DSSV Pressure Drop: Descriptive Report

Yap Trench

April 30- May 2, 2020

Report developed for Caladan Oceanic by Cassie Bongiovanni

Internal Use Only

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0.0 Survey Information

0.1 Survey Limits

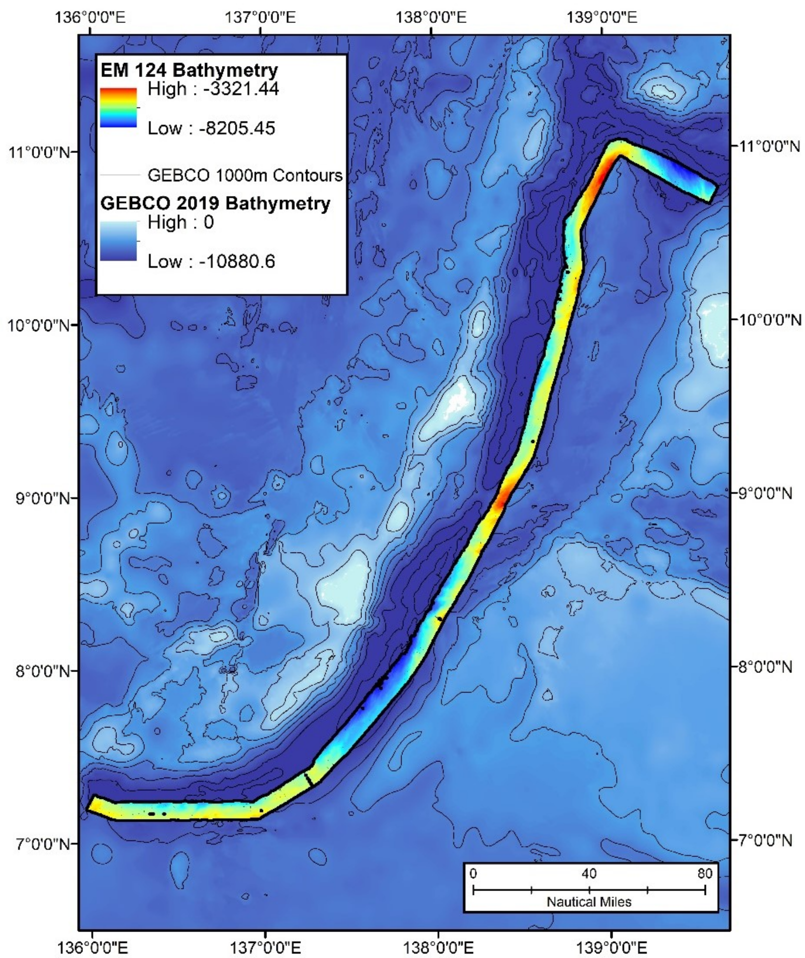

Figure 1: Yap Trench bathymetry collected with the Kongsberg EM 124 over GEBCO 2019 estimated bathymetry.

The Yap 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 three days – April 30-May 2, 2020. The data meet the requirements for IHO Special Order standards.

The Yap Trench survey is within the following limits:

Northwest Limit	Southeast Limit
11°4'25.74"N	7°6'21.282"N
135°58'15.675"E	139°37'34.442"E

Table 1: Survey Limits

0.2 Survey Purpose

The Yap Trench was opportunistically mapped during the transit between the Philippine Trench and the Mariana Trench. The data collected during this transit was intended to both line up with data collected from the Five Deeps Expedition but also inform possible additional dive sites within the Ring of Fire. 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's Seabed 2030).

