Ocean Cryosphere Exchanges in Antarctica:

Impacts on Climate and the Earth system

Deployment of moorings in South Sandwich Trench

Milestone MS9

OCEAN:ICE is co-funded by the European Union, Horizon Europe Funding Programme for research and innovation under grant agreement Nr. 101060452 and by UK Research and Innovation

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Document information: Milestone Report

Work Package	WP5 Ice sheet impacts on global ocean circulation
Milestone no. & title	MS9 Deployment of moorings in South Sandwich Trench
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Version	Final
Due date	30 November 2023
Delivery date	22 March 2024

Means of Verification of the Achievement of the Milestone

Mooring deployments. Partner in charge of delivery of the milestone: UKRI-BAS.

Work performed and main achievements

This report summarises the work performed, and reasons for the delay to the milestone.

The mooring deployment is described in more details in the full cruise report for FV *Argos Georgia* voyage SS24, which will be submitted to the British Oceanographic Data Centre (BODC), to be linked from https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/18630/.

Background

Weddell Sea Deep Water (WSDW) is a key precursor to Antarctic Bottom Water (Orsi et al., 1999), which covers much of the abyssal World Ocean (Johnson, 2008), forming the lower limb of the meridional overturning circulation (Lumpkin & Speer, 2007). The British Antarctic Survey (BAS) has monitored exports of WSDW since 2006, deploying moorings in collaboration with Lamont-Doherty Earth Observatory, Columbia University, in Orkney Passage and the northwest Weddell Sea. Orkney Passage, east of the South Orkney Islands, is the largest export route for WSDW across South Scotia Ridge into the Scotia Sea (Naveira Garabato et al., 2002). However, little is known about the deeper export route through South Sandwich Trench (SST), farther to the east.

As part of OCEAN:ICE work package 5, investigating Antarctic deep water formation and export routes, we proposed to deploy two moorings in South Sandwich Trench (SST). The original plan was to deploy and recover these moorings in collaboration with project partners in South Africa, from RV *S. A. Agulhas II* in early 2023. Much of the mooring equipment used here was recovered from Orkney Passage on RRS *Discovery* cruise DY158 in January 2023; it would have been logistically impossible to redeploy in the same season from the *Agulhas*, and, in addition, some equipment required servicing and recalibration before redeployment. Consequently, deployment was postponed to the 2023-24 season, to be performed in conjunction with the logistics voyage to SANAE station in December 2023-February 2024. This change resulted in a reduction in the time series length from two years to one year (a mitigation measure identified in the project's risk register), reducing our ability to investigate interannual variability in WSDW exports, but still giving one full annual cycle of observations, and giving enough time after recovery for in-depth analysis.

Unfortunately, these plans fell through in autumn 2023 for logistical reasons, and a search for other research vessels going to the deployment area in 2023-24 proved fruitless. However, we identified that longline fishing vessel *Argos Georgia*, operated by Argos Froyanes Limited (AFL), was undertaking research and commercial fishing near the South Sandwich Islands in CCAMLR sub-area 48.4, north of 60°S. In collaboration with AFL we managed to secure a berth on the vessel, obtain the required permits from the UK Foreign Commonwealth and Development Office (Antarctic Permit no. 20/2023-2024) and the Government of South Georgia and the South Sandwich Islands (Regulated Activity Permit no. 2024/006), and ship the mooring equipment from Cambridge to Stanley just in time for the vessel's departure. One

box of instruments, which had been sent by airfreight from Cape Town to Stanley, did not reach the ship in time, so the moorings were deployed with slightly fewer SBE-37 “Microcat” conductivity-temperature-pressure loggers than originally planned.

