Joint Ocean Ice Study (JOIS) 2008
Cruise Report

Photo: David Meldrum

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,* July 17 to August 21, 2008

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Updates: 30Nov2009 SZ Change location of zooplankton cast at AG5.

1. OVERVIEW

The Joint Ocean Ice Study (JOIS) program is a component of Canada's contribution to the International Polar Year. It is an observationally-driven climate study of waters in the southern Canada Basin and includes the Beaufort Sea. Emphasis is on the study of the effects of climate variability and the changing properties and distributions of the Pacific and Atlantic waters within the Arctic. The ongoing study is a combination of the Joint Western Arctic Climate Study (JWACS), a collaboration between Fisheries and Oceans Canada (IOS) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) scientists; and the Beaufort Gyre Exploration Project (BGEP), a collaboration between Fisheries and Oceans Canada (IOS) and Woods Hole Oceanographic Institution scientists. In 2008 JOIS also included ancillary programs carried out by researchers from the International Arctic Research Center in Fairbanks Alaska, Fisheries & Oceans Canada from Bedford Institute of Oceanography, Institute of Oceanology Polish Academy of Science, University of British Columbia, Trent University, outreach through PolarTREC and additional programs with WHOI. Our research questions seek to:

- Understand the impacts of global change on the physical environment and corresponding biological responses by tracking and linking decadal scale perturbations in the Arctic atmosphere (e.g. Arctic Oscillation and Beaufort Gyre) to interannual basin-scale changes in water mass properties and their distribution, ocean circulation and biota distribution.
- Understand the impacts of global change on sea ice and other fresh water products by utilizing a suite of stable isotopes and geochemical markers to quantify freshwater components and investigate water mass pathways.
- Investigate physical processes such as thermohaline intrusions, ventilation, boundary currents and nutrient fluxes.

2. CRUISE SUMMARY

This science program onboard the *CCGS Louis S St-Laurent* took place between July 17th and August 21st in the Canada Basin from the Beaufort Shelf north to 83°N. Full depth CTD casts with water samples were conducted, measuring biological, geochemical and physical properties of the seawater. The deployment of expendable temperature, salinity and current meter probes increased the spatial resolution of measurements. Moorings and ice-buoys were both serviced and deployed in the deep basin for daily time-series. Hourly ice observations were taken and on-ice surveys conducted. Zooplankton net tows, phytoplankton and bacteria measurements were collected to examine lower trophic level distributions. Underway measurements were made of the surface water. For outreach, a middle school teacher from Durham Academy, NC brought in by WHOI from an organization called PolarTREC, sent out daily dispatches for the WHOI and PolarTREC's websites, as well as responding to students' questions regarding the program.

New science and ship equipment were used this year, greatly benefiting the program. Of particular note was the new foredeck container lab replacing the old lab, a new fiber-optic network with dedicated space for science on the server which increased the access and transfer speed for sharing and posting data, and access to the internet.

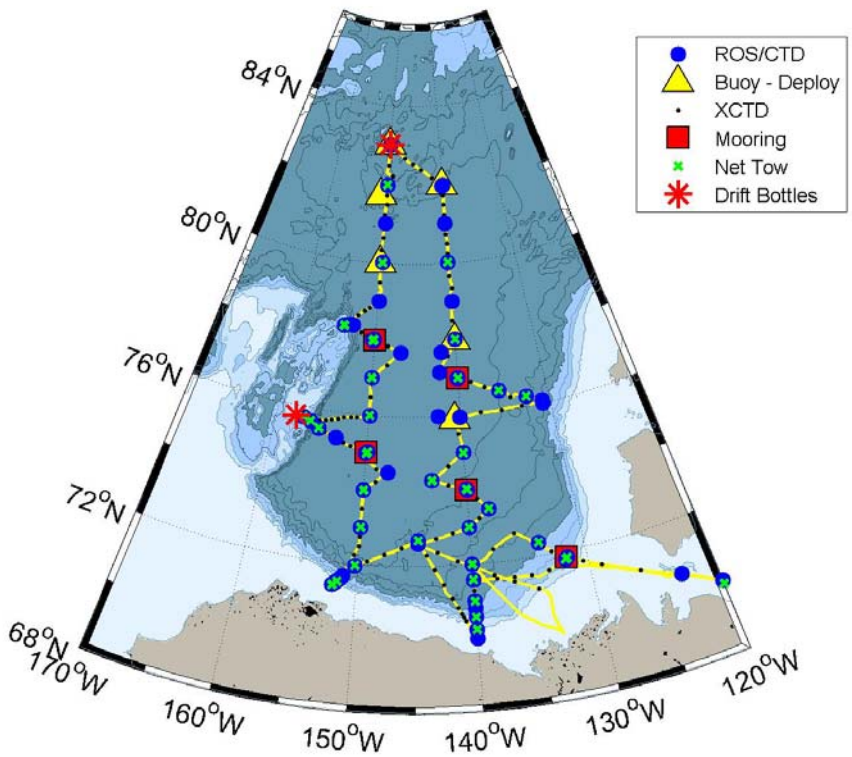


Figure 1.The JOIS-2008 cruise track showing the location of science stations.

3. PROGRAM COMPONENTS

Distance Covered: 8500km

Measurements:

- 73 CTD/Rosette Casts at 54 Stations
- Upper ocean current measurements from Acoustic Doppler Current Profiler during most CTD casts.
- 1617 Water Samples
  At all stations: Salinity, Oxygen, Nutrients, Barium, ^{18}O, Bacteria, Alkalinity, Colored Dissolved Organic Matter (CDOM), Dissolved Organic Carbon (DOC), Chlorophyll-a, and ChloroFluoroCarbons (CFC).

At selected stations: ^{129}I, ^{137}Cs, Ammonium, Carbohydrates, Dissolved Inorganic Carbon (DIC), $DO^{14}C$, $DI^{14}C$ and Soot (black carbon).

- 4 Mooring Recoveries (4 deep basin)
- 4 Mooring Deployments (3 deep basin and 1 slope mooring)
- 6 Ice Buoy Deployments
  - 1 site with an Ice Tethered Profiler (ITP)
  - 1 site with a SAMS Ice Mass Balance Arrays (SIMBA)
  - 1 multi-buoy site with an ITP and Arctic Ocean Flux Buoy (AOFB)
  - 1 multi-buoy site with an ITP, AOFB, Ice Mass Balance Buoy, and SIMBA
  - 2 sites with an ITP and SIMBA
- 5 Casts at 3 stations with in-situ pumping, with up to eight pumps attached to the wire per cast.
- Ice Observations
  - Hourly visual observations from bridge and automated photo-taking
  - Opportunistic aerial observations during helicopter flights
  - 6 on-ice floe mapping surveys
  - 3 on-ice ice-coring and water sampling
  - 43 snow samples at 14 sites collected for black carbon (soot) analyses
- Underway collection of meteorological, depth, near-surface seawater, and navigation data.
- 104 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1100m depth
- 6 near surface CTD SBE19+ casts and water sampling from the zodiac at the four deep basin mooring stations, STA-A and NW-3
- 74 Vertical Net Casts, typically to 100m depth, at 37 selected Rosette stations
- 2 Polar Profiling Floats deployed at 2 sites (WHOI)
- 1 Drifting GPS buoy deployed (SAMS)
- Drift Bottles deployed at 2 sites
- Outreach conducted through PolarTREC with dispatches going to two web sites

Other:

- Passenger transfer to Tuktoyaktuk
- Fuel (2000m^3 litres) loaded by barge near Tuktoyaktuk

4. PROGRAM COMPONENT DESCRIPTIONS

4.1 **Rosette/CTD Casts:** Fiona McLaughlin (IOS) PI, Mike Dempsey

The primary CTD system used on board was a Seabird SBE9+ CTD s/n 0724, 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

Figure 2. Rosette deployment.

collected real-time using the SBE 11+ deck unit and computer running Seasave V7 acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, one oxygen sensor, fluorometer, two transmissometers, CDOM fluorometer and altimeter. In addition two internally recording LADCPs were mounted initially, with one looking up and one looking down. Problems were encountered with water ingress on both units and for half of the cruise only the downward looking unit was installed.

Figure 3. Rosette Sampling

On all rosette casts we sampled Salinity, Dissolved Oxygen, Nitrate (NO3), Silicate (SiO4), Phosphate (PO4), Chlorophyll-a (filtered at 0.7 µm with chlorophyll-a and phaeopigment values for each), Colored Dissolved Organic Matter (CDOM), Dissolved Organic Carbon (DOC), Alkalinity, ChloroFluoroCarbons (CFC), ^{18}O, Barium, and Bacteria. On selected casts we sampled ^{129}I, ^{137}Cs, Ammonium, Carbohydrates, Dissolved Inorganic Carbon (DIC), $DO^{14}C$, $DI^{14}C$ and Soot (black carbon).

For a typical cast, the transmissometer(s) and CDOM sensor windows were wiped with deionized water soaked Kimwipe prior to each deployment. The package was lowered to 5m, the pumps were turned on and the system soaked for 3 minutes in order to cool the system to ambient sea water temperature, remove bubbles from the sensors and allow the oxygen sensor to equilibrate. The package was then brought up to just below the surface to begin a clean cast, and lowered to 400m at 30m/m then the descent rate was increased to 60m/m to a depth 20 m above the bottom, determined by the sounder depth. The casts were typically to within 10 metres of the bottom. Niskin bottles were closed during the upcast generally without a stop. Different methods of flushing bottles were tried such as " up-down-up" (up 1 metre, down 2 metres and up one metre) to explore more complete mixing. The rosette was also ballasted for level (<2 ° tilt) operation when LADCPs were added and removed. The instrumented sheave (Brook Ocean Technology) readouts to the winch operator, CTD operator and bridge allowed all three to monitor cable out, wire angle and CTD depth.

Figure 4. Bringing the full rosette in the sampling room.

In the upper 400m, the sample depths were chosen to match a set of salinity values. During the downcast, the depths of the salinity values were noted so that on the upcast the bottle could be closed at the pre-determined depths.

Improvements to the CTD system this year:

- The latest version (ver 7.17, 2008) of Seasave V7 was used. Many improvements in display features (zoomable plots and faster and complete re-draws) were appreciated. The s/w also appeared to be more stable with only a few crashes.
- New wet-pluggable cables were used on the sensors. (There have been no failures of wet-pluggable cables or connectors since used in 2007)
- Niskin spigot o-rings replaced with Silicon rubber (less sticky when cold)

Data/Performance notes:

The SBE9+ CTD overall performance was good.

Problems were seen with the SBE43 oxygen sensors. Initially intermittent drop outs and full scale voltage events appeared to be cable related but were later assessed to be associated with the two sensors. Of the three sensors brought out, two failed during the cruise.

Two RDI LADCPs were mounted on the rosette this year. Unfortunately, the upward looking unit was mounted directly above bottle 1 and provided a partial shadow to bottles 24 and to a lesser extent 23. Since bottle 1 is closed at the bottom, it is effectively flushed from below, and should show no effect on flow. Bottles 23 and 24 did however appear from the data to be flushing poorly and an alternative “up-down-up” triggering method was used later in the cruise to correct this.

There were no communication errors between computer and deck unit as seen in 2007. There were however a couple of s/w and full system crashes during casts. In all instances the crash was an isolated event.

The 73 CTD/Rosette cast location are listed in the appendix

Sampling took place immediately after each cast in the heated rosette room. The order of sampling was fixed, based on sampling water most susceptible to gas exchange or temporal changes first. Dissolved Oxygen, Nutrients, Salinity, Alkalinity, CFCs, CDOM, Chlorophyll-a and Ammonium were analysed on board. All other samples were prepared as required and stored for analysis on shore.

Figure 5. Salinity bottles

Figure 6. CDOM analyses by Chad Cuss

Figure 7. CFC analyses by Nes Sutherland and Rick Nelson*(Gerty Ward 2008 courtesy of ARCUS (PolarTREC))*

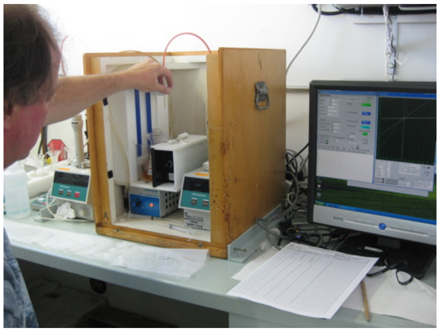


Figure 8. Hugh Maclean runs oxygens on the 'Scripps kit'. *(Gerty Ward 2008 courtesy of ARCUS (PolarTREC))*

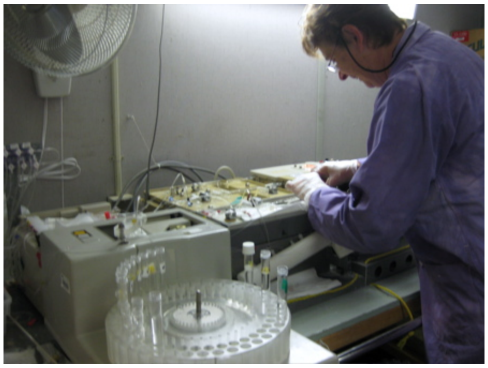


Figure 9. Linda White runs the nutrients. *(Gerty Ward 2008 courtesy of ARCUS (PolarTREC))*

Figure 10. Ammonium samples prepared by Melissa Hennekes *(Gerty Ward 2008 courtesy of ARCUS (PolarTREC))*

Figure 11. Michiyo Kawai analyses Alkalinity.

4.2 Side-of-ship ADCP (Svien Vagle PI)

Figure 12. ADCP being lowered to 5m during rosette cast.

In conjunction with the CTD/Rosette Casts, an acoustic doppler current profiler (ADCP) measuring currents in the upper waters and two backscatter transducers looking for layers of zooplankton were lowered over the side. The package was lowered by crane from the boatdeck 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, are used to determine the orientation of the ADCP which is then used to determine the velocity of the surface currents.

4.3 BGOS Field Operations as part of JOIS 2008

Rick Krishfield, Will Ostrom, and Jim Dunn, P.I Andrey Proshutinsky (WHOI)

As part of the Beaufort Gyre Observing System (BGOS; http://www.whoi.edu/beaufortgyre), four bottom-tethered moorings (which were deployed in 2007) were recovered, data was retrieved from the instruments, refurbished, and three were redeployed at the same locations in August 2008 from the *CCGS Louis S. St. Laurent* during the JOIS 2008 Expedition. In addition, five Ice-Tethered Profiler (ITP; http://www.whoi.edu/itp) buoys were deployed, three in combination with SAMS Ice Mass Balance Arrays (SIMBA), one with an Ice Mass Balance (IMB) and two with Arctic Ocean Flux Buoys (AOFB).

Summary of BGOS 2008 field operations.