0.3 Survey Plans

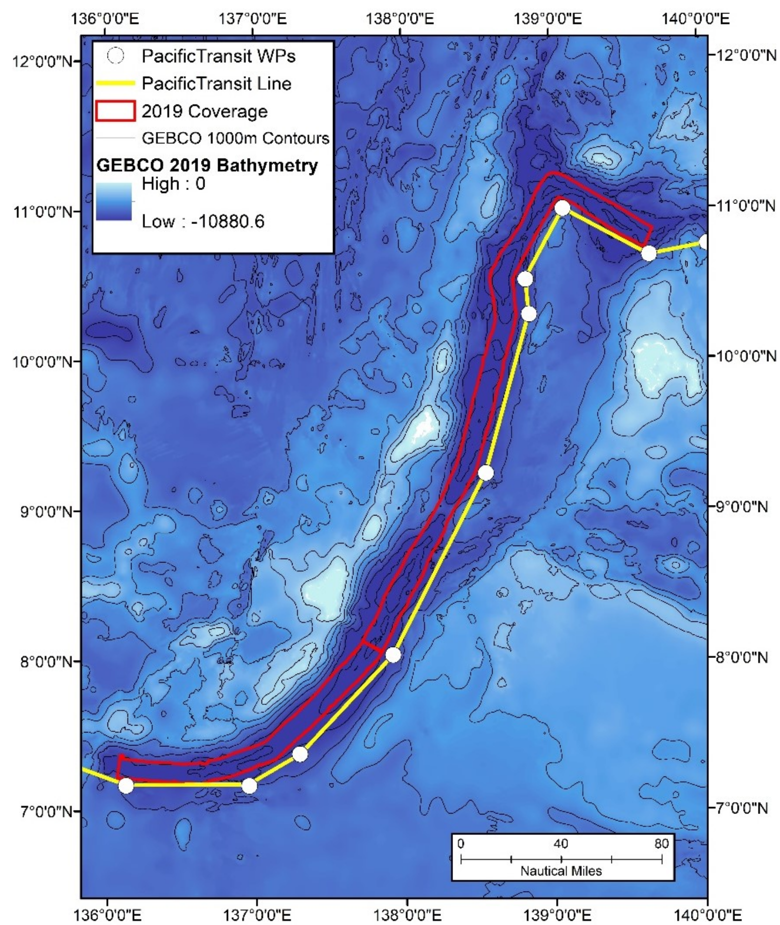

Figure 2: Yap Trench area with GEBCO 2019 bathymetry. Survey line plan and waypoints in comparison to 2019's coverage.

The final mapping plan is depicted in Figure 2. It took over two days to complete at 10 kts.

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.

