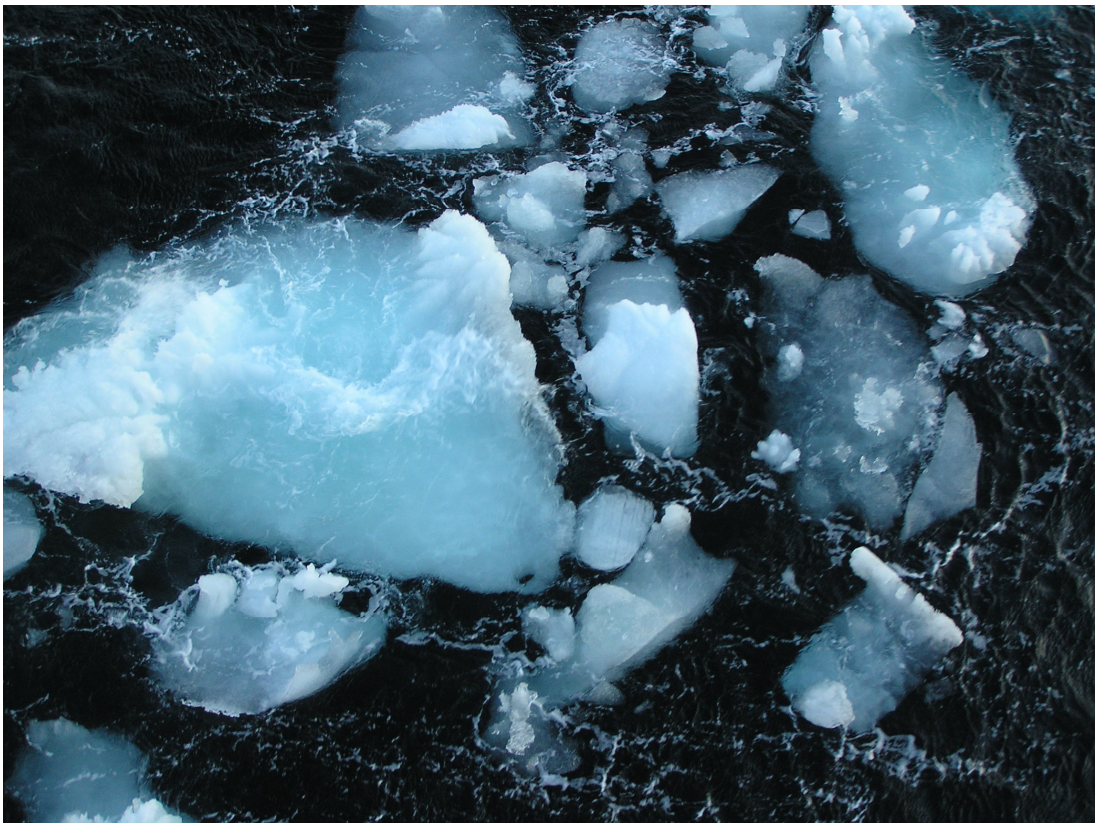
CRUISE REPORT JM06-WP

Marine geological cruise to
West Spitsbergen Margin and Fram Strait

RV "Jan Mayen" 11 – 19 October 2006



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Preface

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 these factors, thus showing how the environment was on the sea bottom and in the water masses back in time. The main purpose of the cruise is to obtain sediment samples from the uppermost part of the sea bottom at stations from two transects across the polar North Atlantic in order to improve our reconstructions. The transects crosses the oceanographic fronts between the main water masses in the polar North Atlantic in addition to the sea ice margin covering the widest possible oceanographic range in the area. The other purpose of the cruise is to achieve marine environmental records covering the last 10.000 years from the West Spitsbergen area.

Background and objectives

This cruise is part of the preparation at University of Tromsø to the International Polar Year (IPY) and is mainly part of the "Arctic Ocean warming in the Past" (WARMPAST) initiative (IPY activity no. 36) with several international partners.

The overall goal of the WARMPAST project 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 modelling experiments projecting temperatures for the next 100 years show a large scatter at high northern latitudes. The project includes the following modules: M1) Rapid changes in the Atlantic Water inflow into the Eurasian Basin of the Arctic Ocean, M2) Ice sheet/glacier response to warming, M3) Improving ocean temperature and sea-ice proxies; M4) Climate modelling.

The main focus of this cruise is module M3: Improving ocean temperature and sea-ice proxies. Quantitative reconstructions of ocean temperatures in particular below 5ºC based on stratigraphical proxy data (foraminifera, diatoms, geochemical tracers) are subject to large uncertainties. This is partly due to incomplete modern training sets at high latitudes such as incomplete geographical coverage, poor sample quality (e.g. core tops) and unsuitable sediment preparation (Pflaumann et al. 2003). We aim to improve modern analogue data on planktonic and benthic foraminifera, coccoliths, diatoms, dinocysts, foraminiferal Ca/Mg-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, and to refine the taxonomy used in the transfer functions.

The second purpose of the cruise is to attain high resolution Holocene sediment cores from the West Spitsbergen Margin in order to investigate fluctuations of the West

Spitsbergen Current during Holocene. Minor sediment sequences of assumed Holocene age have previously been identified on the slope outside of the Kongsfjorden Through (Spielhagen, pers. com.), and during this cruise it was hoped to identify a good sampling site, and obtain long sediment cores.

Cruise narrative

Wednesday (October 11): The participants embarked in Longyarbyen, Svalbard in the afternoon. The coring equipment was taken onboard and installed during the afternoon and early evening. The ship left the harbour and the multi corer was tested in Isfjorden (Karlskronadjupet) in the evening. After a successful test the ship left Isfjorden at 1 am and set course for the West Spitsbergen Margin off Kongsfjorden.

Thursday (October 12): In the morning the starting point of seismic line "A" was reached (Figure 1), and seismic recording with the sub-bottom profiler began. Two promising sites were identified, among them the Holocene sediment sequence that has previously been identified by R. Spielhagen. The first site was sampled with gravity corer and multi corer. A CTD profile was also obtained at the site. All equipment worked satisfactory. The second site, the "Holocene sediment bulge", was sampled with gravity corer, and a CTD profile was obtained. The site was sampled with a box corer instead of the multi corer. It had been revealed that the tubes for the multi corer had other dimensions than the ones the company had given. All technical information before delivery had clearly stated that the tubes were 0.6 m, but the delivered multi corer and the enclosed tubes were 0.8 m. Spliced tubes were necessary if the multi corer should be used. The gravity corer was only 4.11 m on the second site, so a piston corer was taken at the first site. After this the course was set for the Fram Strait.

Friday (October 13): A seismic survey with the sub-bottom profiler was carried out, before a site was chosen. Here CTD measurements were carried out, in addition to sampling with the box corer early in the morning. The coring was successful. The transect from West Spitsbergen towards the sea-ice edge was then continued, and further two stations were sampled, before the edge of the sea-ice was reached late afternoon. A seismic survey with the sub-bottom profiler was carried out, and a site was chosen. Sampling was attempted first with the box corer, but after 4 attempts, the multi corer was tried with spliced tubes (0.6 + 0.2 m). The second try succeeded, and sampling ended Saturday morning.

Saturday (October 14): A seismic survey was started along the ice edge in order to find suitable sampling sites. Two successful samplings with multi corer were carried out at 78º N and 77º N. A site was sampled close to 76º N but without success. Two core liners were lost.

Sunday (October 15): The weather deteriorated and the wind strength picked up to strong gale, so it was not possible to sample the next 24 hours. The ship set a southern course towards the ice edge.

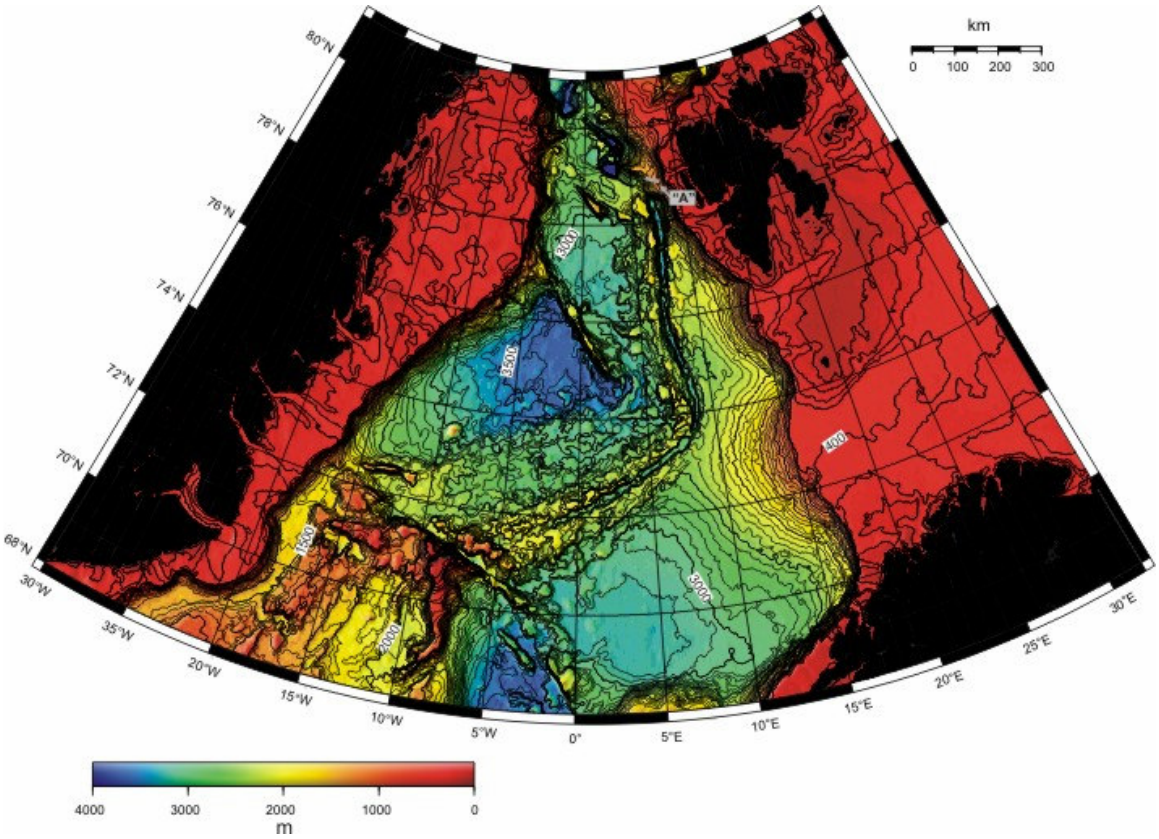


Figure 1. Map of the Fram Strait. The position of seismic line "A" is shown.

Monday (October 16): The weather improved, and a station was sampled close to the ice edge at 74º 38.00' N. It was successful despite swells. Another station was sampled along the ice edge at ca. 75º N. Three tubes broke, but there were three with sediments. The course was again set for 76º N because the weather forecast for the eastern Greenland Sea and Norwegian Sea was unsuitable for sampling, and the first sampling at 76º N was fruitless. The weather deteriorated to near gale/gale and since sampling would be impossible an eastern course was set across the Fram Strait.

Tuesday (October 17): The weather had further deteriorated to strong gale and it was not possible to sample any stations. At midnight the course was set in a more easterly direction in order to wait for better weather,

Wednesday (October 18): The weather had only improved slightly to strong breeze/near gale, and the course was set for Tromsø with 6-8 planned stations along the way (in case the weather would allow sampling). Sub-bottom profiling was carried out, but the wind was still too strong for sampling.

Thursday (October 19): The weather did not improve, and steaming towards Tromsø continued. Sub-bottom profiling was continued till 12 o'clock. The labs were cleaned and the samples packed during the afternoon. The ship arrived in Tromsø in the evening.

Methods

The positions of the sediment cores were identified with sub-bottom profiler (3.5 kHz penetration echo sounder placed in the keel of the ship). The longer sediment cores were sampled with gravity corer (max core length 6 m) and/or piston corer (max core length 12 m). The surface samples were sampled with box corer (50 x 50 x 50 cm) or multi corer (6 core liners, outer diameter 110mm, length 0.8m). CTD measurements were obtained at every station 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.

Subsampling of box corer and multi corer

Subsampling was carried out immediately so compaction of the unconsolidated surface sediments was avoided. Five different subsamples were taken for the proxies; 0-1 cm for the planktonic and benthic foraminifera, 0-15 cm (every cm) for dinocysts, coccoliths and ^{210}Pb, 0-1 cm diatoms, 0-1 cm foraminiferal Ca/Mg-ratios, and 0-1 cm foraminiferal oxygen and carbon isotopes. One core was not subsampled and kept as a reference core. The sediment samples were stored at 5° C. The foraminiferal samples were additionally preserved with ethanol and Rosa Bengal stain.

