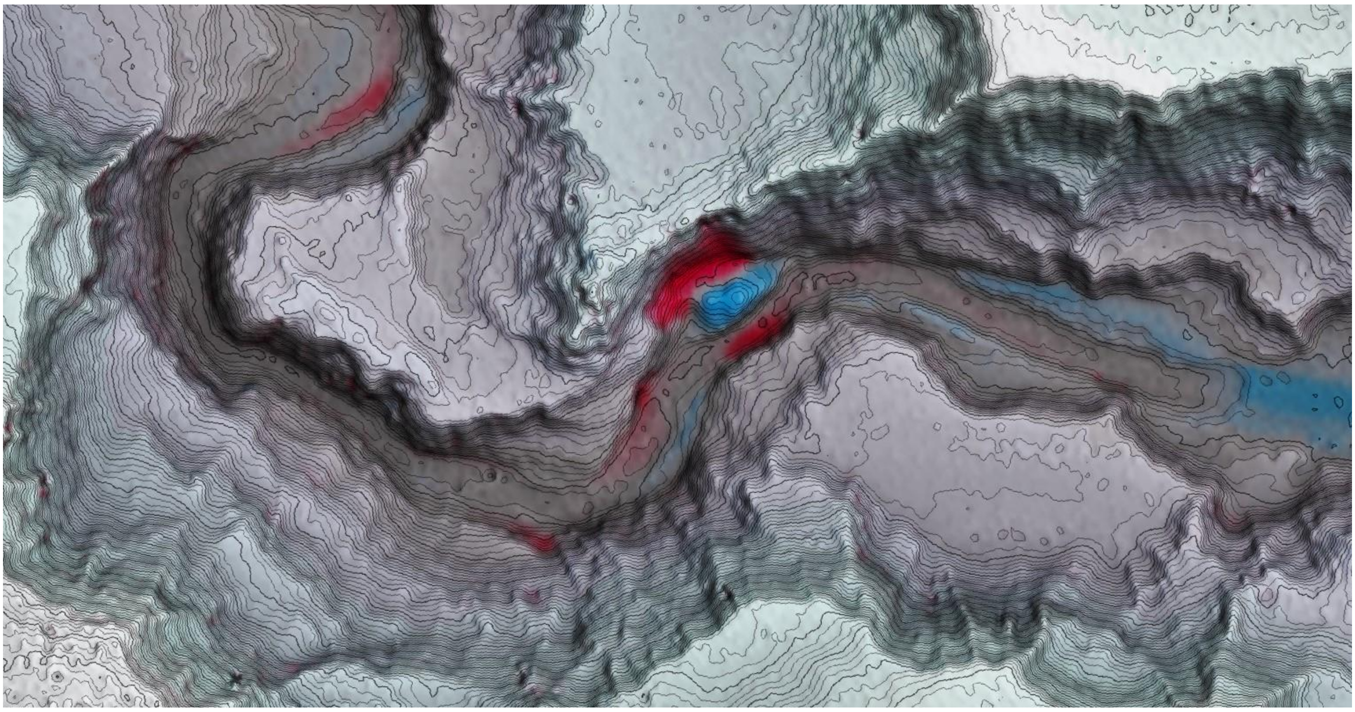
Cruise Report - DY173

Understanding Hazardous Seafloor Sediment Flows

RRS Discovery – DY173



Cover figure: Difference map superimposed on contoured and hillshaded bathymetry picks out a recent canyon-wall landslide in the upper canyon, which has occurred since 2020. Areas of erosion are shown in red, whilst areas of deposition are in blue.

Note: The RRS Discovery logged time in UTC (= GMT) and this is the timing system adopted in this cruise report unless otherwise stated.

Contents

1. Introduction

Flows of sediment along the seafloor (called turbidity currents) dominate sediment transfer into much of the deep ocean, and form the largest sediment accumulations on Earth (called submarine fans). These spectacular underwater flows carve the deepest canyons and longest channel systems found on our planet, which can extend for hundreds to thousands of kilometers. However, turbidity currents are notoriously challenging to measure in action, especially the larger and more powerful flows that flush submarine canyons and reach the deep sea (Talling et al., 2023). This cruise is part of a project that has measured turbidity currents in detail in the deep-sea for the first time, building on earlier detailed studies led by Ifremer in the same system. Two previous cruises in 2019 (JC187) and 2020 (JC209) deployed an array of ADCP-moorings along the Congo Canyon offshore West Africa that recorded deep-sea turbidity currents, including a flow in January 2020 that travelled for >1,100 km at 5-8 m/s, making it the longest sediment flow of any type yet measured on Earth (Talling et al. 2022).

The scale of turbidity currents is not the only reason they have global importance. They can break valuable seabed telecommunications cables that carry over 99% of global data traffic, and which underpin the internet and many other aspects of our daily lives. For example, the turbidity current in January 2020 broke both seabed telecommunication cables to West Africa, such that the internet slowed from Nigeria to Cape Town during a covid-related lockdown when bandwidth was most needed (Talling et al., 2021, 2022). In this Congo Canyon study area, one or more submarine cables have been broken seven times by turbidity currents since 2020. These seabed sediment avalanches also play a globally important role in organic carbon transfer and burial. It was once thought that most terrestrial organic carbon that reached the ocean was oxidised on continental shelves. But more recent work, including in the Congo Fan system now shows that terrestrial organic carbon can be efficiently transferred and buried in the deep sea by turbidity currents (Galy et al., 2007; Baudin et al., 2020; Talling et al., 2024; Baker et al., 2024). Turbidity currents also supply key nutrients and physically disturb deep-sea ecosystems, which include biological diversity hot spots along canyons.

However, despite their importance, there are remarkably few direct observations from turbidity currents in action, and they are thus poorly understood. This is a stark contrast to other major sediment transport processes, such as rivers. Down-canyon changes in turbidity current power, frequency, duration, and runout distance, are therefore hard to predict for geohazard assessment.

Flow monitoring in the Congo Canyon started with studied led by Ifremer that made innovative point measurements of flow speeds and other properties (Khripounoff et al., 2003; Vangreisheim et al., 2009), which was allied to detailed seabed mapping, seismic surveys and coring (e.g. Babonneau et al., 2002, 2010; Picot et al., 2015; Dennielou et al., 2017; Rabouille et al., 2019). Then, previous work at 2 km water depth in the Congo Canyon successfully made the first detailed (sub-minute, profiling) measurements of turbidity currents in the deep ocean (Cooper et al., 2013, 2016), using acoustic sensors called ADCPs (acoustic Doppler current profilers). These initial measurements produced a major advance in understanding of turbidity currents, including that powerful flows can be a week-long, and are active for ~30% of the time in the upper Congo Canyon (Azpiroz-Zabala et al., 2017; Simmons et al., 2020). This preliminary work formed the basis for a subsequent NERC funded project that comprises a series of four scientific research cruises using UK research vessels. The NERC-funded scientific project is led by Professor Talling at the University of Durham in the UK, and involves UK colleagues at the Universities of Hull, Southampton and Newcastle, together with the UK's National Oceanography Centre in Southampton. The project includes key partners at IFREMER in France, as well as GEOMAR and Kiel in Germany, who are providing extra equipment and their expertise. The project also involves close collaboration with Angola Cables to disseminate results to submarine telecommunication cable operators in the region (e.g. via the West Africa Cable (WAC) consortium).

Research cruise DY173 is the third of four research cruises. The first two cruises in 2019 (JC187) and 2020 (JC209) deployed and recovered a series of 11 moorings with acoustic Doppler current profilers (ADCPs), and 12 Ocean Bottom Seismometers (OBS). These instruments successfully recorded sediment flows in 2019-20 that travelled for over 1,100 km along the canyon-channel system at speeds of 5-8m/s (Talling et al., 2021, 2022; Baker et al., in prep). These are the longest sediment flows yet measured on Earth. The 2019 and 2020 cruises also collected repeat (time lapse) bathymetry surveys along the upper canyon in Angolan waters, and along the deeper-water channel and lobe in international waters (Talling et al., 2022). A series of sediment cores were collected to study the deposits of these turbidity currents.

This cruise in 2024 (DY 173) is the third cruise in the wider NERC project. It has deployed 6 moorings (4 from NERC, and 2 from Ifremer), and completed further time lapse bathymetric surveys along the upper canyon, deep-water channel and distal lobe. It also collected a more extensive survey of the lobe area, and extended a survey of the upper canyon into Democratic Republic of Congo (DRC) waters. A series of sediment cores were also taken along the upper canyon, deep-water channel and across the lobe. CTD casts were used to both calibrate multibeam surveys, and study active flows in the canyon-channel. The 6 moorings deployed in 2024 will be recovered by a final research cruise planned for April 2025, which will also completed further time-lapse bathymetric surveys and coring.

2. Overall Aims

The first overall aim of the DY173 cruise is to use ADCP-moorings to understand the speed, frequency, runout distance, and character of turbidity currents within the Congo Canyon. These ADCP-moorings will be recovered by a final cruise in April 2025. In particular, we seek to understand how flows behave once they leave the main channel and move through a less well-developed channel across the lobe.

The second aim is to understand how turbidity currents sculpt the seabed, and how submarine canyon and channel or lobe morphology evolves through time. This includes time lapse surveys of the lobe area, which aim to understand how submarine channels extend and grow. Time lapse surveys of the upper canyon also focus on the role of knickpoints (waterfall-like features in the canyon-channel profile), landslide dams (Pope et al., 2022), and outer bend erosion in canyon and channel evolution.

This second aim is linked to better understanding why some seabed telecommunication cables are broken by these powerful seabed avalanches, whilst adjacent cables can survive the events. We seek insights that will help to route cables across canyon is areas of somewhat lower hazard.

A third aim is to understand how the flows monitored since 2019 are recorded by seabed deposits, and thus link direct flow measurement to associated deposits. This will help to understand how seabed deposits and ancient rock sequences record flow processes, whilst the seabed deposits cored here also provide further information on the nature of recent flows that have occurred since 2019.

A fourth aim is to use sediment cores to understand how microplastics are dispersed into the deep sea.

A fifth aim is to determine how organic carbon is being transferred to the deep sea by turbidity currents across submarine fans. For example, we seek to understand transfer efficiency, and whether different types of organic matter are fractionated along the transport pathway. This is important because turbidity currents may play a globally significant role in organic matter transfer and burial, which could affect global climate over long (> 1 ka) time scales (Talling et al., 2023; Baker et al., 2024).

A final aim was to collect sediment cores to help determine whether degradation of terrestrial organic matter can lead to carbon isotopic signatures that are commonly attributed to marine organic matter.

3. Executive Summary

The study can be subdivided into three main areas, which are (i) the termination of the submarine channel and transition to unconfined flow (termed the 'lobe') in international waters, (ii) the main submarine channel within international waters, and (iii) upper canyon in Angolan and DRC waters.

Lobe area: This DY-173 research cruise initially sought to understand how turbidity currents evolve at the end of the submarine channel system, in an area termed the lobe, beyond the final mooring deployed in 2019-2020 (Talling et al., 2022). This and older lobes have previously been studied by Ifremer (e.g. Dennielou et al., 2017). The objective was to understand the final stages of turbidity currents as they leave a submarine channel and become less well confined. Sensors deployed in 2019-2020 recorded turbidity currents with front speeds of 5-8 m/s within the submarine channel (Talling et al., 2022; Baker et al., in prep), and we wish to determine what happens at the end of this channel, and as flows then become less confined. This lobe area was also chosen because all previous monitoring of turbidity currents has been in confined canyons and channels (Talling et al., 2023), and this would be the first monitoring of turbidity currents as they leave a channel and become unconfined. The Congo River also had an exceptionally large flood with a peak discharge of 79,000 m^3 on 9th Jan 2024, the largest flood since the 1960s, and this flood occurred only a few weeks before the DY-173 cruise. It seems likely this exceptional river flood may bring a lot of sediment into the canyon head, thus causing powerful turbidity currents in the canyon-channel (Talling et al., 2022), which might break moorings sited further up the system. Situating moorings further down the system was thus felt to be prudent, and this distal lobe area is also situated in international waters to simplify permitting.

A detailed swath multibeam survey of the end of the channel was thus completed initially by DY-173. In general, it was found that the submarine channel becomes much less deeply (< 20m) incised, as compared to its upper (>20-to-200 m) reaches. However, the new survey also showed there are two reaches of deeper (~20m) incision, interspersed with less confined (< 5-8 m) flow, along the final part of the channel. The more deeply incised reaches are linked to knickpoints, likely caused by seabed failure with 'ragged edges' seen in mapping, and consistent with previous work by Ifremer on the lobe (Dennielou et al., 2017). The final deepest-water knickpoint has developed between 2019-2020, as it is not visible in earlier Ifremer surveys (Dennielou et al., 2017), and it seems to have been formed by the unusually powerful turbidity currents in January and March 2020. Beyond this final knickpoint, the channel ends and flows become unconfined. This unconfined area has blocky topography in sub-bottom profiler data suggesting a debris flow, and this is consistent with sediment facies observed in DY173 cores. The bathymetric survey of the lobe was extended towards the south and west to include the un-channelised area immediately beyond the channel mouth, and in order to provide a base map for the 2025 cruise that can then determine whether the channel extends further in 2025.

The 4 NERC moorings were then deployed at sites along the axis of the distal channel on the lobe, at sites where it was more deeply (moorings M1, M3, and M4) or more poorly (mooring M2) incised. The two Ifremer moorings (PG1 and PG2) were deployed outside the channel on levees, on either side of the most proximal M1 mooring. The Ifremer moorings are thus located in a (somewhat…) less risky position, and these Ifremer moorings can record processes of overspill by turbidity currents, as well as how turbidity currents interact with other background ocean currents. The moorings were deployed quickly at the start of the cruise, so they were in place for flows linked to a spring tide, although it is not yet clear whether that spring tide on Feb 10-12th 2024 caused any major flows.

Work on the lobe area then concluded with a transect of piston (PC1-16) and multicores (MC1-6), starting with the unconfined area beyond the channel. The most distal piston cores in this area recovered one or more very thin (< 20 cm) poorly consolidated (soupy) muddy recent turbidites, above a thick interval of background hemipelagic sedimentation, which is underlain by turbidites from an earlier channel-lobe system. Closer to the mouth of the channel, cores recovered a near-surface debrite, perhaps linked to erosion of the nearby knickpoint by slope failures, possibly in 2019-2020. Cores along the axis of the channel consistently recovered clean turbidite sand, but these cores struggled to penetrate >50cm, except where sand was sucked in by the piston corer, and some piston core barrels were bent and some multicores failed to recover significant sediment.

This detailed multibeam survey of the lobe, together with the transect of sediment cores now provides a base-map to determine how the channel may evolve and extend from 2024-2025. The ADCP-moorings will be recovered in the 2025 cruise, in order to record any turbidity current activity.

Submarine channel: The rest of the submarine channel that is located within International waters was they surveyed, which was a 2024 repeat of swath bathymetry surveys of the channel in 2019 and 2020 (Talling et al., 2022). There was very substantial erosion along this channel between 2019-2020, including at multiple knickpoints. Comparison of 2020 and new 2024 survey showed that one of the knickpoints had again migrated and eroded deeply, and this was a knickpoint that had also migrated in 2019-2020. The outer parts of some sinuous bend may also have undergone erosion in 2020-2024, as in 2019-2020. However, other knickpoints that migrated significantly in 2019-2020 had not eroded in 2020-2024, and there was generally less erosion in 2020-2024 than during 2019-20290.

After this survey of the submarine channel we completed a boat transfer for Angolan observers in Luanda, and received permits for both Angolan and Democratic Republic of Congo waters. However, efforts to obtain a permit to work in waters of Congo (Brazzaville) were ultimately unsuccessful.

At the very end of DY-173, 4 piston cores (PC26-PC30) were collected along the axis of the channel in international waters, at heights of up to 20m above the channel floor. These cores were dominated by facies comprising clean sand and common mud-clasts, which suggest that the flows traversing the channel had high sediment concentrations in their lower parts, and some may be debris flow like.

Upper canyon: We resumed work after the boat transfer with a multibeam survey along the axis of the Congo Canyon in Angolan and DRC waters. The area in Angolan waters was a repeat of similar surveys collected in 2019 and 2020, and in both Angolan and DRC waters by Ifremer in 2005.

Previously, 2019 and 2020 surveys of the canyon floor in Angolan waters had recorded deep (often 20 m) erosion associated with powerful turbidity currents in January and March 2020, which was notably patchy, and often associated with knickpoints (Talling et al., 2022). The largest (> 110 m) knickpoint was caused by a landslide that occurred between the 2019 and earlier (2000) Ifremer survey (Pope et al., 2022), and this landslide-dam caused thick deposits in areas upstream for > 25 km.

The 2024 survey showed that two new landslide dams had occurred between 2020 and 2024. The deeper water landslide is a clearly visible block that has slumped into the channel, which is 600 m wide. This produced deposition of up to ~20m of sediment in upstream areas, and produced a knickpoint that is migrating upstream and eroding into this wedge of recent sediment. There is a second area of thick (~20m) deposition further up-canyon, presumably linked to a second landslide, although the landslide deposit is not clearly visible, and may be eroded by the knickpoint produced by the second event. The largest knickpoint in the upper canyon (> 40m deep) is associated with the 2000-2019 landslide studied by Pope et al. (2022), and that knickpoint has again migrated up canyon by ~2.7 km between 2020 to 2024. Thus, much of the upper canyon has undergone remarkable alternations of erosion and deposition of up to 20 m, all in a period of just 5 years from 2019-2024.

A series of piston (PC 17 to 25) and multicores (MC7 and 8) were collected along the floor of the canyon in Angolan waters. This includes repeats of coring sites that had produced mud dominated cores in 2019. Surprisingly, these 2024 cores were consistently dominated by clean turbidite sand, which was often very difficult to penetrate deeply. Thus, there has been a transition from a mud dominated to sand dominated canyon floor since 2019, likely due to deposition by one or more of the powerful (5 m/s) canyon flushing turbidity currents that have occurred since 2019. We are not aware of such a similar change from muddy to sandy canyon floor being recorded in past work.

The new survey in DRC waters showed the most deeply incised and proximal part of the canyon, extending to water depths of ~900m, and ~25 km (13 NM) from the mouth of the river estuary. The outer bends of meanders had been eroded over the ~19 year period between 2005 and 2024, but otherwise there was relatively little change over this longer period, at least as compared to the reach of the upper canyon located in Angolan waters. No further landslide dam deposits were observed.

Microplastics and Organic matter: Multicores collected across the lobe, and with less success in the upper canyon They will be used to understand the fate of microplastics, and the efficiency of organic matter transfer and burial. These cores will also be used to test whether terrestrial organic matter can degrade to produce C-isotope ratios previously assumed to be those of marine organic matter.

Acknowledgements: We are very grateful to the authorities in Angola and the Democratic Republic of Congo (DRC) for permitting scientific work in their territorial waters, as such permissions are critical. In particular we would like to thank Rui Faria and Costa Cula and their team at Angola Cables, who facilitated that process for Angolan waters again in 29024, together with the Angolan Ministry for Telecommunications (MTTI), Ministry for Foreign Affairs, Ministry for Oil and Gas, Hydrographic Office (IMPA), Angolan Navy and others for their assistance in Angola. We also thank Cristall Banzoulou and Congo Telecoms for their time and efforts in organising meetings that sought a permit for the waters of Congo (Brazzaville). We also thank Artur Pacavira and Emanuel Miala (Agencia Maritima Nacional in Angola) for being a key part of DY183 as Observers, and for transiting to Cape Verde with the vessel.

4. People on Board

Scientific Team

Night Shift (midnight – midday)	Day Shift (midday – midnight)
Peter Talling (Durham University, U.K.)	Matthieu Cartigny (Durham University, UK)
Megan Baker (Durham University, U.K.)	Ricardo de Silva Jacinto (IFREMER, France)
Rebecca Englert (Kiel University)	Pelle Adema (Utrecht University, Netherlands)
Bernard Dennielou (IFREMER, France)	Carlos Arenas (GEOMAR, Germany)
Amisha Salian (Bangor University)	Morgan Wolfe (NOC, UK)
Justyna Bulawa (Bangor University)	Benoit Loubrieu (IFREMER, France)
Edward Stanning (Bangor University)	Ronan Apprioual (IFREMER, France)
	Pierre Guyavarch (IFREMER, France)

Observers: Artur Pacavira and Emanuel Miala (Agencia Maritima Nacional in Angola)

Technicians

David Childs – Moorings

Tina Thomas – Moorings

Tim Powell – Moorings

Zoltan Nemeth – Ship Systems and Data

Daniel Phillips – Ship Systems and Data

Dougal Mountifield – CTD systems

Will Richardson – Coring and sensors

Andy Leadbetter – Coring and sensors

Martin Weeks – Coring and sensors

Jason Scott – Cruise Manager and Coring

Crew

Antonio Gatti – Master
Rob Ovenden – Chief Officer
Jordan Greenhow – 2nd Officer
Jake Crosby – 3rd Officer
James Bills – Chief Engineer
Dan Evans – 2nd Engineer
Marc Smith – 3rd Engineer
Elliot Draper – 3rd Engineer
David Pascoe – ETO
Valerija Forbes-Simpson – Purser
Andrew Maclean – CPOD
Craig Lapsley – CPOS
Marshall Mackinnon - POD
John Hopley - POS
Steven Crickmore – SG1A
Gary Crabb – SG1A
Joseph Brady – SG1A
Henry Glyndor - ERPO
Mark Ashfield – Head Chef
Vincent Puchalt - Chef
David Williams - Steward
Paul Anderson - Steward

5. Itinerary

Day	Time	Activity
Monday 5th February 2024	13.00 (UTC)	Depart Walvis Bay in Nambia
Friday 9th February	17:00	Arrived at lobe work area in international waters
Thursday 22nd February	16.30	Departed first work area (lobe and deep-channel)
Saturday 24th February	12.00-17.00	Boat transfer in Luanda for Angolan observers
Sunday 25th February	13:00	Arrived second work area in Upper Canyon (in Angolan and DRC waters)
Thursday 29th February	22:30	Depart upper canyon for International Waters
Friday 1st March	13.00	Arrive international waters (deep-sea channel)
Saturday 2nd March	18.00	End of science, and start of transit to Cape Verde
Wednesday 13th March	09.00	Arrive Cape Verde, and end of cruise DY-173

5.1. Overview of Events (Cruise Narrative)

This section provides a brief overview of what happened during cruise DY-173, which is also summaries within Appendix A. An electronic copy of the original detailed master log sheets, which contain a full record of activities at all stations during the cruise, is provided by Appendix B.

Note that all times are in UTC/GMT (i.e. ship's time) and not local time.

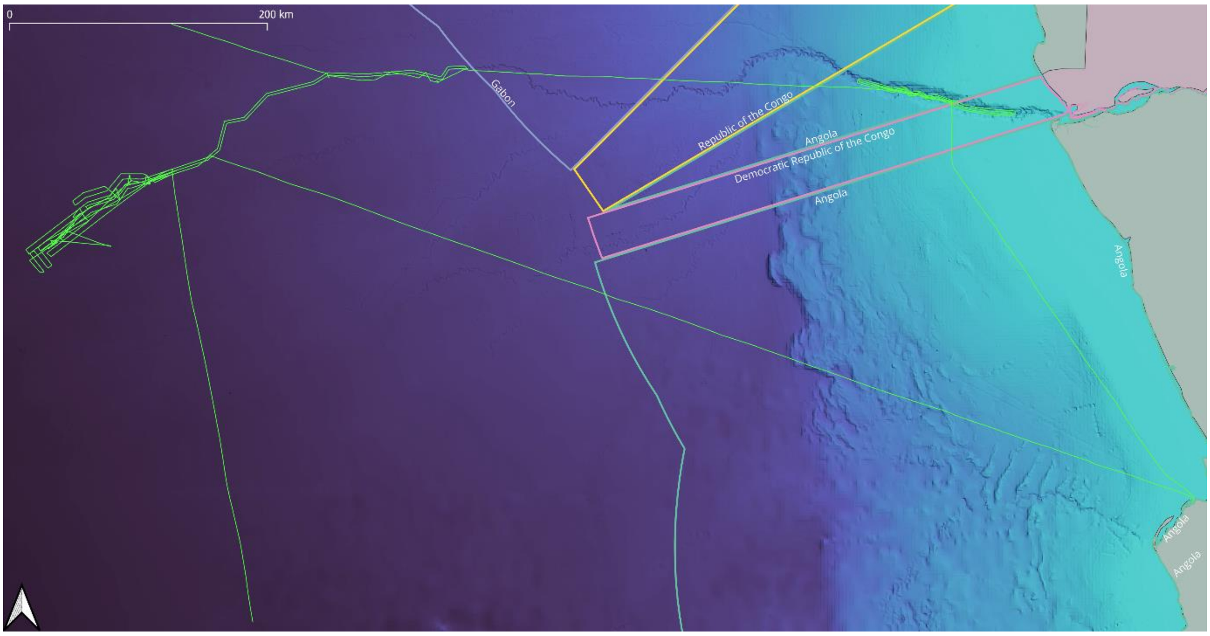


Figure 1.1. *Research cruise DY-173 started at Walvis Bay in Namibia. It completed work on the lobe and channel in international waters, before collecting observers via a boat transfer in Luanda. This was followed by work in the upper canyon, located in waters of Angola and DRC. The cruise briefly moved back to international waters, before transiting to Cape Verde, where cruise DY-173 finished.*

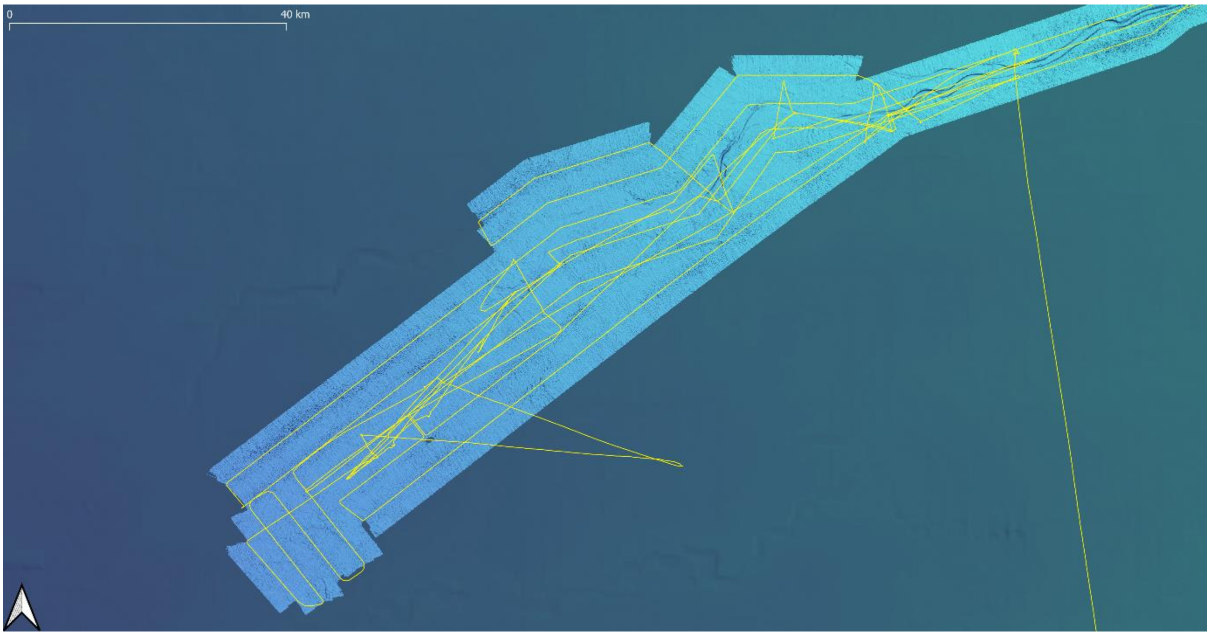


Figure 1.2. *Map of the lobe area, showing the ship track lines and swath multibeam data collected.*

5th February 2024 (13.00): Cruise DY173 departed from Walvis Bay at 13.00, after a short delay due to a visa issue to one of the science party. The science team arrived in Walvis Bay on 3rd/4th of February, whilst the vessel arrived there a few days earlier.

5th to 9th February: The vessel transited from Walvis Bay to the first work area on the lobe area at the end of the submarine channel, located within International Waters.

9th February (17.00): Arrived at lobe work area at 17.00, after transit of 4 days and ~4 hours that benefitted from prevailing current direction.

9th Feb (17.00) to 13th Feb (16.00): Lobe - Multibeam surveys and deployment of ADCP-moorings across the lobe. Multibeam surveys 1-4 and **CTD Dips 01 & 02**, were used to eventually fully map out a shallow channel system across the lobe, which included a new knickpoint generated between 2019 and 2020 surveys by large flow(s). In several places this channel is less deeply incised, and in others it passes through more deeply incised knickpoints. The channel surveys were extended to include the area of deposition beyond the end of this shallow channel system, which has evidence for debris flows.

Moorings: During this period **a series of 6 ADCP-moorings were also deployed (M1-to-M4 from NERC, and PG1 and PG2 from Ifremer)**. The moorings aim to understand what happens when flows exit the main channel, beyond the last mooring site in the 2019-20 deployments. The moorings were deployed early on during the cruise in order to have them in place during a major spring tide (Feb 10-12th) when flows may be more likely (Talling et al., 2022), although no submarine cables broke during this period.

13th Feb (16.00) to 16th Feb (15.30): The first two lines of **Multibeam Survey 5 of the deep-sea channel in international waters** were completed, together with **CTD 03**, before returning to the lobe area.

16th Feb (15.30-20.00): A winch test was performed, needed for piston coring, which was successful.

16th Feb (20.00) to Feb 22nd (09.00): A transect of sediment cores were collected across the lobe area and its channel system. They include **Piston Cores PC1 to PC16, and Multicores MC1 to MC6**. There was also a **short addition to Multibeam Survey 4** to the lobe, when piston coring was not possible. One multicore was located to the side of the lobe for work on carbon isotope signatures of organics. The latter cores were sandy, and some piston cores bent and multicores had limited recovery.

22nd Feb (13.00 to 16.30) Started the third line of Multibeam Survey 5 along the deep sea channel, **but aborted** that line after a short distance to steam for Luanda in order to pick up observers.

22nd Feb (16.30) to 25th Feb (13.00): Luanda - Visit to have a boat transfer of Angolan observers.

25th Feb (13.00) to 29th Feb (22.30): Multibeam Surveys 8 and 9 of Angolan and DRC waters, including CTD Dips 04 to 08. Both of these multibeam surveys had 4 lines. The DRC survey was conducted in daylight hours, such that two surveys (day and night) were interleaved.

This was followed by a **transect of piston cores (PC17-25) and multicores (MC07 and 08) along the axis of the upper canyon,** which was found to be sandy, such that the barrel length was eventually reduced to 6m after some bent barrels.

29th Feb (22.30) to 1st March (13.00): Transit from Angolan to International Waters. The transit was delayed in the hope of obtaining Congo (Brazzaville) permit, but eventually this was not obtained.

1st March (13.00) to 2nd March (18.00): Coring along deep-sea channel in International Waters. A series of 5 piston cores (PC26 to PC30) were collected along the axis of the channel.

2nd March (18.00): Science ended, and the RRS Discovery started its transit towards Cape Verde.

2nd March (1800) to 13th March (09.00): Transit to Sao Vincente in Cape Verde.

13th March (09.00): Arrived into Cape Verde.

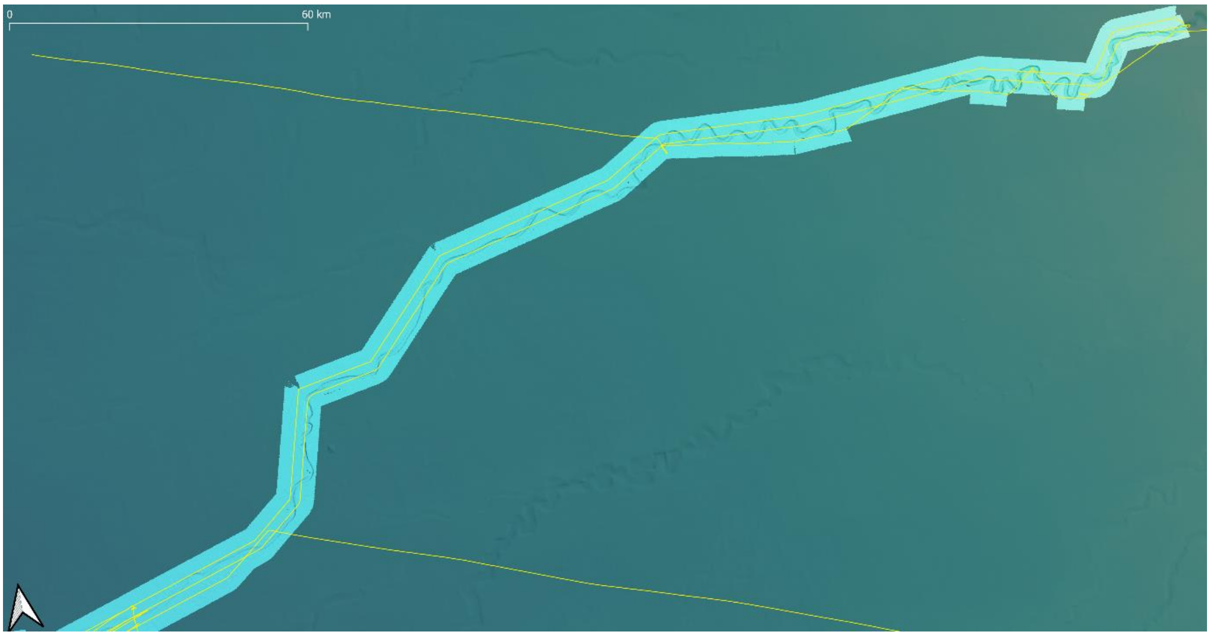


Figure 1.3. *Map of the deep sea channel, showing ship track lines and swath multibeam surveys.*

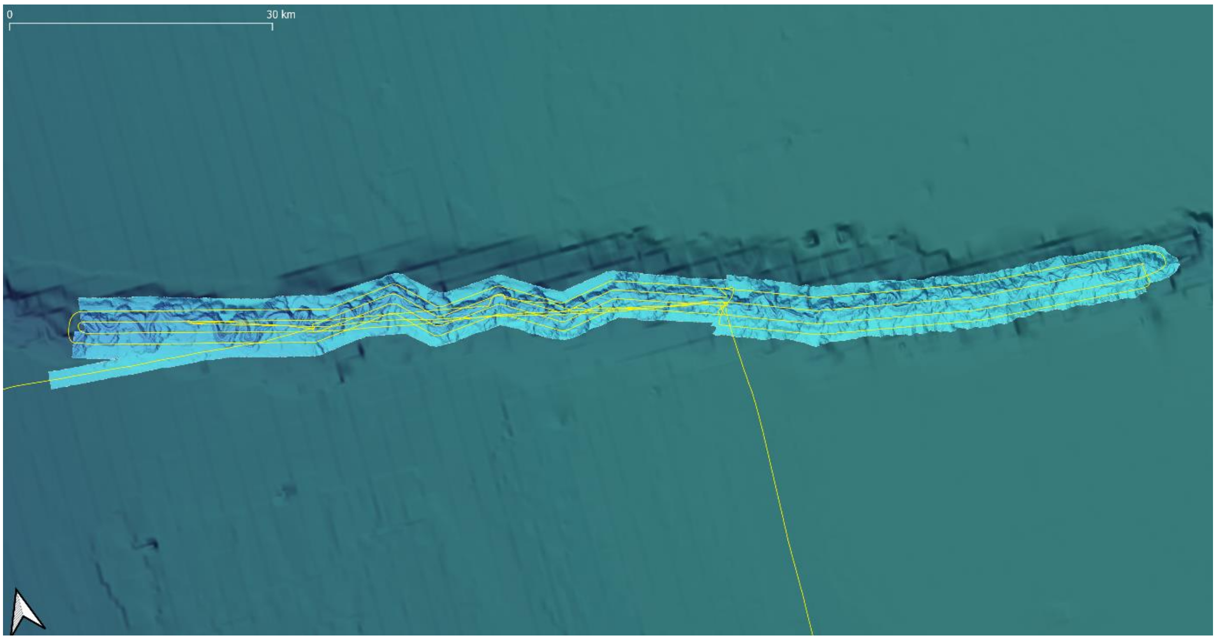


Figure 1.4. *Map of the upper canyon, showing the ship track lines and swath multibeam surveys. The western part of the area is in Angolan waters, and the eastern side is in DRC waters.*

6. Swath Multibeam (EM122) surveys and data processing

6.1. Configuration of swath multibeam data acquisition

The R/V Discovery's multibeam echosounder is a Kongsberg EM122 1°x1°. The acquisition software is SIS (Kongsberg Simrad software). Bathymetric surveys were carried out at a speed of 5 to 6 knts. Transits between work areas or station points are carried out at a speed of 10 knts. Data are acquired on some of these transits and integrated into DTMs when they contribute to extended coverage or a higher density of soundings. The aim of the survey is a detailed survey, rather than high coverage.

The sounder is used in DEEP mode and with a 45°/45° angular aperture for lobe and channel areas, as well for canyon zone in the Angola part.

For the upper part of the canyon, in the Congo DRC waters, the angular aperture has been widened to 60/60°, and the multibeam set to MEDIUM mode.

The positioning system is a differential GPS system.

The sound velocity profiles entered into the multibeam echosounder acquisition software come from the CTD stations set up during the cruise.

Thanks to the speed of acquisition and the close spacing between profiles, the data can be processed at fine scale. However, we warn about resolution and uncertainty of the multibeam. The signal provides 1° beams: therefore, the footprint of the beams is expected about 80 m at 5,000 m water depth, and about 50 m at 3,000 m water depth.

6.2. Data organisation

According to the data acquisition, the data processing is divided in four areas:

- Lobe zone, which comprises the final reaches of the deep-sea channel, and the area of unconfined flow at its mouth (all within international waters).
- Channel: deep-sea channel that is located within international waters
- Angola Canyon: section in the more deeply incised canyon in the Angola waters
- DRC Canyon: section within the DRC (Democratic Republic of the Congo) waters.

Location of the four areas is shown on the figure below.

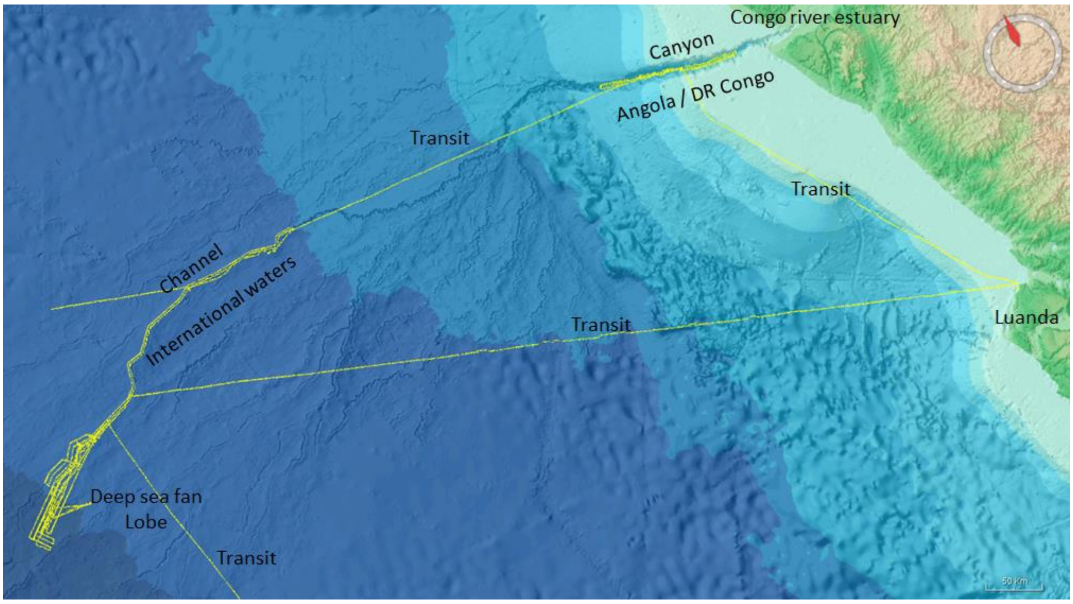


Figure 6.1. Overview of DY173 ship tracks and working areas.

For the data processing, the raw data are combined into lines, listed in the table below, with their chronology for each area.

Lobe					Processed line number
	09/02/24	22:24:00	10/02/24	11:18:59	dy173_001
	10/02/24	17:11:54	11/02/24	06:37:47	dy173_002
	11/02/24	23:37:52	12/02/24	01:46:02	dy173_003
	11/02/24	23:38:03	12/02/24	01:48:13	dy173_004
	12/02/24	01:48:24	12/02/24	04:37:44	dy173_005
	12/02/24	21:24:09	12/02/24	23:04:22	dy173_006
	12/02/24	23:05:45	13/02/24	03:27:40	dy173_007
	13/02/24	03:52:07	13/02/24	06:35:19	dy173_008
	13/02/24	06:36:30	13/02/24	07:14:46	dy173_009
	13/02/24	15:38:20	13/02/24	17:40:00	dy173_010
	13/02/24	17:50:28	13/02/24	19:32:03	dy173_011
	13/02/24	19:35:13	13/02/24	19:56:41	dy173_012
	13/02/24	19:59:28	13/02/24	21:26:17	dy173_013
	13/02/24	21:30:15	13/02/24	21:56:05	dy173_014
	13/02/24	21:58:52	14/02/24	01:42:18	dy173_015
	14/02/24	01:42:30	14/02/24	05:41:46	dy173_016
	17/02/24	15:54:07	17/02/24	17:06:26	dy173_023
	17/02/24	17:09:01	17/02/24	18:46:36	dy173_024
	17/02/24	19:14:02	17/02/24	20:48:27	dy173_025
	17/02/24	21:19:04	17/02/24	23:10:22	dy173_026
	17/02/24	23:35:37	18/02/24	00:39:13	dy173_027
	18/02/24	00:41:12	18/02/24	01:46:36	dy173_028

	18/02/24	13:58:28	18/02/24	15:20:42	dy173_029
	18/02/24	20:06:19	18/02/24	22:00:19	dy173_030
	19/02/24	13:30:40	19/02/24	14:03:07	dy173_031
	20/02/24	16:58:40	20/02/24	18:55:07	dy173_032
	21/02/24	05:45:48	21/02/24	06:14:33	dy173_033
Channel					
	14/02/24	05:42:58	14/02/24	11:59:34	dy173_017
	14/02/24	12:00:53	14/02/24	21:11:33	dy173_018
	14/02/24	21:11:43	15/02/24	08:05:47	dy173_019
	15/02/24	12:55:09	15/02/24	13:54:54	dy173_020a
	15/02/24	13:55:09	15/02/24	23:52:54	dy173_020
	15/02/24	23:53:05	16/02/24	07:18:14	dy173_021
	16/02/24	07:18:24	16/02/24	15:05:44	dy173_022
	22/02/24	12:30:48	22/02/24	16:06:04	dy173_034
	01/03/24	17:26:27	01/03/24	18:29:18	dy173_052
	01/03/24	18:56:35	01/03/24	19:30:42	dy173_053
	02/03/24	00:17:03	02/03/24	00:55:34	dy173_054
	02/03/24	06:45:10	02/03/24	07:48:18	dy173_055
	02/03/24	07:48:38	02/03/24	09:11:51	dy173_056
Transit to Luanda					
	22/02/24	16:09:38	23/02/24	09:50:31	dy173_035
DRC Canyon					
	26/02/24	05:39:12	26/02/24	10:25:24	dy173_038
	26/02/24	10:25:26	26/02/24	10:47:25	dy173_039
	26/02/24	10:47:26	26/02/24	15:36:25	dy173_040
	27/02/24	07:26:35	27/02/24	12:03:46	dy173_043
	27/02/24	14:30:28	27/02/24	18:09:06	dy173_044
Angola Canyon					
	25/02/24	16:18:45	25/02/24	21:14:14	dy173_036
	26/02/24	00:30:42	26/02/24	05:27:09	dy173_037
	26/02/24	16:05:01	26/02/24	23:24:59	dy173_041
	26/02/24	23:53:51	27/02/24	07:13:55	dy173_042
	27/02/24	21:12:23	27/02/24	23:50:25	dy173_045
	27/02/24	23:50:26	28/02/24	02:23:57	dy173_046
	28/02/24	02:39:25	28/02/24	05:19:06	dy173_047
	28/02/24	05:19:11	28/02/24	06:17:09	dy173_048
	29/02/24	06:16:29	29/02/24	08:14:43	dy173_049
	29/02/24	11:05:18	29/02/24	11:53:53	dy173_050
	29/02/24	20:38:18	29/02/24	22:16:53	dy173_051

Table 1 : List of processed lines for each sector of the data acquisition

6.3. Tide correction

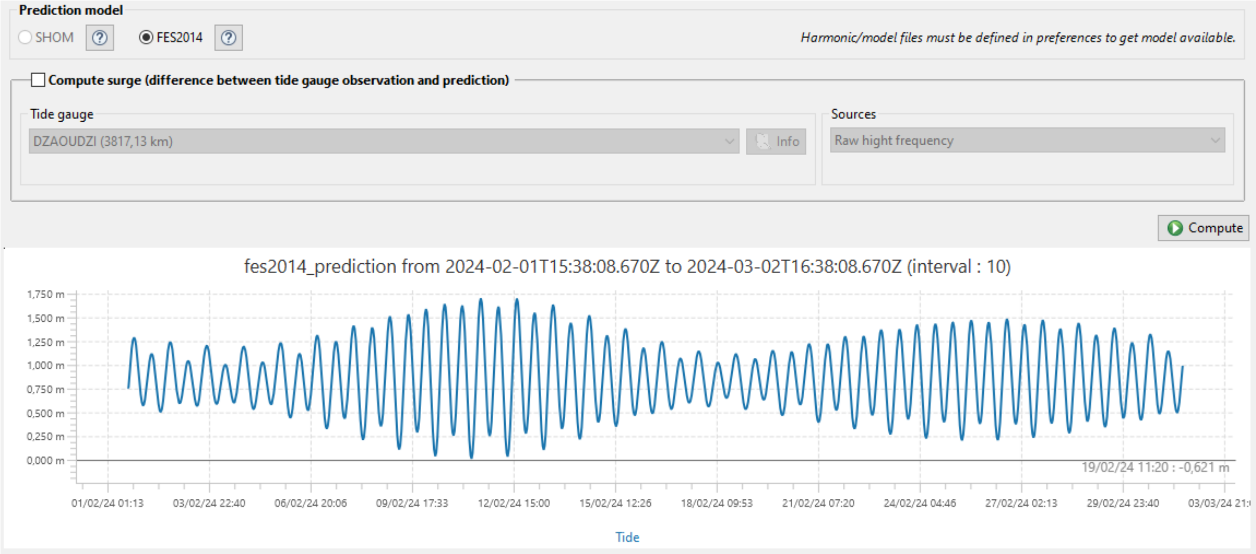
Tide prediction is calculated in the Globe software, based on the FES2014 global model. It provides a correction related to the LAT (Lowest Astronomical Tide).

For the DY173 cruise, two reference points were used.

-for the lobe and channel areas, beyond the international waters, the reference point is located at S06°30 E006°00.

-for both zones of the canyon in Angola waters and in Democratic Republic of Congo waters, the reference point is set at S006° E012°15.

The prediction is applied to all multibeam data lines. Tidal ranges do not exceed 1.5 to 2 meters.



Prediction model

○ SHOM ● FES2014

Harmonic/model files must be defined in preferences to get model available.

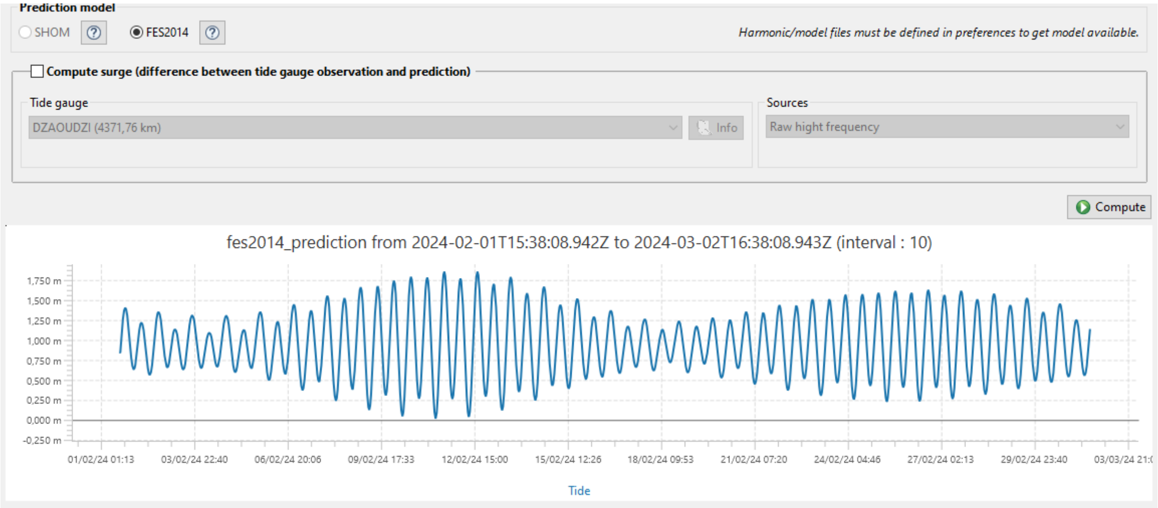
☐ **Compute surge (difference between tide gauge observation and prediction)**

Tide gauge: DZAOUDZI (3817,13 km)

Sources: Raw hight frequency

fes2014_prediction from 2024-02-01T15:38:08.670Z to 2024-03-02T16:38:08.670Z (interval : 10)

A)



Prediction model

○ SHOM ● FES2014

Harmonic/model files must be defined in preferences to get model available.

☐ **Compute surge (difference between tide gauge observation and prediction)**

Tide gauge: DZAOUDZI (4371,76 km)

Sources: Raw hight frequency

fes2014_prediction from 2024-02-01T15:38:08.942Z to 2024-03-02T16:38:08.943Z (interval : 10)

B)

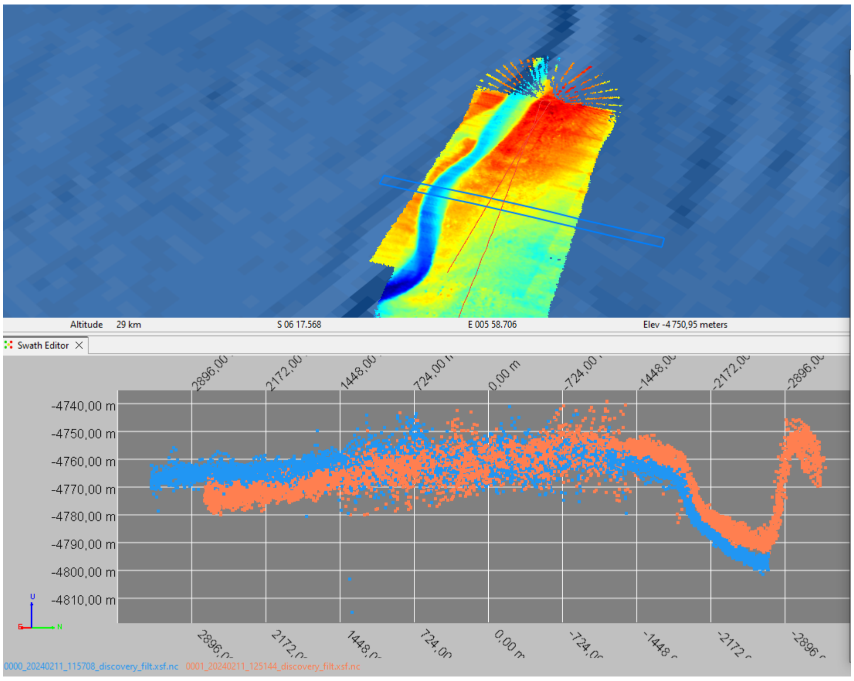
Figure 6.1. Tidal prediction for reference points (A) for the lobe at S06°30 / E06°00, and for the B) upper canyon at S06° / E12°15

6.4. Calibration and compensation of the multibeam data

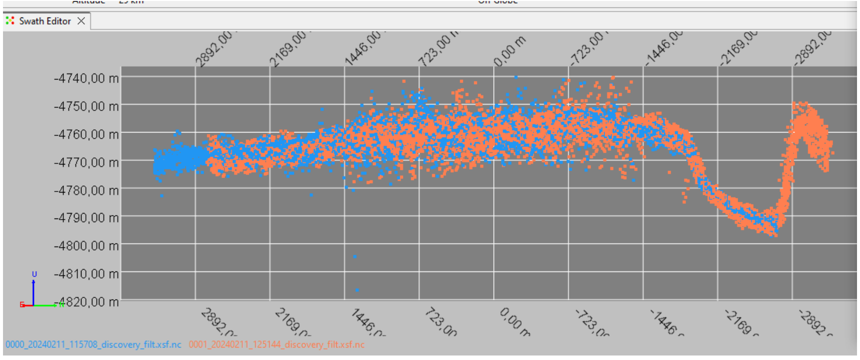
6.4.1. Roll compensation

Two lines in the opposite direction, and in a deep and flat zone, allow us to check the calibration in roll. These are the two lines of 11/02/2024 between 11:56 and 13:51 (files 0000_20240211_115708_discovery_filt.xsf and 001_20240211_125144_discovery_filt.xsf).

We can observe a misalignment of the data (figure below).
A heel compensation of 0.08° is adopted for all DY173 cruise data.



A) Data not corrected for an offset of roll compensation. Data collected in 2 opposite survey lines are distinguished by their colour (orange and blue). The shift is observed for the outer beams.



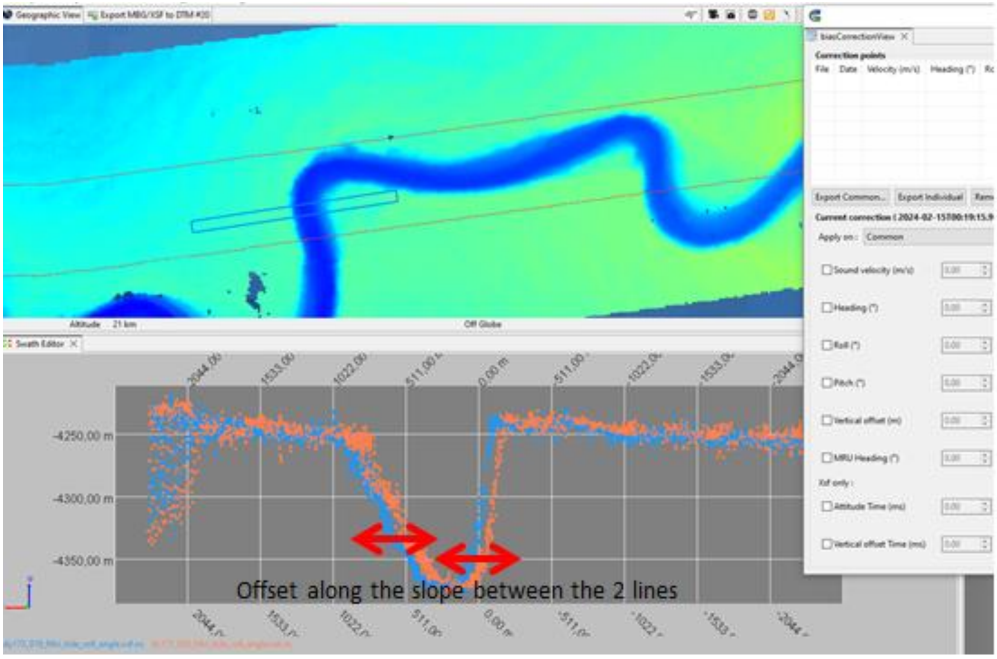
B) Data corrected with an offset of roll compensation. Data collected from the 2 opposite survey lines are aligned along the swath of the multibeam.

Figure 6.2 : Roll compensation that is A) without correction, B) with correction of 0.08°, showing the two lines are more closely correlated. These data comes from the swath lines shown in the uppermost figure.

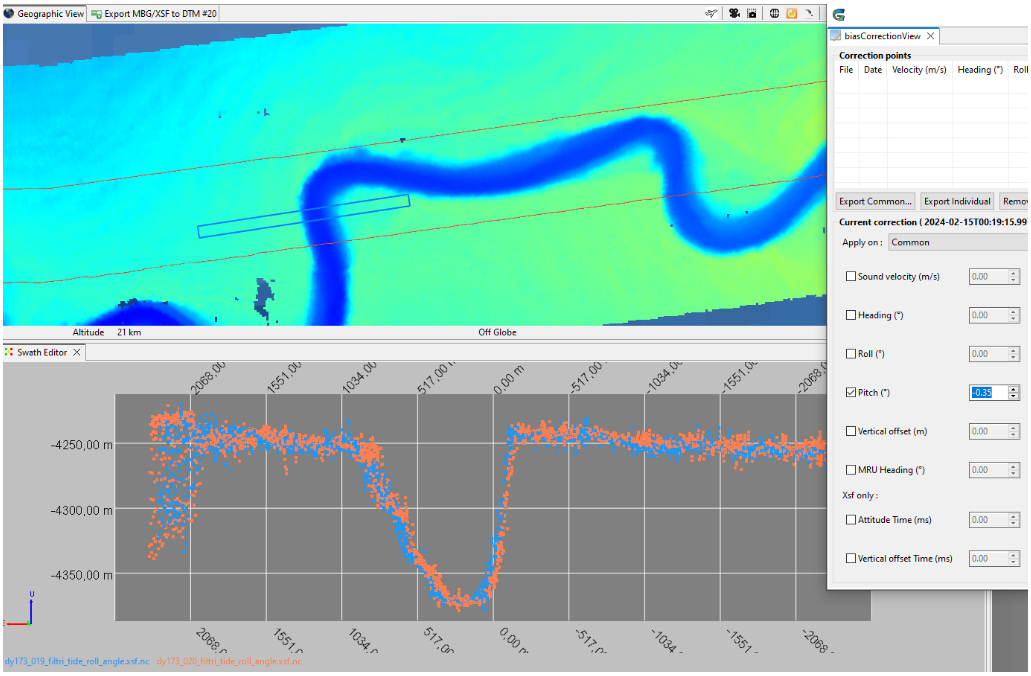
6.4.2. Pitch compensation

When looking at the data acquired along the intermediate channel, artifacts have been observed, especially in the meandering zones. Further analysis has shown an offset of data in the overlapping zone of two opposite lines along steep slopes. This offset is explained by an offset of the pitch compensation. **A pitch compensation correction of -0.35° is thus adopted and applied to all swath multibeam data of DY173 cruise.**

This pitch correction has been validated for the lines along the deep-sea channel, as well along the upper canyon in shallower Angola and RDC waters.



A)



biasCorrectionView

Correction points

File | Date | Velocity (m/s) | Heading (°) | Roll

Export Common... | Export Individual | Remo

Current correction (2024-02-15T00:19:15.99

Apply on : Common

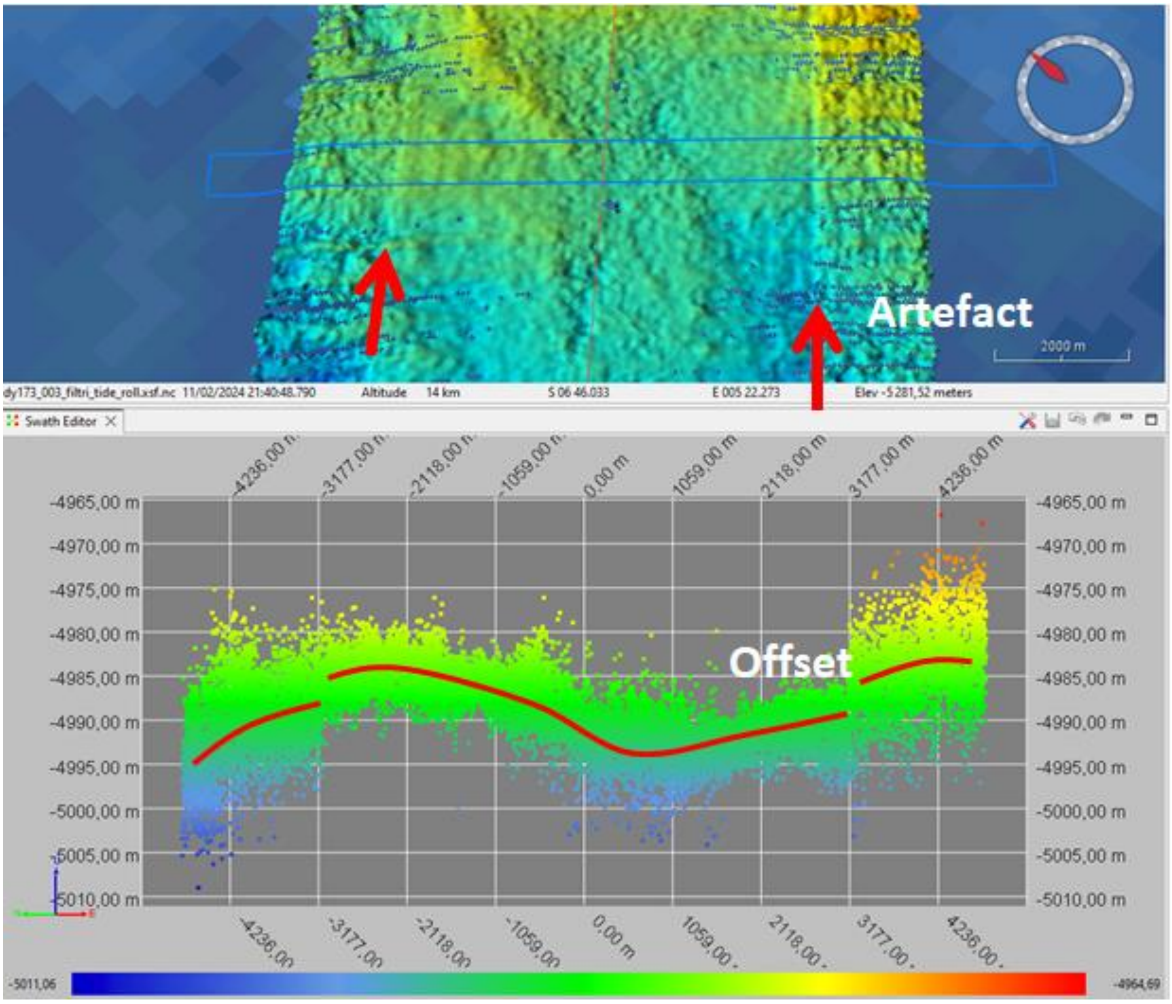
☐ Sound velocity (m/s) 0.00
☐ Heading (°) 0.00
☐ Roll (°) 0.00
☑ Pitch (°) -0.35
☐ Vertical offset (m) 0.00
☐ MRU Heading (°) 0.00
Xsf only :
☐ Attitude Time (ms) 0.00
☐ Vertical offset Time (ms) 0.00

B)

Figure 6.3 : Pitch compensation that is A) without correction, B) with correction of -0.35°, showing the two lines are more closely correlated.

6.4.3. Outer beams of the multibeam

A default has been observed mainly in the deep-sea data from the channel and lobe zones, on the outer beams of the swath. All the data from the 2 outer sectors of the antenna, to port and starboard, show a high noise level (which is not abnormal at this depth), but this is also an offset in relation to the other sectors. Attempts to set different parameters for the acquisition mode and yaw correction had not modified this artefact.



dy173_003_filtri_tide_roll.xsf.nc 11/02/2024 21:40:48.790 Altitude 14 km S 06 46.033 E 005 22.273 Elev -5 281,52 meters

Figure 6.4 : Illustration of strong noise and offset for data from outer sectors of the swath.

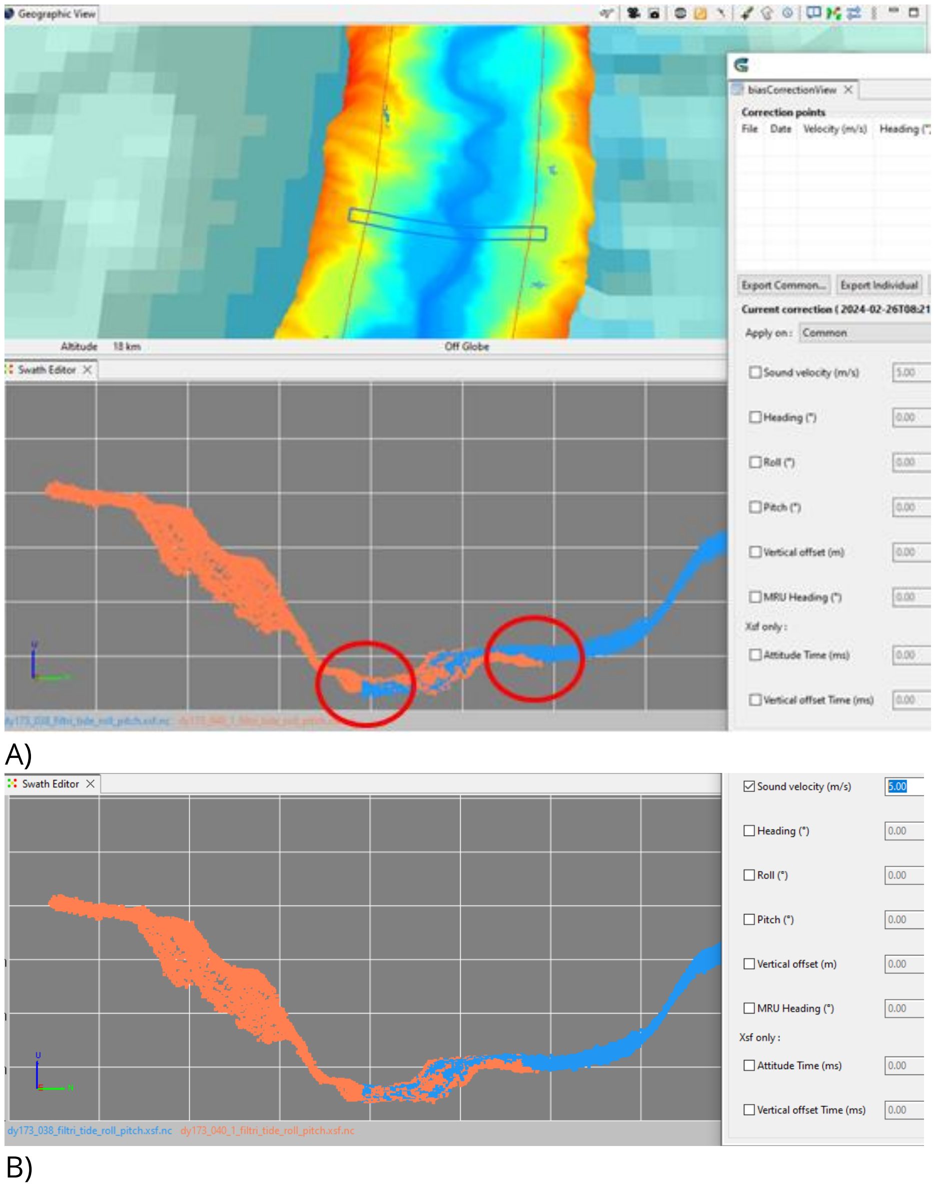
Thanks to the narrow spacing between acquisition lines in the lobe and channel zones (no more than 1.5 km), we were able to reject the data comprising the outer sectors of the swath, by filtering with a maximum incidence angle of 32°. This angle corresponds to the transition of sectors. Because of the wide overlap between lines, this issue has not impacted the quality of the processed bathymetry, and it has only reduced the area of coverage outside the channel.

The default has not been strongly observed in the Angola and DRC Canyon zones, which are shallower.

For the processing: this filtering at a maximum angle of 32° is applied for all data in the lobe, channel and Angola part of the canyon areas. It is not applied for the data in the DRC canyon.

6.4.3. Sound velocity correction of the data in the DRC canyon zone

The lines of the upper part of the canyon in DRC waters are acquired with an angular opening of 60°. This is closer to the river estuary zone, so there is a high risk of water mixing. Two CTDs (CTD4 and CTD6) were carried out at each of the ends of these lines in DRC waters. Data are acquired with the celerity calculated with the deepest CTD cast (CTD n°4). Post-processing quality control in the swath data editor shows an error in the overlapping part between profiles in DRC waters, which is corrected by applying a surface sound velocity bias.



Current correction (2024-02-26T08:21
Apply on : Common
☐ Sound velocity (m/s) 5.00
☐ Heading (°) 0.00
☐ Roll (°) 0.00
☐ Pitch (°) 0.00
☐ Vertical offset (m) 0.00
☐ MRU Heading (°) 0.00
Xsf only :
☐ Attitude Time (ms) 0.00
☐ Vertical offset Time (ms) 0.00

A)

☑ Sound velocity (m/s) 5.00
☐ Heading (°) 0.00
☐ Roll (°) 0.00
☐ Pitch (°) 0.00
☐ Vertical offset (m) 0.00
☐ MRU Heading (°) 0.00
Xsf only :
☐ Attitude Time (ms) 0.00
☐ Vertical offset Time (ms) 0.00

B)

Figure 5.6. Sound velocity correction for lines in the upper part of the canyon (DRC waters).

The correction is applied to lines 38, 39, 40, 43 et 44, with 5m/s used for the surface sound velocity.

6.4.4. Sound velocity correction of data in the Channel zone

Similar issues linked to sound velocity correction has been also observed in the Channel zone for the last lines of the cruise (lines 52 to 56). This is because of acquisition with a sound velocity profile provided by a CTD cast carried far away in the upper canyon

A surface sound velocity correction of 4 m/s is applied to these lines 52 to 56 in the channel. Data from line 52 (speed of 10 knts) are not further used for generating DTMs.

6.5. Bathymetry and DTM processing

Data processing is carried out during the cruise using Globe software version 2.4.3. (DOI 10.17882/70460).

Rawdata files (.all files) are converted into Globe format (.xsf files), with the tool “Convert/ Raw files to sounder files”.

6.5.1. Merging rawddata files

Rawdata files do not exceed 60 minutes. For the processing, they are merged into lines according to the list provided in §data organisation above.

- Execute with/ Cut-Merge tool: Generating one file per line, dy173_xxx file for the 56 lines

6.5.2. Automatic corrections

A systematic flow of automatic corrections is applied to all multibeam lines.
All corrections that were described above are applied at this step.

- Outliers filtering : Globe tool Execute with/ Filtering by triangulation
- Pitch and roll correction : Globe tool Execute with / Bias correction
- Outer beams filtering : Globe tool Execute with/ Detection filter. This correction is not applied to multibeam processed lines 38, 39, 40, 43 and 44.

6.5.3. Tide correction

- Predicted tide correction: Clobe toolExecute with/ Tide correction

6.5.4. Sound velocity correction

Sound velocity correction is applied to lines 38, 39, 40, 43 and 44 for the DRC canyon zone, and to lines 52 to 56 for the Channel zone.

- Sound velocity correction: Globe tool Execute with/ Bias correction :

6.5.5. Data editing and cleaning

Once the systematic corrections have been applied, all the data is imported into the Swath Editor module for visual validation and invalidation of all outlier probes, prior to calculation of a digital terrain model. In particular, lines overlaps and data quality are checked along the entire length of the channel and canyon.

- Data editing: Globe tool Swath Editor

6.5.6. Calculating DTMs

DTMs are calculated with homogeneous settings, for further analysis of bathymetry differential:

- Projection UTM zone 32 South.
- Pixel size: 30 meters for lobe and channel zones, 25 meters for Angola and DRC canyon sectors.
- DTMs bounding box coordinates are aligned along multiple of the grid size. Statistics layers: Standard deviation, Interpolation flag and Value count (number of soundings in each pixel) are also processed.
- Export to Geotiff files for GIS software.

- Gridding: Globe tool Export to/ Digital Terrain Model (.dtm/ .dtm.nc)
- Export to/ Geotiff (.tif)

6.5.7. Summary of data corrections

Corrections	
Tide	Predicted tide (LAT), max 2m
Sound velocity correction	5m/s for lines 38, 39, 40, 43 et 44 4m/s for lines 52 à 56
Pitch	-0.35°
Roll	0.08°

Table 2: Corrections applied to multibeam lines

6.5.8. Summary of calculated DTMs

Name	**Grid size**	**Projection**
240303_dy173_canyon_drc_UTM32_25m.elevation.tif	25m	UTM32S
240303_dy173_canyon_drc_UTM32_50m.elevation.tif	50m	UTM32S
240303_dy173_canyon_angola_UTM32_25m.elevation.tif	25m	UTM32S
240303_dy173_channel_UTM32_30m.elevation.tif	30m	UTM32S
240303_dy173_lobe_UTM32_30m.elevation.tif	30m	UTM32S

Table 3: Summary of processed DTM

6.6. Backscatter data processing

Backscatter data processing is also carried out with the Globe software (version 2.4.3).

Multibeam acquisition is performed in DEEP mode for the lobe, channel and Angola canyon zones, and in MEDIUM mode for the DRC Congo canyon zone.

