DSSV Pressure Drop: Descriptive Report

Izu-Bonin Trench

July 21-28, 2020

Report developed for Caladan Oeanic by Cassie Bongiovanni

Internal Use Only

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0.0 Survey Information

0.1 Survey Limits

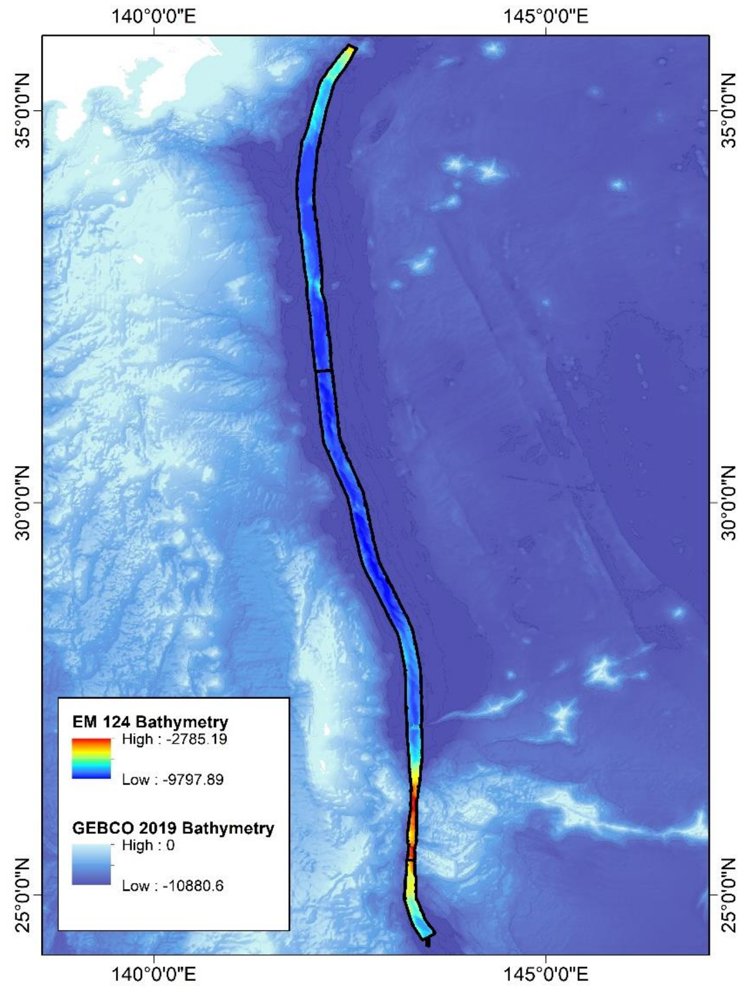

Figure 1: Bathymetry collected within the Izu-Bonin Trench collected with the Kongsberg EM 124 over GEBCO 2019 estimated bathymetry.

The Izu-Bonin Trench (Figure 1) was surveyed with a Kongsberg EM 124 gondola-mounted to the hull of the 225-foot DSSV Pressure Drop. The surveys were conducted over the course of six days – July 21-25 & 27-28, 2020. These data meet the requirements for IHO Order 1 standards.

The Izu-Bonin survey is within the following limits:

Northwest Limit	Southeast Limit
35°48'52.785"N	24°21'18.642"N
141°48'42.336"E	143°36'4.013"E

Table 1: Survey Limits

0.2 Survey Purpose

The data were collected as part of the Ring of Fire Expedition, where we set out to map the western Pacific and all the trenches it holds to the highest resolution possible. 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

