Voyage Report

RV Tangaroa Voyage TAN1703

5 April – 1 May 2017

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1 Background Information

1.1 MARCAN Project Overview

Meteoric recharge and topographically-driven flow are the most important sources of groundwater recharge in terrestrial settings. In passive continental margins, topographically-driven meteoric (TDM) groundwater is only one of a range of drivers of offshore groundwater flow. Other drivers include seawater recirculation, sediment loading, geothermal convection, and diagenesis. Sea level has been much lower than today for 80% of the Quaternary, resulting in the emergence of extensive sections of continental shelf, a reduction of pressure exerted by the sea water column, as well as steepening of the hydraulic gradient and an increase in hydraulic head. The potential of TDM recharge to establish extensive water tables, create massive groundwater fluxes, and generate pore overpressures and discharges across the continental shelf and upper continental slope must have been significantly higher during the majority of the last 2.6 Ma than it is today. Considering that geothermal convection is strongest beneath the continental slope and tends to be dominated by TDM flow during sea level lowstands, whereas sediment loading is most important during rapid deglaciations in high sedimentation zones, TDM recharge is a likely very important driver of offshore groundwater systems in continental shelves and upper slopes globally.

Offshore groundwater systems driven by TDM recharge comprise two key elements that have received increased attention in the last decade. The first consists of offshore fresh and brackish groundwater reservoirs, which occur extensively around the world, have a global estimated volume of 5×10^5 km^3, and can provide potential archives of paleo-environments and valuable sources of good quality drinking water. The second is submarine groundwater discharge, which delivers volumes 3-4 times greater than rivers globally and directly influences biological processes and geochemical balances.

The characteristics and dynamics of modern TDM offshore groundwater systems remain poorly constrained, and there are many first order questions, related to aquifer geometry, distribution, characteristics and flow dynamics, waiting to be addressed. This mainly arises from a paucity of appropriate offshore data and rare geophysical and geochemical characterisation of offshore groundwater. As a consequence, exploration of offshore groundwater has had to rely on predictive mathematical models. These, however, have generally been based on limited well data, low resolution seismic data and poorly defined aquifer properties. They pay little attention to the land–sea connection and seafloor morphologic evolution during glacial cycles, despite these being proposed as key controls of some of the best-studied offshore reservoirs. The geologic environment influences the distribution and flow of offshore groundwater at several scales, but such a relationship has not been investigated in detail, and contrasting results have been reported.

Offshore groundwater reservoirs are seldom in equilibrium with sea level. Current and past continental margin morphology and processes can only be understood in terms of a framework where sea levels are lower and TDM groundwater systems extend further offshore. Better understanding of the response of TDM offshore groundwater systems to the integral glacial cycle, and of how TDM flows can be geomorphically significant, is crucial. Understanding the architecture, history, and dynamics of TDM offshore groundwater systems has thus emerged as a new scientific frontier of critical value to seafloor geomorphology.

The MARCAN project is a 5-year project funded by the European Research Council. MARCAN addresses the hypothesis that topographically-driven meteoric groundwater plays a key role in the geomorphic development of passive continental margins.

The objectives of MARCAN are to:

1. Define the characteristics and dynamics of topographically-driven meteoric groundwater systems in passive continental margins.
2. Test the hypothesis that topographically-driven meteoric groundwater is an important geomorphic agent in passive continental margin

Two study areas provide a context for MARCAN. Study area 1 is the siliclastic sedimentary Canterbury margin, eastern South Island of New Zealand (Figure 1). Study area 2 comprises the north-eastern Maltese Islands, an example of a carbonate bedrock margin. These study areas have been selected because they are representative of the most prevalent passive continental margin types globally, and because they are comprehensively covered by available good quality seafloor and terrestrial topographic, stratigraphic, structural and groundwater data.

1.2 Study area background

The Canterbury Plains host an exceptional and well utilised groundwater system. Aquifers are fed by very large catchments extending up to the main divide (Figure 1). Screen depths (denoting the depth where groundwater abstraction is occurring) from groundwater wells compiled into coast-normal profiles illustrate the structure of the unconfined (surface) and confined groundwater aquifers (Figure 2 and 3). Critically, both the profiles show significant abstraction occurring right up to the coast and well below sea level.

IODP drilling on the outer continental shelf has identified a low salinity signal in porewater that is interpreted as an offshore aquifer (Figure 4 and 5). A large amount of information is available for these sites including extensive geophysical logs and geochemical analysis. The decrease in salinity from the surface down to 40 m bsf (below sea floor) then increasing again from 60 m bsf downwards indicates the freshwater bearing unit (Figure 5). TAN1703 uses this information as a focal point to investigate the potential offshore aquifers on the Canterbury Shelf.

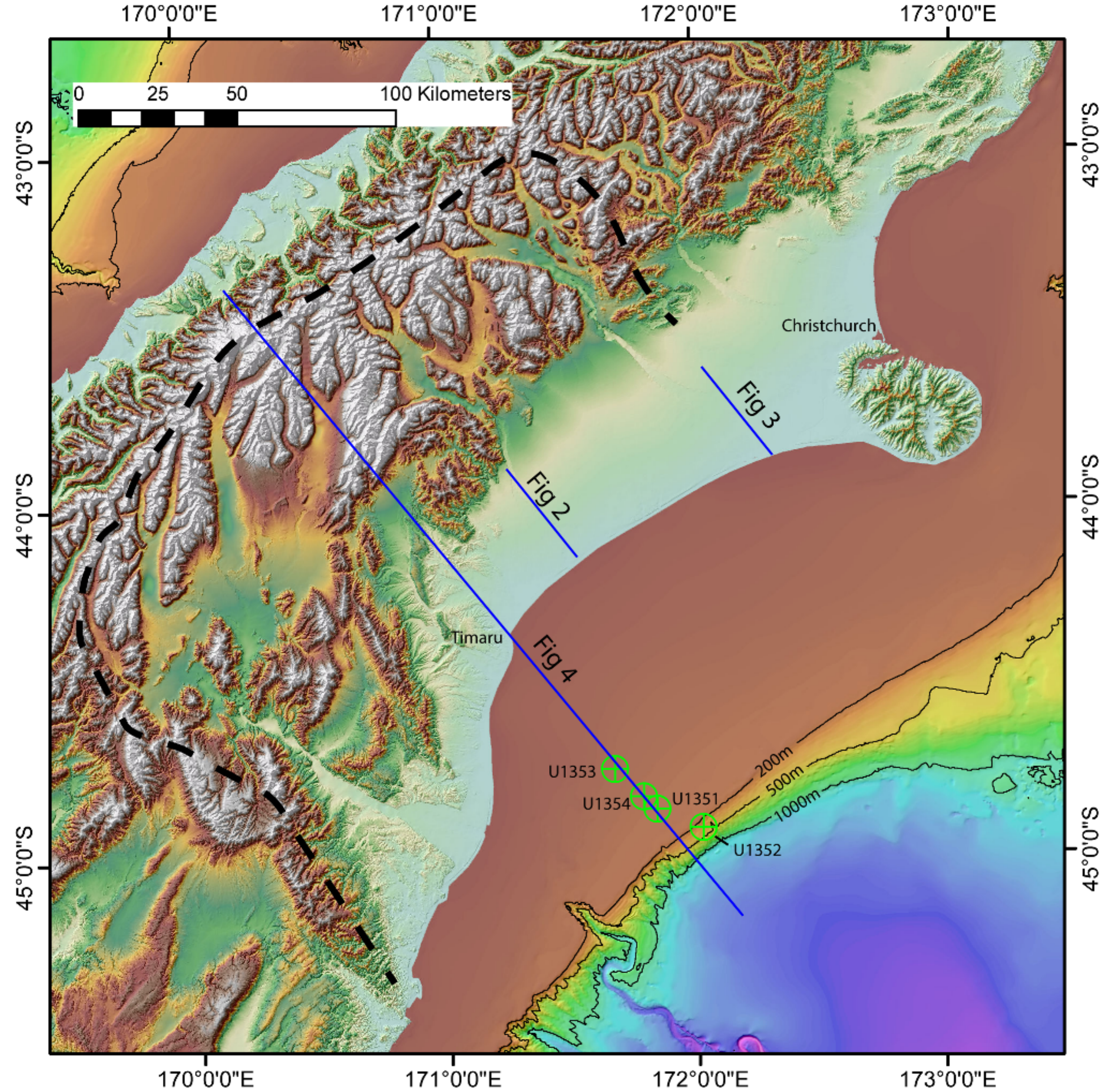


Figure 1: Regional setting of the Canterbury plains and shelf including the TAN1703 study area. Onshore the black dashed line shows the approximate extent of the river catchments that feed the Canterbury aquifers. The locations of the profiles in Figures 2 and 3 are indicated. The location of offshore IODP drill holes from Expedition 317 are indicated by blue circles and crosses.

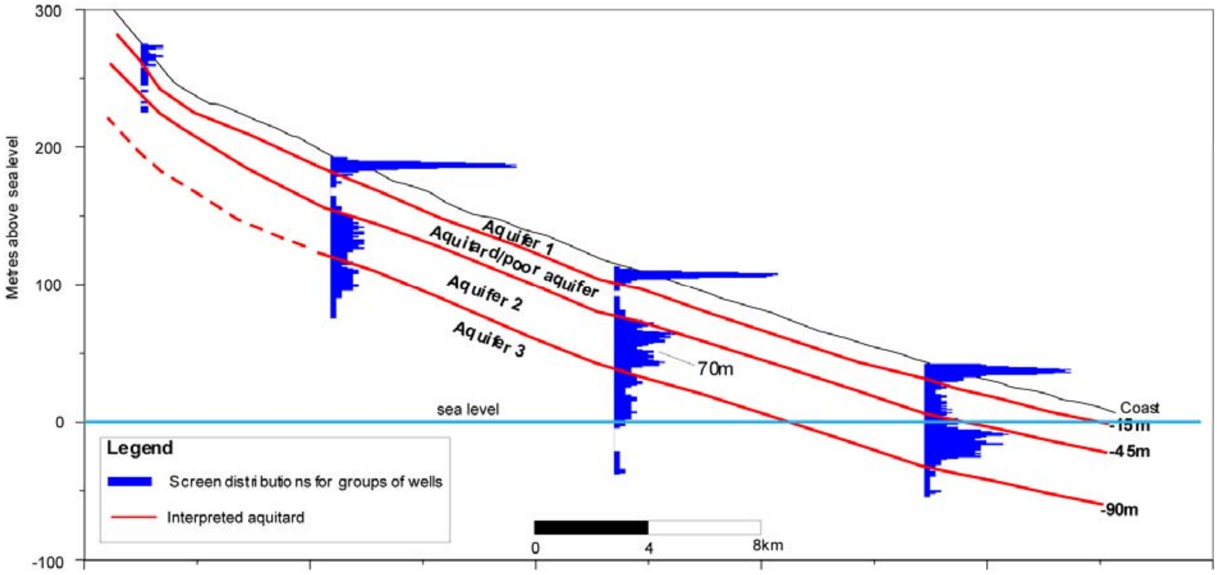


Figure 2: Schematic delineation of the Canterbury Plains aquifers at the southern end of the plains based on screen depths from active groundwater wells. Profile location in Figure 1.

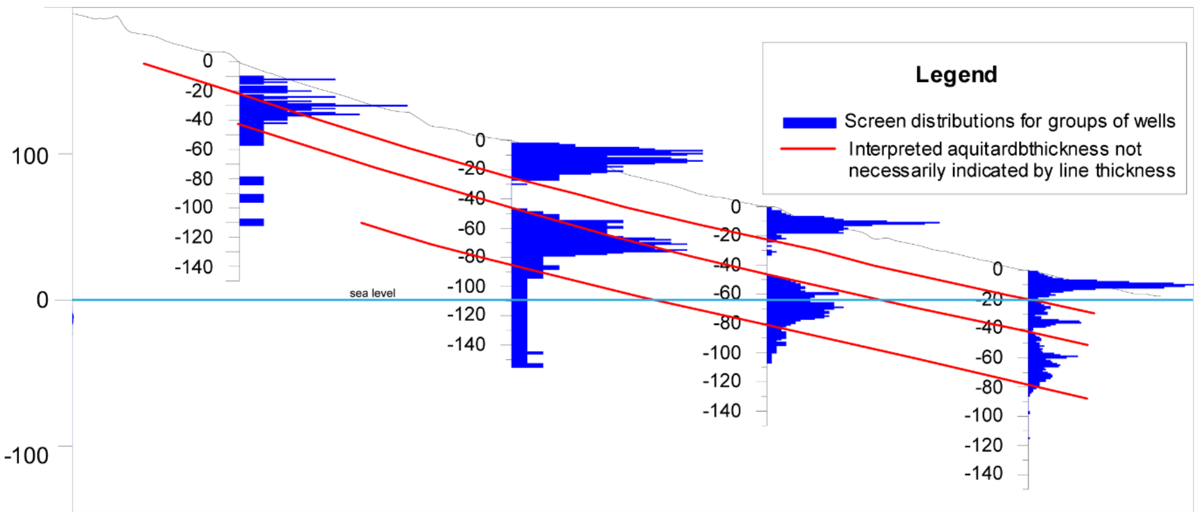


Figure 3: Schematic delineation of the Canterbury Plains aquifers towards the northern end of the South Canterbury Plains based on screen depths from active groundwater wells. Profile location in Figure 1.

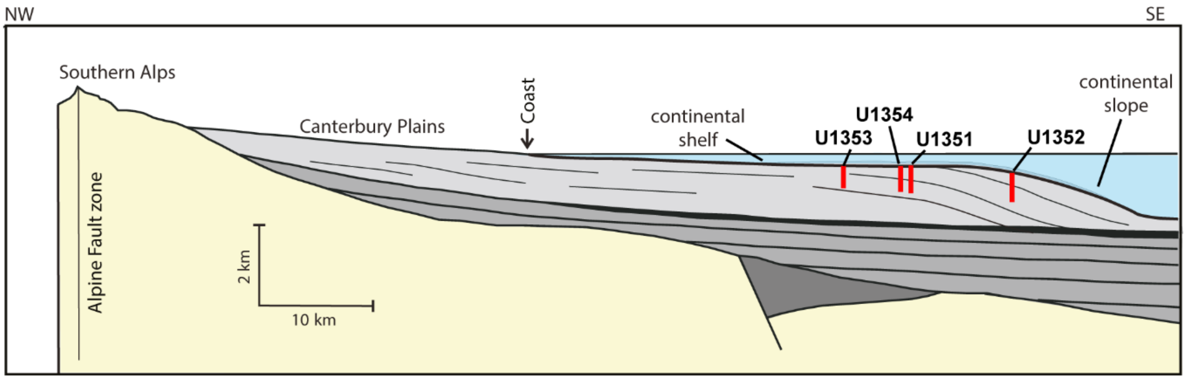


Figure 4: Schematic cross section from the Southern Alps out to beyond the continental slope showing the indicative location and penetration depth of IODP Exp-317 drill holes. Cross section location Figure 1.

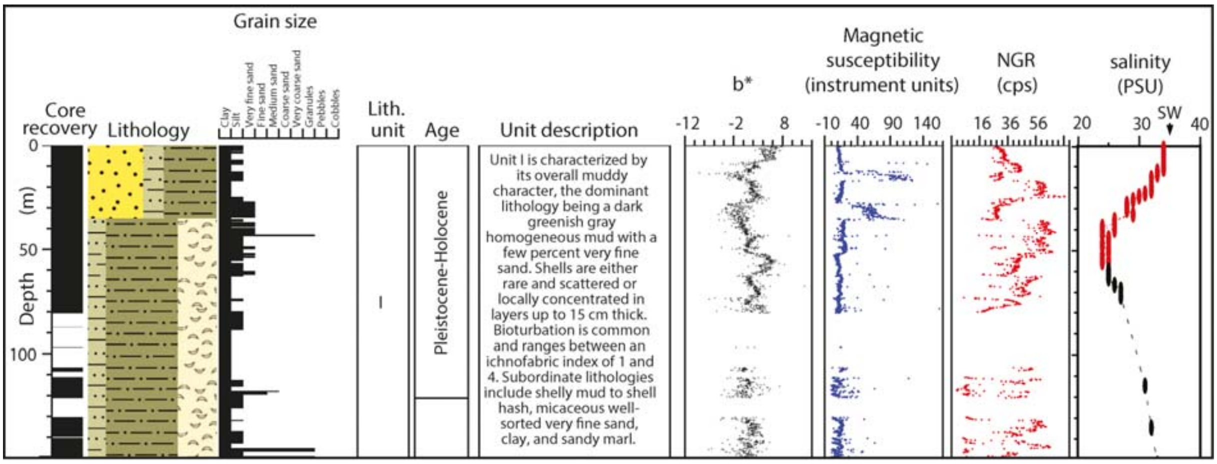


Figure 5: compiled logs from IODP site U1353. The pore water salinity profile is at right. Location in Figure 1.

1.3 TAN1703 Voyage Objectives

The objectives of TAN1703 are to:

1. Characterise the geometry and distribution of the offshore groundwater reservoir in the Canterbury shelf using controlled-source electromagnetic surveying;
2. Generate a model of the shelf stratigraphy and structure using seismic reflection profiling;
3. Identify sites of groundwater seepage using multibeam echosounder water column data, CTD casts, seafloor imagery, pore water geochemistry (from sediment cores) and water column geochemistry (from Niskin bottle samples)
4. Determine the sedimentological, geotechnical and hydraulic properties of seabed sediment from sediment coring.

2 Voyage Participants

Name	Affiliation	Role(s)
Dr Joshu Mountjoy	NIWA	Voyage Leader
Dr Aaron Micallef	University of Malta	MARCAN Project Leader
Dr Marion Jeger	GEOMAR	CSEM Lead
Martin Wollatz Vogt	GEOMAR	CSEM
Dr Brad Weymer	GEOMAR	CSEM
Dr Katrin Schwalenberg	BGR	CSEM Lead
Dr Susi Woelz	NIWA	Multichannel Seismic Lead
Peter Gerring	NIWA	Coring and CTD Lead
William Quinn	NIWA	Electronics, IT
Alan Hart	NIWA	Multibeam
Nick Eton	NIWA	Electronics
Daniel Cunarro Otero	University of Malta	Watchkeeping, Outreach
Dr Daniele Spatola	University of Malta	Watchkeeping, Outreach
Neeske Luebben	MARUM	Core Processing
Dr Christof Mueller	GNS Science	Multichannel Seismic

3 Summary of activities

The following is a brief summary of the survey activities.

- 5-6 April Vessel mobilisation
- 7-8 April Depart wharf 1130 hrs transit to site
- 9-20 April Alternating CSEM with CTD casts and coring.
- 20 April Port call at Timaru to exchange scientists
- 21-24 April Multichannel seismic survey
- 24-29 April Alternating CSEM with CTD casts and coring.
- 30 April Transit to Wellington
- 1 May Vessel demobilisation

A detailed day by day activity log is provided in Appendix A.

4 Outreach

One of the aims of the MARCAN project is to share the research activities that we carried out onboard the *R/V Tangaroa* to as many people as possible. During the cruise, photos and video (including GoPro footage and video recorded with different cameras) were acquired. The main research techniques used onboard (e.g. CSEM, MSC, piston corer, CTD, water sampling, MBES) as well as the deployments and recoveries of the instruments were recorded. The outreach program during the MARCAN cruise consisted mainly of daily Facebook posts that were posted on the Marine Geology and Seafloor Surveying page of the University of Malta. The posts were also shared on the personal page of some of the participants at the MARCAN project to increase the reach.

Due to a limited Internet connectivity on board, it was only possible to upload some photos and text for each post.

The posts can be classified in three categories:

Scientific posts: all the main instruments used during the cruise and the scientific principles behind them were covered. The scientific background of the project as well as the study area were explained. The main research groups that are involved in the MARCAN project (i.e., University of Malta, NIWA and GEOMAR) have been tagged, and the main funding agencies (ERC and NIWA) have been acknowledged.

Interviews: we carried out short interviews with the main scientific leaders of the MARCAN cruise, covering not only scientific questions related to the instrumentation or the MARCAN project, but also more ‘personal’ questions with the aim of encouraging students to follow similar career pathways.

Non-scientific posts: related to the daily life and special occasions on board the R/V Tangaroa, such as Easter, dolphin and whale observations, food, sunsets, etc.

Facebook Insights. The Facebook posts published during the MARCAN cruise have reached more than 5600 people (Figure 6). Individually, every post reach an average of 400 persons, which is approximately the number of followers of the Facebook page. However when some of the posts were shared or some people were tagged, the number of views increased considerably (Figure 7, Figure 8, Figure 9).

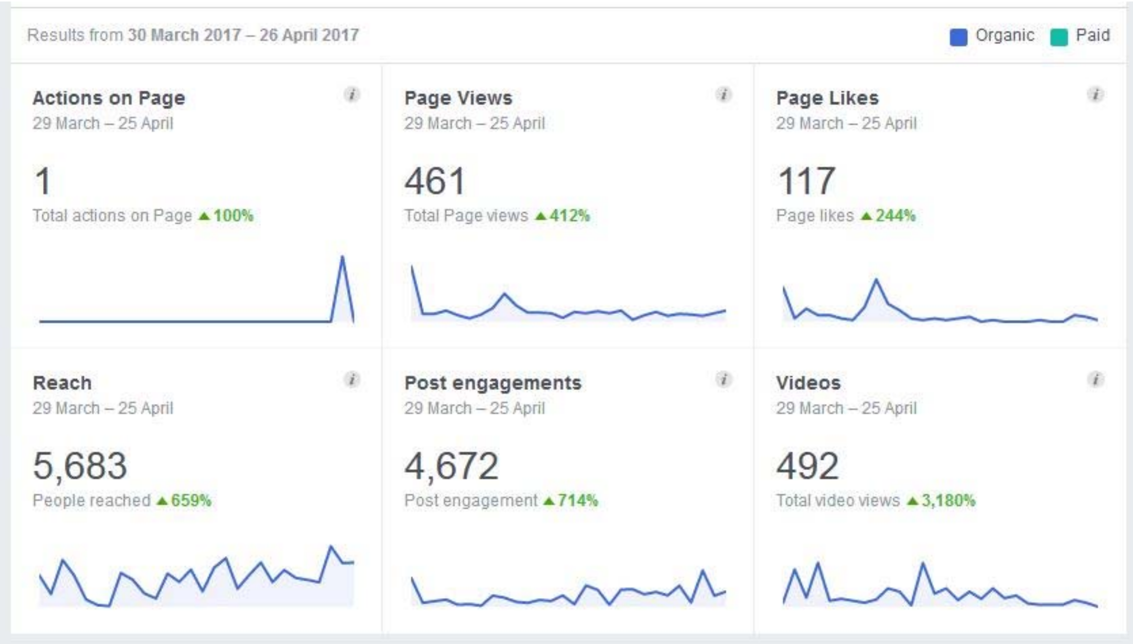


Figure 6: General statistics of the Facebook page from 30th March to 26th April

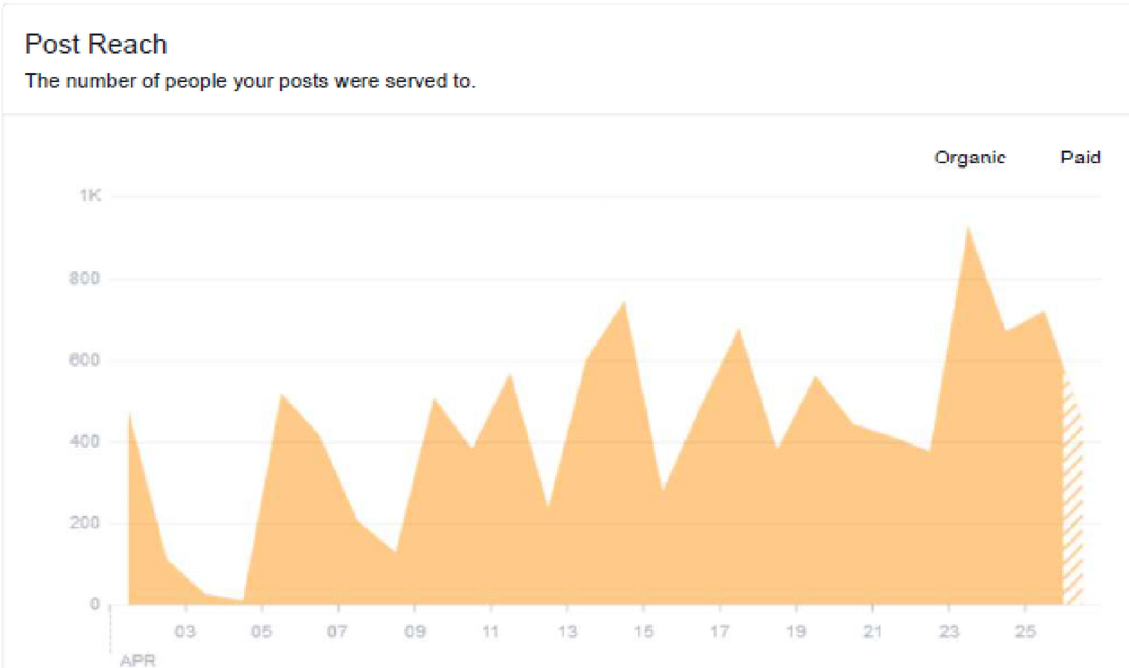
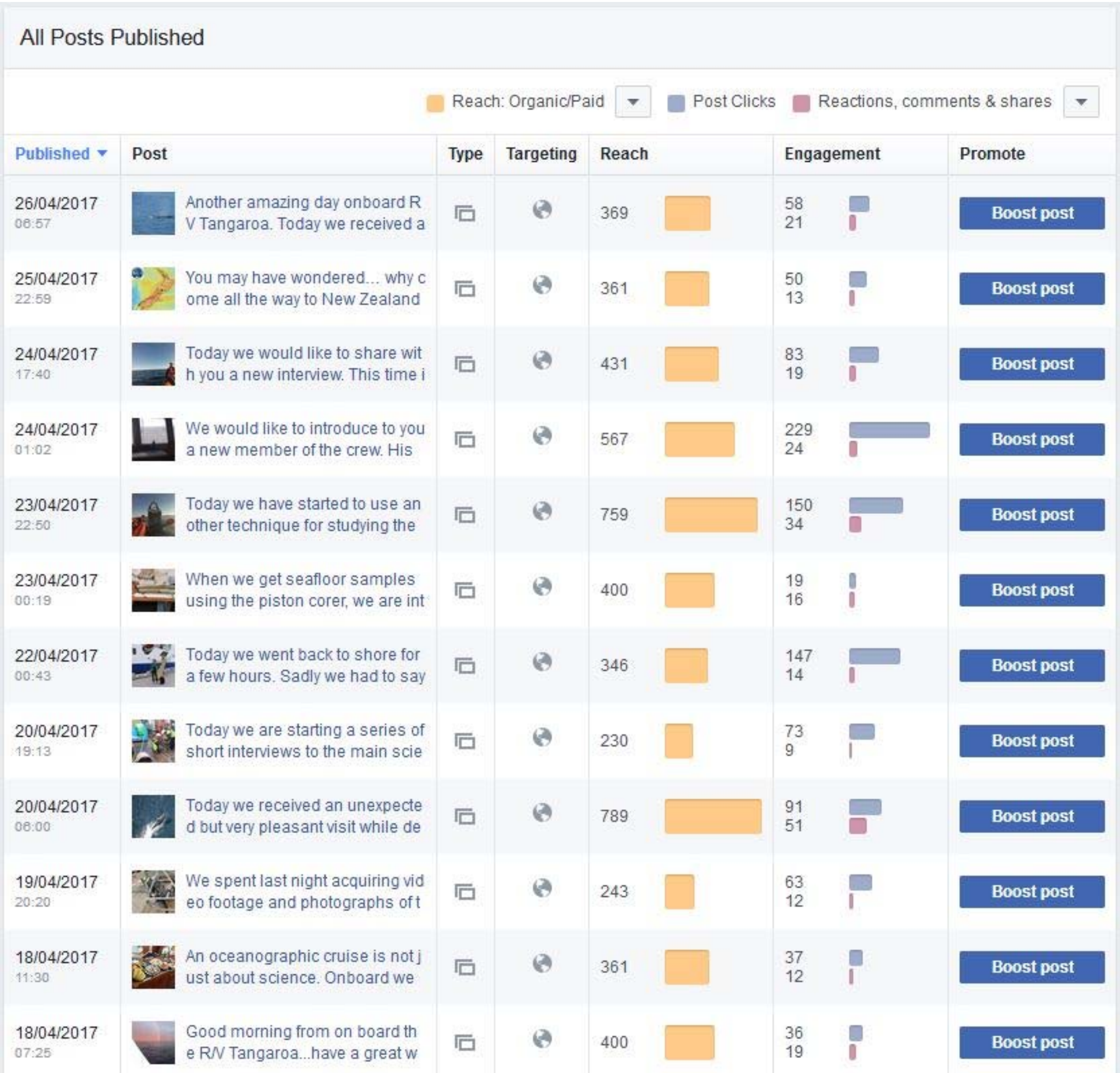


Figure 7: Number of people that saw the post, from the beginning of April to 26th April

17/04/2017 08:18	Today a marine Easter bunny ca me to the RV Tangaroa and hid	788	156 29	Boost post
15/04/2017 07:59	A cyclone with winds of more tha n 120 km/s have hit the North Isl	615	71 23	Boost post
14/04/2017 06:12	How would you check whether fr eshwater is present in the seafl	537	76 19	Boost post
13/04/2017 22:43	Although the seafloor is the mai n target of our expedition, investi	526	214 30	Boost post
12/04/2017 00:32	Marine CSEM (controlled-source electromagnetic) is a cutting-ed	603	63 19	Boost post
10/04/2017 22:56	A short video about the first days of the MARCAN cruise, onboard	498	52 26	Boost post
10/04/2017 00:05	On Friday morning we finally dep arted from Wellington! Although i	692	74 37	Boost post
06/04/2017 22:04	The MARCAN research cruise is funded by the European Resear	251	29 5	Boost post
06/04/2017 01:00	The MARCAN cruise will be carri ed out on board the RV Tangaro	713	123 40	Boost post
01/04/2017 05:12	The second survey of the MARC AN project involves a 4 week lon	1.5K	83 78	Boost post

Figure 8: Posts that were published on the Facebook page from 1/04 to 17/04, showing the number of people reached and the 'engagement'



All Posts Published

Reach: Organic/Paid | Post Clicks | Reactions, comments & shares

Published	Post	Type	Targeting	Reach	Engagement	Promote
26/04/2017 06:57	Another amazing day onboard R V Tangaroa. Today we received a			369	58 21	Boost post
25/04/2017 22:59	You may have wondered... why c ome all the way to New Zealand			361	50 13	Boost post
24/04/2017 17:40	Today we would like to share wit h you a new interview. This time i			431	83 19	Boost post
24/04/2017 01:02	We would like to introduce to you a new member of the crew. His			567	229 24	Boost post
23/04/2017 22:50	Today we have started to use an other technique for studying the			759	150 34	Boost post
23/04/2017 00:19	When we get seafloor samples using the piston corer, we are int			400	19 16	Boost post
22/04/2017 00:43	Today we went back to shore for a few hours. Sadly we had to say			346	147 14	Boost post
20/04/2017 19:13	Today we are starting a series of short interviews to the main scie			230	73 9	Boost post
20/04/2017 06:00	Today we received an unexpecte d but very pleasant visit while de			789	91 51	Boost post
19/04/2017 20:20	We spent last night acquiring vid eo footage and photographs of t			243	63 12	Boost post
18/04/2017 11:30	An oceanographic cruise is not j ust about science. Onboard we			361	37 12	Boost post
18/04/2017 07:25	Good morning from on board th e R/V Tangaroa...have a great w			400	36 19	Boost post

Figure 9: Posts that were published on the Facebook page from 18/04 to 26/04, showing the number of people reached and the 'engagement'

Besides the Facebook posts the, following activities are planned as part of the outreach programme:

- Publication of a small report/article of the cruise in EOS Transactions.
- Edit a short documentary using the video footage from the cameras and GoPro and photos, and upload it on different platforms (e.g. Facebook, Youtube, website of the MARCAN project, etc.).
- Record interviews with the main leaders of the cruise to be included in this documentary.

5 Permitting

All permitting for sampling activities and for the import and export of samples was carried out by NIWA. The required documents were submitted to the Environmental Protection Agency (EPA) at the specified intervals as per *Regulation 11(a), Exclusive Economic Zone and*

Continental Shelf (Environmental Effects–Permitted Activities) Regulations 2013. Specific dates of submission are shown in Table 1. The specified commencement date prior to the voyage was 06-04-2017. The actual activity period (during which sampling was undertaken) was 09-04-2017 to 28-04-2017.

Table 1: Schedule of documentation submitted to the Environmental Protection Agency

Relevant documentation	Date submitted
Form 1: Pre-activity notice	04-01-2017
Form 2: Report of pre-activity notification of relevant iwi	14-03-2017
Form 3: Initial environmental assessment and sensitive environments contingency plan	14-03-2017
Notice of commencement of a permitted activity	09-04-17
Permitted activity logbook 1	15-04-17
Permitted activity logbook 2	22-04-17
Permitted activity logbook 3	29-04-17
Notice of completion of a permitted activity	29-04-17
Form 4: Post-activity report	29-04-17

All samples were catalogued on the vessel to comply with New Zealand biosecurity import regulations. The appropriate document and the date it was obtained are given in Table 2.

Table 2: Schedule of documentation submitted to and received from Biosecurity NZ, Ministry for Primary Industries for sample import and export.

Relevant documentation	Date submitted/received
Biosecurity Authority Clearance Certificate (BACC) C2015/201700 (BACC # B2015/169768)	28/04/2017

6 Survey Equipment

The following equipment was used on this voyage for data collection:

- DGPS navigation.
- GEOMAR/BGR CSEM system.
- *Reavell* air compressor.
- 2D Geometrics multichannel seismic reflection system.
- Piston Corer.
- Sound velocity probe.
- Seabird CTD and 24 rosette Niskin water column sampling array
- NIWA CoastCam
- Kongsberg Simrad EM2040 Multibeam Echosounder+ POS/MV motion sensor.
- Kongsberg Simrad EM302 Multibeam Echosounder+ POS/MV motion sensor.
- Kongsberg TOPAS PS-18 sub-bottom profiler.

7 Distribution of collected data

The overall distribution of data collected during this voyage are presented for the working area in Figure 10. The detailed distribution of different data types are presented in subsequent sub-sections.

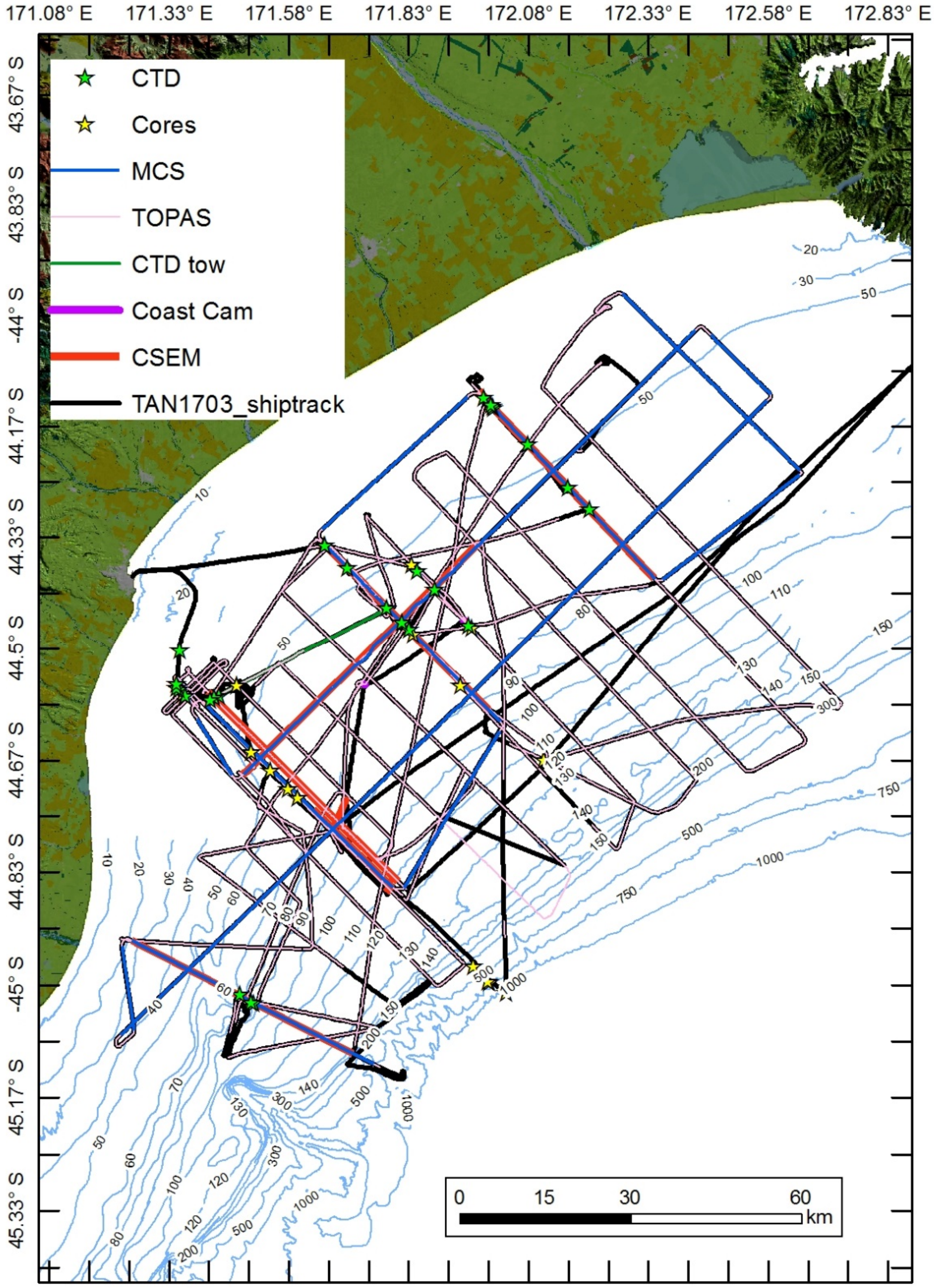


Figure 10: Total distribution of all data collected

7.1 Controlled Source Electromagnetics

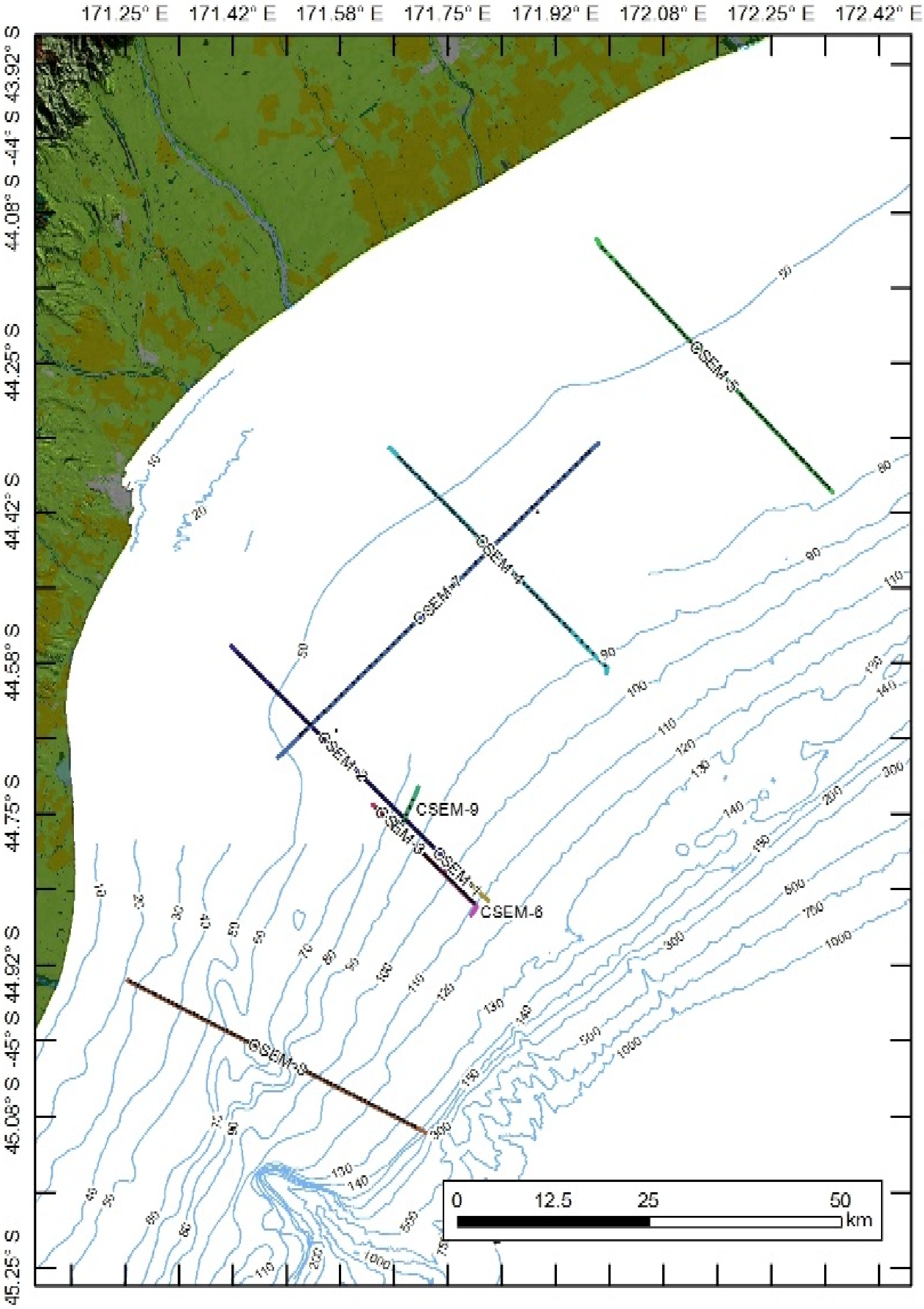


Figure 11: Distribution of CSEM transects. Detail of CSEM acquisition and processing are provided in Section 7.1

7.2 Multi-Channel Seismic Reflection

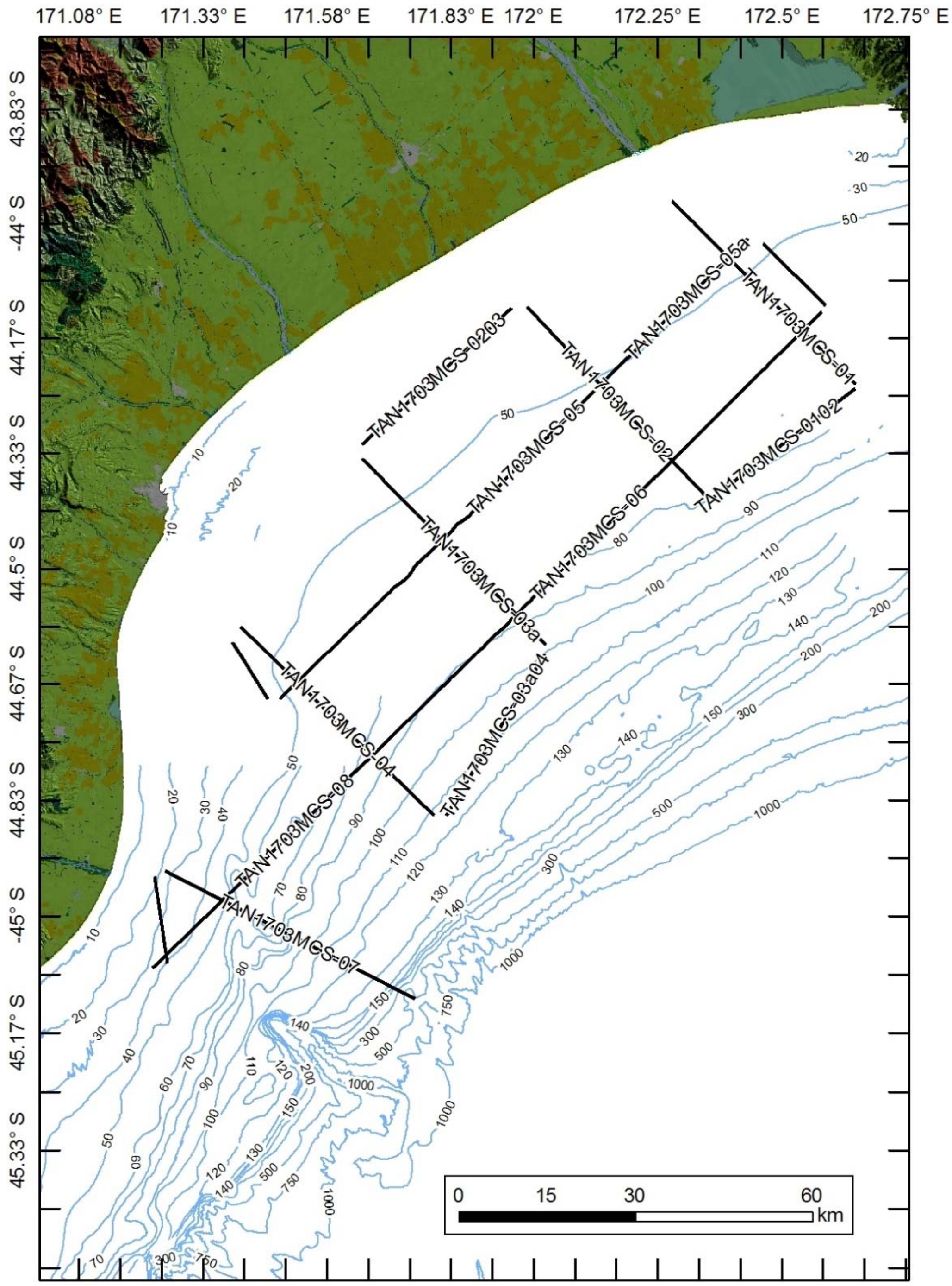


Figure 12: Distribution of Multichannel Seismic Reflection Data. Detail of MCS acquisition and processing are provided in Section 7.2

