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Short Cruise Report
RV METEOR cruise M194

The Effect of Spreading Rate on the Volcanic Activity and Frequency Distribution of Hydrothermal Vent Sites in the Red Sea Rift

Jeddah (SA) – Piraeus (GR)
10.09.2023 – 07.11.2023

Chief Scientist: Dr. Nico Augustin
Captain: Rainer Hammacher

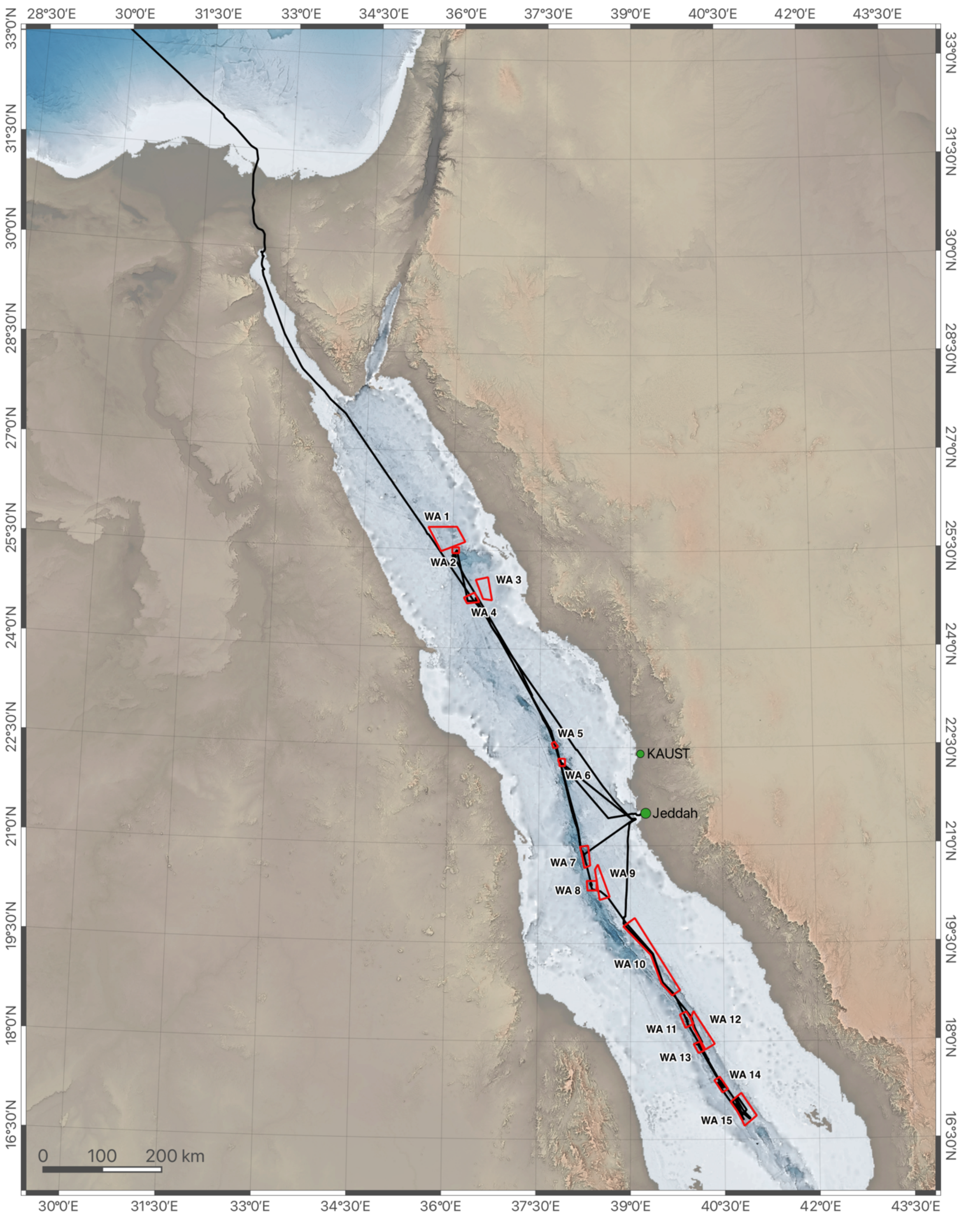

Fig. 1: Overview of the M194 cruise track and working areas in the Red Sea. Planned WA1 and WA4 have not been visited as they were already mapped before expedition M194 by cruise Meteor M193 (WA1) and KAUST RV Thuwal surveys (WA4).

