Pakiri Sand Extraction Review: Dredge Trench Assessment

Prepared for:

Friends of Pakiri Beach Inc.

MOHIO - AUAHA - TAUTOKO
UNDERSTAND - INNOVATE - SUSTAIN

Pakiri Sand Extraction Review: Dredge Trench Assessment

Report Status

Version	Date	Status	Approved by
V. 1	23 December 2020	Incomplete Draft	
V. 2	4 February 2021	Final Draft	STM
V. 3	10 February 2021	Rev 1	EAA
V. 4	20 February	Rev 2	STM

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1 Scope of Survey

This report of survey details the planning, methodology and results of a hydrographic survey conducted by eCoast Marine Consulting and Research at Pakiri Beach, which is located on New Zealand's northeast coast, some 70 km north of Auckland. The bathymetry survey was undertaken using a Single Beam Echo Sounder (SBES) to collect collocated depths in a cross-shore fashion to determine seabed depths within the vicinity of seabed mining activities. The survey was undertaken on the 31st August 2020. The survey (and previous surveys also included here) are focussed on the offshore dredging consents in Area 1, which is offshore of Pakiri Beach, in depths of approximately 30-34 m (Auckland vertical datum), and includes locations found to have been dredged successively (McIntosh et al., 2021).

The aim of the survey was to confirm the presence of dredge trenches and more accurately determine the depths of any trenches present, that are made during trailer suction dredge activities, and observed in Side-Scan Sonar (SSS) survey data collected in February 2019 by SeaROV Technologies Ltd. The area targeted by the 2019 survey was determined from Automatic Identification System (AIS) data collected/broadcasted by the dredge vessel. The approximate seabed area was surveyed again at the same time as the hydrographic survey conducted by eCoast.

2 Geodesy

2.1 Survey Datum

Table 2.1. Survey Datums

Horizontal Datum Parameters	
Datum	International Terrestrial Reference Frame 2008
Reference Frame	WGS 84 (G1762)
Semi-Major axis	a = 6378137.000m
Inverse flattening	1/f = 298.257223563
Vertical Datum	
Reference Datum	Ellipsoid

2.2 Horizontal and Vertical Control

Table 2.2: Equipment used for horizontal and vertical control.

Equipment	Model	Accuracy
GNSS receiver	Emlid Reach RS2	Static H: 5 mm + 1 ppm Static V: 10 mm + 2 ppm

2.3 Hydrographic Survey Equipment

The Research Vessel (RV) *Hawere* was utilised as the vessel and collected side-scan sonar data and bathymetry data. Table 2.3 provide details of the equipment used during the survey.

Table 2.3: Survey equipment

System	Model	Expected Accuracy
Single Bean Echo Sounder	Ceepulse 100	See below
Transducer	Airmar SS510 200 kHz, 9°	0.01 m +/- 0.1% of depth
GNSS	Emlid Reach RS2	Kinematic H: 7 mm + 1 ppm Kinematic V: 14 mm + 2 ppm

3 Post-Processing and Bathymetric Data

Data was cleaned of outliers and bathymetric data collected while the research vessel made abrupt turns was removed. A comparison of all points, some ~54,000, was undertaken. Only pairs of points with a time difference of greater than 30 minutes were compared, and a mean offset calculated from points closer than 0.3 m. Figure 3.1 presents the data from this comparison.

Data is subdivided into cross-shore transects. Figure 3.2 presents the transect locations overlain on a satellite image of the study site. Transects 1 through 13 were collected offshore, in the vicinity of the dredge vessel's most recent activity. Transects 14 to 33 targeted the 2019 side scan survey area.

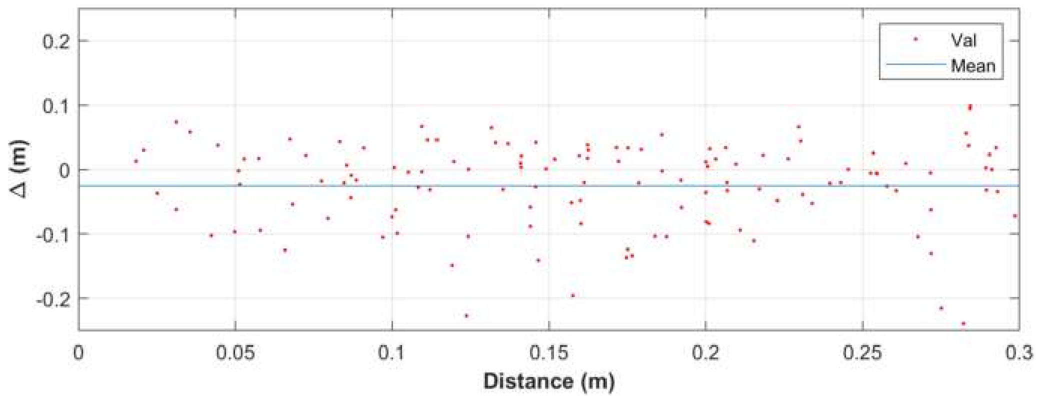


Figure 3.1: Delta values against distance between points from a comparison of points within the bathymetric survey with a time difference of no less than 30 minutes, the mean difference in calculated from points less than 0.3 m apart.

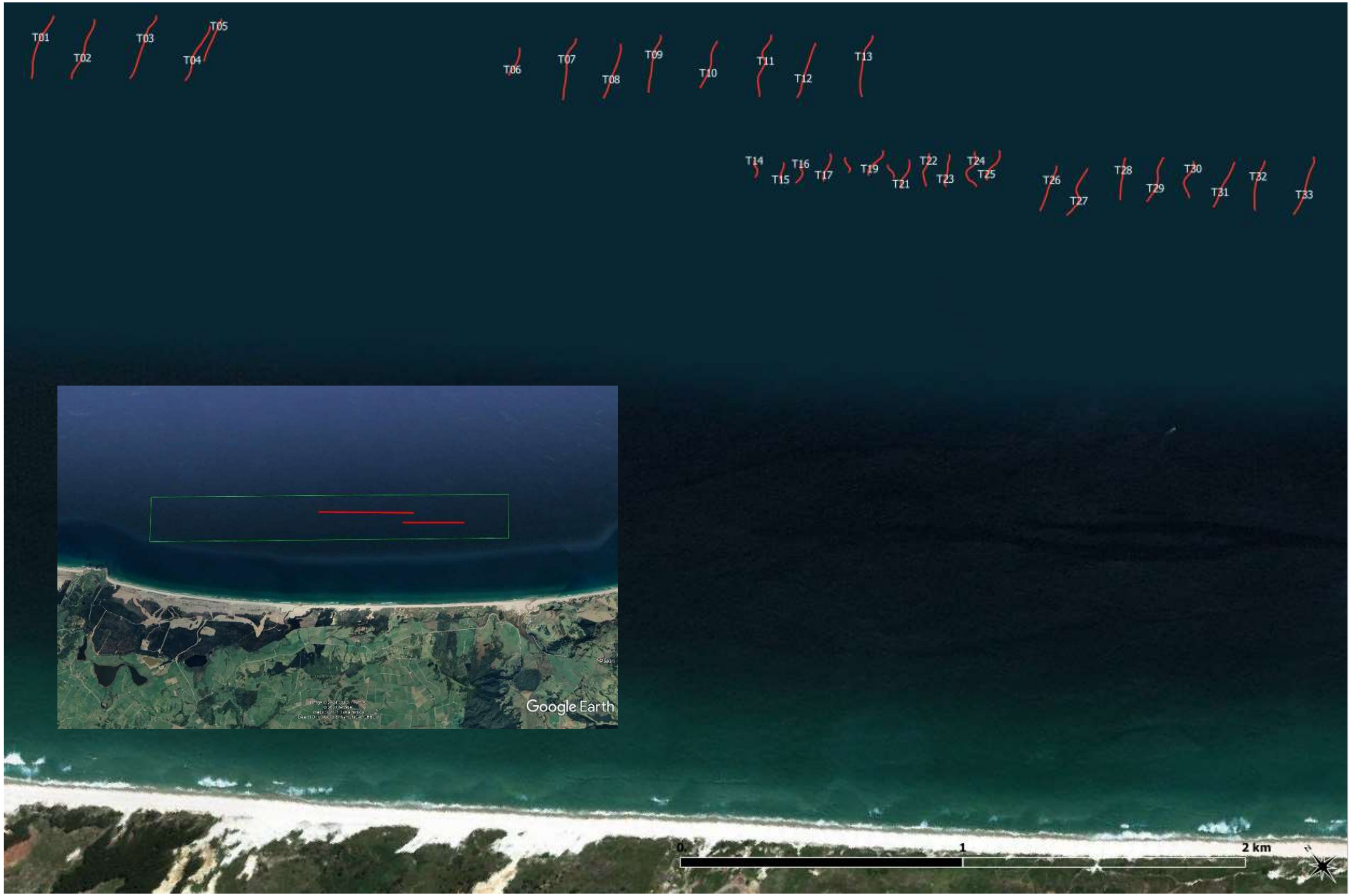


Figure 3.2: Transects overlain on an aerial photo of the study site. Inset indicating the approximate location of Area 1 (green) and the dredging lines surveyed (red).

4 Side-Scan Sonar Survey Validation

Figure 4.1 peresents a schematic of SSS functionality. In the example of Figure 4.1, and in the data presented here, lighter areas indicate strong returns, and darker areas indicate weak returns. Weak returns can be caused by softer seabed material, but are most readily observed where “shadowing” occurs. Shadowing is the result of reduced acoustic reflection. In the example, the beam passes over the crest of the channel closest to the SSS tow fish (i.e, the device towed behind the vessel to collect the data), the area on the far side fo the crest receives little, or none, of the emitted signal. The side of the channel farthest from the tow fish can have a high acoustic reflection if the orientation reduces scattering and sends a strong signal back to the tow fish.

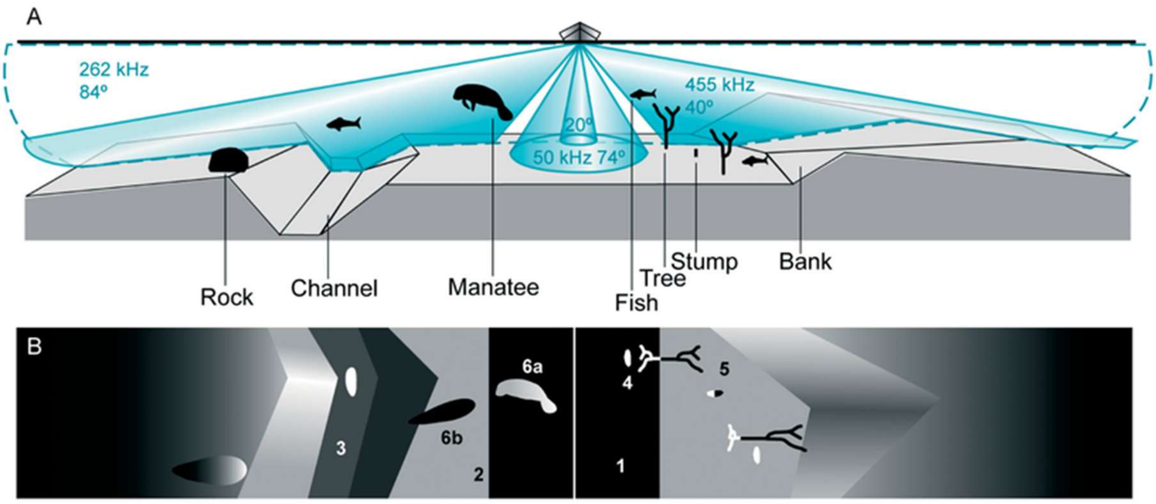


Figure 4.1: Schematic of side-scan survey functionality. Channels (3) appear as low intensity (dark) features because of the reduced acoustic reflection as the beam passes over the top of the side of the channel closest to the tow fish. The side of a channel farthest from the tow fish can provide a strong reflection.

The SSS survey data of 2019 and 2020 are presented in both Figure 4.2 and Figure 4.3. Apparent in both datasets are extensive shore parallel features – characterised by the large contrasts in colour, but most readily observed as a shadow zone. The prominent shadow zones of the 2020 survey data have beeen digitized, and overlain on both datasets in Figure 4.3. The location of the prominent shadow zones in 2020 colocate well with shadow zones in the 2019 survey data; i.e. they are consist with each other. Given this is the area of operation for the dredge vessel, the extent, continuity, depth and lienarity of the seabed features; and that these features do not fit the description of known sandy seafloor bedforms; it is extremely likey these features are dredge trenches. The colocation and prolonged existence of these features across two separate surveys conducted approximately 18 months apart indicates that they are either persistent, repeatedly dredged and/or were coincidently dredged in a similar pattern prior to this survey.

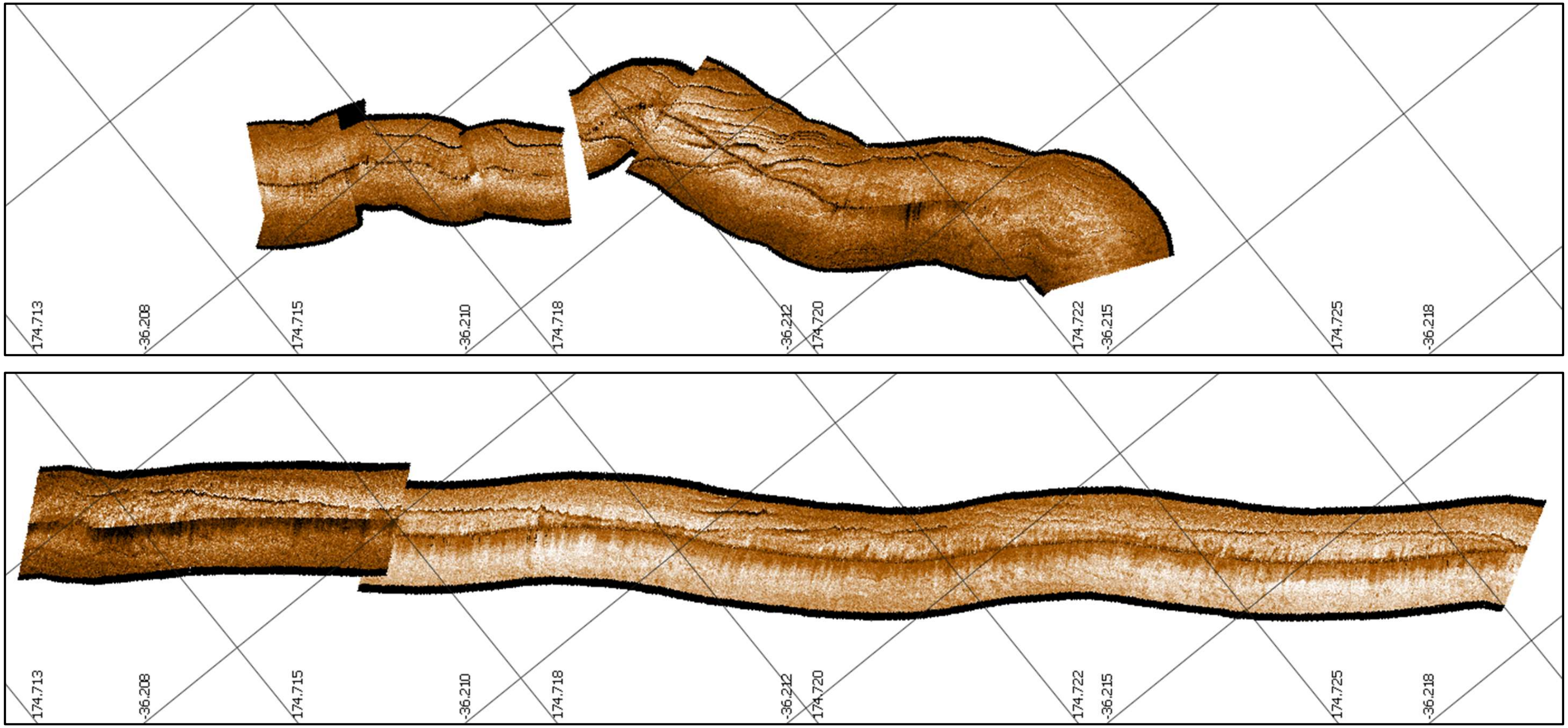


Figure 4.2: SSS survey data for 2019 (top) and 2020 (bottom).