The box corer was sampled with short core tubes using a vacuum pump. For station JM06-WP-07-BC only 3 cores were obtained, two as references and one for the dinocyst/coccoliths/ ^{210}Pb sampling. Samples for the other proxies were achieved with a spoon. For station JM06-WP-10-BC 2 cores were retrieved, one for reference and one for the dinocyst/coccoliths/ ^{210}Pb sampling. The multi corer automatically gives 6 cores, which then were sampled. In case of less than 6 cores (St. JM06-WP-16-MC, JM06-WP-24-MC, JM06-WP-26-MC), the samples were split in halves, and at two stations reference cores had to be given up (JM06-WP-24-MC, JM06-WP-26-MC).
The reference cores were frozen for each station. An additionally reference core was stored at 5 °C from the stations JM06-WP-04-MC and JM06-WP-07-BC.

Preliminary results

A total of 11 stations were sampled for surface sediments with either multi corer or box corer (Figure 2, Appendix 4). One station was sampled unsuccessfully. Two other stations were additionally sampled with gravity corer, and one of them also with piston corer. Sub-bottom profiling (3.5 kHz) was done at every station and supplementary survey was carried out in selected areas (Figure 3, Appendix 5). Further, CTD measurements were performed at all stations (Appendix 6).

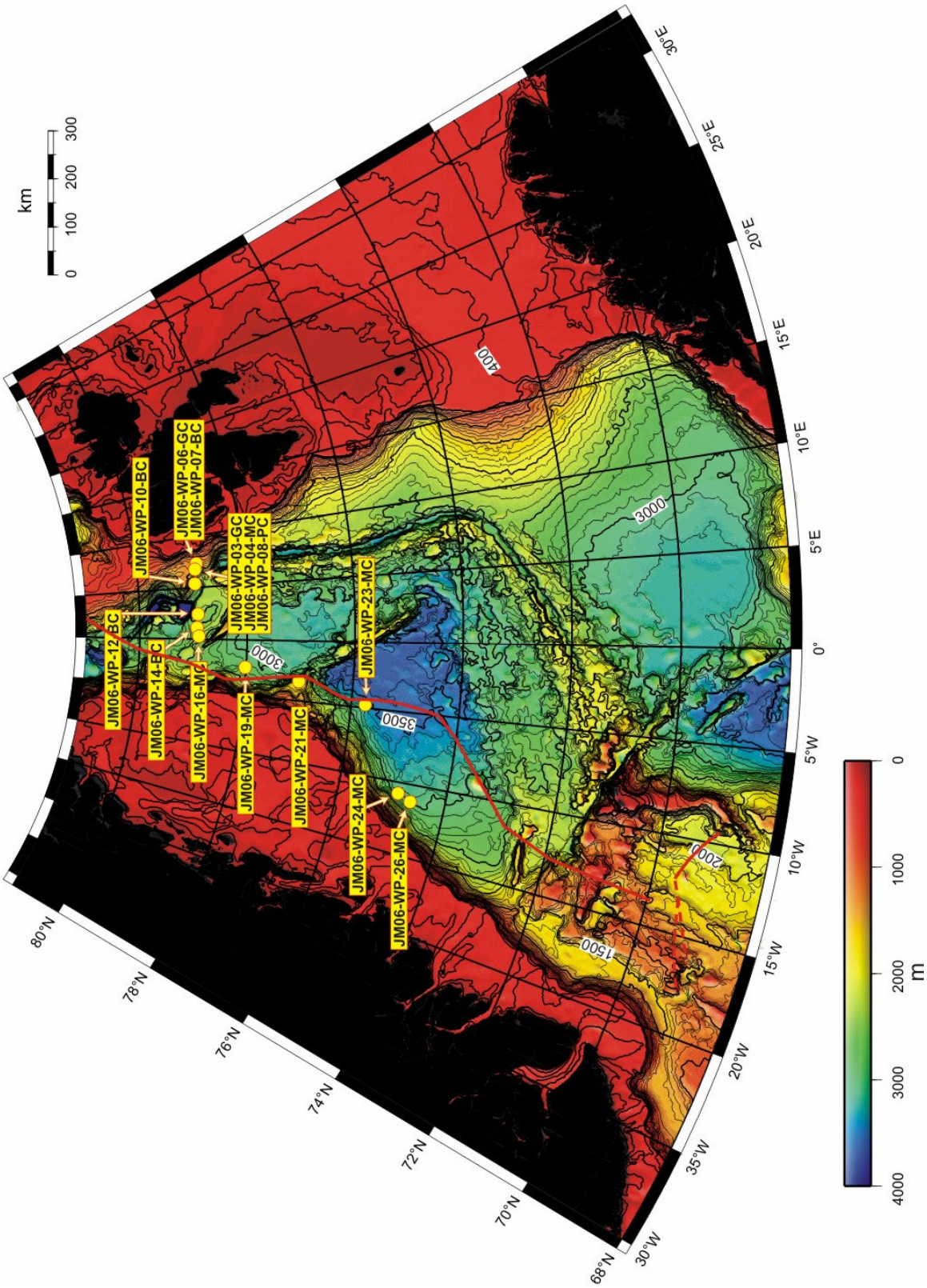


Figure 2. Map of the Fram Strait showing the locations of the core stations. The red line shows the territorial boundaries between Greenland, Iceland, and Norway.

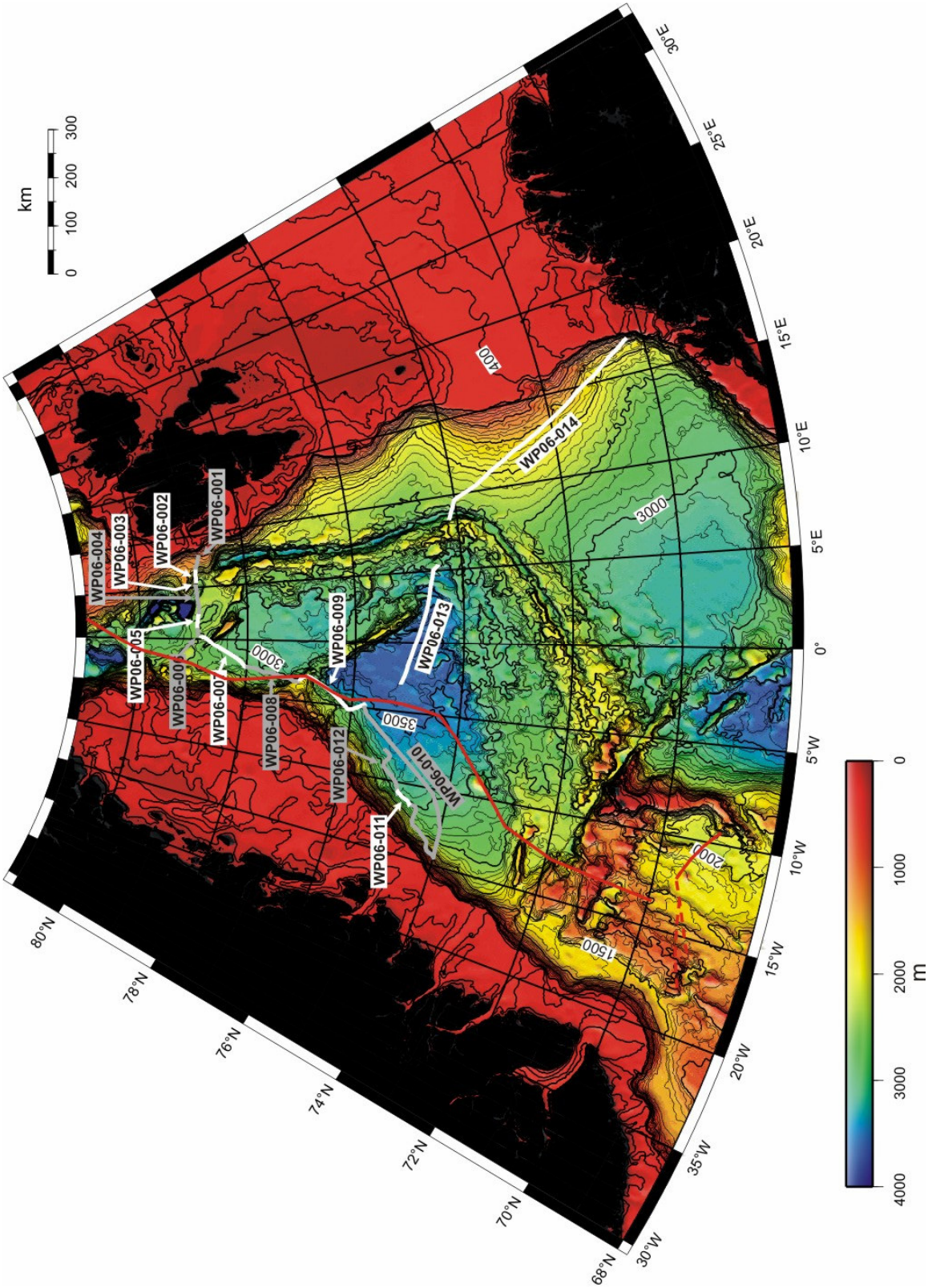


Figure 3. Map of the Fram Strait showing the seismic lines. The red line shows the territorial boundaries between Greenland, Iceland, and Norway.

Future work

The gravity cores and piston core are stored at the University of Tromsø (Kræmer Kaia Cool storage facility). They will be logged with the Multi Sensor core logger with regard to e.g. magnetic susceptibility at the Department of Geology, University of Tromsø during 2006. The cores will be opened and sampled during January 2007.

The samples from the multicores will be prepared and analysed during 2006/2007 by the different research groups:

Analysis	**PI/Co-worker**	**Affiliation**
^{210}Pb dating	Anne de Vernal	GEOTOP, Université du Québec a Montreal, Canada
Coccoliths	Jacques Giraudeau/Sandrine Solignac	EPOC, Université Bordeaux, France
Diatoms	Nalan Koc	Norwegian Polar Institute, Norway
Dinocysts	Anne de Vernal/Sandrine Solignac	GEOTOP, Université du Québec a Montreal, Canada
Foraminifera (benthic)	Nalan Koc/Dorthe Klitgaard Kristensen	Norwegian Polar Institute, Norway
Foraminifera (planktonic)	Morten Hald/Katrine Husum	University of Tromsø, Norway
Foraminiferal oxygen and carbon isotopes	Robert Spielhagen	IFM-GEOMAR, Leibniz Institute of Marine Sciences Kiel, Germany
Foraminiferal Ca/Mg	Tom Marchitto	Instaar, University of Colorado, USA

APPENDICES

1) Participants
2) Equipment
3) Ship log
4) Sample log
5) Acoustic line log
6) CTD profiles from the stations
7) 3.5 kHz penetration echo sounder profiles from the stations

APPENDIX 1

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

Katrine Husum, University of Tromsø, Norway (scientific cruise leader)

Steffen Aagaard Sørensen, University of Tromsø, Norway

Robert Spielhagen, IFM-GEOMAR, Leibniz Institute of Marine Sciences Kiel, Germany

Anne de Vernal, GEOTOP UQAM-McGill, Université du Québec a Montreal, Canada

Sandrine Solignac, GEOTOP UQAM-McGill, Université du Québec a Montreal, Canada

Steinar Iversen, University of Tromsø, Norway

Kyrre Lydersen, Norwegian College of Fishery Sciences, University of Tromsø, Norway

Shift A (8-14, 20-02):
Katrine Husum

Steffen Aagaard Sørensen

Steinar Iversen

Shift B (02-8, 14-20):
Robert Spielhagen

Anne de Vernal

Sandrine Solignac

Kyrre Lydersen

APPENDIX 2

Equipment

Acoustic equipment
Geoacoustic/Ferranti O.R.E. 3.5 kHz penetration echo sounder, 10kW, 2 pulses;
Transmittet: Geopulse 5430 A; Reciever: Geopulse 5210 A
EPC 9800 thermo recorder, 2 channel
Digital recorder: PC with Delph 2 channel; log format: ELICS; Store formats: CD-rom
Echo sounder, Simrad EK 500, 38 kHz

Coring equipment
Large box corer (0.5m x 0.5m x 0.5m)
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)
Piston corer (core length max 12 m outer diameter of liners 110 mm)

Water properties
CTD (Seabird 911 Plus) 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-rom

