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CRUISE REPORT
FOCUS-AUV
RV TANGAROA, CRUISE NO. TAN2011,

30 SEPTEMBER (WELLINGTON, NZ) – 28 OCTOBER 2020 (WELLINGTON, NZ)

Joshu Mountjoy, Jasper Hoffmann, Sally Watson, Marta Ribo, Lana Young, Pascale Otis, Susi Woelz, Johan Rolandsson and Mark Symons

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Cover image AUV Ran onboard REV Tangaroa. Photo credit Lana Young

1. Summary

RV Tangaroa voyage FOCUS-AUV (TAN2011) took place over 29 days with the primary objective of deploying the University of Gothenburg HUGIN 3000 AUV (Figure 1). Due to the COVID-19 pandemic travel restrictions none of the international scientists named in the Eurofleets+ proposal were able to participate in this voyage. A revised programme and science team was developed to account ensure a successful campaign.

A total of 14 dives were completed out of 17 planned dives. The survey areas had to be modified to allow for weather conditions, however the final overall operations and survey coverage are considered highly successful. Instrument issues meant that not all dives include the full data suite but the main instrument, the EM2040 multibeam echosounder, operated well on all surveys. In between AUV dives operations included multicoring, gravity coring, video tows, acoustic surveys, and lander and mooring deployments. As these alternate operations were not directly Eurofleets+ related they are not reported here, however the NIWA voyage report covering all voyage operations can be requested from the voyage leader. A significant amount of media outreach meant that the science of the voyage was widely publicized and achieved very good coverage. There are exceptional opportunities in this new dataset to gain scientific insights into the processes of canyon formation, the sedimentary processes associated with canyon flushing, and how submarine landslides and canyons interact.

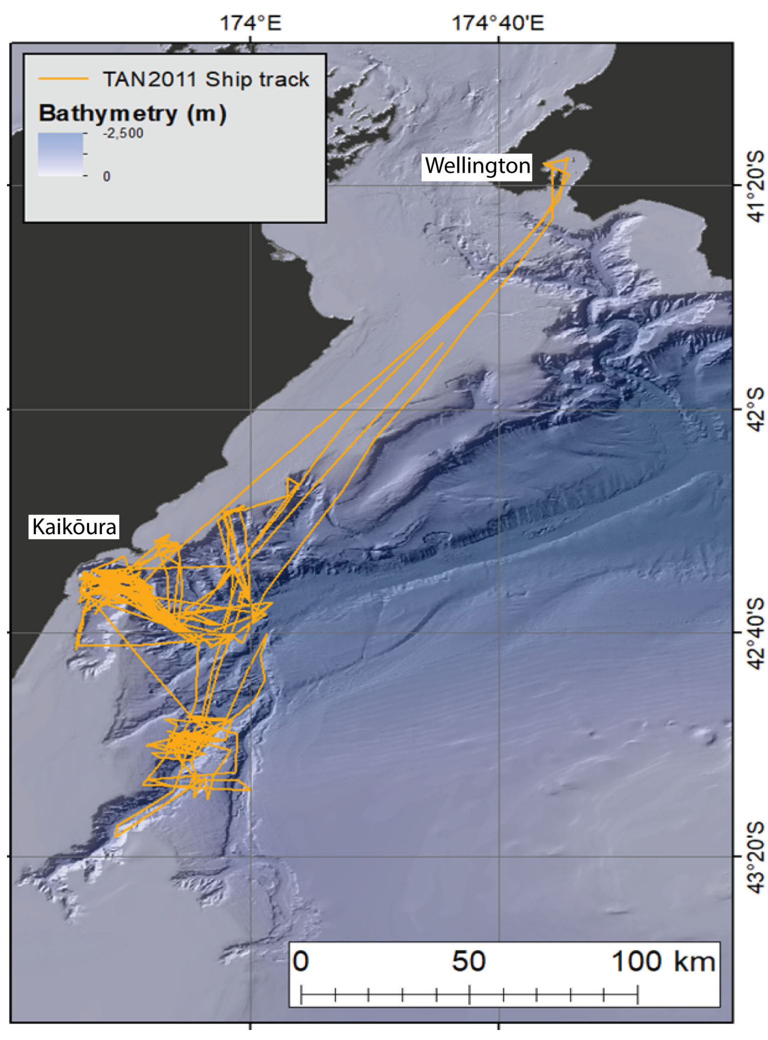

Figure 1: Working area and track chart of R/V Tangaroa Cruise FOCUS-AUV (TAN2011). Bathymetry courtesy of NIWA

2. Research Programme/Objectives

The primary objective of this voyage was to re-map the Kaikōura Canyon and nearby targets using an Autonomous Underwater Vehicle (AUV *RAN* operated by the University of Gothenburg, Sweden). Additionally, the voyage provided the opportunity to progress ongoing studies into the ecological and sedimentological impact and recovery following the 2016 Kaikōura Earthquake.

The November 2016 M_w7.8 earthquake in Kaikōura destabilized most of the large Kaikōura submarine canyon (Figure 2). At least 1 km^3 of sediment flowed through the canyon and travelled >580 km along the Hikurangi Channel (Mountjoy et al., 2018). The dynamic energy of this event revealed unprecedented information on submarine canyon responses to major flushing events, including widespread landslides around the canyon rim, large-scale sediment evacuation from the upper canyon, bedrock erosion in the central canyon, movement of deep-water bedforms/mega-ripples comprised of gravel –boulder-sized sediment, and catastrophic changes to the benthic ecosystem. Each of these elements offers an exceptional and unique opportunity to understand how submarine canyons respond to short-term tectonic forcing. Repeat mapping of the canyon rim at 1-2 m resolution using small vessel-based, high resolution (200 kHz) multibeam sonar reveals the location, magnitude and failure mechanism of submarine landslides, but this high level of detail can only be revealed down to approximately 100 m water depth. Vessel-mounted 30 kHz multibeam bathymetry datasets acquired before and after the earthquake have been very revealing of morphological changes through the deeper parts (>200 m) of the canyon in response to the earthquake. In the upper canyon up to 60 m thickness of sediment was removed from the canyon rim; however, the failure mechanisms for this sediment movement are unclear. In the central canyon, pre-earthquake seafloor video transects show bedrock exposures in places while poorly resolved canyon floor features suggest there were crescentic bedforms, diagnostic of mobile sand infill (cf. Monterey Canyon). Pre- and post-earthquake multibeam surveys show local erosion of up to 30 m in bedrock areas and the creation of new bedforms, and an overall region-averaged lowering of the canyon floor by 5 m. However, with the resolution of the available data, the details of how change has occurred in this central part of the canyon are poorly understood. Intriguingly, in the lower canyon, gravel bedforms with crest to crest lengths of up to 250 m and amplitudes up to 20 m moved down the canyon by as much as 500 m yet maintained a consistent plan-form layout. The mechanism by which this translational movement occurs is unclear.

Kaikōura Canyon was previously identified as a benthic biomass hotspot (voyage TAN0616, De Leo et al., 2010), and post-earthquake observations (TAN1701 and TAN1708) indicate a major disruption to the deep-seafloor ecosystem following the canyon flushing event, as well as early signs of recovery, ten months after the earthquake-induced, canyon-flushing event. The objectives of voyage TAN2011 were designed to acquire key data to better understand what caused the catastrophic erosion and change in Kaikōura Canyon, to advance knowledge of canyon formation processes and to facilitate better quantification and prediction of the recovery of the canyon's benthic ecosystem. The findings from the voyage will have implications for the understanding of all submarine canyons in terms of how they evolve and how they respond to earthquake ground-shaking.