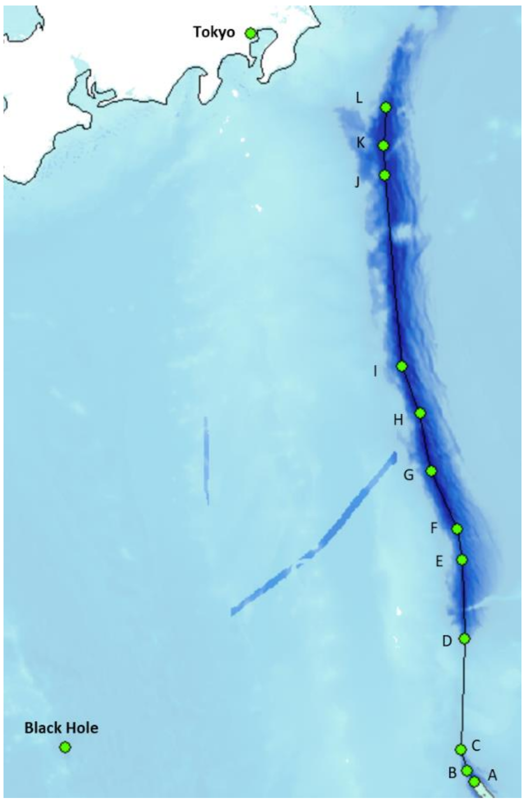

Figure 2: Izu-Bonin line plan with GEBCO 2019 bathymetry constrained to show the deep.

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

0.4 Survey Quality

These data meet IHO Order 1 specifications and should be used to verify any prior data for all intents and purposes.

0.5 Survey Coverage

No notable holidays (or gaps in coverage) were created during this survey, only slight fanning occurred during changes in heading.

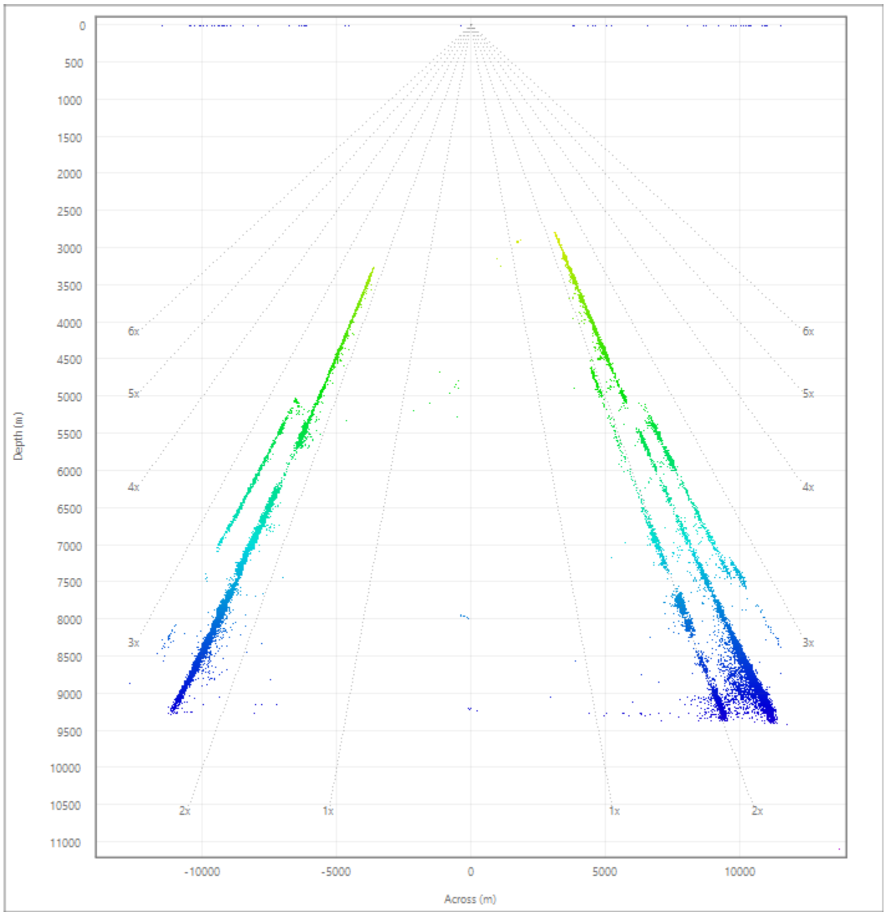

Figure 3: EM 124 Izu-Bonin Trench survey extinction plot.

Throughout the area, we achieved swath widths around 22 km with 45-60° coverage on either side of nadir ~ 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 Type	SBES Mainscheme	0
	MBES Mainscheme	2,063
	SBES/MBES Combo	0
	MBES Crosslines	0
Number of Bottom Samples		0
Survey Area (KM^2)		23,215

Table 2: Survey Statistics

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

Date	Julian Day
07-21-2020	203
07-28-2020	210

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 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 10 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 Izu-Bonin survey areas have a depth range between 2,785 – 9,798 m. With these values, the range of allowable TPU is ± 20.8 – 73.5 m at 95% confidence.