Objectives

The HEXPLORES project aims to locate, study, and understand hydrothermal vent fields in the Red Sea Rift at accessible locations outside the brine pools. We posit that the comparably high heat flow in the Red Sea leads to higher hydrothermal activity and, therefore, more hydrothermal vent fields than predicted for ultra-slow spreading ridges, but the search for hydrothermalism outside of any brine pool is unprecedented.
We identified several key target areas for hydrothermal exploration based on indications from the tectonic setting, morphology, volcanology, and geochemistry. From N to S, these key targets are Mabahiss Mons, Thetis-Hadarba-Hatiba Trough (particularly Hatiba Mons), Aswad Dome, Poseidon Deep, and the Red Sea rift 17-18°N. We will survey these key areas and several transects in the less studied southern Red Sea rift with CTD/MAPR Tow-Yo's to pick up signals of hydrothermal effluents. ROV dives will help to search for hydrothermal vent fields, which, once discovered, we will study to address the following scientific questions and hypotheses:
Do currently used models for global vent field frequency underestimate ultraslow-spreading ridges? Due to the low number of observations at ultraslow-spreading ridges, it is unclear if the connection between decreasing vent field frequency and decreasing spreading rate along mid-ocean ridges is correct or if there is "excess" hydrothermal activity at ultra-slow spreading ridges. Exploration along the Red Sea rift axis will help to answer that question.
What is the size and grade of activity of hydrothermal vent fields in the Red Sea? The ultra-slow spreading rate, an overall elevated heat flow in the Red Sea, and high saline hydrothermal fluids may lead to larger massive sulfide deposits than found elsewhere, as indicated by the large amount of metalliferous sediments in Atlantis II Deep. This will be determined by high-resolution imaging and, if possible, photogrammetry. In addition, carefully selected and positioned samples of chimneys and surrounding host rocks will be taken by ROV.
What are the composition, origin, and pathways of the hydrothermal fluids? The chemistry of the fluids gives information on the host rock types the fluids reacted with on their path through the crust. Furthermore, the fluids may show unique signatures due to the high heat flow in the Red Sea, the warm Red Sea bottom water, and probably a high salinity of the fluids due to the high-saline seawater, the brine pools, and the presence of evaporites.
What are the micro- and macrofauna occurring at hydrothermal vent fields in the Red Sea? So far, undiscovered chemosynthetic communities at Red Sea rift hydrothermal vents may be endemic and thus unique. These communities may play a key role in understanding the evolution and migration of species to and between hydrothermal vents of the global oceans. In addition, the Red Sea bottom water is saltier and 10x warmer than in other oceans, requiring the adaption of deep-sea organisms relative to the global marine fauna. Photographic surveys by ROV will yield habitat maps of chemosynthetic ecosystems aligned with photogrammetric models. Selected macrofaunal specimens and microorganisms will be sampled by ROV depending on their abundances.
To understand the hydrothermal activity in the Red Sea in detail, it is essential to study the volcanism that drives the hydrothermal activity in concert. Based on our previous intensive work (see above), we have an excellent general understanding of volcanism and tectonics in the central Red Sea; nevertheless, there are several remaining questions to tackle to understand regional Red Sea geology, ocean opening, and young ultraslow-spreading ridges that we will address during the expedition by sampling of volcanic rocks and bathymetric mapping.

Narrative

After a reception in the port of Jeddah on Sunday, 08 October, when RV Meteor was visited by the Ambassador and the General Consul of Germany in Saudi Arabia and representatives of the Saudi Ministry of Foreign Affairs, King Abdullah University for Science and Technology (KAUST), Jeddah Port Authorities, and other Saudi entities, the majority of the scientific and ROV team embarked RV METEOR on Monday, 09 October around noon time. The ROV team started to set up the ROV Kiel 6000 system, and the scientists began to prepare the lab space. After a successful port test of the ROV system, RV Meteor left Jeddah port on 10 October, 04:45 PM. We took two gravity cores on the summit of the axial volcano Hatiba Mons in the early hours of 11 October. After that, we did an OFOS video survey over a potentially volcanic area east of Kebrit Deep. Unfortunately, the winch failed shortly before the end of the station. Repairs and recovery of the OFOS took until the late afternoon. We finished the day with a CTD cast in the Kebrit brine pool. The night from 12 to 13 October was used to transit to Mabahiss Mons Volcano and to perform a CTD Tow-Yo. The ROV was ready to dive into the Mabahiss Mons caldera on the morning of 13 October. Due to problems with the USBL underwater navigation, navigating at the bottom of the Hatiba Mons caldera was difficult. Thus, we dedicated the entire night to 14 October to calibrate the ship's USBL system with a transponder lowered to the seabed, and the Meteor performed multiple defined maneuvers around its position to calibrate the system. The transponder was left on the seafloor in case additional calibration was needed. After the calibration, we started another ROV dive in the Mabahiss Mons caldera but with similar USBL problems. During the dive, the technical support of Meteor installed a spare USBL antenna, which immediately improved our positioning at the seafloor. After the ROV was back on deck, we performed another round of calibration maneuvers until 01:00 AM on Sunday. The transponder could not be recovered during nighttime, and we did one more CTD Tow-Yo over the Mabahiss Caldera before the transponder recovery after sunrise. With the newly installed and calibrated antenna, we could not exceed transit speeds of more than 8-9 knots, which we needed to consider in the planning. We transited to Hadarba Deep and started an ROV dive on Monday, 16 October morning. We could not find signs of hydrothermal activity with the ROV and moved to the Hatiba Mons volcano, where we did a CTD Tow-Yo overnight.