Mooring Designation	Depth (m)	2007 Location	2008 Recovery	2008 Deployment	2008 Location
BGOS-A	3825	75° 0.203'N 149° 58.221'W	27-Jul 15:32 UTC	29-Jul 20:40 UTC	74° 59.998'N 150° 0.002'W
BGOS-B	3821	77° 59.153'N 149° 58.895'W	31-Jul 16:36 UTC	1-Aug 18:13 UTC	77° 59.859'N 150° 4.887'W
BGOS-C	3722	76° 59.063'N 139° 57.222'W	9-Aug 18:16 UTC		
BGOS-D	3515	74° 0.066'N 139° 54.677'W	13-Aug 15:00 UTC	14-Aug 19:26 UTC	73° 59.988'N 139° 59.703'W
ITP21				3-Aug	80° 0.6'N

	22:30	150° 5.3'W
ITP23/AOFB17	5-Aug 00:10	81° 44.5’ N 150° 53.4’ W
ITP22/SIMBA-C	6-Aug 18:10	82° 0.5'N 140° 3.2'W
ITP20/AOFB16/ SIMBA-B/IMB29557	8-Aug 22:45	77° 59.2'N 139° 56.1'W
ITP30/SIMBA-A	12-Aug 17:00	75° 54.6'N 140° 36.9'W

Moorings:

The centerpiece of the BGOS program are the moorings which have been maintained at 3 or 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. To keep the moorings safe from the overhead icepack (where ridges can extend down to 30 m or more), the top floats are positioned approximately 45 m below the surface. 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, a vertical profiling CTD and velocity instrument which samples the water column from 55 to 2000 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.

The moorings are deployed anchor first, rather than top float first (as is typical in lower latitudes), because of the presence of the ice pack. This 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 system.

Recovering the moorings in pack ice is extremely tricky, so that the top float does not surface under an icefloe, where we cannot access it. However, in this case, we do have backup floatation at the bottom of the mooring, which we can also recover the moorings from. First the locations of the moorings have to be pinpointed by triangulating acoustically on the releases at the bottom of the mooring. Then the Captain of the icebreaker creates a pond in the ice over the mooring, and 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. 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.

So far, 5 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. However, the results indicate that budget is not balanced, so other mechanisms must also be at work.

Buoys:

Because the moorings only extend up to about 50 m from the ice surface, we use automated ice-tethered buoys to sample the upper ocean and sea ice. On this cruise, we deployed 5 Ice-Tethered Profiler buoys (or ITPs), 2 Arctic Ocean Flux Buoys and one US Army CRREL Ice-Mass Balance buoy, along with 4 buoy Scottish Association of Marine Science Ice Mass Balance Array. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO).

The 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. In fact, 6 another ITPs will be deployed in the eastern Arctic during the next month from European vessels.

Figure 13. Installing the Upward Looking Sonar (photo Gertie Ward, acknowledgement to ARCUS PolarTREC)

Figure 14. The new ITP float configuration.

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 45 m) was also interrogated to locate the top of the mooring, but effective communications with the top transponder were only available for mooring A. However, at every station the sphere was located by the ship's 400 khz fish finder, except for mooring D where the yellow float (at 30 m depth) was visible through the clear water. Only mooring B top sphere did not release into open water, presumably due to enhanced surface currents which presumably carried the package horizontally, so this mooring system was recovered from the tail end of the mooring beginning with the backup flotation.

All of the mooring recovery and deployment operations were conducted without incident. The actual recovery operations varied from between 3 and 4.5 hours after release, except for B which took 5.5 hours due to the backup recovery procedure. The deployment operations normally entailed an hour of deck preparation once on site, followed by a 3 to 5.5 hour anchor first deployment. Extra instrumentation on mooring A (3 sediment traps) and mooring D (devices clamped to a deep segment of the wire) added time to the operations.

Complete year long data sets with good data were recovered from every ULS, and 3 out of 4 BPRs. Unfortunately, only 1 out of 5 MMPs contained a complete dataset, while the others operated for only approximately 5, 10, 40, and 80% of the year due to a variety of failures. Furthermore, the ADCP on Mooring D exhausted its battery after 11 months.

The ITP deployment operations 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). ITPs 20, 21, 22, 23 and 30 were deployed on 3.4, 3.3, 3.5, 1.9, and 2.4 m thick ice floes respectively. Not including the time to reconnaissance, drill and select the ice floes, the deployment operations took between 3.5 and 8 hours each (depending on the number of systems installed in each IBO) including transportation of gear and personnel each way to the site. Ice analyses and handheld CTD casts were also performed by others in the science party, while the ITP deployment operations took place. Despite verifying communications with each ITP profiler after deployment, two profilers have yet to communicate with the surface package since deployment. If the underwater units never send their data to the surface package, then recovery operations will need to be scheduled for next year to retrieve the instruments and manually download whatever information may have been acquired.

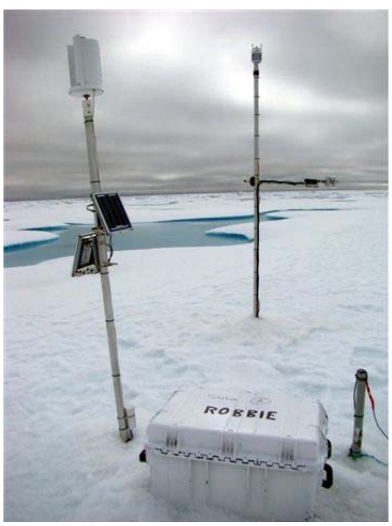


Figure 15. SAMS Ice Mass Balance Arrays (SIMBA)

Figure 16. SAMS Drifting GPS buoy

4.4 Beaufort Gyre Observing System (BGOS) , Particle Flux: Sediment Traps, Pump Casts, Underway Filtration, DO^{14}C and DI^{14}C Sampling

Andrey Proshutinsky (WHOI) PI BGOS, Tim Eglinton (WHOI) PI Particle Flux, Rick Krishfield, Will Ostrum, Jim Dunn, and David Griffith

As part of the Particle Flux component of the Beaufort Gyre Observing System, we collected samples from sediment traps, large volume pumps (LVPs), the surface (9m) seawater loop, and the Rosette at BGFE Moorings A, B, C, and D. A detailed summary of the data collected is provided in the worksheet "BGFE2008_master_drg.xls" and short summary is given below.

Location	Sediment Traps Recovered	Sediment Traps Deployed	LVP Casts	24-Depth Profile DO14C and DI14C?	Underway Filters
BGFE-A (CB-4)	3	3	2	y	2
BGFE-B (CB-9)	1	1	1	y	2
BGFE-C (CB-15)	1	0	0	n	2
BGFE-D (CB-21)	1	1	2	n	2

Sediment Traps

Because of cruise timing, sediment traps were recovered before their event schedules could be completed. Thus the final cup (21) in each case was lost. In addition, the traps at BGFE Mooring B, C, and D stopped rotating at cups 19, 17, and 13 respectively (low battery shutdown). The reason for this is unclear, although in the case

Figure 17. Sediment trap. ***(Gerty Ward 2008 courtesy of ARCUS (PolarTREC))***

of Mooring B, there was an unidentified 10cm organism that was bisected by the rotator and could have drained battery life. Trap sample cups were photographed, capped, taped, and refrigerated. Steve Manganini and Tim Eglinton at WHOI will supervise Geochemical and biomarker analyses. Sediment trap redeployment was smooth, and all rotators and batteries tested well prior to deployment. The sediment trap schedules are given below.

Mooring Location	Action	Sediment Trap Approx. Depth (m)	Sediment Trap S/N	Start Time (GMT) m/d/y h:m	Stop Time (GMT) m/d/y h:m
BGFE-A	recovery	2050	ML 12024-02	8/10/07 1:00	8/1/08 1:00
BGFE-A	recovery	3100	ML 11649-06	8/10/07 1:00	8/1/08 1:00
BGFE-A	recovery	3745	ML 11649-02	8/10/07 1:00	8/1/08 1:00
BGFE-B	recovery	3000	ML 12024-01	8/15/07 1:00	8/7/08 1:00
BGFE-C	recovery	3000	ML 11649-04	8/21/07 1:00	8/10/08 1:00
BGFE-D	recovery	3000	ML 11649-03	8/28/07 1:00	8/12/08 1:00
BGFE-A	deployment	2050	ML 12024-02	7/29/08 0:00	7/22/09 0:00
BGFE-A	deployment	3100	ML 11649-06	7/29/08 0:00	7/22/09 0:00
BGFE-A	deployment	3745	ML 11649-02	7/29/08 0:00	7/22/09 0:00
BGFE-B	deployment	3000	ML 12024-01	8/2/08 1:00	7/26/09 1:00
BGFE-D	deployment	3000	ML 11649-04	8/15/08 1:00	8/7/09 1:00

Large Volume Pumps (LVPs)

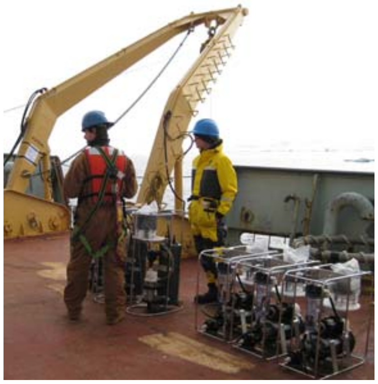


Figure 18. Large Volume Pumps

LVPs (4 from WHOI, 4 from UBC) were sent to multiple depths during 5 casts at 3 different locations (Mooring A, B, and D). LVPs were loaded with GF/F (0.7um) or versapore filters (0.4um) and paired at similar depths when possible. GF/F filters will be analyzed for ^{14}C and biomarkers at WHOI, and the versapore filters will be analyzed for trace metal content at UBC. Together these data will complement sediment trap samples and improve our understanding of particle fluxes through the water column. See the attached data sheet for LVP locations, depths and filters. It should be noted that LVP cast #2 (Mooring A) used all GF/F due to some confusion about volume meter readings and questions about the efficacy of the versapore filters. This was resolved after a simple calibration. There is also reason to suspect that material was lost from some early versapore filters as water poured from the filter as the pump head was removed. This was resolved in later casts by removing water in the pre-filter cartridge compartment and manually pumping for ~10 seconds prior to removing the pump head and the filter.

Rosette Sampling for DO^{14}C and DI^{14}C

Water samples were collected at Mooring A and B for subsequent DO^{14}C and DI^{14}C analysis at the National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS) at WHOI. This will be one of the first full-depth profiles of DO^{14}C in the Arctic Ocean and should complement particle flux data from sediment trap and LVP samples at the same locations. DO^{14}C samples were collected in combusted amber glass bottles using ^{14}C-clean techniques then acidified with 85% H_3PO_4 and stored at 4^oC. Three deep and three shallow duplicates were taken at both locations (Mooring A and B). In addition, 12 method duplicates were taken at each location to test the effect of acidification vs. freezing and the impact of filtration. Acid blanks were collected and will be topped off with organic-free MQ water before processing at WHOI. Water samples that were not filtered represent total organic carbon (TOC), although we suspect that the effect of extremely low particle concentrations will be negligible. DI^{14}C samples were collected in combusted 600mL clear glass DIC bottles then poisoned with 100uL $HgCl_2$, sealed, and stored at room temperature according to NOSAMS protocols.

Underway Filtration

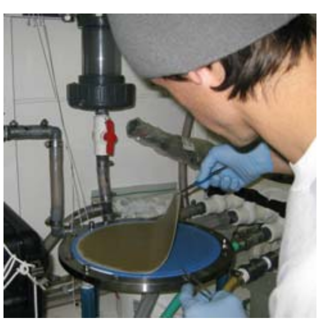


Figure 19. Removing particle laden filter

Combusted GF/F filters (293mm) were used to collect particles from the seawater intake line (9m water depth) while underway and at several stations including all BGFE Mooring locations. These filters will be used for ^{14}C and biomarker analyses (WHOI) and ^{13}C measurements (K. Brown at UBC), which will provide a surface end-member to complement sediment trap and LVP data.

4.5 CABOS Mooring Deployment Report

Igor Polyakov P.I. (IARC), Mike Dempsey

The Canadian Basin Observation System (CABOS) mooring has been deployed on the Institute of Ocean Sciences (IOS) Arctic cruises on behalf of the University of Alaska Fairbanks International Arctic Research Center since 2003 every year except 2007. The location of the mooring has varied due to ice conditions but has been continuously placed to monitor the flow of Atlantic water around the south east slope of the Canada Basin. The mooring is part of a string of moorings deployed by IARC to observe the movement of Atlantic water through the Arctic and measure the heat flux to upper waters. The Nansen/Amundsen Basin Observation System (NABOS) consists of a series of McLane Moored Profiler and conventional moorings located around the self break of the Laptev Sea. The CABOS mooring provides complementary data for this array.

Table 1. 2008 Operations, CABOS mooring

Investigator	Recovery Depth (m)	Recovery Location	Recovery Time (UTC)	Deployment Depth (m)	Deployment Location	Deployment Time (UTC)
UAF/IARC I. Polyakov				1114	71° 49.702'N 131° 46.591'W	22 July 2008 1525 (UTC)

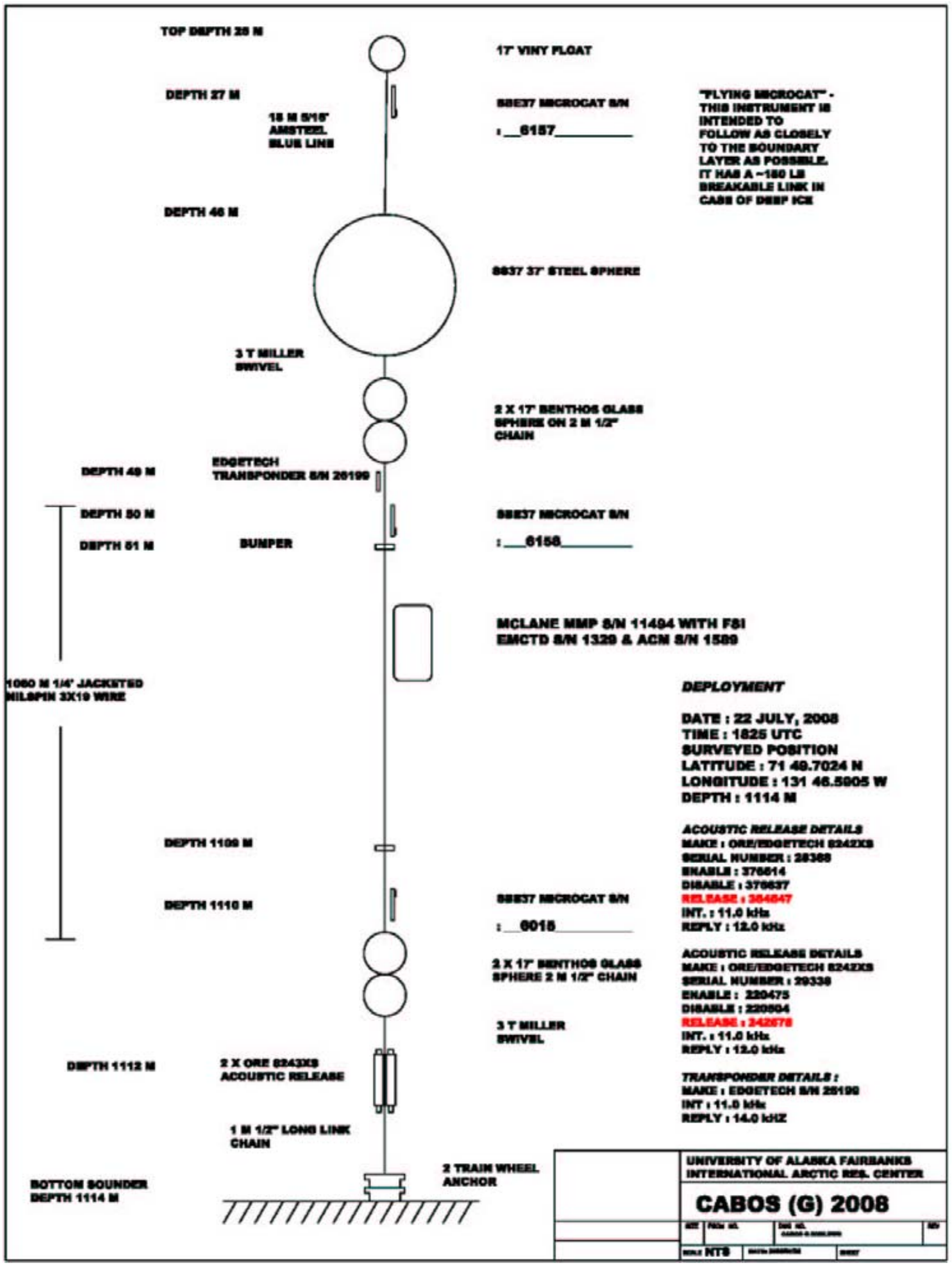


Figure 20. CABOS mooring deployed 2008

Chronology

All times UTC
Conditions : 1 to 2 tenths old ice. Wind 346°T at 10 kts. Light fog and fog bow
22/07/2008
1405 Releases, bottom glass spheres and anchor ready to sling into position.
1415 Hook up Nilspin on winch through Gifford block in A frame.
1504 MMP s/n 11494 lowered into water on bottom bumper.
1554- SBE37 Microcat lowered into water.
1555 Mooring suspended from pelican hook on 1” nylon rope trough A frame.

