DSSV Pressure Drop: Descriptive Report

Palau Trench

April 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

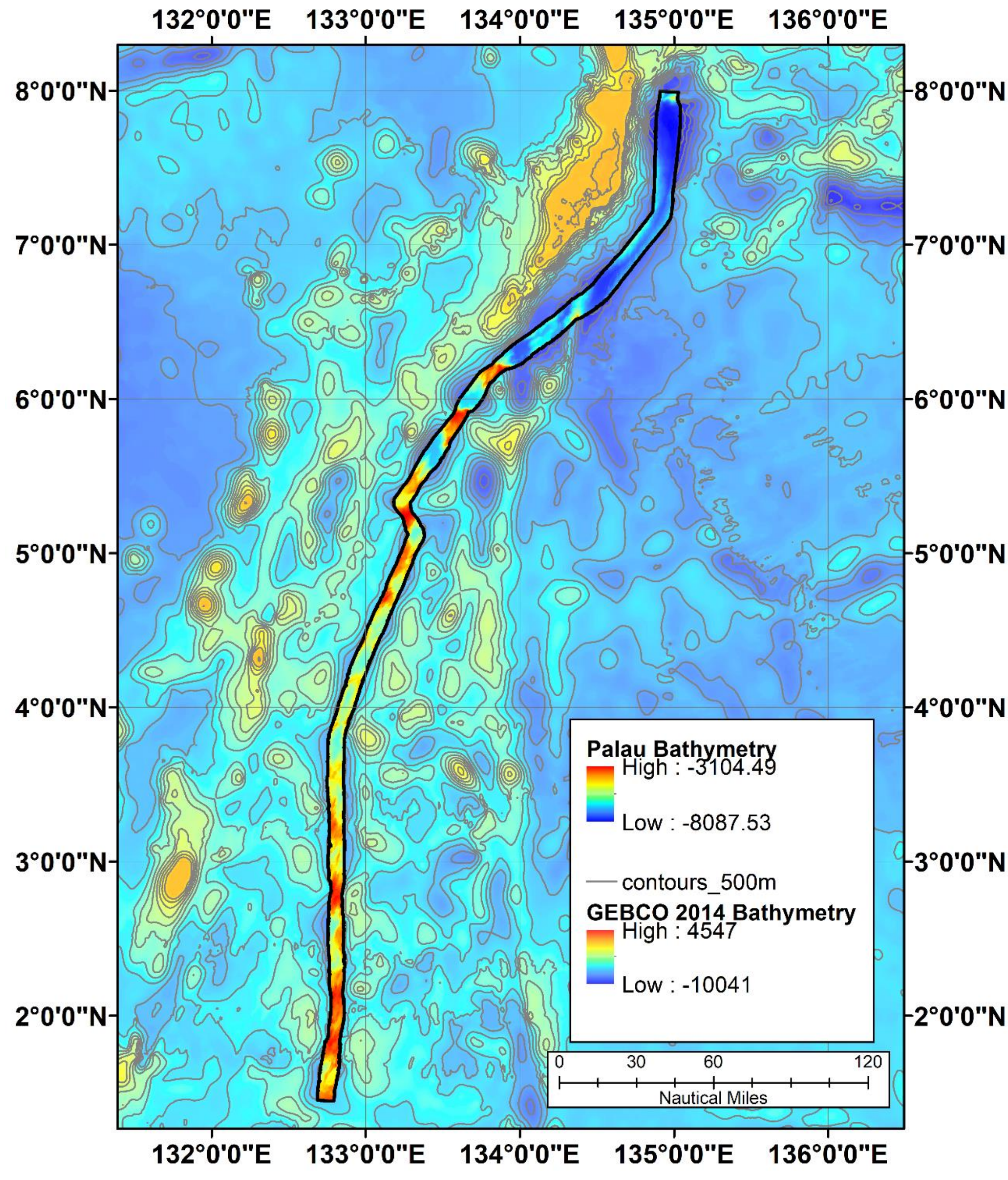

Figure 1: Palau Trench bathymetry collected with the Kongsberg EM 124 over GEBCO 2014 estimated bathymetry.

The Palau Trench (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 two days – April 15th – April 17th, 2018. The data meet the requirements for IHO Special Order standards.

