DSSV Pressure Drop: Descriptive Report

Molloy Trench

August 2019

Report developed for Five Deeps Expedition by Cassie Bongiovanni

Internal Use Only

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0.0 Survey Information

0.1 Survey Limits

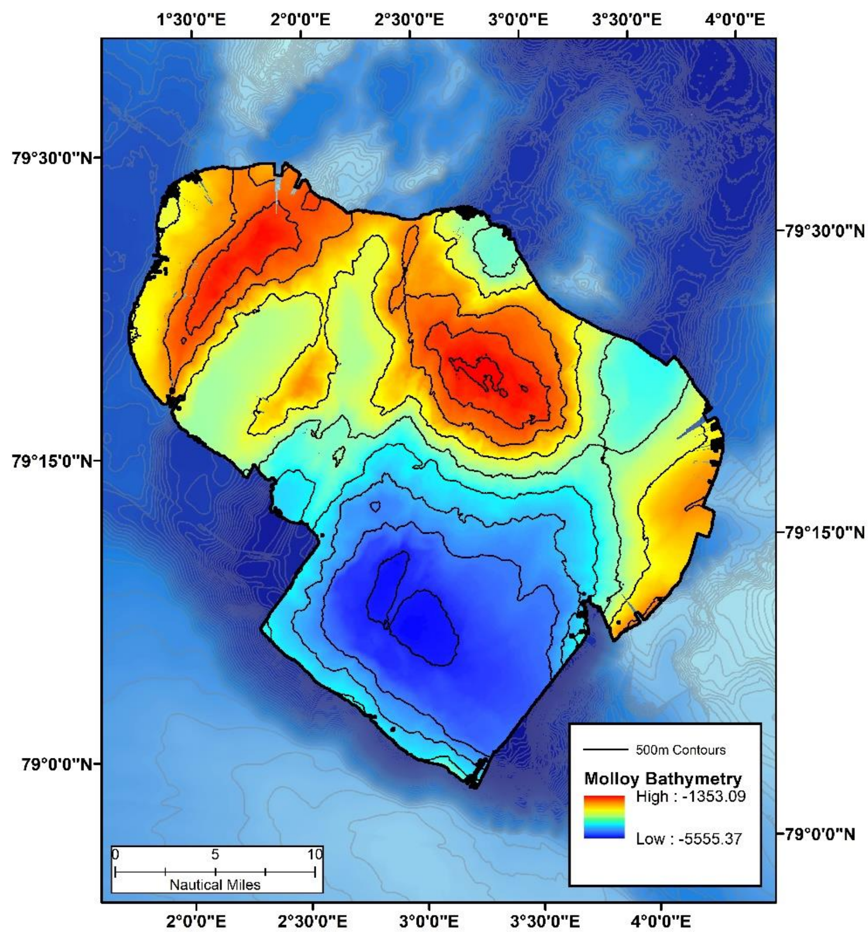

Figure 1: Molloy bathymetry collected with the Kongsberg EM 124 over GEBCO 2014 estimated bathymetry.

The Molloy Hole (Figure 1) was surveyed with a Kongsberg EM 124 gondola-mounted to the hull of the 225-foot DSSV Pressure Drop. The survey was conducted over the course of three days – August 24-26, 2019. The data meet the requirements for IHO Order 1 standards.

The Molloy Hole survey is within the following limits:

Northwest Limit	Southeast Limit
79°30'2.533"N	79°01'58.851"N
1°16'53.099"E	4°14'09.63"E

Table 1: Survey Limits

0.2 Survey Purpose

Multibeam data were acquired by the DSSV Pressure Drop as part of the 5 Deeps Expedition. These data were collected to determine the deepest point in the Pacific Ocean with the specific intention for a manned submersible to dive to it. It is anticipated that these data will help the greater scientific understanding of the area and contribute to the international effort to create a complete high-resolution map of the oceans (i.e. GEBCO 2030).

0.3 Survey Plans

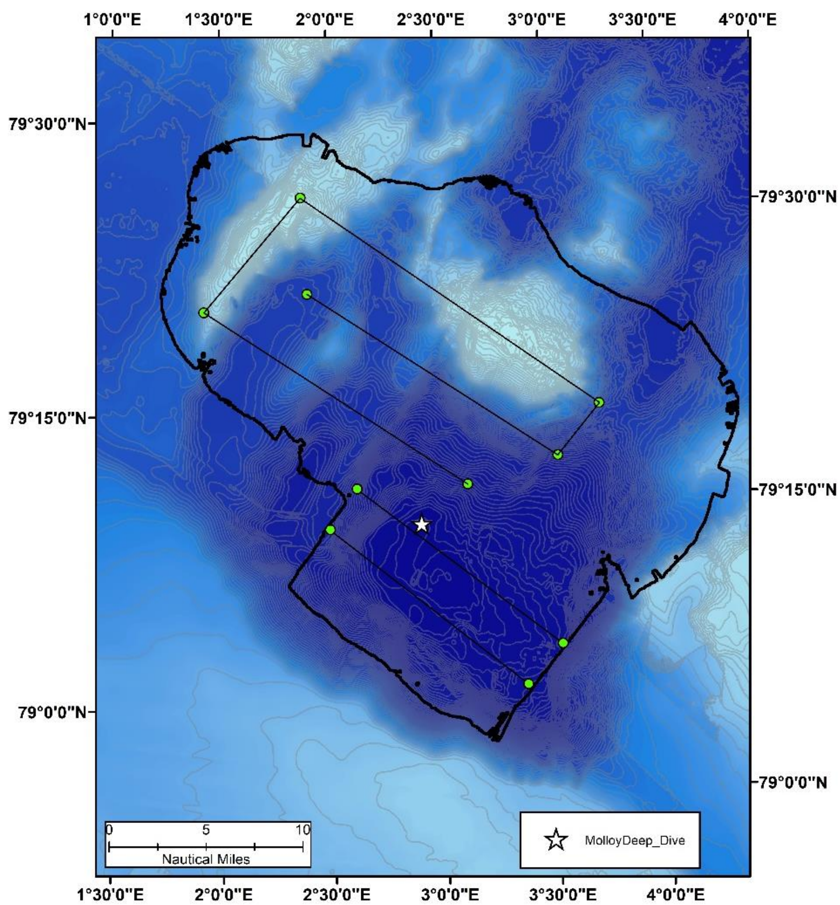

Figure 2: Molloy area with GEBCO 2014 bathymetry and with possible deep location delineated by white star. Molloy line plan with green waypoints.