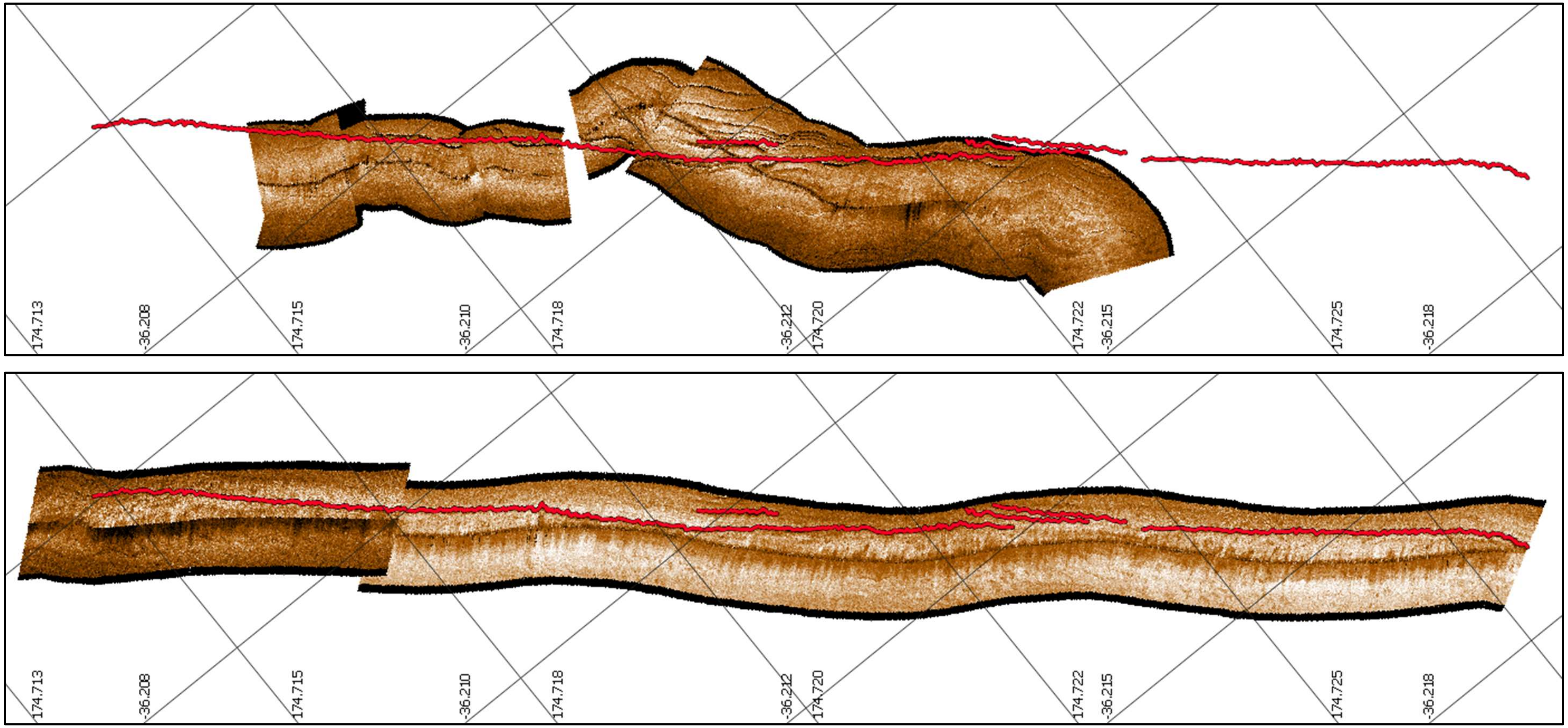


Figure 4.3: SSS survey data for 2019 (top) and 2020 (bottom) annotated with the prominent shadow zone observed in the 2020 dataset.

4.1 Transect Lines 17-33

In order to determine the extent of the dredge trenches, the SBES data, sidescan sonar data from 2020, and the digitised features are plotted together. Transect lines 17 through 33 colocate with the digitised features; the plots are presented in Figure 4.4 and Figure 4.5. Abrupt changes in SBES depth are apparent in almost every transect. The abrupt changes occur proximal to where the transect intersects the digisitized shadow zone. These trenches range in depth from ~0.3 m to >1.5 m. Note that there is a small offset with the transect position and the trenches in some transects because the SBES was undertaken with very accurate RTK-GPS, while the SSS applied uncorrected GPS data, which typically has an accuracy of 3-5 m.

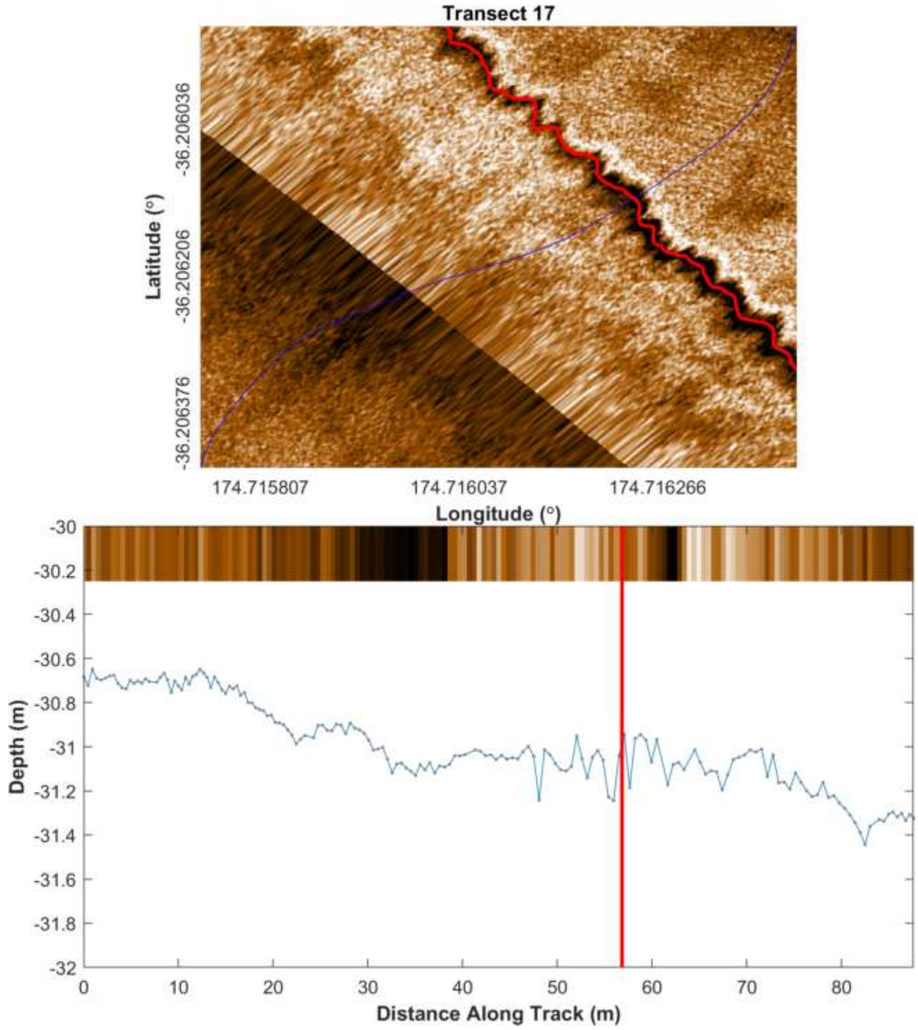
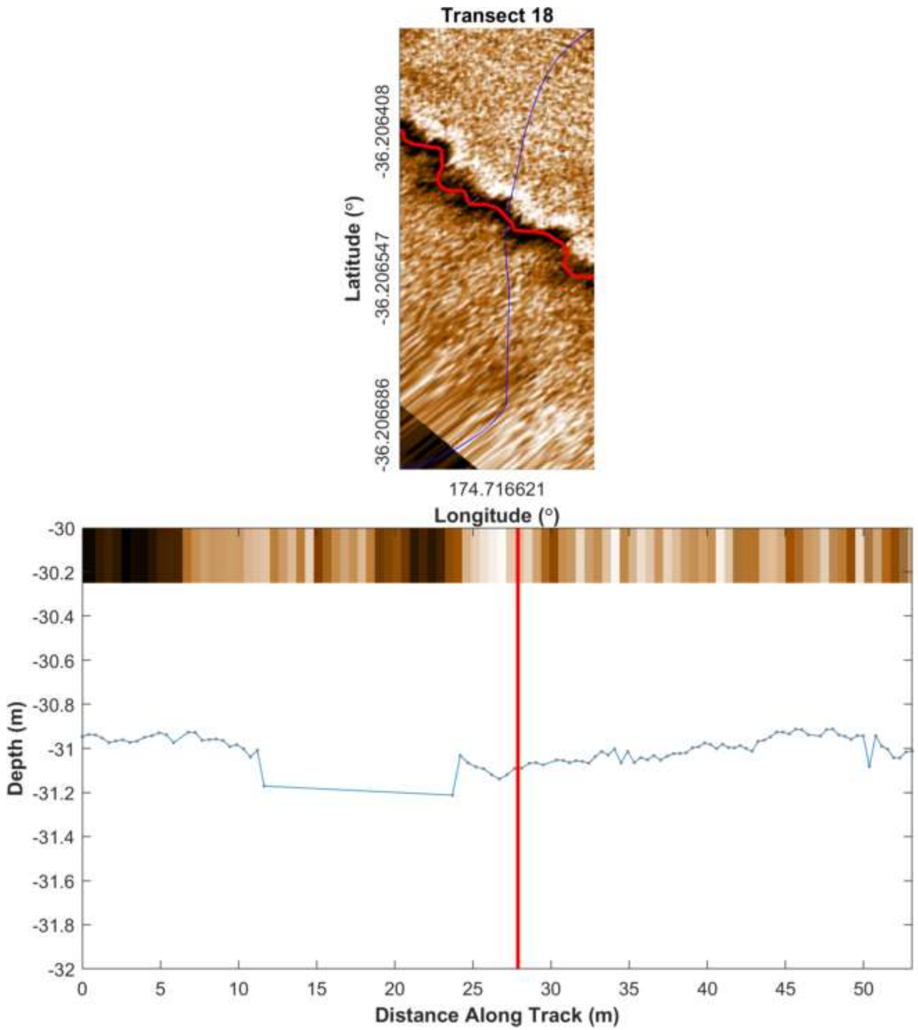
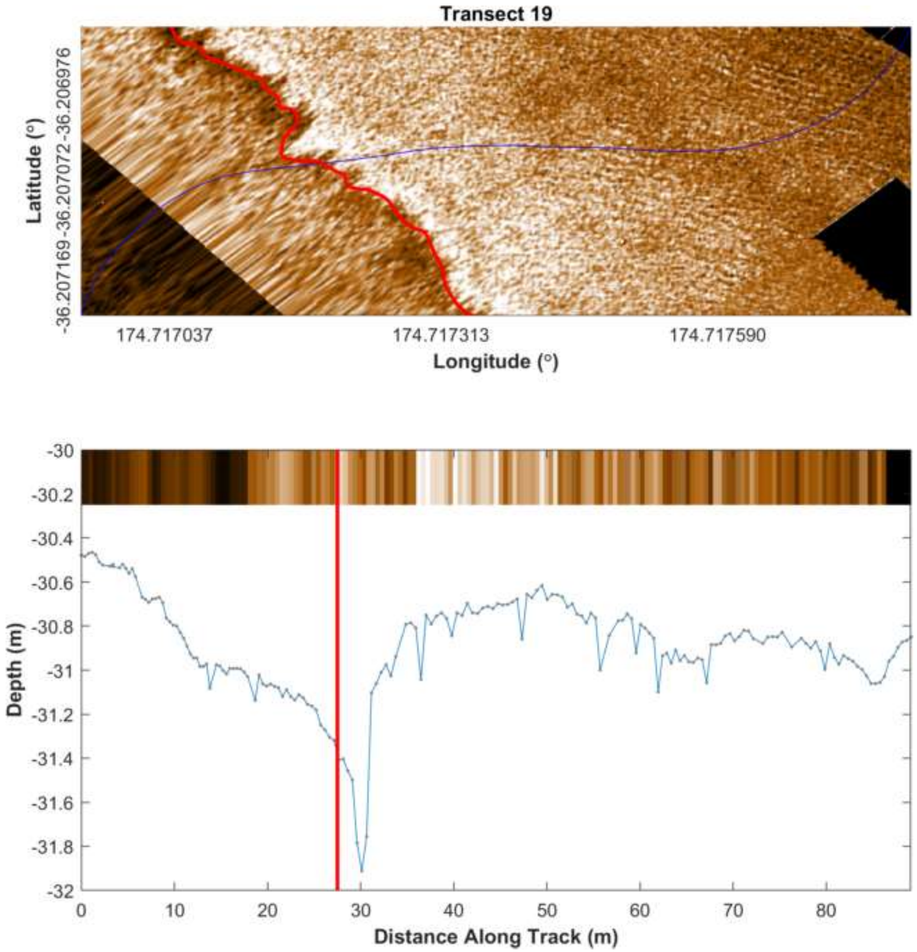
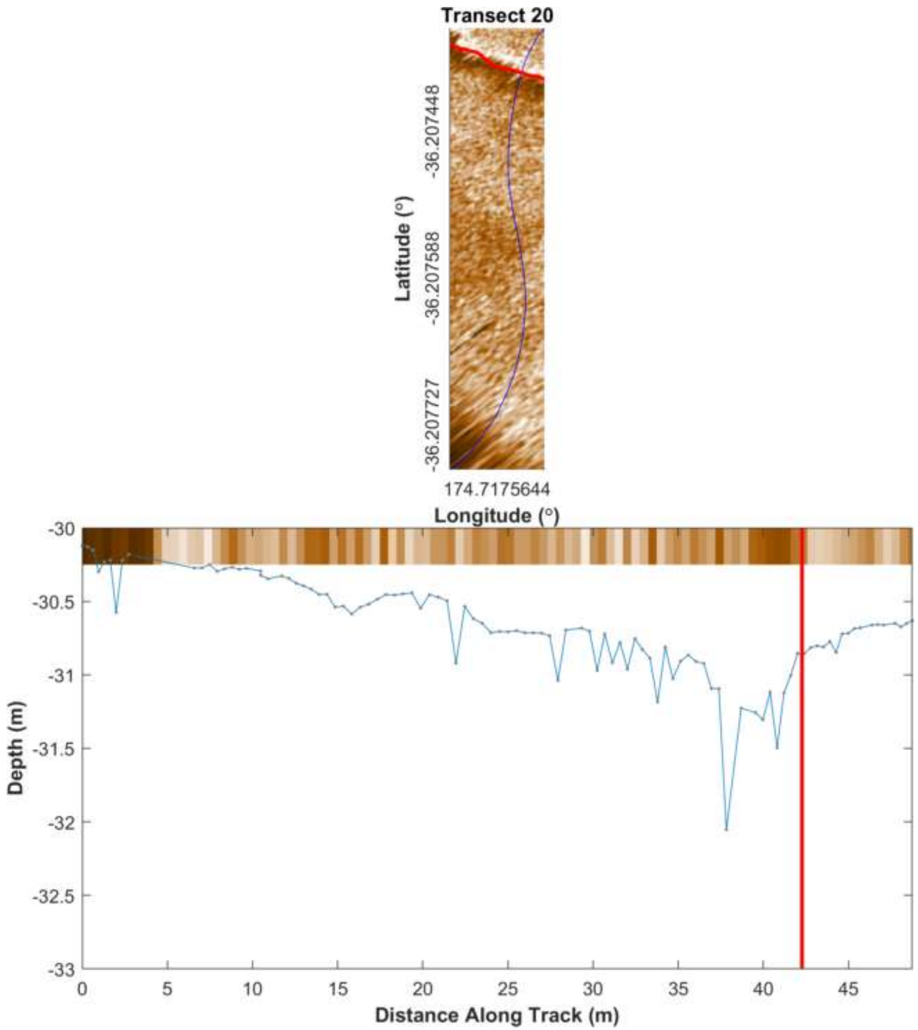
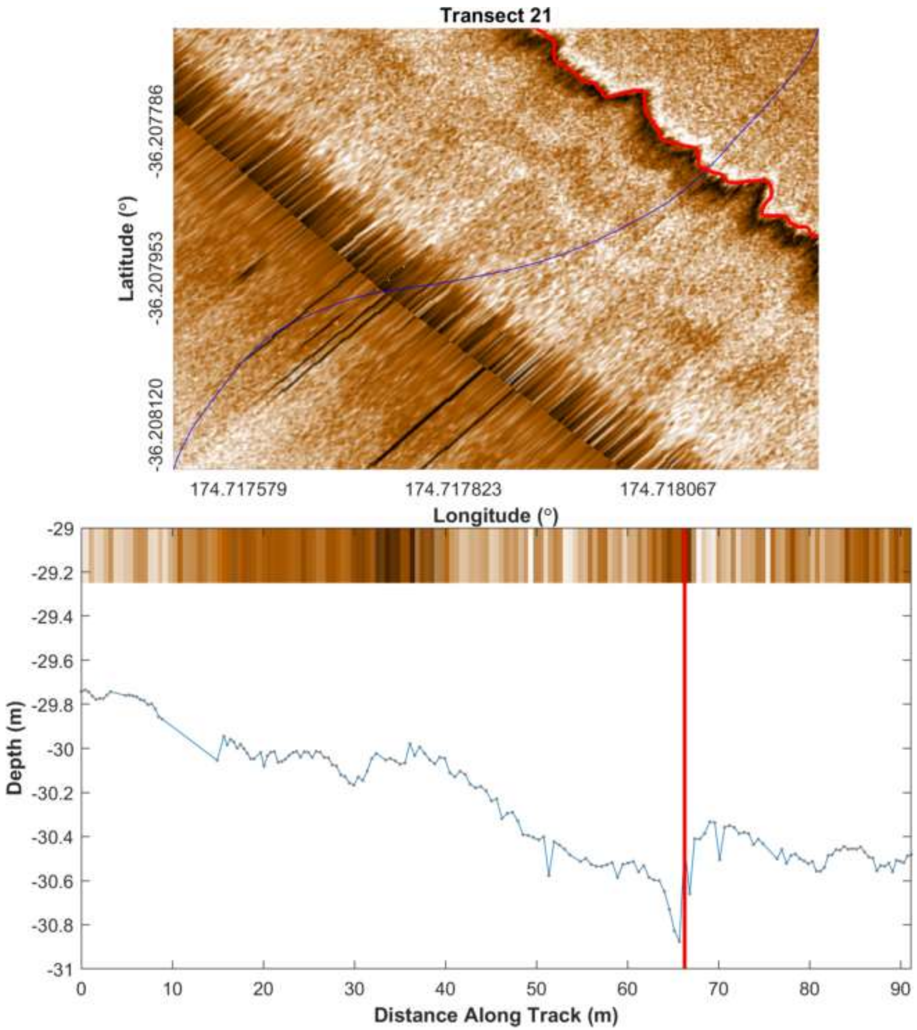


