Oceans 2025 Arctic Cruise Report

ICE CHASER II
(CHAnging Sea-ice and Ecosystem Response)

RRS James Clark Ross (JR219)

13 June to 22 July 2010

Raymond J. G. Leakey
Principle Scientist

CONTENTS

ACKNOWLEDGEMENTS

This research cruise could not have been undertaken without the efforts of a large number people located in several organisations within both the UK and abroad. I am grateful for the help and assistance of all those involved including: the Master Graham Chapman, officers and crew of the *James Clark Ross*; the scientists and technical support staff of cruise JR219; Chris Hindley, Julia Fear and the staff of the British Antarctic Survey, Cambridge; the staff of National Marine Facilities, Southampton; the staff of the Scottish Association for Marine Science, Oban.

I am also grateful to the UK Natural Environment Research Council for funding the research cruise via the Oceans2025 strategic marine research programme, and the Norwegian and Danish diplomatic authorities for granting permission to travel and work in Svalbard and Greenland coastal and offshore waters.

SCIENTIFIC AND TECHNICAL PERSONNEL

Person	Responsibility
Ray Leakey [1,2,3,4]	PSO
Colin Griffiths [1,2,3,4]	Physics CTD & moorings
Estelle Dumont [1,2,3,4]	Physics: CTD & moorings
Timothy Boyd [3,4]	Physics: Turbulent mixing
Mark Inall [4]	Physics: Turbulent mixing
Bernard Hagan [2]	Physics: Sea-ice moorings
Edward Steele [3,4]	Physics: Turbulent mixing
Katherine Woollard [1]	Physics: salinity:$\delta^{18}O$ relationships
Alexey Pavlov [3]	Physics: bio-opticical properties
Heather Bouman [2,3]	Biology: light & phytoplankton
Thomas Jackson [1]	Biology: light & phytoplankton
Eithne Tynan Pascual [1,2,3]	Biology: primary production and calcification
Eric Fouilland [1]	Biology: autotroph-heterotroph coupling
Emily LeFloc'h [1,2,3]	Biology: light & phytoplankton
Debra Brennan [1,2,3]	Biology: autotroph-heterotroph coupling
Michael Zubkov [1]	Biology: heterotrophic microbial processes
Ross Holland [1]	Biology: heterotrophic microbial processes
Elaine Mitchell [2,3]	Biology: heterotrophic microbial processes
Sian Lordsmith [1,2,3,4]	Biology: heterotrophic microbial processes
Sharon McNeill [1,2]	Biology: bacterial production and nutrients
Elena Garcia Martin [1,2,3]	Biology: Respiration and production
Daniel Vogedes [3]	Biology: zooplankton
Jennifer Riley [1,2,3,4]	Geochemistry: carbon export
Ronnie Glud [2]	Geochemistry: sea-ice O_2 and CO_2 dynamics
Søren Rysgaard [2]	Geochemistry: sea-ice O_2 and CO_2 dynamics
Kunuk Lennert [2]	Geochemistry: sea-ice O_2 and CO_2 dynamics
Gavin Turner [2,3,4]	Geochemistry: sea-ice O_2 and CO_2 dynamics
Helen Atkinson [1,2,3]	Geochemistry: sea-ice trace gases
Timothy Brand [3]	Geochemistry: particle flux and nutrients
Richard Abell [3,4]	Geochemistry: particle flux
Henrik Stahl [3,4]	Geochemistry: benthic landers
John Montgomery [1,2,3,4]	Geochemistry: benthic landers
Andy Reynolds [4]	Geochemistry: benthic landers
Dan Mayor [3]	Geochemistry: sediment C and N cycling
Heiko Moossen [1,2,3,4]	Geochemistry: biomarkers
John Howe [4]	Palaeocenography: sediment records
Robert Spielhagan [4]	Palaeocenography: sediment records
Torben Struve [4]	Palaeocenography: sediment records
Jill McColl [4]	Palaeocenography: sediment records
Jason Scott [4]	Technical Support: piston coring
Alan Sherring [4]	Technical Support: piston coring
Hugh Brown [2]	Technical support: diving
Simon Thurston [2]	Technical support: diving
Jeremy Robst [1,2,3,4]	Technical Support: IT
Paul Woodroffe [1,2,3,4]	Technical Support: engineering
Luke Collings [1]	Technical Support: engineering trainee
Richard Hollingham [2]	Media: BBC World Service

1 = Leg 1 (13 to 19 June 2010); 2 = Leg 2 (20 June to 2 July 2010);
3 = Leg 2 (3 to 12 July 2010); 4 = Leg 4 (13 – 22 July 2010).

SHIPS PERSONNEL

Person	Responsibility
Graham P Chapman	Master
Timothy S Page	Chief Officer
Simon D Evans	2nd Officer
Benjamin J Du Feu	3rd Officer
John W Summers	Deck Officer
Charles A Waddicor	ETO (Comms)
David J Cutting	Chief Engineer
Glynn Collard	2nd Engineer
James C Ditchfield	3rd Engineer
Steven J Eadie	4th Engineer
Simon A Wright	Deck Engineer
Nicholas J Dunbar	ETO (Eng)
James S Gibson	Purser
Joe Gregory	Doctor
George M Stewart	Bosun
Derek G Jenkins	Bosun's Mate
Clifford Mullaney	SG1
Paul G Backhouse	SG1
John P O'Duffy	SG1
James F McLhatton	SG1
David W Triggs	SG1 (13 -19 June)
Andrew C Campbell	SG1 (20 June to 22 July)
Mark A Robinshaw	MG1
Carl J Moore	MG1
Keith A Walker	Cook
Glen R Ballard	2nd Cook
Kenneth Weston	Steward
James Newall	Steward
Derek W Lee	Steward
Thomas R Patterson	Steward

INTRODUCTION AND OBJECTIVES

The ICE CHASER II (CHAnging Sea-ice and Ecosystem Response) research cruise was undertaken as part of the UK Natural Environment Research Council Oceans2025 strategic marine strategic research programme. The cruise was organised and led by the Scottish Association for Marine Science (SAMS) as part of the SAMS Oceans2025 research topic "*Arctic and Boreal Seas in a Rapidly Changing Climate*". Research scientists participated in the cruise from several UK and international institutions including the Arctic and Antarctic Research Institute (Russia), the Institute of Natural Resources (Greenland), the Leibniz Institute of Marine Sciences (Germany), the Norwegian Polar Institute, the University of Montpellier (France), the University of Vigo (Spain), the UK National Oceanographic Centre (NOC) and the UK Universities of Aberdeen, East Anglia, Glasgow, Oxford, and St Andrews. The research vessel, officers, crew and ships technical support were provided by the British Antarctic Survey (BAS).

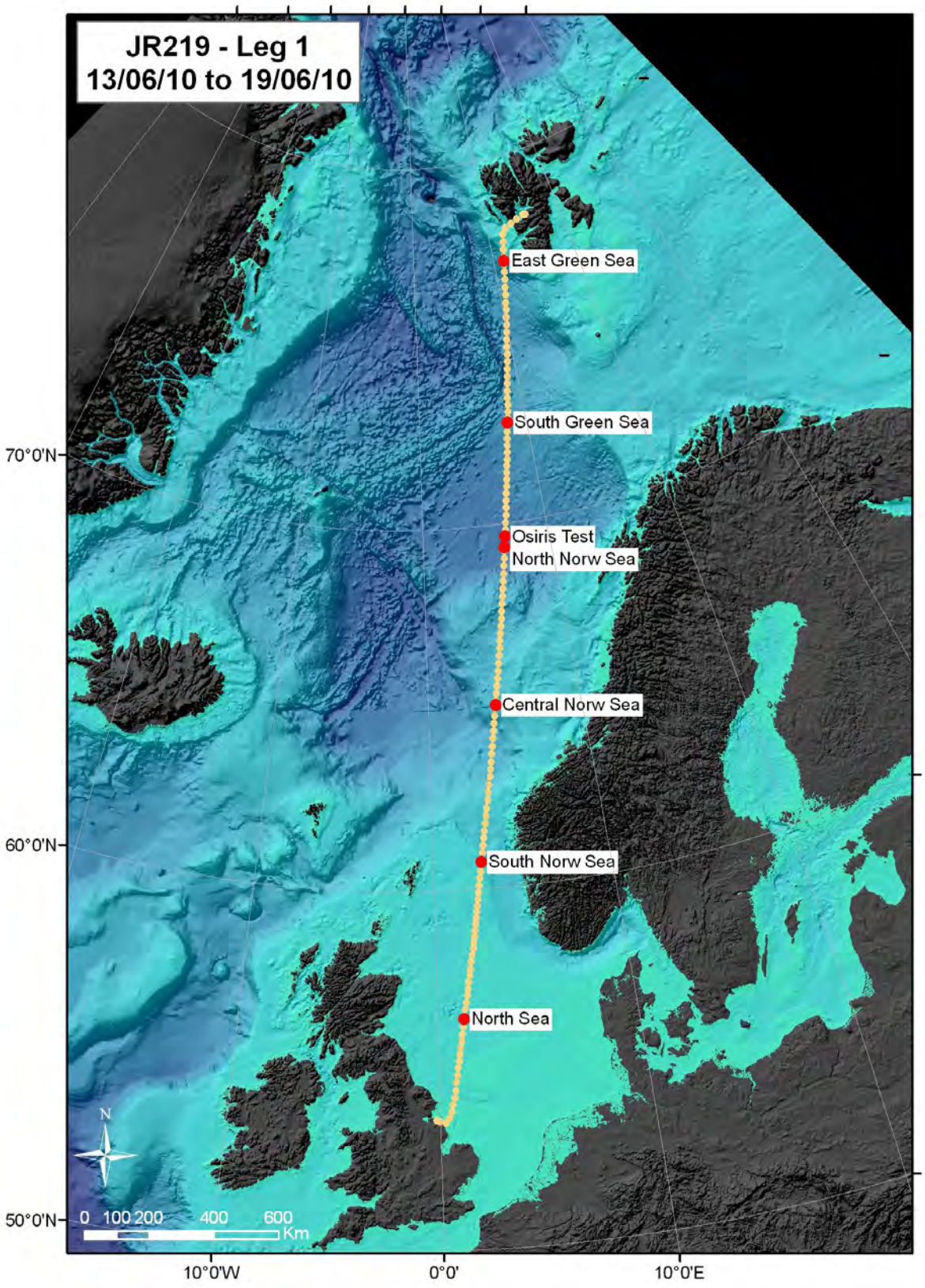
The overall scientific objective of research cruise was to improve understanding of how changing sea ice and water column structure influence Arctic ecosystem structure and function, and subsequent biologically derived carbon export, and thereby help refine models of ecosystem response to environmental change.This was achieved by delivering novel and comprehensive observational and experimental data sets on sympagic, pelagic and benthic biogeochemical parameters in the Greenland Sea and Svalbard shelf waters during the Arctic summer (see table below). A comparative approach was adopted with multidisciplinary studies focused on stations in open waters, marginal ice zone and full ice covered environments (see maps below). Physical oceanographic and palaeo-oceanographic observations were also undertaken to examine (i) mixing in the region of the Atlantic Water boundary and (ii) Holocene variability in sea ice, glacial extent and the northward transport of North Atlantic Water around western Svalbard. Additional studies were conducted during transit from the UK to Svalbard.

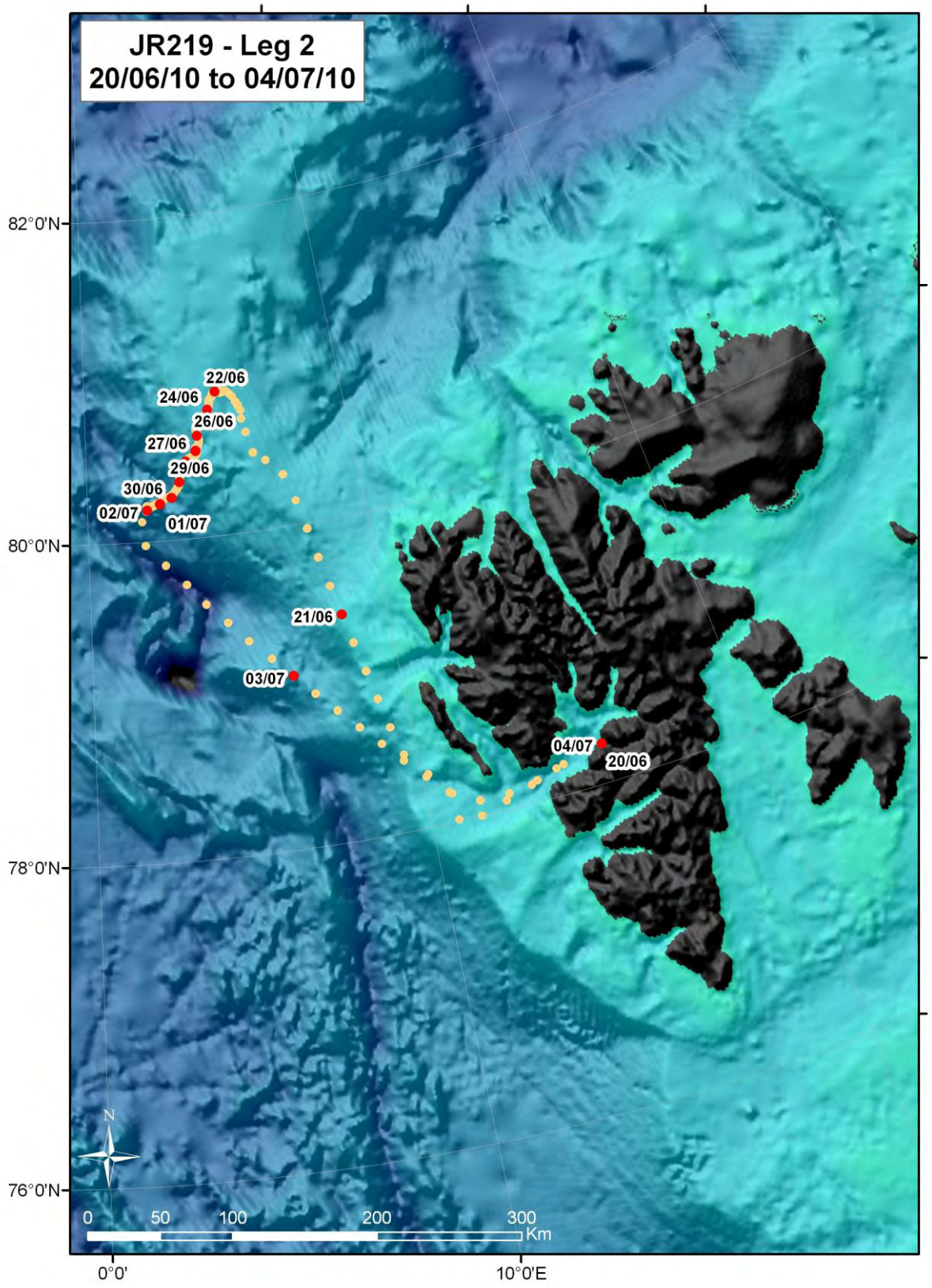
SUMMARY ITINERARY AND MAPS

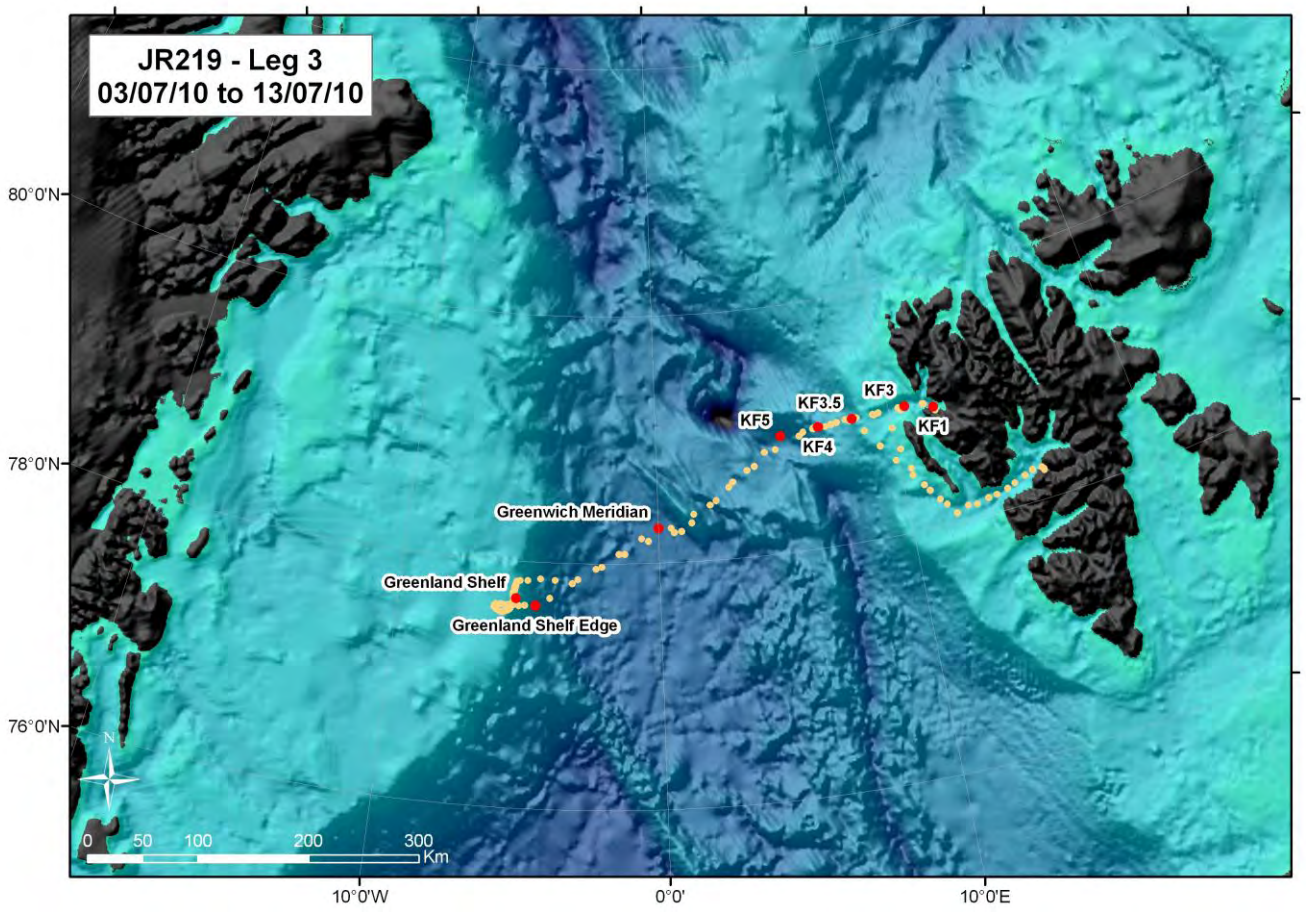
- Sailed from Immingham at mid-afternoon of the 13 June 2010.
- Commenced Leg 1 science activities in North Sea at 18.48 on the 13 June 2010.
- Arrived Longyearbyen, Svalbard on the19 June 2010.
- Commenced Leg 2 science activities in sea-ice of the north Greenland Sea on the 22 June 2010.
- Returned to Lonyearbyen for science staff exchange on the 2 July 2010.
- Commenced Leg 3 science activities in open water and sea-ice of west Svalbard and the Greenland Sea on the 4 July 2010.
- Commenced Leg 4 science activities off west and north Svalbard on the 14 July 2010.
- Concluded science activities at Isfjord Banken off west, Svalbard at 02.21 on the 21 July 2010.
- Returned to Lonyearbyen for science staff exchange and end of research cruise on the 21 and 22 July 2010
- Docked and demobilised at Peterhead on morning of 29 July 2010.

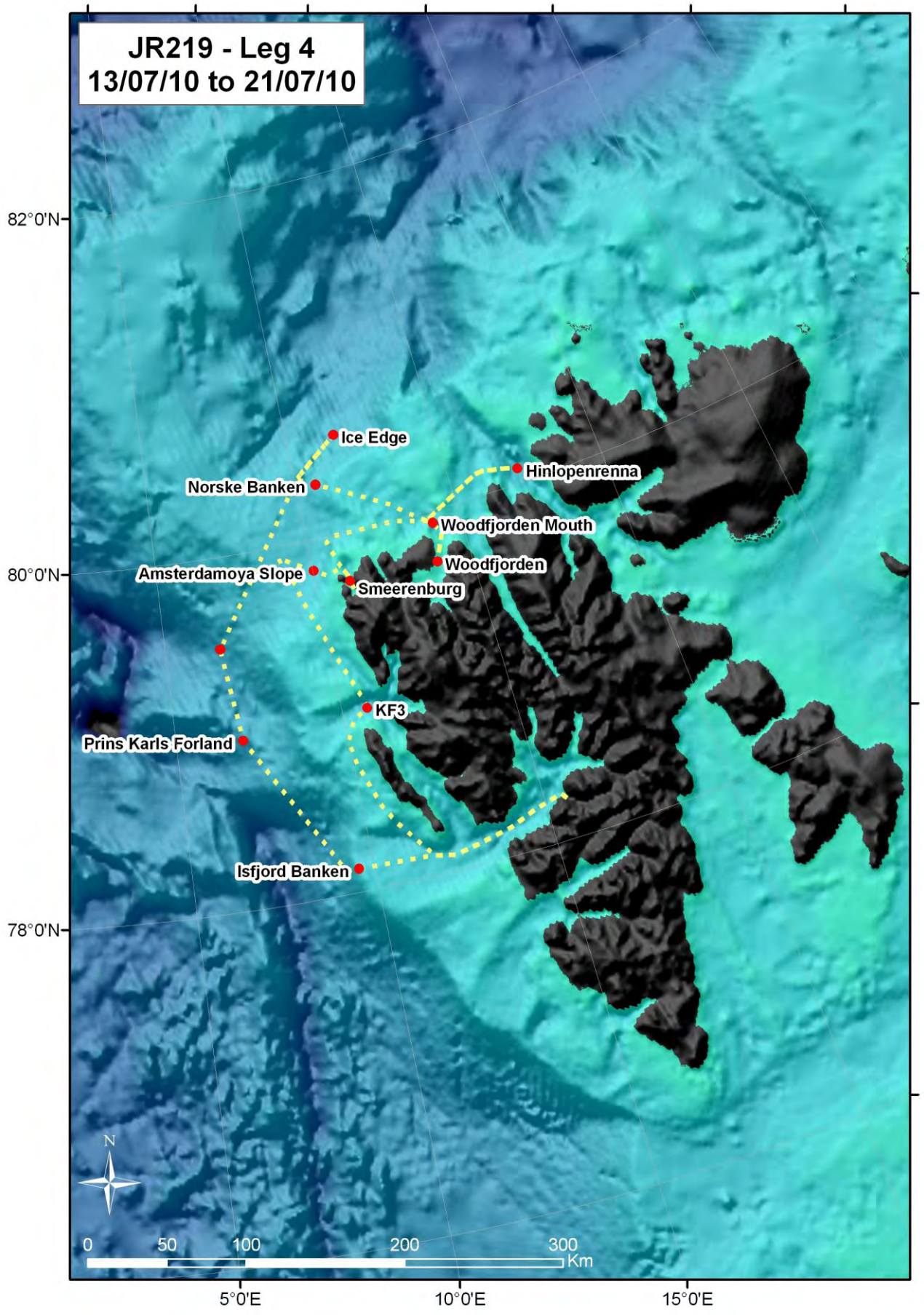
Sympagic, pelagic and benthic biogeochemical variables in Svalbard shelf waters measured during JR210

Sea-ice	Water Column	Sediment
Temperature and bulk salinity	Temperature and salinity	Seabed mapping (EM120 multibeam)
Ice-ocean heat flux	Turbulant mixing by CTD, AOV and MSS	Seabed bottom profiling (TOPAS)
Total alkalinity	Dissolved oxygen and δ^{18}oxygen	Dissolved inorganic carbon
Dissolved inorganic carbon	Optical properties and absorbance	*In situ* oxygen profiles and flux
pCO_2 and oxygen	Organic and inorganic nutrients	*In situ* carbon and nutrient flux
Bubble volume	Chlorophyll *a* and phytoplankton pigments	Sulphate reduction
Carbonate crystals	Phytoplankton composition, abundance and biomass	Trace metal concentration
Inorganic nutrients	Photosynthetic efficiency and P/E curves	Chlorophyll concentrations
Chlorophyll *a*	Primary production and DOC production	Particulate CHN, porosity and particle size
Primary production	Calcification and DIN-uptake	Pore water nutrients
Bacterial abundance	Bacterial composition and abundance	Accumulation/sedimentation rate (^{210}Pb and ^{226}Ra)
Bacterial production	Bacterial production and metabolic diversity	^{13}C and ^{15}N uptake
Protozoan composition, abundance and biomass	Protozoan composition, abundance and biomass	Geochemical biomarkers
Under-ice irradiance and PAM fluorescence	Respiration and community production	Benthic foraminifera
Under-ice horizontal flow velocity	Viral lysis and lysogeny	^{13}C and $^{16/18}$O isotopes
Under-ice oxygen fluxes	Protozoan grazing (bacterivory and herbivory)	High resolution sediment archives
Halocarbon trace gases	Zooplankton community structure and lipids	
Geochemical biomarkers	Suspended particles and aggregates	
Natural radionuclides	Particle flux (^{210}Po/^{210}Pb and ^{226}Ra)	
	Geochemical biomarkers	


JR219 - Leg 1
13/06/10 to 19/06/10
East Green Sea
South Green Sea
Osiris Test
North Norw Sea
Central Norw Sea
South Norw Sea
North Sea
70°0'N
60°0'N
50°0'N
10°0'W
0°0'
10°0'E
N
0 100 200 400 600
Km


JR219 - Leg 2
20/06/10 to 04/07/10
82°0'N
80°0'N
78°0'N
76°0'N
0°0'
10°0'E
22/06
24/06
26/06
27/06
29/06
30/06
02/07
01/07
21/06
03/07
04/07
20/06
N
0
50
100
200
300
Km


JR219 - Leg 3
03/07/10 to 13/07/10
80°0'N
78°0'N
76°0'N
KF3
KF3.5
KF5
KF4
KF1
Greenwich Meridian
Greenland Shelf
Greenland Shelf Edge
N
0 50 100 200 300
Km
10°0'W
0°0'
10°0'E


JR219 - Leg 4
13/07/10 to 21/07/10
82°0'N
80°0'N
78°0'N
Ice Edge
Norske Banken
Hinlopenrenna
Woodfjorden Mouth
Woodfjorden
Amsterdamoya Slope
Smeerenburg
KF3
Prins Karls Forland
Isfjord Banken
N
0
50
100
200
300
Km
5°0'E
10°0'E
15°0'E

NARRATIVE

Ray Leakey

All times given in GMT.
(Local time = GMT+1 h until 2 am on 17/6/10, GMT+2 h until 2 am on 25/7/10, GMT+1h thereafter)
Sea surface temperature readings taken from mid-day underway water supply reading.

Wednesday 9 June

Mobilisation in Immingham. Paul Woodrooffe joins ship.

Thursday 10 June

Mobilisation in Immingham. Emilie LeFoc'h, Eric Fouilland, Estelle Dumont, Colin Griffiths, Ray Leakey, Sharon McNeill and Sian Lordsmith join ship.

Friday 11 June

Mobilisation in Immingham. Debi Brennan, Eithne Tynan, Elena Garcia, Helen Atkinson, Jeremy Robst, John Montgomery, Luke Collings, Mike Zubkov, Ross Holland and Tom Jackson join ship.

Saturday 12 June

Mobilisation in Immingham. Heiko Moossen, Jenny Riley and Kate Woollard join ship.

Sunday 13 June (Leg 1)

Weather: Grey overcast sky with rain at times
Local time = GMT + 1 hr.
Start of cruise. Completed mobilisation and departed Immingham quay at 14.34, passed through Immingham lock and into the Humber estuary at 15.14. *JCR* headed north into North Sea past oil rigs in calm sea. Underway water sampling started at 18.30.

Monday 14 June

Weather: Calm to moderate sea and generally sunny
Sea surface temp: ~12^{o}C
Arrived at the North Sea station (56^{o}24.71N 01^{o}18.85 E) at 08.00 to collect water for first experiments and "shakedown" station tests. Two pelagic CTD casts (No 1 & 2) conducted starting at 08.00 in water column depth of 84 m, and completed at 09.30. Rest of day spent heading north and processing data with continued underway water sampling.
Total of 1 hr and 30 minutes stoppage added to journey north to Longyearbyen.
Eithne Tynan's birthday

Tuesday 15 June

Weather: Calm sea and lightly overcast after moderate sea overnight.
Sea surface temp: ~11^{o}C
JCR continued north passing several oil rigs and entering Norwegian waters. Arrived at the Southern Norwegian Sea station (Viking Bank) at (60^{o}44.58N 02^{o}43.67 E) 09.20. Two pelagic CTD casts (No 3 & 4) conducted starting 09.20 in water column depth of 117 m and completed at 10.34. These CTDs were later than planned due to delay in receiving hard copy of Norwegian diplomatic clearance. Continued north in calm sea with sunshine.

Total of 1 hr and 15 minutes added to stoppage on journey north to Longyearbyen.

Wednesday 16 June

Weather: Misty start to day with moderate seas.
Sea surface temp: ~10^{o}C
Arrived at the Central Norwegian Sea station at 07.32 (65^{o}02.42N 04^{o}24.05 E). Two pelagic CTD casts (No 5 & 6) conducted starting 07.32 in column depth of 995m. These were followed by a test of the Snow Catcher particle flux samplers completed at 09.18. Continued north in calm seas and lightly overcast, crossing Arctic Circle at 16.49 GMT. Repairs to underway system were undertaken during day which necessitated temporary shut-down.
Total of 1 hr and 46 minutes added to stoppage on journey north to Longyearbyen.

Thursday 17 June

Weather: Grey overcast with light rain in morning. Calm sea.
Sea surface temp: ~7^{o}C
At 02.00 *JCR* clocks set forward 1 hour to Svalbard local time.
Arrived at the Northern Norwegian Sea station (69^{o}20.47 N 06^{o}22.45 E) at 06.30. Two pelagic CTD casts (No 7 & 8) conducted starting 06.30 in water column depth of 3246m. These were followed by a second test of the Snow Catchers, and a test of the lander floats and communication system (down to 1500m depth) completed at 09.45 (3 hr and 45 minutes stoppage). The *JCR* continued north and arrived at the OSIRIS test station (69^{o}38.34 N 06^{o}31.90 E) where the OSIRIS *in situ* incubation rig was deployed to 1500m at 11.27. The test was completed at 14.02 (2 hr and 35 minutes stoppage). The *JCR* continued north in calm seas. Ship's fire drill conducted at 14.30.
Total of 6 hr and 20 minutes added to stoppage on journey north to Longyearbyen.

Friday 18 June

Weather: Lightly overcast with moderate sea.
Sea surface temp: ~6^{o}C.
Arrived at the Southern Greenland Sea station (72^{o}45.32 N 08^{o}15.66 E) at 06.32. Two pelagic CTD casts (No 9 & 10) conducted starting 06.32 in water column depth of 2473m. This was follwed by the first Micronet deployment and a third Snow Catcher test as one of the two Snow Catcher samplers failed earlier tests. All deployements completed by 08.17. The *JCR* continued north in calm to moderate seas.
Total of 1 hr and 45 minutes added to stoppage on journey north to Longyearbyen.

Saturday 19 June

Weather: Lightly overcast but clear day with very little wind. Sea very calm.
Sea surface temp: ~3^{o}C.
Arrived at the East Greenland Sea station (77^{o}09.42 N 11^{o}17.55 E) at 06.34. Two pelagic CTD casts (No 11 & 12) conducted starting 06.34 in water column depth of 911m. This was followed by Micronet deployment and fourth successful Snow Catcher test. All deployments completed at 08.20. The *JCR* continued north to Longyearbyen with southern Svalbard hills visible to east and whales spotted in morning. Arrived and docked at Longyearbyen coal quay at about 16.30.
Total of 1 hr and 46 minutes added to stoppage on journey north to Longyearbyen.
Total time for UK to Longyearbyen = 6 days and 2 hours, with 14 hrs and 22 minutes stoppage.
Evening spent in Longyearbyen.

Sunday 20 June (Leg 2)

Weather: Calm and sunny.
Exchange of staff and equipment, including collection of skidoo, sledge and rifles from UNIS. Luke Collins, Eric Fouilland, Ross Holland, Tom Jackson, Kate Woollard and Mike Zubkov departed ship after breakfast. Heather Bouman, Ronnie Glud, Bernard Hagan, Richard Hollingham, Hugh Brown, Kunuk Lennert, Elaine Mitchell, Søren Rysgaard and Simon Thurston embarked ship mid-morning. The *JCR* departed Longyearbyen at 11.00 and sailed west out of Isflord, then north up the west coast of Svalbard in calm seas. Cruise meeting held in evening.
Estelle Dumont's birthday.

Monday 21 June

Weather: Misty in morning with sunny spells, cold wind and ice-associated mist later in the day. Continued north with air temperature now down to -2°C. First sea-ice encountered at about 04.30 increasing in during morning. Polar bear prints spotted on ice. Prepared sea-ice sampling gear and planned sea-ice station logistics during the day whilst ship continued slowly north north-west into thicker ice looking for a large solid flow on which to set up an ice station. Eventually encountered suitable flow (about 500 to 1000 m diameter at 80°53.00 N 05°21.15 E) in late afternoon and tried to lock *JCR* into the ice which subsequently broke under pressure from ship. Laid ship off the ice flow during the evening and night to examine change in flow condition and stability.

Tuesday 22 June

Weather: Clear sunny day with light north to north-easterly wind.
The *JCR* remained off flow during night drifting 3.2 miles to 80°55.44 N 05°01.56 E. At 06.14 the ship moved alongside flow and, after initiating bear observations, an ice team (Colin, Kunuk, Søren and Ronnie) was deployed onto the ice to test ice thickness with auger and take first cores. The ice was 1.2 to 1.7 m thick and found to be melting with a high percentage of water and lots of chlorophyll visible on filters. Conditions were therefore biologically suitable for biogeochemistry studies but physically unstable leading to possible ice break-up. The decision made to stay at the flow at 08.47, and the ship was anchored to the ice by rope mooring lines (completed at 11.26) but with continuous gentle propulsion to reduce pressure on lines and ice. This was followed by a full rifle test (Estelle, Colin, Kunuk and Søren) at 11.50.
At 12.31 a team was deployed onto the ice with skidoo to map out sampling sites on the flow (Estelle, Colin, Helen, Hugh, Kunuk, Ray, Ronnie, Søren). Helen took samples for trace gases and was then replaced by Simon. The team then started coring holes for eddy instruments and diver access. One dive hole was completed and GPS deployed by late afternoon. In the evening Gavin, John M, Kunuk, Ronnie and Soren deployed 2 of the 3 eddy under-ice landers. All tasks were completed by 18.59. No bears were sighted during the day but the first bear appeared in the evening at 20.32. Use of the ship's horn scared the bear but it stayed nearby until early hours of the next day.
Air temperatures at the ice station throughout the 10 day stay were generally between -2 and 1 °C. Sea surface temperature was ~1°C.

Wednesday 23 June

Weather: Misty morning but clear sunny day with light north-westerly wind.
The *JCR* remained moored to the ice flow with no problems and drifted 7 miles midday to midday. On ice: Ice coring and dive hole teams deployed onto ice. Then bear spotted at around 09.30 so recalled all teams. Bear passed ship. Both teams returned onto ice after lunch to complete coring holes (including second dive hole), finish eddy instrument deployment, and start deployment of the sea-ice physics instruments.

On ship: Pelagic CTDs (No 13 to 15) and Snow Catcher deployments were undertaken during the afternoon with sample processing.

Thursday 24 June

Weather: Misty day with occasional sunny spells and light northerly wind.
The *JCR* remained moored to the ice with no problems but with the edge of the ice melting. The ship had drifted about 6 miles to the south overnight to 80°42.48 N 04°20.73 E. During the night a bear visited at about 02.00, sniffed at the GPS gear and proves a problem to scare off with the ship's horn.
On Ice: Deployed under-ice water collection, eddy and APEX instrument teams. A medical evacuation drill was also undertaken, led by Joe, to remove a simulated diver casualty from the dive hole to the recompression chamber located in the ship's forward hold (this took 15 minutes). A polar bear sighting and bad visibility cancelled work mid-morning. Teams then returned to the ice in the early afternoon, and later in the afternoon Kunut and Simon undertook a first test dive observing and filming patches of under-ice algae. Eddy and APEX instrument teams continued working into the evening with some trace gas samples taken by Helen. A polar bear sighting and bad visibility again cancelled work around 18.00.
On ship: Pelagic CTDs (No 16 to 18) and Snow Catcher deployments were undertaken during the day with sample processing.

Friday 25 June

Weather: Misty day with light northerly wind.
The *JCR* remained moored to the ice with no problems but with ice continuing to melt. Ship drifted about 12 miles to the south overnight to 80°36.40 N 04°19.40 E.
On Ice: Bad visibility prevented ice work in the morning. After lunch eddy instrument and APEX teams deployed onto the ice.Trace gas sampling also undertaken. Work was prevented by bad visibility mid-afternoon but continued in the late afternoon and evening, including a second dive (Hugh and Heiko collecting algae).
On Ship: Pelagic CTD (No 19) and Snow Catcher in morning with sample processing.
Heiko's birthday.

Saturday 26 June

Weather: Overcast day with light northerly wind and visibility improving towards evening.
The *JCR* remained moored to the ice with no problems but some more ice cracks appearing. Ship drifted about 4 miles (some of the time to the north-east) to 80°31.88 N 04°12.74 E.
On Ice: During the morning under-ice water collection, mooring, and eddy instrument teams were deployed. By this stage all scientists had been on the ice. During the afternoon more mooring work was undertaken plus the collection of ice cores for radiochemical analysis. In addition, the third and fourth dives were undertaken by High and Kunuk (algal collection) and Hugh and Søren (algal collection/PAM measurements). During the evening trace gas samples and biomarker cores were collected, the under-ice light meter was tested in the dive hole, and media interviews were conducted by Richard.
On Ship: Pelagic CTDs (No 20 and 21) and Snow Catchers in morning with sample processing.

Sunday 27 June

Weather: Bright and sunny with light northerly wind and very good visibility.
The *JCR* remained moored to the ice with no problems drifting about 2 miles to 80°27.71 N 03°44.14 E by the morning.
On Ice: During the morning APEX and eddy instrument teams were deployed and collections made of trace gas samples and ice cores for radiochemical analysis. A polar bear sighting prevented work late morning. During the afternoon the fifth and sixth dives were undertaken by Ray and

Simon (light meter rope deployment and filming) and Kunuk and Søren (algal collection/PAM measurements), with eddy instrument measurements and ice core sampling continuing into the evening. The crew also had an opportunity to go onto the ice in the afternoon.
On Ship: Pelagic CTDs (No 22 and 23) and Snow Catchers in the morning, Micronet in afternoon, and sample processing.
Heather's birthday.

Monday 28 June

Weather: Misty with light northerly wind in morning, sunshine and very good visibility in afternoon.
The *JCR* remained moored to the ice with no problems drifting about 9 miles to 80°19.92 N 03°23.41 E by morning.
On Ice: No work was possible during the morning due to poor visibility. During the afternoon APEX and eddy instrument teams were deployed. In addition the seventh dive was undertaken by Heiko and Kunuk (trace gas and algal collections), then ice coring later in the afternoon. The crew again had an opportunity to go onto the ice in the afternoon.
On Ship: Pelagic CTDs (No 24 and 25) and Snow Catchers in morning, Micronet in afternoon, and sample processing.

Tuesday 29 June

Weather: Early sunshine with light northerly wind, followed by mist, sunshine and overcast.
The *JCR* remained moored to the ice with no problems drifting about 4 miles to 80°16.60 N 03°06.13 E by morning.
On Ice: Late morning under-ice water collection and coring. Also trace gas sample collection and eddy instrument work. During the afternoon and early evening under-ice light meter deployment was undertaken along with further media interviews and filming.
On Ship: Pelagic CTDs (No 26 to 29) and Snow Catchers in morning, Micronet in afternoon, and sample processing.

Wednesday 30 June

Weather: Sunny with a little mist and light northerly wind.
The *JCR* remained moored to the ice with no problems drifting about 6 miles to 80°14.07 N 02°33.49 E by morning.
On Ice: During the morning the last dive was undertaken by Hugh, Kunuk and Simon to collect samples and film the under-ice light meter. Trace gas samples were also collected and the retrieval of permanent equipment started. During the afternoon the last ice cores and under-ice water samples were collected, with continued equipment retrieval. The light meter was also recovered and redeployed in the evening.
On Ship: Pelagic CTD (No 30) and Snow Catchers in morning, and sample processing.

Thursday 1 July

Weather: Very misty during morning and into the afternoon.
The *JCR* remained moored to the ice but with ice moving round ship onto the port side. Ship had drifted about 5 miles to 80°12.03 N 02°10.29 E by morning.
On Ice: Poor visibility prevented work in the morning. During the afternoon the last items of equipment (mooring and light meter) were recovered. Aslo the last trace gas sampling and media filming/interviews. The site was then left clear of all equipment.
On Ship: Pelagic CTDs (No 31 and 32), Snow Catchers and Micronet in morning, and sample processing.
The *JCR* departed the ice station (moorings cast off) at 14.18 and headed to Longyearbyen. The last ice station position was 80°12.94 N 02°12.39 E and the last sea-ice was ecountered on route at about 16.00.

End of Leg 2 drinks in evening.

Friday 2 July

Weather: Calm seas, overcast.
The *JCR* continued south-east to Longyearbyen arriving at 14.36 and docking at the coal quay. Evening spent in Lonyearbyen.

Saturday 3 July (Leg 3)

Weather: Sunny at times.
Kunuk and Søren departed ship in the early hours of morning. Hugh, Richard, Ronnie, Sharon and Simon departed mid-morning. Alexey Pavlov, Daniel Vogedes, Edward Steele, Henrik Stahl, Richard Abell, Tim Boyd and Tim Brand joined ship and unpacked their gear. At 16.07 the *JCR* moved to main (new) Longyearbyen quay to take on zooplankton equipment and water. It then departed the main quay at 19:13 for station KF3 station in a calm sea.

Sunday 4 July

Weather: Bright but overcast with calm sea.
Arrive at the KF3 station (79°01.01 N 10°42.08 E) at 06.25 GMT with good views of Spitzbergen (Kongsfjord mouth) and Prins Karls Forland, and a relatively warm sea surface temperature of ~5°C. Two pelagic CTDs (Nos 33 to 35) and Snow Catcher collections were undertaken in the morning. The surface water warm (5°C) with cold (-1°C) sub-surface water. The Eddy lander was deployed successfully at 11.05 but the Elinor lander remained on deck due to problems. Megacoring started at 11.40 to collect sediment for stable isotope experiments and geochemistry analyses. The first megacore deployment was successful with soft sediment. Coring continued all afternoon and into the evening with the first sprectra optical measurements undertaken in afternoon. In the evening a deep CTD (No 36) was undertaken to collect bottom water for geochemistry analyses and the Elinor lander was deployed sucessfully at 19.32.

Monday 5 July

Weather: Bright but overcast with calm sea.
The *JCR* remained at the KF3 station with pelagic CTD (No 37) and Snow Catcher collections, spectal optical measurements and successfull AUV test deployment in the morning. In the afternoon the first zooplankton net samples were collected, a deep geochemistry CTD (No 38) undertaken and both landers retrieved successfully at 14.46. The ship then departed the KF3 station for the KF4 station with 3 physics CTDs (Nos 39 to 41) undertaken on route, arriving at the KF4 station (78°58.37 N 06°42.70 E) at 21.05. Both landers were then deployed by 21.45 in water depth of 1342m. Whales were observed close to ship.

Tuesday 6 July

Weather: Dull and overcast with calm sea.
The *JCR* remained at the KF4 station with pelagic CTD (No 42 and 43) and Snow Catcher collections, spectal optical measurements and a deep geochemistry CTD (No 44) undertaken in the morning. During the afternoon the ship returned to the previous night's physics CTD locations for an AUV survey (at 79°00.00 N 06°42.70 E) and a physics CTD (No 45). The AUV was deployed at 13.16 and retrieved at 20:00. The *JCR* then returned to the KF4 station for a biomarker CTD (No 46) and geochemistry megacoring. During the day more whales were observed. The RV *Polarstern* was also observed undertaking benthic sampling.

Wednesday 7 July

Weather: Dull and overcast with calm sea.
The *JCR* remained at the KF4 station with zooplankton net collections, a pelagic CTD (No 47), Snow Catcher collections, spectral optical measurements and Micronet deployment in the morning. Both landers were retrieved successfully late morning between 9.00 and 10.00 after 36 hours deployment. The *JCR* then departed the KF4 station heading west south-west in calms seas towards the Greenland Shelf station. In the evening air and sea temperature dropped with fog and sea-ice observed on the ship's radar to the north. The first sea-ice with associated foggy weather was encounted at midnight. The deep-sea seabed started to rise to continental slope just west of 4°W and 77°N.

Thursday 8 July

Weather: Foggy all day with sun almost breaking through fog.
The *JCR* continued west through the sea-ice which was patchy at first, then composed of lots of small compacted flows, then larger flows with pools between. The ship eventually stopped in a pool between ice flows at the Greenland Shelf station (77°47.36 N 05°34.41W) at 01.30. The water depth was 360m so the station was located on the shelf with a low sea surface temp of ~0°C and very cold subsurface water. The ship then drifted with the sea-ice (~2 miles) until 06.25 when pelagic CTDs (No 48 and 49), Snow Catcher collections and spectral optical measurements were undertaken. During the afternoon zooplankton nets and micronet samples were collected, followed by zooplankton and deep geochemistry CTDs (Nos 50 and 51), megacoring and further zooplankton net collections; all complete by early evening. During the day the ship drifted about ~12 miles, mainly to south but still in cold water of ~360m depth. In the morning (about 09.30) a polar bear visited very close to the stern of the *JCR* for about 30 minutres with lots of photographs taken by scientists and crew.

Friday 9 July

Weather: Very foggy all day
The *JCR* relocated at 06.16 to another sampling pool (at 77°36.03 N 06°11.18W) with a water depth of 296 m, then headed north-west due to wind to a pool overlying a shallower depth of ~260m. Pelagic CTDs (No 52 and 53), Snow Catcher, spectral optical measurements and Micronet sampling was undertaken in the morning and early afternoon. The ship then departed station (77°38.69 N 06°17.96W) at 15:00 for the continental slope, travelling through thick ice until 21:40 when ship reached a very sharply defined ice edge (at 77°38.70 N 05°00.69W). The ship then continuted in open-water arriving at the Greenland Shelf Edge station (77°39.93 N 04°46.90W) in 1400m depth of water at 22.07. A deep geochemistry CTD (No 54) was then undertaken followed by megacoring.

Saturday 10 July

Weather: Foggy and damp with calm sea and mild swell.
The JCR remained at the Greenland Shelf Edge station with megacoring completed by 01.30. The ship then departed west north-west to the Greenland Meridian station (78°16.98 N 00°00.00W) arriving at 07.49. Pelagic CTDs (No 55 and 56) and Snow Catcher collections, and spectral optical measurements (with seabird light meter comparision) were undertaken in the morning followed by zooplankton and Micronet collections and a deep geochemistry CTD (No 57) to 2960m, in the afternoon. The *JCR* then departed at 17:53 for the KF5 station encountering sea-ice for about 2 hours on route (until 20:30).

Sunday 11 July

Weather: Overcast with swell and rough sea and wind. Llight drizzle in Kongsfjord during evening. Arrived at the KF5 station (78°15.15 N 01°00.10E) at 02:00 and deployed a deep geochemistry CTD (No 58) to 2478m. This was followed by zooplankton net collections and a pelagic CTD (No 59) in the early morning. The ship then departed the KF5 station at 05.57 for Ny Alesund arriving at the Ny Alesund quay at 14:30. The scientists and crew then visited the science village until 16:00, afterwhich the *JCR* headed the short distance to the KF1 station for lander deployments and megacoring in the evening.

Monday 12 July

Weather: Grey and overcast turning foggy with calm sea.
The JCR remained at the KF1 station with both landers retrieved by 04.30, then departed for the KF3.5 station (78°39.90 N 08°23.39E) arriving at 07.58. The KF3.5 station was chosen as midway between the KF3 and KF4 stations and in the locality of the previous AUV survey. Both landers were deployed (after a quick turnaround) followed by an AUV survey and physics CTDs (No 60 to 62). Both landers were then retrieved by 20.00 afterwhich the ship sailed to Longyearbyen in clear weather.
End of Leg 2 drinks in evening.

Tuesday 13 July (Leg 4)

Weather: Very sunny with breeze.
The *JCR* arrived in Longyearbyen and waited for a berth to become free at the main quay, eventually docking at 08:51. During next few hours exchanges of staff took place with more gear mobilised, including the piston corer. Alexey, Dan, Daniel, Debi, Eithne, Elaine, Elena, Emilie, Heather and Tim Brand departed ship and Alan Sherring, Andy Reynolds, Jason Scott, Jill McColl, John Howe, Mark Inall, Robert Spielhagen and Toben Struve joined. The Greenpeace ship *Esperanza* was docked at the old Longyearbyen quay and it's Captain, a scientist and photographer visited the *JCR*. The ship departed for the KF3 station a 16.36 in sunny conditions with mist later in evening.

Wednesday 14 July

Weather: Lightly overcast with calm sea.
The *JCR* arrived at the KF3 station (79°00.90 N 10°43.71E) at 05.54. Megacoring,a biomarker CTD (No 63) and Snow Catcher collections were undertaken in the morning followed by a multibeam and TOPAS bathymetry survey around midday. In the early afternoon the first piston core (SAMS No 139) was taken successfully with a 12 core extracted. The *JCR* then departed station at 14.33 for the north-west corner of Svalbard near Amsterdamoya, arriving at the offshore end of the Amsterdamoya physics transect (79°56.66 N 08°51.22E) at 17.20. A multibeam and TOPAS search to the north failed to locate suitable sediment for lander deployment and piston coring, so the ship returned to the offshore end of the physics transect to commense physics CTDs (No 64 to 71) at 10.10.

Thursday 15 July

Weather: Sunny with 16 knot wind increasing in evening to ~40 knots.
The CTD survey of the Amsterdamoya physics transect was continued overnight, finishing in shallow waters (79°46.47 N 10°31.81E) at 04.41. The *JCR* then travelled back along transect to a water depth of 405 m depth (79°49.86 N 10°01.68E) where a physics mooring was deployed at 07.58. This was followed by a pelagic CTD (No 72) and Snow Catcher sampling. Due to lack of suitable sediment offshore, the ship then sailed into Smeerenburg fjorden for lander deployment and piston coring. The fjord was surrounded by impressive views of mountains and glaciers, with

two yachts and a tall ship also visiting the fjord. A deep basin with soft sediment (79°43.69 N 11°05.73E) was located using multibeam and TOPAS, and the landers deployed around mid-day. The afternoon was spent testing the MSS turbulence profiler, and collecting megacores, palaeo CTD (No 73) water samples and a second successful piston core (SAMS No 140). This was followed by zooplankton net sampling, a bathymetry survey, and lander recovery in the evening. An attempt was then made to revisit the Amsterdamoya physics transect for MSS and AUV deployments but gale force 8 (30 knot) winds and rough seas forced the ship to head east to Wood Fjord for further piston coring.

Friday 16 July

Weather: Overcast then sunny with strong wind eventually easing towards evening.
The JCR arrived in Wood fjord at 06.45 after undertaking physics CTDs (No 74 to 76) in the outer fjord and a multibeam survey on way in. The fjord was in another beautiful setting of mountains and glaciers. Megacores were collected in the deepest basin (79°41.06 N 13°50.01E) followed by a third piston core (SAMS No 141), then both landers deployed at 09.58 local as physics team waited for sea conditions to calm. In the afternoon the ship headed to the mouth of the fjord for AUV and MSS surveys in calmer seas. The AUV was retrieved successfully at 19.13 followed by retrieval of the landers at 21.37, and a palaeo CTD (no 77). The JCR then departed for the west Svalbard shelf with a further two physics CTDs undertaken on leaving the fjord (CTDs 78 and 79).

Saturday 17 July

Weather: Overcast then sunny with strong wind eventually easing towards evening in east.
At about 04.00 the *JCR* headed around the north-west of Svalbard and encountered rough seas preventing planned work at the mooring site and a prospective coring site further out to sea. The ship therefore headed back east to Hinlopenrenna and calmer seas, passing Moffen Island at 09.20 where several walruses were observed on the beach. A piston coring site (80°04.82 N 17°16.77E) was located in Hinlopenrenna by multibeam survey, and megacores and a fourth piston core (SAMS No 142) collected around mid-day. A pelagic CTD (No 80), Snow Catcher and Micronet collections were also conducted. At 14:46 the ship headed back to Norske Banken near Moffen Island (80°06.74 N 12°47.74E) for another physics transect with CTDs (No 81 to 89) beginning at 21.16.

Sunday 18 July

Weather: Overcast and grey with moderately calm seas and little wind.
The *JCR* remained on Norske Banken with the physics transect completed at 04.39 (80°21.65 N 10°00.29E). The AUV was then deployed some distance back down transect at 06.38 local and the rest of day and early afternoon spent undertaking AUV and MSS surveys until 13.07. The ship then headed north to locate a new piston core station, arriving at a sharply defined ice edge (the ice impacted by wind) at about 14.30. An Ice Edge station was located 1.4 miles to south-east of the ice edge, and a fifth piston core (SAMS No 143), megacores, CTD (No 90) and micronet collections conducted. At 19.53 the *JCR* then headed south-west to the west Svalbard shelf.

Monday 19 July

Weather: Overcast and grey with wind increasing and rough sea..
The *JCR* arrived at the West Svalbard Margin station (79°29.14 N 06°43.25E) at 04.48. During the early morning megacores were collected (after a TOPAS survey) and Snow Catcher and landers deployed. A sixth piston core (SAMS No 144) was then collected followed by Micronet collections and a pelagic CTD (No 91). At 10.40 the ship returned to the Amsterdamoya physics transect to undertake physics CTDs (No 92 and 93) on route to the mooring site. The physics mooring was retrieved successfully and, after a further physics CTD (No 94), the ship returned to collect the landers from the West Svalbard Margin station.

Tuesday 20 July

Weather: Overcast and with strong wind and rough sea. Worst sea conditions encounted on cruise. After retrieving the landers at 00:56, the ship headed to a new coring site near Prins Karls Forland and the KF4 station (78^{o}58.21 N 07^{o}01.87E). Megacoring and a palaeo CTD (No 95) were undertaken (after a TOPAS survey) followed by a seventh piston core (SAMS No 146); all completed by 10:50. The ship then travelled south-east to the the Isfjord Banken shelf break (78^{o}08.01 N 09^{o}13.41E) with decreasing wind and much calmer seas enabling a physics transect with CTDs (No 96 to 100), AUV and MSS surveys to be undertaken in the evening.
End of Leg 2 *drinks* and "pub quiz" in evening.

Wednesday 21 July

Weather: Sunny with light wind and calm sea.
The *JCR* remained on the Isfjord Banken with AUV and MSP surveys completed at 02.21; these were the last science activities of the cruise. The *JCR* then travelled into Isfjorden with Mark, Robert and Torben departing ship by small boat to catch early flights. The ship docked at Longyearbyen quay at 11:36hrs with the rest of the day spent packing and cleaning labs.
Evening spent in Longyearbyen.

Thursday 22 July

Weather: Fine day with calm sea in Isfjorden.
The remaining science team (Alan, Andy, Edward, Gavin, Heiko, Henrik, Jason, Jenny, Jill, John H, John M, Richard A, and Sian) disembarked fro the *JCR* during the early morning with Ray, Colin & Estelle remaining on ship for the journey to UK departing 09.30. End of Cruise.

Wednesday 23 to Wednesday 28 July

JCR travelled to the UK

Thursday 29 July

JCR docked and demobilised at Peterhead

JR219 Ship-based Scientific Event Log

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
1	14/06	08:06	08:12	08:23	North Sea	56°24.729' N	001°18.851' E	84	CTD	CTD001	Eric
2	14/06	09:04	09:10	09:30	North Sea	56°24.730' N	001°18.849' E	84	CTD	CTD002	Ray
3	15/06	09:24	09:33	09:43	South Norwegian Sea	60°44.590' N	002°43.680' E	117	CTD	CTD003	Eric
4	15/06	10:03	10:08	10:31	South Norwegian Sea	60°44.588' N	002°43.670' E	117	CTD	CTD004	Ray
5	16/06	07:34	07:43	07:54	Central Norwegian Sea	65°02.423' N	004°24.035' E	995	CTD	CTD005	Eric
6	16/06	08:01	/	08:08	Central Norwegian Sea	65°02.423' N	004°24.035' E	995	Snow catcher test	Down a few meters. Misfired.	Jenny
7	16/06	08:12	/	08:17	Central Norwegian Sea	65°02.424' N	004°24.031' E	995	Snow catcher test	Down a few meters. Misfired.	Jenny
8	16/06	08:23	08:31	08:56	Central Norwegian Sea	65°02.420' N	004°24.020' E	995	CTD	CTD006	Ray
9	16/06	09:00	/	09:04	Central Norwegian Sea	65°02.420' N	004°24.030' E	995	Snow catcher test	Down a few meters. Successful.	Jenny
10	17/06	06:32	06:42	06:53	Northern Norwegian Sea	69°20.460' N	006°22.430' E	3246	CTD	CTD007	Eric
11	17/06	07:00	/	07:07	Northern Norwegian Sea	69°20.460' N	006°22.440' E	3246	Snow catcher test	Down a few meters.	Jenny
12	17/06	07:20	07:28	07:48	Northern Norwegian Sea	69°20.459' N	006°22.420' E	3246	CTD	CTD008	Ray
13	17/06	08:00	08:51	09:30	Northern Norwegian Sea	69°20.460' N	006°22.420' E	3246	Lander test	Testing at 1500m 2 lander buoyancy units and 6 acoustic releases.	Monty
14	17/06	11:26	11:50	13:52	OSIRIS Test	69°38.332' N	006°31.897' E	3235	OSIRIS test	Running for 35mins at 1500m deep	Mike / Ross
15	18/06	06:35	06:44	06:58	South Greenland Sea	72°45.320' N	008°15.658' E	2473	CTD	CTD009	Eric
16	18/06	07:05	/	07:13	South Greenland Sea	72°45.219' N	008°15.916' E	2472	Snow catcher test	Down a few meters. One part snapped off during recovery, fixed afterwards.	Jenny
17	18/06	07:25	07:32	07:39	South Greenland Sea	72°45.210' N	008°15.920' E	2472	Micronet	~100m wire out to deploy but max depth achieved far less as the net didn't go in vertically (too light and pushed by current)	Mike / Ross
18	18/06	07:43	07:49	08:12	South Greenland Sea	72°45.213' N	008°15.930' E	2471	CTD	CTD010	Ray
19	19/06	06:34	06:44	06:55	East Greenland Sea	77°09.420' N	011°17.550' E	911	CTD	CTD011	Eric
20	19/06	07:11	/	07:16	East Greenland Sea	77°09.420' N	011°17.530' E	911	Snow catcher test	Down a few meters. Nearly successful.	Jenny
21	19/06	07:19	07:25	07:39	East Greenland Sea	77°09.420' N	011°17.530' E	911	Micronet	Down 100m	Mike / Ross

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
22	19/06	07:26	/	07:28	East Greenland Sea	77°09.420' N	011°17.530' E	911	Snow catcher test	Down a few meters. Successful.	Jenny
23	19/06	07:42	07:50	08:18	East Greenland Sea	77°09.421' N	011°17.530' E	911	CTD	CTD012	Ray
24	23/06	11:04	11:24	11:48	Ice Station	80°44.480' N	004°41.930' E	670	CTD	CTD013	Heiko
25	23/06	12:42	12:47	13:06	Ice Station	80°44.480' N	004°39.050' E	674	CTD	CTD014	Jenny
26	23/06	14:04	14:12	14:29	Ice Station	80°44.620' N	004°36.740' E	666	CTD	CTD015	Heiko
27	23/06	14:47	14:52	14:58	Ice Station	80°44.692' N	004°35.512' E	673	Snow catcher	Down 50m. Fired at 14:55. Successful.	Jenny
28	24/06	06:23	06:29	06:37	Ice Station	80°42.800' N	004°20.760' E	749	Snow catcher	Down 100m. Fired at 06:30. Successful.	Jenny
29	24/06	06:52	06:55	06:59	Ice Station	80°42.589' N	004°20.777' E	750	Snow catcher	Down 50m. Fired at 06:55. Leaking.	Jenny
30	24/06	07:14	07:17	07:23	Ice Station	80°42.440' N	004°20.700' E	752	Snow catcher	Down 50m. Fired at 07:18. Successful.	Jenny
31	24/06	07:37	07:42	07:52	Ice Station	80°42.250' N	004°20.534' E	754	CTD	CTD016	Jenny
32	24/06	09:25	09:29	09:43	Ice Station	80°41.499' N	004°19.086' E	771	CTD	CTD017	Emilie
33	24/06	12:22	12:25	12:37	Ice Station	80°40.610' N	004°14.880' E	790	CTD	CTD018	Elaine
34	25/06	07:50	~07:55	08:02	Ice Station	80°35.430' N	004°18.830' E	803	Snow catcher	Down 100m. Successful.	Jenny
35	25/06	08:40	08:49	09:11	Ice Station	80°35.100' N	004°18.290' E	807	CTD	CTD019	Heather
36	26/06	06:45	07:00	07:25	Ice Station	80°31.610' N	004°12.060' E	859	Snow catcher	Down 400m. Successful.	Jenny
37	26/06	08:45	08:55	09:29	Ice Station	80°31.090' N	004°09.870' E	866	CTD	CTD020 = downcast, CTD021 = upcast.	Heather
38	27/06	06:50	07:02	07:18	Ice Station	80°27.610' N	003°43.875' E	1062	Snow catcher	Down 400m. Fired at 07:02. Successful.	Jenny
39	27/06	07:40	07:50	08:11	Ice Station	80°27.318' N	003°43.037' E	1071	CTD	CTD022	Emilie
40	27/06	09:32	09:36	09:47	Ice Station	80°26.380' N	003°39.740' E	1110	CTD	CTD023	Elena
41	27/06	15:08	?	15:20	Ice Station	80°24.070' N	003°30.550' E	?	Micronet		Sian
42	28/06	06:53	~06:57	07:00	Ice Station	80°19.920' N	003°23.410' E	1234	Snow catcher	Down 50m. Successful.	Jenny
43	28/06	07:37	07:46	08:15	Ice Station	80°19.600' N	003°22.180' E	1234	CTD	CTD024	Jenny
44	28/06	09:04	09:09	09:24	Ice Station	80°18.980' N	003°19.387' E	1259	CTD	CTD025	Emilie
45	28/06	10:20	~10:30	10:42	Ice Station	80°18.450' N	003°16.700' E	?	Snow catcher	Down 300m. Successful.	Jenny
46	28/06	15:02	?	15:14	Ice Station	80°17.170' N	003°10.110' E	?	Micronet		Sian
47	29/06	06:42	~06:52	07:02	Ice Station	80°16.580' N	003°05.680' E	1353	Snow catcher	Down 300m. Successful.	Jenny
48	29/06	07:14	~07:22	07:29	Ice Station	80°16.520' N	003°04.530' E	1360	Snow catcher	Down 200m. Successful.	Jenny

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
49	29/06	08:01	08:24	08:56	Ice Station	80°16.470' N	003°03.675' E	1373	CTD	CTD026	Heiko
50	29/06	10:01	10:08	10:27	Ice Station	80°16.180' N	002°59.000' E	?	CTD	CTD027	Jenny
51	29/06	11:34	11:37	11:52	Ice Station	80°15.983' N	002°55.148' E	1412	CTD	CTD028	Heather
52	29/06	14:50	14:59	15:17	Ice Station	80°15.630' N	002°49.210' E	1440	CTD	CTD029	Heiko
53	29/06	15:33	?	15:42	Ice Station	80°15.500' N	002°48.030' E	1448	Micronet		Sian
54	30/06	06:42	06:59	07:13	Ice Station	80°14.070' N	002°33.540' E	1544	Snow catcher	Down 400m. Successful.	Jenny
55	30/06	07:24	?	07:42	Ice Station	80°13.990' N	002°32.356' E	1552	Snow catcher	Down 300m. Misfired.	Jenny
56	30/06	07:49	?	08:05	Ice Station	80°13.920' N	002°31.550' E	1559	Snow catcher	Down 300m. Successful.	Jenny
57	30/06	08:42	08:53	09:16	Ice Station	80°13.780' N	002°29.790' E	1574	CTD	CTD030	Heather
58	01/07	06:42	~06:49	07:03	Ice Station	80°13.050' N	002°10.300' E	1738	Snow catcher	Down 200m. Successful.	Jenny
59	01/07	07:17	07:20	07:26	Ice Station	80°13.099' N	002°10.169' E	1737	Snow catcher	Down 50m. Fired at 07:22. Successful.	Jenny
60	01/07	07:40	?	07:50	Ice Station	80°13.140' N	002°10.080' E	1736	Micronet		Sian
61	01/07	08:13	08:19	08:36	Ice Station	80°13.190' N	002°09.940' E	1736	CTD	CTD031	Jenny
62	01/07	10:12	10:51	11:47	Ice Station	80°13.311' N	002°09.380' E	1737	CTD	CTD032	Estelle
63	01/07	13:00	?	13:07	Ice Station	80°13.330' N	002°10.890' E	?	Snow catcher	Down 10m. Misfired.	Jenny
64	01/07	13:16	?	13:22	Ice Station	80°13.310' N	002°11.150' E	?	Snow catcher	Down 10m. Successful.	Jenny
65	04/07	06:38	06:50	07:19	KF3	79°01.000' N	010°42.040' E	338	CTD	CTD033 = downcast and upcast up to btl 12, CTD034 = rest of the btl and upcast	Emilie
66	04/07	08:00	08:11	08:44	KF3	79°01.000' N	010°42.050' E	339	CTD	CTD035	Ray
67	04/07	09:29	?	09:36	KF3	79°01.000' N	010°42.060' E	338	Snow catcher	Down 50m. Leaking.	Jenny
68	04/07	09:39	?	09:50	KF3	79°01.000' N	010°42.060' E	338	Snow catcher	Down 50m. Still leaking a bit but acceptable for sampling.	Jenny
69	04/07	11:03	11:11	11:11	KF3 – Lander 1	79°01.000' N	010°42.040' E	338	Lander deployment	EDDY lander. Released at 11:05, on bottom at 11:11.	Henrik
70	04/07	11:39	11:53	12:08	KF3	79°00.858' N	010°41.614' E	333	Megacorer	Megacorer001 - 7/8 cores	Dan M.
71	04/07	12:46	13:01	13:15	KF3	79°00.860' N	010°41.610' E	333	Megacorer	Megacorer002 - 8/8 cores	Dan M.
72	04/07	13:57	14:12	14:25	KF3	79°00.856' N	010°41.632' E	333	Megacorer	Megacorer003 - 4/8 cores	Dan M.
73	04/07	14:15	?	14:50	KF3	79°00.860' N	010°41.630' E	333	Light spectrometer	From forward crane. Down 40m.	Alexey
74	04/07	15:38	15:51	16:06	KF3	79°00.856' N	010°41.627' E	334	Megacorer	Megacorer004 - 4/7 cores	Dan M.

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
75	04/07	16:59	17:13	17:28	KF3	79°00.860' N	010°41.630' E	334	Megacorer	Megacorer005 - 5/7 cores	Dan M.
76	04/07	18:30	18:45	19:06	KF3	79°00.856' N	010°41.630' E	334	CTD	CTD036	Dan M.
77	04/07	19:29	19:37	19:37	KF3 – Lander 2	79°00.830' N	010°42.021' E	340	Lander deployment	ELINOR lander. Released at 19:32, on bottom at 19:37.	Henrik
78	04/07	19:58	20:14	20:32	KF3	79°00.910' N	010°41.280' E	332	Megacorer	Megacorer006 - 5/8 cores	Henrik
79	04/07	21:02	21:15	21:32	KF3	79°00.920' N	010°41.270' E	331	Megacorer	Megacorer007 - 6/8 cores	Henrik
80	05/07	04:39	04:43	04:47	KF3	79°00.910' N	010°41.300' E	~332	Snow catcher	Down 50m. Successful.	Jenny
81	05/07	05:00	05:05	05:11	KF3	79°00.910' N	010°41.300' E	~332	Snow catcher	Down 100m. Successful.	Jenny
82	05/07	06:41	06:51	07:22	KF3	79°00.911' N	010°41.280' E	332	CTD	CTD037	Jenny
83	05/07	07:35	?	08:08	KF3	79°00.920' N	010°41.310' E	331	Light spectrometer	From forward crane. Down 40m.	Alexey
84	05/07	08:54	/	09:22	KF3	79°00.920' N	010°41.300' E	331	AUV test deployment	Ballasting assessment + acoustic communications test	Tim Bo.
85	05/07	10:25	10:42	10:52	KF3	79°00.917' N	010°41.260' E	331	Multinet	MN001. Down 300m.	Dan V.
86	05/07	11:06	11:18	11:30	KF3	79°00.918' N	010°41.269' E	331	Multinet	MN002. Down 300m. Did not fire.	Dan V.
87	05/07	11:43	12:00	12:16	KF3	79°00.920' N	010°41.270' E	331	WP3 net	WP3-001. Down 300m.	Dan V.
88	05/07	12:32	12:45	13:25	KF3	79°00.910' N	010°41.311' E	331	CTD	CTD038	Tim Br.
89	05/07	13:50	/	14:17	KF3 – Lander 2	79°00.913' N	010°41.368' E	?	Lander recovery	ELINOR lander. Released at 13:56, on surface at 14:01.	Henrik
90	05/07	14:20	/	14:46	KF3 – Lander 1	79°00.880' N	010°41.450' E	?	Lander recovery	EDDY lander. Released at 14:26, on surface at 14:30.	Henrik
91	05/07	16:59	17:11	17:25	CTD Section ~300m	79°00.000' N	008°35.115' E	275	CTD	CTD039	Tim Bo.
92	05/07	17:47	18:01	18:12	CTD Section ~500m	79°00.020' N	008°28.430' E	547	CTD	CTD040	Tim Bo.
93	05/07	18:49	19:11	19:31	CTD Section ~1000m	79°00.030' N	008°05.800' E	1012	CTD	CTD041	Tim Bo.
94	05/07	21:05	~21:40	21:40	KF4 – Lander 1	78°58.370' N	006°42.700' E	?	Lander deployment	EDDY lander. Released at 21:13, on bottom at ~21:40.	Henrik
95	05/07	21:26	~21:50	21:50	KF4 – Lander 2	78°58.470' N	006°43.080' E	?	Lander deployment	ELINOR lander. Released at 21:29, on bottom at ~21:50.	Henrik
96	06/07	04:34	04:38	04:41	KF4	78°58.510' N	006°42.360' E	?	Snow catcher	Down 50m. Successful.	Jenny

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
97	06/07	04:52	04:56	05:01	KF4	78°58.510' N	006°42.360' E	?	Snow catcher	Down 100m. Successful.	Jenny
98	06/07	06:31	06:39	06:58	KF4	78°58.520' N	006°42.380' E	1371	CTD	CTD042	Jenny
99	06/07	07:58	08:05	08:37	KF4	78°58.520' N	006°42.390' E	1371	CTD	CTD043	Heather
100	06/07	09:36	?	09:56	KF4	78°58.510' N	006°42.390' E	1371	Light spectrometer	From forward crane. Down 40m.	Alexey
101	06/07	09:47	10:16	11:05	KF4	78°58.514' N	006°42.387' E	1371	CTD	CTD044	Tim Br.
102	06/07	13:16	/	13:44	KF3.5	79°00.000' N	008°28.470' E	?	AUV deployment	AUV deployed at 13:23, mission started at 13:44.	Tim Bo.
103	06/07	15:31	15:47	16:02	KF3.5	78°59.810' N	008°21.370' E	751	CTD	CTD045	Tim Bo.
104	06/07	17:27	/	17:56	KF3.5	78°59.840' N	008°28.550' E	?	AUV recovery		Tim Bo.
105	06/07	19:47	20:21	21:07	KF4	78°58.508' N	006°42.370' E	1372	CTD	CTD046	Heiko
106	06/07	21:38	22:23	23:10	KF4	78°58.500' N	006°42.360' E	~1370	Megacorer	Megacorer008 - 7/8 cores	Henrik
107	06/07	23:34	00:21	01:08	KF4	78°58.500' N	006°42.360' E	~1370	Megacorer	Megacorer009 - 6/8 cores	Henrik
108	07/07	02:17	03:02	03:48	KF4	78°58.500' N	006°42.360' E	~1370	Multinet	MN003. Wire out 1305m.	Dan V.
109	07/07	04:07	04:48	05:32	KF4	78°58.500' N	006°42.360' E	~1370	Multinet	MN004. Wire out 1240m.	Dan V.
110	07/07	06:03	?	06:11	KF4	78°58.500' N	006°42.360' E	~1370	Snow catcher	Down 50m. Successful.	Jenny
111	07/07	06:18	?	06:30	KF4	78°58.500' N	006°42.360' E	~1370	Snow catcher	Down 100m. Successful.	Jenny
112	07/07	06:55	07:04	07:40	KF4	78°58.506' N	006°42.379' E	1371	CTD	CTD047	Heather
113	07/07	06:58	?	07:23	KF4	78°58.510' N	006°42.380' E	1372	Light spectrometer	From forward crane. Down 40m.	Alexey
114	07/07	07:56	?	08:12	KF4	78°58.500' N	006°42.360' E	~1370	Micronet	Down 50m.	Ray
115	07/07	08:34	/	09:25	KF4 – Lander 1	78°58.275' N	006°41.690' E	~1370	Lander recovery	EDDY lander. Released at 08:36 and 08:51 (2nd release), on surface at ~09:05.	Henrik
116	07/07	08:49	~08:51	08:53	KF4 – Lander 1	78°58.280' N	006°41.688' E	~1370	Mini micronet	Hand-held, at stern. Down 30m.	Alexey
117	07/07	09:30	/	10:03	KF4 – Lander 2	78°58.360' N	006°41.660' E	~1370	Lander recovery	ELINOR lander. Released at 09:32, on surface at 09:51.	Henrik
118	08/07	06:25	06:39	07:04	Greenland Shelf	77°47.250' N	005°35.390' W	365	CTD	CTD048	Ray
119	08/07	07:42	07:50	08:15	Greenland Shelf	77°46.630' N	005°35.770' W	361	CTD	CTD049	Ray
120	08/07	07:47	?	08:04	Greenland Shelf	77°46.583' N	005°35.789' W	360	Light spectrometer	From forward crane. Technical fault – recovered before 40m.	Alexey

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
121	08/07	08:09	?	08:18	Greenland Shelf	77°46.380' N	005°35.870' W	359	Light spectrometer	From forward crane. Down 40m.	Alexey
122	08/07	08:33	08:35	08:39	Greenland Shelf	77°46.160' N	005°35.900' W	363	Snow catcher	Down 50m. Successful.	Jenny
123	08/07	08:54	08:58	09:03	Greenland Shelf	77°45.960' N	005°35.870' W	365	Snow catcher	Down 100m. Successful.	Jenny
124	08/07	10:51	10:58	11:12	Greenland Shelf	77°44.350' N	005°37.934' W	352	Multinet	MN005. Down 300m.	Dan V.
125	08/07	11:29	11:40	11:52	Greenland Shelf	77°44.060' N	005°38.510' W	361	Multinet	MN006. Down 301m. Did not fire.	Dan V.
126	08/07	12:15	?	12:26	Greenland Shelf	77°43.510' N	005°37.700' W	363	Micronet	Down 50m.	Ray
127	08/07	12:32	?	12:39	Greenland Shelf	77°43.300' N	005°37.590' W	363	Micronet	Down 50m.	Ray
128	08/07	12:56	13:07	13:36	Greenland Shelf	77°42.994' N	005°37.344' W	359	CTD	CTD050	Tim Br.
129	08/07	14:22	14:27	14:37	Greenland Shelf	77°41.763' N	005°36.950' W	370	CTD	CTD051	Dan V.
130	08/07	15:13	15:26	15:40	Greenland Shelf	77°40.641' N	005°37.884' W	370	Megacorer	Megacorer010 – 4/8 cores	Henrik
131	08/07	15:26	15:28	15:30	Greenland Shelf	77°40.560' N	005°38.000' W	369	Mini micronet	Hand-held, at stern. Down 30m.	Alexey
132	08/07	15:59	16:11	16:27	Greenland Shelf	77°40.030' N	005°38.640' W	366	Megacorer	Megacorer011 – 7/8 cores	Henrik
133	08/07	17:03	17:17	17:30	Greenland Shelf	77°39.320' N	005°39.530' W	366	WP3 net	WP3-001. Down 313m.	Dan V.
134	09/07	06:18	06:29	07:11	Greenland Shelf	77°36.054' N	005°11.425' W	299	CTD	CTD052 = downcast, CTD053 = upcast	Eithne
135	09/07	06:36	06:53	06:59	Greenland Shelf	77°36.140' N	005°12.520' W	293	Light spectrometer	From forward crane. Down 40m.	Alexey
136	09/07	07:37	~07:41	07:46	Greenland Shelf	77°36.670' N	005°15.390' W	278	Snow catcher	Down 100m. Successful.	Jenny
137	09/07	07:55	~07:58	08:02	Greenland Shelf	77°36.822' N	005°16.450' W	284	Snow catcher	Down 50m. Successful.	Jenny
138	09/07	11:05	~11:12	11:16	Greenland Shelf	77°38.500' N	005°17.480' W	284	Micronet	Down 50m.	Ray
139	09/07	12:10	?	12:35	Greenland Shelf	77°38.540' N	005°17.560' W	281	Light spectrometer	From forward crane. Down 40m.	Alexey
140	09/07	22:07	22:34	23:30	Greenland Shelf Edge	77°38.920' N	004°46.810' W	1371	CTD	CTD054	Tim Br.
141	09/07	23:52	00:42	01:32	Greenland Shelf Edge	77°38.920' N	004°46.810' W	1398	Megacorer	Megacorer012 – 8/8 cores	Tim Br.
142	10/07	08:10	08:19	08:41	Greenwich Meridian	78°16.997' N	000°00.010' E	3019	CTD	CTD055	Jenny
143	10/07	09:23	09:32	09:59	Greenwich Meridian	78°16.998' N	000°00.015' E	3019	CTD	CTD056	Heather
144	10/07	09:29	?	09:59	Greenwich Meridian	78°17.000' N	000°00.000' E	3019	Light spectrometer	From forward crane. Down 40m.	Alexey
145	10/07	10:04	?	10:17	Greenwich Meridian	78°17.000' N	000°00.000' E	3019	SBE19+ & light sensors board	From forward crane. Down 50m.	Colin
146	10/07	10:13	~10:15	10:18	Greenwich Meridian	78°17.000' N	000°00.000' E	3019	Snow catcher	Down 50m. Successful.	Jenny
147	10/07	10:32	~10:36	10:42	Greenwich Meridian	78°17.000' N	000°00.000' E	3019	Snow catcher	Down 100m. Successful.	Jenny

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
148	10/07	11:07	11:59	12:33	Greenwich Meridian	78°17.000' N	000°00.000' E	3020	Multinet	MN007. Down 1246m (wire out 1250m).	Dan V.
149	10/07	11:34	~11:46	11:54	Greenwich Meridian	78°17.000' N	000°00.000' E	3020	Micronet	Down 50m.	Ray
150	10/07	12:49	13:34	14:29	Greenwich Meridian	78°17.000' N	000°00.000' E	3020	Multinet	MN008. Down 1500m (wire out 1550m).	Dan V.
151	10/07	15:21	16:17	17:40	Greenwich Meridian	78°17.000' N	000°00.000' E	3019	CTD	CTD057	Tim Br.
152	11/07	02:12	03:00	04:29	KF5	78°56.850' N	005°17.290' E	~2485	CTD	CTD058	Tim Br.
153	11/07	04:32	04:39	04:47	KF5	78°56.850' N	005°17.300' E	~2500	WP3 net	WP3-002. Down 100m.	Dan V.
154	11/07	04:58	05:16	05:26	KF5	78°56.850' N	005°17.300' E	~2500	Light spectrometer	From forward crane. Down 40m.	Alexey
155	11/07	05:25	05:35	05:50	KF5	78°56.850' N	005°17.300' E	~2500	CTD	CTD059	Heather
156	11/07	17:03	~17:11	~17:15	KF1	78°57.480' N	011°53.950' E	~345	Lander deployment	ELINOR lander. Released at 17:05, on bottom at ~17:11.	Henrik
157	11/07	17:16	~17:32	~17:35	KF1	78°57.550' N	011°53.500' E	~345	Lander deployment	EDDY lander. Released at 17:26, on bottom at ~17:32.	Henrik
158	11/07	17:51	18:03	18:17	KF1	78°57.620' N	011°53.090' E	346	Megacorer	Megacorer013 – 5/8 cores	Henrik
159	11/07	18:38	18:49	19:02	KF1	78°57.618' N	011°53.079' E	346	Megacorer	Megacorer014 – 5/8 cores	Henrik
160	11/07	19:14	19:27	19:39	KF1	78°57.620' N	011°53.080' E	346	Megacorer	Megacorer015 – 4/8 cores	Henrik
161	12/07	03:18	/	03:58	KF1	78°57.590' N	011°52.620' E	~350	Lander recovery	ELINOR lander. Released at 03:25, on surface at 03:34.	Henrik
162	12/07	04:05	/	04:30	KF1	78°57.730' N	011°53.840' E	~350	Lander recovery	EDDY lander. Released at 04:08, on surface at 04:13.	Henrik
163	12/07	08:03	?	~08:10	KF3.5 – Lander 1	78°59.900' N	008°23.380' E	710	Lander deployment	EDDY lander. Released at 08:03.	Henrik
164	12/07	08:17	?	~08:25	KF3.5 – Lander 2	78°59.791' N	008°23.338' E	709	Lander deployment	ELINOR lander. Released at 08:17.	Henrik
165	12/07	08:55	09:09	09:20	KF3.5	79°00.000' N	008°28.460' E	~550	CTD	CTD060	Tim Bo.
166	12/07	09:35	/	09:56	KF3.5	79°00.000' N	008°28.460' E	~550	AUV deployment	AUV deployed at 09:39, mission started at 09:51.	Tim Bo.
167	12/07	15:05	~15:20	15:36	KF3.5	78°59.782' N	008°21.114' E	746	CTD	CTD061	Tim Bo.
168	12/07	16:20	/	17:07	KF3.5	78°59.890' N	008°28.500' E	~550	AUV recovery	On surface at 16:45.	Tim Bo.

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
169	12/07	17:44	18:03	18:22	KF3.5	79°00.003' N	008°13.865' E	908	CTD	CTD062	Tim Bo.
170	12/07	18:48	/	19:24	KF3.5 – Lander 2	78°59.720' N	008°22.870' E	?	Lander recovery	ELINOR lander. Released at 18:55, on surface at 19:07.	Henrik
171	12/07	19:33	/	20:01	KF3.5 – Lander 1	78°59.820' N	008°23.020' E	?	Lander recovery	EDDY lander. Released at 19:37, on surface at ~19:45.	Henrik
172	14/07	06:30	06:46	07:02	KF3	79°00.890' N	010°43.660' E	336	Megacorer	Megacorer016 – 5/8 cores	Robert
173	14/07	07:40	07:50	08:17	KF3	79°00.900' N	010°43.650' E	335	CTD	CTD063	Heiko
174	14/07	08:49	~08:55	09:02	KF3	79°00.900' N	010°43.700' E	339	Snow catcher	Down 50m. Successful.	Jenny
175	14/07	09:17	~09:20	09:24	KF3	79°00.900' N	010°43.700' E	339	Snow catcher	Down 50m. Successful.	Jenny
176	14/07	09:45	/	11:35	KF3	79°00.210' N	010°44.440' E	337	Multibeam survey		John H.
177	14/07	09:52	/	11:35	KF3	~79°00.210' N	~010°44.440' E	~337	TOPAS survey		John H.
178	14/07	12:06	12:33	13:08	KF3	79°01.064' N	010°47.650' E	345	Piston coring	SAMS core no. 139	John H.
179	14/07	19:19	/	20:50	Underway to Amsterdamoya Transect	79°56.740' N	008°56.420' E	?	Swath survey	Rocky bottom, unsuitable for landers. End position: 80°08.310' N, 09°40.550' E	John H.
180	14/07	22:12	22:30	22:46	Amsterdamoya Transect - A	79°56.660' N	008°56.220' E	~475	CTD	CTD064	Mark
181	14/07	23:30	23:45	23:56	Amsterdamoya Transect - B	79°53.960' N	009°21.940' E	~480	CTD	CTD065	Mark
182	15/07	00:33	00:50	01:00	Amsterdamoya Transect - C	79°51.270' N	009°47.770' E	~450	CTD	CTD066	Mark
183	15/07	01:28	01:43	01:53	Amsterdamoya Transect - D	79°49.660' N	010°01.980' E	~400	CTD	CTD067	Mark
184	15/07	02:21	02:31	02:40	Amsterdamoya Transect - E	79°48.610' N	010°11.590' E	~370	CTD	CTD068	Mark
185	15/07	03:13	03:22	03:29	Amsterdamoya Transect - F	79°47.800' N	010°20.490' E	~250	CTD	CTD069	Mark
186	15/07	03:52	04:01	04:05	Amsterdamoya Transect - G	79°47.120' N	010°26.420' E	~70	CTD	CTD070	Mark
187	15/07	04:32	04:37	04:41	Amsterdamoya Transect - H	79°46.460' N	010°31.800' E	~40	CTD	CTD071	Mark
188	15/07	07:25	/	07:58	Amsterdamoya Slope	79°49.860' N	010°01.680' E	404	Mooring Deployment	Relseased 07:58.	Colin
189	15/07	08:18	~08:23	08:29	Amsterdamoya Slope	79°49.720' N	010°01.260' E	405	Snow catcher	Down 50m. Successful.	Jenny
190	15/07	08:39	08:45	08:50	Amsterdamoya Slope	79°49.710' N	010°01.240' E	404	Snow catcher	Down 100m. Successful.	Jenny
191	15/07	09:09	09:17	09:34	Amsterdamoya Slope	79°49.710' N	010°01.250' E	405	CTD	CTD072	Jenny
192	15/07	09:36	/	12:11	Amsterdamoya to Smeerenburg	79°49.710' N	010°01.250' E	~405	Swath survey	End position: 79°43.690' N, 11°05.720' E	John H.
193	15/07	12:13	?	12:16	Smeerenburg – Lander 1	79°43.690' N	011°05.730' E	~220	Lander deployment	EDDY lander. Released at 12:16.	Henrik

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
194	15/07	12:30	?	12:33	Smeerenburg – Lander 2	79°43.580' N	011°05.710' E	224	Lander deployment	ELINOR lander. Released at 12:33.	Henrik
195	15/07	12:43	/	12:51	Smeerenburg	79°43.540' N	011°05.790' E	~225	MSS	Buoyancy test. Profile 1.	Mark
196	15/07	13:09	13:21	13:46	Smeerenburg	79°43.885' N	011°05.400' E	214	CTD	CTD073	Robert
197	15/07	14:12	14:22	14:31	Smeerenburg	79°43.880' N	011°05.410' E	219	Megacorer	Megacorer017 – 6/8 cores	Robert
198	15/07	14:48	14:55	15:02	Smeerenburg	79°43.880' N	011°05.400' E	220	Megacorer	Megacorer018 – 7/8 cores	Robert
199	15/07	15:32	15:46	16:29	Smeerenburg	79°43.884' N	011°05.403' E	220	Piston coring	SAMS core no. 140	John H.
200	15/07	17:24	~17:27	17:31	Smeerenburg	79°43.890' N	011°05.430' E	~220	Micronet		Ray
201	15/07	17:55	/	19:27	Smeerenburg	79°43.890' N	011°05.430' E	~220	Swath survey	End position: 79°43.900' N, 11°05.740' N	John H.
202	15/07	19:33	/	19:52	Smeerenburg – Lander 1	79°43.890' N	011°05.450' E	?	Lander recovery	EDDY lander. Released at 19:36, on surface at 19:40.	Henrik
203	15/07	19:58	/	20:16	Smeerenburg – Lander 2	79°43.840' N	011°05.770' E	?	Lander recovery	ELINOR lander. Released at 20:00, on surface at 20:05.	Henrik
204	16/07	02:09	02:16	02:21	Woodfjorden Transect A	80°00.001' N	013°48.018' E	130	CTD	CTD074	Mark
205	16/07	03:30	03:35	03:40	Woodfjorden Transect B	79°56.001' N	014°06.036' E	138	CTD	CTD075	Mark
206	16/07	04:32	04:08	04:45	Woodfjorden Transect C	79°52.000' N	014°18.070' E	146	CTD	CTD076	Mark
207	16/07	04:52	/	06:52	Woodfjorden	79°52.000' N	014°18.050' E	~150	Swath survey	End position: 79°41.066' N, 13°50.070' N	John H.
208	16/07	07:13	07:22	07:33	Woodfjorden	79°41.060' N	013°49.990' E	198	Megacorer	Megacorer019 – 4/8 cores	Robert
209	16/07	07:47	07:56	08:04	Woodfjorden	79°41.060' N	013°49.979' E	198	Megacorer	Megacorer020 – 6/8 cores	Henrik
210	16/07	08:32	~08:53	09:36	Woodfjorden	79°41.060' N	013°50.000' E	198	Piston coring	SAMS core no. 141	John H.
211	16/07	09:58	?	09:58	Woodfjorden – Lander 1	79°41.060' N	013°49.970' E	198	Lander deployment	EDDY lander.	Henrik
212	16/07	10:15	?	10:15	Woodfjorden – Lander 2	79°40.970' N	013°49.594' E	198	Lander deployment	ELINOR lander.	Henrik
213	16/07	13:32	/	13:45	Woodfjorden Mouth	79°56.000' N	014°06.030' E	134	AUV deployment	Mission started at 13:41.	Tim Bo.
214	16/07	14:43	/	~14:55	Woodfjorden Mouth	79°55.970' N	014°06.670' E	~140	MSS	Line heading SSE towards Woodfjorden. Profiles 2 and 3.	Mark

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
215	16/07	15:08	/	18:11	Woodfjorden Mouth	?	?	?	MSS	Carry on same line, from where stopped at event no 214. Profiles 4 to 31. End position: 79°54.030' N, 14°11.850' N	Mark
216	16/07	18:46	/	19:11	Woodfjorden Mouth	79°55.970' N	014°07.600' E	?	AUV recovery		Tim Bo.
217	16/07	20:46	/	21:10	Woodfjorden – Lander 2	79°41.200' N	013°51.670' E	188	Lander recovery	ELINOR lander. Released at 20:52, on surface at 20:54.	Henrik
218	16/07	21:14	/	21:36	Woodfjorden – Lander 1	79°41.210' N	013°50.920' E	~190	Lander recovery	EDDY lander. Released at 21:18, on surface at 21:21.	Henrik
219	16/07	21:51	21:59	22:12	Woodfjorden	79°41.030' N	013°49.640' E	197	CTD	CTD077	Robert
220	16/07	23:02	23:13	23:19	Woodfjorden Transect D	79°46.020' N	014°08.020' E	182	CTD	CTD078	Mark
221	17/07	01:15	01:24	01:29	Woodfjorden Transect E	80°02.520' N	013°17.940' E	137	CTD	CTD079	Mark
222	17/07	12:13	/	13:40	Hinlopenrenna	80°05.500' N	017°10.800' E	416	Swath survey	End position: 80°04.786' N, 17°16.800' E	John H.
223	17/07	13:41	13:54	14:09	Hinlopenrenna	80°04.786' N	017°16.798' E	386	Megacorer	Megacorer021 – 8/8 cores	John H.
224	17/07	13:59	~14:04	14:10	Hinlopenrenna	80°04.780' N	017°16.800' E	386	Snow catcher	Down 50m (?). Successful.	Jenny
225	17/07	14:20	~14:30	~14:35	Hinlopenrenna	80°04.780' N	017°16.800' E	386	Snow catcher	Down 100m (?). Successful.	Jenny
226	17/07	14:33	14:55	15:30	Hinlopenrenna	80°04.780' N	017°16.800' E	386	Piston coring	SAMS core no. 142	John H.
227	17/07	14:46	?	14:58	Hinlopenrenna	80°04.780' N	017°16.800' E	386	Micronet		Ray
228	17/07	16:03	16:16	16:43	Hinlopenrenna	80°04.786' N	017°16.830' E	381	CTD	CTD080	Jenny
229	17/07	21:10	21:25	21:30	Norske Banken Transect A	80°06.750' N	012°47.720' E	143	CTD	CTD081	Mark
230	17/07	22:22	22:27	22:32	Norske Banken Transect B	80°10.190' N	012°10.390' E	146	CTD	CTD082	Mark
231	17/07	23:22	23:28	23:33	Norske Banken Transect C	80°13.300' N	011°37.010' E	169	CTD	CTD083	Mark
232	18/07	00:18	00:24	00:29	Norske Banken Transect D	80°15.950' N	011°06.900' E	196	CTD	CTD084	Mark
233	18/07	00:52	01:00	01:08	Norske Banken Transect E	80°16.700' N	010°57.590' E	313	CTD	CTD085	Mark
234	18/07	01:29	01:39	01:48	Norske Banken Transect F	80°17.540' N	010°47.960' E	418	CTD	CTD086	Mark
235	18/07	02:11	02:25	02:36	Norske Banken Transect G	80°18.710' N	010°34.870' E	510	CTD	CTD087	Mark
236	18/07	03:07	03:22	03:35	Norske Banken Transect H	80°19.930' N	010°18.910' E	604	CTD	CTD088	Mark
237	18/07	04:09	04:25	04:39	Norske Banken Transect I	80°21.660' N	010°00.060' E	679	CTD	CTD089	Mark
238	18/07	05:53	/	06:15	Norske Banken	80°18.690' N	010°35.000' E	~500	AUV deployment	Mission started at 06:12.	Tim Bo.