7.3 TOPAS Sub-Bottom Profiler

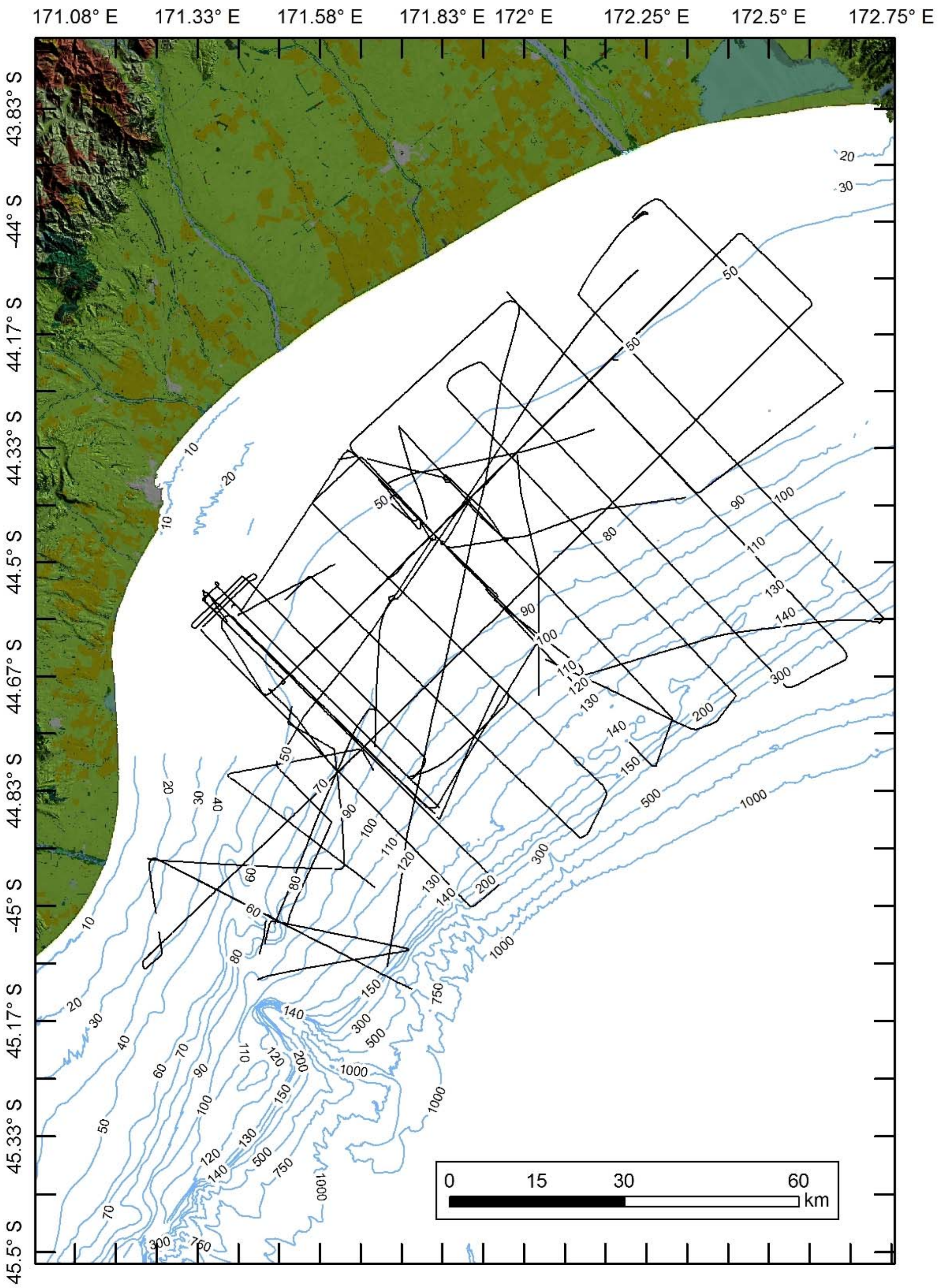


Figure 13: Distribution of TOPAS Data. Detail of TOPAS acquisition and processing are provided in Section 7.3

7.4 EM2040 bathymetry

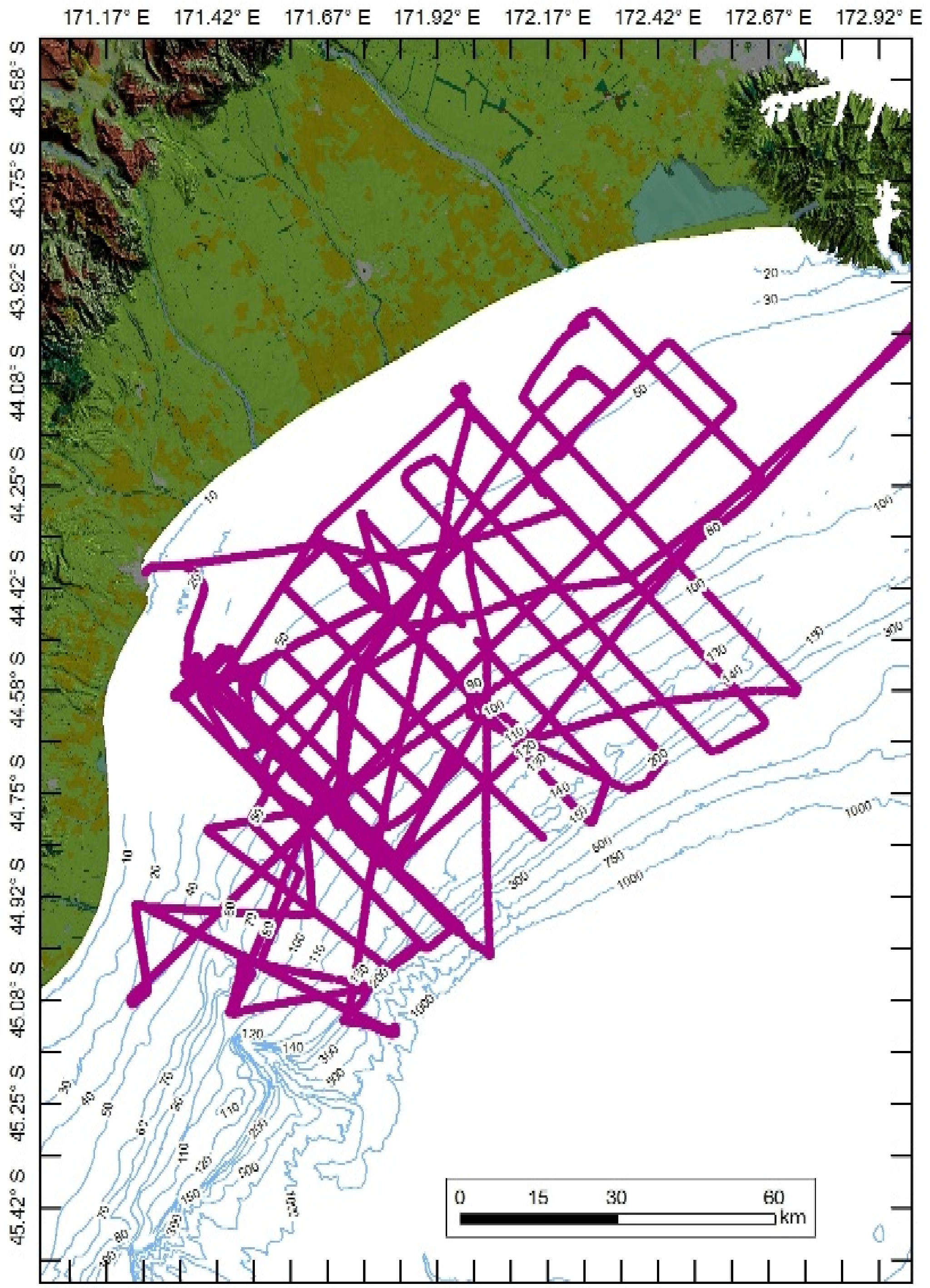


Figure 14: Distribution of Multibeam Bathymetry and Water Column Data (based on shiptrack rather than actual swath coverage). Detail of EM2040 acquisition and processing are provided in Section 7.4

7.5 Sediment Coring

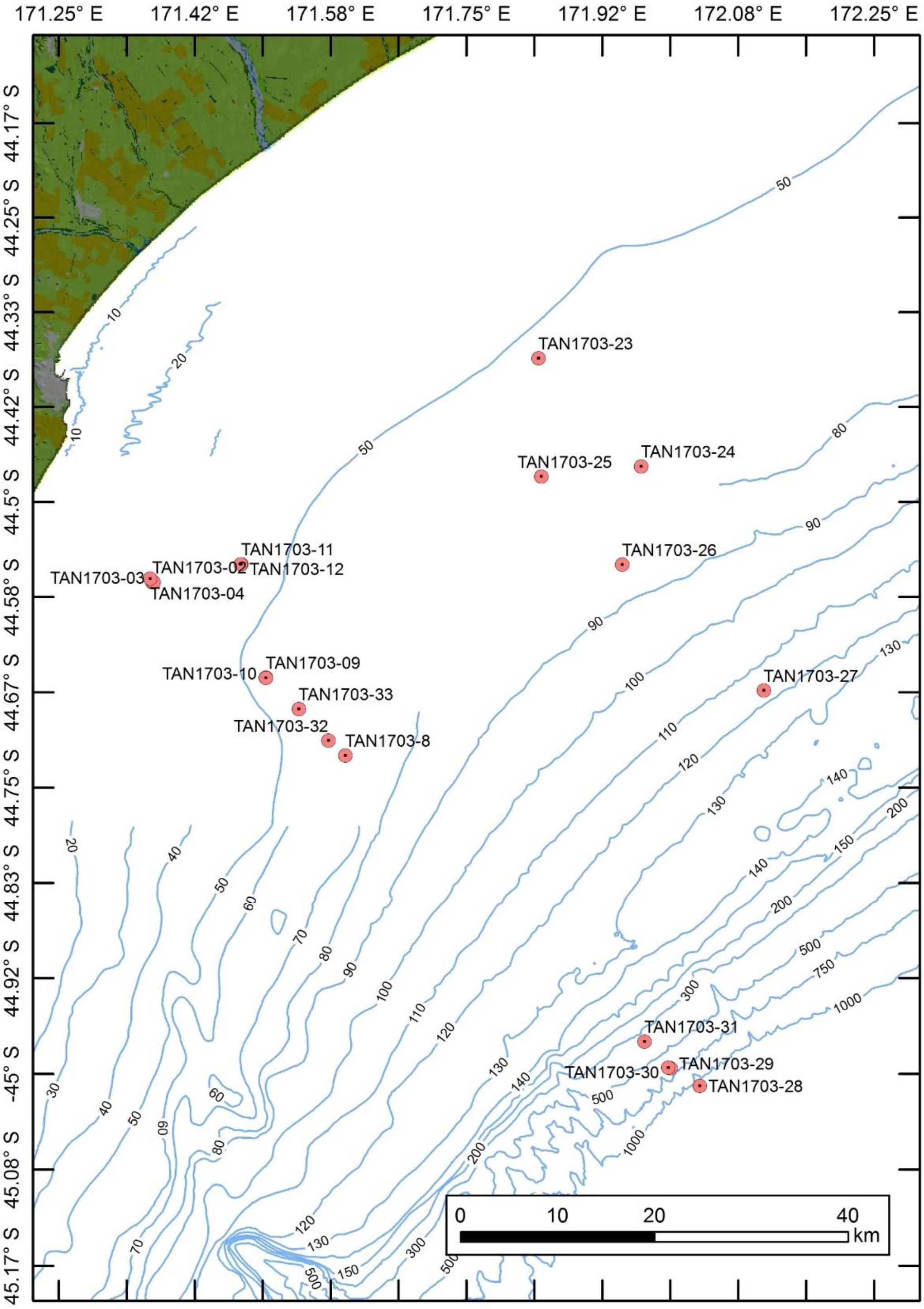


Figure 15: Distribution of sediment cores. Detail of core acquisition and processing are provided in Section 7.5

7.6 CTD data

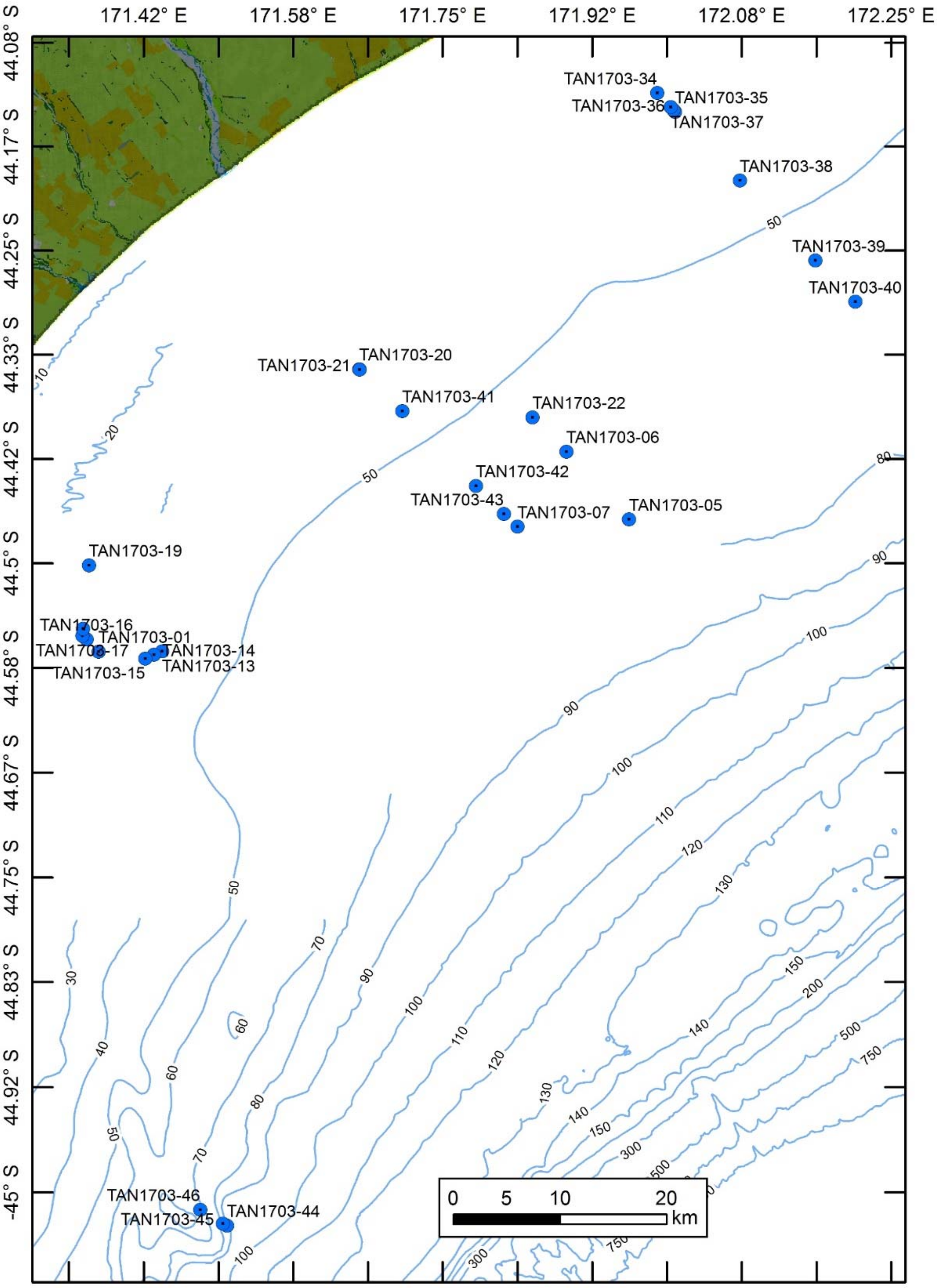


Figure 16: Distribution of CTD casts and tows in the study area. More detail about the specific geometry of CTD tows are provided in Appendix XX. Detail of CTD acquisition and processing are provided in Section 7.6

7.7 Coast Cam

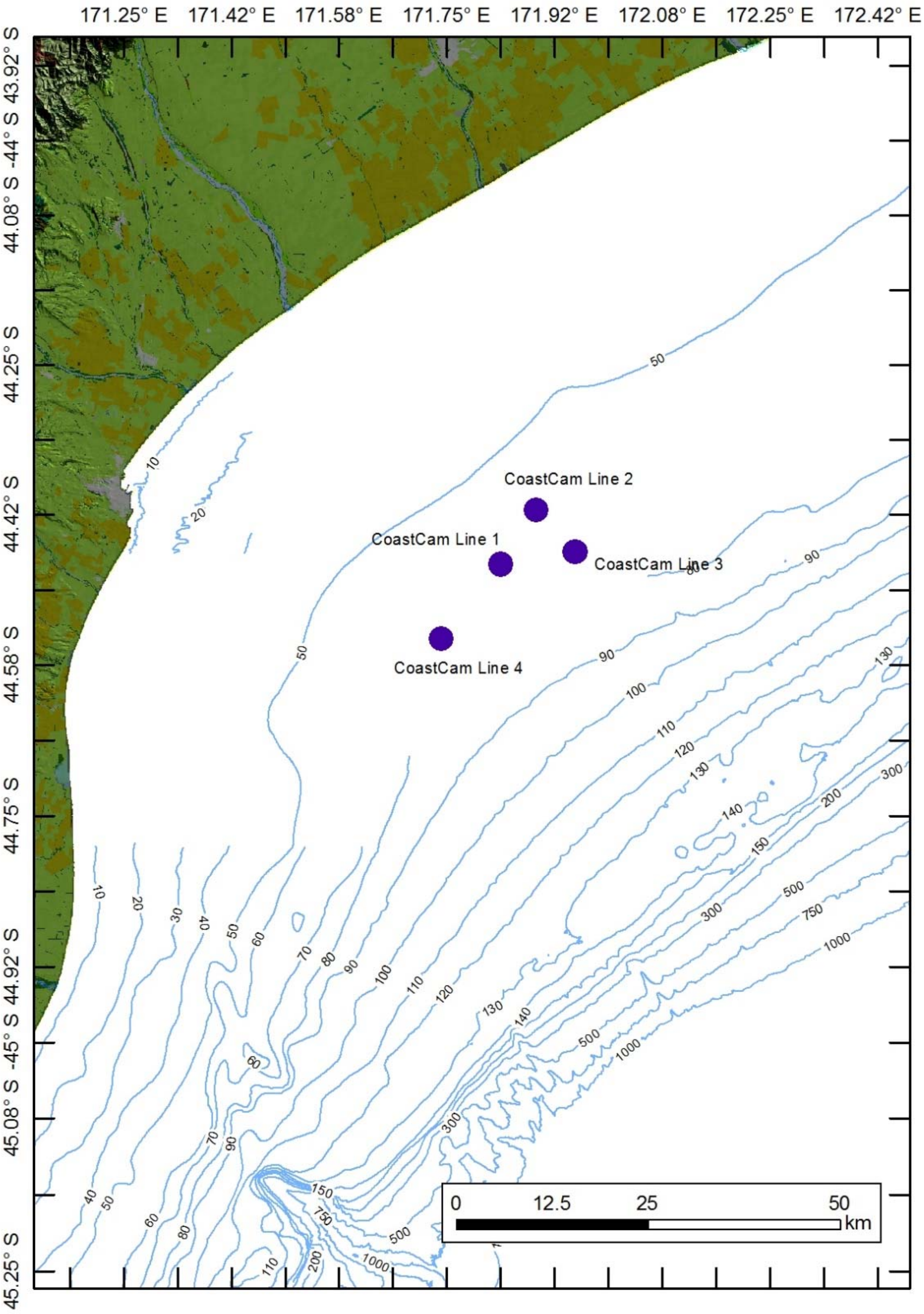


Figure 17: Distribution of CoastCam deployments in the study area. More detail about the specific geometry of CoastCam deployments are provided in Appendix XX. Detail of CoastCam acquisition are provided in Section 7.7

8 Equipment Set Up, Acquisition and Processing Parameters

The following section contains the details of the equipment setup and the acquisition and processing parameters for the different gear types.

8.1 Controlled Source Electromagnetics

8.1.1 Physical concept of controlled source electromagnetics

Marine controlled source electromagnetic (CSEM) is a geophysical exploration method to derive the electrical properties, i.e. resistivity, of the seafloor. Electrical conduction in seafloor sediments occurs through ions in the pore fluids, and therefore the resistivity of seafloor sediments depends mainly on the sediment porosity, pore space connectivity and the conductivity of the pore fluid. An important source for ions is the amount of salt in the pore fluid. Figure 18 shows the relationship between salinity and pore fluids conductivity (1/resistivity) for different temperature values. The relationship between the bulk resistivity of the sediment, porosity and pore fluid resistivity may be described by the experimentally derived Archie's Law, which holds for most sediments with little clay content:

$$\rho_{bulk} = a\,\phi^{-m}\,S^{-n}\,\rho_{fluid}$$

Where ρ_{bulk} is the ρ_{fluid} resistivity of the seafloor and pore fluid respectively, ϕ is the porosity, S the pore fluid saturation, and a, m and n are constants, which range between 0.5-1.5 , 1.8-2.4 and ~2 respectively in marine sediments.

Typical seawater resistivity varies between 0.3 to 0.33 Ωm depending on seawater salinity and shallow marine sediments typical have a bulk resistivity of around 1 Ωm. Fresh water resistivity ranges between 1 and 100 Ohm, thus the bulk resistivity increases by a factor of 3 to 30 for fresh water saturated sediments.

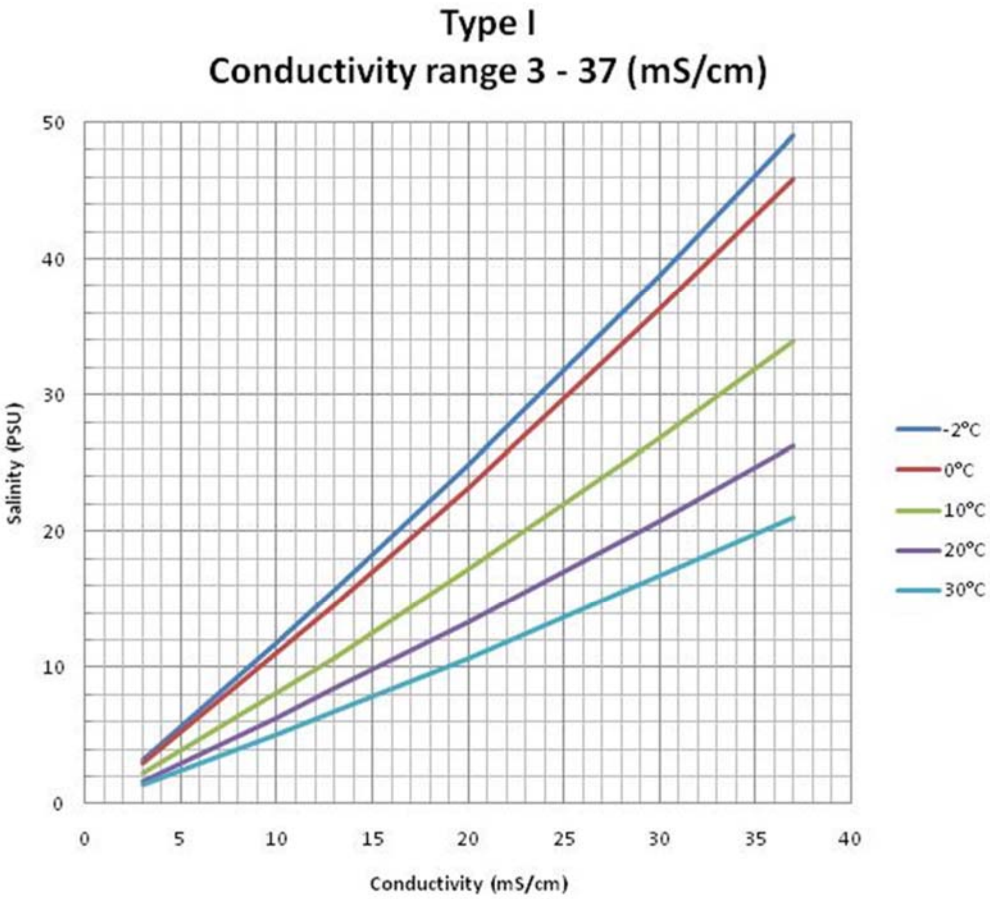


Figure 18: Pore fluid conductivity for different salinity values and temperatures.

Bulk electrical resistivity of marine sediments can be derived from CSEM data. For this, an electromagnetic wave is generated through a seafloor transmitter, which subsequently diffuses outward (Figure 19). The wave's diffusion speed and amplitude damping is a function of seawater and seafloor resistivity. The speed increases with increasing resistivity while amplitude damping decreases with increasing resistivity. Through monitoring the shape of the electromagnetic wave at different offsets, a resistivity model may be derived via inversion. The inversion is a statistical search process which identifies resistivity models with responses that fit well with the instrumented responses. Short offset data and early time signals are most sensitive to shallow structures, while long offset data and late time signals contain information about the deeper structures (penetration depth is about 1/3 of offset).

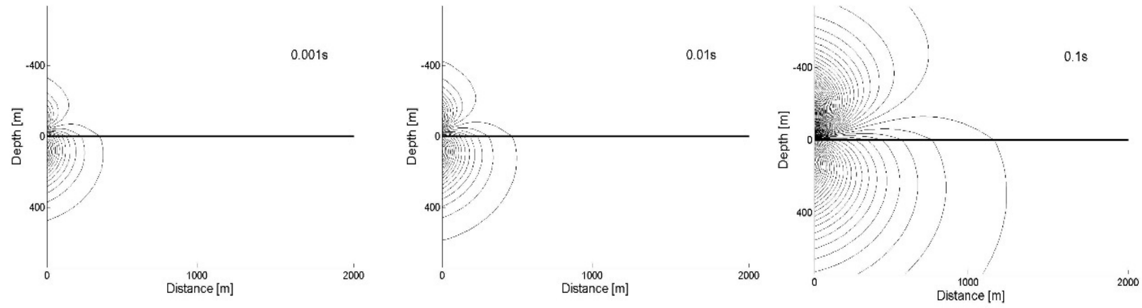


Figure 19: Snapshots of the propagation of an electrical dipole field, generated at the seafloor (black line) at 0.001, 0.01 and 1 sec after current switch on in transmitter dipole. The sea-layer and seafloor are assumed to be infinitely thick with resistivity of 0.3 Ohm and 1 Ohm respectively.

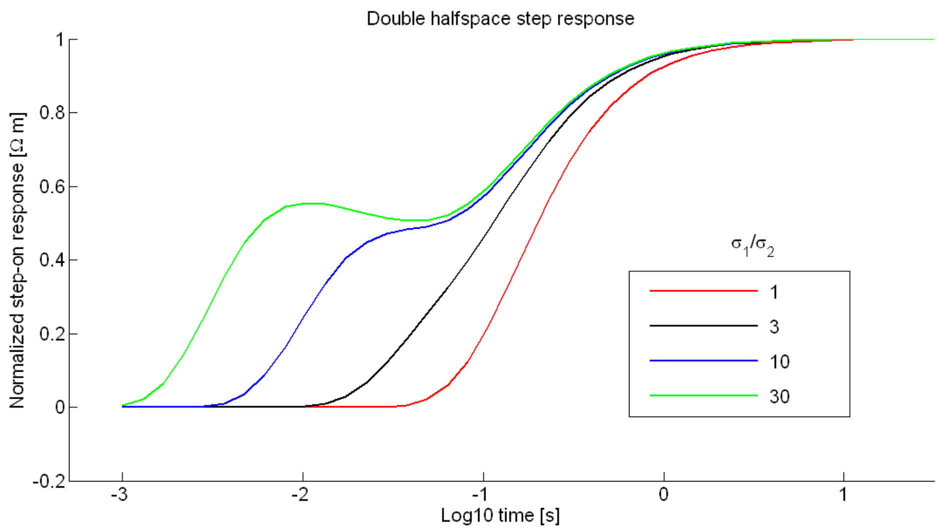


Figure 20: Electric seafloor dipole-dipole response for a switch on transmitter current wave form at 100 m transmitter-receiver offset. Response is shown for different conductivity contrasts between the seafloor (□2) and a subsurface layer (□1).

Figure 20 shows snap shots of the propagation of an electric dipole wave as created by the transmitter used in the experiment. The wave propagates faster through the more resistive seafloor than through the conductive sea-layer. The response as a function of time for a receiver 100 m away from the transmitter is shown in Figure 20 for sub-surface layer/seafloor conductivity (σ_1/σ_2) contrasts ranging between 1 and 30. The response changes significantly for different conductivity contrasts. For a high conductivity contrasts (e.g. high resistivity seafloor and a high conductivity sub-surface layer) the early arrival of the seafloor wave can be easily distinguished from the later time arrival of the sub-surface layer wave. If there is not a strong contrast the waves do not distinctly separate in time yet the transient is altered in amplitude.

Where CSEM measurements are performed in relatively shallow waters compared to the transmitter-receiver distance the so called airwave can have a big effect on the signal. For shallow oceans a fast or even the fastest path to the receiver may actually be through the sea-layer into the very resistive air and back through the sea-layer to the seafloor receiver. This airwave may mask other arrivals of waves through seafloor resistors and thus makes a visual qualitative interpretation of the data more difficult.

8.1.2 CSEM Instrumentation

The seafloor-towed CSEM System HYDRA developed by BGR is a modular electric dipole-dipole system consisting of a 100m long electrical transmitting dipole and 4 electrical receiving units (Figure 21). Each receiving unit (RX) consists of an autonomous, battery powered data logger mounted in a frame, and a receiving dipole being between 10 and 20m long. Transmitting dipole and receiving units are connected with rope at offsets from 150m to about 650m.

A stainless steel tow-body affectionately termed the "pig" is attached to the front end of the seafloor array. It has the function of a weight to keep the array on the seafloor and an instrument platform. For the MARCAN Project it will host the GEOMAR transmitter system that consists of three pressure cylinders containing the electronics being capable to transmit currents of up to 50A. The pig also contains a CTD sensor and an acoustic transponder. A mobile winch with 700m of opto-electrical cable is used to tow the array behind the ship.

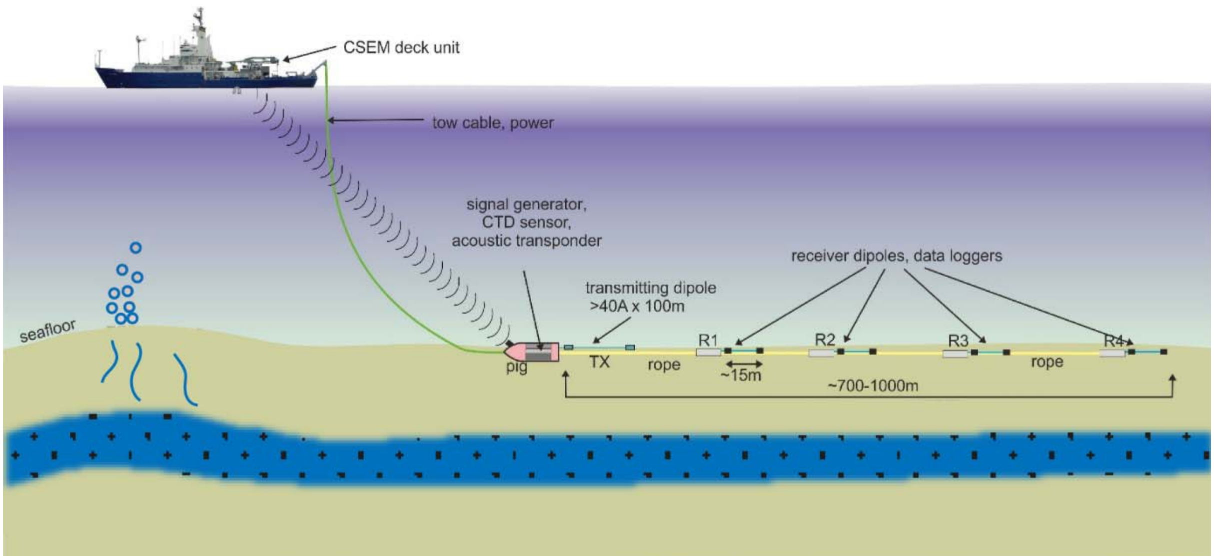


Figure 21: Experiment set-up of the towed electric dipole-dipole system used in this experiment.

8.1.3 Instrument Details

Winch and block.

The CSEM system is deployed and towed directly from its own self-contained electro-hydraulic tow winch that holds 700 m of 22mm diameter electro-optical cable with a peak tension load of 16 tons (Figure 22). For TAN1703 the winch has been welded to the aft deck at a distance of approximately 10m from the stern ramp. An 80cm diameter block with built in payout counter has been installed beneath the fantail on the aft of the ship (Figure 23).

Figure 22: Tow Winch used for the CSEM Survey

Figure 23: Block attached beneath fantail for the CSEM cable

The Pig.

The pig is a stainless steel casing with a weight of 400kg in the air constituting the front end of the electric dipole-dipole seafloor array. For the MARCAN experiment the pig hosts the pressure vessels with GEOMAR transmitter electronics, a CTD sensor and a Kongsberg Hipap acoustic transponder provided by NIWA (Figure 24).

The pig was deployed and recovered down the stern ramp using a combination of the ship winches (Gilson and Cod-end winch) and the CSEM winch (Figure 25).

Figure 24: Pig with open lid showing transmitter pressure vessels, CTD mounted inside its body and acoustic transponder in its nose.

Figure 25: Pig deployment and recovery proceedure

HYDRA Receivers

The HYDRA receivers are battery-powered low-noise data loggers recording the receiver dipole voltage with 22 bit ADC at a sampling rate of 10 kHz. The receiver electronic has been developed and built by MAGSON GmbH Berlin (Figure 26). A precise time signal is provided by Chipscale Atomic clocks, which are synchronized to GPS time prior to each deployment.

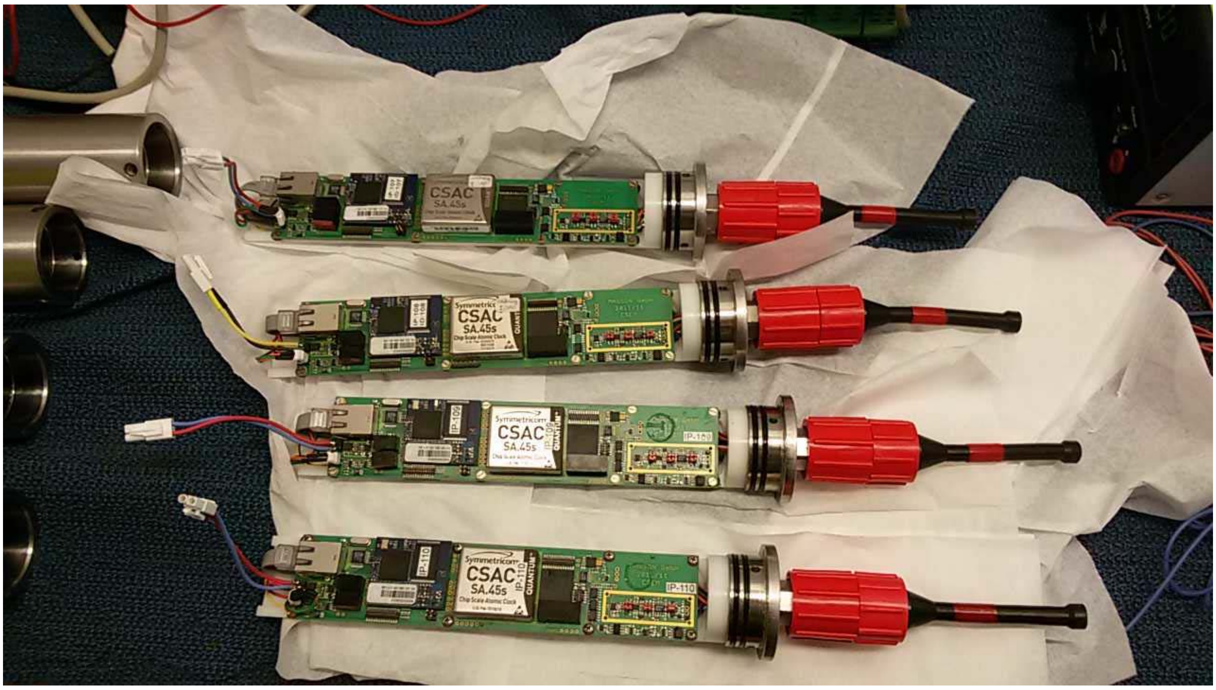


Figure 26: HYDRA Receiver Boards by MAGSON GmbH

GEOMAR Transmitter

The Geomar transmitter has been developed in-house and consists of a modem/data logger, an H-Bridges, three DC-DC convertes, data logger with modem and rechargeable lead gel batteries. It supplies up to 50 A current in a full or half duty cycle with variable length through copper transmitter current electrodes (Figure 27), which are separated in the experiment by 100 m distance (Transmitting dipoles Figure 21). The transmitter is linked to the ship by the winch cable, which serves as a power lead to the transmitter and also as a modem line to communicate real-time with the transmitter. The lead gel batteries serve as a power buffers to the transmitter and are recharged during transmission pauses. Like the receivers, the transmitter is synched to a very stable, chip-scale atomic clock. Maximum drifts observed over 24 hours were 0.2 ms. For safety reasons, the transmitter is switched on after it has been launched, usually at a water depth of approx.40 m, and is switched off before it reaches the water surface at recovery.

Figure 27: One of two transmitter electrodes

8.1.4 Instrument issues encountered during TAN1703

Payout Counter of Tow Winch

The payout counter of the tow winch provides wrong readings, probably due to the false installation of the counter on the block. Pay out readings have been compared with true cable length resulting in an error of about 14%. Thus, 100m on the payout counter compares with 114m measured cable length. Discrepancies remained between the offset recorded between the ship and Hipap transponder on the pig with an error in cable measurements of approximately 5%.

Mechanical connections

The eyes of connection ropes of the seafloor receivers have been damaged during the towing process. Connections were cut off and replaced through knots.
Jackets and Kevlar of the tow cable has been found damaged before CSEM-6 deployment at the pig ends due to sharp edges on the pig's nose. The area has been sealed with splicing tape and protected with tape and spiral wrap, and was functioning for deployment CSEM-6.

Power supply to Hydra Receivers

On deployment CSEM-5 and CSEM-8, the two far offset HDYRA receivers have stopped working. An investigation after the survey showed that the battery power supply to the logger has been disrupted shortly causing a reset of the receivers. Since the reset happened shortly after a tension peak in the cable during deployment CSEM-5 has been observed, we theorized that a seafloor obstacle has been encountered causing a jolt in the receiver housing. However, such a disruption occurred a second time during deployment CSEM-8.

8.1.5 CSEM Experiment

All together 7 CSEM profiles were acquired within this cruise during 9 deployments of the CSEM streamer (Figure 11). Two profiles required double deployments to complete (CSEM-1/CSEM-2 and CSEM-3/CSEM-6). The profiles cover the IODP drill area for calibration purposes, and extend north-east and south-west along the entire bight-shelf.

The survey lines were completed using the ships Dynamic Positioning system. The streamer was towed over the seafloor at a speed of between 1 to 2 knots between stations and then stopped at intervals of 200 m, 500 m or 1000 m depending on the targets for a few minutes to allow low noise data acquisition.

Pay out of the winch cable was set to approximately three time the water depths and adjusted accordingly during the profile. Table 3 lists an overview of the profiles acquired.

Table 3: Deployment start dates, waypoints and deployment details. Times in UTC, start time related to R4 in water, end time related to R4 out of water. Profile locations given in Figure 11

Start Date (UTC)	Deployment Information	Deployment Description
CSEM-1 08.04.2017	Start: 23:14 [UTC] End: 09:09 Duration: 9h 55min No. of Waypoints: 5	Profile parallel to IODP line, direction: SE – NW, Pig back on deck, short circuit in adaptor to tow winch connection, redeployment after repair. Sync signal lost on transmitter because of low buffer batteries caused by deck time Data on all receivers, but receivers are not synchronized with TX
CSEM-2 10.04.2017	Start: 22:38 [UTC] End: 21:32 Duration: 23h 54min No. of Waypoints: 67	Profile CSEM-1 continued in SE-NW direction, 500m offsets between waypoints Data on all receivers
CSEM-3 12.04.2017	Start: 00:08 [UTC] End: 13:00 Duration: 12h 52min No. of Waypoints: 44	Profile over IODP site 1353, in NW – SE direction, 200m offsets between waypoints. Deployment stopped due to weather conditions Data on all receivers
CSEM-4 14.04.2017	Start: 22:26 [UTC] End: 00:45 Duration: 26h 11min No. of Waypoints: 66	Profile in NW - SE direction, 500m offsets between waypoints Data on all receivers
CSEM-5 16.04.2017	Start: 22:45 [UTC] End: 01:20 Duration: 27h 05min No. of Waypoints: 80	Profile parallel to CSEM-4 in NW - SE direction, 500m offsets between waypoints Data on R1 and R2, R3 and R4 stopped recording at 23:58 and 00:00 before surveying started. Likely cause was a seafloor obstacle they run over which interrupted battery connection
CSEM-6 19.04.2017	Start: 00:40 [UTC] End: 09:10 Duration: 8h 30min No. of Waypoints: 28	Profile is completing line CSEM-3 in NW-SE direction, overlapping 2 last waypoints of line CSEM-3. Array was just on IODP site 1354 when survey was stopped due to worsening weather conditions. 200m offsets between waypoints. Data on all receivers
CSEM-7 24.04.2017	Start: 04:30 [UTC] End: 04:10 Duration: 23h:40min No. of Waypoints: 54	Profile constitutes a tie-line between profiles 1 and 3 SW-NE direction. 1000 m offsets between waypoints. Data on all receivers
CSEM-8 25.04.2017	Start: 11:40 [UTC] End: 09:10 Duration: 10h 30min No. of Waypoints: 79	Profile south of IODP site 1353. 500m offsets between waypoints. Data on R1 and R2, R3 and R4 stopped recording at two hours after surveying started.
CSEM-9 28.04.2017	Start: 08:10 [UTC] End: 11:00 Duration: 2h:50min No. of Waypoints: 5	Profile from IODP site 1353 in south-west direction. Acquisition had to be aborted due to electronic failure of the transmitter.

Transmitter Settings.

For all deployments, the same transmitter current setting was used. The transmitter dipole length was chosen as 100 m. A transmitter current waveform is switched on exactly 1 minute and subsequently switched off for recharge of the lead-gel batteries for 1 minute. This cycle of intermittent transmission is repeated for the entire survey time. During the on-time a half duty cycle with a period of 4 seconds has been chosen as a signal form (Figure 28). The current amplitude is +/- 19 A, yielding a dipole moment of the transmitter of 190 A m. A slight current-over shoot is observed at current switch on owing to electrical regulations delay in the DC-DC converters. However, the overshoot has no effect on the data.

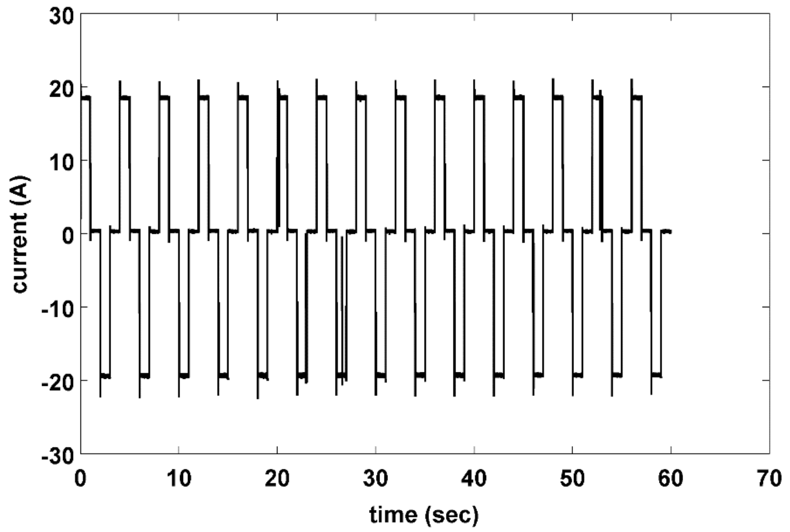


Figure 28: Transmitter signal during 1 minute on-time

Receiver Settings.

4 receivers have been used for the MARCAN experiment (B107 to B110). The dipole length of each receiver remained constant. However, the distance between receiver and transmitter dipoles changed slightly after deployment CSEM-5 due the fact that chafed eyes connecting parts of the transmitter had to be replaced. Detailed receiver settings are listed in Table 4.