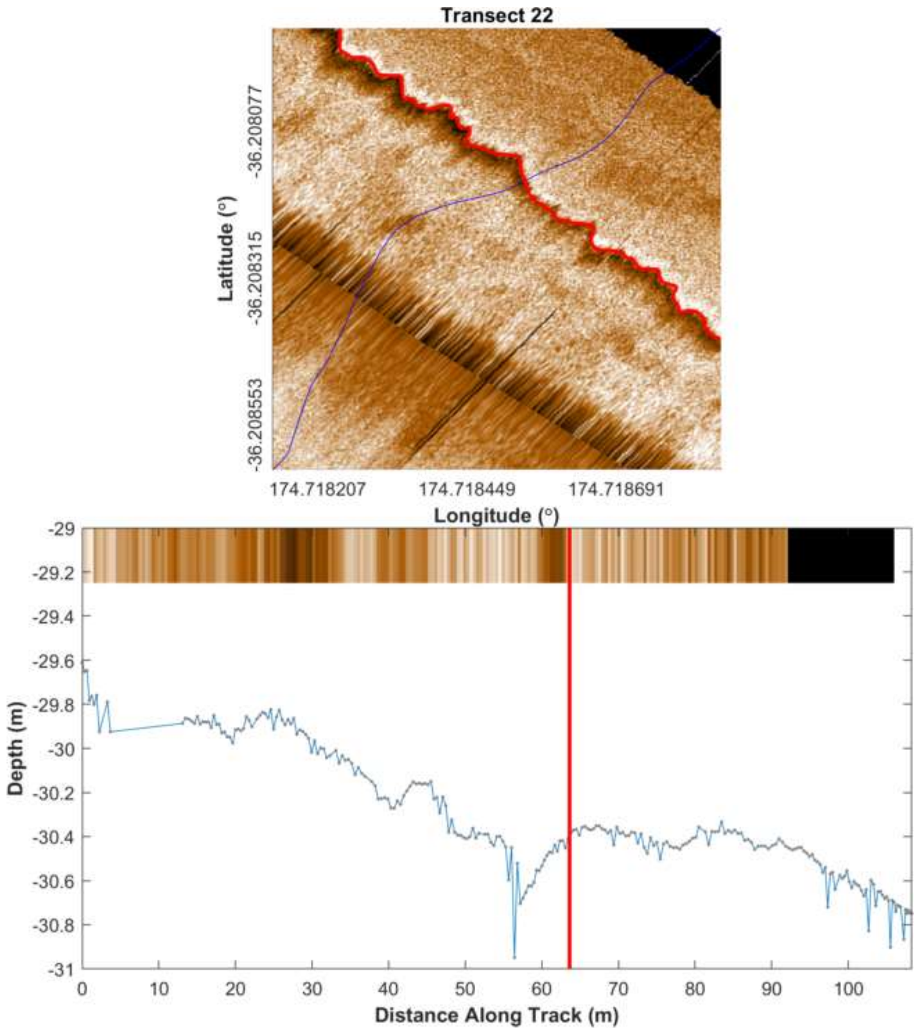
Figure 4.4: Composite plots of SSS (top panel) and along track SBES depth data and pixel intensity (bottom panel), with digitised shadow zone (red line) and transect ship track (blue), for Transect 17.

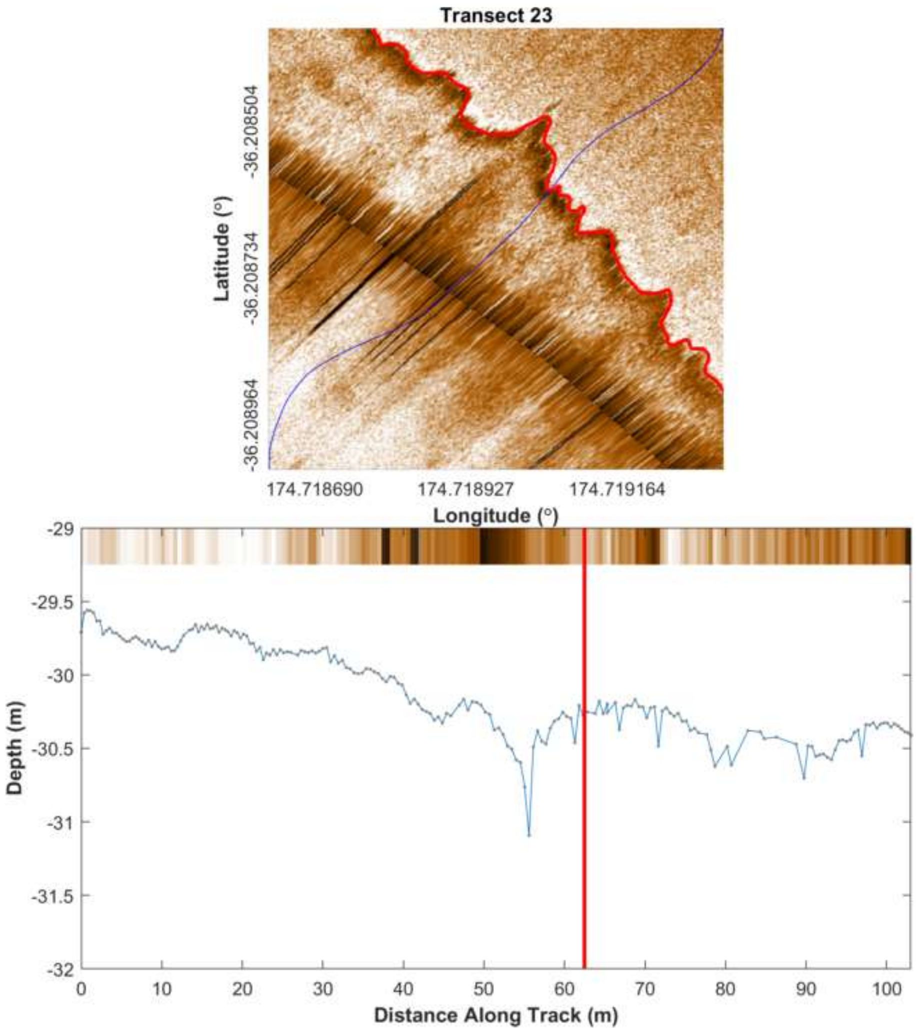

Transect 18
Latitude (°)
-36.206408
-36.206547
-36.206686
174.716621
Longitude (°)
Depth (m)
Distance Along Track (m)

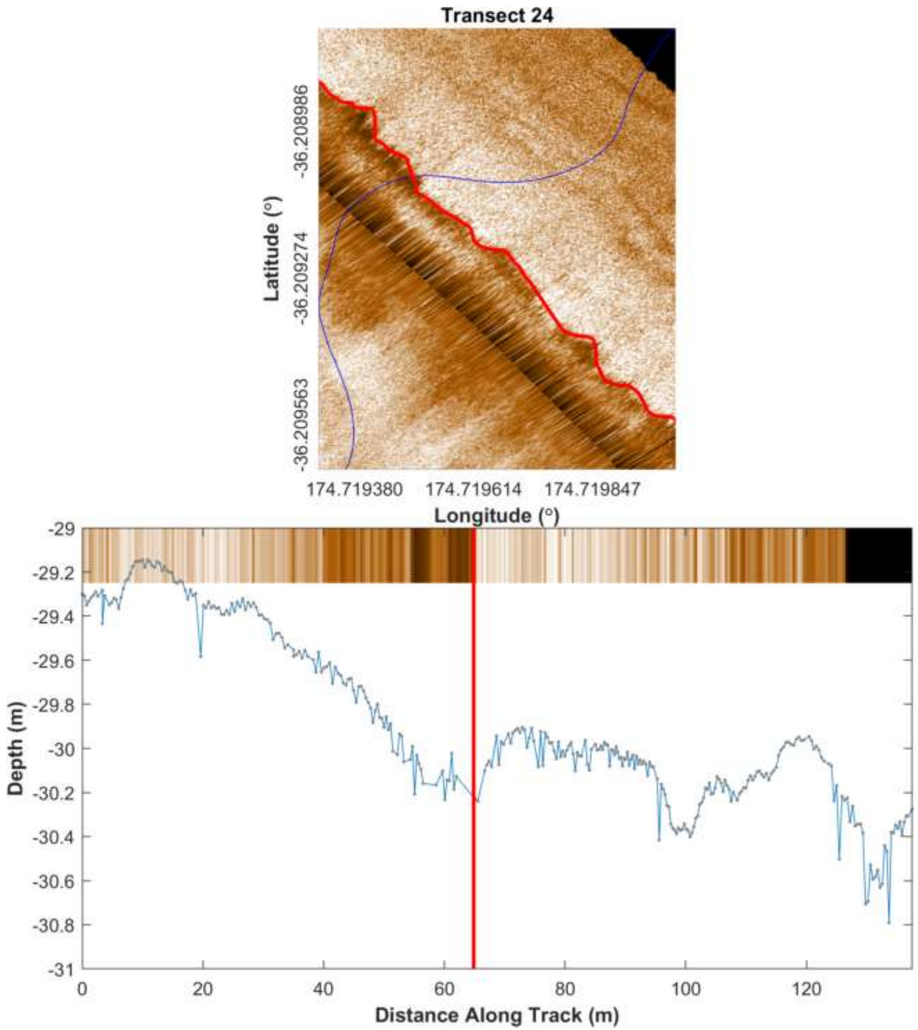

Transect 19
Latitude (°)
-36.207169
-36.207072
-36.206976
174.717037
174.717313
174.717590
Longitude (°)
Depth (m)
Distance Along Track (m)