Globe software provides a processing based on 3 main steps :
1: statistical analysis of the backscatter data for processing a response model according versus incidence angle and for each mode of acquisition. The acoustic response is also corrected of the morphology impact (using the slope of the processed bathymetry).
2: compensation of backscatter data based on the statistical analysis.
3: gridding the backscatter data

The tools are the following:

1: Execute / Backscatter / Backscatter statistical response model
2: Execute / Backscatter / Backscatter angular renormalization
3: Export XSF to DTM : calcul de la couche backscatter corrigée

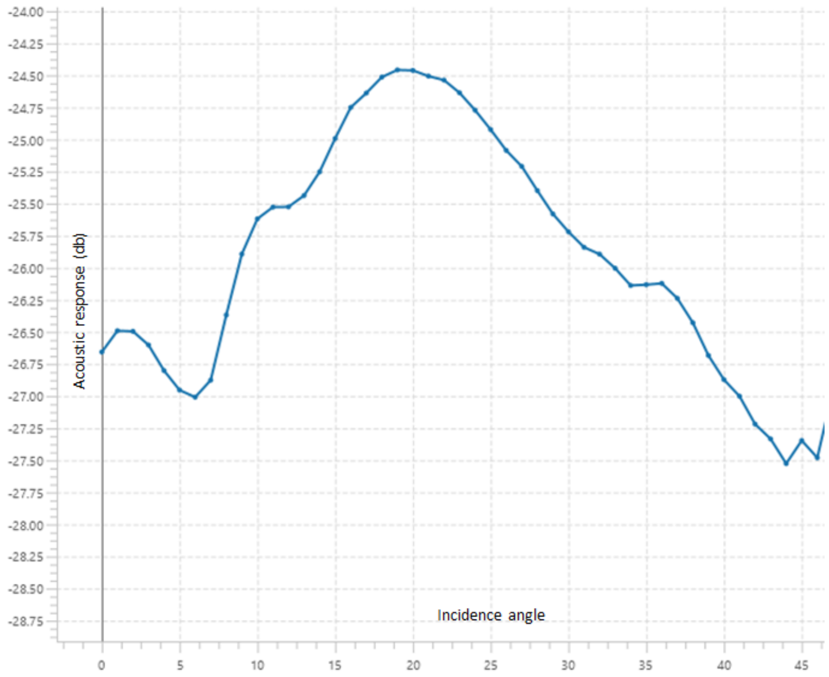


Figure 6.7. Example of statistical analysis of backscatter data (lobe zone)

6.6.1. Summary of the backscatter grid

The grids are processed with the same properties than the bathymetry grids (DTM).

Name	Pixel size	Projection
240303_dy173_canyon_drc_UTM32_25m_bcksc.tif	25m	UTM32S

240303_dy173_canyon_angola_UTM32_25m_bcksc.tif	25m	UTM32S
240303_dy173_channel_UTM32_30m_bcksc.tif	30m	UTM32S
240303_dy173_lobe_UTM32_30m_bcksc.tif	30m	UTM32S
240303_dy173_lobe_UTM32_60m_bcksc.tif	60m	UTM32S

Table 4 : Backscatter grids

6.7. Water column data

Water column data (WCD) have been logged during the survey, excepted several transits. They are recorded as ".wcd" files by the mulitbeam system, one ".wcd" file for each bathymetry ".all" file.

They can be visualised in the Globe software: files are converted into ".xsf" file format and then they can be loaded in Globe. Display tools are available for scrolling through images.

During the cruise, WCD data have not been systematically converted. A selection of lines is made, as close as possible to the axis of the Congo channel and canyon.

For the lobe and the channel zone, lines dy173_002 and dy173_020 to 022 have been selected. No remarkable observation has been made here.

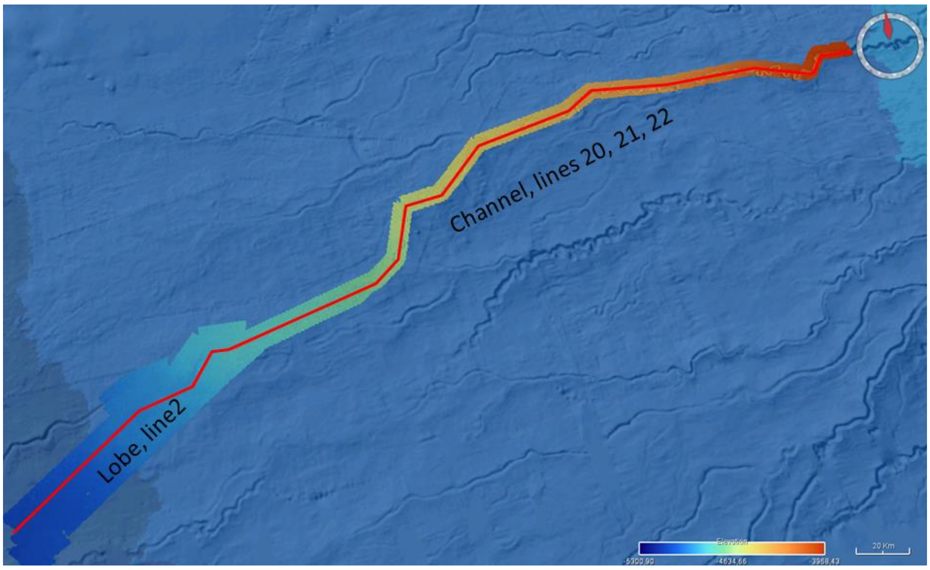


Figure 6.8. Location of line 2 on the lobe, and lines 020-022 in the deep-sea channel.

For the canyon within Angola waters, lines dy173_036, _037, _041, _042, _046 and _047 have been selected and converted, and lines _038, _040 and _043 for the DRC Canyon.

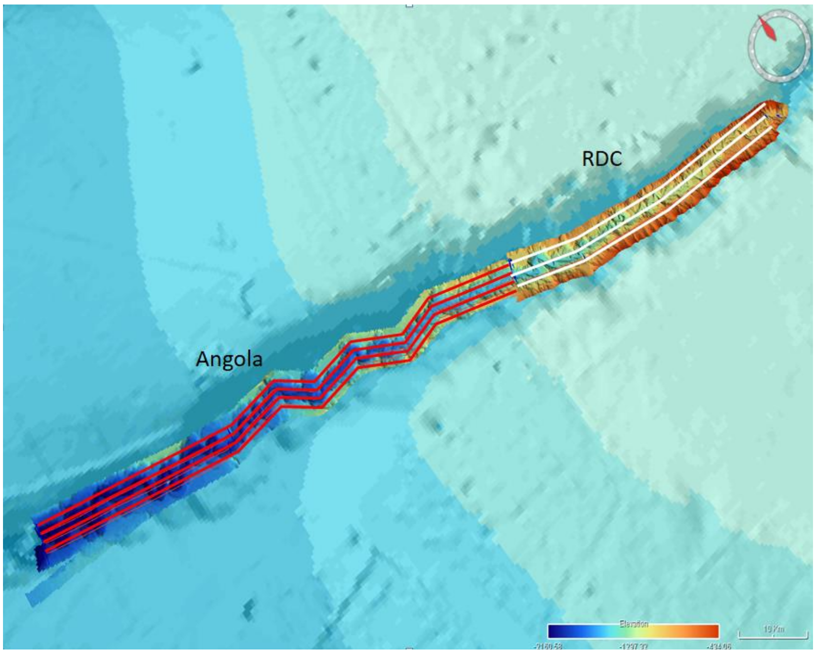


Figure 6.9. Selected lines for visualisation of WCD data in the Angola and DRC canyon zones

For the Angola Canyon zone, a fairly homogeneous echogram is observed along the lines. It shows a stronger acoustic response in the lower part of the water column. This may be indicative of a more turbid slice of water, but the response could be also due to the confined morphology, with echoes from the canyon flanks.

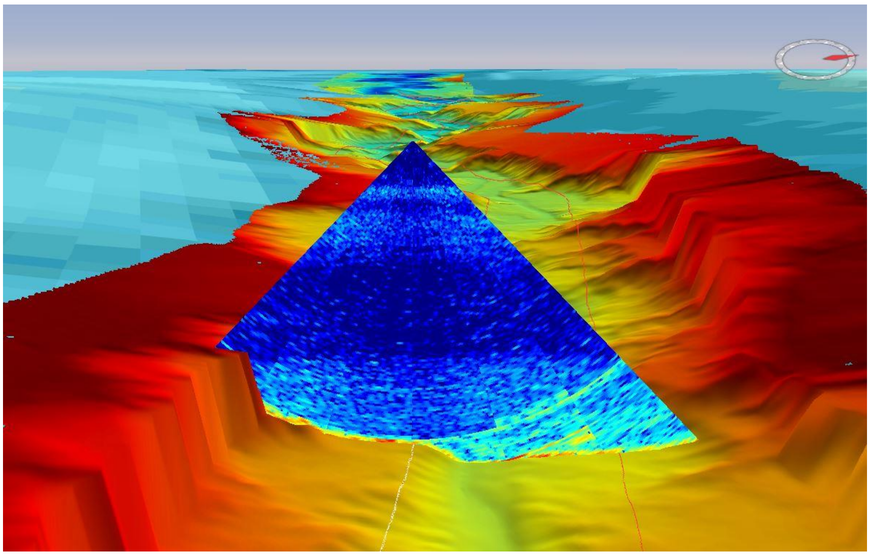


Figure 6.10. Water column data echogram along line 36, in Angola canyon zone.

For the DRC canyon zone, we had the chance to observe a fluid escape.

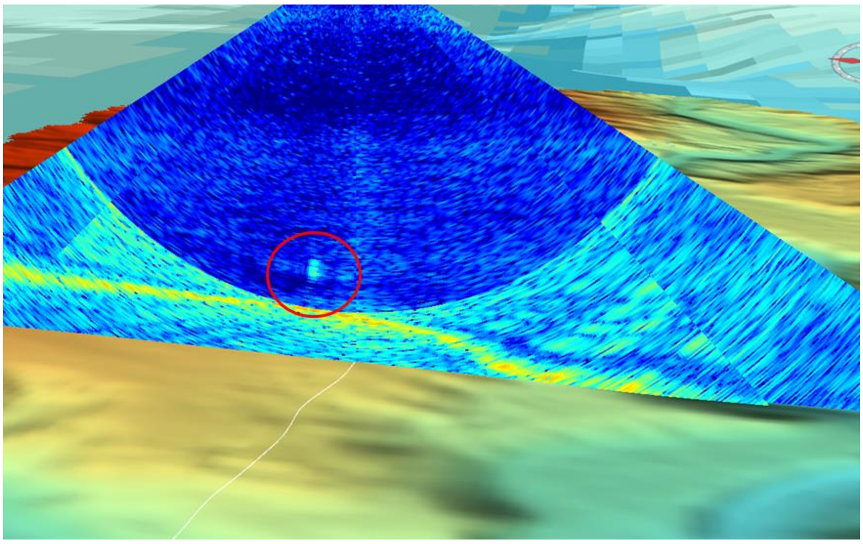


Figure 6 : Water column data of line 43, DRC Canyon. Fluid escape at the seafloor.

This is a very preliminary analysis of the water column data. Further analysis could be planned later, and possibly linking with the CTD data.

6.7. Illustrations of multibeam processed data, bathymetry and backscatter

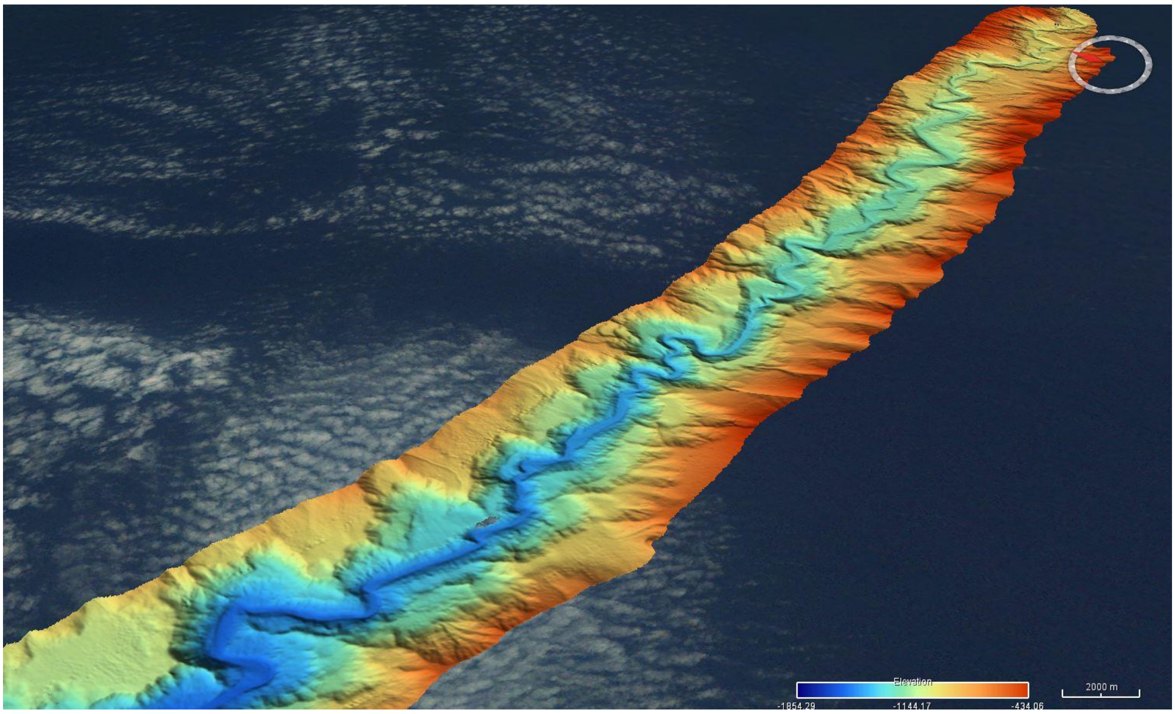


Figure 6.12. Bathymetry of the upper part of the canyon within DRC waters.

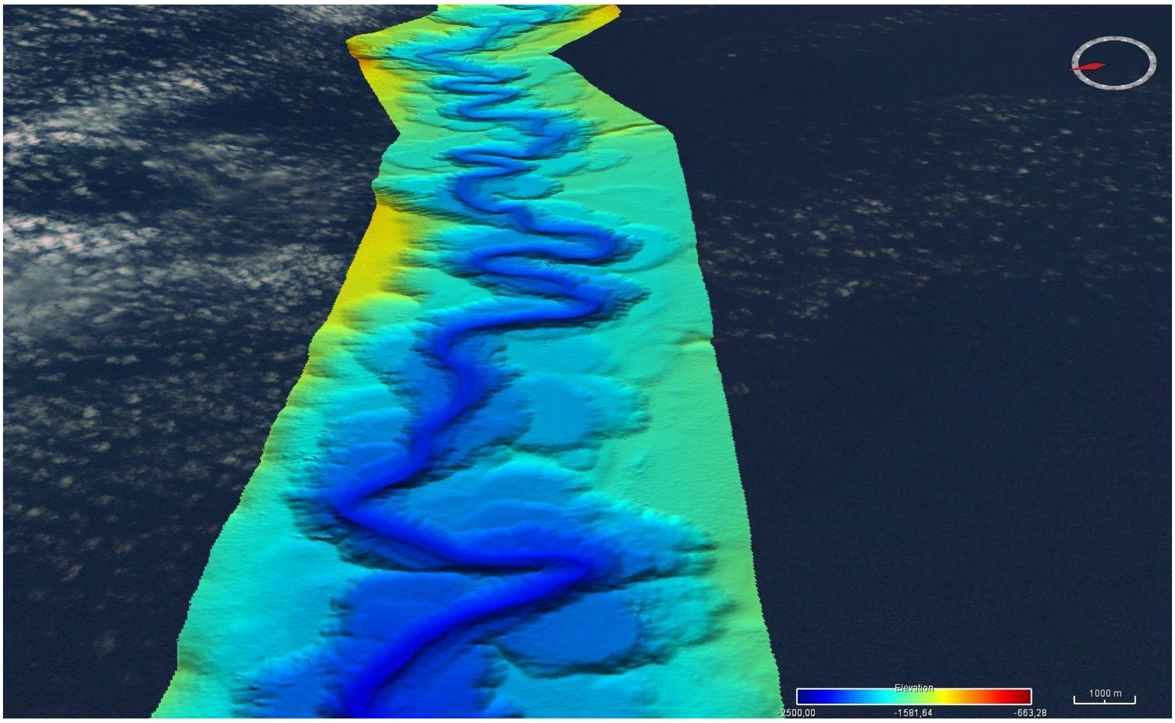


Figure 6.13. Bathymetry of the canyon in Angolan waters.

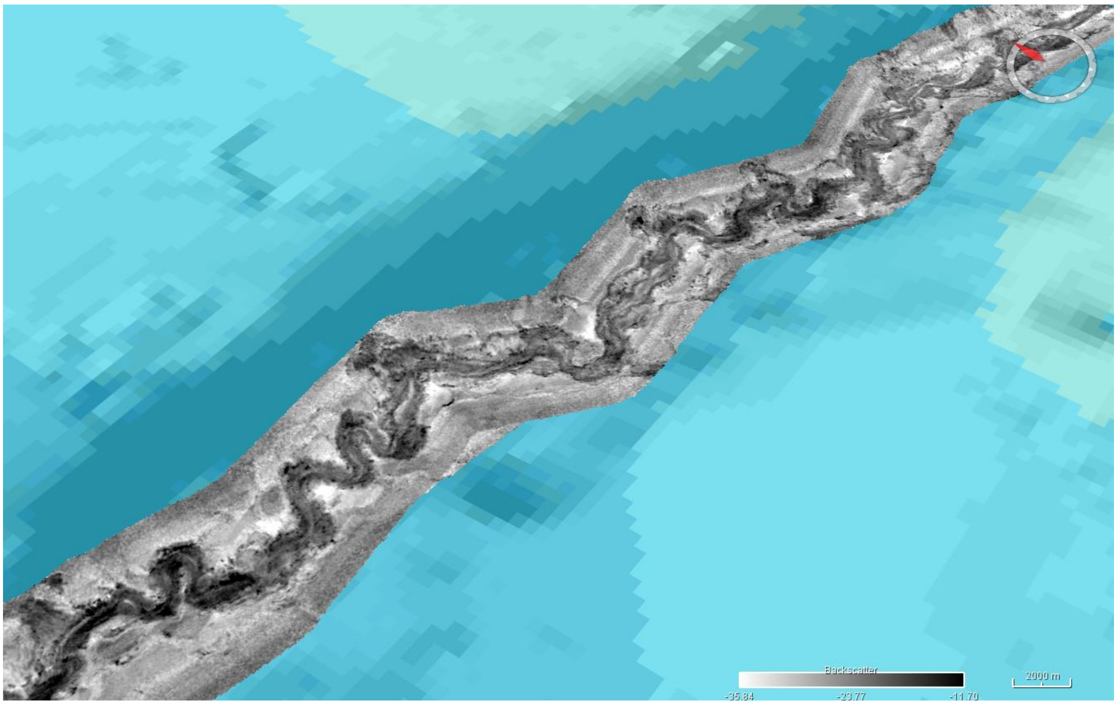


Figure 6.14. Backscatter of the canyon in Angolan waters.

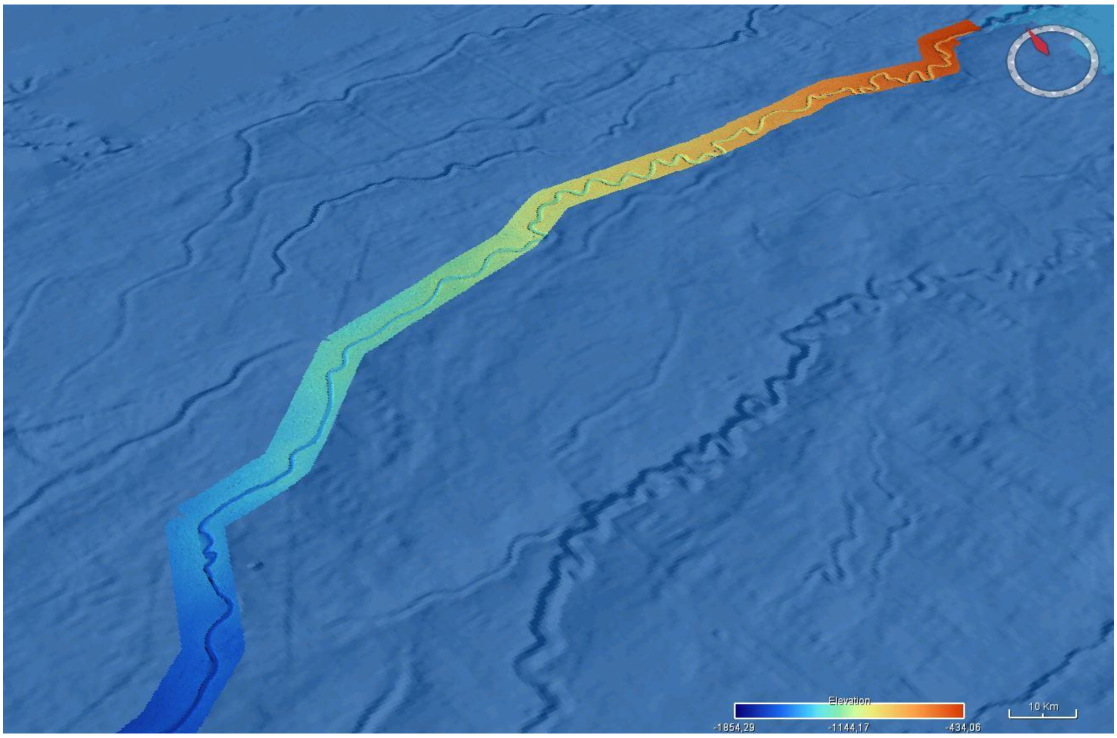


Figure 6.15. Bathymetry of the channel (international waters)

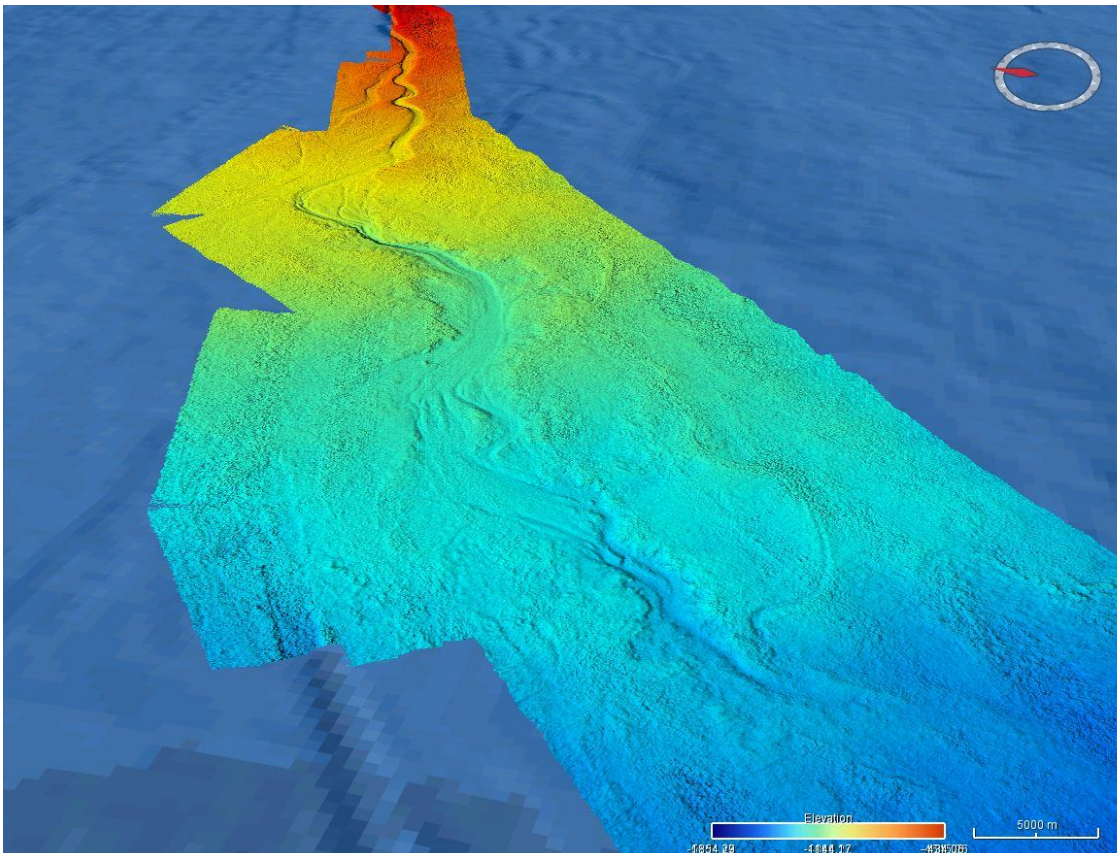


Figure 6.16. Bathymetry of the lobe zone

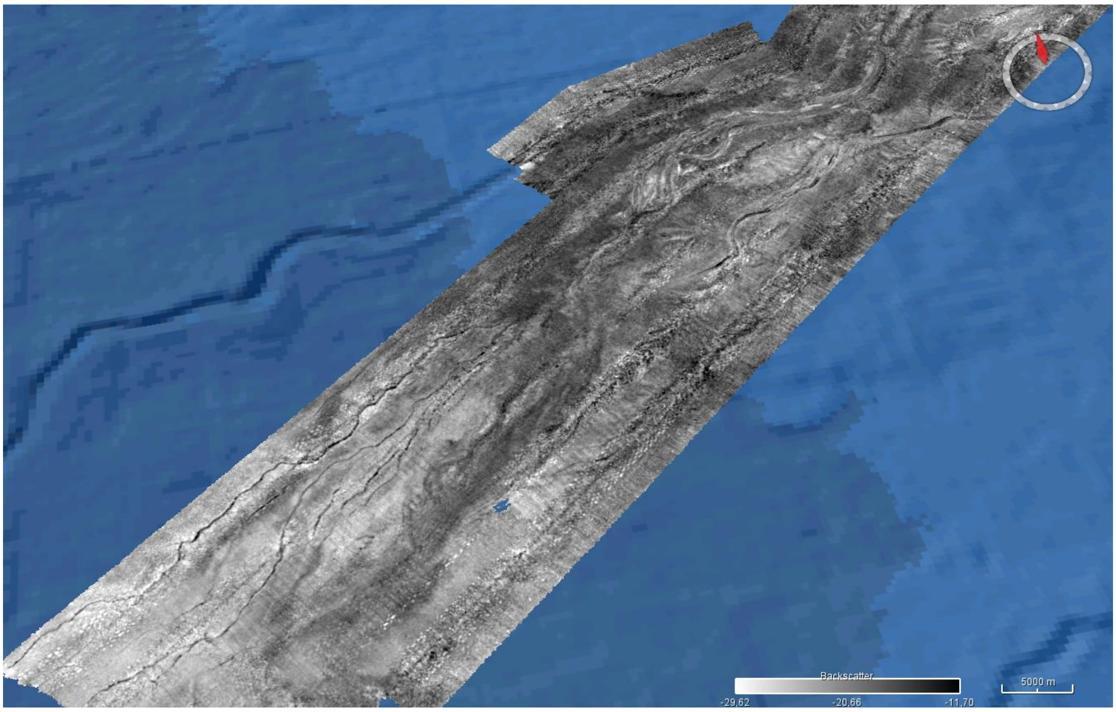


Figure 6.17 Backscatter of the lobe zone

6.8. Approaches to assess data quality

The processed grids are used for calculating differences between successive surveys DY173 (2024), JC209 (2020, JC187 (2019 and OpticCongo2 (2005). On board, we have mainly analysed the difference between DY173 (2024) and JC209 (2020) surveys for the lobe, channel and Angola Canyon zones, and the difference between DY173 (2024) and OpticCongo2 (2005) surveys for the upper part of the canyon in DRC waters. OpticCongo is a cruise of 2005, B/O Beautemps-Beaupré (French Hydrographic Office).

The processing work flow was standardized, in the view of reducing the sources of error or offset between datasets that can be occurred. However, difference grids have to be analysed carefully because of the data accuracy and resolution, and also data processing.

We propose an approach based on the statistical layers of the grids, in order to provide a “warning” layer. Thresholds are estimated using standard deviation layer of the bathymetry grids and the difference grid, and pixel are flagged when these ‘warning thresholds’ are exceeded.

6.8.1. Gridding uncertainty along slope

The depth at each pixel is calculated as the mean of the soundings within the cell, and this mean value is located at the centre of the pixel. This way of calculation may generate some offset along steep slope when the data are not evenly distributed in the cell.

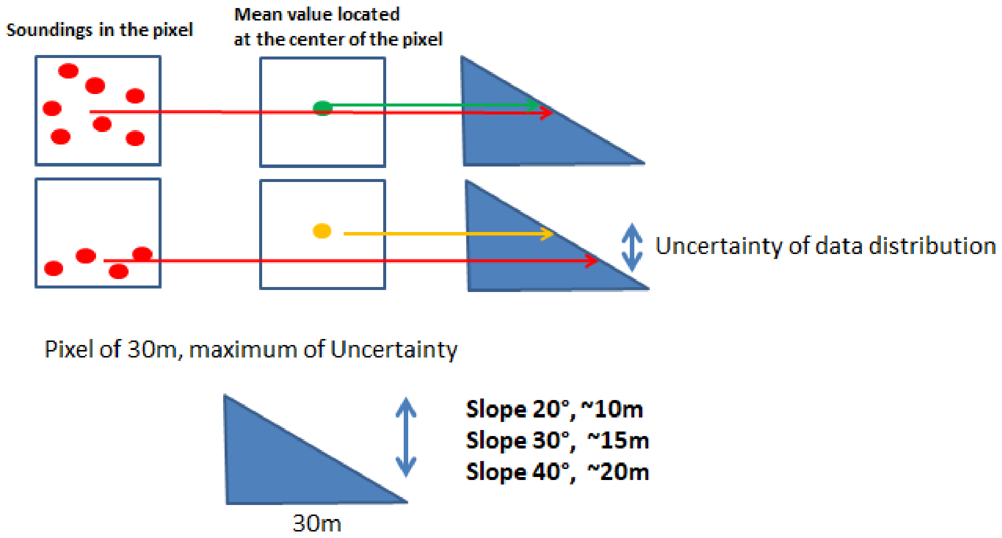


Figure 6.18. Risk of gridding uncertainty along steep slope.

This issue of unevenly distributed soundings per cell does not occur systematically, **but we warn on possible offsets that can impact difference maps along steep slopes.**

We propose an approach for identifying this possible uncertainty. To do this, we use the "number of soundings" layer, which is processed for each DTM. The indicator is based on a minimum number of soundings per pixel, as a criteria for a regular distribution in the cell. This approach is illustrated below using the difference map. Steep slopes are also highlighted; they are flagged when the number of soundings in the cell is low.

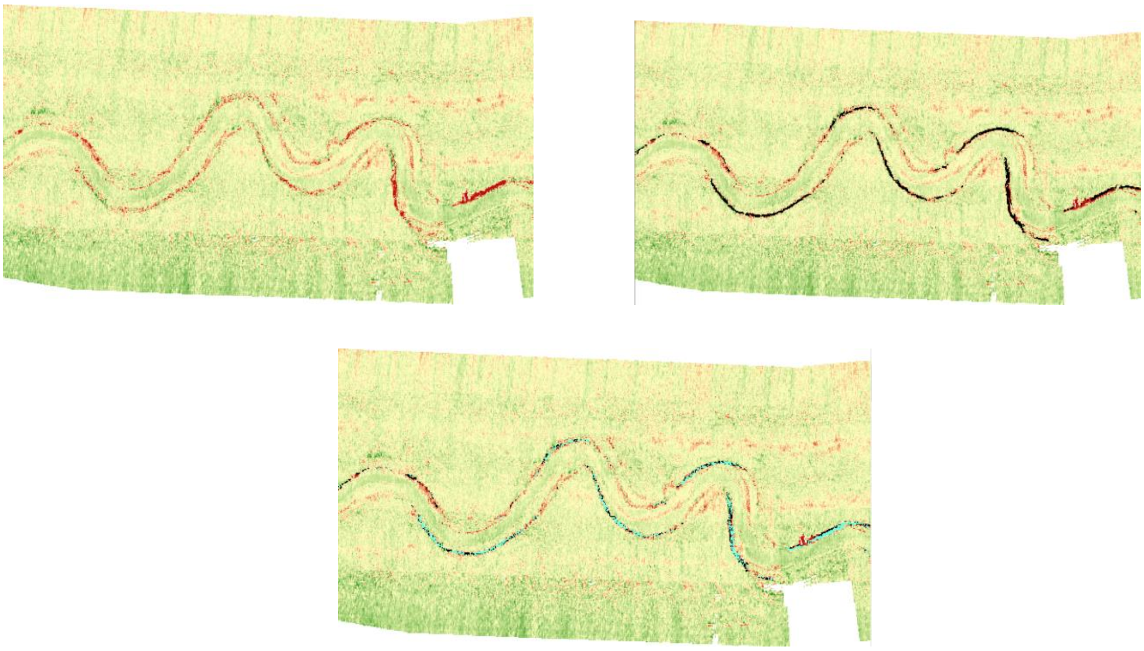


Figure 6.19. Warning flags applied to gridded pixels. Blue pixels highlight steep slope (>30°) and low data density.

6.8.2. Standard deviation layer of the grids

For a difference map, we also work with the statistics of the standard deviation layer of the 3 grids involved in a difference map: 2 bathymetry grids and their difference grid.

We illustrate the approach with the grids of the Angola canyon zone.

Grids	**Mean STD**	**95% confidence interval**	**Mean +/- sigma**
Dy173_angola DTM	3.7m	8.6m	5.7m
JC209_angola DTM	3.5	8.5	5.5
Dif DY173-JC209	0.3m		+/-5m (range within the difference are normal)

The confidence intervals "95% confidence interval" and "mean +/- sigma" are standard confidence interval for Gaussian distribution. Until the data are not Gaussian, we use them as guidance.

The quality indicator for the difference map is built by flagging the pixel, when the pixel is outside the 95% confidence interval for one of the two bathymetry grids.

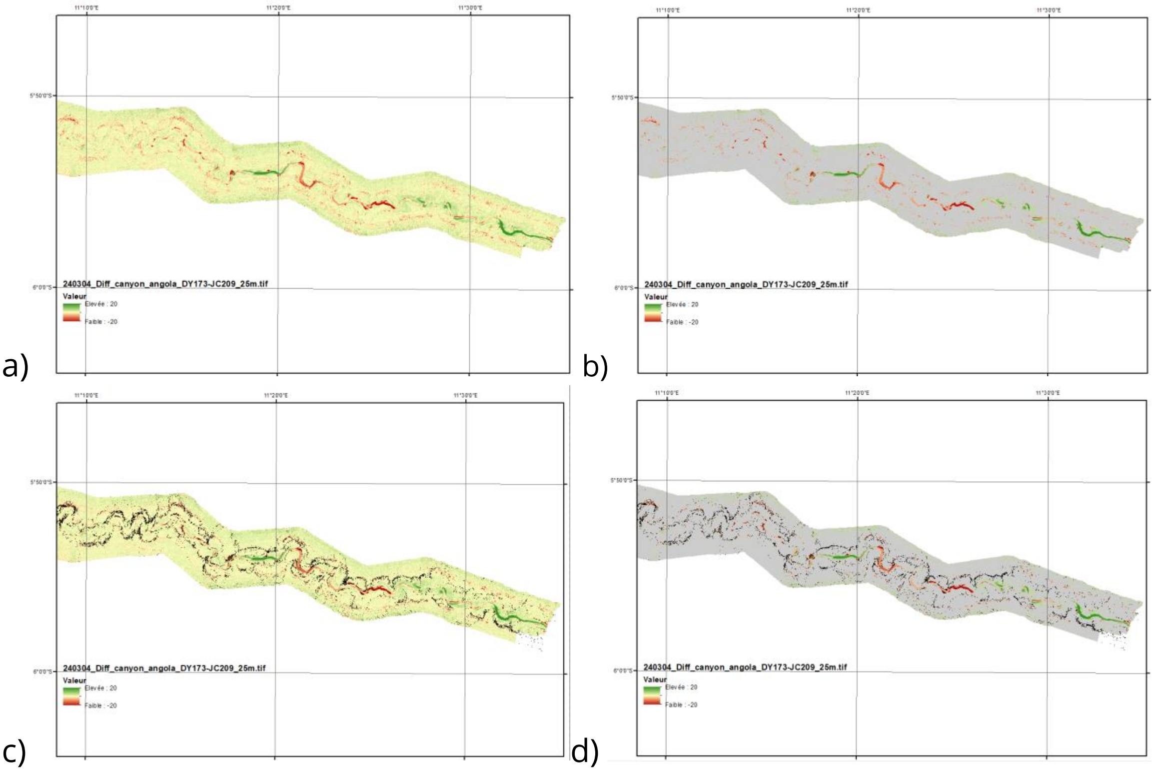


Figure 6.20. a) Difference map. b) Warning flag parameter from the standard deviation of the difference map grid. Red (erosion) and green (deposition) colours denote pixels with difference values that are trusted. When difference values in a pixel are outside 2 standard deviations of the mean difference for that difference grid, those difference values are

discarded (i.e. grey in this figure). c) Warning flag generated if the bathymetry value is outside the 2 standard deviations of the bathymetry grid, for one or both of the bathymetry grids. d) Warning flag indicator based on the superposition of both flags, such that the pixel is flagged either as (i) outside the 2 standard deviations of the difference grid, or (ii) outside the 2 standard deviations for one of the two bathymetry grids.

This approach will be further explored and then generalized in order to provide a "quality indicator" layer for the difference grids and warning for the interpretation.

6.9. Processing of JC187 (2019) and JC209 (2020) cruise data

The JC187 and 209 data had previously been processed by the onboard teams, and DTMs were available during DY173 for morphological analysis. However, in order to ensure the homogeneity of DTM calculations prior to bathymetric differential analyses, it was chosen to re-process these datasets for certain zones. This re-processing follows a similar procedure to the processing of DY173 data. The homogeneity of processing is designed to minimize any possible bias that might affect the differences in DTMs calculated between these cruises.

6.9.1. JC187: re-processing for the lobe zone

The JC187 data is re-processed for the lobe zone.
The processing flow follows identical steps as the DY173 data flow:
-automatic filtering of outliers
-tide correction: predicted tide is calculated at the reference point based on the FES2014 global model.
-filtering of outer beams (maximum angle 32°).
-calculating DTM with same properties as the DY173 DTMs (projection, pixel size and bounding box).

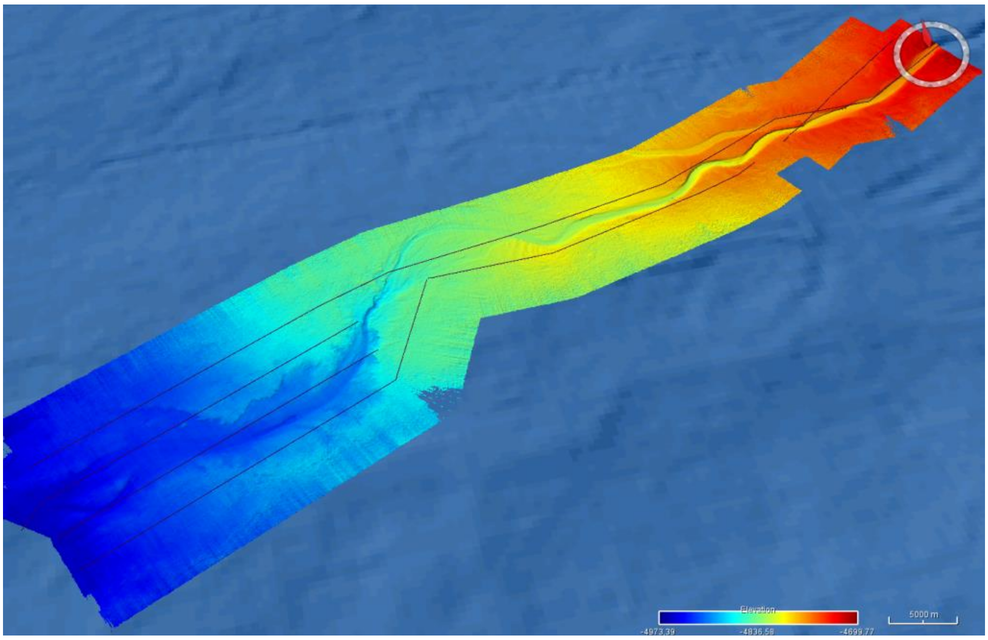


Figure 6.21. Selected lines of the JC187 survey and illustration of the re-processed DTM.

The list of the re-processed lines is:

> 30/09/2019 19:38:02.250 01/10/2019 02:51:11.541 jc187_001
> 01/10/2019 08:39:24.864 01/10/2019 10:57:01.082 jc187_002
> 01/10/2019 11:12:23.490 01/10/2019 13:17:36.112 jc187_003
> 01/10/2019 13:34:59.130 01/10/2019 18:56:58.668 jc187_004
> 01/10/2019 19:28:16.617 01/10/2019 20:27:59.843 jc187_005

6.9.2. JC209: re-processing for the 3 zones, lobe, channel and Angola canyon

The processing flow follows identical steps as the DY173 data flow:
-automatic filtering of outliers
-tide correction: predicted tide is calculated at the reference point based on the FES2014 global model.
- roll compensation correction : a correction of 0.08° is applied. It is evaluated by comparing JC209 and DY173 data on superimposed profiles.
-filtering of outer beams (maximum angle 32°).
-calculating DTM with same properties as the DY173 DTMs (projection, pixel size and bounding box).

Listing of re-processed lines:
For the lobe zone

> 30/09/2020 00:04:05.231 30/09/2020 02:19:15.195 jc189_001
> 30/09/2020 02:28:26.605 30/09/2020 03:38:44.345 jc189_002
> 30/09/2020 08:17:00.706 30/09/2020 12:58:45.258 jc189_003
> 30/09/2020 14:09:23.942 30/09/2020 15:44:57.627 jc189_004
> 30/09/2020 16:16:53.226 30/09/2020 21:19:55.703 jc189_005
> 30/09/2020 21:51:16.345 01/10/2020 06:32:25.664 jc189_006
> 01/10/2020 07:03:22.091 01/10/2020 18:30:01.059 jc189_007
> 01/10/2020 19:22:53.462 02/10/2020 02:18:24.055 jc189_008
> 02/10/2020 02:48:31.743 02/10/2020 09:42:40.864 jc189_009

For the channel zone in the international waters

> 25/09/2020 12:42:14.800 26/09/2020 04:07:35.782 jc209-ch_001
> 27/09/2020 05:59:46.201 27/09/2020 20:50:35.086 jc209-ch_002
> 27/09/2020 21:09:56.937 28/09/2020 23:22:38.447 jc209-ch_003
> 28/09/2020 23:52:47.643 30/09/2020 00:02:29.414 jc209-ch_004

For the canyon within the Angola waters

> 23/09/2020 13:12:46.108 23/09/2020 21:04:14.911 jc209_canyon_003
> 23/09/2020 21:13:49.295 24/09/2020 04:58:31.588 jc209_canyon_004
> 24/09/2020 05:11:42.041 24/09/2020 12:54:31.395 jc209_canyon_005
> 24/09/2020 13:16:41.257 24/09/2020 21:10:40.439 jc209_canyon_006

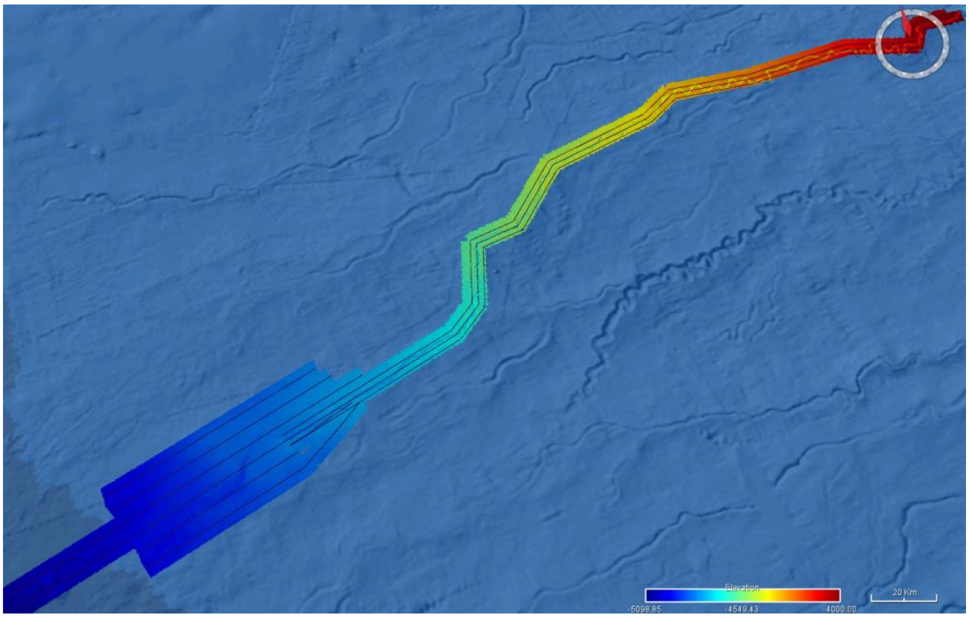


Figure 6.22. Selected lines of the JC209 survey for the lobe and channel zones and illustration of the re-processed DTM.

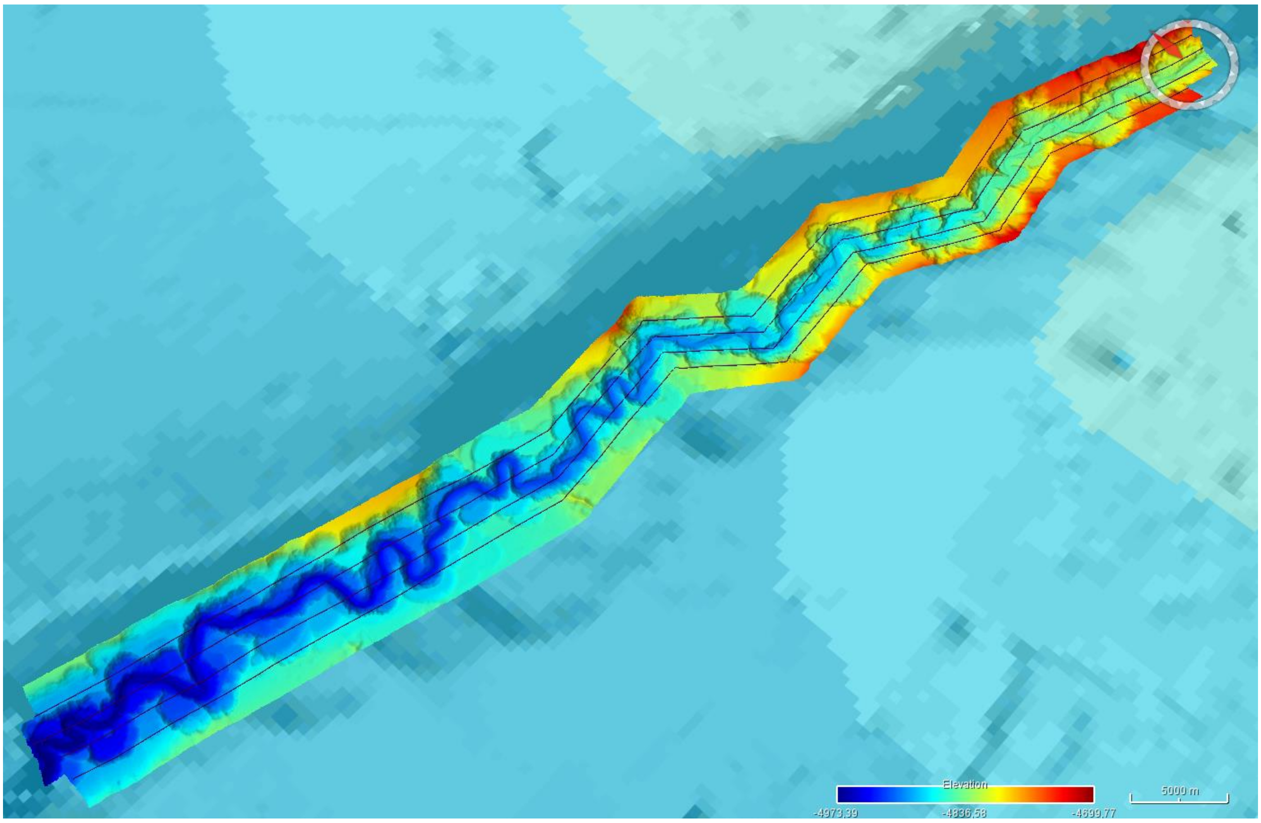


Figure 6.23. Selected lines of the JC209 survey for the canyon within the Angola waters and illustration of the re-processed DTM.

Name	Pixel size	Projection
240303_dy209_canyon_angola_UTM32_25m_elevation.tif	25m	UTM32S
240303_dy209_channel_UTM32_30m.elevation_tif	30m	UTM32S
240303_dy209_lobe_UTM32_30m_elevation.tif	30m	UTM32S
240303_dy187_lobe_UTM32_30m_elevation.tif	30m	UTM32S
240303_dy187_lobe_UTM32_30m_bcksc.tif	30m	UTM32S

Table 6.1. Processed DTM of the JC187 and JC209 multibeam data

Backscatter data have been also reprocessed for the lobe zone of the JC187 cruise, following the same flow as the DY173 data.

6.10. List of Multibeam Echo-sounder (MBES) Lines

These are the swath multi-beam lines collected throughout the cruise

Site number	Multi-beam number	Date (yyyymmdd)	Time (UTC)	Water depth (m)	Length (km)	Merged lines for processing (Globe)	latitude	longitude
2.2	Start of MB1	202402209	21:44	4754		Dy173_001 Dy173_002	6 25.9588	6 5.7823
4.3	End of MB1	20240211	06:18	4947			6 27.0573	6 5.3855
4.3	Start of transect to MB2	20240211	06:18	4725			6 27.0573	6 5.3855
4.4	End of Transect to MB2	20240211	06:38	4746			6 26.5055	6 7.0895
7.1	Start of MB2	20240211	12:51	4990		Dy173_003 _004, _005	6 28.117	6 5.630
14.2	End of MB2	20240212	01:48	4921			6 48.349	5 29.631
21.1	Start of MB3	20240212	21:32	4799		Dy173_006 to _009	6 27.813	5 52.644
22.1	End of MB3	20240213	07:27	4881			6 36.807	5 41.456
27.1	Start of MB4	20240213	17:59	5072		Dy173_010	6 59.693	5 11.248

						to _016		
27.6	End of MB4	20240214	01:41	5074			7 02.516	5 14.842
28.1	Start of MB5	20240214	05:43	4757		Dy173_017 to _022	6 26.2700	6 4.4562
54.1	End of MB5	20240216	15:06	4747			6 27.011	6 05.463
59.1	Start of MB6	20240217	17:10	5030		Dy173_023 to _028	6 59.150	5 9.130
66.1	End of MB6	20240218	00:39	5101			7 4.4967	5 5.4313
Extra MB ines						Dy173_029 to _033		
85.1	Start of MB7	20240222	13:10	4741		Dy173_034	6 28.228	6 05.291
86.1	End of MB7	20240222	15:23	4703		Dy173_035 to Luanda	6 24.555	6 16.369
89.1	Start of MB8	20240225	17:31	1634		Dy173_036, to _042	5 55.606	11 27.870
125.1	End of MB8	20240227	07:13	1261			5 58.3014	11 34.1183
126.1	Start of MB9	20240227	07:26	1582		Dy173_043 , _044	5 57.55	11 34.350
136.1	End of MB9	20240227	18:08	913.8			-5 58.89912	11 33.85908
138.1	Start of MB10	20240227	23:50	2026.4		Dy173_045 to _048	-5 52.83324	11 9.73278
141.1	End of MB10	20240228	05:17	1842.1			-5 52.21140	11 10.08066
Extra MB lines		20240229				Dy173_049 to _051		
153.2	Start of MB transect	20240301	17:15	4150		Dy173_052, _053	5 44.089	08 08.216
155.1	End of MB transect	20240301	19:28	4061			5 48.590	07 54.600
157.1	Start of MB 11	20240302	00:14	4112		Dy173_054	05 47.32116	007 49.25004

159.1	End of MB11	20240302	05:26	4208			05 44.8782	007 37.9021
160.1	Start of MB12	20240302	06:44	4240		Dy173_055, _056	05 48.079	007 31.371
164.1	End of MB12	20240302	17:38	4337			05 47.700	007 10.987 E

Table 6.2. List of positions and times for each individual multibeam survey line.

6.10.1 Location of merged multibeam lines for lobe, channel, Angola and DRC waters

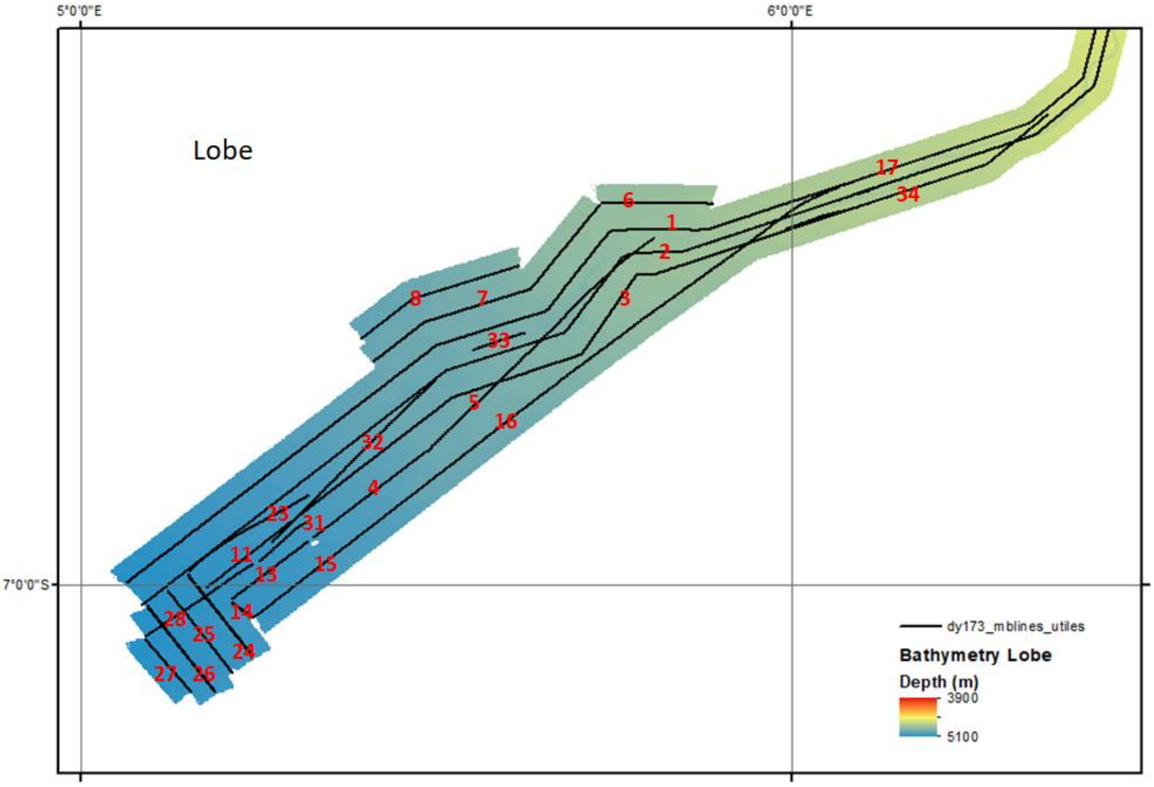


Figure 6.24. Map showing the locations of different multibeam line numbers in the lobe area.

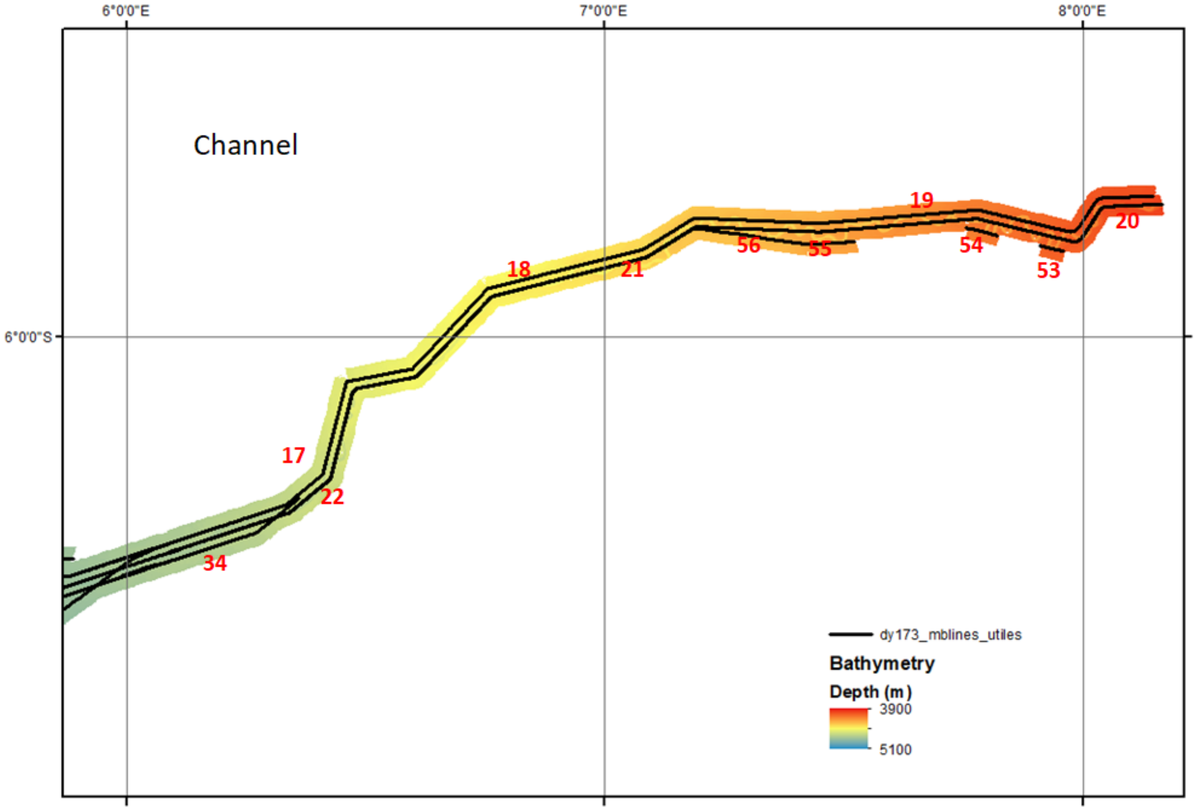


Figure 6.25. Map showing the locations of different multibeam line numbers in the channel area.

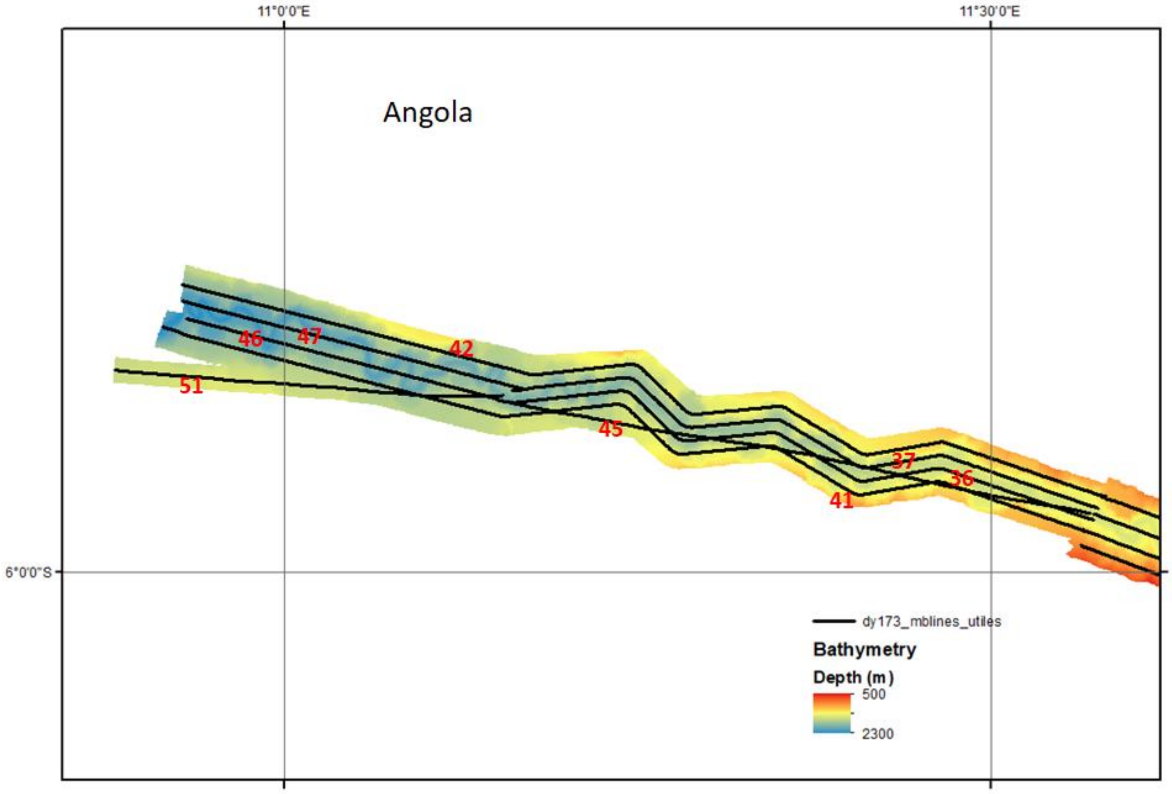


Figure 6.26. Map showing the locations of different multibeam line numbers in Angolan waters in the upper canyon.

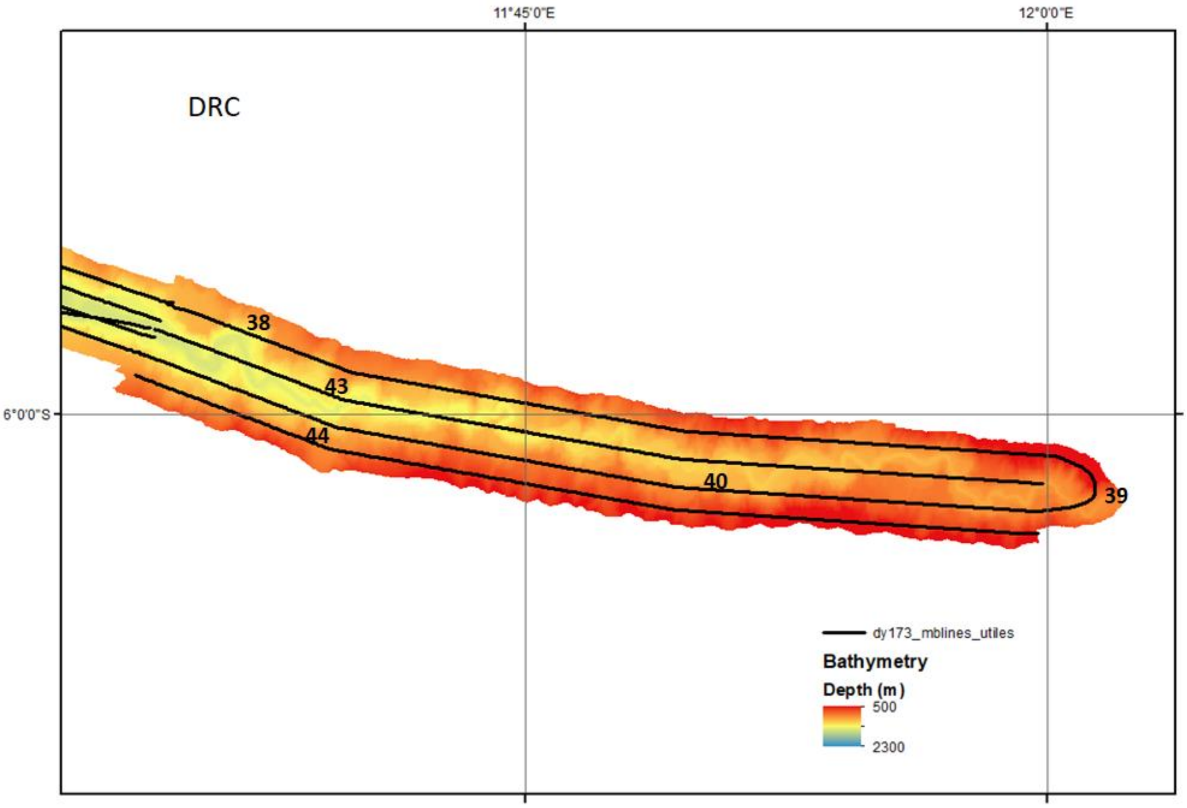


Figure 6.27. Map showing the locations of different multibeam line numbers in DRC waters in the upper canyon.

6.11. Initial Results of Swath Multibeam Surveys

A set of DTMs are available as a result of the data processing previously outlined. These DTMs can then be used for difference grids analysis and interpretation of seabed morphological evolution.

For each work area, both previous DTMs and DTMs collected by DY173 were processed with the same overall work flow. Grids of seabed elevation change (difference maps) can then be are calculated and analysed using in GIS software, without the need for re-projection or interpolation. The only exception was the upper canyon survey in DRC waters. For this DRC canyon zone, the only preceding DTM was collected in 20225 by the the Optic Congo2 cruise (B/O Beautemps-Beaupré, 2005). Raw data are not available on board for re-processing for that Optic Congo2 cruise.

The table below presents the difference maps which have been calculated during the cruise for preliminary analysis for 2020 to 2024, but it is also possible to calculate difference maps for other time intervals (e.g. JC187 in 2019).

	DY173 (2024)	JC209 (2020)	Optic Congo2 (2005)	Diff map
Lobe	DTM 30m	DTM 30m		2020 to 2024
Channel	DTM 30m	DTM 30m		2020 to 2024

Angola sector (canyon)	DTM 25m	DTM 25m		2020 to 2024
DRC sector (canyon)	DTM 25m and 50m		DTM 50m	2005 to 2024

Table 6.3. List of difference map

Difference map for the lobe can be also processed between DY173 and JC187 (2019). However, we focus in this report on the more recent evolution.

6.11.1. Lobe

For the lobe zone, there are few significant difference between seabed elevations surveys by DY173 in 2024 and JC209 in 2020. The most significant changes in 2020-2024 on the lobe area are erosion at outer bends in the better developed reach of the channel near mooring M1. However, a substantial change occurred on the lobe between 2019 and 2020, when a new 20m knickpoint was eroded near the termination of the channel. This recently created knickpoint at the end of the channel syste, was also visible in the 2024 survey, although it was not fully present in the 2005 survey. A second knickpoint occurs further up-slope, which was re-eroded to a degree in 2020-2024. These knickpoints appear to connect via a developing channel, and may show how submarine channels grow. The ragged and flared shape of these knickpoints differs from that seen in other areas, and suggests these knickpoints on the lobe may be created by shallow seabed failures (landslides), which is consistent with the previous cores and AUV surveys in the study of the lobe by Dennielou et al. (2018).

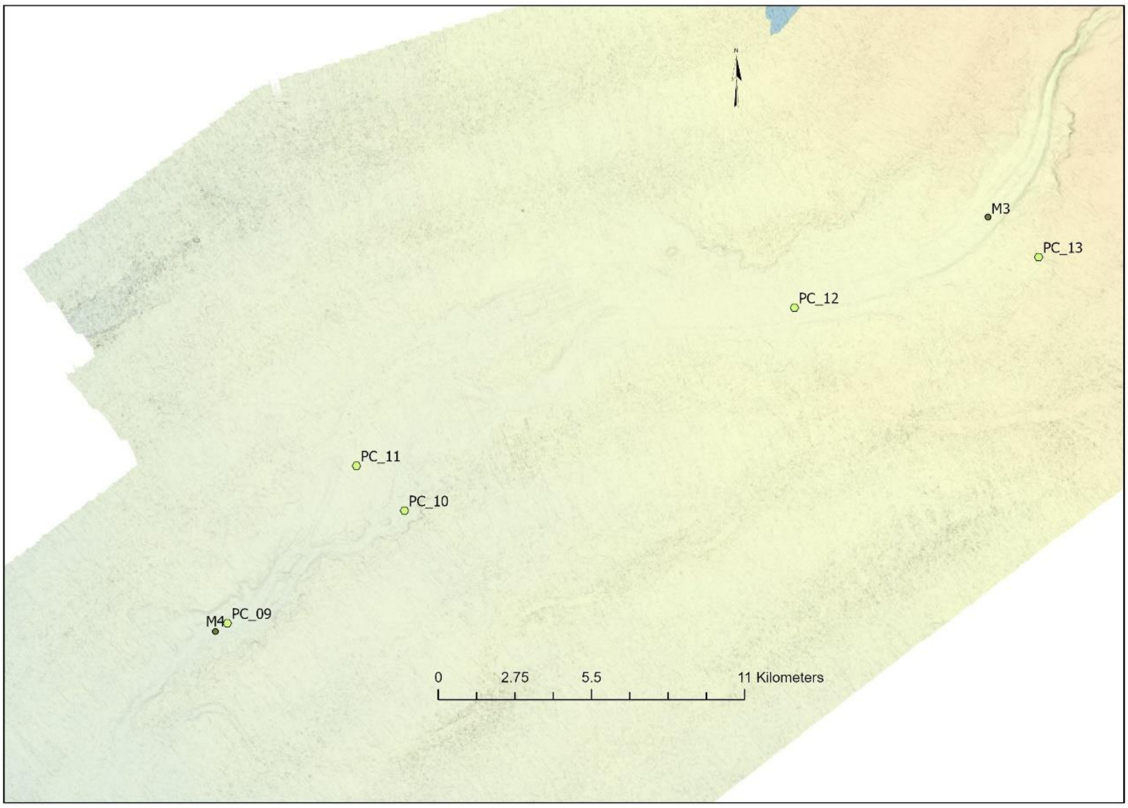


Figure 6.28. A shallow channel connects knickpoints on the lobe. The lower knickpoint (near cores PC9-11 and Mooring M4 was partly created between 2019 and 2020, but not eroded significantly further between 2020 and 2024. The upper knickpoint (near Mooring M3) was eroded in 2020-24.

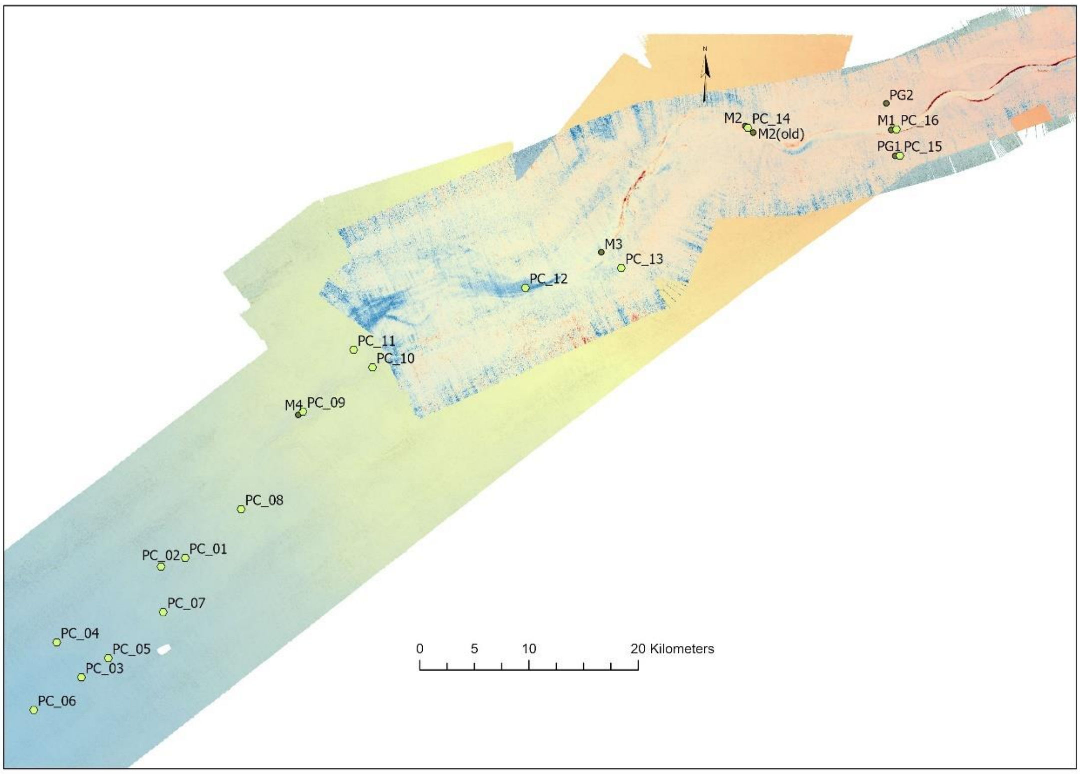


Figure 6.29. Changes in seabed elevation between 2020 and 2024 surveys, showing erosion in the upper knickpoint (near M3), and possibly some erosion at outer bends in the uppermost channel beyond Moorings M1, PG1 and PG2.

6.11.2 Submarine Channel

Only two of the three individual lines surveyed in 2019 and 2020, were resurveyed in 2020. This omission only meant that outermost part of three bends were not well imaged initially, so the final part of DY173 collected extra swath multibeam coverage of 2 of these 3 outer bends.

The submarine channel showed significant change in one of the main knickpoints, which entrenched and extended over a reach of ~10 km (Fig. 6.31). This shows that the channel had significant turbidity current activity during 2020-24, perhaps linked to the 5 flows in this period that broke cables. However, the other knickpoints within the deep-sea channel did not migrate significantly, showing that not all knickpoints migrate during these flows.

Erosion was also observed along some outer bends, as seen to an even greater extent in 2019-2020. This erosion is not an artifact due to ship positioning errors (as there is no paired 'deposition' that such errors would produce). However, there are significant issues around data quality on steep slopes, such as those on the channel walls, as set out in section 6.8.2. on data processing. Thus, further analaysi may be need to confirm that this outer bend erosion is not partly an artifact.