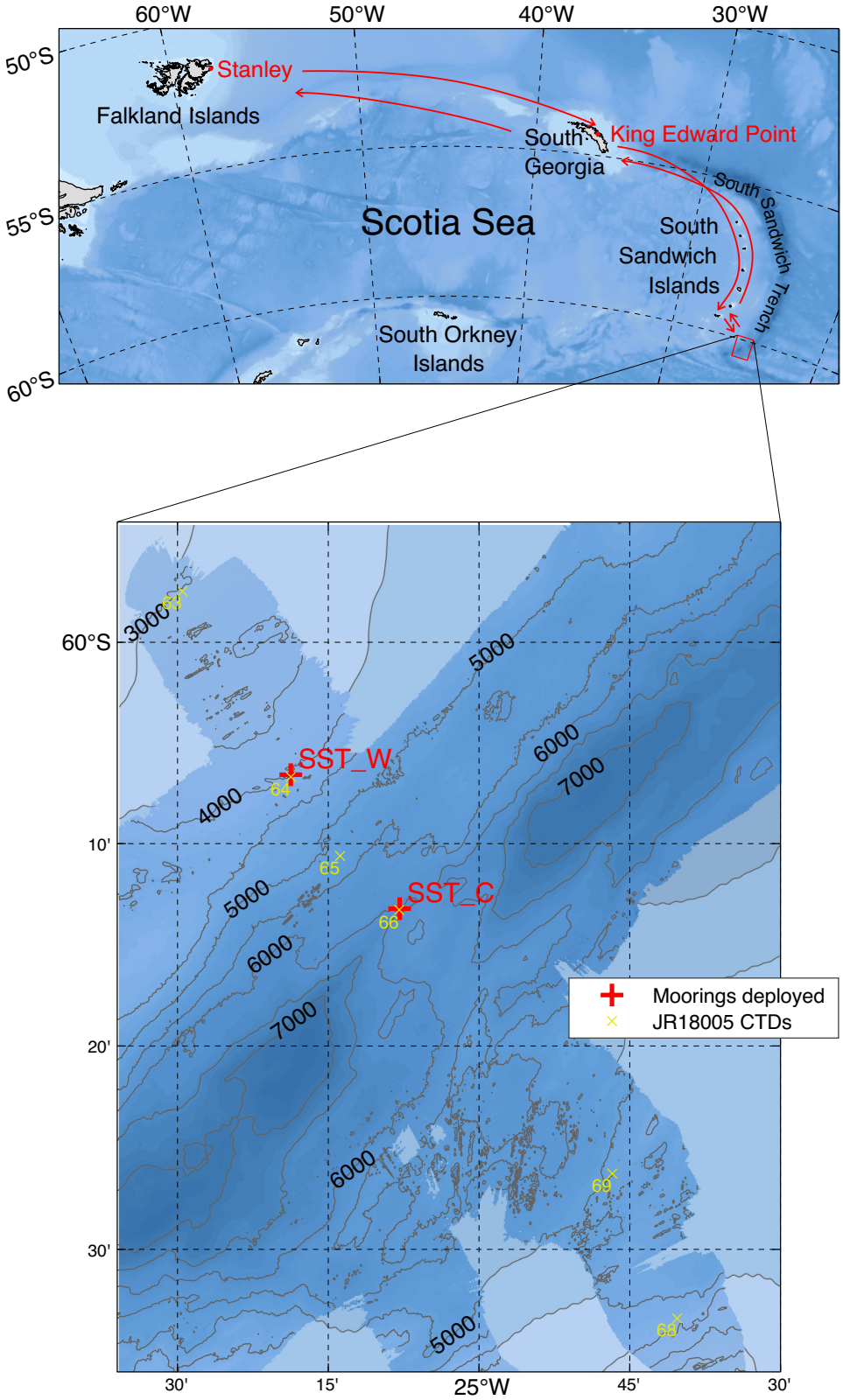

Figure 1: Overview of the vessel route and mooring deployments on the cruise. Locations of the CTD casts from RRS *James Clark Ross* cruise JR18005 are also shown on the detail map, which shows BAS and Five Deeps multibeam data (Caladan Oceanic LLC, 2021) superimposed on GEBCO_2023 (GEBCO Compilation Group, 2023).

Deployment of moorings

The vessel departed Stanley on 30 January 2024 and called into King Edward Point, South Georgia for a fishing license inspection on 3 February 2024. Research fishing near the South Sandwich Islands (in CCAMLR sub-area 48.4, north of 60°S) took place 4-15 February 2024. During this time, mooring equipment was prepared for deployment by the chief scientist and the vessel crew. Two commercial fishing lines were set on the afternoon of 15 February 2024, before the vessel departed for SST, arriving in the morning. The two moorings were deployed on 16 February 2024. The vessel then continued with commercial fishing, in the same sub-area as before, on 16-24 February 2024, before returning to the anchorage in Stanley Harbour on 29 February 2024. The ship berthed, the cruise was demobilised, and the chief scientist disembarked on 1 March 2024.

