CRUISE REPORT

SciencePub – WARMPAST Cruise 2008

Marine geological cruise to
West Svalbard Margin – Fram Strait

RV "Jan Mayen" August 9 - 16 2008

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Introduction

This cruise was carried out within two IPY (International Polar Year) projects: 1) Arctic Natural Climate and Environmental Changes and Human Adaptation: From Science to Public awareness (SciencePub IPY-39) funded by the Research Council of Norway and the University of Tromsø, Norway, and 2) "Arctic Ocean warming in the Past" (WARMPAST IPY-786). Both projects are part of "Arctic Paleoclimate and its Extreme" (APEX) which is a network research program endorsed by the International Arctic Science Committee (IASC). In addition, a third project, "Assessment of benthic foraminifera as environmental proxy in the Arctic region**"** (ForArc)**,** was part of the cruise. This international project is funded by the Norwegian Research Council, University of Tromsø, Norwegian Polar Institute, and the American National Science Foundation.

The overall aim of the IPY projects is to advance our knowledge of climate warming in the Arctic, by studying past climate change. The present climate in the Arctic shows signs of rapid change with decreasing sea ice cover and increasing temperature of the Atlantic Water. The implications of this warming are highly uncertain, as modeling experiments projecting temperatures for the next 100 years show a large scatter at high northern latitudes. Therefore it is crucial to obtain long records of the climate changes in the past to assess the natural limits of Arctic climate. In order to obtain data on temperature, salinity etc in the water masses from the past when it was not possible to get instrumental measurements of these factors; we study fossil micro-flora and micro-fauna in the sediments in addition to their chemical composition. Their composition and abundance depend on climatic factors like temperature and salinity of the sea water, thus showing how the marine environment and water masses were back in time (palaeoclimatic proxy data). Another aim of SciencePub and WARMPAST is to improve the proxies of ocean temperature and sea-ice by achieving high quality modern analogue data and develop new paleoclimatic proxies. This links directly to the ForArc which main aim is to improve benthic foraminifera as proxies by quantifying their response to environmental forcing in the Arctic.

The main objective of this cruise was to collect high quality modern analogue data on planktonic and benthic foraminifera, coccoliths, diatoms, dinocysts, foraminiferal Mg/Ca-ratios, stable oxygen isotopes, stable carbon isotopes, and the phytoplankton marker IP_{25}. Undisturbed sediment samples was taken by multi corer and CTD measurements were obtained along two transects from the West Spitsbergen Margin across the eastern Fram Strait along the 78° and 76° N latitude in order to cover the widest possible oceanographic range in the eastern part of the polar North Atlantic. Water samples were also obtained and will be analyzed with regard to stable isotopes ($\delta^{18}O$ and $\delta^{13}C$). During the cruise measurements of oxygen and pH in the upper sediment layers were carried out immediately after sampling. The secondary objective was to collect high resolution Holocene sediment cores at the West Spitsbergen Margin.

Scientific background and objectives

The last glacial - interglacial period in the Polar North Atlantic region was characterized by high amplitude, millennial scale variations in climate and water masses (Bauch *et al*. 2001; Hald *et al*. 2001; Rasmussen & Thomsen 2004; Spielhagen *et al*. 2004). This variation had a large impact on the growth and decay of the Svalbard Barents and northern

Fennoscandian ice sheets (Knies *et al*. 1999; Spielhagen *et al*. 2004). Glacial build-up phases and subsequent deglaciations were associated to influx of "warm" Atlantic Water during e.g. the last glacial maximum and during marine isotope stage, MIS 4. These periods were followed by oceanic cold extremes associated with meltwater, perennial sea-ice cover and inert oceanic circulation (Hald *et al*. 2001; Knies *et al*. 2003). Thus, we aim to quantify sea surface temperatures and salinity during well known glacial - deglacial sequences during MIS 4 and, MIS 2/1 in high-resolution sediment cores from the continental slope off western and northern Svalbard.

We also aim to test climate model predictions that the Arctic warming may be higher than the global mean, and the Arctic sea ice will almost disappear during summer in the end of this century (IPCC 2007). Further, modeling experiments also predict an inverse relationship between influx of Atlantic Water through the North Cape Current (NCC) and the West Spitsbergen Current (WSC) (Laurantin 2004). This influx is linked to large-scale atmospheric circulation (North Atlantic Oscillation and Arctic Oscillation), which has implications for sea-ice distribution, ocean temperatures and precipitation and thus glaciation in the Barents region. These predictions will be tested in paleoclimate-records reflecting the WSC and NC during the late glacial-Holocene.

In order to investigate natural rapid ocean changes on longer time scales it is crucial to obtain reliable quantitative proxy data. Earlier reconstructions of sea surface temperatures (SST) below 5°C are hampered by incomplete training sets, sample quality and unsuitable sample preparation techniques (e.g. Pflaumann *et al.* 2006). We aim to improve modern analogue data on planktonic and benthic foraminifera, coccoliths, diatoms, dinocysts, foraminiferal Mg/Ca-ratios and oxygen and carbon isotopes. Undisturbed sediment samples will be taken by multi corer and CTD measurements in the polar North Atlantic covering the widest possible oceanographic range in the area. The goal is to extend the marine polar data set to include more sites from Arctic seas to improve the transfer functions, to increase the range of environmental variables (e.g. salinity, seasonality, sea-ice cover) in the transfer functions.

Cruise narrative

Saturday (August 9): The participants (Appendix I) embarked at Kull Kaia, Longyearbyen in the morning. The participants were introduced to the ship and safety routines. A life boat exercise was carried out. Departure for the first station at the West Spitsbergen Slope was at 13:00. The first station was reached in the evening, the chirp profile revealed a very thin sediment package, so coring was abandoned. The next station was suitable for coring and multicoring and CTD casts were carried out (Figures 1-2, Appendices II-V). The multicorer went down twice and 11 cores were retrieved. The cores were sub sampled for the different proxies, before the next station was reached early in the morning. This station was also sampled twice with the multicorer, and CTD measurements were performed. Water samples from the bottom water in the multicores were taken for analyses of $\delta^{18}O$. Measurements of oxygen and the pH value in the sediment and pore-water respectively were also immediately performed on two cores.