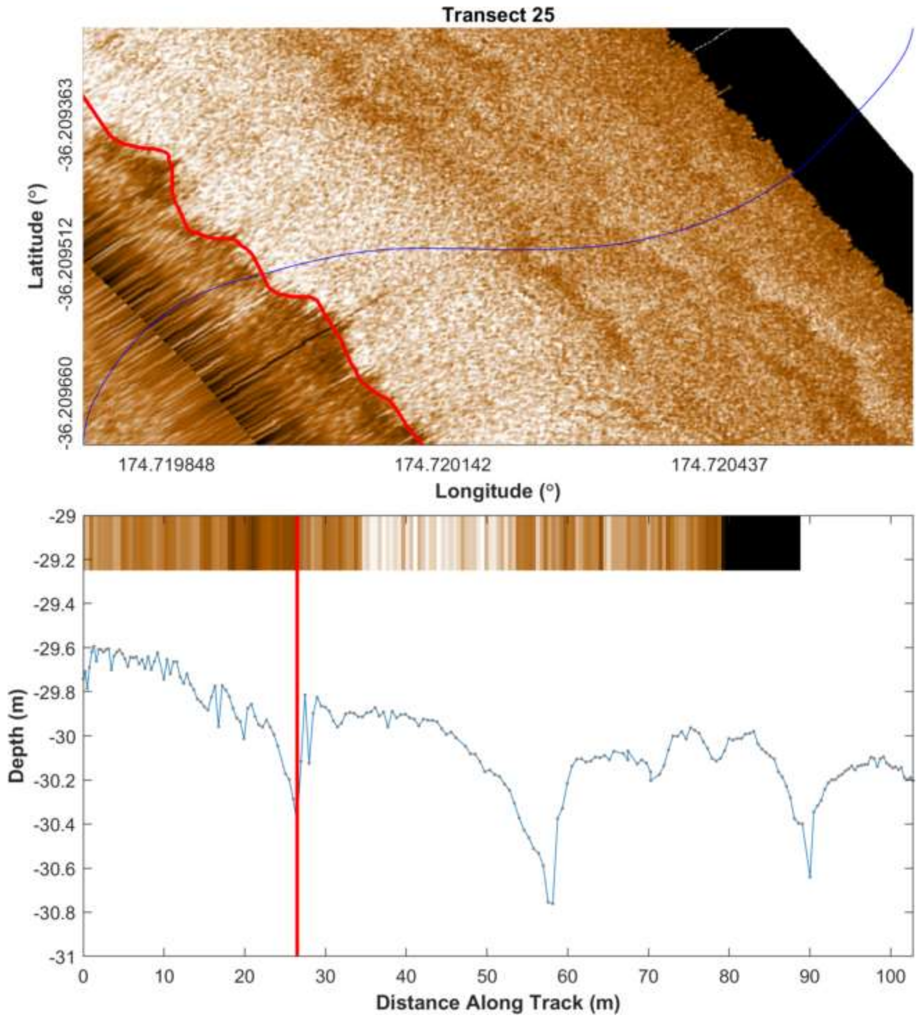

Transect 20
Latitude (°)
-36.207448
-36.207588
-36.207727
174.7175644
Longitude (°)
Depth (m)
Distance Along Track (m)

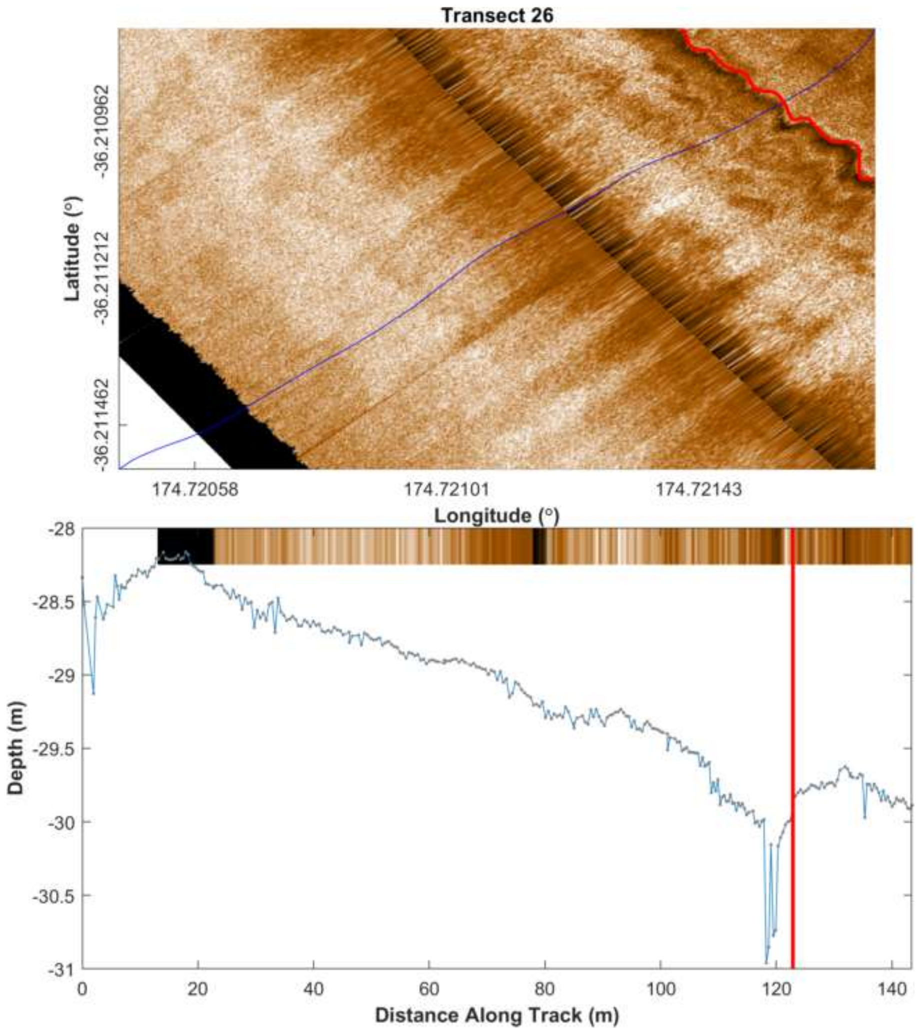

Transect 21
Latitude (°)
-36.207786
-36.207953
-36.208120
174.717579
174.717823
174.718067
Longitude (°)
Depth (m)
Distance Along Track (m)

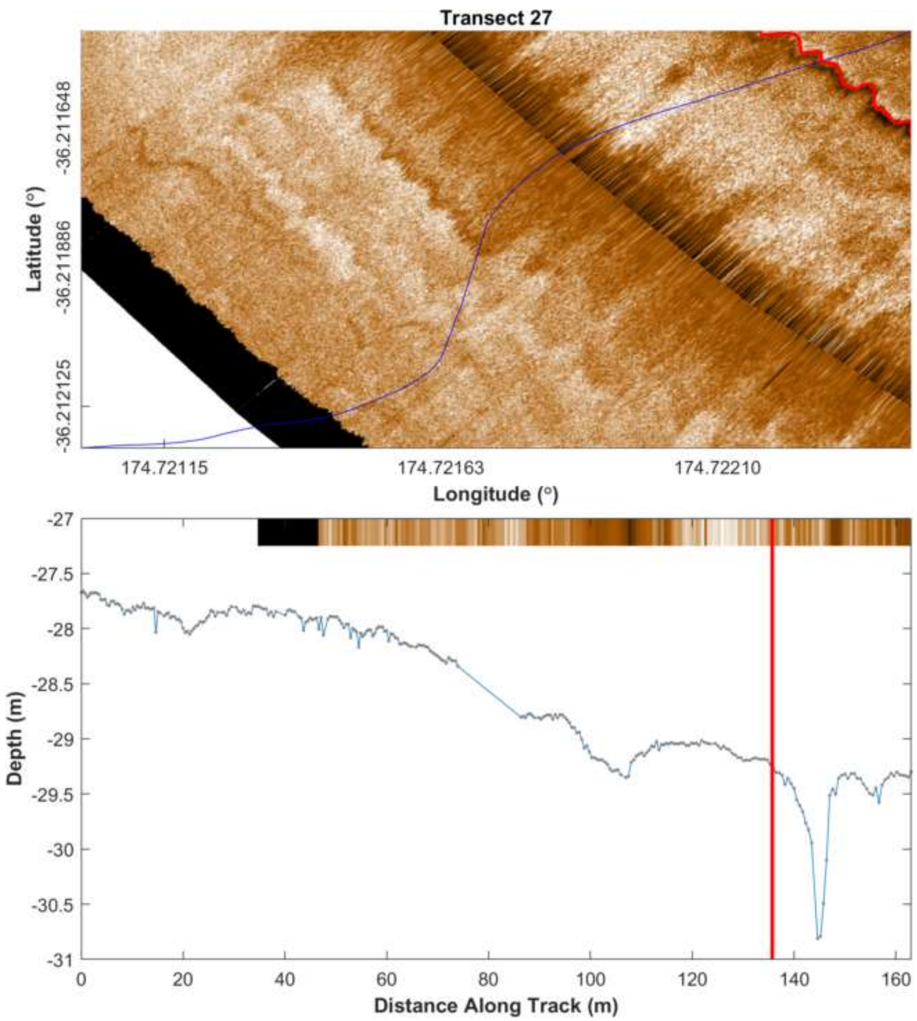

Transect 22
Latitude (°)
-36.208077
-36.208315
-36.208553
174.718207
174.718449
174.718691
Longitude (°)
Depth (m)
Distance Along Track (m)

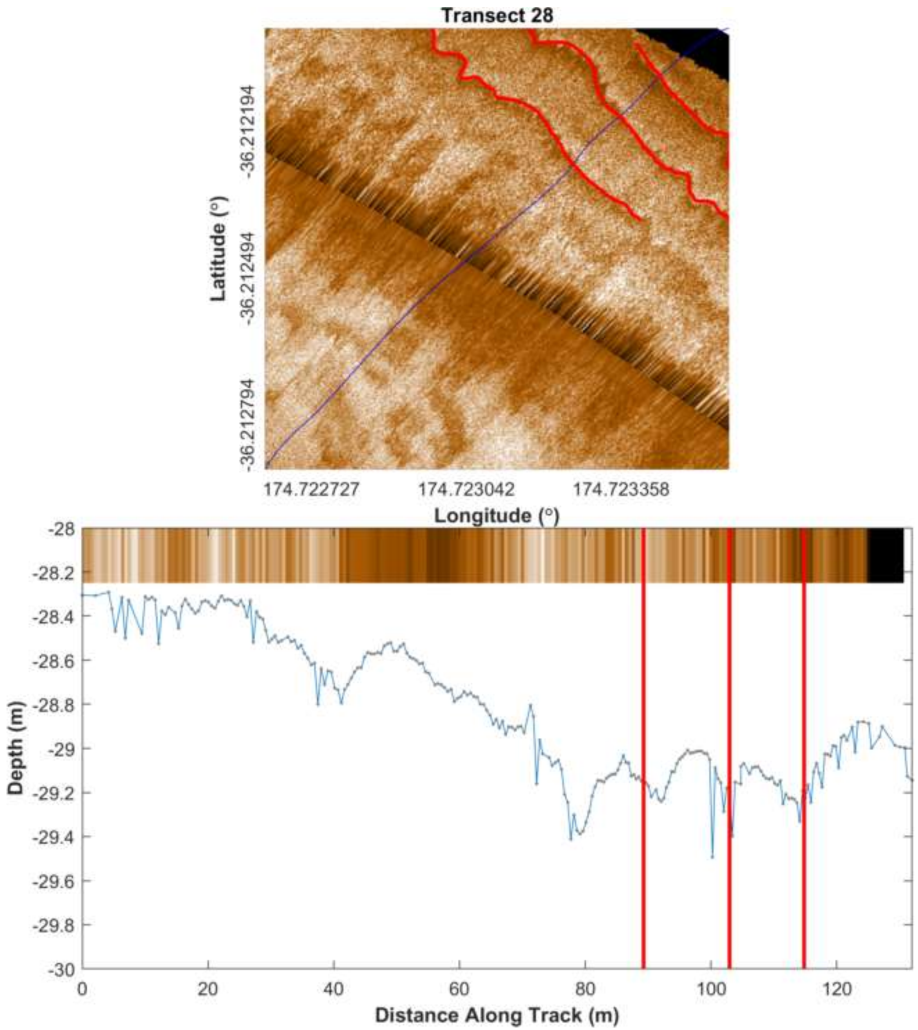

Transect 23
Latitude (°)
-36.208504
-36.208734
-36.208964
174.718690
174.718927
174.719164
Longitude (°)
Depth (m)
Distance Along Track (m)

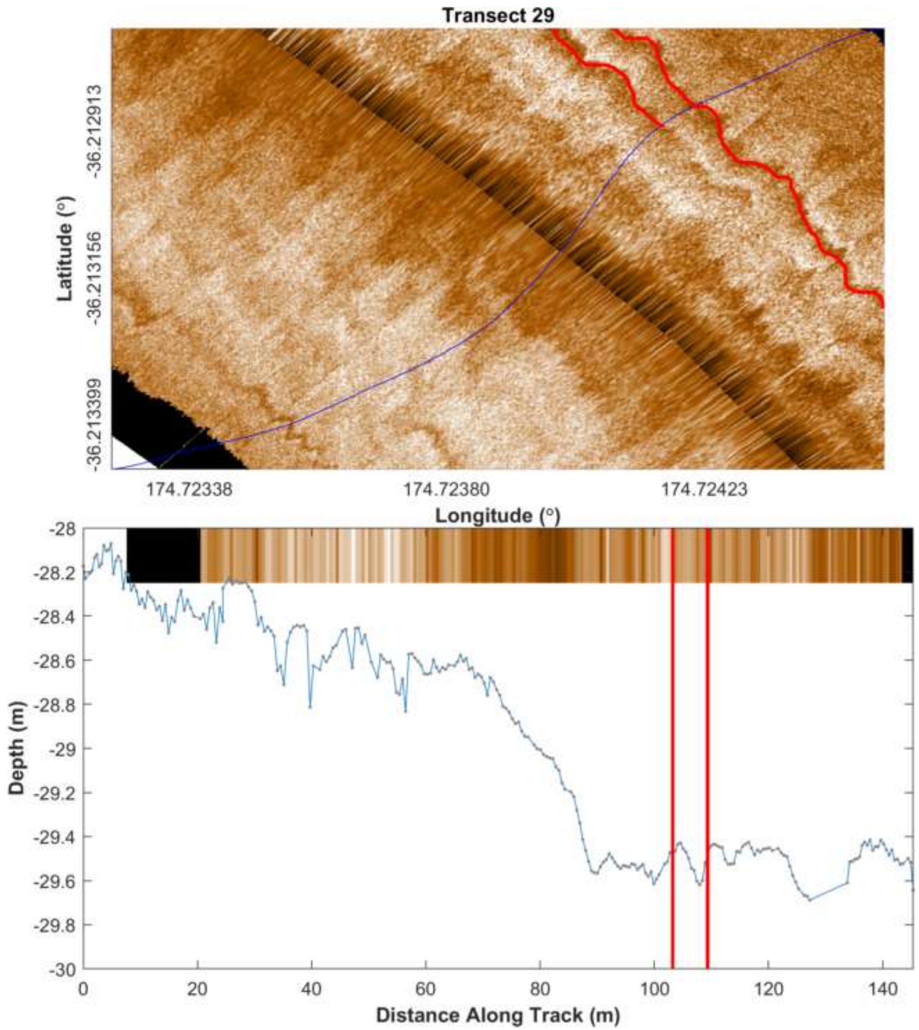

Transect 24
Latitude (°)
-36.208986
-36.209274
-36.209563
174.719380
174.719614
174.719847
Longitude (°)
Depth (m)
-29
-29.2
-29.4
-29.6
-29.8
-30
-30.2
-30.4
-30.6
-30.8
-31
0
20
40
60
80
100
120
Distance Along Track (m)