Table 4: Overview of receiver IDs, gain factors, dipole lengths and transmitter-receiver offsets (dipole center to dipole center) for the respective deployments

Date (UTC)	R1	R2	R3	R4
CSEM-1 08.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 274.21	B109, gain 2 15.03m	B110, gain 2 19.95m
CSEM-2 10.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 274.21m	B110, gain 2 15.03m 401.37m	B109, gain 2 19.95m 649.32m
CSEM-3 12.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 273.19	B110, gain 2 15.03m 401.35m	B109, gain 2 19.95m 649.32m
CSEM-4 14.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 273.19	B110, gain 2 15.03m 400.35	B109, gain 2 19.95m 648.30
CSEM-5 16.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 273.19	B110, gain 2 15.03m 400.35	B109, gain 2 19.95m 647.57
CSEM-6 19.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 273.19	B110, gain 2 15.03m 400.35	B109, gain 2 19.95m 646.77
CSEM-7 24.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 272.26	B110, gain 2 15.03m 398.52	B109, gain 2 19.95m 644.94
CSEM-8 25.04.2017	B107, gain 0 10.53m 149.85m	B108, gain 1 14.85m 271.05	B110, gain 2 15.03m 396.48	B109, gain 2 19.95m 641.97
CSEM-9 28.04.2017	TBA	TBA	TBA	TBA

8.1.6 CSEM preliminary processing

Preliminary processing of selected way points on CSEM-2 and CSEM-4 was carried out for a qualitative assessment of the CSEM data. Figure 29 shows the preliminary processed data in terms of electric fields in V/m per unit dipole moment for the closest and furthest receiver to illustrate the signal record while moving and on station. Transients derived at different positions along one profile are consistent showing a change in saturation field for late times, which increases with decreasing water depths (Figure 30). The wave arrival shows variations along the profile but no dramatic changes, pointing to a relatively layered underground. There is a strong change in general characteristics though between data along CSEM-2 and CSEM-4. At CSEM-4 clear early arrivals point to a shallow resistive layer.

Figure 31 shows modelled responses for the short transmitter receiver configuration at 148 m offset. These theoretical responses are shown for different models and may serve as type curves for a first preliminary interpretation of the observed data. Responses are shown for two water depths (blue colors: water depth=80 m, red colors: water depth = 50 m). The seafloor model consists of a conductive 1 Ωm back ground onto which a 100 m thick resistor with a resistivity of 1000 Ωm is imposed. Solid, dashed and dotted line show the response where the top of the resistor is at 10m, 20m and 40m below seafloor. The cyan and magenta lines show responses for a resistor with a resistance of 10Ωm and a top at 10 m depth. It is evident that the water depth as well as seafloor resistivity exert first order control on the response at late times. At early times however, shallow resistors (at 10m up to 40m depth) cause an early arrival before the air wave, the signal is independent of water depth (solid blue and red line coincide up to about 1 ms). If the shallow resistor has a less pronounced anomaly (10 Ωm instead of 1000 Ωm), the arrival occurs somewhat later, however still at such early times that it is not influenced by the air wave (magenta and cyan line coincide at early times). Going back to the observations along CSEM-2 and CSEM-4 we can conclude based on the type curves, that early signal arrivals may be interpreted independent of the changing water depth along the profile. While only weak early arrivals are visible in the data along CSEM-2, stronger and earlier arrivals are observed along CSEM-4. The change in character between the early arrivals suggests, that a stronger resistive shallow anomaly is present underneath CSEM-4. The anomaly may be associated with the presence of fresh water, however may also be caused by a gas saturated pore space. The existence of the latter is indicated by the presence of gas flares in the water column imaging as well as blanking in the TOPAS data.

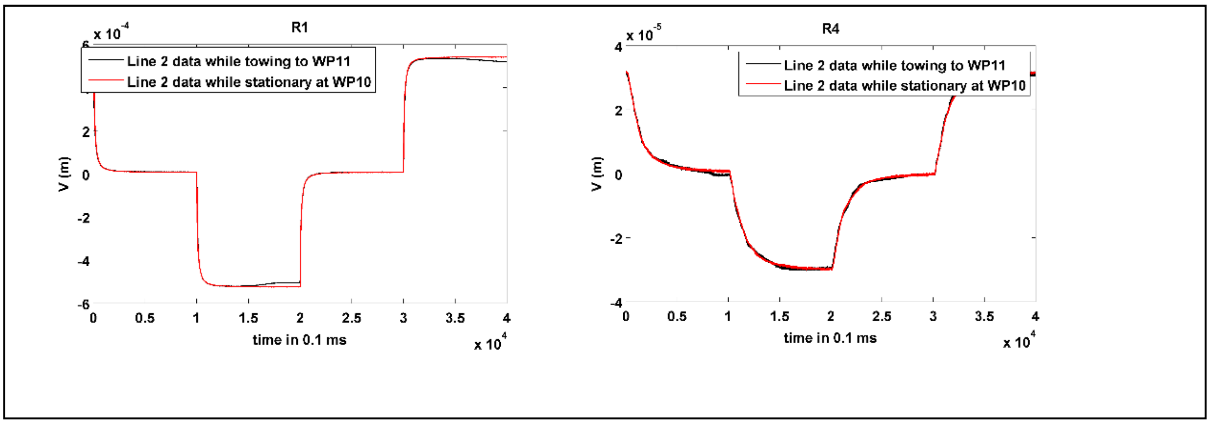


Figure 29: Data example at WP10 and WP11 on CSEM-2 illustrating the difference between data collected while towing and data collected on station. Left panel shows receiver 1 (offset = 149

m) and right panel shows receiver 4 (offset = 646 m). The data shown is a stack of 15 duty cycles recorded during a minute while the transmitter is on. Only a slight deterioration of data quality is visible in this particular data comparison, however, noise levels might increase in other parts of the profile depending on winch angle, wave motion, cable pay-out, seafloor condition and towing speed.

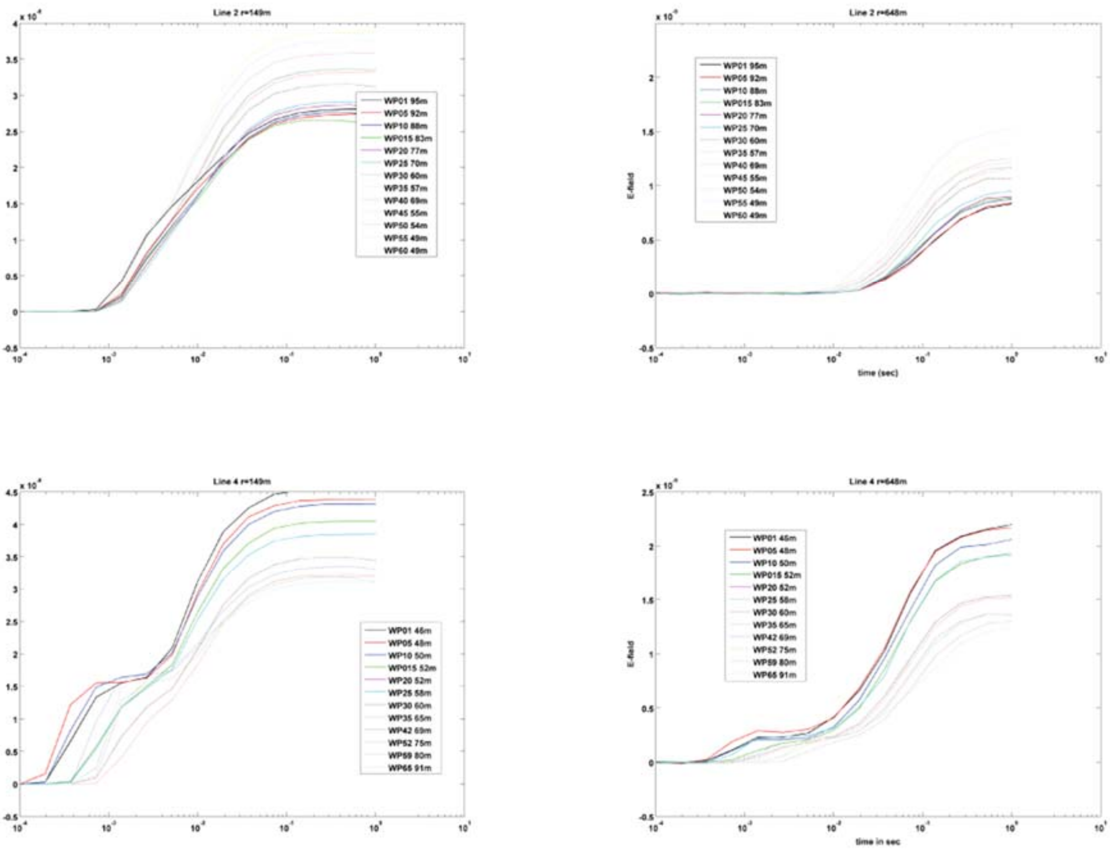


Figure 30: CSEM data stacks at different weigh points for transmitter switch-on transients on profile 2 (top panels) and profile 4 (lower panels). The left two panels show RX1 data at 149 m distance from transmitter, and right two panels show RX4 data at 648 m distance.

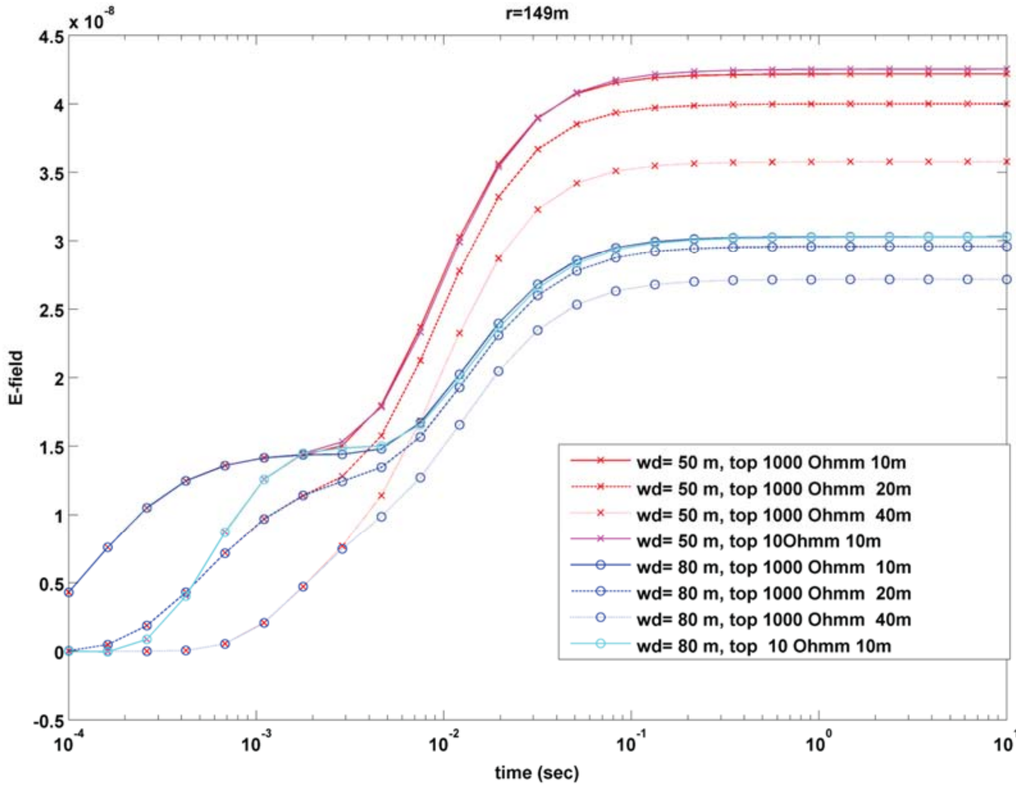


Figure 31: Responses for models with two different two water depths (blue colors: water depth=80 m, red colors: water depth = 50 m). The seafloor model consists of a conductive 1 Ωm back ground onto which a 100 m thick resistor with a resistivity of 1000 Ωm is imposed. Solid, dashed and dotted line show the response where top of the resistor is at 10m, 20m and 40m below seafloor. The cyan and magenta lines show the response for a resistor with a resistance of 10Ωm at 10 m depth.

8.1.7 Pig-mounted CTD

The CSEM ‚pig' has been equipped with a Seabird SBE37 CTD. The instrument is time synchronized with GPS before deployment and records autonomously electrical conductivity and depth information during the CSEM data acquisition. Knowledge of these parameters is essential for electromagnetic data inversion, since the electromagnetic wave propagating through the sea-layer has a strong effect on the data. Precise knowledge and consideration of the sea-layer parameters will enhance the precision of the derived seafloor resistivity variations. In the context of this project, the data will also help to identify seafloor regions with low salinity, which might be indicative of potential ground water seepage area.

The CTD has been merged preliminary with navigation data of the Kongsberg Hipap acoustic transponder, which has also been attached on the pig, via time marks. It should be noted here, that the merging is preliminary since some problems with the navigation recording via OFOP existed that needed to be corrected by hand. No sensible merge of CTD and navigation data could be derived for Line 1, either due to problems in the navigation or ctd files. Due to a power failure on the CTD no data has been acquired along Line 6. Some preliminary analysis of this data is presented in Section 9.5.1

8.2 EM2040 Multibeam

The EM2040 multibeam echo-sounder is a high resolution seabed mapping system for water depths down to 500 m. This echo-sounder operates at bandwidths from 200 to 400 kHz, across track coverage of about 5.5 times water depth (depending on depth and mode) and a maximum ping rate of 50 Hz. The system dynamically applies beam focusing to both transmit and receive functions in order to obtain the maximum resolution inside the acoustic near-field. The transmit beams are electronically stabilised for roll, pitch and yaw, while the receiver beams are stabilised for roll movements. As configured on *RV Tangaroa*, the EM2040 is a single RX system, with 256 beams (or 576 beams in dual swath mode), yielding 400 soundings (or 800 soundings in High Density mode). Detailed specifications of the EM2040 system are shown in Table 5.

Water column data, which show the received amplitude of the entire water column for each beam, were recorded simultaneously with the multibeam echo-sounder data.

Seafloor Information System (SIS) version 4.3.2 was the real-time software application used on board the vessel for multibeam data acquisition. This software includes the necessary features for running and operating the multibeam system. It includes extensive tools for visualising the sounding data as well as the seabed image data, and enables checks on system calibration and data quality to be made in real-time.

Table 5: Summary of EM2040 operating parameters for TAN1703.

Type of Instrument	EM2040
Frequency	200 or 300 kHz user defined, 200 kHz> 100m bottom depth, 300 kHz < 100m bottom depth
Maximum ping rate	50 Hz
Beam spacing	HD Equidistant Beam Spacing
Angular coverage mode	Manual set to 65/65
Number of beams per swath	256
Number of swaths per ping	2, giving a total of 512 beams per ping
Number of soundings per ping	800
Nominal depth range from transducers	10 – 500 m, with typical values for this survey of 20 – 300 m
Beamwidth	0.4 – 0.75 degrees depending on frequency
Coverage	1000 m nominal max (500 m each side, fixed for this survey), ranging from 80 to 1000 m for this survey, with a typical value of approximately 300 m (150 m / side)
Coverage sector	65 degrees per side maximum (fixed for this survey)
Depth resolution	0.25 % of water depth
Ping mode	Manual: 200 or 300 kHz, depending on depth for this survey
Beam forming method	Medium CW < 200m, FM > 200m
Range sampling rate	Up to 60 kHz
Pulse length	Shortest 25 µs
Dual swath	Dynamic
Pitch stabilisation	Enabled
Auto-tilt	Off

During TAN1703, the EM2040 multibeam system generally collected excellent data; however, there was a noticeable heave artefact in the bathymetry data. POS data were recorded during the survey and it is anticipated the heave effect on the data will be corrected in post-voyage data processing. Line orientation and survey scheduling were often focussed on CSEM and seismic survey objectives where swath data was also collected, primarily for the water column data. As a result bathymetry and water column data are collected on turns, perpendicular to, and on occasion over existing swath lines.

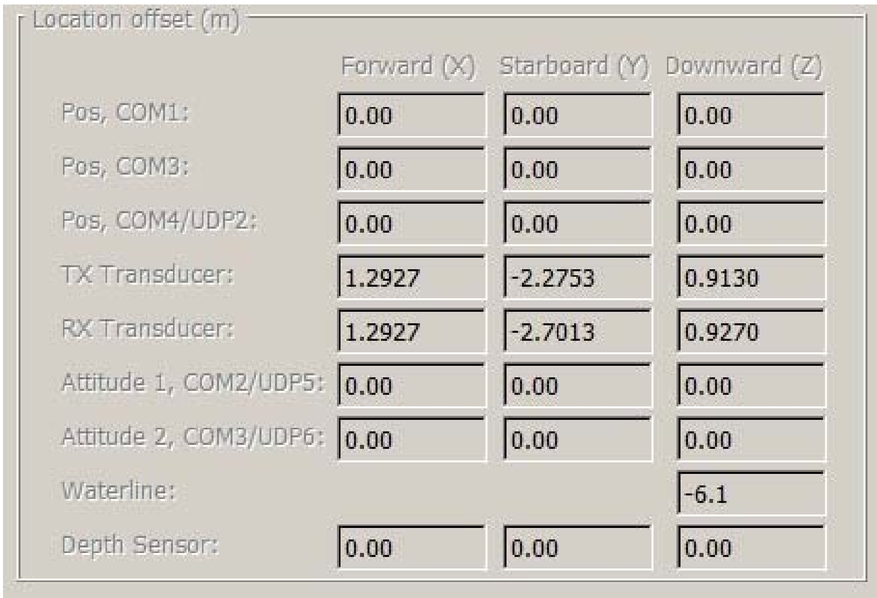
8.2.1 Motion sensors

Throughout TAN1703, a single Applanix POSMV V5 unit was in operation. This system interoperates the data coming from the GPS, Gyros, and MRUs. Lever arms are then applied to these sensor readings to convert them to an established reference point known as the "new keel reference point". This reference point is then used by the EM2040, EM302, and TOPAS when calculating their respective attitude values. The POSMV supplies a pitch and roll accuracy of 0.027°, a heading accuracy 0.022°, and a heave accuracy of +/- 5cm or 5% of the observed heave.

8.2.2 EM2040 Calibration

As a consequence of mounting the Kongsberg EM2040 MBES for the first time on *RV Tangaroa* a calibration of the system was necessary. The calibration was carried out on the wreck of the MV *Jubilee* (42°21.18'S, 174°46.81'E) on Sunday 9th April 2016 by means of a patch test. Weather conditions during the calibration were good with variable winds, 5-10 knots, and c 1 m swell.

Offsets between the Tx and Rx transducer arrays of the EM2040 MBES and the reference point are applied in the SIS acquisition software (Figure 32).


Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	0.00	0.00	0.00
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	1.2927	-2.2753	0.9130
RX Transducer:	1.2927	-2.7013	0.9270
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			-6.1
Depth Sensor:	0.00	0.00	0.00

Figure 32: Sensor setup of the EM2040 MBES

The offsets between the positioning antenna and the reference point are applied in the POS/MV. The POS/MV outputs position and attitude at the reference point. Lever Arms and Mounting Angles of the IMUs are shown in (Figure 33).

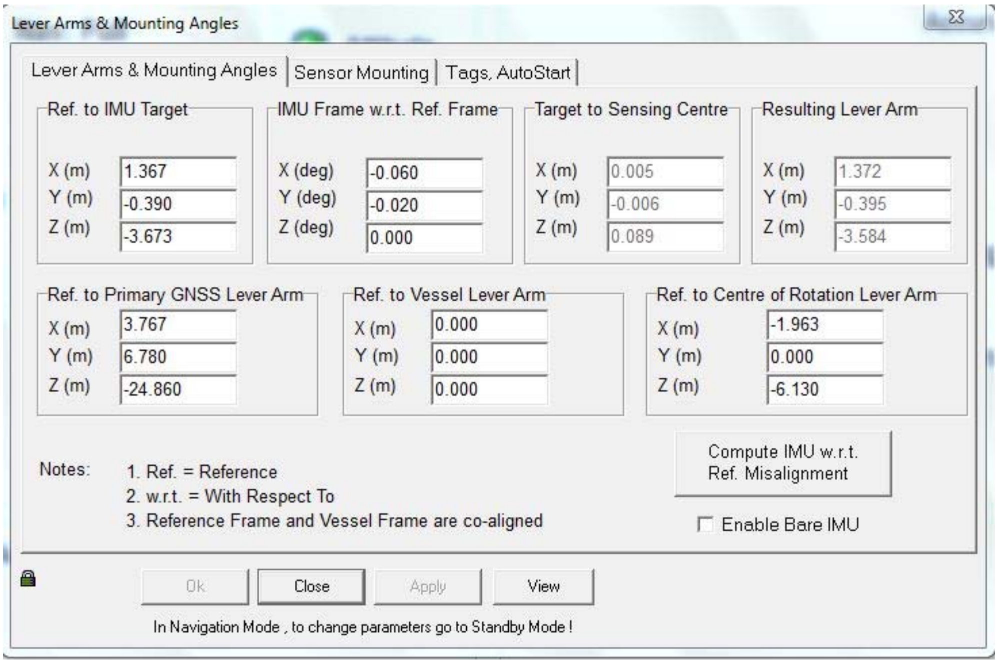


Figure 33: PosMV Lever Arms & Mounting Angles

An SuPlus V2 probe was used to collect a sound velocity profile of the water column for the Pitch, Roll and Heading calibration tests.

Pitch

The pitch tests was undertaken over the wreck of the MV *Jubilee* in the following manner: Two reciprocal collinear lines were surveyed orthogonal over the edges of the wreck. These lines were analysed for pitch offset in the EM2040 MBES using the Kongsberg SIS calibration tools (Figure 9-11) showed a pitch offset of 1.7°.

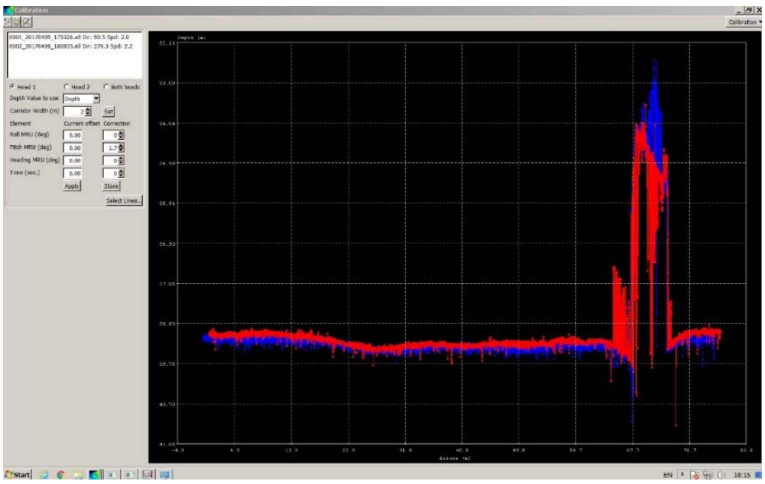


Figure 9-11: Pitch test showing a pitch offset of 1.7° applied.

Roll

The roll test was undertaken over a flat area in the vicinity of the wreck of the MV *Jubilee*. Two collinear lines were run. The lines were analysed in the Kongsberg SIS & CARIS HIPS 9 calibration modules, showing a roll offset of 0.26° (Figure 34).

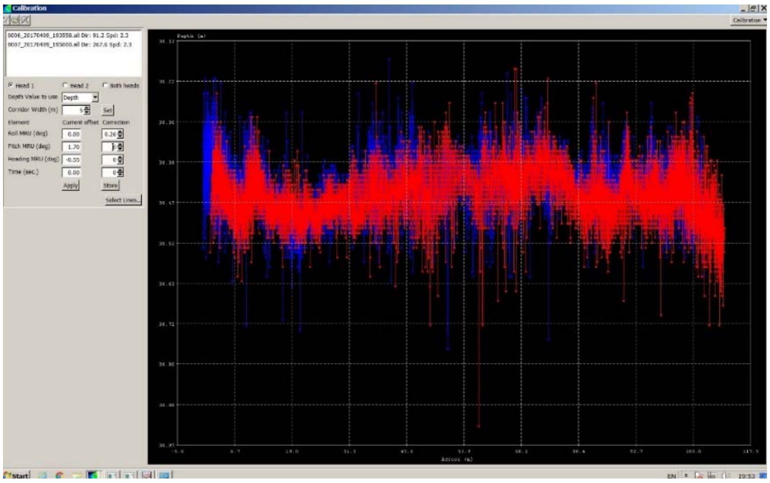


Figure 34: Roll test showing a roll offset of 0.26° applied

Heading

Heading tests were conducted over the wreck of the MV *Jubilee*. Two parallel lines were surveyed in the same line direction across the wreck. The data was analysed in the region of overlap between the two lines using the Kongsberg SIS & CARIS HIPS 9 calibration modules. The test showed a heading offset of -0.55° (Figure 35).

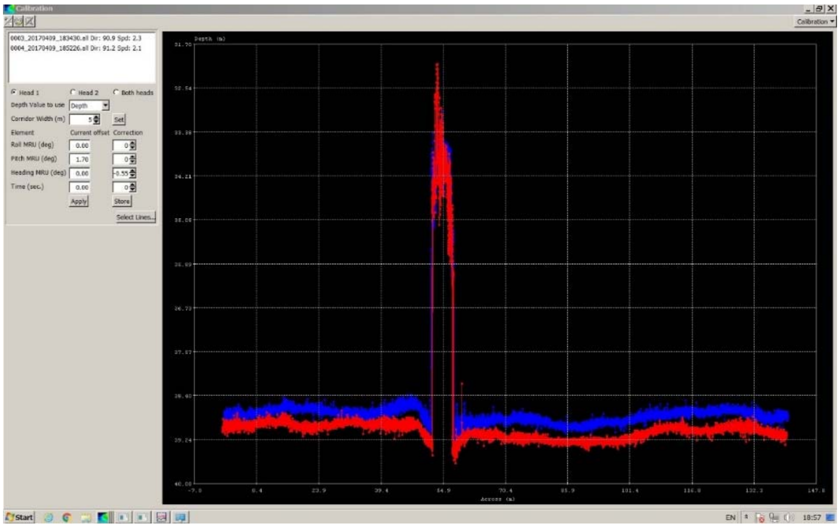


Figure 35: Heading test showing an offset of -0.55° applied

Calibration Results

On completion of the calibration of angular offsets the required offsets for the EM2040 MBES were as shown in Figure 36.

Figure 36: Angular Offsets after calibration

8.2.3 EM2040 bathymetry and backscatter processing

Raw bathymetric data were acquired using a Kongsberg EM2040 multibeam system running Seafloor Information System (SIS) version 4.3.2 Files of soundings (*.all files) from each completed file were imported into CARIS HIPS version 9.1 software for initial processing. A standard CARIS workflow was followed prior to the generation of field sheets and digital elevation models (DEMs). The process involved the following steps:

1. Conversion: HIPS and SIPS files are created from the survey data (*.all files).
2. Load tides: A zero-tide was applied initially on board to the bathymetric soundings. Subsequent processing on land will use a tidal correction.
3. Merge: This component of the processing includes calculating the final geospatial positions and corrected depths for soundings, based on observations such as raw depths, navigation information, vessel motion (gyro, heave, pitch and roll) and tide.
4. Calculate TPU: Total Propagated Uncertainty (TPU) is derived from a combination of all individual error sources, and calculated using error values specified in the RV *Tangaroa* vessel file.

The bathymetry data were examined and cleaned in CARIS HIPS line-by-line basis in the Swath Editor tool. Bathymetric soundings that represented gross errors or obvious noise were manually rejected.

A field sheet was created to cover each of the survey targets. Within each field sheet, the bathymetry data were gridded into a Bathymetry Associated with Statistical Error (BASE) surface at a 25 m-grid resolution (for the shelf surveys) using the Combined Uncertainty Bathymetric Estimation (CUBE) tool. The BASE surface is a georeferenced TIFF representation of the seabed derived from processed bathymetry and computed uncertainty (error) values. When a CUBE surface is created, soundings are weighted and contribute to surface grid nodes based on TPU values and distance from the nodes. The CUBE surface allows for multiple depth estimates or hypotheses to exist at a single grid node, depending on variability of the sounding data. CUBE uses a "Disambiguation" function to determine which hypothesis at each node is the most statistically robust.

The multibeam echo-sounder data were pre-processed on board using Caris software (version 8.1.9), which provides the tools for manual and automatic multibeam data processing and quality control.

Bathymetric data processing accounted for total propagated uncertainty and basic quality control. Noise in the multibeam bathymetry data resulted from high swells during unfavourable weather conditions. Backscatter data were also corrected for beam pattern, gain, time varied gain, angle varied gain, speckle, brightness and contrast.

8.2.4 EM2040 Water column

The water column data logged by the EM2040 system were visualised using the *Fledermaus* Mid-water software tool. The data were generally of good quality, apart from the presence of a pattern of interference with other acoustic sources evident in the shallow shelf data, and a few disrupted pings on some lines where beams were blanked out due to ship movement or bubble-sheeting of the transducer face due to bad weather. Several flare, or gas seep, sites were identified in 2-dimensional, along-track curtain views, generated from horizontal stacking and ordering of the acoustic return data for each echogram.

8.3 EM302 Multibeam

8.3.1 System setup

The EM302 multibeam echo-sounder is a high resolution seabed mapping system for water depths down to 7000 m. This echo-sounder operates at a frequency of 30 kHz, with an angular sector of 140°, across track coverage of 3-5 times water depth (depending on depth and mode) and a maximum ping rate of 10 Hz. The system dynamically applies beam focusing to both transmit and receive functions in order to obtain the maximum resolution inside the acoustic near-field. The transmit beams are electronically stabilised for roll, pitch and yaw, while the receive beams are stabilised for roll movements. As configured on RV *Tangaroa*, the EM302 is a 1° TX by 1° RX system, with 288 beams (or 576 beams in dual swath mode), yielding 432 soundings (or 864 soundings in High Density mode). System operating parameters for the EM302 during TAN1703 are given in Table 6. Throughout TAN1703, two Applanix POSMV V5 motion sensors were run concurrently, and their differentials monitored. These sensors have a Pitch and Roll accuracy of 0.02°, a Heading accuracy 0.02°, and a Heave accuracy of +/- 5cm or 5% of the range.

Water column data, which show the received amplitude of the entire water column for each beam, were recorded simultaneously with the multibeam echo-sounder data.

Seafloor Information System (SIS) version 4.2.1 was the real-time software application used on board the vessel for multibeam data acquisition. This software includes the necessary features for running and operating the multibeam system. It includes extensive tools for visualising the sounding data as well as the seabed image data, and enables checks on system calibration and data quality to be made in real-time.

Table 6: Summary of EM302 operating parameters for TAN1703.

Type of Instrument	EM302
Frequency	30 kHz
Maximum ping rate	Auto / set by K-Sync when in combination with TOPAS sub-bottom profiler and ES60 single-beam
Beam spacing	HD Equidistant Beam Spacing
Angular coverage mode	Auto
Number of beams per swath	288
Number of swaths per ping	2, giving a total of 576 beams per ping
Number of soundings per ping	864
Nominal depth range from transducers	10 – 7000 m, with typical values for this survey of 22 – 1970 m
Beamwidth	1.0 x 2.0 degrees
Coverage	8000 m nominal max (4000 m each side, fixed for this survey), ranging from 80 to 7600 m for this survey, with a typical value of approximately 2800 m (1400 m / side)
Coverage sector	65 degrees per side maximum (fixed for this survey)
Depth resolution	0.25 % of water depth
Ping mode	Auto: Shallow, Medium and Deep, depending on depth for this survey
Beam forming method	CW (FM disabled)
Range sampling rate	45 kHz
Pulse length	Auto 5 ms
Dual swath	Dynamic
Pitch stabilisation	Enabled
Auto-tilt	Off

8.3.2 EM302 bathymetry and backscatter processing

Raw bathymetric data from Seafloor Information System (SIS) version 4.2.1 (*.all files) from each completed file were imported into CARIS HIPS version 9.1 software for initial processing. A standard CARIS workflow was followed prior to the generation of a digital elevation model (DEMs). The process involved the following steps:

5. Conversion: HIPS and SIPS files are created from the survey data (*.all files).
6. Load tides: A zero-tide was applied initially on board to the bathymetric soundings. Subsequent processing on land will use a tidal correction.

7. Merge: This component of the processing includes calculating the final geospatial positions and corrected depths for soundings, based on observations such as raw depths, navigation information, vessel motion (gyro, heave, pitch and roll) and tide.
8. Calculate TPU: Total Propagated Uncertainty (TPU) is derived from a combination of all individual error sources, and calculated using error values specified in the RV *Tangaroa* vessel file.

The bathymetry data were examined and cleaned in CARIS HIPS line-by-line basis in the Swath Editor tool. Bathymetric soundings that represented gross errors or obvious noise were manually rejected.

Bathymetric data processing accounted for total propagated uncertainty and basic quality control. Noise in the multibeam bathymetry data resulted from high swells during unfavourable weather conditions. Backscatter data were also corrected for beam pattern, gain, time varied gain, angle varied gain, speckle, brightness and contrast.

8.4 Sound velocity profiles for multibeam echosounders

5 sound velocity profiles were obtained during TAN1703 to calibrate and correct travel-times and water depth for the EM203 and EM2040 instrument Table 7. An AML Smart Probe Minos.X (serial no. 30195) system was used for 170408a. An SuPlus V2 (serial no. 3604) was used for the remaining SVP casts.

Table 7: Date, time, position and depth of the five sound profiles obtained during TAN1703

File name	Date	Time (UTC)	Position		Profile depth (m)
			Latitude (S) decimal degrees	Longitude (E) decimal degrees	
170408a	08/04/2017	23:15	42.0°	174.0°	544
170409c	09/04/2017	04:23	44.6°	172.2°	29
170412a	12/04/2017	20:19	44.6°	171.4°	41
170416a	16/06/2017	13:19	44.6°	172.0°	85
170420a	20/06/2017	01:07	44.6°	172.7°	189

8.5 TOPAS Sub-Bottom profiler

This survey used a TOPAS PS 18 Parametric Sub-Bottom Profiler (SBP), which is permanently mounted to a pod on the ship's hull and controlled with software by the multibeam operators.

The transmitted waveform used throughout TAN1703 was a linear chirp (LFM). The chirp frequencies used throughout the survey were 2.0 to 6.0 kHz, with a chirp length of 15 ms on the shelf (depths less than approximately 200 m). Transmitter output level was set to 0 dB, providing a manufacturer's maximum output level of 100%.

The TOPAS PS 18 beam is stabilised for heave, roll and pitch movements via motion data fed from the POSMV. In addition, a “Master depth” is provided from the EM2040 MBES to aid the “bottom track” function. The acoustic beam can also be steered manually or automatically – when slope is available from the multibeam echo sounder system – to take into account bottom slope. Both of these methods were employed during TAN1703 to optimise results. TOPAS operating parameters are given in Table 8.

Table 8: TOPAS operating parameters

Control	Setting	Comment
Trigger mode	External (K-Sync)	
Pulse form	Chirp (LFM)	
Chirp frequency	2.0–6.0 kHz	
Chirp length	15 and 20 ms	Optimised for bottom type and water depth
Transmitter output level (power)	0 dB (max)	
Heave/Roll/Pitch (HRP) stabilisation	Auto	From primary POSMV
Delay control	Automatic	Set to manual only if bottom-lock is lost
Upper / Lower delay	10% / 50%	
Delay offset	0 ms	
Sample rate	40 kHz	
Trace length	300 ms	
Gain	0 dB, very occasionally 3 dB	Optimised for bottom type and water depth
High-pass filter	1.0 kHz	
Sound speed	Referenced to EM2040 velocity sensor (typically 1514–1515 m/s)	Stand-alone underway AML sensor in bow-thruster room
Processing		
Bottom tracker	Enabled	
Filters	Matched, Corner frequencies High Res	
Gain (digital)	Auto (typically 0–12), or adjusted manually to obtain best display	Optimised for bottom type and water depth
Time-varying filter	Disabled	
Time-varying grain	Bottom-tracked Offset -1 ms Typical ramp A–B: length 4.3 ms, slope 3.86 dB/ms B–C: length 9.0 ms, slope 0.56 dB/ms C–D: length 20.1 ms, slope 0.08 dB/ms	Optimised for bottom type and water depth
Attribute processing	Instantaneous amplitude	

8.6 2D Multichannel Seismic Reflection (MCS) System

8.6.1 Equipment and Acquisition Setup

The MARCAN MCS survey used 3 active solid-state sections of the GeoEel Digital seismic streamer (Geometrics) consisting of 24 channels with a group interval of 12.5 m. Offsets of 22 m and 308 m for first and last channel, respectively, were changed at Line3a to 61 m and 348 m and maintained for the rest of survey A. Digicourse “birds” were used to support a streamer depth at 2.5 m.

The seismic source was a single mini GI-gun (13/35 cu inch) towed in 1.5 m depth. The gun floatation was provided by a mussel float.

Figure 37 shows the streamer and source setup. All survey parameters and geometry values can be found in Table 9.

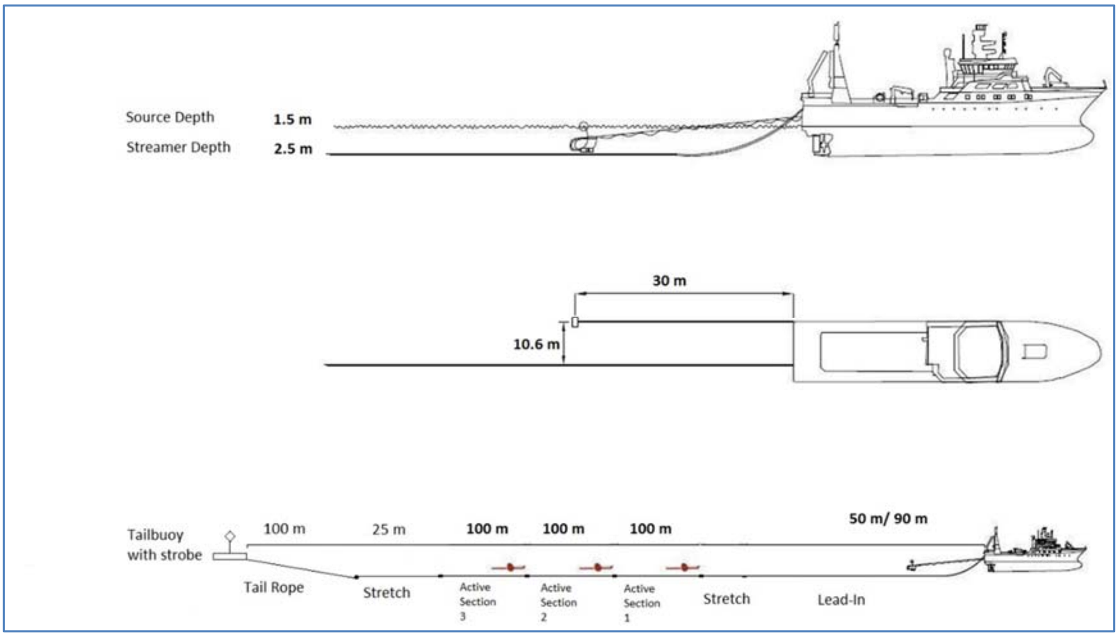


Figure 37: Streamer and Source setup and geometry used for the seismic surveys.

The CompAir Reavell 5000 compressor was used during both seismic surveys with a combined runtime of almost 100 hours, constantly providing between 1800 and 2000 PSI (124 - 138 bar) for nearly 100000 airgun blows. Manual dumps of condensate from the 2^{nd}, 3^{rd}, and 4^{th} stages of the compressor and from the accumulator tank were carried out every 30 minutes by the seismic watch-keeper and the stage temperatures, oil pressure, and air pressure readings at these times were recorded.

The dry components of the seismic acquisition system consisted of the GeoEel deck unit, the trigger unit, the bird controller, the acquisition computer and the navigation computer. The HydroPro navigation software from Trimble was used to merge DGPS position provided by POSMV through DAS (POSMV fwd antenna accurate to +/- 0.4 m) and streamer geometry information into a format that could be easily interpreted by the seismic watch-keepers. A serial string containing smoothed ship's navigation and interpolated gun position was fed from the navigation computer into the acquisition computer to be logged with the SEG-D files. An example of the string follows, showing the shot/file number, time, date, ship and gun positions, ship heading and speed:

```
Record=1008, User_string=110708.026,20042017,Ship,43.968382 S,172.278943
E,Gun,43.968053 S,172.278283 E,Heading_true,118.50,Ship_SOG,4.05,Tow,
$$$$$,$$$$$$
```

A schematic of the complete seismic acquisition setup including wet and dry components is shown in Figure 38.

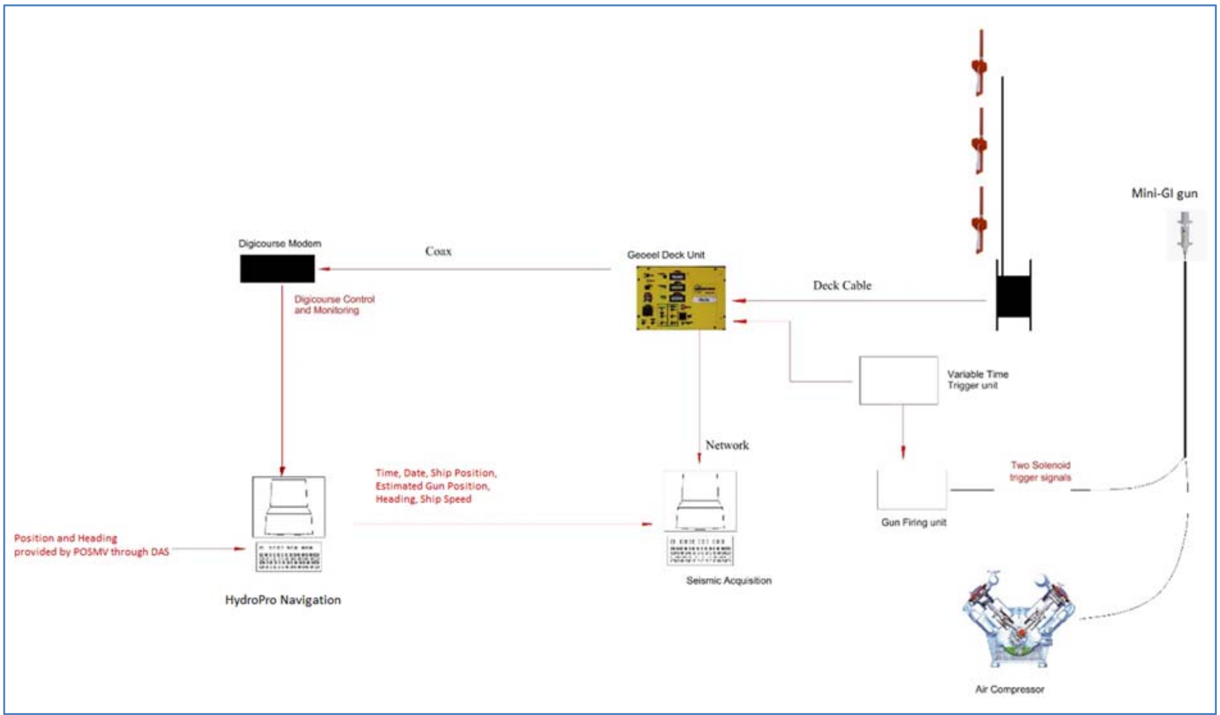


Figure 38: Complete seismic acquisition setup with wet and dry components.

8.6.2 Seismic Surveys

The seismic equipment was used in two different surveys, totalling around 92 hours, c 100000 fired shots and 603 line km of recorded seismic data.

Prior to gear deployment and recovery, tool box meetings were carried out. After reducing ship's speed to 2 knots and turning the ship into the wind the streamer was launched into the water, beginning with the solar light-equipped tail buoy. Three Digicourse birds were attached without at the beginning of each active section of the streamer, which was then moved to the starboard stern side into a snatch block to begin testing prior to surveying. The distance of the streamer behind the ship was estimated by counting the turns on the winch and calculating the circumference (winch diameter 1.2 m). After testing the streamer for connection and leaks, the airgun was lowered into the water by hand from the trawl deck level and also tested. Upon testing and configuring the survey with the desired parameters, the bridge was informed to proceed towards the given waypoints and surveying started with 4 knots ship's speed. During the surveys the gear was recovered several times to change bird's batteries or remove kelp from birds and/or the tail buoy. Two small boat operations

All deployments and recoveries went smoothly and without incident. Communications between seismic chief and bosun/leading hand was done via radio. Safety gear, including glasses, gloves and ear protection, was worn during all deployments and recoveries.

Two people were on watch in the hydro dry-lab during seismic data recording to always ensure data quality during the acquisition. This meant constantly watching all sub-windows on the acquisition software and half-hourly entries in the logbook, checking birds, leakage and to undertake the compressor checks. During rougher weather and at night time, a visual check out the stern of the vessel was added to look for anything suspicious. Also at night time during tight portside turns, visual control over possible entanglement of streamer and airgun was carried out by one person, observing out over the ship's stern and carrying a radio for rapid communication with the bridge. Figure 39 shows a screenshot of the acquisition window.

