ROCS June 7 -20, 2021 cruise to the Irminger Sea, Denmark Strait & the Iceland Basin

Table 1 Scientific Participants

	Name	
1	Katherine Richardson	Professor, University of Copenhagen (cruise leader)
2	Paul Knutz	Professor, GEUS
3	Hans Røy	Associate professor, University of Aarhus
4	Jørgen Bendtsen	Office manager and senior scientist, NIVA Denmark
5	Angel Ruiz-Angulo	Professor, University of Iceland
6	Lasse Prins	Associate professor, University of Aarhus
7	Rebecca Jackson	Post Doc, GEUS
8	Angela Rawlings	Post Doc, ROCS
9	Arndís Bergsdóttir	Post Doc, ROCS
10	Jakob Fritzbøger	Stud. Scient, University of Copenhagen
11	Hjalte Drejer Jørgensen	Stud. Scient, Ålborg University
12	Jacek Sliwinski	HAFRO

Aims: The primary goal of the cruise was to collect sediment cores for eDNA analysis. A program for study of pelagic processes was developed to ensure maximum use of ship time, i.e. utilize time where weather conditions did not allow coring and to carry out when sufficient cores were collected:

Scientific goals of the pelagic program

1. To identify relations between physical conditions, i.e., water masses, turbulent mixing and light, nutrients and the vertical distribution of chlorophyll a, with a special focus on the subsurface chlorophyll a maximum (SCM).
2. To investigate phytoplankton diversity in the upper 100 m via eDNA analysis and size-fractionated chlorophyll a distribution.
3. Analyze optical properties of phytoplankton in relation to photosynthetic activity, photosynthetic parameters and photoinhibition in the upper 100 m.
4. Provide baseline measurement of water column and phytoplankton characteristics for supporting the analysis of sediment cores.

Cruise summary of the coring program

1. Nine gravity cores were collected containing more than 5 m of sediment
2. Eight gravity cores were collected containing <1 m sediment
3. Four Rumohrlot cores were collected
4. A recovery going farther back than the Last Glacial Maximum is likely for most of the gravity cores.
5. Samples were retrieved from the core catcher for imminent radiocarbon dating that can provide basal ages.

6. High-resolution seismic data and multibeam bathymetry data was collected proving detailed imaging of the sub-seabed stratigraphy.

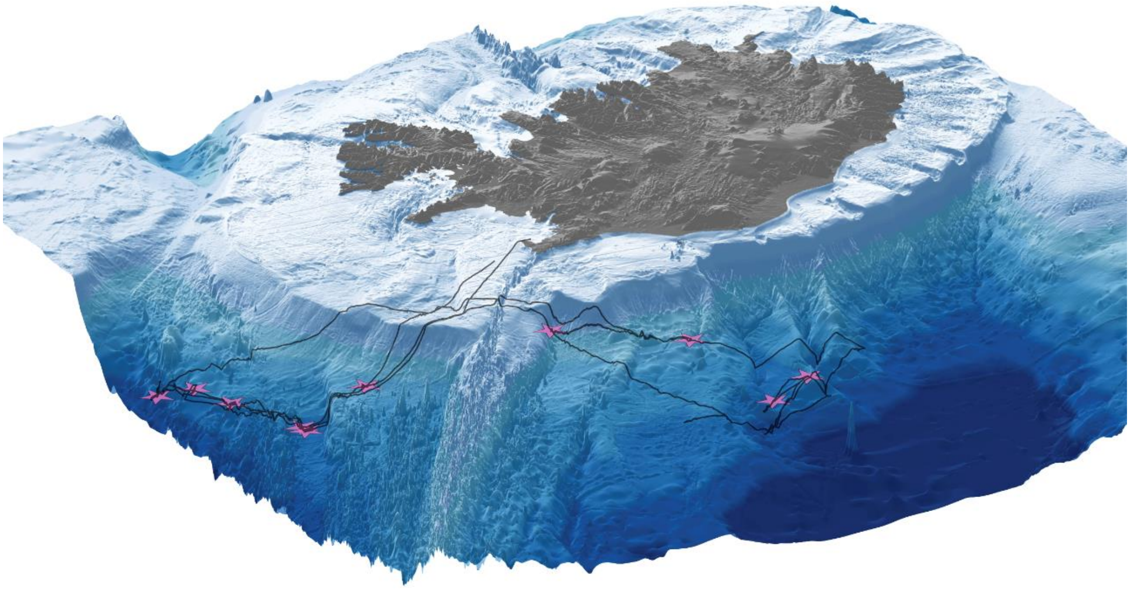


Figure 1. Positions of the collected cores

Cruise summary of the pelagic program

The pelagic program was carried out in connection with the sediment sampling program and station locations were determined by being suitable sites for gravity coring (Figure 1). A full pelagic program was made at each location where gravity cores were taken, and in one case, high sea hindered gravity coring and therefore only the pelagic measurements were made (Table 2). *This resulted in different station numbering between the pelagic measurements and the sediment cores. Thus, station numbers of the Pelagic program follow the table below (Tables 2-4).* A time series station from the same location was made during a two-day period for making a temporal analysis of the daily variation of water mass characteristics, turbulence and intra-thermocline eddy mixing and the photosynthetic activity of phytoplankton.