On 17 October, a dive of ROV Kiel 6000 started at Hatiba Mons, the largest axial volcano in the Red Sea rift to a hydrothermal active area, recently discovered by the lead PIs. Some USBL issues in the late afternoon made it unsafe to navigate between the meter-high hydrothermal iron oxide mounds. The dive was interrupted to get the ROV save on deck. We used the night hours to work on the USBL transponders and recovered gravity cores from the Hatiba Mons iron mounds. On 18 October, we finished the planned program from the day before during the morning. In the afternoon, we visited a second site of potential hydrothermal activity and found a surprisingly high amount of low-T venting.

We traveled further south during the night to start a CTD and MAPR (Miniature Autonomous Plume Recorder) tow-yo at the Aswad Dome volcano at 20°55'N. We started the Tow-Yo on the morning of 19 October. Unfortunately, a medical emergency interrupted the scientific work, and we returned to Jeddah to disembark one crew member for medical treatment. After the detour to Jeddah, we postponed the planned station work at Aswad Dome and Poseidon Deep in favor of the more southern working areas and headed towards working area 13 at 18°N in the Red Sea rift. During the transit to the "Pisces volcano" (our working name after the Soviet submersible that dived there in 1979/80), we collected multibeam bathymetry data over formerly unmapped areas. We arrived at "Pisces volcano" in the late afternoon of 20 October and started a CTD and MAPR TowYo. A reconnaissance dive over the volcano and an adjacent volcanic ridge showed pillow lavas of different ages but no signs of hydrothermal activity. We then proceeded towards working area 14, a magmatically stable segment center with a well-developed volcano. The work started again with a CTD and MAPR TowYo along the axial valley in the night from 21 to 22 October. The following ROV dive along the NW-SE striking eastern boundary fault discovered multiple sites of low-temperature iron-oxide chimneys and microbes with well-visible venting of clear fluids, similar to the northern and central Red Sea. Before proceeding with CTD measurements and ROV dives in the southernmost working area 15, we started more extensive multibeam mapping on the night of Monday, 23 October. We mapped the summit of Ramad Seamount and continued with a CTD and MAPR Tow-Yo over two cone-shaped volcanoes south of Ramad Seamount. On Tuesday morning, the 24 October, we started the shallowest dive of the expedition at one of the cone volcanoes. Large parts of the volcano were scattered with low-temperature fluid outlets, surrounded by microbes and some large microbial mats. Thus, at our southernmost target, we found the same style of hydrothermal activity as observed in the central and northern Red Sea rift. We spent the night of 25 October with another To-Yow at the southern part of Ramad Seamount. We continued with an ROV dive at the eastern rift of Ramad Seamount. We soon found the first hydrothermal sites with shimmering water of up to 30°C, bacterial mats, and flourishing macrofauna. After that, it was time to move North to investigate the working areas that we postponed on our way to the South. Before heading to working area 11, we did a second ROV dive in the "Crescent Moons" volcano in WA14. Earlier in the expedition, we found numerous smaller vent sites on its eastern boundary fault. After multibeam mapping, we did a second dive at its western fault on 26 October, where we also found hydrothermal iron oxide mounds comparable to those at Hatiba Mons volcano, venting of shimmering water and bacterial mats right at its western boundary fault. The following night, we transited northwards, followed by a CTD and MAPR Tow-Yo in the Red Sea axis at 18°18'N. Due to thunderstorms with high wind speeds, our planned station work got delayed. Friday morning, 27 October, we started to dive over a rift oblique fault close to a volcanic active axial high in the same working area. This rift segment was much older than expected without hydrothermal activity. A second ROV dive in Poseidon Deep on 28 October also revealed older-than-expected lava fields but no hydrothermal activity. After Poseidon Deep, we moved to our last working area, the Aswad Dome volcano at 20°55'N, and began a CTD and MAPR Tow-Yo. The last ROV dive of expedition M194 was at the Aswad Dome volcano on 29 October. After passing some faulted and sedimented volcanic terrain, we found another low-temperature vent site with iron oxide mounds and microbial mats comparable to Hatiba Mons. We could sample microbial mats and hydrothermal precipitates and left the area at 15:30 hrs local time. We transited northwards to do three more gravity coring stations in the Majarrah Mounds hydrothermal field at Hatiba Mons volcano in the night from 29 to 30 October before the scientific program of M194 was finished. Unfortunately, the local authorities rejected the planned disembarkation of participants from different Saudi entities at KAUST at the last minute, and thus, we had to go to Jeddah Islamic Port. Thanks to the immediate support from KAUST CMR and the port agency HASCO, the group of seven KAUST scientists, two NCW employees, and the GEOSA observer left RV Meteor with samples and equipment at around 16:30 hrs on Monday afternoon, 30 October. RV Meteor started the transit in the direction of the Suez Canal. On the evening of 01 November, the Gulf of Suez was reached and, one day later, the waiting position for the Suez convoy. We entered the Suez Canal on 03 November, 14:00 local time, and arrived in the Mediterranean Sea around 22:00 hrs the same day. Meteor arrived in Piraeus, Greece, one day earlier than planned on Monday morning, 06 November.