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
239	18/07	06:30	/	11:29	Norske Banken	80°18.790' N	010°35.960' E	~500	MSS	Profiles 32 to 52. End position: 80°17.340' N, 10°52.000' N	Mark
240	18/07	12:35	/	13:07	Norske Banken	80°17.210' N	010°50.190' E	~500	AUV recovery		Tim Bo.
241	18/07	13:23	/	15:15	Norske Banken to Ice Edge	~80°17.270' N	~010°50.290' E	~500	Swath survey	End position: 80°33.280' N, 11°38.190' E	John H.
242	18/07	15:15	15:57	16:33	Ice Edge	80°33.280' N	011°38.190' E	967	Piston coring	SAMS core no. 143	John H.
243	18/07	16:59	17:27	17:54	Ice Edge	80°33.270' N	011°38.190' E	964	Megacorer	Megacorer022 – 8/8 cores	Henrik
244	18/07	18:36	?	18:55	Ice Edge	80°33.271' N	011°38.184' E	967	Micronet		Sian
245	18/07	18:40	19:01	19:41	Ice Edge	80°33.270' N	011°38.180' E	939	CTD	CTD090	Mark
246	19/07	03:25	/	~04:45	West Svalbard Margin	79°29.160' N	006°26.470' E	1300	TOPAS survey		John H.
247	19/07	05:00	05:51	~06:30	West Svalbard Margin	79°29.140' N	006°43.290' E	1348	Megacorer	Megacorer023 – 8/8 cores	John H.
248	19/07	05:32	05:37	05:42	West Svalbard Margin	79°29.140' N	006°43.270' E	~1345	Snow catcher	Down 50m. Successful.	Jenny
249	19/07	05:54	05:59	06:05	West Svalbard Margin	79°29.140' N	006°43.260' E	~1345	Snow catcher	Down 100m. Successful.	Jenny
250	19/07	06:54	?	06:56	West Svalbard Margin – Lander 1	79°28.950' N	006°44.270' E	1328	Lander deployment	EDDY lander. Released 06:56.	Henrik
251	19/07	07:07	?	07:09	West Svalbard Margin – Lander 2	79°28.827' N	006°44.294' E	1339	Lander deployment	ELINOR lander. Released 07:09.	Henrik
252	19/07	07:25	08:03	08:56	West Svalbard Margin	79°29.180' N	006°43.330' E	1323	Piston coring	SAMS core no. 144	John H.
253	19/07	07:27	?	07:44	West Svalbard Margin	79°29.170' N	006°43.310' E	~1330	Micronet		Sian
254	19/07	09:30	09:56	10:33	West Svalbard Margin	79°29.140' N	006°43.300' E	1259	CTD	CTD091	Jenny
255	19/07	14:32	14:45	14:54	Amsterdamoya Transect - C	79°51.200' N	009°47.390' E	453	CTD	CTD092	Mark
256	19/07	15:29	15:43	15:54	Amsterdamoya Transect - D	79°49.640' N	010°02.046' E	402	CTD	CTD093	Mark
257	19/07	16:15	/	17:38	Amsterdamoya Slope	79°49.640' N	010°02.000' E	~400	Mooring recovery	Released ~16:25. Surface 16:30.	Colin
258	19/07	18:38	18:47	18:58	Amsterdamoya Transect - E	79°48.600' N	010°11.390' E	361	CTD	CTD094	Mark
259	19/07	23:05	/	23:44	West Svalbard Margin – Lander 1	79°28.700' N	006°43.130' E	?	Lander recovery	EDDY lander. Released 23:09. Surface 23:26.	Henrik
260	19/07	23:54	/	00:40	West Svalbard Margin – Lander 2	79°28.710' N	006°42.470' E	?	Lander recovery	ELINOR lander. Released 00:06. Surface 00:23.	Henrik
261	20/07	03:46	/	06:25	Prins Karls Forland	78°54.920' N	006°45.900' E	?	Swath + TOPAS survey	End position: ~78°58.205' N, 7°01.850' E	John H.
262	20/07	06:43	07:10	07:34	Prins Karls Forland	78°58.215' N	007°01.901' E	1208	CTD	CTD095	Robert
263	20/07	07:54	08:28	09:05	Prins Karls Forland	78°58.210' N	007°01.900' E	~1210	Megacorer	Megacorer024 – 7/8 cores	Robert

Evt No.	Date	Start Time (GMT)	Bottom Time (GMT)	End Time (GMT)	Station	Latitude	Longitude	Depth (m)	Activity	Comments	Lead
264	20/07	~09:20	10:00	10:50	Prins Karls Forland	78°58.220' N	007°01.890' E	~1210	Piston coring	SAMS core no. 145	John H.
265	20/07	16:07	16:25	16:40	Isfjord Banken Transect A	78°08.014' N	009°13.405' E	750	CTD	CTD096 (10m above seafloor)	Mark
266	20/07	17:06	17:22	17:35	Isfjord Banken Transect B	78°07.990' N	009°18.438' E	593	CTD	CTD097 (11m above seafloor)	Mark
267	20/07	18:03	18:14	18:22	Isfjord Banken Transect C	78°07.990' N	009°23.980' E	359	CTD	CTD098 (9m above seafloor)	Mark
268	20/07	18:41	18:53	18:58	Isfjord Banken Transect D	78°07.997' N	009°30.483' E	239	CTD	CTD099 (5m above seafloor)	Mark
269	20/07	19:18	19:26	19:31	Isfjord Banken Transect E	78°07.996' N	009°34.350' E	228	CTD	CTD100 (5m above seafloor)	Mark
270	20/07	19:46	/	20:08	Isfjord Banken	78°07.990' N	009°34.360' E	225	AUV deployment	Mission started at 20:04.	Tim Bo.
271	20/07	20:26	/	00:32	Isfjord Banken	78°07.770' N	009°34.290' E	220	MSS	Profiles 53 onwards. End position: 78°07.660' N, 09°20.490' N	Mark
272	21/07	02:04	/	02:21	Isfjord Banken	78°07.700' N	009°34.240' E	~220	AUV recovery		Tim Bo.

JCR219 Sea-Ice Scientific Event Log

Evt No	Date	Start time (GMT)	End time (GMT)	Ship's latitude	Ship's longitude	Working area	Activity	Comments	Lead
I1	22/06	06:37	07:17	80°52.320' N	005°01.240' E	All	Coring	4 cores to assess ice thickness (inc. 1 for CT profile). Results = ice 1.2 to 1.6m thick.	Soren / Ronnie
I2	22/06	12:31	18:59	80°50.900' N	004°53.450' E	All	Camp mapping and set-up	Cf ice camp map	Ray
I3	22/06	12:53	15:02	80°50.900' N	004°53.450' E	Gas Sampling	Water sampling	For trace gases	Helen
I4	22/06	15:02	16:15	80°50.400' N	004°52.380' E	Physics 1	GPS receivers installation	2 units	Bernard
I5	22/06	16:41	18:59	80°49.810' N	004°51.900' E	EDDYs	EDDYs + CTD installation	Shallow Water EDDY started at 18:10 Deep Water EDDY started at 18:30 CTD started at 18:40	Ronnie
I6	23/06	08:14	09:31	80°45.200' N	004°46.720' E	Diving area + Gas Sampling	Water sampling	For trace gases	Helen
I7	23/06	11:26	12:57	80°44.470' N	004°41.410' E	Gas Sampling	Water sampling	For trace gases	Helen
I8	23/06	11:26	16:35	80°44.650' N	004°36.500' E	EDDYs	EDDY installation	SAMS EDDY started at 18:10	Ronnie
I9	24/06	06:51	08:26	80°42.610' N	004°20.790' E	Water Sampling	Water sampling - experimental + pelagic		Ray
I10	24/06	08:26	12:36	80°41.920' N	004°20.110' E	Water Sampling	Water sampling - pelagic	Matching CTD017	Ray
I11	24/06	14:16	14:44	80°40.250' N	004°13.760' E	Diving	Diving	Test dive + video	Hugh
I12	24/06	17:29	18:20	80°39.410' N	004°15.070' E	Coring	Coring (Heiko + Helen) + brine sampling (Helen)		Helen + Heiko
I13	25/06	11:30	12:10	80°33.850' N	004°13.920' E	Physics 1	Doppler installation	Started at 12:10	Colin
I14	25/06	11:42	13:15	80°33.810' N	004°13.580' E	Coring	Coring		Ronnie
I15	25/06	11:55	13:30	80°33.810' N	004°13.580' E	Physics 1	Coring + brine sampling	For trace gases	Helen
I16	25/06	15:07	15:43	80°33.500' N	004°09.390' E	Diving	Diving		Hugh
I17	25/06	17:30	18:43	80°33.200' N	004°09.070' E	Physics 1	Coring	6 cores for ice isotopes (R. Turnewitsch)	John
I18	26/06	08:20	08:25	80°31.450' N	004°11.450' E	Water Sampling	CTD	SBE19+, 23m deep	Ray
I19	26/06	08:30	09:30	80°31.450' N	004°11.450' E	Water Sampling	Water sampling	Matching CTD020 / 021	Ray
I20	26/06	11:16	11:50	80°30.380' N	004°03.990' E	Diving	Diving	Algae collection + photography	Hugh
I21	26/06	11:51	12:02	80°30.280' N	004°02.470' E	Physics 2	Mooring deployment		Colin
I22	26/06	12:02	12:10	80°31.450' N	004°11.450' E	Diving	Diving	PAM fluorometer	Kunuk
I23	26/06	12:33	15:25	80°30.200' N	004°00.600' E	From Physics 1 up to 100m away towards the ship	Coring	9 cores for ice isotopes (R. Turnewitsch)	John
I24	26/06	17:42	18:11	80°29.750' N	003°51.140' E	Gas sampling	Water sampling	For trace gases	Helen

Evt No	Date	Start time (GMT)	End time (GMT)	Ship's latitude	Ship's longitude	Working area	Activity	Comments	Lead
I25	26/06	18:07	19:11	80°29.690' N	003°50.550' E	Diving	CTD & light sensors board	Test cast	Colin
I26	26/06	18:48	19:28	80°29.510' N	003°49.480' E	Coring	Coring	For ice-algae lipids	Heiko
I27	27/06	06:53	08:22	80°27.690' N	003°44.080' E	Coring	Coring	4 cores	Ronnie
I28	27/06	06:53	08:22	80°27.690' N	003°44.080' E	Physics 1	Coring + brine sampling	For trace gases	Helen
I29	27/06	06:53	07:55	80°27.210' N	003°42.680' E	Physics 1	APEX deployment		Bernard
I30	27/06	11:23	11:51	80°25.480' N	003°36.130' E	Diving	Diving	Video and light meter rope deployment	Hugh
I31	27/06	14:16	14:33	80°24.350' N	003°31.600' E	Diving	Diving + surface PAR measurement	Ice sampling + PAM	Soren
I32	27/06	16:02	16:45	80°23.780' N	003°29.620' E	Ice edge at aft of ship ~100m away	Coring	Ice too thick – no cores taken	John
I33	27/06	16:55	17:10	80°23.780' N	003°29.620' E	Physics 1	APEX recovery	Taken back onboard for re-batterying	Bernard
I34	28/06	11:31	12:01	80°18.080' N	003°14.470' E	Physics 1	APEX deployment		Bernard
I35	28/06	11:50	12:23	80°17.980' N	003°13.110' E	Diving	Diving	Gas samples for Helen Particle flux + algae sample for Jen	Hugh
I36	28/06	12:45	12:57	80°17.720' N	003°12.600' E	Diving	CTD & light sensors board deployment + surface PAR measurement	3 casts under ice, max 23m deep	Colin / Estelle
I37	28/06	13:48	15:55	80°17.460' N	003°11.400' E	Water Sampling + Coring	Coring		Ronnie
I38	28/06	15:11	15:55	80°17.140' N	003°09.960' E	Coring ?	Coring	For coupling experiment	Emilie
I39	29/06	09:07	10:44	80°16.330' N	003°01.300' E	Coring ?	Coring		Ronnie / Soren
I40	29/06	09:07	11:05	80°16.330' N	003°01.300' E	Physics 1	APEX recovery		Bernard
I41	29/06	10:00	10:05	80°16.340' N	003°01.510' E	Water Sampling	CTD & light sensors board	1 cast, 24m deep	Colin
I42	29/06	10:05	11:50	80°16.340' N	003°01.510' E	Water Sampling	Water sampling	Experimental (5m) Pelagic (5m and 10m)	Ray
I43	29/06	10:50	12:22	80°16.070' N	002°56.960' E	Physics 2 + Gas sampling	Ice coring & brine sampling + Water sampling	For trace gases	Helen
I44	29/06	11:52	11:57	80°16.070' N	002°56.960' E	Water Sampling	CTD & light sensors board	1 cast, 33m deep	Colin
I45	29/06	17:30	17:45	80°15.090' N	002°45.310' E	Diving	CTD & light sensors board + surface PAR sensor deployment	Deployed for overnight sampling, 7m deep	Colin / Estelle
I46	29/06			80°15.090' N	002°45.440' E	Coring	Coring		Heiko
I47	30/06	08:09	~08:30	80°13.800' N	002°31.000' E	Diving	CTD & light sensors board + surface PAR sensor recovery	3 casts, max 38m deep.	Colin / Estelle
I48	30/06	08:09	~10:00	80°13.800' N	002°31.000' E	Physics 1	GPS receivers recovery		Bernard
I49	30/06	08:58	10:11	80°13.740' N	002°29.250' E	Physics 1	Coring + brine sampling	For trace gases	Helen

Evt No	Date	Start time (GMT)	End time (GMT)	Ship's latitude	Ship's longitude	Working area	Activity	Comments	Lead
I50	30/06	09:01	09:41	80°13.730' N	002°29.140' E	Diving	Diving		Hugh
I51	30/06	~10:00	10:27	80°13.440' N	002°25.870' E	Physics 1	Doppler recovery		Colin
I52	30/06	11:35	14:22	80°13.250' N	002°23.460' E	EDDYs	EDDYs + thermistor chains recovery		John / Gavin
I53	30/06	13:41	14:56	80°13.080' N	002°20.040' E	Water Sampling	Water sampling	Pelagic	Ray
I54	30/06	13:41	14:56	80°13.080' N	002°20.040' E	Coring	Coring		Ronnie
I55	30/06	14:59	15:53	80°12.930' N	002°18.480' E	Diving	CTD & light sensors board + surface PAR sensor deployment	7 casts under ice , max 45m deep.	Colin / Estelle
I56	30/06	19:21	19:47	80°12.150' N	002°13.840' E	Diving	CTD & light sensors board + surface PAR sensor deployment	1 cast, 26m deep, then deployed for overnight sampling, 5m deep.	Colin / Estelle
I57	30/06	19:52	20:03	80°12.140' N	002°13.780' E	Gas Sampling	Water sampling	For trace gases	Helen
I58	01/07	11:46	12:17	80°13.380' N	002°09.700' E	Diving	CTD & light sensors board + surface PAR sensor recovery		Colin / Estelle
I59	01/07	12:03	13:01	80°13.380' N	002°09.940' E	Physics 2	Mooring recovery		Bernard
I60	01/07	12:17	12:53	80°13.380' N	002°10.160' E	Gas Sampling	Water sampling	For trace gases	Helen

SUMMARY OF PRELIMINARY RESULTS

Ray Leakey

A range of oceanographic conditions were encountered during the cruise including: (1) warm North and Norwegian Sea waters (Leg 1); (ii) warm Atlantic influenced water in the Greenland Sea (Leg 1) and offshore from the Svalbard shelf (Legs 3 and 4); (iii) cold coastal waters on the Svalard shelf subject to surface warming (Legs 3 and 4); (iv) cold, low salinity surface waters influenced by ice melt at the ice station (Leg 2), on the Greenland shelf (Leg 3) and to the north-west of Svalbard (Leg 3); (v) cold but higher salinity true Arctic water on the Greenland Shelf.

Interleaving and mixing between the West Spitsbergen Current and waters of the continental shelf west of Isforden, Svalbard, led to enhanced variability in temperature, salinity, and turbulent kinetic energy shoreward of the WSC.

Chlorophyll-a concentrations showed significant spatial and temporal variation. At the ice station, surface concentrations varied from 0.11 mg m^{-3} under sea ice, to 6.94 mg m^{-3}. A subsurface chlorophyll maximum was observed at most stations under stratified bloom conditions, with relatively uniform concentrations observed with depth in surface waters at the ice station. Phytoplankton assemblages varied in their photosynthetic efficiencies and adaptation to light.

Pelagic biomass was dominated by nanoplankton, dinoflagellates and ciliates with few large diatoms at the ice, KF3 and Greenwich Meridian stations. KF4 and Greenland Shelf stations were dominated more by diatoms in surface waters. Highest bacterial biomass wsa recorded at KF4 with lowest values at the Greenland Shelf station.

Gross primary production and community respiration generally increased from the UK to Svalbard with autotrophic processes predominating at most stations (Leg 1). Surface waters at the ice station were less productive compared to open waters possibly due to light limitation of photosynthesis under the ice.

Pelagic bacteria were found to be poorly coupled to phytoplankton in cold Arctic waters characterised by low phytoplankton production, obtaining much of their carbon from other sources. This in turn led to high phytoplankton versus bacterial competition for nitrogen.

The sea-ice at the ice station (Leg 2) was melting and highly permeable, declining in thickness from 98 to 89 cm during the 9 day's campaign. The ice microbial community was composed of a diverse range of taxa dominated by small pennate diatoms (*Navicula* spp). Ice primary production was moderate and bacterial production low.

Crystals of ikaite, a polymorph of calcium carbonate, were found in sea-ice at the ice station (Leg 2). These crystals are associated with a recently discovered sea-ice carbon pump in Arctic sea ice.

Concurrent irradiance, oxygen flux and velocity measurements at the ice-water interface suggest that oxygen flux is in part controlled by light and horizontal flow at the sea-ice station (Leg 2).

Enhanced concentrations of halocarbons were measured in the ice brine at the sea-ice station (Leg 2) compared to the water below. Higher atmospheric mixing ratios of some halocarbons were found in the atmosphere above sea ice compared to that above the open ocean.

Svalbard fjordic sediments had significantly higher sediment oxygen uptake rates than deeper water sediments offshore. However, surprisingly two northern fjords slightly higher respiration rates the most southern fjordic site which experiences higher bottom water temperatures. Overall oxygen flux data displayed a significant negative correlation with depth.

SCIENTIFIC REPORT 1: Physics CTDs

Estelle Dumont

1 Shipboard CTD (SBE911)

1.1 Methodology

Two CTDs were used during the cruise: both were housed in standard stainless steel frames, and were equipped with dual T and C sensors, SBE43 oxygen sensor, Chelsea Aqua 3 fluorometer, altimeter, Wetlab CStar transmissometer and Biospherical/Licor PAR/irradiance sensor.

Figure 1.1-1: CTD being deployed from the mid-ship gantry.

Twenty-four 10 litres Niskin bottles were fitted on the first CTD carousel. The system was deployed from the CTD winch on the starboard side during legs 1, 3 and 4. The second CTD only carried twelve 10 litres bottles and was deployed at the stern of the ship due to ice conditions during leg 2.
The usual procedure was to first lower the CTD to around 10m deep for the pumps to switch on. The system was then brought back up to the surface before starting the cast.

1.2 Data processing

The CTD data were processed according the standards described in the SAMS CTD data Processing Protocol (Dumont and Sherwin, 2008, SAMS internal report No 257), using Seabird Data Processing version 7.18b and Matlab R2007a. The processing steps were:
Step 1(SBE Data Processing, batch processing): modules Data Conversion, Align CTD, Cell Thermal Mass, Filter, Derive, Translate and Bottle Sum.
Step 2 (Matlab): despiking of the 24Hz data
Step 3 (SBE Data Processing, batch processing): modules Ascii In,, Bin Average (2db-bins) and Ascii Out
Step 4 (Matlab): plot of the data
Step 5 (Matlab): calibration of oxygen and salinity data on both 24Hz and 2db-bin averaged datasets (post-cruise).

(a) Raw data processing (SBEDataProcessing)

Data Conversion converted raw data from engineering units to binary .cnv files and produced the .ros files. Variables exported were scan number, pump status, Julian day, pressure [db], temperature0 [ITS-90, deg C], conductivity0 [mS/cm], temperature1 [ITS-90, deg C], conductivity1 [mS/cm], oxygen [mg/l], beam attenuation [1/m], altimeter [m], fluorescence [µg/l], beam transmission [%], PAR and depth [m].
Please note:
The primary TC sensors were labelled 0, secondary 1.
The depth exported here was only for indicative purposes in the bottle files. Accurate depth calculation was performed at the Derive stage, and this first depth removed in processed files.

AlignCTD was then run to compensate for sensor time-lag.
The secondary conductivity was advanced by 0.073s, as recommended by Seabird.
The oxygen sensor response was advanced relative to pressure (+5s applied here). This ensures that calculations of dissolved oxygen concentration are made using measurements from the same parcel of water.

In **Cell Thermal Mass**, a recursive filter was run to remove conductivity cell thermal mass effects from the measured conductivity. The constants used were the ones given by Seabird: thermal anomaly amplitude α=0.03 and thermal anomaly time constant 1/β=7.

Filter applied a low-pass filter (value of 0.15) on the pressure and depth data, which smoothed the high frequency (rapidly changing) data. To produce zero phase (no time shift), the filter was first run forward through the data and then run backward through the data. This removed any delays caused by the filter.

At the **Derive** stage, twin densities sigma-theta (kg/m3), twin salinities (psu) and depth (m) were calculated.

The data was converted from binary to ASCII format by the module **Translate**. The data had been kept in binary format up to this stage to avoid any loss in precision that could occur when converting to Ascii.

Finally, the module **BottleSum** created the ASCII bottle files (.btl) from the .ros files, for each bottle fired during a cast. These files contain mean, standard deviation, maximum and minimum values for all variables (average of 48 scans, i.e. 2s).

(b) Despiking (Matlab)
The pressure, oxygen, temperature (primary and secondary) and salinity (primary and secondary) data were manually despiked. Any data recorded while the pumps were not on were deleted at this stage.
Notes on the despiking:
- When a spike occurred in the pressure, temperature or salinity data, making that/those point(s) flagged as bad, the whole corresponding scan has been deleted.
- When a spike occurred in the oxygen data, making that point flagged as bad, the erroneous value was set to NaN, and other variables of the scan (i.e. temperature, salinity, etc) were kept in the dataset (if not flagged as bad themselves).

(c) Averaging (SBEDataProcessing)
After going through Matlab, the data files needed to be re-formatted to be recognised by SBE Data Processing. **ASCII In** added a header to the input .asc file and output a .cnv file (XXX_2.cnv).
The module **Bin Average** averaged the 24Hz data into 2db-bins, using the downcast data only.
Ascii Out output the bin-averaged data files as ASCII (with a simplified header).

(d) Datafiles
The different types of files created are (example of cast no 001):
jr219_001_1.cnv : non despiked, non calibrated 24Hz data
jr219_001_2.asc : despiked, non calibrated 24Hz and 2db-bin averaged data
jr219_001_3.asc : despiked, calibrated 24Hz data
jr219_001.CTD: despiked, calibrated 2db-bin averaged data (WOCE format conventions)
jr219_001.btl : bottle data file, non calibrated
jr219_001.hdr : header file, describing the data processing details

1.3 Data calibration
(a) Salinity calibration
Throughout the cruise the CTD was sampled for salinity measurements, in order to calibrate the conductivity sensors. Salinity was measured using a Guildline Autosal8400, in a temperature-controlled room onboard the ship. The CTD data used for calibration comes from the .btl files (created by the Seabird software).

For the first CTD (leg 1, 3 and 4) a total of 90 salinity samples were collected and analysed, including a few duplicate samples. The Autosal and the Seabird values were in good agreement. Six data points had a difference over 0.1 psu and were not used for calibration.

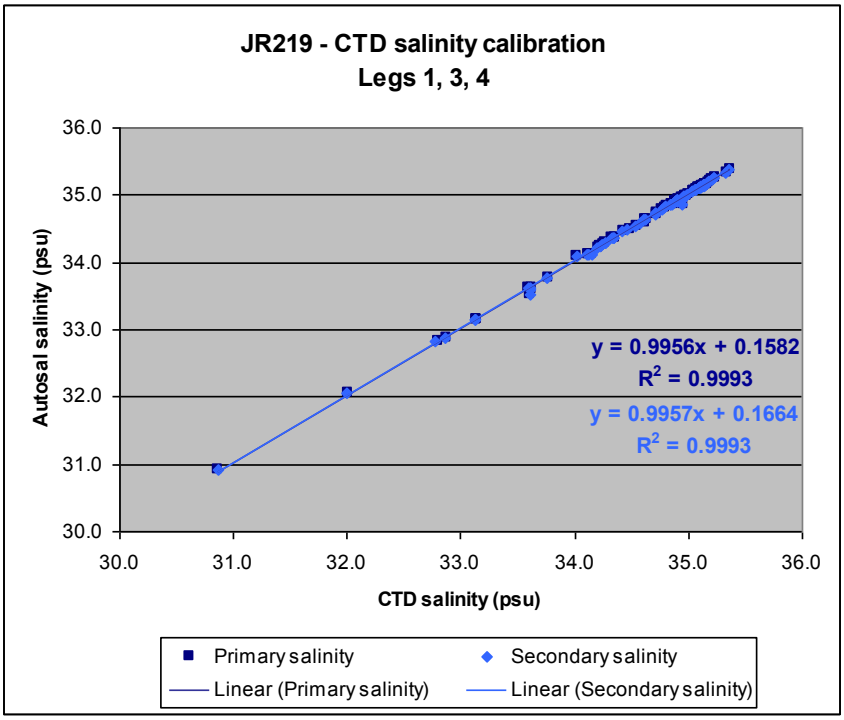


Figure 0 -1: CTD salinity calibration data and equation for leg 1, 3 and 4.

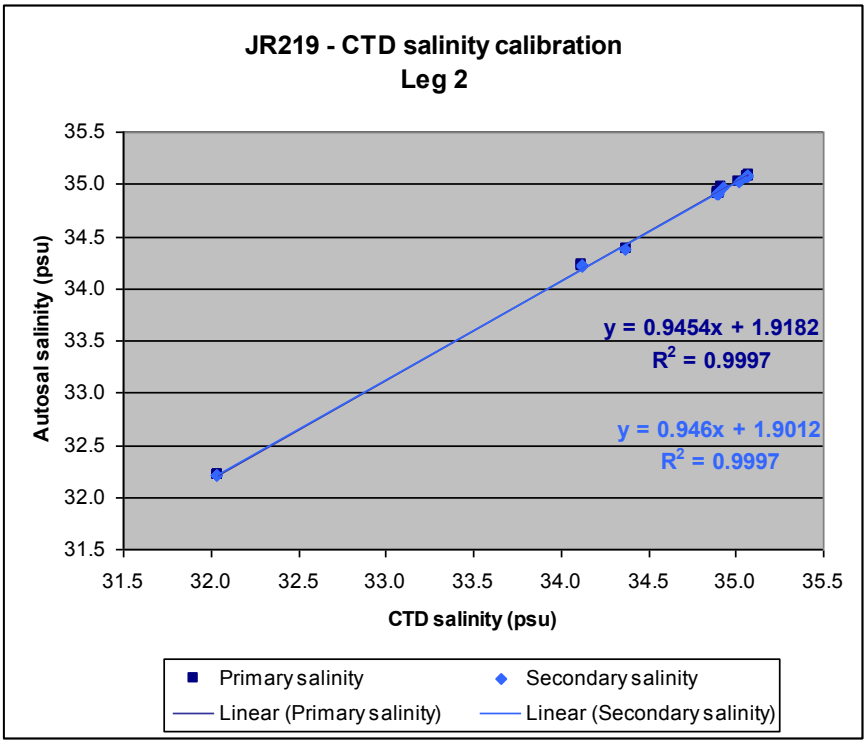


Figure 1.3-2: CTD salinity calibration data and equation for leg 2.

For the second CTD (leg2) 25 salinity samples were collected and analysed, including a few duplicate samples. The correlation was not as good as for the other CTD, particularly in surface waters. This is probably because the casts were done when the ship was moored to the ice floe, in highly stratified surface waters. Often, the propellers were running to clear the ice drifting at the stern, disturbing the surface layers. Five data points, showing a difference over 0.2 psu between the Autosal and the CTD readings, were removed.

The final calibration equations are summarised below in Table Error! No text of specified style in document.**-1**.

Table Error! No text of specified style in document.**-1: CTD salinity calibration equations summary.**

CTD package	Sensor	Calibration equation	R^2
CTD 1 (leg 1, 3, 4)	Primary	$SAL_{calib} = 0.9956 \times SAL_{ctd} + 0.1582$	0.9993
CTD 1 (leg 1, 3, 4)	Secondary	$SAL_{calib} = 0.9957 \times SAL_{ctd} + 0.1664$	0.9993
CTD 2 (leg 2)	Primary	$SAL_{calib} = 0.9454 \times SAL_{ctd} + 1.9182$	0.9997
CTD 2 (leg 2)	Secondary	$SAL_{calib} = 0.9460 \times SAL_{ctd} + 1.9012$	0.9997

(b) Dissolved Oxygen calibration

For the methodology refer to Scientific Report 15.

To follow WOCE data format conventions, the calibrated O_2 values in the final datafiles have been converted from mg/l to µmol/kg using the formula:
[µmol/Kg] = (([mg/L] / 1.42903) * 44660) / (sigma_theta + 1000)

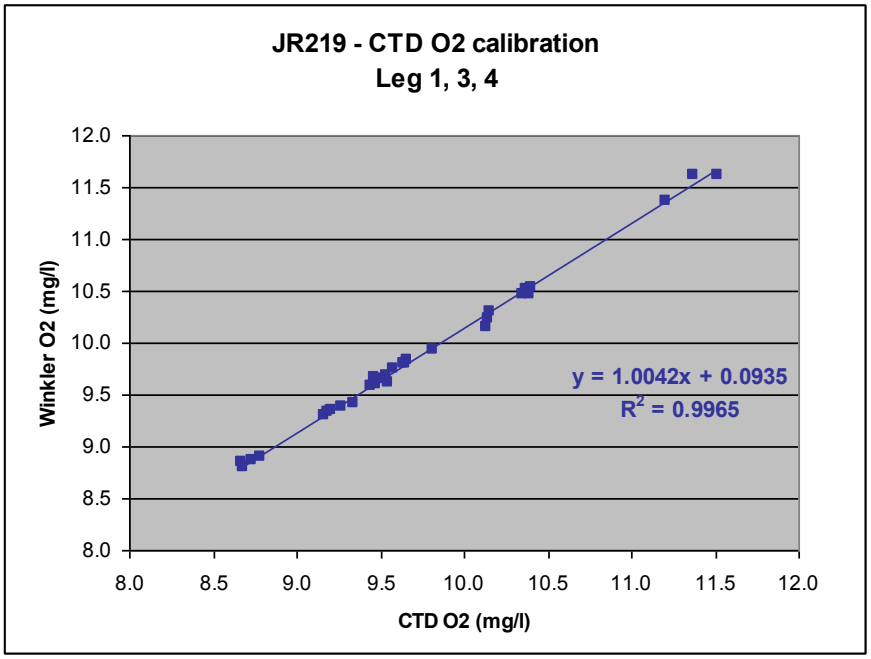


Figure 1.3-3: CTD O_2 calibration data and equation for leg 1, 3 and 4.

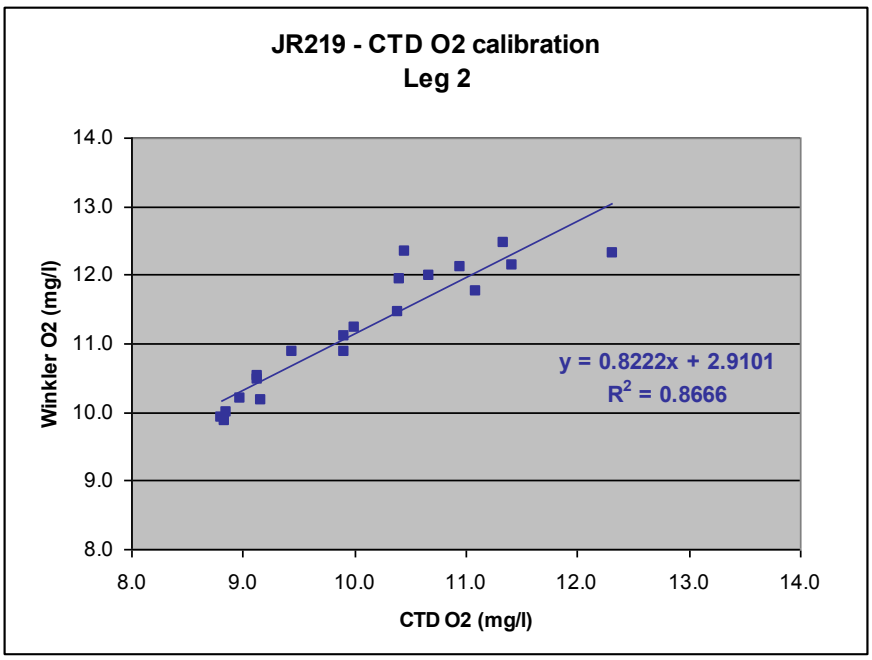


Figure 1.3-4: CTD O_2 calibration data and equation for leg 2.

(c) Fluorometer calibration

Please note that the fluorescence data has not been calibrated in the final dataset. Users wishing to use calibrated data should refer to the chlorophyll discrete sampling carried out throughout the cruise to determine a suitable calibration equation.

1.4 Comments

The CTDs have generally performed well during the cruise, although a few points are worth noting:

The dual temperature and conductivity measurements were in good agreement throughout the cruise, except at the beginning of leg 2. The secondary conductivity sensor appeared to be faulty, and was replaced after a few casts. Therefore, the secondary conductivity, salinity and density for CTD013 to 017 should not be used.

The acquisition software (Seasave) installed on the ship's CTD computer was an old version, not supporting the use of the new oxygen calibration method and coefficients. The CON file used for data acquisition was therefore an inaccurate one (keeping the old oxygen calibration method). However, the data processing was performed with a more recent version of the Seabird software, and an up-to-date CON file was used to process the data.
Some errors in the calibration coefficients of the PAR sensor and fluorometer were also found in the original CON file. These were corrected shortly after the start of the cruise, and all the data were processed using the up-to-date CON file.
In the final data, the transmittance values reported were sometimes over 100% (up to 102%), indicating that the transmissometer is probably slightly out of calibration.

A misfiring issue was encountered several times on CTD1 (leg 3 and 4) for bottle 16: the acquisition software would not report the bottle as fired, although it did close correctly. The bottle firing was not recorded in the data either, shifting the bottles recordings in the .btl files (e.g. the bottle recorded as 16 was actually bottle 17, bottle 17 was bottle 18, etc). This happened for casts number 33, 34, 43, 46, 49, 53, 56, 57, 58, 59 and 80. Those .btl files have been corrected post-cruise by re-attributing the correct bottle number to the recordings. As there was no data for bottle 16 on those casts, the data from the previous or following bottle, if fired at the same depth, was used instead. If bottle 16 was the only bottle fired at a certain depth the data has been replaced by a "bad flag" value (99999).

1.5 T-S diagrams

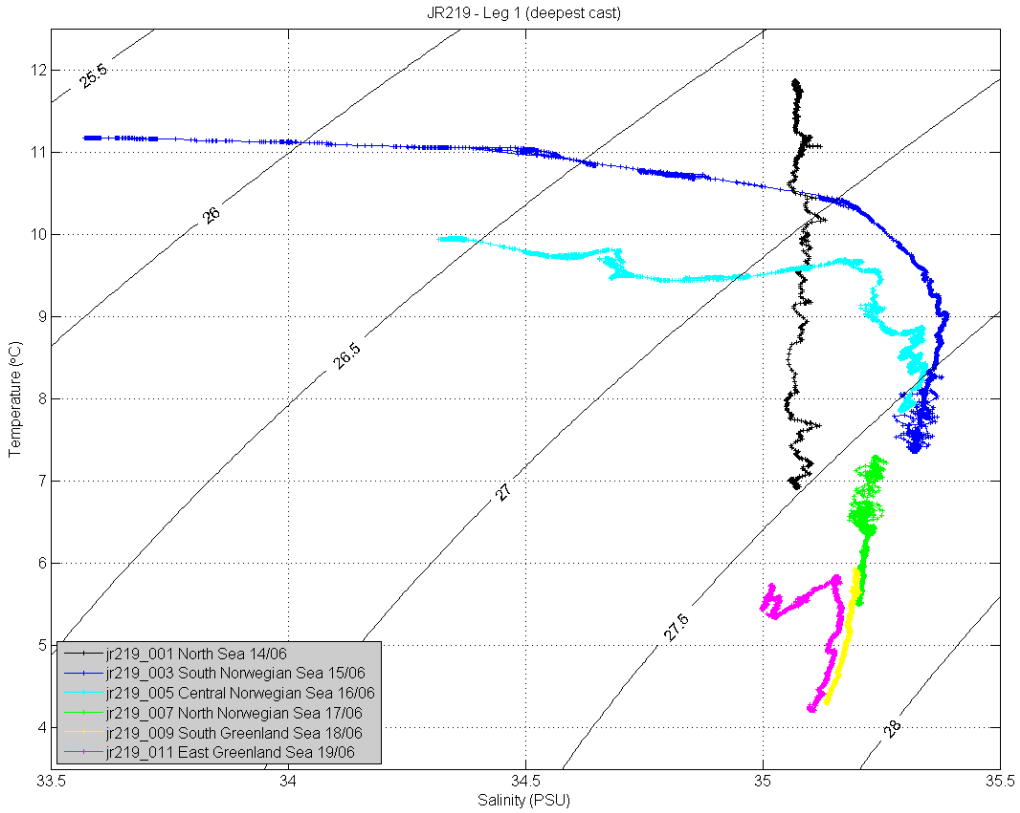


Figure 1.5-5: T-S diagram of the CTD stations in leg 1 (deepest cast).

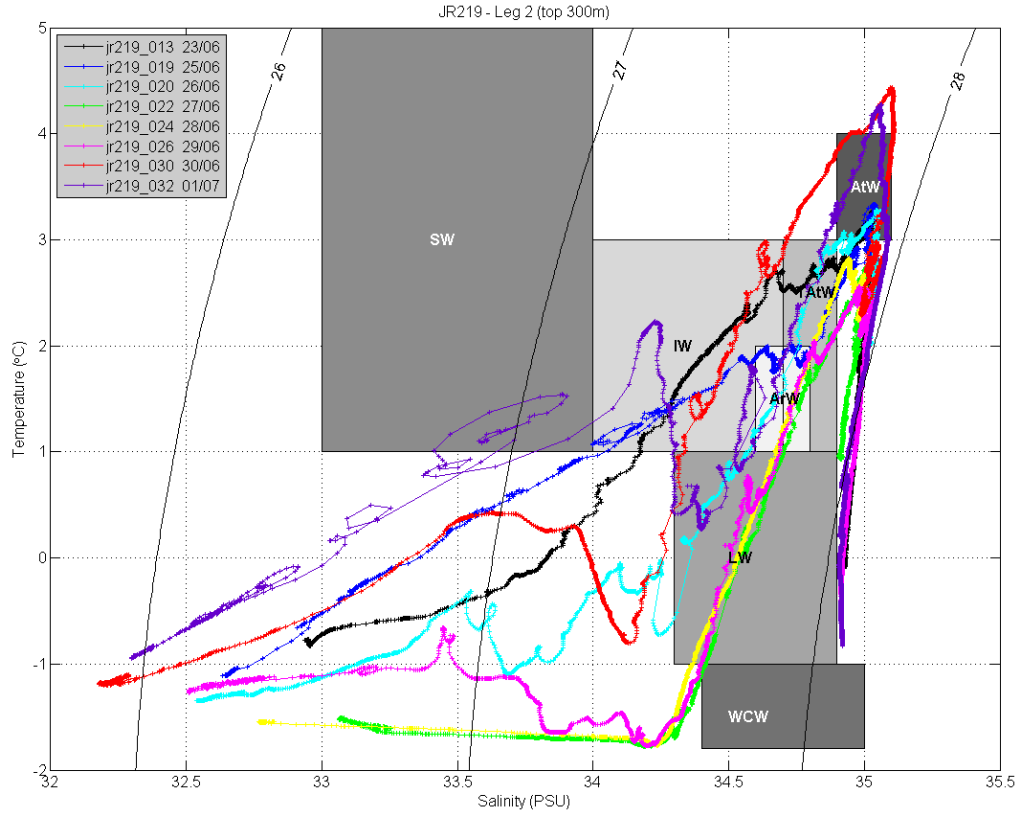


Figure 1.5-6: T-S diagram of the CTD stations in leg 2 (top 300m of the water column).

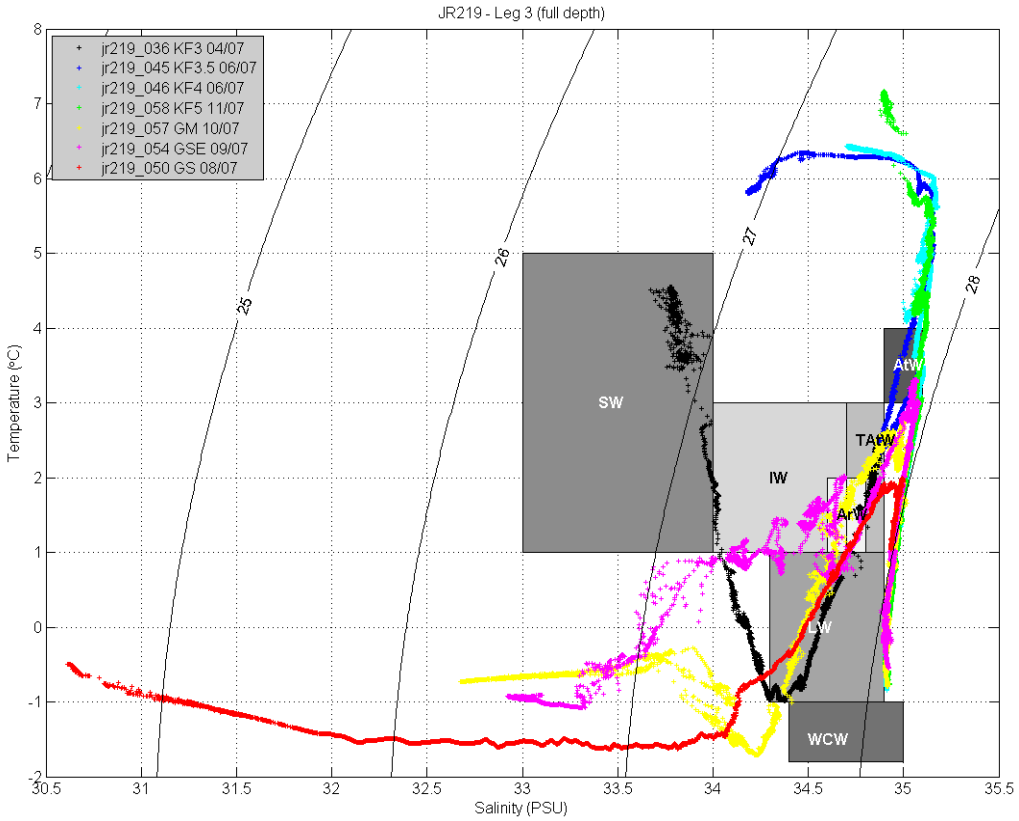


Figure 1.5-7: T-S diagram of the CTD stations in leg 3 (full depth casts).

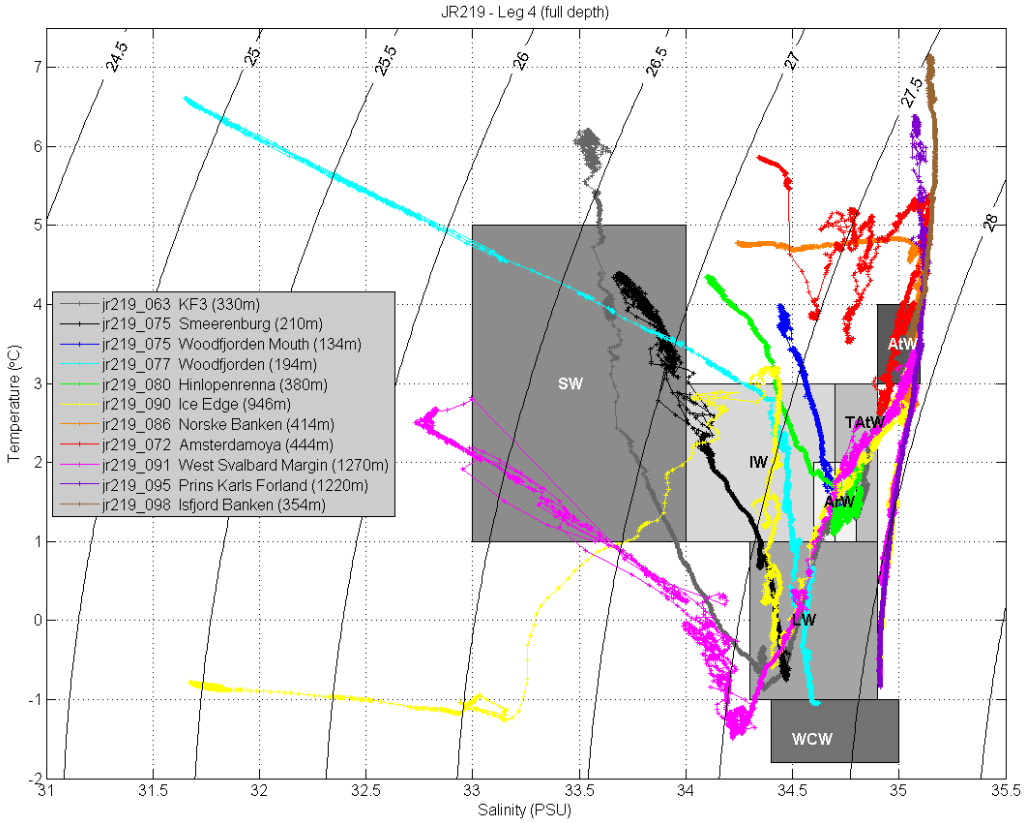


Figure 1.5-8: -S diagram of the CTD stations in leg 4 (full depth casts).

The water masses represented on the diagrams are: AtW = Atlantic Water; ArW = Arctic Water; SW = Surface Water; LW = Local water; WCW= Winter Cooled Water IW = Intermediate Water; TAtW = TYransforemed Atlantic Water.

1.6 CTD Transects

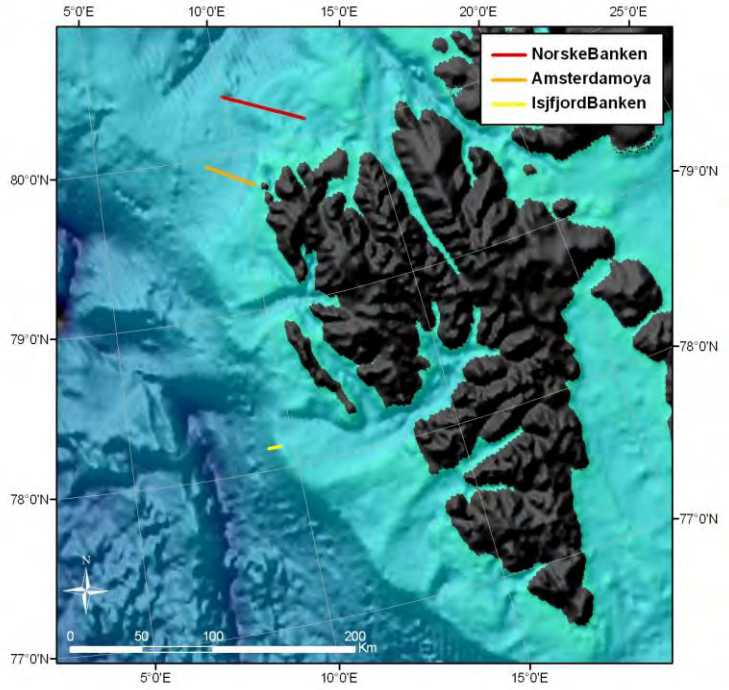


Figure 1.6-9: Location of the CTD transects realised during leg 4.

Amsterdamøya (14/07/10 – 15/07/10)

Data (left to right) from casts 64, 65, 66, 76, 68, 69, 70 and 71.

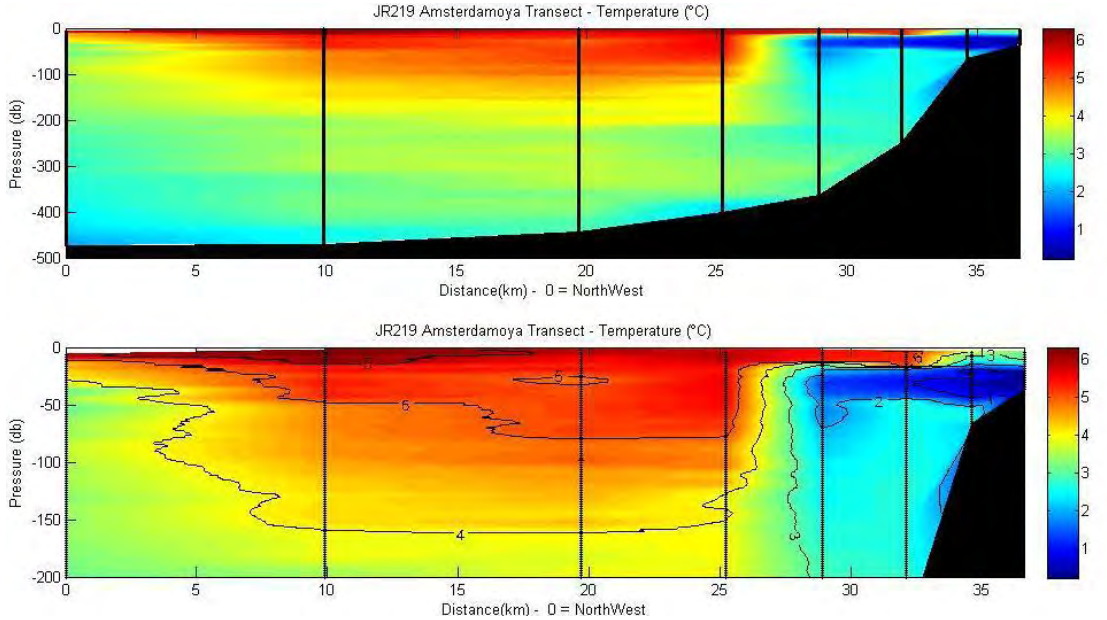


Figure 1.6-2: Amsterdamoya transect temperature, for the whole depth and close-up on the 200m surface layer.

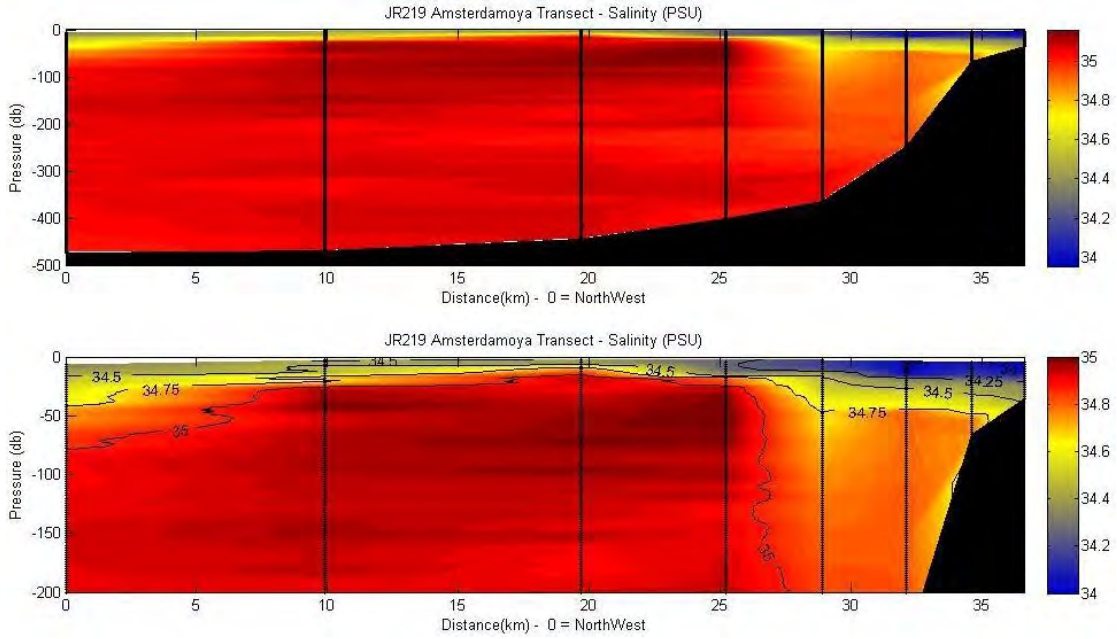


Figure 1.6-3: Amsterdamoya transect salinity, for the whole depth and close-up on the 200m surface layer.

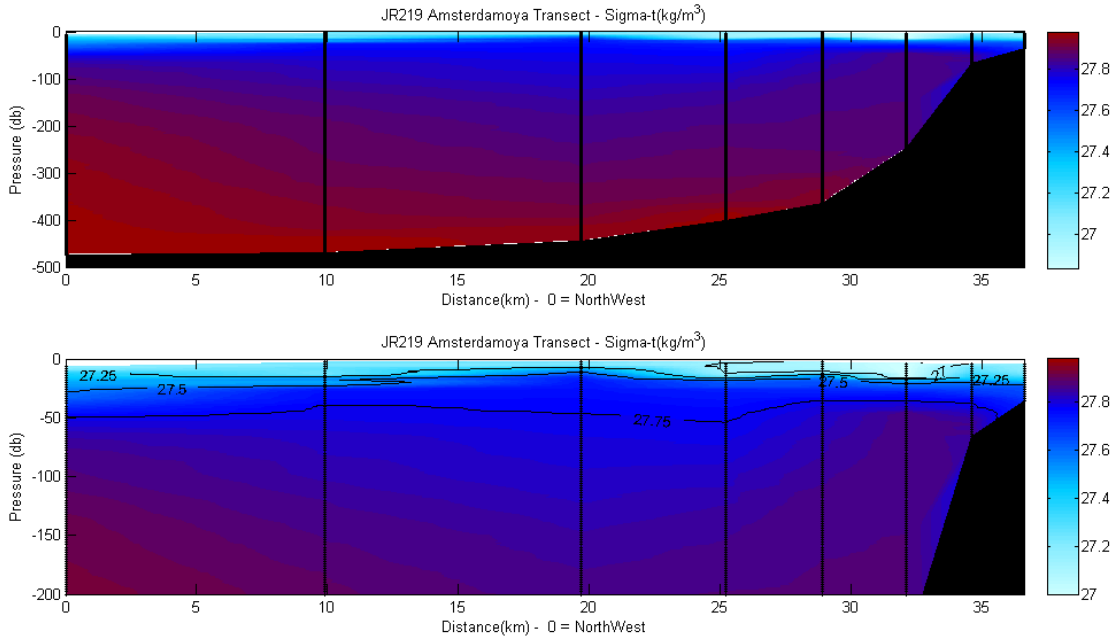


Figure 1.6-4: Amsterdamoya transect sigma-theta, for the whole depth and close-up on the 200m surface layer.

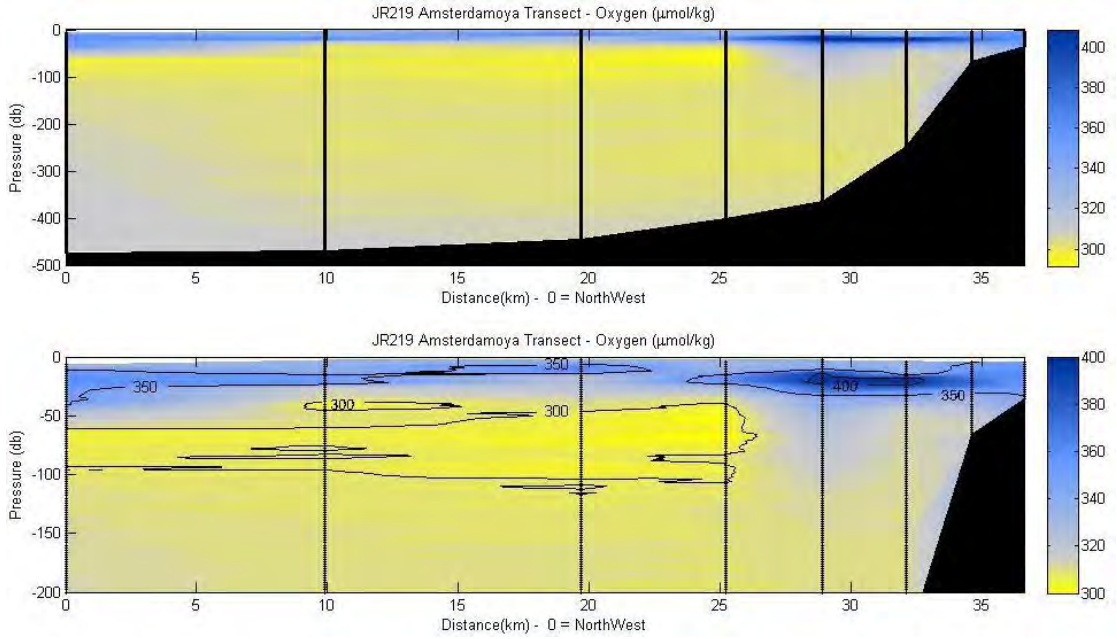


Figure 1.6-5: Amsterdamoya transect dissolved oxygen, for the whole depth and close-up on the 200m surface layer.

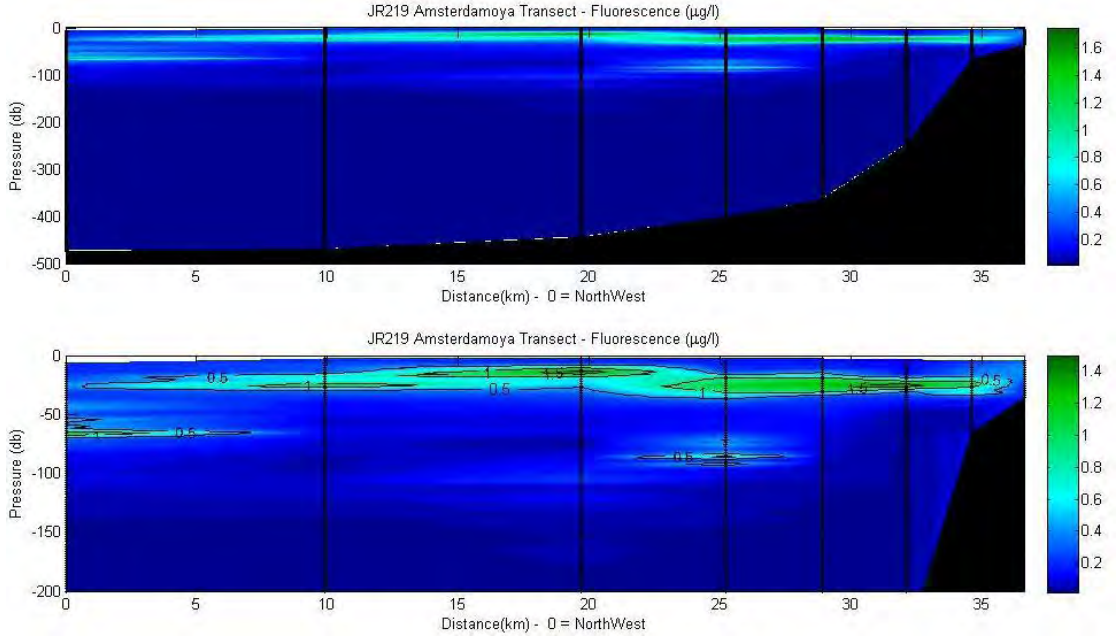


Figure 1.6-6: Amsterdamoya transect fluorescence, for the whole depth and close-up on the 200m surface layer.

(b) Norske Banken (17/07/10 – 18/07/10)

Data (left to right) from casts. 89, 88, 87, 86, 85, 84, 83, 82 and 81.

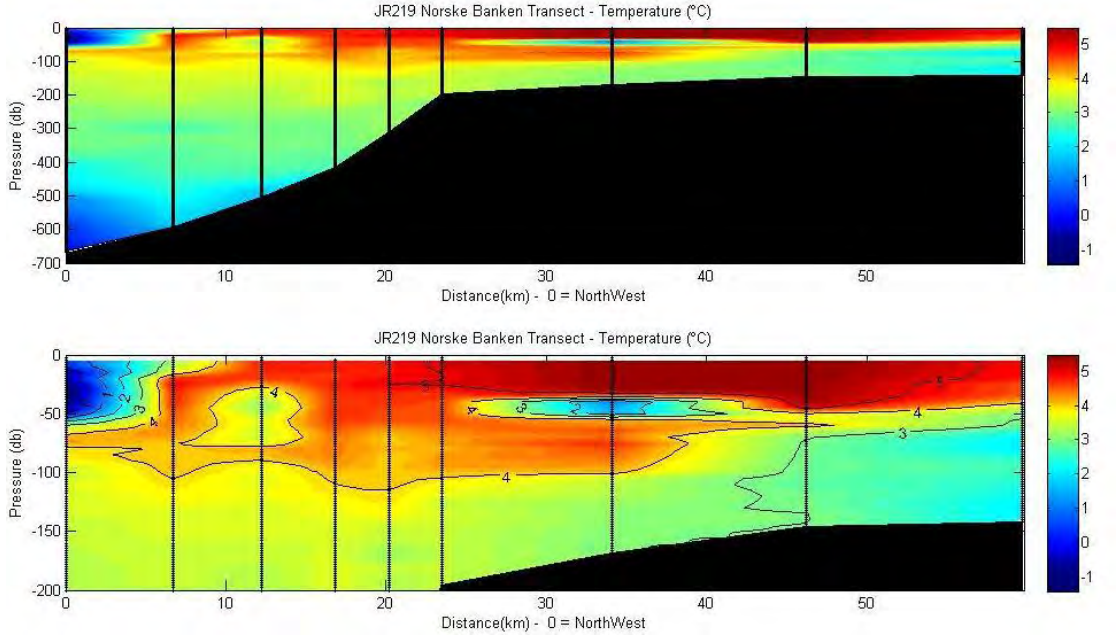


Figure 1.6-7: Norske Banken transect temperature, for the whole depth and close-up on the 200m surface layer.

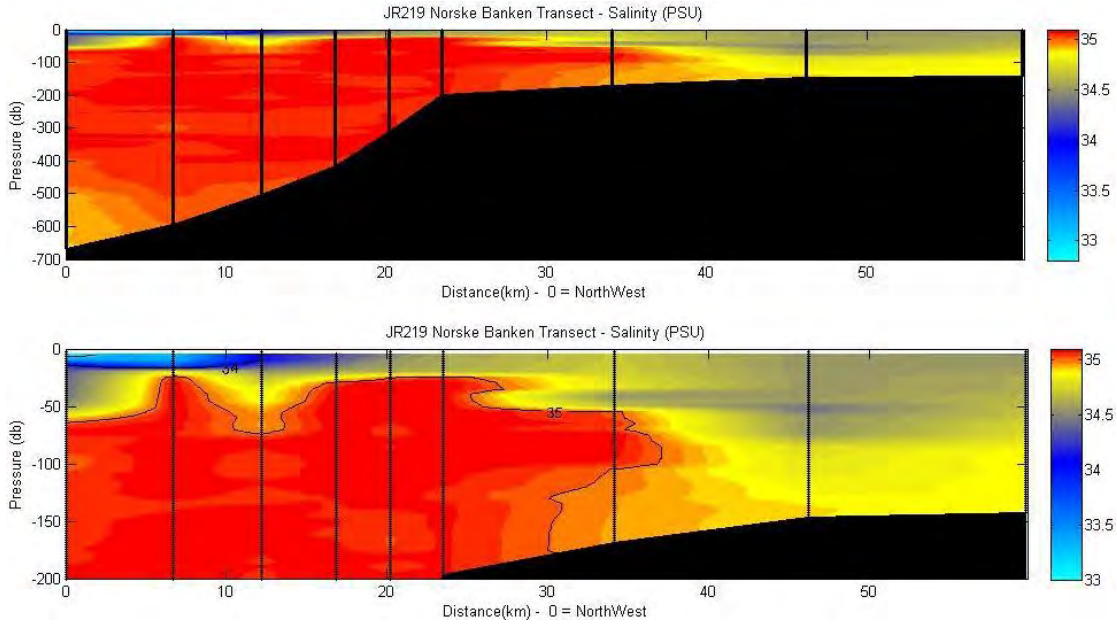


Figure 1.6-8: Norske Banken transect salinity, for the whole depth and close-up on the 200m surface layer.

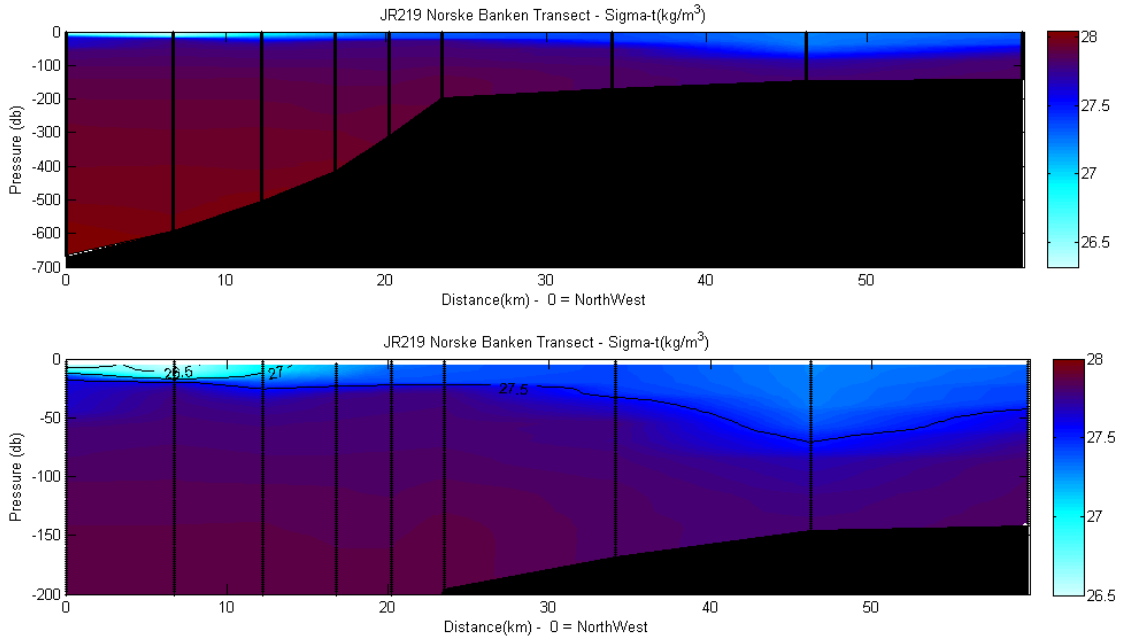


Figure 1.6-9: Norske Banken transect sigma-theta, for the whole depth and close-up on the 200m surface layer.

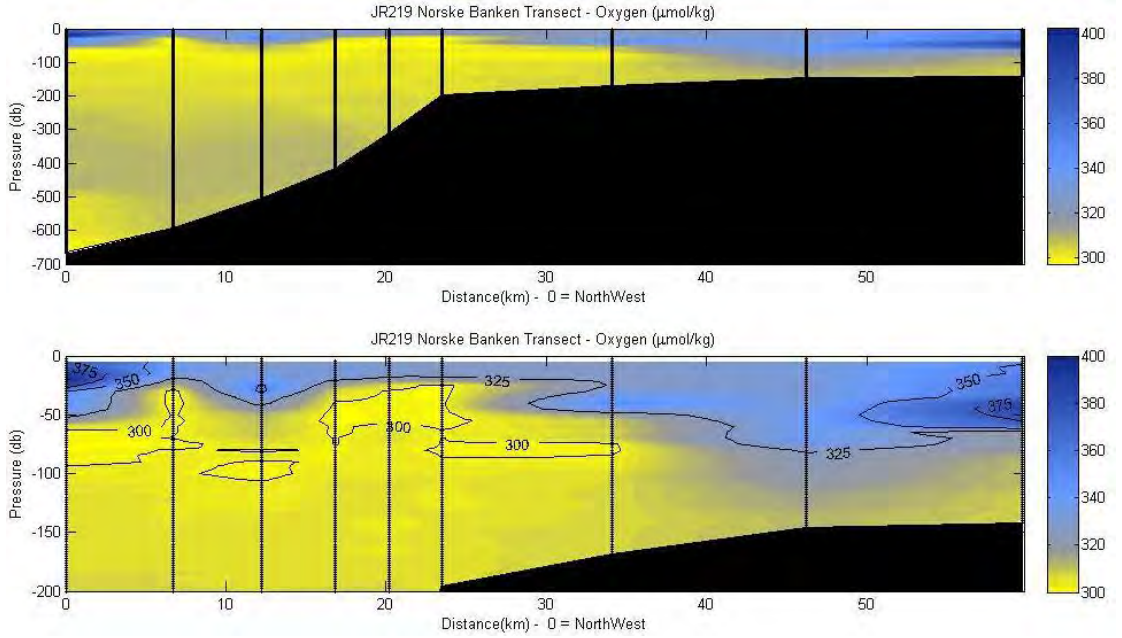


Figure 1.6-10: Norske Banken transect dissolved oxygen, for the whole depth and close-up on the 200m surface layer.

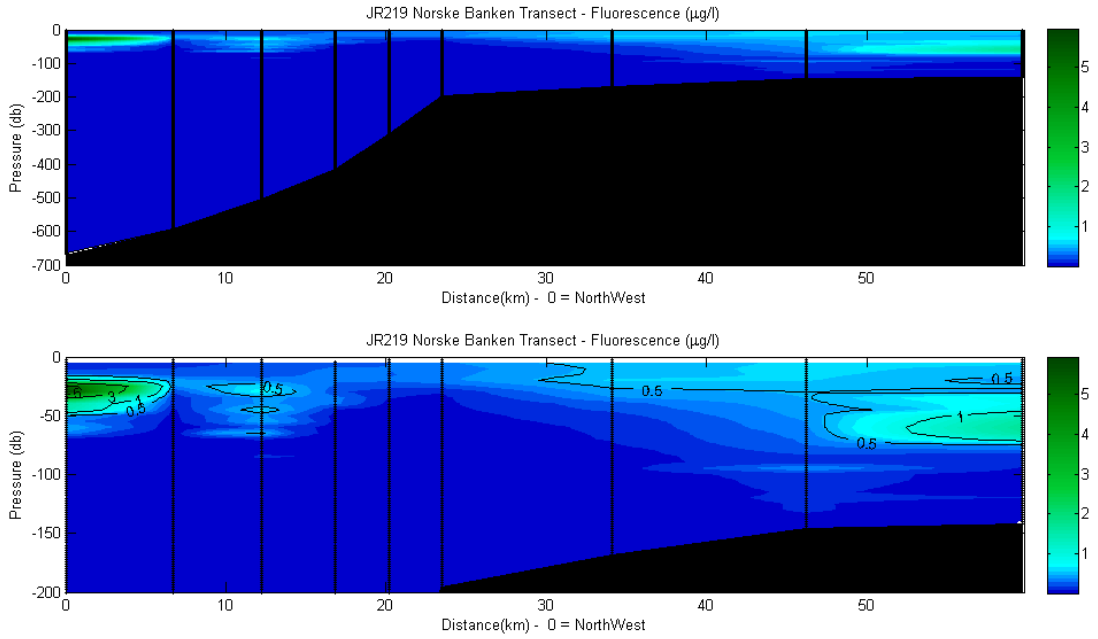


Figure 1.6-11: Norske Banken transect fluorescence, for the whole depth and close-up on the 200m surface layer.

(c) Isfjord Banken (20/07/10)

Data (left to right) from casts 100, 99, 98, 97 and 96.

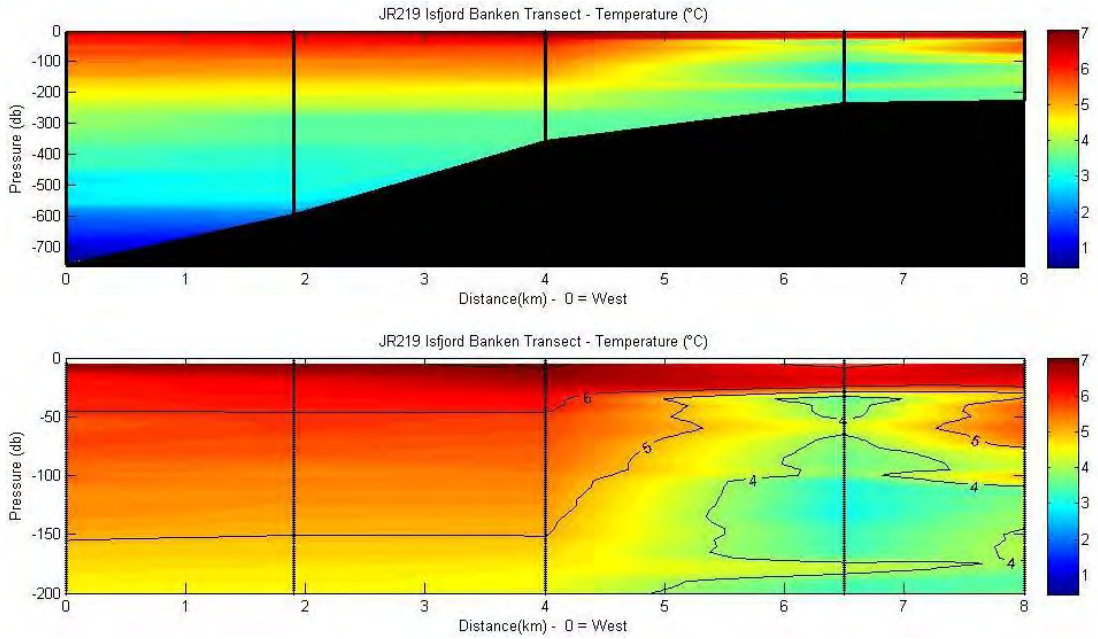


Figure 1.6-12: Isfjord Banken transect temperature, for the whole depth and close-up on the 200m surface layer.

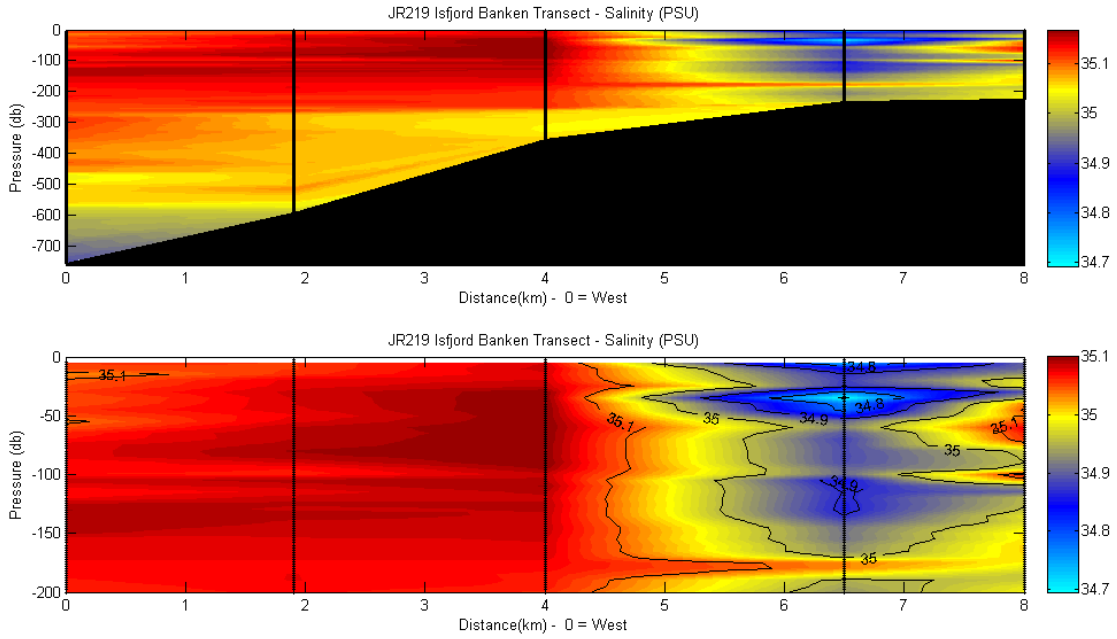


Figure 1.6-13: Isfjord Banken transect salinity, for the whole depth and close-up on the 200m surface layer.

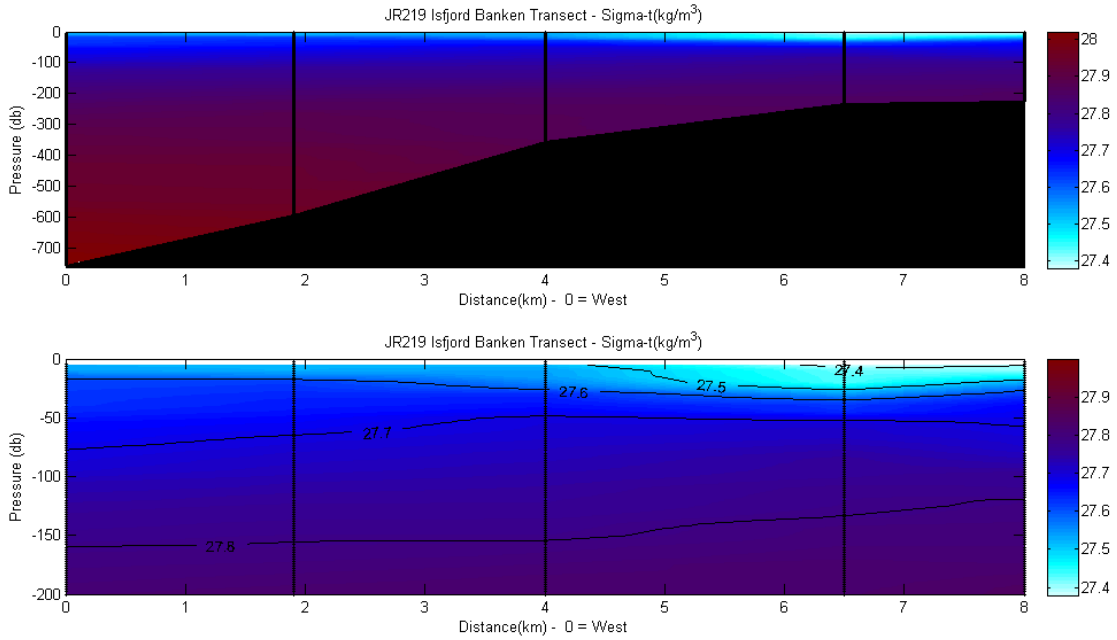


Figure 1.6-14: Isfjord Banken transect sigma-theta, for the whole depth and close-up on the 200m surface layer.

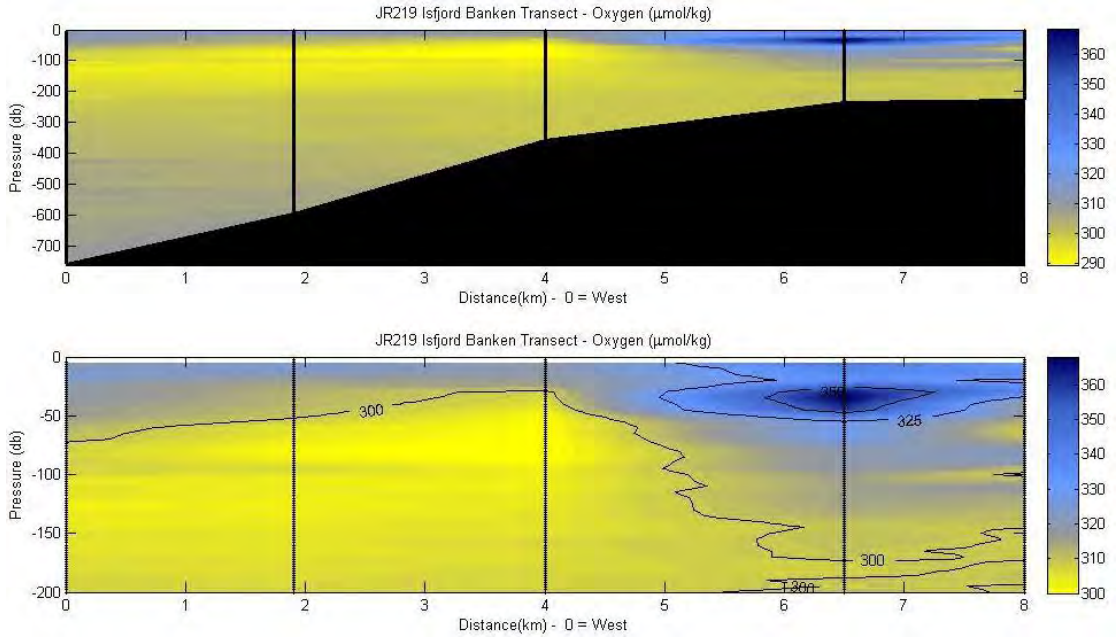


Figure 1.6-15: Isfjord Banken transect dissolved oxygen, for the whole depth and close-up on the 200m surface layer.

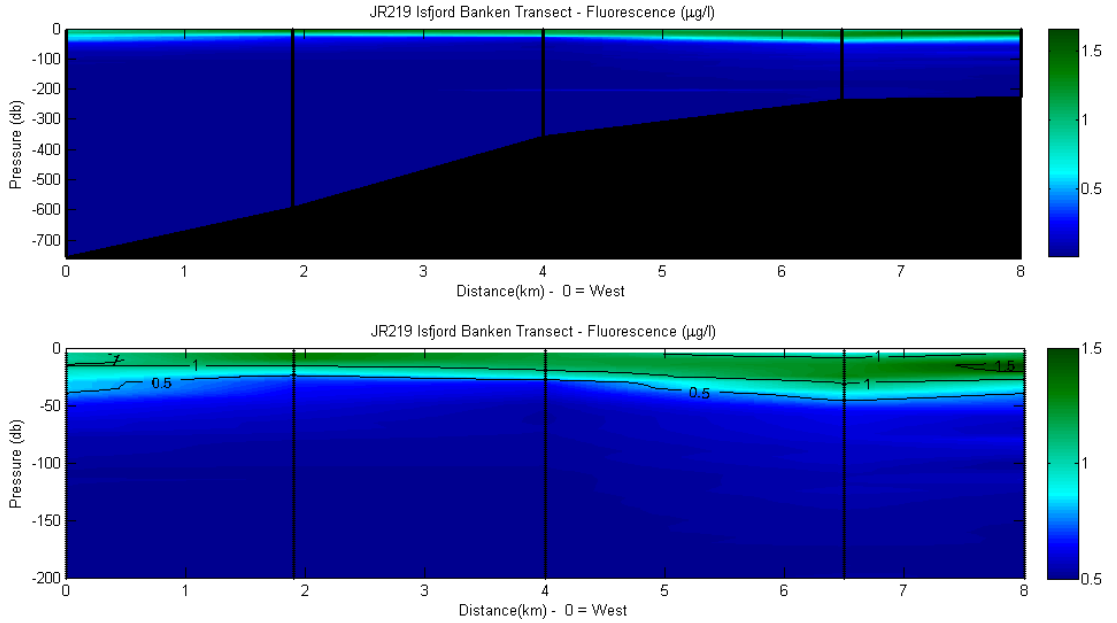


Figure 1.6-16: Isfjord Banken transect fluorescence, for the whole depth and close-up on the 200m surface layer.

1.7 Instrument specifications

SBE911 Leg 1, 3, 4

```
Configuration report for SBE 911plus/917plus CTD
--------------------------------------------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
NMEA position data added      : No
NMEA depth data added         : No
NMEA time added               : No
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature
   Serial number : 5042
   Calibrated on : 12/04/2008
   G             : 4.33201372e-003
   H             : 6.33549986e-004
   I             : 2.08531346e-005
   J             : 1.84440097e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity
   Serial number : 3488
   Calibrated on : 22/04/2008
   G             : -1.02006618e+001
   H             : 1.56812636e+000
   I             : -2.01455756e-003
   J             : 2.36866095e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
   Serial number : 0541-75429
   Calibrated on : 18/07/2007
   C1            : -4.398881e+004
   C2            : -5.551403e-001
   C3            : 1.279490e-002
   D1            : 3.603000e-002
   D2            : 0.000000e+000
   T1            : 2.986716e+001
   T2            : -5.274889e-004
   T3            : 4.092900e-006
   T4            : 1.616590e-009
   T5            : 0.000000e+000
   Slope         : 0.99994000
   Offset        : 0.52570
   AD590M        : 1.287420e-002
   AD590B        : -8.793390e+000

4) Frequency 3, Temperature, 2
   Serial number : 5043
   Calibrated on : 09/04/2008
   G             : 4.34448076e-003
   H             : 6.34699898e-004
   I             : 2.11669515e-005
   J             : 1.90896423e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2
   Serial number : 3491
   Calibrated on : 22/04/2008
   G             : -1.01164027e+001
   H             : 1.55766840e+000
   I             : -1.88282087e-003
   J             : 2.27423366e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

6) A/D voltage 0, PAR/Irradiance,
Biospherical/Licor
   Serial number        : 7274
   Calibrated on        : 12/1/2009
   M                    : 1.00000000
   B                    : 0.00000000
   Calibration constant : 55248618784.50000000
   Multiplier           : 1.00000000
   Offset               : -0.02596740

7) A/D voltage 1, Free

8) A/D voltage 2, Oxygen, SBE 43
   Serial number : 0245
   Calibrated on : 10/12/2008
   Equation      : Sea-Bird
   Soc           : 3.97100e-001
   Offset        : -4.31400e-001
   A             : -4.94730e-004
   B             : 1.36160e-004
   C             : -2.43420e-006
   E             : 3.60000e-002
   Tau20         : 1.20000e+000
   D1            : 1.92630e-004
   D2            : -4.64800e-002
   H1            : -3.30000e-002
   H2            : 5.00000e+003
   H3            : 1.45000e+003

9) A/D voltage 3, Altimeter
   Serial number : 2130.27001
   Calibrated on : no calibration available
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Fluorometer, Chelsea Aqua 3
    Serial number : 088-249
    Calibrated on : 27/08/2009
    VB            : 0.154130
    V1            : 2.015700
    Vacetone      : 0.199600
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer,
Chelsea/Seatech/Wetlab CStar
    Serial number : CST-396DR
    Calibrated on : 23/08/2007
    M             : 22.2100
    B             : -1.3104
    Path length   : 0.250

13) A/D voltage 7, Free
```

SBE911 Leg 2

```
Configuration report for SBE 911plus/917plus CTD
-------------------------------------------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
NMEA position data added      : No
NMEA depth data added         : No
NMEA time added               : No
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature
   Serial number : 2307
   Calibrated on : 20/7/2007
   G             : 4.33439937e-003
   H             : 6.44608874e-004
   I             : 2.37793994e-005
   J             : 2.31412704e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity
   Serial number : 1913
   Calibrated on : 17/7/2007
   G             : -4.02881844e+000
   H             : 5.32503936e-001
   I             : -6.89373545e-004
   J             : 6.23129385e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
   Serial number : 09p30856-0707
   Calibrated on : 13/06/2007
   C1            : -4.925971e+004
   C2            : -2.136250e-001
   C3            : 9.435710e-003
   D1            : 3.900400e-002
   D2            : 0.000000e+000
   T1            : 2.983458e+001
   T2            : -3.883229e-004
   T3            : 3.262440e-006
   T4            : 3.429810e-009
   T5            : 0.000000e+000
   Slope         : 1.00005000
   Offset        : -0.81450
   AD590M        : 1.277500e-002
   AD590B        : -9.391460e+000

4) Frequency 3, Temperature, 2
   Serial number : 4472
   Calibrated on : 11/7/2007
   G             : 4.41422567e-003
   H             : 6.43319527e-004
   I             : 2.23249357e-005
   J             : 1.96317455e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2
   Serial number : 2255
   Calibrated on : 17/7/2007
   G             : -1.02637082e+001
   H             : 1.41424921e+000
   I             : -2.97291304e-003
   J             : 3.13705184e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

6) A/D voltage 0, PAR/Irradiance,
Biospherical/Licor
   Serial number        : 7275
   Calibrated on        : 26/7/2007
   M                    : 1.00000000
   B                    : 0.00000000
   Calibration constant : 59523809523.80999800
   Multiplier           : 1.00000000
   Offset               : -0.02516571

7) A/D voltage 1, Free

8) A/D voltage 2, Oxygen, SBE 43
   Serial number : 0242
   Calibrated on : 12/06/2007
   Equation      : Owens-Millard
   Soc           : 3.8420e-001
   Boc           : 0.0000
   Offset        : -0.4887
   Tcor          : 0.0003
   Pcor          : 1.35e-004
   Tau           : 0.0

9) A/D voltage 3, Altimeter
   Serial number : 2130.27001
   Calibrated on : no calibration available
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Fluorometer, Chelsea Aqua 3
    Serial number : 088-249
    Calibrated on : 13/09/2007
    VB            : 0.181000
    V1            : 2.097600
    Vacetone      : 0.202800
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free
```

2 Hand-help CTD (SBE19+)

2.1 Methodology

This CTD was used during leg 2 for a) profiling in the water sampling hole drilled in the ice; and b) in association with under-ice light sensors for profiles and overnight deployments from the diving hole (see details in the PAR/ Under-ice light measurements section). It was also deployed once from the ship on leg 3 in association with the light spectrometer and SAtlantics sensors.
All data was recorded at 4Hz (maximum sampling rate).

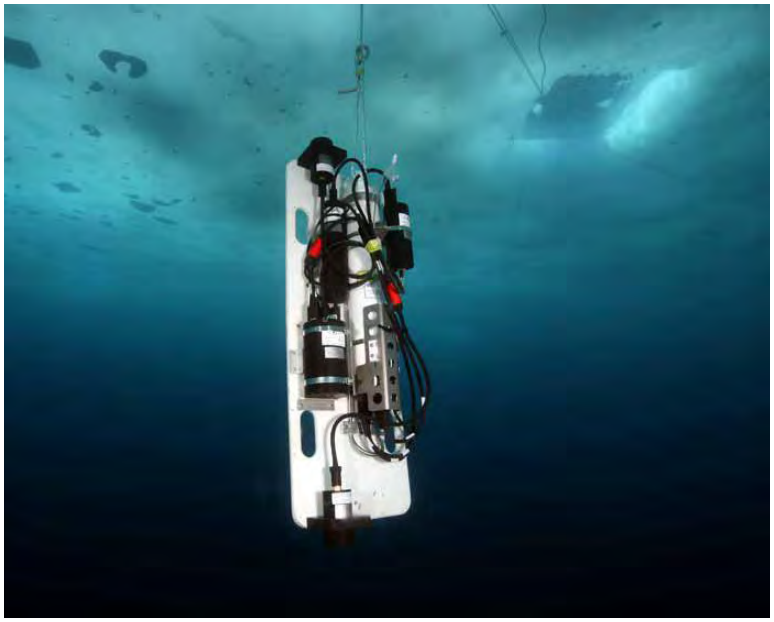


Figure 0-10: SBE19+ and SAtlantics light sensors installed on the board and profiling under ice.

2.2 Data processing

The CTD data were processed according the recommended Seabird procedures, using Seabird Data Processing version 7.18b. The processing steps were: Data Conversion, Filter, Align CTD, Cell Thermal Mass, Derive, Translate, Bin Average (1 second) and Ascii Out.

2.3 Data summary

Data file	Date	Start Time	Event No	Description
sbe19+_5215_260610_a	26-Jun-10	08:13	I18	Cast associated with water sampling
sbe19+_5215_260610_b	26-Jun-10	18:07	I25	Under-ice CTD/light profile (test)
sbe19+_5215_270610	27-Jun-10	11:41	I31	Under-ice CTD/light profile
sbe19+_5215_280610	28-Jun-10	12:41	I36	Under-ice CTD/light profile
sbe19+_5215_290610_a	29-Jun-10	10:00	I41	Cast associated with water sampling
sbe19+_5215_290610_b	29-Jun-10	11:52	I44	Cast associated with water sampling
sbe19+_5215_290610_c	29-Jun-10	17:34	I45	Under-ice CTD/light overnight deployment
sbe19+_5215_300610_a	30-Jun-10	08:48	I47	Under-ice CTD/light profiles
sbe19+_5215_300610_b	30-Jun-10	15:05	I55	Under-ice CTD/light profiles
sbe19+_5215_300610_c	30-Jun-10	19:35	I56	Under-ice CTD/light profile + overnight deployment
sbe19+_5215_100710	10-Jul-10	10:02	145	CTD/light profile from ship

2.4 Instrument specifications

```
Configuration report for SBE 19plus Seacat CTD
-------------------------------------------------------------------------------

Pressure sensor type      : Strain Gauge
External voltage channels : 4
Mode                      : Profile
Scans to average          : 1
NMEA position data added  : No
NMEA depth data added     : No
NMEA time added           : No
Surface PAR voltage added : No
Scan time added           : No

1) Count, Temperature
   Serial number : 5215
   Calibrated on : 07-Aug-07
   A0            : 1.20495500e-003
   A1            : 2.77321400e-004
   A2            : -1.96517300e-006
   A3            : 2.21643700e-007
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 0, Conductivity
   Serial number : 5215
   Calibrated on : 07-Aug-07
   G             : -1.02557600e+000
   H             : 1.57749000e-001
   I             : -5.98424400e-004
   J             : 7.12694500e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000



Offset        : 0.00000

3) Count, Pressure, Strain Gauge
   Serial number : 5215
   Calibrated on : 01-Aug-07
   PA0           : 1.34278800e+000
   PA1           : 2.63258600e-003
   PA2           : 1.71027200e-011
   PTEMPA0       : -6.22525800e+001
   PTEMPA1       : 5.25907100e+001
   PTEMPA2       : -2.89748100e-001
   PTCA0         : 5.24870500e+005
   PTCA1         : 3.67886900e+001
   PTCA2         : -6.45002600e-001
   PTCB0         : 2.56046200e+001
   PTCB1         : -4.75000000e-004
   PTCB2         : 0.00000000e+000
   Offset        : 0.000000

4) A/D voltage 0, Fluorometer, Wetlab Wetstar
   Serial number : 1359
   Calibrated on : 10/05/2010
   Vblank        : 0.071
   Scale factor  : 15.000

5) A/D voltage 1, Free

6) A/D voltage 2, Free

7) A/D voltage 3, Free
```

SCIENTIFIC REPORT 2: Ice-based observations of upper ocean physics

Tim Boyd, Estelle Dumont, Colin Griffiths, and Bernard Hagan

Introduction

This work was undertaken in collaboration with Pedro Elosegui (Institute for Space Sciences and Marine Technology Unit, Spanish National Research Council, Spain) and Jeremy Wilkinson (SAMS).