The Palau Trench is within the following limits:

Northwest Limit	Southeast Limit
8°0'5.876"N	1°26'3.551"N
132°40'11.073"E	135°5'14.19"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 Indian 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

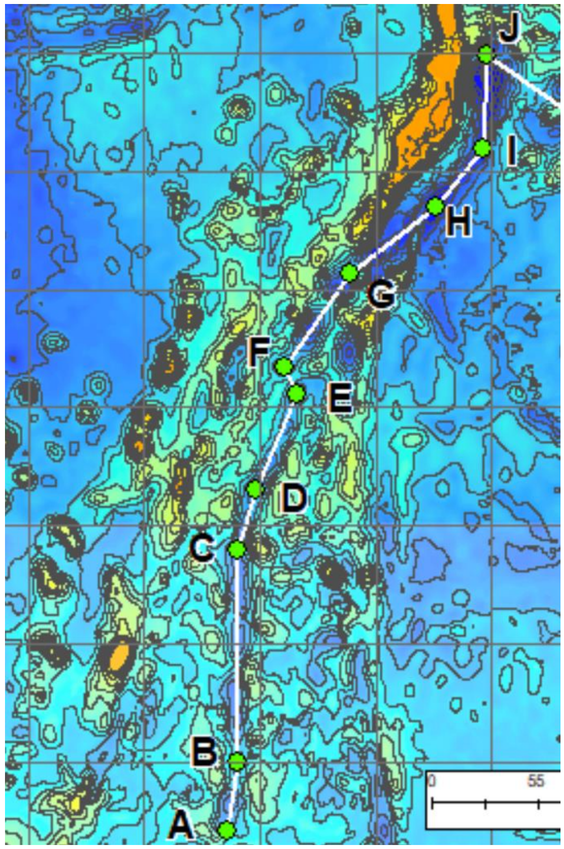

Figure 2: Palau Trench area with GEBCO 2014 bathymetry and the line plan with waypoints in green and labeled with letters A-J.

0.4 Survey Quality

These data meet IHO Special Order 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.

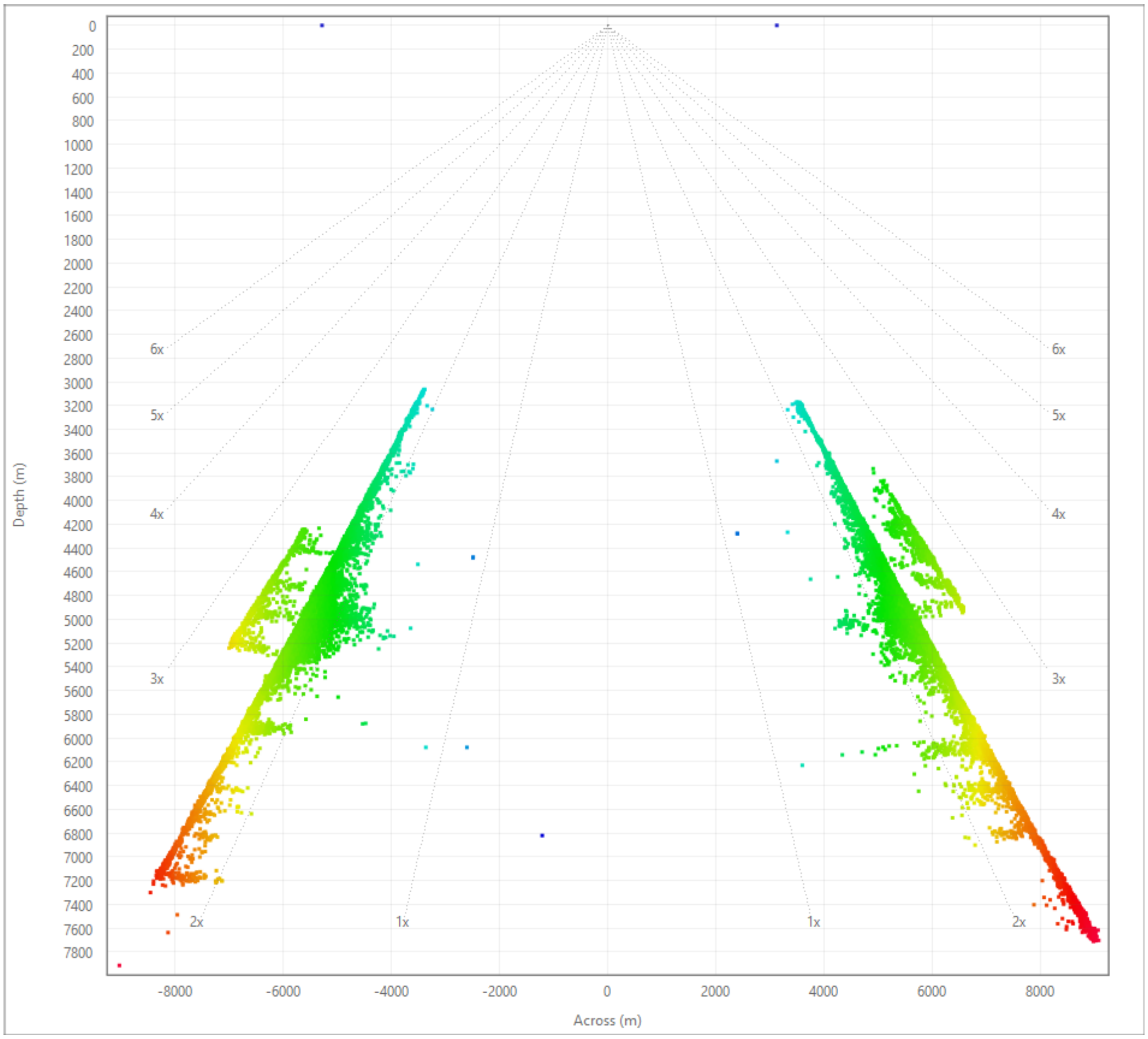

Figure 3: EM 124 Palau survey extinction plot.

