2005 Joint Western Arctic Circulation Study and Beaufort Gyre Observing System

Cruise Report

Beaufort Sea and Canada Basin
CCGS Louis S. St-Laurent
29 July – 1 September, 2005

Institute of Ocean Sciences Cruise 2005-04

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1. Cruise Summary

The research cruise aboard the *CCGS Louis S St-Laurent*, July 29th to September 1st 2005, studied the circulation and chemistry of the Beaufort Sea and Canada Basin. A group of 18 scientists conducted rosette, mooring, buoy, XCTD and net tow operations. The data will be used to address our standing questions on freshwater storage in the Beaufort Gyre, water mass circulation, inter-annual variability of water properties, and distribution and concentration of bacteria and plankton. This year we had the additional focus of measuring the Atlantic Water intrusions using three supplemental water chemistry tracers ChloroFluoroCarbons (CFCs), Cesium-137 and Iodine-129.

This cruise marked the fourth year of international collaboration under the Joint Western Arctic Circulation Study between the Institute of Ocean Sciences (IOS) and the Japan Marine Sciences and Technology Center (JAMSTEC). This is the third year the Woods Hole Oceanographic Institution (WHOI) has been a leading participant in the project, first with the Beaufort Gyre Freshwater Experiment and now with the Beaufort Gyre Observation System. The principle investigators from these institutions are Fiona McLaughlin and Eddy Carmack (IOS), Andrey Proshutinsky (WHOI) and Koji Shimada (JAMSTEC).

The science program went well. Of the four recovered moorings, the three WHOI moorings preformed flawlessly, completing their year long profiles between 50 and 2000m as scheduled. The fourth, the CABOS mooring, profiled as expected but unfortunately the CTD inside the profiler failed a month after deployment. These four moorings were redeployed along with two more, one on the Beaufort Shelfbreak and the other in the southeast corner of the Canada Basin. The CTD/rosette system worked well with its new altimeter except we did have trouble with the oxygen probe, the transmissometer, and communication with the water sampler. It is hoped that the oxygen sensor's data can be calibrated to the bottle data although the drift over time was substantial. The transmissometer worked well after it was repositioned from a vertical to a horizontal orientation. The intermittent communication problems with the water sampler required multiple commands to close bottles and occasionally a confirmation was returned even when a bottle had not closed. The XCTDs had a good success rate. Only one site required a second probe due to the wire getting caught in the ice. On board, chemistry analysis was performed for salinity, oxygen, nutrients, alkalinity, CFC, chlorophyll-a and ammonium. The pre-cruise repairs to the salinity system and the new colorimeter for the oxygen system were key to achieving good results. The CFC equipment required repair and maintenance at sea but the system provided quality data for F11 and F12 throughout. Ammonium was sampled at only a few stations, with the main purpose of developing a methodology. Complimenting the data sets of the last two years, this cruise has provided an additional year of high resolution, full ocean-depth data over the Canada Basin.

Figure 1. Following the Oden's track.

Ice and weather conditions were similar to the previous year but with heavier ice in the northeast section of our study area. The thick ice slowed our speed and required the use of more fuel. As last year, we also encountered heavy ice from Resolute to Cambridge Bay through Larsen Sound. This year we were fortunate to have an open track to follow made by the week prior by the research ship Oden. We saved approximately 120 m^3 of fuel (based on the previous year) by following the track. The support from the Canadian Ice Service was very helpful. Radarsat imagery was important during the cruise for scheduling the work, choosing our routes to make the best use of time and helping to identify areas of thick ice needed for the ice-drift buoys. Two ice-survey flights from shore were conducted which provided information on ice conditions and ground-truthing radarsat imagery. The second flight was particularly useful as the ship's helicopter was not operational after August 18th. While operational the helicopter provided valuable ice reconnaissance for an ice-buoy site and assistance in slinging gear to the site. In general, the weather consisted of fog and rain while we were southern Canada Basin with colder temperatures, and less fog further north. Besides slower progress through the fog, the weather was not an issue for the cruise.

A major loss of time to the project (6 days out of the 35 day project) occurred due to engine difficulties in the remote northeast corner of the Canada Basin. Thanks to the dedicated engine department, the massive repair effort was undertaken and completed as quickly as possible, allowing us time to complete our highest priority tasks. Fast turnaround time by the mooring group, long hours from the deck department and faster though less efficient ship speed allowed us to save time for the remaining work. Four rosette casts were not completed due to the delay and two casts shortened to save time, but all of the mooring work and our key rosette stations were accomplished. The helicopter experienced engine trouble as well, taking it out of service the same day the ship's engine went down. This loss prevented us from deploying the ice-buoy in a preferred location - instead the buoy was deployed in the closest acceptable spot to the ship while waiting for the ship's engine repair. The helicopter was also missed for ice reconnaissance for route-finding through the ice.