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

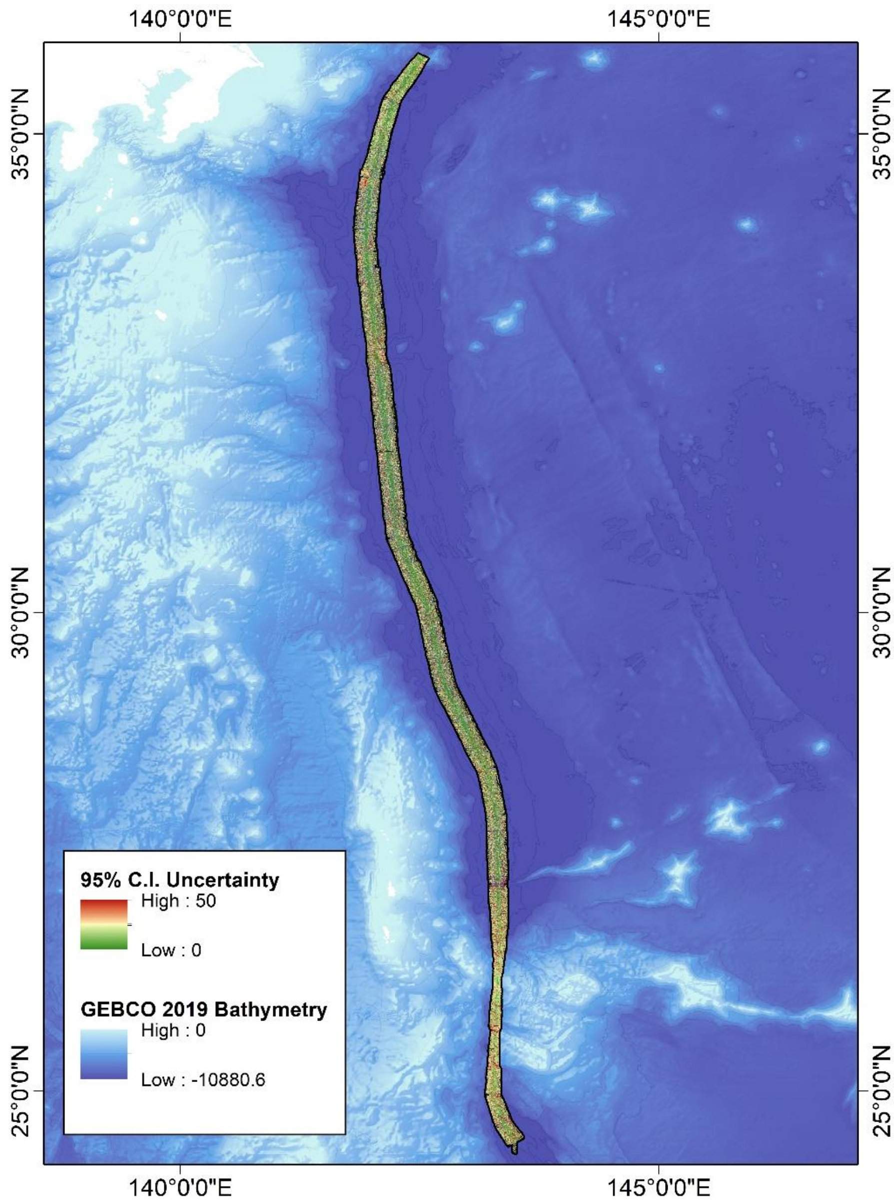

Figure 4: Izu-Bonin Trench uncertainty at 95% confidence - red indicating areas of higher uncertainty.

Figure 4 shows that uncertainty surface mapped to a color range with a minimum of 0. The average estimated uncertainty of the Izu-Bonin Trench survey areas is 21.6 m. This exceeds the lowest bound of the maximum uncertainty for these data; however, this does not accurately reflect the bulk of the data. The average depth of these data is ~8,300 m which corresponds to a maximum uncertainty of 62 m, of which our estimates are much lower.

These data meet IHO Order 1 specifications as shown in Figure 5.