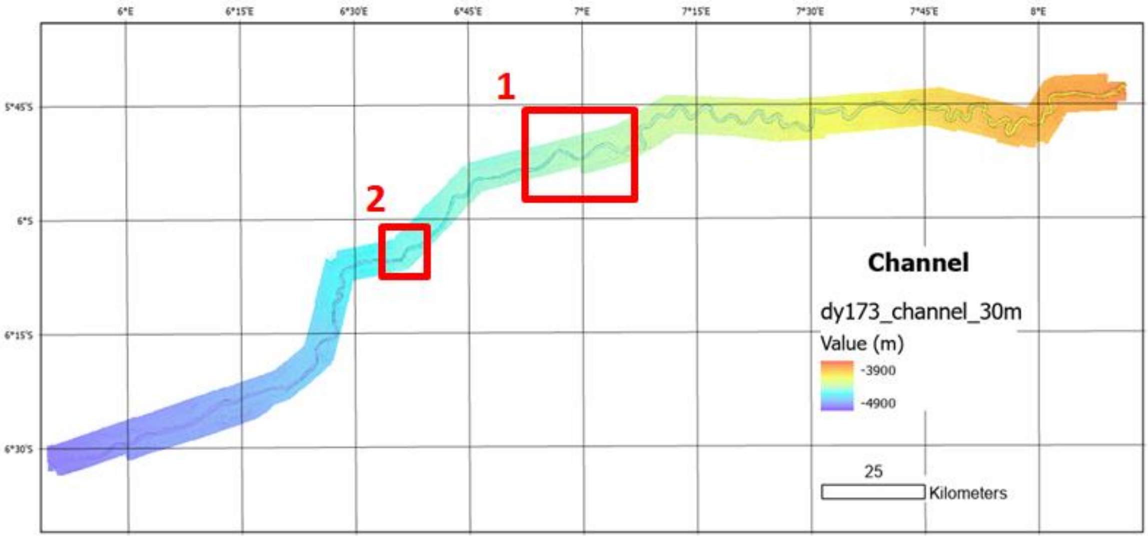
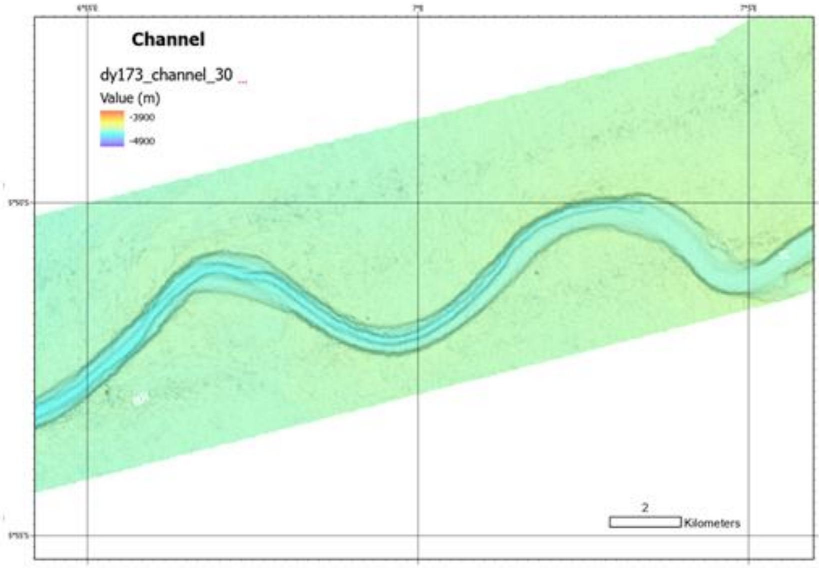
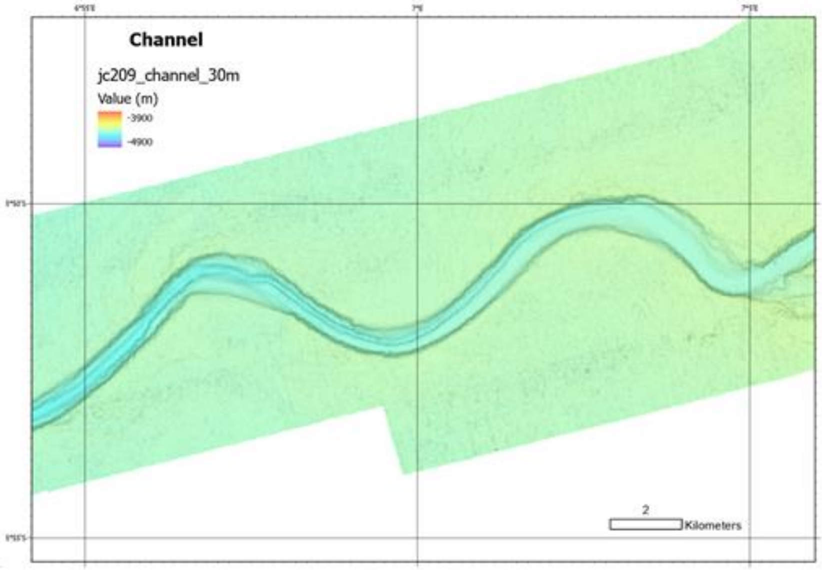


Figure 6.30. Bathymetry map along the submarine channel in 2020, with locations of Fig. 6.31 shown.





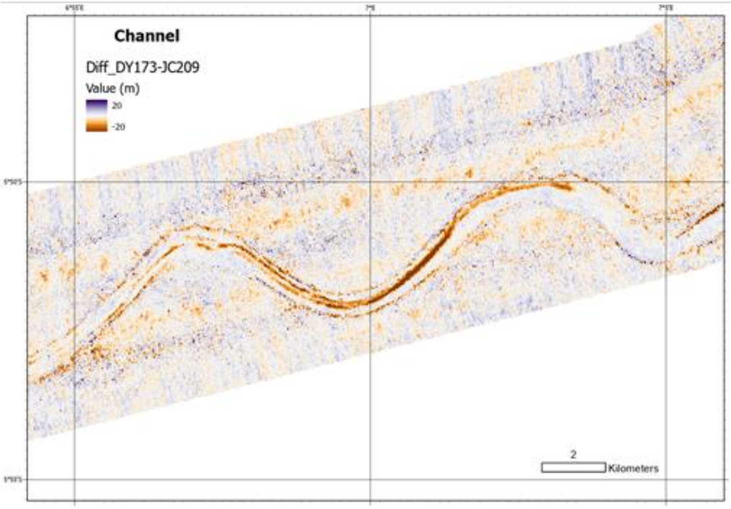
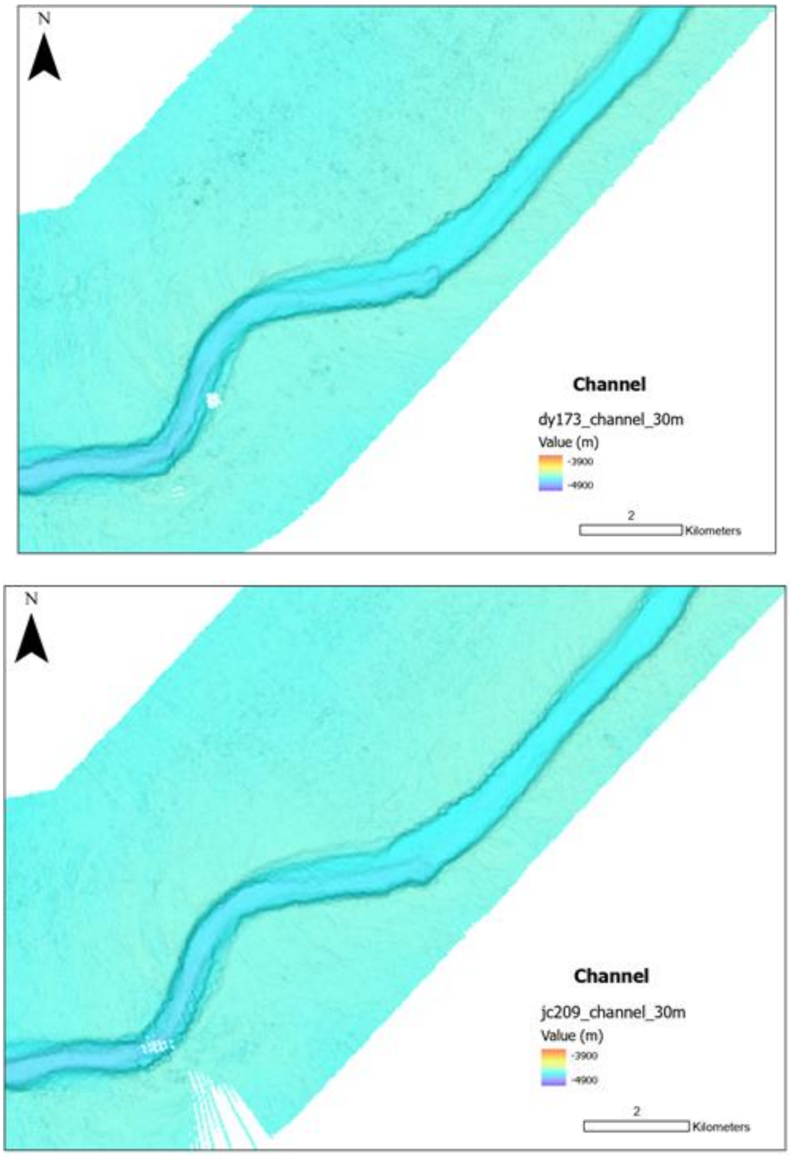


Figure 6.31. The top two images show surveys of a major knickpoint in 2024 (top) and 2020 (middle), with the lower panel showing the 2020-2024 difference map for this area. The knickpoint entrenched and extended between 2020 and 2024.



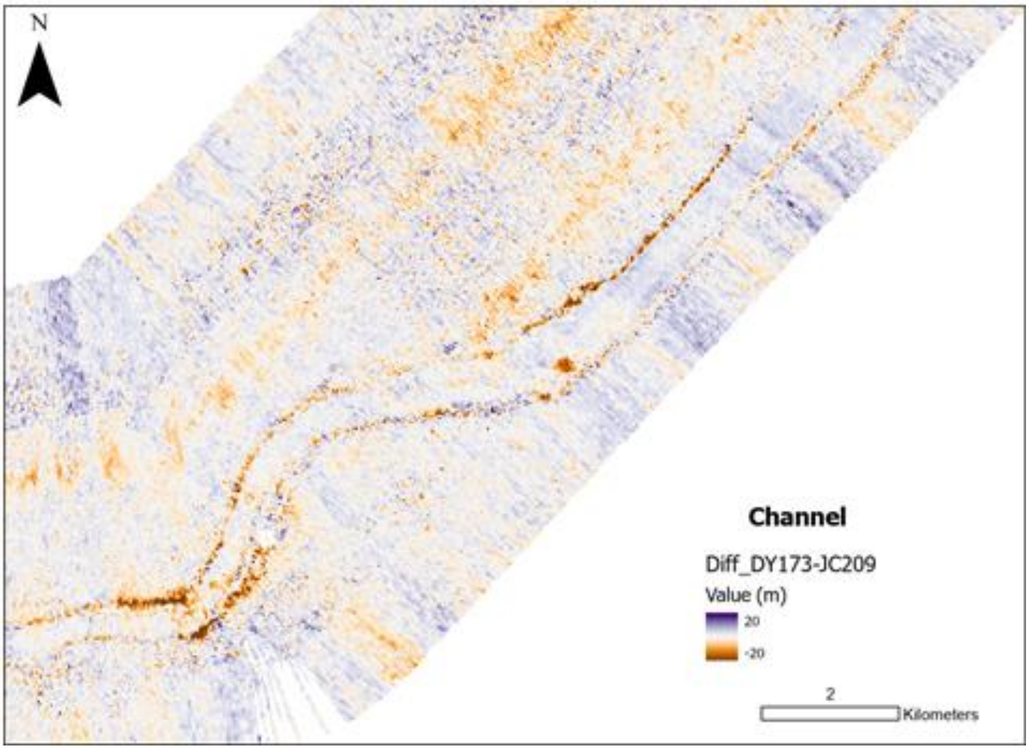


Figure 6.32. The top two images show surveys of a second major knickpoint in 2024 (top) and 2020 (middle), with the lower panel showing the 2020-2024 difference map for this area. The very tip of the knickpoint has extended slightly (by ~200m), but otherwise there is little change. Note that steeper canyon walls may generate artifacts in such a difference survey.

6.11.3. Upper Canyon within Angola Waters

The upper canyon in Angolan waters showed substantial change between 2020 and 2024. There were two new areas of thick deposits (up to 25 m thick). The first of these thick deposition areas was linked to a 50m high landslide dam, with the landslide clearly visible in comparisons of 2020 and 2024 data. A knickpoint had started to erode into the landslide dam, and extended for ~2km. The landslide-dammed sediment itself infilled an old knickpoint, and extended for ~7 km. A second area of thick (up to 25 m) deposition located further up-canyon is probably linked to a second landslide dam, but the location of that landslide is not visible in the 2024 data, and further work is needed. This area of deposition extended into DRC waters at its far end.

Other knickpoints migrated significantly in 2020, notable into the 110m high landslide dam emplaced previously from 2005-2019 (see Pope et al., 2022). That knickpoint extended by ~2.7 km in 2020-24, and it is now over 40m deep near its termination.

Other areas of the upper canyon in Angolan waters showed little change, notably along the western third of the survey area, despite at least 5 major flows traversing the upper canyon in 2020-2024 as shown by cable breaks.

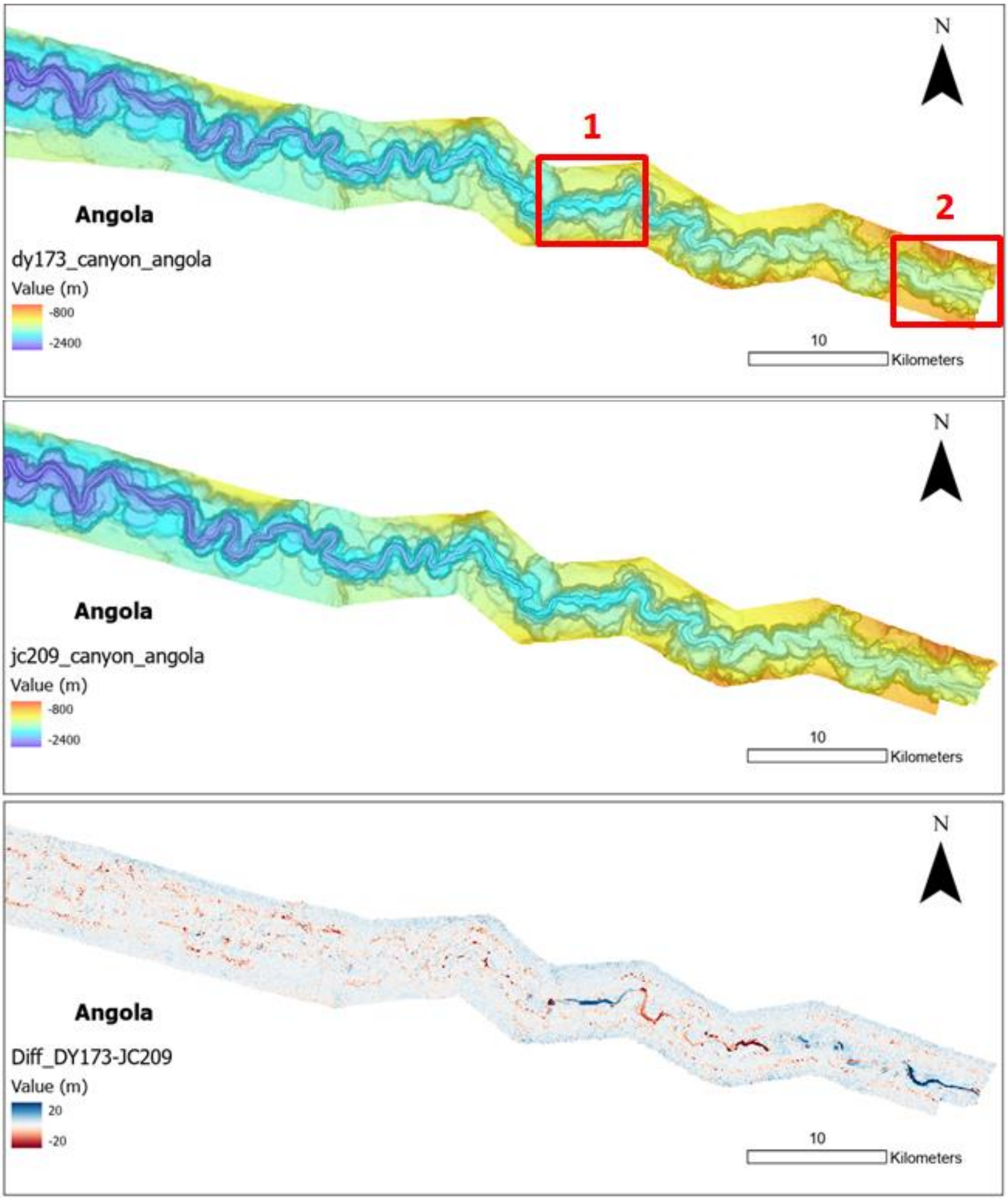
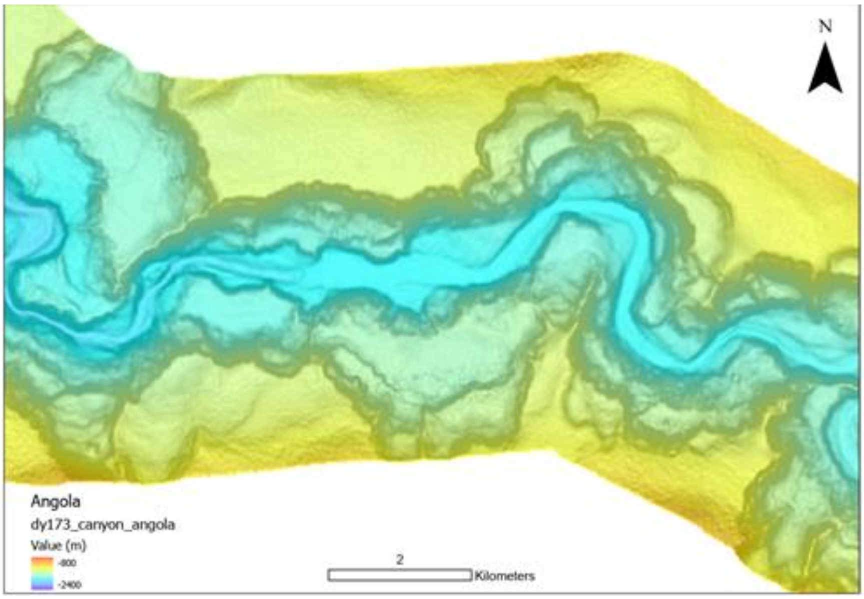
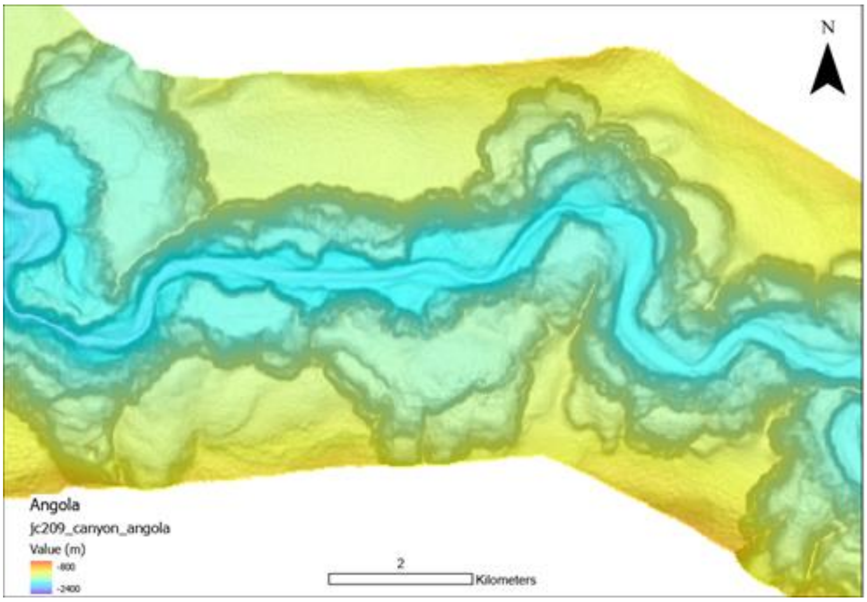


Figure 7.33. Overview of bathymetric surveys and seabed elevation changes in the upper canyon in Angolan waters. (upper panel). Bathymetry in 2024. (middle panel) Bathymetry in 2020. (lower panel) Changes in seabed elevation between 2020 and 2024, showing two main areas of deposition (in blue), and intervening areas of erosion (in dark red). Minor changes also occur elsewhere, but see previous sections form a discussion of uncertainties and data quality.


N
Angola
dy173_canyon_angola
Value (m)
-800
-2400
2
Kilometers


N
Angola
jc209_canyon_angola
Value (m)
-800
-2400
2
Kilometers

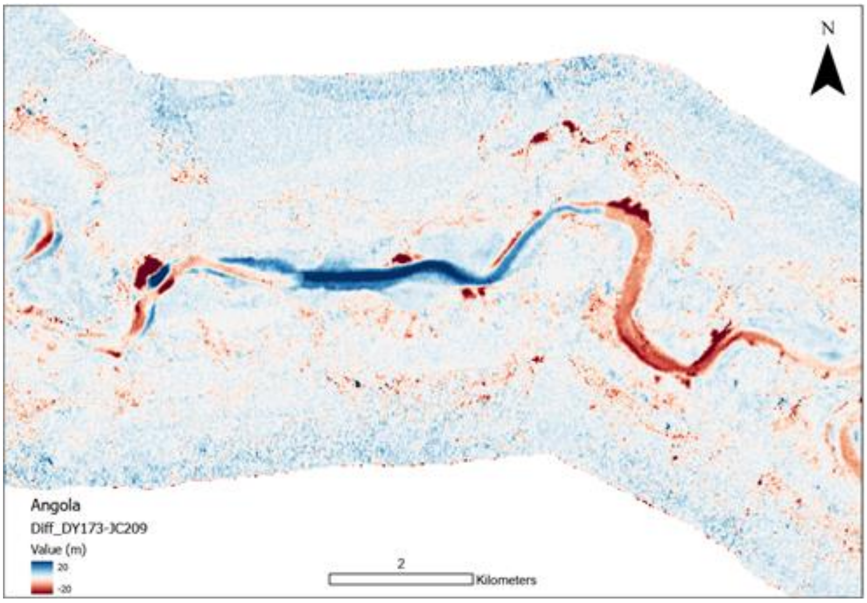
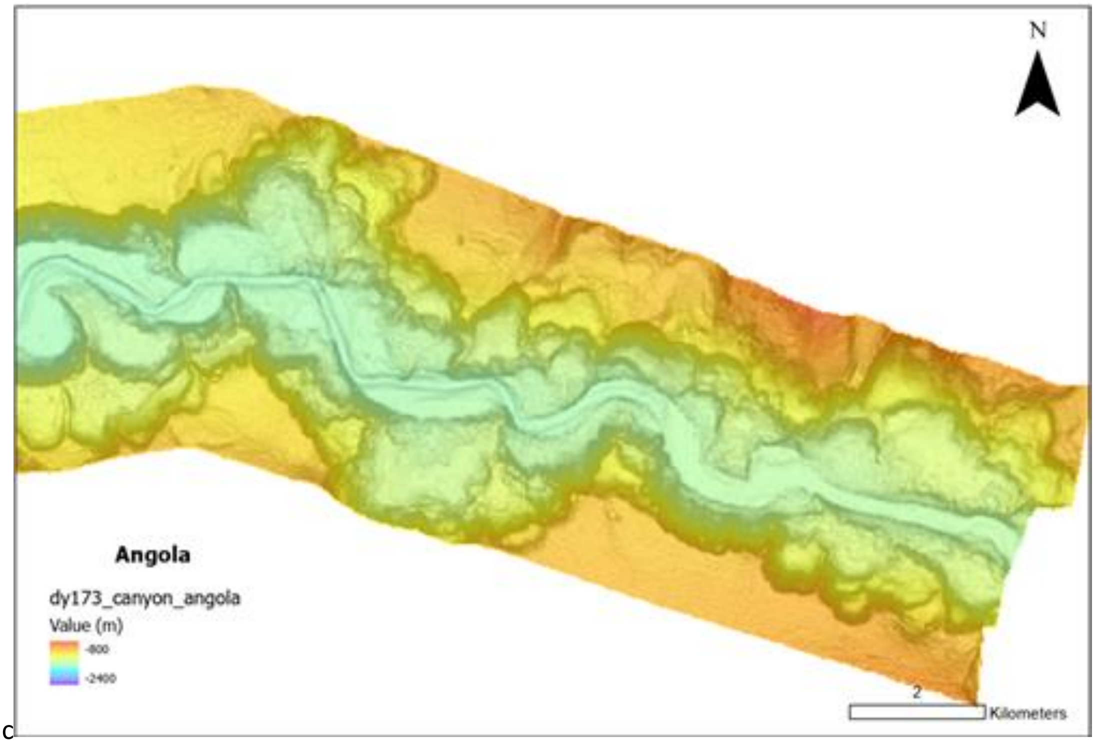
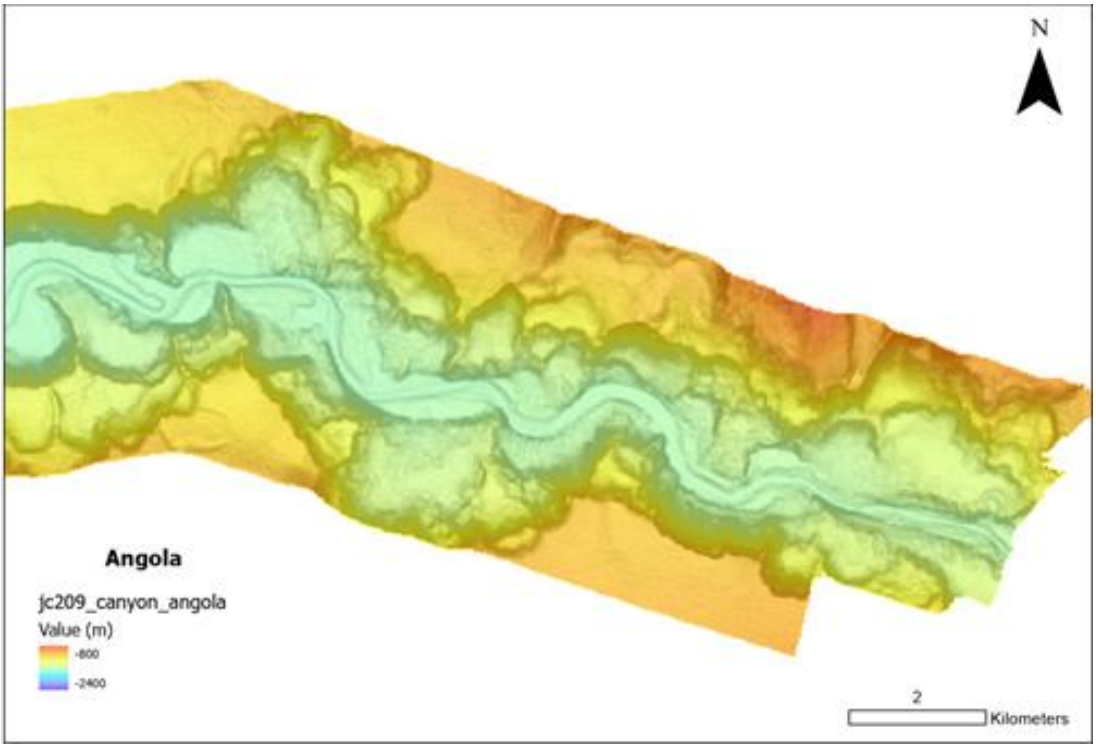

N
Angola
Diff_DY173-JC209
Value (m)
20
-20
2
Kilometers

Figure 8.34. Overview of bathymetric surveys and seabed elevation changes around a new landslide dam in the upper canyon. (upper panel). Bathymetry in 2024. (middle panel) Bathymetry in 2020. (lower panel) Changes in seabed elevation between 2020 and 2024. The landslide is a paired area of deep erosion (excavation in red) on the channel side wall, and thick deposition (in blue) near the channel axis. A knickpoint has then eroded through the landslide dam, which also produced thick deposition (in blue) in upstream areas for ~7 km. A second knickpoint has eroded in 2020-2024 to produce the red area to the eastern (right) side of the map.



c



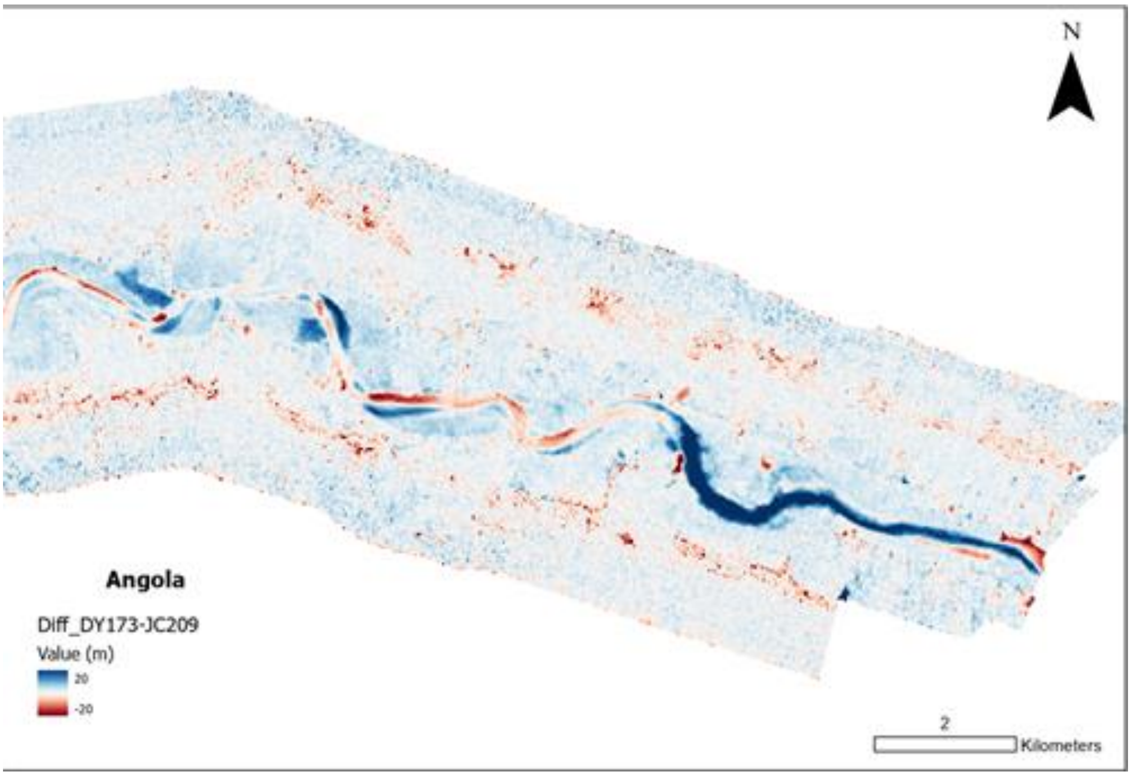


Figure 9.35. Overview of bathymetric surveys and seabed elevation changes around a second area of thick deposition in the upper canyon. (upper panel). Bathymetry in 2024. (middle panel) Bathymetry in 2020. (lower panel) Changes in seabed elevation between 2020 and 2024.

6.11.4. Upper Canyon in Democratic Republic of Congo (DRC) waters

There morphology of this stretch of the canyon has undergone changes during the ~20 year period between 2005 and 2024. In particular, there has been significant erosion focussed on some outer bends, which has made the canyon somewhat more sinuous. At least 2 major landslide scarps are seen on canyon flanks, but there are no obvious areas of thick landslide-dam related deposition in the difference map (i.e. no areas of thick 2020-24 deposition), unlike the canyon in Angolan waters.

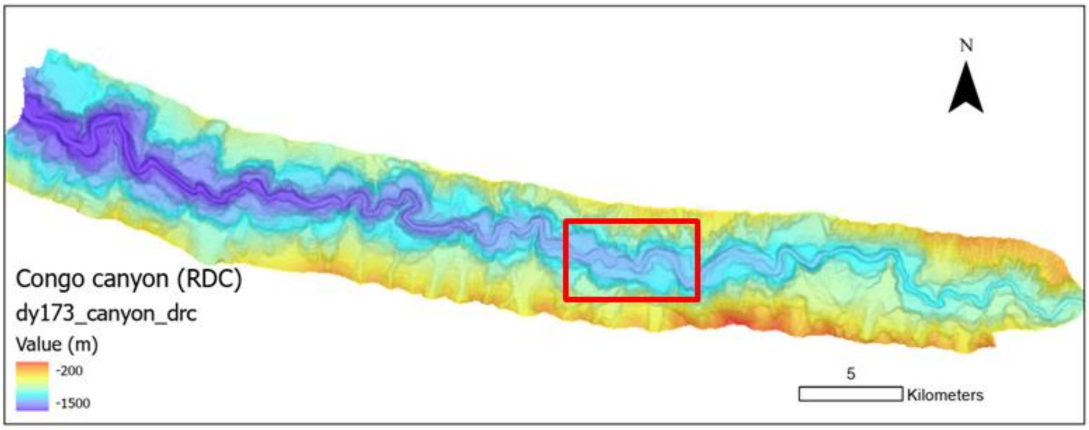
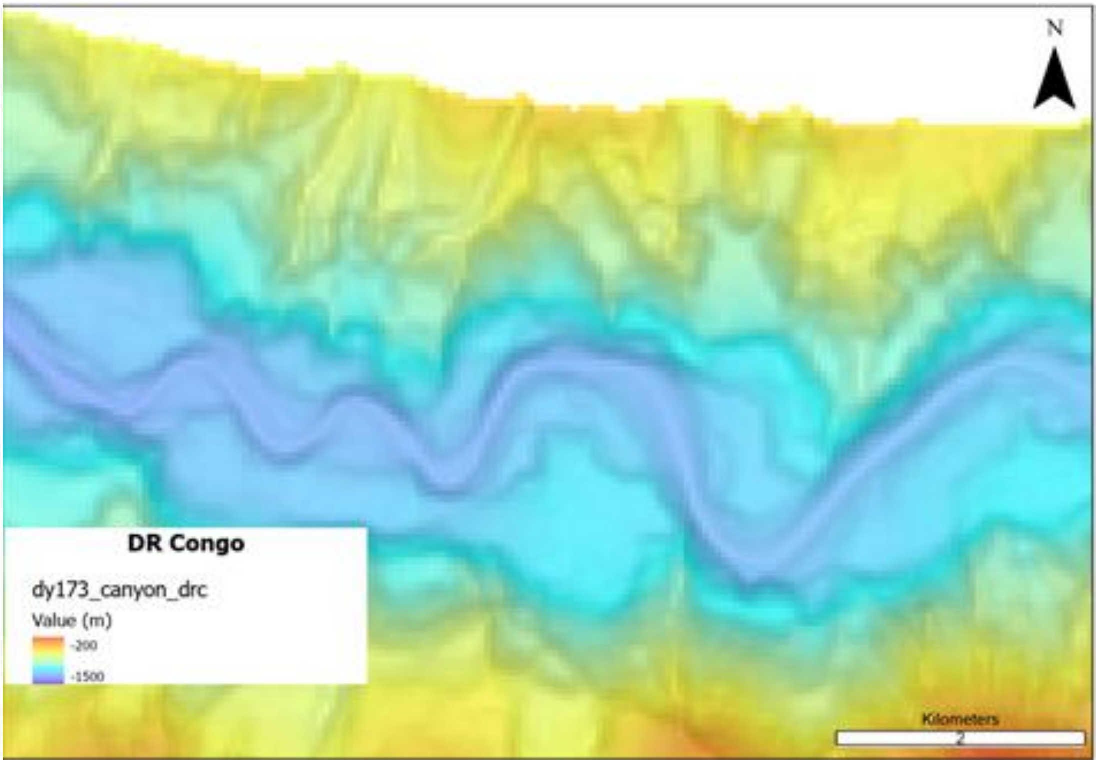
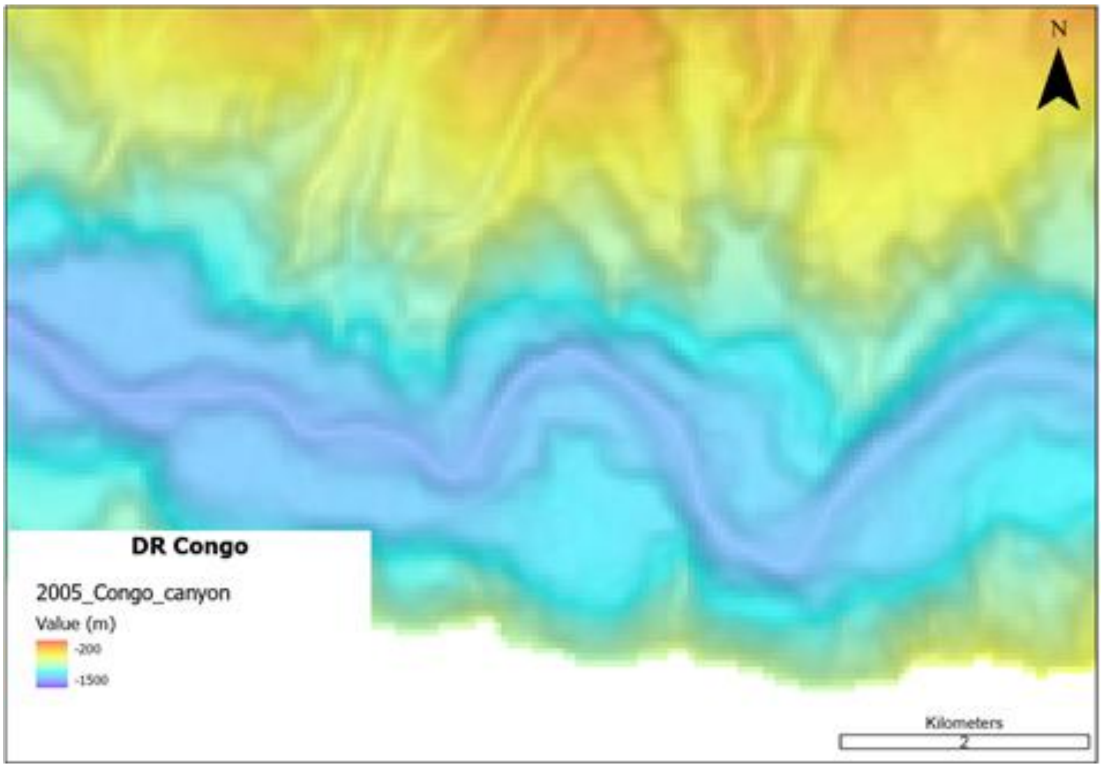


Figure 6.36 : Overview of the bathymetry survey in the upper canyon collected within DRC waters.

There is a major topographic knickpoint in DRC waters (as shown by a long profile), but this major knickpoint does not seem to have migrated significantly in the last ~20 years. This is a surprising result, given the high mobility of many other knickpoints in the upper canyon and system generally. However that knickpoint seem to be linked to a series of terraces in upstream areas, which may be remnants of previous thick landslide dam sediment wedges that were eroded by later knickpoints.





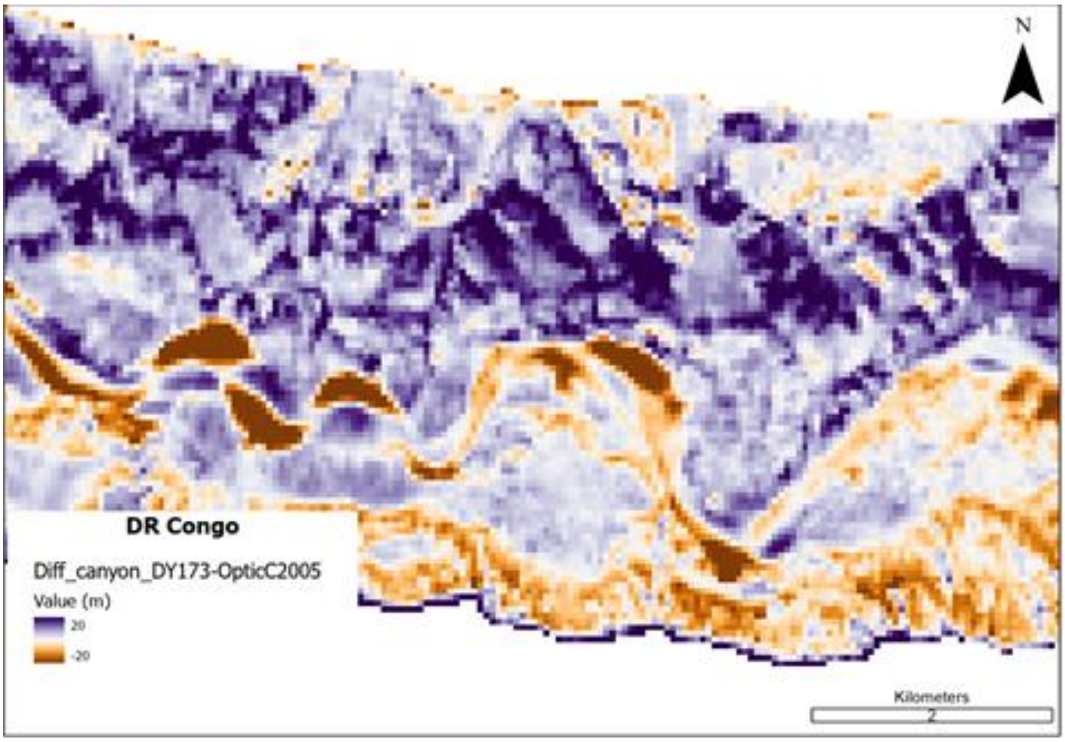


Figure 6.37. Bathymetric surveys and seabed elevation changes with part of the upper canyon in DRC waters. (upper panel). Bathymetry in 2024. (middle panel) Bathymetry in 2020. (lower panel) Changes in seabed elevation between 2020 and 2024, showing evidence of significant outer bend erosion and sidewall slope failures, albeit without thick deposition in 2020-24 in a landslide dam.

6.11.5. List of DTM and grids generated during the DY173 cruise for the GIS.

DY173 bathymetry

Name	Pixel size	Projection
240303_dy173_canyon_drc_UTM32_25m_bcksc.tif	25m	UTM32S
240303_dy173_canyon_angola_UTM32_25m_bcksc.tif	25m	UTM32S
240303_dy173_channel_UTM32_30m_bcksc.tif	30m	UTM32S
240303_dy173_lobe_UTM32_30m_bcksc.tif	30m	UTM32S
240303_dy173_lobe_UTM32_60m_bcksc.tif	60m	UTM32S

DY173 backscatter

Name	Pixel size	Projection
240303_dy173_canyon_drc_UTM32_25m_bcksc.tif	25m	UTM32S
240303_dy173_canyon_angola_UTM32_25m_bcksc.tif	25m	UTM32S
240303_dy173_channel_UTM32_30m_bcksc.tif	30m	UTM32S

240303_dy173_lobe_UTM32_30m_bcksc.tif	30m	UTM32S
240303_dy173_lobe_UTM32_60m_bcksc.tif	60m	UTM32S

JC209 and JC187 bathymetry (elevation) and backscatter (bcksc)

Name	Pixel size	Projection
240303_dy209_canyon_angola_UTM32_25m_elevation.tif	25m	UTM32S
240303_dy209_channel_UTM32_30m.elevation_tif	30m	UTM32S
240303_dy209_lobe_UTM32_30m_elevation.tif	30m	UTM32S
240303_dy187_lobe_UTM32_30m_elevation.tif	30m	UTM32S
240303_dy187_lobe_UTM32_30m_bcksc.tif	30m	UTM32S

10m grids for the canyon within the Angola and DRC waters

Name	Pixel size	Projection
dy173_canyon_angola_UTM32_10m_Elevation.tif	10m	UTM32S
dy173_canyon_DRC_UTM32_10m_Elevation.tif	10m	UTM32S
jc209_angola_UTM32_10m_Elevation.tif	10m	UTM32S
JC187_Site83_84_UTM32S_reproject10m_Elevation.tif	10m	UTM32S

DTM have been processed in Globe.
The JC187_Site83_84_UTM32S_reproject10m_Elevation is only the reprojection of the existing 5m grid from the JC187 survey into a 10m grid spacing DTM.

Ifremer DTMs

Old DTMs published by Ifremer have been reprojected in UTM32S projection : one for the regional bathymetry and the second one for the upper canyon area

Name	Pixel size	Data source
Synthese_Congo_canyon_reprojectUTM32_50m_Elevation	50m	OpticCongo2 cruise (2005)
Synthese_Congo_UTM90m_Elevation	90m	Data synthesis

Difference grids

	DY173 (2024)	JC209 (2020)	JC187 (2019)	Optic Congo2 (2005)	Difference grid
Lobe	DTM 30m	DTM 30m			2020-2024

Lobe	DTM30m		DTM30m		2019-2024
Channel	DTM 30m	DTM 30m			2020-2024
Angola sector (canyon)	DTM 25m	DTM 25m			2020-2024
DRC sector (canyon)	DTM 50m			DTM 50m	2005-2024

7. Multi-Cores (Shallow cores with sediment interface)

7.1. Aims of multi-core sampling

Multi-cores (sometimes called megacores) are able to take high-quality, undisturbed samples of the top ~0.6 m of the seabed and preserve the seabed-water interface. Multiple transects of mega-cores were collected to compare the different areas of the Congo channel; cores were also taken on the lobe. The mega-cores were collected to try to answer the following questions:

1. Examine the top 60cm of seafloor sedimentology along the Congo canyon.
2. Examine the carbon stable isotope using the top 10cm of one sediment core.
3. Quantify the organic carbon characteristics along the Congo canyon system.
4. Collect microplastic samples from the top 60cm of sediment.

7.2. Multi-coring process

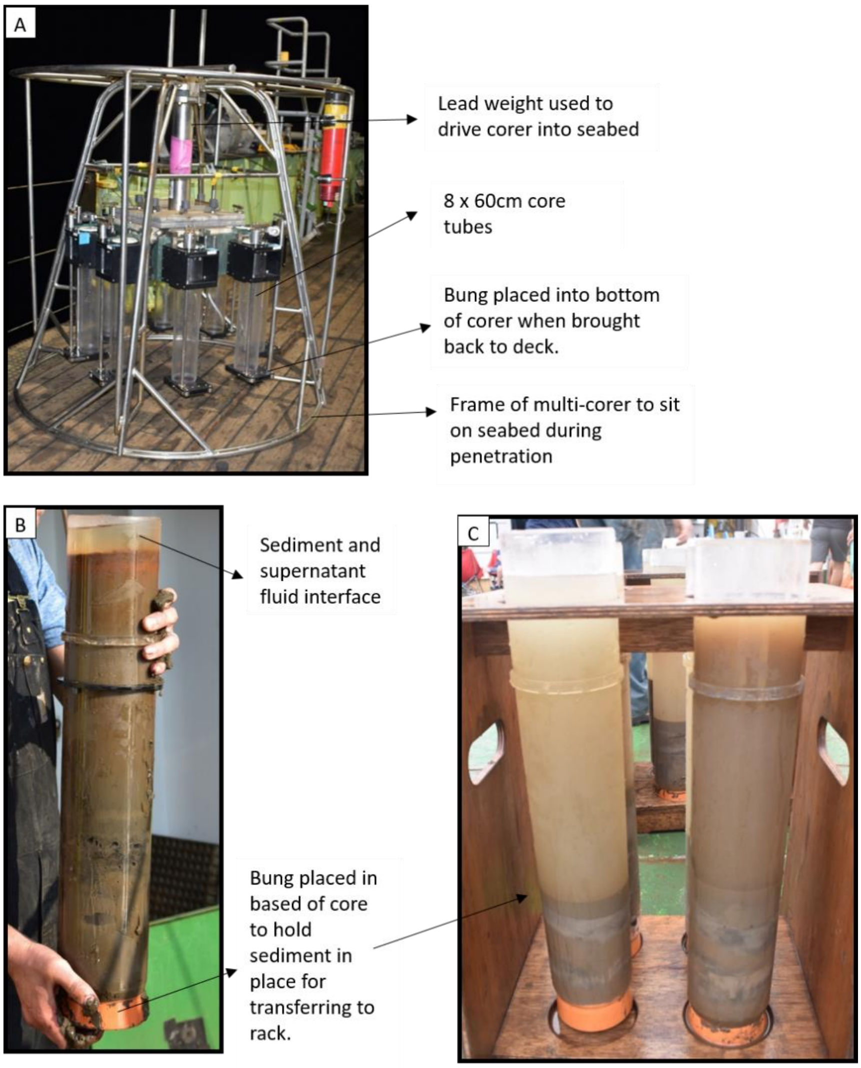
The multicore platform used to collect undisturbed sediment core samples from seafloor surface holds 6 x 110mm wide x 600mm long clear multicore tubes in a circular pattern, shown in Figure(...). Of the retrieved cores, the six most intact cores were used. The multicore uses a unique hydrostatic damping system that slows the penetration rate to ~10 mm/s.

The multicore platform was lifted from the deck via crane and lowered to the seabed at ~1ms^{-1}. Once on the seabed the multicores were pushed into the sediment whilst the frame remains on the surface of the seafloor.

For every multi-core site, 5 cores were subsampled using a Trigger Weight Core (TWC) liner and two microplastics liners, and the top 10cm of tube 4 was extruded for δ13C analyses = requiring 6 successful multicores. Should the multicore platform be retrieved and not contain six full core tubes then the number of microplastic cores may be reduced to one.

The order and purpose in which tubes were used, with tube number and purpose.

1. Micro-plastic
2. Micro-plastic Leachates
3. Sedimentology & OC
4. δ13C (top 10 cm extruded)
5. Archive 1
6. Archive 2



Lead weight used to drive corer into seabed

8 x 60cm core tubes

Bung placed into bottom of corer when brought back to deck.

Frame of multi-corer to sit on seabed during penetration

Sediment and supernatant fluid interface

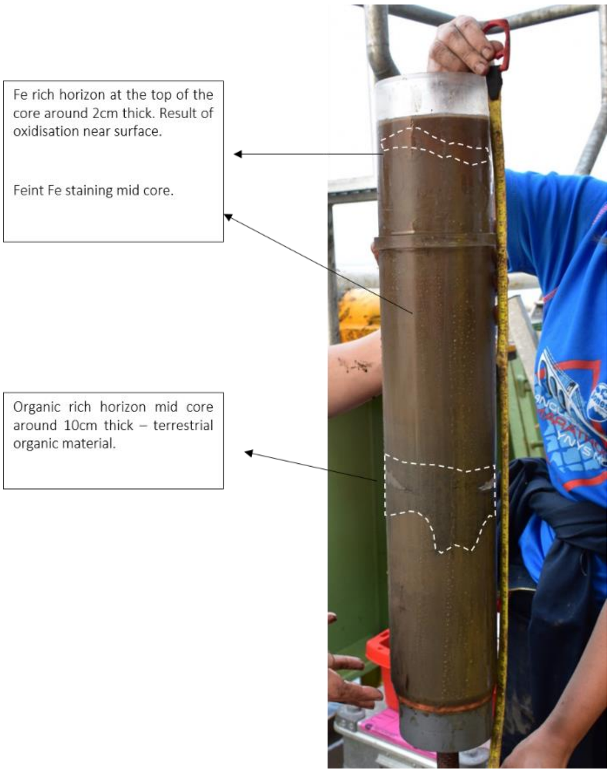
Bung placed in based of core to hold sediment in place for transferring to rack.

Figure 7.1. A) Photo of the multicore platform on deck without the added “feet”. B) A photo of a complete core that has been plugged and removed from the multicore platform. C) Multiple cores in the wooden core frame.

Overpenetration of the multicore tubes into the seafloor can occur if the locking mechanisms at the top and the bottoms of the core tubes fail to activate due to a lack of friction from the seabed. This results in the collected sample not truly representing the seafloor surface but instead what is just below the surface. To minimise the chance of this happening, the base of the multicore platform has been fitted with several large surface-area “feet” to help reduce the platforms ground pressure and increase the likelihood of the locking mechanisms functioning correctly.

Once the multicore platform has completed the sediment capture, it is winched up from the seafloor and carefully secured on deck. The individual core tubes are plugged at the base using a rubber bung, carefully removed from the multicore platform, and placed in a wooden core frame where they are stored whilst the rest of the tubes are plugged and removed.

After all tubes are plugged and placed in the wooden frame, the outside of the tubes are wiped down using a cloth and water so that the captured sediment can be seen. Each tube is inspected and the tube with the best multicore is selected, and a rough graphic is made of the observable sediment structures. This is demonstrated in Figure (…).



Fe rich horizon at the top of the core around 2cm thick. Result of oxidisation near surface.

Feint Fe staining mid core.

Organic rich horizon mid core around 10cm thick – terrestrial organic material.

Figure 7.2. A plugged multicore showing how the rough log may be described.

The subsampling of 5 multicore tubes is done using TWC liners. The TWC liner was cleaned to remove grease and loose plastic before use. The TWC liner is slowly pushed down from the top of the core until it reached the bottom, all while being careful not to disturb the sediment. Once the TWC liner reached the rubber bung at the bottom of the tube, a labelled top cap was fitted and secured using black tape to the top of the TWC liner. Making sure to keep the TWC liner pressed against the rubber bung at the bottom of the tube, the multicore tube was slowly rotated 180° so the rubber bung was facing upwards. The rubber bung was then removed and the now full TWC liner was carefully pushed upwards allowing for a labelled bottom cap to be fitted and secured to the base of the full TWC liner. The now sealed multicore subsample is now removed from the tube, the outside cleaned of any remaining sediment and labelled with the; cruise number (DY173), multicore site and tube number (MC##_#). E.g. DY173_MC01_1 (Cruise DY173, multi-core number 1, tube 1). After labelling, the core tubes were transported upright and secured upright in the refrigerated shipping container. This process is demonstrated in Figure (…).

Figure 7.3. Photos demonstrating taking sub-cores using the trigger weight core liner. A) The core liner is slowly pushed into the centre of the multi-core. B) A cap is placed on the top of the core and labelled as the top of the core. C) The multi-core and core liner have carefully been turned upside down and the bung is removed. D/E) The core liner is held securely upright, and the multi-core is pulled up.

7.3. Methods for microplastic sampling

If there was enough sediment recovered in the multi-core, then two subsamples were taken for further micro-plastic analysis. Additionally, several procedural blanks have been collected to rule out contamination of the samples.

To avoid contamination while subsampling the multicore, care was taken to remain downwind of the sample, to wear designated lab coats/overalls, to wear gloves, to avoid the use of plastic equipment or tools and to rinse all required equipment in milli-Q water.

Provided polycarbonate tubes were used to subsample the multicore tubes. The multicore tube stood in a wooden crate with a bung at the bottom. A pre-cut 60-cm polycarbonate (PC) liner was then pushed in from the top of the core. If the subsample was for micro-plastic, then blue role was inserted to fill the empty space between the sediment and the top of the PC tube. If the subsample was taken for leachates, then the space was let open. The next step was to put some aluminium foil over the top of the tube and to place an end-cap. To remove the extra sediment, the whole core and subsample was rotated, and while holding on to the subsample PC tube the multicore tube was carefully pulled of while the surplus sediment was removed. Then the bottom of the PC tube was either filled with blue roll (if for microplastic) or left open (for leachates). After covering the bottom of the tubes with aluminium foil another endcap was placed on the bottom of the PC tube. Finally, the PC tube was cleaned, labelled and the end-caps were secured with black electric tape. The tube are either labelled microplastic (MP) or leachate (L), before being stored in the refer at ~4°C.

Several procedural blanks were collected to rule out airborne or water contamination. At the beginning and the end of the cruise three bottles of milli-Q purified water were collected. The bottles and caps were rinsed with milli-Q water before being filled. A sheet of rinse aluminium foil was placed between the bottle and the lid. The bottles are labelled and stored in the plastic container that held all our microplastic equipment and clothing. Similarly, during the second and the last multicore subsampling, airborne samples were collected. As there were no petri-dishes, we placed wetted filter paper on small dishes folded of aluminium foil on the back deck within 2-3 metre of the subsampling location. These wet filter papers were separated by at least 50cm and were placed about a 1m above the deck. After 30 minutes the filter papers were covered by aluminium foil, and then stored in a zip-lock bag with the dedicated microplastic container.

7.4. Multi-coring Results

Eight multicores were collected: 5 from the lobe in international waters, 1 from a location on the basin plain away from the active turbidite system, and 2 from the upper canyon in Angolan waters (Table X.1, Figures X.1 & X.2). Common sediments found in cores included soupy homogenous brown mud, grey sand layers, and more consolidated grey mud (Figure X.3).

Multicore sites on the lobe coincide with piston core sites and/or mooring sites (Figure X.1). The most distal core MC05, which was obtained from the same site as PC06, contained 27 – 60 cm of fluid mud. Further upslope from an area of high backscatter and from the same location as PC01, MC03 retrieved 50 – 59 cm of muddy sediment with fluidized brown mud at the top that became more consolidated in the bottom 15 – 20 cm of the core and contained indistinct brown-grey mud layers (Figure X.3C). The more proximal, lobe multicores contained both mud and sand (Figure X.1). MC04 was collected at the end of the channel at PCO9 and near the last mooring (M4). It contained fining upward units 5 - 56 cm thick of grey fine sand or coarse silt and brown mud (Figure X.3D-F). MC06 (near the M3 mooring) was unsuccessful and drained before reaching the surface; however mud was found on the sides of the barrels and sand was found in the mechanism on top of the cores. MC01 was taken near the first mooring (M1) and contained brown mud with muddy sand at the top of the core (Figure X.3A).

One core, MC02, was obtained from an adjacent location on the basin plain to get a background sample for carbon isotope analysis (Figure X.1). The core contained an upper unit with a homogenous brown colour and lower units that are light and dark grey (Figure X.3B). Sediments are described as being mud with some sand.

Multicore sites in the canyon also coincided with piston core locations (Figure X.2). MC07 is from a depositional area of the canyon thalweg and the same location as PC23. It was unsuccessful and only a small sample of draining mud was recovered. MC08 is from the same location as PC25 and recovered a surficial unit of brown mud underlain by alternating units of sand and grey mud (Figure X.3G).

Table 7.1. *Summary of multi-core collection.*

Core Name	Site Number	Environment	Number of Cores Collected	Recovery (cm)
MCO1	56	Channel Thalweg	6	22 – 44.5
MCO2	69	Basin Plain, away from lobe	6	39 - 43
MC03	71	Mid – Distal Lobe	6	50 – 59
MC04	75	Mid Lobe, Scour	5	31 – 56
MC05	76	Distal Lobe	2	27 - 60
MC06	80	Mid – Proximal Lobe	2	~ 20
MC07	149	Canyon Thalweg	0	0
MC08	151	Canyon Thalweg	4	5 – 30

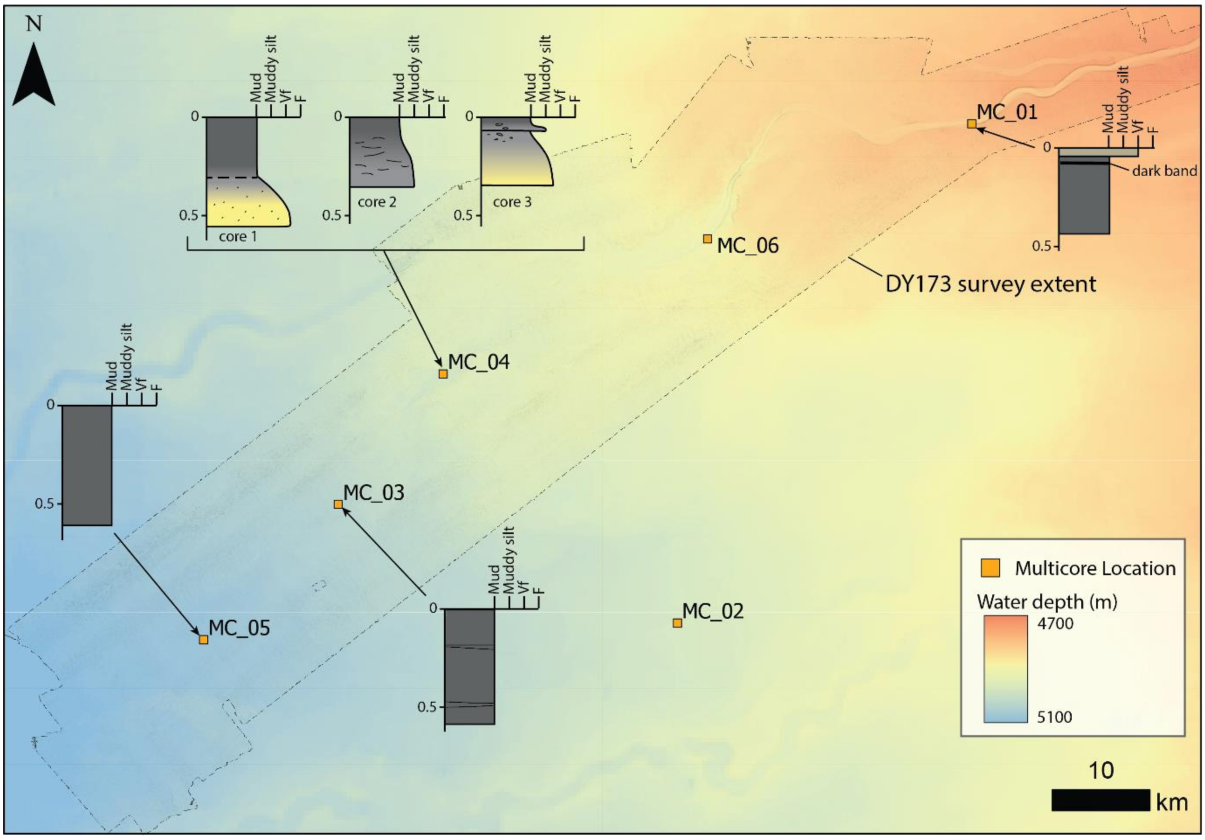


Figure 7.4. *Locations and schematic logs of multicores from the lobe in international waters.*

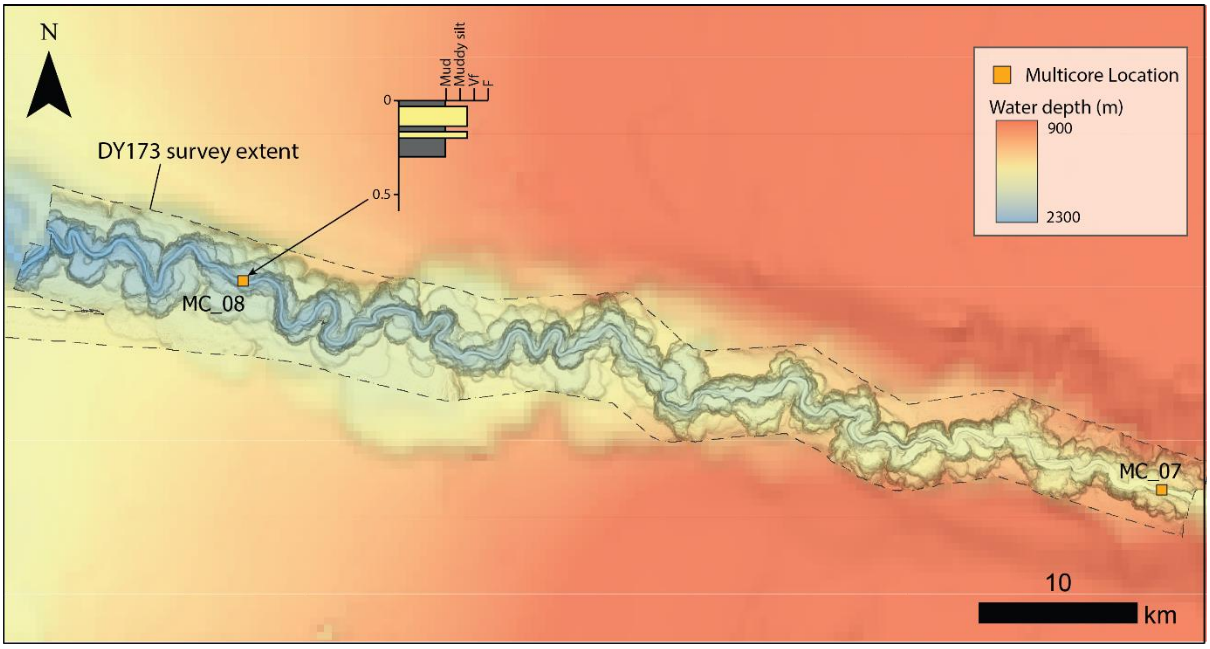


Figure 7.5. *Locations and schematic logs of multicores from the upper canyon in Angolan waters.*

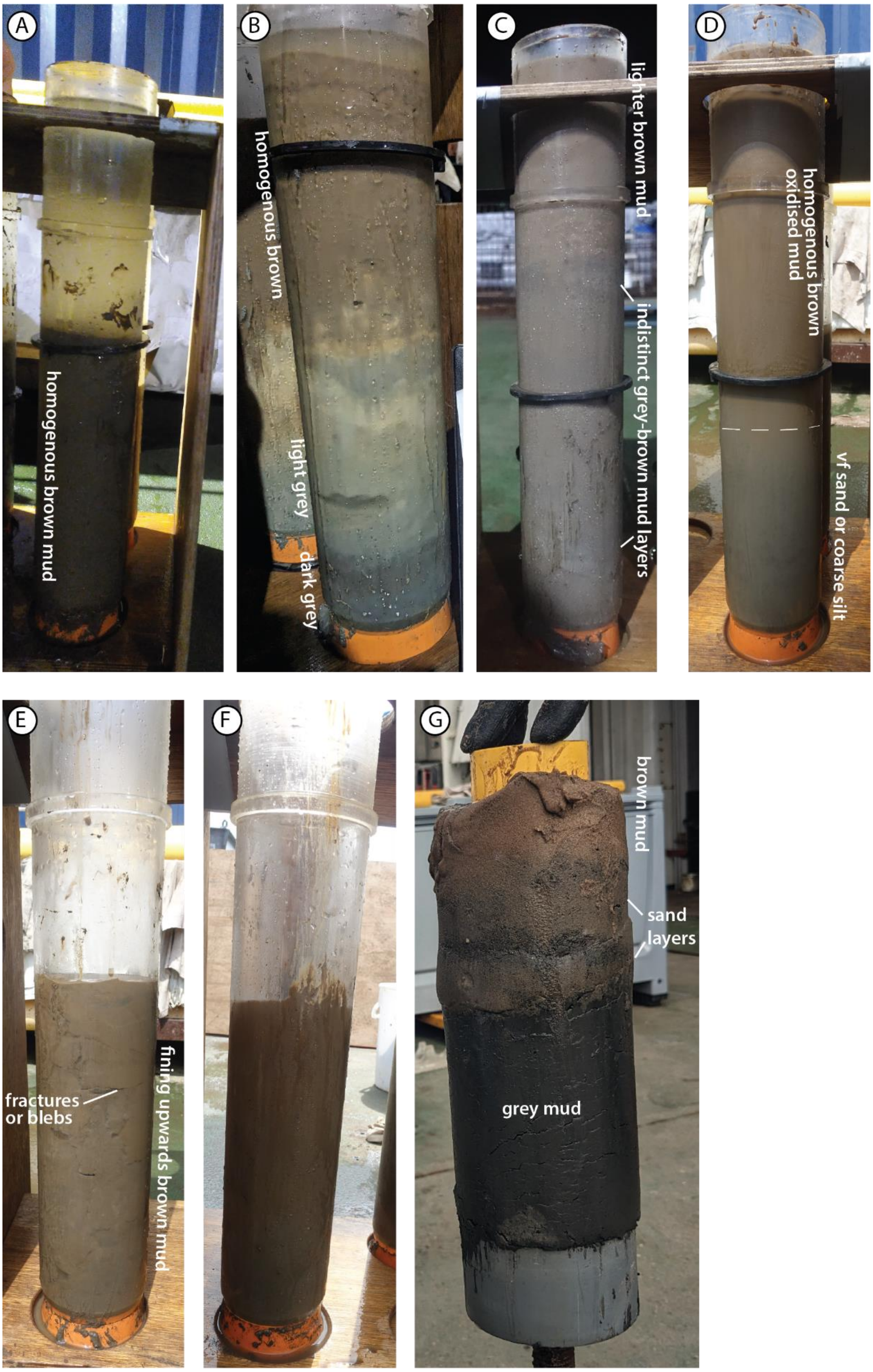


Figure 7.6 *Multicore photos from (A) MC01, (B) MC02, (C) MC03, (D) MC04 core 1, (E) MC04 core 2, (F) MC04 core 3, and (G) MC08.*

Microplastic

In five locations microplastic subsamples have been collected (see overview table). Additionally, the airborne (stored in microplastic contained in lab) and water blanks (stored in the reefer) have been stored. Finally, a sample of a plastic like substance spotted while logging core PC09 has been collected and stored together with the other microplastic samples (labelled DY173_PC09 section1/5 Work Filament samples; stored in the microplastic container in the lab).

	purpose	Multicore tube	blanks
MC01	Microplastic	5	
MC01	Leachate	5	
MC02	Microplastic	1	Airborne blanks_01
MC02	Leachate	2	Water Blanks_01 (labelled WB1.1-1.2-1.3)
MC03	Microplastic	6	
MC03	Leachate	5	
MC04	Microplastic	6	
MC04	Leachate	5	
MC08	Microplastic	2	Airborne blanks_01
MC08	Leachate	7	Water Blanks_02 (labelled WB2.1-2.2-2.3)

Table 7.2. Summary of sampling for microplastics in multicores

8. Piston Cores

8.1. Methods of piston coring

The piston corer used during the 2024 Discovery cruise DY173 was assembled to collect 6, 12 and 18-meter sediment cores from the lobe, terraces, levees and inner channel on the canyon floor. The construction of the piston core (Fig. 8.1) consists of a PVC liner barrel that collects sediments pushed inside the steel tubes, with a 1500 kg weight fitted on top to ensure burial of the tube. The trigger weight is held by a 1-meter-long arm attached to the upper part of the corer.

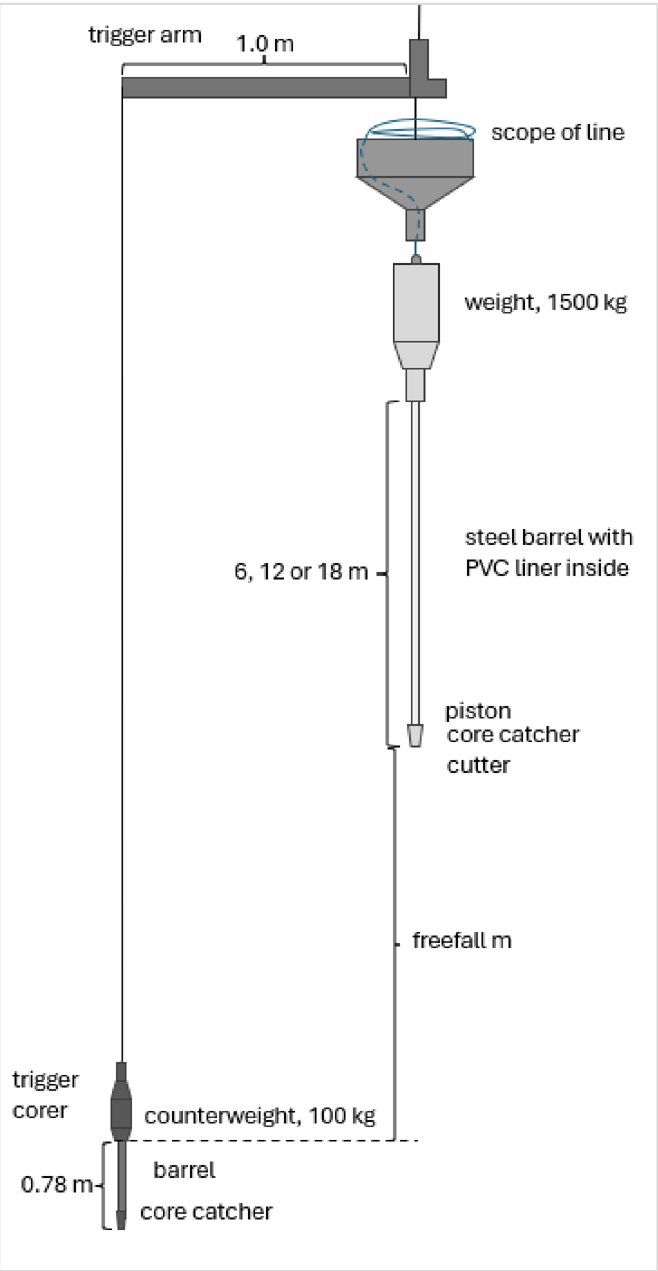


Figure 8.1: *An overview description of the piston core used during the DY173 cruise. The Trigger core reaches the seabed before the steel barrel with the PVC liner inside. This determines the freefall of Xm, speeding up the penetration caused by the 1500kg weight near the top.*

8.1.1. Trigger Cores

The trigger corer consists of a counterweight and an attached 78cm barrel (Fig. 8.1, Fig. 8.2). The core's role is to contact the sea floor before the steel barrel can reach the seabed. This mechanism then allows the barrel to freefall between 1 to 2.5 m, accelerated by the 1500 kg weight placed on top of the barrel (Fig 8.3). In Addition to the sediment collected in the barrel, the trigger core also collects sediment as it reaches and penetrates the seafloor. The Trigger core is limited to 78 cm of sediment penetration however the trigger core has returned in this cruise, either fully disturbed or partial/fully empty. Sediment collection from the trigger core can be useful as the sediment collected has a greater chance at being undisturbed as opposed to the main barrel which has 1500kg weights attached.

Figure 8.2: Image taken from the DY173 cruise, before attachment to the barrel of the piston core.