The overall objective of the SAMS physics department contribution during the second leg of JR219 was to evaluate the heat flux from the ocean to drifting sea ice in the area northwest of Spitsbergen. In the area of the Yermak Plateau (YP), sea ice in the southward flowing transpolar drift encounters warm, northward flowing water of the West Spitsbergen Current (WSC) which contributes to rapid melting of the sea ice and accounts for the persistent presence of the ice edge in this region. In addition, enhanced upper ocean heat flux observed over the Yermak Plateau over the past 30 years has been attributed to mixing associated with upward propagating internal waves generated through the interaction of the barotropic tide with this significant bathymetric feature.

Two separate autonomous systems were deployed in order to estimate the ice-ocean heat flux for the duration of the manned ice camp of JR219 Leg 2 (Table 2.1). The first of these was the opportunistic test deployment of a system developed for sea ice-based autonomous measurement of turbulent mixing profiles. This APEX-MSS system was a tethered APEX profiling float (Teledyne Webb Research), as used in the Argo array, to which an MSS (ISW Wassermesstechnik) microstructure package was added.

The second system consisted of an ice-mounted string of temperature and CTD sensors in conjunction with an ice-mounted downward-looking 300 kHz acoustic Doppler current profiler (ADCP, mfg by Teledyne RDI), from which ice-relative currents were obtained for the duration of the ice camp. In combination with high-precision GPS buoys supplied by P. Elosegui of CSIC, Barcelona, the ADCP relative velocities will be converted to absolute velocities. The temperature sensors and ice-relative currents will enable us to estimate the ice-ocean heat flux using a standard parameterization, and in combination with the absolute velocities will enable us to relate these to the northward flow of the WSC.

Event No	Date	Day of Year 2010	Start time (GMT)	End time (GMT)	Ship's latitude	Ship's longitude	Activity
I4	22/06	173	15:02	16:15	80°50.400' N	004°52.380' E	GPS receivers installation
I13	25/06	176	11:30	12:10	80°33.850' N	004°13.920' E	ADCP installation
I21	26/06	177	11:51	12:02	80°30.280' N	004°02.470' E	Mooring deployment
I29	27/06	178	06:53	07:55	80°27.210' N	003°42.680' E	APEX deployment
I33	27/06	178	16:55	17:10	80°23.780' N	003°29.620' E	APEX recovery
I34	28/06	179	11:31	12:01	80°18.080' N	003°14.470' E	APEX deployment
I40	29/06	180	09:07	11:05	80°16.330' N	003°01.300' E	APEX recovery
I48	30/06	181	08:09	~10:00	80°13.800' N	002°31.000' E	GPS receivers recovery
I51	30/06	181	~10:00	10:27	80°13.440' N	002°25.870' E	ADCP recovery
I59	01/07	182	12:03	13:01	80°13.380' N	002°09.940' E	Mooring recovery

Table 2.1. Subset of Leg 2 event log for activities related to the ice-based physical oceanography measurements.

High-precision GPS Buoys

Two high-precision GPS buoys were deployed for the duration of the ice-based sampling on the same ice floe, separated by approximately 106 m. The buoys documented the ice floe motion over the next 5-6 days, which consisted primarily of translation and rotation. The net displacement was about 70 km to the southwest, as shown in Figure 2.1, and included oscillations at near the inertial period (12.13 hr at 80.5 °N)

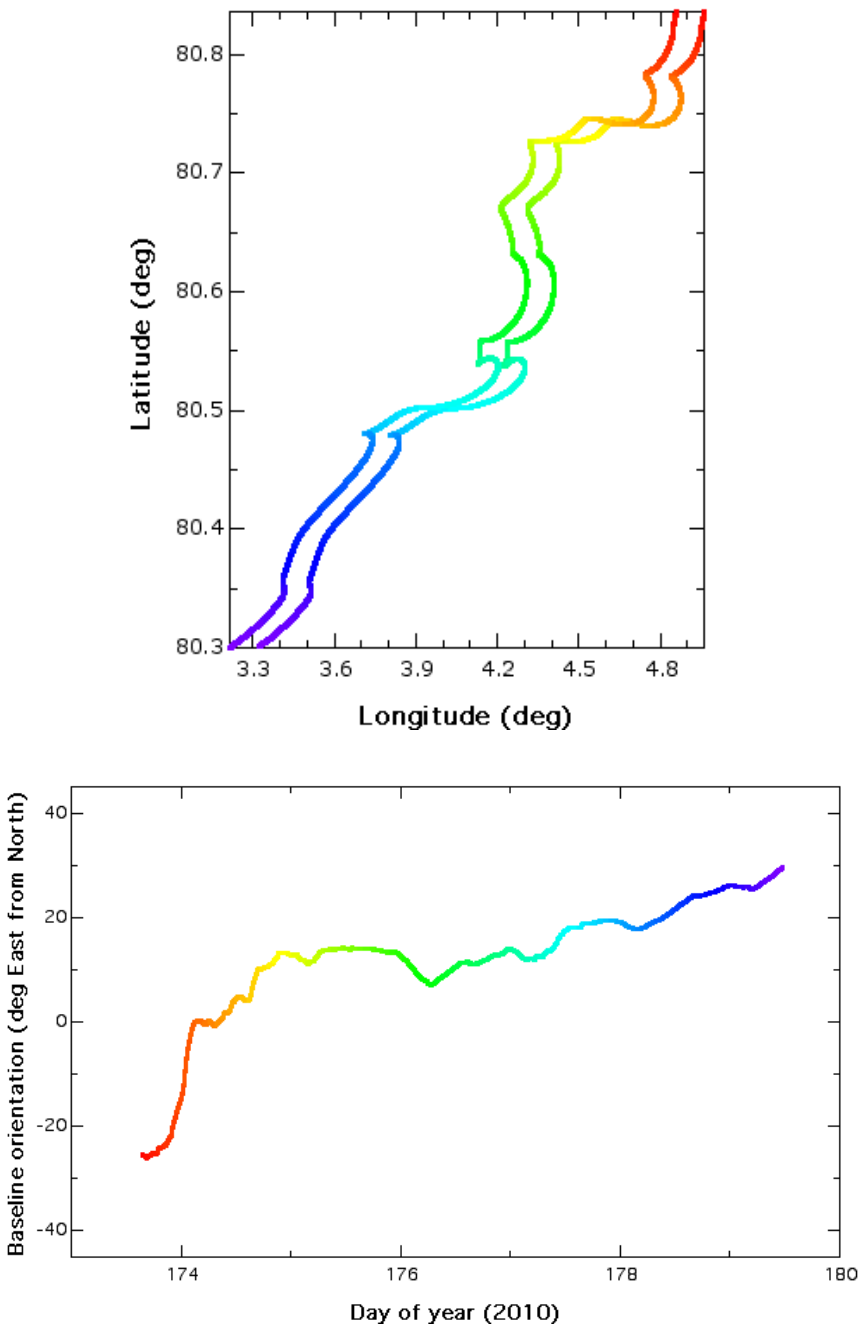


Figure 2.1. Tracks of the two GPS buoys (top) and baseline orientation (bottom) during Leg 2 of JR219. (Estimated position errors are cm level, and hence not visible.) In the left panel, direction of motion is from red to blue, and color length is time-coded, thus consistent with the horizontal axis in the bottom panel. The position of PB01 (see Figure 2.3) in the top panel is shown offset by 0.05 degrees to the east, for clarity.

GPS buoy PB02 (see Figure 2.3) was deployed to the northwest of buoy PB01. During the experiment, baseline orientation, as seen from PB01, changed from -25º to 0º (i.e., to a north-south direction) over the first few hours, and then increased gradually to reach a final value of 29º.

The high-precision of the GPS buoys enabled us to also determine the vertical displacement of the ice floe as it responded to changes in the height of the geoid along the southwestward drift as well as to vertical displacement due to the barotropic tide. The observed and predicted heights of the GPS buoys are shown in Figure 2.2 for the duration of the drift.

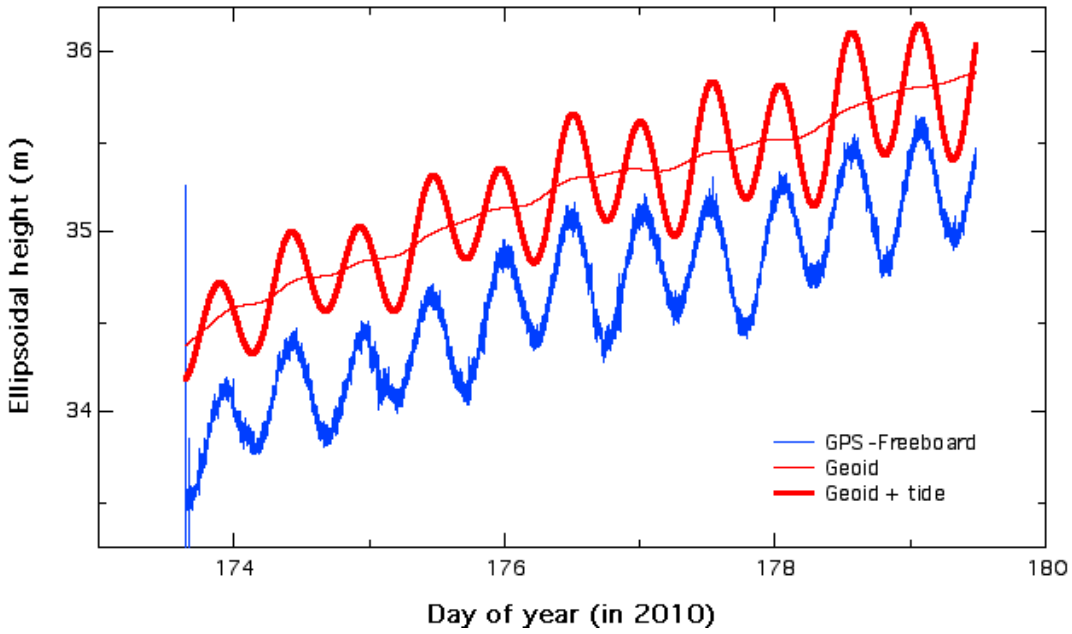


Figure 2.2. Observed (blue) and predicted (red) height above the WGS84 ellipsoid along the GPS drift track of PB01. Differences are due to dynamic ocean topography (which amounts to about -50 cm in this region), sea ice freeboard, height of the GPS antenna phase-center above the sea ice surface, and errors in the geoid model, ocean tidal model, and GPS position estimates. About the latter, the standard deviation of the difference between height estimates of PB01 and PB02 (not shown) over the duration of the experiment is 2.8 cm.

ADCP Deployment

An RDI 300kHz ADCP (Ser No 13616), on loan from UNIS, was deployed through the ice on Leg 2 of JR219. The unit was housed within a frame constructed from 1m & 0.275m shelving brackets. A hole was bored with the SAMS auger and squared off with an ice saw. The hole was ~mid-way between the two GPS buoys which had already been deployed ~115m apart (Figures 2.1 and 2.3.). Beam 4 was aligned with PB02, the GPS located nearest to the stern of the JCR. The ADCP was set to record velocities in 'instrument coordinates' (Tables 2.2 and 2.3), with orientation relative to geographic coordinates to be provided after sampling by reference to the changing orientation of the baseline between the GPS buoys PB01 and PB02. Looking at the ADCP face, the transducer beams are labelled clockwise in order 3-1-4-2, such that in instrument coordinates the x-axis lies in the direction from transducer 1 towards transducer 2, and the y-axis lies in the direction from transducer 4 towards transducer 3. Thus the y-axis (what would be labelled as 'northward' velocity in Earth Coordinates) is towards PB01, and the x-axis is clockwise from the y-axis (what would be labelled as 'eastward' velocity in Earth Coordinates). The ADCP compass measures the heading of the y-axis (beam 4 to beam 3, PB02 to PB01) relative to magnetic north.

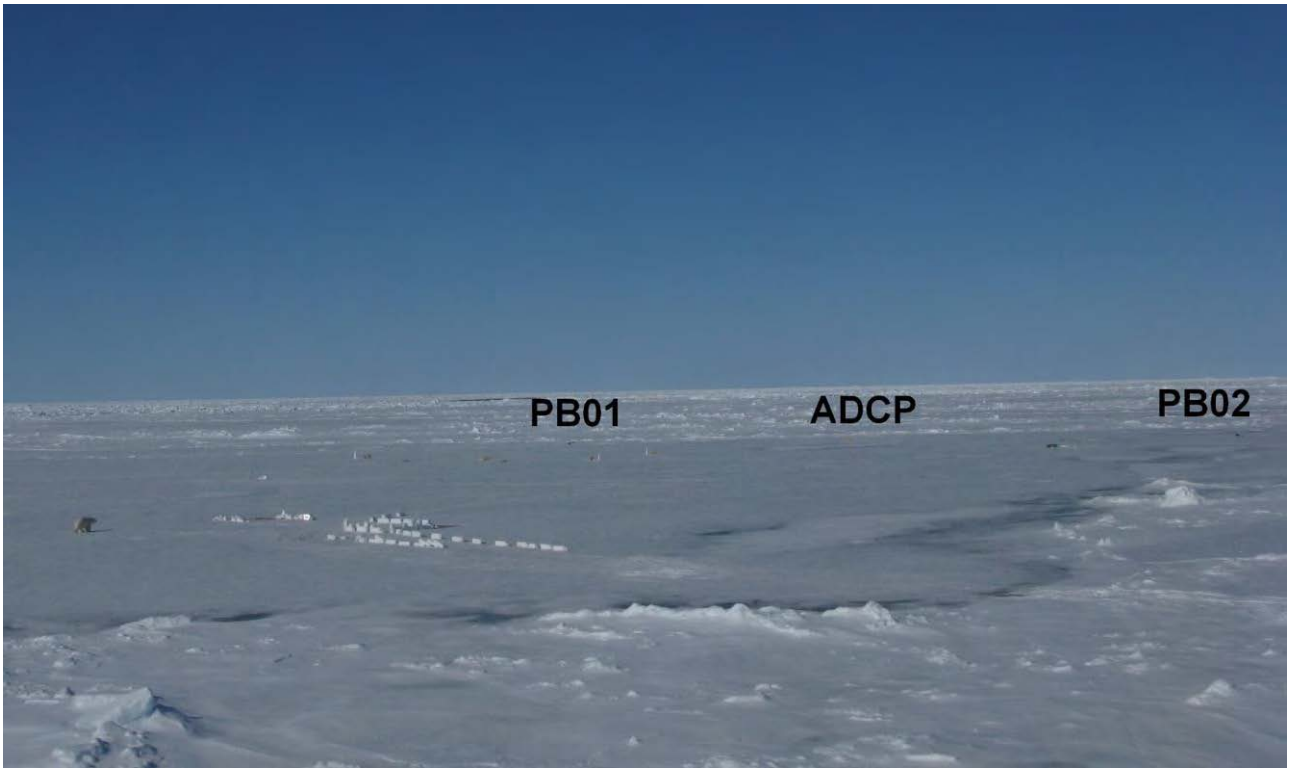


Figure 2.3. Site layout as viewed from the Starboard bridge wing of the JCR.

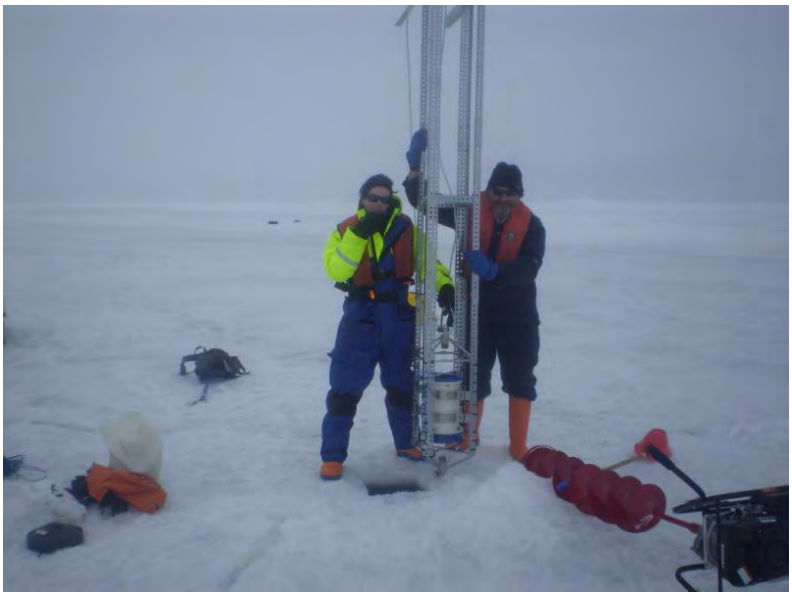


Figure 2.4. ADCP prior to deployment

The ADCP was housed within a standard in-line frame and this was attached to the constructed frame with rope & cable ties (Figure 2.6). A safety line was attached from the ADCP in-line frame to a 17” glass sphere. The instrument fitted snugly into the hole and was inspected routinely during the deployment period (Figure 2.5).

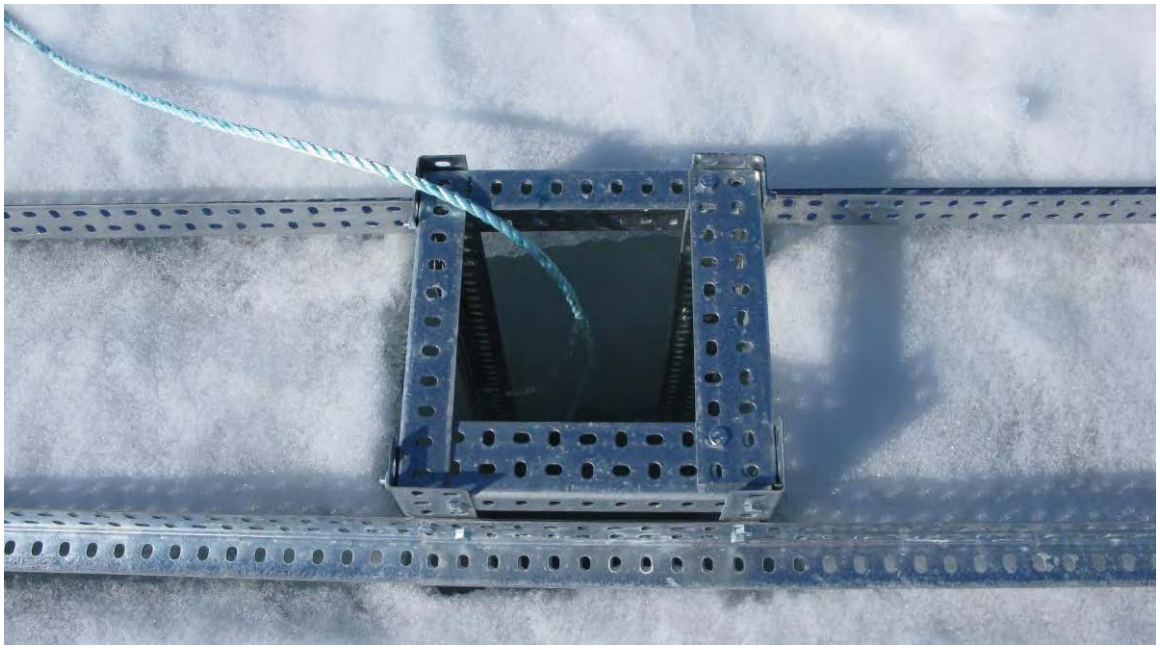


Figure 2.5. ADCP frame screwed onto the floe.

The first attempt to retrieve the instrument at the conclusion of sampling was unsuccessful, and the auger was required in order to remove the instrument from the hole.

Figure 2.6. ADCP & frame following recovery

RDI Command	Content
CR1	Reset to factory defaults
CF11101	Control Flow:enable auto ensemble cycle, auto ping cycle, and binary data output;disable serial output; enable data recorder
EA0	Beam Heading Alignment: no correction
EB0	Magneting Heading Alignment: no correction
ED30	Transducer Depth: 3m
ES32	Salinity: 32 psu
EX01010	Coordinate Transformation: instrument coordinates (Heading/Pitch/Roll not applied); no pitch/roll; 3-beam solutions; no bin-mapping
EZ1111111	Source of Environmental Sensors: use all available sources; compute sound speed
WA50	False Target Threshold: default
WB1	Bandwidth: narrow (greater range, higher single ping std)
WD111100000	Data Out: all (velocity, correlation, echo intensity, percent good)
WF176	Blank after Transmit: 1.76m (default)
WN50	Number of Depth Cells (bins): 50
WP25	Pings per Ensemble: 25
WS200	Depth Cell Size: 2m
WV175	Ambiguity Velocity: default
TE00:00:30.00	Time per Ensemble: hh:mm:ss.ff: 30 seconds
TP00:01.20	Time between Pings: mm:ss.ff: 1.2 seconds (ff is hundredths)
CK	Store commands to memory
CS	Start Pinging

Table 2.2. ADCP Configuration as uploaded to the 300kHz ADCP using the RDI routine BBtalk

The ADCP record (raw data file name: _RDI_000.000, time stamped: 30/06/2010) consists of 20870 ensembles of 25 pings over 30 seconds, beginning on 23/06/2010 at 13:01:54 and ending on 30/06/2010 at 18:56:25 GMT. The pressure in air was 0.06 psu prior to deployment and 0.1 after recovery.

EX Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
EX00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4
EX01xxx	Instrument	Bm 1 – Bm 2	Bm 4 - Bm 3	To Xducer	Error Velocity
EX10xxx	Ship	Port-Starboard	Aft-Forward	To Surface	Error Velocity
EX11xxx	Earth	To East	To North	To Surface	Error Velocity

Table 2.3. From the RDI Workhorse Commands and Output Data Format manual, illustrating how the the Workhorse ADCP references the velocity data for various settings of the EX (coordinate transformation) command

One of the significant advantages of deploying an ADCP on a rigid frame beneath the sea ice is that the ADCP experiences variation in tilt (pitch and roll). In this case, the ADCP and GPS buoy baseline also experienced little rotation over our short deployment. The slow variation in ADCP pressure is as yet unexplained.

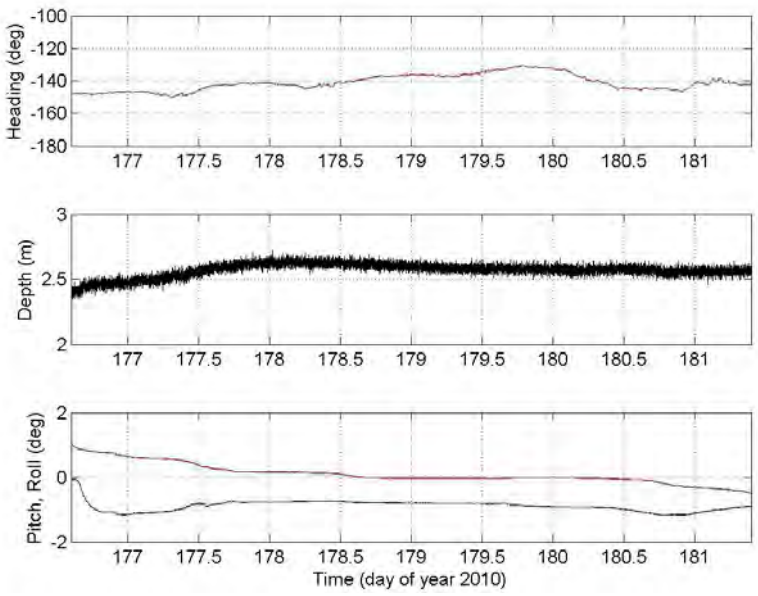


Figure 2.7. ADCP magnetic heading (top), depth (center), and pitch and roll (bottom). The ADCP measures orientation of the y-axis (beam 4 to beam 3, PB02 to PB01) CW from magnetic north. Note that the ice camp, as indicated by the heading of the PB02-to-PB01 baseline, does not rotate much over the deployment, and that the instruments is relatively stable with respect to pitch and roll.

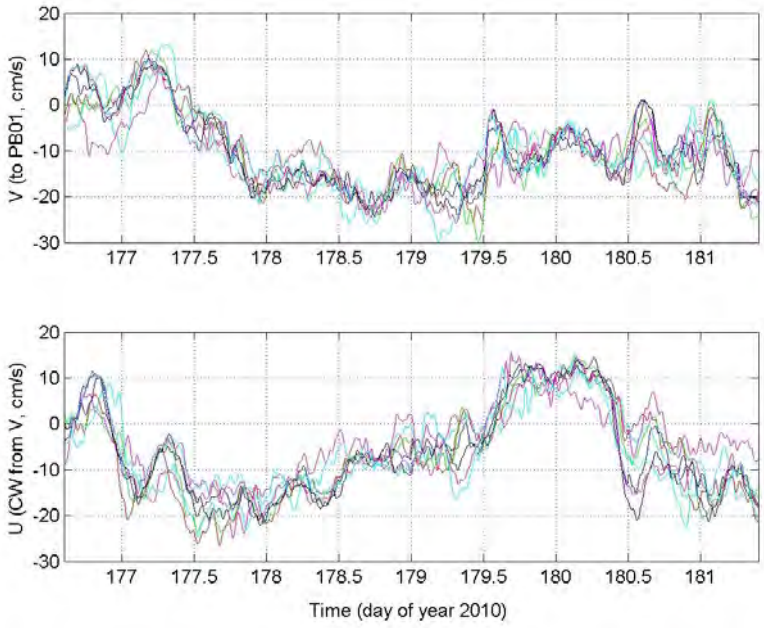


Figure 2.8. Y-axis (top) and X-axis (bottom) components of velocity for bin ranges of 10 m to 80 m in 10 m increments. Note the increased vertical shear after day 180.5, corresponding to the increased water temperature (Figure 2.10) as the ice camp drifted over the West Spitzbergen Current.

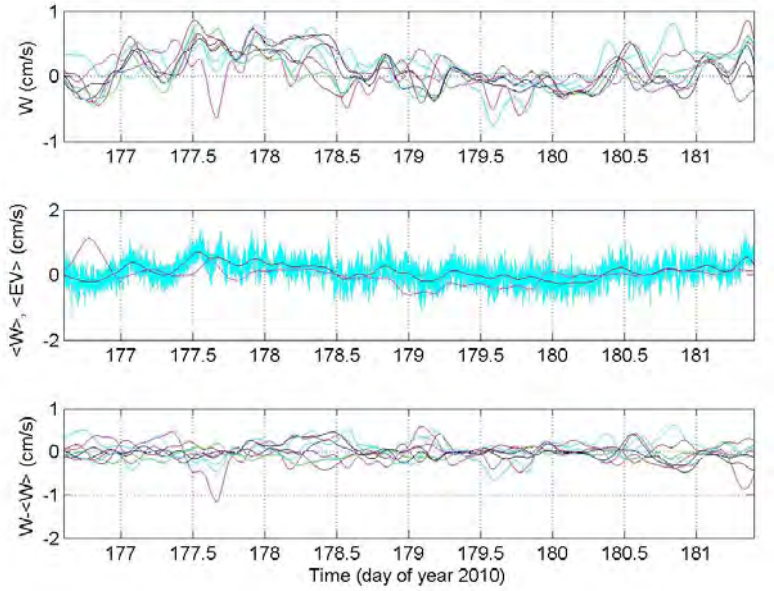


Figure 2.9. Vertical velocity (top), vertically averaged vertical velocity (black) and error velocity (magenta, center), and velocity anomaly (bottom) from the ice-mounted ADCP. Vertical velocities are for bin ranges of 10 m to 80 m in 10 m increments, and average is over all bins from 10 m to 70 m range.

Ice-Based T/S mooring

During leg 2, a string consisting of both temperature and temperature/salinity/pressure sensors was deployed beneath the ice.

Depth (m)	Instrument type	Serial Number	Variables Measured	Sample Interval (s)
10	SBE-39	87	T	30
25	SBE-39	88	T	30
50	SBE-39	664	T	30
75	SBE-39	666	T	30
100 (108)	SBE-37	4609	T, S, P	30
125	SBE-39	667	T	30
150	SBE-39	668	T	30
175	SBE-39	869	T	30
200	SBE-39	875	T	30
225 (238)	SBE-37_IM	1125	T, S, P	30
250	SBE-39	876	T	30
300	SBE-39	878	T	30

Table 2.4. JR219 leg 2 ice-based temperature/salinity mooring instrumentation. Depths shown are nominal, except for the average measured depths of the microcat T/S/P sensors shown in brackets in the first column.

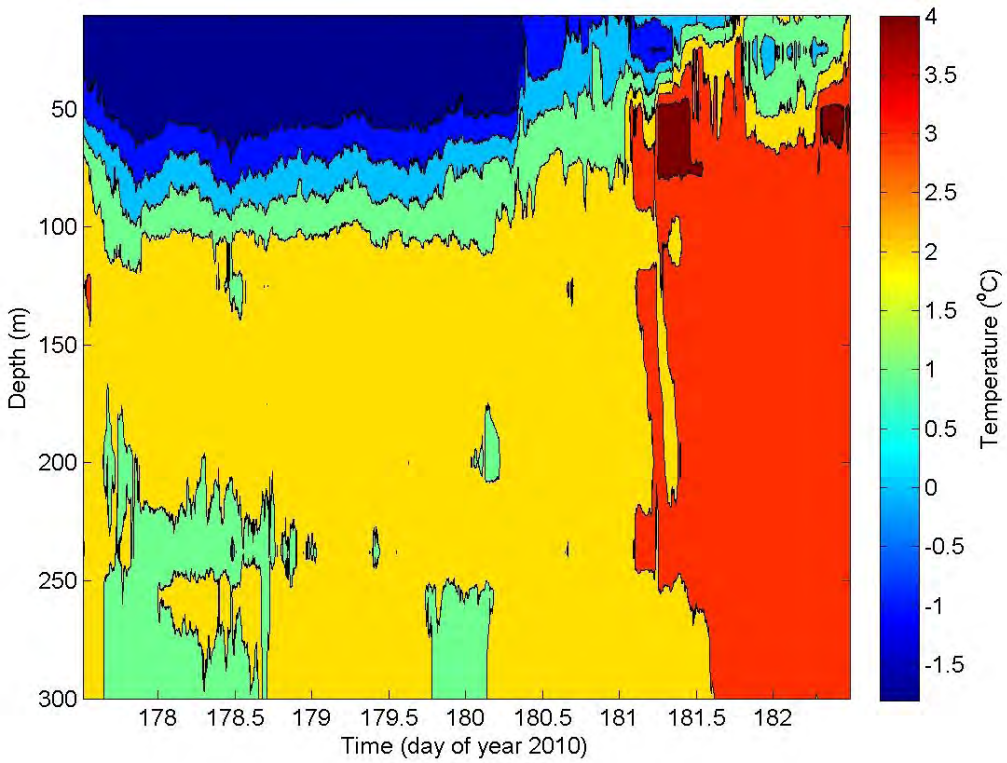


Figure 2.10 Temperature contours from Leg 2 ice-based mooring

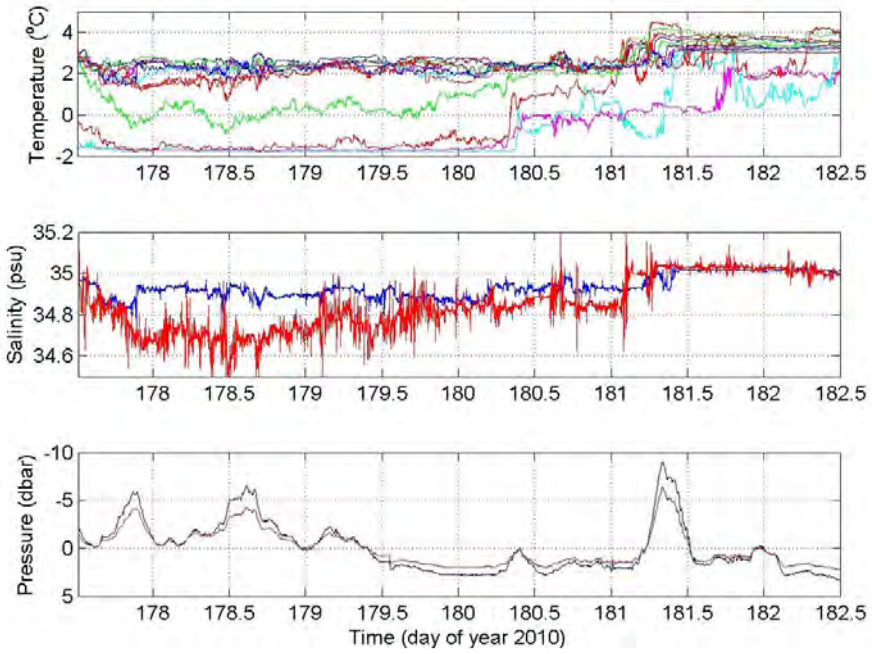


Figure 2.11 Temperature (top), salinity (middle), and deviation from average pressure (bottom). Pressure and salinity are both measured by SBE-37 sensors at the average depths, 108m (red) and 238m (blue), shown in Table 2.4. Note that the instrument depths shoal as the mooring string encounter different water masses, indicating horizontal shear.

Ice Mass Balance Buoy

Two SAMS ice mass balance buoys (IMBs) were deployed for the short duration of the ice camp. IMBs consist of a chain of individually addressable temperature sensors at fixed separation (0.04 m in this case) along the length of the chain, which is 4.32 m in this case. The temperature sensors are each adjacent to a resistor that is periodically supplied with current to create resistive heating. The time scale of the thermistor response to and recovery from this heating is dependent upon the phase (liquid water or ice) of the immediate surroundings of the thermistor. The chains have been designed as a relatively inexpensive means to determine the evolution of sea ice thickness in remote regions, with data return through the Iridium satellite communication network. Because the chains were deployed for only a few days in summer, while the air temperature was above freezing, the chains did not freeze in place, and in fact were both removed on July 30, year day 181. The chief limitation of these sensors for ocean usage is the relatively coarse temperature resolution of 1/16 °C = 0.0625°C.

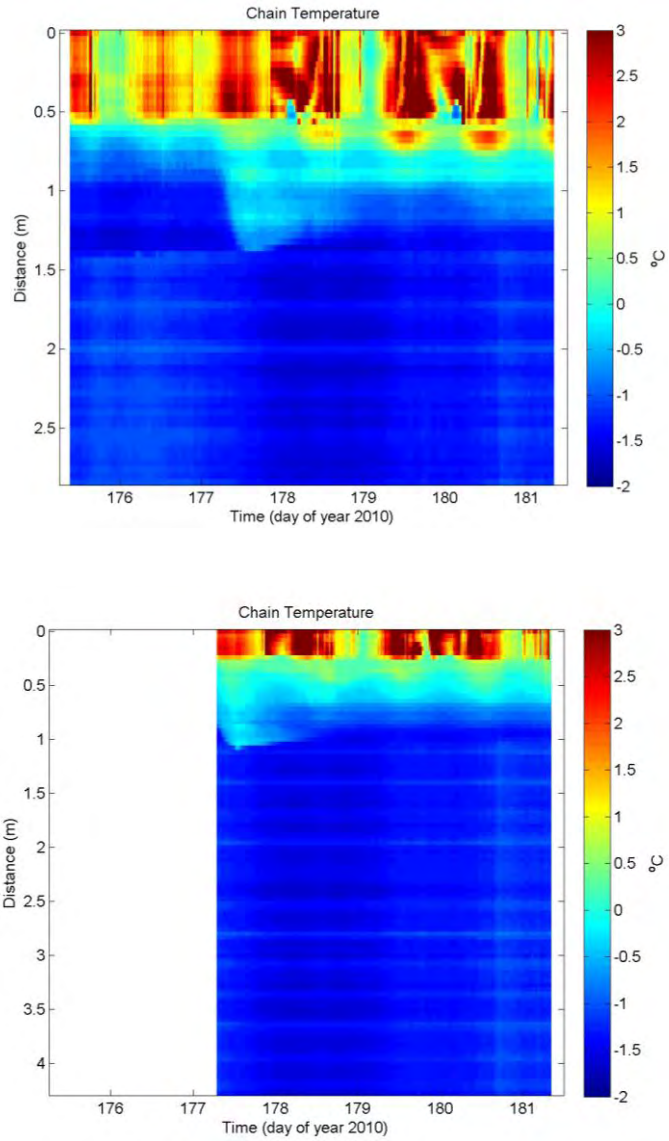


Figure 2.12. Temperature from Ice Mass Balance buoys 1 (top) and 2 (bottom), deployed during JR219 Leg 2 on behalf of R. Glud. Sample interval was 30 minutes. Day 181 is June 30. Sensors at distances less than 0.3 m are in the air, and temperatures well above freezing (the maximum temperature on IMB 2 was 6.8 °C) are due to atmospheric warming. Horizontal stripes below 1.5 m result from a systemic calibration inaccuracy that has subsequently been remedied.

In this case the temperature was measured every 30 minutes, and the heating cycle was conducted every 6 hours. Analysis of subsequent thorough testing in the SAMS cold room facility has revealed that the heating cycle used during 2010 was not optimal, and perhaps not even adequate. Best identification of the phase of the surroundings requires a longer heating cycle. Despite these caveats, it is clear that the IMB temperature chains are recording the same ocean/and ice temperatures. Assuming that the water both in the hole surrounding the IMB chain and in the upper ocean beneath the ice is near the freezing point, then the differences between the freezing temperature of nearly fresh ice melt (near 0°C) and salty water (near -1.8°C) reveals either the ice ocean interface or the extent of a fresh meltwater lens beneath the ice. Diurnal variation of the temperature near 0.5 m is in phase with the diurnal solar heating of the sensors measuring the air temperature of 2-6 °C (Figure 2.13).

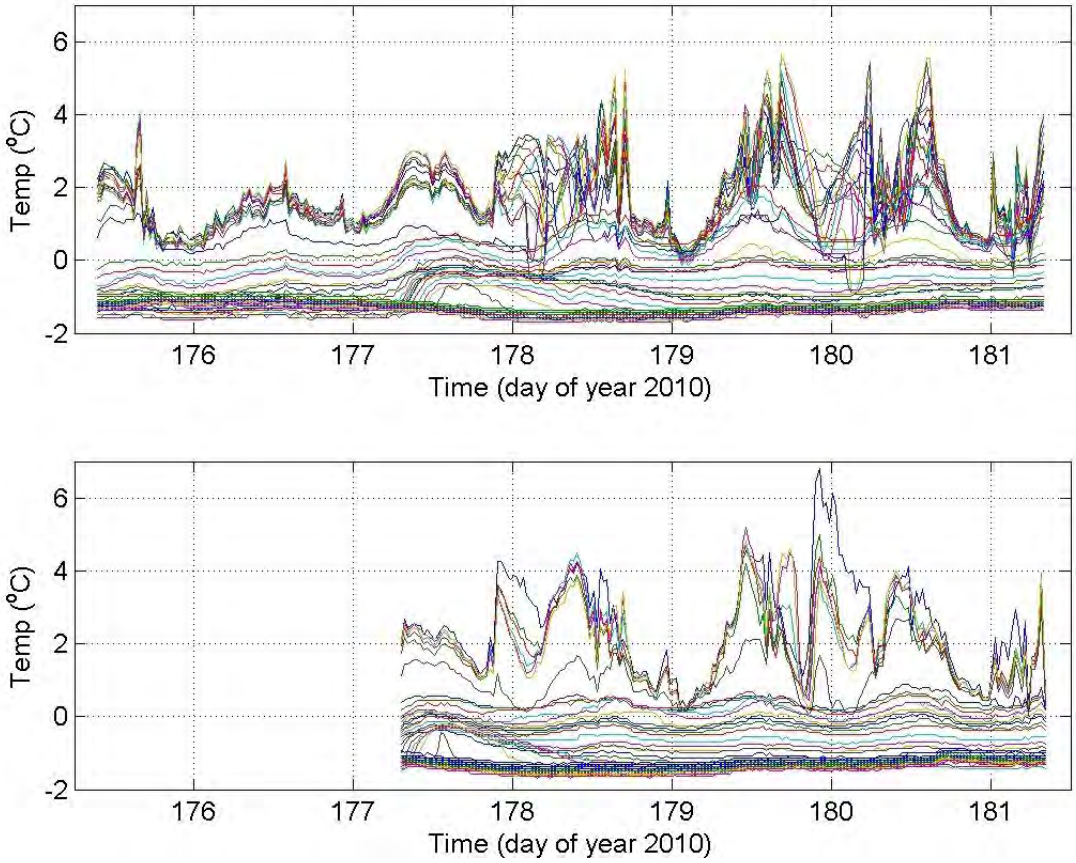


Figure 2.13 Time series of temperatures from IMB1 (top) and IMB2 (bottom). Sensors with maximum temperatures in the range of 2-6 °C are assumed to be in air. Time series clustered below about 1.5 °C are in the layer below the ice melt, and temperatures in the range of -1 to 1 °C are assumed to be within the melt layer or the hole surrounding the IMB chain.

The IMBs were installed in the ice during the early stages of the drift over the warm WSC, however there is no indication the warming that would correspond to the temperature signal observed at 10 m on day 180.5 in Figure 2.10.

For comparison, daily manual ice thickness measurements were made by Gavin Turner at four locations over the course of the ice camp (Table 2.5). Gavin's measurements show that the initial trend in decreasing ice thickness reversed dramatically on day 180. Interpretation of the IMB temperatures is problematic: penetration of both the diurnal heating cycles and the 0°C layer is to greater distance following day 178.

Date	YearDay	Site 1	Site 2	Site 3	Site 4	Average	Δ Avg	Median	ΔMedian
22/06/2010	173	99	102	100	-	100.33		100.00	
23/06/2010	174	100	100	101	92	98.25	-2.08	100.00	0.00
24/06/2010	175	97	97	95	87	94.00	-4.25	96.00	-4.00
25/06/2010	176	95	93	88	86	90.5	-3.50	90.50	-5.50
26/06/2010	177	89	91	86	81	86.75	-3.75	87.50	-3.00
27/06/2010	178	80	92	85	83	85.00	-1.75	84.00	-3.50
28/06/2010	179	83	87	81	83	83.5	-1.50	83.00	-1.00
29/06/2010	180	90	90	89	88	89.25	5.75	89.50	6.50
30/06/2010	181	87	91	88	89	88.75	-0.5	88.50	-1.00

Table 2.5. Daily manual measurements of ice thickness (cm) at 4 sites adjacent to each of 4 instrument sites, referred to as the CTD (1), Deep Eddy (2), Shallow Eddy (3), and SAMS Eddy (4). Instrumented holes were separated by about 7m. New test holes were drilled each day for the ice thickness measurements. New ice formation was noted in the bottom of the instrument holes on 27 June. On 28 and 29 June, each hole had about 1cm of new ice at the surface.

APEX Turbulence Profiling Buoy

An Autonomous Profiling Explorer (APEX) float was modified at SAMS to measure turbulent microstructure while profiling vertically downwards through the water column, in addition to the normal CTD profiling on ascent. The APEX float was further modified for JR219 in order to profile along a vertical line suspended through a hole in the ice. The objectives for JR219 were (1) to demonstrate the capability to autonomously conduct repeated microstructure profiles under sea ice, and (2) to obtain a time series microstructure profiles to investigate mixing processes in the neighborhood of the WSC and the YP. Prior to deployment in the Arctic, the APEX float was tested on a mooring in the upper basin of Loch Etive.

Figure 2.14. APEX buoy in preparation for deployment through the ice. The float is constrained to profile along the weighted line suspended from the tripod and passing through the line guides mounted to the outside of the hull.

The normal buoyancy control of the float was circumvented in order to increase the rate of descent to improve the microstructure measurements. Data from both the MSS microstructure sensor (ISW-Wassermesstechnik) and the APEX SBE41 CTD (SeaBird Electronics) were logged to the SAMS data logger.

Three 10” diameter holes were drilled in the ice and connected with an ice saw to give an (almost) triangular opening. Above the hole, the aluminium tripod was assembled (Figure 2.14). A stainless steel cable was connected between adjacent legs of the tripod to prevent the legs from moving apart. At the top of the tripod, a 2mm stainless steel line ~ 100m long with a 25kg weight on the bottom was fixed and the line lowered into the water. The buoy was attached to this line (Figure 2.15), via low friction (nylube) line guides.

Figure 2.15. Deployment of the APEX float through the sea ice

A microcontroller running bespoke firmware controls the profile of the buoy. The start and finish depths and number of profiles are selectable prior to each deployment via a serial link. At the beginning of each deployment, the bladder pump stroke was set to its mid position and the buoyancy of the buoy very carefully adjusted to neutral by adding or removing tiny weights.

Despite three attempts, the buoy failed to correctly execute a full profile. Inspection of the log files indicated that the pump travelled to its lower extreme but that the buoy failed to descend. It was noticed that the tether wire was heavily affected by the tide under the ice which drew it away from the vertical, increasing resistance in the line guides, which showed evidence of wear on final recovery. There was speculation that this along with reduction in surface buoyancy due to melting sea ice prevented the buoy from operating as designed.

SCIENTIFIC REPORT 3: Turbulent mixing in the West Spitsbergen Current

Tim Boyd, Estelle Dumont, Colin Griffiths, Mark Inall, and Edward Steele

Introduction

The overall objective of the SAMS physics department contribution during the fourth leg of JR219 was to evaluate the impact of turbulent mixing on heat flux from the West Spitsbergen Current (WSC) as it traverses west and north of Svalbard. The WSC has been extensively studied over the past 30 years, but the mechanisms by which the current loses heat are still an active research topic. As the WSC traverses northward along the continental slope west of Svalbard, it splits into an inshore branch which follows the shelf break around the north of Svalbard, and an offshore branch which continues northward along the periphery of the Yermak Plateau (YP). Given the overall structure of the JR219 cruise, access to the YP branch of the WSC was not possible, so we focused our investigation on the lesser known inshore branch of the WSC, using a variety of instruments and instrument platforms to observe variability within and across the shoreward edge of the WSC. In particular, a conventional bottom-anchored mooring provided time series observations within the WSC, while ship-based CTD and turbulence profilers provided transects of vertical profiles, and an autonomous underwater vehicle (AUV) provided horizontal profiles across its shoreward edge. Simultaneous sampling with the MSS and AUV-based turbulence sensors were conducted to enable comparison of vertical and horizontal profiles of turbulent mixing and thus provide a conventional reference for the AUV-based horizontal measurements.

The region offshore of the northwest corner of Spitsbergen was the primary site of interest for our combined mooring/AUV/MSS observations during Leg 4, due to the high likelihood of internal wave generation by interaction of the barotropic tide with the continental slope bathymetry. Although a preliminary CTD transect was conducted, and a mooring deployed along this Amsterdamoya transect, no AUV or MSS observations were attempted there due to inclement weather.

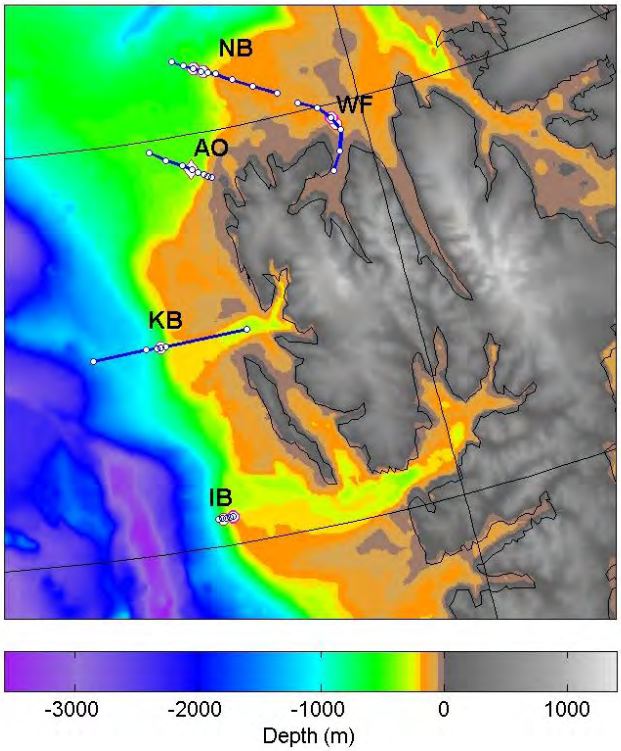


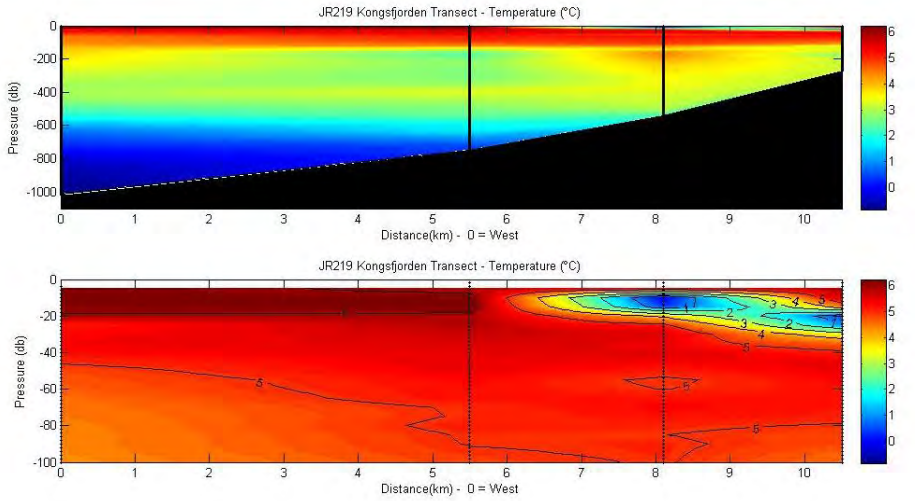
Figure 3.1. shows the locations of five CTD transects conducted during JR219, together with the Amsterdamoya Transect mooring location. CTD transects are shown as blue lines with CTD locations identified by small white circles, and labeled: WF (Woodfjorden), NB (Norske Banken), AO (Amsterdamoya), KB (Kongsfjord Banken), and IB (Isfjord Banken). The Amsterdamoya mooring location is identified by a white diamond. Endpoints of the MSS and AUV transects are indicated by large white circles.

Transect	Type	Profile/ Deploy No.	Start				Stop			
			Latitude	Longitude	Date	Time	Latitude	Longitude	Date	Time
Kongsfjorden										
	CTD	38-41, 45-46	79° 00.91' N	010° 41.31' E	05/07	12:32	78° 58.51' N	006° 42.37' E	06/07	19:47
	AUV	1	79° 00.00' N	008° 28.47' E	06/07	13:16	78° 59.84' N	008° 28.55' E	06/07	17:27
	AUV	2	79° 00.00' N	008° 28.46' E	12/07	09:35	78° 59.89' N	008° 28.50' E	12/07	16:20
Amsterdamoya										
	CTD	64-71	79° 56.66' N	008° 56.22' E	14/07	22:12	79° 46.46' N	010° 31.80' E	15/07	04:32
	CTD	92-94	79° 51.20' N	009° 47.39' E	19/07	14:32	79° 48.60' N	010° 11.39' E	19/07	18:38
	AUV	N/A	not	conducted	due	to	adverse	weather		
	MSS	N/A	not	conducted	due	to	adverse	weather		
Woodfjorden										
	CTD	74-79	80° 00.00' N	013° 48.01' E	16/07	02:09	80° 02.52' N	013° 17.94' E	17/07	01:15
	AUV	3	79° 56.00' N	014° 06.03' E	16/07	13:32	79° 55.97' N	014° 07.60' E	16/07	18:46
	MSS	2-31	79° 55.97' N	014° 06.67' E	16/07	14:43	79° 54.03' N	014° 11.85' E	16/07	18:11
Norske Banken										
	CTD	81-89	80° 06.75' N	012° 47.72' E	17/07	21:10	80° 21.66' N	010° 00.06' E	18/07	04:09
	AUV	4	80° 18.69' N	010° 35.00' E	18/07	05:53	80° 17.21' N	010° 50.19' E	18/07	12:35
	MSS	32-52	80° 18.79' N	010° 35.96' E	18/07	06:30	80° 17.34' N	010° 52.00' E	18/07	11:29
Isfjord Banken										
	CTD	96-100	78° 08.01' N	009° 13.41' E	20/07	16:07	78° 08.00' N	009° 34.35' E	20/07	19:18
	AUV	5	78° 07.99' N	009° 34.36' E	20/07	19:46	78° 07.70' N	009° 34.24' E	21/07	02:04
	MSS	53-71	78° 07.77' N	009° 34.29' E	20/07	20:26	78° 07.66' N	009° 20.49' N	21/07	00:32

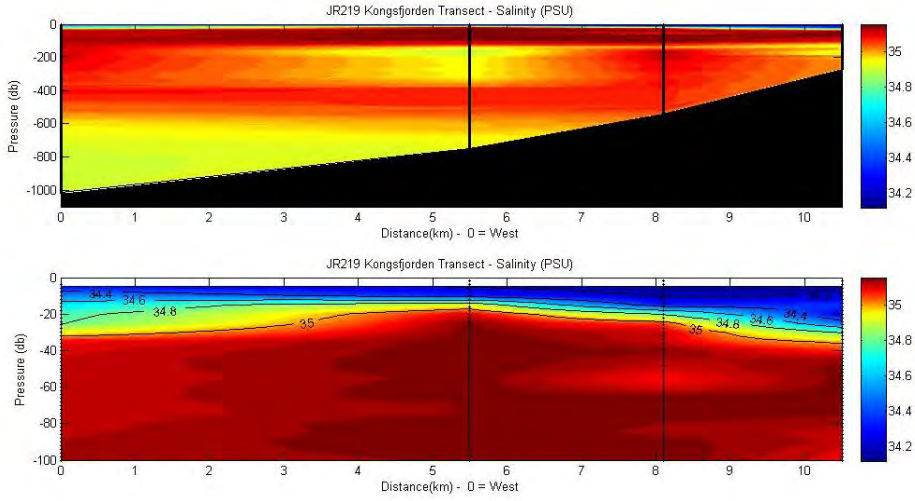
Table 3.1. List of the profiles/deployment numbers and associated start/stop times and locations of the CTD, AUV, and MSS sampling conducted along both the Kongsfjorden transect of cruise leg 3 and each of the four transects conducted during leg 4. Time and location data are drawn from the Ship-based Scientific Event Log.

CTD Transects

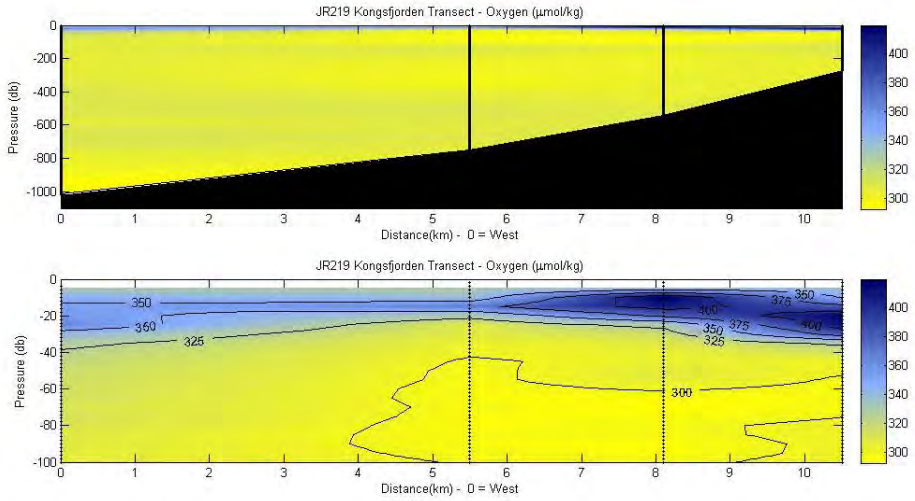
The collection and processing of the CTD cast data during JR219 is discussed in **Scientific Report 1: Physics CTD**, where contour plots are shown for temperature, salinity, potential density, dissolved oxygen, and cholorphyll fluorescence data along three of the five Svalbard transects: Amsterdamoya (Figures 1.6-2 to -6), Norske Banken (Figures 1.6-7 to -11), and Isfjord Banken (Figs 1.6-12 to -16). Similar plots for the coarsely sampled Konsfjord Banken transect of Leg 3 and the Woodfjorden transect of Leg 4 are shown here as Figures 3.2 and 3.3, respectively.



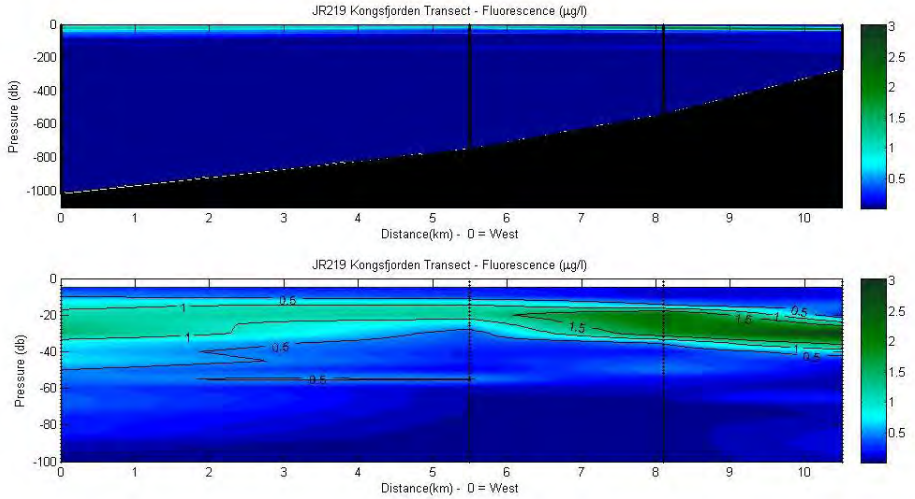
3.2a. Temperature



3.2b Salinity

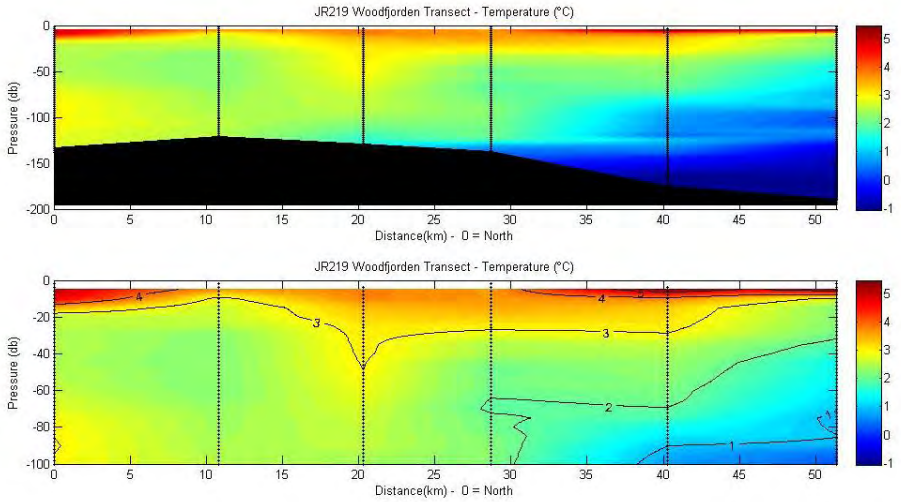


3.2c Dissolved Oxygen

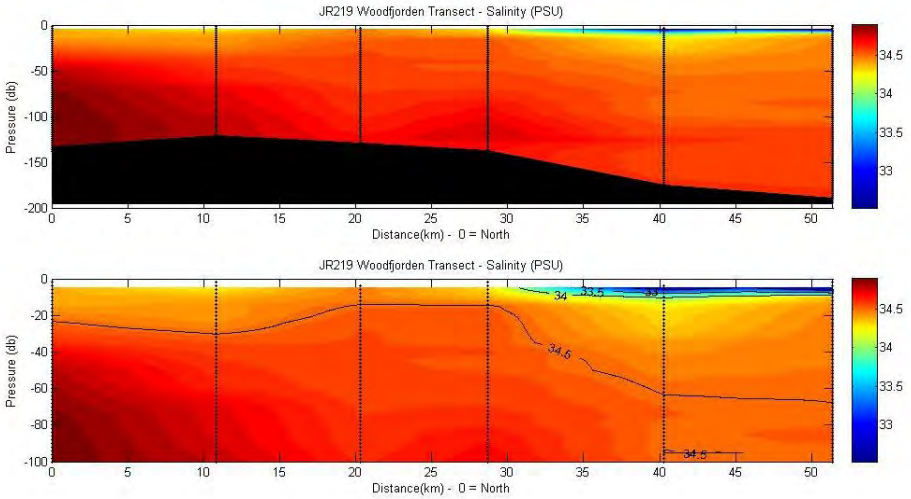


3.2d Cholorphyll Fluorescence

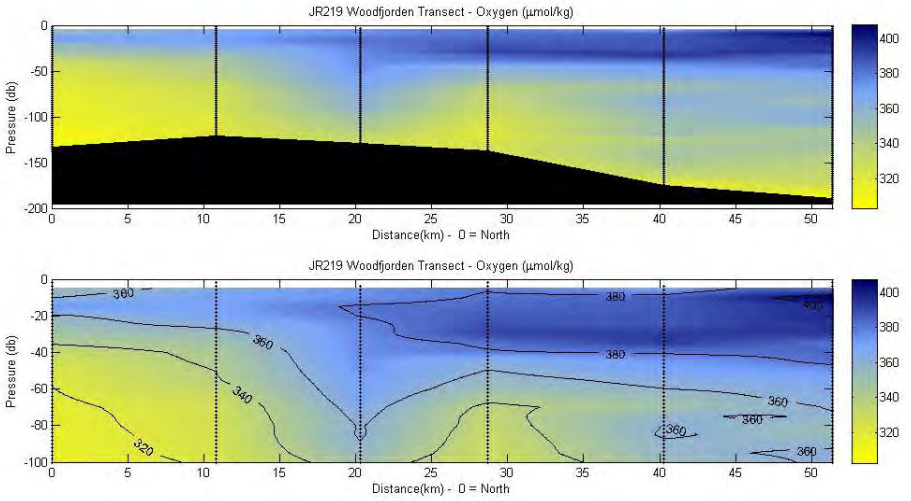
Figure 3.2. Kongsfjord Banken CTD transect of Leg 3 consisting of CTD casts 41, 45, 40 and 39, from west (left) to east (right), with temperature (a), salinity (b), dissolved oxygen (c), and chlorophyll fluorescence (d), for the entire water column (upper panels) and the upper 100 m (lower panels). AUV deployments 1 on 6 July and 2 on 12 July (see Table 3.1) began close to the location of CTD cast 40 (near Distance = 8 km) and consisted of reciprocal 5 km legs conducted on an initial bearing of 270°, towards deeper water (i.e., towards the left in this figure, see Table 3.3). Vertical black lines indicate the locations of the CTD profile data.



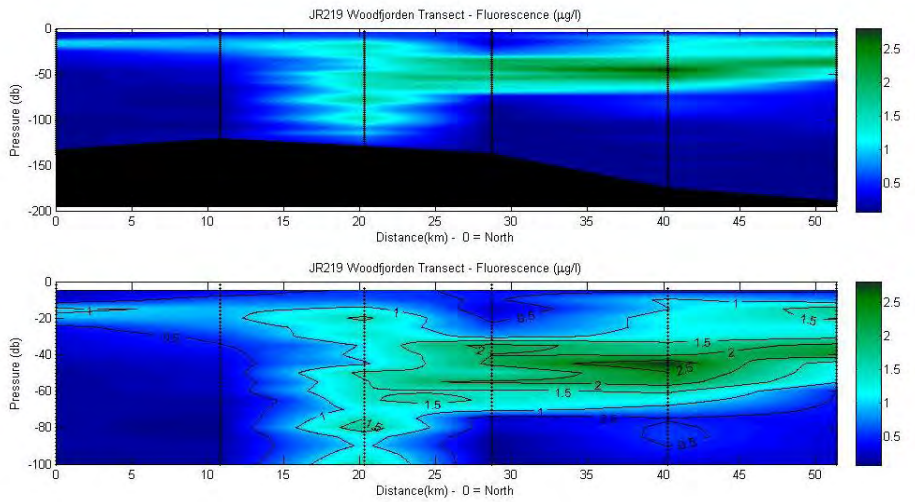
3.3a Temperature



3.3b Salinity



3.3c Dissolved Oxygen



3.3d Chlorophyll Fluorescence

Figure 3.3. Woodfjorden Leg 4 CTD transect consisting of CTD casts 79, 74, 75, 76, 78, and 77, from north (left) to south (right), with temperature (a), salinity (b), dissolved oxygen (c), and chlorophyll fluorescence (d), for the entire water column (upper panels) and the upper 100 m (lower panels). AUV deployment 3 on 18 July (and the associated MSS transect consisting of profiles 2-31, see Table 3.1) began close to the location of CTD cast 75 (near Distance = 20 km) and consisted of reciprocal 5km legs conducted on an initial bearing of 155°, towards the fjord (i.e., towards the right in this figure, see Table 3.3). Vertical black lines indicate the locations of the CTD profile data.

Mooring

The mooring was deployed in about 400 m of water over the upper continental slope along a transect running NW from the island of Amsterdamoya, off Smeerenburg Fjord. The mooring consisted of instrumentation to measure ocean velocity, temperature, and salinity variability from 25 m above the bottom to 12 m beneath the ocean surface.

Figure 3.4 shows the mooring instrument distribution. High vertical resolution temperature measurements were augmented by near surface and mid water column salinity and and pressure measurements. The perturbation pressure from instruments near 10 m and 150 m depth show the response of the mooring to the lateral force of tidal velocities: tilting and thus increasing the instrument depths by up to 20 m (Figure 3.4). The tidally induced tilt of the ADCP is up to 12 degrees, but ADCP depth fluctuates by only about 1 m due to proximity to the bottom (Table 3.2 and Figure 3.7).

Figures 3.5 and 3.6 illustrate water column temperature and salinity variability during the deployment. The predominant features are the period of stable temperature stratification over days 197.7 to 199.7, punctuated on either end by intervals of low/marginal stability associated with strong wind events. The yearday convention is such that January 1 begins at day 1.0. Yeardays during Leg 4 are numbered 181 + day of July, and thus July 1 begins at yearday 182.0. The relatively low stratification of day 196.5-197.7 (July 15-16) resulted from high winds that precluded open water AUV sampling on the Amsterdamoya section and drove the ship eastward to the more sheltered waters of Woodfjorden (see the July 15-16 entries in the cruise narrative). CTD, AUV and MSS sections were then conducted just offshore of Woodfjorden and followed by similar sampling over Norske Banken (Figure 3.1). The wind picked up again on 19 July (see the cruise narrative, yearday 200), and created rough conditions that mixed the water column, as shown in both Figures 3.5 and 3.6. This prevented AUV and MSS sampling, and also forced the early recovery of the mooring.

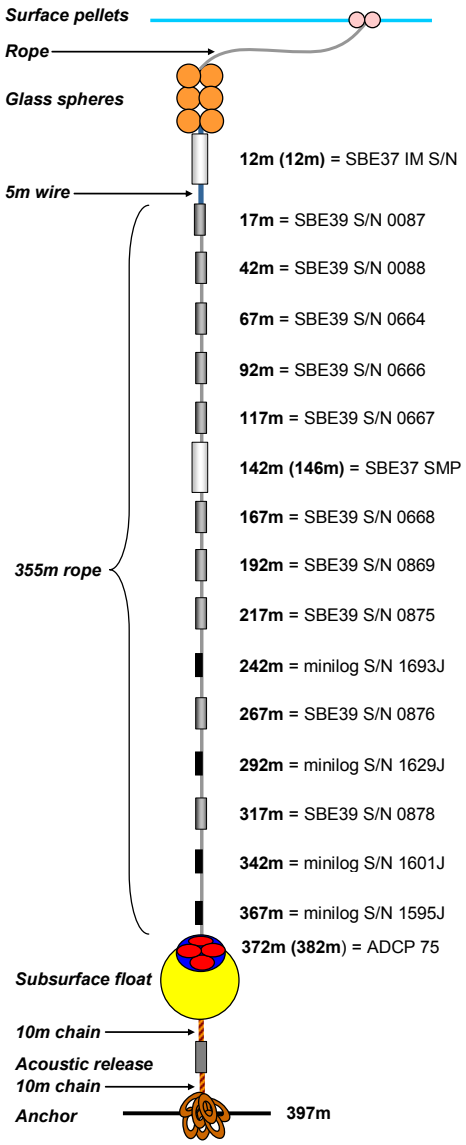


Figure 3.4. Distribution of instruments on the Amsterdamoya mooring, showing the nominal depths (left), instrument types, and serial numbers. Depths shown as derived from the mooring plan, which included a 355m piece of rope between SBE39 s/n 087 and the 75kHz ADCP-LR. Depths in brackets are as measured by the various pressure sensors, using the shallowest points in the time series of pressure, which varies with tidal frequency mooring knockdown. Variables measured are: Seabird Electronics SBE-39 (T), SBE-37 (T,S,P), Vemco Minilogger (T), RDI 75kHz ADCP (velocity,T,P). The SBE sensors sampled at 30 second intervals, and the ADCP averaged 49 pings in 120 second ensembles.

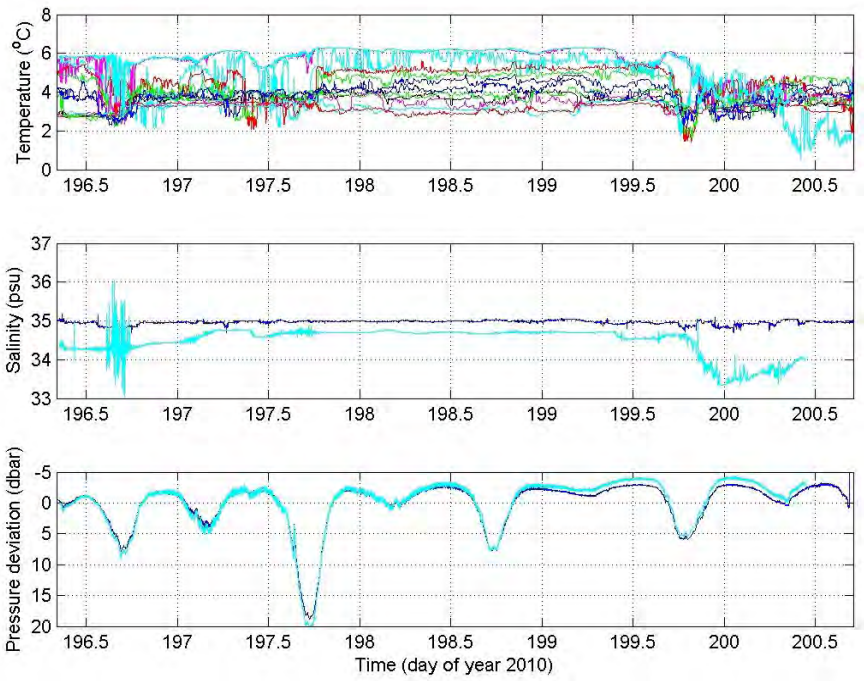


Figure 3.5. Time series of mooring temperature (top), salinity (middle), and pressure deviation from the deployment mean (bottom). Temperature was measured at 17 depths (nominal values shown in Table 3.3 – temperatures from Vemco miniloggers are not shown). Salinity and pressure were measured at two depths, the nominal values for which are shown in Table 3.2 and the deployment mean of which are 12.77 decibars (cyan) and 146.91 decibars (blue). Note that the shallow points decrease in pressure slightly over time, possibly due to mooring movement into shallower water.

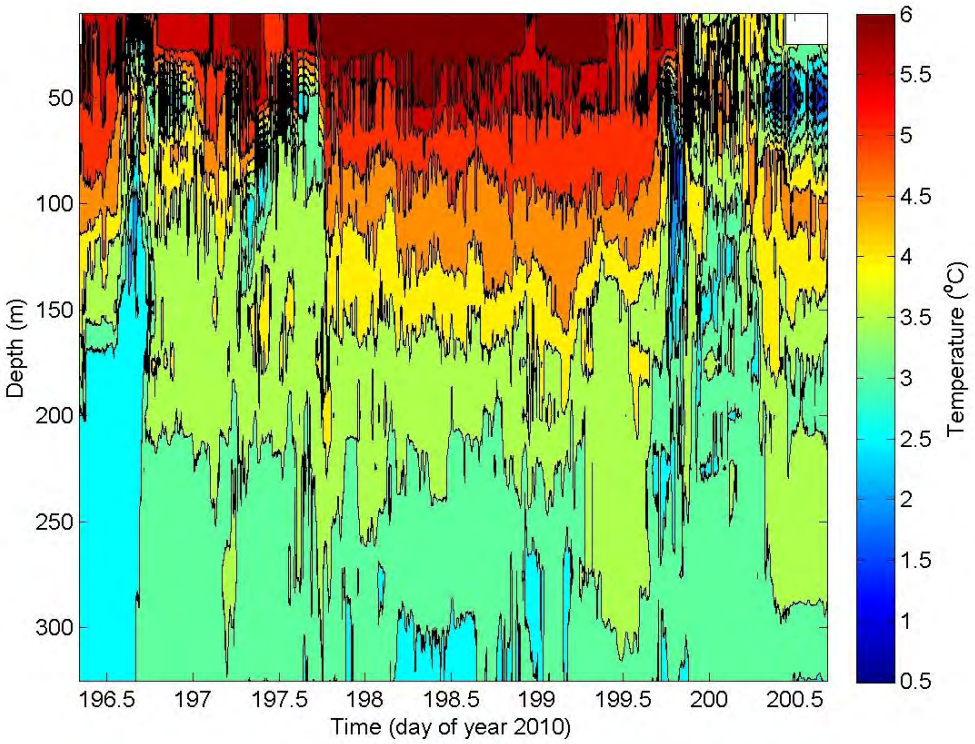


Figure 3.6. Contours of temperature from the Amsterdamoya mooring. Temperatures from VEMCO miniloggers are not shown.

An upward-looking 75kHz RDI 'Long Ranger' ADCP, on loan from Prof. Ilker Fer, U. Bergen, was mounted within a flotation sphere near the bottom of the mooring, and set to record in 8m bins, with 49 pings in each ensemble of 120 seconds length. The ADCP was set up to form velocity solutions using measured tilts (pitch and roll, Figure 3.8), 3-beam solutions and bin mapping, and then record results in earth coordinates. According to the RDI PlanADCP software, this setup should result in a 2 cm/s standard deviation for the velocity measurement in bins that span the entire water column. The ADCP record (raw data file name JR219000.000, time stamped: 20/07/2010) consists of 3976 ensembles beginning on 15/07/2010 at 04:00 and ending on 20/07/2010 at 16:30 GMT.

The velocity data shown in Figure 3.7 are uncorrected for the magnetic declination, estimated at 1° 58' E for 18 July, 2010 at the mooring location (Latitude = 79° 49.86' N; Longitude = 10° 01.68' E) using the model of the NOAA National Geophysical Data Center (http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp). Velocity component time series are shown in Figure 3.6 for the depth range from 126 m to 366 m only, because some velocity dropouts occur near the surface, due to decreasing amplitude and correlation of the ADCP received signal. Both velocity component signals are primarily barotropic with some indication of increasing phase lag with depth in the eastward (U) component. The principal mode of the velocity signal is likely due to a coastally trapped wave of near inertial frequency.

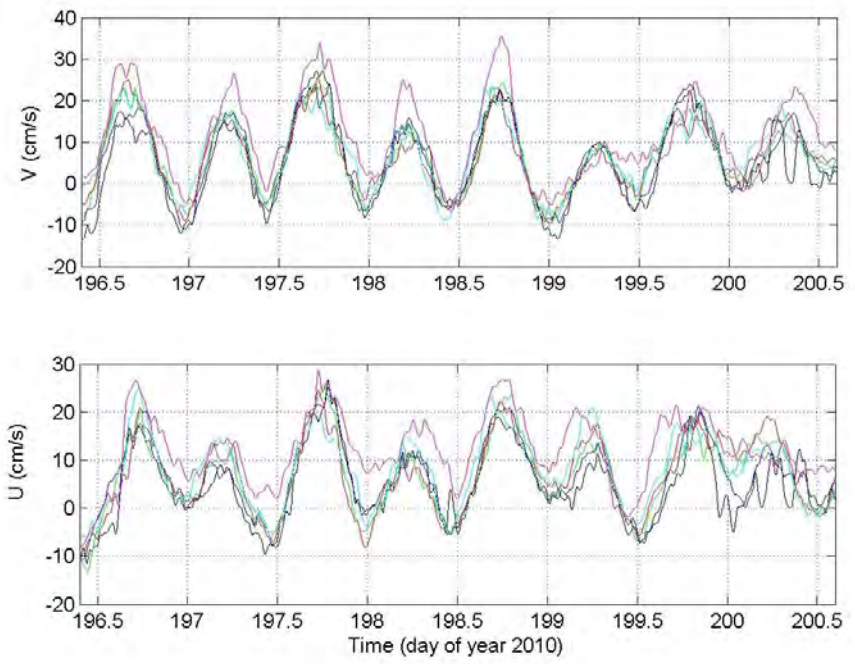


Figure 3.7. ADCP northward (top) and eastward (bottom) velocity components from the 75kHz ADCP at 380 m depth on the Amsterdamoya mooring. Velocity has been median filtered to remove outliers and low pass filtered using a Gaussian window of scalewidth 12 minutes. Velocity components shown are from 126 m, 174 m, 222 m, 270 m, 318 m, and 366 m depth (colors are black, blue, green, red, cyan, and magenta, respectively).

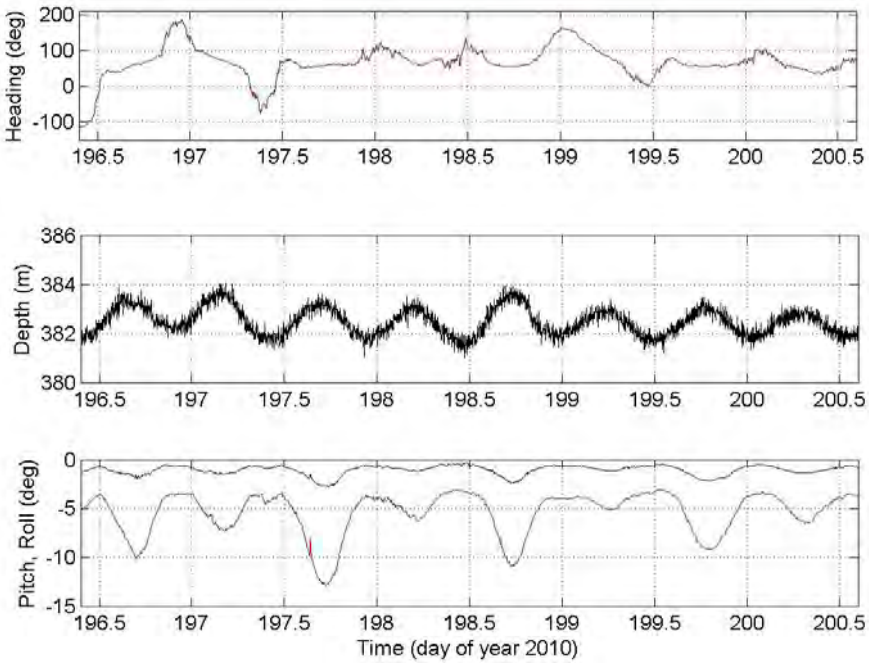


Figure 3.8. ADCP heading (top), depth (middle), and pitch and roll (bottom). This figure illustrates the stability of the mooring: near-bottom pressure fluctuates with amplitude up to one meter at tidal time scales; both pitch and roll fluctuate at tidal timescales and are within acceptable values; instrument heading varies slowly,

AUV-based Turbulence Measurements

AUV-based observations were conducted using SAMS' 600m-rated REMUS vehicle (Hydroid, Inc), known as 'Rebus' (Figure 3.9), equipped with 600 kHz upward- and downward-looking ADCP velocity sensors, Neil Brown Ocean Sensors CT sensor, WET Labs chlorophyll-a fluorometer and 660nm optical backscatter sensors as well as Rockland Scientific microstructure shear and temperature sensors. The AUV was deployed and recovered over the JCR starboard side using the ship's crane. The ship's small boat was launched after each deployment to tow the AUV to the JCR's aft starboard side where the ship's crane was hooked into the AUV bale for recovery. The AUV deck unit was operated from the main lab, from where the mission progress was also monitored. The AUV mast box was mounted on the rail above the starboard side of the main lab, enabling clear Wifi communications with the AUV while on deck or at the ocean surface to either the immediate starboard or stern of the JCR. Battery charging of the AUV was conducted in the scientific workshop, where the AUV was also stored during passage. All ship operations were conducted by the day crew, except for the final deployment of the cruise, which was conducted off Isfjorden and concluded in the early hours (see Table 3.2) just before the ship returned to Longyearbyen to end the science program.

Figure 3.9. SAMS' REMUS 600 m vehicle on the aft deck of the JCR, and in the process of deployment via the ship's crane on 16 July near the mouth of Woodfjorden.

In total, five AUV deployments were completed (Table 3.2). During Leg 3, preliminary tests of AUV operations were conducted in two deployments over a segment of the continental slope west of Kongsfjorden, (see Figure 3.2). The remaining 3 deployments were conducted over the upper continental slope and shelf during Leg 4. In each deployment, AUV sampling was nested within broader CTD transects to provide hydrographic context at the meso- to large-scale, in particular with respect to the temperature and salinity structure of the WSC. During leg 4, simultaneous transects of MSS profiles provided AUV transect 'calibration' through comparison with conventional microstructure surveys. Locations of the CTD, AUV, and MSS transects are shown in Figure 3.1, as well as in Table 3.1 together with the sampling times. More details of the deployments and individual missions can be found in Table 3.2. In the AUV operational lexicon, a 'deployment' refers to the full period in which the AUV is operating in the water, and may consist of more than one 'mission', or execution of a pre-programmed sequence of tasks. Ideally, each deployment during JR219 would have consisted of a single mission, however the mission executed during the second deployment (on 12 July) terminated early due to a short timeout setting. This setting was subsequently lengthened to relax the AUV acoustic monitoring schedule, thus enabling ship multi-tasking (in this case to simultaneous conduct AUV and MSS transects).

'Rebus' AUV navigation is conducted by dead-reckoning aided by knowledge of the vehicle's motion over the ground, if available. When the vehicle is operating within about 100m of the bottom, the downward-looking 600kHz ADCP tracks the vehicle motion relative to the bottom, which significantly improves the navigation accuracy relative to solutions based solely on propeller turns (i.e., speed through the water) and compass heading. Typical accuracy for this vehicle with bottom-tracking is of order 4% of distance covered underwater, or about 200 m for the JR219 missions with 5 km legs between surfacings with GPS position updates. The navigation accuracy experienced during JR219 was significantly worse, up to 10% of the distance travelled underwater, because the water was mostly too deep for bottom-tracking, and because the AUV was not operated long enough in this region to have developed a local compass bias table. For the most part, the AUV was operated at altitudes greater than 100 m, and was thus mostly outside of bottom-tracking range. Two exceptions are during the deeper Woodfjorden transects, and the eastern section of the deeper Isfjorden transects. Bottom-tracking also contributes significantly to improving the accuracy of the conversion of ADCP-derived relative water velocities into earth coordinates. Thus the only sections during which we expect reasonably accurate AUV-based water velocity measurements are those deeper transects in the Woodfjorden and Isfjorden deployments. This processing has yet to be conducted.

AUV Deployment		Date	Start			Stop Time	Missions: Reciprocal Transects		
No.	Mission Name		Lat	Lon	Time		1st Leg Heading	Leg Length	Depth (m) Sequence
1	100706_1R	06/07	79N 00.00	08E 28.43	13:44	17:20	270	5 km	10, 70, 130, 170
2	100712_1R 100712_2R 100712_3R	12/07	79N 00.00	08E 28.43 08E 13.84 08E 28.43	09:52 11:18 12:42	10:49 15:45	270 90 270	5 km	25 25 70, 70, 130, 130
3	100716_1R	16/07	79N 56.00	14E 06.00	13:41	18:46	155	5 km	25, 25, 50, 50, 100, 100
4	100718_1R	18/07	80N 18.68	10E 35.00	06:12	12:35	118	5 km	25, 40, 50, 60, 80, 100, 120
5	100720_1R	20/07	78N 08.00	09E 34.40	20:04	02:04	270	5 km	25, 50, 75, 100, 125, 150

Table 3.2. AUV deployments were conducted on 5 separate occasions during JR219. Each of the missions was structured around reciprocal transects at several different depths. The second deployment consisted of 3 separate missions due to AUV operational difficulties associated with vehicle timeout parameters. In this case, the sampling objectives were met through 3 sequential missions.

The rate of dissipation, ε, of turbulent kinetic energy (TKE) is computed over 3 second intervals, or approximately 5 m of distance travelled, from the wavenumber-integrated shear spectrum, after correction to remove vehicle related shear variance.

The highest priority for AUV sampling was along the Amsterdamoya section, on which the mooring had been deployed and a CTD transect conducted on 15 July, however the subsequent AUV sampling was prevented by winds that built up to 40 knots during that period. The high southerly winds experienced on the Amsterdamoya section forced the scientific sampling into the sheltered waters of Woodfjorden, after which the wind speed decreased and simultaneous AUV/MSS sampling was conducted in the afternoon of 16 July in the open water of the continental shelf north of Woodfjorden.

Continuing rough water near the Amsterdamoya mooring on July 18 prevented AUV sampling along that transect, but moderately calm conditions and weaker winds to the north and east permitted combined AUV/MSS sampling at the conclusion of a CTD transect from Norske Banken into deep water

With strong easterly winds driving very rough seas and preventing scientific sampling in open water north of Svalbard on 20 July, the ship headed southward and conducted the final AUV/MSS sampling in the relatively calm waters to the west of Isfjorden.

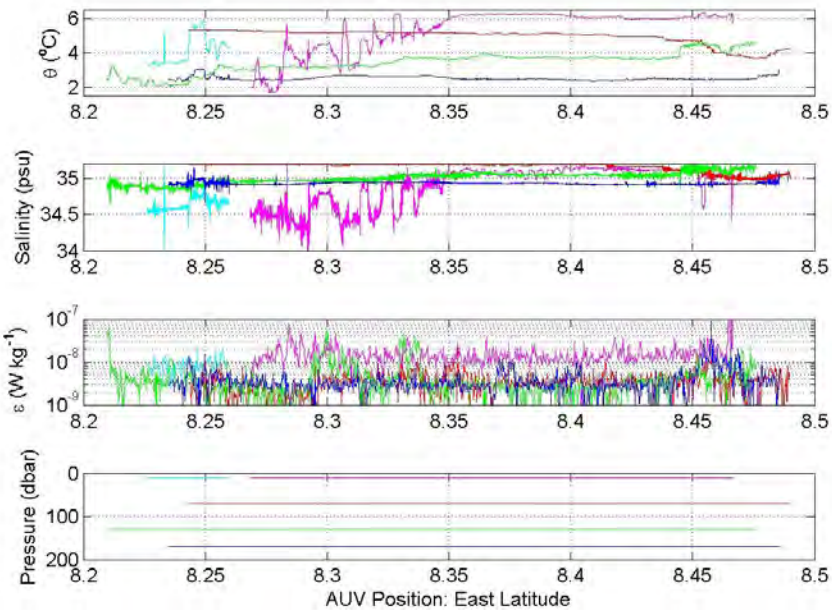


Figure 3.10. Temperature (top), salinity, TKE dissipation rate, ε, and AUV depth (bottom) for the AUV transects on the offshore side of the WSC at 79°N off Kongsfjord on 06 July. The AUV mission began close to the location of CTD cast 40 (near Distance = 8 km in Figure 3.2, see also Table 3.1) and consisted of reciprocal nominally 5 km legs conducted on an initial bearing of 270°, towards deeper water (i.e., towards the left in this figure). The sequence of transect depths is 10, 70, 130 and 170 m (Table 3.2). The first transect was split into two pieces (magenta and cyan), in order to excise a short period of unusually noisy AUV depth control.

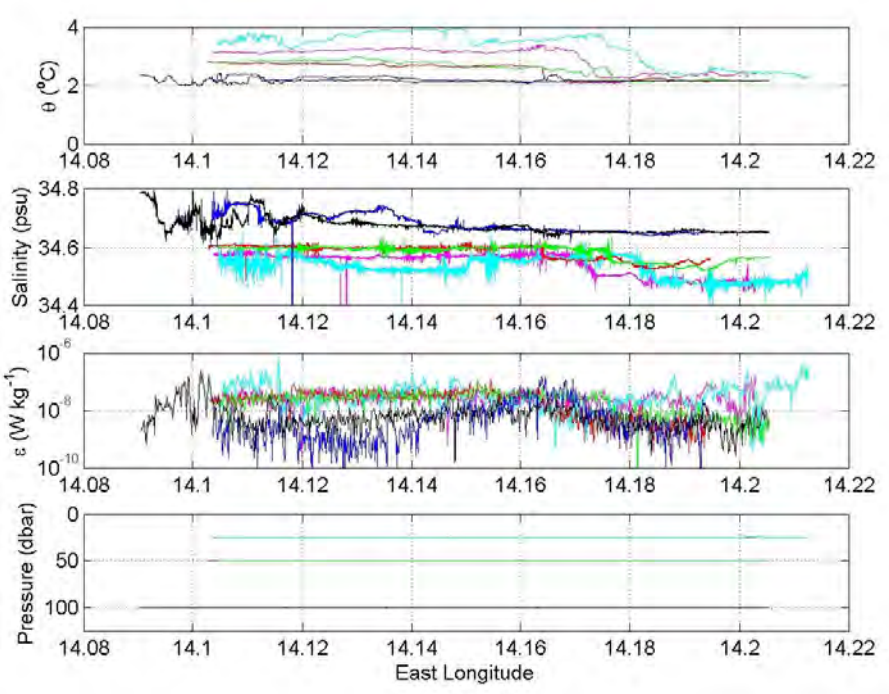


Figure 3.11. Temperature (top), salinity, TKE dissipation rate, and AUV depth (bottom) for AUV transects just off of Woodfjorden, over the broad continental shelf north of Spitsbergen, on 16 July. The AUV mission (and the associated MSS transect consisting of profiles 2-31, see Figure 3.14) began close to the location of CTD cast 75 (near Distance = 20 km in Figure 3.3, see also Table 3.1), and consisted of reciprocal 5km legs conducted on an initial bearing of 155°, towards the mouth of Woodfjorden (i.e., towards the right in this figure). The sequence of transect depths is 25, 25, 50, 50, 100, and 100 m (see Table 3.2).

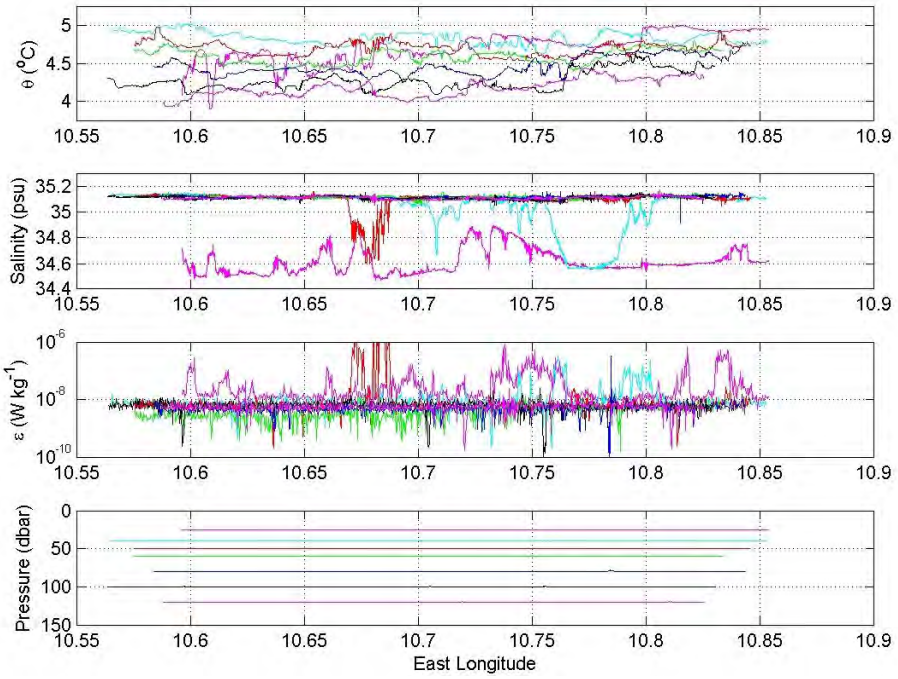


Figure 3.12. Temperature (top), salinity, TKE dissipation rate, and AUV depth (bottom) for AUV transects over Norske Banken at 80° 18' N on 18 July. The AUV mission (and the associated MSS transect consisting of profiles 32-52, see Figure 3.16) began close to the location of CTD cast 87 (near Distance = 12 km in Figure 1.6-7) and consisted of reciprocal 5km legs conducted on an initial bearing of 118°, upslope towards the continental shelf (i.e., towards the right in this figure). The sequence of transect depths is 25, 40, 50, 60, 80, 100, and 120 m (see Table 3.2).

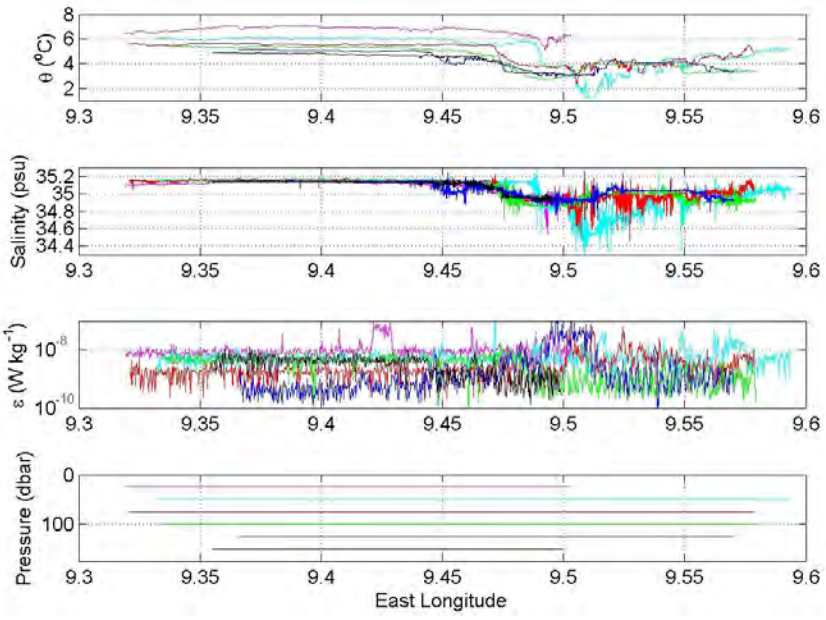


Figure 3.13. Temperature (top), salinity, TKE dissipation rate, and AUV depth (bottom) for AUV transects across the shoreward edge of the WSC at 78° 08' N, just west of Isfjorden, on 20-21 July. The AUV mission (and the associated MSS transect consisting of profiles 53-71, see Table 3.1) began close to the location of CTD cast 100 (near Distance = 8 km in Figure 1.6-12) and consisted of reciprocal 5km legs conducted on an initial bearing of 270°, towards deeper water and the WSC (i.e., towards the left in this figure, see Table 3.2).