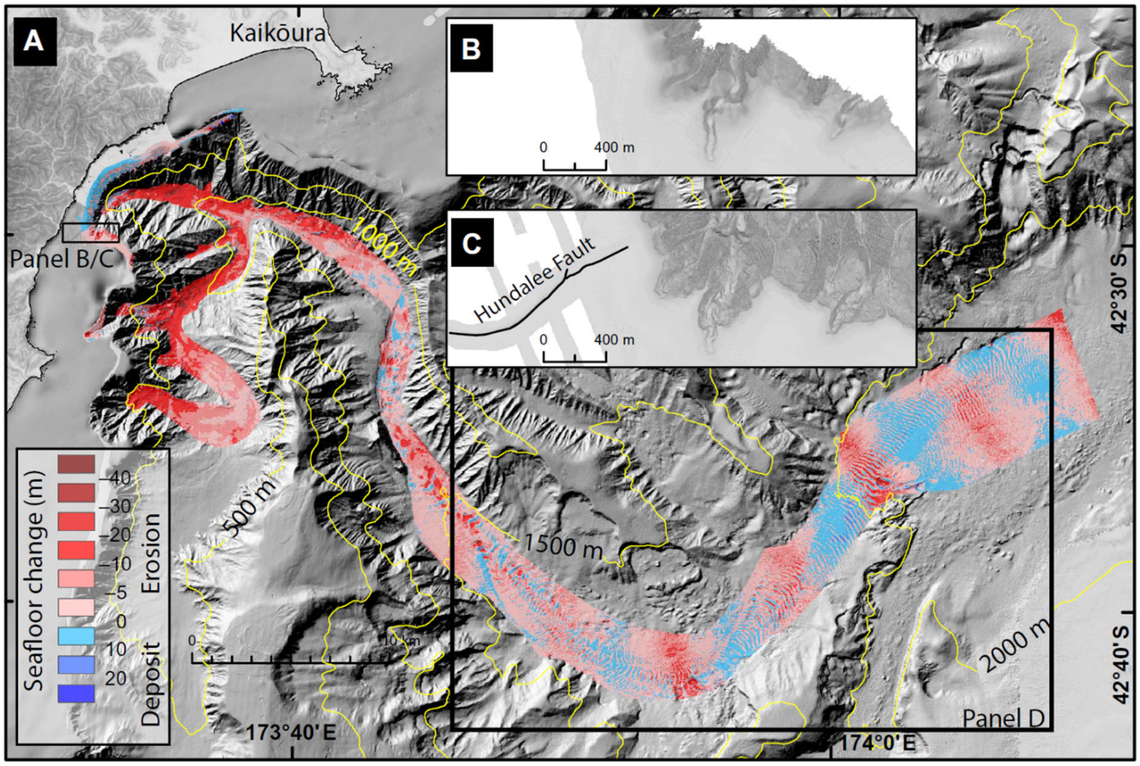

Figure 2: Calculated vertical change in the floor of the Kaikōura Canyon from pre- and post- earthquake multibeam bathymetry. Inset panel B/C shows changes in the canyon rim area where widespread landsliding occurred (after Mountjoy et al., 2018).

3. Narrative of the Cruise

23 – 27 September

- Pre-mobilisation. AUV and coring containers lifted onboard and LARS installed on Tangaroa. AUV technicians setting up from 27th Sept.

28 – 29 September

- Mobilisation period. All equipment onboard.

30 September – 12 October

- Test AUV dive in Wellington Harbour. Transit to Kaikōura and commence surveying Kaikoura Canyon.
- Alternating AUV deployment/recovery with DTIS, multicoring and lander deployment.
- AUV dives 1-6 completed. All priority repeat DTIS and multicoring stations completed. Additional DTIS tows along canyon floor and canyon walls. Three Moorings deployed.

12 – 17 October

- Wellington for science team change 12 October.
- Weather did not permit surveying in Cook Strait or Wairarapa.
- Return to Kaikōura Canyon and complete AUV dives 7-9 to map entire canyon floor.
- Alternate AUV dives with DTIS, gravity coring and repeat EM2040 survey of canyon rim.

17 – 22 October

- AUV surveys of pockmarks and landslides in Pegasus Canyon.
- Alternate AUV surveys with TOPAS profiles over landslides/canyon and gravity coring.

23 – 26 October

- Transit to Kaikōura Canyon and recover Lander 1.
- Invite group from Ngāti Kuri Rūnanga onboard for science visit and lunch.
- Recover remaining landers then complete multicoring.
- Complete AUV surveys in Kowhai Sea Valleys.

27 – 28 October

- Demobilisation.

1.1 Weather

Overall the weather on TAN2011 was favourable. For the majority of the time the NW airflow resulted in strong winds and rough seas through the Cook Strait area but light winds and calm seas in the Kaikōura region study area (Figure 3).

The AUV operation, particularly its recovery, has a very low weather threshold of <2 m swell. As three of our proposed sites were in locations adversely affected by this pattern the voyage plan was modified to focus in the more sheltered areas, away from eastern Cook Strait-Wairarapa.

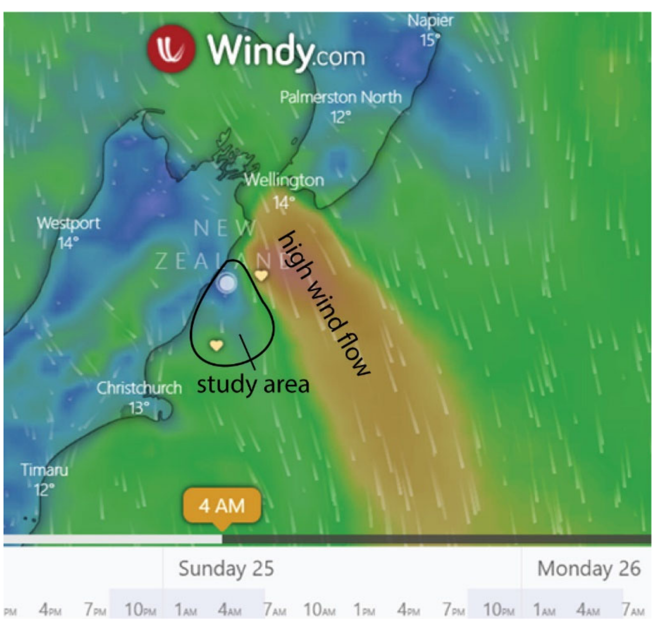

Figure 3: Typical wind flow pattern during voyage TAN2011. Reddish brown colours depict high wind flow up to 30 knots while blue colours are around 5 knots. The main study area where surveying took place is outlined.

4. Science Communication

Throughout the first leg of the voyage images and video were taken of all science activities on board by Lana Young (NIWA videographer) primarily used a Sony A74iv for stills and vision, as well as a Nikon D810 for stills and two GoPro Hero 5's for videos and time lapses.

524 video clips of footage were collected of the main activities on board, including AUV, DTIS, AUV, benthic lander and multicore sampling operations. Interviews were also conducted on board with Sally Watson and Johan Rolandsson, Alan Orpin, Rachel Hale, Ashley Rowden, Mark Symons, Katie Bigham, Scott Nodder and Joshu Mountjoy. These files will also be stored in the Videographer Archive at NIWA.

