Joint Ocean Ice Study (JOIS) 2012
Cruise Report

Ice free at 79N, 150W on 25 Aug 2012

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,* August 2 to September 8, 2012 IOS Cruise ID 2012-11

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2012 is an important contribution from Fisheries and Oceans Canada to international Arctic climate research programs. Primarily, it involves the collaboration of Fisheries and Oceans Canada researchers with colleagues in the USA from Woods Hole Oceanographic Institution (WHOI). The scientists from WHOI lead the Beaufort Gyre Exploration Project (BGEP, **http://www.whoi.edu/beaufortgyre/**) which forms part of the Arctic Observing Network (AON).

In 2012, JOIS also includes collaborations with researchers from:

Japan:

- Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan, as part of the Pan-Arctic Climate Investigation (PACI) collaboration with DFO.
- National Institute of Polar Research (NIPR), Japan as part of the Green Network of Excellence (GRENE) Program.
- Tokyo University of Marine Science and Technology, Tokyo, Japan
- Kitami Institute of Technology, Hokkaido, Japan.

USA:

- Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.
- Yale University, New Haven, Connecticut, USA.
- International Arctic Research Center (IARC), University of Alaska Fairbanks, Alaska, USA.
- Cold Regions Research Laboratory (CRREL), Hanover, New Hampshire, USA.
- Bigelow Laboratory for Ocean Sciences, Maine, USA.
- Applied Physics Laboratory, University of Washington, Seattle, Washington, USA.
- University of Montana, Missoula, Montana, USA.
- Naval Postgraduate School, Monterey, California, USA.

Canada:

- University of Manitoba, Winnipeg, Manitoba, Canada.
- Trent University, Peterborough, Ontario, Canada.
- Université Laval, Quebec City, Quebec, Canada.

UK:

- Bangor University, Gwynedd, Wales, UK.

Research questions seek to understand the impacts of global change on the physical and geochemical environment of the Beaufort Gyre Region of the Canada Basin of the Arctic Ocean and the corresponding biological response. We thus collect data to link decadal-scale perturbations in the Arctic atmosphere to interannual basin-scale changes in the freshwater content of the Beaufort Gyre, freshwater sources, ice properties and distribution, water mass properties and distribution, ocean circulation, ocean acidification and biota distribution.

2. CRUISE SUMMARY

The JOIS science program onboard the *CCGS Louis S. St-Laurent* began August 2nd and finished September 8th, 2012. The research was conducted in the Canada Basin from the Beaufort Shelf in the south to 81°N by a research team of 30 people. Full depth CTD casts with water samples were conducted, measuring biological, geochemical and physical properties of the seawater. The deployment of underway expendable and non-expendable temperature and salinity probes increased the spatial resolution of CTD measurements. Moorings and ice-buoys were serviced and deployed in the deep basin and the Northwind and Chukchi Abyssal Plains for year-round time-series. Underway ice observations were taken and on-ice surveys conducted. Zooplankton net tows, phytoplankton and bacteria measurements were collected to examine distributions of the lower trophic levels. Underway measurements were made of the surface water. Daily dispatches were posted to the web.

The goals of the JOIS program, led by Bill Williams of Fisheries & Oceans Canada (DFO), had to be adjusted as the lack of ice in our study area this year affected the ice-based programs. Additionally, the lack of ice meant an increased sea-state with the passing storms, requiring us to give up stations and/or plan alternate routes to continue working.

Our primary goals were largely met during the successful five-week program. Our science program was completed thanks to:

a) Efficiency and multitasking of the Captain and crew in their support of science.
b) Light ice conditions leading to faster transit times.
c) Minimizing the science program prior to the cruise:

Keeping additional projects that might require wire-time to a minimum
Selecting the minimal geographic extent needed for the science stations.

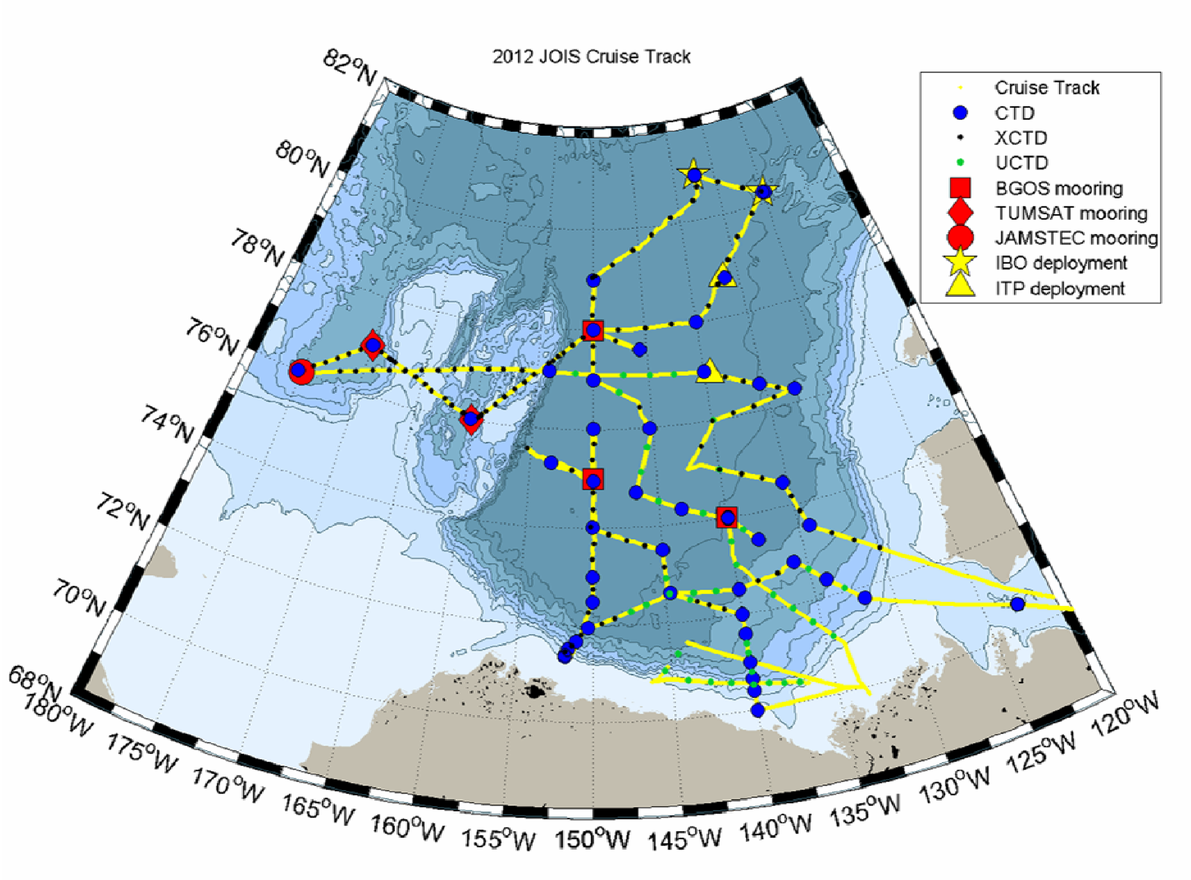


Figure 1.The JOIS-2012 cruise track showing the location of science station.

PROGRAM COMPONENTS

Measurements:

- At CTD/Rosette Stations:
    - 56 CTD/Rosette Casts at 47 Stations (DFO) with 1396 water samples collected for hydrography, geochemistry and pelagic biology (bacteria and phytoplankton) analysis (DFO, TrentU, TUMSAT, WHOI)
        - At all stations: Salinity, Oxygen, Nutrients, Barium, ^{18}O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), Coloured Dissolved Organic Matter (CDOM), and Chlorophyll-a
        - At selected stations: Ammonium, DIC (full profile), Argon and Oxygen isotopes, ^{129}I and ^{137}Cs
    - Upper ocean current measurements from Acoustic Doppler Current Profiler during most CTD casts (DFO)
    - 80 Vertical Net Casts at 42 select Rosette stations typically to a depth of 100m with one cast to 500m. (DFO)
    - 43 Turbulence measurements in the upper 500m using a Rockland Vertical Microstructure Profiler (VMT500) (Bangor University)

    - 29 stations (18 using the smaller foredeck rosette with a SBE 19+ CTD, the others using the main rosette and CTD) sampling 2 to 7 depths to assess the microbial diversity in the Canadian Basin using molecular tools (ULaval)
- 108 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1100m depth (JAMSTEC, WHOI , Tokyo University,)
- 39 UCTD (underway temperature, salinity and depth profiles) Casts typically to 600m depth. (DFO)
- Mooring and buoy operations
    - 4 Mooring Recoveries (3 deep basin (WHOI), 1 recovery and 1 dragging operation on the slope of the Chukchi Abyssal Plain (JAMSTEC assisted by WHOI))
    - 5 Mooring Deployments (3 deep basin (WHOI), 2 in the Chukchi and Northwind Abyssal Plains (TUMSAT , NIPR, performed by WHOI)
    - 2 Ice-Based Observatories (IBO, WHOI)

      the first consisting of :

      1 Ice Tethered Profiler (ITP, WHOI)
      1 Ice Mass Balance Buoy (IMBB, CRREL)
      1 Arctic Ocean Flux buoy (AOFB, NPS)
      1 O-buoy (Bigelow, UAF)
      1 Ice-Tethered Micros (Yale University)

      the second:

      1 Ice Tethered Profiler (ITP, WHOI)
      1 Ice Mass Balance Buoy (IMBB, EC)
      1 Arctic Ocean Flux buoy (AOFB, NPS)
      1 O-buoy (Bigelow, UAF)
      1 Ice-Tethered Micros (Yale University)
      4 GPS Buoys at corners of 10nm square around IBO site (UAF/IARC)
    - Apart from buoys, on-ice measurements were made during the Ice-Based Observatories set up

      Ocean current using an ADCP, temperature, salinity and depth using repeated casts of a UCTD, and a time series of temperature measurements using 8 SBE57 temperature loggers spaced every 7m and a SBE19 (TUMSAT)

      ADCP measurements (Bangor University)
    - 2 Ice Tethered Profilers deployed in open water (ITP, WHOI)
    - 2 UpTempo buoys and 2 SVP buoys, both near surface temperature profile buoys. One set (one of each) deployed near StnA in open water, the other set with one of the open water ITPs (UW, performed by WHOI)
    - 1 AXIB buoy deployed in open water (EC, performed by WHOI)
- Ice Observations
    - Ice Observations (UAF/IARC)

Hourly visual observations from bridge with photographs,.
Automated fixed-camera photos from two cameras using time interval of 30minutes or less
Screen capture snapshots of the ship's ice RADAR at 30 second intervals.
CNR-1 net-radiometer mounted on the bow for five days while the ship was in or near the sea-ice.
Opportunistic aerial observations during helicopter flight (1 flight)
On-ice observations of ice-depth transects and ice-cores at both IBO sites

- Ice Observations (KIT)

  Underway measurements of ice thickness from passive microwave radiometers (PMR), an electromagnetic inductive sensor (EM-31), and fixed forward-looking cameras
  On-ice observations of snow composition (snow pit survey), ice-depth transects, and spectrum albedo surveys

- Ice Observations (UofM)

  Cloud radiative forcing: underway measurements made using a FLIR SC660 thermal infared camera at intervals throughout the day.
  Incoming short wave, long wave and ultraviolet radiation: underway measurements made using radiometers mounted above the helicopter hangers.
  On ice observations made with a CNR1 net radiometer.
  Meteorlogical conditions measured hourly from the bridge
  Hyperspectral observation of sea ice (shipboard and on ice) using a HyperSAS instrument mounted to the bow of the ship for five days while the ship was near ice.
  On-ice CTD measurements (30 to 60m) using the 2" holes augured to measure ice thickness
  Helicopter based EM induction ice thickness surveys.

- Underway collection of meteorological, depth, photosynthetically active radiation (PAR), navigation data and near-surface seawater measurements of temperature, salinity, chlorophyll fluorescence and CDOM fluorescence (DFO). A combined 155 water samples were collected from the underway seawater loop for: Salinity, CDOM, Oxygen isotope and Argon, and chlorophyll (DFO, TrentU, WHOI) along with a few samples for oxygen, DIC, Alkalinity, Barium and 18O (TUMSAT). In addition, near-surface seawater was continuously measured for partial pressure of CO_2 (pCO_2) (UMontana).
- Underway sampling from an Airpointer, an automated instrument measuring air samples (EC)
- Daily dispatches to the web (WHOI)
- Drift bottles launched at 3 locations (DFO)

3. COMMENTS ON OPERATION

3.1 Ice conditions

We had a substantial amount of open water and/or weak and thin first and second year ice in our study area (see cover photo), more so than last year. The first and second year ice was heavily melt-ponded, though melting of sea ice was somewhat slowed during much of our expedition due to persistent fog (very likely resulting from the open water) that blocked incoming solar radiation (see www.nsidc.org).

The thickest multiyear ice was generally to the east of 140W near the northwestern border of the Canadian Arctic Archipelago. In general, ice was not a constraint during our program. Instead, it was a challenge to find ice thick enough, and far enough away from the ice edge, to install the ice-buoys of the Iced Based Observatories in the northern area.

This was a record low ice-extent year, with less ice on 26th of August than the 2007 record low. NSIDC reported on the event (http://nsidc.org/arcticseaicenews/2012/08/): "Arctic sea ice extent fell to 4.10 million square kilometers (1.58 million square miles) on August 26, 2012. This was 70,000 square kilometers (27,000 square miles) below the September 18, 2007 daily extent of 4.17 million square kilometers (1.61 million square miles).Including this year, the six lowest ice extents in the satellite record have occurred in the last six years (2007 to 2012)."

The eventual sea-ice minimum was reported by the National Snow and Ice Data Center to have occurred on 16 September with a record-low level of 3.41 million km^2. This new record is 18% below the previous record low set in 2007 of 4.17 million km^2 and 49% below the 1979-2000 average. New loss of sea ice in the north and east of the JOIS study area is evident from the satellite imagery and ice charts (below)

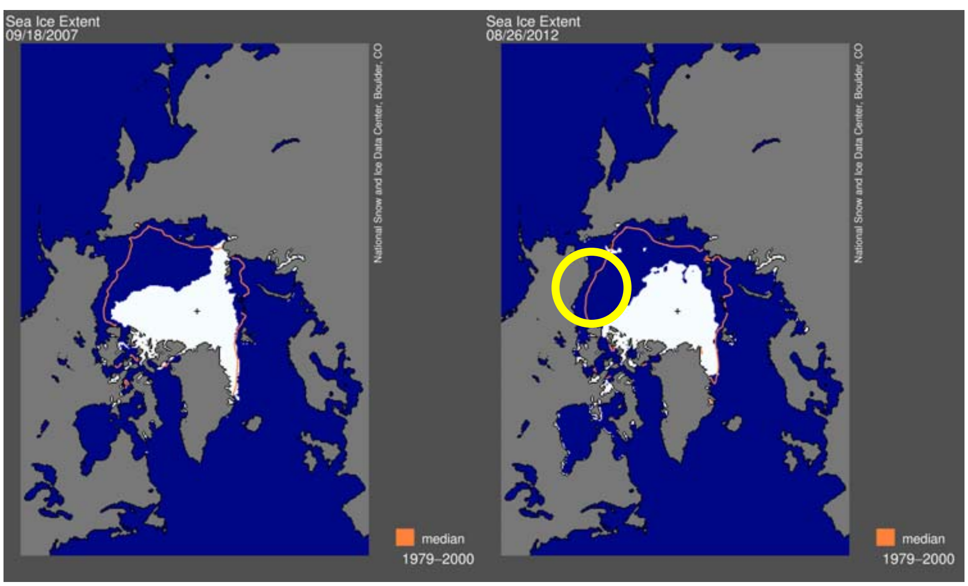


Figure 1. Sea-ice extent shown in white for 2007(left) and 2012 (right) with the 1979 to 2000 ice extent mean shown by the orange line. JOIS study area shown in the yellow circle.

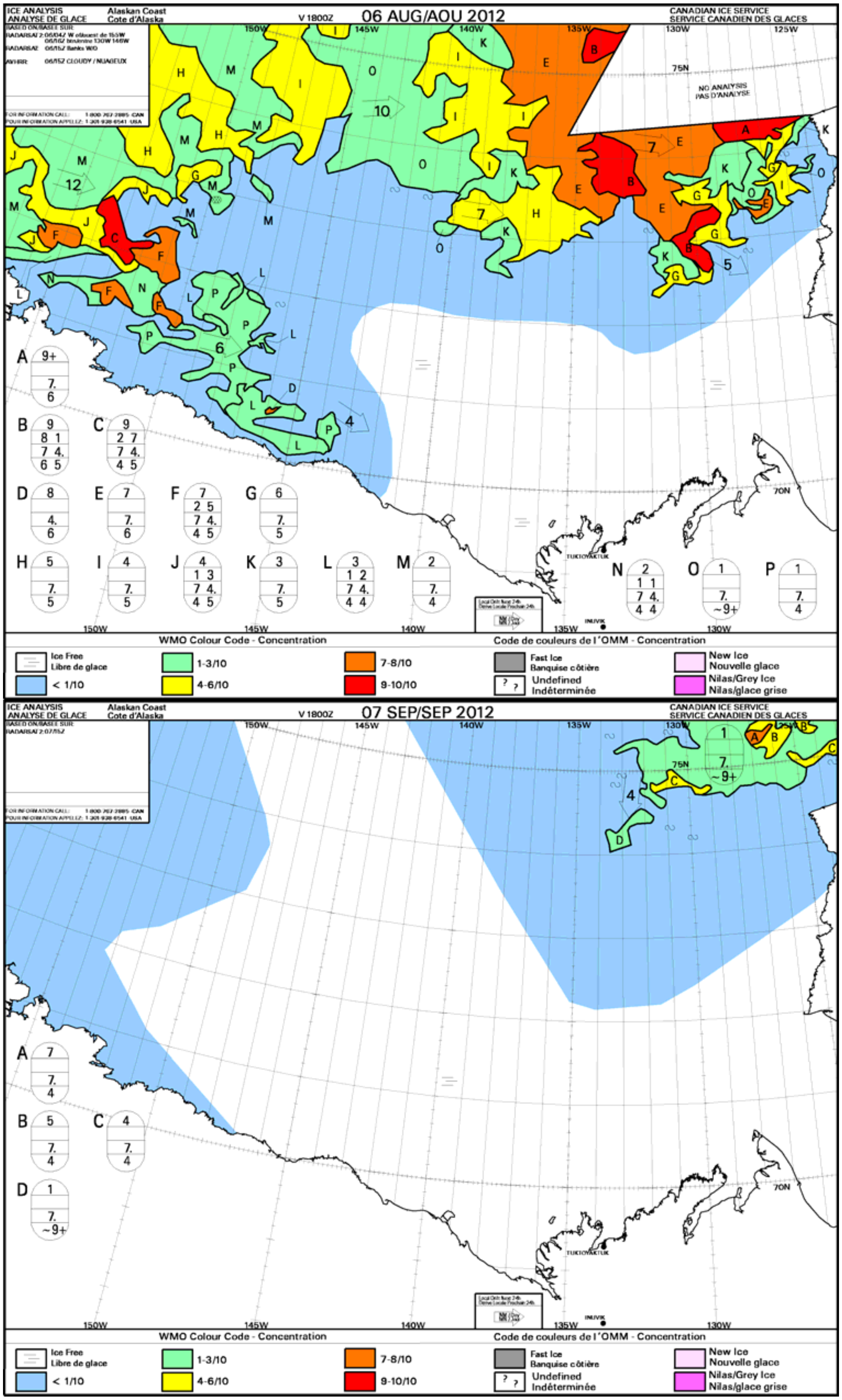


Figure 2: Canadian Ice Service ice concentration charts from the beginning and end of the cruise for the southern part of the JOIS cruise track.

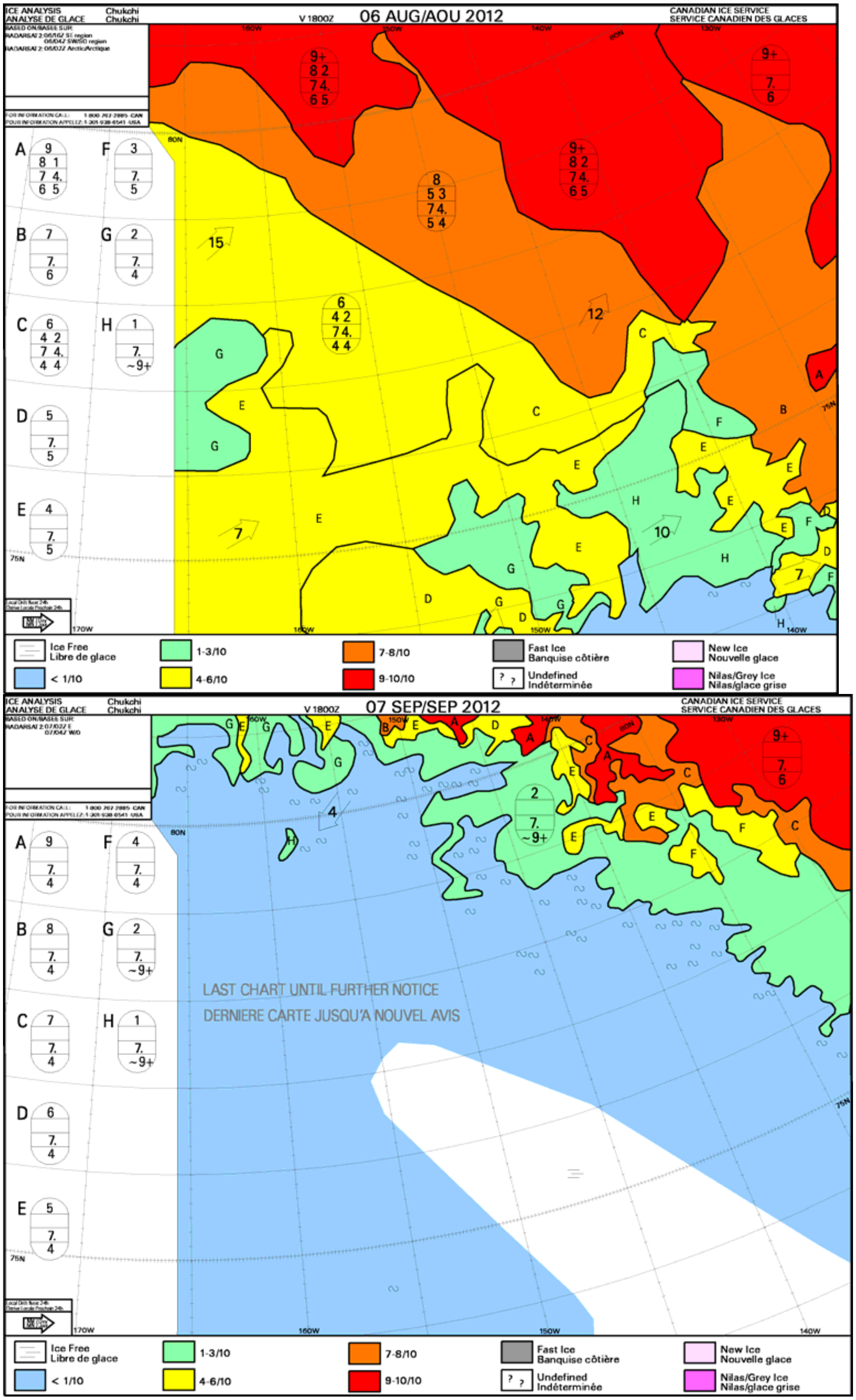


Figure 3: Canadian Ice Service ice concentration charts for the northern part of the JOIS cruise track.

3.2 Completion of planned activities

Nearly all primary objectives were met. However, due to lack of ice, work-stopping storms, return for spare parts, ship repair, SAR and med-evac:

- AIM mooring was not serviced (neither recovered nor redeployed)
- Ice buoys were not deployed:
    - Ice Beacon Buoys, IMBBs (not deployed)
    - 2xITP and 1 set of UpTempO/SVP (deployed in open water rather than in ice)
- at least 3 repeat-survey CTD stations missed
- Ice surveys reduced
    - EM helicopter surveys
    - on ice surveys (snow and ice thickness, ice composition, radiation studies, sub-ice current studies)
    - ship based ice surveys (ice thickness, composition, radiation studies)
- additional stations towards Banks Island and Price Patrick Island missed

3.3 Ship improvements completed for 2012

We are very appreciative of the items identified last year for improvement that were addressed such as assistance with the Hawboldt winch' repair, replacement of windows in the science lab containers, painting the rosette container and researching options for the replacement of the foredeck winch pads.

In addition, the improvements to the ship's local area network were helpful to the science team.

3.4 Suggestions for 2013

A list of suggested improvements to and comments about the ship's equipment and lab spaces will be sent separately.