Individual legs of the Isfjorden transect are plotted separately in Figures 3.14 – 3.16 to more clearly illustrate the relationships between the mesoscale temperature/salinity variability, and the magnitude of the TKE dissipation rate at 75, 100, and 125 m depth.

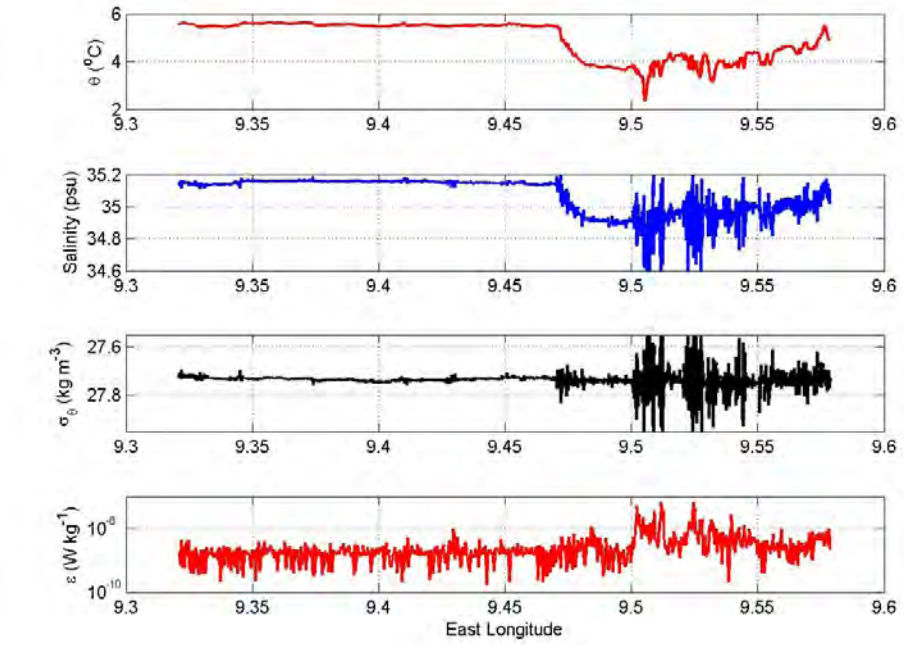


Figure 3.14. Temperature (top), salinity, density, and TKE dissipation rate (bottom) for only the 75 m transect of 20-21 July (see also Figure 3.13), showing the relationship between the edge of the West Spitsbergen Current and the significant change in the level of TKE dissipation rate, ε.

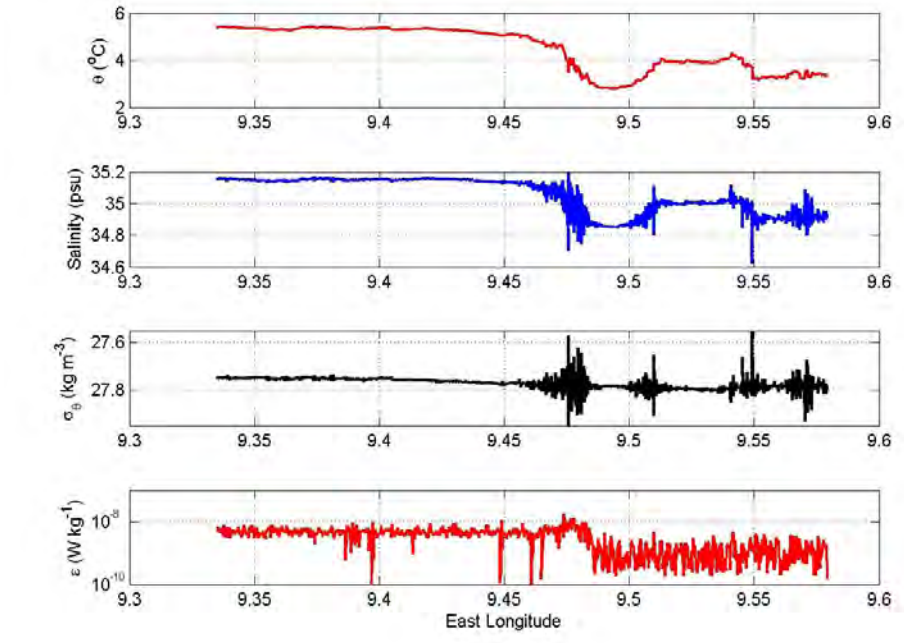


Figure 3.15. Temperature (top), salinity, density, and TKE dissipation rate (bottom) for only the 100 m transect of 20-21 July (see also Figure 3.13), showing the relationship between the edge of the West Spitsbergen Current and the significant change in the level of TKE dissipation rate, ε.

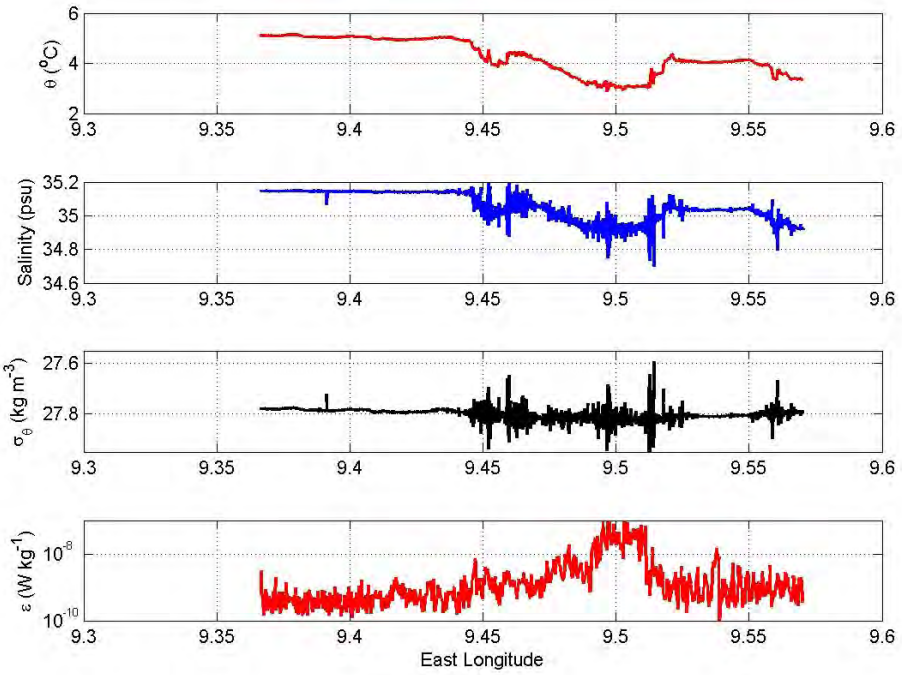


Figure 3.16. Temperature (top), salinity, density, and TKE dissipation rate (bottom) for only the 125 m transect of 20-21 July (see also Figure 3.13), showing the relationship between the edge of the West Spitsbergen Current and the significant change in the level of TKE dissipation rate, ε.

Profiler-based Turbulence Measurements

A sequence of vertical profiles of turbulent kinetic energy dissipation were conducted along the paths of the Woodfjorden, Norske Banken, and Isfjorden CTD transects simultaneously with the AUV-based microstucture measurements. These microstructure transects were conducted with the ship steaming ahead at approximately 1 knot (0.5m/s). The MSS microstructure profiler was deployed off the stern at the outset of each transect, and remained loosely tethered to a shipboard winch during free fall from the surface to about 200 m. It was winched back to the surface at the termination of each profile. Buoyancy of the MSS profiler was adjusted for local conditions with modular floats in order to achieve a typical fall rate of 0.7-0.9 m/s. Fall rate during JR219 was close to 0.9 m/s. Spatial density of profiles varied over the three transects due to vessel speed over the ground. Over the Woodfjorden transect, 30 profiles over 3.97 km (see Table 3.1) resulted in an average spatial resolution of 137 m between profiles. Similarly, the Norske Banken and Isfjorden transects embody 21 and 19 profiles over 5.68 km and 5.26 km to provide average spatial resolutions of 284 m and 292 m, respectively. The ship speed over the ground varied from 0.31 m/s during the Woodfjorden and Norske Banken transects to 0.73 m/s over the Isfjorden transect. The shear sensors used are MSS type PNS airfoil probes, serial numbers 048 (shear channel 2) and 050 (shear channel 1). The smaller of the 2 decibar binned values derived from shear channels 1 and 2 are plotted throughout figures 3.14, 3.15, and 3.16.

For each of the transects, color contours of TKE dissipation rate, ε, are overlaid with density contours in Figures 3.17, 3.18, and 3.19.

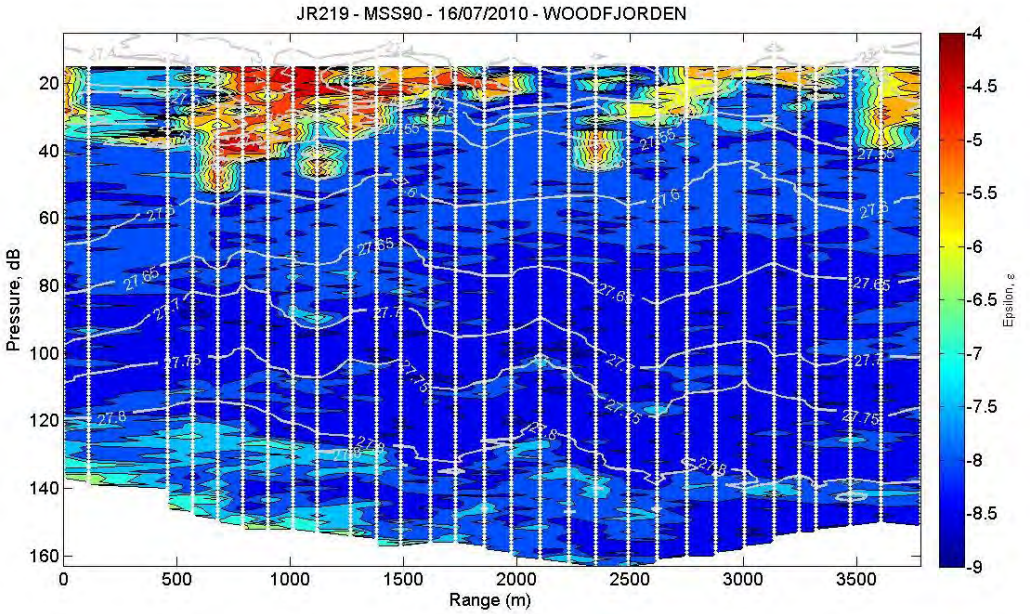


Figure 3.17. Woodfjorden MSS transect from 16 July 2010, consisting of 30 microstructure profiles and covering about 4 km. Color contours are $\log_{10}$ of TKE dissipation rate ε in W kg^{-1}, and the overlaid white contours are density as σ (density – 1000) in units of kg m^{-3}. Dissipation rates shown are the smaller of the values derived from shear channels 1 and 2 for each 2decibar bin. Vertical white lines indicate the locations of the MSS profile data.

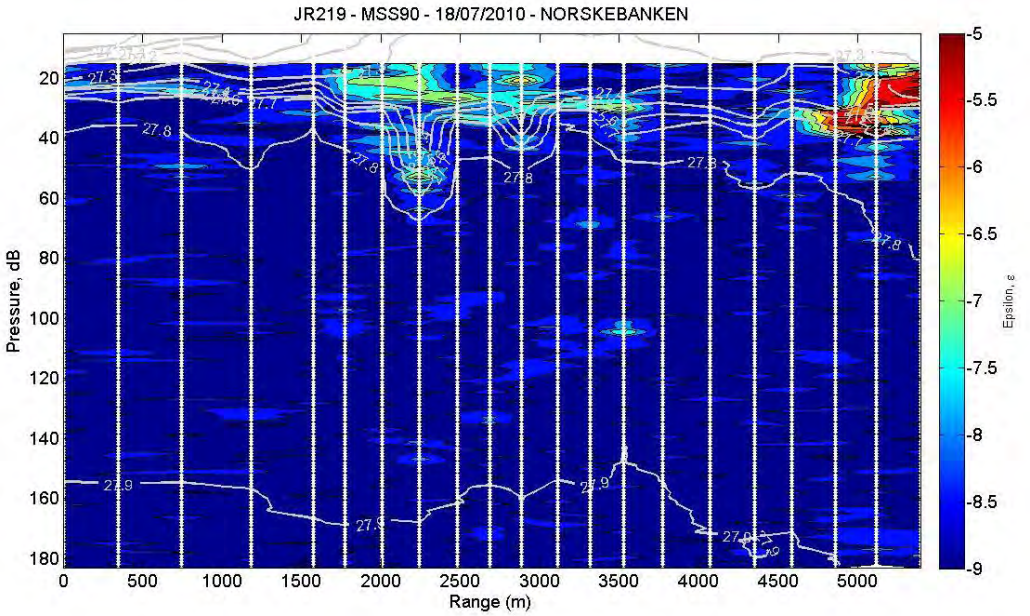


Figure 3.18. Norske Banken MSS transect from 18 July 2010, consisting of 21 microstructure profiles and covering about 5.7 km. Color contours are $\log_{10}$ of TKE dissipation rate ε in W kg^{-1}, and the overlaid white contours are density as σ (density – 1000) in units of kg m^{-3}. Dissipation rates shown are the smaller of the values derived from shear channels 1 and 2 for each 2decibar bin. Vertical white lines indicate the locations of the MSS profile data.

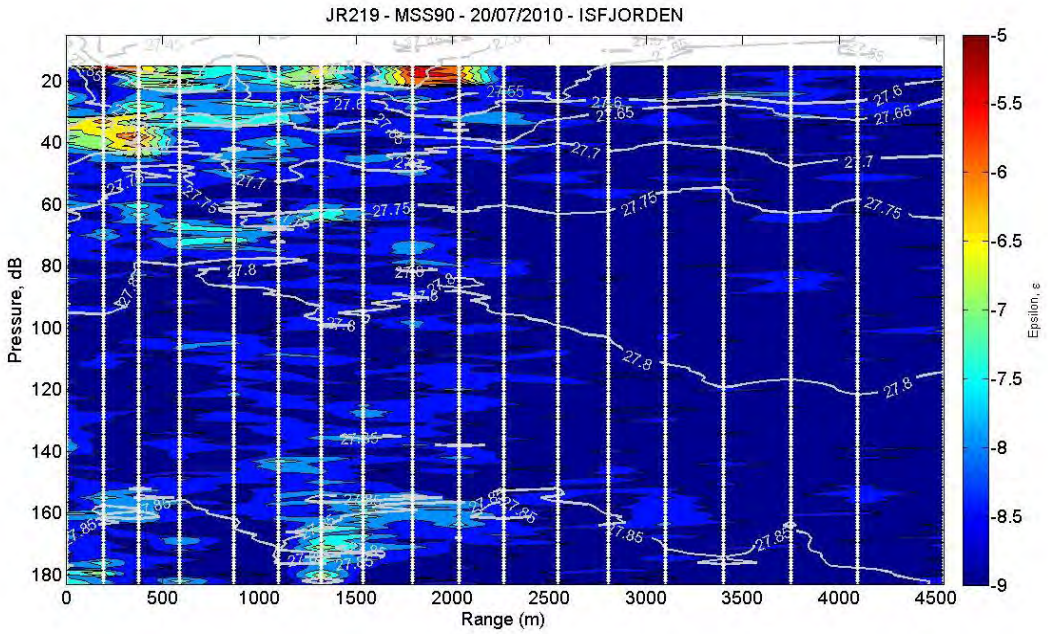


Figure 3.19. Isfjorden MSS transect from 20 July 2010, consisting of 19 microstructure profiles and covering about 4.5 km. Color contours are $\log_{10}$ of TKE dissipation rate ε in W kg^{-1}, and the overlaid white contours are density as σ (density – 1000) in units of kg m^{-3}. Dissipation rates shown are the smaller of the values derived from shear channels 1 and 2 for each 2decibar bin. Vertical white lines indicate the locations of the MSS profile data.

Vessel-mounted ADCP

Vessel-mounted ADCP data was recorded through much of Leg 4, with the notable exception of during the Woodfjorden CTD, AUV, MSS survey, at which time the VM-ADCP sampling was shut down to avoid potential acoustic interference with the AUV acoustic tracking communications. Preliminary plots were created, but are not shown here.

SCIENTIFIC REPORT 28: Salinity:δ^{18}O relationships in surface water masses

Katherine Woollard

Background

The salinity:δ^{18}O relationship in surface water masses reflects spatial variability in freshwater distribution. Through correlation of these two variables, and the generation of salinity:δ^{18}O mixing lines, regional freshwater can be quantified from the gradient of the line with the intercept of the line reflecting the regional freshwater source (Austin et al., 2006 explain this method).

Freshwater distribution is thought to be changing with time as a result of global warming and the melting of both glaciers and ice sheets with possible impacts on global oceanographic circulation. The collection of high latitude surface ocean samples at hourly intervals throughout Leg 1 of cruise JR219 along a transect between Immingham, UK and Longyearbyen, Svalbard, and derivation of freshwater data, supplements ongoing work to monitor such changes.

The surface water samples collected were primarily for oxygen isotope analysis to be carried out using the gas source mass spectrometer at the School of Geography and Geosciences, University of St Andrews. Salinity data will be been extracted from RSS *James Clark Ross* underway data continually monitored throughout Leg 1. Additional data from the continuous underway monitoring may also be utilised to provide background context to the salinity:δ^{18}O mixing lines.

The freshwater data acquired from cruise JR219 will be utilised within geographical information systems software and combined with secondary data sources (including sea surface temperature and current velocity data from satellites) to provide an ocean current framework with global isotopic data aiding interpretation of freshwater sources.

Methods/Sampling

Underway surface water samples: 5m depth
Triplicate 15ml samples (A, B and C) were collected hourly from the ship's underway outflow pipe by Kate Woollard with the aid of other research scientists onboard. There were 140 sample points along the transect and 420 samples collected in total. The samples were stored in the cool specimen room in the dark until collection in the UK and analysis back at the University of St Andrews.

CTD samples: 5/6m, 20m, 40m
Triplicate 15ml samples (A, B and C) were taken at 3 depths: 5/6m, 20m and 40m. Samples were taken at 5/6m to test the underway sampler. The other two depths were to provide a background context to the underway data collected. In total six CTDs were sampled (18 samples).

Sample Summary

The following tables provide a sampling summary for Leg 1 of cruise JR219.

NB. These are preliminary tables showing the times of sample collection. Underway data, yet to be collected, will enable the conversion of sample times to latitude and longitude.
Table 1 shows all 5m underway samples collected
Table 2 shows all CTD samples collected

Table 1: Summary of Underway Samples

Date	Sample Number	Sample Letter	Time
13/06/10	1	A-C	20:15
	2	A-C	21:15
	3	A-C	22:15
	4	A-C	23:15
14/06/10	5	A-C	00:15
	6	A-C	01:15
	7	A-C	02:15
	8	A-C	03:15
	9	A-C	04:15
	10	A-C	05:15
	11	A-C	06:15
	12	A-C	07:15
	13	A-C	08:15
	14	A-C	09:15
	15	A-C	10:15
	16	A-C	11:15
	17	A-C	12:15
	18	A-C	13:15
	19	A-C	14:15
	20	A-C	15:15
	21	A-C	16:15
	22	A-C	17:15
	23	A-C	18:15
	24	A-C	19:15
	25	A-C	20:15
	26	A-C	21:15
	27	A-C	22:15
	28	A-C	23:15
15/06/10	29	A-C	00:15
	30	A-C	01:15
	31	A-C	02:15
	32	A-C	03:15
	33	A-C	04:15
	34	A-C	05:15
	35	A-C	06:15
	36	A-C	07:15
	37	A-C	08:15
	38	A-C	09:15
	39	A-C	10:15
	40	A-C	11:15
	41	A-C	12:15
	42	A-C	13:15
	43	A-C	14:15
	44	A-C	15:15
	45	A-C	16:15
	46	A-C	17:15
	47	A-C	18:15

Date	Sample Number	Sample Letter	Time
15/06/10	48	A-C	19:15
	49	A-C	20:15
	50	A-C	21:15
	51	A-C	22:15
	52	A-C	23:15
16/06/10	53	A-C	00:15
	54	A-C	01:15
	55	A-C	02:15
	56	A-C	03:15
	57	A-C	04:15
	58	A-C	05:15
	59	A-C	06:15
	60	A-C	07:15
	61	A-C	08:15
	62	A-C	09:15
	63	A-C	10:15
	64	A-C	11:15
	65	A-C	12:15
	66	A-C	13:15
	67	A-C	14:15
	68	A-C	15:15
	69	A-C	16:15
	70	A-C	17:15
	71	A-C	18:15
	72	A-C	19:15
	73	A-C	20:15
	74	A-C	21:15
	75	A-C	22:15
	76	A-C	23:15
17/06/10	77	A-C	00:15
	78	A-C	01:15
	79	A-C	02:15
	80	A-C	03:15
	81	A-C	04:15
	82	A-C	05:15
	83	A-C	06:15
	84	A-C	07:15
	85	A-C	08:15
	86	A-C	09:15
	87	A-C	10:15
	88	A-C	11:15
	89	A-C	12:15
	90	A-C	13:15
	91	A-C	14:15
	92	A-C	15:15
	93	A-C	16:15
	94	A-C	17:15

Date	Sample Number	Sample Letter	Time
17/06/10	95	A-C	18:15
	96	A-C	19:15
	97	A-C	20:15
	98	A-C	21:15
	99	A-C	22:15
	100	A-C	23:15
18/06/10	101	A-C	00:15
	102	A-C	01:15
	103	A-C	02:15
	104	A-C	03:15
	105	A-C	04:15
	106	A-C	05:15
	107	A-C	06:15
	108	A-C	07:15
	109	A-C	08:15
	110	A-C	09:15
	111	A-C	10:15
	112	A-C	11:15
	113	A-C	12:15
	114	A-C	13:15
	115	A-C	14:15
	116	A-C	15:15
	117	A-C	16:15

Date	Sample Number	Sample Letter	Time
18/06/10	118	A-C	17:15
	119	A-C	18:15
	120	A-C	19:15
	121	A-C	20:15
	122	A-C	21:15
	123	A-C	22:15
	124	A-C	23:15
19/06/10	125	A-C	00:15
	126	A-C	01:15
	127	A-C	02:15
	128	A-C	03:15
	129	A-C	04:15
	130	A-C	05:15
	131	A-C	06:15
	132	A-C	07:15
	133	A-C	08:15
	134	A-C	09:15
	135	A-C	10:15
	136	A-C	11:15
	137	A-C	12:15
	138	A-C	13:15
	139	A-C	14:15
	140	A-C	15:15

Table 2: Summary of CTD samples

Date	Depths
14/06/2010	5m, 20m, 40m
15/06/2010	5m, 20m, 40m
16/06/2010	6m, 20m, 40m
17/06/2010	6m, 20m, 40m
18/06/2010	5m, 20m, 40m

Results

The samples are yet to be analysed and therefore no preliminary results are available at this time.

The results will be presented in my undergraduate dissertation to be produced for the University of St Andrews. This will be completed by Easter 2011.

Reference

Austin et al. 2006. Mid-latitude shelf seas: a NW European perspective on the seasonal dynamics of temperature, salinity and oxygen isotopes. Holocene 16:937-947.

SCIENTIFIC REPORT 5: Inorganic nutrients and dissolved oxygen concentrations

Sharon McNeill and Tim Brand

Inorganic Nutrients

Introduction

Water column dissolved nutrients, ammonia, phosphate, silicate and nitrate were analysed from CTD casts along 2R219 Legs 1, 2 and 3. Depths for the samples were chosen to correspond with those of the chlorophyll, bioassay studies and water column radionuclide studies. Samples were taken from the conventional steel framed CTD. A full list of nutrient samples taken and analysed on board are shown in Tables 1 to 4.

During leg 3 nutrient samples were also analysed from Lander deployment incubation and deck board incubation experiments (see Section Y Stahl) together with sediment pore water nutrient samples collected and extracted from sediment cores (see Section Y Stahl and Turner).

Method

Water column amples were collected in 60ml acid cleaned polythene syringes directly from the CTD spigots with the use of a tube. Samples were then filtered through a 25mm GFF filter and always analyzed within 24 hours of collection and stored in a fridge prior to analysis. If the analyzer had mechanical problems then samples were stored frozen until its repair then defrosted overnight and run the next morning. Measurement was conducted using a Lachat *QuikChem 8500* flow injection autoanalyzer using the manufacturers recommended methods: Ammonia, 31-107-06-1-B; Orthophosphate, 31-115-01-1-G; Silicate, 31-114-27-1-A and Nitrate/Nitrite, 31-107-04-1-A.

Samples were measured in triplicate to identify instrument precision. Standards were prepared in deionised water and the samples were run in a carrier stream of deionised water. Pore water samples were diluted 8 times prior to analysis. Overlying water from the incubated sediment work was run undiluted.Salt correction of the result was performed by running a small number of Low Nutrient Sea Water samples (OSIL, http://www.osil.co.uk, Batch LNS 17, Salinity 35) during each sample batch run and the mean result was subtracted from sample results.

A standard reference solution prepared from nutrient standard solutions supplied by OSIL containing 1µMNH_4, 1µMPO_4, 10µMSiO_2 and 10µMNO_3 was run at the start and end of each sample batch.

Water Column Dissolved Oxygen

Water samples were collected from a selected number of depths and CTD casts so that a comprehensive calibration of the CTD oxygen probe could be made. Samples were collected in designated oxygen samples bottles and analysed by Winkler titration using an automatic Radiometer auto-titrator. Replicates samples were taken from a selected number of depths from a selected number of deep CTD casts (See Figure 1)

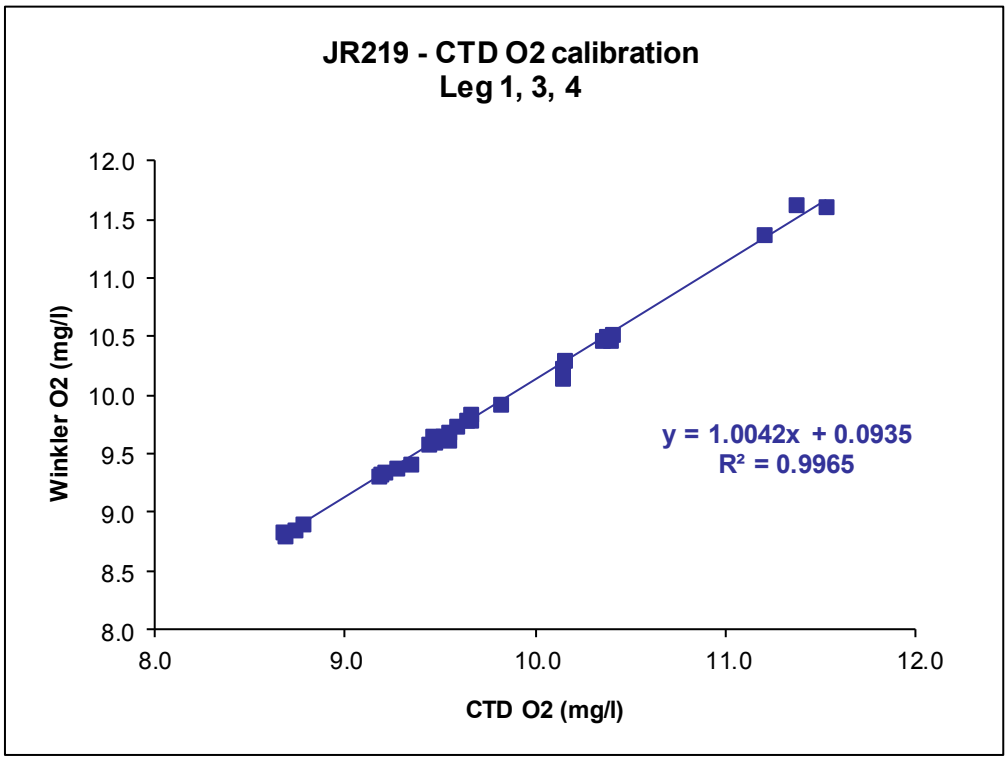


Figure 1. JR219 CTD oxygen calibration

Table 1: CTD nutrients sampled on JR219 leg 1 & 2

Leg	CTD	CTD bottle	Depth (M)		Leg	CTD	CTD bottle	Depth(M)
1	2	22	1		1	12	2	150
		19	5				1	200
		16	20		2	14	12	5
		14	30				9	18
		1	40				8	25
1	4	24	1				7	30
		23	3.5				5	46
		21	5				3	50
		17	9				2	60
		16	18				1	100
		7	23		2	15		200
		4	40					300
		2	80					60
1	6	24	1					400
		23	5					500
		20	6					600
		19	15		2	16	7	5
		8	35				5	25
		5	45				3	50
		2	60				1	100
		1	100		2	17	12	5
1	8	23	2				9	10
		21	5				7	16
		18	6				6	30
		17	10				4	45
		14	20		2	18	6	5
		5	35				5	10
		1	80				4	16
1	10	24	2.5				3	30
		21	5				2	45
		19	6				1	60
		17	16		2	19	11	5
		5	40				7	30
		3	60				3	75
		2	80		2	20/21	10	5
		1	100				9	10
1	12	23	5				8	25
		18	15				6	40
		8	30				5	50
		4	50				4	55
		3	100				3	60

Table 1: cont

Leg	CTD	CTD bottle	Depth (M)		Leg	CTD	CTD bottle	Depth(M)
2	20/21	2	100		2	30	8	20
		1	400				7	25
2	22	12	5				5	30
		10	10				4	50
		8	20				3	100
		7	25				2	300
		5	30				1	400
		3	50		2	31	11	5
		2	100				10	10
		1	400				9	15
2	23	9	3				8	20
		7	15				7	25
		5	30				5	30
		3	60				3	50
2	24	11	5				2	100
		6	25				1	200
		4	50					
		2	100					
		1	300					
2	25	12	5					
		10	10					
		8	15					
		7	20					
		6	30					
		4	60					
2	27	12	5					
		10	25					
		8	50					
		6	100					
		4	200					
		2	300					
2	28	12	1					
		10	5					
		9	10					
		7	11					
		6	13					
		4	25					
		2	30					
		1	36					
2	30	12	5					
		9	10					

Table 2: Ice cores sampled for nutrients JR219 leg 1 & 2

Leg	Date	Core depth (cm)	Station		Leg	Date	Core depth (cm)	Station
2	22/06/10	0-10	1st day trial		2	25/06/10	0-10	K7
		10-20					10-20	
		20-30					20-30	
		30-40					30-40	
		40-50					40-50	
		60-70					50-60	
		70-80					70-80	
		90-100					80-90	
		100-110			2	27/06/10	0-10	K10
		110-bottom					10-20	
		410-bottom					20-30	
2	23/06/10	0-10	K2				30-40	
		10-20					40-50	
		20-30					50-60	
		30-40					60-70	
		40-50					70-80	
		50-60					80-90	
		60-70			2	27/06/10	0-10	K12
		70-80					10-20	
		80-90					20-30	
		90-Bottom					30-40	
2	23/06/10	0-10	K3				40-50	
		10-20					50-60	
		20-30					60-70	
		30-40					70-80	
		40-50			2	29/06/10	0-10	K14
		50-60					10-20	
		60-70					20-30	
		70-80					30-40	
		80-90					40-50	
		90-Bottom					50-60	
2	25/06/10	0-10	K6				60-70	
		10-20					70-80	
		20-30			2	29/06/10	0-10	K15
		30-40					10-20	
		40-50					20-30	
		50-60					30-40	
		70-80					40-50	
		80-90					50-60	
		90-100					60-70	
							70-80	
							80-bottom	

Table 3: Sampled nutrients for deckboard incubations JR219 leg 1 & 2

Leg	Date	Treatment		Leg	Date	Treatment
1	14/06/10	C1 T0				GLU1 TF
		C2 T0				GLU2 TF
		C1 TF				GLU1 + NO3
		C2 TF				GLU1 + NH4
		C1 + NO3				ARA1 TF
		C1 + NH4				ARA2 TF
		GLU1 TF				ARA1 +NH4
		GLU2 TF				ARA1 + NO3
		GLU1 + NO3				AMO1 TF
		GLU1 + NH4				AMO2 TF
		ARA1 TF				NIT1 TF
		ARA2 TF				NIT2 TF
		ARA1 +NH4		1	17/06/10	C1 T0
		ARA1 + NO3				C2 T0
		AMO1 TF				C1 TF
		AMO2 TF				C2 TF
		NIT1 TF				C1 + NO3
		NIT2 TF				C1 + NH4
1	15/06/10	C1 T0		1	17/06/10	GLU1 TF
		C2 T0				GLU2 TF
		C1 TF				GLU1 + NO3
		C2 TF				GLU1 + NH4
		C1 + NO3				ARA1 TF
		C1 + NH4				ARA2 TF
		GLU1 TF				ARA1 +NH4
		GLU2 TF				ARA1 + NO3
		GLU1 + NO3				AMO1 TF
		GLU1 + NH4				AMO2 TF
		ARA1 TF				NIT1 TF
		ARA2 TF				NIT2 TF
		ARA1 +NH4				C1 NO3 silver TF
		ARA1 + NO3				C1 NH4 silver TF
		AMO1 TF		1	18/06/10	C1 T0
		AMO2 TF				C2 T0
		NIT1 TF				C1 TF
		NIT2 TF				C2 TF
1	16/06/10	C1 T0				C1 + NO3
		C2 T0				C1 + NH4
		C1 TF				GLU1 TF
		C2 TF				GLU2 TF
		C1 + NO3				GLU1 + NO3
		C1 + NH4				GLU1 + NH4

Table 3: cont

Leg	Date	Treatment		Leg	Date	Treatment
		ARA1 TF		2	24/06/10	NIT1 TF
		ARA2 TF				NIT2 TF
		ARA1 +NH4				C1 NO3 silver TF
		ARA1 + NO3				C1 NH4 silver TF
		AMO1 TF		2	29/06/10	C1 T0
		AMO2 TF				C2 T0
		NIT1 TF				C1 TF
		NIT2 TF				C2 TF
1	19/06/10	C1 T0				C1 + NO3
		C2 T0				C1 + NH4
		C1 TF				GLU1 TF
		C2 TF				GLU2 TF
		C1 + NO3				GLU1 + NO3
		C1 + NH4				GLU1 + NH4
		GLU1 TF				ARA1 TF
		GLU2 TF				ARA2 TF
		GLU1 + NO3				ARA1 +NH4
		GLU1 + NH4				ARA1 + NO3
1	19/06/10	ARA1 TF		2	29/06/10	AMO1 TF
		ARA2 TF				AMO2 TF
		ARA1 +NH4				NIT1 TF
		ARA1 + NO3				NIT2 TF
		AMO1 TF		2	30/06/10	C1 T0
		AMO2 TF				C2 T0
		NIT1 TF				C1 TF
		NIT2 TF				C2 TF
2	24/06/10	C1 T0				C1 + NO3
		C2 T0				C1 + NH4
		C1 TF				AMO1 TF
		C2 TF				AMO2 TF
		C1 + NO3				NIT1 TF
		C1 + NH4				NIT2 TF
		GLU1 TF				
		GLU2 TF				
		GLU1 + NO3				
		GLU1 + NH4				
		ARA1 TF				
		ARA2 TF				
		ARA1 +NH4				
		ARA1 + NO3				
		AMO1 TF				
		AMO2 TF				

Table 4: Underway nutrients sampled on JR219 leg 1 & 2

Leg	Date	Labelled	Time		Leg	Date	Labelled	Time
1	17/06/10	UW5	15:34		2	21/06/10	UW14	04:03
		UW6	18:35				UW15	06::27
1	18/06/10	UW8	10:46				UW16	09:07
		UW9	13:28		2	26/06/10	UW18	19:31
		UW10	16:27				UI1	10:30
		UW11	19:13				UI3	10:30
1	19/06/10	UW12	09:58		2	27/06/10	UW19	
		UW13	12:25				UW20	83
					2	29/06/10	UW21	Ice station 92

Table 5: CTD nutrients sampled on JR219 leg 3

Leg	**CTD**	**CTD bottle**	**Depth (m)**		**Leg**	**CTD**	**CTD bottle**	**Depth (m)**
3	33	10	5		3	43	23	2
		4	25				22	5
		3	50				17	8
		2	100				16	10
		1	200				13	13
							12	19
3	35	22	1				11	21
		20	3.5				8	25
		16	6.5				7	30
		14	15				4	50
		10	26				2	100
		7	35					
		5	45		3	44	24	5
		2	150				22	15
		1	302				21	21
							17	50
3	37	19	5				16	75
		16	10				14	100
		13	25				13	200
		9	32				9	500
		6	50				8	800
		4	100				4	1000
		2	200				2	1298
							1	1338
3	38	23	5					
		20	15		3	47	21	5
		19	35				17	27
		15	50				3	50
		14	75				2	100
		12	100				1	200
		11	150					
		7	200					
		3	275					
		1	320					

Table 5: cont

Leg	CTD	CTD bottle	Depth (m)		Leg	CTD	CTD bottle	Depth (m)
3	49	19	2		3	56	24	2
		17	5				23	5
		13	9				18	10
		11	14				11	18
		8	16				5	27
		4	29				3	50
		3	50				2	200
		2	100				1	200
		1	200					
					3	57	24	5
3	50	23	5				23	20
		21	20				21	50
		20	30				17	100
		16	50				16	200
		15	75				14	500
		13	100				10	1000
		12	150				9	1500
		8	200				5	2500
		7	250				4	2919
		3	308				2	2959
		2	355					
					3	58	24	5
3	52/53	23	2				23	25
		18	5				21	50
		16	8				20	100
		13	15				18	200
		11	25				14	500
		6	42				13	800
		3	100				9	1000
		1	200				8	1500
							4	2000
3	54	24	5				2	2446
		22	20				1	2486
		18	45					
		17	75		3	59	20	5
		15	100				17	13.5
		14	200				12	20
		10	500				7	30
		9	800				5	40
		5	1000				3	50
		4	1200				2	100
		2	1320				1	200
		1	1361					

Table 6: Sampled nutrients for deckboard algal incubations JR219 leg 3

Leg	Date	Treatment		Leg	Date	Treatment
3	04-07-10	C1T0		3	08-07-10	C1T0
		C2T0				C2 TO
		C1TF				C1 TF
		C2TF				C2 TF
		C1 NO3 TF				C1 NO3 TF
		C1NH4 TF				C1NH4 TF
		GLU1 TF				GLU1 TF
		GLU TF				GLU TF
		GLU NO3 TF				GLU NO3 TF
		GLU NH4 TF				GLU NH4 TF
		ARA1 TF				ARA1 TF
		ARA2 TF				ARA2 TF
		ARA1 NO3 TF				ARA1 NO3 TF
		ARA NH4 TF				ARA NH4 TF
		ANO1 TF				ANO1 TF
		ANO2 TF				ANO2 TF
		NIT1 TF				NIT1 TF
		NIT2 TF				NIT2 TF
						ARA2 NO3
3	06-07-10	C1T0				ARA NH4
		C2T0				
		C1TF		3	10-07-10	C1 TO
		C2TF				C2 TO
		C1 NO3 TF				C1 TF
		C1NH4 TF				C2 TF
		GLU1 TF				C1 NO3 TF
		GLU TF				C1NH4 TF
		GLU NO3 TF				GLU1 TF
		GLU NH4 TF				GLU TF
		ARA1 TF				GLU NO3 TF
		ARA2 TF				GLU NH4 TF
		ARA1 NO3 TF				ARA1 TF
		ARA NH4 TF				ARA2 TF
		ANO1 TF				ARA1 NO3 TF
		ANO2 TF				ARA NH4 TF
		NIT1 TF				ANO1 TF
		NIT2 TF				ANO2 TF
						NIT1 TF
						NIT2 TF

SCIENTIFIC REPORT 6: Particulate and dissolved organic nutrient and photosythetic pigment concentrations

Elaine Mitchell and Sian Lordsmith

Introduction and Objectives

The objective of this study was to measure the concentrations of: (a) dissolved organic carbon, nitrogen and phosphorus (DOC/N/P), (b) particulate organic carbon and nitrogen (POC/N), and (c) photosynthetic pigments including chlorophyll a (Chl a), in surface waters at different sampling stations during the cruise. Samples were collected for post-cruise analysis on return to the UK. Sampling details are shown in the tables at the end of this report.

Approach and Methodology

DOC/N/DOP samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre – cooled in the cold room. The thermos flasks were returned to the cold room where 100ml of sample was removed and placed into 100ml clear nalgene bottles. All equipment and sample bottles used to produce and store these samples were acid washed overnight and thoroughly rinsed in milliQ water before use.
For each sample an ashed GF/F 25mm filter was placed into a re-useable 'swinex' filter holder. Using a clean glass 20ml syringe the sample water was pushed through the filter and collected.
DOP – 30ml of sample was filtered into a 30ml LDPE bottle, capped and labelled.
DOC/N – 20ml of sample was filtered into an ashed glass vial and treated with 60µl of 85% orthophosphoric acid. The vials are then capped using a lid and silicone insert and labelled.
The samples were stored in the cold room at 4°C for post-cruise analysis of DOC, DON and DOP concentrations in the samples.

POC/N samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre–cooled in the cold room. The thermos flask were returned to the cold room where up to 200mls of sample was removed (the volume filtered depends on the condition of the sample). The sample was then placed into a 250ml Nalgene bottle which had, attached to the lid, a re-useable 'swinex' filter holder containing an ashed 13 mm GF/F filter. The Nalgene bottles were then taken through to the main lab where they were inverted and attached to a filtration rig and a pump was used to draw the sample water through the filter. The filter was then removed and placed into a 1.5ml plastic 'Eppindorff' tube and frozen at -80°C for post-cruise analysis of POC/N concentration.

Photosynthetic pigment (Chl a) samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre–cooled in the cold room. The thermos flask were returned to the cold room where up to 500ml of sample were removed (the volume filtered depends on the condition of the sample). The sample was then placed into a 500ml Nalgene bottle which had, attached to the lid, a re-useable 'swinex' filter holder containing a 25 mm GF/F filter. The Nalgene bottles were then taken through to the main lab where they were inverted and attached to a filtration rig and a pump was used to draw the sample water through the filter. A portion of the filtrate was captured in a plastic bottle and used for nutrient analysis (see Scientific Report 5). The filter itself was removed and placed into a 15ml plastic 'Sterilin' tube and frozen at -80°C for post-cruise analysis of Chl.a. and other pigment concentrations by HPLC.

At the Ice station (Leg 2) ice cores were taken and sliced up into 10cm sections, with a maximum of 12 sections per station. These ice cores were melted in the cold room and water samples of up to 200ml were removed (the volume filtered depends on the condition of the sample). The sample

was then placed into a 500ml Nalgene bottle which had, attached to the lid, a re-useable ‘swinex’ filter holder containing a 25 mm GF/F filter. The Nalgene bottles were then taken through to the main lab where they were inverted and attached to a filtration rig and a pump was used to draw the sample water through the filter. A portion of the filtrate was captured in a plastic bottle and used for nutrient analysis (see nutrient analysis Section of the cruise report). The filter itself was removed and placed into a 15ml plastic ‘Sterilin’ tube and frozen at -80°C for post-cruise analysis of Chl.a. and other pigment concentrations by HPLC.

At the ice station there were also water samples containing ‘algal mats’ which were filtered for pigment analysis. A small volume of sample 1-5ml was filtered through a 25 mm GF/F filter held in a millipore glass filtration rig using a vacuum pump to draw the water sample through the filter. The filter itself was removed and placed into a 15ml plastic ‘Sterilin’ tube and frozen at -80°C for post-cruise analysis of Chl.a. and other pigment concentrations by HPLC.

DOC/N from JCR 219 - Depth Profiles

Depth Profiles from CTDs.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 7 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Greenwich Meridian, 78º17N.0ºW, 8 samples

TOTAL SAMPLES = 49

Date	Station Name	CTD	Bottle No.	Depth (m)
24.6.10	Ice Station 1	18	6	5
	Ice Station 1	18	5	10
	Ice Station 1	18	4	16
	Ice Station 1	18	3	30
	Ice Station 1	18	2	45
	Ice Station 1	18	1	60
	Ice Station 1	ice	/	5
	Ice Station 1	ice	/	10
29.6.10	Ice Station 2	28	12	1
	Ice Station 2	28	10	5
	Ice Station 2	28	9	10
	Ice Station 2	28	7	11
	Ice Station 2	28	6	13
	Ice Station 2	28	4	25
	Ice Station 2	28	2	30
	Ice Station 2	28	1	36
	Ice Station 2	ice	/	5
	Ice Station 2	ice	/	10
4.7.10	Kongsfjord 3	33	11	5 A
	Kongsfjord 3	33	13	5 B
	Kongsfjord 3	33	14	5 C
	Kongsfjord 3	35	19	3.5
	Kongsfjord 3	35	13	15
	Kongsfjord 3	35	9	26
	Kongsfjord 3	35	4	45
6.7.10	Kongsford 4	42	6	5 A
	Kongsford 4	42	7	5 B
	Kongsford 4	42	8	5 C
	Kongsford 4	43	20	5
	Kongsford 4	43	16	10
	Kongsford 4	43	11	22
	Kongsford 4	43	7	30
	Kongsford 4	43	4	50
8.7.10	Greenland S.	48	10	5 A
	Greenland S.	48	11	5 B
	Greenland S.	48	12	5 C
	Greenland S.	49	20	2
	Greenland S.	49	15	9
	Greenland S.	49	11	14
	Greenland S.	49	6	29
	Greenland S.	49	3	50
10.7.10	Greenwich M.	55	10	5 A
	Greenwich M.	55	11	5 B
	Greenwich M.	55	12	5 C
	Greenwich M.	56	21	5
	Greenwich M.	56	19	10
	Greenwich M.	56	16	15
	Greenwich M.	56	13	18
	Greenwich M.	56	7	25

DOP from JCR 219 -Depth Profiles

Depth Profiles from CTDs.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 7 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Grenwich Meridian, 78º17N.0ºW, 8 samples

TOTAL SAMPLES = 49

Date	Station Name	CTD	Bottle No.	Depth (m)
24.6.10	Ice Station 1	18	6	5
	Ice Station 1	18	5	10
	Ice Station 1	18	4	16
	Ice Station 1	18	3	30
	Ice Station 1	18	2	45
	Ice Station 1	18	1	60
	Ice Station 1	ice	/	5
	Ice Station 1	ice	/	10
29.6.10	Ice Station 2	28	12	1
	Ice Station 2	28	10	5
	Ice Station 2	28	9	10
	Ice Station 2	28	7	11
	Ice Station 2	28	6	13
	Ice Station 2	28	4	25
	Ice Station 2	28	2	30
	Ice Station 2	28	1	36
	Ice Station 2	ice	/	5
	Ice Station 2	ice	/	10
4.7.10	Kongsfjord 3	33	11	5 A
	Kongsfjord 3	33	13	5 B
	Kongsfjord 3	33	14	5 C
	Kongsfjord 3	35	19	3.5
	Kongsfjord 3	35	13	15
	Kongsfjord 3	35	9	26
	Kongsfjord 3	35	4	45
6.7.10	Kongsford 4	42	6	5 A
	Kongsford 4	42	7	5 B
	Kongsford 4	42	8	5 C
	Kongsford 4	43	20	5
	Kongsford 4	43	16	10
	Kongsford 4	43	11	22
	Kongsford 4	43	7	30
	Kongsford 4	43	4	50
8.7.10	Greenland S.	48	10	5 A
	Greenland S.	48	11	5 B
	Greenland S.	48	12	5 C
	Greenland S.	49	20	2
	Greenland S.	49	15	9
	Greenland S.	49	11	14
	Greenland S.	49	6	29
	Greenland S.	49	3	50
10.7.10	Greenwich M.	55	10	5 A
	Greenwich M.	55	11	5 B
	Greenwich M.	55	12	5 C
	Greenwich M.	56	21	5
	Greenwich M.	56	19	10
	Greenwich M.	56	16	15
	Greenwich M.	56	13	18
	Greenwich M.	56	7	25

POC from JCR 219 - Depth Profiles

Depth Profiles from CTDs.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 7 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Grenwich Meridian, 78º17N.0ºW, 8 samples

TOTAL SAMPLES = 49

Date	Station Name	CTD	Bottle No.	Depth (m)
24.6.10	Ice Station 1	18	6	5
	Ice Station 1	18	5	10
	Ice Station 1	18	4	16
	Ice Station 1	18	3	30
	Ice Station 1	18	2	45
	Ice Station 1	18	1	60
	Ice Station 1	ice	/	5
	Ice Station 1	ice	/	10
29.6.10	Ice Station 2	28	12	1
	Ice Station 2	28	10	5
	Ice Station 2	28	9	10
	Ice Station 2	28	7	11
	Ice Station 2	28	6	13
	Ice Station 2	28	4	25
	Ice Station 2	28	2	30
	Ice Station 2	28	1	36
	Ice Station 2	ice	/	5
	Ice Station 2	ice	/	10
4.7.10	Kongsfjord 3	33	11	5 A
	Kongsfjord 3	33	13	5 B
	Kongsfjord 3	33	14	5 C
	Kongsfjord 3	35	19	3.5
	Kongsfjord 3	35	13	15
	Kongsfjord 3	35	9	26
	Kongsfjord 3	35	4	45
6.7.10	Kongsford 4	42	6	5 A
	Kongsford 4	42	7	5 B
	Kongsford 4	42	8	5 C
	Kongsford 4	43	20	5
	Kongsford 4	43	16	10
	Kongsford 4	43	11	22
	Kongsford 4	43	7	30
	Kongsford 4	43	4	50
8.7.10	Greenland S.	48	10	5 A
	Greenland S.	48	11	5 B
	Greenland S.	48	12	5 C
	Greenland S.	49	20	2
	Greenland S.	49	15	9
	Greenland S.	49	11	14
	Greenland S.	49	6	29
	Greenland S.	49	3	50
10.7.10	Greenwich M.	55	10	5 A
	Greenwich M.	55	11	5 B
	Greenwich M.	55	12	5 C
	Greenwich M.	56	21	5
	Greenwich M.	56	19	10
	Greenwich M.	56	16	15
	Greenwich M.	56	13	18
	Greenwich M.	56	7	25

Chlorophyll-a from JCR 219 - Depth Profiles

Depth Profiles from CTDs.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 9 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Grenwich Meridian, 78º17N.0ºW, 8 samples

TOTAL SAMPLES = 51

Date	Station Name	CTD	Bottle No.	Depth (m)	Chlora A Vol. Filtered (mls)	POC Vol. Filtered (mls)
24.6.10	Ice Station 1	18	6	5	300	200
	Ice Station 1	18	5	10	300	200
	Ice Station 1	18	4	16	300	200
	Ice Station 1	18	3	30	300	200
	Ice Station 1	18	2	45	300	200
	Ice Station 1	18	1	60	300	200
	Ice Station 1	ice	/	5	300	200
	Ice Station 1	ice	/	10	300	200
29.6.10	Ice Station 2	28	12	1	300	200
	Ice Station 2	28	10	5	300	200
	Ice Station 2	28	9	10	300	200
	Ice Station 2	28	7	11	300	200
	Ice Station 2	28	6	13	300	200
	Ice Station 2	28	4	25	300	200
	Ice Station 2	28	2	30	300	200
	Ice Station 2	28	1	36	300	200
	Ice Station 2	ice	/	5	300	200
	Ice Station 2	ice	/	10	300	200
4.7.10	Kongsfjord 3	33	11	5 A	300	200
	Kongsfjord 3	33	13	5 B	300	200
	Kongsfjord 3	33	14	5 C	300	200
	Kongsfjord 3	35	22	1 (FAO Alexy)	300	X
	Kongsfjord 3	35	20	3.5	300	200
	Kongsfjord 3	35	16	6.5(FAO Alexy)	300	X
	Kongsfjord 3	35	14	15	300	200
	Kongsfjord 3	35	10	26	300	200
	Kongsfjord 3	35	5	45	300	200
6.7.10	Kongsford 4	42	6	5 A	300	200
	Kongsford 4	42	7	5 B	300	200
	Kongsford 4	42	8	5 C	300	200
	Kongsford 4	43	20	5	300	200
	Kongsford 4	43	16	10	300	200
	Kongsford 4	43	11	22	300	200
	Kongsford 4	43	7	30	300	200
	Kongsford 4	43	4	50	300	200
8.7.10	Greenland S.	48	10	5 A	X	100
	Greenland S.	48	11	5 B	X	100
	Greenland S.	48	12	5 C	X	100
	Greenland S.	49	21	2	X	100
	Greenland S.	49	16	9	X	100
	Greenland S.	49	11	14	X	100
	Greenland S.	49	7	29	X	100
	Greenland S.	49	3	50	X	100
10.7.10	Greenwich M.	55	10	5 A	300	200
	Greenwich M.	55	11	5 B	300	200
	Greenwich M.	55	12	5 C	300	200
	Greenwich M.	56	22	5	300	200
	Greenwich M.	56	10	10	300	200
	Greenwich M.	56	16	15	300	200
	Greenwich M.	56	14	18	300	200
	Greenwich M.	56	8	25	300	200

Chlorophyll-a from JCR 219 – Sea-ice samples

TOTAL SAMPLES = 85

Date	Core	Depth	Volume Filtered (mls)	Notes
22.6.10		0-10	450	Microwaved?
		10-20	450	
		20-30	450	
		30-40	450	
		40-50	450	
		50-60	450	
		60-70	450	
		70-80	450	
		80-90	450	
		90-100	450	
		100-110	450	
		110-bottom	400	
23.6.10	K2	0-10	200	Filtered on 24th after melting overnight
	K2	10-20	200	
	K2	20-30	200	
	K2	30-40	200	
	K2	40-50	200	
	K2	50-60	100	
	K2	60-70	200	
	K2	70-80	200	
	K2	80-90	100	
	K2	90-bottom	100	
	K3	0-10	200	
	K3	10-20	200	
	K3	20-30	200	
	K3	30-40	200	
	K3	40-50	200	
	K3	50-60	100	
	K3	60-70	200	
	K3	70-80	200	
	K3	80-90	100	
	K3	90-bottom	70	
26.6.10	K6	0-10	200	
	K6	10-20	200	
	K6	20-30	200	
	K6	30-40	200	
	K6	40-50	200	
	K6	50-60	200	
	K6	60-70	200	
	K6	70-80	200	
	K6	80-90	100	
	K6	90-100	100	
	K7	0-10	200	
	K7	10-20	200	
	K7	20-30	200	
	K7	30-40	200	
	K7	40-50	200	
	K7	50-60	100	
	K7	60-70	200	
	K7	70-80	100	
	K7	80-90	100	

Date	Core	Depth	Volume Filtered (mls)	Notes
28.6.10	K10	0-10	200	And 7x Chlora A algal mats in duplicate.
	K10	10-20	200	
	K10	20-30	200	
	K10	30-40	200	
	K10	40-50	200	
	K10	50-60	200	
	K10	60-70	200	
	K10	70-80	100	
	K10	80-90	100	
	K12	0-10	200	
	K12	10-20	200	
	K12	20-30	200	
	K12	30-40	200	
	K12	40-50	100	
	K12	50-60	200	
	K12	60-70	100	
	K12	70-80	100	
30.6.10	K14	0-10	200	And 7x Chlora A algal mats in duplicate.
	K14	10-20	200	
	K14	20-30	200	
	K14	30-40	200	
	K14	40-50	100	
	K14	50-60	200	
	K14	60-70	200	
	K14	70-80	200	
	K15	0-10	200	
	K15	10-20	200	
	K15	20-30	200	
	K15	30-40	200	
	K15	40-50	100	
	K15	50-60	200	
	K15	60-70	200	
	K15	70-80	200	
	K15	80-bottom	100	

SCIENTIFIC REPORT 7: Bio-optical observations

Alexey Pavlov and Daniel Vogedes

1.1 Introduction

Bio-optical properties of sea water are of vital importance for many processes, such as underwater light regime, spectral quality and quantity of underwater irradiance. Information on the amount and optical properties of colored dissolved organic matter (CDOM) and particles, complemented by direct spectral optical observations, provides a basis for comprehensive description of bio-optical state of the sea surface layer. This set of observations was carried out in the central part of the Fram Strait. Depths for the samples were chosen to correspond with those of chlorophyll and other biological sampling. A full list of optical samples and observations taken on board during Leg 3 is shown in Table 1.

1.2 Method

Direct measurements of spectral down-welling irradiance
Manual optical measurements were done at 8 stations. Measurements were done preferably from the sunny side of the ship. To perform observations, a side crane was used every time allowing the sensor to be positioned away from the ship (approx. 4 m) to minimize shadowing effect. Underwater profiles were obtained with 1 or 2 meters vertical resolution. The maximum depth of readings was about 39-41 m depending on a cable inclination. An additional air sensor was used all the time as a surface reference.

Sampling for CDOM (Colored Dissolved Organic Matter)
CDOM samples were collected in order to estimate the contribution of the dissolved organic matter fraction to the light absorption. Samples for CDOM were collected at 7 stations (Table 1). Samples were taken from Niskin bottles. Sampling was undertaken using plastic syringes. Samples were then filtered through double 0.8 / 0.2 µm syringe membrane filters. Filtered samples were placed in glass amber vials and kept at +4 degrees Celsius in a fridge. For CDOM sampling, special precautions were applied to minimize contamination risk (use of plastic laboratory gloves, use of acid bath for storing and rinsing syringes between stations). After the cruise, samples were transported to the Norwegian Polar Institute, Tromso and were analyzed using a spectrophotometric technique.

Sampling for suspended particles
Samples for suspended matter were collected at 7 stations in order to estimate spectral properties of the particles in the area under study. After collection from Niskin bottles, samples were filtered through standard 25 mm GF/F filters. Filters were placed into Petri dishes and were frozen immediately at -80 ^{o}C in a bio freezer until laboratory analysis, which was performed on a spectrophotometer with integrating sphere at the Aarhus University, Denmark.

Table 1: Samples for CDOM, Suspended particles and Spectral optical measurements

Date	Leg	CTD	Depth	Depth (m)	Bottle	CDOM	Particles	Vol. filtered water, ml	Spectral Optical measurements
4/07/2010	3	35	1	1	23	+	+	1000	0 m – 41 m
			2	6.5	16	+	+	1200	
			3	15	15	+	+	1000	
			4	26	11	+	+	1000	
			5	45	6	+	+	1000	
			6	150	2	+	-	-	
			7	300	1	+	-	-	
5/07/2010	3	37	-	-	-	-	-	-	0 m – 40 m
6/07/2010	3	43	1	5	22	+	+	800	0 m – 40 m
			2	10	16	+	+	700	
			3	22	11	+	+	500	
			4	30	7	+	+	900	
			5	50	4	+	+	1000	
			6	100	2	+	-	-	
			7	200	1	+	-	-	
7/07/2010	3	47	1	5	21	+	+	950	0 m – 40 m
			2	15	19	+	+	600	
			3	27	17	+	+	800	
			4	38	8	+	+	1000	
			5	50	3	+	+	1000	
			6	100	2	+	-	-	
			7	200	1	+	-	-	

Date	Leg	CTD	Depth	Depth (M)	Bottle	CDOM	Particles	Vol. filtered water, ml	Spectral Optical measurements
8/07/2010	3	49	1	2	21	+	+	875	0 m – 39 m
			2	9	16	+	+	900	
			3	13	11	+	+	950	
			4	29	7	+	+	1000	
			5	50	3	+	+	1000	
			6	100	2	+	-	-	
			7	200	1	+	-	-	
9/07/2010	3	53	1	5	17	+	+	1200	0 m – 41 m
			2	15	14	+	+	1000	
			3	25	11	+	+	1200	
			4	42	8	+	+	1200	
			5	50	5	+	+	1200	
			6	100	4	+	-	-	
			7	200	2	+	-	-	
10/07/2010	3	56	1	5	22	+	+	900	0 m – 40 m
			2	10	19	+	+	300	
			3	18	14	+	+	600	
			4	25	8	+	+	1200	
			5	50	3	+	+	1100	
			6	100	2	+	-	-	
			7	200	1	+	-	-	
11/07/2010	3	59	1	5	20	+	+	800	0 m – 29 m
			2	13.5	17	+	+	700	
			3	20	12	+	+	1000	
			4	30	7	+	+	1100	
			5	50	3	+	+	1500	
			6	100	2	+	-	-	
			7	200	1	+	-	-	

SCIENTIFIC REPORT 8: Assessment of the optical and photosynthetic properties of sub-arctic and arctic phytoplankton

Heather Bouman and Thomas Jackson

1. Rationale and Objectives

Our aim was to examine the spatial and temporal variability phytoplankton community structure in sub-arctic and arctic waters. Gross community structure was examined through the use of marker pigments obtained by High Performance Liquid Chromatography (HPLC) analysis of filtered samples. Photosynthesis-irradiance (*P-E*) experiments were conducted to assess the rate of carbon uptake across a range of light intensities. The two parameters derived from these experiments may be used to estimate primary production from remotely sensed images of sea-surface chlorophyll. We also collected filtered samples to determine the absorptive properties of phytoplankton to compare the light-harvesting capability of different communities (pelagic versus ice algae).

2. Fluorometric Chlorophyll-a

Objectives
To capture the vertical structure of chlorophyll-a concentration within the surface ocean, measurements of chlorophyll-a were conducted on discrete water samples along the cruise transect. Vertical profiles of chlorophyll-a will be used to calibrate *in vivo* fluorescence profiles made using an *in situ* fluorometer mounted on the CTD package.

Sampling Protocol
Seawater samples were collected in large (9-20 litre) Nalgene carboys. Each carboy was rinsed three times with sample water and then filled. Triplicate samples of 100 ml were filtered through 25 mm GF/F filters. The filters are placed in 10 ml of 90% acetone in 20ml glass scintillation vials and stored overnight at -20°C to allow pigment to extract.

Samples collected
A complete list of the samples analysed on the ICE CHASER cruise can be found in Table 1.

Sample analysis
The samples were analysed onboard using a Trilogy fluorometer (Turner Designs). Prior to the cruise, the fluorometer was pre-calibrated using spinach chlorophyll-a standard (Sigma). The pigment extract is measured both before and after acidification according to be method of Holm-Hansen et al. (1965).

Preliminary results
Chlorophyll-a concentrations showed significant spatial and temporal variation. At the ice station, surface concentrations varied from 0.11 mg m^{-3} under sea ice, to 6.94 mg m^{-3} at 20m on June 29. At most sampling stations, a subsurface chlorophyll maximum was observed (Fig. 1). Vertical profiles also varied in terms of their shape, with a large subsurface maximum present under stratified bloom conditions, and relatively uniform concentrations observed during the first few days of sampling at the ice station.

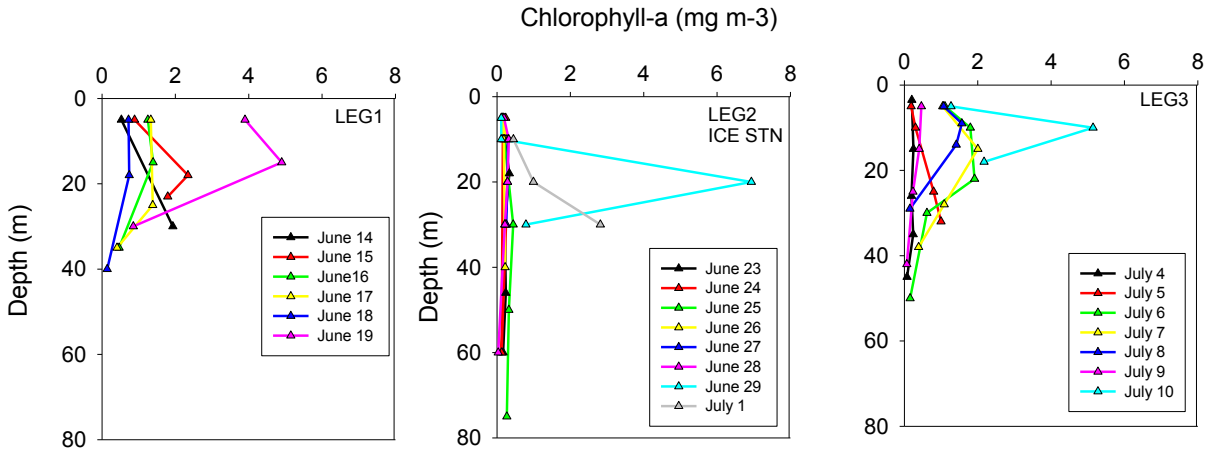


Fig. 1 Vertical profiles of chlorophyll-a concentration measured onboard using the fluorometric method.

3. High Performance Liquid Chromatography Analysis of Algal Pigments

Objectives

Phytoplankton pigments can be used as chemotaxonomic markers of key phytoplankton taxonomic groups involved in biogeochemical cycles. These pigments also jointly contribute to the absorptive properties of marine phytoplankton and thus can assist in analysing sources of spectral variation in the shape of the phytoplankton absorption spectra. Thus to examine the spatial and temporal distribution of marine phytoplankton groups and their optical properties seawater samples were collected at 3-6 depths within the photic zone.

Sampling Protocol

Between 500 ml and 1 litre of seawater was subsampled from large (9-20 litre) Nalgene carboys and filtered through 25 mm GF/F filters. The filters were placed in 2 ml cryovials and flash frozen in liquid nitrogen. Filters were then transferred to a -80°C freezer for long-term storage.

Samples Collected

Sampling depths coincided with those selected for fluorometric, absorption and photophysiological experiments (FRRF and photosynthesis-irradiance response). A detailed list of samples collected may be found in Table 1.

Sample analysis

Frozen samples will be transported back to the Plymouth Marine Laboratory in a dry shipper and stored at -80°C until analysed. Pigment extracts will be analysed using a reverse-phase HPLC column (Hypersil 3 mm C8 MOS-2) using Thermo-separations and Agilent instruments (Barlow et al., 1997). The instrument is calibrated using pigment standards (DHI Water and Environment, Denmark) on an annual basis.

Phytoplankton pigments are extracted in 2 to 5 m1 90% acetone by ultrasonication and centrifugation. Extracts were loaded into a Thermo Separations autosampler (capable of cooling pigment extracts to 2°C) and mixed with 1 M ammonium acetate (1:1, v/v) prior to injection onto a Shimadzu HPLC system (dual LC-GB pumps; SCL-6B controller).

The column is a 3 pm Shandon Hypersila MOS2 (endcapped), C-8 (6.2 to 6.8% carbon), 120 A pore size, 100 X 4.6 mm and maintained at 30°C. Pigments are separated at a flow rate of 1 m1 min-1 by a linear gradient programmed as follows (minutes; % solvent A; '% solvent B): (0; 75; 25),(1; 50; 50), (20; 30; 70), (25; 0; l00), (32; 0; 100). Pigments are detected by absorbance at 440 nm using a Shimadzu SPD-6AV spectrophotometric detector. Pigments are identified by retention

time and on-line visible spectroscopy using a Waters 990 diode array detector.

Chemotaxonomic pigment concentrations will be compared with cell counts obtained by conventional microscopy and flow cytometry.

4. Absorption by Marine Particulates

Objectives
Samples were collected to examine the absorptive properties of phytoplankton cells. These data will be used to derive information on the absorptive efficiency of the natural phytoplankton assemblage, which in turn will aid in the interpretation of the photochemical signal obtained by Fast Repetition Rate (FRR) Fluorometry and to obtain quantum yields of phytoplankton from photosynthesis-irradiance experiments. Another motivation is to test and refine algorithms used to detect the concentration of chlorophyll-a and the presence of algal functional types by ocean-colour remote sensing.

Sampling protocol
Between 500 ml and 1 litre of seawater was subsampled from large (9-20 litre) Nalgene carboys and filtered through 25 mm GF/F filters. The filters were placed in 2ml cryovials and flash frozen in liquid nitrogen. Care was taken to avoid creases or folds in the filter by rolling the filter with the particle laden side facing inwards. Filters were then transferred to a -80°C freezer for long-term storage.

Samples Collected
A detailed list of samples collected may be found in Table 1.

Sample analysis
Frozen samples will be transported back to Oxford in a dry shipper and stored at -80°C until analysed. Filters will be scanned using a Shimadzu UV-2550 spectrophotometer equipped with an integrating sphere over the visible range (350-750 nm). A pre-wetted blank filter is placed in the "Sample" holder and scanned against air and save the blank spectrum. The blank filter is then removed and placed in the "Reference" holder and place the sample filter in the "Sample" holder ensuring proper hydration. The sample OD spectrum is then measured from 350-750 nm.

Replace sample and blank filters on a filtration system. Add ~10 ml of 100% methanol to filters (sample and blank) by gently pouring down the side of the funnel to minimise re-suspension. Let stand for 1 min. then filter through. Close valve and add another 10 – 15 ml methanol and let stand for ~1 hour. Cover funnel with foil to minimise contamination during extraction. Draw methanol and dissolved pigments through. Rinse sides of funnel with methanol, draw though again, then rinse twice with ~ 20 ml 0.2 □m filtered seawater. Pigment extraction is complete when the 675 nm chl-a absorption peak is not present in OD spectrum. If present, repeat with successive short (10 min) extractions.

Measure OD spectrum of the blank and the de-pigmented samples on the spectrophotometer, as before (from 350 to 750 nm).

To compute particle absorption $a_p(\lambda)$ in suspension from spectrophotometric OD_{fp} measurements on a filter, it is necessary to adjust the optical pathlength. This includes substituting the geometric optical path length of the particles in suspension, and a scaling factor β, to account for pathlength amplification due to scattering by the filter. The geometric absorption pathlength is given by:

$$l_s = \frac{V}{S}$$

where V is the volume of water filtered (m^3) and S is the clearance area of the filter (mm^2) calculated from the diameter of the coloured part of the filter containing particles.

The absorption coefficient of filtered particles must be corrected for pathlength amplification and the equivalent absorption coefficient in m^{-1} in suspension is computed as:

$$a_p(\lambda) = \frac{2.303S}{\beta V}[\mathrm{OD}_{fp}(\lambda) - \mathrm{OD}_{bf} - \mathrm{OD}_{750}]$$

where 2.3 is the conversion factor for transforming decimal logarithms to natural logarithms, $\mathrm{OD}_{fp}(\lambda)$ is the measured optical density of the sample filter (mean of 10 measurements), $\mathrm{OD}_{bf}(\lambda)$ is the optical density of the blank filter (mean of 10 measurements), OD_{750} compensates for baseline offsets and β is a quadratic function used to correct for pathlength increases due to multiple scattering in the filter. We use the quadratic equation proposed by Hoepffner and Sathyendranath (1992):

$$\beta = 0.31[\mathrm{OD}_{pf}(\lambda)] + 0.57[\mathrm{OD}_{pf}(\lambda)]^2$$

The de-pigmented particle absorption coefficients, $a_d(\lambda)$, is calculated in the same way. The spectral absorption coefficient for phytoplankton, $a_{\phi}(\lambda)$, can then be obtained by subtracting the absorption coefficients of detritus $a_d(\lambda)$, from the total particulate absorption spectrum, $a_p(\lambda)$.

$$a_{\phi}(\lambda) = a_p(\lambda) - a_d(\lambda)$$

Pigment specific absorption coefficients of phytoplankton can then be calculated by dividing absorption by chlorophyll-*a* concentration (Turner or HPLC).

5. Photosynthesis-irradiance (PE) experiments

Objectives

Seawater samples were collected to determine the photosynthetic response of sub-arctic and arctic phytoplankton assemblages. These data will be used to derive information on the photosynthetic efficiency of the natural phytoplankton community, which in turn will be used to derive parameters used in remotely-sensed models of marine primary production

Sampling protocol

PI experiments were conducted in a custom-built incubator holding 15 60ml polycarbonate bottles. The incubator window was covered with a Lee ¼ CT blue filter to diminish the spectral dependency of the light source (2 x 35 W halogen bulbs).

Samples were maintained at in situ temperatures throughout the incubation period using a circulating water bath. At stations were temperatures were below 4°C, ethylene glycol was added to the water bath to prevent freezing.

Each of the 60ml polycarbonate bottles are rinsed three times with sample water then filled to the shoulder in a low-light environment. 200 µl of ^{14}C stock sodium bicarbonate solution is added to each of the 15 bottles (4 µCi added per bottle). The bottles were placed into the incubator and diffusing filters were spaced between bottles to obtain a gradient of light levels. A single dark bottle was also placed in the incubator to measure ^{14}C incorporation in the dark. Bottles are incubated for between 1.5 and 2 hours under the light gradient at ambient temperature.

The vial containing the ^{14}C sodium bicarbonate solution is stored in the refrigerator until the next experiment is conducted.

200µl of stock solution was pipetted into a scintillation vial containing 100µl of hyamine hydroxide. 5 ml of scintillation cocktail (Optima Gold or equivalent) were added, the cap is replaced and the solution is mixed well. Counts obtained from these vials are estimates of the activity added in disintegrations per minute (DPM).

At the end of the incubation period, samples were filtered through GF/F filters at a vacuum pressure of 200 mm Hg. Filters are removed from the towers and carefully placed in order on a porcelain plate in a glass dessicator (in a fumehood) containing 200 – 300 ml of concentrated hydrochloric acid (HCl). The filters remain in the dessicator for 12 hours and then placed individually into numbered plastic scintillation vials. Scintillation cocktail are added to each vial and were counted in the scintillation counter onboard the ship.

The light intensity inside of the incubator is measured using a Biospherical QSL2101 quantum scalar irradiance meter.

Samples Collected
A detailed list of samples collected may be found in Table 1.

Sample analysis
The biomass-normalised primary production, P^B, at each light level is calculated from the formula:

$$P^B = ((DPM_{light} - DPM_{dark}) \times 12000 \times ALK \times 1.05) / ((DPM_{add} \times 500) \times N \times Chl)$$

Where DPM_{light} is the counts in the light bottle, DPM_{dark} is the counts in the dark bottle, ALK is the carbonate alkalinity (Meq), 12000 converts Meq to µgC, 1.05 is the isotope discrimination factor, DPM_{add} is the counts from the flask inoculated with 10 µl of ^{14}C, 500 converts counts to total counts for the DPM_{add} flask, N is the duration of the incubation in hours and Chl is the chlorophyll concentration in µg l^{-1}. The units for P^B is µg C l^{-1} h^{-1} (µg Chl)$^{-1}$ or mg C m^{-3} h^{-1} (mg Chl)$^{-1}$

Preliminary results
Photosynthetic irradiance response curves showed variation in both the maximum rate of photosynthesis at saturating irradiance (assimilation number) and the initial slope of the curve (α^B) (Fig. 2). To determine the principal biotic and abiotic factors controlling these parameters we will conduct multivariate statistical analyses. Our aim is to determine a suite of parameters that can be used to estimate primary production in the Norwegian and Greenland Seas using ocean colour radiometry.

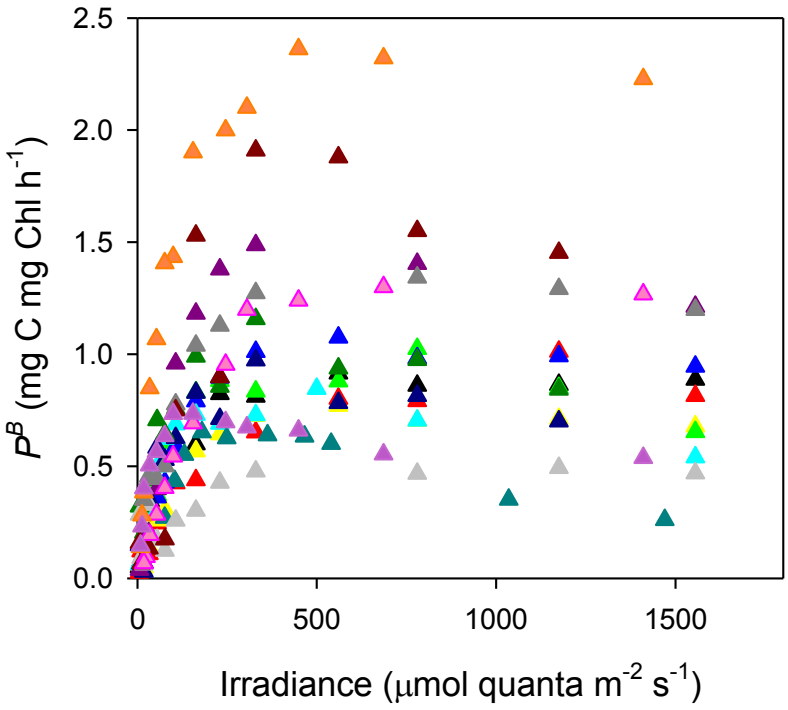


Fig 2. Photosyntheisis-irradiance response curves for experiments conducted on the ice camp (June 26-July 1, 2010)

Table 1: List of samples collected for analysis of phytoplankton photosynthesis, pigment concentration and absorption. PE_start and PE_end note the start and stop times of the photosynthesis-irradiance incubation. Volumes of samples filtered for High Performance Liquid Chromatography (HPLC) analysis of algal pigments, absorption by phytoplankton and other particulates (Abs) and fluorometric analysis of chlorophyll-a concentration (Turner) in millilitres is also shown.

Leg	Date	Station	Event	CTD	Time GMT	Lat	Long	CTD/Ice	Depth	PE_start	PE_end	HPLC	Abs	Turner
1	14/06/2010	North Sea	2	2	09:04	56°24.730' N	001°18.849' E	CTD	5	10:57	12:38	1000	1000	100x3
1	14/06/2010	North Sea	2	2	09:04	56°24.730' N	001°18.849' E	CTD	30	10:28	12:00	1000	1000	100x3
1	15/06/2010	South Norwegian Sea	4	4	10:03	60°44.588' N	002°43.670' E	CTD	5	11:45	13:16	1000	500	100x3
1	15/06/2010	South Norwegian Sea	4	4	10:03	60°44.588' N	002°43.670' E	CTD	18	12:04	01:46	500	500	100x3
1	15/06/2010	South Norwegian Sea	4	4	10:03	60°44.588' N	002°43.670' E	CTD	23	12:25	14:20	500	500	100x3
1	16/06/2010	Central Norwegian Sea	8	6	08:23	65°02.420' N	004°24.020' E	CTD	5	10:07	11:37	500	500	100x3
1	16/06/2010	Central Norwegian Sea	8	6	08:23	65°02.420' N	004°24.020' E	CTD	15	10:26	12:03	500	500	100x3
1	16/06/2010	Central Norwegian Sea	8	6	08:23	65°02.420' N	004°24.020' E	CTD	35	10:43	12:28	500	500	100x3
1	17/06/2010	North Norwegian Sea	12	8	07:20	69°20.459' N	006°22.420' E	CTD	5	08:57	10:27	800	500	100x3
1	17/06/2010	North Norwegian Sea	12	8	07:20	69°20.459' N	006°22.420' E	CTD	25	09:25	11:06	800	500	100x3
1	17/06/2010	North Norwegian Sea	12	8	07:20	69°20.459' N	006°22.420' E	CTD	35	09:50	11:30	1000	500	100x3
1	18/06/2010	South Greenland Sea	18	10	07:43	72°45.213' N	008°15.930' E	CTD	5	09:08	10:39	800	500	100x3
1	18/06/2010	South Greenland Sea	18	10	07:43	72°45.213' N	008°15.930' E	CTD	18	09:28	11:08	800	500	100x3
1	18/06/2010	South Greenland Sea	18	10	07:43	72°45.213' N	008°15.930' E	CTD	40	09:47	11:31	1000	800	100x3
1	19/06/2010	East Greenland Sea	23	12	07:42	77°09.421' N	011°17.530' E	CTD	5	09:12	10:42	400	430	100x3
1	19/06/2010	East Greenland Sea	23	12	07:42	77°09.421' N	011°17.530' E	CTD	15	09:30	11:10	500	450	100x3
1	19/06/2010	East Greenland Sea	23	12	07:42	77°09.421' N	011°17.530' E	CTD	30	09:52	11:31	700	500	100x3
2	23/06/2010	Ice Station	25	14	12:42	80°44.480' N	004°39.050' E	CTD	5			1000	500	100x3
2	23/06/2010	Ice Station	25	14	12:42	80°44.480' N	004°39.050' E	CTD	18	16:10	17:40	1000	500	100x3
2	23/06/2010	Ice Station	25	14	12:42	80°44.480' N	004°39.050' E	CTD	30			1000	500	100x3
2	23/06/2010	Ice Station	25	14	12:42	80°44.480' N	004°39.050' E	CTD	46			1000	500	100x3
2	23/06/2010	Ice Station	25	14	12:42	80°44.480' N	004°39.050' E	CTD	60			1000	500	100x3
2	24/06/2010	Ice Station	32	17	09:25	80°41.499' N	004°19.086' E	CTD	5					
2	24/06/2010	Under Ice	N/A	N/A	10:00	80°41.499' N	004°19.086' E	Ice	5					
2	25/06/2010	Ice Station	35	19	08:40	80°35.100' N	004°18.290' E	CTD	5			1000	500	100x3
2	25/06/2010	Ice Station	35	19	08:40	80°35.100' N	004°18.290' E	CTD	10			1000	500	100x3
2	25/06/2010	Ice Station	35	19	08:40	80°35.100' N	004°18.290' E	CTD	30			1000	500	100x3

Leg	Date	Station	Event	CTD	Time GMT	Lat	Long	CTD/Ice	Depth	PE_start	PE_end	HPLC	Abs	Turner
2	25/06/2010	Ice Station	35	19	08:40	80°35.100' N	004°18.290' E	CTD	50			1000	500	100x3
2	25/06/2010	Ice Station	35	19	08:40	80°35.100' N	004°18.290' E	CTD	75			1000	500	100x3
2	26/06/2010	Ice Station	37	20	08:45	80°31.090' N	004°09.870' E	CTD	5	14:30	16:00	980	500	100x3
2	26/06/2010	Ice Station	37	20	08:45	80°31.090' N	004°09.870' E	CTD	10			1000	500	100x3
2	26/06/2010	Ice Station	37	20	08:45	80°31.090' N	004°09.870' E	ICE	5	15:00	16:30	980	500	100x3
2	26/06/2010	Ice Station	37	20	08:45	80°31.090' N	004°09.870' E	ICE	10			1000	500	100x3
2	26/06/2010	Ice Station	37	20	08:45	80°31.090' N	004°09.870' E	CTD	40			1000	500	100x3
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	0-10			300	200	
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	10-20			275	200	
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	20-30			360	200	
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	30-40			354	200	
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	40-50			300	200	
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	50-60			500		
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	60-70			500		
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	70-80			500		
2	26/06/2010	Ice Core	N/A	N/A	M	80°31.090' N	004°09.870' E	Core	80-90			770		
2	27/06/2010	Ice Station	39	22	07:40	80°27.318' N	003°43.037' E	CTD	10			1000	500	100x3
2	27/06/2010	Ice Station	39	22	07:40	80°27.318' N	003°43.037' E	CTD	20	11:52	13:22	1000	500	100x3
2	27/06/2010	Ice Station	39	22	07:40	80°27.318' N	003°43.037' E	CTD	30	12:20	13:50	1000	500	100x3
2	28/06/2010	Ice Station	44	25	09:04	80°18.980' N	003°19.387' E	CTD	5	13:05	14:35	1000	500	100x3
2	28/06/2010	Ice Station	44	25	09:04	80°18.980' N	003°19.387' E	CTD	10	13:28	14:58	1000	500	100x3
2	28/06/2010	Ice Station	44	25	09:04	80°18.980' N	003°19.387' E	CTD	20	13:52	15:22	1000	500	100x3
2	28/06/2010	Ice Station	44	25	09:04	80°18.980' N	003°19.387' E	CTD	30			1000	500	100x3
2	28/06/2010	Ice Station	44	25	09:04	80°18.980' N	003°19.387' E	CTD	60			1000	500	100x3
2	29/06/2010	Ice Station	51	28	11:34	80°15.983' N	002°55.148' E	ICE	5	16:25	17:55	1000	500	100x3
2	29/06/2010	Ice Station	51	28	11:34	80°15.983' N	002°55.148' E	ICE	10	15:45	16:15	1000	500	100x3
2	29/06/2010	Ice Station	51	28	11:34	80°15.983' N	002°55.148' E	CTD	20			200	100	100x3
2	29/06/2010	Ice Station	51	28	11:34	80°15.983' N	002°55.148' E	CTD	30			500		100x3
2	29/06/2010	Ice Station						BRINE	0-50	14:55	15:55	750	500	100x3
2	30/06/2010	Ice Station	57	30	08:42	80°13.780' N	002°29.790' E	CTD	10			200	100	100x3
2	30/06/2010	Ice Station	57	30	08:42	80°13.780' N	002°29.790' E	CTD	20			200	200	100x3
2	30/06/2010	Ice Station	57	30	08:42	80°13.780' N	002°29.790' E	CTD	30			1000	500	100x3

Leg	Date	Station	Event	CTD	Time GMT	Lat	Long	CTD/Ice	Depth	PE_start	PE_end	HPLC	Abs	Turner
2	01/07/2010	Ice Station	61	31	08:13	80°13.190' N	002°09.940' E	CTD	10			500	580	100x3
2	01/07/2010	Ice Station	61	31	08:13	80°13.190' N	002°09.940' E	CTD	20	10:30	12:25	200	400	100x3
2	01/07/2010	Ice Station	61	31	08:13	80°13.190' N	002°09.940' E	CTD	30	10:10	12:10	200	300	100x3
3	04/07/2010	KF3	66	35	08:00	79°01.000' N	010°42.050' E	CTD	3.5	11:55	13:28	1000	500	100x3
3	04/07/2010	KF3	66	35	08:00	79°01.000' N	010°42.050' E	CTD	15	12:30	14:00	1000	500	100x3
3	04/07/2010	KF3	66	35	08:00	79°01.000' N	010°42.050' E	CTD	26			1000	500	100x3
3	04/07/2010	KF3	66	35	08:00	79°01.000' N	010°42.050' E	CTD	35			1000	500	100x3
3	04/07/2010	KF3	66	35	08:00	79°01.000' N	010°42.050' E	CTD	45			1000	500	100x3
3	05/07/2010	KF3	82	37	06:41	79°00.911' N	010°41.280' E	CTD	5			1000	500	100x3
3	05/07/2010	KF3	82	37	06:41	79°00.911' N	010°41.280' E	CTD	10			1000	500	100x3
3	05/07/2010	KF3	82	37	06:41	79°00.911' N	010°41.280' E	CTD	25	10:30	12:30	1000	500	100x3
3	05/07/2010	KF3	82	37	06:41	79°00.911' N	010°41.280' E	CTD	32	10:55	12:55	1000	500	100x3
3	06/07/2010	KF3	99	43	07:58	78°58.520' N	006°42.390' E	CTD	5	11:35	13:05	700	500	100x3
3	06/07/2010	KF3	99	43	07:58	78°58.520' N	006°42.390' E	CTD	10			720	500	100x3
3	06/07/2010	KF3	99	43	07:58	78°58.520' N	006°42.390' E	CTD	22	11:55	13:25	710	500	100x3
3	06/07/2010	KF3	99	43	07:58	78°58.520' N	006°42.390' E	CTD	30			1000	500	100x3
3	06/07/2010	KF3	99	43	07:58	78°58.520' N	006°42.390' E	CTD	50			1000	500	100x3
3	07/07/2010	KF4	112	47	06:55	78°58.506' N	006°42.379' E	CTD	5	11:35	13:05	1000	500	100x3
3	07/07/2010	KF4	112	47	06:55	78°58.506' N	006°42.379' E	CTD	15			900	500	100x3
3	07/07/2010	KF4	112	47	06:55	78°58.506' N	006°42.379' E	CTD	28	12:00	13:30	1000	500	100x3
3	07/07/2010	KF4	112	47	06:55	78°58.506' N	006°42.379' E	CTD	38			1000	500	100x3
3	08/07/2010	Greenland Shelf	119	49	07:43	77°46.630' N	005°35.770' E	CTD	5	12:05	13:52	1000	500	100x3
3	08/07/2010	Greenland Shelf	119	49	07:43	77°46.630' N	005°35.770' E	CTD	9	11:45	13:32	1000	500	100x3
3	08/07/2010	Greenland Shelf	119	49	07:43	77°46.630' N	005°35.770' E	CTD	14	11:07	12:37	1000	500	100x3
3	08/07/2010	Greenland Shelf	119	49	07:43	77°46.630' N	005°35.770' E	CTD	29			1000	500	100x3
3	09/07/2010	Greenland Shelf	134	52/53	06:18	77°36.054' N	005°11.425' W	CTD	5	10:10	12:10	1000	1000	100x3
3	09/07/2010	Greenland Shelf	134	52/53	06:18	77°36.054' N	005°11.425' W	CTD	15	10:30	12:30	1000	1000	100x3
3	09/07/2010	Greenland Shelf	134	52/53	06:18	77°36.054' N	005°11.425' W	CTD	25			1000	500	100x3
3	09/07/2010	Greenland Shelf	134	52/53	06:18	77°36.054' N	005°11.425' W	CTD	42			1000	500	100x3
3	10/07/2010	Greenwich Meridian	143	56	09:23	78°16.998' N	000°00.015' E	CTD	5	13:15	15:15	500	1000	100x3
3	10/07/2010	Greenwich Meridian	143	56	10:23	78°16.998' N	000°00.015' E	CTD	10	13:40	15:40	250	400	100x3
3	10/07/2010	Greenwich Meridian	143	56	11:23	78°16.998' N	000°00.015' E	CTD	18	14:02	16:02	500	700	100x3

Leg	Date	Station	Event	CTD	Time GMT	Lat	Long	CTD/Ice	Depth	PE_start	PE_end	HPLC	Abs	Turner
3	10/07/2010	Greenwich Meridian	143	56	12:23	78°16.998' N	000°00.015' E	CTD	18B			250		
3	11/07/2010	KF5	155	59	05:25	78°56.850' N	005°17.300' E	CTD	5			500	500	
3	11/07/2010	KF5	155	59	06:25	78°56.850' N	005°17.300' E	CTD	13.5			770	500	
3	11/07/2010	KF5	155	59	07:25	78°56.850' N	005°17.300' E	CTD	20			1000	500	
3	11/07/2010	KF5	155	59	08:25	78°56.850' N	005°17.300' E	CTD	30			1000	500	
3	11/07/2010	KF5	155	59	09:25	78°56.850' N	005°17.300' E	CTD	50			1000	500	

SCIENTIFIC REPORT 9: Primary production, calcification, coccolithophores and the carbonate system

Eithne Tynan

Background and cruise objectives

Ocean acidification is the result of increasing carbon dioxide in the atmosphere being absorbed by the ocean. This shifts the carbonate system towards more CO_2 and H^+ and less carbonate ion (CO_3^{2-}) which in turn decreases calcite saturation state in the seawater. Experiments imply that ocean acidification and the subsequent decline in calcite saturation state will have a negative impact on marine calcifiers such as corals, mussels, sea urchins, pteropods and coccolithophores. Coccolithophores are of particular importance as they comprise a great proportion of biogenic calcification (50-80%). Moreover, calcite is considered to be an important ballast material for organic carbon transport from the surface to the deep ocean and is therefore playing an important role in the global carbon cycle.

Extensive lab experiments have been done on coccolithophore responses to ocean acidification and some of them show contradictory results, but studies on natural populations are limited. The cruise track crossed a natural gradient of calcite saturation state; from high values at low latitudes to very low values in the Arctic. Thus, a "natural lab" was provided in order to investigate how *in-situ* assemblages of coccolithophores might respond to ocean acidification, in a natural system were parameters like temperature, nutrients, mixing e.t.c. are not controlled but have a joint effect on biological processes.

The objective of this cruise was to produce high quality carbonate system measurements and observe the response of coccolithophores to changes in these parameters.

Sampling and Methods

Samples were taken for coccolithophores (*SEM*), *primary production* and *calcification* and dissolved inorganic carbon (*DIC*) and alkalinity (*TA*). A total of 20 CTD casts were sampled, although water was not collected for all the variables on some casts (see Table 1). Underway samples for DIC, TA and coccolithophore SEM observation (31 in total, see Table 2) were also collected during the cruise.

DIC and TA

About 4-8 depths from 19 CTD casts were sampled for DIC and TA, plus 31 underway samples. The sampling procedure used for the determination of DIC and TA from both the CTD casts and the underway followed establish standard operating procedures. Samples were collected in 250 ml Schott Duran borosilicate glass bottles with glass stopper. Samples were taken as soon as possible after the Niskin bottle was opened (following trace gases and dissolved oxygen). A piece of tygon tubing was used for the sampling and care was taken to prevent any air bubbles being trapped in the sample. The glass stopper was inserted in the bottle in order to remove the stopper volume and a head space of 1% (2.5 ml) was allowed for water expansion. Samples were poisoned with 50 µl of mercuric chloride for later analysis in the lab. Analysis will be done using the VINDTA (Versatile INstrument for Determination of Total Alkalinity) connected with a UIC coulometer. DIC will be measured using a coulometric titration and alkalinity by titrating the sample with hydrochloric acid. Certified Reference Materials (CRMs) from A.G. Dickson (Scripps Institute of Oceanography) will be used to calibrate the instrument before sample analysis. DIC and alkalinity values will then be used to calculate the rest of the carbonate system parameters; carbon dioxide, bicarbonate and carbonate ion, pH and finally calcite and aragonite saturation state.

SEM

Samples for coccolithophore analysis were taken at 2-5 depths from 19 CTD stations and from the underway supply (22 samples). Exactly 1000 mL of seawater were filtered on 1.2 µm isopore membrane filters under low vacuum. The filters were rinsed with analytical grade trace ammonium solution (pH ~ 9.2) to prevent the formation of salt crystals that makes analysis under the SEM difficult. Filters were dried at room temperature, placed in sealed Petri dishes, wrapped in tin foil and kept in a cool and dry place until analysis at NOCS using a Leo 1450VP Carl Zeiss scanning electron microscope. Analysis will involve identification, enumeration and morphometric analysis of coccospheres and loose coccoliths.