1525 Mooring released. GPS position on bridge 71 49.681'N 131 46.575'W. Corrections made for draught and sound speed (calculated from that morning's rosette cast) give corrected sounder depth of 1114 m (sound velocity 1457ms-1).
1530-. Enable command 376617 sent to release 28388. SR 1119 m
1531 – Use MCAL 1.04 to do survey of CABOS release position. Conduct 30 point survey covering 270° arc around mooring. Surveyed position 71 49.702'N 131 46.591'W.
1625- Complete survey
1630- Ping top transponder (Interogate 11.0 kHz Reply 14.0 kHz) SR 489-496 m
1631 Send disable command 376637 to acoustic release s/n 28388. Acknowledgement received and no further replies.
1605- Move ship off station.

The deployment of the CABOS 2008 mooring was accomplished quickly with the help of many others. The assistance of a trained and motivated deck crew was much appreciated. Also the station keeping of the ship during deployment was excellent. Many thanks also to Will Ostrom, Jim Dunn and Rick Krishfield of WHOI for their help and the use of their Lebus dual capstan traction winch.

4.6 Anthropogenic Radionuclide Measurements

Richard Nelson, P.I. John Smith (DFO)

This direct intrusion of water from the North Atlantic along the continental margin of the Eurasian Basin into the Canada Basin is also carrying elevated inventories of the radioactive tracers, ^{129}I and ^{137}Cs, which during the past 30 years have been released in large quantities from the nuclear fuel reprocessing plants at Sellafield, UK and La Hague, France, which discharge into the Irish Sea and English Channel, respectively. Changes in the reprocessing plant release rates of ^{129}I and ^{137}Cs are propagated through the Norwegian and Atlantic Coastal Currents into the marginal seas and interior of the Arctic Ocean on time scales of 4–5 years (Livingston, 1988; Smith *et al*., 1990; Kershaw and Baxter, 1995) and measurements of these signals can be used to constrain water circulation time-scales throughout the Arctic Ocean (Smith *et al*., 1998). There are two basic tracer applications of these radionuclides in the Arctic Ocean: (1) measurements of ^{129}I and ^{137}Cs, separately provide evidence for Atlantic-origin water labeled by discharges from European reprocessing plants; and (2) measurements of ^{129}I and ^{137}Cs, together can be used to identify a given year of transport through the Norwegian Coastal Current (NCC) thereby permitting the determination of a transit time from the NCC to the sampling location (Smith *et al*., 1998).

Samples were collected from 12 stations for ^{129}I (1 liter) for a total of 160 samples, 8 stations ^{137}Cs (40 liters) for a total of 48 samples.

4.7 Zooplankton Vertical Net Haul

P.I. John Nelson(DFO), Brian Hunt (University of British Columbia), Kelly Young (University of Victoria)

A total of 74 Bongo net hauls were completed during 2008-30, at 37 of 57 oceanographic stations. The Bongo used comprised 4 nets, two 50cm hoops and two 15cm hoops. The large hoops were harnessed with a 236 µm and 150 µm mesh, while the two smaller hoops were harnessed with 53 µm mesh. On arrival on the ship the larger hoops had both been harnessed with 236µm nets by Glenn Cooper, and one of these was switched to a 150 µm net.

Each net had its own flowmeter. The 53 µm and 236 µm nets were harnessed with MF-315 flowmeters, and the 150 µm nets with a TSK mechanical flowmeter. Glenn Cooper had communicated having inconsistent readings with the MF-315 flowmeters. These MF-315 flowmeters were given a basic service by B. Hunt on arrival on the ship, involving cleaning and greasing the propeller axels. One of the MF-315 flowmeters had a permanent malfunction and so was removed from the net configuration, leaving only three operational flowmeters. One of the 53 µm nets was therefore used without a flowmeter for the duration of the voyage and volume filtered was assumed to be the same as that for the second 53 µm net. Problems with inconsistent readings were encountered periodically with the remaining MF-315 flowmeters throughout the voyage.

Figure 21. Zooplakton Cast

The net was operated using the starboard A-frame near the bow of the ship. With the winch in low gear for adequate speed control, the net was lowered to the desired depth at ~ 0.5 m.s^{-1} and raised at the maximum speed possible at this gear ratio (~ 0.8 m.s^{-1}). The hauling speed was higher to increase the catching efficiency of larger more mobile mesozooplankton species, and was consistent throughout the voyage. Once on deck the nets were washed down using a fire hose connected to the on deck sea-water line. This water line was not permanently open and it was necessary to request it be turned on prior to net deployment. It was important to run the water some minutes prior to washing the nets as it was invariably rusty in the beginning. It is required that the hose be left running once the line has been opened in order to prevent pressure build up and freezing when the air temperature was less than zero.

Routine sampling involved conducting two vertical hauls to 100m depth. The 53 µm net samples were combined for each cast leaving a total of 6 samples at these stations. Zooplankton preservation aimed to provide samples suitable for taxonomic / population / biogeographic studies (Formalin), DNA analysis (ethanol), and biomass estimation. The latter was intended to be performed by dry mass estimation after salt removal using ammonium formate. A pre-requisite for this was pre-weighed pans for drying the zooplankton in, however, these were not provided. Consequently, samples for biomass estimation were transferred to petri-dishes and frozen in the -80°C freezer. This may not be ideal for biomass estimation, but does enable more to be done with the samples than just bulk biomass estimation e.g. stable isotope analyses. The breakdown of sample preservation at a typical two net station was as follows:

Cast 1 (100m):	Cast 2 (100m):
236 µm into formalin	236 µm ethanol
150 µm into formalin	150 µm frozen
both 53 µm combined to single formalin sample	both 53 µm combined ethanol (optional if ethanol is in short supply)

Single net hauls were completed at the following stations: CB10a, CB11b, NW2, CB19, CB22, CB27, CB29, CB31b, and CABOS (second occupation of site on 19/8/08). In the case of CB10a to CB22 this was due to logistical problems. A hydraulic fluid leak in the A-frame meant that net tows from CB10a to CB22 had to be completed with the forward crane until the mooring work had been completed. This required four crew members and so nets were reduced to only day time tows (8am to 6pm), and also initially limited sampling to only one cast per station.

Single net hauls at CB27 to CABOS were due to insufficient zooplankton jars (including an additional extra 20 jars obtained from the galley) towards the end of the voyage. Since the priority stations had been completed by this stage the focus was put on spatial coverage rather than preservation of zooplankton for all potential analyses. The 236 µm samples were preserved in ethanol to enable both DNA and taxonomic analyses, the 150 µm sample frozen or preserved in formalin, and the 50 µm sample preserved in formalin.

Short term temporal sampling duplicates were obtained at three stations which were occupied for 12 hours or more, and this will provide some data on diel variability. At CB4 and CB21 double bongo net hauls were completed at night and during the day, while at CB9 single Bongo net hauls were completed at night and during the day.

Mesopelagic net hauls were completed at the same three stations where these temporal duplicates were obtained. At each of CB4 and CB9 additional single net hauls were completed to 500m and 1000m, while at CB21 an additional single net haul was made to 1000m.

At five stations individual zooplankton were selected, representative of the dominant species in the community, and frozen individually in cryotubes at -80°C. IN combinations with the extensive POM collections, these specimens will be used for stable isotope analysis of the food web structure and carbon flow in the study area.

4.8 Particulate Organic Matter (POM)

P.I. Brian Hunt (UBC)

A total of 79 POM samples were collected from the inboard sea water line (LOOP samples) for carbon isotope measurement. Samples were collected at the majority of CTD stations as well as at mooring and sea-ice station sites. Sampling entailed filtering 2 to 8 litres of water onto pre-combusted glass fiber filters. Filters were then dried in an oven at 50^{o}C for 24 hours.

4.9 Lowered Acoustic Doppler Current Profiler

P.I. Waldemar Walczowski (IOP)

Lowered Acoustic Doppler Current Profiler (LADCP) allows to measure the sea currents during standard CTD casts. Device transmits sound burst and receives echoes from particles carried by the water currents. Movement towards and out of the device produce the Doppler shift. The final ocean velocity profile is obtained during complicated data processing.

Using the LADCP in the Arctic Ocean, especially in the deep layers is difficult, because of low amount of particles. Therefore during the cruise two LADCP devices were used, both RDI 300 kHz WHS300.

The basic configuration were synchronized upper (slave) and down looking (master) LADCPs connected by RDI Star-cable. Sampling rate was 1 s, 1 ping/assemble, 20 bins, 10 m thick each. Because of problems with equipment, configuration has been changed during the cruise g and later the measurements were carried by means of one, down looking LADCP. Measurements were carried at 65 stations (Table 1), there are doubled data files from station 2-25.

Processing of raw data were done by means of LDEO IX software for Matlab. Some parts of software were modified. All files were processed in the same way. Profiles were averaged every 20m. Because of the very weak signal and increased error, filtration and smoothing of data were much higher than usually. CTD and GPS data were used in LADCP processing. Finally the theoretical velocity error is less than 5 cm/s.

Description of casts and data files

Casts 2-25

Device nr 10540 were used as the down looking, master LADCP, device 10746 as upper looking, slave LADCP. Both devices were connected RDI- Star cables. The pinging rate was 1 s, 20 bins, 20 m thick each. Both compasses were calibrated in Halifax, before 2008_29 leg. Files 200830_M02.000 - 200830_M25.000 origin from down looking (master) LADCP,
Files 200830_S02.000 - 200830_S25.000 origin from upper looking (slave) LADCP.
The results are very good, it was no problems with data processing.

Casts 26-33

During battery changes in the upper looking LADCP a small lick (few drops) to the device were noticed. Casts 26-33 were made by means of one, 10540 LADCP. All casts were made with 1s rate, 1 ping per assemble, 20 beans, 10 m thick each.
Files 200830_D26.000 - 200830_D33.000

Casts 34-42

After cleaning and drying LADCP 10746 were used again, but compass and pick&roll sensor did not work. Unfortunately all S-files are wrong, as a result of the water in the device, firmware was injured.
Files 200830_M34.000, 200830_M35.000, 200830_M37.000, 200830_M39.000, 200830_M40.000, 200830_M41.000, 200830_M42.000 are useful.

Casts 43-48 were not measured, because of LADCP 10540 injuring. After changes batteries water penetrated into the device and injured electronics.
Finally electronics from two devices were assembled into one and measurements started again from the cast 48.
Casts 48-56
Down looking LADCP were used. Ping ratio 0.5 s, 1 ping per assemble, 15 beans, 10 meter each
Weak beam 3 ! Results will be probably rejected. Too big currents
Files 200830_H48- 200830_H55
Cast 57
Down looking LADCP. Weak beam 3 !
Ping ratio 0.5 s, 2 ping per assemble, 15 beans, 10 meter each
File 200830_H57
Cast 58 - 72
Down looking LADCP. Weak beam 3 !
Ping ratio 1 s, 1 ping per assemble, 20 beans, 10 meter each
File 200830_W58 - 200830_W72

Results
The quasi-synoptic picture of in situ currents were obtained. In some regions currents very good fit to our knowledge about Canada Basin circulation, in other are too high. Currents over the bottom, measured with the bottom track are the most real. Accuracy of these data (*.bot files) is the highest.
Better understanding of the currents may be obtained by analyzing it together with the water mass properties. This works are carried on.

Remarks
LADCP measurements in the Canada Basin are very hard and results are still inaccurate. The causes are mostly low backscattering and high magnetic compasses errors. Besides the nature of oceanic currents in this region (low Rossby radius) do not allow to obtain circulation pattern from scattered, low horizontal resolution measurements.
However during the cruise valuable data were collected, which will be processed and analyzed.

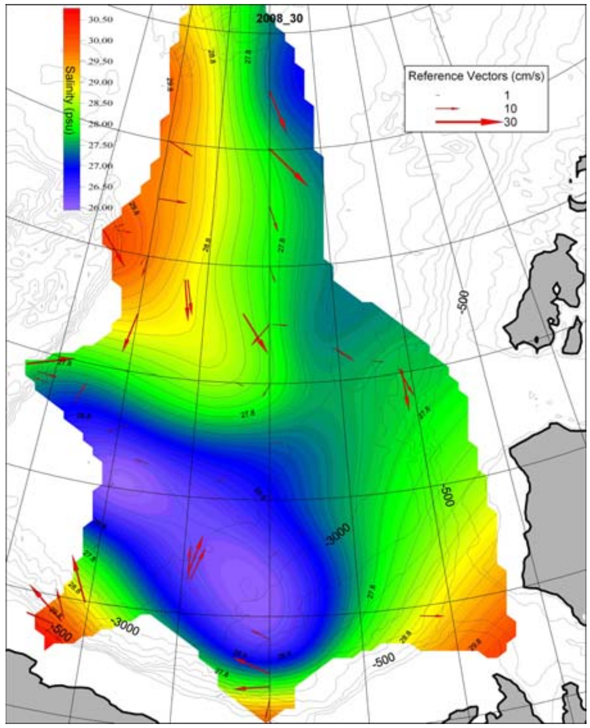


Fig. 1. Salinity and LADCP currents at 20 m.