4. ACKNOWLEDGMENTS

The science team would like to thank Captain Andrew McNeill, the crew of the *CCGS Louis S. St-Laurent* and the Coast Guard for their support. At sea, we were very grateful for everyone's top-notch performance and assistance with the program. Of special note were the successfully mounted sensors required for the science team's ice observers' measurements, repairs of the mooring operation traction winch, the shuffling of winches on the foredeck and all the steps completed to use the EM sensor on the helicopter. We'd like to thank the Canadian Ice Service and ice specialist Barb Molyneaux for assistance with ice images and weather information. It was a pleasure to work with helicopter pilot Chris Swannell again and we thank him and his mechanic for their valuable help with ice reconnaissance flights, support on the ice, and transport. Importantly, we'd like to acknowledge DFO, NSF and JAMSTEC for their continued support of this program.

This is the program's 10th year and the exciting and valuable results are a direct result of working with such an experienced, well trained and professional crew.

Joint Ocean Ice Study
2003 to 2012

With great appreciation for the

Officers and Crew of the
CCGS Louis S. St-Laurent

we recognize ten years of ocean study with our national and international colleagues in the Arctic's Canada Basin, the northern arc of Canada's Three Oceans.

Institute of Ocean Sciences
Sidney, BC

Fisheries and Oceans Canada   Pêches et Océans Canada

5. PROGRAM COMPONENT DESCRIPTIONS

Descriptions of the programs are given below with event locations listed in the appendix. Please contact program principle investigators for complete reports.

5.1 Rosette/CTD Casts:

PI: Bill Williams (DFO-IOS)
Sarah Zimmermann (DFO-IOS)

The primary CTD system used on board was a Seabird SBE9+ CTD s/n 0756 and the secondary system, used for casts 4 to 27, was also a SBE9+ with s/n 0724. The CTDs were configured with a 24- position SBE-32 pylon with 10L Niskin bottles fitted with internal stainless steel springs in an ice-strengthened rosette frame. The data were collected real-time using the SBE 11+ deck unit and computer running Seasave V7.21d acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, dissolved oxygen sensor, chlorophyll-a fluorometer, transmissometer, CDOM fluorometer and altimeter. In addition, on some of the casts shallower than 1000m, an ISUS nitrate sensor and PAR sensor were installed. A surface PAR sensor was installed but did not work well so data have been removed from the data set. A separate PAR was installed on the upper deck, logging continuously. These 1-minute averaged data are reported with the underway suite of sensors. The CTD sensors have 0-5V analogue output which is included in the CTD data string.

During a typical station:
During a typical cast, the rosette would be deployed followed by the ADCP. Two zooplankton vertical net hauls (bongo) to 100m were conducted from the foredeck and at select stations a secondary foredeck rosette with 8 bottles was deployed to 100m. Following the rosette cast a turbulence profile was performed from the foredeck using a VMP. As the VMP was ascending the ADCP was recovered. Please see the individual reports for more information on the ADCP, bongo, foredeck rosette, and VMP.

During a typical deployment:
The transmissometer and CDOM sensor windows were sprayed with deionised water and wiped with a DI water-soaked lens cloth prior to each deployment.
The pumps turned on manually at the surface. The package was lowered to 10m to cool the system to ambient sea water temperature and remove bubbles from the sensors. After 3 minutes the package was brought up to just below the surface to begin a clean cast, and lowered at 30m/min to 300m, then at 60m/min to within 10m of the bottom. Niskin bottles were normally closed during the upcast without a stop. During a "calibration cast" and when closing bottles of extreme interest, the rosette was yo-yo'd to

mechanically flush the bottle, meaning it was stopped for 30sec, lowered 1m, raised 2m, lowered 1m and stopped again for 30 seconds before bottle closure. The instrumented sheave (Brook Ocean Technology) provides a readout to the winch operator, CTD operator, main lab and bridge, allowing all to monitor cable out, wire angle, tension and CTD depth.

A single configuration file (.con file) per CTD was applied throughout. The .con file included the ISUS and PAR even though they were used only on a few of the casts. The data fields will be ignored in processing on casts when the sensors were not installed.

Use:
Casts 1 to 3 used CTD s/n 756
Casts 4 to 27 used CTD s/n 724
Casts 28 to 56 used CTD s/n 756

Data/Performance notes:

The SBE9+ CTD overall performance was good. Editing and calibration have not yet been done, but the data will likely meet the SBE9+ performance specifications given by Seabird. Header information of position, station name, and depth has not been quality controlled yet. Salinity and oxygen were sampled from the water and will be used to calibrate the sensors. Due to the asymmetrical plumbing on the temperature and conductivity sensor pairs, some post processing will be required for phase adjustment. CDOM and Chlorophyll-a water samples were collected and can be used for calibration at the user's discretion.

The biggest issue was trouble with delayed closure of the bottles (latches stuck/hung-up, and with incomplete flushing of the bottles. The pylon head was replaced during the cruise which helped improve the miss-trip problems. Washing the pylon head with hot soapy water freed some of the sticking latches. Readjusting the weight on the bottom of the frame also helped with some of the bottle flushing issues. The salinity samples taken from each bottle are very useful at determining if there has been a miss-trip or bottle flushing problem.

Casts 1 – 3 flow problems with primary sensors (temperature, conductivity, oxygen). Primary pump tested and confirmed it was not working.

Casts 4 to 27 performed using CTD s/n 724. Possible reduction of pressure accuracy based on in-air on-deck readings before and after each cast and slight salinity hysteresis of 0.002 PSU equivalent to a pressure difference of 4db between down and upcasts.

Cast 28 CTD s/n 756 reinstalled after replacing the primary pump with a pump from CTD s/n 724.

Cast 32 CTD pumps not turned until 50m depth. Will need to replace 1-50m with upcast data.

Cast 33 flow problems in primary sensors (temperature, conductivity, oxygen) likely caused by mechanical blockage. Problem affected depths 800 to 2000 and then self-cleared and did not reoccur. Pump was removed and inspected after cast, determined to still be working and was reinstalled.

Rough weather caused snapping in CTD wire resulting in a slight kink in the wire.
CDOM sensor: At cast 28 when changing between CTDs, noticed the bulkhead connector on CTD s/n 724 (coming off) had corrosion on pins. Cable was cleaned and CTD s/n 756 bulkhead connector inspected after ~10 casts. No corrosion was seen. End of cruise still no corrosion seen.

ISUS sensor: ISUS performed when installed except for casts 41 where it is likely that the ISUS was not powered on long enough in advance of the CTD. The ISUS data flickered on and off during cast. On cast 44 the profile is odd, and afterwards it was found that both the ISUS and PAR data were configured on the 2nd auxiliary channel due to an adapter mistakenly on the PAR cable. The profile ahs high values at the surface reducing to near zero at 60m with a normal looking ISUS profile below. The data look like it may the sum of the output voltages on the PAR and the ISUS as 0 to 60m is where PAR values go from highest to zero while nitrate is depleted but increases below this.

Hawboldt winch repair prior to cruise at Hawboldt:
- Wire was greased
- Spooling was realigned by installation of the correct spooling gear.

The winch worked well during cruise. On a few casts the brake was making noise, but was reset and did not cause anymore problems. One cold day at the end of the cruise the winch made a higher pitch wine ("whale song"). The noise seemed to be coming from the forward end of the winch though it was not determined where the noise was coming from. It was not a problem for the following casts, in warmer weather.

Block:
Grooves being cut into red delrin wheels. These will need to be replaced.

Temperatures were almost always above freezing which reduced wear on equipment in respect to other years. Lack of ice meant there was only one station where the CTD operator had to actually take care due to close drifting ice, otherwise we were in open water.

Foredeck rosette
A second smaller rosette was used on the foredeck to collect shallow (200m and less) additional water samples for the microbial diversity program (see below). The rosette had space for 12 10-L Niskins, though only 8 were installed. An internally-recording SBE 19+ with PAR and nitrate ISUS sensor were connected with the pylon using an Auto Fire Module (AFM) . Because multiple bottles were needed at certain depths, the time delay bottle closure method was used instead of using pressure values. The CTD does

not have a recent calibration and data should be compared with the main rosette before use.

5.2 Side-of-ship ADCP

Edmand Fok, Sarah Zimmermann (DFO-IOS)
PI: Svein Vagle (DFO-IOS)

Figure 2. ADCP being lowered to 5m during rosette cast. *Photo by Sarah Zimmermann*

While the ship is stopped for the CTD/Rosette casts, an RDI acoustic doppler current profiler (ADCP) that measures currents in the upper waters and acoustic backscatter from layers of zooplankton was lowered over the side. During previous JOIS cruises, 50kHz and 200kHz backscatter transducers have typically been mounted on the ADCP frame, however due to electronic problems they were not installed again this year. The package was lowered by crane from the boat-deck to approximately 5m beneath the surface and left in place until the completion of the CTD cast. The ship's heading and location, recorded using the SCS data collection system, provides ADCP orientation information so the velocity of surface currents can be determined.

Please see list of cast locations in ***Appendix B***

5.3 XCTD Profiles

PIs: Koji Shimada (TUMSAT), Daisuke Hirano (NIPR/TUMSAT), Motoyo Itoh (JAMSTEC), Andrey Proshutinsky (WHOI), Rick Krishfield (WHOI)

XCTD (Expendable Conductivity, Temperature and Depth profiler, Tsurumi-Seiki Co., Ltd.) probes provided by JAMSTEC, WHOI and TUMSAT were deployed from the ship's stern with temperature, salinity and depth data acquired by computer located in the stern (AVGAS) hold. The data converter, MK-130 (Tsurumi-Seiki Co., Ltd.) was used for XCTD deployment and for data conversion from raw binary to ascii data (original and 1-m interval). Salinity, density and sound speed were automatically calculated after XCTD probe deployment. Types of XCTD probe were XCTD-1 and XCTD-3 which can be deployed when ship steams at up to 12 knot and 20 knot, respectively. The casts took approximately 5 minutes for the released probe to reach its final depth of 1100m. In open water, depending on the probe type, the ship may have slowed to 12 knots for deployment, but when ship is surrounded by sea ice ship had to stop or be slower. XCTD deployments were spaced every 20-30 nm on the ship track typically between CTD casts to increase the spatial resolution. In/around the Northwind Ridge area, XCTD deployments had higher horizontal resolution, especially across the slope region.

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD are as follows;

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]
Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

During this cruise, 108 XCTDs were successfully launched, and 3 (highlighted by gray and yellow in Table.1) failed. Some of the working XCTDs had shortened profiles (see Table.1) presumably due to broken wires.

<u>CAUTION</u>: Positions given in the XCTD data files are incorrect. The corrected positions, taken from the underway GPGGA GPS data are based on deployment time. The corrected positions are given in the list of XCTD locations in the appendices.

Figure 1: XCTD probe deployment from the ship's stern (2011) and XCTD data converter MK-150.

The corrected positions are given in the list of XCTD locations in Appendix B

5.4 Zooplankton Vertical Net Haul.

Kelly Young (DFO-IOS)
PI: John Nelson(DFO-IOS)
Day Watch: Kelly Young and Hugh Maclean (DFO-IOS)
Night Watch: Rick Nelson (DFO-BIO), Paul Dainard (Trent)

Summary

A total of 80 bongo net hauls were completed at 42 stations. Bongos were harnessed and deployed in the same manner as previous JOIS cruises. Standard, duplicate tows to 100m were sampled at all stations except where weather and time restraints limited the deployment to one 100m tow (AG5, BL1, CB28aa, CB9 and MK2). Samples were preserved as follows:

Cast 1 (100m):

- 236 µm into buffered formalin (10%)

- 150 µm into buffered formalin (10%)
- both 53 µm combined to single buffered formalin (10%) sample

Cast 2 (100m):
- 236 µm 95% ethanol
- 150 µm frozen in whirl-pak at -80°C
- both 53 µm combined 95% ethanol

Stations with only one cast:
- 236 µm 95% ethanol
- 150 µm into buffered formalin (10%)
- both 53 µm combined to single buffered formalin (10%) sample

500m cast:
- 236 µm into buffered formalin (10%)
- 150 µm into 95% ethanol
- both 53 µm combined to single buffered formalin (10%) sample

Additions
Calanus lipid analysis (Carlton Rauschenberg, Bigelow)

Calanus hyperboreus females (20 individuals) and occasionally *C.* glacialis (up to 30 individuals, if present in sufficient numbers) were picked out of the second tow 150um sample. They will be used for lipid class analysis with LC-MS. This is an exploratory examination, possibly to compare with samples collected last year for the same purpose.

Please see table of casts in Appendix B

5.5 Microbial Diversity

Emmanuelle Medrinal, Mary Thaler
PIs: Connie Lovejoy (ULaval)

Introduction and objectives

Microbial communities, from all three domains of life, form the basis of marine food webs and have an important role in all biogeochemical cycles. While these communities are highly diverse, the majority of organisms cannot be cultured, and are virtually impossible to distinguish morphologically. We must therefore use molecular tools to describe their genetic and functional diversity. Pyrosequencing, clone libraries, denaturing gradient gel electrophoresis, qPCR and fluorescent *in situ* hybridization are all examples of such tools. Our goal for the 2012 JOIS cruise through the Canadian Basin was to collect samples for nucleic acids-based analyses, conventional and epifluorescent microscopy and chlorophyll analyses. These samples will be analyzed in the laboratory at Université Laval (Québec city).

Methodology

General Overview

In August and September 2012, seawater was collected from 2-7 depths using the main and the foredeck rosette onboard the CCGS *Louis St Laurent*.

Depths were chosen for sampling based on characteristics of the water column as profiled by the downcast of the CTD of the main rosette. The surface and chlorophyll maximum were always sampled, along with up to five other depths of interest such as the O_2 minimum, temperature minimum or maximum, or halocline.

DNA and RNA

Samples for nucleic acids were collected by filtering seawater onto a 3 µm polycarbonate filter and a 0.2 µm sterivex cartridge (Fisher Scientific) using a peristaltic pump. This method allows us to separate the large and small size fractions of the microbial community.

6 l of water were filtered at room temperature. Filters were stored in RNA Later buffer at -80 ºC.

Proteomics

Proteomics is a technique for identifying proteins in the samples. We collected samples from surface, chlorophyll maximum and deep water (600m) at two mooring stations : CB-21 and CB-9. We filtered 7 litres in triplicates. We use the same protocol as for nucleic acids.

Chlorophyll a and HPLC

We collected chlorophyll samples to quantify the biomass of phototrophic organisms. 500 ml of seawater was filtered through a glass fibre filter and stored in darkness at -80 ºC. In addition, we pre-filtered the same quantity of water through a 3 µm polycarbonate filter before filtering onto a glass fibre filter, in order to sample only the <3 µm size fraction of the photosynthetic community. Chlorophyll *a* will be extracted with ethanol and quantified at Université Laval.

Samples for HPLC analyses were collected at the surface and chlorophyll maximum. 2 l of seawater was filtered through a glass fibre filter, flash-frozen in liquid nitrogen, and then stored at -80 ºC. In addition, we pre-filtered the same quantity of water through a 3 μm polycarbonate filter before filtering onto a glass fibre filter, in order to sample only the <3 μm size fraction.

Epifluorescent Microscopy

Slides were made for epifluorescent microscopy at each station and depth sampled. These slides will be used to estimate bacterial and eukaryote abundance. Seawater was fixed with 1 % glutaraldehyde and processed 1-24 hours after sampling. For eukaryotic organisms, 50 ml of fixed sample was filtered through a 0.8 μm black polycarbonate filter and stained with DAPI, a nucleic acid stain. This filter was mounted on a slide using a drop of immersion oil and stored in darkness at -20 ºC. An identical procedure was followed for bacteria, except that 15 ml were filtered onto a 0.2 μm black polycarbonate filter.

Fluorescent in situ *Hybridization (FISH)*

FISH is a technique that uses fluorescent-labelled nucleic acid probes to identify a specific phylogenetic group of organisms under the microscope. Samples for FISH were collected in duplicate for eukaryotes and bacteria at each station and depth sampled. Seawater was fixed with 3.7 % formaldehyde and processed 6-24 hours after sampling. For eukaryotic organisms, 90 ml of fixed sample was filtered onto a 0.8 μm polycarbonate filter. For bacteria, 10 ml was filtered onto a 0.2 μm polycarbonate filter. Filters were air-dried and stored at -80 ºC.

Conventional Light Microscopy

At each station, at the surface and chlorophyll maximum, 250 ml of seawater was collected and fixed using Lugol's iodine as a fixative. At Université Laval, larger organisms, such as diatoms and dinoflagellates, will be identified to the highest possible taxonomic resolution on an inverted microscope.

Conclusions

With the samples we have collected for molecular and microscopic analyses, we hope to arrive at a more detailed understanding of the phylogeny, structure, and function of microbial communities in the Canadian Basin.

Please see full report for list of stations sampled and depths

5.6 Turbulence Profiles

Ben Lincoln and Ben Powell (Bangor University)
PI: Sheldon Bacon

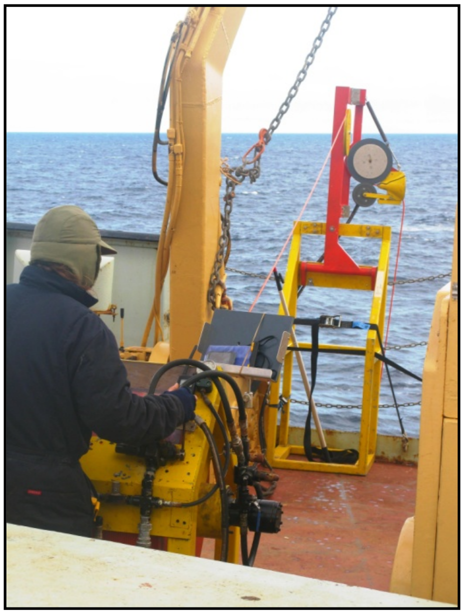


Figure 3: Hydralic winch and line puller for deployment of the VMP500 through the A-frame doors.

Turbulence was measured in the upper 500m using a Rockland Vertical Microstructure Profiler (VMP500). The instrument free-falls at 0.6m/s while excess cable is fed out by means of a hydraulic line puller and a hydraulic winch was used for recovery. In St Johns the winch was mounted in the centre of the foredeck on a winch pad aft of the hold access hatch with the line puller strapped to the gunwale. However on arrival onto the ship the winch was moved to a pad on the starboard side in order to provide better visibility during mooring operations. Deployment of the VMP was therefore conducted underneath the A-frame with the line-puller secured in position at the edge of the open gunwale door using ratchet straps to the A-frame. The open door meant that the A-frame was not required to raise the instrument for deployment. Instead the VMP was raised up to the line puller using the instruments own winch while being guided by hand. The hydraulic power-pack used to power the winch and line-puller was housed in the port side container along with the computer and GPS system which recorded and relayed the data in real time.

The dissipation rate of turbulent kinetic energy was calculated from measurements of velocity shear at dissipation length scales. Temperature and conductivity were sampled by Seabird sensors on the side of the instrument. Two airfoil type shear probes were used although issues with the probes meant that only one channel generated usable data during 10 of the casts (16 to 28). A total of 43 turbulence profiles were collected with maximum depths ranging from 540m deep to 85m (on the continental shelf).

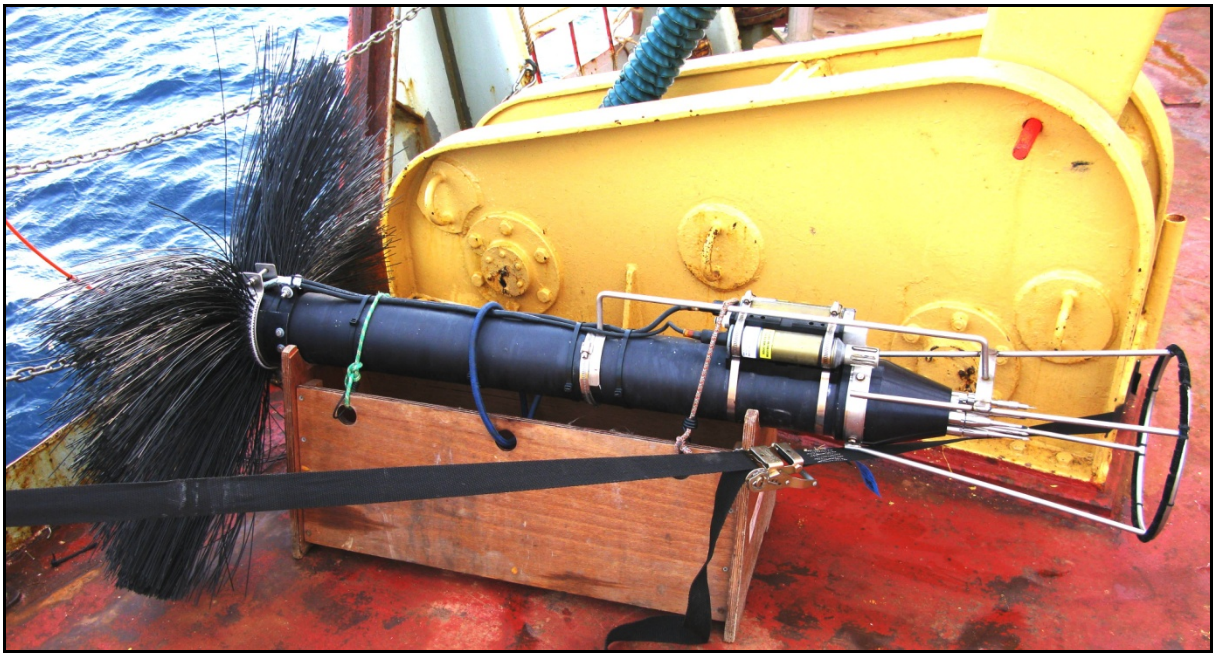


Figure 4: The Rockland VMP 500 turbulence profiler

Please see Appendix B for list of VMP station locations.

5.7 Underway Measurements

Edmand Fok, Sarah Zimmermann
PIs: Svein Vagle (DFO-IOS), Celine Gueguen (Trent University)

Overview

This report describes measurements taken at frequent regular intervals throughout the cruise. These measurements include:

- From the seawater loop system: salinity, temperature (inlet and lab), fluorescence, CDOM, gas tension, and oxygen saturation. *Please see separate report by Mike DeGrandpre below for underway measurements of pCO2.*
- SCS system was used to log
    a. From the Novatel GPS: all NMEA strings (GPRMC, GPGGA, HEHDT, among others) as well as position, time, speed and total distance
    b. AVOS weather observations of: air temperature, humidity, wind speed, barometric pressure
    c. Sounder reported depth and applied soundspeed
- Photosynthetically Active Radiation (PAR)

Seawater Loop

The ship's seawater loop system draws seawater from below the ship's hull at 9m using a 3" Moyno Progressive Cavity pump Model #2L6SSQ3SAA to the TSG lab, a small room just off the main lab ("aft lab"). This system allows measurements to be made of the sea surface water without having to stop the ship for sampling. The water is as unaltered as possible coming directly from outside of the hull through stainless steel piping without recirculation in a sea-chest. The manifold in the TSG has been insulated to minimize condensation. Flow rate is controlled to the lab by a Honeywell electronic system which has a data feed from a pressure sensor in the lab, and on one arm of the manifold, by a Kates mechanical flow rate controller. This arm also has a vortex debubbler so that the water provided to the TSG and other instruments is as bubble free as possible.

Autonomous measurements were made using:

- SBE38: Temperature s/n 0319
  Sensor was installed in-line, approximately 4m from pump at intake. This is the closest measurement to actual sea-temperature.
  SBE21 Seacat Thermosalinograph s/n 3297
  Temperature and Conductivity, Fluorescence (WET Labs WETStar fluorometer) and CDOM (WET Labs CDOM s/n WSCD-1281). The Fluorometer and CDOM sensors were plumbed off of a separate, manifold output than that supplying the Temperature and Conductivity. GPS was provided to the SBE-21 data stream using the NMEA from PC option rather than the interface box. A 5 second sample rate was recorded.
- Blue Cooler: Total gas (Gas Tension Device) 40s sampling interval, Oxygen.
  5 second sample rate, fed by water that has gone through the debubbler .
  (Svein Vagle, DFO)

Flow rate

During 2012-11, the manifold readings were typically 18.5 PSI and 30% output. Flow rates to the gas cooler varied from 3-5 liters/min and to the TSG from 8-10 l/min.

This year, due to communication issues between the sensor and the logger, the SBE48 Hull temperature sensor was not used.

Discreet Water Samples:

- Salinity, Chlorophyll-a, and CDOM were collected to calibrate the underway sensors.
- Barium, O18, DIC and Alkalinty were collected at limited locations
- Oxygen Isotope/Argon samples were collected to compare with CTD surface bottle samples to see if this could be an alternate collection method for near-surface water.

Figure 1. Seawater loop system providing uncontaminated seawater from 9m depth to the science lab for underway measurements. No “Black Box” was used this year, and a laptop replaces the desktop PC, otherwise the setup was similar to this photo from 2008.

Figure 2. Pump for seawater loop at intake in engine room (2007 photo)

The data from these instruments were connected to a single data storage computer. The data storage computer provided a means to pass ship’s GPS for integration into sensor files, to pass the SBE38 data from the engine room to the TSG instrument, and to pass the TSG data to the ship's data collection system (SCS).