Reviewing previously collected data, the Molloy Hole was identified as the target for the deepest point in the Arctic Ocean. Due to an extremely limited time window as a result of weather, a couple of lines were run over the expected deep and additional lines were created over scientific areas of interest as needed. Lines were run at 10 kts. The final line plans are shown in Figure 2.

The final dive location was: 79.194° N, 02.706° E.

The official final depth was recorded as: 5,817 +/- 6 m (from Sub) and 5,555 +/- 14m (from EM 124)

0.4 Survey Quality

These data meet IHO Order 1 specifications and should supersede any prior data for all intents and purposes.

0.5 Survey Coverage

No notable holidays (or gaps in coverage) were created during this survey. Few times a sudden change in heading resulted in slight fanning, but nothing substantial.

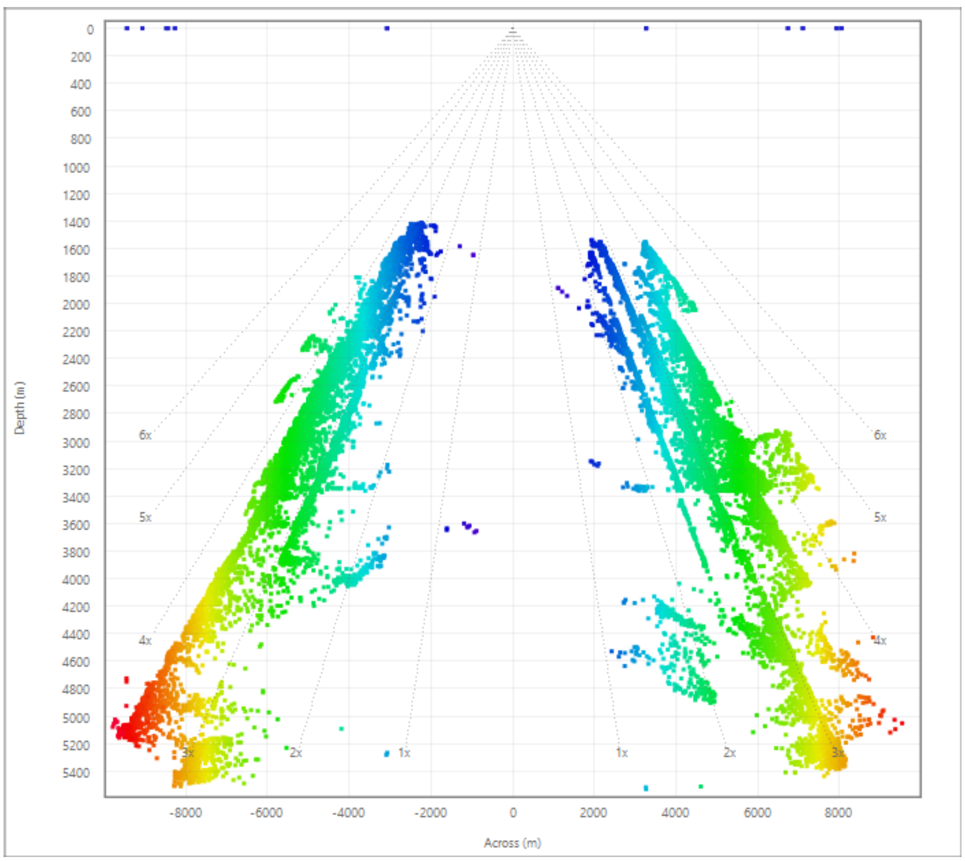

Figure 3: EM 124 Molloy survey extinction plot.

Inside the trench, we achieved swath widths around 16 km with 55-60° coverage on either side of nadir ~ 3x water depth (Figure 3). During the sonar installation, Kongsberg technicians determined that the DSSV Pressure Drop inherently produces 65-70 dB of noise which can contribute to the smaller swath widths.

0.6 Survey Statistics

The following tables lists the survey mileage for this survey:

	Vessel	Total (km)
Line Type	SBES Mainscheme	0
	MBES Mainscheme	355
	SBES/MBES Combo	0
	MBES Crosslines	0
Number of Bottom Samples		0
Survey Area (KM^2)		1,850

Table 2: Survey Statistics

The following table lists the specific dates of data acquisition for this survey:

Date	Julian Day
08-24-2019	236
08-26-2019	238

Table 3: Julian Day, survey dates

Survey lines were run with a 12 kHz multibeam echosounder. Statistics were calculated in ESRI ArcGIS 10.6.1 (*personal license*).

1. Data Acquisition and Processing

1.1 Equipment and Vessel

Refer to the Data Acquisition and Processing Report (DAPR) for a complete description of data acquisition and processing systems, survey vessels, quality controls, and processing methods. Additional information will be discussed in the following sections.

The following vessels were used for data acquisition during this survey:

Vessel	DSSV Pressure Drop
LOA	72.6 meters
Draft	4.18 meters

Table 4: Vessel Used

The following systems were used for data acquisition during this survey:

Manufacturer	Model	Purpose
Kongsberg	EM 124	Multibeam Echosounder (MBES)
Kongsberg	Seapath 380+	Positioning and Attitude System
Reson	SVP70	Fixed Mount Sound Speed
Seabird	SBE49 Fast Cat CTD	Sound Speed/CTD System

Table 5: Systems used during data acquisition

The DSSV Pressure Drop single beam echosounder (SBES) was turned off during data acquisition as interference becomes visible in the MBES due to the frequency of the two signals. The Seabird CTD was attached to the Limiting Factor submarine vehicle and each of the Caladan science landers. These data were collected during the deep dive and were used during post-processing for ray-path corrections.

1.2 Uncertainty

Total propagated uncertainty values were derived from fixed values with instrumental detailed in the DAPR, vessel characteristics, and uncertainty associated with the sound speed measurement and data processing (Table 6). The Seabird SBE49 derived full-ocean depth sound velocity from temperature and conductivity sensors while surface sound speed was determined by the Reson SVP70.