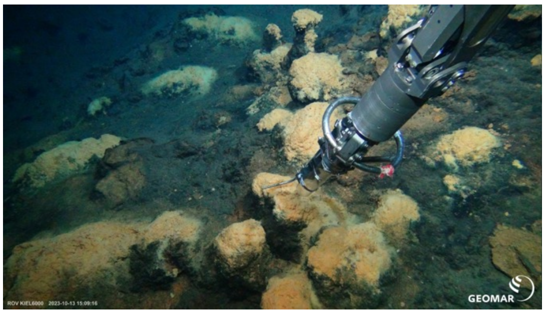

Fig. 2: Sampling bacterial mats at Mabahiss Mons volcano.

Fig. 3: Larger animals, like this sea anemone, are rare in the deep Red Sea.

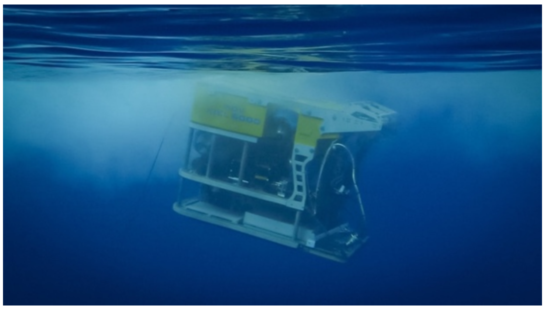

Fig. 4: ROV Kiel 6000 under the surface of the sea.

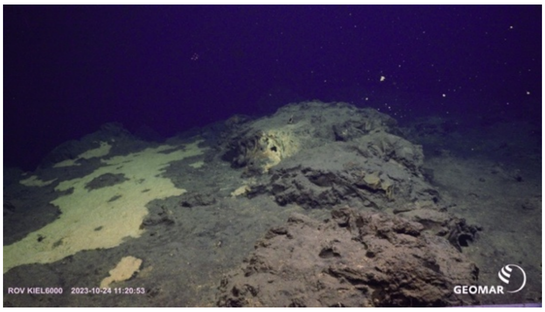

Fig: 5: Vent outlets and large microbial mats on the crest of a large cone volcano in the southern Red Sea.

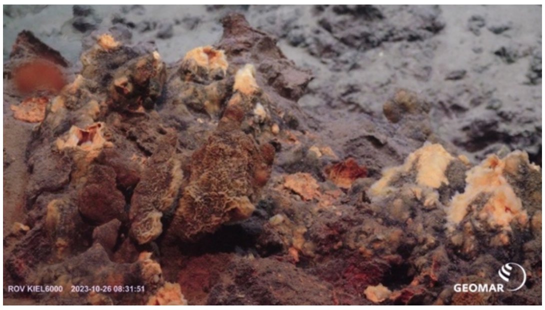

Fig. 6: Small patch of microbes and Iron oxide chimneys at the western flank of the "Crescent Moons" volcano.