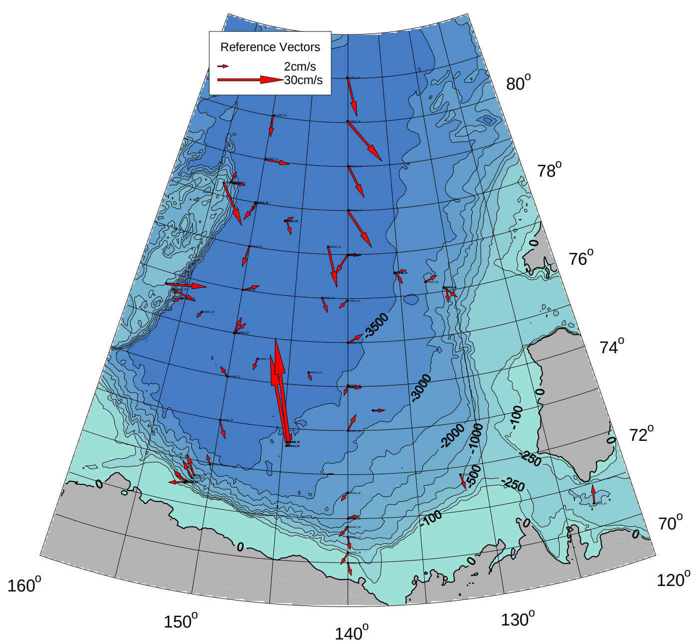


Fig. 2 LADCP currents at 200 m.

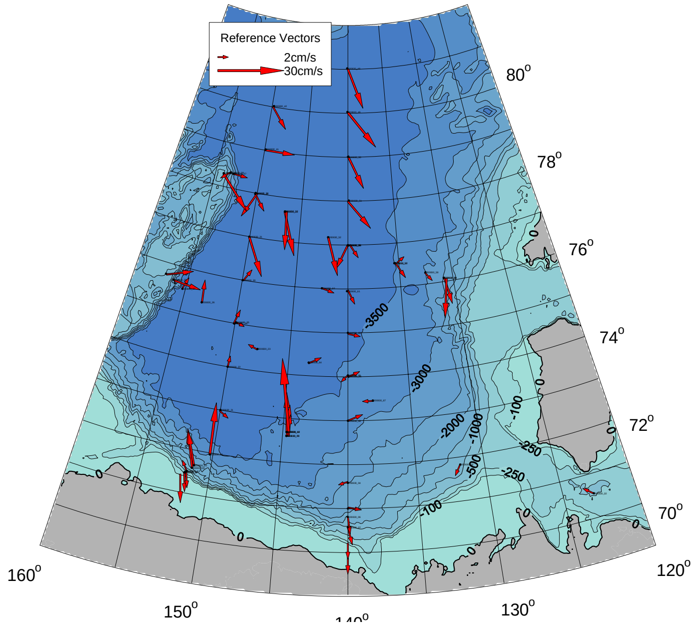


Fig. 3 LADCP currents at 400 m.

4.10 Ice Observations

P.I.s Jennifer Hutchings, Alice Orlich (UAF)

Many thanks to Kristina Brown, Nes Sutherland, Brian Hunt, Mike Dempsey, Kenny Scozzafava, Edmand Fok, Melissa Hennekes, Kelly Young, Hugh Maclean, Will Burt, Gerty Ward, Marie-Claude Bouchard, and Sarah Zimmermann, for assistance in collecting ice data. The hourly ice observations and field program was lead by Alice Orlich, directed by Jennifer Hutchings of IARC/UAF. Data and insight was shared by the ship's ice observer, Marie-Claude and her organization and patience was greatly appreciated. We would especially like to thank Captain McNeill and the crew of the Louis S. St. Laurent for making these ice observations and sampling excursions possible.

Ice observations recording during the Louis S. St. Laurent 2008-30 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 zones. This information, as well as the 2007-20 cruise data will be used to support a joint drifting-buoy, RADARSAT SAR, field and modelling campaign to investigate sea ice dynamics in the Beaufort Sea during winter 2006 to spring 2008. The project, "Sea ice tide-inertial interaction: Observations and Modelling" is funded by the National Science Foundation, with PIs Jenny Hutchings and Bill Hibler. The observations from this cruise will also support a field project "Detailed investigation of the dynamic component of the sea ice mass balance" which occurred during spring 2007, with PIs Jenny Hutchings, Jackie Richter-Menge and Cathy Geiger. We anticipate that the observations will be useful for investigating the evolution of the ice cover over the last three years when used in conjunction with satellite and buoy data.

The cruise occurred in August, providing a snapshot of ice conditions at the end of the 2008 melt season. Throughout the cruise we experienced melt conditions, with only rarely witnessing frozen meltponds or new ice on the coldest of nights. This season's cruise occurred closer to the summer's schedule of the 2006, and therefore relatively earlier than the 2007 cruise dates. This should be considered when forecasting ice concentration and thickness in the areas visited because almost another month of melt conditions is to be expected.

Observations from Bridge: Methodology

Every hour, while the ship was steaming and light conditions allowed, an observation of ice conditions was recorded. Each observation was made from the bridge, and photos were taken from the monkey island to document ice regions. Although the goal was to cover continuous 24-hour periods, observations were reduced because only one observer was available, long periods of time were spent on station with little change in the icescape, and many days at the beginning and end of the trip were ice free. These results are available on request from Jennifer Hutchings.

A combination of ASPECT (Worby & Alison 1999), Standard Russian and Canadian Ice Service codes were used to describe ice conditions. The codes are described in detail below. During each observation period we estimated the total ice coverage within 3km of the ship (when visibility allowed), the types of ice present and the state of open water. For each ice type we estimate the coverage of that type, thickness, flow type, topography, sediment coverage, algae presence, snow type, snow thickness and stage of melt. There was space for detailed observations of three ice types (primary, secondary and tertiary) in the log sheets. We also recorded the codes for any other types of ice present that was at lower concentration than the three main types. We recorded basic meteorological phenomena of cloud coverage and type, visibility and precipitation.

Comments on Bridge Observing Methodology

As we did not have a continuous ice watch, the observations should not be used alone to estimate ice type coverage on scales smaller than 100km. The ship track and speed will introduce a bias into the type and thickness of ice overturned. Hence, although the sampling of thin and medium first year ice may be reasonable, thicker first year and multiyear ice will be under represented in thickness estimates. Poor visibility affects the area of ice observed, and could compound ship track bias in spatial coverage estimates. It should also be noted that flat light conditions hinder the estimation of ridge height, quality of photos, and visibility for distance estimations. The majority of the days experienced flat light due to overcast skies and low fog.

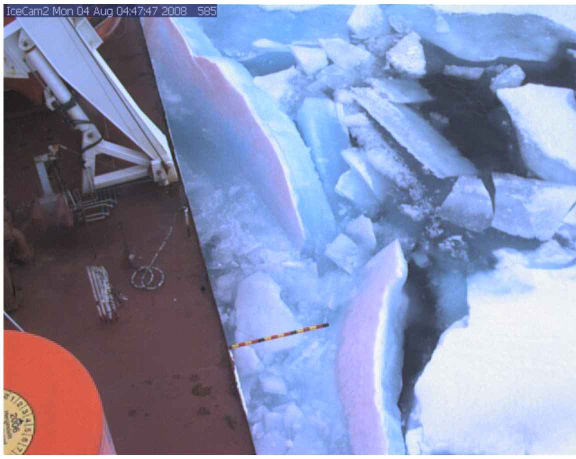
We found that the photographic record helped in consistency checking of the bridge ice observations. We placed two webcams on the monkey island to record ice automatically. However, due to poor resolution of the forward facing camera, we continued to take hourly photographs for our consistency checks.

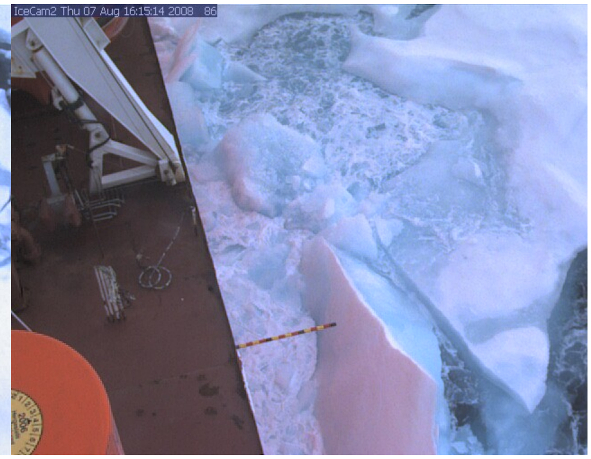
Webcam Imagery

Two cameras were installed on the monkey island. Back on land, we will investigate whether the images from the cameras are useful for mapping ice types and concentration by an ice expert who does not attend the cruise. My inclination is that a lot of information is lost by the cameras, as they can not provide 360^{o} vision, and can not be focused on a variety of ice features as the human eye can.

Camera 1 pointed forward on the port side of the ship, and took an image every 10 minutes. This provided a wide field view of the ice pack the ship was heading into. When ice conditions intensified, the camera was adjusted to capture photos more often. This not only provides more imagery, but allows for more continuous record of change in floe size and ice type.

Camera 2 was trained on the “ice thickness pole” to observe overturning ice. In order to get a representative sample of overturned ice, this camera took pictures more often than Camera 1. Both cameras were linked into the NOAA server for image storage. On this cruise Alice Orlich downloaded the images directly to a laptop, external hard drive, and CD-roms. Anyone who is interested in these may contact Jenny.





We have not processed the ice thickness data from this camera as it will take considerable time. However, once the data is processed it will give us a much more representative estimate of pack ice thickness than our visual observations from the bridge.

We had a couple of small issues in setting up the camera system. First, the image size needs to be not too large. We found that images over 100 kbytes would become pixilated in file transfer. Second, the netcam cameras do not have a small enough aperture for bright summer time pack ice photos. Hence most images from camera 1 are slightly blurry as they were over exposed. At times, Camera 2 produced bright, near white-out, images due to sun reflecting off fresh snow or the ice pack. The fix to this problem we would like to add a filter on the webcam lenses.


As for the location on the rail of monkey island, the selection was made to be similar to the positions used in 2007. Due to the limited space with appropriate holes for the fasteners, one bolt was used and additional webbing straps held the cameras in place.

Cameras on rail

Cam1 base

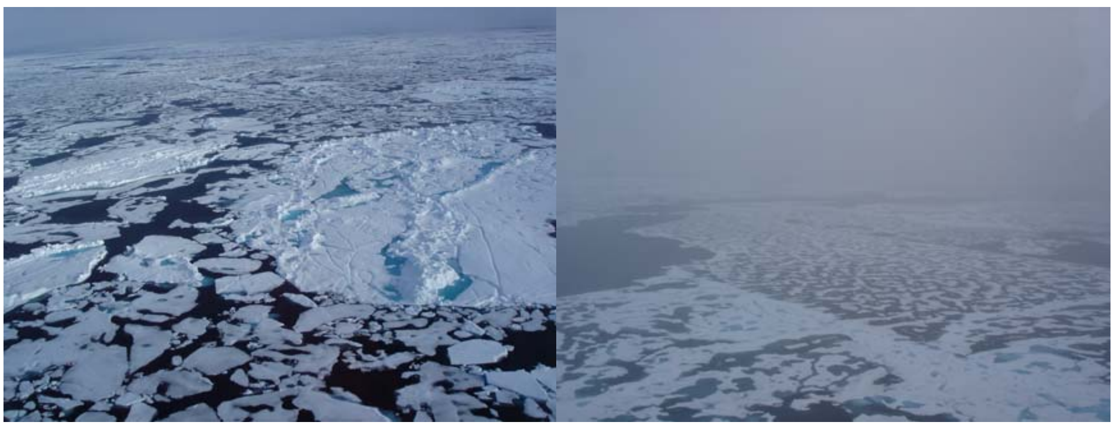
Cam2 base

Changes in precipitation combined with temperature drops and overcast skies, caused Camera 1 to form ice or other obstructions on the outer window. Monitoring the camera view from a laptop allowed for near-instant removal of ice and maintenance of the quality of photos captured.

Aerial Ice Observations

At various times during the cruise we had the opportunity to observe the ice cover from helicopter. In flying conditions when visibility was good, and the helicopter could travel at an altitude of 2000 feet, these flights were very helpful in extrapolating ship based observations to the wider field. Although this is the preferred altitude of the ship’s ice observer, low fog sometimes restricted flights to as low as 100’, more often staying at 200’. Compared to last year’s trips, we witnessed greater expanses of open water and small floe sizes. At times, searching for viable sites for buoy deployment required extended flights and multiple test sites due to poor ice availability. During flights, notes were taken of ice coverage, distribution of types and state of melt. Photographs and GPS waypoints were taken as a record of ice conditions.

These two images are from the first helicopter recon, on Saturday, 26 July, 2008. The edge of the ice is seen at 74° 21’, 148° 24’ from 1000’.



On 30 July, 2008, an ice recon flight was sent to fly the 150° line an overfly stations CB8, CB12, and CB9. Larger flows of multiyear ice with ridging, as on the left, were viewed from 200’. The visibility changed in areas of rotting first year floes with large breaks, as seen on the right from 800’.

During future cruises it would be advantageous to have a camera mounted on the helicopter, pointing downwards with a coincident record of geodetic location and altitude. This could provide a record of ice conditions that could be used to estimate scale of features on the ice and would not take up a seat on the helicopter. The camera which has been used on the Louis helicopter was designed to mount in the cargo hold, and can only be used when there is no load in the hold. This is not an optimal situation for the work we do. It would be better to design a camera that is affixed to the exterior of the helicopter. However, this will require extensive flight testing.

Comments on ice type observations

During the majority of the cruise in the western Beaufort Sea we were traveling through very rotten ice in small, flat floes. These had a smattering of obvious multi-year floes with hummucking and ridges scattered between them. Some first year thick ice had noticeable new ridging with either an unconsolidated surface, or filled with snow or recent snow cover. Much of the ice continued to be rotting first year, perhaps second year, floes with an advanced stage of melt and heavy ponding. Some of the floes had uneven surfaces, suggesting they had experienced a previous melt season. However the majority of this ice type was remarkably flat.

Be aware that the ice type observations in our spread sheets and the Canadian Ice Service charts might be coded wrongly. The CIS charts identify the young ice type as thin to medium thickness first year ice. We described first year by thickness, and considered “old ice” as multi-year type in our observations.