Problems

The GPS data feed was distributed by the Knudsen computer in the CTD shack. This computer had a faulty motherboard and would occasionally hang up requiring a reboot until it finally died mid-way through the cruise. During these down periods no GPS would be received by the SCS server and therefore no feed was provided to the TSG, ADCP, Fugawi and CTD computers. The replacement Knudsen computer worked well for the rest of the trip.

SCS Data Collection System

The ship uses the Shipboard Computer System (SCS) written by the National Oceanographic and Atmospheric Administration (NOAA), to collect and archive underway measurements. This system takes data arriving via the ship's network (LAN) in variable formats and time intervals and stores it in a uniform ASCII format that includes a time stamp. Data saved in this format can be easily accessed by other programs or displayed using the SCS software.

The SCS system on a shipboard computer called the "NOAA server" collects:

- Location, speed over ground and course over ground as well as information about the quality of GPS fixes from the ship's GPS (GPGGA and GPRMC sentences)
- Heading from the ship's gyro (HEHDT sentences)
- Depth sounding from the ship's Knudsen sounder (SDDBT sentences)
- Air temperature, apparent wind speed, apparent and relative wind direction, barometric pressure, and relative humidity from the ship's AVOS weather data system (AVRTE sentences). Apparent wind gust data were not available this year. SCS derives true wind speed and direction (see note on true wind speed below).
- Sea surface temperature, conductivity, salinity, CDOM and fluorescence from the ship's SBE 21 thermosalinograph and ancillary instruments
- Sea surface temperature from the SBE48 hull mounted temperature sensor, though not available this year.

The RAW files were set to contain a day's worth of data, restarting around midnight. The ACO and LAB files grew until they were moved out of the datalog/compress directory for archiving.

Photosynthetically Active Radiation (PAR)

The continuous logging Biospherical Scalar PAR Reference Sensor, QSR2100, sn10350, calibration date 2/27/2007, was mounted above the helicopter hanger, with an unobstructed view over approximately 300deg. The blocked area is due to the ship's crane and smoke stack which are approximately 50' forward of the sensor. Data was sampled at 1/5second intervals but averaged and recorded at 1 minute intervals.

5.8 BGOS Field Operations

Rick Krishfield, Kris Newhall, Jim Dunn, and Steve Lambert (WHOI)
P.I.s not in attendance: Andrey Proshutinsky, John Toole,(both WHOI) and Mary-Louise Timmermanns (Yale University)

As part of the Beaufort Gyre Observing System (BGOS; www.whoi.edu/ beaufortgyre), three bottom-tethered moorings deployed in 2011 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in August 2012 from the *CCGS Louis S. St. Laurent* during the JOIS 2012 Expedition. Furthermore, two similar moorings (labeled GAM-1 and GAM-2) were deployed to the west of our array as part of a collaboration with the National Institute of Polar Research (NIPR) and Tokyo University Marine Science and Technology Center (TUMSAT) in Japan. Four Ice-Tethered Profiler (ITP; www.whoi.edu/itp) buoys were deployed, two in combination with an Arctic Ocean Flux Buoy (AOFB), Ice Mass Balance (IMBB), atmospheric chemistry O-Buoy, and Ice-Tethered Micros (ITM), and two in open water. In addition, our group participated in the open water deployments of two Uptempo, two temperature profiling buoys, one AXIB, and assisted the recovery of one JAMSTEC mooring and the attempted dragging operations.

Summary of BGOS 2012 field operations.

Mooring Designation	Depth (m)	2011 Location	2012 Recovery	2012 Deployment	2012 Location
BGOS-A	3825	74° 59.977'N	11-Aug	12-Aug	75° 0.007'N
		149° 58.655 'W	15:10 UTC	23:46 UTC	152° 0.005'W
BGOS-B	3824	78° 0.269'N	24-Aug	29-Aug	77° 59.987'N
		149° 58.638'W	15:19 UTC	22:15 UTC	150° 0.002'W
BGOS-D	3507	73° 59.623'N	21-Aug	22-Aug	73° 59.647'N
		139° 58.864'W	19:18 UTC	21:19 UTC	139° 58.844'W
GAM-1	2103			30-Aug	76° 0.002'N
				16:20 UTC	160° 9.999'W
GAM-2	2222			31-Aug	77° 0.009'N
				19:48 UTC	169° 59.996'W
ITP65/AOFB24/IMBB/O-Buoy/ITM1				27-Aug	80° 53.3'N
				01:32	137° 26.3'W
ITP66/AOFB27/IMBB/O-Buoy/ITM2				27-Aug	80° 12.7'N
				23:53	130° 2.3'W
ITP64				28-Aug	78° 46.5’N
				17:58	136° 39.8’W
ITP62				4-Sep	76° 57.0'N
				17:32	139° 32.4'W

Moorings:

The centerpiece of the BGOS program are the bottom-tethered moorings which have been maintained at 3 (sometimes 4) locations since 2003. The moorings are designed to acquire long term time series of the physical properties of the ocean for the freshwater and other studies described on the BG webpage. The top floats were positioned approximately 30 m below the surface to avoid ice ridges. The instrumentation on the moorings include an Upward Looking Sonar mounted in the top flotation sphere for measuring the draft (or thickness) of the sea ice above the moorings, an Acoustic Doppler Current Profiler for measuring upper ocean velocities in 2 m bins, one (or two) vertical profiling CTD and velocity instruments which samples the water column from 50 to 2050 m (and 2010 to 3100 m) twice every two days, sediment traps for collecting vertical fluxes of particles, and a Bottom Pressure Recorder mounted on the anchor of the mooring which determines variations in height of the sea surface with a resolution better than 1 mm.

As of this year, 9 years of data have been acquired by our mooring systems, which document the state of the ocean and ice cover in the BG. The seasonal and interannual variability of the ice draft, ocean temperature, salinity and velocity, and sea surface height in the deep Canada Basin are being documented and analyzed to discern the changes in the heat and freshwater budgets. Trends in the data show an increase in freshwater in the upper ocean in the 2000s, some of which can be accounted for by the observed decrease in ice thickness, but Ekman (surface driven) forcing is also a significant contributor.

This year, in collaboration with NIPR and TUMSAT in Japan, 2 additional mooring systems (which are delineated GAM-1 and GAM-2) were installed west to augment the BGOS array. The configuration of these moorings is the same as the BGOS systems, except half as long as they were located in the shallower Chukchi/Northwind topography. The deployment operations were conducted in the same manner as the BGOS moorings described below.

Buoys:

Because the moorings only extend up to about 30 m from the ice surface, we use automated ice-tethered buoys to sample the upper ocean and sea ice. On this cruise, we deployed 4 Ice-Tethered Profiler buoys (or ITPs), and assisted with the deployments of two Naval Postgraduate School Arctic-Ocean Flux Buoys, two US Army CRREL Ice-Mass Balance buoys, two O-Buoys, two ITMs, two Uptempo, and two temperature profiling buoys. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO). Two IBOS were installed, the remainder of the buoys were deployed in open water over the side of the ship.

The centerpiece ITPs obtain profiles of seawater temperature and salinity from 7 to 760 m twice each day and broadcast that information back by satellite telephone. The flux buoys measure the fluxes of heat, salt, and momentum at the ice ocean interface, and the ice mass balance buoys measure the variations in ice and snow thickness, and obtain surface meteorological data. Most of these data are made available in near-real time on the different project websites.

The acquired CTD profile data from ITPs document interesting spatial variations in the major water masses of the Canada Basin, show the double-diffusive thermohaline staircase that lies above the warm, salty Atlantic Layer, measure seasonal surface mixed-layer deepening, and document several mesoscale eddies. The IBOs that we have deployed on this cruise are part of an international collaboration to distribute a wide array of systems across the Arctic as part of an Arctic Observing Network to provide valuable real-time data for operational needs, to support studies of ocean processes, and to initialize and validate numerical models.

Operations:

The mooring deployment and recovery operations were conducted from the foredeck using a dual capstan winch as described in WHOI Technical Report 2005-05

(Kemp et al., 2005). Before each recovery, an hour long precision acoustic survey was performed using an Edgetech 8011A release deck unit connected to the ship's transducer and MCal software in order to fix the anchor location to within ~10 m. The mooring top transponder (located beneath the sphere at about 30 m) may also be interrogated to locate the top of the mooring. In addition, at every station the sphere was located by the ship's 400 khz fish finder.

This year, no ice was present over the mooring sites simplifying the release process. In coordination with the Captain acoustic release commands are sent to the release instruments just above anchor, which let go of the anchor, so that the floatation on the mooring can bring the system to the surface. Then the floatation, wire rope, and instruments are hauled back on board. Hydraulic problems with the dual capstan cart required that the wire be manually spooled which lengthened the deployment time by up to an hour. Data is dumped from the scientific instruments, batteries, sensors, and other hardware are replaced as necessary, and then the systems are subsequently redeployed for another year.

The moorings were redeployed anchor first, which requires the use of a dual capstan winch system to safely handle the heavy loads. Typically it takes around 5 hours to deploy the 3800 m long systems but the problems with the dual capstan cart required that a backup spooling cart be used which lengthened the deployment time by up to an hour.

Complete year long data sets with good data were recovered from all ULSs, all ADCPs, and every BPR. In addition both sediment traps collected samples for the duration of the deployment. The MMPs had mixed results, with full year-long data recovered from both deep profilers, but incomplete results from the shallow profilers.

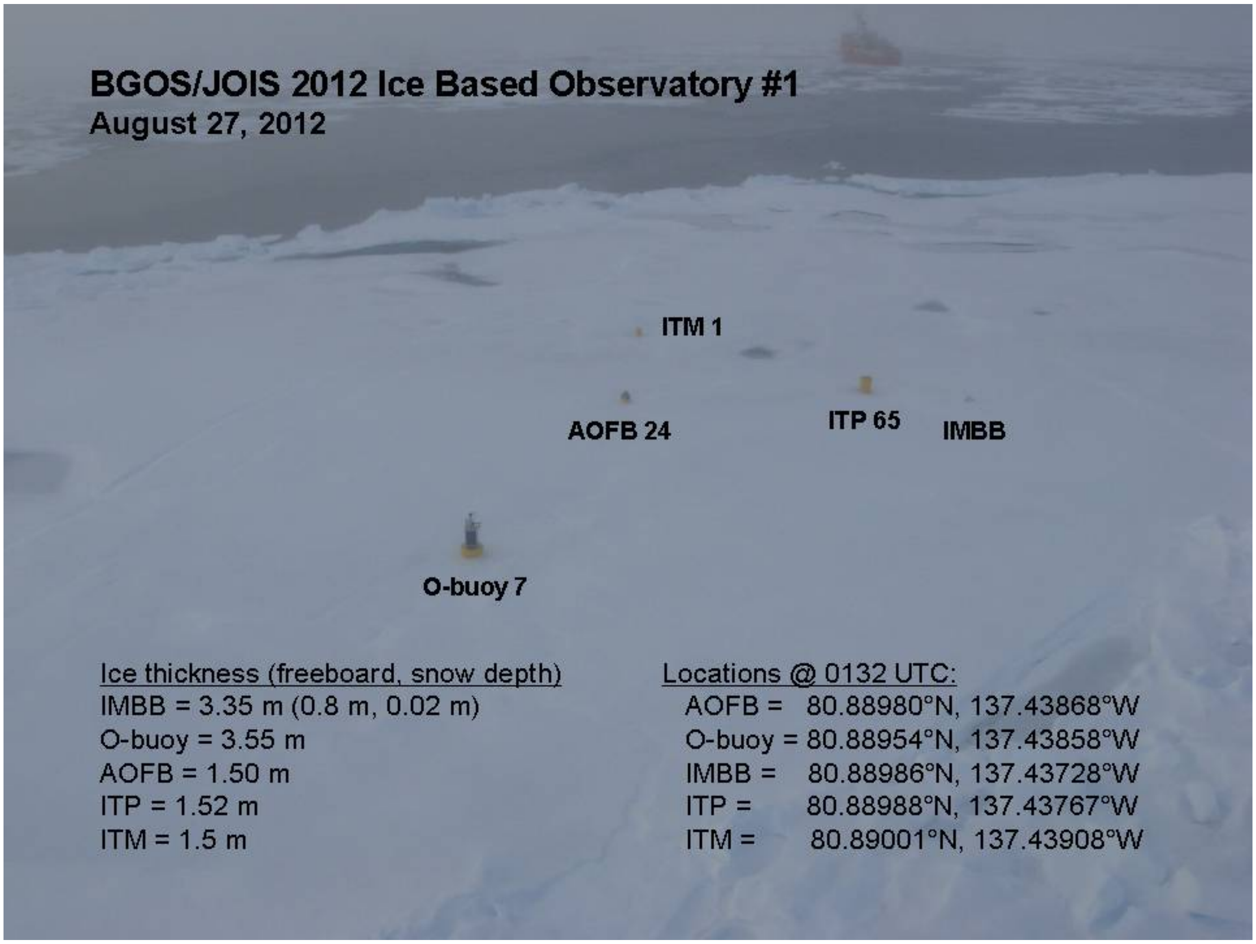
ITP deployment operations on the ice were conducted with the aid of helicopter transport to and from each site according to procedures described in a WHOI Technical Report 2007-05 (Newhall et al., 2007). Not including the time to reconnaissance, drill and select the ice floes, these deployment operations took between 5-6 hours each (depending on the number of systems installed in each IBO) including transportation of gear and personnel each way to the site. ITPs 65 (with full biosuite sensors and fixed SAMI PCO_2) and 66 (with MAVS current profiler and fixed microcat) were deployed with the IBOs. Photos of the IBOs as deployed with some initial information are presented below. Ice analyses were also performed by others in the science party, while the ITP deployment operations took place.

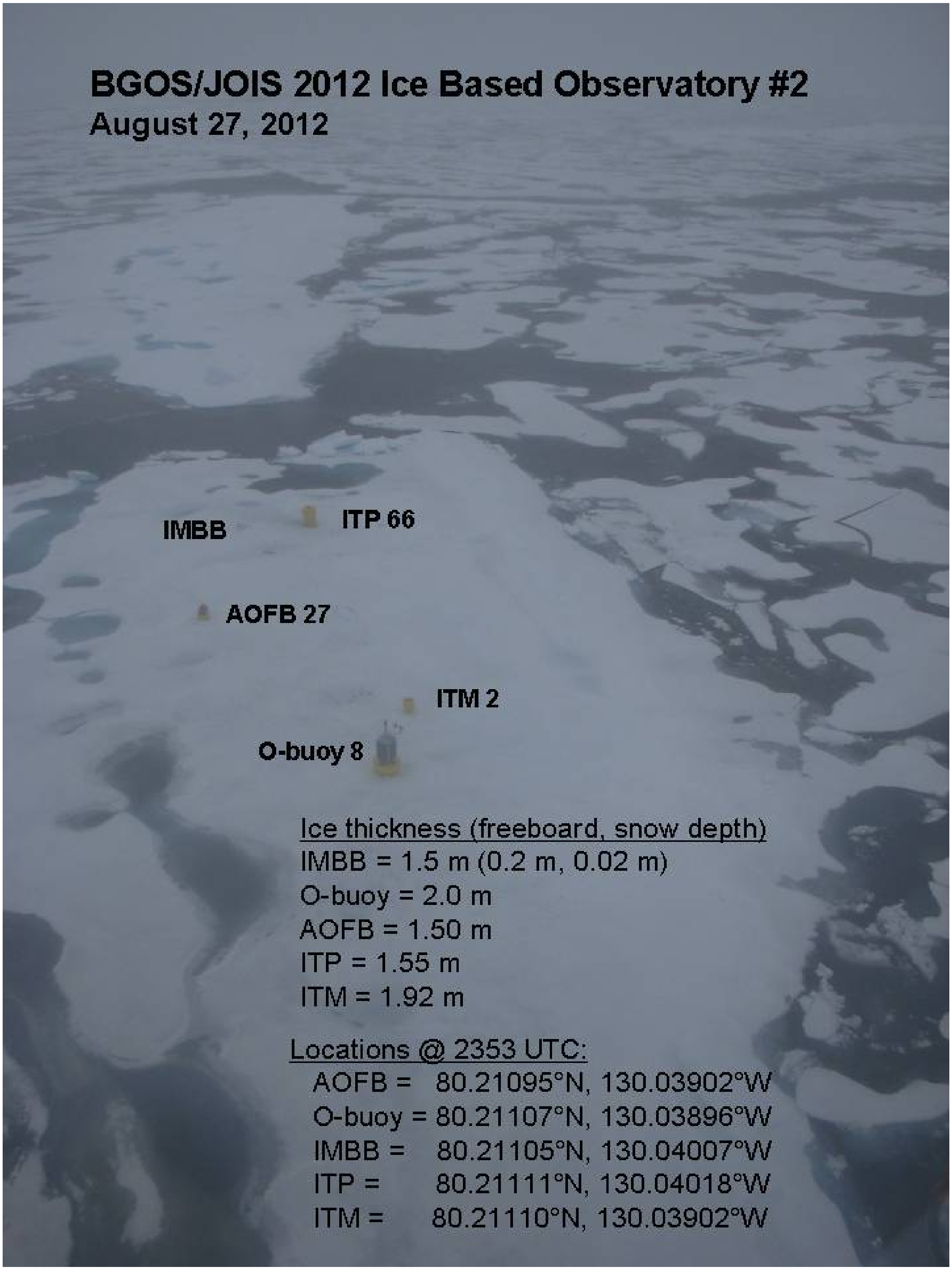
ITPs 64 (with full biosuite sensors and fixed SAMI PCO_2) and 62 were deployed in open water using the ship's forward A-frame. Two ITPs were to be recovered this cruise, but lack of ship time prevented these operations to be performed.

Since deployment, all of the ITPs have begun profiling and transmitting data except for the profiler on ITP 66 which hasn't communicated with the surface package although the microcat on the same inductive modem loop is functioning.

Other:

Dispatches documenting all aspects of the expedition were posted in near real time on the WHOI website at: www.whoi.edu/beaufortgyre/2012-dispatches.




BGOS/JOIS 2012 Ice Based Observatory #2
August 27, 2012
IMBB
ITP 66
AOFB 27
ITM 2
O-buoy 8
Ice thickness (freeboard, snow depth)
IMBB = 1.5 m (0.2 m, 0.02 m)
O-buoy = 2.0 m
AOFB = 1.50 m
ITP = 1.55 m
ITM = 1.92 m
Locations @ 2353 UTC:
AOFB = 80.21095°N, 130.03902°W
O-buoy = 80.21107°N, 130.03896°W
IMBB = 80.21105°N, 130.04007°W
ITP = 80.21111°N, 130.04018°W
ITM = 80.21110°N, 130.03902°W

5.9Arctic Ocean Sea Surface pCO_2 and pH Observing Network

Mike DeGrandpre (University of Montana)

U.S. National Science Foundation Project: Collaborative Research: An Arctic Ocean Sea Surface pCO_2 and pH Observing Network

Overview: This project is a collaboration between the University of Montana and Woods Hole Oceanographic Institution (Rick Krishfield and John Toole). The primary objective is to provide the Arctic research community with high temporal resolution time-series of sea surface partial pressure of CO_2 (pCO_2) and pH. The pCO_2 and pH sensors will be deployed on the WHOI ice-tethered profilers, or ITPs. Placed on the ITP cable just under the ice, the sensors will send their data via satellite using the WHOI ITP interface. During 2012, pCO_2 sensors will be deployed and in year 2, pH sensors will be added to the ITPs.

Figure 1: SAMI being deployed on ITP 65 during the first ice station. A conductivity and dissolved oxygen sensor are also deployed as part of this system.

Cruise Objectives: Our objectives during the JOIS 2012 cruise were as follows:

1. deploy 2 pCO_2 sensor systems on WHOI bio-optical ITPs.
2. conduct underway pCO_2 measurements to provide data quality assurance for the ITP-based sensors and to map the spatial distribution of pCO_2 in the Beaufort Sea and surrounding margins.
3. PI to assist with other shipboard research activities and to interact with ocean scientists from other institutions.

Cruise Accomplishments: We deployed 2 SAMI-CO_2 sensors on ITPs, one at the first ice station (Figure 1) and another at an "open water" site. We collected underway pCO_2 data using an underway autonomous sensor (SAMI-CO_2) and an infrared equilibrator-based system (SUPER, Sunburst Sensors). These instruments were connected to the Louis seawater line located in the main lab. The sensor data collection is summarized in the table below.

Table 1: Instruments utilized or deployed by the University of Montana during the JOIS 2012 cruise

pCO_2 measurement system	Instrument IDs	Location	Duration
underway infrared-equilibrator pCO_2	SUPER (Sunburst Sensors)	entire cruise track (see IOS report in this document)	8/5/12 – 9/7/12
underway indicator-based pCO_2	SAMI-CO_2 (Sunburst Sensors)	cruise track except from stations PP to into Kugluktuk	8/5/12-9/5/12
ITP SAMI-CO_2 including dissolved O_2, salinity and temperature	WHOI ITP #65, SAMI-14	first ice station, 6 m depth (see WHOI cruise report in this document)	8/26/12 - present
ITP SAMI-CO_2 including dissolved O_2, salinity and temperature	WHOI ITP #64, SAMI-12	6 m depth (see WHOI cruise report in this document)	8/28/12 - present

5.10 CAP10 Mooring Operations

Jonaotaro Onodera, Hirokatsu Uno
PI: Takashi Kikuchi, Motoyo Itoh, Naomi Harada (JAMSTEC)

Summary: Bottom-tethered mooring at Station CAP10 was successfully recovered. Acoustic search and dragging of bottom-tethered sediment traps at Station CAP10t was conducted. However, the sediment trap mooring was not found in this cruise.

At first, we express the deepest gratitude to ungrudging supports by captain and crew of Louis S. St-Laurent, mooring work members from the Woods Hole Oceanographic Institute (WHOI), chief scientist, and Dr. Daisuke Hirano (TUMSAT) for our mooring works at Stations CAP10 and CAP10t. In particular, in despite of no prior contract for cooperative mooring works between WHOI and JAMSTEC in this cruise, WHOI's positive supports were significantly helpful for our works.

Recovery of CAP10

The bottom-tethered mooring for physical oceanographic observation at Station CAP10, which was deployed by R/V Mirai in autumn 2010 (MR10-05 cruise), was successfully recovered with the full cooperation of the Woods Hole team at 1 September 2012. Both the deployed acoustic releasers (Nichiyu Model L-Ti and EdgeTech 8242XS) responded to enable command and ranging. The estimation of accurate mooring location and the mooring release were conducted with the WHOI's system (EdgeTech deck unit, software M-Cal ver. 1.07) in the fore lab. and transducer at the bottom of ship. The estimated coordinate at Station CAP10 is 75°59.7940'N 175°14.9552W. Just after the release of CAP10 mooring at 9:03 (16:03 UTC), the top buoy came up to surface near the starboard side of fore deck.

The recovery method established by the Woods Hole research team for BGOS project was applied to the recovery of this mooring with WHOI's Lebus winch. The recovery work completed without incidents. The on-deck time of double releasers was 2 hours and 44 minutes later since the mooring release. All observation data recorded in the deployed CT/CTD and current meter were successfully retrieved within 24hours after the mooring recovery.

Acoustic search of CAP10t

The bottom-tethered mooring with two sediment traps, which was deployed by R/V Mirai in 2010, had not responded to any call signals for deployed acoustic releasers (Nichiyu Model-L) in tandem. The acoustic search was conducted as described below.