MANUFACTURER	SOURCE	CONTRIBUTION
QIMERA	Roll & Pitch	0.02°
	Heading	0.075°
	Heave Fixed	0.05m
	Heave Variable	5%
	Roll Offset	0.05°
	Pitch Offset	0.05°
	Heading Offset	0.05°
SEABIRD	Conductivity Accuracy	± 0.0003 S/m
	Temperature Accuracy	± 0.002 °C
	Pressure Accuracy	± 0.1% of full-scale range
RESON SVP70	Sound Velocity Accuracy	0.05 m/s
	Sampling Time	50 ms to 10s

Table 6: Uncertainties associated with processing and sound velocity measurements.

For Special Order surveys, the maximum allowable horizontal uncertainty is 2 m at 95% confidence while the maximum allowable vertical uncertainty is $\pm\sqrt{(0.25)^2 + (0.0075 \times d)^2}$ of a given depth (d) at 95% confidence. The Molloy survey area has a depth range between 1,353 – 5,555 m. With these values, the range of allowable TPU is ± 10.15 – 41.66 m at 95% confidence.

TPU statistics were generated for the Qimera CUBE uncertainty surface in the ESRI ArcGIS.

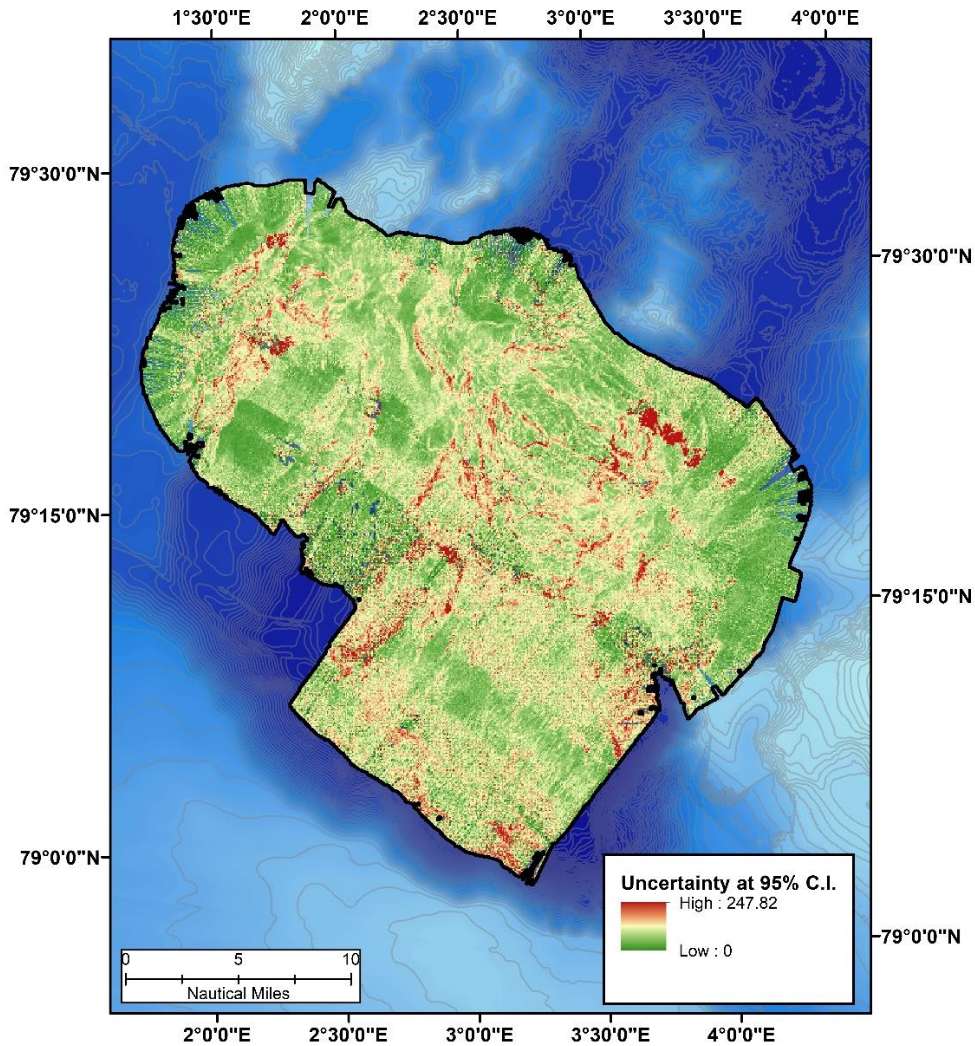

Figure 4: Molloy uncertainty at 95% confidence - red indicating areas of higher uncertainty.

The average estimated uncertainty of the Molloy survey area is 14.8 m. This exceeds the lower TPU bound of acceptable uncertainty but is well below the upper bound for the depth range. Figure 4 shows that uncertainty surface mapped to a color range with a minimum of 0.

Despite this, these data still meet IHO Order 1 specifications as shown in Figure 5.

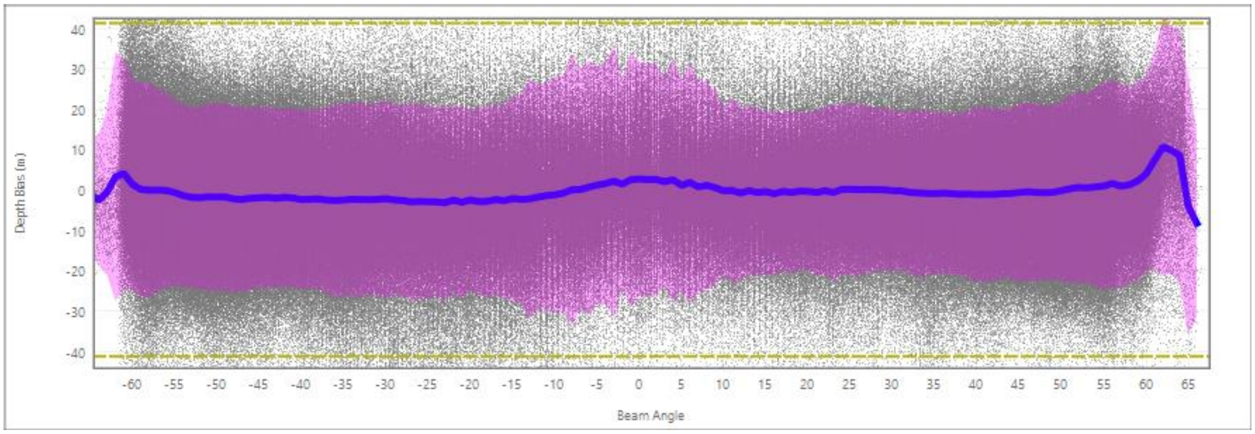

Figure 5: Molloy data (purple) in comparison with the IHO Order 1 specifications (yellow dotted lines). This figure proves these data meet the limitations set forth by the Order 1 survey classification.

