ArcticNet
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2013 | Expedition Report

CCGS *Amundsen*

LEG 1A
ArcticNet
Coasts of Northern Labrador and Baffin Island

LEG 1B
ArcticNet
Baffin Bay and Canadian Arctic Archipelago

LEG 2A
ArcticNet
Canadian Arctic Archipelago

CCGS *Pierre Radisson*

BaySys/ArcticNet
Hudson Bay

CCGS *Sir Wilfrid Laurier*

BREA
Beaufort Sea

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2013 Expedition Report

The 2013 Expedition Report is a collection of all cruise reports produced by the participating research teams and assembled by the Chief Scientists at the end of their leg. This report also includes information about cruises carried out in support of ArcticNet's mooring program and the maintenance of long-term ocean observatories in Hudson Bay (BaySys project) aboard the CGGS *Pierre Radisson* and in the Beaufort Sea (BREA program) onboard the CCGS *Sir Wilfrid Laurier*. The 2013 Expedition Report is divided into two parts:

Part I provides an overview of the expedition, the ship track and the stations visited, a synopsis of operations conducted during the two legs as well as for the mooring program in Hudson Bay and Beaufort Sea.

Part II contains the reports submitted by participating science teams or researchers, with details on the specific objectives of their project, the field operations conducted and methodology used, and in some cases, preliminary results. When results are presented, they show the data as they were submitted at the end of the legs in 2013. The data presented in this report are illustrative only and have not been quality controlled, thus parties interested in the results should contact the project leader or the researchers who collected the data.

The 2013 Expedition Report also includes four appendices: 1) the list of stations sampled, 2) the scientific log of activities conducted, 3) a copy of the CTD logbook and 4) the list of participants onboard during each leg.

The core oceanographic data generated by the CTD-Rosette operations, as well as meteorological information (AAVOS, Environment Canada) and data collected using the Moving Vessel Profiler (MVP), the ship-mounted current meter (SM-ADCP) the thermosalinograph (TSG) are available in the Polar Data Catalogue (PDC) at www.polardata.ca.

Following ArcticNet's data policy, research teams must submit their metadata to the PDC and insure that their data are archived on the long-term, but it is not mandatory to use the PDC as a long-term archive as long as a link to the data is provided in the metadata (see www.arcticnet.ulaval.ca/Docs/data-policy for more details on data policy).

Part I – Overview and synopsis of operations

1 Overview of the 2013 ArcticNet Expedition

1.1 Introduction

Understanding the transformation of the Arctic environment is one of the great challenges faced by Canadians and the national and international scientific communities. ArcticNet is a Network of Centres of Excellence of Canada that brings together scientists and managers in the natural, human health and social sciences with their partners from Inuit organizations, northern communities, federal and provincial agencies and the private sector to study the impacts of climate change and modernization in the coastal Canadian Arctic.

Since 2004, ArcticNet researchers have been conducting extensive multidisciplinary sampling programs in the Canadian Arctic using the Canadian research icebreaker CCGS *Amundsen*. The overarching goal of the ArcticNet marine-based research program is to study on a long-term basis how climate induced changes are impacting the marine ecosystem, contaminant transport, biogeochemical fluxes, and exchange processes across the ocean-sea ice-atmosphere interface in the Canadian Arctic Ocean. The knowledge generated from this multi-year program is being integrated into regional impact assessments to help decision makers and stakeholders develop effective adaptation strategies for the changing coastal Canadian Arctic.

The geographic scope of the ArcticNet marine-based research program (see Phase 3 projects at www.arcticnet.ulaval.ca/research/phase 3) includes the Beaufort Sea in the western Canadian Arctic, the Canadian Arctic Archipelago and Baffin Bay in the eastern Arctic, and extends into Hudson Bay, Ungava Bay and along the northern Labrador coast.

On 26 July 2013, the CCGS *Amundsen* left its homeport of Quebec City for a scientific expedition to the Canadian Arctic in support of ArcticNet's marine-based research program with operations in the Labrador Sea and fjords, in Baffin Bay and Nares Strait, and in the Canadian Arctic Archipelago (Figure 1.1).

Mooring operations were also conducted as part of the BaySys project in Hudson Bay aboard the CCGS *Pierre Radisson* and as part of the Beaufort Regional Environmental Assessment (BREA) project in the Beaufort Sea on the CCGS *Sir Wilfrid Laurier*. The overarching objective of ArcticNet's mooring project is to track changes in the physical, biological and geochemical properties of Canadian Arctic waters and collect fundamental information to better understand how climate warming is affecting the Arctic.

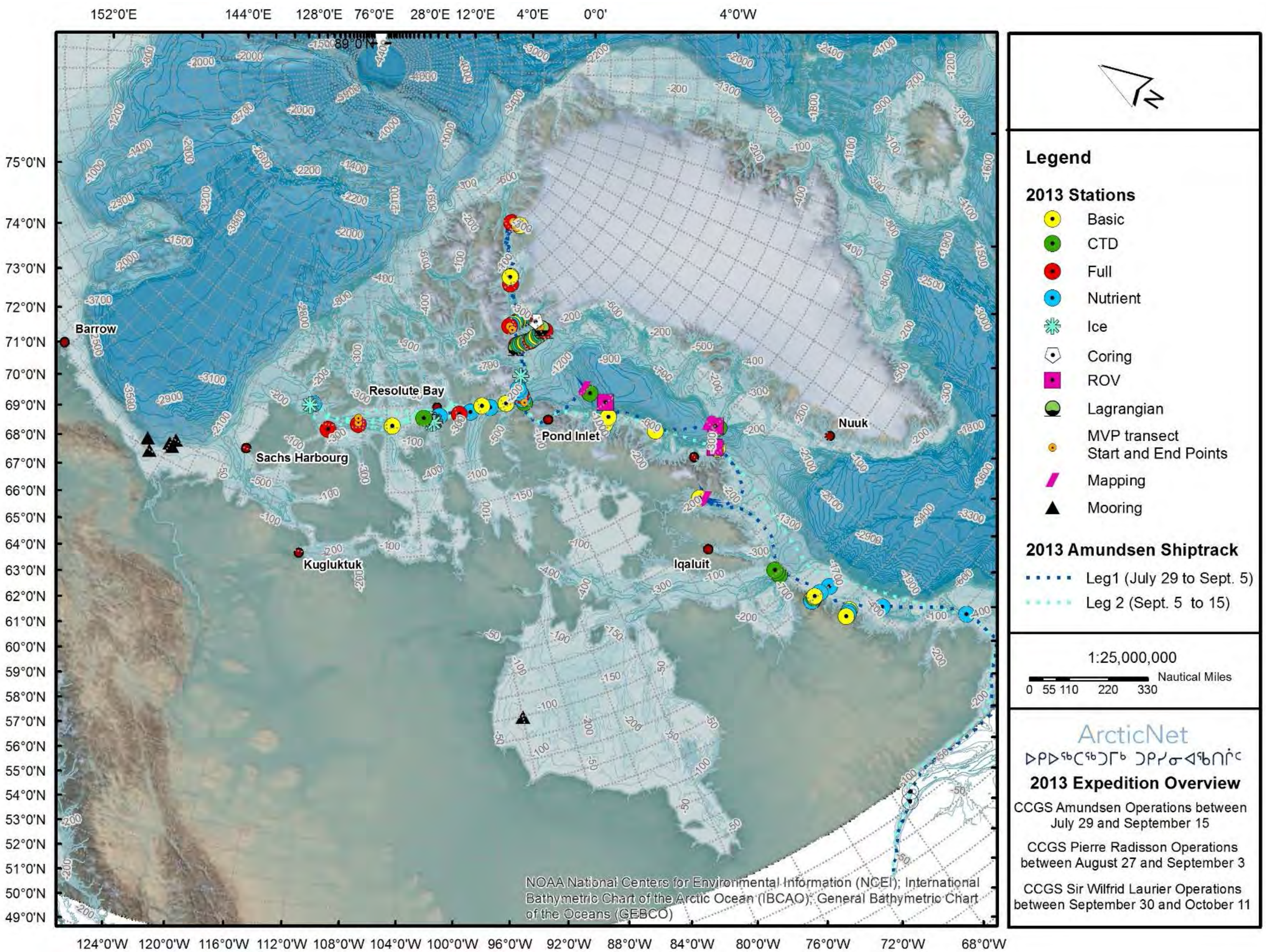

Figure 1.1. Overview of the ship track and the locations of stations sampled in the Labrador Sea and fjords and along Baffin Island (Leg 1a), as well as in northern Baffin Bay (Leg 1b) and the Canadian Arctic Archipelago (Legs 1b and 2a) by the CCGS *Amundsen*. Also shown on this map are the locations of ArcticNet mooring sites where operations took place in Hudson Bay (BaySys) aboard the CCGS *Pierre Radisson*, and in the Beaufort Sea (BREA) on the CCGS *Sir Wilfrid Laurier*.

1.2 Regional settings

1.2.1 Labrador Sea and fjords

Since 2006, the *Amundsen* has supported research efforts to address the prevailing concerns of Nunatsiavut Inuit along the northern Labrador coast. The ArcticNet Nunatsiavut-Nuluak project focused on four northern Labrador fjords, Nachvak fjord, Saglek fjord and Anaktalak fjord and Okak Bay, to study the effects of climate change, industrialization (particularly expanding mining/exploration activities) and contaminants on the coastal environment. In 2013, two of the fjords (Okak Bay and Nachvak fjord) as well as stations in the coastal Labrador Sea were visited and sampled (Figure 1.2).

1.2.2 Baffin Bay and Nares Strait

Baffin Bay is located between Baffin Island and Greenland and connects the Arctic Ocean and the Northwest Atlantic and is an important pathway for exchange of heat, salt and other properties between these two oceans. Baffin Bay's connection to the Arctic Ocean consists of three relatively narrow passages through the Canadian Arctic Archipelago (CAA). One of these passages, Nares Strait, is located between Ellesmere Island and Greenland and includes from south to north: Smith Sound, Kane Basin, Kennedy Channel, Hall Basin and Robeson Channel. Each winter, there is a prolonged period during which a land-fast ice arch spans the strait at the entrance to Robeson Channel and south of Kennedy Channel the southward flux of ice. However, in the past decade, variability in the formation of the ice arch has been observed with weaker conditions resulting in an increase in ice flux from the Arctic Ocean into Baffin Bay.

The formation of an ice arch in Nares Strait, the input of warm and salty Atlantic water from the West Greenland Current moving northward along the coast of Greenland, and upwellings of warmer waters, all contribute to the creation of a large polynya, a year-round expanse of open waters, in Smith Sound and northern Baffin Bay. The North Water (NOW) Polynya is the largest (~80,000km^2) and most productive polynya in the Canadian Arctic and in addition to the tremendous marine bird resources in this area, it is of significance to many species of marine mammals. The NOW polynya has been the subject of intense ecosystem studies, including the Canadian-led study of the NOW Polynya in 1998.

Petermann Glacier is part of the Greenland ice sheet and is located east of Nares Strait near 81°N latitude. Two major ice calving events from this glacier have taken place in recent years: In August 2010, a giant ice island measuring 260 km^2 broke off from the floating portion of Petermann Glacier, reducing its area and volume by 25% and 10%, respectively, and in July 2012, a 130-km^2 ice island (about twice the area of Manhattan), calved from the northern tip of the glacier. These large ice islands have entered Nares Strait and flowed south into Baffin Bay.

In 2013, scientists used the *Amundsen* to extend their time series of oceanographic measurements in the NOW Polynya and revisited designated stations along the east-west transects across Baffin Bay. The *Amundsen* sailed north into Nares Strait to conduct oceanographic and ice sampling operations in Kane Basin and at Petermann Fjord and Glacier. This expedition presented a unique opportunity to study the ice and ocean in these rapidly changing Arctic systems.

1.2.3 Canadian Arctic Archipelago

The Canadian Arctic Archipelago (CAA) is a vast array of islands and channels that lies between Baffin and Ellesmere Islands in the east and Banks Island in the west (Figures 1.3 and 1.4). While transiting through the Northwest Passage, the science teams aboard the *Amundsen* extended their time series of atmosphere, ice and ocean data. This work is aimed at better understanding how the climate, ice conditions as well as ocean currents and biogeochemistry are changing under the effects of climate change. With ice extent and volume shrinking in the Arctic, the Northwest Passage may be ice free and open to navigation during summer in the near future. Seafloor bathymetry data and sub-bottom information were also collected while transiting through the Northwest Passage to map the seafloor and identify potential geohazards and obstacles to the safe navigation of this new seaway.

1.2.4 Hudson Bay

The CCGS *Pierre Radisson* was used in Hudson Bay for the BaySys project, a partnership between ArcticNet, the University of Manitoba and Hydro Manitoba. The aim of the 2013 BaySys cruise was to recover, service and redeploy one mooring deployed in western Hudson Bay in 2012 and conduct limited sampling at the mooring site. Hudson Bay is a virtually landlocked, immense inland sea that possesses unique characteristics among the world's oceans: a limited connection with the Arctic and Atlantic Oceans, a low salinity, a high volume of freshwater inputs from numerous rivers that drain central North America,

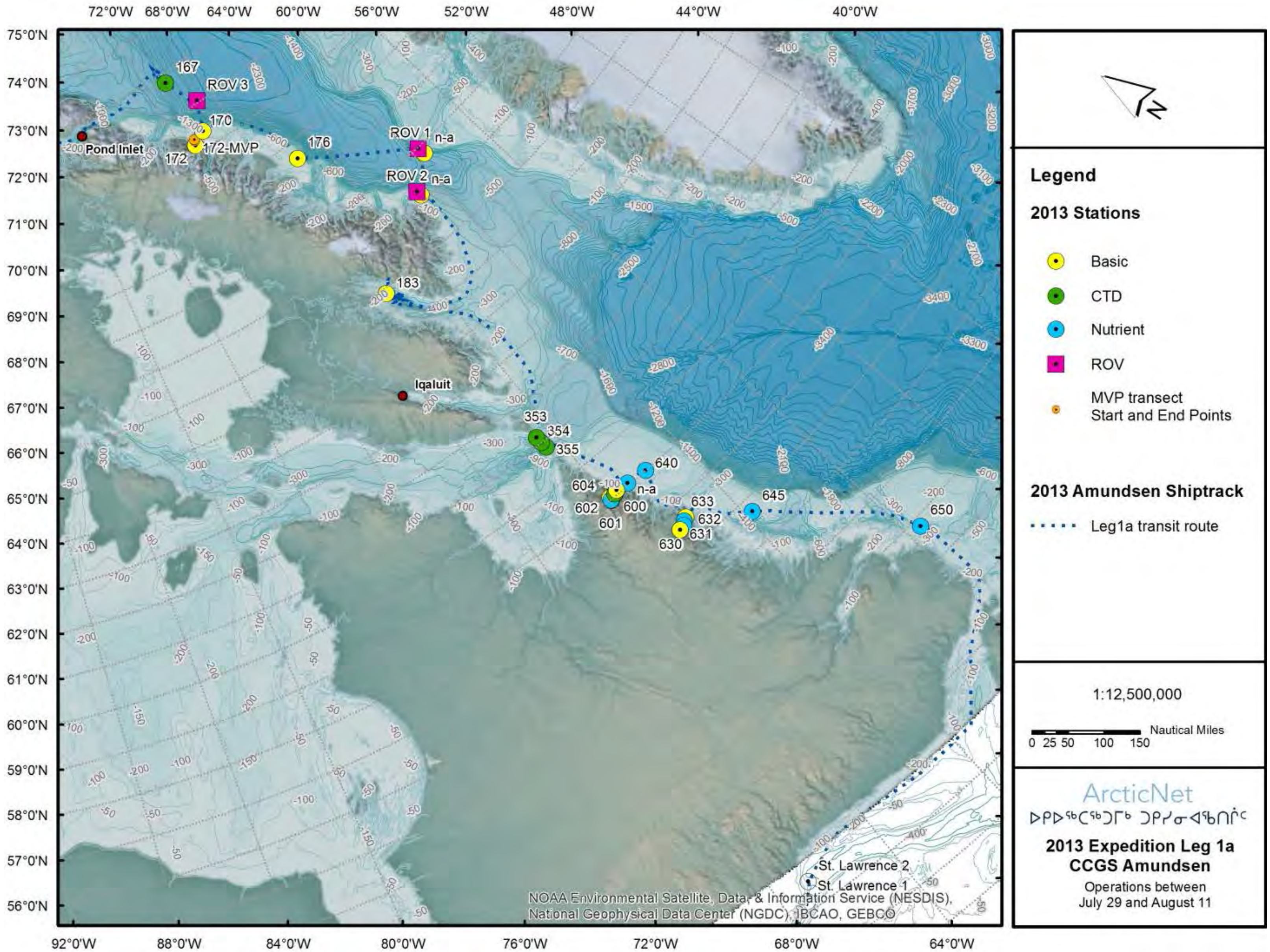

Figure 1.2. map showing the ship track and the locations of stations sampled in northern Labrador Sea and fjords, in Hudson Strait and along the coast of Baffin Island by the CCGS *Amundsen* during Leg 1a of the 2013 ArcticNet Expedition.

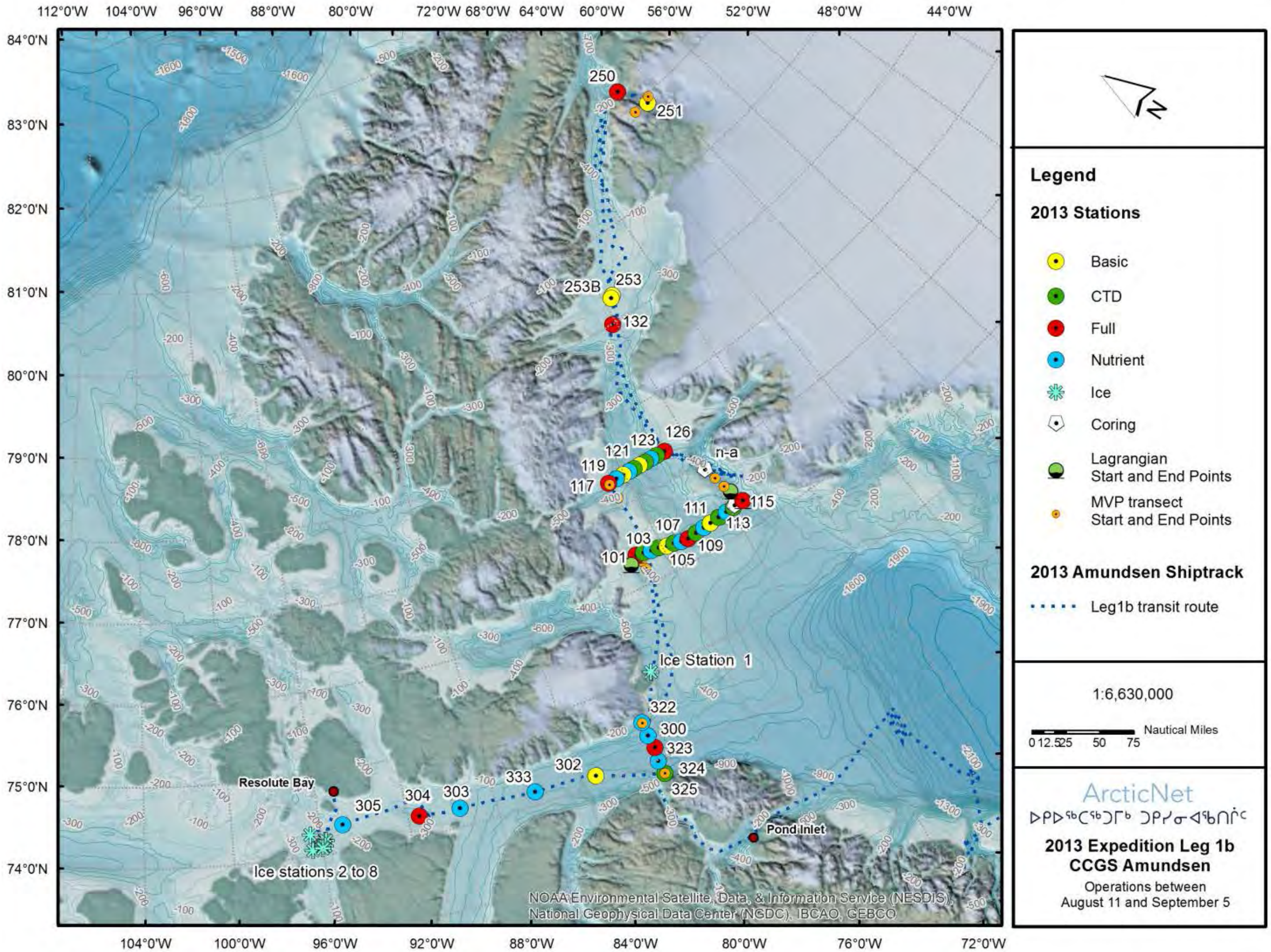

Figure 1.3. Map showing the ship track and the locations of stations sampled in northern Baffin Bay and the Canadian Arctic Archipelago (Lancaster Sound) by the CCGS *Amundsen* during Leg 1b of the 2013 ArcticNet Expedition.

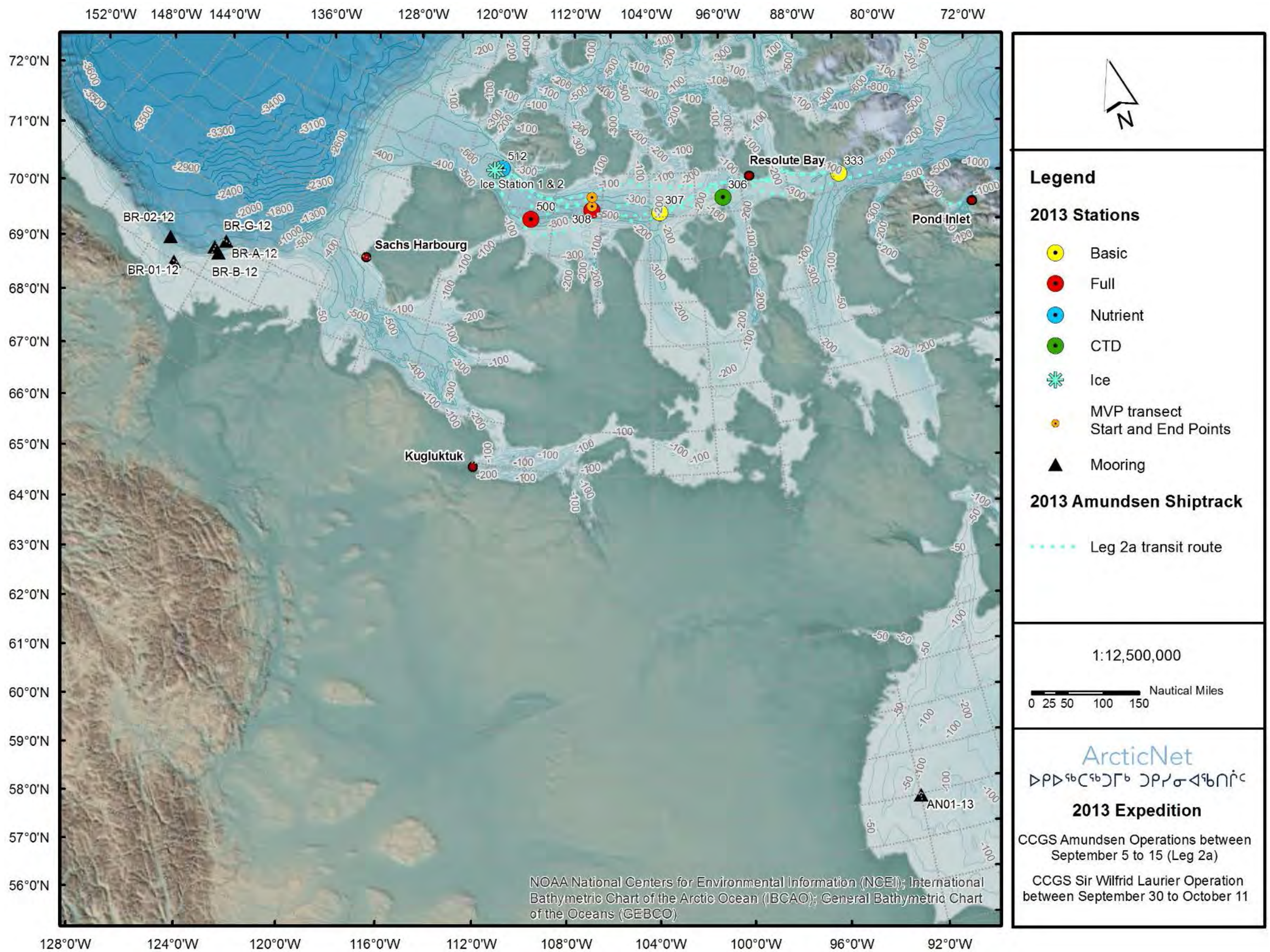

Figure 1.4. Map showing the ship track and the locations of stations sampled in the Canadian Arctic Archipelago (Northwest Passage) by the CCGS *Amundsen* during Leg 2a. Also shown on this map are the Beaufort Sea mooring sites (recoveries only) and Hudson Bay mooring site (recovery and redeployment).

and a winter season in which it is completely ice covered while summer is characterized by ice-free conditions.

1.2.5 Beaufort Sea

The Canadian Beaufort Sea/Mackenzie Shelf region of the Arctic Ocean has witnessed major changes in recent years, with decreasing sea ice cover and major shifts in sea-ice dynamics. The Beaufort Sea is characterized by a broad shelf onto which the Mackenzie River, the largest river in North America, carries large amounts of freshwater. The mixing of freshwater from the Mackenzie River and Arctic marine waters of the Beaufort Sea establishes an estuarine system over the shelf, with associated inputs of land-derived nutrients and freshwater biota. Along the Mackenzie Shelf stretches the Cape Bathurst polynya, an expanse of open water that exists year-round and is highly productive. This ecosystem is also exceptional since it provides habitat for some of the highest densities of birds and marine mammals in the Arctic.

Since 2002, extensive multidisciplinary research programs have been conducted in the Beaufort Sea area. Major oceanographic research activities were carried out as part of two major international overwintering research programs conducted onboard the CCGS *Amundsen* in 2003-2004 (CASES program) and in 2007-2008 (CFL Study). Environmental and oceanographic research activities were also conducted in the offshore region of the Mackenzie Shelf, shelf slope and Beaufort Sea since 2009, in partnership with the Oil & Gas industry and within the framework of the Beaufort Regional Environmental Assessment (BREA, www.beaufortrea.ca) initiative. Overall since 2004, a marine observatory of a minimum of five oceanographic moorings (from 5 to 17 moorings) has been deployed and maintained annually in the area by ArcticNet researchers. In 2013, five BREA oceanographic moorings deployed in 2012 were recovered by the CCGS *Sir Wilfrid Laurier*.

1.3 2013 *Amundsen* Expedition Plan

1.3.1 General schedule

The CCGS *Amundsen* Expedition left Quebec City on 26 July 2013 and returned on 6 October 2013, traveling a total of 11 692 nautical miles in 63 days. The 2013 Expedition was divided into two legs, with Leg 1 further sub-divided into two parts.

Additionally, mooring operations were carried out in Hudson Bay from 27 August to 3 September 2013 onboard the CCGS *Pierre Radisson* as well as in the Beaufort Sea from 30 September to 11 October 2013, aboard the CCGS *Sir Wilfrid Laurier*.

1.3.2 Leg 1a – ArcticNet – 26 July to 12 August 2013 –Northern Labrador Sea and Baffin Bay

Leaving Quebec City on 26 July, the *Amundsen* sailed north and conducted oceanographic sampling operations along the coast of northern Labrador and in Nachvak and Okak fjords. A dedicated multibeam survey was carried out in Cumberland Sound (Baffin Island) in support of ArcticNet's and the Government of Nunavut's fisheries habitat mapping objectives. Continuing north towards Pond Inlet, the *Amundsen* conducted three ROV dives for deep-sea coral and methane seep exploration and carried out basic sampling operations, multibeam surveys and ice island operations along the coast of Baffin Island. The ship was in Pond Inlet on 12 August for a science rotation and the end of Leg 1a.

1.3.3 Leg 1b – ArcticNet – 12 August to 5 September 2013 – Northern Baffin Bay and Canadian Arctic Archipelago

Leg 1b started from Pond Inlet on 12 August and the *Amundsen* resumed its transit north into Baffin Bay. The next three weeks were dedicated to oceanographic sampling operations at designated stations in northern Baffin Bay and Lancaster Sound. Sampling operations were conducted as far north as Kane Basin (79°N) and included MVP operations as well as Lagrangian drift sampling of water masses on the NOW transect. The ship was in Resolute on 5 September for a full crew change and the end of Leg 1.

1.3.4 Leg 2a – ArcticNet – 5 September to 15 September 2013 – Canadian Arctic Archipelago

Leg 2a started from Resolute on 5 September and the vessel headed toward the Beaufort Sea via the northern route through Viscount Melville Sound and M'Clure Strait to conduct oceanographic and sea-ice sampling operations, as well as multibeam surveys in this seldom travelled region.

1.4 2013 *CCGS Pierre Radison* Expedition Plan

1.4.1 BaySys – 27 August to 3 September 2013 – Hudson Bay

The CCGS *Pierre Radisson* conducted mooring operations in western Hudson Bay near Churchill, MB, to recover one mooring deployed in 2012 (AN01) and to re-deploy instruments on this mooring for two years.

1.5 2013 *CCGS Sir Wilfrid Laurier* Expedition Plan

1.5.1 BREA – 30 September – 11 October 2013 – Beaufort Sea

The CCGS *Sir Wilfrid Laurier* spent approximately two weeks in the Beaufort Sea/Amundsen Gulf region to recover five moorings deployed in 2012 as part of ArcticNet's Long-Term Ocean Observatories program and the Beaufort Regional Environmental Assessment (BREA).

2 Leg 1a – 26 July to 12 August 2013 – Northern Labrador Sea and Baffin Bay

Chief Scientist: Louis Fortier[1] (louis.fortier@bio.ulaval.ca)
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2.1 Introduction and objectives

Leg 1a of the 2013 *Amundsen* Expedition was centered on the ArcticNet marine science program aiming to study the impacts of climate change in the coastal Canadian Arctic, more specifically in the coastal and fjord environments of northern Labrador, in Hudson Strait and along Baffin Island in Baffin Bay (Figure 2.1).

Leg 1a was also the occasion to conduct ROV dives to look for and collect deep-sea corals in Baffin Bay at a site where a DFO experimental trawl revealed the presence of deep cold-water corals in 1999. In preparation for the ROV dive to this exceptional habitat, an extensive seafloor mapping survey of the area was conducted.

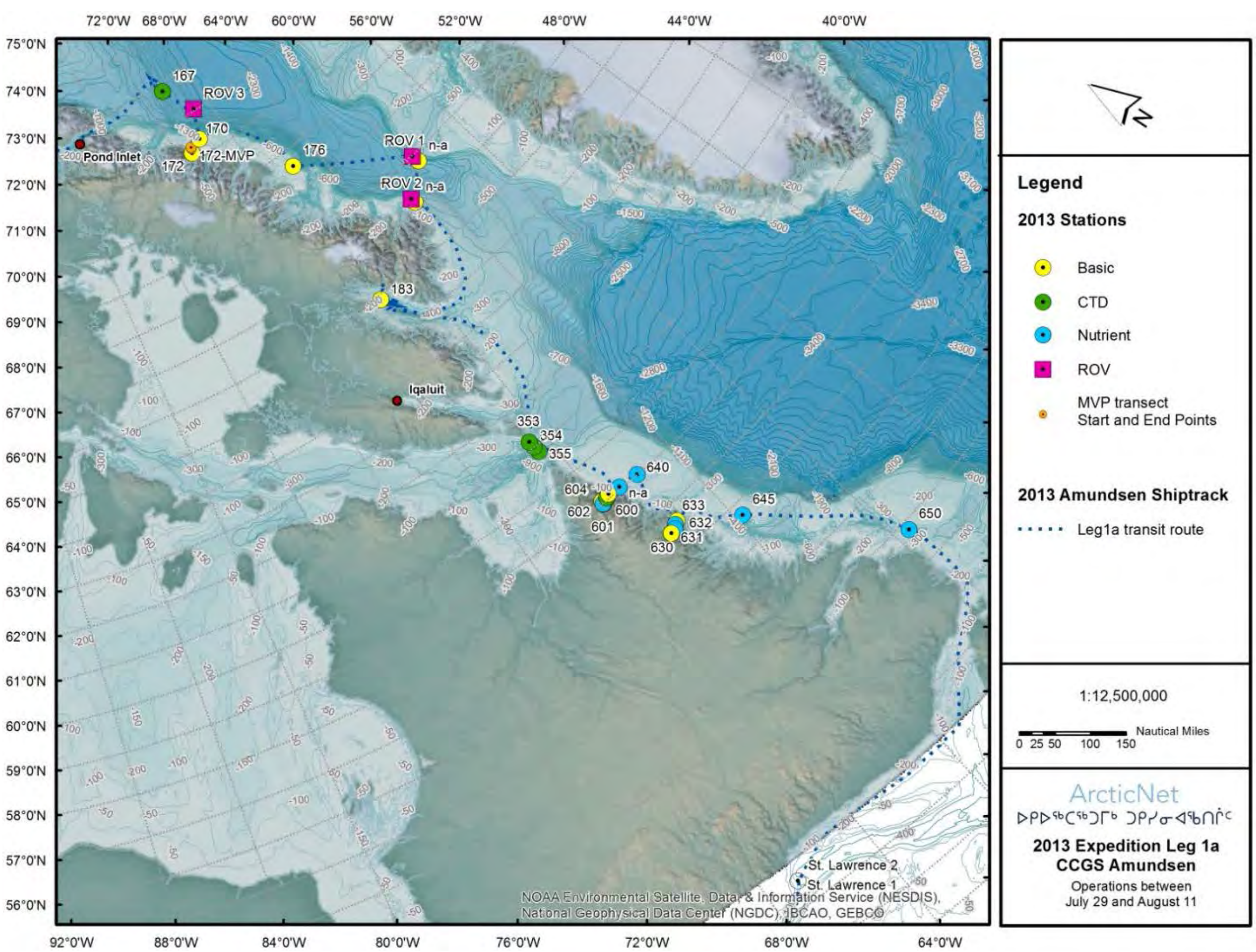

Figure 2.1. Ship track and the locations of stations sampled along northern Labrador coast, in Hudson Strait and along Baffin Island during Leg 1a.

Following observations reporting the presence of a subsurface methane (CH_4) enriched layer in southwest Baffin Bay (near Station 180), an exploration of the seabed using the ROV was performed to look for CH_4 seepages in the water column.

In collaboration with the Government of Nunavut's Fisheries Habitat Survey, a 24-hour seafloor mapping and bathymetric survey was carried out in Cumberland Sound on Baffin Island. Another dedicated bathymetric and sub-bottom profiling survey was conducted to investigate the area near the known epicenter of the M 7.3 earthquake in 1933, the largest instrumentally recorded passive margin earthquake in North America, and possibly in the world.

The specific objectives and priorities of Leg 1a were to:

- Sample the atmosphere and quantify gas fluxes at the sea ice-seawater-atmosphere interface along the cruise track.
- Sample the water column for physico-chemical properties of the water and components of the marine food web at stations located on the continental shelf along the Labrador coast (#650, 645, 640 and off Nachvak fjord), in Okak Bay (#630-633) and Nachvak fjord (#600-604), along a transect across Hudson Strait (#353-355), in Cumberland Sound (#183) and along Baffin Island in southern Baffin Bay (#180, 176, 172, 170 and 167).
- Sample the sediments at 7 stations located in northern Labrador and Baffin Bay.
- Conduct ROV dives in Baffin Bay for deep-sea coral and methane seep exploration.
- Conduct multibeam mapping surveys at the ROV dive sites.
- Obtain bathymetry and sub-bottom information using the multibeam sonar system along the cruise track.
- Conduct a 24-h dedicated seafloor mapping survey in Cumberland Sound in support of the Government of Nunavut Fisheries Habitat and ArcticNet's collaborative project.
- Conduct a 12-h multibeam survey in northern Baffin Bay in an area of high seismic activity.
- Carry out an opportunistic active acoustic survey in Cumberland Sound.
- Survey and sample ice islands (if present) and conduct a multibeam survey of PII-B ice island grounding site (near Station 176).

2.2 Synopsis of operations

This section provides a general synopsis and timeline of operations during Leg 1a. Detailed cruise reports provided by onboard participants and including specific objectives, methodology and preliminary results for projects conducted during this leg are available in Part II of this report.

During Leg 1a, the *Amundsen* left Quebec City on 26 July and reached Pond Inlet on 12 August. A total of 38 sites and stations were visited, with an overall tally of operations and activities as follows:

- 1 CTD cast
- 36 CTD-Rosette casts
- 1 MVP transect

- 4 ROV dives
- 18 optical and phytoplankton profiles, including Secchi disk and PNF.
- 30 plankton net tows, including horizontal and vertical net tows, Hydrobios and Bioness
- 6 Agassiz trawls to sample the benthic fauna
- 10 box core and 2 gravity core sampling of the sediments
- Three dedicated seafloor mapping survey

A detailed scientific log for all sampling operations conducted during Leg 1a with the positions and depths of the visited stations is provided in Appendix 2.

2.2.1 Timeline of operation

Leaving Quebec City on 26 July, the *Amundsen* made short stops at two stations in the Gulf of St. Lawrence to test oceanographic instruments and gear, before sailing north to the Labrador Sea. On 29 and 30 July, oceanographic sampling operations were conducted at Nutrient Stations 650 and 645 along the coast of Labrador and the ship reached Okak Bay where Basic/Nutrient Stations 630-633 were sampled until 31 July under good weather conditions and relatively calm seas. Nachvak fjord was visited on 31 July and 1 August (Stations 600-604), starting with two Nutrient stations located offshore on the shelf and at the mouth of the fjord.

Following sampling operations in the Labrador Sea and fjords, the ship headed for Hudson Strait where a series of CTD casts were conducted along a transect across the Strait. The *Amundsen* then set a course north for Cumberland Sound. On 3 and 4 August, a 20-h multibeam mapping survey was carried out in support of ArcticNet's and the Government of Nunavut's fisheries habitat project, in addition to various sampling operations at Station 183 (Basic) that were conducted in bergy waters and with the wind picking up.

Continuing north along the coast of Baffin Island, the *Amundsen* conducted a first ROV dive (ROV 2) near Basic Station 180 on 6 August to look for methane seeps on the seafloor and collect the emitted gases using a gas sampling bag carried by the ROV. The full suite of oceanographic and sediment sampling operations usually done at Basic stations was then performed and Station 180 was completed in the morning of 7 August. The *Amundsen* then headed for the ROV 1 site for deep-sea coral exploration. The seafloor near and around the potential coral habitat was first mapped using the multibeam system during the evening of 7 August, then the ROV was launched for the dive, which allowed to confirm the presence of this deep cold-water coral ecosystem, to conduct video transects to characterize and determine the extent of the population, and to collect specimens.

Basic sampling operations (CTD-Rosette, nets and trawls, and box cores) were conducted on the route north along the coast of Baffin Island, at Station 176 on 9 August and at Stations 170 and 172 on 10 August. Additionally, the MVP was deployed at Station 172 and the ROV made a very successful dive (ROV 3) around a mobile ice island near Station 170.

On 11 August, at Station 167, a 12-h survey permitted to acquire multibeam data and sub-bottom profiles of an area of high seismic activity near the known epicenter of the M 7.3 earthquake in 1933, the largest instrumentally recorded passive margin earthquake in North America, and possibly in the world. Leg 1a ended in Pond Inlet on 12 August with a science crew change.

2.3 Chief Scientist's comments

The cruise was carried out according to the Expedition plan with all stations visited and operations successfully conducted between 29 July and 11 August 2013. Lower priority multibeam activities in Hatton Basin were abandoned and on-ice activities on ice islands were cancelled because the fog precluded helicopter flights. The ROV dives to locate methane seeps and deep-sea corals and sample them were successful in terms of scientific objectives, although recoveries of the ROV were problematic on the first 2 dives. Science participants expressed disappointment that the ROV dives were often cut short due to logistical and time constraints and suggested more time be allowed to these operations.

The Chief Scientist and all the science participants would like to thank the Commanding Officer, and the officers and crew of the CCGS *Amundsen* for their hard work and dedication during all the scientific operations, which were vital to the success of this cruise.

3 Leg 1b – 12 August to 5 September 2013 – Northern Baffin Bay and Canadian Arctic Archipelago

Chief Scientist: David Barber[1] (dbarber@cc.umanitoba.ca)
[1] *University of Manitoba, Centre for Earth Observation Science (CEOS), Wallace Building, 125 Dysart Rd, Winnipeg, MB, R3T 2N2, Canada.*

3.1 Introduction and objectives

Leg 1b started in Pond Inlet on 12 August and ended in Resolute on 5 September, and focused on ArcticNet's marine-based research program in northern Baffin Bay and Lancaster Sound (Figure 3.1). The *Amundsen* continued north further into Kane Basin, Nares Strait and Petermann Glacier fjord, where oceanographic and ice sampling operations took place.

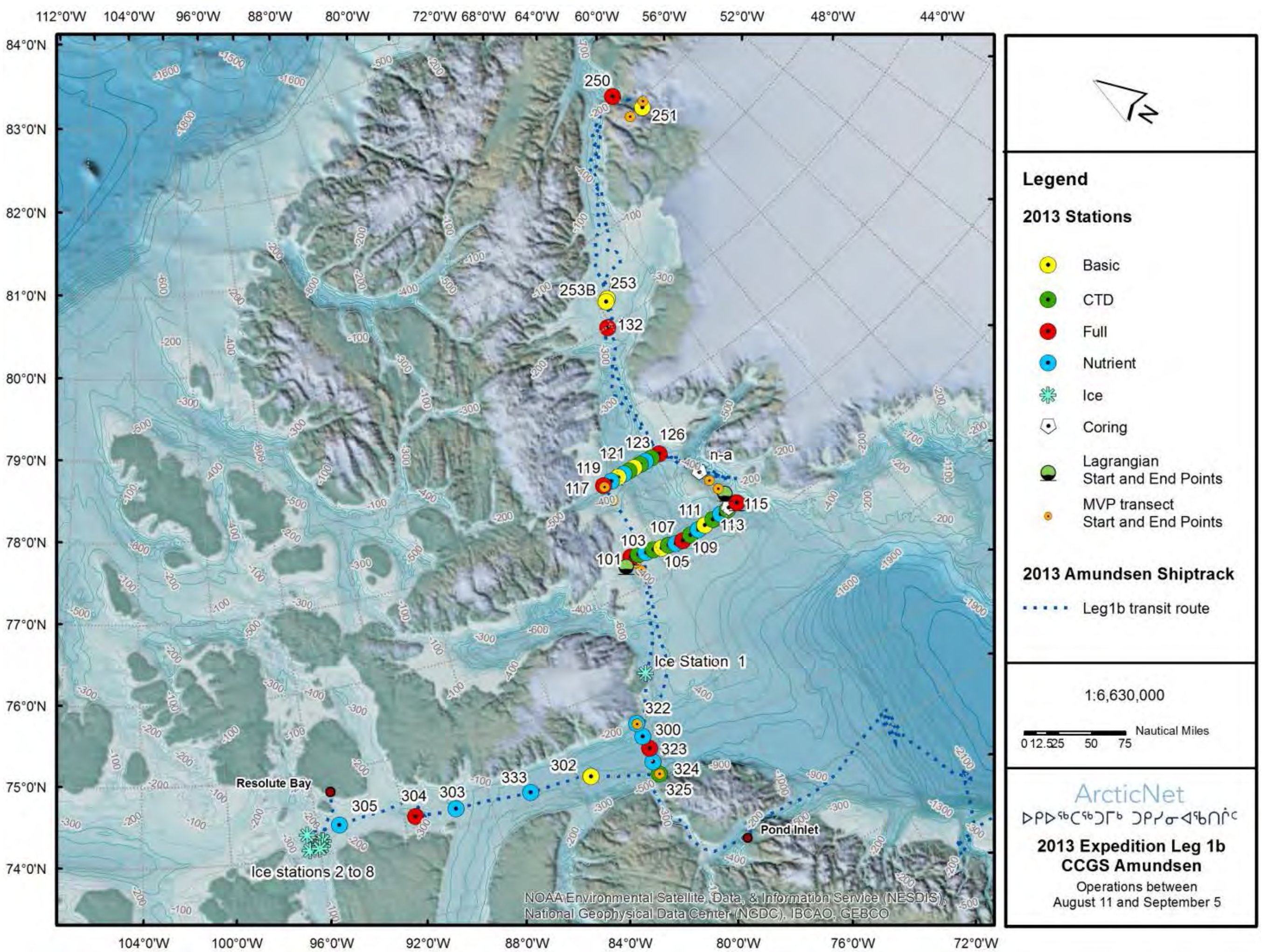

Figure 3.1. Ship track and the locations of stations sampled in northern Baffin Bay and the Canadian Arctic Archipelago (Lancaster Sound) by the CCGS *Amundsen* during Leg 1b of the 2013 ArcticNet Expedition.

Specific objectives and priorities of Leg 1b were to:

- Sample the atmosphere and quantify gas fluxes at the sea ice-seawater-atmosphere interface along the cruise track.
- Deploy Met/Ocean buoys (MOBs) at Full and Basic stations to measure meteorological and surface ocean parameters during 5 to 12-h periods.
- Sample the water column for physico-chemical properties of the water and components of the marine food web at a total of 40 stations.
- Sample the sediments at 14 stations located in northern Baffin Bay and Lancaster Sound.
- Conduct at least 3 MVP transects or operations: 1) across Lancaster Sound, 2) along the east coast of Ellesmere Island and, 3) along the west coast of Greenland.
- Sample Full Stations 101 and 115 using a Lagrangian drift study approach (24-h following a surface water mass).
- Conduct on-ice operations using the helicopter, ice cage or barge to access ice features of interest.
- Obtain bathymetry and sub-bottom information using the multibeam sonar system along the cruise track.

3.2 Synopsis of operations

This section provides a general synopsis and timeline of operations during Leg 1b. Detailed cruise reports provided by onboard participants and including specific objectives, methodology and preliminary results for projects conducted during this leg are available in Part II of this report.

During this leg, the *Amundsen* traveled from Pond Inlet (12 August) to Resolute (5 September) and 51 stations were visited, with an overall tally of operations and activities as follows:

- 5 CTD casts
- 76 CTD-Rosette casts
- 37 optical and phytoplankton profiles, including Secchi disk and PNF.
- 6 MVP profiles
- 75 plankton net tows, including horizontal and vertical net tows, Hydrobios and RMT
- 15 Agassiz trawls to collect benthic fauna
- 22 box cores and 5 gravity cores to sample the sediments
- 2 Lagrangian drift experiments (24-hours sampling of one water mass)
- 8 Met/Ocean Buoy (MOBs) deployments
- 14 on-ice operation using the helicopter, the ice cage or the barge.

A detailed scientific log for all sampling operations conducted during Leg 1b with the positions and depths of the visited stations is available in Appendix 2.

3.2.1 Timeline of operations

Leg 1b started from Pond Inlet on 12 August with the *Amundsen* transiting north through Navy Board Inlet to reach stations in Lancaster Sound on 13 August. The ship spent the next day sampling the 5 stations located across Lancaster Sound: 325 (CTD), 324 (Nutrient), 323 (Full), 300 and 322 (both Nutrient). A MVP transect across Lancaster Sound was also conducted on 29 August on the return trip toward Resolute. Continuing north, the *Amundsen* carried out an ice station on the eastern coast of Devon Island on 14 August. On 15 August, Full Station 101 was reached, and operations started with a 1-hour MVP transect and the deployment of the Lagrangian drifter buoy during the night. Over the next 24 hours, Stations 101 was extensively sampled for water column properties and components of the pelagic and benthic food webs, including seven CTD-Rosette casts near the Lagrangian buoy to sample the targeted water mass.

The vessel then proceeded across Baffin Bay and the North Water (NOW) Polynya toward Greenland, sampling 13 stations (102 to 114) over two days. At Station 114, box coring and gravity coring operations were carried out during the night before heading to the last station of the transect on the Greenland side. Full Station 115 was reached the morning of 18 August and operations started with the deployment of the Lagrangian drift buoy to mark the surface water mass. The full suite of operations was successfully performed during the next 24 hours, including 7 CTD-Rosette casts at the Lagrangian drift buoy location. Station 115 ended with a south-to-north MVP transect along the coast of Greenland.

With ice and weather conditions favourable, the ship then sailed north toward Peterman Fjord and Glacier on the northern Greenland coast, quickly sampling Station 132 (Full) on the way during the night and morning of 20 August. The mouth of Peterman Fjord (Station 250) was reached in the evening of 21 August and operations at the site included oceanographic sampling, on-ice sampling using the cage as well as box & gravity coring to collect sediments. A MVP transect was carried out across the fjord then Basic Station 251 located near the Glacier was sampled and the ship left Peterman Fjord to head south around mid-day on 22 August.

Basic Stations 253 and 253B in Kane Basin, as well as a coring station located between 115 and 126 along the coast of Greenland, were visited on 25 and 26 August, respectively. The second transect across Baffin Bay (126 to 117) was carried out on 27-28 August, ending with a north-to-south MVP transect along Ellesmere Island mirroring the one done on the Greenland side earlier.

Once operations in northern Baffin Bay were completed, the vessel returned west and conducted sampling operations at designated stations in Lancaster Sound (301 to 305), starting with a MVP transect across the entrance to Lancaster Sound, between Stations 322 and 325. After Nutrient Station 305 was completed in the evening of 31 August, the rest of Leg 1b was dedicated to ice floe samplings and operations in Barrow Strait and Peel Sound (Ice Stations 2 to 8).

In the evening of 3 September, operations for Leg 1b ended and the *Amundsen* headed for Resolute for the crew change scheduled on 5 September.

3.3 Chief Scientist's comments

The very ambitious cruise plan for Leg 1b was successfully completed and often involved over 15 science operations being performed each day, including water column sampling, coring, on-ice activities, etc. The favourable ice and weather conditions allowed sampling in Kane Basin in northern Baffin Bay (the preliminary goal set in the expedition plan) and further, to Peterman Fjord and Glacier in northern Greenland. The two Lagrangian drift experiments and the 8 MOBs buoy deployments were successfully conducted, as well as 6 MVP transects, exceeding what was originally planned.

The Chief Scientist and the science participants of Leg 1b express their gratitude to the Commanding Officer and the officers and crew of the CCGS *Amundsen* for their unrelenting support and hard work throughout the cruise.

4 Leg 2a – 5 September to 15 September 2013 – Canadian Arctic Archipelago

Chief Scientist: Steve Blasco[1] (Steve.Blasco@NRCan-RNCan.gc.ca)
[1] Geological Survey of Canada (GSC-Atlantic), Bedford Institute of Oceanography, 1 Challenger Dr., Box 1006, Dartmouth, NS, B2Y 4A2, Canada.

4.1 Introduction

Leg 2a took place from 5 to 15 September and focused on the ArcticNet marine-based program with scientific activities carried out in the Canadian Arctic Archipelago in Viscount Melville Sound, M'Clure Strait and Lancaster Sound.

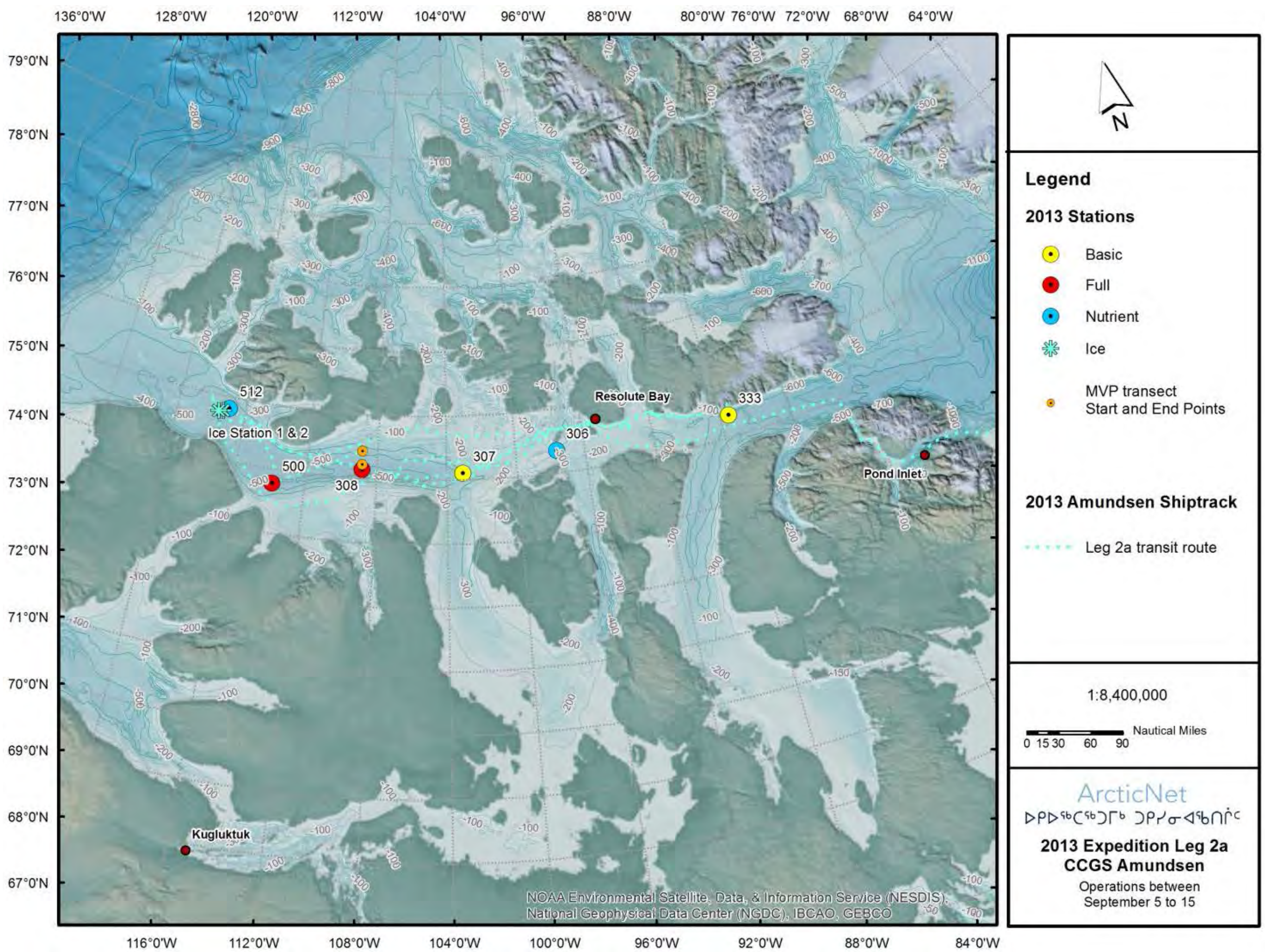

Figure 4.1. Map showing the ship track and the locations of stations sampled in the Canadian Arctic Archipelago in Viscount Melville Sound, M'Clure Strait and Lancaster Sound during Leg 2a.

The specific objectives for Leg 2a were to:

- Sample the atmosphere and quantify gas fluxes at the sea ice-seawater-atmosphere interface along the cruise track.
- Deploy Met/Ocean buoys (MOBs) at Full and Basic stations to measure meteorological and surface ocean parameters during 5 to 12-h periods.
- Sample the water column for physico-chemical properties of the water and components of the marine food web.
- Sample the sediments at 5 stations located in Viscount Melville Sound and McClure Strait.
- Conduct at least one MVP transect across Viscount Melville Sound.
- Conduct on-ice operations using the helicopter, ice cage and/or barge to access ice features of interest.
- Obtain bathymetry and sub-bottom information using the multibeam sonar system along the cruise track.

4.2 Synopsis of operations

This section provides a general synopsis and timeline of operations during Leg 2a. Detailed cruise reports provided by onboard participants and including specific objectives, methodology and preliminary results for projects conducted during this leg are available in Part II of this report. During this leg, the *Amundsen* traveled from Resolute (5 September) to Resolute (15 October) and 8 stations were visited with an overall tally of operations and activities as follows:

- 4 CTD casts
- 7 CTD-Rosette casts
- 6 optical and phytoplankton profiles, including Secchi disk and PNF.
- 1 MVP profile
- 12 plankton net tows, including horizontal and vertical net tows, Hydrobios and RMT
- 3 Agassiz trawls and 2 benthic beam trawls to collect benthic fauna
- 5 box cores to sample the sediments
- 2 Met/Ocean Buoy (MOBs) deployments
- 5 on-ice operations using the helicopter or the ice cage
- 2 acoustic surveys (Sx90) to detect fish schools

A detailed scientific log for all sampling operations conducted during Leg 2a with the positions and depths of the visited stations is available in Appendix 2.

4.2.1 Timeline of operations

Leaving Resolute Bay on 5 September, the *Amundsen* headed west toward the Beaufort Sea. After a quick stop to carry out a CTD cast at Station 306, the first Basic station (307) was reached during the night of 7 September. Once pelagic, sediments and benthic sampling were completed, the vessel headed for Full Station 308, which started with the deployment of a MOB buoy and ended with a MVP transect across the channel of Viscount Melville Sound.

The full suite of operations was conducted successfully at Station 500 on 8 September, including multiple box cores to collect sediments as well as one Agassiz trawl and two benthic beam trawls to sample the benthic fauna. A CTD-Rosette was conducted at Station 512, then the ship approached the ice to conduct on-ice operations (Ice Stations 1 & 2) using the ice cage and the helicopter. These operations were concurrent with acoustic surveys trying to detect fish schools at or near the ice edge.

The 2013 expedition was curtailed following the crash of the *Amundsen's* helicopter in M'Clure Strait on 9 September.

4.3 Chief Scientist's comments

We tragically lost three of our friends and colleagues, D. Dubé, helicopter pilot, M. Thibault, Commanding Officer of the CCGS *Amundsen* and Dr. K. Hochheim, research scientist at the University of Manitoba, when the *Amundsen*'s helicopter crashed in M'Clure Strait on 9 September 2013 during Leg 2a. Daniel, Marc and Klaus were long time members of the ArcticNet – Coast Guard family and were highly respected for their expertise and commitment to Arctic research. They were passionate about life and dedicated to their work and will be deeply missed.

Part II – Project reports

1 Surface climate, air-surface fluxes and carbon exchange dynamics – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Carbon Exchange Dynamics in Coastal and Marine Ecosystems*. ArcticNet/Phase3/Carbon-dynamics

Project leader: Tim Papakyriakou[1] (papakyri@cc.umanitoba.ca)
Cruise participants Leg 1a: Tonya Burgers[1] and Brent Else[1]
Cruise participant Leg 1b: Tonya Burgers[1]
Cruise participant Leg 2a: Meredith Pind[1]
[1] *University of Manitoba, Centre for Earth Observation Science (CEOS), Wallace Building, 125 Dysart Rd, Winnipeg, MB, R3T 2N2, Canada.*

1.1 Introduction

Specific objectives relate to the development of tools (observation, model, and remote sensing) to assist with regional budgeting of (primarily) heat, CO_2, and momentum, and in the longer term, to develop the necessary process-level understanding of the exchange dynamics, to forecast how the ocean's response to climate change and variability will affect the atmosphere-ocean cycling of CO_2.

The surface meteorology and flux program conducted onboard the *Amundsen* is designed to record basic meteorological and surface conditions, and to study exchanges of momentum, heat and mass across the atmosphere-sea ice-ocean interface in support of the objectives described above.

Novel to air-sea studies is the ship-based application of the eddy covariance technique to the direct measurement of heat, CO_2 and momentum. Eddy covariance represents the lone local scale (100s m to km) direct measurement of the respective fluxes using micrometeorological approaches.

1.2 Methodology

1.2.1 Overview

Table 1.1 lists the variables that were monitored, the location where the sensor was installed, the purpose for each variable, along with the sampling and averaging frequency (if applicable).

Table 1.1. Summary of instruments with variable inventory and applications used to measure air-surface fluxes and carbon exchange dynamics.

Variable	Instrumentation	Location	Purpose	Sample / Avg freq (s)
Air temperature (Ta)	HMP45C-212	foredeck tower	meteorological parameter	1 / 60
relative humidity (RH)	HMP45C-212	foredeck tower	meteorological parameter	1 / 60
wind speed (ws-2D)	RM Young 05106-10	foredeck tower	meteorological parameter	1 / 60
wind direction (wd-polar)	RM Young 05106-10	foredeck tower	meteorological parameter	1 / 60
barometric pressure (Patm)	Vaisala PTB101B	foredeck tower	meteorological parameter	1 / 60
sea surface temperature (Tsfc)	Apogee SI-111	foredeck	meteorological parameter	1 / 60
ship heading (H)	OceanServer OS5000	foredeck tower	ancillary information	1 / --
ship speed over ground (SOG)	Garmin GPS16x-HVS	foredeck tower	ancillary information	1 / --
ship course over ground (COG)	Garmin GPS16x-HVS	foredeck tower	ancillary information	1 / --
ship location (latitude, longitude)	Garmin GPS16x-HVS	foredeck tower	ancillary information	1 / --
incident solar radiation	Eppley Pyranometer	wheelhouse platform	heat budget and microclimate	2 / 60
incident long-wave radiation	Eppley Pyrgeometer	wheelhouse platform	heat budget and microclimate	2 / 60
photosynthetically active radiation (PAR)	Kipp & Zonen PARLite	wheelhouse platform	heat budget and microclimate	2 / 60
wind speed 3D (u, v, w)	Gill Wind Master Pro	foredeck tower	air-sea flux	0.1 (10 Hz)
sonic temperature (Ts)	Gill Wind Master Pro	foredeck tower	air-sea flux	0.1 (10 Hz)
atm. water vapour concentration (ρ_v)	LICOR LI7500 & LI7000	foredeck tower	air-sea flux	0.1 (10 Hz)
atm. concentration of CO_2 (ρ_c)	LICOR LI7500 & LI7000	foredeck tower	air-sea flux	0.1 (10 Hz)
rotational motion (accx, accy, accz, r x, r_y, r_z)	Systron Donner MotionPak	foredeck tower	air-sea flux	0.1 (10 Hz)
barometric pressure (mbar)	All Sensors BARO-A-4V-MINI-PRIME	foredeck tower	air-sea flux	0.1 (10 Hz)
upper sea water temperature (Tsw)	General Oceanics 8050 *p*CO_2	underway system, forward engine room	air-sea flux and ancillary information	3 / 60
sea water salinity (s)	General Oceanics 8050 *p*CO_2	underway system, forward engine room	air-sea flux and ancillary information	3 / 60
dissolved CO_2 in seawater	General Oceanics 8050 *p*CO_2	underway system, forward engine room	air-sea flux and ancillary information	3 / 60
pH	General Oceanics 8050 *p*CO_2	underway system, forward engine room	air-sea flux and ancillary information	3 / 60
dissolved O_2 in seawater	General Oceanics 8050 *p*CO_2	underway system, forward engine room	air-sea flux and ancillary information	3 / 60

1.2.2 Micrometeorology and eddy covariance flux tower

The micrometeorological tower located on the front deck of the *Amundsen* provides continuous monitoring of meteorological variables and eddy covariance parameters. The tower consists of slow response sensors that record bulk meteorological conditions (air temperature, humidity, wind speed/direction, surface temperature) and fast response sensors that record the eddy covariance parameters (CO_2/H_2O concentration, 3D wind velocity, 3D ship motion, air temperature). In addition, radiation sensors are installed on the roof of the wheelhouse to provide information on incoming long-wave, short-wave and photosynthetically active radiation. All data was logged to Campbell Scientific dataloggers; a model CR3000 logger was used for the eddy covariance data, a CR1000 logger for the slow response met data, and a CR23X for the radiation data. All loggers were synchronized to UTC time using the ship's GPS system as a reference. Ship heading and location (latitude and longitude) were measured to compensate measured apparent wind information for ship direction and motion.

The eddy covariance system on the tower made use of three separate gas analyzers (one shrouded and two open) and a single 3D sonic anemometer. The shrouded gas analyzer allowed to measure the influence of ship motion on the CO_2 measurements. A closed path gas analyzer, located inside the container on the foredeck, was also employed. While the open path gas analyzer has the benefit of making measurements concurrently with the sonic anemometer, the closed path gas analyzer is not as easily disturbed by adverse weather conditions.

In order to make sure that the two systems were comparable, careful calibrations were performed on both instruments. The closed path system is based on a LI-7000 gas analyzer which employs two optical cells, one of which was used to monitor the drift of the instrument by constantly passing a stream of ultra-high purity N_2. In addition, the sample cell of the instrument was calibrated daily using the ultra-high purity N_2 to zero the CO_2 and H_2O measurements, and a reference gas of known CO_2 to span the instrument. Occasionally, a span calibration of the H_2O sensor is performed using a dew point generator (model LI-610). The open path gas analyzer (LI-7500) could not be calibrated as conveniently, and so it was calibrated approximately every two weeks. In general, it was found that this was effective for this instrument, which did not drift significantly over time.

The ship motion correction necessary for the application of the eddy covariance technique requires accurate measurement of ship motion (3 plane measurement of angular acceleration and rate), heading and location. Rotational motion was monitored using a multi-axis inertial sensing system. Data related to heading and location was available from the ship's GPS and gyro. Using these data, yaw, pitch and roll, in addition to translational motion was calculated, and collectively this information was used to correct our 3D wind measurements.

The slow sequence largely meteorological variables were scanned at 1-second intervals and saved as 1-minute averages. In regard to wind speed and direction, ship motion correction was applied in post-processing.

The high frequency variables associated with the eddy covariance system were scanned at 0.1-second intervals and stored as raw data and as 1-minute averages. The raw data were used to compute the fluxes (heat, mass and momentum) over time intervals that can range from 10 to 60 minutes. Fluxes were computed during post processing.

1.2.3 On-track pCO_2 system

A General Oceanics 8050 pCO_2 system has been installed on the ship to measure dissolved CO_2 within the upper 5 m of the sea surface in near real time. The system was located in the engine room of the *Amundsen*, and drew sample water from the ship's clean water intake. The water was passed into a sealed container through a shower head, maintaining a constant headspace. This set up allowed the air in the headspace to come into equilibrium with the CO_2 concentration of the seawater, and the air was then cycled from the container into an LI-7000 gas analyzer in a closed loop. A temperature probe was located in the equilibrator to provide the equilibration temperature. The system also passed subsample of the water stream through an Idronaut Ocean Seven CTD, which measured temperature, conductivity, pressure, dissolved oxygen, pH and redox. All data was sent directly to a computer using software customized to the instrument.

The LI-7000 gas analyzer was calibrated daily using ultra-high purity N_2 as a zero gas, and a gas with known CO_2 concentration as a span gas. Spanning of the H_2O sensor was not necessary because a condenser removed H_2O from the air stream before passing into the sample cell.

1.3 Preliminary results

At this time, no preliminary results are available.

1.4 Comments and recommendations

At this time, there are no recommendations that would improve sampling rate or efficiency. As previously requested, the ship should be pointed into the wind (when possible) when at station, so that the ship's smoke is not blown towards the met tower.

2 Ocean – sea ice – atmosphere system – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Sea Ice, Climate Change and the Marine Ecosystem.* ArcticNet/Phase3/Sea-ice.

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2.1 Introduction

This project is a continuation of the legacy project to improve understanding of the Arctic as a system, from the ocean, to the sea ice, and into the upper atmosphere. The research program was divided into several components.

2.1.1 Upper atmosphere program

The upper atmosphere program is designed to monitor the atmospheric variables that can affect the Arctic atmosphere-ocean interactions. The instrumentation used provided high temporal measurements of temperature, humidity, pressure and wind for the surface up to approximately 20 km. The boundary layer is of particular importance and was monitored using a Microwave Profiling Radiometer (MWRP) at a frequency of approximately 1 second.

2.1.2 Remote sensing and physical sampling program

The primary objective of the remote sensing program is to obtain both active and passive microwave (MW) signatures of a variety of sea ice targets, along with coincident *in situ* geophysical data, for the purposes of describing the dominant sea ice scattering mechanisms and electromagnetic wave interactions. Specific research objectives were to:

- Investigate the polarimetric radar response of multi-year sea ice (MYI) using coincident C-band and L-band scatterometer systems.
- Investigate how the combination of C-band and L-band radar signatures can improve the ability to retrieve the properties of newly-formed sea ice (e.g., thickness, brine volume) using modeling techniques.
- Examine the relationship between microwave brightness temperature and sea ice thermodynamic/physical state during the late summer and early fall freeze-up periods.
- Study the microwave emission and scattering response of open ocean in a variety of sea states and under a variety of meteorological conditions.
- Characterize the near-surface physical state of snow, sea ice, and melt ponds.

2.1.3 Ice dynamics program

The main objective of the ice dynamics program is to study large-scale sea ice motion and properties. Research is conducted in support of several objectives, including:

- Monitoring the ice flux from the Arctic Ocean, through Nares Strait and into Baffin Bay through ice beacon deployment.
- Characterization of the ocean surface roughness and wavefield through Met Ocean Buoy (MOB) deployment.
- Ice thickness measurement using helicopter based EMI surveys.

2.2 Methodology – Upper atmosphere program

2.2.1 Microwave profiling radiometer instrumentation

A Radiometrics temperature and water vapour 3000A profiling radiometer (TP/WVP3000A) was used to measure the temperature and water vapour within the atmosphere up to 10 km using passive microwave radiometry at 22–29 GHz, and 51–59 GHz. The TP/WVP3000A was installed on a mount attached to the white container laboratory (the 'Met Shack') located directly behind the ship's wheelhouse, approximately 19 m above sea level. The instrument was suspended away from the roof of the shed to ensure that the field-of-view (approximately 15° above the horizon to the left and right to the zenith) was clear of any obstruction.

The instrument generates a vertical profile of upper-level air variables including temperature, water vapour density, relative humidity, and liquid water from the surface to an altitude of 10km. The resolution of the measurements varies with height. The resolution of the instrument is 50 m from the surface to an altitude of 500 m, then increases to 100 m from 500 m to 2 km altitude, and is 250 m for measurements from 2 km to 10 km. Note that the height given for 50 m was actually 69 m as the instrument assumes it is at sea level when it is mounted 19 m above sea level. In addition, the instrument also measures concurrent basic surface meteorology variables, including pressure, relative humidity, and ambient temperature. A skyward-looking infrared sensor measures the temperature of the sky. A rain-sensor detects the presence of any precipitation. It should be noted that the fog registered as precipitation during much of the field season. The instrument also calculates integrated column water vapour, and liquid water content. The sampling frequency for all data is approximately one complete profile per minute.

The calibration of the water vapour profiling process was continuously maintained by hourly tip curves. An external liquid-nitrogen-cooled blackbody was used to intermittently calibrate the temperature profiling process. All channels also viewed an internal black body target every 5 minutes for relative calibration. Temperature and humidity values (0 to 200 m at 50 meter intervals, 500 to 2000 m at 100 meter intervals, and 2000 to 10,000 m at 250 meter intervals) were derived from microwave brightness temperatures using the manufacturer's neural network retrievals that had been trained using historical radiosonde measurements, and a radiative transfer model (Solheim et al. 1998). Historical radiosonde data from Inuvik, N.W.T., was used to develop neural network coefficients for the Southern Beaufort Sea Region.

2.2.2 Vaisala radiosondes

Weather balloon launches were used to profile low-pressure systems, cyclones, and periods of significant warm or cold-air advection aloft. Vertical profiles of temperature, pressure, relative humidity, wind speed and wind direction were obtained using Vaisala RS92G GPS wind-finding radiosondes. The sondes were attached to 200 gm helium-filled balloons at a target ascent rate of 2 to 5 m/s to ensure a good vertical resolution through the boundary layer. An 8-channel uncoded GPS receiver in each sonde automatically detected all satellite signals in visible range. Raw wind vectors were transmitted to the ground station every 0.5 seconds during the flight via digital 1200 baud downlink. All wind computation was done within the ground equipment. Temperature was measured with a THERMOCAP® Capacitive bead, which has a +600°C to -900°C range, resolution of 0.10°C and accuracy of 0.20°C up to 50 hPa (most launches terminated before this level). The sensor also had a lag of less than 2.5 seconds in 6 m/s flow at 1000 mb. Pressure was measured with a BAROCAP® Capacitive aneroid. Its measuring range was 1060 mb to 3 mb with a resolution of 0.1 mb and accuracy of 0.5 mb. Humidity was measured with a HUMICAP® thin film capacitor with a measuring range from 0 to 100% relative humidity, with a resolution of 1% relative humidity and accuracy of 3%.

The sensor also had a lag of 1 second in 6 m/s flow, 1000 mb pressure and +200°C. The temperature, pressure and humidity sensors were collectively sampled at 7 times per 10 seconds. All raw data from the sonde were processed at the ground station through a DigiCORA/MARWIN processor. The DigiCORA was connected to a computer, where data could be viewed in real time throughout the launch and where the data was archived. PILOT and TEMP codes were also produced after the launch terminated. PILOT and TEMP codes, as well as raw and edited measurements were archived for each launch. The edited data was then stored in a text file in delimited columns.

Before launch, the radiosonde's temperature, pressure and humidity sensors were calibrated using the Vaisala ground station calibration unit. Surface meteorological observations were also noted and recorded for each launch. Starting meteorological conditions were input into the sounding including: sea level pressure, air temperature, relative humidity, and wind speed and direction.

Data was transmitted at a rate of one message per second via UHF radio (~400.00 MHz). Each data message reported a value for pressure, temperature and humidity data (raw PTU data). GPS strings were also transmitted, and were used to calculate upper-level wind speed and direction. All raw PTU and GPS data was used to generate an ensemble of time series data (Table 2.1).

Table 2.1. Variable denotation header found within radiosonde data files.

Record name:	Unit:	Data type:	Divisor:	Offset:
time	sec	float (4)	1	0
Pscl	ln	short (2)	1	0
T	K	short (2)	10	0
RH	%	short (2)	1	0
v	m/s	short (2)	-100	0
u	m/s	short (2)	-100	0
Height	m	short (2)	1	30000
P	hPa	short (2)	10	0
TD	K	short (2)	10	0
MR	g/kg	short (2)	100	0
DD	dgr	short (2)	1	0
FF	m/s	short (2)	10	0
AZ	dgr	short (2)	1	0
Range	m	short (2)	0.01	0
Lon	dgr	short (2)	100	0
Lat	dgr	short (2)	100	0
SpuKey	bitfield	unsigned short (2)	1	0
UsrKey	bitfield	unsigned short (2)	1	0
RadarH	m	short (2)	1	30000

As part of the Environment Canada agreement, two radiosonde launch data sets will be sent to their FTP site for input into their local forecast models. These radiosondes will be launched at 0000 UTC and 1200 UTC.

2.2.3 Vaisala CT25K ceilometer

The Vaisala CT25K laser ceilometer measured cloud heights and vertical visibilities using pulsed diode laser LIDAR (Light Detection And Ranging) technology, where short powerful laser pulses are sent out in a vertical or near-vertical direction. The laser operated at a centre wavelength of 905 ± 5 nm, a pulse width of 100 ns, beamwidth of ±0.53 mrad edge, ±0.75 mrad diagonal and a peak power of 16 W. The manufacturer suggested measurement range is 0 – 25,000ft (0 – 7.5 km), however, it had been found that high, very visible cirrostratus cloud (~18-20 kft) were consistently undetected by the unit (Hanesiak 1998). The vertical resolution of the measurements was 50 ft, but decreased to 100 ft after ASCII data file conversion. The reflection of light backscatter caused by haze, fog, mist, virga, precipitation, and clouds was measured as the laser pulses traverse the sky. The resulting backscatter profile (i.e., signal strength versus height) was stored, processed and the cloud bases were detected. Knowing the speed of light, the time delay between the launch of the laser pulse and the backscatter signal indicated the cloud base height. The CT25K is designed to detect three cloud layers simultaneously, given suitable conditions. Besides cloud layers, it detected whether there was precipitation or other obstruction to vision. No adjustments in the field were needed. Output files were created hourly by the system in ASCII format.

2.2.4 All-sky camera

The all-sky camera system took images of the sky and cloud cover. The system consisted of a Nikon D-90 camera outfitted with fish-eye lenses with a viewing angle of 160 degrees, mounted in a heated weather-proof enclosure. The camera was programmed to take pictures using an external intervalometer set at 10-minute intervals, or 144 images per day. The system was mounted in a small 'crow's nest' immediately above the ship's wheelhouse.

2.2.5 Manual meteorological observations

Manual meteorological observations were conducted hourly throughout the entire leg. Observations included current conditions with relation to precipitation type and intensity, visibility, cloud cover (octets), and sea ice coverage (tenths) (Table 2.2). Basic meteorological values were read and recorded from the onboard weather station, owned and operated by the Meteorological Service of Canada. Visibility, cloud octets, sea ice concentration, and precipitation type and intensity observations were subjective based on the observer. If the cloud coverage was not 100% it was not recorded at 8/8, similarly if the coverage has even 1% of clouds the cloud fraction was not recorded as 0/8.

The CCGS *Amundsen* is equipped with an AXYS Automated Voluntary Observation Ship (AVOS), with all sensors located on the roof of the wheelhouse. The AVOS is an interactive environmental reporting system that allows for the hourly transmission of current meteorological conditions to a central land station via Iridium satellite telemetry. Temperatures (air and sea surface), pressure, relative humidity (RH), wind speed, wind direction, and current GPS location were updated every ten minutes and displayed on a computer monitor located in the wheelhouse of the ship. The AVOS deployed a Rotronics MP 101A sensor for temperature and RH, with a resolution of 0.1°C and an accuracy of ± 0.3°C, and a 1% ± 1% accuracy for temperature and RH, respectively. Atmospheric pressure was obtained from a Vaisala PTB210 sensor with a 0.01mb resolution and an accuracy of ±0.15 mb. Wind speed and direction was collected from an RM Young 05103 anemometer, accurate to ±3° in direction and ±0.3 m/s.

As part of the 2013 agreement with Environment Canada, meteorological observations were inputted into the AVOS system. This was done a minimum of 4 times per day, preferably at 0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC.

Table 2.2. Parameters recorded during manual meteorological observations.

Parameter	Units
Date	UTC
Time	UTC
Latitude	decimal degrees
Longitude	decimal degrees
Temperature	ºC
Relative Humidity	%
Wind Speed	kts
Wind Direction	º
Precipitation Type	snow, rain etc
Precipitation Intensity	Heavy, moderate, light etc.
Visibility	km
Cloud Fraction	Octets
Wave Height	m
Beaufort Sea State	0-10
Sea Ice Concentration	Tenths
Sea Ice Type	MYI, FYI, rotten, icebergs

2.3 Methodology – Remote sensing and physical sampling program

The sampling strategy was highly opportunistic and depended upon the presence of sea ice in the vicinity of the ship. Sampling occurred in two methodologies: Station Sampling and Transect Sampling. During Leg 1b, 12 ice floes or locations were visited to conduct physical sampling in support of the EM measurements.

2.3.1 C-band scatterometer measurement

The C-band scatterometer (Figure 2.1 left) is a fully-polarimetric MW radar designed to transmit a chirp pulse with a centre frequency of 5.5 GHz and bandwidth of 500 MHz. The full polarimetric response of a target in terms of the combinations of four linear polarizations: VV, HH, HV, and VH, and their relative phases, were recorded during each scan. Scan data was processed using proprietary software and calibrated relative to an external calibration reference (trihedral corner reflector). The instrument was located at a height of 8.3 m above the sea surface on the port side of the ship. Scans were performed on station only (Table 2.3) with a 40° swath in the azimuth, with elevation angles from 20° to 60° in 5° steps.

2.3.2 L-band scatterometer measurement

The L-band scatterometer (Figure 2.1 right) is a fully-polarimetric MW radar designed to transmit a chirped pulse with a centre frequency of 1.27 GHz. The full polarimetric response of a target in terms of the combinations of four linear polarizations: VV, HH, HV, and VH, and their relative phases, were recorded during each scan. Scan data was processed using proprietary software and calibrated relative to an external calibration reference (trihedral corner reflector). The instrument was located at a height of 18 m above the sea surface on the port side of the ship. Scans were performed at station stops only (Table 2.3) with a 30° swath in the azimuth, with elevation angles from 20° to 60° in 5° steps.

Figure 2.1. Left: C-band scatterometer system mounted on the port side of the ship. Right: L-band scatterometer system.

Table 2.3. Summary of EM measurements and physical sampling of sea ice during Leg 1.