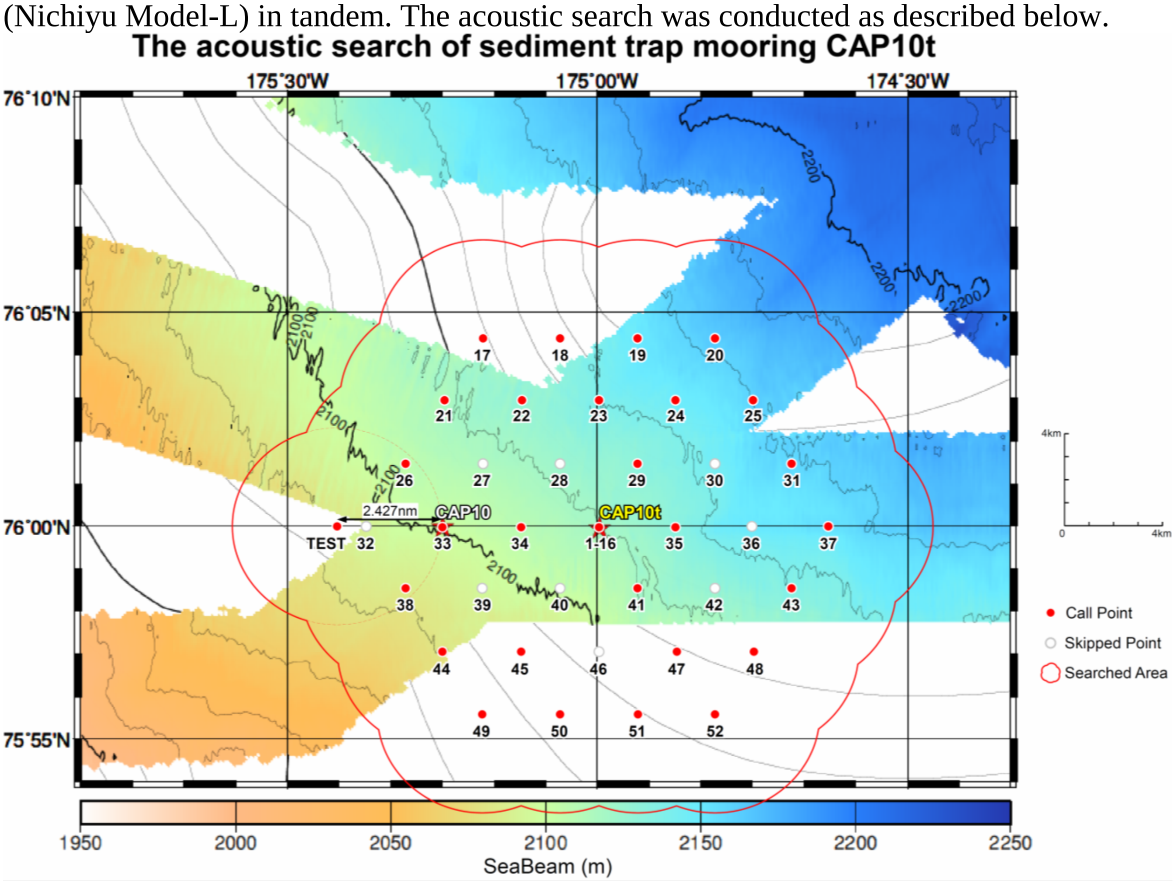


Figure 1. The map for wide acoustic search of CAP10t. The red dots represent call point. Inside the rounded hexagonal line in red corresponds to the acoustic search area in this cruise. The color contour represents water depth measured by the Sea Beam system in R/V Mirai. The white-black contour is based on the

1. Making call points around Station CAP10t (Figures 1 and 2). Total of 52 call points were arranged: 16 points within 1km from the CAP10t; and 36 for wider area (1.81nm

interval) in 12-13.6km from CAP10t. The map with call points and coordinate list for each call point was shared with bridge and working space in foredeck.

2. Operation check of deck unit without any malfunction. Before the recovery of CAP10, sending call signal (= enable command) to releaser and the detecting response was attempted between Nichiyu deck unit (Model SH-100) and the Nichiyu releaser (Model L-Ti) deployed at CAP10. This operation test was successful on the call and ranging.
3. Confirmation of the operative area between the deck unit and releaser for wider acoustic search. The operation between deck unit and deploying releaser at CAP10 was attempted at the test point 2.427nm away from CAP10 (Figure 1). This communication test was successful, and thus the alignment of call point with 1.81nm interval should be meaningful.
4. Acoustic search of CAP10t. The call signal (= enable command) was sent at the arranged call points. Some call points were skipped because the search area was fully covered without those points. However, we could not detect any responses from the releasers of CAP10t. At three call points 200 m away from CAP10t, we sent release command to releasers under ship's permission. However, nothing came up to surface. The travel time between wider call points (1.81nm in distance) was about 25-30minites. Total of 19.5 hours were consumed for this acoustic search.

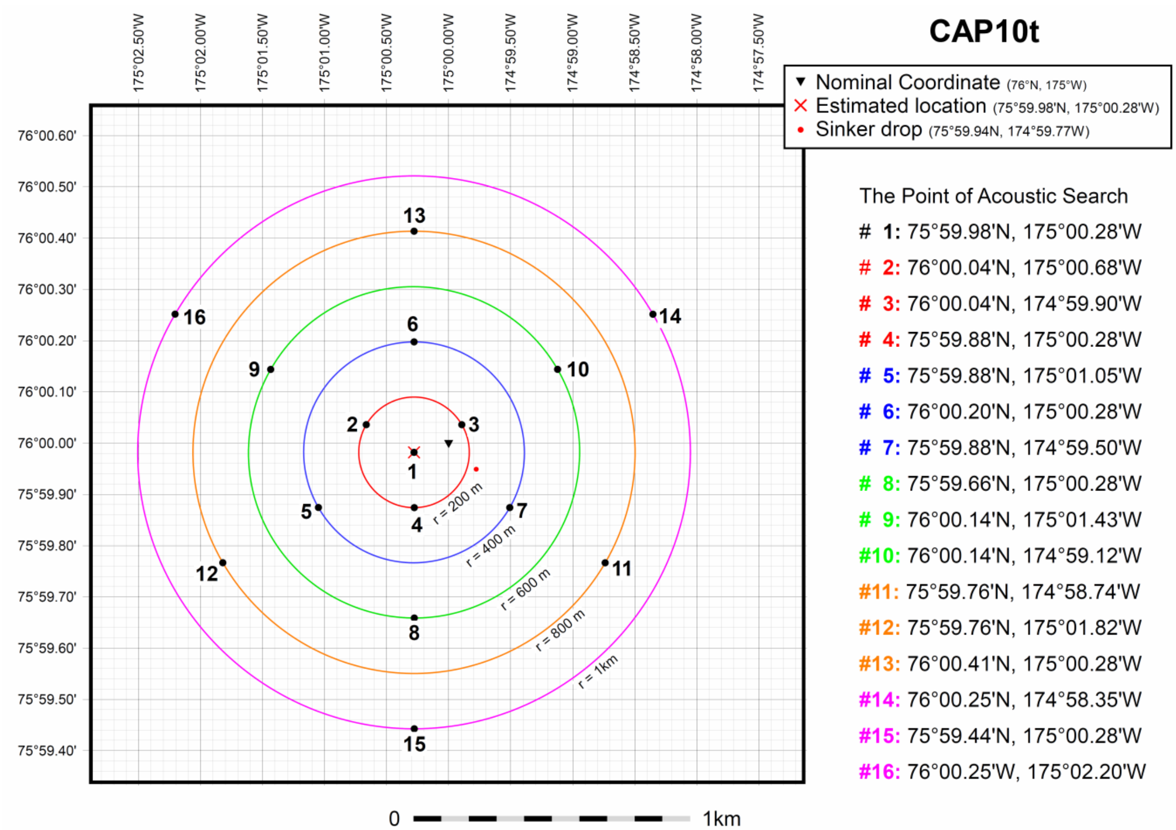


Figure 2. The call-points #1-16 near Station CAP10t. The sending release command was also attempted at points #2-7.

Dragging CAP10t

Because CAP10t did not respond to call signals, dragging of CAP10t mooring was attempted under the cooperation by the Woods Hole team at 2nd September. However, we could not find the mooring by the end of our ship time. The dragging method is as described below.

During the early-middle cruise period, the design of dragging tool, the dragging method, and the safety had been discussed several times among captain, crew, chief scientist, WHOI's mooring team, and us. Based on the idea supplied by captain, crew, and WHOI team, the applied dragging line was composed of chain connected to bitt on the foredeck, weak link rope for safety, 1995 m mooring wire recovered at the BGOS Station, chain with two depressors (~26kg weight), 6 hooks, and three of 17 inch glass buoys (Figure 3). In case of accidental lost of dragging line due to the break of weak link, berthing line was also connected between dragging wire and bitt on the fore deck (Figure 4). The alignment of one + two glass buoys was decided with an expectation for snaking motion of dragging tools by water resistance to glass floats. If hooks of dragging tool could hit the nylon rope of the mooring, the upper part of sediment trap mooring might come up to surface by cutting mooring rope with hook.

For the deployment and retrieve of dragging line, A-frame and WHOI's Lebus winch in foredeck was employed. The deployment of dragging line completed within 1hour and 30min. The ship's route plan for dragging was decided by captain. The dragging was continued for about 4 hours. The ship's cruise track during this dragging operation shows that the dragging tools passed through the acoustic call points near CAP10t and the estimated location of CAP10t three times (Figure 5).

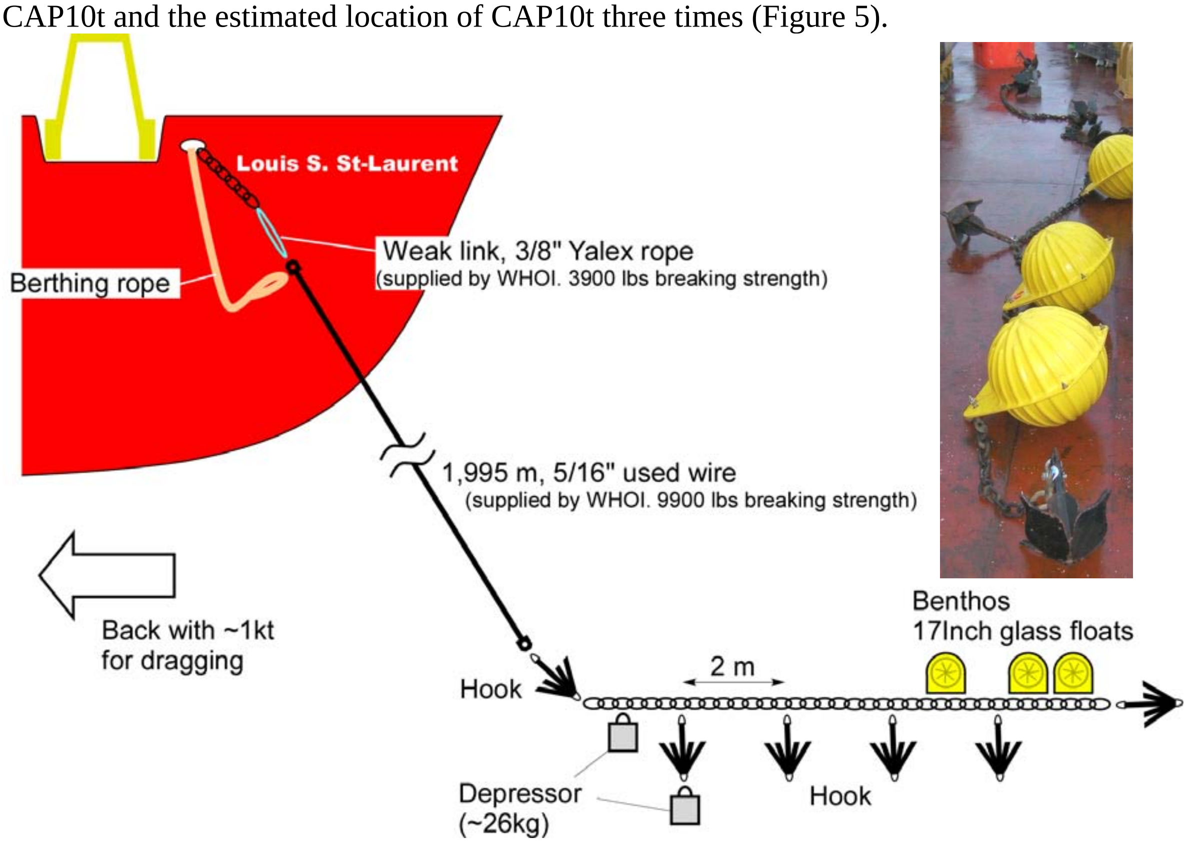


Figure 3. The main components of dragging line for CAP10t. The connecting parts such as shackles are not figured here. The photograph of dragging tools

Figure 4. The photographs of dragging line. (a) connection part of weak link, 1995m wire, chain, and ship's berthing line. (b & c) the chain and berthing line lashed to bitt on the fore deck.

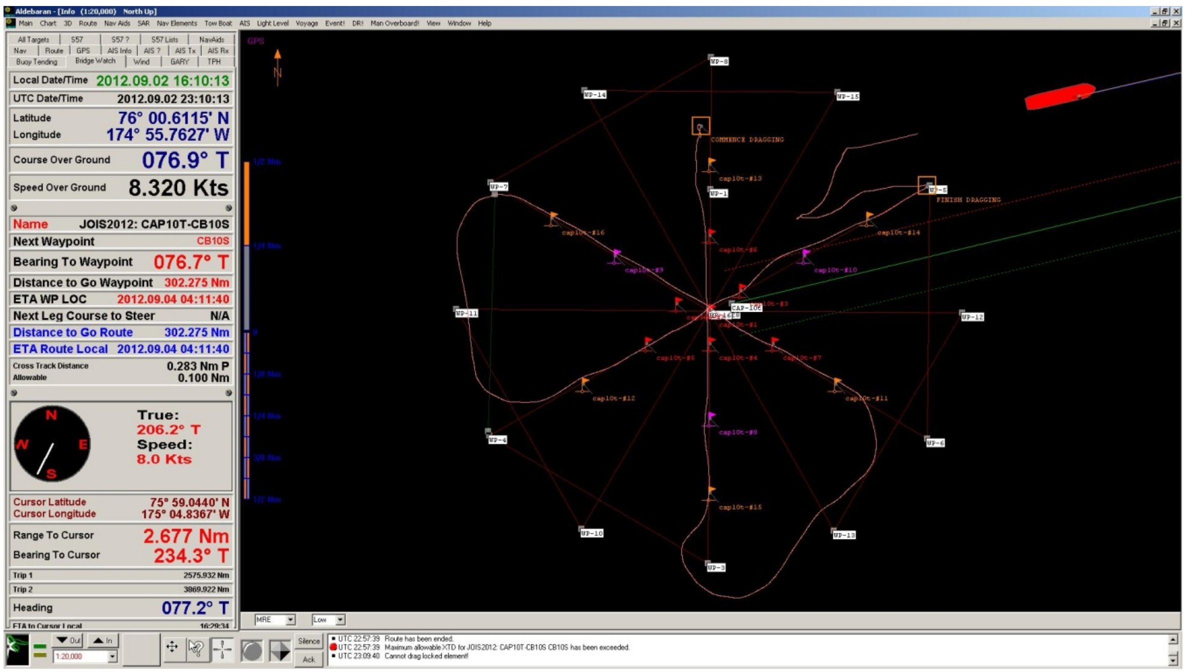


Figure 5. The ship track in dragging operation for CAP10t search. The small flags in track map represent the acoustic call point #1-16 shown in Figure 2.

5.11 UpTempo program

PI: Mike Steele (UW)

Four buoys were deployed by the WHOI team during JOIS.as part of the UpTempo Program. Two were manufactured by MetOcean, 60m long SVP buoys and two by Marlin-Yug, 80m long UpTempo buoys.. All buoys were deployed in the open water. The plan had been to deploy the second pair of buoys in the ice along with a seasonal ice mass balance buoy and an ice-tethered profiler. However due to the lack of ice, the seasonal-IMB was not deployed and the buoys brought back south for deployment into open water along with ITP #62.

"UpTempO buoys are designed to measure ocean temperature in the euphotic (light-influenced) surface layer of the Polar Oceans. These relatively inexpensive ocean buoys are designed to be easily deployed in open water or sea ice – covered conditions. As sea ice thins and retreats more and more each summer, the magnitude of ocean surface warming is accelerating. Our main goal is to measure this warming."

Text from: http://psc.apl.washington.edu/UpTempO/UpTempO.php

SVP's are Surface Velocity Program buoys, described at this link below:
http://www.metocean.com/ProdCat.aspx?CatId=1&SubCatId=5&ProdId=1

Buoy Type	Manufact.	Deployment Date and Time (UTC)	Deployment Latitude (N)	Deployment Longitude (E)	Notes
Iridium SVP-BTC80	Metocean	2012-08-07 15:42	72 30.476' N	139 58.966' W	Open water deployment from ship
UpTempO-IM (IMEI 300234011162190)	Marlin-Yug	2012-08-08 00:13	72 35.831' N	144 42.450' W	Open water deployment from ship
SVP-BTC60 (IMEI 300234011240990)	Metocean	2012-09-04 18:14	76 55.916'N	139 28.350'W	Open water deployment from ship. Deployed about 2 miles away from ITP62 which was deployed an hour previously.
Uptempo (IMEI 300234011468710)	Marlin-Yug	2012-09-04 20:38	76 46.852'N	137 50.652'W	Open water deployment from ship

5.12 International Arctic Buoy Program

P.I. Champika Gallage, Environment Canada

Two buoys were deployed by the WHOI team during JOIS for Champika Gallage of Environment Canada in support of the International Arctic Buoy Program.
The ice mass balance buoy was part of the second ice based observatory (IBO) where several buoys were placed on the same ice floe to provide information on ocean and atmosphere processes which in turn support the wider Arctic Observing Network.
The airborne expendable ice buoy (AXIB) buoy was deployed in open water and will provide location information to track ocean circulation and ice movement

Note – AXIB deployment lat and lon from website are not consistent with our logged deployment position

Buoy Type	Manufact.	Program	Deployment Date and Time (UTC)	Deployment Latitude (N)	Deployment Longitude (E)	Notes
AXIB (113547)	LBI	Environment Canada (IABP)	2012-09-02 20:33:11	75.9939	-175.055	Deployed in open water from side of ship
IMBB (300025010128510)	MetOcean	Environment Canada (IABP)	2012-08-27 21:00:00	80.2467	-129.864	Deployed into ice at second IBO ice station (see WHOI's report)

5.13 Ice Observations

PI: Kazutaka Tataeyama, Kitami Institute of Technology, Japan
With Jun Ono (University of Tokyo)

Measurements:

- Underway Ice thickness observations
  Underway measurements of ice thickness from an electromagnetic induction sensor, Passive microwave Radiometers(PMR), Net radiometer, and fixed forward-looking cameras.
- Ice station measurements
  EM Survey, Spectrum albedo survey and Snow Pit Survey.

Underway measurements
Kazu Tateyama (KIT)
Jun Ono (UT)

Underway measurements of ice thickness were made using, an Electromagnetic induction (EM) sensor, Passive Microwave Radiometers (PMR) and a forward looking camera. The radiation balance of solar and far infrared was observed using a net radiometer (CNR1) corroborated with Alice Orlich, UAF. These data will be used to help interpret satellite images of sea ice which have the advantage of providing extensive area and thickness but lack the groundtruthing of just what the images represent. The EM sensor with a new FRP water proof case was deployed from the foredeck's crane on the port side, collecting data while underway. The passive microwave sensor was mounted one deck higher also on the ship's port side looking out over the EM's measurement area and collected data continuously.

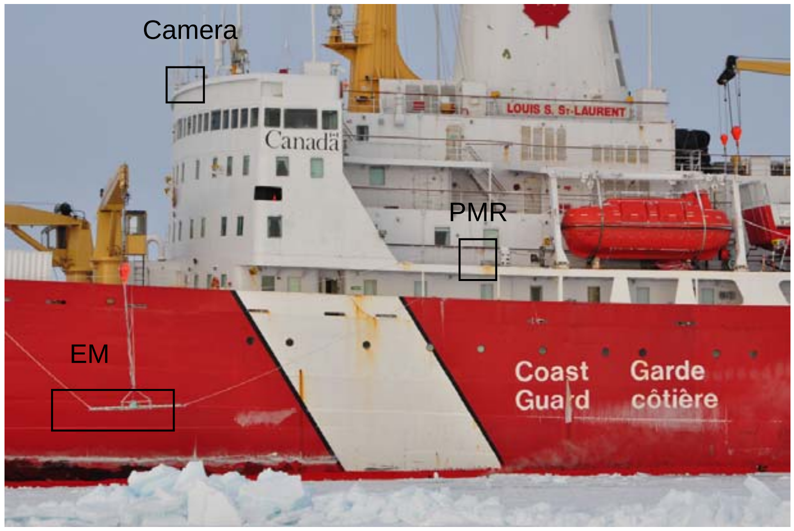
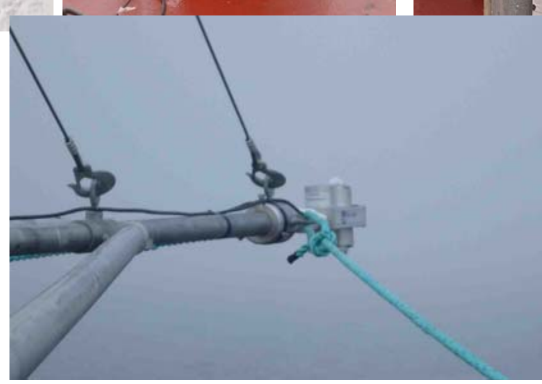


Figure 1. Pictures of EM , PMR and forward-looking camera.

loo



EM ice thickness profiles and PMR observation

An Electro-Magnetic induction device EM31/ICE (EM) and laser altimeter LD90 will be used for sea-ice thickness sounding. EM provides apparent conductivities in mS/m which can be converted to a distance between the instrument and sea water at sea-ice bottom (H_E) by using inversion method. LD90 provides a distance between the instrument and snow/sea-ice surface (H_L). The total thickness of snow and sea-ice (H_T) can be derived by subtracting H_L from H_E. Ice concentration can be measured by EM system.

To develop new algorithm for estimation of the Arctic snow/sea-ice total thickness by using satellite-borne passive microwave radiometer (PMR), snow/sea-ice brightness temperatures and surface temperature measurements will be conducted. The portable PMR, called MMRS2A, which is newly developed by Mitsubishi Tokki System Co. Ltd., Japan, have 5 channels which are the vertically polarized 6GHz, 18GHz and 36GHz, the horizontally polarized 6GHz and 36GHz with radiation thermometers and CCD cameras. The radiation thermometers IT550, which are developed by HORIBA Corp., Japan, were used. Those sensors were mounted on the port side below the bridge in 55 incident angle which is same angle as the satellite-borne passive microwave radiometer AQUA/AMSR2. All data are collected every 1 second continuously except during CTD and ice stations.

EM and PMR ice thickness observation started at 8 -10 August and at 27-29 August. 6 ice thickness profiles are observed as shown in figure 5 and summarized in table 1. The total distance of 21 profiles are 1,492 km. EM was calibrated two times on 27 and 29 August over open water.

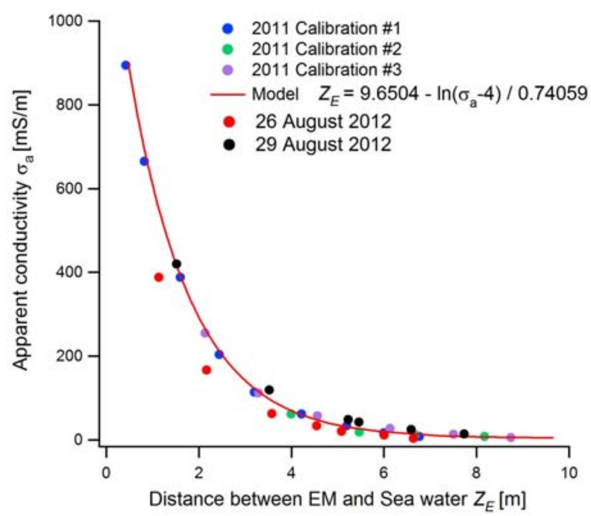


Figure 4. Result of EM calibration over open water.

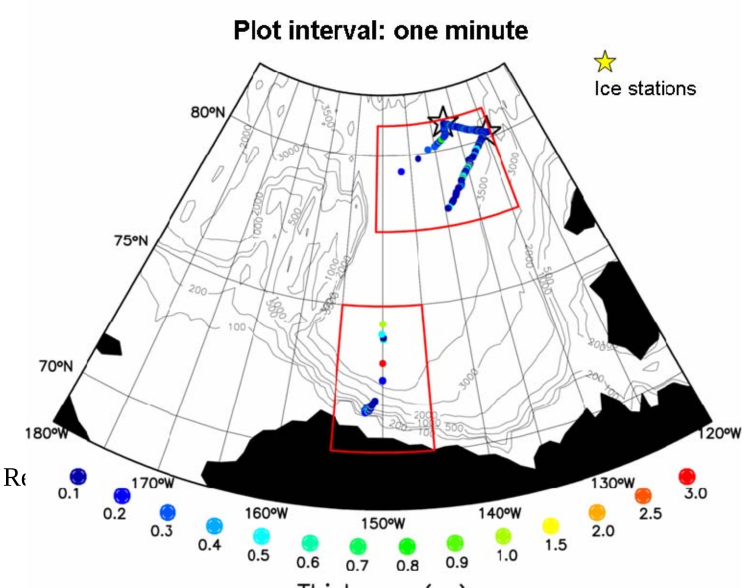


Figure 5. EM thickness profile during 8 – 10 and 27 – 29 August, 2012.

Table 1. EM and PMR observation log.

Profile Number	Start Time(UTC)	Start Position	End Time(UTC)	End Position	Length of profile [km]
1	2012/8/8 20:27:55	71.658681N 151.01667W	2012/8/9 5:02:25	71.387548N 151.726745W	58.29
2	2012/8/9 5:41:15	71.381945N 151.721765W	2012/8/9 19:58:03	72.500951N 149.987231W	163.26
3	2012/8/9 23:17:04	72.907317N 149.973158W	2012/8/10 15:36:23	75.001237N 149.99678W	240.84
4	2012/8/26 2:01:16	79.398977N 147.314741	2012/8/26 18:04:34	80.863109N 137.337549W	284.27
5	2012/8/27 3:47:13	80.840861N 136.841286W	2012/8/27 16:06:33	80.197561N 129.617545W	158.84
6	2012/8/28 1:52:05	80.224217N 130.126235W	2012/8/29 13:32:34	78.007357N 149.992594W	586.54

A looking-forward digital camera on the upper bridge recorded sea ice concentration and melt pond every 10 minutes during 8 – 10 August. These images will be used for calculation of concentrations of open water, melt pond, and ice.