The weather conditions during the first week were relatively windy with high swells whereas the working conditions were relatively good during the last week. Several low-pressure systems passed through the study area during the cruise and the weather changed accordingly.

The pelagic program included CTD-casts, turbulence measurements, water sampling for nutrients, eDNA, chlorophyll a, salinity and water samples for light/dark incubations for photosynthetic activity. In general, a CTD cast was made to the bottom followed by a second CTD cast for sampling additional water for the eDNA and chlorophyll a filtration. Turbulence profiles were made after the CTD casts and the sampling of water from the Niskin bottles was finalized. There were then made two turbulence profiles with the free-falling turbulence-profiler with a 200 m rope and this resulted in turbulence profiles to ~120 m depth, depending on the drift of the ship and the subsurface currents.

In total, 30 CTD-casts and 26 turbulence profiles were made from 9 different locations (Table 3).

CTD-measurements

The CTD procedure was in general carried out as follow: the CTD was first lowered to ~5 m depth and was kept there for more than 1 minute until the sensors had stabilized. Thereafter it was brought to the surface and a profile was made to a few meters above the bottom with a descending speed of 0.5 – 1 m s^{-1}. After 3 minutes at a few meters above the bottom, the first bottle was closed and the CTD was brought to 50 m above the bottom for taking a sample for eDNA (50 m above the bottom was chosen to avoid too much resuspended material in the eDNA sample). Thereafter the CTD was brought to the remaining bottle depths and after 1 minute the bottles were closed at these depths. Samples for eDNA and chlorophyll a required up to 3 Niskin bottles per depth, and therefore a second CTD-cast were made to collect additional water. Water samples were made at the following depths: a few meters above the bottom (for salinity), 50 m above the bottom (for eDNA, water chemistry), 400 m, 200 m, 100 m, 60 m, 40 m, 30 m, 10 m and 5 m. Additional depth levels were made at some stations (80 m, 50 m, 20 m and 1 m) for resolving nutrient gradients and increase the depth resolution of measurements for the photosynthetic activity.

The CTD was a part of a SeaBird 911plus system measuring conductivity, temperature and pressure (depth) and it was equipped with an oxygen SBE 43 sensor for measurements of oxygen, a LI-COR Biospherical PAR sensor for measuring photosynthetic available radiation, a Seapoint Fluorometer for measuring fluorescence and an altimeter to determine the depth above the bottom. The rosette was equipped with 11 bottles (5-liter Niskin bottles).

Water sampling and filtering for eDNA and chlorophyll a

Water samples for salinity were taken from the bottle close to the bottom.
Water samples for nutrients were then taken in small plastic bottles (rinsed 3 times, with gloves) and frozen immediately after sampling (-20 °C). Water samples will be analyzed for nutrients (NO_3^-, NO_2^-, NH_4^+, Si, PO_4^{3-}) and TN and TP (total nitrogen and phosphorous, respectively) in the laboratory after the cruise.
Water samples were then taken for light- and dark-incubations for measuring photosynthetic activity. Samples for light-incubations were brought to the laboratory and bottles for dark-incubations were stored outside on deck.
Finally, water was collected from bottle depths 50 m above the bottom, 100 m depth, the depth of the SCM (typically ~30 m depth) and 5 m depth and collected in large plastic cans (10 – 20 l, rinsed 1-2 times with gloves) from each bottle depth. These samples were subsequently prefiltered through a 200 µm filter and then size fractionated by 2 filter sizes (< and > 10 µm) and immediately flash frozen (liquid nitrogen), and stored at -20 °C) for subsequent analysis of eDNA and chlorophyll a.

Optical measurements

LABSTAF active fluorometer measurements were made at 2 stations and 5 experiments were in addition made at the time series station (station 12-16). Samples were taken for both light and dark incubations. The dark-samples were stored outside on deck, except station 10 where incubations were stored on the Lab-floor. Light incubations were made at least 4 hours after the incubations were started and was placed on a table in the laboratory below a weak light source (<50 muE). Samples were taken from 100 m, 60 m, 50 m, 40 m, 30m, 20 m, 10m, 5m and 1m. Notes were made of FvFm, F_0 and photosynthetic parameters during the light intensity sequence and LABSTAF-files were saved with these incubation results.

Turbulence measurements

Microscale turbulence was measured with a loose-tethered, freely-falling Rockland Scientific International (RSI) VMP-250 microstructure vertical profiler equipped with two shear probes, an FP07 thermistor, a microconductivity sensor and a conductivity, temperature (CT) and pressure-sensor (JFE Advantech, JAC). In addition, the VMP-250 was equipped with a fluorometer and turbidity Combo sensor. Microstructure measurements of shear, temperature, conductivity, fluorescence, turbidity and pressure were sampled at 64 Hz and the CT-sensor operated at 16 Hz. Two profiles were made at each station with a 200 m rope.