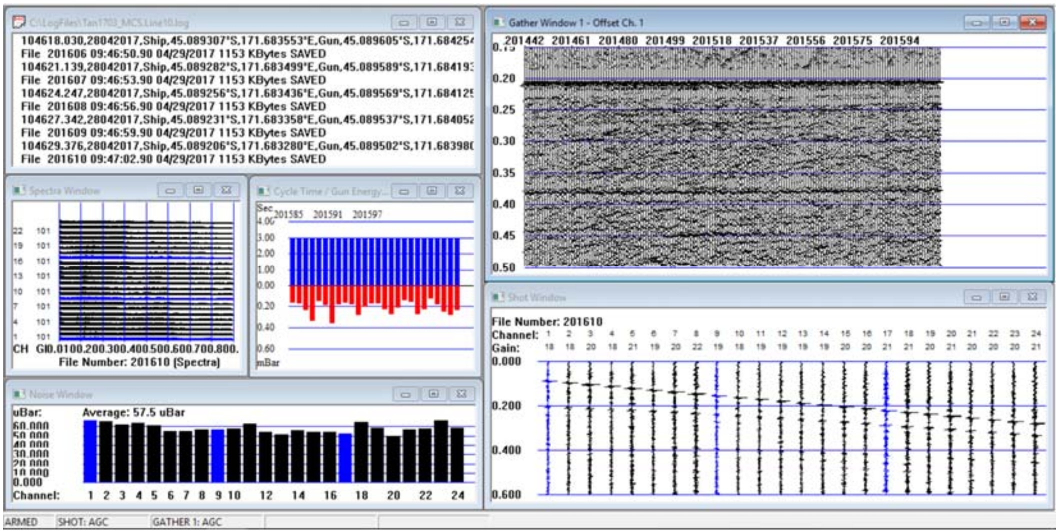


Figure 39: Screenshot of acquisition window. Sub-windows showing, clockwise starting from top left: incoming serial strings and file/shot number, seismic gather of a single channel, 48 channels of a single shot with noise/signal defining polygons in red and green, respectively, noise window as a bar graph of RMS amplitude of each channel, and cycle time and gun energy in blue and red, respectively.

The Bird controller allows for defining the bird position along the streamer and depth settings. Figure 40 shows a screenshot of the bird controller window with 3 birds deployed at 2.5 m depth.

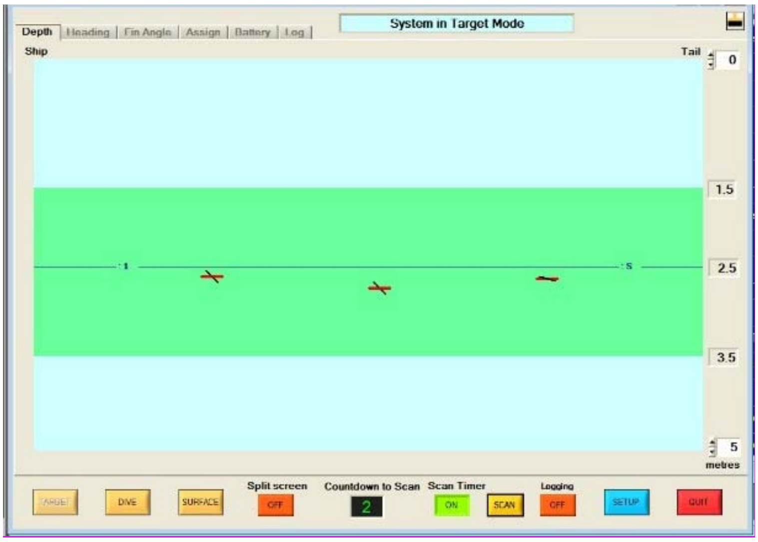


Figure 40: Screenshot of bird control. Birds are attached at the beginning of each section, set to the desired depth and monitored regularly.

The overall quality of the acquired data is good. Figure 39 shows a screenshot of the acquisition window taken during the second survey. Weather conditions were rougher than during the first survey with 2-3 m long period swell and an additional short period chop. While shot gather and single channel gather show good data quality, relatively high noise levels in the noise window (averaging around 60 µBar) are observed. Given the very shallow water depth in this survey, direct arrival and seafloor reflection are very close together which made it impossible to locate the noise measuring window between direct arrival and the seafloor reflection. Instead the noise was measured above the direct arrivals which in general gives higher values.

Table 9 shows seismic survey parameter and geometry settings for all three surveys. For detailed information about change of parameters, i.e. depth of streamer and seismic record length, refer to the table with seismic log sheets in Appendix D.

Table 9: Parameter and geometry settings for TAN1703 seismic surveys.

Item	Value 1	Value 2	Value 3	Comments
Source to GPS	30 + 34 m			Behind vessel + on board to GPS
Source to 1st channel	20 m	60 m	100 m	x-offset
Offset between Source and Streamer	10.6 m			y-offset
1st channel behind boat	50 m	90 m	130 m	First change within survey 1, see logbook, Value 3 valid for survey2
Source depth	1.5 m			
Streamer depth	2.5 m			
Streamer length	300 m			3 x 100m solid sections with 8 hydrophone groups
Hydrophone groups	24			
Group spacing	12.5 m			
Source	13/35 cu inch			
Sampling rate	0.125 ms			
Record length	1.5 s			
Shot interval	3 s			
Nominal ships speed	4 knots			

8.6.3 2D Multichannel Seismic Line-Keeping Navigation.

Ship's navigation was provided to the officer on watch by the scientific crew. For the EM2040, this was undertaken using a Helmsman display from the Multibeam lab. Due to complications with running 2 different SIS systems on the same network, using a standard remote Helmsman display feed was not available. To mitigate this issue a Helmsman display was run locally and a UltraVNC remote desktop connection was used to view it from the bridge. For the 2D seismic line-keeping, a specific navigation setup was implemented.

To provide run line location, ship location, and technical support to the Tangaroa's bridge, two third-party software packages were used. Trimble's HYDROpro was used to interpret GPS data and to provide ship reference point orientation capability. HYDROpro was also used to provide a visual representation of run line and ship locations. A UltraVNC client was used to provide a remote desktop connection from the bridge allowing the bridge to view the navigation information on the computer in the hydro dry lab. The bridge mouse and keyboard inputs were disabled for the remote connection. Figure 41 shows the run-line navigation system configuration and information flow lines used during TAN1703.

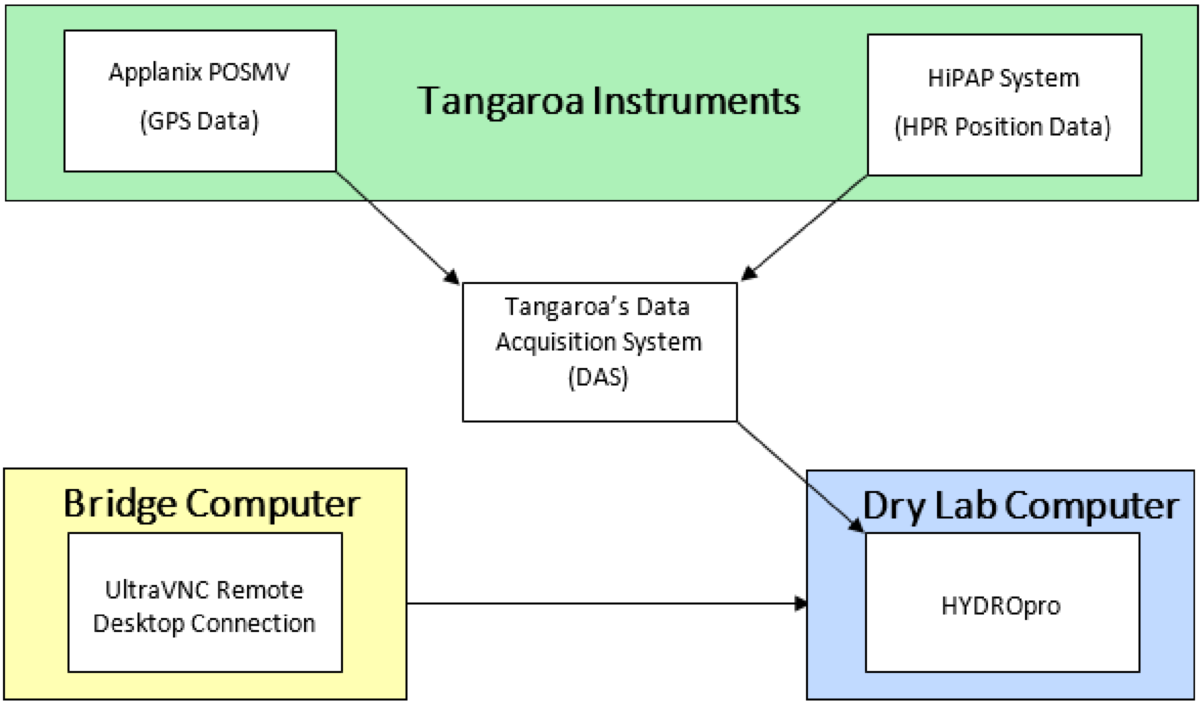


Figure 41: Run-line navigation system setup and information flow lines

Figure 42 shows the graphical user interface of HYDROpro which was used by the hydro dry lab and the bridge. On the right side of the screen important information like ships location, UTC time, ships speed, ships heading, and MCS line information is displayed. Along the bottom of the screen is a large offline bar which was used by the bridge.

The gun position for each shot is needed for the MCS processing. This can be obtained be using the GPS location of the ship and applying an appropriate offset. As no MCS gun tow reference point was calculated in relation to any existing reference points in use on the Tangaroa, measurements were calculated from a schematic drawing relating the known position of the 8200 GPS antenna and the gun tow point. Since the 8200 antenna location is known in relation to other reference points the appropriate offsets could be calculated. The MCS gun position was then calculated 30m behind the gun tow point. Figure 43 shows the offsets used for the MCS gun tow point, 8200 GPS antenna location, and the “new keel reference point” used for the POSMV GPS locations. Please note that these reference points are all calculated using an arbitrary “origin” location which HYDROpro requires. This “origin” location is along the keel of the Tangaroa but has no other meaning and does not refer to any reference point used by the Tangaroa systems.

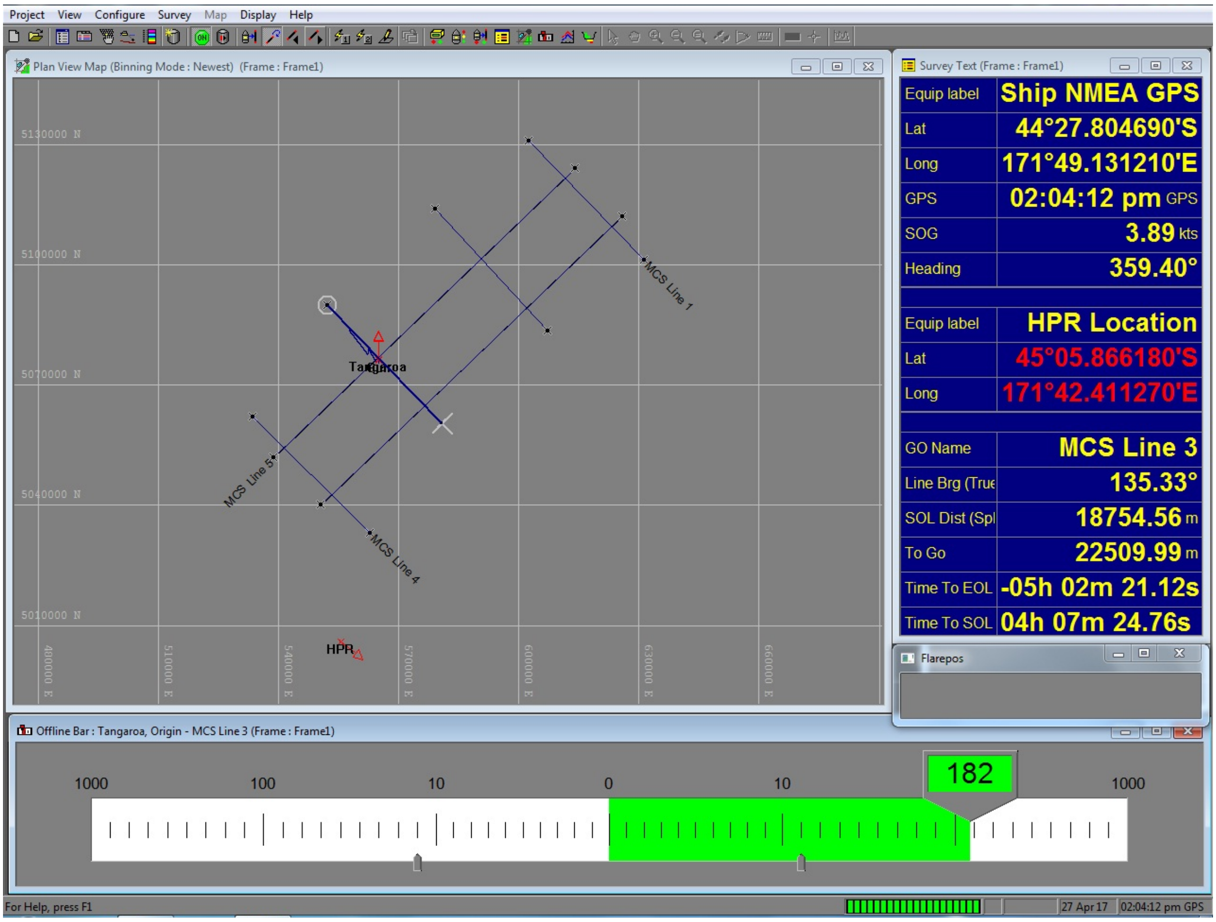


Figure 42: User interface for HYDROpro used for MCS navigation

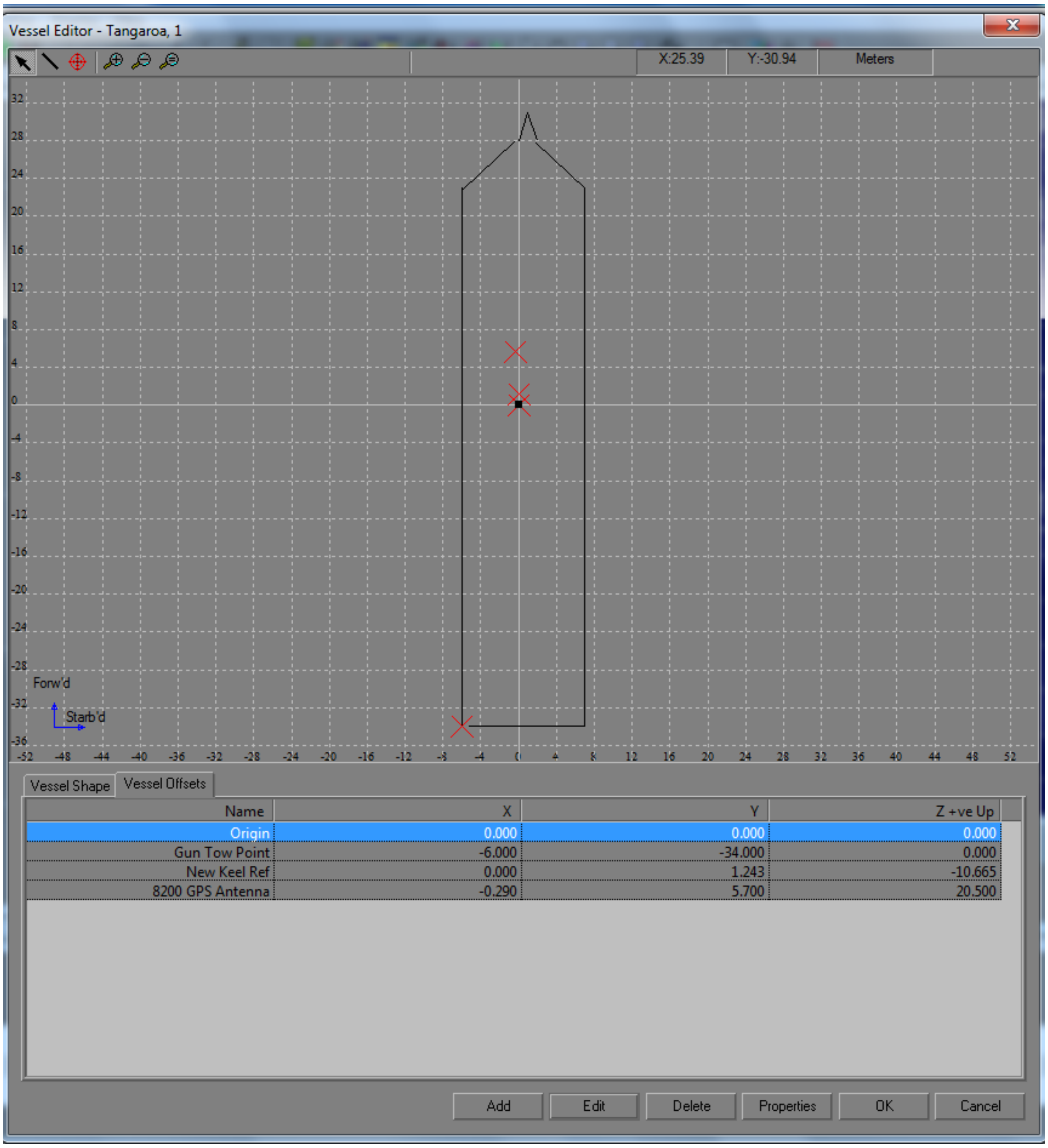


Figure 43: Tangaroa Reference points and Offsets used in HYDROpro

8.6.4 Marine Mammal Observations

Using a single mini GI-gun (13/45 cu inch) the seismic survey falls within the criteria for Level 3 surveys, which are exempt from the provisions of the *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*, as mandated by the Department of Conservation. Nevertheless, during the daylight hours of seismic operation watch-keepers kept on eye on the water for any marine mammal sightings. There were two sightings of 2-3 Blue or Finn Whales and 1 Sperm Whale during the first seismic survey, both between 1 to 2 miles away (Appendix D).

8.6.5 2D Multichannel Seismic Processing Workflow and Parameters

The following section outlines the on-board data processing workflow for the multichannel seismic reflection data. When the acquisition parameters varied at any stage during data collection, this was noted in the survey logs. This was later accounted for by using appropriate streamer geometry definition files for generating the line geometry.

We carried out the seismic processing using *Globe Claritas*. Python scripts and libraries were used to pre-process navigation data and to convert from geographical to NZTM projected coordinates. The full processing sequence consisted of the following steps:

SEGD to SEGY

SEGD formatted data from individual shots were converted to SEGY data for each entire line. A line was defined by selecting suitable start and end shot point numbers. Source positions in geographic (WGS84) coordinates were extracted from the SEGD headers during the conversion from SEGD to SEGY and were written to text files.

Coordinate conversion

Prior to application of marine geometry and signal processing, the geographic coordinates were transformed into projected NZTM coordinates. The navigation data had sub meter precision. The SEGY standard can only handle integer numbers in the segy headers. Therefore the data was converted into decimetres and written to the seismic headers in this form. The COORD_SCALE parameter was set to -10 in the Claritas work flows.

Define streamer geometry

The streamer geometry was defined from measured offsets between the shot position and the first receiver. The layout of the streamer geometry with respect to the airgun is given in Figure 37. This layout was occasionally changed during the survey as given in Table 9.

Bandpass filtering and spherical divergence corrections

To remove low-frequency swell noise, the data were filtered with a bandpass filter with corner frequencies of 50, 100, 500 and 700 Hz. Figure 9-6 shows examples before and after bandpass filtering. Overall the data quality is excellent with as high signal to noise ratio and well defined wavelet shape.

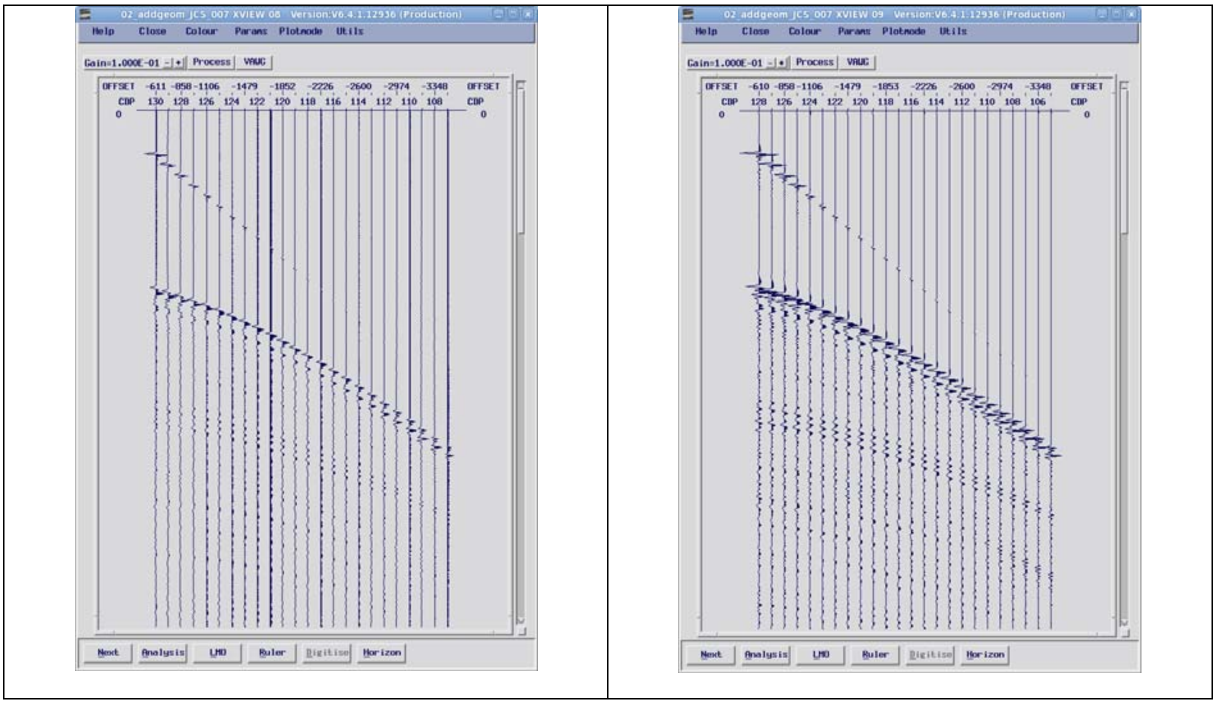


Figure 44: Example shot gathers before and after bandpass filtering to remove swell noise. Filter frequencies of the band pass filter: 50, 100, 500, 700 Hz

CDP binning and sorting

For each line the location of common midpoints and source receiver offsets was determined using the Claritas GEMOETRY tool and later added to the segy data in a Claritas job flow. A crooked line geometry was established for each seismic line from the distribution of shot points. Traces were binned at a 6.25 m Common Depth Point (CDP) spacing along the line, which resulted in a nominal fold of 24 traces per CDP given that each shot gather consisted of 24 channels, spaced 12.5 m apart. The CDP numbers and CDP trace coordinates were written to the trace headers and the data were then sorted into CDP gathers. A bulk static shift of 27 ms was applied to the seismic traces to account for the gun triggering delay.

Normal move-out correction and stacking

A constant velocity (1500 m/s) was used to apply NMO corrections to the CDP gathers prior to stacking. Figure 9-7 shows an excerpt from the stacked section of line 4 to illustrate data quality of the brute stack. An AGC of 250 ms was applied.

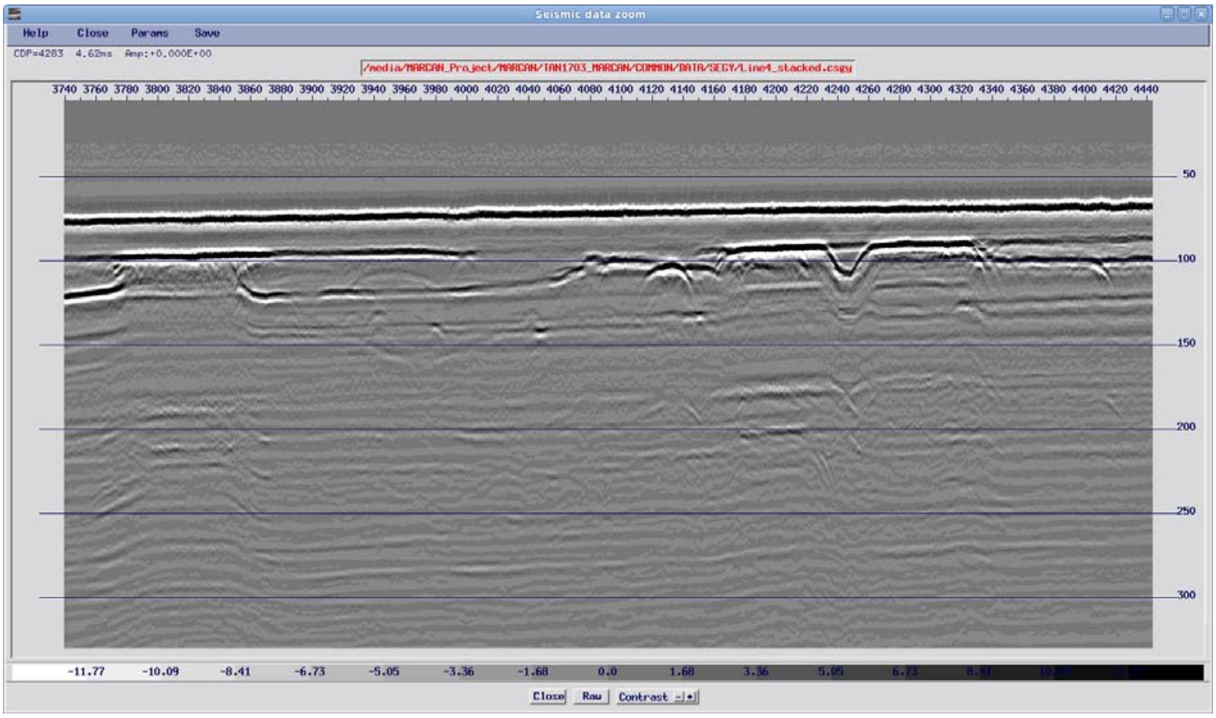


Figure 45: Brute stack example section excerpt featuring bright spots about 50 ms below seafloor typically interpreted to be gas intrusions. A lot of the deeper features (TWT > 150) are likely multiples and peg-lack multiples in this example.

Processed data viewing

SEGY data were imported into the *Kingdom Suite* software for subsequent viewing. CDP location coordinates were set in the SOURCE_X and SOURCE_Y headers for compatibility with *Kingdom Suite*. A scaling factor of 0.01 has to be applied to scale to NZTM meters.

8.7 K-Sync Unit

The Kongsberg K-Sync unit provides synchronisation between the various echo-sounders used on TAN1703 to avoid interference between sounders of similar frequencies. Echo-sounders that do not affect each other can be placed in groups. For TAN1703 only 2 sounders were in operation at a time and each had a different time slice assigned. An example of typical shot-synchronisation periods in 200 m of water were as follows: EM2040 MBES (0.5 s), TOPAS SBP (0.3) and ES60 single-beam echo-sounder (0.3 s, fixed, and an additional 100 ms delay in water depths more than 200m).

8.8 Sediment Coring and Geochemistry

Coring was carried out using NIWA's in-house, purpose-built piston coring system (Figure 46). The corer is deployed through the starboard cutaway using a railway trolley system. The corer is then lifted over the side with the A-Frame and deployed on the deep ocean winch, fitted with 16 mm-diameter steel wire.

8.8.1 Piston Corer Setup and Operation

The corer comprises a steel framework supporting a lead-filled, stainless steel, spiral-welded pipe ~35 cm diameter x 920 mm in length, and weighing about 725 kg. More weights can be added in 35 kg increments, up to a total of about 1200 kg. Barrels made from Schedule 40 seamless line pipe (outside diameter (OD) of 88.9 mm and a 5.49 mm wall thickness) are attached to the lower end of the head using 12 mm bolts. The barrels are available in three lengths (4 m, 3 m, or 2 m) and are joined using a sleeve secured with 12 mm bolts that locate in holes drilled at each end of the barrels. A stainless steel core catcher is fitted inside the lower end of the core liner and a core cutter is attached to the lower end of the barrel again using 12 mm bolts.

During TAN1703, polypropylene core liners (73 mm OD, 3 mm wall thickness) were placed inside the barrel and were cut to length using a fine toothed hand-saw. A solid stainless steel piston was connected to the end of a 14 mm diameter, 6x31 galvanized steel piston strop. The piston strop length was matched to the barrel length and the desired free-fall distance (usually 3 m). The trigger strop length was set to that required for the desired free-fall and a 60 kg lead trip weight was attached.

Accurate positioning of the core location is achieved using the ship's Kongsberg HiPAP system. For the deeper cores, a beacon was attached approximately 30 m up the wire from the top of the core head. A beacon was not used for the shallow cores.

8.8.2 Corer Configuration for TAN1703

The basic corer configuration used during TAN1703 was the standard core head with a 6 m barrel (1 x 4 m, and 1 x 2m length) with the beacon attached to the wire. Difficulties were encountered with core recovery at all shallow shelf sites due to the sediment being mainly coarse sand or eroded strata. The core configuration was changed to a gravity core with a 3 m barrel and seven 35 kg extra weights added to the head bringing the total head weight up to about 955 kg. However no useable cores were recovered using this configuration. Attempts were also made to use a 3 m piston core in this sediment type but only one useable core of about 1.8 m was recovered.

Coring operations were then moved into deeper water and piston cores with a 6 m barrel were used with 955 kg of weight. This configuration was successful in recovering four cores ranging from 4-6 m in length. The configuration was changed back to a piston core with a 3 m barrel for the final few cores on the shelf but no sediment was recovered from these sites.

Figure 46: NIWA Piston Corer configuration and deployment procedures

8.8.3 Sediment Core Sampling Procedure

Recovered core material was taken directly from the coring system and capped and taped. The cores were cut into 1 m long sections starting from the top and the recapped and taped. All sections were then labelled top and bottom and the station and core number. Any material in the core catcher was bagged and retained.

The lowermost 1m sections were taken to the temperature controlled lab for pore water extraction. All other sections and core catcher samples were stored in a refrigerated space.

8.8.4 On-board Laboratory Analyses

Pore water sampling

The core sections were transferred to the temperature controlled lab (temperature constantly kept between 5 and 7°C) and the pore water was extracted from the whole ground liner using rhizon samplers (Dickens et al, 2007). Before use, the rhizons were placed in a beaker with DI water. A standard 3.8 mm diameter drill bit was used to drill a hole in the plastic liner. A spacer on the drill bit prevented it from going into the core material. A rhizon sampler was carefully pushed into the sediment and connected to a 20 mL disposable syringe. Vacuum was established by pulling the syringe plunger and keeping it open with a wooden spacer. After a few minutes, the syringes were taken off and the first 1 mL of sample was discarded. The vacuum was then reattached and sampling continued until either the syringe was filled or sampling was stopped. For further subsampling and measurements a total amount of 30 mL was required for each sample, thus two extraction-runs were needed. At sample volumes over 15 mL (or after a reasonable time) the vacuum was released, the pore water was stored in a scintillation vial and the syringe was attached for the second run (sometimes overnight in a 5°C refrigerated room). The pore water flow was medium to good, so that most sample volumes (both runs, ~37 mL) were sampled after a maximum of six hours. The pore water from both runs was mixed to a master sample and sample splits were taken from this pool. Filtering was not necessary because the maximum pore width of the rhizons is 0.2 µm (thus the samples are sterile filtrated).

Adjustable pipettes (Eppendorf 2500 µL, Eppendorf 1000 µL, Eppendorf 200 µL) were used to transfer the sample from the pool to the splits for isotopes, cations, anions and DIC. The latter was preserved with 90 µL saturated copper sulfate solution (>25g CuSO4*5H2O in 100 mL MQ water).

All samples and sample splits were labelled with core information, a sequential sample number and the sample split (**TAN1703 -** ”station number” **- P** ”sequential sample number” and sample split). Table 10 summarizes the core sampling approach.

A detailed core sampling table is provided in Appendix F.

Table 10: Division and preservation scheme for samples taken from cores

sequence	1	2	3	4	5	6	7
split	δ18O	δ2H	DIC	anions	cations	residual of master sample	measurements pH, temperature, DO, conductivity
analysis	onshore	onshore	onshore	onshore	onshore	backup	offshore
CTD amount / type	~4.7 mL	~1.85 mL	9 mL	4 mL	4 mL	~4 - ~20 mL	~7 mL
preserve	very small headspace, sealed with tape, dark & refrigerated	very small headspace, sealed with tape, dark & refrigerated	0.09 mL $CuSO_4$, dark & refrigerated	dark & refrigerated	dark &room temp	dark & refrigerated	-
vial	4 mL twist cap glass vial	1.5 mL twist cap plastic vial	9 mL crimp cap glass vial	4 mL twist cap glass vial	4 mL twist cap glass vial	Scintillation vial PP 20ml	-
TAN1703-08	5x	5x	4x	5x	5x	5x	yes
TAN1703-26	5x	5x	4x	5x	5x	5x	yes
TAN1703-28	18x	18x	11x	18x	18x	18x	yes
TAN1703-29	13x	13x	10x	13x	13x	13x	yes
TAN1703-30	17x	17x	11x	17x	17x	17x	yes
TAN1703-31	12x	12x	7x	12x	12x	12x	yes
TAN1703-32	2x	2x	0	2x	2x	2x	yes

8.9 CTD

CTD data acquisition instrumentation combined a Seabird Electronics Inc. (SBE) 911plus CTD and a 24 x 10-litre SBE 32 Carousel water sampler. The CTD sensor configuration consisted of TC-ducted primary temperature and conductivity (SBE 3plus and SBE4, respectively), and primary dissolved-oxygen (SBE 43), plumbed horizontally and pumped by a SBE 5T pump; TC-ducted secondary temperature and conductivity (SBE 3plus and SBE 4), and secondary dissolved-oxygen (SBE 43), plumbed horizontally and pumped by a second SBE 5T pump; pressure (Digiquartz); a single fluorometer (Seapoint SCF); a single transmissometer (Wetlabs C-Star 25-cm Red); solar photosynthetically active radiation (PAR) (Biospherical Instruments QCP-2300L-HP); and sonar altitude (Tritech PA500/6K8). The instruments and their calibration dates are shown in Table 11.

Table 11: CTD instruments and their calibration dates (where available)

Instrument	Model	Calibration date
Primary Temperature	SBE 3Plus	4 Mar 2017
Primary Conductivity	SBE 4	8 Mar 2017
Secondary Temperature	SBE 3Plus	8 Mar 2017
Secondary Conductivity	SBE 4	8 Mar 2017
Primary Dissolved Oxygen	SBE 43	18 Mar 2017
Pressure	Digiquartz	02 Jun 2014
Fluorometer	Seapoint SCF 2972	
Wetlabs C-Star 2cm red transmissometer	CST1493-DR	16 Nov 2011
sonar altimeter	Tritech PA500/6K8	
PAR sensor	Biosherical Instruments	

The exact instrument and sensor configuration, including sensor type, serial number and calibration coefficients, for each station were specified in the corresponding .xmlcon file. The water sampler carried 24 10-litre external-spring Niskin-type bottles (Ocean Test Equipment Standard 10 BES). Data acquisition software was SBE Seasave Version 7.22.3.

The raw CTD dataset was stored in directories under the top-level directory ctd3225. The time series of raw sensor outputs for any station u88nn cast 1, filename u88nna1, was stored in the corresponding .hex file: ctd3225\raw\u88nn\u88nna1.hex. Other files created by the data acquisition software (a .xmlcon file, a .hdr file and a .bl file) were also stored in the same directory (ctd3225\raw\u88nn\).

CTD3225 (TAN1703, MARCAN) occupied 27 stations, named u8861 to u8887. The first seven casts were made by towing the CTD at between 2 and 5 m above the bottom at a ship speed of about 1.5 knots. This was an attempt to target the many flare positions identified in the EM2040 water column data to see if the flares were freshwater. Note that the files u8862–u8864 were all recorded on the same tow. The files were stopped and restarted without bringing the CTD back on-board at about 4 hour intervals in case the data was lost. The towed deployments were files u8861–u8867.

The remainder of the casts (u8868 onwards) were standard vertical casts with bottles fired either at the bottom or at any depth where low salinity water was detected.

The performance of all instrumentation was within nominal limits. The CTD routine 'process_one' creates a rosette file (*.ros) for each cast where bottles are fired. Because the data frequency is so high (24 Hz), the files produced contain the data from 48 scans around the presumed bottle closing time. The data from the 48 scans for each bottle fired was averaged and is included in Appendix G.

8.9.1 CTD water sampling and on-board laboratory analyses

Water column water samples were collected from Niskin bottles. Immediately after the CTD returned on deck, the drawtube (stored in a container of fresh seawater) was pre-rinsed with sample water and attached to the Niskin bottle's spigot. The temperature probe was pre-rinsed with sample water followed by the flask and the stopper for the DO water (3 rinses). The flask was then filled and overflowed, avoiding the formation of air bubbles. During the overflow the temperature probe was inserted and the oxygen draw temperature was measured after a threefold overflow of the flask volume was ensured. With the sample water still flowing, the temperature probe and the drawtube were removed. The sample (significantly filled above the neck) was taken to the Hydro wet lab, where 1mL of each reagent #1 (MnCl2, first) and reagent #2 (NaI/NaOH, second) were added to the sample as close to the bottom of the flask as possible. The formation of air bubbles in the dispensers as well as during the closure of the flask was avoided. The flask was well shook to allow a mixing of the reagents with the sample water. A second shake was given after 20-30 minutes before the neck was filled with DI water. The flask was stored in the dark.

For the DIC sample the Schott bottle and the cap were pre-rinsed (3 times) and filled ensuring a 1.5 overflow and the avoiding of formation of air bubbles. A headspace of ~1cm was created and one drop of saturated HgCl2 was added to the sample in the chemical lab. The sample was stored dark and refrigerated.

Another Schott bottle was taken for the subsamples and the measurements in the same way as the DIC sample was taken, but without headspace. This sample was then taken to the temperature controlled lab. For the splits the required amount of sample was filtered through 0.2 µm one way filter attached to a disposable syringe. The first mL was discarded. Sample splits for isotope analyses were taken directly from the filters, splits for anions and cations (pipetted with adjustable pipette, Eppendorf 2500 µL) as well as the volumes for further measurements (pH and conductivity) were taken from a scintillation vial filled with the filtered sample water. The remaining unfiltered sample was stored refrigerated and dark as backup. All samples and sample splits were labelled with CTD information, a sequential sample number and the sample split (**TAN1703 -** ”station number” **- C** ”sequential sample number” and sample split). Table 12 summarizes the splitting scheme and preservation for all samples by CTD station. Further sampling details are included in Appendix H.

Water measurements

Except of the measurement for the oxygen draw temperature, all other measurements were carried out in the temperature controlled lab (temperature constantly kept between 5 and 7 °C). The former was performed on deck at ambient temperature conditions.

pH value

The pH value was measured with a WTW SenTix 41 glass electrode, connected to a WTW pH 3210 pH meter. The pH meter was calibrated prior to a measurement interval using AppliChem color coded NBS scale pH buffer solutions (pH = 4.01 and 7.00). Slope and offset of the sensor were recorded. The instrument shows the pH with a resolution of 0.001 pH units. The measurement has an accuracy of better than ±0.02 pH units.

Temperature

The temperature was measured simultaneously with the pH measurement for the pore water samples and during the DO sampling for the water column water samples by using the same probe and meter as already mentioned in the pH value section above. The integrated temperature sensor has a resolution of 0.1 °C and the accuracy of the measurement is ±0.1 °C.

Dissolved Oxygen value

The DO value of the pore water samples was determined by a luminescent dissolved oxygen (IntelliCAL™ LDO101) probe, connected to a Hach HQ30d portable single input, multi-parameter meter. Calibration was carried out before each measurement interval using tab water for a water-saturated air (100%) calibration procedure. Slope and offset of the sensor were recorded. DO values are measured with a resolution of 0.01 mg/L and an accuracy of ±0.1 mg/L for 0 to 8 mg/L and ±0.2 mg/L for > 8 mg/L.

Conductivity value

The conductivity was measured with a conductivity (IntelliCAL™ CDC401) probe, connected to a Hach HQ30d portable single input, multi-parameter meter. Calibration was carried out prior to each measurement interval using a seawater standard (IAPSO). The value for the cell constant (K) of the electrode was recorded. The resolution of the conductivity values is 0.1 µS/cm (for values between 20.0 and 199.9 µS/cm) and the accuracy of ±0.5% of the reading.

Pure water

DI water was brought to the vessel in two 20 L carboys and was used for the preparation of rhizons as well as for the cleaning of the probes after each sample measurement.

Table 12: division and preservation scheme for CTD samples

sequence	1	2	3	4	5	6	7	8
split	DO	measurement temperature	DIC	isotopes δ18O and δ2H	anions	cations	residual of master sample	measurements pH, conductivity
analysis	onshore	offshore	onshore	onshore	onshore	onshore	backup	offshore
CTD amount / type	~125 mL	sample draw temp	~280 mL	~4.7 mL each	4 mL	4 mL	~280 mL	~10 mL
preserved	1 mL MnCl2 and 1 mL NaI/NaOH, DI water in bottle neck, stored dark	-	1 drop satur. HgCl2, dark & refrigerated	very small headspace, sealed with tape, dark & refrigerated	dark & refrigerated	dark &room temp	dark & refrigerated	-
vial	125 mL PYREX flask	-	250 mL Schott bottle	4 mL twist cap vial	4 mL twist cap vial	4 mL twist cap vial	250 mL Schott bottle	-
TAN1703-01	2x	yes	2x	4x	1x	1x	1x	yes
TAN1703-05	2x	yes	2x	4x	1x	1x	1x	yes
TAN1703-06	2x	yes	2x	4x	1x	1x	0	yes
TAN1703-07	2x	yes	2x	4x	1x	1x	1x	yes
TAN1703-13	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-14	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-15	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-16	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-17	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-18	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-19	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-20	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-21	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-22	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-34	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-35	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-36	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-37	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-38	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-39	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-40	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-41	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-42	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-43	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-44	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-45	1x	yes	1x	2x	1x	1x	1x	yes
TAN1703-46	1x	yes	1x	2x	1x	1x	1x	yes

8.10 Coast Cam

The Coast Cam is NIWAs in-house built shallow water (<350 m) towed camera system (Figure 47). It uses NIWA Deep Towed Imaging System (DTIS) software to remotely control a 12

MegaPixel Canon EOS 540 SLR and a Sony AVC HD hybrid HDD handy Cam. The SLR camera fires two 580EX2 flashes via an ST-E2 speedlite transmitter. A controller inside the camera housing fires the camera automatically at a preselected interval. On TAN1703 we used a 15 second interval. The HD video records to an internal HDD and a SD feed is monitored via an on deck monitor. The main LiPo 22 volt battery on the coast cam gives approximately a two hour battery life before the system needs to be retrieved and have the batteries replaced.

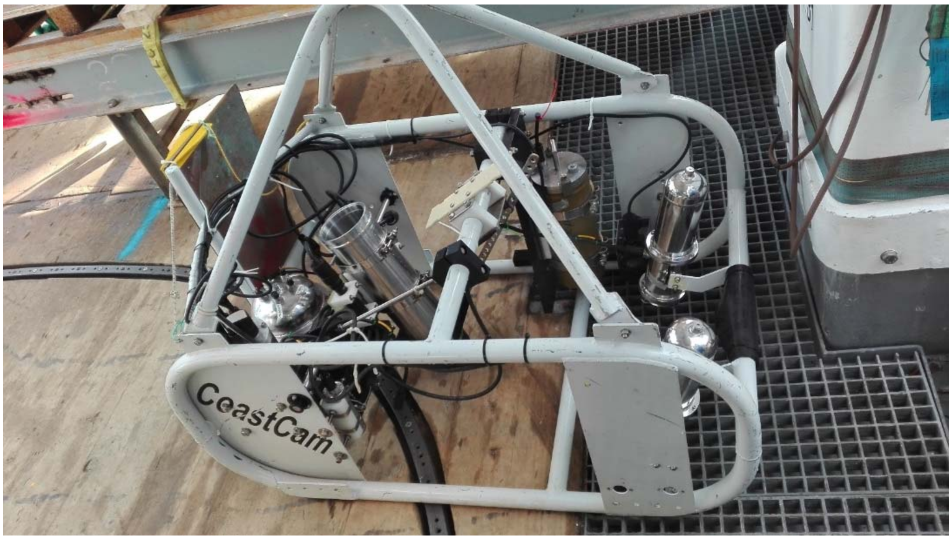


Figure 47: NIWA CoastCam

Coast Cam was deployed using its dedicated winch and controller. The winch was secured to the coring railway and the winch cable fed through a block on the starboard cut away A frame. HYDROpro navigation was used to record time of deployment, ships position and Hipap beacon position.

An issue with the winch slip-rings meant that when the winch was driving the modem connection was lost and would reconnect once the winch had stopped. As a result we were not able to maintain the camera to a constant 1M above the seafloor.

9 Preliminary results

The following sections provide preliminary results from the data as analysed during the TAN1703 voyage. The intention is to provide an overview of data quality and to highlight features of interest rather than provide a comprehensive interpretation and correlation of the datasets. All interpretations presented here are subject to change and refinement with further analysis.

9.1 Controlled Source Electromagnetics

Preliminary analysis was carried out for the CSEM data to assess whether it delivers realistic resistivity models. We compare a preliminary inversion model to logging data and observations at the IODP site U1353 (Figure 1). Figure 48 shows the inversion model and corresponding data fit to the transients at weigh point 15 on CSEM-2, which is close to IODP Hole U1353C. While the inversion model may only be considered quantitatively due to first order data processing, the results suggest bulk part resistivity values which are on the same order of magnitude as observed in borehole below 100 m depth (Figure 49 left panel). The existence of a high resistivity zone with a top above 100 m corresponds to the observation of a fresh water aquifer in the IODP borehole (Figure 49 right panel). There is a disagreement in the depth of the aquifer however, which is predicted to be around 50 m at U1353C according to drill hole data, while slightly greater depths are predicted by the preliminary CSEM inversion. Clearly this is a very preliminary look at the data and further more thorough analysis will refine the model understanding significantly.