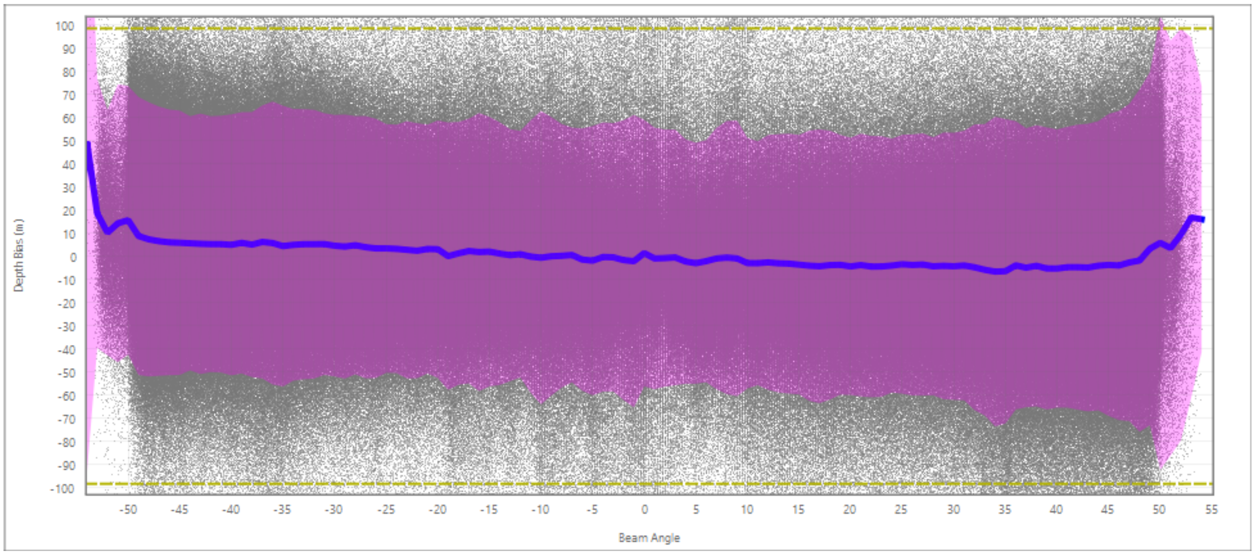

Figure 5: Izu-Bonin Trench uncertainty data (purple) in comparison with the IHO Order 1 specifications (yellow dotted lines). This figure proves these data meet the limitations set forth by the Order 1 survey classification.

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 Izu-Bonin Trench survey areas were extracted from the GEBCO website and used as a base-layer map to help with line-planning (https://www.gebco.net/data_and_products/gridded_bathymetry_data/). This surface was differenced with the EM 124 survey data in ESRI ArcGIS.