Table 2 CTD station list. Station number refers to the CTD-station number, Depth is the bottom depth at the station, "Cast number" shows the CTD-cast number and Hex file show the file ID for the CTD-cast. "VMP-file" shows the file ID for the turbulence measurements made after the last CTD-cast at the station. All VMP-casts contain two profiles. The blue shading (no. 12-19) shows the information from the time series station.

Station	Date	Time (UTC)	Latitude		Longitude		Depth	Cast no.	Hex file	VMP-file
			degree (N)	minutes	degree (W)	minutes	m			
3	09.06.21	*16:03*	63	51,750	28	57,860	1663	1	260	
3	09.06.21	*17:37*	63	50,880	29	0,750	1663	2	260a	VMP_050
4	12.06.21	*08:25*	61	52,350	20	28,970	1975	1	262	
4	12.06.21	*10:13*	61	51,960	20	30,080	1975	2	262a	VMP_051
6	13.06.21	*09:50*	61	42,510	21	28,120	1650	1	263	
6	13.06.21	*11:32*	61	43,850	21	28,610	1650	2	263a	VMP_052
7	14.06.21	*08:12*	63	8,030	23	18,230	796	1	264	
7	14.06.21	*09:20*	63	8,440	23	16,960	796	2	264a	VMP_054
8	14.06.21	19:21	62	43,190	20	57,220	1117	1	265	
8	14.06.21	20:54	62	42,830	20	58,790	1117	2	265a	VMP_055
9	16.06.21	08:13	64	32,460	29	32,740	1930	1	270	
9	16.06.21	10:09	64	32,560	29	37,000	1930	2	270a	VMP_057
10	17.06.21	10:11	64	33,120	29	33,880	1930	1	274	
10	17.06.21	11:02	64	33,200	29	35,210	1930	2	274a	VMP_058
11	17.06.21	17:44	64	14,220	29	12,800	1560	1	275	
11	17.06.21	17:44	64	13,810	29	14,640	1560	2	275a	VMP_062
12	18.06.21	08:13	63	15,490	28	14,900	1730	1	276	
12	18.06.21	09:58	63	14,800	28	14,600	1730	2	276a	VMP_063
13	18.06.21	16:05	63	14,960	28	15,380	1730	1	283	VMP_064
14	18.06.21	22:01	63	15,090	28	15,240	1730	1	284	VMP_065
15	19.06.21	08:12	63	15,080	28	15,170	1730	1	285	VMP_066
16	19.06.21	14:06	63	15,080	28	14,130	1730	1	286	VMP_067
17	19.06.21	15:19	63	14,930	28	13,500	1730	1	287	
18	19.06.21	16:16	63	14,900	28	12,950	1730	1	288	
19	19.06.21	16:48	63	14,870	28	12,700	1730	1	289	
19	19.06.21	17:17	63	14,870	28	12,340	1730	1	290	

Table 3 Summary of the pelagic program.

Stations	Number
CTD	
CTD stations	9
Repeat CTD casts at timeseries station (12-19)	8
Total number of CTD casts	30
VMP	
Turbulence stations (VMP)	9
Repeat VMP cast at timeseries station (12-19)	5
Total number of VMP profiles	26

Table 4 LABSTAF incubations. Station number refer to the CTD-station list (Table 2) and blue shading (station 12-16) indicates measurements at the time series station.

Station	**Date**	**Time (UTC)**	**Latitude**		**Longitude**		**LABSTAF**
			Degree N		Degree W		
10	17.06.21	11:02	64	33,200	29	35,210	yes
11	17.06.21	17:44	64	13,810	29	14,640	yes
12	18.06.21	09:58	63	14,800	28	14,600	yes
13	18.06.21	16:05	63	14,960	28	15,380	yes
14	18.06.21	22:01	63	15,090	28	15,240	yes
15	19.06.21	08:12	63	15,080	28	15,170	yes
16	19.06.21	14:06	63	15,080	28	14,130	yes

Preliminary results

Preliminary results from the CTD and turbulence profiler were analyzed during the cruise. An example is shown from the time series station where repeated CTD casts were performed at stations 12-19 (Figure 2). Temperature and salinity anomalies were observed from depth 500 to 1000 meters (corresponding to 5-6 °C interval in the T/S-diagram) suggesting the presence of an Intra-Thermocline Eddy presumably formed upstream of the Denmark Strait. The temperature-salinity (TS) diagram showed very intense mixing at those depths associated with those anomalies. This feature was persistent during the 24hrs CTD yo-yo carried out at the time series station.

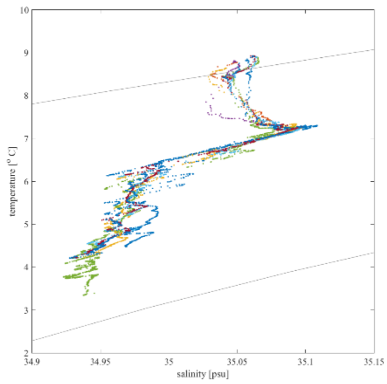


Figure 1 TS diagram from the time series station. The figure shows temperature versus salinity for profiles taken at the time series station during a two-day period. Relatively large variations in salinity is seen in the depth interval between 5-6 °C, corresponding to a depth range between 500 – 1000 m. Such variations indicate the presence of an intra-thermocline eddy.