A small selection of still images were transferred back to land during the voyage to be used alongside online communications and on social media. Three 1 minute videos were also cut on board using Adobe Premiere Pro and sent back to land for use on the NIWA website and social media. These video topics were about why we were in Kaikōura using the AUV in Kaikōura canyon, how landers are deployed to the seafloor, and benthic biological recovery post the earthquake. After returning to land, a longer video was cut that summarises the voyage in more detail and this achieved significant uptake through social media channels. A summary of all media and outreach material produced and the uptake achieved is provided in Table 1.

Table 1: Science communication resources from TAN2011

Video	Eurofleets+ collaboration	1	0:37	https://vimeo.com/463980465
Video	AUV trial in harbour	1	0:50	https://vimeo.com/463652219
Video	Hugins AUV	1	1:00	https://vimeo.com/464628152
Video	Benthic landers	1	0:33	https://vimeo.com/466415470
Video	Benthic ecology	1	1:04	https://vimeo.com/466309774
Video	Dolphins riding the bow	1	1:00	https://vimeo.com/470813543
Video	b-roll compiles for the media	1	2:26	https://vimeo.com/464026662/b8392cc19f
Video	b-roll compiles for the media	1	1:34	https://vimeo.com/464026365/3d02e41853
Video	b-roll compiles for the media	1	1:54	https://vimeo.com/464025615/d37af3e6b0
Video	Kaikōura Canyon	1	3:11	https://vimeo.com/472408367/aa951ed1c4
TV	Feature story on TVNZ - One News	1	1:52	https://www.tvnz.co.nz/one-news/new-zealand/scientist-borrow-swedish-submarine-investigate-earthquakes-impact-kaik-uras-sea-floor
Press	Kaikoura star	1	-	http://readnow.isentia.com/Temp/36604-93790999/1351121608.pdf
Press	Westport News	1	-	http://readnow.isentia.com/Temp/36604-80077527/1348163511.pdf
Press	Sunlive	1	-	https://www.sunlive.co.nz/news/253651-underwater-robot-to-fly-through-kaikura-canyon.html
Press	Voxy	1	-	http://www.voxy.co.nz/national/5/374895
Internal	Article on One.NIWA	1	-	https://one.niwa.co.nz/pages/viewpage.action?pageId=186482957
Internal	Article on One.NIWA	1	-	https://one.niwa.co.nz/pages/viewpage.action?pageId=185186635
Social	Facebook: Ran intro (video)	1	-	5461 reach, 76 likes, 9 comments, 16 shares
Social	Facebook: Joshu Mountjoy (video)	1	-	6891 reach, 77 likes, 7 comments, 23 shares
Social	Facebook: Benthic landers (video)	1	-	3887 reach, 53 likes, 8 comments, 6 shares
Social	Facebook: Sediment cores (video)	1	-	4374 reach, 78 likes, 20 shares
Social	Facebook: Lana Young (photo)	1	-	3648 reach, 74 likes, 6 comments, 2 shares
Social	Facebook: Dolphins bow (video)	1	-	4382 reach, 93 likes, 3 comments, 18 shares
Social	Facebook: overview (video)	1	-	53079 reach, 297 likes, 24 comments, 138 shares
Social	Twitter: Joshu Mountjoy (video)	1	-	654 views, 29 likes, 0 comments, 14 shares
Social	Twitter: Benthic landers (video)	1	-	359 views, 22 likes, 1 comment, 7 shares
Social	Twitter: link to TVNZ story	1	-	5 likes, 0 comments, 5 shares
Social	Twitter: Dolphins bow (video	1	-	1181 views, 77 likes, 1 comment, 15 shares
Social	Twitter: Eurofleets+ (text)	1	-	5 likes, 2 shares
	Twitter: Sediment Core			421 views, 32 likes, 8 shares
Social	Instagram: photo gallery	1	-	299 likes, 5 comments
Social	Instagram: Dolphins bow (video)	1	-	3591 views, 8 comments (most viewed video on Instagram)
Social	Instagram: Lana Young	1	-	341 likes, 2 comments
Social	Instagram: Ran Kaikoura (photo)	1	-	306 likes, 1 comment
Social	Instagram: AUV (photo)	1	-	450 likes, 22 comments

5. HUGIN 3000 AUV Acquisition parameters

The HUGIN 3000 Autonomous Underwater Vehicle (AUV) has a depth rating of 3000 m and is equipped with an EdgeTech 2205 sonar system (side-scan sonar and sub-bottom profiler), a Kongsberg EM2040 multibeam system and oceanographic sensors such as a CTD (conductivity, temperature, depth), O_2, CO_2, and chlorophyll/turbidity sensors (Figure 4).

The AUV was deployed on 14 successful missions. The pre-voyage workplan proposed 17 dives including AUV-based video surveys. The HUGIN 3000 "RAN" did not have a camera instrument installed so no AUV-based video footage could be collected. An addendum proposal for additional AUV survey days proposed several missions away from the Kaikōura Canyon region. Due to the weather and swell threshold for AUV recovery, surveying at several of these locations was not possible. Subsequently alternative surveys were made in the Kowhai Sea Valleys adjacent to Kaikōura Canyon. The specific parameters for all successful missions are listed in Table 2.

Table 2: AUV dive parameters. MBES = multibeam echosounder (WC = water column), SSS = side-scan sonar, SBP = sub-bottom profiler, ADCP = acoustic Doppler current profiler. All dives also collected downward-looking ADCP, Seabird CTD, CO_2, and SeaBird WetLabs ECOtriplet (FLBBCD) data.

DIVE	Mission duration (hh:mm)	Total Survey Lines (km)	Survey speed (m/s)	Main altitude (m)	MBES bathy	MBES WC	SSS 410 kHz	SSS 75 kHz	SBP	ADCP Up
AUV1	11:00	79.2	2.00	50	Yes	Part	No	No	No	Yes
AUV2	26:38	191.8	2.00	50	Yes	Yes	No	No	No	Yes
AUV3	22:37	162.9	2.00	50	Yes	Yes	No	No	No	Yes
AUV4	2:57	21.4	2.00	50	Yes	No	No	No	No	Yes
AUV5	26:09	188.3	2.00	50	Yes	No	No	No	No	Yes
AUV6	24:57	134.7	1.50	20	Yes	No	Yes	No	Yes	Yes
AUV7	26:56	194.0	2.00	50	Yes	No	Yes	No	Yes	Yes
AUV8	28:25	204.7	2.00	50	Yes	No	Yes	No	Yes	Yes
AUV9	9:44	70.2	2.00	50	Yes	No	Yes	No	Yes	Yes
AUV10	20:53	150.4	2.00	50	Yes	Yes	Yes	No	Yes	Yes
AUV11	22:32	162.2	2.00	50	Yes	Part	Yes	No	Yes	No
AUV12	27:05	195.0	2.00	50	Yes	No	Yes	No	Yes	No
AUV13	26:00	187.2	2.00	50/80	Yes	No	Part	No	Part	No
AUV14	16:00	115.2	2.00	50/80	Yes	No	No	No	No	No

Figure 4: HUGIN 3000 AUV being serviced by Johan and Mark. Photo credit Lana Young

2.1 AUV Navigation

While the AUV was on board R/V *Tangaroa* it received GSP from the ship. Once the headings standard deviation was satisfactory (below 0.01°) the AUV entered the water. High precision navigation of the AUV was achieved by GPS antennas while the AUV is at the surface. This GPS signal was also fed into a Honeywell Hg9900 Inertial Measurement Unit (IMU) as a position aiding source. The vehicle dives to a set altitude above the sea floor, either unaided (dead reckoning – just inertial sensors) or aided using the ship's positioning system (HiPAP).