Ice Stations

Transects of ice thickness, snow depth and melt pond shape and orientation can provide additional information about ice conditions that is not possible to gauge with shipboard methods. We had many objectives for ice station work: (1) Snow sampling for black carbon in Arctic snow and ice, (2) Thickness transects with drill holes every 10 meters, (3) Ice core sampling at start, middle, and end of transect line for a study of salinity and multiple chemical analysis, (4) Collect water at ice/water interface for chemical analysis with water pumping/niskin bottles, (5) Ridge thickness study to access sail, keel, and voids in dynamic features, and (6) Collection of dirty ice for sediment transport or algal community characterization

The work conducted on the ice stations was coordinated with Kristina Brown of UBC. Before venturing off the ship, a meeting was organized to discuss the goals, priorities, preferred locations, operations, participant list and sampling plan. The discussion included the Captain, 1st Mate, helicopter pilot, Chief and co-chief scientist, as well as Orlich and Brown. The ice stations were selected by the Captain based on the ship schedule and therefore often occurred on the same floes were buoys were deployed by WHOI or SAMS. The time allotted was adjusted at each location and therefore dictated the type of work performed. On occasion, ice time was extended after the field team was on the floe, and they adjusted their priorities as needed. Typically, Orlich flew out on the first flight to assess the features and potential drill and core sites. This was done in coordination with the needs of the WHOI team and safety concerns. The team consisted of Orlich and Brown, but was able to enlist additional members if many helicopter flights were scheduled, or the time on station was expected to be more than 1.5 hours. Multiple volunteers from the science staff joined the ice sampling team and this increased productivity and allowed for a learning opportunity for researchers with little or no on-ice experience. Data was shared amongst the IARC/UBC, WHOI, and SAMS crews. Maps and GPS waypoints, along with observations and photos will be complied into reports for each station.

Thickness transects with drill holes

When offered an opportunity to have ice time, however brief, the primary sampling gear that was used was the 2” auger system. The choice was made to always acquire floe thickness data based on either transects of the greatest possible length across flat ice, or across ridges, and if those features were unavailable, random sites or smaller transects. The efficiency of the system allows for relatively minimal space in the helicopter, quick results, and simple operation. Many trips were offered with the understanding that the time on ice was to be limited and that readiness was immediate. Thickness transects are the quickest way to profile a floe.

Ice core sampling for a study of salinity and multiple chemical analyses

When time allowed, ice cores were extracted from the drill-hole transect lines at the beginning (0m distance), middle, and end of the line. The initial core at each distance was taken for temperature and salinity, where temperatures of the core were take on site at increments of 10 cm, starting at 5cm deep, and salinity was later found after 10 cm core pieces were melted back aboard the ship. The pieces were measured starting at the top of the core, thus providing a temperature at the center of each slice. The 10cm pieces were measured in three thicknesses with a caliper for consistency, and then averaged to use in calculating the volume, and ultimately, density.

A second group of cores were collected for use in Brown's chemical analysis of the ice at different depths. Select pieces were stored in tedlar bags with excess air removed, melted on the ship and later analyzed for del 13C-DIC, alkalinity, salinity, del18O, and nutrients.

Water collection at ice/water interface for chemical analysis

After core collections were completed, a submersible aquarium pump was used to collect water from near the ice/water interface. The samples were analyzed for the aforementioned constituents as well as Ba, Chla, and del 13C-POC. The practice could be well-coordinated with two field personnel managing it while a second team travelled on to begin another core site.

Ridge thickness study

Where ridges were transected a floe, ridge thickness studies were planned. By transecting the ridge perpendicularly, a drill-hole line can be used to access sail, keel, and voids in the dynamic feature. There was only one floe in which this brief study was conducted. Given the relation to melt ponds bordering the ridgeline, the transect line travelled over the spine of the ridge for a distance of 70m.

Collection of dirty ice

Dirty ice includes any samples that may be helpful to determine sediment transport or algal community occupation. During the 2007-20 cruise, ice with sediment or algae was collected wherever found. Some sites were easy to access by Zodiac boatcraft, and yielded ice and water samples that could be collected by reaching out of the boat. No boat trips were offered this season. One floe utilized for a buoy deployment had sediment and was collected for student David Griffith from WHOI/MIT.

Additional notes

Because the ice sampling program is regarded as a "science of opportunity" by the trip schedulers, it is important to plan multiple goals for ice work that have reasonable tasks and elements of flexibility incorporated into the research design. By having those goals presented and discussed early in the trip, all interested and affected parties were able to anticipate the field operations when the opportunities arose. The obvious disadvantage to

Figure 22. Ice core is prepared for sampling by Alice Ohrlich and Mike Dempsey.

this system is that consistency in field data is uncertain, and mixed data collections result. However, at this point in ship-based sea ice observations, it is accepted and appreciated that any opportunity to collect in-situ data using any method is instrumental in contributing to groundtruthing satellite interpretation, modelling, and future on-going ice observation and sampling programs. We would like to thank IOS, WHOI, and the Canadian Coast Guard for their collective effort in helping us make progress in this objective.

4.11 Ice Chemistry

P.I. Fiona McLaughlin (DFO), Kristina Brown (UBC), Alice Ohrlich (IARC)

Ice coring and water sampling was conducted at three different ITP sites during the LSSL 2008-30 cruise. These sites were chosen in combination with the 2008-30 Soot Sampling (Kristina Brown), Sea Ice Floe Mapping (Alice Orlich), and Ice Tethered Profiling (WHOI) programs. ITP 23, 25, & 26, provided sites that were both easily accessible to the coring team and allowed enough time for both ice coring and ice auguring programs to take place. Sea ice core locations were chosen based on ice thickness measurements taking during the ice auguring program (Alice Orlich).

At each station location, sea ice cores were collected to obtain a profile of temperature and salinity and samples for assessing chemical characteristics of the ice floe. Sea ice cores collected for temperature profiles were measured on site, with holes drilled at 10cm intervals down the core for a measurement of floe in *situ* temperature. Following this, cores were cut up into 10cm pieces to be melted on the ship for salinity analyses. After temperature profiles were completed, one or two more cores were obtained to asses changes in sea ice chemistry at various depth intervals in the floe (effectively top, middle, & bottom). Chemistry cores were cut up on site in 2x10cm pieces at each depth interval and pieces were partitioned into air-tight tedlar bags. Tedlar bags were then evacuated of outside air using a hand pump, and taken back to the ship to be melted in the back Lab B.   In total 5 cores were collected for temperature and salinity profile measurements, and 7 cores were collected for chemical parameter sampling back on the ship. Once ice core sections were melted on the ship, samples of the homogenized melt were taken for del13C-DIC, Alkalinity, Salinity, del18O, and nutrients. 24 individual core sections were sampled for chemical parameters from the 7 cores obtained.

After cores were removed from the bore hole, a submersible aquarium pump was lowered to 1.5m below the surface to attempt to extract water from the ice/water interface. Samples were collected at 4 of the 7 chemistry core sites and included del13C-DIC, Alkalinity, Salinity, del18O, Ba, Chla, del13C-POC and nutrients.

Ice Camp Swiss Cheese (ITP-25) provided an opportunity to try and collect brine from varying depth intervals in the ice floe. Brine holes were drilled out with the corer to 1m and 2m at site 1, covered, and let to sit for the duration of the time on the floe. Unexpected traffic at this site, as well as freezing of the holes due to low temperatures, meant that brine collection was conducted at only the 1m deep brine hole. Samples were collected for del13C-DIC, Alkalinity, & Salinity.


Figure 23 - Coring Operations at Ice Camp Moonscape (Mike Dempsey & Alice Orlich)

Figure 24 - Ice/Water Interface Pumping Operations at Ice Camp Moonscape (Nes Sutherland)


Figure 25 - Pumping Operations at Ice Camp Last Chance (Brian Hunt & Sarah Zimmermann)

Figure 26 - Ice Core Temperature Profiles at Ice Camp Moonscape (Kenny Scozzafava)

4.12 Black Carbon (Soot) Sampling

P.I.s Stephen Warren and Thomas Grenfell (UW), Kristin Brown (UBC)

Samples for the evaluation of black carbon (soot) in Arctic Sea Ice were collected during the 2008-30 JOIS cruise in an effort to determine the effect of this atmospheric contaminant on sea ice albedo. Sampling began once the ship reached the southern extent of the summer sea ice pack, and continued opportunistically during sea ice reconnaissance surveys, ITP deployment operations, and any other occasion available to obtain such samples. In total, 43 soot samples were collected at 14 different locations between 75 to 83 deg N and 139 to 153 deg W (Figure 1).

Sampling locations on each floe were selected based on the floe layout. Floe safety, visible distance from bear guard, location of floe edge, melt ponds, & ridging features, were all taken into consideration when selecting a site for soot samples. When possible, a location was chosen at the furthest distance upwind of the helicopter allowed by the safety precautions. Ideally samples were taken on a floe also upwind from the ship; however this was not always possible. At each location a sample of the upper snow layer (0-2cm) and lower granular layer (2-10cm) were taken from a 45cm x 45cm snow pit dug out with a metal spatula. As it was the summer season and melting was obvious at most locations, the upper snow layer (0-2cm) was often a layer of more loosely compacted granular snow/ice, followed underneath by more densely packed granular layers, and finally a harder layer of ice. In all instances the layer of hard ice was not sampled, but the granular layers were sampled in two sections (0-2cm & 2-10cm) even when separation between the two sections was not obvious. The depth of the upper snow layer was often determined by pushing a plastic ruler into the snow until feeling resistance, giving the upper “snow” layer. When new snow fall was obvious its depth determined the upper and lower layers of the samples. Duplicate samples of both the upper and lower snow/granular layers were obtained at almost all sites.

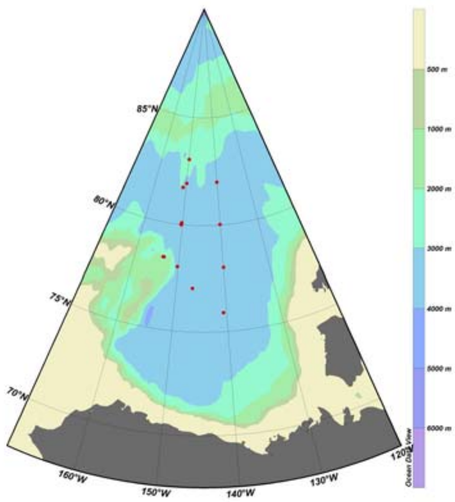


Figure 27 - 2008-30 Soot Sampling Locations

Figure 28 - Soot Sample Snow Pit (ITP26)

Outreach, XCTD, (nuts, sal, ammonium, oxy? No CDOM, no Alice)

4.13 Underway Measurements

P.I. Svien Vagle, Sarah Zimmermann DFO

Seawater Loop

The ship's seawater loop system draws seawater from below the ship's hull at 9m, to 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 uncontaminated as possible coming directly from outside of the hull through stainless steel piping without recirculation in a sea-chest. The manifold has been insulated this year to minimize condensation. The rate is controlled for systematic measurements, and allows for continuous autonomous sampling. Measurements were taken by installing sensors in-line, and by diverting water through a manifold to run through various sensors.

Autonomous measurements made:

- SBE38: Temperature.
  Sensor was installed in-line, approximately 4m from pump at intake. This is the closest measurement to actual sea-temperature.
- SBE21 Seacat Thermosalinograph: Temperature and Conductivity, Fluorescence and CDOM
  5 second sample rate, run off the manifold in the main lab
  (Fiona McLaughlin, DFO)
- Blue Cooler: Total gas (Gas Tension Device), Oxygen.
  15 (?) second sample rate, run off the manifold in the main lab.
  (Svein Vagle, DFO)
- Black Box: Methane, Oxygen, pCO2.
  Hourly samples, run off the manifold in the main lab.
  (Patricia Ramlal, DFO)

Independent of the seawater loop:

- SBE48: Hull Temperature
  This measurement is an approximation of seawater temperature, and is taken using a temperature sensor mounted on the ship's hull, inside, aft of the pump approximately 15m, starboard side.

Discreet Water Samples drawn for analyses on other instruments

- Salinity, Chlorophyll-a, CDOM (Chad Cuss), POM (Brian Hunt), and filtration for ^{14}C and ^{13}C (David Griffith)

Figure 29. Seawater loop system providing uncontaminated seawater from 9m depth to the science lab for underway measurements

Some of the instruments were self-contained; others 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 and SBE48 data to the ship's data collection system (SCS).

PAR Data

Photosynthetically available radiation (PAR) was measured continuously. The sensor location was on the hanger top aft of the stack in the most unobstructed spot possible. The PAR sensor received no servicing during the cruise and it is anticipated there will be an accumulation of dust on the sensor.

Ice Cameras

Ice Cameras mounted on above the bridge took pictures every 5 to 30minutes depending on ice conditions. Two cameras were installed, one looking forward, the other looking aft along the side of the ship to observe upturned ice. See the complete report on this system by Alice Orlich.

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.

Data collected by SCS:

- Location 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, relative humidity, and apparent wind gusts from the ship's AVOS weather data system (AVRTE sentences). SCS derives true wind speed.
- Sea surface temperature, conductivity, salinity and fluorescence from the ship's SBE 21 and SBE38 thermosalinograph
- Sea surface temperature from the SBE48 hull mounted temperature sensor
- SCS derives speed over ground and course over ground

The RAW files 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.

We were still experiencing some problems this year with the system losing data strings due to communication errors, sensor reconfigurations or sensors having stopped. After removing the SBE48 hull mounted temperature data stream from SCS, the system operated more smoothly without hanging. The SCS system required regular checks to confirm data was being collected. The majority of problems were communication, and were fixed by stopping and restarting either the software of the GPSgate communication software.

4.14 Near Surface Seawater Measurements of Undisturbed Water

P.I.s Fiona McLaughlin and Michiyo Kawai (DFO)

Figure 30. Zodiac being lowered for sample collection.

To study the CO_2 and fresh water components of seawater accurately in the near-surface water, CTD SBE19+ casts with water samples at 1, 5 and 10m were conducted from a zodiac approximately 300m away from the ship at the four deep basin mooring stations, STA-A and NW-3. Water samples were collected for analyses of salinity, alkalinity, DIC, barium, ^{18}O at all zodiac stations and nutrients at two of these stations. Samples were collected using a 1.7L Niskin bottle attached to a rope and closed by messenger, with two casts per depth, starting at 1m and sampling progressevly deeper. From the first cast, DIC was sampled and pickled immediately. From the second cast, a bottle was filled that was later used for sub-sampling the remaining samples back on board. The CTD, configured with pumped temperature and conductivity, was attached to the bottom of the rope and left on and in the water until the six casts were compete.

4.15Outreach, Drift Bottles, and Opportunistic Measurements

Gerty Cori Ward (PolarTREC, WHOI)

Outreach

I joined the LSSL-30 science cruise as a PolarTREC teacher with Rick Krishfied of Woods Hole Oceanographic institution (WHOI www.whoi.edu). PolarTREC is a 3-year program funded by the National Science Foundation USA) whose mission is to improve contacts and communication between scientists in the field and teachers in the classroom (www.polartrec.com). I wrote and filed a daily journal, describing all aspects of the LSSL-30 cruise: the science, the equipment, the people, the ship and its officers and crew, the Arctic ecosystem and the ice. My primary audience was middle school students (ages 10-14) so my descriptions and discussions are aimed at improving science and field work understanding to that age and stage. I observed or participated in almost all scientific activities and aspects of ship life. I strove to find a balance between science and technical descriptions and human interest discussions. In addition, I kept in mind that all most all of my audience was on summer holiday.

Figure 31. Gerty Ward is a hands-on observer working as sample-cop.

I wrote 36 dispatches, filing one copy to PolarTREC and another, similar copy to WHOI for a total of 72. I used a combination of real-time internet and ShipNet to file the dispatches. My PolarTREC journals can be found here: http:// www.polartrec.com/ocean-dynamics-beaufort-sea/journals/gerty-ward The Dispatches that I filed for WHOI are here: http://www.whoi.edu/beaufortgyre/dispatch2008/index2008.html The science team and LSSL officers and crew were generous in sharing their time and expertise and were instrumental in all my efforts.