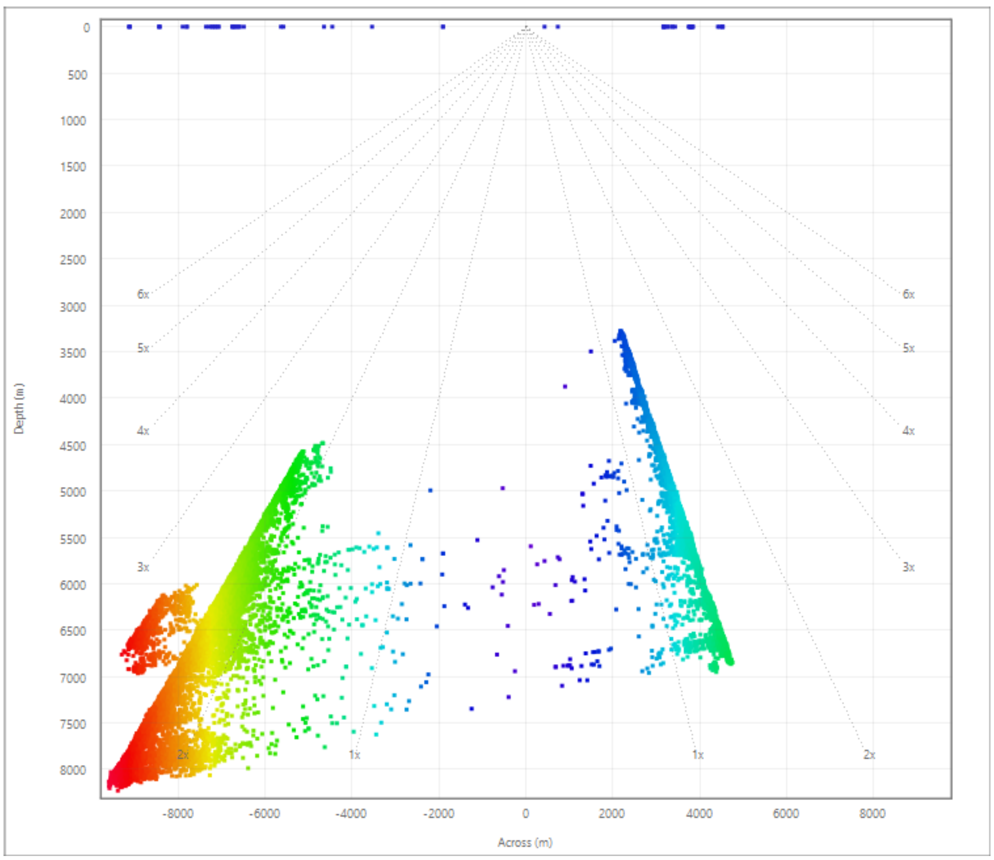

Figure 3: EM 124 Yap Trench survey extinction plot.

Along the ridge, we achieved swath widths around 12 km with extended coverage on port side to align with previously collected data (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	335
	SBES/MBES Combo	0
	MBES Crosslines	0
Number of Bottom Samples		0
Survey Area (KM^2)		8,031

Table 2: Survey Statistics

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

Date	Julian Day
04-30-2020	121
05-02-2020	123

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 5+	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 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 Order 1 surveys, the maximum allowable horizontal uncertainty is 5 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 Yap Trench survey area has a depth range between 3,321 – 8,205 m. With these values, the range of allowable TPU is ± 25 – 61.5 m at 95% confidence.