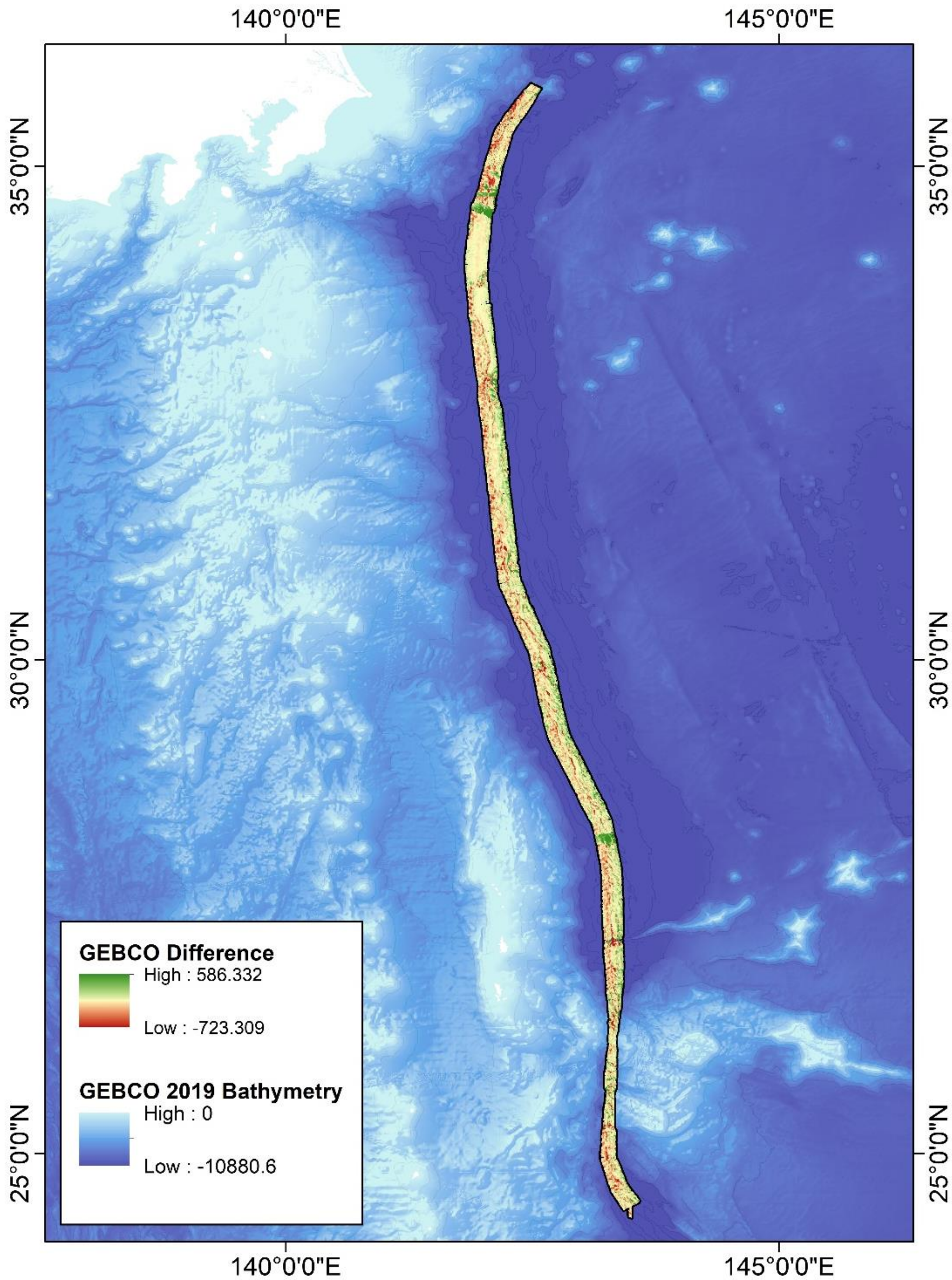

Figure 6: Difference grid between GEBCO 2019 grid and the EM 124 data. Positive values are where EM 124 is deeper than GEBCO (green) and negative values indicate where the EM 124 reads shallower than GEBCO (red).

The average difference between the two grids is 6 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 100 m Izu-Bonin Trench survey. This resolution discrepancy contributes to the majority of the difference values seen in Figure 6.

1.3.2 Summary

According to the GEBCO 2019 grid sources available at the time of survey, 0% of the area we covered was interpolated from satellite estimates, meaning the entire survey area has been mapped before (Figure 7).