PolarTREC also had an Ask The Team link, where readers of the journal could ask follow-up questions. I answered 46 questions posed by a wide range of people, from my students to the general public. The questions and my responses are here: http://www.polartrec.com/ocean-dynamics-beaufort-sea/ask-the-team To give my journals readers a more full experience of the topics that I reported on, I made about 12 short movies. Through video, I was able to communicate the noise of the engine room, the sound of the ship breaking ice, the process of Rosette sampling and Bongo net casting. I received lots of positive feedback from these additions to my journals. I plan to use these movies to introduce the science, techniques and field work life to my students. These movies are available on select PolarTREC Journals. Anyone wishing a full-quality copy of any movie may email me at gcw.mail@gmail.com.

I participated in a Live-From-IPY event. Also participating were Rick Krishfield WHOI, Sarah Zimmermann DFO, and Brian Hunt UBC. We answered about 15 questions from a variety of participants. A PDF of the slides used in this event is Appendix 2. Sarah Zimmermann DFO, Brian Hunt UBC, Rick Krishfield WHOI, The entire event will be archived and is available at www.polartrec.com

Drift Bottles

Prior to coming on board, I prepared 24 drift bottles from the DFO Drift Bottle Project (http://www.pac.dfo-mpo.gc.ca/SCI/osap/projects/driftbottle/intro_e.htm) Once on board, I corked and sealed them. When we reached 83N, 150W the bottles were tossed into the ocean.

In addition, two other sets of bottles were tossed at NW-03, our most northerly station. One set of 24 bottles had been prepared by Halifax High School Student Bonita LeBlanc. The other set was prepared on the board with notes from the LSSL crew.

A second group of 48 bottles prepared by Bonita LeBlanc were tossed at the most westerly station RS-01 at 75 44.14'N and 157 52.82'W.

Solar Radiation Measurements

I was asked to take measurements of solar radiation by Andrey Proshutinsky of WHOI using a Microtops Photometer. Though we saw very little sun on this cruise, I was able to take several repeat measurements on the few days that we saw the sun. Overall I took 41 measurements.

Water Samples for Black Carbon (Soot)

At Station D, 14 Aug 2008 0200, 74N, 140W, I collected 30 water samples from the Rosette cast for Mary-Louise Timmermans of WHOI. She is planning to use a new technique to determine black carbon concentration of sea water.

5. COMMENTS ON OPERATION

5.1 Ice conditions

Although last summer was record breaking in the reduction of minimum sea-ice extent for the entire Arctic, it was this summer that changes were very noticeable for the Canada Basin. We encountered areas of open water up to our most northerly station at 83°N, 150°W. The ice was not difficult to pass through, typically we were on 2 engines, meaning time between stations was mostly defined by time required to process samples, not ship transit time.

The program started a week earlier than last year and two weeks earlier than the year before. Even with this early start, ice was not a constraint once the ship was in the Canada Basin. The transit through the Canadian Arctic Archipelago however was difficult. Being first-year landfast ice, there is less variation in the timing of the break up and with the cold winter, we were transiting before much melt had occurred in Peel Sound

Comments from Marie-Claude Bouchard
Ice observer, Canadian Ice Service

Weather

The weather conditions were cloudy (overcast) and foggy throughout the trip.

The mean air temperature was about 2 degrees Celsius. Over the Western Arctic, the mean temperature was normal for the 2 last weeks of July and above the normal during the first part of August.

There was only few days with precipitations. Some snow showers were encountered above 78N.

The predominant winds were northwest at a mean speed of 10 to 15 knots except for a 7 days period (July 25th to July 31st) where the winds blew from southeast and increased to 25-35 knots on July 29th . This low pressure system lost 1mb/hour to deepen to 978 mb. Snow, rain and mixed precipitations occurred during this time. This was the only significant weather event of the trip.

Ice

Generally speaking, the situation in the Western Arctic bears little resemblance with past break-up patterns because of the Beaufort Sea was so open. The ice conditions encountered during the trip were easy. The ice was at an advanced stage of decay and the ice pack was loose enough to sail. Thick first year ice was predominant up to 78N and lightly underestimated throughout the trip. Multi-year ice was predominant above 80N and east of 140th W meridian.

Thick first year in fast ice was encountered in mid-July through Dease and Coronation Gulf. The ice was rotten and there were many fractures and openings. It was open water from Dolphin and Union Strait about 75N/150W. From 75N to 78N, thick first year was predominant with a few tenths of multi year ice. Multi-year ice was more and more present from 78N to 80N and became predominant beyond 80N. The ice edge on the way back was located at 74N/140W. Except for a zone of multi-year floes encountered at 170nm south-east of Banks Island, it was ice free up to Kugluktuk.

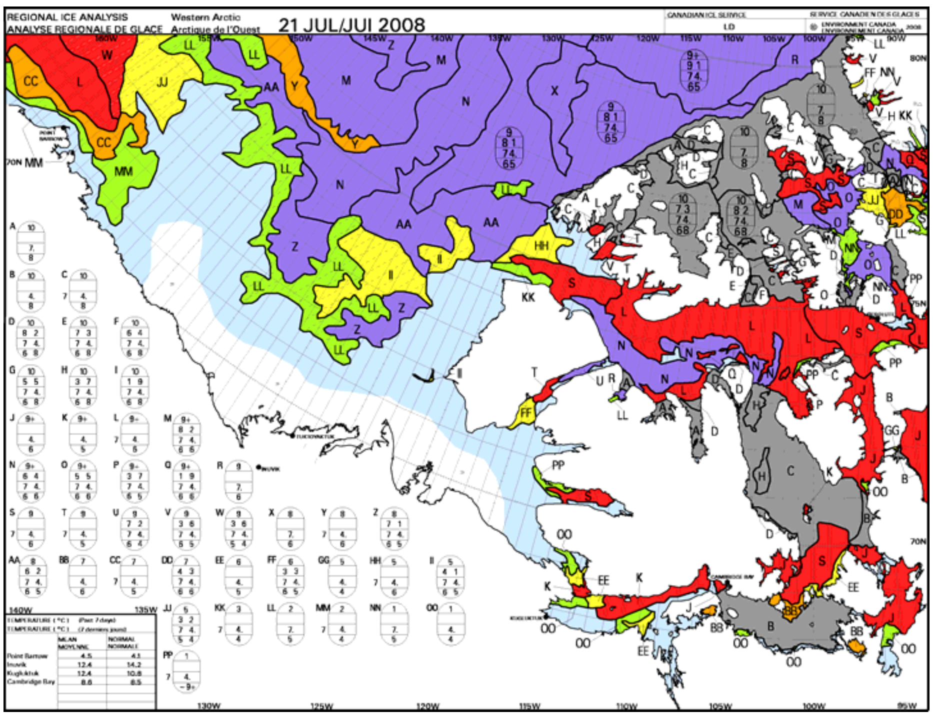


Figure 32. Ice concentration at the start of the program

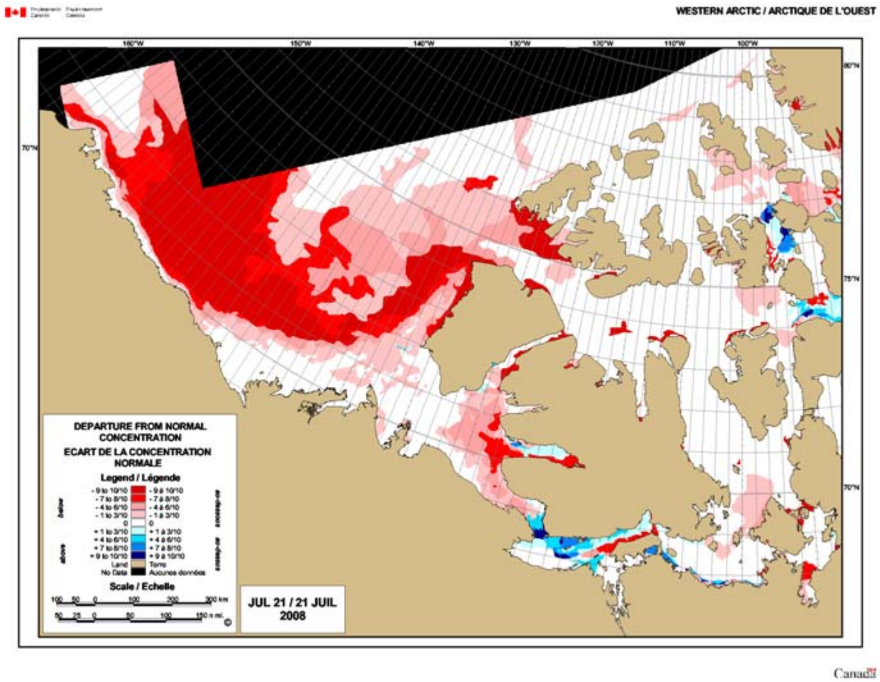


Figure 33. Ice concentration anomaly at the start of the program.

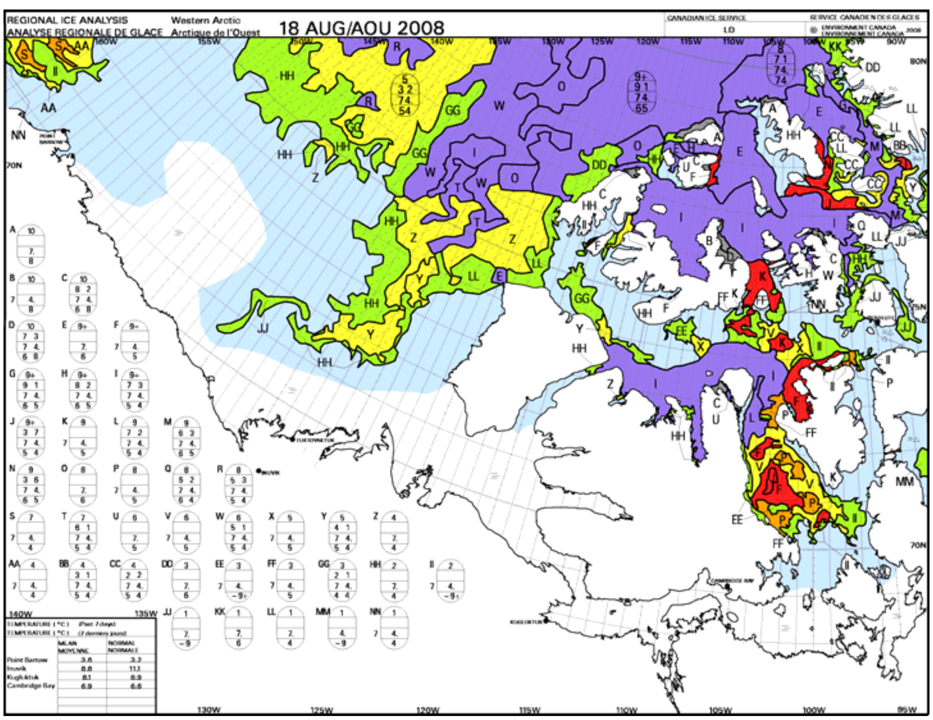


Figure 34. Ice concentration at the end of the program

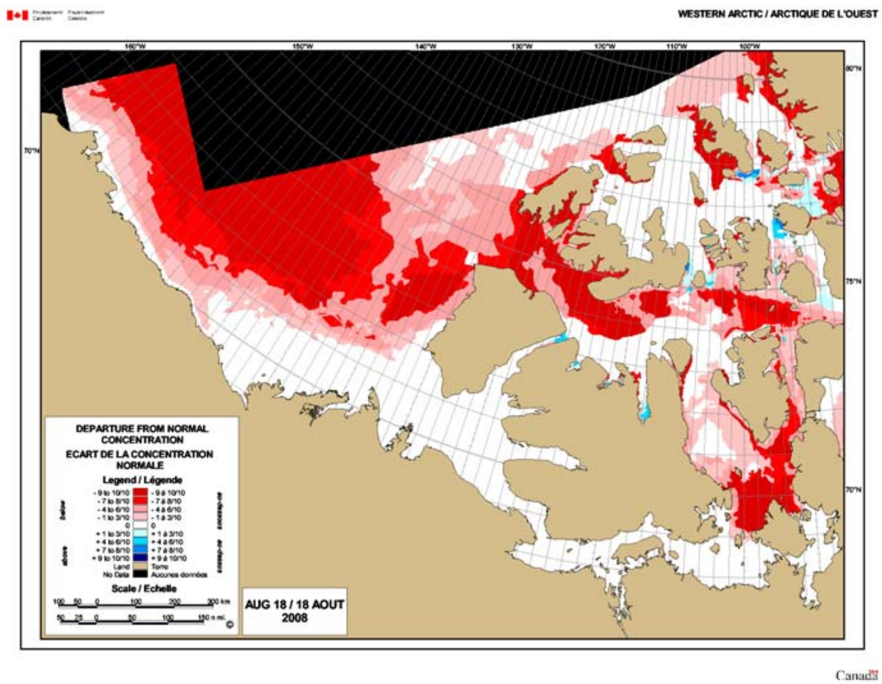


Figure 35. Ice concentration anomaly at the end of the program.

5.2 Completion of planned activities

All objectives were met.

5.3 Ship improvements completed for 2008

We are very appreciative that items identified last year for improvement were addressed. Through discussion and prioritising funds, decisions were made regarding what was feasible and could be improved. Some of the highlighted outcomes of last winter's efforts are listed below.

General Ship:

- Air conditioning to the forward science lab was added for performance and operation of ship's network servers, sounder equipment and computers as well as to make a more comfortable work space.

- A second network system was installed for use by science. This added network was fast and had plenty of room for data storage. The drawback to the system is that there is no way to connect from one network to the other, meaning one needs to physically change networks to go from working with email, internet access and the Knudsen sounder access to the science data drive. We tried installing a wireless router in the boardroom that was very useful when it worked, allowing connections to the ship's network via cable and the science network via the wireless, however for unknown reasons the router would fail and need restarting/reconnecting.

- The ship had access to the internet. It was very useful to having 24-hour access to email, access to web pages with relevant information such as ice images and software. Although communication was cut off at the northern end of our study area, I understand there is a plan in place to correct this for next year.

Science:

- Foredeck Lab container was replaced with new container.
- Steps from door to deck improved for the lab containers
- Coat hooks, bench, suit up area added to lab spaces.
- Sea water loop manifold insulated to prevent condensation.
- Shelves added to the lab attached to main lab (aft most lab).

6. ACKNOWLEDGMENTS

The science team would like to thank the Coast Guard for their support, particularly Captain McNeill and the crew of the *CCGS Louis S. St-Laurent*. At sea, we were very grateful for everyone's top-notch performance and assistance with fabricating and modifying parts for missing and broken equipment. We appreciate that a substantial number of projects were completed by the ship in preparation for the summer science season. We'd like to thank the Canadian Ice Service for their assistance with ice images and weather information as well as Chris Swannell, the helicopter pilot for his and the helicopter mechanic's valuable help with ice reconnaissance flights, support on the ice and transport. Thanks to the *Amundsen* for providing batteries when it was discovered we were missing this important supply for some of our science equipment. Importantly, we'd like to acknowledge DFO, NSF and JAMSTEC for their continued support of this program.