Inside the trench, we achieved swath widths around 15-18 km with 50-60° coverage on either side of nadir – just about 2.5x 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	SBES Mainscheme	0
Type	MBES Mainscheme	887

	SBES/MBES Combo	0
	MBES Crosslines	0
Number of Bottom Samples		0
Survey Area (KM^2)		9,755.6

Table 2: Survey Statistics

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

Date	Julian Day
04-15-2019	105
04-17-2019	107

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

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.

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 sound velocity from temperature and conductivity sensors.

MANUFACTURER	SOURCE	CONTRIBUTION
QIMERA	Roll & Pitch	0.01°
	Heading	0.01°
	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
AML	Sound Velocity Accuracy	0.5 m/s
	Conductivity Accuracy	± 0.010psu
	Density Accuracy	± 0.027 kg/m^3
	Depth Accuracy	± 3 dbar

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 Palau survey area has a depth range between 3,104 – 8,088 m. With these values, the range of allowable TPU is ± 23.3-60.7 m at 95% confidence.

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

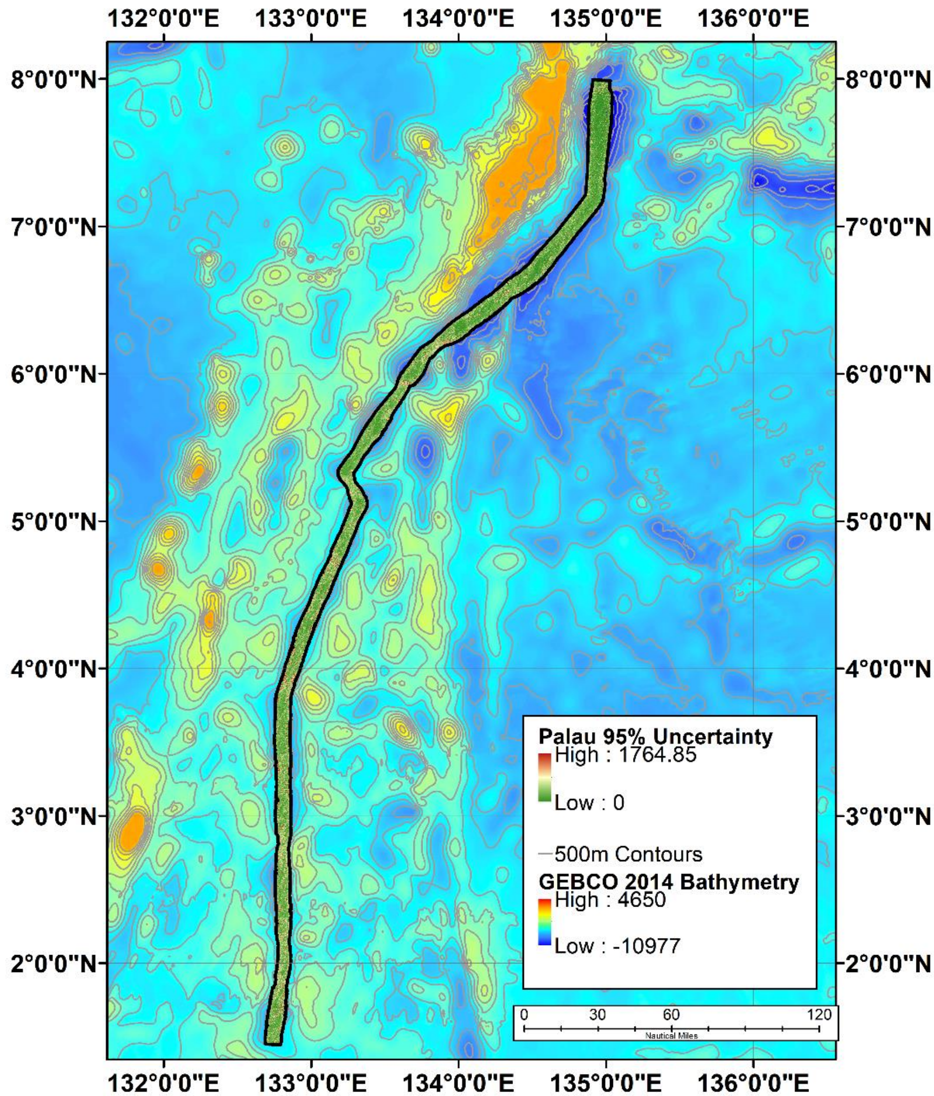

Figure 4: Palau uncertainty at 95% confidence - red indicating areas of higher uncertainty.