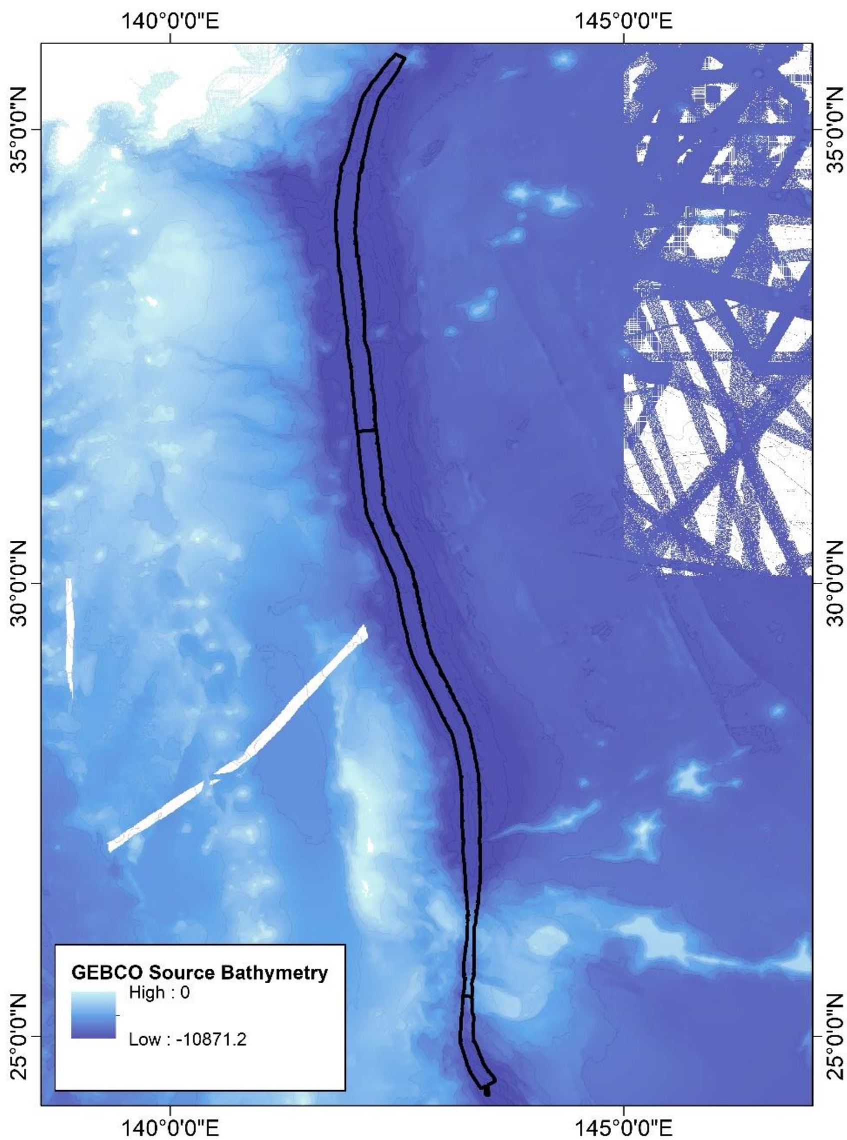

Figure 7: GEBCO source bathymetry – where blue exists, data exists. Black outline of the EM 124 bathymetry collected during this survey.

Our efforts were not the first to map the Izu-Bonin Trench in its entirety, but it is anticipated that these data will further verify existing data.

1.4 Sound Speed

One XBT was deployed during the survey and applied to the data. It was combined with World Ocean Atlas 2009 (WOA) salinity data to accurately calculate sound velocity (Figure 8). The profile is accurate to ~1400m and was extended to full-ocean depth using WOA values. As the upper portion of the water column is the most dynamic and influenced constantly by outside sources (wind, waves, sun, biological movements, etc.), it is the most important to sample.

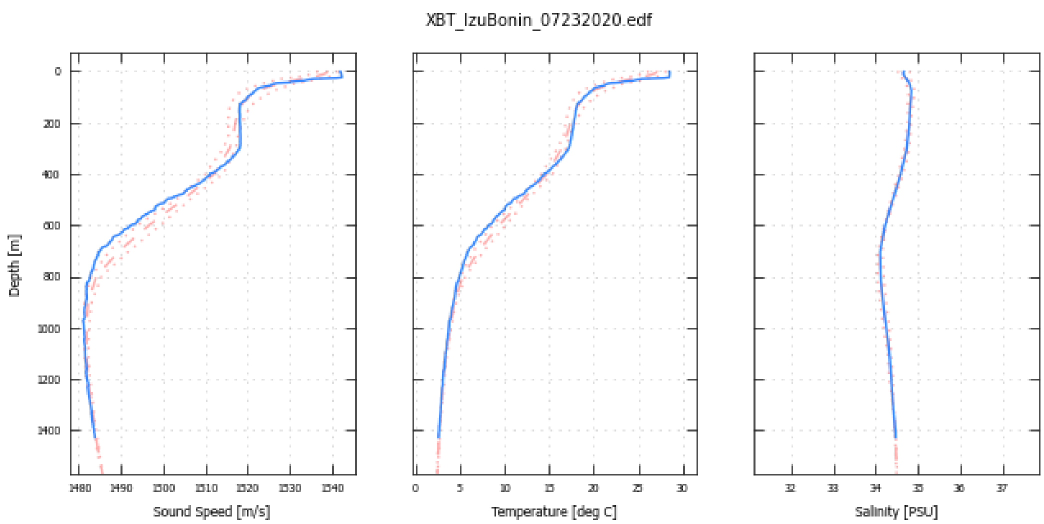

Figure 8: One XBT was collected in the survey area (blue) in comparison to World Ocean Atlas modeled data (dashed pink lines).