APPENDIX 3
Ship log

Date	Time	Subject	Weather	Area
11/10	15:00	Loading equipment at Bykaia in Longyearbyen and installing coring equipment (piston, gravity, box, multi)	calm clear weather	Longyearbyen
11/10	20:00	Safety instructions and demonstration of emergency exits and survival suits on RV Jan Mayen	calm clear weather	Longyearbyen
11/10	22:00	Starting testing multicorer in Isfjorden (Karlskronadjupet)	calm clear weather	Isfjorden
11/10	01:00	Departure Isfjorden	calm clear weather	Isfjorden
12/10	09:10	Arrival Seismic line "A" at the west Spitsbergen margin off Kongsfjorden	calm, overcast	West Spitsbergen Slope
12/10	09:15	Seismic line WP_001 started in Fram Strait	calm, overcast	West Spitsbergen Slope
12/10	12:05	Seismic line WP_001 finished in Fram Strait	calm, overcast	West Spitsbergen Slope
12/10	13:15	Starting sampling on site "A1" (CTD St 2, GC St 3, MC St 4)	calm, cloudy	West Spitsbergen Slope
12/10	17:45	Starting sampling on site "A2" (CTD St 5, GC St 6, BC St 7)	calm, overcast	West Spitsbergen Slope
12/10	21:05	Starting sampling on site "A1" (PC St 8)	calm, overcast	West Spitsbergen Slope
12/10	22:15	Seismic line WP_002 started in Fram Strait	calm, overcast	Northern Fram Strait
12/10	00:35	Seismic line WP_002 finished in Fram Strait	calm, overcast	Northern Fram Strait
13/10	00:40	Starting sampling in Fram Strait (CTD St 9, BC St 10)	calm, overcast	Northern Fram Strait
13/10	02:30	Seismic line WP_004 started in Fram Strait	calm, overcast	Northern Fram Strait
13/10	07:22	Seismic line WP_004 finished in Fram Strait	calm, overcast	Northern Fram Strait
13/10	09:30	Starting sampling in Fram Strait (CTD St 11, BC St 12)	calm, overcast, snow	Northern Fram Strait
13/10	09:35	Seismic line WP_005 started in Fram Strait	calm, overcast, snow	Northern Fram Strait
13/10	12:15	Seismic line WP_005 finished in Fram Strait	calm, overcast, snow	Northern Fram Strait

Date	Time	Subject	Weather	Area
13/10	14:30	Starting sampling in Fram Strait (CTD St 13, BC St 14). NB! First attempts with BC labelled 14 on bridge and the successful attempt 15. Samples labelled 14!!	calm with some swell, overcast, snow	Northern Fram Strait
13/10	16:25	Seismic line WP_006 started in Fram Strait	calm, overcast, snow, open sea ice	Fram Strait at the boundary of sea ice
13/10	17:35	Seismic line WP_006 finished in Fram Strait	calm, overcast, snow, open sea ice	Fram Strait at the boundary of sea ice
13/10	15:35	Starting sampling in Fram Strait at the boundary of sea ice (CTD St 15, BC St 16, MC St 17). NB! Attempts with BC labelled 16 on bridge and attempts with multicorer labelled 17! Samples labelled 16!!	calm, overcast, snow, open sea ice	Fram Strait at the boundary of sea ice
14/10	02:00	Ending sampling in Fram Strait at the boundary of sea ice (CTD St 15, BC St 16, MC St 17) NB! Attempts with BC labelled 16 on bridge and attempts with multicorer labelled 17! Samples labelled 16!!	calm, overcast, snow, open sea ice	Fram Strait at the boundary of sea ice
14/10	02:00	Seismic line WP_007 started in Fram Strait	calm, overcast, snow, open sea ice	Western Fram Strait
14/10	07:40	Seismic line WP_007 finished in Fram Strait	calm, foggy	Western Fram Strait
14/10	08:00	Starting sampling in Fram Strait at the boundary of sea ice (CTD St 18, MC St 19)	calm, foggy, open sea ice	Western Fram Strait
14/10	11:49	Seismic line WP_08 started in Fram Strait	calm, slightly overcast, open sa ice	Western Fram Strait
14/10	17:20	Seismic line WP_08 finished in Fram Strait	calm, overcast	Western Fram Strait
14/10	19:00	Starting sampling in Fram Strait at the boundary of sea ice (CTD St 20, MC St 21)	calm, overcast, open sa ice	Western Fram Strait
14/10	19:30	Seismic line WP_09 started in Fram Strait	calm, overcast	Western Fram Strait
15/10	03:45	Seismic line WP_09 finished in Fram Strait	windy, overcast	Western Fram Strait
15/10	03:45	Starting sampling in Fram Strait at the boundary of sea ice (CTD St 22, MC St 23). Coring failed! Two core liners were lost, the others were empty.	some swells, overcast	Western Fram Strait
16/10	07:25	Seismic line WP_10 started in Fram Strait	swells, overcast	Western Fram Strait
16/10	10:05	Seismic line WP_10 finished in Fram Strait	swells, clear skies	Western Fram Strait
16/10	10:15	Starting sampling in Fram Strait at the boundary of sea ice (MC St 24, CTD St 25).	minor swells, clear skies	Western Fram Strait
16/10	13:54	Seismic line WP_11 started in Fram Strait	minor swells, clear skies	Western Fram Strait
16/10	16:06	Seismic line WP_11 finished in Fram Strait	minor swells, clear skies	Western Fram Strait

Date	Time	Subject	Weather	Area
16/10	18:30	Starting sampling in Fram Strait at the boundary of sea ice (MC St 26, CTD St 27).	minor swells, clear skies	Western Fram Strait
16/10	20:04	Seismic line WP_12 started in Fram Strait	overcast, windy	Western Fram Strait
17/10	02:20	Seismic line WP_12 finished in Fram Strait	overcast, very windy (gale)	Western Norwegian Sea
17/10	08:13	Seismic line WP_13 started in Fram Strait	overcast, very windy (gale)	Norwegian Sea
18/10	01:15	Seismic line WP_13 finished in Fram Strait	overcast, very windy (gale)	Norwegian Sea
18/10	08:00	Seismic line WP_14 started in Fram Strait	overcast, very windy (gale)	Eastern Norwegian Sea
19/10	12:00	Seismic line WP_14 finished in Fram Strait	overcast, very windy (strong breeze - gale)	Eastern Norwegian Sea
19/10	19:00	Arrival in Tromsø	overcast, windy	Tromsø

APPENDIX 4
Sample logs

Station Number	Date	Time GMT +1	Water depth (m)	Latitude	Longitude	Corer Type	Core Recovery	Core length	No of core sections/ multitubes	Area
JM06-WP-03-GC	12/10	15:00	1493	N 78 54,945	E 006 46,742	GC	> 6m	5,55	6	West Spitsbergen Slope
JM06-WP-04-MC	12/10	16:15	1497	N 78 54,931	E 006 46,005	MC	full	0,54	4	West Spitsbergen Slope
JM06-WP-06-GC	12/10	19:00	1177	N 78 52,743	E 007 20,574	MC	Full	4,11	5	West Spitsbergen Slope
JM06-WP-07-BC	12/10	20:30	1181	N 78 52,620	E 007 20,459	BC	full	0,5	3	West Spitsbergen Slope
JM06-WP-08-PC	12/10	22:00	1489	N 78 55,013	E 006 46,775	PC	12 m	11,04	11	Fram Strait
JM06-WP-10-BC	13/10	2:30	2483	N 78 56,176	E 005 24,075	BC	Not full	0,37	2	Fram Strait
JM06-WP-12-BC	13/10	9:30	2426	N 78 54,461	E 002 24,919	BC	full	0,25	6	Fram Strait
JM06-WP-14-BC	13/10	14:30	2502	N 78 55,888	E 001 06,460	BC	Full	0,32	5	Western Fram Strait, sea-ice edge
JM06-WP-16-MC	14/10	2:00	2546	N 78 53,767	E 016,916	MC	full	0,5	4	Western Fram Strait, sea-ice edge
JM06-WP-19-MC	14/10	11:45	2859	N 78 00,776	W 002 30,173	MC	full	0,52	6	Western Fram Strait, sea-ice edge
JM06-WP-21-MC	14/10	19:00	1779	N 77 00,204	W 003 23,662	MC	full	0,5	6	Western Fram Strait, sea-ice edge
JM06-WP-23-MC	15/10	3:45	3377	N 75 44,336	W 004 44,921	MC	Not full	0	0	Western Fram Strait, sea-ice edge
JM06-WP-24-MC	16/10	10:34	2974	N 74 38,00	W 011 11,21	MC	Not full	0,4	3	Western Fram Strait, sea-ice edge
JM06-WP-26-MC	16/10	18:30	3064	N 74 53,49	W 010 46,10	MC	Not full	0,3	4	Western Fram Strait, sea-ice edge

Station Number	Subcoring labelling	Comments
JM06-WP-03-GC	JM06-WP-03-GC, zero from the top	combined core catcher and core cutter sample
JM06-WP-04-MC	MC A (subsamp. every cm 0-54 cm forams), B (subsamp. every cm 0-54 cm dinocysts/coccoliths and isotopes), C (cool storage), D (freezer)	
JM06-WP-06-GC	section 1 is the lowermost part of the core, labelled form the bottom	
JM06-WP-07-BC	JM06-WP-07-BC A (frozen), JM06-WP-07- BC B (cool storage), JM06-WP-07-BC C (subsamp. every cm 0-15 cm. 210Pb and dinocysts/coccoliths), 4 surface samples for the other proxies	4 surface samples (no control of volume)
JM06-WP-08-PC	JM06-WP-08-PC, zero from the top	0-5 m of the core not full, 5-11 m full liner
JM06-WP-10-BC	JM06-WP-10 BC A (freezer), JM06-WP-10-BC (subsamp. every cm 0-15 cm 210Pb and dinocysts/coccoliths)	sediment slided, rock on the edge of the box, surface samples for the other proxies in plastic bags
JM06-WP-12-BC	BC A (freezer), BC B (subsamp. every cm 0-15 cm 210 Pb and dinocysts/coccoliths), BC C (0-1 cm forams), BC D (0-1 cm isotopes), BC E (0-1 cm Mg/Ca), BC F (0-1 cm diatoms)	In dinocysts sample 9-10 there is a large rock (> 2cm), that was situated 9-11 cm
JM06-WP-14-BC	BC A (freezer), BC B (0-1 cm forams), BC C (0-1 cm Mg/Ca), BC D (0-1 cm diatoms), BC E (subsamp. every cm 0-15 cm 210Pb and dinocysts/coccoliths), surface sample for isotopes	First and second attemps failed, no release, third attempt succesful. This station is labelled 15 on the bridge.
JM06-WP-16-MC	BC A (freezer), BC B (subsamp. every cm 0-40 cm 210 Pb and dinocysts/coccoliths), BC C (0-1 cm 1/2 for forams, 1/2 for Mg/Ca), BC D (0-1 cm 1/2 isotopes, 1/2 diatoms)	Four failed attemps with box corer. Two attempts with multicorer, the second with extra weight was succesful.
JM06-WP-19-MC	MC A (freezer), MC B (subsamp. every cm 0-15 cm 210 Pb and dinocysts/coccoliths), MC C (0-1 cm forams), MC D (0-1 cm diatoms), MC E (0-1 cm isotopes), MC F (0-1 cm Mg/Ca)	Succes, New spliced tubes worked perfectly.
JM06-WP-21-MC	MC A (0-1 cm Mg/Ca), MC B (0-1 cm diatoms), MC C (0-1 cm forams), MC D (0-1 cm isotopes), MC E (subsamp. every cm 0-15 cm 210 Pb and dinocysts/coccoliths), MC F (freezer)	
JM06-WP-23-MC		Failed! Two tubes lost, but it had touched the sea floor
JM06-WP-24-MC	MC A (subsamp. every cm 0-15 cm 210 Pb and dinocysts/coccoliths), MC B (0-1 cm 1/2 for forams, 1/2 for diatoms), MC C (0-1 cm 1/2 for isotopes, 1/2 for Mg/ca). NO reference	Some swells
JM06-WP-26-MC	MC A (0-1 cm 1/2 for forams, 1/2 for isotopes), MC B (0-1 cm 1/2 for diatoms, 1/2 for Mg/ca), MC C (subsamp. every cm 0-15 cm 210 Pb and dinocysts/coccoliths). NO reference	3 tubes broke! Two were lost, one still came up with sediment, but it was broken at the top. NB Surface oblique on MC C