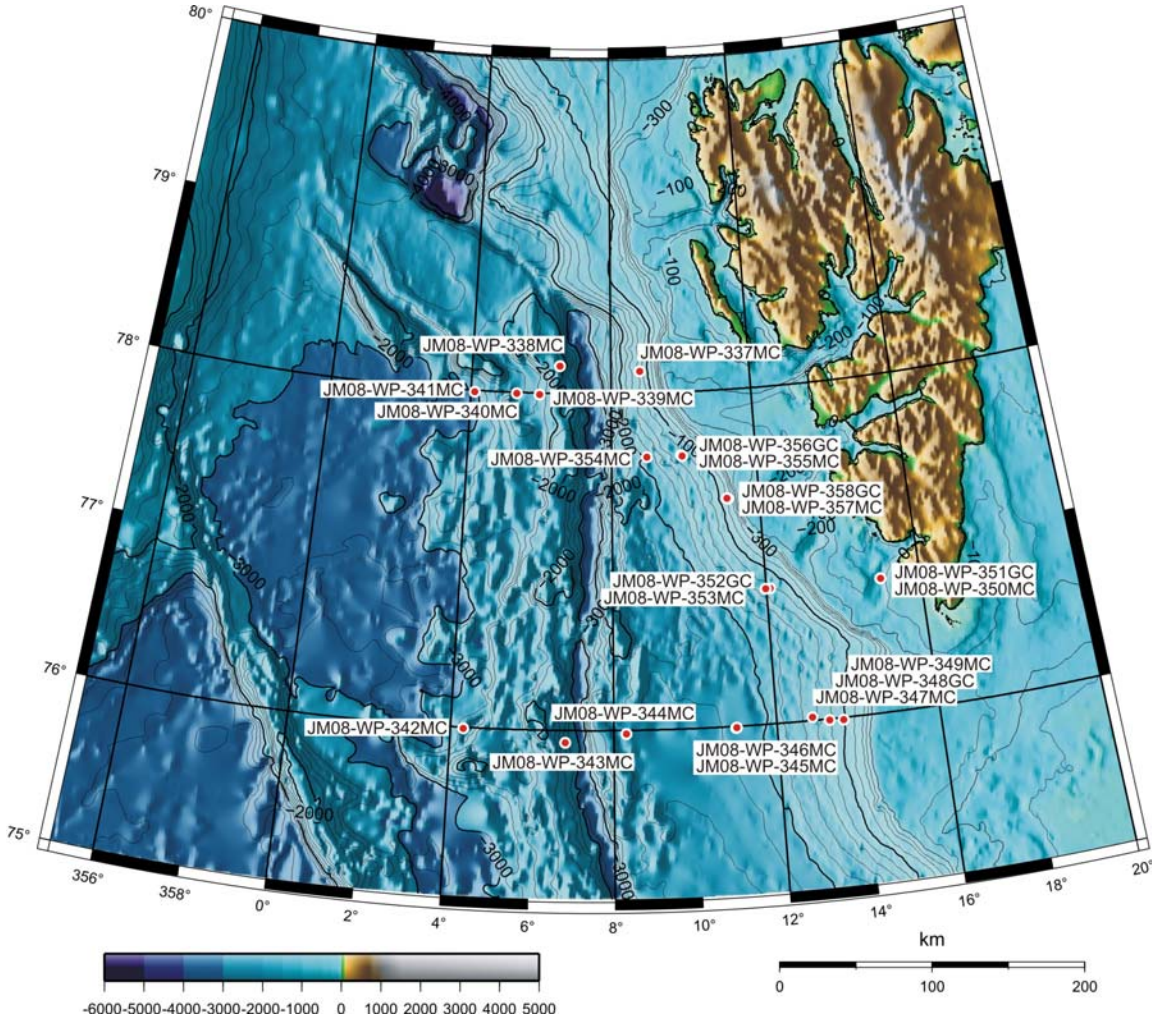

Figure 1. Bathymetric map showing the positions of sampling stations (multi cores and gravity cores) taken during the cruise. Please also refer to Appendix IV.

Sunday (August 10): A station was sampled in the morning and consequently sub sampled. Measurements of oxygen and the pH value in the sediment and pore-water were immediately performed on two cores. A CTD profile was obtained. A new station was sampled in the afternoon. The first attempt was semi-successful with 2 cores. Two new attempts were done without success. Several factors can have influenced the sampling: great depth (hard to identify touchdown), a gravel layer was ca 20 cm down in the sediments, and the "arms" of the shovels were not flexible enough. They had to be loosened.

Monday (August 11): The westernmost station of the 78° N transect was reached 01:00 and sampled. The course was then set for the 76° N transect beginning at 4° E. Sub-bottom profiling was begun during the afternoon, and the first station of the 76° N transect was sampled in the afternoon. All multicores were sub sampled immediately after retrieval for

the different proxies. Measurements of oxygen and the pH value in the sediment and pore-water respectively were also immediately performed on two cores.