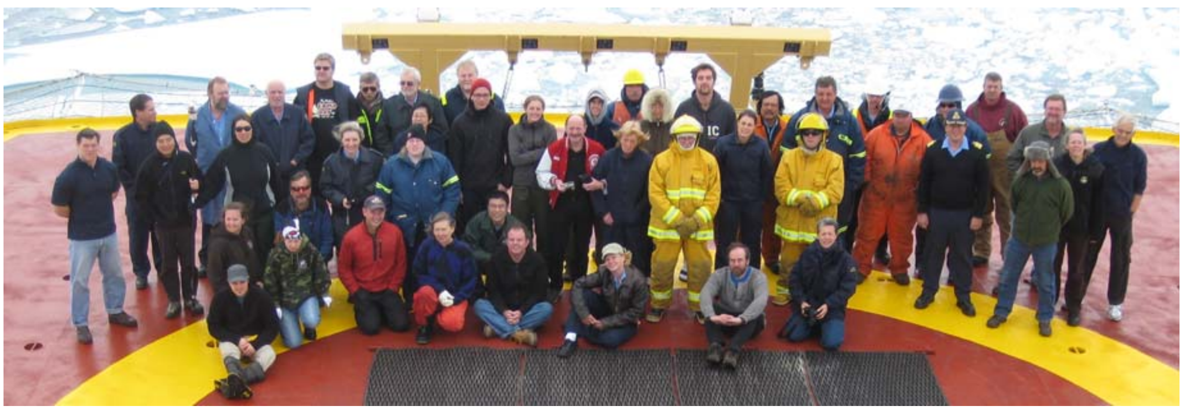


Figure 36. JOIS-2008 ***(Gerty Ward 2008 courtesy of ARCUS (PolarTREC))***

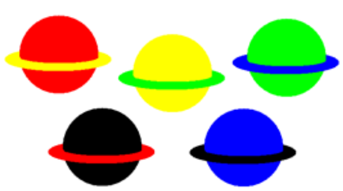


Figure 37. And the Gold Medal team of the Intergalactic Olympics ***(photo: Nes Sutherland)***

APPENDIX A: Participants

Table 1. Cruise Participants

Name	Role	Affiliation
Sarah Zimmermann	Chief Scientist, Underway	DFO
Michiyo Kawai	Co-Chief Scientist, Alkalinity	DFO
Mike Dempsey	Chief Technician, CTD Watch	DFO
Will Burt	CTD Watch (deck), bacteria	DFO
Linda White	Nutrients	DFO
Melissa Hennekes	NH4, Salinity	DFO
Kenny Scozzafava	CTD Watch, Salinity	DFO
Hugh Maclean	Oxygen, Salinity supervisor	DFO
Nes Sutherland	CFC 2	DFO
Rick Nelson	CFC 1, Iodine & Cs	DFO
Kristina Brown	Chemistry Data, Assist Lab management, C-13/DIC, Soot Samples	DFO
Edmand Fok	CTD Watch, Underway system, Data	DFO
Chad Cuss	CDOM, DOC, Carbohydrates	DFO
Brian Hunt	CTD Watch (nets), Chlorophyll assist	DFO
Kelly Young	CTD Watch (nets), Chlorophyll	DFO
Waldek Walczowski	CTD Watch, LADCP	IOP
Shigeto Nishino	CTD Watch, XCTD	JAMSTEC
Alice Orlich	Ice observations	UAF
David Meldrum	Ice-buoy deployment	SAMS
Gerty Ward	Outreach, Teacher	PolarTREC/WHOI
Rick Krishfield	WHOI moorings	WHOI
Will Ostrom	WHOI moorings	WHOI
Jim Dunn	WHOI moorings	WHOI
David Griffith	WHOI sediment traps, pumps	WHOI

Table 2. Principal Investigators on Shore

Name	Affiliation	Program
Fiona McLaughlin	DFO	CTD and chemistry
Eddy Carmack	DFO	CTD and chemistry
Andrey Proshutinsky	WHOI	WHOI moorings
Koji Shimada	JAMSTEC	XCTD
Chris Guay	OSU	Barium samples
Bill Li	DFO	Bacteria samples
John Smith	DFO	Cs-137, I-129 samples
Russ Hopcroft	UAF	Zooplankton net tows
John Nelson	DFO	Zooplankton net tows
Igor Polyakov	IARC	CABOS mooring
Tim Eglington	WHOI	Sediment traps and pumps

Thomas Grenfell and Stephen Warren	UW	Soot Samples
Patricia Ramlal	DFO	Underway Seawater Gas Sampling
Svien Vagle	DFO	Underway Seawater Gas Sampling, Ship-side ADCP
Jennifer Hutchings	IARC	Ice Observations
Celine Gueguen	Trent University	CDOM, DOC and Carbohydrates

Affiliation Abbreviation

DFO	Department of Fisheries and Oceans, Canada
IARC	International Arctic Research Center, Alaska
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
IOP	Institute of Oceanology, Poland
OSU	Oregon State University, OR
SAMS	Scottish Association for Marine Science
UAF	University of Alaska Fairbanks, Alaska
UBC	University of British Columbia, BC
UW	University of Washington, Washington
WHOI	Woods Hole Oceanographic Institution, Massachusetts
UW	University of Washington, Washington

APPENDIX B: Science Station Locations

Table 3. Rosette/CTD Casts

Cast Start Time (UTC)	Station	Cast #	Lat (N)	Lon (W)	Uncorrected Bottom Depth (m)	Max Depth (m)	Sample #
2008/07/20 19:49	Test	1	69.5083	117.6817	378	76.1	1-24
2008/07/21 05:55	AG5	2	70.5520	122.9052	638	635	25-48
2008/07/22 08:19	CABOS	3	71.8275	131.7597	1100		49-73
2008/07/23 07:07	MK6	4	71.5858	140.0090	2447	2460	74-97
2008/07/23 11:11	MK5	5	71.0013	140.0000	2062	2059	98-121
2008/07/23 15:39	MK4	6	70.8122	140.0147	1484	1481	122-145
2008/07/23 19:10	MK-3	7	70.5740	140.0030	785	759	146-167
2008/07/23 22:43	MK-1	8	70.2296	140.0022	230	230	168-179
2008/07/24 01:09	CB28-aa	9	69.9998	140.0013	50	50	180-183
2008/07/24 14:44	STN-A	10	72.6875	144.6905	3410	3409	184-204
2008/07/24 19:37	STN-A	11	72.6879	144.7065	3400	1000	205-228
2008/07/24 21:13	STN-A	12	72.6864	144.6973	3400	700	229-252
2008/07/25 07:09	BL-08	13	71.9648	150.2266	2980	2997	253-276
2008/07/25 13:56	BL-04	14	71.5012	151.6575	1007	983	277-300
2008/07/25 17:01	BL-02	15	71.3956	152.0369	149	142	301-312
2008/07/25 19:04	BL-03 (near)	16	71.4556	151.8214	412	400	
2008/07/25 20:00	BL-03	17	71.4696	151.7775	640	100	313-336
2008/07/25 21:13	BL-03	18	71.4683	151.7792	580	580	337-356
2008/07/25 23:57	BL-05	19	71.5933	151.3595	1557	1500?	
2008/07/26 02:03	BL-06	20	71.6585	151.2322	1993		359-382
2008/07/26 09:46	CB-2	21	73.0000	150.0002	3680	3679	383-406
2008/07/26 17:02	CB-3	22	73.9997	150.0044	3749	3810	407-430
2008/07/26 23:41	CB-6	23	74.4996	147.7352	3709		431-454
2008/07/27 21:44	CB-4	24	74.9920	150.0563	3819		455-478

2008/07/28 07:13	CB-4	25	75.0215	149.9012	3817	3807	479-502
2008/07/29 04:35	CB-5	26	75.3193	153.2804	3838	3838	503-526
2008/07/29 11:19	RS-06	27	75.5132	155.2689	3840	3832	527-550
2008/07/29 18:08	RS-01	28	75.7432	157.0933	1000	987	551-574
2008/07/29 21:18	RS-02	29	75.6604	156.2594	1593	1574	575-598
2008/07/30 08:10	CB-7	30	75.9965	149.9770	3825	3818	599-622
2008/07/30 16:18	CB-8	31	76.9978	150.0429	3826	3814	623-646
2008/07/31 01:47	CB-12	32	77.6781	146.7466	3805	1000	647-670
2008/07/31 03:20	CB-12	33	77.6775	146.7489	3805	3801	671-694
2008/08/01 00:52	CB-9	34	78.0029	150.1752	3818	3806	695-717
2008/08/01 08:10	CB-9	35	77.9774	150.1978	3818	1000	718-741
2008/08/01 10:05	CB-9	36	77.9822	150.2811	3818	800	742-758
2008/08/02 06:54	CB-10	37	78.3292	153.0209	3197	3090	759-782
2008/08/02 10:44	CB-10a2	38	78.3362	153.3595	2281		783-806
2008/08/02 12:28	CB-10a2	39	78.3395	153.3611	2297	2295	807-830
2008/08/02 16:36	CB-10a	40	78.2923	154.0999	940	916	831-851
2008/08/03 04:41	CB-11	41	79.0174	149.8899	3819	3810	852-875
2008/08/03 16:49	CB-11B	42	80.0210	149.7890	3817	3795	876-899
2008/08/04 07:04	NW-1	43	81.0286	149.8499	3796	3783	900-923
2008/08/05 04:07	NW-2	44	82.0047	149.9623	3169	3160	924-947
2008/08/05 15:33	NW-3	45	83.0298	149.9916	2918	2890	948-971
2008/08/06 14:12	NE-3	46	81.9905	140.0163	3524	3506	972-995
2008/08/06 19:24	NE-3	47	82.0038	139.9976	3447	1002	996-1004
2008/08/07 06:50	NE-2	48	81.0204	140.1053	3753	3742	1005-1028
2008/08/07 17:29	NE-1	49	80.0290	140.0672	3758	3756	1029-1052
2008/08/08 06:56	CB-16N	50	79.0060	139.9329	3764	3759	1053-1076

2008/08/08 19:57	CB-16	51	78.0124	139.9055	3744	3743	1077-1100
2008/08/09 08:52	CB-13	52	77.1714	142.0252	3754	3751	1101-1124
2008/08/09 22:00	CB-15	53	76.9927	139.9527	3722	1000	1125-1148
2008/08/10 00:47	CB-15	54	76.9889	139.9966	3722	3000	1149-1172
2008/08/10 03:45	CB-15	55	76.9922	140.0127	3721	3716	1173-1196
2008/08/10 14:44	PP-07	56	76.5460	135.4393	3566	1000	1197-1220
2008/08/10 16:18	PP-07	57	76.5446	135.4317	3565		1221-1244
2008/08/11 02:45	PP-06	58	76.2659	132.5303	3059	3047	1245-1268
2008/08/11 08:21	PP-05	59	76.0087	130.8754	2476	1000	1269-1288
2008/08/11 09:51	PP-05	60	76.0839	130.8768	2471	2454	1289-1312
2008/08/12 02:22	CB-17	61	75.9506	140.0822	3703	3696	1313-1336
2008/08/12 09:06	CE-1	62	76.0032	142.4474	3744	2500	1337-1360
2008/08/13 00:09	CB-18	63	75.0004	140.0002	3620	3617	1361-1384
2008/08/13 07:34	CB-19	64	74.2993	143.3061	3693	3688	1385-1408
2008/08/13 19:15	CB-21	#756	74.0013	139.9140	3503	3500	
2008/08/14 03:49	CB-21	65	74.0324	140.0025	3519	3505	1409-1432
2008/08/14 11:24	CB-21	66	74.0100	139.9490	3506	2000	1433-1449
2008/08/14 23:11	CB-22	67	73.4500	137.9998	3127	3116	1450-1473
2008/08/15 05:13	CB-27	68	73.0006	139.9980	3221	3203	1474-1497
2008/08/15 14:06	Stn-A	69	72.6008	144.6966	3428	1000	1498-1521
2008/08/15 15:43	Stn-A	70	72.6008	144.7000	3429	3419	1522-1545
2008/08/19 10:26	CB-29	71	71.9998	139.9992	2691	2670	1546-1569
2008/08/19 20:35	CB-31b	72	72.3646	133.9622	2092	2077	1570-1593
2008/08/20 03:06	CABOS-Again	73	71.7877	131.8975	1141	1123	1594-1617

Table 4. XCTD Casts

Time (UTC)			Lat (N)	Lon (W)	Uncor. Bottom Depth	File name	Probe number
Jul	22	1:37:04	70.9889	125.9803	401	200830-XCTD-001	7012631
Jul	22	5:57:26	71.4373	128.9833	111	200830-XCTD-002	7012638
Jul	22	8:19:54	71.6510	130.4817	291	200830-XCTD-003	7012634
Jul	22	20:17:00	71.5783	133.4598	1100	200830-XCTD-004	7012635