1.3 Junctioning Surveys

1.3.1 GEBCO 2019 Comparison

General Bathymetric Chart of the Ocean (GEBCO) is an international effort funded by the Nippon Foundation that focuses on maps of the ocean. The GEBCO 2019 world ocean grid is the widely used standard of known bathymetric information and vertically referenced to mean sea level (MSL). The portion of the data covering the Molloy survey area was extracted from the GEBCO website (https://www.gebco.net/data_and_products/gridded_bathymetry_data/) and used as a base-layer map to help with line-planning and deep dive location identification. This surface was differenced with the EM 124 Molloy survey data in ESRI ArcGIS.

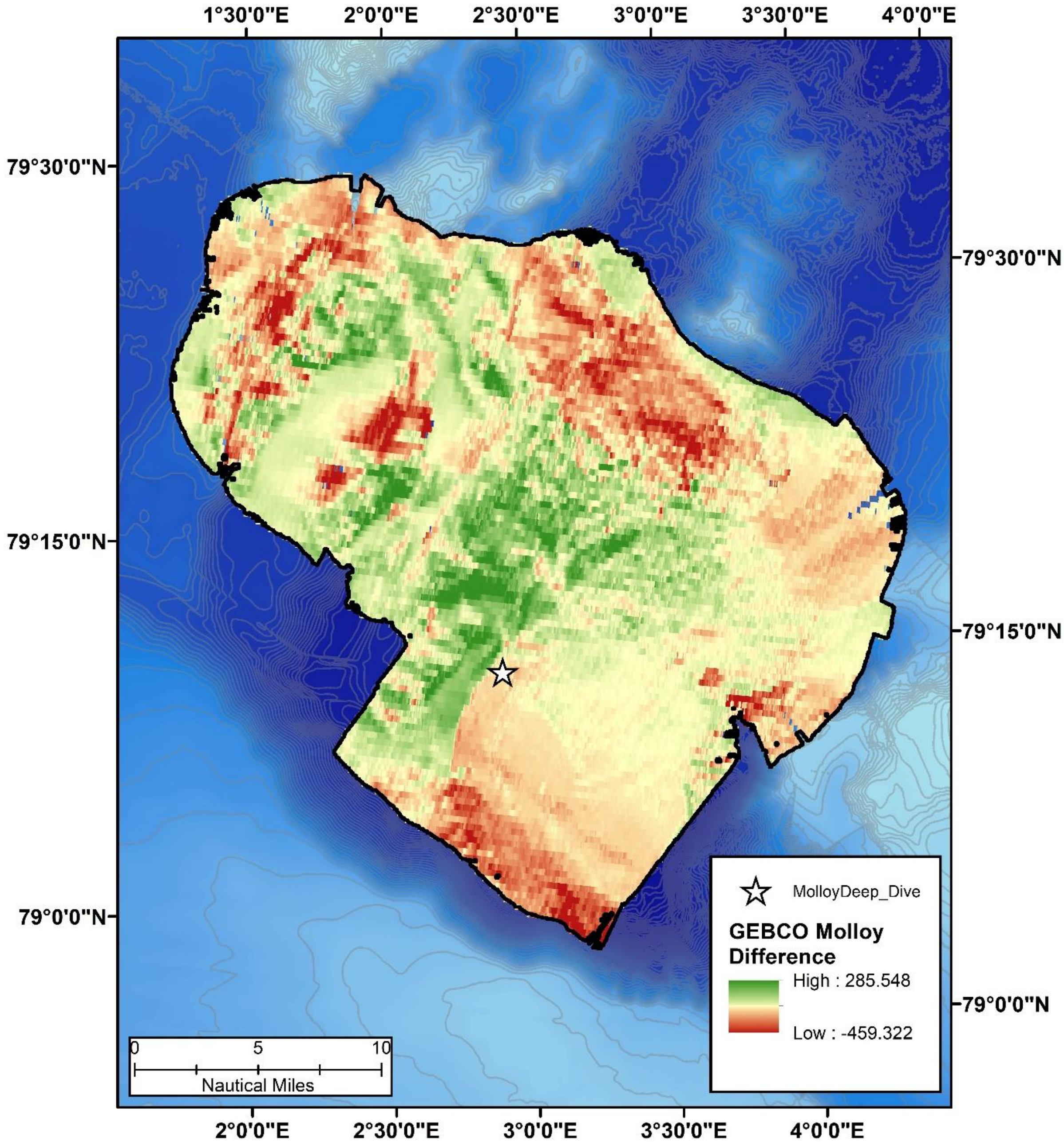

Figure 6: GEBCO 2019 bathymetric grid differenced with the Molloy data. Green indicated areas where Molloy is deeper than GEBCO estimates.

There is an average difference of 4.5 m, with the Molloy survey (on average) being deeper (Figure 6). At the exact dive location, Molloy is ~19 m shallower than GEBCO reports. The GEBCO 2019 grid has a resolution of ~900 m which is of lower quality in comparison to the 75 m Molloy survey. This resolution discrepancy likely contributes to some of the large difference values.

1.3.2 Summary

According to the GEBCO 2014 grid sources available at the time of survey, ~0% of the area we covered was interpolated from satellite estimates, meaning 100% of the area has been mapped before (Figure 7).