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

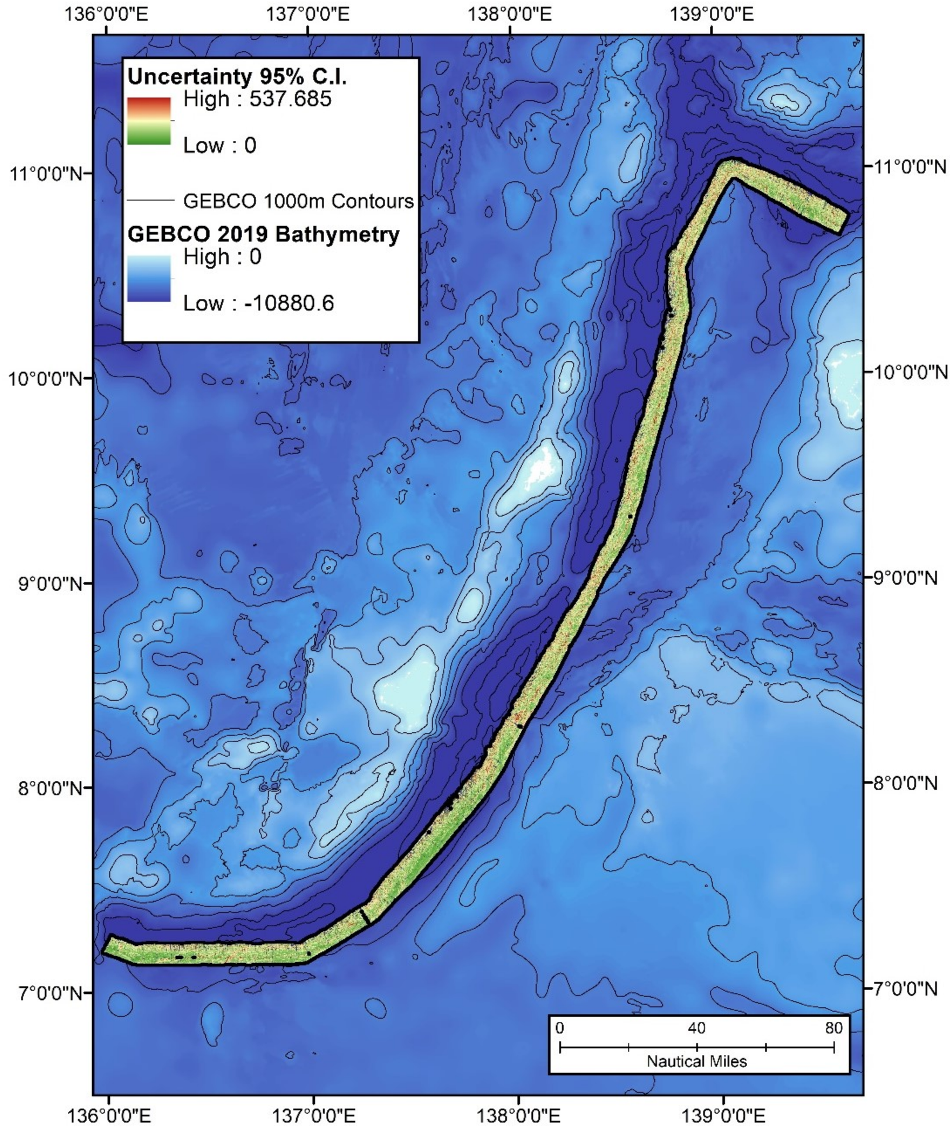

Figure 4: Yap Trench uncertainty at 95% confidence - red indicating areas of higher uncertainty.

Figure 4 shows that uncertainty surface mapped to a color range with a minimum of 0. The average estimated uncertainty of the Yap Trench survey area is 20 m. The average uncertainty calculated for the Yap survey is well below the lower uncertainty requirement for the survey.

These data meet IHO Special Order specifications as shown in Figure 5.

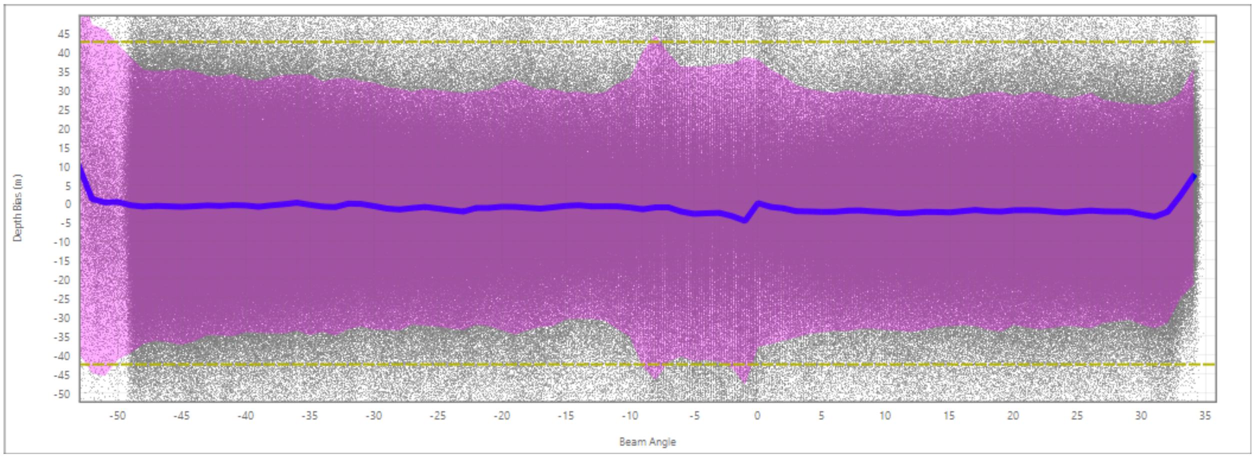

Figure 5: Yap Trench uncertainty data (purple) in comparison with the IHO Special Order specifications (yellow dotted lines). This figure proves these data meet the limitations set forth by the Special Order survey classification.

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 Yap 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 Yap Trench survey data in ESRI ArcGIS.