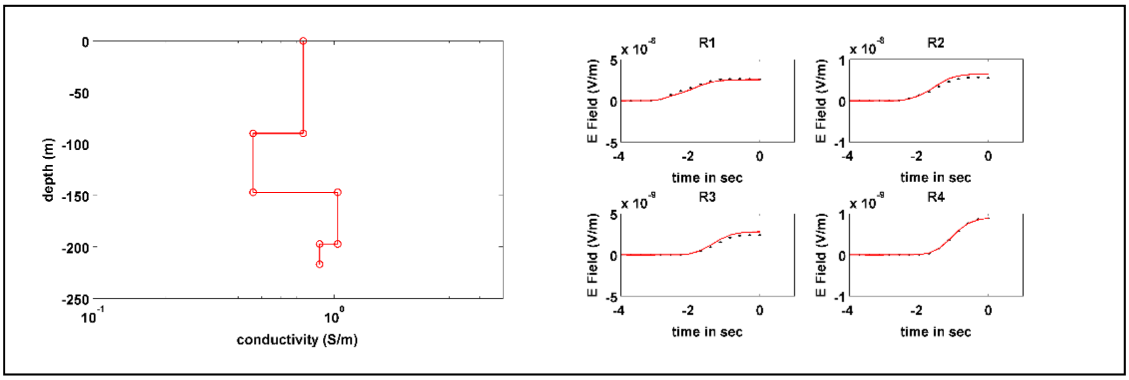


Figure 48: Inversion conductivity model (left panel) obtained by fitting data for receiver 1 to 4 at weigh point 15 on Line 2 in the vicinity of the IODP borehole 15353. Right panel shows the observed data from CSEM-2 (black) compared to the responses to the inversion model (red).

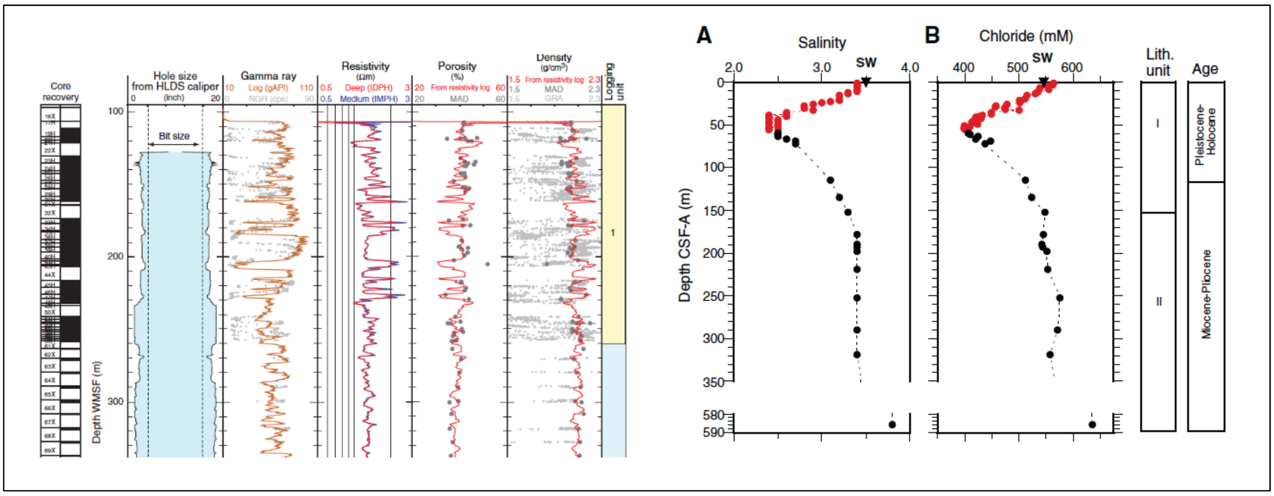


Figure 49: IODP wire line logging data in hole U1353C and salinity and chloride values in holes U1353A (black) and U1353B (red).

9.2 Multichannel Seismic Reflection Data

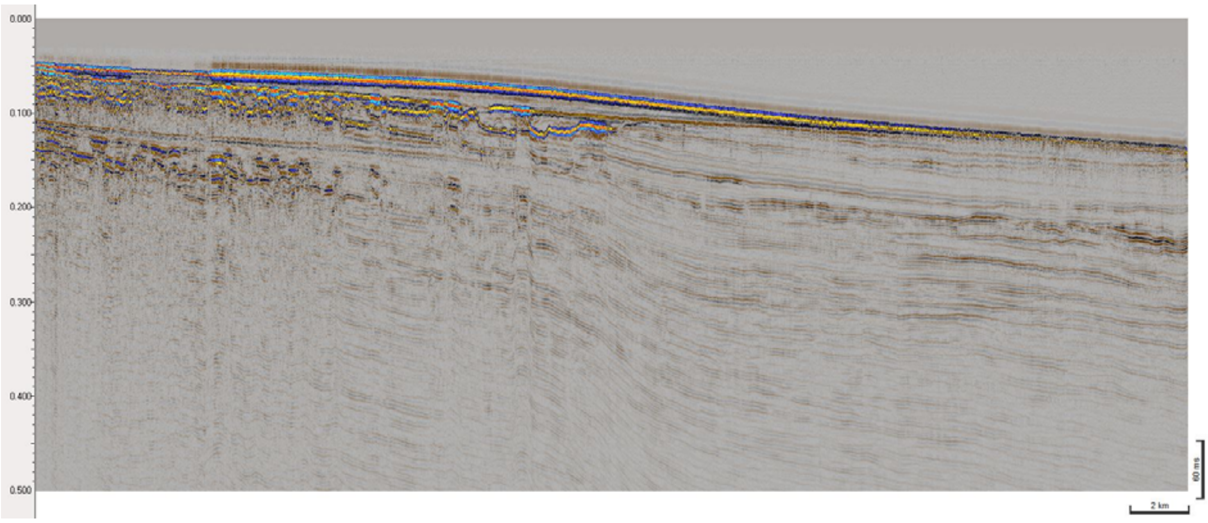


Figure 50: Example multichannel seismic profile from Line-4. bright (high amplitude) regions just below the seafloor likely indicate shallow gas.

9.3 TOPAS Sub-Bottom Profiler

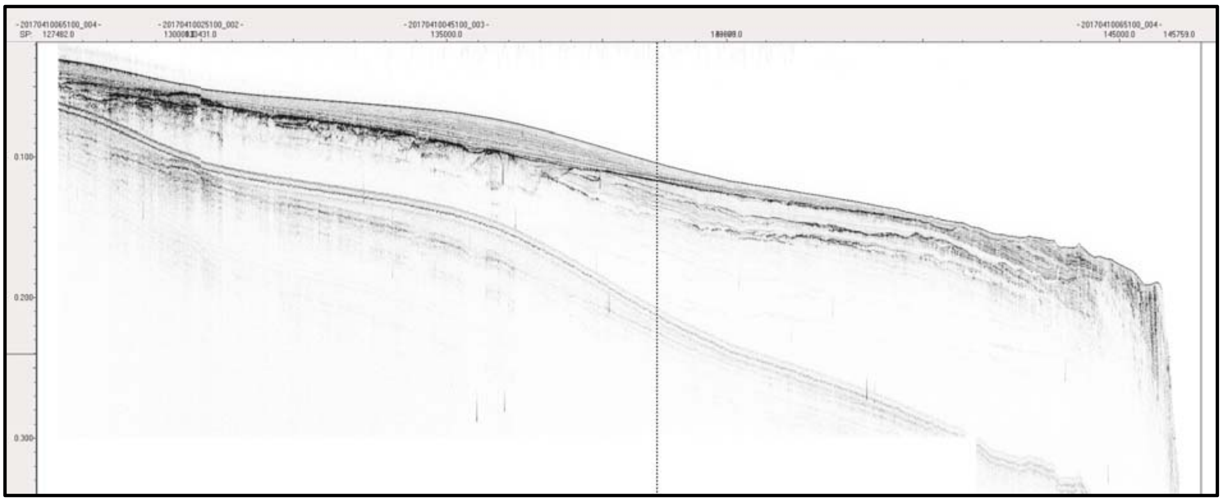


Figure 51; TOPAS line across southern shelf illustrating post glacial sediment drape. Location of IODP drill hole shown by vertical dash line We were able to collect one sucessful core in this drape despite several attempts. Beneath the drape erosional and depositional stratigraphy relating to the fluvial history of the shelf is clearly evident.

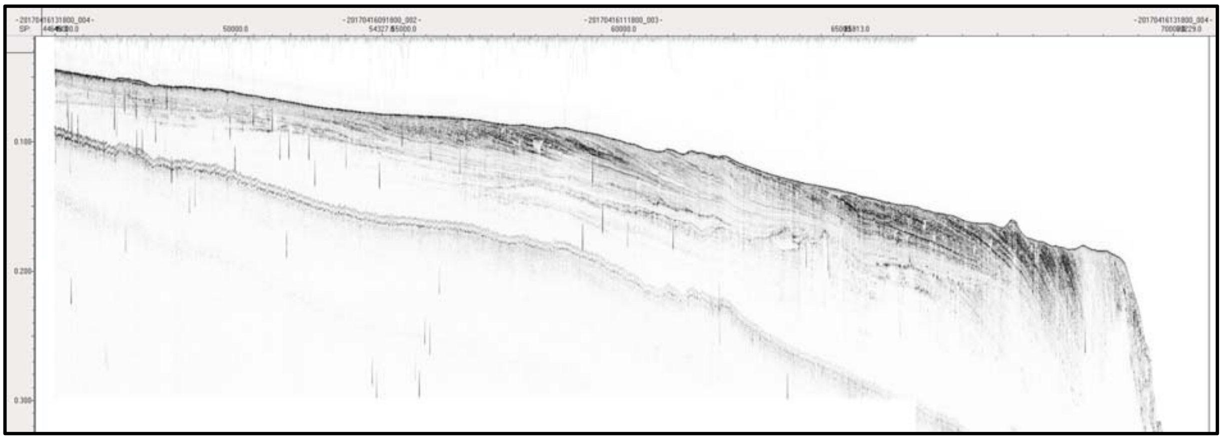


Figure 52: TOPAS line across northern shelf illustrating eroded surface with no post glacial drape. No coring was possible in these sedments

9.4 EM2040 water column data

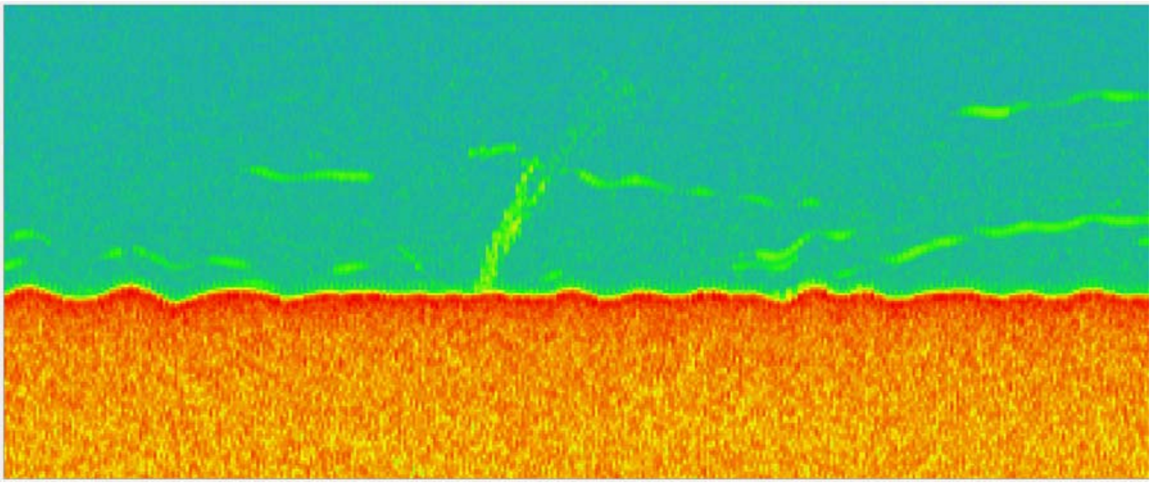


Figure 53: Water column flare (sub-vertical feature in centre of profile). Feature is characteristic of gas flares observed in other regions of New Zealand's East Coast.

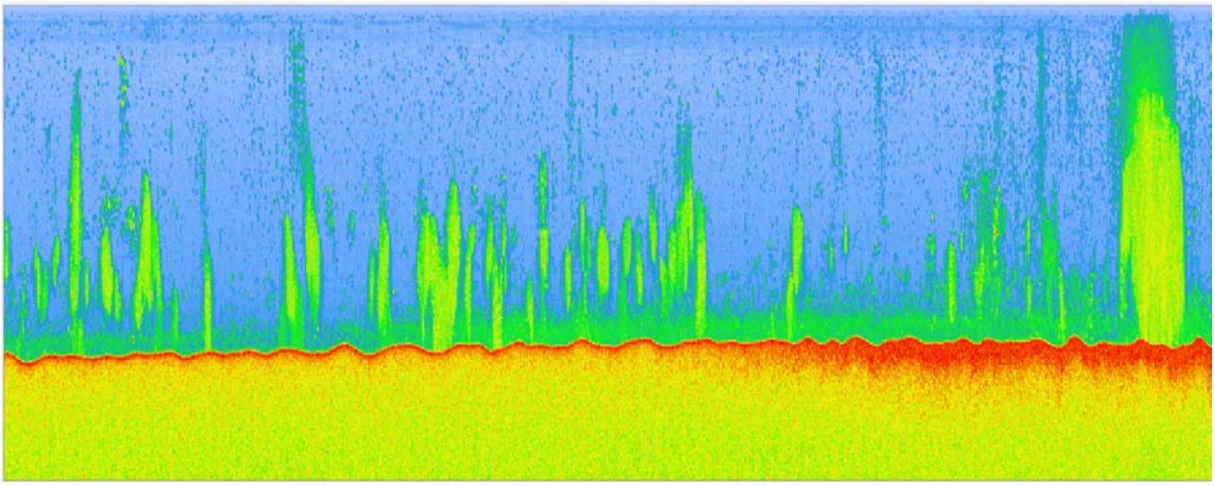


Figure 54: Water column features imaged in a region where CTD observations show a region of low salinity

9.5 CTD data

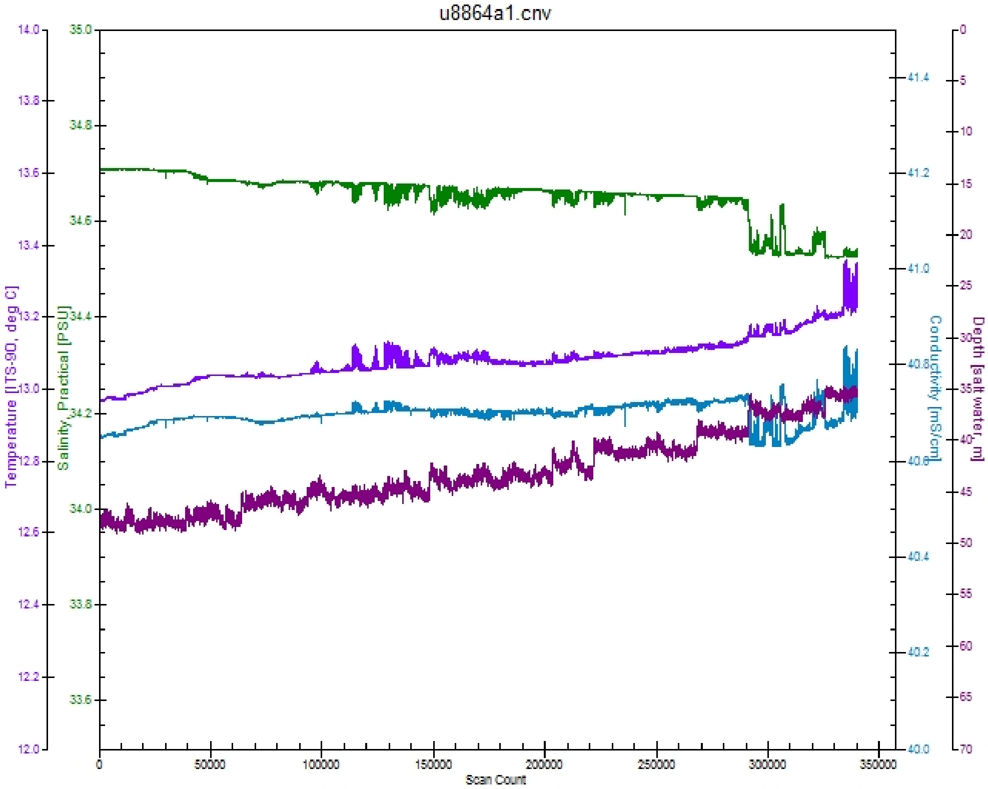


Figure 55: Towed CTD plot from the NIWA CTD and Nisken rosette. Measurements are taken approximately 5m above the seabed. Note marked change in salinity readings towards end of line that does not correlate with a temperature change. The water column image in Figure 54 is from this region.

9.5.1 GEOMAR CTD

The pig-mounted towed CTD data are illustrated by 3D scatter plots of conductivity as a function of location and depth for each profile (Figure 56). There is a general trend to be observed between depth and conductivity. This is due to the fact that the temperature generally decreases with depth, and temperature decrease causes a reduction in electrical conductivity at the same salinity (see Figure 18 from EM report). Next to the general trend, some more local variations exist though. E.g. along Line 8, a major decrease in conductivity is observed without a larger change of depth. Assuming that there is not larger temperature variations at such a small scale, it suggests that the decrease in conductivity may be attributed to a decrease in salinity. However, whether the decrease in salinity is due to ground water discharge or may be attributed to small scale currents of fresher coastal water may not be derived from the data.

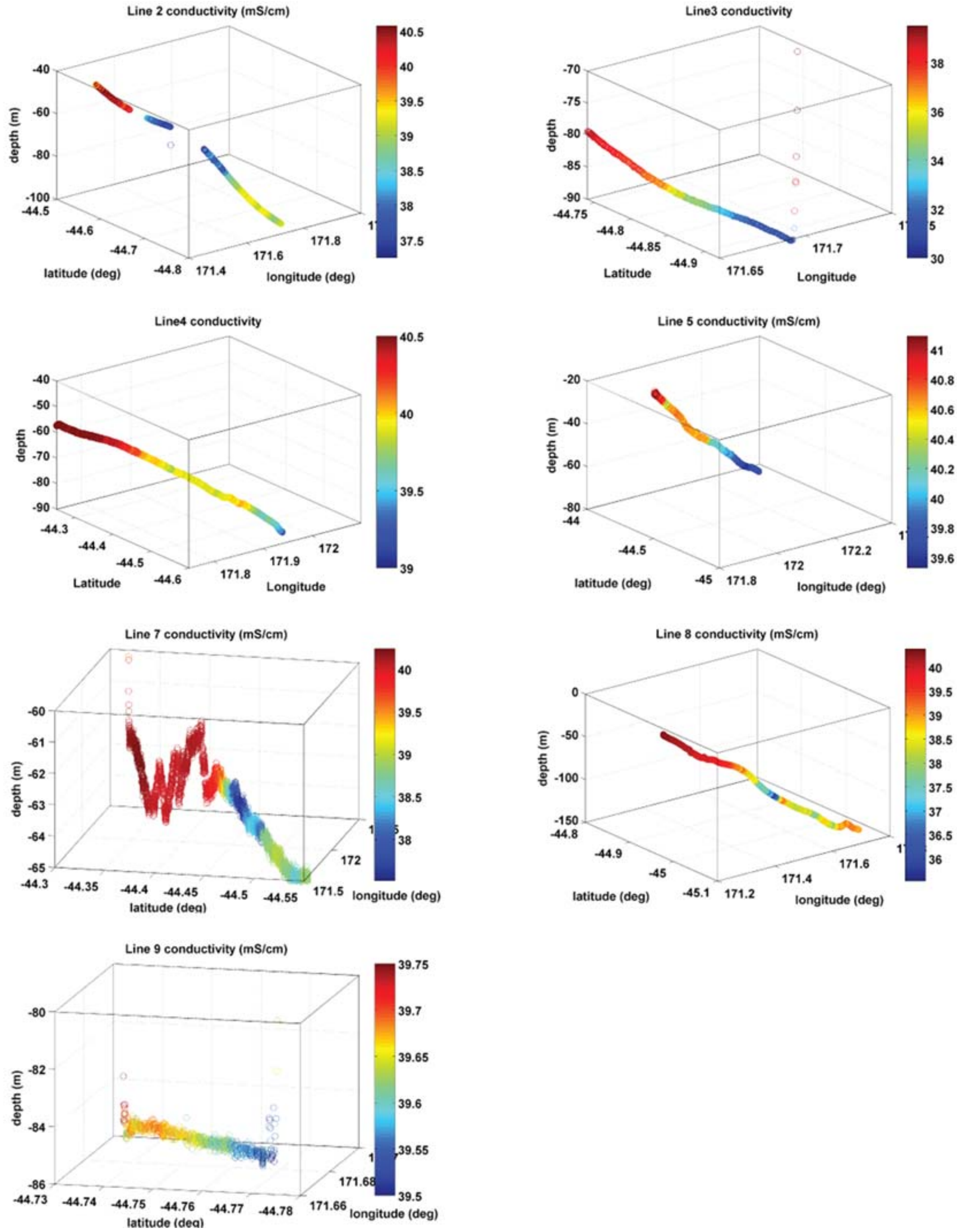


Figure 56: Towed CTD conductivity as a function of depth and position for Line 2 to Line9. Note different colour scale for each Line.

To investigate the relationship between conductivity, depth and temperature further and to identify possible anomalies we have plotted these parameters for all lines (Figure 57). The observed relationship between conductivity and temperature primarily follows a linear trend. However some anomalies may be observed, particularly along the southern most profiles. In an attempt to identify these regions we defined visually a linear relationship between temperature and conductivity (upper panel Figure 58). We then determined the difference between the observed conductivity and the conductivity predicted based on the concurrent observed temperature measurement (lower panel Figure 58). Figure 59 shows the measurement points, for which the predicted conductivity is smaller than a threshold value set to -1.25 mS/cm. Particularly strong anomalies are identified by this analysis mainly in the southern regions and along borehole 1353. While this analysis identifies local anomalies, it is not, however, able to identify the cause of the anomalies.

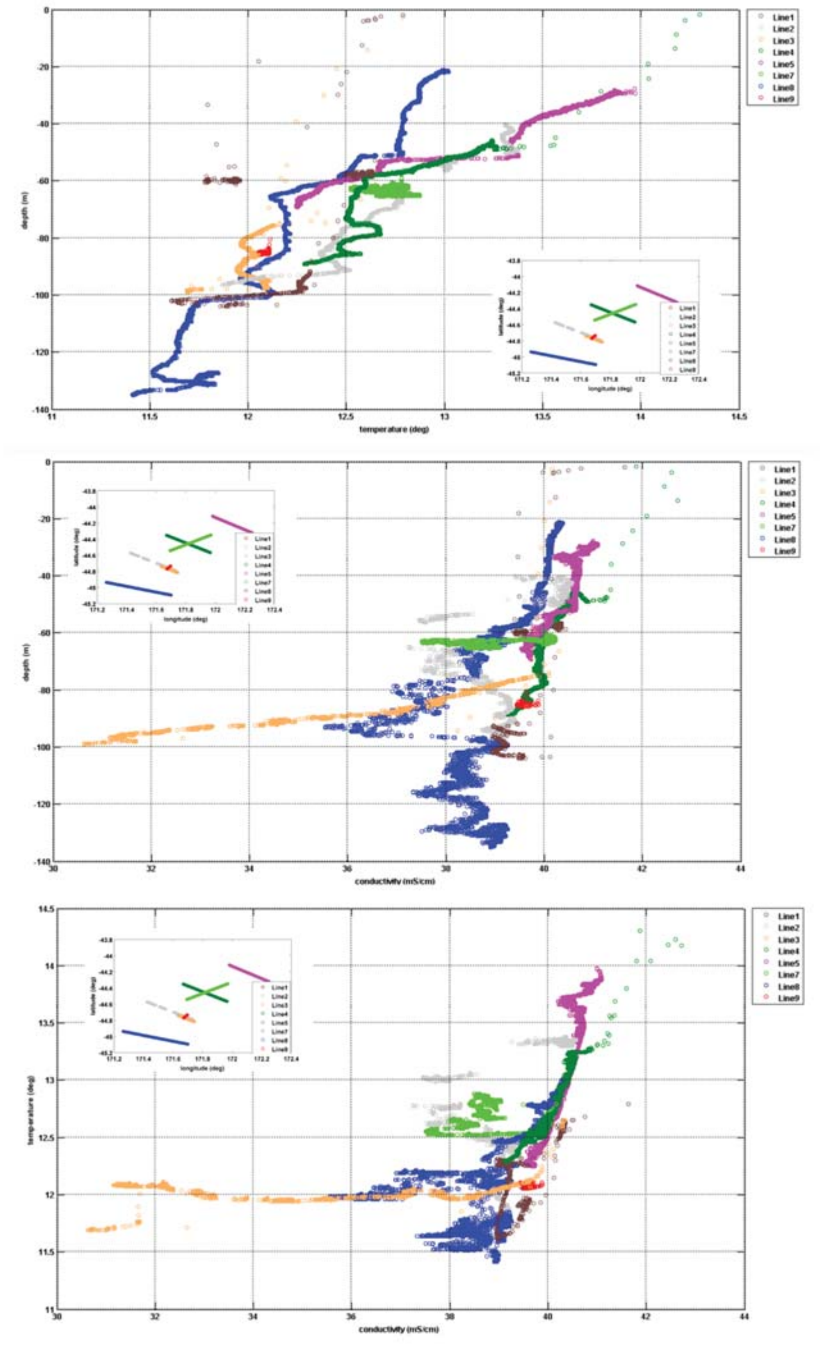


Figure 57: Graphs of observed relationship between conductivity, temperature and depth for towed CTD along all profile lines.

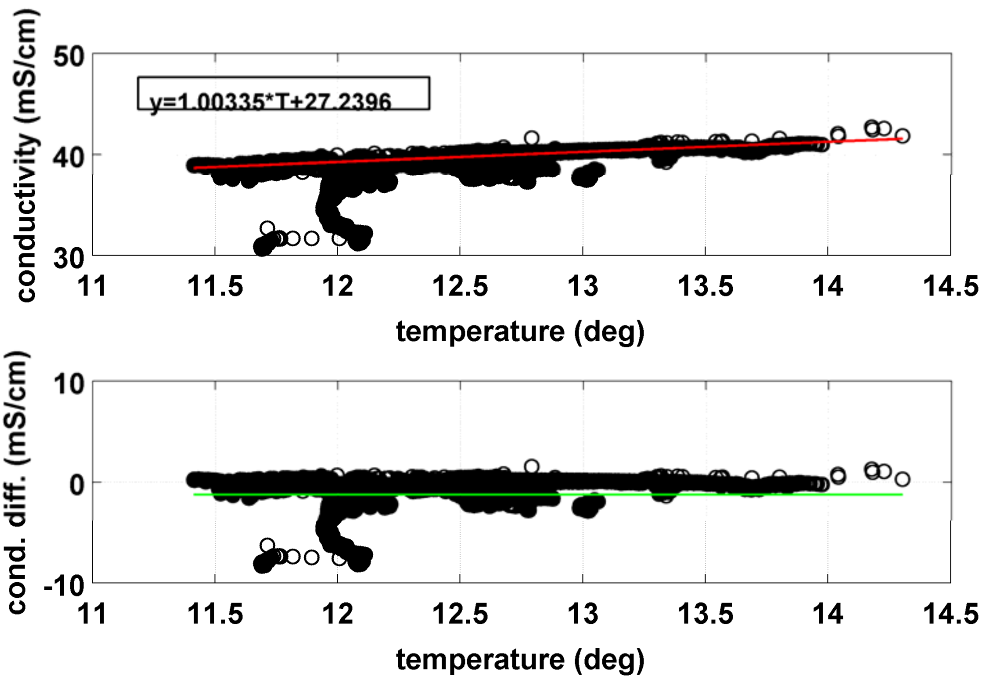


Figure 58: Upper panel: Observed temperature values against observed conductivity for all Lines. Red line denotes a visually defined linear relationship of temperature versus conductivity, which is obeyed by most points. Lower panel: Difference in conductivity predicted based on observed temperature and observed temperature. Green line identifies threshold values of -1.25

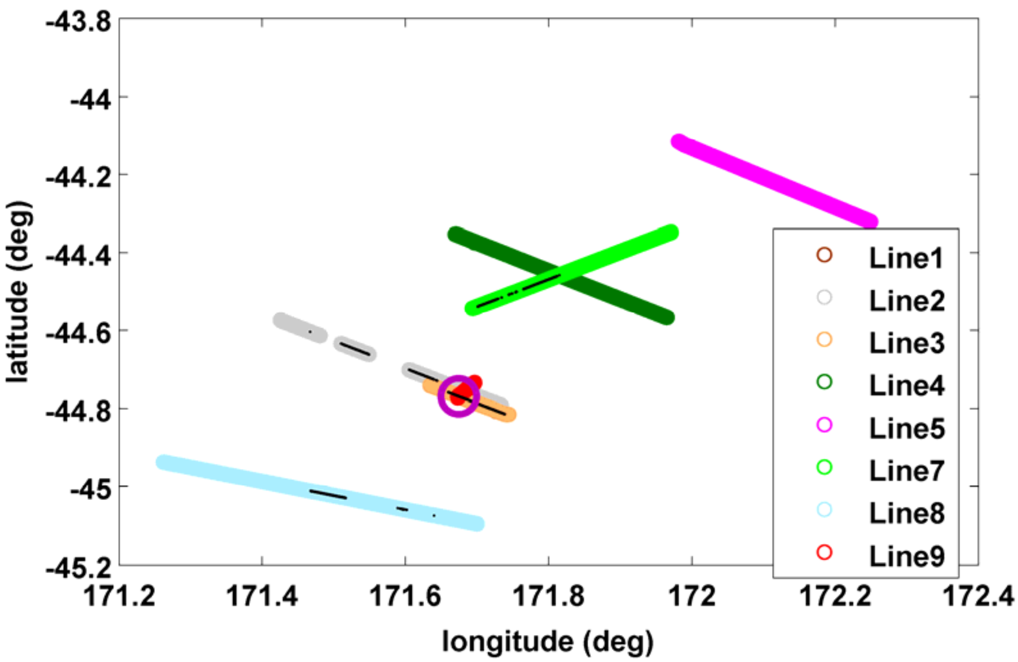


Figure 59: Profile lines and ctd anomalies (>-1.25 mS/cm) shown as black dots. The large pink circle denotes the position of U1353.

9.6 Coast Cam

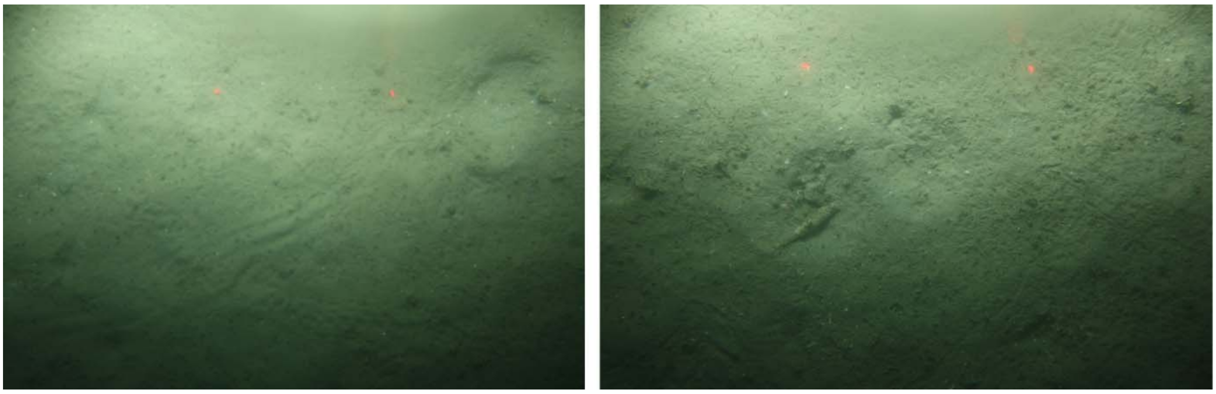


Figure 60: Coastcam photos showing generally muddy seabed with scattered fauna and trace marks indicating faunal perambulation

10 Acknowledgements

Funding for RV *Tangaroa* was from the New Zealand Ministry of Business, Innovation and Employment (MBIE) through the Tangaroa Reference Group (TRG).

Scientific personnel and equipment were funded by European Research Council (ERC) Grant 677898 as part of the MARCAN project.

Appendix A TAN1703 Daily Activity Log

7/4/17
Scheduled departure of 0900 hrs pushed out to 1100 hrs
1130 hrs Away from wharf
Abandon ship drill carried out in the harbour
Proceed out of heads into heavy sea (6-8 m swells)
Transit to Kaikoura for multibeam survey, arrive 2330 hrs

8/4/17
Issues with Camera Winch delayed SVP to 0530 hrs
0600 hrs Commence EM302 survey of Kaikoura Canyon at
1600 hrs completed swath mapping and commence transit to main study area

9/4/17
0810 hrs on site for first CSEM deployment
1030 hrs Toolbox covering SOP and JHA for CSEM then commence CSEM deployment
1400 hrs having issue with CSEM pig so recover back onboard for maintenance
1745 hrs pig redeployed but still issues remaining with synchronisation and HDP feed
2000 hrs commence CSEM recovery
2110 hrs CSEM system on board
2130 hrs transit to ship wreck of Jubilee for EM2040 patch test

10/4/17
0800 hrs EM2040 patch test complete. Attempted drone flight following discussion of SOP but drone flight aborted after impact with ship railing on takeoff.
0830 hrs commence EM2040 transect across shelf

11/4/17
1000 hrs commence CSEM redeployment
1130 hrs CSEM pig deployed and commence survey

12/41/7
0930 hrs commence CSEM recovery
1030 hrs CSEM recovery complete and commence water column acoustic survey
1400 hrs CTD deployment for towed transect
1600 hrs CTD recovered
1730 hrs Coring Toolbox covering SOP and JHA
1820 hrs deploy piston corer
2030 hrs no core recovery from 3 attempts. Heading to acoustic survey through the night

13/4/17
1030 hrs deploy CSEM
2300 weather degrading likely will need to recover gear

14/4/17
0000 hrs weather degraded to the point where gear recovery required. First mate made the call and CSEM recovery commenced
0130 hrs CSEM on board. Moving to acoustics survey
0630 hrs commence CTD survey to run through the night

15/4/17
0800 hrs Recover CTD

Transit to start of CSEM line-3
1115 hrs CSEM deployed
1200 hrs identified issue with pig CSEM recovered
1446 hrs CSEM in the water and running. Ship DP system playing up a bit

16/4/17
1330 hrs CSEM recovered
1345 hrs deploy SVP in advance of acoustics survey
1400 hrs commence acoustics survey

17/4/17
0830 CSEM toolbox
0900 hrs Acoustics complete. Ship commencing DP trials.
1000 hrs Commence CSEM deployment
1130 hrs CSEM in water and running

18/4/17
1230 hrs Commence CSEM recovery
1530 hrs Deploy CTD for towed surveys
2330 hrs completed CTD deployments

19/4/17
0000 hrs Deploy Coastcam
0700 hrs Coastcam deployment completed moving to CSEM start
1230 hrs commence CSEM deployment following delays due to technical issues
1400 hrs gear in the water and running
2015 hrs Wind up to 30 kts sustained. Required to recover gear.
2130 hrs CSEM onboard and transit to coring stations
2230 hrs Commence coring

20/4/17
0730 hrs meet with Port Timaru pilot
0800 hrs alongside wharf. Delayed ETD due to arrival of batteries for CSEM
1430 hrs Depart port
1630 hrs onsite for CTD deployment

21/4/17
0000 hrs finish coring. Very poor recovery.
0015 hrs Commence TOPAS survey
0700 hrs Finish TOPAS survey and transit to MCS deployment location
0900 hrs Commence MCS gear deployment
1100 hrs MCS gear deployed and running
1545 hrs loose belts on compressor. Fixed by engineers

22/4/17
0930 hrs Large amount of seaweed on tail buoy. Recover to remove seaweed. Tail buoy flipped and GPS unit flooded.
Lots of seaweed in water requiring minor course diversions

23/4/17
0200 hrs recover first section to change out front bird as non responsive
1600 hrs pull streamer out of water to remove seaweed

24/4/17

1400 hrs EOL for seismic survey commence gear recovery
1500 hrs Seismic gear onboard and moving to CSEM deployment start
1830 hrs CSEM deployed and running
1912 hrs adjust station interval to 1000 m to optimise coverage

25/4/17
1600 hrs recover CSEM
2100 hrs on station for coring

26/4/17
0600 hrs coring complete. Commence Acoustic surveying to CSEm deployment start at 1030 hrs
1145 hrs CSEM in water and running

27/4/17
1030 hrs Commence CSEM recovery
1130 hrs transiting to CTD sites

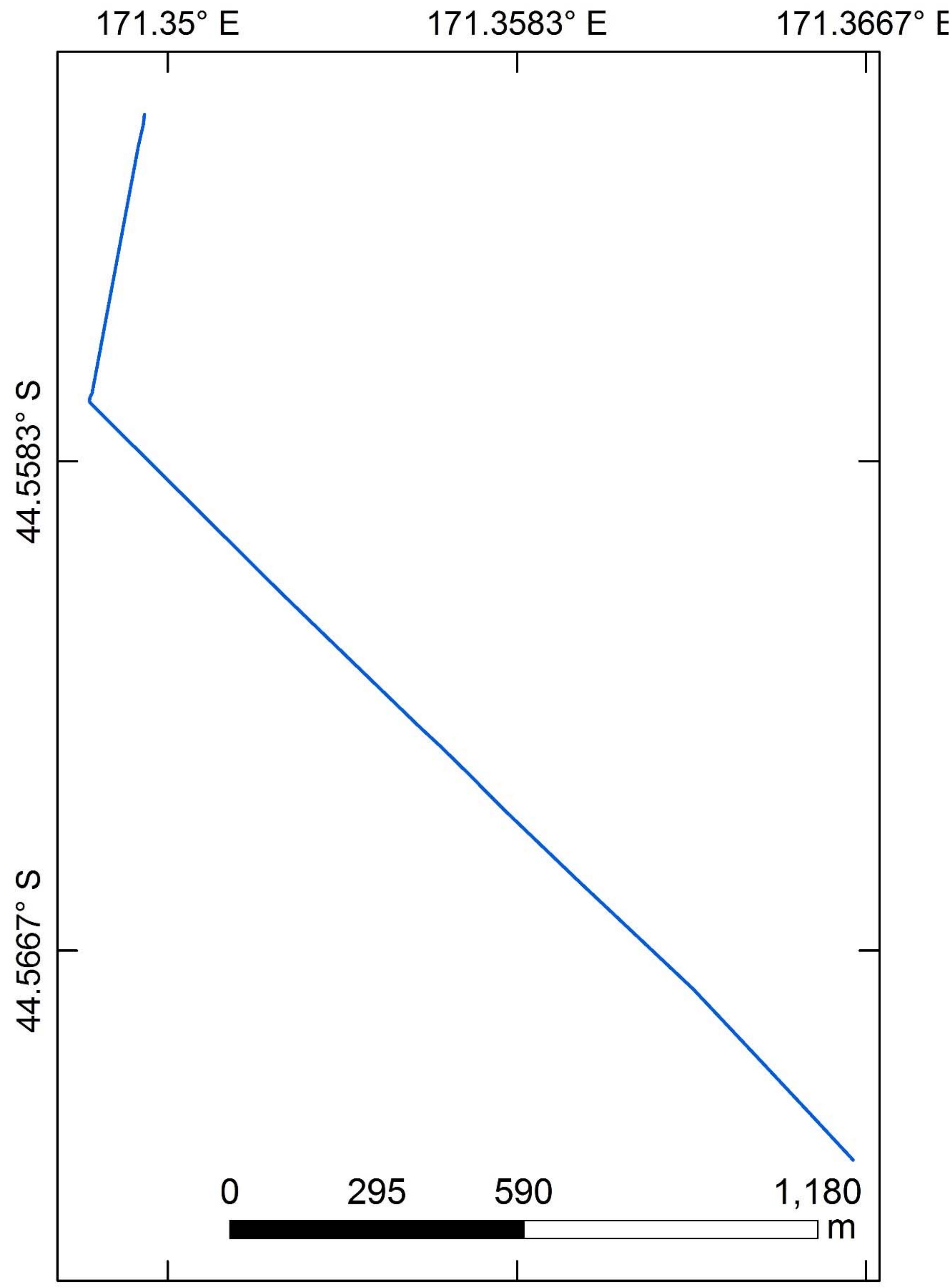
28/4/17
0230 hrs completed CTDs
0630 hrs Transit to CSEM start
0900 hrs onsite for CSEM and deploy receiver string. Wind gusting 45 kt NE. Master call to abort deployment and recover receiver string
1030 hrs Shift to acoustics survey and wait for weather to ease as forecast
1400 hrs Return to CSEM deployment site for weather assessment. Wind now 30 kt from south. Hold for easing
1900 hrs Deploy CSEM
2330 hrs CSEM communication fault. Recover gear and terminate CSEM surveying for trip

29/4/17
0030 hrs move to acoustic mapping
0750 hrs on site for MCS deployment
0850 hrs commence seismic deployment
0920 hrs Seismic system running

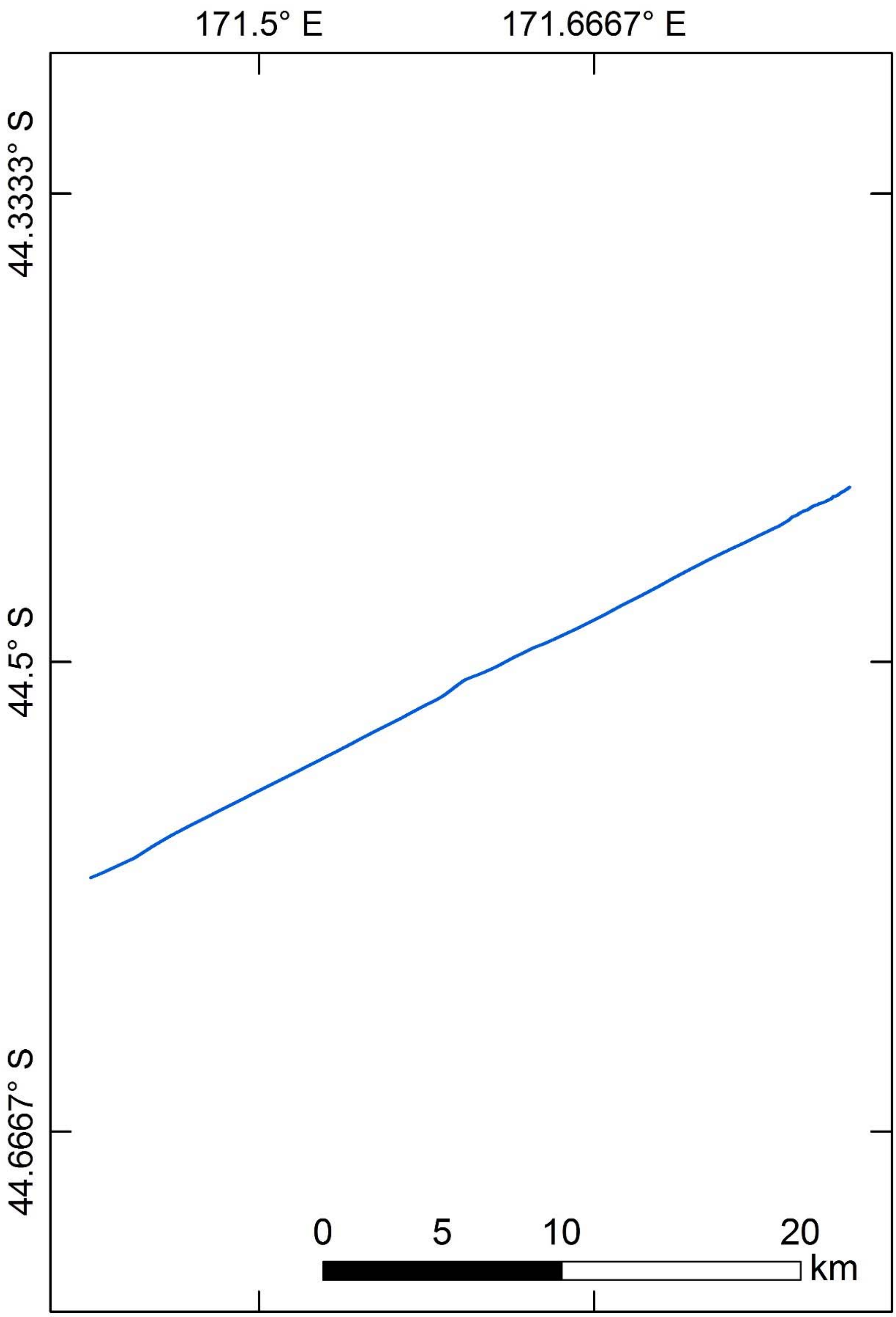
30/4/17
0120 hrs completed seismic survey and recovering equipment
0200 hrs seismic equipment onboard and commence transit to Wellington