The two sub-surface oceanographic moorings were deployed in South Sandwich Trench, one at the saddle point of the ridge across the trough (SST_C), and the other on the western flank at approx. 4000 m depth (SST_W). The moorings were not triangulated after deployment, but the anchor drop positions are shown in Table 1, with the most reliable depth estimate underlined. The approximate route of the vessel and the locations of the two moorings are shown in Figure 1.

Table 1. Mooring deployment (anchor drop) times, positions, and estimated depths, with the most reliable depth source underlined.

Mooring	Deployment time (UTC)	Latitude	Longitude	Bottom depth (est.)
SST_W	16/02/2024 13:52	60° 06.583'S	025° 18.728'W	<u>3958 (BAS multibeam)</u> 3973 (JR18005 CTD 64)
SST_C	16/02/2024 17:04	60° 13.220'S	025° 07.897'W	<u>5964 (Five Deeps MB)</u> 6008 (BAS multibeam) 5932 (JR18005 CTD 66)

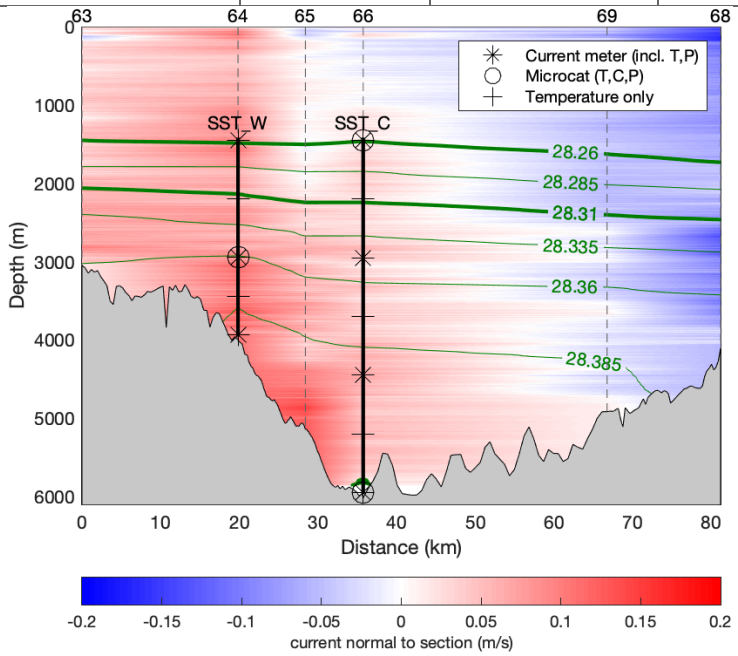

Figure 2. LADCP section from RRS *James Clark Ross* cruise JR18005 showing currents normal to the section, with the location of the moorings and their instruments superimposed. Contours of neutral density γ^n are plotted in green, with the 28.26, 28.31, and 28.40 kg m^{-3} contours, the upper limits of WSBW, lWSDW, and WSDW/uWSDW, plotted in bold.

The placement of mooring instruments relative to the CTD/LADCP casts on JR18005 (Meijers, 2019) is shown in Figure 2. The moorings were designed to cover a distribution of water mass properties and currents within the WSDW layer. The upper boundary of WSDW in SST lies at approx. 1500 m depth. The original intention was to deploy an SBE-37SM ("Microcat") temperature-conductivity-pressure recorder with each current meter. Unfortunately, because of shipping problems, four Microcats did not arrive in Stanley in time to reach the vessel, and the three available Microcats were distributed with two at the bottom and top of the SST_C, and the third in the middle of SST_W.

Plans for recovery of moorings

The next milestone for these moorings is the OCEAN:ICE milestone MS10, "Recovery of moorings in South Sandwich Trench". This is due in April 2025. Ship time has been secured to recover the moorings on UK research vessel RRS *Sir David Attenborough* in February/March 2025, in conjunction with turnaround of the Orkney Passage moorings as part of the second Antarctic cruise of the BIOPOLE programme ("Biogeochemical processes and ecosystem function in changing polar systems and their global impacts"). This should keep us on track for on-time delivery of MS10, and subsequently of deliverables D5.1, "Mooring dataset from South Sandwich Trench", due in October 2025, and D5.2, "South Sandwich Trench and Orkney Passage comparison", July 2026. There is an ongoing risk, identified in the project's risk register, of access to South Sandwich Trench, due to logistics, weather, Covid, etc. Any significant delays to recovery would severely curtail our ability to analyse new observations from South Sandwich Trench within the timespan of the project, though research effort could still be put toward further analysis of existing data from export routes such as Orkney Passage.