The depth in which the barrel penetrates the seabed is dependent on two factors. The first is the composition of sediment at the seabed, and the second is the speed in which the barrel has had a chance to free fall. When comparing areas for coring with sandy environments to mud environments, it is noted that the barrel behaves differently.

Sand has a higher rigidity than mud and consequently the sand can become harder to penetrate which often leads to bends in the barrel if the freefall is not great enough. This issue can be solved by using a sub-bottom profiler that can determine the sediment composition at the seabed which then allows for calculations and changes to be made to the length of the barrel and the freefall distance. Although, bends in the barrel are indicated by the lack of increased pullout tension as the core reaches the seabed and begins its journey to the surface. An idealised result for the pullout tension is observed as a peak in tension as the core is pulled out of the seabed to retreat to the sea surface.

8.1.2. Deployment

The deployment of the piston core begins when the trigger core is attached to the main barrel and is lowered at a constant speed of 1m/s towards the seabed. In deep water where the depth ranged between 4000 – 5000 m at the lobe, the core would arrive to the seabed ~2 hours after initial deployment and arrive at the surface a further 2 hours later. In areas further up the channel where the water depth ranged from 1500 – 2500 m the core took ~1.5 hours to reach the bottom and then return to the surface.

Once the Piston core is 100m from the seabed the cable slows down to 0.5m/s until cable tension comes off. The cable stops moving entirely once the cable tension drops indicating seabed penetration. Recovery of the cable begins at a speed of 0.2m/s. Once the core has raised 30m above the seabed then the cable can return to the 1m/s speed until the core has returns to the surface.

When the piston core has returned to the surface, the barrel is then transferred to racks on the side deck (Fig. 8.3) where cutting (Fig. 8.9) and processing begun. Sediment from the core catcher was collected and logged (Fig. 8.8). The PVC liner was pushed out of the barrel by applying pressure from the head of the core and then cut into 1.5m lengths (desired by the British Ocean sediment core research facility). If bending had occurred to the barrel, then a hydraulic pressure pump aided in removing the PVC liner from the barrel. The 1.5m sections are labelled adequately and then stored in the reefer until split and logged.

Removing Piston cores from the sea;

Figure 8.3: *Once trigger core has been removed (fig.2) then piston core (red circle) is placed on a stand using two cranes working simultaneously.*

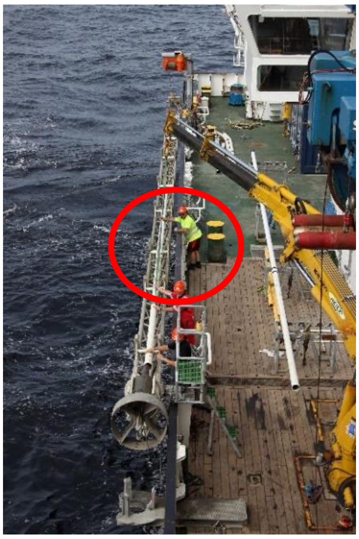


Figure 8.4: *The piston core is turned horizontally by a winch (red circle) located near the stern of the vessel.*

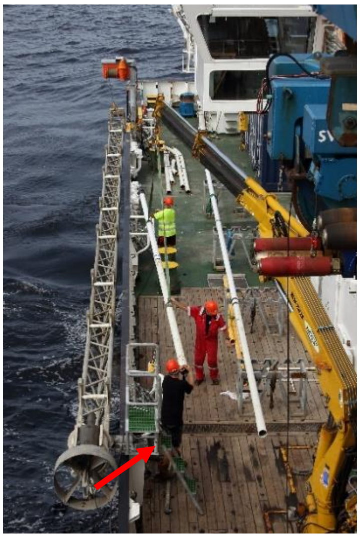


Figure 8.5: *The piston core was removed (red arrow) from the barrel and 1500kg weight. Leaving the barrel free to be moved separately.*

Figure 8.6: *The barrel is then placed on stands where the PVC liner will be removed and split into 1.5m sections for processing.*

Figure 8.7: *On some occasions where the freefall calculations and the sediment were too rigorous, the barrels will have bent to the 1500kg weight attached at the top.*

8.1.3. Processing on deck

Core catcher: A core cutter was used to cut through the PVC liner without disturbing sediments (Fig 8.9) and once through the liner a cheese cutter was able to provide a clean cut in the sediments. The end of the liner was caped and secured by tape. In instances where the sediment core held gas, small intrusions were made on the cap to allow gas to escape. If there was space in the liner, then blue roll was used to fill in gaps to prevent the sediment from moving during splitting.

Figure 8.8: *Collecting sediment from the core catcher.*

Figure 8.9: *Labelling the PVC liner with the system mentioned below and cutting the liner into 1.5m sections with a core cutter.*

Figure 8.10. *Sediment core splitting using a core splitter.*

Following the removal of excess plastic accumulated on the sides during splitting, the core was transferred to the lab. End caps were cut, and each core side was divided by pulling the cheese wire along the core, from top to bottom. The blue roll stuffing was removed before using the cheese wire otherwise the sediment would be disturbed and cutting would become more difficult. With the help of scrapers, sediment was finally separated into working and archive. The sediment within the liner was then cleaned using scrapers to remove layer of sediment disturbed while cutting with the cheese wire to improve sediment layers visualisation and distinguishment for the logging process and sediment record were analysed (Fig. 8.11 and 8.12). Photographs of the sediment layers at approximately 30 cm intervals were taken and a tape measurer indicated the length of the core in each image taken. These images were then stitched together and used for further analysis later.

Each 1.5m section of the sediment core was then split in half along the lines that reached top to bottom of the core (Fig. 8.10). Once split, the sediment cores were taken to the lab where the 'Archive' half was wrapped in cling film and packed away in a D tube. The D tubes were stored in the reefer until arrival in Southampton to be stored and examined. The other section, 'Working', was described, and examined in the lab on the research vessel before being wrapped and stored in D tubes in the reefer.

Figure 8.11. *Sediment record cleaning and initial scientific curiosity in the sediment grain sizes.*

Figure 8.12. *Cleaning excess sediments before the sediment record analysis.*

8.1.4. Labelling

Each 1.5-meter section was firstly marked with a line along the PVC liner with arrows indicating the top. Then section was labelled with letters at each end in accordance with each section order. If there were 6 sections of 1.5m within a section, then section 6 would be labelled A – B, Section 5 would be labelled B-C and so on (Fig 8.13).

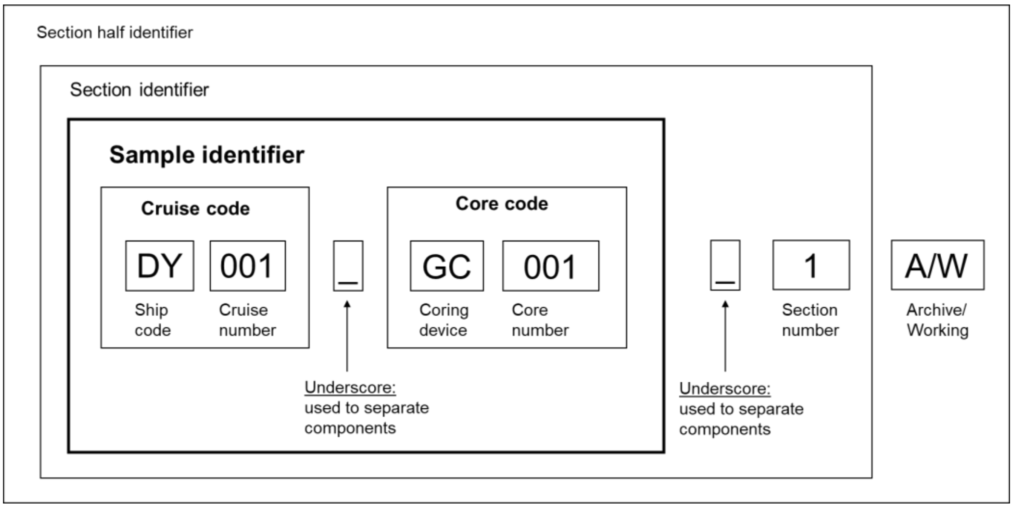


Figure 8.13. *The system used when labeling the 1.5 m section of PVC liners from the Piston cores.*

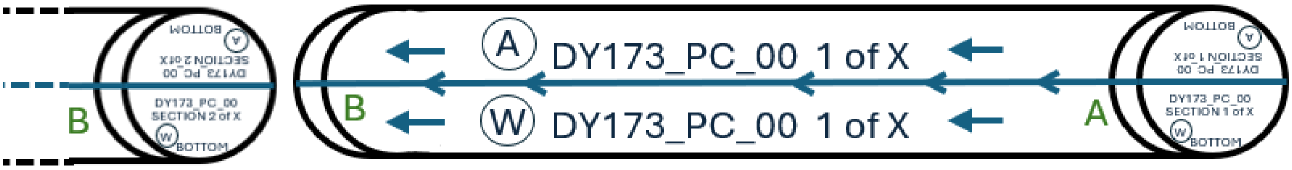


Figure 8.14*: The layout of the labelling system on each PVC 1.5m core section.*

Figure 8.14 shows a visual representation of the labelling system used to organize all piston cores collected during the DY173 cruise. The Archive and the Working sections of the core was labeled with (A) and (W). Additionally, the section number (1 of X) and piston core number (PCXX) were labeled alongside this. Section A-B would be the last section of the core, moving in a backwards labeling direction. Caps where also labeled to show working or archive, Piston core number, section and either the top or bottom placement of the core.

8.2. Results of Piston Coring

Thirty cores were taken on DY173, 26 of which were successful. The coring can be divided into three sections, from proximal to distal these are: canyon, channel and lobe. Nine cores were taken in the canyon (8 successful), 5 cores taken in the channel (4 successful) and 16 cores taken in the lobe (14 successful). All channel cores were located in the proximal part of the surveyed channel.

The following sections show the core locations and detailed sedimentary logs for cores collected in each area (canyon, channel, lobe). This is followed by overview figures highlighting general proximal to distal trends.

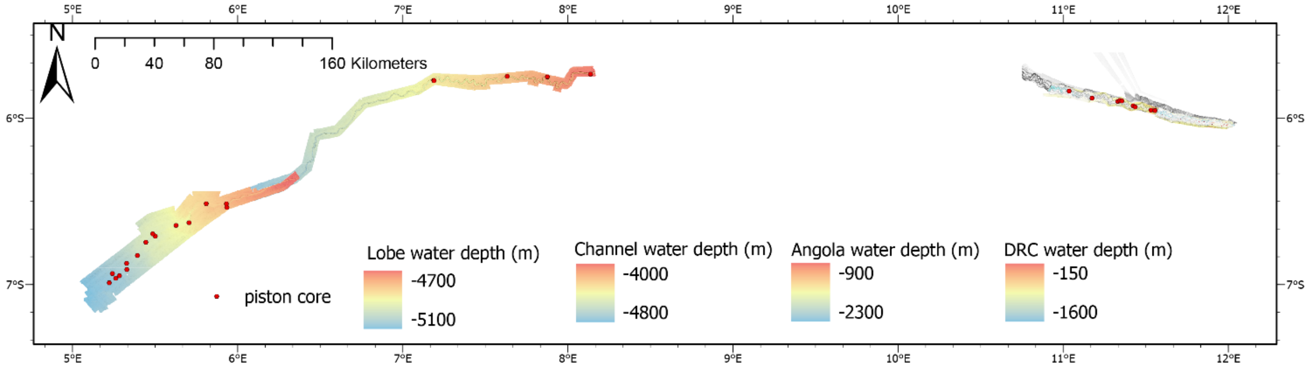


Figure 8.15. Map showing the bathymetry collected on DY173 and the 30 piston cores collected.

Table 8.1: Piston cores collected in DY173. For further details please refer to 'Sediment Cores and Samples Metadata' excel spreadsheet.

Core	**USBL**			**Environment**	

	Latitude	**Longitude**	**Depth**	**No. of sections**	**Core length (m)**		**Repeat of previous core**
PC_01	6 51.90992	5 20.79833	5029	6	9	Lobe	
PC_02	6 52.339	5 19.606	5033	7	9.23	Lobe	
PC_03	6 57.76370	5 15.673129	5069	6	9	Lobe	
PC_04	6 56.0477	5 14.4553	5058	7	9.62	Lobe	
PC_05	6 56.8229	5 17.0027	4948	7	10	Lobe	
PC_06	6 59.36251	5 13.32245	5071	7	9.93	Lobe	
PC_07	6 54.5715	5 19.708	5040	6	9	Lobe	
PC_08	6 49.524	5 23.557	4980	7	9.93	Lobe	
PC_09	6 44.7370	5 26.6082	4945	5	4.81	Lobe	
PC_10	6 42.5727	5 30.0373	4953	0	0	Lobe	
PC_11	6 41.71122	5 29.10801	4944	3	4.02	Lobe	JC187_PC01; KZR-06
PC_12	6 38.67209	5 37.58692	4914	1	1.02	Lobe	
PC_13	6 37.70016	5 42.31412	4879	3	4.12	Lobe	
PC_14	6 30.82693	5 48.56343	4827	1	0.47	Lobe	
PC_15	6 32.19291	5 56.06676	4795	7	9.77	Lobe	
PC_16	6 30.90001	5 55.89668	4808	0	0	Lobe	JC187_PC16, PC15
PC_17	5 53.92638	11 19.82575	1851	2	2.36	Canyon	JC187_PC08,07
PC_18	5 53.572435	11 20.57721	1853	5	7.5	Canyon	
PC_19	5 53.75436	11 21.31326	1849	1	0.75	Canyon	
PC_20	5 55.50685	11 25.4338	1726	5	7.5	Canyon	JC87_PC12
PC_21	5 55.93118	11 26.15355	1656	3	3.4	Canyon	
PC_22	5 57.07410	11 31.91368	1578	3	3.38	Canyon	
PC_23	5 57.22317	11 33.35949	1582	0	0	Canyon	
PC_24	5 52.73507	11 10.48467	2032	1	1.07	Canyon	JC187_PC17
PC_25	5 50.192975	11 02.14630	2189	1	0.31	Canyon	JC187_PC04

PC_26	5 44.09347	08 08.21981	4153	0	0	Channel	JC187_PC18 KZAI-06
PC_27	05 45.06259	07 52.5361	4238	2	1.75	Channel	
PC_28	5 44.88215	7 37.94436	4316	2	3.04	Channel	
PC_29	5 46.33271	11 24905	4435	2	3	Channel	
PC_30	5 46.44780	7 11.33787	4522	1	1.4	Channel	

8.2.1. Piston Cores in Upper Canyon (Angola Waters)

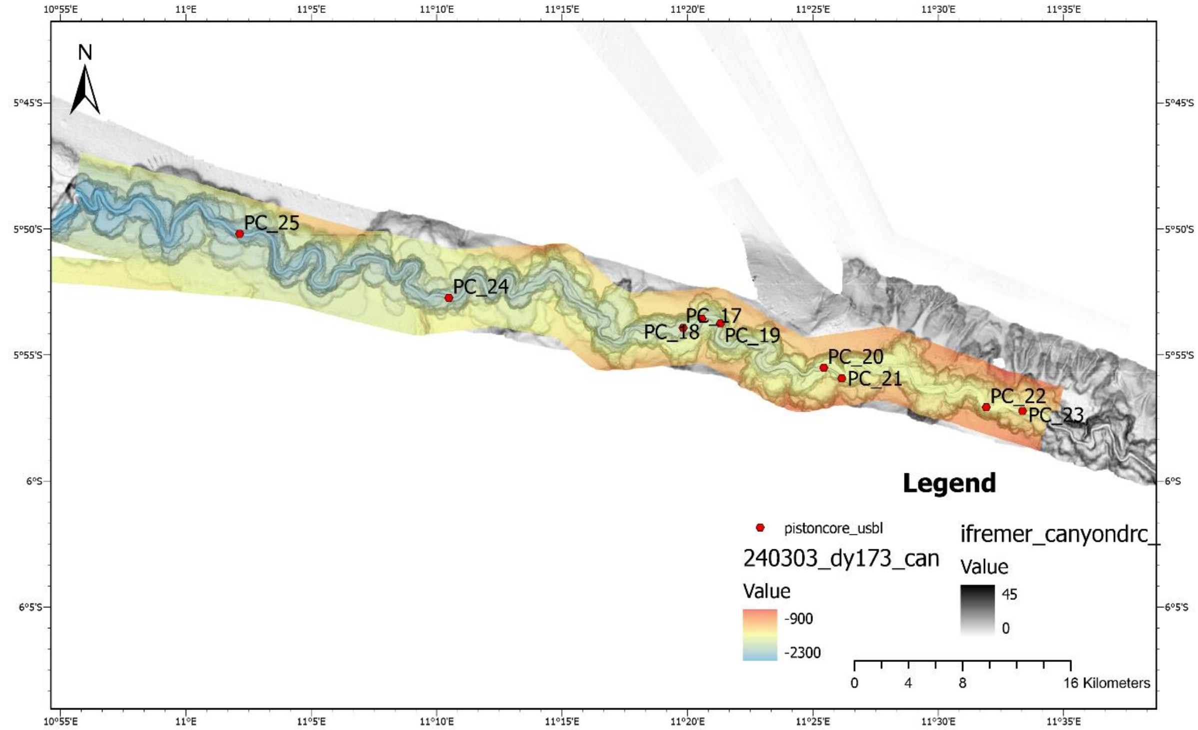


Figure 8.2: Location of the 9 piston cores collected in the canyon during DY173.

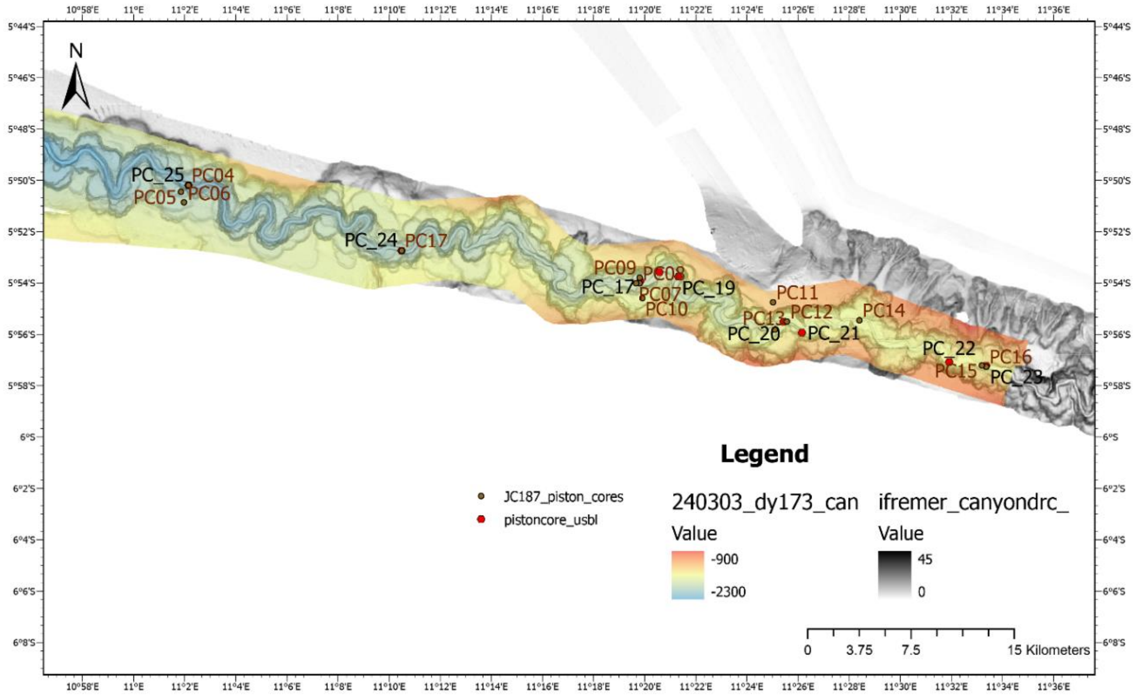


Figure 8.3 Location of the 9 piston cores collected in the canyon in DY173 (in red) and the sites of the piston cores collected in JC187 (in brown).

8.2.1.1. PC23 and PC22

PC23 and PC22 are the most proximal cores deployed. These cores aimed to target an area of deposition observed in the 2024-2019 difference maps. This site of deposition is interesting as there is no obvious landslide-dam encouraging sediment deposition. PC23 was unsuccessful. PC23 was at the same site as JC_187_PC16, which contained remobilised sand.

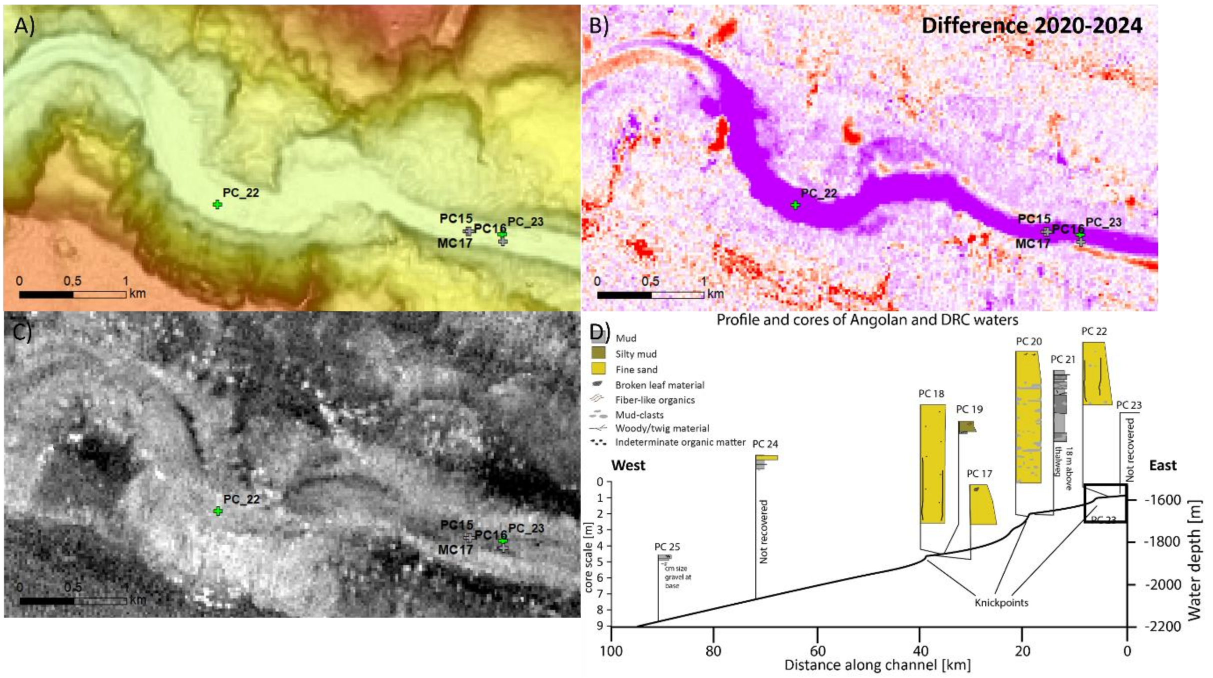


Figure 8.4 A) 2024 bathymetry showing cores collected in 2024 (green crosses) and those collected in 2019 (grey crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of core transect.

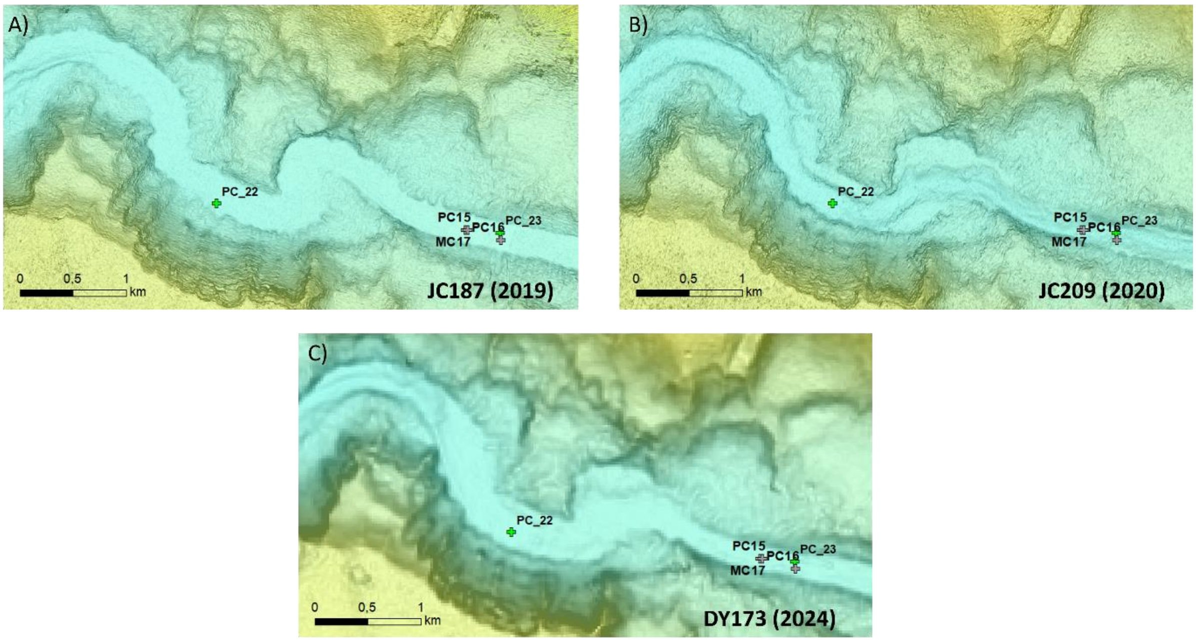


Figure 8.5. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses) and in 2019 (grey crosses).

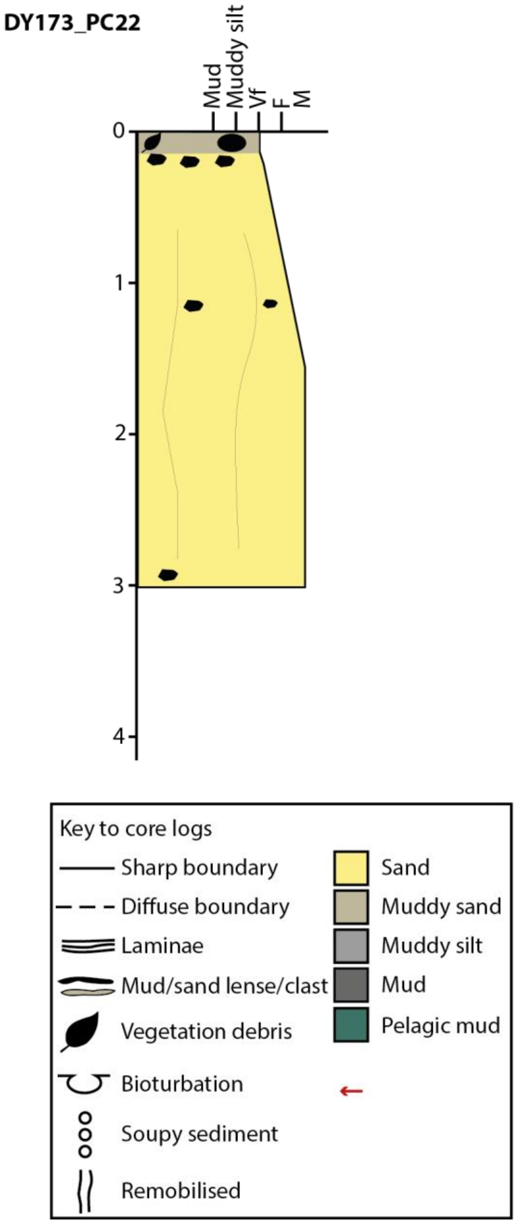


Figure 8.6 Detailed log of PC22.

8.2.1.2. PC21 and PC20

PC21 and PC20 were taken near the top of the canyon and aimed to target the erosional area of a knickpoint (PC20) and the area just above the head to the knickpoint to see what would be eroded as the knickpoint moved further up the canyon (PC21). Unfortunately PC21 was slightly off-axis of the main thalweg, and captured material out of the thalweg. PC20 was 300 m downstream of JC187_PC12.

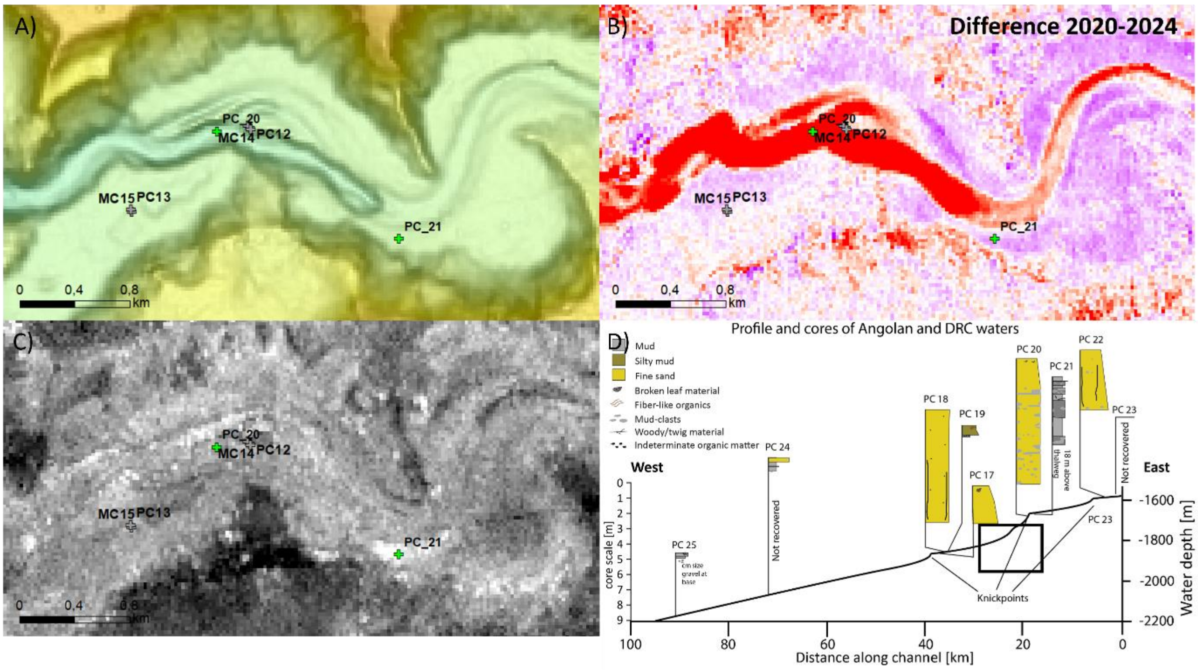


Figure 8.7 A) 2024 bathymetry showing cores collected in 2024 (green crosses) and those collected in 2019 (grey crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of core transect.

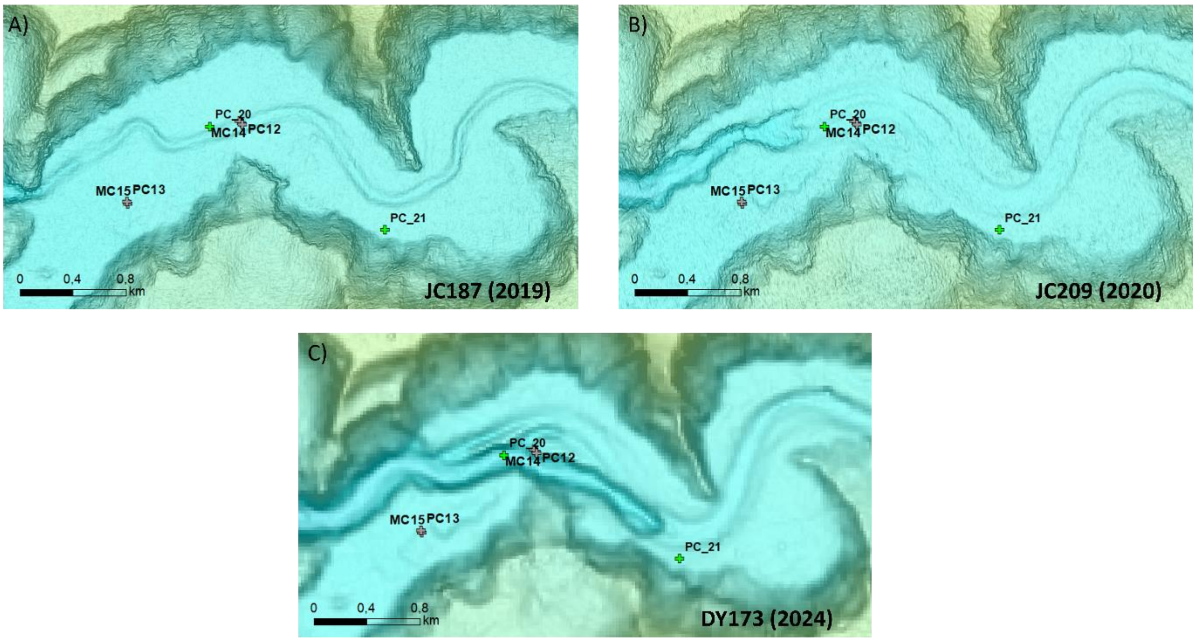


Figure 8.8. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses) and in 2019 (grey crosses).

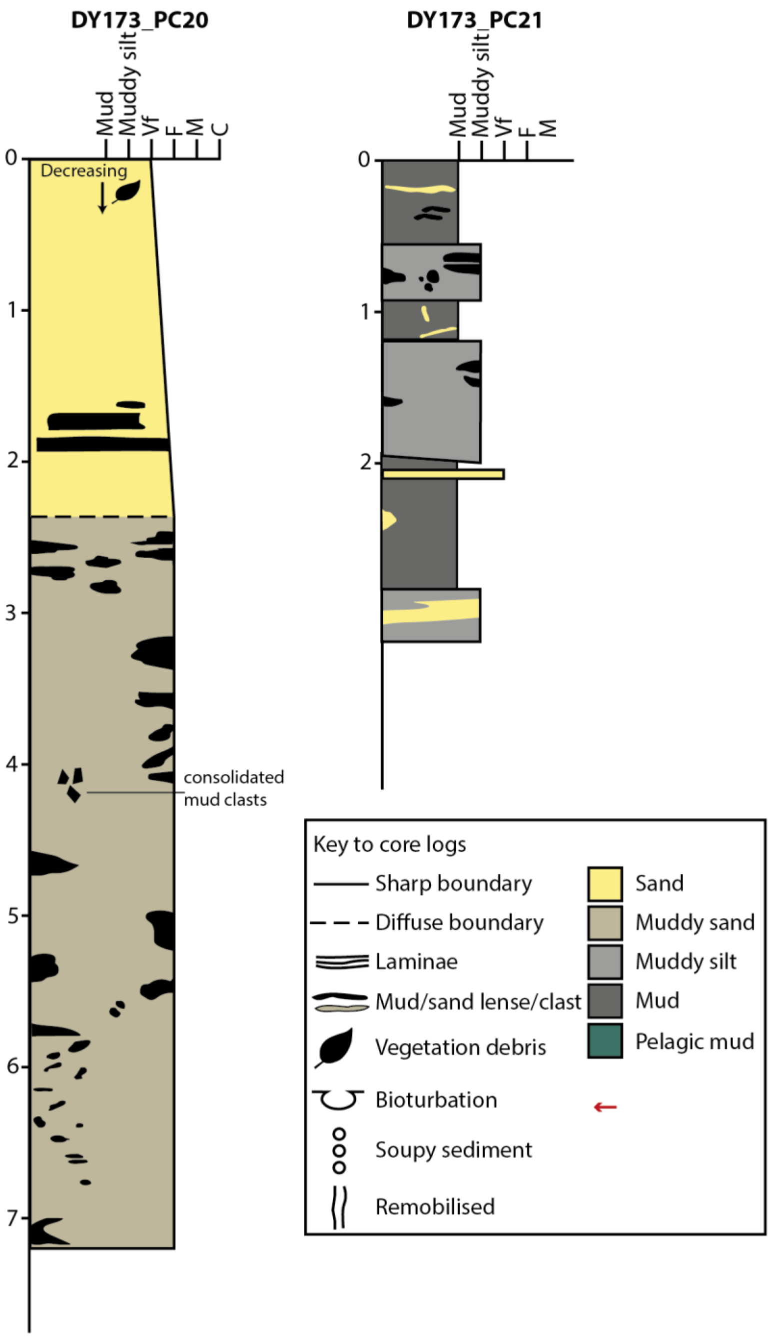


Figure 8.9. Detailed log of PC20 and PC21.

8.2.1.3. PC17, PC18 and PC19

PC17 and PC18 are in a transect of deposition above a landslide dam in the 2020-2024 difference map. PC19 is located slightly more upstream in a zone of erosion. PC17 is near cores JC187_PC08 and JC187_PC07, which were located in channel thalweg in 2019 (since then, the thalweg has shifted slightly).

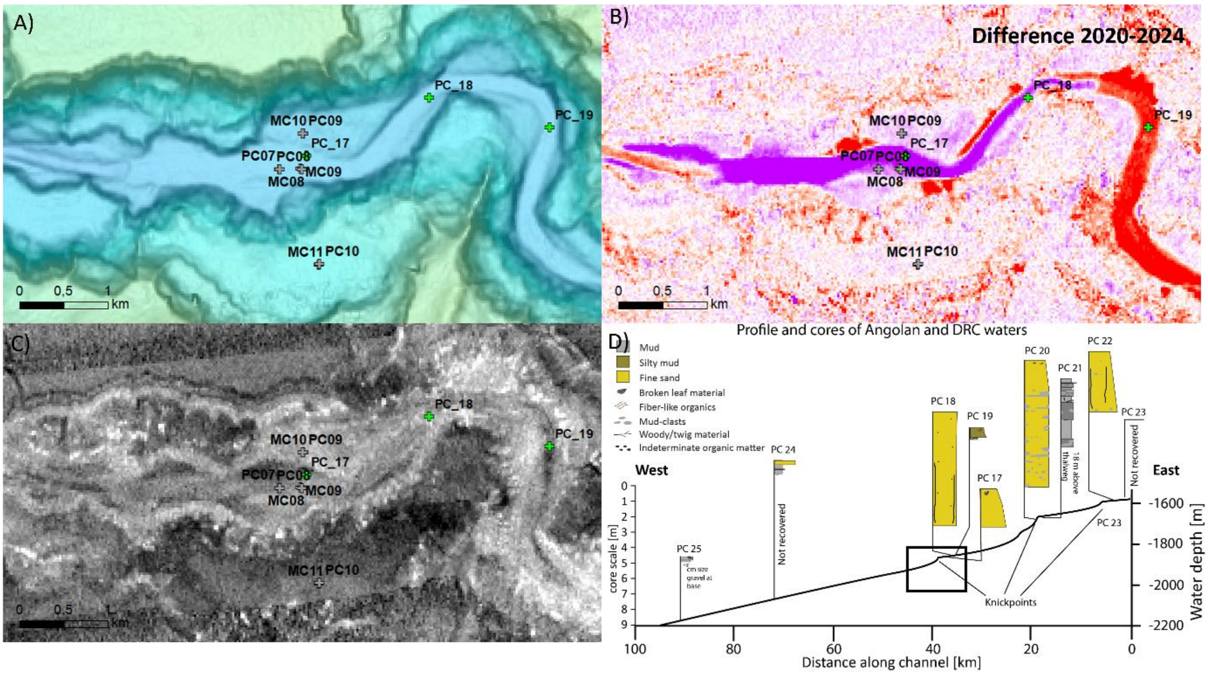


Figure 8.10 A) 2024 bathymetry showing cores collected in 2024 (green crosses) and those collected in 2019 (grey crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of core transect.

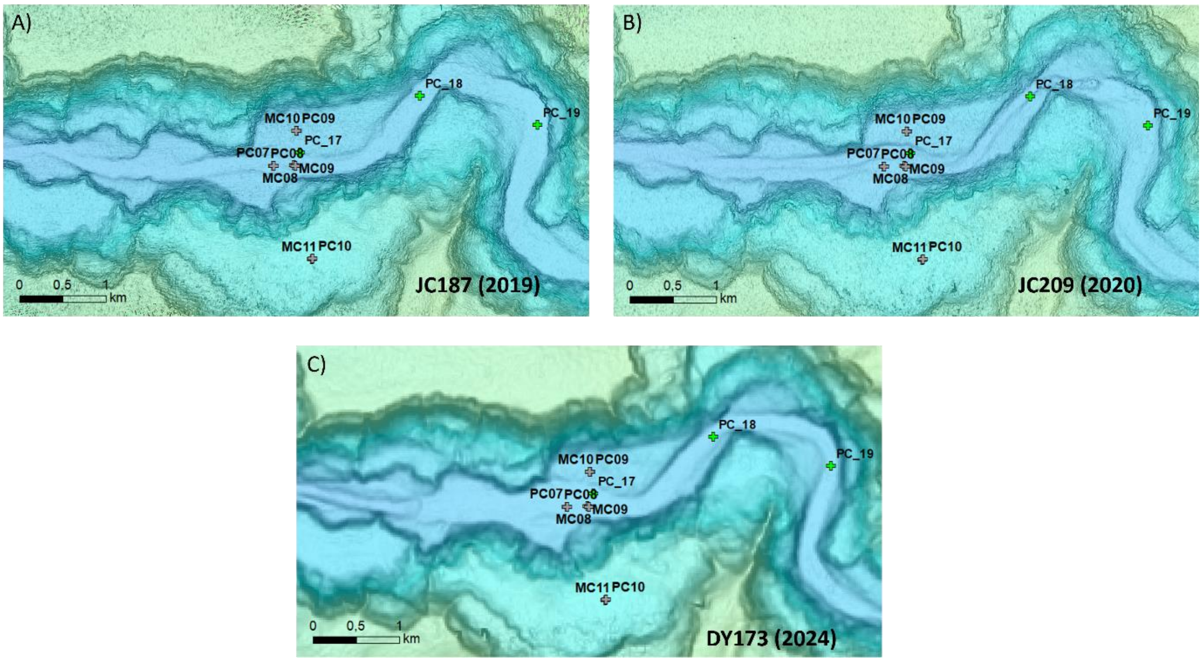


Figure 8.11. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses) and in 2019 (grey crosses).

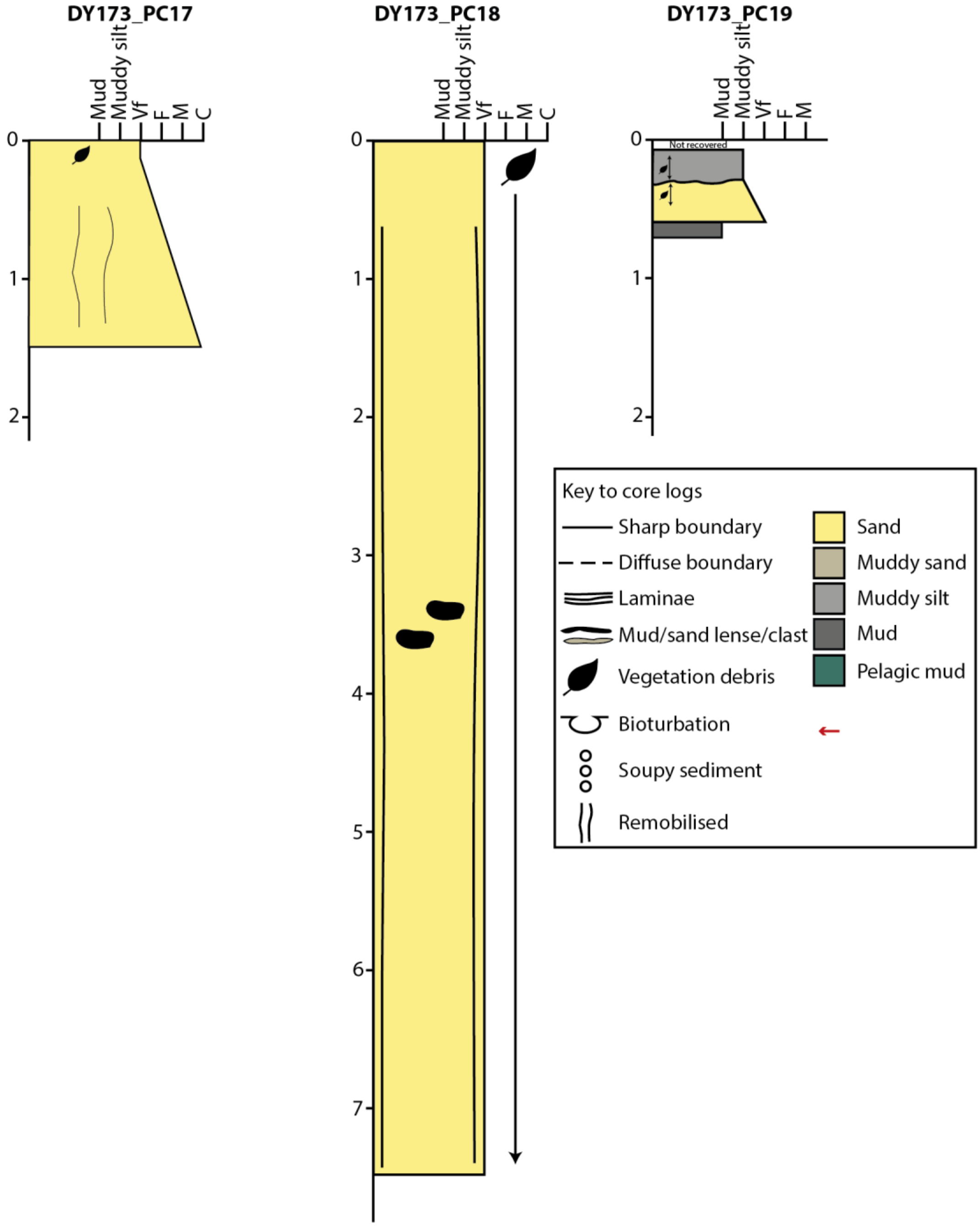


Figure 8.12 Detailed logs of PC17, PC18, and PC19.

8.2.1.4. PC24

PC24 is a repeat of JC187_PC17. This site had limited change on difference maps between 2019-2020 and 2020-2024.

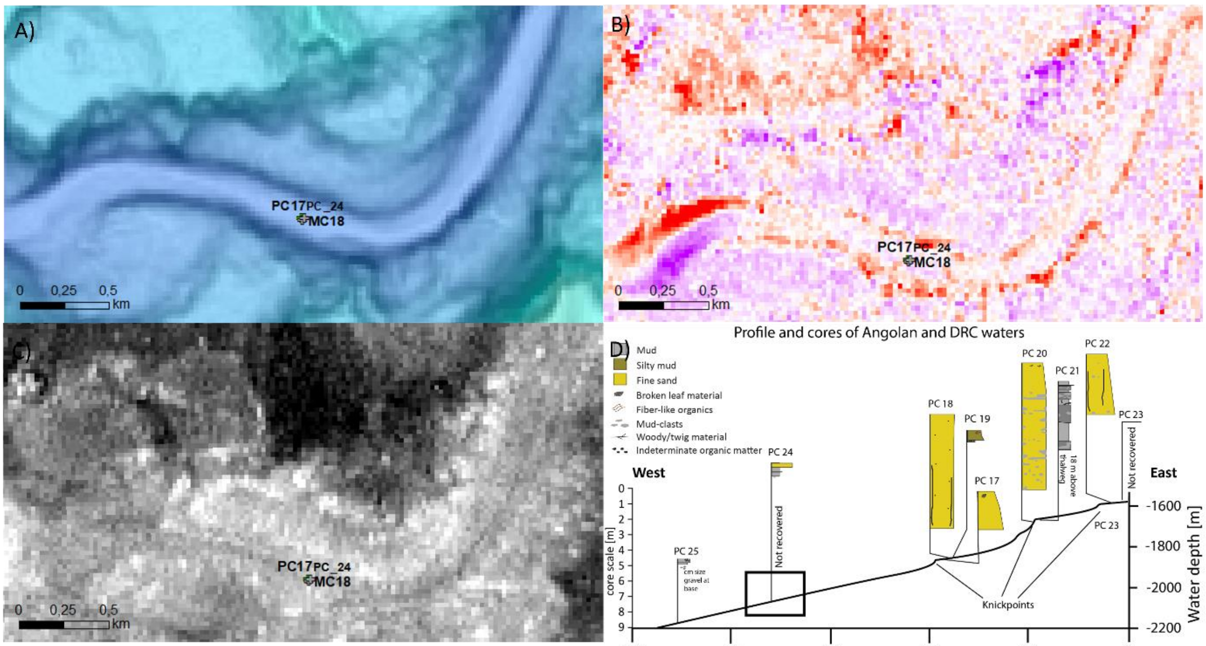


Figure 8.13. A) 2024 bathymetry showing cores collected in 2024 (green crosses) and collected in 2019 (grey crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of core transect.

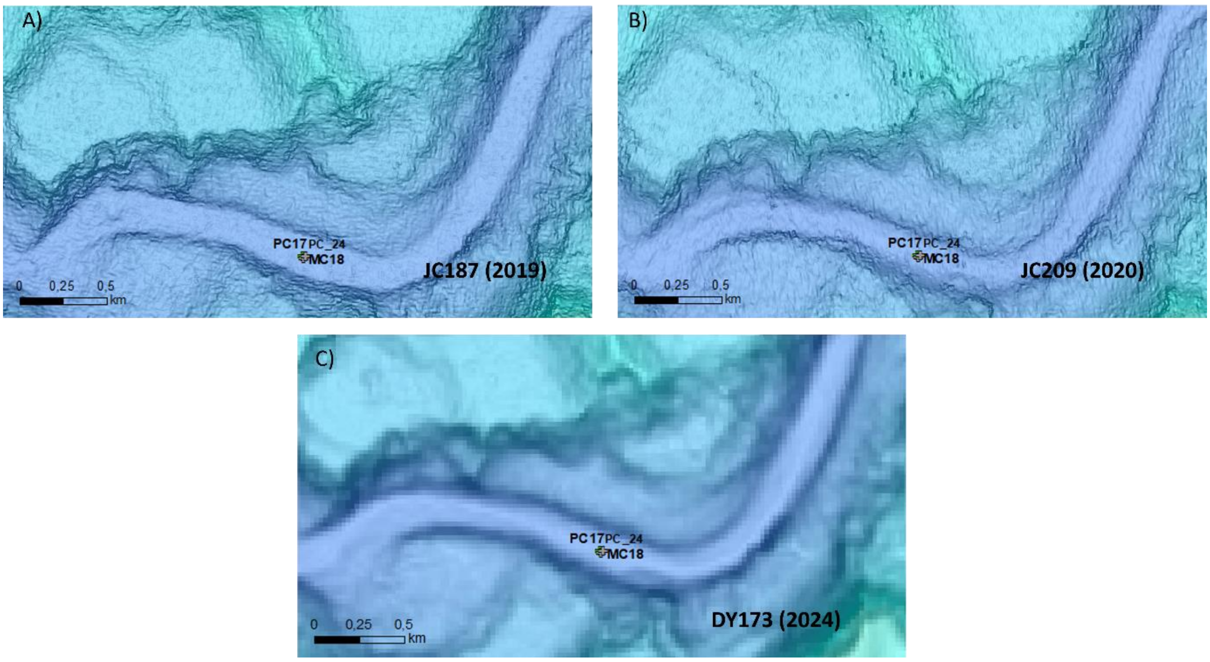


Figure 8.14. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses) and in 2019 (grey crosses).

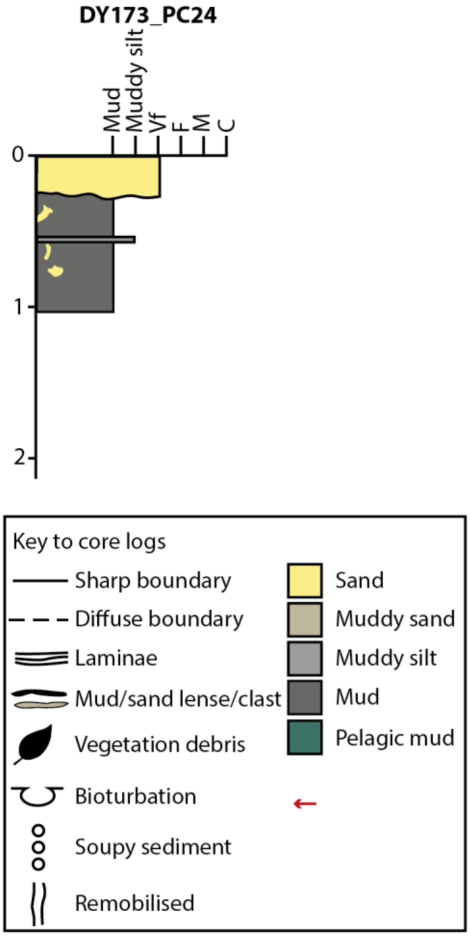


Figure 8.15. Detailed log of PC24.

8.2.1.5. PC25

PC25 is a repeat of JC187_PC04. This site had limited change on difference maps between 2019-2020 and 2020-2024.

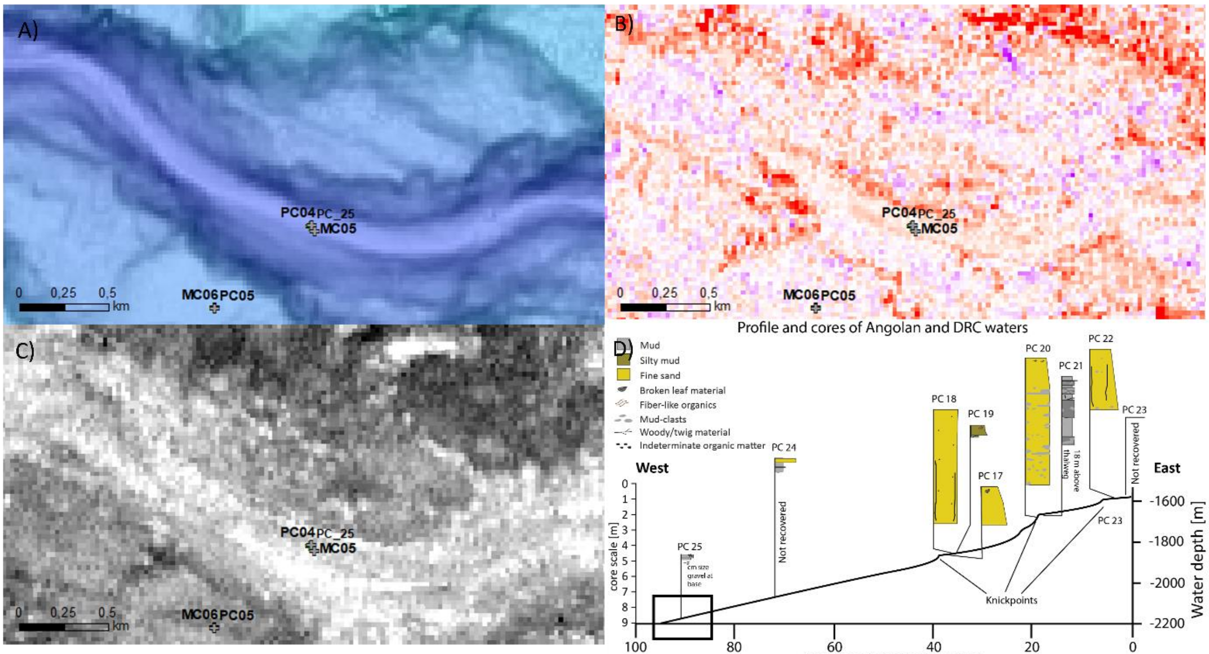


Figure 8.16. A) 2024 bathymetry showing cores collected in 2024 (green crosses) and collected in 2019 (grey crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of core transect.

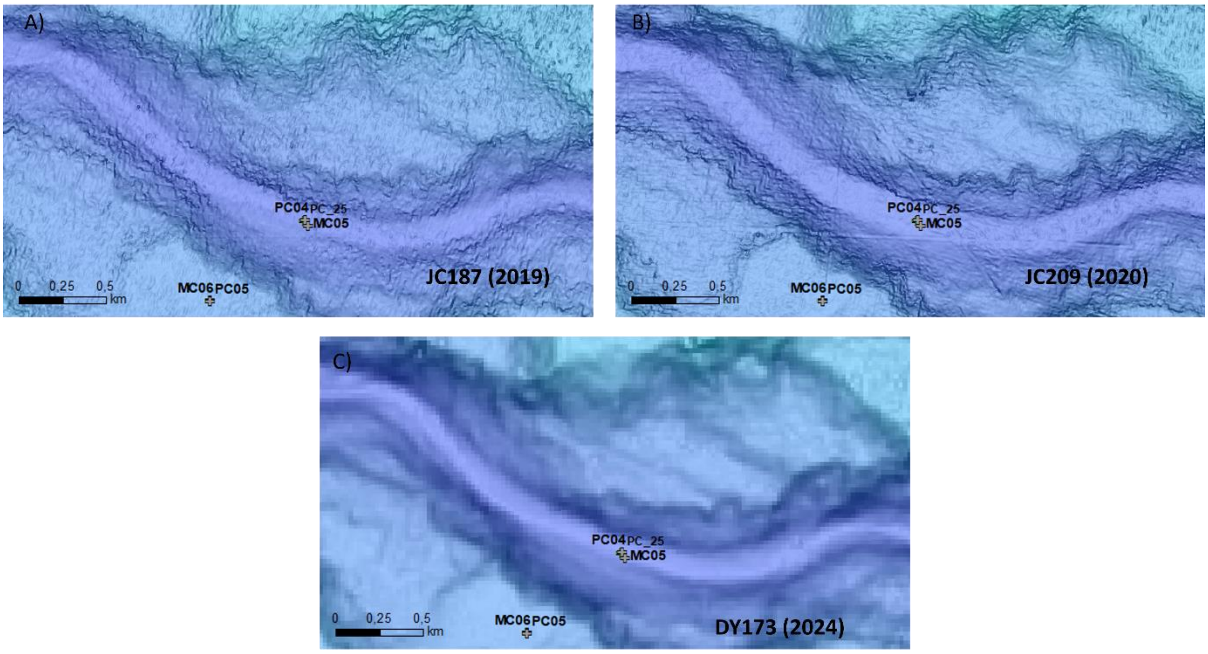


Figure 8.17. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and locations of cores collected 2024 (green crosses) and in 2019 (grey crosses). PC25 is at the same site as JC197_PC04.

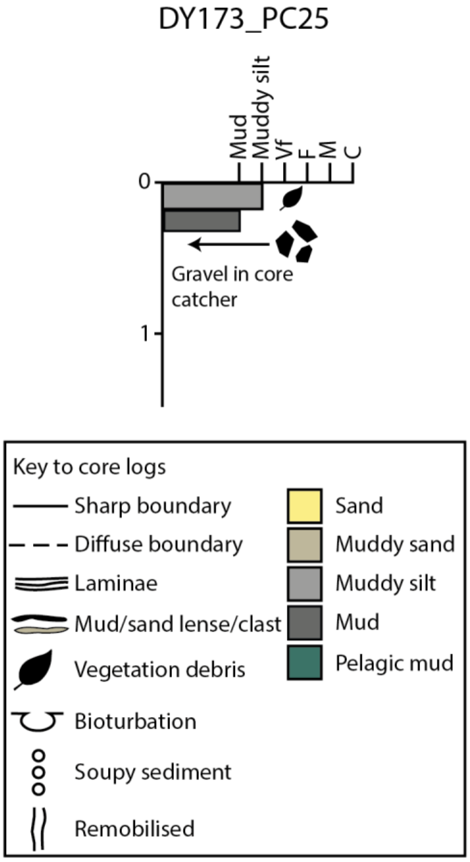


Figure 8.18. Detailed log of PC25.

8.2.2. Channel cores

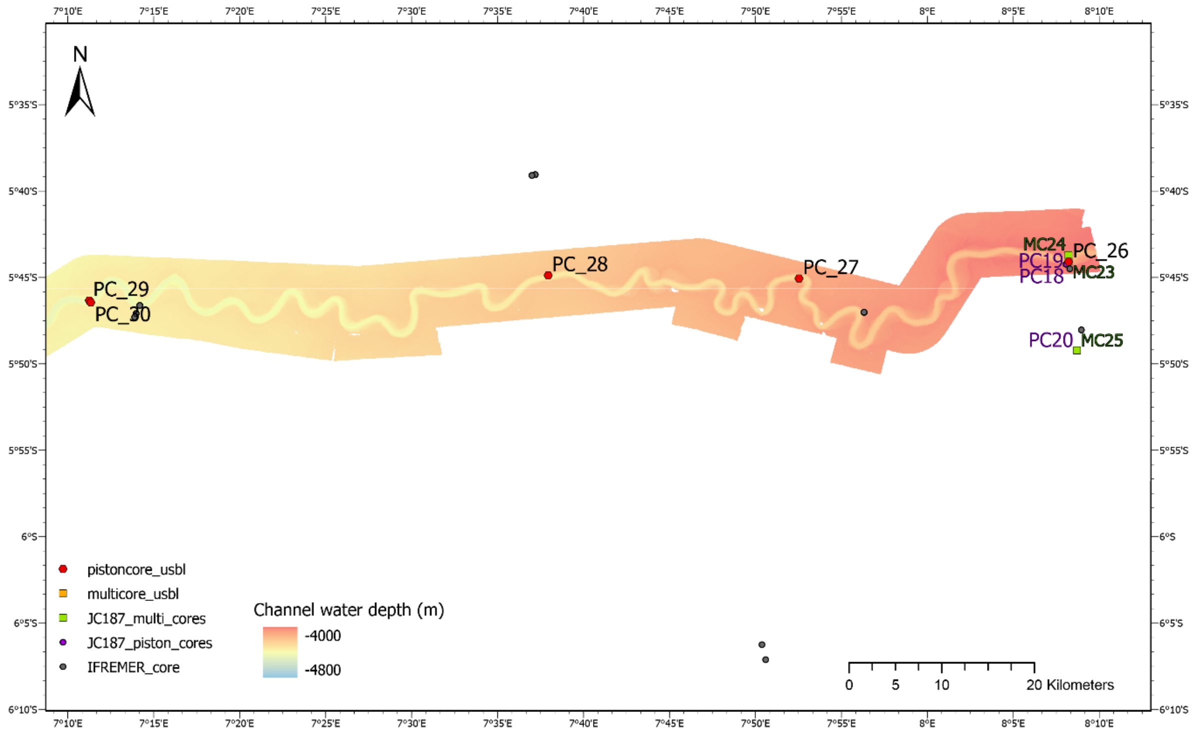


Figure 8.19. Location of the 5 piston cores collected in the channel in DY173 (in red) and the sites of the cores collected in JC187 (in purple and green).

8.2.2.1. PC26

PC26 was located at the most proximal part of the surveyed channel area on a site of limited change on the difference maps. The core was taken at the centre of thalweg, near to JC187_PC18, which was located on the edge of the channel outer bend. PC26 unfortunately failed to recover any sediments. As a result of this, subsequent channel cores (apart from PC30) targeted low terraces which were expected to be muddier and thus easier to core.

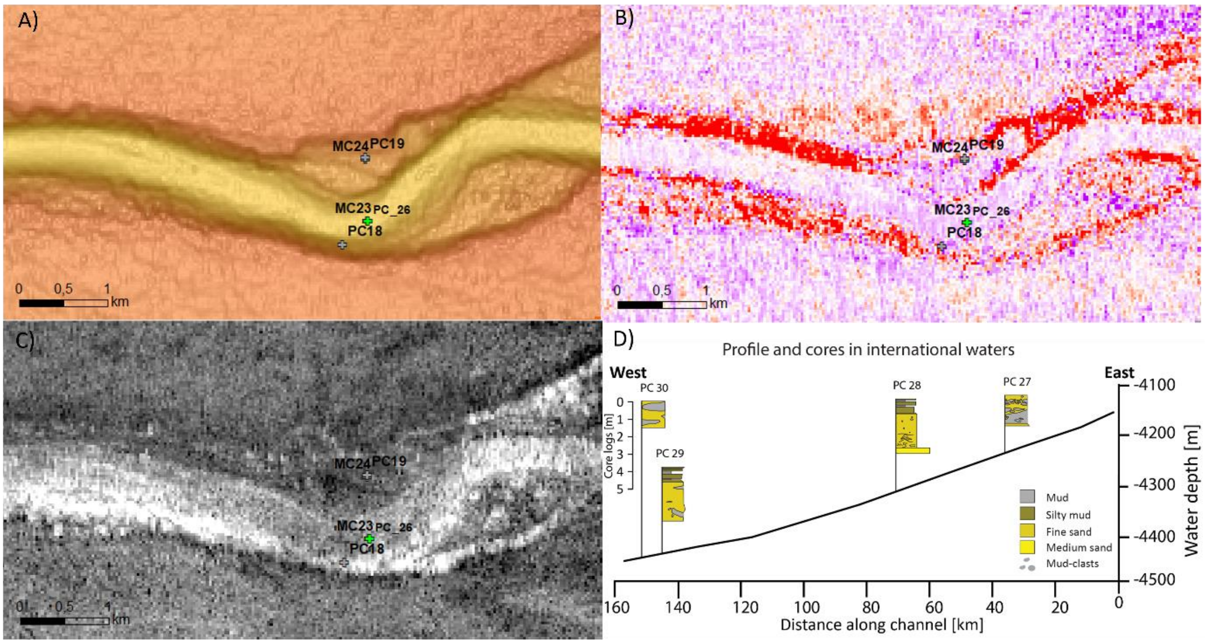


Figure 8.20. A) 2024 bathymetry showing cores collected in 2024 (green crosses) and collected in 2019 (grey crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of channel transect.

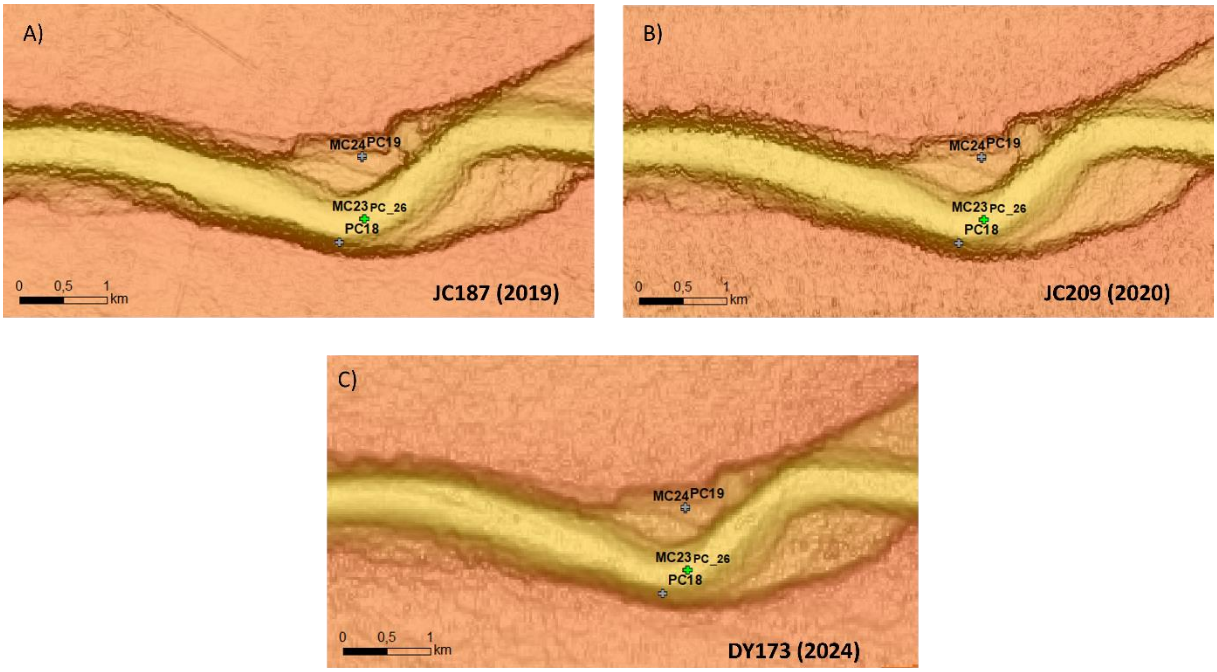


Figure 8.21. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses) and in 2019 (grey crosses).

8.2.2.2 PC27

PC27 was located on a low terrace inside a meander bend, 25 m above the channel floor. This area showed no change within the resolution of the 2024-2020 difference map.

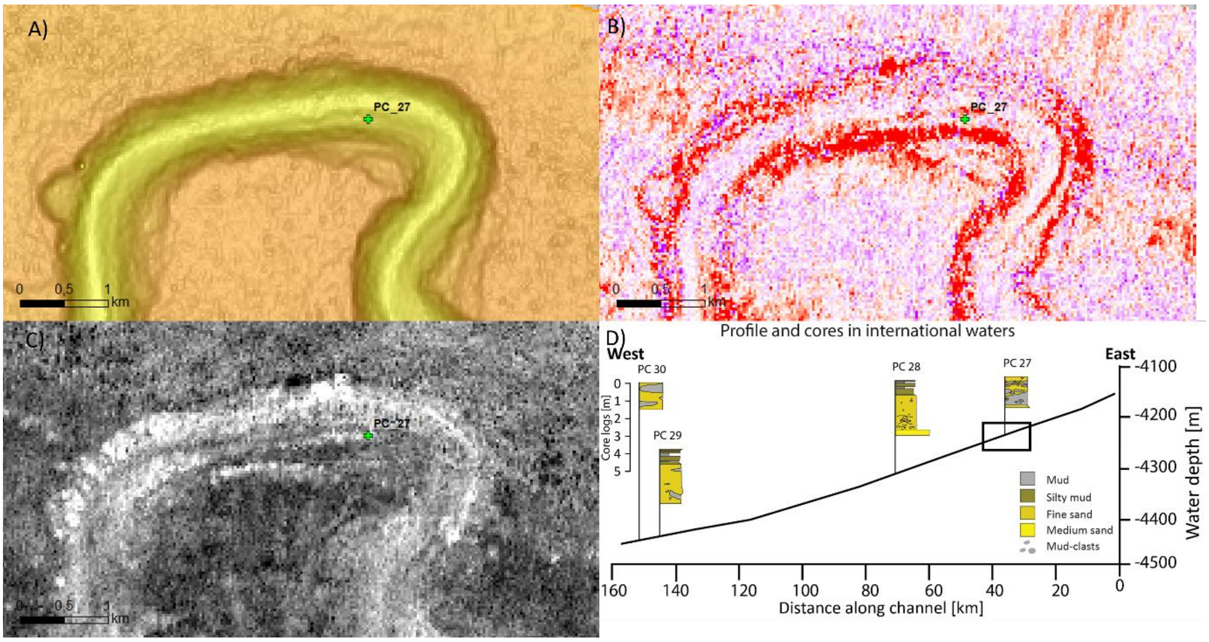


Figure 8.22. A) 2024 bathymetry showing cores collected in 2024 (green crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of channel transect.

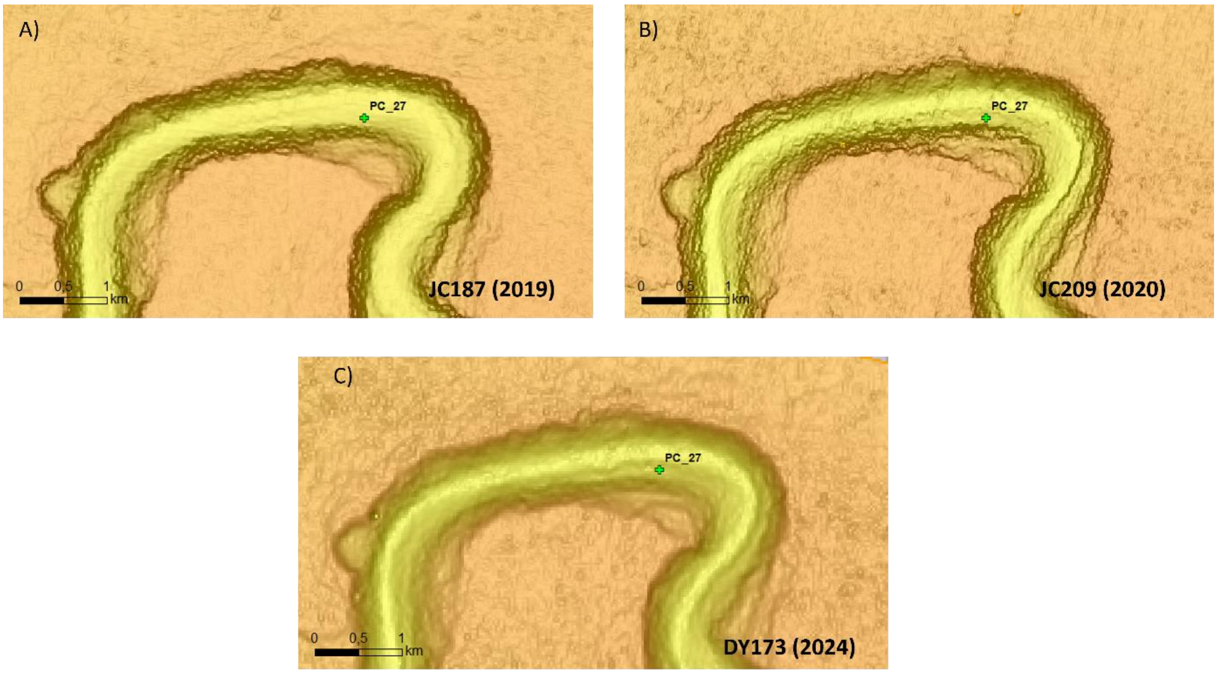


Figure 8.23. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses).