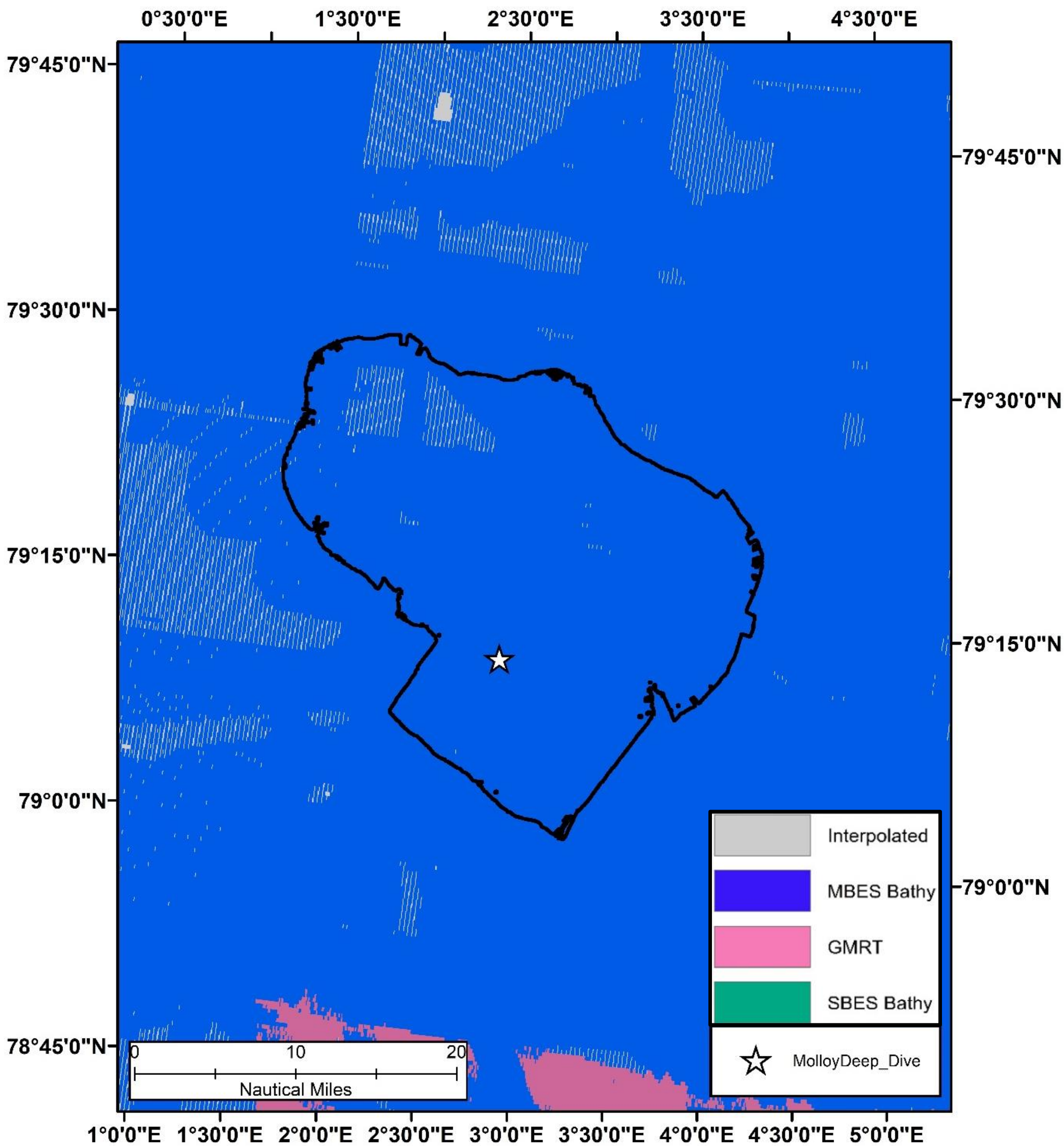

Figure 7: GEBCO data sources. Grey represents areas that were interpolated, and blue and pink are previously collected bathymetry data. The black outline is the area in Molloy where EM 124 data were collected.

While our efforts were not the first to map the Molloy Hole, we did collect many full-ocean depth CTD data that were used to provide full-ocean sound velocity profiles for these data. Thus, it is likely we have the most accurate dataset of the area to date. It is anticipated that these data will be a fundamental contribution to the scientific community.

1.4 Sound Speed

Synthetic profiles were generated as needed during the survey operations using Sound Speed Manager. Full-ocean depth sound velocity profiles were collected by the Limiting Factor's (submersible) onboard CTDs and lander CTDs.

The sub CTD data were applied to all Molloy data.