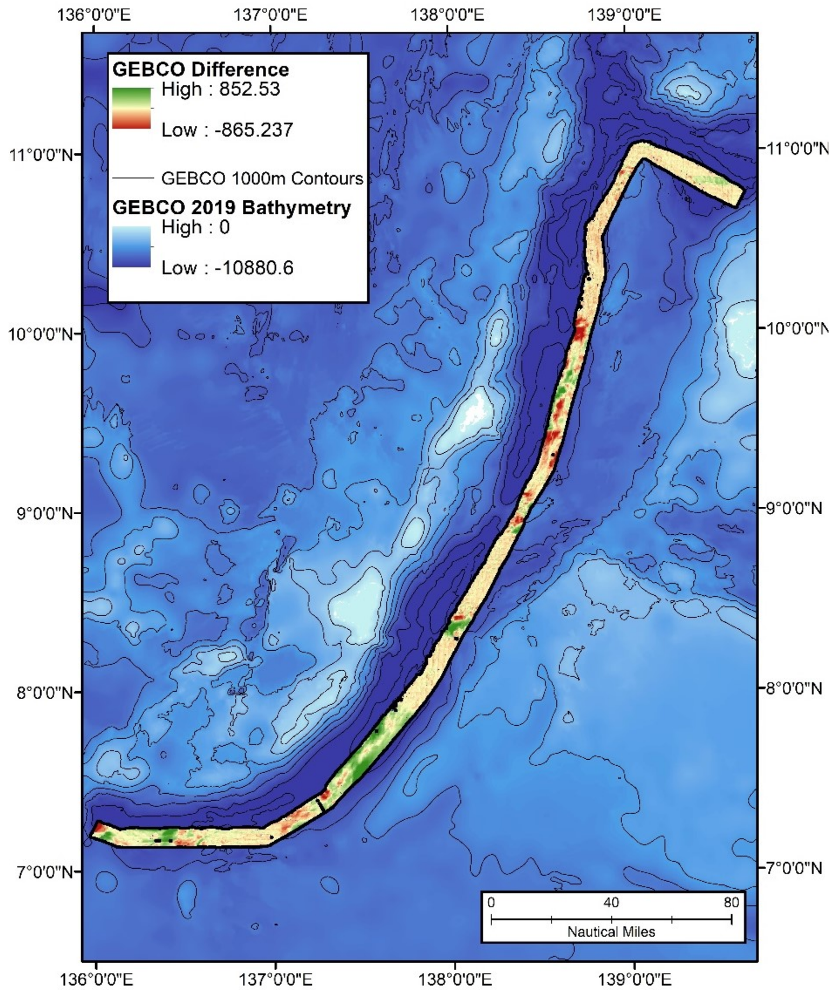

Figure 6: Difference grid between GEBCO 2019 grid and the EM 124 data. Positive values are where EM 124 is deeper than GEBCO (green) and negative values indicate where the EM 124 reads shallower than GEBCO (red).

The average difference between the two grids is 40 m with the EM 124 being deeper. The GEBCO 2019 grid has a resolution of ~600 m which is of lower quality in comparison to the 75 m Yap Trench survey. This resolution discrepancy likely contributes to some of the large difference values seen in Figure 6. However, a large part of this area has never been mapped with high-resolution equipment, so it's not unsurprising that larger differences are observed. Additionally, where data were previously collected, the observed differences are smaller.

1.3.2 Summary

According to the GEBCO 2019 grid sources available at the time of survey, ~53% of the area we covered was interpolated from satellite estimates, meaning 47% of the area has been mapped before (Figure 7).