CNR1 on the bow recorded every 10 seconds during 25 August – 4 September. This data will be used for assuming ice albedo feedback.

On-Ice Measurements
Ice Thickness Survey

Kazu Tateyama (KIT)
Jun Ono (UT)

Ice station measurements

Drill-hole and EM Survey

An electromagnetic induction device (EM) is capable of measuring a total thickness of snow and sea-ice. The output signal of EM; i.e. the apparent conductivity (in mS/m) can be converted to the distance (in m) between the instrument and the sea-ice bottom, i.e., the seawater-sea-ice interface with an inversion method. More accurate thickness values of EM can be derived from calibrations with drill-hole thicknesses. Calibrations of an ice-based EM31SH, whose boom is shorter than a ship-borne EM31/ICE, were performed at each ice station in conjunction with drill-hole measurements, which provide snow depth, freeboard and total thickness of sea-ice. The apparent conductivity of the Vertical Magnetic Dipole (VMD) and Horizontal Magnetic Dipole (HMD) modes was collected every 2 m on the transect line, and correspondingly, the drill-hole was made on the same transect line but every 10 m. The ice station was decided to establish on an ice floe large enough for buoy deployment. Transect lines were determined nearby or surrounding the buoys' deployment array. EM31SH and drill-hole measurements carried out on each ice station are summarized in Table 1.

Comparison of EM total snow and sea-ice thicknesses with drill-hole thicknesses are shown for Ice Stations 1 to 2 in Fig. 1, respectively. Each transect line is variable in thickness, but comparison indicates a rather good agreement between EM and drill-hole thicknesses even though frozen ponds or melt ponds are included on the transect line.

Apparent conductivities are compared with drill-hole thicknesses, together with the data obtained from the JOIS2010 and JOIS2011 experiments in Fig. 2. The JOIS2011 data during this cruise were separated from the ones including melt ponds and water-filled-gap as well with different symbols in the figure. The regression line was calculated from all JOIS2010 and JOIS2011 data but without melt ponds and water-filled-gas data. Comparison between 2012 and past two years indicates a good agreement even though melt ponds are included. The thickness composing of water-filled-gap does not appear a good agreement with the regression line, probably appearing deformed ice, whose thickness might be converted by a different model.

Spectral albedo of ice and melt pond was measured by ASD FieldSpec3 on the 2nd ice station

Table 1. A summery of EM31SH and drill-hole measurements.

Ice Station	Latitude Longitude	Transect Line	Length of profile [m]	Snow depth [m]		Ice thickness [m]	
				Mean	s.d.	Mean	s.d.
St.1	80.875694N 137.41700W	Line-1	150	0.00	0.00	1.33	0.08
		Line-2	150	0.00	0.00	1.34	0.13
St.2	80.205306N 129.969639W	Line-1	40	0.00	0.00	0.39	0.08
		Line-2	40	0.01	0.00	2.42	0.14

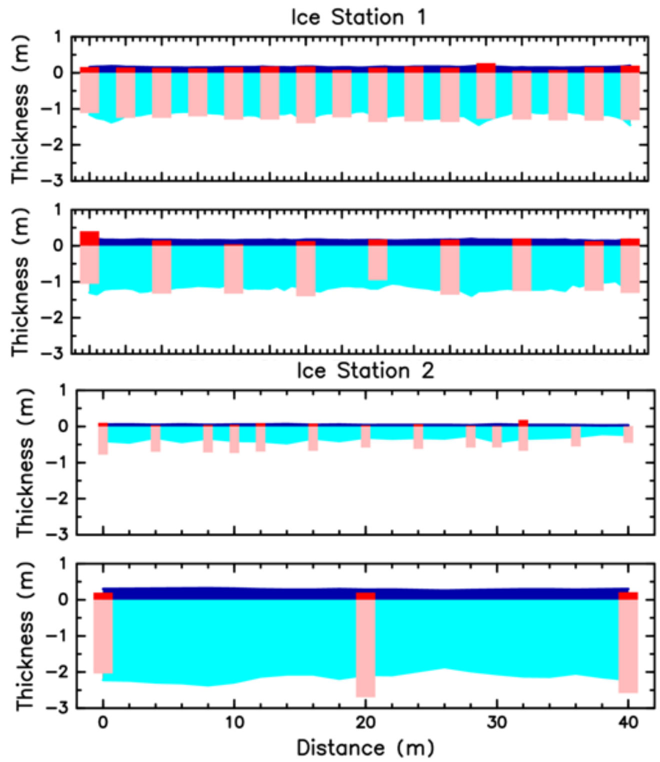


Figure 1. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #1 on 26th of August 2011 and #2 on 27th of August 2011.

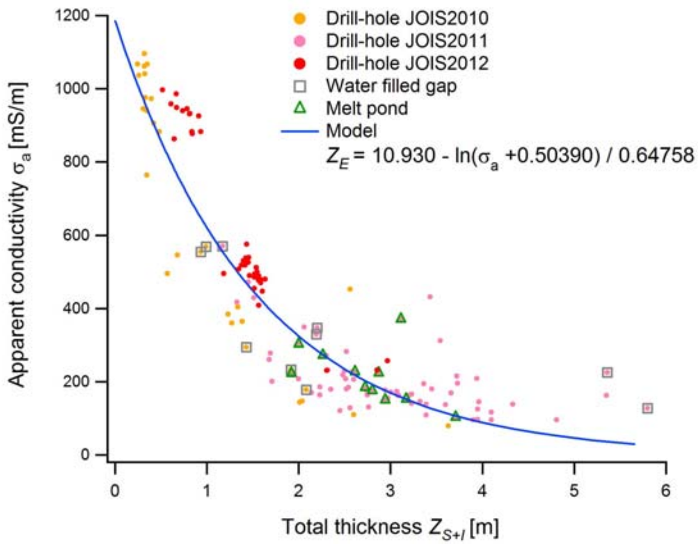


Figure 2. Comparison of EM31SH apparent conductivity with drill-hole total thickness.

5.14 On-ice Measurements

PIs: Koji Shimada (TUMSAT), Daisuke Hirano (NIPR/TUMSAT)

During ice-buoy deployments on 26 and 27 August, an Acoustic Doppler Current Profiler (ADCP), Underway CTD (UCTD), temperature loggers (SBE56), SEACAT profiler CTD (SBE19) were moored and deployed to obtain time series and vertical profiles of ocean current, temperature, salinity, and density under the sea ice.

1) **Ocean current measurements**

   An ADCP (RDI WH-sentinel 600 kHz) suspended through an augered hole. Two GPSs were set on the ice to detect sea ice motion as well as direction of 3rd and 4th beam of ADCP.

2) **Time series of temperature measurement**

   Temperature array with eight SBE 56 temperature loggers and SBE 19 CTD was suspended through and augered hole. SBE56 and SBE19 were placed every 7m then the array ideally covered from surface to about 56m-depth.

3) **Repeat UCTD casts**

   To obtain near-surface (from surface to 45m-depth) CTD profiles, UCTD was lowered and raised by electronic hoist at constant rate.

Period, sampling rate, and notes of on-ice observations are shown in Table.2.

Table.2 Period and sampling rate for on-ice measuremtns.

Date: 2012/8/26	Period	sampling interval	Note
ADCP (600kHZ)	2012/8/26 21:29-2012/08/27 1:00	2 min	Data after 2012/08/27 22:17 looks strange
SBE56, SBE19	2012/8/26 21:25-2012/08/27 1:00	1 min	
UCTD-1	2012/8/26 21:58:00	-	
UCTD-2	2012/8/26 22:12	-	
UCTD-3	2012/8/26 22:55	-	
UCTD-4	2012/8/26 23:10	-	
UCTD-5	2012/8/26 23:24	-	
UCTD-6	2012/8/26 23:39	-	
UCTD-7	2012/8/26 23:55	-	no-data obtained
UCTD-8	2012/8/27 0:08	-	
UCTD-9	2012/8/27 0:24	-	
UCTD-10	2012/8/27 0:38	-	
UCTD-11	2012/8/27 0:46	-	

Date: 2012/8/27	Period	sampling interval	Note
ADCP (600kHZ)	2012/8/27 20:00 - 23:01	2 min	
SBE56, SBE19	2012/8/27 20:03 - 22:49	1 min	
UCTD-1	2012/8/27 20:20	-	
UCTD-2	2012/8/27 20:48	-	
UCTD-3	2012/8/27 20:55	-	no-data due to some limitations of system
UCTD-4	2012/8/27 21:04	-	no-data due to some limitations of system
UCTD-5	2012/8/27 21:12	-	no-data due to some limitations of system
UCTD-6	2012/8/27 21:20	-	no-data due to some limitations of system
UCTD-7	2012/8/27 21:28	-	no-data due to some limitations of system
UCTD-8	2012/8/27 21:37	-	no-data due to some limitations of system
UCTD-9	2012/8/27 21:45	-	no-data due to some limitations of system
UCTD-10	2012/8/27 21:52	-	no-data due to some limitations of system
UCTD-11	2012/8/27 22:10	-	
UCTD-12	2012/8/27 22:16	-	no-data due to some limitations of system
UCTD-13	2012/8/27 22:24	-	no-data due to some limitations of system
UCTD-14	2012/8/27 22:32	-	no-data due to some limitations of system
UCTD-15	2012/8/27 22:39	-	no-data due to some limitations of system
UCTD-16	2012/8/27 22:47	-	no-data due to some limitations of system
UCTD-17	2012/8/27 22:54	-	no-data due to some limitations of system
UCTD-18	2012/8/27 23:01	-	no-data due to some limitations of system

5.15 Ice Observation Program

Alice Orlich, University of Alaska Fairbanks
PI: Jennifer Hutchings, International Arctic Research Center

Photo 1. A typical view of the ice from JOIS 2012.

Our typical program consists of multiple activities: Hourly ice observations from the bridge, helicopter reconnaissance flights, on-ice sampling, buoy deployment, webcamera ocean surface captures, collaborations with other sea ice researchers and volunteer training. New this season was the introduction of the observation software and the installation of a Kipp & Zonen CNR1 to the ship's bow for advanced observations for the study of irradiative influence on ocean and ice surface albedo.

Ice observers Alice Orlich(IARC), Kazu Tateyama(KITAMI) and Jun Ono(KITAMI) recorded observations from the bridge into the new software ASSIST(Arctic Shipborne Sea Ice Standardization Tool), which is a product of UAF's IARC sea ice group and GINA software programming department. Content and design was created based on collaborative input of the members of the international sea ice community and the project is sponsored by CliC(WCRP's Climate and Cryosphere Group).

As in previous years, the ice observations recorded during the Louis S. St. Laurent 2012-11 cruise will provide detailed information for the interpretation of satellite imagery of the ice pack. Our objective was to identify the major sea ice zones in the Beaufort Sea and determine the types and state of ice in these areas. The observations collected will be useful for investigating the evolution of the ice cover over the last seven years when used in conjunction with satellite and buoy data. The ice camera images we collected, in combination with visual ship and helicopter-based observations, will also be used to develop an autonomous camera based ice observation system. Our ongoing participation in the JOIS cruises has been vital in working towards a satellite validation project and the development of the ASSIST program.

The cruise occurred 2 August – 8 September 2012, a time period which falls well before the average date of the melt season apex of mid-September. Prior to arriving for the cruise, the Beaufort Sea and Canada Basin ice area had experienced extreme ice loss. Once underway with the science plan, it became evident that the ice extent would only reach into a few of our stations along the planned route and that in order to deploy ice buoys and collect samples, the cruise track would have to be modified to travel deeper to the Northeast to find older ice of reasonable floe size. Unforeseen logistical issues required rerouting of the ship into the southern Beaufort Sea multiple times before finally heading North to approach the ever-shrinking ice extent. Coincidentally, the two days of ice visits occurred 26 & 27 August, the latter being the same date on which the global sea ice research community would announce the new record low extent, displacing the 2007 minimum with approximately 3 weeks of additional melt expected. Over the entire cruise, the ship navigated through only areas of ice with 50% or less total coverage, none of which could be considered "ice pack", but more appropriately the Marginal Ice Zone. The ice was primarily second year and multi-year ice in small to medium floes with a stage of melt so advanced that the ice would be classified as "rotten". The ice was organized in areas of "strips and patches," defined by how the floes and associated brash take forms of continuous elongated strips and confined groupings of uncongealed ice.

Since the first year of the IARC team's participation in 2006, the JOIS cruise has been scheduled at various times throughout the summer season. Attention should be given when comparing the 2012 data to the results from the years 2006-2008 and 2011(JOIS), which witnessed the early summer melt, or the later years with data from 2009 and 2010, 2011(UNCLOS) where we experienced the onset of freeze-up of the sea ice for the entirety of the cruise track because the cruises were conducted a month later in the season than the current and previous cruises.

Observations from the Bridge: Methodology

While traveling in ice, an observer was present on the bridge. A typical observation includes a three-stage process. The first stage starts at the top of the hour and involves recording sea ice conditions and gathering ship data from bridge instruments such as latitude/longitude location, navigational details, and meteorological data into the observation software. The second stage involves taking photographs from monkey island, web camera maintenance, and observing sky conditions. The final stage of an observation requires data input and webcam monitoring, both of which can be accomplished from the chart room or from the private berth. Often the observer/s remain/s on bridge beyond the designated observation time to further study the sea ice conditions, discuss the evolving science plan, and gather input from others present who have witnessed interesting features, wildlife, etc.

A combination of the WMO, Canadian Ice Service and Standard Russian sea ice codes and the ASPECT (Worby & Alison 1999) observation program were used to describe ice conditions. The codes are described in detail and available as an appendix to this report. During each observation period we estimated the total ice coverage within 1nm of the ship (when visibility allowed), the types of ice present and the state of open water. For the primary, secondary, and tertiary ice types we recorded the percent coverage, thickness, flow size, topography, percent sediment coverage, extent of algae presence, snow type, snow thickness and stage of melt for each type. Other types of ice present that were at lower concentrations than the three main types were also documented. We observed basic meteorological phenomena of cloud coverage and type, visibility and precipitation.

Photo 2. View during an observation made from monkey island as the ship enters an area of rotten, diffuse ice.

Comments on Bridge Observations

Ideally, the program aims to take hourly observations throughout the 24-hour cycle each day of the cruise. When on station, observations are suspended. A designated space was provided near the forward starboard windows for the sea ice laptop. Access to monkey island was requested from the officer on watch and the new RADAR system was temporarily deactivated for safety reasons when people went atop. Additionally, a small workspace was provided in the chart room.

This season's vast area of open water greatly limited the data from the ice observation program. While most daylight hours in transit of sea ice were recorded, some hours of observations were lost during the period of ice visits which dictated that all potential observers be available for the long hours on the ice station. For the 2 days during which the ship traversed the loose ice while approaching the 2 IBO sites, the evening observations were not completed due to the adjusted sleep schedule. Given the consistent ice coverage and composition during the day hours of transit, we can assume the ice to have been similar while underway during the dark hours.

We found that the photographic record helped in consistency checking of the bridge ice observations. We placed two webcams on the monkey island to record ice conditions automatically. In addition, we continued to take routine hourly photographs from monkey island for consistency checks and the opportunity to capture specific features of the ice. This year, the bridge was testing out a new ice RADAR, expected to identify ice with higher precision. The Second Mate programmed the software to capture screensaves every 30 seconds while the ship was in ice. That data set will be used to validate some observations and extend the ice record during hours not viewed by observers.

Webcam Imagery

Webcams have been positioned atop the rail of monkey island for multiple seasons. The images serve to supplement the hourly visual in-situ observations made from the bridge while traveling in ice. Frequency of image capture is altered by changing the settings manually via the software program. The rate of capture this year averaged at half-hour intervals, but was increased while the ship transected through ice. Images are stored on the ship's NOAA server in the IceCameras folder of the S-drive. The forward-looking camera (1) is trained on the bow of the ship, with the ship shown in the lower center quarter of the image, the ocean and ice set in the center half, and the sky bordering the upper quarter. The port-side camera (2) is positioned to capture dynamic ice movement and overturning that occurs when the ship passes through ice. In the view, the ice thickness pole with 10cm color band measurements which is secured perpendicular to the ship, as well as the passive microwave instruments from Dr. Tateyama's study can be seen. Both cameras are the netcam XL from Stardot Technologies.

Comments on webcam operations

The webcam system requires initial set-up and installation, then programming via the main frame computer or a laptop with access to the ship's net. This year the cameras were easily accessed via the new wireless system. The cameras are unpacked and electronic connections and camera operability is tested while inside the ship. Once the cameras are properly recording, the installation includes mounting the cameras on the rail of monkey island and running the cables into the ice observer's office. Typically the cables are run through the window and into the net board. Further details of the technology, installation and photo archiving are available as an appendix to this report.

The cameras can be accessed via the ship's wireless connection with addresses 10.1.20.32 (cam 1) and 10.1.20.33 (cam 2). This flexibility allows for real-time adjustment if ice conditions become more interesting based on ship speed, varying daylight or weather conditions. Also, capture frequency can be reduced if the ship is on station.

Due to the forward exposure of the camera 1, close attention should be made to the clarity of the case window. It is common for freezing rain and snow to accumulate and cause poor image capture. The icing can be easily removed by soaking a soft sponge with hot water and holding it to the frozen case window until it is completely melted. We have found that a sponge and approximately 1-2cups of hot water from the tap works well. On occasion, the port-side camera window collects rain or fog droplets which are easily wiped clean for an improved image capture.

Both camera cases have ventilation at the front and back which unfortunately allows drifting snow and moisture to condense within the housing and occasionally affect image capture and electronic connections. These openings can be filled with packing foam or paper towels and sealed with duck tape.

Aerial Ice Observations

When invited onto ice reconnaissance flights, an IARC ice observation team member typically sits behind the CIS ice specialist, allowing full window access for photography and ice observations. In addition to personal supplies in a day pack positioned behind the front seat, the IARC observer would conduct sea ice surveys with a digital camera, handheld GPS unit and clipboard to complete the flight data form. Ideally, the flight would maintain an altitude of 2,000' to provide a wide horizon, yet observable sea ice and ocean detail. The electronic record of the flight, including GPS waypoints along the route for where photos were taken as well as other details of the flying conditions and comments about the ice is available on the end of cruise data disk. Typically, the CIS ISS posts the recon map to the science of public drive, making a digital copy available for reference. I flew one ice reconnaissance flight during this cruise for the buoy array deployment.

Comments on aerial ice observation operations

Given that each flight has unique objectives, the IARC observer needs to be able to adjust expectations and equipment, if required. Adverse weather conditions or ship logistics may alter the flight plan, resulting in extended or shorted flight time, reduced altitude, or unplanned delays on the ice. For these reasons, participants would always pack additional clothing and safety gear, as well as back-up batteries and other surplus observational supplies. On occasion, the IARC observer is invited to assist with the WHOI program's buoy recovery reconnaissance or buoy deployment ice floe selection. These flights are equally valuable, as they provide better perspective to the ice conditions surrounding the area of interest. When flying in areas of low ice concentration, the CCGS requires passengers to wear the orange neutral buoyancy flight suits provided by the ship. There are only 3 suits available, and the sizes are restricting for most guests. It would be helpful to increase the number of suits in stock on the ship and to acquire more size options.

On-ice measurements

Photo 3. Two flagged lines mark the transect lines used for thickness and albedo surveys.

Floe thickness transects and ice core samples are conducted when the IARC team is invited onto ice floes chosen for buoy deployments. The general goal is to provide characterization of the floe by completing one or more ice thickness survey drill transect lines and sampling ice with a 9-mm corer at multiple locations.

This season, the sea ice component of the JOIS cruise grew exponentially. Additional groups added new field measurements such as albedo data with a FieldSpec3 (KIT) and net radiation values with a CNR1 (University of Manitoba), as well as near-ice surface water sampling and monitoring with CTDs(UoM and TUMSAT), a thermistor string(TUMSAT) and two ACDPs (TUMSAT and TEA-COSI). The multiple teams on ice required a highdegree of coordination in order to satisfy all goals, yet remain safe and out of the way of other on-ice operations. Two planning meetings were conducted aboard the ship beforehand to agree on the order of activities and logistics of transportation and gear set-up. A third meeting focusing on safety on ice was conducted just days before the first ice station.

It was agreed to have Alice and Kazu out on the floe immediately after the WHOI team was deployed. This provided the opportunity to discuss real estate issues with Rick Krishfield and take time to layout what were meant to be “clean” lines in the interest of the sensitive EM-31 and albedo instruments. Once the remaining ice group members joined the floe, there was a specific order to how the ice group conducted each activity. First, the EM-31 was deployed to get thickness estimates of the ice along the transect lines. Then the FieldSpec3 followed to capture undisturbed albedo of the surface along the lines. When given the points of interest (thickest, thinnest, or curious ice areas) the coring team would begin on the selected sites. As one side of the transect line is reserved for foot traffic, the drilling team proceeded while the albedo measurements were still underway on the other side. Drill holes are made at 10-meter increments at depths up to 8 meters along the line to help validate the EM. The drill hole data is recorded as a series of depths along the line, with details of total ice thickness, freeboard, snow cover, and a GPS waypoint. This year, we integrated the UoM CTD into the drill program by taking a measurement up to 30m at each thickness hole.

Photo 4. Volunteers persist along a 150m drill transect line with the 2” auger system and CTD.

Photo 5. A core section is measured for length before temperatures are taken and the core is sectioned into 10cm pieces for later analysis.

The core sample data includes identical records as well as photographs of each core section, temperatures at 10 cm intervals, and measurements of 10cm sample sections which are bagged and transported to the ship for further processing. Once melted and measured for volume, salinity and conductivity are determined by typically using a YSI handheld salinometer. Density is calculated from these parameters. However, that particular instrument was not available this season and Kazu’s AQUAMAN Horiba CEH-12 salinometer was used instead. Because the measurement capabilities are different, some of the calculations for the ice core analysis are not available at the time of this report. A total of 5 cores were taken between the 2 IBOs. The preliminary analysis suggests that both areas where cores were taken consisted of second-year ice. Additional field data for the thickness surveys and core analysis will be available as an appendix to the JOIS report.

The IARC field team has a minimum efficiency of two persons. However, when human resources are available and logistics allow, volunteers from the science crew are assigned to either the drill or core team. Another factor dictating the breadth of the on-ice program is time allotted for the ice station. The briefest visit can last less than two hours if conducted during a single ITP deployment. Typically, this ice station occurs first in the science plan and is a great opportunity for the field team to test equipment and practice a safe, efficient routine. Optimum conditions can occur when there is a multi-buoy site, or Ice Based Observatory (IBO), which can last up to 8 hours. During these ice visits the data collection is exponentially increased, as the volunteer crew can employ as many as 5 additional technicians. During this cruise, the IARC team was able to participate in the 2 IBO ice stations.

Comments on ice visits

Generally, the plan for a station is decided up to a day in advance, allowing for complete preparation of gear, supplies and volunteers. However, it is not uncommon for an ice visit invitation to occur in a shorter time frame, thus emphasizing the need to always have the gear clean and packed for immediate departure. Additional fuel in a spare jug, duplicate ice core sampling supplies (bags and buckets), and a complete personal day pack should always be stored in the helicopter hanger amongst the field gear staging area.

This years' complicated ice field program warranted much more coordination. There were new parties with no previous experience on ice or new to the JOIS/Louis operations. Some individuals were not fully outfitted with personal gear, an issue that should be addressed well in advance to the cruise. It should not be underestimated as to how sensitive the on-ice operations and logistics can be in regards to space on the floe, weather and visibility, allotted helicopter time and well-coordinated activities being completed without conflict amongst the ice parties.

Since there are many buoy deployments and therefore slingloads and other helicopter traffic, it is paramount that the floe layout is well understood by all parties of interest – WHOI, the helicopter pilot, the on-ice ship crew, and all remaining ice parties. A very valuable element to this quick turn-around is the initial selection and thickness testing of the floe. In the best scenarios of past seasons, an IARC member accompanied the WHOI team, if space provided. This allows for better communication and planning of the inevitable spontaneous decisions which are made quickly to begin operations. Unfortunately, for both ice sampling excursions this season, an additional passenger was taken to the potential floe sites, neither of whom was to be on ice for the main field campaign. This critical opportunity for better on-ice coordination should be recognized as the time to confer, plan, map and designate on-ice activities and work areas. Too easily is time wasted when communication is not clear and prime work areas are compromised or precious field sampling time is misappropriated when all parties are not universally aware of each others' needs.

Volunteer Training

A preliminary training for volunteers was conducted approximately a day before the first ice station. Topics covered included ice sampling goals, research methodology, gear familiarization, equipment operation, safety awareness and field etiquette. The volunteer program provides opportunities to access the sea ice and learn about field research techniques, and in turn theoretically increases the volume of data from each ice station.

Photo 6. Group glamour shot on ice.