The average estimated uncertainty of the Palau survey area is 15.3 m. This falls well below the average acceptable value for this survey based on the TPU estimates for the depth range. Figure 4 shows that uncertainty surface mapped to a color range with a minimum of 0.

1.3 Junctioning Surveys

1.3.1 GEBCO 2014 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 2014 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 Palau Trench 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 Palau survey data in ESRI ArcGIS.

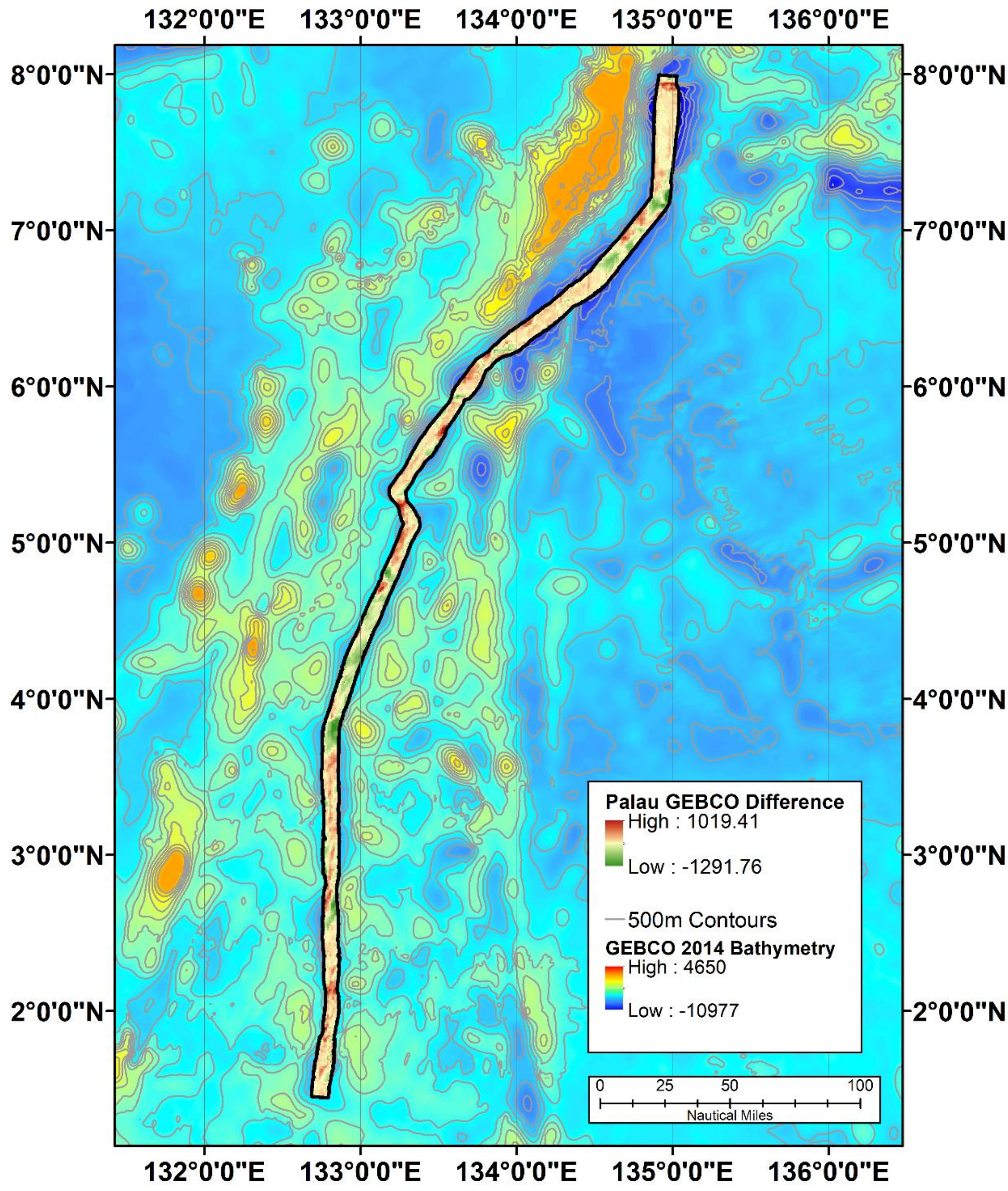

Figure 5: GEBCO 2014 bathymetric grid differenced with the Palau data. Green indicated areas where Palau is deeper than GEBCO estimates.

There is an average difference of 57.5 m, with the Palau survey (on average) being deeper (Figure 5). The GEBCO 2014 grid has a resolution of ~900 m which is of lower quality in comparison to the 75 m Palau survey. This resolution discrepancy likely contributes to some of the large difference values.