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.

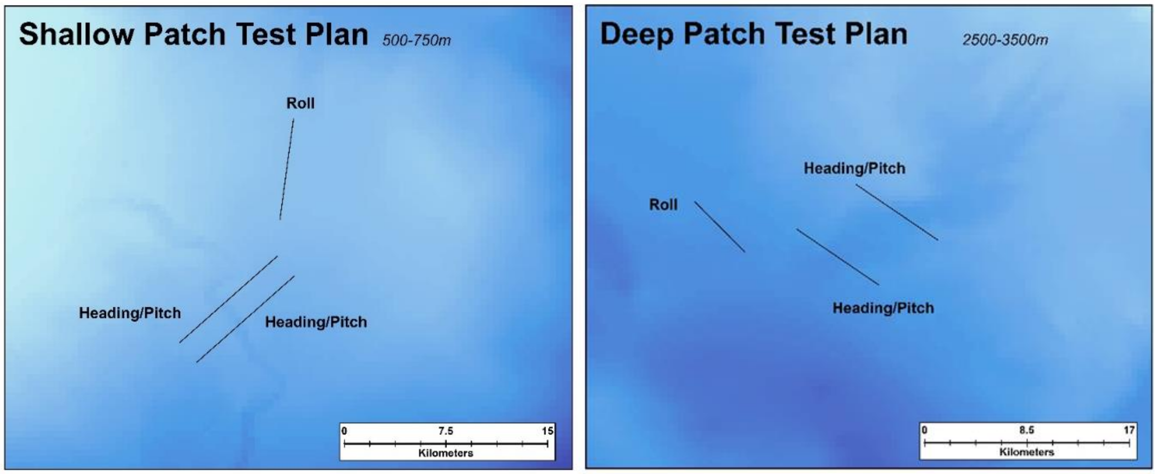

Figure 9: Two patch test plans in the Mediterranean Sea – shallow one was performed off southern Italy over a submarine channel, and the deep one was performed two days later near Calypso Deep off western Greece.

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.

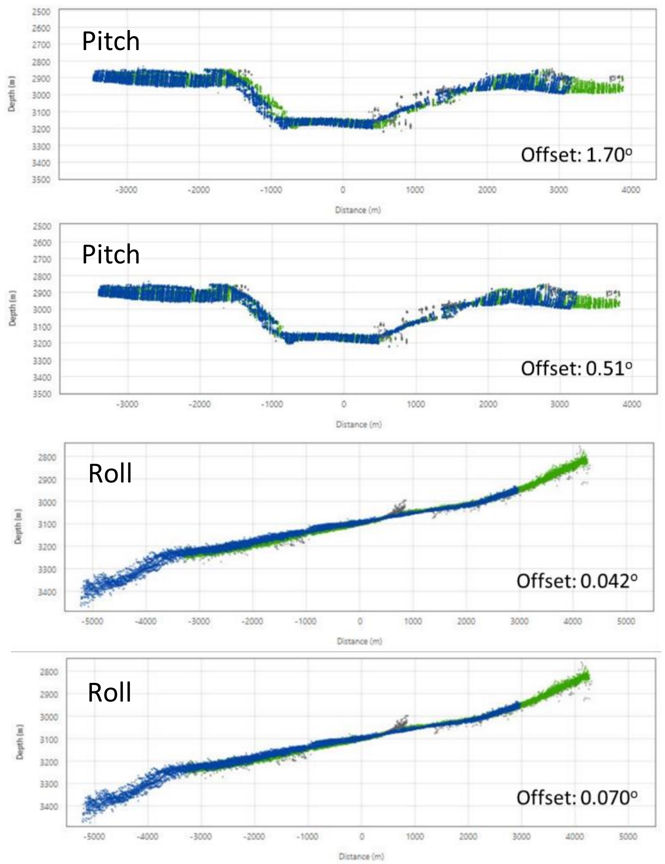

Figure 10: Deep patch test results for pitch and roll using Qimera's patch test toolbox.