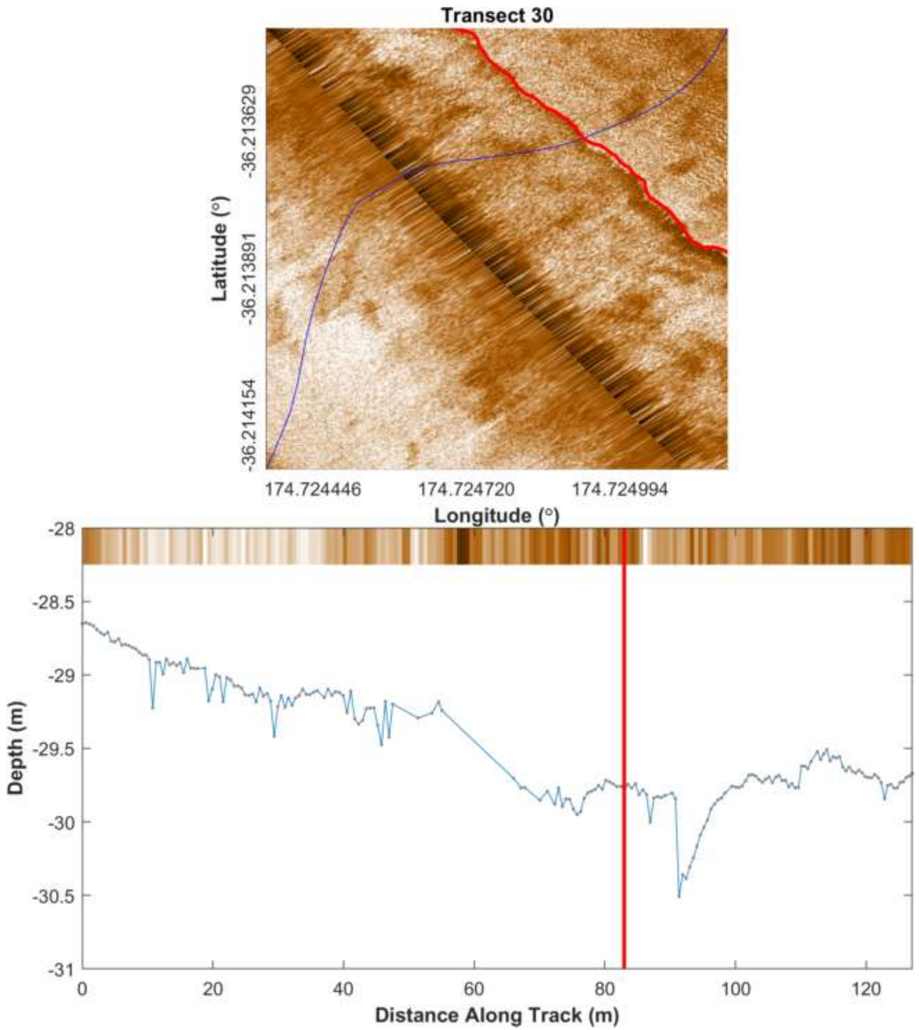

Transect 25
Latitude (°)
-36.209363
-36.209512
-36.209660
174.719848
174.720142
174.720437
Longitude (°)
Depth (m)
-29
-29.2
-29.4
-29.6
-29.8
-30
-30.2
-30.4
-30.6
-30.8
-31
0
10
20
30
40
50
60
70
80
90
100
Distance Along Track (m)

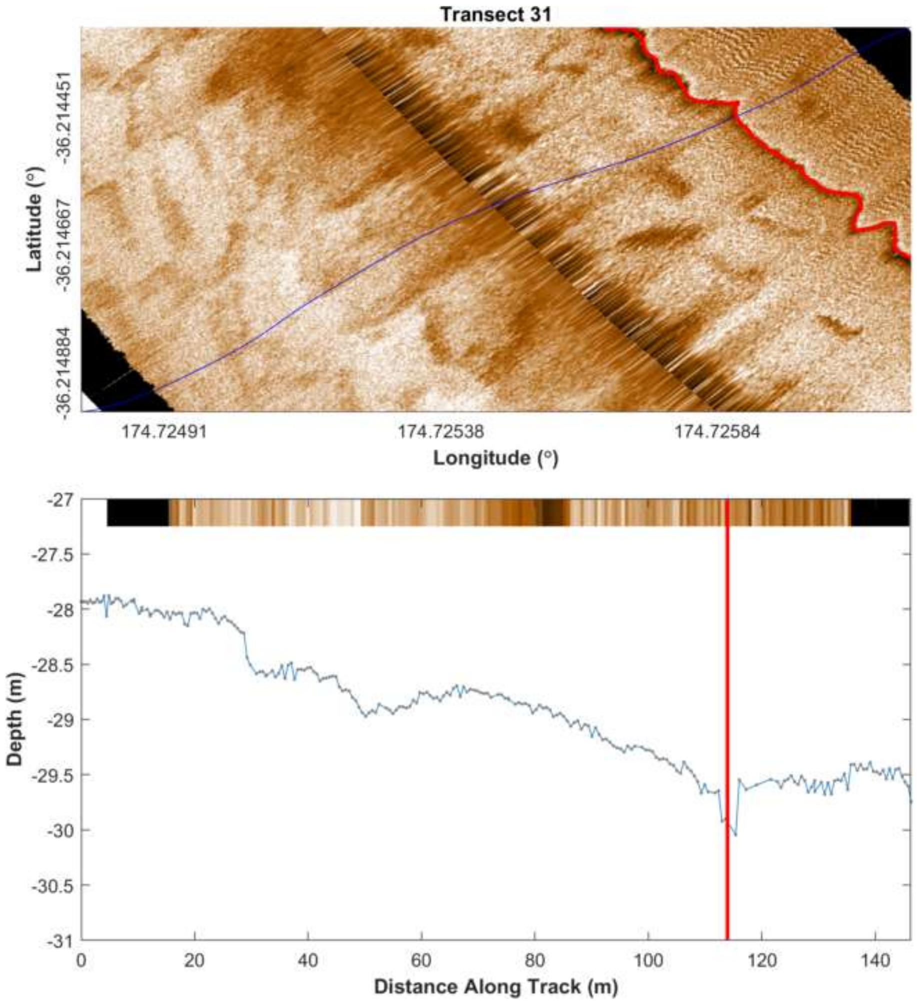

Transect 26
Latitude (°)
-36.210962
-36.211212
-36.211462
174.72058
174.72101
174.72143
Longitude (°)
Depth (m)
-28
-28.5
-29
-29.5
-30
-30.5
-31
0
20
40
60
80
100
120
140
Distance Along Track (m)


Transect 27
Latitude (°)
-36.211648
-36.211886
-36.212125
174.72115
174.72163
174.72210
Longitude (°)
Depth (m)
-27
-27.5
-28
-28.5
-29
-29.5
-30
-30.5
-31
0
20
40
60
80
100
120
140
160
Distance Along Track (m)


Transect 28
Latitude (°)
-36.212194
-36.212494
-36.212794
174.722727
174.723042
174.723358
Longitude (°)
Depth (m)
Distance Along Track (m)


Transect 29
Latitude (°)
-36.212913
-36.213156
-36.213399
174.72338
174.72380
174.72423
Longitude (°)
Depth (m)
Distance Along Track (m)


Transect 30
Latitude (°)
-36.213629
-36.213891
-36.214154
174.724446
174.724720
174.724994
Longitude (°)
Depth (m)
-28
-28.5
-29
-29.5
-30
-30.5
-31
0
20
40
60
80
100
120
Distance Along Track (m)


Transect 31
Latitude (°)
-36.214451
-36.214667
-36.214884
174.72491
174.72538
174.72584
Longitude (°)
Depth (m)
-27
-27.5
-28
-28.5
-29
-29.5
-30
-30.5
-31
0
20
40
60
80
100
120
140
Distance Along Track (m)

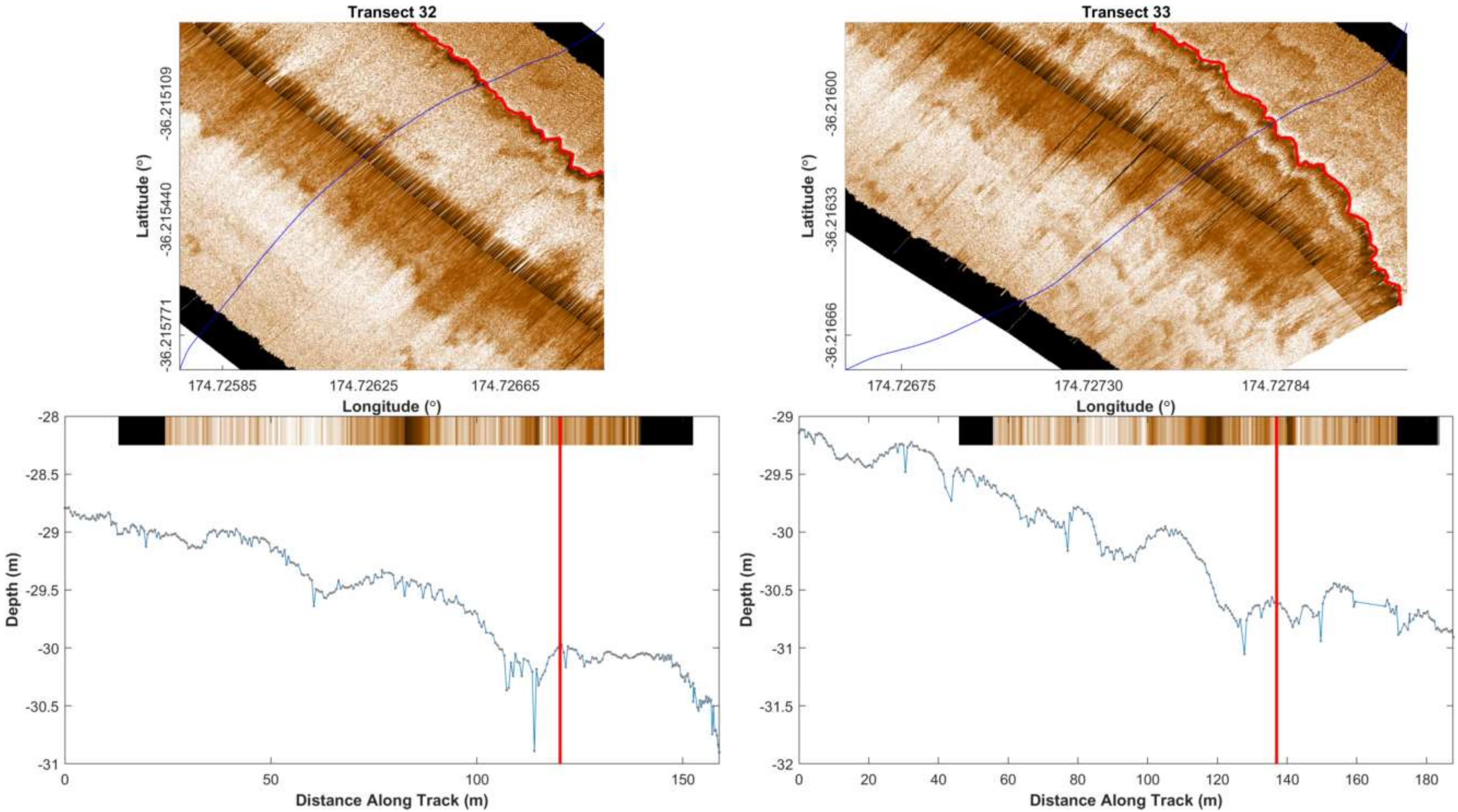


Figure 4.5: Composite plots of SSS (top panel) and along track SBES depth data and pixel intensity (bottom panel), with digitised shadow zone (red line) and transect ship track (blue), for Transect 18 through 33.

4.2 Transect Lines 1-13

Cross-shore transects (1 through 13) were undertaken, along with SSS, further offshore, in an area of the more recent dredge vessel activity. Figure 4.6 provides "screenshots" taken by SeaROV technologies during this part of the survey. The screen shots show very distinct seabed features, interpeted as dredge trenches.

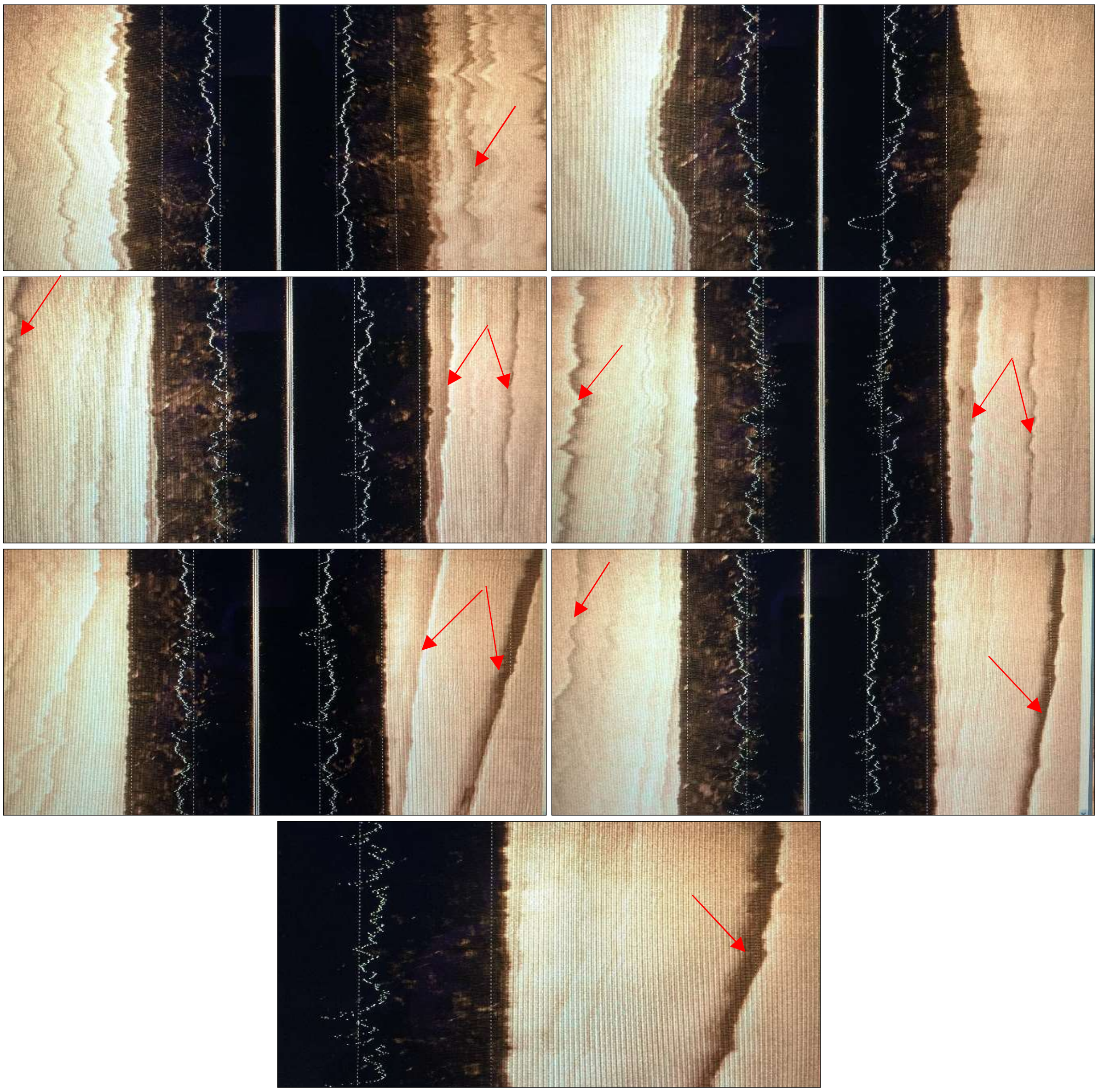


Figure 4.6: Screenshots of SSS software display taken by SeaROV Technologies during the survey of the offshore area. The dredge trenches are evident from the pronounced shadow zones (examples are indicated by red arrows). The top right image is a cross shore segment that shows the cross-sectional profile of a trench.

Figure 4.7 through Figure 4.19 present the SBES depth data for Transects 1 through 13. In each of these transects there are similar abrupt changes in seabed depth that are observed in all transect presented in Figure 4.7. Eight out of the thirteen transects indicate trench depth estimates that are greater than 1.5 m. The deepest trench depth estimate is 2.75 m. It is ~2.6 km alongshore from Transect 1 to Transect 13.