1.3.2 Summary

Only small amounts of bathymetric data have ever been collected in the Palau Trench where we surveyed (Figure 6). Specifically, ~66% of the area was interpolated from satellite estimates, meaning 66% of the area has never been mapped before. Only about 34% of the area was mapped previously with either a multibeam system or from single beam echosounders. As such, this mapping effort collected over 6,438 km^2 of new data.

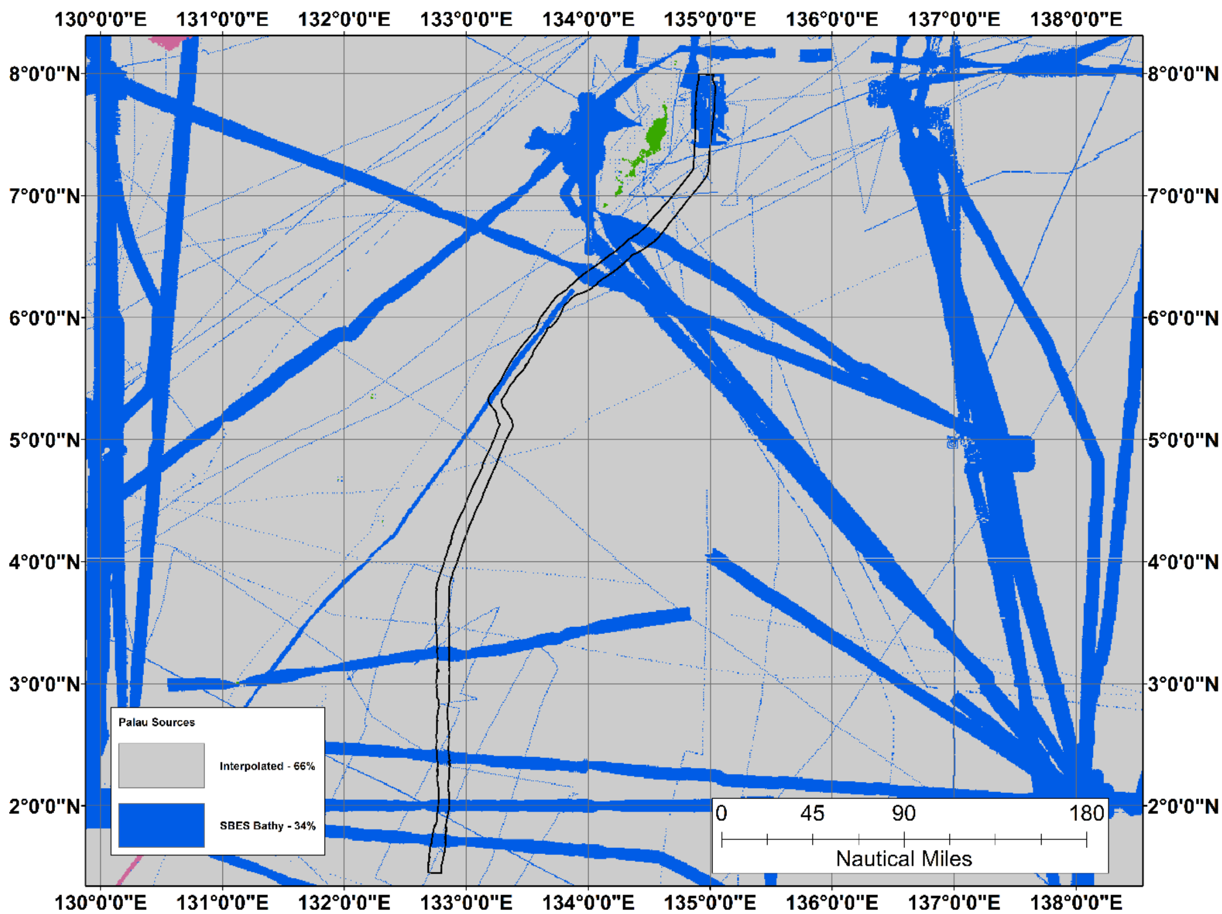

Figure 6: GEBCO data sources. Grey represents areas that were interpolated, and blue are previously collected bathymetry data. The black outline is the area in the Palau Trench where EM 124 data were collected.

This was the first time most of the Palau Trench has ever been mapped. It is anticipated that these data will be a fundamental contribution to the scientific community and the GEBCO 2030 effort.

1.4 Sound Speed

Synthetic profiles were generated as needed during the survey operations using Sound Speed Manager.

1.5 Calibrations

1.5.1 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.