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Mooring diagrams

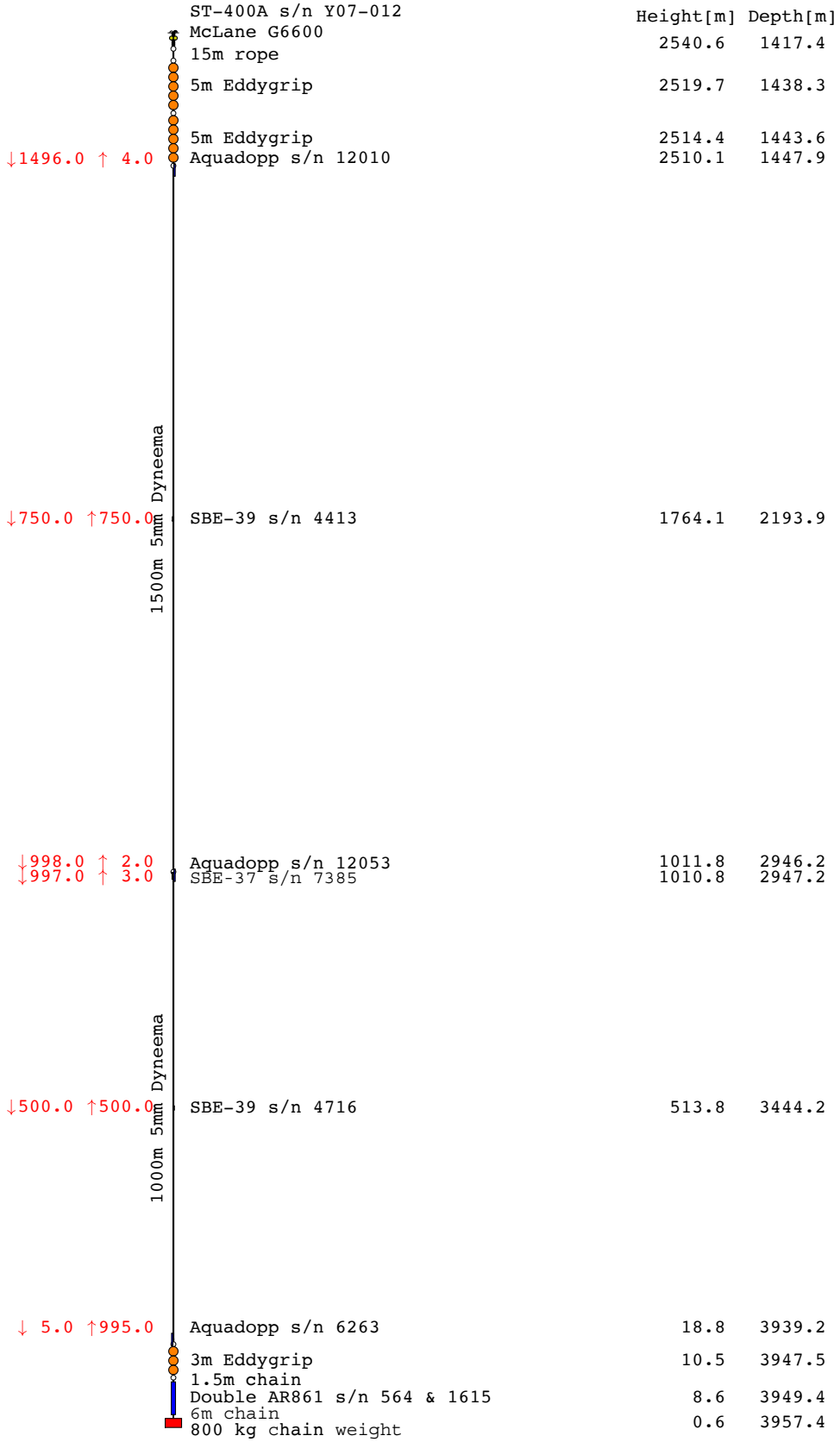

Figure 3. Mooring SST_W as deployed in 2024.