An example from the turbulence profiler at station 3 (Figure 3) shows the presence of a well-defined subsurface chlorophyll a maximum (SCM, brown curve in the middle figure) located around 40 m depth. The instrument shows the fluorescence, and this will be calibrated to a chlorophyll a concentration when the filter-samples have been analyzed. The turbulence profiler shows variations at the centimeter-scale and this explains the relatively large variation in fluorescence. The temperature and salinity profiles show water above 8 °C in the upper 30 m and a low-saline upper layer (<35.1) in the upper 40 m. However, salinity changes are relatively small. Turbulent mixing can be calculated from the dissipation rate of turbulent kinetic energy (right figure with blue and red curves) and estimates of these show significantly elevated rates in the upper 30 m (note the logarithmic scale). This shows that elevated mixing in the surface layer decrease by at least an order of magnitude below 30 m. The relation between the vertical phytoplankton distribution, chlorophyll a, nutrients, water mass characteristics and turbulence will be analyzed further when the water samples have been analyzed.

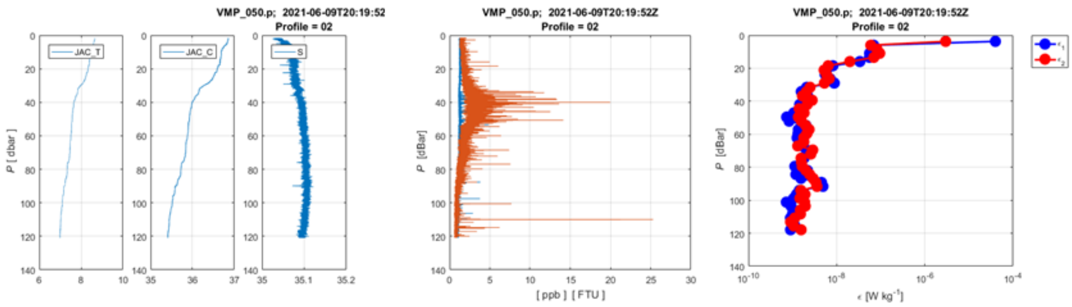


Figure 2 Profiles in the upper 120 m from the turbulence profiler. Measurements of Temperature (JAC_T), Conductivity (JAC_C) and salinity (S) from the CTD mounted on the turbulence profiler. The middle figure shows chlorophyll a (brown) and turbidity (blue) and the right figure shows estimates of the dissipation of turbulent kinetic energy based on the vertical velocity shear inferred from the two shear probes (red and blue, respectively. The two curves are almost similar and this shows a consistent turbulence estimate from the two independent shear probes).

Marine Sediment Coring

Objective and coring strategy

A key objective of the ROCS Center is to study paleo-ecology and paleo-oceanography in Icelandic waters on a range of time scales (decadal-millennial) going back to the Last Interglacial. This period is also known as the Eemian or marine oxygen isotope stage (MIS) 5. This requires the recovery of marine sediment cores that are either long enough to reach the Eemian stratigraphic horizon, or to locate positions with low Holocene and/or Weichselian (last glacial period) sedimentation rates were the Eemian is positioned at relatively shallow depths. For the ROCS cruise, we used the Aarhus University gravity corer conventionally used in a 6 m length configuration but with a possibility of extension to 9 m.

Prior to the survey, a study was made of where Eemian sediments had been recovered at previous core sites and the distribution of late Quaternary sediments (Fig. 4). Sedimentation rates in the Iceland Basin are generally enhanced due to sediment focusing by geostrophic boundary currents linked with AMOC, high bio-productivity and terrigenous input from Iceland. As a result, sediments have accumulated into thick, mounded depositional bodies known as contourite drifts (McCave & Tucholke, 1986; Knutz et al. 2002; Nielsen et al. 2008). The Bjørn Drift accumulates on the lower slope south of Vestmanna Islands and extends southwestward along the flank of the Reykjanes Ridge at 1600-2200 m depths (Bianchi & McCave, 2000). The Gardar Drift also traces the ridge flank but at slightly larger depths, e.g. down to 2500 meters. The Bjørn Drift is cored by sites SU9032 (Lacasse et al. 1996) and ODP 984 where the Eemian is recovered at approximate stratigraphic depths of 8-12 m and 17-20 m, respectively (Fig. 4). North of the Reykjanes Ridge sedimentation rates are more variable but generally lower and with more a patchy development of contourite drifts over an accentuated volcanic basement relief. The depth of the Eemian is therefore more uncertain. In core SU9029 on the lower slope WSW of Iceland it appears to be recovered at a stratigraphic level of 1-2 m (Lacasse et al. 1996) although the age model is uncertain as it lacks a C-14 based chronology.