When the AUV comes within bottom track range of the sea floor, acceleration in x, y, z axes are measured using a downward-looking Nortek 600 kHz DVL (Doppler Velocity Log). The IMU solution is now being aided by the velocity sensor calculated from the Doppler Velocity Log (DVL).

Temporary moorings on the seafloor (Underwater Transponder Positioning moorings (UTP's)) were deployed prior to each dive in the vicinity of the study area. These transponders were accurately positioned on the seafloor before the AUV dive using the R/V *Tangaroa*'s HiPAP positioning system. The initial part of the dive is planned and used to lower the standard deviation of the latitude and longitude of the AUV. This is achieved by navigating the AUV in a circular to star-forming pattern around one of the transponders on the seafloor. The position on each transponder is loaded into the AUVs positioning system prior to each dive. As the AUV passes the transponder the distance between AUV and transponder is calculated from acoustic wave travel times. It uses these ranges to aid its navigation, thus utilising another positioning source for the IMU to generate a more confident absolute position for the AUV. The transponders have a range of 500-1000 m where communication between AUV and transponder occurs.

After circumnavigating the transponder, a survey pattern will commence. The vehicle will generally navigate using its inertial sensors and the DVL. Under these circumstances a navigation error of approximately 6 m per hour can be expected. This error is reduced each time the AUV comes into range of one of the UTPs, allowing the AUV to navigate successfully around the desired survey area. The navigation error that accumulates between the transponders is smoothed during post-processing of the navigation, using available sensor aiding and a forward and backward Kalman filtering processes.

In general, the AUV was programmed to keep a constant distance of 50 m above the seafloor. In specific areas, higher resolution surveys required a closer distance to the seafloor and accordingly the AUV was operated at 25 m to 10 m above the seafloor. Similarly, in steep terrain the AUV was collecting data at a constant depth without following the terrain of the seafloor. The survey speed varied between the dives from 1.5 - 2 m/s.

3.1 AUV Kongsberg EM2040 Multibeam

The EM2040 is a high-resolution, shallow water multibeam echo-sounder (MBES) used for seabed mapping. This MBES operates at bandwidths from 200 to 400 kHz with an across track coverage of about 5.5 times water depth (depending on depth and mode). 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 sound velocity in the vicinity of the transducer is continuously measured and used for beam forming. The transmit beams are electronically stabilised for roll, pitch and yaw, while the receiver beams are stabilised for roll movements by a Honeywell Hg9900 IMU. Water column data, which show the received amplitude of the entire water column for each beam, were recorded during some AUV dives simultaneously with the MBES data. We operated the MBES with a constant frequency of 300 kHz. The dives during which water column imaging data were collected is specified in Table 2.

The fixed installation of the multibeam system in the HUGIN 3000 makes a yaw, pitch and heave calibration unnecessary. Appropriate lines were used for verification and no offsets were needed.

1.1.1 Processing

The raw data from the EM2040 were stored in .all files and subsequently processed using Qimera 2.2.5 and QPS add-ons to process acoustic seafloor backscatter and water column backscatter (Fledermaus Geocoder, Fledermaus MidWater).

During import of the .all files into Qimera, .qpd files were generated which include all edits made to the raw .all files. The bathymetry and quality of the data was examined and surfaces with 0.5 m, 1 m, and 2 m grid resolutions (dependant on the dive height above the seafloor) were generated for each AUV dive. The data were subsequently cleaned in 2D using a line by line manual cleaning approach where gross errors and obvious noise were manually rejected. During close examination of the raw .all files we discovered that internal filter processes that are implemented in the Kongsberg SIS acquisition software automatically remove soundings in areas with steep slopes. It was therefore decided to accept all automatically filtered soundings prior to the manual cleaning process in the steep terrain datasets acquired subsequently to Dive 3.

Tide files to correct the AUV’s depth below the sea-surface were provided by NIWA Hamilton and used to project all bathymetry data to a true depth below the mean sea level. Tide files were applied according to the location of data acquisition. Although the initial online navigation of the AUV in most regions produced satisfying bathymetric results post-processed navigation, motion and depth of the AUV was implemented and quality controlled on board. This removed additional artefacts produced by the sudden repositioning of the AUV when coming into transponder range after relying on the IMU and DVL. Due to technical difficulties post-processed navigation could not be provided for Dive 9. These issues are currently under investigation by the Kongsberg support group and hopefully will result in accurately post-processed navigation subsequently to this voyage. An example of how the processing affected data quality is shown in Figure 5.

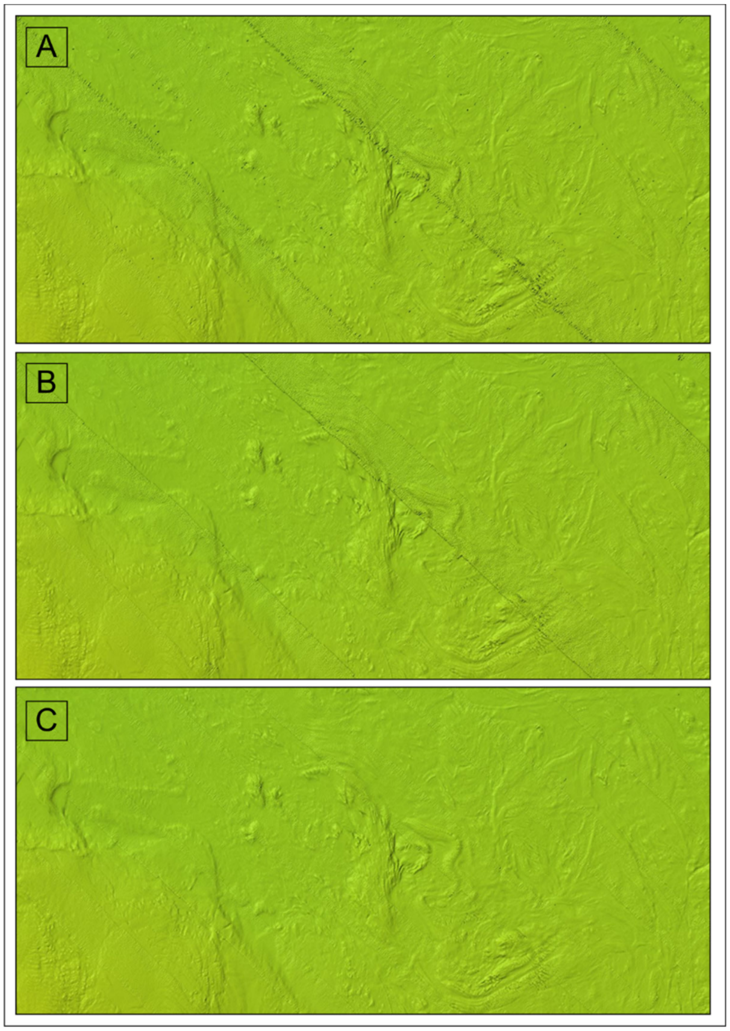

Figure 5:Example of processing steps applied to the AUV EM2040 bathymetric datasets. A) Raw bathymetry, B) Cleaned and navigation corrected, C) with tides applied

4.1 AUV EdgeTech 2205 Sub-bottom Profiler and Side-Scan system

The EdgeTech 2205 is a flexible sonar system designed to be operated on unmanned vehicles. The system simultaneously acquires sub-bottom profiling and side-scan sonar imaging data.