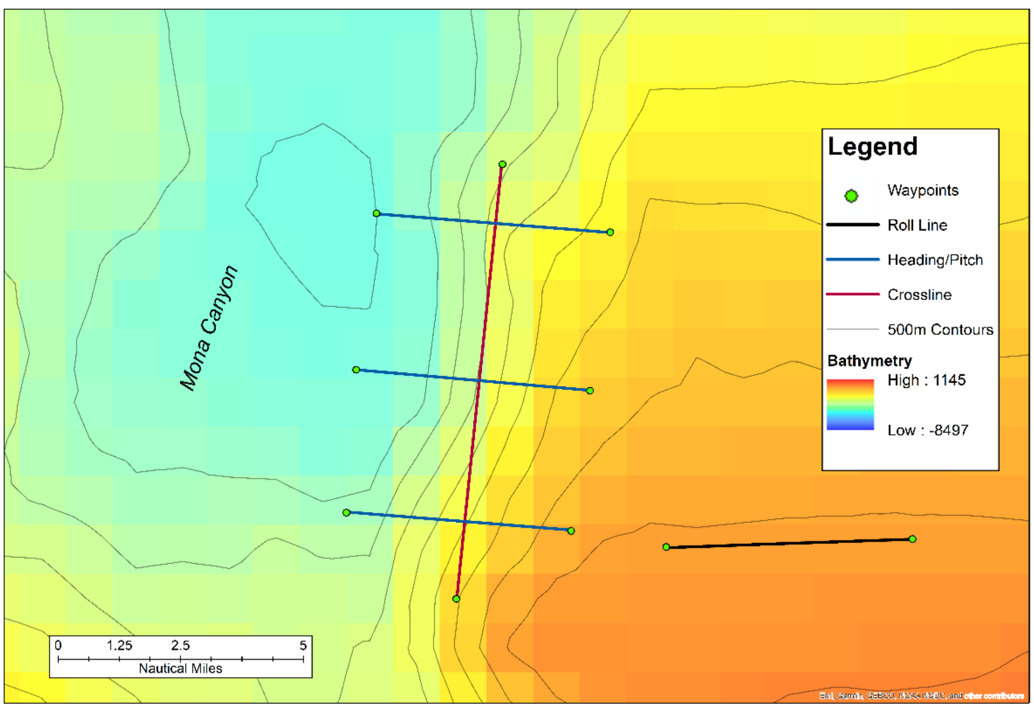

Figure 7: Sonar Acceptance Test (SAT) plan in the Mona Canyon offshore Palau and near the Palau Trench.

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).

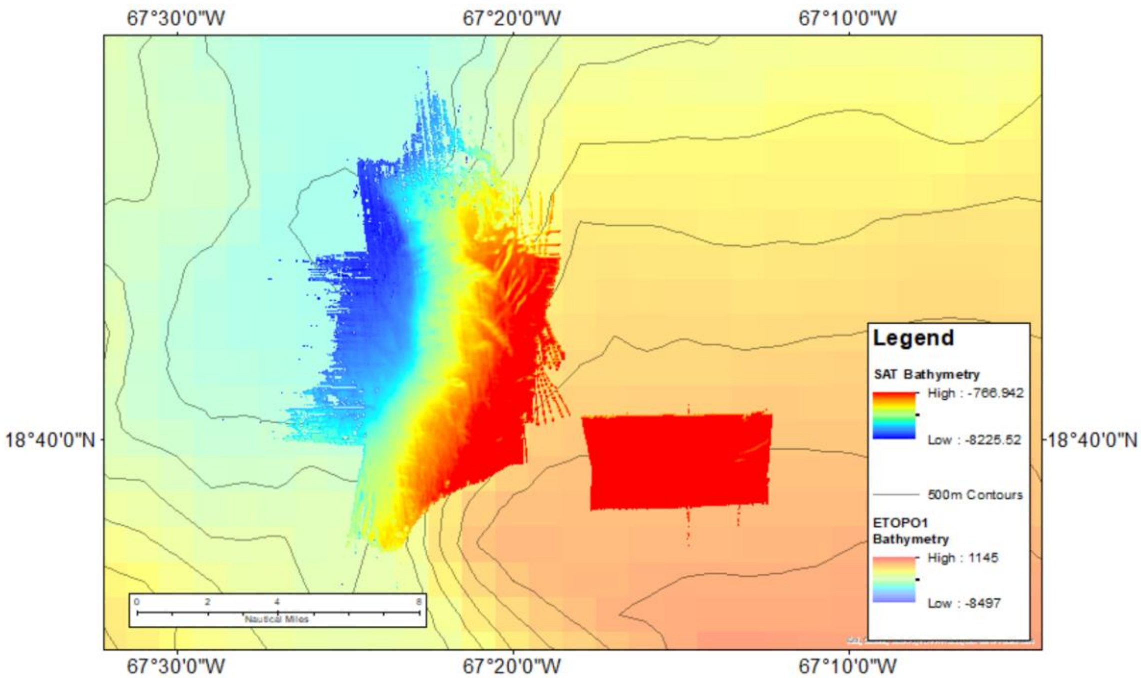

Figure 8: SAT resulting bathymetry

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.