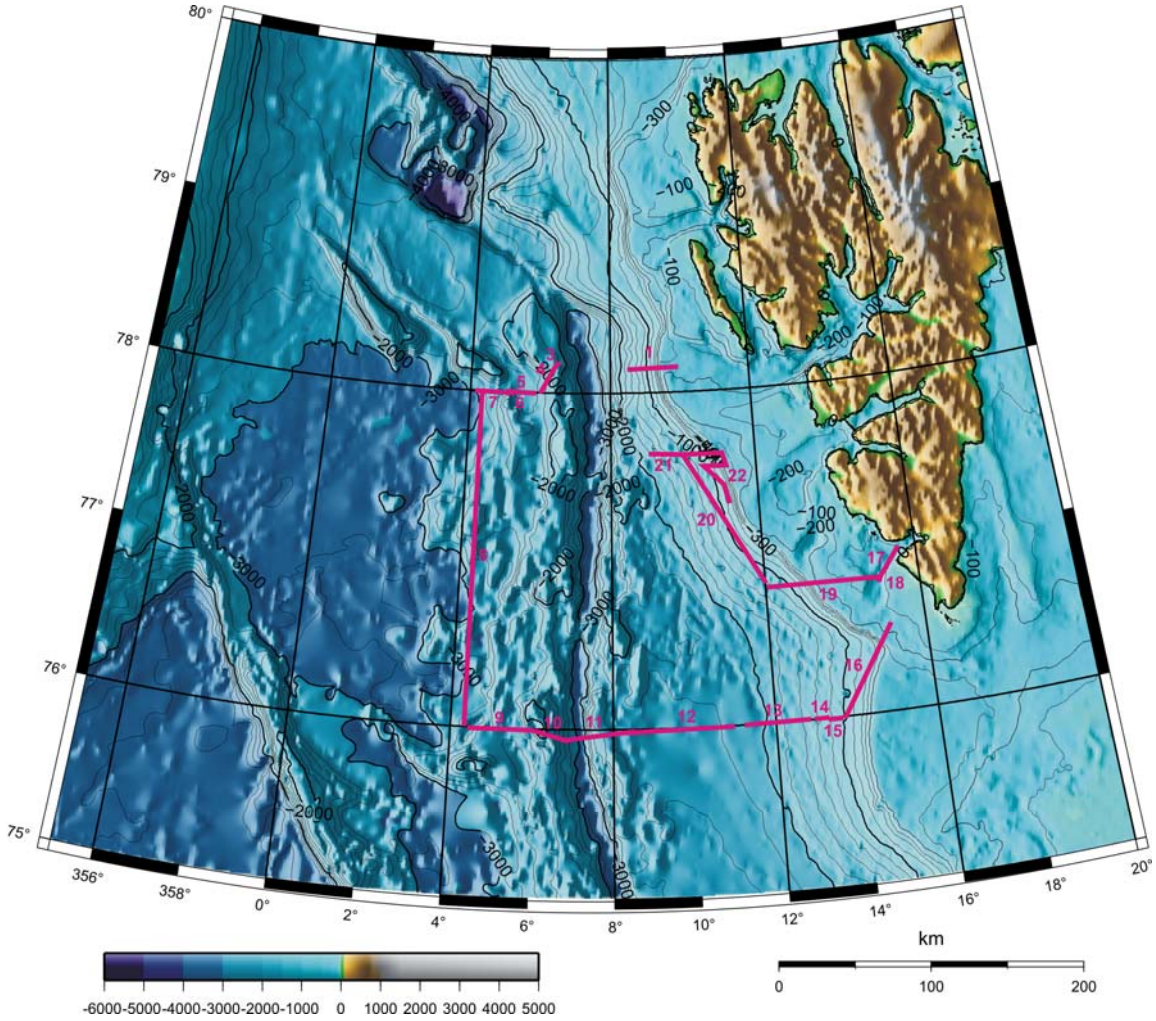

Figure 2. Bathymetric map showing the sub-bottom profiles which was obtained during the cruise. Please also refer to Appendix V.

Tuesday (August 12): Sub-bottom profiling was continued, and it hard to find a good coring site across the Knipovich Ridge. A good site was identified after midnight and sampled. The next station identified just east of the Knipovich Ridge and sampled in the morning. Two stations were sampled along 76 N in the Fram Strait, before the Storfjord Through was reached. In the Storfjord Trough 3 sites were identified at ca. 1500, 1250 and 1000 m water depth. These sites should be suitable for oxygen and pH measurements as they represent mid-range values of organic flux. The multicores were sub sampled immediately after retrieval, and two cores were used for oxygen and pH were measurements in the sediment and pore water.

Wednesday (August 13): Early in the morning the weather deteriorated to strong gale/storm. The weather forecast was 24 hours of strong gale. It was not possible to do any coring during these conditions and sub-bottom profiling only gave bad data in this weather. It was then decided to shelter in Hornsund fjord for the day.

Thursday (August14): The weather improved and sub-bottom profiling began in the morning from the mouth of the fjord. A site for gravity coring was identified and sampled with both multi- and gravity corer in the Hornsund Deep. The sub-bottom profiling was then continued towards the west crossing the shelf and continuing to the slope. A good site was identified in the afternoon and sampled with both gravity and multi corer. The course was towards the north, east of the site of MD99-2304. Sub-bottom profiling was carried out during the transport.

Friday (August 15): The station was reached early in the morning and sampled with the multicorer, and a new station was sampled later in the morning. In addition, a gravity corer was obtained here. Afterwards sub-bottom profiling was continued searching for a sampling site at 800 m water depth. A good site was not identified until the afternoon, where multicoring was carried out. The course was set for Bredjupet surveying for a Holocene high resolution site. Sub-bottom profiling was carried out on way to Bredjupet, and continued in Bredjupet in the evening. During the transect equipment and samples were packed, and the cleaning of the wet lab begun.

Saturday (August 16): The sub-bottom profiling in Bredjupet ended at 02:00, when the ship had to start sailing back to Longyearbyen. A promising site had already been identified. In the morning the dry labs were cleaned. The ship arrived in Longyearbyen 11:30.

Methods

The positions of the sediment cores were identified with sub-bottom profiler (chirp 3 - 5 kHz) (Appendix II). The surface samples were sampled with multi corer (6 core liners, outer diameter 110mm, length 0.8m). CTD measurements were obtained in order to measure salinity, temperature, conductivity and turbidity through the water column. CTD measurements are carried out with a Seabird 911 CTD with an attached turbidimeter (Appendix II).

Sub sampling of multi corer

The multi corer automatically gives 6 cores, and at most stations two casts were done in order to achieve enough material. Subsampling of the multicores was carried out immediately so compaction of the unconsolidated surface sediments was avoided. The sediment samples were stored at 5° C. The foraminiferal samples were additionally preserved with ethanol and Rosa Bengal stain. Measurements of oxygen and pH values in the sediment column and within the pore water were also carried out. The reference samples from the multi cores are kept frozen at the Department of Geology, University of Tromsø.

Subsampling of gravity corer and piston corer

The cores were cut into shorter pieces of 1 m, capped, labeled and transported back to Tromsø. The cores are stored at 5° C at the Kræmer Kaia cool storage (University of Tromsø).

Preliminary results

A total of 17 stations were sampled for surface sediments with the multi corer, and 4 of these stations were also sampled successfully with the gravity corer (Figure 1, Appendix IV). CTD measurements were performed at all stations. The bottom water above the sediment in the cores was also sampled for $\delta^{18}O$ analyses at all stations (Appendix IV B). Additional water sampling for $\delta^{13}C$ analyses from different depths at in the water column were done at 7 stations (Appendix IV B). At 12 stations oxygen and pH measurements were carried out within the upper sediment column. The oxygen and pH value of the pore water was measured as well on 7 of these stations (Appendix IV B). Sub-bottom profiling (2 - 12 kHz) was done at every station and supplementary survey was carried out in selected areas (Figure 2). The 17 stations supplemented the previous WARMPAST and SciencePub cruises that were carried out in 2006 and 2007 (Figure 3).