The side-scan sonar uses a uniform linear sensor array to emit a narrow fore/aft beam that creates an “acoustic slice” along the seafloor, perpendicular to the vehicle’s path. The side-scan operates at frequencies of 75 kHz and 410 kHz. This dual-frequency operation provides a low frequency for long range target detection (with decreased resolution) and a higher frequency for increased resolution (with decreased range). Both frequencies as well as the sub-bottom profiler acoustic pulse are emitted simultaneously without any cross-pulse interference to ensure the highest ping rate (along-track resolution) possible. Generally, a ping frequency of 4 Hz was specified. The raw data are stored in .xtf and .jsf file formats.

The sub-bottom profiler (DW-106) emits a chirp/sweep pulse with frequencies ranging from 1-6 kHz, 2-6 kHz or 1.5-4.5 kHz. A linear power amplifier is used to generate the output pulse which is emitted at a beam width of 28°-36° (centre frequency dependant). The returning signal is de-convoluted with the output pulse to create a high-resolution output function. Additionally, the pulse is weighted in the frequency domain to have a Gaussian-like shape to preserve its bandwidth during attenuation by the sediment. The envelope of this signal is stored into a raw .xtf and .jsf file system.

The .jsf files were converted into .segy format using EdgeTech's software "JSFFileConverter". All data was projected from geographical coordinates into New Zealand Transverse Mercator (NZTM) projection using IHS Kingdom Suite's "SeismicExplore" software package. The depth of the AUV at each ping was converted into two-way travel time (TWT) using a constant water velocity of 1500 m/s.

Visualisation of the data and preliminary interpretation to determine coring locations was done in IHS Kingdom Suite seismic interpretation software.

5.1 AUV Oceanographic sensors

The conductivity, temperature and depth were measured with a frequency of 4 Hz during each AUV dive using a SeaBird 911 19plusv2 CTD. The CTD data were used to accurately measure the AUV's depth and were stored as .txt files.

A SeaBird SBE43 was used to determine the dissolved oxygen concentration in the water column while a Contros HydroC measured the dissolved carbon dioxide concentration at a frequency of 1 Hz. The measured data were not calibrated on board.

Chlorophyll concentration and particle back-scattering in the water column were determined during the AUV dives using a SeaBird WetLabs ECOtriplet (FLBBCD) at a frequency of 1 Hz.

6. Data distribution

The footprint of AUV MBES related to the 14 dives listed in Table 2 is shown in Figure 6. For each dive the same footprint is shown by region with the navigation overlain to show the actual track of the AUV in Figure 7 to Figure 11.

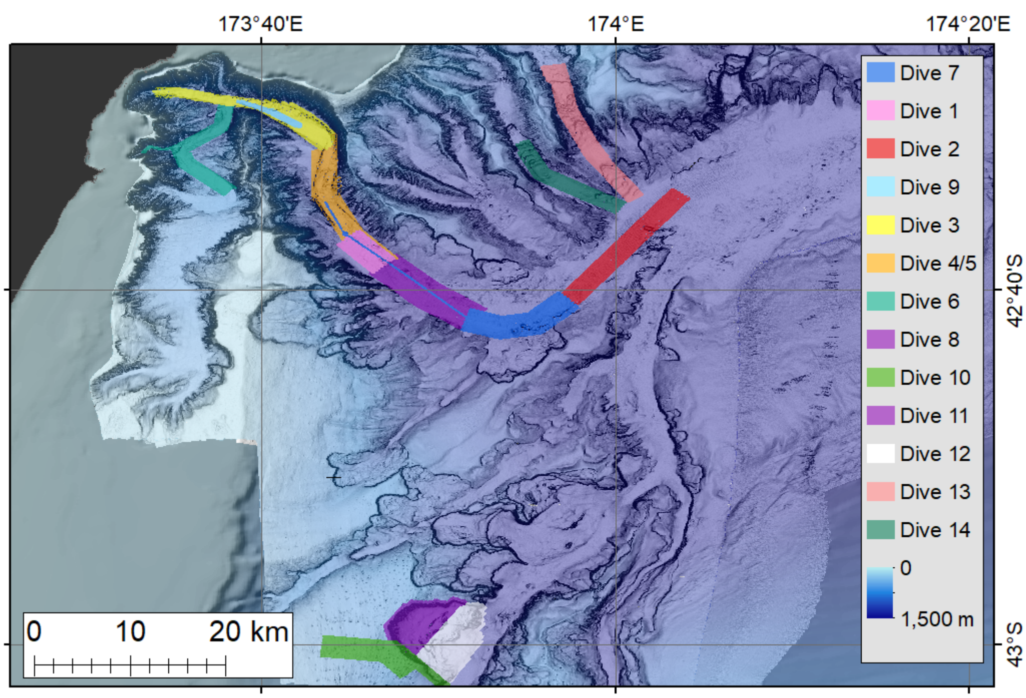

Figure 6: Distribution of all AUV data collected on TAN2011.

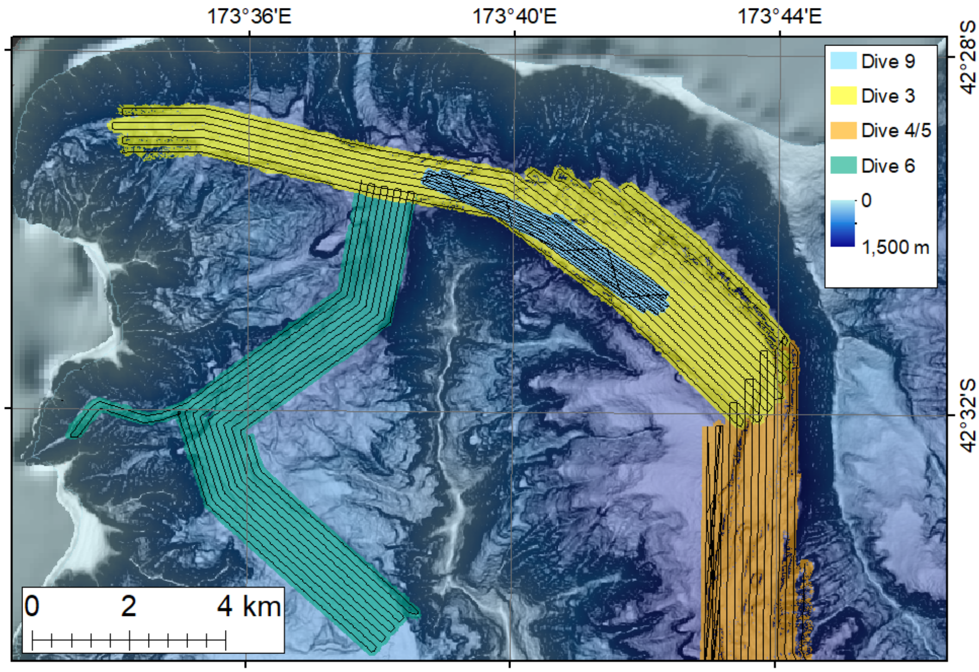

Figure 7: AUV dives in upper Kaikōura Canyon showing MBES coverage coloured by mission and track navigation indicating where other data has been collected. Dive 9 is a lower altitude dive that overlaps with Dive 3. For detail of which instruments were active on specific dives refer to Table 2.