31/4/17
0800 hrs Scheduled to meet pilot at Wellington Heads

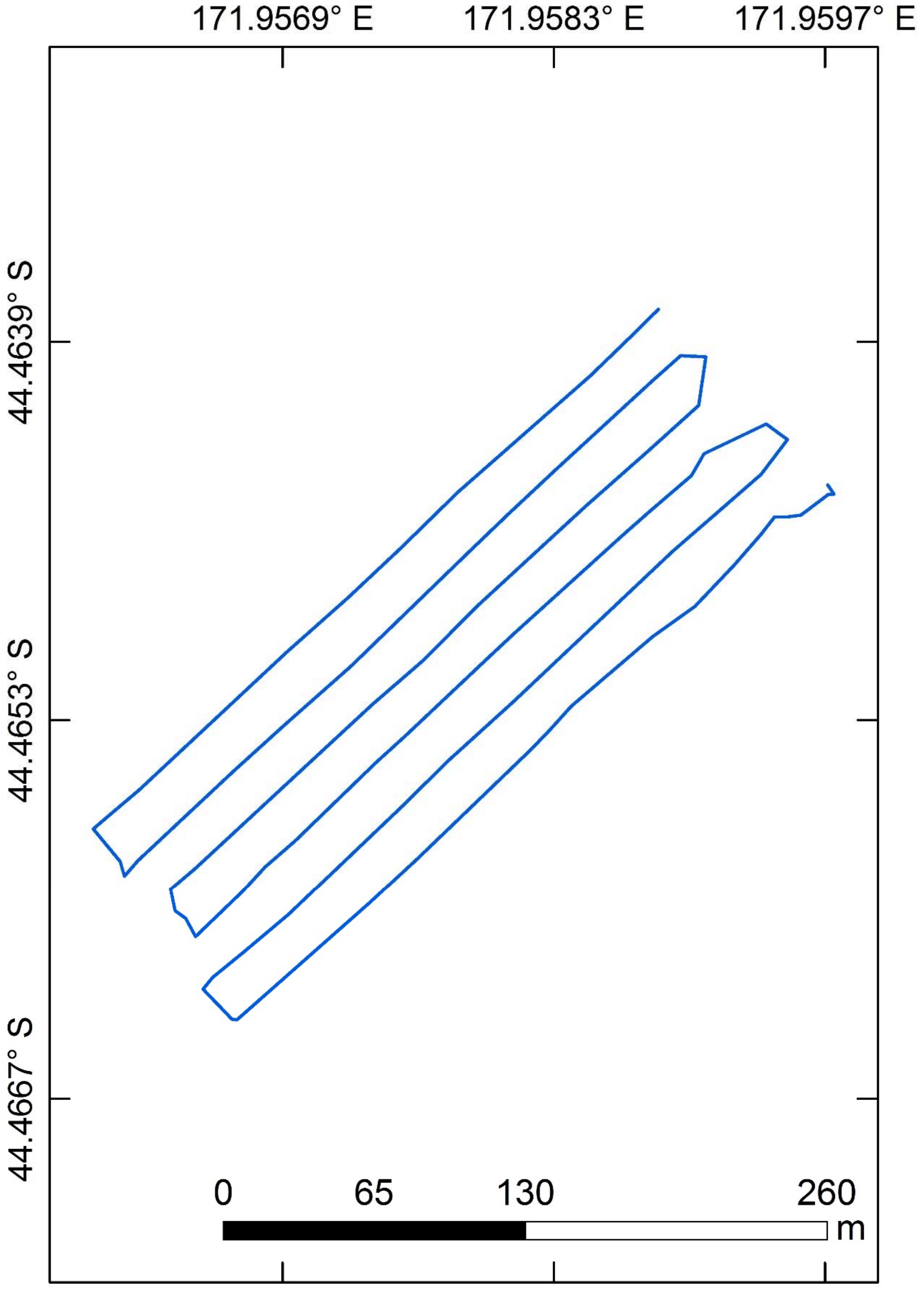
Appendix B Detailed maps of CTD tows



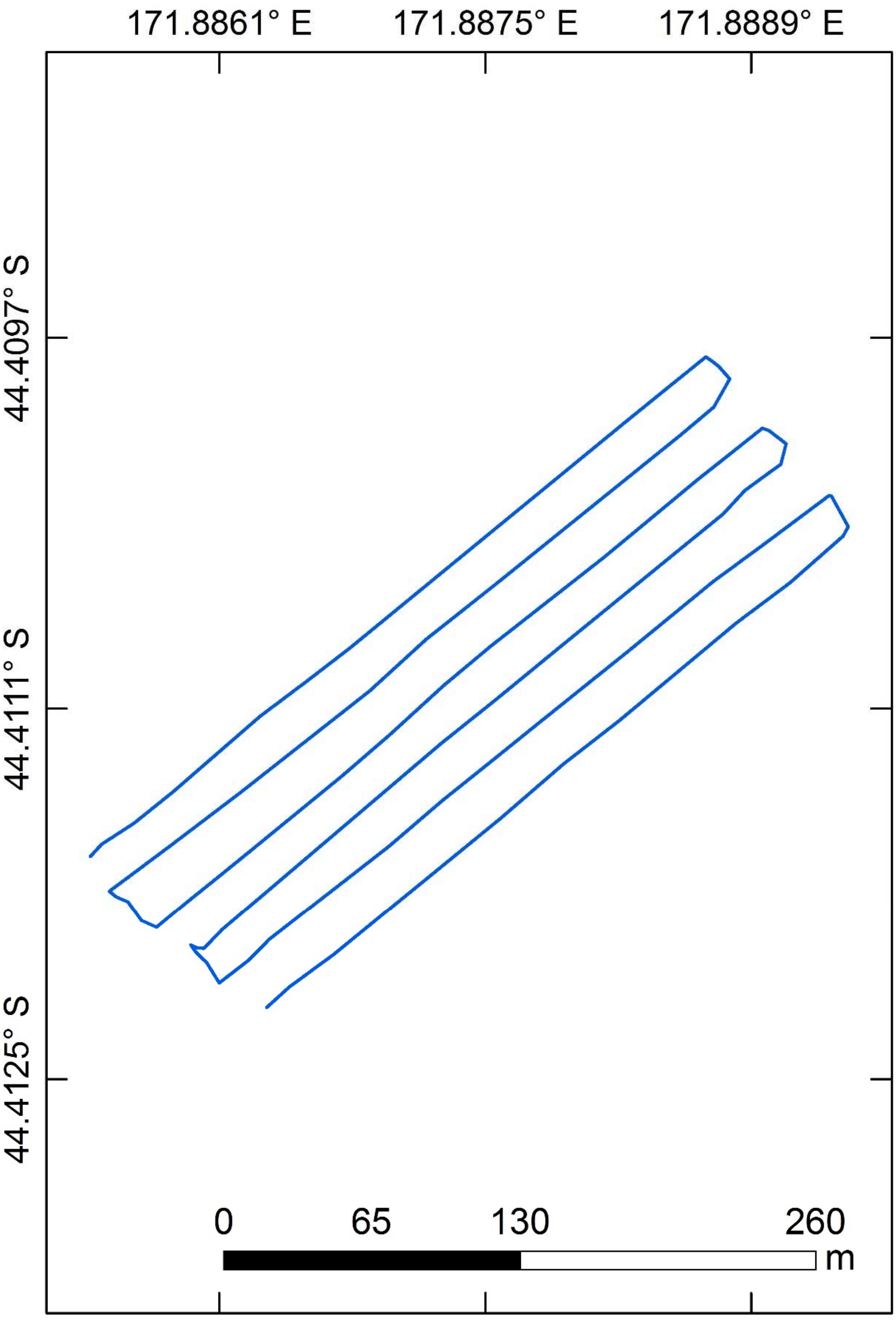
CTD Tow 1



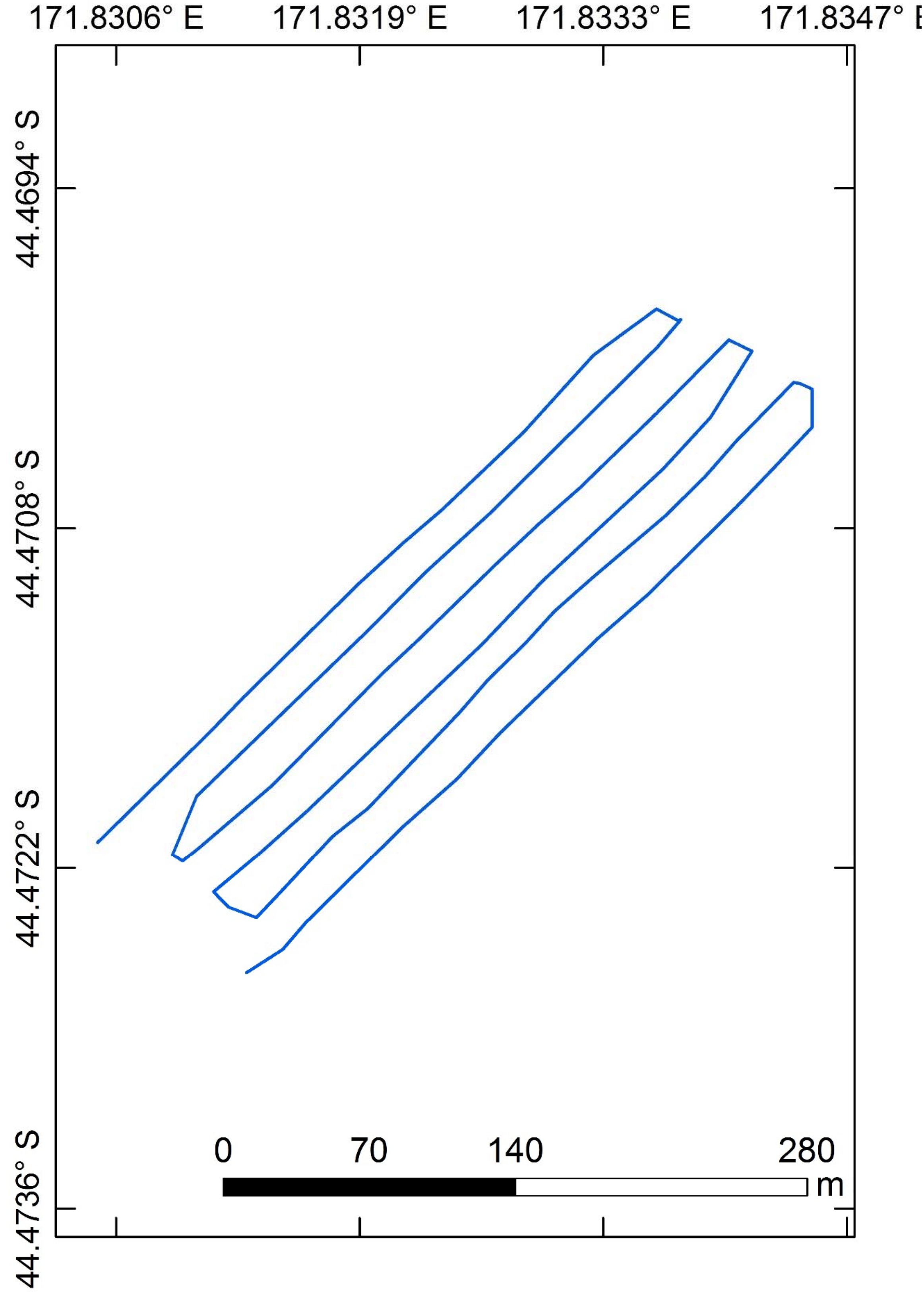
CTD Tow 2


171.9569° E
171.9583° E
171.9597° E
44.4639° S
44.4653° S
44.4667° S
0
65
130
260
m

CTD Tow 3

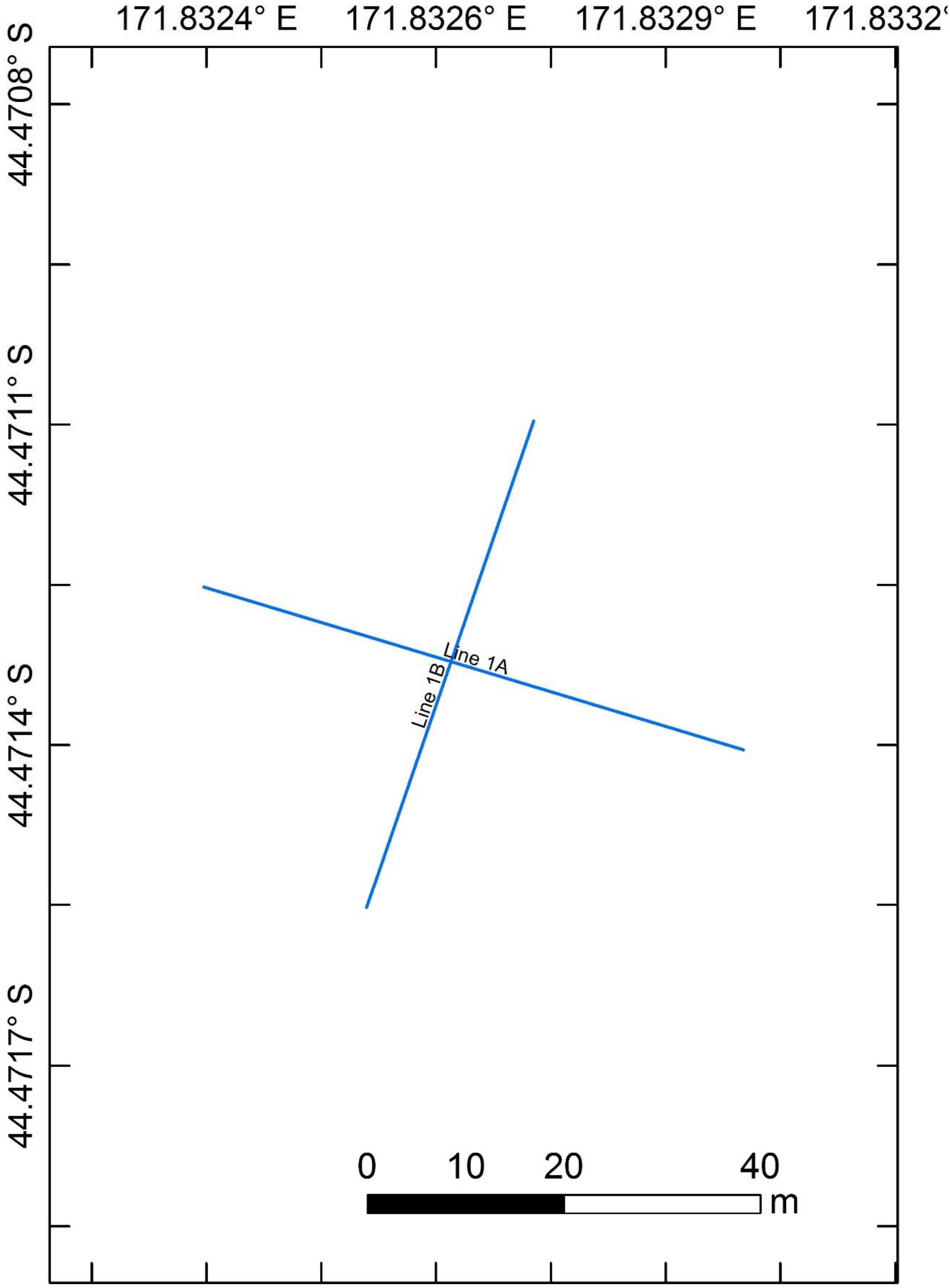

171.8861° E
171.8875° E
171.8889° E
44.4097° S
44.4111° S
44.4125° S
0
65
130
260
m

CTD Tow 4

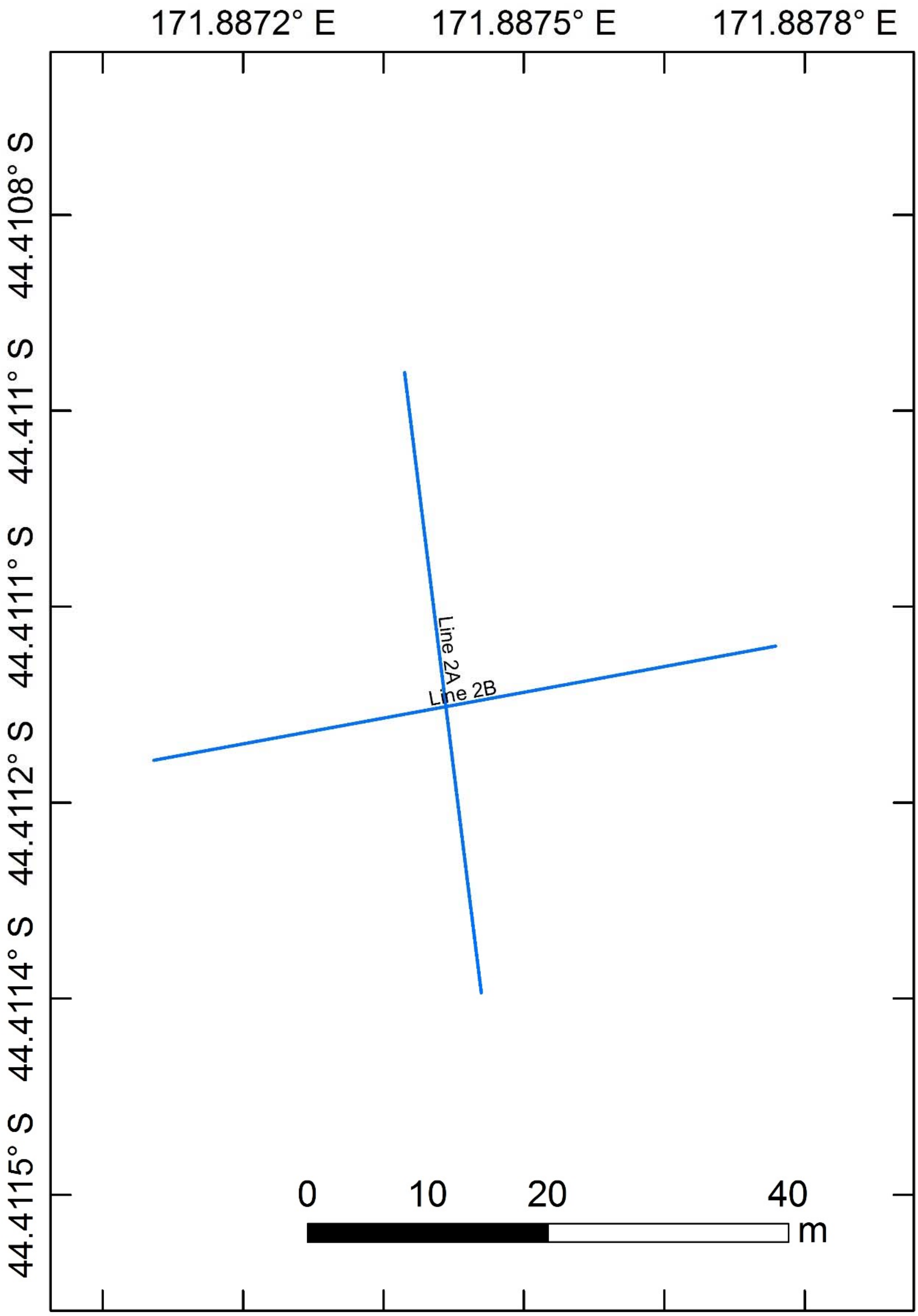

171.8306° E
171.8319° E
171.8333° E
171.8347° E
44.4694° S
44.4708° S
44.4722° S
44.4736° S
0
70
140
280
m

CTD Tow 5

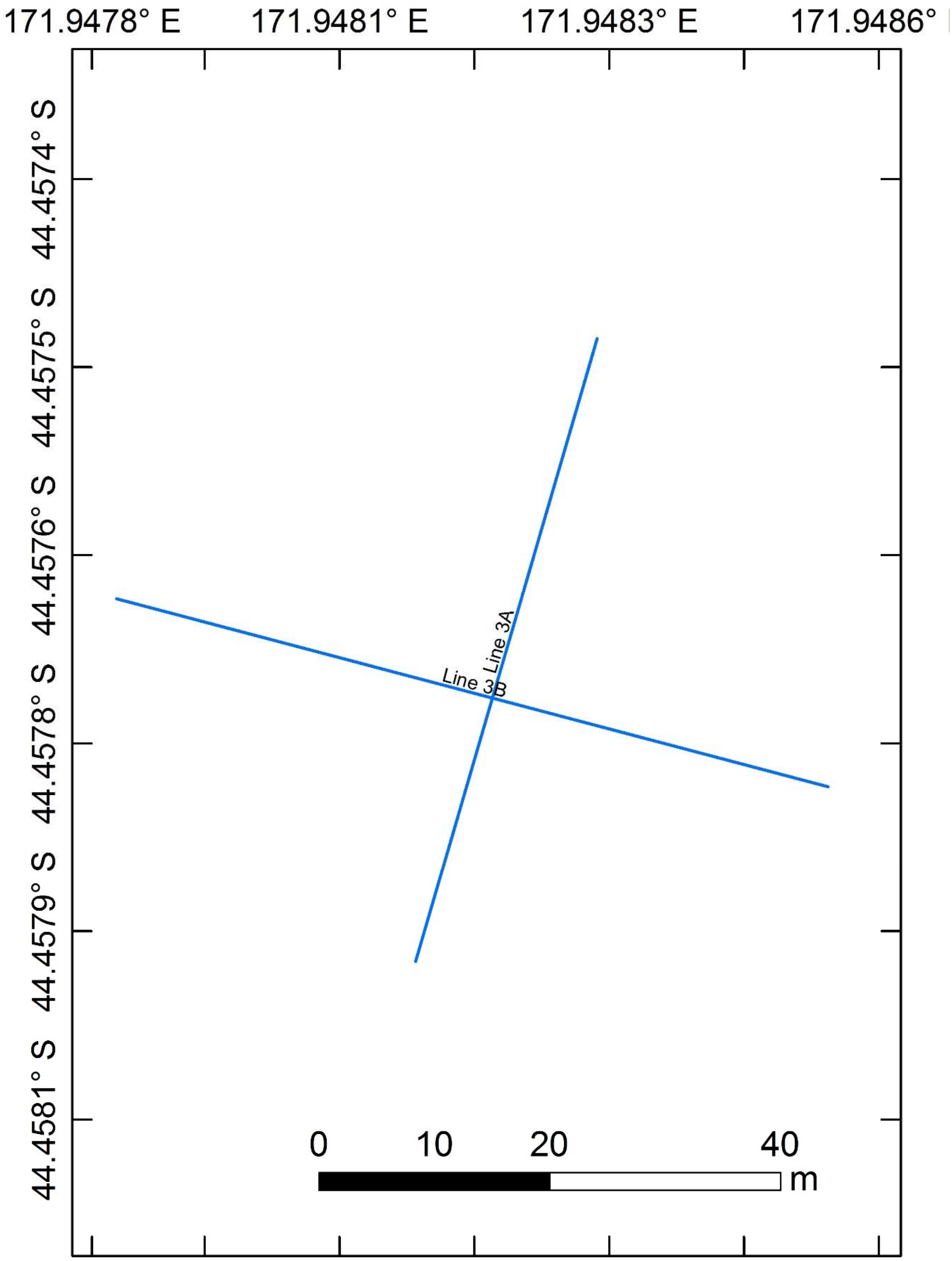
Appendix C Detailed maps of Camera tows



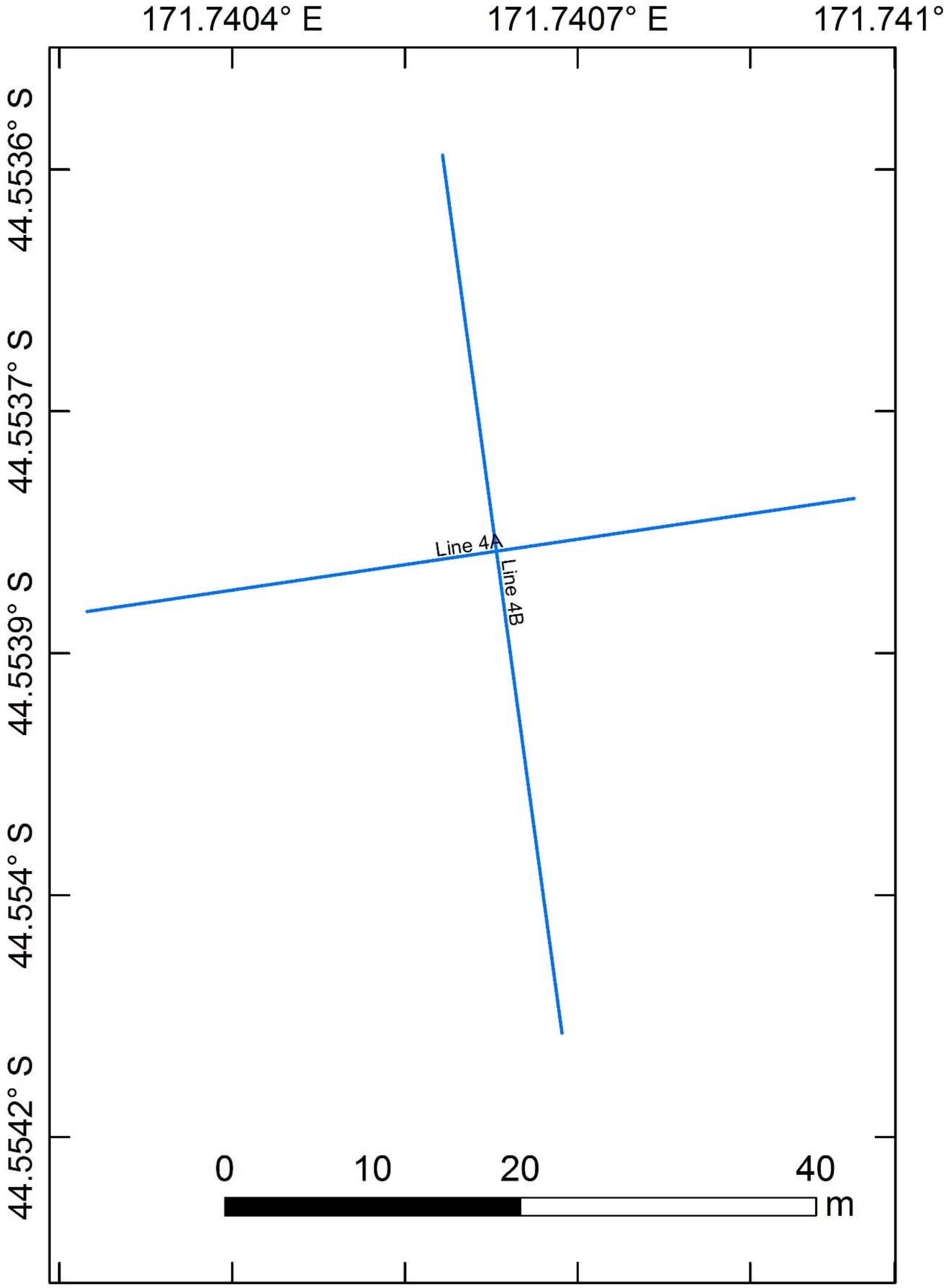
Coast Cam Site 1



Coast Cam Site 2



Coast Cam Site 3



Coast Cam Site 4

Appendix D Seismic Log Sheets

Date UTC dd/mm/yy	Time UTC hrs:min	Line No.	Shot No.	Lattitude dd.mmmm	Longitude dd.mmmm	Speed knots	Ship Heading	Compressor Check	Leakage check	Bird check	Notes
20/04/17	23:06	Line1	1000	43.96826	172.2788	3.6	117	yes	30	yes	SOS1, SOL1, set-up I
20/04/17	23:29	Line1	1590	43.9908	172.3111	4	135	yes	30	yes	
21/04/17	00:10	Line1	2276	44.01968	172.35099	3.4	136	yes	44	yes	Bird3 surfaces sometimes
21/04/17	00:40	Line1	2861	44.04351	172.3839	4.4	137		61	yes	
21/04/17	01:06	Line1	3416	44.06608	172.41519	3.5	134	yes	95	yes	
21/04/17	01:31	Line1	3891	44.08376	172.43997	3.8	132	yes	127	yes	
21/04/17	02:03	Line1	4528	44.1076	172.1076	3.8	126	yes	112	yes	
21/04/17	02:30	Line1	5083	44.1291	172.5031	3.9	130	yes	80	yes	
21/04/17	03:02	Line1	5702	44.1538	172.5377	4.4	131	yes	55	yes	
21/04/17	03:32	Line1	6302	44.1782	172.5717	3.9	131	yes	45	yes	
21/04/17	03:57	Line1	6833	44.1991	172.6007	34.3	132	yes	39	yes	
21/04/17	04:35	Line1	7575	44.2286	172.6422	3.4	134	yes	37	yes	Compressor belt repaired
21/04/17	04:41	Line1	7690	44.2332	172.6487	3.8	134	yes	38	yes	EOL1
21/04/17	04:50	Line1-2	8000	44.24089	172.645	3.8	228	yes	43	yes	SOL1-2
21/04/17	05:20	Line1-2	8600	44.26189	172.6069	3.5	233	see comment	34	yes	Compressor stopped
21/04/17	05:24	Line1-2	8676	44.2642	172.6027	4	234	see comment	35	yes	Compressor started again
21/04/17	05:30	Line1-2	8793	44.2678	172.5959	4	236	yes	36	yes	
21/04/17	06:00	Line1-2	9386	44.2873	172.5609	4	236	yes	32	yes	
21/04/17	06:30	Line1-2	10004	44.3083	172.5223	4.1	232	yes	28	yes	
21/04/17	07:00	Line1-2	10596	44.3293	172.4841	4.1	231	yes	30	yes	
21/04/17	07:34	Line1-2	11294	44.35307	172.44048	4	229	yes	34	yes	Bird3 almost at surface
21/04/17	08:00	Line1-2	11805	44.3699	172.4101	3.9	229	yes	34	yes	
21/04/17	08:30	Line1-2	12398	44.38927	172.3747	3.9	228	yes	29	yes	
21/04/17	08:41	Line1-2	12627	44.3972	172.3602	4.3	233		27	yes	EOL1-2
21/04/17	08:53	Line2	13000	44.3941	172.344	3.5	311	yes	27	yes	SOL2
21/04/17	09:30	Line2	13733	44.3644	172.3055	4.3	313	yes	26	yes	
21/04/17	10:00	Line2	14321	44.3404	172.274	4.2	314	yes	24	yes	
21/04/17	10:30	Line2	14926	44.3166	172.2425	3.78	317	yes	22	yes	
21/04/17	11:00	Line2	15520	44.294	172.2129	3.8	314	yes	22	yes	
21/04/17	11:30	Line2	16140	44.2699	172.1798	4	317	yes	22	yes	
21/04/17	12:00	Line2	16760	44.2424	172.145102	4	321	yes	20	yes	
21/04/17	13:00	Line2	17902	44.1966	172.085	3.5	318	yes	18	yes	
21/04/17	13:30	Line2	18549	44.1704	172.0506	4.6	317	yes	16	yes	
21/04/17	14:00	Line2	19111	44.147	172.0205	4	317	yes	14	yes	

Date UTC dd/mm/yy	Time UTC hrs:min	Line No.	Shot No.	Lattitude dd.mmmm	Longitude dd.mmmm	Speed knots	Ship Heading	Compressor Check	Leakage check	Bird check	Notes
21/04/17	14:29	Line2	19721	44.1215	171.9867	3.7	311	yes		13 yes	EOL2
21/04/17	14:56	Line2-3	20000	44.1238	171.953	4.1	224	yes		12 yes	Transit line to Line3
21/04/17	15:30	Line2-3	20685	44.1494	171.915	4.5	228	yes		13 yes	
21/04/17	16:00	Line2-3	21310	44.1729	171.8786	4.1	228	yes		13 yes	
21/04/17	16:30	Line2-3	21903	44.1964	171.8425	4	226	yes		12 yes	
21/04/17	17:00	Line2-3	22479	44.2187	171.8085	4.6	226	yes		12 yes	
21/04/17	17:30	Line2-3	23099	44.24409	171.7695	4.32	225	yes		12 yes	
21/04/17	18:00	Line2-3	23662	44.2665	171.7357	4.1	225	yes		12 yes	
21/04/17	18:30	Line2-3	24310	44.2926	171.6955	5	226	yes		13 yes	
21/04/17	19:00	Line2-3	24898	44.316	171.66	3.8	223	yes		13 yes	
21/04/17	19:06	Line2-3	25017	44.3204	171.6534	3.8	224	yes		18 yes	EOL2-3
21/04/17	19:28	Line3	26000	44.3424	171.656	4.2	137	yes		14 yes	SOL3
21/04/17	20:00	Line3	26722	44.3709	171.6945	3.4	135	yes		16 yes	
21/04/17	20:32	Line3	27271	44.392	171.724	3.8	135	yes		20 yes	
21/04/17	21:00	Line3	27827	44.4137	171.7538	4.1	140	yes		21 yes	
21/04/17	21:09	Line3	28007	44.4206	171.7634	2.6	141				tailbouy sank
21/04/17	23:15	Line3a	30000	44.4247	171.7689	4	133	yes		0 yes	SOL3a, new set-up II
21/04/17	23:30	Line3a	30381	44.4361	171.7843	3.7	139	yes		4 yes	
22/04/17	00:00	Line3a	30956	44.4584	171.8146	3.8	136	yes		10 yes	
22/04/17	00:30	Line3a	31565	44.4829	171.849	4.2	135	yes		13 yes	
22/04/17	01:00	Line 3a	32155	44.5065	171.8819	3.9	136	yes		14 yes	
22/04/17	01:32	Line3a	32818	44.5323	171.9174	4	131	yes		140 yes	
22/04/17	02:00	Line 3a	33374	44.5549	171.9487	3.9	133	yes		67 yes	
22/04/17	02:30	Line 3a	33973	44.5795	171.9829	4.3	138	yes		50 yes	
22/04/17	03:05	Line3a	34699	44.6091	172.024	3.7	139	yes		39 yes	EOL3a
22/04/17	03:24	Line3-4	35000	44.6247	172.0205	3.4	217	yes		38 yes	SOL3-4,transit to Line4
22/04/17	04:00	Line 3-4	35711	44.656	171.9934	3	217	yes		32 yes	
22/04/17		Line3-4	35850								slowed to 1 kn for zodiac
22/04/17	04:22	Line3-4	36100								back to 4 kn
22/04/17	04:34	Line3-4	36388								boat still out slow
22/04/17	05:03	Line3-4	36975	44.699	171.9577	4.2	212	yes		18 yes	up to speed
22/04/17	05:35	line3-4	37622	44.7296	171.9304	4.05	212			160 yes	
22/04/17	06:12	line3-4	38346	44.763	171.902	3.4	211	yes		18 yes	
22/04/17	06:30	line3-4	38802	44.7843	171.8838	3.7	213	yes		28 yes	

Date UTC dd/mm/yy	Time UTC hrs:min	Line No.	Shot No.	Lattitude dd.mmmm	Longitude dd.mmmm	Speed knots	Ship Heading	Compressor Check	Leakage check	Bird check	Notes
22/04/17	07:00	line3-4	39314	44.8088	171.8619	3	209	yes	31	yes	
22/04/17	07:33	line3-4	39977	44.8403	171.8351	4.1	208	yes	28	yes	
22/04/17	07:50	line3-4	40311	44.8569	171.8213	4.5	225	yes	27	yes	end of line, gun trigfger off
22/04/17											Compressor switched itself off at 2700psi
22/04/17	08:08	line4	50000	44.8533	171.7958	4.4	317	yes	27	yes	SOL Line 4
22/04/17	08:30	line4	50450	44.8371	171.772	4.6	314	yes	26	yes	
22/04/17	09:00	line4	51090	44.8122	171.7364	4.1	310	yes	16	yes	
22/04/17	09:30	line4	51639	44.7917	171.7066	4	314	yes	25	yes	
22/04/17	10:00	line4	52275	44.7679	171.6726	4.2	319	yes	24	yes	
22/04/17	10:30	line4									
22/04/17	11:00	line4	53485	44.7214	171.6054	3.8	315	yes	23	yes	
22/04/17	11:30	line4	54039	44.6999	171.5747	4.3	310	yes	22	yes	
22/04/17	12:00	line4	54692	44.6737	171.5369	4.5	315	yes	7	yes	
22/04/17	12:30	line4	55290	44.6491	171.5019	4.4	313	yes	19	yes	
22/04/17	13:00	line4	55809	44.6284	171.4726	4	314	yes	13	yes	1st bird on surface. Pressure sensor fail
22/04/17	13:30	line4	56444	44.6043	171.4383	3.5	311	yes	15	yes	
22/04/17	13:46	line4	56759	44.5923	171.4209	3.5	309	yes	15	yes	EOL Line4. Replaced 1st bird before turn
22/04/17											
22/04/17	14:54	line4-5	60000	44.6068	171.3942	4	150	yes	36	yes	SOL line4-5. Leakage slowly coming down
22/04/17	15:30	line4-5	60777	44.6449	171.4263	4.6	150	yes	17	yes	
22/04/17	16:00	line4-5	61361	44.672	171.4499	4.3	148	yes	17	yes	
22/04/17	16:09	line4-5	61709	44.6898	171.4652	4.3	148		18	yes	EOL4-5
22/04/17	16:36	Line5	63000	44.6861	171.4898	4.3	40	yes	16	yes	SOL 5
22/04/17	17:00	line5	63485	44.6676	171.5166	3.8	46	yes	15	yes	
22/04/17	17:30	Line5	64100	44.6436	171.5511	4.1	49	yes	14	yes	
22/04/17	18:00	Line5	64685	44.6212	171.5832	4	53	yes	15	yes	
22/04/17	18:30	Line5	65350	44.5936	171.6229	4	46	yes	16	yes	
22/04/17	19:00	Line5	65889	44.5729	171.6524	4.2	45	yes	21	yes	
22/04/17	19:30	Line5	66456	44.5496	171.6859	5	48	yes	13	yes	
22/04/17	20:00	Line5	67078	44.5253	171.7214	4	59	yes	13	yes	slightly off course, seaweed
22/04/17	20:30	Line5	67686	44.5028	171.7542	4.5	30	yes	13	yes	
22/04/17	21:00	Line5	68290	44.4787	171.7863	4	51	yes	14	yes	
22/04/17	21:30	Line5	68871	44.45568	171.82006	3.7	54	yes	15	yes	
22/04/17	22:07	Line5	69622	44.4274	171.863	4.1	52	yes	17	yes	slightly off course, seaweed

Date UTC dd/mm/yy	Time UTC hrs:min	Line No.	Shot No.	Lattitude dd.mmmm	Longitude dd.mmmm	Speed knots	Ship Heading	Compressor Check	Leakage check	Bird check	Notes
22/04/17	22:30	Line5	70045	44.4107	171.8856	4.1	45	yes	16	yes	
22/04/17	23:01	Line5	70698	44.3863	171.9213	4.2	62	yes	20	yes	
22/04/17	23:32	Line5	71318	44.3622	171.9526	3.7	49	yes	25	yes	Whales starboard 1.5 nm away
23/04/17	00:00	Line5	71861	44.3426	171.9813	3.1	43	yes	16	yes	
23/04/17	00:30	Line5	72482	44.3193	172.0137	3.8	46	yes	28	yes	
23/04/17	01:00	Line5	73076	44.2971	172.0452	3.9	48	yes	21	yes	
23/04/17	01:30	Line5	73673	44.2752	172.0763	4	43	yes	25	yes	
23/04/17	02:00	Line5	74275	44.2532	172.1071	3.8	45	yes	18	yes	
23/04/17	02:07	Line5	74422								slowing down for zodiac
23/04/17	02:15	Line5	74577								down to 1.5 -2 kn
23/04/17	02:30	Line5	74895	44.2395	172.1258	1.5	41	yes	10		birds at 7, 10 and 18 m depth
23/04/17	02:40	Line5	75103								back up to 4 kn
23/04/17	03:00	Line5	75470	44.2204	172.1533	3.7	45	yes	19	yes	
23/04/17	03:30	Line5	76068	44.197	172.1861	3.7	44	yes	15	yes	
23/04/17	03:48	Line5	76433								stopped for compressor repair
23/04/17	05:26	Line5a	77000	44.1945	172.1899	4.1	43	yes	6	yes	SOL 5a
23/04/17	06:00	Line5a	77698	44.1679	172.2268	3.7	46	yes	4	yes	
23/04/17	06:30	Line5a	78244	44.1479	172.255	3.5	47	yes	4	yes	
23/04/17	07:00	Line5a	78805	44.1249	172.2872	3.5	47	yes	3	yes	
23/04/17	07:30	Line5a	79510	44.0975	172.3258	4.3	43	yes	3	yes	
23/04/17	08:00	Line5a	80029	44.0769	172.3544	4	42	yes	3	yes	
23/04/17	08:30	Line5a	80687	44.0523	172.3889	3.7	44	yes	3	yes	
23/04/17	09:00	Line5a	81240	44.0303	172.4196	3.7	44	yes	3	yes	
23/04/17	09:10	Line5a	81434								turn end of line, switched off
23/04/17	09:36	Line5a-6	90000	44.0299	172.4361	4.2	133	yes	2	yes	start pof line
23/04/17	10:00	Line5a-6	90440	44.0474	172.4873	3.8	134	yes	2	yes	
23/04/17	10:30	Line5a-6	91089	44.0732	172.5236	4.2	132	yes	2	yes	
23/04/17	11:00	Line5a-6	91628	44.0945	172.5535	4.2	136	yes	3	yes	
23/04/17	11:29	Line5a-6	92241	44.1199	172.587	4	169	yes	3	yes	end of line, gun trigfger off
23/04/17	11:40	Line6	100000	44.1298	172.5772	3.8	232	yes	3	yes	start pof line
23/04/17	12:00	Line6	100404	44.1454	172.5552	4.5	225	yes	2	yes	
23/04/17	12:30	Line6	100975	44.1669	172.5259	4.2	226	yes	2	yes	
23/04/17	13:00	Line6	101580	44.1906	172.4924	4.2	227	yes	2	yes	
23/04/17	13:30	Line6	102194	44.21456	172.4589	4.4	225	yes	2	yes	

Date UTC dd/mm/yy	Time UTC hrs:min	Line No.	Shot No.	Lattitude dd.mmmm	Longitude dd.mmmm	Speed knots	Ship Heading	Compressor Check	Leakage check	Bird check	Notes
23/04/17	14:00	Line6	102777	44.2369	172.4277	3.9	225	yes	2	yes	
23/04/17	14:30	Line6	103380	44.2606	172.3945	4	227	yes	3	yes	
23/04/17	15:00	Line6	103965	44.2841	172.3616	4.2	227	yes	3	yes	
23/04/17	15:30	Line6	104575	44.3085	172.3273	4.1	226	yes	2	yes	
23/04/17	16:00	Line6	105222	44.3343	172.2913	4.2	228	yes	2	yes	
23/04/17	16:30	Line6	105848	44.3592	172.2563	4.1	229	yes	2	yes	
23/04/17	17:00	Line6	106386	44.3805	172.2261	3.7	229	yes	2	yes	
23/04/17	17:30	Line6	106978	44.4037	172.1935	4.2	229	yes	2	yes	
23/04/17	18:00	Line6	107578	44.428	172.1601	4.1	229	yes	2	yes	
23/04/17	18:30	Line6	108178	44.45	172.128	4.3	227	yes	2	yes	
23/04/17	19:00	Line6	108778	44.4734	172.0951	4	224	yes	2	yes	
23/04/17	19:30	Line6	109378	44.4965	172.0623	3.8	227	yes	2	yes	
23/04/17	20:00	Line6	110022	44.5215	172.0268	3.9	225	yes	2	yes	
23/04/17	20:30	Line6	110598	44.5434	171.9957	4.3	223	yes	3	yes	
23/04/17	21:00	Line6	111177	44.5653	171.9646	3.6	231	yes	3	yes	
23/04/17	21:30	Line6	111824	44.59	171.9291	3.6	230	yes	3	yes	
23/04/17	22:00	Line6	112385	44.6109	171.8997	4	217	yes	2	yes	
23/04/17	22:30	Line6	112990	44.6347	171.8658	3.6	225	yes	2	yes	
23/04/17	23:00	Line6	113602	44.6579	171.8322	4	218	yes	2	yes	
23/04/17	23:30	Line6	114177	44.6801	171.801	3.9	221	yes	2	yes	
24/04/17	00:00	Line6	114806	44.7041	171.7664	3.6	223	yes	2	yes	
24/04/17	00:30	Line6	115390	44.7276	171.7329	3.8	222	yes	2	yes	
24/04/17	01:00	Line6	115990	44.7516	171.6982	4.2	222	yes	2	yes	
24/04/17	01:30	Line6	116615	44.7772	171.6618	4.2	227	yes	1	yes	
24/04/17	01:53	Line6	117039	44.7947	171.6365	4.5	226		1	yes	EOL 6, EOS1
28/04/17	21:27	Line10	200016	45.12776	171.79033	3	283	yes	8	yes	SOS2, SOL10, new set-up III
28/04/17	22:00	Line10	200705	45.1115	171.7439	4	287	yes	9	yes	20 kn dropping, 2-3m swell
28/04/17	22:30	Line10	201290	45.097	171.7042	3.5	297	yes	9	yes	long swell +choppy
28/04/17	23:00	Line10	201896	45.0882	171.6642	3.2	291	yes	9	yes	
28/04/17	23:30	Line10	202462	45.06925	171.6277	4.4	290	yes	10	yes	
29/04/17	00:00	Line10	203088	45.0541	171.5854	4.1	286	yes	9	yes	
29/04/17	00:33	Line10	203741	45.0376	171.5401	4.3	289	yes	9	yes	
29/04/17	01:00	Line10	204285	45.02448	171.50338	4.2	289	yes	9	yes	dolphins at bow

