					
	Offset System Amy Gale	Preferred position SD	System D	Priver 🗾 💌		
	Copy of Position Navigation Sys	Position a priori SD	0.25	[m]		
Copy Computation	🗹 🛄 Amy Gale	Preferred height SD	System D	Priver 🗾		
\sim	Position Navigation !	Height a priori SD	0.50	[m]		
~~~	₩ \$\$ Gyro	Dynamic a priori SD	Disa	bled		
Remove	EM2040C					
Computation	🕂 🕂 Offset System Amy Gale					
		1				
		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]		
		Satellite Count	0	0.00 [m]		
			Ū			
Shortcuts	< >>					
	ΟΚ Απηίν	Cancel				

 $\times$ 

#### Computation Setup

Computations	Position Navigation System	System Parameters		
÷	Amy Gale	Use this system to trigger the o	computation	
New Computation		Height status	Tide (Unreliab	e Height) 💌
		Preferred position SD	System D	river 🗨
	Compared Different System Amy Gale	Position a priori SD	0.25	[m]
Copy Computation	Copy of Position Navigatio	Preferred height aiding SD	Database	Setup 👻
	Position Navigati	Height aiding a priori SD	Auton	natic
53	— 🗹 🖗 Gyro			
Parmana	🛛 🗹 🙀 Pitch Roll Heave Se	Dynamic a priori SD	Disal	bled
Computation				
		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	< >>			
	OK Apply	Cancel		

Computations	Position Navigation System	Computation Parameters						
<u>~</u> ~	Amy Gale	Computation name		Position Navigation System				
50°	v v v v v v v v v v v v v v v v v v v	Triggering sy	/stem			Position Navigation System		-
New Computation	Pitch Roll Heave Se	Max. triggering rate			20 [Hz]			<b>.</b>
-		Iteration threshold			5			
	🗧 👘 🕂 Offset System Amy Gale		Statistical testing		Separate Objects			-
Conv Computation	Copy of Position Navigation Sys	Data snooping		Enabled			<b>-</b>	
copy computation	Male Amy Gale	Redundancy minimum		1				
$\sim$	Position Navigation	Level of significance		1 %				
$\sim$	Pitch Boll Heave Se	Power of test		80 %				
Remove		Lower limit max, ages		0.0 [s]				
Computation	Offset System Amy Gale				-			
		- Approvimate Position						
	Approximate Position							
		Coordinate system			Grid			
		Easting			4840352.1			
		Northing			8669036.1			
		Height			0.0			
		Computation Priority						
		Priority Status			Heights	Computation	Movel	Up
		1	Enabled	•	Tide (Unrelia	Copy of Position Navigation System		
		2	Enabled	•	RTK (Accurat	Position Navigation System	Move D	own
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)



88



### 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