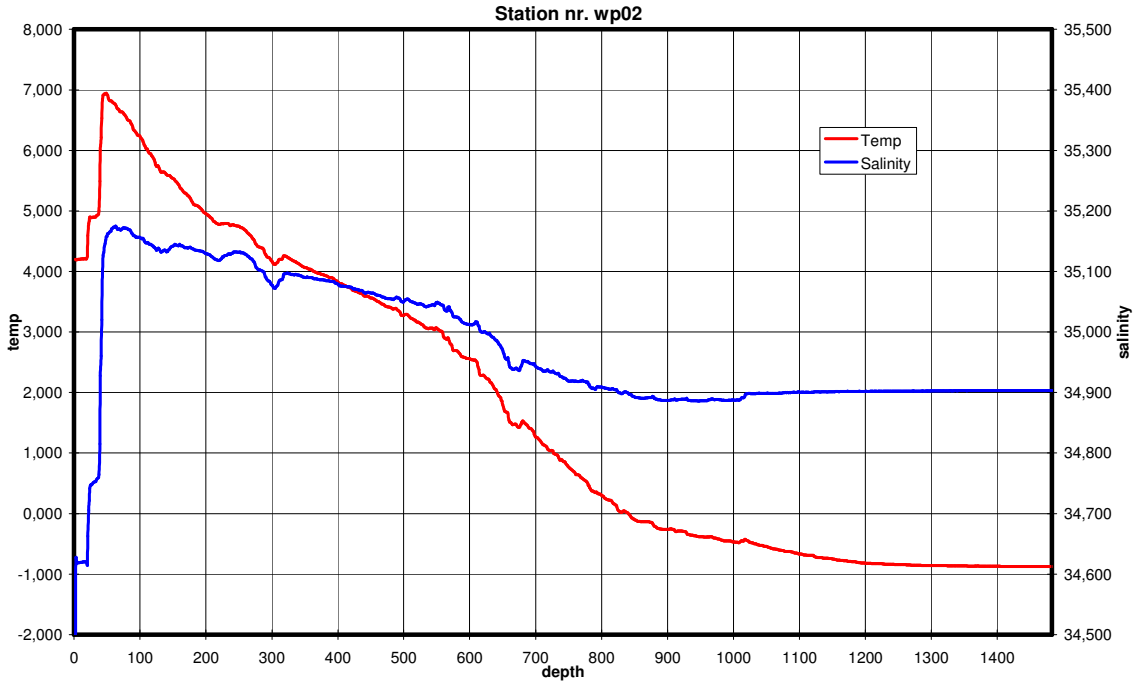
APPENDIX 5
Acoustic log

Date	Time UTC	Activity(SOL,EOL,etc):	Position LAT WGS84	Position LON WGS84	Comment(sailing dir,area,downtime etc)
12.10	07:12	SOL WP06-01	78d49.55N	8d05.33E	East-West. Pingrate 3 sec.
	10:03	EOL	78d56.72N	6d06.19E	
	20:15	SOL WP06-02	78d55.26N	6d43.30E	East-West. Pingrate 4 sec.
	22:36	EOL	78d55.46N	5d19.61E	
		WP06-03	----	----	Used as a test line
13.10	01:25	SOL WP06-04	78d56.64N	5d21.77E	East-West. Pingrate 4 sec.
	05:21	EOL	78d54.39N	2d21.99E	
	07:35	SOL WP06-05	78d54.67N	2d26.37E	East-West. Pingrate 4 sec.
	09:12	EOL	78d56.15N	1d04.66E	
	14:25	SOL WP06-06	78d55.75N	1d05.77E	East-West. Pingrate 4 sec.
	15:33	EOL	78d54.81N	00d13.58E	
14.10	00:01	SOL WP06-07	78d52.30N	00d08.22E	NE-SW direction. Pingrate 4 sec.
	05:38	EOL	78d02.35N	2d24.47W	
	09:49	SOL WP06-08	78d01.10N	2d27.69W	NE-SW direction. Pingrate 5 sec.
	15:22	EOL	77d00.58N	3d21.93W	
	17:29	SOL WP06-09	76d59.98N	3d23.90W	E-W direction. Pingrate 5 sec.
	17:51		76d59.39N	3d12.02W	Coursechange Southwards
	18:29		76d53.37N	2d55.70W	Coursechange
	18:58		76d48.07N	3d00.88W	Coursechange
	21:38		76d31.73N	3d40.20W	Coursechange
	23:49		76d03.89N	5d14.11W	Coursechange
15.10	00:11		75d59.87N	5d13.30W	Coursechange
	01:43	EOL	75d44.84N	4d42.50W	
	05:31	SOL WP06-10	75d46.63N	4d50.40W	SW course. Pingrate 5 sec.
	06:27		75d42.66N	5d27.05W	Coursechange
	16:55		74d16.22N	10d19.79W	Coursechange
	19:02		74d06.96N	11d24.74W	Coursechange
	21:26		74d00.38N	12d43.63W	Coursechange
16.10	00:14		74d00.02N	14d25.51W	Halting.

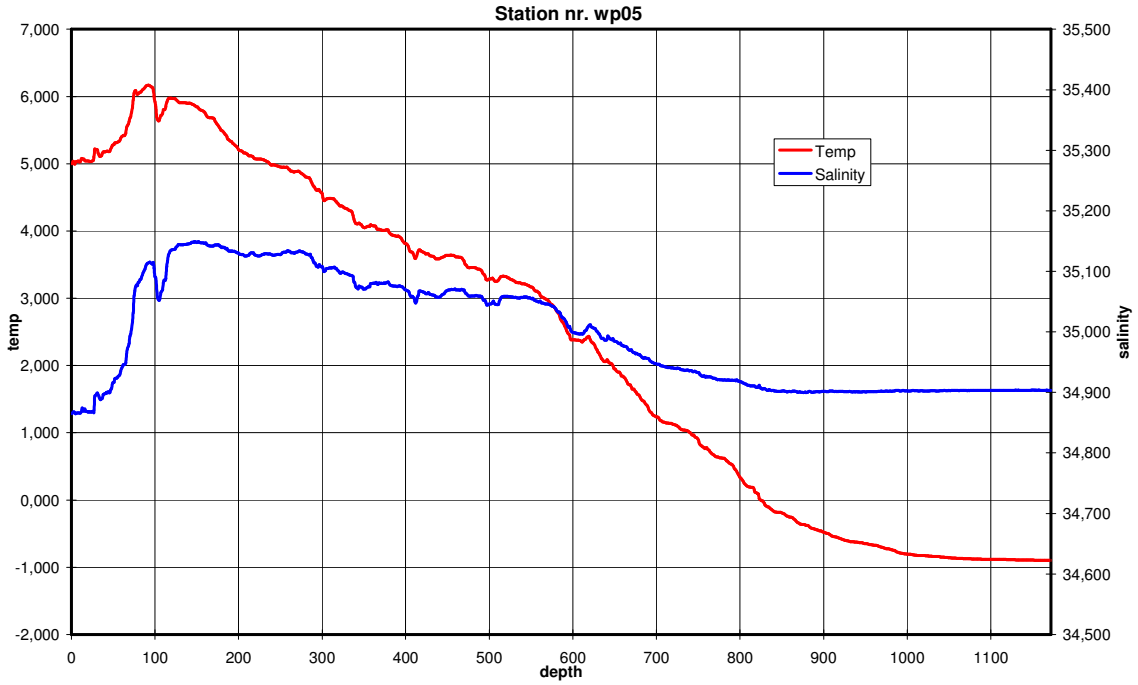
Date	Time UTC	Activity(SOL,EOL,etc):	Position LAT WGS84	Position LON WGS84	Comment(sailing dir,area,downtime etc)
16.10	00:30		74d00.36N	14d25.58W	Continue in norteast direction.
	01:44		74d08.91N	14d10.14W	Coursechange
	02:47		74d11.37N	13d38.37W	Coursechange
	05:28		74d31.20N	12d41.49W	Coursechange
	06:04		74d32.96N	12d20.79W	Coursechange
	07:07		74d31.02	11d41.52W	Coursechange
	07:35		74d32.68	11d26.09W	Coursechange
	08:13	EOL	74d38.20	11d21.65W	
	11:54	SOL WP06-11	74d39.74N	11d25.55W	SW-NE direction
	14:06	EOL	74d56.90N	11d35.34W	
	18:04	SOL WP06-12	74d54.03N	10d54.47W	SW-NE direction
17.10	00:20	EOL	75d18.44N	7d47.44W	
	06:13	SOL WP06-13	75d08.19N	3d03.81W	
	23:15	EOL	74d25.82N	5d24.31E	
18.10	06:00	SOL WP06-14	74d09.02N	8d22.03E	
19.10	10:00	EOL	70d16.88N	16d54.62E	

APPENDIX 6
CTD profiles

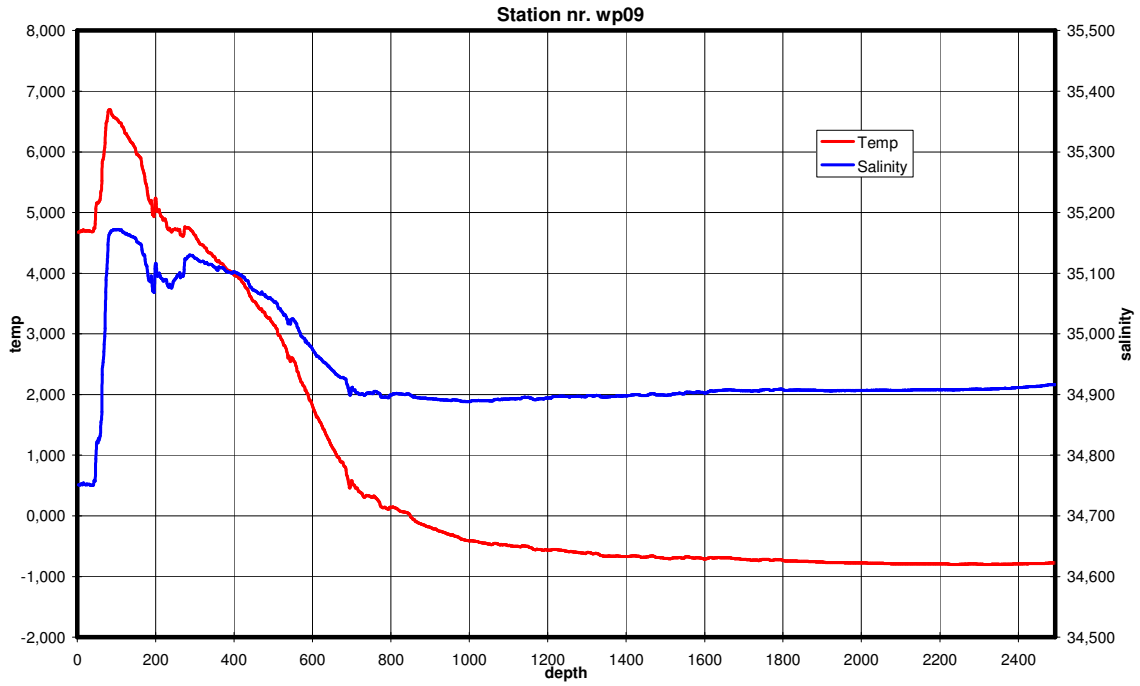
Station JM06-WP-02 (same site as JM06-WP-03 GC, JM06-WP-04 MC, and JM06-WP-08 PC)



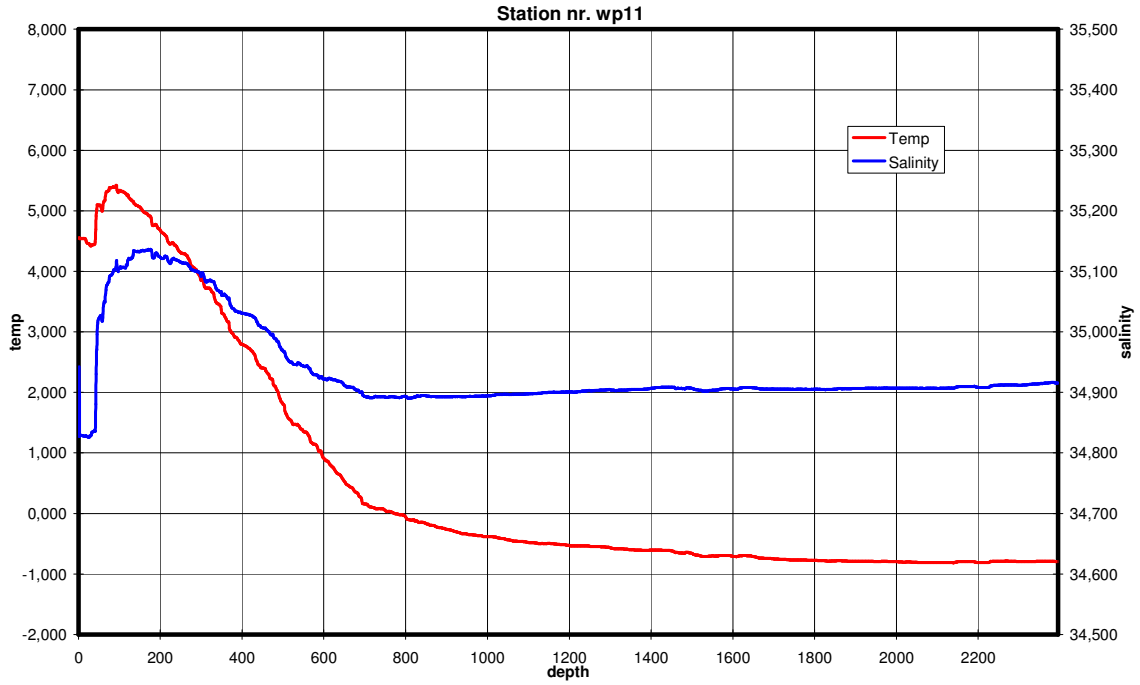
Station JM06-WP-05 (same site as JM06-WP-06 GC and JM06-WP-07 BC)