Date UTC dd/mm/yy	Time UTC hrs:min	Line No.	Shot No.	Lattitude dd.mmmm	Longitude dd.mmmm	Speed knots	Ship Heading	Compressor Check	Leakage check	Bird check	Notes
29/04/17	01:30	Line10	204882	45.0096	171.463	3.6	287	yes	9	yeah	
29/04/17	02:00	Line10	205483	44.9948	171.4213	3.4	290	yes	8	yes	
29/04/17	02:30	Line10	206085	44.97978	171.3799	4.5	290	yes	8	yes	
29/04/17	03:00	Line10	206686	44.9653	171.34057	3	291	yes	8	yes	
29/04/17	03:30	Line10	207282	44.9511	171.3015	4.2	295	yes	9	yes	
29/04/17	04:08	Line10	208054	44.9322	171.2496	4	300	yes	9	yes	EOL10,
29/04/17	04:30	Line10-11	300000	44.9475	171.2358	3.9	174	yes	9	yes	SOL10-11, transit line
29/04/17	05:00	Line10-11	300605	44.9797	171.2419	4.05	174	yes	8	yes	very shallow
29/04/17	05:30	Line10-11	301184	45.0098	171.2486	3.9	173	yes	8	yo	
29/04/17	06:00	Line10-11	301798	45.0409	171.2555	4.4	177	yes	8	ya	
29/04/17	06:23	Line10-11	302251	45.0658	171.2604	4	179			yes	end of transit line
29/04/17	07:10	Line11	400000	45.0741	171.2311	4.1	40	yes	8	yes	SOL11
29/04/17	07:30	Line11	400383	45.0592	171.252	4	42	at start of line	9	yes	
29/04/17	08:00	Line11	400967	45.0365	171.2859	3.85	42	yes	9	yes	
29/04/17	08:30	Line11	401592	45.0123	171.3215	3.89	39.5	yes	9	yes	
29/04/17	09:00	Line11	402175	44.9893	171.3548	4.4	43	yes	9	yes	
29/04/17	09:30	Line11	402779	44.9651	171.39	4.3	46	yes	9	yes	
29/04/17	10:00	Line11	403383	44.94	171.4266	4.3	46	yes	9	yes	
29/04/17	10:30	Line11	403992	44.9149	171.4629	4.16	49	yes	9	yes	
29/04/17	11:00	Line11	404618	44.8891	171.5003	4.37	45	yes	9	yes	
29/04/17	11:30	Line11	405175	44.8688	171.5294	3.8	47	yes	9	yes	
29/04/17	12:00	Line11	405789	44.8472	171.5613	3.7	50	yes	9	yes	
29/04/17	12:30	Line11	406350	44.827	171.59	4	47	yes	10	yes	
29/04/17	13:00	Line11	406974	44.8039	171.6237	3.7	48	yes	10	yes	
29/04/17	13:23	Line11	407443	44.7862	171.6488	3.5	50				EOL11, EOS2

Appendix E Marine Mammal Observations

Day	Time	Location	Latitude (S)	Longitude (E)	Type	Number	Directions / heading
27/04/17	22:00	South Canterbury	45º 04.6900	171º 28.056	Dusky < 2 m	hundreds	SW
24/04/17	15:30	South Canterbury	44º 44.2385	171º 29.12	Finn Whale <24 m	1	NE
24/04/17	15:00	-	44º 41.10	171º 28.6	Dusky < 2 m	200-300	South
23/04/17	11:30	-	44º 21.39	171º 57.65	Blue whale or Finn Whale	2-3	East
23/04/17	10:00	South Canterbury	44º 26.05	171º 50.9	Sperm whale < 18m	1	East

Appendix F Core sampling table

					samples taken					measurements					
date NZST 2017	core station TAN1703-	sample #	total length [cm]	depth from core top [cm]	δ18O mL	δ2H mL	DIC mL	Cations mL	Anions mL	temp sample in lab °C	pH	DO mg/L	conductivity mS/cm	master leftover (approx.)	remarks
12 Apr	IAPSO	-	-	-	-	-	-	-	-	5.0	8.170	9.51	51.1	-	
19 Apr	8	P1	184	160	~4.7	~1.85	9	4	4	7.9	7.952	10.25	52.4	5	
19 Apr	8	P2	184	150	~4.7	~1.85	9	4	4	7.3	7.954	9.16	52.3	8	
21 Apr	IAPSO	-	-	-	-	-	-	-	-	7.0	8.184	12.46	54.3	-	
21 Apr	26	P3	129	119	~4.7	~1.85	9	4	4	6.6	7.961	9.92	51.2	14	TAN1703-26: PW sampling over night
21 Apr	26	P4	129	109	~4.7	~1.85	9	4	4	6.5	8.033	9.69	51.6	14	
25 Apr	28	P5	416	5	~4.7	~1.85	9	4	4	7.0	7.903	11.94	51.6	5	
25 Apr	28	P6	416	15	~4.7	~1.85	9	4	4	6.6	7.826	10.53	51.7	18	
25 Apr	28	P7	416	396.5	~4.7	~1.85	9	4	4	7.7	7.926	7.13	51.3	8	DIC: black after addition of CuSO4 solution
25 Apr	28	P8	416	407	~4.7	~1.85	9	4	4	7.4	7.842	7.14	51.3	10	DIC: black after addition of CuSO4 solution
25 Apr	IAPSO	-	-	-	-	-	-	-	-	6.8	8.087	11.82	52.6	-	
25 Apr	29	P9	570	5	0	0	0	0	0	-	-	-	-	0	0 mL sample
25 Apr	29	P10	570	15	~4.7	~1.85	9	4	4	6.8	7.809	7.81	51.7	15	TAN1703-29 to 32: PW sampling over night
25 Apr	29	P11	570	110	~4.7	~1.85	9	4	4	6.6	7.849	10.84	51.5	15	
25 Apr	29	P12	570	210	~4.7	~1.85	9	4	4	6.6	7.840	10.80	51.5	15	
25 Apr	29	P13	570	310	~4.7	~1.85	9	4	4	6.9	7.828	10.96	51.7	15	
25 Apr	29	P14	570	410	~4.7	~1.85	9	4	4	7.2	7.843	11.31	51.7	8	
25 Apr	29	P15	570	510	~4.7	~1.85	9	4	4	7.2	7.844	11.28	51.6	10	
25 Apr	29	P16	570	551	~4.7	~1.85	9	4	4	7.3	7.876	11.19	51.7	10	
25 Apr	29	P17	570	561	~4.7	~1.85	9	4	4	7.4	7.915	10.32	51.6	12	
26 Apr	30	P18	385	5	~4.7	~1.85	9	4	4	7.1	7.914	11.25	51.7	12	
26 Apr	30	P19	385	15	~4.7	~1.85	9	4	4	6.9	7.905	11.28	51.7	10	
26 Apr	30	P20	385	110	~4.7	~1.85	9	4	4	7.1	7.891	10.96	51.7	6	
26 Apr	30	P21	385	210	~4.7	~1.85	9	4	4	7.1	7.880	10.71	51.5	8	
26 Apr	30	P22	385	310	~4.7	~1.85	9	4	4	7.0	7.874	9.81	51.6	5	
26 Apr	30	P23	385	375	~4.7	~1.85	9	4	4	6.9	7.818	8.64	51.6	8	DIC: slightly black after addition of CuSO4 solution
26 Apr	31	P24	535	5	~4.7	~1.85	9	4	4	7.1	7.884	10.94	52.0	10	
26 Apr	31	P25	535	15	~4.7	~1.85	9	4	4	6.9	7.924	11.05	51.9	10	
26 Apr	31	P26	535	525	~4.7	~1.85	9	4	4	7.0	7.935	7.55	51.6	8	DIC: slightly black after addition of CuSO4 solution
26 Apr	8	P27	184	90	~4.7	~1.85	9	4	4	6.8	7.874	9.96	51.9	15	
26 Apr	26	P28	129	90	~4.7	~1.85	9	4	4	6.7	7.944	10.53	51.2	12	

					samples taken					measurements					
date NZST 2017	core station TAN1703-	sample #	total length [cm]	depth from core top [cm]	δ18O mL	δ2H mL	DIC mL	Cations mL	Anions mL	temp sample in lab °C	pH	DO mg/L	conductivity mS/cm	master leftover (approx.)	remarks
26 Apr	32	P29	0	10	~4.7	~1.85	-	4	4	7.3	7.876	10.74	52.2	18	core' in zip bag (sediment sample)
26 Apr	32	P30	0	24	~4.7	~1.85	-	4	4	7.2	7.865	10.64	52.1	15	
26 Apr	8	P31	184	50	~4.7	~1.85	-	4	4	7.1	7.789	10.69	51.8	19	
26 Apr	8	P32	184	123	~4.7	~1.85	9	4	4	7.2	7.799	10.68	52.2	4	
26 Apr	26	P33	129	33	~4.7	~1.85	-	4	4	6.8	7.882	10.94	51.7	18	
26 Apr	26	P34	129	63	~4.7	~1.85	9	4	4	6.8	7.981	11.15	51.5	12	
26 Apr	28	P35	416	40	~4.7	~1.85	-	4	4	6.8	7.873	9.47	51.8	20	
26 Apr	28	P36	416	65	~4.7	~1.85	9	4	4	6.4	7.799	10.06	51.5	12	
26 Apr	28	P72	416	100	~4.7	~1.85	-	4	4	6.8	7.824	10.35	51.5	20	
26 Apr	28	P37	416	125	~4.7	~1.85	9	4	4	6.5	7.829	9.46	51.9	13	
26 Apr	28	P38	416	150	~4.7	~1.85	-	4	4	6.5	7.835	9.59	51.6	19	
26 Apr	28	P39	416	175	~4.7	~1.85	9	4	4	6.9	7.721	8.79	51.7	10	
26 Apr	28	P40	416	205	~4.7	~1.85	-	4	4	6.8	7.721	8.69	51.3	20	
26 Apr	28	P41	416	230	~4.7	~1.85	9	4	4	6.6	7.842	7.75	51.4	6	
26 Apr	28	P42	416	255	~4.7	~1.85	-	4	4	6.9	7.732	8.52	51.1	20	
26 Apr	28	P43	416	280	~4.7	~1.85	9	4	4	6.8	7.737	8.47	51.2	10	
26 Apr	28	P44	416	306	~4.7	~1.85	-	4	4	6.8	7.798	7.92	51.2	18	
26 Apr	28	P45	416	331	~4.7	~1.85	9	4	4	7.2	7.682	7.31	51.5	8	
26 Apr	28	P46	416	356	~4.7	~1.85	-	4	4	7.1	7.687	6.75	51.5	18	
26 Apr	28	P47	416	380.5	~4.7	~1.85	9	4	4	6.9	7.924	8.92	51.4	14	DIC: black after addition of CuSO4 solution
26 Apr	29	P48	570	65	~4.7	~1.85	-	4	4	6.9	7.860	11.45	51.5	18	
26 Apr	29	P49	570	159	~4.7	~1.85	-	4	4	6.9	7.788	9.76	51.5	17	
26 Apr	29	P50	570	259.5	~4.7	~1.85	9	4	4	6.8	7.838	11.00	51.5	8	
26 Apr	29	P51	570	359.5	~4.7	~1.85	-	4	4	6.8	7.860	11.22	51.5	20	
26 Apr	29	P52	570	459.5	~4.7	~1.85	9	4	4	6.8	7.835	10.75	51.5	8	
26 Apr	30	P53	385	40	~4.7	~1.85	-	4	4	6.7	7.873	9.98	51.8	18	
26 Apr	30	P54	385	65	~4.7	~1.85	-	4	4	6.8	7.838	10.16	51.5	18	
26 Apr	30	P73	385	85	~4.7	~1.85	9	4	4	6.8	7.861	10.29	51.6	10	
26 Apr	30	P55	385	135	~4.7	~1.85	-	4	4	6.8	7.884	11.05	51.8	16	
26 Apr	30	P56	385	160	~4.7	~1.85	9	4	4	6.8	8.263	10.68	51.7	9	
26 Apr	30	P57	385	180	~4.7	~1.85	-	4	4	7.0	7.843	9.30	51.3	20	

					samples taken					measurements					
date NZST 2017	core station TAN1703-	sample #	total length [cm]	depth from core top [cm]	δ18O mL	δ2H mL	DIC mL	Cations mL	Anions mL	temp sample in lab °C	pH	DO mg/L	conductivity mS/cm	master leftover (approx.)	remarks
26 Apr	30	P58	385	236	~4.7	~1.85	9	4	4	6.9	7.894	11.32	51.6	8	
26 Apr	30	P59	385	261	~4.7	~1.85	-	4	4	7.3	7.940	10.08	51.6	18	
26 Apr	30	P60	385	280.5	~4.7	~1.85	9	4	4	6.7	7.844	9.82	51.5	10	
26 Apr	30	P61	385	332	~4.7	~1.85	-	4	4	6.9	7.791	9.30	51.5	18	
26 Apr	30	P62	385	357	~4.7	~1.85	9	4	4	7.1	7.756	8.35	51.5	12	
26 Apr	31	P63	535	66	~4.7	~1.85	-	4	4	6.9	7.882	10.52	51.7	17	
26 Apr	31	P64	535	108	~4.7	~1.85	-	4	4	6.9	7.923	9.96	51.7	19	
26 Apr	31	P65	535	158	~4.7	~1.85	9	4	4	7.2	7.874	7.93	51.8	10	
26 Apr	31	P66	535	208	~4.7	~1.85	-	4	4	6.6	7.849	10.15	52.0	16	
26 Apr	31	P67	535	258	~4.7	~1.85	9	4	4	6.7	7.855	10.30	52.0	8	
26 Apr	31	P68	535	309	~4.7	~1.85	-	4	4	6.8	7.786	8.32	51.8	20	
26 Apr	31	P69	535	359	~4.7	~1.85	9	4	4	6.9	7.722	6.89	51.7	13	
26 Apr	31	P70	535	409	~4.7	~1.85	-	4	4	6.8	7.713	4.43	51.7	20	
26 Apr	31	P71	535	459	~4.7	~1.85	9	4	4	6.8	7.865	6.95	51.6	8	
26 Apr	IAPSO	-	-	-	-	-	-	-	-	7.3	8.042	11.75	52.9	-	

Appendix G Nisken Bottle table

File_name	Bottle #	Depth (m)	Altimeter (m)	Lat (dd)	Long (DD)	Salinity (PSU)	Temp (°C)	O2_ml/l	Density (Kg/m^3)	Conductivity (mS/cm)
u8861	1	24.98	6.04	-44.57036	171.36654	34.4599	13.6271	5.2057	1025.9595	41.0105
u8861	2	25.02	5.98	-44.57038	171.36652	34.4773	13.6112	5.0327	1025.9765	41.0137
u8865	1	68.56	3.98	-44.46502	171.95786	34.7226	12.4682	5.1224	1026.5928	40.1938
u8865	2	70.65	2.07	-44.46502	171.95790	34.7222	12.4529	5.1174	1026.6049	40.1796
u8866	1	59.45	3.31	-44.41098	171.88767	34.6955	12.6070	4.9952	1026.5033	40.2946
u8866	2	59.24	3.57	-44.41096	171.88770	34.6955	12.6071	4.9923	1026.5024	40.2946
u8867	1	63.70	2.21	-44.47094	171.83304	34.7003	12.5310	5.8197	1026.5413	40.2287
u8867	2	63.89	1.76	-44.47078	171.83327	34.7005	12.5361	5.7972	1026.5412	40.2338
u8868	1	39.99	2.14	-44.57012	171.43704	34.4642	13.4747	5.3826	1026.0617	40.8753
u8869	1	37.92	2.88	-44.57294	171.42806	34.4632	13.4838	5.3571	1026.0498	40.8821
u8870	1	36.56	2.44	-44.57590	171.41860	34.4605	13.4908	5.3547	1026.0402	40.8854
u8871	1	25.95	1.65	-44.56093	171.35296	34.4751	13.5387	4.8135	1025.9938	40.9420
u8872	1	24.49	2.59	-44.55752	171.34822	34.4580	13.5649	4.7626	1025.9687	40.9485
u8873	1	24.41	2.53	-44.55232	171.34922	34.4162	13.5945	4.8015	1025.9299	40.9322
u8874	1	21.95	2.64	-44.50110	171.35342	34.2663	13.7939	4.8123	1025.7617	40.9622
u8875	1	41.66	2.18	-44.34480	171.66022	34.6225	13.1869	4.7965	1026.2505	40.7671
u8876	1	41.96	1.95	-44.34549	171.65984	34.6260	13.1746	4.7916	1026.2570	40.7591
u8877	1	52.10	2.54	-44.38290	171.85051	34.6779	13.0056	5.1422	1026.3770	40.6557

Appendix H CTD sampling table

					samples taken								measurements				
date NZST 2017	NZOI style station #	CTD station TAN1703-	sample #	depth m	DO unfiltered	DO flask #	DIC unfiltered	δ18O filtered mL	δ2H filtered mL	Cations filtered mL	Anions filtered mL	Residual unfiltered mL	Oxygen Draw temp °C	pH	temp (of sample in lab) °C	conductivity mS/cm	remarks
12 Apr	U8861	01	C1	25	yes	9	yes	~4.7	~4.7	4	4	~280	13.7	8.087	6.9	50.9	
12 Apr	U8861	01	C2	25	yes	25	yes	~4.7	~4.7	4	4	~280	13.6	8.151	6.8	50.7	
12 Apr	-	-	IAPSO	-	-	-	-	~4.7	~4.7	-	-	-	-	8.170	5.0	51.1	
18 Apr	U8865	05	C3	69	yes	38	yes	~4.7	~4.7	4	4	~280	12.7	8.030	8.1	52.7	
18 Apr	U8865	05	C4	71	yes	77	yes	~4.7	~4.7	4	4	~280	12.6	8.048	8.3	52.6	
18 Apr	U8866	06	C5	59	yes	84	yes	~4.7	~4.7	4	4	~280	12.8	8.009	9.9	53.1	
18 Apr	U8866	06	C6	59	yes	95	yes	~4.7	~4.7	4	4	-	12.7	8.107	9.6	52.9	residual discarded afterwards
18 Apr	U8867	07	C7	64	yes	97	yes	~4.7	~4.7	4	4	~280	12.7	8.036	11.1	54.5	
18 Apr	U8867	07	C8	64	yes	104	yes	~4.7	~4.7	4	4	~280	12.7	8.108	10.7	52.8	
18 Apr	-	-	IAPSO	-	-	-	-		-	-	-	-	-	8.115	7.0	53.5	
19 Apr	U8868	13	C9	40	yes	118	yes	~4.7	~4.7	4	4	~280	13.5	8.192	8.6	52.3	
20 Apr	U8869	14	C10	38	yes	136	yes	~4.7	~4.7	4	4	~280	13.5	8.232	8.6	52.3	
20 Apr	U8870	15	C11	36	yes	142	yes	~4.7	~4.7	4	4	~280	13.5	8.242	8.7	52.3	
20 Apr	U8871	16	C12	26	yes	149	yes	~4.7	~4.7	4	4	~280	13.5	8.141	8.2	51.9	
20 Apr	U8872	17	C13	25	yes	151	yes	~4.7	~4.7	4	4	~280	13.6	8.189	6.7	51.8	
20 Apr	U8873	18	C14	24	yes	155	yes	~4.7	~4.7	4	4	~280	13.6	8.206	6.6	51.8	
20 Apr	U8874	19	C15	22	yes	163	yes	~4.7	~4.7	4	4	~280	13.5	8.229	9.8	51.9	
20 Apr	U8875	20	C16	42	yes	165	yes	~4.7	~4.7	4	4	~280	13.3	8.177	7.5	52.6	
20 Apr	U8876	21	C17	42	yes	166	yes	~4.7	~4.7	4	4	~280	13.3	8.151	7.7	52.7	
20 Apr	U8877	22	C18	52	yes	167	yes	~4.7	~4.7	4	4	~280	13.1	8.163	10.9	52.9	
20 Apr	-	-	IAPSO	-	-	-	-	-	-	-	-	-	-	8.184	7.0	54.3	
26 Apr	-	-	IAPSO	-	-	-	-	-	-	-	-	-	11.75	8.042	7.3	52.9	
27 Apr	U8878	34	C19	28	yes	170	yes	~4.7	~4.7	4	4	~280	13.5	8.192	7.1	52.0	
27 Apr	U8879	35	C20	32	yes	171	yes	~4.7	~4.7	4	4	~280	13.8	8.229	7.3	51.9	
27 Apr	U8880	36	C21	32	yes	202	yes	~4.7	~4.7	4	4	~280	13.6	8.224	7.3	51.7	
27 Apr	U8881	37	C22	31	yes	259	yes	~4.7	~4.7	4	4	~280	13.8	8.236	7.5	51.8	
27 Apr	U8882	38	C23	46	yes	257	yes	~4.7	~4.7	4	4	~280	13.4	8.193	7.6	52.3	
27 Apr	U8883	39	C24	56	yes	256	yes	~4.7	~4.7	4	4	~280	13.2	8.205	7.4	52.0	
27 Apr	U8884	40	C25	63	yes	255	yes	~4.7	~4.7	4	4	~280	13.0	8.184	7.4	52.3	
27 Apr	U8885	41	C26	46	yes	251	yes	~4.7	~4.7	4	4	~280	13.3	8.207	7.6	52.3	
28 Apr	U8886	42	C27	57	yes	250	yes	~4.7	~4.7	4	4	~280	13.0	8.208	7.8	52.3	
28 Apr	U8887	43	C28	62	yes	247	yes	~4.7	~4.7	4	4	~280	12.8	8.178	7.5	52.1	
28 Apr	U8888	44	C29	92	yes	243	yes	~4.7	~4.7	4	4	~280	12.9	8.209	8.0	52.2	
28 Apr	U8889	45	C30	91	yes	242	yes	~4.7	~4.7	4	4	~280	12.5	8.226	8.1	52.3	
28 Apr	U8890	46	C31	79	yes	236	yes	~4.7	~4.7	4	4	~280	12.8	8.236	7.8	52.6	
28 Apr	-	-	IAPSO	-	-	-	-	-	-	-	-	-	-	8.027	7.2	52.9	

Appendix I Core Sampling Table

TAN1703 – MARCAN

Core ID:	**TAN1703-02**	Latitude:	-44°34.223	Date/Time (NZST):	12/04/2017 18:30
Other ID:		Longitude:	171°21.898	Depth (m):	**31.0**

Sample Description

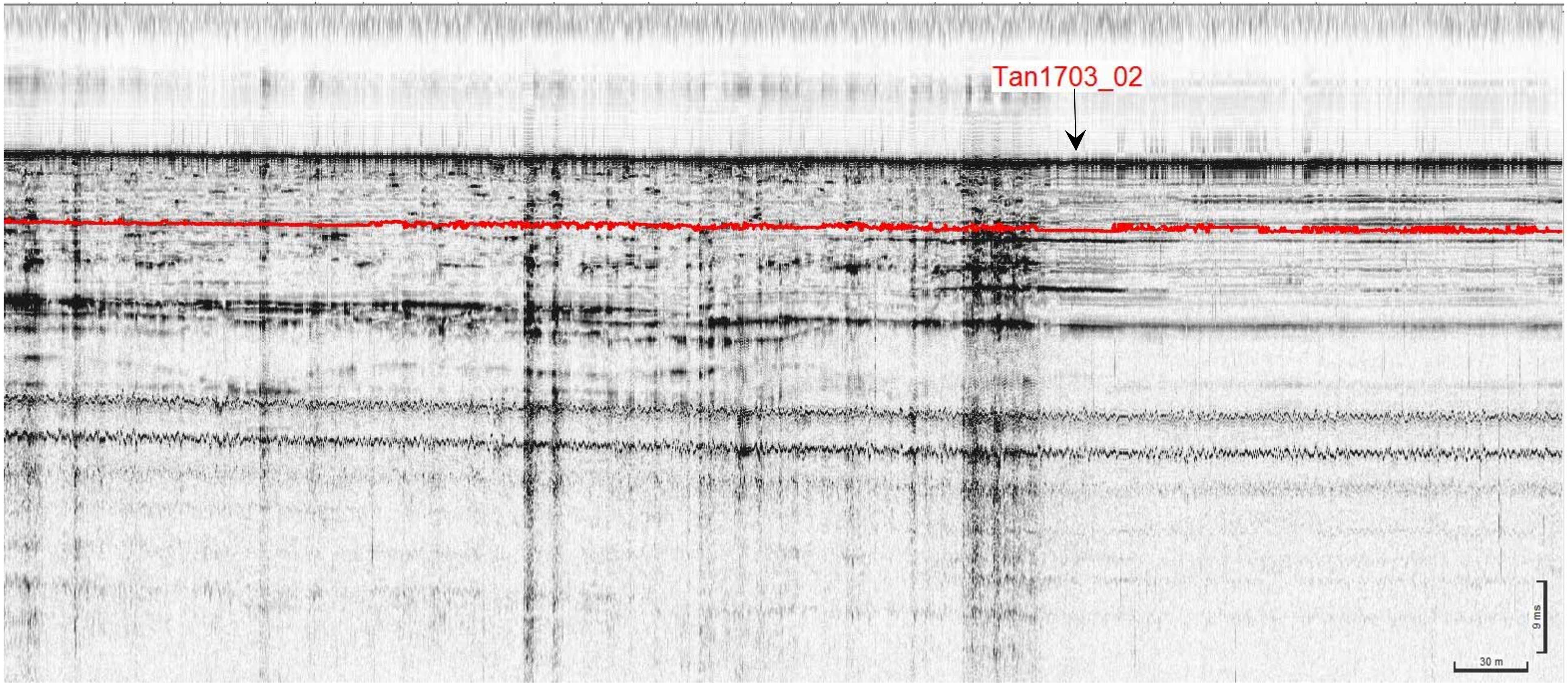
General Description

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	0
Core length (m)	0	Samples	0
Sections	N	Tephra	N
Fauna	N		unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
-	-	-	.	.	-
-	-	-	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-02**	Other ID	Water Depth **31.0 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-03**	Latitude:	-44°34.224	Date/Time (NZST):	12/04/2017 19:14
Other ID:		Longitude:	171°21.989	Depth (m):	**31.2**

Sample Description

General Description

Small volume of muddy sand retained in zip-locked bag

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	0
Core length (m)	0	Samples	1
Sections	N	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
-	-	-	.	.	-
-	-	-	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
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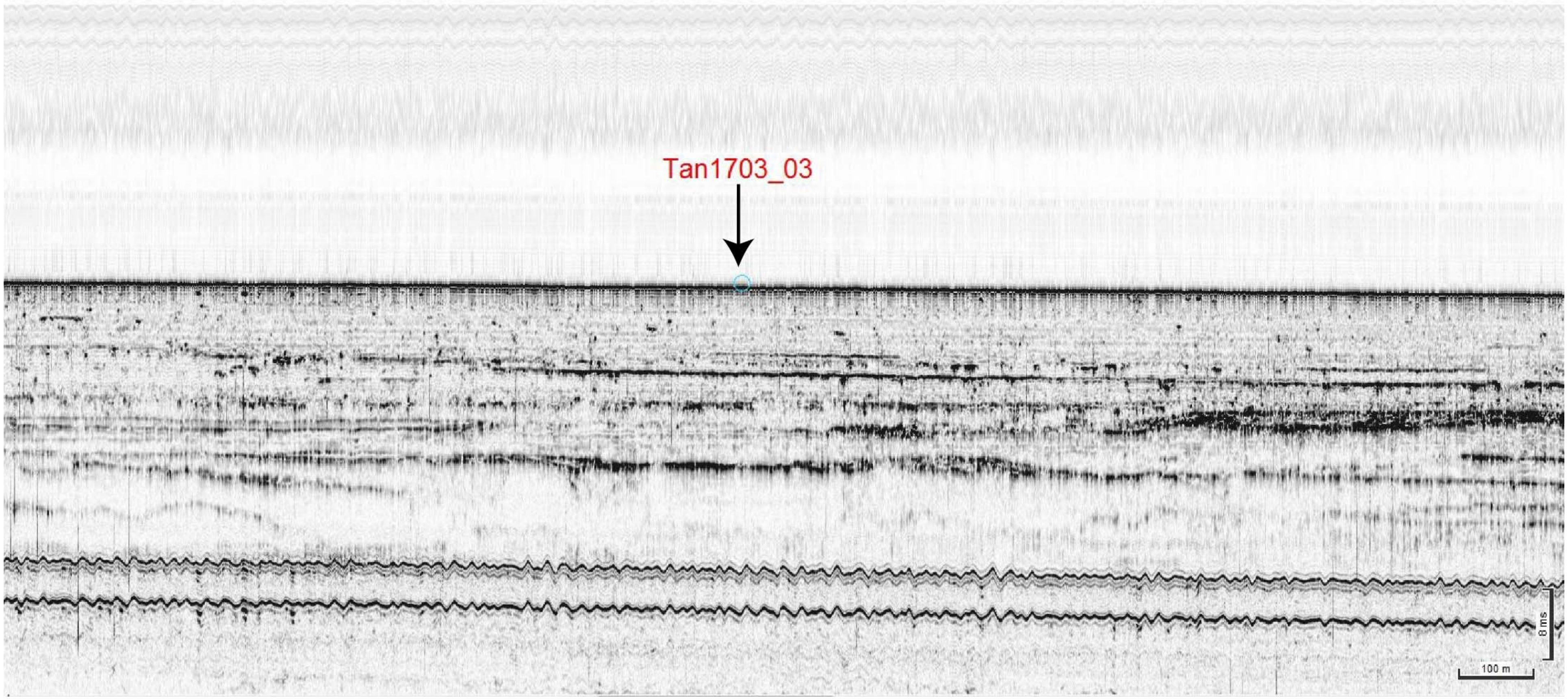
TAN1703 – MARCAN		
Core ID: **TAN1703-03**	Other ID	Water Depth **31.2 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-04**	Latitude:	-44°34.030	Date/Time (NZST):	12/04/2017 20:11
Other ID:		Longitude:	171°21.730	Depth (m):	**29.8**

Sample Description

General Description

Small volume of muddy sand retained in zip-locked bag

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	0
Core length (m)	0	Samples	1
Sections	N	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
-	-	-	.	.	-
-	-	-	.	.	-
.	.	.	.	.	.
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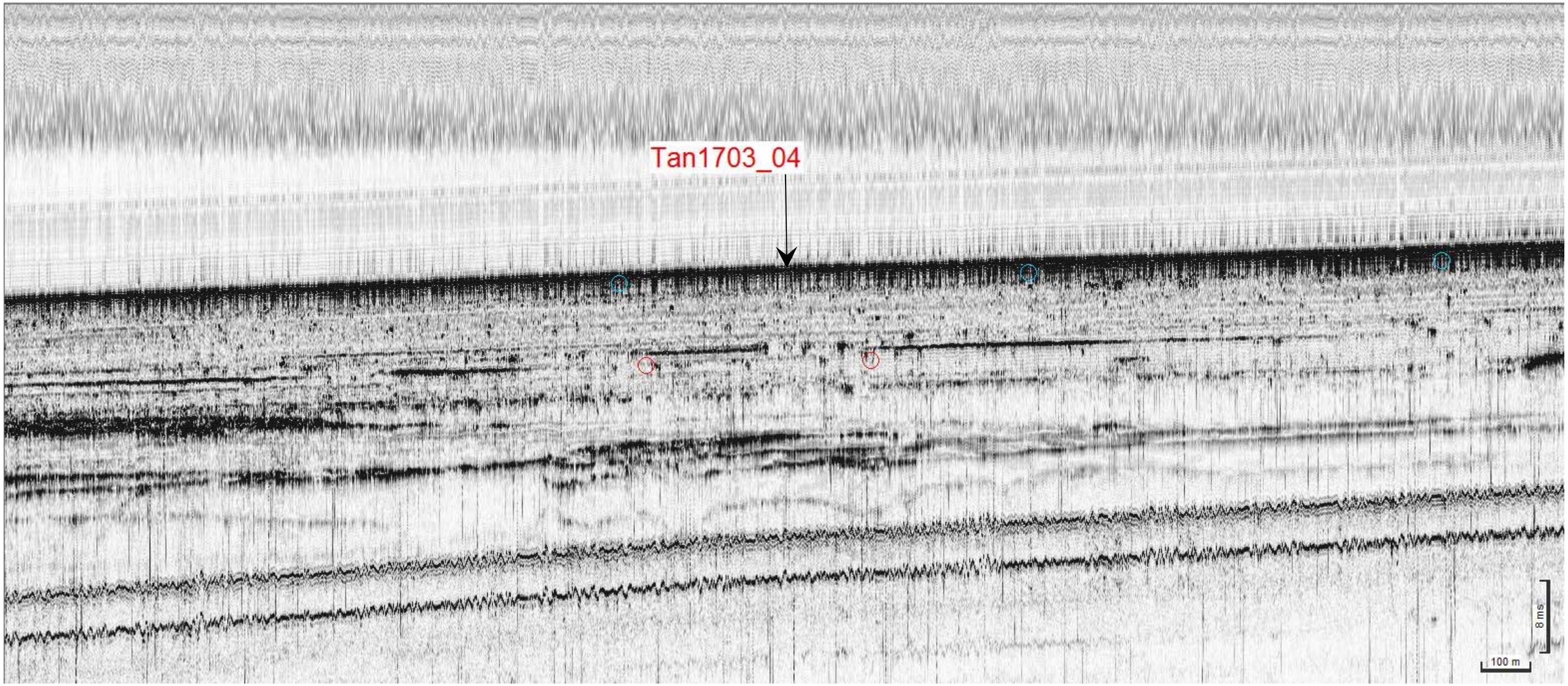
TAN1703 – MARCAN		
Core ID: **TAN1703-04**	Other ID	Water Depth **29.8 m**



TAN1703 – MARCAN

Core ID: **TAN1703-08**	Latitude: -44°43.321	Date/Time (NZST): 19/04/2017 23:06
Other ID:	Longitude: 171°36.080	Depth (m): **65.6**

Sample Description

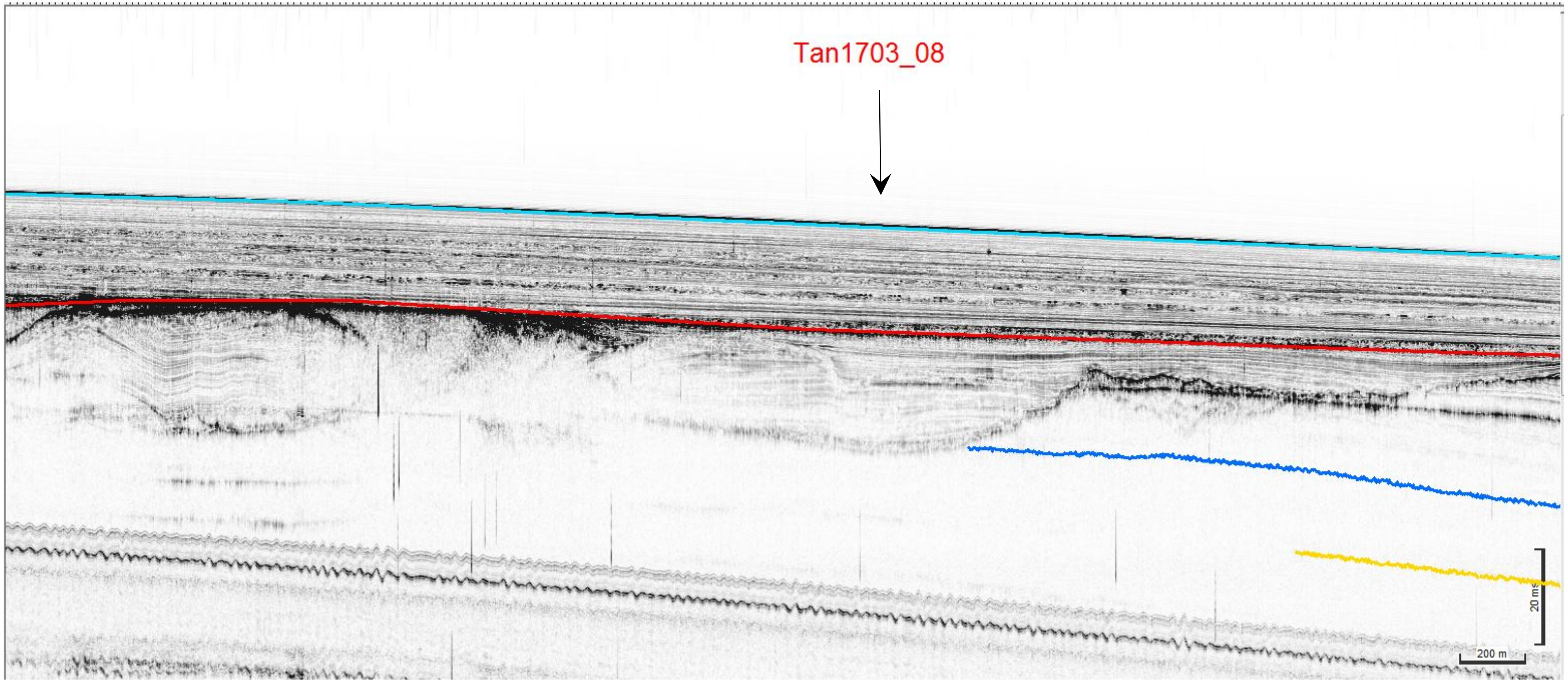
General Description

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	1.84	Samples	0
Sections	2	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
1	0	100	.	.	-
2	100	184	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-08**	Other ID	Water Depth **65.5 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-09**	Latitude:	-44°39.231	Date/Time (NZST):	20/04/2017 00:16
Other ID:		Longitude:	171°30.245	Depth (m):	**51.5**

Sample Description

General Description

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	0
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
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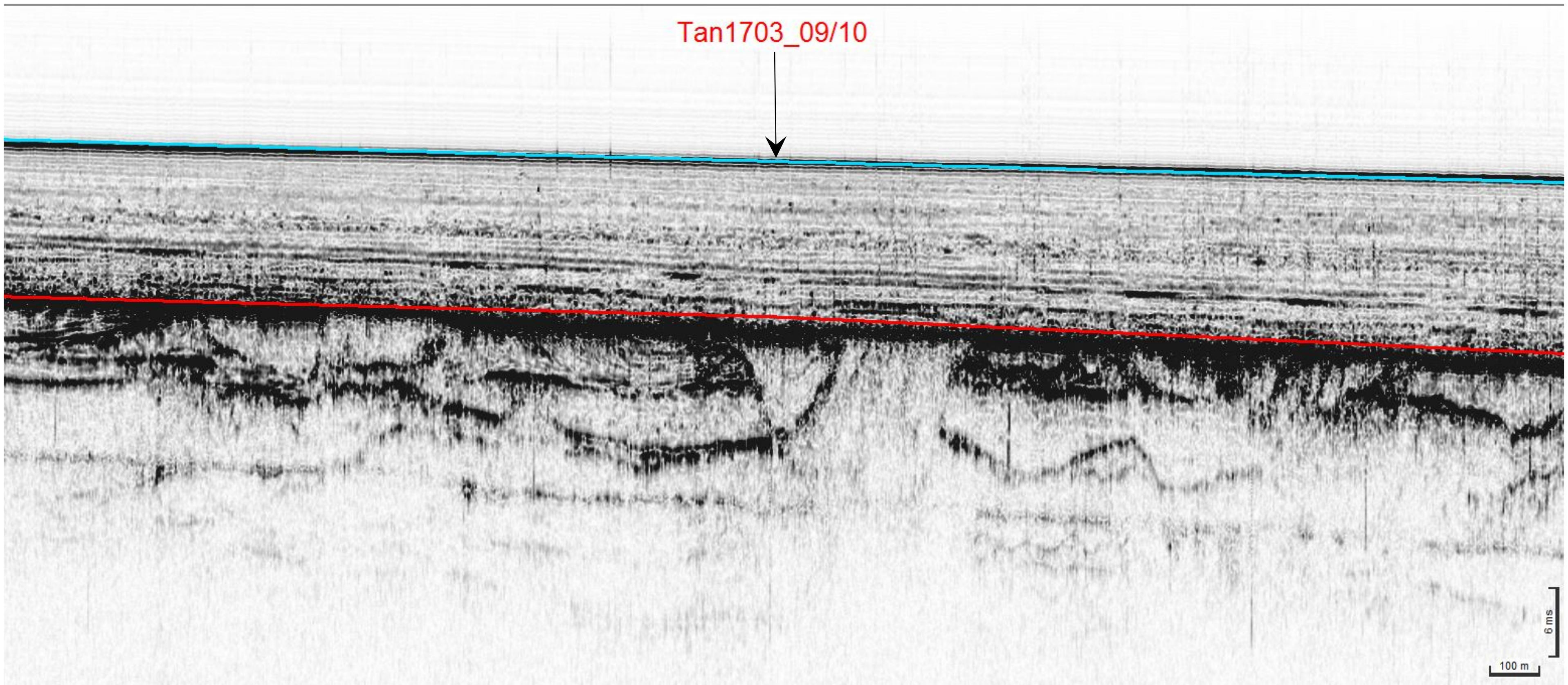
TAN1703 – MARCAN		
Core ID: **TAN1703-09**	Other ID	Water Depth **51.5 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-10**	Latitude:	-44°39.256	Date/Time (NZST):	20/04/2017 00:29
Other ID:		Longitude:	171°30.246	Depth (m):	**51.0**

Sample Description

General Description	**Gear type**	**Gravity corer**		
	Barrel Length (m)	3	Bent barrel	N
	Penetration (m)	-	Catcher/Cutter bags	-
	Core length (m)	0	Samples	0
	Sections	0	Tephra	N
	Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
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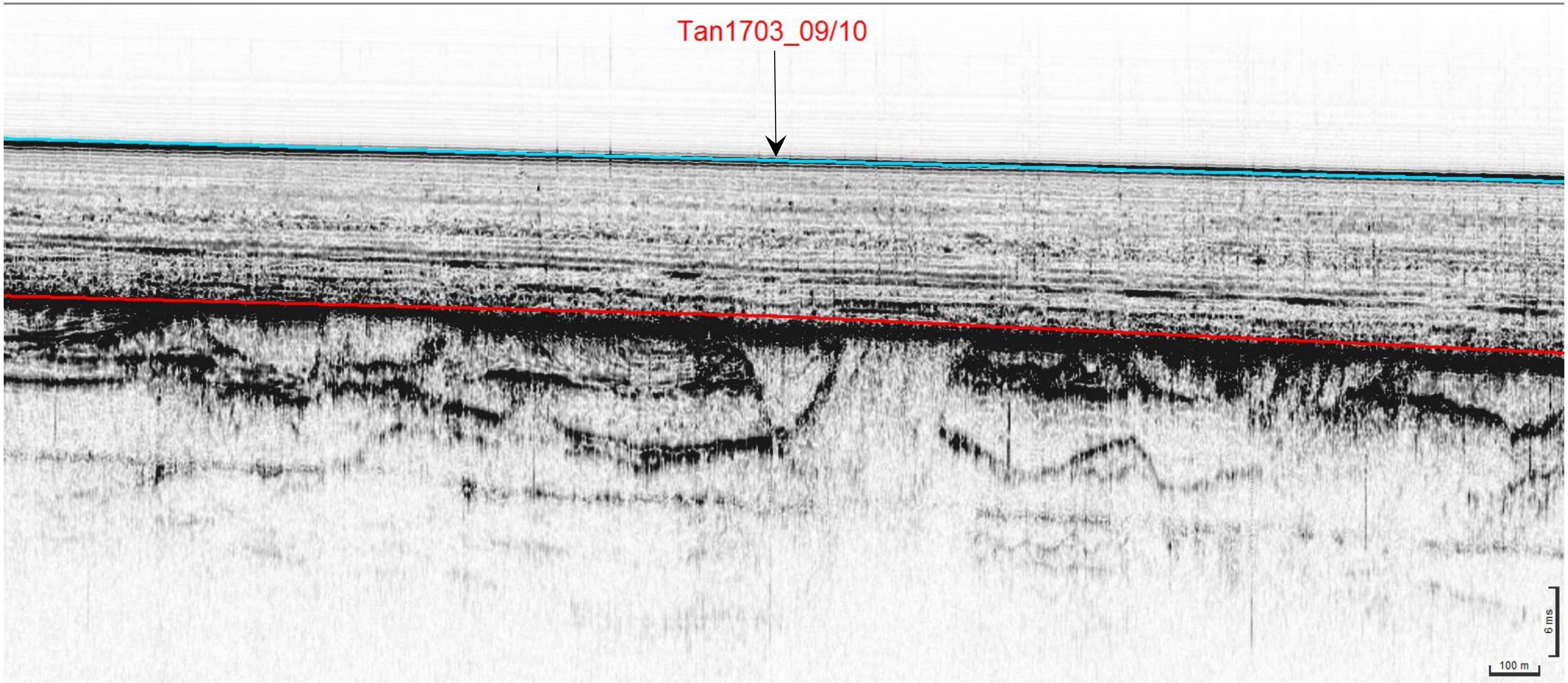
TAN1703 – MARCAN		
Core ID: **TAN1703-10**	Other ID	Water Depth **51.0 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-11**	Latitude:	-44°33.275	Date/Time (NZST):	20/04/2017 00:35
Other ID:		Longitude:	171°28.426	Depth (m):	**46.6**

Sample Description

Gear type	Gravity corer		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	0
Sections	0	Tephra	N
Fauna			unit