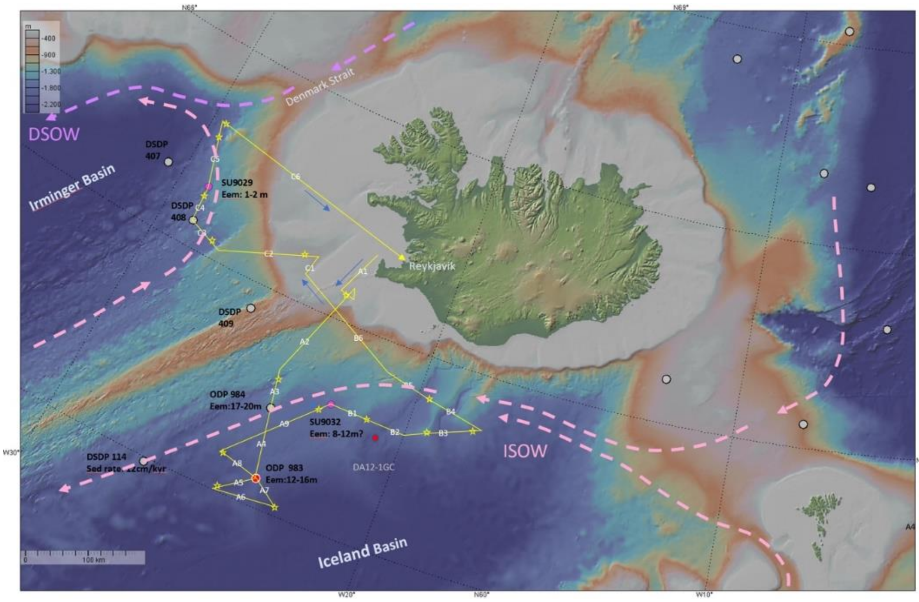


Fig. 4. Planned transects with line segments (A-C) guided by existing sites were Eemian sediments have been recovered. Potential coring locations marked by yellow stars. DSOW = Denmark Strait Overflow Water; ISOW = Iceland Scotland ridge Overflow Water.

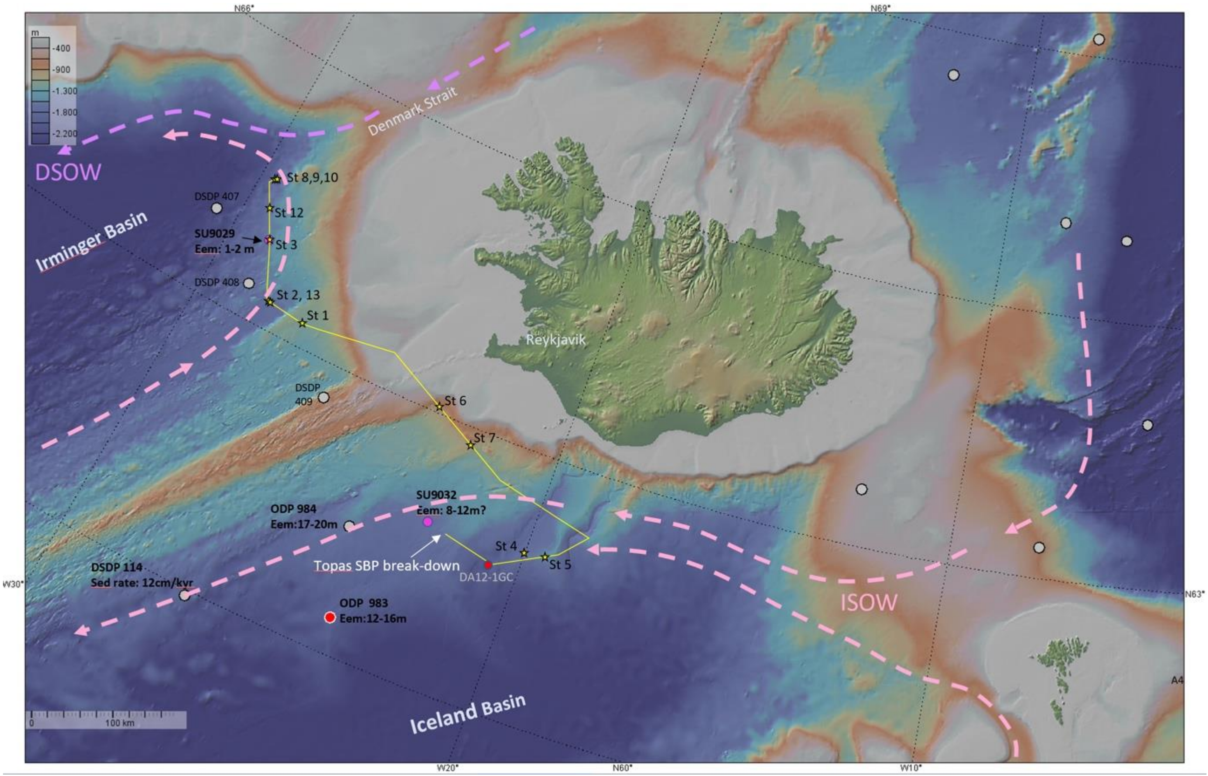
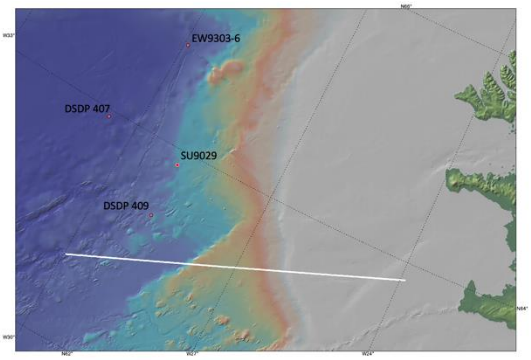
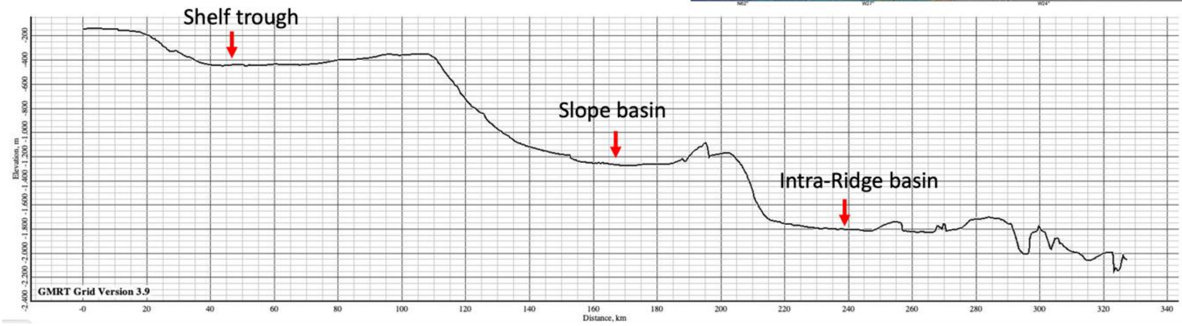