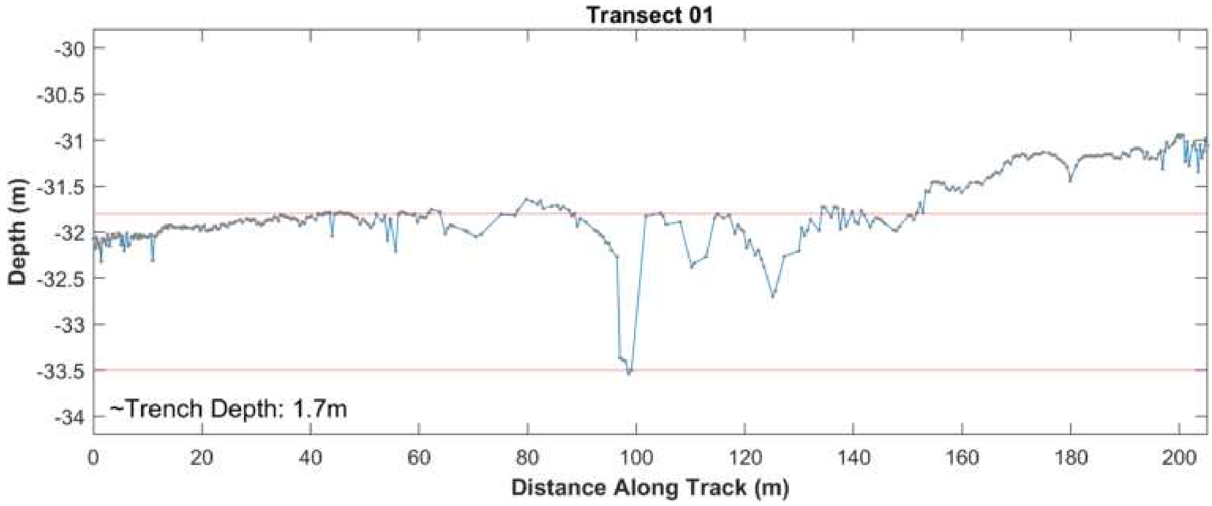


Figure 4.7: Cross-shore SBES depth data from Transect 01 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

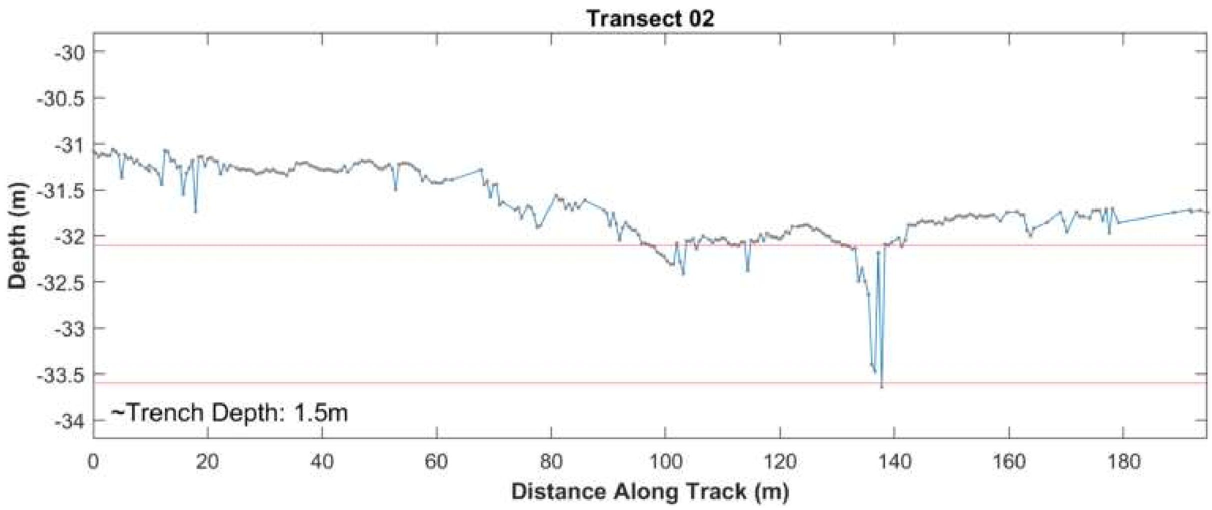


Figure 4.8: Cross-shore SBES depth data from Transect 02 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

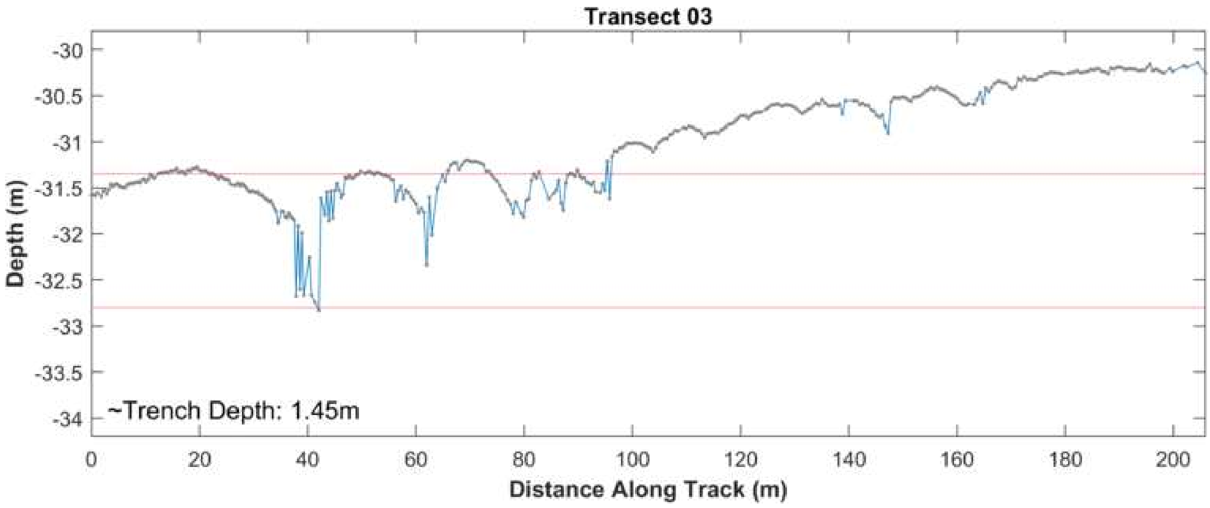


Figure 4.9: Cross-shore SBES depth data from Transect 03 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

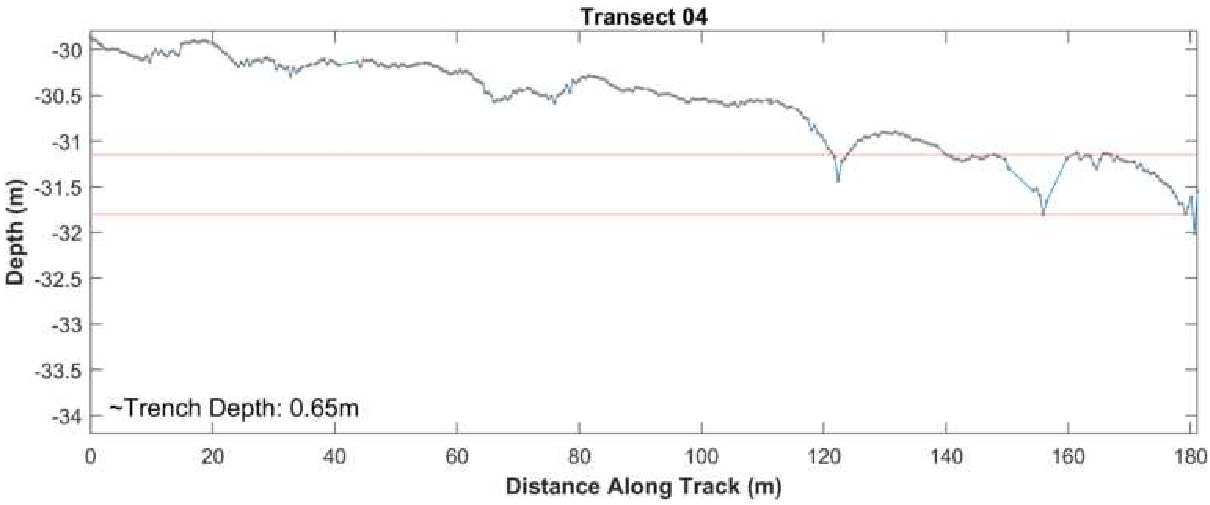


Figure 4.10: Cross-shore SBES depth data from Transect 04 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

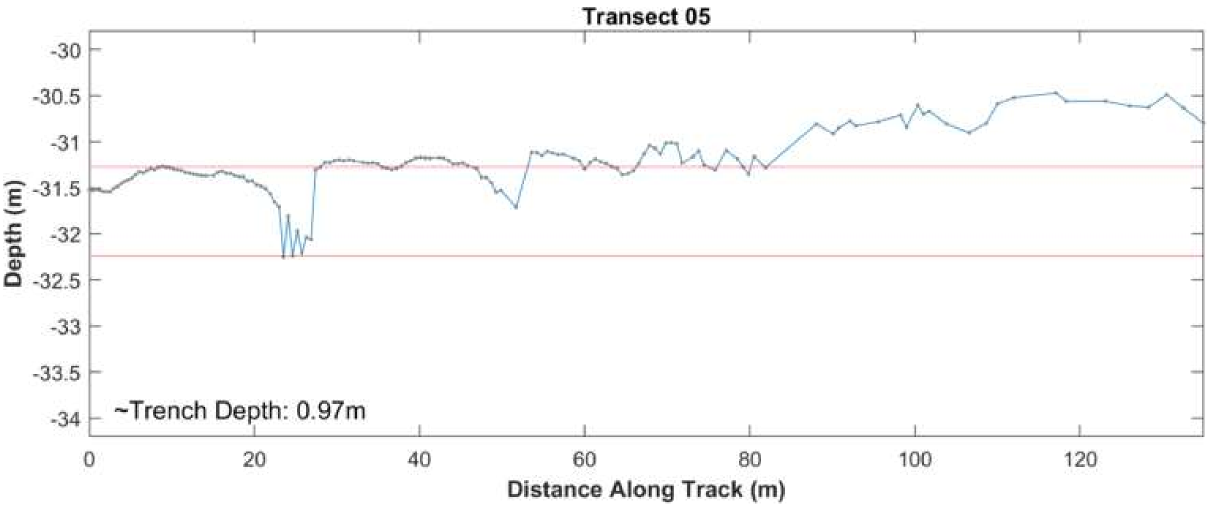


Figure 4.11: Cross-shore SBES depth data from Transect 05 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

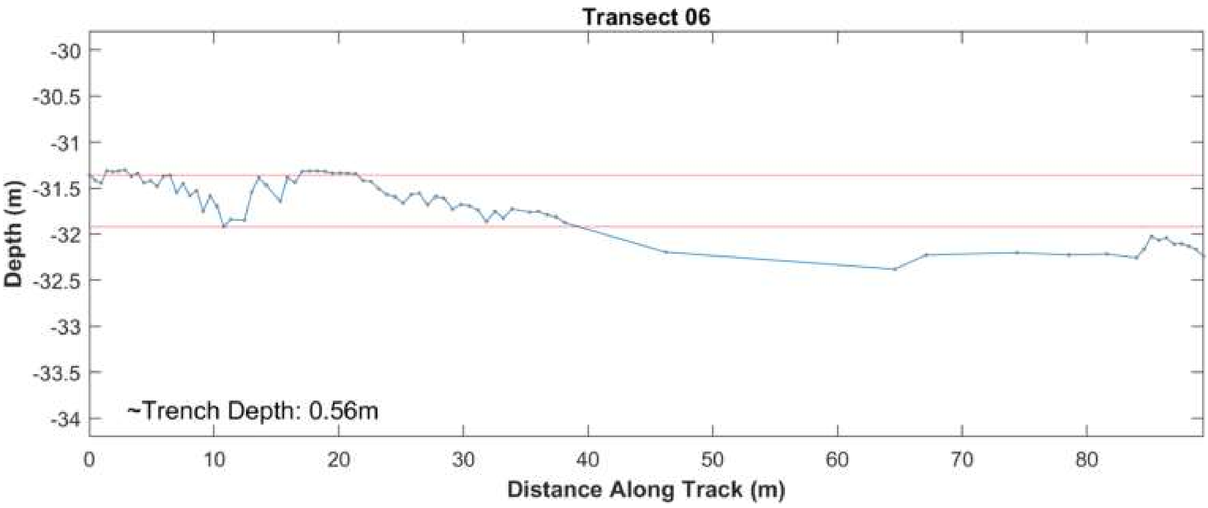


Figure 4.12: Cross-shore SBES depth data from Transect 06 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

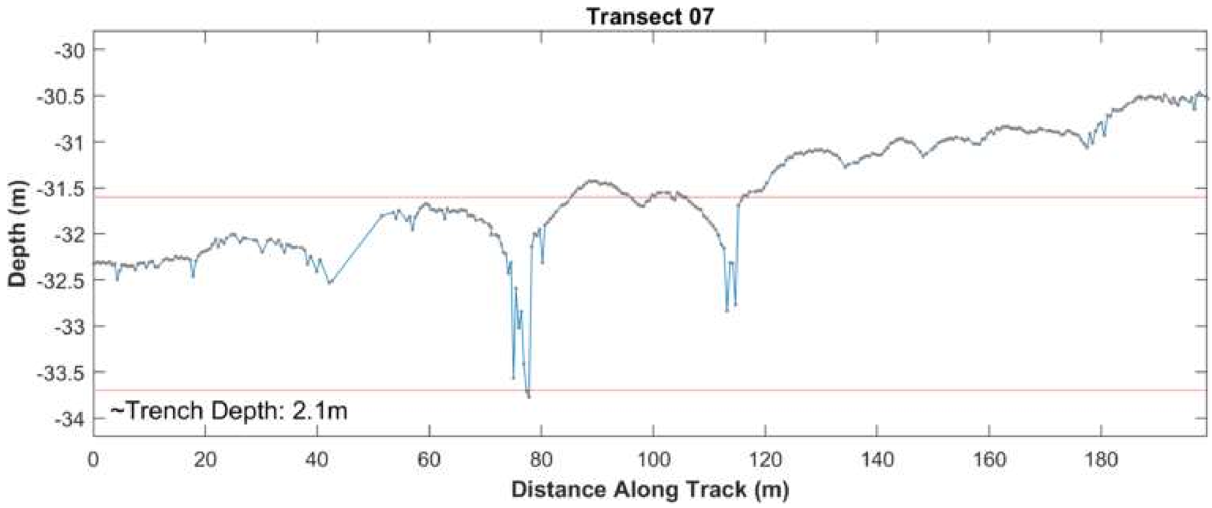


Figure 4.13: Cross-shore SBES depth data from Transect 07 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