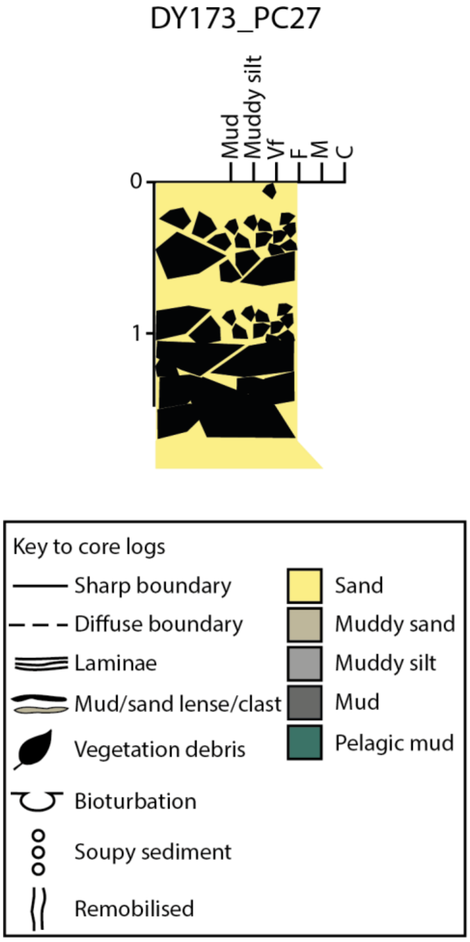


Figure 8.24 Detailed log of PC27.

8.2.2.3. PC28

Core PC28 was also located on a low terrace, situated 28 m above the channel floor, on a straight section of the channel. This area showed no change within the resolution of the 2024-2020 difference map.

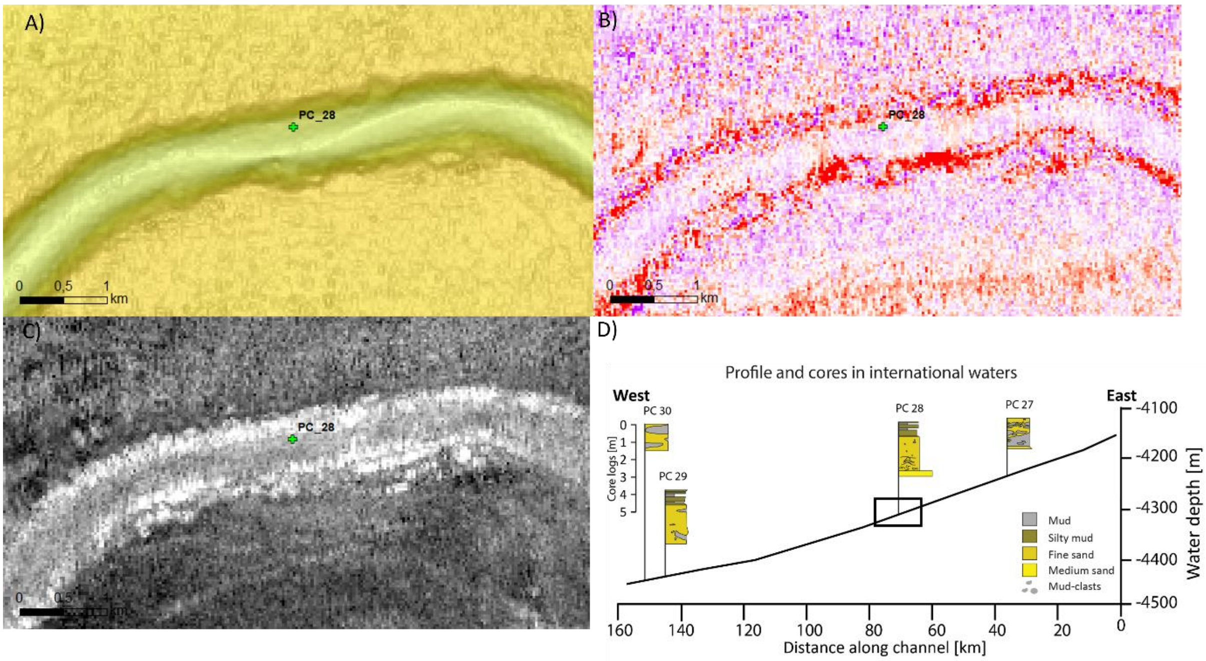


Figure 8.25. A) 2024 bathymetry showing cores collected in 2024 (green crosses; B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of channel transect.

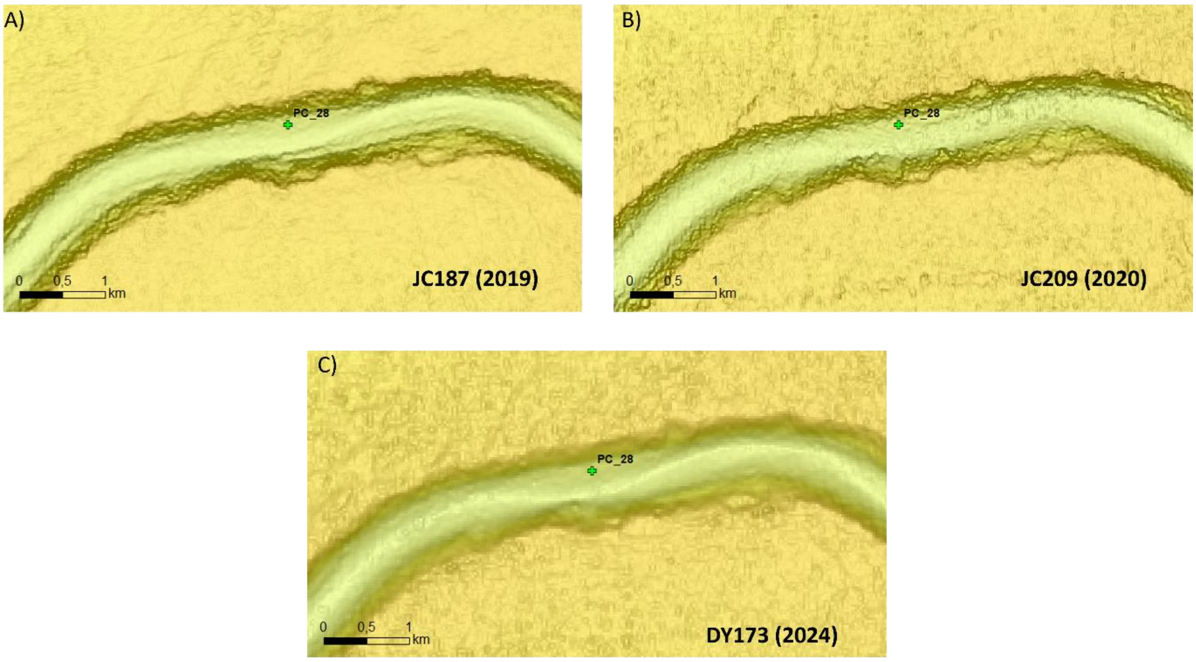


Figure 8.26. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses) and in 2019 (grey crosses).

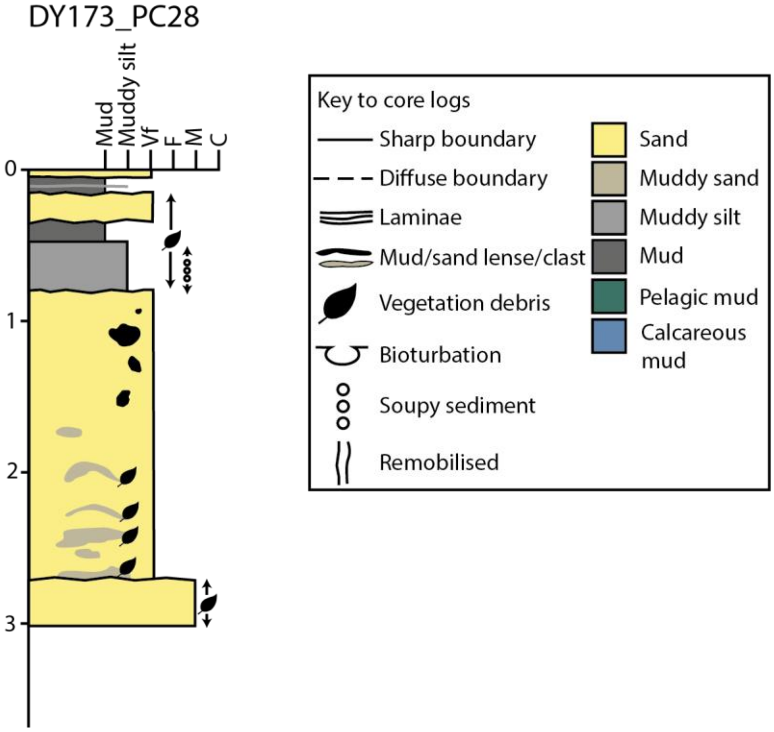


Figure 8.27. Detailed log of PC28.

8.2.2.4. PC29 and PC30

These cores formed part of transect across a meander bed, PC29 was located inside the meander bend on a slope 21 m above the channel thalweg. PC30 was in the thalweg of the meander bend.

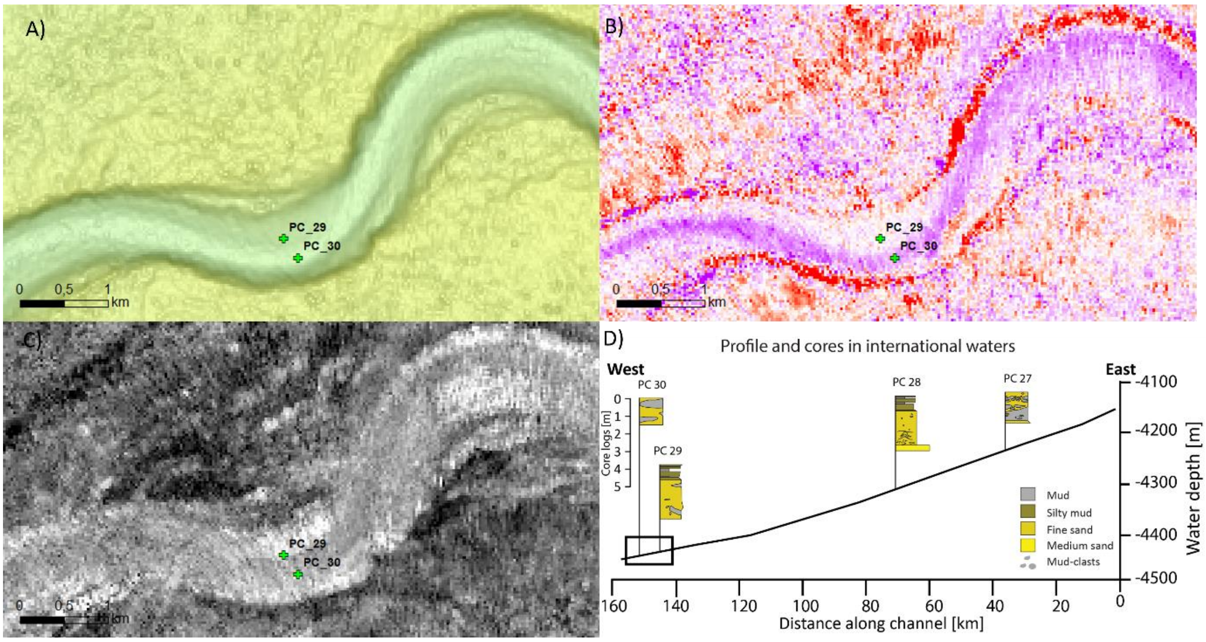


Figure 8.28. A) 2024 bathymetry showing cores collected in 2024 (green crosses); B) Difference map between 2020 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) location of cores on summary diagram of channel transect.

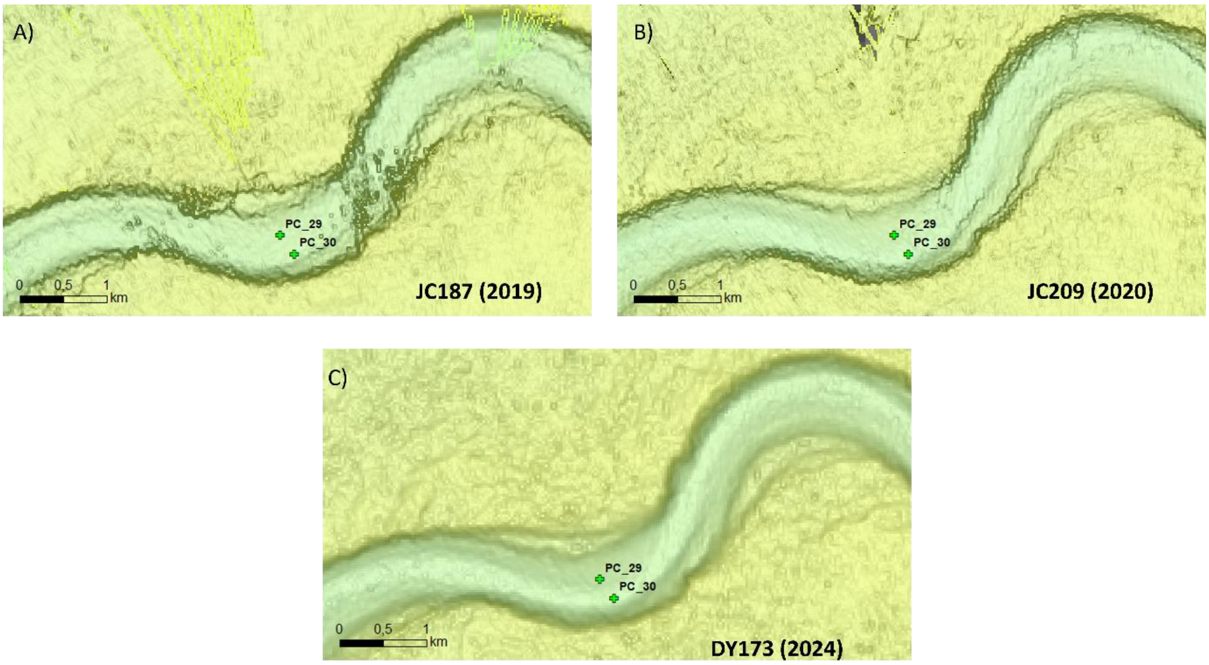


Figure 8.29. Changes in bathymetry between A) 2019, B) 2020 and C) 2024, and core locations of cores collected 2024 (green crosses).

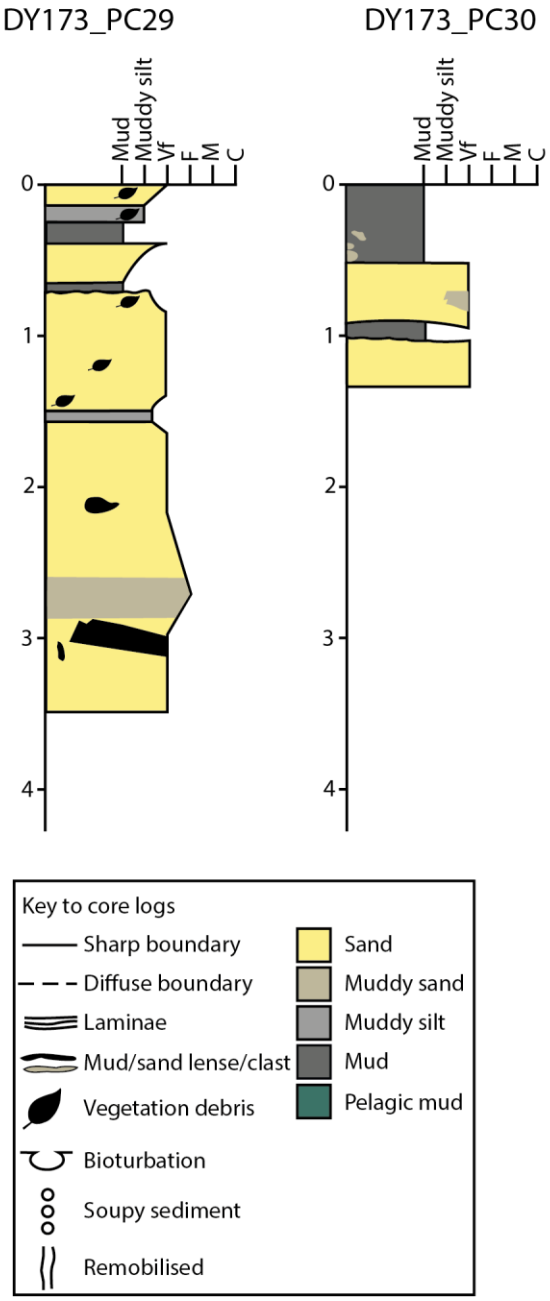


Figure 8.30. Detailed logs of PC29 and PC30.

8.2.3. Lobe cores

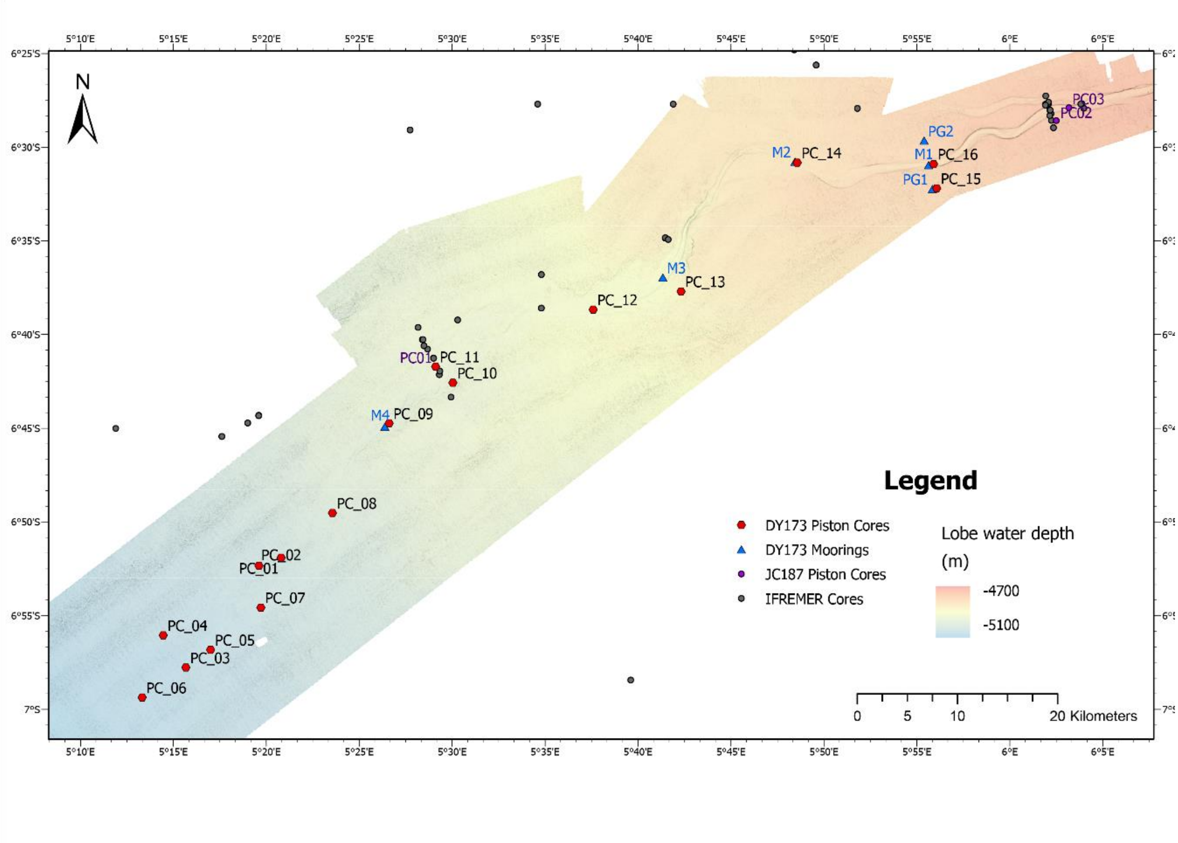


Figure 8.31. Location of the 16 piston cores collected on the lobe in DY173. Also shown are DY173 mooring locations and core sites of JC187 and previous IFREMER cruises.

8.2.3.1 PC14, PC15 and PC16

PC14, PC15 and PC16 were taken at the top of the lobe system, where the channel is still clearly visible. PC16 was taken in the channel thalweg, just proximal of NERC mooring M1, but was unfortunately unsuccessful. PC15 was taken outside of the channel on the overbank levee, just proximal of IFREMER mooring PG1. PC14 was taken slightly further down the channel, where it is slightly less confined, at the site of NERC mooring M2.

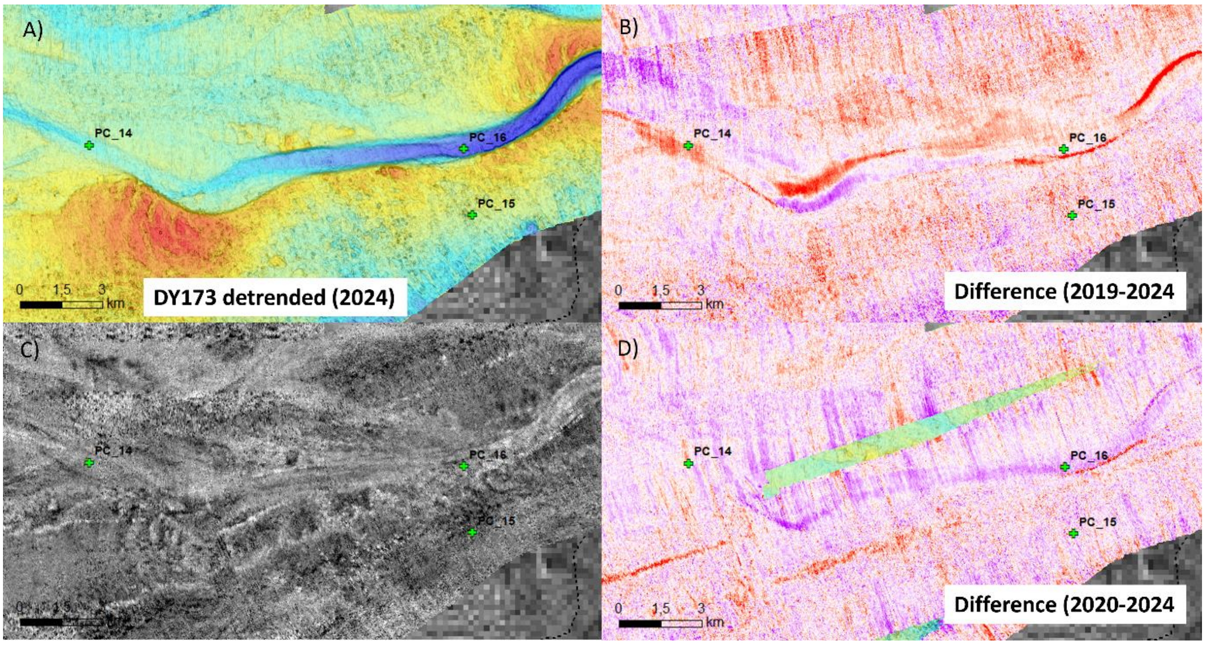


Figure 8.32. A) 2024 detrended bathymetry showing cores collected in 2024 (green crosses); B) Difference map between 2019 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) difference map between 2020 and 2024 (red = erosion, purple = deposition).

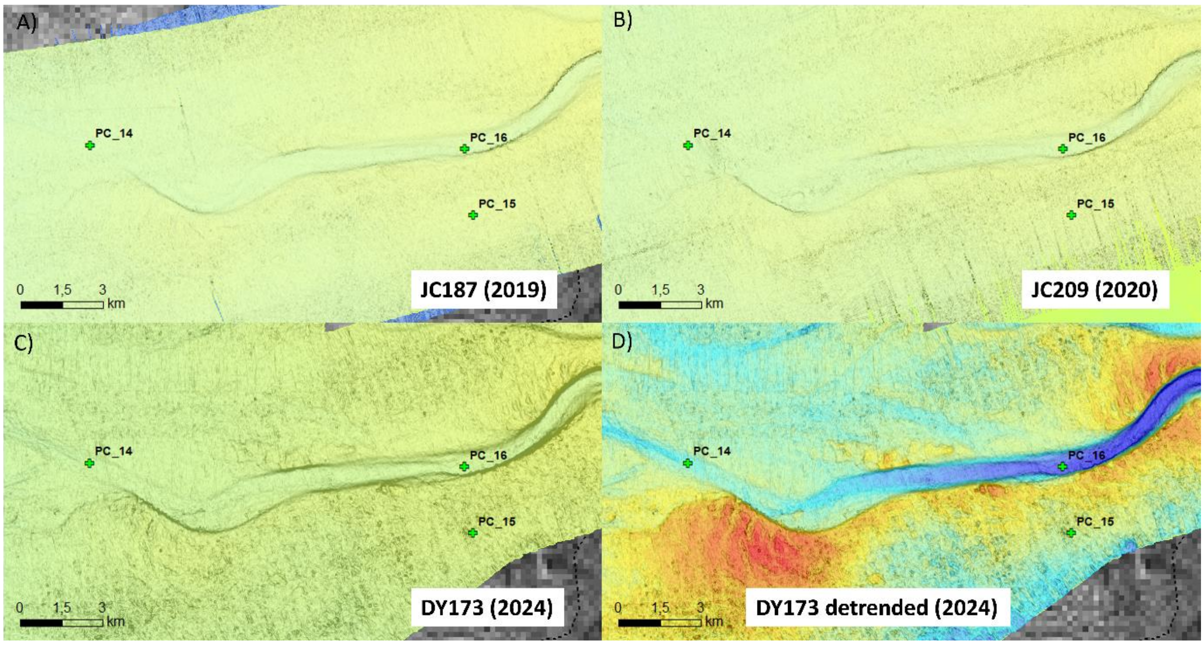


Figure 8.33. Changes in bathymetry between A) 2019, B) 2020, and C) 2024. D) shows detrended 2024 bathymetry.

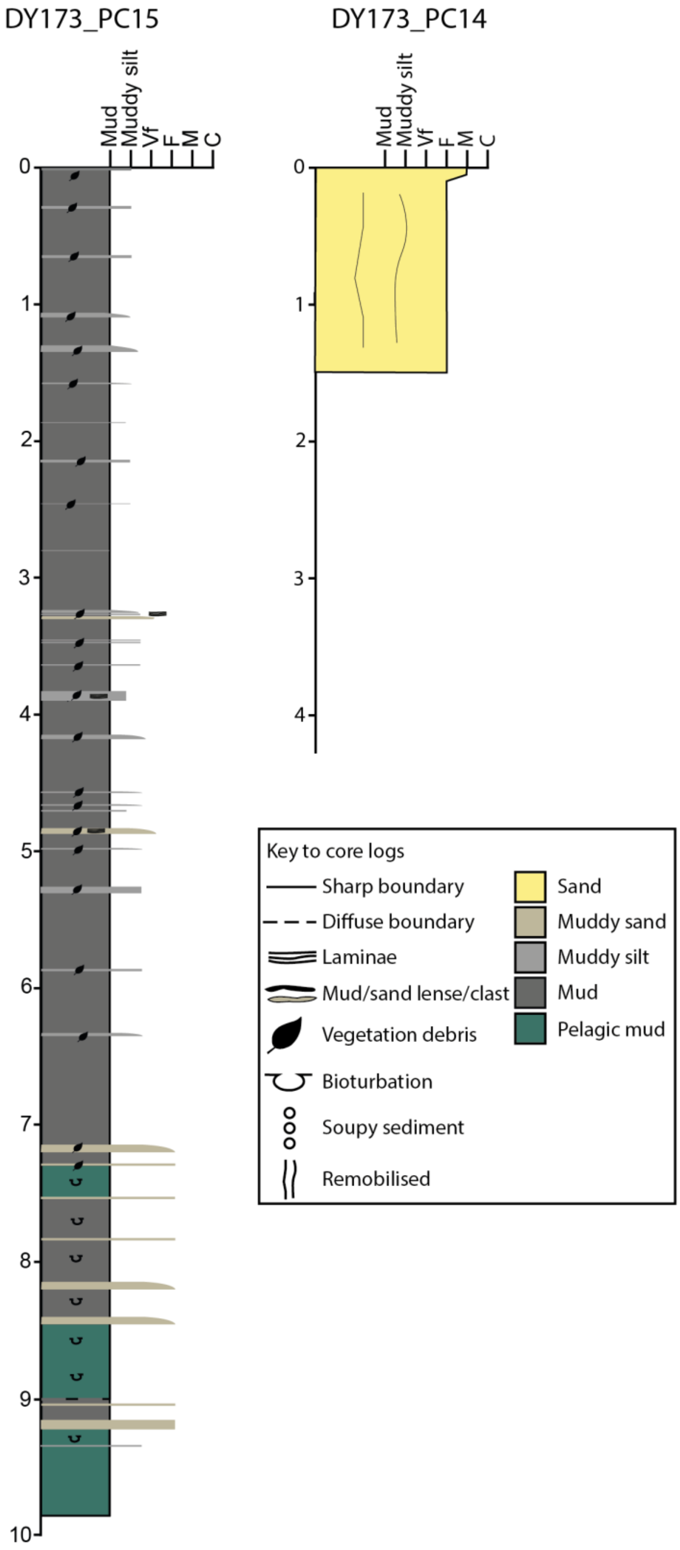


Figure 8.34. Detailed log of PC14 and PC15. PC16 was unsuccessful.

8.2.3.2. PC09 to PC13

The five cores from PC09 to PC13 cover an interesting area of the lobe, where the channel changes from confined to unconfined and then back to confined. PC13 is the most proximal core of this group and was taken from an area outside of the channel meander bend (24 m above the thalweg) within an area of ragged edges, which may represent landslide scars. PC13 was ~2.3 km to the south-east of NERC Mooring M3.

PC12 was located inside the channel as it became wider before becoming fully unconfined. Difference maps from 2019-2024 and 2020-2024 suggest this was a site of deposition. PC10 and PC11 were taken as a roughly north-south transect where the channel was fairly unconfined. This area was surveyed in high-resolution by IFREMER in 2011. Profiles across this area showed that PC11 was in a site of deposition and PC10 a site of erosion between 2019 and 2020. PC11 was a repeat of JC187_PC01.

Core PC09 was in a site where the channel became more confined, just proximal of NERC mooring M4.

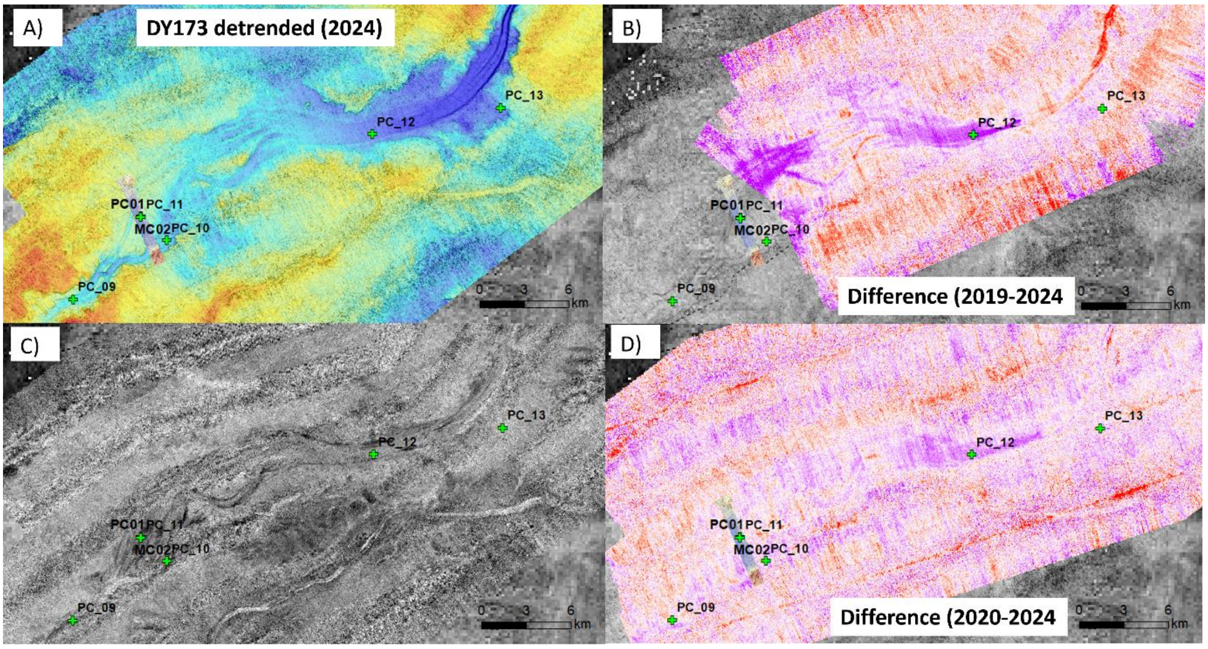


Figure 8.35. A) 2024 detrended bathymetry showing cores collected in 2024 (green crosses); B) Difference map between 2019 and 2024 (red = erosion, purple = deposition); C) backscatter from 2024 survey; D) difference map between 2019 and 2024 (red = erosion, purple = deposition).

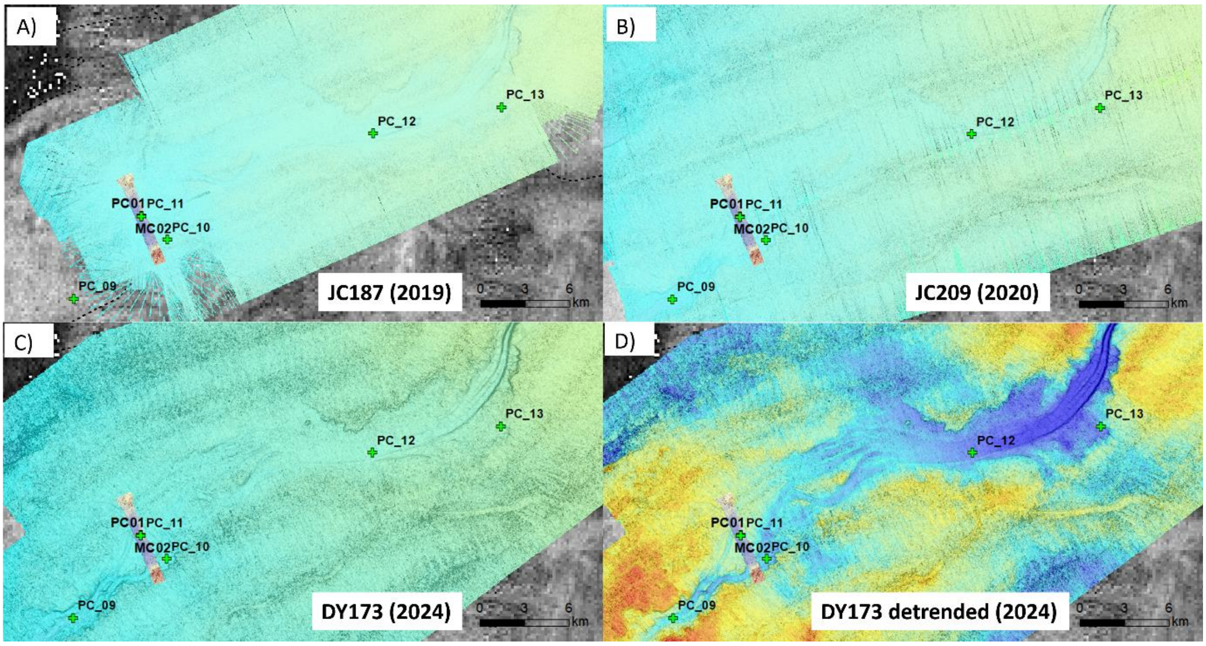


Figure 8.36. Changes in bathymetry between A) 2019, B) 2020, and C) 2024. D) shows detrended 2024 bathymetry. Small strip of red-blue bathymetry across PC11 and PC10 is the high resolution IFREMER survey from 2011. PC11 was a repeat of JC187_PC01.

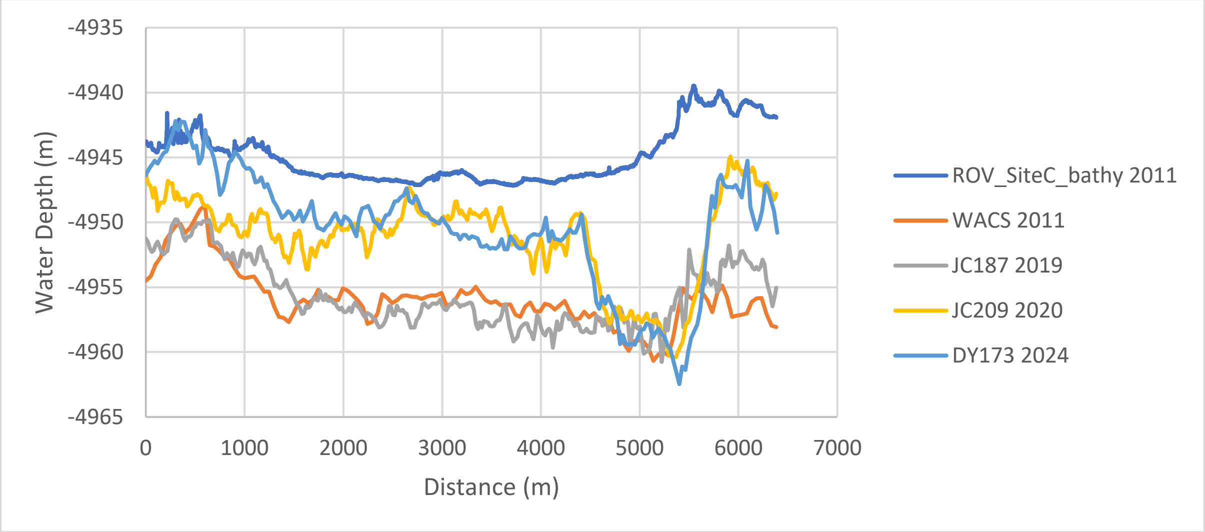


Figure 8.37. Bathymetric profile across the area of IFREMER ROV bathymetry collected in 2011 (note that this has a systematic offset). The area shows no change between 2011 and 2019, but then significant deposition and erosion between 2019 and 2020.

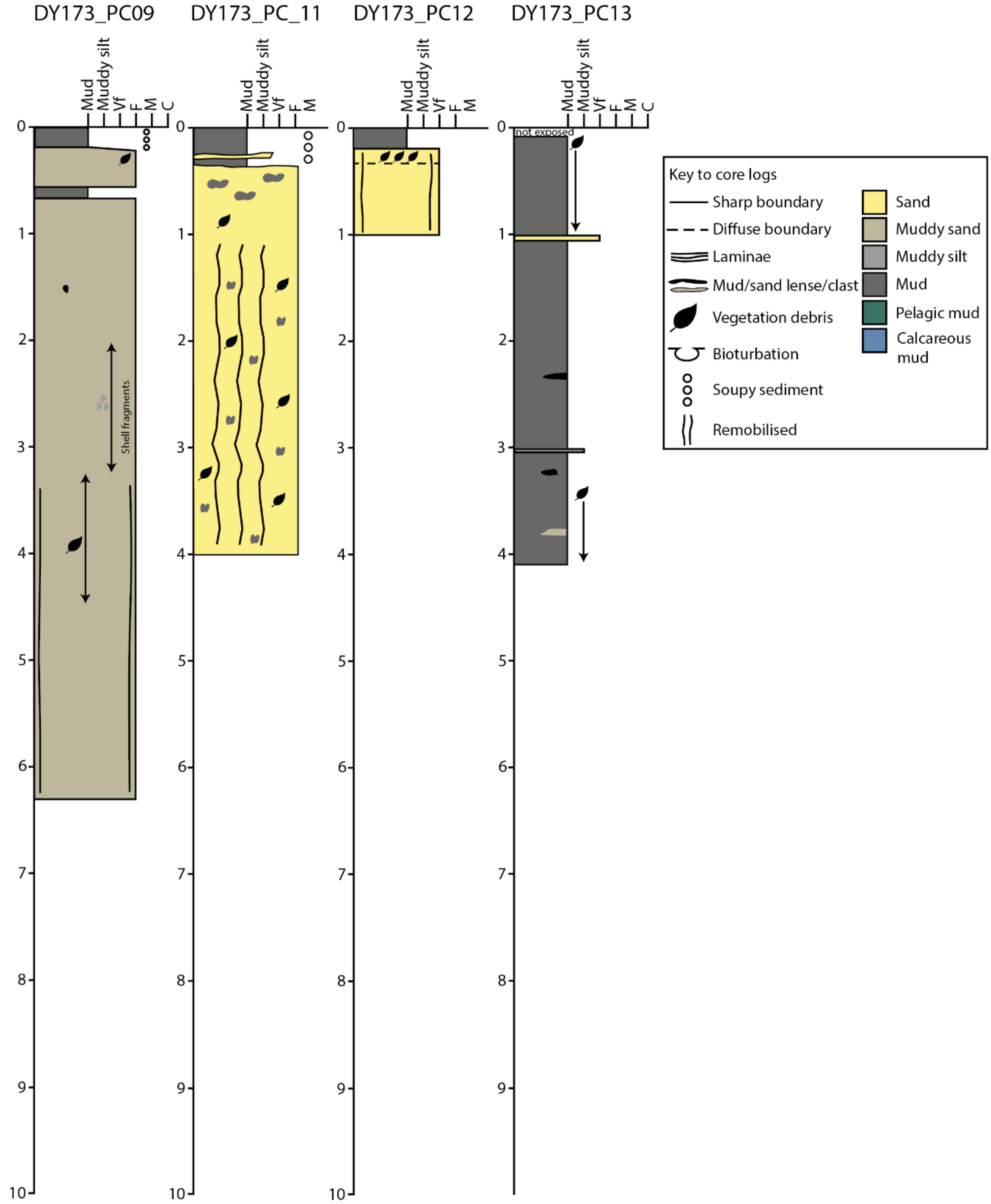


Figure 8.38. Detailed logs of PC09, PC11, PC12 and PC13. PC10 was unsuccessful.

8.2.3.3. PC01 to PC08

The eight cores from PC01 to PC08 cover the end of the lobe, where the channel becomes unconfined for the last time. This area can only be compared to low-resolution bathymetry collected by IFREMER in 1998. The bathymetry backscatter was used to identify the lobe, see how it has changed since the IFREMER survey, and select targets for coring.

PC08 and PC01 are the most proximal cores of this group. PC08 is downstream of where the channel has lost confinement and is in an area of high backscatter. PC01 is also in an area of high backscatter and may be in a channel, PC02 is 2.3 km distal of PC01 in an area of low backscatter.

PC07, PC05, PC03 and PC06 cover a NE to SW transect in an area of high backscatter, interpreted to follow the transect of sediment deposition along the lobe. PC04 is off-axis of this transect, 4 km NW of PC03 in an area of low backscatter.

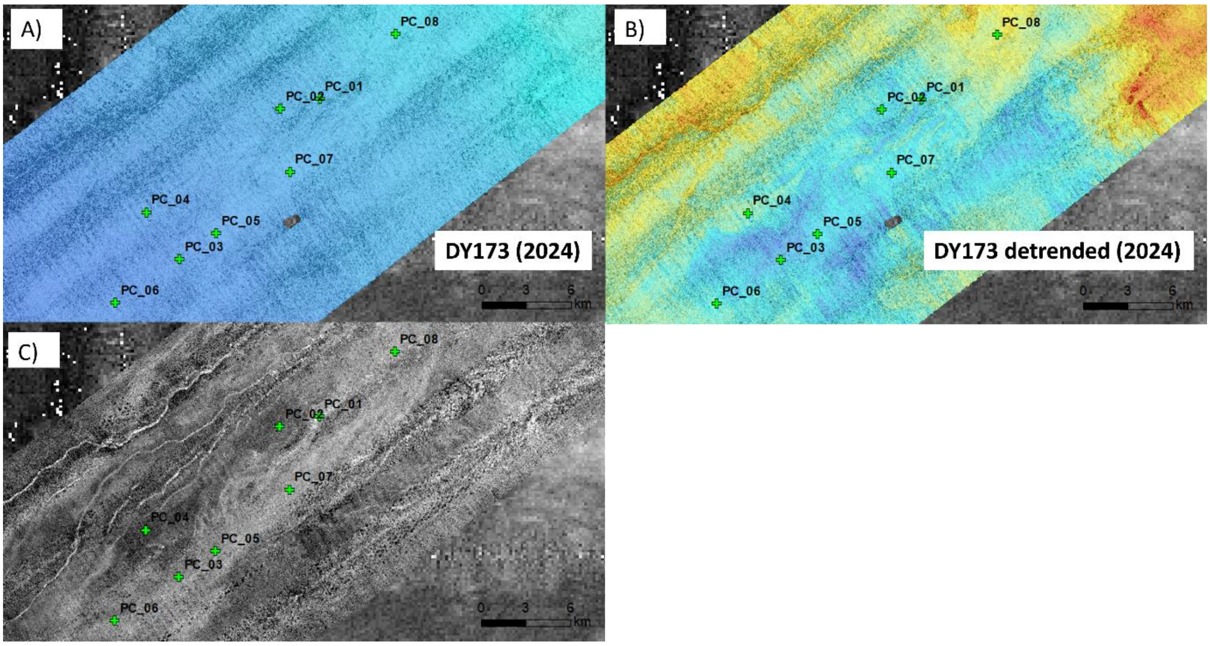


Figure 8.39. Cores collected on the lobe with the 2024 A) bathymetry, B) detrended bathymetry and C) backscatter base maps.

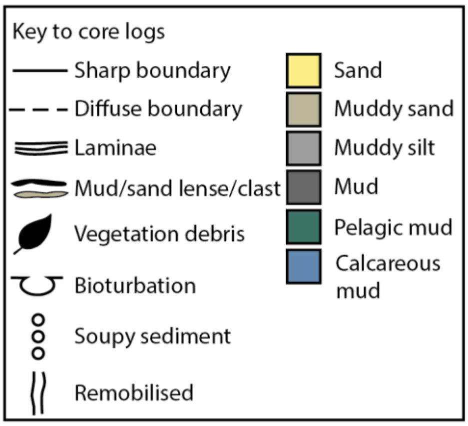


Figure 8.40. Key for the detailed logs.

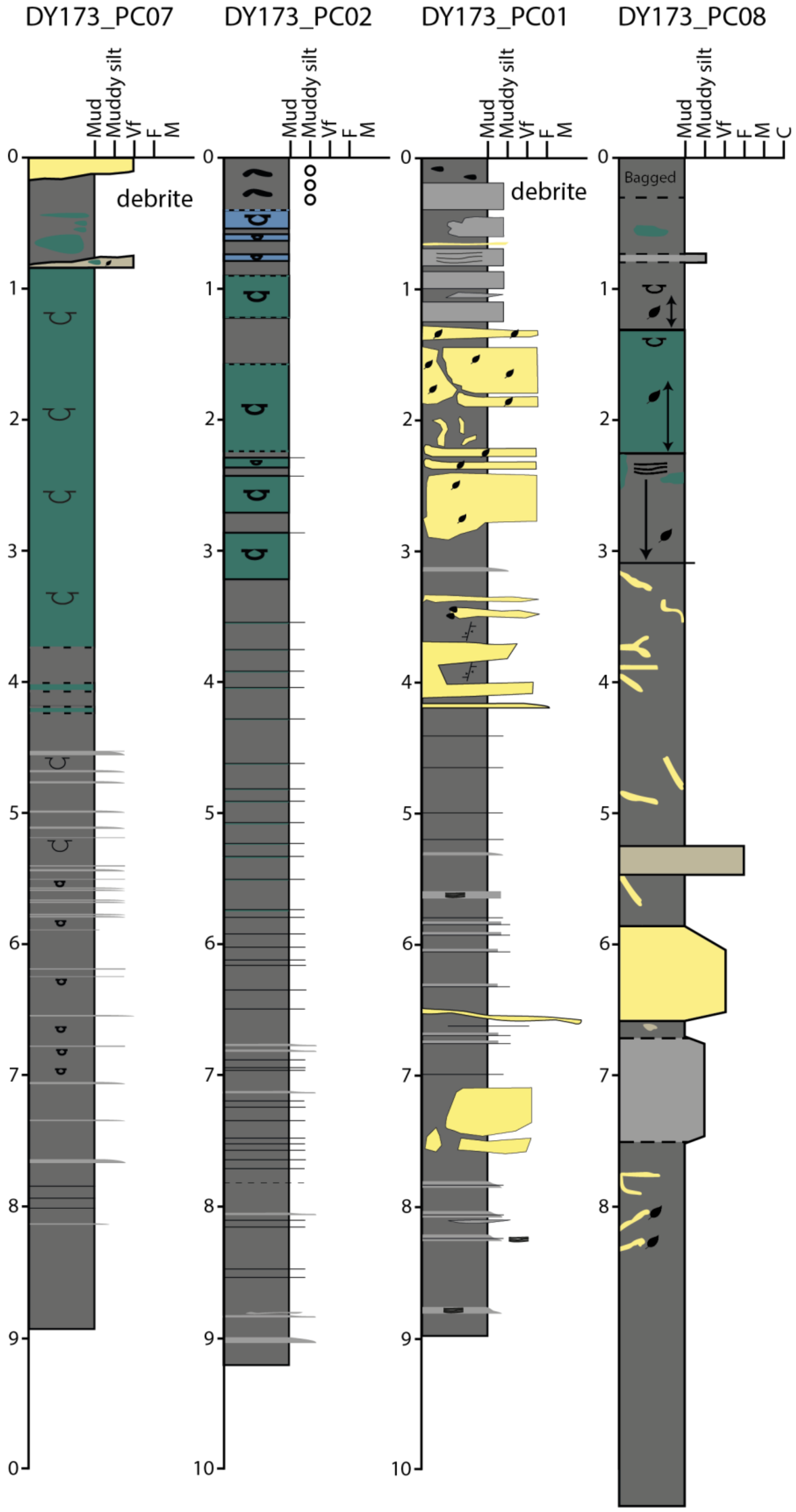


Figure 8.41. Detailed logs of PC07, PC02, PC01 and PC08.

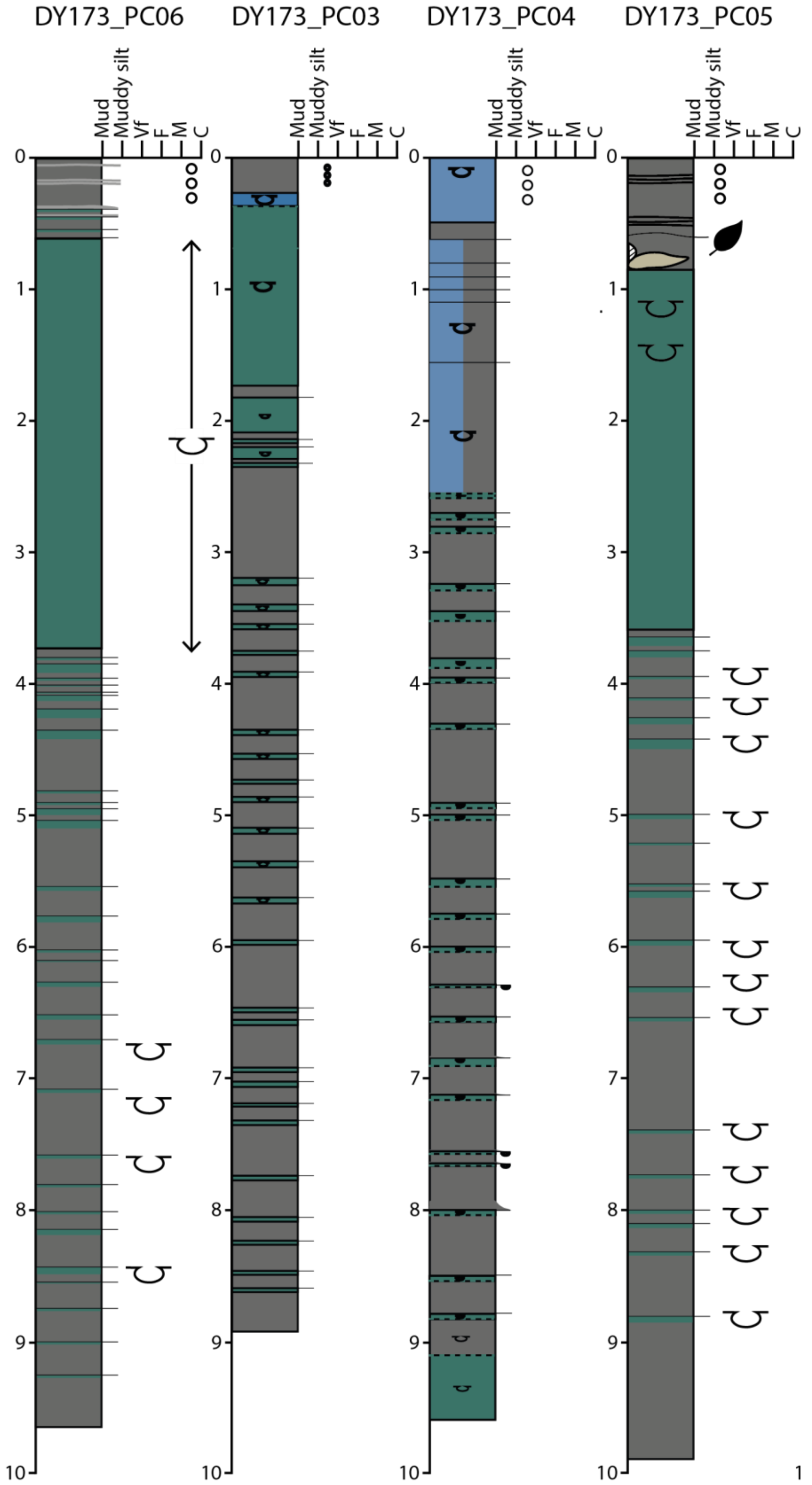


Figure 8.42. Detailed logs of PC06, PC03, PC04 and PC05.

8.3. Summary figures for piston coring

This section concludes with a series of figures summarising the results of piston coring.

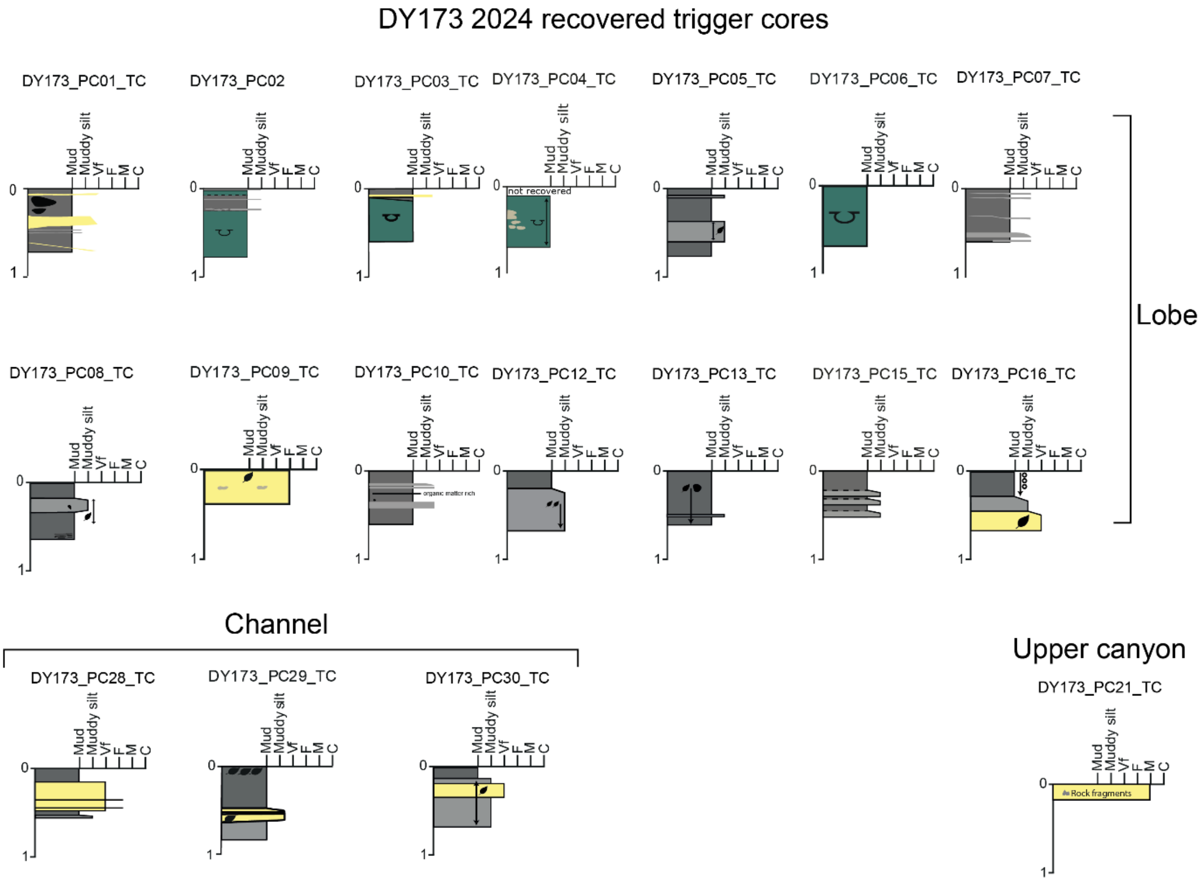


Figure 8.43. Compilation of all recovered trigger cores

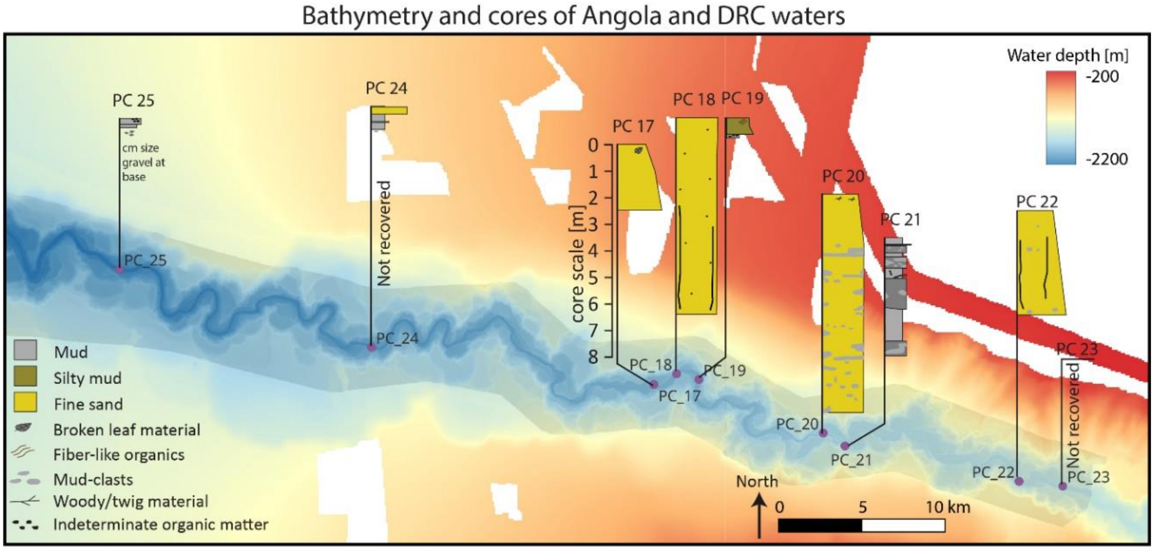


Figure 8.44. Bathymetric map and summary logs of the upper canyon.

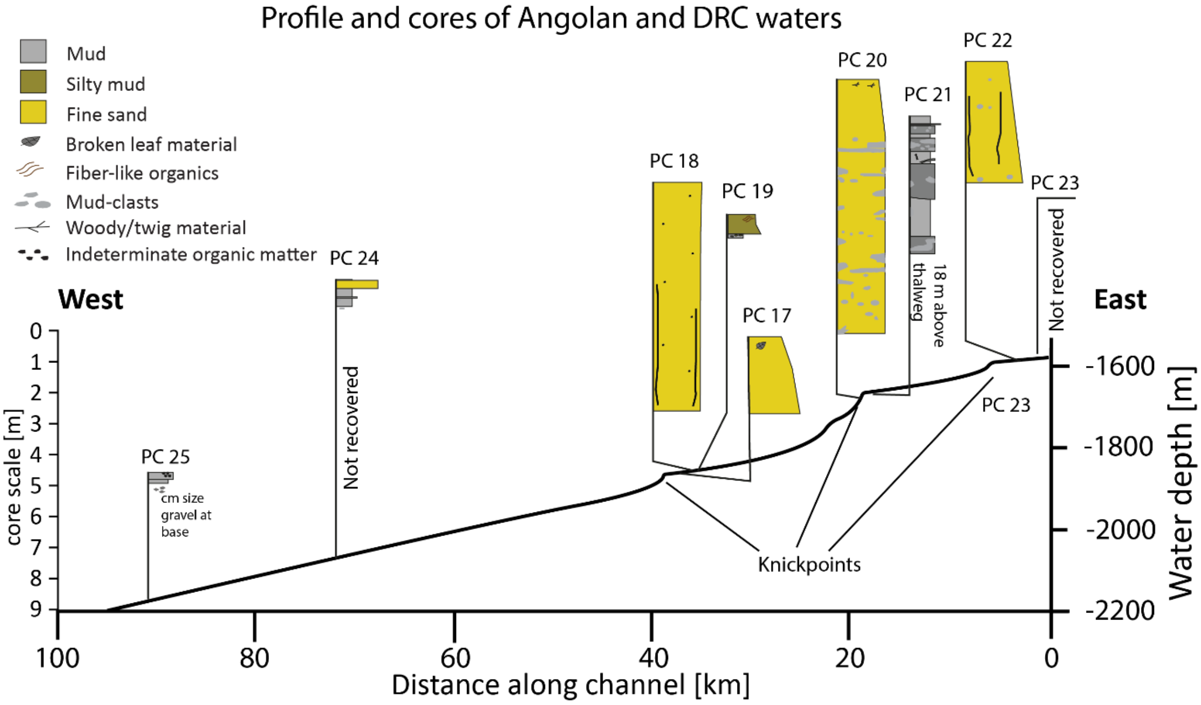


Figure 8.45. Canyon profile and summary logs of the upper canyon.

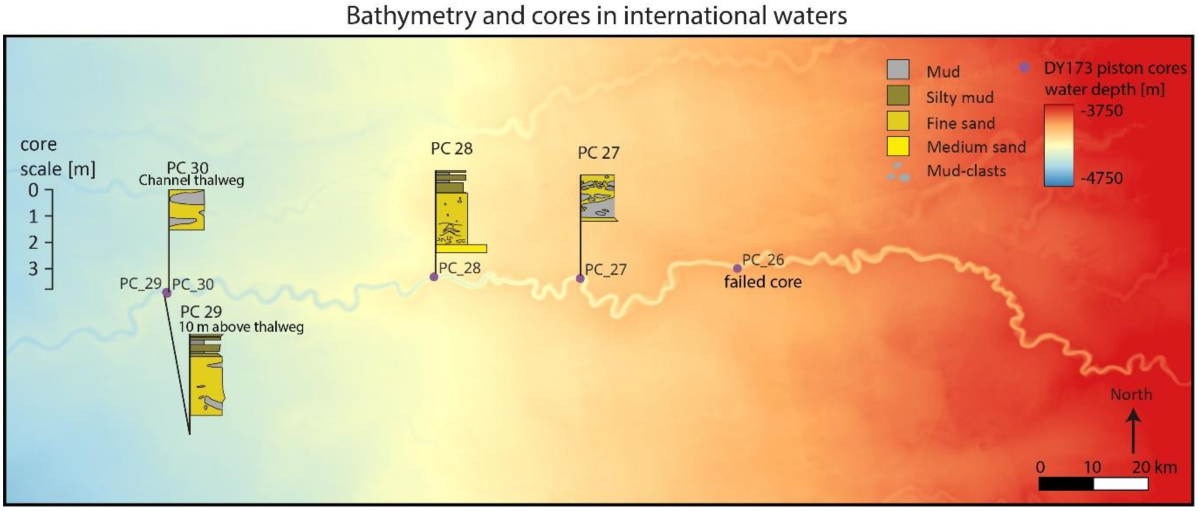


Figure 8.46. Bathymetric map and summary logs of the submarine channel.

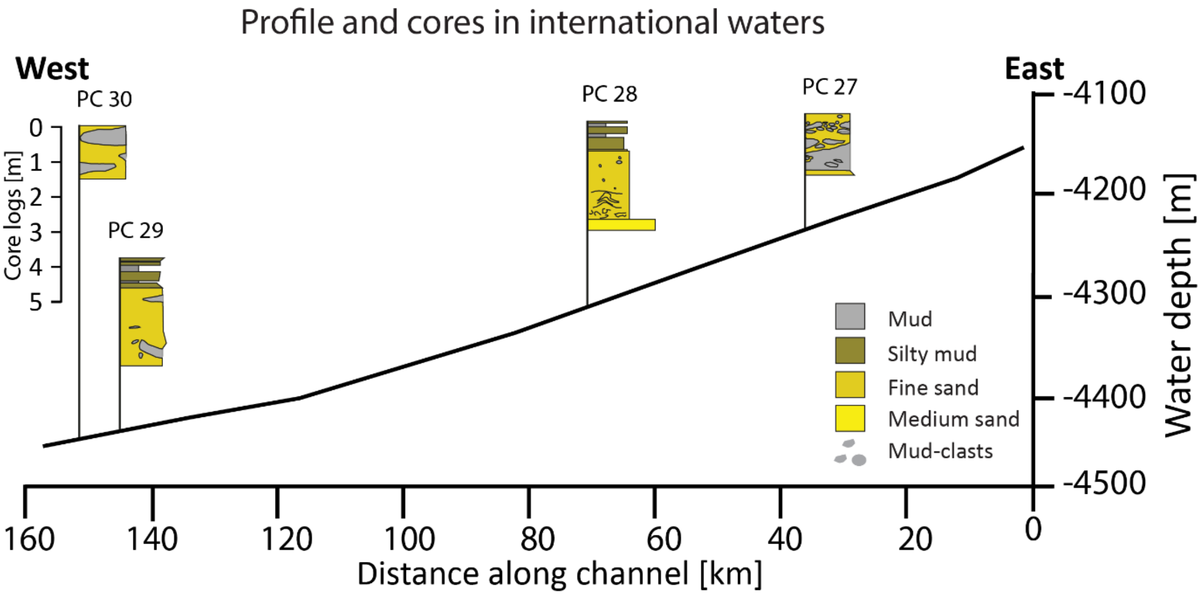


Figure 8.47. Canyon profile and summary logs of the submarine channel.

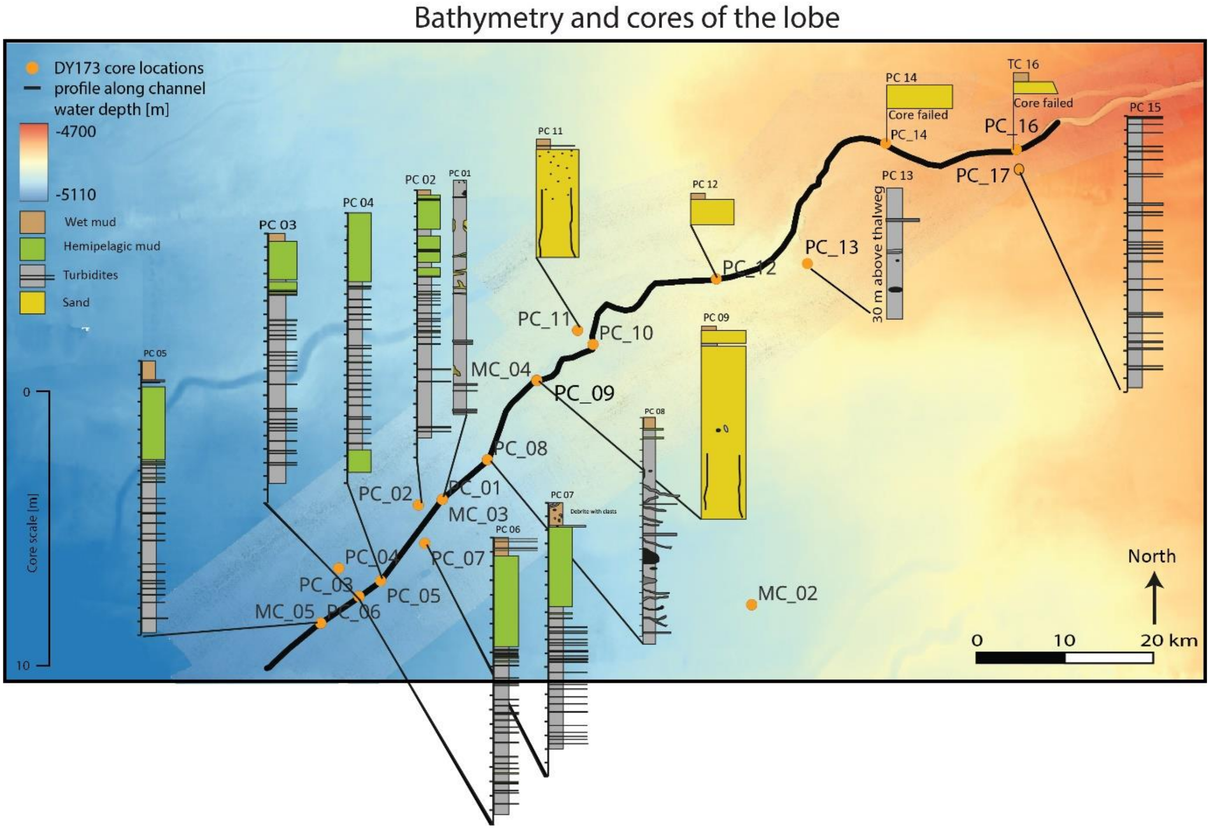


Figure 8.48. Bathymetric map and summary logs of the lobe.

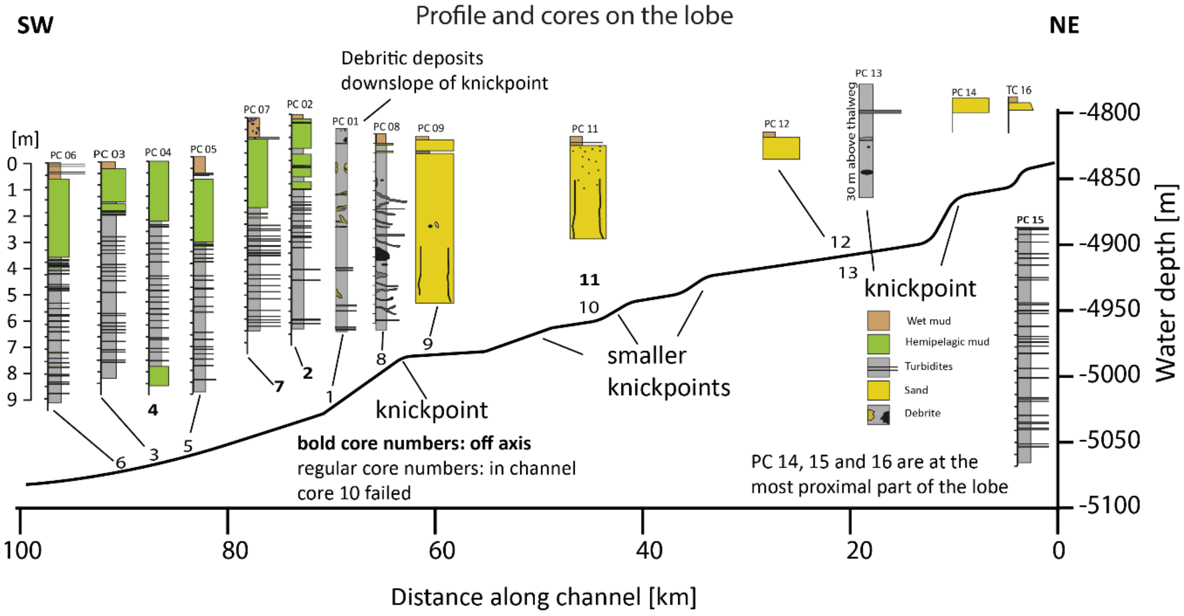


Figure 8.49. Channel profile and summary logs of the lobe. PC 14, 15 and 16 are located proximal (NE) of 0 in this figure. See the bathymetric map of the lobe for the exact position.

8.4. Piston core locations (Table 8.2)

Core	USBL			No. of sections	Core length (m)	Environment
	Latitude	Longitude	Depth			
PC_01	6 51.90992	5 20.79833	5029	6	9	Lobe
PC_02	6 52.339	5 19.606	5033	7	9.23	Lobe
PC_03	6 57.76370	5 15.673129	5069	6	9	Lobe
PC_04	6 56.0477	5 14.4553	5058	7	9.62	Lobe
PC_05	6 56.8229	5 17.0027	4948	7	10	Lobe
PC_06	6 59.36251	5 13.32245	5071	7	9.93	Lobe
PC_07	6 54.5715	5 19.708	5040	6	9	Lobe
PC_08	6 49.524	5 23.557	4980	7	9.93	Lobe
PC_09	6 44.7370	5 26.6082	4945	5	4.81	Lobe
PC_10	6 42.5727	5 30.0373	4953	0	0	Lobe
PC_11	6 41.71122	5 29.10801	4944	3	4.02	Lobe
PC_12	6 38.67209	5 37.58692	4914	1	1.02	Lobe
PC_13	6 37.70016	5 42.31412	4879	3	4.12	Lobe
PC_14	6 30.82693	5 48.56343	4827	1	0.47	Lobe
PC_15	6 32.19291	5 56.06676	4795	7	9.77	Lobe
PC_16	6 30.90001	5 55.89668	4808	0	0	Lobe
PC_17	5 53.92638	11 19.82575	1851	2	2.36	Canyon
PC_18	5 53.572435	11 20.57721	1853	5	7.5	Canyon
PC_19	5 53.75436	11 21.31326	1849	1	0.75	Canyon
PC_20	5 55.50685	11 25.4338	1726	5	7.5	Canyon
PC_21	5 55.93118	11 26.15355	1656	3	3.4	Canyon
PC_22	5 57.07410	11 31.91368	1578	3	3.38	Canyon
PC_23	5 57.22317	11 33.35949	1582	0	0	Canyon
PC_24	5 52.73507	11 10.48467	2032	1	1.07	Canyon
PC_25	5 50.192975	11 02.14630	2189	1	0.31	Canyon
PC_26	5 44.09347	08 08.21981	4153	0	0	Channel

PC_27	05 45.06259	07 52.5361	4238	2	1.75	Channel
PC_28	5 44.88215	7 37.94436	4316	2	3.04	Channel
PC_29	5 46.33271	11 24905	4435	2	3	Channel
PC_30	5 46.44780	7 11.33787	4522	1	1.4	Channel

9. Moorings

9.1. Rationale for 2024-2025 mooring sites

Six ADCP moorings (4 from NERC and 2 from Ifremer) were deployed across the lobe of the Congo Fan system to characterise turbidity currents that traverse this lobe area. The 6 moorings were placed on the lobe for the following reasons. First, it was thought that powerful flows are likely to occur in the next 12 months, following the recent (79,000 m^3 peak on 9th January 2024) very large flood along the Congo River. Second, more proximal mooring locations were considered to be to hazardous due to more confined flow within these more proximal canyon and channel reaches. Finally, the lobe lies in international waters, and this simplifies issues around permitting.