Station name	Ice type	UTC date	UTC time	Physical sampling	Latitude N	Longitude W
Station MIZ	Rotten FYI	14-Aug-13	21:45	No		
Station 132	Open Water	20-Aug-13	13:40	No		
Station 250	MYI	21-Aug-13	23:35	Yes	81°13.800	062°21.000
Station 252	MYI	23-Aug-13	20:45	Yes	80°47.400	066°27.600
Station 1	2nd Year	1-Sep-13	02:00	Yes	74°09.600	096°16.800
	2nd Year	1-Sep-13	08:45	Yes	74°07.800	096°16.800
Station 2	2nd Year	1-Sep-13	15:10	Yes (x2)	74°02.400	096°16.200
Station 3	2nd Year	2-Sep-13	02:13	No	74°03.000	096°03.600
	2nd Year	2-Sep-13	05:28	No		
	2nd Year	2-Sep-13	09:20	Yes		
Station 4	MYI	2-Sep-13	17:26	Yes	74°10.800	095°55.800
	MYI	2-Sep-13	20:48	No		
Station 5	MYI	3-Sep-13	01:35	Yes	74°10.200	095°48.600
Station 6	MYI	3-Sep-13	09:00	Yes	74°05.400	095°29.400
	MYI	3-Sep-13	13:45	Yes		
Station 7	Rubble	3-Sep-13		No		
	Rubble	3-Sep-13		No		
	Rubble	3-Sep-13		No		
Station 8	New Ice	3-Sep-13		Yes		

2.3.3 Passive microwave measurement

The passive microwave radiometers (PMW; Figure 2.2) are dual-polarized systems operating at centre frequencies of 19 GHz, 37 GHz, and 89 GHz. They recorded the surface emission as voltage readings and converted them into brightness temperature using an internal calibration procedure. The instruments were located at a height of 14 m above the sea surface. Scans were performed with elevation angles from 30° to 125° in 5° steps (no azimuthal swath) at all station stops. Sky emissions were recorded at an incidence angle of 125° when the sky is clear (for checking the stability of the measurements).

During transect operation, the system was set to an incidence angle of 55° in order to coordinate with the Advanced Microwave Scanning Radiometer 2 (AMSR2).

Figure 2.2. Passive microwave radiometer systems.

2.3.4 Ice station sampling

Upon arrival at a regular station stop at an ice floe, the EM scan region was designated off the port side of the ship. The ship-mounted C-band, L-band, and PMW systems were configured to scan the sea ice surface. When sampling permitted personnel to disembark and walk on the ice floe, physical sampling occurred in the scan region in order to characterize the sea ice physical properties and thermodynamic state.

An ice auger and an ice thickness tape measure were used to establish the ice floe thickness. A core barrel was used to extract a sample of the upper 1.5 to 2 m of the ice. Ice temperatures were measured by drilling into the core at 10 cm intervals, with a starting point of 5 cm from the top of the core. The core was then sliced into 10 cm segments and placed into plastic containers. These core samples were melted and the conductivity and temperature were measured to yield the salinity. Surface snow and ice scrapings were obtained for salinity measurements.

2.3.5 IR transducer

An infrared transducer was positioned in the C-band scatterometer shed. It was oriented toward the sea surface in order to record the surface temperature. This instrument operated continuously throughout the cruise at a fixed incidence angle.

2.3.6 LiDAR measurement

A laser scanning system (LiDAR, a Leica Scanstation C10) was used to provide measurements of the large-scale topography and small-scale roughness of the ice surface. The LiDAR was configured to emit pulses at a frequency of 50 kHz and subsequently recorded the time-of-flight for each of the pulses to be reflected by surrounding objects and returned to the scanner. The system operated at a wavelength of 532 nm, so laser pulses were consistently reflected by surfaces such as snow and ice, but were absorbed by water.

It was possible to collect LiDAR data at Ice Station 1 of the cruise. Measurements were made after physical sampling and scanning using the other remote sensing instruments. From these scans, the surface topography and roughness of the snow-covered sea ice will be reconstructed.

2.3.7 CTD profiles

CTD profiles were made at the Peterman Glacier and the Ice Island Station 253 in the upper layer of the ocean (0-40 m). The objective was to characterize the effect of melting ice on the upper ocean layer. The Ocean Seven 304 CTD probe (Idronaut) measured pressure, temperature, conductivity, salinity, and turbidity. The instrument was set to take measurements at a rate of 8 Hz. The system was deployed by hand at a rate of about 1 m/s. The CTD remained at the maximum cast depth (40 m) for a few seconds before it was retrieved. Profiles were also taken at ice stations, by drilling a two-inch auger hole and deploying the CTD through the hole and into the water column beneath the ice.

<u>**Peterman Fjord and Glacier**</u>

CTD measurements were conducted on an approach toward the Peterman Glacier face (Stations 1-7, Table 2.4), as well as at eight stations on a line parallel to the face of the glacier. Three additional measurements were made close to the glacier face (~50 m away). Station identification, latitude, longitude, and start time are given in Table 2.4.

Table 2.4. Location and time of CTD profiles conducted at Peterman Glacier and fjord during Leg 1.

Station	Latitude N	Longitude W	UTC Time start
1	81°12.076	62°04.406	13:42
2	81°09.551	61°58.087	14:10
3	81°06.090	61°50.600	14:47
4	80°03.200	61°38.120	15:56
5	80°00.500	61°28.250	16:30
6	80°58.400	61°21.250	17:03
7	80°54.550	61°12.950	17:40
8	80°54.830	61°42.060	18:37
9	80°54.290	61°41.230	18:47

Station	Latitude N	Longitude W	UTC Time start
10	80°54.920	61°39.985	18:56
11	80°54.962	61°38.201	19:02
12	80°55.075	61°29.546	19:14
13	80°55.500	61°09.924	19:32
14	80°56.293	61°05.500	19:39
15	80°57.300	60°58.944	19:48
16	80°58.130	60°46.824	20:24
17	80°56.905	60°59.280	20:41
18	80°56.165	61°05.022	20:52

<u>Ice Island Station 253</u>

CTD measurements were conducted on three radial lines, consisting of 5 sample stations. Each line started at the ice island (at about ~50 m away) and progressed away from it. Station identification, latitude, longitude, start time, air temperature, and sea surface temperature are given in Table 2.5.

Table 2.5. Location and time of CTD profiles conducted at Ice Island Station 253 during Leg 1.

Station	Latitude N	Longitude W	UTC Time Start	T_{air} [°C]	SST [°C]
1	81°12.076	62°04.406	13:42	-1.75	-1.07
2	81°09.551	61°58.087	14:10	-1.97	-1.02
3	81°06.090	61°50.600	14:47	-0.98	-1.02
4	80°03.200	61°38.120	15:56	-0.37	-0.99
5	80°00.500	61°28.250	16:30	-0.66	-1.01
6	80°58.400	61°21.250	17:03	-0.81	-1.01
7	80°54.550	61°12.950	17:40	-1.29	-1.00
8	80°54.830	61°42.060	18:37	-1.48	-0.99
9	80°54.290	61°41.230	18:47	-0.94	-0.99
10	80°54.920	61°39.985	18:56	-1.11	-1.03
11	80°54.962	61°38.201	19:02	-0.82	-0.94
12	80°55.075	61°29.546	19:14	-0.81	-0.95
13	80°55.500	61°09.924	19:32	-1.42	-0.92
14	80°56.293	61°05.500	19:39	-0.63	-0.93
15	80°57.300	60°58.944	19:48	-0.63	-0.96

2.4 Methodology – Ice motion program

2.4.1 Ice beacons

A minimum of 7 beacons was originally planned for deployment in Leg 1, but due to exceptional atmospheric and ice conditions, 18 beacons were deployed in Nares Strait. Through multiple helicopter flights and ice stations, the 18 beacons were deployed on both multi-year ice floes and ice islands. Table 2.6 outlines the details of the beacons deployed and the associated ice conditions. Of the 18 beacons deployed, CEOS (U. Manitoba) owned 11 Oceanetics position-only beacons and 4 Canatec position-only beacons (Figure 2.3). S. Prinsenberg (DFO-BIO) owned the 3 additional position-only beacons. 17 of the beacons were deployed via helicopter flights from 20 to 25 August, while the remaining beacon was deployed at a small ice station on 23 August. All beacons were deployed for the lifetime of the ice floe or ice island.

Table 2.6. Summary of ice beacon deployments carried out in Leg 1b.

Beacon ID	Date deployed	Latitude N	Longitude W	Status	Floe comments
O-64160	08-20-13	79°18.180	71°13.560	T	Grounded Peterman ice island, freeboard ~15m
O-61170	08-20-13	79°18.180	71°13.560	T	Grounded Peterman ice island, freeboard ~15m
BIOL-1	08-21-13	81°00.300	65°12.000	T	Multi-year ice
BIOL-2	08-21-13	81°04.200	66°00.000	T	Multi-year ice
O-68150	08-23-13	80°54.780	65°17.400	T	Multi-year ice, thickness: 5+m
O-63160	08-23-13	81°00.000	66°39.120	T	Multi-year ice, thickness: 7+m
O-69160	08-23-13	80°47.460	66°27.600	T	2nd year ice, thickness: 5+m
BIOL-3	08-24-13	80°30.000	68°42.000	T	Multi-year ice, thickness 5+m
O-28480	08-24-13	79°39.7200	64°14.640	NT	Rectangular tabular iceberg, freeboard: 10-15m
O-64170	08-24-13	79°35.100	68°03.780	T	Triangular tabular iceberg, freeboard: 15-20m
O-60170	08-24-13	79°34.500	67°46.980	T	Triangular tabular iceberg, freeboard:10-15m
O-68160	08-24-13	79°32.760	67°24.480	T	Square tabular iceberg, freeboard: 20-25m
O-22490	08-25-13	79° to 79°24.7	70°54.4 to 71°27.6	T	grounded triangular ice island, freeboard 20m, size 5kmx2km
O-22480	08-25-13	79° to 79°24.7	70°54.4 to 71°27.6	T	grounded triangular ice island, freeboard 20m, size 5kmx2km
C-300234011241410	08-25-13	79° to 79°24.7	70°54.4 to 71°27.6	T	rough tabular ice island, freeboard: 5-20m, size 300mx1.5km
C-300234011938510	08-25-13	79° to 79°24.7	70°54.4 to 71°27.6	T	crescent shaped iceberg, freeboard 20+m, 250x500m
C-300234011242410	08-25-13	79° to 79°24.7	70°54.4 to 71°27.6	T	long high tabular ice island, freeboard 20+m, 600mx300m
C-300234011240410	08-25-13	79° to 79°24.7	70°54.4 to 71°27.6	T	tabular ice island, freeboard 3-5m, size: 500mx500m
O-64160	08-20-13	79°18.180	71°13.560	T	Grounded Peterman ice island, freeboard ~15m

At least every two hours, the ice beacons logged their location and transmitted this information via an iridium satellite phone contained within the beacon. The Canatec and BIOL beacons updated a web server, while the Oceanetics beacons stored their data on a University of Manitoba email account.

Figure 2.3. Types of ice beacons deployed during Leg 1b.

2.4.2 MOB sampling

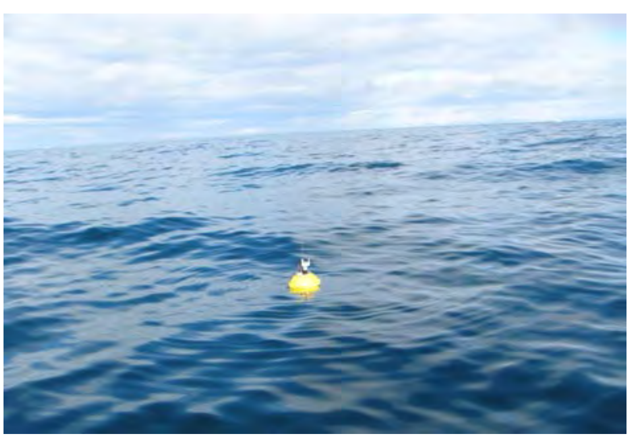


Figure 2.4. Met Ocean buoy (MOB) deployed during Leg 1.

At open water stations, a Met Ocean Buoy (MOB; Figure 2.4) was deployed at an appropriate distance from the ship (>200 m) (Table 2.7).

Deployment and retrieval of the MOB was conducted using the barge or Zodiac and was coordinated with the Coast Guard personnel. The ship-mounted PMW systems were configured to scan the open water until the MOB was retrieved.

Table 2.7. Summary of time and locations of the Met Ocean Buoys (MOB) deployed during Leg 1.

Date and time	Latitude N / Longitude W	Station	Comments
Aug. 15, 2013 1756 UTC	76°21.350 077°26.730	101	-Swell, ~2 hr deployment
Aug. 16, 2013 1635 UTC	76°18.646 075°46.975	105	Swell, ~3 hr deployment
Aug. 19, 2013 1629 UTC	76°22.834 071°14.725	115	Very rough, whitecaps, ~17 hr deployment
Aug. 20, 2013 0444 UTC	78°59.744 072°06.850	132	MIZ, calm, damped waves, breeze, ~10 hr deployment
Aug. 25, 2013 0425 UTC	79°17.722 071°18.463	253	Sunny, clear sky, close to ice island, ripples, ~14 hr deployment
Aug. 27, 2013 0348 UTC	77°21.123 073°26.271	126	Cloudy, windy, ~9 hr deployment
Aug. 27, 2013 2147 UTC	77°19.709 075°02.412	122	Very rough, whitecaps, ~4 hr deployment
Aug. 28, 2013 0901 UTC	77°18.856 076°02.839	119	Rough, swell, no whitecaps, ~6 hr deployment
Aug. 28, 2013 1838 UTC	77°18.917 077°01.374	117	Swell, ~4 hr deployment
Aug. 30, 2013 0708 UTC	74°06.853 083°21.259	301	Swell, ~7 hr deployment
Aug. 31, 2013 0457 UTC	74°15.001 091°26.078	304	MIZ, Calm, ~5 hr deployment

2.4.3 Ice thickness helicopter surveys

The BO105 helicopter on board the CCGS *Amundsen* was used during the northern section of Leg 1b to measure the ice thickness along flight paths across Kennedy Channel. The main collection of data was done on three days between 23 and 26 August. In addition, a total of 5 beacons were deployed on thick ice floes during these flights to monitor the ice drift of the floes within Kennedy Channel. From the two datasets the ice flux through Kennedy Channel can be estimated. Video data along flight tracks were also collected during period of high altitude sections of the flight paths.

Table 2.8. Date and location of helicopter ice surveys conducted during Leg 1b.

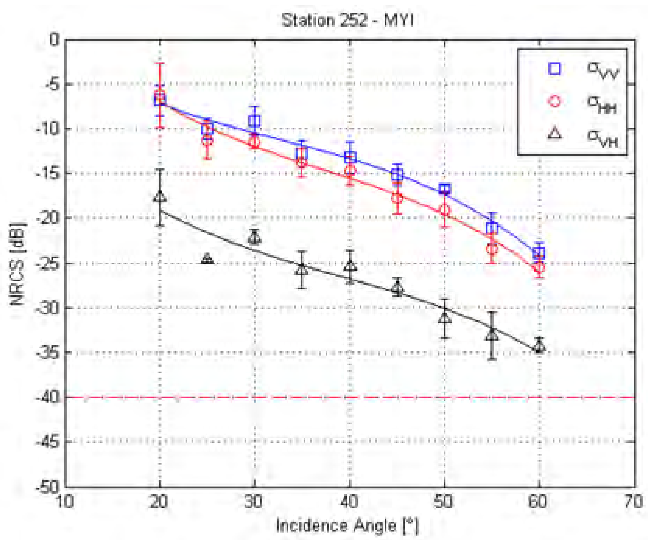
Date in 2013 / morning (M) or afternoon (A)	Stn # / Area	EM file number	Length (~km)	Video files
Aug. 14/A	322-101	Test FEM13003	1	226F136
Aug. 15/A	Stranded Ice island	Laser FEM13004	30	232F137-141
Aug. 23/M	N of Hans Isl.	FEM13006	170	233F142-147
Aug. 23/A	N of Hans Isl. + Reco	FEM13007	30	233F148-154
Aug. 23/A	N Hans Isl. to 250	FEM13009	120	233F155-159
Aug. 25/A	Hans Isl. 252	FEM13011	42	235160-161
Aug. 25/A	N of Hans Isl. 252	FEM13012	64	235162
Aug. 25/A	N of Hans Isl. beacons	FEM13013	---	235F163
Aug. 25/A	Video floe 252	FEM13013	---	235F164
Aug. 26/A	S Kennedy Channel	FEM13016	41	236F165
Aug. 26/A	S Kennedy Channel.	FEM13017	41	236F167-168

2.5 Preliminary results

2.5.1 Upper atmosphere program

No preliminary results are available at this time.

2.5.2 Remote sensing program



C-band and L-band scatterometer measurements were made at all ice stations. An example scatterometer scan from Station 252 is provided below (Figure 2.5). These data are preliminary, as the final calibration has not been applied.

Figure 2.5. Example C-band scatterometer signature from Station 252 conducted during Leg 1.

2.5.3 Physical sampling

Characterization of sea ice physical properties was conducted at all ice stations. Example plots of the temperature, salinity, and microstructural profiles of the ice at Station 250 are provided in Figure 2.6.

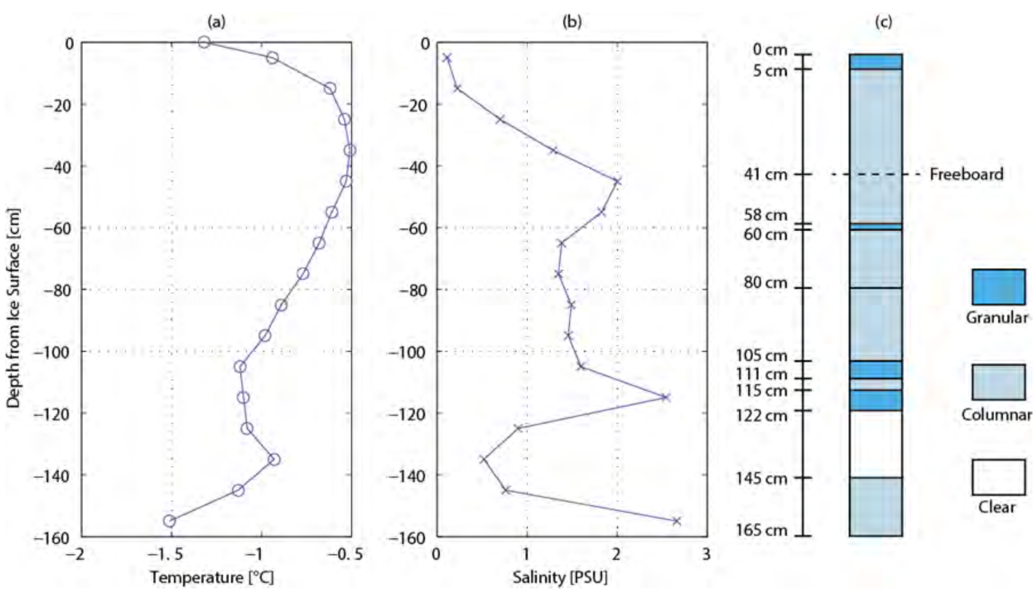


Figure 2.6. Physical characterization of the multiyear sea ice at Station 250. (a) Temperature profile, (b) salinity profile, and (c) ice structure.

The ice was almost isothermal (a), whereas the salinity shows some distinctive peaks and minimums (b) that can be linked with the sea ice structure (c).

2.5.4 CTD vertical profiles

Several example plots from the CTD measurements near the Peterman Glacier in Peterman Fjord are given in Figure 2.7. There was a slight decrease in the surface water temperature as the glacier face was approached. The salinity profiles show minor variability, which will be examined in further detail.

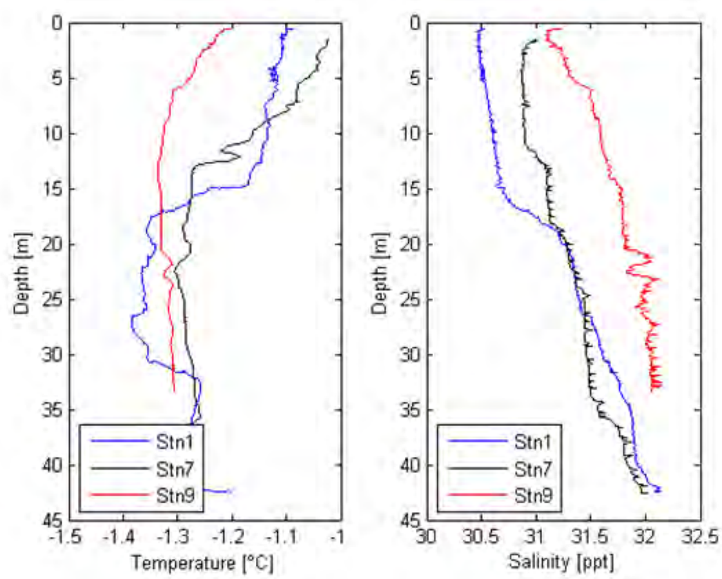


Figure 2.7. Vertical profiles of temperature and salinity obtained with the CTD at Peterman Fjord during Leg 1.

2.5.5 Ice motion

The Canatec beacons immediately updated a web server called Cantrack where the drift paths were outlined on a map of the deployment region.

2.5.6 Ice thickness

The list of file numbers of the ice thickness and video data are listed in Table 2.8 above. The data in the northern part of Kennedy Channel was collected the day before entering the bay leading to the Peterman Glacier on 23 August, north of Hans Island. The total flight track covered a total distance of 170 km (Figure 2.8) with a total mean ice thickness including the open water areas (32%) along the flight of 1.2 m. Excluding the 32% of open water, the mean ice thickness of the ice floes along the track converted to 1.78 m. A small section of this helicopter survey across Kennedy Channel is shown Figure 2.9, where the

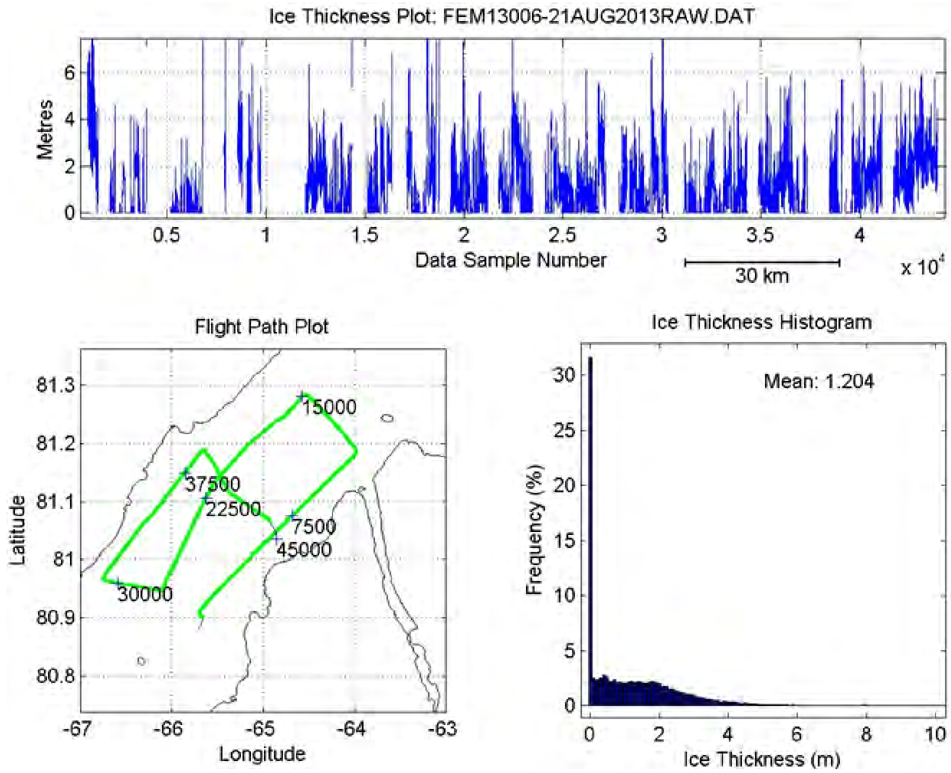


Figure 2.8. Helicopter flight track and thickness profile data from northern Kennedy Channel obtained during a survey conducted in Leg 1.

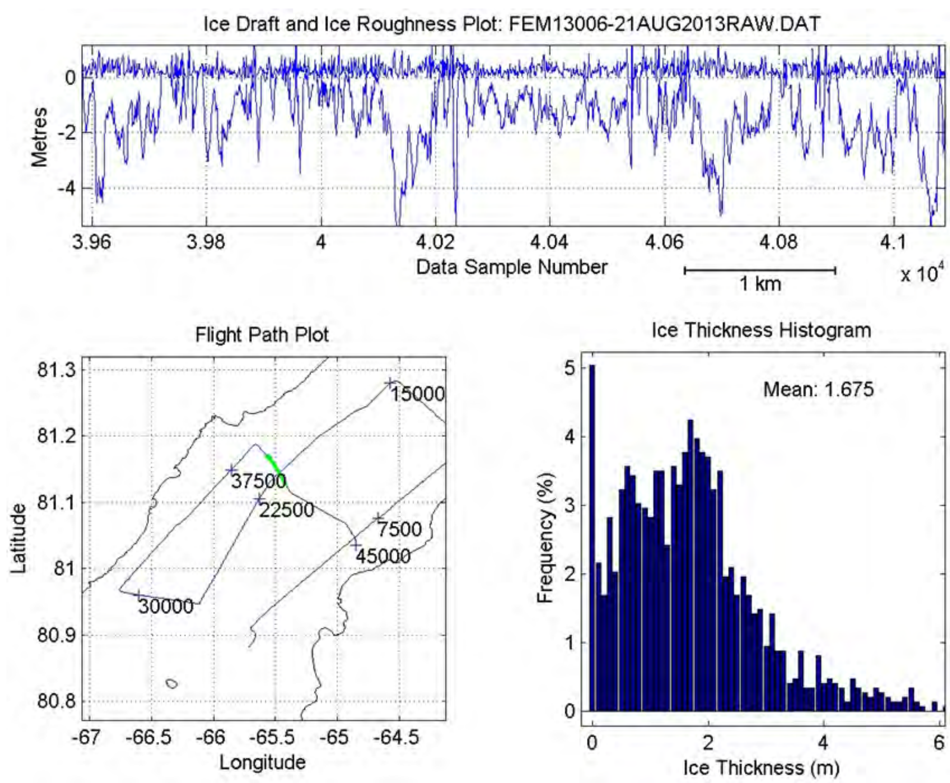


Figure 2.9. Section (in green) of the helicopter survey shown in Figure 2.8 across Kennedy Channel where the laser data is plotted upwards and shows the pack ice surface while the EM data is plotted downwards and shows the keel depths.

laser data in the upper panel is plotted upwards and shows the pack ice surface while the EM data is plotted downwards and shows the keel depths.

The line ice thickness profile shown covers a flight track length of 6 km and has 8 or so floes of more than a ½ km in length. Three of the larger reached keel depths of 4 m (see upper panel of Figure 2.9).Open water regions between these densely packed floes still amounted to 5% of the total profile length shown.

On the way south from Peterman glacier, two areas were sampled. The south survey (Figure 2.10) track was flown from SE to NW and the location of the beacon deployment shows as the constant 2.5 m ice thickness section of the plot. This corresponds to the helicopter being stationary on the ice while the EM-Laser sensors collected data at a rate of 10 per second.

A small section of the data across this southern part of Kennedy Channel (Figure 2.11) shows four distinct floes with their keels reaching 4-6 m deep. The floes were between 300-500 m in length with a lot off open water (38%) between them which when removed from the mean ice thickness resulted in a mean ice-only thickness of 2.75 m.

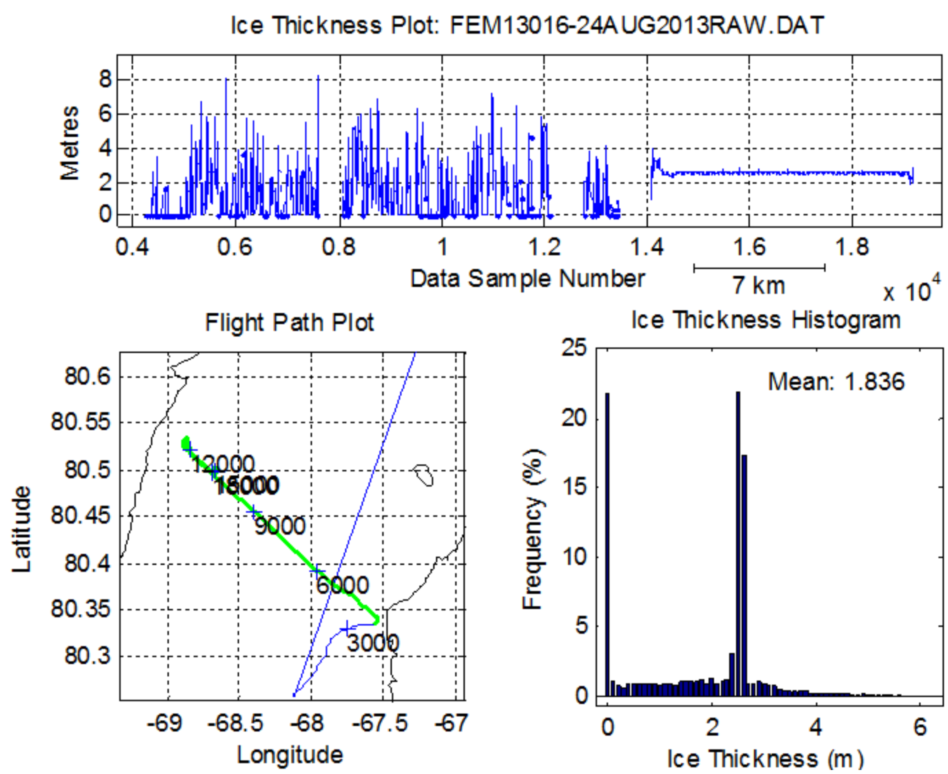


Figure 2.10. Helicopter flight track and ice thickness profile data from obtained in Kennedy Channel during a survey near Peterman Glacier in Leg 1.

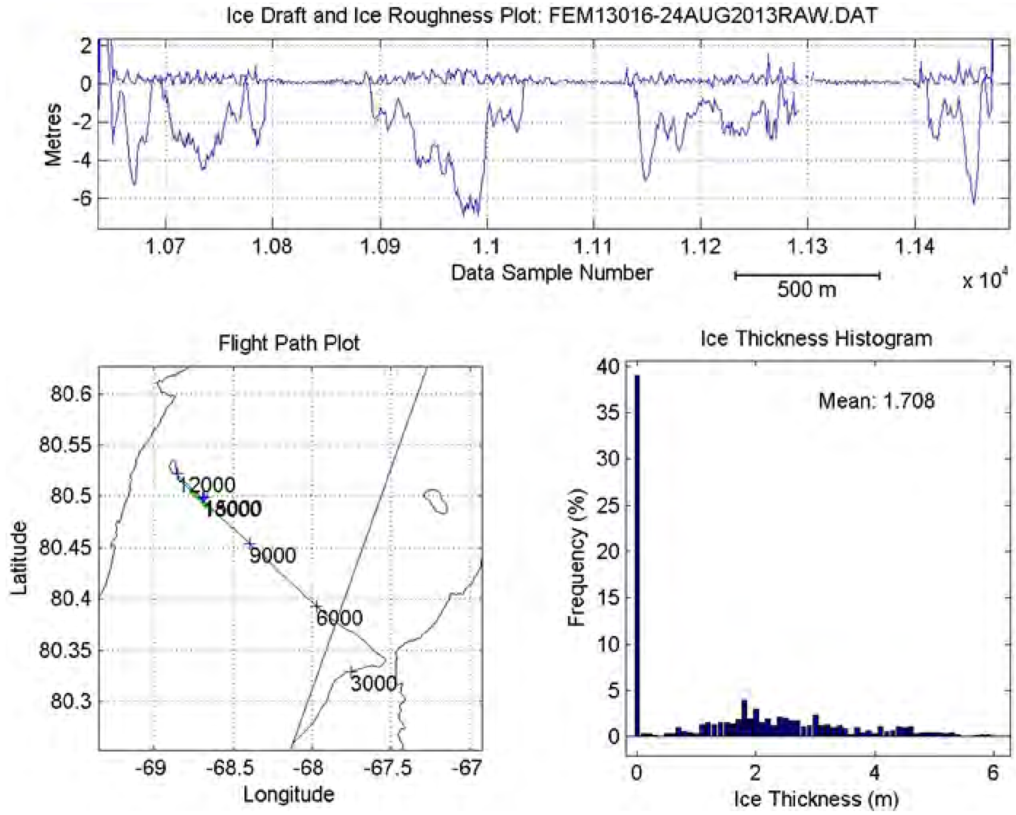


Figure 2.11. Section (in green) of the helicopter survey shown in Figure 2.10 across Kennedy Channel showing four distinct ice floes.

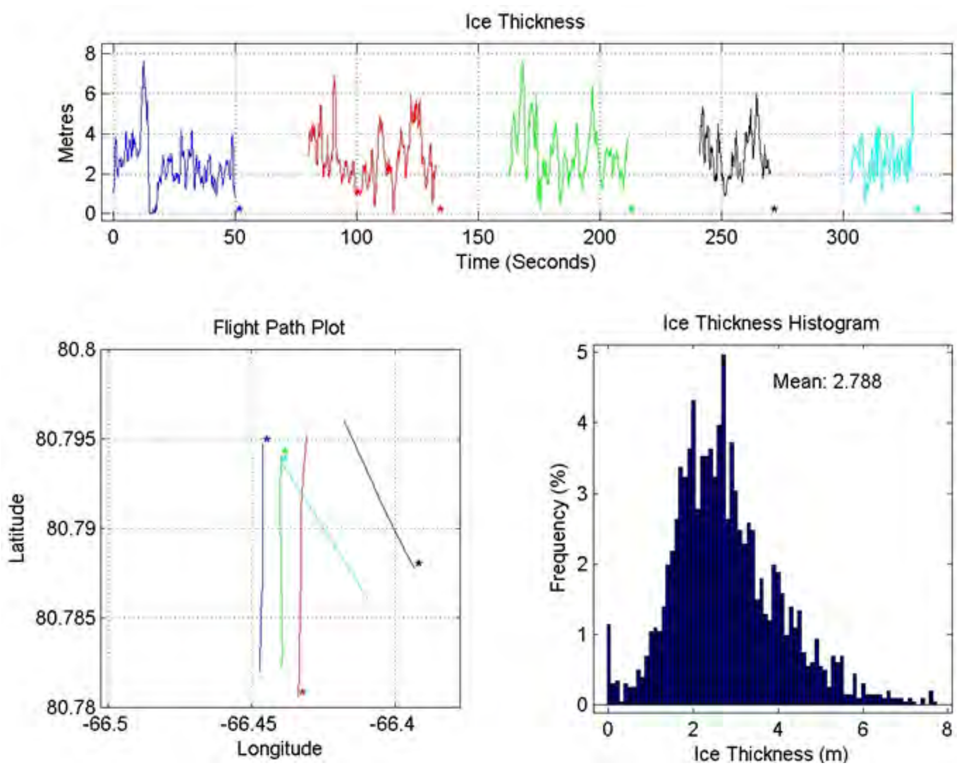


Figure 2.12. Helicopter flight track and ice thickness profile data from obtained from five passes over a floe south of Crozier Island in Leg 1.

Ice volume across Kennedy Channel was estimated from the ice thickness profiles obtained at several locations. The following method and definitions were used in the calculation:

% open water along sampled profile track length: this value is the zero ice thickness bin and thus represents open water within the pack ice sample along the sampled track and does not include "Background Check (BG)" values where the helicopter was too high and no ice values were taken and listed as NA = non available; so track or **transect length L** is the profile length including the Back Ground BG track length covered.

Mean thickness (**total profile thickness**) is the average ice thickness sampled along the track including the zero thickness values as recorded in the %; but excluding samples in the BG area. It is listed in the ice thickness histogram plots.

Mean ice-only thickness is the ice thickness of ice floes only, excluding open water areas, and represents the floes true mean ice thickness.

Mean ice thickness T over transect is the ice thickness along the transect and included areas near the coast where zero ice was present. This is the lowest mean ice thickness but represents the total transect ice thickness from coast to coast to calculate the ice flux through the cross section.

Multiplying the **width W of the Channel** with the mean ice thickness T gives the ice cross sectional area that is required to be multiplied by an ice drift to get the ice flux. Note that at times the sample track length and coastal sections not sampled added up to a length that was longer than the width. This occurred when the transect was not perpendicular to the channel axis (i.e. FEM13016).

Drift rate from a single beacon traveling 100 km over the first 4.5 days or 0.9km/hr. Note that late on 29 August, under strong NW winds of 25 knots, two beacons traveled 30 km in 12 hours or 2.5 km/hr along the Canadian coast in Kane Basin.

Table 2.9. Mean ice thicknesses along transects flown across Kennedy Channel during Leg 1.

	Transect #				
	1	**2**	**3**	**4**	**5**
Latitude in centre of Channel (°N)	81.10	80.95	80.83	80.55	80.45
FEM #	13006	13012	13011	13017	13016
% open water	31.5	19.5	23.6	42.0	36.0
Total profile thickness (m)	1.204	1.48	1.28	1.11	1.38
Mean ice only thickness (m)	1.78	1.83	1.67	1.91	2.16
Mean ice thickness over transect T (m)	1.21	1.18	1.02	0.92	1.04
Transect length L (km)	170	27.2	36.6	34.0	31.0
Transect with zero ice at ends (km)	----	6.8	7.3	7.0	10.0
Channel length W (km)	36.0	34.0	36.6	41.0	35.0
Ice cross section area WxT (10^4 m^2)	4.36	4.01	3.73	3.79	3.65
Drift rate (cm/s)	25	25	25	25	25
Ice volume flux x ($10^4 m^3$/sec)	1.1	1.0	0.95	0.95	0.91

These ice fluxes appear large but they represent only 0.01 Sv, where Sv is the oceanic water transport unit equivalent to 10^6 m^3/s. In comparison, the water transport through Kennedy Channel is two orders of magnitude larger and the freshwater transport through the Channel is an order of magnitude larger.

2.6 Comments and recommendations (Leg 1 only)

2.6.1 Upper atmosphere program

The upper atmosphere program ran smoothly during Leg 1. The only recommendations suggested here would be to have a sun photometer to measure the optical depth of the atmosphere and to have several high resolution forward, port, starboard and aft looking cameras to give relative directions to ice features of interest and to record the sea state.

2.6.2 Remote sensing and physical sampling program

No major problems were encountered during Leg 1. Ice conditions made finding a suitable floe for 24-hour EM measurements very challenging. Taking a 2-m long core sample (instead of the standard 1-m core) was feasible and provided useful information that will aid in the interpretation of L-band and C-band scatterometer signatures, as well as in analysis of the ice floe morphology.

The L-band scatterometer system was exposed to the elements on top of the wheelhouse, and it must be covered with a tarp when it is not being used. A better method for protecting the system (such as building a small storage shed) should be considered for future cruises.

2.6.3 Ice dynamics program

It is imperative that all beacons work properly before deploying them on ice. Prior to departing for the field, it is highly recommended that all beacons are tested to ensure the longevity of the beacon on an ice floe.

3 Ice Islands – Drift, deterioration and identification – Leg 1a

ArcticNet Phase 3 – Project titled *Sea Ice, Climate Change and the Marine Ecosystem.* ArcticNet/Phase3/Sea-ice.

Project leader: Derek Mueller[1] (derek.mueller@carleton.ca)
Cruise participants Leg 1a: Anna Crawford[1] and Melissa Nacke[1]
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3.1 Introduction

Ice islands (large, tabular icebergs) are hazards to offshore industry in the Canadian Arctic. They are created after break-off events (calving) from floating glacial tongues (Greenland) or ice shelves (Ellesmere Island, NU, Canada). Since 2000, the Eastern Canadian Arctic has seen an influx of ice islands originating from the Petermann Glacier of NW Greenland (Peterson 2005; Peterson 2011; Halliday et al. 2012). The increased frequency of ice island calving events has been linked to environmental (ocean temperatures, reduced sea ice) changes associated with climate change (Johannessen et al. 2011). This has led to a greater number of ice hazards along Canada's east coast and pose risks to offshore natural resource extraction already underway (Grand Banks, NL) and activity (resource extraction and shipping) poised to expand into the Labrador Sea and Baffin Bay.

Drift and deterioration modelling of ice islands has begun in order to avoid an economically and environmentally destructive collision between an ice island and offshore equipment or operating vessels (Crocker 2012). These have not been validated with *in-situ* data. This project aims to collect relevant data to calibrate and validate these models and to gather basic dimensional and drift data to enlarge the sparse ice island informational database. Another important aspect of this project is the identification and monitoring of ice islands with remote-sensing. This will aid in ice hazard location during times of high sea ice concentration when identification of ice hazards is more difficult.

3.2 Methodology

The aim of the team during Leg 1a was to visit an ice island via helicopter to collect dimensional and drift information as well as install equipment to allow for remote monitoring and to record dimensional change. A re-visit is also planned for October for re-measurement of these installations and change calculation.

Two sites were to be established on opposite ends of PII-A-3, a fragment of the Petermann Ice Island (PII) which calved from the Petermann Glacier of NW Greenland in July 2012. This was a rectangular shape, approximately 5 km x 1 km in dimension. Two high precision GPS units were to be installed on at these two sites to record drift and rotation during the field visit. A ground penetrating radar transect would record ice thickness. Ablation stakes would be drilled into the ice along this transect so that surface melt and total thickness change could be assessed upon revisit in October. Air temperature and humidity would be recorded by a sensor at each stake for melt modelling efforts. GPS beacons would be placed at each site for remote monitoring of the ice island's drift between field visits. This would also help in RADARSAT-2 image acquisition. These images are then digitized for areal dimension change. Ice cores were to be taken for ice structure characterization and correlation to RADATSAT-2 data. Finally, photogrammetry work was to be conducted for 3D model creation, which would aid in deterioration and drift modelling efforts. Figure 3.1 shows common ice island morphological terminology.

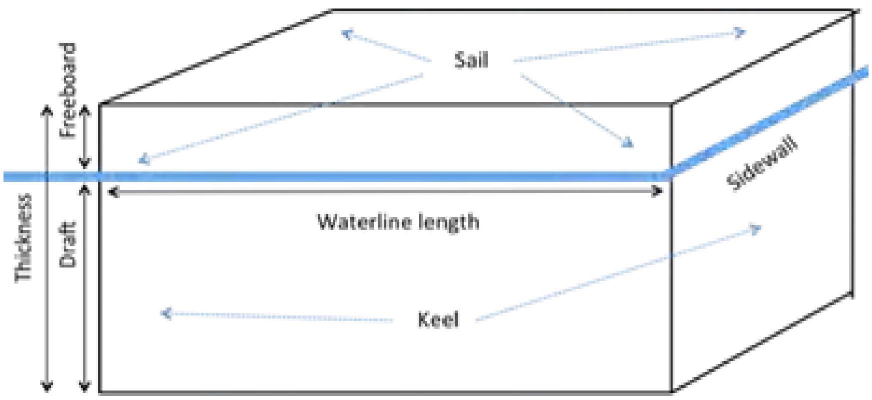

Figure 3.1. Ice island terminology.

3.3 Preliminary results

Unfortunately, the target ice island was surrounded by fog for the duration of time allocated to the ice island field work. Helicopter access was impossible and the effort had to be canceled for this field season.

Other researchers on board were able to collect data of interest, however, and make the best of the weather situation. The MVP recorded the surrounding water characteristics (surface to 200 m depth). The ROV made 2 dives – reaching both the sidewall at the water-edge, the ice island 'skirt' or 'ram' just under the water-edge and underneath the ice island. Initial data show the ice island to be approximately 80 m thick, with a 65 m keel and 15 m freeboard (Figure 3.2).

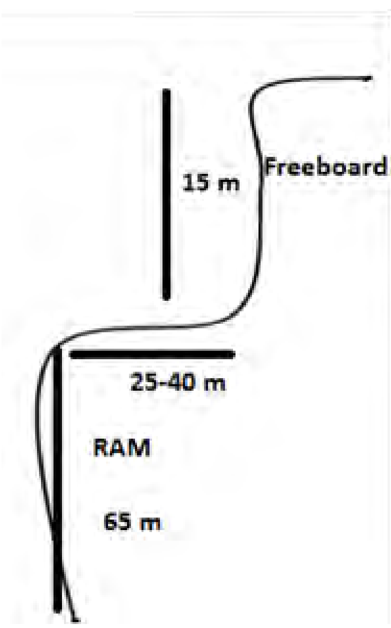

Figure 3.2. Initial ice island dimensional information provided by ROV dives.

3.4 Comments and recommendations

Field work was hampered by unfavourable weather. This is out of the control of any crew or researcher on board. To make future visits more likely to be successful, it would be helpful to have the ice island work scheduled for early or mid-leg. If the targeted ice island is surrounded by fog (or there is any other reason that field work cannot be conducted at that location or point in time) the field work can then be re-scheduled for a planned back-up target later on in the leg.

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Peterson IK (2005) Large tabular icebergs and ice islands off Eastern Canada in 2001-2003 and their probable source. Proc 18th Intl Conf on Port and Ocean Eng under Arctic Conditions 1:143-152. St. John’s, NL

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4 Mooring program – BaySys (Hudson Bay) and BREA (Beaufort Sea)

ArcticNet Phase 3 – Project titled *Long-Term Observatories in Canadian Arctic Waters.* ArcticNet/Phase3/Marine-observatories.
ArcticNet Phase 3 – Project titled *Freshwater-Marine Coupling in the Hudson Bay IRIS*. ArcticNet/Phase3/Freshwater-marine-coupling.

Project leaders: Louis Fortier[1] (louis.fortier@bio.ulaval.ca) and Martin Fortier[2] (Martin.Fortier@arcticnet.ulaval.ca)
Mooring operations participants BaySys (CCGS *Pierre Radisson*): Luc Michaud[1] and Shawn Meredyk[2]
Mooring operations participants BREA (CCGS *Sir Wilfrid Laurier*): IMG-Golder Corporation
[1] *Université Laval, Québec-Océan, Pavillon Alexandre-Vachon local 2078, 1045 avenue de la Médecine, Québec, QC, G1V 0A6, Canada.*
[2] *ArcticNet, Université Laval, Pavillon Alexandre-Vachon local 4081, 1045 avenue de la Médecine, Québec, QC, Canada, G1V 0A6, Canada.*

4.1 Introduction

4.1.1 BaySys – Hudson Bay

BaySys is an ArcticNet funded project to procure environmental water quality data and inter-annual water mass movements in the west and southwest areas of Hudson Bay's, to monitor the Nelson River's environmental characteristics (hydroelectric dam installations are present) and to sample the Hayes River, a control site where there is currently no anthropogenic influence.

4.1.2 BREA – Beaufort Sea marine observatories project

As part of the Beaufort Regional Environmental Assessment (BREA) program, ArcticNet and IMG-Golder deployed moored oceanographic instruments in the Beaufort Sea from September 2012 to October 2013. The aim of these moorings, or permanent observatories, is to characterize physical oceanographic conditions from surface to bottom, as well as sea ice draft and velocity, at the margin and over the continental slope. The data collected will advance knowledge of the regional and multi-annual oceanography (ocean circulation, biogeochemical fluxes and sea ice data time series) and contribute information that is relevant to environmental assessment of offshore drilling and other Oil & Gas activity in the Beaufort Sea. The specific objectives of the ArcticNet/IMG-Golder Beaufort Sea Observatories project were to:

- Quantify the along shelf and across shelf seasonal and annual variability in oceanic circulation and related water mass assemblage and properties.
- Quantify the annual movement and thickness distribution of sea-ice, with a special emphasis on heavy thick multi-year ice features.
- Quantify the seasonal and annual variability of particulate matter fluxes of organic and inorganic matter at the shelf edge and on the mid-slope.

- Maintain existing time-series in Exploration Licenses (EL) 476 and 477, and fill important gaps in the northeastern Beaufort Sea.

4.2 Methodology – Hudson Bay mooring operations (BaySys)

The BaySys Expedition took place in western Hudson Bay, near Churchill, Manitoba (Figure 4.1) onboard the CCGS *Pierre Radisson*. The two rivers (Nelson (West) and Hayes (East)) were explored and surface water samples were collected by the CEOS / U. Manitoba team. Stations 782 and 784 were not sampled as was initially planned. All of the other stations were sampled as Nutrient stations.

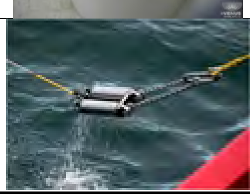
Mooring AN01 (Station 707) is a long-term mooring site at 107 m depth with 7 years of data already recorded. The objective of the mooring at this location is to monitor the W–SW area of the Hudson Bay's inter-annual water mass movements. A mooring recovery and re-deployment was planned at Station 707 (AN01).

Figure 4.1. The route and locations of stations as in the Expedition Plan for the BaysSys cruise. Note that Stations 782 and 784 were not sampled as was initially planned.

4.2.1 *Mooring design and instrumentation*

Mooring AN01-13 was designed in a taut-line configuration consisting of a top float, CTD (RCM11), hydrophone (Aural M2), in-line float, current profiler (ADCP), sediment trap (Technicap PPS 3/3), two mooring releases (Benthos 861B2S) and an anchor (two train wheels) (Table 4.1).

Table 4.1. Description of oceanographic equipment as deployed on mooring AN01-13 (Station 707).

Photo	Description and specifications
	The Aanderaa RCM11 was used to record the CTD and single-point (0.1m resolution) water current velocity. Depth 30m
	The AURAL M2 hydrophone from Multiélectronique was deployed to record underwater sounds at a sampling rate of 16 kHz. Depth 40m
	The RDI-Teledyne 300 kHz Quarter Master (QM) Acoustic Doppler Current Profiler (ADCP) was housed in stainless steel cage and four Viny floats were attached to each side of the ADCP cage. The upward looking profiler was used at approximately 75m water depth to profile currents with a vertical resolution of 0.8 m with a standard deviation of 2.84 cm/s upwards for 82m. Depth 74 m
	Technicap PPS 3/3-24S 24 cup sequential sediment trap was deployed to record the annual cycle in vertical carbon flux. Depth 85m
	Dual / tandem RDI-Teledyne Benthos 861B2S acoustic releases were used as the primary recovery / release device. Depth 100m

The mooring diagram for equipment as deployed on AN01-13 is shown in Figure 4.2. The water depths are based on the sum of individual component lengths in the mooring design with a target top float depth of approximately 30 m.

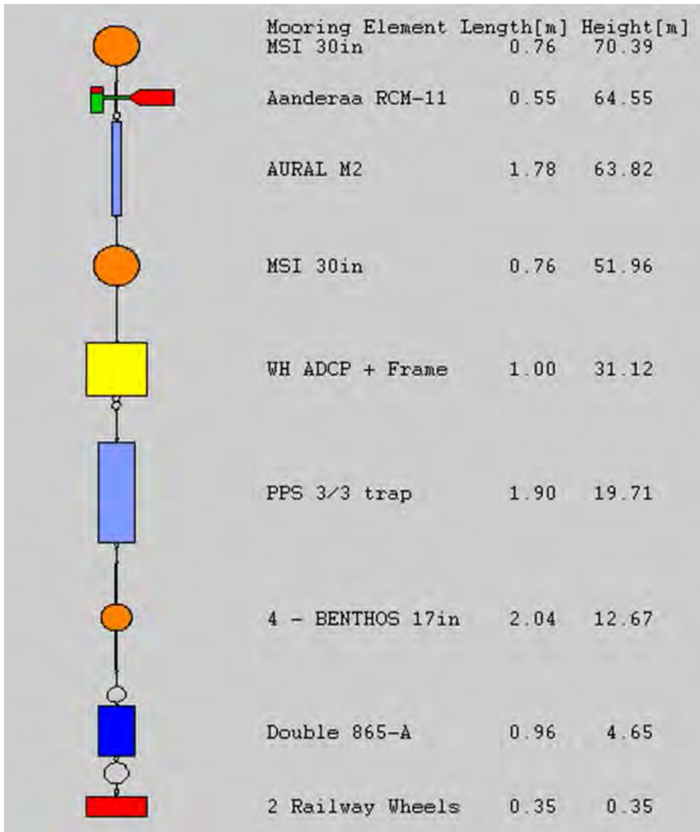


Figure 4.2. Block Diagram of equipment connections used in AN01-13 mooring design and modelling simulations.

4.2.2 Field calibrations

Compass accuracy is essential for current meters deployed near or above the Arctic Circle, due to the reduced magnitude of the horizontal component of the earth's magnetic field. Therefore, it was important to calibrate internal compasses near the approximate latitude where they were deployed and care was taken to eliminate all ferrous material in the mooring cages and in the calibration environment (shipboard calibrations are therefore impossible).

The *Radisson* was unable to make port in Churchill due to adverse weather and the *Radisson*'s helicopter was used to make passenger and equipment transfers. All ArcticNet personnel brought coast guard-standard Mustang immersion suits for Helicopter transfers to and from the *Radisson*. A safety briefing was conducted prior to boarding the helicopter and the team attended the *Radisson* safety briefing and familiarization on the ship.

Figure 4.3. Helicopter transfer to non-ferrous calibration location 7 miles up the Churchill River, MB.

The compass calibrations, prior to deployment on the mooring, were completed on 29 August at a site situated 7 miles up Churchill River, on the outskirts of Churchill, Manitoba (58°40.536'N, 94°10.072'W), near a culvert flow recording station. This site was used previously for calibrations and is known to be non-ferrous.

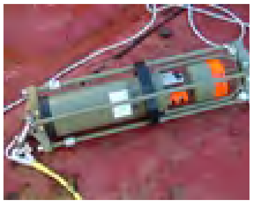
The calibrations were conducted with a leveled tilt and rotate jig/table (Figure 4.4). The calibration procedures followed standard manufacturer protocols for each instrument. The general calibration procedure is outlined in Table 4.2 and followed these steps:

- Communication was established with the instrument using the manufacturer's calibration software after a serial communication line was connected to the instrument.
- Power was provided to the instrument by the instrument's internal battery pack.
- The current meters were oriented in the configuration in which they would be deployed.
- On-screen directions were followed to rotate the instrument through 360 degrees with varying degrees of pitch and roll, until a successful calibration was achieved.

True North was determined by placing a marker along the same longitude as the calibration table 0 heading (placed using a handheld Garmin GPS). Magnetic declination was determined by observing the difference between the magnetic north heading seen on an analog magnetic compass and the heading of true north identified by the distant marker.

Figure 4.4. The calibration table / jig leveled and loaded with an RCM 11 being readied for calibration before deployment on the mooring.

Table 4.2. Mooring AN01-13 oceanographic equipment and calibration procedures.

Instrument	Location	Purpose	Equipment used	Calibration procedure
Aanderaa RCM #266 	Churchill, MB 58°40.536'N 94°10.072'W	Single-Point water velocity profiler and CTD	Calibration Table / Jig, RCM Deck Unit , Laptop to record readings from Deck Unit	Install into calibration table, point to 0 heading and record the sensor readings, when similar consecutive readings are recorded, advance the table by 10° and continue until 360° is reached. These readings are converted into headings and the deviation between device and calibration table heading is determined.
RDI 300 kHz Quarter Master ADCP #5560 and #8682 	Churchill, MB 58°40.536'N 94°10.072'W	4 beam 3D water velocity profiler	Calibration Table / Jig, Laptop with WinSC installed, USB to Serial adapter	Install into calibration table, point to 0 heading and open WinSC software, 'test' unit to verify all tests pass, set unit to zero pressure, set unit to UTC, verify compass, calibrate compass using af command, record the heading deviation by using pc2 to view the heading of the ADCP relative to the calibration table heading, measured at 15° intervals.

<u>Calibration problems</u>

RCM11 (#266) deck unit failed to register correct readings during the first calibration attempt after heading 250 and a power cycle solved this problem. RCM11 (#266) required several readings at the same heading before true readings were obtained. RCM 11 #266 was pre-tested at Université Laval's experimental farm location and its compass operations passed calibration / verification on 30 April 2013. Overall, the RCM 11 #266 calibration data was sporadic and a **post-calibration will be necessary**.

ADCP 8682 failed compass calibration twice (would not read 180 to 360 degree headings); therefore, ADCP 8682 was not used and unit 5560 was then successfully calibrated and used for deployment. The calibration error of 6.6° was however higher than the recommended value and of that previously recorded on 30 April 2013 (3.7°) and a **post-calibration is recommended.**

4.2.3 Mooring operations

A mooring operations meeting / information session was led by L. Michaud (ArcticNet) with attending Coast Guard crew, the night before recovery and deployment operations commenced (on 29 August). The information session was held to instruct the coast guard crew of the general steps in mooring operations, each person's role and responsibility, safety considerations (Hard Hats, Mustang Suits, Eye Protection, Safety Harness, Safety Knife / Steel Pick, Gloves and Steel-Toe Rubber Boots) and to address any questions that the mooring or ship's crew might have. The mooring team (ArcticNet) also met the night before to address any safety or operational concerns. A Toolbox Meeting was also held on the foredeck prior to each deployment/recovery operation to review the procedures, roles and safety considerations.

<u>**Mooring recovery**</u>

Mooring AN01-12 was not recovered due to complications in communicating with the Benthos mooring releases. A weighted transducer (metal rod taped to the cable, just above the transducer head) and Benthos deck box were used to communicate with the mooring releases. The enable codes were confirmed and reconfirmed, to no avail. After 2 hours of trying to communicate with the releases and making sure to have the ship's echo sounder turned-off, the ship's engines were also turned off but unfortunately to no avail.

Figure 4.5. Trying to communicate with the unresponsive mooring releases for AN01-12, using the Zodiac to eliminate any possible acoustic interference from the CCGS *Pierre Radisson.*

A Zodiac with the Benthos deck unit and weighted transducer were then deployed and communication with the mooring releases was tried again for an hour, unfortunately, without any response (Figure 4.5). At this point the search for the mooring releases was aborted (13:30, 30 August 2013).

<u>**Mooring deployment**</u>

Mooring AN01-13 was deployed top-down, starting with the top float and ending with a free-falling anchor (two train wheels). Sea ice was not present during the deployment, there were sunny skies and the sea state was relatively calm (Beaufort F3 – 15 knot winds at 260° heading; 1-1.5 m wave height; Air Temp 9°C). The mooring diagram for equipment as deployed on AN01-13 is shown in Figure 4.2. The water depths are based on the sum of individual component lengths in the mooring design with a target top float depth of approximately 30 m.

<u>*Mooring deployment procedure*</u>

- Confirm that the mooring design is proper for the site conditions.
- Hold a Toolbox meeting with Mooring and Ship's crew to identify roles and review safety considerations.
- Program the ADCP, Hydrophone, Technicap carousel motor (sediment trap) and RCM 11 for the desired sampling rate and deployment period (specific start date and time).
- Verify Mooring releases function properly.

- Assemble the mooring top-down on the foredeck as per mooring design (Figure 4.6)

Figure 4.6. Mooring AN01-13 assembled on the foredeck of CCGS *Pierre Radisson* in Hudson Bay, ready for deployment.

- Launch the Zodiac
- Perform a pre-deployment CTD cast for vertical profile of water column properties (0.5 m sec^{-1} descent / ascent rate).
- Record date and time at the start of the mooring operations.
- Attach a throw-line to top metal loop of the top float and secure the SeaCatch® (connected to the bottom of the crane's hook) to the bottom metal loop of the top float.
- Throw the throw-line to the Zodiac and have the Zodiac attach the throw-line to the bow horn / tack.

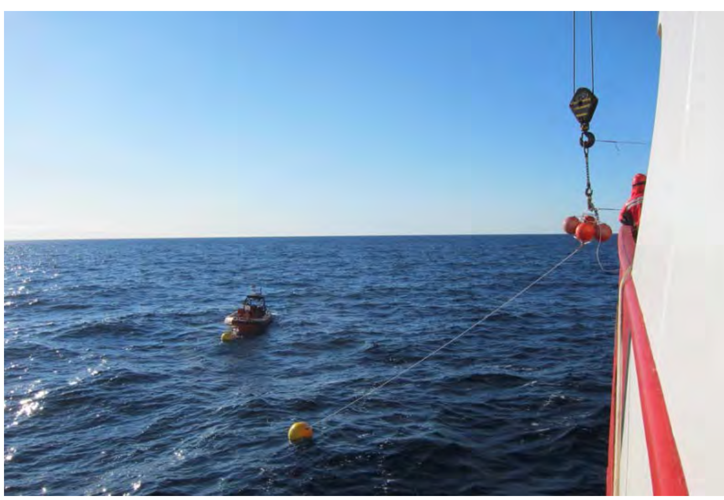
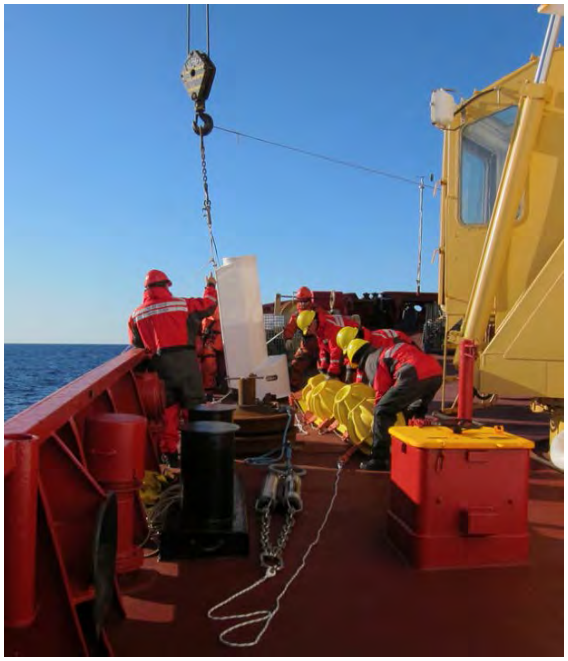


Figure 4.7. Zodiac-assisted mooring deployment on the CCGS Pierre Radisson in Hudson Bay. The top float and mid float are already in-water, ADCP being lowered to water surface.

- Raise and then lower the mooring float, release the safety pin of the SeaCatch®, at deck level, then release the SeaCatch® and top float on the water surface.
- Tack / secure the mooring line and instruct the Zodiac to maintain a taut-line (not tight), unless otherwise instructed by the lead mooring professional or boswain (Figure 4.7)



- Attach the SeaCatch® to a solid structure (i.e. cage) or add an extra shackle to the top-side of the next device. Then raise the SeaCatch® with the crane as the mooring line in-tack is released.
- Repeat the same procedure of lowering the device to the water then putting the mooring line on tack, then attaching the SeaCatch® to the top-side of the next device until each device is in the water (Figure 4.8). Meanwhile the Zodiac continues to maintain a taut-line, so as to not allow for the deployed / in-water equipment to get entangled.

Figure 4.8. The foredeck setup during the deployment of mooring AN01-13 using the port foredeck crane of the *Radisson*.

- The final release of the anchor is preceded by the Zodiac releasing its tack of the top float (trying to retain its tack line, or at least a good portion of it).
- Release the SeaCatch® on the Anchor chain shackle (located in the middle of the 2 m anchor chain just above the protective chain cylinder) and let the mooring free-fall into position.
- Note the time and mooring / target location of the last seen vertical position of the top float on-descent (by the Zodiac).
- Proceed to 3 triangulation points around the target location (by the *Radisson*) where the mooring releases are ranged ('pinged') to allow for a position and range to target. Input these data into a MatLab® triangulation script to determine the triangulated position of the mooring.
- Return the zodiac to the vessel and secure the foredeck crane and other equipment.
- Carry out a post-deployment CTD cast / profile to account for any change in sea state/water masses that occurred between pre and post deployment times.
- Conclude the mooring operations and record the date and time.

Triangulation of mooring position procedures

The Zodiac from the *Radisson* was used both in the deployment of mooring AN01-13 and in the triangulation of its position. After deployment, the Zodiac moved to where the top float was last seen descending and marked this as the target location. Then the *Radisson* moved to three marked positions around this target location. At each marked position, a Benthos Deck box and transducer were used to communicate to both mooring releases.

The ping / enable command was received with a ranged distance from both of the releases, which needed to be within 1 m of each other, and recorded (Table 4.3).

Table 4.3. Triangulation data for mooring AN01-13 deployed in Hudson Bay.

Source	Latitude N	Longitude W	Range (m)
AN01-13 (Zodiac)	59°58.2570	091°58.4293	
Position 1	59°58.2937	091°58.3188	157
Position 2	59°58.3167	091°58.5104	165
Position 3	59°58.1792	091°58.4154	157
AN01-13 (Triangulated)	59°58.2529	091°58.4344	

The range and bearing data is then input into the publicly available MatLab® triangulation program called 'Art's Acoustic Survey Software' and generates the triangulated position and provides a graphical arc plot of the positions and triangulated position (Figure 4.10).

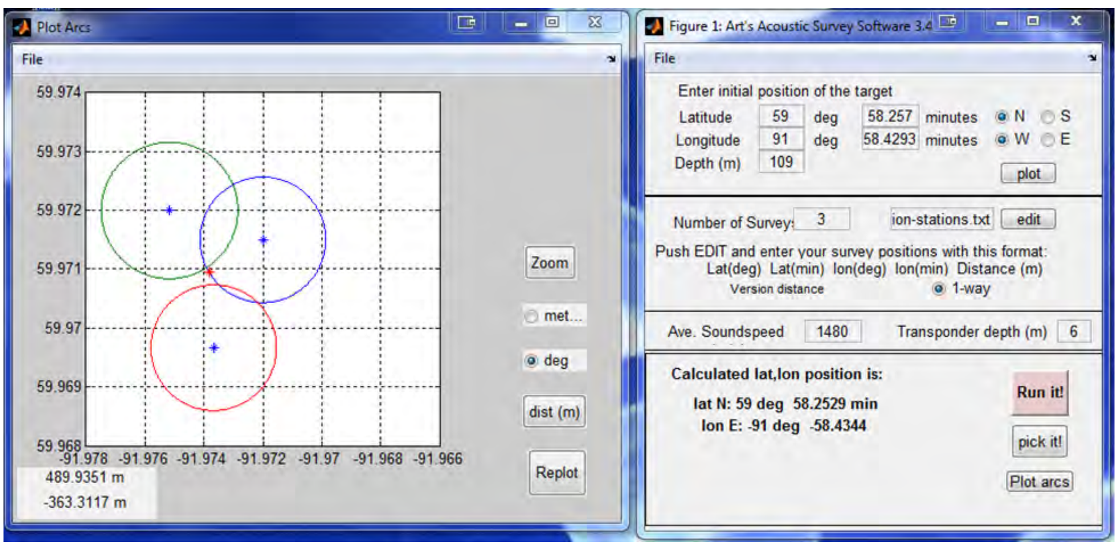


Figure 4.9. Triangulation screenshot of plotted Arcs with indicated triangulated position of the mooring (red star).

4.3 Methodology – Beaufort Sea mooring operations (BREA)

The mooring operations took place on the CCGS *Sir Wilfrid Laurier* from 30 September to 11 October 2013. They were conducted as part of the Beaufort Regional Environmental Asessment (BREA) program led by ArcticNet/IMG-Golder personnel with support from Fisheries and Oceans' Institute of Ocean Sciences (DFO-IOS). Five moorings were successfully deployed in 2012 and recovered in 2013: two in EL 446 (BR-A-12 and BR-B-12), one in EL476 (BR-G-12) and two across the Mackenzie Trough Area (BR-01-11 and BR-02-12).

4.3.1 Mooring design and instrumentation

All the moorings recovered in 2013 were designed in a taut-line configuration, with in-line buoyancy and steel anchor weights (train wheels). The moorings consisted of pairs of similarly designed moorings, each pair consisting of one long mooring (~700-750 m depth) located on the mid-to-lower continental slope and one short mooring (~150 m water depth) located near the continental shelf edge, which is situated bout 80-100 m depth. Diagrams of the BREA moorings and detailed descriptions of each the components and instruments can be found in IMG-Golder mooring report (2015).

The long moorings consisted of the following components and instruments:

- Ice Profiling Sonar (IPS, ASL Environmental Sciences Ltd (ASL)) at approximately 60 m depth to measure ice draft and non-directional waves during intervals of open water. IPS were mounted in 30-inch spherical Mooting Systems International (MSI) syntactic foam floats.
- 150 kHz Quarter Master Acoustic Doppler Current Profilers (QM-ADCP, Teledyne RD Instruments (TRDI)) were used at approximately 200 m water depth to profile upper water column currents with a vertical resolution of 8 m, as well as measure ice velocity using the Bottom-Track feature. The QM-ADCPs were mounted up-looking in 40-inch syntactic foam floats manufactured by Flotation Technologies.
- 75 kHz Long Ranger ADCPs (LR-ADCP, TRDI) were used at approximately 450 m water depth to measure water velocity profiles at a coarser 16 m resolution. The LR-ADCPs were mounted up-looking in 40-inch syntactic foam floats manufactured by Flotation Technologies.
- On moorings deployed in water depths greater than 500 m, high frequency short range (< 1 m) Nortek Aquadopp DW (AQD) single point current meters were used approximately every 100 m to measure water velocity.
- Two Technicap PPS 3/3-24S 24 cup sequential sediment traps were deployed between the IPS, QM-ADCP and LR-ADCP to record the annual cycle in vertical carbon flux.
- Conductivity and temperature loggers (CT, RBR Ltd) were installed at various depths to measure water temperature and salinity and to compute sound speed (used to improve IPS and ADCP processing). In some case conductivity temperature and depth (CTD) loggers were used on the moorings.
- Various smaller syntactic foam floats were distributed along the mooring as required.
- Tandem ORE Edgetech acoustic releases were used as the primary recovery device.

The shallow moorings consisted of the following components and instruments:

- IPS were used at approximately 60 m depth to measure ice draft and non-directional waves during intervals of open water. IPS were mounted on an ASL dual cage with 8 Viny 12B3 floats.
- 300 kHz Workhorse Sentinel Acoustic Doppler Current Profilers (WHS-ADCP, TRDI) were used at approximately 130 to 140 m water depth to profile currents with a vertical resolution of 8 m, as well as measure ice velocity using the Bottom-Track feature. The WHS-ADCPs were mounted on ASL dual cages.

- Conductivity and temperature loggers (CT, RBR Ltd) were installed at various depths to measure water temperature and salinity and to compute sound speed (used to improve IPS and ADCP processing). In some case conductivity temperature and depth (CTD) loggers were used on the moorings. Additionally, certain RBR loggers also have auxiliary sensors to measure turbidity, dissolved oxygen, fluorometry and chlorophyll.
- Laser In-Situ Scattering Transmissometer (LISST, Sequoia) 100X systems were located 18 m above the seafloor to provide measurements of particle size distributions and associated volume concentrations in the lower water column. The LISST measurements will help to better quantify the seasonal and annual variability of vertical and horizontal fluxes of organic and inorganic solids.
- 1 MHz Nortek Aquadopp profiling current meters (AQP) were mounted down-looking below the LISST instrument to provide details of the flow and acoustic backscatter structure near the seafloor on the continental shelf edge. The AQPs measure three-dimensional current velocities and provide a measure of acoustic backscatter intensity in 2 m range bins from the bottom to about 16 m above the seabed. Combined with the velocity profile information from upward looking ADCPs the profilers provide a detailed and near complete view of the water column vertical structure.
- Additional Viny floats were located above the LISST cage to provide floatation for the lower portion of the mooring.
- Tandem ORE Edgetech acoustic releases were used as the primary recovery device.

4.3.2 Calibration/correction of current meters

Pressure sensors on the TRDI ADCPs were zeroed at the time of setup in order to account for atmospheric pressure in the depth calculation. Processing routines were used to convert pressure measured by the Nortek AQDs to water depth; pressure measurements in air before and after the instrument deployment were averaged to account for atmospheric pressure.

Easting and northing current directions were corrected to true north based on local magnetic declination. An annual average magnetic declination was used for the deployment period based on the Natural Resources Canada numerical model for the International Geomagnetic Reference Field (http://www.geomag.nrcan.gc.ca/calc/mdcal-eng.php). Over the course of the year-long deployment (September 2012 to October 2013), the declination was found to vary by less than 1 degree. Table 4.4 summarizes the declination used for each mooring site.

Table 4.4. Magnetic declination values used to correct current meters deployed on the 2012-2013 BREA moorings recovered in the Beaufort Sea in September and October of 2013.

Mooring ID	Magnetic declination (deg E)
BR-A-12	25.1°
BR-B-12	25.1°
BR-G-12	25.2°
BR-01-12	24.5°
BR-02-12	24.6°

4.3.3 Mooring recoveries

The CCGS *Laurier* recovered the 5 BREA moorings from 30 September to 11 October 2013 (Table 4.5).

Table 4.5. Summary of locations and deployment/recovery dates for the 5 BREA moorings retrieved in the Beaufort Sea in 2013.

Mooring ID	Latitude N	Longitude W	Water depth (m)	2012 deployment (UTC)	2013 recovery (UTC)
BR-A-12	70°45.408	136°00.798	660	25 Sep 2012 22:30:34	30 Sep 2013 00:54:00
BR-B-12	70°40.296	135°35.172	156	29 Sep 2012 15:39:40	30Sep 2013 15:16:00
BR-G-12	71°00.468	135°29.910	703	01 Oct 2012 02:08:00	03 Oct 2013 17:41:00
BR-01-12	70°26.010	139°01.392	753	04 Oct 2012 23:22:00	11 Oct 2013 00:58:00
BR-02-12	69°59.478	137°57.648	155	04 Oct 2012 17:49:20	09 Oct 2013 20:34:00

<u>Recovery procedure</u>

When the ship arrived at each mooring location, an acoustic transponder was lowered over the side of the ship from the port side of the foredeck. Commands were sent from an Edgetech 8011M deck box located in the mooring container on the foredeck to enable one or both of the acoustic releases associated with the mooring and to determine range. A command was sent to release the mooring. The mooring components then surface and were towed alongside (starboard) the bow area using the fast rescue craft (FRC). The FRC then connected the IPS cage to the crane hook. Individual mooring elements were lifted onto the foredeck using the overhead crane and boom; the mooring line recovered by hand over the side. Once on the foredeck, the instruments were inspected, rinsed with freshwater, and lowered into the between decks hold for servicing. The recovered moorings were transferred to the DFO-IOS warehouse at Patricia Bay near Sidney, BC for servicing by Golder personnel, which was carried out on 4-8 November 2013.

4.4 Preliminary results – Hudson Bay mooring operations (BaySys)

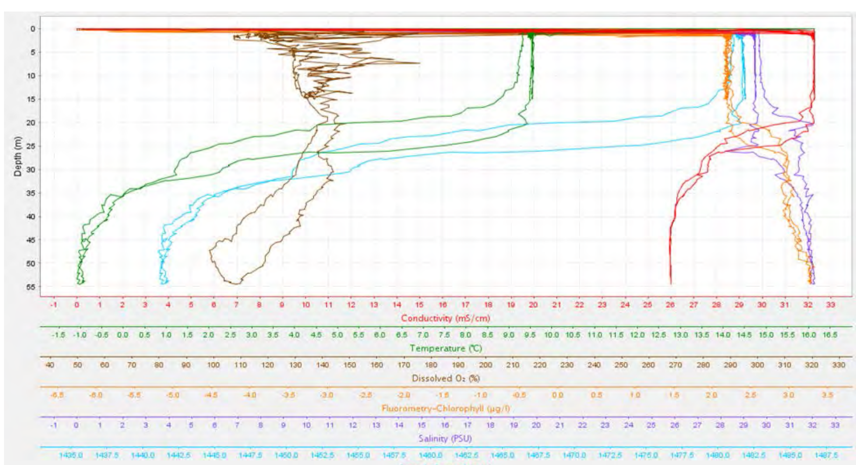


Figure 4.10. Pre-deployment CTD vertical profiles conducted at Station 707 / Mooring site AN01-13 in Hudson Bay as part of the BaySys expedition.

4.5 Comments and recommendations – Hudson Bay mooring operations (BaySys)

Non-taut mooring line during deployment can cause large items (i.e. sediment traps) to get entangled between taut and slack line periods during deployment. The Zodiac operator needs to be mindful to keep a taut-line; however, not a tight line. As too much slack in the line during deployment could result in an entangled device (large sediment traps and ADCP cages are most susceptible).

Table 4.6. Summary of Lessons Learned during the BaySys expedition in Hudson Bay.

Problem	Solution	Operation
Lost time in calibration Procedure due to compass verification failure for ADCP 5560	Verify compass operation at the experimental farm location before mobilization, as a positive in-lab verification of compass operations lead to a failure in the field	Calibration
Sporadic readings from the RCM 11 #266 during calibration was not expected as this unit was pre-tested at the University of Laval's experimental farm test location April 30th, 2013 and the data indicated that this unit is working properly.	A solution to this odd calibration experience is not evident at this moment and a post-calibration of this device will be necessary.	Calibration
The ADCP 5560 was successfully calibrated but a larger than expected (3.7°) compass error (6.6°) was recorded.	A solution to this odd calibration experience is not evident at this moment and a post-calibration of this device will be necessary.	Calibration
Non-taut mooring line during deployment can cause large items (i.e. sediment traps) to get entangled between taut and slack line periods during deployment	Zodiac operator needs to be mindful to keep a taut-line; however, not a tight line. As too much slack in the line during deploy could result in an entangled device (large sediment traps and ADCP cages are most susceptible)	Deployment

References

Meredyk, S. 2014. 2013 ArcticNet Mooring Program Report – BaySys, ArcticNet Inc. 22 p.

IMG-Golder. 2015. Beaufort Regional Environmental Assessment, Southern and Northeastern Beaufort Sea Marine Observatories, Field Data Report, 2012-2013 Program BREA Moorings A, B, G, 01 and 02. Report Number 14047 18/6000/6001. 135 pp.

5 Water column structure and ocean circulation (CTD-Rosette, ADCP and UVP operations) – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change.* ArcticNet/Phase3/Marine-ecosystem-services.

Project leader: Yves Gratton[1] (yves_gratton@ete.inrs.ca)
Cruise participants Legs 1a and 1b: Jessy Barrette[2] and Guislain Bécu[2,3]
Cruise participants Leg 2a: Pascal Guillot[4] and Mélany Belzile[2]

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[2] *ArcticNet, Université Laval, Pavillon Alexandre-Vachon local 4081, 1045 avenue de la Médecine, Québec, QC, G1V 0A6, Canada.*
[3] *TAKUVIK, UMI 3376 CNRS and Université Laval, Pavillon Alexandre-Vachon, local 2058, 1045 avenue de la Médecine, Québec, QC, G1V 0A6, Canada.*
[4] *Québec-Océan, Université Laval, Pavillon Alexandre-Vachon local 2078, 1045 avenue de la Médecine, Québec, QC, G1V 0A6, Canada.*

5.1 Introduction

The objective of the ocean circulation and water column structure program onboard the *Amundsen* is to characterize the water column physical and chemical properties: temperature, salinity, fluorescence, CDOM, dissolved oxygen concentration, nitrate concentration, light penetration and turbidity.

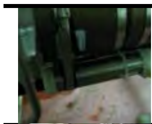
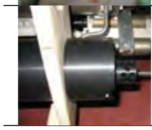
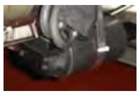
5.2 Methodology – CTD-Rosette

5.2.1 Instrumentation

A SBE 911 CTD with various other sensors (Tables 5.1 and 5.2) were used, mounted on a cylindrical Rosette frame. A Lowered Acoustic Doppler Current Profiler (LADCP) was also equipped on the Rosette to provide vertical profiles of the horizontal current velocities when lowered in the water column. The Rosette also supplied water samples for biologists and chemists using twenty-four (24) 12-L Niskin-type bottles (Figure 5.1).

Table 5.1. List and specifications of the sensors equipped on the Rosette.