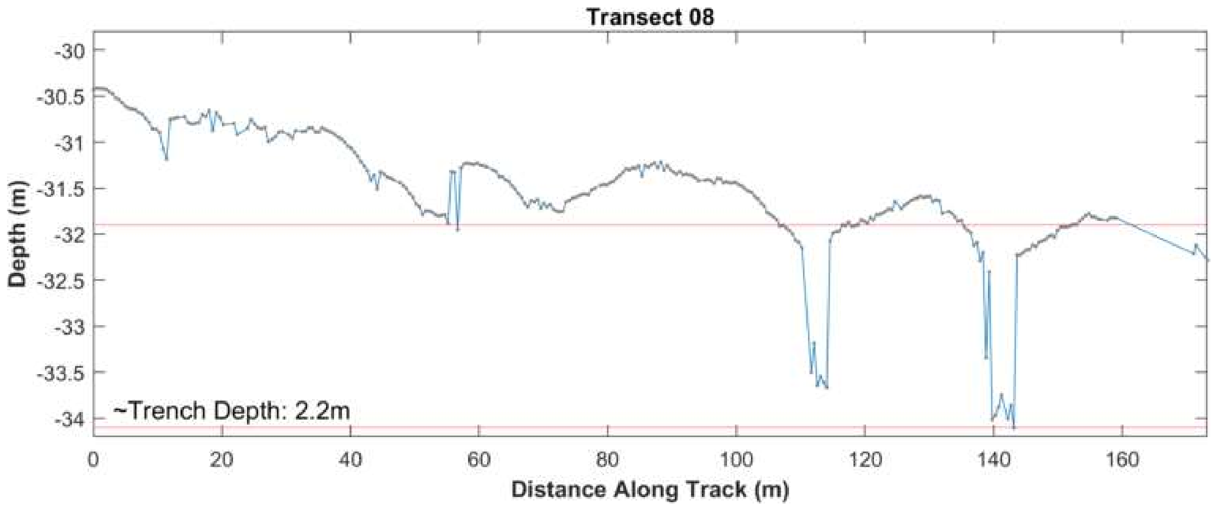


Figure 4.14: Cross-shore SBES depth data from Transect 08 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

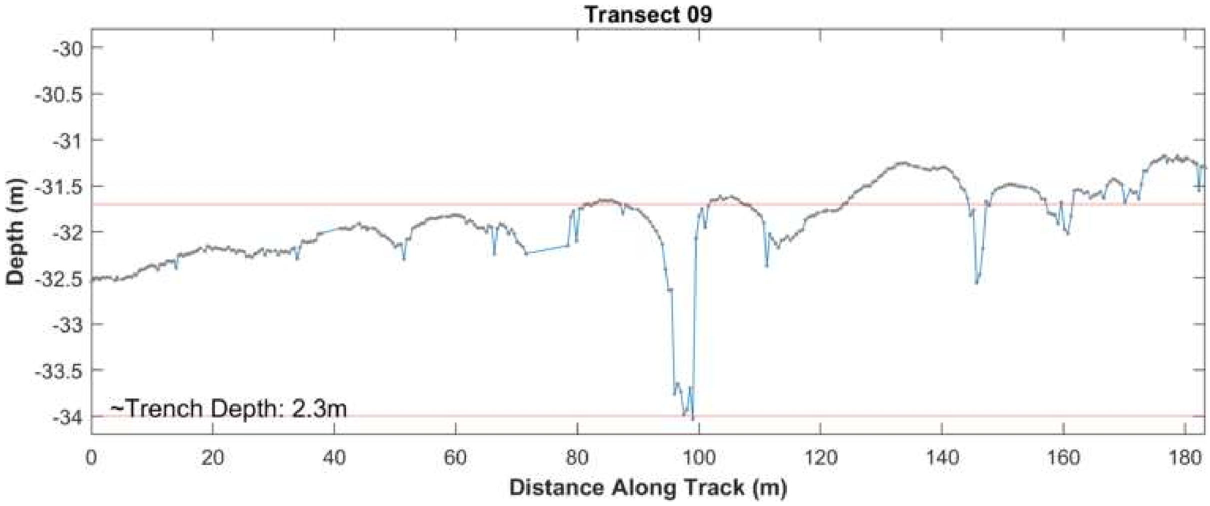


Figure 4.15: Cross-shore SBES depth data from Transect 09 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

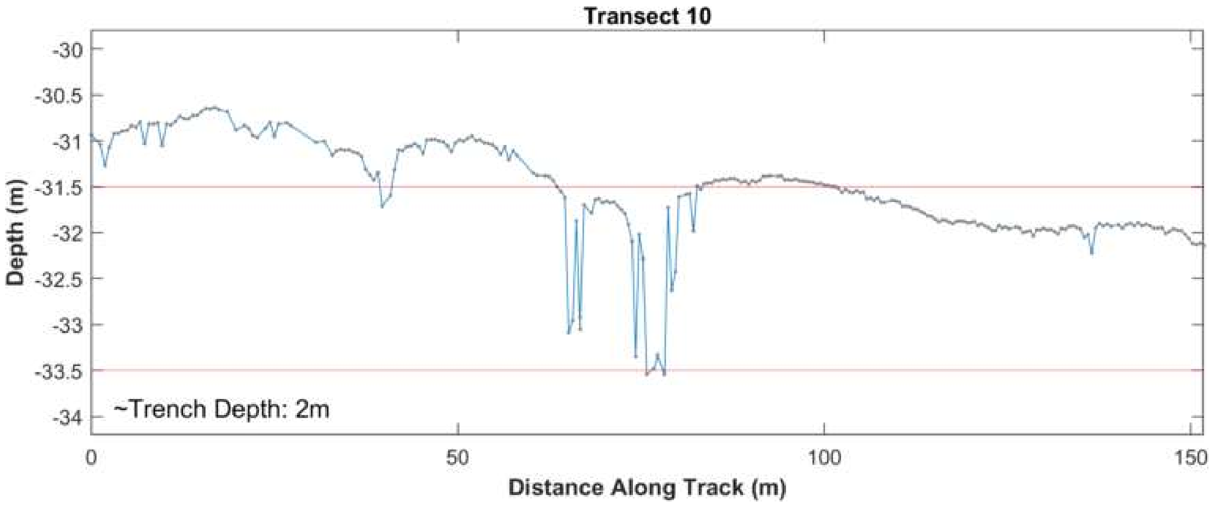


Figure 4.16: Cross-shore SBES depth data from Transect 10 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

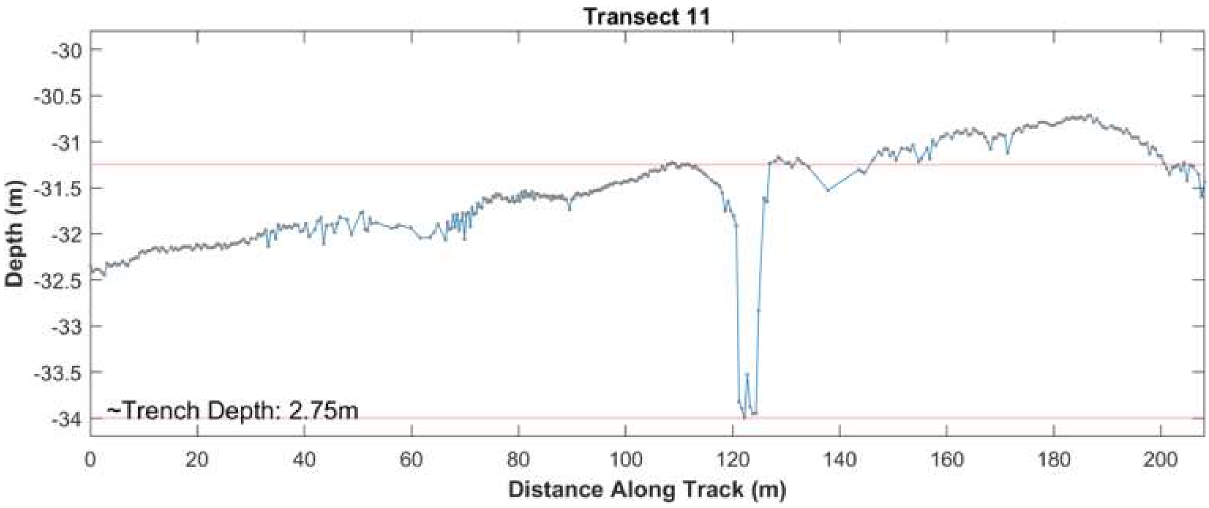


Figure 4.17: Cross-shore SBES depth data from Transect 11 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

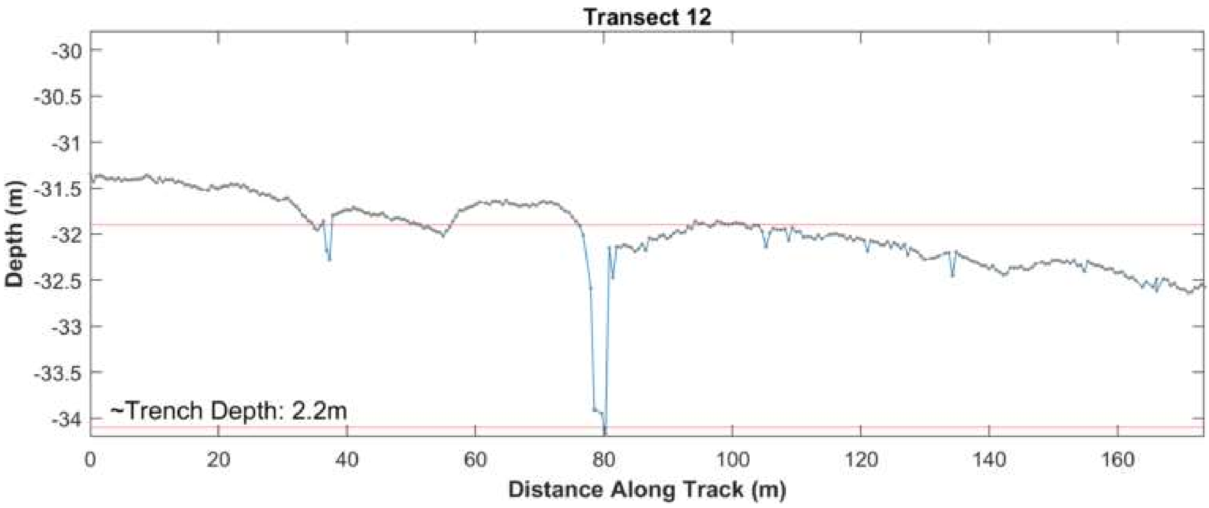


Figure 4.18: Cross-shore SBES depth data from Transect 12 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

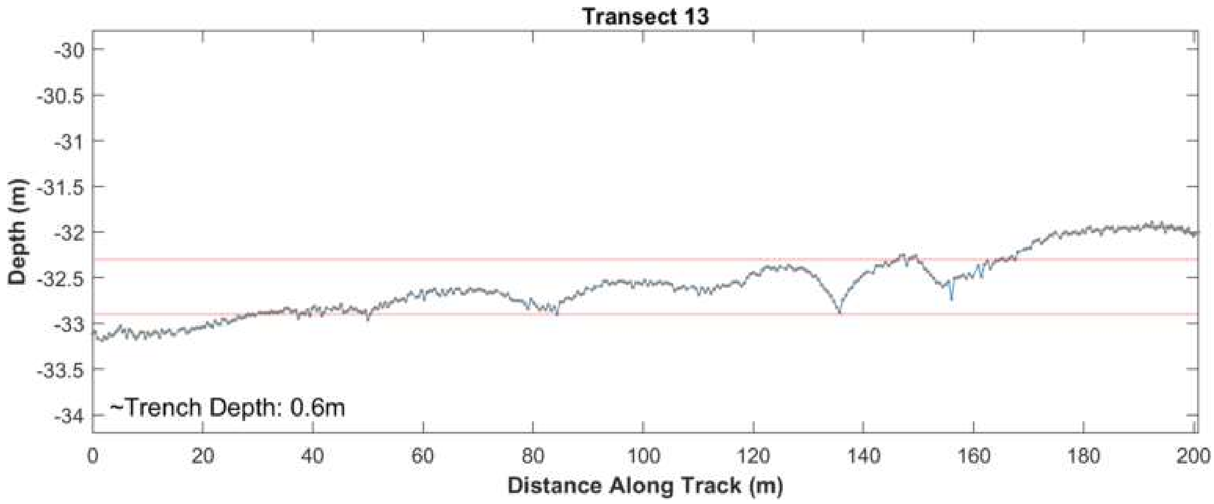


Figure 4.19: Cross-shore SBES depth data from Transect 13 in the offshore survey area. Depths are along track, and relative to Auckland Vertical Datum (MSL).

5 Trench Infill Investigation (Jacobs, 2020a, 2020b)

According to Kaipara Limited's current application and evidence, sand has been and is proposed to continue to be extracted from the seafloor using a trailer suction dredge. The dredge drag head is trailed behind the vessel and along the seafloor. The nature of the drag head is such that it disturbs the surface sand to a depth of around 30 cm. Suction is created via a sand pump that is halfway up the suction pipe between the seafloor and the surface. Water entering the drag head takes sand with it to create a slurry which is pumped through two flume pipes that have wire screens positioned on the bottom half of the flume pipe. The sand and water slurry passes over these screens with a portion passing through the screens into the hopper on board the vessel. Oversized material continues along the flume pipe and is ejected from the end of the flume pipe over the side of the vessel (Beca, 2019).

Table 5-1 provides the characteristics for MBL dredge vessels. When looking at the direct implications of the creation of trenches in the seabed on the seabed, Jacobs (2020a, 2020b[1]) report that the average trench for each pass of the existing Coastal Carrier is 150 mm deep by 1200 mm wide (top Figure 5.1). In contrast, the new vessel (William Fraser) will have an anticipated trench depth of 650 mm and width of 1600 mm. That is to say that the new vessel will create a trench at least 4 x times the existing trenches created.

Table 5-1 Dredging characteristics for MBL dredge vessels (Jacobs, 2020a, 2020b).

Vessel	Coastal Carrier	William Fraser (anticipated)
Width of extraction trench	Average 1.2 m	Average 1.6 m
Depth of extraction trench	Average 0.15 m	Average 0.65m
Extraction trench shape	Trapezoidal	Trapezoidal
Hopper volume capacity	460 m^3	900 m^3
Volume required to be extracted from seabed to fill hopper	1100 m^3	1350 m^3
Length of extraction track needed to fill hopper	6 km	13.1 km
Time to fill hopper	3 -4 hrs	4 – 5 hrs
Number of trips in 30 consecutive days for 15,000 m^3 limit	33 trips	17 trips

[1] These reports have been produced for MBL, although include offshore investigations of dredge tracks and diabathic sediment transport.