9.2. Background to previous monitoring via moorings in Congo Canyon

This project has previously deployed an array of 11 NERC and Ifremer moorings along the upper canyon and deeper-water channel, for 12 months from October 2019 (cruise JC187) to October 2020 (cruise JC209). In late December 2019, the discharge of the Congo river exceeded 65,000 m^3/s. Such an extreme flood has an estimated return period of 50 years. Two moorings had already broken and surfaced in November and December 2019. But an unusually powerful (5-8 m/s) turbidity current then occurred on 14-16th January 2020 , and it broke all of the remaining 9 moorings, as well as 3 telecommunication cables where they crossed the canyon (Talling et al., 2022). Nine the 11 moorings were eventually recovered via passing vessels.

The powerful cable breaking flow on 14th to 16th January 2020 occurred a few weeks after the peak of the major Congo River flood, but its final trigger coincided with a spring tide. There had been no previous cable breaks since 2002, and the cable breaking flow seems to be linked to a large sediment flux into the canyon head during that 50-year flood. There were then six further cable breaking flows on March 6th 2020, and in 2021, 2023 and 2024. These cable breaking flows also tended to occur after major river floods, and at spring tides, although there are exceptions. The latest cable breaking flow occurred on January 9th 2024, less than one month before the DY173 cruise, and it came a few weeks after an even larger flood of the Congo River that peaked above 79,000 m^3/s at Kinshasa.

Considering the emerging understanding of the generation of major turbidity currents in the canyon, we have estimated that in the following weeks and months several major turbidity currents might be generated after the January 2024's flood. These future flows are thought to be able to break any moorings deployed in the canyon and the upper part of the turbiditic channel, where flows are fully confined by the geomorphology. These potential flows are also believed to potentially propagate as far down the systems as those observed in January 2020, and hence to reach the lobe where flows become unconfined, and consequently spread laterally and terminate.

The mooring deployment strategy during the DY173 cruise aims to capture this final phase of flows across the depositional lobe. An array of four NERC moorings (M1 to M4) were deployed along the main active channel of the lobe. Three of the moorings were located in shallow channels. Mooring 1 was located at the start of the lobe in the axis of a 40m deep channel, whilst Moorings 3 and 4 were placed in knickpoints where the channels had incised to depths of ~20-30m. Mooring 2 was placed in an intervening reach with much less confinement, and channel depth of < 5-8m. Both of Ifremer's PeerGynt moorings (PG1 and PG2) were deployed on either side of Mooring M1, on levees situated southward and northward of the channel. They form a cross transect centred at the position of mooring M1. This transect is dedicated to observing how flows diverge laterally while losing confinement, and how background circulation may modulate the final phase of flows, this influence of background currents may explain the observed asymmetry of levee deposits and morphologies.

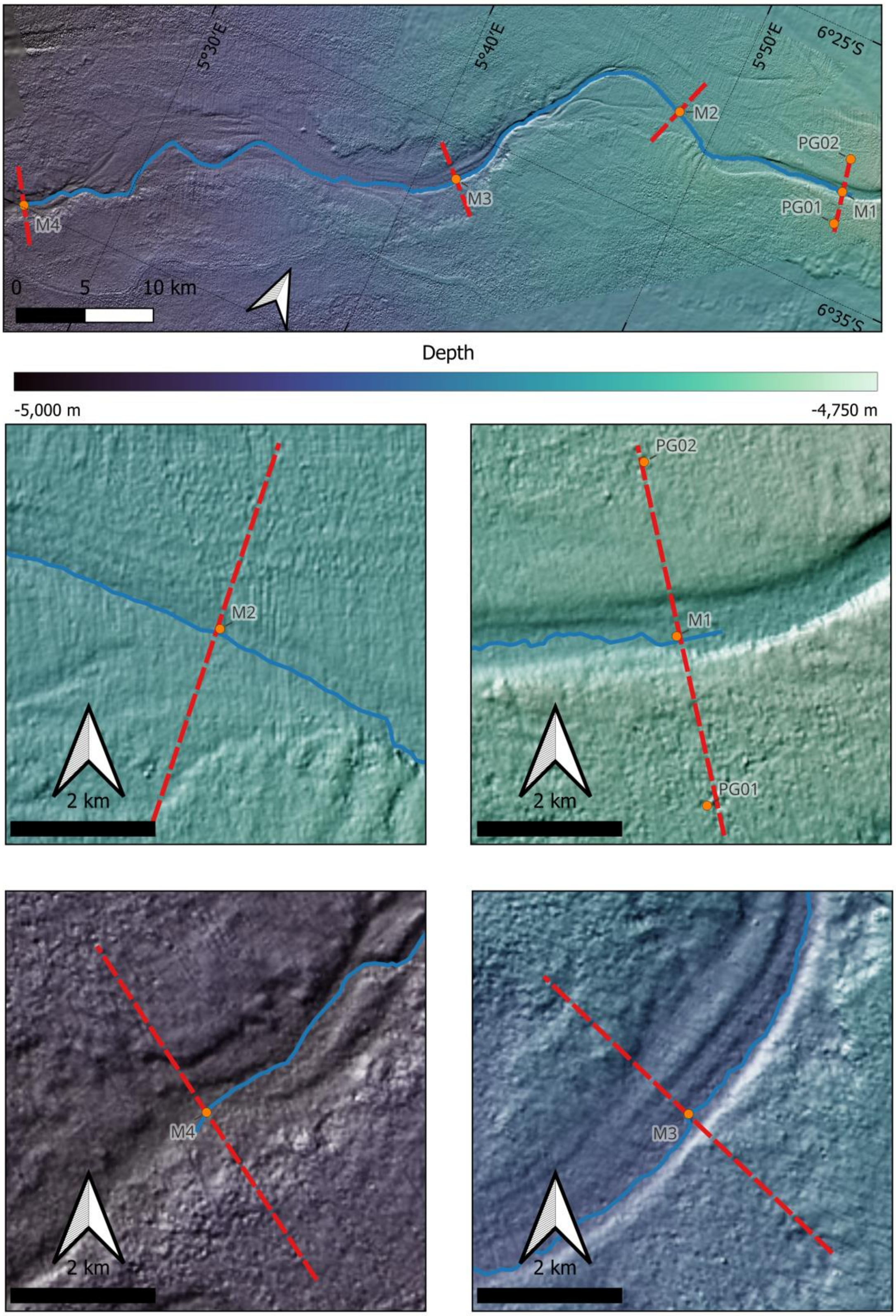
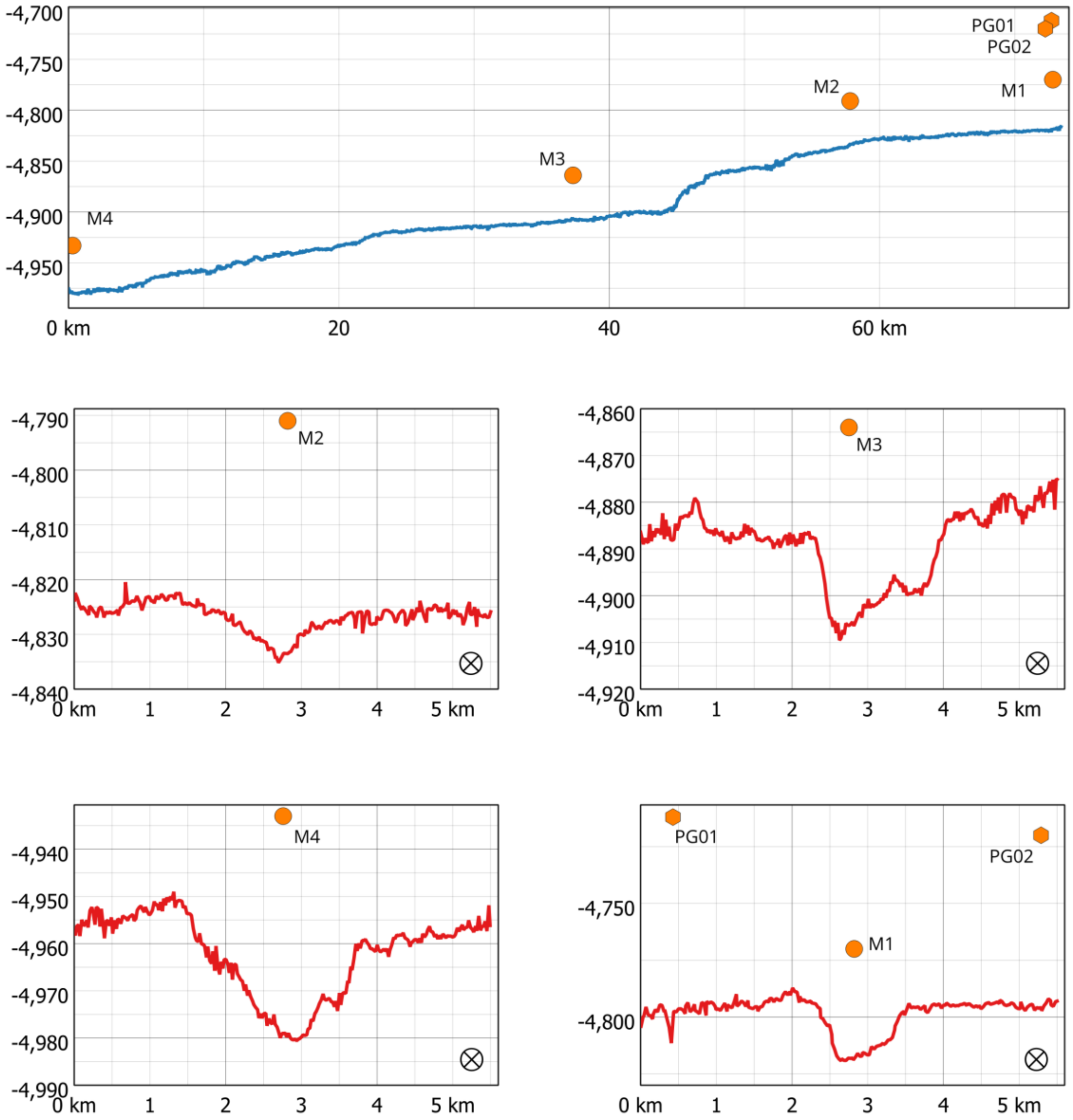


Figure 9.1. Deployment location of the DY173 moorings (bathymetry from 2024)



Name	Longitude	Latitude	Depth	Metres ASF
M1	5°55.6230′E	6°30.9270′S	-4770	42
M2	5°48.4450′E	6°30.7310′S	-4791	42
M3	5°41.5030′E	6°36.8450′S	-4864	42
M4	5°26.3695′E	6°44.9090′S	-4933	42
PG01	5°55.8443′E	6°32.2062′S	-4712	80
PG02	5°55.3857′E	6°29.6099′S	-4720	80

Figure 9.10. Bathymetric transects at the deployment locations of the moorings.

9.3. Instruments and programming

A total of 6 moorings were deployed during the DY173 cruise across the lobe in international waters. The 4 NERC moorings are deployed along the shallow channel that traverses the lobe. The 300 kHz ADCPs were located 43m above seabed, and recorded measurements with a vertical resolution of 1 m, every 11 s. The two PeerGynt (Ifremer) moorings were deployed on lateral levees, on either side of Mooting 1. The PeerGyny moorings have 300 kHz ADCPs located 80 m above the sea bed, with data collected that has a vertical resolution of 1 m every 2 minutes.

9.3.1. NERC Moorings

This information on the NERC moorings is largely copied from the Mooring Cruise Report generated by David Childs, Tim Powell and Tina Thomas. More details of the mooring deployment and set-up of the ADPC and sediment trap can be found in their report (Appendix C). During DY173 four NOC moorings were deployed, consisting of a range of different instrumentation. All instruments were serviced, and bench tested back at NOCS prior to being shipped for the cruise.

Each Sea-Bird SMP Microcat was sent to the NOCS Calibration Laboratory prior to the cruise for a new calibration and function test. Calibration certificates for each instrument were issued, copies are included with the cruise data.

Once onboard new battery packs were fitted to all instruments ahead of their deployment. Novatech beacons were function tested to ensure they were operating as expected, with no issues found.

All Ixsea releases were serviced, and bench tested at NOC prior to the cruise, but in order to verify their operation the releases were attached to the CTD frame during an early CTD dip, and then tested using the TT801 Deck Unit and the ship fitted transducer on the drop keel.

The four down-looking 300 kHz ADCPs were programmed on board.

Three identical moorings were deployed, these being designated M1, M2 and M4. A slightly different mooring, designated M3, included an additional Sea-Bird 37 SMP Microcat and a user supplied Anderson sediment trap.

Mooring diagrams for each mooring can be found at the end of this section.

NERC moorings were deployed “anchor last”. The ship setup on station for deployment with the stern A-frame positioned at the target location. No run in was necessary as the moorings were short and deployment was expected to be quick. A light surface current was sufficient to stream the moorings clear of the stern, whilst the ship remained in position ready for the anchors to be released. The final position of each mooring was obtained via triangulation on their acoustic beacon.

9.3.2. Ifremer Moorings

The information on the two Ifremer’s PeerGynt moorings (Particle Trap and Recorder of Recurrent Gravity Flows with Turbiditic Signature, from the French *Piège à particules et Enregistreur d’Ecoulements Récurrents Gravitaires aYant SigNature Turbiditique*) are translated from the report produced by Ronan Apprioual and Pierre Guyavarch who have prepared and shipped all instruments for the cruise.

All instruments were again checked on board and charged with new battery packs. Localisation instruments (Novatech beacons, gonio, flash) were tested. Mors releasers were attached to the CTD frame in one of the dips to verify their operation in natural conditions using a TT301 Deck Unit.

The two PeerGynt mooring (PG1 and PG2) are similar, with 300 kHz ADCPs looking downwards from 100 m above the sea bottom. There is also a Technicap PPS4/3 sediment trap with 24 500 ml bottles deployed 28 m above the levees’ bed. One of the PG moorings (deployed north of the channel) was equipped with a turbidimeter.

PeerGynt moorings were deployed “anchor-first’. The anchors were streamed down the water column out of the stern whilst the several mooring components were mounted on the line thanks to dedicated lifting ropes. With the ship maintained at station with DP, the moorings were eventually placed 50 m above the targetted sea bed position and released. The USBL position of the releaser is used as final position.

9.3.3. NERC Mooring 1

For the NERC M1 Mooring deployment the following instrumentation were used (Table 9.1):

Instrument	Serial Number
Sea-Bird SBE 37	9395
Teledyne 300 kHz ADCP	10689
Novatech Light	Y01-015
Novatech Iridium	H07-055
Ixsea Release	1141
Ixsea Release	2328

A Sea-Bird SBE 37 (SN: 9395) was used on the mooring and installed into the Deepwater syntactic buoyancy using a instrument clamp programmed using Sea-Bird SeaTerm Version 2 software and AutoSBE scripts.

The following settings were used to program the Sea-Bird SMP Microcats for deployment (table 9.2).

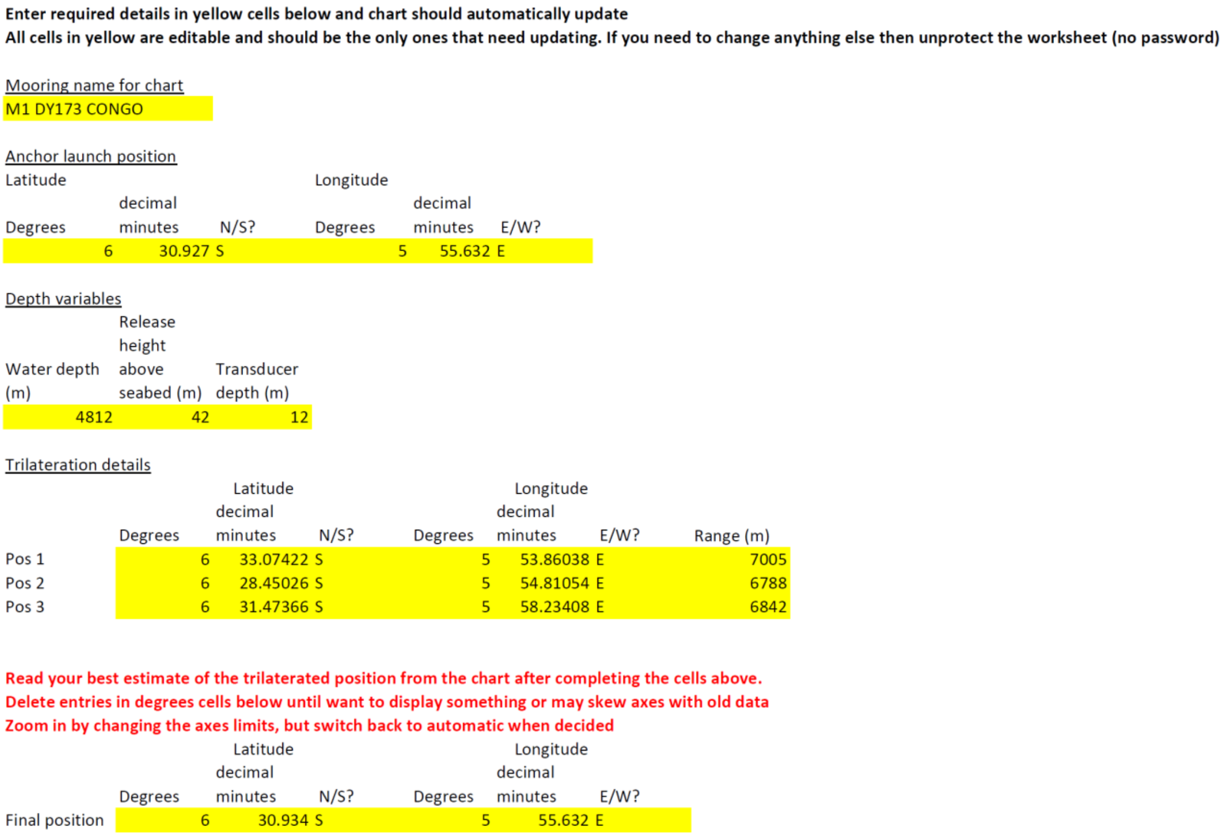
Sea-Bird SBE 37 (SN: 9395)

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9395  07 Feb 2024 12:16:30
vMain = 13.32, vLith =  2.84
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3295.7
S>
```

The final position of the M1 mooring that only 13 m away from the initial target, and it was estimated via triangulation (Table 9.3):

Latitude	Longitude
6° 30.934’ S	5° 55.632’ E

The 300 kHz Teledyne ADCP (S/N 10689) was fitted into the deepwater syntactic buoyancy and placed on the top of the mooring line 43 m above the sea bed. The acquisition was programmed to start on board on the 8th February 2024, before deployment on 11th February 2024 at 08:2 UTC. The ADCP is measuring every 11 s. Each measurement ensemble is obtained from a single ping. The available total range was 50 m with a blanking distance of 1,76 m. The distance of 43 m to the sea bed is resolved by a first cell with a height of 2.96 m, and then 49 cells of 1 m. The total measuring range of the 50 cells is of 51.96 m. The ambiguity velocity was set to 3 m/s.



Enter required details in yellow cells below and chart should automatically update
All cells in yellow are editable and should be the only ones that need updating. If you need to change anything else then unprotect the worksheet (no password)

Mooring name for chart
M1 DY173 CONGO

Anchor launch position

Latitude			Longitude		
Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
6	30.927	S	5	55.632	E

Depth variables

Water depth (m)	Release height above seabed (m)	Transducer depth (m)
4812	42	12

Trilateration details

	Latitude			Longitude			
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?	Range (m)
Pos 1	6	33.07422	S	5	53.86038	E	7005
Pos 2	6	28.45026	S	5	54.81054	E	6788
Pos 3	6	31.47366	S	5	58.23408	E	6842

Read your best estimate of the trilaterated position from the chart after completing the cells above.
Delete entries in degrees cells below until want to display something or may skew axes with old data
Zoom in by changing the axes limits, but switch back to automatic when decided

	Latitude			Longitude		
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
Final position	6	30.934	S	5	55.632	E

Table 9.4. Settings for Mooring M1.

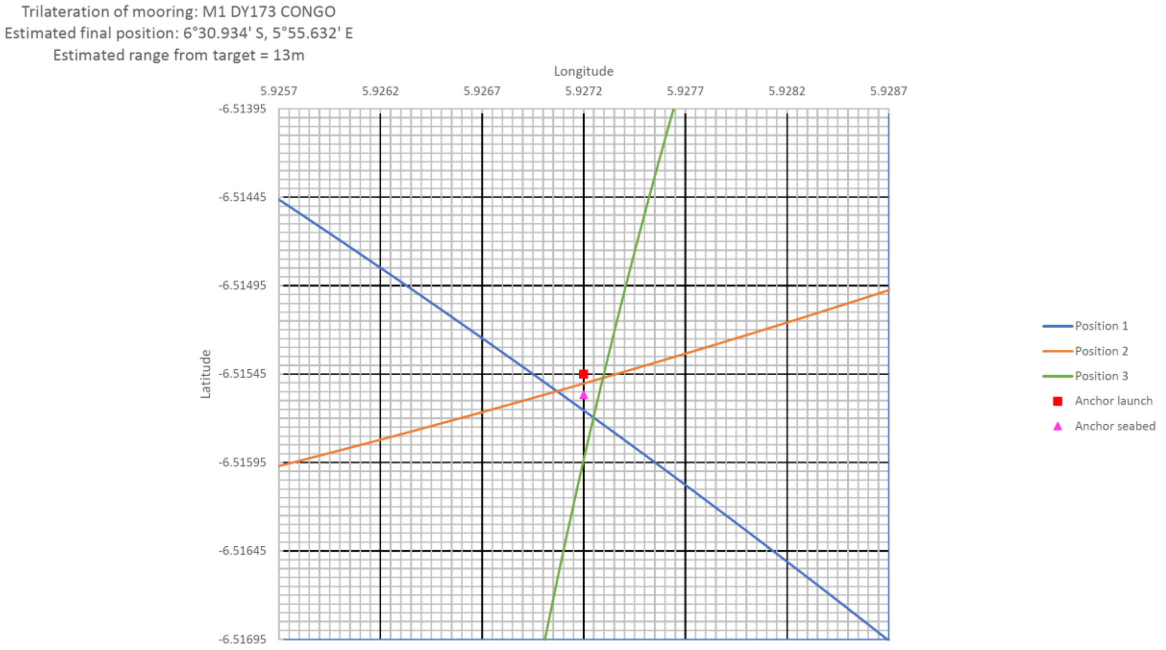


Figure 9.3. Graphic representation of M1 triangulation.

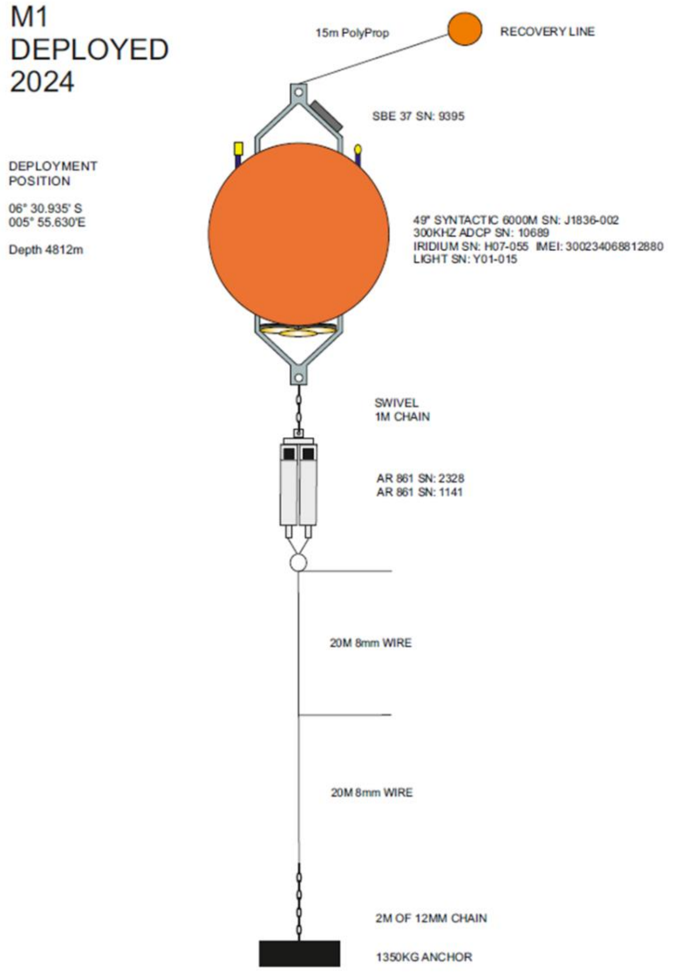


Figure 9.4. NERC Mooring 1.

9.3.4. NERC Mooring 2

For the M2 Mooring deployment the following instrumentation were used (Table 9.3):

Instrument	Serial Number
Sea-Bird SBE 37	9374
Teledyne 300 kHz ADCP	2666
Novatech Light	A08-010
Novatech Iridium	H04-023
Ixsea Release	1468
Ixsea Release	2247

A Sea-Bird SBE 37 (SN: 9374) was used on the mooring and installed into the Deepwater syntactic buoyancy using a instrument clamp programmed using Sea-Bird SeaTerm Version 2 software and AutoSBE scripts. The following settings were used to program the Sea-Bird SMP Microcats for deployment (Table 9.4).

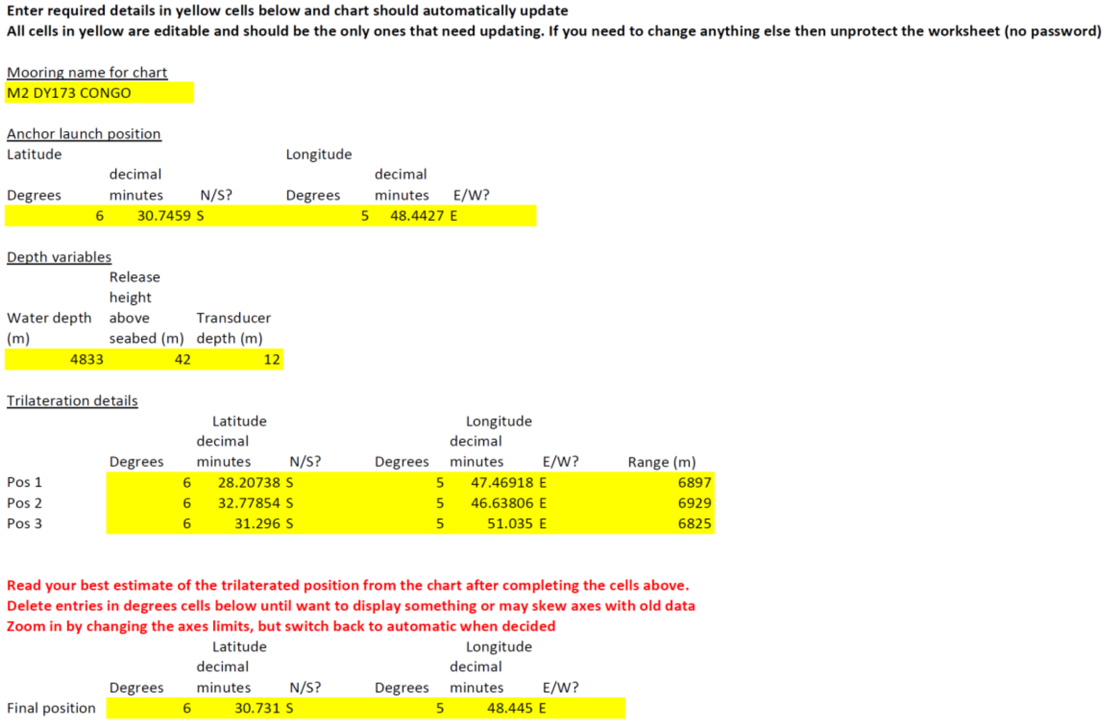
Sea-Bird SBE 37 (SN: 9374)

```
 S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9374  07 Feb 2024 12:11:14
vMain = 13.37, vLith =  2.94
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3323.0
S>
```

The final position of the M2 mooring, which was 28 m away from the initial target, was estimated by triangulation (Table 9.5).

Latitude	Longitude
6° 30,731’ S	**5° 48,445’ E**

The 300 kHz Teledyne ADCP (S/N 2666) was fitted into the deepwater syntactic buoyancy and placed on the top of the mooring line 43 m above the seabed. The acquisition was programmed to start on board on 08/02/2024 before deployment (12/02/2024 05:38). The ADCP is measuring every 11 s. Each measurement ensemble is obtained from a single ping. The available total range was 52 m with a blank of 1.76 m. The 43 m of distance to the sea bed is resolved by a first cell that is 2.96 m, and then 49 cells of 1 m. The total measuring range of the 50 cells is of 51,96 m. The ambiguity velocity was set to 3 m/s.



Enter required details in yellow cells below and chart should automatically update
All cells in yellow are editable and should be the only ones that need updating. If you need to change anything else then unprotect the worksheet (no password)

Mooring name for chart
M2 DY173 CONGO

Anchor launch position

Latitude			Longitude		
Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
6	30.7459	S	5	48.4427	E

Depth variables

Water depth (m)	Release height above seabed (m)	Transducer depth (m)
4833	42	12

Trilateration details

	Latitude			Longitude			
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?	Range (m)
Pos 1	6	28.20738	S	5	47.46918	E	6897
Pos 2	6	32.77854	S	5	46.63806	E	6929
Pos 3	6	31.296	S	5	51.035	E	6825

Read your best estimate of the trilaterated position from the chart after completing the cells above.
Delete entries in degrees cells below until want to display something or may skew axes with old data
Zoom in by changing the axes limits, but switch back to automatic when decided

	Latitude			Longitude		
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
Final position	6	30.731	S	5	48.445	E

Figure 9.5. Triangulation positioning of Mooring M2

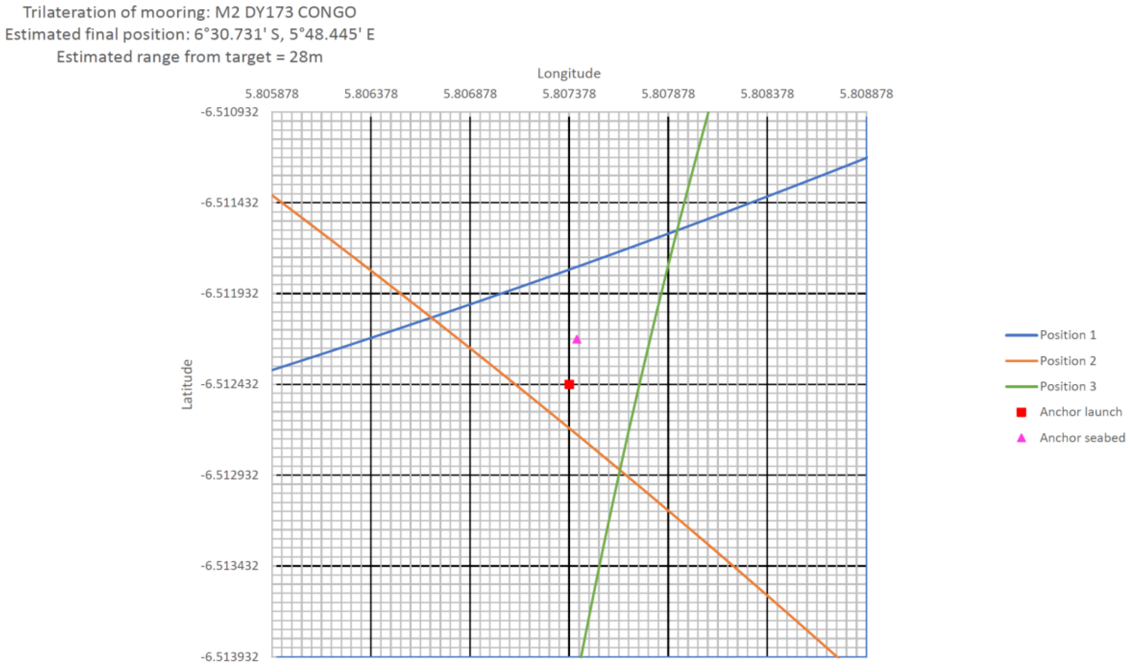


Figure 9.6. Graphic representation of Mooring M2 triangulation.

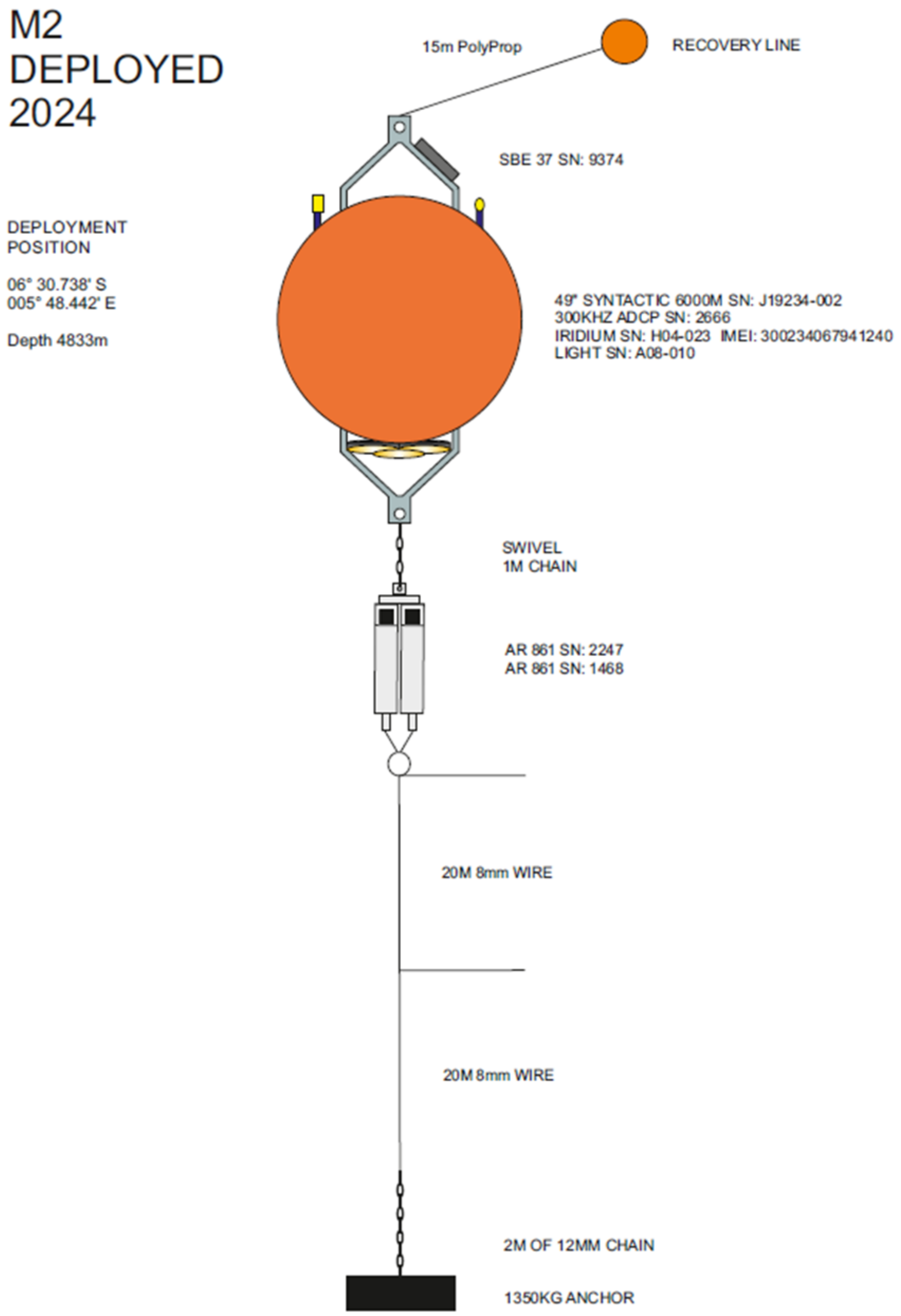


Figure 9.7. NERC Mooring M2.

9.3.5. NERC Mooring 3

For the M3 Mooring deployment the following instrumentation were used (Table 9.6):

Instrument	Serial Number
Sea-Bird SBE 37	9371
Sea-Bird SBE 37	11108
Teledyne 300 kHz ADCP	13872
Novatech Light	C01-020
Novatech Iridium	H04-022
Ixsea Release	1613
Ixsea Release	2327
Anderson Sediment Trap	N/A

Two Sea-Bird SBE 37 instruments were used on M3 (SN: 9371 and 11108). These instruments were clamped directly to the mooring wire. Programming was made using Sea-Bird SeaTerm Version 2 software and AutoSBE scripts.

The following settings were used to program the two Sea-Bird SMP Microcats for deployment (Table 9.7).

Sea-Bird SBE 37 (SN: 9371)

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9371  07 Feb 2024 12:13:44
vMain = 13.45, vLith =  2.87
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3326.9
S>
```

Sea-Bird SBE 37 (SN: 11108)

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9371  07 Feb 2024 12:13:44
vMain = 13.45, vLith =  2.87
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3326.9
S>
```

An Anderson sediment trap was used on mooring M3. A delayed start date and time of 12:00 noon on the 12/02/2024 was chosen, with subsequent disk drops programmed every 21 days at 12:00 noon. Details of the cycle interval and delay time are shown below.
Interval: 504 Hours
Delay: 6035 Minutes

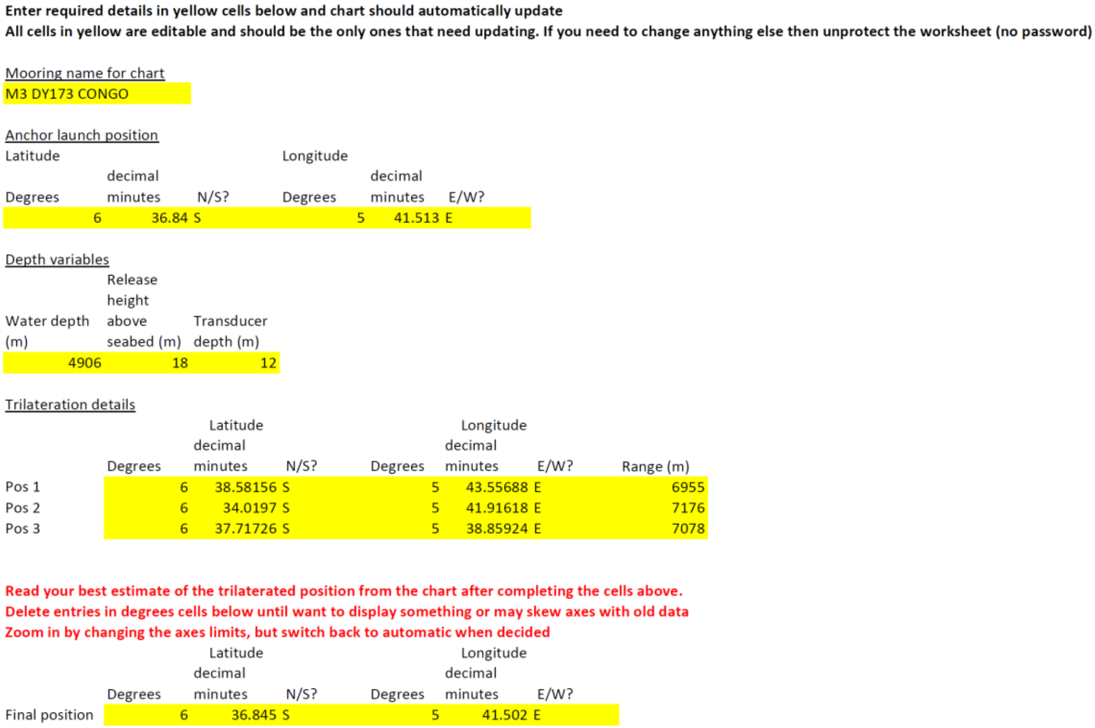
Table 9.8. Intervals and delays for the sediment trap on mooring M3.

Event No:	Date:	Event No:	Date:
1	04/03/2024	11	30/10/2024
2	03/04/2024	12	20/11/2024
3	15/05/2024	13	11/12/2024
4	05/06/2024	14	01/01/2025
5	26/06/2024	15	22/01/2025
6	17/07/2024	16	12/02/2025
7	07/08/2024	17	05/03/2025
8	28/08/2024	18	26/03/2025
9	18/09/2024	19	16/04/2025
10	09/10/2024	20	07/05/2025

The final position of the M3 mooring, which 21 m away from the initial target, was estimated by triangulation (Table 9.9.).

Latitude	Longitude
6° 36.845’ S	**5° 41.502’ E**

The 300 kHz Teledyne ADCP (S/N 13872) was fitted into the deepwater syntactic buoyancy and placed on the top of the mooring line 43 m above the seabed. The acquisition was programmed to start on board the 08/02/2024 before deployment (13/02/2024 07:32). The ADCP is measuring every 11 s. Each measurement ensemble is obtained from a single ping. The available total range was 45m with a blank of 1.76 m. The 43 m of distance to the sea bed is resolved by a first cell 2.96 m, and 49 cells of 1 m. The total measuring range of the 50 cells is of 51.96 m. The ambiguity velocity was set to 3 m/s.



Enter required details in yellow cells below and chart should automatically update
All cells in yellow are editable and should be the only ones that need updating. If you need to change anything else then unprotect the worksheet (no password)

Mooring name for chart
M3 DY173 CONGO

Anchor launch position

Latitude			Longitude		
Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
6	36.84	S	5	41.513	E

Depth variables

Water depth (m)	Release height above seabed (m)	Transducer depth (m)
4906	18	12

Trilateration details

	Latitude			Longitude			
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?	Range (m)
Pos 1	6	38.58156	S	5	43.55688	E	6955
Pos 2	6	34.0197	S	5	41.91618	E	7176
Pos 3	6	37.71726	S	5	38.85924	E	7078

Read your best estimate of the trilaterated position from the chart after completing the cells above.
Delete entries in degrees cells below until want to display something or may skew axes with old data
Zoom in by changing the axes limits, but switch back to automatic when decided

	Latitude			Longitude		
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
Final position	6	36.845	S	5	41.502	E

Figure 9.8. Triangulation positioning of Mooring M3.

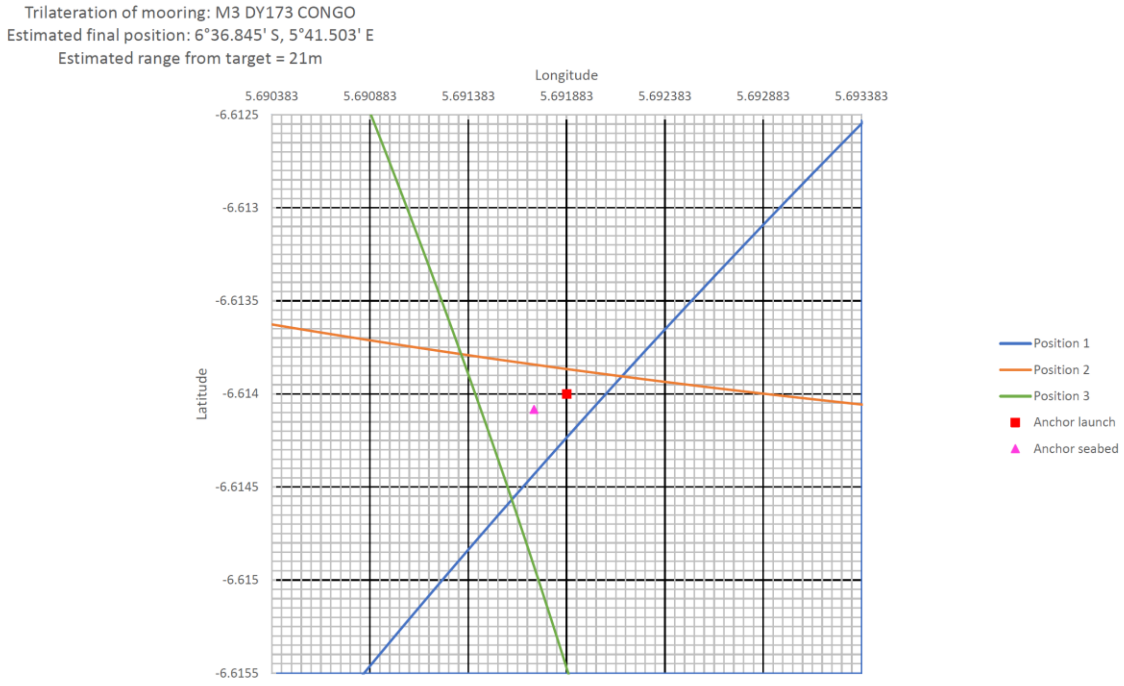


Figure 9.9. Graphic representation of M3 triangulation.

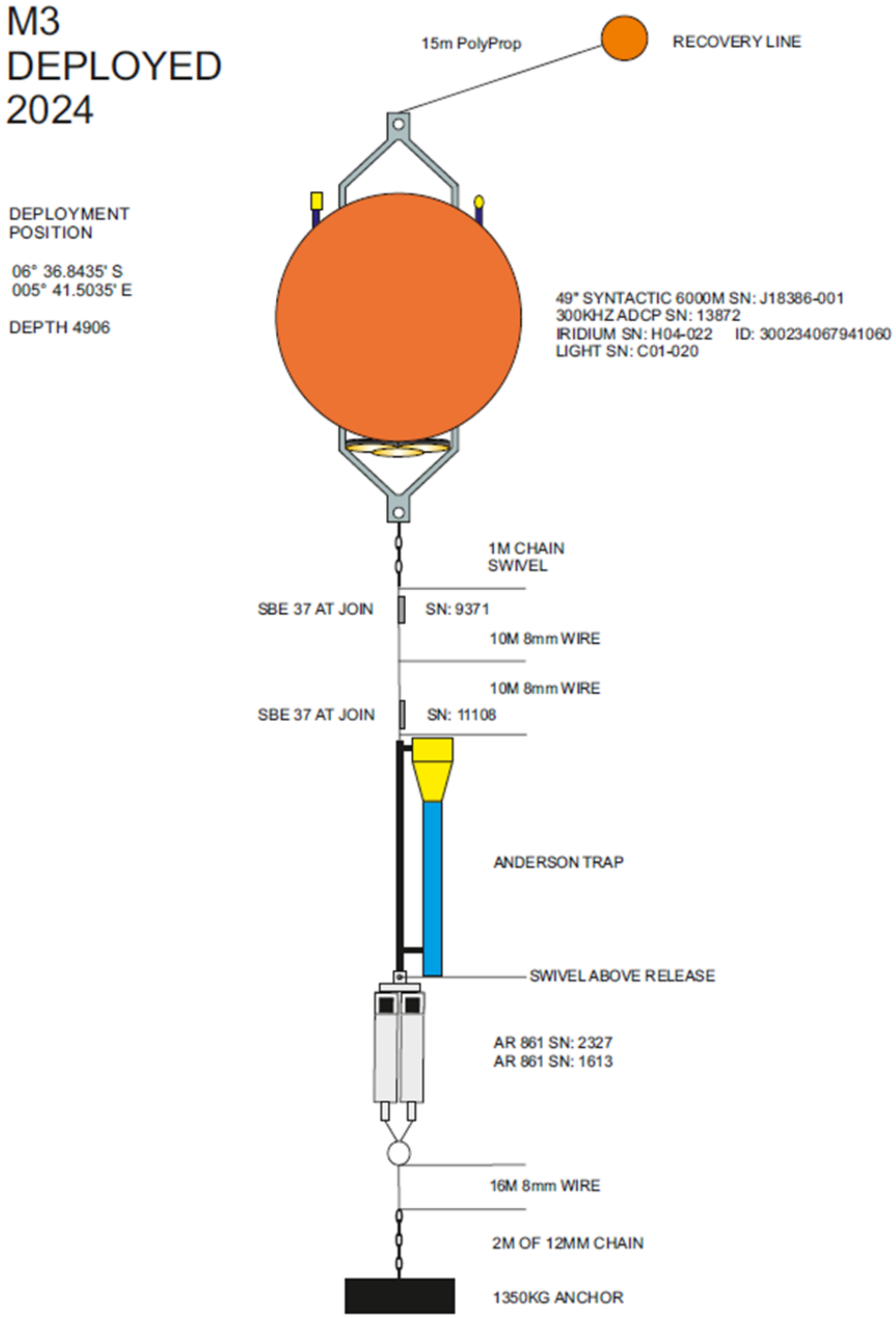


Figure 9.10. NERC Mooring M3.

9.3.6. NERC Mooring 4

For the M4 Mooring deployment the following instrumentation were used (Table 9.10).

Instrument	Serial Number
Sea-Bird SBE 37	9389
Teledyne 300 kHz ADCP	10628
Novatech Light	S01-178
Novatech Iridium	J06863
Ixsea Release	1383
Ixsea Release	2254

The Sea-Bird SBE 37 instruments is used on M4 (SN: 9389) and housed into the Deepwater syntactic buoyancy using a instrument clamp programmed using Sea-Bird SeaTerm Version 2 software and AutoSBE scripts.

The following settings were used to program the Sea-Bird SMP Microcats for deployment (Table 9.11).

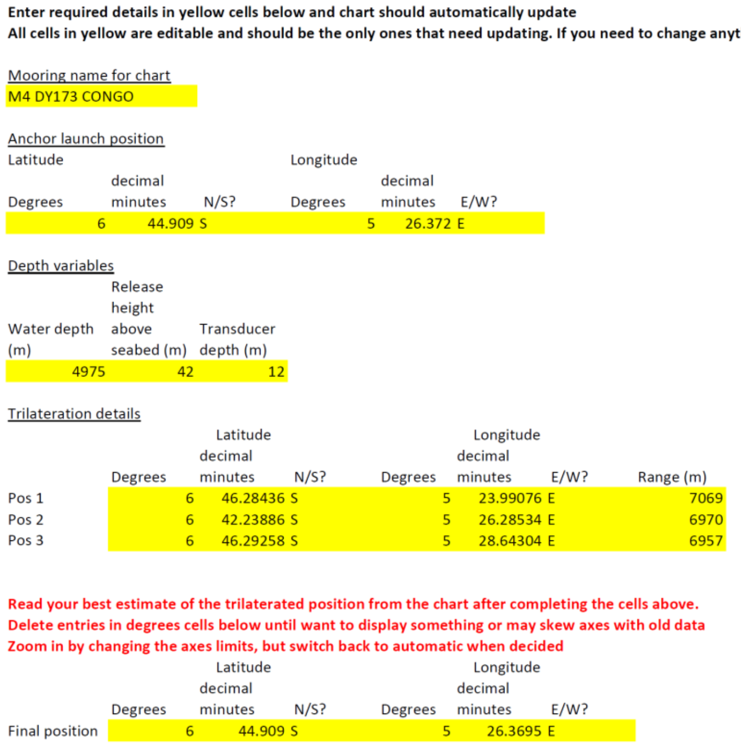
Sea-Bird SBE 37 (SN: 9389)

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9389  07 Feb 2024 12:02:43
vMain = 13.34, vLith =  2.79
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3334.1
S>
```

The final position of the M4 mooring, which was 5 m away from the initial target, was estimated by triangulation (Table 9.12):

Latitude	Longitude
6° 44.909’ S	**5° 26.3695’ E**

The 300 kHz Teledyne ADCP (S/N 10628) was fitted into the deepwater syntactic buoyancy and placed on the top of the mooring line 43 m above the sea bed. The acquisition was programmed to start on board the 08/02/2024 before deployment (13/02/2024 12:28). The ADCP is measuring every 11 s. Each measurement ensemble is obtained from a single ping. The available total range was 43 m with a blanking distance of 1.76 m. The 43 m of distance to the seabed is resolved by a first cell that is 2.96 m high, and then 49 cells of 1 m. The total measuring range of the 50 cells is 51.96 m. The ambiguity velocity was set to 3 m/s.



Enter required details in yellow cells below and chart should automatically update
All cells in yellow are editable and should be the only ones that need updating. If you need to change anything else then unprotect the worksheet (no password)

Mooring name for chart
M4 DY173 CONGO

Anchor launch position

Latitude			Longitude		
Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
6	44.909	S	5	26.372	E

Depth variables

Water depth (m)	Release height above seabed (m)	Transducer depth (m)
4975	42	12

Trilateration details

	Latitude			Longitude			
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?	Range (m)
Pos 1	6	46.28436	S	5	23.99076	E	7069
Pos 2	6	42.23886	S	5	26.28534	E	6970
Pos 3	6	46.29258	S	5	28.64304	E	6957

Read your best estimate of the trilaterated position from the chart after completing the cells above.
Delete entries in degrees cells below until want to display something or may skew axes with old data
Zoom in by changing the axes limits, but switch back to automatic when decided

	Latitude			Longitude		
	Degrees	decimal minutes	N/S?	Degrees	decimal minutes	E/W?
Final position	6	44.909	S	5	26.3695	E

Figure 12.11. Trilateration positioning of Mooring M4

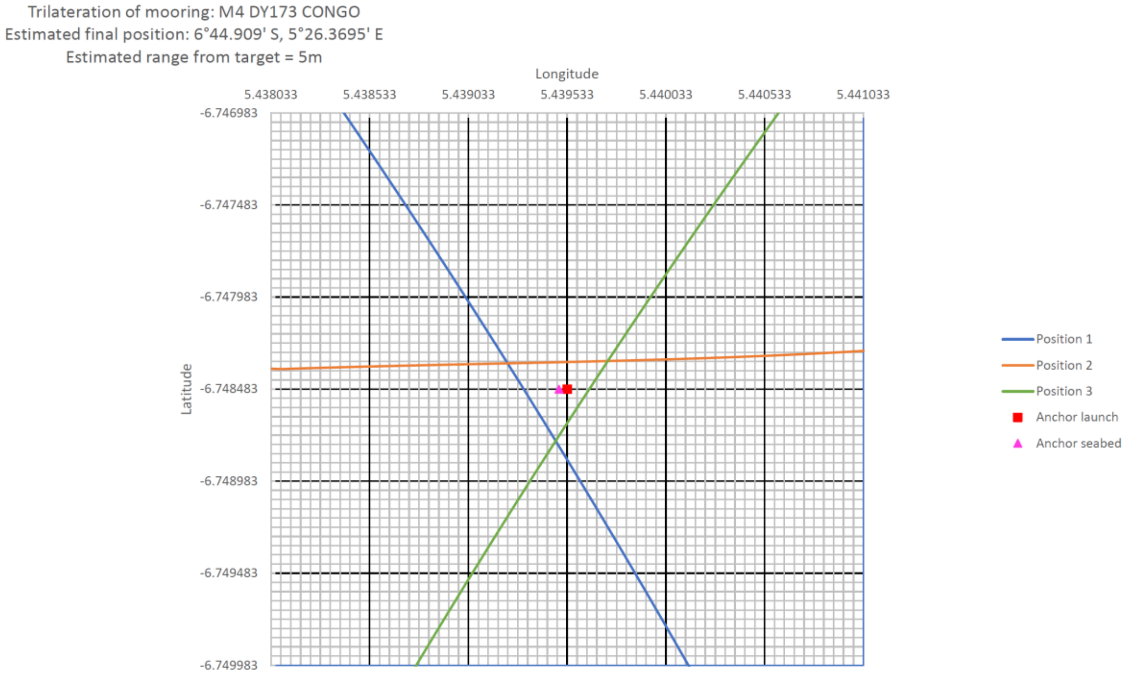


Figure 9.12. Graphic representation of M4 triangulation.

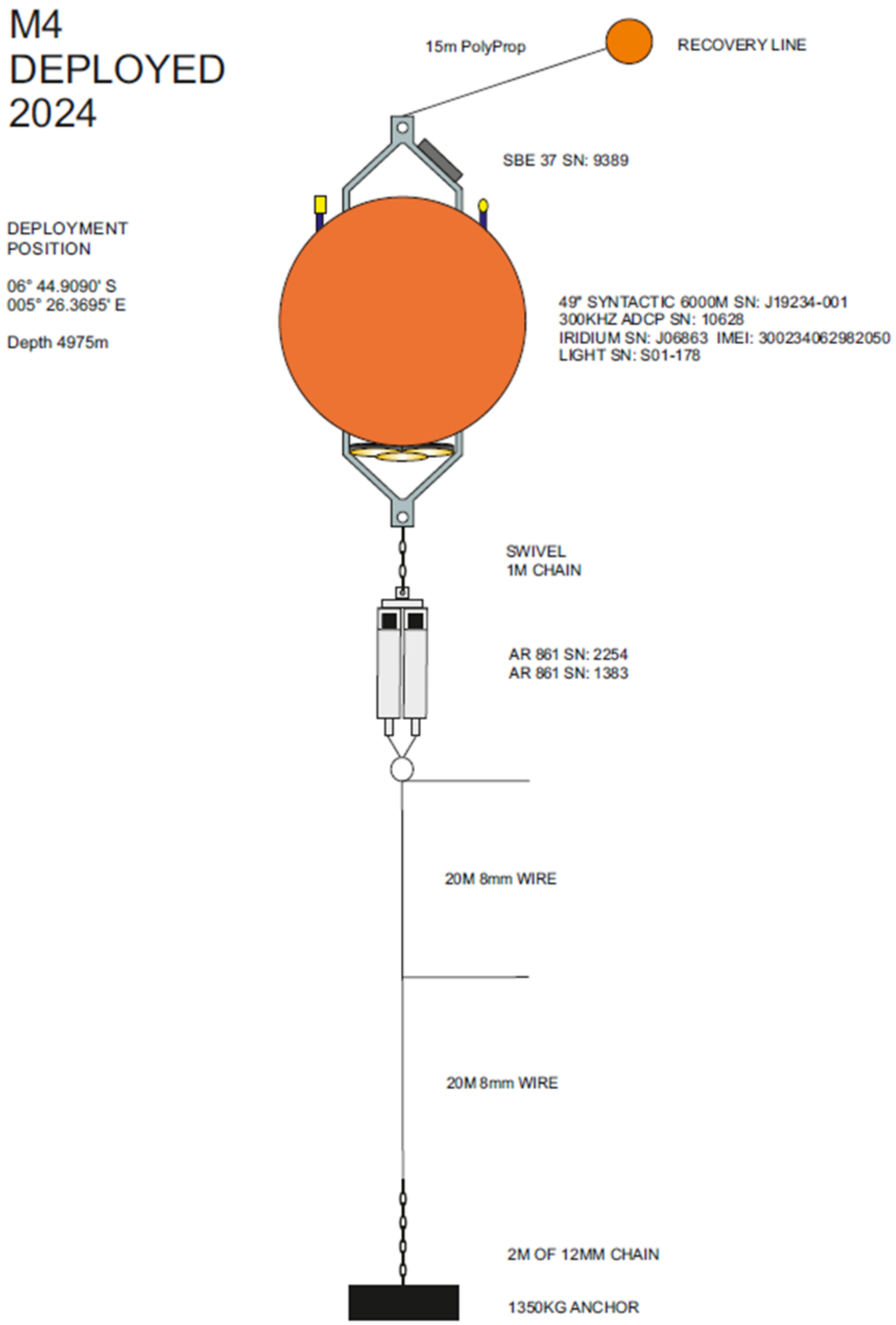


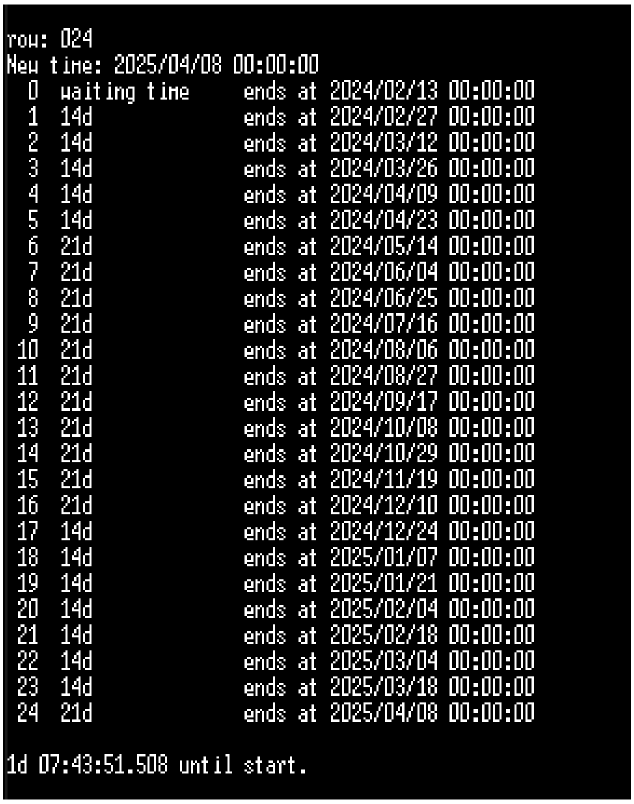
Figure 9.13. NERC Mooring M4.

9.3.7. Ifremer Mooring PeerGynt 1 (PG1)

The textile 10 mm dyneema line of PG1 mooring hosts the following instruments (Table 9.13):

Instrument	Serial Number
Teledyne 300 kHz ADCP	24483
Light	YES
ARGOS Beacon	126 839
VHF	Type 73
Flag	Yellow
Mors AR6 ALU Release	592 (Inter 3A03 ; RLS 3A04)
Mors AR5 ALU Release	750 (Inter 4663 ; RLS 4664)
Sediment Trap Technicap PPS 4/3 24 btl/250 ml	Trap: 33 ; Motor 13-295

The Technicap sediment trap is placed 29 m above the sea bed. Its 24 bottles of 250 ml are collecting sediment from 13/02/2024 at 00:00 until 08/04/2025 at 00:00. Some bottles will be collecting during



```
row: 024
New time: 2025/04/08 00:00:00
  0  waiting time      ends at 2024/02/13 00:00:00
  1  14d               ends at 2024/02/27 00:00:00
  2  14d               ends at 2024/03/12 00:00:00
  3  14d               ends at 2024/03/26 00:00:00
  4  14d               ends at 2024/04/09 00:00:00
  5  14d               ends at 2024/04/23 00:00:00
  6  21d               ends at 2024/05/14 00:00:00
  7  21d               ends at 2024/06/04 00:00:00
  8  21d               ends at 2024/06/25 00:00:00
  9  21d               ends at 2024/07/16 00:00:00
 10  21d               ends at 2024/08/06 00:00:00
 11  21d               ends at 2024/08/27 00:00:00
 12  21d               ends at 2024/09/17 00:00:00
 13  21d               ends at 2024/10/08 00:00:00
 14  21d               ends at 2024/10/29 00:00:00
 15  21d               ends at 2024/11/19 00:00:00
 16  21d               ends at 2024/12/10 00:00:00
 17  14d               ends at 2024/12/24 00:00:00
 18  14d               ends at 2025/01/07 00:00:00
 19  14d               ends at 2025/01/21 00:00:00
 20  14d               ends at 2025/02/04 00:00:00
 21  14d               ends at 2025/02/18 00:00:00
 22  14d               ends at 2025/03/04 00:00:00
 23  14d               ends at 2025/03/18 00:00:00
 24  21d               ends at 2025/04/08 00:00:00

1d 07:43:51.508 until start.
```

Figure 9.14. Opening dates and duration for the sediment trap installed on the PG1 mooring line

21 days, while some others will stay open only during 14 days. The collecting periods for each bottle is indicated hereafter.

Mooring PeerGynt 1 was deployed the 12/02/2024 at 12:34 UTC. The final position of the PG1 mooring at 4,791 m of water depth (with ADCP at 4,712 m) was estimated by the USBL (Table 9.14).

Latitude	Longitude
6° 20.619' S	**5° 55.84430' E**
6°32.21054' S (SHIP)	**Ship 5°55.85488' E (SHIP)**

The 300 kHz Teledyne ADCP (S/N 24483) was fitted into the deepwater syntactic buoyancy and placed on the top of the mooring line 80 m above the seabed. The acquisition was programmed to start at 00:00 on the 13/02/2024. The ADCP is measuring every 2 min. Each measurement ensemble is obtained from 11 pings, with a 1 s interval. The available total range was 99.98 m with a blanking distance of 1.76 m. The 80 m of distance to the seabed is resolved by 81 cells of 1 m. The ambiguity velocity was set to 3 m/s.

9.3.8. Ifremer Mooring PeerGynt 2

The textile 10 mm dyneema line of PG2 mooring hosts the following instruments (Table 9.15):

Instrument	Serial Number
Teledyne 300 kHz ADCP	24484
Light	YES
ARGOS Beacon	126 840
VHF	Type 73
Flag	Yellow
Mors AR6 ALU Release	588 (Inter 4A33 ; RLS 4A34)
Mors AR5 ALU Release	590 (Inter 4A37 ; RLS 4A38)
Sediment Trap Technicap PPS 4/3 24 btl/250 ml	Trap: 17 ; Motor 19-329
Turbidimeter NKE STBD 6000	9001

The Technicap sediment trap is placed 29 m above the seabed. Its 24 bottles of 250 ml are collecting sediment from 13/02/2024 at 00:00 until 08/04/2025 at 00:00. Some bottles will be collecting samples for a duration of21 days, while some other bottles will stay open only during 14 days. The collecting periods for each of these bottles is thus similar to the bottles deployed on PG1.

PeerGynt 2 was deployed the 12/02/2024 at 12:34 UTC. The final position of the PG1 mooring at 4,791 m of water depth (ADCP at 4,712 m) was estimated by the USBL (Table 9.16).

Latitude	Longitude
6° 20.619’ S	5° 55.84430’ E
6°32.21054’ S (SHIP)	Ship 5°55.85488’ E (SHIP)

Similarly to Mooring PG1, the 300 kHz Teledyne ADCP (S/N 24484) was fitted into the deepwater syntactic buoyancy and placed on the top of the mooring line 80 m above the sea bed. The acquisition was programmed to start at 00:00 on the 13/02/2024. The ADCP is measuring every 2 min. Each measurement ensemble is obtained from 11 pings, with a 1 s interval. The available total range was 99.98 m with a blanking distance of 1.76 m. The 80 m of distance to the seabed is resolved by 81 cells of 1 m. The ambiguity velocity was set to 3 m/s.

Below are diagrams showing how the two Ifremer moorings have been set up., which are followed by the data sheets for the these moorings.

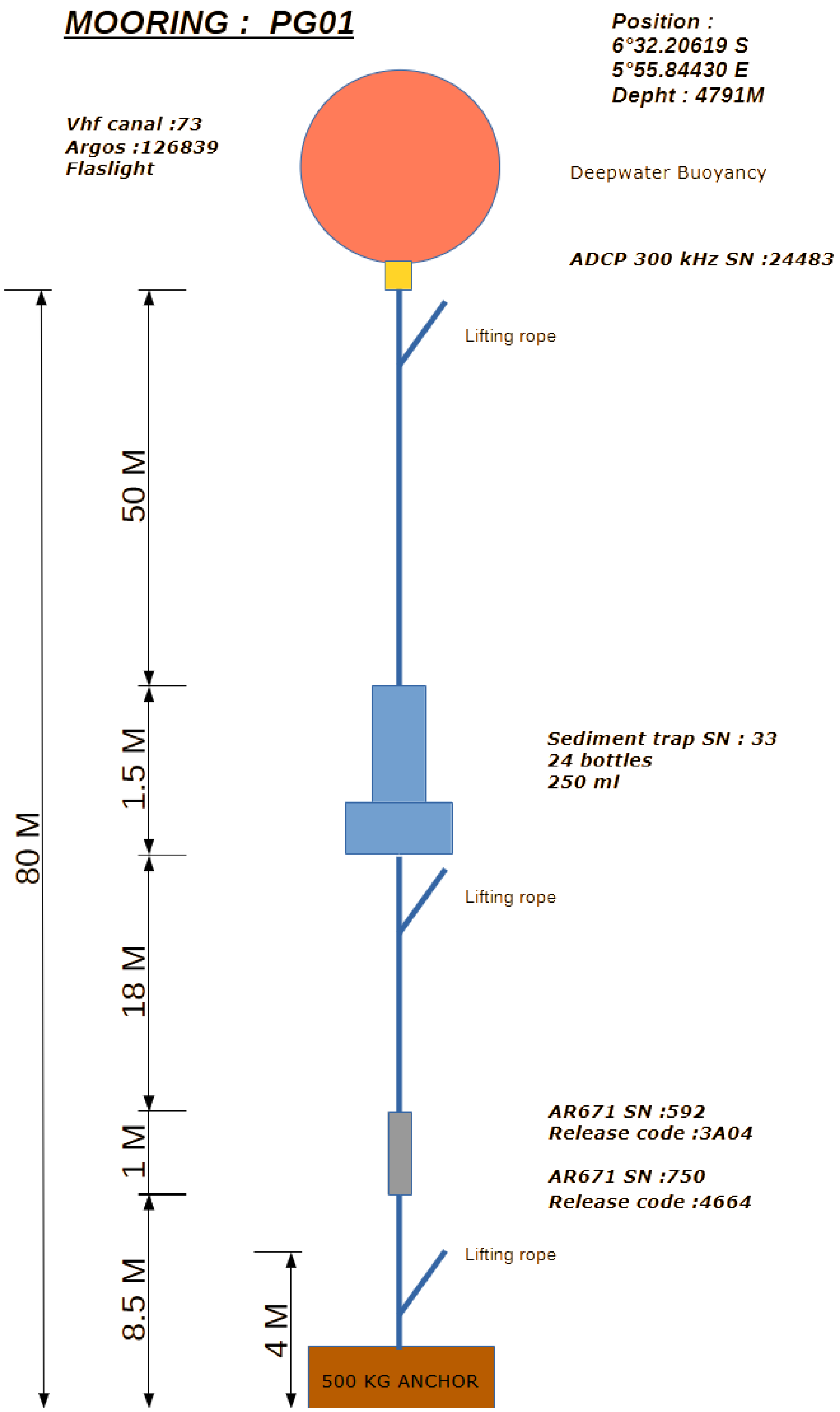
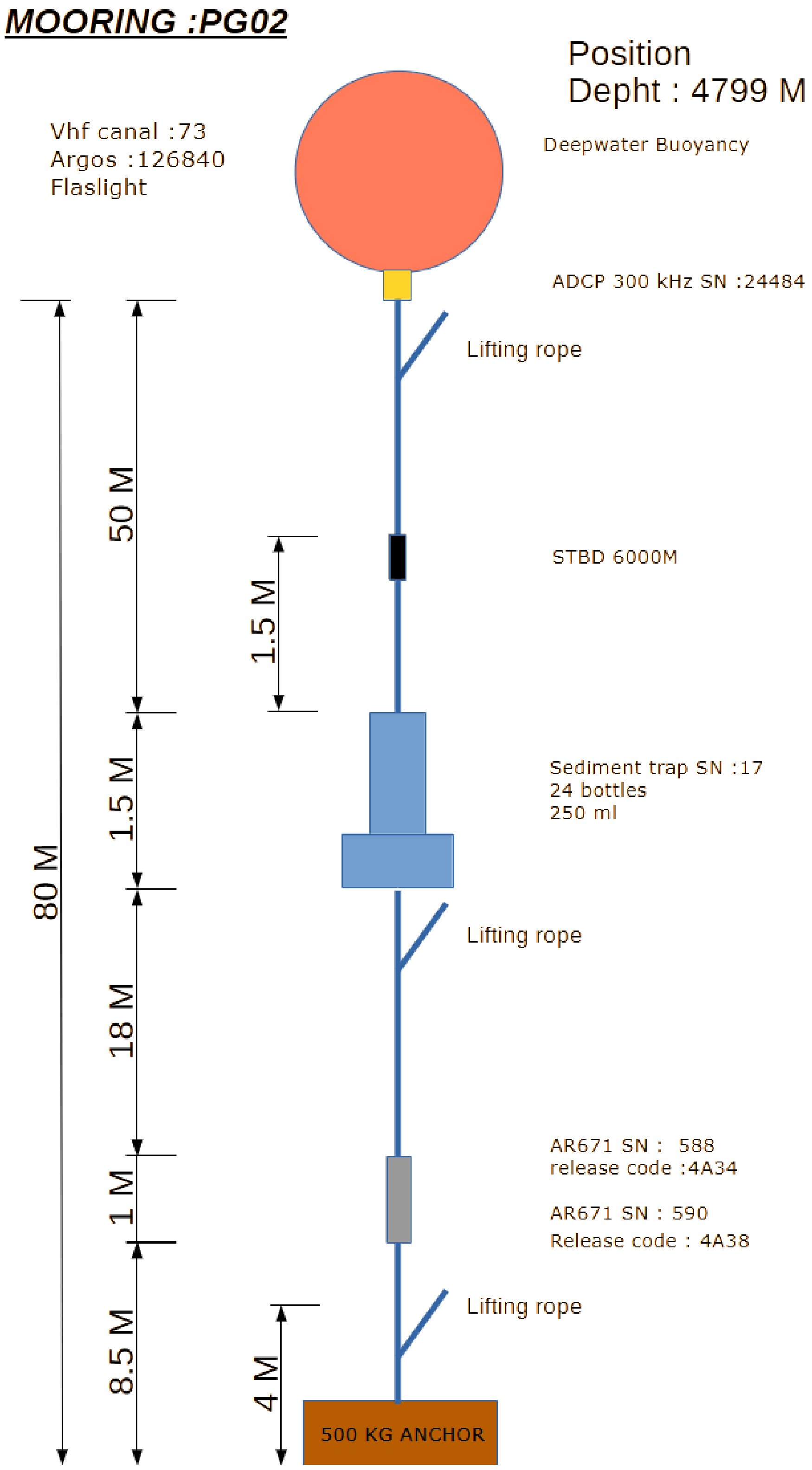
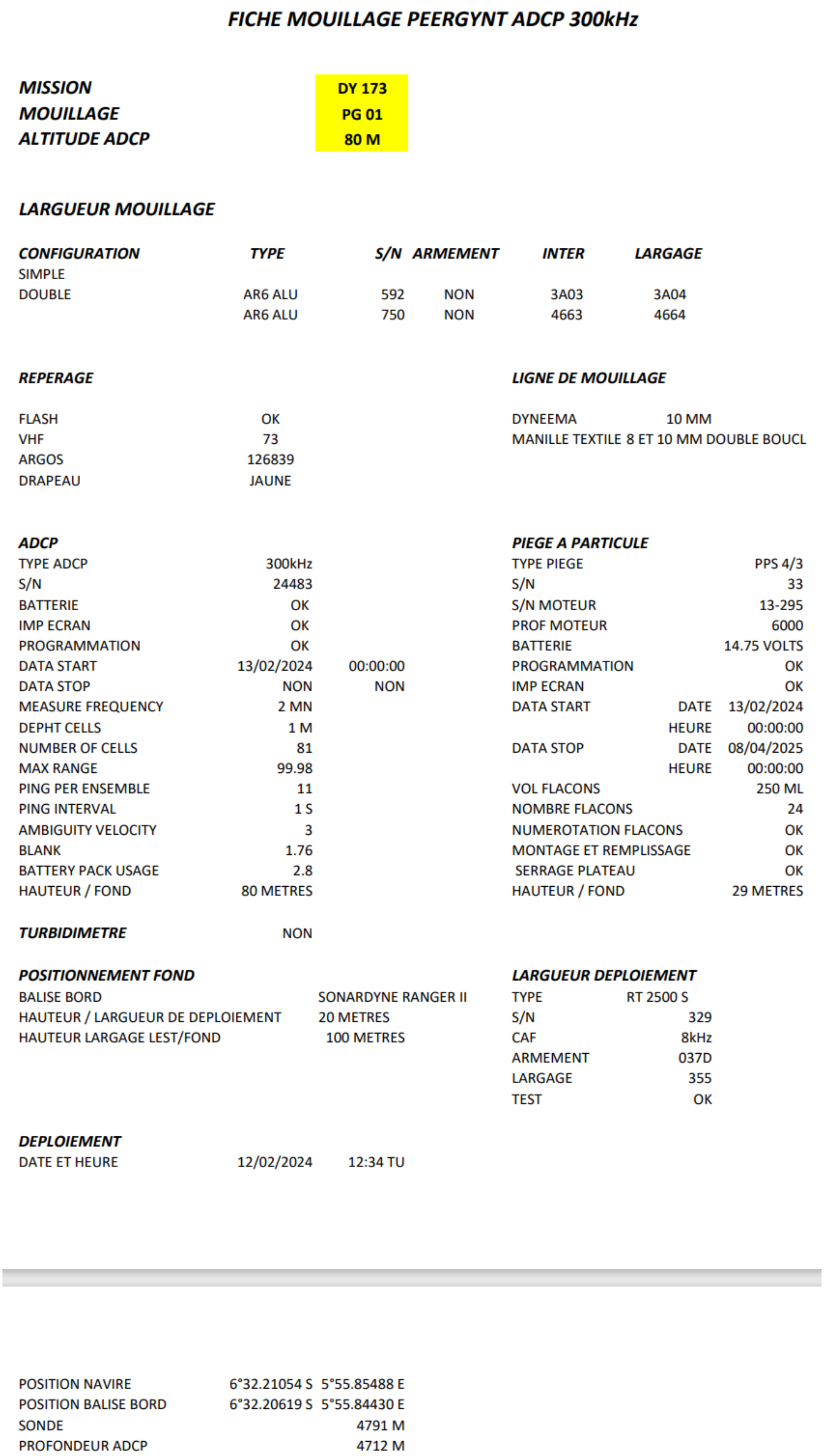


Figure 9.15. Ifremer mooring PG1.