Water column primary production and calcification

Daily rates of primary production and calcification were determined following the 'micro-diffusion' technique of Paasche and Brubak 1994 (as modified by Balch *et al*., 2000). Primary production was determined at 11 CTD stations, while calcification rates were determined at 7 of these stations. Water samples (3 incubated, 1 formalin-killed) were collected from 4-6 light depths (around 80, 55, 33, 14, 4.5, 1% incident light), spiked with ^{14}C-labelled sodium bicarbonate and incubated in on-deck incubators. When only primary productivity was determined 60ml polycarbonate bottles were used and 15µCi of spike were added, whereas when both primary productivity and calcification were determined 150ml polycarbonate bottles were filled and spiked with 100µCi of ^{14}C sodium bicarbonate. Light depths were replicated through the use of a mixture of misty blue and neutral density filters and continuous flow of water from the underway supply in the incubators kept samples at sea surface temperature. Incubations were terminated by filtration through 25mm 0.2 µm polycarbonate filters, with extensive rinsing with filtered seawater to remove any labeled ^{14}C-DIC. When only primary productivity was determined, the filters were placed in vials in a closed container with fuming HCl for 24 hours. When also determining calcification rates the filters were placed in a glass vial with gas-tight septum and a bucket containing a GFA filter soaked with phenylethylamine (PEA) attached to the lid. Phosphoric acid (1 mL, 1%) was then injected through the septum into the bottom of the vial to convert any labeled ^{14}C-PIC to ^{14}C-CO_2 which was then captured in the PEA-soaked filter. After 24 hours, the GFA filters were removed and placed in a fresh vial. Liquid scintillation cocktail was then added to the vials containing the polycarbonate filter (non-acid labile production, organic or primary production) and the other containing the GFA filter when also doing calcification(acid labile production, inorganic production or calcification). Activity in both filters was determined after at least 24 hours on a liquid scintillation counter and counts converted to uptake rates using standard methodology. Daily uptake rates per cell will also be calculated using the data from the SEM samples.

Primary production curves of ice-cores

Ice-cores were taken on Leg 2 by Ronnie Glud and Søren Rysgaard. The cores were cut up in 10cm pieces and melted. Three different sections of the ice-cores (one from the middle of the core, two from the bottom part of the ice core) were incubated at six different light depths each. One replicate for each light depth and one formalin for each section were taken. Each melted ice-core was put in seven 60ml polycarbonate bottles (6 light depths, one formalin) and spiked with 15uCi of 14C sodium bicarbonate. The bottles were then incubated for 24 hours at around 80, 55, 33, 14, 4.5, 1% incident light. Light depths were replicated through the use of a mixture of misty blue and neutral density filters and continuous flow of water from the underway supply in the incubators kept samples at sea surface temperature. Incubations were terminated by filtration through 25mm 0.2 µm polycarbonate filters, with extensive rinsing with filtered seawater to remove any labeled ^{14}C-DIC. The filters were then placed in vials in a closed container with fuming HCl for 24 hours. After this time the vials were removed from the acid and filled with liquid scintillation cocktail. Activity in both filters was determined after at least 24 hours on a liquid scintillation counter and counts converted to uptake rates using standard methodology.

Table 2: CTD stations and depths at which samples were collected

Station	CTD Cast	Niskin bottle no.	Depth (m)	DIC/TA	SEM	PP	Calcification
North Sea	002	22	2	x	x		
		19	5	x	x		
		16	20	x	x		
		13	28	x	x		
		1	40	x	x		
South Norwegian Sea	004	24	2	X	X	X	
		23	3.5	X		X	
		21	5	X	X	X	
		17	9	X		X	
		16	18	X	X	X	
		07	23	X	X	X	
		04	40	X	X		
		02	80	x	X		
Central Norwegian Sea	006	23	5	x	X		
		19	17	X	X		
		09	20	X	X		
		08	35	X	x		
		05	38	X			
		02	60	X			
		01	100	X			
North Norwegian Sea	008	23	2	X	X	X	
		21	5	X	X	X	
		17	10	X	X	X	
		14	20	X	X	X	
		5	35	X	X	X	
		1	80	X			
South Greenland Sea	010	19	6	x	X		
		17	16	X	X		
		05	40	X	X		
		03	60	X	X		
		02	80	X	X		
		01	100	X			
East Greenland Sea	012	23	5	X	X		
		18	Dcm	X	X		
		08	30	X	X		
		04	50	X	X		
		03	100	X			
		02	150	X			
		01	200	X			

Station	CTD Cast	Niskin bottle no.	Depth (m)	DIC/TA	SEM	PP	Calcification
Ice-Station	013	09	400	X			
		05	500	X			
		01	600	X			
	014	12	5	X	X		
		10	18	X	X		
		04	46	X	X		
		02	60	X	X		
		01	100	X			
	015	09	60	X			
		05	200	X			
		01	300	X			
Ice Station	017	12	5			X	
		09	10			X	
		07	16			X	
		06	30			X	
		04	45			X	
Ice Station	I10	-	5			X	
		-	10			X	
Ice Station	**I18**	**-**	**5**	X	X		
		-	10	X			
Ice-Station	022	11	5	X	X		
		09	10	X	X		
		06	30	X			
		04	50	X			
Ice station	025	12	5	X	X		
		08	15	X	X		
		06	30	X	X		
		02	70	X			
		01	150	X			
Ice Station	I44	-	5	X	X	X	X
		-	10	x	X	X	X
Ice Station	028	12	1	X	X	X	X
		07	11	X	X	X	X
		06	13	X		X	X
		04	25	X		X	X
		02	30	X	X	X	X
		01	36	x		X	X
Ice Station	031	12	5	X	X		
		09	15	X	X		
		06	30	X	X		
		04	50	X	X		
Kongsfjord 3	035	20	3.5	X	X	X	X
		16	6.5	X	X	X	X
		14	15	X	X	X	X
		10	26	X	X	X	X
		05	45	X	X	X	X
		02	150	X			
		01	302	X			

Station	CTD Cast	Niskin bottle no.	Depth (m)	DIC/TA	SEM	PP	Calcification
Kongsfjord 4	043	23	2	X	X	X	X
		22	5	X	X	X	X
		17	8	X	X	X	X
		13	13	X	X	X	X
		12	19	X	X	X	X
		08	25	X	X	X	X
		04	50	X			
		02	100	X			
Kongsfjord 4	047	21	5	X	X		
		17	27	X	X		
		04	40	X	X		
		03	50	X			
		02	100	X			
Greenland Shelf	049	19	2	X	X	X	X
		17	5	X	X	X	X
		13	9	X	X	X	X
		08	16	X	X	X	X
		04	29	X	X	X	X
		03	50	X	X	X	
		02	100	X			
		01	200	X			
Greenland Shelf	053	23	2	X	X	X	X
		18	5	X	X	X	X
		16	8	X	X	X	X
		13	15	X	X	X	X
		11	25	X	X	X	X
		06	42	X	X	X	X
		03	100	X			
		01	200	x			
Greenwich	056	24	2	X	X	X	X
		23	5	X	X	X	X
		18	10	X	X	X	X
		11	18	X	X	X	X
		05	27	X	X	X	X
		03	50	X	X	X	X
		02	100	X			
		01	200	X			

Table 2: Dates, times and positions of underway sampling

Event no.	Date	Time (GMT)	Lat (N)	Long (E)	DIC/TA	SEM
1	16/06/10	12:54	65 44.777	4 42.3633	X	X
2	16/06/10	22:06	67 36.950	5 32.9000	X	
3	17/06/10	09:00	69 20.4610	6 22.418	X	
4	17/06/10	11:08	69 36.7000	6 30.6059	X	
5	17/06/10	15:34	69 55.6900	6 41.5300	X	X
6	17/06/10	18:33	70 32.3600	7 0.5100	X	X
7	17/06/10	21:12	71 02.1278	7 16.3580	X	
8	18/06/10	10:46	73 11.1250	8 32.0482	X	
9	18/06/10	13:28	73 42.6712	8 50.4411	X	
10	18/06/10	16:27	74 18.2800	9 14.0600	X	
11	18/06/10	19:13	74 51.4100	9 25.6900	X	
12	19/06/10	09:58	77 27.5300	11 32.4300	X	X
13	19/06/10	12:25	77 57.4700	11 68.5500	X	X
14	21/06/10	04:08	80 10.4600	7 40.0900	X	X
15	21/06/10	06:27	80 26.9300	6 29.4264	X	X
16	21/06/10	09:07	80 42.5849	6 1.4476	X	X
17	26/06/10	06:53	80 36.1400	4 19.4400	X	X
18	26/06/10	19:31	80 29.2007	3 47.4700	X	X
19	27/06/10		80 23.0400	3 27.9000	X	X
20	28/06/10	17:54	80 16.5776	3 07.9400	X	X
21	29/06/10	20:57	80 14.2995	2 41.9210	X	X
22	02/07/10	11:51	78 09.6200	13 52.9300	X	X
23	05/07/10	19:50	78 59.9700	7 58.990	X	
24	07/07/10	12:10	78 49.59	4 52.65	X	X
25	07/07/10	15:02	78 27.8600	2 13.3300	X	X
26	07/07/10	17:49	78 11.9231	0 12.7869 W	X	X
27	08/07/10	20:27	77 36.930	5 44.700 W	X	X
28	09/07/10	14:50	77 38.6907	6 17.9004 W	X	X
29	10/07/10	19:46	78 14.9300	0 50.5000	X	X
30	10/07/10	22:32	78 30.6500	2 31.2000	X	X
31	11/07/10	06:20	78 56.9631	5 35.8779	X	X

SCIENTIFIC REPORT 10: Evaluation of C-coupling and N-competition between the microbial community in surface waters: importance of different DOC and DIN sources on interactions and metabolic bacterial diversity

Eric Fouilland, Emilie Le Floc'h and Debra Brennan.

1. Rationale and Objectives

Previous results from the Oceans2025 Arctic cruise in 2008 clearly revealed a low C-dependency of bacteria from phytoplankton exudation. Bacteria in Arctic waters may use sources of carbon other than that freshly produced by phytoplankton. The composition of labile dissolved organic carbon was previously investigated with respect to neutral sugar distribution in arctic waters (Amon & Benner 2003). These authors suggest that the molecular composition of neutral sugars in Arctic waters was related to their diagenetic alteration, with glucose and fucose considered as "fresh" DOC, and arabinose and galactose considered as "old" DOC. We hypothesise that heterotrophic bacteria will be sensitive to old DOC in arctic coastal waters but not in Atlantic open waters where fresh DOC will be used. *Preferential use of old DOC will increase bacterial N demand and therefore induce a stronger N competition with phytoplankton.* Bacterial C-dependency on phytoplankton exudates may strongly depend on N availability. *Higher C-dependency could be observed under DIN sufficiency* when phytoplankton N competition pressure is alleviated.

In order to test the above hypotheses, the importance of DOC diagenetic status on bacterial production, respiration and N-competition between bacteria and phytoplankton, and the importance of DIN availability on bacterial production, respiration and bacterial C-dependency on phytoplankton were investigated for:
surface waters (5m) along a transect from the North Sea to East Greenland Sea (Leg 1)
under the ice pack and in an ice core (Leg 2)
surface waters (5m) along a transect from the Svalbard coast to Greenland continental shelf (Leg 3).

The potential bacterial use of various carbon sources was also tested (using Biolog-Ecoplate containing 31 carbon sources in triplicate; Sala et al 2008).

2. Experimental procedures

2.1 Incubations of samples under 3 DOC conditions and under 3 DIN conditions

Incubations of samples under 3 DOC conditions (natural DOC, +glucose & Fucose, + arabinose & galactose) and under 2 DIN conditions (natural DIN, +NO3, +NH4) were performed for 6-12h in duplicate for final measurements of (fig. 1):
- N-competition (addition of $^{15}NO3$, $^{15}NH4$, $^{13}CO2$ and size-fractionation) performed with and without DOC additions only
- C-dependency (addition of $^{14}CO2$ and size-fractionation) performed with and without DIN additions only
- bacterial respiration performed with and without DIN additions only
- bacterial production
- N-regeneration estimation
- bacterial abundance
- Chla concentrations
- Nutrient concentrations

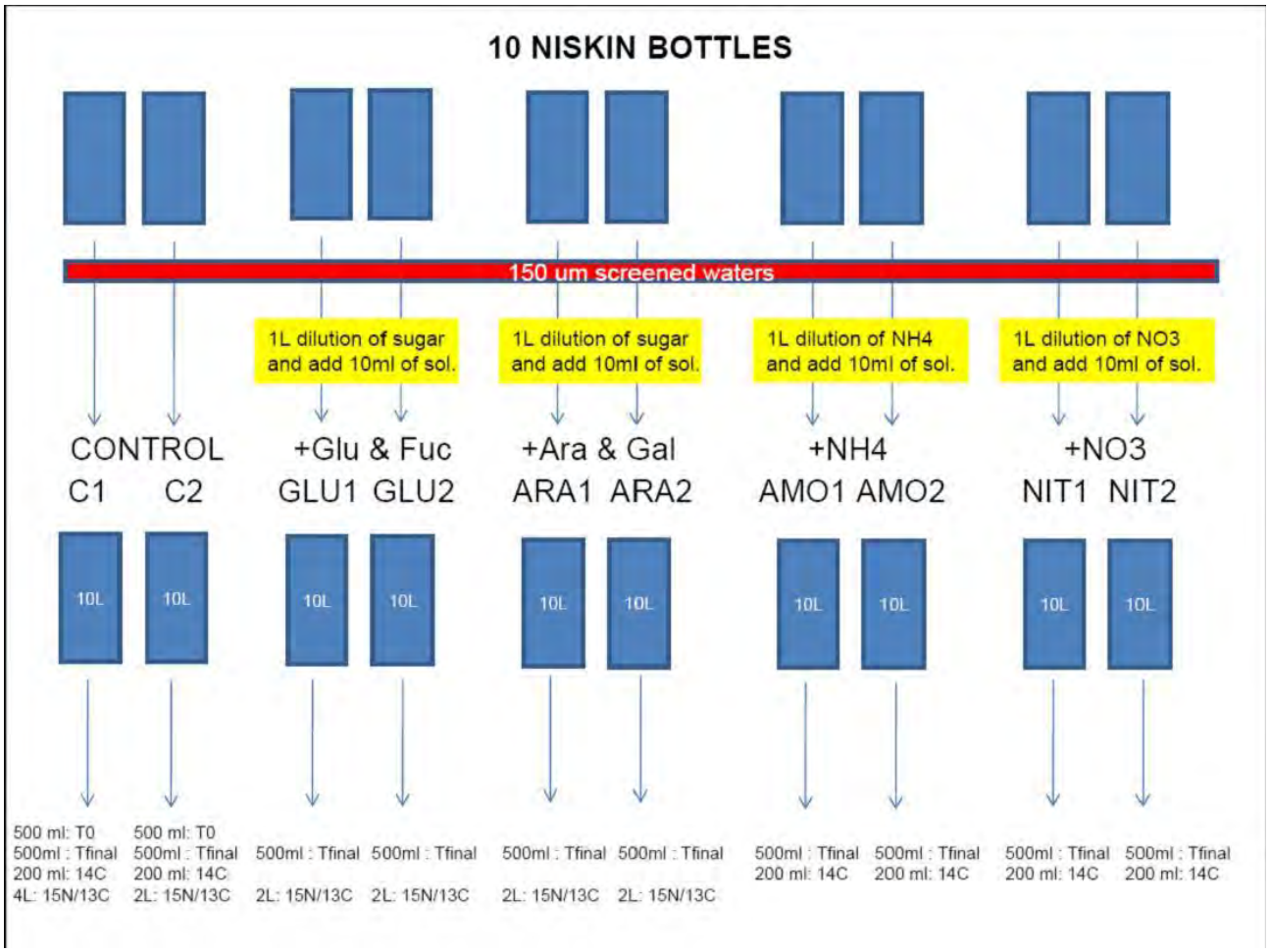


Figure 11: Experimental design used for investigating C-Coupling and N-competition in natural waters, for evaluating the importance of the diagenetic states of labile DOC on N-competition and for evaluating the importance of DIN availability on C-coupling. Glu: addition of D-glucose, Fuc: addition of L-and D-fucose, Ara: addition of L- and D-arabinose, Gal: addition of L- and D-arabinose,+NH4: addition of ammonia, +NO3: addition of nitrate.

Incubations were performed in on-deck incubators at in situ temperature (continuous inflow of underway water) and at surface irradiance (except during leg 2, the incubators were covered with a neutral density filter to mimic under ice irradiance level). The name of the stations and dates are summarised in table 1.

Table 1: List of stations where incubation experiments were performed

LEG	STATION	DATE	N-competition and DOC additions	C-Coupling and DIN additions
1	North Sea	14/06/10	X	X
1	South Norwegian Sea	15/06/10	X	X
1	Central Norwegian Sea	16/06/10	X	X
1	Northern Norwegian Sea	17/06/10	X	X
1	South Greenland Sea	18/06/10	X	X
1	East Greenland Sea	19/06/10	X	X
2	Ice Station – Ice core	23/06/10		X
2	Ice Station – Under ice	24/06/10	X	X
2	Ice Station – Ice core	28/06/10		X
2	Ice Station – Under ice	29/06/10	X	X
3	Kongsfjord 3	04/07/10	X	X
3	Kongsfjord 4	06/07/10	X	X
3	Greenland Shelf	08/07/10	X	X
3	Greenwich Meridian	10/07/10	X	X

2.2 Incubations of samples in Biolog-Ecoplates

Incubations of samples (unfiltered, concentrated and size-fractionned) in Biolog-Ecoplates were performed under darkness at 4°C for 30 days (fig. 2). The bacterial use of different substrates was evaluated every day by optical density measurements (Biorad microplate reader).

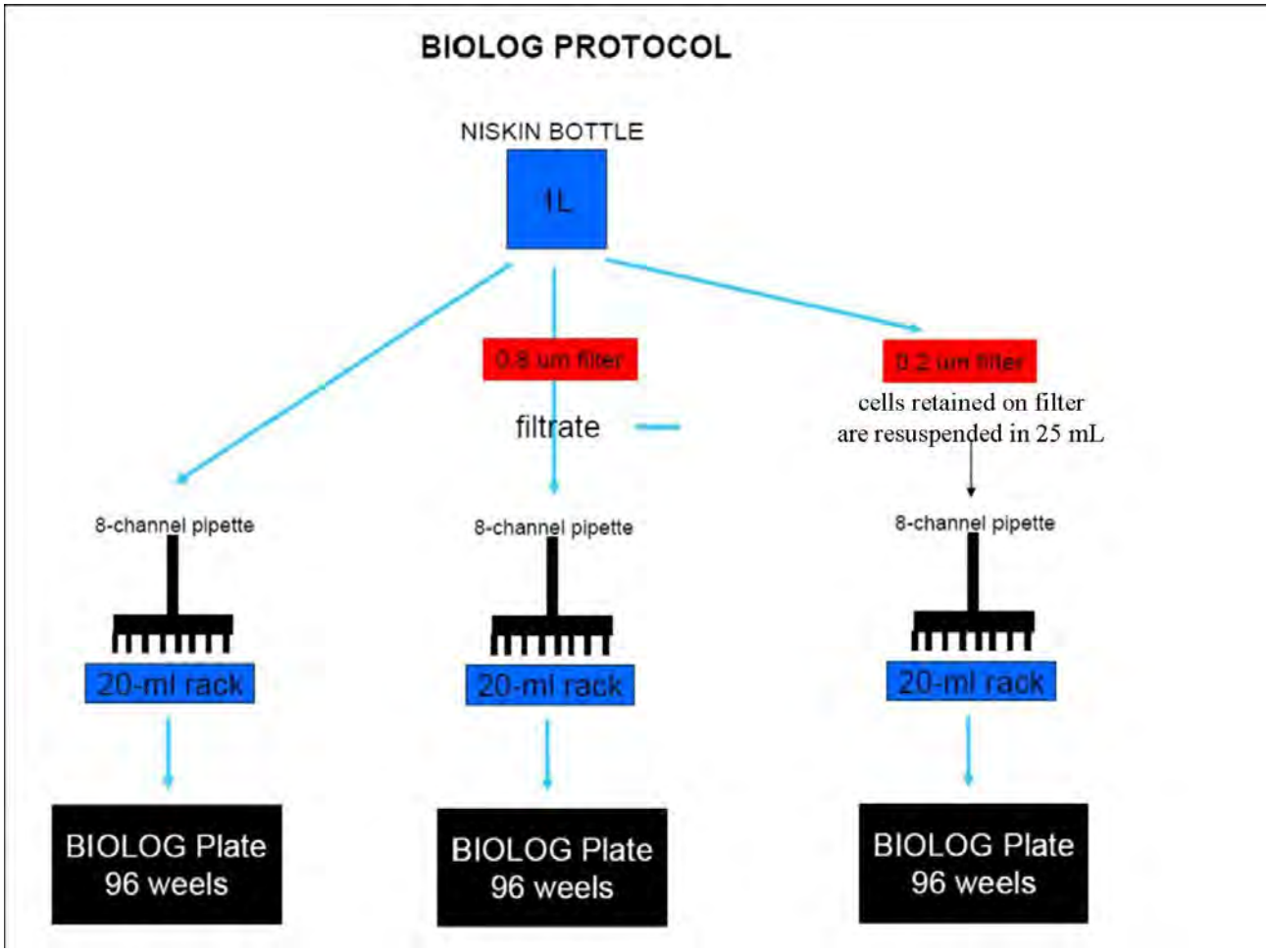


Figure 12: Experimental design used for evaluating the potential diversity of carbon sources for heterotrophic bacteria

All the incubated samples are listed in table 2.

*Table 2: List of samples incubated in BIOLOG-ECOPLATES. * 2 thirds of the plate were filled with total sample, 1 third was filled with concentrated sample.*

Leg	Station	Date	Plate Reference	Total	Concentrated	Filtrated
1	North Sea	14/06/10	1	X	X (24 fold)	X
1	South Norwegian Sea	15/06/10	2	X		
1	Central Norwegian Sea	16/06/10	3	X	X (27 fold)	X
1	Northern Norwegian Sea	17/06/10	4	X		
1	South Greenland Sea	18/06/10	5	X	X (30 fold)	X
1	East Greenland Sea	19/06/10	6	X		
2	Ice Station – Ice core	23/06/10	8	X*	X* (24 fold)	
2	Ice Station – Under ice	24/06/10	7	X		
2	Ice Station – Under ice	29/06/10	9	X	X (50 fold)	X
3	Kongsfjord 3	04/07/10	10		X (30 fold)	
3	Kongsfjord 4	06/07/10	11		X (30 fold)	
3	Greenland Shelf	08/07/10	12		X (40 fold)	

3. Preliminary results

Evaluation of C-Coupling and N-competition in surface waters

Bacterial production – see Scientific Report 14.
Bacterial respiration – see Scientific Report 15.
During Leg 3, bacterial respiration was only measured for the experiment at Greenland Shelf station.
Nutrient concentrations – see Scientific Report 5.
Bacteria and picoplankton abundance – see Scientific Report 11.

Potential bacterial use of various carbon sources

From the first incubation achieved (North Sea), we observed that the concentration or fractionation of the sample had an influence on the expressed metabolic pathways (see table 3). The 3 different sample conditions gave 2 common positive results on 31 tested substrates: one carbohydrate (N-acetyl-D-Glusamine) and one amino-acid (Glycyl-L-Glutamic acid). The concentrated sample shows a higher number of used C sources, as a consequence of increasing the number of bacteria (especially the rarest ones) in the sample. None of the carboxylic acids tested were potentially used by the North Sea community.

Table 3: Comparison of carbon sources used by heterotrophic bacteria in water from North Sea station depending on the fraction of the population. Total sample, concentrated (Conc.) or fractioned through 0.8µm (Filtr.).

		Total	**Conc.**	**Filtr.**
Polymers	Pyruvic Acid Methyl Ester		[redacted]	
	α-Cyclodextrin		[redacted]	
	Tween 40			[redacted]
Carbohydrates	D-Mannitol		[redacted]	
	N-acetyl-D-Glucosamine	[redacted]	[redacted]	[redacted]
Carboxylic acids				
Amino acids	L-Arginine		[redacted]	
	Glycyl-L-Glutamic acid	[redacted]	[redacted]	[redacted]

SCIENTIFIC REPORT 11: Microbial community composition, abundance and biomass

Elaine Mitchell and Sian Lordsmith

Introduction and Objectives

The objective of this study was to determine the taxonomic composition, abundance and biomass of micro-organisms in surface waters and sea-ice at different sampling stations during the cruise. Samples were collected for post-cruise analysis on return to the UK. Sampling details are shown in the tables at the end of this report. The microbial community was categorised according to size as either:
Picoplankton (autotrophic and heterotrophic prokaryotes and picoeukaryotes <2 μm in size, including cyanobacteria and bacteria)
Nanoplankton (autotrophic and heterotrophic protistan eukaryotes 2-20 μm in size, including smaller flagellates, diatoms and dinoflagellates)
Microplankton (autotrophic and heterotrophic protistan eukaryotes 20-200 μm in size, including larger flagellates, diatoms, dinoflagellates and ciliates)

Approach and Methodology

Picoplankton abundance and biomass by flow cytometry:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 4ml of sample were removed and placed in a labelled 5ml 'Cryovial' along with 200ul of paraformaldehyde and mixed to form a 1% final concentrated solution. The vials are left for no longer than 12 hours before either:
Being analysed on the BD FacsSort Flow cytometer to enumerate picoplankton abundance, or
Transferred into the -80°C freezer for post-cruise analysis of picoplankton abundance by BD FacsSort Flow cytometer.

Picoplankton composition by fluorescence in-situ hybridisation (FISH):
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 10ml of sample were removed and placed into a 15ml Sterilin tube with 400μl of 37% formaldehyde and mixed to form a 1% final concentrated solution. The tubes were left for no longer than 12 hours, and then 5ml of each sample was filtered onto a 25mm 0.2μm white polycarbonate membrane. The filters were transferred to 30mm Petri dishes, and with the lid on, allowed to dry out.
Once dry the Petri dishes were sealed with Parafilm and then frozen at -20°C for post-cruise analysis of picoplankton community composition by FISH.

Pico- and nanoplankton composition, abundance and biomass by microscopy:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 50ml of the CTD sample were removed and placed into a labelled 125ml brown plastic Nalgene bottle containing 1ml of 25% glutaraldehyde and mixed, making a final concentrated solution of 0.5% glutaraldehyde. This sample was then stored in the cold room for no longer than 12 hours to allow the fixation process to stabilise. The fixed samples were then removed from the cold room, stained, concentrated onto filters using a 25mm filtration rig, and the filters mounted on microscope slides. Three slide preparations were made for each sample:
5ml of sample were stained with the fluorescent dye DAPI and filtered onto a 25mm 0.2μm black polycarbonate filter for bacterial enumeration.
5 ml of sample were filtered directly onto a 25mm 0.2μm white polycarbonate membrane for cyanobacterial enumeration. (No DAPI added)

15ml of sample were stained with the fluorescent dye DAPI and filtered onto a 25mm 0.8µm white polycarbonate filter for enumeration of heterotrophic and phototrophic nanoplankton taxa.
All slides were labelled, frozen flat and then transferred to slide boxes and frozen at -20°C for post-cruise analysis by epifluorecence microscopy.

Microplankton composition, abundance and biomass by microscopy:
Lugol's samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 400ml of sample were removed and placed into a glass 500ml amber bottle containing 4mls of Lugol's iodine fixative and mixed making a 1% final concentrated solution. These bottles were then labelled and stored in the cold room at 4°C in plastic boxes for post-cruise analysis of microplankton composition, abundance and biomass by inverted microscopy.
Bouin's samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 400ml of sample were removed and placed into a 500ml brown Nalgene bottle containing 10mls of Bouin's fixative (a mix of picric acid & formaldehyde) and mixed to form a 2.5% final concentrated solution. These bottles were then labelled and stored in the cold room at 4°C in plastic boxes for post-cruise analysis of ciliate taxonomy by protargol staining and conventional microscopy.
Formaldehyde samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 400ml of sample were removed and placed into a 500ml brown Nalgene bottle containing 10mls of 37% formaldehyde and mixed to form a 1% final concentrated solution. These bottles were then labelled and stored in the cold room at 4°C in plastic boxes for post-cruise analysis of microplankton chlorophyll fluorescence and taxonomy by epiflorescence and electron microscopy.
Glutaraldehyde samples:
Water samples were taken from the CTD bottles and collected in thermos flasks which had been pre-cooled in the cold room. The thermos flasks were returned to the cold room where 400ml of sample were removed and placed into a 500ml brown Nalgene bottle containing 16mls of 25% glutaraldehyde and mixed to form a 1% final concentrated solution. These bottles were then labelled and stored in the cold room at 4°C in plastic boxes for post-cruise analysis of microplankton chlorophyll fluorescence and taxonomy by epiflorescence and electron microscopy.

Sea-Ice sample methodology

Three replicate cores were collected from the ice station coring site on 30 June 2010. The cores were 9 cm in diameter and 77-85 cm in length, and were obtained from positions 50 cm apart on the ice using a manually operated MARK II Kovacs coring system. Special care was taken to prevent loss of ice and brine from the bottom of each core on retrieval. Each core was immediately cut horizontally into 10 cm long sections which were returned to the ships' laboratories in clean Nalgene plastic jars. Each ice section was then cut vertically in half to provide samples for the analysis of microbial community composition, abundance and biomass using a dilution technique to reduce osmotic changes and associated cells loss during ice melt (Garrison and Buck, 1986, *Polar Biology*, 6, 237-239). Each sample, along with half the volume of any brine which had drained from the original 10 cm long ice section, was weighed and added to an 800 ml volume of 0.2 µm filtered seawater (collected from surface waters adjacent to the ice flow) to give a x3.4 to x4.9 dilution*. The samples were then allowed to melt (~14 hours) at 3^{o}C after which they were preserved for post cruise analysis by microscopy and flow cytometry as outlined above. Samples of the 0.2 µm filtered seawater were also preserved to check for removal of bacteria.

[*Note that the exact dilution factor was calculated for each core by multiplying the core weight in grams by the bulk salinity of cores taken at the same site (see Scientific Report 21) to get the core volume in millilitres. The percentage ice core volume in the diluted volume could then be calculated

to derive the dilution factor which was then used to multiply any subsequent counts to generate cell abundance per litre melted ice core. Abundance per kilogram and counts per metre^3 could be calculated using salinity and density data from cores taken at the same site]

Table of sea-ice samples depths and volumes of melted samples preserved with different fixatives

Core	Depth (cm)	1% Lugols (ml)	1% GLUT (ml)	0.3% PFA (ml)	5% Bouins (ml)	1% GLUT (ml)	1% FORM (ml)
A	0 - 10	400	100	4			
	10 - 20	400	100	4	300		
	20 - 30	400	100	4			
	30 - 40	400	100	4			
	40 - 50	400	100	4	300		
	50 - 60	400	100	4			
	60 - 70	400	100	4			
	70 - 77	400	100	4	300		
B	0 - 10	400	100	4			
	10 - 20	400	100	4		300	
	20 - 30	400	100	4			
	30 - 40	400	100	4			
	40 - 50	400	100	4		300	
	50 - 60	400	100	4			
	60 - 70	400	100	4			
	70 - 81	400	100	4		300	
C	0 - 10	400	100	4			
	10 - 20	400	100	4			300
	20 - 30	400	100	4			
	30 - 40	400	100	4			
	40 - 50	400	100	4			300
	50 - 60	400	100	4			
	60 - 70	400	100	4			
	70 - 80	400	100	4			300
	80 - 85	400	100	4			

Flow cytometry samples from JCR 219

All samples for analysis by flow cytometry were fixed in 5ml cryoviles with 250ul paraformaldehyde to make a 1% final concentration PFA. The majority of these samples were then run on ship before being stored in a -80C freezer to be re-run post cruise as required.

Depth Profiles

Depth Profiles from CTDs.
For each sample bacteria, cyano-bacteria and pico-plankon abundance was measured.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 7 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Greenwich Meridian, 78º17N.0ºW, 8 samples

TOTAL SAMPLES = 49

Date	Station Name	CTD	Bottle No.	Depth (m)
24.6.10	Ice Station 1	18	6	5
	Ice Station 1	18	5	10
	Ice Station 1	18	4	16
	Ice Station 1	18	3	30
	Ice Station 1	18	2	45
	Ice Station 1	18	1	60
	Ice Station 1	ice	/	5
	Ice Station 1	ice	/	10
29.6.10	Ice Station 2	28	12	1
	Ice Station 2	28	10	5
	Ice Station 2	28	9	10
	Ice Station 2	28	7	11
	Ice Station 2	28	6	13
	Ice Station 2	28	4	25
	Ice Station 2	28	2	30
	Ice Station 2	28	1	36
	Ice Station 2	ice	/	5
	Ice Station 2	ice	/	10
4.7.10	Kongsfjord 3	33	11	5 A
	Kongsfjord 3	33	13	5 B
	Kongsfjord 3	33	14	5 C
	Kongsfjord 3	35	20	3.5
	Kongsfjord 3	35	14	15
	Kongsfjord 3	35	10	26
	Kongsfjord 3	35	5	45

Date	Station Name	CTD	Bottle No.	Depth (m)
6.7.10	Kongsford 4	42	6	5 A
	Kongsford 4	42	7	5 B
	Kongsford 4	42	8	5 C
	Kongsford 4	43	20	5
	Kongsford 4	43	16	10
	Kongsford 4	43	11	22
	Kongsford 4	43	7	30
	Kongsford 4	43	4	50
8.7.10	Greenland S.	48	10	5 A
	Greenland S.	48	11	5 B
	Greenland S.	48	12	5 C
	Greenland S.	49	21	2
	Greenland S.	49	16	9
	Greenland S.	49	11	14
	Greenland S.	49	7	29
	Greenland S.	49	3	50
10.7.10	Greenwich M.	55	10	5 A
	Greenwich M.	55	11	5 B
	Greenwich M.	55	12	5 C
	Greenwich M.	56	22	5
	Greenwich M.	56	10	10
	Greenwich M.	56	16	15
	Greenwich M.	56	14	18
	Greenwich M.	56	8	25

Other Depth Profiles

Depth Profiles from CTDs. Correspond to bacterial production.
14.6.10. North Sea. 56º 24.729'N, 001º 18.849'E. 5 samples
15.6.10. Southern Norwegian Sea 60º 44.588'N, 002º 43.670'E. 5 samples
16.6.10. Central Norwegian Sea. 65º 02.420'N, 004º 24.020'E. 5 samples
17.6.10. North Norwegian Sea. 69º 20.459'N, 006º 22.420'E. 5 samples
18.6.10. South Greenland Sea. 72º 45.213'N, 008º 15.930'E. 5 samples
19.6.10. East Greenland Shelf. 77º 09.421'N, 0011º 17.530'E. 5 samples
26.6.10. Ice Station. 80º 31.090'N, 004º 09.870'E 4 samples
27.6.10. Ice Station. 80º 27.318'N, 003º 43.037'E. 4 samples
28.6.10. Ice Station. 80º 18.980'N, 003º 19.387'E. 4 samples
9.7.10. Greenland Shelf. 77º 36.054'N, 006º 11.425'W. 4 samples

TOTAL SAMPLES = 46

Date	Station Name	CTD	Bottle No.	Depth (m)
14.6.10	North Sea	2	23	2
	North Sea	2	20	5
	North Sea	2	17	20
	North Sea	2	14	28
	North Sea	2	1	40
15.6.10	Southern Norwegian Sea	4	20	5
	Southern Norwegian Sea	4	18	6
	Southern Norwegian Sea	4	15	18
	Southern Norwegian Sea	4	6	23
	Southern Norwegian Sea	4	3	40
16.6.10	Central Norwegian Sea	6	24	1
	Central Norwegian Sea	6	22	5
	Central Norwegian Sea	6	20	6
	Central Norwegian Sea	6	18	17
	Central Norwegian Sea	6	7	35
17.6.10	North Norwegian Sea	8	24	2
	North Norwegian Sea	8	22	5
	North Norwegian Sea	8	18	6
	North Norwegian Sea	8	15	20
	North Norwegian Sea	8	6	35
18.6.10	South Greenland Sea	10	24	2.5
	South Greenland Sea	10	22	5
	South Greenland Sea	10	19	6
	South Greenland Sea	10	18	16
	South Greenland Sea	10	6	40

Date	Station Name	CTD	Bottle No.	Depth (m)
19.6.10	East Greenland Sea	12	/	1
	East Greenland Sea	12	/	5
	East Greenland Sea	12	/	10
	East Greenland Sea	12	/	15
	East Greenland Sea	12	/	30
26.6.10	Ice Station	20	10	5
	Ice Station	20	7	39
	Ice Station	20	4	55
	Ice Station	20	3	60
27.6.10	Ice Station	22/23		3
	Ice Station	22/23		5
	Ice Station	22/23		18
	Ice Station	22/23		60
28.6.10	Ice Station	25		5
	Ice Station	25		10
	Ice Station	25		30
	Ice Station	25		60
9.7.10	Greenland Shelf	52	17	5
	Greenland Shelf	52	15	10
	Greenland Shelf	52	9	25
	Greenland Shelf	52	7	42

C- and N-Coupling Experiments

All samples are from a depth of 5m. Bacterial abundance was the main point of interest for these experiments but counts of cyano-bacteria and pico-plankton were also obtained. For most experiments there were 24 AFC samples. These were:

C1 T0	NIT1 Tf	GLU NO3 <0.8 Tf
C2 T0	NIT2 Tf	GLU NO3 <Gf/f Tf
C1 Tf	AMO1 Tf	GLU NH4 <0.8 Tf
C2 Tf	AMO2 Tf	GLU NH4 <Gf/f Tf
GLU1 Tf	C NO3 <0.8 Tf	ARA NO3 <0.8 Tf
GLU2 Tf	C NO3 <Gf/f Tf	ARA NO3 <Gf/f Tf
ARA1 Tf	C NH4 <0.8 Tf	ARA NH4 <0.8 Tf
ARA2 Tf	C NH4 <Gf/f Tf	ARA NH4 <Gf/f Tf

This is with the exception of the ice core where there was not sufficient water to run all the different conditions. For this experiment samples run were:

C1 T0	NIT1 Tf	C NO3 <0.8 Tf
C2 T0	NIT2 Tf	C NO3 <Gf/f Tf
C1 Tf	AMO1 Tf	C NH4 <0.8 Tf
C2 Tf	AMO2 Tf	C NH4 <Gf/f Tf.

Experiments ran on 17.6.10 and 24.6.10 had additional samples. There were:
C NO3 silver <0.2 Tf
C NO3 silver <0.8 Tf
C NH4 silver <0.2 Tf
C NH4 silver <0.8 Tf

TOTAL SAMPLES = 308

Date	Station Name	CTD	No. of Samples
14.6.10	North Sea	1	24
15.6.10	South Norwegian Sea	3	24
16.6.10	Central Norwegian Sea	5	24
17.6.10	Northern Norwegian Sea	7	28
18.6.10	South Greenland Sea	9	24
19.6.10	East Greenland Sea	11	24
24.6.10	Ice Station 1 – Under ice	/	28
29.6.10	Ice Station 2 – Under ice	/	24
30.6.10	Ice Core	/	12
4.7.10	Kongsfjord 3	33	24
6.7.10	Kongsfjord 4	42	24
8.7.10	Greenland Shelf	48	24
10.7.10	Greenwich Meridian	55	24

Dilution Experiments

All experimental water was from a depth of 5 meters. Bacterial abundance was the main point of interest for these experiments but counts of cyano-bacteria and pico-plankton were also obtained. Dilutions were 0%, 10%, 25%, 50%, 75% and 100% and each dilution was run in replicates of 3; A, B and C. samples for flow cytometry were taken at T0, T24 and T48 with the exception of the Greenland station where samples were taken at T0 and T24 only.

TOTAL SAMPLES = 306

Date	Station Name	CTD	T0	T24	T48	No. of Samples
26.6.10	Ice Station	/				54
29.6.10	Ice Station	/				54
4.7.10	KF3	33				54
6.7.10	KF4	42				54
8.7.10	Greenland	48			X	36
10.7.10	Greenwich Meridian	55				54

Calibration Experiments

Samples were for a bacterial production calibration experiment, only bacterial counts were obtained. Each time was run in replicates of 3; A, B and C.

TOTAL SAMPLES = 30

Date	Station	Time
28.6.10	Ice Station	0
		12
		24
		36
		48

Date	Station	Time
8.7.10	Greenland Shelf	0
		6
		12
		18
		24

Isotope Dilution Experiment

Bacterial counts were obtained for the 3 replicates of a 2 bacterial production isotope dilution experiment.

TOTAL SAMPLES = 6

Others

Elena's samples. Bacteria Only
Heather's samples. Bacteria, Cyano-bacteria, Pico-plankton.

TOTAL SAMPLES = 13

Date	Station Name	CTD	Bottle No.	Depth (m)
	Elena			
6.7.10				A
7.7.10				A
				B
				C
8.7.10				A
				B
				C

Date	Station Name	CTD	Bottle No.	Depth (m)
	Heather			
25.6.10	Ice Station	19		5
	Ice Station	19		10
	Ice Station	19		30
	Ice Station	19		50
	Ice Station	19		75
4.7.10	Kongsfjord 3	35		35

Slide Preps from JCR 219

Depth Profiles

Depth Profiles from CTDs.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 9 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Greenwich Meridian, 78º17N.0ºW, 8 samples

TOTAL SAMPLES = 51 x 4 (Bacteria, cyanobacteria, PNAN/HNAN, FISH)

Date	Station Name	CTD	Bottle No.	Depth (m)
24.6.10	Ice Station 1	18	6	5
	Ice Station 1	18	5	10
	Ice Station 1	18	4	16
	Ice Station 1	18	3	30
	Ice Station 1	18	2	45
	Ice Station 1	18	1	60
	Ice Station 1	ice	/	5
	Ice Station 1	ice	/	10
29.6.10	Ice Station 2	28	12	1
	Ice Station 2	28	10	5
	Ice Station 2	28	9	10
	Ice Station 2	28	7	11
	Ice Station 2	28	6	13
	Ice Station 2	28	4	25
	Ice Station 2	28	2	30
	Ice Station 2	28	1	36
	Ice Station 2	ice	/	5
	Ice Station 2	ice	/	10
4.7.10	Kongsfjord 3	33	11	5 A
	Kongsfjord 3	33	13	5 B
	Kongsfjord 3	33	14	5 C
	Kongsfjord 3	35	22	1
	Kongsfjord 3	35	20	3.5
	Kongsfjord 3	35	16	6.5
	Kongsfjord 3	35	14	15
	Kongsfjord 3	35	10	26
	Kongsfjord 3	35	5	45

Date	Station Name	CTD	Bottle No.	Depth (m)
6.7.10	Kongsford 4	42	6	5 A
	Kongsford 4	42	7	5 B
	Kongsford 4	42	8	5 C
	Kongsford 4	43	20	5
	Kongsford 4	43	16	10
	Kongsford 4	43	11	22
	Kongsford 4	43	7	30
	Kongsford 4	43	4	50
8.7.10	Greenland S.	48	10	5 A
	Greenland S.	48	11	5 B
	Greenland S.	48	12	5 C
	Greenland S.	49	21	2
	Greenland S.	49	16	9
	Greenland S.	49	11	14
	Greenland S.	49	7	29
	Greenland S.	49	3	50
10.7.10	Greenwich M.	55	10	5 A
	Greenwich M.	55	11	5 B
	Greenwich M.	55	12	5 C
	Greenwich M.	56	22	5
	Greenwich M.	56	10	10
	Greenwich M.	56	16	15
	Greenwich M.	56	14	18
	Greenwich M.	56	8	25

C- and N-Coupling Experiments

2 Samples for each date experiment was run, these are C1 T0 and C2 T0. All samples are from a depth of 5m.

TOTAL SAMPLES = 24 x 3 (Bacteria, cyanobacteria, PNAN/HNAN)

Date	Station Name	Sample
14.6.10	North Sea	C1 T0
	North Sea	C2 T0
15.6.10	South Norwegian Sea	C1 T0
	South Norwegian Sea	C2 T0
16.6.10	Central Norwegian Sea	C1 T0
	Central Norwegian Sea	C2 T0
17.6.10	Northern Norwegian Sea	C1 T0
	Northern Norwegian Sea	C2 T0
18.6.10	South Greenland Sea	C1 T0
	South Greenland Sea	C2 T0
19.6.10	East Greenland Sea	C1 T0
	East Greenland Sea	C2 T0

Date	Station Name	Sample
24.6.10	Ice Station 1 – Under ice	C1 T0
	Ice Station 1 – Under ice	C2 T0
29.6.10	Ice Station 2 – Under ice	C1 T0
	Ice Station 2 – Under ice	C2 T0
4.7.10	Kongsfjord 3	C1 T0
	Kongsfjord 3	C2 T0
6.7.10	Kongsfjord 4	C1 T0
	Kongsfjord 4	C2 T0
8.7.10	Greenland Shelf	C1 T0
	Greenland Shelf	C2 T0
10.7.10	Greenwich Meridian	C1 T0
	Greenwich Meridian	C2 T0

Sea Ice Cores

50mls filtered for each

TOTAL SAMPLES = 25 x 2 (Bacteria, PNAN/HNAN)

Date	Core	Depth
30.6.10	A	0-10
		10-20
		20-30
		30-40
		40-50
		50-60
		60-70
		70-77

Date	Core	Depth
30.6.10	B	0-10
		10-20
		20-30
		30-40
		40-50
		50-60
		60-70
		70-81

Date	Core	Depth
30.6.10	C	0-10
		10-20
		20-30
		30-40
		40-50
		50-60
		60-70
		70-80
		80-85

Bacterial Production – Calibration Experiment

TOTAL SAMPLES = 30 (Bacteria only)

Date	Time	Rep
28.6.10	0	A
		B
		C
	12	A
		B
		C
	24	A
		B
		C
	36	A

Date	Time	Rep
28.6.10		B
		C
	48	A
		B
		C
8.7.10	0	A
		B
		C
	6	A
		B

Date	Time	Rep
8.7.10		C
	12	A
		B
		C
	18	A
		B
		C
	24	A
		B
		C

Lugol's Fixed Samples from JCR 219

Depth Profiles

Depth Profiles from CTDs. 400mls fixed in 500ml amber glass bottles for lugols and 400mls in 500ml brown Nalgene for Buins/Glut/Form. On 8/7/10 there was not enough sample to get Buins/Form/Glut from 14m so 9m was used instead. The volumes fixed were 300/300/250mls for Buins/Form/Glut respectively.
24.6.10 (CTD no. 18) ICE Station 1, 80º43N.4º21E, 8 samples
29.6.10 (CTD no. 28) ICE Station 2, 80º16N.3º1E, 10 samples
4.7.10 (CTD no. 33 & 35) Kongsford 3, 79º6N.10º42E, 9 samples
6.7.10 (CTD no 42 & 43) Kongsford 4, 78º59N.6º42E, 8 samples
8.7.10 (CTD no 48 & 49) Greenland Shelf, 77º38N.5º42E, 8 samples
10.7.10 (CTD no 55 & 56) Grenwich Meridian, 78º17N.0ºW, 8 samples
TOTAL SAMPLES = 51

Date	Station Name	CTD	Bottle No.	Depth (m)	Notes
24.6.10	Ice Station 1	18	6	5	
	Ice Station 1	18	5	10	
	Ice Station 1	18	4	16	
	Ice Station 1	18	3	30	
	Ice Station 1	18	2	45	Bouins/Form
	Ice Station 1	18	1	60	
	Ice Station 1	Under ice	/	5	Bouins/Form
	Ice Station 1	Under ice	/	10	
29.6.10	Ice Station 2	28	12	1	
	Ice Station 2	28	10	5	
	Ice Station 2	28	9	10	
	Ice Station 2	28	7	11	
	Ice Station 2	28	6	13	
	Ice Station 2	28	4	25 DCM	Bouins/Form
	Ice Station 2	28	2	30	
	Ice Station 2	28	1	36	
	Ice Station 2	Under ice	/	5	Bouins/Form
	Ice Station 2	Under ice	/	10	
4.7.10	Kongsfjord 3	33	11	5 A	Bouins
	Kongsfjord 3	33	13	5 B	Form
	Kongsfjord 3	33	14	5 C	Glut
	Kongsfjord 3	35	22	1	FAO Alexey
	Kongsfjord 3	35	20	3.5	
	Kongsfjord 3	35	16	6.5	FAO Alexey
	Kongsfjord 3	35	14	15	Bouins/Form/Glut
	Kongsfjord 3	35	10	26	
	Kongsfjord 3	35	5	45	
6.7.10	Kongsford 4	42	6	5 A	Bouins
	Kongsford 4	42	7	5 B	Form
	Kongsford 4	42	8	5 C	Glut
	Kongsford 4	43	20	5	
	Kongsford 4	43	16	10	
	Kongsford 4	43	11	22	Bouins/Form/Glut
	Kongsford 4	43	7	30	
	Kongsford 4	43	4	50	
8.7.10	Greenland Shelf	48	10	5 A	
	Greenland Shelf	48	11	5 B	
	Greenland Shelf	48	12	5 C	
	Greenland Shelf	49	21	2	
	Greenland Shelf	49	16	9	Bouins/Form/Glut
	Greenland Shelf	49	11	14	
	Greenland Shelf	49	7	29	
	Greenland Shelf	49	3	50	
10.7.10	Greenwich Mer.	55	10	5 A	Bouins
	Greenwich Mer.	55	11	5 B	Form
	Greenwich Mer.	55	12	5 C	Glut
	Greenwich Mer.	56	22	5	
	Greenwich Mer.	56	10	10	
	Greenwich Mer.	56	16	15	
	Greenwich Mer.	56	14	18	Bouins/Form/Glut
	Greenwich Mer.	56	8	25	

Sea Ice Cores

TOTAL SAMPLES = 25

Date	Core	Depth
30.6.10	A	0-10
		10-20
		20-30
		30-40
		40-50
		50-60
		60-70
		70-77

Date	Core	Depth
30.6.10	B	0-10
		10-20
		20-30
		30-40
		40-50
		50-60
		60-70
		70-81

Date	Core	Depth
30.6.10	C	0-10
		10-20
		20-30
		30-40
		40-50
		50-60
		60-70
		70-80
		80-85

C- and N-Coupling Experiments

2 Samples for each date experiment was run, these are C1 T0 and C2 T0. 200mls was fixed in 250ml amber glass bottles. All samples are from a depth of 5m.

14.6.10 x 2 North Sea
15.6.10 x 2 South Norwegian Sea
16.6.10 x 2 Central Norwegian Sea
17.6.10 x 2 Northern Norwegian Sea
18.6.10 x 2 South Greenland Sea
19.6.10 x 2 East Greenland Sea
24.6.10 x 2 Ice Station – Under ice
29.6.10 x 2 Ice Station – Under ice
4.7.10 x 2 Kongsfjord 3
6.7.10 x 2 Kongsfjord 4
8.7.10 x 2 Greenland Shelf
10.7.10 x 2 Greenwich Meridian

TOTAL SAMPLES = 24

SCIENTIFIC REPORT 12: Pelagic microbial diveristy and deep water incubator trials.

Mike Zubkov and Ross Holland

Microbial Diversity

Seawater samples were drawn every 12 minutes from the ships non-toxic seawater supply and analysed flow cytometrically in order to characterise changes in composition and abundance of sea surface microbial communities at high resolution along a transect from Immingham, UK to Longyearbyen, Svalbard.

The first sample was drawn at 18:48 on 13/06/10 and the last sample was drawn at 12:48 on 19/06/10. Samples were drawn from the non-toxic seawater supply and fixed with paraformaldehyde (1% final concentration) using a liquid handling robot. Samples were stained with SYBR Green I DNA-specific dye and incubated in the dark for at least an hour before FC analysis using a Becton Dickinson FACSCalibur instrument. Populations were resolved on bivariate dotplots as follows:

Population	X parameter	Y parameter
Heterotrophic Bacterioplankton	Side scatter	Green (DNA) fluorescence
Synechococcus cyanobacteria	Green (DNA) fluorescence	Orange (phycoerithryn) fluorescence
Heterotrophic flagellates	Green (DNA) fluorescence	Red (chlorophyll) fluorescence
Phototrophic flagellates	Green (DNA) fluorescence	Red (chlorophyll) fluorescence

A number of samples were frozen for detailed molecular identification ashore at NOCS.

Deep Water Incubator trials

A novel incubator for determining in-situ microbial rates in the twighlight and abyssal waters was technically trailed. The incubator was deployed to a depth of 1000 m. Food dye of differing colour was injected into the top and bottom of all incubation bottles at 3 minute intervals using pre-programmed syringe-firing regime. The level of dye mixing within the bottles was assessed by sampling from the bottom, middle and top parts of the bottles for spectrophotometeric analyses ashore. The aim of the test was to assess the level of short-term mixing of reagents in future experimental deployments. Ship-board observation revealed that internal mixing within bottles was unsatisfactory and that modifications would have to be made to the apparatus before full experimental deployment.

SCIENTIFIC REPORT 13: Microplankton sampling by Micronet

Sian Lordsmith, Ray Leakey and Mike Zubkov

Introduction and Objectives

Micronet is a multiple plankton net, designed and custom made by Mike Zubkov, composed of a series of meshes nets of decreasing mesh size concurrent with increasing mesh area. On JR219 the net encompassed 3 mesh sizes: 150µm, 100µm and 40µm. The purpose of this unique design is to fractionate and concentrate differently sizes of microplankton cells within the water column. The outer nets slow the flow of water so that minimal damage is caused to delicate smaller cells, especially the ciliate fauna.

The objective of this study was to test the use of the Micronet in Arctic waters and use it ti concentrate and isolate individual microplankton cells for subsequent post-crusie taxonomic analysis.

Methodology

The net was lowered on the aft or bow deck crane. First there was an initial dip in and out of the water to wash the net allowing water to completely drain from the net. Upon draining, tubes with valves were attached to the 3 sample ports and the net was deployed on 50m of wire. The maximum depth the net achieved is unknown as despite lead weights the decent is not vertical and varying currents effected individual casts uniquely. The net was winched back to the surface at its slowest speed and the concentrate from the 40µm and 100µm meshes were collected in 500ml glass Durans bottles before being transferred into pre-cooled thermos flasks and stored in the ships 4°C CT room.

The <40µm size concentrate was of the most interest consisted of a densely populated “cell soup” of ciliates, diatoms, dinoflagellates and flagellates. All subsequent isolation and fixation of microplankton cells was undertaken on this fraction. For each Micronet deployment (see table), a subsample of the <40µm concentrate was placed in 100ml culture flasks and observed on-ship using a Zeiss Axiovert 200 inverted microscope prior to decided what further work should be carried out on the sample.

Sampling details and fixation
Sampling details are shown in Table 1. Where indicated, a 40 ml subsamples of <40µm concentrate fixed with:
2.5% final concentration Bouin’s fixative for post cruise analysis of ciliate taxonomy via protargol silver staining.
1% final concentration Lugol’s iodine fixative for post-cruise analysis of microplankton abundance and taxonomy.
1% final concentration gluteraldehyde for post cruise analysis of microplankton chlorophyll fluorescence and taxonomy by epifluorescence and electron microscopy.
1% final concentration formaldehyde for post-cruise analysis of microplankton chlorophyll fluorescence and taxonomy by epifluorescence and electron microscopy.
All samples were placed in 50 ml plastic tubes, labelled and stored in the ships 4°C CT room for post-cruise analysis.

Ciliates isolation for molecular and histological taxonomic analysis
Subsamples of <40µm concentrate were placed in watch glasses and observed using a binocular microscope set up in the ships 4°C CT room. Ciliate cells were isolated using a micropipettes constructed by drawing-out the tip of a Pasteur pipette. Cells were rinsed by transfer between a series of watch glasses containing 0.2 µm filtered seawater. Once a number of cells of specific cell

type were collected a subsample were either (a) fixed with either a 5% final conctration Bouin's solution, or (b) frozen at -80°C.

Culturing

Prior to departure on the cruise, enrichment media were prepared for the purpose of isolating specific cell types. The media were:
L1/2 for flagellates and dinoflagellates
L1/2 + Silica for diatoms
L1/2 + NaCl for ice flagellates and dinoflagellates
L1/2 + NaCl + Silica for ice diatoms
ASWP - Artificial sea water for protozoa
25mls of ASWP in 100ml culture flasks with a boiled barley grain.
Isolation of cells for culturing was attempted on 3 separate casts as indicated in Table 1. Isolation was undertaken on ship using a Zeiss Axiovert200 inverted microscope in settling chamber bases. The surface sea temperature on culturing days varied between 4 and 6°C, bearing this in mind isolation media and samples were kept cool whilst culturing using thermos flasks and ice. Several drops of <40µm concentrate were diluted in the relevant media and a variety of autotrophic cell types were picked out using micropipettes (constructed as outlined above). Single cells were placed in sterile 48 x 1.6 ml multi-well Costar tissue culture plates containing the relevant enrichment media. Completed plates were labelled and transferred to an on-board incubator set at 4°C (and with its own light source) for return to the Uk for further culturing of species, taxonomic identification and molecular analyses.

Table 1 Details of Micronet Sampling

Date	Event	Station	Latitude	Longitude	Notes
18.6.10	17	East Greenland Sea	72°45.210' N	008°15.920' E	100m let down from bow of ship – test with Mike and Ross
19.6.10	21	South Greenland Sea	77°09.420' N	011°17.530' E	100m let down from bow of ship – test with Mike and Ross
27.6.10	41	Ice Station	80°24.070' N	003°30.550' E	50m let down from aft deck of ship. Suspension Fixed. Ciliate isolation.
28.7.10	46	Ice Station	80°17.170' N	003°10.110' E	50m let down from aft deck of ship. Ciliate isolation.
29.6.10	53	Ice Station	80°15.500' N	002°48.030' E	50m let down from aft deck of ship. Suspension Fixed. Ray picked out ciliates?
1.7.10	60	Ice Station	80°13.140' N	002°10.080' E	50m let down from aft deck of ship. Ray picked out ciliates?
7.7.10	114	KF4	78°58.500' N	006°42.360' E	50m let down from aft deck of ship. Ray picked out ciliates?
8.7.10	126	Greenland Shelf	77°43.510' N	005°37.700' W	50m let down from bow of ship. Ray picked out ciliates?
8.7.10	127	Greenland Shelf	77°43.300' N	005°37.590' W	50m let down from bow of ship. Ray picked out ciliates?
9.7.10	138	Greenland Shelf	77°38.500' N	005°17.480' W	50m let down from bow of ship. Ray picked out ciliates?
10.7.10	149	Greenwich Meridian	78°17.000' N	000°00.000' E	50m let down from bow of ship. Ray picked out ciliates?
15.7.10	200	Smeerenburg	79°43.890' N	011°05.430' E	50m let down from bow of ship. Suspension Fixed. Ray picked out ciliates?
17.7.10	227	Hinlopenrenna	80°04.780' N	017°16.800' E	50m let down from bow of ship. Suspension Fixed. Ray picked out ciliates? Culturing.
18.7.10	244	Ice Edge	80°33.271' N	011°38.184' E	50m let down from aft deck of ship. Suspension Fixed. Ray picked out ciliates? Culturing.
19.7.10	253	West Svalbard Margin	79°29.170' N	006°43.310' E	50m let down from aft deck of ship. Suspension Fixed. Ray picked out ciliates? Culturing.

SCIENTIFIC REPORT 14: Bacterial production

Sharon McNeill, Sian Lordsmith and Ray Leakey

1.1 Introduction

Bacterial production was determined from radiolabelled ^{14}C-leucine and ^{3}H-thymidine incorporation during Legs 1 to 3 of the cruise (Bell 1993; Kirchman 1993). Depths for the water samples were chosen to correspond with those of the chlorophyll distribution in surface waters and and associated experimental studies. Sea-ice samples were in melted (liquid) form as provided by Ronnie Glud. A full list of bacterial production samples taken and analysed on board are shown in Tables 1 to 11.

1.2 Method

Leucine
Water samples were collected from the CTD Niskin bottles, placed in thermos flasks and stored in the ship's cold room until ready to process. Aliquots of 10µl leucine working solution (0.01 MBq ml^{-1}) were pipetted into 2ml sterile centrifuge tubes then additions of 1.6ml of water sample added. This was carried out in the ship's cold room. For each depth, two 1.6 ml samples were run for T_0, T_1, T_2 and T_3, and incubated in a coolbox at ambient temperatures in the dark. Samples were fixed with 80µl of 20% paraformaldehyde (giving a final concentration of 1%). Samples were then transferred to the radiochemistry lab for processing. 25mm GFF and 0.2µm polycarbonate filters, presoaked in 1mM non labelled leucine in separate petri dishes, were placed on a 25mm filter rig with the GFF as a backing filter. 2ml of deionised water was then added to the filter holder followed by the sample. Both 1.6 ml samples at each timepoint were combined and filtered as one. To remove the any remaining sample the tube was rinsed with deionised water. The concentrated sample on the 0.2µm polycarbonate filter was placed into a scintillation vial and dried overnight in the fumehood. 10ml Optiphase Hi-Safe II scintillant was then added and preliminary counts undertaken after 24 hours using the on-ship the scintillation counter. Samples were also returned to the UK for longer counts.

Thymidine
Experimental samples were held at ambient temperatures in the ship's cold room as above until ready to process. For each sample, a 9.84ml (volumes for leg 3 recorded in Table 9) was then pipetted into 50ml centrifuge tubes (pre-cooled to ambient temperature) and 160ul radiolabelled thymidine working solution (1.85 MBq ml^{-1}) added. One sample for T_0 was fixed with 10ml of ice cold 10% TCA with the remainder incubated at ambient temperatures in the dark for either 1 or 3 hours then fixed as before. Samples were then transferred to the radiochemistry lab for processing. 25mm GFF and 0.2µm polycarbonate filters, presoaked with 1mM non labelled thymidine in separate petri dishes, were placed on a 25mm filter rig with the GFF as a backing filter. Samples were then filtered and the sample tube was rinsed twice with 5ml deionised water. The concentrated sample on the 0.2um poycarbonate filter then processed as for leucine samples.

Calibration experiment - thymidine and leucine
For each experiment, three replicate 10 litre samples were collected by separate CTD Niskin bottles from the same depth. Each sample was then processed by diluting 100 ml with 900 ml of 0.2um Gelman Vacucap filtered water from the same replicate sample. Each replicate diltured samples was then placed in a 1 litre polycarbonate bottle, incubated in a screened deck tank, and sampled at T_0, T_6, T_{12}, T_{18} and T_{24} for thymidine and leucine incorporation (as outlined above), and bacterial counts by flow cytometer and DAPI slide preps (see Scientific Report 11)

Isotope dilution experiment - leucine

For each experiment, three replicate 10 litre samples were collected by separate NIO (under-ice) or CTD Niskin bottles. Each sample was then processed for radioactice leucine incorporation, as outlined above, but using differnent volumes of working solution to give different radioactivity spikes: 2, 5, 10, 20, 30, 40, 60, 80, 100nM. The 9 treatments were then incubated at ambient temperatures in the dark. Samples were fixed at T_0 and T_2 with 80µl of 20% paraformaldehyde, samples then process as above.

1.3 References

Bell, R.T. (1993). Estimating production of heterotrophic bacterioplankton via incorporation of tritiated thymidine. In: Kemp, P.F., Sherr, B.F., Sherr, E.B. and Cole, J.J. (eds.) *Handbook of methods in aquatic microbial ecology*, Lewis, USA, p. 495-503.

Kirchamn, D.L. (1993). Leucine incorporation as a measure of biomass production by heterotrophic bacteria.. In: Kemp, P.F., Sherr, B.F., Sherr, E.B. and Cole, J.J. (eds.) *Handbook of methods in aquatic microbial ecology*, Lewis, USA, p. 509-512.

Table 1: Leucine sampling Leg 1

Date	Leg	CTD	Depth	Depth (M)	Bottle	T0 (mins)	T1 (mins)	T2 (mins)	T3 (mins)	Comments
14/06/2010	1	2	1	1	23	0	60	120	180	
			2	5	20	0	60	120	180	D2 -1T0 filtered
			3	20	17	0	60	120	180	
			4	30	14	0	60	120	180	
			5	40	1	0	60	120	180	
15/06/2010	1	4	1	5	20	0	60	120	180	
			2	6	8	0	60	120	180	
			3	18	15	0	60	120	180	
			4	23	6	0	60	120	180	
			5	40	3	0	60	120	180	
16/06/2010	1	6	1	1	24	0	60	120	180	1 sample filtered for T3
			2	5	22	0	60	120	180	
			3	6	20	0	60	120	180	
			4	15	18	0	60	120	180	
			5	35	7	0	60	120	180	
17/06/2010	1	8	1	2	24	0	62	120	180	
			2	5	22	0	60	120	180	
			3	6	18	0	60	120	180	
			4	20	15	0	60	120	180	Possibly 1 sample @ T2 fixed at T1
			5	35	6	0	60	120	180	
18/06/2010	1	10	1	surface	24	0	60	120	180	
			2	5	22	0	60	120	180	
			3	6	19	0	60	120	180	
			4	16	18	0	60	120	180	
			5	40	6	0	60	120	180	
19/06/2010	1	12	1	surface	24	0	60	120	180	
			2	5	22	0	60	120	180	
			3	10	19	0	60	120	180	
			4	15	17	0	60	120	180	
			5	30	7	0	60	120	180	

Table 2: Leucine sampling Leg 2

Date	Leg	CTD	Depth	Depth (M)	Bottle	T0 (mins)	T1 (mins)	T2 (mins)	T3 (mins)	Comments
23/06/2010	2	15	1	5	11	0	60	120	180	
			2	18	9	0	60	120	180	
			3	30	6	0	60	120	180	
			4	46	5	0	60	120	180	
24/06/2010	2	18	1	5	6	0	60	120	180	
			2	10	5	0	60	120	180	
			3	16	4	0	60	120	180	
			4	30	3	0	60	120	180	
			5	45	2	0	60	120	180	Possibly T2 fixed at T1
			6	60	1	0	60	120	180	
		Ice water	7	5		0	60	120	180	
			8	10		0	60	120	180	T2 spill on filtration rig
26/06/2010	2	20/21	1	5	1	0	60	120	180	
			2	40	7	0	60	120	180	
			3	55	4	0	60	120	180	
			4	60	3	0	60	120	180	
27/06/2010	2	23	1	3	9	0	60	120	180	
			2	15	7	0	60	120	180	
			3	30	5	0	60	120	180	
			4	60	3	0	60	120	180	
29/06/2010	2	28	1	5	10	0	60	130	180	
			2	10	9	0	60	130	180	
		Ice water	3	10		0	60	130	180	
		A	4	5		0	60	130	180	
		B	5	5		0	60	130	180	
		C	6	5		0	60	130	180	

Table 3: Leucine sampling Leg 3

Date	Leg	CTD	Depth	Depth (M)	Bottle	T0 (mins)	T1 (mins)	T2 (mins)	T3 (mins)	Comments
04/07/2010	3	33	1	5A	11	0	60	120	180	Incubation temp. 2ºC.
			2	5B	13	0	60	120	180	
			3	5C	14	0	60	120	180	
		35	4	3.5	19	0	60	120	180	
			5	15	13	0	60	120	180	
			6	26	9	0	60	120	180	
			7	45	4	0	60	120	180	
06/07/2010	3	42	1	5A	6	0	60	120	180	Incubation temp. 6ºC
			2	5B	7	0	60	120	180	
			3	5C	8	0	60	120	180	
		43	4	5	20	0	60	120	180	
			5	10	15	0	60	120	180	
			6	22	10	0	60	120	180	
			7	30	6	0	60	120	180	
			8	50	4	0	60	120	180	
		Elena's Exp.	9	/	/	0	60	120	180	
07/07/2010	3	Elena's Exp.	1	/	/	0	60	120	180	Incubation temp. 6ºC
			2	/	/	0	60	120	180	
			3	/	/	0	60	120	180	
08/07/2010	3	48	1	5A	10	0	60	120	180	Incubation temp. -1ºC
			2	5B	11	0	60	120	180	
			3	5C	12	0	60	120	180	
		49	4	2	20	0	60	120	180	
			5	9	15	0	60	120	180	
			6	14	11	0	60	120	180	
			7	29	6	0	60	120	180	
		Elena's Exp.	1	/	/	0	85	120	180	T1 fixed late
			2	/	/	0	82	120	180	T1 fixed late
			3	/	/	0	80	120	180	T1 fixed late
09/07/2010	3	52	1	5	17	0	60	120	180	Incubation temp. -1ºC
			2	10	15	0	60	120	180	
			3	25	9	0	60	120	180	
			4	42	7	0	60	120	180	
10/07/2010	3	55	1	5A	10	0	60	120	180	
			2	5B	11	0	60	120	180	
			3	5C	12	0	60	120	180	Only one of the two leucine tubes
		56	4	5	21	0	60	120	180	was filtered from T1 and from T2
			5	15	16	0	60	120	180	
			6	18	13	0	60	120	180	
			7	25	7	0	60	120	180	

Table 4: Eric's leucine Leg 1

Date	Sample	T0 (mins)	T1 (mins)	T2 (mins)	T3 (mins)	Comments
14/06/2010	Control 1	11	60	120	180	T0 incubated for 11mins
	Control 2	11	60	120	180	
15/06/2010	Control 1	0	60	120	180	
	Control 2	0	60	120	180	

Table 5: Isotope dilution experiment

Date	Station	Replicate	T0 (time)	T2 (time)	Incubation time (mins)	Comments
30/06/2010	Ice	A	22:15	00:15	180	A,B and C at 5M depth taken from under the ice
			22:16	00:16	180	
			22:17	00:17	180	
		B	22:19	00:19	180	
			22:20	00:20	180	
			22:21	00:21	180	
		C	22:23	00:23	180	
			22:24	00:24	180	
			22:26	00:26	180	
09/08/2010	Greenland Shelf	A	14:10	16:10	180	Incubation temp. -1ºC.
			14:10	16:10	180	
			14:10	16:10	180	
		B	14:15	16:15	180	
			14:15	16:15	180	
			14:15	16:15	180	
		C	14:20	16:20	180	
			14:20	16:20	180	
			14:20	16:20	180	

Table 6: Leucine calibration experiment

Date	Station	Replicate	Time (T)	T0 (time)	T0 (mins)	T1 (mins)	T2 (mins)	T3 (mins)	Comments
26/06/2010	Ice	A	T0	20:02	0	60	120	180	
		B		20:05	0	60	120	180	
		C		20:07	0	60	120	180	
27/06/2010	Ice	A	T12	08:09	0	60	120	180	
		B		08:11	0	60	120	180	
		C		08:13	0	60	120	180	
		A	T24	20:15	0	80	120	180	T1 fixed late
		B		20:17	0	82	120	180	
		C		20:20	0	85	120	180	
28/06/2010	Ice	A	T36	08:18	0	60	120	180	
		B		08:20	0	60	120	180	
		C		08:22	0	60	120	180	
		A	T48	20:10	0	60	120	180	
		B		20:12	0	60	120	180	
		C		20:14	0	60	120	180	
08/07/2010	Greenland Shelf	A	T0	13:12	0	68	120	180	Incubation temp. -1ºC. T1 +8 minutes
		B	T0	13:15	0	65	120	180	T1 + 5 minutes
		C	T0	13:18	0	63	120	180	T1 + 3 minutes
		A	T6 + 8	19:20	0	60	120	180	
		B	T6 + 9	19:24	0	60	120	180	
		C	T6 + 8	19:26	0	60	120	180	T1 chamber was partially spilt on filtering.
09/07/2010	Greenland Shelf	A	T12 + 2	01:14	0	60	120	180	
		B	T12 + 2	01:17	0	60	120	180	
		C	T12 + 3	01:21	0	60	120	180	
		A	T18 + 26	07:38	0	60	120	180	
		B	T18 + 29	07:44	0	60	120	180	
		C	T18 + 28	07:46	0	60	120	180	
09/07/2010	Greenland Shelf	A	T24 + 11	13:23	0	60	120	180	
		B	T24 + 11	13:26	0	60	120	180	
		C	T24 + 10	13:28	0	60	120	180	

Table 7: Deckboard thymidine Leg 1

Date	Sample	Time T0	Time T1	Comments	Date	Sample	Time T0	Time T1	Comments
14/06/2010	control 1 (start)	12:31	13:31		17/06/2010	control 1 (start)	10:45	11:45	
	control 2 (start)	12:31	13:31			control 2 (start)	10:45	11:45	
	control 1 (end)	20:35	21:35			control 1 (end)	19:57	20:57	
	control 2 (end)	20:35	21:35			control 2 (end)	19:57	20:57	
	ARA1 TF		21:35	filter not covering rig completely, fast filtration		ARA1 TF		20:57	
	ARA2 TF		21:35			ARA2 TF		20:57	
	GLU1 TF		21:35			GLU1 TF		20:57	
	GLU2 TF		21:35			GLU2 TF		20:57	
	AMO1 TF		21:35			AMO1 TF		20:57	
	AMO2 TF		21:35			AMO2 TF		20:57	
	NIT1 TF		21:35			NIT1 TF		20:57	
	NIT2 TF		21:35			NIT2 TF		20:57	
15/06/2010	control 1 (start)	13:05	14:05		18/06/2010	control 1 (start)	11:00	12:00	
	control 2 (start)	13:05	14:05			control 2 (start)	11:00	12:00	
	control 1 (end)	20:33	21:33			control 1 (end)	19:35	20:35	T1 possible T0
	control 2 (end)	20:33	21:33			control 2 (end)	19:35	20:35	
	ARA1 TF		21:33			ARA1 TF		20:35	
	ARA2 TF		21:33			ARA2 TF		20:35	
15/06/2010	GLU1 TF		21:33			GLU1 TF		20:35	
	GLU2 TF		21:33			GLU2 TF		20:35	
	AMO1 TF		21:33			AMO1 TF		20:35	
	AMO2 TF		21:33			AMO2 TF		20:35	
	NIT1 TF		21:33			NIT1 TF		20:35	
	NIT2 TF		21:33			NIT2 TF		20:35	
16/06/2010	control 1 (start)	10:57	11:57		19/06/2010	control 1 (start)	11:05	12:05	
	control 2 (start)	10:57	11:57			control 2 (start)	11:05	12:05	
	control 1 (end)	19:35	20:35			control 1 (end)	17:55	18:55	
	control 2 (end)	19:35	20:35			control 2 (end)	17:55	18:55	
	ARA1 TF		20:35			ARA1 TF		18:55	
	ARA2 TF		20:35			ARA2 TF		18:55	
	GLU1 TF		20:35			GLU1 TF		18:55	
	GLU2 TF		20:35			GLU2 TF		18:55	
	AMO1 TF		20:35			AMO1 TF		18:55	
	AMO2 TF		20:35			AMO2 TF		18:55	
	NIT1 TF		20:35			NIT1 TF		18:55	
	NIT2 TF		20:35			NIT2 TF		18:55	

Table 8: Deckboard thymidine Leg 2

Date	Sample	Time T0	Time T1	Comments	Date	Sample	Time T0	Time T1	Comments
24/06/2010	control 1 (start)	12:38	13:38		30/06/2010	control 1 (start)	18:02	19:02	
	control 2 (start)	12:38	13:38			control 2 (start)	18:02	19:02	
	control 1 (end)	21:15	22:15			control 1 (end)	22:45	23:45	
	control 2 (end)	21:15	22:15			control 2 (end)	22:45	23:45	
	ARA1 TF		22:15			AMO1 TF		23:45	
	ARA2 TF		22:15			AMO2 TF		23:45	
	GLU1 TF		22:15			NIT1 TF		23:45	
	GLU2 TF		22:15			NIT2 TF		23:45	
	AMO1 TF		22:15						
	AMO2 TF		22:15						
	NIT1 TF		22:15						
	NIT2 TF		22:15						
29/06/2010	control 1 (start)	14:42	15:56	T1 = 74 mins					
	control 2 (start)	14:42	15:56						
	control 1 (end)	20:42	21:42						
	control 2 (end)	20:42	21:42						
	ARA1 TF		21:42						
	ARA2 TF		21:42						
	GLU1 TF		21:42						
	GLU2 TF		21:42						
	AMO1 TF		21:42						
	AMO2 TF		21:42						
	NIT1 TF		21:42						
	NIT2 TF		21:42						

Table 9: Deckboard thymidine Leg 3

Date	Sample	Time T0	Time T2	Comments	Date	Sample	Time T0	Time T2	Comments
04/07/2010	control 1 (start)	11:47	13:47	9.84mlsThymidine Stock 1	08/07/2010	control 1 (start)	12:42	14:42	9.84mls Thymidine Stock 2
	control 2 (start)	11:47	13:47	Incubation temp. 2ºC.		control 2 (start)	12:42	14:42	Incubation temp. -1ºC.
	control 1 (end)	20:25	22:25			control 1 (end)	19:11	21:11	
	control 2 (end)	20:25	22:25			control 2 (end)	19:11	21:11	
	ARA1 TF		22:25			ARA1 TF		21:11	
	ARA2 TF		22:25			ARA2 TF		21:11	
	GLU1 TF		22:25			GLU1 TF		21:11	
	GLU2 TF		22:25			GLU2 TF		21:11	
	AMO1 TF		22:25			AMO1 TF		21:11	
	AMO2 TF		22:25			AMO2 TF		21:11	
	NIT1 TF		22:25			NIT1 TF		21:11	
	NIT2 TF		22:25			NIT2 TF		21:11	
06/07/2010	control 1 (start)	12:00	13:00	9.84mls Thymidine Stock 2	10/07/2010	control 1 (start)	13:30	15:30	9.9mls Thymidine Stock 3
	control 2 (start)	12:00	13:00	Incubation temp. 6ºC.		control 2 (start)	13:30	15:30	Incubation temp. -1ºC.
	control 1 (end)	19:55	22:23	T2 + 28 minutes		control 1 (end)	19:30	21:30	
	control 2 (end)	19:55	22:23	T2 + 28 minutes		control 2 (end)	19:30	21:30	
	ARA1 TF		21:00	T2 + 5 minutes		ARA1 TF		21:30	
	ARA2 TF		21:00	T2 + 5 minutes		ARA2 TF		21:30	
	GLU1 TF		21:00	T2 + 5 minutes		GLU1 TF		21:30	
	GLU2 TF		21:00	T2 + 5 minutes		GLU2 TF		21:30	
06/07/2010	AMO1 TF		21:00	T2 + 5 minutes		AMO1 TF		21:30	
	AMO2 TF		21:00	T2 + 5 minutes		AMO2 TF		21:30	
	NIT1 TF		21:00	T2 + 5 minutes		NIT1 TF		21:30	
	NIT2 TF		21:00	T2 + 5 minutes		NIT2 TF		21:30	

Table 10: Thymidine ice core's leg 2

Date	Station	Sample	Time T0	Time T1	Incubation (mins)	Date	Station	Sample	Time T0	Time T1	Incubation (mins)
23/06/2010	K2	0-10cm	09:10	10:10	60	27/06/2010	K10	0-10cm	09:00	12:00	180
		10-20cm		10:10	60			10-20cm		12:00	180
		20-30cm		10:10	60			20-30cm		12:00	180
		30-40cm		10:10	60			30-40cm		12:00	180
		40-50cm		10:10	60			40-50cm	09:00	12:00	180
		50-60cm	09:10	10:10	60			50-60cm		12:00	180
		60-70cm		10:10	60			60-70cm		12:00	180
		70-80cm		10:10	60			70-80cm		12:00	180
		80-90cm		10:10	60			80-90cm	09:00	12:00	180
		90-100cm	09:10	10:10	60	27/06/2010	K12	0-10cm	09:00	12:00	180
23/06/2010	K3	0-10cm	09:14	10:14	60			10-20cm		12:00	180
		10-20cm		10:14	60			20-30cm		12:00	180
		20-30cm		10:14	60			30-40cm		12:00	180
		30-40cm		10:14	60			40-50cm	09:00	12:00	180
		40-50cm		10:14	60			50-60cm		12:00	180
		50-60cm	09:14	10:14	60			60-70cm		12:00	180
		60-70cm		10:14	60			70-80cm	09:00	12:00	180
		70-80cm		10:14	60	29/06/2010	K14	0-10cm	09:17	12:17	180
		80-90cm		10:14	60			10-20cm		12:17	180
		90-96cm	09:14	10:14	60			20-30cm		12:17	180
25/06/2010	K6	0-10cm	09:00	10:00	60			30-40cm	09:17	12:17	180
		10-20cm		10:00	60			40-50cm		12:17	180
		20-30cm		10:00	60			50-60cm	09:17	12:17	180
		40-50cm	09:00	10:00	60			60-70cm		12:17	180
		50-60cm		10:00	60			70-80cm	09:17	12:17	180
		60-70cm		10:00	60	29/06/2010	K15	10-20cm	09:15	12:15	180
		70-80cm		10:00	60			20-30cm		12:15	180
		80-90cm		10:00	60			30-40cm		12:15	180
		90-100cm	09:00	10:00	60			40-50cm		12:15	180
25/06/2010	K7	0-10cm	09:05	10:05	60			50-60cm	09:15	12:15	180
		10-20cm		10:05	60			60-70cm		12:15	180
		20-30cm		10:05	60			70-80cm		12:15	180
		40-50cm		10:05	60			80-bottom	09:15	12:15	180
		50-60cm	09:05	10:05	60						
		60-70cm		10:05	60						
		70-80cm		10:05	60						
		80-90cm	09:05	10:05	60						

Table 11:Thymidine calibration experiment Leg 2 and 3

Date	Station	Replicate	Time (T)	Incubartion start (time)	Incubation end (time)	Incubation (mins)	Comments
26/06/2010	Ice	A	T0	20:00	23:00	180	
		B		20:00	23:00	180	
		C		20:00	23:00	180	
		A	T12	08:05	11:05	180	
		B		08:05	11:05	180	
		C		08:05	11:05	180	
		A	T24	20:10		1620	fixed @ 27hrs incubation
		B		20:10	23:10	180	
		C		20:10	23:10	180	
		A	T36	08:15	11:30	195	fixed 15mins late
		B		08:15	11:30	195	
		C		08:15	11:30	195	
		A	T48	20:07	23:07	180	
		B		20:07	23:07	180	
		C		20:07	23:07	180	
08/07/2010	Greenland Shelf	A	T0	13:08	15:08	180	Incubation temp. -1ºC. 9.48mls Thymidine Stock 2 used
		B	T0	13:08	15:08	180	
		C	T0	13:08	15:08	180	
		A	T6 + 5	19:13	21:13	180	
		B	T6 + 5	19:13	21:13	180	
		C	T6 + 5	19:13	21:13	180	
09/07/2010		A	T12 + 2	01:10	03:10	180	
		B	T12 + 2	01:10	03:10	180	
		C	T12 + 2	01:10	03:10	180	
09/07/2010	Greenland Shelf	A	T18 + 21	07:29	09:29	180	9.9mls Thymidine Stock 2 used
		B	T18 + 21	07:29	09:29	180	
		C	T18 + 21	07:29	09:29	180	
		A	T24 + 10	13:18	15:18	180	9.9mls Thymidine Stock 3 used
		B	T24 + 10	13:18	15:18	180	
		C	T24 + 10	13:18	15:18	180	

SCIENTIFIC REPORT 15: Dissolved oxygen concentration, gross primary production, community respiration, net community production and size fractionated respiration (>0.8 µm, 0.8-0.2 µm).

Elena Garcia Martin

Background

Dissolved Oxygen (O_2) in seawater is produced by photosynthesis (P) and consumed by respiration (R) and photochemical reactions in the surface layer. The relationship between P and R represents the magnitude of biologically fixed C that is available for export to the deep ocean or for transference to upper levels of the marine food-web. Moreover, P/R represents the planktonic contribution to the marine and atmospheric CO_2 balances, as equilibrium between dissolved O_2 in seawater and the atmosphere is maintained through air-sea gas exchange.

The aims of this work were:
1. To quantify gross primary production (GPP) and community respiration (CR) of O_2 in photic waters with the Winkler technique.
2. To calibrate the O_2 sensor on the depth profiler.
3. To log and quantify continuously the CR with an oxygen electrode.
4. To measure community respiration and bacterial respiration with enzymatic techniques.

Methods

Discrete dissolved oxygen concentration

This was measured by automated precision Winkler titration performed with a Metrohm 721 DMS Titrino, utilising a potentiometric end point as described in Serret et al. (1999). The concentration of thiosulphate was calibrated every day.
CTD calibration. Five glass 125 mL bottle were filled with seawater taken directly from the Niskin bottles at 5 different depths using a silicone tube. Samples were fixed immediately and analysed during the following 24 hours.
For the P and CR measurements, seawater samples were collected daily from the depth profile in 10 L carboys (4 depths within the euphotic zone, Table 1). Each carboy was sub-sampled into 125 mL glass O_2 bottles (light and dark bottles) which were placed in on-deck incubators for 24 hours. The incubators were covered with neutral and blue density light filters simulating the PAR light in the water column, and temperature incubator was maintained with the underway water. Additional subsamples were fixed at the start of the incubation ('zero' sub-samples). Light and dark O_2 bottles were removed from the incubators after the 24h incubation period and fixed and analysed for O_2. Each treatment for each depth (Zero, Light and Dark) was replicated four times.
Production and respiration rates were calculated from the difference between the means of the replicate light and dark incubated bottles and zero time analyses (CR= Dark-Zero; Net community production (NCP) = Light-Dark; GPP = NCP + CR).

Continuous monitoring of in vitro O_2 evolution.

Eighty mL borosilicate respiration chambers (Unisense) were filled with seawater from the 10L carboy. Chambers (two replicates from one depth, Table 1) were sealed with a lid with a capillary pore to allow access for the oxygen microsensor. The pore size was sufficiently small to minimize the oxygen exchange between the sample inside the chamber and the water in the bath. Measurements of the dissolved oxygen were made using a Unisense microrespiration system (Unisense S/A, Aarhus, Denmark) with an internal tip diameter of 500 µm. Prior to each measurement, the microelectrode was calibrated using a two-point procedure with a 0% saturation dissolved oxygen concentration (50:50 volumes of a solution of ascorbic acid 0.1M and NaOH 0.3M) and a 100% saturation dissolved oxygen concentration (0.2 µm filtrated and vigorously bubbled sea water) endpoints at in situ temperature.
The respiration chambers were placed in a submerged rack in a temperature controlled water bath in complete darkness. Oxygen concentration was recorded every 10 second during 24 hours on a

chart recorder. Oxygen consumption rates were determined as the slope of the oxygen concentration decrease as a function of time.

In vivo INT-reduction analysis

One or two depths were analyzed with this enzymatic technique at each station (Table 2). Four replicates of 200-250 mL seawater samples were poured from the 10L carboys into plastic bottles. One replicate was immediately fixed by adding formaldehyde (2% w/v final concentration) and used as a killed control. Fifteen minutes later the remaining three replicates were inoculated with a sterile solution of 7.9 mM INT to a final concentration of 0.8 mM. The solution was freshly prepared for each experiment using Milli-Q water. After incubation (4 - 6 h), samples were fixed by adding formaldehyde in the same way as for the killed controls. After 15 minutes, samples were filtered through 0.8 and 0.2 µm pore size polycarbonate filters, air-dried for 1 min approximately, and stored frozen in 1.5 mL cryovials at –20°C until further processing.

Table 3. Station log for samples collected for communty respiration (CR) during JR219. The mark (*) indicates water sample collected also for oxygen microelectrode measurements

Date	CTD Number	Latitude (+ve N)	Longitude (+ve E)	Station ID	Niskin Sampled	Depth (m)
14/06/2010	CTD_002	56°24.730’	001°18.849’	North Sea	23	2
					20	5
					17	20
					14	28 *
15/06/2010	CTD_004	60°44.588’	002°43.670’	South Norwegian Sea	20	5
					15	28 *
					6	23
16/06/2010	CTD_006	65°02.420’	004°24.020’	Central Norwegian Sea	24	2
					22	5
					18	17
					7	35 *
17/06/2010	CTD_008	69°20.459’	006°22.420’	Northern Norwegian Sea	24	2
					22	5
					15	20
					6	35 *
18/06/2010	CTD_010	72°45.213’	008°15.930’	South Greenland Sea	24	2
					22	5
					18	16
					6	40 *
19/06/2010	CTD_012	77°09.421’	011°17.530’	East Greenland Sea	22	5
					19	15
					17	15
					7	30 *
23/06/2010	CTD_014	80°44.480’	004°39.050’	Ice Station	11	5 *
					9	18
					6	31
					5	46

Date	CTD Number	Latitude (+ve N)	Longitude (+ve E)	Station ID	Niskin Sampled	Depth (m)
24/06/2010	CTD_017	80°41.499’	004°19.086’	Ice Station	11	5
					3	45
				under ice		5
				under ice		10
26/06/2010	CTD_020/021	80°31.090’	004°09.870’	Ice Station	12	5 *
					7	39
					4	55
					3	60
27/06/2010	CTD_023	80°26.380’	003°39.740’	Ice Station	9	2 *
					7	15
					5	30
					3	60
29/06/2010	CTD_028	80°15,983’	002°55.148’	Ice Station	10	5
					2	10
				under ice		5
				under ice		10
30/06/2010	CTD_030	80°13.780’	002°29.790’	Ice Station	11	4 *
					6	10
					4	30
					3	61
04/07/2010	CTD_034/035	79° 01.000’	010° 42.050’	KF3	19	3 *
					13	15
					9	26
					4	45
06/07/2010	CTD_043	78° 58.520’	006° 42.390’	KF4	20/19/18	5 *
					15	10
					10	21
					6	30
08/07/2010	CTD_049	77° 46.630’	-005° 35.770’	Greenland Shelf	20	4 *
					15	8
					10	14
					6	29
09/07/2010	CTD_052/53	77° 36.054’	-006° 11.425’	Greenland Shelf	17	5 *
					15	10
					9	25
					7	42
10/07/2010	CTD_056	78° 16.997’	000° 00.015’	Greenwich Meridian	21	4 *
					13	18
					7	25
					4	51

Table 4. Station log for samples collected for community and bacterial respiration (CR, BR) for the enzymatic technique during JR219.

Date	CTD Number	Latitude (+ve N)	Longitude (+ve E)	Station ID	Niskin Sampled	Depth (m)	Comments
14/06/2010	CTD_001	56°24.730’	001°18.849’	North Sea		5	Eric´s Experiments
	CTD_002	56°24.730’	001°18.849’	North Sea	20	20	
15/06/2010	CTD_003	60°44.588’	002°43.670’	South Norwegian Sea		5	Eric´s Experiments
	CTD_004	60°44.588’	002°43.670’	South Norwegian Sea	15	28	
16/06/2010	CTD_005	65°02.420’	004°24.020’	Central Norwegian Sea		5	Eric´s Experiments
	CTD_006	65°02.420’	004°24.020’	Central Norwegian Sea	18	17	
17/06/2010	CTD_007	69°20.459’	006°22.420’	Northern Norwegian Sea		5	Eric´s Experiments
	CTD_008	69°20.459’	006°22.420’	Northern Norwegian Sea	15	20	
18/06/2010	CTD_09	72°45.213’	008°15.930’	South Greenland Sea		5	Eric´s Experiments
	CTD_010	72°45.213’	008°15.930’	South Greenland Sea	18	16	
19/06/2010	CTD_011	77°09.421’	011°17.530’	East Greenland Sea		5	Eric´s Experiments
	CTD_012	77°09.421’	011°17.530’	East Greenland Sea	19	15	
23/06/2010	CTD_014	80°44.480’	004°39.050’	Ice Station	6	31	
24/06/2010	CTD_017	80°41.499’	004°19.086’	Ice Station		5	
26/06/2010	CTD_020/021	80°31.090’	004°09.870’	Ice Station	12	5	Eric´s Experiments
27/06/2010	CTD_023	80°26.380’	003°39.740’	Ice Station	9	2	
29/06/2010	CTD_028	80°15,983’	002°55.148’	Ice Station	10	5	
30/06/2010	CTD_030	80°13.780’	002°29.790’	Ice Station	11	4	
04/07/2010	CTD_034/035	79° 01.000’	010° 42.050’	KF3	19	3	
	CTD_034/035	79° 01.000’	010° 42.050’	KF3	4	45	
06/07/2010	CTD_043	78° 58.520’	006° 42.390’	KF4	15	10	
	CTD_043	78° 58.520’	006° 42.390’	KF4	10	21	
	CTD_043	78° 58.520’	006° 42.390’	KF4	6	30	
08/07/2010	CTD_049	77° 46.630’	-005° 35.770’	Greenland Shelf	15	8	
	CTD_049	77° 46.630’	-005° 35.770’	Greenland Shelf	10	14	
	CTD_049	77° 46.630’	-005° 35.770’	Greenland Shelf	6	29	
09/07/2010	CTD_052/53	77° 36.054’	- 006° 11.425’	Greenland Shelf	17	5	Eric´s Experiments
10/07/2010	CTD_056	78° 16.997’	000° 00.015’	Greenwich Meridian	21	4	
	CTD_056	78° 16.997’	000° 00.015’	Greenwich Meridian	13	18	

Table 5. Station log for samples collected for discrete dissolved oxygen concentration to callibrate the CTD oxygen sensor.

Date	CTD Number	Latitude (+ve N)	Longitude (+ve E)	Station ID	Niskin Sampled	Depth (m)
14/06/2010	CTD_002	56°24.730’	001°18.849’	North Sea	23	2
					20	5
					17	20
					14	28
					1	40
15/06/2010	CTD_004	60°44.588’	002°43.670’	South Norwegian Sea	20	5
					15	28
					6	23
					3	40
					1	80
16/06/2010	CTD_006	65°02.420’	004°24.020’	Central Norwegian Sea	24	2
					22	5
					18	17
					7	35
					4	38
					2	60
17/06/2010	CTD_008	69°20.459’	006°22.420’	Northern Norwegian Sea	24	2
					22	5
					15	20
					6	35
					2	80
18/06/2010	CTD_010	72°45.213’	008°15.930’	South Greenland Sea	24	2
					22	5
					18	16
					6	40
					2	80
19/06/2010	CTD_012	77°09.421’	011°17.530’	East Greenland Sea	22	5
					19	15
					17	15
					7	30
					3	100

Results
In total, 17 experiments were carried out for the determination of GPP and CR, 15 for the continuous monitoring of in vitro O_2 and 17 for in vivo INT respiration.

The O_2 concentration data from the titrations and corresponding O2 sensor data are shown in Figure 1. The data show that the O2 sensor and Winkler attained similar values, being the equation regression not different from 1 ($p = 0.48$, $n = 31$). This suggests that no relevant "drift" on the sensor occurred during this leg in this cruise.