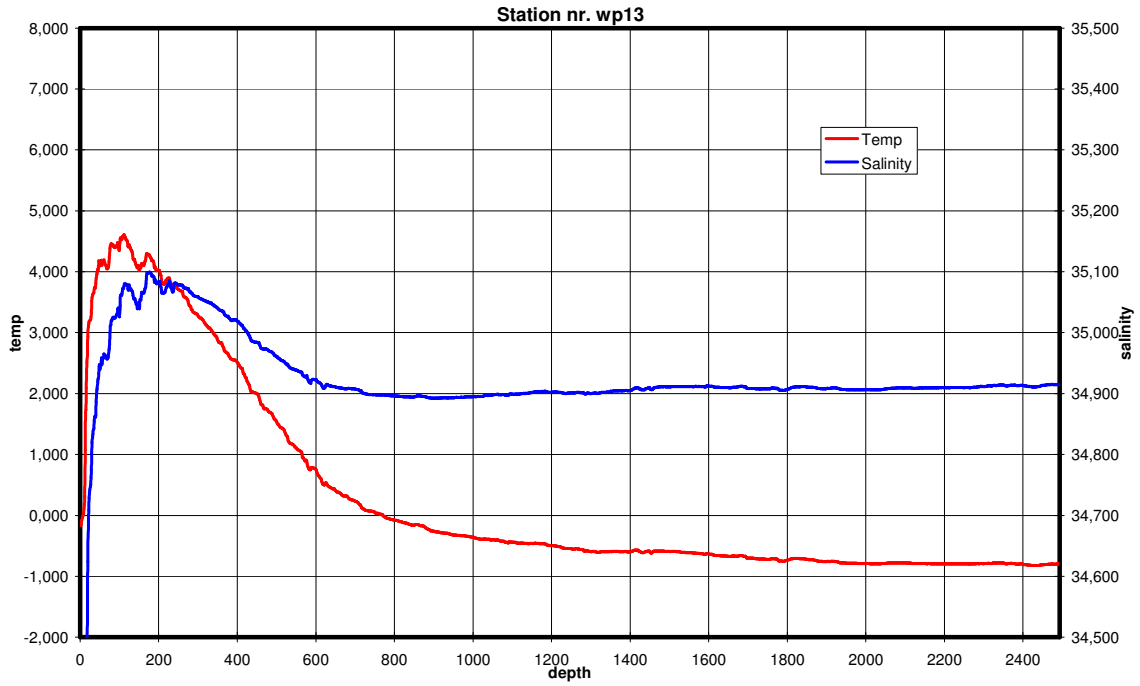
Station JM06-WP-09 (same site as JM06-WP-10 BC)



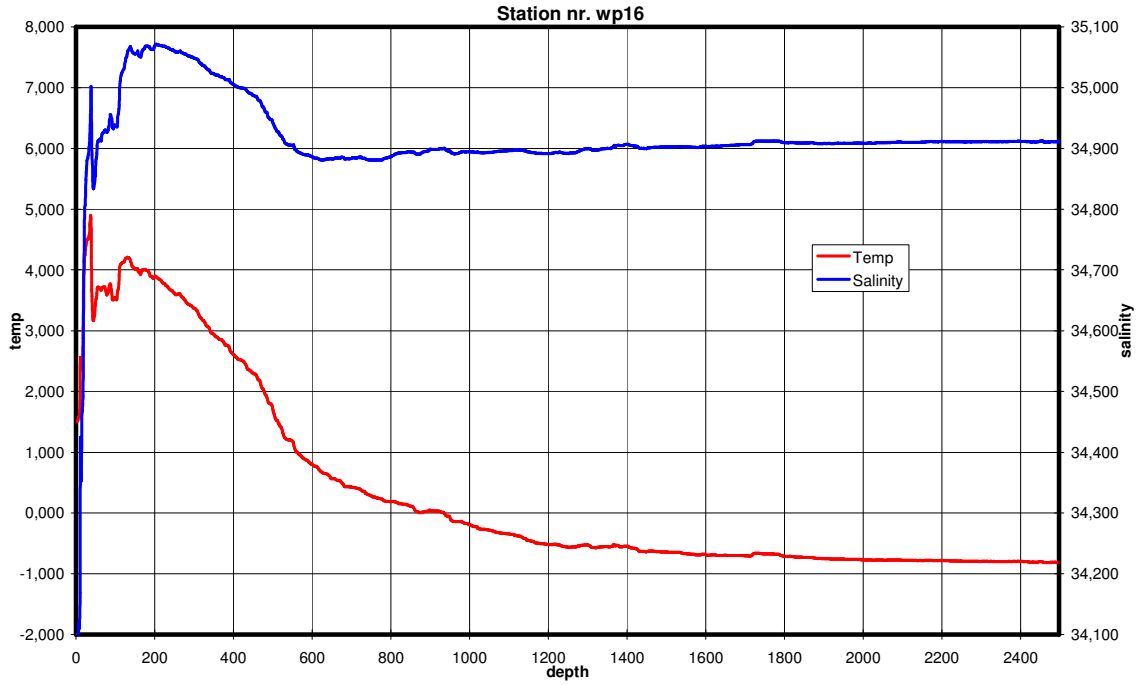
Station JM06-WP-11 (same site as JM06-WP-12 BC)



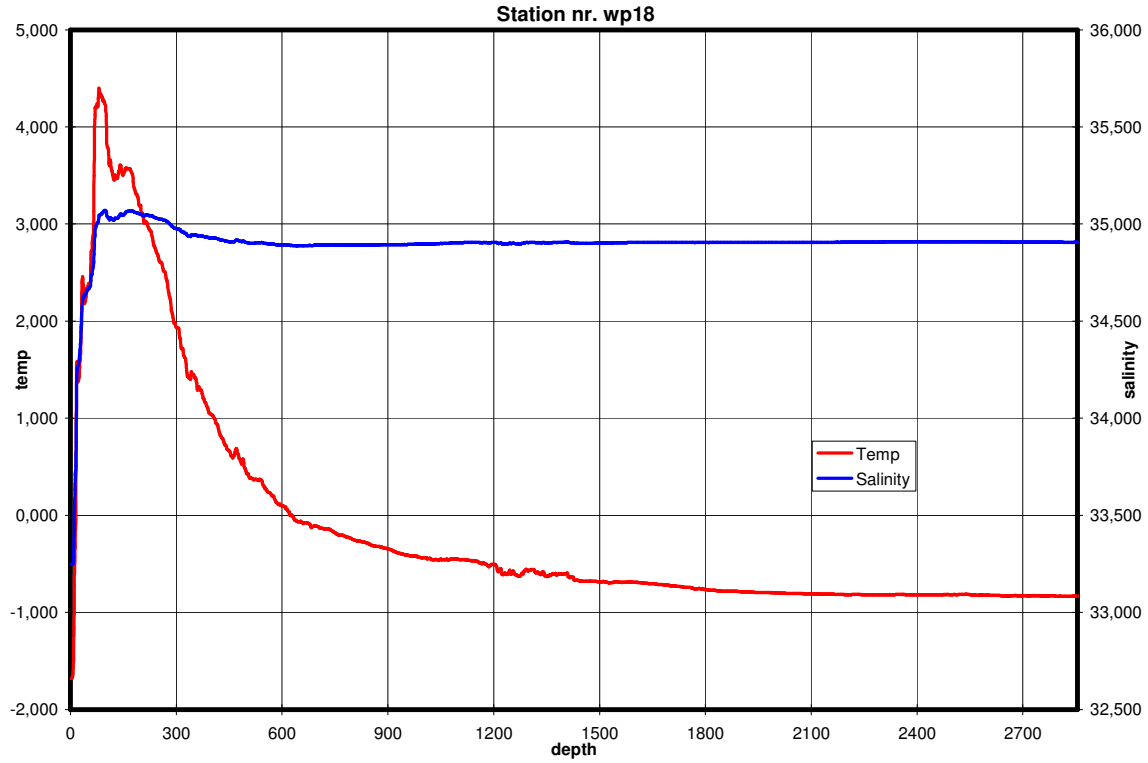
Station JM06-WP-13 (same site as JM06-WP-14 BC)



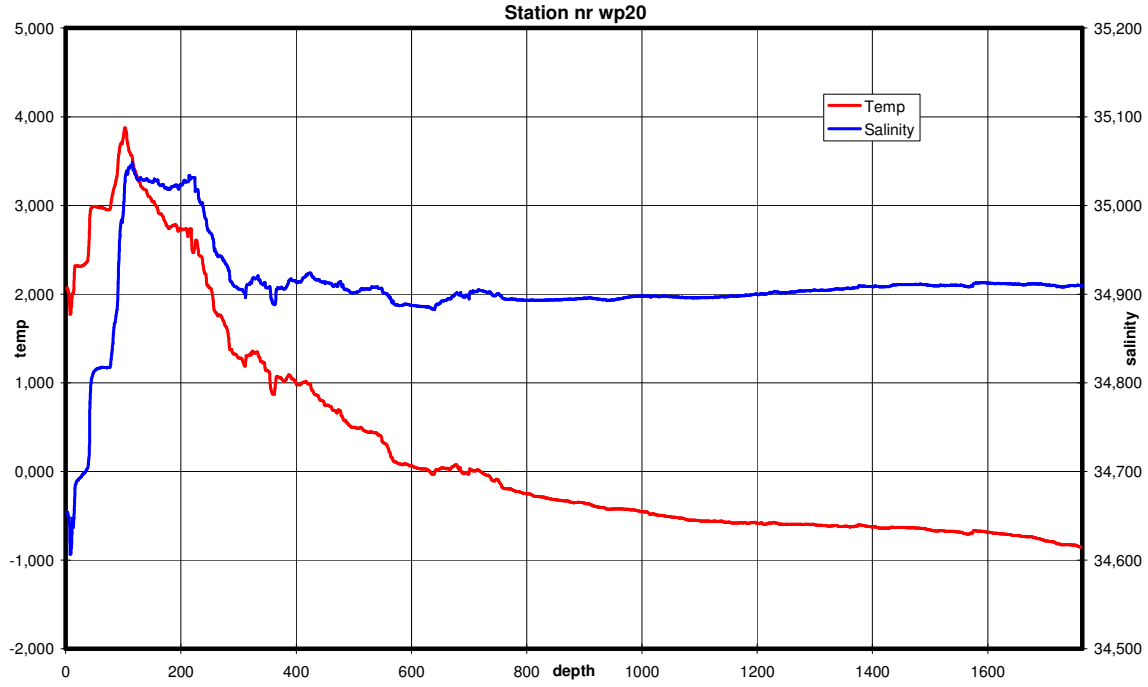
Station JM06-WP-15 (same site as JM06-WP-16 MC)



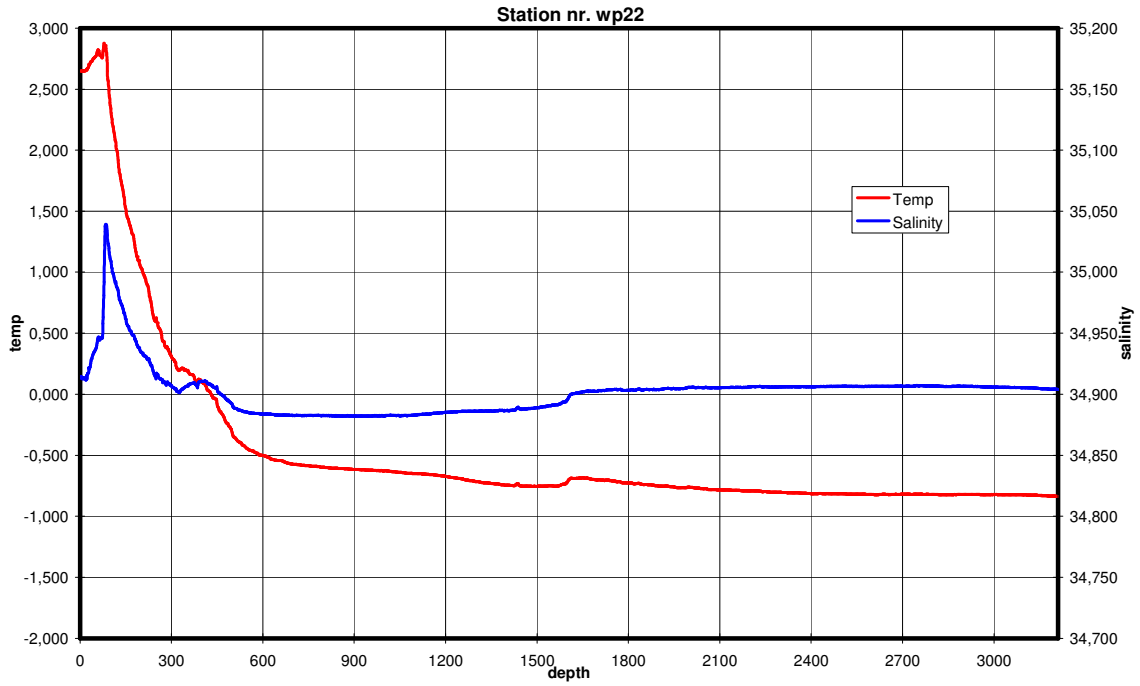
Station JM06-WP-18 (same site as JM06-WP-19 MC)