Figure 9.16. Ifremer mooring PG2.





FICHE MOUILLAGE PEERGYNT ADCP 300kHz

MISSION	**DY 173**
MOUILLAGE	**PG 01**
ALTITUDE ADCP	**80 M**

LARGUEUR MOUILLAGE

CONFIGURATION	*TYPE*	*S/N*	*ARMEMENT*	*INTER*	*LARGAGE*
SIMPLE					
DOUBLE	AR6 ALU	592	NON	3A03	3A04
	AR6 ALU	750	NON	4663	4664

REPERAGE

FLASH	OK
VHF	73
ARGOS	126839
DRAPEAU	JAUNE

LIGNE DE MOUILLAGE

DYNEEMA	10 MM
MANILLE TEXTILE	8 ET 10 MM DOUBLE BOUCL

ADCP

TYPE ADCP	300kHz	
S/N	24483	
BATTERIE	OK	
IMP ECRAN	OK	
PROGRAMMATION	OK	
DATA START	13/02/2024	00:00:00
DATA STOP	NON	NON
MEASURE FREQUENCY	2 MN	
DEPHT CELLS	1 M	
NUMBER OF CELLS	81	
MAX RANGE	99.98	
PING PER ENSEMBLE	11	
PING INTERVAL	1 S	
AMBIGUITY VELOCITY	3	
BLANK	1.76	
BATTERY PACK USAGE	2.8	
HAUTEUR / FOND	80 METRES	

PIEGE A PARTICULE

TYPE PIEGE		PPS 4/3
S/N		33
S/N MOTEUR		13-295
PROF MOTEUR		6000
BATTERIE		14.75 VOLTS
PROGRAMMATION		OK
IMP ECRAN		OK
DATA START	DATE	13/02/2024
	HEURE	00:00:00
DATA STOP	DATE	08/04/2025
	HEURE	00:00:00
VOL FLACONS		250 ML
NOMBRE FLACONS		24
NUMEROTATION FLACONS		OK
MONTAGE ET REMPLISSAGE		OK
SERRAGE PLATEAU		OK
HAUTEUR / FOND		29 METRES

TURBIDIMETRE NON

POSITIONNEMENT FOND

BALISE BORD	SONARDYNE RANGER II
HAUTEUR / LARGUEUR DE DEPLOIEMENT	20 METRES
HAUTEUR LARGAGE LEST/FOND	100 METRES

LARGUEUR DEPLOIEMENT

TYPE	RT 2500 S
S/N	329
CAF	8kHz
ARMEMENT	037D
LARGAGE	355
TEST	OK

DEPLOIEMENT

DATE ET HEURE	12/02/2024	12:34 TU

POSITION NAVIRE	6°32.21054 S	5°55.85488 E
POSITION BALISE BORD	6°32.20619 S	5°55.84430 E
SONDE		4791 M
PROFONDEUR ADCP		4712 M

Table 9.17. PG1 Mooring settings.

FICHE MOUILLAGE PEERGYNT ADCP 300kHz

MISSION	DY 173
MOUILLAGE	PG 02
ALTITUDE ADCP	80 M

LARGUEUR MOUILLAGE

CONFIGURATION	*TYPE*	*S/N*	*ARMEMENT*	*INTER*	*LARGAGE*
SIMPLE					
DOUBLE	AR6 ALU	588	NON	4A33	4A34
	AR6 ALU	590	NON	4A37	4A38

REPERAGE

FLASH	OK
VHF	73
ARGOS	126840
DRAPEAU	JAUNE

LIGNE DE MOUILLAGE

DYNEEMA	10 MM
MANILLE TEXTILE	8 ET 10 MM DOUBLE BOUCLE

ADCP

TYPE ADCP	300kHz	
S/N	24484	
BATTERIE	OK	
IMP ECRAN	OK	
PROGRAMMATION	OK	
DATA START	13/02/2024	00:00:00
DATA STOP	NON	NON
MEASURE FREQUENCY	2 MN	
DEPHT CELLS	1 M	
NUMBER OF CELLS	81	
MAX RANGE	99.98	
PING PER ENSEMBLE	11	
PING INTERVAL	1 S	
AMBIGUITY VELOCITY	3	
BLANK	1.76	
BATTERY PACK USAGE	2.8	
HAUTEUR / FOND	80 METRES	

PIEGE A PARTICULE

TYPE PIEGE		PPS 4/3
S/N		17
S/N MOTEUR		19-329
PROF MOTEUR		6000
BATTERIE		14.75 VOLTS
PROGRAMMATION		OK
IMP ECRAN		OK
DATA START	DATE	13/02/2024
	HEURE	00:00:00
DATA STOP	DATE	08/04/2025
	HEURE	00:00:00
VOL FLACONS		250 ML
NOMBRE FLACONS		24
NUMEROTATION FLACONS		OK
MONTAGE ET REMPLISSAGE		OK
SERRAGE PLATEAU		OK
HAUTEUR / FOND		29 METRES

TURBIDIMETRE	OUI	S/N	STBD 6000
CADENCE	4 MN	DT START	13/02/2024 00:00:00
HAUTEUR / FOND	32 M		

LARGUEUR DEPLOIEMENT

TYPE	RT 2500 S
S/N	329
CAF	8kHz
ARMEMENT	037D
LARGAGE	355
TEST	OK

POSITIONNEMENT FOND

BALISE BORD	SONARDYNE RANGER II
HAUTEUR / LARGUEUR DE DEPLOIEMENT	20 METRES
HAUTEUR LARGAGE LEST/FOND	100 METRES

DEPLOIEMENT

DATE ET HEURE	12/02/2024	17:40 TU
POSITION NAVIRE	6°29.62492 S	5°55.40653 E
POSITION BALISE BORD	6°29.60991 S	5°55.38571 E
SONDE		4799 M
PROFONDEUR ADCP		4720 M

Table 9.18. PG1 Mooring settings.

10. Sub-bottom profiler

The Sub-Bottom Profiler system (SBP) SBP-27 used in this survey consists of a one linear transmitter array which is mounted along the vessel keel, and one linear hydrophone array – shared with the EM – mounted orthogonal to the keel. The System is controlled with the software Kongsberg SBP 27 by the multibeam operators.

The transmitted waveform used throughout DY173 was Ricker pulses. The frequency sweep range used throughout the survey was between 2.0 to 9.0 kHz, with a pulse length of 50 ms.

The SBP-27 beam is electronically stabilized for roll and pitch. The ping rate along the survey was set as normal. Furthermore, a "Master depth" is provided from the EM 122 MBES to aid the "bottom track" function. The operating parameters are given in Table 1.

Table 10.1: Summary of SBP27 operating parameters for DY173.

Control	Setting	Comment
Trigger Mode	internal/external	
Pulse form	Ricker	
Ricker Frequency	2.0 - 9.0 kHz	
Pulse length	50 - 10 ms	
Power ramping rate	0 db/min (disabled)	For mammal observation
Roll and pitch stabilization	Auto	
Delay control	Auto	
Pulse length	10 ms	
Sample length	200 ms	
Ping interval	500 ms	
Number of beams	5 or 3	
Beam spacing	6	
Gain	Auto	No amplitude reduction
Sound speed	1480 m/s	No referenced to EM 122
Processing		
Bottom tracker	enabled	
Time Varying Filter (TVF)	2.5/2.4/9.0/9.5 kHz	Bandpass
Gain (digital)	Auto	
Attribute processing	Instantaneous amplitude	

10.1. Recommendations for SBP acquisition for upcoming voyages

The use of SBP data for this research was unplanned and therefore the parameters were not adjusted according to specific objectives required by the research, with the exception of a few tests during data acquisition. Because of this, the acquisition of SBP data was irregular in quality throughout the study area.

However, during this survey the SBP data was sorted, classified and analyzed and it was determined that it has the potential to add value to the study of the dynamic processes occurring on the ocean floor. As such, the forthcoming expedition will include strategic planning for the gathering of SBP data within the Congo river system. Below, a number of key recommended improvements in the data acquisition are enlisted:

Pulse Form	Chirp (LFM)	Modulated pulse
Pulse Length	30 – 40 ms	Increase with depth; values for deep waters
Transmit Mode	Normal	
Sweep Frequency	2.5 – 6.5 kHz	
Beam Width	Full Array	Both, beams TRX and RX
Number of Beams	3	
Beam Spacing	3	Beam width decreases with increasing frequency. The rule of thumbs is the Beam Spacing is the reduction of 4/6 the used frequency. E.g. 6 kHz → 2° Beam Spacing

The primary application of the Sub-Bottom Profiler is to visualize the sediment layers to observe their spatial distribution, dip and geological structures as well as to get information about their "roughness". Considering the above, for a better acquisition the parameters need to be set considering the depth and the geology of the targeted area. For example, constrained and narrowed areas (e.g. canyons) will need, in general, lower angles (beam spacing). Additionally, it is worth noting that stiff sediments will absorb wave front energy more readily, showing little or no penetration where stiff sediments are present, whereas in areas composed of soft sediments the wave front can penetrate up to 100 ms (~90 m below seabed.). The maximum resolution of this system is ~30 cm.

10.2 Results of sub-bottom profiler

The following figure illustrate initial results from the sub-bottom profiler. Note that the length in milliseconds of the piston cores (barrel length) were defined by using a sound velocity equal to 1650 m/s, and thus ~6 m = 0.007 s = 7 ms; ~12 m = 0.014 s = 14 ms.

10.2.1. Figures from the lobe

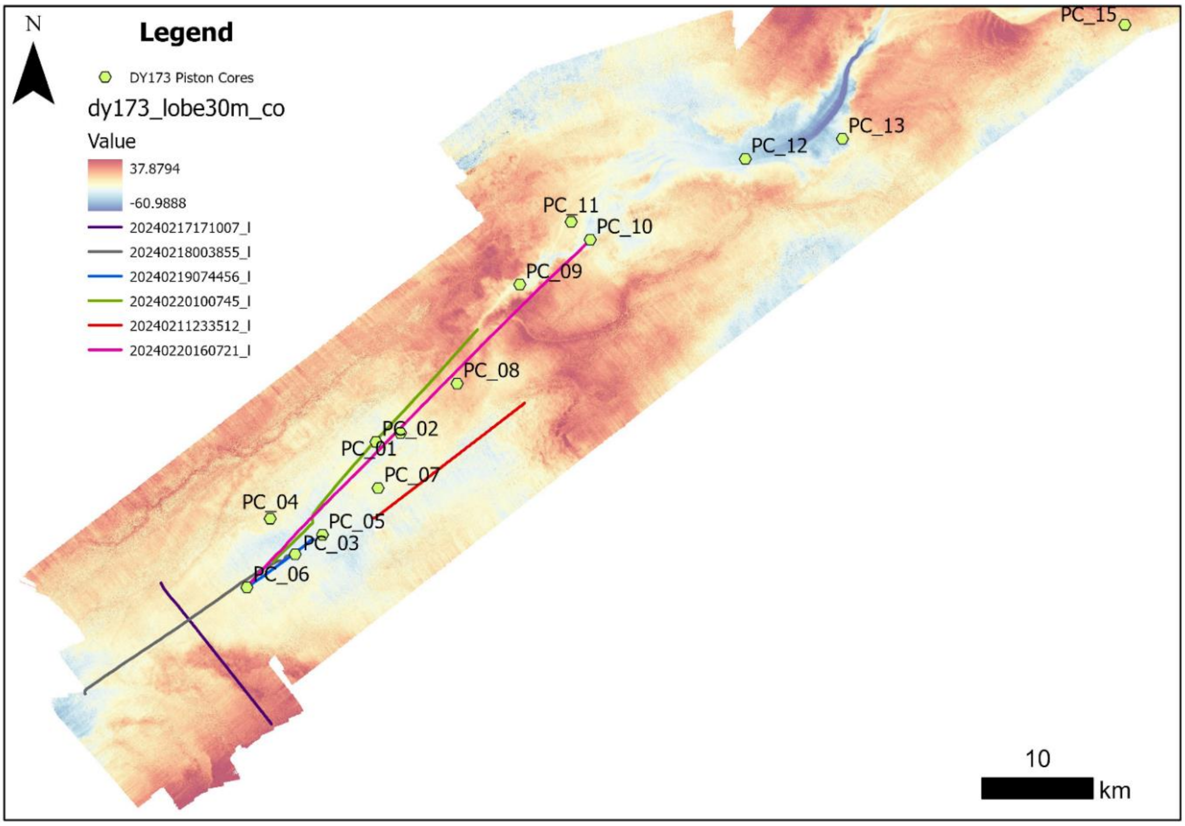


Figure 130.1: Sub-bottom profiles lines superimposed on the slope compensation (i.e. detrended bathymetry) map of lobe zone, with DY173 piston cores sites marked as circles.

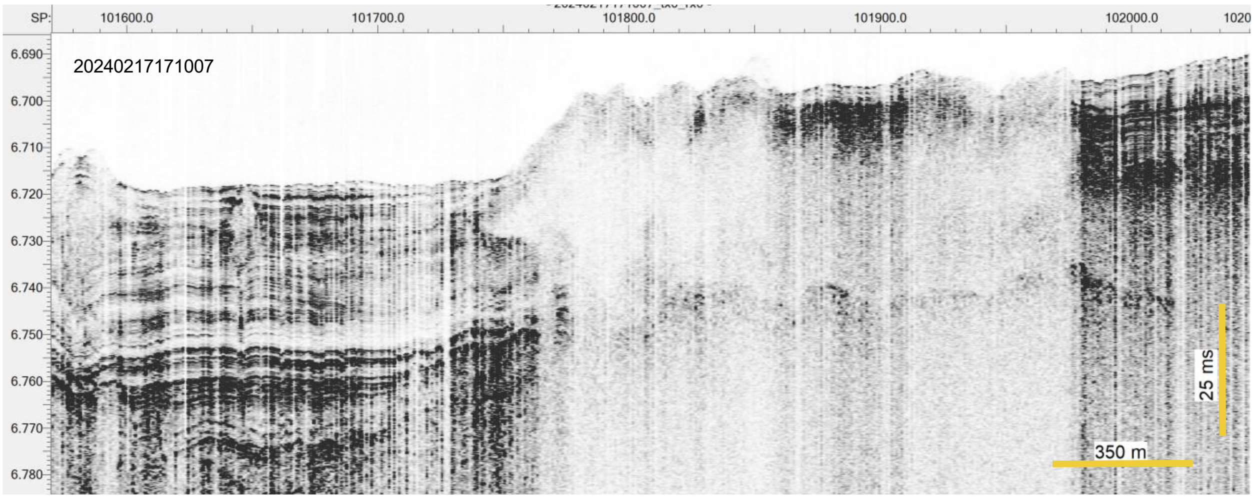


Figure 10.14: SBP-profile 20240217171007 transversal (NW-SE; purple in Fig. 10.1) at the end of the lobe zone. The opaque topographic ridge on the right shows blanking.

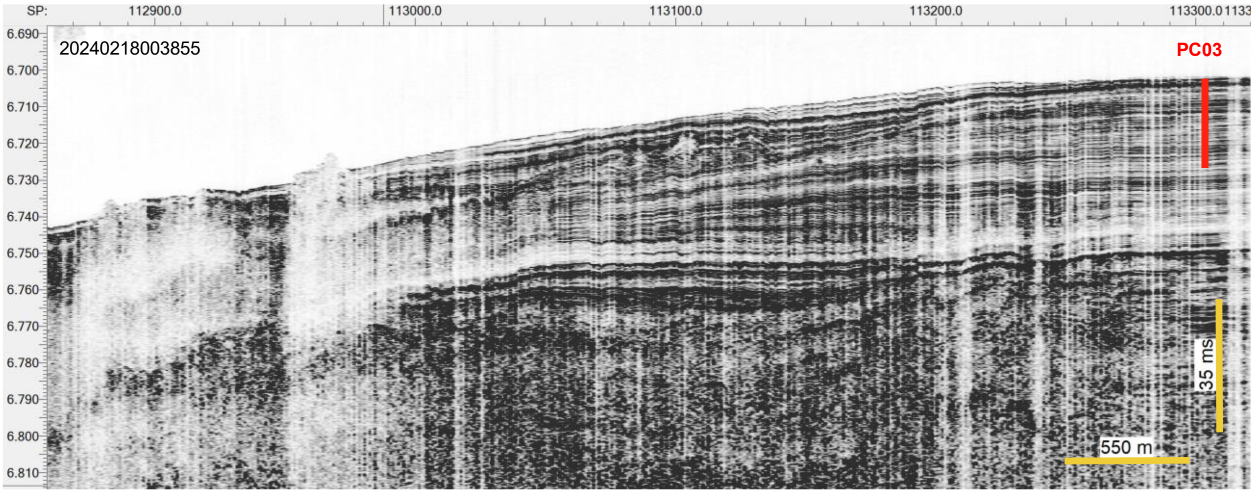


Figure 10.15: SBP-profile 20240218003855 oriented down the regional slope's dip, in the lower part of lobe zone. Piston core PC03 is shown in upper part of the section. Note PC-03 comprises ~2m of hemiplegic mud, underlain by turbidites from an earlier system (Fig. 8.42) whose extend can be seen here.

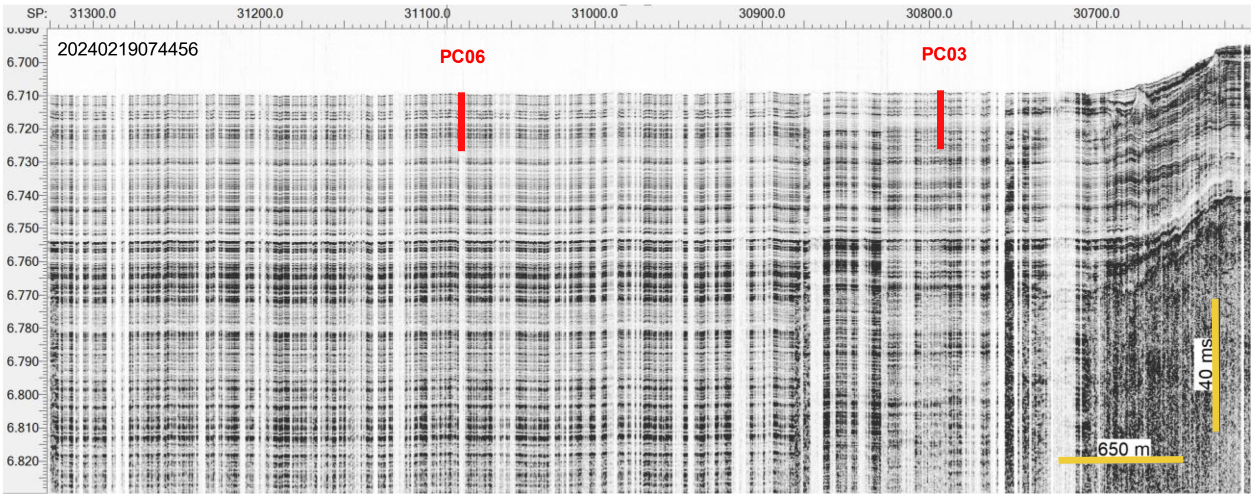


Figure 10.16: SBP-profile 20240219074456 longitudinal to the lower part of lobe zone. Piston cores PC03 and PC06 in the section. Note that the x-axis is shot number, and the ship may have been near-stationary at times, but the character of beds is well shown at these two distal core sites (Fig. 10.1). Both PC03 and PC06 also comprise an upper 2 m of hemipelagite, underlain by an older turbidite system (Fig. 8.42).

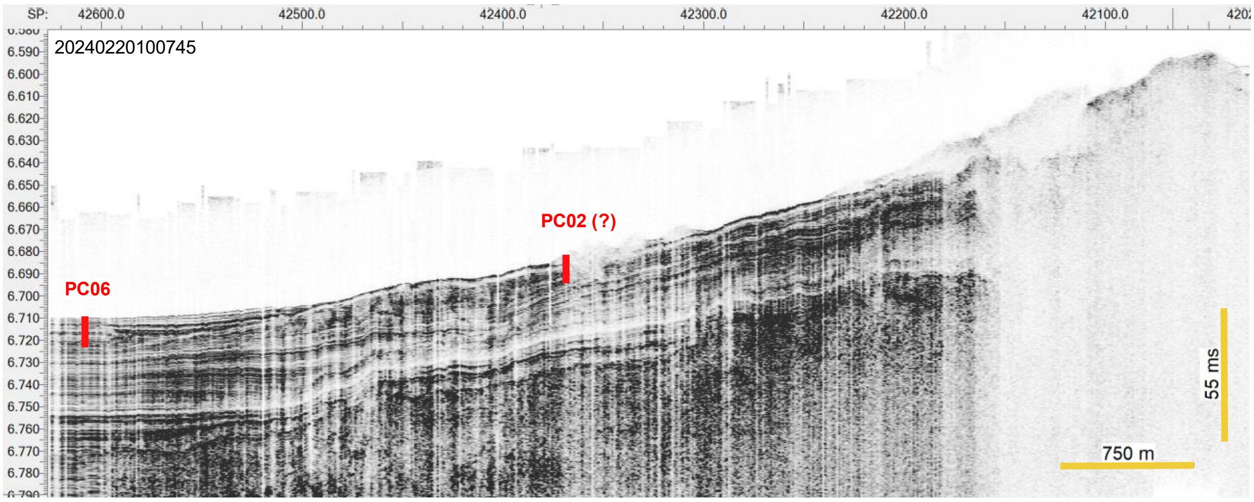


Figure 10.5: SBP-profile 20240220100745 along the lobe zone. Piston cores PC02 and PC06 are shown. Location along the profile of PC02 is approximate. Note the near surface debris flow (opaque unit) seen near and upslope of PC02. PC01 is near to PC02, and has a debrite, as does PC08, and this line may show the debris flow deposit.

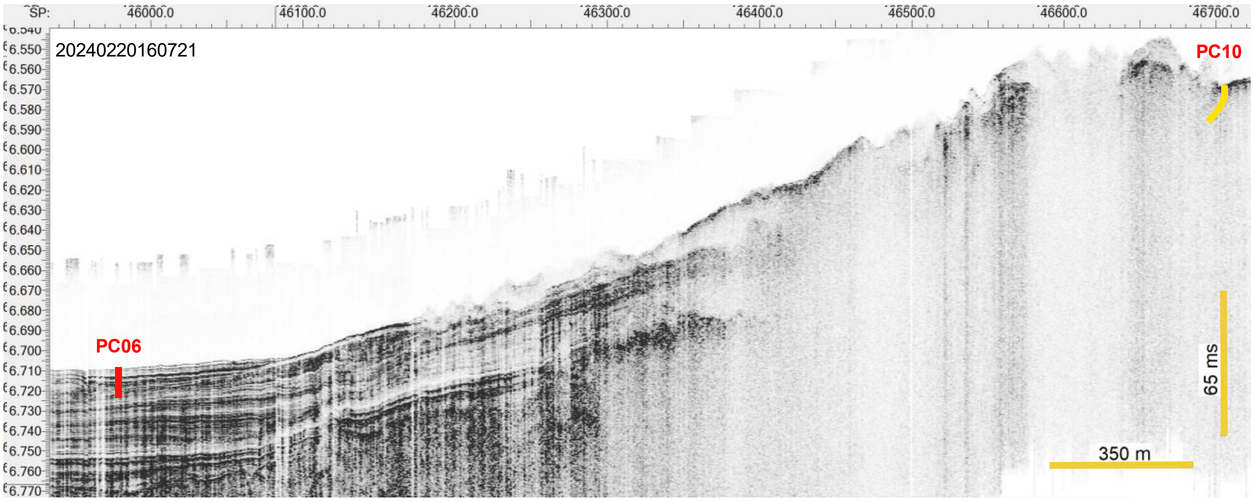


Figure 10.17: SBP-profile 20240220160721 along the lobe zone. Blank layer on top of the central part of the section (near sea surface) indicates homogeneous sediment deposit, which is likely the debris flow seen in PC08 and 02. Piston cores PC06 and PC10 are shown. PC10 was bent, indicating stiff sandy-rich sediment the seabed.

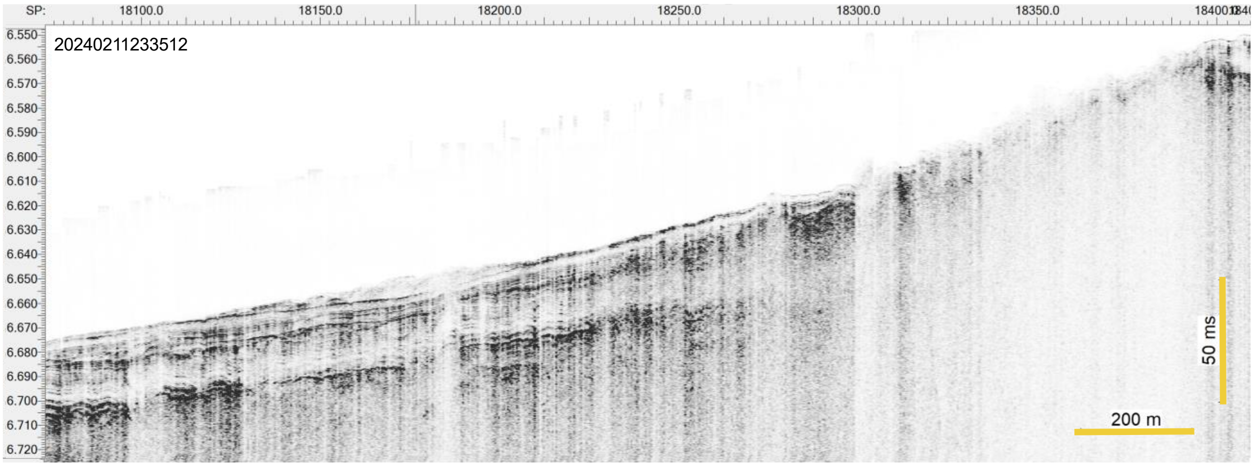


Figure 10.18: SBP-profile 20240211233512 along the central part of the lobe zone. Blank layer on top of the lower-central part of the section indicates homogeneous sediment deposit, which again may represent a thin and very recent debris flow deposit seen in cores.

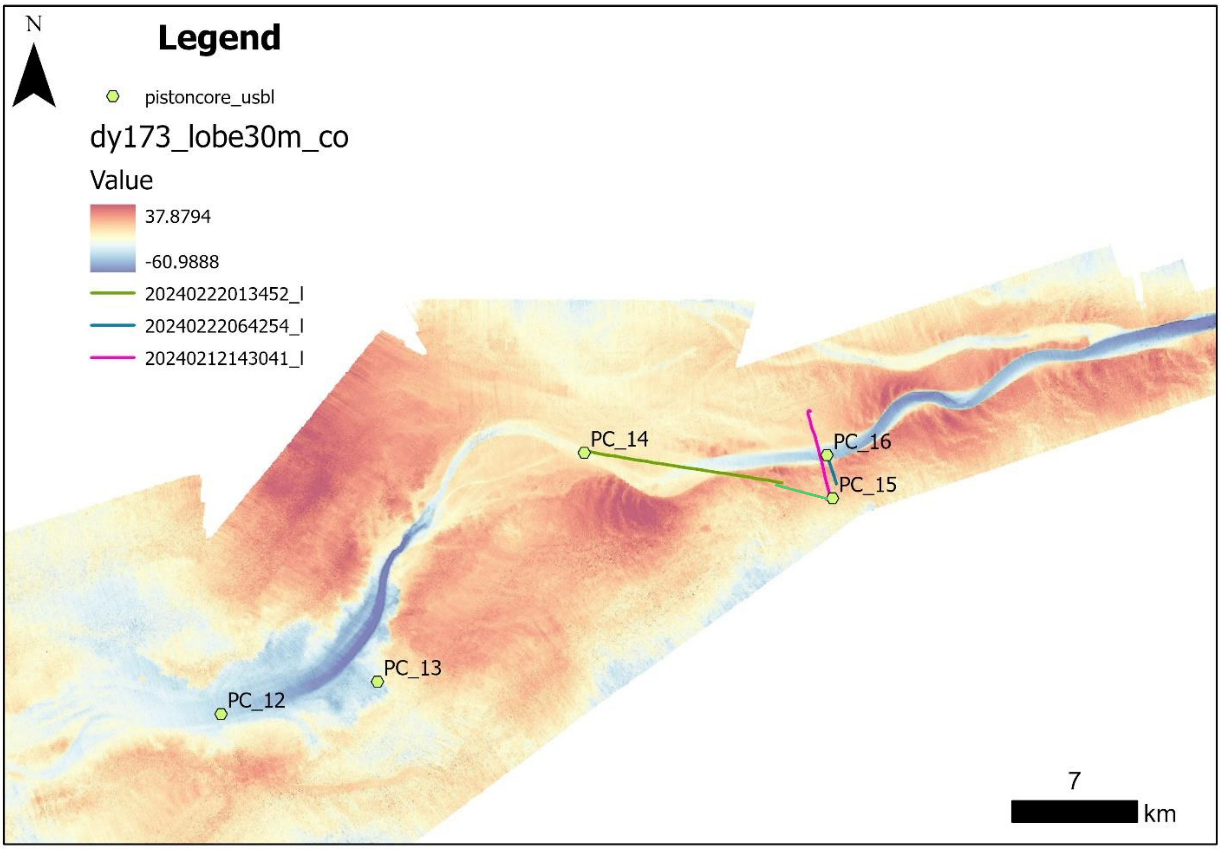


Figure 10.19: Sub-bottom profiles lines superimposed on the slope compensation (detrended bathymetry) map of the zone on the lobe and end of deep-sea channel, with cores marked.

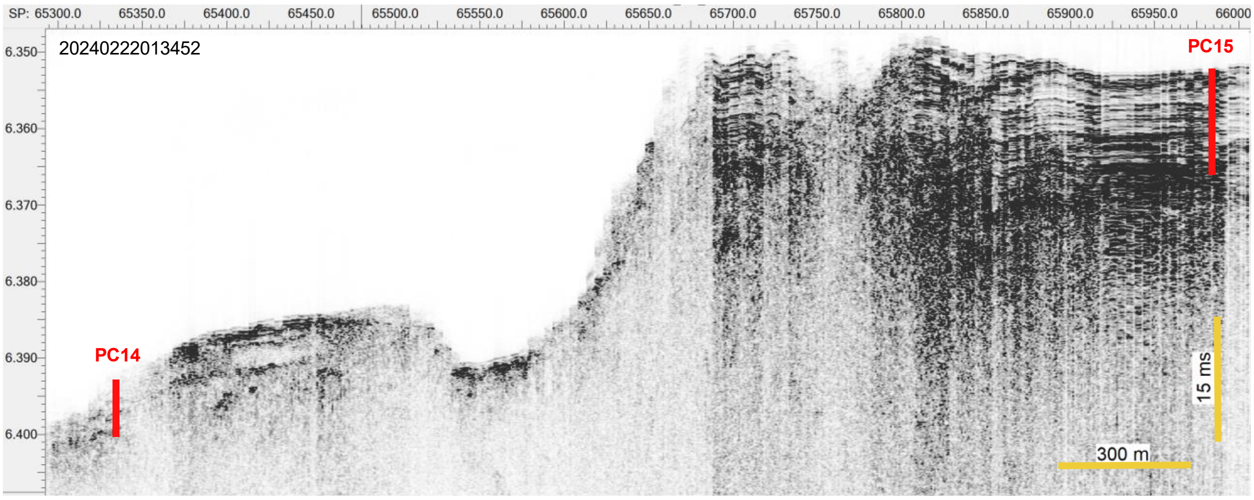


Figure 10.20: SBP-profile 20240222013452 across the channel. Piston cores PC14 and PC15 are shown. PC14 has 47 cm of sample from a possible 6 m in an area of stiff seabed sand. PC15 has ~10 m sample from a possible 12 m in an area with much great penetration. This contract in core length correlated with the depth of sub-bottom profiler penetration and facies, showing how sub bottom profiler can be a guide to plan effective coring.

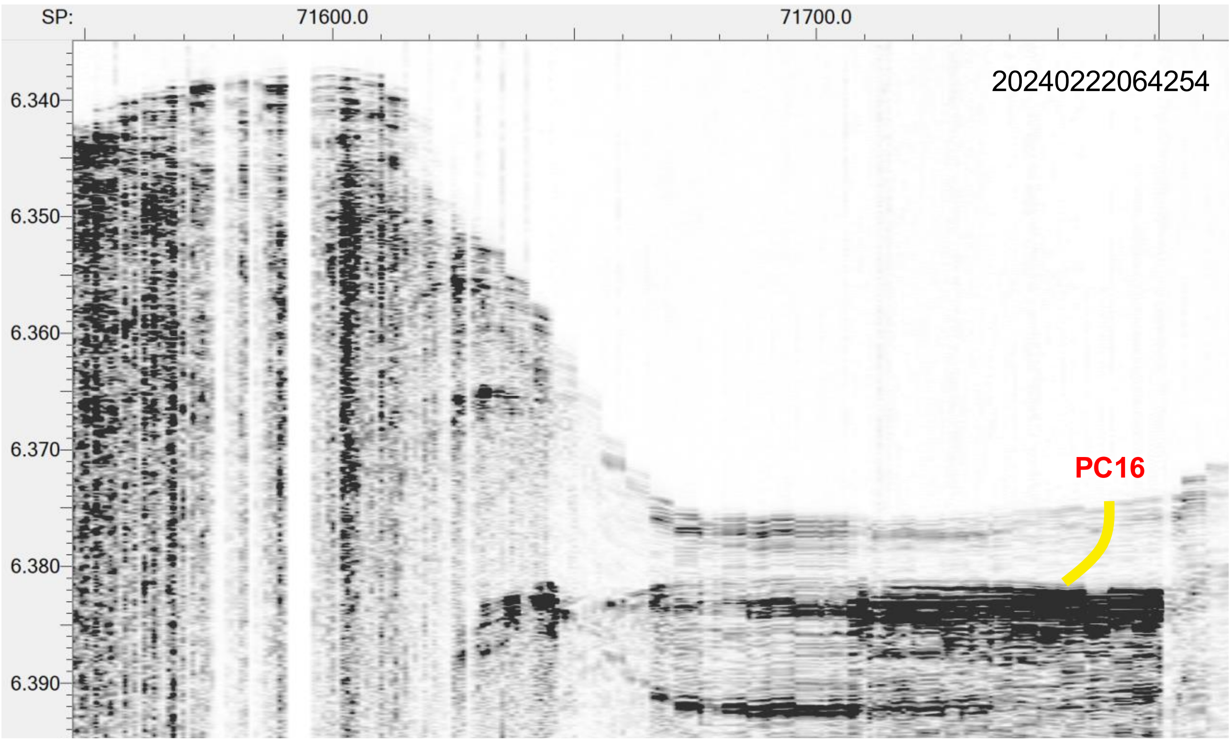


Figure 21.10. SBP-profile 20240222064254 partially across the channel. PC16 was bent and provided no samples, and it is located in an area of sandy seabed close to mooring M1.

10.3. List of Sub-bottom profiler lines (Table 10.2).

File Name	Coordinate System	Area	Beams	Cores
20240207093600_tx0	Second of arc - EPSG:4326	Transit	5	
20240207093816_tx0	Second of arc - EPSG:4326	Transit	5	
20240207094717_tx0	Second of arc - EPSG:4326	Transit	5	
20240207103714_tx0	Second of arc - EPSG:4326	Transit	9	
20240207103831_tx0	Second of arc - EPSG:4326	Transit	9	
20240207104004_tx0	Second of arc - EPSG:4326	Transit	1	
20240207104033_tx0	Second of arc - EPSG:4326	Transit	9	
20240207120241_tx0	Second of arc - EPSG:4326	Transit	9	
20240207120357_tx0	Second of arc - EPSG:4326	Transit	9	
20240207121020_tx0	Second of arc - EPSG:4326	Transit	5	
20240207153124_tx0	Second of arc - EPSG:4326	Transit	5	
20240207160225_tx0	Second of arc - EPSG:4326	Transit	5	
20240207160544_tx0	Second of arc - EPSG:4326	Transit	5	
20240207165246_tx0	Second of arc - EPSG:4326	Transit	5	
20240208063804_tx0	Second of arc - EPSG:4326	Transit	5	
20240209054441_tx0	Second of arc - EPSG:4326	Transit	5	
20240209214448_tx0	Second of arc - EPSG:4326	Transit	5	
20240209214534_tx0	Second of arc - EPSG:4326	Transit	5	
20240209214557_tx0	Second of arc - EPSG:4326	Transit	5	

20240209215734_tx0	Second of arc - EPSG:4326	Transit	5	
20240209221250_tx0	Second of arc - EPSG:4326	Transit	5	
20240209221251_tx0	Second of arc - EPSG:4326	Transit	5	
20240209221313_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210004206_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210021200_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210034613_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210053001_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210111929_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210113849_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210165133_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210165256_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210170650_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210171214_tx0	Second of arc - EPSG:4326	Lobe	5	
20240210230325_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211010048_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211023141_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211033114_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211115738_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211115749_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211120908_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211125214_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211161046_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211162803_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211175834_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211200350_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211230822_tx0	Second of arc - EPSG:4326	Lobe	5	
20240211233512_tx0	Second of arc - EPSG:4326	Lobe	5	
20240212014830_tx0	Second of arc - EPSG:4326	Lobe	5	MC06
20240212043653_tx0	Second of arc - EPSG:4326	Lobe	5	
20240212143041_tx0	UTM 31S - EPSG:32731	Lobe	5	PC15, PC16; MC01
20240212210610_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240212210643_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240212213249_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240212230452_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213004918_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213022741_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213032834_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213035037_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213045211_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213063231_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213153605_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213175922_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213193309_tx0	UTM 31S - EPSG:32731	Lobe	5	

20240213195846_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213212835_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240213215946_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240214014138_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240214054327_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214084142_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214094356_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214115918_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214133446_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214161321_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214194903_tx0	UTM 32S - EPSG:32732	Channel	5	
20240214211117_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215000248_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215033537_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215054737_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215064835_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215080708_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215082337_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215124124_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215125531_tx0	UTM 32S - EPSG:32732	Channel	5	
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20240215173816_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215211027_tx0	UTM 32S - EPSG:32732	Channel	5	
20240215235515_tx0	UTM 32S - EPSG:32732	Channel	5	
20240216011448_tx0	UTM 32S - EPSG:32732	Channel	5	
20240216044726_tx0	UTM 32S - EPSG:32732	Channel	5	
20240216071841_tx0	UTM 32S - EPSG:32732	Channel	5	
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20240216110038_tx0	UTM 32S - EPSG:32732	Channel	5	
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20240218003855_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240218021109_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240218132328_tx0	Second of arc - EPSG:4326	Transit MC02	5	
20240218132439_tx0	Second of arc - EPSG:4326	Transit MC02	9	
20240218152842_tx0	Second of arc - EPSG:4326	Transit MC02	9	MC02

20240218153843_tx0	Second of arc - EPSG:4326	Transit MC02 - Lobe	5	PC01, PC05; MC02, MC03
20240219074456_tx0	Second of arc - EPSG:4326	Lobe	5	PC03; MC05
20240219130332_tx0	Second of arc - EPSG:4326	Lobe	5	
20240219130343_tx0	Second of arc - EPSG:4326	Lobe	5	MC05
20240219170650_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240219183206_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240220043226_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240220100745_tx0	UTM 31S - EPSG:32731	Lobe	5	PC02; MC05
20240220160721_tx0	UTM 31S - EPSG:32731	Lobe	5	PC01, PC06, PC10; MC03, MC05
20240220230546_tx0	UTM 31S - EPSG:32731	Lobe	5	PC10, PC11
20240221051649_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240221051724_tx0	UTM 31S - EPSG:32731	Lobe	5	PC11, PC12
20240221062053_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240221103639_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240221103702_tx0	UTM 31S - EPSG:32731	Lobe	5	PC12; MC06
20240221152246_tx0	UTM 31S - EPSG:32731	Lobe	5	PC13; MC06
20240221195553_tx0	UTM 31S - EPSG:32731	Lobe	5	PC13, PC14
20240222013406_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240222013452_tx0	UTM 31S - EPSG:32731	Lobe	5	PC14, PC15
20240222022954_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240222064254_tx0	UTM 31S - EPSG:32731	Lobe	5	PC15, PC16; MC01
20240222114118_tx0	UTM 31S - EPSG:32731	Lobe	5	
20240222114221_tx0	UTM 31S - EPSG:32731	Lobe	5	PC16; MC01
20240222123343_tx0	UTM 32S - EPSG:32732	Transit	5	
20240222131136_tx0	UTM 32S - EPSG:32732	Channel	5	
20240222152639_tx0	UTM 32S - EPSG:32732	Transit Luanda	5	
20240223054209_tx0	UTM 32S - EPSG:32732	Transit Luanda	5	
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20240225101348_tx0	UTM 32S - EPSG:32732	Transit Luanda	5	
20240225112114_tx0	UTM 32S - EPSG:32732	Transit Luanda	5	
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20240225152249_tx0	UTM 32S - EPSG:32732	Canyon	5	
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20240226020343_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226024837_tx0	UTM 32S - EPSG:32732	Canyon	5	
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20240226041238_tx0	UTM 32S - EPSG:32732	Canyon	5	
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20240226042111_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240226052703_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240226054105_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240226064213_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240226075331_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240226075515_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226075607_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226075639_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226082548_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226103157_tx0	UTM 33S - EPSG:32733	Canyon top end - turning	5	
20240226104529_tx0	UTM 32/33S - EPSG:32732/32733	Canyon top end - turning	5	
20240226120447_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226142905_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226152647_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226160512_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226172126_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226175648_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226183951_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226192120_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226204332_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240226232122_tx0	UTM 32S - EPSG:32732	Canyon	5	
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20240227082853_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240227110001_tx0	UTM 32S - EPSG:32732	Canyon	5	
20240227120447_tx0	UTM 32/33S - EPSG:32732/32733	Canyon top end	5	
20240227143127_tx0	UTM 32S - EPSG:32732	Canyon	5	

20240227155546_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240227155549_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240227155808_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240227181050_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240227193202_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240227211254_tx0	UTM 32S - EPSG:32732	Canyon	3	PC22, PC23; MC07
20240227235008_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240228022452_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240228023938_tx0	UTM 32S - EPSG:32732	Canyon	3	PC25; MC08
20240228051714_tx0	UTM 32S - EPSG:32732	Canyon	3	PC17
20240228083458_tx0	UTM 32S - EPSG:32732	Canyon	3	PC17, PC18
20240228083525_tx0	UTM 32S - EPSG:32732	Canyon	3	PC17, PC18
20240228105806_tx0	UTM 32S - EPSG:32732	Canyon	3	PC18, PC19
20240228132855_tx0	UTM 32S - EPSG:32732	Canyon	3	PC19
20240228152149_tx0	UTM 32S - EPSG:32732	Canyon	3	PC19, PC20
20240228174521_tx0	UTM 32S - EPSG:32732	Canyon	3	PC20, PC21 (?)
20240228201718_tx0	UTM 32S - EPSG:32732	Canyon	3	PC21
20240228210135_tx0	UTM 32S - EPSG:32732	Canyon	3	PC21, PC22
20240228230839_tx0	UTM 32S - EPSG:32732	Canyon	3	PC22
20240229002709_tx0	UTM 32S - EPSG:32732	Canyon	3	PC22, PC23; MC07
20240229023402_tx0	UTM 32S - EPSG:32732	Canyon	3	PC23; MC07
20240229050113_tx0	UTM 32S - EPSG:32732	Canyon	3	PC23; MC07
20240229060101_tx0	UTM 32S - EPSG:32732	Canyon	3	PC22, PC23; MC07
20240229075803_tx0	UTM 32S - EPSG:32732	Canyon	3	PC24
20240229090231_tx0	UTM 32S - EPSG:32732	Canyon	3	PC24
20240229142901_tx0	UTM 32S - EPSG:32732	Canyon	3	
20240301160347_tx0	UTM 32S - EPSG:32732	Channel	3	
20240301171408_tx0	UTM 32S - EPSG:32732	Channel	3	PC26
20240301184009_tx0	UTM 32S - EPSG:32732	Channel	3	
20240301185650_tx0	UTM 32S - EPSG:32732	Channel	3	
20240301192929_tx0	UTM 32S - EPSG:32732	Channel	3	PC27
20240301233302_tx0	UTM 32S - EPSG:32732	Channel	3	PC27
20240302001647_tx0	UTM 32S - EPSG:32732	Channel	3	
20240302004307_tx0	UTM 32S - EPSG:32732	Channel	3	PC28
20240302053111_tx0	UTM 32S - EPSG:32732	Channel	3	PC28
20240302064425_tx0	UTM 32S - EPSG:32732	Channel	3	
20240302070951_tx0	UTM 32S - EPSG:32732	Channel	7	
20240302074734_tx0	UTM 32S - EPSG:32732	Channel	7	PC30
20240302092244_tx0	UTM 32S - EPSG:32732	Channel	7	
20240302121410_tx0	UTM 32S - EPSG:32732	Channel	7	
20240302160055_tx0	UTM 32S - EPSG:32732	Channel	5	
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20240302172309_tx0	UTM 32S - EPSG:32732	Channel	3	

20240302172323_tx0	UTM 32S - EPSG:32732	Channel	3	
20240302172620_tx0	UTM 32S - EPSG:32732	Channel	3	PC30
20240302172942_tx0	UTM 32S - EPSG:32732	Channel	3	
20240302173035_tx0	UTM 32S - EPSG:32732	Channel	3	PC29
20240302174100_tx0	UTM 32S - EPSG:32732	Channel	3	
20240302174114_tx0	UTM 32S - EPSG:32732	Channel	3	
20240302174128_tx0	UTM 32S - EPSG:32732	Channel	3	

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APPENDIX A: BRIEF OVERVIEW OF ACTIVITIES

Date (day/month)	Time (UTC) Start	Time (UTC) End	Latitude (Deg DDM)	longitude (Deg DDM)	Depth (m)	Device (equipment)	Activity + comments (what happened)
LOBE							
9th Feb 2024	17:18	13:55	6 27.4142	6 5.5883	4758	CTD	CTD_01 Location is at boundary of lobe and deep-sea channel.
9-10th Feb	21:44	11:20	6 25.9588	6 5.7823	4731-5090	MB-1	Start Swath Multibeam Survey 1 on the Lobe
10th Feb	12:10	15:50	7 1.626	5 5.174	5063	CTD	CTD_02 Location is on lobe
10-11th Feb	15:40	06:18	7 1.3645	5 5.1343	5093-4725	MB-2	Swath Multibeam Survey 1 (continued) on Lobe
11th Feb	08:07	10:40	6 30.9388	5 55.6489	4807	M1 Mooring	NERC M1 Mooring (Triangulated location 6 30.935 S 005 55.630 E)
11-12th Feb	12:03	01:48	6 30.520	6 0.025	4764	MB	Swath Multibeam Survey 2 on the Lobe
12th Feb	04:36	07:21	6 30.7987	5 48.3140	4811	M2 Mooring	NERC M2 Mooring
12th Feb	09:25	14:35	6 32.2085	5 55.8535		PG1 Mooring	Ifremer PG1 Mooring
12th Feb	15:08	20:36	6 29.617	3 55.4006		PG2 Mooring	Ifremer PG2 Mooring
12th-13th Feb	21:32	07:16	6 27.813	5 52.644	4799	MB-3	Swath Multibeam Survey 3 on Lobe
13th Feb	07:27	10:24	6 36966	5 41.6732	4904	M3 Mooring	NERC M3 Mooring
13th Feb	12:15	15:08	6 44.9284	5 26.3832	4909	M4 Mooring	NERC M4 Mooring
13th-14th Feb	17:59	01:41	6 59.693	5 11.248	5072	MB-4	Swath Multibeam Survey 4 on Lobe
14th Feb	01:58	05:43	6 48.6613	5 32.;7825	4919	Transit	Transiting to start of channel survey 5
CHANNEL							
14th-15th Feb	05:43	08:06	6 26.2700	6 4.4562	4757	MB-5	Swath Multibeam Survey 5 in deep-sea channel
15th Feb	08:50	12:41	5 43.5768	8 9.9355	4086	CTD3	CTD_03 at boundary international waters
15th-16th Feb	12:55	15:06	5 43.348	8 9.943	4127	MB-5	Swath Multibeam Survey 5 (continued) channel
16th Feb	15:34	01:55	6 28.192	6 02.439	4740	Winch	Winch test
LOBE							
16th-17th Feb	20:08	00:10	6 30.886	5 55.916	4747	MC_01	Multicore_01 (USBL: 6 30.8913; 5 55.8950)
17th Feb	05:52	09:12	6 51.91165	5 20.8002	5032	PC_01	Piston Core PC-01 [GIS site 18] [USBL 6° 51.90992 S 5° 20.79833' E]
17th Feb	11:35	15:10		6 52.2630	5 19.3716	PC_02	Piston Core PC-02 [GIS site 18] [USBL 6 52.339S, 5 19.606E]
17-18th Feb	17:10	00:39	6 59.150	5 9.130	5062-5101	MB6	Swath Multibeam Survey 6 on far end of Lobe
18th Feb	02:08	06:49	6 57.7745	5 15.6888	5067	PC_03	Piston Core PC-03 [USBL 6 57.76370 S, 5 15.673129 E]
18th Feb	07:24	12:42	6 56.0443	5 14.4556	5058	PC_04	Piston Core PC-04 [USBL: 6 56.04765 S, 5 14.45526 E]
18th Feb	15:32	19:59	6 58.467	5 39.507	4966	MC02	Multicore_02 [USBL , 658.4472, 539.5906]
18th-19th Feb	22:17	01:58	6 51.910	5 20.793	5028	MC03	Multicore_03 [USBL: 6 51.91509S, 5 20.79304E]
19th Feb	03:36	07:00	6 56.83488	5 16.87236	4982	PC_05	Piston Core PC-05 [USBL 6 56.82295 S, 5 17.0027 E]
19th Feb	09:20	12:33	6 59.3737	5 13.3114	5076	PC_06	Piston Core PC-06
19th Feb	14.13	18:30	654.633	519.635	5041	PC_07	Piston Core PC-07 [USBL = 654.5715, 519.708]
19th Feb	19.33	23:46	649.485	523.585	4980	PC_08	Piston Core PC-08
20th Feb	01:13	05:03	644.737	626.6082	4945	PC_09	Piston Core PC-09
20th Feb	05:34	08:09	644.7301	526.6075	4928	MC_04	Multicore_04 [USBL=6 44.74799, 5 26.60650]
20th Feb	12:19	16:10	6 51.366	5 13.325	5034	MC_05	Multicore_05 [USBL= 5 56 59.36767; 5 13.32367]
20th Feb	19:07	22:59	5 30.031	5 30.031	4953	PC_10	Piston Core PC-10 [USBL = 6 42.57269 S, 5 30.03727 E]
21st Feb	01:20	04:33	6 41.6961	5 29.0707	4925	PC_11	Piston Core PC-11 - Bent Barrel; switched from 6 to 12m barrel
21st Feb	06:44	10:28	6 38.6597	5 37.5767	4890	PC_12	Piston Core PC-12
21st Feb	11:40	15:26	6 37.31686	5 41.06670	4859	MC_06	Multicore_06 [USBL = 6 37.32574 S, 5 41.06492 E]
21st Feb	16:02	19:35	6 37.671	5 42.299	4879	PC_13	Piston Core PC-13 [USBL: 6 37.70016 S, 5 42.31412 E]
21st-22nd Feb	21:32	00:14	6 30.822	5 48.569	4827	PC_14	Piston Core PC-14 [USBL: 6 30.82693 S, 5 48.56343 E]
22nd Feb	03:07	06:39	6 32.16114	5 6.0086	4772	PC_15	Piston Core PC-15 [USBL : 6 32.19292, 5 56.06676]
22nd Feb	07:33	10:41	6 30.89472	5 55.90278	4789	PC_16	Piston Core PC-16
CHANNEL							
22nd Feb	13:10		6 28.228	6 05.291	4741	MB7	Swath Multibeam Survey 7 (final line of channel)
22- 25th Feb	15:23		6 24.555	6 16.369	4703	Transit	Swath survey stopped and transit to Luanda for observers
TRANSIT							Luanda boat transfer
25th Feb	16:30		5 57.563	11 34.327	1596	Transit	Transit from Luanda and arrive upper canyon
UPPER CANYON							
25th Feb	13:44	15:59	5 57.563	11 34.327	1596	CTD_04	CTD_04 (boundary of Angola & DRC waters)
25th Feb	16:18	21:13	5 57.773	11 34.310	1505	MB_08	Swath Multibeam Survey 8 in Angola waters
25th-26th Feb	21:42	00:05	5 52.552	11 9.395	2006	CTD05	CTD_05 Western end of Angolan waters
26th Feb	00:35	05:27	5 52.2486	11 10.1571	1837	MB_08	Swath Multibeam Survey 8 (continued) in Angola waters
26th Feb	05:40	15:26	5 56.8118	11 34.70766	1166	MB_09	Swath Multibeam Survey 9 in DRC waters
26th-27th Feb	16:05	06:05	5 56.780	11 34.826	1146	MB_08	Swath Multibeam Survey 8 (continued) in Angola waters
27th Feb	07:13	12:04	5 58.3014	11 34.1183	1261	MB_09	Swath Multibeam Survey 9 (continued) in DRC waters
27th Feb	12:16	14:06	6 01.960	11 59.986	985	CTD_06	CTD_06 Eastern end of DRC waters
27th Feb	14:31	18:08	-6 3.41988	11 59.66400	645	MB_09	Swath Multibeam Survey 9 (continued) in DRC waters
27th Feb	18:42	20:53	-5 57.59334	11 34.30446	1587	CTD_07	CTD_07 Boundary of Angola and DRC waters (repeats CTD_04)
27th-28th Feb	23:50	05:17	-5 52.83324	11 9.73278	2026	MB_08	Swath Multibeam Survey 8 (continued) in Angola waters
28th Feb	06:24	08:50	-5 53.92602	11 19.81998	1853	PC_17	Piston Core PC-17
28th Feb	10:19	12:05	-5 53.52300	11 20.58900	1853	PC_18	Piston Core PC-18 [USBL = 5° 53.57243 S, 11° 20.57721 E]
28th Feb	13:14	15:20	-5 53.75406	11 21.31314	1795	PC_19	Piston Core PC-19 [USBL = 5 55.50685, 11 25.4338]
28th Feb	16:10	18:05	-5 55.50612	11 25.43442	1681	PC_20	Piston Core PC-20 [USBL = 5 55.50685, 11 25.4338] bent
28th Feb	20:26	21:20	555.83634	1126.16189	1656	PC_21	Piston Core PC-21 [USBL, 5 55.93118, 11 26.15355]
28th Feb	22:54	07:55	557.135	1131.838	1574	PC_22	Piston Core PC-22 [USBL, 5 57.0847, 11 31.8718]
29th Feb	01:40	03:38	557.2117	1133.34032	1541	PC_23	Piston Core PC-23 [USBL, 5 57.22317, 11 33.35949]
29th Feb	04:14	05:55	557.2129	1133.3603	1543	MC_07	Multicore_07 [USBL = 5 57.21823, 11 33.35540]
29th Feb	09:00	10:32	5 52.7104	11 10.4825	2032	PC_24	Piston Core PC-24 [USBL: 5 52.73507 S 11 10.48467 E]
29th Feb	12:23	14:28	5 50.180	11 02.152	2182	MC_08	Multicore_08 [USBL : S5°50.1848, E11°02.12998]
29th Feb	15:18	16:39	5 50.198	11 02.151	2182	PC_25	Piston Core PC-25 [USBL = 5°50.192975, 11°02.14630]
29th Feb	18:11	20:21	5 52.592	11 09.426	2014	CTD_08	CTD_08 Western end of Angolan waters (repeat CTD_05)
29th Feb - 1st Mar	20:30						Transit to international waters
CHANNEL							
1st March	13:59	16:56	5 44.984	08 08.155	4150	PC_26	Piston Core PC-26 [USBL: 5°44.09347, 08°08.21981]
1st March	17:15	19:28	5 49.273	07 57.495	4150	MB_10	Swath Multibeam Survey 10 (short extra line for channel bend)
1st March	20:14	23:35	5 45.071	07 52.532	4244	PC_27	Piston Core PC-27 [USBL : 05°45.06259, 07°52.5361]
2nd March	00:14	01:41	05 47.32116 S	007 49.25004 E	4112	MB_11	Swath Multibeam Survey 11 (short extra line for channel bend)
2nd March	02:12	05:33	05 44.8827 S	007 37.9316 E	4272	PC_28	Piston Core PC-28
2nd March	05:26	07:48	05 44.8782 S	007 37.9021 E	4208	MB_12	Swath Multibeam Survey 12 (short extra line for channel bend)
2nd March	09:22	12:40	05 46.3099 S	007 11.2389 E	4522	PC_29	Piston Core PC-29
2nd March	14:08	16:44	05 46.443 S	007 11.324 E	4735	PC_30	Piston Core PC-30 [USBL: 05 46.44780 S; 007 11.33787 E]

APPENDIX B: SUMMARY OF ACTIVITIES IN DETAILED LOG SHEETS

Site (location on GIS)	Event (activity number)	Date (YYYYMMDD)	Time (UTC)	Latitude (Deg DM)	longitude (Deg DM)	Depth (m)	Device (equipment)	Activity + comments (what happened)
1	1	20240209	17:18	6 27.4142	6 5.5883	4758	CTD	CTD_1 @ Surface START
1	1	20240209	19:01	6 27.419	6 5.587	4754	CTD	CTD_1 @ Seafloor [15 masb]
1	1	20240209	19:05	6 27.42	6 5.5900	4754	CTD	CTD_1 Bottles #1, #2, #3 fired [15 masb; 4730 cable length]
1	1	20240209	19:12	6 27.42	6 5.5900	4754	CTD	Tested Ac. Releases - OK
1	1	20240209	19:48	6 27.428	6 5.587	4753	CTD	CTD_1 Bottle #4 fired [3000m cable length]
1	1	20240209	20:19	6 27.4184	6 5.5874	4753	CTD	CTD_1 Bottle #22 fired [1500m cable len.]
1	1	20240209	20:35	6 27.4185	6 5.5871	4753	CTD	CTD_1 Bottle #23 fired [850m cable len.]
1	1	20240209	20:49:00	6 27.4182	6 5.5866	4753	CTD	CTD_1 Bottle #24 fired [250m cable len.]
1	1	20240209	20:58	6 27.4183	6 5.5870	4754	CTD	CTD_1 @ Surface END
2	1	20240209	21:44	6 25.9588	6 5.7823	--	MB	Start MB Acquisition
2	2	20240209	22:29	6 26.034	6 5.7038	4731	MB	MBS1_channel - START
2	3	20240210	02:33	6 31.5067	5 43.5563	4815	MB	MBS1 _the line counter timing switched from 30 min to 60 min
2	4	20240210	11:20	6 59.8464	5 3.8053	5090	MB	End of MB survey. Waypoint 7
3	1	20240210	12:10	7 1.626	5 5.174	5063	CTD	CTD2 @ surfacae
3	1	20240210	13:47	7 1.6300	05 5.1700	5064	CTD	CTD 10 masf + 6 acoustic releases tested
3	1	20240210	15:11	7 1.6300	5 5.1700	5065	CTD	Bottle fired at 1500m cable out
3	1	20240210	15:50	7 1.6300	5 5.1700	5065	CTD	CTD back on deck
3	2	20240210	15:40				MMO	Started MMO (needed because MB was not switched on after testing releases.
3	2	20240210	16:40	7 1,7005	5 5.0490	5065	MB	Start ramp up MB
4	1	20240210	17:12	7 1.3645	5 5.1343	5093	MB	Start MBS1 part 2
4	2	20240210	23:02	6 41.911 S	5 30.835	4947	MB	Waypoint in MBS start line 8
4	3	20240211	06:18	6 27.0573	6 5.3855	4725	MB	End of MBS1, waypoint 12
4	3	20240211	06:18	6 27.0573	6 5.3855	4725	MB	Sub-bottom turned off
4	3	20240211	06:18	6 27.0573	6 5.3855	4725	MB	Start of 20 minute extension survey, continuing on same bearing past waypoint 12
4	4	20240211	06:38	6 26.5055	6 7.0895	4746	MB	End of extension survey
5	1	20240211	08:07	6 30.9388	5 55.6489	4807	M	M_1 mooring deployment started
5	1	20240211	08:24	6 30.9388	5 55.6469	4790	M	Small sphere on water surface
5	1	20240211	08:27	6 30.9439	5 55.6463	4790	M	Sphere with ADCP on water surface
5	1	20240211	08:30	6 30.9439	5 55.6465	N/A	M	Mooring ready to be released
5	1	20240211	08:31	6 30.9436	5 55.6466	N/A	M	Anchor released and going down (fall rate ~200 m/min)
5	1	20240211	09:30	6 31.40154	5 55.37274	N/A	M	Anchor confirmed on the seafloor after issues receiving signal from acoustic releas
5	1	20240211	09:50	6 33.0845	5 53.8512	N/A	M triangle	Triangulation point 1. 6967,6967 m; 6972 m 6972 m
5	1	20240211	10:40	6 28.4537	5 54.8099	N/A	M triangle	triangulation point 2. 6753, 6743 m 6738, 6735 m
5	2	20240211	10:45	6 30.1223	5 56.6674		MMO	start MMO
5	1	20240211	11:25	6 31.4549	5 58.2382		M triangle	Triangulation point 3. 5803, 6807m 6812 only 3 ranges check against paper log
6	1	20240211	12:03	6 30.520 S	6 0.025	4764	M triangle	Triangulated location of M1: 6 30.935 S 005 55.630 E
7	1	20240211	12:51	6 28.117	6 5.630	4990	MB	start of MBS2
8	1	20240211	16:10	6 33.783	5 5.482	4825	MB	WP start line 2
9	1	20240211	16:27				MB	WP start line 3
10	1	20240211	16:58	6 40.575 s	5 42.220	4890	MB	WP start line 4
11	1	20240211	20:03	6 44.180 S	5 31.355	4946	MB	WP start line 5
12	1	20240211	23:08	6 54.359	5 18.168	5049	MB	WP start line 6
13	1	20240211	23:35			5048	MB	WP start line 7
14	1	20240212	01:48	6 48.349	5 29.631	4921	MB	end of line 7, transit to M2
14	2	20240212	01:48	6 48.349	5 29.631	4921	MB	start of survey line to M2, traveling at 10 knots
15	1	20240212	04:36	6 30.7987	5 48.3140	4811	M2	arrival at the location of M2
15	1	20240212	05:28	6 30.7619	5 48.4528	4812	M2	M2 deployment start
15	1	20240212	05:31	6 30.7622	5 48.4538		M2	Small sphere on water surface
15	1	20240212	05:35	6 30.7612	5 48.4552	4812	M2	Sphere with ADCP on water surface
15	1	20240212	05:37	6 30.7615	5 48.4556	4812	M2	ready to release
15	1	20240212	05:37	6 30.7615	5 48.4556	4812	M2	Anchor released
15	1	20240212	06:12	6 38.5344	5 48.1783	-	M2	anchor likely on the bottom (not receiving signal, heading to triangulation point 1)
16	1	20240212	06:39	6 28.2060	5 47.4689	-	M2	triangulation point 1. 6864, 6864 / 6864, 6862
17	1	20240212	07:21	6 32.7803	5 46.6395	-	M2	triangulation point 2. 6903, 6896 / 6898, 6898
18	1	20240212		6 31.19334	5 51.08172	-	M2	triangulation point 3. 6791, 6795 / 6778 av=6793.
19	1	20240212	09:25	6 32.2085	5 55.8535		PG1	start of deployment
19	1	20240212	09:39	6 32.2103	5 55.8553		PG1	anchor in the water
19	1	20240212	09:27	6 32.2107	5 55.8550		PG1	acoustic releases in the water
19	1	20240212	10:00	6 32.2098	5 55.8552		PG1	sediment trap in the water
19	1	20240212	10:21	6 32.21064	5 55.8549		PG1	ADCP in the water
19	1	20240212	10:26	6 32.2096	5 55.8554		PG1	USBL in the water, mooring being lowered
19	1	20240212	12:33	6 32.200	5 55.8282		PG1	PG1 reached the bottom, position = beacon position
19	1	20240212	14:35				PG1	Mooring finalized
20	1	20240212	15:08	6 29.617	3 55.4006		PG2	At the mooring location
20	1	20240212	15:23	6 29.625	5 55.407		PG2	acoustic releases in the water
20	1	20240212	15:37	6 29.626	5 55.407		PG2	Sediment trap and turbidity meter in water
20	1	20240212					PG2	
20	1	20240212					PG2	
20	1	20240212	17:49	6 29.6099	5 52.644		PG2	PG2 released
20	1	20240212	20:36	6 29.6099	5 52.644		PG2	winch cable back on deck, start sailing.
21	1	20240212	21:32	6 27.813	5 52.644	4799	MB	Start multibeam deep3A survey. start line 27/line 1
21	1	20240212	23:04	6 27.821	5 43.929	4839	MB	start line 28/line 2
21	1	20240213	00:49	6 35.052	5 37.952	4878	MB	Start line 29/line 3
21	1	20240213	02:28	6 37.837	5 28.981	4917	MB	Start line 4
21	1	20240213	03:28	6 41.136	5 24.568	4966	MB	Start line 5 to 8 (cutting original survey short to save time)
21	1	20240213	03:50	6 39.310	5 23.586	4988	MB	Start of line 8
21	1	20240213	04:52	6 35.864	5 28.001	4951	MB	Start of line 9
21	1	20240213	06:33	6 33.119	5 36.731	4884	MB	Line 10 to M3. End of deep3A survey. Continue logging to M3, travelling at 10 knots
21	1	20240213	06:36	6 33.1192	5 37.0098	4883	MB	Transit continues to M3, start of straight track line to M3 on MBES
21	1	20240213	07:16	6 36.807	5 41.456	4881	MB	Stop MB survey
22	1	20240213	07:27				MB	M3 mooring deployment start
22	1	20240213	08:05	6 36966	5 41.6732	4904	Mooring 3	Anchor at bottom
23	1	20240213	08:38	6 38.58156	5 43.55688	4883	Mooring 3	Triangulation point 1 6920 6919 6918
24	1	20240213	09:33	6 34.0197	5 41.9161		M3	Triangulation point 2 7139, 7138, 7139
25	1	20240213	10:24	6 37.717 (check with paper log)	5 38.8592		M3	triangulation point 3. 7038, 7039, 7041
26	1	20240213	12:15	6 44.9284	5 26.3832		M4	M4 mooring deployment
26	1	20240213	12:55	6 45.2	5 2532		M4	Anchor at bottom @ 4909m
26	1	20240213	13:36	6 46.284	5 23.99076		M4	Triangulate point 1 7027, 7028, 7031
26	1	20240213	14:27	6 42.23886	5 26.28534		M4	Triangulate point 2. 6927, 6929, 6931 - 6932
26	1	20240213	15:08	6 46.2925	5 28.6930		M4	Triangulate point 3. 6913, 6918, 6912 [6920]
27	1	20240213	17:59	6 59.693	5 11.248	5072	MBS4	starting MBS4 at waypoint 1
27	2	20240213	19:33	6 54.536	5 17.996	5053	MB4	Passing WP2
27	3	20240213	19:58	6 56.178	5 19.269	5049	MB4	start line 50, passing WP 3
27	4	20240213	21:28	7 0.318	5 12.713	5074	MB4	Start line 52, passing WP 4
27	5	20240213	21:54	7 02.516	5 14.842	5074	MB4	Start line 53, passing WP 5
27	6	20240214	01:41					End of survey line for MB 4
		20240214	01:58	6 48.6613	5 32.;7825	4919		Transiting to start of channel survey (still pinging + logging)
28	1	20240214	05:43	6 26.2700	6 4.4562	4757	MB5	Start of channel survey (deep 5)
29	1	20240214	05:51	6 25.927	6 05.332	4754		Chage of UTM zone from 31 m to 32 m
30	1	20240214	08:41	6 20.8909	6 20.2454	4675	MB5	start of line 2
31	1	20240214	09:40	6 17.2660	6 24.6915	4634	MB5	start of line 3
32	1	20240214	11:59	6 5.6623	6 27.6109	4573	MB5	start of line 4
33	1	20240214	13:34	6 04.018	6 35.913	4524	MB5	passing WP5, starting line 5
34	1	20240214	16:15	5 33.971	6 45.300	4482	MB5	passing WP6, start of line 6
35	1	20240214	19:48	5 49.005	7 04.857	4403	MB5	passing wp 7, start line 7
36	1	20240214	21:11	5 45.146	7 11.247	4348	MB5	passing WP 8, start line 8
37	1	20240215	00:02	5 45.764	7 26.929	4272	MB5	Passing WP 9, start of line 9
38	1	20240215	04:35			4149	MB5	Passing WP10, start of line 10
39	1	20240215	05:47	5 46.812	7 58.671	4064	MB5	Passing WP11, start of line 11
40	1	20240215	06:48	5 42.76308	8 1.87566	4019	MB5	Passing WP12, start of line 12
41	1	20240215	08:06	5 42.4195	8 08.958	4008	MB5	Reached WP 13, travelling to CTD3 station
42	1	20240215	08:50	5 43.5768	8 9.9355	4086	CTD3	CTD@ surface going down
42	1	20240215	10:34	5 43.5768	8 9.942	4086	CTD3	CTD @ lowest point 10m above seafloor
42	1	20240215	10:37	5 43.575	8 9.942	4084	CTD3	bottle fired @ 10 masf #1 and 2, cable out 4110
42	1	20240215	10:47	6 43.575	8 9.942	4086	CTD3	Bottle fired @ 35 masf #4 and 5
42	1	20240215	10:56	7 43.575	8 9.942	4085	CTD3	Bottle fired @ 95 masf # 6 and 7 cable out 4022 m
42	1	20240215	11:03	8 43.575	8 9.942	4085	CTD3	Bottle fired @ 172 masf #8 and 9 cable out 3947 m
42	1	20240215		9 43.575	8 9.943	4090	CTD3	CTD @ surface
42	1	20240215	12:41	5 43.584	8 9.943	4113	MB	Slowly turning onto suvey MBS5 to check out the potential side channel / land slide

key
Multi-beam
CTD
Marine-Mammal Observation
Moorings
PG Moorings
Piston Core
Multi-cores
Sub Bottom Profiler