Photo	Instrument	Manufacturer	Type & Properties	Serial Number
	CTD	SeaBird	SBE-911 Sampling rate : 24 Hz	0679
	Temperature	SeaBird	SBE 3plus Range: -5ºC to + 35ºC Accuracy: 0.001	4318
	Pressure	SeaBird	Accuracy: 0.015% of full range	88911
	Conductivity	SeaBird	SBE 4C Range: 0 to 7 S/m Accuracy: 0.0003	042696

Photo	Instrument	Manufacturer	Type & Properties	Serial Number
	Oxygen	SeaBird	SBE-43 Range: 120% of saturation Accuracy: 2% of saturation	0247
	Nitrates	Satlantic	MBARI ISUS Range: 0.5 to 200 μM Accuracy: ± 2 μM	132
	PAR	LICOR	PAR Dynamic Range: $1.4x10^{-5}$ to 0.5 μE/(cm^2 sec)	4664
	SPAR	LICOR	PAR Spectral Response: Equal (better than ±10%) quantum response from 400 to 700nm	20123
	Fluorometer	Sea Point	Minimum Detectable Level 0.02 µg/l Gain Sens, V/(µg/l) Range/(µg/l), 30x 1.0 5 10x 0.33 15 3x 0.1 50 1x 0.033 150	3119
	Transmissometer	WetLab	Path length: 25 cm Sensitivity: 1.25 mV	CST-558DR
	Altimeter	Benthos	Range: 50 m from bottom	1061
	ECO fluorometer (CDOM)	Wet Labs	FL(RT)D Digital output resolution : 14 bit Analog output signal: 0-5V Range: 0.09-500ppb Ex/Em: 370/460nm	2344
	Underwater Vision Profiler (UVP)	Hydroptic		008

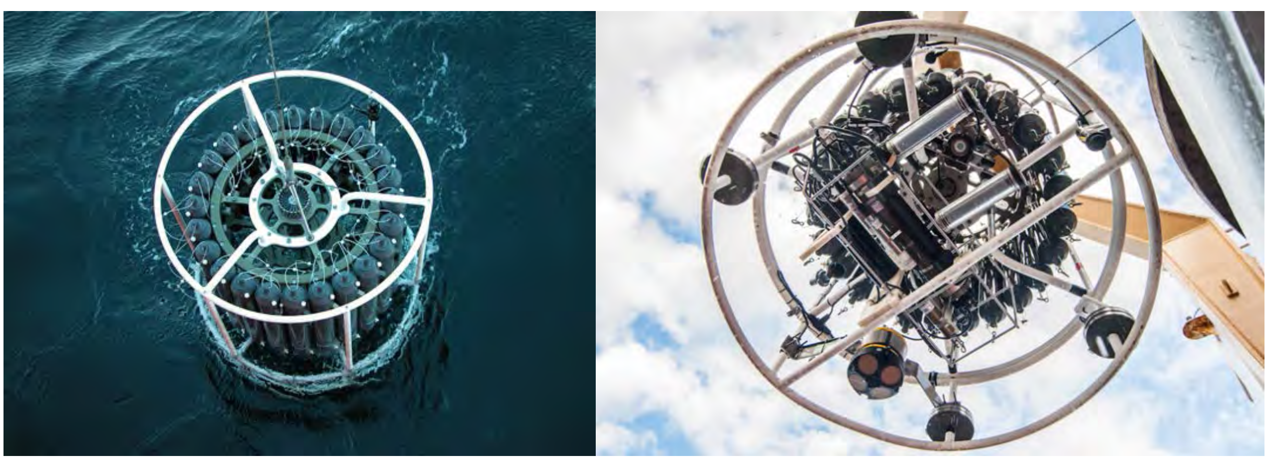


Figure 5.1. Photos showing the Rosette with the 24 Niskin bottles for collecting seawater samples and the various sensors measuring properties of the water column (Photo on the right: J. Barrette).

Table 5.2. Rosette sensors specifications.

Parameter	Sensor		Range	Accuracy	Resolution
	Manufacturer	Instrument Type			
CTD	SeaBird	SBE-9plus [1]			
Temperature	SeaBird	SBE-03 [1]	-5°C à +35°C	0.001°C	0.0002°C
Conductivity	SeaBird	SBE-4C [1]	0-7 S/m (0-70mmho/cm)	0.0003 S/m (0.003mmho/cm)	0.00004 S/m (0.0004 mmho/cm)
Pressure	Paroscientific	410K-105	up to 10 500m (15 000psia)[2]	0.015% of full scale	0.001% of full scale
Dissolved oxygen	SeaBird	SBE-43 [3]	120% of surface saturation[4]	2% of saturation	unknown
pH	SeaBird	SBE-18-I [5]	0-14 pH units	0,1 pH unit	unknown
Nitrates concentration	Satlantic	MBARI-ISUS 5T[6]	0.5 to 2000 µM	±2 µM	±0.5 µM
Light intensity (PAR)	LICOR				
sPAR	LICOR				
Fluorescence	Seapoint	Chlorophyll-fluorometer	0.02-150 µg/l	unknown	30
Transmissiometer	Wetlabs	C-Star	0-5 V	unknown	1.25 mV
Altimeter	Benthos	PSA-916 [7]	0 - 100 m	unknown	0.01 m
CDOM fluorescence	Wetlabs	FL(RT)D [7]	0.09-500 ppb	unknown	14 bit
UVP	Hydroptic	UVP	150 µm – 3 cm		

Notes: [1] Maximum depth of 6800m
[2] Depending on the configuration
[3] Maximum depth of 7000m
[4] In all natural waters, fresh and marine
[5] Maximum depth of 1200m
[6] Maximum depth of 1000m
[7] Maximum depth of 6000m

5.2.2 Rosette sensors calibration

Salinity: water samples were taken on many casts using 200 ml bottles. They were analyzed with a GuildLine Autosal model 8400B with a range of 0.005 to 42 PSU and an accuracy of <0.002.

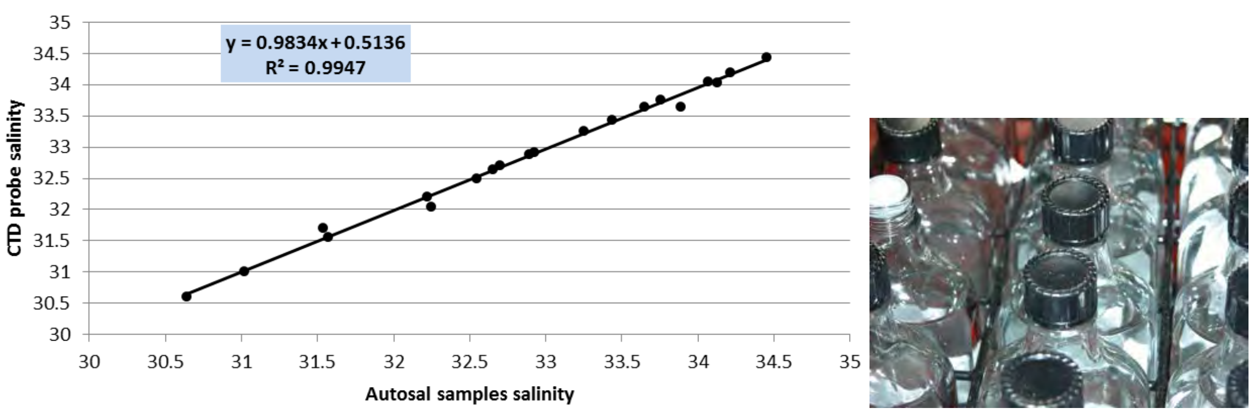


Figure 5.2. Example of comparison between salinity measurements made by the Rosette's CTD and calibration samples (Autosal).

Oxygen: Oxygen sensor calibration was performed using Winkler's method and a Mettler Toledo titration machine. Reagent blanks verification was performed once with results showing that chemicals were still good (m<1). Oxygen was sampled on five casts on Leg 1 (#003, 040, 030, 043, 091) and one cast on Leg 2a, at five depths displaying a range of oxygen concentrations, each sampled in triplicate.

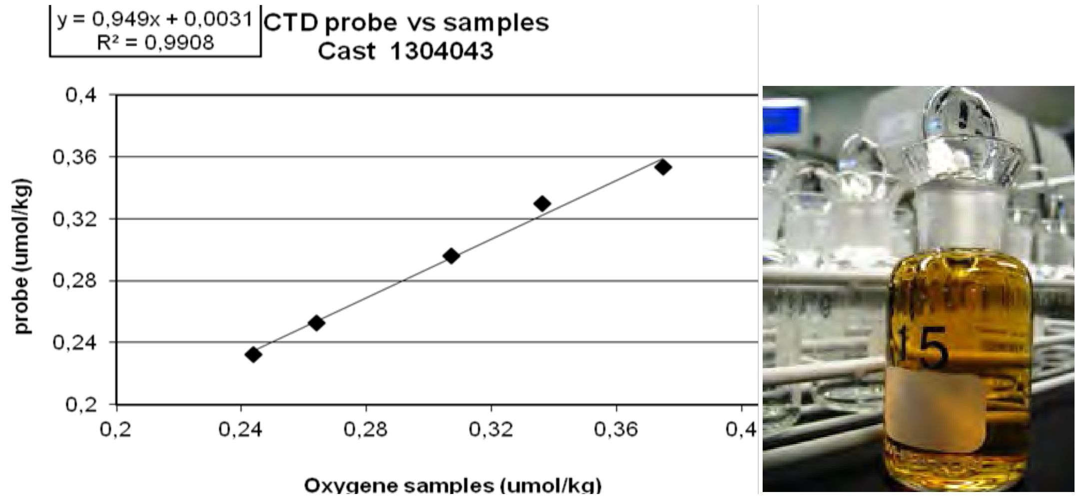


Figure 5.3. Example of comparison of oxygen measurements between the Rosette's sensor and calibration samples (Winkler).

5.2.3 Sampling sites

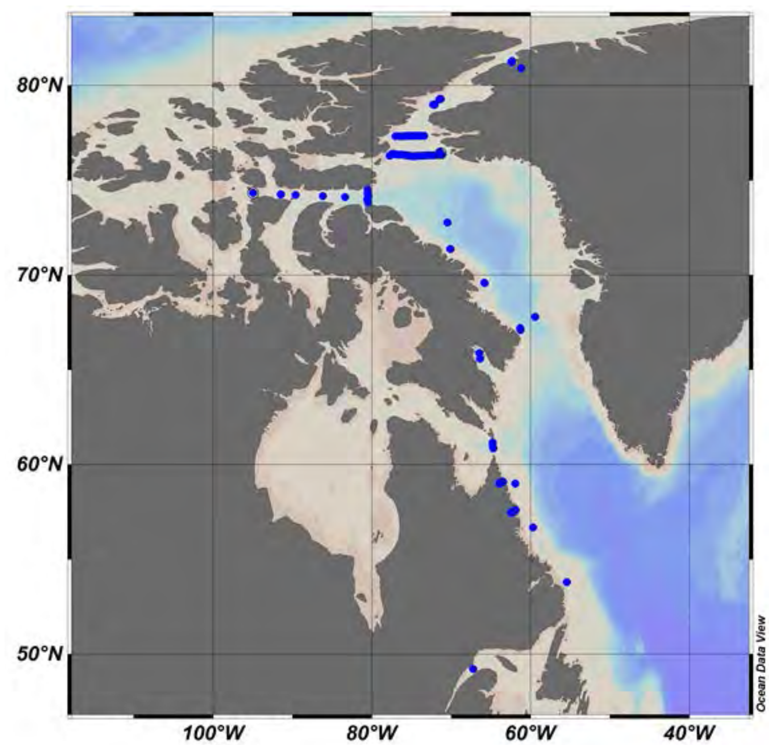


Figure 5.4. Study region in Eastern Canadian Arctic showing the locations of CTD-Rosette casts carried out during Legs 1a and 1b.

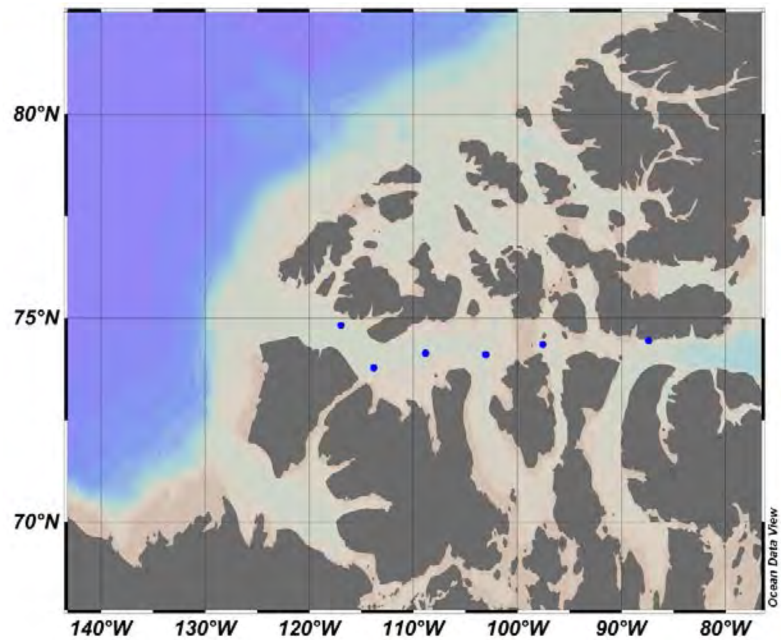


Figure 5.5. Study region in Canadian Arctic Archipelago (Northwest Passage) showing the locations of CTD-Rosette casts carried out during Leg 2a.

5.2.4 Water samples

Seawater from various depths in the water column was sampled with the Rosette according to each scientific team's request. To uniquely identify each water sample, a Rosette cast described one CTD-Rosette operation, and the cast number was incremented every time the Rosette was lowered in the water. Each of the twenty-four Rosette bottles closed on each cast was similarly labeled with a bottle number (01 to 24).

Three types of CTD-Rosette casts were defined.

CTD cast: CTD profiles were conducted only for sound speed (multibeam calibration) and mooring calibration.

Nutrients cast: Samples were obtained for Nutrients (J.-É. Tremblay).

General cast: Samples are obtained for Mercury (G. Stern and H. Hintelmann), Diversity (C. Lovejoy), Dissolved Oxygen, CDOM, DNA (C. Lovejoy), CH_4 (H. Xie), Salinity, etc.

5.2.5 Data availability

Information concerning the Rosette casts is summarized in Appendix 3 and includes station ID and cast number, date and time of sampling in UTC, latitude and longitude, bottom and cast depths, and short comments concerning each cast. A Rosette Sheet was also created for each cast and included the same information as the CTD Logbook plus a table of bottle closure and sampling depths.

For every bottle and cast, data from three seconds after a bottle was closed to seven seconds after was averaged and recorded in an ascii file. The information included the bottle number, time and date, trip pressure, temperature, salinity, light transmission, fluorescence, dissolved oxygen, irradiance and CDOM measurements.

5.3 Methodology – LADCP

A 300 kHz Lowered Acoustic Doppler Current Profiler (LADCP; RD-Instrument Workhorse®) was mounted on the Rosette frame (Figure 5.6). The LADCP was powered through the Rosette cable and the data was uploaded on a laptop computer connected to the instrument through a RS-232 interface after each cast. The LADCP was programmed in *individual ping* mode (one every second). The horizontal velocities were averaged over thirty-two, 4 m *bins* for a total (theoretical) range of 100 to 120 m. The settings were set at 57600 bauds with no parity and one stop bit. Since the ADCP was lowered with the Rosette, there were several measurements for each depth interval. The processing was done in Matlab® according to Visbek (2002).

Figure 5.6. The LADCP equipped on the Rosette frame to measure current velocities in the water column.

5.4 Methodology – SM-ADCP

Figure 5.7. Schematic of a SM-ACDP measuring current velocities under the ship.

The ship-mounted Acoustic Doppler Current Profiler (SM-ADCP; RD-Instruments Ocean Surveyor 150 kHz) recorded current velocity data continuously. The GPS signal was available through the ship's navigation system or through the EK-60 sonar. The 150 kHz SM-ADCP provided dependable horizontal currents every 8 m down to 125 or 150 m, the protective ice window absorbing part of the energy. The signal could reach down to 200-300 m when the ship was on station. The SM-ADCP computer and chassis were installed in the Acquisition room.

5.5 Methodology – UVP

The Underwater Vision Profiler (UVP5) equipped on the Rosette frame (Figure 5.8) is an instrument designed to take pictures of a slice of water lighted by 2 rows of flashing LEDs while profiling or while being moored. An image processing performed either onboard while profiling, or in delayed mode after data recovery (at the user's convenience), estimates the particles size distribution and stores vignettes of the particles found in the images. The pixel size of the camera is approximately 150 microns, so that the particles detected by the UVP are ranging from 150 microns up to few centimeters.

Figure 5.8. The UVP equipped on the Rosette frame to take pictures of particles and organisms in the water column.

The UVP main cylindrical case includes a camera, containing itself a hard drive (HD) and a flash drive (FD). There are several modes that can be used to record the images and process them. In clear waters especially, the user can select the so-called "mixfd" mode, which processes the images while acquiring data, and stores only vignettes taken from the entire image on the camera flash drive. The flash drive size is less than the hard drive one (16 Go instead of 64 Go), but allow a faster rate of data storage. In the case of more turbid waters, the user might select the so-called "fullhd" mode, which stores the entire image on the camera hard drive, for later data processing from a computer on which the data will have been transferred.

The instrument was newly acquired by Takuvik and no complete training was achieved before the *Amundsen* left Quebec City. Nevertheless, the UVP acquired data on all the casts with a few exceptions, when the battery died for example. In Leg 1, on a total of 114 Rosette casts, the UVP recorded on 110 casts, i.e. only 4 of them were problematic. In Leg 2a, on casts #007 and #009, the UVP camera didn't start properly during the first 10 m probably because the descent speed reached at 5 m depth was too slow.

5.6 Preliminary results

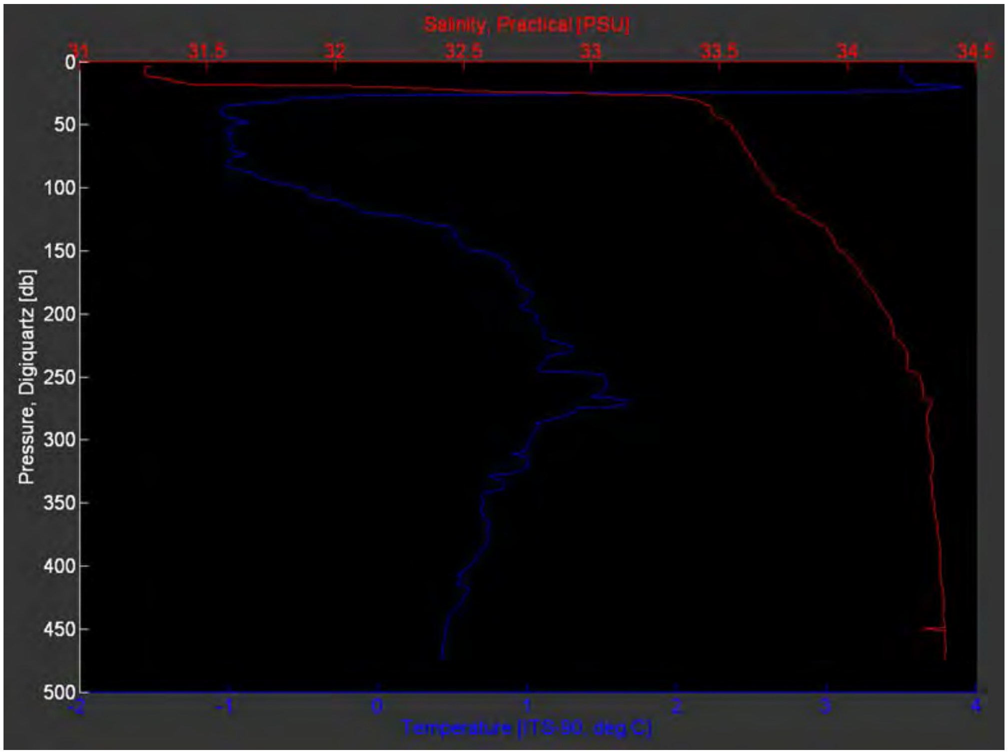


Figure 5.9. Example of vertical profiles of temperature and salinity obtained with the Rosette's CTD for cast #073 in Leg 1.

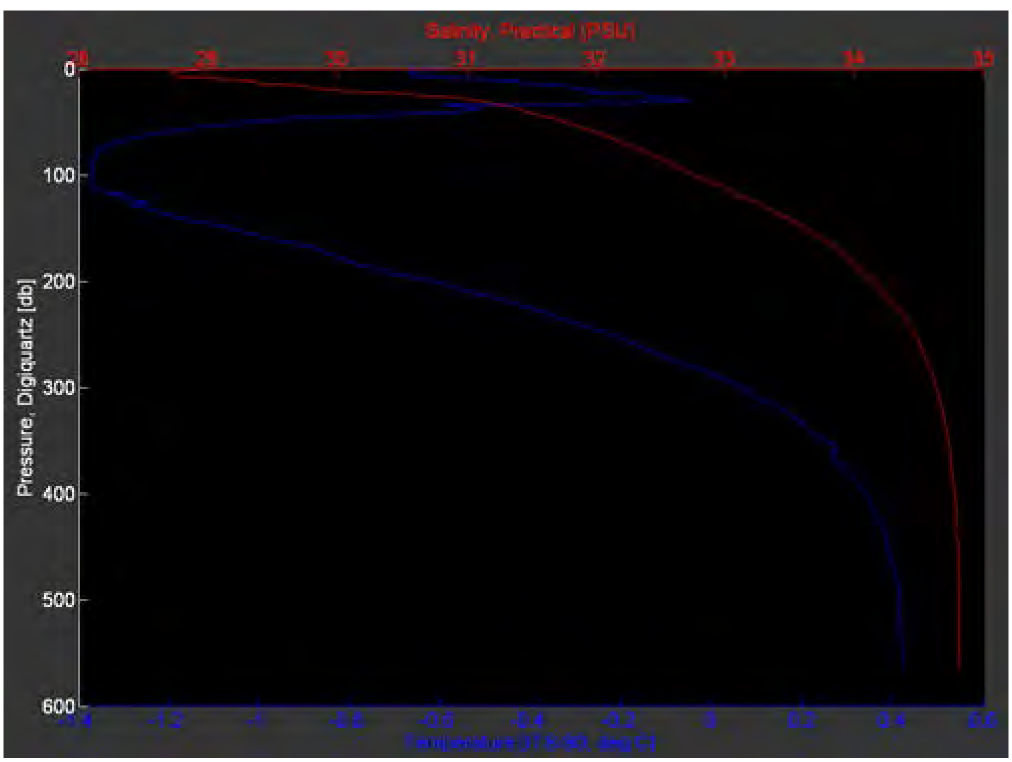


Figure 5.10. Example of vertical profiles of temperature and salinity obtained with the Rosette's CTD on cast #006 in Leg 2a.

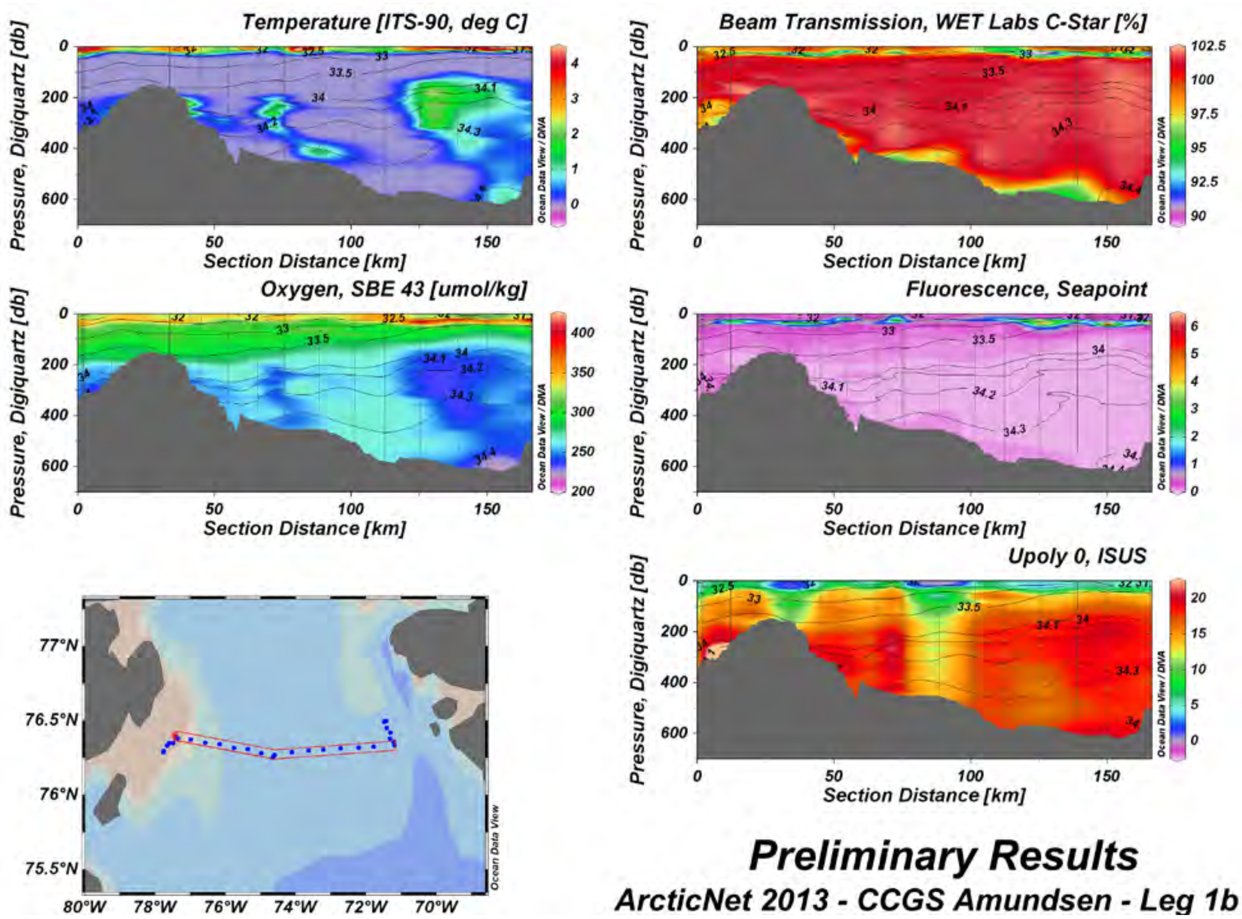


Figure 5.11. Sections of temperature, dissolved oxygen, transmissivity (attenuation of incident light), fluorescence and nitrate concentration from the transect conducted across Baffin Bay (Stations 101 to 115) during Leg 1b.

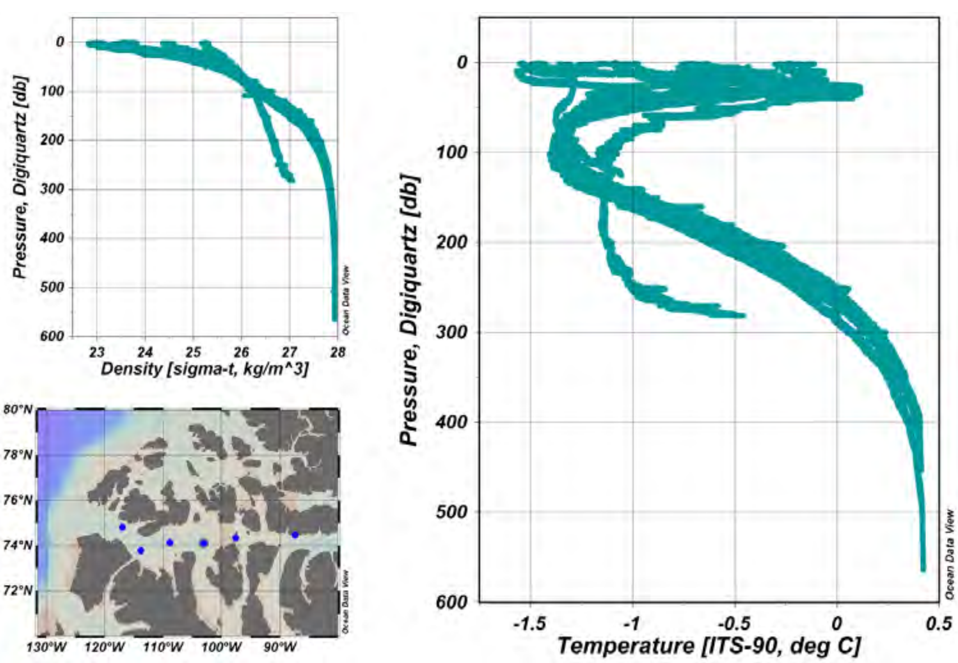


Figure 5.12. Temperature and salinity vertical profiles for all casts conducted in the Northwest Passage during Leg 2a.

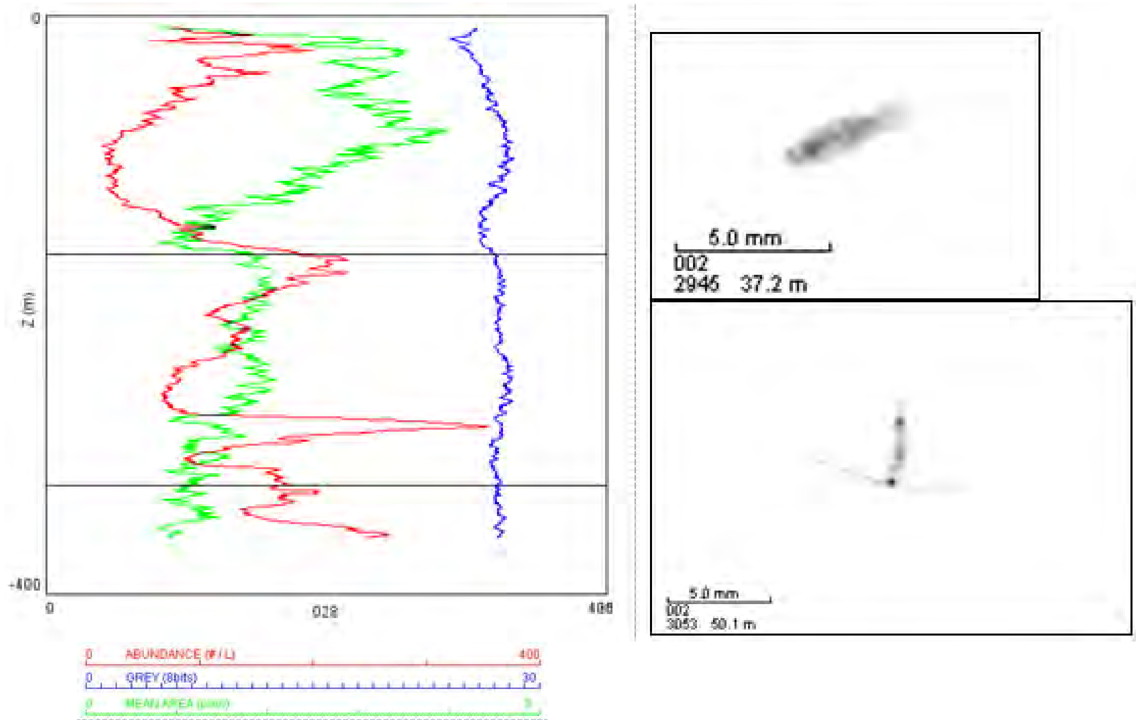


Figure 5.13. Example of a UVP profile and sample pictures of organisms taken during Leg 1.

5.7 Comments and recommendations

Rosette: The Rosette frame is unbalanced and too light. Weight (probably an extra 200 lbs) should be added to compensate for the LADCP and in general make the Rosette heavier.

Rosette's sensors: Dissolved oxygen concentration measurements performed using the Winkler method showed that the probe on the Rosette overestimated dissolved oxygen concentration by about 10%. The Nitrate probe ISUS seemed unstable which was mostly visible on the section plots where a complete shift of up to 5 units over the whole cast have been recorded for some casts.

Rosette bottles: In Leg 2a, several bottles were leaking and elastic bands were changed (#13, 17, 18, and 19). One entire bottle (#22) was changed because it was broken. The elastic band of bottle #2 was also changed when it broke down.

Rosette computers: The Rosette computers are getting old and the one used to process the data has trouble running Matlab 2013. Getting a new one is essential. It also would be important to have at least one spare computer equipped with 5 RS-232 ports, which is the minimum needed for the Acquisition computer.

Rosette shack: It was impossible to clean the surface PAR sensor on the roof of the Rosette shack because there were some barrels blocking the access. These barrels need to be put somewhere else.

ADAS server data backup: During all of Leg 1, it was impossible to backup the data from the Processing computer to the ADAS server. Multiple errors were generated during the data transfer via the NetBak Replicator. It was suspected that these errors were related to the slow connection from the Rosette shack to the servers. After having replaced the converter in the Rosette shack, the speed of the server increased drastically and it was then possible to backup successfully the data to the ADAS.

LADCP: The LADCP was pitching and rolling a lot because the Rosette was unbalanced which had an impact on data quality. The exact amplitude of this effect will be assessed during data processing.

LADCP data processing: The MatLab Data Processing toolbox usually used for the processing of the LADCP data needs to be updated to the newest version, which was impossible to acquire during Leg 1. In consequence, the processing of the data will be completed in a subsequent leg.

Adobe Acrobat also needs to be installed on this computer. The software is used for combining the multiple postscript figures produced by the LADCP Processing toolbox into a single PDF file.

One of the beams (4 of 4) appeared to be weak. At first, interference with the Rosette's frame was thought to be the problem but the LADCP was moved and the problem persisted. The instrument has to be further tested and inspected. In shallow water, Visbek's (2002) approach performs poorly because the instrument "sees" the bottom from the surface. At the beginning of the cast, the Rosette should be kept under the surface a longer than the three minutes suggested by SeaBird before starting the downcast to make sure that the LADCP has at least three "Short-term averages" (STA: one minute averages) to work with.

LADCP cables: Cheaper "extension" cables for the LADCP should be bought that could be used as expendable interface cables between the much more expensive T-cable and the RS-232 cable.

SM-ADCP: During the mobilization and the beginning of Leg 1, several problems were encountered and seemed all related to a malfunction of the SM-ADCP chassis in the acquisition room. Data recorded by the SM-ADCP during the sea trial in the St. Lawrence River in July 2013 presented low ping intensity for every beam. It was first suspected that the problem originated from the ice window under the ship but after having contacted RDI and performed different tests on the system, the conclusion was that the chassis was possibly the cause. RDI sent a test chassis and once installed, the SM-ADCP was again operational. A meticulous clean up of the defective chassis interior by the technician (S. Blondeau) gave it a second life but similar tests completed a week after showed some internal components (mainly current transformers) of the chassis had started to burn. A new chassis was acquired by ArcticNet in September 2013; the test chassis from RDI was used during most of Leg 1 and the new was installed at the beginning of Leg 2.

SM-ADCP data acquisition: A 75 kHz (or better a bi-frequency transducer) should be bought at the next opportunity. The vertical resolution would be halved using this but the depth penetration would be doubled.

UVP: Finding a known entry (variable) of the UVP to connect to the CTD to make it easier to know if the UVP's camera is turned on.

Reference

Visbeck, 2002. J. Atmos. Ocean. Tech., 19, 794-807.

6 Dissolved Inorganic Carbon (DIC) system – Legs 1a and 1b

ArcticNet Phase 3 – Project titled *Carbon Exchange Dynamics in Coastal and Marine Ecosystems*. ArcticNet/Phase3/Carbon-dynamics

Project leader: Helmuth Thomas[1] (helmuth.thomas@dal.ca)
Cruise participants Leg 1a: Brent Else[2] and Tonya Burgers[2]
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6.1 Introduction

The ocean's exchange of carbon dioxide with the atmosphere is governed by the biogeochemical cycling of carbon and physical processes throughout the water column, which determine the concentration of dissolved inorganic carbon (DIC) and total alkalinity (TA) in the surface waters. Out of the four measurable carbon system parameters (DIC, TA, pH and pCO_2), a minimum of two are needed to calculate the others and fully describe the inorganic carbon chemistry, over-determination of the system being beneficial.

Biological activity alters the chemical signatures of the water, affecting both the isotopic carbon ratio ($\partial^{13}C$) and dissolved inorganic carbon (DIC) concentrations. Phytoplankton cells incorporate carbon into their organic matter and preferentially select light carbon (^{12}C) over the heavier carbon isotope (^{13}C). This biological fraction leads to isotopically heavy productive surface waters exhibiting low concentrations of DIC. At depth, particularly below the pycnocline, the organic carbon from sinking particulate matter is reminizeralized into DIC and the waters become istotopically light due to the release of ^{12}C. These signals can provide powerful insight into the biological processes occurring in the water column. Further processes alter the C-isotopic signature of DIC are the uptake of isotopically lighter anthropogenic CO_2 from the atmosphere, and from terrestrial sources (runoff) revealing individual $DI^{13}C$ characteristics. Together with further oceanographic tracers, $DI^{13}C$ data will be used to unravel processes controlling the observed DIC distributions in the investigation area.

6.2 Methodology

During Leg 1, a total of 480 samples were collected for analysis of DIC and TA. A further 134 samples were collected for analysis of $DI^{13}C$. All samples were collected in parallel with the Nutrients Rosette casts (Table 6.1). DIC and TA samples were collected in 300 mL bottles and $DI^{13}C$ samples were collected in 10 mL vials. 200 of the DIC and TA samples were analyzed on board during Leg 1b. The remaining bottles were spiked with $HgCl_2$ and stored in the dark at 4°C. All of the $DI^{13}C$ vials were spiked with $HgCl_2$ and stored in the dark at 4°C.

Table 6.1. Stations sampled to characterize the dissolved inorganic carbon system (DIC, TA and $DI^{13}C$) during Legs 1a and 1b.

Station	Latitude	Longitude	Cast #	Date	Samples Taken
650	53°47.999	55°26.093	1304002	29 July 2013	DIC/TA
645	56°42.046	59°41.729	1304003	30 July 2013	DIC/TA
633	57°36.402	61°53.761	1304004	30 July 2013	DIC/TA
632	57°34.002	62°03.304	1304007	31 July 2013	DIC/TA
631	57°29.626	62°11.624	1304008	31 July 2013	DIC/TA
630	57°28.301	62°26.469	1304009	31 July 2013	DIC/TA
602	59°03.161	63°52.196	1304012	1 August 2013	DIC/TA
604	58°59.548	63°53.656	1304014	1 August 2013	DIC/TA
600	59°05.105	63°27.118	1304016	1 August 2013	DIC/TA
355	60°51.173	64°41.692	1304019	2 August 2013	DIC/TA
354	61°00.191	64°45.031	1304020	2 August 2013	DIC/TA
353	61°09.472	64°47.245	1304021	2 August 2013	DIC/TA
183	65°35.352	66°20.260	1304023	4 August 2013	DIC/TA
180	67°08.369	61°15.749	1304025	6 August 2013	DIC/TA
180	67°12.484	61°18.346	1304026	7 August 2013	DIC/TA
176	69°35.830	65°47.744	1304030	9 August 2013	DIC/TA
170	71°22.772	70°04.418	1304032	10 August 2013	DIC/TA
170	71°22.788	70°04.271	1304033	10 August 2013	DIC/TA
325	73°48.708	80°27.761	1304036	13 August 2013	DIC/TA
101	76°23.245	77°23.368	1304044	15 August 2013	DIC/TA
105	76°19.097	75°45.642	1304054	16 August 2013	DIC/TA
108	76°16.134	74°36.295	1304058	16 August 2013	DIC/TA
110	76°17.932	73°37.845	1304062	17 August 2013	DIC/TA
111	76°18.436	73°12.364	1304063	17 August 2013	DIC/TA
115	76°20.330	71°11.408	1304069	18 August 2013	DIC/TA
132	78°59.419	72°59.419	1304077	20 August 2013	DIC/TA, $DI^{13}C$
250	81°14.680	62°21.253	1304080	22 August 2013	DIC/TA, $DI^{13}C$
251	80°54.460	61°11.702	1304083	22 August 2013	DIC/TA, $DI^{13}C$
253a	79°17.675	71°17.911	1304085	25 August 2013	DIC/TA, $DI^{13}C$
126	77°20.735	73°25.715	1304091	27 August 2013	DIC/TA, $DI^{13}C$
124	77°20.814	74°18.046	1304094	27 August 2013	DIC/TA, $DI^{13}C$
122	77°19.978	74°58.338	1304097	28 August 2013	DIC/TA, $DI^{13}C$
119	77°19.526	76°04.321	1304101	28 August 2013	DIC/TA, $DI^{13}C$
117	77°19.418	77°01.166	1304104	28 August 2013	DIC/TA, $DI^{13}C$
301	74°06.215	83°22.238	1304106	30 August 2013	DIC/TA
304	74°15.016	91°28.183	1304111	31 August 2013	DIC/TA

DIC and TA were analyzed on board using a VINDTA 3C (Versatile Instrument for the Determination of Titration Alkalinity) by J. Mol (Dalhousie U.). TA was determined by titrating a volumetrically accurate subsample using 0.1 N HCl as titrant. For DIC analysis, a volumetrically determined subsample was acidified with 8.5% H_3PO_4 to convert all inorganic carbon into gaseous CO_2. The CO_2 is then stripped out of the sample using ultra-pure N_2 gas, transferred into a coulometric titration cell and detected using the coulometric method (Johnson et al. 1993).

Reference

Johnson, K.M., K.D. Wills, D.B. Butler, W.K. Johnson and C.S. Wong (1993). Coulometric total carbon dioxide analysis for marine studies: maximizing the performance of an automated gas extraction system and coulometric detector. Marine Chemistry 44: 167-187.

7 Marine productivity and ocean nutrients dynamics – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change.* ArcticNet/Phase3/Marine-ecosystem-services.

Project leader: Jean-Éric Tremblay[1] (Jean-Eric.Tremblay@bio.ulaval.ca)
Cruise participants Leg 1a: Pierre Coupel[1], Jonathan Gagnon[1] and Gabrièle Deslongchamps[1]
Cruise participants Leg 1b: Jonathan Gagnon[1] and Gabrièle Deslongchamps[1]
Cruise participants Leg 2a: Pierre Coupel[1] and Jean-Sébastien Côté[1]
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7.1 Introduction

The Arctic climate displays high inter-annual variability and decadal oscillations that modulate growth conditions for marine primary producers. Much deeper perturbations recently became evident in conjunction with globally rising CO_2 levels and temperatures (IPCC 2007). Environmental changes already observed include a decline in the volume and extent of the sea-ice cover (Johannessen et al. 1999, Comiso et al. 2008), an advance in the melt period (Overpeck et al. 1997, Comiso 2006), and an increase in river discharge to the Arctic Ocean (Peterson et al. 2002, McClelland et al. 2006) due to increasing precipitation and terrestrial ice melt (Peterson et al. 2006). Consequently a longer ice-free season was observed in both Arctic (Laxon et al. 2003) and subarctic (Stabeno & Overland 2001) environments. These changes entail a longer growth season associated with a greater penetration of light into surface waters, which is expected to favor phytoplankton production (Rysgaard et al. 1999), food web productivity and atmospheric CO_2 drawdown in the surface ocean. However, phytoplankton productivity is likely to be limited by light but also by allochtonous nitrogen availability. The supply of allochtonous nitrogen is influenced by climate-driven processes, mainly the large-scale circulation, river discharge, upwelling and regional mixing processes. In the global change context, it appears crucial to improve the knowledge of the environmental processes (i.e. mainly light and nutrient availability) interacting to control phytoplankton productivity in the Canadian Arctic.

The main goals of the project were to establish the horizontal and vertical distributions of phytoplankton nutrients and the influence of different processes (e.g. mixing, upwelling and biological processes) on these distributions. An auxiliary objective was to calibrate the *ISUS* nitrate probe attached to the Rosette.

7.2 Methodology

Samples for inorganic nutrients (ammonium, nitrite, nitrate, orthophosphate and orthosilicic acid) were taken at all Rosette stations (Table 7.1) to establish detailed vertical profiles.

Table 7.1. List of sampling stations and measurements made for nutrient concentrations and rates during Leg 1a, 1b and 2a.

Station	NO_3, NO_2, Si, PO_4	NH_4	Urea	Stable isotopes	NO_3/NH_4 uptake	N_2 fixation	Nitrification	NO_3, NO_2, PO_4, Si uptake	^{15}N/^{18}O-NO_3	^{15}N-PI
Leg 1a										
650	x	x	x		x	x	x		x	
645	x	x	x		x	x				
633	x	x	x	x	x	x				
632	x									
631	x									
630	x	x	x							
640	x	x	x	x	x	x	x		x	
600	x	x	x	x	x	x				
601										
602	x	x	x							
604	x									
355	x	x	x	x	x	x	x		x	
354	x									
353	x									
183	x	x	x	x	x	x				
180	x	x	x	x	x	x	x		x	
176	x	x	x	x	x	x	x			
170	x	x	x	x	x	x				
Leg 1b										
325	x	x	x	x	x	x				
324	x									
323	x	x	x	x	x	x				
300	x									
322	x									
101	x	x	x	x	x	x				x
102										
103	x									
104										
105	x			x						
106										
107	x									
108	x	x	x	x	x	x				
109										
110	x									
111	x			x						
112										
113	x									
114										
115	x	x	x	x	x	x				x

Station	NO_3, NO_2, Si, PO_4	NH_4	Urea	Stable isotopes	NO_3/NH_4 uptake	N_2 fixation	Nitrification	NO_3, NO_2, PO_4, Si uptake	^{15}N/^{18}O-NO_3	^{15}N-PI
117	x	x	x	x	x	x	x		x	
118	x									
119	x			x						
120	x									
121										
122	x			x						
123										
124	x									
125										
126	x	x	x	x	x	x	x		x	
132	x	x	x	x	x	x	x		x	
250	x	x	x	x	x	x	x		x	
251	x	x		x		x			x	
253a	x	x	x	x	x					
253b	x	x	x	x	x	x				
301	x			x						
302	x									
303	x									
304	x	x	x	x	x	x	x		x	
305	x									
Leg 2a										
307	x									
308	x	x	x	x	x	x	x	x		
500	x	x	x	x	x	x				
512	x									
Ice Core 1	x									
Ice Core 2	x									

Samples were stored at 4°C in the dark and analyzed for nitrate, nitrite, orthophosphate and orthosilicic acid within a few hours on a Bran+Luebbe AutoAnalyzer 3 using standard colorimetric methods adapted for the analyzer (Grasshoff et al. 1999). Additional samples for ammonium determination were taken at stations where incubations were performed and processed immediately after collection using the fluorometric method of Holmes et al. (1999).

7.3 Preliminary Results

Unexpectedly high ammonium (NH_4) concentrations were found in the top part of the ice cores and in the overlying snow cover at the ice station in McClure Strait in Leg 2a.

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8 Methane (CH_4) air-sea flux and biogeochemical cycling – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Carbon Exchange Dynamics in Coastal and Marine Ecosystems*. ArcticNet/Phase3/Carbon-dynamics

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8.1 Introduction

Methane (CH_4) is the second most important greenhouse gas (after CO_2) in the atmosphere. The ocean has long been recognized as a source of atmospheric CH_4 but the oceanic CH_4 emission is considered to be minor as compared to anthropogenic inputs and other natural sources (e.g. release from wetlands). However, climate warming, particularly over the Arctic region, may dramatically change the CH_4 budget. The thawing of the Arctic permafrost, a large part of which lies on coastal shelves, greatly increases the concentration of CH_4 in Arctic seawater either by direct injection of CH_4 into the water column or by increased CH_4-enriched freshwater discharge. The increased river runoff also brings large amounts of dissolved and particulate organic materials to the Arctic Ocean, fuelling microorganisms, some of which produces CH_4. CH_4 is also injected into the water column from submarine hydrothermal vents, which are not rare in northern polar seas.

Few historic data are available about CH_4 distribution and its biogeochemical cycling in Canadian Arctic seas. The current status of CH_4 in the Canadian Arctic is largely unknown. The objectives of this survey were to:

- Map the distribution of CH_4 in surface and subsurface waters
- Estimate the air-sea flux of CH_4.
- Evaluate the net production (or consumption) of CH_4 in the water column.
- Identify potential CH_4 "hotspots" associated with hydrothermal activity or permafrost melting.

Data from this survey aids in assessing the impact of climate change on the CH_4 distribution and cycling in the Arctic Ocean.

8.2 Methodology

Underway surface water samples were intermittently collected from the ship's pumping system located in the engine room. CH_4 profiles were collected at each Basic and Full station, as well as at four Nutrient stations (324, 302 and 305 in Leg 1 and 512 in Leg 2a). In Leg 1, dark incubation samples for determining net production or consumption of CH_4 were taken at selected stations and depths (usually bottom and chlorophyll maximum).

Underway air samples were also collected at irregular time intervals. CH_4 concentration was determined using a PP1 methane analyzer (Peak Laboratories). In collaboration with L. Fortier (U. Laval) and I. Church (OMG-UNB), operations of the ROV, EK60 echosounder and EM302 multibeam sonar were launched to search for CH_4 seepages on the seafloor.

8.3 Preliminary results

8.3.1 Leg 1a – 26 July to 12 August 2013 – Northern Labrador Sea and Baffin Bay Leg 1b – 12 August to 5 September 2013 – Northern Baffin Bay and Canadian Arctic Archipelago

Following the observation of S. Punshon (DFO-BIO), the presence of a subsurface CH_4-enriched layer in the southwest Baffin Bay (Station 180) was re-confirmed. CH_4 seepages were also identified on the seafloor near Scott Inlet where CH_4 concentration in bottom water reached ca. 290 nmol L^{-1}. The lowest subsurface CH_4 concentration was found in Peterman Fjord (Leg 1b). Surface water CH_4 concentration increased from east to west in Landcaster Sound and Barrow Strait. CH_4 concentration in the atmosphere was very stable throughout the cruise (1.80 ± 0.03 ppm).

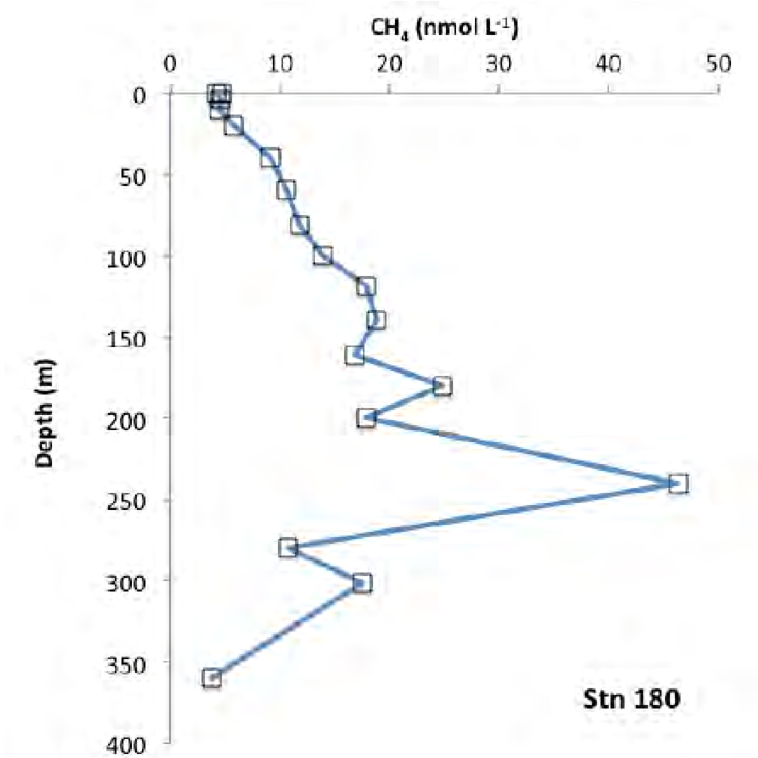

Figure 8.1. Vertical profile of CH_4 at Station 180 in Baffin Bay in Leg 1 showing subsurface maximum at ca. 250 m.

8.3.2 Leg 2a – 5 September to 15 September 2013 – Canadian Arctic Archipelago

Like the typical methane depth distributions in ocean waters containing oxygen, CH_4 showed subsurface maximum in the Viscount Melville Sound (Figure 8.2). No increased CH_4 concentration in bottom water was found at the stations sampled during Leg 2a. CH_4 concentration in the atmosphere was very stable throughout the cruise (1.80 ± 0.03 ppm).

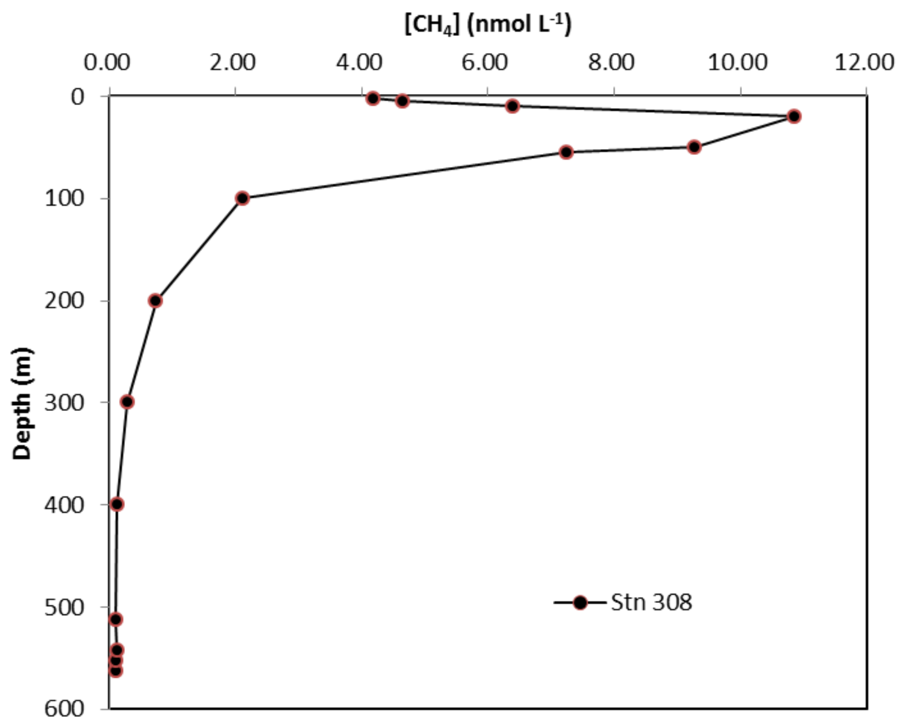

Figure 8.2. Vertical profile of CH_4 at Station 308 in Leg 2a showing subsurface maximum at ca. 20 m.

8.4 Comments and recommendations

Not enough time was available to map the CH_4 distribution in the southwest Baffin Bay area where the subsurface CH_4-enriched layer and submarine CH_4 seepages were located.

9 DMS(P) cycling and nitrous oxide (N_2O) – Legs 1a and 1b

ArcticNet Phase 3 – Project titled *Carbon Exchange Dynamics in Coastal and Marine Ecosystems*. ArcticNet/Phase3/Carbon-dynamics.

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9.1 Introduction

This project is divided into two main sections. The first one was conducted by M. Gourdal and S.-J. Royer for M. Levasseur's laboratory (U. Laval) with the overall objective of providing critical knowledge on the dynamics, distribution and production of dimethylsulfide (DMS) and distribution of nitrous oxide (N_2O) in the Arctic, in relation with the complex oceanic circulation and sea ice retreat. The second part was conducted by S.-J. Royer for the Institut de Ciències del Mar (CSIC), Barcelona, Spain, and aimed at studying the spectral irradiance dependence of sunlight effects (UV/PAR) and photo-acclimation response of phytoplankton cells on (DMS) production.

9.1.1 Climate active gases dimethylsulfide (DMS) and nitrous oxide (N_2O)

Dimethyl sulfide (DMS) is the dominant biogenic sulfur compound in the oceans (Lovelock et al. 1972). DMS oceanic emissions sum up to 15% of the global sulfur annual emissions and 50% of the natural sulfur emissions (Bates et al. 1992). This biogenic trace gas may play an important part in natural climate regulation (Charlson et al. 1987). DMS ventilated to the atmosphere can be oxidized in SO_2, SO_4^{2-}, and ultimately aerosols (Pio et al. 1996). Other oxidation pathways do not produce aerosols but other sulfured compounds such as dimethlysulfoxide (DMSO). Aerosols strongly influence the Earth radiative balance (Gabric et al. 2004) by 1) directly scattering solar radiations back to space, and 2) potentially acting as cloud condensation nuclei. DMS-derived cloud condensation nuclei enhance the formation of high reflectivity clouds (Curran and Jones 2000).

Oceanic DMS production is the result of trophic interactions involving phytoplankton, zooplankton, viruses, bacteria and macro-zooplankton (Malin and Kirst 1997; Simo 2001; Archer et al. 2002). The links between phytoplankton, sulphate aerosols, cloud albedo, and climate regulation inspired the CLAW hypothesis. The CLAW hypothesis, named after the authors' names Charlson, Lovelock, Andreae and Warren, suggests a retroactive mechanism between marine phytoplankton and climate leading to global temperature stabilisation (Charlson et al. 1987). This theory is yet to be completely validated by *in situ* observations and is still debated (e.g. Quinn and Bates 2011).

In remote regions such as the Arctic Ocean, atmosphere pollution is relatively low and DMS-derived aerosols may dominate the cloud condensation nuclei population. Ocean-to-atmosphere DMS fluxes and regional cloud cover seem to be empirically linked at such high latitudes (Fitzgerald 1991). Still, DMS is mostly studied in mid-and low-latitude regions (Sharma et al. 1999). The first DMS studies in the Arctic date back to the 1980s and 1990s (e.g., Barnard et al. 1984; Leck and Persson 1996). Maximum DMS concentrations in Arctic waters are usually measured in the marginal ice zone (Matrai and Vernet 1997; Sharma et al. 1999) or during blooms of high DMS-productive species, such as *Phaeocystis* sp. (Gabric et al. 2005; Luce et al. 2011). From a broader perspective, warming sea temperatures in the future may influence sea-atmosphere DMS fluxes. Gabric et al. (2005) model forecasts 80% increase in DMS sea-to-air flux in a 1°C warmer Arctic. It is thus crucial to gain a better understanding of the DMS production dynamic and fate in the Arctic during the melt period.

Atmospheric nitrous oxide (N_2O) plays a significant role in the global climate. N_2O's infrared absorption capacity is 300 times that of carbon dioxide's (Prather et al. 2001; Kitidis et al. 2010). N_2O is also the second most efficient greenhouse gas (after methane) (Syakila and Kroeze 2011). N_2O also influences high atmospheric chemistry: its photochemical degradation in the stratosphere produces ozone depleting nitrogen oxides (i.e. NOX) (Ravishankara et al. 2009). Its residence time in the atmosphere is ≈120 years (Prinn et al. 1990).

The global amount of atmospheric N_2O has risen from 270 to 319 (ppvb) (part per billion by volume) since the beginning of the industrial era (Syakila and Kroeze 2011). Estimates of oceanic contribution to the global N_2O emissions range from 2.0 to 6.8 Tg N_2O-N. yr^{-1} (Nevison et al. 1995; Suntharalingam and Sarmiento 2000). However, insufficient spatial and seasonal coverage of the ocean still limit the extent of knowledge on N_2O marine cycle (Syakila and Kroeze 2011). In addition, while the processes of N_2O production are generally well described, the controls of this production are yet to be established.

Microbial mediated nitrification and denitrification are the two pathways leading to N_2O oceanic production (Nevison et al. 2004). Both of these processes are light inhibited (Canfield et al. 2005). N_2O and O_2 are linked in the ocean. Oxygen concentration determines which bacterial communities are present, and hence the microbial pathway for N_2O production (i.e., nitrification or denitrification). Nitrification is the oxidation of ammonium (NH_4^+) into nitrate (NO_3^-) by aerobic bacteria. Nitrification only produces N_2O as a by-product, under suboxic conditions (Codispoti 2010). N_2O is also an intermediate compound formed during denitrification (Nevison et al. 2003). Denitrification is the uptake of oxygen from NO_3^- molecules. This reaction takes place under anoxic conditions. Denitrification is thus generally limited to the anoxic/hypoxic sediments (Hirota et al. 2009) and oxygen depleted water masses (oxygen minimum zones, OMZ) (Codispoti et al. 2001). Therefore, a stratified ocean such as the Arctic holds a potential for N_2O production through denitrification. The relative contribution of nitrification and denitrification in the oceanic N_2O production is yet to be determined (Yamagishi et al. 2004). Some of the greatest ocean-atmosphere fluxes of N_2O originate from the release of N_2O produced through denitrification in the OMZ (e.g. Bange 2008; Naqvi et al. 2000), provided the oxygen depleted waters reach the surface through upwelling.

Because of their remoteness, N_2O data are even scarcer in the Polar oceans than for the rest of the globe. Ocean-atmosphere N_2O fluxes in the Arctic Ocean seem to compare to the rest of the global ocean (Seitzinger et al. 2000). N_2O ocean-atmosphere fluxes in the Arctic present interesting particularities because of the presence of sea ice. The massive input of N_2O-depleted waters during the snow melt and the ice thaw in the annual ice area (Rees et al. 1997) seem to create overall a temporary sink for atmospheric N_2O (Randall et al. 2012). The Arctic seasonal ice zone is therefore likely to be an important region for the cycling and ocean-atmosphere exchanges of N_2O. The extent of the knowledge about this climatically active biogenic trace gas is still limited and data acquisition is urgently needed in these times of global climate upheaval.

The first objective was to provide critical knowledge on the dynamics, distribution and production of DMS and distribution N_2O in the Arctic, in relation with the complex oceanic circulation and the retreat of sea ice.

The hypotheses were the following:

1. Complex circulation through the Canadian Arctic Archipelago (inflow and outflow currents) induces strong horizontal gradients in N2O / DMS concentrations and production
2. DMS, DMSO and DMSP distribution follow a diurnal cycle in the Arctic, influenced by the changes of the sun angle during the 24 h polar day.
3. Highly productive polynya waters lead to important downward export of organic matter which result in high N_2O production below the mixed layer
4. Northernmost waters are still highly productive in DMS/P in August, with a high DMSP turnover. The increasing contribution of ice algae to the DMSP pool is observable as stations get closer to sea ice.

9.1.2 DMS production and photo-acclimation

Ultraviolet radiation (UVR) is a natural fraction of the solar spectrum. Although organisms have been coping with UVR light for thousands of years it has now become a subject of importance since the amount of UVR radiation reaching the earth's surface has increased over the last 30 years due to ozone depletion (Häder et al. 2006). UVR is differentiated into three wavebands: UVC: 190-280 nm, UVB: 280-315 nm, UVA: 315-400 nm. UVC does not reach the Earth's surface, as it is absorbed completely by the ozone. Part of the UVB radiation is absorbed by the ozone layer while the remaining radiation reaches the surface's ocean. In contrast to UVC and UVB, UVA easily penetrates the atmosphere and reaches the earth's surface. Because of the global change and the absorption properties of ozone, the UVB is the most likely radiation range to increase at the surface of the earth due to stratospheric ozone destruction (Solomon 1988).

Environmental UV radiation causes different levels of damage to marine ecosystem (Häder and Sinha 2005). The most biologically harmful wavelengths, UVB represent only about 0.25% of the sunlight reaching the earth's surface. However UVB may penetrate to a water depth of 20 m and have deleterious effects on many biological processes (Booth and Morrow 1997). The energy generated by UVB radiation has negative effects on photosynthesis and growth rate of phytoplankton and may be directly absorbed by nucleic acids leading to structural lesions (Pfeifer et al. 2005; Ravanat et al. 2001).

The second objective was to study the spectral irradiance dependence of sunlight effects (UV/PAR) and photo-acclimation response of phytoplankton cells on dimethylsulfide (DMS) production.

9.2 Methodology

9.2.1 Overview of sampling and experiments

DMS, DMSP (total and dissolved) (DMSP is DMS precursor molecule produced by most of the phytoplankton), DMSO and N_2O vertical profiles were obtained at Stations 322, 323 and 325, as well as at Stations 101, 108, 115, 132, 250 and 251. Surface and Chlorophyll maximum water was also incubated using labelled sulphur (^{35}S) for 3 stations in the Lancaster Sound as well as at Stations 101, 108, 115, 132, 250 and 251 (Table 9.1).

DMS-DMSP and DMSO profiles were measured every 4 hours during 24-h Lagrangian drifts at Stations 101 and 115.

IP 25 and other lipids characterizing ice algae were collected using surface net tows.

To test whether light and UV availability affected the content in DMS and DMSP along with the physiological state of phytoplankton cells and variability in the content of chlorophyll, 3 experiments were performed where natural seawater was exposed to the full spectrum of light (total irradiance) and to UVB filtered light.

Table 9.1. Summary of DMS(P) and N2O measurements and experiments conducted during Leg 1.

Stn #	Rosette cast #	DMS	DMSP	DMSO	N_2O	Incubation ^{35}S	FRRF	SUNTIME experiments
183	23	x	x		x	x		
180	28	x	x		x	x		
176	30	x	x		x	x		
170	32	x	x		x			
325	36	x	x		x	x		
323	38	x	x		x	x		
322	43	x	x		x	x		
101	44 to 50	x	x	x	x	x	x	x
108	59	x	x	x	x	x		
111	65	x	x	x	x			
115	69 to 76	x	x	x	x	x		

Stn #	Rosette cast #	DMS	DMSP	DMSO	N_2O	Incubation ^{35}S	FRRF	SUNTIME experiments
132	77	x	x	x	x	x	x	x
250	79 and 80		x	x	x	x	x	
251	82 and 83		x	x	x	x	x	
253a	86		x		x			
253b	86		x	x	x		x	
126	92		x	x	x		x	
117	103		x	x	x		x	
301	107		x	x	x		x	
304	113		x	x	x		x	
109			x	x	x			

9.2.2 Rosette sampling

All water samples were collected on the Phytoplankton Rosette casts at different optical depths (100%, 50%, 30%, 15%, 5%, 1% and 0.2%) and fixed depths down to the bottom of the water column. Nitrous oxide samples included all the optical depths mentioned above, the chlorophyll maximum depth, and aphotic depths, starting from 100 m. Below 100 m, water was sampled every 100 m until the bottom of the water column was reached. DMS, DMSP and DMSO were sampled at all optical depths, the chlorophyll maximum depth, and at 80m and 100 m.

N_2O and DMS profiles were produced at all Full stations and some Basic stations (see Table 9.1 for the complete list of work accomplished per station). To collect the water, a Teflon tube fitted with a 210 μm mesh was connected to a Niskin bottle tap. Once all the bubbles were eliminated from the tube, water was poured in two 25 mL glass vials for N_2O and two 120 mL glass vials for DMS-DMSP and DMSO. All the vials were rinsed by overfilling the water at the sampling depth. A butyl rubber cap was immediately placed on the vials to isolate them from the atmosphere. On some occasions, surface water was collected with a bucket, the water was then poured through a funnel fitted with a 210 μm mesh into the vials. Water for ^{35}S experiments (surface and chlorophyll maximum) was collected in dark polyethylene bottles and incubated on foredeck.

For photo-acclimation experiments, seawater from the surface was collected from Niskin bottles using a dark 20 L bag. A special care was taken to avoid having a head space considering DMS was measured during the experiment. After mixing gently the seawater was put in 20 - 100 mL Whirl Pak bags. The bags were then incubated at ambient light and in situ temperature for 2 hrs. The first 15 minutes of the experiment were dedicated to the acclimation period where the cells were covered for the first 5 minutes with 3 layers of neutral screens, then 2 layers at 10 minutes and 1 layer at 15 minutes. For the remaining 105 minutes, half of the bags were exposed to the total irradiance while two layers of Mylar foil to cut all UVB radiations covered the other half. DMS(P) measurements, fluorescence and photosystem efficiency of the phytoplankton cells was then monitored every 10 minutes until the end of the 2 hours.

9.2.3 DMS

DMS gas was directly measured after collection on a gas chromatograph (GC, Varian 3800) brought on board. Water was withdrawn from one of the two 120 mL glass vials (filled at the Rosette) with a 20 mL plastic syringe fitted with a needle. After 2 rinses with the sample water, the sample was directly injected in a purge-and-trap (PNT) system connected to the GC (Scarratt et al. 2000). Immediately following the sample injection, 2 mL of distilled water was injected to insure that the sample was completely flushed into the PNT sparging column. DMS was extracted in the PNT by constantly bubbling helium (45 mL/min). A Nafion dryer system (70 mL/min) prevented the accumulation of humidity in the PNT during the bubbling process. PNT and Nafion fluxes were monitored using a flowmeter. DMS extraction process was accelerated by warming the outside of the bubbling column with a 70°C circulating bath. A 4°C cooling circulating bath helped the condensation of the water after the warming step. The gas extracted was kept in a cold trap (liquid N_2) while the sample was sparged for 4 minutes. The sample was then released into the GC detector and measured.

On Leg 1a, the liquid nitrogen generator was broken and thus the cold trap step was missing from the method. Another method was chosen to keep the DMS samples. As mentioned before, samples were sparged with helium (He) for 4 minutes in the PNT system. DMS extracted from the samples in the PNT system was then trapped onto a Gas Chromatograph liners filled with Tenax polymer (Figure 9.1). The liners were cooled between 2 ice packs kept at -80°C. Ice packs were regularly replaced to control their temperature. Tenax polymer is frequently used for sulfured gas trapping (Pandley and Kim 2009). Tenax cartridges are mainly used for atmospheric and seawater DMS pre-concentration before immediate desorption on a GC (e.g. Sharma et al. 1999; Park and Lee 2008). Here, the liners replaced the cold trap and once conserved at -80°C, they can be kept for several weeks before measurement.

To control the stability of PNT system and the conservation efficiency of the DMS on Tenax, at least two DMS liquid standards were trapped every DMS sampling day. Liquid DMS standards were obtained by injecting 1 mL of NaOH 5N, 1 mL of DMSP solution (350 nM DMSP), and 1 mL of distilled water, in this order, in the PNT system for 4 minutes of bubbling. DMSP is cleaved into DMS and acrylate (ratio 1:1) when mixed with NaOH.

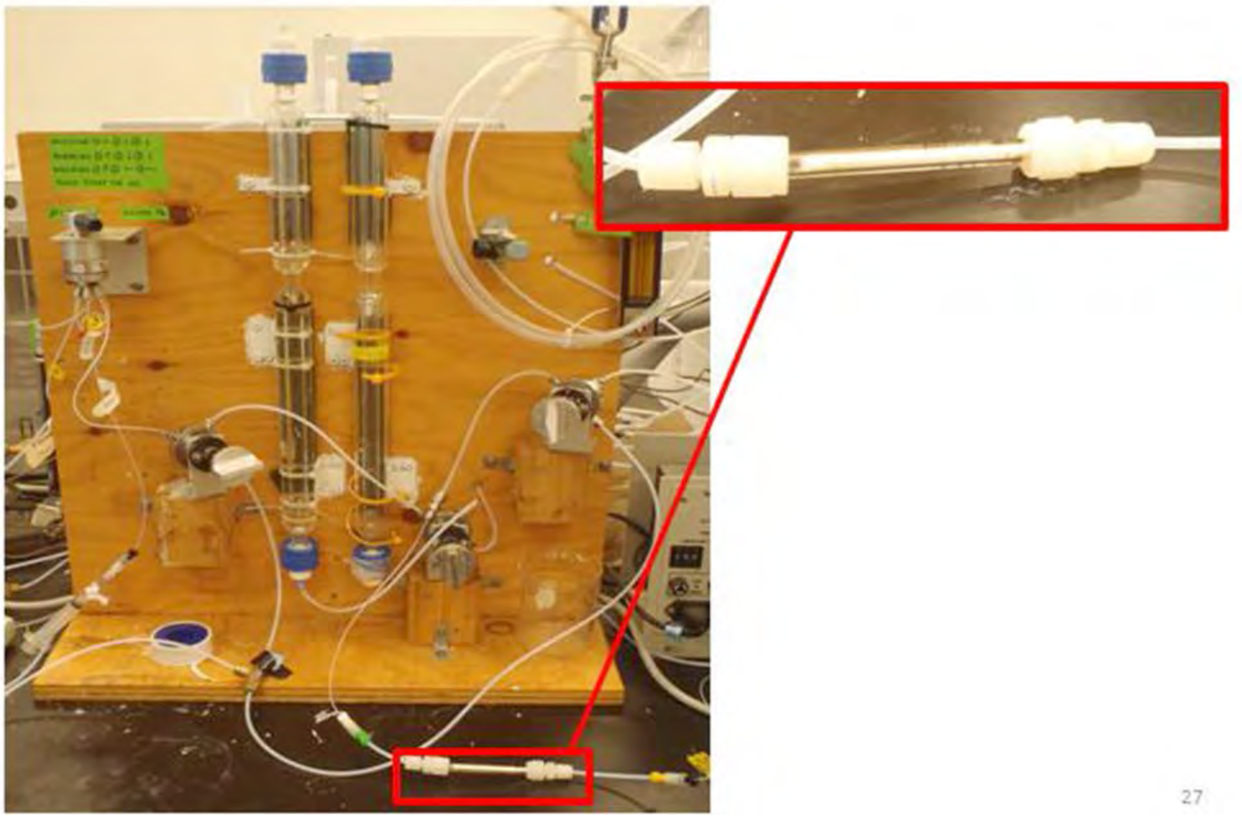

Figure 9.1. PNT system and GC liner filled with Tenax polymer used in measuring DMS during Leg 1a.

9.2.4 DMSP

Dimethylsulfoniopropionate (DMSP) is DMS precursor molecule produced by most of the phytoplankton. Duplicates of DMSP were taken in the same 120 mL vial as DMS, after the DMS duplicates were measured. The DMSP samples were treated following methods described in Levasseur et al. (1994) and Scarratt et al. (2000). DMSP samples include total DMSP (DMSPt) and the dissolved fraction (DMSPd). DMSPd was obtained by gravity-filtering 4 mL of through GF/F filters (Kiene and Slezak 2006). All DMSP samples (dissolved and total) were preserved in sterile 5 mL plastic tubes with 50 µL of sulfuric acid (H_2SO_4), and kept refrigerated until measurement at Laval University.

9.2.5 DMSO

The second 120 mL vial filled at the Rosette for each optical depth, the chlorophyll maximum depth and at 80 m was used for DMSO samples. After gently mixing the bottle, 22 mL of water was withdrawn into a plastic syringe fitted with a small Teflon tube. After rinsing the syringe twice, the sample was filtered through a 25 mm diameter GFF filter held in a Sweenex. Filtering pressure was gentle to minimize cell breakage during the process. Filters were kept in sterile 5 mL plastic tubes and stored in the -80°C freezer until analysis at the CSIC laboratory in Barcelona.

9.2.6 N_2O

For N_2O samples, a small drop of sample water was removed from each 25 mL vial to allow the addition of 200 µL of saturated mercuric chloride ($HgCl_2$). The vials were closed using a butyl rubber lid and an aluminum cap. Samples will be analyzed on a GC at Institut Maurice-Lamontagne (DFO) in Mont-Joli.

A phytoplankton net with a mesh of 20 µm was also used for some of the stations. The net was dragged for about 15 minutes at the water surface and the biomass collected in a dark glass bottle. Photosynthetic efficiency, fluorescence and DMSP were measured along with lipid characterization will be conducted at G. Massé's laboratory (U. Laval).

9.3 Preliminary results

Overall, the northernmost stations were the most productive, concurrent with the highest levels of fluorescence and chlorophyll a at the surface. Most of the results are not processed at this stage. Due to technical problems encountered with the GC, DMS was not characterised and the samples taken for DMSP, DMSO and N_2O will be analyzed in the facilities of Laval University.

9.4 Comments and recommendations

Laboratory 561: All the plugs in the palaeography-laboratory are located on one side of the room. This makes access to electricity more difficult for one of the team in the laboratory. If possible, more electrical outlets would be appreciated.

Radvan: The fume hood space is insufficient when more than one team works in the Radvan.

General: The system of seawater pumps feeding the laboratories taps should be more efficient in terms of volume and quality of water. It was difficult to feed all the incubators on the foredeck at once. More direct pathways for the water would be necessary for quality continuous surface sampling.

A TV monitor showing the feed from cameras in the Rosette shack and foredeck would be useful in the paleo laboratory to follow ongoing scientific activities.

10 Microbial diversity down the water column – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change.* ArcticNet/Phase3/Marine-ecosystem-services.

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10.1 Introduction

Arctic ecosystems are cold environments hosting a large variety of diverse species well adapted to the extreme conditions. Over the past 15 years, C. Lovejoy (U. Laval) and her collaborators have actively participated in the study of the diversity of Arctic microbial species, defined as single celled organisms that are invisible to the naked eye (Lovejoy et al. 2002; Lovejoy et al. 2006; Lovejoy et al. 2007). These microbial species, which span the three domains of life (Archaea, Bacteria and Eukaryote microbes), have key roles in biogeochemical cycles of our planet (C cycle, N cycle and S cycle). Firstly, they are responsible for photosynthesis, with primary production by phytoplankton species. Secondly, microbial food webs regenerate nutrients and carbon and make them available to higher food webs, mostly by regeneration of dissolved organic carbon by bacteria. Understanding the diversity of these communities is essential for describing and predicting how Arctic ecosystems operate. Moreover, following microbial community changes over time will help to resolve questions about impacts of climatic changes on Arctic Ocean dynamics. In a changing Arctic, the study of the organisms responsible for primary production and the associated microbes will provide the basis that is needed to track consequences of climate change. The diversity of both the microbes and the genes expressed over time and space provides a window into the physiological processes that are ultimately responsible for nutrient cycling and overall productivity of marine systems.

One of the objectives of this mission was to describe the spatial compositional changes observed among microbial communities and to relate these shifts with local environmental conditions measured in the Arctic Ocean. The Arctic represents a unique opportunity to address this question as drastic vertical and horizontal changes in terms of the ambient environmental conditions are observed. For example, one defining characteristic of the Arctic Ocean is the vertical stratification of the water column. Due to the presence of different water masses, important variations in the main driving environmental variables (e.g. temperature, salinity, oxygen) are measured. The ongoing work will provide information on these biogeochemical processes as well as information on the dominant quality and type of food available to zooplankton and the benthic community.

10.2 Methodology

10.2.1 Sampling activities Leg 1

The main goal was to characterize microbial community using mostly genetic diversity. In parallel, samples for microscopic and pigment analysis were collected to gain a broader view of the real microbial standing stocks. In addition to the general overview of diversity gained by sampling Full and Basic stations, some specific features found in local environments were targeted, for example at high methane and ice/glacier stations (Table 10.1).

Table 10.1. Summary of stations sampled for microbial diversity during Leg 1.

Date	Time	Station #_Cast #
31/07/2013	05:05	630_005
30/07/2013	19:00	633_009
01/08/2013	9:40	602_009
01/08/2013	18:00	600_017
04/08/2013	14:20	183_024
06/08/2013	10:50	180_025
07/08/2013	04:00	180_027
09/08/2013	09:00	176_031
10/08/2013	14:50	170_034
14/08/2013	02:45	323_041
15/08/2013	05:40	101_044
	09:40	101_045
	13:50	101_046
	17:45	101_047
	21:45	101_048
16/08/2013	01:35	101_049
	04:00	101_050
17/08/2013	03:30	108_060
18/08/2013	05:48	115_069
	09:20	115_070
	12:50	115_071
	16:40	115_072
	21:30	115_073
19/08/2013	01:16	115_074
	04:16	115_075
21/08/2013	00:30	132_076
22/08/3012	03:05	250_081
22/08/2013	15:09	251_082
		251_083
22/08/2013	18:00	S Pet
25/08/2013	00:23	253A_084
		253B_087
25/08/2013	15:00	SIP
26/08/2013	23:25	126_090
27/08/2013	17:35	122_096
28/08/2013	04:33	119_100

Date	Time	Station #_Cast #
28/08/2013	21:42	117_105
30/08/2013	08:30	301_108
31/08/2013	03:20	304_112

Labrador fjords: Seawater in the Labrador Fjord at Stations 630, 633, 602 and 600 were collected in association with M. Gosselin's team (UQAR-ISMER) to obtain genetic diversity pigments and microscopic samples.

High methane stations: Water samples were also collected for microbial genetic analyses from the stations featuring high methane (Stations 180 and 170) located between Pangnirtung and Pond Inlet, jointly with the work of H. Xie (UQAR-ISMER). The aim will be to identify specific microbial species that use methane (methanotrophic bacteria).

Lagrangian drift: A major effort this year was to collect samples to determine microbial gene expression and diversity every 2 h over a 24 h cycle in sub-surface Arctic waters. This study was carried using McLane pump phytoplankton sampler, which was deployed and then allowed to follow a Lagrangian drift. The concept was to attempt to sample for messenger and ribosomal RNA and proteins, in the same water mass over 24 h. This is the first time such a study has been attempted in the Arctic Ocean. Two deployments were carried out on either side of Baffin Bay (Stations 101 and 115). During these deployments, the pump was attached to a buoy and allowed to drift while the ship followed. Water and other samples were then collected every four hours using the CTD-Rosette. Parallel sampling by the Takuvik group provided back up data in case results were inconclusive (the first deployments of the pump were less than optimal). Overall samples for DNA/RNA/proteins, primary production, pigments, photosynthetic parameters, and nutrient were collected from a single water mass identified by following the pump. After recovering the pump, it was realized that the deployments only partially worked and the lessons learned from these operations will be presented in a later report, once the samples are processed at Université Laval.

Baffin Bay transects: Standard sampling was carried out along two transects across Baffin Bay (Stations 101-108-115 and Stations 126-122-119-117) to characterize the diversity of organisms and compare the two sides of the Bay.

Ice stations: Several ice stations were opportunistically sampled, close to Peterman glacier (Stations 250-251) and around an ice island (Station 253) originating from the Peterman glacier. Data from these samples should provide information on taxonomic diversity in this environment, which is unexplored until now and dramatically affected by global climate change.