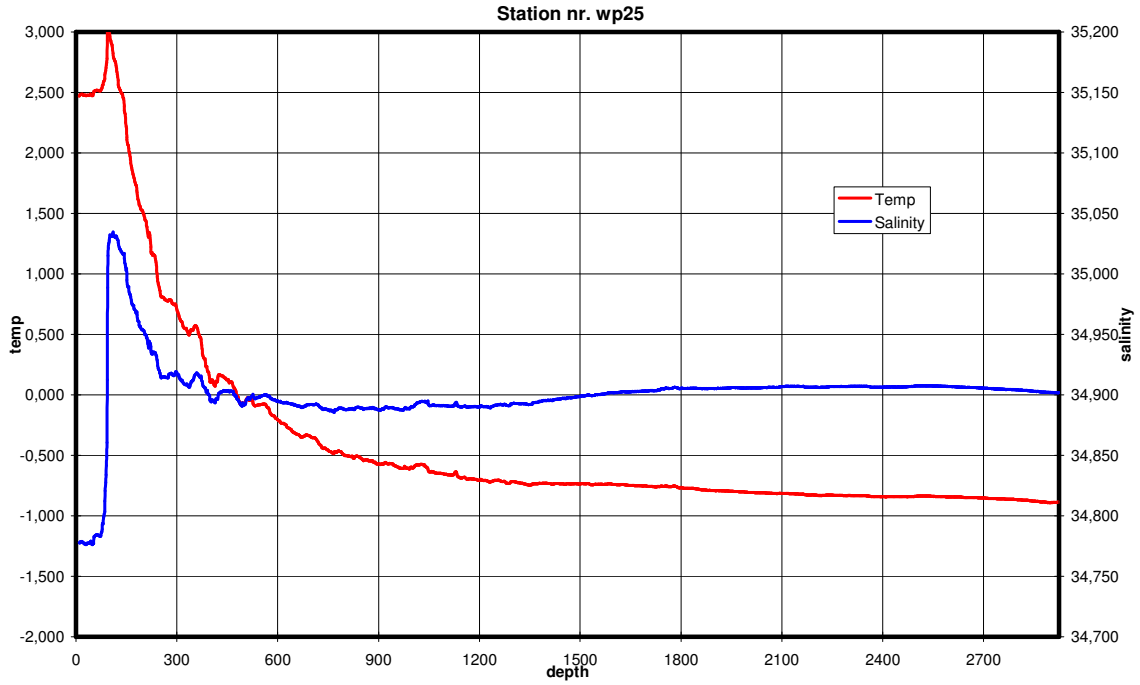
Station JM06-WP-20 (same site as JM06-WP-21 MC)



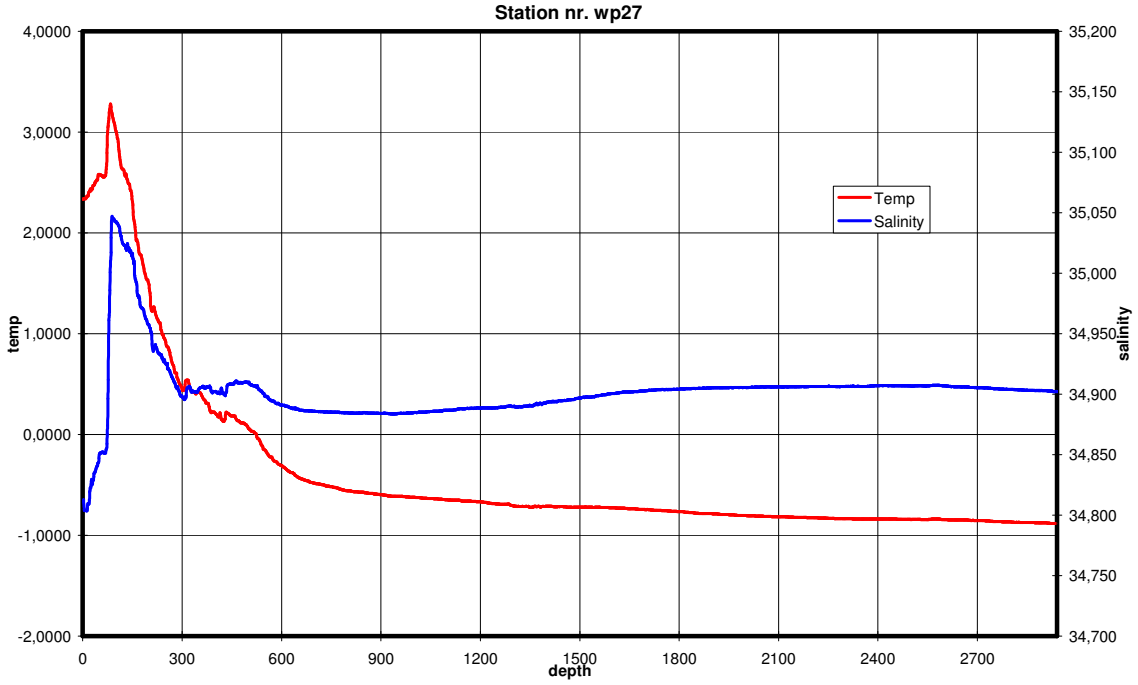
Station JM06-WP-22 (same site as JM06-WP-23 MC)



Station JM06-WP-25 (same site as JM06-WP-24 MC)



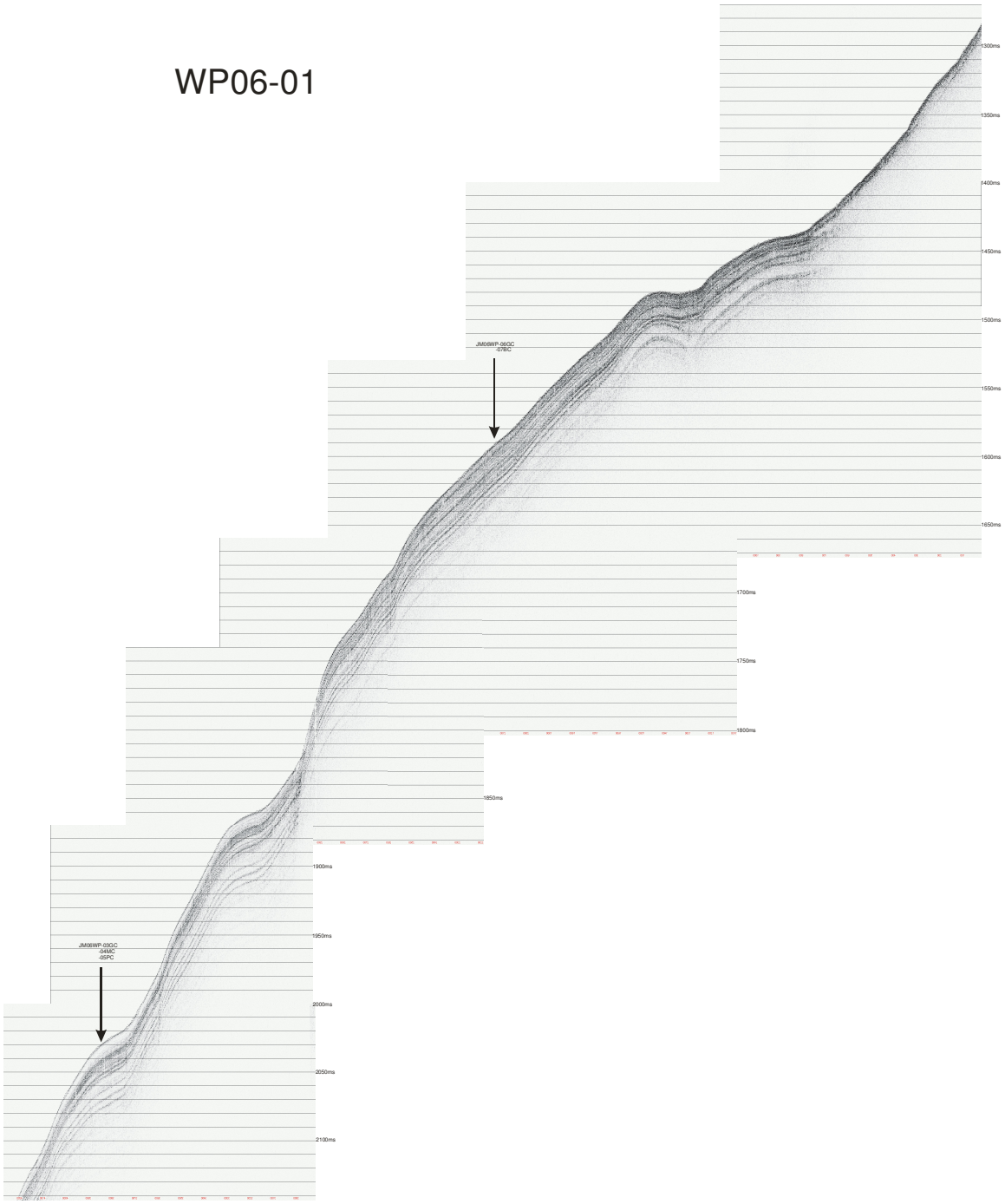
Station JM06-WP-27 (same site as JM06-WP-26 MC)