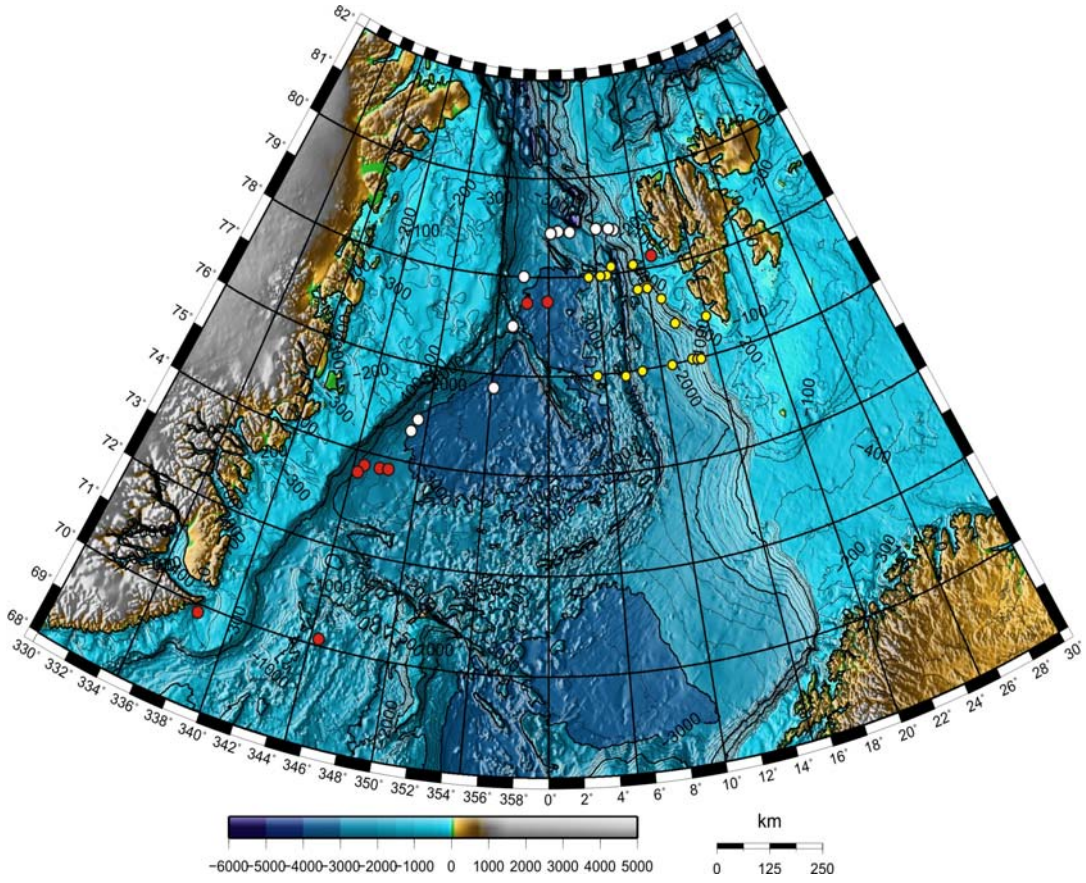

Figure 3. All WARMPAST stations sampled from 2006 to 2008. The different filled circles represent different years: white (2006), red (2007), and yellow (2008).

Future work
The gravity cores are stored at the University of Tromsø (Fløya Cool storage facility). They will be logged with the Multi Sensor core logger at the Department of Geology, University of Tromsø during the winter 2008/2009.

The samples from the multi sediment cores will be prepared and analysed during 2008 – 2009 by the different research groups (Table 1).

Analysis	**PI**	**Affiliation**
Coccoliths	J. Giraudeau	Université Bordeaux, France
Diatoms	A. Miettinen/ N. Koc	Norwegian Polar Institute, Norway
Dinocysts/ ^{210}Pb dating	A. de Vernal/ S. Bonnet	Université du Québec a Montreal, Canada
Foraminifera (benthic)	D. Klitgaard Kristensen	Norwegian Polar Institute, Norway
Foraminifera (planktonic)	K. Husum/ M. Hald	University of Tromsø, Norway
Foraminiferal oxygen and carbon isotopes	R. Spielhagen/ K. Werner	Leibniz Institute of Marine Sciences Kiel, Germany
Foraminiferal Mg/Ca	T. Marchitto	Instaar, USA
Radiogenic isotopes (Lead and neodymium)	C. Hillaire-Marcel/ J. Maccali	University of Nancy, France/Université du Québec à Montréal, Canada
Phytoplankton biomarker IP_{25}	G. Masse	University of Plymouth, UK

Table 1. Overview of proxies and research groups within WARMPAST.

References

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APPENDICES

I. Participants
II. Equipment
III. Ship log
IV. Sample log
V. Acoustic line log

APPENDIX I
Participants

In addition to the crew of RV "Jan Mayen" led by Captain Hans Hansen, the participants were:

University of Tromsø, Norway

1. Steffen Aagaard Sørensen
2. Franceline De Oliveira Ramalho
3. Steinar Iversen (engineer)
4. Katrine Husum (PI)
5. Juho Junttila
6. Kari Skirbekk
7. Kasia Zamelczyk

Norwegian Polar Institute, Norway

8. Patrycja Jernas

Université du Québec à Montréal, Canada

9. Sophie Bonnet

University of Nancy, France/Université du Québec à Montréal, Canada

10. Jenny Maccali

Northern Illinois University, USA

11. Brittani Duhamel
12. Paul Loubere (PI)
13. Jianwen (Jay) Zhu

California State University, USA

14. Mathieu Richaud

Leibniz Institute of Marine Sciences Kiel (IFM-GEOMAR), Germany

15. Kirstin Werner

Université Bordeaux, France

16. Jacques Giraudeau (PI)

University of Plymouth, UK

17. Guillaume Masse (PI)

Oslo University College, Faculty of Journalism, Library and Information Science

18. Guro Løseth
19. Martin Wright

APPENDIX I (cont.)
Participants

Shift A (08-14, 20-02):
Katrine Husum*
Steinar Iversen
Juho Junttila
Jenny Maccali
Guillaume Masse
Kari Skirbekk
Kirstin Werner