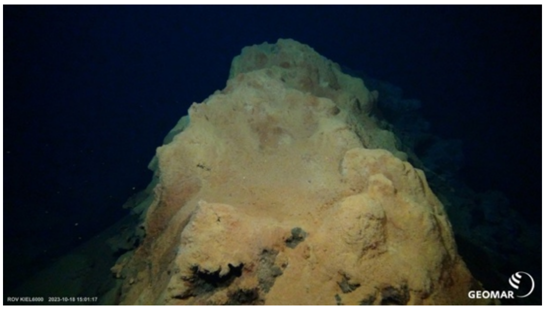

Fig. 7: Thick hydrothermal microbial mats form a steep iron oxide mound at Hatiba Mons volcano.

Acknowledgments

We are very grateful to the German Research Foundation (DFG), the German Research Fleet Coordination Centre at the Universität Hamburg, the shipping company BRIESE Research, and LPL Projects + Logistics GmbH for their support to both science and ship logistics. The captain, officers, and crew of the RV METEOR are thanked for their tremendous support, which has made a significant contribution to the success of the cruise. We also thank KAUST Government Affairs (GA), KAUST Coastal and Marine Resources Corelab (CMR), and HASCO Group Jeddah for their special efforts to obtain the research permit from the Saudi Arabian government and the support with the embarkation and disembarkation of the scientific team, equipment, and samples in Jeddah Islamic Port.

Participants

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21. Huusmann, Hannes	ROV	GEOMAR
22. Suck, Inken	ROV	GEOMAR
23. Matthiessen, Torge	ROV	GEOMAR
24. Striewski, Peter	ROV	GEOMAR
25. Alqalaiti, Bander	Observer	GEOSA
26. Elsäßer, Antje	Meteorology	DWD
27. Stelzner, Martin	Meteorology	DWD

Participating Institutes

GEOMAR	Helmholtz Centre for Ocean Research Kiel, Germany
KAUST	King Abdullah University for Science and Technology, Thuwal, Saudi Arabia
NCW	National Center for Wildlife, Saudi Arabia
BAS	British Antarctic Survey, UK
MUST	Macau University for Science and Technology, China
UO	University of Ottawa, Canada
GNSL	Geological Survey of Newfoundland and Labrador, Canada
GEOSA	General Authority for Survey and Geospatial Information, Saudi Arabia

Station List

Methods abbreviations: CG = Gravity Corer; OFOS = Ocean Floor Observation System (towed camera, GEOMAR); CTD = ships own CTD and rosette water sampler and MAPR (Miniature Autonomous Plume Recorder); MBES = shipboard multibeam echosounder EM122; ROV = Remotely Operated Vehicle Kiel 6000 GEOMAR

Station	Sample	Method	Date (UTC)	Time (UTC)	Latitude (°N)	Longitude (°E)	Depth (m)
01		**GC**	10.10.2023	23:21 – 23:59	22°16.79	37°50.46	942
02		**GC**	11.10.2023	01:07 – 01:47	22°15.37	37°50.76	883
03		**OFOS**	11.10.2023	19:25	24°45.881	36°24.225	1085
			12.10.2023	12:25	24°43.403	36°24.639	1099
04		**CTD**	12.10.2023	14:03 – 15:22	24°43.319	36°16.547	1518
	01	bottle 1-2			24°43.319	36°16.547	1573
	02	bottle 3			24°43.319	36°16.547	1475
	03	bottle 4-9			24°43.319	36°16.547	1470
	04	bottle 10-11			24°43.319	36°16.547	95
	05	bottle 12-13			24°43.319	36°16.547	15
05	start	**CTD Tow-Yo**	12.10.2023 – 13.10.2022	20:20 – 02:54	25°28.635	36°04.634	957
	01	bottle 3			25°28.942	36°04.428	-
	02	bottle 4			25°28.943	36°04.303	860
	03	bottle 5			25°29.196	36°04.183	860
	04	bottle 6			25°29.164	36°04.224	933
	05	bottle 7			25°28.809	36°04.427	850
	end				25°28.636	36°04.589	957
06	on bottom	**ROV**	13.10.23	06:42	25°28.934	36°04.178	941
	01	push core B3		10:37	25°28.474	36°04.352	947
	02	push core A4		10:42	25°28.975	36°04.355	947
	03	green net		10:49	25°28.978	36°04.353	947
	04	Niskin bottle yellow		11:41	25°29.062	36°04.434	969
	05	yellow net		12:24	25°29.086	36°04.480	913
	06	Niskin bottle blue		12:46	25°29.085	36°04.485	912
	07	red net		14:07	25°29.099	36°04.486	920
	08	Niskin bottle red		14:23	25°29.099	36°04.486	920
	09	push core D8		14:40	25°29.103	36°04.483	919
	10	SG chamber 1		15:09	25°29.033	36°04.517	917
	11	SG chamber 2		15:11	25°29.123	36°04.478	923
	off bottom			15:19	25°29.111	36°04.395	921
07	on bottom	**ROV**	14.10.2023	06:09	25°28.810	36°04.487	964
	01	red net		07:46	25°28.88	36°04.34	963