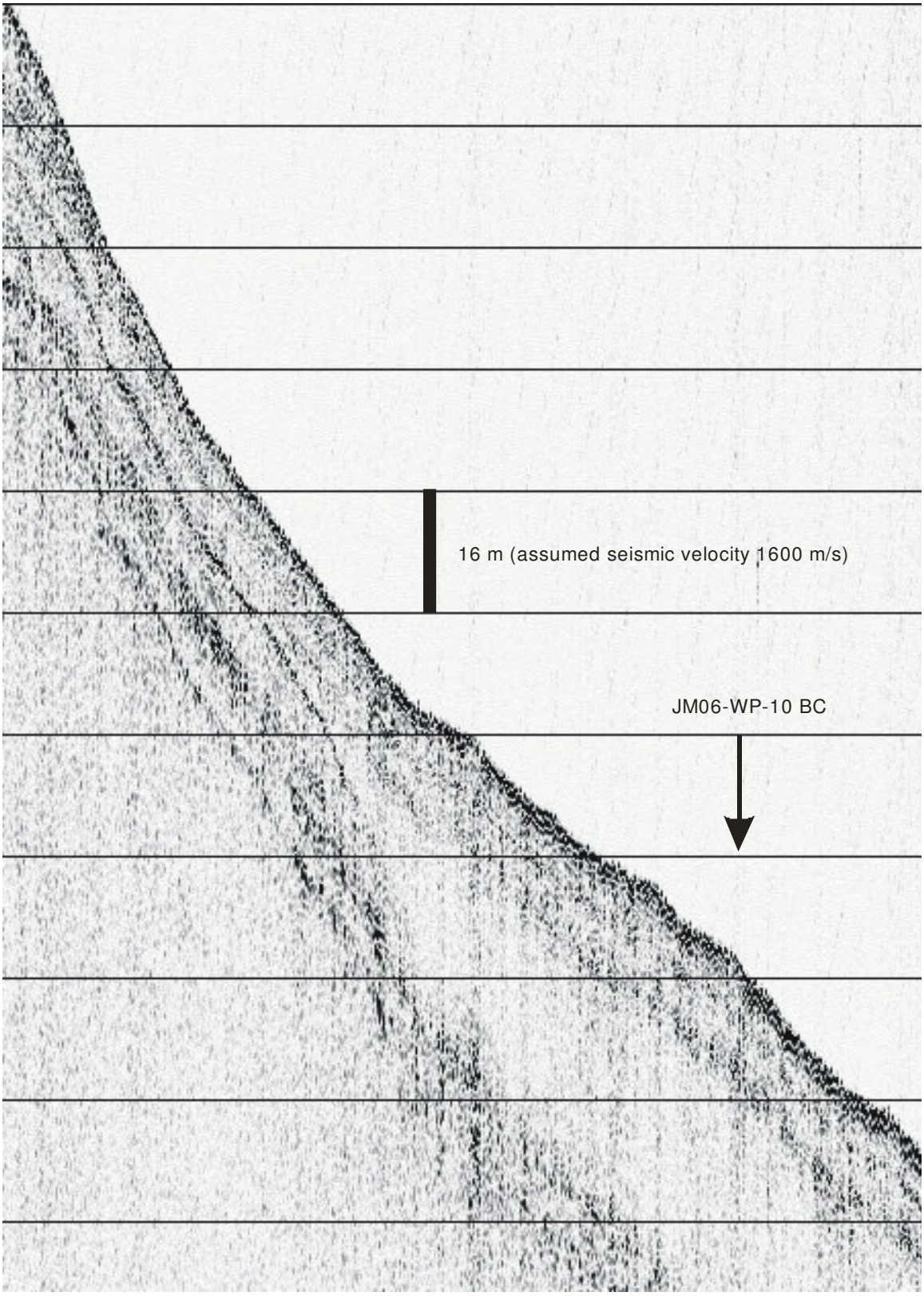
APPENDIX 7

3.5 kHz penetration echo sounder profiles from the stations

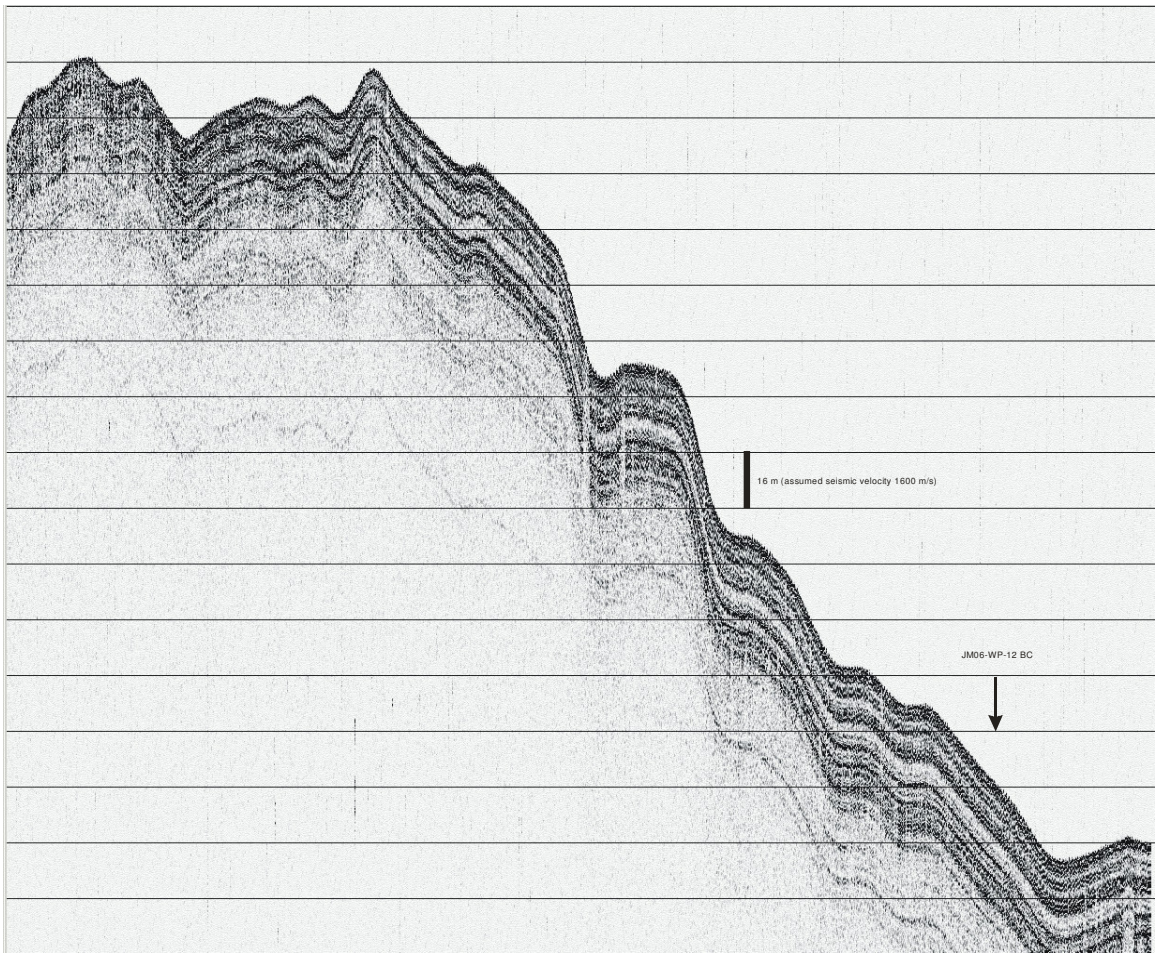
St. JM06-WP-03 GC, St. JM06-WP-04 MC, St. JM06-WP-06 GC, St. JM06-WP-07 BC, St. JM06-WP-08 PC