Fig. 5. Map showing the transects that we actually completed together with coring stations. Annotations as in Fig.4. The complete navigation is shown in Fig. 1.

WSW profile; topography flattening out at three levels

Core on each step:
Reykjavik to shelf trough margin: 4.5 hours
Transect to limit of third step: 12 hours (260 km)
3 cores: 9 hours
Total of 26 hours.





NW profile; crossing SU9029

From intra-ridge basin to Denmark Strait flank is 170 km
(8 hours @ 10 kn).

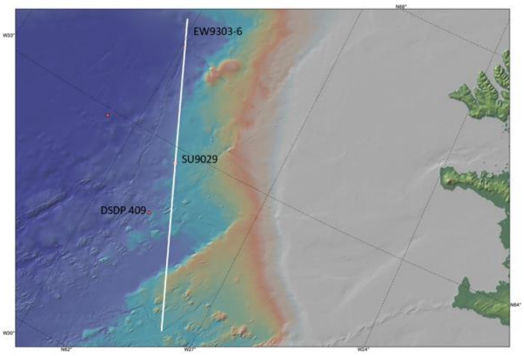


Fig. 6. Topographic profiles approximately following the Irminger Basin transect. Existing and potential coring sites for the ROCS cruise are indicated.

The coring strategy was to collect shallow seismic profiles using *Arni Fridriksson's* Topas sub-bottom profiler along transects north and south of the Reykjanes Ridge, staying mainly within depths of up to 2300 m, which is the limit of the winch cable. By crossing previous sites where the stratigraphic depths of the Eemian is known, allows us to identify and trace the Eemian horizon to positions of lower sedimentations, e.g. flanks of the sedimentary drifts were the seismic reflections converge, amenable to shallow coring. The original plan was to start transecting in the Icelandic Basin but the weather decided that we would start off heading southwestward into the Irminger Basin (Figs. 4-5). The difference between the planned and the final route was determined by cyclone patterns and sea state (Fig. 5), as well as failure on the Topas. The eastern transect crossing deep-sea channels and sedimentary drifts on the southern Iceland margin was completed but a combination of Topas break-down and bad weather meant that the southern transect, e.g. crossing ODP 983, was abandoned.