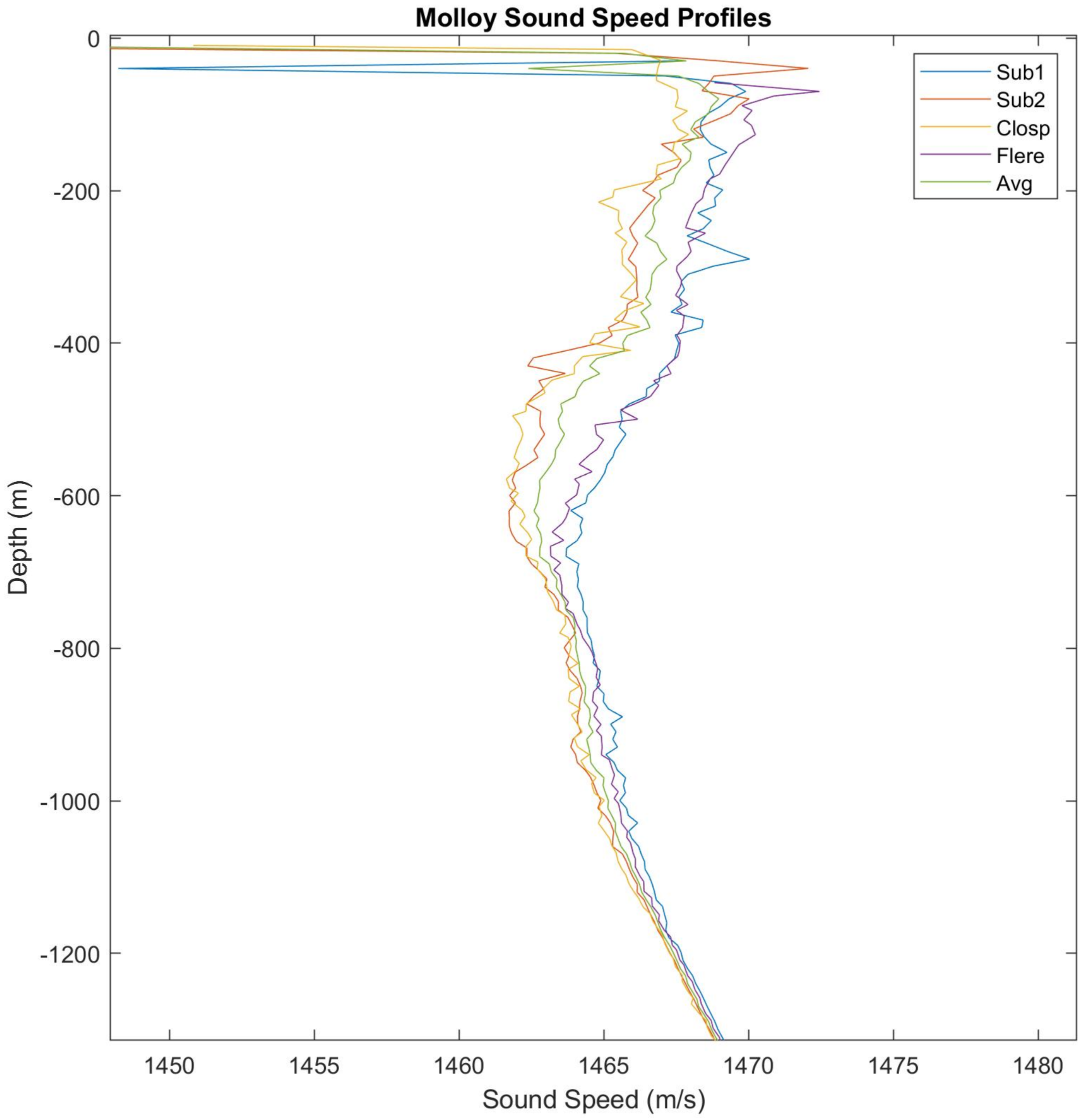

Figure 8: Sound Speed Manager comparison of all collected sound speed profiles from sub and XBT.

The profiles from the two onboard sub CTDs in comparison to the two Caladan lander CTDs show that there is a definitive split. On one hand, sub CTD1 matches Flere and on the other, sub CTD2 matches Closp; however, neither matches closely with each other. This is indicative of the calibration being out of date. But, at 1200 m all profiles match.

The final profile used to correct the data was an average of all the CTD data.

1.5 Data Corrections

No data corrections were required during this survey.

1.6 Calibrations

1.6.1 Sonar Acceptance Test (SAT)

A Sonar acceptance test was performed on the new Kongsberg EM 124 by Cassie Bongiovanni and four Kongsberg technicians/engineers beginning December 13, 2018. More information on the survey plan is outlined in the SAT Plan report.

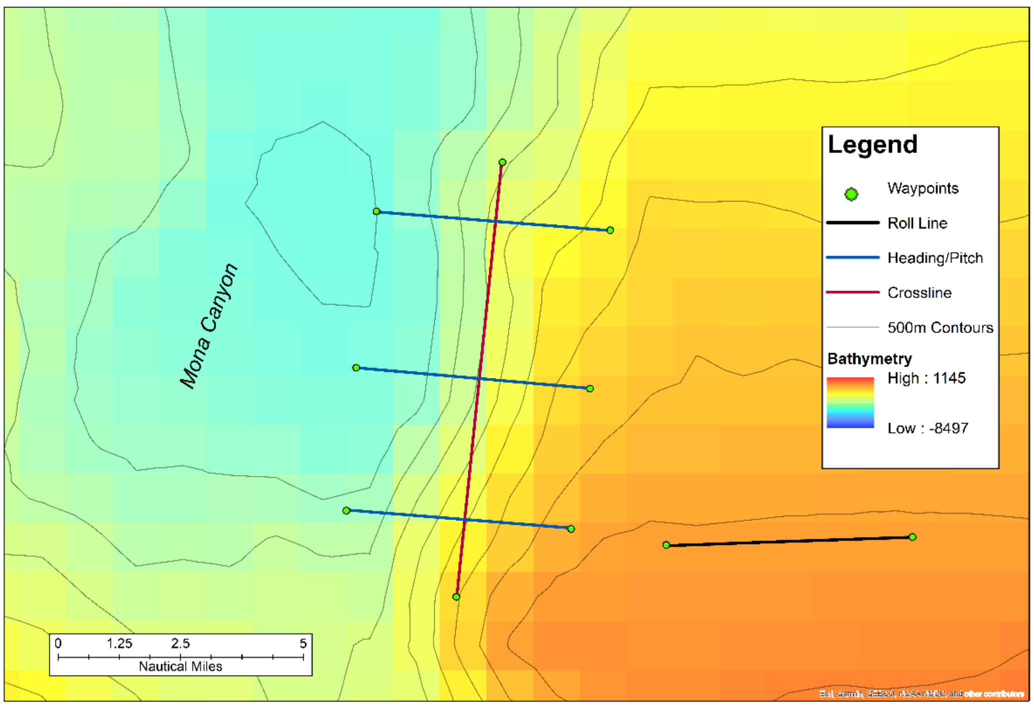

Figure 9: Sonar Acceptance Test (SAT) plan in the Mona Canyon offshore Puerto Rico and near the Puerto Rico Trench.

Data was collected over all lines twice. To be certain of the offset values, the calibration was processed in Qimera, SIS, and Kongsberg proprietary software. All three resulted in near zero offsets for all three major components (Roll, Pitch, and Heading).