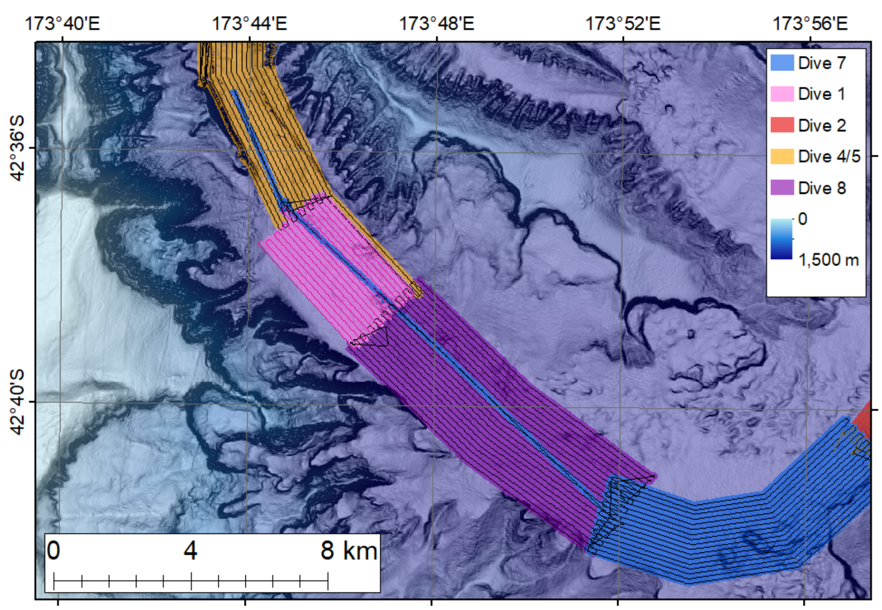

Figure 8: AUV dives in middle Kaikōura Canyon showing MBES coverage coloured by mission and track navigation indicating where other data has been collected. For detail of which instruments were active on specific dives refer to Table 2.

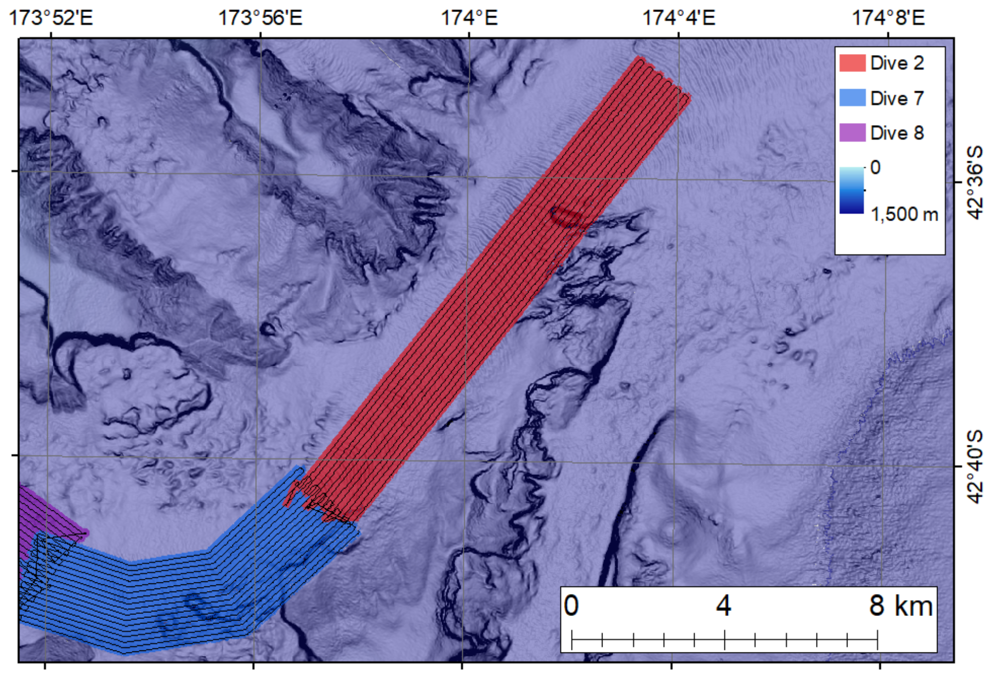

Figure 9: AUV dives in lower Kaikōura Canyon showing MBES coverage coloured by mission and track navigation indicating where other data has been collected. For detail of which instruments were active on specific dives refer to Table 2.