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
Pitch	1.7	0.51
Roll	0.042	0.07
Heading	0.2	0

It was also determined later (using the Qimera wobble toolbox) that a latency offset of 0.163 seconds needed to be applied to all data.

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

Backscatter data were collected from the EM 124 during bathymetric data collection. No sediment samples were taken for verification.

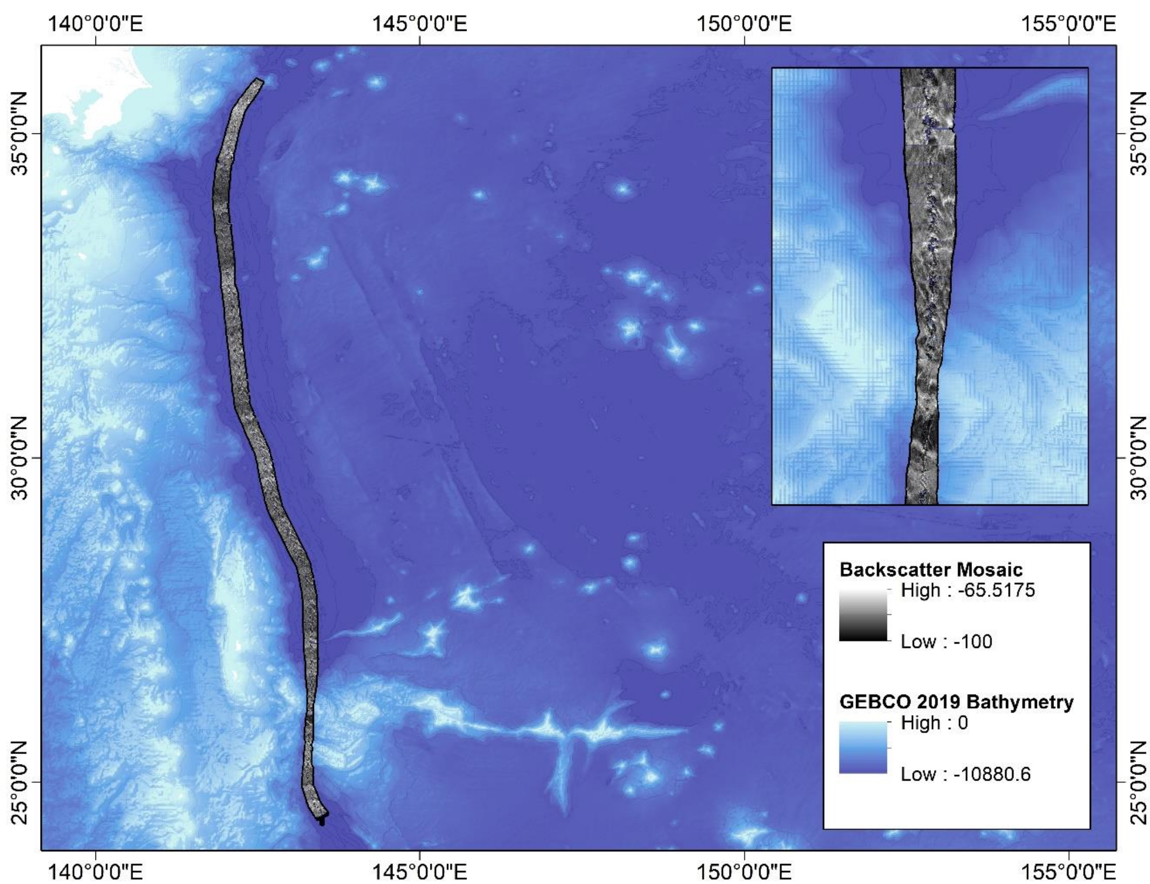

Figure 11: Izu-Bonin Trench backscatter mosaic at 55m resolution.

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
IzuBonin _Surface_100m.bag	CUBE	100m	-2,785 m to -9,798 m
IzuBonin _95Uncertainty.tiff	Uncertainty	120 m	N/A
IzuBonin_Mosaic_55m.tiff	Mosaic	55m	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.