	02	manipulator box A		08:17	25°28.91	36°04.32	970
	03	Niskin bottle yellow		12:41	25°28.94	36°04.37	935
	04	SG chamber 1		12:54	25°28.94	36°04.37	934
	05	Niskin bottle blue		14:05	25°28.99	36°04.50	973
	06	Niskin bottle red		14:07	25°28.99	36°04.50	973
	07	SG chamber 3		14:24	25°28.99	36°04.50	973
	08	white net		15:14	25°28.965	36°04.470	973
	off bottom			15:53	25°28.941	36°04.433	896
08CTD Tow-Yo	start	**CTD Tow-Yo**	15.10.2023	00:12	25°28.955	36°04.838	957
	01	bottle 1-4			25°28.925	36°04.263	916
	end			01:53	25°28.900	36°03.983	959
09ROV	start	**ROV**	16.10.2023	05:11	22°32.000	37°46.567	1820
	end			07:20	22°32.009	37°46.532	1820
10ROV	start	**ROV**	16.10.2023	07:56	22°31.994	37°46.526	1881
	01	manipulator box B		09:30	22°31.978	37°46.535	1883
	02	black net		09:53	22°31.986	37°46.532	1882
	03	manipulator box C		10:49	22°33.050	37°46.362	1846
	04	manipulator box C*		11:10	22°32.122	37°46.361	1826
	05	manipulator box 13		11:40	22°32.170	37°46.386	1804
	end			15:40	22°32.621	37°46.359	1610
11	start	**CTD Tow-Yo**	16.10.2023 – 17.10.2023	18:07	22°18.756	37°50.034	1076
	end			04:15	22°17.617	37°50.855	950
12	start	**ROV**	17.10.2023	05:36	22°15.336	37°50.816	-
	01	SG chamber 2		06:58	22°15.348	37°50.799	897
	02	red net		07:12	22°15.348	37°50.799	896
	03	manipulator box C		08:11	22°15.372	37°50.739	897
	04	SG chamber 4		08:39	22°15.363	37°50.716	898
	05	Niskin bottle yellow		09:13	22°15.328	37°50.754	903
	06	Niskin bottle blue		09:46	22°15.300	37°50.778	900
	07	major green		09:50	22°15.300	37°50.777	900
	08	SG chamber 6		10:02	22°15.299	37°50.777	903
	end			13:28	22°15.320	37°50.846	-
13		**GC**	17.10.2023	15:11 – 15:46	22°15.212	37°50.799	869.8
14		**CTD**	17.10.2023	16:10	22°15.277	37°50.79	868
15		**GC**	17.10.2023	17:48 – 18:25	22°16.804	37°50.466	938.2
16		**GC**	17.10.2023	19:11 – 19:50	22°16.747	37°50.458	947.8