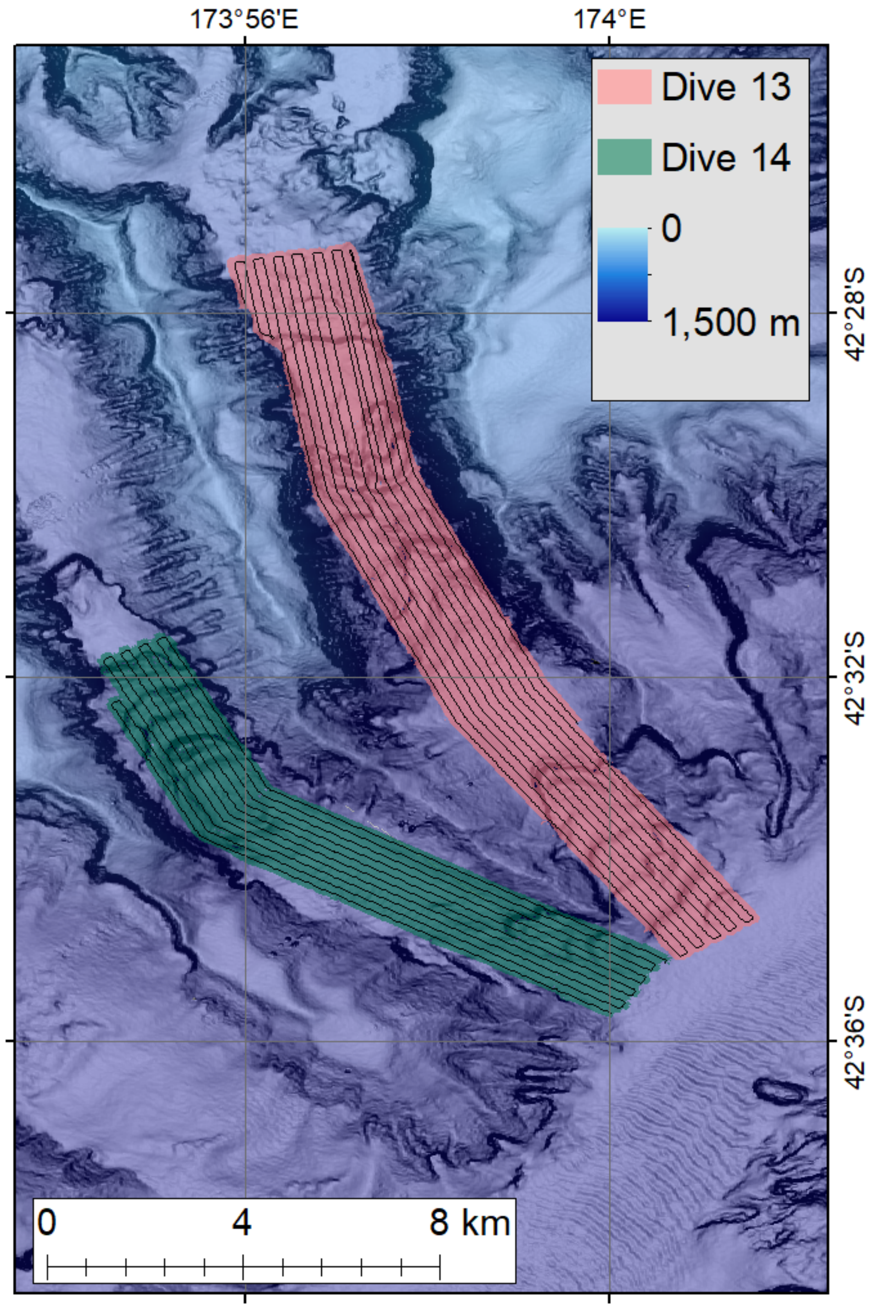

Figure 10: AUV dives in Kowhai Sea Valleys showing MBES coverage coloured by mission and track navigation indicating where other data has been collected. For detail of which instruments were active on specific dives refer to Table 2.

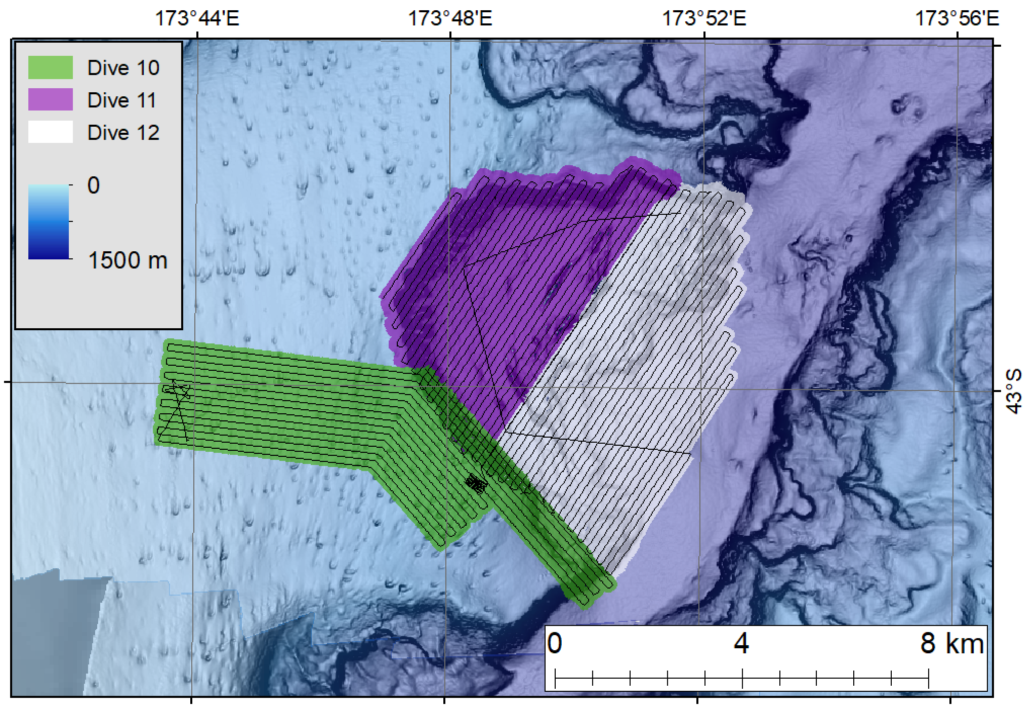

Figure 11: AUV dives in Pegasus Canyon Area showing MBES coverage coloured by mission and track navigation indicating where other data has been collected. For these three missions the Edgetech instrument was fully functioning so sub-bottom profiler data are available on all lines. For detail of which instruments were active on specific dives refer to Table 2.

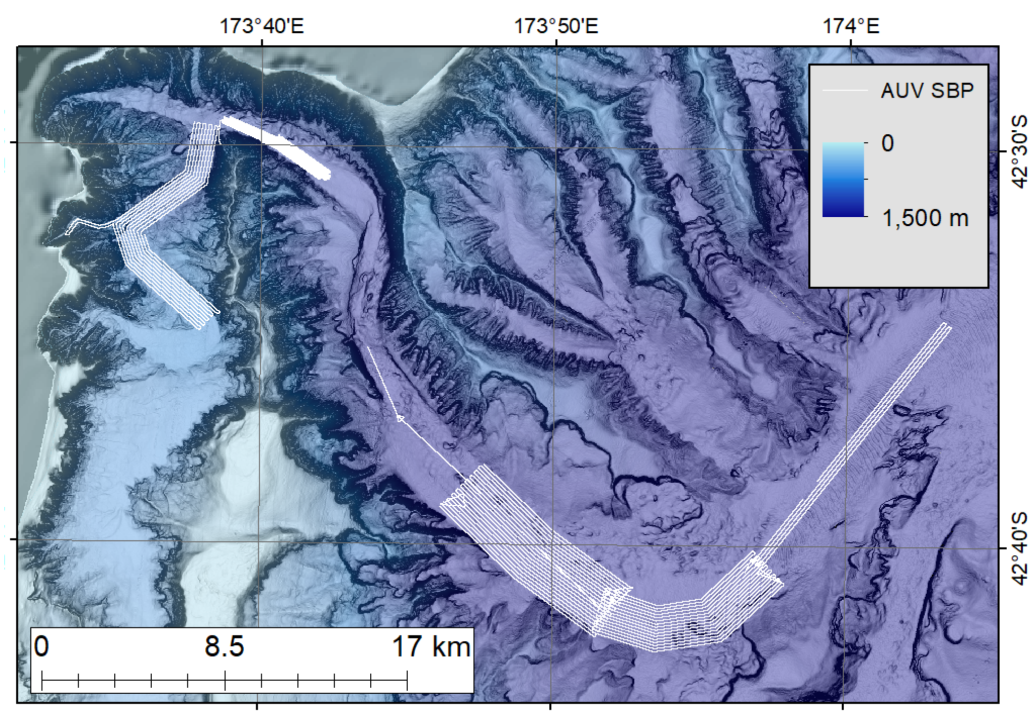

Figure 12: AUV navigation where Edgetech sub-bottom profiler and sidescan data were collected. Data was also collected on all AUV tracks shown in Figure 11.

7. Preliminary results

The data collected on TAN2011 have only had a preliminary screening on board in terms of scientific results. Below are a few examples that highlight some interesting features and showcase the quality of the AUV MBES bathymetric and sub-bottom profiler data.