For all these sampling activities, the collected water was used for the following analyses:

- Filtration for DNA, RNA and proteins extraction
- Filtration for HPLC and chlorophyll for pigment extraction

- Filtration for FISH and DAPI observation
- Microscopic observation using FNU method
- Cell counts by flow cytometry

10.2.2 Sampling activities Leg 2a

As of 15 September, four stations have been sampled with success (307, 308, 500 and 333; Table 10.2). Stations 307, 308 and 500 are located along an East-West transect in the Northwest Passage, but Station 333 is more isolated and located close to Blanley Bay.

Table 10.2. Summary of stations sampled for microbial diversity during Leg 2a.

Date	Time	Station #_Cast #
07/09/2013	07:07	307_003
08/09/2013	03:49	308_006
09/09/2013	19:24	500_008
15/09/2013		333_010

Seawater samples were collected utilizing the deployment of the Rosette, from 8 depths ranging from the surface to the bottom, with a focus on layers where major changes in chlorophyll concentration, temperature, salinity, etc,, were observed. Interestingly, Station 333 presented a distinct and more dynamic CTD profile than usually observed at other stations, suggesting different water column structure and then different environmental forcing on local communities. The sampling was coordinated with J.-É. Tremblay's team (U. Laval) such that investigation of microbial diversity could be coupled with nutrients dynamics through the water column.

The same stations were further sampled for viral diversity investigation. This work, in collaboration with Dr. A. Culley (U. Laval), is a first preliminary survey of the diversity of viruses in the Arctic Ocean. This data will represent an important step forward to improve the currently limited understanding of virus diversity in the Arctic as well as a new component for future expeditions.

In addition to a general overview of diversity by sampling Full and Basic stations in the Arctic Ocean, some specific features found in local environments were targeted as well. For example, methane concentrations at various depths in the water column and an ice station exploring the presence of contaminants in ice cores. Sampling effort was paralleled with H. Xie (UQAR-ISMER) team's investigations of the variations in methane concentration with the aim of identifying specific species that use methane (methanotrophic bacteria).

There was also an opportunity to get ice cores from two stations (close to Nutrient Station 512). Data from these samples will provide information on taxonomic diversity within sea ice, which is largely unexplored until now and dramatically affected by global climate change. In particular, we collaborated with F. Wang's team (U. Manitoba) investigating mercury content in sea ice. The aim is to link variations in mercury content through sea ice with microbial biomass and diversity.

For all these sampling activities, the collected water was used for the following measurements and experiments:

- Filtration for DNA and RNA extraction
- Filtration for HPLC and chlorophyll for pigment extraction
- Filtration for FISH and DAPI observation
- Microscopic observation using FNU method
- Cell counts by flow cytometry

10.3 Comments and recommendations

It was unfortunate that the 24-h Lagrangian drift was cut short to 22 hours.

11 Remote sensing of primary productivity – Legs 1a and 1b

ArcticNet Phase 3 – Project titled *Remote Sensing of Canada's New Arctic Frontier*. ArcticNet/Phase3/Remote-sensing.

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11.1 Introduction

The Takuvik team aimed to document optical properties of seawater, photosynthesis and major organic C cycle elements from the Baffin Bay/Labrador Sea and the Northwest Passage area (Lancaster Sound). In addition, coastal waters of the Labrador fjords introduce data from terrestrial-influenced water masses into the dataset. Potentially richer ice edge stations and melting glacier and/or iceberg stations are also of great interest as they represent ‘spring type’ condition rarely sampled during ArcticNet cruises, and are precursor data for coming projects.

The main objective of the Takuvik team was to evaluate the potential impacts of climate change on the ecology of phytoplankton in the Canadian Arctic waters. To achieve this aim, it is important to monitor light and nutrient budget, essential elements to phytoplankton production, as well as stock and physiological variables to define the state of the phytoplankton community. As an alternative approach, past climatic events (last 2-5 k year) will also be reconstructed to study their link to primary productivity. The objective was to collect several undisturbed sediment archives in a number of key locations across the Canadian Arctic and perform multiproxy analyses to allow for high-resolution paleoenvironmental reconstructions.

11.2 Methodology

11.2.1 Stock measurements

<u>Phytoplankton pigment content (HPLC)</u>

Seawater collected from the Rosette was filtered on Whatman GF/F glass fiber filters at each Basic and Full station, at a minimum of 6 depths on each cast (usually 10 depths). Filters were kept frozen at -80°C onboard the *Amundsen* until the ship returned to Quebec City. Using the same protocol, water samples were also collected from the barge.

Particulate Organic Carbon (POC) content (and SPM)

Seawater from the Rosette was filtered at each Basic and Full station at a minimum of 6 depths at each cast (usually 10 depths). Water samples were filtered onto pre-combusted and pre-weighted Whatman GF/F glass fiber filters, then filters were dried in the oven at 60°C and kept dried in the dark until the analysis was performed. Using the same protocol, water samples were also taken from the barge.

Lipid content

Surface water samples were taken from the Rosette at each Basic and Full stations. Samples were filtered onto pre-combusted Whatman GF/F glass fiber filters and kept in the freezer in 4 mL chloroform until the ship returned to Quebec City.

CDOM content

Water samples were collected from the Rosette at each Basic and Full stations, and from the barge, at 11 depths on each cast. CDOM content was determined using a variable pathlength spectrophotometer (Ultrapath, WPI ltd.) after filtration with Acrodisc 0.2 µm.

Particulate absorption of phytoplankton

Samples taken from the Rosette or the barge were used to determine particulate absorption using a double beam spectrophotometer equipped with an integrating sphere. Samples were filtered onto Whatman GF/F glass fiber filters and absorption was read directly from the filter. Phytoplankton pigments were then extracted using methanol and detritus absorption was read on the spectrophotometer 24 hours later.

Table 11.1. Summary of seawater sampling for phytoplankton and particulates measurements in Leg 1.

						Number of samples per variables					
Station	Date (yymmdd)	Latitude (N)	Longitude (W)	Time (UTC)	Cast	Ap	CDOM	HPLC	CHN-SPM	PP	Comments
Leg 1A											
633	13-07-30	57°36.37	61°53.84	22:50	5	11	11	11	11	–	Oakak fjord
630	13-07-31	57°28.3	62°26.483	09:18	9	8	8	8	8	–	Oakak fjord
602	13-08-01	59°3.288	63°52.166	12:51	13	10	10	10	10	–	Nachvak fjord
600	13-08-01	59°5.413	63°26.219	21:48	17	10	10	10	10	–	Nachvak fjord
183	13-08-04	65°35.204	66°20.023	23:17	24	10	10	10	10	10	Labrador Sea
180	13-08-07	67°5.492	61°15.709	07:20	27	10	10	10	10	10	Labrador Sea
176	13-08-09	69°35.517	65°48.62	12:02	31	10	10	10	10	10	Labrador Sea
170	13-08-10	71°22.788	70°4.232	16:34	33	11	11	11	11	10	Labrador Sea
Leg 1B											
325	13-08-13	73°48.92	80°28.796	12:04	36	8	8	8	8		End Lancaster Sound
323	13-08-14	74°9.472	80°28.508	05:57	41	10	10	10	10	10	End Lancaster Sound
322	13-08-14	74°29.833	80°32.251	14:55	43	10	10	10	10	10	End Lancaster Sound
101-1	13-08-15	76°23.242	77°23.412	09:33	44	5	5	5	5	5	Baffin Bay, 24hres
101-2	13-08-15	76°22.884	77°21.902	13:24	45	3	3	3	3	3	Baffin Bay, 24hres
101-3	13-08-15	76°21.065	77°29.065	18:53	46	3	3	3	3	3	Baffin Bay, 24hres
101-4	13-08-15	76°20.962	77°35.322	21:33	47	3	3	3	3	3	Baffin Bay, 24hres

						Number of samples per variables					
Station	Date (yymmdd)	Latitude (N)	Longitude (W)	Time (UTC)	Cast	Ap	CDOM	HPLC	CHN-SPM	PP	Comments
101-5	13-08-16	76°19.928	77°39.868	01:48	48	3	3	3	3	3	Baffin Bay, 24hres
101-6	13-08-16	76°17.623	77°45.54	05:47	49	3	3	3	3	3	Baffin Bay, 24hres
101-7	13-08-16	76°17.623	77°46.264	08:20	50	3	3	3	3	3	Baffin Bay, 24hres
108	13-08-17	76°16.205	74°35.773	07:32	60	10	10	10	10	8	Baffin Bay
111	13-08-17	76°18.328	73°12.185	21:35	64	10	10	10	10		Baffin Bay
115-1	13-08-18	76°20.297	71°11.514	09:46	69	3	3	3	3	3	Baffin Bay, 24hres
115-2	13-08-18	76°21.425	71°12.86	13:22	70	7	7	7	7	8	Baffin Bay, 24hres
115-3	13-08-18	76°22.766	71°19.192	16:50	71	3	3	3	3	3	Baffin Bay, 24hres
115-4	13-08-18	76°25.182	71°18.391	20:35	72	3	3	3	3	3	Baffin Bay, 24hres
115-5	13-08-18	76°27.011	71°24.894	01:33	73	3	3	3	3	3	Baffin Bay, 24hres
115-6	13-08-19	76°29.59	71°29.365	05:16	74	3	3	3	3	3	Baffin Bay, 24hres
115-7	13-08-19	76°29.858	71°26.615	08:30	75	3	3	3	3	3	Baffin Bay, 24hres
132	13-08-20	78°59.677	72°15.558	04:36	76	10	10	10	10	8	Entrance Kane Bassin
250	13-08-21	81°14.929	62°22.097	23:39	79	10	10	10	10	8	Peterman fjord mouth
Peterman -Barge-1	13-08-22	81°12.076	62°04.406	09:42	Bucket	1	1	1	1	–	Peterman transect
Peterman -Barge-3	13-08-22	81°06.09	61°50.6	10:47	Bucket	1	1	1	1	–	Peterman transect
Peterman -Barge-4	13-08-22	80°03.2	61°38.12	11:56	Bucket	1	1	1	1	–	Peterman transect
Peterman -Barge-5	13-08-22	80°00.5	61°28.25	12:30	Bucket	1	1	1	1	–	Peterman transect
Peterman -Barge-6	13-08-22	80°58.4	61°21.25	13:03	Bucket	1	1	1	1	–	Peterman transect
Peterman -Barge-7	13-08-22	80°54.55	61°12.95	13:40	Bucket	1	1	1	1	–	Peterman transect
251	13-08-22	81°54.46	61°11.75	18:47	82	6	6	6	6		Peterman fjord IN
253a	13-08-25	79°17.658	71°17.704	04:25	84	10	10	10	10	8	Peterman Island near
253b	13-08-25	79°14.326	71°27.388	13:23	87	10	10	10	10	8	Peterman Island far
Peterman -Barge-1	13-08-25	81°12.076	62°04.406	13:42	Bucket	1	1	1	1	–	Peterman -Barge-A
Peterman -Barge-2	13-08-25	81°09.551	61°58.087	14:10	Bucket	1	1	1	1	–	Peterman -Barge-C
Peterman -Barge-3	13-08-25	81°06.09	61°50.6	14:47	Bucket	1	1	1	1	–	Peterman -Barge-D
Peterman -Barge-5	13-08-25	80°00.5	61°28.25	16:30	Bucket	1	1	1	1	–	Peterman -Barge-E
Peterman -Barge-6	13-08-25	80°58.4	61°21.25	17:03	Bucket	1	1	1	1	–	Peterman -Barge-F
Peterman -Barge-7	13-08-25	80°54.55	61°12.95	17:40	Bucket	1	1	1	1	–	Peterman -Barge-B
Peterman -Barge-8	13-08-25	80°54.83	61°42.06	18:37	Bucket	1	1	1	1	–	Peterman -Barge-G
Peterman -Barge-9	13-08-25	80°54.29	61°41.23	18:47	Bucket	1	1	1	1	–	Peterman -Barge-H
Peterman -Barge-10	13-08-25	80°54.92	61°39.985	18:56	Bucket	1	1	1	1	–	Peterman -Barge-I
Peterman -Barge-11	13-08-25	80°54.962	61°38.201	19:02	Bucket	1	1	1	1	–	Peterman -Barge-J
Peterman -Barge-12	13-08-25	80°55.075	61°29.546	19:14	Bucket	1	1	1	1	–	Peterman -Barge-K
Peterman -Barge-13	13-08-25	80°55.50	61°09.924	19:32	Bucket	1	1	1	1	–	Peterman -Barge-L
Peterman -Barge-14	13-08-25	80°56.293	61°05.500	19:39	Bucket	1	1	1	1	–	Peterman -Barge-M
Peterman -Barge-15	13-08-25	80°57.30	60°58.944	19:48	Bucket	1	1	1	1	–	Peterman -Barge-N
126	13-08-27	77°20.580	73°25.778	03:22	90	10	5	10	10	8	Baffin Bay transect
122	13-08-27	77°20.562	75°0.806	21:41	96	10	10	10	10	–	Baffin Bay transect
119	13-08-27	77°20.005	76°3.186	08:30	100	10	10	10	10	–	Baffin Bay transect
117	13-08-29	77°20.006	77°0.770	01:43	105	10	10	10	10	8	Baffin Bay transect
301	13-08-30	74°6.169	83°22.484	12:39	108	11	11	11	11	–	Lancaster Sound
304	13-08-31	74°14.968	91°27.342	07:12	112	10	10	10	10		Lancaster Sound
ICE-2	13-09-01	74°04.408	96°27.001	10:56		–	–	1	1	–	Lancaster Sound
ICE-3	13-09-02	74°11.698	95°56.322	19:22	115	10	11	10	10		Lancaster Sound

11.2.2 Phytoplankton physiology measurements

Photosynthetic parameters were determined according to Babin et al. (1996) using ^{14}C enrichment incubations in a radial photosynthetron. A profile of 5 to 10 curves (5-10 depths) was done at Basic stations in the Labrador fjords and Labrador Sea and at each Full station (Table 11.1).

11.2.3 Optical measurements

Apparent and inherent optical properties (AOP and IOP), were measured *in situ* from the barge or from the *Amundsen*'s foredeck at every Basic and Full stations when the weather allowed (Table 11.2).

- Inherent optical properties (IOP) were measured using two optical packages:
  - Takuvik optical package included a CTD (Seabird), backscattering meters at thirteen wavelengths (WetLabs; BB9, BB3 and 1 BB from a FLBBDC), a hyper-spectral absorption-attenuation meter (WetLabs, ac-s) and a fluorometer (WetLabs, FLBBCD) for CDOM and Chl.
  - UQAR optical package included a CTD (Seabird), a backscattering meter with 6 wavelengths (Hobilabs; Hydroscat-6) and two fluorescence channels for CDOM and Chl a, a spectral absorption meter (Hobilabs; a-sphere) and a ECOtriplet fluorescence meter with 3 ex/em for CDOM.
- Apparent optical properties (AOP) were measured using Takuvik's Compact Optical Profiling System (COPS; Biospherical).

Particles and zooplankton imagery was also performed using an underwater vision profiler (UVP) instrument, fitted on the Rosette frame. The UVP5 is an instrument designed to take pictures of a slice of water lighted by 2 rows of flashing LEDs while profiling (or when moored). An image processing, performed either onboard while profiling, or in delayed mode after data recovery, estimates the particles size distribution and stores vignettes of the particles found in the images. The pixel size of the camera is approximately 150 microns, and the particles detected by the UVP range from 150 microns to few centimeters.

11.2.4 Above-water radiometry

Incident downwelling spectral irradiance (Ed0+) was measured continuously from the top bridge using the radiometer from UQAR's COPS mounted on a 5-m telescoping mast (Table 11.2). It was cleaned once a day during the cruise and deployed as high as the meteorological conditions allowed.

Table 11.2. Summary of optical instruments deployed during Legs 1a and 1b.

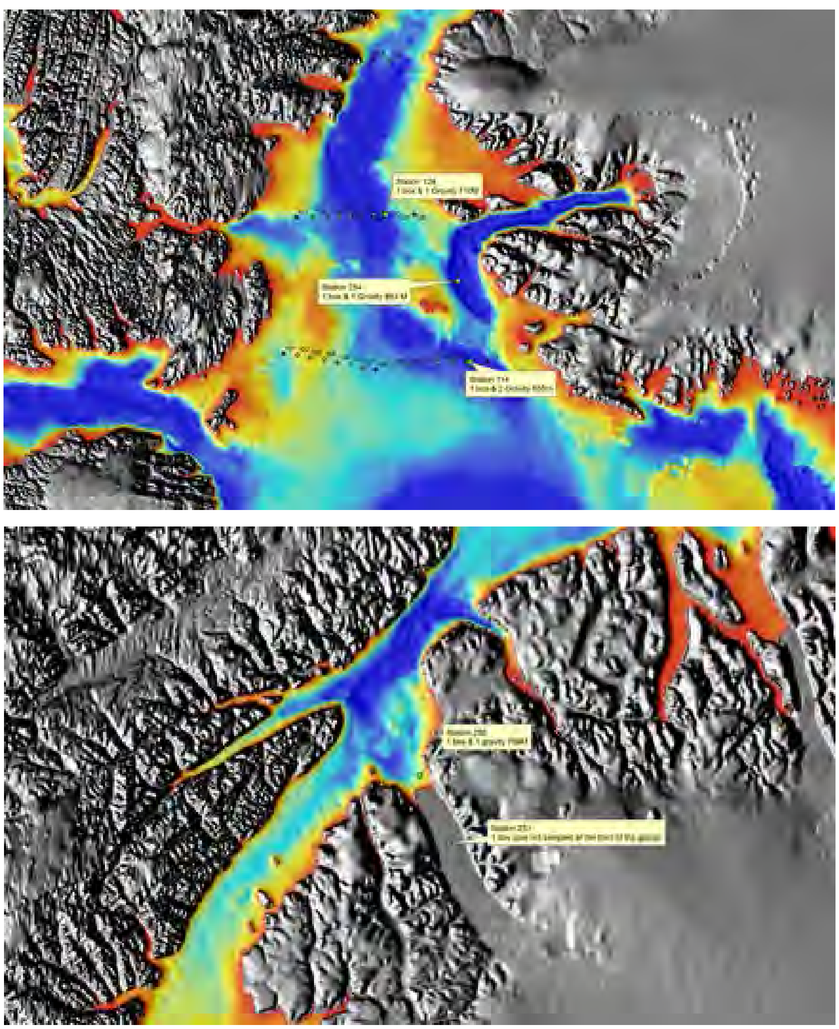
Stn#	Latitude N	Longitude W	Depth (m)	Date in 2013	Cast#	Time	Type
633	57°36.273	053°89.500	185	07/30	1	0847	Test
					2	0854	COPS
					3	0912	COPS
					4	0925	COPS
					5	0928	Bioshade
					Run1	1750	IOPS
					Run2	1754	IOPS
630				07/31	100	1017	IOPS_Simon
					101	1126	IOPS_Simon
600	59°03.316	063°52.742	154	08/01	1	0139	Bioshade
					2	0155	COPS
					3	0201	COPS
					4	0207	COPS
					5	0212	COPS
					6	0223	COPS
					7	0228	COPS
					8	0234	COPS
					9	0237	Bioshade
					Run3	2039	IOPS
					Run4	2044	IOPS
602	59°05.018	063°27.366	185	08/01	1	1820	COPS
					2	1826	COPS
					3	2043	COPS
					Run5	1844	IOPS
					Run6	1909	IOPS
183	65°35.170	066°19.860		08/03	67	1947	IOPS_Simon
					68	2009	IOPS_Simon
	65°35.394	066°20.511		08/04	70	1457	IOPS_Simon
					71	2359	IOPS_Simon
ROV2	67°09.646	061°16.281		08/07	72	0258	IOPS_Simon
					73	0248	IOPS_Simon
					74	0227	IOPS_Simon
180	67°33.345	061°48.649		08/09	75	1237	IOPS_Simon
					76	1225	IOPS_Simon
					77	1139	IOPS_Simon
170	71°23.179	070°03.697	385	08/10	Run7	1945	IOPS
					Run8	1948	IOPS
					Run9	1952	IOPS
					1	1443	COPS
					2	1452	COPS
					3	1504	COPS
					4	1513	COPS
					5	1517	Erreur
					6	1520	Bioshade
323	74°10.350	080°19.000	750	08/14	79	0458	IOPS_Simon
					80	0555	IOPS_Simon
101	76°21.406	077°24.793	350	08/15	1	1622	COPS
					2	1626	COPS

Stn#	Latitude N	Longitude W	Depth (m)	Date in 2013	Cast#	Time	Type
101 (cont'd)					3	1631	COPS
					4	1643	COPS
					5	1653	COPS
					6	1703	COPS
					7	1705	Bioshade
					Run10	2251	IOPS
					Run11	2256	IOPS
					Run12	2256	IOPS
					Run13	2256	IOPS
				08/15	70	0058	IOPS_Simon
				08/16	71	1231	IOPS_Simon
					72	1249	IOPS_Simon
105	76°18.596	075°46.650	350	08/16	1	1640	COPS
					2	1646	COPS
					3	1655	COPS
					4	1703	COPS
					5	1710	COPS
					6	1720	COPS
					7	1728	COPS
					8	1734	COPS
					9	1739	COPS
					10	1757	Bioshade
					Run15	1548	IOPS
					Run16	1613	IOPS
					Run17	1800	IOPS
					Run18	1826	IOPS
	76°20.543	077°04.430		08/16	74	0738	IOPS_Simon
					75	0808	IOPS_Simon
108	76°16.097	074°35.826	445	08/17	76	0541	IOPS_Simon
					78	0606	IOPS_Simon
111	76°18.366	073°17.855		08/17	79	1046	IOPS_Simon
					81	1108	IOPS_Simon
115	76°22.637	071°14.545		08/18	1	1545	COPS
					2	1552	COPS
					3	1601	COPS
					4	1607	COPS
					5	1614	COPS
					6	1616	Bioshade
					Run19-26	Xx	IOPS
	76°24.342	071°21.497	558	08/18	83	0648	IOPS_Simon
					85	0737	IOPS_Simon
				08/19	88	0734	IOPS_Simon
132	78°59.179	072°05.300	250	08/20	89	0847	IOPS_Simon
					90	0900	IOPS_Simon
					91	0956	IOPS_Simon
	79°00.958	071°57.128		08/20	Run27	1256	IOPS
					Run28	1321	IOPS
	79°00.620	072°05.820		085/20	1	1427	COPS
					2	1436	COPS
					3	1442	COPS

Stn#	Latitude N	Longitude W	Depth (m)	Date in 2013	Cast#	Time	Type
132 (cont'd)					4	1453	COPS
					5	1509	Bioshade
250			250	08/22	93	0607	IOPS_Simon
					94	0554	IOPS_Simon
Fjord Peterman	81°09.551	061°58.087		08/22	Run29	1455	IOPS
					1	1525	COPS
					2	1534	COPS
	81°00.350	061°27.481			1	1637	COPS
					2	1640	COPS
					Run30	1741	IOPS
	80°54.566	061°12.891			1	1810	COPS
					2	1813	COPS
	80°57.441	060°58.815			Run31	1951	IOPS
253	79°17.631	071°18.502	185	08/25	70	0841	IOPS_Simon
					71	0807	IOPS_Simon
				08/25	Run32	1346	IOPS
					1	1258	COPS
					2	1413	COPS
					3	1415	COPS
					4	1426	COPS
					Run33	1527	IOPS
					5	1559	COPS
					Run34	1703	IOPS
					Run35	1716	IOPS
126	77°20.712	073°25.585	332	08/27	72	0634	IOPS_Simon
					73	0710	IOPS_Simon
	77°19.882	073°30.071	300	08/27	Run36	1018	IOPS
					Run37	1043	IOPS
					1	1112	COPS
					2	1115	COPS
					3	1120	COPS
					4	1126	COPS
					5	1132	COPS
					6	1136	Bioshade
122	77°20.786	075°04.152	643	08/28	5	0431	IOPS_Simon
					Run38	0431	IOPS
119	77°20.004	076°04.224	500	08/28	76	1321	IOPS_Simon
					Run39	1321	IOPS
117	77°19.180	077°01.380	500	08/28	1	1820	COPS
					2	1824	COPS
					3	1830	COPS
					4	1837	COPS
					5	1843	COPS
					6	1850	Bioshade
					Run40	1859	IOPS
					Run41	1912	IOPS
					Run42	1931	IOPS
					Run43	1955	IOPS
			450	08/28	77	0006	IOPS_Simon
				08/29	78	0021	IOPS_Simon

Stn#	Latitude N	Longitude W	Depth (m)	Date in 2013	Cast#	Time	Type
301				08/30	Run44		IOPS
					Run45		IOPS
					1	1327	COPS
					2	1334	COPS
					3	1335	COPS
					4	1341	COPS
					5	1353	COPS
					6	1408	Bioshade
304	74°15.100	091°29.100	323	08/31	Run46		IOPS
					79	0615	IOPS_Simon
304	74°15.696	091°23.497		08/31	Run47		IOPS
					80	1040	IOPS_Simon
					Run48		IOPS
					81	1101	IOPS_Simon

11.2.5 Sediment sampling



Analysis of the sub-bottom data allowed for the identification and selection of 5 sites according to their position and the presence of soft recent sediments (Figures 11.1 and 11.2). At each site, surface and deeper (up to 2.5 m) sediments were collected using a box corer and a gravity corer respectively. Cores were sealed immediately after retrieval and stored at 4°C.

Figure 11.1. Sediments sampling sites where box coring and gravity coring activities were conducted during Leg 1.

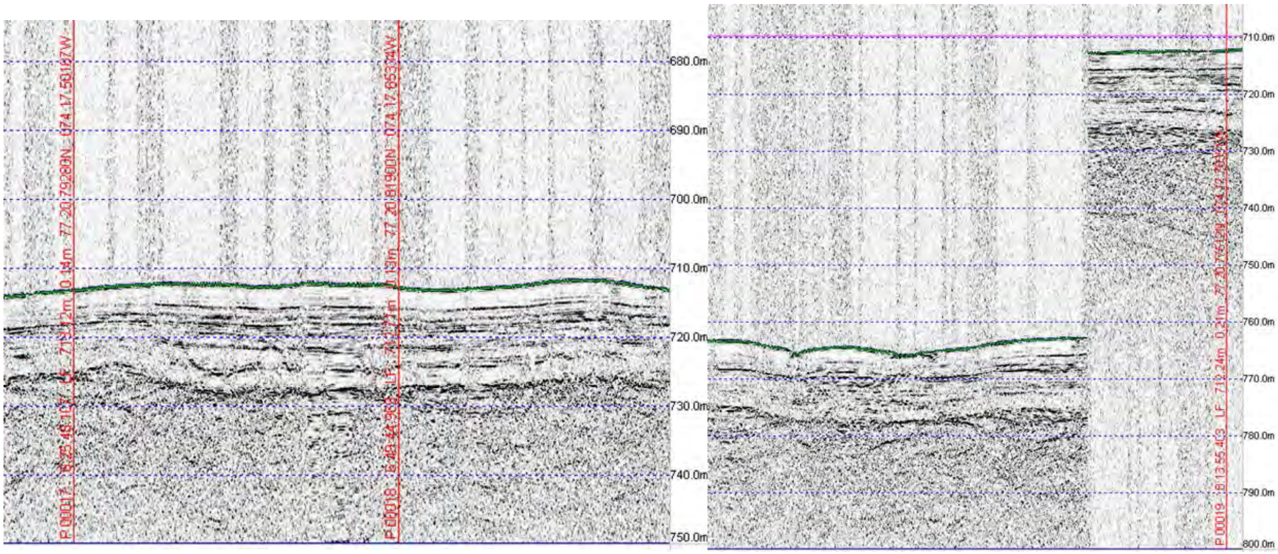


Figure 11.2. Sub-bottom (3.5 kHz) record for coring sites BC02 & BC03 (left panel) and GC01 (right panel) located at Station 124 (~713 m water depth) sampled during Leg 1.

11.3 Preliminary results

11.3.1 Optical measurements

Typical IOP cast showing a profile of absorption (*a*) and attenuation (*c*) at 445 nm, a spectrum of *a* and *c* (thus *b*=*c*–*a*) at 20 m, a profile of particulate backscattering coefficient at 440 nm, a profile of Chl *a* fluorescence as well as a profile of CDOM fluorescence (Figure 11.3).

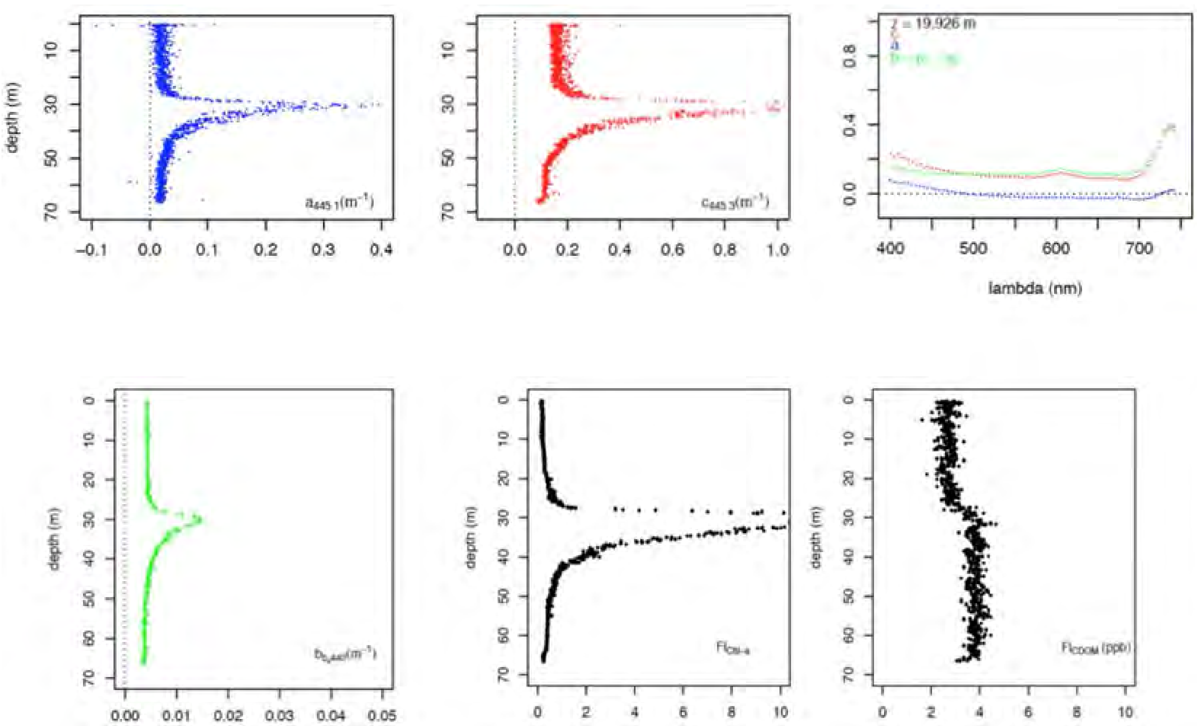


Figure 11.3. Example of a typical IOP cast conducted on 16 August at Station 105 during Leg 1.

Typical profiles and examples of images obtained with the UVP are presented in Figure 11.4.

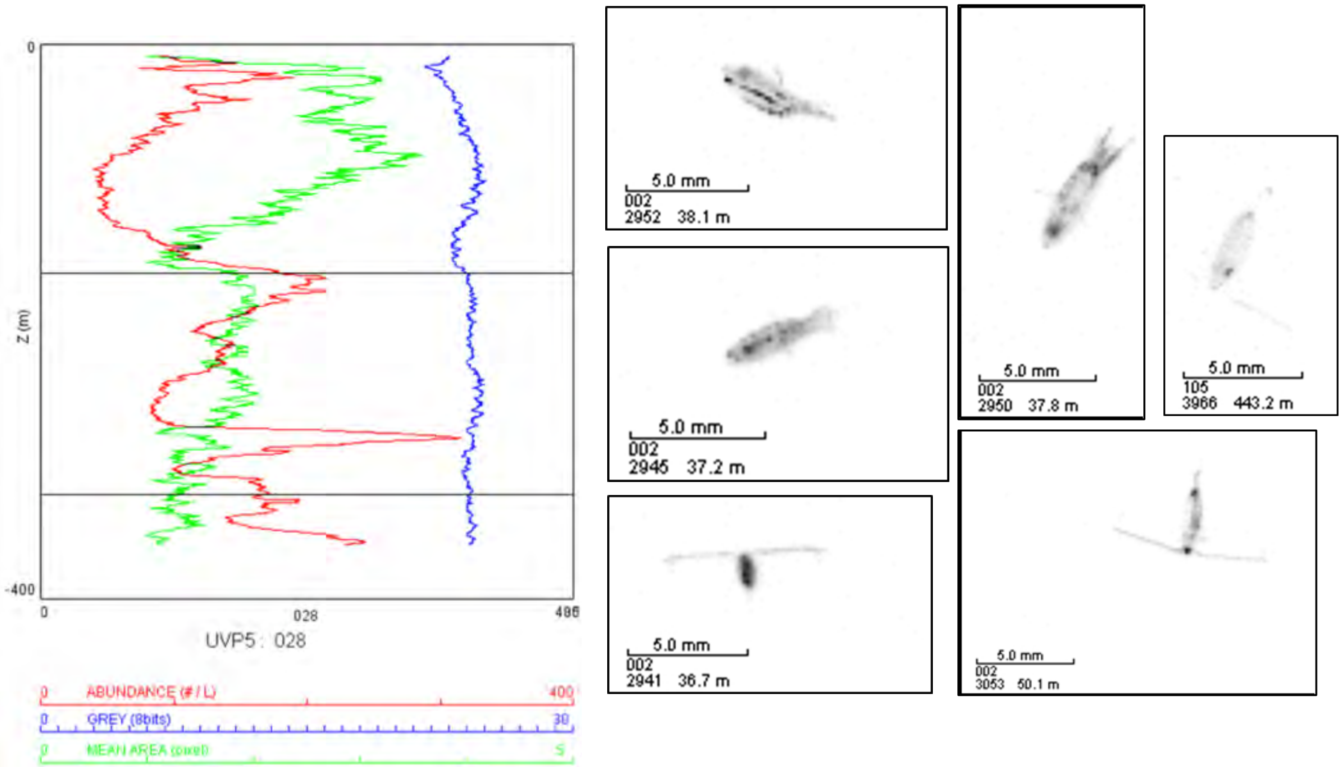


Figure 11.4. Left: Profile of particles abundance, mean object area and objects mean grey level (an object being defined as an independent part of the entire image). Right: Vignettes of typical objects recorded by the UVP (images were processed).

11.3.2 Sediments

Multi-proxy analyses will be performed after the return of the ship to Quebec City. The sediment cores will be stored in the ISMER/UQAR sediment facility (A. Rochon, UQAR), sectioned and the sediment samples will be distributed amongst the project partners for their respective analyses. It is anticipated that the first results (e.g. dating) will be obtained in early 2014.

11.4 Comments and recommendations

During particulate absorption filtration, a non-homogeneous distribution of the biomass on the filters was noticed, which is problematic for the analysis. A degassing of the water samples was suspected to occur when samples were brought to room temperature. This hypothesis was tested in the lab and it was concluded that, at least, temperature was not the only parameter involved in the formation in such bubbles. Various kinds of filters were also tested with no observed effect. The phenomenon was station- and depth-dependent but it was impossible to relate it to any environmental or biological parameter. It was suspected that the design of the filtration system was involved because the problem was not observed with other filtration systems.

Accessibility to chemicals (room 605) was reduced and often dangerous during the cruise as several containers were stored on this room. The floor in front of the cabinet should be kept clear of any boxes or objects.

The underway seawater pumping system still released a lot of particulate matter (likely rust) and it would be really appreciated that one of the lines be changed to plastic plumbing to avoid this.

Some stations sampled using the barge required a long time to carry out due to the numerous profiles. During these activities, there were no power sources on board, and twice, batteries ran out and operations had to stop. Thus, it would be a valuable asset that the barge be equipped with a 110V power source. This would also allow the real-time visualization of the IOPs data acquisition.

Although very convenient during the deployment, the gravity corer did not allow for long (>10 m) sediment sequences to be recovered, limiting reconstructions to the last few millennia (2-3k). Important climatic transitions occurred >12k year ago and it would be very useful to obtain sediment archives extending back to that period during future ArcticNet cruises.

This cruise represented the first opportunity for ArcticNet researchers to obtain some unique sedimentary archives from previously ice covered areas such as in front of the Petermann glacier. Unfortunately, due to time constraints and heavy ice conditions, it was impossible to reach the Lincoln Sea. This site should be considered for the coming ArcticNet cruises.

12 Phytoplankton and primary production – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change.* ArcticNet/Phase3/Marine-ecosystem-services.

Project leaders: Michel Gosselin[1] (michel_gosselin@uqar.ca) and Michel Poulin[2] (mpoulin@mus-nature.ca)
Cruise participants Leg 1a: Marjolaine Blais[1], Armelle Simo[1] and Joannie Charette[1]
Cruise participants Leg 1b: Marjolaine Blais[1] and Joannie Charette[1]
Cruise participants Leg 2a: Michel Gosselin[1] and Marie-France Lavoie[1]
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12.1 Introduction

Primary production plays a central role in the oceans as it supplies organic matter to the higher trophic levels, including zooplankton, fish larvae, marine mammals and birds. Marine polar ecosystems are particularly sensitive to any changes in primary production due to their low number of trophic links (Grebmeier et al. 2006; Moline et al. 2008; Post et al. 2009). The Arctic Ocean is changing as evidenced by the decrease in sea ice thickness and extent (Stroeve et al. 2007; Kwok et al. 2009), the early melt and late freeze-up of sea ice (Markus et al. 2009) and the enhancement of the hydrological cycle (Peterson et al. 2006; Serreze et al. 2006). These environmental changes have already altered the phytoplankton biomass distribution in the Arctic Ocean (Arrigo et al. 2008; Pabi et al. 2008).

In this context, the general objectives of this research project were to:

- Determine the spatial and temporal variability in production, biomass, abundance and taxonomic composition of the phytoplankton communities.
- Determine the role of environmental factors on the phytoplankton dynamics and its variability in the Labrador fjords as well as in Baffin Bay and Lancaster Sound (Leg 1) and in the Northwest Passage and McClure Strait (Leg 2a).

12.2 Methodology

12.2.1 Overview

The following parameter determinations and analyses were conducted in the water column:

- Downwelling incident irradiance, every 10 minutes, with a Li-COR 2 pi sensor.
- Transparency of the upper water column with a Secchi disk.
- Underwater irradiance profile with a PNF-300 probe.
- Concentrations of dissolved organic carbon (DOC), total organic carbon (TOC), total dissolved nitrogen (TDN) and total nitrogen (TN) with a Shimadzu TOC-V_{CPN} analyzer.
- Chlorophyll *a* and pheopigment concentrations with a Turner Designs fluorometer (3 size-classes: >0.7 µm, >5 µm, >20 µm).

- Abundance and taxonomic composition of phytoplankton using the inverted microscopy method.
- Abundance of pico- and nanophytoplankton and heterotrophic bacteria by flow cytometry.
- Estimates of the grazing rate of phytoplankton and bacteria by microzooplankton using dilution method and 24 hours incubations.
- Phytoplankton production using the ^{14}C assimilation method (2 size-fractions: >0.7 µm, >5 µm).

In Leg 2a, the concentrations of TOC, DOC, TN, pico- and nanophytoplankton and bacteria were also determined in glacier ice floating in the front of the main glacier in Blanley Bay (south of Devon Island).

At each station, water samples were collected with 12 L Niskin-type bottles attached to the CTD-Rosette. During the daytime, the depth of the euphotic zone was determined with the Secchi disk and the PNF-300 probe. Size-fractionated (3 size-classes: >0.7 µm, >5 µm and >20 µm) chlorophyll *a* concentrations were measured onboard the ship at each sampling depth with a Turner Designs fluorometer (model 10-AU). Size-fractionated (2 size-classes: >0.7 µm and >5 µm) primary production was estimated at 7 optical depths (i.e. 100%, 50%, 30%, 15%, 5%, 1%, and 0.2% of surface irradiance) following JGOFS protocol for simulated *in situ* incubation. The other samples collected during this expedition will be analyzed at ISMER. Detailed sampling activities are summarized in Table 12.1. Chlorophyll *a* data were shared with J.-É. Tremblay's team (U. Laval) for the calibration of the chlorophyll *a* fluorescence sensor. Grazing experiments were conducted at four stations in Leg 1 according to the dilution method of Landry et al. (2008).

Table 12.1. Sampling operations conducted for phytoplankton stocks and production rates during Legs 1a, 1b and 2a.

Stn #	Cast #	Date in 2013	Position		Chlorophyll a			POC/ PON	DOC/DN TOC/TN	HPLC	Taxo	Cyto. flux	Grazing	Primary prod.	
			Latitude N	Longitude W	> 0.7um	>5um	>20um							>0.7um	>5um
Leg 1															
650	2	07-29	49°13.115	067°14.121	X			X	X		X	X			
633	4	07-30	57°36.402	061°53.771	X	X	X	X	X	X	X	X	X	X	X
630	10	07-31	57°28.253	062°24.468	X	X	X	X	X	X	X	X	X	X	X
602	12	08-01	59°03.180	063°52.199	X	X	X	X	X	X	X	X	X	X	X
600	16	08-01	59°05.082	063°27.253	X	X	X	X	X	X	X	X	X	X	X
183	23	08-04	65°35.204	066°20.470	X	X	X	X	X	X	X	X		X	X
180	28	08-07	67°09.988	061°16.310	X	X	X	X	X	X	X	X		X	X
176	30	08-09	69°35.892	065°47.856	X	X	X	X	X	X	X	X		X	X
170	32	08-10	71°22.784	070°04.441	X	X	X	X	X	X	X	X		X	X
323	38	08-13	74°09.482	080°28.400	X	X	X	X	X	X	X	X		X	X
101-T1	44	08-15	76°23.242	077°23.412	X	X									
101-T2	45	08-15	76°22.884	077°21.902	X	X									

Stn #	Cast #	Date in 2013	Position		Chlorophyll a			POC/ PON	DOC/DN TOC/TN	HPLC	Taxo	Cyto. flux	Grazing	Primary prod.	
			Latitude N	Longitude W	> 0.7um	>5um	>20um							>0.7um	>5um
101-T3	46	08-15	76°21.065	077°29.065	X	X	X	X	X	X	X	X		X	X
101-T4	47	08-15	76°20.962	077°35.322	X	X									
101-T5	48	08-15	76°19.928	077°39.868	X	X									
101-T6	49	08-16	76°17.632	077°45.540	X	X									
101-T7	50	08-16	76°17.372	077°46.264	X	X									
105	54	08-16	76°19.103	075°45.150	X	X	X	X	X	X	X	X			
108	59	08-17	76°15.010	074°39.276	X	X	X	X	X	X	X	X		X	X
111	65	08-17	76°18.392	073°12.907	X	X	X	X	X	X	X	X			
115-T1	69	08-18	76°20.297	071°11.514	X	X									
115-T2	70	08-18	76°21.425	071°12.860	X	X									
115-T3	71	08-18	76°22.766	071°19.192	X	X	X	X	X	X	X	X		X	X
115-T4	72	08-18	76°25.182	071°18.391	X	X									
115-T5	73	08-18	76°27.011	071°24.894	X	X									
115-T6	74	08-19	76°29.590	071°29.365	X	X									
115-T7	75	08-19	76°29.858	071°26.615	X	X									
132	77	08-20	78°59.446	072°06.008	X	X	X	X	X	X	X	X		X	X
250	79	08-21	81°14.929	062°22.097	X	X	X	X	X	X	X	X		X	X
251	82	08-22	81°54.460	061°11.750	X	X	X	X	X	X	X	X			
Glacier 1	Barge	08-22	81°12.076	062°04.406	X	X									
Glacier 3	Barge	08-22	81°06.090	061°50.600	X	X									
Glacier 4	Barge	08-22	80°03.200	061°38.120	X	X									
Glacier 5	Barge	08-22	80°00.500	061°28.250	X	X									
Glacier 6	Barge	08-22	80°58.400	061°21.250	X	X									
Glacier 7	Barge	08-22	80°54.550	061°12.950	X	X									
253a	86	08-25	79°17.431	071°18.787	X	X	X	X	X	X	X	X		X	X
253b	89	08-25	79°17.760	071°26.699	X	X	X	X	X	X	X	X			
Ice island 1	Barge	08-25	81°12.076	062°04.406	X										
Ice island 3	Barge	08-25	81°06.090	061°50.600	X										
Ice island 5	Barge	08-25	80°00.500	061°28.250	X										
Ice island 6	Barge	08-25	80°58.400	061°21.250	X										
Ice island 8	Barge	08-25	80°54.830	061°42.06	X										
Ice island 10	Barge	08-25	80°54.920	061°39.985	X										
Ice island 11	Barge	08-25	80°54.962	061°38.201	X										
Ice island 13	Barge	08-25	80°55.500	061°09.924	X										
Ice island 15	Barge	08-25	80°57.300	060°58.944	X										
126	92	08-27	77°20.501	073°25.577	X	X	X	X	X	X	X	X		X	X
122	96	08-27	77°20.562	075°00.806	X	X	X	X	X	X	X	X			
119	100	08-28	77°20.005	076°03.186	X	X	X	X	X	X	X	X			
117	103	08-28	77°17.471	077°19.423	X	X	X	X	X	X	X	X		X	X
301	107	08-30	74°06.502	083°22.154	X	X	X	X	X	X	X	X		X	X
304	113	08-31	74°15.492	091°28.765	X	X	X	X	X	X	X	X		X	X
Ice station 2	115	09-02	74°11.698	095°56.322	X										
Leg 2a															
307	2	09-07	74°06.497	103°04.088	X	X	X	X	X	X	X	X		X	X
308	4	09-07	74°08.224	108°50.203	X	X	X	X	X	X	X	X		X	X

Stn #	Cast #	Date in 2013	Position		Chlorophyll a			POC/ PON	DOC/DN TOC/TN	HPLC	Taxo	Cyto. flux	Grazing	Primary prod.	
			Latitude N	Longitude W	> 0.7um	>5um	>20um							>0.7um	>5um
500	7	09-08	74°46.666	113°49.345	X	X	X	X	X	X	X	X		X	X
Ice Station 2		09-09	74°45.680	117°31.700											
333	11	15-09	74°26.962	087°24.484	X	X	X	X	X	X	X	X		X	X
333 Glacier		15-09	74°26.400	087°24.500					X			X			

12.3 Preliminary results

12.3.1 Leg 1a – 26 July to 12 August 2013 – Northern Labrador Sea and Baffin Bay

Phytoplankton biomass in the upper 100 m was similar in the outer and inner stations of Okak fjord, averaging 30 mg Chl *a* m^{-2}. Biomass was more than 5 times higher in Nachvak fjord, with peak concentrations occurring at the inner station. Large cells (>5 µm) accounted for about 15% of total biomass at all stations, except at the outer Nachvak station, where it accounted for 65% (Figure 12.1). Chlorophyll *a* vertical profiles showed a subsurface chlorophyll *a* maximum located between 10 and 20 m deep.

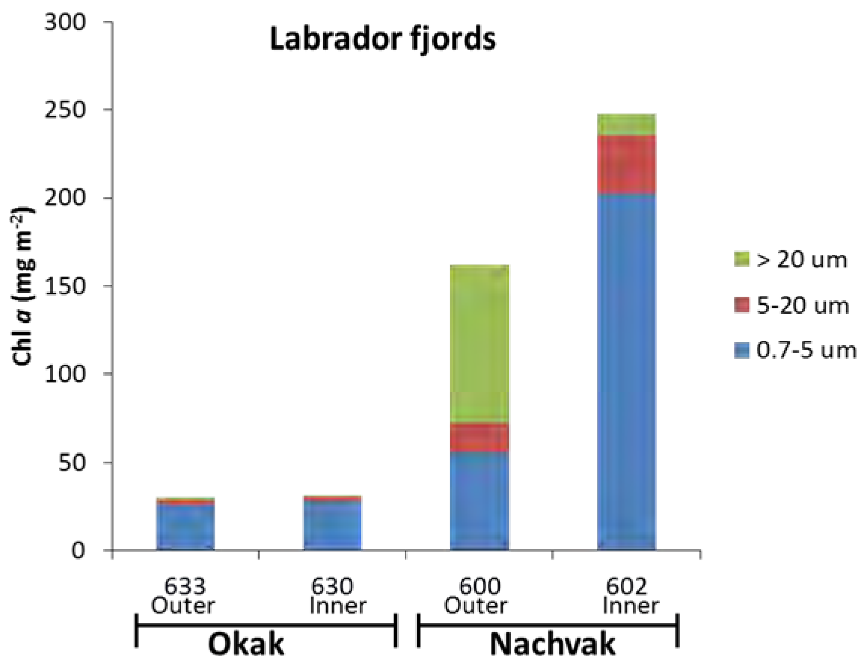

Figure 12.1. Chlorophyll a (Chl a) concentration integrated over 100 m (or down to the bottom when bottom <100 m) for different size fractions of phytoplankton (0.7-5 µm, 5-20 µm and > 20 µm) collected in the Labrador fjords during Leg 1a.

12.3.2 Leg 1b – 12 August to 5 September 2013 – Northern Baffin Bay and Canadian Arctic Archipelago

Phytoplankton biomass in the upper 100 m increased from south to north in Baffin Bay showed that large cells (>5 µm) accounted for an average of 70% of the total biomass. This contribution increased to almost 90% for northernmost stations (Figure 12.2). Chlorophyll *a* vertical profiles showed a latitudinal gradient in the stage of the bloom; late stage bloom condition were found in the southern transect and early stage bloom conditions at the northern stations.

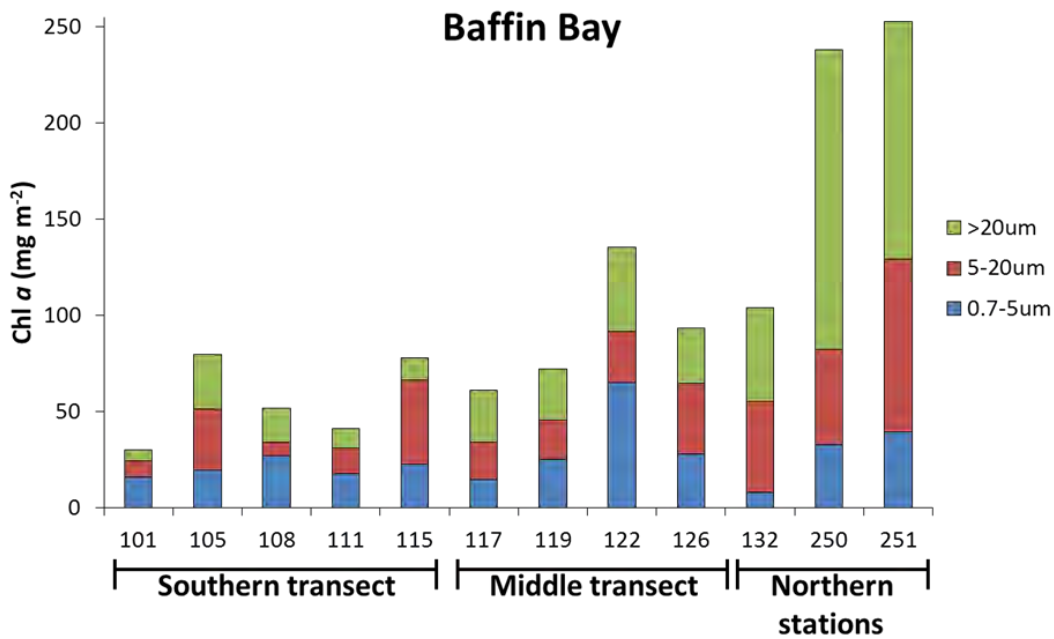

Figure 12.2. Chlorophyll *a* (Chl *a*) concentration integrated over 100 m for different size fractions of phytoplankton (0.7-5 µm, 5-20 µm and > 20 µm) collected in Baffin Bay during Leg 1b.

12.3.3 Leg 2a – 5 September to 15 September 2013 – Canadian Arctic Archipelago

Phytoplankton chlorophyll *a* biomass in the upper 100 m of the water column increased from the entrance of the Lancaster Sound (Station 323) to Barrow Strait (Stations 333 and 304) (Figure 12.3). The chlorophyll biomass was lower in the western section of the transect. However, it tended to increase again toward the the McClure Strait (Figure 12.3). Large cells (>5 µm) made up between 57 and 90% of the total algal biomass in the Lancaster and Barrow Strait while they represented less than 37% in the western section of the transect. These preliminary data confirms that the Lancaster Sound-Barrow Strait region is a biological hotspot.

Subsurface chlorophyll maximums were observed at each station along the transect at depths varying from 20 to 50 m, which is consistent with subsurface chlorophyll maximums being a typical feature of Arctic waters during late summer.

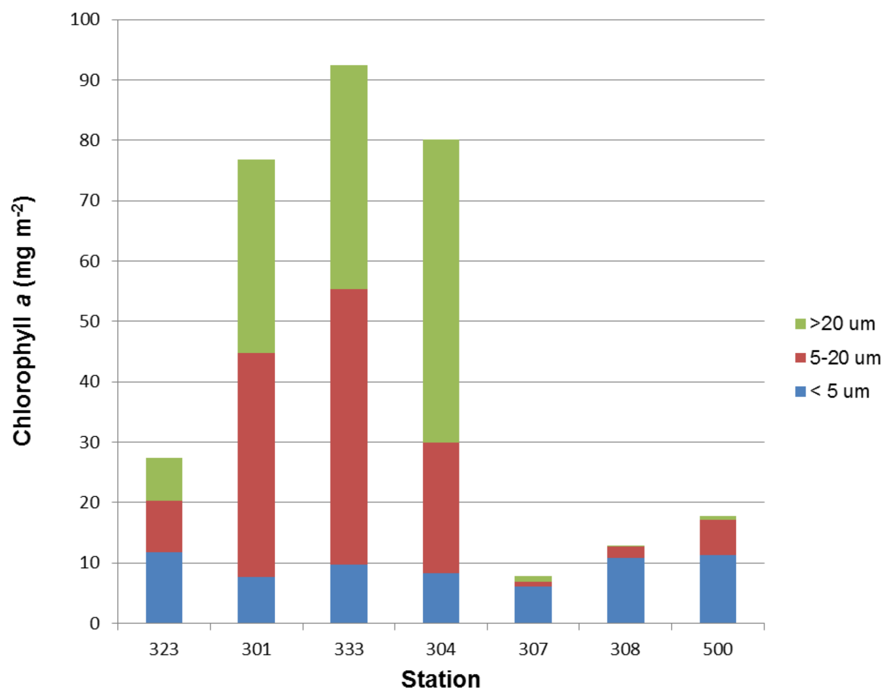

Figure 12.3. Size-fractionated chlorophyll *a* concentration along a longitudinal transect from the entrance of Lancaster Sound to the central region of the McClure Strait during Leg 2a. Values were integrated from surface to 100 m.

12.4 Comments and recommendations

12.4.1 Leg 1a – 26 July to 12 August 2013 – Northern Labrador Sea and Baffin Bay Leg 1b – 12 August to 5 September 2013 – Northern Baffin Bay and Canadian Arctic Archipelago

Problems arose with the pump used to supply the foredeck incubators with surface water. Four incubators had to be connected to this pump as well as another instrument from J.-É. Tremblay's team. The flow was insufficient for all the connected instruments and the incubators. It would be strongly suggested to setup 2 different pumps for instruments that need continuous water inflow or to have a more powerful pump.

The location of the pump's intake at the front of the ship was also problematic. When there were big waves or if the ship was breaking ice, the intake would be raised above the surface water level and pumped air. The pump then ceased to work and water froze in the incubators. It is be strongly suggested to find another location for the pump.

12.4.2 Leg 2a – 5 September to 15 September 2013 – Canadian Arctic Archipelago

Two racks for 20 ml scintillation vials were trashed because they blocked the functioning of the liquid scintillation counter (LSC). There are only 8 racks for 20 ml vials left in the LSC room (room 665). The new racks bought by ArcticNet but not received before the 2013 expedition should be put onboard the ship for the next cruises. The LSC worked very well when the ship was anchored in Resolute Bay.

The pipes of the freshwater supply in the Radvan froze when air temperature was low. To solve this problem, an additional heater was put under the bench of the Radvan.

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13 Zooplankton, ichtyoplankton and bioacoustics – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *The Arctic cod (Boreogadus saida) ecosystem under the double pressure of climate change and industrialization*. ArcticNet/Phase3/Arctic-cod.

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Cruise participants Leg 1a: Louis Fortier[1], Moritz Schmid[1], Maxime Geoffroy[1], Cyril Aubry[1] and Marianne Falardeau[1]
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Cruise participants Leg 2a: Moritz Schmid[1], Maxime Geoffroy[1], Cyril Aubry[1] and Jordan Grigor[1]
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13.1 Introduction

The objectives of the zooplankton, ichthyoplankton & bioacoustics program were (1) to sample the overall mesozooplankton assemblage over the entire water column, (2) to sample the ichthyoplankton community, focusing on the dominant species Arctic cod (*Boreogadus saida*) and (3) to collect baseline data on fish distribution and abundance using the SX90 fish finding sonar and the EK60 echosounder. The fine-tuning of the relation between ichthyoplankton size and target strength will enable to better understand biacoustical data obtained from the echosounders.

13.2 Methodology

The sampling carried out during Leg 1 and leg 2a was performed at Basic, Full and opportunistic stations (Table 13.1). A total of 33 stations were sampled during Leg 1 and 4 stations were visited in Leg 2a, with 103 deployments of equipment made. The team completed all planned operations as well as added sampling at several opportunistic sites in Leg 1.

Table 13.1. Summary of stations sampled for zooplankton and ichtyoplankton with the different deployments performed during Leg 1 and Leg 2a.

Leg	Date (UTC)	Station	5NVS and LOKI	Hydrobios	Bioness	Tucker net	RMT
Leg 1a							
1a	2013-07-30	633	x	x	x		
1a	2013-07-31	630	x			x	
1a	2013-08-01	Nachvak AC1 (600)				x	
1a	2013-08-01	Nachvak AC2				x	
1a	2013-08-01	Nachvak AC3				x	
1a	2013-08-01	Nachvak AC4 (602)				x	

Leg	Date (UTC)	Station	5NVS and LOKI	Hydrobios	Bioness	Tucker net	RMT
1a	2013-08-01	Nachvak AC5				x	
1a	2013-08-01	600	x				
1a	2013-08-04	183	x				
1a	2013-08-07	Methane2	x				
1a	2013-08-07	Methane3				x	
1a	2013-08-07	Methane4		x			
1a	2013-08-09	176 #1 cast 1	x		x		
1a	2013-08-09	176 #1 cast 2	x				
1a	2013-08-10	172	x		x		
1a	2013-08-10	170	x		x		
Leg 1b							
1b	2013-08-13	323	x	x	x		x
1b	2013-08-15	101 #1 cast 1(Lagrangien)	x	x			
1b	2013-08-15	101 #2 cast 1(Lagrangien)	x				
1b	2013-08-15	101 #2 cast 2(Lagrangien)	x		x		
1b	2013-08-15	101 #3 cast 1(Lagrangien)	x				
1b	2013-08-15	101 #4 cast 1(Lagrangien)	x				
1b	2013-08-15	101 #4 cast 2(Lagrangien)	x				
1b	2013-08-16	101 #5 cast 1(Lagrangien)	x				
1b	2013-08-16	101 #5 cast 2(Lagrangien)	x				
1b	2013-08-16	101 #6 cast 1(Lagrangien)	x				
1b	2013-08-16	105	x	x		x	
1b	2013-08-17	108	x	x	x		x
1b	2013-08-17	111	x	x		x	
1b	2013-08-18	115 #1 cast 1(Lagrangien)	x	x			
1b	2013-08-18	115 #2 cast 1(Lagrangien)	x		x		
1b	2013-08-20	132	x	x	x		x
1b	2013-08-22	250 #1 cast 1	x	x			
1b	2013-08-22	250 #1 cast 2	x		x		
1b	2013-08-22	251	x				
1b	2013-08-25	253a #1 cast 1	x	x	x		
1b	2013-08-25	253a #1 cast 2	x				
1b	2013-08-25	253b #1 cast 1	x				
1b	2013-08-25	253b #1 cast 2	x	x			
1b	2013-08-25	253b #1 cast 3	x				
1b	2013-08-27	126 #1 cast 1	x	x	x		
1b	2013-08-27	126 #1 cast 2	x				
1b	2013-08-27	122	x	x		x	
1b	2013-08-28	119	x	x		x	
1b	2013-08-28	117 #1 cast 1	x	x	x		
1b	2013-08-28	117 #1 cast 2	x				
1b	2013-08-30	301	x	x		x	
1b	2013-08-31	304	x	x	x		
1b	03-09-2013	Ice_peelsound #1	x				
1b	03-09-2013	Ice_peelsound #2	x				
1b	03-09-2013	Ice_peelsound #3	x				

Leg	Date (UTC)	Station	5NVS and LOKI	Hydrobios	Bioness	Tucker net	RMT
1b	03-09-2013	Ice_peelsound #4	x				
1b	03-09-2013	Ice_peelsound #5	x				
1b	03-09-2013	Ice_peelsound #6	x				
Leg 2a							
2a	2013-09-07	307	x			x	
2a	2013-09-07	308	x	x	x		
2a	2013-09-08	500	x			x	x
2a	2013-09-15	333	x			x	
Total			**51**	**19**	**14**	**15**	**4**

13.2.1 Zooplankton

The zooplankton assemblage integrated over the entire water column was collected by deploying the 5-Net Vertical Sampler (5NVS; Figure 13.1) from 10 m above the bottom to the surface at a retrieval rate of 0.6 m s^{-1}. It was necessary to deviate from previous years where the retrieval rate was 0.5 m s^{-1} due to the winch that was only running at 0.2 m s^{-1}, 0.4 m s^{-1} or 0.6 m s^{-1}. The 5NVS carried three 1-m^2 aperture nets (two with 200-µm mesh and one with 500-µm mesh), and one 50-µm mesh cylindrical net of 0.1 m diameter, for the collection of the entire meso-zooplankton size spectrum. In addition, the 5 NVS was fitted out with a fifth item, a Lightframe Onsight Keyspecies Investigation System (LOKI). The LOKI is an optical imaging system taking images of zooplankton with a vertical resolution of approximately 30 cm, depending on the towing speed (Figure 13.1).

One of the two 200-µm mesh samples and the smaller 50-µm mesh sample (copepod eggs and nauplii) were preserved in formalin and the 200-µm mesh was provided to the ArcticNet contaminant team (A. Burt, U. Manitoba) for assessment of contaminant levels. On an opportunistic basis in Leg 1, samples from the 5NVS were also shared with G. Massé (Takuvik/U. Laval) for RNA profiling studies. The 500-µm mesh sample (macrozooplankton including jellies) were preserved in formalin (Leg 1) or used in chaetognath feeding experiments (Leg 2a).

Sampling of the zooplankton assemblage stratified by depth was carried out using the Hydrobios, a multi-depth plankton profiler equipped with nine 200 µm-mesh nets (mouth opening 0.5 m^2) that was towed vertically (Figure 13.1). The Hydrobios was also equipped with a CTD to record water column properties while collecting biological samples. Downward and upward winch speeds were 40 and 30 m/min respectively. The content of each net was preserved in formalin, except at station 308 (Leg 2a) where it was used for the Chaetognath feeding experiment and to test the effect of $MgCl_2$ on anaesthetizing chaetognaths.

Figure 13.1. Vertically towed equipment used to sample zooplankton. Left: Schematic of LOKI, Middle: 5NVS with the LOKI as deployed during Leg 1 (Photo J. Barette), Right: Hydrobios being deployed (Photo S. Prinsenberg).

13.2.2 Ichthyoplankton and mesozooplankton

The ichthyoplankton and mesozooplankton assemblages in the surface layer were sampled with the Double Square Net sampler (DSN), a rectangular metal frame carrying a 500-, a 750- and a 50-µm mesh net of cylindrical shape (Figure 13.2). All fish from the 500- and 750 µm nets were sorted at sea and preserved either frozen individually in a pre-weighted Ziploc bag or in 95% ethanol. At each station, a subset of up to 25 Arctic cod was measured (standard length). The zooplankton (except fish larvae) from the 750-µm mesh net was provided fresh to the ArcticNet contaminants team (A. Burt, U. Manitoba) for the assessment of mercury contaminant levels. Zooplankton (except fish larvae) from the 50-µm and 500-µm mesh nets was preserved in formalin for further analysis of the micro- and macro-zooplankton assemblage in the layer occupied by fish larvae.

At some stations on Legs 1a and 2a, and at every Full stations on Leg 1b, the Bioness was utilized (Figure 13.2). The Bioness consists of nine 750 µm-mesh nets, sequentially closing and opening during an oblique tow. Downward and upward winch speeds were 30 and 20 m/min respectively. Preservation of fish larvae followed the DSN procedure as outlined above. Bioness samples, except for fish larvae, were split, and half of the sample was given to the ArcticNet contaminants team.

Altogether the Vertical net and LOKI were deployed 51 times, the Hydrobios 19 times, the Bioness 14 times, the Tucker Net 15 times and the RMT 4 times (Table 13.1).

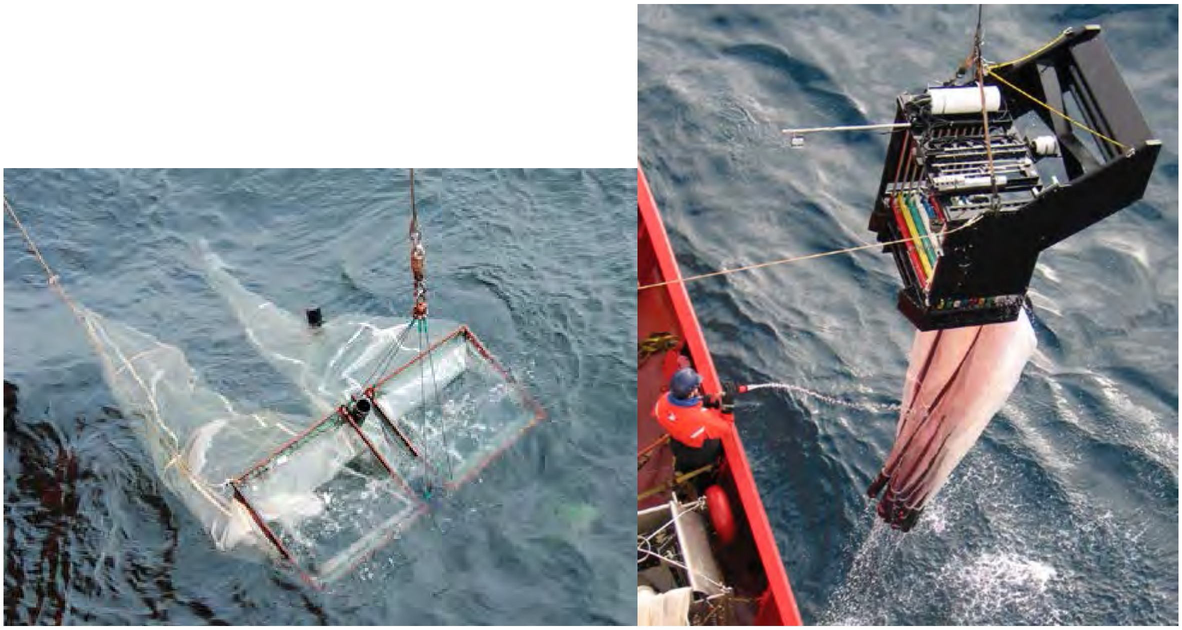

Figure 13.2. Obliquely towed sampling gear to capture fish larvae. Left: DNS at the surface, Right: Bioness being rinsed and recovered (Photo S. Prinsenberg).

13.2.3 Fish sampling

Figure 13.3. The benthic beam trawl used to collect demersal fish (Photo: DFO Winnipeg).

A new benthic beam trawl with an aperture of 3 m^2 was deployed in Leg 2a to collect demersal fish (Figure 13.3). It consists in a net with mesh of 1-5/8" x 1.2 mm in the first section, 1-1/4" in the last section, and 3/8" liner fixed to the bottom panel. The trawl was deployed at selected stations and on an opportunistic basis and towed near the seafloor for a maximum of 20 minutes per station.

13.2.4 Bioacoustic sampling

The deployments of the DSN as well as the Bioness were also part of a special program on bioacoustics to link zooplankton and ichthyoplankton distribution and size with acoustic data and target strength. The split-beam multifrequecy (38, 120 kHz) Simrad EK60 echosounder was continuously operating and recording. In addition, the Simrad SX90 sonar (20-30 kHz by 1 kHz increment) was deployed during four surveys in Leg 1 (Table

13.2) and at 2 ice stations during Leg 2a to detect surface fish school at the marginal ice zone. The primary objectives of the bioacoustics program were (1) to collect baseline data on fish, particularly Arctic cod (*Boreogadus saida*), distribution and abundance using the SX90 fish finding sonar and the multifrequecy (38, 120 kHz) EK60 echosounder; and (2) to detect plumes of methane with the EK60 echosounder.

Table 13.2. Summary of dedicated SX90 surveys conducted during Leg 1.

Date (UTC)	Area	Duration
2013-07-31	Okak fjord	6.25 hours
2013-08-01	Nachvak fjord	6.25 hours
2013-08-04	Cumberland Sound	14 hours
2013-08-06	Methane survey (offshore Baffin Island)	11 hours

13.2.5 Chaetognath feeding experiment (Leg 2a)

A lab experiment was set up to examine feeding in chaetognaths (gelatinous zooplankton). Three species of predatory chaetognaths make up a considerable portion of the Arctic zooplankton biomass (e.g. Søreide et al. 2003; Hopcroft et al. 2005; Blachowiak-Samolyk et al. 2008; Hirche & Kosobokova 2011). All species have varied diets and can, in some cases, exert high predation pressure on Arctic copepods and compete with larval fish (e.g. Sameoto 1978). In general, there are few studies on the feeding ecology of Arctic chaetognaths (*Parasagitta elegans*, *Eukrohnia hamata* and *Pseudosagitta maxima*). Available studies have typically estimated diets and feeding rates from analyses of the gut contents of preserved individuals, however there are several drawbacks with this method. Chaetognaths, when hauled in nets, can easily become stressed and regurgitate their gut contents. Chaetognaths are also well known "cod-end feeders" consuming many prey types during net towing that they may otherwise avoid (Baier & Purcell 1997).

Maintaining living specimens in experimental conditions and monitoring their live feeding with video recording equipment can overcome these challenges. The experiment was set up in the cold-lab (-4°C), and its design is shown in Figure 13.4. The aims of the experiment were to determine 1) how long chaetognaths can survive without concurrent food intake, 2) how frequently are suitable prey taken by these predators, and 3) which, if any, prey items are preferred by each species?

Figure 13.4. Chaetognath feeding experiment setup in the cold-lab during Leg 2a.

Efforts were made to examine feeding in all three chaetognath species. The largest species *Pseudosagitta maxima* was examined first. Three *P. maxima* were added to each of three Corning treated plastic flasks (0.75 L) filled with filtered seawater. The water was continuously aerated with an aquarium pump, and light conditions in the room were carefully controlled. Counted prey items (e.g. copepods, krill, appendicularians) identified to genus/species level were added to animals in two of the flasks, whilst the third would act as a control containing only unfed chaetognaths. The experiment was continuously recorded using a GoPro Hero 3 Handheld Video Recorder, and terminated once either all prey were consumed or the predators died. Video footage will eventually be reviewed to satisfy the experimental aims.

13.3 Preliminary results

13.3.1 Leg 1a – 26 July to 12 August 2013 – Northern Labrador Sea and Baffin Bay Leg 1b – 12 August to 5 September 2013 – Northern Baffin Bay and Canadian Arctic Archipelago

Several echoes, most likely given by schools of fish, were observed with the SX90 (Figure 13.5) in Cumberland Sound, Okak fjord, and Nachvak fjord. Further analysis will be conducted to determine their scale and biomass.

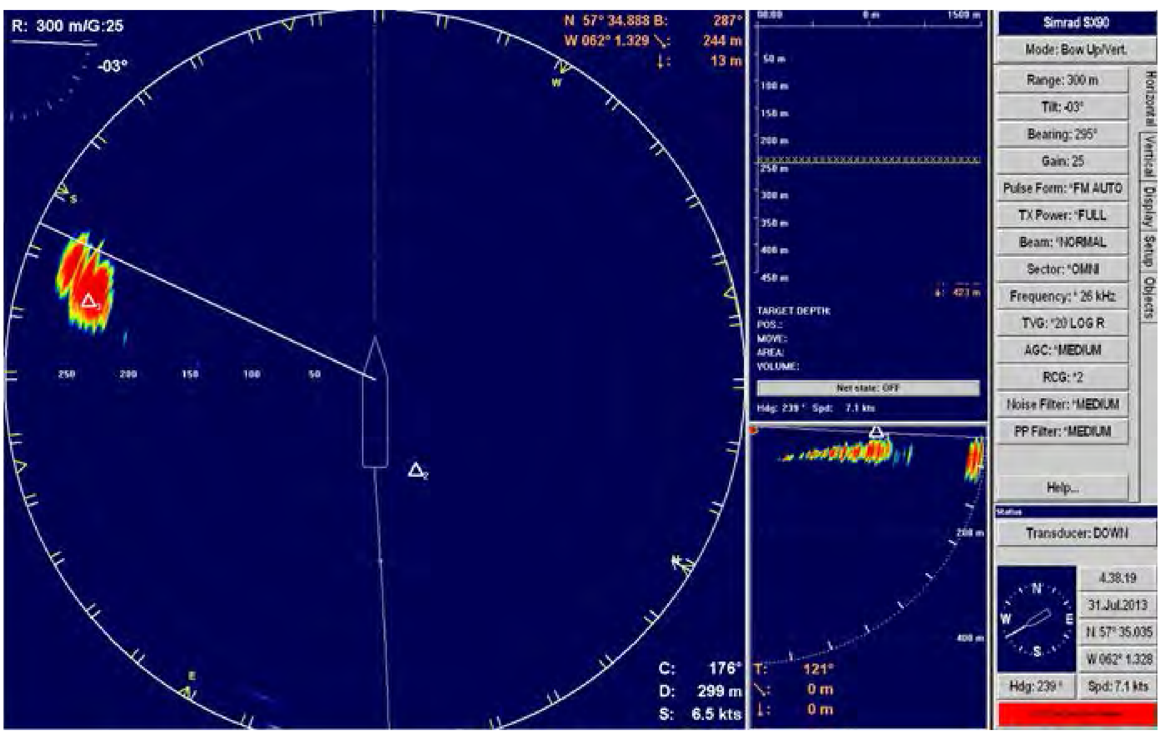

Figure 13.5. Echo of a school of fish detected with the SX90 sonar in Okak fjord during Leg 1.

Strong echoes, either provided by schools of pelagic fish or by methane plumes, were observed on the EK60 screen at two locations (Figure 13.6). Further analysis will be conducted to determine the target strength of the signals.

Preliminary results from the ichthyoplankton sampled with the Tucker and Bioness nets in the area suggest that the top layer observed on the EK60 (see bottom panel in Figure 13.6) was mainly formed by Age-0 fish and that these young stages only occupy the top 40 m in August.

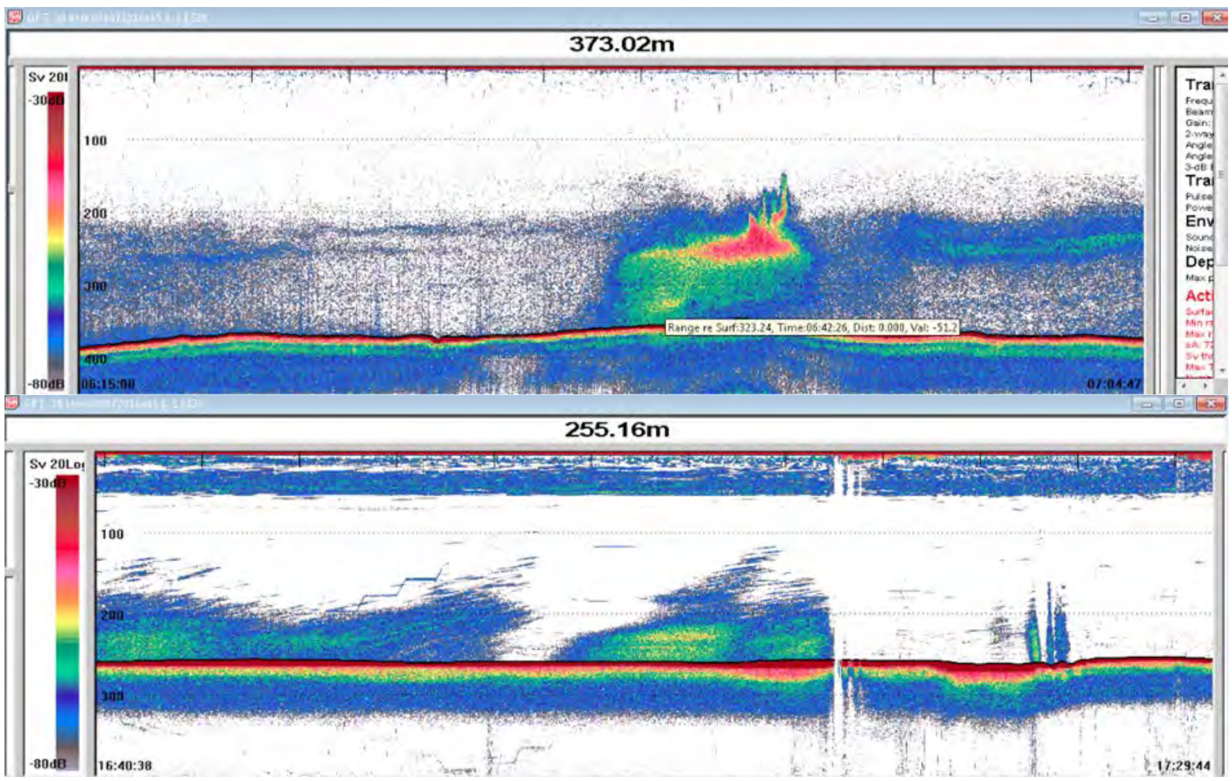

Figure 13.6. Top panel: Strong echo at 38 kHz in an area of methane seeps. Bottom panel: Strong echo at 38 kHz in an area of methane seeps and echoes of Age-0 fish in the top 40 m.

A dead sperm whale floating at the surface was encountered on 9 August (Figure 13.7) and was used as an opportunity to insonify it with the SX90 to enhance understanding of marine mammal echoes and target strength (Figure 13.8).

Figure 13.7. Dead sperm whale floating off Baffin Island in Leg 1.

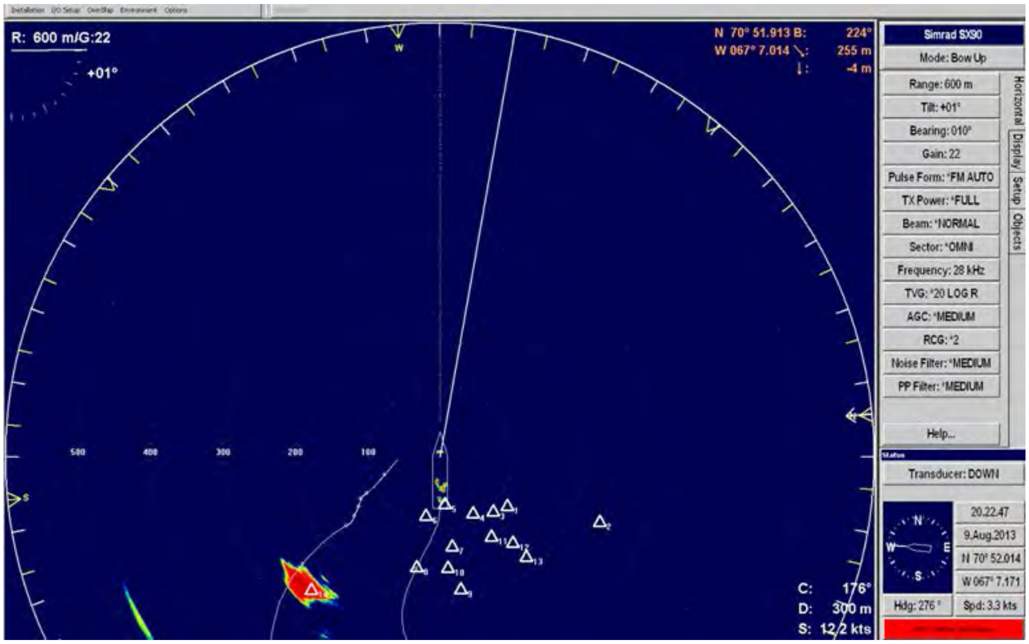

Figure 13.8. Echo of the dead sperm whale detected with the SX90 sonar.

The LOKI successfully captured the vertical distribution of organisms ranging in size from 200 micrometers to several centimeters (Figure 13.9). Further analysis at Université Laval will include the automatic taxonomic classification of these images.