17	01	**CTD Tow-Yo** bottle 1-5	17.10.2023 – 18.10.2023	20:43 – 04:12	22°17.599 22°15.168	37°50.797 37°51.795	960 989
18	start	**ROV**	18.10.2023	05:04	22°15.177	37°50.891	881
	n/a	marker 1		06:18	22°15.191	37°50.842	885
	n/a	marker 2		06:24	22°15.190	37°50.846	885
	n/a	marker 3		06:30	22°15.188	37°50.842	885
	01	SG bottle 2		08:21	22°15.222	37°50.775	880
	02	major green		08:37	22°15.222	37°50.775	880
	03	Niskin bottle yellow		08:53	22°15.222	37°50.775	880
	04	Niskin bottle blue		08:56	22°15.222	37°50.775	880
	05	major yellow		09:24	22°15.189	37°50.843	886
	06	Niskin bottle red		09:31	22°15.190	37°50.844	886
	07	SG bottle 4		09:43	22°15.185	37°50.844	886
	08	SG bottle 5		09:46	22°15.185	37°50.844	886
	end			10:22	22°15.278	37° 50.849	886
19	start	**ROV**	18.10.2023	11:34	22°16.679	37°50.273	-
	01	green net		12:59	22°16.749	37°50.380	968
	02	SG bottle 1		13:25	22°16.759	37°50.393	969
	03	SG bottle 2		13:28	22°16.759	37°50.393	969
	04	SG bottle 4		14:31	22°50.490	37°50.490	950
	05	SG bottle 5		14:35	22°50.490	37°50.490	950
	end			15:46	22°16.895	37°50.535	-
20		**CTD Tow-yo**	19.10.2023	04:56 – 07:13	20°51.472 20°51.772	38°14.681 38°14.503	1953 1932
21	n/a	**MBES**	19.10.2023 – 20.10.2023	23:10 – 14:00	19°47.274 17°57.479	38°54.265 40°04.631	844 1544
22	start	**CTD Tow-Yo**	20.10.2023	14:27	17°57.610	17°58.587	1542
	end		21.10.2023	03:14	17°58.597	40°02.957	
23	start	**ROV**	21.10.2023	05:21	17°57.271	40°03.723	1586
	01	manipulator box B		06:38	17°57.433	40°03.705	1564
	02	manipulator box 1 + 5		09:06	17°57.870	40°04.177	1420
	03	manipulator box K		11:09	17°58.090	40°04.128	1307
	04	white net		11:41	17°58.134	40°04.024	1333
	05	manipulator box K		12:06	17°58.146	40°04.010	1303
	end			13:22	17°58.109	40°04.046	-
24	start	**CTD Tow-yo**	21.10.2023	19:01	17°20.818	40°26.465	1078
	end		22.10.2023	04:00	17°20.672	40°26.438	1063
25	start	**ROV**	22.10.2023	05:37	17°20.511	40°26.763	986
	01	SG vortex		06:57	17°20.560	40°26.874	1023
	02	SG bottle 1		07:51	17°20.538	40°26.911	1007
	03	SG bottle 3		09:51	17°20.450	40°27.050	935

	04	white net		10:02	17°20.450	40°27.050	935
	05	major green		12:26	17°20.304	40°27.180	929
	06	major yellow		12:47	17°20.304	40°27.180	929
	07	Niskin bottle yellow		13:00	17°20.304	40°27.180	929
	08	Niskin bottle blue		13:02	17°20.304	40°27.180	925
	09	red net		13:13	17°20.304	40°27.181	925
	10	manipulator box B		13:24	17°20.304	40°27.178	931
	11	Niskin bottle red		14:38	17°20.093	40°27.334	918
	end			15:17	17°20.102	40°27.247	-
26		**MBES**	22.10.2023 – 23.10.2023	15:53 – 00:15	17°22.599 17°01.339	40°26.863 40°39.615	1094 684
27+28	start	**CTD Tow-yo**	23.10.2023	2:21	16°49.705	40°46.748	876
	end			12:03	16°52.678	40°44.877	516
29		**MBES**	23.10.2023	13:09 – 16:50	16°48.488 17°02.661	40°47.652 40°38.159	1187 1013
30		**MBES**	23.10.2023 – 24.10.2023	17:34 – 03:44	17°01.319 16°56.863	40°39.617 40°50.625	689 909
31	start	**ROV**	24.10.2023	05:24	16°51.814	40°45.623	-
	01	manipulator bio box		06:32	16°51.738	40°45.602	718
	02	manipulator bio box		07:37	16°51.812	40°45.503	668
	03	green net		07:55	16°51.817	40°45.496	667
	04	manipulator box 2		08:33	16°51.851	40°45.430	656
	05	manipulator box 3 and 6		08:57	16°51.872	40°45.388	635
	06	manipulator bio box		09:28	16°51.911	40°45.350	615
	07	SG bottle 1		11:31	16°52.154	40°45.199	410
	08	SG bottle 2		11:32	16°52.154	40°45.199	410
	09	SG bio box		12:17	16°52.187	40°45.181	400
	10	Niskin bottle blue		12:24	16°52.187	40°45.181	400
	11	manipulator box 9		14:01	16°52.292	40°45.113	309
	12	manipulator bio box		14:26	16°52.310	40°45.120	301
	13	manipulator box 5		14:48	16°52.336	40°45.097	282
	14	Manipulator bio box		15:05	16°52.284	40°45.118	316
	15	Niskin bottle yellow		15:29	16°52.229	40°45.179	376
	16	Niskin bottle red		15:31	16°52.229	40°45.109	376
	end			15:55	16°52.306	40°45.192	-
32	start	**CTD Tow-Yo**	24.10.2023	16:52	16°55.365	40°42.700	907
	end		25.10.2023	04:10	16°59.903	40°39.888	454