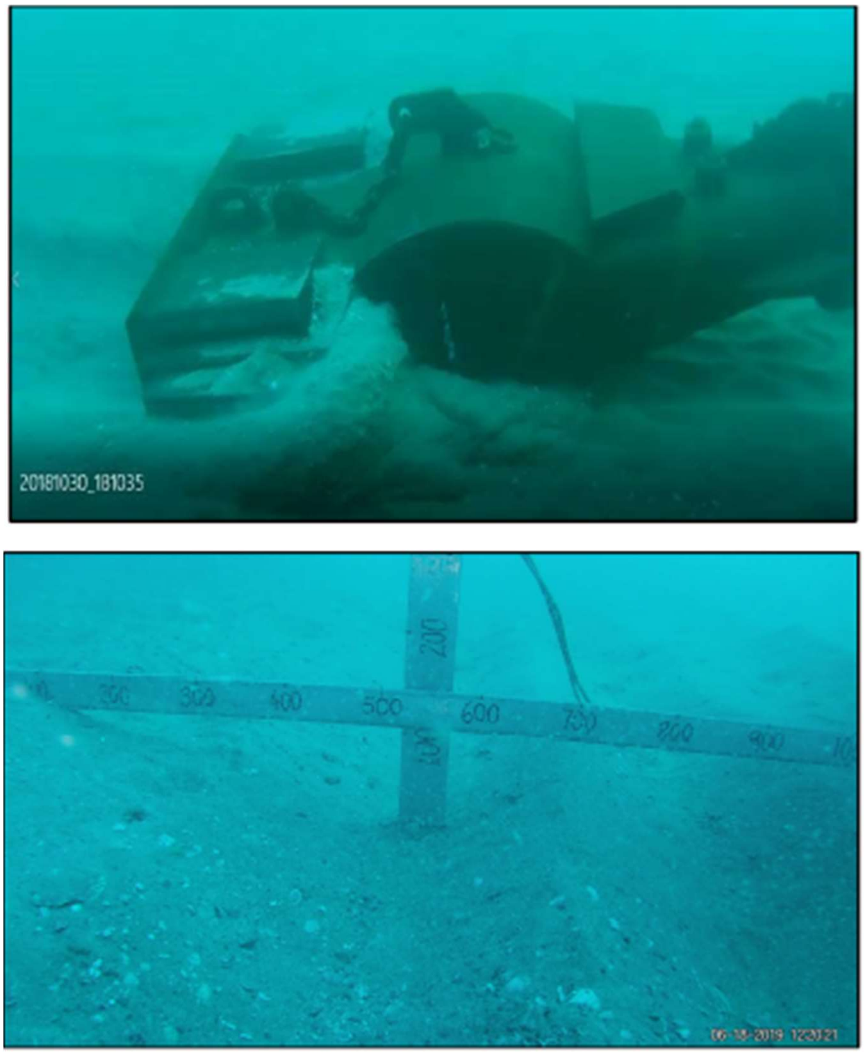


Figure 5.1 Coastal carrier drag head in operation in 10 m water depth (top) and resulting dredge trench after 8 hours post dredging (bottom) (Jacobs, 2020a, 2020b).

Jacobs (2020a,b) carried out trench infill investigation, which saw divers measure different dredge tracks (bottom Figure 5.1) at approximately 10 m water depth within the existing McCallum Brothers Limited consent area and in 25-30 m water depth in the Kaipara Limited consent area several times over a period of days to weeks to measure the trenches infilling rates (Figure 5.2). The purpose of these measurements was to establish a duration of seabed disturbance within the consent areas and to assess the volumes moving across a theoretical closure depth around the 25 m water depth (diabathic transport). This investigation also considered waves and currents between measurements provided by 3-hourly time series of modelled data at the Profile 1 location in 30 m depth. It is noted, and is the opinion of the authors of this report, that the dredge trench presented in Figure 5.1 (bottom image by Jacobs (2020a,b) just 8 hours after dredging seems to resemble bedforms with a wave-length of ~350 mm rather than a 1,200 mm width track of a trailer suction dredge; bedforms are also evident in the side-scan images above; that is, these bedforms were more likely created by wave action than from dredging

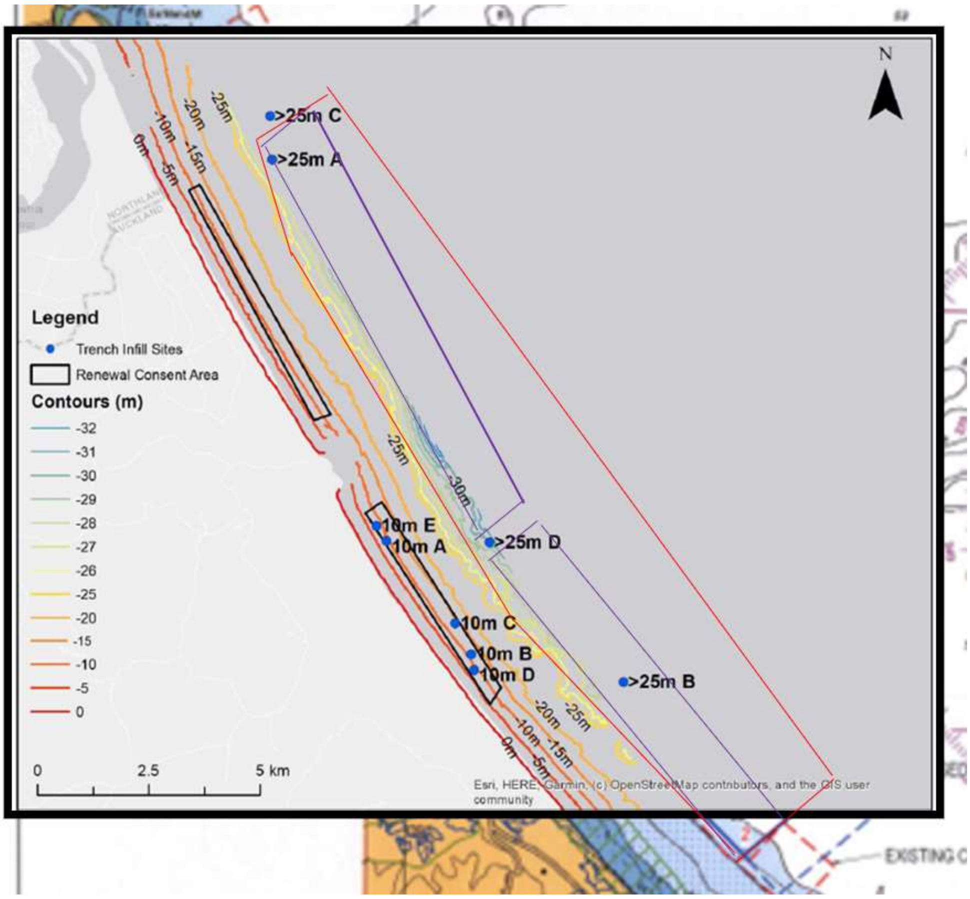


Figure 5.2 Location of dredge infill measurements (blue dots, Jacobs, 2020b). The black boxes indicate the nearshore dredging areas, the purple represent the existing offshore dredge area, and the red box is for the current offshore application.

Table 5-2 presents the trench infill measurements along with exceedance of waves and currents above sediment entrainment thresholds for trenches greater than 25.0 m water depth. The key points reported by Jacobs (2020a, 2020b) were that:

- At no time during any of the observation periods were the combination of *wave heights and periods* above the theoretical critical threshold for entrainment of the seabed sand sediments (i.e., seabed sediments were not able to be moved). This includes a high energy event during the monitoring period, which is reported to have essentially completely infilled the trench. This event did not reach storm status on the Marsden Point wave buoy data.

- Despite the lack of events theoretically capable of entraining sediment, infill occurred across all observation periods, indicating that transport from the adjacent seabed was occurring.
- This is supported by diver observations of sediment moving on the bed due to swell (Bedload Creep – i.e., wave orbitals lift the sediment and residual currents move it).
- The near-bed current modelling indicated that if sediment was already entrained (e.g., by waves or currents), the near-bed currents were of sufficient strength to transport sand for 30 to 45% of the time.
- While infill volumes were generally low, the results showed even in these water depths trenches could be totally infilled within a 1 – 2-month period without extreme storm events.

Table 5-2 Trench infill results in water depths greater than 25.0 m (Jacobs, 2020a, 2020b).

Trench	Total Observation period	No of Days	Max Hs (m)	Modelled % time exceed entrainment threshold		% time currents exceed transport threshold(1)	Infill Depth (mm)(2)	Infill volume (m^3/m/day)(3)	Diver Observations
				By waves	By currents				
>25 m A	30/10-13/11/2018	15	1.57	0	0	46.1	100	0.06	30/11: Surge from swell noticeable on the bottom and sediment moving (Hs=0.9 m, Tp=9.4 s)
>25 m B	19/11-7/12/2018	18	2.82	0	0	44.1	250	0.175	20/11: Surge from swell noticeable on the bottom (Hs=0.9-1 m, Tp=9 s) 7/12: Track largely non-existent after high event on 30/11 (max Hs=2.82 m, Tp= 7.2 s)
>25 m C	14/4-2/5/2019	35	1.01	0	1.4	28.9	200	0.14	Lot of shell present in area at time of final observation.
>25 m D(4)	27/11-5/12/2019	8	No data	No data	No data	No data	40(4)	0.06(4)	Track much shallower than Coastal Carrier

Notes: (1) Is theoretical % of time that currents in any direction could transport sand if it had already been entrained.
(2) Average trench depth from Coastal Carrier in this water depth is 300 mm.
(3) Average fill volume to totally infill trench from Coastal Carrier in this water depth is 0.21 m^3/m
(4) Trench extracted by William Fraser. Average Trench depth is 0.105mm and total infill volume is 0.115 m^3/m

The trench infilling investigation is important because this is claimed to provide the scientific evidence upon which the new diabathic transport rates for the new sediment budget were based for the recent consent renewal of McCallum Brothers Limited (a reported increase from 12,000 m^3/year to 76,500 m^3/yr, as discussed in Mead *et al*., 2021). The key points provided by Jacobs (2020a, 2020b), as recorded in relation to Table 5.2 above, would appear to be completely contrary to the hydrographic data presented here, which indicates that the features created by dredging are likely persistent over 18 months and are maintained to significant depths, which is due to repeatedly dredging the same shore-normal line within the consent area (Figure 3.2) (McIntosh *et al*., 2021). Trenches of >1.5 m are clearly evident, which are contrary to the 0.15 m deep and 1.2 m wide trenches reported by Jacobs (2020a,b).

6 Summary and Conclusions

A combination of Side Scan Sonar (SSS) and Single Beam Echo Sounder (SBES) data has been used to identify and characterise dredge trenches made by the operators of the dredging carried out under the existing Kaipara Limited resource consent; these features are in line with AIS data showing repeated shore-parallel dredge runs (Figure 6.1). The dredge trenches have been identified as shadow zones and areas of sharp contrast. The features collocate over an 18-month period. The features also collocate with abrupt changes in SBES depths. The dredge trenches are in excess of 1.5 m deep in areas that have not been mined recently, and in areas of more recent activity the dredge trenches are in excess of 2.5 m deep. The dredge trenches are persistent and shore parallel.

It is ~2.6 km between Transect 1 and 13 in the offshore extraction site, where 8 out of 13 transects are >1.5 m deep. According to the EMMP, these types of seabed effects should have triggered Tier 2 monitoring under the terms of the existing Kaipara Limited resource consent , although this has never occured since the consent was granted.

These findings are contrary to findings set out in the work of Jacobs (2020a, 2020b), particularly when considered in conjunction with other issues with the modelling and calculations undertaken by Jacobs (2020a, 2020b). It is also worth noting that similar deep trenches have been observed in the nearshore dredging areas (reported in Hilton, 2018).

These findings cast serious doubts on the likelihood that diabathic sediment transport is occurring. The Sand Study (Hume *et al*., 1999) concluded that an average of 12,000 m^3/yr of offshore sediment moves shoreward past the 25 m contour (this has been increased in the current nearshore dredging consent application to 76,500 m^3/yr (Jacob 2020b)). It is very likely that trenches in the offshore area of 1 to >2.5 m depth running shore-parallel for some 18.8 km along the Mangawhai-Pakiri embayment (>70% of the beach length), is greatly reducing and/or preventing transport of sediment to the beaches. Depending on the source of information, this represents an average yearly deficit to the nearshore of 8,600 m^3 (Sand Study) to 57,375 m^3 (Jacobs 2020a,b). If the 20 year duration of the current consent is considered, then trenches will have prevented between 172,000 and 1,147,500 m^3 of sand being transported shoreward, and if not well managed, that will double with the new consent.

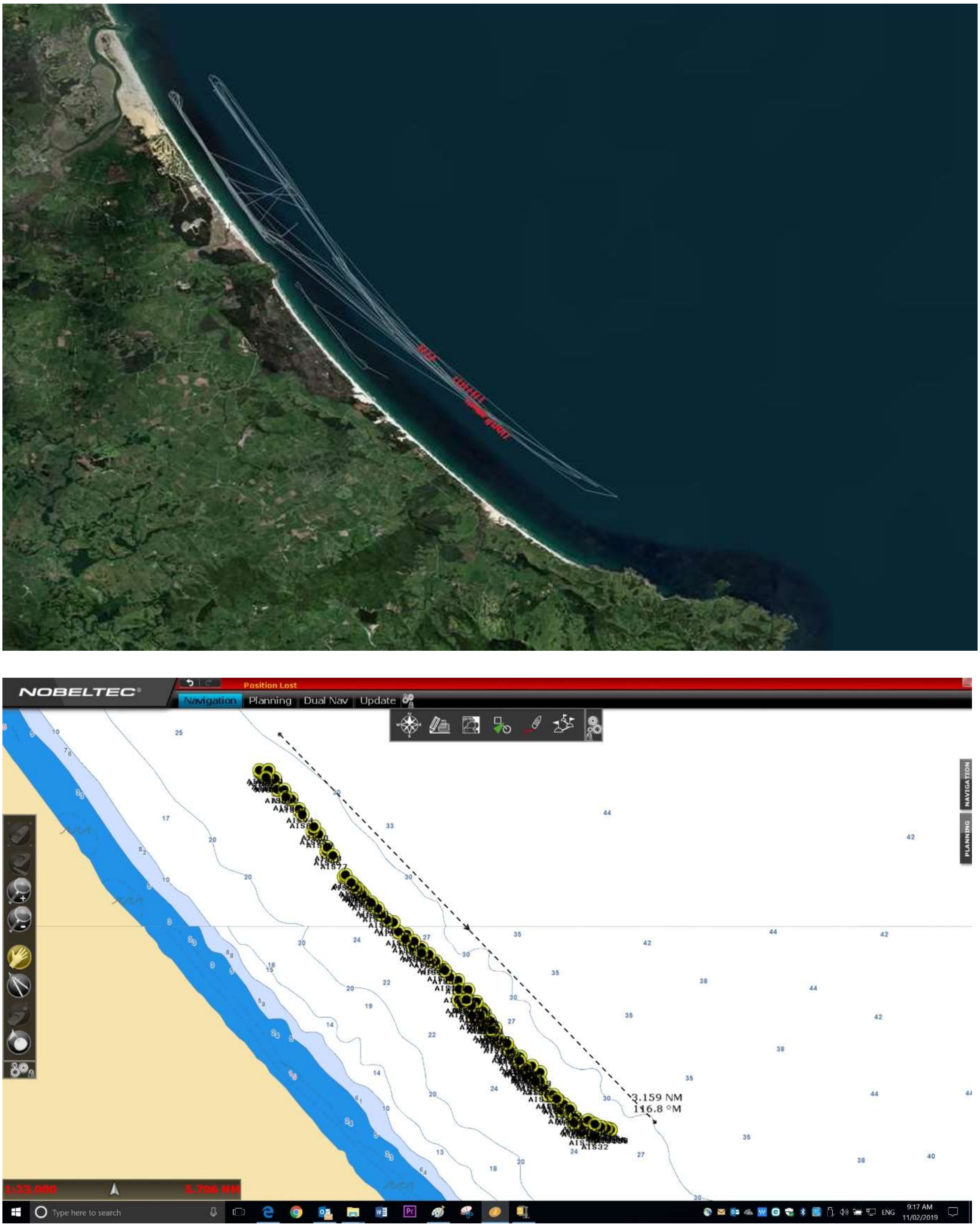


Figure 6.1. Top) AIS dredging data with the bathymetry transects overlaid in Area 1. Bottom) AIS data used to plot the 20 February 2019 SSS survey, which was repeated 31 August 2020 (Section 4 above).

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