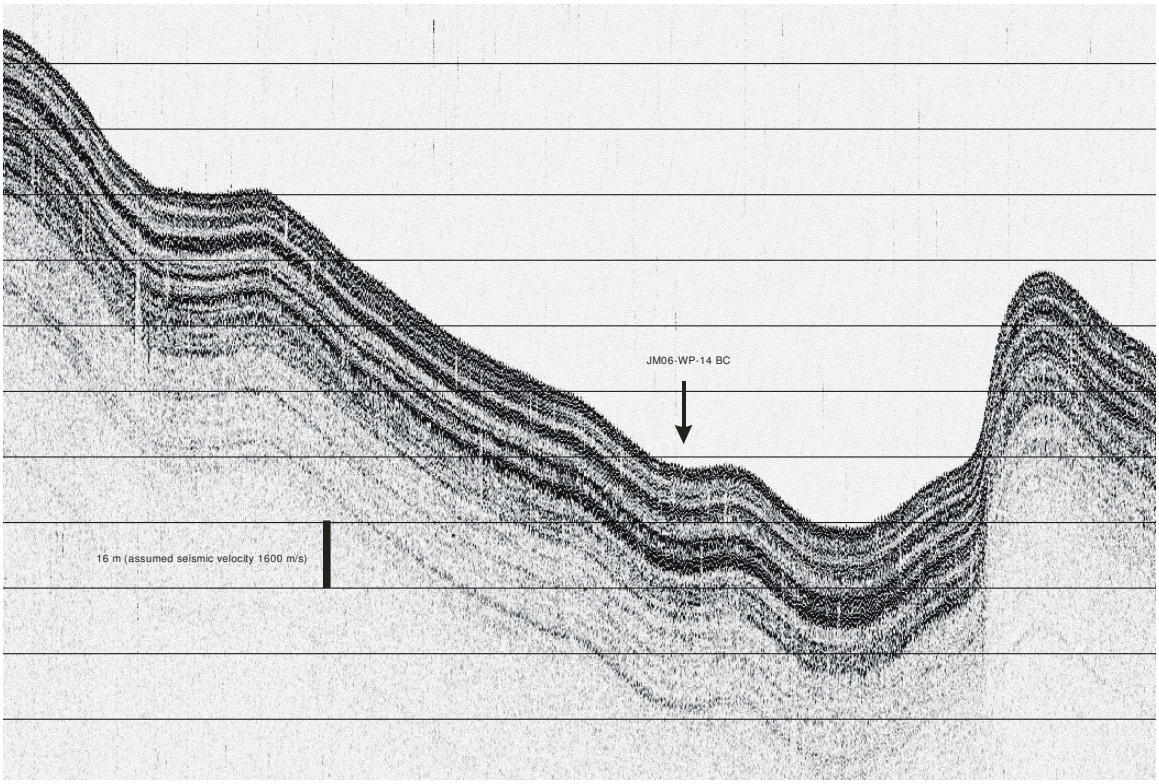
St. JM06-WP-10 BC



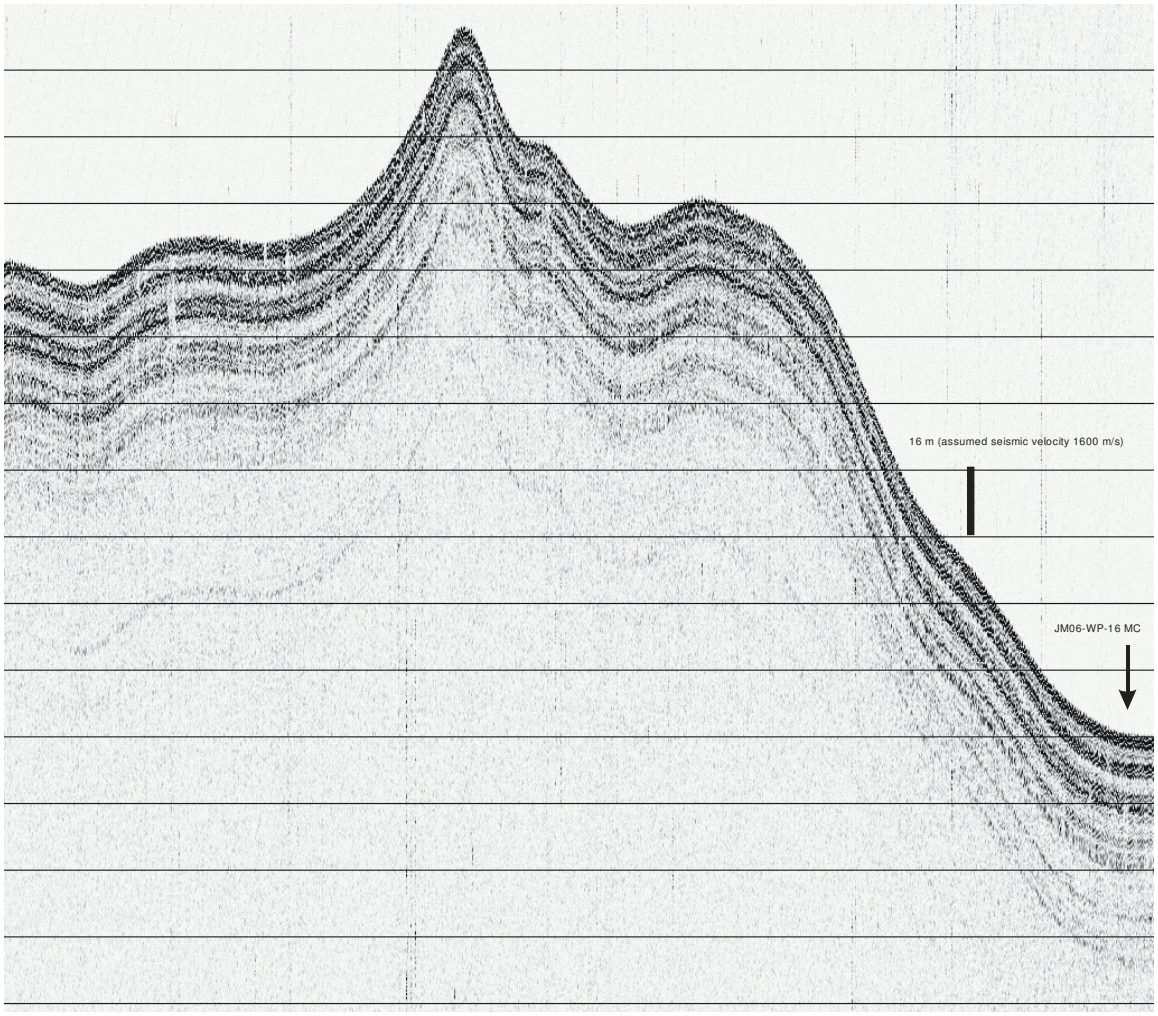
JM06-WP-12 BC



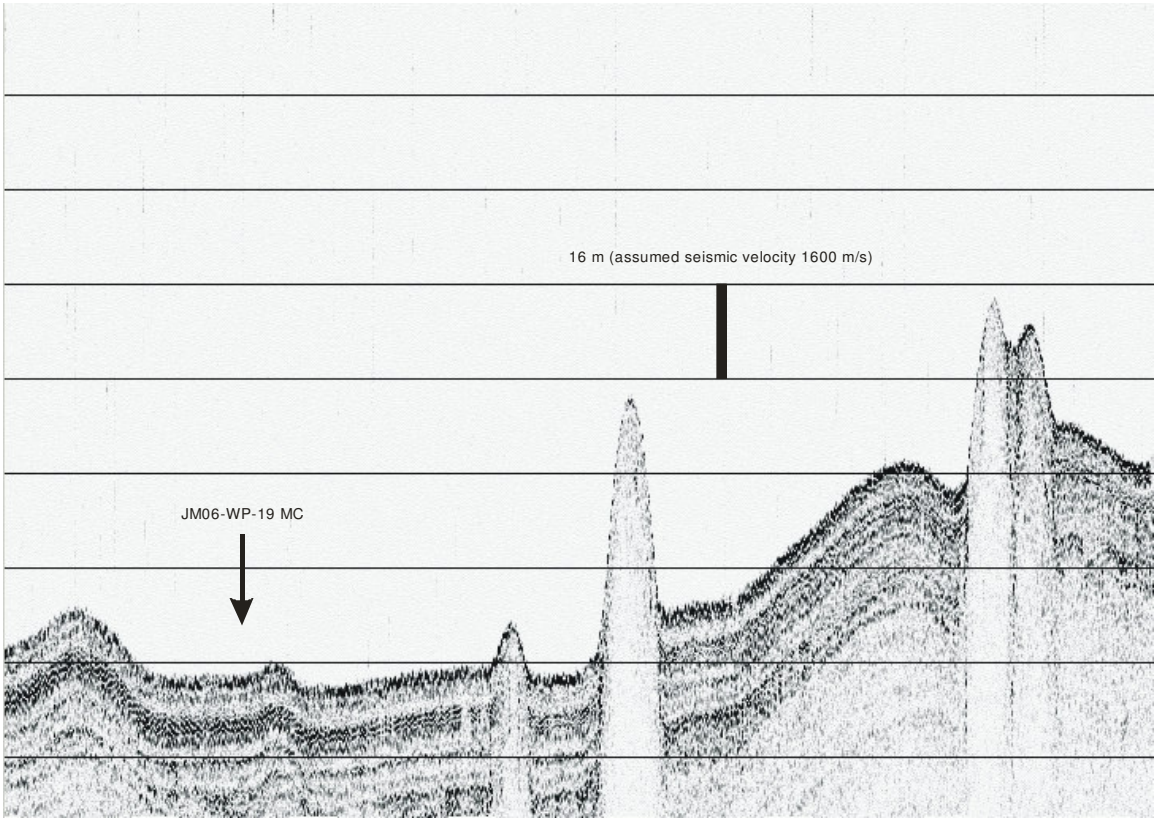
JM06-WP-14 BC



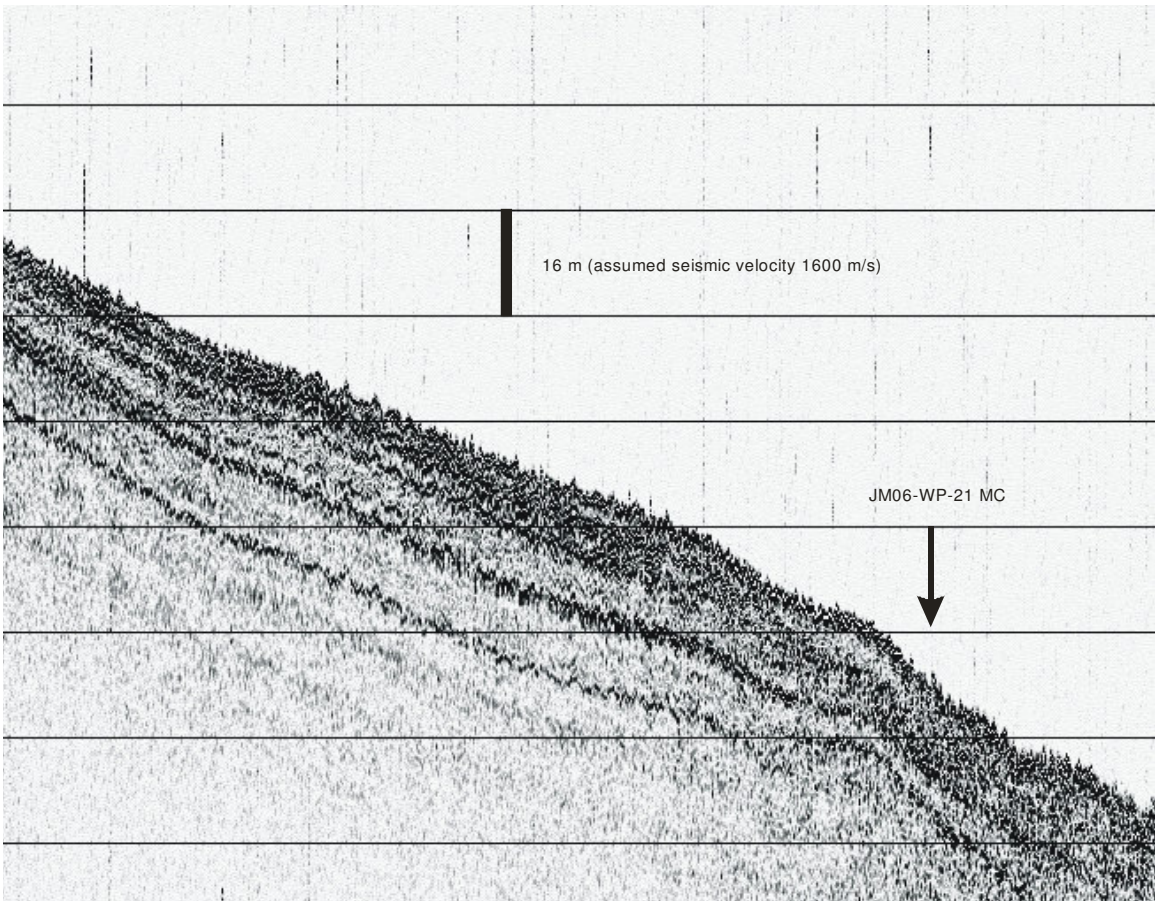
JM06-WP-16 MC



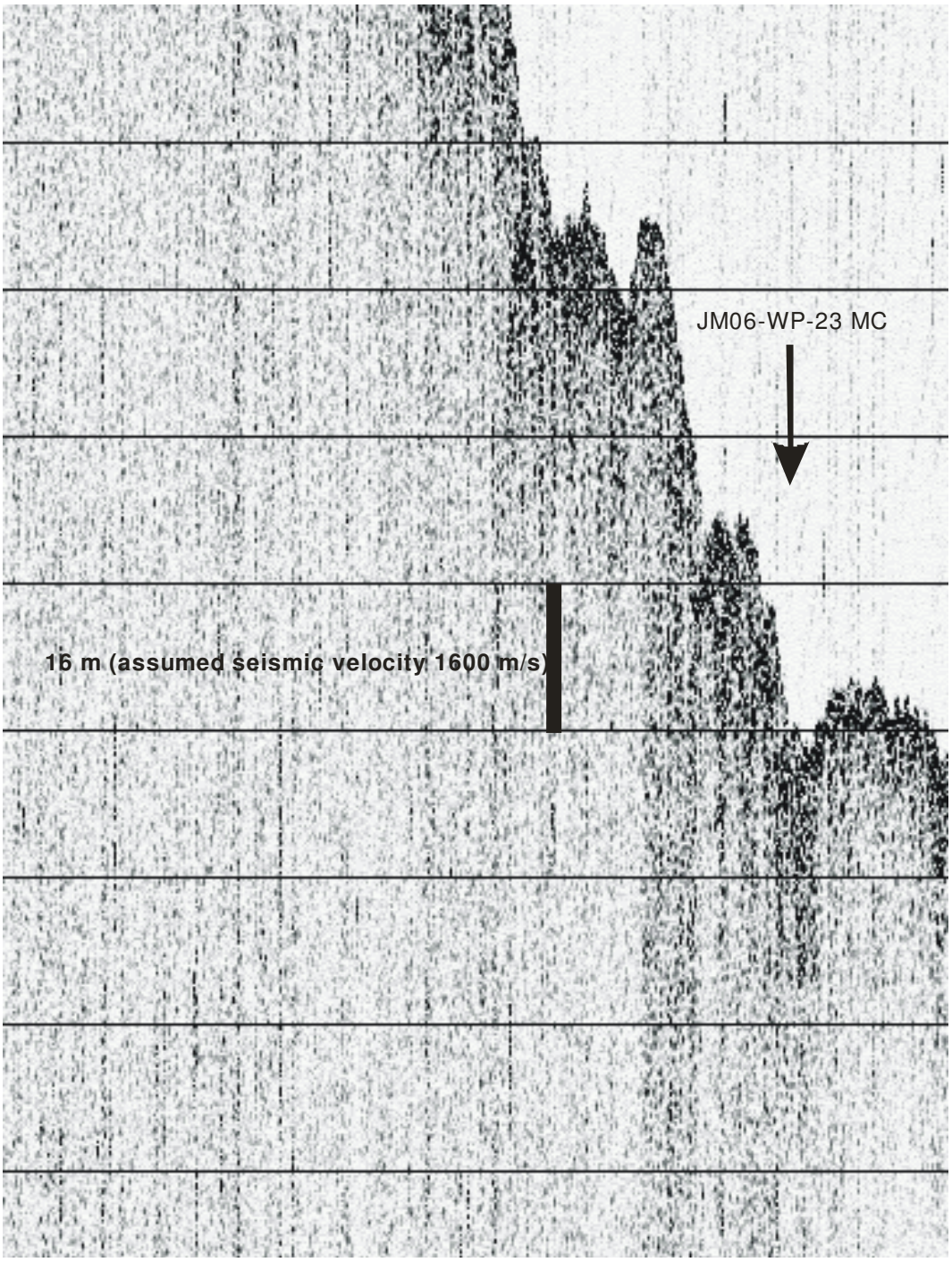
JM06-WP-19 MC



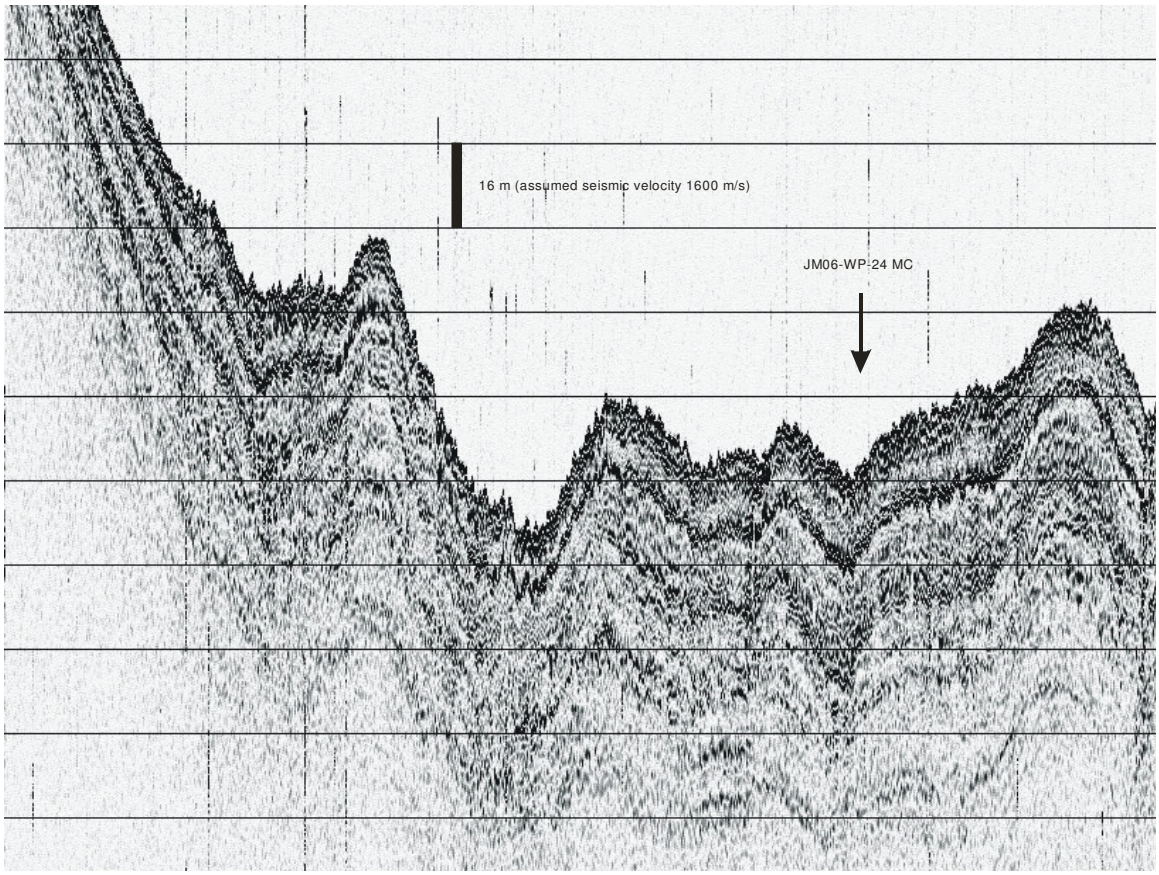
JM06-WP-21 MC



JM06-WP-23 MC



JM06-WP-24 MC



JM06-WP-26 MC