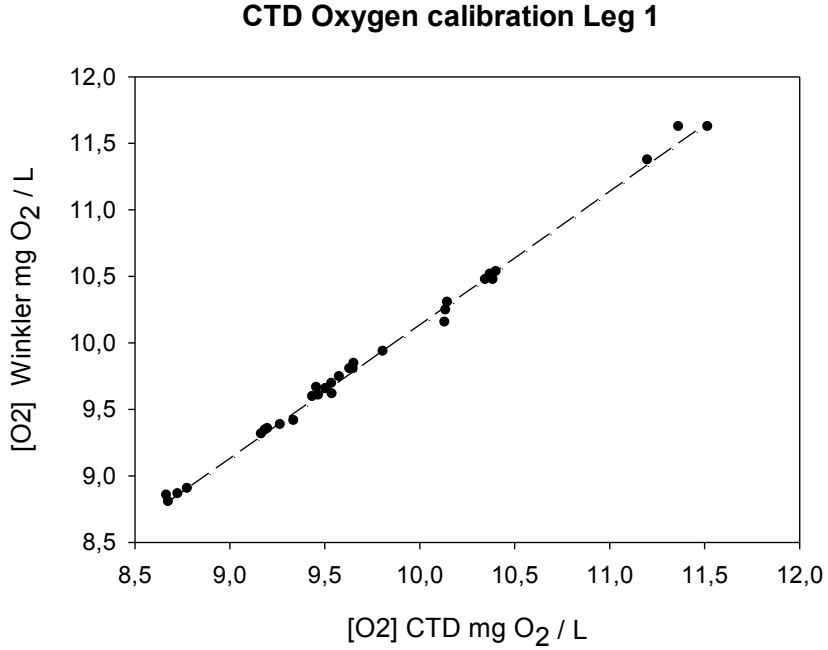


Figure 13. Calibration of O2 sensor on the Conductivity Temperature Depth profiler. O2 determined by Winkler titration against sensor data.

Preliminary results of GPP and CR showed an increasing production pattern in the UK-Svaldbard transect, being more productive as we were reaching arctic waters, except the South Greenland Sea station where low values of production were found (Table 6, Figure 2). Net autotrophy was predominantly encountered in this transect except in the North Sea station were net heterotrophy was recorded.

The ice stations were less productive compared to the free open waters, although net autotrophy was seen in almost all the stations (4 out of 5).

GPP and CR, from water taken at the same point under the ice and from the CTD open water, were compared at one of the stations. The results showed that GPP and CR were higher in the open waters than in the under-ice sample. This result might be explained by the light limitation of algae under the under-ice experiment.

The Greenland-Svaldbard transect did not show any clear pattern in GPP and CR.

Final results will be delivered to BODC by the end of November 2011.

Results obtained with the oxygen electrode will be further revised and data will be complimented and corrected with temperature changes inside the water bath as bubbles appeared inside the chambers in nearly all the stations. The bubbles could be caused by differences in temperature of the samples and the incubation bath, and also, by the melting of micro ice crystals.

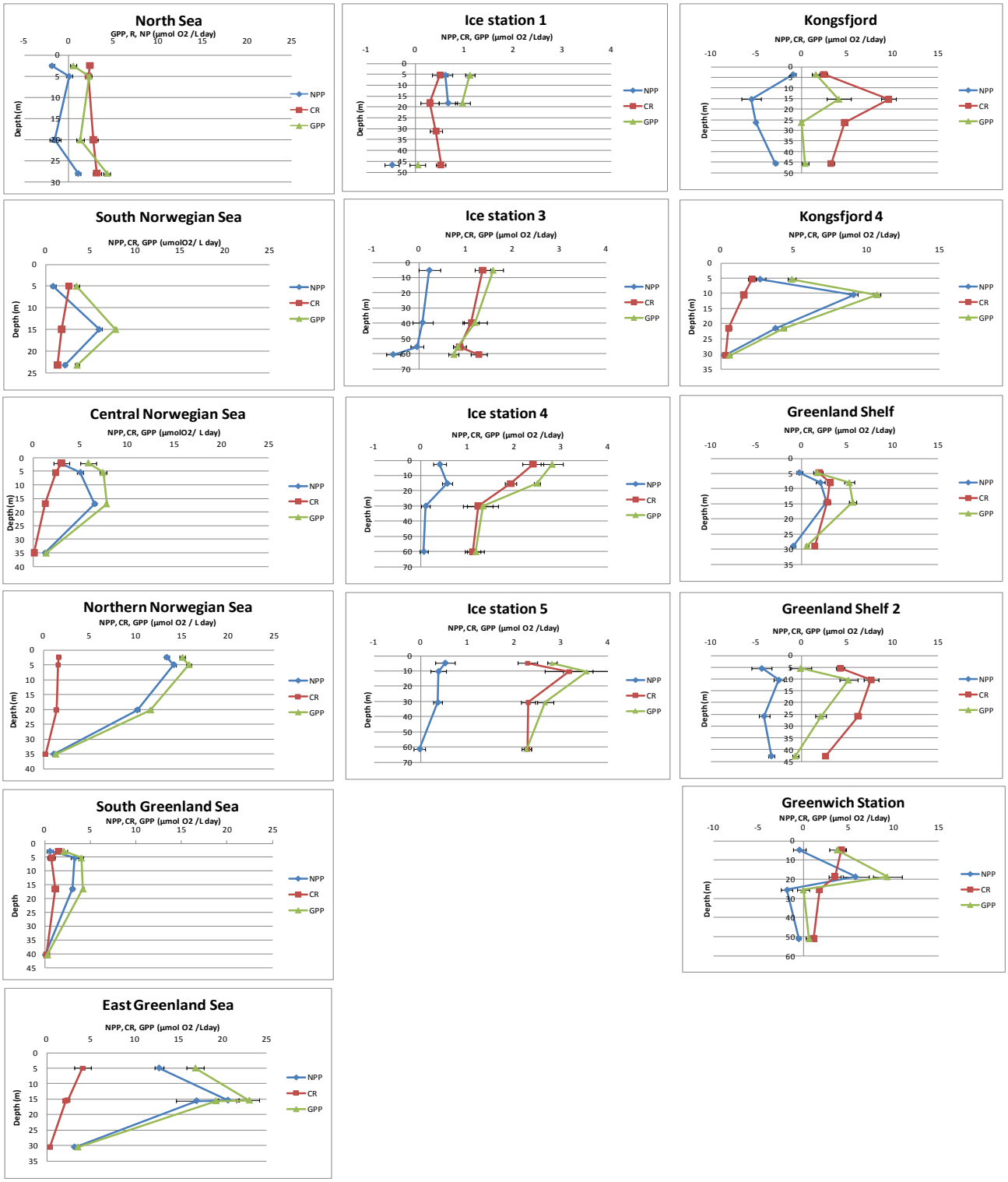


Figure 2. NCP, CR and GPP of the station sampled. Error bars correspond to the propagated standard error.

Temperature problems with the water bath hindered a good acquisition data.

Community and bacterial respiration measured with the INT technique will be analyzed in the lab during the following months.

All final data will be available by November 2011.

Table 6. Integrated rates of primary production and respiration within the euphotic layer of the water column during Leg1-3 of the Arctic cruise 2010.

Day	Latitude	Longitude	Station	integrated GPP	s.e	integrated CR	s.e	integrated NPP	s.e
				mmol O_2 m^{-2} day^{-1}		mmol O_2 m^{-2} day^{-1}		mmol O_2 m^{-2} day^{-1}	
14/06/2010	56,40	1,31	North Sea	53,79	4,68	73,80	4,58	-14,58	5,89
15/06/2010	60,74	2,73	South Norw Sea	120,70	2,88	48,42	3,76	69,26	2,73
16/06/2010	65,03	4,40	Central Norw Sea	206,53	3,26	49,74	3,85	151,41	3,31
17/06/2010	69,34	6,37	Northern Norw Sea	381,55	3,18	43,87	2,44	304,82	3,38
18/06/2010	72,76	8,26	South Greenland Sea	113,29	2,20	34,40	3,55	78,31	4,31
19/06/2010	77,15	11,29	East Greenland Sea	467,25	20,21	73,40	7,00	332,36	19,22
23/06/2010	80,74	4,65	Ice 1	33,83	1,78	19,96	2,60	11,73	2,04
26/06/2010	80,51	4,16	Ice 3	76,51	6,29	71,27	4,41	5,27	6,01
27/06/2010	80,45	3,66	Ice 4	107,08	6,46	92,31	6,24	14,05	2,40
30/06/2010	80,23	2,50	Ice 5	170,14	6,40	152,18	6,32	16,45	3,40
04/07/2010	79,00	10,07	Kongsfjord	61,35	11,73	236,23	8,27	-170,73	8,93
06/07/2010	78,97	6,70	Kongsfjord 4	172,00	2,56	37,16	2,27	122,00	2,94
08/07/2010	77,77	5,60	Greenland Shelf	100,33	4,51	68,38	3,47	34,46	4,14
09/07/2010	77,60	6,19	Greenland Shelf Edge	80,93	13,04	235,15	7,70	-124,45	10,85
10/07/2010	78,28	0,00	Greenwich	150,47	17,63	130,32	8,66	25,59	15,58

References:

Serret P., Fernández E., Sostres J.A., Anadón R., 1999. Seasonal compensation of plankton production and respiration in a temperate sea. Marine Ecology Progress Series 187: 43–57.

Acknowledgement

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SCIENTIFIC REPORT 16: Viral lysis and lysogeny

Elaine Mitchell

Summary

This work was undertaken in collaboration with Elanor Bell (SAMS).

The aim was to investigate viral-bacterial interactions at the Ice station (Leg 2) to support some interesting findings that were discovered from the previous cruise (JC210). This involved collecting water from the sea-ice surface and up to 5m under the sea-ice to measure viral abundance and production within the Ice environment.

Introduction

Virus-like particles (VLP; a term including both infectious and non-infectious viruses[1]) are abundant in all aquatic environments, marine and freshwater. Viruses are responsible for 20-50% of bacterial mortality in the water columns of these environments[2] and up to 100% in sediments[3]. Viruses can infect and exploit bacterial cells (or indeed any other type of cell, e.g. phytoplankton) in two ways (Figure 1):

a) During what is termed the *lytic pathway* (1) infectious virus particles bind to the wall of a suitable host bacterial cell and inject viral DNA into the cell's cytoplasm. (2) The viral DNA takes over the host cell's genetic machinery and causes the bacterial cell to produce viral proteins and copies of viral DNA. (3) The viral proteins are then assembled into coats and the viral DNA is packed inside, (4) creating new, viral particles. (5) These replicated virus particles cause the rupture, or *lysis*, of the bacterial cell membrane, killing the cell and releasing infectious virus particles into the surrounding environment. Then, they can go on to infect other bacteria;

b) Alternatively, during the *lysogenic pathway* infectious viruses occupy bacterial cells and use them as factories for replicating viral genes. (1) The viral DNA injected into the bacterial cell is integrated into bacterial DNA. (2) The bacterial cell continues to grow and (3) reproduce as normal and (4) passes viral DNA onto all of its descendents or daughter cells. (5) The infected bacterial cell then either continues to grow and divide following the lysogenic pathway passing on viral DNA with its own, or enters the lytic pathway which ultimately leads to the death of the infected bacterial cells, the release of virus particles into the environment and a new cycle of infection.

In pelagic environments, virus-induced lysis of bacteria provides a major source of dissolved organic matter for phytoplankton[4] because when the bacterial cell membranes are ruptured, all of the carbon and nutrients stored within the bacterial cell are released into the surrounding environment along with the virus particles. The same is true of phytoplankton lysed due to viral infection. Phytoplankton, such as green algae, can use the released organic material as an energy and mineral source for their own growth and reproduction. Thus, virus-induced mortality of bacteria has far reaching consequences for microbial population dynamics and biogeochemical (e.g. carbon) cycling[5].

Nevertheless, huge gaps exist in our knowledge. Scientists have very little understanding of the environmental processes that affect viral abundance, virus-induced bacterial mortality and the

[1] http://www.answers.com/topic/virus-like-particle
[2] Weinbauer MG. 2004. Ecology of Prokaryotic viruses. *FEMS Microbiological Reviews* **28**: 127-181.
[3] Corinaldesi C, Dell'Anno A, Danavaro R. 2007. Viral infection plays a key role in extracellular DNA dynamics in marine anoxic systems. *Limnology & Oceanography* **52**: 508-516.
[4] Fuhrman JA. 1999. Marine viruses and their biogeochemical and ecological effects. *Nature* **399**: 541-548.
[5] Middelboe M, Riemann L, Steward F, Hansen V, Nybroe O. 2003. Virus-induced transfer of organic carbon between marine bacteria in a model community. *Aquatic Microbial Ecology* **33**: 1-10.

subsequent activity of microbial communities. Gaining such knowledge is essential for assessing the role VLP play in bacterial mortality and biogeochemical cycles, e.g. local and global carbon cycling[5], and the influence that global climate change will have upon them. Climate change is likely to alter virus-bacteria dynamics; potentially increasing the vulnerability of bacteria (and algae) to viral infection.

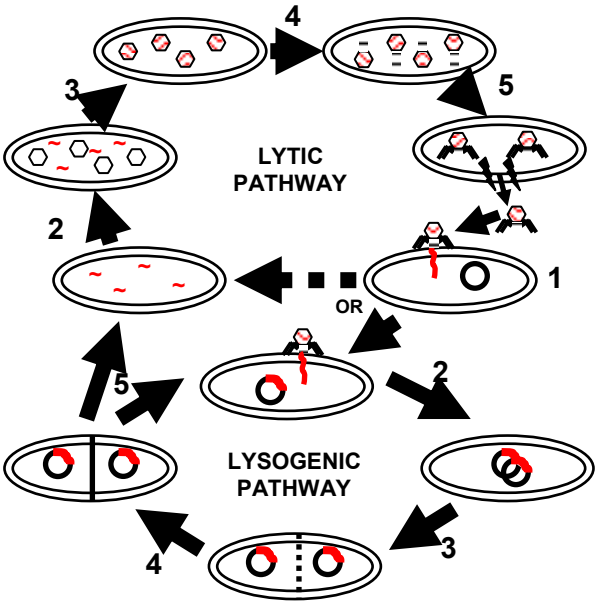

Figure 1: Viral replication pathways. Redrawn and modified from C. Evers
http://web.mit.edu/esgbio/www/cb/virus/phagereplication.html

Method – Viral production.

Water samples were collected at the Ice station from three different depths: Ice brine pool, 1m and 5m below the Ice. One litre of seawater was collected in triplicate from each depth. The surface sample was collected directly into 1 Litre brown Nalgene bottles. The 1m & 5m samples were collected by a hand held NIO bottle lowered through a previously made ice sampling hole in the ice flow. This water was pre-filtered through a 47mm GF/C filter to remove grazers.

In order to measure the rate of viral *lysogeny* 150ml of GF/C filtered water from each depth was dispensed into duplicate, acid washed, 250ml brown Nalgene bottles. A 4.5ml sub-sample of water was immediately removed (T_0) from each bottle, placed in a sterile 5ml cryovial and fixed with 1% final concentration of EM grade glutaraldehyde and stored in the refrigerator (ca. 4°C). The bottles were incubated in the dark, under continuously flowing seawater at *in situ* temperatures for 24 hours. Further sub-samples were taken at time intervals of 6, 12, 12.5, 18 and 24 hours. Immediately after the 12h sub-sampling, 205µl Mitomycin C (final concentration of 1µl ml^{-1}) was added to one of each duplicate per depth to induce lysogeny. At the end of the experiment all cryovials were snap-frozen in liquid nitrogen before being stored in a -80°C freezer.

In order to investigate the rate of viral *lysis* 300ml of GF/C filtered water was filtered-concentrated through a 47mm 0.2µm polycarbonate filter to remove the majority of viruses from the sample.The filter was never allowed to run dry and the sample was continuously but gently agitated using a

sterile Pasteur pipette. Simultaneously, approximately 100ml of the 0.2µm filtered filtrate was passed through a 0.2µm Anodisc filter to produce virus free water. Once the sample had been filter concentrated to an approximate10ml retentate it was resuspended with approximately 50ml of virus-free water. 50ml of the resuspended retentate was then placed into a sterile 25cm² culture flask and incubated in the dark, under continuously flowing seawater at in situ temperatures for 24 hours. 5ml sub-samples were removed from each replicate at 0, 6, 12, 18 and 24 hours after the start of the incubation, and placed into a sterile cryovial. The sub-samples were fixed with EM grade glutaraldehyde to a final concentration of 1% in fume hood and stored in the dark in a refrigerator (ca. 4°C). At the end of the experiment all cryovials were snap-frozen in liquid nitrogen before being stored in a -80°C freezer.

The glutaraldehyde-fixed sub samples from both experiments will be used for the post-cruise preparation microscope slides and also be processed using Flow cytometry to enumerate the population abundance.

JCR219 Viral experiment sampling

Date	Station	Bottles	Depth (m)	Lysogeny	Lysis
30/06/2010	Ice Station	Hand Collection	Ice brine pool	√	√
		Hand Collection	Ice brine pool	√	√
		Hand Collection	Ice brine pool	√	√
		Hand Collection	1	√	√
		Hand Collection	1	√	√
		Hand Collection	1	√	√
		Hand Collection	5	√	√
		Hand Collection	5	√	√
		Hand Collection	5	√	√

JCR219 Sampling times

Date	Time	Time point	No samples taken	Lysogeny	Lysis
30/06/2010	23:45:00	T0	18	√	
01/07/2010	04:00:00	T0	9		√
01/07/2010	05:45:00	T6	18	√	
01/07/2010	10:00:00	T6	9		√
01/07/2010	11:45:00	T12	18	√	
01/07/2010	12:30:00	T12.5	18	√	
01/07/2010	16:00:00	T12	9		√
01/07/2010	17:45:00	T18	18	√	
01/07/2010	22:00:00	T18	9		√
01/07/2010	23:45:00	T24	18	√	
02/07/2010	04:00:00	T24	9		√

SCIENTIFIC REPORT 17: Protozooplankton bacterivory

Elaine Mitchell, Sian Lordsmith and Ray Leakey

Introduction and Objectives

The objective of this study was to experimentally determine protozooplankton bacterivory rates at the sub-surface chlorophyll maximum at different sampling stations during the cruise. Sampling details are shown in the tables below. Experimental samples were collected for post-cruise analysis on return to the UK.

Approach and Methodology

Grazing rates were measured during the cruise using a dilution approach in which bacteria are uncoupled from their protozoan predators by serial dilution of the natural community. Experimental are then incubated and bacterial growth and protozoan bacterivory under differing predation pressures determined from changes in bacterial abundance measured by flow cytometry.

Experimental water was collected by CTD rosette from the chlorophyll maximum depth (table 1). 5 litres of water from each of 3 replicate Niskin bottles were then passed through 150µm mesh and collected into 10 L Nalgene carboys which were then held at ambient temperature in the ships cool room.

From each replicate carboy, 2 Litres were filtered through a 0.2µm ‘Gelman Vacucap’ bottle top filter into a sterile duran bottle to produce bacterial free-water. This ‘dilutant’ was mixed with the unfiltered water from the same carboy to produce 100ml volumes of the following concentrations of unfiltered seawater: 0% 10% 25% 50% 75% 100%. Each 100 ml volume was placed in a 125ml Nalgene polycarbonate bottles which were incubated in the deck incubator for up to 2 days in low light (Lee Filter n°299 resulting in 6.6 % of incident irradiance) at ambient water temperature (table 2). Sub-samples of 4 ml were taken at 0, 24 and 48 hours intervals and preserved with paraformaldehyde (1% final concentration) in Cryovial tubes. The first two dilution experiment samples were run straight way on the AFC. Samples from the remaining four experiments were stored in the -80°C freezer for post-cruise analysis by flow cytometry back at the lab.

Table 1. Sampling details for protozooplankton bacterivory experiements

Date	26th June			**Date**	29th June			**Date**	4th July		
Station	Ice Station			**Station**	Ice Station			**Station**	Ice Station		
Event No				**Event No**				**Event No**	65		
Bottle	**Depth**	**Rep**	**Samples**	**Bottle**	**Depth**	**Rep**	**Samples**	**Bottle**	**Depth**	**Rep**	**Samples**
Ice Hole	5m	A	1	Ice Hole	5m	A	1	11	5m	A	1
	5m	B	1		5m	B	1	13	5m	B	1
	5m	C	1		5m	C	1	14	5m	C	1
Total			3	Total			3	Total			3

Date	6th July			**Date**	8th July			**Date**	10th July		
Station	Ice Station			**Station**	Ice Station			**Station**	Ice Station		
Event No	98			**Event No**	118			**Event No**	142		
Bottle	**Depth**	**Rep**	**Samples**	**Bottle**	**Depth**	**Rep**	**Samples**	**Bottle**	**Depth**	**Rep**	**Samples**
6	5m	A	1	10	5m	A	1	10	5m	A	1
7	5m	B	1	11	5m	B	1	11	5m	B	1
8	5m	C	1	12	5m	C	1	12	5m	C	1
Total			3	Total			3	Total			3

Table 2. Experimental details for protozooplankton bacterivory experiements

	Ice 26/6	**Ice 29/6**	**KF3 4/7**	**KF4 6/7**	**Greenland 8/7**	**Greenwhich 10/7**
Dilutions	6	6	6	6	6	6
Times	3	3	3	2	3	3
Rep	3	3	3	3	3	3
Total Sub samples	54	54	54	36	54	54

SCIENTIFIC REPORT 18: Protozooplankton hervivory

Sian Lordsmith, Elaine Mitchell and Ray Leakey

Introduction and Objectives

The objective of this study was to experimentally determine protozooplankton herbivory rates at the sub-surface chlorophyll maximum at different sampling stations during the cruise. Sampling details are shown in table 1. Experimental samples were collected for post-cruise analysis on return to the UK.

Table 1. FLA experiment sampling details

Date	26th June			**Date**	6th July			**Date**	9th July		
Station	Ice Station			**Station**	KF4			**Station**	Greenland shelf		
Event No				**Event No**	98			**Event No**	134		
Bottle	**Depth**	**Rep**	**Samples**	**Bottle**	**Depth**	**Rep**	**Samples**	**Bottle**	**Depth**	**Rep**	**Samples**
Ice Hole	5m	A	1	6	5m	A	1	19	5m	A	1
	5m	B	1	7	5m	B	1	20	5m	B	1
	5m	C	1	8	5m	C	1	21	5m	C	1
Total			3	Total			3	Total			3

Approach and Methodology

Grazing rates were measured during the cruise using fluorescently labelled algae (FLA) as tracers of ingestion (Sherr and Sherr 1993 Protistan grazing rates via uptake of fluorescently labelled prey. In Kemp, et al. Eds. *Handbook of methods in aquatic microbial ecology*). FLA were prepared in the UK from cultured algal cells which had been fluorescently labelled with DTAF stain and stored frozen until use on ship. A single direct FLA assay was conducted in which water samples were incubated with a single concentration of FLA for up to 80 minutes with uptake of FLA by individual protozoan cells observed using fluorescence microscopy.

Experimental water was collected by CTD rosette from the chlorophyll maximum depth. 5 litres of water from each of 3 replicate Niskin bottles and collected into 10 L Nalgene carboys which were then held at ambient temperature in the ships cool room. From each replicate carboy, 3 litres was placed in a polycarbonate bottle and one of three types of FLA (*Chlorella stigmatophora* CCAP 211/20*, Pycnococcus provasolii* CCAP 190/1 or *Duniella tertiolecta* CCAP 19/6B) were added to the natural sample at a density of 1000 FLA ml^{-1}. After 0, 5, 10, 20, 40 and 80 minutes, 300ml was removed and poured into 500 ml glass amber bottles containing 3mls of Lugol's iodine to fix the sample (1% final concentration) (table 2). The samples were then stored at 4°C for post-cruise analysis of FLA uptake per cell by inverted epifluorescence microscopy.

Table 2. FLA experiment details

	Ice 26/6	**KF4 6/7**	**Greenland 9/7**
Times (mins)	6	6	6
Rep	3	3	3
FLA *Chlorella*	1	1	1
FLA *Duniella*	1	1	1
FLA *Pycnococcus*	1	1	1
Total Sub samples	54	54	54

SCIENTIFIC REPORT 19: Plankton wheel test

Sian Lordsmith and Ray Leakey

Introduction

The purpose of the experiment was to determine the best conditions in which to incubate live microbial plankton samples which result in minimal changes to the abundances and dynamics of the sample community. For several experimental techniques (e.g. fractionation, dilution and fluorescence labelled particle uptake) it is necessary to study live samples over a period of time. In such studies it is important to limit and to understand those variables that are out of our control so that any changes observed over time can be more confidently attributed to the deliberate alterations of the experiment rather than the unknown 'bottle effects'.

Method

The experiment was set up on the 17th of August at 80º 04.786N, 017º 16.830E. At 16:40 three Niskin bottles were fired from CTD no. 80 at a depth of 5m: bottle nos. 20, 21 and 22. This was the same the depth as that from which most microbial experimental waters were collected on the JR219 cruise. The water temperature was around 6ºC.

Three Carboys were filled from the three CTD bottles. Bottle 20 became Rep A, bottle 21, Rep B and bottle 22, Rep C. Carboys were stored in the dark in the ships CT room (set to 4ºC). At 21:15 the experiment was started. A 200ml sub-sample was taken from each replicate and fixed with 2mls Lugols iodine (final conc.1% Lugols) and stored in 250ml amber glass bottles. A further 5mls was removed and fixed with 50ul paraformaldehyde (final conc. 2.5% PFA) in 5ml cryovials and frozen at -80 ºC. These were the T-zero samples (see Figure 1).

1 litre from each carboy was gently decanted into 4 x 250ml Nalgene clear polycarbonate bottles. For each replicate, 250 ml samples were subjected to one of 4 treatments:
One bottle was put onto a plankton wheel in the CT room to be slowly and continuously inverted (= WHEEL).
One bottle was left next to the wheel to be left stationary (= CT LIGHT).
One bottle was left next to the wheel but this time in the dark and stationary (= CT DARK).
One bottle was put into the incubation tank on deck with continuously flowing sea water and under a blue filter (= TANK). These bottles were loose in the tank so able to move.

Each sample was incubated for 24 hours until 21:15 on the 18th of August afterwhich each T-24 sample was fixed with Lugols or paraformaldehyde each T-24 Nalgene bottle as described above. All Lugols samples were kept in boxes in the CT room before being transferred to SAMS for full microbial plankton analysis. All AFC cryovial tubes were kept frozen at -80 ºC until being thawed and analysed at SAMS by flow cytometry.

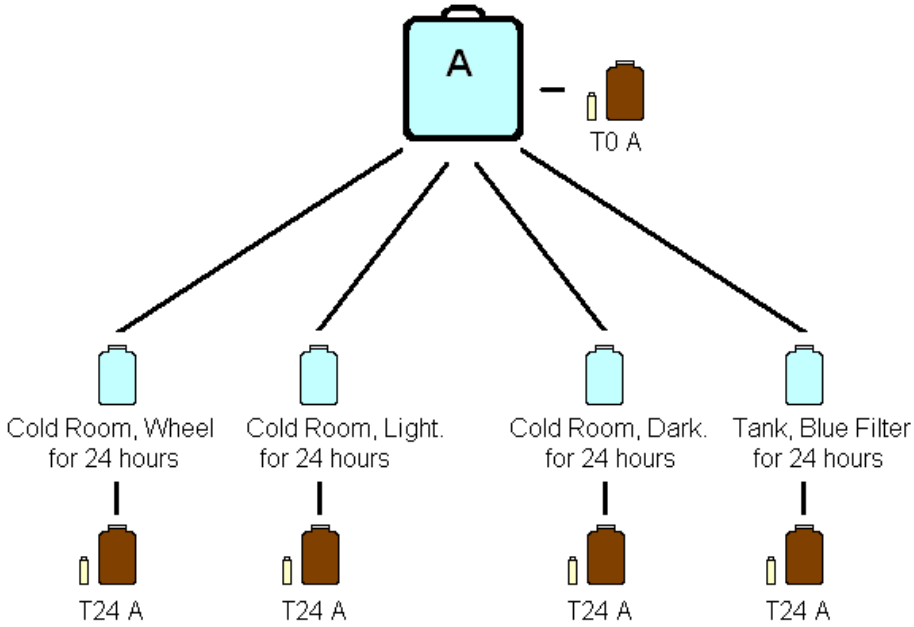

Figure1: Experimental design. There were 5 lugols and AFC samples taken for each replicate (a total of 15 samples).

Results

Microplankton abundance (Table 1) was calculated from full chamber counts of 50mls Lugols, with the exception of dinobryon which was in bloom and counted in 20 Fields of View (FoV). Anundance data were also converted to biomass using standard conversion factors. Autotrophic pico-plankton and bacteria abundance were calculated from flow cytometry counts. Relationships in the data were not clear due to higher variabliliy than expected between replicates (replicate C counts were especially low across taxa).

Table 1. Abundance of micro- and pico-plankton in plankton wheel experiement samples

			Per Litre					Per ml	
			TOTAL				TOTAL	TOTAL	TOTAL
			DIATOM	DINO.	CIL.	Micro-PLANK.	DINOBRYON	AUTO-PICO	BACTERIA
Time	Condition	Rep							
T0	(A)	A	1683	9742	1782	13207	571329	1065	322300
T24	Wheel (B)	A	1109	9266	1822	12197	532620	862	336833
T24	CT Light (C)	A	812	10672	1980	13464	644351	485	360414
T24	CT Dark (D)	A	1228	8910	1505	11642	649341	739	315058
T24	Tank (E)	A	515	5544	1327	7385	629422	867	343614
T0	(A)	B	911	10553	1346	12811	442471	994	269332
T24	Wheel (B)	B	257	6752	1247	8257	472883	1201	305435
T24	CT Light (C)	B	1307	10039	1208	12553	351767	1197	364643
T24	CT Dark (D)	B	1148	6257	1168	8573	396574	945	325500
T24	Tank (E)	B	2911	6910	1030	10850	407068	364	317095
T0	(A)	C	1445	8356	832	10633	604514	440	279605
T24	Wheel (B)	C	1544	5762	911	8217	681952	1002	374749
T24	CT Light (C)	C	990	6158	752	7900	305296	333	329497
T24	CT Dark (D)	C	376	5702	851	6930	533729	1446	337461
T24	Tank (E)	C	416	5069	515	5999	301435	1071	361909

The purpose of this experiment was to clarify the 'bottle effects' on live samples and to find the best conditions in which to keep experimental water which will minimise these effects. Two-way ANOVAs (data not shown) did reveal that the different treatments/time conditions affected the abundance of some taxa, and the abundance of all taxa pooled, but the difference in replicates was often more significant than the changes between treatment/times effects. A one-way ANOVA, focusing on T-24 data only to remove the time effect, revealed no significant differences between treatments (Table 2).

Table 2: One-Way ANOVA (with replication) for each taxa conducted on T-24 data only

One-Way ANOVA (with replication) 24 hour data only		
	Treatment	
	f-value	p-value
Total Macro-Plankton	0.84	0.509
Diatoms	0.11	0.949
Dinos	1.52	0.282
Ciliates	0.41	0.754
Bacteria	0.60	0.635
Auto-Pico	0.81	0.522
Dinobryon	0.52	0.679

Paired T-tests revealed where the changes in abundance and biomass appear to be the most significant (Table 3 and 4).

Table 3: Paired T-test on abundance data. Where p-value is less than 0.05 the null hypothesis that there has not been a decrease between T0 and T24 is rejected.

Paired T-test p-values	T0 to T24 (A)	T0 to T24 (B)	T0 to T24 (D)	T0 to T24 (E)
Total Micro-Plankton	0.061	0.214	**0.03**	**0.034**
Diatoms	0.128	0.247	0.187	0.478
Dinos	0.077	0.289	0.061	**0.003**
Ciliates	0.543	0.477	0.118	**0.008**
Bacteria	0.909	0.964	0.881	0.948
Auto-Pico	0.758	0.276	0.672	0.438
Dinobryon	0.718	0.215	0.403	0.239

Table 4: Paired T-test on cell biomass. Where p-value is less than 0.05 the null hypothesis that there has not been a decrease between T0 and T24 is rejected.

Paired T-test p-values	T0 to T24 (B)	T0 to T24 (C)	T0 to T24 (D)	T0 to T24 (E)
Total Micro- Plankton	0.109	0.121	0.16	0.089
Diatoms	0.377	0.658	0.444	0.4
Dinos	0.266	0.415	**0.027**	0.067
Ciliates	0.121	0.28	0.059	0.167

Diatoms are a poor indicator of changes in populations. Firstly they were present in low numbers and only make up a small proportion of the micro-plankton biomass on average 0.8%, secondly the most abundant diatom types were *Pseudo-nitzchia delicatissima* and *Chaetoceros socialis*. These are both very small species (below 20µm) and were observed forming dense and tangled clumps. The presence of a single clump in the 50ml sub-sample counted may contain over 100 cells and considerably skew counts. Dinoflagellates and ciliates are a better indicator; these cells were numerous and evenly distributed through counting chamber making up 70.5% and 28.7% of the micro-plankton biomass respectively. Ciliates are of particular interest due to their importance in experiments carried out on this and previous cruises and because they are fragile, easily damaged cells. *Dinobryon* is also a poor indicator of cell changes. *Dinobryon* was observed in blooms within lugol samples contributing large numbers to the total plankton biomass (numbers). For this species 20 fields of view within the chamber were counted. Like diatoms, *Dinobryon* forms compact branches of cells resulting in one field of view varying considerably from another (counts between the fields of views generally ranged between 30-60 cells). Multiplying these small numbers up to get cells per Litre is quite inaccurate. P-values on the 2-way ANOVA suggest the variation between reps in *Dinobryon* is far greater compared to that seen between conditions indicating the patchy nature of these cells within the water column and within our samples.

The tank conditions appeared to have the greatest effect on dinoflagellate and ciliate abundance and biomass. This may be due to the lower temperature within the tanks which were being continuously flushed with local sea water. As the experiment progressed over the 24hour period the boat was moving further North and East into the Ice Edge so that the water temperature within the tanks would have dropped. Possible rolling of bottles within tanks may also have contributed.

Within the experiment we were particularly interested in whether there were any advantages to having samples on the plankton wheel but it seemed to make no great difference. Of all the treatments, those samples left in the CT room in the light seemed to suffer the least change although the difference between the CT conditions was slight.

Incubation of samples for a longer period, or incorporation of more replicates (from different stations), may help in producing more conclusive results.

Extra samples from each rep could be counted and may help to clarify and improve statistical analysis i.e. only 50mls from the 200ml had been counted. Looking at the variation within a single bottle will help in understanding the variation within counting and sub-samples.

SCIENTIFIC REPORT 20: Seasonal variation in zooplankton community structure and variation in lipid content *Calanus* copepods in different depth strata along a transect

Daniel Vogedes and Alexey Pavlov

1. Rationale and Objectives

Many copepod species store large amounts of energy as lipids in a clearly visible lipid sac for overwintering and reproduction. Recent studies from the Antarctic have revealed a variation in lipid composition between copepods of the same species and developmental stage in the surface water layer vs. those encountered in deep water layers.

The sampling campaign on the JR219 cruise was part of larger campaign throughout 2010, collecting copepod samples covering both geographic and temporal range. We expect to see changes not only in the total lipid content of copepods later in the season, but also differences in lipid composition.

2. Sampling

Zooplankton samples were taken at different depth strata with a Hydrobios Multi-Plankton Sampler (MPS). The MPS is pre-programmed to trigger at certain depths, thus collecting several samples throughout the water column within one haul. In addition some samples were taken with a WP3 net and stored on alcohol for genetic analysis by a different project run by UNIS.

The copepods were kept alive in large buckets with sea water. Digital images were taken of random subsamples to measure lipid sac size and prosome length (see preliminary results). The copepods were then stored in cryovial and frozen in -80 C for lipid analysis. The remainder was stored on Formaldehyde for community analysis.

Phytoplankton/Microplankton samples were also taken from CTD bottles for another project.

3. Stations

The cruise consisted of 4 main stations (KF [=Kongsfjorden] 3, 4; GS [=Greenland Shelf] and GM [Greenwich Meridian]). Another shorter station was KF 5, where only a limited set of samples was taken. All stations were located along a transect from Kongsfjorden to the Greenland Shelf (Fig. 1)

4) Sampling

Station KF3 (04/07/10-05/07/10); N 79.0143 E 10.9637. Kongsfjorden shelf. Bottom depth 340 m.

Zooplankton:
1 Multinet, 310-200-100-50-20-0 m. Samples stored on Formaldehyde. On second haul net did not release because of drift, no time to repeat.
Note: Flow meter did not work on first haul, but conditions were calm thus no major drift occurred on first haul.

1 WP3 net 315-0 m. Stored on 80% EtOH. Sample stored at UNIS at Tove Gabrielsen. Sample not quantitative, small fraction spilled.

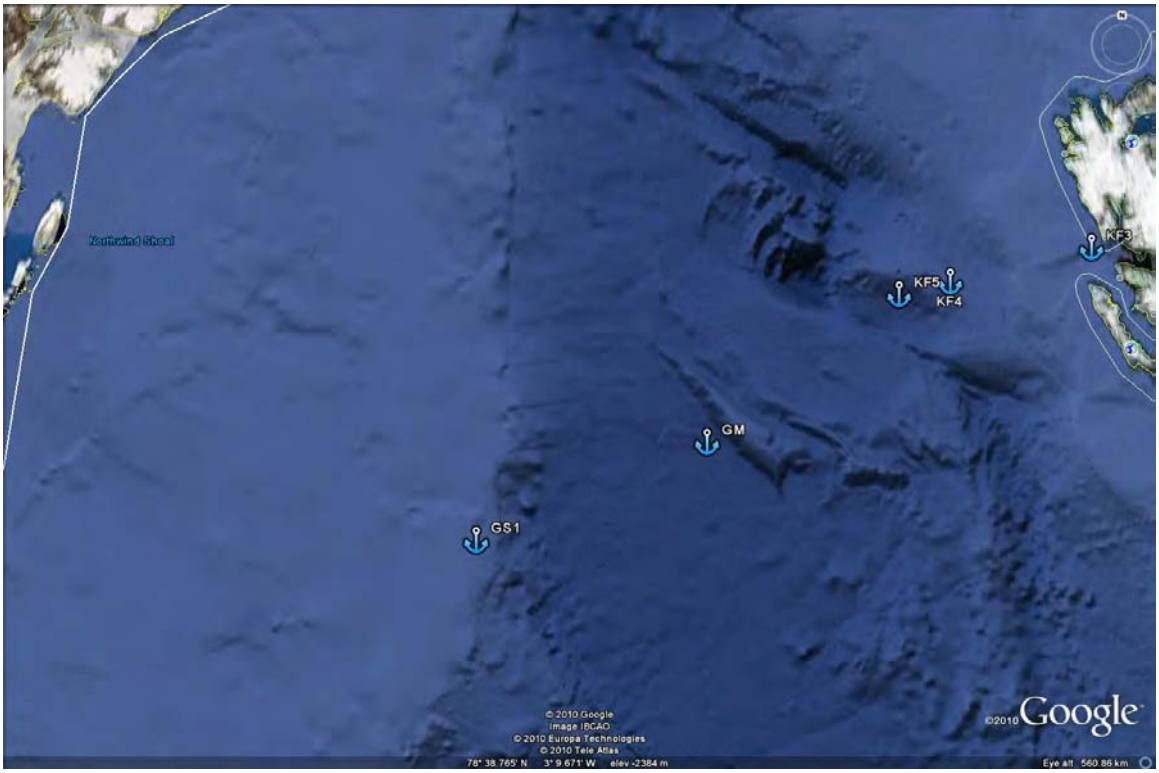

Fig 1. Main stations of the cruise.

Phytoplankton/Microplankton:
3 x 3 Niskin bottles a 10 L taken at 1 m, 40 m (chl max), 50 m. Total of 30 L on each depth filtered through 20 um net. Stored in Lugol/Formaldehyde.

Water (stn 035):
300, 150 m: Salinity, O18, Tracers, CDOM.
45, 26, 15, 6.5, 1 m: Salinity, O18, Tracers, CDOM & SPM

Light:
Spectral irradiance & Secchi measured (Alexey) on both days (04 & 05/07)

Station KF4 (07/07/10-08/07/10); N 78.9753 E 642.390; off the Kongsfjorden shelf. Bottom depth 1335 m.

NOTE:
Very intense phytoplankton bloom in 50-20 m layer led to net clogging.

Zooplankton:
2 Multinets.
1 Multinet 1280-200-100-50-20-0. OBS: Not according to standard depths (wrong programming). Stored on EtOH. Lowest layer and 2 uppermost not quantitative, partly spilled and partly specimen taken out for freezing.

Single living copepods taken out from deepest (1280-200 m) and highest (20-0 m) layer, photographed and stored in cryovials in -80 freezer.
Frozen samples:
20 – 0 m: C fin C5 (2x 10, 1x 11) – by far dominant spec/stge, >90%
1280-200 m: C fin C5 (2x 10, 1x 11)
C hyp AF (3x 4)

1 Multinet 1200-600-200-50-20-0. All samples stored on Formaldehyde.

Phytoplankton/Microplankton:
3 x 3 Niskin bottles a 10 L taken at 1 m, 26 m (chl max), 50 m. Total of 30 L on each depth filtered through 20 um net. Stored in Lugol/Formaldehyde.

Phytoplankton taxonomy:
20 um hand net taken 30-0 m. Stored on Lugol/Formaldehyde

Water (stn 043):
200, 100 m: Salinity, O18, Tracers, CDOM.
50. 30. 22. 10. 5 m: Salinity, O18, Tracers, CDOM & SPM

Water (stn 047):
200, 100 m: Salinity, O18, Tracers, CDOM.
50, 38, 27, 15, 5 m: Salinity, O18, Tracers, CDOM & SPM

Light:
Spectral irradiance & Secchi measured on both days (06 & 07/07)

Station GS1 (08/07/10 – 09/07/10); N 77.7796 W (!) 535.690; on the Greenland shelf, bottom depth 335 m.

Zooplankton:
1 Multinet 305-200-100-50-20-0. Shallowest layer (20-0 m) split 50/50. One half on EtOH, on half on Formaldehyde. All other samples stored on Formaldehyde.

1 WP3 net 340-0 m. Stored on 80% EtOH. Sample stored at UNIS at Tove Gabrielsen. Sample not quantitative, small fraction spilled.

Phytoplankton/Microplankton:
3 x 3 Niskin bottles a 10 L taken at 1 m, 18 m (chl max), 25 m. Total of 30 L on each depth filtered through 20 um net. Stored in Lugol/Formaldehyde.

Phytoplankton taxonomy:
20 um hand net taken 30-0 m. Stored on Lugol/Formaldehyde

Water (stn 049):
200, 100 m: Salinity, O18, Tracers, CDOM.
50, 29, 13, 9, 2 m: Salinity, O18, Tracers, CDOM & SPM

Water (stn 053):
200, 100 m: Salinity, O18, Tracers, CDOM.
50, 42, 25, 15, 5 m: Salinity, O18, Tracers, CDOM & SPM

Light:
Spectral irradiance & Secchi measured on both days (08 & 09/07)

Station GM (10/07/10); N 78.2833 E 000.000; at the zero meridian over deep waters, bottom depth 3020 m.

Zooplankton:
2 Multinets

1 Multinet 1200-600-200-50-20-0. On deepest layer (1200-600 m) flow meter malfunction, data need to be corrected manually. All samples stored on Formaldehyde.

1 Multinet 1500-600-200-50-20-0.
Single living copepods taken out from deepest (1500-600 m) and second highest (50-20 m) layer, photographed and stored in cryovials in -80 freezer. OBS: deepest layer differs from standard depth, shallowest layer virtually empty, therefore used 50-20 m to pick out single specimens. All samples stored on EtOH.

Frozen samples:
50-20 m: C hyp C4 (2x 8, 1x 9)
C hyp C5 (3x 6)
1500-600 m: C hyp C4 (2x 8, 1x 7)
C hyp C5 (3x 6)
C hyp AF (3x 4)

Phytoplankton/Microplankton:
Not taken because of time constraints

Water (stn 056):
200, 100 m: Salinity, O18, Tracers, CDOM.
50, 25, 18, 10, 5 m: Salinity, O18, Tracers, CDOM & SPM

Light:
Spectral irradiance & Secchi measured

Station KF5 (11/07/10): N 78.9475 E 517.3122; additional station still over deep waters, further east than GM, bottom depth 2500 m

Zooplankton:
1 WP3 net 100-0 m. Stored on 80% EtOH. Sample stored at UNIS at Tove Gabrielsen.

Phytoplankton/Microplankton:
1 Niskin bottle (10 L) taken at 1 m and at 20 m (chl max), 3 x 10 L taken at 50 m. For the first 2 depths 10 L and the lowest depth 30 L filtered through 20 um net. Stored in Lugol/Formaldehyde.

Water (stn 056):
200, 100 m: Salinity, O18, Tracers, CDOM.
50, 30, 20, 13.5, 5 m: Salinity, O18, Tracers, CDOM & SPM

Light:
Spectral irradiance & Secchi measured

5) Some preliminary *Calanus* imaging results

There was no significant difference in prosome lengths between individuals of the same species/stage between different layers (high = upper layer, low = bottom layer) and stations (GM = Greenwich Meridian, KF4 = Kongsfjorden shelf), see Fig 2.

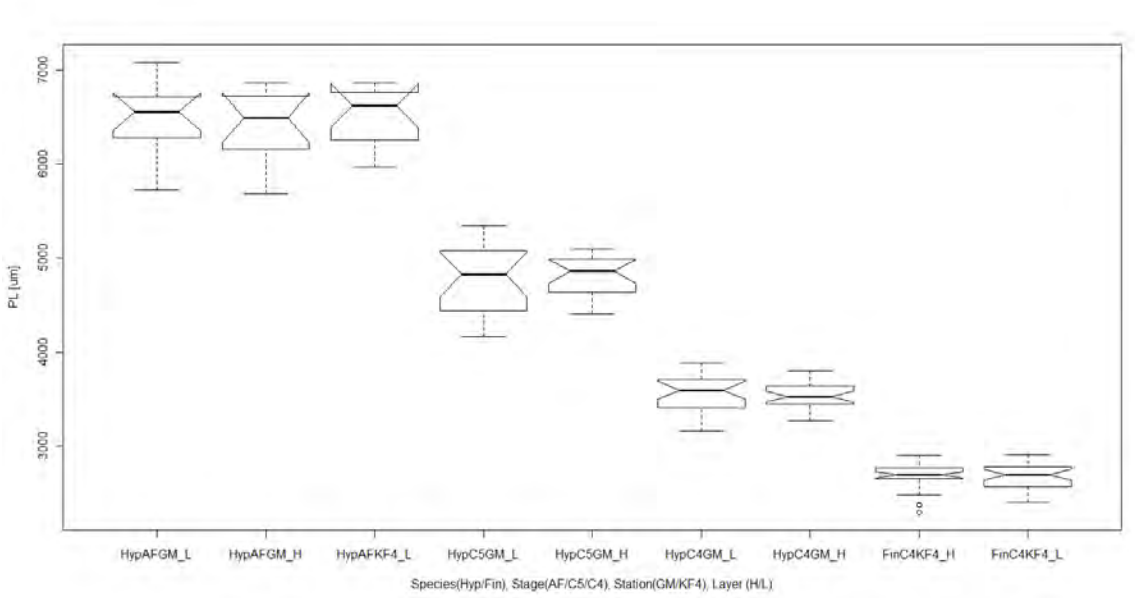

Figure 2 *Calanus* prosome length.

WE content as calculated by lipid sac area (Fig 3) differed significantly in all cases between upper and lower layer. *C. hyperboreus* AF at GM differed significantly between upper and lower layer. *C. hyperboreus* AF at KF4 lower was in between GM upper and lower.
C. hyperboreus C5 differed significantly between upper and lower on GM, the same goes for *C. hyperboreus* C4 at that station.
Also *Calanus finmarchicus* C4 at station KF4 differed significantly between upper and lower layer. It should be noted though that no attempt was made to properly randomize the sampling of the single specimens.

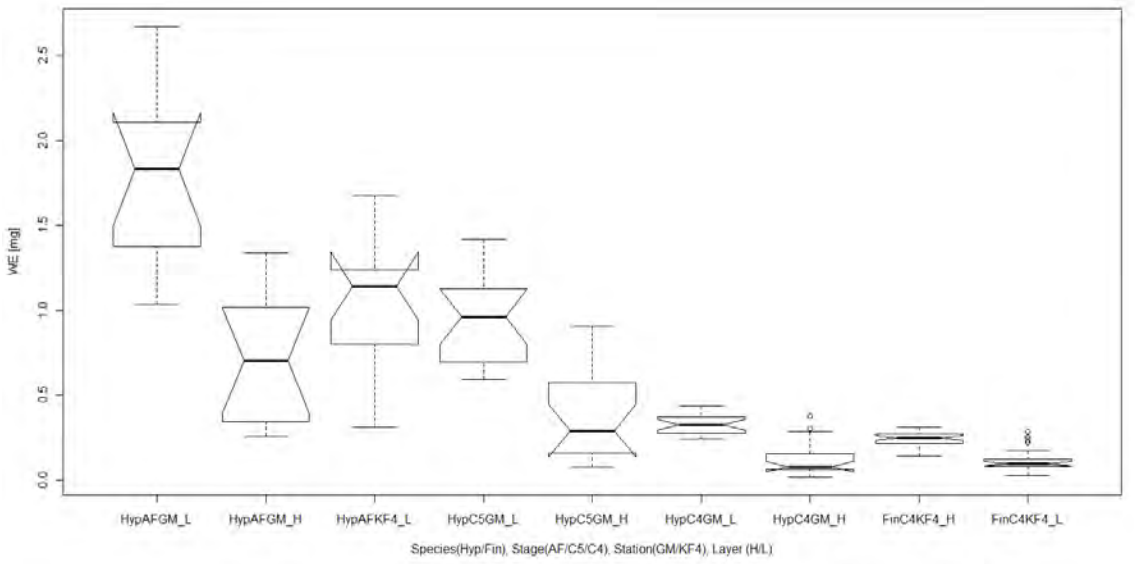

Figure 3 *Calanus* WE content.

SCIENTIFIC REPORT 21: Physical and biological mediated O_2 and CO_2 dynamics in a melting ice floe.

Ronnie Glud, Søren Rysgaard, Kunuk Lennert, Gavin Turner and John Montgomery

Introduction and objectives

Sea-ice is a distinct feature of the polar seas and the ice-cover in many ways regulates the biological activity as well as the chemical and physical conditions in the regions. But the extent and dynamic of the sea-ice-cover also has implications well beyond the polar regions and interrelates to the global ocean current systems and the energy balance.

The brine channels of sea-ice host a complex biological community consisting of 3-4 trophic levels. The base of this food web consists of sea ice algae that are well adapted to the special conditions within the sea-ice, and they do generally become abundant right at the sea-ice-water interface. Much of the primary production is grazed by amphipods and larvae of benthic fauna, but bacteria represent the single most important group turning over the organic carbon fixed by the algae. Apart from the biological driven O_2 and CO_2 dynamic, it has in recent years been documented that freezing of sea-water and thawing of sea-ice act as a prime regulator of the O_2 and CO_2 dynamic in sea-ice. As sea ice forms gasses are expelled from the ice crystals and concentrated in the brine; as such it becomes supersaturated with gasses and holds high concentrations of inorganic carbon. It is hypothesized that this can lead to formation of carbonate crystals. During winter the heavy brine gradually sinks out of the ice-matrix along with nutrients, gasses and inorganic carbon leaving behind carbonate crystals. Consequently, the melt-water of the ice released during spring is strongly depleted in O_2 and CO_2, to the extent that complete anoxia and denitrification activity has been observed in melting sea-ice. The under-saturated melt-water drives an uptake of CO_2 and O_2 from the atmosphere which we call the sea-ice gas pump. There are many open and unresolved questions on the importance of this pump and basic quantification data of its magnitude are lacking. The special conditions within forming and melting sea-ice induce a complex dynamic in inorganic carbon chemistry and we only have a fragmented understanding on how this interrelates to an overall net uptake of CO_2 from the atmosphere.

The overall objective of this study was to characterize the distribution of O_2 and CO_2 (i.e. Dissolved Inorganic Carbon - DIC) in sea-ice, quantify the exchange of O_2 and CO_2 between water and sea-ice, and quantify the respective contributions of biology and physics to this net exchange.

Sea-ice characteristics

A total of 17 ice cores were recovered during the 9 day Leg 2 sea-ice campaign and on each occasion the vertical temperature profile was recorded. Eight ice-cores were sectioned in 10 cm pieces, crushed and melted overnight in the onboard cool-room (4^{o}C). Subsequently samples were taken for: bulk salinity, bacteria production (^{3}H-Thymidine and Leucine incubations), primary production (^{14}C), nutrient and Chl *a* concentration. Most of these analyses are still in progress, but from the salt and temperature profiles it is apparent that the sea-ice was melting with high brine volumes and temperature and low salinities leading to highly permeable conditions (Fig. 1). Overall the ice thickness at 4 study sites on average declined from 98 to 89 cm during the 9 day's campaign. The preliminary analysis of the other parameters show a moderate sea-ice related bacteria production and primary production mediated by shade adapted diatoms.

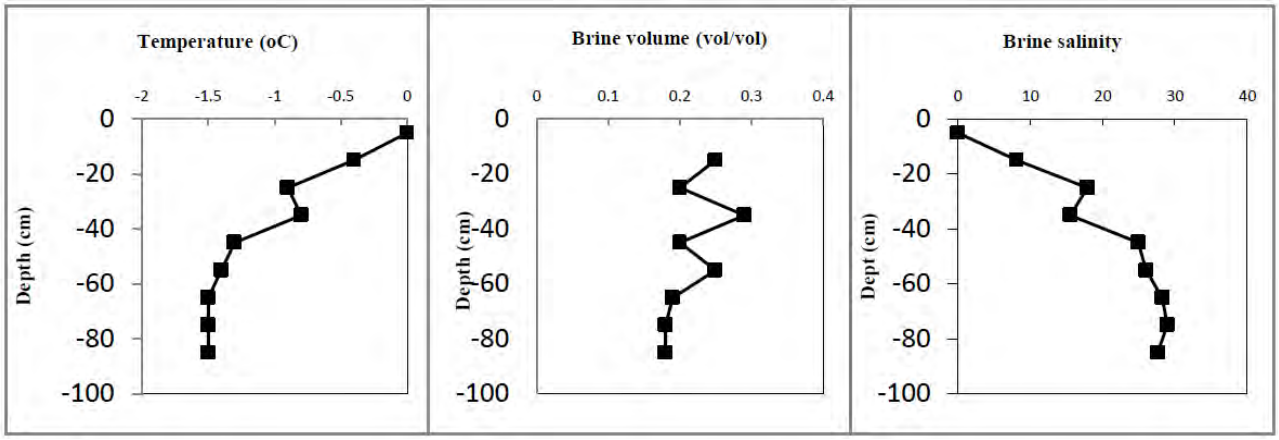

Fig 1. One example of the temperature, brine volume and brines salinity profile – all reflecting a rapidly melting sea-ice

Inorganic carbon chemistry and O_2 content

Seven ice cores were sectioned and used for determination of: Total Alkalinity (TA), DIC, pCO_2, O_2 and bubble volume. This was done by two different procedures where ice sections were melted in gas tight metal chambers or plastic bags. Most of analyses are still in progress and others will first be carried out upon the return to our respective laboratories. However, the preliminary data documents that the melting ice was strongly O_2 depleted.

Two ice-cores were sectioned and melted at 0°C to search for carbonate crystals– indeed crystals were found (Fig. 2). Various forms and sizes were found, all dissolving at elevated temperatures and when exposed to slight lowering of the pH. Especially the more upper sections of the sea-ice held many crystals. Extra ice cores were taken and will, together with frozen crystals, be used for later characterizing of the crystal structure and chemical composition.

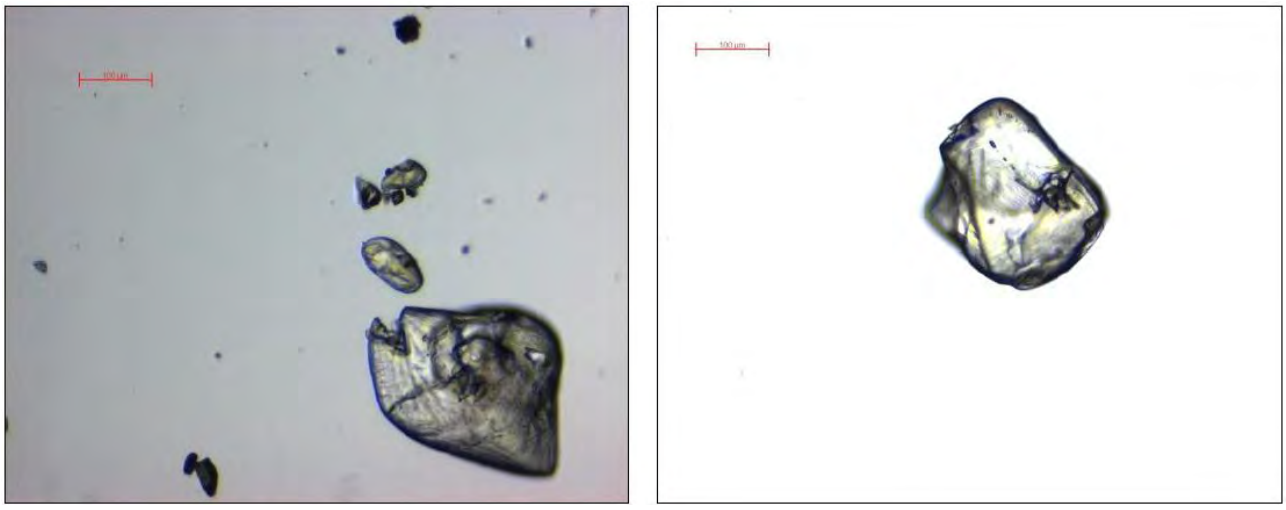

Fig 2. Examples of crystals found in the ice-cores (red bar 100 µm)

Oxygen dynamic in sea-ice

Underwater photos showed that the phototropic biomass was very unevenly distributed; patches of brown coloured ice held dense communities of diatoms and 1-5 cm large lumps of sea-ice algae had accumulated in depressions of the ice (Fig 3). Diver operated in situ PAM (Pulse Amplitude Modulated flourometer) measurements (calibrated on ship to Chl *a* concentrations) were used to map the distribution of phototrophic biomass.

Fig 3. The sea-ice underside reflecting an uneven distribution of brown patches of ice algae and lumps of diatoms trapped in small depressions of the ice (stick = 1m) (photo by Hugh Brown & Simon Thurston)

Samples of the phototrophic biomass wese incubated in glass vials onboard and the O_2 production was determined as a function of down-welling irradiance for both intact lumps and suspended algae (Fig. 4). Data still need to be normalized to the Chl *a* concentration but the preliminary plots reflect a shade adapted community with optimal performance at low light levels – in accordance with the ^{14}C incubations (see above). From these data, PAM-determined biomass distribution, and the light levels recorded below the ice (see below) overall O_2 production by sea-ice algae will be determined and compared quantitatively with the ^{14}C incubations.

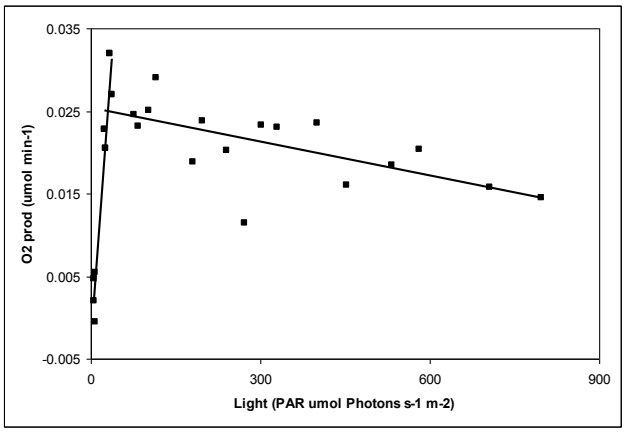

Fig 4. Preliminary O_2 production versus light of suspended sea-ice algae, data still not normalized to Chl a (similar plots for intact lumps are still in progress).

O_2 exchange between sea-ice and water

For non-invasive determination of the O_2 exchange between sea-ice and water, 3 eddy correlation instruments were deployed at different distances to the sea-ice interface. In parallel, a CTD instrument equipped with an O_2 optode and a PAR-meter continuously recorded the conditions below the ice and occasional profiling confirmed well mixed conditions close to the sea-ice surface. From combined measurements of fluctuations in the vertical velocity and the O_2 concentration the O_2 flux rate was derived (Fig. 5). The O_2 exchange derived from the eddy approach will be compared quantitatively with the primary and bacterial production to deduce the importance of physical and biological mediated O_2 exchange. We anticipate that the O_2 fluxes are controlled by 4 variables: horizontal flow, light availability, temperature (i.e. ice melt) and O_2 concentration. With >270 h of continuous data detailed statistical analysis between the fluxes and the controls will be carried out later.

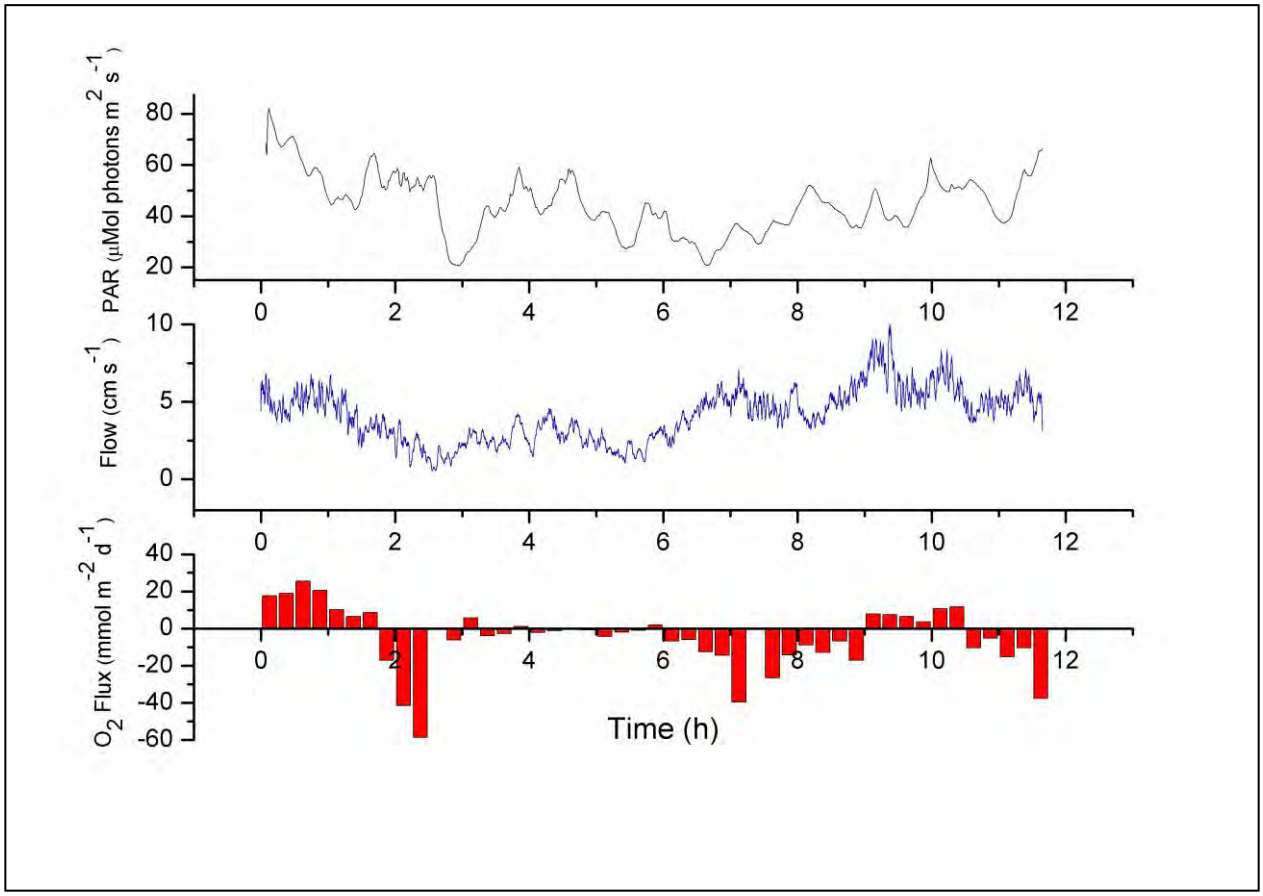

Fig *5. Down-welling irradiance, horizontal flow velocities and concurrent O_2 fluxes measured 20 cm off the ice interface by an eddy correlation instrument and a CTD unit*.

SCIENTIFIC REPORT 22: Impact of declining multiyear sea ice cover on the production of climatically active halogenated trace gases in the Arctic Ocean

Helen M. Atkinson

Introduction

Sea ice diatoms have been shown to emit bromocarbons (e.g. $CHBr_3$, CH_2Br_2) and iodocarbons (e.g. CH_3I, C_2H_5I)[1]. The photolysis of these compounds yields reactive iodine and bromine in the troposphere, the presence of which leads to the destruction of ozone and impacts the oxidising capacity of the atmopshere[2]. Within the atmospheric boundary layer, reactive iodine has been implicated in new particle formation[3], so also affects the radiative properties of the atmosphere. Products of the reactions between the halogens and ozone (BrO and IO) have been observed in the Antarctic[4] and Arctic[5] sea ice zone. Whereas BrO concentrations in these regions are similar in both hemispheres, there is much less IO in the atmosphere over Arctic sea. Differences in the sea ice may be responsible, Antarctic sea ice is thinner, more porous, mostly first year and more biologically rich. Arctic sea ice, until recently, was mostly multi-year and over 2m thick[6]. However, as the planet warms, Arctic sea ice may become more like that of the Antarctic and this may impact sea ice habitats, biota and emissions.

It is important to understand where the production of halocarbons is occurring in ice covered waters and the factors affecting production rates by sea ice algae. Halocarbon concentrations were measured in sea ice brine, in the water below the ice, and in the atmosphere above. Water samples taken from CTD casts allowed halocarbons to be measured in surface waters and in areas of high biological activity, both close to sea ice and in the open ocean. Fluxes, calculated based on simultaneous air and water measurements, will allow an understanding of the factors which influence halocarbon emissions and the impact of declining sea ice in the Arctic.

Methods

A 9cm diameter Kovacs corer was used to make cores in the sea ice, from which brine was collected. Cores were made to different depths in the ice in order that a vertical profile could be ascertained. Biological activity was studied via chlorophyll a analysis, and physical measurements of the ice determined brine volume and brine channel connectivity. Halocarbon concentrations in the sea ice brine, seawater and air were determined by gas chromatography / mass spectrometry (GCMS) instrumentation on board the ship, chlorophyll a analysis was carried out back in the UK via fluorometry, and flux calculations were carried out as detailed in Johnson 2010[7].

Sample list

Date	Time (GMT)	Sample type	Event no.	Bottle no.
19/06/2010	06:45	air		
	08:18	CTD surface	23	24
	08:18	CTD DCM	23	18
21/06/2010	09:05	air		
22/06/2010	07:30	air		
	11:00	water under ice	I3	
	18:30	sea ice brine		
23/06/2010	11:30	sea ice brine	I6	
	11:45	water under ice	I7	
	12:45	air		
24/06/2010	07:00	air		
	17:35	sea ice brine	I12	
25/06/2010	06:30	water under ice		

Date	Time (GMT)	Sample type	Event no.	Bottle no.
	09:11	CTD surface	35	12
	09:11	CTD DCM	35	4
	13:00	sea ice brine	I15	
	17:15	air		
26/06/2010	11:15	air		
	17:30	water under ice	I24	
	18:00	sea ice brine	I24	
27/06/2010	08:00	sea ice brine	I28	
	09:00	water under ice	I28	
	14:00	air		
28/06/2010	08:15	CTD surface	43	12
	08:15	CTD 5m	43	10
	08:15	CTD 10m	43	9
	08:15	CTD 15m	43	8
	08:15	CTD 25m	43	7
	08:15	CTD 50m	43	5
	08:15	CTD100m	43	3
	12:20	Dive samples	I35	
	18:00	air		
29/06/2010	11:00	sea ice brine	I43	
	11:40	water under ice	I43	
	14:15	air		
30/06/2010	18:30	air		
	19:15	water under ice	I49	
01/07/2010	12:30	water under ice	I60	
	13:30	air		
04/07/2010	08:00	CTD surface	66	23
	08:00	CTD DCM	66	6
	11:15	air		
05/07/2010	06:44	CTD surface	82	21
	06:44	CTD DCM	82	10
	09:00	air		
	17:00	air		
	17:00	CTD surface	91	3
	17:00	CTD DCM	91	2
06/07/2010	04:45	air		
	07:58	CTD surface	99	24
	07:58	CTD DCM	99	11
07/07/2010	06:00	air		
	06:55	CTD surface	113	24
	06:55	CTD DCM	112	10
08/07/2010	08:15	CTD surface	119	22
	08:15	CTD DCM	119	12
		air		
09/07/2010	06:18	CTD surface	134	24
	06:18	CTD DCM	134	10
	11:15	air		
10/07/2010	09:24	CTD surface	143	24
	09:24	CTD DCM	143	15
	12:00	air		

Preliminary Results

Enhanced concentrations of halocarbons were measured in the sea ice brine compared to the water below. Higher atmospheric mixing ratios of some halocarbons were found in the atmosphere above sea ice compared to that above the open ocean. More work is still to be carried out to calculate fluxes, and elucidate sources and sinks of the halocarbons.

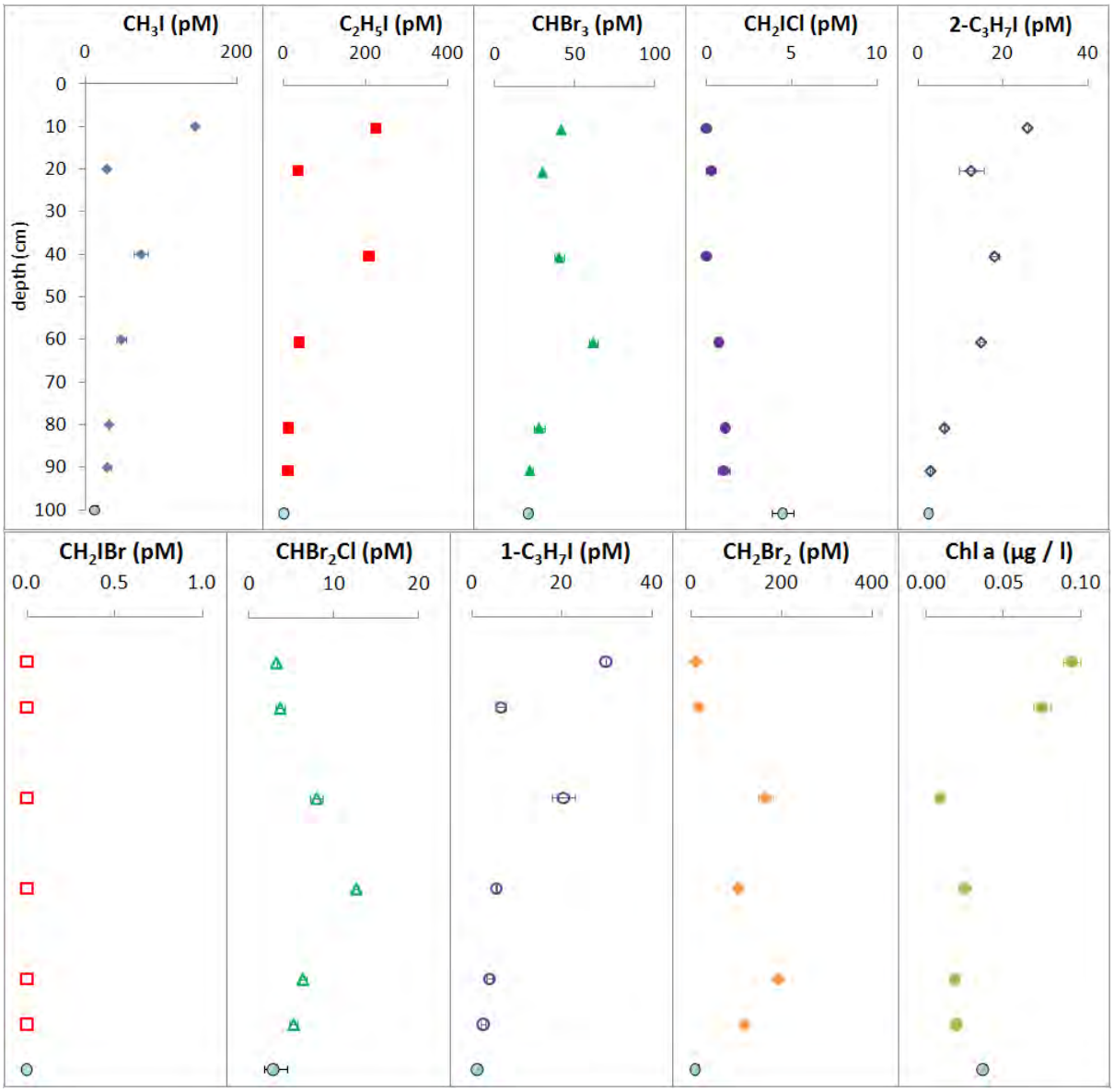

Figure 1. Halocarbon concentrations and chlorophyll a in sea ice brine collected from cores of different depths of Arctic sea ice, made on 29th June 2010. The ice thickness was 90 cm, the lowest point on the graph at 100 cm represents halocarbon concentrations in the underlying seawater

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SCIENTIFIC REPORT 23: Upper ocean carbon export

Jennifer Riley

Background

Sinking particles and aggregates are thought to be a major vector for organic matter transport from the surface to the deep ocean. The ballast hypothesis suggests that the speed at which organic matter sinks is facilitated by the presence of dense biominerals such as calcium carbonate and biogenic silica. It is unclear however if this relationship seen in the deep ocean is present in the upper ocean. The speed at which individual particles sink is unclear, with limited *in situ* measurements having been made. Furthermore, it is not clear how properties such as particle biomineralising organism presence and morphology as well as the surface plankton community control the variability in observed sinking speeds.

The Marine Snow Catcher (MSC) is able to sample 100L of water from a pre determined depth in the water column. When left to settle for a predefined time period any particulate matter sinking in that snapshot of water collects in a bottom 5L chamber. The top 95L can then be drained off and sub-sampled if desired. Any particles and aggregates can then be picked out and isolated from the remaining water column and experimental work carried out on them. Again the base 5L of water can be sub sampled if desired.

During JR219 the MSC was used to determine the upper ocean carbon fluxes associated with aggregates and smaller size fractioned particles being exported out of the euphotic zone. To this end the MSC was deployed no shallower than 50m depth which was just below the 1% light level in the water column. Particles were collected where possible and their sinking speeds measured. Information about the surface community structure was also collected to relate what is exported in aggregates to the surface community. Furthermore, deployment of the MSC at multiple depths in the water column will also hopefully highlight how particle sinking speed changes with depth and if the settling velocity of different size fractions stays constant with depth.

Methods/Sampling

CTD Samples

CTD samples were taken to provide background context for each MSC deployment. In total 20 CTD's were sampled. The samples included:

POC/N and PIC Profiles: Water samples were taken from the CTD from 4 – 5 depths in the upper 400m of the water column and filtered for POC. Between 1.5 and 2 L of water was filtered on to pre-combusted (450°c for at least 12 hours), 25mm diameter GFF filters. Samples were then stored in petri dishes at -20°c for analysis back at NOCS using a Carlo-Erba CHN Analyzer. Particulate inorganic carbon (PIC) analysis will also be determined by calculated through the acidification method from the same samples.

BSi Profiles: Profiles of biogenic silica were taken from the CTD from 4 – 5 depths. Volumes of 1 – 1.5L were filtered onto 0.4μm nominal pore size, 25mm diameter, polycarbonate filters. Samples were then placed into labelled tubes and stored at -20°C for analysis back at NOCS.

Coccolithophores: Samples for coccolithophore counts were taken from every CTD. The main reason for collection was to determine the numbers of coccolithophores in the euphotic zone. Resultantly a depth-integrated sample was taken. Three depths from the top 50m of the water column were sampled from the CTD (5m, 25m and 50m). One litre from each depth was taken and thoroughly mixed together before a 0.5L aliquot was filtered onto a cellulose nitrate filter under low

pressure (~400bar). Each sample was rinsed with slightly alkaline pH adjusted milliQ water to remove any salt crystals. Samples were dried at 50°c for a minimum of 12 hours in an oven before being stored in a cool dry place. Counts will be carried out under a microscope back at NOCS.

Lugols: Depth integrated lugols samples were taken to estimate the euphotic zone plankton community. 1L was taken from 5m, 25m, and 50m and thoroughly mixed together. A 100ml subsample was then taken and preserved with 1-2% lugols iodide solution. Samples were stored in a cool dark place until analysis back at NOCS.

Nutrients: During the final leg of the cruise nutrients were no longer being measured as part of the core cruise data set. Therefore nutrient samples were also taken from each CTD cast sampled for POC/N, BSi, coccolithophores and lugols samples. 20ml water samples were taken and frozen at -20°c for analysis of nitrate/nitrite, phosphate and silica back at NOCS.

Chlorophyll: As above no core chlorophyll samples were being taken on leg 4 of the cruise. Therefore 4 depths from the euphotic zone were sampled from the CTD for chlorophyll-a. 0.3L of water was filtered onto 25mm GFF filters and immediately frozen at -80°c for analysis back at SAMS.

Marine Snow Catcher Deployments

Over the entire cruise 35 successful MSC deployments were made at depths between 50m and 400m throughout the water column. Each MSC deployment had a corresponding CTD profile to match. Post deployment the MSC was left to settle on deck for approximately 3 hours. After this settling period the top 95L of water was drained out of the MSC and sub-sampled. Any particles or aggregates identified in the bottom 5L chamber of the marine snow catcher were picked out individually. The remaining water in the bottom 5L chamber was then also sub-sampled. Samples taken from the MSC included:

Aggregate and Particle Collection: Any particles or aggregates identified in the bottom 5L chamber of the marine snow catcher were picked out individually. Each particle collected was:
Settled in a 1L glass measuring cylinder to determine the speed at which they sink.
(Particles were introduced to the measuring cylinder using a Pasteur pipette and then timed sinking between the graduation marks on the glass. Each particle was then recovered where possible using the Pasteur pipette.)
Photographed to document each individual collected.
(From these photographs, particle size can be determined and this later related to their sinking speed.)
Placed onto cellulose nitrate filters and dried out for transport back to the lab and later preservation as microscope slides.
(These will then be used for microscopic analysis of any calcifying organisms present inside the particles.)

Size Fractionated Filtering: The top 95L and bottom 5L subsample of water from the MSC were both filtered into different size fractions for POC/N, PIC and BSi. The samples collected can be divided into total and <10μm. On the leg 4 the 10μm mesh used to fractionate the samples was preserved for potential microscopic analysis. The methods for POC/N, PIC and BSi are the same as above. The only difference being a 10μm mesh was placed in front of the filter in the filtration tower for the <10μm size fractions.

Particle Density: On deployments where aggregates were abundant some were subsampled and placed into a layered solution of sodium polytungstate (SPT). Four distinct density layers were apparent (2.014g cm^{-3}, 1.2 g cm^{-3}, 1.02 g cm^{-3} and the water the particles sank through initially. After particles were added to the SPT solution they were left to settle through the layers for a few

hours. Regular checks were made on the descent progress of the particles. When they had reached a density horizon that matched their individual densities the particles remained suspended. A digital image was then taken to record the position of the particles and by proxy the approximate density of the particles in the SPT solution.

Particle POC Content: Again when aggregates were identified in great enough abundances a sub-sample of aggregates were removed and individually placed onto a pre-combusted GFF filter for POC/N analysis. The number of particles placed onto the filter was carefully counted in order to be able to normalise the POC value to a "per aggregate" number.

Preservation: When aggregates were identified in great enough abundances a sub sample of aggregates were removed and preserved in one of two ways:
Preserved individually in eppendorf tubes with 5% buffered formalin for high-resolution image analysis back at NOCS.
Individually frozen in the ambient water collected in for bacterial exenzyme analysis (time permitting) back at NOCS.

Time Series Settling: Some stations were passed through twice. This gave an opportunity for repeat MSC deployments to be made. On some stations that were re-visited the top 95L of the MSC was sub sampled for total POC/N every 30 minutes during the 3 hour settling period. After the 3 hour settling time the remaining water was sampled in the same was as normal. When the time settling sampling occurred a control MSC deployment was made to the same depth but not sub sampled at 30 minute intervals. This was done in order to determine if the sub sampling procedure affects the ultimate POC/N values in the top and base chambers.

The following tables provide a detailed sampling summary for the cruise:

Table 1 shows all the stations sampled and what data was collected.

Table 2 gives more detailed information about the CTD station and depths sampled.

Table 3 shows all the MSC deployment locations, depths sampled and data collected.

Table 1. Sample Summary

Date	Snow Catcher(s) (m)	POC/PIC Profile	Bsi Profile	Integrated Lugols	Integrated Coccos	Size Fractionated SC filters	Particle Density Test	Preserved	Nuts & Chl-a
LEG 2 - ICE STATION									
23/06/2010	50	x	-	x	x	x	-	-	-
24/06/2010	50, 100	x	x	x	x	x	-	-	-
25/06/2010	100	x	x	x	x	x	x	-	-
26/06/2010	400	x	x	x	x	x	-	-	-
27/06/2010	400	x	x	x	x	x	-	-	-
28/06/2010	50, 300	x	x	x	x	x	x	x	-
29/06/2010	200, 300	x	x	x	x	x	-	x	-
30/06/2010	300, 400	x	x	x	x	x	x	x	-
01/07/2010	50, 200	x	x	x	x	x	-	x	-
LEG 3 - GREENLAND TRANSECT									
04/07/2010	50	x	x	x	x	x	-	-	-
05/07/2010	50, 100	x	x	x	x	x	-	-	-
06/07/2010	50, 100	x	x	x	x	x	-	-	-
06/07/2010	50, 100	x	x	x	x	x	-	-	-
07/07/2010	50, 100	x	x	x	x	x	x	x	-
09/07/2010	50, 100	x	x	x	x	x	-	-	-
10/07/2010	50, 100	x	x	x	x	x	-	-	-

Table 1. Continued

LEG 4 - NW SVALBARD SHELF									
Date	**Snow Catcher(s) (m)**	**POC/PIC Profile**	**Bsi Profile**	**Integrated Lugols**	**Integrated Coccos**	**Size Fractionated SC filters**	**Particle Density Test**	**Time Series**	**Nuts & Chl-a**
14/07/2010	50, 50	x	x	x	x	x	-	x	x
15/07/2010	50, 100	x	x	x	x	x	-	-	x
17/07/2010	50, 50	x	x	x	x	x	-	x	x
19/07/2010	50, 100	x	x	x	x	x	-	-	x

Table 2. CTD Samples

Leg 2 - Ice Station - CTD Samples										
Date	**CTD Number**	**Lat**	**Long**	**Depths (m)**	**POC/N**	**Bsi**	**Integrated Depths (m)**	**Coccos**	**Lugols**	**Nuts &Chl-a**
23/06/2010	14	80 44.4N	04 36.7E	5, 25, 50, 100	x	-	5, 25, 50	x	x	x
24/06/2010	16	80 42.25N	04 20.53E	5, 25, 50, 100	x	x	5, 25, 50	x	x	x
25/06/2010	19	80 35.43N	04 18.83E	5, 50, 100, 400	x	x	5, 25, 50	x	x	x
26/06/2010	20	80 31.09N	04 09.87E	5, 50, 100, 400	x	x	5, 25, 50	x	x	x
27/06/2010	22	80 27.61N	03 43.88E	5, 50, 100, 400	x	x	5, 25, 50	x	x	x
28/06/2010	24	80 19.6N	03 22.18E	5, 50, 100, 400	x	x	5, 25, 50	x	x	x
29/06/2010	27	80 16.18N	02 59.00E	5, 50, 100, 200, 300	x	x	5, 25, 50	x	x	x
30/06/2010	30	80 13.78N	02 29.79E	5, 50, 300, 400	x	x	5, 25, 50	x	x	x
01/07/2010	31	80 13.19N	02 09.94E	5, 25, 50, 100, 200	x	x	5, 25, 50	x	x	x

Table 2. Continued

Leg 3 - Greenland Transect - CTD Samples										
Date	**CTD Number**	**Lat**	**Long**	**Depths**	**POC/N**	**Bsi**	**Integrated Depths**	**Coccos**	**Lugols**	**Nuts* & Chl-a****
04/07/2010	33	79 01.00N	01 42.04E	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
05/07/2010	37	79 00.91N	10 41.28W	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
06/07/2010	42	78 58.51N	06 42.36W	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
07/07/2010	47	78 58.50N	06 42.36W	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
08/07/2010	52	77 46.63N	05 35.77W	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
09/07/2010	53	77 36.05N	06 11.42W	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
10/07/2010	55	78 16 99N	0 00.010E	5, 25, 50, 100, 200	x	x	5, 25, 50	x	x	x
Leg 4 - NW Svalbard Shelf - CTD Samples										
14/07/2010	63	79 00.9N	10 43.65E	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
15/07/2010	72	79 49.71N	10 01.24E	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
17/07/2010	80	80 04.78N	17 16.83E	5, 50, 100, 200	x	x	5, 25, 50	x	x	x
19/07/2010	91	79 29.14N	06 43.30E	5, 50, 100, 200	x	x	5, 25, 50	x	x	x

* All Depths sampled plus DCM (Deep Chlorophyll Maximum)

** Depths samples 5m, 25m, DCM, 50m

Table 3. Snow Catcher Samples

Leg 2 - Ice Station - Snow Catcher Samples						
Date	**Snow Catcher Depth**	**Lat**	**Long**	**Size Fractionated Filters**	**Density Test**	**Preserved**
23/06/2010	50	80 44.69N	04 35.51E	x	-	-
24/06/2010	50	80 42.44N	04 20.7E	x	-	-
24/06/2010	100	80 42.8N	04 20.7E	x	-	-
25/06/2010	100	80 35.43N	04 18.83E	x	x	-
26/06/2010	400	80 31.61N	04 12.06E	x	-	-
27/06/2010	400	80 27.61N	03 43.88E	x	-	-
28/06/2010	50	80 19.92N	03 23.4E	x	x	-
28/06/2010	300	80 18.45N	03 16.7E	x	-	-
29/06/2010	200	80 16.52N	03 04.53E	x	-	-
29/06/2010	300	80 16.58N	03 05.68E	x	-	-
30/06/2010	300	80 13.92N	02 31.55E	x	-	-
30/06/2010	400	80 14.07N	02 29.79E	x	-	-
01/07/2010	50	80 13.09N	02 10.169E	x	-	-
01/07/2010	200	80 13.05N	02 10.3E	x	-	-

Table 3. Continued

Leg 3 - Greenland Transect - Snow Catcher Samples						
Date	**Snow Catcher Depth**	**Lat**	**Long**	**Size Fractionated Filters**	**Density Test**	**Preserved**
05/07/2010	50	79 00.91N	01 41.3E	x	-	-
05/07/2010	100	79 00.91N	01 41.3E	x	-	-
06/07/2010	50	78 58.51N	06 42.36W	x	-	-
06/07/2010	100	78 58.51N	06 42. 36W	x	-	-
07/07/2010	50	78 58.51N	06 42. 36W	x	x	x
07/07/2010	100	78 58.51N	06 42. 36W	x	-	-
08/07/2010	50	77 46.160	05 35.90W	x	-	-
08/07/2010	100	77 45.96N	05 35.87W	x	-	-
09/07/2010	50	77 36.67N	06 15.39W	x	-	-
09/07/2010	100	77 36.82N	06 16.45W	x	-	-
10/07/2010	50	78 17.00N	00 00.00E	x	-	-
10/07/2010	100	78 17.00N	00 00.00E	x	-	-

Table 3. Continued

Leg 4 - NW Svalbard Shelf - Snow Catcher Samples						
Date	**Snow Catcher Depth**	**Lat**	**Long**	**Size Fractionated Filters**	**Density Test**	**Preserved**
14/07/2010	50	79 00.90N	10 43.70E	x	-	-
14/07/2010	50	79 00.90N	10 43.70E	x	-	-
15/07/2010	50	79 49.72N	10 01.26E	x	-	-
15/07/2010	100	79 49.72N	10 01.26E	x	-	-
17/07/2010	50	80 04.78N	17 16.8E	x	-	-
17/07/2010	50	80 04.78N	17 16.8E	x	-	-
19/07/2010	50	79 29.14N	06 43.27E	x	-	-
19/07/2010	100	79 29.14N	06 43.26E	x	-	-

SCIENTIFIC REPORT 24: Radionuclides in sea-ice and radiochemical determined particle flux

Tim Brand, Richard Abell and John Montgomery

1. Natural radionuclides in sea ice (Leg 2)

This work was undertaken in collaboration with Robert Turnewitsch (SAMS).

There is a history of radionuclide measurements in the atmosphere, terrestrial ice and snow, and in the water column and sediments of the Arctic environment. Naturally occurring radionuclides are very useful tracer substances as their chemistry and input functions are usually well constrained and their radioactive half lives are known. Despite the proven usefulness of these tracers in a range of contexts it seems that, until very recently, no information on radionuclide analyses has been reported for the sea-ice compartment of the Arctic environment. The very few sea-ice studies that have looked into radionuclide distributions support our view that radionuclide measurements in sea ice could prove very valuable in quantifying sea-ice dynamics and aspects of sea-ice biogeochemistry on a broad range of time scales.

Three particle-reactive radionuclides with different half lives and sources were chosen: (1) ^{234}Th originates from long-lived ^{238}U in seawater and has a very short half life of only 24.1 days (to the best of our knowledge these will be the first published ^{234}Th measurements in sea ice); (2) ^{210}Po is produced through radioactive decay of its grandparent ^{210}Pb and has a half life of 138.3 days; and (3) ^{210}Pb originates from atmospheric fall-out and from radioactive decay of its effective long-lived parent ^{226}Ra in seawater and has a half life of 22.1 years. Because of the different sources and half lives the combined measurement of these radionuclides will provide independent information on sea-ice and particulate-matter-related (biogeochemical) dynamics.

Methods

Samples for particulate and dissolved ^{234}Th, ^{210}Po and ^{210}Pb and for total ^{226}Ra were collected during the occupation of the Ice Station. Two sites were sampled: the so-called Station 1 close to the ice edge (25/06 and 26/06/2010) and the so-called Station 2, further away from Station 1 and further into the ice (28/06/2010). At each station a total of 15 ice cores were retrieved (see Tables 1 and 2). To take into account possible horizontal patchiness on spatial scales of meters up to tens of meters, at each station 3 cores were collected at 5 sites near and around the center of the station: i.e., at each of the 5 station sites one core was collected for ^{234}Th, one core for the ^{210}Po / ^{210}Pb pair, and one core for ^{226}Ra (for each station 5 cores were available for ^{234}Th analysis, 5 cores for the analysis of the ^{210}Po / ^{210}Pb pair, and 5 cores for the analysis of ^{226}Ra). Snow was removed from the core tops and all cores were cut in half. To have sufficient sample material for analyses the upper halves of the 5 cores for each radionuclide and station were combined and the lower halves were also combined (see Tables 1 and 2).

For ^{210}Po, ^{210}Pb and ^{226}Ra, combined ice samples were melted in acid-cleaned plastic buckets plus lid and processed on board as described for water-column samples.

For ^{234}Th, combined ice samples were also melted on board in acid-cleaned plastic buckets plus lid. But the melted ice was acidified and stored until processing in the labs at the Scottish Association for Marine Science (SAMS). Ammonia solution was added to a measured volume of acidified sample water until a slightly alkaline pH was reached. Then the measured volume was immediately filtered through a 0.4 µm pore width, 142 mm diameter polycarbonate filter to separate the particle–associated ^{234}Th from the sample. Immediately after the particle filtration a manganese dioxide (MnO_2) precipitation was conducted which transfers the dissolved ^{234}Th into the artificial particulate MnO_2 phase. For several hours the manganese dioxide particles were left to grow into a

filterable particle size. Then they were filtered through 1.0 µm pore width, 142 mm diameter polycarbonate filters. All filters were air-dried and folded in a reproducible geometry. They were then counted directly in a Risø Low-Level Beta GM-25-5 Multicounter system. Repeat counts were conducted over approximately eleven ^{234}Th half lives to check whether the activity changes according to the half-life of ^{234}Th and to determine background values. Counting efficiencies were determined using standard filters. In oxygenated environments the parent radioactivity of ^{238}U can be calculated from salinity.

The analyses of all raw data are still in progress and no preliminary results can be reported at this stage.

Table 1. Information on sea-ice sampling at Radionuclide Station 1 of the Ice station.

Station 1: close to ice edge, total water depth ~ 1230 m – ~ 1260 m					
Nominal ship position: 80°19.920' N, 3°23.410' E					
	Total core length (cm)	Top length (cm)	Bottom length (cm)	Position during ice coring	Date / time (GMT)
Site A					
^{234}Th	80	40	40	80°17'17" N 3°10'3" E	28/06/2010 14:24
^{226}Ra	82	41	41		
^{210}Po/^{210}Pb	76	38	38		
Site B					
^{234}Th	91	45.5	45.5	80°17'23" N 3°10'31" E	28/06/2010 14:05
^{226}Ra	87	43.5	43.5		
^{210}Po/^{210}Pb	88	44	44		
SiteC					
^{234}Th	81	40.5	40.5	80°17'12" N 3°9'50" E	28/06/2010 14:43
^{226}Ra	82	41	41		
^{210}Po/^{210}Pb	76	38	38		
Site D					
^{234}Th	86	43	43	80°17'0" N 3°9'10" E	28/06/2010 15:39
^{226}Ra	86	43	43		
^{210}Po/^{210}Pb	86	43	43		
Site E					
^{234}Th	86	43	43	not recorded	28/06/2010 time not recorded
^{226}Ra	92	46	46		
^{210}Po/^{210}Pb	83	41.5	41.5		

Table 2. Information on sea-ice sampling at Radionuclide Station 2 of the Ice station.