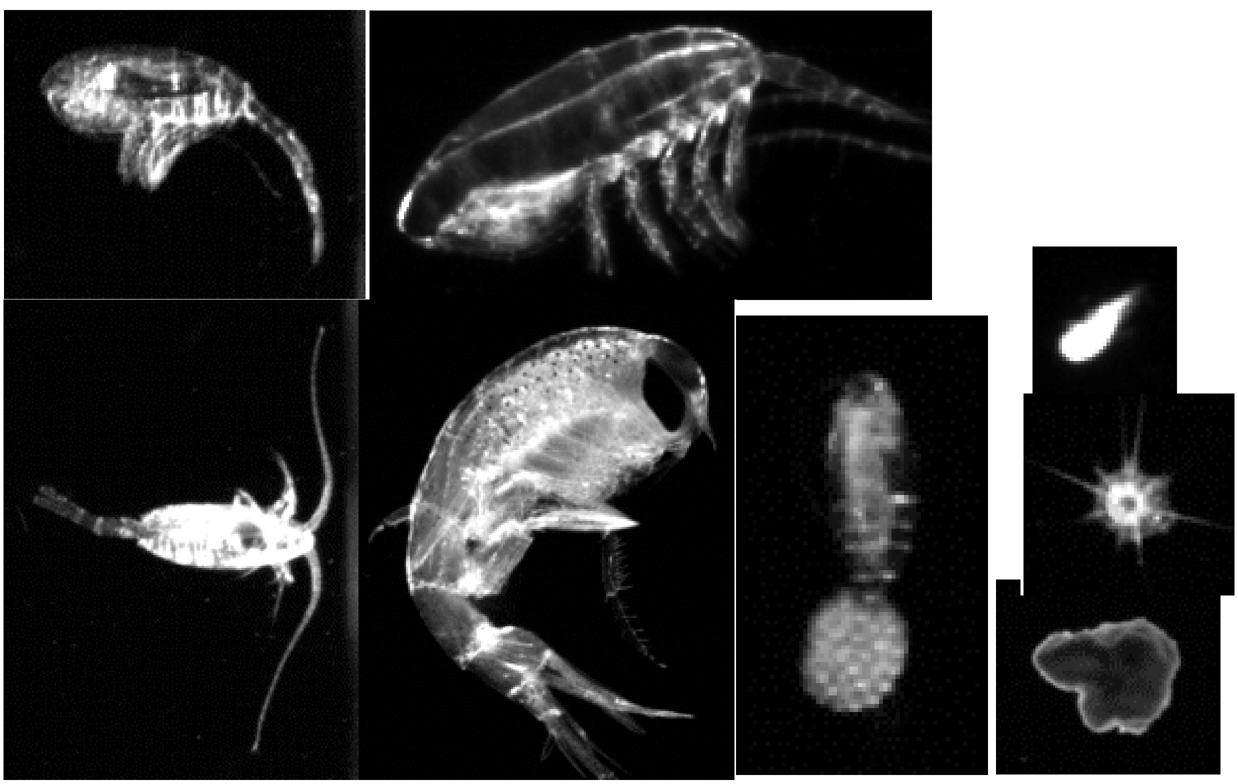

Figure 13.9. Sample images taken by LOKI. Top row: *Metridia longa* stage 5 and *Calanus glacialis* stage 5. Bottom row: *Metridia longa* female; *Themisto libellula*; *Pseudocalanus* sp. female with eggs; *Triconia borealis*; Radiolaria and Detritus.

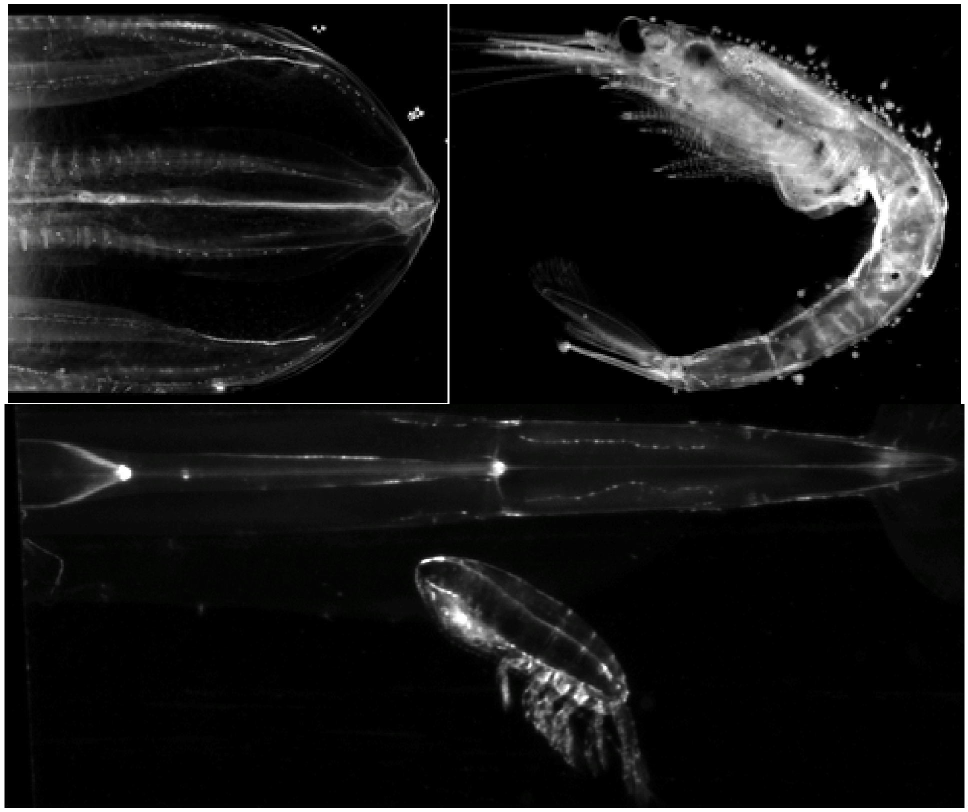

Figure 13.9 (continued from previous page). Sample images taken by LOKI. Top: Ctenophora and *Mysis* sp. Bottom: Part of Chaetognath and *Calanus glacialis.*

13.3.2 Leg 2a – 5 September to 15 September 2013 – Canadian Arctic Archipelago

Based on preliminary acoustic observations, fish biomass in Lancaster Sound and Mc'Clure Strait seemed lower than what was observed in the Beaufort Sea and the Amundsen Gulf in previous years. Despite the visual observation of fish in pieces of broken ice, no schools of fish were detected at the marginal ice zone near the ice island during the dedicated SX90 sonar survey.

The beam trawl net seemed to work properly as no mud was collected during the 20 minute tow. No fish were caught, but it was deployed at a regular Basic station (#500) where no layer of fish could be seen on the echosounder.

13.4 Comments and recommendations

All operations were carried out with success. Communication issues were experienced between the computer and the Bioness at the first stations of Leg 1, but these problems were resolved and the system was fully operational afterwards. The LOKI that was deployed together with the 5NVS also had software related issues initially but worked properly after these issues were fixed. The EK60 needed to be checked twice a day to ensure that it was recording properly.

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14 Contaminants sampling program – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Effects of Climate Change on Contaminant Cycling in the Coastal and Marine Ecosystems*. ArcticNet/Phase3/Contaminants.

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Cruise participants Legs 1a and 1b: Alexis Burt[2], Marc Cadieux[2], Amanda Chaulk[2] and Kang Wang[2]
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14.1 Introduction

14.1.1 Mercury and methyl mercury in the water column

Mercury (Hg) levels in marine mammals and fish are an ongoing concern in Arctic regions because of their inclusion in traditional subsistence diets among indigenous peoples in northern regions. This research on Hg in the Arctic is focused on determining the environmental processes responsible for the distribution and speciation of Hg in Arctic marine ecosystems, for the purpose of supporting the development of strategies to lessen the impact of Hg on human and ecosystem health. The main purpose of this program is to understand the uptake of mercury into the aquatic food chain.

The main priority of the project was to collect water samples for total and methyl mercury, dissolved organic carbon, and $\delta^{18}O$. In addition, larger volumes of seawater were filtered for particulate mercury with the objective of investigating the role of particles and nano-environments in the methylation process of mercury in the water column.

14.1.2 Mercury and methyl mercury in sea ice

The role of sea ice in Arctic mercury cycling represents a knowledge gap in our current understanding of Hg dynamics in the environment. Previous research (Chaulk et al. 2011; Beattie et al. unpubl.) is limited and further investigation is required to elucidate the role of sea ice in mercury transport and transformation within the Arctic Ocean system.

14.1.3 Hydrocarbon sampling

Oil reserves under the sediments in Baffin Bay (including the North Water Polynya, Davis Strait, Lancaster Sound and Jones Sound) are the largest in Arctic Canada; with some potential reservoirs estimated to contain billions of barrels of oil. Global warming and reduced ice coverage has made these reserves more accessible and the exploration/exploitation of offshore oil in the region more feasible. With declining ice conditions, oil exploration and shipping traffic through the Northwest Passage will only increase; both of these activities have the potential to increase petroleum hydrocarbon concentrations in Baffin Bay. However, hydrocarbons are also naturally present as a result of natural oil seeps, fossil fuel combustion, and terrestrial run-off. The purpose of this study is to measure baseline concentrations of hydrocarbons in the Baffin Bay marine environment in advance of future oil exploration/exploitation and increased shipping.

14.1.4 Benthic microbial diversity

Marine sediment environments are high in microbial diversity and abundance with a cubic centimeter of seabed typically containing billions of microbial cells – about a thousand fold more than in overlying seawater. The goal of this research project in the Canadian Arctic Archipelago is to establish baseline data for the diversity and activity of microorganisms in Arctic sediments, and experimentally investigate how short and long term changes in environmental parameters (e.g. temperature; pulses of organic compounds such as hydrocarbons) may affect the community composition, metabolic rates and cycling of carbon and other nutrients. This work will determine the impact of permanently cold temperatures on the rates of biogeochemical processes such as sulfate reduction, which is responsible for up to half of organic carbon mineralization in coastal sediments (Jørgensen 1982).

A second goal is to conduct targeted diversity studies to explore the abundance and function of spore-forming thermophilic sulfate-reducing bacteria in permanently cold sediments, extending biogeography analyses that have been performed in other Arctic sediments (Hubert et al. 2009). Arctic thermophiles are thought to derive from warm deep sediments and get transported up into the cold ocean via seabed hydrocarbon seepage.

The occurrence of marine hydrocarbon seeps in Canada's Arctic is related to a third goal, to assess the ability of microbiota in Arctic seawater and sediments to biodegrade accidentally released crude oil or other pollutants. A rapid natural response may depend on a region's microbiota being 'primed' for such biodegradation by the slow natural release of hydrocarbons from seabed seeps (Hazen et al. 2011). Given that industrial activity and traffic in the Northwest Passage is poised to increase, the inherent biodegradative capacity of marine microorganisms will be tested experimentally on the samples obtained during the filed campaign on the *Amundsen*. This data will be used to help develop a predictive measure of how different regions of the Arctic could respond to various pollution scenarios.

14.2 Methodology

14.2.1 Rosette cleaning

Prior to sample collection at the beginning of Leg 1, every Rosette bottle was cleaned and tested. In brief, the cleaning process involved rinsing each bottle with warm water (using the garden hose in the Rosette shack), filling each Niskin bottle with half a capful of Triton-X soap, then filling the Niskin bottle with hot water. The soapy water sat in the bottles for two hours before being drained. The Niskins were then rinsed with hot tap water until all suds and bubbles were gone. The bottles were given a final rinse with Milli-Q water (Hg free) and then filled with a small volume of Milli-Q water. This water was allowed to stand in the Rosette bottles for four hours then immediately analyzed for total mercury onboard in the PILMS (Portable In-Situ Laboratory for Mercury Speciation). It was determined that the Rosette bottles were clean and would not induce contamination to the water samples.

14.2.2 Sample collection

<u>**Mercury and methyl mercury in the water column**</u>

During Leg 1, samples were collected from the marine water column in Northern Labrador, the Eastern Arctic and the Petermann Fjord system in Northern Greenland. In Leg 2a, samples were collected in Viscount Melville Sound (Table 14.1). Samples from 10 m below the surface (including at the chlorophyll max depth) to the seafloor were collected with the Rosette equipped with PVC 'Niskin-style' sample bottles.

Table 14.1. List of stations sampled for contaminants analyses during Legs 1 and 2a.

Stn #	Location	Latitude N	Longitude W	Bottom Depth (m)	Rosette cast #	Samples collected
Leg 1						
633	Okak Fjord, Northern Labrador	57˚36.394	061˚53.771	183	4	Hg_T, $\delta^{18}O$
630	Okak Fjord, Northern Labrador	57˚28.180	062˚26.233	51	10	Hg_T, $\delta^{18}O$
183	Pangnirtung / Cumberland Sound	65˚35.442	066˚24.080	583	23	Hg_T, $\delta^{18}O$
180	North side of Baffin Island	67˚12.479	061˚18.364	360	26	Hg_T, $\delta^{18}O$
170	North side of Baffin Island	71˚22.774	070˚04.441	255	32	Hg_T, Hg_R, $\delta^{18}O$; bottle comparison study
323	Lancaster Sound	74˚09.588	080˚28.476	790	39	Hg_T, $MeHg_T$, $\delta^{18}O$, DOC, Hg_D, $MeHg_D$, Hg_P
101	Northern Baffin Bay; SE coast of Devon Island	76˚23.242	077˚23.412	313	44	Hg_T, $MeHg_T$, $\delta^{18}O$, DOC
108	Northern Baffin Bay	76˚16.145	074˚36.190	452	58	Hg_T, $MeHg_T$, $\delta^{18}O$, DOC
115	Northern Baffin Bay; W coast of Greenland	76˚20.145	074˚11.514	652	69	Hg_T, $MeHg_T$, $\delta^{18}O$, DOC, Hg_D, $MeHg_D$, Hg_P
132	Northern Baffin Bay / Kane Basin	78˚59.020	074˚06.738	224	78	Hg_T, $MeHg_T$, $\delta^{18}O$, DOC, Hg_D, $MeHg_D$, Hg_P
250	Mouth of Petermann Fjord, Greenland	81˚14.626	062˚21.262	472	80	Hg_T, $MeHg_T$, $\delta^{18}O$
251	Ice edge of Petermann Glacier, Greenland	81˚54.464	061˚11.770	838	83	Hg_T, $MeHg_T$, $\delta^{18}O$

Stn #	Location	Latitude N	Longitude W	Bottom Depth (m)	Rosette cast #	Samples collected
117	Eastern Elsmere Island	77˚19.441	077˚00.955	449	104	Hg_T, $MeHg_T$, $\delta^{18}O$, DOC
301	Northwest Passage	74˚06.215	083˚22.249	674	106	Hg_T
304	Northwest Passage	74˚15.011	091˚28.206	322	111	Hg_T
Leg 2a						
307	Viscount Melville Sound	74˚06.467	100˚04.724	370	002	HgT
308	Viscount Melville Sound	74˚08.413	108˚00.201	563	005	HgT, MeHgT, $\delta^{18}O$, DOC

Legend: Hg_T = total mercury; $MeHg_T$= total methyl mercury; $\delta^{18}O$ = oxygen isotopes; DOC = dissolved organic carbon; Hg_D = dissolved mercury; $MeHg_D$ = dissolved methyl mercury; Hg_P = particulate mercury

High resolution profiles for 'total Hg' (Hg_T) were generated at each of the stations sampled in Leg 1 and 2a, as well as surface water samples collected during a transect from the mouth of the Petermann Fjord to the ice-edge of the Petermann Glacier (Leg 1). Total mercury was analyzed onboard the ship in the Portable In-Situ Laboratory for Mercury Speciation (PILMS) using a Tekran 2600 CVAFS instrument. Samples were analyzed within 36 hours of collection.

Eight stations in Leg 1 and one station in Leg 2a were sampled for methyl mercury (Table 14.1). Samples for methyl mercury analysis were collected in Teflon bottles and frozen for shipment to University of Manitoba for analysis. At each depth sampled, water was also collected for $\delta^{18}O$ analysis in tightly sealed glass scintillation vials. After collection of $\delta^{18}O$ samples, bottles were further sealed with Parafilm and stored at 4°C. Samples for dissolved organic carbon were collected at six stations following a modified protocol provided by M. Gosselin (UQAR-ISMER). Samples for DOC analysis were preserved using 2 N HCl, sealed using Parafilm, wrapped in aluminum foil and stored at 4°C to be shipped back to the lab at U. Manitoba for analysis using a Thermalox TOC-TN instrument.

In Leg 1, at Station 170, a small study was carried out the compare the difference in results between mercury samples collected in Falcon tubes (traditionally used by this research group) and pre-cleaned glass bottles (suggested for use by Lamborg et al. 2012). It was decided to carry out this comparison study as recent literature suggested that pre-cleaned glass bottles should be the standard of use when collecting water samples for trace level total mercury analysis.

In Leg 1, at three stations (323, 115, and 132) a large volume of seawater was also collected from the Rosette and filtered inside the airlock of PILMS for collection of particulate mercury species. At Stations 323 and 115, 5 L of water at 8 depths were collected and filtered; at Station 132, 20 L of water at 8 depths was collected and filtered. A tandem filtration system was used where the first filter collected particulate species and the second acted as a filtering blank. Two depths could be to be filtered at the same time (see Figure 14.1).

Figure 14.1. Seawater filtration set-up inside the airlock of PILMS. Taken at Station 323 during Leg 1.

Mercury and methyl mercury in sea ice

There was an opportunity to collect two ice cores (along with a temperature and salinity profile) both during Leg 1 and during Leg 2a.

In Leg 1, the ice cores were collected at a thick first year ice station on 1 September, where the ice was 1.3 m thick. In Leg 2a, the ice cores were collected at a thick second-year ice station on 9 September with the sea ice team. The ice was 2.7 m thick and demonstrated an isothermal temperature profile. The ice cores were shipped frozen to the University of Manitoba for total mercury and methylmercury analysis.

Hydrocarbon

While on board the CCGS *Amundsen*, water column particulates, invertebrates (benthic and pelagic) and sediment cores were collected for this research.

Large volume seawater sampling: Water column particulates were collected on pre-weighed GFF filters from between 50 and 90 L of water at the chlorophyll a maximum and from the bottom water at 4 stations (Table 14.2). Filters were frozen at -20°C and will be shipped to the University of Manitoba for hydrocarbon analysis.

Table 14.2. List of stations and locations where seawater filtrations were carried out for suspended particulates during Leg 1.

Date in 2013	Leg	Stn #	Depth (m)	Location		Sample descr	Sample depth (m)	Time (UTC)	Volume filtered (L)
				Latitude N	Longitude W				
30-Jul	1a	633	178	57°36.226	061°53.743	Bottom	167	01:41	78.60
30-Jul	1a	633	178	57°36.226	061°53.743	Chla MAX	26	01:41	62.30
06-Aug	1a	180	366	67°08.368	061°15.736	Bottom	360	14:31	85.50
07-Aug	1a	180	370	67°12.479	061°18.364	Chla MAX	40	02:30	49.00
10-Aug	1a	170	266	71°22.798	070°04.271	Bottom	254	16:38	50.20
10-Aug	1a	170	266	71°22.798	070°04.271	Chla MAX	45	16:38	57.10
17-Aug	1b	111	598	76°18.294	073°12.132	Bottom	582	21:46	78.20
17-Aug	1b	111	598	76°18.294	073°12.132	Chla MAX	30	21:46	73.50

Zooplankton: Zooplankton was sampled from the whole water column using the vertical net tow (Monster Net with LOKI: 1 m^2 200 µm mesh), and two oblique net tows (Bioness: 9 x 1 m^2 750 µm mesh, and Tucker Net: 1 m^2 750 µm mesh) at 7 stations during Leg 1a, at 15 stations during Leg 1b and 4 stations in Leg 2a (Table 14.3). Species of interest included: *Calanus hyperboreus*, *C. glacialis*, *Paraeuchaeta glacialis*, Chaetognaths (including *Sagitta elegans*, *S. maxima*, and *Eukrohnia* sp.), *Themisto libellula*, *T. abyssorum*, *Hyperia galba, Cleone limacina*, *Limacina helicina,* Ostracoda, Appendicularia (*Oïkopleura* sp.), Amphipods, Decapods (Family Crangonidae and Mysidae), Shrimp (*Hymenodora glacialis*) and Jelly fish. Some unique species were found, including nudibranchs, *Eusirus cuspidatus, Themisto gaudichaudi, Scina borealis,* and *Gammarus wikitzii*.

Table 14.3. List of stations and locations where zooplankton tows were made for contaminants analyses during Legs 1a, 1b and 2a.

Station	Date in 2013	Latitude N	Longitude W	Tow	Bottom depth (m)	Sampled depth (m)
Leg 1a						
633 (Okak Fjord)	30-Jul	57°36.40	061°53.48	Vertical Tow (200um mesh)	184	174
633 (Okak Fjord)	30-31 Jul	57°36.62	061°52.54	Bioness (750um mesh)	173	148
600 (Natchvac Fjord)	01-Aug	59°05.23	063°26.27	Vertical Tow (200um mesh)	207	197
183	04-Aug	65°35.57	066°20.39	Vertical Tow (200um mesh)	596-612	595
180 (FULL "methane2")	07-Aug	67°11.67	061°15.81	Vertical Tow (200um mesh)	404	394
180 (FULL "methane3")	07-Aug	67°04.16	061°14.36	Oblique Tow (750um mesh)	315-335	103
176	09-Aug	69°35.59	065°47.54	Vertical Tow (200um mesh)	201-207	197
176	09-Aug	69°35.40	065°47.37	Vertical Tow (200um mesh)	207-204	194
176	09-Aug	69°35.03	065°47.04	Bioness (750um mesh)	196-207	176
172 ("zoop" Scott Inlet)	10-Aug	71°11.52	071°04.38	Vertical Tow (200um mesh)	300	290
172 ("zoop" Scott Inlet)	10-Aug	71°11.17	071°01.81	Bioness (750um mesh)	365	345
170 (Scott Inlet)	10-Aug	71°22.79	070°04.43	Vertical Tow (200um mesh)	262	252
170 (Scott Inlet)	10-Aug	71°22.78	070°03.66	Bioness (750um mesh)	247	nr
Leg 1b						
323	13-Aug	74°09.62	080°28.60	Vertical Tow (200um mesh)	790	770
323	14-Aug	74°10.34	080°17.85	Bioness (750um mesh)	788-782	760
101	15-Aug	76°23.26	077°22.74	Vertical Tow (200um mesh)	356	346

Station	Date in 2013	Latitude N	Longitude W	Tow	Bottom depth (m)	Sampled depth (m)
101	15-Aug	76°22.57	077°23.34	Vertical Tow (200um mesh)	357	347
101	15-Aug	76°21.27	077°29.11	Bioness (750um mesh)	383	360
105	16-Aug	76°19.15	075°45.45	Vertical Tow (200um mesh)	326	316
105	16-Aug	76°18.95	075°46.08	Oblique Tow (750um mesh)	329	106
108	17-Aug	76°16.15	074°34.69	Vertical Tow (200um mesh)	445	430
108	17-Aug	76°14.15	074°31.97	Bioness (750um mesh)	440	430
111	17-Aug	76°18.40	073°11.61	Vertical Tow (200um mesh)	595	585
111	17-Aug	76°18.51	073°08.47	Oblique Tow (750um mesh)	602	103
115 (Thule, Greenland)	18-Aug	76°21.60	071°13.63	Vertical Tow (200um mesh)	nr	nr
115 (Thule, Greenland)	18-Aug	76°27.205	071°27.28	Bioness (750um mesh)	545	500
132 (North station)	20-Aug	78°58.68	072°13.58	Bioness (750um mesh)	233	210
132 (North station)	20-Aug	78°59.94	072°03.70	Vertical Tow (200um mesh)	214	204
250 (Petermann Fjord)	22-Aug	81°16.10	062°20.20	Vertical Tow (200um mesh)	432	422
250 (Petermann Fjord)	22-Aug	81°16.61	062°19.80	Vertical Tow (200um mesh)	416	400
250 (Petermann Fjord)	22-Aug	81°16.50	062°13.66	Bioness (750um mesh)	469-474	350
251 (Petermann Glacier)	22-Aug	80°54.44	061°11.73	Vertical Tow (200um mesh)	835	800
126 (North transect)	27-Aug	77°19.53	073°27.27	Bioness (750um mesh)	336-341	320
126 (North transect)	27-Aug	77°20.34	073°29.25	Vertical Tow (200um mesh)	323	313
122	28-Aug	77°20.645	074°59.59	Vertical Tow (200um mesh)	645	632
122	28-Aug	77°19.410	074°57.72	Oblique Tow (750um mesh)	647	90
119	28-Aug	77°19.57	076°03.98	Vertical Tow (200um mesh)	522	512
119	28-Aug	77°19.338	076°03.48	Oblique Tow (750um mesh)	522	90
117	28-Aug	77°19.29	077°00.42	Vertical Tow (200um mesh)	nr	nr
117	28-29-Aug	77°18.17	077°04.27	Bioness (750um mesh)	483	465
301	30-Aug	74°06.32	083°22.30	Vertical Tow (200um mesh)	665	655
301	30-Aug	74°07.24	083°22.15	Oblique Tow (750um mesh)	671	90
304	31-Aug	74°15.01	091°25.84	Vertical Tow (200um mesh)	nr	nr
304	31-Aug	74°15.69	091°23.68	Bioness (750um mesh)	nr	nr
Leg 2a						
307	7-Sept	74°06.24	103°03.64	Vertical Tow (200um mesh)	372	362
307	7-Sept	74°06.24	103°03.96	Oblique Tow (750um mesh)	372	90
308	7-Sept	74°08.20	108°50.23	Vertical Tow (200um mesh)	565	555
308	8-Sept	74°08.22	108°49.67	Bioness (750um mesh)	562	552
500	8-Sept	73°46.90	113°48.62	Vertical Tow (200um mesh)	458	448
333	15-Sept	74°26.95	87°25.14	Vertical Tow (200um mesh)	280	270
333	15-Sept	74°26.93	87°28.10	Oblique Tow (750um mesh)	288	90

Benthic invertebrates: Benthic fauna (Table 14.4) was collected using the Agassiz trawl, identified as best as possible and set aside by the members of the P. Archambault's team (UQAR). They were subsequently labelled and frozen at -20°C. Groups of interest included: *Asteroidea* (sea stars), *Ophiopleura* (brittle stars), molluscs, isopods, amphipods, and polychaete worms.

Sediment push coring: Samples destined for hydrocarbon analysis were collected using 10 cm diameter plastic push cores from the boxcore (Table 14.4). Sediment compression was limited by using an electric negative-suction pump connected to the top cap of the plastic core. The sediment core was subsequently placed on a manual extruder and sectioned by 0.5 cm intervals for the first 10 cm, and then 1.0 cm for the balance of the core (approximately 30 cm total). Sediment was stored in Whirlpac plastic bags, and stored at -20°C.

Benthic microbial diversity

Sediment surface sampling: Samples collected (Table 14.4) for microorganism incubation experiments were scraped from the top 5 cm of the box core using a plastic spatula, stored in ~475 ml self-locking plastic Starfrit containers and then kept at 4°C. An effort was made to eliminate all headspace from the plastic containers.

Surface samples destined for microorganism diversity analysis were scraped from the top 1 cm of the box core using a stainless steel pallet knife into 7 ml plastic vials, spiked with 3.0 ml of 95 % ethanol and kept at -80°C. Headspace was limited by aiming to collect ~3.5 ml of surface sediments. Triplicate sample vials were collected whenever possible.

Push coring: Cores for microorganism incubations and diversity were collected using the same equipment as for the hydrocarbon study. These cores were sectioned by 2.0 cm intervals for the first 10 cm and then 5.0 cm intervals for the balance. At each interval, triplicate subsamples were collected for microorganism diversity using the same 7 ml vials and methods described above. The bulk of the remaining section was kept in 150 ml plastic bottles and stored at 4°C.

Gravity coring (Leg 1 only): One single ~2 m gravity core was collected in a plastic core barrel by G. Massé and stored in the 4°C container. Other gravity cores collected may be sectioned in Rimouski and shared between groups at a later date.

Table 14.4. List of sediments and benthic microbial community samples collected for contaminants determination and experiments during Legs 1 and 2a.

Station	Surface	Hydrocarbon cores	Incubation cores	Gravity core	Agassiz benthos
Leg 1					
633	X		2X*		X
602					X
600	3X		2X*		
183					X
180		X			X
176	X				X
172	X				
170	X	2X*	2X*		
323	3X		3X		X
101	X				X
105	X				X
108	X				X
111	X				X

Station	Surface	Hydrocarbon cores	Incubation cores	Gravity core	Agassiz benthos
115	X			X	
132					X
250	3X	2X	2X		
251	X				
254	X	X			
126					X
124	3X	3X			X
119					X
117	X				X
301	X				X
304	X	X			X
Leg 2a					
307	X				X
308	X				NSO
500	3X		3X		NSO

*same boxcore
NSO = No sample obtained

14.3 Preliminary results

14.3.1 Mercury and methyl mercury in the water column

The results of the bottle comparison study (Falcon tubes vs. pre-cleaned glass bottles) show that both sample collection methods produce comparable results and that Falcon tubes are an acceptable vessel for collecting water samples for total mercury analysis.

Water profiles generated during Leg 1 show low levels of Hg_T in the water column (<0.3 ng/L) as expected. Subsurface (100-150 m) peaks in Hg_T were observed at some stations in the North Water (NOW) Polynya.

In Leg 2a, the vertical profile generated at Stations 307 showed low levels of Hg_T in the water column (<0.2 ng/L).

14.4 Comments and recommendations

Many of the stations that were planned for Leg 2 did not occur due to sea ice, but would still be interesting and sample collection should continue in this region in the future.

14.4.1 Mercury and methyl mercury in the water column

It is imperative that the Rosette be cleaned and tested prior to the beginning of sampling to ensure that the Niskin bottles do not induce any contamination of the samples.

14.4.2 Benthic microbial diversity

Always take push cores from the boxcore when expecting a gravity core, since the top ~15 cm of the gravity core is disturbed and not ideal for sectioning.

The boxcore failed to collect sediment samples several times, thus samples should be collected opportunistically at nearby stations as a backup.

References

Hubert et al. 2009, Science 325: 1541
Jørgensen 1982, Nature 296: 643
Hazen et al. 2011, Science 330: 204

15 Persistent organic pollutants and emerging contaminants – Leg 2a

ArcticNet Phase 3 – Project titled *Effects of Climate Change on Contaminant Cycling in the Coastal and Marine Ecosystems*. ArcticNet/Phase3/Contaminants.

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15.1 Introduction

Persistent organic pollutants identified by the Stockholm convention indicate the prevalence of compounds because of their persistence, bioaccumulation and toxicity (PBT), along with their long range atmospheric transportation (LRAT). The presence of organochlorine pesticides (OCPs) and current use pesticides (CUPs) have been documented in the arctic environment and biota in the past. More recently the presence of perfluorinated compounds (PFCs) in Arctic air, polar bears and fish indicates the transportation of these compounds and the concentrations in the water column are an indication of the impact upon the local biota.

More recently with the addition of polybrominated diphenylethers (PBDE) formulations pentaBDE and octaBDE to the Stockholm Convention and the subsequent phase out of PBDEs in North America the flame retardant industry have begun to supply a variety of halogenated and non-halogenated alternatives. These alternatives have similar properties and are considered as potential emerging contaminants. Of particular popularity are organophosphate flame retardants (OPFRs), which are currently not included in monitoring programs (Reemtsma et al. 2008). These compounds are more volatile than PBDEs and are not considered to be typical “POPs” because of their high volatilities. However, recent evidence suggests that they are more persistent in the environment than first thought (Kawagoshi et al. 2002). Due to the high production volume of these compounds and their abundant use they undergo LRAT and are currently beginning to accumulate in the Arctic environment (Jantunen et al. 2013). OPFRs include suspected carcinogens, genotoxins and neurotoxins (WHO 1991).

Within this work samples will be analysed for organochlorine pesticides (OCPs), current use pesticides (CUPs), perfluorinated compounds (PFCs) and organophosphate flame retardants (OPFRs). The objective of the project is to assess current concentrations of OCPs and CUPs being transported to the Arctic, and to understand the fate of OPFRs and their potential to be transported via LRAT despite their physical characteristics. Additionally the water column will be assessed for the presence of PFCs, to address the fate of these chemicals.

15.2 Methodology

15.2.1 Air sample collection

Figure 15.1. Passive air sampler, located at bow of ship, used to collect air samples for contaminants analyses.

Samples were collected continuously over a two day period using a passive air sampler (Figure 15.1), located at bow of ship. Both particulate and gaseous phase were collected using a glass fibre filter and XAD/polyurethane foam (PUF), respectively. Sampling locations are detailed in Table 15.1.

15.2.2 Water sample collection

<u>Bulk phase surface samples</u>

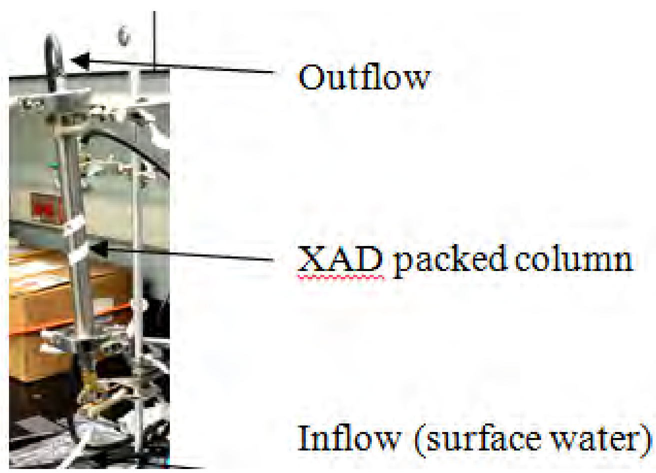

Figure 15.2. XAD solid phase extraction procedure used for bulk phase surface seawater samples.

Unfiltered surface water samples were collected for the analysis of OCPs, CUPs and OPFRs. Approximately 100 L was passed over a solid phase (XAD) extraction column (Figure 15.2). Four samples were collected in total from Rosette Stations 500, 510, 306, 307 (Table 15.1). Samples were either collected from the Rosette or from the in-line pump.

<u>Surface particulate samples</u>

Surface water received from the in-line water pumps was used to collect particulates for the measurement of perfluorinated compounds (PFCs). Each sample consisted of approximately 400 – 500 L of water filtered through a glass wool filter over a period of 8 hours. Sampling locations are located in Table 15.1.

Depth samples

Samples (1 L) were collected from the Rosette deployment at various depths. Sample locations and depths are detailed in Table 15.1.

Table 15.1. Summary of samples collected for persistent organic pollutants and emerging contaminants during Leg 2a.

Sample	Depth	Location	Volume	Analytes
Particulate				
1	Surface Water	74° 11 N, 102° 06 W –74° 06 N, 103° 01 W	400 L	OCPs, CUPS, OPFRs
2	Surface Water	74° 02 N, 106° 45 W –74° 02 N, 106° 45 W	500 L	
3	Surface Water	74° 42.786 N, 095° 07.056 W	800 L	
3	Surface Water	74° 34 N, 093° 29 W	710 L	
5	Surface Water	74° 26 N, 087° 25 W – 74° 33 N, 090° W	570 L	
Bulk Surface				
1	Surface Water	Rosette Station 306	88 L	OCPs, CUPS, OPFRs
2	Surface Water	Rosette Station 307	100 L	
3	Surface Water	Rosette Station 308	90 L	
4	Surface Water	Rosette Station 500	100 L	
5	Surface Water	Rosette Station 330	100 L	
Depth Samples				
1	250 m	Rosette Station 307	1 L	PFCs
2	120 m	Rosette Station 307	1 L	
3	50 m	Rosette Station 307	1 L	
4	30 m	Rosette Station 307	1 L	
5	Surface	Rosette Station 308	1 L	
6	40 m	Rosette Station 308	1 L	
7	140 m	Rosette Station 308	1 L	
8	300 m	Rosette Station 308	1 L	
9	Surface	Rosette Station 500	1 L	
10	120 m	Rosette Station 500	1 L	
11	300 m	Rosette Station 500	1 L	
Passive Air				
1	-	74° 32.002 N, 100° 99.25 W – 74° 20 N, 109° 39 W	37 hrs	OCPs, CUPs, OPFRs
2	-	74° 20 N, 109° 39 W – 74° 20 N, 109° 39 W	52 hrs	
3	-	74° 20 N, 109° 39 W – 74° 42 N, 095° 07 W	36 hrs	
4	-	74° 39 N, 095° 06 W – 74° 42 N, 091° 46 W	36 hrs	
5	-	74° 42 N, 091° 58 W – 74° 43 N, 095° 07 W	36 hrs	

15.2.3 Sample Extraction and Analysis

All samples require extraction via an accelerated solvent extractor (ASE), sample clean-up and analysis using GC-MS and LC-MS/MS instrumentation. This is all to be completed at CARE (Environment Canada).

15.3 Preliminary results

All results will be generated by Environment Canada at CARE and Downsview laboratories. Samples will undergo extraction, clean-up and mass spectrometry analysis (both GC-MS and LC-MS/MS).

15.4 Comments and recommendations

Very few problems were encountered during the setup of the sampling instruments, and the collection of samples. A greater availability of in-line surface water outlets would be preferential; the three currently available are in non-ideal locations (nutrients lab, clean lab, and sediment room). Taps streaming water directly from the surface (not passed around engine room) is essential as the break-down of some organic analytes can occur when the water is heated.

References

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Reemtsma, T., Quintana, J.B.,Rodil, R.,Garcia-Lopez, M., Rodriguez, I., 2008. Trends in Anal. Chem. 727.

16 Mercury cycling and isotope signatures – Leg 1b

ArcticNet Phase 3 – Project titled *Effects of Climate Change on Contaminant Cycling in the Coastal and Marine Ecosystems*. ArcticNet/Phase3/Contaminants.

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16.1 Introduction

Mercury (Hg) is a persistent pollutant that is transported to remote areas, far from its emission sources. Hg is transported to the Arctic environment by atmospheric and oceanic transport. In aqueous environment, Hg is converted to its toxic and bio-available form, monomethylmenrcury (MMHg) and bio-accumulates along the food chain. Hg is transported to the Artic region by atmospheric transport and deposition, riverine inputs and water masses transport. The contamination of the Arctic marine ecosystem is a great concern as it poses a health threat to the local communities relying on marine food as part of their traditional diet.

During the past decade, numerous studies have contributed to a better understanding of the Hg cycle in polar environment. However, considerable knowledge gaps still exist on the pathways and delivery processes of mercury to the aquatic food chain.

Recent developments in Hg isotopic ratios and signatures measurement provide a new tool for the identification of Hg biogeochemical reactions in environment (Foucher and Hintelmann 2006; Point et al. 2011) as well as the potential to discriminate between Hg sources (Berquist 2007; Laffont et al. 2009; Sonke 2012). This recent analytical tool offers great opportunities for a better understanding of Hg biogeochemical cycling in Arctic environment and consequently in establishing policies to reduce and control Hg contamination in the Arctic.

However, little has been reported for Hg isotope geochemistry in natural aqueous environment with trace levels of Hg which represent an analytical challenge since fairly high amount of Hg (40 ng) is required for reliable isotopic analysis. Indeed, despite the high bioaccumulation rate in biota, total Hg concentrations in the Arctic Ocean vary between 0.14 and 0.4 ng L^{-1} on average (St. Louis et al. 2007; Kirk et al. 2008) stressing the importance of a better understanding of Hg mobility, toxicity, transformation, and biogeochemical cycle in Arctic marine waters. A pre-concentration technique was developed in H. Hintelmann's laboratory (Trent U.), adapted from Chen et al. (2010), for quantitative Hg pre-concentration from large sea water sample volumes (more than 20 L) for reliable Hg stable isotope measurement.

The main aim of the cruise was to collect samples for Hg isotopic preliminary measurement from different environmental compartments, namely the water column, sediments and sea ice. The main objectives for seawater sampling component were to:

- Test the practicality of the method for Hg pre-concentration from seawater onboard the *Amundsen.*
- Determine for the first time the Hg isotope ratio as a preliminary step for future isotope signature studies in the Arctic Ocean.

For sediment and ice core samples, exploratory measurements of total Hg will be conducted for future studies. Air sample for organic Hg species (monomethylmercury and dimethylmercury) determination was also conducted as a follow up of previous sampling campaigns (AN 2010 and 2011) with the aim to have a better understanding of the cycle and sources of organic Hg in the Arctic marine environment.

16.2 Methodology

16.2.1 Hg in seawater

Water samples were collected for Hg preconcentration and isotope ratio determination using acid-washed Teflon® lined Niskin bottles (12 L) mounted on the CTD-Rosette. Water (11 L) was collected in duplicate at 3 different depths (surface, mid and bottom depth) and processed for preconcentration onboard the ship. The preconcentration step involved a first sequential filtration using 8 or 1.2 and 0.45 μm filters (Figure 16.1).

Figure 16.1. Set up for the pre-concentration of mercury from seawater (filtration step).

The sequential filtration was followed by (i) purging for 8 hours after acidification with reagent grade concentrated nitric acid (HNO_3), (ii) digestion with concentrated hydrochloric acid (HCl) and 0.2 M bromine chloride (BrCl) solution and finally (iii) preconcentration of an anion-exchange resin AG1-X4 (200–400 mesh, Bio-rad®).

An aliquot of the sample solution was taken for Hg concentration measurement after digestion and 20% (w/v) solution of hydroxylamine ($NH_2OH.HCl$, 99%, reagent plus, Aldrich) was added to the solution for BrCl neutralization prior to preconcentration. The resins with preconcentrated Hg were stored in air-tight glass containers until analysis, after elution, on a Neptune MCICP-MS (Thermo-Fisher, Germany) at the Worsfold Water Quality Centre (WWQC), Trent University. Hg concentration will be measured by an atomic fluorescence spectrometry (Tekran Series-2600, Tekran Instruments Corporation) in the laboratory at Trent University.

Table 16.1. List of water samples for total Hg concentration and isotopic ratio determination during Leg 1b.

Date	Time (UTC)	Station	Latitude	Longtitude	Rosette cast	Sample depth (m)
13-Aug-13	17:00	323	74°9.482	80°28.400	38	4
	1:35		74°9.458	80°27.308	40	375
	5:57		74°10.103	80°28.098	41	781
15-Aug-13	17:53	101	74°9.458	80°27.308	46	2
			74°9.459	80°27.309	47	171
	1:48		76°19.897	77°41.351	48	271
18-Aug-13	20:35	115	76°25.498	71°19.296	72	4
	1:33		76°27.015	71°24.894	73	270
	5:16		76°29.635	71°29.338	74	471
20-Aug-13	4:36	132	78°59.687	72°15.422	76	115
	7:39		78°59.446	72°6.008	77	2
	10:15		78°59.056	72°5.740	78	215
25-Aug-13	4:25	253a	79°17.651	71°17.758	84	2
	7:59		79°17.693	71°17.924	85	93
	9:54		79°17.653	71°17.760	86	173
27-Aug-13	3:22	126	77°20.580	73°25.660	90	3
	5:33		77°20.708	73°25.704	91	162
	8:14		77°20.505	73°25.577	92	320
28-Aug-13	18:27	117	77°17.471	77°0.498	103	2
	21:32		77°19.441	77°0.935	104	225
	1:43		77°19.442	77°0.770	105	441
31-Aug-13	4:53	304	74°15.040	91°28.205	111	2
	7:12		74°14.968	91°27.476	112	161
	8:53		74°15.545	91°28.765	113	310

16.2.2 Sediment and sea ice sampling

Opportunistic sediment and ice core samplings were also conducted during the cruise for preliminary Hg concentration and isotopic ratio measurement.

The sediment cores were sampled at five stations (Stations 115, 108, 250, 254, 304) using PVC push cores from the box core. The cores were mounted on an extruder and sectioned in 0.5 cm layers for the first 3 cm and 1 cm up to 20 cm. The sliced sediment samples were stored in glass jars or plastic bags and kept at -20°C for analysis in the laboratory.

Two sea ice samplings (approximately 60 cm, in triplicate) were also conducted over multiyear ice floes at Ice Stations 1 and 1C, respectively. The ice cores were collected in plastic bags which were vacuum sealed and kept at -20° C until processing and analysis in the laboratory.

16.2.3 Air sampling

Air was also sampled over seawater for organic Hg determination during transit and preferably when the relative wind was between 0 to 30° (to minimize the influence of the ship exhaust). The air sample set up was located in a container on the foredeck while the sample line and intake was on the side of the ship so that air above the water could be sampled.

Air was pumped at a rate of 1 L min^{-1} and passed through an online ethylation system before trapping on Bond Elut traps over a period of 2-3 hours for each sample for a total volume of 160 – 300 L. The ethylation system consists of a 45 μm cellulose filter impregnated with freshly prepared ethylating reagent (200 ml acetate buffer with 100 ml of sodiumtetraethylborate). The ethylated monomethylmercury and dimethylmercury if present in the air sample was trapped on collection trap made of borosilicate glass tubes (11.5 cm long, 0.7 cm ID) packed with Tenax® TA 20/35 (Mandel Scientific, 0.1 g) or Bond Elut ENV (Varian Inc. 0.1g). The traps with preconcentrated Hg species were capped after sampling and stored in the dark at -20ºC. The traps will be analyzed for organic Hg species by thermal desorption to release the Hg species followed by analysis by GC-ICPMS (Baya et al. 2013) at Trent University. Ten air samplings (160–300 L) were conducted during the cruise.

16.3 Preliminary results

No preliminary results are available at this time as the samples will be analyzed in the laboratory at Trent University in the coming months.

16.4 Comments and recommendations

Efforts to maintain "clean" conditions in the Rosette shack would be much appreciated to reduce risks of contamination during sampling. Furthermore, as much as possible, laboratory and storage space should not be shared with other teams manipulating mercuric chloride ($HgCl_2$) on board of the ship.

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17 Seabed mapping – Legs 1a and 1b

ArcticNet Phase 3 – Project titled *The Canadian Arctic Seabed: Navigation and Resource Mapping*. ArcticNet/Phase3/Seabed-mapping.

Project leader: John Hughes Clarke[1] (jhc@omg.unb.ca)
Cruise participants Legs 1a and 1b: Ian Church[1] and Danar Pratomo[1]
[1] *University of New Brunswick, Ocean Mapping Group, Department of Geodesy and Geomatics Engineering, P.O. Box 4400, Fredericton, NB, E3B 5A3, Canada.*

17.1 Introduction

The Ocean Mapping Group (OMG) was on board for Leg 1 to perform seabed mapping as part of its role in ArcticNet's marine research program. Three areas were preselected for dedicated seabed mapping surveys on Leg 1: Cumberland Sound, deep water coral slopes in Baffin Bay, and the 1933 earthquake site in Northern Baffin Bay.

17.2 Methodology

17.2.1 Overview of activities

The three dedicated seafloor mapping surveys were completed successfully, along with multiple other opportunistic dedicated mapping campaigns. Multibeam bathymetry and sub-bottom information was collected 24 hours per day while transiting between science stations along the ship's route. The seabed mapping team also provided additional support to various science activities:

- The water-column imaging capabilities of the EM302 multibeam were used to provide the location of the gas seeps and image the underwater extents of ice islands and glacier faces.
- The K320R sub-bottom profiler was used to help the benthic team determine the geological composition on the seabed prior to deploying the box and gravity corers.

The Kongsberg K-Sync synchronization system was used to alleviate interference issues between the EM302, K320R, SX90, OS150 and the EK60. The Ocean Mapping Group was tasked with running the K-Sync.

In 2013, the Ocean Mapping Group also took over operations of the MVP300. Sections were completed around two ice islands on Leg 1a and along numerous transects on Leg 1b. The MVP provided salinity, temperature, sound velocity, transmission, fluorescence and dissolved oxygen data while transiting at speeds up to 12 knots.

17.2.2 Equipment

- Kongsberg EM302 30 kHz multibeam echosounder
- Knudsen K320R 3.5 kHz sub-bottom profiler

- Applanix POS/MV 320 motion and orientation sensor
- C&C Technologies CNAV 2000 GPS
- AML Smart Probe surface sound speed probe
- Kongsberg K-Sync sonar synchronization system
- Moving Vessel Profiler – MVP300

17.2.3 Onboard logging and data processing

Multibeam and sub-bottom profiler collection began immediately after leaving Quebec City and both systems were logged continuously throughout the entire leg except during stationary science sampling operations. Bottom mistracking occurred in the areas of sea ice and high sea states resulting in the loss of coverage.

The EM302 30 kHz multibeam data (bathymetry and water column) was logged in the Kongsberg raw formats (.all & .wcd) and converted to the OMG format after line completion (new survey lines were automatically generated every half hour). The soundings were cleaned and inspected, using the OMG swathed toolkit, in near real-time with two members maintaining a 24-hour watch throughout the cruise. The soundings were reduced to mean sea level (MSL) using the Arctic-9 tidal model.

The EM302 had no problems during the leg. The system performed as normal and was not powered down for any reason. The EM302 controller PC experienced some software and hardware issues related to long durations of data collection and vibrations from ice breaking. The newest version of the collection software, SIS 3.9.2, was found to be partially at fault and was downgraded to SIS 3.8.3 from 2011 with no reduction in functionality. The hardware issue with the PC was related to memory issues with the ram/motherboard connection due to vibrations.

All sub-bottom profiling was performed using the Knudsen 320R 3.5 kHz system. The K320R was logged in the Knudsen raw format (.keb and .sgy) and converted to the OMG format after line completion (new survey lines were generated every hour or so. Heave was fed into the Knudsen transceiver from the POS-MV.

In addition the following data was logged at all times:

- CNAV GPS
- Raw pseudo-ranges
- NMEA at 1 Hz
- POSMv delayed heave and full POSPac format files at 50Hz
- POSMv ASCII position, heading, speed and motion data at 1Hz

Sound speed profiles were collected at each science station using the Rosette's CTD. Raw .cnv files were converted to OMG format, at which time the profiles were visually inspected for spurious data points. The CTD casts were input directly into the EM302 SIS logging software. Post-processing of the multibeam soundings with respect to sound speed profiles will be done upon return to UNB.

Use of a sound speed profile server was new for 2013. The server is developed and maintained by the U.S. Multibeam Advisory Committee (MAC) as part of their work with the U.S. Academic Research Fleet. The server connects to either the locally stored World Ocean Atlas 2009 (WOA09) or the online Real Time Ocean Forecast System (RTOFS) to provide synthetic sound speed profiles based on either historic data collection or model forecasts respectively. The sound speed server allow for improved multibeam data collection over the long transits between stations.

Images in strip map format (two sun-illuminations for bathymetry, a backscatter image, a sub-bottom image, and the navigation track) were created daily. These images will be posted online (www.omg.unb.ca) after the completion of all legs. The historical bathymetry from all transits, overlaid on the navigation system was also updated regularly to expand coverage during transit between stations. This allowed the helmsman to steer coverage and build upon the previously collected data.

17.2.4 MVP (underway sound speed profiling)

The Moving Vessel Profiler MVP-300 was deployed several times during Leg 1: in Scott Inlet around a grounded ice island (Station 170 in Leg 1a), in Baffin Bay around a mobile ice island, along several transits in the North Water of Baffin Bay, at the mouth and face of the Peterman Glacier, and finally, during a transect line across Lancaster Sound.

The MVP provided information on the salinity, temperature, sound velocity, transmissivity, fluorescence and dissolved oxygen along the transect lines. The sound velocity data from the MVP is also valuable for improving the accuracy of the multibeam data. Routine post-cruise reprocessing of the multibeam data will apply all the MVP sound speed data to the multibeam soundings. A total of 230 successful MVP casts were obtained during Leg 1.

During the initial deployment of the MVP, it was determined that it could only be run at a maximum vessel speed of 7 knots based on the location of the messengers along the winch line. 7 knots is approximately around 2/3 of maximum operating speed, which drastically increased the survey time necessary to complete the designated survey area, but increased the spatial resolution of the observations. The MVP fish was kept at a depth of 10 m below the water surface, ensuring that the data was not contaminated by mixed waters generated by the propeller wash. The MVP operations used an automatic deployment without delay between casts, to get better spatial coverage. For safety reasons, the maximum depth was set to 20 m above the seabed surface. The navigation data was input to the MVP from the POSMv and the depth from the EM302. The MVP required a hydraulic fluid filter change during the leg, but otherwise worked well.

17.2.5 K-Sync

Together with the SX90 operator, the EM302 operators determined the following settings to be optimal.

<u>Shallow water transit no SX90 & EM302 Surveys no SX90</u>
Group 1: EM302, K320R, OS150
Group 2: EM302, K320R, EK60

<u>Deep water transit no SX90</u>
Group 1: EM302, K320R, OS150
Group 2: K320R, EK60

<u>SX90 surveys</u>
Group 1: SX90, K320R, OS150
Group 2: EK60, EM302

17.3 Preliminary results

17.3.1 Cumberland Sound – Nunavut Fisheries Habitat Survey

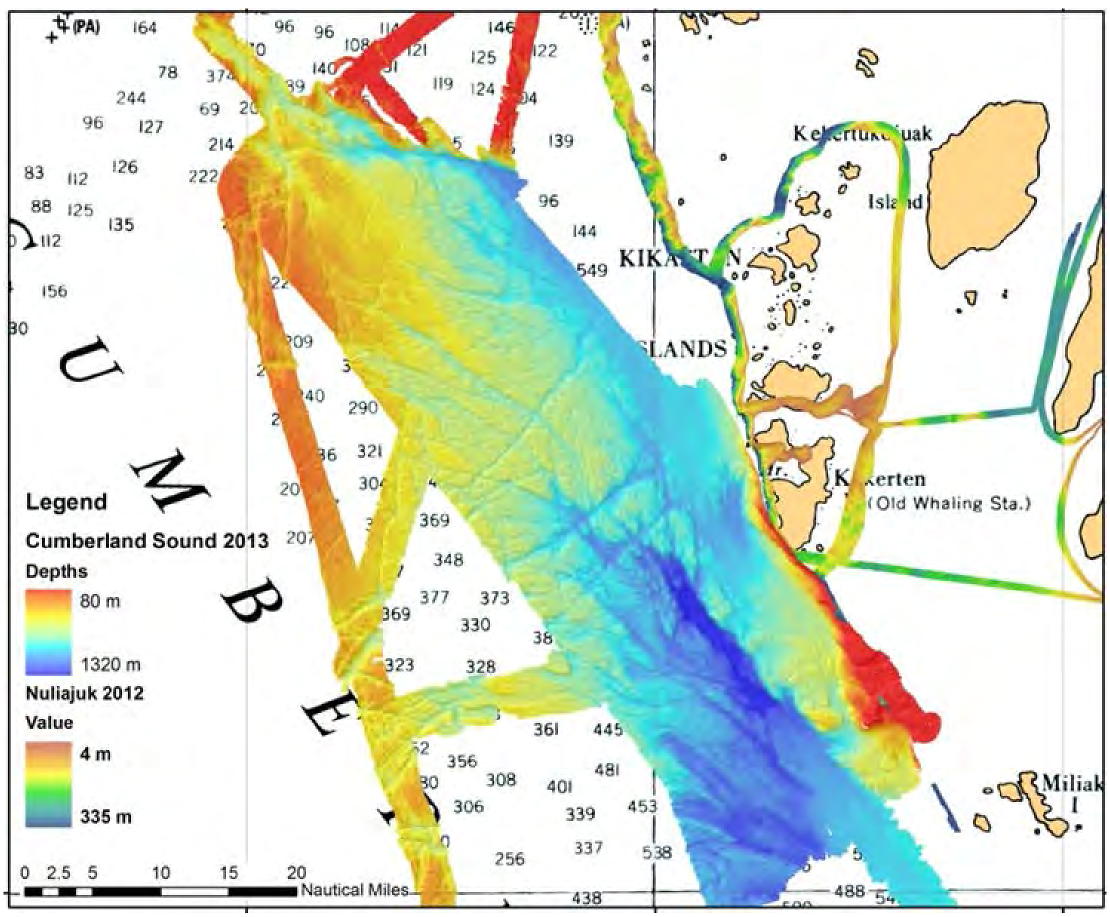

Figure 17.1. Bathymetry obtained from the seafloor mapping survey conducted in Cumberland Sound (Baffin Island) during Leg 1a.

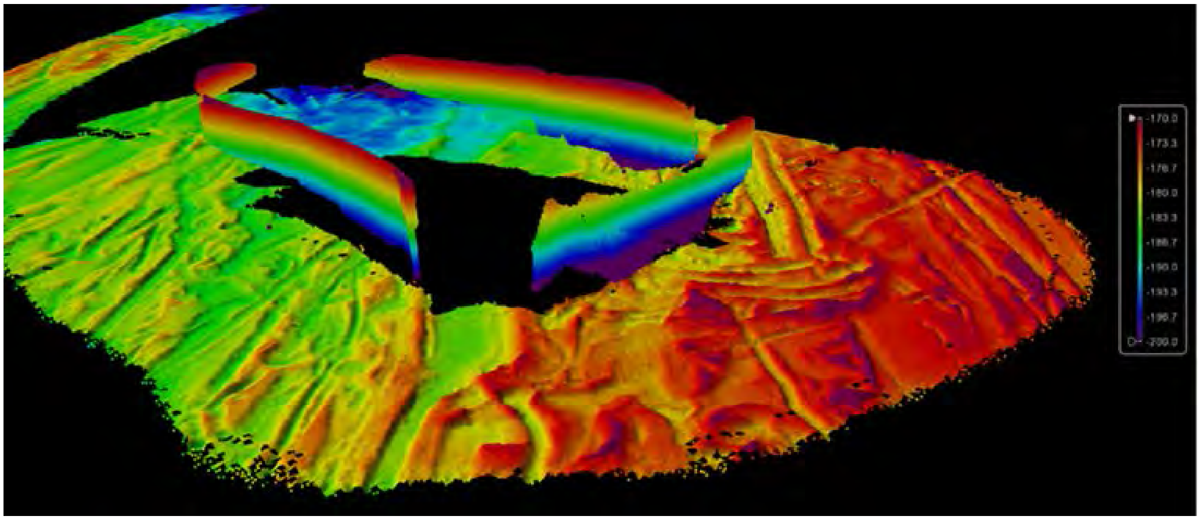

Figure 17.2. A grounded Ice Island in Kane Basin mapped during Leg 1b.

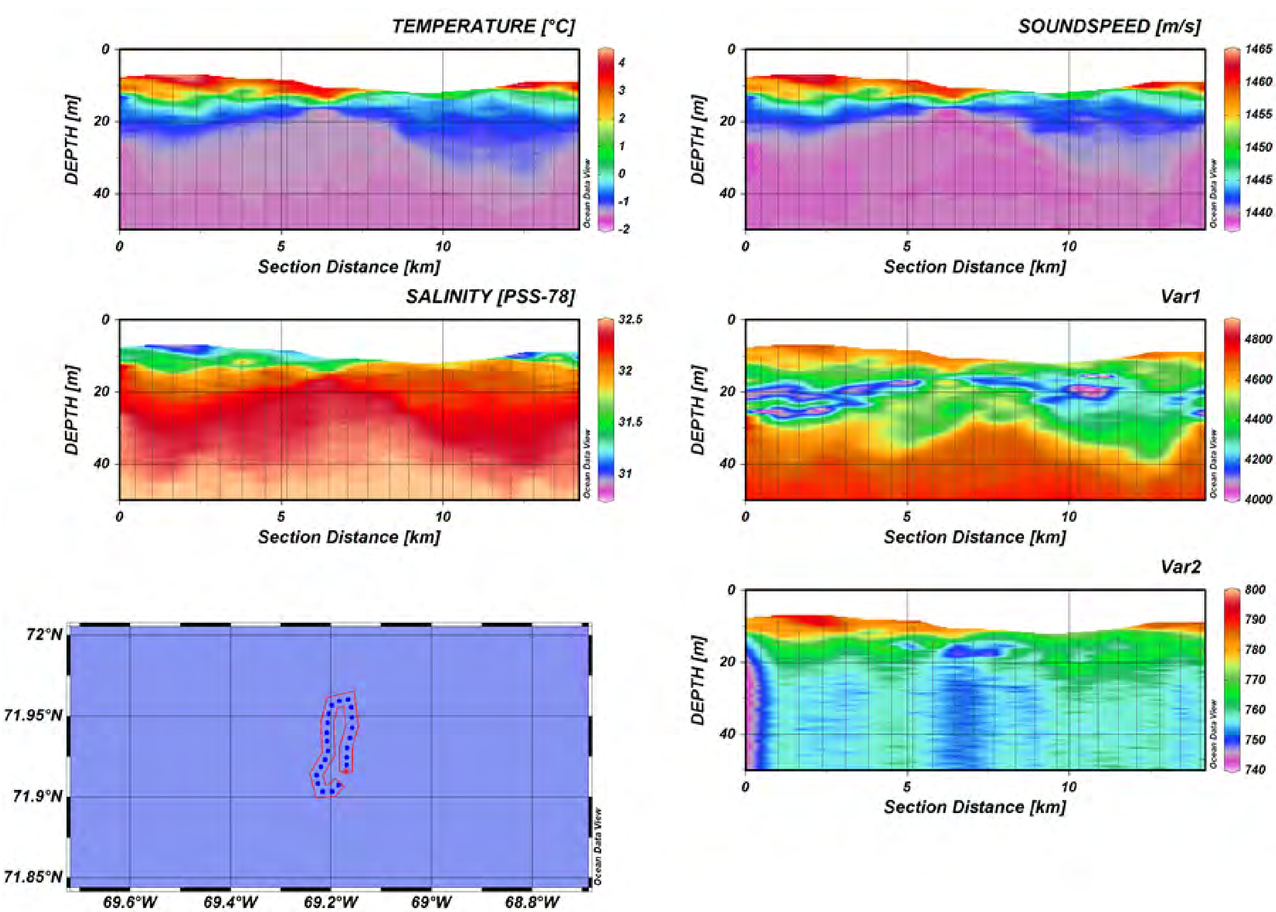

Figure 17.3. Sections of temperature, salinity, sound speed obtained with the MVP near a mobile ice island in Baffin Bay during Leg 1b.

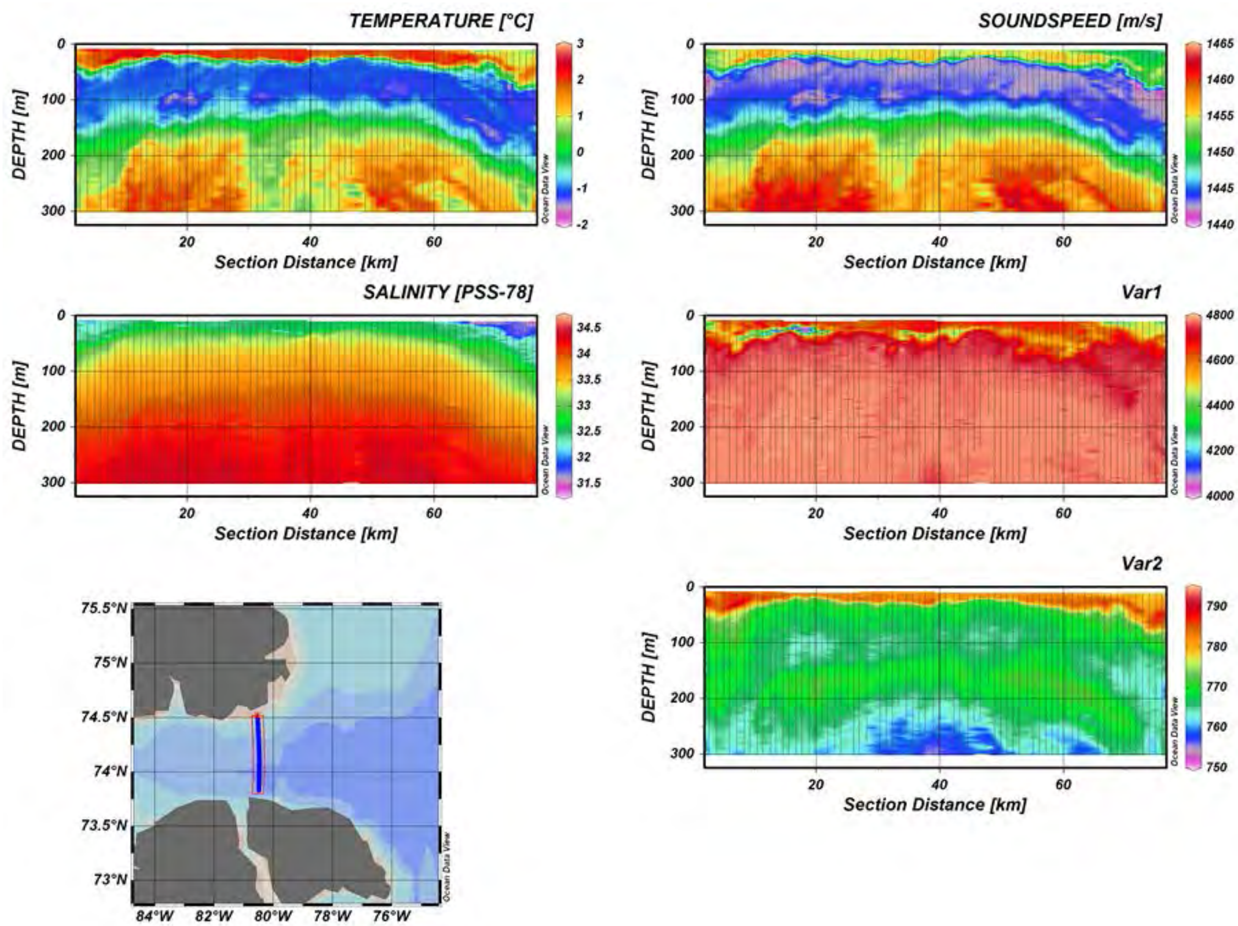

Figure 17.4. Sections of temperature, salinity, sound speed obtained with the MVP on a transect in Lancaster Sound during Leg 1b.

18 Remotely Operated Vehicle (ROV) operations – Leg 1a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change*. ArcticNet/Phase3/Marine-ecosystem-services.

Project leader: Evan Edinger[1] (eedinger@mun.ca)
Cruise participants Leg 1a: Ian Murdock[2], Trevor Shepherd[2] and Sylvain Blondeau[3]
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18.1 Introduction

The primary purpose of ROV operations for Leg 1 was to conduct a coral collection dive for E. Edinger (Memorial U.) and his student, B. Neves (see Section 19). The ROV was mobilized in Quebec City before the ship left but a number of non-essential things were still left to do, such as upgrading workboat on the console computer. On arrival on the ship near Pangnirtung, the vehicle was run through a pre-dive check and found to be fully functional. An acoustic beacon which was rented for this trip was tested and installed. The acoustic head was installed in the acoustic well.

About a day and a half was spent preparing to dive then the rest of the trip was spent diving or repairing things. The last day was spent cleaning up the system for a prolonged absence and updating the files.

18.2 Methodology

Four ROV dives were conducted during Leg 1 between 6 and 10 August in Baffin Bay, along Baffin Island and at an Ice Island. The total dive time for Leg 1 was 15 hours and 8 minutes (see dive logs in Tables 18.1 to 18.4).

The dives were generally successful in reaching the dive objectives but the vehicle had some recurrent problems that need to be resolved. This would best be done in a controlled setting such as a shop with a test tank. Most problems were occurring after the unit was in the water and running for a few hours, such as the Thruster driver board fuses blowing or the communications drop outs (see dive logs and recommendations below). They are difficult and time consuming to track and assess. Operating the ROV in its current condition will be labour intensive and challenging. Off season maintenance is thus crucial to the continued operation of this system.

18.2.1 ROV operations

ROV Dive #31

Date: Tuesday 6 August 2013.
Depth: 400m

Duration: 5h55

This dive was an opportunity to observe gas bubbles at the bottom and potentially collect a sample of the gas. Suspected plumes had been seen in the sounder in the region and past history had found methane. The search area was known and since it appeared active, it was decided to go ahead with a dive. A SIP sampler pair was cleaned and prepared by the scientists, for the collection of any bubbles that might be found. A second SIP pair was used to practice the operation of the process.

The dive ended without having found any bubbles. There were indications of methane in the form of white bacterial mat spots but no active venting observed. The SIP sampler was taken back to the TMS and while trying to clip it onto the TMS bridle, the ROV HPU failed. This caused the arms to stop functioning with them extended out AND holding onto the TMS. The vehicle was eventually freed of the TMS and recovered with the help of the Zodiac alongside the ship. The tether was unterminated and used to orient the TMS such that it would fit through the moon pool. Everything was recovered without further damage and the SIP sample was full of gas.

The vehicle had to be reterminated by removing 5.5 m of tether because some damage to the cable was suspected and a reterm had not been done on the tether for a considerable time. The port aft thruster had also stopped working due to a blown a fuse in the PCB 0433 driver board, which was replaced. The ROV HPU had also blown the same fuse on the driver board and the oil in it was murky. The fuse was replaced and the unit tested. The HPU was flushed with oil, filled, air vented and did not show any leaks.

The SIP sample was very gassy and was a problem for the science group to manage but clearly showed the abundance of methane in the area.

Table 18.1. Dive log of Dive #31 conducted on 6 August 2013 in Baffin Bay during Leg 1a.

Time	Comment
12:45	In Water
12:55	FOG reading 111°, onboard compass showing 145°
13:02	Tracklink Working, sub position in workboat
13:08	Sub and TMS at 150m
13:17	ROV out of cage at 122m
13:20	Cage in sight
13:22	Cage depth 128m
13:26	Getting down to 300m at 25m/min
13:35	Reach 300m
13:39	Auto heading needs work
13:40	Reach 380m
13:45	Cage up to 360m
13:49	ROV at bottom
13:54	Moving SIP up
13:55	Anemone
13:57	Fish
13:59	Crioydes (bottom life)
14:05	Bottom life
14:14	A rock
14:15	Change video from cage to black and white
14:19	Fish

Time	Comment
14:20	Rocky bottom
14:29	Coral
14:32	Going back to cage
14:35	Cage tether counter wrong
14:37	Tether cable mark 10m and counter -40m
14:39	Tether mark 45m, counter 95
14:40	Cage depth around 360
14:41	Bacteria site at bottom
14:45	Start logging sonar
14:50	Cable counter gone crazy, non-stop counting
14:55	Sponges
14:58	Ship stop moving
14:59	Bottom depth 383
15:00	Sit at bottom
15:02	Ship moving to position
15:03	Starfish
15:04	Changed threshold from 9 to 15 in tracklink
15:08	Sponge
15:10	Round sponge?
15:15	S.Blondeau takes over from I.Murdock as pilot
15:18	Doing laps of the area trying to find anything
15:32	N 67° 14.134', W 61° 19.066', moving to 'Point 1'
15:35	N 67° 15.287', W 61° 20.222 'Point 2'
16:11	Threshold value in tracklink somehow reset to 9 (from 15). Reset to 15
16:12	Moving to 'Point 2'
16:42	Fish (ray?)
16:49	Flat fish
16:50	Flat fish
16:55	Flat fish
17:00	Fishes
17:02	Arctic cods (many) in video 2
17:09	Arctic cod
17:14	Flat fish swimming
17:15	Ray
17:42	May be an offset on the compass
17:43	Shrimp and sponge
17:45	Closing SIP
17:52	2 sip samples at 365m depth, N 67° 15.289', W 61° 20.215'
17:57	Sip sampler dropped while on bottom, then picked up
18:07	Cage in sight during ascent
18:10	ROV back in cage
18:14	Both ROV arms lose power, thrusters still have power
18:19	Tried cycling thruster power, TMS power, ROV power – still no arm power
18:20	Signal can be seen in valve pack, still no arm power
18:22	Main winch started, 25 m/min in, from 335m depth
18:25	Sub power, TMS power switched off
18:26	Sub power, TMS power switched on – still no arm power
18:40	Ship in sight
	Arms would not retract enough to fit inside the moon pool. The cage was raised until the top was just inside the moon pool, and the sub was driven out of the cage. The arms were grabbing the rope holding the pear ring on the front of the cage, which made leaving the cage difficult. The rope eventually broke and the sub was free. The sub was recovered by zodiac and the A-frame on the port side at the bow. The sub tether was pulled onto the ship (~70m) and was pulled around the bow to the starboard side of the ship to re-align the cage. Once the cage was aligned, it was lifted through the moon pool and landed. The ROV tether was disconnected and pulled through the moon pool, and the ROV was lowered through the access hatch above the moon pool into the room.
	POST DIVE • Both TMS light bulbs burnt out. They were turned off during recovery, before leaving the water. • TMS Pod 'Vacuum Mute' button light indicates an alarm. A few drops of water were found in the vacuum port so the pod was opened and found to be dry. • Drawing of ROV Term Box had no colours – updated.

Time	Comment
	• Fuse (white 5A 250V) was replaced in PCB 433 slot 1 to repair port aft thruster (board slot 10) • Counter on TMS Connector at pod examined – OK. Pins show high resistance but counter at console is rolling when TMS power is on. • 5m of tether cut off for re-term. • Marks put on tether to 80m. • New PCB 433 in slot 10 #106 (105 out). Fried several fuses with yellow HPU. Assembly of replacement HPU problematic – fittings and cable.

ROV Dive #32

Date: Wednesday 7 August 2013.
Depth: 950 m
Duration: 5h35

Figure 18.1. Cold water corals photographed by the ROV at 910 m in Baffin Bay during Leg 1.

This was the primary dive of Leg 1 with the objective to gather coral samples and assess their diversity. The corals were to be collected in a diver (scuba) collection bag which is a big mesh bag with a heavy wire closure. The bags needed some work on the closure and a few trial runs were conducted to refine the process. A measuring stick was attached to the bag for easier access and a second measuring stick was put on the frame of the ROV as a backup. A second bag was attached to the TMS where the ROV could reach it. Corals were successfully found on this dive, but unfortunately, only two types of coral were observed. It was not possible to collect more varieties.

The ROV HPU failed again at the end of the dive with the arms extended and the ROV in the TMS. Again the Zodiac put a strap on the ROV for a crane recovery on the side of the ship. The ROV was unterminated and put back into the moon pool room through the hatch. And the tether used to align the TMS for individual recovery. Everything was recovered without further damage.

The starboard forward thruster had water in it and the electrical compensator was empty. The thruster was cleaned up and tested for leaks. The gauge was transferred from the hydraulic comp to the electrical so this could be monitored. The ROV HPU was tested and continued to blow a pair of fuses in its driver board and so both the driver board and HPU were replaced.

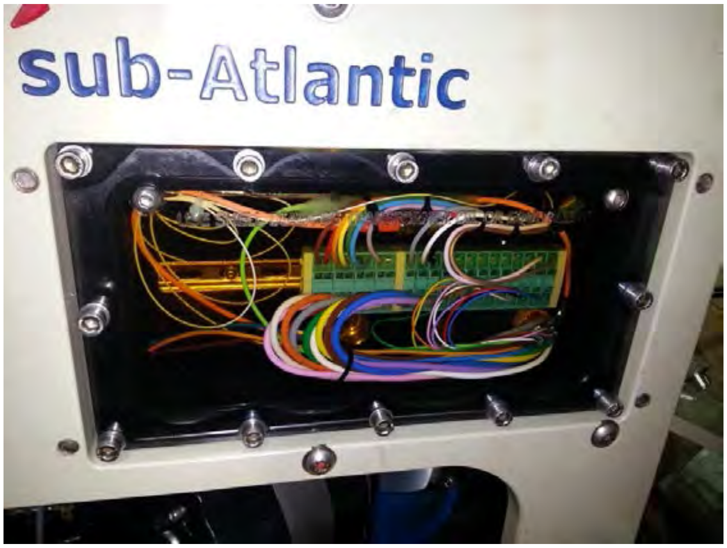


Figure 18.2. The termination Can Post Reterm of the ROV.

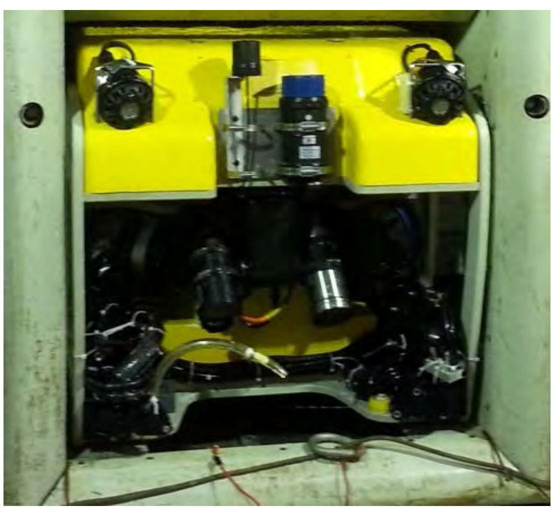
Table 18.2. Dive log of Dive #32 conducted on 7 August 2013 in Baffin Bay during Leg 1.

Time	Comment
23:40	Moon pool opened, nav recording started
23:45	Sub lowered into moon pool with overhead crane
23:46	Sub on weight of cable
32:46	Sub and TMS power on, video recording started
23:47	Sub in water
23:48	Sonar logging begins
23:51	Cable guide installed
23:53	Sub in water, outside moon pool
23:59	Hydraulics gauge pinned
00:15	Rov at 500m
00:30	Rov at 780m
00:32	Rov leaving cage
00:38	Starboard arm moved arm down on its own (sudden movement, not slow)
00:41	Bottom in sight (950m)
00:43	Soft coral found
00:47	More coral found
01:03	Small coral sample placed in net, now headed south east
01:23	60m tether from cage to ROV
01:32	Started heading east to next waypoint
01:50	Dropped bag, picked it up, continuing east
01:55	Comms dropped, camera and controls dropped, back on after 5 seconds, intermittent for 10 seconds then back to normal.
01:56	Movement continued
02:25	Arrived at point ‘B’, continuing to ‘C’
03:00	Arrived at point ‘C’, took live and dead coral sample in bag
03:22	During sampling intermittent coms – camera, lights, thrusters in and out
03:28	Leaving point ‘c’, heading south to point ‘D’. Bag samples are secure and doing well.
03:37	Hydraulics gauge still pinned
03:44	Squid

Time	Comment
03:50	Turn around halfway to point ‘D’ to head back to ‘C’ to collect samples
03:57	More intermittent loss of comms
04:05	Arrive at ‘C’, looking for samples
04:51	Last sample in bag, bag closed, ROV heading to cage
05:02	Rov in cage, both arms dead
05:15	Colour camera cuts out frequently, props spin randomly, 440V insul alarm at surface, thrusters auto off. Arms would not retract enough to fit inside the moon pool. The cage was raised until the top was just inside the moon pool, and the sub was driven out of the cage. The sub was recovered by zodiac and the A-frame on the port side at the bow. The sub tether was pulled onto the ship (~85m) and was pulled around the bow to the starboard side of the ship to re-align the cage. Once the cage was aligned, it was lifted through the moon pool and landed. The ROV tether was disconnected and pulled through the moon pool, and the ROV was lowered through the access hatch above the moon pool into the room. POST DIVE • Tracking off • Lost 2nd sample bag (black) at surface. It was empty. • Comp (hydraulics) at 6psi, launched at 7psi • Arms (HPU) fuse was blown FAULTS • 440V insul fault near surface, lost control • Forward starboard thruster has water in it, no apparent leaks. Elec comp empty • Arms removed for next dive.

Dive #33

Date: Saturday 10 August 2013.
Depth: 260 m
Duration: 1h51



To prepare for the next dive the arms were removed down to the swing clevises so that they would not need to be moved in order for the cameras to see and to fit in the TMS during recovery (expecting an HPU failure as in previous dives).

Figure 18.3. The ROV with the arms removed. Note the small white CTD probe inside the transparent hose.

The dive was originally dedicated to the investigation of an Ice Island but suspected methane seep (bubbles) were found in the SK90 echosounder and the proposed dive was postponed. The ROV was instead launched to look for bubbles. During deployment, at 100 m, a fault was found in the thrusters, which was determined to be the starboard forward again. Since the conditions were excellent, this would be a short dive, and the gauge showed good pressure in the compensator, the dive continued with the forward thrusters off.

Several patches of bubbles were found fairly quickly with the characteristic white mat (Figure 18.4).