General Description

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
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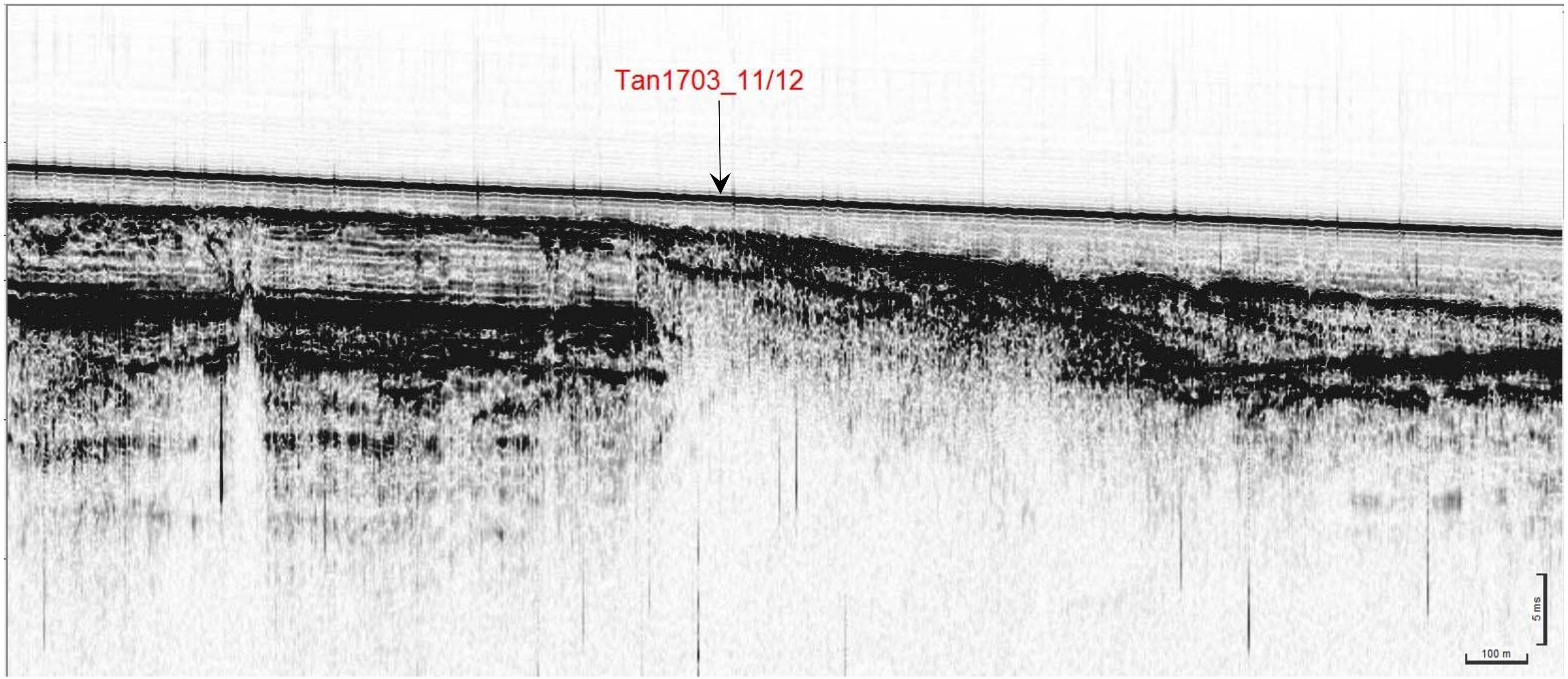
TAN1703 – MARCAN		
Core ID: **TAN1703-11**	Other ID	Water Depth **46.6 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-12**	Latitude:	-44°33.288	Date/Time (NZST):	20/04/2017 00:45
Other ID:		Longitude:	171°28.396	Depth (m):	**46.2**

Sample Description

General Description

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	0
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
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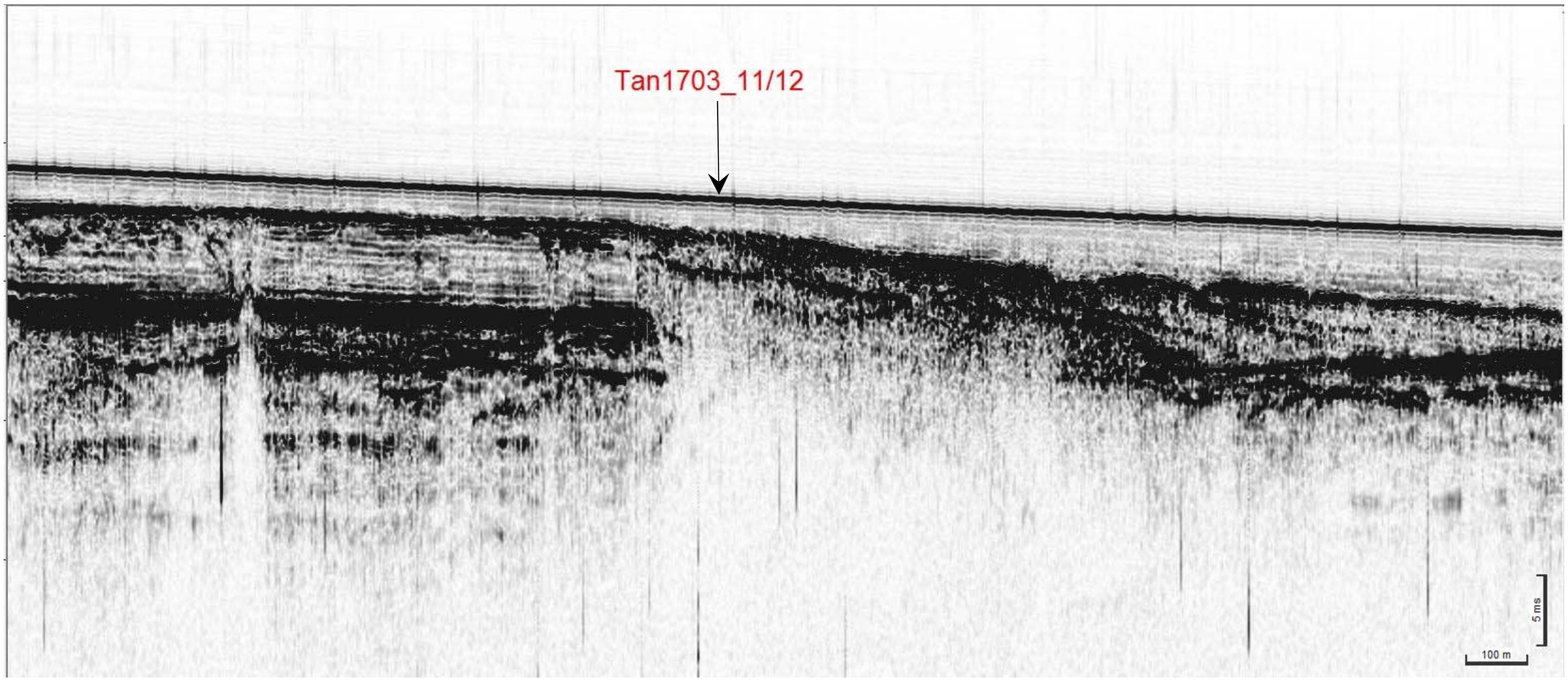
TAN1703 – MARCAN		
Core ID: **TAN1703-12**	Other ID	Water Depth **46.2 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-23**	Latitude:	-44°22.433	Date/Time (NZST):	20/04/2017 18:48
Other ID:		Longitude:	171°50.307	Depth (m):	**54.2**

Sample Description

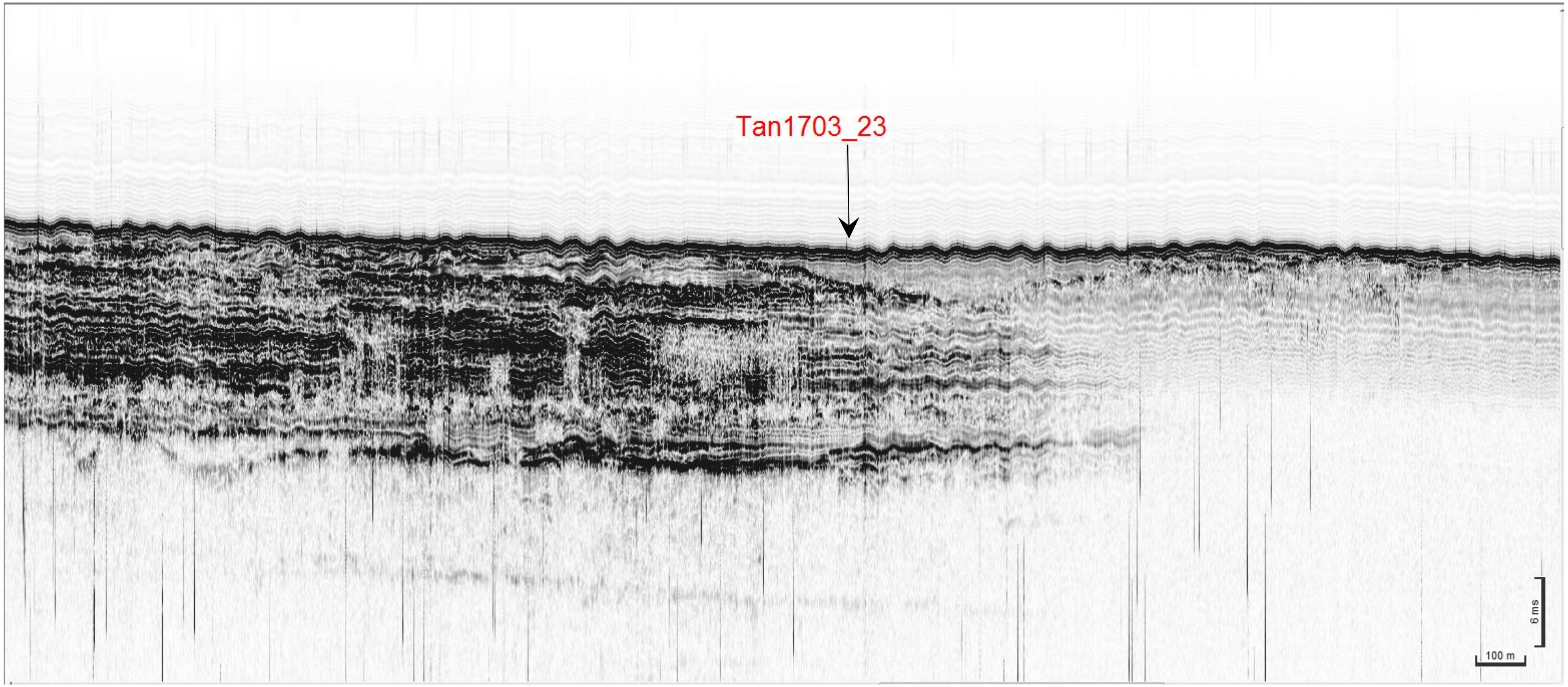
Gear type	Gravity corer		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	0
Sections	0	Tephra	N
Fauna			unit

General Description

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-23**	Other ID	Water Depth **54.2 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-24**	Latitude:	-44°28.136	Date/Time (NZST):	20/04/2017 20:00
Other ID:		Longitude:	171°57.860	Depth (m):	**72.8**

Sample Description

General Description

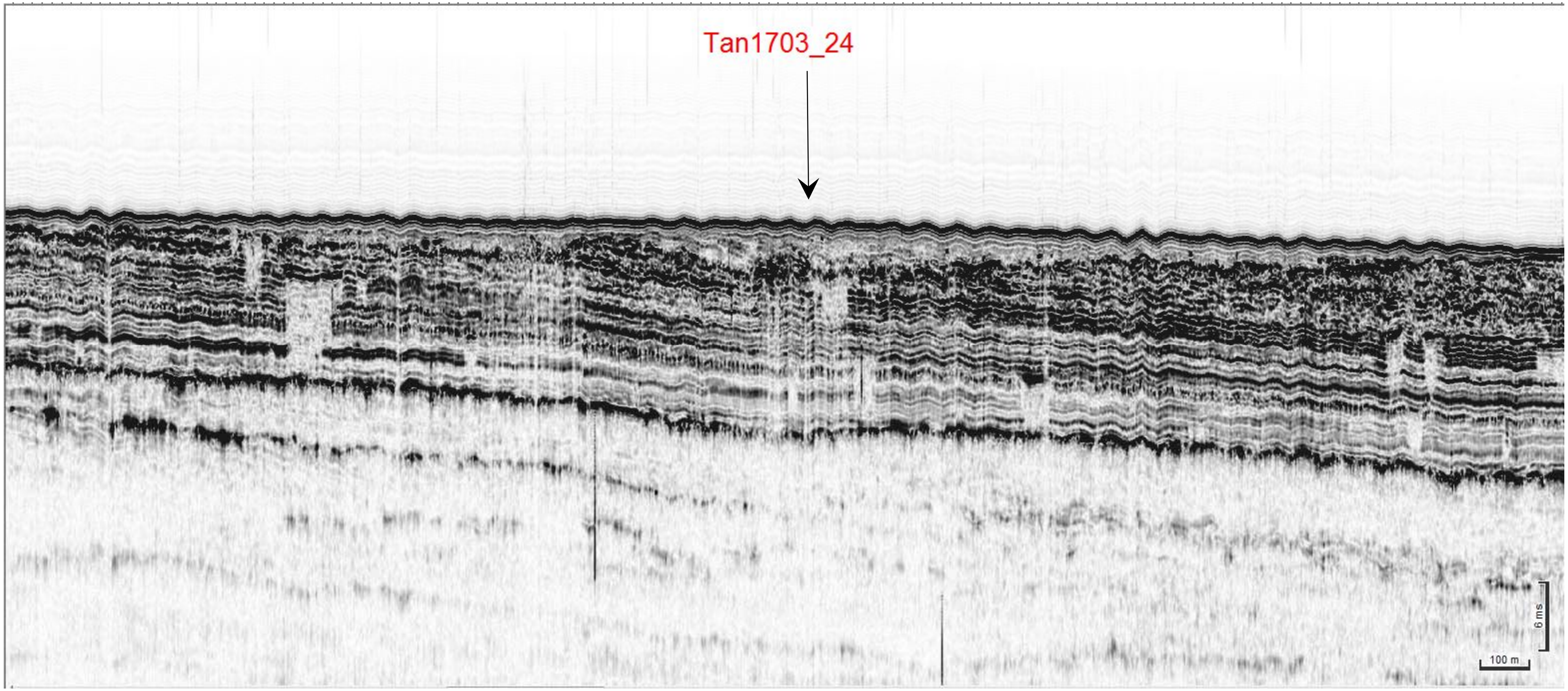
Small volume of sandy mud retained in zip-locked bag

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	1
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-24**	Other ID	Water Depth **72.8 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-25**	Latitude:	-44°28.674	Date/Time (NZST):	20/04/2017 20:53
Other ID:		Longitude:	171°50.507	Depth (m):	**66.8**

Sample Description

General Description

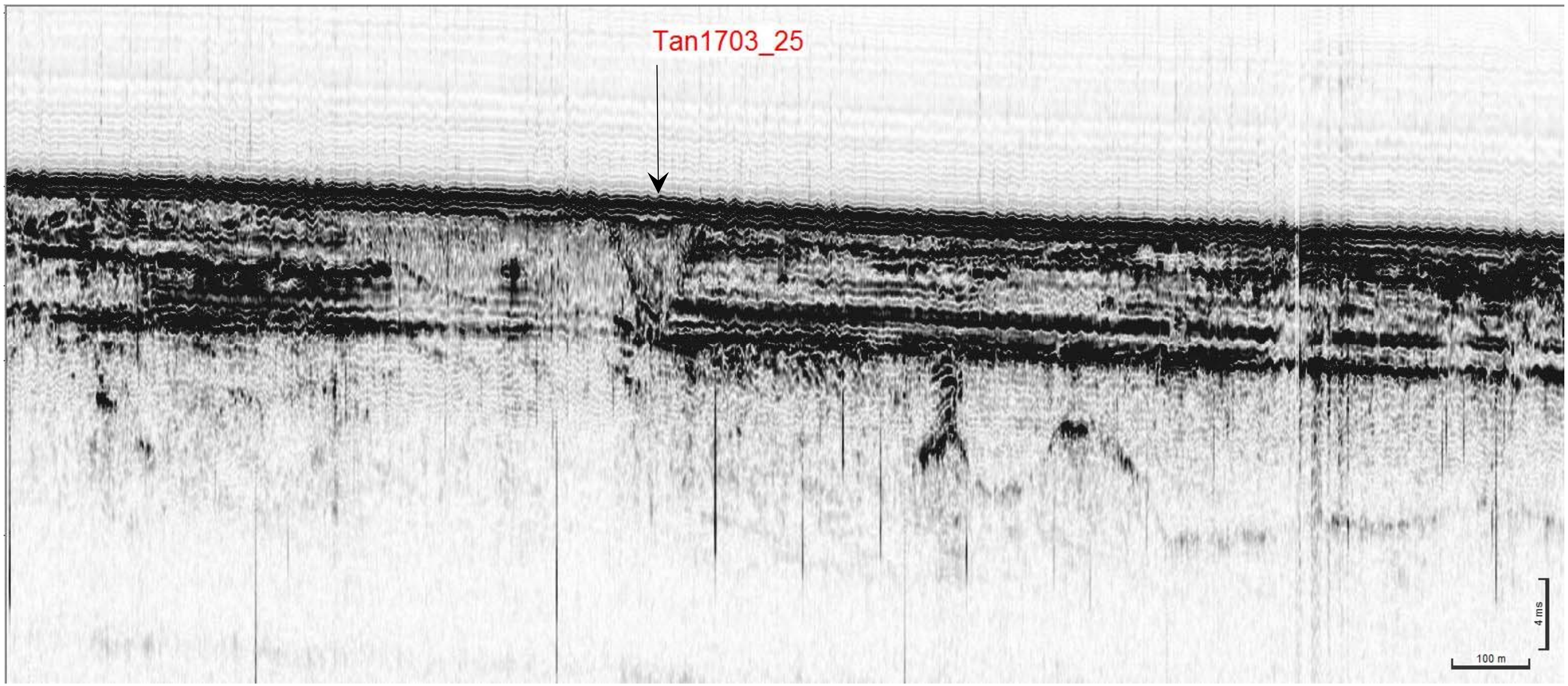
Small volume of sandy mud retained in zip-locked bag

Gear type	**Gravity corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	1
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-25**	Other ID	Water Depth **66.8 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-26**	Latitude:	-44°33.303	Date/Time (NZST):	20/04/2017 21:57
Other ID:		Longitude:	171°56.478	Depth (m):	**83.3**

Sample Description

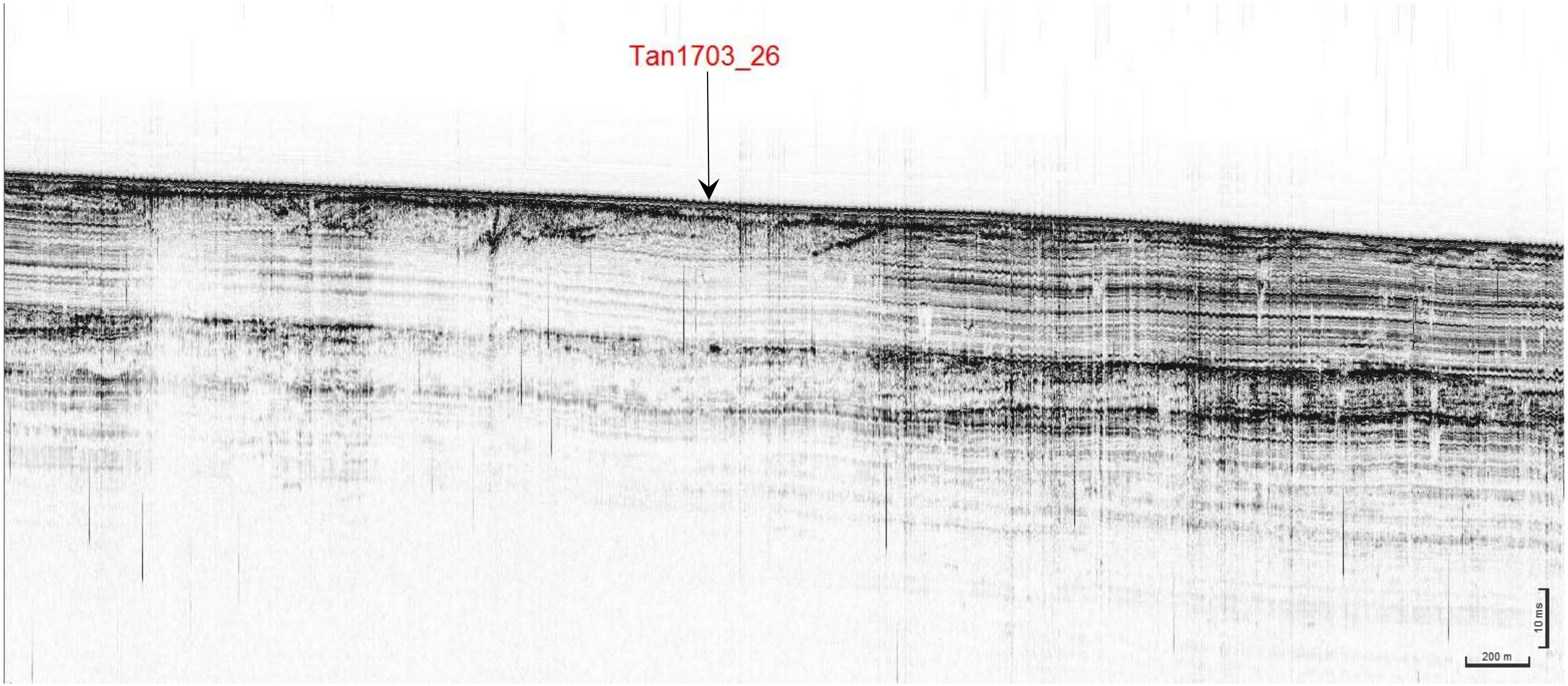
General Description

Gear type	**Piston corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	1.29	Samples	0
Sections	2	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
1	0	100	.	.	-
2	100	129	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-26**	Other ID	Water Depth **83.3 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-27**	Latitude:	-44°39.917	Date/Time (NZST):	20/04/2017 23:28
Other ID:		Longitude:	172°06.889	Depth (m):	**116.5**

Sample Description

General Description

Small volume of sandy mud retained in zip-locked bag

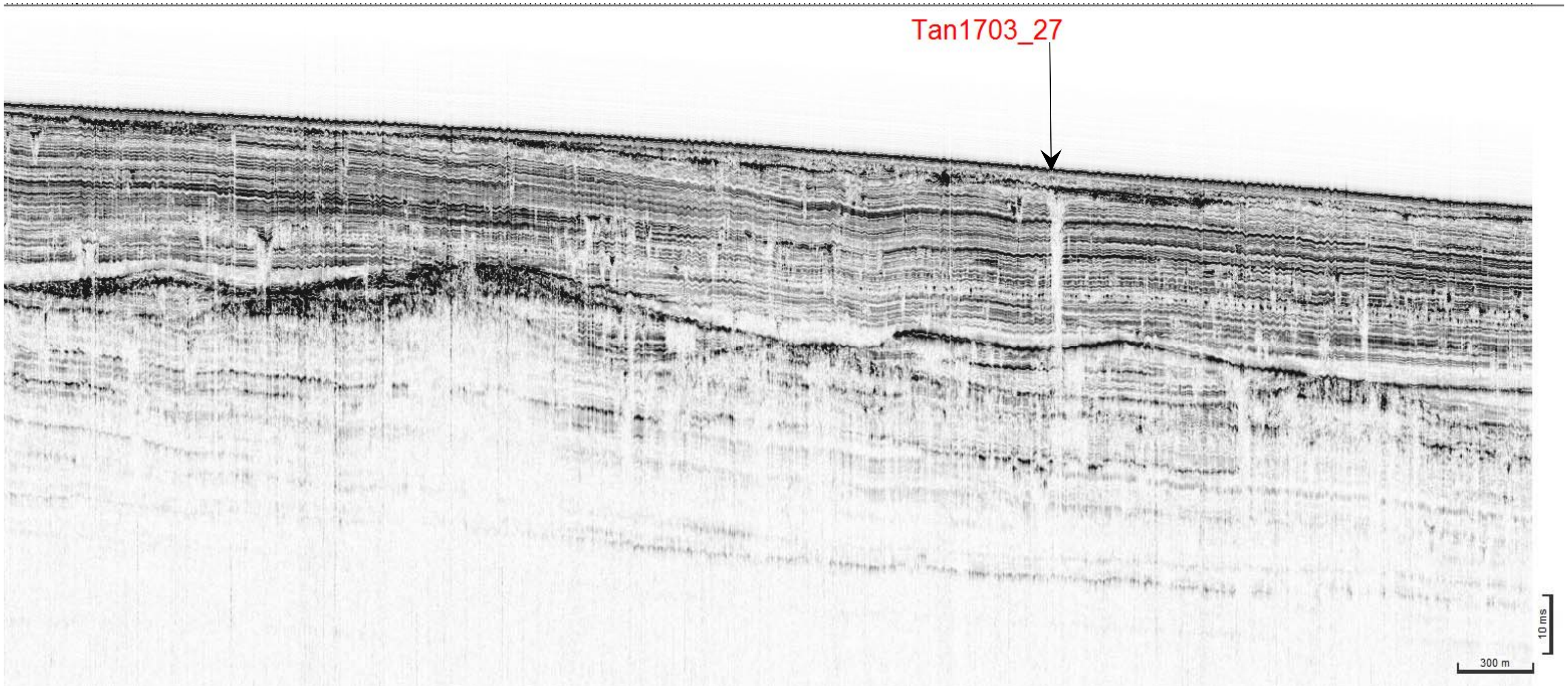
Gear type	**Piston corer**		
Barrel Length (m)	3	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	1
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
.	.	.	.	.	-
.	.	.	.	.	-
.	.	.	.	.	.
.	.	.	.	.	.
..	.	.	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN

Core ID:	**TAN1703-27**	Other ID		Water Depth	**116.5 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-28**	Latitude:	-45°00.634	Date/Time (NZST):	25/04/2017 21:30
Other ID:		Longitude:	172°02.185	Depth (m):	**1117**

Sample Description

General Description

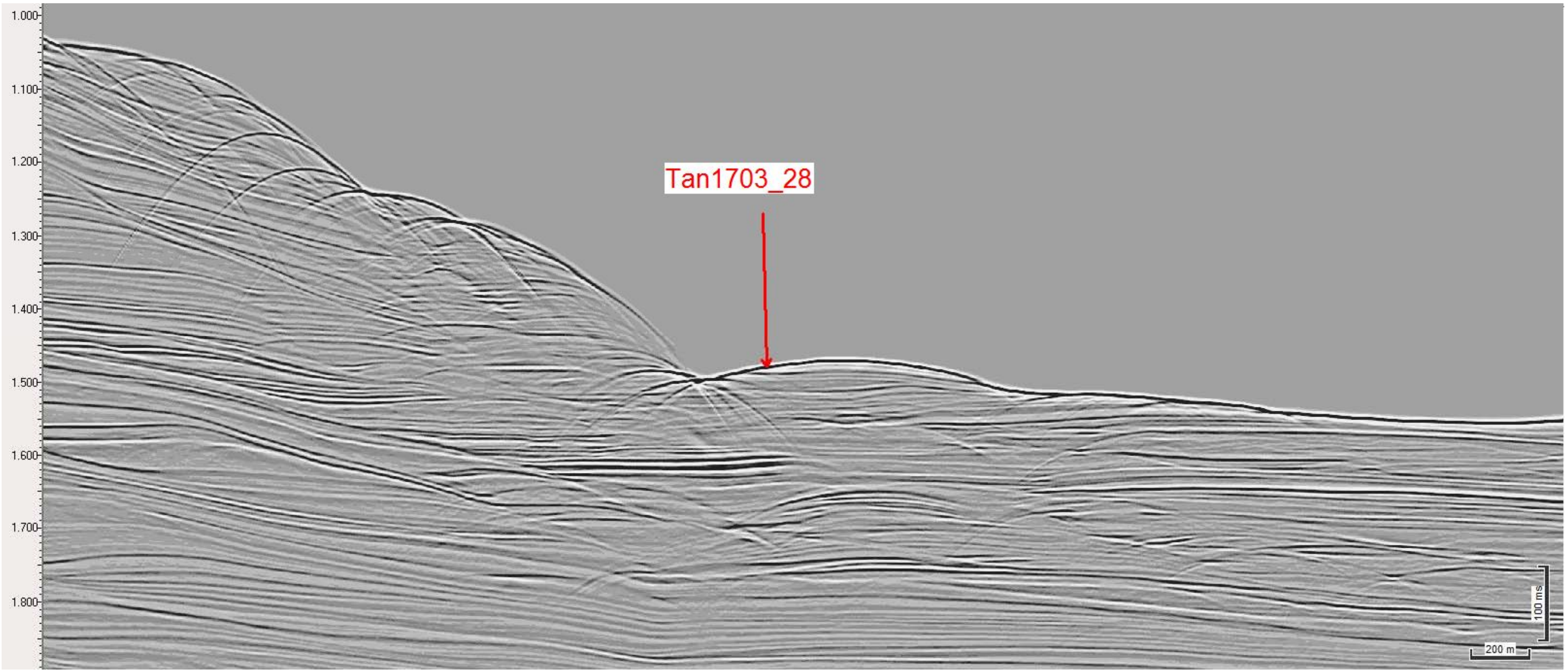
20 cm top sample retained in zip-locked bag

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	4.16	Samples	1
Sections	5	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
1	0	100	.	.	-
2	100	200	.	.	-
3	200	300	.	.	.
4	300	400	.	.	.
5	400	416	.	.	.
.	.	.	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-28**	Other ID	Water Depth **1117 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-29**	Latitude:	-44°59.708	Date/Time (NZST):	25/04/2017 23:10
Other ID:		Longitude:	172°00.032	Depth (m):	**658**

Sample Description

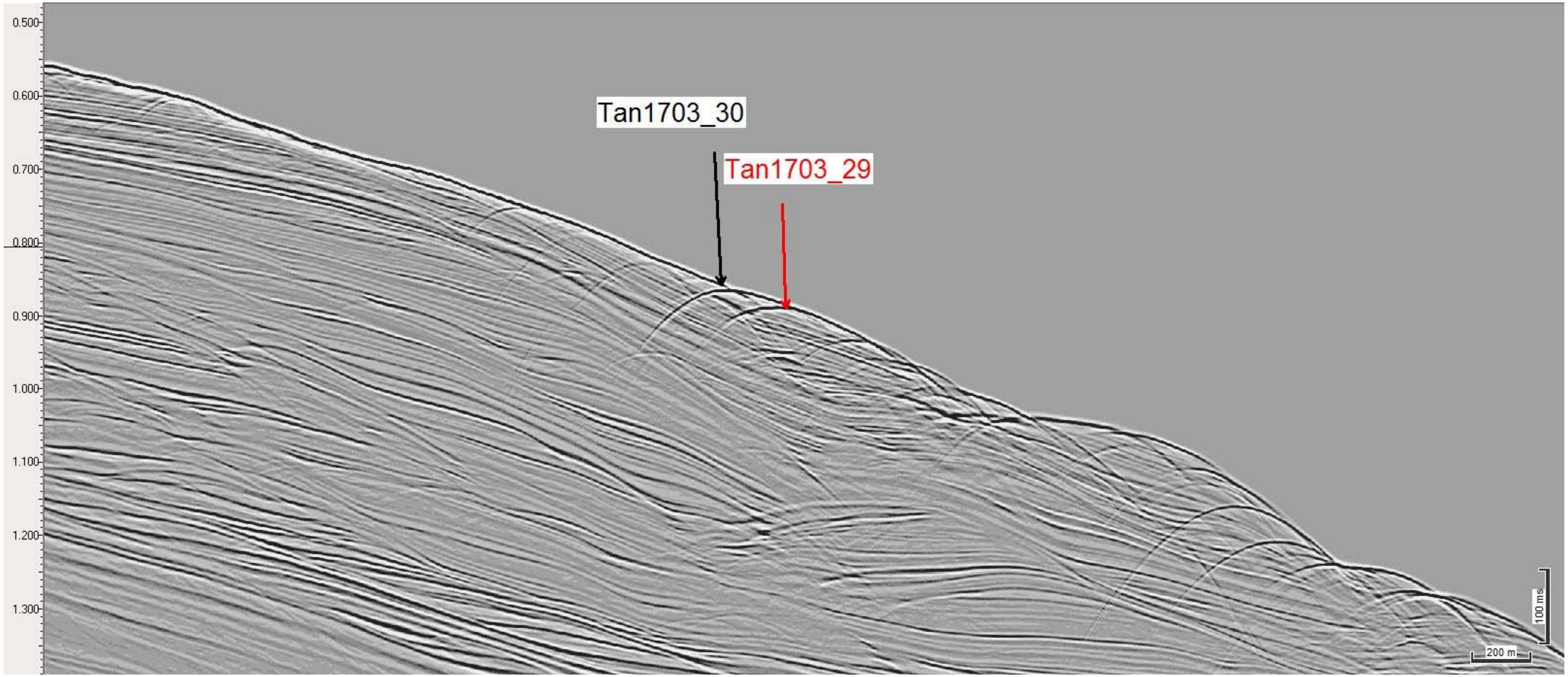
General Description

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	5.70	Samples	0
Sections	6	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
1	0	100	.	.	-
2	100	200	.	.	-
3	200	300	.	.	.
4	300	400	.	.	.
5	400	500	.	.	.
6	500	570	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-29**	Other ID	Water Depth **658 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-30**	Latitude:	-44°59.677	Date/Time (NZST):	26/04/2017 00:04
Other ID:		Longitude:	171°59.854	Depth (m):	**652**

Sample Description

General Description

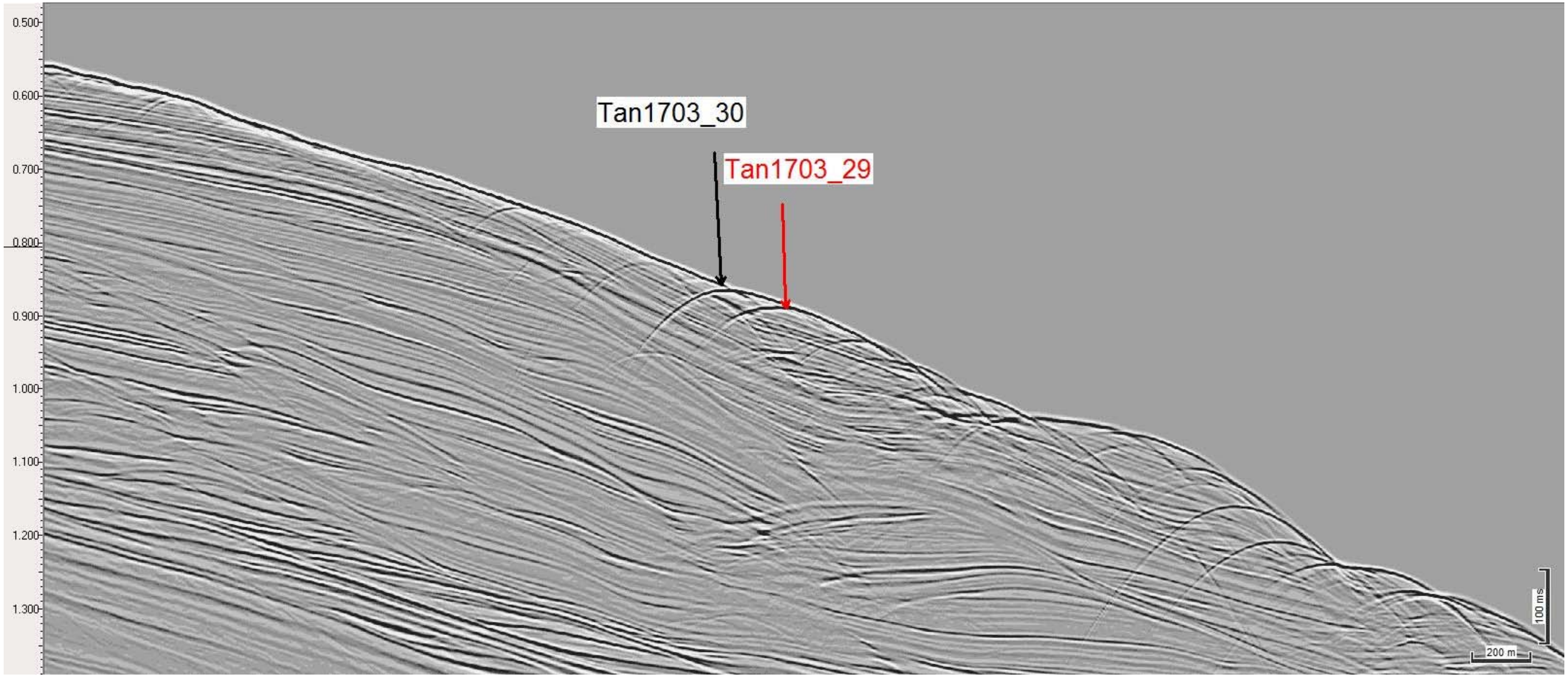
31 cm top sample kept in liner

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	3.85	Samples	1
Sections	4	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
1	0	100	.	.	-
2	100	200	.	.	-
3	200	300	.	.	.
4	300	385	.	.	.
-	-	-	.	.	.
-	-	-	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-30**	Other ID	Water Depth **652 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-31**	Latitude:	-44°58.311	Date/Time (NZST):	26/04/2017 01:58
Other ID:		Longitude:	171°58.104	Depth (m):	**350**

Sample Description

General Description

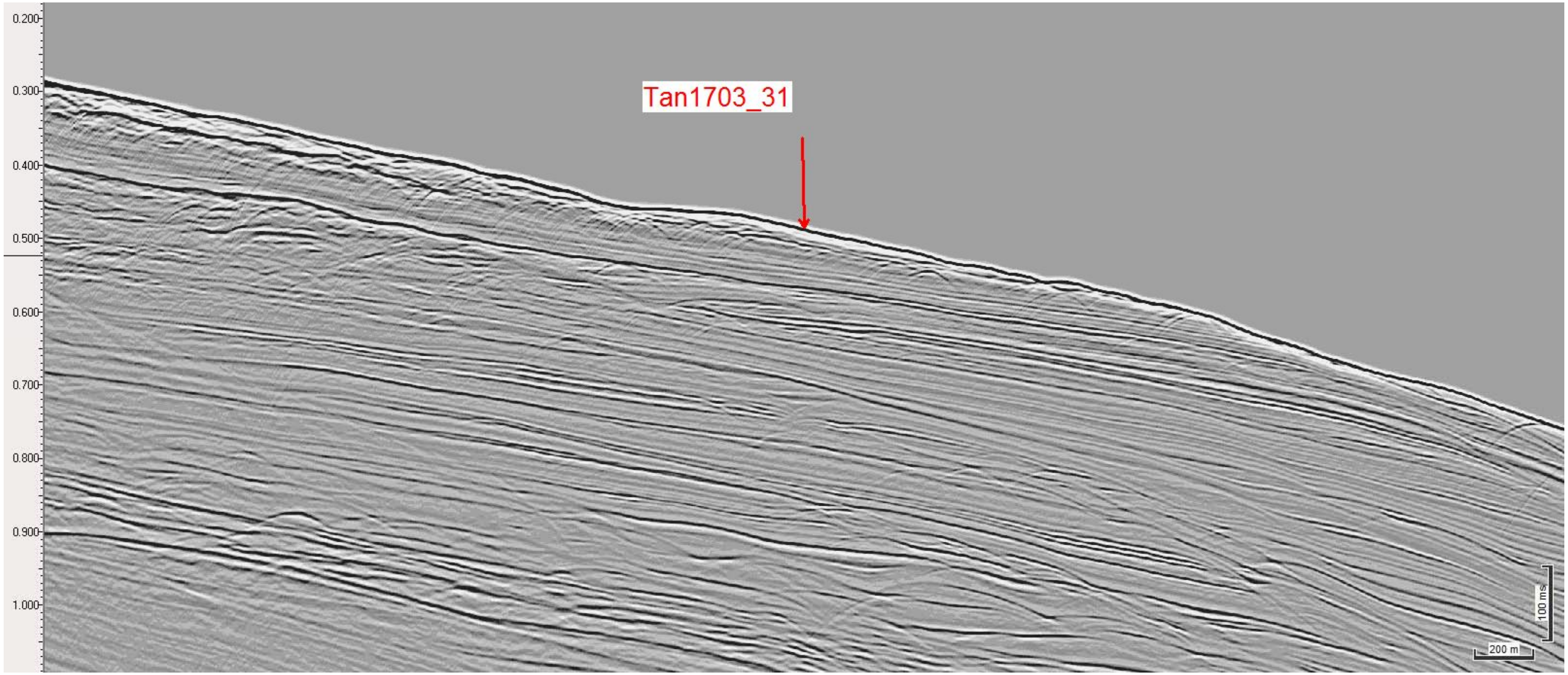
Top sample retained in zip-locked bag

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	5.35	Samples	1
Sections	6	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
1	0	100	.	.	-
2	100	200	.	.	-
3	200	300	.	.	.
4	300	400	.	.	.
5	400	500	.	.	.
6	500	535	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-31**	Other ID	Water Depth **350 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-32**	Latitude:	-44°42.547	Date/Time (NZST):	26/04/2017 05:01
Other ID:		Longitude:	171°34.864	Depth (m):	**58.6**

Sample Description

General Description

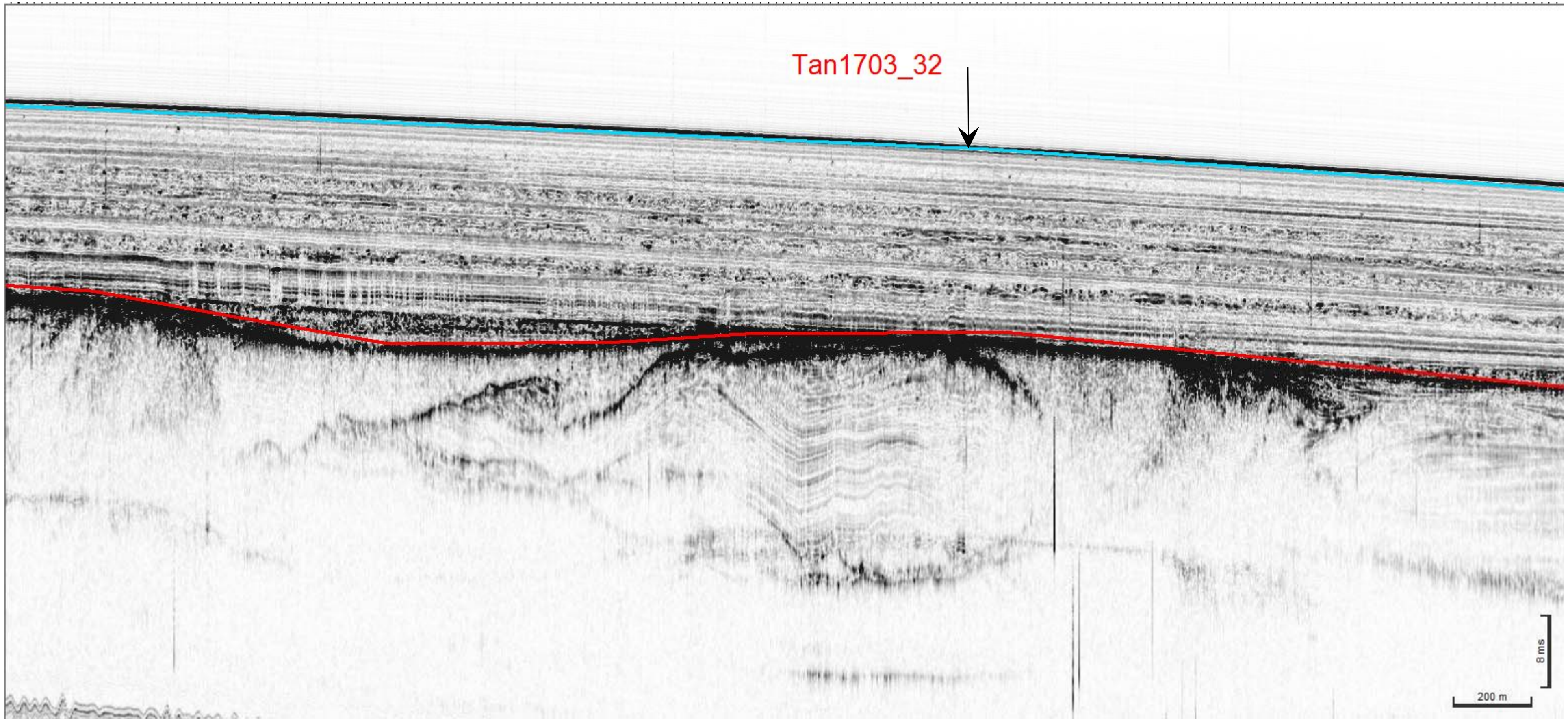
Small volume of material retained in zip-locked bag

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	1
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
-	-	-	.	.	-
-	-	-	.	.	-
-	-	-	.	.	.
-	-	-	.	.	.
-	-	-	.	.	.
-	-	-	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-32**	Other ID	Water Depth **58.6 m**



TAN1703 – MARCAN

Core ID:	**TAN1703-33**	Latitude:	-44°40.889	Date/Time (NZST):	26/04/2017 05:41
Other ID:		Longitude:	171°32.672	Depth (m):	**53**

Sample Description

General Description

Gear type	**Piston corer**		
Barrel Length (m)	6	Bent barrel	N
Penetration (m)	-	Catcher/Cutter bags	-
Core length (m)	0	Samples	0
Sections	0	Tephra	N
Fauna			unit

Sample processing – core ID:

Section	Top depth (cm)	Btm depth (cm)	Logged	Phys Props	Summary
-	-	-	.	.	-
-	-	-	.	.	-
-	-	-	.	.	.
-	-	-	.	.	.
-	-	-	.	.	.
-	-	-	.	.	.

TAN1703 – MARCAN		
Core ID: **TAN1703-33**	Other ID	Water Depth **53 m**