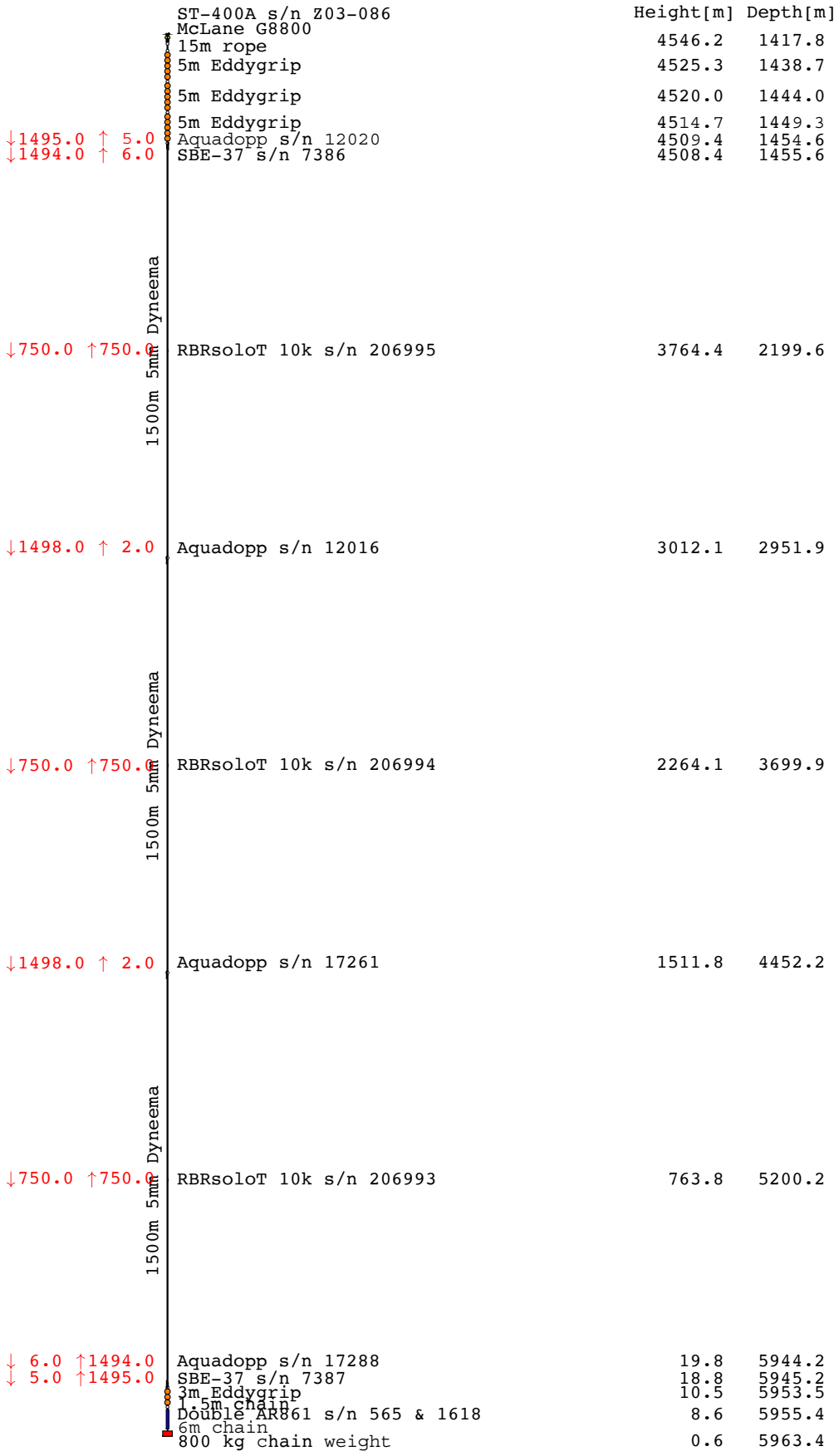

Figure 4. Mooring SST_C as deployed in 2024.