1.5.2 Backscatter Calibration

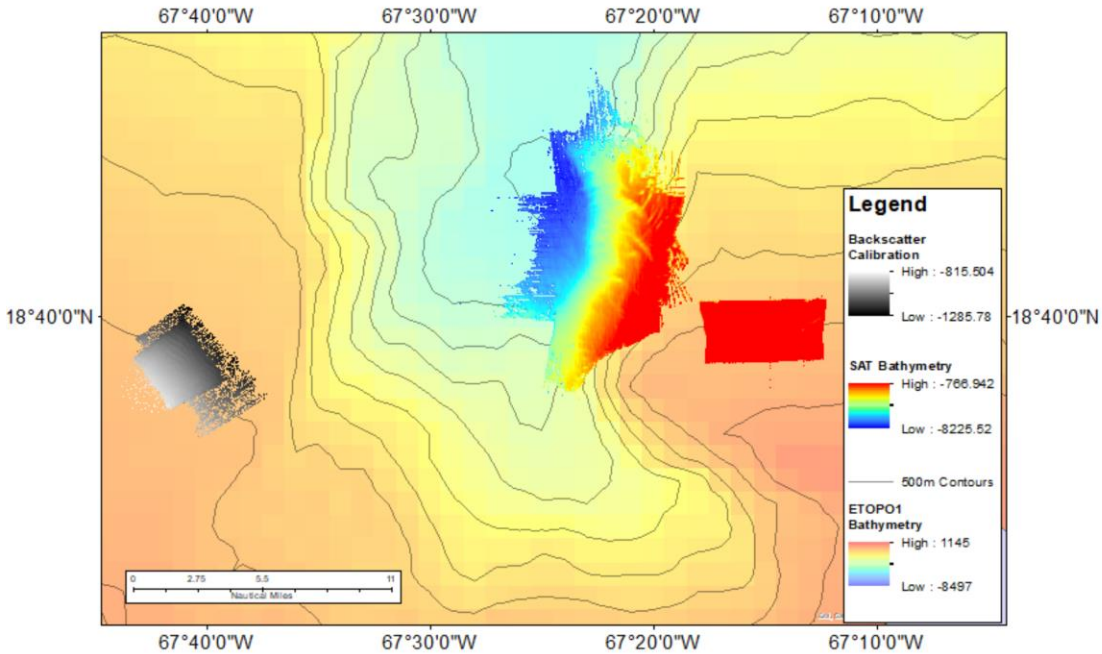

Figure 9: Backscatter calibration in relation to the SAT calibration site.

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).

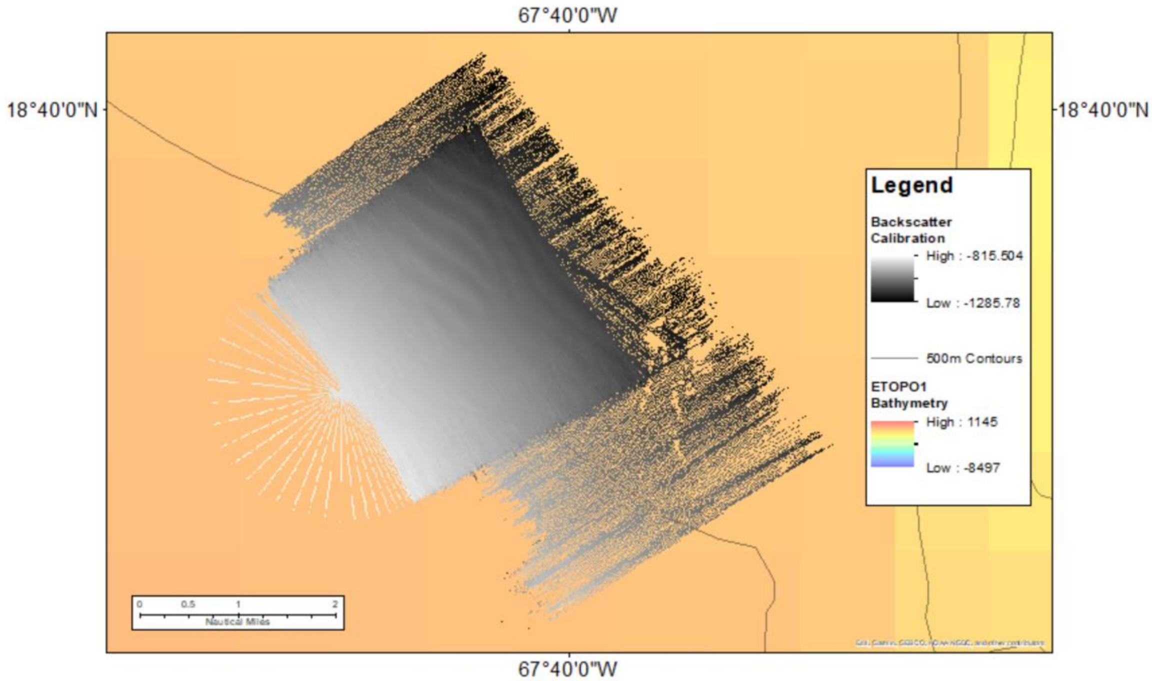

Figure 10: Backscatter calibration bathymetry.