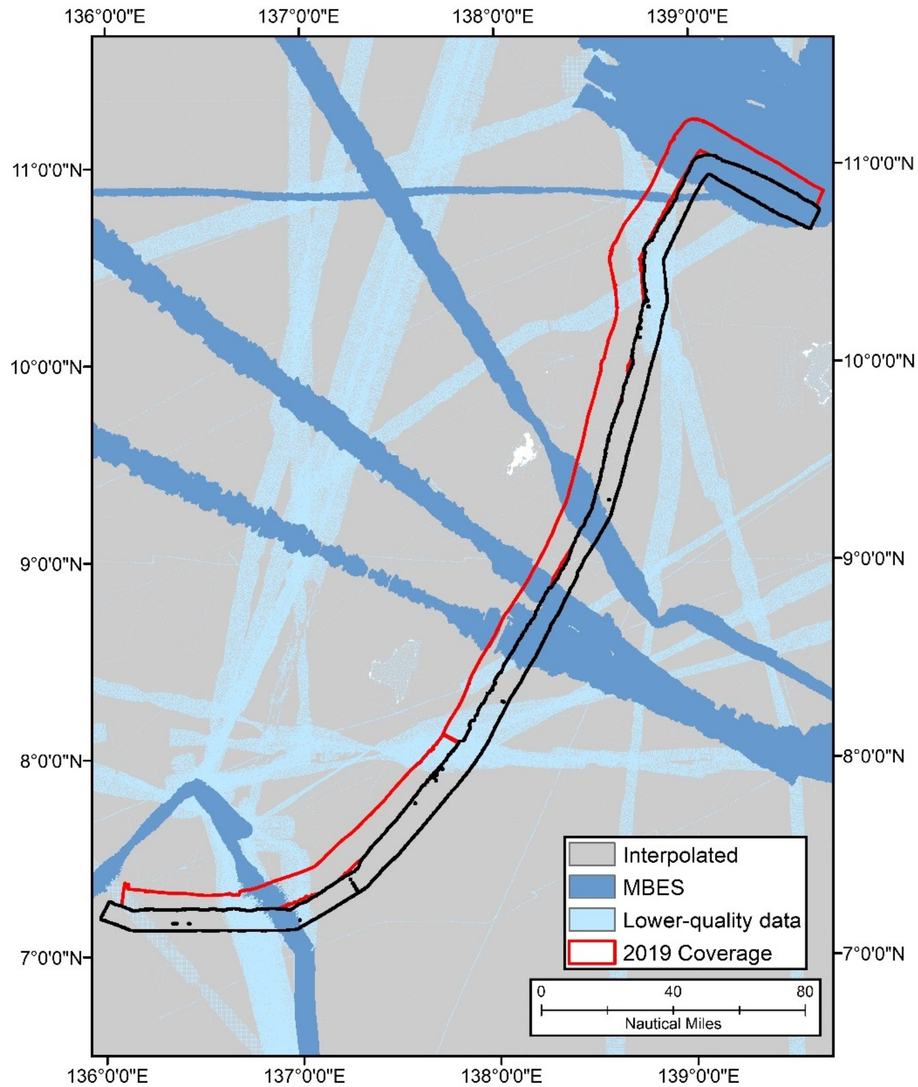

Figure 7: GEBCO data sources. Grey represents areas that were interpolated, and blue and light blue are previously collected bathymetry data. The black outline is the area in Yap Trench where EM 124 data were collected.

Our efforts were the first to map the Yap Trench in its entirety. It is anticipated that these data will be a fundamental contribution to the scientific community.

1.4 Sound Speed

No XBTs or CTDs were collected during this survey. Only synthetic profiles were created as needed using modeled estimates from World Ocean Atlas 2009.

1.5 Data Corrections

No data corrections were required during this survey.

1.6 Calibrations

1.6.1 Patch Test

Two sets of patch tests were performed by Cassie Bongiovanni in early February at the beginning of the 2020 DSSV *Pressure Drop* field season - one in shallow water (500-700 m) and one in deep water (> 2500 m). More detailed information is outlined in the Patch Test Report.