Shift B (02-08, 14-20):
Steffen Aagaard-Sørensen
Sophie Bonnet
Franceline De Oliveira Ramalho
Jacques Giraudeau*
Patrycja Jernas
Katarzyna Zamelczyk

Ad hoc:
Brittani Duhamel
Poul Loubere
Mathieu Richaud
Jianwen Zhu

APPENDIX II
Equipment

Acoustic equipment

- Edgetech Chirp (full range 1.5 - 12 kHz) sub-bottom profiler with XSTAR software. Store formats: CD-rom
- EPC 2086 plotter, 2 channel
- Echo sounder, Simrad EK 500, 38 kHz

Coring equipment

- Multi-corer, KC model 72.000 (6 liners, outer diameter 110 mm, length 0.8m)
- Gravity corer (core length max 6 m, outer diameter of liners 110 mm)

Water properties

- Seabird 911 Plus CTD with compact rosette. Turbidimeter attached to CTD (gain: 1x, 5x, 20x, 100x, light source wavelength: 880nm, sensing distance from window: < 5cm approx.). Store formats: CD.

APPENDIX III Ship log

Date	Time	Subject	Weather	Area
9/8	10:00	The participants arrived.	calm, overcast	Longyearbyen (Kullkaia)
9/8	11:00	Introduction and orientation	calm, overcast	Longyearbyen (Kullkaia)
9/8	11:45	Safety instructions and demonstation of emergency exits and survival suits on RV "Jan Mayen"	calm, overcast	Longyearbyen (Kullkaia)
9/8	13:00	Departure heading for station at West Spitsbergen Slope	calm, overcast	Longyearbyen (Kullkaia)
9/8	23:30	CTD measurements with water sampling. Multicore sampling (2 casts).	calm, overcast	West Spitsbergen Slope
10/8	04:55	CTD measurements with water sampling. Multicore sampling (2 casts).	some swells, overcast	West Spitsbergen Slope
10/8	08:30	Multicore sampling (2 casts).CTD measurements with water sampling.	calm, overcast	Fram Strait
10/8	15:35	Multicore sampling (3 casts).CTD measurements with water sampling.	calm, overcast	Fram Strait
11/8	01:00	Multicore sampling (1 cast).CTD measurements with water sampling.	calm, overcast	Fram Strait
11/8	17:00	Multicore sampling (1 cast).CTD measurements with water sampling.	calm, overcast	Fram Strait
11/8	1:00	Multicore sampling (1 cast).CTD measurements with water sampling.	calm, overcast	Fram Strait
12/8	7:00	Multicore sampling (1 cast).CTD measurements with water sampling.	calm, overcast	Fram Strait
12/8	13:30	Multicore sampling (1 cast) and gravity coring.CTD measurements with water sampling.	calm, overcast	Fram Strait
12/8	13:30	Multicore sampling (1 cast).CTD measurements with water sampling.	calm, overcast	Fram Strait
12/8	19:30	Multicore sampling (2 casts).CTD measurements with water sampling.	some winds, overcast/rain	Storfjord Through
12/8	22:30	Multicore sampling (1 cast).CTD measurements with water sampling.	some winds, overcast	Storfjord Through
13/8	1:00	Multicore sampling (1 cast).CTD measurements with water sampling.	some winds, sun	Storfjord Through
13/8	02:00	Sub-bottom profiling for next station at 76 N, 15 E	some winds, sun	Storfjord Through

Date	Time	Subject	Weather	Area
13/8	03:00	Sub-bottom profiling towards the Hornsund fjord	some - high winds	Storfjord Through - SW Spitsbergen Slope
13/8	08:00	The course was set for shelter in Hornsund fjord.	Strong gale	SW Spitsbergen Margin
13/8	10:00	Arrival in Hornsund Fjord	Strong gale outside fjord, some winds in the fjord	Hornsund Fjord
14/8	08:00	Starting sub-bottom profiling	calm with some swells, overcast	Hornsund Deep
14/8	10:30	Multicore sampling (1 cast) and gravity coring.CTD measurements with water sampling.	calm with some swells, overcast	Hornsund Deep
14/8	14:00	Sub-bottom profiling westward to the slope.	calm with some swells, overcast	SW Spitsbergen Slope
14/8	16:00	Multicore sampling (2 casts) and gravity coring.CTD measurements with water sampling.	calm with some swells, overcast	SW Spitsbergen Slope
14/8	20:00	Sub-bottom profiling towards the next station at 77 N, 9 E	calm, sunny	SW Spitsbergen Slope
15/8	03:00	Multicore sampling (1 cast).CTD measurements with water sampling.	calm, sunny	West Spitsbergen Slope
15/8	07:00	Multicore sampling (1 cast) and gravity coring.CTD measurements with water sampling.	calm, overcast	West Spitsbergen Slope
15/8	11:00	Sub-bottom profiling towards south-east at 800 m water depth, looking for a MC site.	calm, overcast	West Spitsbergen Slope
15/8	16:00	Multicore sampling (3 casts) and gravity coring. CTD measurements with water sampling.	calm, overcast	West Spitsbergen Slope
15/8	18:00	Sub-bottom profiling steaming towards Bredjupet.	calm, overcast	West Spitsbergen Slope
15/8	20:00	Packing samples and equipment. Cleaning the wet lab	calm, overcast	West Spitsbergen Slope
15/8	22:00	Sub-bottom profiling Bredjupet.	calm, overcast	West Spitsbergen Slope
16/8	02:00	Sub-bottom survey stopped, and the course was set for Longyearbyen.	calm, overcast	West Spitsbergen Slope
16/8	08:00	Cleaning the dry lab and seismics room	calm, overcast	West Spitsbergen Slope
8/8	11:30	Arrival Longyearbyen	calm, overcast	Isfjorden