Site (location on GIS)	Event (activity number)	Date (YYYYMMDD)	Time (UTC)	Latitude (Deg DM)	longitude (Deg DM)	Depth (m)	Device (equipment)	Activity + comments (what happened)
43	1	20240215	12:55	5 43.348	8 9.943	4127	MB5	Start MB5 part 2, line 41
44	1	20240215	15:18	5 48.042	7 59.170	4050	MB5	Start MB5 line 16
45	1	20240215	17:38	5 45.184 S	7 26.889	4140	MB5	Start line 17
46	1	20240215	21:10	5 46.848	7 26.876	4253	MB5	start line 18
47	1	20240215	23:54	5 46.193 S	7 11.508		MB5	Start line 19
48	1	20240216	01:15	5 50.065	7 05.143	4375	MB5	start line 20
49	1	20240216	04:47	5 54.996	6 45.88	4471	MB5	start of line 21 (sub bottom line 23)
50	1	20240216	07:18	6 504.984	6 36.371	4515	MB5	start line 22 (sub bottom line 24)
51	1	20240216	08:45	6 6.6940	6 28.6665	4594	MB5	start line 23 (sub bottom line 25)
52	1	20240216	11:00	6 17.8086	6 25.5496	4620	MB5	start line 24 (sub bottom line 26)
53	1	20240216	12:13	6 22.045	6 20.558		MB	MB5 start line 25
54	1	20240216	15:06	6 27.011	6 05.463	4747	MB	MB5 finished
55	1	20240216	15:34	6 28.192	6 02.439	4740	Winch	start winch test
56	1	20240216	20:08	6 30.886	5 55.916	4794	MC (multi core	MC @ surface 8 barrels
56	1	20240216	22:36	6 30.9028	5 55.9013	4815	MC (multi core	MC on seafloor. USBL: 6 30.8913; 5 55.8950 @ 4747 m + 50 m (USBL is at 50 masf)
56	1	20240217	00:10	6 30.90318	5 55.90182	4780	MC (multi core	Megacore back on deck, processing cores began
57	1	20240217	05:52	6 51.91165	5 20.8002	5003	PC1	PC-01 in water. Lowering @ 60 m/min [core GIS site 18]
57	1	20240217	07:37	6 51.90992	5 20.79833	5029	PC1	PC-01 at seafloor. Pull-out tension ~5.5 Te
57	1	20240217	07:37	6 51.90992	5 20.79833	5029	PC1	PC-01 USBL location 6° 51.90992 S 5° 20.79833' E
57	1	20240217	09:12	6 51.9081	5 20.7953	5004	PC1	PC-01 at surface [transit from 18 to 19 ~20min]
58	1	20240217	11:35	6 52.2630	5 19.3716	5004	PC2	PC-02 in water lowering @ 60m/min[Core GIS site 19]
58	1	20240217	13:26	6 52.265	5 19.368	5032	PC2	PC-02 at seafloor, tension 6.17T, USBL 6 52.339S, 5 19.606E
58	1	20240217	15:00	6 52.26	5 19.369	5049?	PC2	PC-02 at surface
58	1	20240217	15:45	6 52.246	5 19.334	5033	PC2	PC-02 on board
58	1	20240217	15:48	6 52.247	5 19.342	5030	PC2	End of station and ?
59	1	20240217	17:10	6 59.150	5 9.130		MB	Multibeam survey (lobe) MB5 line 1a
60	1	20240217	18:37	7 6.028	5 14.514	5062	MB	MB5 - start line 2
61	1	20240217	19:15	7 7.220	5 12.710	5068	MB	Start line 3
62	1	20240217	20:45	7 0.563	5 7.410	5082	MB	Start line 4
63	1	20240217	21:27	7 2.125	5 15.916	5096	MB	Start line 5
64	1	20240217	23:10	7 9.2	5 11.372	5065	MB	Start line 6
65	1	20240217	23:43	7 8.444	5 8.866	5075	MB	Start line 7
66	1	20240218	00:39	7 4.4967	5 5.4313	5101	MB	End of survey. Start steaming to core site 26/PC03
67	1	20240218	02:08	6 57.7745	5 15.6888	5065	PC_03	Arriving on ite for PC_03
67	1	20240218	02:46	6 57.6855	5 15.6141	5035	PC_03	PC_03 on water surface
67	1	20240218	02:58	6 57.7236	5 15.6559	5035	PC_03	PC_03 going down at 60m/min
67	1	20240218	04:32	6 57.7637	5 15.67329	5068	PC_03	PC_03 at seafloor. USBL = 6 57.76370 S, 5 15.673129 E, 5068.9 m. Max Te = 6.4
67	1	20240218	06:08	6 57.7498	5 15.6832	5062	PC_03	PC_03 at surface
67	1	20240218	06:49	6 57.7498	5 15.6832	5062	PC_03	Core on deck (site 26 on GIS)
67	1	20240218	07:02	6 57.7498	5 15.6832	5062	PC_03	Ship moving
68	1	20240218	07:24	6 56.0443	5 14.4556	5030	PC_04	Ship arrived (site 23 on GIS)
68	1	20240218	08:15	6 56.0443	5 14.4556	5030	PC_04	Piston core in water
68	1	20240218	10:18	6 56.04765	5 14.45526	5058	PC_04	Core at seafloor. USBL: 6 56.04765 S, 5 14.45526 E, 5058 m. Max Te ~6.5
68	1	20240218	11.59	6 56.042	5 14.456	5068	PC_04	Core at the sueface.
68	1	20240218	12:42	6 56.003	5 14.321	5029	PC_04	Left core location, starting transit.
69	1	20240218	15:32	6 58.467	5 39.507	4966	MC02	Arrival at station
69	1	20240218	15:49	6 58.440	5 39.585	4965	MC02	Core at water
69	1	20240218	18:03	6 58.444	5 39.591	4967	MC02	Core at bottom. USBL: 4905+50m, 658.4472, 539.5906
69	1	20240218	19:36	6 58.445	5 39.592	4967	MC02	USBL recovery
69	1	20240218	19:40	6 58.445	5 39.592	4967	MC02	Out of the water
69	1	20240218	19:43	6 58.445	5 39.592	4967	MC02	On the deck
69	1	20240218	19:59	6 58.445	5 39.592	4967	MC02	Moving to next station
70	1	20240218	22:17	6 51.910	5 20.793	5028	MC03	Arriving at station
70	1	20240218	22:21	6 51.913	5 20.796	5030	MC03	In water, USBL at 150m
70	1	20240219	00:13	6 51.899	5 20.795	5034	MC03	USBL: 6 51.914S, 5 20.7546E, Multi-core at bottom.
70	1	20240219	00:21	6 51.899	5 20.795	5039	MC03	USBL: 6 51.91509S, 5 20.79304E, hit the bottom, depth 4976.9m
70	1	20240219	01:58	6 57.8988	5 20.7955	5031	MC03	MC03 back on deck
71	1	20240219	03:36	6 56.83488	5 16.87236	5028	PC_05	PC_05 in water surface and going down
71	1	20240219	05:12	6 56.8228	5 17.0025	5056	PC_05	PC_05 at seafloor, USBL position = 6 56.82295 S, 5 17.0027 E, 4982 m
71	1	20240219	07:00	6 57.00990	5 16.76016	5030	PC_05	PC_05 at sea surface
72	1	20240219	09:20	6 59.3737	5 13.3114	5076	PC_06	PC_06 at at water surface and going down (core planning site 27)
72	1	20240219	10:55	6 59.36251	5 13.32245	5060	PC_06	PC_06 at seafloor, check USBL position on ships systems, Te = ~7.5
72	1	20240219	12.33	659.385	513.317	5076	PC06	PC_06 @ the surface
72	1	20240219	12.38	659.385	513.317	5076	PC_06	Prob onboard, leaving for PC07
72	2	20240219	13.12				PC_06	Start transit to next site (SITE 22_
73	1	20240219	14.13	654.633	519.635	5041	PC_07	Arrive at site
73	1	20240219	14.38	654.57	519.638	5012	PC_07	core at surface. Going down
73	1	20240219	14.47	644.1559	519.643	5040	PC_07	USBL on at 80m depth
73	1	20240219	16.19	654.569	519.708	5040	PC_07	USBL = 654.5715, 519.708, core at bottom
73	1	20240219	17.56	654.296	519.831	5010	PC_07	core at surface.
73	1	20240219	18.3				PC_07	Start transit.
74	1	20240219	19.33	649.485	523.585	4996	PC_08	Arrive at site.
74	1	20240219	20.02	659.4927	523.581	4971	PC_08	Core @ surface
74	1	20240219	21:49	649.524 = USBL	USBL = 523.557	4993	PC_08	core @ seafloor, 4980m USBL
74	1	20240219	23:18	649.509	523.583	4994	PC_08	Core @ seafloor.
74	1	20240219	23:46	6 49.508	523.58	4994	pc_08	core on board.
75	1	20240220	01:13	644.737	626.6082	4945	pc_09	core @ surface
75	1	20240220	02:56	644.737	526.6082	4945	pc_09	core at seafloor
75	1	20240220	04:33	644.7377	526.6082	4945	pc_09	core at surface
75	1	20240220	05:03	644.7205	526.593	4950	pc_09	core on board.
75	2	20240220	05:34	644.7301	526.6075	4952	MC04	Multicore in water
75	2	20240220	07:41	644.74791	526.6065	4927	MC04	Multicore at seafloor. USBL=644.74799, 526.60650, 4927.9m water depth
75	2	20240220	09:21	6 44.74212	5 26.61012	4954	MC04	Multicore back on deck
76	1	20240220	12:19	6 51.366	5 13.325	5034	MC05	Multicore on surface
76	1	20240220	12:28	6 59.370	5 13.327	5074	MC05	USBL on
76	1	20240220	14:27	6 59.3633	5 13,3327	5071	MC05	USBL: 556 59.36767;5 13.32367; MC05 @ bottom (5015.7 m)
76	1	20240220	16:05	6 59.363	5 13.332	5082	MC05	MC05 @ surface
76	1	20240220	16:10	6 59.363	5 13.332		MC05	Back on deck
77	1	20240220	19:07	5 30.031	5 30.031	4954	PC10	Arrival at station
77	1	20240220	19:28	6 42.560	5 30.044	4954	PC10	PC in the water
77	1	20240220	21:10	6 42.560	5 30.043	4957	PC10	USBL: 6 42.57269 S, 5 30.03727 E (4953m), PC at bottom
77	1	20240220	22:59	6 42.5606	5 30.0433	4934	PC10	core at surface
78	1	20240221	00:43	6 41.738	5 29.101	4949	SBP	end line pc10topc11. Arrival on site PC11
78	2	20240221	01:20	6 41.6961	5 29.0707	4925	PC11	PC in the water
78	2	20240221	03:00	6 41.71122	5 29.10801	4944	PC11	PC11 on seafloor. No pull-out spike on cable-tension-tune plot.
78	2	20240221	04:33	6 41.70816	5 29.11092	4944	PC11	core at surface
78	2	20240221	05:05	6 41.701265	5 29.07066	4924	PC11	core on deck. Banana:((12m so far PC01-PC11, will switch to 6m barrel at next site)
78	3	20240221	05:17	6 41.6629	5 29. 1631	4947	SBP	start line pc11topc12
79	1	20240221	06:21	6 38.6493	5 37.5722	4890	SBP	end line pc11topc12. Arrival on site PC12
79	1	20240221	06:44	6 38.6597	5 37.5767	4890	PC_12	PC12 in the water
79	1	20240221	08:25	6 38.67209	5 37.58692	4914	PC_12	PC12 at the seafloor. Max Te=5.56. USBL in lat and long
79	1	20240221	08:35	6 38.6682	5 37.5868	4892	PC12 /USBL	USBL off
79	1	20240221	10:12	6 38.66868	5 37.58625	4892	PC_12	core at surface
79	1	20240221	10:28	6 38.61768	5 37.5485	4890	PC_12	core on deck, 6 m, bended
79	2	20240221	10:38	6 38.63040	5 37.55994	4890	SBP	transit to PC13, SBP on
80	1	20240221	11:25	6 37.320	5 41.059	4907	SBP	stopped recording
80	2	20240221	11:40	6 37.31686	5 41.06670	4885	MC06	MC_06 on surface and going down
80	2	20240221	11:44	6 37.318	5 41.067	4907	MC06	USBL on
80	2	20240221	13:40	6 37.318	5 41.067	4909	MC06	USBL: 6 37.32574 S, 5 41.06492 E (4858.6m), core at bottom
80	2	20240221	15:26	6 37.319	5 41.067	4909	MC06	MC at surface
81	1	20240221	16:02	6 37.671	5 42.299	4884	PC13	arrive at site
81	1	20240221	16:32	6 37.692	5 42.317	4887	PC13	In water, USBL on
81	1	20240221	18:00	6 37.692	5 42.317	4885	PC13	PC at the bottom, USBL: 6 37.70016 S, 5 42.31412 E (4879m)
81	1	20240221	19:35	6 37.586	5 42.420	4851	PC13	core at surface
82	1	20240221	21:32	6 30.822	5 48.569	4828	PC14	PC14 at surface
82	1	20240221	23	6 30.8222	5 48.56467	4830	PC14	PC at bottom, USBL: 6 30.82693 S, 5 48.56343 E (4827m)
82	2	20240222	00:14	6 30.8219	5 48.56526	4811	PC14	USBL off
82	1	20240222		6 30.78306	5 48.55356	4811	PC14	PC14 back on deck
82	3	20240222	01:34	6 30.7491	5 48.6041	4812	SBP	SBP on, start line pc14topc15
83	1	20240222	02:28	6 32.2063	5 6.03124	4800	SBP	Kept SBP on, ended trransit line and called new line site PC15
83	2	20240222	03:07	6 32.16114	5 6.0086	4772	PC15	PC15 at surface, 12m

key
Multi-beam
CTD
Marine-Mammal Observation
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Sub Bottom Profiler

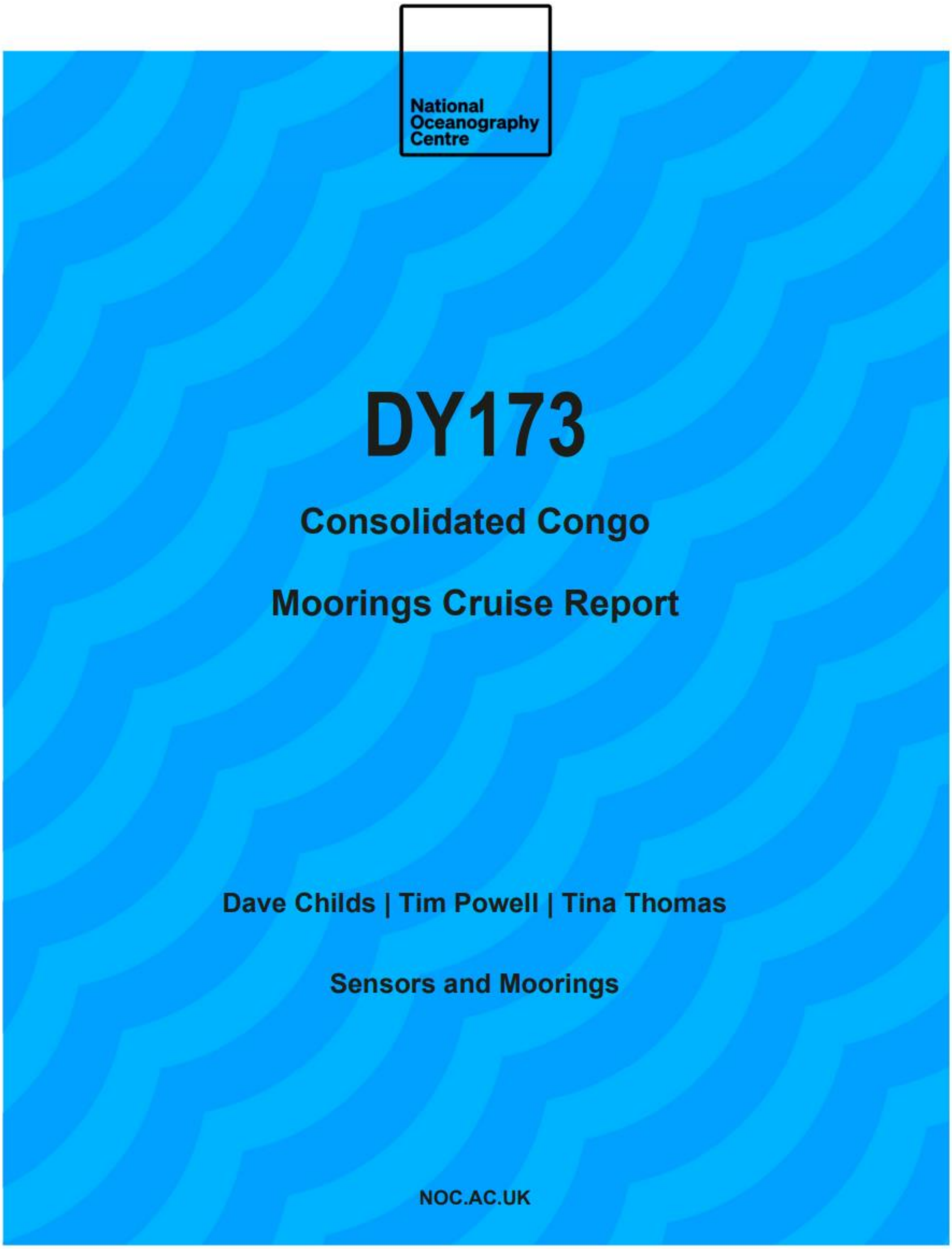
Site (location on GIS)	Event (activity number)	Date (YYYYMMDD)	Time (UTC)	Latitude (Deg DM)	longitude (Deg DM)	Depth (m)	Device (equipment)	Activity + comments (what happened)
83	1	20240222	03:09	6 32.16078	5 56.00832	4779	SPB	SPb off, end of line. Site PC15
83	3	20240222	03:11	6 32.16096	5 56.00838	4773	PC15/USBL	USBL on
83	2	20240222	04:37	6 32.18364	5 56.06772	4789	PC15	PC15 at seabed USBL : 632.19292, 556.06676,
83	2	20240222	06:10	6 32.045	5 56.2496	4770	PC15	PC15 at surface
83	2	20240222	06:39	6 31.92002	5 56.2531	4767	PC15	Muddy core at top when being recovered. PC15 back on deck
83	3	20240222	06:43	6 31.6972	5 56.1607	4769	SPB	SPB on, start line PC15 TO PC16
84	1	20240222	07:15	6 30.89526	5 55.9026	4789	SPB	SBP off, end of line. Site PC15 to PC16
84	2	20240222	07:33	6 30.89472	5 55.90278	4789	PC16	PC16 piston core (6m barrel) in water
84	2	20240222	07:34	6 30.90001	5 55.89668	4789	PC16	PC16 USBL: on
84	2	20240222	09:11	6 30.89673	5 55.90364	4808	PC16	PC16 on seafloor, limited pull out
84	2	20240222	10:41	6 30.89496	5 55.90214	4789	PC16	PC16 at surface. Muddy top, slightly bent (small banana)
84	3	20240222	11:42	6 30.89760	5 55.8130	4816	SBP	Steaming to start of MBES channel line 3 survey, turned SBP on
85	1	20240222	13:10	6 28.228	6 05.291	4741	MB7	start of MBES survey 7 (channel)
86	1	20240222	15:23	6 24.555	6 16.369	4703	MB7	Line stopped, 10 knots transit to east
86	1	20240222	16:30					Transit to Luanda
		20240223	09:54					Stop acquisition as in Angolan waters
87	1	20240225	13:44	5 57.563	11 34.327	1596	CTD4	CTD at surface
87	2	20240225	14:19	5 57.5772	11 34.3275	1578	CTD4	obs blanked by high sediment concentration
87	3	20240225	14:41	5 57.513	11 34.2706	1576	CTD4	cable out 1560 m out
87	4	20240225	14:47	5 57.5113	11 34.2592	1579	CTD4	fire 4 bottles 1, 2, 3, 4, 14 masf, USBL coordinates
87	5	20240225	14:54	5 57.509	11 34.262	1578	CTD4	fire 2 bottles 5, 6, 20 masf, USBL coordinates
87	6	20240225	14:58	5 57.509	11 34.2626	1579	CTD4	fire 2 bottles 7, 8, 25 masf, USBL coordinates
87	7	20240225	15:01	5 57.5101	11 34.2636	1578	CTD4	fire 2 bottles 9, 10, 35 masf, USBL coordinates
87	8	20240225	15:04	5 57.5187	11 34. 269	1591	CTD4	fire 2 bottles 11, 12, 45 masf, USBL coordinates
87	9	20240225	15:07	5 57.529	11 34.279	1583	CTD4	fire 2 bottles 13, 14, 55 masf, USBL coordinates
87	10	20240225	15:11	5 57.577	11 34.297	1578	CTD4	fire 2 bottles 15, 16, 65 masf, USBL coordinates
87	11	20240225	15:15	5 57.564	11 34.307	1578	CTD4	fire 2 bottles 17, 18, 75 masf, USBL coordinates
87	12	20240225	15:21	5 57.576	11 34.318	1581	CTD4	fire 2 bottles 19, 20, 175 masf, USBL coordinates
87	13	20240225	15:25	5 57.575	11 34.319	1578	CTD4	fire 2 bottles 21, 22, 275 masf, USBL coordinates
87	14	20240225	15:32	5 57.576	11 34.321	1574	CTD4	fire 2 bottles 23, 24, 575 masf, USBL coordinates
87	15	20240225	15:59	5 57.575	11 34.419	1578	CTD4	CTD at surface, on deck
88	1	20240225	16:18	5 57.773	11 34.310	1505	MB08	start (chase to) of MB08 - WP1
89	1	20240225	17:31	5 55.606	11 27.870	1634	MB08	MB08 waypoint line 2
90	1	20240225	18:10	5 56.130	11 24.420	1641	MB08	MB08 line 3
91	1	20240225	18:54	5 54.460	11 20.847	1674	MB08	MB08 line 4
92	1	20240225	19:39	5 54.350	11 16.738	1907	MB08	MB08 line 5
93	1	20240225	20:13	5 52.329	11 14.455	1747	MB08	MB08 line 6
94	1	20240225	21:13	5 52.800	11 9.690	2030	MB08	MB08 end
95	1	20240225	21:42	5 52.552	11 9.395	2006	CTD05	CTD at surface
95	2	20240225	22:49	5 52.557	11 9.392	2038	CTD05	CTD deepest point, fire bottle 1 and 2, 10 mabsf
95	3	20240225	22:53	5 52.553	11 9.386	2038	CTD05	CTD 15 masf bottle 3, 4
95	4	20240225	22:56	5 52.553	11 9.387	2039	CTD05	CTD 20 masf bottle 5, 6
95	5	20240225	22:59	5 52.555	11 9.389	2039	CTD05	CTD 30 masf bottle 7, 8
95	6	20240225	23:03	5 52.555	11 9.391	2038	CTD05	CTD 40 masf bottle 9, 10
95	7	20240225	23:05	5 52.557	11 9.389	2035	CTD05	CTD 50 masf bottle 11, 12
95	8	20240225	23:12	5 52.561	11 9.398	2038	CTD05	CTD 60 masf bottle 13, 14
95	9	20240225	23:18	5 52.552	11 9.390	2040	CTD05	CTD 1920 m bottle 15, 16
95	10	20240225	23:21	5 52.559	11 9.392	2035	CTD05	CTD 1890 m bottle 17, 18
95	11	20240225	23:23	5 52.560	11 9.394	2038	CTD05	CTD 1850 m bottle 19, 20
95	12	20240225	23:27	5 52.561	11 9.395	2035	CTD05	CTD 1790m bottle 21, 22
95	13	20240225	23:42	5 52.557	11 9.394	2041	CTD05	CTD 1000m bottle 23, 24
95	14	20240226	00:05	5 52.531	11 9.396	2016	CTD05	CTD at surface, bottle 8,11,15,21
96	1	20240226	00:35	5 52.2486	11 10.1571	1837	MB08	start line 7 (8 on the SBP) towards proximal part of Angolan waters
97	1	20240226	01:28	5 51.8308	11 14.8367	1960	MB08	start line 8 (line 0014 in MB) SBP = 0009_MB08
98	1	20240226	02:04	5 53.3523	11 17.1946	1750	MB08	start line 9, line 15 in MB, SBP= 0010_MB08
99	1	20240226	02:38	5 53.5573	11 21.0219	1839	MB08	start line 10, line 16 in MB, SBP= 0011_MB08
99	1	20240226	03:32	5 55.54380	11 24.48680	1861.1	MB08	start line 11, line 17 in MB, SBP = 0012_MB08
100	1	20240226	04:13	5 55.0455	11 28.0888	1625	MB08	start lin 12, line 18 in MB, SBP= 0013_MB08
101	1	20240226	05:27	5 57.2846	11 34.5647	1419	MB08	end of line 12, line 20 (missed line19?), SBP = 0014_turn_MB08, Beam angle on MBE
102	1	20240226	05:40	5 56.8118	11 34.70766	1166	MB09	start of line 21, SBP = 0001_MB09
103	1	20240226	06:42	5 58.798	11 40.047	925	MB09	start line 2, SBP = 0002_MB09
104	1	20240226	08:26	6 0.49106	11 49.58202	895	MB09	start line 3, SBP = 0003_MB09
105	1	20240226	10:31	6 1.626	12 01.189	462	MB09	Starting to turn on line 3 early due to traffic. Top end of DRC Survey Line 28. SBP = 0
106	1	20240226	10:44	6 2.649	12 0.725	991	MB09	start of line 5, heading back down the canyon. SBP = 0005_MB09
107	1	20240226	10:58	6 2.7733	11 59.5001	866	MB09	back in UTM zone M32
108	1	20240226	14:29	6 00.369	11 39.594	1197	MB09	MB09 start line 8
109	1	20240226	15:26	5 58.477	11 34.577	1274	MB09	MB09 start line 9
110	1	20240226	16:05	5 56.780	11 34.826	1146	MB08	Back to Angola water and old Survey MB08; start WP 17
111	1	20240226	17:20	5 54.485	11 27.942	1260	MB08	MB08 start waypoint 18
112	1	20240226	17:56	5 54.998	11 24.550	1451	MB08	MB08 start WP 19
113	1	20240226	18:39	5 52.089	11 21.145	1521	MB08	start WP 20
114	1	20240226	19:21	5 53.249	11 17.150	1782	MB08	passed WP 21
115	1	20240226	19:54	5 51.116	11 14.981	1735	MB08	pass WP 22
116	1	20240226	20:42	5 51.1610	11 10.414	1692	MB08	WP 23
117	1	20240226	23:21	5 47.867	10 55.924	1981	MB08	WP24
118	1	20240227	00:02	5 49.795	10 55.509	2102	MB08	WP25
119	1	20240227	02:32	5 53.400	11 09.393	1565	MB08	way point 26, SBP: line4-26-mbs8
120	1	20240227	03:26	5 52.9451	11 14.4460	1603	MB08	way point 27, SBP: line5-27-mbs8
121	1	20240227	04:00	5 54.9880	11 16.78600	1520	MB08	way point 28, SBP: line6-28-mbs8
122	1	20240227	04:44	5 54.6651	11 20.7715		MB08	way point 29, SBP: line7-29-mbs8
123	1	20240227	05:27	5 56.707	11 24.319	1287	MB08	way point 30, SBP: line8-30-mbs8
124	1	20240227	06:05	5 56.603	11 29.100		MB08	way point 31, SBP: line9-31-mbs8
125	1	20240227	07:13	5 58.3014	11 34.1183	1261	MB09	MB09- line 32, SBP- MBS8+MBS9, End of MB08 transit to MB09. Changed settings 60
126	1	20240227	07:26	5 57.55	11 34.350	1582	MB09	start of MB09, Line 11. SBP line 11-MB09
127	1	20240227	08:29	5 59.583	11 39.833	1409	MB09	START MB09, line 12. SBP-line 12-MB09
128	1	20240227	10:19	6 01.282	11 49.470	1244	MB09	START MB09, line 13. SBP-line 13-MB09
129	1	20240227	12:04	6 01.9573	11 59.9598	1002	MB09	End of line 13, end of SBP-line 13
130	1	20240227	12:16	6 01.960	11 59.986	985	CTD06	CTD6 at surface
131	1	20240227	0.54167	-6 1.98666	11 59.98776	671.8	CTD06	CTD6 @ 12m; 1,2 bottle
131	2	20240227	0.54514	-6 1.98630	11 59.98854	980.4	CTD06	CTD6 @ 15m; 3,4 bottle
131	3	20240227	0.54583	-6 1.98666	11 59.98818	984.6	CTD06	CTD6 @ 20m; 5,6 bottle
131	4	20240227	13:08	-6 1.98654	11 59.98830	972.7	CTD06	CTD6 @ 25m; 7,8 bottle
131	5	20240227	13:11	-6 1.98624	11 59.98818	972.9	CTD06	CTD6 @ 30m; 9,10 bottle
131	6	20240227	13:13	-6 1.98666	11 59.98878	996.6	CTD06	CTD6 @ 35m; 11,12 bottle
131	7	20240227	13:15	-6 1.98570	11 59.98818	979	CTD06	CTD6 @ 40m; 13,14 bottle
131	8	20240227	13:18	-6 1.98594	11 59.98824	977.3	CTD06	CTD6 @ 50m; 15,16 bottle
131	9	20240227	13:24	-6 1.98660	11 59.98824	973	CTD06	CTD6 @ 70m; 17,18 bottle
131	10	20240227	13:30	-6 1.98708	11 59.98830	986.6	CTD06	CTD6 @ 926m out; 19,20 bottle
131	11	20240227	13:35	-6 1.98606	11 59.98860	978.7	CTD06	CTD6 @ 850m out; 21,22 bottle
131	12	20240227	13:40	-6 1.98618	11 59.98836	973.4	CTD06	CTD6 @ 750m out; 23,24 bottle
131	13	20240227	13:59	-6 1.98822	11 59.98914	972.6	CTD06	CTD6 on deck, bottle 4 not fired
132	1	20240227	14:06	-6 1.97988	11 59.98494	979.1	MB09	Back to MB09 from estuary to border DRC/Angola
133	1	20240227	14:31	-6 3.41988	11 59.66400	0	MB09	MB09 point 18 (6.8 Kts)
134	1	20240227	15:58	-6 2.73492	11 49.29636	645.3	MB09	WP 19 (7.3 Kts)
135	1	20240227	17:20	-6 1.00332	11 39.44004	947.5	MB09	WP20 (7.5 Kts)
136	1	20240227	18:08	-5 58.89912	11 33.85908	913.8	MB09	End of DRC Survey; WP 21 (7.7 Kts)
137	1	20240227	18:42	-5 57.59334	11 34.30446	1587.4	CTD07	(CTD7) CTD @ the surface
137	2	20240227	19:25	-5 57.59526	11 34.30428	1584.9	CTD07	CTD 3min avg ADCP
137	3	20240227	19:29	-5 57.59376	11 34.30470	1569.5	CTD07	CTD deepest point @ 10 masf; bottle 1,2
137	4	20240227	0.81389	-5 57.59574	11 34.30476	1584.9	CTD07	CTD @ 15 masf; bottle 3,4
137	5	20240227	19:34	-5 57.59490	11 34.30536	1583.7	CTD07	CTD @ 20 masf; bottle 5,6
137	6	20240227	19:36	-5 57.59448	11 34.30488	1583.9	CTD07	CTD @ 25 masf; bottle 7,8
137	7	20240227	19:38	-5 57.59466	11 34.30506	1587.3	CTD07	CTD@ 30masf; bottle 9,10
137	8	20240227	19:40	-5 57.59580	11 34.30554	1577.2	CTD07	CTD@ 35 masf; bottle 11,12
137	9	20240227	0.82083	-5 57.59490	11 34.30530	1570.1	CTD07	CTD@ 40masf; bottle 13,14
137	10	20240227	0.82361	-5 57.59526	11 34.30530	1569.9	CTD07	CTD@ 50 masf; bottle 15,16
137	11	20240227	19:48	-5 57.59688	11 34.30656	1579.6	CTD07	CTD@ 70masf; bottle 17,18
137	12	20240227	20:00	-5 57.59622	11 34.30602	1554.1	CTD07	CTD@ 120masf; bottle 19,20
137	13	20240227	20:13	-5 57.59664	11 34.30644	1570.3	CTD07	CTD@ 1380m out; bottle 21,22
137	14	20240227	20:28	-5 57.59688	11 34.30632	1569.8	CTD07	CTD@ 1100m out; bottle 23,24 (usbl failed)
137	15	20240227	20:53	-5 57.59712	11 34.30692	1580.8	CTD07	CTD@ Surface
138	1	20240227	23:50	-5 52.83324	11 9.73278	2026.4	MB08	Start of MB08 - middle lines; Deep ANG water - WPoint 7
139	1	20240228	02:25	-5 49.20186	10 55.72128	2138.9	MB08	Started line 1 part 3_MBES8 (turning)
140	1	20240228	02:40	-5 48.50268	10 55.74678	2316.7	MB08	End of turn. Start of line2part1_mbes8. Continue straight.

key
Multi-beam
CTD
Marine-Mammal Observation
Moorings
PG Moorings
Piston Core
Multi-cores
Sub Bottom Profiler

Site (location on GIS)	Event (activity number)	Date (YYYYMMDD)	Time (UTC)	Latitude (Deg DM)	longitude (Deg DM)	Depth (m)	Device (equipment)	Activity + comments (what happened)
141	1	20240228	05:17	-5 52.21140	11 10.08066	1842.1	MB08	End of survey transit to PC17. Line 87 on the MBES. SBP mbes8-to-PC17. Changed m
142	1	20240228	06:24	-5 53.92602	11 19.81998	1860.8	PC17	Arrival on site for PC17. SBP turned off.
142	2	20240228	06:49	-5 53.92782	11 19.82364	1867.9	PC17	PC17 in water.
142	2	20240228	06:57	-20 20.21376	11 34.07856	989.4	PC17	PC17 going down.
142	2	20240228	07:00	-5 53.92656	11 19.82580	1864.2	PC17	USBL turned on.
142	2	20240228	07:35	-5 53.92656	11 19.82574	1863.6	PC17	core at seabed. Max Te=3.21 looks like normal pullout. Position is from USBL.
142	2	20240228	08:01	-5 53.92956	11 19.82736	1860.9	PC17	USBL turned off
142	2	20240228	08:16	-5 53.92980	11 19.82748	1861.8	PC17	Core at surface.
142	1	20240228	08:50	-5 53.98314	11 19.83576	1864	PC17	SBP turned on.
143	1	20240228	10:19	-5 53.52300	11 20.58900	1852.7	PC18	Core in water.
143	1	20240228	11:00	-5 53.52246	11 20.58780	1851.8	PC18	USBL turned on
143	1	20240228	11:05	-5 53.52312	11 20.58852	1853.6	PC18	CORE ON SEABED - MAX Te 3.13; WEAKISH BUT DISTINCT PULLOUT?; USBL 5° 53.5724
143	1	20240228	12:05	-5 53.52780	11 20.58582	1861.9	PC18	PC18 ON DECK
144	1	20240228	13:14	-5 53.75406	11 21.31314	1794.5	PC19	PC19 on Surface
144	1	20240228	14:20	-5 53.75436	11 21.31326	1795.3	PC19	PC19 @ bottom
144	1	20240228	14:55	-5 53.75448	11 21.31380	1852	PC19	PC19 @ surface
144	1	20240228	15:20	-5 53.77368	11 21.28362	1804.1	PC19	PC19 on deck
145	1	20240228	16:10	-5 55.50612	11 25.43442	1680.7	PC20	PC20 station
145	1	20240228	16:38	-5 55.50528	11 25.43952	1679.5	PC20	PC20 on surface
145	1	20240228	17:22	555.502	1125.439	1726	PC20	(1709) PC20 at bottom, 555.50685, 1125.4338
145	1	20240228	18:05	555.504	1125.438	1726	PC20	PC20 at surface. It was a banana
147	1	20240228	20:26	555.83634	1126.16189	1656	PC21	PC21, at the bottom. USBL, 5555.93118, 1126.15355.
147	2	20240228	21:20	555.827	1126.152	1670	PC21	core at the surface
147	1	20240228	22:54	557.135	1131.838	1574	PC22	Core at sea
148	1	20240228	23:33	557.074	1131.913	1591	PC22	core at bottom, USBL, 557.0847, 1131.8718. USBL turned off
149	1	20240229	01:40	557.2117	1133.34032	1541	PC23	PC23 in the water
149	2	20240229	01:50	557.1969	1133.33372	1542	PC23/USBL	USBL ON
149	1	20240229	02:20	557.222	1133.35597	1582	PC23	PC23 at the bottom, depth 1581.1m, USBL, 557.22317, 1133.35949
149	1	20240229	03:12	557.236	1133.3609	1563	PC23	PC23 at the surface
149	1	20240229	03:38	557.2173	1133.3489	1582	PC23	PC23 on the deck
149	3	20240229	04:14	557.2129	1133.3603	1543	MC07	MC07 in the water
149	2	20240229	04:17	557.21314	1133.36032	1587	MC07	USBL turned on
149	3	20240229	05:06	557.20832	1133.36	1527	MC07	MC07, on the seafloor. USBL 557.21823, 1133.35540
149	2	20240229	05:08	557.21108	1133.36012	1586	MC07/USBL	USBL off
149	3	20240229	5.55	557.292	1133.341	1584	MC07	MC07 on the deck
149	4	20240229	06:01	557.25	1133.046	1583	SBP	changed line to PC23_to_PC24. Transit to PC_24
150	1	20240229	09:00	5 52.7104	11 10.4825	1993	PC24	PC24 in water and going down
150	2	20240229	09:02	5 52.716	11 10.4852	1986	SBP	SBP & MBES stopped logging
150	1	20240229	09:50	5 52.73507	11 10.48467	2023	PC24	PC24 at seafloor. USBL: 5 52.73507 S 11 10.48467 E, 2032 m water depth
150	1	20240229	10:32	-5 52.73058	11 10.49664	2025	PC24	PC-24 at water surface.
150	3	20240229	11:05	-5 52.70322	11 10.31748	2026.7	MB	MB on, transit to PC25 location
151	1	20240229	12:23	5 50.180	11 02.152	2182	MC08	Station fo MC08 / MC08 at surface
151	1	20240229	13:27	5 50.180	11 02.153	2183	MC08	MC08 at bottom, USBL : S5°50.1848, E11°02.12998
151	1	20240229	14:28	5 50.179	11 02.160	2168	MC08	MC08 on deck
151	2	20240229	15:18	5 50.198	11 02.151	2182	PC25	PC25@17m
151	2	20240229	16:13	5 50.192	11 02.152	2189	PC25	PC25 at bottom USBL S5°50.192975 E11°02.14630
151	2	20240229	16:39	5 50.214	11 02.132	2183	PC25	PC25 at surface
152	1	20240229	18:11	5 52.592	11 09.426	2014	CTD08	CTD08 at surface
152	2	20240229	19:08	5 52.589	11 09.357	2015	CTD08	CTD08 10m above seafloor bottle 1,2
152	3	20240229	19:11	5 52.572	11 09.345	2017	CTD08	CTD08 15m asf bottle 3,4
152	4	20240229	19:12	5 52.595	11 09.348	2020	CTD08	CTD08 20m asf bottle 5,6
152	5	20240229	19:15	5 52.578	11 09.350	2021	CTD08	CTD08 25m asf bottle 7,8
152	6	20240229	19:16	5 52.584	11 09.352	2015	CTD08	CTD08 30m asf bottle 9, 10
152	7	20240229	19:18	5 52.591	11 09.359	2030	CTD08	CTD08 35m asf bottle 11, 12
152	8	20240229	19:20	5 52.595	11 09.360	2023	CTD08	CTD08 40m asf bottle 13, 14
152	9	20240229	19:22	5 52.596	11 09.365	2018	CTD08	CTD08 45m asf bottle 15, 16
152	10	20240229	19:25	5 52.592	11 09.362	2014	CTD08	CTD08 50m asf bottle 17, 18
152	11	20240229	19:33	5 52.597	11 09.366	2011	CTD08	CTD08 60m asf bottle 19, 20
152	12	20240229	19:37	5 52.599	11 09.366	2032	CTD08	CTD08 80m asf bottle 21, 22
152	13	20240229	19:39	5 52.587	11 09.366	2024	CTD08	CTD08 100m asf bottle 23, 24
152	14	20240229	20:21	5 52.588	11 09.359		CTD08	CTD at surface
	1	20240229	20:30					Transit to international waters
153	1	20240301	13:59	5 44.984	08 08.155	4150	PC26	Station PC26; core at surface
153	1	20240301	15:35	5 44.085	08 08.219	4153	PC26	PC26 at bottom, USBL : S5°44.09347 E08°08.21981
153	1	20240301	16:56	5 44.089	08 08.216	4150	PC26	PC26 at surface
153	2	20240301	17:15			4150	MB	Multibeam transit 10knts
154	1	20240301	18:56	5 49.273	07 57.495	4061	MB10	Multibeam 5knts, short line along channel
155	1	20240301	19:28	5 48.590	07 54.600	4061	MB10	Enf of line 5knts
156	1	20240301	20:14	5 45.071	07 52.532	4244	PC27	Station PC27, core at surface
156	1	20240301	21:51	5 45.051	07 53.540	4241	PC27	PC27 at bottom, USBL : S05°45.06259, E07°52.5361
156	1	20240301	23:13	5 45.051 S	007 52.540 E	4242	PC27	PC27 @ surface
156	1	20240301	23:35	05 45.034 S	007 52.312 E	4240	PC27	PC27 on deck; transit MB to PC28
157	1	20240302	00:14	05 47.32116 S	007 49.25004 E	4112	MB11	Start of MB11 - Line 11; Sub-bottom = MBES_Survey11
158	1	20240302	00:39	05 46.69350 S	007 47.99188 E	4125	MB11	Line MB11 to WP_2; SBP WP_2 on MB; End of MB11, transit ot PC28
159	1	20240302	01:41	05 44.8312 S	007 37.9890 E	4200	SBP+MB	Arrived on site for PC28. Turned SBP + MB logging off
159	2	20240302	02:12	05 44.8827 S	007 37.9316 E	4272	PC28	PC28 going down
159	2	20240302	02:14	05 44.8738 S	007 37.9345 E	4319	PC28	USBL on
159	2	20240302	03:36	05 44.88215 S	007 37.94436 E	4316	PC28	PC28 at seafloor. Poor pull out. USBL position in boxes
159	2	20240302	04:58	05 44.8764 S	007 37.9324 E	4203	PC28	PC28 at surface
159	2	20240302	05:33	05 44.8774 S	007 37.9207 E	4208	PC28	PC28 on deck
159	1	20240302	05:26	05 44.8782 S	007 37.9021 E	4208	MB, SBP	MB , SBP on
160	1	20240302	06:44	05 48.079 S	007 31.371 E	4240	MB, SBP	start of MB12 survey. MBES line 18. SBP = MBES12_02032024
161	1	20240302	07:48	05 46.568 S	007 09.537 E	4260	MBES	transit to PC29
162	1	20240302	09:22	05 46.3099 S	007 11.2389 E	4415	PC29	At PC29; MBES + SBP stopped logging
162	1	20240302	09:50	05 46.3138 S	007 11.2539 E	4383	PC29	PC29 going down. USBL on.
162	1	20240302	11:17	05 46.33271 S	007 11.24905 E	4435	PC29	PC29 at seafloor. USBL position in boxes.
162	1	20240302	12:40	05 46.401 S	007 11.283 E	4440	PC29	PC29 @ surface
163	1	20240302	14:08	05 46.443 S	007 11.324 E	4735	PC30	on the way down
163	1	20240302	15:24	05 46.435 s	007 11.312 E	4441	PC30	@ bottom; USBL (4522?) 05 46.44780 S; 007 11.33787 E
163	1	20240302	16:44	05 46.625 S	007 11.244 E	4382	PC30	@ surface
164	1	20240302	17:17	05 47.311 S	007 11.645 E	4372	BSP01	Bottom Sediment Profiler BSP Start recording
164	1	20240302	17:23	05 46.997 S	007 11.586 E	4352	BSP01	BSP WayPoint 1
164	1	20240302	17:38	05 47.700 S	007 10.987 E	4337	BSP01	BSP Way Point 2 (end) Line 24 of MB...

key
Multi-beam
CTD
Marine-Mammal Observation
Moorings
PG Moorings
Piston Core
Multi-cores
Sub Bottom Profiler

APPENDIX C: NERC MOORING REPORT



National
Oceanography
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DY173

Consolidated Congo

Moorings Cruise Report

Dave Childs | Tim Powell | Tina Thomas

Sensors and Moorings

NOC.AC.UK

National
Oceanography
Centre

INTRODUCTION

During DY173 a total of four NOC moorings were deployed, consisting of a range of different instrumentation. All instruments were serviced, and bench tested back at NOCS prior to being shipped for the cruise.

Each Sea-Bird SMP Microcat was sent to the NOCS Calibration Laboratory prior to the cruise for a new calibration and function test. Calibration certificates for each instrument were issued, copies are included with the cruise data.

Once onboard new battery packs were fitted to all instruments ahead of their deployment. Novatech beacons were function tested to ensure they were operating as expected, with no issues found.

All Ixsea releases were serviced, and bench tested at NOC prior to the cruise, but in order to verify their operation at depth the releases were attached to the CTD frame and then tested using the TT801 Deck Unit and the ship fitted transducer on the drop keel.

Three identical moorings were deployed, these being designated M1, M2 and M4 whilst a slightly different mooring, designated M3, included an additional Sea-Bird 37 SMP Microcat and a user supplied Anderson sediment trap.

Mooring diagrams for each mooring can be found at the end of this cruise report.

INSTRUMENT SERIAL NUMBERS

For the M1 Mooring deployment the following instrumentation was used:

Instrument	Serial Number
Sea-Bird SBE 37	9395
Teledyne 300 kHz ADCP	10689
Novatech Light	Y01-015
Novatech Iridium	H07-055
Ixsea Release	1141
Ixsea Release	2328

For the M2 Mooring deployment the following instrumentation was used:

Instrument	Serial Number
Sea-Bird SBE 37	9374
Teledyne 300 kHz ADCP	2666
Novatech Light	A08-010
Novatech Iridium	H04-023
Ixsea Release	1468
Ixsea Release	2247

For the M3 Mooring deployment the following instrumentation was used:

Instrument	Serial Number
Sea-Bird SBE 37	9371
Sea-Bird SBE 37	11108
Teledyne 300 kHz ADCP	13872
Novatech Light	C01-020
Novatech Iridium	H04-022
Ixsea Release	1613
Ixsea Release	2327
Anderson Sediment Trap	N/A

For the M4 Mooring deployment the following instrumentation was used:

Instrument	Serial Number
Sea-Bird SBE 37	9389
Teledyne 300 kHz ADCP	10628
Novatech Light	S01-178
Novatech Iridium	J06863
Ixsea Release	1383
Ixsea Release	2254

TELEDYNE ADCP'S

Each ADCP had two, 2 GB memory cards installed, as well as a lithium battery pack. A typical alkaline battery pack provides approximately 450 Wh of power whilst a lithium battery pack has approximately 3.66 times the power of an alkaline pack, this being 1650 Wh.

A conservative 1350 Wh estimate of power was used during the Deployment planning stage to ensure ample battery life for the expected deployment duration of 410 days.

The ADCP's were programmed in the lab prior to being fitted into the deepwater syntactic buoyancy and an audio check was performed to make sure the instruments were logging before being deployed.

The following configuration settings were applied to the ADCP's, assuming a 410 day deployment. This was to allow for a full year's deployment plus some additional time to cover any possible delays in the turnaround next year.

M1 - SN: 10689 (300 kHz)

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 16.30
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>CR1
[Parameters set to FACTORY defaults]
>CF11111
>EA0
>EB0
>ED50000
>ES35
>EX11111
>EZ1111101
>WA50
>WB0
>WD111100000
>WF176
>WN50
>WP1
>WS100
>WV300
>TE00:00:11.00
>TP00:11.00
>CK
[Parameters saved as USER defaults]
>The command CS is not allowed in this command file.  It has been ignored.
>The following commands are generated by this program:
>CF?
CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
>CF11111
>RN 173_1
>cs
```

M2 - SN: 2666 (300 kHz)

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 16.28
RD Instruments (c) 1996-2005
All Rights Reserved.
>CR1
[Parameters set to FACTORY defaults]
>CF11111
>EA0
>EB0
>ED50000
>ES35
>EX11111
>EZ1111101
>WA50
>WB0
>WD111100000
>WF176
>WN50
>WP1
>WS100
>WV300
>TE00:00:11.00
>TP00:11.00
>CK
[Parameters saved as USER defaults]
>The command CS is not allowed in this command file.  It has been ignored.
>The following commands are generated by this program:
>CF?
CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
>CF11111
>RN 173_2
>cs
```

M3 - SN: 13872 (300 kHz)	M4 - SN: 10628 (300 kHz)
[BREAK Wakeup A]	[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 50.36	WorkHorse Broadband ADCP Version 50.36
Teledyne RD Instruments (c) 1996-2009	Teledyne RD Instruments (c) 1996-2009
All Rights Reserved.	All Rights Reserved.
>CR1	>CR1
[Parameters set to FACTORY defaults]	[Parameters set to FACTORY defaults]
>CF11111	>CF11111
>EA0	>EA0
>EB0	>EB0
>ED50000	>ED50000
>ES35	>ES35
>EX11111	>EX11111
>EZ1111101	>EZ1111101
>WA50	>WA50
>WB0	>WB0
>WD111100000	>WD111100000
>WF176	>WF176
>WN50	>WN50
>WP1	>WP1
>WS100	>WS100
>WV300	>WV300
>TE00:00:11.00	>TE00:00:11.00
>TP00:11.00	>TP00:11.00
>CK	>CK
[Parameters saved as USER defaults]	[Parameters saved as USER defaults]
>The command CS is not allowed in this command file. It has been ignored.	>The command CS is not allowed in this command file. It has been ignored.
>The following commands are generated by this program:	>The following commands are generated by this program:
>CF?	>CF?
CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)	CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
>CF11111	>CF11111
>RN 173_3	>RN 173_4
>cs	>cs

SEA-BIRD 37 SMP MICROCATS

A total of five Sea-Bird SMP Microcats was used on the moorings, each instrument was programmed using Sea-Bird SeaTerm Version 2 software and AutoSBE scripts.

For moorings M1, M2 and M4 each Sea-Bird SMP Microcat was installed into the Deepwater syntactic buoyancy using an instrument clamp, for mooring M3 both Sea-Bird SMP Microcats were clamped directly to the mooring wire.

The following settings were used to program the Sea-Bird SMP Microcats for deployment.

SN: 9395

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9395  07 Feb
2024 12:16:30
vMain = 13.32, vLith =  2.84
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity
frequency = 3295.7
S>
```

SN: 9374

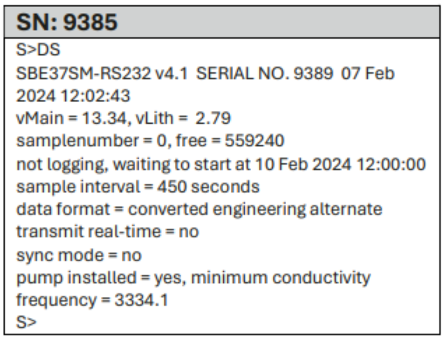
```
 S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9374  07 Feb
2024 12:11:14
vMain = 13.37, vLith =  2.94
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity
frequency = 3323.0
S>
```

SN: 9371

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9371  07 Feb
2024 12:13:44
vMain = 13.45, vLith =  2.87
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity
frequency = 3326.9
S>
```

SN: 11108

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 11108  07 Feb
2024 12:06:58
vMain = 13.63, vLith =  2.86
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity
frequency = 3182.1
S>
```



SN: 9385

```
S>DS
SBE37SM-RS232 v4.1  SERIAL NO. 9389  07 Feb
2024 12:02:43
vMain = 13.34, vLith =  2.79
samplenumber = 0, free = 559240
not logging, waiting to start at 10 Feb 2024 12:00:00
sample interval = 450 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity
frequency = 3334.1
S>
```

ANDERSON SEDIMENT TRAP

For the sediment trap on the M3 mooring an Anderson sediment trap was used. Individual drop disks were loaded into the electronics and motor assembly, fresh deployment batteries installed and then the electronics timer was set-up before finally being installed into the funnel housing.

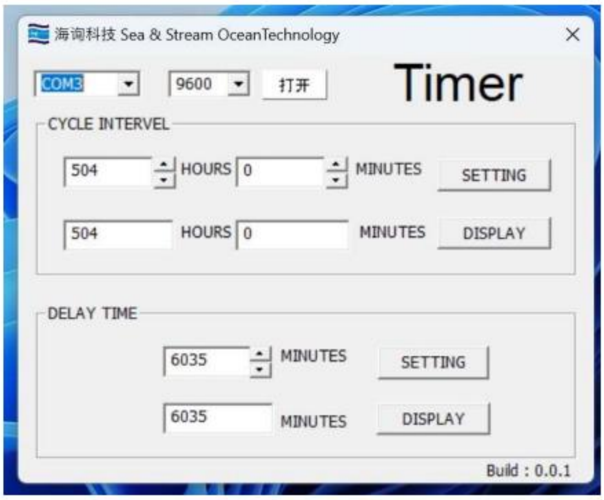
A delayed start date and time of 12:00 noon on the 12/02/2024 was chosen, with subsequent disk drops programmed every 21 days at 12:00 noon.

Details of the cycle interval and delay time are shown below.

Interval: 504 Hours

Delay: 6035 Minutes

Event No:	Date:	Event No:	Date:
1	04/03/2024	11	30/10/2024
2	03/04/2024	12	20/11/2024
3	15/05/2024	13	11/12/2024
4	05/06/2024	14	01/01/2025
5	26/06/2024	15	22/01/2025
6	17/07/2024	16	12/02/2025
7	07/08/2024	17	05/03/2025
8	28/08/2024	18	26/03/2025
9	18/09/2024	19	16/04/2025
10	09/10/2024	20	07/05/2025



COM3 9600

CYCLE INTERVEL

504 HOURS 0 MINUTES

504 HOURS 0 MINUTES

DELAY TIME

6035 MINUTES

6035 MINUTES

MOORING OPERATIONS SUMMARY

The ship setup on station for deployment with the stern A frame positioned at the target location. No run in was necessary as the moorings were short and deployment was expected to be quick.

A light surface current was sufficient to stream the moorings clear of the stern whilst the ship remained in position ready for the anchors to be released.

Due to the short length of the moorings they were prepared for deployment with the wires flaked on the red deck ready to run. M1, M2 and M3 were deployed using the ships pedestal cranes and released by SeaCatch toggle release hooks. The starboard crane with runner deployed the syntactic buoyancy and the port crane with hard eye deployed the anchors.

A subsequent failure of the port pedestal crane valve block led to a revised deployment plan for the final mooring.

M4 was deployed using the ships A frame and Rexroth winches again using the SeaCatch toggle release hooks. The syntactic buoyancy and anchor were lifted in tandem from the deck. The A frame was then positioned outboard and the mooring was deployed.

Once the moorings were released they were monitored to their seabed rest position using an IXSEA TT801 deck unit connected to the moorings transducer fitted to the port drop keel. The drop keel was in its lowered position and remained there until trilateration was completed.

The moorings were trilaterated after each deployment by ranging the IXSEA releases from three equidistant positions approximately 5000m away from the drop location.
To Improve accuracy these ranges were then corrected for local sound velocities measured by the CTD by applying the harmonic mean of the velocities calculated using the Del Grosso equation.

MOORING DEPLOYMENT DETAILS

M1 Mooring

Deployment date: 11/02/2024 Estimated final position: Lat: 06° 30.9270' S Long: 005° 55.6230' E Depth: 4812m	Target position: Lat: 06° 30.9274' S Long: 005° 55.6320' E
Initial ship set-up: At target position Estimated fall-back: 0m	Deployment start: 08:24 Ready to deploy: 08:29 Anchor released: 08:31 Descent speed (estimated): 200m/min Anchor landed (estimated): 08:55

M2 Mooring

Deployment date: 12/02/2024 Estimated final position: Lat: 06° 30.731' S Long: 005° 48.445' E Depth: 4833m	Target position: Lat: 06° 30.7459' S Long: 005° 48.4427' E
Initial ship set-up: At target position Estimated fall-back: 0m	Deployment start: Ready to deploy: Anchor released: 05:38 Descent speed (estimated): 200m/min Anchor landed (estimated): 06:02

M3 Mooring

Deployment date: 13/02/2024 Estimated final position: Lat: 06 36.845' S Long: 005 41.503' E Depth: 4906m	Target position: Lat: 06 36.8397' S Long: 005 41.5133' E
Initial ship set-up: At target position Estimated fall-back: 0m	Deployment start: 07:32 Ready to deploy: 07:37 Anchor released: 07:38 Descent speed: 200m/min Anchor landed: 08:03

M4 Mooring

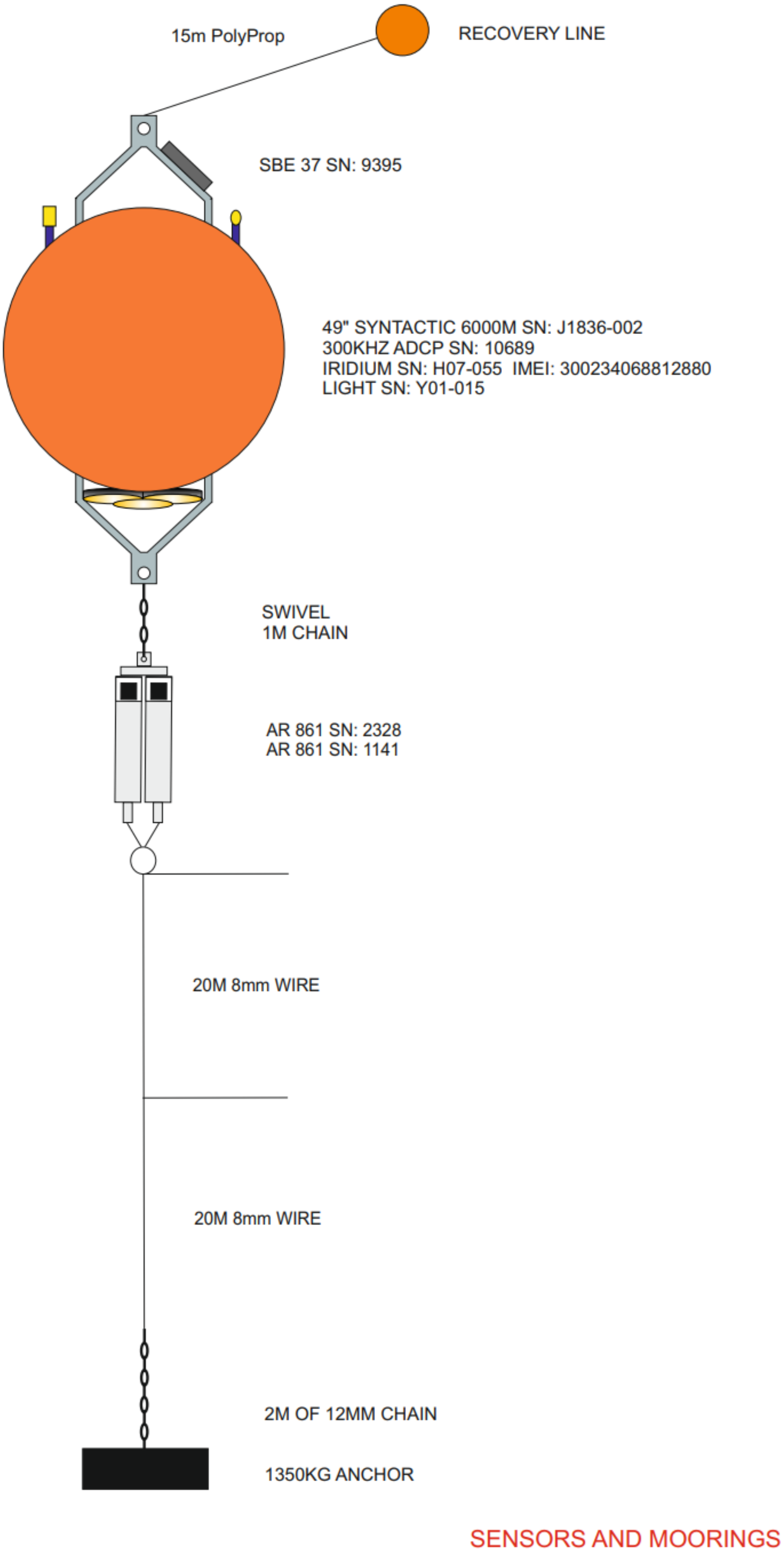
Deployment date: 13/02/2024 Estimated final position: Lat: 06 44.9090' S Long: 005 26.3695' E Depth: 4975	Target position: Lat: 06 44.9091' S Long: 005 26.3724' E
Initial ship set-up: At target position Estimated fall-back: 0m	Deployment start: 12:28 Ready to deploy: 12:31 Anchor released: 12:32 Descent speed: 200m/min Anchor landed: 12:57

M1
DEPLOYED
2024

DEPLOYMENT
POSITION

06° 30.935' S
005° 55.630'E

Depth 4812m

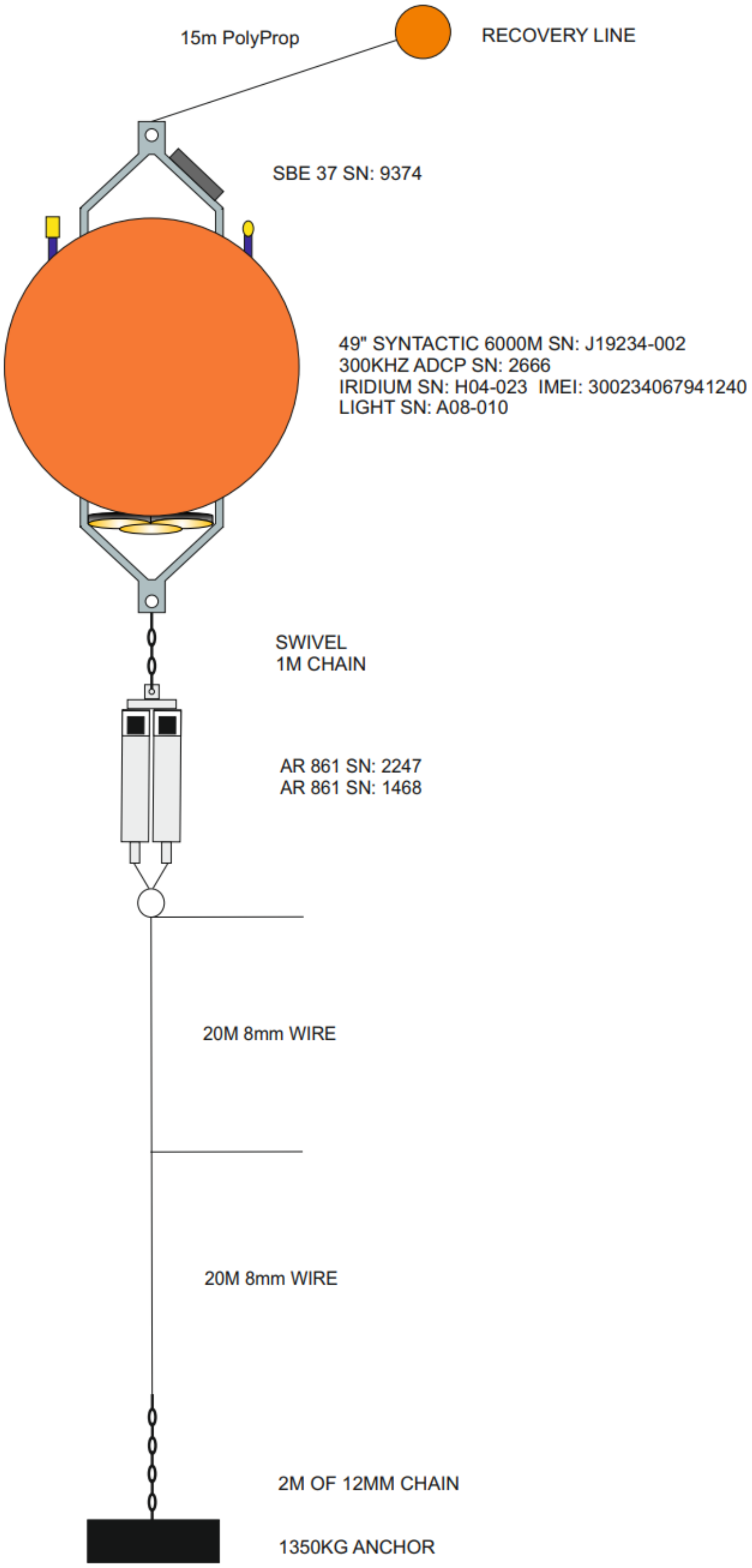


M2
DEPLOYED
2024

DEPLOYMENT
POSITION

06° 30.738' S
005° 48.442' E

Depth 4833m

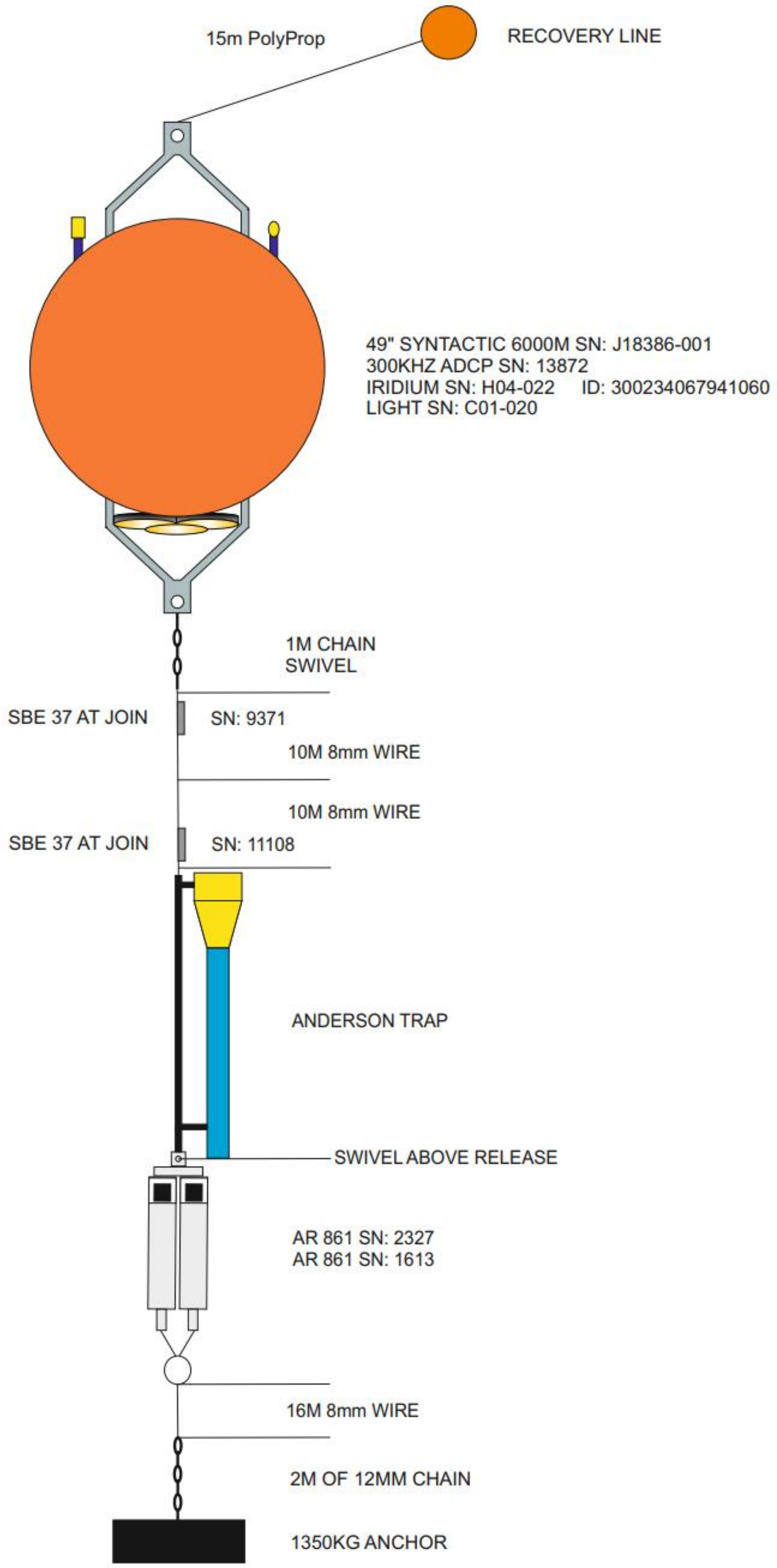


M3
DEPLOYED
2024

DEPLOYMENT
POSITION

06° 36.8435' S
005° 41.5035' E

DEPTH 4906

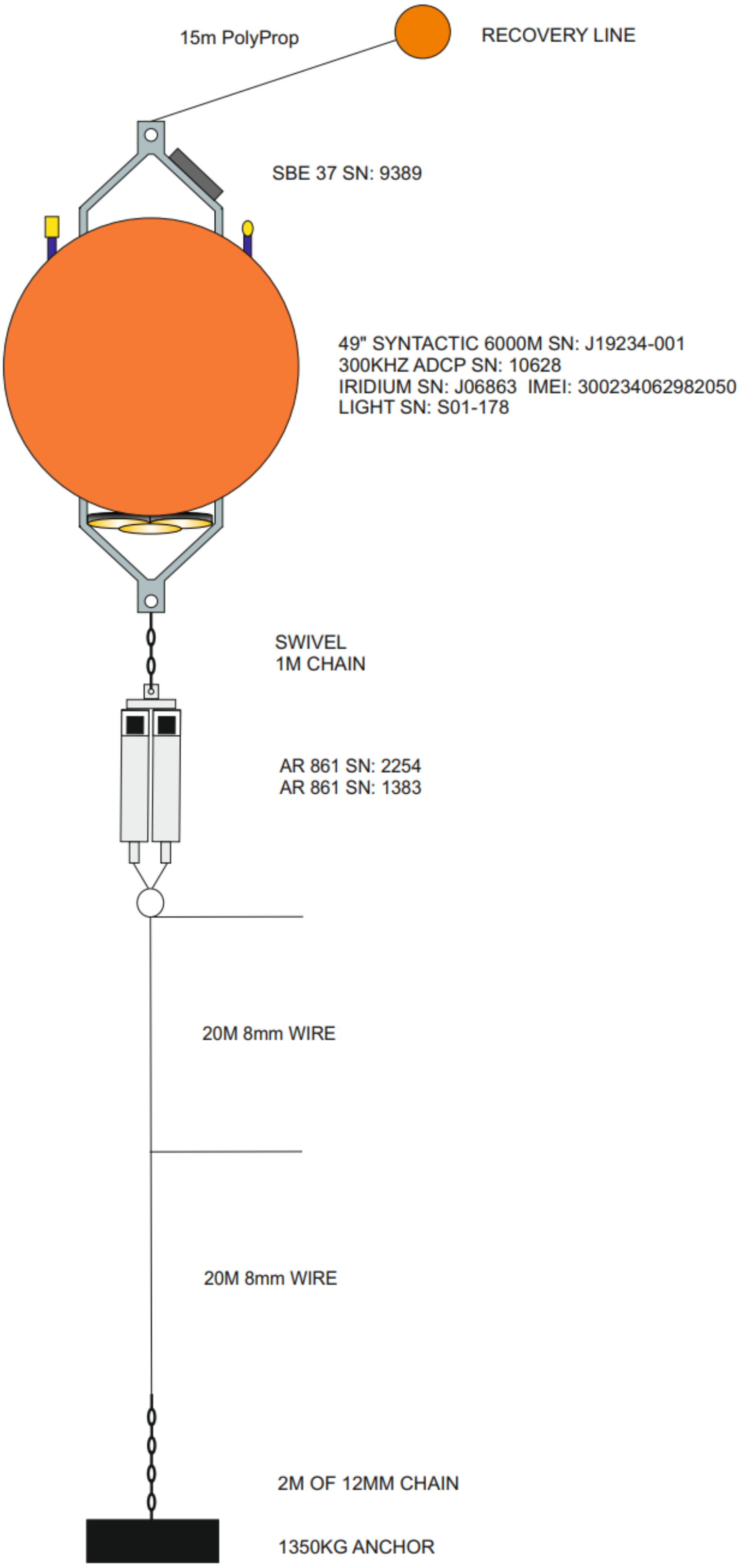


M4
DEPLOYED
2024

DEPLOYMENT
POSITION

06° 44.9090' S
005° 26.3695' E

Depth 4975m



SENSORS AND MOORINGS

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