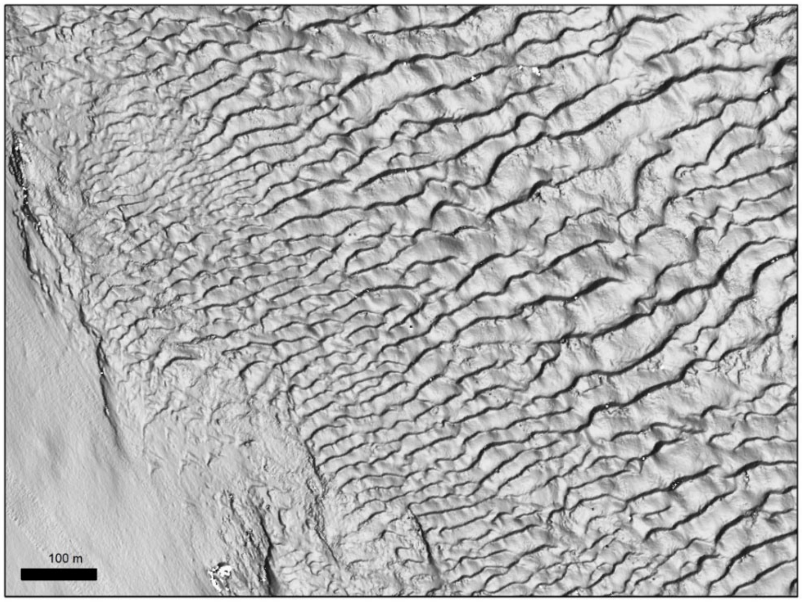

Figure 13: AUV EM2040 data over sediment waves in Kaikōura Canyon. Water depth is ~1450m.

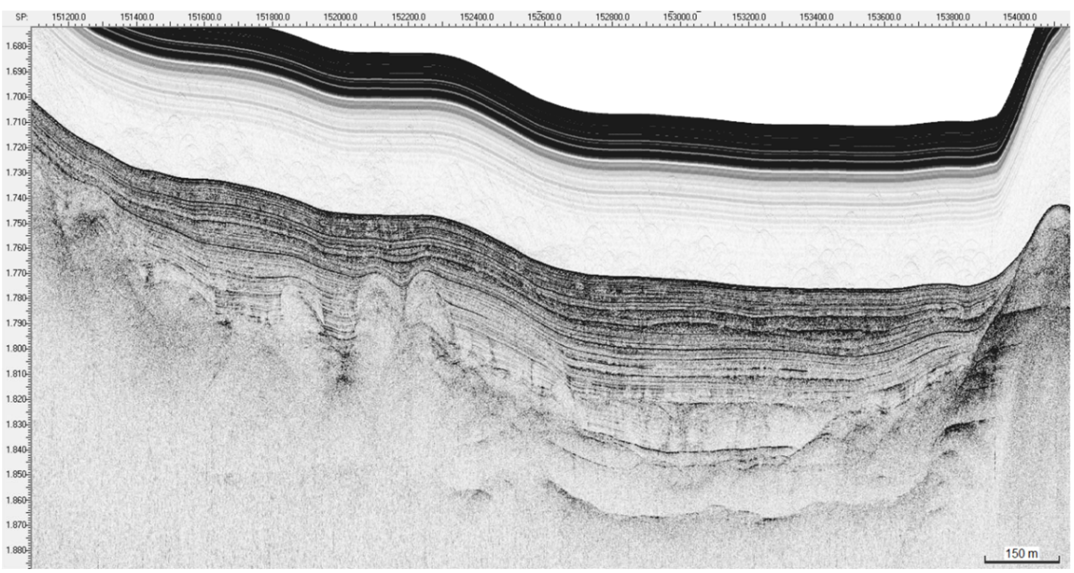

Figure 14: AUV sub-bottom profiler data showing laterally continuous layered sediments.

8. Data and Sample Storage / Availability

Metadata will be made available through NIWA's Open Data Portal once fully processed. Full datasets from the AUV instruments will be made available after a voluntary restriction of 2 years from November 2020 that will allow FOCUS-AUV partners to process, interpret and disseminate project data. Once the embargo period is over data will be available through the Belgian Marine Data Centre (BMDC).

9. Participants

No.	Name	Early career (Y/N)	Gender	Affiliation	On-board tasks
1	Joshu Mountjoy	N	M	NIWA	Voyage Leader, Safety officer
2	Scott Nodder (SL)	N	M	NIWA	Sedimentology biogeochemistry. Chemical safety officer
3	Alan Orpin (SL)	N	M	NIWA	Core processing, sedimentology
4	Ashley Rowden	N	M	NIWA	Ecology Lead, DTIS, core processing
5	Sally Watson (SL)	Y	F	NIWA	Acoustics Lead
6	Marta Ribo	Y	F	UoA	Watch keeping
7	Peter Gerring	N	M	NIWA	Landers and moorings, multicoring, gravity coring
8	Steve George	N	M	NIWA	DTIS Lead, electronics
9	Will Quinn	N	M	NIWA	HiPap, DTIS, electronics
10	Katie Bigham	Y	F	NIWA	Ecology, DTIS, core processing
11	Sarah Searson	N	F	NIWA	Moorings and landers
12	Jennie Mowatt	Y	F	NIWA	Moorings and landers
13	Rachel Hale	Y	F	NIWA	Biogeochemistry and incubations
14	Jasper Hoffman	Y	M	NIWA	acoustics
15	Johan Rolandsson*	N	M	MMT	AUV Lead technician
16	Mark Symons*	N	M	MMT	AUV technician
17	Colin Bloom	Y	M	UoC	Watch keeping
18	Lucy McLeod	Y	F	Ngati Kuri	Watch keeping
19	Lana Young	Y	F	NIWA	Science Communication
20	Susi Woelz (SL)	N	F	NIWA	Shift Leader, acoustics
21	Tehlia Richardson	Y	F	Ngati Kuri	Watch keeping
22	Sam Richardson	Y	F	Ngati Kuri	Watch keeping

*participant funded by EUROFLEETS+. SL shift leader

NIWA: National institute of Water and Atmospheric Research

UoA: University of Auckland

UoC: University of Canterbury

10. Acknowledgements

Funding for the HUGIN AUV was secured through Eurofleets+ who have been very supportive of this project through the exceptional challenges of operating an international voyage during a global pandemic. We are especially very grateful for the effort of Professor Anna Wåhlin, AUV lead scientist at the University of Gothenburg Sweden, for the significant amount of work required to make the project happen through the COVID-19 affected period. Special mention needs to be made of AUV technicians Johan Rolandsson and Mark Symons who were required to spend 2 weeks in managed isolation prior to joining the month long voyage.

Funding for R/V *Tangaroa* was secured through the New Zealand Ministry of Business, Innovation and Employment (MBIE) through the Tangaroa Reference Group (TRG).

Greg Foothead of NIWA Vessels led a project to modify and install the launch and recovery system (LARS) on the stern ramp of RV Tangaroa enabling concurrent AUV operations to take place with complimentary operations through the starboard cutaway. The cost for this was shared between the NIWA Vessels company and NIWA SSIF.

Funding for NIWA personnel onboard was covered by MBIE SSIF Programme COPR in the Coasts and Oceans Centre, NIWA capability fund PhD scholarship to Katie Bigham, and funding for videographer Lana Young from the Communications and Marketing group.

We were honoured to be able to host Ngāti Kuri representatives Samantha and Tehlia Richardson and Lucy McLeod during the voyage and thank them for their enthusiastic contribution to all aspects of data collection and processing.

We particularly appreciate the participation and contribution of research fellow Marta Ribo and PhD student Colin Bloom who joined the voyage as self-funded participants.

The work of videographer Lana Young onboard, along with Pascale Otis and Susan Pepperell onshore, enabled us to develop an exceptional range of science communication resources for this voyage.

As always, the officers and crew of R/V *Tangaroa* stepped up to the challenge of new and varied operations to make this voyage a success.

11. References

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