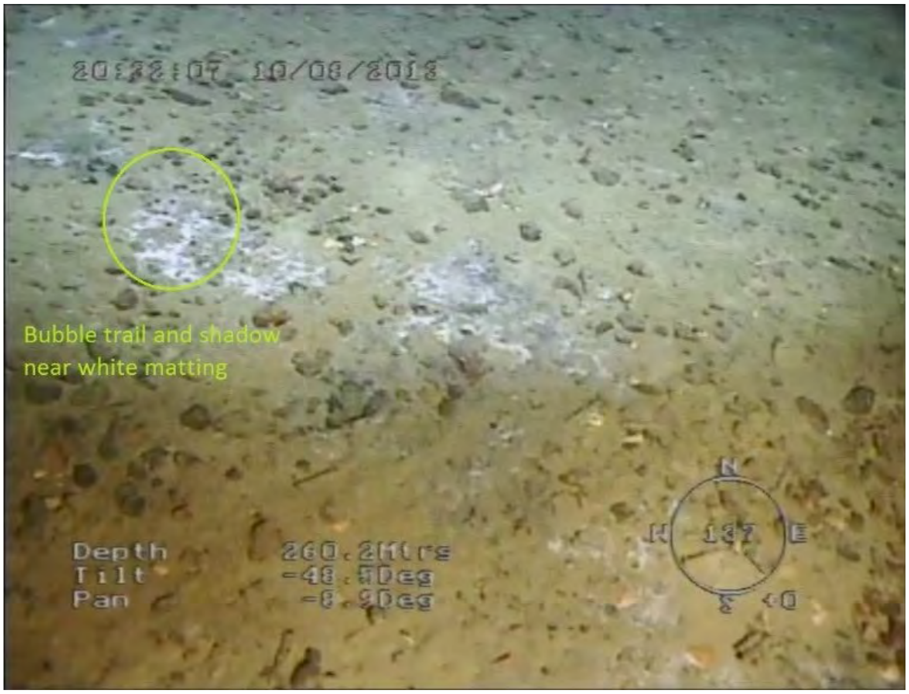
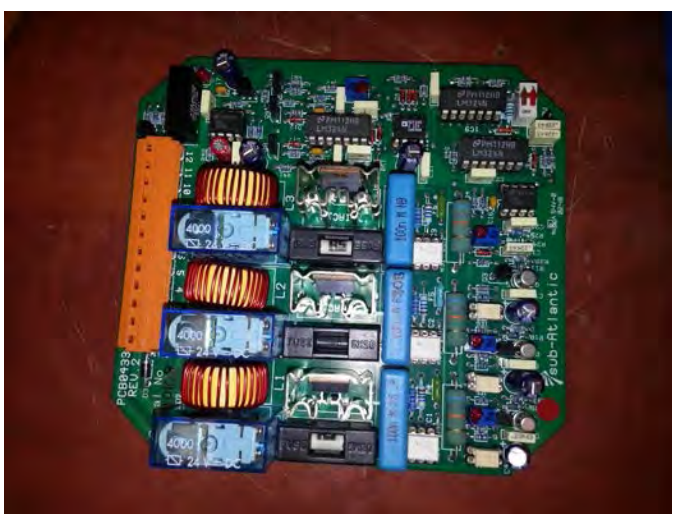


Figure 18.4. White microbial mats and (methane) bubbles photographed and sampled by the ROV at 260 m in Baffin Bay during Leg 1a.



Again, a fuse in the driver board was blown. The oil in the thruster was also a bit suspicious. The starboard forward thruster was removed and the TMS drive motor cannibalized for parts. It was cleaned thoroughly and the thruster housing and seals were replaced.

Figure 18.5. Thruster Driver Board PCB 0433 – Fuses are in black casings.

Table 18.3. Dive log of Dive #33 conducted on 10 August 2013 in Baffin Bay during Leg 1.

Time	Comment
15:18	Upper moon pool door opened
15:24	Cage lowered into moon pool with overhead crane
15:25	Cage on weight of tether
15:26	Cable guard malfunctions, dropped on cage. All stop.
15:29	Broken connection fixed, cable guard installation continues
15:31	Pictures taken of guide
15:35	Cage lowered into water, power switched on
15:36	No com errors, below ship.
15:41	20m, heading down
15:46	Spinny, suspect one thruster dead. Gauge at 10-15 psi, fluctuates with thrusting. Sonar on, tracking on and working, workboat on.
15:50	Ground fault on thrusters, suspect one of the forward thrusters
16:03	New TMS counter working perfectly, old counter must be broken
16:04	ROV on bottom, 260m
16:05	Using sonar to find seep sources
16:14	Heading south toward potential site, still nothing seen on sonar
16:19	Bubbles and hydrates found, noodle deployed. N 71°22.7348, W 70°04.3509
16:32	Found many more hydrates, exploring the area
16:36	No more ground faults since forward thrusters were disabled
16:45	Heading to surface
16:52	Intermittent comms
17:00	ROV in moon pool, re-enabled port forward thruster to match heading of ship. No ground faults. ROV thruster power switched off
17:02	ROV and Cage power switched off
17:03	ROV and Cage rinsed with fresh water over moon pool
17:04	ROV and cage off weight of tether, on overhead crane
17:05	ROV and cage landed safely on deck
17:06	Moon pool doors closed
17:09	
	POST DIVE • Starboard forward motor had ground fault, increase of electrical system pressure when thruster was used. Perhaps pumping water into thruster? • Comms still intermittent

Dive #34

Date: Saturday 10 August 2013.
Depth: 65 m
Duration: 1h47

The final dive for Leg 1 was an investigation of an Ice Island. The Island was moving south at roughly half a knot with winds in the opposite direction. The island was about 10-20 m tall above the water and showed to be roughly 70 m deep. Weather conditions continued to be excellent. The ship kept the island close ahead and on the starboard side and maintained the distance extremely well. The TMS was deployed to 30 m and the Island scanned with the sonar (which worked very well). The ROV approached the Island and stretched out about seventy meters of tether. The side of the Island was followed up to the surface and down to a depth of about sixty five meters. The recorded video file was found to be unusable on the trip back to the TMS so the vertical transect was done a second time.

Two very small CTDs were carried on the vehicle for this dive (see Figure 18.3). One was mounted on the port upper light and the other was on a piece of hose so it would project forward of the vehicle.

Overall, this was an amazing dive. The video file failure was the only problem on this dive.

Table 18.4. Dive log of Dive #34 conducted on 10 August 2013 in Baffin Bay during Leg 1.

Time	Comment
21:04	Moon Pool doors opened
21:07	Cage lowered into moon pool
21:09	Sub power on, ROV in water
21:11	Cable guard installed, FOG inaccurate
21:17	Cage at 29m
21:25	Heading toward ice island, 100m south
21:28	Workboat recording started, leaving cage
21:30	Colour camera intermittent
21:31	Nudging ice with noodle
21:36	At surface. Going to ice. Planning to descend next to ice
21:42	Landed on ice shelf, depth 11.2m
21:43	Descending cliff dragging noodle
21:49	Video recording stopped? Restarted
21:50	55m, going under ice
21:52	Cage at 50m, ROV at 63m
21:56	Ascending cliff
22:00	Reached shelf at surface
22:08	Almost reached surface cliff, tether out to 120m
22:22	While tethering out, depth reading jumped from 25m to 4m then back
22:23	Video recording issues may have been solved, repeating noodle
22:36	Sub has reached top shelf, descended cliff, and gone under ice
22:42	Parking in cage
22:51	Sub on deck
	POST DIVE • Payout counter about 5% off • Still experiencing comms failures • With no arms, sub trim (pitch and roll) was way out • Need to re-calibrate clocks on console computers

18.2.2 Post operations

After the dives, the arms were reassembled onto the vehicle. A bushing had been lost in the process and had to be fabricated. Everything on the vehicle appeared mechanically solid but the communications were definitely a problem. The telemetry cards may be causing the loss (as previously) but there was no time to troubleshoot it. The video recorder was also a problem: some files were found to be unreadable and will require work to repair if possible. Again, there was no time to explore the causes but it was suspected that when the communications are dropped, the video is unable to handle the signal noise and fails.

Figure 18.6. The required arm position for recovery of the ROV.

The equipment was cleaned up and stored, the vehicle was washed, air bled, oils checked and given a general mechanical inspection. The setup of the consoles was recorded and the maintenance log updated. The network had been reorganized after the sea trials in July 2013 so there were some difficulties with the ships system.

Navigation and sonar both appear fairly solid: NAV worked consistently for extended periods at 900 m. There were periods where the NAV was not giving any positioning but it is unknown why. Sonar was useful in finding the methane bubbles and the rocky bottom favoured by the corals.

Technically, the four dives were very successful and the ROV recovered a SIP gas sample, a specimen of coral, video of bubbles, corals, and the contour on an ice island. However, the erratic outstanding problems with the driver fuses blowing more and more frequently, the communications failures and the failure of some video files need to be addressed. These problems should be worked on well before the ROV is used again. An offseason maintenance period of extensive testing is highly recommended.

18.3 Comments and recommendations

18.3.1 Outstanding work

<u>Purchasing</u>

1) Purchase and replace ROV HPU steel and brass fittings with a single stainless fitting (Qty 4).
2) Purchase a complete spare thruster assembly.
3) Purchase twenty (20) Fuses 5 A 250VAC, 5 x 20 mm for the PCB 0433 driver boards. There are eight boards and three fuses in each. They seem to blow regularly without a known cause.

4) Purchase a KVM for the many keyboards and mice.
5) Purchase a new spare tether counter. LAV-0643-WIS 0306193
6) Qty 20 of JIC SS caps and plugs #4 for arm hoses.
7) Qty 3 of the Moonpool light (fishnlight DL175) metal halide 175 watt bulbs.
8) Qty 10 mated pairs of thruster quick disconnects.
9) Qty 2 Complete set of arm bushings.
10) Qty 2 Upgrade workboat to 5.20

<u>Modifications to the system</u>

1) Power the cable counter display on the consoles from the console power rather than a battery.
2) Install a pan and tilt on the TMS.
3) Install a small gauge manifold for the comp pressures.
4) Install a roller sheave to enable the TMS to be taller and the ROV to have a toolskid.
5) Replace plastic comp fittings with real quick disconnects.
6) Replace FOG with smaller unit.
7) Update console workboat to version 5.20

<u>General work</u>

1) Update inventory.
2) Upgrade inventory spreadsheet into a search format. It is currently difficult to do much with the Access file.
3) Investigate comms drop out. The system currently take roughly 10 minutes to warm up such that there are no consistent communications failures.
4) Investigate voltage on slipring core. Currently, this has been grounded but prior to being grounded the core of the sliprings had a very weak 215 VAC voltage on it. The hypothesis is that it is induced by the tether coiled around it.
5) Repair the ROV HPU (yellow one) removed from the vehicle Aug 10th. This unit consistently destroyed two PCB 0433 fuses at a time. This failure was much more dramatic that the usual burn out of a single fuse as has been previously seen from the thrusters. Both fuses were very burnt. It is uncertain if the fuses might be arcing while the pump is running. The fuses were burnt more if the pump was run longer.
6) Correct video file failures as well as video 'roll'. Currently the video files are occasionally unusable and periodically, the video recorded has the screen split through the middle with half the image above and half cut below. Example below (Figure 18.7).

Figure 18.7. Misaligned video problem on the ROV camera.

19 ROV dive for corals in SE Baffin Bay – Leg 1a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change*. ArcticNet/Phase3/Marine-ecosystem-services.

Project leader: Evan Edinger[1] (eedinger@mun.ca)
Cruise participant Leg 1a: Bárbara de Moura Neves[1]
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19.1 Introduction

Bamboo corals (Octocorallia: Isididae) are cosmopolitan gorgonians occurring on hard or soft substrates to depths up to >4 000 m. Among the most conspicuous bamboo corals found in the northwest Atlantic are members of the genus *Keratoisis*, which are commonly observed as single colonies attached to hard substrates, such as bedrock walls and boulders. In the NW Atlantic, *Keratoisis* has been reported in the Newfoundland and Labrador region and in southeast Baffin Bay (between Greenland and Canada). The *Keratoisis* record from SE Baffin Bay results from a 1999 scientific trawl survey in this location, where fragments of this coral were recovered as bycatch (DFO 2007). According to this DFO report, a “large mound or reef of gorgonian coral (predominantly comprising *Keratoisis ornata*) was encountered” at this site. However, colonies had not been observed in situ and a survey is planned using the *Amundsen*’s remotely operated vehicle (ROV) to explore the area, locate and sample colonies of the bamboo coral *Keratoisis* sp. in this deep, cold, and muddy Arctic environment.

The objectives of the ROV dive were to:

- Collect live bamboo corals (*Keratoisis* and *Acanella*) and stony cup corals (Scleractinia, especially *Desmophyllum*) from the location to determine their longevity, growth rates, and skeletal chemistry, particularly Sr/Ca, Mg/Ca and Ba/Ca ratios.
- Collect dead or subfossil bamboo corals and other subfossil corals from the location in order to conduct the same measurements on corals that have sampled previous oceanographic conditions.
- Collect live sea pens (Octocorallia: Pennatulacea) for age and growth studies, in order to compare these with sea pen age and growth data from other parts of Atlantic Canada and the eastern Arctic.
- Measure size-frequency distributions of corals from this location, in order to compare with video data on size-frequency of corals off the Grand Banks and Flemish Cap.
- Characterize habitat geology and coral species diversity in this location.
- Compare size and density of bamboo corals and other corals in the path of the 1999 trawl with adjacent untrawled areas.
- Provide video ground-truth data with which to estimate the extent of bamboo corals habitat based on multibeam sonar data to be collected during the cruise.

19.2 Methodology

19.2.1 Pre-dive multibeam mapping survey

The multibeam survey took place on 7 August through an area of 356.65 km^2 at depths ranging 465-1326 m, the final track being a slightly modified version of the original track plan (Figure 19.1).

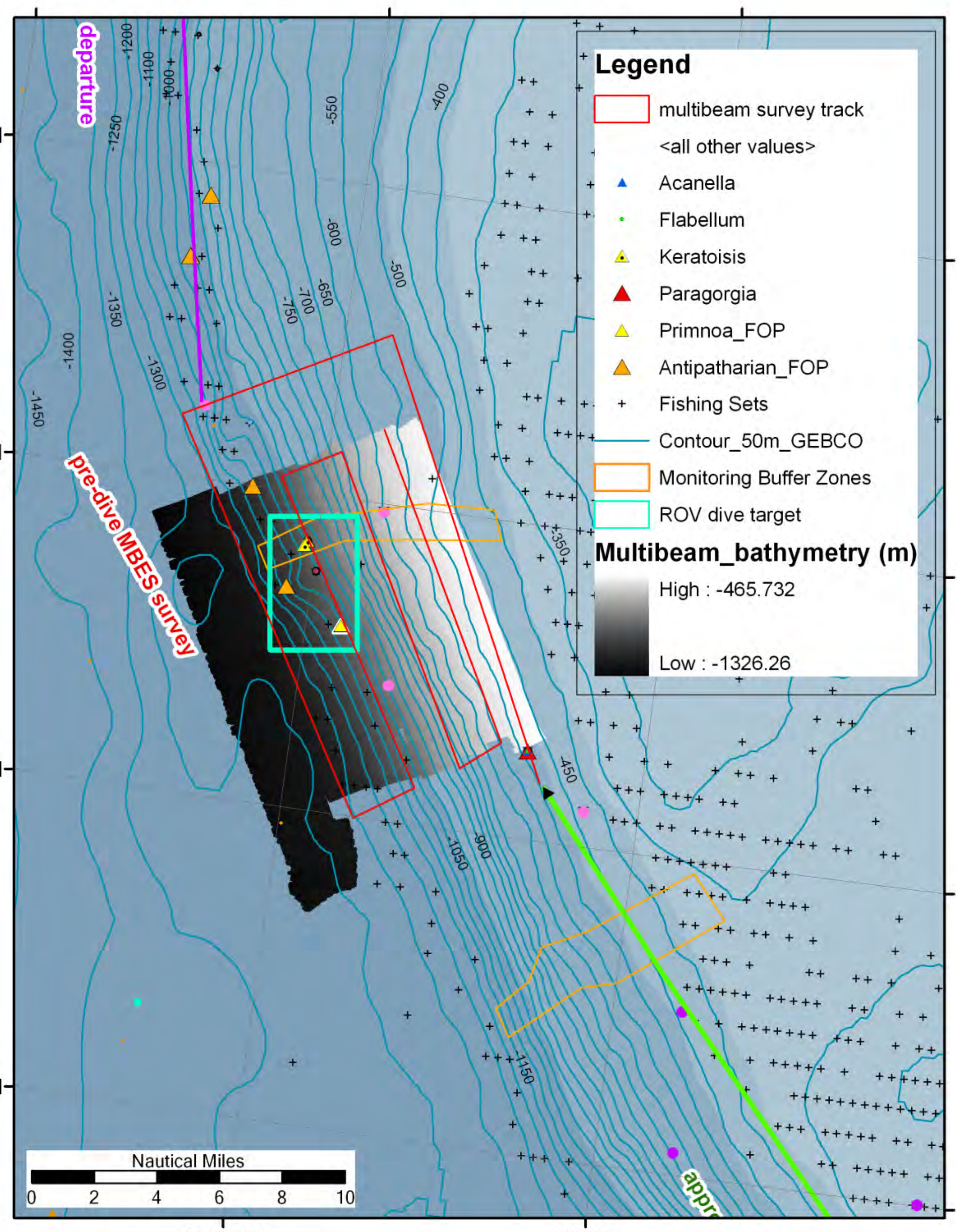

Figure 19.1. Initial multibeam survey plan (red lines) and realized multibeam track (black) carried out before the ROV dive to look for and sample deep-sea corals in Baffin Bay during Leg 1.

This survey yielded bathymetry, backscatter and slope layers with 15 m grids (Figures 19.2 to 19.4). Because the *Amundsen* is an icebreaker, and the multibeam transducers are flush-mounted to the hull, the backscatter data have a lot of bubble-induced noise, which may reduce the ability to use them for habitat characterization.

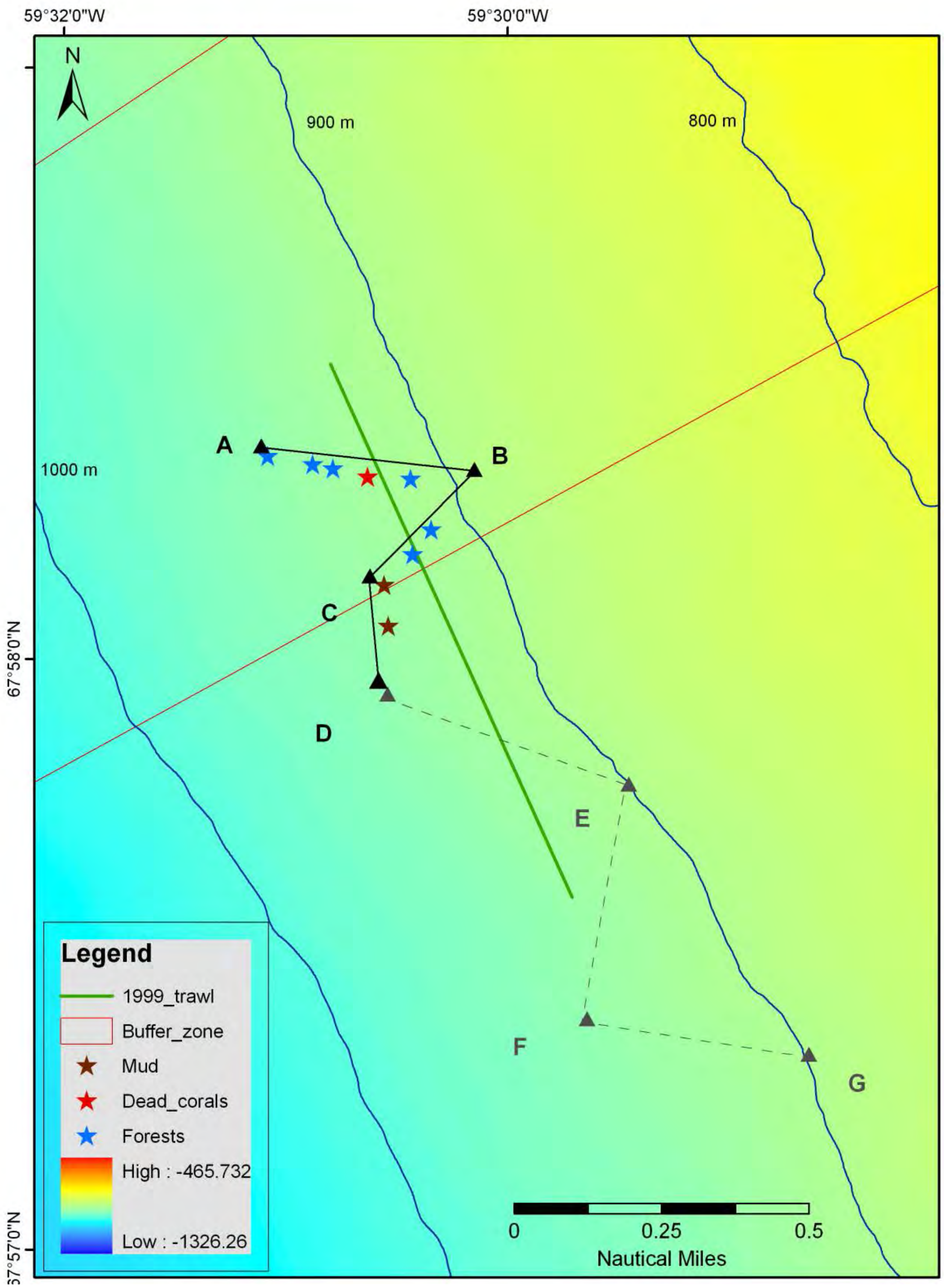

Figure 19.2. Bathymetry map resulting from the ROV pre-dive multibeam survey at Baffin Bay showing the planned transect (A-G) and realized transect (black triangles). Depth is meters. Stars represent some of the points where bamboo coral forests (Figure 19.5) and fragments of dead corals (Figure 19.7) were observed.

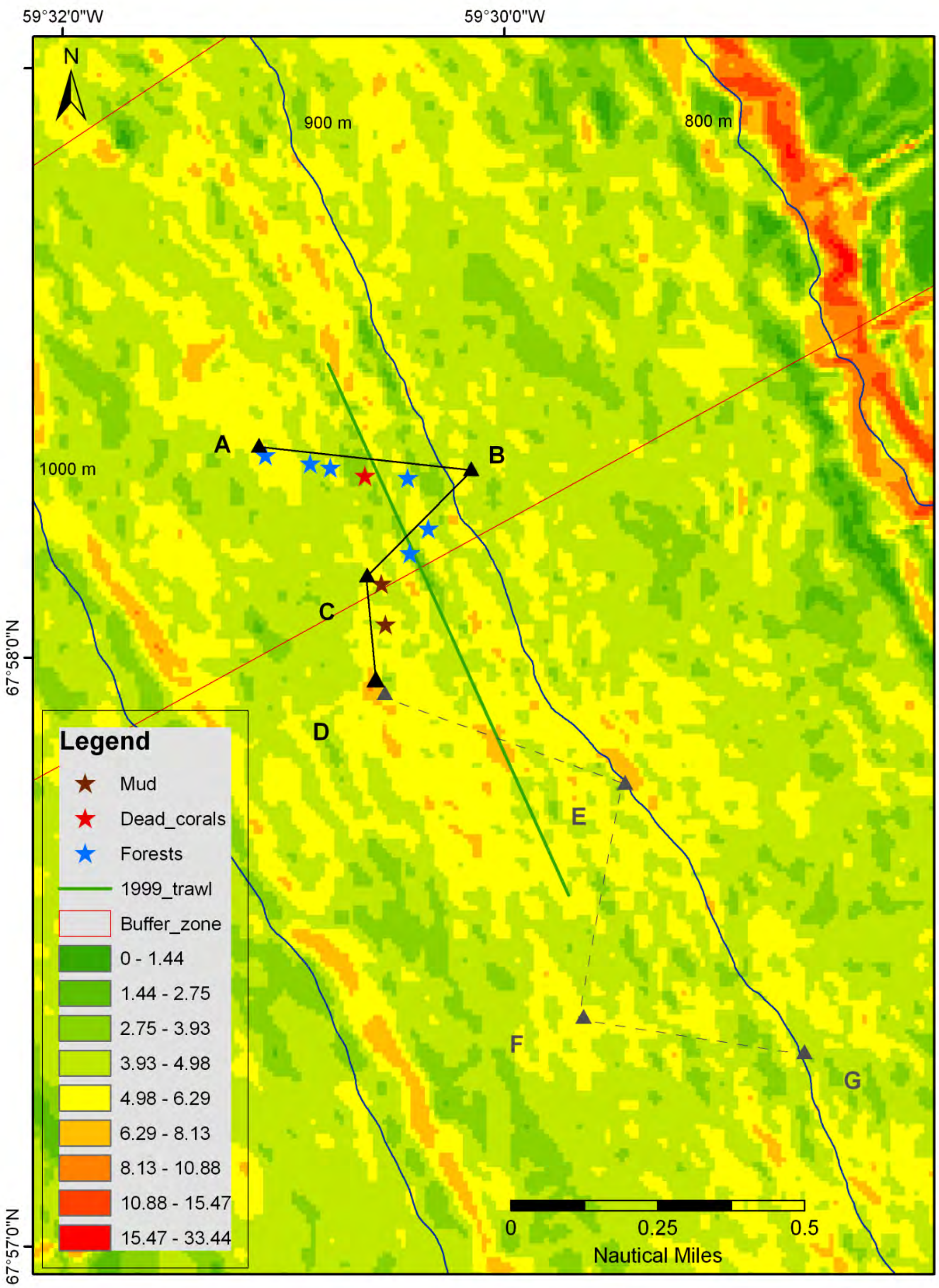

Figure 19.3. Slope map resulting from the ROV pre-dive multibeam survey at Baffin Bay showing the planned transect (A-G) and realized transect (black triangles). Stars represent some of the points where bamboo coral forests (Figure 19.5) and fragments of dead corals (Figure 19.7) were observed. Slope is in degrees. The large orange lines (supposedly high slope) are probably artifacts.

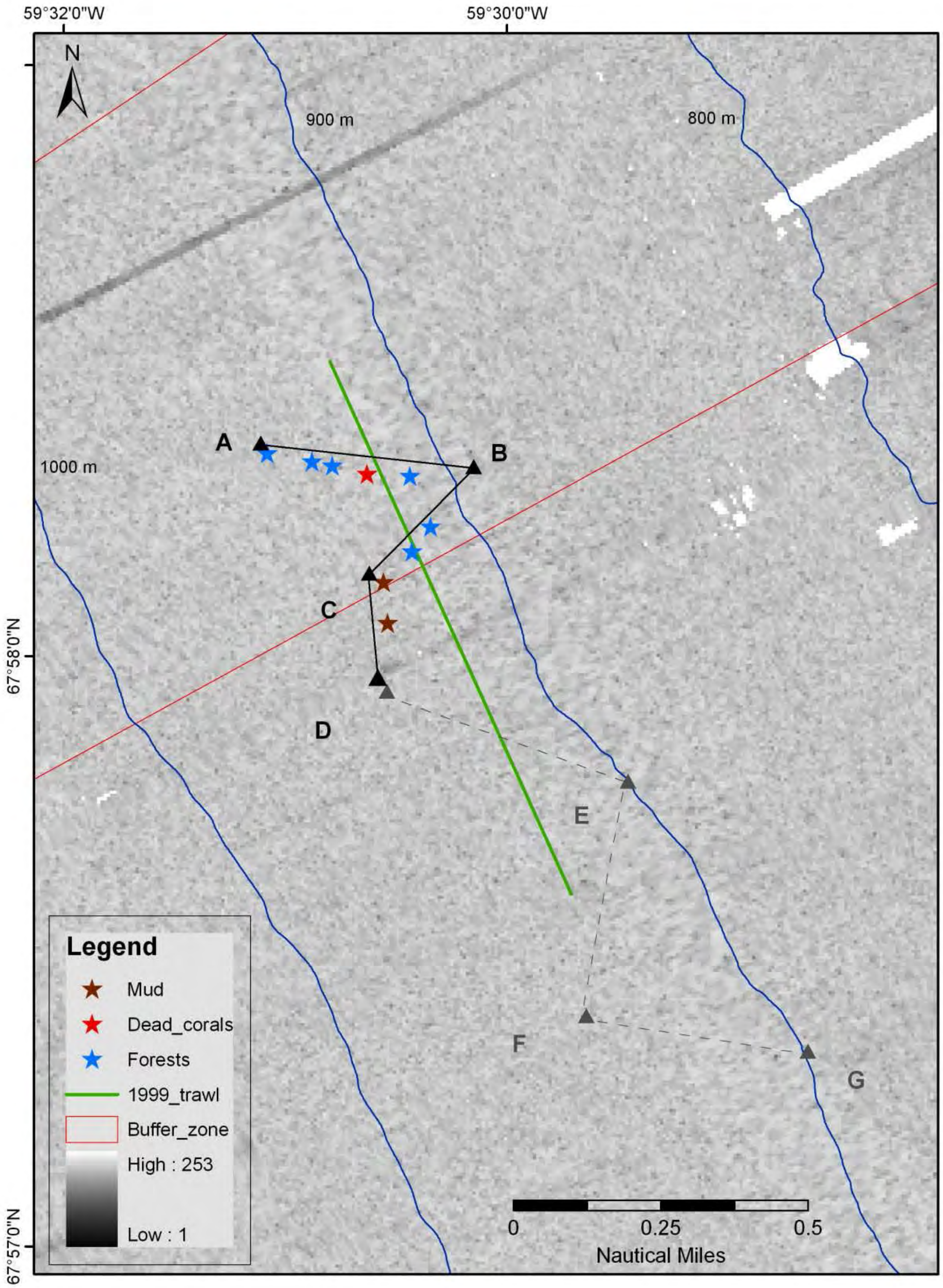

Figure 19.4. Backscatter map resulting from the pre-dive multibeam survey at Baffin Bay during the Amundsen expedition 2013, showing the planned transect (A-G) and realized transect (black triangles). Stars represent some of the points where bamboo coral forests (Figure 19.5) and fragments of dead corals (Figure 19.7) were observed. Blanks are areas of no data. The dark linear features going across the image are probably artifacts.

The multibeam data was obtained before the ROV dive, but because the areas closer to the planned transect did not show great changes in slope, it was decided to keep the original dive plan starting at the location from where colonies of bamboo corals had already been obtained in the past.

A copy of the raw multibeam sonar data was provided to MUN, so that the data can be re-analyzed at higher spatial resolution over the winter, and with more careful error correction to remove artifacts in the slope raster, and to improve the signal-to-noise ratio in the backscatter data.

19.2.2 ROV dive

The initial plan was to have one 8-hour ROV dive (including time to descend and surface), but due to technical problems with the ROV, the starting time for the dive was delayed and less time could be allocated to the dive. The ROV dive started at around 11:30 pm (Québec time) on 7 August. As planned, the ROV dive initiated at waypoint A (67°58.36’N/ 59°31.11’W) (Figures 19.2 to 19.4).

19.2.3 Coral sampling

Most of the corals were observed in the buffer area (Figures 19.2 to 19.4). From waypoint C to D the bottom was basically composed of mud with little variation and a large decrease in the abundance of epifauna was evident. Because the dive time was close to its end it was decided to return waypoint C to prioritize sampling bamboo corals. Sampling was conducted just outside the buffer zone. The collected specimens were mostly fragments and a mix of live and dead bamboo coral branches. The dive finished around waypoint C at 940 m.

19.2.4 Procedures after the dive

The ROV had technical problems while surfacing (i.e. the manipulator arms were frozen). It was rescued by the Fast Rescue Craft instead of coming directly through the moon pool. Because the arms were not functioning it was necessary to cut off the sampling bag in order to recover the samples.

After collection of the bamboo corals, samples were photographed and frozen at -20°C. These samples have already started to be sub-sampled to look for growth rings for studying growth rates and to determine their geochemical profiles.

19.2.5 Difficulties and problems encountered

The dive was started in the buffer zone where it was not permitted to sample live colonies, and where large dead colonies were not clearly observed. The largest colonies were the live ones and the plan was to sample them outside the buffer zone. But because of time limitations the planned transect (waypoints A-G) could not be completed and those forests were not observed in the surveyed zone outside the buffer area (between waypoint C and D). It is not known if after waypoint D these bamboo forests are frequent again. Therefore, sampling effort was limited by conservation issues and time constraints.

The ROV has no sample storage devices, so a SCUBA diving sample bag was adapted by the ROV team. However, sampling was not straightforward because it was challenging to open and close the bag; also it took time to properly fit the samples inside the bag. Furthermore, the sampling bag was not attached to the ROV and it was temporarily lost more than once, which again required time to find it and to restart the survey. The fragile nature of the colonies also made it difficult for the ROV arms to handle them without breaking. Finally, a measuring stick was used for size scaling since the ROV has no lasers for scaling; however using the stick was not straightforward, an again very time consuming.

19.3 Preliminary results

19.3.1 ROV dive and video footage

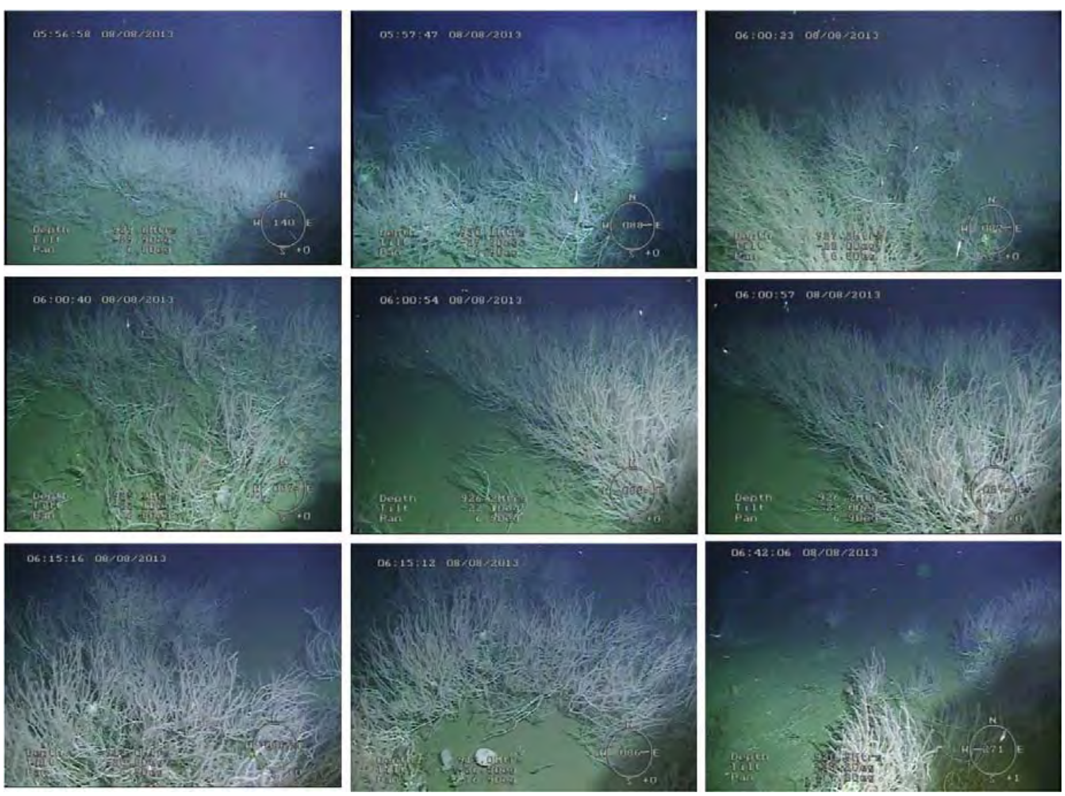

Figure 19.5. Photos from video transects showing the high abundance of bamboo corals at the sampled location (SE Baffin Bay). The bottom is muddy. Depths in these figures range between 913 and 929 m.

The first impression was that of a muddy environment with rare epifauna over the bottom and only a few boulders and cobbles. But a few minutes after the starting point, extensive forests of a bamboo coral (family Isididae) started to appear (Figure 19.5). These corals were observed at such high densities that their presence could be detected beforehand by the ROV scanning sonar. The number of colonies per unit of space has not been estimated yet, but they were so dense that it was challenging to distinguish colonies from one another (Figure 19.5).

The species' identification has not been determined yet, but based on previous reports it is possible that these corals represent a species of *Keratoisis*. However, the observed bamboo corals grow by means of root-like branches, known to be used by deep-water isidids for anchorage in muddy sediments (Deichmann, 1936), which is a very different growth pattern when compared to the species of *Keratoisis* previously recorded elsewhere in the Northwest Atlantic, which usually have a base attached to a hard surface. Subsamples of this coral have been sent to Dr. S. France (University of Louisiana at Lafayette) for genetic identification.

Figure 19.6. Top: Live colony of bamboo coral with expanded polyps. Bottom: Zoom in on the same colony (each bar on the measuring stick = 1 cm in direction of red arrow). (67°58.346'N, 59°31.087'W, 947 m).

Bamboo coral was the dominant species observed during the dive. Most of the colonies were alive (Figure 19.6), but dead colonies and fragments were also observed spread over the bottom, including a location approximately at the intersection of the 1999 DFO trawl survey path and the video transect (Figure 19.7). Other corals including soft corals (fam.

Nephtheidae) and sea pens (mostly *Pennatula* sp.) were also observed but in much less densities than the bamboo coral. No *Desmophyllum* or other scleractinian corals were observed. Other invertebrates included sea anemones, crinoids, and sea stars. Crinoids were observed over colonies of the bamboo coral. Fish observed include skates and flatfish (probably Greenland halibut). In this environment the bamboo coral might have an important structural role, especially considering the rarity or absence of hard substrates.

No trawl marks or fishing gear were observed. Zooplankton seemed abundant during the entire dive. Currents seemed weak, since coral colonies could be seen practically immobile, although zooplankton drift was visible.

Figure 19.7. Fragments of dead bamboo corals lying on the soft substrate in SE Baffin Bay (67°58.3124'N, 59°30.6266'W, 981 m). This location is within 30 m of the path of the 1999 DFO survey trawl that first detected *Keratoisis*. For location refer to Figure 19.2 (red star).

19.3.2 Coral sampling

Sampling was conducted just outside the buffer zone near waypoint C. The collected specimens were mostly fragments and a mix of live and dead bamboo coral branches. The number of colonies represented in the collection is difficult to estimate since most of them were fragmented, but is probably about 5 colonies. Total sample weight was approximately 730 g.

The bamboo corals collected had no tissue around the branches, being mainly white (calcite internode) and in several fragments the organic nodes could not be readily visualized (which might be involved with calcite). Polyps were pale pink (Figure 19.8). Associated fauna included sessile organisms like sponges, sea anemones, hydroids, soft corals, barnacles and tiny clams. Other organisms present in the sampling bag but not necessarily associated to the corals include shrimps, amphipods, worms, and one squid. Because samples were fragmented, it is not possible to know the exact location of each fragment. After collection, samples were photographed and frozen at -20°C. These samples have already started to be sub-sampled to look for growth rings for studying growth rates and to determine their geochemical profiles.

Figure 19.8. Fragments of the bamboo coral colonies sampled at SE Baffin Bay. Top left: several fragments including live (or partially alive) and dead colonies; Top right: fragment of live colony showing pink polyps; Bottom left: fragment of dead colony; Bottom right: fragment of colony partially alive.

19.3.3 Publication plans

Growth rate studies using these samples will be part of B. de Moura Neves' thesis. Geochemical characterization of the coral skeletons, in relation to water column properties, will be used to calibrate coral paleothermometry studies for interpreting subfossil coral data (EE/CHM). A short note is in preparation for *Coral Reefs* ("Reef sites") describing the coral forests found during this dive.

19.4 Conclusions

The dive objectives were partially attained. Physical samples of bamboo coral were obtained for growth and geochemical studies, as well as video data describing the habitat, and crossing the path of the 1999 survey trawl. The video provided a very good estimate of the high density of bamboo corals in this region. Other coral species (objective 1) were not sampled because they were not observed or because they were in the buffer zone where sampling could not be carried out. The size-frequency distribution study will be limited by the absence of lasers in the ROV and the difficulties associated with the use of the measuring stick. Future video surveys and sample collection in this area and in the surrounding areas are highly recommended.

20 Benthic diversity and functioning – Legs 1a, 1b and 2a

ArcticNet Phase 3 – Project titled *Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change*. ArcticNet/Phase3/Marine-ecosystem-services.

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Cruise participants Legs 1a and 1b: Cindy Grant[1] and Anni Makela[2]
Cruise participants Leg 2a: Cindy Grant[1] and Georgios Kazanidis[2]
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20.1 Introduction

It is widely recognized that wide areas of the Arctic are changing from arctic to subarctic conditions. Rapid warming is causing higher water temperatures and reduced ice cover, two factors that will certainly provoke severe ecosystem changes propagating through all trophic levels. Over the past decade, a geographical displacement of marine mammal population distribution has been observed, that coincides with a reduction of benthic prey populations. According to a widely accepted model, the relative importance of sea-ice, pelagic and benthic biota in the overall carbon and energy flux will shift from a sea-ice algae-benthos to a phytoplankton-zooplankton dominance. In the context of the potential benthic community changes, it is essential to establish benchmarks in biodiversity and understand the functioning of the benthic community at key locations in the Canadian Arctic prior to the expected changes in ice cover, ocean chemistry and climate and the future human activities (transport, trawling or dredging, drilling, etc.) that are likely to happen in response to the predicted environmental changes. Unlike Canada's two other oceans, we have the opportunity to document pristine conditions before ocean changes and exploitation occurs. The main objectives were to:

- Describe and compare the biodiversity (using a variety of different diversity indices) in different locations of the Canadian Arctic in relation to environmental variables.
- Describe the relative importance of phytoplankton and ice algae as a food source to benthic organisms by looking at compound specific isotopes in faunal tissues and water column particulate organic matter.
- Track pathways of particulate organic carbon processing and uptake by the benthic community during isotope tracing experiment.

20.2 Methodology

20.2.1 Sediment sampling and analyses

The box core (Figure 20.1) was deployed to quantitatively sample diversity, abundance and biomass of mega- and macro-endobenthic fauna and to obtain sediment cores for sediment analyses and incubations. 27 box cores were performed in Leg 1 and 5 in Leg 2a (Table 20.1). Sub-samples of sediments, usually a surface area of 0.125 m^2 and 10-15 cm in depth, were collected from the box cores and passed through a 0.5 mm mesh sieve and preserved in a 4% formaldehyde solution for further identification in the laboratory. Sub-cores of sediments (with 60 mL truncated syringes of an area of 5 cm^2 each) were collected for sediment pigment content, organic carbon content and sediment grain size; for sediment pigments and organic carbon content, the top 1 cm was collected, although for sediment grain size, the top 5 cm was collected. Sediment pigment samples were frozen at -80°C, and organic carbon samples, porosity and sediment grain size samples were frozen at -20°C. All samples were transported off the ship for analyses in the lab at the Université du Québec à Rimouski.

Figure 20.1. Box core deployment and sediment cores sampling.

Table 20.1. List of stations where box coring operations were conducted during Legs 1 and 2a.

Station	Date in 2013	Latitude N	Longitude W	Depth (m)	Diversity	Incubation	Grain size	Organic content	Pigments	Comments
Leg 1										
633	07/30	57°36.39	061°53.68	183	X		X	X	X	
600	08/01	59°05.30	063°26.34	206		X				
600	08/01	59°05.26	063°26.19	206		X				
600	08/01	59°05.28	063°26.15	206	X		X	X	X	
180	08/07	67°12.30	061°18.61	362	X		X	X	X	
176	08/09	69°36.02	065°48.16	197	X		X	X	X	
172	08/10	71°11.47	071°04.39	331						All for contaminants team
170	08/10	71°22.84	070°04.45	262	X		X	X	X	
323	08/14	74°09.78	080°28.23	788		X				
323	08/14	74°09.39	080°28.33	794		X				
323	08/14	74°09.35	080°28.27	795	X		X	X	X	
101	08/15	76°22.47	077°28.66	398	X		X	X	X	
105	08/16	76°19.05	075°45.46	329	X		X	X	X	
108	08/17	76°16.39	074°36.38	446	X		X	X	X	
111	08/17	76°18.23	073°12.29	598	X		X	X	X	
115	08/18	76°19.28	071°42.25	635	X		X	X	X	
250	08/22	81°13.79	062°03.50	760		X				

Station	Date in 2013	Latitude N	Longitude W	Depth (m)	Diversity	Incubation	Grain size	Organic content	Pigments	Comments
250	08/22	81°13.74	062°04.11	745		X				
250	08/22	81°13.69	062°04.07	751	X		X	X	X	
253	08/25	79°18.90	071°27.03	191	X		X	X	X	
254	08/26	76°53.57	072°04.67	854	X		X	X	X	
124	08/27	77°20.83	074°17.58	707		X				
124	08/27	77°20.79	074°17.50	709		X				
124	08/27	77°20.80	074°17.40	713	X		X	X	X	
117	08/29	77°19.42	077°00.30	448	X		X	X	X	
301	08/30	74°06.21	083°22.66	671	X		X	X	X	
304	08/31	74°15.66	091°22.00	326	X		X	X	X	
Leg 2a										
307	09/07	74°06.65	103°01.22	359	X		X	X	X	
308	09/08	74°08.37	108°49.92	563	X		X	X	X	
500	09/08	73°46.68	113°49.19	456		X				
500	09/08	73°46.67	113°49.37	456		X				
500	09/08	73°46.88	113°48.69	458	X		X	X	X	

For the isotope tracing experiment (Figure 20.2), incubations of 15 sediment cores were performed at 4 stations in Leg 1 and at one station in Leg 2a (Table 20.1) in a dark and temperature controlled room (ca. 4°C). Three cores acted as controls; ^{13}C, ^{15}N labelled ice algae or phytoplankton was added to six cores each. The oxygen concentrations in the water column overlying the sediment (bottom water collected using the Rosette at the same station) in the incubation cores were measured periodically (~24-h intervals) over 4 days to examine sediment community oxygen consumption. To examine carbon remineralization rates, water samples for $DI^{13}C$ analysis were collected at 24-h intervals. Additional water samples for nutrient and $DO^{13}C$ (bacterial breakdown of organic matter) analysis were taken at days 0, 2 and 4.

Figure 20.2. Isotope tracing experiment set-up in the temperature controlled room and sieving of sediment samples after finishing the experiment.

At the end of the incubations, the top 10 centimeters of sediment in the cores was sliced. Half of each slice was frozen in -80°C for phospholipid fatty acid analysis whereas the other half was sieved on a 0.5 mm mesh sieve to obtain macrofauna that were preserved in a 4% seawater-formalin solution for later isotope tracer uptake analysis.

20.2.2 Rosette sampling

At all the stations in Leg 1 and at 3 stations (#307, 308 and 500) in Leg 2a, water samples (10 m above bottom and chlorophyll maximum) were taken from the CTD-Rosette, filtered on GF/F filters and kept at -80°C for particulate organic matter compound specific isotope analysis.

20.2.3 Benthos sampling

At 21 stations in Leg 1 and at 3 stations in Leg 2a, the Agassiz trawl (Figure 20.3) was deployed to collect mega- and macroepibenthic fauna (Table 20.2). Specimens were identified to the lowest possible taxonomic level and frozen at -80°C for compound specific isotope analysis.

Figure 20.3. Agassiz trawl deployment to collect benthic organisms.

Table 20.2. List of stations where Agassiz trawl operations were conducted during Legs 1 and 2a.

Station	Date in 2013	Start			End			Duration	Comments
		Latitude N	Longitude W	Depth (m)	Latitude N	Longitude W	Depth (m)		
Leg 1									
633	07/30	57°36.56	061°53.95	186	57°36.49	061°53.98	187	3 min	
604	08/01	59°03.13	063°52.37	151	59°02.74	063°52.28	117	3 min	
183	08/04	65°35.15	066°20.52	635	65°35.62	066°21.25	707	3 min	
180	08/07	67°03.89	061°13.87	345	67°03.94	061°12.65	352	3 min	
176	08/09	69°35.88	065°48.11	202	69°35.33	065°47.11	200	4 min	
170	08/10	71°22.74	070°04.71	265	71°22.57	070°05.65	266	3 min	Empty
323	08/14	74°09.39	080°28.25	794	74°09.79	080°27.50	796	5 min	
101	08/15	76°20.50	077°35.86	343	76°20.71	077°32.72	371	4 min	
105	08/16	76°19.06	075°45.06	328	76°19.25	075°45.62	329	4 min	
108	08/17	76°16.32	074°35.22	449	76°15.82	074°32.15	441	4 min	
111	08/17	76°18.27	073°12.09	595	76°17.94	073°12.42	569	4 min	
115	08/18	76°24.74	071°18.92	526	76°25.51	071°21.82	473	3 min	Empty
132	08/20	78°59.66	072°05.82	244	78°59.28	072°04.80	227	4 min	
250	08/22	81°14.41	062°09.27	622	81°14.25	062°01.10	398	5 min	Almost nothing
253	08/25	79°18.91	071°26.93	191	79°19.26	071°24.76	201	3 min	
126	08/27	77°21.29	073°29.48	313	77°20.91	073°28.01	313	3 min	
124	08/27	77°20.83	074°17.25	709	77°21.58	074°13.92	717	3 min	
119	08/28	77°20.03	076°04.04	524	77°19.36	076°03.58	520	4 min	
117	08/29	77°19.20	077°00.11	463	77°18.80	076°57.40	475	2.5 min	
301	08/30	74°06.20	083°22.56	669	74°06.38	083°20.62	693	3 min	
304	08/31	74°15.65	091°21.60	330	74°15.69	091°19.55	332	3 min	
Leg 2a									
307	09/07	74°06.28	103°00.41	357	74°06.40	102°59.96	357	3 min	
308	09/08	74°08.27	108°49.43	563	74°08.01	108°47.07	565	3 min	
500	09/08	73°46.72	113°48.77	456	73°46.62	113°49.22	456	3 min	

20.3 Preliminary results

At this point, it is not known exactly if spatial and temporal variability of benthic diversity was governed by sediment type, food availability or other environmental variables. Samples collected for compound specific isotope analysis and those taken during the incubation experiments require further analysis. For detailed results, identification of organisms and sediment analyses will be carried on in home labs.

Some observations can be made at this point: Stations 250 and 253 exhibited very lower benthic diversity, abundance and biomass relative to all the other stations sampled.

20.4 Comments and recommendations

The box core was not deployed at Stations 183, 132, 126, 119 because the bottom was too rocky; using a benthic camera might be a good alternative to get data at those stations.

Appendix 1 - List of stations sampled during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Depth (m)
Leg 1a								
1a	St. Lawrence 1	n-a	27/Jul/2013	09h40		49°13.000	067°14.000	321
1a	St. Lawrence 2	n-a	27/Jul/2013	12h50		49°33.570	066°48.980	222
1a	650	Nutrient	29/Jul/2013	15h37		53°48.060	055°25.850	204
1a	645	Nutrient	30/Jul/2013	08h15		56°41.900	059°41.800	118
1a	633	Basic	30/Jul/2013	15h57		57°36.410	061°53.870	185
1a	632	Nutrient	31/Jul/2013	00h59		57°34.000	062°03.290	91
1a	631	Nutrient	31/Jul/2013	02h17		57°29.620	062°11.620	92
1a	630	Basic	31/Jul/2013	04h22		57°28.250	062°26.470	51
1a	640	Nutrient	31/Jul/2013	17h08		58°59.970	061°54.000	143
1a	600	Basic	31/Jul/2013	22h31		59°05.320	063°26.190	206
1a	601	CTD	31/Jul/2013	23h57		59°02.690	063°36.630	150
1a	602	Basic	01/Aug/2013	01h12		59°03.090	063°47.250	94
1a	604	Nutrient	01/Aug/2013	02h46		58°58.750	063°53.390	52
1a	n-a	Nutrient	01/Aug/2013	06h32		59°03.220	062°52.040	153
1a	602	Basic	01/Aug/2013	08h48		59°03.310	063°52.180	154
1a	604	Nutrient	01/Aug/2013	11h06		58°59.550	063°53.700	60
1a	601	CTD	01/Aug/2013	12h58		59°02.860	063°36.250	167
1a	600	Basic	01/Aug/2013	14h07		59°05.140	063°26.600	208
1a	355	CTD	02/Aug/2013	08h18		60°51.100	064°42.070	426
1a	354	CTD	02/Aug/2013	10h15		61°00.210	064°45.310	497
1a	353	CTD	02/Aug/2013	12h18		61°09.510	064°46.720	407
1a	183	Mapping	03/Aug/2013	16h15		65°35.280	066°20.400	582
1a	183	Basic	04/Aug/2013	10h38		65°38.430	066°05.920	789
1a	ROV 2	ROV	06/Aug/2013	12h45		67°15.340	061°19.520	400
1a	180	Basic	06/Aug/2013	22h20		67°12.450	061°18.740	357
1a	ROV 1	CTD	07/Aug/2013	14h40		67°47.970	059°25.740	1277
1a	ROV 1	ROV	07/Aug/2013	23h55		67°58.400	059°31.470	968
1a	176	Basic	08/Aug/2013	23h58		69°36.100	065°48.270	196
1a	172	Basic	10/Aug/2013	00h01		71°11.690	071°04.080	305
1a	172	MVP-Start	10/Aug/2013	03h15		71°17.250	070°57.080	351
1a	172	MVP-End	10/Aug/2013	04h50		71°19.320	070°55.050	178
1a	170	Basic	10/Aug/2013	06h55		71°22.760	070°04.360	265
1a	ROV 3	ROV	10/Aug/2013	21h15		72°02.160	069°12.160	2009
1a	167	CTD	11/Aug/2013	16h43		72°46.910	070°27.720	1600
Leg 1b								
1b	325	CTD	13/Aug/2013	08h02		73°48.930	080°29.080	673
1b	324	Nutrient	13/Aug/2013	10h14		73°59.270	080°32.650	767
1b	323	Full	13/Aug/2013	12h31		74°09.260	080°26.710	802
1b	300	Nutrient	14/Aug/2013	08h12		74°19.340	080°30.500	699
1b	322	Nutrient	14/Aug/2013	10h52		74°29.820	080°31.960	659
1b	Ice Station 1	Ice	14/Aug/2013	17h00		75°01.270	079°11.850	553
1b	101	MVP-Start	15/Aug/2013	02h25		76°11.280	077°14.120	407
1b	101	MVP-End	15/Aug/2013	03h25		76°17.790	077°18.230	393
1b	101	Lagrangian-Start	15/Aug/2013	04h47		76°23.040	077°24.130	353
1b	101	Full	15/Aug/2013	05h30		76°23.230	077°23.440	343
1b	101	Lagrangian-End	16/Aug/2013	05h15		76°18.270	077°50.220	331
1b	102	CTD	16/Aug/2013	06h38		76°22.430	076°59.360	250
1b	103	Nutrient	16/Aug/2013	07h35		76°21.190	076°34.530	150
1b	104	CTD	16/Aug/2013	09h05		76°20.630	076°10.370	193
1b	105	Basic	16/Aug/2013	10h14		76°19.160	075°45.620	330
1b	106	CTD	16/Aug/2013	18h00		76°18.518	075°22.117	378
1b	107	Nutrient	16/Aug/2013	19h04		76°16.905	074°59.335	439
1b	108	Full	16/Aug/2013	20h50		76°16.240	074°36.450	300
1b	109	CTD	17/Aug/2013	10h05		76°17.400	074°06.760	450
1b	110	Nutrient	17/Aug/2013	11h09		76°17.940	073°37.960	530

Appendix 1 - List of stations sampled during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Depth (m)
1b	111	Basic	17/Aug/2013	12h40		76°18.370	073°12.740	600
1b	112	CTD	17/Aug/2013	23h14		76°18.940	072°42.110	564
1b	113	Nutrient	18/Aug/2013	00h23		76°19.230	072°12.860	556
1b	114	CTD	18/Aug/2013	02h00		76°19.460	071°47.30	608
1b	114	Coring	18/Aug/2013	02h39		76°19.890	071°43.000	636
1b	115	Lagrangian-Start	18/Aug/2013	05h26		76°20.020	071°11.840	673
1b	115	Full	18/Aug/2013	05h42		76°20.290	071°11.570	654
1b	115	Lagrangian-End	19/Aug/2013	06h49		76°30.700	071°28.670	464
1b	115	MVP-Start	19/Aug/2013	08h30		76°36.090	071°38.520	n-a
1b	115	MVP-End	19/Aug/2013	09h50		76°44.720	071°49.850	732
1b	132	Full	20/Aug/2013	00h34		78°59.660	072°15.570	245
1b	250	Full	21/Aug/2013	19h00		81°14.700	062°23.800	447
1b	250	MVP	22/Aug/2013	11h00		81°14.040	061°59.890	404
1b	251	Basic	22/Aug/2013	14h46		80°54.460	061°11.800	838
1b	251	MVP-Start	22/Aug/2013	20h12		80°57.730	060°51.080	850
1b	251	MVP-End	22/Aug/2013	21h57		80°55.350	061°82.850	497
1b	253	Basic	25/Aug/2013	00h25		79°17.690	071°17.660	185
1b	253B	Basic	25/Aug/2013	09h22		79°16.330	071°27.410	181
1b	n-a	Coring	26/Aug/2013	17h56		76°53.570	072°04.660	853
1b	126	Full	26/Aug/2013	22h56		77°20.697	073°25.665	314
1b	125	CTD	27/Aug/2013	09h14		77°20.770	073°54.588	449
1b	124	Nutrient	27/Aug/2013	10h10		77°20.801	074°17.567	708
1b	123	CTD	27/Aug/2013	15h40		77°20.640	074°38.490	697
1b	122	Basic	27/Aug/2013	16h42		77°20.560	075°00.960	646
1b	121	CTD	28/Aug/2013	01h43		77°20.360	075°21.930	574
1b	120	Nutrient	28/Aug/2013	02h40		77°20.200	075°40.660	569
1b	119	Basic	28/Aug/2013	04h05		77°19.950	076°03.150	525
1b	118	Nutrient	28/Aug/2013	12h12		77°19.780	076°29.780	448
1b	117	Full	28/Aug/2013	14h02		77°19.220	076°59.810	461
1b	117	MVP-Start	29/Aug/2013	01h39		77°18.091	076°59.242	500
1b	117	MVP-End	29/Aug/2013	03h20		77°06.690	076°54.240	267
1b	322	MVP-Start	29/Aug/2013	16h10		74°29.360	080°31.800	661
1b	325	MVP-End	29/Aug/2013	22h13		73°48.900	080°29.340	672
1b	301	Basic	30/Aug/2013	02h18		74°06.191	083°21.705	667
1b	302	Nutrient	30/Aug/2013	14h43		74°09.740	086°10.490	520
1b	303	Nutrient	30/Aug/2013	20h12		74°13.409	089°36.815	236
1b	304	Full	31/Aug/2013	00h43		74°15.110	091°28.053	321
1b	305	Nutrient	31/Aug/2013	18h00		74°19.660	094°56.870	172
1b	Ice station 1	Ice	31/Aug/2013	22h38		74°15.851	096°28.075	181
1b	Ice station 2	Ice	01/Sep/2013	10h56		74°04.408	096°27.001	220
1b	Ice station 3	Ice	02/Sep/2013	06h25		74°07.580	095°57.450	176
1b	Ice station 4	Ice	02/Sep/2013	17h45		74°10.580	095°50.880	199
1b	Ice station 5	Ice	02/Sep/2013	22h46		74°10.118	095°47.495	181
1b	Ice station 6	Ice	03/Sep/2013	11h05		74°06.406	095°52.760	176
1b	Ice station 7	Ice	03/Sep/2013	14h43		74°05.688	095°59.337	189
1b	Ice station 8	Ice	03/Sep/2013	16h38		74°04.740	096°00.170	188
Leg 2a								
2a	306	Nutrient	06/Sept/2013	11h28	-6	74°21.020	097°36.600	140
2a	307	Basic	07/Sept/2013	00h09	-6	74°06.320	103°04.810	371
2a	308	Full	07/Sept/2013	15h29	-7	74°08.310	108°50.170	567
2a	308	MVP-Start	08/Sept/2013	03h27	-7	74°13.010	108°51.290	502
2a	308	MVP-End	08/Sept/2013	05h15	-7	74°25.630	108°53.770	404
2a	500	Full	08/Sept/2013	12h10	-7	73°46.960	113°49.030	459
2a	512	Nutrient	09/Sept/2013	08h07	-7	74°49.290	116°57.910	434
2a	Ice Station 1	Ice	09/Sept/2013	11h23	-7	74°45.960	117°17.890	457
2a	Ice Station 2	Ice	09/Sept/2013	16h16	-7	74°45.170	117°34.470	458

Appendix 1 - List of stations sampled during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Depth (m)
2a	333	Basic	15/Sept/2013	12h34	-6	74°20.600	087°27.560	154
Mooring programs - Hudson Bay and Beaufort Sea								
BaySys	AN01-13	Mooring	30/Aug/2013	14h00	-4	59°58.253	091°58.434	107
BREA	BR-A-12	Mooring	29/Sep/2013	17h54	-7	70°45.408	136°00.798	660
BREA	BR-B-12	Mooring	30/Sep/2013	08h16	-7	70°40.296	135°35.172	156
BREA	BR-G-12	Mooring	03/Oct/2013	10h41	-7	71°00.468	135°29.910	703
BREA	BR-02-12	Mooring	09/Oct/2013	13h34	-7	70°26.010	139°01.392	155
BREA	BR-01-12	Mooring	10/Oct/2013	17h58	-7	69°59.478	137°57.648	753

Appendix 2 - Scientific log of activities conducted during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
Leg 1a																	
1a	St. Lawrence 1	n-a	27/Jul/2013	09h00		49°12.000	067°15.000	Bioness + Hydrobios	324	n-a	30	15-20	12.50	9.40	1017.00	n-a	n-a
1a	St. Lawrence 1	n-a	27/Jul/2013	09h40		49°13.000	067°14.000	CTD-Rosette ↓	321	240	30	19	11.90	9.40	1016.30	93	n-a
1a	St. Lawrence 1	n-a	27/Jul/2013	09h49		49°13.000	067°14.000	CTD-Rosette ↑	321	262	20	18	11.90	9.40	1016.20	94	n-a
1a	St. Lawrence 1	n-a	27/Jul/2013	09h53		49°13.100	067°14.200	CTD-Rosette ↓	321	243	20	18	11.90	9.40	1016.20	94	n-a
1a	St. Lawrence 1	n-a	27/Jul/2013	10h13		49°13.000	067°14.100	CTD-Rosette ↑	321	271	20	22	11.80	9.30	1016.20	94	n-a
1a	St. Lawrence 2	n-a	27/Jul/2013	12h50		49°33.570	066°48.980	Hydrobios ↓	222	292	330	19	16.90	16.90	1013.30	73	n-a
1a	St. Lawrence 2	n-a	27/Jul/2013	13h07		49°33.540	066°49.040	Hydrobios ↑	222	250	340	8	16.60	12.14	1013.30	75	n-a
1a	St. Lawrence 2	n-a	27/Jul/2013	13h33		49°33.520	066°49.380	Bioness ↓	219	277	320	6 - 8	17.10	12.33	1013.13	72	n-a
1a	St. Lawrence 2	n-a	27/Jul/2013	13h53		49°33.660	066°49.480	Bioness ↑	217	182	300	5	18.20	12.40	1013.21	66	n-a
1a	650	Nutrient	29/Jul/2013	15h37		53°48.060	055°25.850	CTD-Rosette ↓	204	276	170	10	13.50	9.50	1020.00	81	n-a
1a	650	Nutrient	29/Jul/2013	16h25		53°47.880	055°26.010	CTD-Rosette ↑	203	54	80	10	14.00	8.50	1020.00	81	n-a
1a	645	Nutrient	30/Jul/2013	08h15		56°41.900	059°41.800	CTD-Rosette Nutrient ↓	118	64	180	12	8.60	6.50	1015.80	90	BW
1a	645	Nutrient	30/Jul/2013	08h49		56°42.200	059°41.700	CTD-Rosette Nutrient ↑	n-a	71	180	13	9.20	6.90	1015.70	88	BW
1a	633	Basic	30/Jul/2013	15h57		57°36.410	061°53.870	PNF ↓	185	330	70	7	14.30	8.45	1011.29	81	BW
1a	633	Basic	30/Jul/2013	16h03		57°36.390	061°53.830	PNF ↑	185	320	70	7	14.30	8.45	1011.29	81	BW
1a	633	Basic	30/Jul/2013	16h03		57°36.390	061°53.830	Secchi ↓	185	314	60	6	14.30	8.45	1011.29	81	BW
1a	633	Basic	30/Jul/2013	16h05		57°36.380	061°53.830	Secchi ↑	185	300	60	6	14.30	8.45	1011.29	81	BW
1a	633	Basic	30/Jul/2013	16h23		57°36.390	061°53.790	Plankton Net ↓	183	300	120	5	14.00	6.81	1011.21	81	BW
1a	633	Basic	30/Jul/2013	16h25		57°36.390	061°53.790	Plankton Net ↑	183	300	120	5	14.00	6.81	1011.21	81	BW
1a	633	Basic	30/Jul/2013	16h27		57°36.390	061°53.790	CTD-Rosette ↓	183	300	120	5	14.00	6.81	1011.21	81	BW
1a	633	Basic	30/Jul/2013	17h10		57°36.410	061°53.740	CTD-Rosette ↑	184	311	100	7	13.40	4.93	1011.08	84	BW
1a	633	Basic	30/Jul/2013	18h07		57°36.390	061°53.780	Hydrobios ↓	184	10	60	9	14.60	4.71	1011.02	82	BW
1a	633	Basic	30/Jul/2013	18h23		57°36.390	061°53.680	Hydrobios ↑	183	340	20	10	14.00	4.31	1011.00	84	BW
1a	633	Basic	30/Jul/2013	18h46		57°36.390	061°53.820	CTD-Rosette ↓	183	343	75	5	14.20	4.25	1010.90	83	BW
1a	633	Basic	30/Jul/2013	19h27		57°36.380	061°53.520	CTD-Rosette ↑	180	352	75	5	14.00	4.43	1010.90	82	BW
1a	633	Basic	30/Jul/2013	20h47		57°36.460	061°53.520	Vertical Net Tow + Loki ↓	184	208	230	5	16.70	5.23	1011.10	77	BW
1a	633	Basic	30/Jul/2013	20h57		57°36.400	061°53.480	Vertical Net Tow + Loki ↑	181	272	230	5	16.90	5.39	1011.20	76	BW
1a	633	Basic	30/Jul/2013	21h34		57°36.240	061°53.820	CTD-Rosette + SB ↓	178	190	250	6	15.60	6.75	1011.30	81	BW
1a	633	Basic	30/Jul/2013	21h55		57°36.160	061°53.500	CTD-Rosette + SB ↑	169	139	250	6	16.80	6.68	1011.40	78	BW
1a	633	Basic	30/Jul/2013	22h17		57°36.480	061°53.290	Bioness ↓	181	28	290	3	16.70	5.65	1011.30	79	BW
1a	633	Basic	30/Jul/2013	22h34		57°36.620	061°53.540	Bioness ↑	167	187	240	3	17.80	7.31	1011.40	76	BW

Appendix 2 - Scientific log of activities conducted during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1a	633	Basic	30/Jul/2013	23h22		57°36.430	061°53.700	Box Core ↓	184	215	250	7	17.60	8.10	1011.10	81	BW
1a	633	Basic	30/Jul/2013	23h28		57°36.390	061°53.680	Box Core (bottom)	183	200	250	7	17.60	8.10	1011.10	81	BW
1a	633	Basic	30/Jul/2013	23h34		57°36.340	061°53.610	Box Core ↑	183	182	250	8	17.60	6.93	1011.20	80	BW
1a	633	Basic	30/Jul/2013	23h52		57°36.560	061°53.950	Agassiz Trawl ↓	186	350	250	7	17.90	7.10	1011.10	80	BW
1a	633	Basic	31/Jul/2013	00h10		57°36.490	061°53.980	Agassiz Trawl ↑	187	120	250	7	17.60	7.07	1011.10	80	BW
1a	632	Nutrient	31/Jul/2013	00h59		57°34.000	062°03.290	CTD-Rosette ↓	91	220	260	7	17.20	11.70	1009.00	75	BW
1a	632	Nutrient	31/Jul/2013	01h21		57°34.020	062°03.330	CTD-Rosette ↑	91	295	160	5	17.00	9.00	1009.00	75	BW
1a	631	Nutrient	31/Jul/2013	02h17		57°29.620	062°11.620	CTD-Rosette ↓	92	222	210	5	16.80	12.89	1009.08	75	BW
1a	631	Nutrient	31/Jul/2013	02h41		57°29.620	062°11.500	CTD-Rosette ↑	92	137	270	0/5	16.30	8.70	1009.19	76	BW
1a	630	Basic	31/Jul/2013	04h22		57°28.250	062°26.470	Vertical Net Tow ↓	51	335	300	6	14.60	14.20	1012.17	81	0/10
1a	630	Basic	31/Jul/2013	04h27		57°28.250	062°26.440	Vertical Net Tow ↑	51	0	300	6	14.60	14.20	1012.17	81	0/10
1a	630	Basic	31/Jul/2013	04h54		57°28.250	062°26.460	PNF + Secchi ↓	51	106	310	8	13.80	6.59	1012.22	84	0/10
1a	630	Basic	31/Jul/2013	05h02		57°28.230	062°26.470	PNF + Secchi ↑	51	106	300	9	13.60	5.70	1012.15	82	0/10
1a	630	Basic	31/Jul/2013	05h15		57°28.290	062°26.480	CTD-Rosette ↓	51	156	300	8	18.10	4.15	1012.03	76	0/10
1a	630	Basic	31/Jul/2013	05h41		57°28.270	062°26.250	CTD-Rosette ↑	52	185	300	9	15.10	4.15	1012.03	76	0/10
1a	630	Basic	31/Jul/2013	05h53		57°28.210	062°26.220	Horizontal Net Tow ↓	53	315	300	9	14.70	3.96	1012.00	78	0/10
1a	630	Basic	31/Jul/2013	06h00		57°28.220	062°26.540	Horizontal Net Tow ↑	53	300	300	10	13.60	4.05	1011.90	80	0/10
1a	630	Basic	31/Jul/2013	06h07		57°28.230	062°26.480	Optical Profile ↓	50	n-a	290	8	15.60	5.60	1011.80	75	0/10
1a	630	Basic	31/Jul/2013	06h17		57°28.220	062°26.470	Optical Profile ↑	50	n-a	290	8	15.60	5.60	1011.80	75	0/10
1a	630	Basic	31/Jul/2013	06h41		57°28.240	062°26.430	CTD-Rosette ↓	51	100	300	6	14.70	4.30	1011.80	78	0/10
1a	630	Basic	31/Jul/2013	07h06		57°28.180	062°26.210	CTD-Rosette ↑	53	40	285	7	14.40	4.00	1011.80	78	0/10
1a	640	Nutrient	31/Jul/2013	17h08		58°59.970	061°54.000	CTD-Rosette ↓	143	227	0	9	4.90	4.73	1011.90	99	BW
1a	640	Nutrient	31/Jul/2013	17h44		58°59.750	061°54.090	CTD-Rosette ↑	142	252	50	0	5.20	4.43	1009.14	99	BW
1a	600	Basic	31/Jul/2013	22h31		59°05.320	063°26.190	Horizontal Net Tow ↓	206	307	30	8	9.20	5.71	1012.20	89	BW
1a	600	Basic	31/Jul/2013	22h42		59°05.190	063°26.640	Horizontal Net Tow ↑	207	135	30	8	9.10	5.35	1012.10	91	BW
1a	601	CTD	31/Jul/2013	23h57		59°02.690	063°36.630	Horizontal Net Tow ↓	150	310	30	5/10	11.30	7.21	1011.70	86	0/10
1a	601	CTD	01/Aug/2013	00h08		59°02.750	063°37.150	Horizontal Net Tow ↑	210	210	30	5/10	11.30	7.21	1011.70	86	0/10
1a	602	Basic	01/Aug/2013	01h12		59°03.090	063°47.250	Horizontal Net Tow ↓	94	285	130	0/5	12.50	7.92	1009.13	82	0/10
1a	602	Basic	01/Aug/2013	01h19		59°03.070	063°47.620	Horizontal Net Tow ↑	127	223	130	0/5	12.50	7.91	1009.13	82	0/10
1a	602	Basic	01/Aug/2013	01h45		59°03.210	063°51.920	Horizontal Net Tow ↓	155	303	100	0/5	12.40	7.29	1008.14	81	0/10
1a	602	Basic	01/Aug/2013	01h56		59°03.090	063°52.410	Horizontal Net Tow ↑	152	137	90	0/5	13.00	7.03	1008.92	77	0/10
1a	604	Nutrient	01/Aug/2013	02h46		58°58.750	063°53.390	Horizontal Net Tow ↓	52	170	170	0	11.50	9.16	1008.80	86	0/10

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1a	604	Nutrient	01/Aug/2013	02h51		58°58.610	063°53.200	Horizontal Net Tow ↑	51	92	200	3	11.50	9.16	1008.85	86	0/10
1a	n-a	Nutrient	01/Aug/2013	06h32		59°03.220	062°52.040	PNF + Secchi + Plankton Net ↓	153	188	100	10	8.20	4.48	1011.50	92	open water
1a	n-a	Nutrient	01/Aug/2013	06h47		59°03.200	062°52.160	PNF + Secchi + Plankton Net ↑	153	202	90	16	8.00	5.13	1011.60	93	0/10
1a	n-a	Nutrient	01/Aug/2013	06h57		59°03.210	062°52.160	CTD-Rosette ↓	180	290	75	8	8.00	5.13	1011.60	93	0/10
1a	n-a	Nutrient	01/Aug/2013	07h37		59°03.070	062°52.430	CTD-Rosette ↑	154	342	90	8	9.80	5.46	1011.90	87	0/10
1a	602	Basic	01/Aug/2013	08h48		59°03.310	063°52.180	CTD-Rosette ↓	154	329	90	14	9.60	4.96	1011.80	89	0/10
1a	602	Basic	01/Aug/2013	09h29		59°03.180	063°52.340	CTD-Rosette ↑	152	337	80	12	11.60	3.74	1011.70	81	0/10
1a	602	Basic	01/Aug/2013	09h45		59°03.130	063°52.370	Agassiz Trawl ↓	151	222	90	11	12.20	3.86	1011.60	79	0/10
1a	602	Basic	01/Aug/2013	09h59		59°02.740	063°52.280	Agassiz Trawl ↑	117	78	90	12	11.60	4.74	1011.50	81	0/10
1a	604	Nutrient	01/Aug/2013	11h06		58°59.550	063°53.700	CTD-Rosette ↓	60	227	N	17	14.90	8.70	1011.00	69	0/10
1a	604	Nutrient	01/Aug/2013	11h22		58°59.510	063°53.590	CTD-Rosette ↑	60	206	N	15	16.20	6.97	1010.90	66	0/10
1a	601	CTD	01/Aug/2013	12h58		59°02.860	063°36.250	CTD-Rosette ↓	167	315	110	15	9.10	8.48	1008.95	88	0/10
1a	601	CTD	01/Aug/2013	13h13		59°02.800	063°36.480	CTD-Rosette ↑	164	33	90	5	10.00	7.43	1009.36	83	0/10
1a	600	Basic	01/Aug/2013	14h07		59°05.140	063°26.600	PNF ↓	208	316	40	12	8.80	6.66	1009.76	88	BW
1a	600	Basic	01/Aug/2013	14h11		59°05.110	063°26.800	PNF ↑	209	319	40	15	8.60	5.84	1009.83	89	BW
1a	600	Basic	01/Aug/2013	14h11		59°05.110	063°26.800	Secchi ↓	209	319	40	15	8.60	5.84	1009.83	89	BW
1a	600	Basic	01/Aug/2013	14h14		59°05.100	063°26.820	Secchi ↑	209	319	40	15	8.60	5.84	1009.83	89	BW
1a	600	Basic	01/Aug/2013	14h33		59°05.210	063°26.470	CTD-Rosette ↓	208	275	40	16	8.60	4.49	1009.85	89	BW
1a	600	Basic	01/Aug/2013	15h24		59°04.830	063°26.080	CTD-Rosette ↑	212	328	60	15	7.70	3.69	1009.93	90	BW
1a	600	Basic	01/Aug/2013	16h30		59°05.250	063°26.260	Vertical Net Tow + Loki ↓	209	209	20	15	6.30	3.36	1013.10	99	BW
1a	600	Basic	01/Aug/2013	16h42		59°05.230	063°26.270	Vertical Net Tow + Loki ↑	207	200	20	12	8.90	3.12	1013.20	84	BW
1a	600	Basic	01/Aug/2013	17h45		59°05.250	063°26.260	CTD-Rosette ↓	207	338	10	8	10.40	3.04	1011.15	84	BW
1a	600	Basic	01/Aug/2013	18h26		59°05.130	063°26.950	CTD-Rosette ↑	209	296	50	20	7.10	3.19	1013.50	91	BW
1a	600	Basic	01/Aug/2013	19h14		59°05.420	063°26.170	CTD-Rosette ↓	206	243	50	15	3.80	4.34	1013.90	99	BW
1a	600	Basic	01/Aug/2013	19h35		59°05.230	063°26.360	CTD-Rosette ↑	207	295	60	13	4.70	3.67	1014.00	99	BW
1a	600	Basic	01/Aug/2013	19h53		59°05.260	063°26.260	Box Core ↓	207	273	60	12	3.60	3.46	1014.00	99	BW
1a	600	Basic	01/Aug/2013	20h05		59°05.300	063°26.340	Box Core ↑	206	238	40	12	3.80	3.35	1014.00	99	BW
1a	600	Basic	01/Aug/2013	20h20		59°05.310	063°26.190	Box Core ↓	206	293	50	13	4.00	3.15	1014.20	99	BW
1a	600	Basic	01/Aug/2013	20h31		59°05.260	063°26.190	Box Core ↑	206	215	50	14	4.00	3.15	1014.20	99	BW
1a	600	Basic	01/Aug/2013	20h45		59°05.260	063°26.150	Box Core ↓	207	233	50	12	4.10	2.98	1014.40	99	BW
1a	600	Basic	01/Aug/2013	20h57		59°05.280	063°26.150	Box Core ↑	206	203	50	12	4.30	2.83	1014.40	99	BW
1a	355	CTD	02/Aug/2013	08h18		60°51.100	064°42.070	CTD-Rosette ↓	426	221	90	17	2.70	2.53	1014.60	99	n-a