Station 2: far from ice edge, total water depth ~ 800 m - ~ 870 m					
Nominal ship position: 80°31.090' N, 4°09.870' E					
	Total core length (cm)	Top length (cm)	Bottom length (cm)	Position during ice coring	Date / time (GMT)
Site A					
^{234}Th	98	49	49	80°33'9" N 4°8'12" E	25/06/2010 17:29
^{226}Ra	102	51	51		
^{210}Po/^{210}Pb	100	50	50		
Site B					
^{234}Th	98	49	49	80°40'10" N 4°12'42" E	25/06/2010 17:06
^{226}Ra	96	48	48		
^{210}Po/^{210}Pb	96	48	48		
SiteC					
^{234}Th	88	44	44	80°30'17" N 3°58'28" E	26/06/2010 13:26
^{226}Ra	87	43.5	43.5		
^{210}Po/^{210}Pb	87	43.5	43.5		
Site D					
^{234}Th	94	47	47	80°30'6" N 3°56'3" E	26/06/2010 14:19
^{226}Ra	92	46	46		
^{210}Po/^{210}Pb	104	52	52		
Site E					
^{234}Th	96	48	48	80°30'4" N 3°54'46" E	26/06/2010 14:58
^{226}Ra	92	46	46		
^{210}Po/^{210}Pb	93	46.5	46.5		

2. Pelagic and benthic radiochemistry (Legs 3 and 4)

The water column natural uranium series radionuclides ^{210}Po, ^{210}Pb and ^{226}Ra are measured to determine water column particle flux rates and residence times. In addition, a comparison of water column and sediment inventories of ^{210}Pb enables identification of areas of lateral removal of particles within the water column or areas of enhanced deposition.

Methods:

Water column ^{210}Po and ^{210}Pb: Between six to eight 20l water samples were collected from a selected number of CTD stations from cruise legs 3 and 4. Particulate and dissolved fractions were separated and collected. Samples were initially collected in acetone and acid cleaned 25l Nalgene polyethylene thick walled containers. The particulate fraction was collected using pressurised air to filter the seawater through a 142mm 0.45 ester filter paper. Efficient filtering was maintained by monitoring flow rate and using a bleed valve in the filter housing. The dissolved fraction filtrate was collected in 20l flexible polythene canisters. Immediately after collection the sample was acidified with 40 ml conc. HCL, lowering the pH to ~ 1.5. A radiogenic ^{208}Po spike was added (100µl ~30mBq) in addition to a stable ^{206}Pb nitrate (0.5ml, ~2000ppm) spike. The samples were left for between 24 – 48 hours to equilibrate. After equilibration, 0.5ml of cobalt nitrate solution and 1g of ammonium pyrrolydine dithiocarbamate (APDC) were added. After several hours samples were filtered onto Whatman GFF filters using gravity filtration. Dissolved and particulate samples were then stored for post-cruise alpha spectroscopy.

Water column ^{226}Ra: Between and 3 and 4 20l samples for Radium 226 were collected from selected CTD stations from cruise legs 3 and 4. The samples were initially collected in 20l flexible polythene canisters and then pumped filtered through 5µm wound polypropylene cartridges to remove particulate material into 20l Nalgene polycarbonate bottles. 100mls of 5gl^{-1} $BaCl_2$ solution (0.5g) was added to each sample and the sample was stirred using a magnetic stirrer for 1 hour. The barium chloride solution quickly combines with the dissolved sulphate present in the seawater to form a precipitate of barium sulphate with which radium co-precipitates. The 20l bottles were then up-turned and the solution and precipitate was gravity filtered through 7cm diameter 0.45µm nylon filters. The filters were cleaned with DI water and stored in a petri dish. Full details of station information is shown in Table 3

3. Sediment geochemistry and radiochemistry (Legs 3 and 4)

Sediment cores were collected from selected Megacore stations for the determination of solid phase biogeochemistry (metals, particle size, POC/N, chlorophyll) and radionuclides (^{210}Pb and ^{226}Ra).

Methods:

Cores were split into 0.5cm intervals between core top and 10cm. Between 10 to 20cm, sediments were sampled at 1cm intervals. Thereafter, 2cm intervals were sampled to the end of the core. Samples were placed into labelled zip-lock bags and frozen before post-cruise analysis.

Metal chemistry and POC/N measurements will be used to determine the redox characteristics of the sediment and be used alongside the pore-water nutrient chemistry studies (see Scientific Report 25) and will also be used alongside the particle size data to determine sediment provenance and transport features. Sediment chlorophyll determinations are used to determine bioturbation rates within the sediment or the scale of up to 100days and will be compared with previous sediment chlorophyll and thorium 234 measurements taken from samples from earlier cruises in similar areas.

Sediment radiochemistry will be used to determine sediment mass accumulation and linear sedimentation rates using ^{210}Pb excess profiles. The inventory of excess 210Pb will also be compared with the *deficit* inventory of 210Pb in the overlying water, at stations where both water column and sediment cores were taken, to determine the amount of lateral advection of particles into or out of the station. Full details of sediment core information are shown below in Table 3.

Table 3. Table of sediment biogeochemical and pelagic radionuclide samples collected during JCR219.

Station I.D.	Date	Latitude	Longitude	Depth (mbsl)	^{210}Pb Particulate Phase	^{210}Pb Dissolved Phase	^{226}Ra Sample I.D.	Sediment core samples.
KF3	05/072010	78°58.514' N	006°42.387' E	320	**x**	**x**		
KF3	05/072010	78°58.514' N	006°42.387' E	275	**x**	**x**	**x**	
KF3	05/072010	78°58.514' N	006°42.387' E	200	**x**	**x**	**x**	
KF3	05/072010	78°58.514' N	006°42.387' E	100	**x**	**x**		
KF3	05/072010	78°58.514' N	006°42.387' E	50	**x**	**x**	**x**	
KF3	05/072010	78°58.514' N	006°42.387' E	15	**x**	**x**		
KF3 Sediment Core	04/07/2010	79°00.860' N	010°41.610' E	331				**x**
KF4	08/07/2010	78°58.508' N	006°42.370' E	1298	**x**	**x**		
KF4	08/07/2010	78°58.508' N	006°42.370' E	1000	**x**	**x**	**x**	
KF4	08/07/2010	78°58.508' N	006°42.370' E	500	**x**	**x**	**x**	
KF4	08/07/2010	78°58.508' N	006°42.370' E	100	**x**	**x**		
KF4	08/07/2010	78°58.508' N	006°42.370' E	50	**x**	**x**	**x**	
KF4	08/07/2010	78°58.508' N	006°42.370' E	15	**x**	**x**		
KF4 Sediment Core	06/07/2010	78°58.500' N	006°42.360' E	1350				**x**
Greenland Shelf	10/07/2010	77°42.994' N	005°37.344' W	308	**x**	**x**	**x**	
Greenland Shelf	10/07/2010	77°42.994' N	005°37.344' W	200	**x**	**x**	**x**	
Greenland Shelf	10/07/2010	77°42.994' N	005°37.344' W	100	**x**	**x**		
Greenland Shelf	10/07/2010	77°42.994' N	005°37.344' W	50	**x**	**x**	**x**	
Greenland Shelf	10/07/2010	77°42.994' N	005°37.344' W	20	**x**	**x**		
Greenland Shelf	10/07/2010	77°42.994' N	005°37.344' W	5	**x**	**x**		
Greenland Shelf Sediment Core	08/07/2010	77°40.641' N	005°37.884' W	370				**x**
Greenland Shelf Edge	10/07/2010	77°38.920' N	004°46.810' W	1320	**x**	**x**		
Greenland Shelf Edge	10/07/2010	77°38.920' N	004°46.810' W	1000	**x**	**x**	**x**	
Greenland Shelf Edge	10/07/2010	77°38.920' N	004°46.810' W	500	**x**	**x**	**x**	
Greenland Shelf Edge	10/07/2010	77°38.920' N	004°46.810' W	100	**x**	**x**		
Greenland Shelf Edge	10/07/2010	77°38.920' N	004°46.810' W	45	**x**	**x**	**x**	
Greenland Shelf Edge	10/07/2010	77°38.920' N	004°46.810' W	20	**x**	**x**		
Greenland Shelf Edge Sediment Core	09/07/2010	77°38.920' N	004°46.810' W	1398				**x**
Greenwich Meridian	10/07/2010	78°17.000' N	000°00.000' E	2919	**x**	**x**		

Greenwich Meridian	10/07/2010	78°17.000' N	000°00.000' E	2000	**x**	**x**	**x**	
Greenwich Meridian	10/07/2010	78°17.000' N	000°00.000' E	1000	**x**	**x**	**x**	
Greenwich Meridian	10/07/2010	78°17.000' N	000°00.000' E	500	**x**	**x**		
Greenwich Meridian	10/07/2010	78°17.000' N	000°00.000' E	100	**x**	**x**	**x**	
Greenwich Meridian	10/07/2010	78°17.000' N	000°00.000' E	50	**x**	**x**		
Greenwich Meridian Sediment Core								
KF5	11/07/2010	78°56.850' N	005°17.290' E	2446	**x**	**x**		
KF5	11/07/2010	78°56.850' N	005°17.290' E	2000	**x**	**x**	**x**	
KF5	11/07/2010	78°56.850' N	005°17.290' E	1000	**x**	**x**	**x**	
KF5	11/07/2010	78°56.850' N	005°17.290' E	500	**x**	**x**	**x**	
KF5	11/07/2010	78°56.850' N	005°17.290' E	200	**x**	**x**		
KF5	11/07/2010	78°56.850' N	005°17.290' E	50	**x**	**x**		
KF5 Sediment Core								
Woodfjorden	16/07/2010	79°41.030' N	013°49.640' E	149	**x**	**x**		
Woodfjorden	16/07/2010	79°41.030' N	013°49.640' E	75	**x**	**x**		
Woodfjorden	16/07/2010	79°41.030' N	013°49.640' E	0	**x**	**x**		
Woodfjorden Sediment Core	16/07/2010	79°41.060' N	013°49.990' E	198				**x**
Hinlopenrenna	17/07/2010	80°04.786' N	017°16.830' E	331	**x**	**x**		
Hinlopenrenna	17/07/2010	80°04.786' N	017°16.830' E	220	**x**	**x**		
Hinlopenrenna	17/07/2010	80°04.786' N	017°16.830' E	110	**x**	**x**		
Hinlopenrenna	17/07/2010	80°04.786' N	017°16.830' E	0	**x**	**x**		
Hinlopenrenna Sediment Core	17/07/2010	80°04.786' N	017°16.798' E	386				**x**
Ice Edge	18/07/2010	80°33.271' N	011°38.180' E	889	**x**	**x**		
Ice Edge	18/07/2010	80°33.271' N	011°38.180' E	700	**x**	**x**		
Ice Edge	18/07/2010	80°33.271' N	011°38.180' E	500	**x**	**x**		
Ice Edge	18/07/2010	80°33.271' N	011°38.180' E	300	**x**	**x**		
Ice Edge	18/07/2010	80°33.271' N	011°38.180' E	150	**x**	**x**		
Ice Edge	18/07/2010	80°33.271' N	011°38.180' E	0	**x**	**x**		
IceEdge Sediment Core	18/07/2010	80°33.271' N	011°38.180' E	964				**x**

SCIENTIFIC REPORT 25: Benthic landers and biogeochemistry

Henrik Stahl, John Montgomery, Gaving Turner and Andy Reynolds.

Objectives

Little is known about the importance of Arctic sediments for the global marine carbon cycle and how this will be affected by a rapidly changing climate. Retreating ice cover and increased sea water temperatures will have effects on surface ocean productivity and export fluxes of organic matter to the benthos. In order to understand the response of Arctic sediments to such changes it is important to estimate current recycling and burial efficiencies of organic matter in these sediments. A central question for this study is how much of the organic matter input is turned over by the benthos and released back to the overlying water column and how much is sequestered over geological timescales in Arctic sediments?

Oxygen is a good proxy for benthic organic matter turnover as it is the ultimate electron donor in early diagenesis. Oxygen is taken up by the sediment by both biotic (aerobic respiration) as well as abiotic processes (reoxidation of reduced compounds formed during anaerobic respiration) while dissolved nutrients and inorganic carbon is released from the sediments to the overlying water column, where it can continue to fuel primary production.

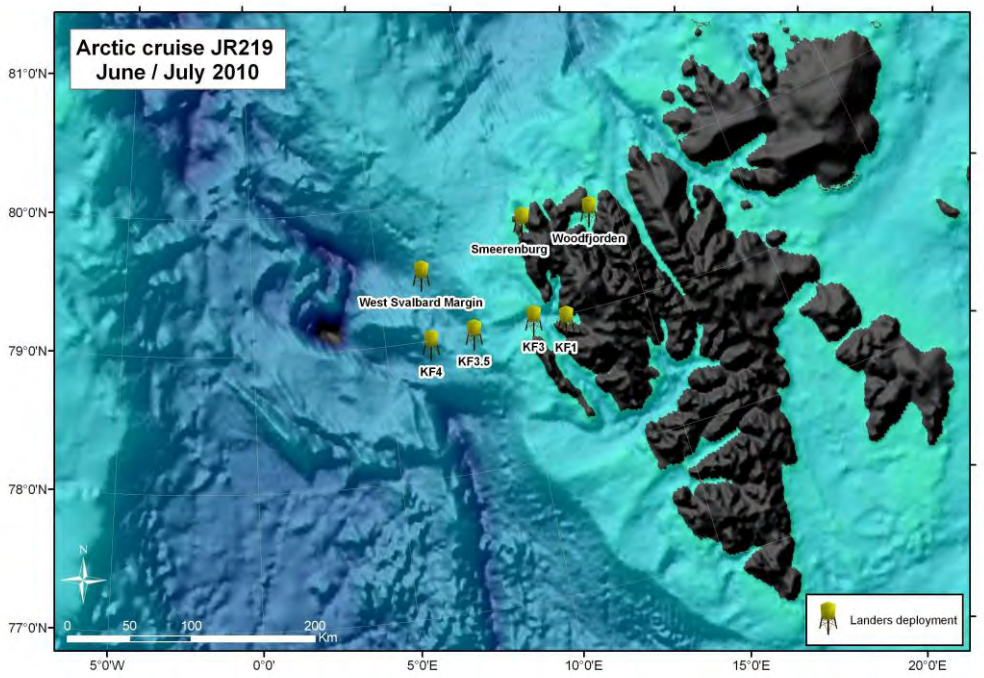

Figure 1. Map over the 7 main lander stations on the western and north western Svalbard margins and slopes.

In order to constrain benthic fluxes of oxygen, nutrients and dissolved inorganic carbon in Arctic sediments during the JR219 cruise, we used a combined approach of novel *in situ* benthic landers, *ex situ* sediment incubations and profiling as well as porewater chemistry. In conjunction with results from other work carried out onboard during the same cruise (see Scientific Report 24) such as particle flux rates from the overlying water column and solid phase sediment geochemistry, we ultimately aim to construct benthic carbon and nutrients budgets for coastal and deep margin sediments around western and northern Svalbard (Fig 1). Results from the current cruise will also be combined with data from previous cruises (JR75, JR179 and JR210) in order to understand inter-annual variability in benthic respiration rates at selected revisited stations.

Benthic lander activity

The benthic landers used during the JR219 cruise were autonomous free-falling vehicles that descended by their own gravity to the seafloor where they performed *in situ* investigations of benthic exchange rates of oxygen, nutrients and dissolved inorganic carbon. After each deployment the landers where recovered from the sea-floor by sending an acoustic signal from the ship which initiated the release of their ballast, providing them with positive buoyancy, which made them return back to the surface. During the JR219 cruise two types of landers where used (Fig 2):
The Elinor lander incubated ~0.1m^2 of the sea-floor using a closed chamber in which the oxygen concentration change was measured over time using an Aanderaa optode (Fig 3). Furthermore, water samples where collected from within the chamber at pre-programmed intervals for later analysis of nutrients and inorganic carbon.
The Eddy lander measures the benthic oxygen uptake non-invasively over a considerably larger surface area than the chamber lander. By simultaneously measuring the net vertical velocity (using an Nortek ADV) and the oxygen concentration (with a fast responding microelectrode) in a well defined water volume just above the sediment, an eddy flux can be calculated for an area of typically ~10m^2 upstream the lander.

Fig 1. Elinor and Eddy lander onboard JCR in Smeerenburg Fjord.

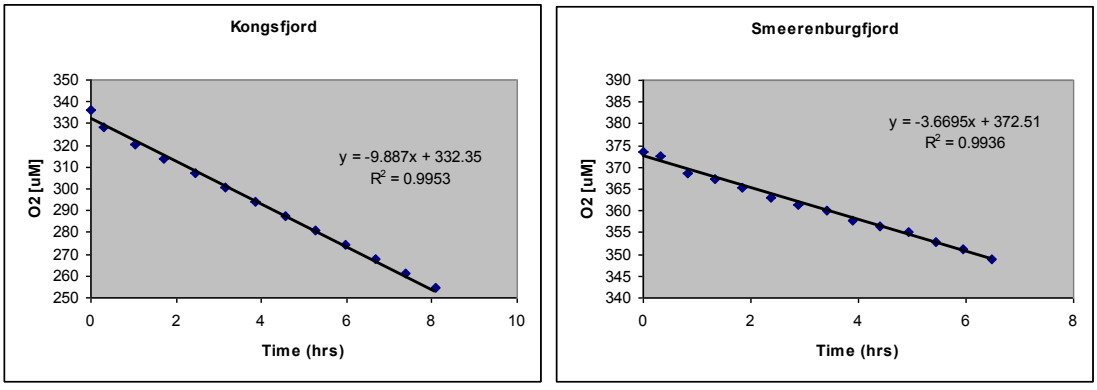

Figure 3. Examples of oxygen concentration change over time in the Elinor chamber from KF1 and SBF site respectively.

In total, 14 lander deployments were carried out at 7 main stations (Fig 1 & Table 1) between the 4th and 20th of July 2010. On average it took ~0.5 hr to deploy both landers from the JCR and recovery took ~1-1.5 hrs. The Elinor lander was equipped with 11 x 17" glass spheres plus one 10" sphere, providing a total buoyancy of 268.5 kg and the Eddy lander had 9 x 17" spheres plus one 10" sphere (total buoyancy of 225kg). Both landers were provided with 180 and 150kg of ballast respectively when deployed, giving an approximate decent/ascent rate of 60-70m/min for the Elinor lander and 50-60m/min for the Eddy lander.

Table 1. All lander deployments made during the JR 219 (Leg 3 & 4) cruise and their respective stations in chronological order.

Depl. no	Station	Start (GMT)	End (GMT)	Depl time	Latitude (N)	Longitude (E)	Depth (m)	Activity	Comments
1	KF3	4/7 13:08	5/7 16:26	27hrs 18min	79°01.000	10°42.040	338	Eddy	Electrode 129mm above bottom
2	KF3	4/7 21:32	5/7 15:56	18hrs 24min	79°00.830	10°42.021	340	Elinor	50mm water height in chamber
3	KF4	5/7 23:14	7/7 10:36	34hrs 22min	78°58.370	06°42.700	1370	Eddy	Electrode 146mm above bottom
4	KF4	5/7 23:31	7/7 11:32	35hrs 1min	78°58.470	06°43.080	1370	Elinor	160mm water height in chamber
5	KF1	11/7 19:05	12/7 05:25	10hrs 20min	78°57.480	11°53.950	345	Elinor	60mm water height in chamber
6	KF1	11/7 19:26	12/7 06:08	10hrs 32min	78°57.550	11°53.500	345	Eddy	Electrode 43mm above bottom
7	KF3.5	12/7 10:03	12/7 21.37	11hrs 34min	78°59.900	08°23.380	710	Eddy	Electrode 88mm above bottom
8	KF3.5	12/7 10:17	12/7 20:55	10hrs 38min	78°59.791	08°23.338	709	Elinor	Lid did not close
9	SBF	15/7 14:16	15/7 21:37	7hrs 21min	79°43.690	11°05.730	220	Eddy	Electrode 95mm above bottom
10	SBF	15/7 14:33	15/7 22:01	7hrs 32min	79°43.580	11°05.710	224	Elinor	200mm water height in chamber
11	WDF	16/7 11.58	16/7 22:51	10hrs 53min	79°40.976	13°49.594	198	Elinor	65mm water height in chamber
12	WDF	16/7 12:16	16/7 22:19	10hrs 3min	79°41.060	13°49.970	198	Eddy	Electrode 91mm above sediment
13	WSM	19/7 08:56	20/7 01:00	16hrs 4min	79°28.950	06°44.270	1328	Eddy	Deployment aborted early, due to weather
14	WSM	19/7 09:09	20/7 02:00	16hrs 51min	79°28.827	06°44.294	1339	Elinor	Deployment aborted early, due to weather

**KF =Kongsfjord; SBF =Smeerenburg fjord; WDF=Woodsfjord; WSM=West Spitsbergen Margin*

Preliminary oxygen results from the Elinor chamber (Fig 3) shows as expected the shallower fjordic sites had significantly higher oxygen uptake (17.6-14.2 mmol m^{-2} d^{-1}) compared to the KF3 margin (-7.5 mmol m^{-2} d^{-1}) and deep margin sites (<1 mmol m^{-2} d^{-1}). Somewhat surprisingly, both the SBF and WDF sites had slightly higher respiration rates (-17.6 and 15.2 mmol m^{-2} d^{-1} respectively) compared to the most southern fjordic site KF1 (-14.2 mmol m^{-2} d^{-1}) which experiences higher bottom water temperatures than both SBF and WDF.

The results from the Eddy lander needs further evaluation and processing before any flux data can be presented with any certainty, although preliminary results show similar trends as from the chamber lander. Furthermore, fluxes of nutrients and DIC will be calculated from all sites once the samples have been analysed back at the lab.

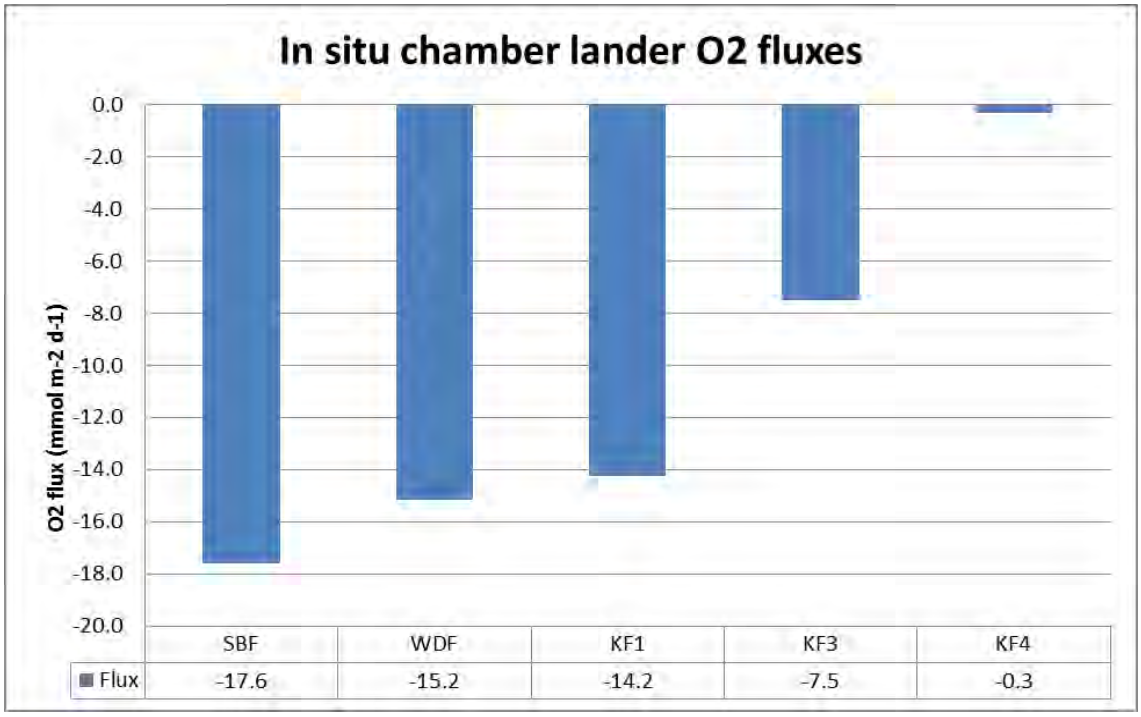

Figure 3. Chamber lander O2 fluxes from all stations in size-order.

Sediment core incubations

In order to complement the benthic lander results as well as facilitate flux measurements on sites where the landers could not be deployed, retrieved megacores where incubated at *in situ* temperature in the CT room onboard ship. In total, 46 cores from 10 different sites were incubated *ex situ* for oxygen, nutrients, DIC, sulphate reduction (Table 2) which will be analysed back at the lab.

Table 2. All ex situ core incubations made during the JR 219 (Leg 3 & 4) cruise and their respective positions and O_2 flux rates in chronological order.

Inc.	Station	Date	Inc. time (hrs)	Latitude (N)	Longitude (E)	Depth (m)	Mean O_2 flux	No. cores
1	KF3	5/7	22.3	79°00.910’	10°41.280’	332	9.05 ± 1.20	6
2	KF4	7/7	25.2	78°58.500’	6°42.360’	1370	2.25 ± 0.49	6
3	GS	9/7	21.5	77°40.64’	5°37.884’	370	2.33 ± 0.37	5
4	GSE	11/2	14.0	77°38.920’	4°46.810’	1398	3.07	1
5	KF1	12/7	10.2	78°57.620’	11°53.090’	346	9.86 ± 0.95	6
6	KF3.1	14/7	10.6	78°57.620’	11°53.090’	333	10.60 ± 0.47	2
7	SBF	15/7	14.1	79°43.580	11°05.710	220	13.31 ± 2.38	6
8	WDF	17/7	13.6	79°41.060	13°49.970	198	14.82 ± 3.02	5
9	HL	18/7	9.0	?	?	386	13.3 ± 1.42	3
10	WSM	19/7	17.8	79°28.950	06°44.270	1257	3.84 ±0.46	3

**KF =Kongsfjord; GS = Greenl.and shelf; GSE = Greenland Shelf Edge; SBF =Smeerenburg fjord; WDF=Woodsfjord; HL = Hinloopen; WSM = West Spitsbergen Margin*

The preliminary results from the lab incubations showed similar trends and values to the *in situ* lander incubations in terms of the O_2 fluxes (Fig 4). WDF and SBF were again the most active sites followed by the KF sites, which were not significantly different from each other. In comparison to chamber data, it was mainly the deeper station (KF4) that showed a significantly higher values which might be due to pressure/temperature artefacts. Hence, the lab flux values from the deeper sites (WSM, GSE and KF4) might be overestimated.

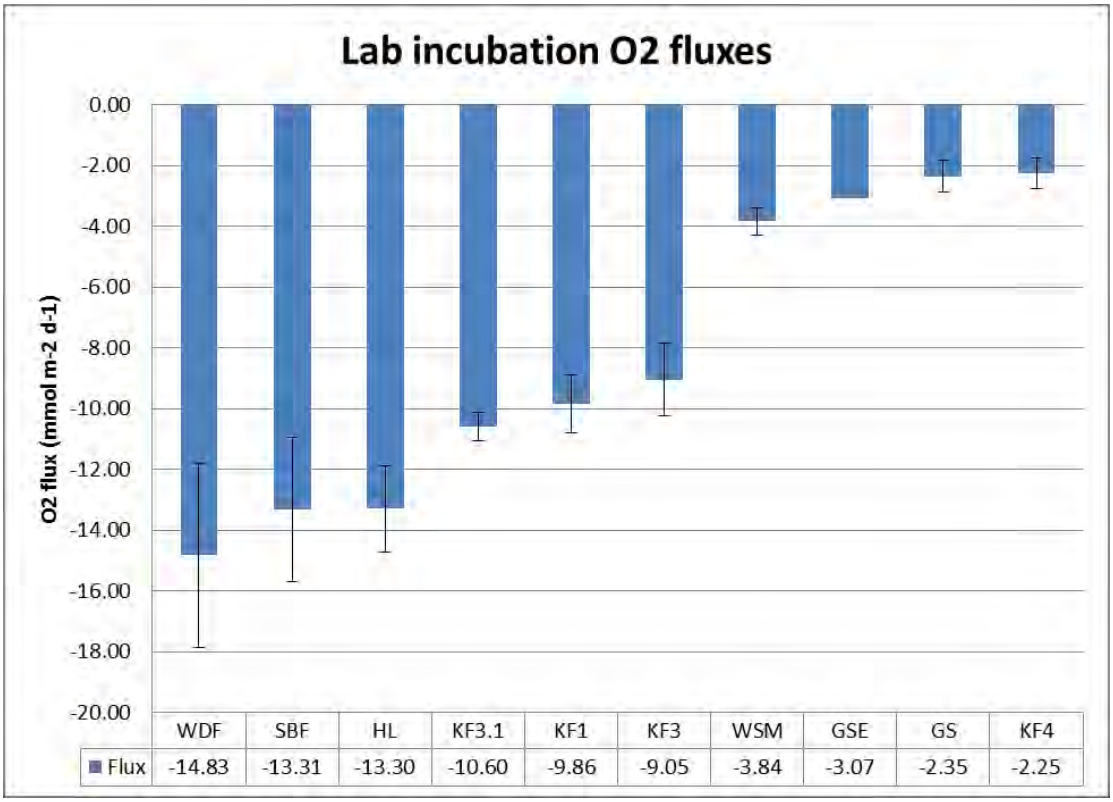

Figure 4. Lab incubation O2 fluxes (TOU) from all stations in size-order

Nevertheless, all the oxygen flux data (both chamber and lab incubations) displayed a significant correlation with depth (Fig 5).

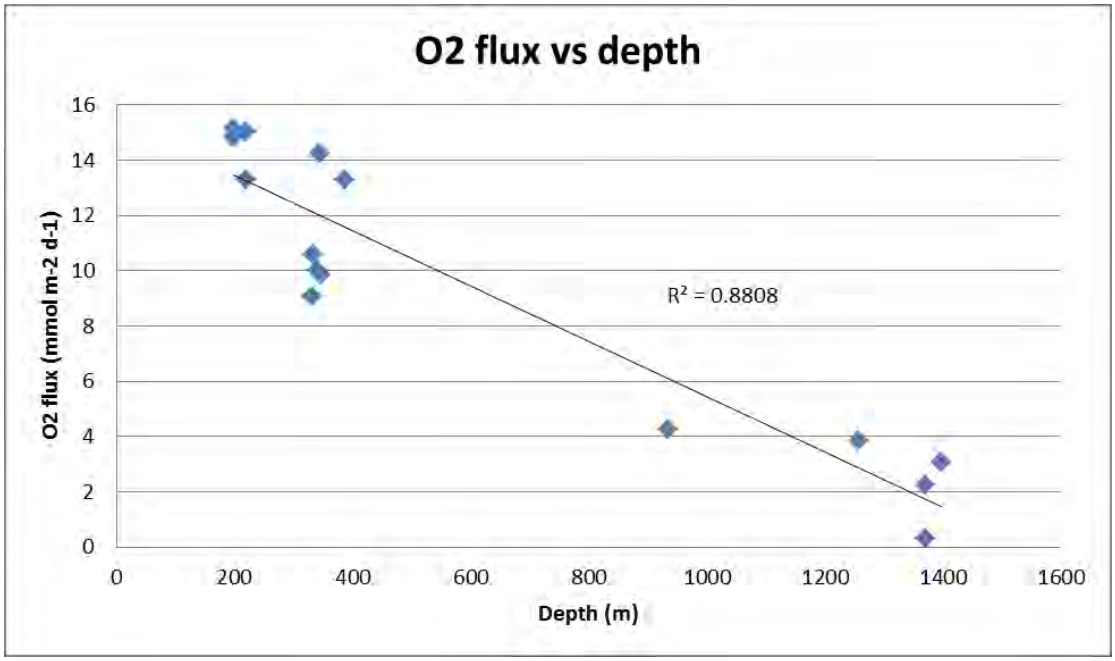

Figure 5. All oxygen flux data (chamber and lab incubations) vs depth.

Lab profiling

In order to complement the whole core lab incubations, multiple oxygen micro-profiles were conducted in 1 or 2 retrieved sediment cores from each station. In total, 71 oxygen micro-profiles where measured in 13 cores from the various stations (Table 3). The oxygen distribution in the sediment generally agreed well with the total oxygen uptake rates from the whole core incubations, with shallower oxygen penetration depth at the sites with high total oxygen uptake rates (Fig 6).

Table 3. All *ex situ* microprofiles during the JR 219 (Leg 3 & 4) cruise

Inc.	Station	Date	No of profiles	Latitude (N)	Longitude (E)	Depth (m)	No. cores
1	KF3	6/7	9	79°00.910’	10°41.280’	332	2
2	KF4	10/7	9	78°58.500’	6°42.360’	1370	1
3	GS	10/7	3	77°40.64’	5°37.884’	370	1
4	KF1	14/7	14	78°57.620’	11°53.090’	346	2
5	SBF	16/7	12	79°43.580	11°05.710	220	2
6	WDF	17/7	13	79°41.060	13°49.970	198	2
7	HL	16/7	5	?	?	386	1
8	WSM	20/7	6	79°28.950	06°44.270	1257	2

**KF =Kongsfjord ;GS = Greenl.and shelf; GSE = Greenland Shelf Edge; SBF =Smeerenburg fjord; WDF=Woodsfjord; HL = Hinloopen; WSM = West Spitsbergen Margin*

The oxygen micro-profiles will also be used to model the diffusive oxygen uptake of the sediment (DOU), which can be compared with the total oxygen uptake (TOU) as a proxy for the contribution of macrofauna to the overall oxygen consumption. Furthermore, volume specific respiration rates will also be modelled from the shape of the oxygen profiles, indicating the relative importance of aerobic and anaerobic respiration processes in the sediment at the various sites.

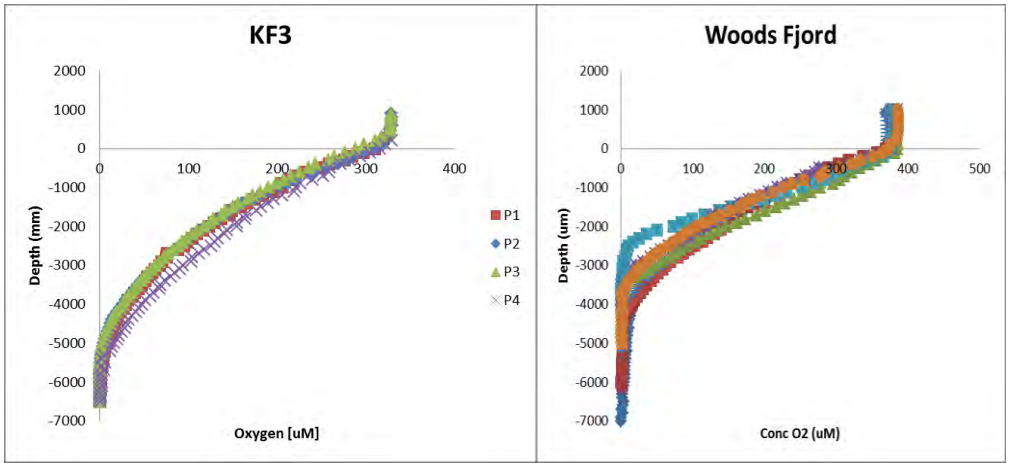

Figure 6. Examples of multiple oxygen micro-profiles measured in cores retrieved from the Kongsfjorden area (average TOU = -9.03 mmol*m-2*d-1) and the Woods Fjord area (average TOU = -14.86 mmol*m-2*d-1).

SCIENTIFIC REPORT 26: Investigating how food quantity and quality affect the biogeochemistry of Arctic sediments

Dan Mayer

Introduction

Benthic communities beyond the photic zone are fuelled by particulate organic matter (POM) produced in the upper ocean. Much of this material is mineralized by the resident organisms and returned to the overlying waters as dissolved inorganic carbon and nitrogen. Any POM arriving at the seabed that escapes mineralization is liable to persist in the sediments for millennia, and sees elements such as carbon (C) and nitrogen (N) shift from their biological to their geological cycles. The effects of temperature on benthic mineralization are well described. In contrast, very little is known about how the quantity and 'quality' (biochemical composition) of POM affect the fate of C and N in marine sediments. This study examined the overarching hypothesis that both *food quantity and food quality affect the fate of C and N in Arctic sediments* using a stable isotope 'pulse-chase experiment'. Different quantities of either low- or high-quality $^{13}C/^{15}N$-labelled POM were introduced into undisturbed sediment cores and subsequently followed (chased) into dissolved compounds in the overlying waters and bacterial and faunal biomass, as evidenced by incorporation of the $^{13}C/^{15}N$ signature.

Methods

This study focussed on the sediments at station 'KF3' located in the mouth of Kongsfjord, Svalbard (79°00.858'N, 010°41.614'E). The seabed was 333m beneath the surface, where the bottom water temperature was approximately 1.8°C. A total of 28 sediment cores (internal diameter 100mm) were retrieved using a Bowers and Connelly-type maxicorer (Ocean Scientific Instruments Limited) equipped with eight individual coring mechanisms. Undisturbed sediment cores were rapidly transferred to a temperature controlled chiller unit set to the *in situ* temperature. Quantities of $^{13}C/^{15}N$-labelled diatoms (*Chaetoceros radicans*; high-quality) and *Phaeocystis* sp. (low-quality) equivalent to 8.3 mmol C m^{-2} (low-quantity) and 16.6 mmol C m^{-2} (high-quantity) were introduced into 6 replicate cores each. Only 4 replicates were run for the low-quantity, low-quality treatment owing to insufficient cores. Following the introduction of the POM, the cores were topped up with bottom water and sealed with lids to prevent gaseous exchange with the air. Water samples were drawn through re-sealable ports in the lids at the outset of the experiment, and every 12 hours thereafter, to determine the concentrations of dissolved oxygen, organic carbon, inorganic carbon, nitrate, nitrite, ammonium and phosphorus. The experiment was terminated after 48 hours. The sediments in half of the cores from each treatment were sectioned at 0-1, 1-2, 2-3, 3-5 & 5-10 cm and sampled for bacterial uptake of ^{13}C and ^{15}N. The remaining sediments were sectioned at 0-2, 2-5 & 5-10 cm and sampled for faunal uptake of the isotope tracers. This work would not have been possible without the tireless help of Richard Abell and the officers and crew of *RRS James Clark Ross*. Thanks also to Ray Leakey for allowing me to participate on this research cruise and to Colin Griffiths for the logistical support. This research is funded by NERC (NE/G014744/1).

SCIENTIFIC REPORT 27: Organic geochemical biomarker analysis

Heiko Moossen

During the ICE CHASER 2010 cruise aboard the RRS *James Clark Ross* from the 13th of June 2010 to the 22nd of July 2010 through the North Sea and the Arctic Ocean, sediment-, ice-, POM (Particulate Organic Matter) - and ice algae-samples were collected to be analysed at the University of Glasgow in the Glasgow-Molecular Organic Laboratory (G-MOL). See Table 1 for a full account of the samples collected.

Background and Aim

Organic geochemical biomarkers have long since been used to elucidate changes in the palaeoclimate (Eglinton & Eglinton, 2008), and to clarify trophic linkages between different species (Dalsgaard *et al.*, 2003). The samples collected on the ICE CHASER 2010 cruise will shed light on trophic linkages and the use of biomarkers as palaeoclimate indicators in the Arctic environment. By contrasting our molecular measurements with the complimentary environmental and biological data, collected *in situ*, we aim to obtain a better understanding of the controls on our geochemical methods in the Arctic region. This will contribute to the broader aim of constraining the extent of the changing climate in the past and how climate change affects life in the Arctic Ocean.

We specifically aim to answer the following questions:

How does the abundance of organic molecules, which are used to reconstruct past climate change, vary during their residence time in the water column?

Water from seven different locations was sampled at different depth. These depths profiles will help us to understand fluxes of biomarkers associated with particulate organic matter (POM) in the water column.

How is organic matter deposited in arctic environments? How has the climate changed in the past in the sampling area?

Sediment cores at eight sites were sampled. These cores were taken using a Megacorer. Each core was between 20 and 40 cm in length. Ten to thirteen sediment samples were collected from each core. POM samples from different depths in the water column were taken at all but one coring site. By analyzing these samples, we hope to better understand the fluxes of particulate organic matter from the water column into the sediments in the arctic region.

How important are ice algae as a food source to zooplankton and subsequent trophic levels? What is the carbon isotopic signature of lipids derived from ice algae, specifically diatoms?

Different Zooplankton samples were collected on the ICE CHASER 2008 cruise. The lipid composition of these zooplankton samples was analysed. We also analysed the carbon isotopic composition of certain alcohols and acids which can be used as trophic markers. Following on from, and to supplement this work, a number of different samples were collected at the Ice Station during Leg 2 of the 2010 cruise. Ice algae were collected in order to analyse the lipid composition and the carbon isotopic signature of their lipids. Ice core samples were collected to better understand the distribution of lipid biomarkers throughout the ice. We also collected POM samples from different water depth to understand fluxes within the water columns of lipids associated with POM which are derived from ice algae.

Sample Collection and Storage

Particulate Organic Matter Samples

Sea Water from CTD-casts and from the non-toxic underway water supply was sampled using Nalgene Carboys. Depending on the POM content of the water at the sampling site between 10 and 100 litres of seawater were filtered per sample. The seawater was filtered through Whatman 47 mm GF/F glass fiber filters (pore size 0.7 µm; ashed at 450°C/8 hours). The filters were placed in Al-foil (ashed at 450°C/8 hours) and dried at 50°C for 24 hours before being packed in Whirl packs and stored at -20°C.

Ice core samples

At the Ice Station (Leg 2; 80° 16.47N, 003° 3.67E) six ice cores were retrieved. The ice at the time of sampling had a thickness of 80 to 100 cm. The cores were cut into three sections, bottom (30 cm), middle (30 cm) and top (rest of ice core) and placed in buckets to melt. Once the cores had melted, the water was filtered through Whatman 47 mm GF/F glass fiber filters (ashed at 450°C/8 hours). The filters were placed in Al-foil (ashed at 450°C/8 hours) and dried at 50°C for 24 hours before being packed in Whirl packs and stored at -20°C.

Ice algae samples

Ice algae samples were collected by divers at the Ice Station (Leg 2; 80° 16.47'N, 003° 3.67'E). These samples were filtered and placed in Al-foil, dried at 50°C and then stored in Whirl packs at -20°C.

Sediment samples

Sediment samples were collected on Legs 3 and 4 of the cruise. These samples were obtained with a multi corer. The cores were between 20 and 40 cm in length and the sediment surface was in pristine condition. The cores were sliced in one and two centimetre slices and then sediment from those slices was placed in a 5 ml glass vial (ashed at 450°C/8 hours) and sealed with ashed Al-foil. Alternatively some samples were placed in ashed Al-foil which in turn was placed in Whirl packs. Samples from two cores were placed directly in Whirl packs without the use of ashed Al-foil. All Sediment samples were stored at -20°C.

References

Dalsgaard, J., St John, M., Kattner, G., Muller-Navarra, D., Hagen, W., (2003) Fatty acid trophic markers in the pelagic marine environment. *Advances in Marine Biology, Vol 46*, 46, 225-340.
Eglinton, T.I., Eglinton, G., (2008) Molecular proxies for paleoclimatology. *Earth and Planetary Science Letters*, 275(1-2), 1-16.

Table 1: Complete list of samples acquired on the ICE CHASER 2010 cruise.

Leg 1	Date	Sample ID	Event Nr.	CTD	Sampling depth [m]	Water filtered [l]	Filters used	Time [GMT]	Lat	Long	Sample Type
North Sea	14.06.10	100614_E2_CTD2_25m	2	2	25	50	11		56º 24.729N	001º 98.849E	POM
S. Norwegian Sea	15.06.10	100615_E4_CTD4_15m	4	4	15	50	10		60º 44.588N	002º 43.670E	POM
Central Norwegian Sea	16.06.10	100616_E8_CTD6_15m	8	6	15	50	10		65º 02.420N	004º 24.020E	POM
N. Norwegian Sea	17.06.10	100617_E12_CTD8_20	12	8	20	50	10		69º 20.459N	006º 22.420E	POM
S. Greenland Sea	18.06.10	100618_E18_CTD10_16m	18	10	16	50	10		72º 45.43N	008º 15.930E	POM
E. Greenland Sea	19.06.10	100619_E23_CTD12_15m	23	12	15	50	14		77º 09.421N	011º 17.530E	POM
Leg 2	**Date**	**ample ID**	**Event Nr.**	**CTD**	**Sampling depth [m]**	**Water filtered [l]**	**Filters used**	**Time [GMT]**	**Lat**	**Long**	**Sample Type**
MIZ	21.06.10	100621_UW1_MIZ			non-toxic H2O supply 6m	50	10	05:20:00	80º 22.40 N	007º 05.21E	POM
MIZ		100621_UW2_MIZ			non-toxic H2O s pply 6m	100	14	10:00:00	80º 45.3 N	006º 02.18E	POM
Ice Station	23.06.10	100623_E24_CTD13_600m	24	13	600	40	5		80º 44.480N	004º 41.930E	POM
		100623_E24_CTD13_500m	24	13	500	40	5		80º 44.480N	004º 41.930E	POM
		100623_E24_CTD13_400m	24	13	400	40	5		80º 4.480N	004º 41.930E	POM
		100623_E26_CTD15_300	26	15	300	40	5		80º 44.480N	004º 41.930E	POM
		100623_E26_CTD15_200	26	15	200	40	5		80º 44.480N	004º 41.930E	POM
		100623_E26_CTD15_60	26	15	60	40	10		80º 44.480N	004º 41.930E	POM
	26.06.10	100626_Icealga _1							80º 35.1N	004º 18.29	Ice Algae
	27.06.10	100627_Icealgae_2							80º 35.1N	004º 18.29	Ice Algae
		Amphipod_1							80º 35.1N	004º 18.29	Amphipod
		Amphipod_2							80º 35.1N	004º 18.29	Amphipod
	29.06.10	100629_CoreTop_11L				11	5		80º 16.47N	003º 3.475	Ice Core
		100629_CoreBottom_13L				13	5		80º 16.47N	003º 3.475	Ice Core
		100629_CoreMiddle_13L				13	5		80º 16.47N	003º 3.475	Ice Core
		100629_E49_CTD26_1000m	49	26	1000	40	5		80º 16.47N	003º 3.475	POM

		100629_E49_CTD26_800m	49	26	800	4	5		80º 16.47N	003º 3.475	POM
		100629_E49_CTD26_600m	49	26	600	40	5		80º 16.47N	003º 3.475	POM
		100629_E52_CTD29_400m	52	29	400	40	5		80º 16.47N	003º 3.475	POM
		100629_E52_CTD29_200m	52	29	200	40	5		80º 16.47N	003º 3.475	POM
		100629_E52_CTD29_37m	2	29	37	10	5		80º 16.47N	003º 3.475	POM
	30.06.10	100630_Icealgae_3							80º 16.47N	003º 3.475	Ice Algae
Leg 3	**Date**	**Sample ID**	**Event Nr.**	**CTD**	**Sampling depth [m]**	**Water filtered [l]**	**Filters used**	**Time [GMT]**	**Lat**	**Long**	**Sample Type**
KF	04.07.10	100704_E65_CTD33_25m	65	33	25	50	10		79º 01.00N	010º 42.04E	POM
KF4	06.07.10	100706_E105_CTD46_1200m	105	46	1200	40	5		79º 58.508N	006º 42.370E	POM
		100706_E105_CTD46_1000m	105	46	1000	40	5		79º 58.508N	006º 42.370E	POM
		100706_E105_CTD46_8 0m	105	46	800	40	5		79º 58.508N	006º 42.370E	POM
		100706_E105_CTD46_600m	105	46	600	40	5		79º 58.508N	006º 42.370E	POM
		100706_E105_CTD46_400m	105	46	400	40	5		79º 58.508N	006º 42.370E	POM
		100706_E105_CTD46_200m	105	46	200	30	5		79º 58.508N	006º 42 370E	POM
		100706_KF4_2cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_3cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_4cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_5cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_6cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_10cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_15cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_20cm							78º 58.5N	006º 42.36E	Sediment
		100706_KF4_25cm							78º 58.5N	006º 42.36E	Sediment
		00706_KF4_30cm							78º 58.5N	006º 42.36E	Sediment
	07.07.10	100707_E112_CTD47_27m	112	47	27	20	9		78º 58.5N	006º 42.36E	POM
Greenland Shelf Station	08.07.10	100708_E118_CTD48_17m	118	48	13	40	10		77º 47.250N	005º 35.390W	POM
	08.07.10	100708_GS_0-2cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_3cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_4cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_5cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_6cm							77º 58.5N	004º 46.800W	Sedime t
		100708_GS_7cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_8cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_9cm							77º 58.5N	004º 46.800W	Sediment

		100708_GS_10cm							77º 58.5N	004º 46.800W	Sediment
		100708_GS_15cm							77º 58.5	004º 46.800W	Sediment
		100708_GS_20cm							77º 58.5N	004º 46.800W	Sediment
	10.07.10	100710_E142_CTD55_18m	142	55	18	20	10		79º 16.997N	000º 00.010E	POM
KF 1	11.07.10	100711_KF1_0-2cm							78º 57.620N	011º 53.080E	Sediment
	.	100711_KF1_3cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_4cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_5cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_6cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_7cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_8cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_9cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_10cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_15cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF _20cm							78º 57.620N	011º 53.080E	Sediment
		100711_KF1_25cm							78º 57.620N	011º 53.080E	Sediment
	12.07.10	Ny-Alesund					1 g				Soil Sample
		Ny-Alesund					1 g				Soil Sample
Leg 4	**Date**	**Sample ID**	**Event Nr.**	**CTD**	**Sampling depth [m]**	**Water filtere [l]**	**Filters used**	**Time [GMT]**	**Lat**	**Long**	**Sample Type**
KF3	14.07.10	100714_E173_CTD63_300m	173	63	300	40	5		79º 00.900N	010º 43.650E	POM
		100714_E173_CTD63_200m	173	63	200	40	5		79º 00.900N	010º 43.650E	POM
		100714_E173_CTD63_100m	173	63	100	0	5		79º 00.900N	010º 43.650E	POM
		100714_E173_CTD63_35m(DCM)	173	63	35	20	5		79º 00.900N	010º 43.650E	POM
KF3	14.07.10	100714_KF3_0-2cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_3cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_4cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_5cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_6cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_7cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_8cm							79º 00.890N	010º 3.660E	Sediment
		100714_KF3_9cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_10cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_15cm							79º 00.890N	010º 43.660E	Sediment
		100714_KF3_20cm							79º 00.890N	010º 43.660E	Sediment
		1 0714_KF3_25cm							79º 00.890N	010º 43.660E	Sediment

CTD Section 2-A	14.07.10	100714_E180_CTD64_65m(DCM)	180	64	65	20	5		79º 56.660N	008º 56.220E	POM
Smeerenburg Fjord	15.07.10	100715_E196_CTD73_200	196	73	200	20	5		79º 43.885N	011º 05.400E	POM
		1007 5_E196_CTD73_100	196	73	100	20	5		79º 43.885N	011º 05.400E	POM
		100715_E196_CTD73_20 (DCM)	196	73	20	20	5		79º 43.885N	011º 05.400E	POM
		100715_SF_0-2cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_3cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_4cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_5cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_6cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_7cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_8cm							79º 43 885N	011º 05.400E	Sediment
		100715_SF_9cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_10cm							79º 43.885N	011º 05.400E	Sediment
		100715_SF_15cm							79º 43.885N	011º 05.400E	Sediment
Woodfjorden	16.07.10	100716_WF_0-2cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_3cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_4cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_5cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_6cm							79º 41.060N	013º 49.990E	Sediment
		10 716_WF_7cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_8cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_9cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_10cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_11cm							79º 41.0 0N	013º 49.990E	Sediment
		100716_WF_15cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_20cm							79º 41.060N	013º 49.990E	Sediment
		100716_WF_25cm							79º 41.060N	013º 49.990E	Sediment
Hinlopen	17.07.10	100717_HL_0-2cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_3cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_4cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_5cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_6cm							80º 04.786N	017º 16.798E	Sediment
		100717 HL_7cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_8cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_9cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_10cm							80º 04.786N	017º 16.798E	Sediment

		100717_HL_15cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_20cm							80º 04.786N	017º 16.798E	Sediment
		100717_HL_25cm							80º 04.786N	017º 16.798E	Sediment
	17.07.10	100717_E228_CTD80_376	228	80	376	20	5		80º 04.786N	017º 16.830E	POM
		100717_E228_CTD80_200	228	80	200	20			80º 04.786N	017º 16.830E	POM
		100717_E228_CTD80_35(DCM)	228	80	35	20	10		80º 04.786N	017º 16.830E	POM
Ice Edge	18.07.10	100718_IE_0-2cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_3cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_4cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_5cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_6cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_7cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_8cm							80º 33.270N	011º 38.19 E	Sediment
		100718_IE_9cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_10cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_15cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_20cm							80º 33.270N	011º 38.190E	Sediment
		100718_IE_ 5cm							80º 33.270N	011º 38.190E	Sediment
	18.07.10	100718_E245_CTD90_934	245	90	934	40	5		80º 33.270N	011º 38.180E	POM
		100718_E245_CTD90_500	245	90	500	40	5		80º 33.270N	011º 38.180E	POM
		100718_E245_CTD90_57(DCM)	245	90	57	20	5		80º 33.270N	011º 38.180E	POM

SCIENTIFIC REPORT 28: Seabed mapping and piston core sampling off NW Svalbard

John A. Howe, Robert Spielhagen, Torben Struve, Jill McColl, Richard Abell, Jason Scott and Alan Sherring

Objectives

These projects build on the work conducted on JR75 and JR127 and aim to examine sediment pathways and the signal of climatic amelioration from high-latitude marine sediments using sediment texture and geochemistry. This project aims to investigate Holocene climate change using marine sediment archives from western Svalbard as part of the NERC-funded Oceans 2025 programme. The Svalbard archipelago occurs directly to the east of the Fram Strait which forms the only oceanic gateway between the Arctic Ocean basin and the North Atlantic thereby regulating world climate through the exchange of Arctic & North Atlantic Water. We aim to test coupled ocean-climate models, providing quantitative records detailing the past interactions of Arctic and North Atlantic Water and investigate Holocene variability in sea ice, glacial extent and the northward transport of NAW around western Svalbard. A 12m-long piston corer is used to obtained sediment records spanning that least the last glacial-interglacial cycle. Core site selection involved a short acoustic survey (TOPAS and EM120 Multibeam) to identify key areas of current influenced sedimentation. Post-cruise analysis will entail sediment texture (laser Particle Size Analysis), microfaunal and geochemical (organic and inorganic) analysis.

Summary of Work

The main science aims of the cruise were:

Coring – Using Piston Corer + Trigger Core & SAMS megacore

(a) Coring depostional areas of the western Svalbard slope. These current-influenced sediments provide evidence for records of West Spitsbergen Current variability. The contourite sediments are deposited in regions with high background of ice-rafted debris (IRD). Sedimentation will be examined in the context of foraminifera and geochemistry (see Table 1 for details).

(b) High-resolution records of Arctic environmental change from fjordic and shelf sediments.

Seabed Mapping – Using EM120 Multibeam and TOPAS systems

(c) Opportunistic shelf and fjord multibeam surveys. Each coring station has been surveyed, but in some instances (PC141, Wood fjord) the surveys were run due to bad weather curtailing other activities.

National Oceanography Centre – Coring Equipment

The equipment supplied for coring by NOC marine facilities consisted of the standard piston coring suite.

Piston Core Stations

Core samples were obtained at seven stations using the standard piston coring suite with 1m trigger core (see Table 1). The corer uses a 1400kg bomb with a 12m long, steel barrel, in 3m bolted sections. Within the barrels are polycarbonate liner inside which runs the piston and wire. The corer is deployed from the starboard main gantry using the piston core bucket and two winches. The rate of descent was controlled by the winchman at about 40m/min until 100m above

the seabed, where the corer was stabilised before being run in at about 20m/min. Freefall and trigger lengths were calculated using the "Driscol" formula for the indicated barrel lengths. Some adjustment was made to these lengths to increase the core length obtained. Once inboard the barrels were unbolted, core cutter and catcher were removed and the polycarbonate liner pushed out of the barrel in 3m sections and capped. The core was then measured and sliced on deck into 1m sections. Following sectioning, the complete core was passed through a Bartington MS2 magnetic susceptibility loop in the ships' wet lab.

Sample recovery was very good and varied between 8.20-11.48m, depending on the sediment type and barrel length. Some core top loss and compaction is possible at the softer sediment sites (e.g. Smeerenburg fjord). The biggest problem, and one that was not resolved was the continuing implosion of the liner, this was especially a problem in soft sediments. At the final station, PC145 the core liner imploded and jammed in the barrel. The stainless steel barrel was cut into three sections to try and remove the sample, but it was jammed solid and the sample was abandoned. The core loss was approximately 1.0m between 6-7mbsf. The reasons for the implosion might be a combination of freefall length and running in speed. Gas was also a problem at the fjord stations, the core caps being pushed off by the expanding sediment from escaping hydrogen sulphide gas. Rigging and derigging the corer was conducted very smoothly.

Table 1: Piston Core Samples

Date & Time on Seabed	Event/ Core Number	Position	Water Depth	Recovery	Barrel Length & Bomb Weight	Sediment Type	Area & Comment
14/7/10 11:56hrs	219/139	79˚01.6636 N 10˚ 47.7921 E	337 m	10.58m PC + CC	12m 1400kg	Fine-grained gas-rich muds	Kongsfjordrenna Liner imploded
15/7/10 15:46hrs	219/140	79˚ 43.8800 N 11˚ 05.4100 E	220 m	11.48m PC + CC	12m 1400kg	Fine-grained gas-rich muds	Smeerenburg Fjord Liner imploded
16/7/10 0853hrs	219/141	79˚ 41.0581 N 13˚ 49. 9800 E	198 m	9.20 m PC + CC	12m 1400kg	Organic, gas-rich muds	Wood fjord Liner imploded
17/7/10 14:55hrs	219/142	80˚ 04.7765 N 17˚ 16.8000 E	386m	8.30 m PC + CC	12m 1400kg	Greenish muds to diamict at base	Outer Hinlopen Strait
18/7/10 07:44hrs	219/143	80˚ 31.8242 N 11˚ 16.0846 E	865 m	9.70 m PC + CC	12m 1400kg	Olive muds	Northern Svalbard slope
19/7/10 0803hrs	219/144	79˚ 29.1398 N 06˚ 43.3000 E	1268 m	9.12 m PC + CC	12m 1400kg	Grey muds sandy at base	Western Svalbard margin Liner imploded
20/7/10 10:00hrs	219/145	78˚ 58.2156 N 07˚ 01.8997 E	1215 m	8.20m PC+CC	12m 1400kg	Olive muds	Western Svalbard margin – liner imploded – core lost between 6-7m

Mega Cores

The megacorer (tube diameter 10 cm) was used for sampling of near-surface sediments and bottom water at seven stations (MC016, MC017, MC020, MC021, MC022, MC023, MC024) where also long piston cores were obtained (PC139-PC145). Recovery was usually 30 cm (max. 38 cm, min. 20 cm). To sample the bottom water, it was sucked by a silicone hose from the upper part of one tube into two glass bottles per station immediately after the megacorer had come on deck. 0.2 ml of saturated $HgCl_2$ solution was added to one of the bottles to stop microbial activity. The rest of

the water was released. About 50% of the sediment surface sample (uppermost 1 cm) was filled into PVC bottles and pure denatured alcohol with rose bengal was added to preserve organic matter and stain alive benthic microfossils. The other half of the surface sample was filled in plastic beakers. The remaining sediment core was sampled every 1 cm (every 0.5 cm in upper part). All samples were stored cool (4°C).

During the sampling process, a rough visual inspection of the near-surface sediments was possible. All sediments were relatively fine-grained (estimated coarse-fraction content <5%), but occasionally contained single rock clasts interpreted as ice-rafted debris. The thickness of the uppermost oxygenated, olive-brown layer was variable from core to core. Generally, it was significantly thicker (ca. 10 cm) in the megacores from the western and northern Svalbard continental margin and the Kongsfjorden trough (MC016, MC022, MC023, MC024) than in cores from the north Svalbard fjords, where the thickness was reduced to a few centimeters. The lower part of all megacores had olive-grey colours and is interpreted to be less oxygenated.

The megacore samples serve as an archive of environmental variability on the Svalbard margin and in the fjords. Previous work has shown that sedimentation rates in the study are highly variable (5-200 cm/1000 yr). Coring during Leg 4 was performed at sites where high sedimentation rates (>30 cm/1000 yr) can be expected which allow palaeoenvironmental reconstructions on (multi)decadal scales. Of particular interest is the variability of Atlantic Water advection to the Svalbard margin because it determines the position of the sea ice margin in the area and has a strong bearing on, e.g., heat advection to the Arctic, warming of the Arctic atmosphere, and marine biological productivity. Analyses of various sedimentological, geochemical, and micropaleontological parameters will be performed at SAMS, IFM-GEOMAR, and cooperationg institutions to reconstruct the paleoenvironmental history of the study area.

The water samples (both from megacores and niskin bottles attached to the CTD) and the rose bengal stained sediment surface samples will be used for a study to be conducted at IFM-GEOMAR within the EU-funded project CASE (The Changing Arctic and Subarctic Environment; a Marie Curie International Training Network). Oxygen and carbon isotopes will be measured both in bottom waters and in alive (stained) benthic microorganisms (foraminifera) to investigate how the isotopic composition of the bottom waters is reflected in the calcareous shells of the bottom-dwelling organisms. CTD results will be used to determine the influence of temperature as well as sea ice formation and melting (which change salinity but hardly the isotopic composition of sea water) on the isotopic composition of the shells. This composition is a commonly used parameter in paleoenvironmental studies but few such groundtruthing studies exist so far in the northern Nordic Seas and Arctic Ocean.

Acoustic Seabed Mapping

Seabed mapping was achieved using the RRS *James Clark Ross* EM120 multibeam system, running in parallel with the TOPAS sub-bottom profiling system. These two systems provide detailed data of the seabed morphology (EM120 Multibeam) and the sediment geometry and acoustic character (TOPAS). Both systems were operated throughout the cruise, with surveys conducted both underway and detailed surveying of each station prior to sampling.

Sub-Bottom Profiling using TOPAS

An updated version of TOPAS was supplied by BAS for the cruise (version 2.1.2). This was found to work very well using the settings stated below, as outlined in SAMS Cruise Report from JR75 & JR127:
Sampling rates of 10kHz, trace length 400ms, file size 10MB. Swell OFF, dereverb OFF and stacking OFF.
In deep-water (>1000m). Chirp source, 15 ms pulse length, 1.5-5kHz, level 85%; bandpass filter settings 1400-1600/4900-5100 Hz. Manual triggering, generally 2000 msec. Gain 20-25 dB

depending on water depth, seabed type and weather. Processing: filter ON, deconv ON (1pmm), TVG ON, scale 3000%.
In shallow-water (<1000m). Burst source, period 2, level 100%, secondary frequency 2800 Hz. SSU triggering, ping interval set to 0. Gain 10-20 dB depending on water depth, seabed type and weather. Processing: filter ON, AVC ON, scale 2000%.
EPC Chart recorder settings; TOPAS on channel A, 0.5 second sweep, 0 delay, threshold about 1/3 turn clockwise from minimum, trigger level 0, gain 10 (max), sweep direction left to right, print polarity +/- (centre setting). Takeup was left ON, scale lines ON, mark/annotate OFF, chart drive internal (centre setting), 100 LPI, contrast centre setting.

EM120 Multibeam seabed mapping

The EM120 multibeam system performed, on the whole, very well throughout the cruise. Seabed bathymetric maps could be produced within 20 minutes of a survey ending in some cases. This was especially important when the bridge needed core positions and sampling stations as soon as possible after a survey. Only in rougher weather and whilst turning did the system perform less well with drop-outs and spurious depth readings commonly encountered. Sound velocity profiles were gathered from the ship's CTD rather than using the EM120 sound velocity probe.

Multibeam and Topas surveys

Kongsfjordrenna – multibeam revealing the core site as a small complex of basins. Close to AWI Polarstern core sites.
Smeerenburg fjord – complete survey of the entire fjord basin.
Wood fjord – short survey file name as Smeerenburg and encompassing the shelf adjacent between the two fjords.
Hinlopen Strait – a short survey of the Nordporten basin, numerous mega-scale glacial lineations and ice berg furrows.
Storlisnaget – short survey of the northern Svalbard margin.
Western Svalbard margin - short surveys of the downslope area below 1000m for core location only. A survey was run continuously during passage to and from the stations adjacent to Amsterdamoya.

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APPENDIX 2: JR219 sea-ice operation guidelines

Ray Leakey and Colin Griffiths

1. Introduction

Undertaking scientific activities on Arctic sea-ice as part of an oceanographic research cruise presents considerable logistical and operational challenges. Most important are safety considerations with respect to the cold weather conditions, unstable ice platform and presence of polar bears. Other considerations include the transport and operation of equipment on the ice. This report presents a guide to working on sea-ice based on the operational procedures and equipment used in support of research conducted on the sea-ice during JR219. Under-ice diving operations are summarised elsewhere (see Appendix 3).

2. Pre-cruise preparation

- It is essential that the ships operators and Captain are informed at an early stage (several weeks) prior to the cruise of the requirement to conduct sea-ice studies involving scientific personnel leaving the ship to work on or dive under sea-ice. Both parties will need to be informed of the scientific objectives and operational requirements of the sea-ice work in order to advise the PSO on the feasibility of the proposed work and implications for the ships operation and cruise planning.

- A generic risk assessment document should be prepared by the PSO covering all aspects of work on the ice and made available to the ships operators and Captain prior to the cruise. Work under the ice involving diving should be covered by a separate under-ice diving risk assessment.

- Work on ice requires the use of guns to protect from polar bears (see below). Arrangements will therefore need to be made prior to the cruise for the access and use of guns on ship and sea-ice. Selected personnel will need to be fully trained and competent in the use of guns. Sufficient personnel should be trained to ensure all activities on the ice are provided with gun cover. Note that personnel providing gun cover will not be able to undertake science activities. They will also be subject to fatigue and cold when providing gun cover for prolonged periods so may need to be rotated. In addition, activities based at separate locations on an ice flow may require independent gun cover. Several personnel may therefore have to be trained prior to the cruise to provide adequate support for the science plan. In preparation for JR219 two SAMS personnel received a week long survival course in Longyearbyen in January 2010. The course was run by UNIS, the University Centre in Svalbard. The course included rifle training, polar bear awareness training, the dangers of travelling on sea ice including skidoo training. UNIS rifles are only available to personnel who have attended this course and the course is only available to personnel who are registered as guest lecturers at UNIS.

- All personnel working on the sea-ice should be physically fit and before the cruise will have to have passed the relevant medical tests (e.g. MCA ENG 1) and sea-survival training (STCW 95 Reg. VI/1 Section A-Vi/1 Para. 2.1.1 Personal Survival Techniques) required for working on ship.

3. Mitigation of risk from polar bears

3.1 Polar bear observations on ship:

- No personnel should be allowed on to the sea-ice without dedicated polar bear observations underway on the ship and weather conditions suitable for the observers to identify and warn of

bears in time to evacuate the ice safely (e.g. at least 2 miles visibility). Should observations fail due to weather or other unforeseen circumstances then personnel should immediately return to the ship.

- The PSO should arrange a polar bear observation rota well in advance of any on-ice activity and this should be held on the bridge by the officer on watch. The PSO must ensure that all staff listed on the rota will be available at their specified time, regardless of all other activities, and that they are contactable before they are required from the bridge. The ship's officers and crew will not be available for observations so scientific personnel will need to provide all observations. Therefore, if on-ice activity is anticipated to be high it is recommended that dedicated personnel are included on the cruise with the specific role of acting as observers in order to reduce conflicts between observations and other science duties.

- Observations should be undertaken by two personnel from a high, prominent position on the ship's superstructure offering unimpeded views of all areas of sea-ice surrounding ship (e.g. the "monkey island" above the bridge on the RRS *James Clark Ross*).

- Each observer should be equipped with high quality marine binoculars (7 x 50), two-way ship's radio, sunglasses and cold weather protective clothing. Because observers are exposed to the weather and remain mainly stationary for up to one hour it is essential that their protective clothing is adequate. It is therefore recommended that high quality down parkers (e.g. Arctic Kingdom Expedition jackets) and waterproof insulated gloves (e.g. Showa 490) are provided and held ready for use on the ships bridge.

- Polar bear observations should commence at least 15 minutes before any personnel are allowed on the sea-ice to check the ice is clear of bears. No one should be allowed on the ice until instructed by the officer on watch following confirmation from both observers that the ice is clear of bears.

- Each observer should contact the bridge by radio when they are ready to start observations. One observer should concentrate on observations starboard, forward and aft, while the other should observe port, forward and aft. Observers should scan the entire ice landscape continuously paying special attention to less visible areas (e.g. aft and close in to the ship's hull).

- Each observer should spend no more than 30 minutes on duty in order to reduce the risk of cold and fatigue. After 15 minutes the bridge should contact each observer to check there are no problems. After half an hour each observer should be rotated handing over radios, binoculars and, where necessary, cold outer clothing to the next observer who should report by radio to the bridge. If an observer is unable to continue on duty for the full half hour (e.g. due to cold) then the observer should contact the bridge by radio and a replacement should be found as soon as possible. If this is not possible then personnel on ice should return to the ship. The observer should not discontinue observations unless a replacement is found or the ice is clear of personnel.

- If a polar bear is seen the observer should immediately contact the bridge. If there is any doubt about a sighting then the bridge should still be contacted so that the sighting can be confirmed. It is important that confirmation is undertaken by the ships staff on the bridge rather than by the other observer so that the latter is not distracted from their own observations. After confirmation the officer on watch should immediately notify by radio the on-ice personnel who should immediately return to the ship. The only exception to this is if the bear is several (2+) miles distant traversing the horizon away from the ship. In this case the on-ice personnel should be placed on standby to evacuate the ice and the bear carefully monitored.

3.2 Precautionary measures on ice

- No personnel should be allowed onto sea-ice without protection provided by polar bear observations and dedicated gun cover. Observations need to confirm that the ice is free of bears and that visibility is sufficient at all times to enable continued bear observations. Gun cover needs to be provided by someone fully trained and competent in the use of guns for polar bear protection, and in full communication with the ship. Whilst on the ice the rifles should be half loaded at all times.

- Access to and from the sea-ice should be controlled by the ship's officer on watch via use of a personnel basket winched onto and off the ice surface. Gangway ladders should not be used to prevent bears accessing the ship or unauthorised access by personnel onto the ice. A cargo safety net extending from the ship's deck to ice surface should also be provided to act as an emergency exit from the ice in event of basket winch failure. To allow immediate evacuation from the ice, the basket winch should be manned throughout on-ice operations by the ship's personnel. The number of personnel allowed onto the ice should not exceed the number able to be immediately evacuated (e.g. four per basket on the RRS *James Clark Ross*).

- Gun cover should be provided by one designated person for each group of scientists working in a localised area (< 200 m diameter) on the ice. This person will be primarily responsible for providing gun cover and should be able to communicate with the officer on watch on the ship's bridge, plus the on-ice personnel within their team, at all times. They should therefore carry an operational rifle, ammunition, flare pistols and flares, and ship's two way radio at all times. They should also have access to binoculars. They should not undertake any other duties whilst on the ice but instead remain continuously vigilant watching for bears in case the ship-based observations should fail.

- When not in use all rifles and ammunition should be held by the Captain in a secure location. Rifles should be test fired from a safe position on the ship's deck prior to first deployment on the ice. They should be carried unloaded onto the ice in the ships basket and immediately half loaded with ammunition on the ice. This should be the first task undertaken on the ice. The last task on the ice is to unload the rifles. Once aboard the rifles and ammunition are returned immediately to the Captain. A check is kept on the ammunition count on return to the vessel.

- Each team should work as close to the ship as possible and should be able to evacuate the ice within 5 minutes if required (leaving all equipment on the ice if required). They should therefore work within 300 m of the ship and no team member should be further from the ship than the person providing gun cover. If work has to be undertaken further from the ship then it is recommended that two personnel provide gun cover (in case of equipment failure) and that a skidoo and sledge is used to speed transport of personnel to the ship. However, in all cases, each team has to be able to protect themselves from bear attack if unforeseen circumstances delay a safe return to the ship. Additional equipment to scare bears (flares, air horns) may therefore be useful additions to each team's safety equipment.

3.3 Preventative measures to protect equipment:

- Where possible no equipment should left on the ice after personnel have returned to the ship.

- Any equipment remaining on the ice (e.g. deployed instruments) should be encased where possible in the strongest possible containers to protect from bears. It should be noted that bears can easily damage standard aluminium packing cases so containers and their anchors/floats need to be exceptionally strong. Bears also have exceptionally good sense of

smell so any containers should be free any traces of food, even if wrapped in sealed packaging. Alternative means of protecting equipment, if available, should be considered.

- Marker posts and ropes are vulnerable to interference from bears so duplicate markers or alternative methods of marking sites (e.g. paint) should be considered.

- Equipment left on the ice should be routinely observed from the ship for interference by bears. Should a bear be spotted approaching equipment then attempts should be made to deter the bear using the ship's horn, flares or gun shot. These may, however, prove ineffective and scientists need to be prepared to lose equipment. Where important and/or expensive equipment is to be deployed then more effective ways of deterring or immobilising bears, if available, should be considered which can be implemented from the safety of the ship.

- Personnel should not be deployed onto the ice to deter or immobilise a bear in order to protect equipment.

4. Protection from cold and immersion in water

- All personnel working on the sea-ice should be physically fit and able to swim.

- Protective clothing should be worn to protect from cold, drowning and sunlight. The following items are recommended: ships inflatable life jacket, immersion survival suit, insulated waterproof boots, insulated waterproof gloves, insulated hat, UV protection sunglasses. Arctic sea-ice is characterised by melt pools in summer so wellingtons (e.g. Dunlop Thermo+) may be more effective than RBLT (rubber-bottom leather-top) polar boots.

- For prolonged work on the ice it is recommended that warm drinks (e.g. thermos), food (energy bars) and spare gloves are available on the ice but food should not be held in equipment boxes to be left on the ice (even if wrapped in sealed packaging) or consumed near equipment.

- When travelling and working on the ice, care should be taken to ensure that the ice is capable of bearing the weight of personnel and equipment (including skidoo and sledge). Ice structure and character may vary considerably over short spatial and temporal scales and the ability of ice to bare weight may change rapidly in warm conditions or when subject to strong currents or wind. A boat hook or similar long wooden pole is recommended to test the thickness of ice when walking on new ice locations. For substantial, prolonged on-ice work it is recommended that ice thickness is measured initially and at routine intervals at various working locations by drilling a small (5 cm) diameter hole and using an ice thickness gauge. Hazardous areas (e.g. thin ice, edge of flow, etc.) should be clearly marked (e.g. with flag poles and tape).

5. Injuries and emergency evacuation

- Hard hats are required to protect from overhead hazards (crane failure) during use of the personnel basket to access the ice. These are generally not required when working on ice.

- To prevent cold and frostbite, steel-toe cap boots are not recommended unless essential for specific high-risk equipment use (e.g. chain saw operation).

- A two way radio should be carried by a member of each team on the ice (usually the person providing gun protection) and communication maintained with the ship in event of a medical emergency, ice breakup and/or polar bear evacuation.

- A first aid kit equipped to deal with minor injuries should be available at all times on the ice,

- When working away from the ship, use of a skidoo and sledge is recommended to speed transport of injured personnel to and from the ship. It is also recommended that an ice evacuation drill is conducted involving the use of the ships stretcher.

- In an extreme event where evacuation for the ice is delayed (e.g. rapid ice break up), personnel need to be equipped to stay on the ice for several hours

6. Working on the sea-ice

- When selecting an ice flow for study, logistical as well as scientific criteria must be considered Criteria include considerations of the structural integrity of the ice to support personnel and equipment, the necessity and capability to secure the ship to the flow, and the effect of the ship on the ice flow characteristics (shading, wind-driven mobility and stress).The time spent working at one particular area of sea-ice should also be minimised to reduce the risk of bears locating the ship by smell.

- Personnel and small items of equipment should be deployed and retrieved on and off the ice using the personnel basket. Larger items (e.g. skidoo and sledge) should be winched as single items.

- Personnel working on the ice should maintain regular communications with the ship's officer on watch using the ships two way radios and periodically report on progress of on-ice activities or changes to plan.

- The ship may be anchored to the ice to help secure the flow to the ship during long-term (days) ice stations. Anchors should be constructed from large wooden stakes driven into thick ice, some distance from the ship, to which ship's anchor ropes are attached. However, it may be necessary to continuously use the ship's bow and stern thrusters or main propulsion to prevent stress from the ship breaking up the flow, or to clear ice from around the ship to provide open water access (e.g. for CTD deployment).

- Sampling and instrument deployment positions, along with access paths, should be planned in advance and clearly marked out on the ice using bamboo flag poles and, where necessary, rope or tape. This should be done carefully to ensure minimum disturbance or contamination of ice and snow surface, including areas overlying out-of -sight under-ice dive sampling sites. The working area of the flow should, if possible, be easily observable from the ship's bridge and as close to the ship as possible.

- Equipment should be transported to sampling/deployment sites using man-haul sledges. For large ice stations and heavier equipment the use of a skidoo and sledge (by trained personnel) is recommended.

- It is often necessary to drill ice holes in order to test ice depth, position equipment in the ice, or access the water column underlying the ice. Holes can be drilled using ice augers with flights of various lengths and diameters, powered by hand or electric/petrol motor. The holes should be marked by flag poles and can be sealed with plastic or wood stoppers to help prevent refreezing between sampling events. The maximum length of auger flights is usually about 1 m

and to drill thicker ice, extensions rods or (preferably) flights will be required (an extension flight can be constructed by removing the cutting head from a 1 m auger and using the remaining flight as an extension for another 1 m auger). In all cases a 1 m hole will have to be drilled first before fitting connecting flight or rod extensions. The maximum diameter of commercially available augers is (for legal reasons) 10 inches. To create larger diameter holes it is necessary to drill several holes and cut between them using an ice saw. Augers used on JR219 were 5 cm and 10cm in diameter and powered by electric and petrol motors respectively.

- Larger holes (e.g. for deployment of divers) require physical removal of large volumes of ice which can take substantial time and effort (up to one day for a 2 x 2 m hole). A chain saw with long (e.g. 1.5m) cutting bar can be used to vertically cut through the entire depth of the ice (when less than the length of the bar) creating a series of blocks. These blocks can then be removed by attaching a rope to the top of each black, using ice screws, and lifting the block out of the water by hand and crow (gorilla) bar, or by using a skidoo. The chain saw should be used by trained personnel using appropriate safety equipment (helmet with visor, ear protection, protective gloves, boots and clothing).

- It is often necessary to collect intact ice cores for a variety of scientific uses, or to create a smooth walled hole of precise depth in which to collect sea-ice brine. Holes can be drilled using ice corers of various lengths and diameters powered by hand or electric/petrol motor. Note that careful hand-coring is recommended to maintain the integrity of the core, including the fragile bottom-ice horizon (and associated algae). 9 cm diameter coring systems were used on JR219and powered by hand.

- The underlying water column can be sampled using standard pelagic instruments suspended on wires or ropes so long as they fit comfortably though the ice hole. Heavy instruments should be suspended using a pulley and A-frame (with the bottom of the poles sitting on wide platforms to prevent sinking into the snow and ice). Ocean currents under the ice may pull instruments and their deployment wires/ropes towards the side of the hole. This can prevent equipment release messengers reaching the instruments, or the retrieval of instruments due to their catching on the underside edge of the hole. It is therefore advisable to leave sufficient gap between the instrument and the wall of the hole to allow manipulation of the messenger/instrument clear of the underside edge of the hole. It should also be remembered that ice holes allow significant light to penetrate the underlying water column, and that water bought to the surface will be exposed to high light levels and subject to rapid freezing.

- Water and ice samples can be transported in thermos flasks or insulated plastic cool boxes to protect from light and cold, and to maintain ambient the temperature.

- Equipment deployed onto or into the ice for long periods should be clearly marked and secured to the ice in case of snowfall or ice movement and break-up. It may be advisable to connect floatation devices should the ice melt or break releasing equipment into the water.

- Freezing-melt cycles and the pressure created by equipment weight or use may make equipment retrieval difficult after long deployments. Shovels, crow bars and saws should therefore be available. Retrieval of large items of equipment may require the use of skidoos or the ships winches. These factors should be considered when positioning equipment on, in or under the ice. The ice holes should be cleared of ice on a daily basis to ensure that the equipment does not become completely frozen in.

- No equipment, contamination or litter should be left on the ice after completion of work and departure from the ice flow.

7. Sea-ice equipment used on JR219:

Item	Size	Number	Supplier
Skidoo and sledge		1	UNIS (Svalbard)
Rifles & ammunition		2	UNIS (Svalbard)
Flare pistols & flares		2	UNIS (Svalbard)
Boat Hooks		2	RRS *James Clark Ross*
Jerry cans, funnel, ear defenders and tool kit		1	RS Components (UK)
5.5HP petrol powerhead (Eskimo Honda 9800H)		1	Earthaugers/Altapower (USA)
10 inch auger drill with twin quantum blades (Eskimo QT10N)		3	Earthaugers/Altapower (USA)
18 inch drill extension(Eskimo EXT 18)		3	Earthaugers/Altapower (USA)
9 cm coring system (Kovacs Mark II)		2	Kovacs (USA)
5 cm diameter auger (Kovacs)		2	Kovacs (USA)
Electric powerhead(Electra Lazer 12000 DP)		1	Kovacs (USA)
Spare 12 V rechargeable battery		1	Kovacs (USA)
Ice thickness gauge (Kovacs)		1	Kovacs (USA)
Folding 44 inch ice saw (Fish's)		1	Fish's Sporting Toys (USA)
Ice axes (Grivel Munro – 60 to 70 cm)		3	Outside Edge (UK)
Crow/gorilla bars		2	Homebase (UK)
Shovels		2	Jewsons (UK)
Bamboo Canes		20	Homebase (UK)
Chainsaw (Stihl ms880)	120cm	1	Hamilton Brothers (UK)
	150cm	1	
Chainsaw gloves with cut protection	M	1	Hamilton Brothers (UK)
	L	1	
Chainsaw helmet set		2	Hamilton Brothers (UK)
Chainsaw boots(Ranger GTX)	41	1	Hamilton Brothers (UK)
	44	1	Hamilton Brothers (UK)
Chainsaw cut protection jacket	M	1	Hamilton Brothers (UK)
	XL	1	
Chainsaw trousers (Advance design A)	32-34	2	Hamilton Brothers (UK)
Chainsaw membrane work gloves (Advance)	M	1	Hamilton Brothers (UK)
	L	1	
Metal A-frame, pully and rope		1	SAMS (UK)
Water sampling bottle (NIO) and messenger	5L	2	SAMS (UK)
Insulated cool boxes and thermos flasks		2	Homebase (UK)
First Aid Kit		1	RRS *James Clark Ross*
Thermos flasks		2	RRS *James Clark Ross*
Aluminium kit boxes	S	2	Light Alloy (UK)
Marine binoculars (Artimis 7 x 50 ZIF)		3	Monk Optics (UK)
UV Sunglasses (Cebe)		6	Outside Edge (UK)
Hand-held airhorn (Ecoblast)		3	Bosun's Locker (UK)
Canadian goose down jacket (Arctic Kingdom Expedition)		2	Arctic Kingdom (Canada)
Insulated gloves (Showa 490)	9	5	Arco (UK)
	10	5	
Inflatable life jackets		10	RRS *James Clark Ross*
Survival anti-exposure work suit (Mustang deluxPNMS2175)	S	5	Columbus Supply (USA)
	M	5	
	L	2	
Insulated wellington (Dunlop thermo+)	7	4	Arco (UK)
	8	7	
	9	4	
	10	2	
	11	2	
	12	1	

APPENDIX 3: Under-ice diving operations

Hugh Brown and Simon Thurston

Dive Hole Cutting

Two 1.5m x 2m dive holes were cut using Stihl ms880 chainsaws. Ice was a maximum thickness of 110cm so 120cm bar was used. For thicker ice we had a 150cm bar, but this was not required. As soon as the bottom of the ice was reached the hole flooded leaving less than 10cm freeboard – it would therefore be impossible to cut a two stage hole (i.e. remove ice blocks from first cut then make second deeper cut from pit).

Some problems were experienced with the chain jamming on the rim sprocket on the larger bar (120cm), this was easily resolved but in future could be changed to a spur sprocket. Chain oil residue remained in the dive holes and surrounding snow for some time, it was felt that seawater would provide enough lubrication and the oil could have been dispensed with.

30cm square blocks were easily removed manually from the hole using ice screws and rope. Use of a Skidoo made the task easier, especially dragging blocks away.

Diving Equipment

No problems were experienced with Poseidon Extreme primary and bailout regulators, the most used regulator. We also used Poseidon cyclon and Poseidon full face masks without any issues; however, divers preferred half mask and demand valve configuration for ease of bailout.

Diving operations

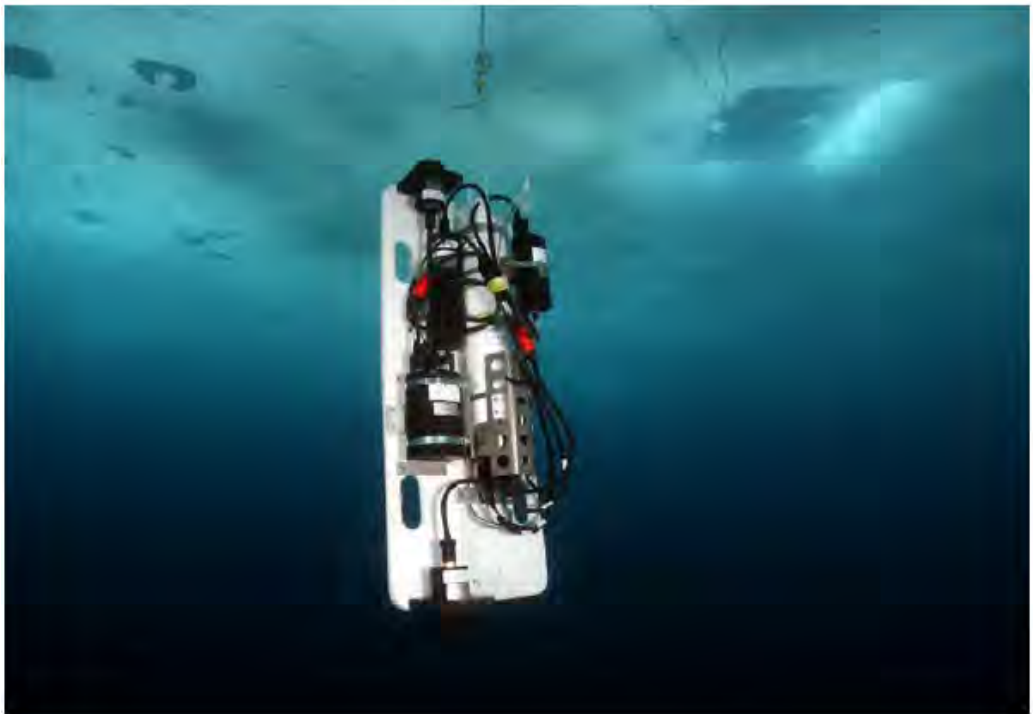
An Evacuation exercise was conducted before diving operations commenced. A diver was recovered from the dive hole to the recompression chamber (forward hold) in about 14minutes, with a doctor attending.

Response to a request from the bridge to terminate diving operations and evacuate the ice due to deteriorating visibility was also quick. Divers were signaled, recovered, and de-kitted promptly, and were back at the JCR within 10 minutes.

20 Man dives were conducted over the diving days allowed to us using all six divers on the team at least once.

Tasks included Sample Collection, Rigging for Light Meter, PAM measurements as well as photographic surveys and general photography and videography commissioned for outreach.

All the scientific objectives were completed and additional requests for sample collections accommodated in the program. The Diving program had to remain flexible to allow for the good surface visibility required, and to fit with the maximum ice party numbers, of which a dive team made up over half.



JR219 Under-Ice Diving Event Log

Event No	Date	Start time (GMT)	End time (GMT)	Duration (min)	Location	Supervisor	Diver(s)	Stand-by diver	Activity	Comments
I11	24/06	14:17	14:40	00:23	Primary diving hole	Hugh	Simon Kunuk	Heiko	Test dive & video	Max depth = 6.9m
I16	25/06	15:06	15:36	00:30	Primary diving hole	Simon	Hugh Heiko	Kunuk	Sample collection & photography	Max depth = 6.2m
I20	26/06	11:17	11:47	00:30	Primary diving hole	Simon	Hugh Kunuk	Soren	Algae collection & photography	Max depth = 6.1m
I22	26/06	12:02	12:10	00:08	Primary diving hole	Simon	Hugh Soren	Kunuk	Algae collection, PAM test & photography	Max depth = 2.0m
I30	27/06	11:24	11:50	00:26	Primary diving hole	Hugh	Simon Ray	Heiko	Light meter rope deployment & video	Max depth = 6.3m
I31	27/06	14:17	14:32	00:15	Primary diving hole	Hugh	Kunuk Soren	Simon	Algae collection & PAM measurments	Max depth = 4.1m
I35	28/06	11:50	12:24	00:26	Primary diving hole	Hugh	Heiko Kunuk	Simon	Gas sampling (for Helen), particle flux sampling (for Jenny) & algae collection	Max depth = 7.8m
I50	30/06	09:02	09:40	00:38	Primary diving hole	Hugh	Kunuk Simon	Heiko	Photography & video	Max depth =7.7m
						Simon	Kunuk Hugh			

APPENDIX 4: Polar bear sightings

Ben du Feu (3rd Officer)

The *James Clark Ross* had been carrying out scientific work on a large ice flow approximately 40 miles north of the Arctic ice cap edge. The vessel entered the loose pack ice at the southern edge of the ice cap at 04:00 GMT on 21 June, mid-summers day. By 18:43 GMT at 80 53.5N the ship was stopped alongside a large flow approximately 1.5km in diameter for scientific work. Whilst breaking ice prior to arriving at the flow, polar bear footprints were observed on at least four flows near to the vessel. In addition to the usual watch kept by the bridge team, two polar bear spotters with binoculars kept a constant watch over the nearby pack ice when science work was being carried out on the ice.

Observors:

Graham Chapman	Captain
Timothy Page	Chief Officer
Simon Evans	2nd Officer
Ben du Feu	3rd Officer

BEAR 1 20:32:00 GMT 22/06/2010 80 48.1N 004 50.1E
Spotted by Ben du Feu
Single polar bear sighted approximately 800 meters off starboard bow (downwind); it was scared off with horn when approaching science equipment. Headed out approximately 600 meters to west of vessel where it stopped after pounding the ice perhaps eating. 2 hours later the polar bear was moving again, and half an hour after that it swam from one ice flow to another and slowly moved out of sight of the vessel.

BEAR 2 09:24 GMT 23/06/2010 80 44.79N 004 45.25E
Spotted by Heather Atkinson
Single polar bear sighted approximately 1.5kM astern of vessel (upwind bearing 000), walking slowly towards us. The bear swam from one flow to other then dried off by rolling in the snow before passing up starboard side of vessel, bear believed to be different to previous bear. The bear stopped in same location as the bear of the previous night. By 1000GMT bear was at far edge of flow and moving away from the vessel.

BEAR 3 16:30 GMT 23/06/2010 80 44.76N 004 33.05E
Single polar bear sighted approximately 3.5km from the vessel on a bearing of 285. The bear was seen to be walking back and forth before visibility closed in and sight was lost.

BEAR 4 01:25 GMT 24/06/2010 80 43.6N 004 21.0E
Single polar bear sighted approximately 500m dead ahead (brg 193 T) moving closer to the vessel 01:33 GMT Whistle sounded to scare off polar bear which was now approximately 100m off the starboard bow. After the first whistle the bear was scared and started to move away however it then approached the scientific equipment so the whistle was again sounded. The bear was now a little braver and seemed considerably less scared when the whistle was sounded again and remained interested in the scientific equipment. By 02:00 GMT the bear was moving away from the vessel. Fortunately, on inspection the following day, the bear had not damaged the equipment.

BEAR 5 12:16 GMT 24/06/2010 80 40.63N 04 14.95E
Single polar bear sighted south east of vessel on the port side at approximately 1km. It appeared to be uninterested in the vessel and was moving away. Scientific work continued on the starboard side whilst bear was monitored. Fifteen minutes later the science team was recalled as the polar bear, now approximately 800m away, started making its way towards the science team. Visibility then reduced and on improvement 1.5 hours later there was no sign of the bear.

BEAR 6 18:15 GMT 24/06/2010 80 39.2N 004 15.4E
Spotted by Captain Chapman
Single polar bear sighted approximately 800 meters ahead of vessel walking away from vessel after playing in snow, lost sight after 30 minutes as visibility reduced.

BEAR 7 16:50 GMT 25/06/2010 80 33.3N 004 09.1E
Single polar bear sighted bearing east of the vessel at a range of about one and a half miles. Bear was seen to be making its way northwards.

BEAR 8 07:58 GMT 27/6/10 80 27.07N 003 42.21E
Spotted by Paul Backhouse
Single polar bear sighted dead ahead at approximately 3kM range. It slowly moved towards the vessel, picking its way between the ice floes; occasionally stopping and peering into the water. It continued to work its way around the starboard bow of the ship. At 08:22 GMT, the science party was recalled from the ice; all were on board by 0831. By 08:45, the bear was 100 metres off the bow and walking towards the forward mooring. When it began chewing at the rope, the ship's whistle was sounded. The startled bear ran towards the science equipment on the ice. It proceeded to investigate one of the dive holes, pawing at a locked metal box that had contained chocolate and coffee. Unable to open the box, the bear moved further out across the ice. It seemed intrigued by an area where ice cores had been taken. It then moved towards some of the more delicate experimental equipment and the horn was sounded again to scare it away. Eventually by 0900, the bear had passed some 300 metres across the bow of the ship towards the port side and continued to move away. By 10:15 GMT the bear was no longer visible from the ship.

Bear 9 18:35 GMT 27/6/10 80 22.5N 003 27.9E
Spotted by Paul Backhouse
Single polar bear sighted as a small yellow spot approximately 4kM away to the south west. Until 21:00 GMT the bear was be seen with binoculars slowly plodding along northward near the horizon. After this time visibility reduced to less than 1kM and the bear was not seen again.

Bear 10 15:40 GMT 28/06/10 80 17.0N 003 09.4E
Single polar bear sighted due north of the vessel approximately 3km away.

Bear 11 03:00 GMT 29/06/10 80 16.2N 003 06.5E
Singe polar bear entered the fieldwork site from the north and took a look at the aft mooring before making its way to the dive holes where it started mauling the an aluminium case containing the first aid kit. Several blasts on the ships whistle throughout eventually distracted the bear which then decided to leave the work site and make its way to the edge of the ice flow one hundred metres ahead of the vessel. After several minutes, the bear made its way back to the work site, stopping every few metres to look up at the ship. It then approached the instruments located in the south western corner of the site. Several more blasts on the ships whistle deterred him from getting too close to the instruments and the bear finally departed the site towards the west.