As the learning and experiential curve is steep for people new to sea ice field work, and the brief time allotted to the sea ice team is extremely valuable, it was a tremendous relief to have the seasoned crew of Kelly Young, Kenny Scozzafava and Sarah Zimmermann willing to lead teams at the ice stations. Ben Lincoln and Ben Powell were both very valuable to this season's ice core sampling.

GPS buoy deployment

Four GPS buoys were deployed in a 10nm x 10nm array surrounding the 2nd IBO. IARC grad student Alice Orlich was assisted by Linda White and Chris Swanell during the deployment of the buoys. The operation was completed in 1.5 hours, after which Orlich returned to the IBO2 site to complete on-ice sampling.

Photo 7. Volunteers White and Swanell rest and refresh after buoy deployment.

The area of interest was dominated by thick first and/or second-year ice in an advanced stage of melt, but rare multiyear floes with substantial level ice distant from melt ponds and ridges were selected. The buoys were secured with anchors attached to each handle of the buoy. The anchors were set into a 2" hole hand drilled with an auger at an approximate depth of 1 meter. The buoys had been tested aboard the ship a week in advance of deployment. Transmission was confirmed by the manufacturer, Chris Paynter of Oceanetic Measurement, within hours of the deployment on Monday, 27 August 2012. An aerial photo survey was conducted en route to each chosen ice floe, and additional photos and notes were taken to document the installation of each buoy as well as the floe features and conditions. After each buoy was successfully deployed, a confirmation email was received from Mr. Paynter, noting the updated location and the success of the operation. The buoys will be tracked as they continue to transmit their location on the International Arctic Buoy Program website: http://iabp.apl.washington.edu/index.html.

Synopsis of ice types along cruise

For most of the cruise, the ship traveled through open water. When encountered, ice conditions consisted mainly of low concentration (50% or less) of strips and patches composed of brash and cake, small and medium floes of old ice which appeared to be more second-year rather than traditional multi-year ice. Ice encountered off the coast of Alaska had patches of "dirty" ice which appeared to be entrained and surface sediments, but some had appearance of organic matter from a walrus haul-out. Fragments of an ice island were spotted from the ship on 21 August at 74 40.6N , 139 44.5W and on 22 August at 73 39.34N, 139 07.83W and reported to the CIS in Ottawa.

The greatest concentration of ice was met when the ship rerouted off the original science plan course in search of larger floes of old ice. However, even when venturing into areas which the CIS ice charts labeled as 6-8/10s concentration, wide leads and thin new ice made navigation easy and the degradation of the floes present required a slow search for an ideal IBO site. This brought us into the area of ~81N, 137W for the two ice stations. Both IBO sites were sampled in the areas of average thickness and yielded thickness transect measurements between 1-2m, with chemistry and structural characteristics of second-year ice. Remote areas of the floes were heavy ridging lined the edges proved to have areas of rafting up to 5m. New ice began to grow in the cold temperature of the higher latitudes. Nilas and grey ice was common, along with refrozen meltponds and patches of grease ice.

When the ship returned to the original science plan stations, occasional bits of old ice were passed. All were at an advanced stage of melt and no new ice was present.

Photo 8. Example of new ice in between the remnant ice in the area of the IBOs.

Visibility posed a problem for both ship navigation and ice observation from the bridge. Persistent low-level fog and overcast skies lead to reduced ship speed, even in some areas ice-free waters.

5.16 Studies of solar radiation, cloud radiative forcing, hyperspectral observations of sea ice and on-ice CTD measurements.

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University of Manitoba - Centre for Earth Observation Science (CEOS)

Outlined below are contributions of CEOS to the JOIS 2012 program. These included collecting data for work related to cloud radiative forcing, incoming SW/LW/UV radiation, hyperspectral observations of sea ice (shipboard/on-ice), on ice CTD measurements. Helicopter based EM induction ice thickness surveys were of a very limited nature this year largely due to the general absence of ice this year along the planned survey routes, poor flying conditions (persistent fog), and an ill-timed technical issue during our first day in the ice.

1.0 Cloud Radiative Forcing

The objective of the component part of the project seeks to better understand the nature of cloud radiative forcing. The FLIR SC660 thermal infrared camera (7.5-13μm) was employed. The camera was used to record the thermal properties of clouds through direct observation (camera directed to the sky) and with the camera observing a thermally reflective dome providing a 360˚ view of the sky, Figure 1. The camera acquired imagery every 30 seconds (both optical and thermal) for 1-2 hour periods at 3hour intervals during the day. The camera/dome was located on the roof of the helicopter hanger (starboard side) on a crate level with the rail.

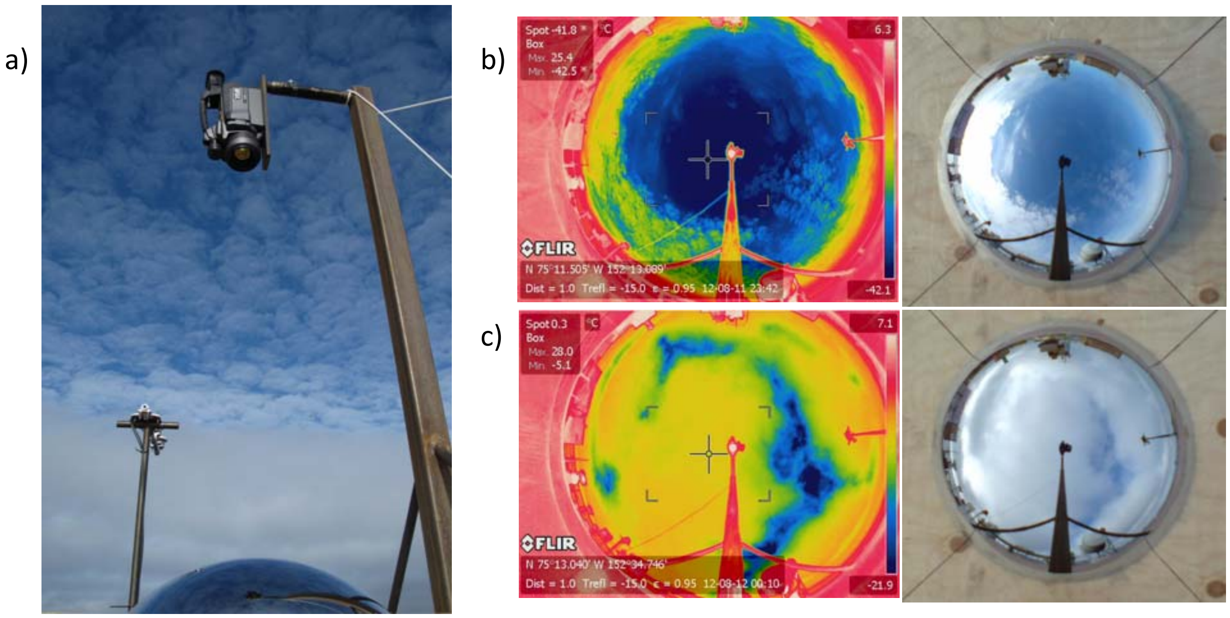


Figure 1. a) FLIR camera on mount observing thermally reflective dome, b) thermal/optical pair for "clear sky" (spot temp -42.5˚C), c) thermal/optical pair, cloud temp., -5.1˚C.

For calibration of the dome imagery, vertical direct sky measurements (90˚) were incorporated in the data acquisition sequence as well as direct sky series at 0-90˚(horizontal-vertical) at 15˚ intervals. General background images (ship structures etc.) visible in the dome images were also acquired. A general summary of the imagery collected during the cruise is listed in Tables 1a&b. Associated with the FLIR observation were down-welling shortwave, longwave and UV (A/B) radiation data (See Section 1.1)

Table 1a Summary of FLIR/optical imagery acquired for cloud radiative forcing, August 11-12 (UTC).

Date (M/D/Y)	UTC	UTC End	Image	Dome	Sky	Sky_0-90	BkGrd
11/08/2012	22:47	1:01	1991-2468	x			x
12/08/2012	17::03	19:05	2487-2973	x			x
12/08/2012	20:28	20:35	2989-3016	x			
13/08/2012	20:30	20:39	3061-3094	x			
14/08/2012	16:09	16:23	3096-3547	x			x
14/08/2012	16:40	18:23	3550-4047	x			
14/08/2012	19;50	20:50	3550-4048	x			x
15/08/2012	2:36	4:31	4050-4509	x			
16/08/2012	0:55	2:30	4511-4888	x			
16/08/2012	5:24	6:24	4890-5129				
16/08/2012	11:29	12:41	5130-5385				
16/08/2012	15:47	16:24	5386-5537	x			
16/08/2012	17:39	18:39	5538-5771	x	x		x
16/08/2012	20:31	22:42	5772-6243	x	x		
16/08/2012	23:29	0:29	6244-6483				
17/08/2012	2:23	3:23	6484-6723	x			
17/08/2012	17:22	18:21	6964-7203	x			
17/08/2012	14:15	15:15	6724-6963	x			x
17/08/2012	20:20	22:15	7204-7584	x	x		x
18/08/2012	2:26	4:11	7586-7967	x			x
18/08/2012	15:18	16:22	8234-8489	x	x		
18/08/2012	17:25	19;25	8490-8965	x	x		x
18/08/2012	2044	0:46	8966-9843	x	x	x	x
19/08/2012	0:03	6:04	10186-10941	x	x	x	
19/08/2012	15:19	17:48	10943-11539	x	x	x	
19/08/2012	19:07	1:20	11540-12980	x		x	
20/08/2012	15:46	18:02	12981-13517	x		x	
20/08/2012	19:12	21:00	13518-13955	x	x		x
20/08/2012	23:09	0:34	13956-14297	x	x	x	
21/08/2012	02:24	2:47	14298-14345	x		x	
22/08/2012	02:24	3:34	15033-15306	x	x	x	x
22/08/2012	14:15	15:48	15307-15648	x	x	x	x
22/08/2012	17:37	19:02	15649-15982	x	x	x	
22/08/2012	23:37	0:24	16265-16534	x	x		
22/08/2012	02:31	3:30	16535-16770	x	x		

Table 1b. Summary of FLIR imagery acquired for loud radiative forcing, Aug. 13-Sept. 5 (UTC)

Date (M/D/Y)	UTC	UTC End	Image	Dome	Sky	Sky_0-90	BkGrd
23/08/2012	06:45	7:00	16772-16832	x	x		
23/08/2012	15:01	15:30	16833-16904	x		x	
23/08/2012	20:22	21:35	16905-17204	x	x	x	
24/08.2012	0:40	1:48	17205-17478	x	x		
24/08/2012	05:10	6:26	17480-17774	x	x	x	x
24/08/2012	16:05	18:22	17775-18320	x	x	x	
24/08/2012	18:27	21:39	18321-19094	x			
25/08/2012	0:51	0:58	19095-19122			x	
25/08/2012	15:30	18:09	19123-19735	x	x	x	x
25/08/2012	20:33	22:54	19739-20304	x	x		
28/08/2012	16:37	17:07	20305-20362			x	x
28/08/2012	19:17	20:06	20363-20548	x	x	x	x
28/08/2012	22:09	23:26	20549-20836	x	x		
29/08/2012	0:51	1:19	20837-20937	x		x	
29/08/2012	19:37	21:33	21085-21516	x	x	x	
30/08/2012	2:37	3:27	21517-21712	x	x	x	x
30/08/2012	15:35	16:25	21713-21896	x	x	x	x
30/08/2012	17:38	19:11	21897-22268	x	x	x	x
30/08/2012	20:28	21:29	22269-22512	x	x	x	x
31/08/2012	16:19	18;24	22513-23012	x	x		
31/08/2012	19:01	21:20	23013-23568	x	x	x	x
01/09/2012	2:34	3:34	23569-23792	x	x	x	x
01/09/2012	15:55	17:37	23793-24180	x	x	x	
01/09/2012	20:33	22:43	24181-24690	x	x	x	x
02/09/2012	1:44	x	24691-24872	x		x	
02/09/2012	21:43	x	24873-25028	x		x	x
02/09/2012	22:46	0:48	25029-25506	x	x	x	x
03/09/2012	2:50	4:30	25507-25908	x	x		
03/09/2012	16_10	17:06	25910-26084	x	x	x	
03/09/2012	19:48	22:14	26086-26654	x	x	x	x
04/09/1202	0:21	1:29	26656-26931	x	x	x	x

1.2 Radiation Data

A combination of radiation sensors were mounted aft of the CCGS Louis S St Laurent above the helicopter hanger (Figure 2, Table 2). Radiometers provide a continuous record of surface incoming shortwave (wavelengths of 300 to 2800nm) and long-wave (wavelengths of 4500 to 42000nm) radiation. A third sensor was mounted at the same location collecting ultraviolet A and B radiation, (wavelengths 315 to 400 nm / 280 to 315 nm). Due to the location of the sensors and the possibility of interference from the ship's stack and aft crane, two sets of radiation sensors were mounted above the helicopter hanger – a pyranometer and pyrgeometer on the port side and an identical set mounted on the starboard side. The UV sensor was mounted on the port side on the same mounting bracket as the pyranometer and pyrgeometer.
Sensor output was collected on a Campbell Scientific datalogger. A CR3000 was used to collect and store the radiation data, scanning at 2sec intervals and archived as 1-minute averages. Data was retrieved by regular download using an RS232 cable connected to a computer.

Figure 2.Radiation sensors mounted on the port side, including the UV sensor, pyranometer and pyrgeometer.

Table 2 Sensors and Associated Specifications

Sensor	Variables	Units	Ht from deck (m)	Scan (s)/A (min)	Specs
Pyranometer #1 (Kipp & Zonen, s/n 060370)	SW_in	W/m^2	2	2/1	~±5% Port
Pyranometer #2 (Kipp & Zonen, s/n 060369)	SW_in	W/m^2	2	2/1	~±5% Starboard
Pyrgeometer #1 (Kipp & Zonen, s/n 060066)	LW_in	W/m^2	2	2/1	~±10% Port
Pyrgeometer #2 (Kipp & Zonen, s/n 060068)	LW_in	W/m^2	2	2/1	~±10% Starboard
UV Sensor (Kipp & Zonen, s/n 070670)	UV-A UV-B	W/m^2	2	2/1	~±10% Port

The ship-based radiation data is paired with the on-ice radiation data collected from a Kipp & Zonen CNR1 net radiometer (Figure 3). During the two Ice Based Observatories on 26 & 27 August 2012 the net radiometer measured upwelling and down-welling short- and long-wave radiation along two 150m transects and one 40m transect. Sensor output was collected on a Campbell Scientific datalogger. A CR1000 was used to collect and store the radiation data, scanning at 2sec intervals and archived as 1-minute averages. Data was retrieved by regular download using a RS232 cable connected to a computer.

Figure 3. CNR1 Net Radiometer set-up at Ice Based Observatory #1

Charted below are the radiation data collected both on ship and on-ice. The ice-based data is taken from 26 August 2012 and paired with the ship-based data of that same time interval in the subsequent graphs. Figure 4 shows the on-ice radiation, while Figures 5 and 6 displays the ship based radiation data (note that times on the x-axis are UTC).

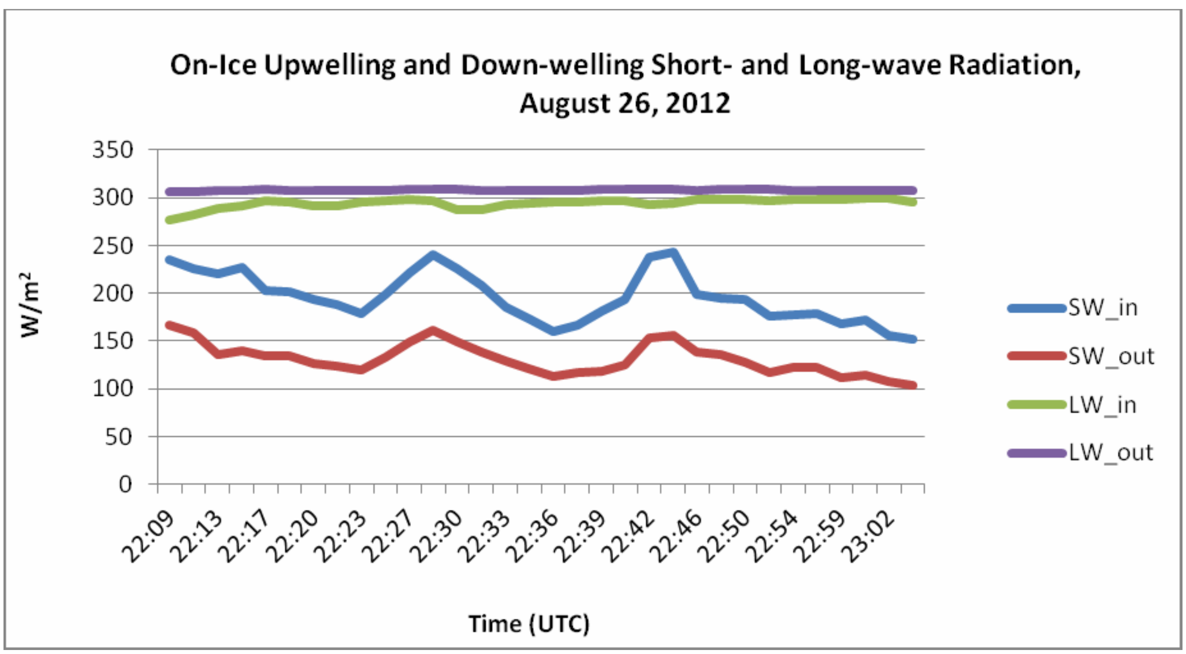


Figure 4. On-ice upwelling and down-welling short- and long-wave radiation for August 26, 2012

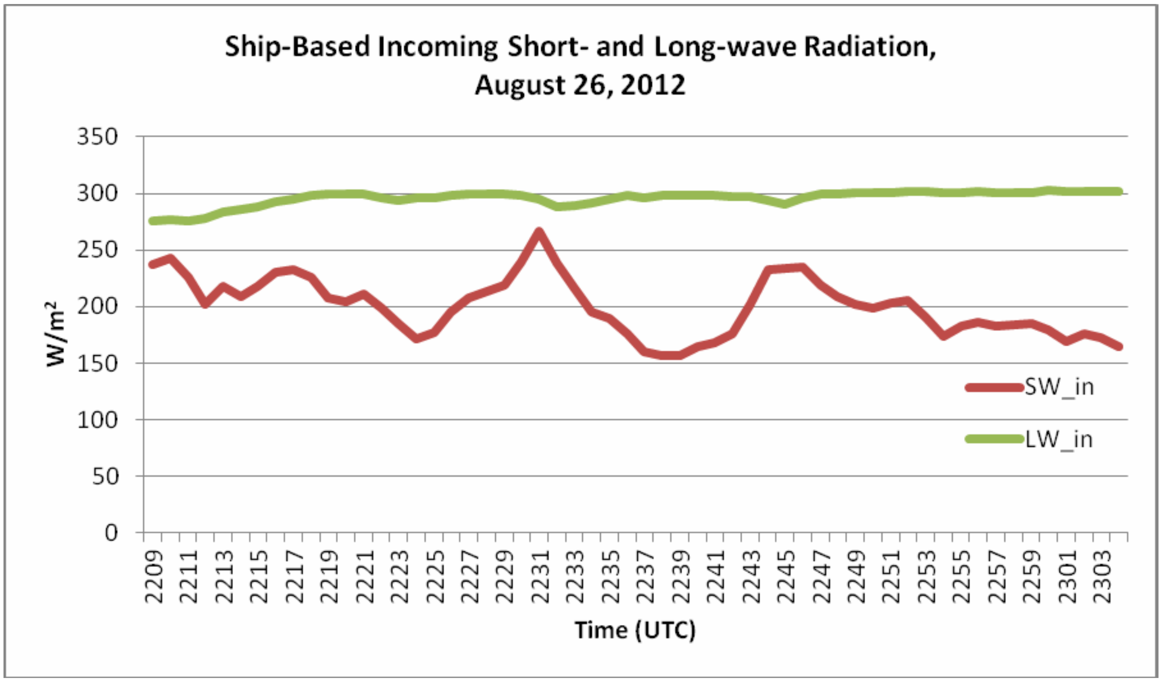


Figure 5. Ship-based incoming short- and long-wave radiation for August 26, 2012

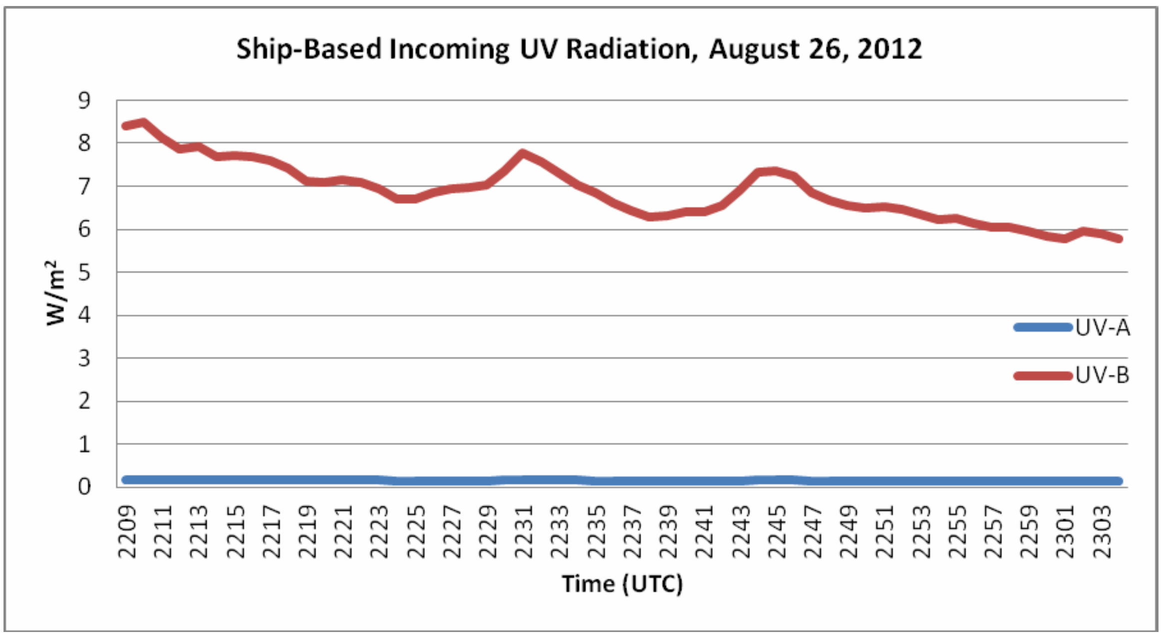


Figure 6. Ship-based incoming UV radiation for August 26, 2012

2.0 Surface Meteorological Data

To complement the radiation data collected on ship and on ice, surface meteorological data was collected at regular intervals. The first being an All Sky Camera – an upward facing Nikon D90 DSLR camera with a fisheye lens. The camera was placed in a tube with a clear dome enabling the camera to capture a continuous set of images every 10 minutes. The images assist in the classification of general sky conditions, including cloud fraction and cloud identification. Figure 7 shows the All Sky Camera mount and a sample image.

Figure **7.** All Sky Camera mount and sample image

The other portion of the meteorological data collected consists of an hourly monitoring of weather conditions. At the top of the hour from 8AM to 8PM, a variety of weather conditions are recorded, including: temperature, pressure, precipitation, wind speed, wind direction, ship direction, wave height, Beaufort scale, swell height, distance between swells in meters and seconds, visibility, sea ice fraction, sea ice type, cloud fraction, cloud layers, cloud type, visibility of solar disk, and the presence shadowing. The ships AVOS data was also downloaded to supplement this data.

3.0 HyperSAS data

The HyperSAS instrument (Figure 8) was used in ice to observe the spectral properties of sea ice during transit and while at ice stations. The spectral range of the sensor is 300-800 nm (256 channels).and is an above water sensor that was mounted on the bow of the ship (Figure x.). The sensor was accompanied by a time lapse camera, set at 10 second interval to provide information as to the nature of the ice scape surface and a CNR-1 net-radiometer (Alice Orlich, International Arctic Research Centre). Table summarizes the data collected during the ice portion of the cruise.

Figure 8. Bow mounted HyperSAS instrument with time lapse camera and a CNR-1 net radiometer (Alice Orlich) in the background.

Table 3.HyperSAS data collected

Date	Day	start (UTC)	end (UTC)	interval	No. Files	Comment
26/8/12	239	17:03	23:59	5 min	70	In ice
27/8/12	240	0:05	18:05	5 min	197	in ice
28/8/12	241	1:07	23:56	5 min	273	Transitout of ice
29/8/12	242	0:01	16:11	5 min	199	open w ater
29/8/12	242	15:01	23::54	10 min	6	open w ater
30.08/12	243	0:04	16:49	10min	101	open w ater

4.0 On Ice CTD Measurements.

For on ice CTD measurements an Oceans seven 304 CTD-T probe was used. This CTD has a Conductivity, temperature, pressure and turbidity sensor. This probe was used during on ice operations to obtain under ice CTD data. The sensor was deployed through 2” auger holes drilled for ice thickness and free board measurements.

Prior to deployment our two Ocean Seven CTDs were strapped to the foredeck rosette, to compare to the Seabird CTD (Figure 9) to a depth of 100m. The data between the sensors were comparable.