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1a	355	CTD	02/Aug/2013	09h17		60°51.430	064°39.790	CTD-Rosette ↑	408	283	90	15	3.10	2.80	1015.30	99	n-a
1a	354	CTD	02/Aug/2013	10h15		61°00.210	064°45.310	CTD-Rosette ↓	497	326	90	15	2.20	2.38	1016.80	99	n-a
1a	354	CTD	02/Aug/2013	11h18		61°00.150	064°44.540	CTD-Rosette ↑	507	330	90	14	3.60	2.97	1015.00	99	n-a
1a	353	CTD	02/Aug/2013	12h18		61°09.510	064°46.720	CTD-Rosette ↓	407	350	90	17	2.00	2.74	1012.73	99	0/10
1a	353	CTD	02/Aug/2013	13h15		61°08.930	064°48.640	CTD-Rosette ↑	432	301	90	11	3.10	2.64	1013.08	98	n-a
1a	183	Basic	03/Aug/2013	15h16		65°35.280	066°20.400	Plankton Net ↓	582	40	140	18	5.20	2.38	1012.08	94	BW
1a	183	Basic	03/Aug/2013	15h20		65°35.360	066°20.480	Plankton Net ↑	585	22	140	18	5.20	2.38	1012.08	94	BW
1a	183	Basic	03/Aug/2013	15h25		65°35.460	066°20.600	Plankton Net ↓	605	290	130	8	5.30	2.38	1011.85	92	BW
1a	183	Basic	03/Aug/2013	15h27		65°35.520	066°20.630	Plankton Net ↑	632	270	130	8	5.30	2.38	1011.85	92	BW
1a	183	Basic	03/Aug/2013	15h37		65°35.800	066°20.930	Optical Profile ↓	569	227	130	20	4.70	2.73	1011.74	95	BW
1a	183	Basic	03/Aug/2013	15h48		65°36.110	066°21.160	Optical Profile ↑	547	215	180	22	4.30	3.00	1011.56	97	BW
1a	183	Basic	03/Aug/2013	15h55		65°36.250	066°20.930	Optical Profile ↓	592	219	120	22	4.30	3.16	1011.58	97	BW
1a	183	Basic	03/Aug/2013	16h08		65°36.600	066°21.160	Optical Profile ↑	617	245	110	29	4.50	3.44	1014.00	96	BW
1a	183	Basic	04/Aug/2013	00h15		65°52.780	066°25.330	CTD-Rosette ↓	616	347	120	19	5.60	4.25	1011.76	94	0/10
1a	183	Basic	04/Aug/2013	00h40		65°52.880	066°25.740	CTD-Rosette ↑	610	350	110	11	7.40	5.00	1012.08	85	0/10
1a	183	Basic	04/Aug/2013	02h55		65°38.430	066°05.920	Plankton Net ↓	789	251	120	15	4.20	2.86	1012.58	94	BW
1a	183	Basic	04/Aug/2013	10h38		65°35.150	066°20.040	PNF + Secchi ↓	687	145	140	20	4.60	2.58	1017.07	98	BW
1a	183	Basic	04/Aug/2013	10h44		65°35.160	066°19.900	PNF + Secchi ↑	594	144	140	19	4.60	2.58	1017.00	98	BW
1a	183	Basic	04/Aug/2013	10h45		65°35.180	066°19.870	Optical Profile ↓	606	143	140	19	4.60	2.58	1017.00	98	BW
1a	183	Basic	04/Aug/2013	10h57		65°35.290	066°19.580	Optical Profile ↑	609	146	140	17	4.70	2.83	1017.00	98	BW
1a	183	Basic	04/Aug/2013	11h03		65°35.340	066°19.460	Optical Profile ↓	594	147	140	18	5.00	2.99	1017.20	98	BW
1a	183	Basic	04/Aug/2013	11h14		65°35.500	066°19.230	Optical Profile ↑	619	146	140	23	4.90	3.02	1017.30	98	BW
1a	183	Basic	04/Aug/2013	12h05		65°35.180	066°20.480	CTD-Rosette ↓	625	146	140	25	4.90	3.12	1015.00	99	BW
1a	183	Basic	04/Aug/2013	12h59		65°35.440	066°19.040	CTD-Rosette ↑	673	134	140	20	4.90	2.93	1015.28	99	BW
1a	183	Basic	04/Aug/2013	13h26		65°35.180	066°20.250	Vertical Net Tow + Loki ↓	598	118	120	20	4.70	2.87	1015.22	99	BW
1a	183	Basic	04/Aug/2013	13h57		65°35.440	066°20.390	Vertical Net Tow + Loki ↑	604	162	130	25	4.90	3.00	1014.97	97	BW
1a	183	Basic	04/Aug/2013	14h25		65°35.240	066°20.080	CTD-Rosette ↓	587	126	130	25	5.50	3.13	1014.52	95	BW
1a	183	Basic	04/Aug/2013	15h12		65°35.710	066°18.790	CTD-Rosette ↑	607	126	130	20	4.90	2.94	1015.80	97	BW
1a	183	Basic	04/Aug/2013	15h38		65°35.640	066°20.050	Bioness ↓	557	67	120	20	5.80	3.03	1014.96	95	BW
1a	183	Basic	04/Aug/2013	15h44		65°35.800	066°20.390	Bioness ↑	507	43	120	20	5.40	3.04	1014.86	96	BW
1a	183	Basic	04/Aug/2013	16h02		65°35.150	066°20.520	Agassiz Trawl ↓	635	162	120	25	5.00	3.11	1015.15	96	BW
1a	183	Basic	04/Aug/2013	16h31		65°35.620	066°21.250	Agassiz Trawl ↑	707	226	130	23	5.80	3.03	1017.21	91	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1a	183	Basic	05/Aug/2013	05h50		65°35.530	065°58.860	Plankton Net ↑	935	170	160	13	4.10	2.59	1021.90	95	BW
1a	180	Basic	06/Aug/2013	10h22		67°08.330	061°15.760	CTD-Rosette ↓	366	117	310	17	2.40	1.96	1023.80	96	BW
1a	180	Basic	06/Aug/2013	11h07		67°08.290	061°15.690	CTD-Rosette ↑	369	182	280	19	3.20	1.85	1023.60	93	BW
1a	ROV 2	ROV	06/Aug/2013	12h45		67°15.340	061°19.520	ROV 2 (Methane) ↓	400	280	300	15	2.10	1.81	1020.32	98	BW
1a	ROV 2	ROV	06/Aug/2013	19h45		67°15.150	061°17.820	ROV 2 (Methane) ↑	464	199	290	18	3.00	2.53	1019.90	86	BW
1a	180	Basic	06/Aug/2013	22h20		67°12.450	061°18.740	CTD-Rosette ↓	357	179	320	24	4.60	2.29	1018.60	78	BW
1a	180	Basic	06/Aug/2013	23h13		67°12.460	061°17.100	CTD-Rosette ↑	396	164	300	20	6.40	2.03	1018.50	75	BW
1a	180	Basic	06/Aug/2013	23h35		67°11.960	061°16.260	Vertical Net Tow + Loki ↓	402	97	310	22	4.50	2.01	1018.20	81	BW
1a	180	Basic	06/Aug/2013	23h57		67°11.670	061°15.810	Vertical Net Tow + Loki ↑	165	358	300	23	4.20	2.19	1017.90	86	BW
1a	180	Basic	07/Aug/2013	00h37		67°12.450	061°18.850	Box Core ↓	344	318	300	21	4.10	2.20	1014.95	86	BW
1a	180	Basic	07/Aug/2013	01h00		67°12.080	061°17.980	Box Core ↑	373	47	280	20	3.80	2.17	1014.53	88	BW
1a	180	Basic	07/Aug/2013	01h15		67°12.480	061°18.910	Box Core ↓	349	322	290	20	3.80	2.17	1014.26	89	BW
1a	180	Basic	07/Aug/2013	01h33		67°12.300	061°18.610	Box Core ↑	362	32	280	19	3.60	2.14	1014.39	90	BW
1a	180	Basic	07/Aug/2013	03h17		67°05.660	061°15.760	CTD-Rosette ↓	340	211	300	15	5.10	2.33	1013.99	87	BW
1a	180	Basic	07/Aug/2013	04h15		67°04.470	061°15.300	CTD-Rosette ↑	324	136	300	26	5.40	2.40	1016.00	87	BW
1a	180	Basic	07/Aug/2013	04h28		67°04.250	061°15.480	Horizontal Net Tow ↓	315	120	300	23	6.20	2.40	1015.90	83	BW
1a	180	Basic	07/Aug/2013	04h48		67°04.160	061°14.360	Horizontal Net Tow ↑	335	60	300	27	4.90	2.40	1015.50	87	BW
1a	180	Basic	07/Aug/2013	04h56		67°03.890	061°13.870	Agassiz Trawl ↓	345	84	300	28	7.70	2.40	1015.60	78	BW
1a	180	Basic	07/Aug/2013	05h15		67°03.940	061°12.650	Agassiz Trawl ↑	352	40	300	26	5.30	2.40	1015.12	87	BW
1a	180	Basic	07/Aug/2013	07h08		67°09.870	061°16.620	Hydrobios ↓	362	270	300	22	5.20	2.18	1014.65	84	BW
1a	180	Basic	07/Aug/2013	07h30		67°09.780	061°16.560	Hydrobios ↑	366	222	290	21	5.50	1.90	1014.25	83	BW
1a	180	Basic	07/Aug/2013	07h44		67°09.800	061°16.620	PNF + Secchi ↓	364	247	300	21	5.70	1.97	1014.24	83	BW
1a	180	Basic	07/Aug/2013	07h54		67°09.790	061°16.730	PNF + Secchi ↑	363	247	300	21	5.70	1.90	1014.06	83	BW
1a	180	Basic	07/Aug/2013	08h07		67°09.780	061°16.570	Optical Profile ↓	397	38	300	21	5.50	1.90	1013.80	83	BW
1a	180	Basic	07/Aug/2013	08h23		67°09.780	061°16.390	Optical Profile ↑	367	87	300	26	5.80	2.24	1013.70	81	BW
1a	180	Basic	07/Aug/2013	08h27		67°09.770	061°16.350	Optical Profile ↓	369	65	300	26	5.80	2.24	1013.70	81	BW
1a	180	Basic	07/Aug/2013	08h40		67°09.660	061°16.300	Optical Profile ↑	370	122	300	25	6.20	2.35	1013.50	80	BW
1a	180	Basic	07/Aug/2013	08h48		67°09.590	061°16.080	Plankton Net ↓	369	112	300	22	5.80	2.40	1013.50	81	BW
1a	180	Basic	07/Aug/2013	08h50		67°09.590	061°16.080	Plankton Net ↑	370	85	320	22	6.90	2.43	1013.80	75	BW
1a	180	Basic	07/Aug/2013	09h25		67°09.990	061°16.420	CTD-Rosette ↓	364	160	300	24	5.70	2.46	1013.40	83	BW
1a	180	Basic	07/Aug/2013	10h11		67°10.440	061°15.540	CTD-Rosette ↑	390	142	300	23	5.80	2.11	1012.90	83	BW
1a	ROV 1	CTD	07/Aug/2013	14h40		67°47.970	059°25.740	CTD ROV Corals ↓	1277	156	310	20	4.90	4.34	1007.12	98	0/10

Appendix 2 - Scientific log of activities conducted during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1a	ROV 1	CTD	07/Aug/2013	15h14		67°47.660	059°25.190	CTD ROV Corals ↑	1265	153	310	15	9.50	4.45	1006.86	79	0/10
1a	ROV 1	ROV	07/Aug/2013	23h55		67°58.400	059°31.470	ROV 1 (Corals) ↓	968	15	330	11	2.80	4.43	1007.40	99	0/10
1a	ROV 1	ROV	08/Aug/2013	05h50		67°58.000	059°30.300	ROV 1 (Corals) ↑	968	300	320	18	4.30		1006.10	99	0/10
1a	176	Basic	08/Aug/2013	23h58		69°36.100	065°48.270	Box Core ↓	196	168	340	21	4.00	4.03	1007.08	93	BW
1a	176	Basic	09/Aug/2013	00h03		69°36.070	065°48.280	Box Core ↑	196	188	340	20	4.20	4.14	1007.15	93	BW
1a	176	Basic	09/Aug/2013	00h15		69°36.040	065°48.160	Box Core ↓	196	165	330	15	6.00	4.18	1007.24	87	BW
1a	176	Basic	09/Aug/2013	00h19		69°36.020	065°48.160	Box Core ↑	197	158	330	15	6.00	4.18	1007.24	87	BW
1a	176	Basic	09/Aug/2013	00h41		69°35.880	065°48.110	Agassiz Trawl ↓	202	133	340	19	4.50	4.23	1007.33	92	BW
1a	176	Basic	09/Aug/2013	00h59		69°35.330	065°47.110	Agassiz Trawl ↑	200	132	330	19	3.90	4.24	1007.28	95	BW
1a	176	Basic	09/Aug/2013	02h00		69°35.640	065°47.610	Vertical Net Tow + Loki ↓	209	152	340	18	4.00	4.21	1007.68	97	BW
1a	176	Basic	09/Aug/2013	02h14		69°35.590	065°47.540	Vertical Net Tow + Loki ↑	206	135	340	18	3.70	4.16	1007.62	98	BW
1a	176	Basic	09/Aug/2013	02h35		69°35.430	065°47.390	Vertical Net Tow + Loki ↓	205	160	340	18	4.90	4.09	1007.74	93	BW
1a	176	Basic	09/Aug/2013	02h46		69°35.400	065°47.370	Vertical Net Tow + Loki ↑	200	155	330	17	4.10	4.03	1007.78	94	BW
1a	176	Basic	09/Aug/2013	03h26		69°35.710	065°47.720	Bioness ↓	205	171	330	18	4.70	4.19	1007.69	90	BW
1a	176	Basic	09/Aug/2013	03h45		69°35.030	065°47.040	Bioness ↑	205	167	310	13	6.50	4.23	1007.88	85	BW
1a	176	Basic	09/Aug/2013	04h10		69°34.590	065°46.660	PNF + Secchi + Plankton Net ↓	220	139	330	21	4.00	4.17	1010.22	95	BW
1a	176	Basic	09/Aug/2013	04h30		69°34.260	065°46.470	PNF + Secchi + Plankton Net ↑	218	145	330	22	3.80	4.02	1010.36	95	BW
1a	176	Basic	09/Aug/2013	05h10		69°35.900	065°47.900	CTD-Rosette ↓	200	173	320	26	4.20	4.19	1010.32	96	BW
1a	176	Basic	09/Aug/2013	05h50		69°35.390	065°46.910	CTD-Rosette ↑	193	173	330	24	7.50	4.05	1011.77	83	BW
1a	176	Basic	09/Aug/2013	07h00		69°35.880	065°47.250	Optical Profile ↓	193	337	340	23	3.90	4.41	1012.26	98	BW
1a	176	Basic	09/Aug/2013	07h20		69°35.780	065°47.830	Optical Profile ↑	205	345	340	28	3.90	4.49	1011.50	98	BW
1a	176	Basic	09/Aug/2013	08h00		69°35.770	065°48.570	CTD-Rosette ↓	213	341	330	20	4.00	4.56	1011.18	99	BW
1a	176	Basic	09/Aug/2013	08h42		69°35.570	065°50.440	CTD-Rosette ↑	212	337	330	21	4.00	4.56	1011.50	99	BW
1a	172	Basic	10/Aug/2013	00h01		71°11.690	071°04.080	Vertical Net Tow + Loki ↓	305	78	130	3	5.40	5.65	1017.62	88	BW
1a	172	Basic	10/Aug/2013	00h20		71°11.520	071°04.380	Vertical Net Tow + Loki ↑	325	52	150	1	5.30	5.73	1017.56	88	BW
1a	172	Basic	10/Aug/2013	00h45		71°11.480	071°04.380	Box Core ↓	329	21	160	2	5.60	5.76	1017.51	85	BW
1a	172	Basic	10/Aug/2013	00h55		71°11.470	071°04.390	Box Core ↑	331	8	170	2	5.60	5.88	1017.51	85	BW
1a	172	Basic	10/Aug/2013	01h38		71°11.270	071°04.680	Bioness ↓	360	232	140	4	4.70	5.88	1017.55	88	BW
1a	172	Basic	10/Aug/2013	02h12		71°11.170	071°04.810	Bioness ↑	367	136	230	4	4.90	5.99	1017.89	89	BW
1a	172	Basic	10/Aug/2013	03h15		71°17.250	070°57.080	MVP ↓	351	39	230	2	5.80	6.09	1018.05	89	BW
1a	172	Basic	10/Aug/2013	04h50		71°19.320	070°55.050	MVP ↑	178	90	180	7	5.20	5.06	1020.70	89	BW
1a	170	Basic	10/Aug/2013	06h55		71°22.760	070°04.360	PNF + Secchi + Plankton Net ↓	265	123	150	6	5.80	5.64	1021.57	86	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1a	170	Basic	10/Aug/2013	07h12		71°22.730	070°04.480	PNF + Secchi + Plankton Net ↑	261	111	135	6	5.00	5.43	1021.71	90	BW
1a	170	Basic	10/Aug/2013	07h47		71°22.770	070°04.380	CTD-Rosette ↓	264	111	140	7	4.70	5.74	1022.00	92	BW
1a	170	Basic	10/Aug/2013	08h25		71°22.770	070°04.270	CTD-Rosette ↑	261	109	140	8	4.30	5.78	1022.00	94	BW
1a	170	Basic	10/Aug/2013	08h55		71°22.780	070°04.760	CTD-Rosette ↓	268	135	130	7	3.10	5.73	1022.00	99	BW
1a	170	Basic	10/Aug/2013	09h06		71°22.760	070°04.580	CTD-Rosette ↑	262	121	140	6	3.00	5.73	1022.20	99	BW
1a	170	Basic	10/Aug/2013	09h21		71°22.810	070°04.290	Deployment Barge	264	110	120	5	3.00	5.76	1022.40	99	BW
1a	170	Basic	10/Aug/2013	09h33		71°22.800	070°04.300	Vertical Net Tow + Loki ↓	265	116	120	6	2.70	5.75	1022.40	99	BW
1a	170	Basic	10/Aug/2013	09h47		71°22.790	070°04.430	Vertical Net Tow + Loki ↑	263	139	110	5	2.70	5.75	1022.40	99	BW
1a	170	Basic	10/Aug/2013	10h06		71°22.770	070°04.270	Gravity Core ↓	261	85	130	6	2.60	5.79	1022.50	99	BW
1a	170	Basic	10/Aug/2013	10h21		71°22.780	070°04.340	Gravity Core ↑	264	116	100	5	2.80	5.79	1022.40	99	BW
1a	170	Basic	10/Aug/2013	10h58		71°22.860	070°04.040	Bioness ↓	256	85	140	7	3.20	5.75	1022.40	99	BW
1a	170	Basic	10/Aug/2013	11h22		71°22.780	070°03.660	Bioness ↑	247	250	130	8	3.10	5.85	1022.40	99	BW
1a	170	Basic	10/Aug/2013	10h26		71°22.770	070°04.320	Gravity Core ↓	265	97	120	6	2.80	5.75	1022.40	99	BW
1a	170	Basic	10/Aug/2013	10h43		71°22.800	070°04.370	Gravity Core ↑	265	51	140	7	2.60	5.71	1022.50	99	BW
1a	170	Basic	10/Aug/2013	11h35		71°22.730	070°04.060	Recovery Barge	254	300	130	6	3.10	5.85	1022.40	99	BW
1a	170	Basic	10/Aug/2013	12h32		71°22.780	070°04.200	CTD-Rosette ↓	262	339	150	8	3.10	5.93	1020.05	99	BW
1a	170	Basic	10/Aug/2013	13h12		71°22.760	070°04.510	CTD-Rosette ↑	266	315	140	6	4.00	5.94	1020.14	99	BW
1a	170	Basic	10/Aug/2013	13h35		71°22.830	070°04.290	Box Core ↓	263	136	140	7	3.10	5.89	1020.04	99	BW
1a	170	Basic	10/Aug/2013	13h41		71°22.840	070°04.450	Box Core ↑	262	123	140	9	2.80	5.83	1020.07	99	BW
1a	170	Basic	10/Aug/2013	14h02		71°22.740	070°04.710	Agassiz Trawl ↓	265	323	130	3	3.30	5.80	1020.14	99	BW
1a	170	Basic	10/Aug/2013	14h16		71°22.570	070°05.650	Agassiz Trawl ↑	266	165	130	7	3.30	5.83	1020.14	99	BW
1a	170	Basic	10/Aug/2013	14h32		71°22.800	070°04.290	CTD-Rosette ↓	263	101	130	7	2.80	5.86	1020.13	99	BW
1a	170	Basic	10/Aug/2013	15h13		71°22.800	070°04.400	CTD-Rosette ↑	265	56	140	7	3.10	5.89	1020.25	99	BW
1a	170	Basic	10/Aug/2013	15h40		71°22.800	070°04.380	ROV (Test+Methane) ↓	265	40	150	7	3.10	5.94	1020.34	99	BW
1a	170	Basic	10/Aug/2013	17h01		71°22.800	070°04.380	ROV (Test+Methane) ↑	265	42	180	8	3.20	5.95	1021.20	99	BW
1a	170	Basic	10/Aug/2013	21h15		72°02.160	069°12.160	ROV 3 (Ice Island) ↓	2009	175	150	8	3.40	5.15	1022.30	99	BW
1a	170	Basic	10/Aug/2013	22h50		72°01.540	069°11.220	ROV 3 (Ice Island) ↑	2012	139	150	9	3.00	4.88	1022.00	99	BW
1a	167	CTD	11/Aug/2013	16h43		72°46.910	070°27.720	CTD-Rosette ↓	1600	19	180	13	5.40	5.76	1014.61	98	0/10
1a	167	CTD	11/Aug/2013	17h22		72°46.980	070°22.790	CTD-Rosette ↑	1600	12	190	11	7.30	5.66	1011.75	91	0/10
Leg 1b																	
1b	325	CTD	13/Aug/2013	08h02		73°48.930	080°29.080	CTD-Rosette ↓	673	244	204	30	7.90	4.39	1004.70	75	BW
1b	325	CTD	13/Aug/2013	09h06		73°48.240	080°25.970	CTD-Rosette ↑	649	250	220	26	5.10	4.63	1004.60	84	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	324	Nutrient	13/Aug/2013	10h14		73°59.270	080°32.650	CTD-Rosette ↓	767	291	290	30	6.00	4.35	1003.40	86	BW
1b	324	Nutrient	13/Aug/2013	11h21		73°58.870	080°31.590	CTD-Rosette ↑	770	262	270	25	5.20	4.57	1003.80	89	BW
1b	323	Full	13/Aug/2013	12h31		74°09.260	080°26.710	PNF + Secchi ↓	802	127	260	18	8.80	4.89	1000.74	71	0/10
1b	323	Full	13/Aug/2013	12h38		74°09.250	080°26.600	PNF + Secchi ↑	805	129	270	16	8.80	4.89	1000.73	71	0/10
1b	323	Full	13/Aug/2013	12h31		74°09.260	080°26.710	Small Net ↓	802	127	260	18	8.80	4.89	1000.74	71	0/10
1b	323	Full	13/Aug/2013	12h38		74°09.250	080°26.600	Small Net ↑	805	129	270	16	8.80	4.89	1000.73	71	0/10
1b	323	Full	13/Aug/2013	12h58		74°09.450	080°28.600	CTD-Rosette ↓	792	293	270	21	7.00	4.91	1000.62	77	0/10
1b	323	Full	13/Aug/2013	13h59		74°09.780	080°27.780	CTD-Rosette ↑	778	282	280	24	5.90	4.86	1000.81	79	0/10
1b	323	Full	13/Aug/2013	14h26		74°09.200	080°28.400	Hydrobios ↓	792	258	270	28	6.00	4.87	1000.96	77	0/10
1b	323	Full	13/Aug/2013	15h10		74°09.250	080°28.730	Hydrobios ↑	790	270	270	25	5.80	5.01	1001.16	77	0/10
1b	323	Full	13/Aug/2013	15h35		74°09.440	080°28.360	CTD-Rosette DNA ↓	787	270	260	21	5.50	5.00	1001.64	80	0/10
1b	323	Full	13/Aug/2013	16h47		74°09.470	080°27.790	CTD-Rosette DNA↑	792	220	70	5	5.40	4.93	1004.74	87	BW
1b	323	Full	13/Aug/2013	17h46		74°09.550	080°28.280	Vertical Net Tow + Loki ↓	793	182	120	12	4.60	4.88	1003.20	90	BW
1b	323	Full	13/Aug/2013	18h32		74°09.620	080°28.600	Vertical Net Tow + Loki ↑	786	215	100	12	4.60	4.87	1006.22	88	BW
1b	323	Full	13/Aug/2013	19h21		74°09.450	080°28.760	RMT ↓	794	175	120	14	4.20	4.83	1007.12	90	BW
1b	323	Full	13/Aug/2013	20h20		74°09.220	090°29.960	RMT ↑	788	26	130	16	4.40	4.84	1007.80	88	BW
1b	323	Full	13/Aug/2013	20h57		74°09.590	080°28.250	CTD-Rosette TAK ↓	783	145	130	16	4.80	4.72	1008.30	83	BW
1b	323	Full	13/Aug/2013	21h07		74°09.650	080°27.670	CTD-Rosette TAK ↑	785	145	140	12	4.80	4.72	1008.30	83	BW
1b	323	Full	13/Aug/2013	21h31		74°09.360	080°28.250	CTD-Rosette TAK ↓	788	155	150	15	4.20	4.61	1008.70	85	BW
1b	323	Full	13/Aug/2013	22h12		74°09.470	080°27.330	CTD-Rosette TAK ↓	797	170	170	13	3.60	4.44	1008.90	91	BW
1b	323	Full	13/Aug/2013	22h27		74°09.310	080°27.370	Bioness ↓	794	83	170	16	3.50	4.35	1008.90	91	BW
1b	323	Full	13/Aug/2013	23h56		74°10.340	080°17.850	Bioness ↑	789	177	210	15	3.70	3.79	1006.96	90	BW
1b	323	Full	14/Aug/2013	00h58		74°09.450	080°28.480	A-Frame Optical Profile ↓	789	27	210	0	4.40	4.13	1006.81	87	BW
1b	323	Full	14/Aug/2013	01h14		74°09.490	080°28.300	A-Frame Optical Profile ↑	785	37	220	12	3.80	4.35	1006.76	88	BW
1b	323	Full	14/Aug/2013	01h25		74°09.390	080°28.670	A-Frame Optical Profile ↓	790	33	220	13	3.80	4.41	1006.76	88	BW
1b	323	Full	14/Aug/2013	01h42		74°09.410	080°28.490	A-Frame Optical Profile ↑	787	31	220	10	3.60	4.56	1006.64	89	BW
1b	323	Full	14/Aug/2013	01h55		74°09.440	080°28.580	CTD-Rosette ↓	790	27	210	12	4.00	4.62	1006.64	88	BW
1b	323	Full	14/Aug/2013	02h55		74°10.100	080°28.060	CTD-Rosette ↑	783	136	230	10	5.10	4.59	1006.54	86	BW
1b	323	Full	14/Aug/2013	03h15		74°09.460	080°28.190	Box Core ↓	788	322	210	15	3.80	4.65	1006.19	91	BW
1b	323	Full	14/Aug/2013	03h36		74°09.780	080°28.030	Box Core ↑	788	210	220	14	3.60	4.67	1005.78	93	BW
1b	323	Full	14/Aug/2013	04h10		74°09.410	080°28.320	Box Core ↓	793	206	230	10	3.40	4.66	1007.90	95	BW
1b	323	Full	14/Aug/2013	04h54		74°09.390	080°28.330	Box Core ↑	794	212	280	10	3.10	4.65	1007.66	99	BW

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											Dir	Speed					
1b	323	Full	14/Aug/2013	05h05		74°09.400	080°28.380	Box Core ↓	794	197	270	9	3.20	4.55	1007.51	98	BW
1b	323	Full	14/Aug/2013	05h53		74°09.350	080°28.270	Box Core ↑	795	230	260	21	4.70	4.45	1007.15	88	BW
1b	323	Full	14/Aug/2013	06h00		74°09.390	080°28.250	Agassiz Trawl ↓	794	290	270	19	4.90	4.45	1007.15	88	BW
1b	323	Full	14/Aug/2013	06h48		74°09.790	080°27.500	Agassiz Trawl ↑	796	50	260	17	4.30	4.52	1007.00	82	BW
1b	300	Nutrient	14/Aug/2013	08h12		74°19.340	080°30.500	CTD-Rosette ↓	699	262	270	26	4.50	5.27	1005.20	70	BW
1b	300	Nutrient	14/Aug/2013	09h18		74°19.140	080°31.280	CTD-Rosette ↑	700	700	270	27	3.80	5.31	1004.70	80	BW
1b	322	Nutrient	14/Aug/2013	10h52		74°29.820	080°31.960	CTD-Rosette ↓	659	21	calm	calm	2.30	1.73	1004.30	82	BW
1b	322	Nutrient	14/Aug/2013	11h51		74°29.820	080°36.420	CTD-Rosette ↑	661	350	200	3	2.70	1.97	1004.10	84	BW
1b	322	Nutrient	14/Aug/2013	11h27		74°29.930	080°34.510	Plankton Net ↓	659	41	100	5	3.10	1.95	1004.00	81	BW
1b	322	Nutrient	14/Aug/2013	11h52		74°29.860	080°36.520	Plankton Net ↑	660	352	190	5	3.10	1.95	1004.00	81	BW
1b	Ice Station 1	Ice	14/Aug/2013	17h00		75°01.270	079°11.850	Vessel Stopped / Ice edge	553	3.7	70	3	0.50	0.56	1001.25	95	n-a
1b	Ice Station 1	Ice	14/Aug/2013	19h01		75°00.700	079°10.700	Underway	553	31	calm	calm	1.50	0.56	1003.00	95	n-a
1b	101	MVP	15/Aug/2013	02h25		76°11.280	077°14.120	MVP ↓	407	320	260	18	3.00	3.81	993.12	89	0/10
1b	101	MVP	15/Aug/2013	03h25		76°17.790	077°18.230	MVP ↑	393	300	240	17	2.80	4.21	992.43	91	0/10
1b	101	Full	15/Aug/2013	04h47		76°23.040	077°24.130	Deployment Lagrangian Drifter	353	240	230	19	2.70	4.73	993.86	93	BW
1b	101	Full	15/Aug/2013	05h30		76°23.230	077°23.440	CTD-Rosette #1 ↓	343	226	240	21	2.80	4.74	993.33	93	BW
1b	101	Full	15/Aug/2013	06h15		76°23.170	077°22.990	CTD-Rosette #1 ↑	349	231	255	20	2.90	4.70	992.75	93	BW
1b	101	Full	15/Aug/2013	06h34		76°23.230	077°22.980	Vertical Net Tow #1 ↓	349	348	240	22	3.10	4.66	992.70	92	BW
1b	101	Full	15/Aug/2013	06h54		76°23.260	077°22.740	Vertical Net Tow #1 ↑	347	248	260	22	3.30	4.62	992.74	90	BW
1b	101	Full	15/Aug/2013	07h29		76°23.080	077°21.270	PNF + Secchi ↓	346	313	340	14	2.60	4.62	993.05	94	BW
1b	101	Full	15/Aug/2013	07h37		76°23.090	077°21.180	PNF + Secchi ↑	345	304	0	12	2.60	4.62	993.14	95	BW
1b	101	Full	15/Aug/2013	08h14		76°23.020	077°20.770	Hydrobios ↓	344	299	0	11	2.40	4.64	993.40	96	BW
1b	101	Full	15/Aug/2013	08h35		76°22.960	077°20.850	Hydrobios ↑	346	310	40	11	2.20	4.64	993.50	96	BW
1b	101	Full	15/Aug/2013	09h22		76°22.900	077°21.910	CTD-Rosette #2 ↓	354	315	50	7	2.30	4.67	993.40	95	BW
1b	101	Full	15/Aug/2013	10h08		76°22.850	077°22.260	CTD-Rosette #2 ↑	356	328	80	7	2.00	4.70	993.20	95	BW
1b	101	Full	15/Aug/2013	10h27		76°22.670	077°22.930	Vertical Net Tow #2 ↓	357	118	50	8	2.00	4.72	993.10	94	BW
1b	101	Full	15/Aug/2013	10h44		76°22.570	077°23.340	Vertical Net Tow #2 ↑	355	145	50	7	1.17	4.73	993.10	94	BW
1b	101	Full	15/Aug/2013	11h05		76°22.420	077°23.310	Vertical Net Tow #2 ↓	356	136	50	2	2.00	4.73	993.30	94	BW
1b	101	Full	15/Aug/2013	11h30		76°22.330	077°23.740	Vertical Net Tow #2 ↑	365	141	90	3	2.10	4.73	993.30	92	BW
1b	101	Full	15/Aug/2013	12h05		76°21.780	077°24.550	Deployment Barge	397	206	80	1	2.70	4.77	990.97	90	BW
1b	101	Full	15/Aug/2013	12h10		76°21.780	077°24.550	Balise Barge	395	206	80	1	2.70	4.77	990.97	90	BW
1b	101	Full	15/Aug/2013	13h00		76°21.000	077°28.620	Bioness ↓	383	230	100	2	2.40	4.69	991.06	89	BW

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	101	Full	15/Aug/2013	13h32		76°21.270	077°29.110	Bioness ↑	380	134	80	4	2.70	4.71	991.04	88	BW
1b	101	Full	15/Aug/2013	13h50		76°21.050	077°29.040	CTD-Rosette #3 ↓	381	149	260	1	3.70	4.71	991.10	83	BW
1b	101	Full	15/Aug/2013	14h32		76°21.040	077°28.280	CTD-Rosette #3 ↑	381	180	300	1	5.60	4.71	991.25	75	BW
1b	101	Full	15/Aug/2013	14h35		76°21.040	077°28.890	Recovery Barge	381	180	300	1	5.60	4.71	991.25	75	BW
1b	101	Full	15/Aug/2013	15h05		76°21.200	077°32.200	Vertical Net Tow + Loki #3 ↓	370	49	340	7	3.70	4.77	991.20	76	BW
1b	101	Full	15/Aug/2013	15h30		76°21.180	077°32.650	Vertical Net Tow + Loki #3 ↑	367	143	0	7	2.80	4.75	991.29	83	BW
1b	101	Full	15/Aug/2013	16h00		76°22.530	077°25.650	Box Core ↓	393	145	0	6	2.50	4.71	993.55	83	BW
1b	101	Full	15/Aug/2013	16h22		76°22.470	077°28.660	Box Core ↑	398	123	0	5	2.60	4.37	993.66	82	BW
1b	101	Full	15/Aug/2013	17h31		76°20.970	077°35.390	CTD-Rosette #4 ↓	344	140	320	14	4.10	4.69	991.48	64	BW
1b	101	Full	15/Aug/2013	18h20		76°20.790	077°34.800	CTD-Rosette #4 ↑	359	160	340	19	5.40	4.65	993.91	61	BW
1b	101	Full	15/Aug/2013	18h37		76°20.710	077°34.470	Vertical Net Tow + Loki #4 ↓	356	0	0	16	4.40	4.64	993.98	65	BW
1b	101	Full	15/Aug/2013	19h48		76°20.430	077°34.570	Vertical Net Tow + Loki #4 ↑	352	13	0	20	2.00	4.61	994.67	88	BW
1b	101	Full	15/Aug/2013	20h19		76°20.550	079°34.410	A-Frame Optical Profile ↓	354	15	340	22	1.80	4.65	994.80	90	BW
1b	101	Full	15/Aug/2013	20h49		76°20.530	077°34.120	A-Frame Optical Profile ↑	359	12	350	21	1.90	4.74	995.00	91	BW
1b	101	Full	15/Aug/2013	20h42		76°20.520	077°34.190	Plankton Net ↓	355	9	340	22	1.70	4.72	995.00	91	BW
1b	101	Full	15/Aug/2013	20h52		76°20.510	077°34.060	Plankton Net ↑	356	41	350	21	1.90	4.74	995.00	91	BW
1b	101	Full	15/Aug/2013	21h45		76°19.940	077°39.730	CTD-Rosette #5 ↓	277	350	350	17	2.00	4.68	995.40	86	BW
1b	101	Full	15/Aug/2013	22h15		76°19.900	077°41.410	CTD-Rosette #5 ↑	263	352	350	13	2.20	4.68	995.80	83	BW
1b	101	Full	15/Aug/2013	22h38		76°19.780	077°42.200	Vertical Net Tow #5 ↓	246	7	330	22	2.80	4.68	995.70	63	BW
1b	101	Full	15/Aug/2013	22h57		76°19.710	077°41.840	Vertical Net Tow #5 ↑	251	3	330	20	2.60	4.96	995.50	64	BW
1b	101	Full	15/Aug/2013	23h15		76°19.770	077°42.050	Vertical Net Tow #5 ↓	249	352	330	18	2.50	4.20	995.50	65	BW
1b	101	Full	15/Aug/2013	23h32		76°19.740	077°41.850	Vertical Net Tow #5 ↑	250	359	330	17	2.30	4.73	995.80	66	BW
1b	101	Full	16/Aug/2013	00h02		76°20.500	077°35.860	Agassiz Trawl ↓	343	60	320	18	2.10	4.75	993.27	64	BW
1b	101	Full	16/Aug/2013	00h25		76°20.170	077°32.720	Agassiz Trawl ↑	371	60	320	15	2.00	4.60	993.33	66	BW
1b	101	Full	16/Aug/2013	01h45		76°17.640	077°45.390	CTD-Rosette #6 ↓	290	324	330	13	2.60	4.46	993.26	58	BW
1b	101	Full	16/Aug/2013	02h17		76°17.520	077°45.750	CTD-Rosette #6 ↑	283	60	330	13	2.00	4.42	993.22	62	BW
1b	101	Full	16/Aug/2013	02h37		76°17.480	077°45.620	Vertical Net Tow + Loki #6 ↓	282	51	300	10	1.90	4.36	993.15	58	BW
1b	101	Full	16/Aug/2013	02h55		76°17.390	077°45.940	Vertical Net Tow + Loki #6 ↑	275	81	310	8	2.00	4.32	993.08	60	BW
1b	101	Full	16/Aug/2013	03h25		76°17.430	077°45.830	A-Frame Optical Profile ↓	276	54	290	8	2.20	4.26	992.97	58	BW
1b	101	Full	16/Aug/2013	03h39		76°17.440	077°45.90	A-Frame Optical Profile ↑	275	71	300	7	2.20	4.24	992.92	59	BW
1b	101	Full	16/Aug/2013	03h55		76°17.410	077°46.090	A-Frame Optical Profile ↓	266	83	330	10	2.20	4.21	995.23	59	BW
1b	101	Full	16/Aug/2013	04h07		76°17.380	077°46.200	A-Frame Optical Profile ↑	262	96	340	6	2.00	4.19	995.06	59	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	101	Full	16/Aug/2013	04h17		76°17.370	077°46.220	CTD-Rosette #7 ↓	261	77	350	7	2.10	4.16	995.00	60	BW
1b	101	Full	16/Aug/2013	04h45		76°17.390	077°46.290	CTD-Rosette #7 ↑	261	80	50	3	2.20	4.13	994.90	66	BW
1b	101	Full	16/Aug/2013	05h15		76°18.270	077°50.220	Recovery Lagrangian Drifter	331	324	315	7	2.30	4.12	994.80	63	BW
1b	102	CTD	16/Aug/2013	06h38		76°22.430	076°59.360	CTD ↓	250	318	315	11	1.80	3.51	994.38	65	BW
1b	102	CTD	16/Aug/2013	06h50		76°22.410	076°59.470	CTD ↑	251	314	315	11	1.60	3.48	994.36	64	BW
1b	103	Nutrient	16/Aug/2013	07h35		76°21.190	076°34.530	CTD ↓	150	302	300	10	2.40	3.20	994.08	56	BW
1b	103	Nutrient	16/Aug/2013	08h12		76°21.070	076°34.760	CTD ↑	149	310	270	7	1.90	2.95	993.90	61	BW
1b	104	CTD	16/Aug/2013	09h05		76°20.630	076°10.370	CTD ↓	193	307	270	9	2.20	3.40	993.40	62	BW
1b	104	CTD	16/Aug/2013	09h14		76°20.620	076°10.370	CTD ↑	191	306	270	11	2.00	3.43	993.30	63	BW
1b	105	Basic	16/Aug/2013	10h14		76°19.160	075°45.620	CTD-Rosette #1 ↓	330	264	280	10	2.20	3.17	992.90	63	BW
1b	105	Basic	16/Aug/2013	10h56		76°18.900	075°45.845	CTD-Rosette #1 ↑	327	327	270	5	2.40	3.10	992.80	66	BW
1b	105	Basic	16/Aug/2013	12h31		76°19.050	075°45.380	Hydrobios ↓	327	308	300	6	3.30	3.07	990.02	64	BW
1b	105	Basic	16/Aug/2013	12h51		76°19.040	075°45.280	Hydrobios ↑	327	318	300	6	3.40	3.08	990.08	63	BW
1b	105	Basic	16/Aug/2013	13h07		76°19.065	075°45.222	CTD-Rosette #2 ↓	332	296	300	6	3.40	3.10	992.40	63	BW
1b	105	Basic	16/Aug/2013	13h47		76°19.100	075°45.120	CTD-Rosette #2 ↑	326	308	310	5	3.60	3.12	990.04	65	BW
1b	105	Basic	16/Aug/2013	14h35		76°19.120	075°45.500	Vertical Net Tow + Loki ↓	328	303	290	3	3.60	3.11	990.08	70	BW
1b	105	Basic	16/Aug/2013	14h56		76°19.150	075°45.450	Vertical Net Tow + Loki ↑	320	0	0	8	3.30	3.08	990.09	72	BW
1b	105	Basic	16/Aug/2013	15h38		76°18.690	075°47.380	Horizontal Net Tow ↓	329	130	350	7	4.00	3.11	990.11	62	BW
1b	105	Basic	16/Aug/2013	15h53		76°18.950	075°46.080	Horizontal Net Tow ↑	330	343	320	7	2.80	3.13	990.16	66	BW
1b	105	Basic	16/Aug/2013	16h10		76°19.060	075°45.630	Box Core ↓	327	311	300	4	2.80	3.09	992.59	67	BW
1b	105	Basic	16/Aug/2013	16h30		76°19.050	075°45.460	Box Core ↑	329	313	270	4	3.30	3.07	992.69	66	BW
1b	105	Basic	16/Aug/2013	16h46		76°19.060	075°45.060	Agassiz Trawl ↓	328	282	270	3	3.40	3.07	992.78	65	BW
1b	105	Basic	16/Aug/2013	17h01		76°19.250	075°45.620	Agassiz Trawl ↑	329	300	270	12	3.30	3.06	992.77	69	BW
1b	106	CTD	16/Aug/2013	18h00		76°18.518	075°22.117	CTD-Rosette ↓	378	270	300	14	3.30	3.10	992.26	71	BW
1b	106	CTD	16/Aug/2013	18h15		76°18.480	075°22.070	CTD-Rosette ↑	379	275	300	12	3.20	3.05	992.28	74	BW
1b	107	Nutrient	16/Aug/2013	19h04		76°16.905	074°59.335	CTD-Rosette ↓	439	309	300	14	3.00	3.16	992.22	76	BW
1b	107	Nutrient	16/Aug/2013	20h02		76°16.640	074°59.810	CTD-Rosette ↑	438	270	300	17	3.10	3.19	992.24	76	BW
1b	108	Full	16/Aug/2013	20h50		76°16.240	074°36.450	PNF + Secchi ↓	300	311	270	17	2.90	3.11	992.20	76	BW
1b	108	Full	16/Aug/2013	20h56		76°16.240	074°36.150	PNF + Secchi ↑	448	326	270	15	2.90	3.11	992.20	76	BW
1b	108	Full	16/Aug/2013	21h11		76°16.180	074°35.950	CTD-Rosette Phyto #1 ↓	447	308	280	15	2.90	3.08	992.10	76	BW
1b	108	Full	16/Aug/2013	22h01		76°15.680	074°36.090	CTD-Rosette Phyto #1 ↑	447	294	320	12	2.80	3.02	992.20	74	BW
1b	108	Full	16/Aug/2013	22h20		76°15.650	074°36.050	Hydrobios ↓	448	265	320	14	2.60	2.99	992.10	75	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	108	Full	16/Aug/2013	22h57		76°14.960	074°35.550	Hydrobios ↑	442	241	300	20	2.80	2.89	992.20	67	BW
1b	108	Full	17/Aug/2013	00h10		76°15.030	074°39.290	CTD-Rosette Phyto #2 ↓	440	307	320	22	1.70	2.94	990.21	59	BW
1b	108	Full	17/Aug/2013	01h05		76°14.800	074°39.760	CTD-Rosette Phyto #2 ↑	441	313	330	27	1.00	2.88	990.53	67	BW
1b	108	Full	17/Aug/2013	01h28		76°16.080	074°35.770	A-Frame Optical Profile #1 ↓	447	327	310	25	0.90	2.84	990.55	69	BW
1b	108	Full	17/Aug/2013	01h42		76°15.970	074°35.160	A-Frame Optical Profile #1 ↑	447	346	350	16	1.10	2.71	991.16	75	BW
1b	108	Full	17/Aug/2013	01h51		76°16.310	074°35.870	A-Frame Optical Profile #2 ↓	445	2	0	19	1.00	2.71	991.15	75	BW
1b	108	Full	17/Aug/2013	02h06		76°16.190	074°35.160	A-Frame Optical Profile #2 ↑	445	334	0	16	0.90	2.73	991.44	75	BW
1b	108	Full	17/Aug/2013	02h21		76°16.210	074°35.110	Vertical Net Tow + Loki ↓	445	340	0	19	0.90	2.73	991.65	76	BW
1b	108	Full	17/Aug/2013	02h50		76°16.150	074°34.690	Vertical Net Tow + Loki ↑	443	1	350	21	0.80	2.71	991.86	77	BW
1b	108	Full	17/Aug/2013	03h31		76°16.200	074°35.800	CTD-Rosette Phyto #3 ↓	453	346	340	21	0.10	2.71	992.58	83	BW
1b	108	Full	17/Aug/2013	04h24		76°16.005	074°36.335	CTD-Rosette Phyto #3 ↑	450	315	330	20	-0.10	2.78	995.35	85	BW
1b	108	Full	17/Aug/2013	04h46		76°15.930	074°36.670	RMT ↓	448	343	330	23	0.00	2.79	995.31	85	BW
1b	108	Full	17/Aug/2013	05h45		76°15.010	074°30.180	RMT ↑	442	35	330	23	0.70	2.66	996.33	67	BW
1b	108	Full	17/Aug/2013	06h23		76°15.470	074°32.800	Bioness ↓	441	152	330	18	0.70	2.54	996.31	63	BW
1b	108	Full	17/Aug/2013	07h03		76°14.150	074°31.970	Bioness ↑	440	149	330	23	1.60	2.64	997.17	63	BW
1b	108	Full	17/Aug/2013	08h09		76°16.400	074°36.340	Box Core ↓	446	328	310	26	0.50	2.71	997.50	60	BW
1b	108	Full	17/Aug/2013	08h36		76°16.390	074°36.380	Box Core ↑	446	331	320	20	0.50	2.85	997.70	62	BW
1b	108	Full	17/Aug/2013	08h48		76°16.320	074°35.220	Agassiz Trawl ↓	449	106	320	26	0.40	2.88	997.70	62	BW
1b	108	Full	17/Aug/2013	09h14		76°15.820	074°32.150	Agassiz Trawl ↑	441	82	320	22	0.50	2.87	998.00	60	BW
1b	109	CTD	17/Aug/2013	10h05		76°17.400	074°06.760	CTD ↓	450	324	320	21	0.50	2.92	998.00	64	BW
1b	109	CTD	17/Aug/2013	10h23		76°17.360	074°06.690	CTD ↑	453	16	320	23	0.60	3.05	998.40	62	BW
1b	110	Nutrient	17/Aug/2013	11h09		76°17.940	073°37.960	CTD-Rosette Nutrient ↓	530	348	310	15	0.70	3.14	998.50	66	BW
1b	110	Nutrient	17/Aug/2013	11h56		76°17.880	073°38.280	CTD-Rosette Nutrient ↑	529	312	320	16	0.90	2.66	998.80	68	BW
1b	111	Basic	17/Aug/2013	12h40		76°18.370	073°12.740	PNF ↓	600	312	320	15	1.00	2.75	996.79	70	BW
1b	111	Basic	17/Aug/2013	12h43		76°18.360	073°12.710	PNF ↑	595	322	320	15	1.00	2.75	996.79	70	BW
1b	111	Basic	17/Aug/2013	12h44		76°18.360	073°12.710	Secchi ↓	595	320	320	15	1.00	2.75	996.79	70	BW
1b	111	Basic	17/Aug/2013	12h47		76°18.390	073°12.790	Secchi ↑	594	319	320	15	1.00	2.75	996.79	70	BW
1b	111	Basic	17/Aug/2013	12h52		76°18.410	073°12.740	CTD-Rosette #1 ↓	595	322	340	14	1.10	2.59	996.98	71	BW
1b	111	Basic	17/Aug/2013	13h43		76°18.250	073°12.580	CTD-Rosette #1 ↑	598	281	330	11	1.10	2.44	997.34	72	BW
1b	111	Basic	17/Aug/2013	14h22		76°18.360	073°12.950	Hydrobios ↓	591	323	330	6	1.30	2.35	997.84	67	BW
1b	111	Basic	17/Aug/2013	14h58		76°18.160	073°12.570	Hydrobios ↑	597	265	350	4	1.00	2.31	997.62	73	BW
1b	111	Basic	17/Aug/2013	15h25		76°18.430	073°12.540	Vertical Net Tow + Loki ↓	595	263	320	5	0.70	2.32	998.19	73	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	111	Basic	17/Aug/2013	16h00		76°18.400	073°11.610	Vertical Net Tow + Loki ↑	595	294	290	8	1.00	2.10	998.37	60	BW
1b	111	Basic	17/Aug/2013	16h25		76°18.470	073°11.110	Horizontal Net Tow ↓	602	99	270	7	1.10	2.19	998.44	60	BW
1b	111	Basic	17/Aug/2013	16h40		76°18.510	073°08.470	Horizontal Net Tow ↑	610	80	300	8	0.70	2.33	998.71	59	BW
1b	111	Basic	17/Aug/2013	17h34		76°18.310	073°12.300	CTD-Rosette #2 ↓	593	340	290	8	1.00	2.59	998.93	60	BW
1b	111	Basic	17/Aug/2013	18h18		76°18.200	073°11.970	CTD-Rosette #2 ↑	593	313	300	10	0.70	2.61	1001.57	60	BW
1b	111	Basic	17/Aug/2013	18h32		76°18.400	073°12.790	A-Frame Optical Profile ↓	600	320	290	7	0.60	2.66	1001.59	60	BW
1b	111	Basic	17/Aug/2013	19h07		76°18.290	073°12.650	A-Frame Optical Profile ↑	597	320	290	8	0.70	2.94	1001.88	60	BW
1b	111	Basic	17/Aug/2013	19h18		76°18.405	073°12.938	CTD-Rosette #3 ↓	596	306	300	7	0.60	3.00	1002.08	61	BW
1b	111	Basic	17/Aug/2013	20h20		76°18.280	073°13.050	CTD-Rosette #3 ↑	599	303	300	7	0.60	3.13	1002.20	59	BW
1b	111	Basic	17/Aug/2013	20h35		76°18.240	073°13.020	Box Core ↓	604	323	290	7	0.70	3.13	1002.40	61	BW
1b	111	Basic	17/Aug/2013	21h05		76°18.240	073°12.890	Box Core ↑	604	351	280	6	0.70	3.11	1002.50	58	BW
1b	111	Basic	17/Aug/2013	21h08		76°18.240	073°12.840	Box Core ↓	602	340	290	6	0.70	3.11	1002.50	58	BW
1b	111	Basic	17/Aug/2013	21h37		76°18.230	073°12.290	Box Core ↑	598	10	290	4	0.60	3.11	1002.60	57	BW
1b	111	Basic	17/Aug/2013	21h45		76°18.270	073°12.090	Agassiz Trawl ↓	595	344	280	5	0.50	3.12	1002.60	58	BW
1b	111	Basic	17/Aug/2013	22h18		76°17.940	073°12.420	Agassiz Trawl ↑	569	2	300	6	1.10	3.07	1002.80	58	BW
1b	112	CTD	17/Aug/2013	23h14		76°18.940	072°42.110	CTD ↓	564	329	300	3	0.50	3.39	1002.80	60	BW
1b	112	CTD	17/Aug/2013	23h36		76°18.960	072°42.030	CTD ↑	562	356	300	5	0.60	3.56	1003.00	60	BW
1b	113	Nutrient	18/Aug/2013	00h23		76°19.230	072°12.860	CTD-Rosette ↓	556	172	350	1	0.70	3.91	1000.89	58	BW
1b	113	Nutrient	18/Aug/2013	01h21		76°19.240	072°11.190	CTD-Rosette ↑	554	176	340	1	1.60	3.94	1001.30	58	BW
1b	114	CTD	18/Aug/2013	02h00		76°19.460	071°47.300	CTD-Rosette ↓	608	127	340	2	0.60	4.03	1001.32	59	BW
1b	114	CTD	18/Aug/2013	02h23		76°19.460	071°46.290	CTD-Rosette ↑	616	177	300	3	1.60	4.04	1003.99	55	BW
1b	114	Coring	18/Aug/2013	02h39		76°19.890	071°43.000	Box Core ↓	636	9	310	1	1.20	4.00	1001.65	57	BW
1b	114	Coring	18/Aug/2013	02h58		76°19.280	071°42.250	Box Core ↑	635	343	270	1	0.60	3.98	1001.81	56	BW
1b	114	Coring	18/Aug/2013	03h30		76°19.920	071°42.680	Gravity Core #1 ↓	646	236	60	1	1.00	3.98	1001.82	56	BW
1b	114	Coring	18/Aug/2013	03h38		76°19.890	071°42.520	Gravity Core #1 ↑	635	199	n-a	n-a	0.70	3.99	n-a	57	BW
1b	114	Coring	18/Aug/2013	04h13		76°19.950	071°42.970	Gravity Core #2 ↓	638	295	n-a	n-a	0.70	4.00	1004.48	57	BW
1b	114	Coring	18/Aug/2013	04h28		76°19.960	071°42.900	Gravity Core #2 ↑	638	290	n-a	n-a	0.50	3.98	1004.52	57	BW
1b	115	Full	18/Aug/2013	05h26		76°20.020	071°11.840	Deployment Lagrangian drifter	673	183	n-a	n-a	0.90	3.85	1004.68	57	BW
1b	115	Full	18/Aug/2013	05h42		76°20.290	071°11.570	CTD-Rosette #1 ↓	654	190	n-a	n-a	0.90	3.90	1004.95	56	BW
1b	115	Full	18/Aug/2013	06h41		76°20.480	071°11.670	CTD-Rosette #1 ↑	654	188	120	12	0.80	4.05	1004.99	73	BW
1b	115	Full	18/Aug/2013	06h53		76°20.480	071°11.760	Vertical Net Tow #1 ↓	654	150	130	10	0.90	4.05	1005.00	73	BW
1b	115	Full	18/Aug/2013	07h30		76°20.660	071°12.400	Vertical Net Tow #1 ↑	654	125	120	10	0.30	4.05	1005.14	86	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	115	Full	18/Aug/2013	08h28		76°20.990	071°12.480	Hydrobios ↓	651	82	115	12	0.60	4.05	1005.10	83	BW
1b	115	Full	18/Aug/2013	09h05		76°21.350	071°12.740	Hydrobios ↑	640	59	120	10	1.10	3.95	1004.70	81	BW
1b	115	Full	18/Aug/2013	09h20		76°21.400	071°12.820	CTD-Rosette Phyto #2 ↓	639	118	160	10	1.00	3.93	1005.00	73	BW
1b	115	Full	18/Aug/2013	10h08		76°21.590	071°12.440	CTD-Rosette Phyto #2 ↑	630	119	170	11	1.90	4.01	1004.90	60	BW
1b	115	Full	18/Aug/2013	10h23		76°21.600	071°12.540	Vertical Net Tow ↓	631	170	145	12	1.90	4.02	1005.00	61	BW
1b	115	Full	18/Aug/2013	11h02		76°21.600	071°13.630	Vertical Net Tow ↑	639	157	150	12	18.00	4.04	1005.00	59	BW
1b	115	Full	18/Aug/2013	11h28		76°21.950	071°14.060	Deployment Barge	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a	BW
1b	115	Full	18/Aug/2013	12h17		76°22.530	071°18.380	PNF + Secchi ↓	599	190	130	16	1.40	4.06	1004.60	83	BW
1b	115	Full	18/Aug/2013	12h26		76°22.610	071°18.910	PNF + Secchi ↑	598	259	130	18	1.30	4.05	1004.70	85	BW
1b	115	Full	18/Aug/2013	12h47		76°22.760	071°19.130	CTD-Rosette #3 ↓	590	360	130	16	3.80	4.05	1004.70	76	BW
1b	115	Full	18/Aug/2013	13h37		76°23.100	071°20.030	CTD-Rosette #3 ↑	583	4	150	20	3.90	4.01	1004.70	73	BW
1b	115	Full	18/Aug/2013	13h47		76°23.300	071°02.320	Recovery Barge	578	60	150	18	4.10	4.01	1004.80	74	BW
1b	115	Full	18/Aug/2013	14h33		76°24.300	071°21.470	A-Frame Optical Profile ↓	567	308	150	18	0.80	3.94	1002.46	93	BW
1b	115	Full	18/Aug/2013	14h48		76°24.470	071°21.110	A-Frame Optical Profile ↑	539	332	150	12	0.90	3.93	1002.45	94	BW
1b	115	Full	18/Aug/2013	14h58		76°24.590	071°21.010	A-Frame Optical Profile ↓	539	337	150	19	1.00	3.93	1002.42	95	BW
1b	115	Full	18/Aug/2013	15h08		76°24.630	071°20.740	A-Frame Optical Profile ↑	536	324	150	20	1.10	3.93	1002.44	95	BW
1b	115	Full	18/Aug/2013	16h32		76°25.167	071°18.390	CTD-Rosette #4 ↓	512	175	170	10	0.80	3.90	1005.36	95	BW
1b	115	Full	18/Aug/2013	17h30		76°25.500	071°19.310	CTD-Rosette #4 ↑	527	153	150	12	1.00	3.95	1003.01	96	BW
1b	115	Full	18/Aug/2013	18h35		76°25.720	071°22.720	Bioness ↓	463	330	130	22	1.40	3.97	1004.73	94	BW
1b	115	Full	18/Aug/2013	19h32		76°27.210	071°27.280	Bioness ↑	540	290	140	25	2.20	3.98	1004.52	91	BW
1b	115	Full	18/Aug/2013	20h19		76°26.470	071°23.260	Plankton Net ↓	533	112	140	24	1.70	3.97	1004.00	93	BW
1b	115	Full	18/Aug/2013	20h35		76°26.720	071°22.530	Plankton Net ↑	518	136	130	25	1.30	3.93	1003.60	99	BW
1b	115	Full	18/Aug/2013	21h31		76°27.010	071°24.830	CTD-Rosette #5 ↓	539	161	120	26	1.30	3.93	1003.60	99	BW
1b	115	Full	18/Aug/2013	22h15		76°27.130	071°24.990	CTD-Rosette #5 ↑	530	158	120	29	1.50	3.97	1003.10	99	BW
1b	115	Full	18/Aug/2013	22h46		76°24.740	071°18.920	Agassiz Trawl ↓	526	232	140	23	1.40	3.97	1002.20	99	BW
1b	115	Full	18/Aug/2013	23h16		76°25.510	071°21.820	Agassiz Trawl ↑	473	245	140	28	1.30	4.00	1003.00	99	BW
1b	115	Full	19/Aug/2013	01h15		76°29.580	071°29.320	CTD-Rosette #6 ↓	475	167	150	27	2.20	3.99	1001.13	97	BW
1b	115	Full	19/Aug/2013	01h51		76°29.610	071°28.850	CTD-Rosette #6 ↑	472	166	170	24	3.10	4.01	1002.13	94	BW
1b	115	Full	19/Aug/2013	02h05		76°29.130	071°28.500	A-Frame Optical Profile ↓	495	166	180	26	3.20	4.01	1002.05	92	BW
1b	115	Full	19/Aug/2013	02h25		76°29.210	071°28.390	A-Frame Optical Profile ↑	483	175	170	24	3.20	4.01	1000.48	95	BW
1b	115	Full	19/Aug/2013	04h10		76°29.820	071°26.650	CTD-Rosette #7 ↓	464	175	180	30	3.00	4.00	1003.13	92	BW
1b	115	Full	19/Aug/2013	04h42		76°29.900	071°26.440	CTD-Rosette #7 ↑	462	185	160	25	2.60	4.00	1003.26	93	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	115	Full	19/Aug/2013	05h48		76°36.210	071°17.600	Recovery MOBs Buoy	533	n-a	150	28	1.70	3.84	1003.41	98	BW
1b	115	Full	19/Aug/2013	06h49		76°30.700	071°28.670	Recovery Lagrangian Drifter	464	n-a	150	25	1.80	3.90	1004.10	99	BW
1b	MVP	Full	19/Aug/2013	08h30		76°36.090	071°38.520	MVP ↓	n-a	342	n-a	n-a	n-a	n-a	n-a	n-a	BW
1b	MVP	Full	19/Aug/2013	09h50		76°44.720	071°49.850	MVP ↑	732	322	145	30	1.50	2.70	1003.33	93	BW
1b	132	Full	20/Aug/2013	00h00		78°59.920	072°16.280	Deployment MOBs Buoy	244	26	130	5	0.50	0.03	1000.73	99	BW
1b	132	Full	20/Aug/2013	00h34		78°59.660	072°15.570	CTD-Rosette #1 ↓	245	300	90	3	0.30	-0.02	998.31	99	BW
1b	132	Full	20/Aug/2013	01h30		78°59.580	072°13.140	CTD-Rosette #1 ↑	235	311	0	0	0.50	0.03	998.93	99	BW
1b	132	Full	20/Aug/2013	02h20		78°59.470	072°11.310	Bioness ↓	227	154	20	4	0.00	-0.05	998.69	99	BW
1b	132	Full	20/Aug/2013	02h50		78°58.680	072°13.580	Bioness ↑	220	232	60	2	0.50	-0.09	998.88	99	BW
1b	132	Full	20/Aug/2013	03h12		78°58.400	072°12.110	PNF + Secchi ↓	222	84	40	6	0.10	-0.06	999.09	99	BW
1b	132	Full	20/Aug/2013	03h18		78°58.380	072°12.050	PNF + Secchi ↑	222	112	40	6	0.10	-0.06	999.09	99	BW
1b	132	Full	20/Aug/2013	03h37		78°59.450	072°06.050	CTD-Rosette #2 ↓	230	174	40	7	0.30	-0.07	999.16	99	BW
1b	132	Full	20/Aug/2013	04h21		78°59.240	072°05.540	CTD-Rosette #2 ↑	226	152	50	6	0.40	-0.01	1001.72	99	BW
1b	132	Full	20/Aug/2013	04h34		78°59.180	072°05.370	A-Frame Optical Profile ↓	224	166	30	5	0.60	0.01	1001.95	99	BW
1b	132	Full	20/Aug/2013	04h59		78°59.100	072°05.070	A-Frame Optical Profile ↑	226	142	60	9	0.60	0.02	1001.65	98	BW
1b	132	Full	20/Aug/2013	05h16		78°58.970	072°05.030	RMT ↓	224	225	60	9	0.20	0.01	1001.24	97	BW
1b	132	Full	20/Aug/2013	05h49		78°57.740	072°30.000	RMT ↑	220	148	90	10	0.70	0.03	1000.88	88	BW
1b	132	Full	20/Aug/2013	06h12		78°59.030	072°05.710	CTD-Rosette #3 ↓	223	100	100	10	0.70	0.03	1000.88	88	BW
1b	132	Full	20/Aug/2013	06h45		78°59.100	072°05.860	CTD-Rosette #3 ↑	227	204	150	10	2.10	-0.02	1001.48	76	BW
1b	132	Full	20/Aug/2013	06h57		78°59.140	072°05.840	Hydrobios ↓	229	182	160	13	2.50	-0.01	1002.10	74	BW
1b	132	Full	20/Aug/2013	07h12		78°59.170	072°05.770	Hydrobios ↑	226	155	150	7	2.30	0.01	1001.93	81	BW
1b	132	Full	20/Aug/2013	08h37		78°59.930	072°03.450	Barge deployed	208	228	100	17	2.80	-0.08	1001.70	73	BW
1b	132	Full	20/Aug/2013	08h53		78°59.950	072°03.610	Vertical Net Tow ↓	214	144	80	18	2.30	-0.07	1001.30	76	BW
1b	132	Full	20/Aug/2013	09h07		78°59.940	072°03.700	Vertical Net Tow ↑	216	182	80	15	2.30	-0.07	1001.00	79	BW
1b	132	Full	20/Aug/2013	09h24		78°59.660	072°05.820	Agassiz Trawl ↓	244	182	80	18	1.60	-0.07	1000.50	83	BW
1b	132	Full	20/Aug/2013	09h40		78°59.280	072°04.800	Agassiz Trawl ↑	227	115	80	17	1.40	-0.06	999.92	87	BW
1b	132	Full	20/Aug/2013	11h17		79°00.620	071°54.610	Recovery Barge	186	186	80	9	1.60	-0.10	998.60	86	BW
1b	250	Full	21/Aug/2013	19h00		81°14.700	062°23.800	PNF + Secchi ↓	447	268	160	10	1.20	-0.56	999.76	75	3/10 MYI
1b	250	Full	21/Aug/2013	19h05		81°14.700	062°23.800	PNF + Secchi ↑	447	268	160	10	1.20	-0.56	999.76	75	3/10 MYI
1b	250	Full	21/Aug/2013	19h35		81°14.920	062°22.010	CTD-Rosette #1 ↓	455	95	150	8	1.00	-0.54	999.60	76	3/10 MYI
1b	250	Full	21/Aug/2013	20h24		81°14.870	062°20.760	CTD-Rosette #1 ↑	466	74	170	10	0.70	-0.51	999.40	81	3/10 MYI
1b	250	Full	21/Aug/2013	20h46		81°14.840	062°20.370	Hydrobios ↓	471	69	160	10	0.90	-0.52	999.40	80	3/10 MYI

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											Dir	Speed					
1b	250	Full	21/Aug/2013	21h15		81°14.790	062°20.110	Hydrobios ↑	475	61	160	9	1.10	-0.52	999.30	77	3/10 MYI
1b	250	Full	21/Aug/2013	21h32		81°14.750	062°20.110	Ice Cage Sampling ↓	477	56	160	5	1.40	-0.48	999.30	77	3/10 MYI
1b	250	Full	21/Aug/2013	22h34		81°14.680	062°20.700	Ice Cage Sampling ↑	475	46	170	8	2.50	-0.49	999.20	75	3/10 MYI
1b	250	Full	21/Aug/2013	23h03		81°14.670	062°21.270	CTD-Rosette #2 ↓	472	39	130	7	2.40	-0.44	999.00	72	3/10 MYI
1b	250	Full	22/Aug/2013	00h01		81°14.910	062°20.840	CTD-Rosette #2 ↑	268	25	180	5	0.80	-0.48	999.20	79	3/10 MYI
1b	250	Full	22/Aug/2013	00h18		81°15.020	062°20.730	Optical Profile #1 ↓	461	10	180	1	1.80	-0.46	996.84	74	3/10 MYI
1b	250	Full	22/Aug/2013	00h31		81°15.130	062°20.620	Optical Profile #1 ↑	459	7	140	3	2.20	-0.44	996.72	73	3/10 MYI
1b	250	Full	22/Aug/2013	00h33		81°15.130	062°20.620	Optical Profile #2 ↓	459	7	140	3	2.20	-0.44	996.72	73	3/10 MYI
1b	250	Full	22/Aug/2013	00h44		81°15.240	062°20.540	Optical Profile #2 ↑	454	12	140	4	2.30	-0.43	996.67	72	3/10 MYI
1b	250	Full	22/Aug/2013	01h36		81°15.760	062°20.500	Vertical Net + Loki #1 ↓	432	350	130	10	1.40	-0.50	996.36	76	3/10 MYI
1b	250	Full	22/Aug/2013	02h01		81°16.100	062°20.200	Vertical Net + Loki #1 ↑	419	356	140	7	1.90	-0.50	996.51	75	3/10 MYI
1b	250	Full	22/Aug/2013	02h28		81°16.220	062°19.990	Vertical Net + Loki #2 ↓	416	59	160	12	1.00	-0.51	996.48	78	3/10 MYI
1b	250	Full	22/Aug/2013	02h52		81°16.610	062°19.800	Vertical Net + Loki #2 ↑	398	51	180	5	1.50	-0.55	996.55	74	3/10 MYI
1b	250	Full	22/Aug/2013	03h14		81°16.970	062°19.250	CTD-Rosette #3 ↓	388	74	160	10	2.00	-0.54	996.43	70	3/10 MYI
1b	250	Full	22/Aug/2013	03h48		81°17.580	062°18.600	CTD-Rosette #3 ↑	373	77	140	10	1.90	-0.49	996.29	72	3/10 MYI
1b	250	Full	22/Aug/2013	04h17		81°17.400	062°15.790	Bioness ↓	376	220	140	11	1.50	-0.52	998.79	75	3/10 MYI
1b	250	Full	22/Aug/2013	04h57		81°16.500	062°13.660	Bioness ↑	387	193	140	11	1.10	-0.52	998.81	80	3/10 MYI
1b	250	Full	22/Aug/2013	05h35		81°14.410	062°09.270	Agassiz Trawl ↓	622	131	95	3	-1.10	-0.54	998.88	90	3/10 MYI
1b	250	Full	22/Aug/2013	06h17		81°14.250	062°01.100	Agassiz Trawl ↑	398	348	180	11	n-a	n-a	n-a	n-a	3/10 MYI
1b	250	Full	22/Aug/2013	06h40		81°13.730	062°03.620	Box Core #1 ↓	760	128	150	14	2.10	-0.54	998.87	72	3/10 MYI
1b	250	Full	22/Aug/2013	07h05		81°13.790	062°03.500	Box Core #1 ↑	760	138	150	15	2.40	-0.54	998.83	70	3/10 MYI
1b	250	Full	22/Aug/2013	07h15		81°13.790	062°03.550	Box Core #2 ↓	760	155	150	15	2.40	-0.54	998.76	71	3/10 MYI
1b	250	Full	22/Aug/2013	07h40		81°13.740	062°04.110	Box Core #2 ↑	745	170	150	15	2.40	-0.51	998.73	71	3/10 MYI
1b	250	Full	22/Aug/2013	08h25		81°13.690	062°03.690	Box Core #3 ↓	761	142	150	16	2.60	-0.52	998.50	71	3/10 MYI
1b	250	Full	22/Aug/2013	08h48		81°13.690	062°04.070	Box Core #3 ↑	751	140	140	13	2.70	-0.53	998.41	72	3/10 MYI
1b	250	Full	22/Aug/2013	09h30		81°13.780	062°03.550	Gravity Core ↓	764	153	140	22	3.10	-0.49	998.08	69	3/10 MYI
1b	250	Full	22/Aug/2013	09h48		81°13.780	062°03.490	Gravity Core ↑	766	95	160	19	3.00	-0.48	998.08	70	3/10 MYI
1b	250	MVP	22/Aug/2013	11h00		81°14.040	061°59.890	MVP ↓	404	180	150	20	3.30	-0.49	997.56	69	3/10 MYI
1b	251	Basic	22/Aug/2013	14h46		80°54.460	061°11.800	CTD-Rosette #1 ↓	838	200	200	17	3.60	-0.50	995.90	73	n-a
1b	251	Basic	22/Aug/2013	15h14		80°54.440	061°11.820	CTD-Rosette #1 ↑	835	159	190	15	3.30	-0.51	995.79	73	n-a
1b	251	Basic	22/Aug/2013	15h26		80°54.430	061°11.830	Vertical Net Tow + Loki ↓	835	182	190	14	3.00	-0.50	995.73	77	n-a
1b	251	Basic	22/Aug/2013	16h04		80°54.440	061°11.730	Vertical Net Tow + Loki ↑	830	170	190	16	2.90	-0.46	997.79	78	n-a

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	251	Basic	22/Aug/2013	16h22		80°54.430	061°11.740	CTD-Rosette #2 ↓	829	165	190	16	2.90	-0.46	997.71	77	n-a
1b	251	Basic	22/Aug/2013	17h30		80°54.440	061°11.740	CTD-Rosette #2 ↑	832	190	190	14	3.00	-0.49	997.52	77	n-a
1b	251	Basic	22/Aug/2013	18h54		80°54.440	061°11.790	Box Core ↓	830	132	135	13	3.40	-0.47	998.23	77	n-a
1b	251	Basic	22/Aug/2013	19h17		80°54.440	061°11.780	Box Core ↑	834	123	150	20	2.90	-0.48	998.20	79	n-a
1b	251	Basic	22/Aug/2013	20h12		80°57.730	060°51.080	MVP ↓	850	n-a	170	20	2.80	-0.48	999.39	79	n-a
1b	251	Basic	22/Aug/2013	21h57		80°55.350	061°82.850	MVP ↑	497	115	150	15	4.20	-0.60	999.42	80	n-a
1b	251	Basic	24/Aug/2013	23h40		79°17.410	071°17.900	Deployment MOBs Buoy	175	6	20	9	-1.20	-0.53	1003.20	78	BW
1b	253	Basic	25/Aug/2013	00h25		79°17.690	071°17.660	CTD-Rosette #1 ↓	185	186	10	10	-1.20	-0.45	1001.04	75	BW
1b	253	Basic	25/Aug/2013	00h58		79°17.710	071°17.860	CTD-Rosette #1 ↑	187	224	0	6	0.80	-0.44	1001.06	71	BW
1b	253	Basic	25/Aug/2013	01h50		79°17.410	071°18.470	Bioness ↓	180	195	0	9	-1.00	-0.46	1000.81	69	BW
1b	253	Basic	25/Aug/2013	02h06		79°17.550	071°19.630	Bioness ↑	185	85	10	7	-0.50	-0.46	1000.91	69	BW
1b	253	Basic	25/Aug/2013	02h26		79°17.750	071°17.760	Optical Profile #1 ↓	187	184	350	8	-0.90	-0.47	1001.00	68	BW
1b	253	Basic	25/Aug/2013	02h45		79°17.710	071°18.040	Optical Profile #1 ↑	186	209	40	1	0.20	-0.43	1001.24	72	BW
1b	253	Basic	25/Aug/2013	02h47		79°17.710	071°18.080	Optical Profile #2 ↓	185	203	40	1	0.20	-0.43	1001.24	72	BW
1b	253	Basic	25/Aug/2013	03h02		79°17.740	071°18.270	Optical Profile #2 ↑	182	205	290	1	-0.10	-0.42	1001.33	75	BW
1b	253	Basic	25/Aug/2013	03h15		79°17.730	071°17.670	Vertical Net Tow + Loki ↓	190	190	240	2	-0.20	-0.40	1001.34	77	BW
1b	253	Basic	25/Aug/2013	03h30		79°17.710	071°17.810	Vertical Net Tow + Loki ↑	190	201	230	3	-0.40	-0.40	1001.39	79	BW
1b	253	Basic	25/Aug/2013	03h55		79°17.670	071°17.940	CTD-Rosette #2 ↓	186	190	220	2	-0.60	-0.39	1001.46	81	BW
1b	253	Basic	25/Aug/2013	04h33		79°17.618	071°17.826	CTD-Rosette #2 ↑	183	185	285	3	0.10	-0.39	1003.84	79	BW
1b	253	Basic	25/Aug/2013	05h00		79°17.513	071°17.911	Vertical Net Tow + Loki ↓	181	333	300	4	-0.50	-0.41	1004.00	78	BW
1b	253	Basic	25/Aug/2013	05h10		79°17.550	071°17.840	Vertical Net Tow + Loki ↑	181	341	300	3	-1.50	-0.36	1004.07	85	BW
1b	253	Basic	25/Aug/2013	05h28		79°17.660	071°18.630	PNF + Secchi ↓	181	190	300	3	-1.50	-0.36	1004.07	85	BW
1b	253	Basic	25/Aug/2013	05h36		79°17.670	071°18.590	PNF + Secchi ↑	181	185	340	4	0.30	-0.45	1004.11	80	BW
1b	253	Basic	25/Aug/2013	05h53		79°17.419	071°18.796	CTD-Rosette #3 ↓	183	171	340	4	0.30	-0.45	1004.11	80	BW
1b	253	Basic	25/Aug/2013	06h22		79°17.475	071°18.935	CTD-Rosette #3 ↑	183	192	0	6	1.50	-0.46	1003.94	69	BW
1b	253	Basic	25/Aug/2013	06h30		79°17.392	071°19.123	Hydrobios ↓	180	188	0	7	2.00	-0.46	1003.93	62	BW
1b	253	Basic	25/Aug/2013	06h42		79°17.422	071°19.215	Hydrobios ↑	183	199	0	6	2.00	-0.47	1003.81	60	BW
1b	253	Basic	25/Aug/2013	08h21		79°17.784	071°18.868	Deployment Barge	182	65	10	10	0.10	-0.44	1003.60	67	BW
1b	253B	Basic	25/Aug/2013	09h22		79°16.330	071°27.410	CTD-Rosette DNA #1 ↓	181	346	30	12	0.40	-0.42	1003.60	73	BW
1b	253B	Basic	25/Aug/2013	09h57		79°16.350	071°27.150	CTD-Rosette DNA #1 ↑	176	352	20	10	-1.00	-0.34	1003.50	80	BW
1b	253B	Basic	25/Aug/2013	10h14		79°16.480	071°27.440	Vertical Net Tow + Loki ↓	181	36	30	9	-0.60	-0.36	1003.50	81	BW
1b	253B	Basic	25/Aug/2013	10h25		79°16.510	071°27.600	Vertical Net Tow + Loki ↑	181	59	30	11	-1.00	-0.37	1003.60	83	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	253B	Basic	25/Aug/2013	10h53		79°16.610	071°27.750	CTD-Rosette #2 ↓	186	35	20	12	-0.80	-0.29	1003.40	82	BW
1b	253B	Basic	25/Aug/2013	11h25		79°16.650	071°27.770	CTD-Rosette #2 ↑	187	357	30	12	-0.80	-0.29	1003.10	81	BW
1b	253B	Basic	25/Aug/2013	12h44		79°17.440	071°27.150	Vertical Net Tow + Loki ↓	186	300	30	11	0.20	-0.34	1000.39	74	BW
1b	253B	Basic	25/Aug/2013	12h58		79°17.510	071°27.300	Vertical Net Tow + Loki ↑	184	292	40	3	0.70	-0.35	1000.29	72	BW
1b	253B	Basic	25/Aug/2013	13h07		79°17.560	071°27.440	PNF + Secchi ↓	187	297	50	2	2.10	-0.35	1000.25	68	BW
1b	253B	Basic	25/Aug/2013	13h15		79°17.600	071°27.540	PNF + Secchi ↑	187	286	30	7	1.20	-0.36	1000.18	69	BW
1b	253B	Basic	25/Aug/2013	13h53		79°17.740	071°26.790	CTD-Rosette #3 ↓	183	232	0	1	2.20	-0.34	1000.21	67	BW
1b	253B	Basic	25/Aug/2013	14h24		79°17.820	071°26.900	CTD-Rosette #3 ↑	187	274	0	7	2.20	-0.29	1000.01	61	BW
1b	253B	Basic	25/Aug/2013	15h18		79°17.940	071°26.890	Hydrobios ↓	187	216	330	2	2.00	-0.32	999.91	65	BW
1b	253B	Basic	25/Aug/2013	15h30		79°17.960	071°26.730	Hydrobios ↑	185	232	340	1	2.50	-0.32	999.89	64	BW
1b	253B	Basic	25/Aug/2013	16h20		79°18.020	071°26.620	Vertical Net Tow + Loki ↓	184	332	0	12	0.90	-0.35	1002.10	62	BW
1b	253B	Basic	25/Aug/2013	16h32		79°18.020	071°26.560	Vertical Net Tow + Loki ↑	184	298	0	12	1.00	-0.30	1002.00	63	BW
1b	253B	Basic	25/Aug/2013	17h35		79°18.860	071°27.180	Box Core ↓	192	249	20	1	0.90	-0.29	999.79	67	BW
1b	253B	Basic	25/Aug/2013	17h45		79°18.900	071°27.030	Box Core ↑	191	230	10	12	1.40	-0.29	1002.13	68	BW
1b	253B	Basic	25/Aug/2013	17h53		79°18.910	071°26.930	Agassiz Trawl ↓	191	70	10	13	1.40	-0.29	1002.13	68	BW
1b	253B	Basic	25/Aug/2013	18h10		79°19.260	071°24.760	Agassiz Trawl ↑	201	30	20	12	0.10	-0.32	1001.94	76	BW
1b	n-a	Coring	26/Aug/2013	17h56		76°53.570	072°04.660	Box Core ↓	853	8	10	8	0.80	2.73	1001.77	99	BW
1b	n-a	Coring	26/Aug/2013	18h07		76°53.572	072°04.669	Box Core (bottom)	854	358	0	7	0.70	2.78	1002.85	99	BW
1b	n-a	Coring	26/Aug/2013	18h17		76°53.570	072°04.660	Box Core ↑	853	359	10	7	0.70	2.81	1002.93	99	BW
1b	n-a	Coring	26/Aug/2013	18h25		76°53.570	072°04.670	Gravity Core ↓	853	355	0	8	0.70	2.82	1005.41	99	BW
1b	n-a	Coring	26/Aug/2013	18h35		76°53.560	072°04.660	Gravity Core (bottom)	854	2	0	8	0.70	2.82	1005.43	99	BW
1b	n-a	Coring	26/Aug/2013	18h45		76°53.560	072°04.600	Gravity Core ↑	851	12	350	8	0.60	2.82	1005.51	99	BW
1b	126	Full	26/Aug/2013	22h56		77°20.697	073°25.665	Deployment MOBs Buoy	314	360	300	8	-0.20	2.42	1007.10	95	BW
1b	126	Full	26/Aug/2013	23h19		77°20.587	073°25.853	CTD-Rosette DNA ↓	324	315	300	4	-0.10	2.29	1007.18	95	BW
1b	126	Full	27/Aug/2013	00h05		77°20.720	073°25.740	CTD-Rosette DNA ↑	323	214	310	6	-0.10	2.29	1004.79	96	BW
1b	126	Full	27/Aug/2013	00h57		77°20.690	073°25.720	Hydrobios ↓	323	192	340	5	-0.20	2.28	1004.97	96	BW
1b	126	Full	27/Aug/2013	01h14		77°20.700	073°25.820	Hydrobios ↑	323	249	330	3	0.30	2.28	1005.05	95	BW
1b	126	Full	27/Aug/2013	01h32		77°20.700	073°25.680	CTD-Rosette #2 ↓	324	180	350	4	0.50	2.29	1005.17	93	BW
1b	126	Full	27/Aug/2013	02h24		77°20.730	073°25.880	CTD-Rosette #2 ↑	325	251	10	1	0.40	2.37	1005.30	93	BW
1b	126	Full	27/Aug/2013	02h37		77°20.700	073°25.410	Optical Profile #1 ↓	326	359	0	3	0.30	2.37	1005.26	94	BW
1b	126	Full	27/Aug/2013	02h54		77°20.670	073°25.180	Optical Profile #1 ↑	332	87	330	7	-0.40	2.37	1005.29	95	BW
1b	126	Full	27/Aug/2013	02h56		77°20.670	073°25.180	Optical Profile #2 ↓	332	88	330	7	-0.40	2.37	1005.29	95	BW