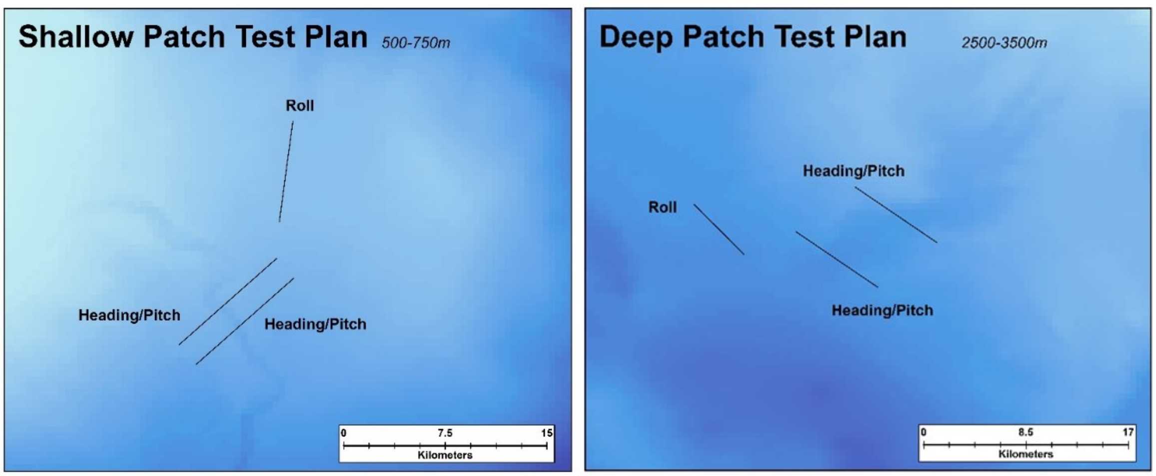

Figure 8: Two patch test plans in the Mediterranean Sea – shallow one was performed off southern Italy over a submarine channel, and the deep one was performed two days later near Calypso Deep off western Greece.

The shallow water lines were run first and then used to determine the offsets applied to the deep lines during collection. The deep patch was performed to make sure that the offsets remained true. In addition to the standard Qimera offset analysis, a secondary verification was performed called “the Over-Under” analysis. The concept behind the over-under approach is to rely on the depth difference between each pair of survey lines to indicate what needs to be recalibrated and by how much. In theory, our eyes will be able to pick up on smaller details that computer systems can’t.

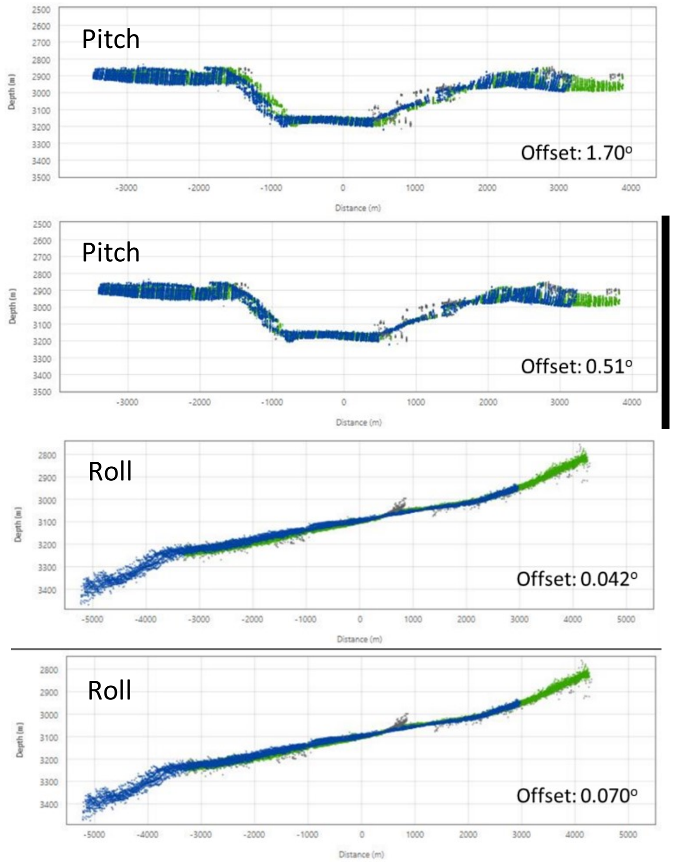

Figure 9: Deep patch test results for pitch and roll using Qimera's patch test toolbox.

Ultimately, the results from the deep patch test will be the final offsets as the system primarily operates in deep water. It is believed that they represent a more realistic estimate of the true system offsets resulting from their amplification in deep water in addition to a calmer weather day during the deep patch collection.

Calibration	Shallow	Deep
[redacted]		

1.6.2 Backscatter Calibration

A backscatter calibration was performed in December of 2018 during the sonar acceptance test (SAT). 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.