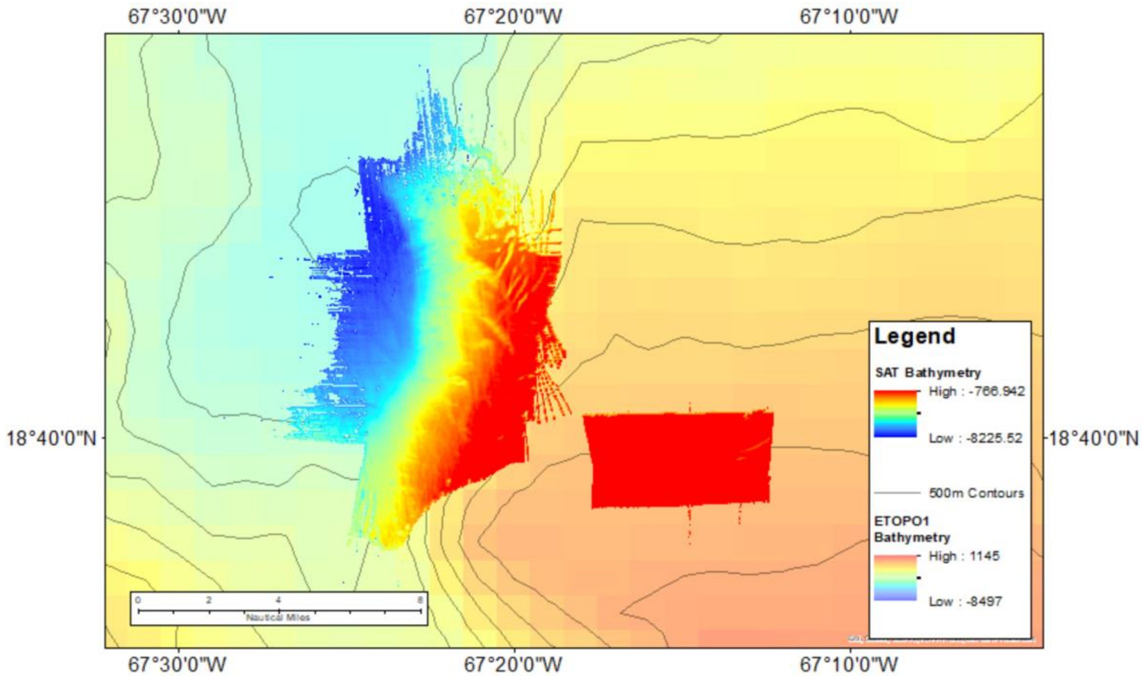

Figure 10: SAT resulting bathymetry

As such, no offsets were input. However, occasional latency (timing between the positioning data and the feed to the sonar) issues were observed and an offset value of 0.185 (seconds) cleared the problem primarily visible in the outer beams of the swath.

1.6.2 Backscatter Calibration

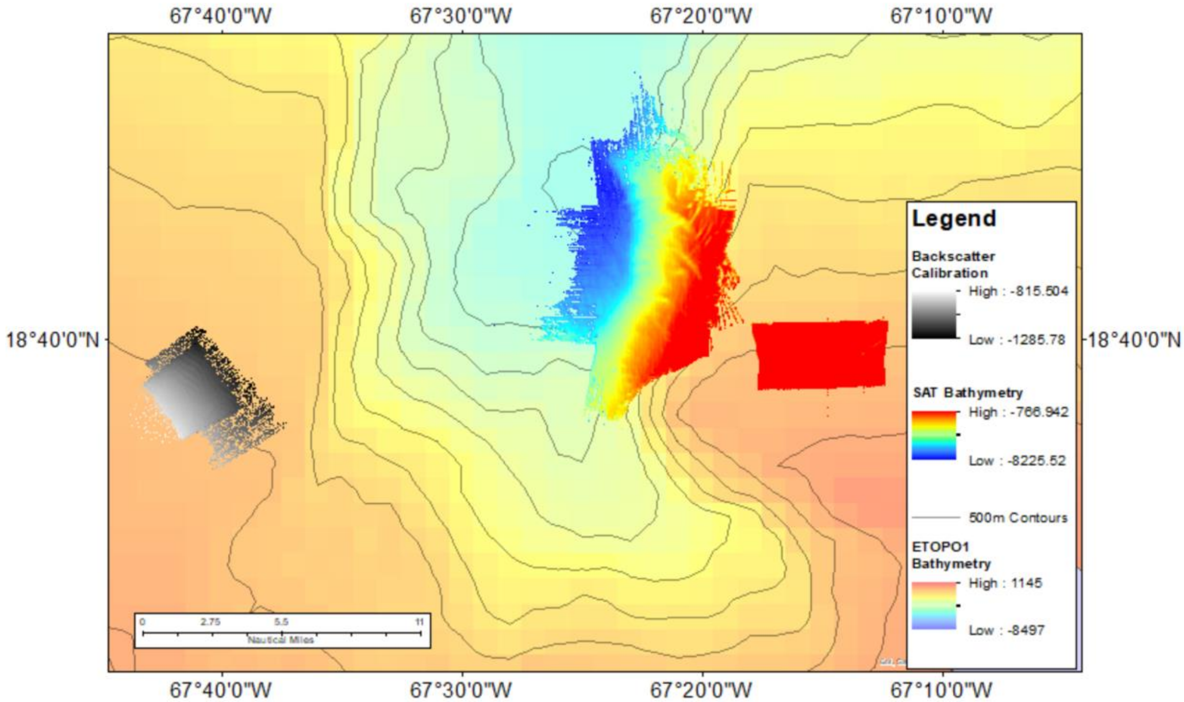

Figure 11: Backscatter calibration in relation to the SAT calibration site.

During the SAT, time was devoted to a backscatter calibration. This was accomplished by running short lines (< 1 nm) in all depth modes (Shallow, Medium, Deep, Deeper, and Very Deep) in two directions – East to West, and West to East. Running a line in opposite directions over flat ground can help determine the scattering components and allow for more accurate backscatter products, which is particularly of interest geologically (structurally) and biologically (for habitat mapping).

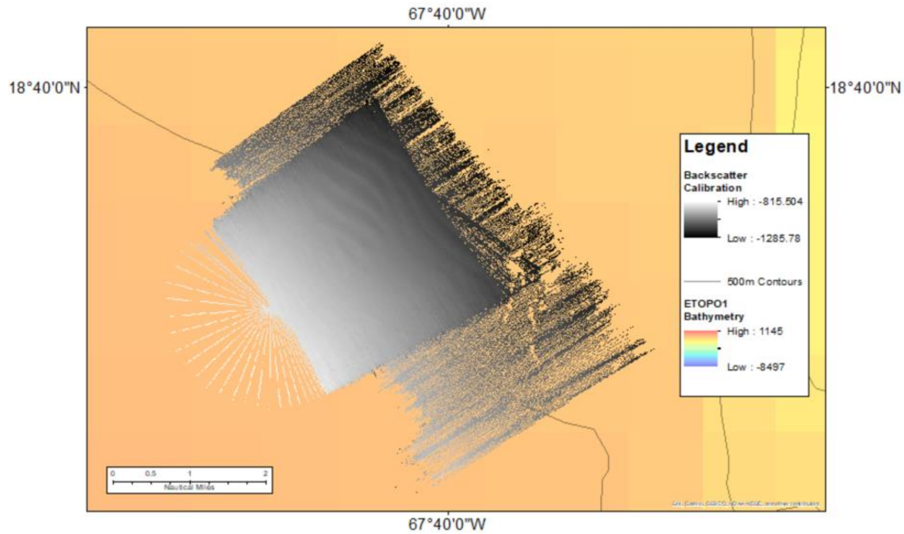

Figure 12: Backscatter calibration bathymetry.