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	126	Full	27/Aug/2013	03h11		77°20.600	073°25.110	Optical Profile #2 ↑	332	91	330	7	-0.40	2.45	1005.34	94	BW
1b	126	Full	27/Aug/2013	03h25		77°20.670	073°25.610	Vertical Net Tow + Loki ↓	323	216	340	8	-0.40	2.51	1005.36	95	BW
1b	126	Full	27/Aug/2013	03h44		77°20.650	073°25.640	Vertical Net Tow + Loki ↑	324	20	350	9	-0.20	2.54	1005.39	95	BW
1b	126	Full	27/Aug/2013	03h52		77°20.630	073°25.570	PNF + Secchi ↓	326	111	350	8	-0.50	2.49	1005.37	95	BW
1b	126	Full	27/Aug/2013	03h57		77°20.580	073°25.600	PNF + Secchi ↑	326	101	350	8	-0.50	2.49	1005.37	95	BW
1b	126	Full	27/Aug/2013	04h11		77°20.520	073°25.560	CTD-Rosette #3 ↓	325	5	350	10	-0.60	2.48	1007.74	94	BW
1b	126	Full	27/Aug/2013	04h53		77°20.480	073°28.580	CTD-Rosette #3 ↑	326	14	0	10	-0.30	2.63	1007.76	94	BW
1b	126	Full	27/Aug/2013	05h05		77°20.270	073°25.510	Bioness ↓	336	155	0	11	-0.30	2.63	1007.76	94	BW
1b	126	Full	27/Aug/2013	05h32		77°19.530	073°27.270	Bioness ↑	341	230	0	12	0.70	2.66	1007.80	91	BW
1b	126	Full	27/Aug/2013	06h28		77°20.350	073°29.290	Vertical Net Tow + Loki ↓	323	33	10	12	-0.10	2.56	1007.77	96	BW
1b	126	Full	27/Aug/2013	06h44		77°20.340	073°29.250	Vertical Net Tow + Loki ↑	322	11	0	13	-0.50	2.42	1007.60	97	BW
1b	126	Full	27/Aug/2013	08h17		77°21.290	073°29.480	Agassiz Trawl ↓	313	161	20	13	0.40	2.48	1007.44	96	BW
1b	126	Full	27/Aug/2013	08h35		77°20.910	073°28.010	Agassiz Trawl ↑	313	65	20	12	-0.10	2.48	1007.20	97	BW
1b	125	CTD	27/Aug/2013	09h14		77°20.770	073°54.588	CTD-Rosette ↓	449	17	20	12	0.50	2.47	1007.01	96	BW
1b	125	CTD	27/Aug/2013	09h31		77°20.182	073°55.060	CTD-Rosette ↑	460	30	20	11	0.10	2.55	1006.89	96	BW
1b	124	Nutrient	27/Aug/2013	10h10		77°20.801	074°17.567	CTD-Rosette Nutrient ↓	708	9	20	10	0.20	2.09	1006.71	96	BW
1b	124	Nutrient	27/Aug/2013	11h09		77°20.900	074°19.058	CTD-Rosette Nutrient ↑	690	335	20	13	0.50	1.87	1006.10	94	BW
1b	124	Nutrient	27/Aug/2013	12h18		77°20.798	074°17.394	Box Core #1 ↓	710	0	0	15	0.30	1.87	1002.89	94	BW
1b	124	Nutrient	27/Aug/2013	12h27		77°20.828	074°17.690	Box Core #1 (bottom)	709	359	0	15	0.30	1.87	1002.82	94	BW
1b	124	Nutrient	27/Aug/2013	12h38		77°21.106	074°17.594	Box Core #1 ↑	707	23	10	15	0.30	1.89	1002.71	95	BW
1b	124	Nutrient	27/Aug/2013	12h42		77°21.144	074°17.726	Box Core #1 take 2 ↓	708	14	10	16	0.30	1.90	1002.61	95	BW
1b	124	Nutrient	27/Aug/2013	12h50		77°20.831	074°17.575	Box Core #1 take 2 (bottom)	707	29	10	16	0.30	1.90	1002.59	94	BW
1b	124	Nutrient	27/Aug/2013	12h59		77°20.800	074°17.647	Box Core #1 take 2 ↑	708	8	10	16	0.30	1.90	1002.59	94	BW
1b	124	Nutrient	27/Aug/2013	13h09		77°20.795	074°17.612	Box Core #2 ↓	707	39	20	16	0.30	1.89	1002.55	93	BW
1b	124	Nutrient	27/Aug/2013	13h19		77°20.795	074°17.497	Box Core #2 (bottom)	709	27	10	17	0.30	1.89	1002.46	92	BW
1b	124	Nutrient	27/Aug/2013	13h29		77°20.782	074°17.545	Box Core #2 ↑	709	7	10	16	0.40	1.88	1002.40	91	BW
1b	124	Nutrient	27/Aug/2013	13h38		77°20.836	074°17.306	Box Core #3 ↓	708	8	10	16	0.40	1.89	1002.34	91	BW
1b	124	Nutrient	27/Aug/2013	13h48		77°20.802	074°17.398	Box Core #3 (bottom)	713	3	0	16	0.30	1.91	1002.18	92	BW
1b	124	Nutrient	27/Aug/2013	13h58		77°20.789	074°17.603	Box Core #3 ↑	708	7	0	16	0.20	1.91	1002.15	93	BW
1b	124	Nutrient	27/Aug/2013	14h05		77°20.774	074°17.659	Gravity Core ↓	707	9	0	15	-0.30	1.92	1002.15	97	BW
1b	124	Nutrient	27/Aug/2013	14h14		77°20.776	074°17.715	Gravity Core (bottom)	707	7	0	15	-0.60	1.94	1002.12	98	BW
1b	124	Nutrient	27/Aug/2013	14h23		77°20.741	074°17.860	Gravity Core ↑	709	5	10	17	-0.30	1.95	1001.94	96	BW

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											Dir	Speed					
1b	124	Nutrient	27/Aug/2013	14h30		77°20.830	074°17.750	Agassiz Trawl ↓	709	29	10	17	-0.30	1.95	1001.94	96	BW
1b	124	Nutrient	27/Aug/2013	15h03		77°21.580	074°13.920	Agassiz Trawl ↑	717	41	340	17	-0.70	1.93	1001.35	97	BW
1b	123	CTD	27/Aug/2013	15h40		77°20.640	074°38.490	CTD-Rosette ↓	697	355	350	22	0.30	2.00	100.90	91	BW
1b	123	CTD	27/Aug/2013	16h04		77°20.620	074°38.340	CTD-Rosette ↑	700	0	0	20	0.10	1.90	1003.31	91	BW
1b	122	Basic	27/Aug/2013	16h42		77°20.560	075°00.960	PNF + Secchi ↓	646	352	0	23	0.20	1.89	1002.96	89	BW
1b	122	Basic	27/Aug/2013	16h55		77°20.500	075°00.940	PNF + Secchi ↑	646	0	0	23	0.10	1.88	1002.89	89	BW
1b	122	Basic	27/Aug/2013	16h57		77°20.500	075°00.940	Deployment MOBS buoy	646	0	0	23	0.10	1.88	1002.84	89	BW
1b	122	Basic	27/Aug/2013	17h40		77°20.580	075°00.890	CTD-Rosette #1 ↓	646	36	0	24	0.00	1.88	1000.00	88	BW
1b	122	Basic	27/Aug/2013	18h29		77°20.240	075°00.940	CTD-Rosette #1 ↑	647	5	335	23	0.30	1.93	1002.00	86	BW
1b	122	Basic	27/Aug/2013	18h53		77°20.470	074°59.960	Hydrobios ↓	650	350	340	20	0.30	1.93	1002.00	86	BW
1b	122	Basic	27/Aug/2013	19h36		77°20.300	074°59.360	Hydrobios ↑	650	37	340	23	0.20	1.98	1001.88	86	BW
1b	122	Basic	27/Aug/2013	19h59		77°20.014	074°58.263	CTD-Rosette #2 ↓	651	20	320	18	0.40	1.98	1001.70	86	BW
1b	122	Basic	27/Aug/2013	21h02		77°19.795	074°59.242	CTD-Rosette #2 ↑	650	1	320	19	0.00	1.96	1001.50	88	BW
1b	122	Basic	27/Aug/2013	21h52		77°16.150	075°05.279	Recovery MOBS buoy	558	80	310	19	0.40	1.93	1000.50	85	BW
1b	122	Basic	27/Aug/2013	22h30		77°20.691	075°00.976	Vertical Net Tow + Loki #1 ↓	641	8	310	20	0.40	1.97	1000.60	86	BW
1b	122	Basic	27/Aug/2013	23h06		77°20.645	074°59.589	Vertical Net Tow + Loki #1 ↑	641	354	330	21	0.40	2.02	1000.60	85	BW
1b	122	Basic	27/Aug/2013	23h35		77°19.910	075°00.333	Horizontal Net Tow ↓	647	94	340	23	0.50	2.01	1000.40	84	BW
1b	122	Basic	27/Aug/2013	23h55		77°19.410	074°57.723	Horizontal Net Tow ↑	650	155	350	21	0.50	2.00	1000.10	84	BW
1b	122	Basic	28/Aug/2013	00h32		77°20.573	074°01.124	Optical Profile ↓	642	358	350	21	0.60	1.96	997.57	83	BW
1b	122	Basic	28/Aug/2013	00h50		77°20.580	075°00.960	Optical Profile ↑	643	357	340	21	0.60	1.99	997.36	84	BW
1b	121	CTD	28/Aug/2013	01h43		77°20.360	075°21.930	CTD-Rosette ↓	574	359	340	21	0.70	2.10	997.55	84	BW
1b	121	CTD	28/Aug/2013	02h05		77°20.250	075°21.820	CTD-Rosette ↑	575	357	340	21	0.70	2.07	997.48	86	BW
1b	120	Nutrient	28/Aug/2013	02h40		77°20.200	075°40.660	CTD-Rosette Nutrient ↓	569	349	340	25	1.00	2.07	997.09	83	BW
1b	120	Nutrient	28/Aug/2013	03h32		77°20.020	075°41.410	CTD-Rosette Nutrient ↑	565	359	350	20	0.70	2.06	997.86	85	BW
1b	119	Basic	28/Aug/2013	04h05		77°19.950	076°03.150	Deployment MOBs buoy	525	11	345	16	0.80	1.09	1000.68	84	BW
1b	119	Basic	28/Aug/2013	04h28		77°20.010	076°03.190	CTD-Rosette #1 ↓	527	0	340	16	0.80	1.09	1000.68	84	BW
1b	119	Basic	28/Aug/2013	05h10		77°19.870	076°03.470	CTD-Rosette #1 ↑	527	2	0	16	0.60	0.85	1000.84	85	BW
1b	119	Basic	28/Aug/2013	05h26		77°19.810	076°03.550	Hydrobios ↓	525	0	350	16	0.70	0.87	1000.75	86	BW
1b	119	Basic	28/Aug/2013	05h57		77°19.640	076°03.690	Hydrobios ↑	522	357	0	18	0.70	1.17	1000.69	85	BW
1b	119	Basic	28/Aug/2013	06h17		77°19.620	076°03.760	Vertical Net Tow + Loki ↓	522	358	0	17	0.90	1.32	1000.95	85	BW
1b	119	Basic	28/Aug/2013	06h47		77°19.570	076°03.980	Vertical Net Tow + Loki ↑	521	356	0	17	0.90	1.45	1001.17	85	BW
1b	119	Basic	28/Aug/2013	07h02		77°19.560	076°04.220	CTD-Rosette #2 ↓	521	357	0	15	0.80	1.47	10001.35	86	BW

Appendix 2 - Scientific log of activities conducted during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	119	Basic	28/Aug/2013	07h59		77°19.470	076°04.510	CTD-Rosette #2 ↑	520	346	10	10	0.50	1.38	1001.87	88	BW
1b	119	Basic	28/Aug/2013	08h44		77°19.789	076°04.250	Horizontal Net Tow ↓	520	196	70	8	0.40	1.13	1001.75	93	BW
1b	119	Basic	28/Aug/2013	08h58		77°19.338	076°03.480	Horizontal Net Tow ↑	521	83	70	5	0.10	1.22	1002.10	95	BW
1b	119	Basic	28/Aug/2013	09h20		77°20.038	076°03.157	Optical Profile ↓	527	24	70	5	-0.70	1.26	1002.35	99	BW
1b	119	Basic	28/Aug/2013	09h41		77°20.031	076°03.189	Optical Profile ↑	526	18	70	5	-0.80	1.27	1002.59	99	BW
1b	119	Basic	28/Aug/2013	09h48		77°20.033	076°04.043	Agassiz Trawl ↓	524	212	80	5	-0.80	1.28	1002.59	99	BW
1b	119	Basic	28/Aug/2013	10h11		77°19.357	076°03.576	Agassiz Trawl ↑	520	117	70	8	-0.16	1.25	1002.80	99	BW
1b	119	Basic	28/Aug/2013	10h53		77°14.117	076°03.595	Recovery MOBS buoy	474	348	70	12	0.30	1.06	1002.90	99	BW
1b	118	Nutrient	28/Aug/2013	12h12		77°19.780	076°29.780	CTD-Rosette Nutrient ↓	448	68	50	9	0.60	0.86	1001.19	93	BW
1b	118	Nutrient	28/Aug/2013	12h57		77°19.770	076°29.950	CTD-Rosette Nutrient ↑	449	117	20	6	0.50	0.82	1001.43	93	BW
1b	117	Full	28/Aug/2013	14h02		77°19.220	076°59.810	Barge deployed	461	13	330	8	-0.90	0.53	1001.93	99	BW
1b	117	Full	28/Aug/2013	14h11		77°19.130	076°59.950	PNF + Secchi ↓	462	343	0	8	-0.70	0.50	1001.96	98	BW
1b	117	Full	28/Aug/2013	14h16		77°19.110	076°00.080	PNF + Secchi ↑	462	436	0	8	-0.70	0.50	1001.96	98	BW
1b	117	Full	28/Aug/2013	14h11		n-a	n-a	Deployment MOBs buoy	462	343	0	8	-0.70	0.50	1001.96	98	BW
1b	117	Full	28/Aug/2013	14h26		77°19.470	077°00.490	CTD-Rosette Phyto #1 ↓	447	3	0	11	-0.50	0.48	1001.97	98	BW
1b	117	Full	28/Aug/2013	15h03		77°19.380	077°00.370	CTD-Rosette Phyto #1 ↑	450	356	350	9	-0.70	0.46	1002.16	99	BW
1b	117	Full	28/Aug/2013	15h18		77°19.400	077°00.320	Hydrobios ↓	449	348	350	10	-0.60	0.47	1002.18	99	BW
1b	117	Full	28/Aug/2013	15h20		77°19.400	077°00.370	Hydrobios ↑	449	355	350	10	-0.60	0.47	1002.18	99	BW
1b	117	Full	28/Aug/2013	15h43		77°19.450	077°00.470	Vertical Net Tow + Loki ↓	449	357	0	10	-0.30	0.52	1002.23	99	BW
1b	117	Full	28/Aug/2013	16h10		77°19.290	077°00.420	Vertical Net Tow + Loki ↑	454	12	0	10	-0.20	0.54	1004.69	99	BW
1b	117	Full	28/Aug/2013	17h33		77°19.450	077°00.490	CTD-Rosette Nutrient ↓	449	339	350	8	-0.20	0.62	1002.56	99	BW
1b	117	Full	28/Aug/2013	18h33		77°19.280	077°01.120	CTD-Rosette Nutrient ↑	452	40	0	9	0.00	0.67	1005.11	99	BW
1b	117	Full	28/Aug/2013	19h05		77°14.760	077°08.140	Recovery MOBS buoy	475	150	340	8	-0.20	0.62	1005.10	99	BW
1b	117	Full	28/Aug/2013	19h50		77°19.240	077°01.140	Optical Profile ↓	455	26	340	8	-0.20	0.62	1005.10	99	BW
1b	117	Full	28/Aug/2013	20h21		77°18.937	077°01.165	Optical Profile ↑	471	75	340	7	-0.30	0.67	1005.00	99	BW
1b	117	Full	28/Aug/2013	20h27		77°18.810	077°00.742	Bioness ↓	475	157	340	6	-0.30	0.67	1005.00	99	BW
1b	117	Full	28/Aug/2013	21h12		77°18.166	077°04.271	Bioness ↑	485	285	340	8	-0.10	0.70	1005.00	97	BW
1b	117	Full	28/Aug/2013	21h41		77°19.470	077°00.713	CTD-Rosette DNA #3 ↓	447	332	350	8	-0.30	0.68	1005.06	98	BW
1b	117	Full	28/Aug/2013	22h20		77°19.377	077°00.966	CTD-Rosette DNA #3 ↑	449	21	330	8	-0.40	0.68	1005.06	98	BW
1b	117	Full	28/Aug/2013	22h42		77°19.361	077°00.244	Vertical Net Tow + Loki ↓	451	65	330	8	-0.50	-0.59	1005.01	98	BW
1b	117	Full	28/Aug/2013	23h09		77°19.154	077°00.142	Vertical Net Tow + Loki ↑	462	36	340	9	-0.50	0.50	1005.01	97	BW
1b	117	Full	29/Aug/2013	00h08		77°19.462	077°00.518	Box Core ↓	447	50	350	7	-0.40	0.58	1002.36	96	BW

Appendix 2 - Scientific log of activities conducted during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	117	Full	29/Aug/2013	00h21		77°19.423	077°00.300	Box Core (bottom)	448	7	350	9	-0.10	0.56	1002.26	92	BW
1b	117	Full	29/Aug/2013	00h34		77°19.356	077°00.320	Box Core ↑	452	96	0	10	0.20	0.55	1002.22	84	BW
1b	117	Full	29/Aug/2013	00h42		77°19.201	077°00.108	Agassiz Trawl ↓	462	160	340	9	0.20	0.55	1002.18	82	BW
1b	117	Full	29/Aug/2013	01h05		77°18.800	076°57.400	Agassiz Trawl ↑	475	33	340	9	0.10	0.54	1002.09	84	BW
1b	117	MVP	29/Aug/2013	01h39		77°18.091	076°59.242	MVP ↓	500	172	20	11	0.30	0.53	1002.05	83	BW
1b	117	MVP	29/Aug/2013	03h20		77°06.690	076°54.240	MVP ↑	267	174	340	13	0.20	1.24	1001.50	85	BW
1b	322	MVP	29/Aug/2013	16h10		74°29.360	080°31.800	MVP ↓	661	163	270	18	0.30	1.46	1003.96	88	BW
1b	325	MVP	29/Aug/2013	22h13		73°48.900	080°29.340	MVP ↑	672	180	270	20	-1.20	1.52	1004.70	86	BW
1b	301	Basic	30/Aug/2013	02h18		74°06.191	083°21.705	Deployment MOBS buoy	667	248	250	15	-0.60	0.66	1001.36	93	0/10
1b	301	Basic	30/Aug/2013	02h36		74°06.191	083°21.705	CTD-Rosette #1 ↓	668	248	250	15	-0.30	0.45	1001.70	93	0/10
1b	301	Basic	30/Aug/2013	03h36		74°06.190	083°22.290	CTD-Rosette #1 ↑	669	222	240	15	-0.40	0.28	1001.79	95	0/10
1b	301	Basic	30/Aug/2013	03h50		74°06.190	083°22.550	Hydrobios ↓	669	207	240	14	-0.40	0.26	1001.82	95	0/10
1b	301	Basic	30/Aug/2013	04h26		74°00.265	083°22.290	Hydrobios ↑	668	222	280	7	-0.10	0.30	1004.21	94	0/10
1b	301	Basic	30/Aug/2013	04h45		74°06.220	083°22.240	Vertical Net Tow + Loki ↓	668	226	300	6	0.20	0.33	1004.46	93	0/10
1b	301	Basic	30/Aug/2013	05h20		74°06.320	083°22.300	Vertical Net Tow + Loki ↑	670	245	340	4	0.30	0.36	1004.53	93	0/10
1b	301	Basic	30/Aug/2013	05h28		74°06.360	083°22.380	PNF + Secchi ↓	670	256	340	4	0.20	0.36	1004.57	93	0/10
1b	301	Basic	30/Aug/2013	05h33		74°06.360	083°22.380	PNF + Secchi ↑	670	250	340	4	0.20	0.36	1004.57	93	0/10
1b	301	Basic	30/Aug/2013	05h45		74°06.480	083°22.160	CTD-Rosette #2 ↓	670	55	340	4	0.20	0.37	1004.59	93	0/10
1b	301	Basic	30/Aug/2013	06h38		74°06.920	083°21.290	CTD-Rosette #2 ↑	670	64	300	5	-0.40	0.47	1004.93	93	0/10
1b	301	Basic	30/Aug/2013	06h45		74°06.940	083°21.240	Horizontal Net Tow ↓	671	330	320	5	-0.40	0.47	1004.93	93	0/10
1b	301	Basic	30/Aug/2013	06h58		74°07.240	083°22.150	Horizontal Net Tow ↑	671	200	330	5	-0.10	0.43	1004.94	91	0/10
1b	301	Basic	30/Aug/2013	08h22		74°06.230	083°20.938	Deployment Barge	674	123	360	8	-0.20	0.49	1005.10	92	0/10
1b	301	Basic	30/Aug/2013	08h37		74°06.156	083°22.514	CTD-Rosette #3 ↓	669	2667	360	9	-0.10	0.45	1005.11	93	0/10
1b	301	Basic	30/Aug/2013	09h21		74°06.186	083°22.722	CTD-Rosette #3 ↑	668	244	350	8	0.90	0.65	1005.10	90	0/10
1b	301	Basic	30/Aug/2013	09h35		74°06.132	083°22.645	Box Core ↓	668	87	360	9	0.60	0.68	1005.18	90	0/10
1b	301	Basic	30/Aug/2013	09h54		74°06.241	083°22.660	Box Core ↑	671	111	350	7	-0.20	0.71	1005.12	91	0/10
1b	301	Basic	30/Aug/2013	09h59		74°06.198	083°22.562	Agassiz Trawl ↓	668	165	350	6	-0.10	0.72	1005.21	92	0/10
1b	301	Basic	30/Aug/2013	10h26		74°06.381	083°20.620	Agassiz Trawl ↑	669	354	360	7	0.00	0.58	1005.41	91	0/10
1b	301	Basic	30/Aug/2013	10h51		74°09.225	083°14.885	Recovery Barge	693	142	30	5	0.10	0.31	1005.20	89	0/10
1b	302	Nutrient	30/Aug/2013	14h43		74°09.740	086°10.490	CTD-Rosette ↓	520	318	340	15	0.40	0.36	1004.25	81	0/10
1b	302	Nutrient	30/Aug/2013	15h35		74°09.760	086°10.540	CTD-Rosette ↑	521	343	340	11	0.80	0.36	1004.40	80	0/10
1b	303	Nutrient	30/Aug/2013	20h12		74°13.409	089°36.815	CTD-Rosette Nutrient ↓	236	288	280	12	-1.10	-0.24	1007.34	97	2/10

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	303	Nutrient	30/Aug/2013	20h50		74°13.062	089°36.478	CTD-Rosette Nutrient ↑	238	231	280	15	-1.10	-0.40	1007.20	96	2/10
1b	304	Full	31/Aug/2013	00h43		74°15.110	091°28.053	Deployment MOBs Buoy	321	90	270	10	-1.60	-0.37	1003.41	99	0/10
1b	304	Full	31/Aug/2013	00h51		74°15.040	091°28.350	CTD-Rosette #1 ↓	320	264	260	13	-1.40	-0.35	1003.26	99	0/10
1b	304	Full	31/Aug/2013	01h36		74°14.880	091°27.750	CTD-Rosette #1 ↑	322	324	0	9	-1.70	-0.32	1003.06	99	0/10
1b	304	Full	31/Aug/2013	01h55		74°15.130	091°29.090	Optical Profile ↓	322	313	350	9	-2.00	-0.32	1003.08	99	0/10
1b	304	Full	31/Aug/2013	02h17		74°15.100	091°28.740	Optical Profile ↑	322	267	350	7	-2.00	-0.31	1007.98	99	0/10
1b	304	Full	31/Aug/2013	02h25		74°15.070	098°28.570	Hydrobios ↓	321	264	350	5	-1.90	-0.31	1002.98	99	0/10
1b	304	Full	31/Aug/2013	02h46		74°15.010	091°28.190	Hydrobios ↑	322	261	340	6	-2.00	-0.31	1002.90	99	0/10
1b	304	Full	31/Aug/2013	03h10		74°14.970	091°27.550	CTD-Rosette #2 ↓	323	258	310	6	-2.10	-0.32	1002.70	99	0/10
1b	304	Full	31/Aug/2013	03h58		74°14.940	091°26.600	CTD-Rosette #2 ↑	321	321	300	5	-2.30	-0.34	1002.48	99	0/10
1b	304	Full	31/Aug/2013	04h10		74°14.980	091°26.230	Vertical Net Tow + Loki ↓	320	292	310	4	-2.20	-0.32	1004.75	99	1/10
1b	304	Full	31/Aug/2013	04h29		74°15.010	091°25.840	Vertical Net Tow + Loki ↑	321	320	270	4	-2.30	-0.30	1004.68	99	1/10
1b	304	Full	31/Aug/2013	04h52		74°15.490	091°28.830	CTD-Rosette #3 ↓	320	231	300	5	-2.30	-0.33	1004.43	97	1/10
1b	304	Full	31/Aug/2013	05h28		74°15.540	091°27.980	CTD-Rosette #3 ↑	320	273	280	4	-2.30	-0.43	1004.23	95	1/10
1b	304	Full	31/Aug/2013	05h42		74°15.550	091°27.930	Bioness ↓	323	68	280	5	-2.30	-0.43	1004.23	95	1/10
1b	304	Full	31/Aug/2013	06h05		74°15.690	091°23.680	Bioness ↑	327	105	280	4	-2.10	-0.38	1004.06	89	1/10
1b	304	Full	31/Aug/2013	06h20		74°15.690	091°23.610	Optical Profile ↓	323	93	290	6	-2.30	-0.35	1003.97	88	1/10
1b	304	Full	31/Aug/2013	07h00		74°15.660	091°22.060	Optical Profile ↑	325	96	280	4	-2.20	-0.33	1003.91	88	1/10
1b	304	Full	31/Aug/2013	07h04		74°15.660	091°22.050	Box Core ↓	330	108	290	6	-2.30	-0.28	1003.87	86	1/10
1b	304	Full	31/Aug/2013	07h10		74°15.660	091°22.000	Box Core (bottom)	326	89	290	5	-2.30	-0.29	1003.85	86	1/10
1b	304	Full	31/Aug/2013	07h16		74°15.660	091°21.940	Box Core ↑	326	99	290	4	-2.30	-0.29	1003.82	86	1/10
1b	304	Full	31/Aug/2013	07h21		74°15.650	091°21.600	Agassiz Trawl ↓	330	100	290	5	-2.20	-0.30	1003.76	85	1/10
1b	304	Full	31/Aug/2013	07h35		74°15.690	091°19.550	Agassiz Trawl ↑	332	66	290	4	-2.20	-0.31	1003.71	85	1/10
1b	304	Full	31/Aug/2013	11h35		74°13.565	091°04.270	Recovery MOBs Buoy	327	7	calm	calm	-2.40	-0.69	1002.20	94	1/10
1b	305	Nutrient	31/Aug/2013	18h00		74°19.660	094°56.870	CTD-Rosette ↓	172	271	290	6	-3.50	-0.68	999.04	91	1/10
1b	305	Nutrient	31/Aug/2013	18h35		74°19.660	094°56.510	CTD-Rosette ↑	174	260	290	5	-3.50	-0.69	1001.45	94	1/10
1b	Ice station 1	Ice	31/Aug/2013	22h38		74°15.851	096°28.075	Ice Floe Sampling ↓	181	191	280	6	-2.20	-0.85	1000.91	88	n-a
1b	Ice station 1	Ice	31/Aug/2013	23h24		74°15.548	096°28.070	Ice Floe Sampling ↑	181	188	250	7	-2.70	-0.84	1000.59	97	n-a
1b	Ice station 1	Ice	31/Aug/2013	05h05		74°12.570	096°38.400	Ice Floe Sampling ↓	194	119	300	4	-2.60	-0.75	1001.16	95	n-a
1b	Ice station 1	Ice	31/Aug/2013	06h15		74°11.870	096°27.220	Ice Floe Sampling ↑	195	101	300	5	-2.50	-0.75	1000.28	93	n-a
1b	Ice station 2	Ice	01/Sep/2013	10h56		74°04.408	096°27.001	Ice Floe Sampling ↓	220	237	290	2	-2.30	-0.67	1000.33	86	n-a
1b	Ice station 2	Ice	01/Sep/2013	19h36		74°05.490	096°13.680	Ice Floe Sampling ↑	211	239	170	12	-2.20	-0.71	998.95	92	n-a

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	Ice station 3	Ice	02/Sep/2013	06h25		74°07.580	095°57.450	Ice Floe Sampling ↓	176	80	140	8	-1.40	-0.81	994.24	93	n-a
1b	Ice station 3	Ice	02/Sep/2013	07h13		74°07.680	095°56.190	Ice Floe Sampling ↑	170	81	140	10	-1.60	-0.80	994.22	97	n-a
1b	Ice station 4	Ice	02/Sep/2013	14h31		74°11.230	095°56.290	Vertical Net Tow + Loki ↓	192	330	50	12	-1.40	-0.82	990.53	91	2/10
1b	Ice station 4	Ice	02/Sep/2013	14h41		74°11.210	095°56.450	Vertical Net Tow + Loki ↑	192	335	60	12	-1.30	-0.81	990.47	91	2/10
1b	Ice station 4	Ice	02/Sep/2013	15h20		74°11.650	095°56.330	CTD-Rosette ↓	192	327	30	10	-1.20	-0.79	990.40	95	2/10
1b	Ice station 4	Ice	02/Sep/2013	15h48		74°11.630	095°56.370	CTD-Rosette ↑	192	325	60	12	-1.00	-0.81	990.39	95	2/10
1b	Ice station 4	Ice	02/Sep/2013	17h45		74°10.580	095°50.880	Ice Floe Sampling ↓	199	327	30	15	-1.10	-0.75	990.58	90	2/10
1b	Ice station 4	Ice	02/Sep/2013	19h35		74°10.270	095°48.290	Ice Floe Sampling ↑	190	327	30	15	-1.00	-0.85	993.11	93	2/10
1b	Ice station 4	Ice	02/Sep/2013	20h02		74°10.327	095°48.307	Vertical Net Tow + Loki ↓	189	298	50	20	-0.70	-0.86	993.11	92	2/10
1b	Ice station 4	Ice	02/Sep/2013	20h12		74°10.279	095°48.092	Vertical Net Tow + Loki ↑	189	299	40	17	-0.60	-0.86	993.16	92	2/10
1b	Ice station 5	Ice	02/Sep/2013	20h50		74°10.220	095°48.620	Ice Scanning	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a
1b	Ice station 5	Ice	02/Sep/2013	21h10		74°10.200	095°48.480	Vessel Rotate and Advance	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a
1b	Ice station 5	Ice	02/Sep/2013	21h21		74°10.177	095°48.327	Ice Scanning Start	190	307	35	15	-0.50	-0.88	993.51	92	2/10
1b	Ice station 5	Ice	02/Sep/2013	22h21		74°10.120	095°47.726	Ice Scanning End	183	309	15	13	-0.80	-0.84	993.63	93	2/10
1b	Ice station 5	Ice	02/Sep/2013	22h46		74°10.118	095°47.495	Ice Floe Sampling ↓	181	312	15	14	-0.90	-0.82	993.74	93	2/10
1b	Ice station 5	Ice	02/Sep/2013	23h41		74°10.138	095°47.085	Ice Floe Sampling ↑	180	314	15	17	-1.60	-0.78	993.79	94	2/10
1b	Ice station 5	Ice	03/Sep/2013	00h28		74°10.810	095°48.370	Vertical Net Tow + Loki ↓	200	346	10	18	-1.40	-0.79	991.54	95	2/10
1b	Ice station 5	Ice	03/Sep/2013	00h40		74°10.810	095°48.350	Vertical Net Tow + Loki ↑	200	330	10	17	-1.40	-0.80	991.58	95	2/10
1b	Ice station 5	Ice	03/Sep/2013	04h35		74°09.750	095°49.690	Vertical Net Tow + Loki ↓	189	292	10	22	-1.10	-0.80	995.26	89	2/10
1b	Ice station 5	Ice	03/Sep/2013	04h45		74°09.650	095°49.680	Vertical Net Tow + Loki ↑	188	293	10	21	-1.10	-0.80	995.26	89	2/10
1b	Ice station 6	Ice	03/Sep/2013	05h36		74°09.140	095°49.700	Ice Floe Sampling ↓	174	292	0	22	-1.00	-0.81	995.80	87	2/10
1b	Ice station 6	Ice	03/Sep/2013	07h00		74°08.300	095°50.070	Ice Floe Sampling ↑	168	289	0	22	-1.20	-0.81	996.65	89	2/10
1b	Ice station 6	Ice	03/Sep/2013	08h37		74°07.428	095°50.782	Vertical Net Tow + Loki ↓	184	286	345	27	-1.50	-0.81	997.03	89	2/10
1b	Ice station 6	Ice	03/Sep/2013	08h47		74°07.342	095°50.847	Vertical Net Tow + Loki ↑	180	284	350	25	-1.40	-0.81	997.11	88	2/10
1b	Ice station 6	Ice	03/Sep/2013	09h41		74°06.880	095°59.600	Ice Scanning Start	179	296	340	25	-0.90	-0.81	997.58	85	2/10
1b	Ice station 6	Ice	03/Sep/2013	11h00		74°06.870	095°51.932	Ice Scanning End	182	295	340	27	1.30	-0.81	997.60	86	2/10
1b	Ice station 6	Ice	03/Sep/2013	11h05		74°06.406	095°52.760	Ice Floe Sampling ↓	176	294	340	26	-1.50	-0.82	997.72	88	2/10
1b	Ice station 6	Ice	03/Sep/2013	11h55		74°06.241	095°53.183	Ice Floe Sampling ↑	182	293	340	27	-1.60	-0.81	998.45	90	2/10
1b	Ice station 6	Ice	03/Sep/2013	12h35		74°06.610	095°53.562	Vertical Net Tow + Loki ↓	180	289	340	26	-1.50	-0.81	996.14	89	2/10
1b	Ice station 6	Ice	03/Sep/2013	12h44		74°06.160	095°53.677	Vertical Net Tow + Loki ↑	180	289	330	26	-1.50	-0.81	996.29	90	2/10
1b	Ice station 7	Ice	03/Sep/2013	14h43		74°05.688	095°59.337	Ice Scanning Start	189	315	330	23	-3.00	-0.80	998.19	90	2/10
1b	Ice station 7	Ice	03/Sep/2013	15h37		74°05.317	095°59.979	Ice Scanning End	195	289	340	23	-2.90	-0.72	998.54	91	2/10

Appendix 2 - Scientific log of activities conducted during the 2013 ArcticNet Expedition

Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
1b	Ice station 8	Ice	03/Sep/2013	16h38		74°04.740	096°00.170	Ice Floe Sampling ↓	188	311	330	21	-2.60	-0.62	1001.65	91	2/10
1b	Ice station 8	Ice	03/Sep/2013	17h00		74°04.610	096°00.210	Ice Floe Sampling ↑	193	308	330	26	-2.40	-0.58	1001.60	91	2/10
Leg 2a																	
2a	306	CTD	06/Sept/2013	11h28	-6	74°21.020	097°36.600	CTD ↓	140	274	330	14	-3.5	-0.61	1008.16	86	n-a
2a	306	CTD	06/Sept/2013	11h31	-6	74°20.880	097°35.850	CTD ↑	138	265	340	13	-3.4	-0.62	1008.17	87	n-a
2a	307	Basic	07/Sept/2013	00h09	-6	74°06.320	103°04.810	CTD ↓	371	138	290	15	-3	-0.73	1011.33	87	1re 2/10
2a	307	Basic	07/Sept/2013	00h55	-6	74°06.480	103°04.090	CTD ↑	369	180	295	15	-0.8	-0.7	1011.1	81	1re 2/10
2a	307	Basic	07/Sept/2013	1h30	-6	74°06.240	103°03.640	Vertical Net Tow ↓	372	372	250	20	-3.1	-0.7	1010.90	88	1re 2/10
2a	307	Basic	07/Sept/2013	1h55	-6	74°06.190	103°03.060	Vertical Net Tow ↑	371	86	282	15	-2.8	-0.7	1010.80	87	1re 2/10
2a	307	Basic	07/Sept/2013	02h20	-6	74°06.240	103°03.960	Horizontal Net Tow ↓	372	120	285	19	-2.90	-0.60	101.70	87	1re 2/10
2a	307	Basic	07/Sept/2013	02h40	-6	74°06.030	103°01.790	Horizontal Net Tow ↑	370	51	285	22	-2.10	-0.70	1010.00	85	1re 2/10
2a	307	Basic	07/Sept/2013	03h09	-6	74°06.310	103°02.430	CTD-Rosette ↓	365	133	277	22	-2.90	-0.70	1010.40	88	1re 2/10
2a	307	Basic	07/Sept/2013	03h54	-6	74°06.170	103°01.330	CTD-Rosette ↑	367	199	292	22	-0.20	-0.70	1010.00	83	1re 2/10
2a	307	Basic	07/Sept/2013	04h26	-6	74°06.680	103°01.270	Box Core ↓	357	129	292	19	-2.50	-0.70	1009.90	90	1re 5/10
2a	307	Basic	07/Sept/2013	04h35	-6	74°06.650	103°01.220	Box Core (bottom)	359	127	292	17	-2.10	-0.70	1010.00	90	1re 5/10
2a	307	Basic	07/Sept/2013	04h45	-6	74°06.590	103°01.140	Box Core ↑	357	124	294	16	-1.9	-0.7	1010	89	1re 5/10
2a	307	Basic	07/Sept/2013	04h58	-6	74°06.280	103°00.410	Agassiz Trawl ↓	357	81	291	17	-1.70	-0.70	1010.00	89	1re 5/10
2a	307	Basic	07/Sept/2013	05h20	-6	74°06.400	102°59.960	Agassiz Trawl ↑	357	254	300	20	-2.70	-0.80	1009.70	92	1re 5/10
2a	308	Full	07/Sept/2013	15h29	-7	74°08.310	108°50.170	Deployment MOBs Buoy	567	150	311.7	19	-0.90	-0.10	1013.80	89	0/10
2a	308	Full	07/Sept/2013	19h20	-7	74°05.860	108°50.504	Recovery MOBs Buoy	529	287	330	13	-0.30	-0.06	1014.96	90	0/10
2a	308	Full	07/Sept/2013	15h36	-7	74°08.290	108°50.240	PNF + Secchi ↓	567	144	319.3	20	0.70	0.00	1013.90	87	0/10
2a	308	Full	07/Sept/2013	15h48	-7	74°08.260	108°50.330	PNF + Secchi ↑	565	178	311	19	0.10	0.00	1013.80	90	0/10
2a	308	Full	07/Sept/2013	15h58	-7	74°08.260	108°50.330	CTD ↓	565	156	311	19	0.10	0.00	1013.80	90	0/10
2a	308	Full	07/Sept/2013	16h57	-7	74°08.010	108°49.560	CTD ↑	562	166	322	13	2.40	0.00	1014.00	83	0/10
2a	308	Full	07/Sept/2013	17h18	-7	74°08.520	108°50.160	Hydrobios ↓	564	107	333	14	0.40	0.00	1014.00	88	0/10
2a	308	Full	07/Sept/2013	17h54	-7	74°08.280	108°50.200	Hydrobios ↑	569	158	331	13	-0.50	0.00	1014.00	89	0/10
2a	308	Full	07/Sept/2013	18h15	-7	74°08.20	108°50.230	Vertical Net Tow ↓	565	158	327	13	3.10	0.00	1014.50	79	0/10
2a	308	Full	07/Sept/2013	18h46	-7	74°08.020	108°50.550	Vertical Net Tow ↑	565	167	326	13	-0.40	0.00	1014.80	89	0/10
2a	308	Full	07/Sept/2013	19h48	-7	74°08.390	108°50.180	CTD-Rosette ↓	563	152	327	15	-0.50	-0.10	1014.60	90	0/10
2a	308	Full	07/Sept/2013	20h45	-7	74°08.260	108°50.060	CTD-Rosette ↑	563	171	310	8	1.00	0.05	1015.33	86	0/10
2a	308	Full	07/Sept/2013	21h06	-7	74°08.160	108°50.270	Vertical Net Tow ↓	565	159	330	13	0.10	0.07	1015.18	87	0/10
2a	308	Full	07/Sept/2013	21h58	-7	74°07.740	108°50.970	Vertical Net Tow ↑	566	124	330	10	-0.60	0.05	1015.34	90	0/10

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
2a	308	Full	07/Sept/2013	22h26	-7	74°08.220	108°49.670	Bioness ↓	562	180	320	10	-0.04	0.04	1015.48	89	0/10
2a	308	Full	07/Sept/2013	23h12	-7	74°07.490	108°53.470	Bioness ↑	560	290	330	12	-0.30	0.04	1015.71	90	0/10
2a	308	Full	07/Sept/2013	23h48	-7	74°08.310	108°50.200	CTD-Rosette ↓	568	169	320	5	-0.30	0.02	1015.96	91	0/10
2a	308	Full	08/Sept/2013	00h35	-7	74°08.310	108°49.770	CTD-Rosette ↑	563	170	310	9	0.30	0.10	1015.90	88	0/10
2a	308	Full	08/Sept/2013	01h22	-7	74°08.380	108°49.770	Box Core ↓	563	143	321	8	-0.60	0.20	1016.90	88	0/10
2a	308	Full	08/Sept/2013	01h43	-7	74°08.370	108°49.920	Box Core ↑	563	157	327	9	-0.80	0.20	1016.20	90	0/10
2a	308	Full	08/Sept/2013	01h53	-7	74°08.270	108°49.430	Agassiz Trawl ↓	563	138	320	6	-0.10	0.20	1016.00	88	0/10
2a	308	Full	08/Sept/2013	02h22	-7	74°08.010	108°47.070	Agassiz Trawl ↑	565	71	300	8	-1.00	0.10	1016.00	90	0/10
2a	308	Full	08/Sept/2013	03h27	-7	74°13.010	108°51.290	MVP ↓	502	357	356	13	-0.90	0.10	1016.30	89	0/10
2a	308	Full	08/Sept/2013	05h15	-7	74°25.630	108°53.770	MVP ↑	404	357	340	18	-2.10	0.10	1016.30	86	0/10
2a	500	Full	08/Sept/2013	12h10	-7	73°46.960	113°49.030	PNF + Secchi ↓	459	130	319	8	-3.90	-0.10	1016.00	97	0/10
2a	500	Full	08/Sept/2013	12h15	-7	73°46.960	113°49.030	PNF + Secchi ↑	459	130	319	8	-3.90	-0.10	1016.00	97	0/10
2a	500	Full	08/Sept/2013	12h19	-7	73°46.910	113°49.200	Deployment MOBs Buoy	483	150	311	10	-3.60	-0.20	1020.00	97	0/10
2a	500	Full	08/Sept/2013	12h39	-7	73°46.870	113°49.500	CTD-Rosette ↓	456	105	306	9	-4.10	-0.20	1020.30	97	0/10
2a	500	Full	08/Sept/2013	13h29	-7	73°46.670	113°49.280	CTD-Rosette ↑	456	090	316	11	-4.10	-0.10	1020.40	97	0/10
2a	500	Full	08/Sept/2013	13h48	-7	73°46.900	113°48.620	Vertical Net Tow ↓	458	109	311	11	-4.60	-0.10	1020.50	97	0/10
2a	500	Full	08/Sept/2013	14h14	-7	73°46.710	113°49.170	Vertical Net Tow ↑	455	144	320	8	-5.00	-0.10	1020.60	96	0/10
2a	500	Full	08/Sept/2013	14h36	-7	73°46.710	113°49.100	Horizontal Net Tow ↓	456	117	333	7	-3.40	-0.10	1020.60	98	0/10
2a	500	Full	08/Sept/2013	14h53	-7	73°46.360	113°47.450	Horizontal Net Tow ↑	449	107	316	5	-4.40	-0.20	1020.70	97	0/10
2a	500	Full	08/Sept/2013	15h22	-7	73°46.940	113°48.870	CTD-Rosette ↓	459	163	325	7	-4.00	-0.20	1020.70	97	1re 1/10
2a	500	Full	08/Sept/2013	16h07	-7	73°46.780	113°49.040	CTD-Rosette ↑	457	186	334	7	-4.30	-0.20	1020.70	97	1re 1/10
2a	500	Full	08/Sept/2013	16h25	-7	73°46.730	113°49.150	Box Core ↓	456	184	338	7	-4.00	-0.20	1020.80	97	1re 1/10
2a	500	Full	08/Sept/2013	16h34	-7	73°46.680	113°49.190	Box Core (bottom)	456	177	339	6	-3.70	-0.20	1020.80	97	1re 1/10
2a	500	Full	08/Sept/2013	16h45	-7	73°46.650	113°49.300	Box Core ↑	456	177	339	6	-3.50	-0.20	1020.80	98	1re 1/10
2a	500	Full	08/Sept/2013	16h57	-7	73°46.720	113°49.330	Box Core ↓	456	182	327	4	-3.40	-0.20	1020.80	98	1re 1/10
2a	500	Full	08/Sept/2013	17h04	-7	73°46.670	113°49.370	Box Core (bottom)	456	168	324	9	-3.40	-0.20	1020.90	98	1re 1/10
2a	500	Full	08/Sept/2013	17h11	-7	73°46.670	113°49.370	Box Core ↑	456	155	315	7	-3.40	-0.20	1020.90	98	1re 1/10
2a	500	Full	08/Sept/2013	18h03	-7	73°46.910	113°48.590	Box Core ↓	460	182	337	5	-3.50	-0.30	1021.20	98	1re 1/10
2a	500	Full	08/Sept/2013	18h12	-7	73°46.880	113°48.690	Box Core (bottom)	458	217	333	3	-3.30	-0.30	1021.20	98	1re 1/10
2a	500	Full	08/Sept/2013	18h20	-7	73°46.840	113°48.700	Box Core ↑	458	188	7	1	-3.20	-0.30	1021.20	98	1re 1/10
2a	500	Full	08/Sept/2013	18h31	-7	73°46.720	113°48.770	Agassiz Trawl ↓	456	120	337	2	-3.00	-0.30	1021.40	98	1re 1/10
2a	500	Full	08/Sept/2013	18h49	-7	73°46.620	113°49.220	Agassiz Trawl ↑	456	196	308	7	-3.60	-0.30	1021.40	98	1re 1/10

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
2a	500	Full	08/Sept/2013	19h22	-7	73°47.420	113°51.430	Benthic Beam Trawl ↓	467	347	356	7	-4.10	-0.40	1021.20	97	1re 1/10
2a	500	Full	08/Sept/2013	19h33	-7	73°47.430	113°52.350	Benthic Beam Trawl (bottom)	467	303	0	6	-4.00	-0.40	1021.10	97	1re 1/10
2a	500	Full	08/Sept/2013	19h51	-7	73°46.920	113°52.280	Benthic Beam Trawl ↑	457	116	338	5	-4.10	-0.50	1021.10	98	1re 1/10
2a	500	Full	08/Sept/2013	20h03	-7	73°46.930	113°52.660	Benthic Beam Trawl ↓	457	286	340	6	-3.90	-0.47	1021.14	98	1re 1/10
2a	500	Full	08/Sept/2013	20h32	-7	73°46.400	113°52.650	Benthic Beam Trawl ↑	445	157	calm	calm	-3.10	-0.48	1021.21	98	1re 1/10
2a	500	Full	08/Sept/2013	21h26	-7	73°46.240	113°54.280	Recovery MOBs Buoy	353	174	348	6.7	-3.70	-0.37	1021.25	97	1re 1/10
2a	512	Nutrient	09/Sept/2013	08h07	-7	74°49.290	116°57.910	CTD-Rosette ↓	434	248	calm	calm	-5.70	-0.80	1022.25	97	Nilas 8/10
2a	512	Nutrient	09/Sept/2013	08h59	-7	74°49.090	116°57.460	CTD-Rosette ↑	436	247	calm	calm	-5.40	-0.80	1022.34	97	Nilas 8/10
2a	Ice Station 1	Ice	09/Sept/2013	11h23	-7	74°45.960	117°17.890	Scatterometer	457	172	calm	calm	-4.20	-0.67	1022.26	98	1re 10/10
2a	Ice Station 1	Ice	09/Sept/2013	13h46	-7	74°44.970	116°36.570	Scatterometer	457	075	113	9	-2.50	-0.70	1022.70	98	1er 6/10 2e 2/10
2a	Ice Station 1	Ice	09/Sept/2013	11h30	-7	n-a	n-a	Ice Cage Sampling ↓	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a
2a	Ice Station 1	Ice	09/Sept/2013	12h15	-7	n-a	n-a	Ice Cage Sampling ↑	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a	n-a
2a	Ice Station 2	Ice	09/Sept/2013	16h16	-7	74°45.170	117°34.470	Ice Cage Sampling ↓	458	328	120	5	-1.30	-0.70	1023	96	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	16h31	-7	74°45.210	117°34.180	Sx90 ↓	457	328	125	4	-0.90	-0.70	1023.10	94	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	17h56	-7	74°45.370	117°32.510	Sx90 ↑	456	339	138	1	0.60	-0.60	1023.50	88	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	18h03	-7	74°45.380	117°32.350	Ice Cage Sampling ↑	454	341	150	1	1.10	-0.60	1023.60	87	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	18h21	-7	74°45.680	117°31.750	Secchi ↓	450	058	080	4	0.00	-0.60	1023.60	87	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	18h23	-7	74°45.680	117°31.720	Secchi ↑	450	054	080	4	0.00	-0.60	1023.60	87	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	18h24	-7	74°45.680	117°31.700	PNF ↓	450	054	080	4	0.00	-0.60	1023.60	87	1er 7/10 2e 3/10
2a	Ice Station 2	Ice	09/Sept/2013	18h28	-7	74°45.690	117°31.610	PNF ↑	451	044	081	4	0.00	-0.60	1023.60	87	1er 7/10 2e 3/10
2a	333	Basic	15/Sept/2013	12h34	-6	74°20.600	087°27.560	Sx90 ↓	154	180	316	6	-1.30	0.00	1018.10	75	0/10
2a	333	Basic	15/sept/2013	13h03	-6	74°26.990	087°24.890	Secchi ↓	286	225	83	15	1.90	0.20	1018.20	69	0/10
2a	333	Basic	15/Sept/2013	13h04	-6	74°26.990	087°24.890	Secchi ↑	286	225	83	15	1.90	0.20	1018.20	69	0/10
2a	333	Basic	15/Sept/2013	13h05	-6	74°26.990	087°24.890	PNF ↓	286	215	83	15	1.90	0.20	1018.20	69	0/10

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Leg	Station ID	Station Type	Local Date	Local Time	UTC to local	Latitude (N)	Longitude (W)	Activity	Depth (m)	Heading (°)	Wind		Air (ºC)	Water (ºC)	Pr Baro	Hum (%)	Ice
											Dir	Speed					
2a	333	Basic	15/Sept/2013	13h09	-6	74°26.990	087°24.880	PNF ↑	286	215	83	15	1.90	0.20	108.20	69	0/10
2a	333	Basic	15/Sept/2013	13h20	-6	74°26.980	087°24.910	CTD-Rosette ↓	286	229	355	6	1.10	0.40	1018.30	71	0/10
2a	333	Basic	15/Sept/2013	14h05	-6	74°26.960	087°25.130	CTD-Rosette ↑	286	240	34	3.5	1.10	0.50	1018.30	72	0/10
2a	333	Basic	15/Sept/2013	14h14	-6	74°26.950	087°25.140	Vertical Net Tow ↓	286	200	7.1	3.8	1.10	0.50	1018.20	71	0/10
2a	333	Basic	15/Sept/2013	14h33	-6	74°26.940	087°25.720	Vertical Net Tow ↑	281	228	19.9	5.6	1.90	0.50	1018.30	65	0/10
2a	333	Basic	15/Sept/2013	15h08	-6	74°26.930	087°25.210	Horizontal Net Tow ↓	288	288	79	3.5	2.30	0.50	1018.30	63	0/10
2a	333	Basic	15/Sept/2013	15h30	-6	74°26.540	087°28.100	Horizontal Net Tow ↑	285	178	88.3	13.1	-0.10	0.50	1018.30	86	0/10
2a	333	Basic	15/Sept/2013	15h51	-6	74°26.950	087°28.360	CTD-Rosette ↓	304	290	89.5	7.6	-0.10	0.40	1018.30	90	0/10
2a	333	Basic	15/Sept/2013	16h19	-6	74°26.930	087°24.670	Sx90 ↑	293	272	089	7.1	0.60	0.40	1018.40	88	0/10
2a	333	Basic	15/Sept/2013	16h32	-6	74°26.910	087°24.820	CTD-Rosette ↑	293	270	83	5	0.40	0.40	1018.30	88	0/10
Mooring program - Hudson Bay (CCGS *Radisson*) et Beaufort Sea (CCGS *Laurier*)																	
BaySys	AN01-13	Mooring	30/Aug/2013	14h00	-4	59°58.253	091°58.434	Mooring Deployment	107								
BREA	BR-A-12	Mooring	29/Sep/2013	17h54	-7	70°45.408	136°00.798	Mooring Recovery	660								
BREA	BR-B-12	Mooring	30/Sep/2013	08h16	-7	70°40.296	135°35.172	Mooring Recovery	156								
BREA	BR-G-12	Mooring	03/Oct/2013	10h41	-7	71°00.468	135°29.910	Mooring Recovery	703								
BREA	BR-02-12	Mooring	09/Oct/2013	13h34	-7	70°26.010	139°01.392	Mooring Recovery	155								
BREA	BR-01-12	Mooring	10/Oct/2013	17h58	-7	69°59.478	137°57.648	Mooring Recovery	753								

Appendix 3 - CTD logbook for the 2013 ArcticNet Expedition

Leg	Cast #	Station	Start Date UTC	Time UTC	Latitude N	Longitude W	Bottom depth (m)	Cast depth (dbar)	Comments	Rosette Type	Init.
Leg 1a											
1a	001	Test	27/07/13	13:56	49°13.115	067°14.212	321	313	Test St. Lawrence Estuary	Test	GB
1a	002	650	29/07/13	19:42	53°48.029	055°25.968	204	196	1h late on UVP and LADCP	Nuts	GB
1a	003	645	30/07/13	12:18	56°42.007	059°41.802	122	112	btl 24 unclosed	Nuts	GB
1a	004	633	30/07/13	20:32	57°36.394	061°53.771	183	173	btl 4 didn't close	Nuts,Phyto,DIC	JB
1a	005	633	30/07/13	22:39	57°36.401	061°53.766	183	173		DNA, Tak, CH4	JB
1a	006	633	31/07/13	01:35	57°36.253	061°53.810	178	167	Nc	Phyto, Benth, OrgC	TL
1a	007	632	31/07/13	05:02	57°34.002	062°03.298	91	80	btl 4 did not close	Nuts	GB
1a	008	631	31/07/13	06:19	57°29.629	062°11.628	92	81	btl 4 closed during rinsing when back on deck only	Nuts	GB
1a	009	630	31/07/13	09:18	57°28.300	062°26.483	51	41	btl 4 did not close	DNA, Tak,CH4	GB
1a	010	630	31/07/13	10:46	57°28.253	062°26.468	51	41	btl 4 did not close; wrong name CTD files	Nuts, Phyto, Hg	JB
1a	011	640	31/07/13	21:12	58°59.968	061°53.990	141	134		Nuts, DIC	JB
1a	012	602	01/08/13	11:01	59°03.180	063°52.199	153	142		Nuts, Phyto, DIC	JB
1a	013	602	01/08/13	12:51	59°03.288	063°52.166	151	143		Tak,DNA,CH4,Benth	JB
1a	014	604	01/08/13	15:09	58°59.557	063°53.663	62	51		Nuts	GB
1a	015	601	01/08/13	17:01	59°02.857	063°36.319	166	157		CTD	TL
1a	016	600	01/08/13	18:51	59°05.118	063°26.922	208	198		Nuts,Phyto,CH4,DIC	JB
1a	017	600	01/08/13	21:48	59°05.244	063°26.219	207	196		DNA, Benth, CH4, Tak	JB
1a	018	600	01/08/13	23:17	59°05.413	063°26.189	205	195		Benth, Phyto	GB
1a	019	355	02/08/13	12:24	60°51.094	064°42.004	426	422		Nuts,DIC	GB
1a	020	354	02/08/13	14:17	61°00.202	064°45.264	506	499		Nuts	GB
1a	021	353	02/08/13	16:26	61°09.521	064°47.012	415	413	CDOM back to good SF	Nuts	GB
1a	022	Mapping	04/08/13	04:17	65°52.788	066°25.408	610	602	no station # - mapping profile - close to stn 183	CTD	GB
1a	023	183	04/08/13	16:07	65°35.204	066°20.470	583	573		Nuts,Phyto, DIC, Hg,S,DMS	JB
1a	024	183	04/08/13	18:25	65°35.270	066°20.023	632	624		DNA,Benth,CH4,Tak	JB
1a	025	180	06/08/13	14:25	67°08.340	061°15.775	366	360		CH4,DNA,DIC,OrgCont	GB
1a	026	180	07/08/13	02:22	67°12.460	061°18.604	370	360		Nuts,DIC,Phyto,DMS,Hg	JB
1a	027	180	07/08/13	07:08	67°05.492	061°15.706	340	329		DNA, CH4, Tak*, OrgC	GB
1a	028	180	07/08/13	13:29	67°09.988	061°16.310	370	361		Phyto,Benth,OrgC, CH4	GB
1a	029	ROV1	07/08/13	18:40	67°47.940	059°25.693	1273	900		CTD	JB
1a	030	176	09/08/13	09:13	69°35.899	065°47.873	204	194		Nuts,DIC,Phyto,DMS,Hg	JB
1a	031	176	09/08/13	12:02	69°35.717	065°48.620	214	207	btl 22: leaking	DNA,Benth,CH4,Tak	JB
1a	032	170	10/08/13	11:50	71°22.784	070°04.441	265	255	upcast stopped @ 20m (Helicopter recovery)	Nuts,DIC,Hg,Phyto,DMS	GB
1a	033	170	10/08/13	16:34	71°22.788	070°04.232	266	254		Org.C, CH4, Tak	GB
1a	034	170	10/08/13	18:34	71°22.781	070°04.339	266	256		DNA,CH4,Tak	GB
1a	035	Earthquake	11/08/13	20:46	72°46.902	070°27.739	1600	1000	mapping calibration		GB
Leg 1b											
1b	036	325	13/08/13	12:04	73°48.920	080°28.796	676	673		Nuts, DMS, Tak,	GB
1b	037	324	13/08/13	14:16	73°59.281	080°32.522	768	766		Nuts	JB

Appendix 3 - CTD logbook for the 2013 ArcticNet Expedition

Leg	Cast #	Station	Start Date UTC	Time UTC	Latitude N	Longitude W	Bottom depth (m)	Cast depth (dbar)	Comments	Rosette Type	Init.
1b	038	323	13/08/13	17:00	74°09.482	080°28.400	787	782		Phyto	GB
1b	039	323	13/08/13	19:35	74°09.457	080°28.373	792	785		Nuts	JB
1b	040	323	14/08/13	01:35	74°09.403	080°28.123	792	789	com errors occuring - reboot	Benth/Tak/HH	GB
1b	041	323	14/08/13	05:57	74°09.472	080°28.508	790	787	no error!!	Benth/Tak/DNA/HH	GB
1b	042	300	14/08/13	12:14	74°19.349	080°30.457	705	698		Nuts	JB
1b	043	322	14/08/13	14:55	74°29.833	080°32.251	659	657		Nuts	JB
1b	044	101	15/08/13	09:33	76°23.242	077°23.412	343	335		Drifter 1 - Nuts	JB
1b	045	101	15/08/13	13:24	76°22.884	077°21.902	354	347		Drifter 2 - Phyto,DMS,CH4	JB
1b	046	101	15/08/13	17:53	76°21.065	077°29.069	381	376		Drifter 3 - Benth	JB
1b	047	101	15/08/13	21:33	76°20.962	077°35.322	343	334	bungee btl 4 replaced	Drifter 4 - CH4,Tak,HH, Phyto, Nuts	GB
1b	048	101	16/08/13	01:48	76°19.928	077°39.868	273	267		Drifter 5 - Nuts,Phyto,Tak,DNA	GB
1b	049	101	16/08/13	05:47	76°17.623	077°45.540	283	269		Drifter 6 - Nuts,Phyto,DNA,Tak	GB
1b	050	101	16/08/13	08:20	76°17.372	077°46.264	261	254		Drifter 7 - Nuts,Phyto,DNA,Tak	GB
1b	051	102	16/08/13	10:40	76°22.427	076°59.341	250	241		CTD	JB
1b	052	103	16/08/13	11:44	76°21.184	076°34.547	151	140		Nuts	JB
1b	053	104	16/08/13	13:08	76°20.621	076°10.318	194	181		CTD	JB
1b	054	105	16/08/13	14:06	76°19.090	075°45.150	321	321		Nuts,DMS,Phyto,Hg,DIC	JB
1b	055	105	16/08/13	17:10	76°19.058	075°45.197	324	318		CH4,Benth	JB
1b	056	106	16/08/13	22:02	76°18.511	075°22.058	378	371		CTD	GB
1b	057	107	16/08/13	23:07	76°16.879	074°59.326	443	433		Nuts	GB
1b	058	108	17/08/13	01:13	76°16.195	074°35.976	452	444	lots of current and large swell	Nuts, DIC, hg	GB
1b	059	108	17/08/13	04:12	76°15.010	074°39.276	440	432	idem, weather quite rough	Phyto,DMS,CH4	GB
1b	060	108	17/08/13	07:32	76°16.205	074°35.773	453	439	idem, weather quite rough	Benth,DNA,Tak	GB
1b	061	109	17/08/13	14:07	76°17.388	074°06.720	450	446	rough weather	CTD	JB
1b	062	110	17/08/13	15:11	76°17.927	073°37.858	530	528		Nuts	JB
1b	063	111	17/08/13	16:52	76°18.410	073°12.740	595	590		Nuts,DIC,Hg	JB
1b	064	111	17/08/13	21:35	76°18.328	073°12.185	598	591		orgC, Tak	GB
1b	065	111	17/08/13	23:20	76°18.392	073°12.907	599	591		Phyto,DMS,Benth,CH4	GB
1b	066	112	18/08/13	03:16	76°18.932	072°42.083	564	556		CTD	GB
1b	067	113	18/08/13	04:24	76°19.223	072°12.803	556	546	fired 260m even if not required	Nuts	GB
1b	068	114	18/08/13	06:01	76°19.476	071°47.231	616	606		CTD	GB
1b	069	115	18/08/13	09:46	76°20.297	071°11.514	660	653	No UVP data	Drifter 1 - Nuts,DIC,Hg	JB
1b	070	115	18/08/13	13:22	76°21.425	071°12.860	639	636		Drifter 2 - Tak,DNA	JB
1b	071	115	18/08/13	16:50	76°22.766	071°19.192	590	591		Drifter 3 - Phyto,DMS	JB
1b	072	115	18/08/13	20:35	76°25.182	071°18.391	512	506		Drifter 4 - CH4,Tak,HH, Phyto, Nuts, DMS	GB
1b	073	115	19/08/13	01:33	76°27.011	071°24.894	540	533		Drifter 5 - Nuts,Phyto,DMS,Benth,Tak	GB
1b	074	115	19/08/13	05:16	76°29.590	071°29.365	478	471		Drifter6 - Nuts,Phyto,DMS,Tak	GB
1b	075	115	19/08/13	08:13	76°29.858	071°26.615	467	462		Drifter7 - Nuts,Tak,Phyto,DMS,DNA	GB
1b	076	132	20/08/13	04:36	78°59.677	072°15.558	242	236		DNA,Benth,Tak,CH4	GB

Appendix 3 - CTD logbook for the 2013 ArcticNet Expedition

Leg	Cast #	Station	Start Date UTC	Time UTC	Latitude N	Longitude W	Bottom depth (m)	Cast depth (dbar)	Comments	Rosette Type	Init.
1b	077	132	20/08/13	07:39	78°59.446	072°06.008	231	220		Nuts,DIC,Phyto,DMS,CH4	GB
1b	078	132	20/08/13	10:15	78°59.056	072°05.740	224	215		Hg.HH	JB
1b	079	250	21/08/13	23:39	81°14.929	062°22.097	457	452		Phyto,DMS,Benth,Tak	GB
1b	080	250	22/08/13	03:06	81°14.664	062°21.326	472	466		Nuts,DMS,CH4,d18O.DIC	JB
1b	081	250	22/08/13	07:15	81°17.012	062°19.330	390	376		DMS,DNA,Benth	GB
1b	082	251	22/08/13	18:47	80°54.460	061°11.750	838	100		Phyto,DMS,DNA,Tak,Nuts	JB
1b	083	251	22/08/13	20:24	80°54.464	061°11.770	838	836		Nuts,DMS,DIC,CH4	GB
1b	084	253a	25/08/13	04:25	79°17.658	071°17.704	185	175		DNA,Tak,HH	GB
1b	085	253a	25/08/13	07:59	79°17.693	071°17.912	186	177		Nuts,DIC,CH4	GB
1b	086	253a	25/08/13	09:54	79°17.431	071°18.787	183	173		Phyto,DMS,Benth	GB
1b	087	253b	25/08/13	13:23	79°16.326	071°27.388	177	169	No UVP Data	DNA,Tak	JB
1b	088	253b	25/08/13	14:55	79°16.597	071°27.827	186	173		Nuts,CH4	JB
1b	089	253b	25/08/13	17:53	79°17.760	071°26.699	183	175		Phyto,DMS,CH4	JB
1b	090	126	27/08/13	03:22	77°20.580	073°25.778	329	319	New DO probe	DNA,Tak	GB
1b	091	126	27/08/13	05:33	77°20.708	073°25.704	324	317	DO and d18O	Nuts,DIC	GB
1b	092	126	27/08/13	08:14	77°20.505	073°25.577	330	320		Phyto,DMS,CH4	GB
1b	093	125	27/08/13	13:16	77°20.761	073°54.698	448	445		CTD	JB
1b	094	124	27/08/13	14:12	77°20.789	074°17.653	708	703		Nuts,DIC	JB
1b	095	123	27/08/13	19:40	77°20.645	074°38.506	700	696		CTD	JB
1b	096	122	27/08/13	21:41	77°20.562	075°00.806	646	643		Phyto,DNA,Tak	JB
1b	097	122	28/08/13	00:01	77°19.990	074°58.219	660	650		Nuts,DIC,DMS,CH4	GB
1b	098	121	28/08/13	05:43	77°20.357	075°21.900	574	569		CTD	GB
1b	099	120	28/08/13	06:40	77°20.195	075°40.694	570	564	replaced bungee btl 3	Nuts, d18O	GB
1b	100	119	28/08/13	08:30	77°20.005	076°03.186	529	522	100th cast, youpi!	Phyto,DNA,Takl	GB
1b	101	119	28/08/13	11:04	77°19.548	076°04.250	521	517		Nuts,CH4,DIC,Benth	JB
1b	102	118	28/08/13	16:12	77°19.790	076°29.819	448	442		Nuts	JB
1b	103	117	28/08/13	18:27	77°19.471	077°00.498	447	446	UVP batt. Discharged after rinsing, before proper cast	Phyto,DMS,Benth,HH,Tak	JB
1b	104	117	28/08/13	21:32	77°19.441	077°00.935	449	444	no UVP - batt. Discharged	Nuts,DIC,CH4,hg	GB
1b	105	117	29/08/13	01:43	77°19.442	077°00.770	448	445	UVP OK	HH,Tak,DNA	GB
1b	106	301	30/08/13	06:38	74°06.238	083°22.404	674	666		Nuts,DIC.Hg	GB
1b	107	301	30/08/13	09:47	74°06.502	083°22.154	673	666		Phyto, DMS, CH4	JB
1b	108	301	30/08/13	12:39	74°06.169	083°22.484	673	665		Tak,DNA,Benth	JB
1b	109	302	30/08/13	18:42	74°09.762	086°10.510	525	516		Nuts,Tak,CH4	JB
1b	110	303	31/08/13	00:14	74°13.393	089°36.752	237	228		Nuts, CH4	GB
1b	111	304	31/08/13	04:53	74°15.040	091°28.332	322	314		Nuts,DIC,Hg,HH	GB
1b	112	304	31/08/13	07:12	74°14.968	091°27.476	323	313	UVP still flashing when coming up since it went to 10m twice, see operator verbose comments	DNA,Tak,HH	GB
1b	113	304	31/08/13	08:53	74°15.492	091°28.765	320	310	no UVP data	Phyto,DMS,Benth,HH	JB

Appendix 3 - CTD logbook for the 2013 ArcticNet Expedition

Leg	Cast #	Station	Start Date UTC	Time UTC	Latitude N	Longitude W	Bottom depth (m)	Cast depth (dbar)	Comments	Rosette Type	Init.
1b	114	305	31/08/13	22:03	74°19.662	094°56.867	172	167		Nuts, CH4	GB/JB
1b	115	Ice station 2	02/09/13	19:22	74°11.698	095°56.322	192	183		Nuts,DMS,Phyto,Tak,CH4	JB
Leg 2a											
2a	001	306	06/09/13	15:21	74°21.017	097°35.586	138	128		CTD	PG
2a	002	307	07/09/13	04:07	74°06.320	103°04.788	370	348		Basic	MB
2a	003	307	07/09/13	07:07	74°06.308	103°02.495	365	345		Basic	PG
2a	004	308	07/09/13	20:00	74°08.291	108°50.329	565	561		Full	MB
2a	005	308	07/09/13	23:47	74°08.413	108°50.201	563	559		Full	PG
2a	006	308	08/09/13	03:49	74°08.316	108°50.195	568	563		Full	MB
2a	007	500	08/09/13	16:37	73°46.847	113°48.569	459	451		Basic	PG
2a	008	500	08/09/13	19:24	73°46.945	113°48.893	459	452		Basic	MB
2a	009	512	09/09/13	12:06	74°49.292	116°57.889	437	429	btl 22 is leaking	Nut	PG
2a	010	333	15/09/13	17:13	74°26.999	087°24.870	286	277	btl 24 is leaking	Basic	PG
2a	011	333	15/09/13	19:53	74°26.939	087°24.359	304	281		Basic	MB

Appendix 4 - List of science participants of the 2013 ArcticNet Expedition

Leg	Name	Position	Affiliation	Network Investigator/ Supervisor	Embark place	Embark date	Disembark place	Disembark date
Leg 1a	Cassar, Nicolas	Researcher	Université Laval	Tremblay, Jean-Éric	Quebec City	26-Jul-13	Pangnirtung	03-Aug-13
Leg 1a	Coupel, Pierre	PhD student	Université Laval	Tremblay, Jean-Éric	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Crawford, Anna	PhD student	Carleton University	Mueller, Derek	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	De Moura Neves, Barbara	PhD student	Memorial University	Edinger, Evan/ Hillaire-Marcel, Claude	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Else, Brent	PDF	University of Manitoba	Papakyriakou, Tim	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Fortier, Louis	Chief Scientist	Université Laval	Fortier, Louis	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Geoffroy, Maxime	PhD student	Université Laval	Fortier, Louis	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Krogh, Jeremy	BSc student	University of Manitoba	Barber, David	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Lassonde, Maryse	Scientific Director	FRNT	ArcticNet	Quebec City	26-Jul-13	Pangnirtung	03-Aug-13
Leg 1a	Linkowski, Thomas	Technician	ArcticNet	Levesque, Keith	Quebec City	26-Jul-13	Pangnirtung	03-Aug-13
Leg 1a	Morin, Philippe-Israel	BSc student	Université Laval	Babin, Marcel	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Murdock, Ian	ROV Pilot	CSSF	Levesque, Keith	Pangnirtung	03-Aug-13	Pond Inlet	12-Aug-13
Leg 1a	Nacke, Melissa	MSc student	Carleton University	Mueller, Derek	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a	Shepherd, Trevor	ROV Pilot	CSSF	Levesque, Keith	Pangnirtung	03-Aug-13	Pond Inlet	12-Aug-13
Leg 1a	Simo, Armelle	PhD student	UQAR	Gosselin, Michel	Quebec City	26-Jul-13	Pond Inlet	12-Aug-13
Leg 1a, Leg 1b	Barette, Jessy	CTD-Rosette Operator	ArcticNet	Levesque, Keith	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Becu, Guislain	CTD-Rosette Operator	Université Laval	Babin, Marcel	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Blais, Marjolaine	Technician	UQAR	Gosselin, Michel	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Blondeau, Sylvain	Technician	Québec-Océan	Québec-Océan	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Burgers, Tonya	MSc student	University of Manitoba	Papakyriakou, Tim	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Cadieux, Marc	Research Assistant	University of Manitoba	Stern, Gary	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Candlish, Lauren	Research Assistant	University of Manitoba	Barber, David	Quebec City	26-Jul-13	Thule	26-Aug-13
Leg 1a, Leg 1b	Charette, Joannie	BSc student	UQAR	Gosselin, Michel	Pangnirtung	03-Aug-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Chaulk, Amanda	Technician	University of Manitoba	Wang, Fei	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Church, Ian	EM302 Operator	University of New-Brunswick	Hughes-Clarke, John	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Colatriano, David	PhD student	Université Laval	Lovejoy, Connie	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Deslongchamps, Gabrièle	MSc student	Université Laval	Tremblay, Jean-Éric	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Falardeau, Marianne	MSc student	Université Laval	Fortier, Louis	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Gagnon, Jonathan	Technician	Université Laval	Tremblay, Jean-Éric	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Gourdal, Margaux	PhD student	Université Laval	Levasseur, Maurice	Quebec City	26-Jul-13	Thule	26-Aug-13
Leg 1a, Leg 1b	Guilmette, Caroline	Research Assistant	Université Laval	Babin, Marcel	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Joli, Nathalie	PhD student	Université Laval	Lovejoy, Connie	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Lacour, Thomas	PDF	Université Laval	Babin, Marcel	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Laliberté, Julien	MSc student	UQAR	Bélanger, Simon	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Larivière, Jade	MSc student	Université Laval	Babin, Marcel	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Makela, Anni Maarit	PhD student	UQAR	Archambault, Philippe	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Pratomo, Danar	EM302 Operator	University of New-Brunswick	Hughes-Clarke, John	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Wang, Kang	PhD student	University of Manitoba	Wang, Fei	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b	Warner, Kerri	Research Assistant	University of Manitoba	Barber, David	Quebec City	26-Jul-13	Resolute	05-Sep-13

Appendix 4 - List of science participants of the 2013 ArcticNet Expedition

Leg	Name	Position	Affiliation	Network Investigator/ Supervisor	Embark place	Embark date	Disembark place	Disembark date
Leg 1a, Leg 1b	Xie, Huixiang	Professor	UQAR	Xie, Huixiang	Quebec City	26-Jul-13	Resolute	05-Sep-13
Leg 1a, Leg 1b, Leg 2a	Aubry, Cyril	Technician	Université Laval	Fortier, Louis	Quebec City	26-Jul-13	Quebec City	19-Sep-13
Leg 1a, Leg 1b, Leg 2a	Burt, Alexis	Research Assistant	University of Manitoba	Stern, Gary	Quebec City	26-Jul-13	Kugluktuk	19-Sep-13
Leg 1a, Leg 1b, Leg 2a	Grant, Cindy	Research Assistant	UQAR	Archambault, Philippe	Quebec City	26-Jul-13	Resolute	19-Sep-13
Leg 1a, Leg 1b, Leg 2a	Schmid, Moritz	PhD student	Université Laval	Fortier, Louis	Quebec City	26-Jul-13	Resolute	19-Sep-13
Leg 1b	Barber, David	Professor	University of Manitoba	Barber, David	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Baya, Anabelle	PhD student	Trent University	Hintelmann, Holger	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Ferland, Joannie	Research Assistant	Université Laval	Babin, Marcel	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Isleifson, Dustin	PhD student	University of Manitoba	Barber, David	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Massé, Guillaume	Researcher	Université Laval	Babin, Marcel	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Mol, Jacoba	PDF	Dalhousie University	Thomas, Helmuth	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Prinsenberg, Simon	Researcher	DFO	Prinsenberg, Simon	pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Royer, Sarah-Jeanne	PhD student	Institut de Ciències del Mar	Levasseur, Maurice	Pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b	Turner, Jeff	Cinematographer	Wild Canada Productions	Turner, Jeff	pond Inlet	12-Aug-13	Resolute	05-Sep-13
Leg 1b, Leg 2a	Gupta, Mukesh	PhD student	University of Manitoba	Barber, David	Pond Inlet	12-Aug-13	Resolute	19-Sep-13
Leg 1b, Leg 2a	Sheilds, Megan	MSc Student	University of Manitoba	Barber, David	Pond Inlet	12-Aug-13	Resolute	19-Sep-13
Leg 1b, Leg 2a	Stark, Heather	MSc student	University of Manitoba	Barber, David	Pond Inlet	12-Aug-13	Resolute	19-Sep-13
Leg 2a	Beattie, Sarah	MSc Student	University of Manitoba	Wang, Fei	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Belzile, Mélany	CTD-Rosette Operator	UQAR	Quebec-Ocean	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Blasco, Steve	Chief Scientist	NRCAN	Blasco, Steve	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Blondeau, Sylvain	Technician	Québec-Océan	Québec-Océan	Resolute	19-Sep-13	Resolute	28-Sep-13
Leg 2a	Brucker, Steve	EM302 Operator	University of New-Brunswick	Hughes-Clarke, John	Resolute	05-Sep-13	Quebec City	06-Oct-13
Leg 2a	Comte, Jérôme	PDF	Université Laval	Lovejoy, Connie	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Côté, Jean-Sébasten	MSc Student	Université Laval	Tremblay, Jean-Éric	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Coupel, Pierre	PhD student	Université Laval	Tremblay, Jean-Éric	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Dmitrenko, Igor	Researcher	University of Manitoba	Dmitrenko, Igor	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Edgar, Robyn	MSc Student	Université Laval	Lovejoy, Connie	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Geoffroy, Maxime	PhD student	Université Laval	Fortier, Louis	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Giesbrecht, Karina	PhD	University of Victoria	Miller, Lisa	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Goosey, Emma	PDF	University of Tortonto	Jantunen, Liisa	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Gosselin, Michel	Professor	UQAR	Gosselin, Michel	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Grigor, Jordan	PhD student	Université Laval	Fortier, Louis	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Guillot, Pascal	CTD-Rosette Operator	Quebec-Ocean	Quebec-Ocean	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Hiroji, Anand	EM302 Operator	University of New-Brunswick	Hughes-Clarke, John	Resolute	05-Sep-13	Quebec City	06-Oct-13
Leg 2a	Hochheim, Klaus	Research Assistant	University of Manitoba	Barber, David	Resolute	05-Sep-13	Resolute	09-Sep-13
Leg 2a	Jarret, Kate	Research Assistant	NRCAN	Blasco, Steve	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Kazanidis, Georgios	PhD student	UQAR	Archambault, Philippe	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Lakeman, Tom	PDF	Dalhousie University	Blasco, Steve	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Lavoie, Marie-France	Technician	UQAR	Gosselin, Michel	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Levesque, Keith	Research Coordinator	ArcticNet	Fortier, Martin	Resolute	05-Sep-13	Resolute	28-Sep-13

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Leg	Name	Position	Affiliation	Network Investigator/ Supervisor	Embark place	Embark date	Disembark place	Disembark date
Leg 2a	Linkowski, Thomas	Technician	ArcticNet	Levesque, Keith	Resolute	05-Sep-13	Resolute	28-Sep-13
Leg 2a	McKillop, Kevin	Research Assistant	NRCAN	Blasco, Steve	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Meredyk, Shawn	Mooring Professional	ArcticNet	Levesque, Keith	Resolute	05-Sep-13	Resolute	28-Sep-13
Leg 2a	Michaud, Luc	Equipment Manager	Québec-Océan	Fortier, Louis	Resolute	05-Sep-13	Resolute	28-Sep-13
Leg 2a	Patton, Eric	GIS techs	NRCAN	Blasco, Steve	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Petrusevich, Vlad	Mooring Professional	University of Manitoba	Dmitrenko, Igor	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Pind, Meredith	MSc Student	University of Manitoba	Papakyriakou, Tim	Resolute	05-Sep-13	Resolute	19-Sep-13
Leg 2a	Zhang, Yong	PDF	UQAR	Xie, Huixiang	Resolute	05-Sep-13	Resolute	19-Sep-13