In February of 2020, the backscatter calibration file was updated to match the file format accepted in the newest version of SIS 5; however, no other calibration details were applied during this process.

1.7 Backscatter

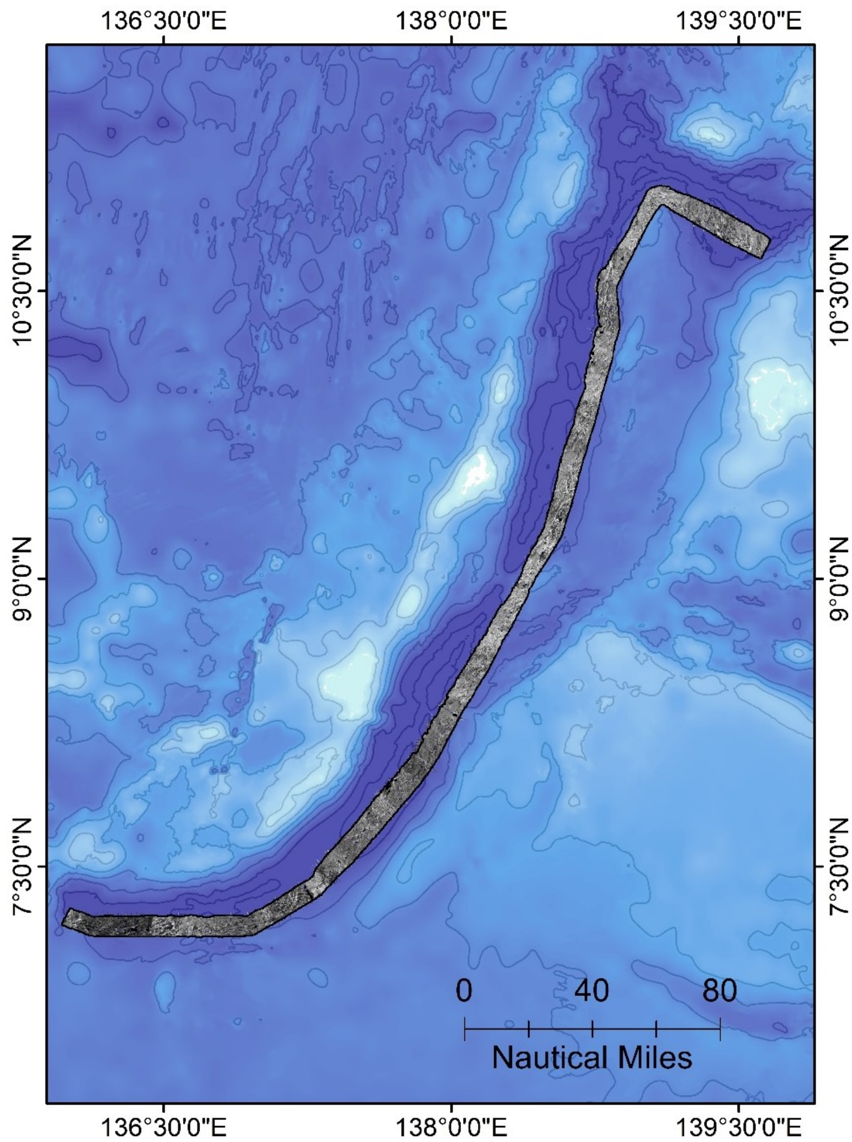

Figure 10: Yap Trench backscatter mosaic. Mosaic created in QPS FMGT.

Backscatter data were collected from the EM 124 during bathymetric data collection. Data were processed in QPS FMGT and an 40 m mosaic was created (Figure 10). 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	10.7.1	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
Yap_CUBE_100m.xyz	CUBE	100 m	-3,321 m to -8,205 m
Yap _95Uncert.tiff	Uncertainty	100 m	N/A
Yap _Surface_100m.bag	Surface	100m	-3,321 m to -8,205 m
Yap _backscatter.tiff	Mosaic	80 m	N/A

Table 8: Final mission surfaces.

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.