The location chosen for the site was originally going to be the SAT roll line but was moved to the other side of the Mona Channel to avoid large swells. The data were processed by Kongsberg engineers and the results were input directly into SIS so they are automatically applied to all future data collection.

1.7 Backscatter

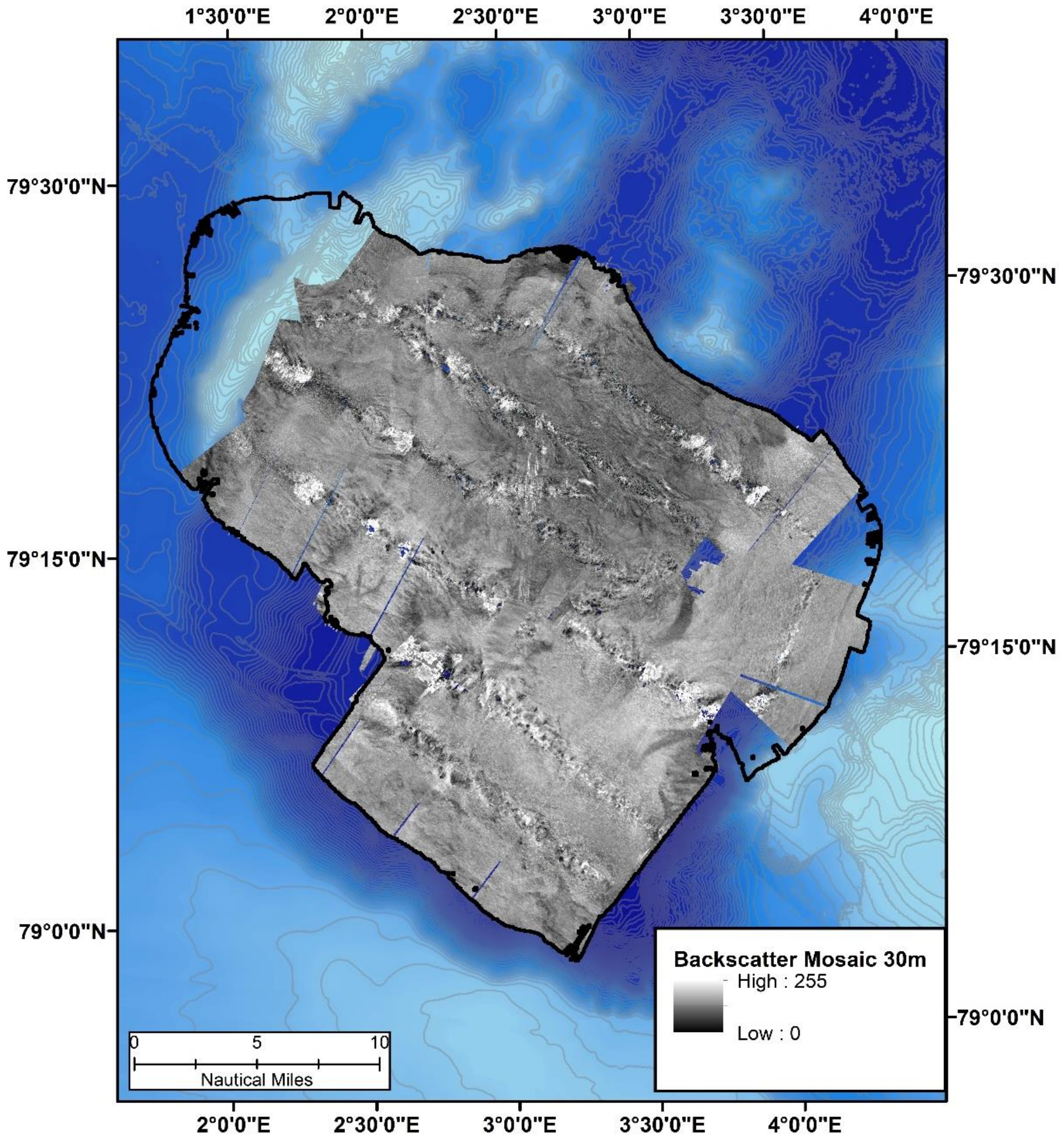

Figure 13: Molloy backscatter mosaic. Mosaic created in QPS FMGT.

Backscatter data were collected from the EM 124 during bathymetric data collection. Data were processed in QPS FMGT and a mosaic was created (Figure 13). No sediment samples were taken for verification.

1.8 Processing Software

Name	Manufacturer	Version	Installation Date
Qimera	QPS	1.7.5	12/04/2018
Hydro Office Sound Speed Manager	UNH CCOM/ Hydro Office	2018.1.50	12/06/2018
Matlab*	Matlab	R2018a	09/18/2018
Fledermaus & FMGT	QPS	7.8	12/04/2018
ArcMap/ArcGIS*	ESRI	10.6.1	09/18/2018

*Table 7: Processing software. *personal license*

More detailed information on processing software is outlined in the DAPR.

1.9 Surfaces

The following surfaces and/or BAGs are submitted with these reports:

Surface Name	Surface Type	Resolution	Depth Range
Molloy_CUBE_75m.xyz	CUBE	75 m	-1,353 m to -5,555 m
Molloy_95Uncertainty.tiff	Uncertainty	75 m	N/A
Molloy_Surface_75m.bag	Surface	75m	-1,353 m to -5,555 m
Molloy_backscatter.tiff	Mosaic	30 m	N/A

Table 8: Final mission surfaces.

1.10 Patch Test

As the system was calibrated only a few months before, a patch test was not needed.

2. Vertical and Horizontal Control

2.1 Vertical Control

All data are referenced to the geoid (MSL). No further vertical corrections were applied.

2.2 Horizontal Control

No horizontal corrections were applied.