33	start	**ROV**	25.10.2023	05:27	16°56.910	40°42.071	555
	01	manipulator box 14		06:48	16°56.929	40°42.097	542
	02	manipulator bio box		06:56	16°56.932	40°42.095	542
	03	manipulator bio box		07:00	16°56.933	40°42.095	542
	04	SG bottle 1		07:05	16°56.933	40°42.095	542
	05	major green		08:20	16°57.018	40°42.037	552
	06	Niskin bottle blue		08:27	16°57.018	40°42.037	552
	07	white net		08:31	16°57.018	40°42.037	552
	08	red net		08:39	16°57.018	40°42.037	552
	09	manipulator bio box		08:50	16°57.018	40°42.037	552
	10	manipulator box 2		10:32	16°57.071	40°42.023	545
	11	manipulator bio box		11:41	16°57.379	40°41.854	548
	12	manipulator box 3		11:43	16°57.379	40°41.854	548
	13	manipulator box 5		11:45	16°57.379	40°41.854	548
	14	Manipulator bio box		12:26	16°57.332	40°41.744	501
	15	manipulator box 7		13:09	16°57.324	40°41.590	575
	16	manipulator box 1		15:18	16°57.802	40°41.317	406
	end			15:48	16°57.859	40°41.256	-
34		**MBES**	25.10.2023 – 26.10.2023	16:09 – 04:00	16°57.828 17°23.918	40°40.361 40°27.077	435 1378
35	start	**ROV**	26.10.2023	05:54	17°19.282	40°27.366	-
	01	manipulator box 3		06:55	17°19.356	40°27.349	1009
	02	red net		07:55	17°19.313	40°27.233	1085
	03	manipulator box 6		08:03	17°19.313	40°27.233	1085
	04	major green		08:56	17°19.318	40°27.216	1084
	05	Niskin bottle blue		09:09	17°19.318	40°27.216	1084
	06	Niskin bottle yellow		09:09	17°19.318	40°27.216	1084
	07	SG bottle 2		09:12	17°19.318	40°27.216	1084
	08	major yellow		11:15	17°19.397	40°26.972	1027
	09	manipulator box 5		11:24	17°19.400	40°26.967	1025
	end			12:00	17°19.380	40°27.020	-
36		**MBES**	26.10.2023	19:17 – 20:13	18°15.919 18°21.606	39°55.066 39°53.383	1841 1683
37	start	**CTD Tow-Yo**	26.10.2023	21:56	18°15.853	39°55.080	1839
	end		27.10.2023	04:38	18°18.919	39°54.221	1685
38	start	**ROV**	27.10.2023	05:21	18°18.308	39°55.076	1653

	01	manipulator box 5		09:53	18°18.380	39°54.969	1665
	02	manipulator box 8		11:30	18°18.683	39°53.891	1571
	end			12:45	18°18.574	39°53.879	-
39MB		**MBES**	27.10.2023 – 28.10.2023	13:00 – 05:26	18°18.207 20°23.586	39°54.390 38°21.205	1678 2014
40	start	**ROV**	28.10.2023	06:19	20°23.130	38°21.361	-
	01	manipulator box 2		08:19	20°23.495	38°29.319	2103
	02	manipulator box K		11:05	20°23.474	38°21.688	1898
	03	manipulator box 8		11:12	20°23.474	38°21.688	1898
	04	manipulator box 12 (and 8, 9, 11)		12:40	20°23.444	38°22.025	1685
	end			13:42	20°23.476	38°22.045	-
41	start	**CTD Tow-Yo**	28.10.2023	17:23	20°52.766	38°13.930	1933
	end		29.10.2023	03:06	20°55.987	38°11.270	1892
42	on bottom	**ROV**	28.10.2023	05:17	20°55.203	38°11.958	-
	01	manipulator box 5		06:50	20°55.190	38°11.892	1936
	02	manipulator box 3		09:33	20°55.649	38°11.361	1831
	03	SG bottle 1		09:50	20·55.665	38°11.348	1830
	04	SG bottle 2		09:52	20°55.665	38°11.348	1830
	05	red net		10:05	20°55.665	38°11.348	1830
	06	SG bottle 3		10:29	20°55.673	38°11.350	1828
	07	SG bottle 4		10:31	20°55.673	38°11.350	1828
	08	white net		11:11	20°55.675	38°11.352	1825
	09						
	off bottom			12:30	20°55.711	38°11.202	-
43		**GC**	29.10.2023	21:23 – 22:07	22°16.805	37°50.493	958
44		**GC**	29.10.2023	22:37 – 23:20	22°16.834	37°50.559	961
45		**GC**	29.10.2023 – 30.10.2023	23:47 – 00:25	22°16.838	37°50.634	961