Appendix IVA Sample log

Station Number	Date	Time GMT +2	Latitude	Longitude	Water depth (m)	Core Recovery (cm)	Core length (cm)	No of core sections/ multitubes	Area
JM08 - WP - 337 - MC	9/8	22:30	78 08.130 N	008 30.411 E	1733		59 - 65	11	West Spitsbergen Slope
JM08 - WP - 338 - MC	10/8	7:00	78 10.029 N	006 32.731 E	1766		26 - 33	4	West Spitsbergen Slope
JM08 - WP - 339 - MC	10/8	10:30	77 59.731 N	005 58.354 E	2343		44 - 53	6	Fram Strait
JM08 - WP - 340 - MC	10/8	15:35	77 59.888 N	005 19.770 E	2633		5 - 60	2	Fram Strait
JM08 - WP - 341 - MC	11/8	1:00	77 59.720 N	004 07.442 E	2952		58 - 65	5	Fram Strait
JM08 - WP - 342 - MC	11/8	17:00	75 59.752 N	004 19.589 E	3037		40 - 60	6	Fram Strait
JM08 - WP - 343 - MC	12/8	1:00	75 55.882 N	006 49.639 E	2618		30 - 37	5	Fram Strait
JM08 - WP - 344 - MC	12/8	7:00	75 58.938 N	008 19.384 E	2288		49 - 53	6	Fram Strait
JM08 - WP - 345 - MC	12/8	13:30	75 59.682 N	011 00.103 E	2184		43-50	6	Fram Strait
JM08 - WP - 346 - GC	12/8	13:30	75 59.811 N	011 01.564 E	2178	600	0	0	Fram Strait
JM08 - WP - 347 - MC	12/8	19:30	76 00.141 N	012 53.475 E	1500		64-70	5	Storfjord Through
JM08 - WP - 348 - MC	12/8	22:30	75 59.737 N	013 17.892 E	1264		62-73	6	Storfjord Through
JM08 - WP - 349 - MC	13/8	1:00	75 59.360 N	013 38.690 E	1026		43-45	5	Storfjord Through
JM08 - WP - 350 - MC	14/8	10:30	76 47.888 N	014 58.809 E	245		42-45	9	Hornsund Deep
JM08 - WP - 351 - GC	14/8	11:30	76 47.793 N	014 59.228 E	249	>600	438	5	Hornsund Deep
JM08 - WP - 352 - GC	14/8	16:00	76 48.534 N	012 00.616 E	1303	600	460	5	SW Spitsbergen Slope
JM08 - WP - 353 - MC	14/8	17:00	76 48.384 N	011 59.627 E	1315		50-57	12	SW Spitsbergen Slope
JM08 - WP - 354 - MC	15/8	03:00	77 37.324 N	008 59.337 E	1926		55-60	6	SW Spitsbergen Slope
JM08 - WP - 355 - MC	15/8	7:00	77 37.626 N	009 56.129 E	1316		52-54	10	West Spitsbergen Slope
JM08 - WP - 356 - GC	15/8	9:30	77 37.315 N	009 57.907 E	1316	>600	486	5	West Spitsbergen Slope
JM08 - WP - 357 - MC	15/8	16:00	77 21.194 N	011 09.928 E	761		48-59	11	West Spitsbergen Slope
JM08 - WP - 358 - GC	15/8	17:00	77 21.372 N	011 08.190 E	792	>600	420	4	West Spitsbergen Slope

Appendix IV B Sample log

Station Number	Comments	Sub-samples
JM08 - WP - 337 - MC	First attempt failed. The penetration was 5-10 cm. Second and third attempt succesful with 5 and 6 cores respectively. CTD station # 332 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC B: porewater. MC C: frozen. MC D: 0-1 cm diatoms. MC E: 0-1 forams. MC F: 0-1 cm isotopes. MC G: 0-1 cm Mg/Ca. MC H: 0-1 cm coccos and IP25. MC I: 0-1 cm dinocyst. MC J: 0-61 cm (every cm) dinoflagellates and Pb. MC K: 0-61 cm (every cm) reference. Water samples for delta 18O analysis from bottom water in MC: 4.
JM08 - WP - 338 - MC	First attempt succesful with 4 cores. Second attempt failed. CTD station # 333 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC C: 0-1 forams + 1-33 cm as reference (every cm). MC D: 0-1 cm diatoms (1/2 sample) + isotopes (1/2 sample). MC E: 0 - 25.5 cm (every cm) coccos and IP25 (1/2 sample) + dinoflagellates and Pb (1/2 sample). NB no MC B.Water samples for delta 18O analysis from bottom water in MC: 2. Rocks sampled from 20-21 cm in MC C.
JM08 - WP - 339 - MC	First and second attempt succesful with 4 and 2 cores respectively.CTD station # 334 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC B: porewater. MC C: 0-53 cm (every cm) dinoflagellates and Pb. MC D: 0-1 cm forams (1/2 sample) + isotopes (1/2 sample) + 1-44 cm (every cm) as reference. MC E: 0-1 diatoms (1/2 sample) + Mg/Ca (1/2 sample). MC F: 0-1 cm coccos and IP25. Water sample for delta 18O analysis from bottom water in MC: 2. Dropstones collected from 0-2 cm in this MC F.
JM08 - WP - 340 - MC	First attempt failed, but the multicorer was released. Second attempt relatively succesful with 2 cores. Third attempt failed. CTD station # 335 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC B: 0-1 forams. Water samples for delta 18O analysis from bottom water in MC: 1.

Station Number	Comments	Sub-samples
JM08 - WP - 341 - MC	First attempt succesful with 5 cores, no further sampling. CTD station # 336 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC B: porewater. MC C:0 - 62 cm (every cm) coccos and IP25 (1/2 sample) + dinoflagellates and Pb (1/2 sample). MC D: 0-1 cm diatoms (1/2 sample) + isotopes (1/2 sample). MC E: 0-1 forams + 1-58 cm as reference (every cm). Water samples for delta 18O analysis from bottom water in MC: 4.
JM08 - WP - 342 - MC	First attempt succesful with 6 cores, no further sampling. CTD station # 337 is this station. Water samples from the bottom for Poul Loubere.	MC A: 0-1 forams + 1-60 cm as reference (every cm). MC B: 0-57 cm (every cm) dinoflagellates and Pb. MC C:0 -1 cm coccos and IP25 (frozen). MC D: 0-1 cm diatoms (1/2 sample) + Mg/Ca (1/2 sample). MC E: 0-1 cm isotopes. MC F: oxygen and pH. Water samples for delta 18O analysis from bottom water in MC: 2.
JM08 - WP - 343 - MC	First attempt succesful with 5 cores, no further sampling. CTD station # 338 is this station. Water samples from the bottom for Poul Loubere.	MC A: 0-1 cm diatoms (1/2 sample) + Mg/Ca (1/2 sample). MC B: 0-1 forams (1/2 sample) + isotopes (1/2 sample) + 1-37 cm as reference (every cm). MC C:0 - 1 cm coccos and IP25. MC D: 0-30 cm (every cm) dinoflagellates and Pb. MC E: oxygen and pH. Water samples for delta 18O analysis from bottom water in MC: 2.
JM08 - WP - 344 - MC	First attempt succesful with 6 cores, no further sampling. CTD station # 339 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC B: 0-1 forams + 1-53 cm as reference (every cm). MC C:0 -1 cm coccos and IP25 (frozen). MC D: 0-1 cm isotopes. MC E: 0-49 cm (every cm) dinoflagellates and Pb. MC F: 0-1 cm diatoms (1/2 sample) + Mg/Ca (1/2 sample). Water samples for delta 18O analysis from bottom water in MC: 2. Large rock (5x3x3 cm) sampled from MC E 29 - 34 cm depth.
JM08 - WP - 345 - MC	First attempt succesful with 6 cores, no further sampling. CTD station # 340 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis.	MC A: 0-1 cm diatoms (1/2 sample) + isotopes (1/2 sample) + 0-45 (every 5 cm) for IP25. MC B: 0-1 forams. MC C: 0-43 cm (every cm) dinoflagellates and Pb. MC D: Coccos and IP25 (frozen). MC E: reference (frozen). MC F: reference (frozen). Water samples for delta 18O analysis from bottom water in MC: 2.