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.

1.6 Backscatter

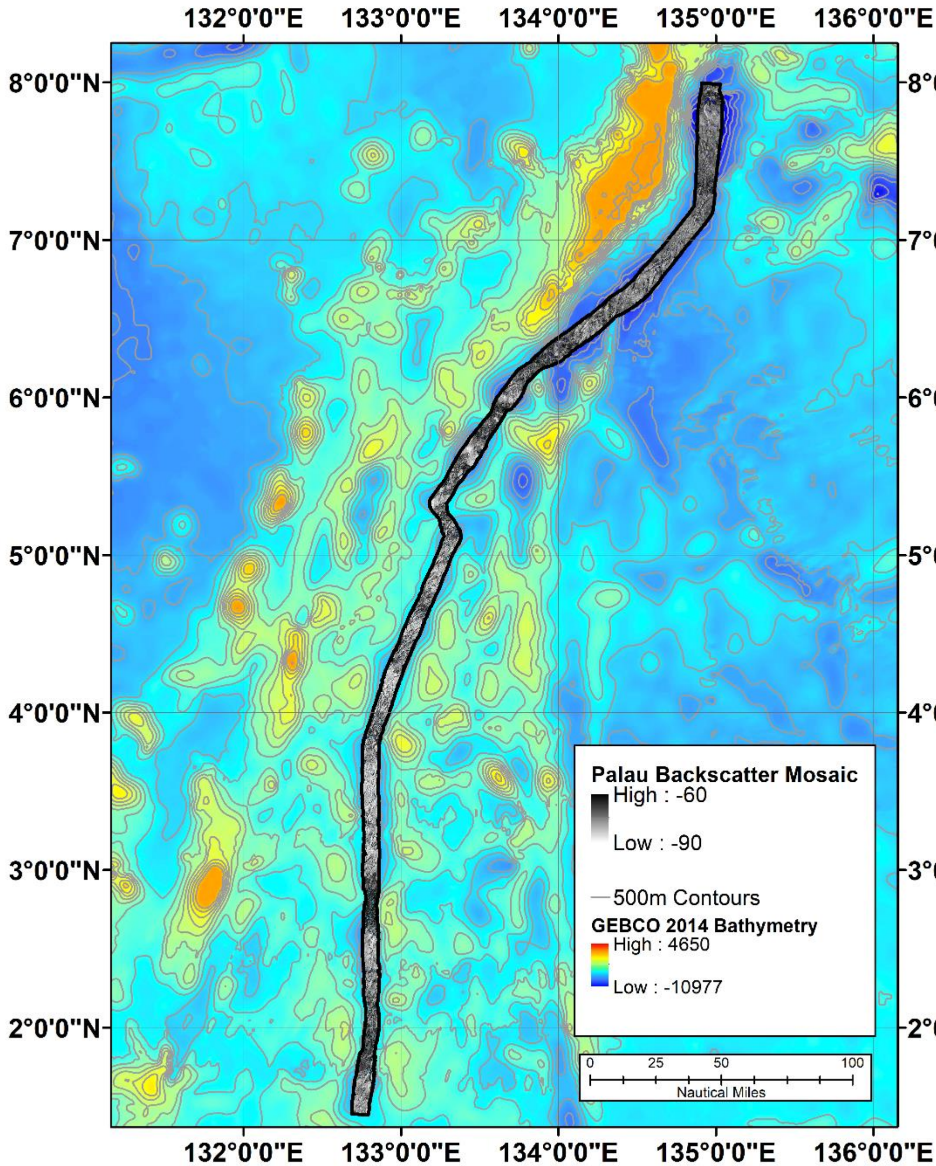

Figure 11: Palau Trench backscatter mosaic. Mosaic created in QPS FMGT.

Backscatter data were collected from the EM 124 during bathymetric data collection. Data were processed in QPS FMGT and a mosaic was created (Figure 11). No sediment samples were taken for verification.

1.7 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.

1.8 Surfaces

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

Surface Name	Surface Type	Resolution	Depth Range
Palau_CUBE_75m.xyz	CUBE	75 m	-3104m to -8088m
Palau_95Uncertainty.tiff	Uncertainty	75 m	N/A
Palau_Surface_75m.bag	Surface	75m	-3104m to -8088m
Palau_backscatter.tiff	Mosaic	60 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.