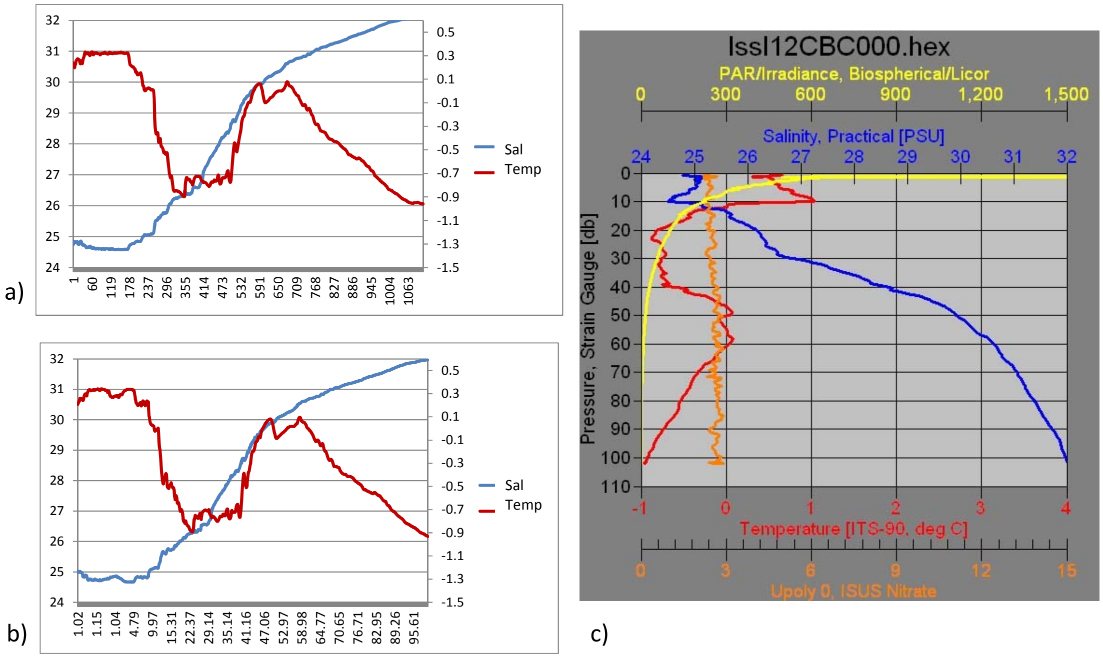


Figure 9. CTD comparison the two U of M CTD's with the fore deck rosette CTD.

As we later discovered one of the CTD's had a malfunctioning pressure sensor, this was the CTD used in the field. Despite this problem, on ice documentation of the casts, combined with ice thickness data and freeboard measurements still permitted a fairly accurate estimation of depth. The casts were made using a marked rope, cast depth ranged from 30-60m. Table 4 provides a summary of the CTD collected, ice depths, freeboard can be referenced elsewhere in the document. Data is provided for both floes (down-casts) on separate spreadsheets (beta version). This data can be cross referenced to other CTD data collected on site for a given location (see other reports). Figure 10 shows an example of CTD profiles obtained at hole 1 and 11 on floe 1, August 26, 2012.

Table 4 Summary of CTD locations and depths for floe 1 (August 26) and floe 2 (August 27).

Hole #:	Floe	Dist. (m)	Latitude	Longitude	Start UTC	Bottom UTC	End UTC	Depth (m)
1	1	0	80 52 48.3	-137 25 20.2	22:08	:09	:11	30
2	1	10	80 52 53.5	-137 25 22.6	:21		:24	30
3	1	20	80 52 57.6	-137 25 23.2	:29	:31	:32	30
4	1	30	80 53 00.2	-137 25 22.0	:38	:40	:42	30
5	1	40	80 53 02.7	-137 25 20.7	:47	:48	:50	30
6	1	50	80 53 05.1	-137 25 19.3	:55	56	:58	30
7	1	60	80 53 07.1	-137 25 18.4	23:02	:04	:06	30
8	1	70	80 53 08.8	-137 25 16.8	:10		:13	30
9	1	80	80 53 10.6	-137 25 16.2	:17	:18	:20	30
10	1	90	80 53 12.2	-137 25 14.5	:24	:25	:27	30
11	1	100	80 53 13.8	-137 25 13.0	:42	:44	:46	30
12	1	110	80 53 17.0	-137 25 13.5	:50	:51	:52	30
13	1	120	80 53 18.3	-137 25 13.4	:56	:57	:59	30
14	1	130	80 53 19.4	-137 25 13.0	0:04	:05	:07	30
15	1	140	80 53 20.5	-137 25 13.0	:14	:15	:17	30
1	2	0	80 11 45.7	-129 47 52.9	19:56	:58	:59	30
2	2	10	80 11 46.6	-129 48 18.9	20:03	:05	:08	60
3	2	20	80 11 48.1	-129 48 59.1	:11	:13	:15	60
4	2	30	80 11 49.1	-129 49 23.8	:18	:20	:22	60
5	2	40	80 11 50.5	-129 49 54.2	:25		:29	60
6	2	4	80 11 51.7	-129 50 35.7	:36	:37	:39	30
7	2	8	80 11 52.8	-129 50 56.9	:41	:42	:44	30
8	2	12	80 11 53.9	-129 51 18.8	:47	:48	:49	30
9	2	16	80 11 56.0	-129 51 59.6	:56	:57	:59	30
10	2	24	80 11 57.8	-129 52 29.6	21:04	:05	:06	30
11	2	28	80 11 59.1	-129 52 52.1	:09	:10	:11	30
12	2	32	80 12 0.5	-129 53 14.8	:15	:16	:18	40
13	2	36	80 12 1.9	-129 53 40.0	:21	:22	:23	30

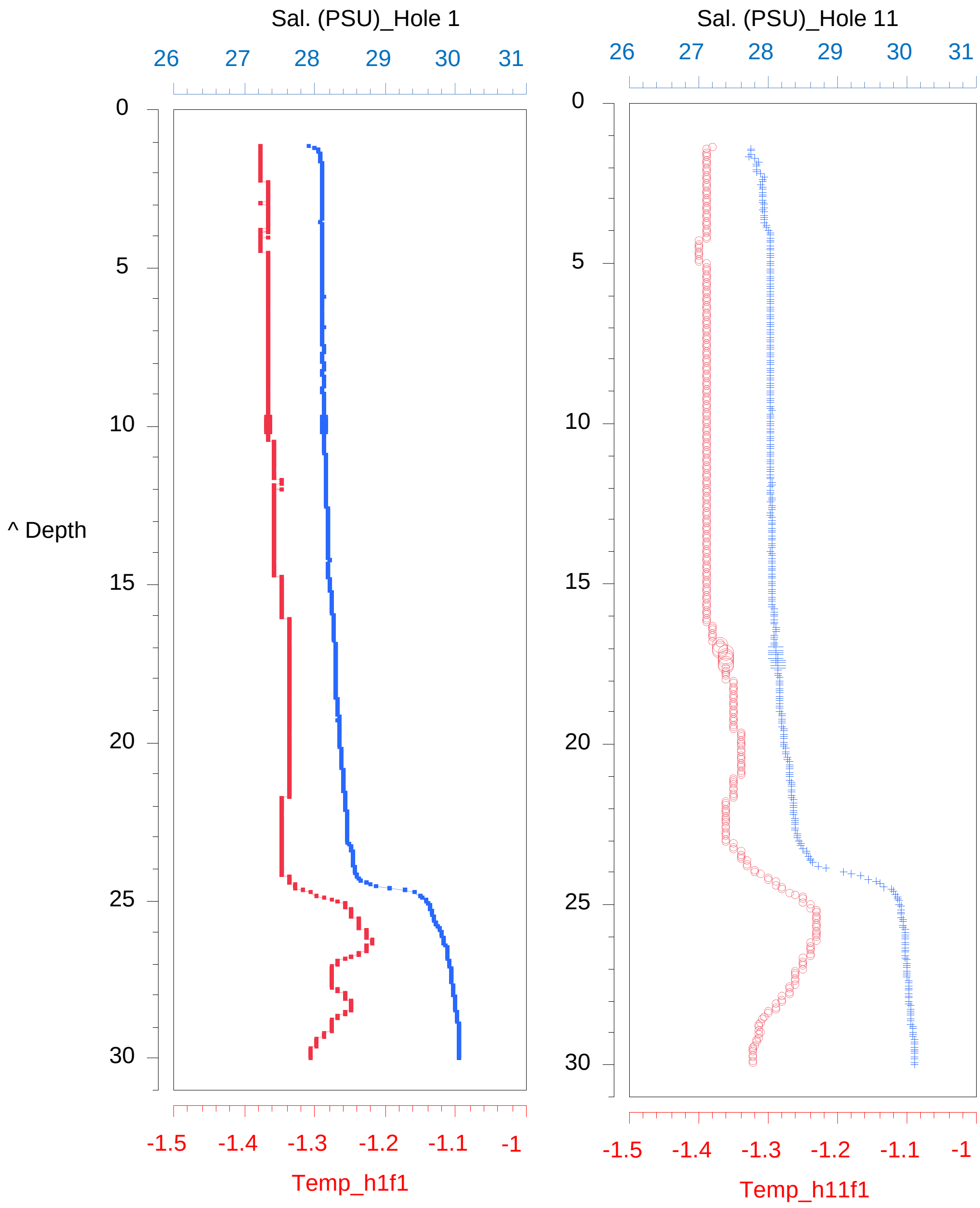


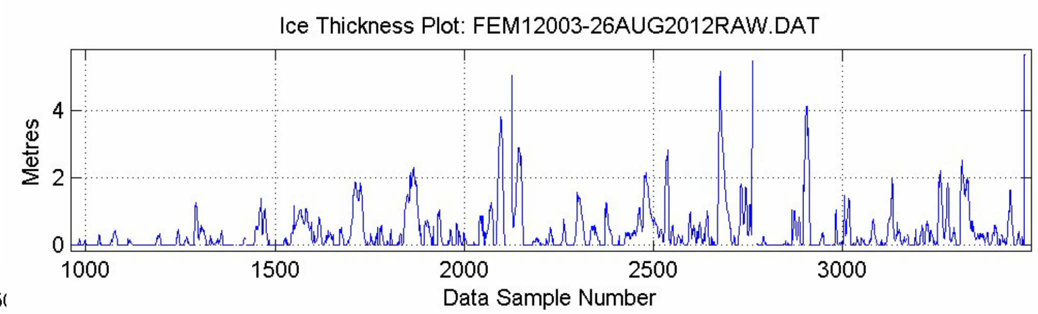
Figure 10. CTD profiles from floe 1, August 26, a) Hole1; b) Hole 11.

5.0 EM induction Surveys

During the JOIS 2012 cruise, ice thickness and ice surface roughness were measured with a helicopter-borne electromagnetic (HEM) system, called the "Ice Pic", Figure 11.. The sensor package consists of an electromagnetic (EM) sensor with transmitter and receiving coils (transmitter frequencies of 1.7, 5.0, 11.7

and 35.1 kHz) and a laser altimeter. The laser altimeter data provides ice-surface roughness profiles and the height of the EM sensor above the pack ice. The EM sensor measures the distance to the ocean surface water as it is the nearest conductor and the laser measures the distance to the pack ice surface. Together they provide the snow-plus- ice thickness.

With only two days in the ice there was very limited opportunity to fly extensive surveys. On August 26 some data was collected on a transect north of the ship. The ice thicknesses ranged from the centimeter scale to about 5m, with the mean thickness of about 0.4 m. Technical issues the first day cut short the survey. A second Ice PIC system (U of M system) replaced the BIO system for the next day's anticipated surveys, unfortunately these were cancelled due to persistent fog.



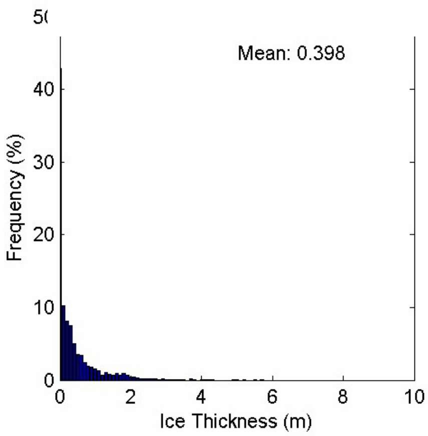
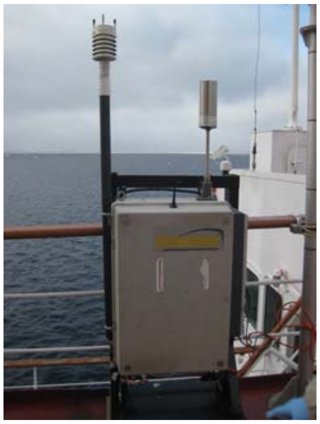


Figure 11. Helicopter mounted EM induction System

5.17 Airpointer System

Environment Canada



An Airpointer system was installed above the bridge by Environment Canada before the ship left port in St. Johns. Edmand Fok changed the airfilter weekly and downloaded data daily to send back to Environment Canada.

APPENDIX A: Participants

Table 1. Cruise Participants

Name	Affiliation	Role
Bill Williams	DFO	Chief Scientist
Rick Krishfield	WHOI	Mooring
Jim Dunn	WHOI	Mooring
Kris Newhall	WHOI	Mooring
Steve Lambert	WHOI	Mooring
Hirokatsu Uno	JAMSTEC	Mooring
Jonaotaro Onadera	JAMSTEC	Mooring
Carlton Rauschenberg	BLOS	Mooring - Obuoy
Daisuke Hirano	TUMSAT	Mooring / XCTD
Michiyo Kawai	TUMSAT	Primary Chemist / Alkalinity
Kelly Young	DFO	CTD / Vertical Net Hauls
Edmand Fok	DFO	CTD / Underway System
Sarah Zimmermann	DFO	CTD / CTD Data Analyst
Rick Nelson	DFO	CTD / RadioNuclide
Hugh Maclean	DFO	CTD / Salt Analyst
Linda White	DFO	Nutrient Analyst
Kenny Scozzafava	DFO	Oxygen Analyst
Marty Davelaar	DFO	DIC Analyst
Paul Dainard	Trent U	CTD / CDOM
Mike deGrandpre	U Montana	pCO2 systems
Mary Thaler	ULaval	Microbial Diversity
Emmanuelle Medrinal	ULaval	Microbial Diversity

Ben Lincoln	TEA-COSI	Turbulence Profiles
Ben Powell	TEA-COSI	Turbulence Profiles
Alice Orlich	UAF	Ice Observations
Kazu Tateyama	KIT	Ice Observations
Jun Ono	KIT	Ice Observations
Klaus Hochheim	UofM	Ice Observations
Heather Stark	UofM	Ice Observations

Table 2. Principal Investigators not on-board ship

Name	Affiliation
Fiona McLaughlin	DFO-IOS
Eddy Carmack	DFO-IOS
John Nelson	DFO-IOS/UVIC
Svein Vagle	DFO-IOS
John Smith	DFO-BIO
Bill Li	DFO-BIO
Andrey Proshutinsky	WHOI
John Toole	WHOI
Mary-Louise Timmermans	Yale U.
Takashi Kikuchi	JAMSTEC
Motoyo Itoh	JAMSTEC
Shigeto Nishino	JAMSTEC
Koji Shimada	TUMSAT
Jenny Hutchings	IARC
Chris Guay	PMST
Celine Gueguen	Trent U.
Connie Lovejoy	Ulaval
Don Perovich	CRREL
Tim Stanton	NPS
Patricia Matrai	BLOS
Mike Steele	APL
Sheldon Bacon	TEA-COSI

Table 3. Affiliation Abbreviation

APL	Applied Physics Laboratory, University of Washington, Seattle, Washington, USA
BIO	Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada
BLOS	Bigelow Laboratory for Ocean Sciences, Maine, USA
CRREL	Cold Regions Research Laboratory, New Hampshire, USA
DFO	Department of Fisheries and Oceans, Canada
IARC	International Arctic Research Center, University of Alaska Fairbanks, Alaska

IOS	Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
KIT	Kitami Institute of Technology
NPS	Naval Postgraduate School, Monterey, California, USA
PMST	Pacific Marine Sciences and Technology LLC
TEA-COSI	The Environment of the Arctic – Climate, Ocean and Sea-Ice, UK
Trent U.	Trent University, Ontario, Canada
TUMSAT	Tokyo University of Marine Science and Technology, Tokyo, Japan
UAF	University of Alaska Fairbanks, Alaska, USA
UBC	University of British Columbia, Vancouver, British Columbia, Canada
UM	University of Montana, Missoula, Montana, USA
UofM	University of Manitoba, Winnipeg, Manitoba, Canada
ULaval	University of Laval, Québec City, Quebec, Canada
UVIC	University of Victoria, Victoria, British Columbia, Canada
WHOI	Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
Yale U.	Yale University, New Haven, Connecticut, USA

APPENDIX B: Science Station Locations (those not included in text)

Table 1. CTD/Rosette Stations

Cast #	Station	CAST START DATE (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Sample Numbers
1	AG5	8/5/2012 15:58	70.5568	122.9098	634	638	1 to 11
2	AG5	8/5/2012 21:27	70.5582	122.9165	635	639	12 to 31
3	CB1	8/6/2012 14:49	71.7708	131.8763	1100	1108	32 to 55
4	CB31b	8/6/2012 21:00	72.3495	134.0038	2020	2059	56 to 79
5	CB23a	8/7/2012 3:59	72.8470	135.9160	4402	2696	80 to 103
6	MK7	8/7/2012 12:51	72.5133	140.0050	2987	2988	104 to 127
7	BL8	8/8/2012 11:38	71.9485	150.2918	2883	2931	135 to 158
8	BL6	8/8/2012 18:30	71.6693	151.0720	1803	1726	166 to 189
9	BL4	8/9/2012 0:44	71.5060	151.6603	805	998	190 to 212
10	BL2	8/9/2012 4:14	71.3880	151.7732	160	159	213 to 235
11	BL1	8/9/2012 6:34	71.3450	151.7877	85	77	236 to 243
12	CB-2a	8/9/2012 16:04	72.4847	150.0065	3874	3712	244 to 267
13	Cb2	8/10/2012 0:45	72.9967	150.0007	3750	3739	268 to 291
14	CB7	8/11/2012 0:08	76.0168	149.9863	3830	3819	300 to 323
15	CB-4	8/11/2012 9:25	74.9598	149.9492	3825	3814	324 to 347
16	CB5	8/12/2012 1:13	75.3165	153.3325	3847	3831	355 to 378
17	CB-3	8/13/2012 7:17	74.0068	150.0473	3825	3814	387 to 410
18	CBS	8/13/2012 19:46	73.5033	144.9913	3646	3634	419 to 442
19	StnA	8/14/2012 4:42	72.6093	144.6947	3440	1002	443 to 466
20	StnA	8/14/2012 6:09	72.6108	144.7015	3440	3423	467 to 490
21	CB29	8/14/2012 16:09	71.9998	140.0105	2704	2680	498 to 521
22	MK6	8/14/2012 21:04	71.5922	140.0107	2517	2486	522 to 545
23	CB28b	8/15/2012 2:23	70.9940	139.9902	2079	2066	553 to 576
24	MK3'	8/15/2012 6:17	70.6563	139.9863	1357	1307	577 to 599
25	MK2	8/15/2012 9:31	70.4012	140.0013	502	490	600 to 623
26	CB28aa	8/15/2012 13:04	69.9997	140.0023	57	52	624 to 635
27	CB22	8/22/2012 2:50	73.4497	138.0098	3137	3109	636 to 659
28	CB21	8/22/2012 8:58	73.9933	139.9813	3484	1002	660 to 683
29	CB21	8/22/2012 11:50	74.0028	139.9698	3492	3496	684 to 707
30	CB19	8/23/2012 1:55	74.3032	143.3167	3699	3689	715 to 738
31	CB6	8/23/2012 9:18	74.6985	146.6782	3780	3771	739 to 762
32	CBC	8/23/2012 20:23	75.9913	145.2080	3786	3779	771 to 794
33	cb8	8/24/2012 6:28	76.9947	149.9920	3825	2983	802 to 825
34	cb12	8/25/2012 1:48	77.5808	145.6308	3802	1002	826 to 849
35	cb12	8/25/2012 3:16	77.5825	145.6285	3802	3794	850 to 873
36	CB9	8/25/2012 11:39	78.0088	149.9678	3826	3813	874 to 897

37	CB11	8/25/2012 19:49	79.0098	149.9880	3825	3003	898 to 921
38	CBN	8/26/2012 20:54	80.8742	137.4295	3728	600	928 to 942
39	CBN	8/26/2012 22:12	80.8813	137.4445	3728	3000	943 to 966
40	CBN2	8/27/2012 20:32	80.1997	129.8483	3497	3482	967 to 990
41	CBN2	8/28/2012 1:11	80.2218	130.1017	3497	500	991 to 999
42	CB16b	8/28/2012 18:17	78.7715	136.4842	3713	3001	1000 to 1023
43	CB16	8/29/2012 1:44	77.9965	140.0070	3753	3734	1024 to 1047
44	CB9	8/29/2012 14:46	78.0047	149.9817	3823	1000	1056 to 1078
45	TU1	8/30/2012 20:53	76.0162	160.2448	2096	524	1079 to 1098
46	TU1	8/30/2012 22:11	76.0160	160.2613	2096	2082	1099 to 1122
47	TU-2	8/31/2012 10:58	76.9998	170.0093	2096	2203	1123 to 1146
48	CAP-10	9/1/2012 7:04	76.0175	175.2915	2111	537	1154 to 1173
49	CAP-10	9/1/2012 8:30	76.0157	175.2987	2111	2092	1174 to 1197
50	CB10S	9/3/2012 20:05	77.1658	153.9018	0	2134	1198 to 1221
51	CB15	9/4/2012 12:41	77.0005	139.9987	3708	3718	1229 to 1252
52	PP7	9/4/2012 23:17	76.5370	135.4363	3554	1001	1261 to 1284
53	PP7	9/5/2012 0:51	76.5368	135.4177	3552	3557	1285 to 1308
54	PP6	9/5/2012 6:53	76.2765	132.5962	3074	3076	1309 to 1332
55	CB40	9/6/2012 13:17	74.4977	135.4335	3247	3242	1341 to 1364
56	CB50	9/6/2012 20:26	73.5043	134.2518	2886	2878	1373 to 1396

Table 2. Foredeck Rosette locations using SBE19+. Note all foredeck cast were used for microbial diversity study with additional stations from the main rosette (see microbial section of report and/or chemistry sample log).

Cast No.	Station Name	Cast Start Time [UTC]	Latitude (N)	Longitude (W)	Water Depth [m]	Cast Depth [m]	Sample Nos.
906	MK7	8/7/12 7:32	72.5133	140.0050	2987	102	128 to 134
907	BL8	8/8/12 6:48	71.9485	150.2918	2883	108	159 to 165
913	Cb2	8/10/12 0:45	72.9967	150.0007	3750		292 to 299

915	CB-4	8/11/12 3:29	74.9598	149.9492	3825	103	348 to 354
916	CB5	8/11/12 19:00	75.3165	153.3325	3847	102	379 to 386
917	CB-3	8/13/12 1:08	74.0068	150.0473	3825	102	411 to 418
920	StnA	8/13/12 23:46	72.6108	144.7015	3440	102	491 to 497
922	MK6	8/14/12 21:04	71.5922	140.0107	2517	101	546 to 552
929	CB21	8/22/12 11:50	74.0028	139.9698	3492	102	708 to 714
931	CB6	8/23/12 9:18	74.6985	146.6782	3780	103	763 to 770
932	CBC	8/23/12 20:23	75.9913	145.2080	3786	102	795 to 801
937	CB11	8/25/12 19:49	79.0098	149.9880	3825	103	922 to 927
943	CB16	8/29/12 1:44	77.9965	140.0070	3753	101	1048 to 1055
947	TU-2	8/31/12 10:58	76.9998	170.0093	2096	103	1147 to 1153
950	CB10S	9/3/12 20:05	77.1658	153.9018		102	1222 to 1228
951	CB15	9/4/12 12:41	77.0005	139.9987	3708	102	1253 to 1260
954	PP6	9/5/12 6:53	76.2765	132.5962	3074	202	1333 to 1340
955	CB40	9/6/12 13:17	74.4977	135.4335	3247	203	1365 to 1372

Table 3. Turbulence profile locations (VMP).