Station Number	Comments	Sub-samples
JM08 - WP - 346 - GC	Core had fully penetrated but was empty. There was a large lump of mud on the core barrel. It may have been down on the side. NB same site as JM08 – WP – 345 – MC.	
JM08 - WP - 347 - MC	First attempt failed, but 1 shovel was released. Second attempt relatively succesful with 5 cores. CTD station # 341 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis.	MC A: oxygen and pH. MC B: porewater. MC C:0 - 54 cm (every cm) coccos and IP25 (1/2 sample) + dinoflagellates and Pb (1/2 sample). MC D: 0-1 cm diatoms (1/2 sample) + isotopes (1/2 sample). MC E: 0-1 forams + isotopes (1/2 sample each) + 1-66 cm as reference (every cm). Water samples for delta 18O analysis and delta 13C from bottom water in MC: 2.
JM08 - WP - 348 - MC	First attempt succesful with 6 cores, no further sampling. CTD station # 342 is this station. Water samples from the bottom for Poul Loubere.	MC A: oxygen and pH. MC B: porewater. MC C: reference (frozen). MC D: 0-1 cm diatoms (1/2 sample) + Mg/Ca (1/2 sample). MC E: 0-1 cm coccos and IP25. MC F: 0-1 forams + isotopes (1/2 sample each) Water samples for delta 18O analysis and delta 13C from bottom water in MC (1 each).
JM08 - WP - 349 - MC	First attempt succesful with 6 cores, no further sampling. CTD station # 343 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis.	MC A: oxygen and pH. MC B: porewater. MC C: 0-1 cm diatoms (1/2 sample) + Mg/Ca (1/2 sample). MC D: 0-1 forams + isotopes (1/2 sample each) + 1 - 45 cm as refereance. MC E: 0 - 43 cm coccos and IP25 + dinoflagellates and Pb (1/2 sample each). Water samples for delta 18O analysis and delta 13C from bottom water in MC: 2.
JM08 - WP - 350 - MC	First and second attempt succesful with 4 and 5 cores respectively.CTD station # 344 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis.	MC A: oxygen and pH. MC B: 0-1 forams + 1-45 cm as reference (every cm). MC C: 0-42 cm (every cm) dinoflagellates and Pb. MC D: reference (frozen). MC E: coccos and IP25 (frozen). MC F: 0-1 cm diatoms. MC G: 0-1 cm isotopes. MC H: 0-1 cm Mg/Ca. Water samples for delta 18O analysis from bottom water in MC: 2.
JM08 - WP - 351 - GC	NB same site as JM08 – WP – 350 – MC.	Sample of core top.
JM08 - WP - 352 - GC		Core cutter and core catcher

Station Number	Comments	Sub-samples
JM08 - WP - 353 - MC	First and second attempt very succesful with 6 each.CTD station # 345 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis. NB same site as JM08 – WP – 352 – GC.	MC A: 0-50 cm (every cm) dinoflagellates and Pb. MC B: reference 57 cm (frozen). MC C: 0-1 forams + 1- 50 cm forams. MC D: reference sampled every cm 0-55 cm. MC E: 0-1 cm diatoms. MC F: 0-52 cm (every cm) coccos and IP25. MC F: reference 56 cm (frozen). MC G: 0-1 cm dinocysts (Rochon). MC H: 0-1 Mg/Ca. MC I: 0-1 cm isotopes. MC J: oxygen and pH. MC K: porewater. Water samples for delta 18O analysis from bottom water in MC: 2.
JM08 - WP - 354 - MC	First and second attempt succesful with 6 cores. CTD station # 346 is this station. Water samples from the bottom for Poul Loubere.	MC A: 0-1 cm diatoms. MC B: 0-1 forams + 1-56 cm as reference (every cm). MC C: o-1 cm isotopes. MC D: 0-1 cm Mg/Ca. MC E: 0-1 cm coccos and IP25. MCF: 0-63 cm (every cm) dinoflagellates and Pb.
JM08 - WP - 355 - MC	First attempt failed, no release of the multicorer. Second attempt succesful with 4 cores. Third attempt succesful with 6 cores. CTD station # 347 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis.	MC A: 0-1 cm diatoms. MC B: 0-50 cm IP25. MC C: 0-1 cm Mg/Ca. MC D: 0-52 cm forams. MC E: 0-1 cm isotopes. MC F: 0-1 cm coccos and IP25. MC G: reference (frozen). MC H: 0-50 cm dinoflagellates and Pb. MC I: 0-1 cm dinocyst. MC J: coccos and IP25 (frozen). Water samples for delta 18O analysis from bottom water in MC: 2. NB MC A - D from first cast, MC E - J from second cast.
JM08 - WP - 356 - GC	NB same site as JM08 – WP – 355 – MC.	Core top, core catcher, 2 samples frm core cutter
JM08 - WP - 357 - MC	First and second attempt succesful with 5 and 6 cores.CTD station # 348 is this station. Water samples from the bottom for Poul Loubere. Addtional water through the water column for delta 13C analysis.	MC A: 0-48 cm (every cm) dinoflagellates and Pb. MC B: 0-1 cm diatoms.MC C: 0-59 cm (every cm) reference. MC D: 0-1 cm Mg/Ca. MC E:0 -1 cm coccos and IP25. MC F: 0-1 cm dinocysts. MC G: coccos and IP25 (frozen). MC H: 0-1 cm isotopes. MC I: 0-58 forams. MC J: porewater. Water samples for delta 18O analysis from bottom water in MC: 2.
JM08 - WP - 358 - GC	NB same site as JM08 – WP – 357 – MC.	Core end, core catcher, core cutter