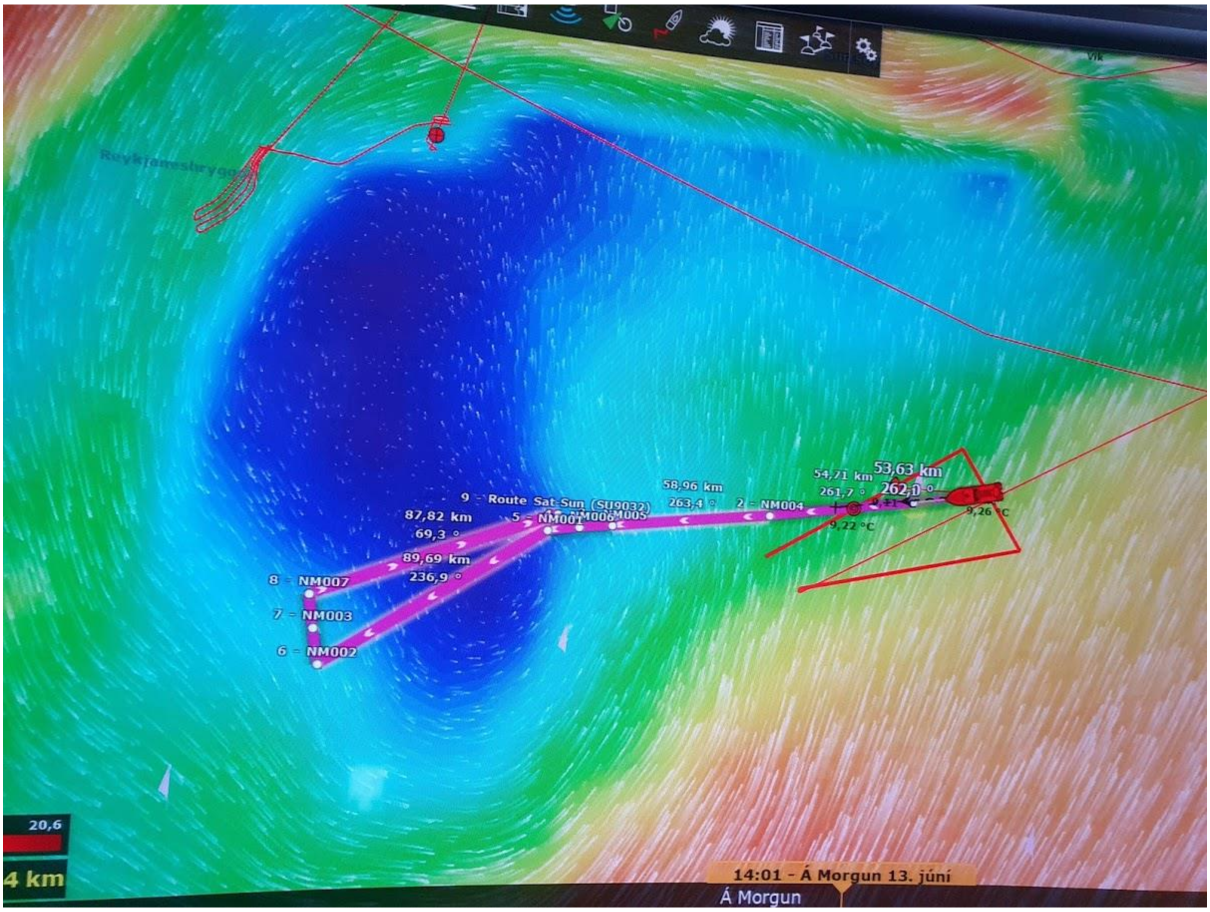


Fig. 6. Screen shot from display on bridge illustrating the weather situation south of Iceland during the first week of the cruise. Essentially, we would follow the transient cyclone centers where the sea state was more amenable for data collection.

Seafloor acoustic equipment

Sub-bottom profiler (SBP); Kongsberg Topas PS18

For seismic data collection, the Kongsberg Topas PS18 parametric sub-bottom profiler was used. It was set up with a low frequency modulated chirp pulse, and a primary frequency of 20 kHz and a secondary frequency of 6 kHz. Ping interval was set according to the water depth, but usually between 300 ms and 700 ms. The sample frequency was set to 96 kHz and the trace length is 200 ms for most traces. In some areas with highly variable bathymetry, the trace length was increased to 400 ms, to make sure we did not lose the seabed. the data is corrected for heave, pitch, and roll, during acquisition with input from motion sensors on the ship. The data was processed while collected, but both processed data (.segy) and raw data files (.raw) were generated. Vertical resolution can go down to 0.15 m depending on water depth and sediment properties. For best observation of the reflectivity response we set up the display using the red-yellow color scale.

The Topas provides a seismic stratigraphy of the geology below seabed, to a depth between 10 -100 meters depending on substrate hardness and character. Sites suitable for gravity coring will have a well-layered stratigraphy with a deep penetration of the acoustic signal (ping), indicating a package of soft, mud-prone sediments. Generally, sub-seabed horizons displaying a strong reflectivity, related to the amplitude of the reflected wavelet, should be avoided. Adjusting the processing gain and the colour scale (yellow-red) helped to identify compact layers. The first few days of the cruise was a learning exercise in how to optimize the settings and interpret the seismic response. Seismic images with coring positions indicated are show in Appendix A (Daily Reports).

<u>Multibeam swath bathymetry (MBES); Kongsberg EM302)</u>

Multibeam bathymetry has been collected for parts of the survey and was used to define the water depth while coring. Over most of the survey area, the swath width of the EM302 was set to 65 degrees, and settings were set for DEEP surveying. Ping rate was set to 5000 ms for the signal to return before the next ping at all water depths. The data is compensated for pitch roll and heave, using motion sensors on the ship. The system also collects backscatter data. All data is stored in .ALL files, that can be used for processing after the cruise. The MBES depth data was continuously corrected using water velocity information collected during the cruise. In areas where the multibeam system and the SBP system were operating simultaneously, triggering was controlled by a k-sync unit.