VMP Cast No.	STATION	DATE	TIME (UTC)	Latitude (N)	Longitude (W)	Max Depth (m)
0	AG5	8/5/2012	20:35:00	70.5550	122.9100	422
1	CB-1	8/6/2012	16:01:00	71.7654	131.8655	370
3	CB-31b	8/6/2012	23:07:00	72.3502	134.0337	475
4	CB23a	8/7/2012	05:59:00	72.8441	135.9200	508
5	MK7	8/7/2012	13:05:00	72.5083	139.9849	468
6	BL-8	8/8/2012	14:36:00	71.9484	150.3160	190
8	BL-6	8/8/2012	20:14:00	71.6600	151.0267	453
9	BL-4	8/9/2012	01:40:00	71.5040	151.6277	457
10	BL-2	8/9/2012	04:57:00	71.3878	151.7310	173
11	BL-1	8/9/2012	07:00:00	71.3429	151.7721	72
12	BL-1	8/9/2012	07:05:00	71.3433	151.7663	85
13	CB2a	8/9/2012	19:08:00	72.4642	150.0083	487
14	CB2	8/10/2012	03:30:00	72.9791	150.0292	485
15	CB7	8/11/2012	02:43:00	76.0122	149.9965	360
16	CB-4	8/11/2012	12:44:00	74.9560	149.9815	500
17	CB-5	8/12/2012	03:47:00	75.3161	153.3244	525
18	CB3	8/13/2012	10:08:00	74.0041	150.0749	515
19	CBS	8/13/2012	22:12:00	73.5015	145.0217	520
20	StnA	8/14/2012	08:43:00	72.6056	144.6968	535
21	CB29	8/14/2012	18:20:00	71.9921	140.0355	524

22	MK6	8/14/2012	22:47:00	71.5951	140.0208	524
23	CB28b	8/15/2012	03:52:00	70.9980	139.9680	520
24	MK3	8/15/2012	07:21:00	70.6544	139.9894	545
25	MK2	8/15/2012	10:16:00	70.4013	139.9972	508
26	MK1	8/15/2012	11:40:00	70.6534	139.9894	238
27	CB22	8/22/2012	04:59:00	73.4398	138.0134	540
28	CB21	8/22/2012	10:32:00	73.9952	139.9760	524
29	CB19	8/23/2012	04:19:00	74.2156	143.3087	530
30	CB6	8/23/2012	11:51:00	74.7016	146.6585	520
31	CBC	8/23/2012	22:51:00	75.9959	145.1941	516
32	CB12	8/25/2012	02:50:00	77.5807	145.6249	520
33	CB11	8/25/2012	21:49:00	79.0059	149.9661	470
34	CBN2	8/28/2012	01:52:00	80.2242	130.1275	516
36	CB16	8/29/2012	04:14:00	77.9990	139.9782	520
37	CB9	8/29/2012	14:11:00	78.0040	149.9846	510
38	TU1	8/30/2012	21:38:00	76.0167	160.2414	521
39	TU-2	8/31/2012	12:42:00	76.9971	170.0489	400
40	CAP-10	9/1/2012	07:59:00	76.0159	175.2910	536
41	CB15	9/4/2012	15:23:00	77.0004	139.9442	519
42	PP7	9/5/2012	00:22:00	76.5369	135.4171	534
43	PP6	9/5/2012	09:05:00	76.2854	132.6223	510
44	CB40	9/6/2012	15:31:00	64.4917	135.4367	530
45	CB50	9/6/2012	22:29:00	73.5050	134.2550	520

Table 4. XCTD launch locations. Locations are from cruise track based on deployment time. Cast Number taken from file name (different than name used at sea). Casts in grey were either incomplete casts or had sensor problems.

XCTD Cast Number (matches filename)	Latitude (N)	Longitude (W)	Start Date (UTC)	BOTTOM DEPTH (m)	MAX DEPTH (m)	COMMENTS
21	72.69134	137.166	8/7/12 8:29	2551	1100	2012-10-XCTD021
22	72.61347	138.632	8/7/12 10:36	2725	1100	2012-10-XCTD022
23	72.15261	148.5442	8/8/12 7:33	3546	1100	2012-10-XCTD023
24	72.04852	149.3953	8/8/12 9:02	3266	1100	2012-10-XCTD024
25	71.82181	150.7674	8/8/12 16:04	2500	1100	2012-10-XCTD025
26	71.5878	151.3675	8/8/12 22:00	1515	1100	2012-10-XCTD026
27	71.44643	151.8123	8/9/12 2:59	397	410	2012-10-XCTD027
28	72.27222	150.2935	8/9/12 14:47	3457	956	2012-10-XCTD028
29	72.74857	149.9771	8/9/12	3745	1100	2012-10-XCTD029

			22:03			
30	73.36784	150.0002	8/10/12 5:48	3754	1100	2012-10-XCTD030
31	73.67347	149.9351	8/10/12 7:13	3718	1100	2012-10-XCTD031
32	74.02051	150.1423	8/10/12 9:37	3825	1100	2012-10-XCTD032
33	74.37341	149.969	8/10/12 12:22	3824	1100	2012-10-XCTD033
34	74.73258	149.9447	8/10/12 14:07	3825	1100	2012-10-XCTD034
35	75.38056	150.0386	8/10/12 20:39	3827	1100	2012-10-XCTD035
36	75.71425	149.8857	8/10/12 22:03	3831	1100	2012-10-XCTD036
37	75.16498	151.6804	8/11/12 23:04	3826	968.7	2012-10-XCTD037
38	75.575	155.3241	8/12/12 7:01	3825	1100	2012-10-XCTD038
39	73.86729	148.8334	8/13/12 13:34	3804	1100	2012-10-XCTD039
40	73.74209	147.5187	8/13/12 15:35	3768	1100	2012-10-XCTD040
41	73.61928	146.2249	8/13/12 17:31	3713	1100	2012-10-XCTD041
42	73.1437	144.9214	8/14/12 0:28	3600	1100	2012-10-XCTD042
43	72.37715	142.9385	8/14/12 12:00	3300	1100	2012-10-XCTD043; UCTD had no data so replaced with XCTD
44	72.27705	142.1729	8/14/12 13:05	3151	1100	2012-10-XCTD044
45	72.14821	141.1513	8/14/12 14:29	2946	1100	2012-10-XCTD045
46	76.42928	145.9816	8/24/12 1:32	3796	1100	2012-10-XCTD046
47	77.33654	149.9743	8/24/12 10:26	3831	1100	2012-10-XCTD047
48	77.68115	149.993	8/24/12 12:09	3830	1100	2012-10-XCTD048
49	77.78145	147.8202	8/24/12 23:17	3818	1100	2012-10-XCTD049
50	78.31042	150.0385	8/25/12 16:38	3830	1100	2012-10-XCTD050
51	78.65141	149.9376	8/25/12 18:01	3827	1100	2012-10-XCTD051
52	79.04582	150.0587	8/25/12 23:17	3800	1100	2012-10-XCTD052
53	79.08216	149.7714	8/25/12 23:37	3823	1100	2012-10-XCTD053
54	79.30566	147.9748	8/26/12 1:22	3819	1100	some ice but lots of open water, so ship doesnlt need to slow past 12 knots; 2012-10-XCTD054 XCTD-1
55	79.57315	145.6809	8/26/12 3:28	3802	1100	2012-10-XCTD055 XCTD-1

56	79.84277	143.407	8/26/12 6:23	3793	1100	2012-10-XCTD056 XCTD-1
57	80.12659	141.0732	8/26/12 9:12	3772	1100	2012-10-XCTD057 XCTD-1
58	80.38832	138.2343	8/26/12 12:53	3738	1100	2012-10-XCTD058 XCTD-1
59	80.64341	137.4624	8/26/12 15:31	3724	1100	2012-10-XCTD059; stopped to deploy; ice around, but big leads/open areas too) XCTD-1
60	80.64707	134.8464	8/27/12 6:20	3683	1100	2012-10-XCTD060
61	80.41798	132.1697	8/27/12 10:04	~3595	1100	2012-10-XCTD061; Hard to get depth in ice
62	80.23881	130.124	8/27/12 13:09	3500	1100	2012-10-XCTD062; ice closed in around wire during cast
63	79.87925	131.9636	8/28/12 5:42	3566	1100	2012-10-XCTD063; Carleton says Alt max unusual open lead, not a lot of line left ~5.5km
64	79.51803	134.1388	8/28/12 9:38	3666	1100	2012-10-XCTD064
65	79.10724	135.6996	8/28/12 13:30	3696	1100	2012-10-XCTD065; Cruise continued in Book #2
66	78.68774	137.1352	8/28/12 21:07	3729	284	2012-10-XCTD066; broke wire early going to run again
67	78.66978	137.2686	8/28/12 21:19	3729	1100	2012-10-XCTD067
68	78.29057	138.5864	8/28/12 23:40	3740	824.3	2012-10-XCTD068
69	78.03051	142.3865	8/29/12 6:45	3788	1100	2012-10-XCTD069
70	78.00306	144.8907	8/29/12 8:53	3803	1100	2012-10-XCTD070
71	77.99868	147.5574	8/29/12 11:10	3818	1100	2012-10-XCTD071; XCTD-3 used
72	77.86017	150.9051	8/30/12 0:31	3825	1100	2012-10-XCTD072
73	77.6932	151.865	8/30/12 1:35	3827	1100	2012-10-XCTD073
74	77.54306	152.7504	8/30/12 2:36	3838	1100	2012-10-XCTD074
75	77.45989	153.2114	8/30/12 3:10	2471	1100	2012-10-XCTD075
76	77.37813	153.6367	8/30/12 3:41	2247	1100	2012-10-XCTD076
77	77.30705	154.0345	8/30/12 4:11	1500	1100	2012-10-XCTD077
78 Try 1	77.07005	155.2629	8/30/12 4:11	820	na	XCTD cast aborted by accident (pressed wrong button) so another probe deployed (the real XCTD cast#78)
78	77.07005	155.2629	8/30/12 5:41	820	790	2012-10-XCTD078
79	76.90523	156.0351	8/30/12 6:40	1500	1100	2012-10-XCTD079

80	76.73851	156.8757	8/30/12 7:43	1356	876	2012-10-XCTD080. Salinity profile looks a little odd. XCTD-3 used
81	76.56587	157.6509	8/30/12 8:46	1830	736	Conductivity profile was wrong, deployed another XCTD-3 used
82	76.55437	157.7054	8/30/12 8:52	1870	1100	Sounder not working, take from chart; 2012-10-XCTD082 XCTD-3 used
83	76.39162	158.3968	8/30/12 9:51	1400	742	Sounder not working, take from chart; 2012-10-XCTD083 XCTD-3 used
84	76.21642	159.0771	8/30/12 10:50	1500	754	Sounder not working, take from chart; 2012-10-XCTD084 XCTD-3 used
85	76.14839	159.4044	8/30/12 11:17	1500	1085	Sounder not working, take from chart; 2012-10-XCTD085 XCTD-3 used
86	76.0879	159.651	8/30/12 11:42	?	1096	Sounder not working, take from chart; 2012-10-XCTD086 XCTD-3 used
87	76.11818	160.948	8/31/12 0:33	2127	133	2012-10-XCTD087; wire broke, cast repeated; XCTD-3 used
88	76.12321	160.9826	8/31/12 0:36	2127	1100	2012-10-XCTD088 XCTD-1 used
89	76.22488	162.0411	8/31/12 1:45	1500	1100	2012-10-XCTD089 XCTD-1 used
90	76.32903	162.7302	8/31/12 2:59	2046	1100	2012-10-XCTD090 XCTD-1 used
91	76.43488	164.0059	8/31/12 4:21	650	683	2012-10-XCTD091 XCTD-1 used
92	76.53099	164.6347	8/31/12 5:05	575	564	2012-10-XCTD092 XCTD-1 used
93	76.61961	165.6109	8/31/12 6:05	1156	1100	2012-10-XCTD093 XCTD-1 used
94	76.71828	166.6119	8/31/12 7:08	656	693	2012-10-XCTD094 XCTD-3 used
95	76.80358	167.623	8/31/12 8:12	942	1100	2012-10-XCTD095 XCTD-3 used
96	76.83254	167.9775	8/31/12 8:34	1496	1100	2012-10-XCTD096 XCTD-3 used
97	76.85573	168.2606	8/31/12 8:53	773	1100	2012-10-XCTD097 XCTD-3 used
98	76.92313	169.0674	8/31/12 9:42	2137	1100	2012-10-XCTD098 XCTD-3 used
99	76.84063	170.876	9/1/12 0:49	2238	1100	2012-10-XCTD099 XCTD-1 used
100	76.68598	171.7596	9/1/12 1:53	2229	1100	2012-10-XCTD100 XCTD-1 used
101	76.53167	172.5557	9/1/12 2:54	2263	1100	2012-10-XCTD101 XCTD-1 used
102	76.36848	173.374	9/1/12 3:58	2234	1100	2012-10-XCTD102 XCTD-1 used
103	76.21185	174.1954	9/1/12 5:01	2224	1100	2012-10-XCTD103 XCTD-1 used
104	76.30117	171.9514	9/3/12 2:25	2230	1100	2012-10-XCTD104 XCTD-1 used
105	76.41212	170.6954	9/3/12 3:43	2221	1100	2012-10-XCTD105 XCTD-1 used
106	76.52612	169.3206	9/3/12 5:08	2194	1100	2012-10-XCTD106 XCTD-1 used

107	76.6175	167.9641	9/3/12 6:31	1782	1100	2012-10-XCTD107 XCTD-1 used
108	76.6954	166.634	9/3/12 7:48	740	674	2012-10-XCTD108 XCTD-1 used
109	76.78784	165.1895	9/3/12 9:14	1120	1100	2012-10-XCTD109 XCTD-1 used
110	76.86184	163.8034	9/3/12 10:35	960	1038	2012-10-XCTD110 XCTD-1 used
111	76.94842	162.3977	9/3/12 11:58	1814	1100	2012-10-XCTD111
112	77.0208	160.9084	9/3/12 13:22	2030	1100	2012-10-XCTD112
113	77.07511	159.4157	9/3/12 14:45	1814	1100	2012-10-XCTD113
114	77.11318	158.0924	9/3/12 15:57	1350	1086	2012-10-XCTD114; Different position than planned for due to Helicopter and buoy operations.
115	77.13547	156.4091	9/3/12 17:34	1819	1074	2012-10-XCTD115
116	76.82159	138.2666	9/4/12 19:29	3663	1099	2012-10-XCTD116 XCTD-3 used
117	76.6667	136.7196	9/4/12 21:48	3620	1100	2012-10-XCTD117 XCTD-3 used
118	76.39579	133.9575	9/5/12 4:43	3357	1099	2012-10-XCTD118 XCTD-3 used
119	76.21338	134.4442	9/5/12 11:56	3375	1100	2012-10-XCTD119 XCTD-3 used
120	76.13888	136.3466	9/5/12 13:48	3540	1100	2012-10-XCTD120 XCTD-3 used
121	76.06864	138.1475	9/5/12 15:33	3606	1100	2012-10-XCTD121 XCTD-3 used
122	76.00128	139.9442	9/5/12 17:45	3674	1100	Rosette cancelled due to bad weather; XCTD and UCTD casts performed instead 2012-10-XCTD122 XCTD-3 used
123	75.52019	141.2062	9/5/12 20:40	3691	1100	Rosette cancelled due to bad weather; XCTD and UCTD casts were performed instead 2012-10-XCTD123 XCTD-3 used
124	75.00289	140.0504	9/6/12 4:16	3616	1100	2012-10-XCTD124 XCTD-3 used
125	74.83033	138.4093	9/6/12 7:30	3520	1100	2012-10-XCTD125 XCTD-3 used
126	74.66342	136.8897	9/6/12 10:11	3359	1100	2012-10-XCTD126 XCTD-3 used
127	74.18077	135.0509	9/6/12 17:24	3130	1100	2012-10-XCTD127.raw 2012-10-XCTD127 XCTD-3 used
128	73.85525	134.6528	9/6/12 18:49	3015	1100	2012-10-XCTD128 2012-10-XCTD128 XCTD-3 used
129	73.24521	132.8246	9/7/12 0:52	2575	1066	2012-10-XCTD129 XCTD-3 used
130	72.98396	131.465	9/7/12 2:44	2176	1070	2012-10-XCTD130 XCTD-3 used

131	72.6702	129.9667	9/7/12 4:58	1237	1100	Final steam into Kugluktuk for Sept 8 departure 2012-10-XCTD131 XCTD-3 used

Table 5. UCTD Cast Locations. Locations are from cruise track based on deployment time. Cast Number taken from file name. Casts in grey were are not good.

Cast No.	Latitude (N)	Longitude (W)	Start Date (UTC)	Bottom Depth (m)	Max Pressure (db)	Filename and Comment
1	72.0801	132.9890	06 Aug 2012 18:37:39	1875	540	uctd001.asc
2	72.6506	135.0720	07 Aug 2012 01:43:28	2475	515	uctd002.asc
3	72.5397	141.5578	07 Aug 2012 17:59:27	3180	541	uctd003.asc
4	72.5698	143.0782	07 Aug 2012 20:27:20	3241	548	uctd004.asc
5	72.5873	144.7581	08 Aug 2012 00:26:50	3328	579	uctd005.asc
6	72.4034	146.3485	08 Aug 2012 03:29:41	1920	555	uctd006.asc
7	72.2837	147.4405	08 Aug 2012 05:31:20	1930	544	uctd007.asc
8	72.9211	144.8742	14 Aug 2012 01:31:37	3541	575	uctd008.asc
9	72.4321	143.3769	14 Aug 2012 11:24:16	3325	0	uctd009.asc No good. Only surface data (!?).
10	71.3968	140.0145	15 Aug 2012 00:14:56	2324	602	uctd010.asc Changed to probe #sn015. The slow rewind worked again (had not been working)
11	71.1857	140.0300	15 Aug 2012 01:15:31	2251	646	uctd011.asc
12	70.8086	140.0045	15 Aug 2012 05:08:52	1500	671	uctd012.asc
13	70.5286	140.0005	15 Aug	697	638	uctd013.asc

			2012 08:28:16			
14	70.4178	137.2025	17 Aug 2012 04:33:52	497	433	uctd014.asc
15	70.4657	138.1129	17 Aug 2012 05:48:50	600	549	uctd015.asc
16	70.5185	139.0697	17 Aug 2012 07:10:55	950	556	uctd016.asc
17	70.6348	141.3591	17 Aug 2012 10:08:50	800	668	uctd017.asc Planned to payout for 3 min but at 2 min50sec the line had completely payed out, coming to a hard stop. Luckily line WAS attached to winch. Bobbin had been filled to max capacity at 650m.
18	70.6961	142.6103	17 Aug 2012 11:50:13	1068	667	uctd018.asc
19	70.7801	143.9962	17 Aug 2012 13:42:00	526	502	uctd019.asc
20	71.0222	145.4225	17 Aug 2012 19:11:56	780	609	uctd020.asc
21	**71.3575**	144.5267	17 Aug 2012 21:10:57	2500	634	uctd021.asc GPS on XCTD computer not working.
22	71.1972	134.5085	21 Aug 2012 00:03:25	650	631	uctd022.asc
23	71.5648	135.5514	21 Aug 2012 02:40:49	1814	610	uctd023.asc
24	71.9220	136.6553	21 Aug 2012 05:16:51	2100	669	uctd024.asc
25	72.2940	137.7713	21 Aug 2012 07:58:27	2410	614	uctd025.asc Note: Casts 10 to 25 (sn#015) display -1C as 64C.
26	73.0168	139.8861	21 Aug 2012 13:14:50	3200	672	uctd026.asc Switch UCTD back to sn#26.
27	73.5038	139.9867	21 Aug 2012 15:56:42	3400	647	uctd027.asc
28	73.7159	138.9839	22 Aug 2012 00:44:33	3494	647	uctd028.asc
29	74.1534	141.7579	22 Aug 2012	3500	666	uctd029.asc Cleaned up memory by deleting all

			23:39:11			files.
30	74.5052	144.9981	23 Aug 2012 06:51:02	3737	622	uctd030.asc
31	75.1189	146.1855	23 Aug 2012 15:01:21	3785	661	uctd031.asc
32	75.6066	145.5337	23 Aug 2012 17:44:08	3887	649	uctd032.asc
33	76.7402	147.7345	24 Aug 2012 03:46:52	3812	650	uctd033.asc
34	77.1287	151.6133	04 Sep 2012 01:11:03	3809	701	uctd034.asc
35	77.0821	147.2316	04 Sep 2012 05:15:36	3791	690	uctd035.asc
36	77.0565	144.9043	04 Sep 2012 07:31:49	3768	660	uctd036.asc
37	77.0337	142.7045	04 Sep 2012 09:40:29	3737	644	uctd037.asc
38	76.0044	139.9138	05 Sep 2012 17:59:06	3674	702	uctd038.asc Weather too rough for CTD at station CB17. Perform UCTD and XCTD instead
39	74.9991	140.0077	06 Sep 2012 04:25:01	3616	715	uctd039.asc Weather too rough for CTD at station CB18. Perform UCTD and XCTD instead

Table 6. ADCP Cast Locations. Filename is of format ADCP###_000000.LOG

File Name	Year	Month	Day	Time (UTC)	STATION	Comments
147	2012	8	5	16:22:00	AG5	try to get in working while in water
148	2012	8	5	16:56:00	AG5	working now
149	2012	8	5	22:13:00	ag5	
150	2012	8	6	16:29:00	CB1	
153	2012	8	7	6:22:00	cb23a	
154	2012	8	7	15:19	mk7	
155	2012	8	8	14:55	BL8	File not closed at end of station?
156	2012	8	8	18:45:00 (about)	BL6	File not closed at end of station?
157	2012	8	9	01:00:00 (about)	BL4	File not closed at end of station?
158	2012	8	9	04:30:00 (about)	BL2	File not closed at end of station?
x						ADCP not deployed for station

						BL1
159	2012	8	9	16:21	CB2a	
160	2012	8	9		CB2	
161	2012	8	10		CB7	
162	2012	8	11	13:01	cb4	
163	2012	8	12	1:19	cb5	
164	2012	8	13	10:33	cb3	
165	2012	8	13	19:49	cbs	
166	2012	8	14	9:07	Sta-a	
167	2012	8	14	18:41	cb29	
168	2012	8	14	21:08	MK6	
169	2012	8	15	22:29	cb28b	
170	2012	8	15	6:17	MK3'	
171	2012	8	15	10:45	mk2	
172	2012	8	15	11:55	mk1	
173	2012	8	15	13:33	cb28aa	
174	2012	8	22	2:59	cb22	
175	2012	8	22	0:00	cb21	end time. ADCP power not turned off until 18:08 (oops)
176	2012	8	23	2:02	cb19	
177	2012	8	23	12:13	cb6	
178	2012	8	23	20:23	cbc	
179	2012	8	24	6:33	cb8	
182	2012	8	25	1:51	cb12	
183	2012	8	25	13:03	cb9	
184	2012	8	25	19:52	c b11	power was still plugged in at start of cast
185	2012	8	28	1:22	cbn2	
186	2012	8	28		cb16b	
187	2012	8	29	2:00	cb16	
188	2012	8	29	14:07	cb9	
189	2012	8	30	20:56	TU-1	lost NMEA feed? Not sure, so stopped cast, unplugged then restarted
190	2012	8	30	20:57	TU-1	
193	2012	9	3	20:10	cb10s	
194	2012	9	3	15:40	cb15	
195						no cast. Forgot to plug in first
196	2012	9	4	23:26	pp7	
197	2012	9	5	9:24	pp6	
199	2012	9	6	20:31	cb50	

Table 7. Vertical Net Hauls for Zooplankton. Summary of the number of samples taken at each station, based on net mesh size (53, 150 or 236μm, or all for live tow) and tow depth (100, 200, 500m).

Station	Depth	53	150	236	Grand Total
AG5	100	1	1	1	3
BL1	75	1	1	1	3
BL4	100	2	2	2	6
BL6	100	2	2	2	6
CAP10	100	2	2	2	6
CB1	100	2	2	2	6
CB10 S	100	2	2	2	6
CB11	100	2	2	2	6
CB12	100	2	2	2	6
CB15	100	2	2	2	6
CB16	100	2	2	2	6
CB16b	100	2	2	2	6
CB19	100	2	2	2	6
CB2	100	2	2	2	6
CB21	100	2	2	2	6
CB22	100	2	2	2	6
CB23a	100	2	2	2	6
CB28aa	50	1	1	1	3
CB28b	100	2	2	2	6
CB29	100	2	2	2	6
CB2a	100	2	2	2	6
CB3	100	2	2	2	6
CB31b	100	2	2	2	6
CB4	100	2	2	2	6
CB40	100	2	2	2	6
CB5	100	2	2	2	6
CB50	100	2	2	2	6
CB6	100	2	2	2	6
CB7	100	2	2	2	6
CB8	100	2	2	2	6
CB9	100	1	1	1	3
	500	1	1	1	3
CBC	100	2	2	2	6
CBS	100	2	2	2	6
MK2	100	1	1	1	3
MK3'	100	2	2	2	6
MK6	100	2	2	2	6
MK7	100	2	2	2	6
PP6	100	2	2	2	6
PP7	100	2	2	2	6
Sta-a	100	2	2	2	6

TU1	100	2	2	2	6
TU2	100	2	2	2	6

Table 8. Drift bottle drop locations

STATION	DATE	TIME (UTC)	Latitude (N)	Longitude (W)	SAMPLE NUMBERS
StnA	8/14/2012	05:03:00	72.6102	144.6970	#43-62
Cap-10	9/2/2012	23:25:00	76.0182	174.7795	#63-80
	9/5/2012	13:09:00	76.1649	135.6959	#81-100