Appendix V Acoustic line log

Line name	Start (UTC)	Latitude North	Longitude East	End (UTC)	Latitude North	Longitude East	Comments
SciencePub08-001	17:38	78°08.92'	009°57.61'	19:54	78°08.25'	008°29.56'	MB line 014-018 , drifting on location from 19:50 – 19:54
SciencePub08-002							Scratch line
SciencePub08-003	02:33	78°09.94'	006°32.73'	06:08	78°10.80'	006°30.65'	MB line 018-026
SciencePub08-004	06:45	78°11.12'	006°29.40'	08:15	77°59.81'	005°59.00'	MB line 027-030
SciencePub08-004 onloc339	10:03	78°00.20'	005°58.76'	10:48	77°59.90'	005°57.11'	Drifting on Core station338 and station339
SciencePub08-005	13:08	77°59.66'	005°52.51'	14:12	78°00.02'	005°02.25'	MB line 031-033
SciencePub08-006 onloc340	14:43	78°00.14'	005°20.36'	15:16	77°59.96'	005°19.89'	Drifting on Core station340
SciencePub08-007	21:24	77°59.59'	005°15.65'	22:53	77°59.78'	004°07.49'	MB line 034-038 , asvp in from lineMB035
SciencePub08-007 onloc341	22:58	77°59.74'	004°07.35'	00:13	77°59.53'	004°09.59'	Drifting on Core station341
SciencePub08-008	02:51	77°58.27'	004°16.25'	14:50	77°59.96'	004°20.57'	MB line 035-063
SciencePub08-008 onloc342	14:59	79°59.87'	004°19.43'	15:30	77°59.77'	004°19.49'	Drifting on Core station342
SciencePub08-009	18:24	77°59.38'	004°25.24'	21:05	79°59.39'	006°04.53'	MB line 064-068
SciencePub08-010	21:05	79°59.39'	006°04.53'	23:06	75°55.70'	006°56.48'	MB line 069-073
SciencePub08-010 onloc343	23:10	75°55.83'	006°50.02'	00:03	75°55.87'	006°49.68'	Drifting on Core station343
SciencePub08-011	02:07	75°56.19'	006°48.34'	04:40	75°59.27'	008°31.83'	MB line 074-080
SciencePub08-011 onloc344	05:02	75°58.89'	008°19.37'	05:34	75°58.93'	008°19.32'	Drifting on Core station344
SciencePub08-012	07:27	75°58.82'	008°19.51'	11:32	75°59.66'	010°59.66'	MB line 071-088
SciencePub08-012 onloc345	11:32	75°59.66'	010°59.66'	12:05	75°59.69'	011°00.32'	Drifting on Core station 345 and station346
SciencePub08-013	15:05	75°59.83'	011°14.25'	17:27	76°00.08'	012°52.42'	MB line 089-094
SciencePub08-013 onloc347	17:29	76°00.04'	012°52.74'	17:59	76°00.16'	012°53.72'	Drifting on Core station347
SciencePub08-014	19:48	75°59.99'	012°56.64'	20:27	76°00.08'	013°18.92'	MB line 095-096
SciencePub08-014 onloc348	21:06	75°59.73'	013°17.90'	21:38	75°59.38'	013°17.10'	Drifting on Core station348
SciencePub08-015	22:00	75°59.41'	013°17.23'	22:37	75°59.34'	013°38.99'	MB line 097-100
SciencePub08-015 onloc349	22:39	75°59.34'	013°38.99'	23:12	75°58.83'	013°34.45'	Drifting on Core station349
SciencePub08-016	23:49	75°59.26'	013°40.77'	05:58	76°31.18'	015°06.34'	MB line 100-112
Bad weather	05:59						MB line 112-157, taking shelter in Horsund
SciencePub08-017	06:13	76°57.87'	015°33.37'	07:48	76°46.28'	014°54.69'	MB line 158-161
SciencePub08-018	08:16	76°46.10'	014°56.33'	08:14	76°48.17'	014°59.45'	MB line 162-163
SciencePub08-018 onloc350	08:26	76°47.89'	014°58.88'	08:48	76°47.99'	014°58.91'	Drifting on Core station350 and station351
SciencePub08-019	09:43	76°47.85'	014°59.01'	14:04	76°48.26'	012°01.11'	MB line 165-173
SciencePub08-019 onloc352	14:08	76°48.50'	012°01.07'	14:38	76°48.51'	012°00.38'	Drifting on Core station352 and station353
SciencePub08-020	17:32	76°49.81'	012°00.60'	23:56	77°37.11'	009°59.24'	MB line 174-186
SciencePub08-020 onloc354	23:59	77°37.11'	009°59.24'	00:35	77°37.26'	009°56.90'	Drifting on Core station354
SciencePub08-021	02:27	77°37.87'	009°02.29'	04:52	77°37.22'	009°57.41'	MB line 187-191
SciencePub08-021 onloc355	04:56	77°37.22'	009°57.41'	00:35	77°37.95'	009°55.13'	Drifting on Core station355 and station356
SciencePub08-022	08:25	77°37.65'	009°57.37'	09:57	77°37.15'	011°04.22'	MB line 192, direction East

Line name	Start (UTC)	Latitude North	Longitude East	End (UTC)	Latitude North	Longitude East	Comments
SciencePub08-022	09:57	77°37.15'	011°04.22'	10:27	77°32.61'	011°10.31'	Change of course, direction South
	10:27	77°32.61'	011°10.31'	11:24	77°32.88'	010°33.23'	Change of course, direction West
	11:24	77°32.88'	010°33.23'	12:25	77°25.96'	011°03.80'	Change of course, direction S-E
	12:25	77°25.96'	011°03.80'	13:08	77°19.01'	011°11.80'	Direction S-S-E, MB line 202, the end
SciencePub08-023	15:41	77°21.49'	011°07.65'				MB line 192, direction East