Jul	22	22:28:55	71.5203	134.9670	1600	200830-XCTD-005	7012636
Jul	23	0:44:50	71.5365	136.4648	1600	200830-XCTD-006	7012632
Jul	23	2:44:40	71.5511	137.9676	2600	200830-XCTD-007	7012633
Jul	23	9:37:17	71.2929	140.0021	2275	200830-XCTD-008	7022787
Jul	23	21:00:21	70.4047	140.0048	508	200830-XCTD-009	7022786
Jul	24	2:50:02	70.2796	140.4744	160	200830-XCTD-010	7022785
Jul	24	3:57:41	70.4833	140.7982	510	200830-XCTD-011	7022788
Jul	24	4:24:04	70.5937	140.9853	1050	200830-XCTD-012	7022790
Jul	24	4:54:57	70.6892	141.1600	1100	200830-XCTD-013	7022789
Jul	24	5:43:42	70.8529	141.4119	2014	200830-XCTD-014	7033322
Jul	24	6:51:21	71.0987	141.8380	2498	200830-XCTD-015	7033323
Jul	24	8:42:27	71.4881	142.5406	2875	200830-XCTD-016	7033324
Jul	24	10:33:46	71.9008	143.2571	3000	200830-XCTD-017	7033327
Jul	24	12:32:01	72.3010	143.9776	3204	200830-XCTD-018	7033326
Jul	25	0:29:59	72.4926	146.2057	3400	200830-XCTD-019	7033325
Jul	25	2:29:00	72.3005	147.7028	3500	200830-XCTD-020	7022654
Jul	25	4:59:20	72.1019	149.1962	3400	200830-XCTD-021	7022653
Jul	25	11:29:29	71.8137	150.6472	2525	200830-XCTD-022	7022652
Jul	26	6:19:31	72.2495	150.3667	3500	200830-XCTD-023	7022651
Jul	26	7:25:20	72.4981	149.9986	3655	200803-XCTD-024	7022650
Jul	26	8:26:14	72.7438	149.9937	3665	Error: no file	7022649
Jul	26	14:31:10	73.5048	150.0039	3728	200830-XCTD-026	7022648
Jul	26	21:43:50	74.2468	148.8776	3773	200830-XCTD-027	7022682
Jul	27	3:39:08	74.5778	148.8451	3800	200830-XCTD-028	7022683
Jul	29	0:36:43	75.1355	151.6793	3830	200830-XCTD-029	7022684
Jul	29	2:10:36	75.2120	152.4928	3738	200830-XCTD-030	7022687
Jul	29	8:41:42	75.3719	153.9542	3847	200830-XCTD-031	7022690
Jul	29	10:04:10	75.4434	154.5740	3838	200830-XCTD-032	7022686
Jul	29	15:01:47	75.6250	155.8833	2883	200830-XCTD-033	7022689
Jul	29	15:24:48	75.6306	155.9695	2470	200830-XCTD-034	7022685
Jul	29	16:00:26	75.6357	156.1337	2032	200830-XCTD-035	7022693
Jul	29	19:51:11	75.7091	156.7495	1110	200830-XCTD-036	7022688
Jul	29	23:20:41	75.6813	155.9840	2350	200830-XCTD-037	7022692
Jul	29	23:53:18	75.7001	155.6764	3666	200830-XCTD-038	7022691
Jul	30	0:19:50	75.7167	155.3558	3842	200830-XCTD-039	8048177
Jul	30	1:16:42	75.7495	154.6665	3837	200830-XCTD-040	8048178
Jul	30	2:13:25	75.7929	154.0176	3836	200830-XCTD-041	8048179
Jul	30	3:08:50	75.8267	153.3628	3835	200830-XCTD-042	8048182
Jul	30	4:02:24	75.8923	152.7260	3834	200830-XCTD-043	8048181
Jul	30	4:58:41	75.9097	151.9970	3831	200830-XCTD-044	8048180
Jul	30	5:47:01	75.9298	151.3663	3829	200830-XCTD-045	8048183
Jul	30	13:06:27	76.4961	150.0041	3891	200830-XCTD-046	8048184
Jul	30	22:36:27	77.3516	148.3718	3821	200830-XCTD-047	8048185

Jul	31	8:50:00	77.8500	148.3333	3822	Error: no file	8048186
Jul	31	9:13:17	77.8589	148.3409	3821	200830-XCTD-048	8048187
Aug	2	2:46:46	78.0853	151.0605	3830	200830-XCTD-049	8048188
Aug	2	3:58:30	78.1586	151.8285	3834	200830-XCTD-050	8048212
Aug	2	5:06:08	78.2430	152.5220	3650	200830-XCTD-051	8048211
Aug	2	5:41:49	78.2716	152.9375	3314	200830-XCTD-052	8048208
Aug	2	21:40:27	78.3790	153.4157	1804	200830-XCTD-053	8048209
Aug	2	22:20:11	78.4534	153.1929	2786	200830-XCTD-054	8048206
Aug	2	22:39:44	78.4783	152.9574	3494	200830-XCTD-055	8048203
Aug	2	23:30:32	78.6093	152.4614	3823	200830-XCTD-056	8048205
Aug	3	0:39:18	78.7296	151.6963	3822	200830-XCTD-057	8048202
Aug	3	2:06:30	78.8319	151.0469	3830	200830-XCTD-058	8048201
Aug	3	11:46:57	79.5017	149.9952	3820	200830-XCTD-059	8048204
Aug	4	1:36:47	80.3347	150.1995	3806	200830-XCTD-060	8048207
Aug	4	3:56:12	80.6610	149.9916	3800	200830-XCTD-061	8048210
Aug	4	10:39:14	81.1037	149.8032	3793	200830-XCTD-062	8048191
Aug	4	12:22:44	81.2417	150.0294	3794	200830-XCTD-063	8048190
Aug	4	15:02:58	81.5066	149.8220	3473	200830-XCTD-064	8048189
Aug	4	17:26:04	81.7477	149.9514	3388	200830-XCTD-065	8048192
Aug	5	8:25:00	82.2333	149.1000	3085	Error: no file	8048195
Aug	5	8:35:02	82.2475	149.1100	3085	200830-XCTD-066	8048196
Aug	5	11:00:11	82.4903	150.0047	3057	200830-XCTD-067	8048199
Aug	5	12:39:10	82.7467	150.0083	2747	200830-XCTD-068	8048193
Aug	6	1:06:49	82.8556	148.4664	2754	200830-XCTD-069	8048194
Aug	6	3:14:40	82.6947	146.9236	2716	200830-XCTD-070	8048197
Aug	6	5:19:02	82.5539	145.3551	2599	200830-XCTD-072	8048200
Aug	6	7:43:30	82.4170	143.8640	3065	200830-XCTD-072	8048198
Aug	6	10:36:37	82.2026	141.8946	2938	200830-XCTD-073	7012330
Aug	7	0:17:39	81.7507	140.0282	3676	200830-XCTD-074	7012331
Aug	7	2:19:39	81.5024	140.0424	3749	200830-XCTD-075	7012332
Aug	7	4:21:39	81.2505	140.0405	3755	200830-XCTD-076	7012334
Aug	7	11:30:53	80.7501	140.1083	3756	200830-XCTD-077	7012335
Aug	7	13:27:53	80.5035	139.9812	3759	200830-XCTD-078	7012333
Aug	7	15:17:52	80.2557	139.9813	3763	200830-XCTD-079	7012336
Aug	7	23:20:46	79.6661	140.0083	3766	200830-XCTD-080	7012337
Aug	8	2:04:39	79.3495	139.7874	3733	200830-XCTD-081	7012338
Aug	8	12:26:42	78.5109	140.1116	3773	200830-XCTD-082	7012343
Aug	9	4:37:15	77.5969	140.9550	3755	200830-XCTD-083	7012342
Aug	10	9:39:32	76.8492	138.4985	3694	200830-XCTD-084	7012341
Aug	10	12:14:35	76.6852	136.9713	3648	200830-XCTD-085	7012604
Aug	10	22:33:28	76.3153	134.2549	3407	200830-XCTD-086	7012605
Aug	11	16:19:31	76.0482	133.1662	3180	200830-XCTD-087	7012601
Aug	11	19:49:54	76.0220	135.4327	3484	200830-XCTD-088	7012602

Aug	11	22:40:45	76.0238	137.7033	3691	200830-XCTD-089	7012603
Aug	12	21:35:49	75.5102	140.3343	3697	200830-XCTD-090	7012606
Aug	13	4:54:28	74.6609	141.6219	3686	200830-XCTD-091	7012598
Aug	13	12:01:27	74.1547	141.7192	3644	200830-XCTD-092	7012599
Aug	14	21:26:56	73.7447	139.0332	3381	200830-XCTD-093	7012595
Aug	15	3:05:46	73.2324	138.9687	3189	200830-XCTD-094	7012596
Aug	15	9:36:39	72.8693	141.5299	3326	200830-XCTD-095	7012600
Aug	15	11:34:45	72.7368	143.0977	3381	200830-XCTD-096	7012597
Aug	15	13:39:40	72.6001	144.6986	3436	200830-XCTD-097	7022647
Aug	15	20:07:41	72.3578	142.9869	3293	200830-XCTD-098	7022646
Aug	15	22:10:29	72.1151	141.2662	3946	200830-XCTD-099	7022696
Aug	16	2:07:38	71.6638	138.1830	2254	200830-XCTD-100	7021633
Aug	16	4:12:16	71.4208	136.5354	1633	200830-XCTD-101	7022695
Aug	16	7:31:00	71.1247	134.5785	530	200830-XCTD-102	7022643
Aug	19	15:17:25	72.3605	138.0192	2522	200830-XCTD-103	7022644
Aug	19	17:48:41	72.7067	136.0311	2653	200830-XCTD-104	7022645
Aug	19	23:59:04	72.0748	132.9762	1741	200830-XCTD-105	7022698

Table 5. Vertical Net Tows

Starting Net Sample	Station	Time (UTC)	Cast Type	Lat (N)	Lon (W)	Uncor. Bottom Depth (m)	Net Cast Depth (m)
1	AG5	2008/07/21 05:55	NETS x 2	70.5507	122.9041	378	100
7	CB1	2008/07/22 08:19	NETS x 2	71.8275	131.7597	1100	100
13	MK6	2008/07/23 07:07	NETS x 2	71.5858	140.0090	2447	100
19	MK5	2008/07/23 11:11	NETS x 2	71.0013	140.0000	2062	100
26	MK3	2008/07/23 19:10	NETS x 2	70.5740	140.0030	785	100
33	MK-1	2008/07/23 22:43	NETS x 2	70.2296	140.0022	230	100
38	STA-A	2008/07/24 14:44	NETS x 2	72.6875	144.6905	3410	100
45	BL-8	2008/07/25 07:09	NETS x 2	71.9648	150.2266	2980	100
52	BL-4	2008/07/25 13:56	NETS x 2	71.5012	151.6575	1007	100
57	BL2	2008/07/25 17:01	NETS x 2	71.3956	152.0369	149	100
64	CB2	2008/07/26 09:46	NETS x 2	73.0000	150.0002	3680	100
67	CB3	2008/07/26 17:02	NETS	73.9997	150.0044	3749	300
70	CB3	2008/07/26 17:02	NETS	73.9997	150.0044	3749	100
73	CB4	2008/07/27 21:44	NETS x 4	74.9853	149.9787	3819	100
85	CB4	2008/07/28 16:00	NETS	75.0215	149.9012	3817	1000
89	CB4	2008/07/28 16:00	NETS	75.0215	149.9012	3817	500
92	RS6	2008/07/29 11:19	NETS x 2	75.5132	155.2689	3840	100
97	RS1	2008/07/29 18:08	NETS x 2	75.7432	157.0933	1000	100
105	RS2	2008/07/29 21:18	NETS x 2	75.6604	156.2594	1593	100
111	CB7	2008/07/30 08:10	NETS x 2	75.9965	149.9770	3825	100

116	CB8	2008/07/30 16:18		76.9978	150.0429	3826	100
121	CB9	2008/08/01 00:52	NETS	78.0029	150.1752	3818	500
124	CB9	2008/08/01 00:52	NETS x 2	78.0029	150.1752	3818	100
127	CB9	2008/08/01 10:05	NETS	77.9822	150.2811	3818	50
130	CB9	2008/08/01 10:05	NETS	77.9822	150.2811	3818	1000
136	CB10a	2008/08/02 16:36	NETS	78.2923	154.0999	940	100
139	CB11b	2008/08/03 16:49	NETS	80.0210	149.7890	3817	100
142	NW2	2008/08/05 04:07	NETS	82.0047	149.9623	3169	100
145	NW3	2008/08/05 15:33	NETS X 2	83.0298	149.9916	2918	100
157	NE1	2008/08/07 17:29	NETS X 2	80.0290	140.0672	3758	100
164	CB16	2008/08/08 19:57	NETS X 2	78.0124	139.9055	3744	100
170	CB15	2008/08/09 22:00	NETS X 2	76.9927	139.9527	3722	100
175	PP7	2008/08/10 14:44	NETS x 2	76.5460	135.4393	3566	100
181	PP6	2008/08/11 02:45	NETS x 2	76.2659	132.5303	3059	100
187	CB18	2008/08/13 00:09	NETS x 2	75.0004	140.0002	3620	100
193	CB19	2008/08/13 07:34	NETS	74.2993	143.3061	3693	100
196	CB21	2008/08/13 19:15	NETS x 3	74.0013	139.9140	3503	100
205	CB21	2008/08/14 03:49	NETS	74.0324	140.0025	3519	1000
208	CB22	2008/08/14 23:11	NETS	73.4500	137.9998	3127	100
211	CB27	2008/08/15 05:13	NETS	73.0006	139.9980	3221	100
214	CB29	2008/08/19 11:32	NETS	72.0002	139.9975	2691	100
217	CB31b	2008/08/19 20:45	NETS	72.3646	133.9622	2092	100
220	CABOS	2008/08/20 03:22	NETS	71.7877	131.8975	1141	100

Table 6. Large Volume Pump Casts

location ID	cast #	pump #	filter type (142mm)	pump depth (m)	actual pumping time (s)	com-puter volume (L)	meter vol (L)	notes
A (CB-4)	1	9	GFF	3805	2	-0.11	0.0	pump no start
	1	3	versapore	3785	159	13	14.0	low bat shutdown, poss loss of material (water in pump head when removed)
	1	11	GFF	3750	9001	879.6	912.3	
	1	2	versapore	3730	9001	771.8	798.0	poss loss of material (water in pump head when removed)
	1	12	GFF	3500	9001	879.6	931.2	

	1	4	versapore	3480	1924	187.8	192.0	sudden flow obstr, poss loss of material (water in pump head when removed)
	1	10	GFF	3000	9001	879.6	870.6	
	1	1	versapore	2980	45	3.64	12.0	low bat shutdown, poss loss of material (water in pump head when removed)
A (CB-4)	2	9	GFF	3750	82	6.25	9.5	min flow reached
	2	10	GFF	3000	9001	879.6	900.9	
	2	11	GFF	2500	9001	879.6	923.6	
	2	12	GFF	2000	9001	879.6	950.1	
	2	1	GFF	1500	9001	879.6	1066.0	no filter
	2	2	GFF	1000	9001	860.5	901.0	
	2	3	GFF	150	9001	803.5	828.0	
	2	4	GFF	50	2516	222.46	207.0	min flow reached
B (CB-9)	3	12	GFF	3000	9001	879.6	938.8	
	3	4	versapore	2980	172	12.69	13.0	min flow reached (lots of water on filter, even after pumping dry after recovery)
	3	11	GFF	1000	9001	879.6	917.2	
	3	3	versapore	980	8706	721.1	720.6	min flow reached (lots of water on filter, even after pumping dry after recovery)
	3	10	GFF	500	9001	879.6	905.5	
	3	2	versapore	480	7833	674.24	690.0	min flow reached (lots of water on filter, even after pumping dry after recovery)
	3	9	GFF	150	428	41.7	45.8	sudden pressure release

	3	1	GFF	50	2120	183.16	188.1	min flow reached, filter collected yellowish material (K Brown has picture)
D (CB-21)	4	10	GFF	3000	82	6.71	8.7	min flow reached
	4	1	versapore	2980	9001	829.55	880.4	
	4	9	GFF	2000	82	6.25	13.2	min flow reached, pump 9 tested ok prior to this deployment
	4	11	GFF	1000	9001	879.6	919.5	
	4	2	versapore	980	9001	822.38	861.8	
	4	12	GFF	500	2177	212.58	232.4	sudden pressure release
	4	3	versapore	480	9001	771.07	802.4	
	4	4	GFF	50	5060	432.75	395.3	low battery
D (CB-21)	5	11	GFF	750	7201	703.66	745.0	
	5	12	versapore	730	444	43.19	49.2	sudden pressure release
	5	10	GFF	150	191	17.36	18.9	min flow reached
	5	4	versapore	130	58	5.27	6.8	sudden flow obstruction
	5	3	GFF	63	452	37.46	43.7	chl max, low battery
	5	1	versapore	50	680	56.07	58.1	min flow reached