Navigation

At the onset of the cruise the Topas navigation was recorded in UTM coordinates since we thought this would work better when importing seismic data into Kingdom Suite interpretation software. However, since this meant that UTM zones 26/27 were crossed in the middle of segy files we reverted to record navigation in degrees and decimal minutes. In switching from UTM to lat-long a command was deleted in the acquisition setup so that during the first 1.5 days the Topas was recording incorrect navigation. As it turned out, the segy files with faulty navigation only affected Stations 8 and 9. Here we used the time stamps in the data files and comparison with the ship trackline for correct positioning.

Coring devices and operation

The gravity core consists of a core catcher, sections of interconnected metal barrels, a PVC liner (125 mm in diam), a metal plate that limits penetration and top mounted lead plates (850 kg) making up a total weight of about 1100 kg (Fig. 7). The system was mainly used in 6 m core barrel configuration except at two locations were a 9 m barrel was deployed. The core catcher prevents soft sediments from sliding out of the barrel after recovery. The gravity corer was deployed from the aft of the ship using both the ships crane and the A-frame. The corer was sent down at 1 m/s descent rate until about 50 m above the seabed. Once the ship had drifted into place above the target the corer would be lowered at a speed of 0.6 – 0.8 m/s. Once the sediment was hit, the winch was paused for 10-20 seconds before recovery. After recovery, the gravity corer was moved inboard using the trawler roller as a resting point. Once the corer was placed firmly in a vertical position on deck the core catcher was removed and the sediment placed into sample bags. Thereafter the liner was retrieved and cut into sections (1 m and 1.80 m), then capped and labelled. Operating the gravity corer successfully required a low to moderate sea state (generally wave heights of <2 m). Thirteen gravity cores were attempted with 9 of them recovering >5 m of sediments (Table 5).

On four occasions, a Rumohr-lot coring device was used consisting of 1 m PVC tube (80 mm in diam.) with weights and a small concentric metal frame on top. The purpose of this device was to obtain and undisturbed section of the seafloor. The Rumohr-lot was deployed from the hatch on starboard side using the CTD winch.

Fig. 7. Deployment of gravity corer using the A-frame and trawler roll as resting point (left). Corer lying vertically on deck after retrieval of the sediment filled core liners (right).

Coring station	lat	long	date	time	Core	WD (m)	Approx. Recovery	Sedimentary environment
ST1a	63' 19.91"	26' 52.02"	08.06.2021	13:21	GC	1250	<1m	Contourite drift
ST1b	63' 20.41"	26' 54.45"	08.06.2021	15:26	GC	1232	<1m	Contourite drift
ST2	63' 17.34"	28' 14.30"	08.06.2021	20:27	GC	1726	<1m	Contourite drift
ST3	63' 52.55"	28' 56.52"	09.06.2021	13:46	GC	1606	5-6 m	Contourite drift/Hemi-pelagic
ST4	61' 57.50"	20' 11.45"	12.06.2021	13:23	GC	1893	5-6 m	Muddy drift (thick Holocene)
ST5	61' 56.88"	19' 29.70"	12.06.2021	16:58	GC	1911	5-6 m	Contourite/channel bank
ST6	63' 08.03"	23' 17.73"	14.06.2021	10:15	GC	802	<1m	Channel levee
ST7	62' 43.49"	20' 56.76"	14.06.2021	18:49	GC	1170	5-6 m	Contourite/channel bank
ST8	64' 33.10"	29' 32.52	16.06.2021	13:41	GC	1908	5-6 m	Contourite drift/Hemi-pelagic
ST9	64' 34.62"	29' 30.31"	16.06.2021	16:49	GC	1835	5-6m	Contourite drift/Hemi-pelagic
ST10	64' 33.10"	29' 32.49"	17.06.2021	09:23	GC, 9 m barrel	1916	6-7 m	Contourite drift/Hemi-pelagic
ST10	64' 33.09"	29' 32.64"	17.06.2021	13:34	RL	1916	<1m	Contourite drift/Hemi-pelagic
ST12	64' 14.09"	29' 14.30"	17.06.2021	16:40	GC, 9 m barrel	1617	5-6m	Contourite drift/Hemi-pelagic
ST12	64' 14.17"	29' 14.34"	17.06.2021	21:14	RL	1617	<1m	Contourite drift/Hemi-pelagic
ST13	63' 15.02"	28' 15.24"	18.06.2021	12:25	GC	1731	5-6 m	Contourite drift
ST13	63' 15.12"	28' 15.25"	18.06.2021	14:25	RL	1734	<1m	Contourite drift
ST13	63' 15.08"	28' 15.31"	18.06.2021	15:15	RL	1731	<1m	Contourite drift

Table 5. Coring data from the ROCS 2021 cruise with Arni Fridriksson. Note ST 11 is missing. Positions of ST8 and ST10 are largely identical and thus presumably recording the same stratigraphy.

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