The James Clark Ross left the ice on the 1st of July at 16:04 GMT in position 80 07.6N 001 57.8E. It is likely other bears were in the vicinity but not sighted when visibility was poor.

After a night in Longyearbyen for scientific personnel change, the James Clark Ross continued on its scientific work west of Svalbard, the vessel entered loose pack ice west of Greenland.

Bear 12 0910 GMT 08/07/10 77 35.5N 005 35.5W
Spotted by Captain Chapman
Single polar bear spotted by the Master walking towards the stern of the vessel. The bear eventually came to within a metre of the ships stern. It stayed there for approximately 10 minutes rolling in the snow and looking up at the ships staff on deck, offering excellent photographic opportunities. The bear then headed away from the ship.

APPENDIX 5: Ships meteorological observation

Date	Latitude	Longitude	Time LT	Wind	Pressure	Air Temp	Sea Temp	Comment about weather	Comment about location/ ice
13/06/10	53°37.8 N	000°11.0 W	1600	SW 3	1010.7	17.7	15.4	Overcast and dry with good vis.	Departed Immingham 1500BST
13/06/10	54°40.1 N	000° 48.0 E	2400	NNE 3	1012.5	11.0	11.5	Vessel pitching in short moderate swell and slight sea. Part cloudy, dry and clear.	
14/06/10	56°41.0 N	001°23.9 E	1200	N 4	1021.7	11.5	11.7	Vessel moving easily in moderate sea. Cloudy, dry and clear.	
14/06/10	58°51.8 N	002°06.8 E	2400	N 5	1024.5	11.0	11.8	Vessel pitching moderately at times in rough head sea. Part cloudy, dry and clear.	
15/06/10	60°48.2 N	002°44.8 E	1200	NxW 3-4	1027.2	10.7	11.3	Vessel moving easily in moderate sea. Mostly overcast, dry and clear.	
15/06/10	63°16.6 N	003°41.4 E	2400	SW 3-4	1024.7	10.3	11.1	Vessel moving easily to slight sea and low swell. Part cloudy, fine with very good visibility.	
16/06/10	65°21.4 N	004° 31.8 E	1200	NNW 4-5	1018.2	8.8	9.9	Vessel moving easily to moderate sea. Overcast, misty with light drizzle at times.	
16/06/10	67°48.2 N	005°38.3 E	2400	WxS 3	1015.8	8.5	9.0	Vessel moving easily to slight sea and low swell. Overcast and dry throughout with good visibility.	
17/06/10	69°22.6 N	006°22.8 E	1200	SE 3	1009.0	7.4	7.7	Vessel moving easily in slight sea. Overcast with rain and mist at times.	Advanced Clocks one hour to GMT +2 hrs
17/06/10	71°11.9 N	007°21.4 E	2400	NNE 5	1010.7	5.9	7.8	Vessel moving easily to moderate sea. Overcast with a few clear patches and occasional light rain.	
18/06/10	73°03.3 N	008°27.1 E	1200	NNW 5	1013.9	4.1	6.2	Vessel moving easily to moderate sea and swell. Mostly overcast and dry but occasional light rain.	
18/06/10	75°24.8 N	009°59.1 E	2400	NE 3	1014.0	4.0	6.0	Vessel moving easily in low swell and rippled sea. Occasional very light rain and overcast sky clearing during watch.	
19/06/10	77°28.1 N	011°32.9 E	1200	ExS 2-3	1017.3	2.5	4.0	Rippled sea and low swell. Overcast and dry with good visibility.	

19/06/10	78°14.6 N	015°32.6 E	2400	SSE 3	1018.6	4.5	3.5	Overcast and dry with good visibility.	Alongside Longyearbyen
20/06/10	78°14.6 N	015°32.6 E	1200	ESE 2	1017.5	6.0	4.1	Cloudy, dry, bright and clear.	Departing 1300.
20/06/10	79°02.5 N	008°54.8 E	2400	NxE 5	1014.0	2.2	3.7	Moderate sea. Mostly sunny, 4/8 cloud, dry and clear.	
21/06/10	80°45.4 N	006°01.9 E	1200	ENE 5/6	1015.9	-1.6	1.3	Vessel making progress through increasing pack ice to 8/10. Light low cloud cover and misty patches.	
21/06/10	80°53.4 N	005°11.7 E	2400	NE 4-5	1014.6	1.0	0.7	Overcast and dry, mist and fog in patches. 9/10 pack ice large floes.	Vessel stopped in very close pack large floes
22/06/10	80°51.4 N	004°57.0 E	1200	NNE 4	1012.0	1.7	0.5	2-7/8's cloud and mist at times.	Vessel stationary drifting with pack ice on ice scientific station, 9/10 pack
22/06/10	80°47.6N	004°48.6 E	2400	NE 4-5	1008.9	0.7	0.3	Clear sky becoming overcast and misty by midnight.	Ice station, 9/10 pack
23/06/10	80°44.6 N	004°44.2 E	1200	N 2-3	1007.5	3.7	0.9	Overcast becoming 4/8's cloud with light snow for most of watch.	Ice station, 9/10 pack
23/06/10	80°43.7 N	004°26.8 E	2400	NE 3	1012.6	0.5	0.4	Overcast but dry with misty patches vis. below 2 miles at times.	Ice station 9/10 pack
24/06/10	80°41.3 N	004°18.3 E	1200	N 2/3	1014.8	3.0	0.9	Mostly overcast with light snow flurries. Visibility reduced in last hour.	Ice station, 9/10 pack
24/06/10	80°38.1 N	004°16.3 E	2400	NW 3	1013.0	1.2	0.6	Overcast with snow flurries, vis reducing, vis moderate or good becoming poor.	Ice station, 9/10 pack
25/06/10	80°34.4 N	004°16.5 E	1200	NxW 3	1012.6	1.9	0.8	Overcast with poor vis and light snow at times.	Ice station, 9/10 pack
25/06/10	80°32.3 N	004° 08.6 E	2400	Lt Airs	1014.6	2.7	0.6	Overcast. Poor vis becoming good.	Ice station, 9/10 pack
26/06/10	80°30.7 N	004°07.2 E	1200	NE 4	1019.6	2.1	0.2	Overcast, occasional light snow and moderate visibility.	Ice station, 9/10 pack
26/06/10	80°28.9 N	003°44.8 E	2400	NE 4	1024.2	2.0	-0.1	Overcast becoming 1/8 cloud, fine and clear.	Ice station, 9/10 pack
27/06/10	80°26.0 N	003°38.7 E	1200	N 3-4	1024.2	3.6	0.0	Clear sky, dry, fine and clear. Good visibility throughout.	Ice station, 9/10 pack
27/06/10	80°21.8 N	003°26.0 E	2400	N 4	1021.6	1.6	0.2	Mostly overcast becoming misty then	Ice station, 9/10 pack

								cleared before midnight.	
28/06/10	80°18.6 N	003°17.7 E	1200	NxW 3-4	1020.4	2.5	0.3	Mist and fog all morning with blue sky overhead.	Ice station, 9/10 pack
28/06/10	80°15.8 N	003°06.1 E	2400	NNW 2	1020.2	1.5	0.6	Clear sky, dry and bright. Mist cleared and good visibility from 1300hrs	Ice station, 9/10 pack
29/06/10	80°16.2 N	002°58.9 E	1200	NxW 3	1020.4	1.3	0.6	Fog and mist till 10 o'clock then patchy cloud, fine and clear.	Ice station, 9/10 pack
29/06/10	80°14.0 N	002°40.9 E	2400	N 3	1020.9	2.0	0.9	Fine and clear till 2000hrs then overcast, misty and occasional light snow showers.	Ice station, 8/10 pack
30/06/10	80°13.5 N	002°26.7 E	1200	N 2	1020.6	3.0	0.8	Mist and fog at first becoming fine and clear around 10o'clock.	Ice station, 8/10 pack
30/06/10	80°11.8 N	002°12.2 E	2400	ENE 2-3	1019.5	-0.4	1.2	Clear skies fine and clear then mist rolled in from the north just before midnight.	Ice station, 8/10 pack
01/07/10	80°13.3 N	002°09.4 E	1200	SW 2	1017.7	-0.5	0.7	Mist and fog all morning with blue sky overhead.	Ice station, 8/10 pack
01/07/10	79°19.6 N	005°15.9 E	2400	SSW 4	1016.5	3.9	5.3	Cloudy, fine and clear with aoccasional mist patches.	Vessel gets underway at 1600 and clears ice at 1800hrs.
02/07/10	78°03.7 N	012°21.5 E	1200	SxE 3	1017.9	2.8	5.8	Overcast with occasional light drizzle, fog and mist patches.	
02/07/10	78°14.7 N	015°34.2 E	2200	WxS 3	1016.0	5.4	8.1	Overcast throughout.	Arrived and berthed Coal Quay Longyearbyen at 1600 hrs.
03/07/10	78°14.7 N	015°34.2 E	1200	W 3	1015.8	7.2	7.5	Dry and mostly overcast.	Longyearbyen, shifted Coal Quay to New Quay
03/07/10	78°08.5 N	013°30.2 E	2400	N 3	1017.6	3.5	4.9	Overcast and dry. Good visibility.	Departed New Quay 2100 hrs.
04/07/10	79°01.0 N	010°42.0 E	1200	S 3-4	1018.0	3.7	6.1	Overcast with drizzle and mist at times. Slight sea.	
04/07/10	79°00.9 N	010°41.3 E	2400	SxE 3	1017.8	4.7	6.2	Overcast, dry and clear. Slight sea.	

05/07/10	79°00.9 N	010°41.3 E	1200	Lt Airs	1018.2	7.5	6.2	Overcast, dry and clear. Rippled sea and low swell.	
05/07/10	78°58.5 N	006°43.1 E	2400	NNE 3-4	1017.5	2.9	6.9	Overcast, dry and clear. Slight sea and short low swell.	
06/07/10	78°58.5 N	006°42.4 E	1200	NNE 2-3	1016.0	2.5	7.3	Overcast, dry and clear. Slight sea and low swell.	
06/07/10	78°58.5 N	006°42.4 E	2400	NNE 3	1014.5	2.1	7.3	Overcast, dry and clear. Slight sea and low swell.	
07/07/10	78°58.5 N	006°42.3 E	1200	NNE 3	1012.7	3.0	7.5	Overcast, dry and clear. Slight sea and low swell.	
07/07/10	77°51.4 N	004°03.5 W	2400	NE 3-4	1011.8	0.0	1.7	Overcast with fog and mist. Slight sea and low swell.	Ice edge to north, some brash.
08/07/10	77°44.8 N	005°38.3 W	1200	N 3	1010.4	0.0	0.9	Overcast, patchy mist and fog.	Entered 8/10 pack ice at 0200hrs.
08/07/10	77°36.3 N	005°47.7 W	2400	NNE 3-4	1008.5	0.0	2.3	Variable mist and fog.	6-8/10 pack.
09/07/10	77°38.3 N	006°19.2 W	1200	E 3	1007.4	3.0	1.0	Variable mist and fog.	5-6/10 pack.
09/07/10	77°38.9 N	004°46.8 W	2400	Lt Airs	1007.9	3.2	0.3	Vessel making progress through increasing pack ice 5 to 9/10. Fog throughout.	Vessel gets underway 1700 and clears ice edge 2340hrs.
10/07/10	78°17.0 N	000°00.0	1200	E 2	1006.6	4.5	1.6	Fog throughout with lighter patches.	Growlers and brash ice sighted.
10/07/10	78°26.9 N	002°09.1 E	2400	ESE 3-4	1003.7	6.8	6.0	Mist and fog throughout, light rain at times.	Vessel working 1-5/10 pack 2000 to 2300 hrs.
11/07/10	79°00.0N	009°29.0 E	1200	SSE 5-6	1004.9	6.5	6.3	Rough sea. Overcast with mist and fog at times.	
11/07/10	78°57.6 N	011°53.1 E	2400	ESE 3	1007.9	6.8	5.7	Overcast, dry and clear.	Alongside Ny-Alesund 1600 to 1800 hrs.
12/07/10	78°59.9 N	008°28.5 E	1200	Lt Airs	1010.2	6.3	7.4	Fog and mist throughout. Calm/rippled seas.	
12/07/10	78°44.4 N	009°22.7 E	2400	Lt Airs	1010.5	6.1	6.3	Overcast with fog patches.	
13/07/10	78°13.8 N	015°36.1 E	1200	ESE 4-5	1009.8	10.0	7.0	1-3/8 cloud, dry, fine and clear.	

13/07/10	78°12.3 N	011°09.4 E	2400	NW 2	1012.7	3.8	6.1	Broken cloud, fine and clear, becoming foggy from 2100hrs.	Alongside Longyearbyen 1100 to 1730 hrs.
14/07/10	79°01.7 N	010°44.7 E	1200	SW 2-3	1014.9	6.0	6.8	Overcast, dry and clear. Slight sea.	
14/07/10	79°56.7 N	008°56.2 E	2400	SW 5-6	1011.8	4.8	6.9	Overcast, dry and clear. Rough sea.	
15/07/10	79°50.5 N	010°17.7 E	1200	SxW 6	1012.9	5.7	6.2	Mostly overcast with some fog and mist.	
15/07/10	79°51.5 N	009°58.9 E	2400	SSW 7-8	1010.3	5.6	6.0	Clear sky, becoming cloudy with front, dry, fine and clear. Good visibility throughout.	
16/07/10	79°41.1 N	013°50.0 E	1200	SSW 5-6	1010.2	9.3	7.4	Cloudy,fine and clear. Rough sea.	
16/07/10	79°41.0 N	013°49.7 E	2400	WSW 5-6	1009.8	8.0	6.1	Part cloudy, light rain showers but good visibility.	
17/07/10	80°00.0 N	014°55.0 E	1200	S 4-5	1010.2	5.6	4.5	Clear sky, fine and clear. Wind very changeable with ships location.	Moffen Is. 1100hrs.
17/07/10	80°08.9 N	012°22.6 E	2400	NW 2	1011.8	4.7	5.7	Overcast, dry and clear.	
18/07/10	80°17.9 N	010°47.6 E	1200	E 4	1010.0	4.2	5.6	Overcast with light rain at times.	
18/07/10	80°15.1 N	010°06.5 E	2400	NE 4	1008.1	3.2	4.7	Overcast, light rain and fog/mist at times. Moderate sea.	Ice edge 1 mile to north of vessel.
19/07/10	79°29.1N	006°43.3 E	1200	NNE 6	1007.5	2.5	3.2	Overcast, light rain otherwise good visibility. Rough sea.	
19/07/10	79°31.8 N	007°13.4 E	2400	NE 6-8	1003.4	3.1	6.3	Overcast, occasional snow and light rain. Very rough sea and short moderate swell.	
20/07/10	78°58.2 N	007°01.9 E	1200	NE 7	1006.0	3.0	6.8	Overcast, occasional light rain. Very rough sea.	
20/07/10	78°07.8 N	009°28.8 E	2400	Lt Airs	1006.2	4.9	6.6	Overcast, dry and clear. Calm sea.	
21/07/10	78°15.8 N	015°27.9 E	1200	Lt Airs	1006.7	4.9	5.7	Overcast, dry and clear. Calm sea.	
21/07/10	78°15.0 N	015°36.0 E	2400	WxS 3-4	1008.3	7.7	6.4	Cloudy, dry, bright and clear	Alongside Longyearbyen.
22/07/10	78°15.5 N	015° 30.7 E	1200	NW 3	1007.9	5.2	7.2	Mostly overcast, dry and clear. Slight sea.	Depart Longyearbyen 1130 hrs.

22/07/10	77°08.1 N	011°04.0 E	2400	Lt Airs	1006.5	5.1	7.4	Mostly overcast, fine and clear with calm sea.	
23/07/10	75°24.7 N	009°22.9 E	1200	SSW 4-5	1003.9	7.4	7.2	Overcast with occasional light rain. Moderate sea and swell.	
23/07/10	73°44.7 N	007°54.9 E	2400	W 5	1006.6	5.3	7.9	Overcast, fine and clear. Moderate sea and swell.	
24/07/10	72°11.2 N	006°37.2 E	1200	WxS 5	1013.1	9.1	8.6	Overcast, fine and clear. Moderate sea and swell.	
24/07/10	70°38.5 N	005°33.4 E	2400	SW 4-5	1017.8	9.6	9.5	Overcast, becoming almost cloudless, fine and clear. Moderate sea and swell.	
25/07/10	68°50.4 N	004°20.7 E	1200	SSW 3	1020.3	11.0	10.0	Part cloudy, dry and clear. Slight sea and moderate swell.	Retarded clocks one hour to GMT +1 (BST)
25/07/10	67°18.4 N	003°23.1 E	2400	E 3-4	1019.9	10.7	11.3	Part cloudy, dry and clear. Slight sea and heavy swell.	
26/07/10	65°45.5 N	002°28.9 E	1200	ENE 4	1013.9	12.1	11.7	Part cloudy, dry and clear becoming overcast. Moderate sea and swell.	
26/07/10	64°13.5 N	001°38.0 E	2400	Lt Airs	1009.2	11.7	12.5	Mostly overcast. Calm sea with moderate swell.	
27/07/10	62°42.1 N	000°51.0 E	1200	SW 3-4	1008.4	12.9	13.1	Overcast, drizzle at times. Moderate sea and low swell.	
27/07/10	61°04.0 N	000°02.0 E	2400	WSW 3	1010.9	13.3	13.4	Part cloudy, dry and clear. Slight sea and moderate swell.	
28/07/10	59°35.5 N	000°38.7 W	1200	SxW 3	1011.3	14.6	13.8	Part cloudy, dry and clear. Slight sea and moderate/heavy swell.	
28/07/10	58°11.2 N	001°16.7 E	2400	W 3	1013.8	13.9	13.8	Part cloudy, becoming overcast with rain. Moderate visibility in rain. Slight sea and moderate swell.	
29/07/10	57°29.7 N	001°47.3 E	0800	NNW 3	1015.1	12.5	12.7	Mostly cloudy, dry and clear.	Arrived Peterhead 0700BST

APPENDIX 6: Megacorer log

Event number	075	Station	KF3
Megacorer number	005	Latitude	79°00.860'N
Date	04/07/10	Longitude	010°41.630'E
Time start	16:59	Depth	334m
Time at bottom	17:13	Comments	
Time end	17:28		

Core	Result	*Radio-chem*	*Incub-ation*	*Profi-ling*	*Bio markers*	*Stable iso.*	*Foram iso.*
A	Not attached						
B	Failed						
C	Failed						
D	OK					X	
E	OK					X	
F	OK					X	
G	OK					X	
H	OK					X	

Event number	078	Station	KF3
Megacorer number	006	Latitude	79°00.910'N
Date	04/07/10	Longitude	010°41.280'E
Time start	19:58	Depth	332m
Time at bottom	20:14	Comments	
Time end	20:32		

Core	Result	*Radio-chem*	*Incub-ation*	*Profi-ling*	*Bio markers*	*Stable iso.*	*Foram iso.*
A	Failed - empty						
B	Failed - ½ empty						
C	OK	X					
D	OK	X					
E	OK		X	X			
F	OK		X	X			
G	Failed - bubbles						
H	OK		X	X			

Event number	079	Station	KF3
Megacorer number	007	Latitude	79°00.920'N
Date	04/07/10	Longitude	010°41.270'E
Time start	21:02	Depth	331m
Time at bottom	21:15	Comments	
Time end	21:32		

Core	Result	*Radio-chem*	*Incub-ation*	*Profi-ling*	*Bio markers*	*Stable iso.*	*Foram iso.*
A	OK						
B	OK						
C	OK		X	X			
D	OK	X					
E	OK		X	X			
F	OK		X	X			
G	Failed - empty						
H	Failed - empty						

Event number	106	Station	KF4
Megacorer number	008	Latitude	78°58.500'N
Date	06/07/10	Longitude	006°42.360'E
Time start	21:38	Depth	~1350m
Time at bottom	22:23	Comments	
Time end	23:10		

Core	Result	*Radio-chem*	*Incub-ation*	*Profi-ling*	*Bio markers*	*Stable iso.*	*Foram iso.*
?	Failed						
?	OK				X		
?	OK	X					
?	OK	X					
?	OK		X	X			
?	OK		X	X			
?	OK		X	X			
?	OK						

Event number	107	Station	KF4
Megacorer number	009	Latitude	78°58.500'N
Date	06/07/10	Longitude	006°42.360'E
Time start	23:34	Depth	~1350m
Time at bottom	00:21	Comments	
Time end	01:08		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
?	Failed						
?	Failed						
?	OK	X					
?	OK	X					
?	OK		X	X			
?	OK		X	X			
?	OK		X	X			
?	OK						

Event number	130	Station	Greenland Shelf
Megacorer number	010	Latitude	77°40.641'N
Date	08/07/10	Longitude	005°37.884'W
Time start	15:13	Depth	370m
Time at bottom	15:26	Comments	
Time end	15:40		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK		X	X			
B	OK		X	X			
C	OK		X	X			
D	Failed - empty						
E	Failed - empty						
F	OK	X					
G	Failed - empty						
H	Failed - empty						

Event number	132	Station	Greenland Shelf
Megacorer number	011	Latitude	77°40.030'N
Date	08/07/10	Longitude	005°38.640'W
Time start	15:59	Depth	366m
Time at bottom	16:11	Comments	
Time end	16:27		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK		X	X			
B	OK		X	X			
C	OK		X	X			
D	OK				X		
E	OK	X					
F	Failed - empty						
G	OK						
H	OK	X					

Event number	141	Station	Greenland Shelf Edge
Megacorer number	012	Latitude	77°38.920'N
Date	09/07/10	Longitude	004°46.800'W
Time start	23:52	Depth	1398m
Time at bottom	00:42	Comments	
Time end	01:32		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK	X					
B	OK	X					
C	OK	X					
D	OK	X					
E	OK	X					
F	OK	X					
G	OK	X					
H	OK	X					

Event number	223	Station	Hinlopenrenna
Megacorer number	021	Latitude	80°04.786'N
Date	17/07/10	Longitude	017°16.798'E
Time start	13:41	Depth	386m
Time at bottom	13:59	Comments	
Time end	14:09		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK						X
B	OK				X		
C	OK		X	X			
D	OK		X	X			
E	OK		X	X			
F	OK	X					
G	OK	X					
H	OK	X					

Event number	243	Station	Ice Edge
Megacorer number	022	Latitude	80°33.270'N
Date	18/07/10	Longitude	011°38.190'E
Time start	16:59	Depth	964m
Time at bottom	17:27	Comments	
Time end	17:54		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK				X		
B	OK	X					
C	OK	X					
D	OK	X					
E	OK						X
F	OK						
G	OK						
H	OK						

Event number	247	Station	West Svalbard Margin
Megacorer number	023	Latitude	79°29.140'N
Date	19/07/10	Longitude	006°43.290'E
Time start	05:00	Depth	1348m
Time at bottom	05:51	Comments	
Time end	06:30		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK		X	X			
B	OK		X	X			
C	OK		X	X			
D	OK		X	X			
E	OK	X					
F	OK	X					
G	OK						X
H	OK						X

Event number	263	Station	Prins Karls Forland
Megacorer number	024	Latitude	78°58.210'N
Date	20/07/10	Longitude	007°01.900'E
Time start	07:54	Depth	~1210m
Time at bottom	08:28	Comments	
Time end	09:05		

Core	Result	Radio-chem	Incub-ation	Profi-ling	Bio markers	Stable iso.	Foram iso.
A	OK	X					
B	OK	X					
C	OK						X
D	OK						
E	OK						
F	OK						
G	OK						
H	Failed - empty						

APPENDIX 7: CTD log

JR219 – LEG 1 - CTD log

Station	North Sea	CTD No	001	Date	14/06/2010	CTD type: 24 bottles
Lat	56° 24.729' N	Event No	001	Time I/W	08:09	
Lon	001° 18.851' E	Depth	84m	Time bottom	08:12	
Filename	jr219_001.dat	Cast Depth	79m	Time O/W	08:22	
Weather / Comments	A few clouds, sea state 3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	5	08:17							X	X								
2	2	5	08:17							X									
3	3	5	08:18							X									
4	4	5	08:18							X									
5	5	5	08:18							X									
6	6	5	08:19							X									
7	7	5	08:19							X									
8	8	5	08:20							X									
9	9	5	08:20							X									
10	10	5	08:20							X									
11	11	5	08:21							X									
12	12	5	08:21							X									
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	North Sea	CTD No	002	Date	14/06/2010	CTD type: 24 bottles
Lat	56° 24.729' N	Event No	002	Time I/W	09:05	
Lon	001° 18.849' E	Depth	84m	Time bottom	09:10	
Filename	jr219_002.dat	Cast Depth	78m	Time O/W	09:30	
Weather / Comments	A few clouds, sea state 3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	40	09:14		X							X		X		X	X		X
2	2	40	09:14				X	X	X										
3	3	28	09:16	X															
4	4	28	09:16	X															
5	5	28	09:16	X															
6	6	28	09:17	X															
7	7	28	09:17	X															
8	8	28	09:18	X															
9	9	28	09:18	X															
10	10	28	09:19	X															
11	11	28	09:19	X															
12	12	28	09:20	X															
13	13	28	09:20									X							X
14	14	28	09:20		X	X								X	X	X	X		
15	15	28	09:20				X	X	X										
16	16	20	09:22		X							X							X
17	17	20	09:23											X	X	X	X		
18	18	20	09:23				X	X	X										
19	19	5	09:25		X							X							X
20	20	5	09:26											X	X	X	X		
21	21	5	09:26				X	X	X										
22	22	2	09:28		X	X						X							
23	23	2	09:28											X	X	X	X		
24	24	2	09:29				X	X	X										
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	South Norwegian Sea	CTD No	003	Date	15/06/2010	CTD type: 24 bottles
Lat	60° 44.590' N	Event No	003	Time I/W	09:25	
Lon	002° 43.680' E	Depth	117m	Time bottom	09:33	
Filename	jr219_003.dat	Cast Depth	112m	Time O/W	09:42	
Weather / Comments	Overcast, sea state 3/4					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	5	09:37							X	X								
2	2	5	09:37							X									
3	3	5	09:37							X									
4	4	5	09:38							X									
5	5	5	09:38							X									
6	6	5	09:38							X									
7	7	5	09:39							X									
8	8	5	09:39							X									
9	9	5	09:39							X									
10	10	5	09:40							X									
11	11	5	09:40							X									
12	12	5	09:40							X									
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	Southern Norwegian Sea	CTD No	004	Date	15/06/2010	CTD type: 24 bottles
Lat	60° 44.588' N	Event No	004	Time I/W	10:04	
Lon	002° 43.670' E	Depth	117m	Time bottom	10:08	
Filename	jr219_004.dat	Cast Depth	80m	Time O/W	10:31	
Weather / Comments	Cloudy, sea state 3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	80	10:09											X					
2	2	80	10:10		X	X						X							
3	3	40	10:12											X		X	X		
4	4	40	10:13		X							X							X
5	5	23	10:14				X	X	X										
6	6	23	10:15											X	X	X	X		
7	7	23	10:15		X							X	X						X
8	8	18	10:18	X															
9	9	18	10:18	X															
10	10	18	10:18	X															
11	11	18	10:19	X															
12	12	18	10:19	X															
13	13	18	10:19	X															
14	14	18	10:20				X	X	X										
15	15	18	10:20											X	X	X	X		
16	16	18	10:20		X							X	X						
17	17	9	10:22		X							X	X						
18	18	6	10:23													X	X		X
19	19	5	10:25				X	X	X										
20	20	5	10:25											X	X	X	X		
21	21	5	10:26		X	X						X	X						
22	22	3.5	10:28																
23	23	3.5	10:28		X							X	X						
24	24	2	10:30		X							X	X						
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	Central Norwegian Sea	CTD No	005	Date	16/06/2010	CTD type: 24 bottles
Lat	65° 02.423' N	Event No	005	Time I/W	07:36	
Lon	004° 24.035' E	Depth	995m	Time bottom	07:43	
Filename	jr219_005.dat	Cast Depth	152m	Time O/W	07:52	
Weather / Comments	Fog, sea state 4/5					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	5	07:47							X	X								
2	2	5	07:48							X									
3	3	5	07:48							X									
4	4	5	07:48							X									
5	5	5	07:49							X									
6	6	5	07:49							X									
7	7	5	07:49							X									
8	8	5	07:50							X									
9	9	5	07:50							X									
10	10	5	07:51							X									
11	11	5	07:51							X									
12	12	5	07:51							X									
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	Central Norwegian Sea	CTD No	006	Date	16/06/2010	CTD type: 24 bottles
Lat	65° 02.420' N	Event No	008	Time I/W	08:25	
Lon	004° 24.020' E	Depth	995m	Time bottom	08:31	
Filename	jr219_006.dat	Cast Depth	100m	Time O/W	08:55	
Weather / Comments	Fog, sea state 4					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	100	08:32		X	X						X							
2	2	60	08:34		X							X		X					
3	3	38	08:37																
4	4	38	08:38											X					
5	5	38	08:38		X							X							
6	6	35	08:40				X	X	X										
7	7	35	08:41											X		X	X		
8	8	35	08:41		X							X							
9	9	20	08:43																X
10	10	17	08:45	X															
11	11	17	08:46	X															
12	12	17	08:46	X															
13	13	17	08:47	X															
14	14	17	08:47	X															
15	15	17	08:47	X															
16	16	17	08:48	X															
17	17	17	08:48				X	X	X										
18	18	17	08:48											X		X	X		
19	19	17	08:49		X	X						X							
20	20	6	08:50		X											X	X		X
21	21	5	08:51				X	X	X										
22	22	5	08:52											X		X	X		
23	23	5	08:52		X							X							
24	24	2	08:53		X									X		X	X		
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	Northern Norwegian Sea	CTD No	007	Date	17/06/2010	CTD type: 24 bottles
Lat	69° 20.460' N	Event No	010	Time I/W	06:33	
Lon	006° 22.430' E	Depth	3246m	Time bottom	06:42	
Filename	jr219_007.dat	Cast Depth	202m	Time O/W	06:52	
Weather / Comments	Cloudy, sea state 2/3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	5	06:46							X	X								
2	2	5	06:47							X									
3	3	5	06:47							X									
4	4	5	06:47							X									
5	5	5	06:48							X									
6	6	5	06:48							X									
7	7	5	06:48							X									
8	8	5	06:49							X									
9	9	5	06:49							X									
10	10	5	06:50							X									
11	11	5	06:51							X									
12	12	5	06:51							X									
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	North Norwegian Sea	CTD No	008	Date	17/06/2010	CTD type: 24 bottles
Lat	69° 20.459' N	Event No	012	Time I/W	07:21	
Lon	006° 22.420' E	Depth	3246m	Time bottom	07:28	
Filename	jr219_008.dat	Cast Depth	80m	Time O/W	07:47	
Weather / Comments	Cloudy, sea state 2/3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	80	07:28		X							X							
2	2	80	07:29											X					
3	3	40	07:30																X
4	4	35	07:32				X	X	X										
5	5	35	07:32		X	X						X	X						
6	6	35	07:33											X	X	X	X		
7	7	35	07:35	X															
8	8	20	07:35	X															
9	9	20	07:35	X															
10	10	20	07:36	X															
11	11	20	07:36	X															
12	12	20	07:37	X															
13	13	20	07:37				X	X	X										
14	14	20	07:37		X							X	X						
15	15	20	07:38											X	X	X	X		
16	16	20	07:38																
17	17	10	07:40		X	X						X	X						
18	18	6	07:41													X	X		X
19	19	6	07:41																
20	20	5	07:44				X	X	X										
21	21	5	07:44		X							X	X						
22	22	5	07:45											X	X	X	X		
23	23	2	07:46		X							X	X						
24	24	2	07:46											X	X	X	X		
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	South Greenland Sea	CTD No	009	Date	18/06/2010	CTD type: 24 bottles
Lat	72° 45.320' N	Event No	015	Time I/W	06:36	
Lon	008° 15.658' E	Depth	2473m	Time bottom	06:44	
Filename	jr219_009.dat	Cast Depth	200m	Time O/W	06:55	
Weather / Comments	Cloudy, sea state 2/3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	5	06:49							X	X								
2	2	5	06:49							X									
3	3	5	06:50							X									
4	4	5	06:50							X									
5	5	5	06:51							X									
6	6	5	06:51							X									
7	7	5	06:51							X									
8	8	5	06:52							X									
9	9	5	06:52							X									
10	10	5	06:53							X									
11	11	5	06:53							X									
12	12	5	06:53							X									
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	South Greenland Sea	CTD No	010	Date	18/06/2010	CTD type: 24 bottles
Lat	72° 45.213' N	Event No	018	Time I/W	07:44	
Lon	008° 15.930' E	Depth	2471m	Time bottom	07:49	
Filename	jr219_010.dat	Cast Depth	100m	Time O/W	08:11	
Weather / Comments	Overcast, sea state 2					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	100	07:50		X							X							
2	2	80	07:52		X							X		X					
3	3	60	07:54		X	X						X							
4	4	40	07:56				X	X	X										
5	5	40	07:56		X							X							X
6	6	40	07:57											X	X	X	X		
7	7	16	08:00	X															
8	8	16	08:00	X															
9	9	16	08:01	X															
10	10	16	08:01	X															
11	11	16	08:01	X															
12	12	16	08:02	X															
13	13	16	08:02																
14	14	16	08:03																
15	15	16	08:03															X	
16	16	16	08:03				X	X	X										
17	17	16	08:04		X							X							X
18	18	16	08:04											X	X	X	X		
19	19	6	08:06		X											X	X		X
20	20	5	08:07				X	X	X										
21	21	5	08:07		X	X						X							
22	22	5	08:08											X	X	X	X		
23	23	2.5	08:10															X	
24	24	2.5	08:10		X									X	X	X	X		
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	East Greenland Sea	CTD No	011	Date	19/06/2010	CTD type: 24 bottles
Lat	77° 09.420' N	Event No	019	Time I/W	06:35	
Lon	011° 17.550' E	Depth	911m	Time bottom	06:44	
Filename	jr219_011.dat	Cast Depth	200m	Time O/W	06:54	
Weather / Comments	Cloudy, sea state 2/3					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1	1	5	06:49							X	X								
2	2	5	06:49							X									
3	3	5	06:49							X									
4	4	5	06:50							X									
5	5	5	06:50							X									
6	6	5	06:51							X									
7	7	5	06:51							X									
8	8	5	06:52							X									
9	9	5	06:52							X									
10	10	5	06:52							X									
11	11	5	06:53							X									
12	12	5	06:53							X									
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 1 - CTD log

Station	East Greenland Sea	CTD No	012	Date	19/06/2010	CTD type: 24 bottles
Lat	77° 09.421' N	Event No	023	Time I/W	07:43	
Lon	0011° 17.530' E	Depth	911m	Time bottom	07:50	
Filename	jr219_012.dat	Cast Depth	200m	Time O/W	08:17	
Weather / Comments	Cloudy, sea state 0. Seasave did not report btl 16 firing after several attempts. However all bottles were closed when the CTD was brought back on deck.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Palaeo
1					X	X						X							
2					X							X							
3					X	X						X		X					
4					X							X							
5																			X
6							X	X	X										
7														X	X	X	X		
8					X							X							
9																			X
10				X															
11				X															
12				X															
13				X															
14				X															
15				X															
16							X	X	X										
17														X	X	X	X		
18					X							X						X	
19														X	X	X	X		
20																X	X		X
21							X	X	X										
22														X	X	X	X		
23					X							X							
24																		X	
Sampler / Analyst				Heiko	Sharon	Estelle	Tom	Tom	Emilie	Eric	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Kate

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	013	Date	23/06/10	CTD type: 12 bottles
Lat	80° 44.480' N	Event No	024	Time I/W	11:05	
Lon	004° 41.930' E	Depth	670m	Time bottom	11:24	
Filename	jr219_0013.dat	Cast Depth	647m	Time O/W	11:48	
Weather / Comments	Slight fog. Secondary conductivity sensor faulty.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	600	11:28	X								X					X			
2	2	600	11:29	X																
3	3	600	11:29	X																
4	4	600	11:29	X																
5	5	500	11:33	X								X					X			
6	6	500	11:33	X																
7	7	500	11:33	X																
8	8	500	11:34	X																
9	9	400	11:37	X								X					X			
10	10	400	11:37	X																
11	11	400	11:38	X																
12	12	400	11:38	X																
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	014	Date	23/06/10	CTD type: 12 bottles
Lat	80° 44.480' N	Event No	025	Time I/W	12:43	
Lon	004° 39.050' E	Depth	674m	Time bottom	12:47	
Filename	jr219_0014.dat	Cast Depth	100m	Time O/W	13:05	
Weather / Comments	Fog. The ship's propeller had to be run prior to the start of the cast in order to clear the ice at the back of the ship. Secondary conductivity sensor faulty.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	100	12:48		X														X	
2	2	60	12:50		X		X	X	X			X					X			
3	3	50	12:52		X														X	
4	4	46	12:54				X	X	X			X					X			
5	5	46	12:55		X									X	X	X				
6	6	31	12:56											X	X	X				
7	7	31	12:57		X		X	X	X											
8	8	25	12:59		X														X	
9	9	18	13:01		X									X	X	X				
10	10	18	13:01				X	X	X			X					X			
11	11	5	13:04											X	X	X			X	
12	12	5	13:04		X		X	X	X			X					X			
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	015	Date	23/06/10	CTD type: 12 bottles
Lat	80° 44.620' N	Event No	026	Time I/W	14:04	
Lon	004° 36.740' E	Depth	666m	Time bottom	14:12	
Filename	jr219_0015.dat	Cast Depth	300m	Time O/W	14:28	
Weather / Comments	Mostly sunny, a bit of fog. Secondary conductivity sensor faulty.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	300	14:13	X								X					X			
2	2	300	14:14	X																
3	3	300	14:14	X																
4	4	300	14:14	X																
5	5	200	14:18	X								X					X			
6	6	200	14:19	X																
7	7	200	14:19	X																
8	8	200	14:19	X																
9	9	60	14:25	X								X					X			
10	10	60	14:25	X																
11	11	60	14:25	X																
12	12	60	14:26	X																
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	016	Date	24/06/10	CTD type: 12 bottles
Lat	80° 42.250' N	Event No	031	Time I/W	07:38	
Lon	004° 20.534' E	Depth	754m	Time bottom	07:42	
Filename	jr219_0016.dat	Cast Depth	100m	Time O/W	07:51	
Weather / Comments	Fog. Secondary conductivity sensor faulty.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	100	07:42																X	
2	2	100	07:43																	
3	3	50	07:45																X	
4	4	50	07:46																	
5	5	25	07:47																X	
6	6	25	07:48																	
7	7	5	07:50																X	
8	8	5	07:50																	
9																				
10																				
11																				
12																				
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	017	Date	24/06/10	CTD type: 12 bottles
Lat	80° 41.499' N	Event No	032	Time I/W	09:26	
Lon	004° 19.086' E	Depth	771m	Time bottom	09:29	
Filename	jr219_0017.dat	Cast Depth	60m	Time O/W	09:42	
Weather / Comments	Fog. Secondary conductivity sensor faulty.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	60	09:31				X	X	X											
2	2	45	09:33				X	X	X											
3	3	45	09:33												X					
4	4	45	09:34		X							X					X			
5	5	30	09:35				X	X	X											
6	6	30	09:36		X							X					X			
7	7	16	09:37		X							X					X			
8	8	10	09:39				X	X	X											
9	9	10	09:39		X							X					X			
10	10	5	09:40				X	X	X											
11	11	5	09:41												X					
12	12	5	09:41		X							X					X			
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	018	Date	24/06/10	CTD type: 12 bottles
Lat	80° 40.610' N	Event No	033	Time I/W	12:22	
Lon	004° 14.880' E	Depth	790m	Time bottom	12:25	
Filename	jr219_0018.dat	Cast Depth	60m	Time O/W	12:36	
Weather / Comments	Slight fog. New secondary conductivity sensor installed, working ok.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	60	12:28		X											X				X
2	2	45	12:29		X											X				X
3	3	30	12:30		X											X				X
4	4	16	12:32		X											X				X
5	5	10	12:34		X											X				X
6	6	5	12:35		X											X				X
7																				
8																				
9																				
10																				
11																				
12																				
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	019	Date	25/06/10	CTD type: 12 bottles
Lat	80° 35.100' N	Event No	035	Time I/W	08:40	
Lon	004° 18.290' E	Depth	807m	Time bottom	08:49	
Filename	jr219_0019.dat	Cast Depth	400m	Time O/W	09:10	
Weather / Comments	Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	400	08:50																X	
2	2	100	08:58																X	
3	3	75	09:00				X	X	X											
4	4	57	09:02															X		
5	5	50	09:03				X	X	X											
6	6	50	09:03																X	
7	7	30	09:05				X	X	X										X	
8	8	30	09:05	LEAKING - UNUSED																
9	9	10	09:07				X	X	X											
10	10	5	09:08				X	X	X											
11	11	5	09:08																X	
12	12	1	09:10															X		
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	020 / 021	Date	26/06/10	CTD type: 12 bottles
Lat	80° 31.090' N	Event No	037	Time I/W	08:45	
Lon	004° 09.870' E	Depth	866m	Time bottom	08:55	
Filename	jr219_020.dat / 021.dat	Cast Depth	401m	Time O/W	09:29	
Weather / Comments	CTD020 = downcast, CTD021 = upcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	401	09:09		X														X	
2	2	100	09:16		X									X					X	
3	3	60	09:18		X									X	X	X				
4	4	55	09:19		X									X	X	X				
5	5	50	09:21		X														X	
6	6	39	09:22		X		X	X	X											
7	7	39	09:22											X	X	X				
8	8	25	09:24		X														X	
9	9	10	09:25		X		X	X	X											
10	10	5	09:27		X											X			X	
11	11	5	09:27				X	X	X											
12	12	5	09:27											X	X					
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	022	Date	27/06/10	CTD type: 12 bottles
Lat	80° 27.318' N	Event No	039	Time I/W	07:40	
Lon	003° 43.037' E	Depth	1071m	Time bottom	07:50	
Filename	jr219_022.dat	Cast Depth	400m	Time O/W	08:10	
Weather / Comments	Sunny.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	400	09:09		X														X	
2	2	100	09:16		X														X	
3	3	50	09:18		X														X	
4	4	50	09:19									X					X			
5	5	30	09:21		X		X	X	X											
6	6	30	09:22									X					X			
7	7	25	09:22		X														X	
8	8	20	09:24		X		X	X	X											
9	9	10	09:25									X					X			
10	10	10	09:27		X		X	X	X											
11	11	5	09:27									X					X			
12	12	5	09:27		X														X	
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	023	Date	27/06/10	CTD type: 12 bottles
Lat	80° 26.380' N	Event No	040	Time I/W	09:33	
Lon	003° 39.740' E	Depth	1110m	Time bottom	09:36	
Filename	jr219_023.dat	Cast Depth	101m	Time O/W	09:46	
Weather / Comments	Sunny.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	101	09:36											X						
2	2	101	09:37																	
3	3	60	09:39		X									X	X	X				
4	4	60	09:39																	
5	5	30	09:41		X									X	X	X				
6	6	30	09:42																	
7	7	15	09:43		X									X	X	X				
8	8	15	09:44																	
9	9	3	09:45		X									X	X	X				
10	10	3	09:45																	
11																				
12																				
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	024	Date	28/06/10	CTD type: 12 bottles
Lat	80° 19.600' N	Event No	043	Time I/W	07:37	
Lon	003° 22.180' E	Depth	1239m	Time bottom	07:46	
Filename	jr219_024.dat	Cast Depth	301m	Time O/W	08:15	
Weather / Comments	Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	301			X														X	
2	2	100			X														X	
3	3	100																X		
4	4	50			X														X	
5	5	50																X		
6	6	25			X														X	
7	7	25																X		
8	8	15																X		
9	9	10																X		
10	10	5																X		
11	11	5			X														X	
12	12	1																X		
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	025	Date	28/06/10	CTD type: 12 bottles
Lat	80° 18.980' N	Event No	044	Time I/W	09:04	
Lon	003° 19.387' E	Depth	1259m	Time bottom	09:09	
Filename	jr219_025.dat	Cast Depth	150m	Time O/W	09:24	
Weather / Comments	Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	150	09:10									X					X			
2	2	69	09:13									X					X			
3	3	60	09:14				X	X	X											
4	4	60	09:14		X										X					
5	5	30	09:16				X	X	X											
6	6	30	09:16		X							X			X		X			
7	7	20	09:18		X		X	X	X											
8	8	15	09:19		X							X					X			
9	9	10	09:20				X	X	X											
10	10	10	09:21		X										X					
11	11	5	09:22				X	X	X											
12	12	5	09:23		X							X			X		X			
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	026	Date	29/06/10	CTD type: 12 bottles
Lat	80° 16.470' N	Event No	049	Time I/W	08:01	
Lon	003° 03.675' E	Depth	1373m	Time bottom	08:24	
Filename	jr219_026.dat	Cast Depth	1000m	Time O/W	08:56	
Weather / Comments	Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	1000	08:25	X																
2	2	1000	08:26	X																
3	3	1000	08:26	X																
4	4	1000	08:27	X																
5	5	800	08:33	X																
6	6	800	08:33	X																
7	7	800	08:33	X																
8	8	800	08:34	X																
9	9	600	08:40	X																
10	10	600	08:41	X																
11	11	600	08:41	X																
12	12	600	08:41	X																
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	027	Date	29/06/10	CTD type: 12 bottles
Lat	80° 16.180' N	Event No	050	Time I/W	10:01	
Lon	002° 59.000' E	Depth	~1380m	Time bottom	10:08	
Filename	jr219_027.dat	Cast Depth	301m	Time O/W	10:27	
Weather / Comments						

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	301	10:09																X	
2	2	301	10:09		X															
3	3	201	10:13																X	
4	4	201	10:13		X															
5	5	101	10:17																X	
6	6	101	10:17		X															
7	7	50	10:20																X	
8	8	50	10:21		X															
9	9	25	10:22																X	
10	10	25	10:23		X															
11	11	5	10:25																X	
12	12	5	10:26		X															
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine	

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	028	Date	29/06/10	CTD type: 12 bottles
Lat	80° 15.983' N	Event No	051	Time I/W	11:34	
Lon	002° 55.148' E	Depth	1412m	Time bottom	11:37	
Filename	jr219_028.dat	Cast Depth	36m	Time O/W	11:51	
Weather / Comments	Sunny. PAR profile looks unusual, it may have been due to a large ice floe breaking and drifting away during the cast, letting more light penetrate in the water.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	36	11:38		X							X					X			X
2	2	30	11:40		X							X					X			X
3	3	30	11:40				X	X	X											
4	4	25	11:41		X							X					X			X
5	5	20	11:42				X	X	X											
6	6	13	11:44		X							X					X			X
7	7	11	11:45		X							X					X			X
8	8	10	11:47				X	X	X											
9	9	10	11:48		X										X	X				X
10	10	5	11:49		X										X	X				X
11	11	5	11:50				X	X	X											
12	12	1	11:50		X							X					X			X
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	029	Date	29/06/10	CTD type: 12 bottles
Lat	80° 15.630' N	Event No	052	Time I/W	14:50	
Lon	002° 49.210' E	Depth	1440m	Time bottom	14:59	
Filename	jr219_029.dat	Cast Depth	400m	Time O/W	15:16	
Weather / Comments	Sunny, with some fog banks. Ship's propeller running to clear the ice during the cast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	400	15:00	X																
2	2	400	15:00	X																
3	3	400	15:01	X																
4	4	400	15:01	X																
5	5	200	15:06	X																
6	6	200	15:07	X																
7	7	200	15:07	X																
8	8	200	15:07	X																
9	9	37	15:13	X																
10	10	37	15:14	X																
11	11	37	15:14	X																
12	12	37	15:14	X																
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	030	Date	30/06/10	CTD type: 12 bottles
Lat	80° 13.780' N	Event No	057	Time I/W	08:42	
Lon	002° 29.790' E	Depth	1574m	Time bottom	08:53	
Filename	jr219_030.dat	Cast Depth	400m	Time O/W	09:16	
Weather / Comments	A bit cloudy.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	400	08:54		X														X	
2	2	300	08:57		X									X					X	
3	3	100	09:03		X									X						
4	4	50	09:05		X									X					X	
5	5	30	09:07		X		X	X	X											
6	6	25	09:09											X						
7	7	25	09:09		X														X	
8	8	20	09:11		X		X	X	X											
9	9	10	09:12		X		X	X	X											
10	10	10	09:12							X										
11	11	5	09:14											X						
12	12	5	09:14		X														X	
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	031	Date	01/07/10	CTD type: 12 bottles
Lat	80° 13.190' N	Event No	061	Time I/W	08:13	
Lon	002° 09.940' E	Depth	1736m	Time bottom	08:19	
Filename	jr219_031.dat	Cast Depth	200m	Time O/W	08:36	
Weather / Comments	Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	201	08:20		X	X													X	
2	2	100	08:23		X	X													X	
3	3	50	08:25		X	X													X	
4	4	50	08:26									X					X			
5	5	30	08:28		X		X	X	X											
6	6	30	08:28									X					X			
7	7	25	08:30		X	X													X	
8	8	20	08:31		X		X	X	X											
9	9	15	08:32		X	X						X					X			
10	10	10	08:33		X		X	X	X											
11	11	5	08:34		X	X													X	
12	12	5	08:35									X					X			
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 2 - CTD log

Station	Ice Station	CTD No	032	Date	01/07/10	CTD type: 12 bottles
Lat	80° 13.311' N	Event No	062	Time I/W	10:12	
Lon	002° 09.380' E	Depth	1701m	Time bottom	10:51	
Filename	jr219_032.dat	Cast Depth	1691m	Time O/W	11:46	
Weather / Comments	Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coupling expt	Bact. Met. Divers	DIC	Primary prod	O2	Respir	Bact prod	Flowcyto	Trace gases	Silica, POC, lugols, cocc.	Microb
1	1	1691	10:52			X														
2	2	1300	11:05			X														
3	3	1000	11:13			X														
4	4	800	11:19			X														
5	5	600	11:25			X														
6	6	500	11:28			X														
7	7	400	11:32			X														
8	8	75	11:39			X														
9	9	40	11:41			X														
10	10	10	11:43			X														
11	11	8	11:44			X														
12	12	3	11:45			X														
Sampler / Analyst				Heiko	Sharon	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Elena	Elena	Sharon	Sian	Helen	Jenny	Elaine

JR219 – LEG 3 - CTD log

Station	KF3	CTD No	033 / 034	Date	04/07/10	CTD type: 24 bottles
Lat	79° 01.000' N	Event No	065	Time I/W	06:39	
Lon	010° 42.040' E	Depth	338m	Time bottom	06:50	
Filename	jr219_033.dat / 034.dat	Cast Depth	300m	Time O/W	07:18	
Weather / Comments	Sea state 0/1, some clouds. Problem with the carousel set-up: could only fire 12 bottles. CTD033= downcast + upcast up to bottle 12, CTD034= upcast from bottle 13 to 24.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	06:52		X														X								
2	2	100	06:57		X														X								
3	3	50	07:00		X														X								
4	4	25	07:03		X														X								
5	5	25	07:04	X																							
6	6	25	07:04	X																							
7	7	25	07:04	X																							
8	8	25	07:05	X																							
9	9	25	07:05	X																							
10	10	5	07:07		X														X								
11	11	5	07:08																		X						
12	12	5	07:12																		X						
13	13	5	07:12																		X						
14	14	5	07:12							X	X																
15	15	5	07:13							X																	
16	16	5	07:13							X																	
17	17	5	07:13							X																	
18	18	5	07:14							X																	
19	19	5	07:14							X																	
20	20	5	07:15							X																	
21	21	5	07:15							X																	
22	22	5	07:16							X																	
23	23	5	07:16							X																	
24	24	5	07:16																								
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF3	CTD No	035	Date	04/07/10	CTD type: 24 bottles
Lat	79° 01.000' N	Event No	066	Time I/W	08:01	
Lon	010° 42.050' E	Depth	339m	Time bottom	08:11	
Filename	jr219_035.dat	Cast Depth	302m	Time O/W	08:44	
Weather / Comments	Sea state 0/1, some clouds.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	302	08:13		X	X						X										X					
2	2	150	08:18		X	X						X										X					
3	3	45	08:22				X	X	X																		
4	4	45	08:22												X	X	X										
5	5	45	08:23		X							X	X							X							
6	6	45	08:23			X												X				X					
7	7	35	08:25		X		X	X	X																		
8	8	26	08:27				X	X	X																		
9	9	26	08:27												X	X	X										
10	10	26	08:28		X							X	X							X							
11	11	26	08:28			X																X					
12	12	15	08:30				X	X	X																		
13	13	15	08:30												X	X	X										
14	14	15	08:31		X							X	X							X							
15	15	15	08:32			X																X					
16	16	6.5	08:35		X	X						X	X							X		X					
17	17	15	08:37																								
18	18	3.5	08:39				X	X	X																		
19	19	3.5	08:40												X	X	X										
20	20	3.5	08:40		X							X	X							X							
21	21	3.5	08:41																								
22	22	1	08:42		X							X								X							
23	23	1	08:42			X												X				X					
24	24	1	08:43																								
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF3	CTD No	036	Date	04/07/10	CTD type: 24 bottles
Lat	79° 00.856' N	Event No	076	Time I/W	18:35	
Lon	010° 41.630' E	Depth	329m	Time bottom	18:45	
Filename	jr219_036.dat	Cast Depth	324m	Time O/W	19:06	
Weather / Comments	Sea state 0/1.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod.+ calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	324	18:46																						X		
2	2	324	18:46																								
3	3	324	18:46																					X			
4	4	324	18:47																					X			
5	5	324	18:47																								
6	6	50	18:54																				X				
7	7	50	18:55																				X				
8	8	50	18:55																				X				
9	9	50	18:56																								
10	10	40	18:58																				X				
11	11	40	18:59																				X				
12	12	40	18:59																				X				
13	13	40	19:00																								
14	14	2	19:04																				X				
15	15	2	19:04																				X				
16	16	2	19:04																				X				
17	17	2	19:05																								
18																											
19																											
20																											
21																											
22																											
23																											
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF3	CTD No	037	Date	05/07/10	CTD type: 24 bottles
Lat	79° 00.911' N	Event No	082	Time I/W	06:42	
Lon	010° 41.280' E	Depth	332m	Time bottom	06:51	
Filename	jr219_037.dat	Cast Depth	200m	Time O/W	07:22	
Weather / Comments	Sea state 0, cloudy.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	06:51																X								
2	2	200	06:56		X																						
3	3	100	07:00																X								
4	4	100	07:00		X																						
5	5	50	07:04																X								
6	6	50	07:05		X																						
7	7	32	07:07				X	X	X																		
8	8	32	07:07																								
9	9	32	07:08		X																						
10	10	32	07:08															X									
11	11	25	07:10																X								
12	12	25	07:11				X	X	X																		
13	13	25	07:11		X																						
14	14	25	07:11																								
15	15	10	07:14				X	X	X																		
16	16	10	07:14		X																						
17	17	5	07:16																X								
18	18	5	07:16				X	X	X																		
19	19	5	07:17		X																						
20	20	5	07:18																								
21	21	1	07:19															X									
22	22	1	07:19		X																						
23	23	1	07:20																								
24	24	1	07:20																								
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF3	CTD No	038	Date	05/07/10
Lat	79° 00.910' N	Event No	088	Time I/W	12:33
Lon	010° 41.311' E	Depth	325m	Time bottom	12:45
Filename	jr219_038.dat	Cast Depth	320m	Time O/W	13:25
Weather / Comments	Sea state 1, a bit cloudy. SBE37 S/N 4609 attached to the CTD frame for calibration.				

CTD type: 24 bottles

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	320	12:46		X																					X	
2	2	320	12:47																							X	
3	3	275	12:50		X																					X	
4	4	275	12:51																							X	
5	5	275	12:51																								X
6	6	275	12:51																								X
7	7	200	13:03		X																					X	
8	8	200	13:03																							X	
9	9	200	13:04																								X
10	10	200	13:04																								X
11	11	150	13:07		X																						
12	12	100	13:09		X																					X	
13	13	100	13:10																							X	
14	14	75	13:12		X																						
15	15	50	13:14		X																					X	
16	16	50	13:15																							X	
17	17	50	13:15																								X
18	18	50	13:16																								X
19	19	35	13:18		X																						
20	20	15	13:20		X																					X	
21	21	15	13:20																							X	
22	22	15	13:20																								
23	23	5	13:23		X																						
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	CTD Section '~300m'	CTD No	039	Date	05/07/10	CTD type: 24 bottles
Lat	79° 00.000' N	Event No	091	Time I/W	17:02	
Lon	008° 35.115' E	Depth	275m	Time bottom	17:11	
Filename	jr219_039.dat	Cast Depth	265m	Time O/W	17:25	
Weather / Comments	Sea state 3, overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	103	17:16			X																					
2	2	30	17:20															X									
3	3	1	17:23															X									
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
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14																											
15																											
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17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF4	CTD No	042	Date	06/07/10	CTD type: 24 bottles
Lat	78° 58.520' N	Event No	098	Time I/W	06:32	
Lon	006° 42.380' E	Depth	1371m	Time bottom	06:39	
Filename	jr219_042.dat	Cast Depth	202m	Time O/W	06:58	
Weather / Comments	Sea state 1/2, overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod.+ calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	202	06:40																X								
2	2	100	06:44																X								
3	3	50	06:46																X								
4	4	25	06:48																X								
5	5	5	06:50																X								
6	6	5	06:51																		X						
7	7	5	06:51																		X						
8	8	5	06:52																		X						
9	9	5	06:52																		X						
10	10	5	06:52							X	X																
11	11	5	06:53							X																	
12	12	5	06:53							X																	
13	13	5	06:54							X																	
14	14	5	06:54							X																	
15	15	5	06:54							X																	
16	16	5	06:55							X																	
17	17	5	06:55							X																	
18	18	5	06:56							X																	
19	19	5	06:56							X																	
20	20	5	06:56							X																	
21	21	5	06:57							X																	
22																											
23																											
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF4	CTD No	043	Date	06/07/10	CTD type: 24 bottles
Lat	78° 58.520' N	Event No	099	Time I/W	07:58	
Lon	006° 42.390' E	Depth	1371m	Time bottom	08:05	
Filename	jr219_043.dat	Cast Depth	202m	Time O/W	08:37	
Weather / Comments	Sea state 1/2, overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	202	08:06			X																X					
2	2	100	08:10		X	X						X										X					
3	3	50	08:12				X	X	X																		
4	4	50	08:12		X	X						X				X	X			X		X					
5	5	30	08:14				X	X	X																		
6	6	30	08:14												X	X	X										
7	7	30	08:15		X	X														X		X					
8	8	25	08:16		X							X	X														
9	9	21	08:18				X	X	X																		
10	10	21	08:18												X	X	X										
11	11	21	08:19		X	X												X		X		X					
12	12	19	08:20		X							X	X														
13	13	13	08:21		X							X	X														
14	14	10	08:23				X	X	X																		
15	15	10	08:24												X	X	X										
16	16	10	08:24		X	X														X		X					
17	17	8	08:29		X							X	X														
18	18	5	08:31												X												
19	19	5	08:32												X												
20	20	5	08:32												X	X	X			X							
21	21	5	08:33				X	X	X																		
22	22	5	08:33		X	X						X	X									X					
23	23	2	08:35		X							X	X														
24	24	2	08:35															X									
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF4	CTD No	044	Date	06/07/10	CTD type: 24 bottles
Lat	78° 58.514' N	Event No	101	Time I/W	09:48	
Lon	006° 42.387' E	Depth	1348m	Time bottom	10:16	
Filename	jr219_044.dat	Cast Depth	1338m	Time O/W	11:05	
Weather / Comments	Sea state 1/2, overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	1338	10:16		X																						
2	2	1298	10:18		X																					X	
3	3	1298	10:19																							X	
4	4	1000	10:25		X																					X	
5	5	1000	10:26											X												X	
6	6	1000	10:26																								X
7	7	1000	10:26																								X
8	8	800	10:31		X																						
9	9	500	10:38		X																					X	
10	10	500	10:39											X												X	
11	11	500	10:39																								X
12	12	500	10:39																								X
13	13	200	10:46		X																						
14	14	100	10:49		X																					X	
15	15	100	10:49																							X	
16	16	75	10:51		X																						
17	17	50	10:53		X																					X	
18	18	50	10:54											X												X	
19	19	50	10:54																								X
20	20	50	10:55																								X
21	21	21	10:58		X																						
22	22	15	11:01		X																					X	
23	23	15	11:02																							X	
24	24	5	11:04		X																						
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF4	CTD No	046	Date	06/07/10	CTD type: 24 bottles
Lat	78° 58.508' N	Event No	105	Time I/W	19:53	
Lon	006° 42.370' E	Depth	1348m	Time bottom	20:21	
Filename	jr219_046.dat	Cast Depth	1343m	Time O/W	21:06	
Weather / Comments	Sea state 2/3, light swell, overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	1343	20:21																					X			
2	2	1200	20:26	X																							
3	3	1200	20:26	X																							
4	4	1200	20:27	X																							
5	5	1200	20:27	X																							
6	6	1000	20:32	X																							
7	7	1000	20:33	X																							
8	8	1000	20:33	X																							
9	9	1000	20:34	X																							
10	10	800	20:39	X																							
11	11	800	20:40	X																							
12	12	800	20:40	X																							
13	13	800	20:41	X																							
14	14	600	20:46	X																							
15	15	600	20:47	X																							
16	16	600	20:47	X																							
17	17	600	20:48	X																							
18	18	400	20:53	X																							
19	19	400	20:54	X																							
20	20	400	20:55	X																							
21	21	400	20:55	X																							
22	22	200	21:00	X																							
23	23	200	21:01	X																							
24	24	200	21:01	X																							
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF4	CTD No	047	Date	07/07/10	CTD type: 24 bottles
Lat	78° 58.506' N	Event No	112	Time I/W	06:55	
Lon	006° 42.379' E	Depth	1371m	Time bottom	07:04	
Filename	jr219_047.dat	Cast Depth	200m	Time O/W	07:40	
Weather / Comments	Sea state 2, cloudy.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	07:05		X	X													X			X					
2	2	100	07:09		X	X						X							X			X					
3	3	50	07:12		X	X						X							X			X					
4	4	40	07:16									X															
5	5	50	07:18																				X				
6	6	50	07:18																				X				
7	7	50	07:19																				X				
8	8	38	07:21				X	X	X													X					
9	9	27	07:25				X	X	X																		
10	10	27	07:25	X														X									
11	11	27	07:26	X																							
12	12	27	07:26	X																							
13	13	27	07:27	X																							
14	14	27	07:27																				X				
15	15	27	07:28																				X				
16	16	27	07:28																				X				
17	17	27	07:29		X	X						X										X					
18	18	25	07:31																X								
19	19	15	07:34				X	X	X													X					
20	20	5	07:36				X	X	X																		
21	21	5	07:37		X	X						X							X			X					
22	22	2	07:38																				X				
23	23	2	07:39																				X				
24	24	2	07:39															X					X				
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenland Shelf	CTD No	048	Date	08/07/10	CTD type: 24 bottles
Lat	77° 47.250' N	Event No	118	Time I/W	06:25	
Lon	005° 35.390' W	Depth	365m	Time bottom	06:39	
Filename	jr219_048.dat	Cast Depth	348m	Time O/W	07:03	
Weather / Comments	In polynia. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	06:43																X								
2	2	100	06:47																X								
3	3	50	06:49																X								
4	4	25	06:51																X								
5	5	13	06:54	X																							
6	6	13	06:54	X																							
7	7	13	06:54	X																							
8	8	13	06:55	X																							
9	9	5	06:56																X								
10	10	5	06:57																		X						
11	11	5	06:57																		X						
12	12	5	06:57																		X						
13	13	5	06:58							X	X																
14	14	5	06:58							X																	
15	15	5	06:58							X																	
16	16	5	06:59							X																	
17	17	5	06:59							X																	
18	18	5	06:59							X																	
19	19	5	07:00							X																	
20	20	5	07:00							X																	
21	21	5	07:01							X																	
22	22	5	07:01							X																	
23	23	5	07:01																								
24	24	5	07:02																								
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenland Shelf	CTD No	049	Date	08/07/10	CTD type: 24 bottles
Lat	77° 46.630' N	Event No	119	Time I/W	07:43	
Lon	005° 35.770' W	Depth	361m	Time bottom	07:50	
Filename	jr219_049.dat	Cast Depth	200m	Time O/W	08:15	
Weather / Comments	In polynia. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	07:51		X	X						X										X					
2	2	100	07:54		X	X						X										X					
3	3	50	07:56		X	X						X				X	X			X		X					
4	4	29	07:59		X							X	X														
5	5	29	07:59				X	X	X																		
6	6	29	08:00												X	X	X										
7	7	29	08:00			X														X		X					
8	8	16	08:01		X							X	X														
9	9	14	08:04				X	X	X																		
10	10	14	08:04												X	X	X										
11	11	14	08:05		X	X														X		X					
12	12	14	08:05															X									
13	13	9	08:07		X							X	X														
14	14	9	08:07				X	X	X																		
15	15	9	08:08												X	X	X										
16	16	9	08:08			X														X		X					
17	17	5	08:10		X							X	X														
18	18	5	08:10				X	X	X																		
19	19	2	08:12		X							X	X														
20	20	2	08:12												X	X	X										
21	21	2	08:13			X														X		X					
22	22	2	08:13															X									
23	23	2	08:13																								
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenland Shelf	CTD No	050	Date	08/07/10	CTD type: 24 bottles
Lat	77° 42.994' N	Event No	128	Time I/W	12:57	
Lon	005° 37.344' W	Depth	359m	Time bottom	13:07	
Filename	jr219_050.dat	Cast Depth	355m	Time O/W	13:36	
Weather / Comments	In polynia. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	355	13:08																					X			
2	2	355	13:08		X									X													
3	3	308	13:11		X																					X	
4	4	308	13:11																							X	
5	5	308	13:12																								X
6	6	308	13:12																								X
7	7	250	13:15		X																						
8	8	200	13:17		X																					X	
9	9	200	13:18																							X	
10	10	200	13:18																								X
11	11	200	13:19																								X
12	12	150	13:21		X									X													
13	13	100	13:23		X																					X	
14	14	100	13:24																							X	
15	15	75	13:26		X									X													
16	16	50	13:28		X																					X	
17	17	50	13:28																							X	
18	18	50	13:29																								X
19	19	50	13:29																								X
20	20	30	13:31		X																						
21	21	20	13:32		X																					X	
22	22	20	13:33																							X	
23	23	5	13:34		X																					X	
24	24	5	13:34																							X	
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenland Shelf	CTD No	051	Date	08/07/10	CTD type: 24 bottles
Lat	77° 41.763' N	Event No	129	Time I/W	14:22	
Lon	005° 36.950' W	Depth	370m	Time bottom	14:27	
Filename	jr219_051.dat	Cast Depth	36m	Time O/W	14:36	
Weather / Comments	In polynia. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	25	14:29																				X				
2	2	25	14:30																				X				
3	3	25	14:30																				X				
4	4	20	14:32																				X				
5	5	20	14:32																				X				
6	6	20	14:33																				X				
7	7	1.5	14:34																				X				
8	8	1.5	14:35																				X				
9	9	1.5	14:35																				X				
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenland Shelf	CTD No	052 / 053	Date	09/07/10	CTD type: 24 bottles
Lat	77° 36.054' N	Event No	134	Time I/W	06:18	
Lon	006° 11.425' W	Depth	299m	Time bottom	06:29	
Filename	jr219_052.dat / 053.dat	Cast Depth	200m	Time O/W	07:10	
Weather / Comments	MIZ. Fog. CTD052 = downcast, CTD053 = upcast					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	06:42		X							X															
2	2	200	06:42			X													X			X					
3	3	100	06:46		X							X															
4	4	100	06:46			X													X			X					
5	5	50	06:49			X													X			X					
6	6	42	06:50		X							X	X														
7	7	42	06:51												X	X	X										
8	8	42	06:51			X	X	X	X													X					
9	9	25	06:53												X	X	X										
10	10	25	06:53															X	X								
11	11	25	06:53		X	X						X	X									X					
12	12	25	06:54				X	X	X																		
13	13	15	06:57		X	X						X	X														
14	14	15	06:58				X	X	X													X					
15	15	10	07:00												X	X	X										
16	16	8	07:01		X							X	X														
17	17	5	07:04			X									X	X	X					X					
18	18	5	07:04		X							X	X						X								
19	19	5	07:05																		X						
20	20	5	07:06																		X						
21	21	5	07:06																		X						
22	22	5	07:07				X	X	X																		
23	23	2	07:08		X							X	X														
24	24	1	07:09															X									
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenland Shelf Edge	CTD No	054	Date	09/07/10	CTD type: 24 bottles
Lat	77° 38.920' N	Event No	140	Time I/W	22:08	
Lon	004° 46.810' W	Depth	1371m	Time bottom	22:34	
Filename	jr219_054.dat	Cast Depth	1361m	Time O/W	23:29	
Weather / Comments	Sea state 1. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	1361	22:36		X	X																					
2	2	1320	22:38		X																					X	
3	3	1320	22:38																							X	
4	4	1200	22:43		X	X																					
5	5	1000	22:48		X																					X	
6	6	1000	22:48																							X	
7	7	1000	22:49																								X
8	8	1000	22:49																								X
9	9	800	22:55		X	X																					
10	10	500	23:01		X																					X	
11	11	500	23:01																							X	
12	12	500	23:02																								X
13	13	500	23:02																								X
14	14	200	23:09		X																						
15	15	100	23:13		X																					X	
16	16	100	23:13																							X	
17	17	75	23:16		X	X																					
18	18	45	23:18		X																					X	
19	19	45	23:18																							X	
20	20	45	23:19																								X
21	21	45	23:19																								X
22	22	20	23:22		X																					X	
23	23	20	23:23																							X	
24	24	5	23:27		X																						
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenwich Meridian	CTD No	055	Date	10/07/10	CTD type: 24 bottles
Lat	78° 16.997' N	Event No	142	Time I/W	08:11	
Lon	000° 00.010' E	Depth	3019m	Time bottom	08:19	
Filename	jr219_055.dat	Cast Depth	201m	Time O/W	08:40	
Weather / Comments	Sea state 2, a bit of fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	201	08:19																X								
2	2	100	08:22																X								
3	3	50	08:25																X								
4	4	25	08:28																X								
5	5	18	08:31	X																							
6	6	18	08:31	X																							
7	7	18	08:32	X																							
8	8	18	08:32	X																							
9	9	5	08:34																X								
10	10	5	08:34																		X						
11	11	5	08:35																		X						
12	12	5	08:35																		X						
13	13	5	08:35							X																	
14	14	5	08:36							X																	
15	15	5	08:36							X																	
16	16	5	08:36							X																	
17	17	5	08:37							X																	
18	18	5	08:37							X																	
19	19	5	08:37							X																	
20	20	5	08:38							X																	
21	21	5	08:38							X																	
22	22	5	08:38							X																	
23	23	5	08:39																								
24	24	5	08:39																								
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenwich Meridian	CTD No	056	Date	10/07/10
Lat	78° 16.997' N	Event No	143	Time I/W	09:24
Lon	000° 00.015' E	Depth	3019m	Time bottom	09:32
Filename	jr219_056.dat	Cast Depth	200m	Time O/W	09:59
Weather / Comments	Sea state 2. Fog.				

CTD type: 24 bottles

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	09:33		X	X						X										X					
2	2	200	09:36		X	X						X										X					
3	3	50	09:38		X	X						X	X									X					
4	4	50	09:39												X	X	X										
5	5	27	09:41		X							X	X														
6	6	25	09:42				X	X	X																		
7	7	25	09:43												X	X	X										
8	8	25	09:43			X														X		X					
9	9	20	09:44				X	X	X																		
10	10	20	09:44												X	X	X										
11	11	18	09:45		X							X	X														
12	12	18	09:48				X	X	X																		
13	13	18	09:49												X	X	X										
14	14	18	09:49			X														X		X					
15	15	18	09:50															X									
16	16	15	09:51												X	X	X			X							
17	17	10	09:52				X	X	X																		
18	18	10	09:53		X							X	X														
19	19	10	09:54			X										X	X			X		X					
20	20	5	09:56				X	X	X																		
21	21	5	09:56												X	X	X										
22	22	5	09:56			X														X		X					
23	23	5	09:57		X							X	X														
24	24	2	09:58		X							X	X					X									
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	Greenwich Meridian	CTD No	057	Date	10/07/10	CTD type: 24 bottles
Lat	78° 17.000' N	Event No	151	Time I/W	15:23	
Lon	000° 00.000' E	Depth	2968m	Time bottom	16:17	
Filename	jr219_057.dat	Cast Depth	2959m	Time O/W	17:38	
Weather / Comments	Sea state 2, slight swell. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	2959	16:18		X																						
2	2	2919	16:22		X																					X	
3	3	2919	16:22																							X	
4	4	2500	16:31		X																						
5	5	2000	16:43		X																					X	
6	6	2000	16:43																							X	
7	7	2000	16:44																								X
8	8	2000	16:44																								X
9	9	1500	16:55		X																						
10	10	1000	17:05		X																					X	
11	11	1000	17:06																							X	
12	12	1000	17:06																								X
13	13	1000	17:07																								X
14	14	500	17:17		X																					X	
15	15	500	17:18																							X	
16	16	200	17:25		X																						
17	17	100	17:28		X																					X	
18	18	100	17:28																							X	
19	19	100	17:29																								X
20	20	100	17:29																								X
21	21	50	17:32		X																					X	
22	22	50	17:32																							X	
23	23	20	17:34		X																						
24	24	5	17:37		X																						
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF5	CTD No	058	Date	11/07/10	CTD type: 24 bottles
Lat	78° 56.850' N	Event No	152	Time I/W	02:12	
Lon	005° 17.300' E	Depth	2496m	Time bottom	03:00	
Filename	jr219_058.dat	Cast Depth	2486m	Time O/W	04:29	
Weather / Comments						

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	2486	03:00		X																						
2	2	2446	03:03		X																					X	
3	3	2446	03:03																							X	
4	4	2000	03:17		X																					X	
5	5	2000	03:17																							X	
6	6	2000	03:18																								X
7	7	2000	03:18																								X
8	8	1500	03:36		X																						
9	9	1000	03:47		X																					X	
10	10	1000	03:47																							X	
11	11	1000	03:48																								X
12	12	1000	03:49																								X
13	13	800	03:55		X																						
14	14	500	04:02		X																					X	
15	15	500	04:02																							X	
16	16	500	04:03																								X
17	17	500	04:03																								X
18	18	200	04:10		X																					X	
19	19	200	04:11																							X	
20	20	100	04:15		X																						
21	21	50	04:18		X																					X	
22	22	50	04:18																							X	
23	23	25	04:22		X																						
24	24	5	04:25		X																						
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 3 - CTD log

Station	KF5	CTD No	059	Date	11/07/10	CTD type: 24 bottles
Lat	78° 56.850' N	Event No	155	Time I/W	05:27	
Lon	005° 17.320' E	Depth	~2500m	Time bottom	05:36	
Filename	jr219_059.dat	Cast Depth	200m	Time O/W	05:49	
Weather / Comments	Sea state 3, slight swell. Overcast. Rapid bottle firing.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Bio-mark	Nuts	Salin	Chl	HPLC, POC, abs, ^{14}C, DNA	Photo eff	Coup-ling expt	Bact. Met. Divers	DIC	Pri-mary prod + calc	O2	Respir	Bact prod	Flow-cyto	Trace gases	Silica, POC, lugols, cocc.	Microb	Gra-zing expt	CDOM tracers ^{18}O, SPM	Zoo-plank-ton	Core Incub	Core Incub 2	^{210}Pb	^{226}Ra
1	1	200	05:36		X	X																X					
2	2	100	05:38		X	X																X					
3	3	50	05:40		X	X																X					
4	4	40	05:41				X	X	X																		
5	5	40	05:41																								
6	6	30	05:42				X	X	X																		
7	7	30	05:42		X	X																X					
8	8	25	05:43																				X				
9	9	25	05:43																				X				
10	10	25	05:43																				X				
11	11	20	05:44				X	X	X																		
12	12	20	05:44		X	X																X					
13	13	20	05:44																				X				
14	14	20	05:44																								
15	15	20	05:44																								
16	16	13	05:45				X	X	X																		
17	17	13	05:46		X	X																X					
18	18	13	05:46																				X				
19	19	5	05:47				X	X	X																		
20	20	5	05:47		X	X																X					
21	21	1	05:48																								
22																											
23																											
24																											
Sampler / Analyst				Heiko	Tim	Estelle	Heather	Heather	Emilie	Emilie	Emilie	Eithne	Eithne	Tim	Elena	Sian	Sian	Helen	Jenny	Elaine	Ray	Alexey	Daniel	Henrik	Dan	Richard	Richard

JR219 – LEG 4 - CTD log

Station	KF3	CTD No	063	Date	14/07/10	CTD type: 24 bottles
Lat	79° 00.900' N	Event No	173	Time I/W	07:40	
Lon	010° 43.650' E	Depth	331m	Time bottom	07:50	
Filename	jr219_063.dat	Cast Depth	326m	Time O/W	08:17	
Weather / Comments	Sea state 2. Fog.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	326	07:51							X		
2	2	326	07:52			X						X
3	3	300	07:54	X								
4	4	300	07:55	X								
5	5	300	07:55	X								
6	6	300	07:55	X								
7	7	200	07:59	X								
8	8	200	08:00	X								
9	9	200	08:00	X								
10	10	200	08:00	X								
11	11	200	08:01		X	X		X				
12	12	100	08:04	X								
13	13	100	08:04	X								
14	14	100	08:05	X								
15	15	100	08:05	X								
16	16	100	08:06		X	X		X				
17	17	50	08:08		X	X	X	X				
18	18	35	08:10	X								
19	19	35	08:10	X								
20	20	35	08:11	X								
21	21	35	08:11	X								
22	22	35	08:12		X		X					
23	23	25	08:13		X	X	X	X				
24	24	5	08:15		X		X	X				
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Amsterdamoya Transect A	CTD No	064	Date	14/07/10	CTD type: 24 bottles
Lat	79° 56.660' N	Event No	180	Time I/W	22:12	
Lon	008° 56.220' E	Depth	~475m	Time bottom	22:30	
Filename	jr219_064.dat	Cast Depth	~465m	Time O/W	22:46	
Weather / Comments						

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	65	22:39	X								
2	2	65	22:40	X								
3	3	65	22:41	X								
4	4	65	22:41	X								
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Amsterdamoya Slope	CTD No	072	Date	15/07/10	CTD type: 24 bottles
Lat	79° 49.710' N	Event No	191	Time I/W	09:09	
Lon	010° 01.250' E	Depth	405m	Time bottom	09:17	
Filename	jr219_072.dat	Cast Depth	200m	Time O/W	09:33	
Weather / Comments	Sea state 4. Overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	200	09:18		X			X				
2	2	100	09:21		X			X				
3	3	50	09:23		X		X	X				
4	4	25	09:27		X		X	X				
5	5	21	09:29		X		X					
6	6	5	09:31		X		X	X				
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Smeerenburg	CTD No	073	Date	15/07/10	CTD type: 24 bottles
Lat	79° 43.855' N	Event No	196	Time I/W	13:11	
Lon	011° 05.400' E	Depth	214m	Time bottom	13:21	
Filename	jr219_073.dat	Cast Depth	208m	Time O/W	13:45	
Weather / Comments	Sea state 1 or 2. Sunny.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	208	13:22							X		
2	2	208	13:22									X
3	3	200	13:23	X								
4	4	200	13:24	X								
5	5	200	13:24	X								
6	6	200	13:24	X								
7	7	100	13:27	X								
8	8	100	13:28	X								
9	9	100	13:28	X								
10	10	75	13:30									X
11	11	50	13:32									X
12	12	50	13:32									
13	13	100	13:35	X								
14	14	30	13:38									X
15	15	22	13:39	X								
16	16	22	13:40	X								
17	17	22	13:40	X								
18	18	22	13:40	X								
19	19	15	13:42									X
20	20	5	13:44									X
21												
22												
23												
24												
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Woodfjorden	CTD No	077	Date	16/07/10	CTD type: 24 bottles
Lat	79° 41.030' N	Event No	219	Time I/W	21:53	
Lon	013° 49.640' E	Depth	197m	Time bottom	21:59	
Filename	jr219_077.dat	Cast Depth	192m	Time O/W	22:11	
Weather / Comments	Sea state 4. Sunny.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	192	22:00							X		
2	2	192	22:00									X
3	3	147	22:03								X	
4	4	147	22:03								X	
5	5	75	22:06								X	
6	6	75	22:06								X	
7	7	0	22:10	Bottle partly out of the water when fired. Not used.								
8	8	1	22:10								X	
9	9	1	22:11								X	
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Hinlopenrenna	CTD No	080	Date	17/07/10	CTD type: 24 bottles
Lat	80° 04.786' N	Event No	228	Time I/W	16:05	
Lon	017° 16.830' E	Depth	381m	Time bottom	16:16	
Filename	jr219_080.dat	Cast Depth	376m	Time O/W	16:43	
Weather / Comments	Sea state 2 or 3. Cloudy.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	376	16:17			X				X		X
2	2	376	16:18	X								
3	3	376	16:18	X								
4	4	331	16:20								X	
5	5	331	16:20								X	
6	6	220	16:24								X	
7	7	220	16:24								X	
8	8	200	16:26	X								
9	9	200	16:26	X								
10	10	200	16:26					X				
11	11	110	16:29								X	
12	12	110	16:30								X	
13	13	100	16:31			X		X				
14	14	50	16:33					X				
15	15	35	16:35				X					
16	16	35	16:36	X								
17	17	35	16:36	X								
18	18	25	16:37			X		X				
19	19	5	16:39					X				
20	20	5	16:39						X			
21	21	5	16:40						X			
22	22	5	16:40						X			
23	23	1	16:41								X	
24	24	1	16:42								X	
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Ice Edge	CTD No	090	Date	18/07/10	CTD type: 24 bottles
Lat	80° 33.271' N	Event No	245	Time I/W	18:42	
Lon	011° 38.180' E	Depth	939m	Time bottom	19:02	
Filename	jr219_090.dat	Cast Depth	934m	Time O/W	19:38	
Weather / Comments	Sea state 2. Overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	934	19:02									X
2	2	934	19:02									
3	3	934	19:02	X								
4	4	934	19:03	X								
5	5	934	19:03	X								
6	6	934	19:03	X								
7	7	889	19:08								X	
8	8	889	19:08								X	
9	9	700	19:12								X	
10	10	700	19:12								X	
11	11	500	19:18								X	
12	12	500	19:18								X	
13	13	500	19:19	X								
14	14	500	19:19	X								
15	15	500	19:19	X								
16	16	500	19:20	X								
17	17	300	19:25								X	
18	18	300	19:25								X	
19	19	150	19:30								X	
20	20	150	19:30								X	
21	21	57	19:34	X								
22	22	57	19:34	X								
23	23	2	19:37								X	
24	24	2	19:37								X	
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	West Svalbard Margin	CTD No	091	Date	19/07/10	CTD type: 24 bottles
Lat	79° 29.140' N	Event No	254	Time I/W	09:32	
Lon	006° 43.300' E	Depth	1259m	Time bottom	09:56	
Filename	jr219_091.dat	Cast Depth	1252m	Time O/W	10:33	
Weather / Comments	Sea state 4 or 5. Overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	1252	09:57			X						X
2	2	1252	09:58							X		
3	3	1000	10:07			X						
4	4	600	10:12			X						
5	5	300	10:18			X						
6	6	200	10:21					X				
7	7	100	10:24					X				
8	8	50	10:26			X		X				
9	9	25	10:28			X		X				
10	10	20	10:30				X					
11	11	5	10:32					X				
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

JR219 – LEG 4 - CTD log

Station	Prins Karls Forland	CTD No	095	Date	20/07/10	CTD type: 24 bottles
Lat	78° 58.215' N	Event No	262	Time I/W	06:45	
Lon	007° 01.901' E	Depth	1208m	Time bottom	07:10	
Filename	jr219_095.dat	Cast Depth	1203m	Time O/W	07:33	
Weather / Comments	Sea state 5 or 6. Overcast.					

Fire Seq	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Biomarkers	Nutrients	Salinity	Chlorophyll a	Silica, POC, lugols, cocc.	Grazing experiment	Core Incubation	^{210}Pb	DIC + calc iso
1	1	1203	07:10									
2	2	1203	07:10									X
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
Sampler / Analyst				Heiko	Jenny	Estelle	Jenny	Jenny	Ray	Henrik	Richard	Robert

APPENDIX 8: Underway salinity samples log

Date	Start Time (GMT)	Latitude	Longitude	Sample 1		Sample 2		End Time (GMT)	Comments
				Crate	Btl No	Crate	Btl No		
14/06/10	12:10:00	56°54.340'N	001°28.610'E	9	9-1	9	9-2	12:11:30	Faulty salinograph
14/06/10	16:06:20	57°38.110'N	001°42.430'E	9	9-3			16:06:40	Faulty salinograph
14/06/10	21:51:30	58°40.550'N	002°03.520'E	9	9-4			21:51:50	Faulty salinograph
15/06/10	04:41:00	59°50.750'N	002°25.470'E	9	9-5	9-6		04:42:40	Faulty salinograph
15/06/10	10:46:20	60°45.500'N	002°43.880'E	9	9-7			10:46:35	Faulty salinograph
15/06/10	13:20:40	61°15.790'N	002°54.721'E	9	9-8			13:20:50	Faulty salinograph
15/06/10	15:49:00	61°46.160'N	003°06.310'E	9	9-9			15:50:12	Faulty salinograph
15/06/10	19:00:20	62°25.470'N	003°21.448'E	9	9-10			19:00:30	Faulty salinograph
16/06/10	06:53:00	64°56.671'N	004°22.094'E	9	9-11	9	9-12	06:55:15	Faulty salinograph
16/06/10	10:05:30	65°10.440'N	004°27.080'E	9	9-13			10:05:40	Faulty salinograph
16/06/10	13:54:50	65°57.043'N	004°47.799'E	9	9-14			13:55:05	Faulty salinograph
16/06/10	18:24:55	66°52.754'N	005°12.790'E	9	9-15			18:25:15	New salinograph installed
17/06/10	04:56:30	69°02.460'N	006°14.290'E	9	9-16			04:57:30	
17/06/10	07:55:20	69°20.459'N	006°22.418'E	9	9-17			07:55:30	North Norwegian Sea station
17/06/10	15:12:10	69°51.591'N	006°39.362'E	9	9-18			15:12:25	
17/06/10	18:55:20	70°36.468'N	007°03.010'E	9	9-19	9	9-20	18:55:55	
17/06/10	22:14:00	71°14.366'N	007°22.487'E	9	9-21			22:14:50	
18/06/10	06:12:00	72°43.330'N	008°14.625'E	9	9-22			06:13:30	
18/06/10	09:13:20	72°54.680'N	008°21.980'E	9	9-23				
18/06/10	13:48:30	73°47.310'N	008°53.230'E	9	9-24			13:51:30	
18/06/10	15:03:40	74°01.334'N	009°03.262'E	3	3-31				
18/06/10	18:07:00	74°38.174'N	009°27.292'E	3	3-2	3	3-3	18:09:10	
18/06/10	23:14:30	75°39.743'N	010°09.482'E	3	3-4			23:15:10	
19/06/10	04:22:25	76°43.150'N	010°57.335'E	3	3-5				
19/06/10	10:15:13	77°31.179'N	011°35.528'E	3	3-6			10:16:10	
19/06/10	13:28:00	78°04.177'N	012°51.398'E	3	3-7			13:29:05	
20/06/10	12:44:00	78°12.360'N	014°30.250'E	3	3-8			12:44:20	
20/06/10	21:13:00	78°53.580'N	009°04.250'E	3	3-9	3	3-10	21:14:00	+ oxygen isotopes samples
21/06/10	08:35:50	80°40.450'N	006°02.280'E	3	3-11			08:37:30	+ oxygen isotopes samples
22/06/10	19:39:00	80°48.488'N	004°50.815'E	3	3-12	3	3-13		+ oxygen isotopes samples
23/06/10	12:19:50	80°44.456'N	004°39.740'E	3	3-14			12:20:30	+ oxygen isotopes samples
23/06/10	15:56:30	80°44.750'N	004°33.700'E	3	3-15			15:57:50	+ oxygen isotopes samples
23/06/10	19:39:50	80°44.213'N	004°30.320'E	3	3-16			19:40:40	+ oxygen isotopes samples
24/06/10	06:42:30	80°42.680'N	004°20.800'E	3	3-17			06:43:50	+ oxygen isotopes samples
24/06/10	09:58:00	80°41.300'N	004°18.367'E	3	3-18	3	3-19	09:59:10	+ oxygen isotopes samples
24/06/10	15:05:30	80°40.064'N	004°13.789'E	3	3-20			15:06:40	+ oxygen isotopes samples
25/06/10	06:10:00	80°36.550'N	004°19.480'E	3	3-21			06:11:30	+ oxygen isotopes samples
25/06/10	09:23:40	80°34.718'N	004°17.433'E	3	3-22			09:24:50	+ oxygen isotopes samples
25/06/10	14:53:00	80°33.505'N	004°09.509'E	3	3-23				+ oxygen isotopes samples
26/06/10	10:52:00	80°30.462'N	004°04.941'E	3	3-24			10:54:30	+ oxygen isotopes samples
26/06/10	20:00:10	80°29.220'N	003°47.596'E	5	5-1	5	5-2	20:01:45	+ oxygen isotopes samples
27/06/10	06:21:20	80°27.910'N	003°44.620'E	5	5-3			06:23:20	+ oxygen isotopes samples
27/06/10	12:20:55	80°25.055'N	003°34.353'E	5	5-5			12:22:20	+ oxygen isotopes samples
28/06/10	06:09:30	80°20.175'N	003°24.295'E	5	5-6			06:11:05	+ oxygen isotopes samples
28/06/10	09:38:30	80°18.740'N	003°18.230'E	5	5-7			09:40:05	+ oxygen isotopes samples
28/06/10	15:41:50	80°17.030'N	003°09.470'E	5	5-8			15:43:20	+ oxygen isotopes samples

Date	Start Time (GMT)	Latitude	Longitude	Sample 1		Sample 2		End Time (GMT)	Comments
				Crate	Btl No	Crate	Btl No		
29/06/10	04:25:00	80°16.410'N	003°06.590'E	5	5-9	5	5-4	04:27:11	+ oxygen isotopes samples
29/06/10	14:28:40	80°15.680'N	002°49.800'E	5	5-10			14:30:45	+ oxygen isotopes samples
29/06/10	20:58:00	80°14.290'N	002°41.890'E	5	5-11			20:59:10	+ oxygen isotopes samples
30/06/10	06:28:55	80°14.090'N	002°33.860'E	5	5-12			06:30:30	+ oxygen isotopes samples
30/06/10	12:01:50	80°13.207'N	002°22.555'E	5	5-13			12:02:40	+ oxygen isotopes samples
30/06/10	17:55:10	80°12.460'N	002°15.408'E	5	5-14			17:56:30	+ oxygen isotopes samples
01/07/10	17:33:20	79°54.342'N	002°23.895'E	5	5-15			17:34:55	+ oxygen isotopes samples
02/07/10	06:21:10	78°16.388'N	010°20.030'E	5	5-16	5	5-17	16:23:45	+ oxygen isotopes samples
02/07/10	11:18:35	78°07.917'N	013°26.332'E	5	5-18			11:20:20	+ oxygen isotopes samples
04/07/10	06:23:30	79°01.034'N	010°42.222'E	5	5-19			06:24:05	
04/07/10	09:45:45	79°00.996'N	010°42.040'E	5	5-20			09:46:50	
04/07/10	12:53:30	79°00.860'N	010°41.610'E	5	5-21			12:54:50	
05/07/10	06:40:00	79°00.910'N	010°41.280'E	5	5-22			06:41:00	
05/07/10	14:58:00	79°01.055'N	010°40.910'E	5	5-23			04:59:05	
05/07/10	16:47:45	78°59.926'N	010°37.337'E	5	5-24			16:49:00	
06/07/10	07:54:30	78°58.520'N	006°42.380'E	2	2-1	2	2-2	07:56:20	KF4 station
07/07/10	11:53:50	78°51.195'N	005°05.752'E	2	2-3	2	2-4	11:54:30	steaming West
07/07/10	17:56:00	78°10.918'N	000°21.994'W	2	2-5			17:56:40	steaming West
08/07/10	07:26:30	77°46.760'N	005°35.700'W	2	2-6	2	2-7	07:27:30	Greenland Shelf station
09/07/10	14:29:00	77°38.700'N	006°17.900'W	2	2-8			14:29:45	Greenland Shelf station
10/07/10	06:26:10	78°07.980'N	001°10.260'W	2	2-9	2	2-10	06:27:10	steaming East
10/07/10	18:29:20	78°15.250'N	000°25.570'E	2	2-11			18:30:30	Lots of spikes on salinograph due to ice blocks in the water
11/07/10	06:41:25	78°57.248'N	005°56.170'E	2	2-12			06:42:50	just left KF5, steaming to Ny Alesund
11/07/10	11:54:50	79°00.250'N	011°24.000'E	2	2-13			11:55:30	entering Kongsfjorden
11/07/10	19:45:15	78°57.619'N	011°53.078'E	2	2-14			19:46:40	KF1 station
12/07/10	07:42:00	79°00.140'N	008°29.720'E	2	2-15			07:42:50	heading West
13/07/10	18:16:45	78°11.710'N	014°19.500'E	2	2-16			18:18:20	leaving Isfjorden
14/07/10	09:18:30	79°00.895'N	010°43.727'E	2	2-17	2	2-18	09:20:50	KF3 station
14/07/10	15:14:50	79°07.940'N	010°33.650'E	2	2-19			15:16:00	
15/07/10	11:09:30	79°44.660'N	011°04.650'E	2	2-21			11:12:45	
16/07/10	10:55:30	79°43.400'N	013°55.370'E	2	2-22			10:56:35	Woodfjorden station
16/07/10	15:27:00	79°55.580'N	014°07.740'E	2	2-23			15:28:30	
17/07/10	06:49:05	79°59.923'N	011°31.827'E	2	2-24			06:50:00	
17/07/10	17:32:45	80°08.268'N	016°35.050'E	A	A-1			17:33:50	
19/07/10	06:49:30	79°28.940'N	006°43.775'E	A	A-2			06:51:15	