The *CCGS Louis S St-Laurent* continues to be a great platform for our work. The support from the Captains and crews was much appreciated during the refit period in Dartmouth, the busy days of set up and throughout the long science days of the cruise. The ship invested a good deal of effort to assist the program at sea, to address our suggestions from last year and has shown a continued interest in discussing improvements for next year. The CCGS Louis S St-Laurent is an excellent choice for Arctic science with its icebreaking capability, lab facilities, comfortable living quarters and helpful, accomplished crew.

2. Objectives

Freshwater Storage in the Beaufort Gyre

The inter-annual variability of accumulation and release of fresh water in Beaufort Gyre are under investigation. A broad-scale pattern of wind-forcing over the Arctic is thought to force the accumulation and release of fresh water contained in the upper 250m. Multi-year data from moorings and CTDs will help show where the freshwater is stored, its volume and its connection to the atmosphere.

Water-Mass Circulation, Inter-Annual Variability and Climate Change

The relatively fresh water from the Pacific and warmer water from the Atlantic typically flow in bathymetrically steered currents cyclonically around the Arctic. These pathways as well as the mechanism that bring the Pacific and Atlantic Waters into the basin interior, such as eddies and thermohaline intrusions are being examined. CTD/Rosette casts with a Lowered Acoustic Doppler Profiler (LADCP), XCTDs, and moorings are used to provide a picture of the water mass properties and current speeds. The program's spatial coverage of the Canada Basin allows for inter-annual comparisons with historical data from the southern region and adds new data to the poorly sampled central and northern basin, ice-covered areas not well studied due to their inaccessibility.

Distribution and Concentration of the Zooplankton, Phytoplankton and Bacteria

The constituents of the lower food chain are being studied by assessing species distribution and concentration over the basin. How ocean circulation, ice cover, and

water properties contribute to the distribution and concentration will be examined. Net tows and water from the rosette will be used for this study building a time-series of tows from the same location each year.

3. Activities

Location and times of events are listed below, in section 10.

Transit from Halifax to Resolute

- 30 XCTDs (31 probes) deployed in Baffin Bay

Transit in Canadian Archipelago (Resolute to Amundsen Gulf, 1571km)

- 5 Rosettes in NorthWest Passage (Resolute to Amundsen Gulf) sampling salinity, nutrients and bacteria.

Canada Basin (4936 km)

- 40 Rosettes casts and 5 CTD-only casts

  CTD: The CTD was equipped with 2 temperature sensors, 2 conductivity sensors, SBE43 oxygen probe, transmissometer, fluorometer, bottom contact warning and an altimeter.

  Rosette: The suite of water chemistry samples regularly sampled from 10-L Niskin bottles were Salinity, Oxygen, Nitrate, Silicate, Phosphate, Freon (11, 12, 113 and carbon-tetrachloride), Chlorophyll-a (filtered at 0.7µm) and Phaeopigment, Alkalinity, Oxygen-18 isotope, Barium, and Bacteria. On selected casts we sampled Cesium-137, Iodine-129, Colored Dissolved Organic Matter, Total Organic Carbon, Dissolved Inorganic Carbon, Carbon-13 isotope and Ammonium.

  LADCP: Current measurements were made with each CTD cast using a downward looking lowered acoustic doppler current meter (LADCP).
- 53 XCTDs
- 6 Moorings
  - 3 WHOI moorings serviced (Bottom depths 3824, 3821 and 3722m)
  - 2 new WHOI moorings deployed (Bottom depths 149 and 3515m)
  - 1 CABOS mooring serviced (Bottom depth 1121m)
- 2 Ice Tethered Profiler (ITP) and Ice Mass Balance Buoy (IMBB) pairs deployed and a search for a set deployed last year
- 10 Vertical Net Tows at 4 stations to 100m using mesh sizes 50, 150 and 236 µm.

Other

- Ship stopped for engine shaft repair from 18th August 5pm to 24th August 9pm
- Retirement Party for Doug Sieberg, our Chief Science Technician

- Total distance from Resolute back to the Resolute area (10 September) was 8210km.

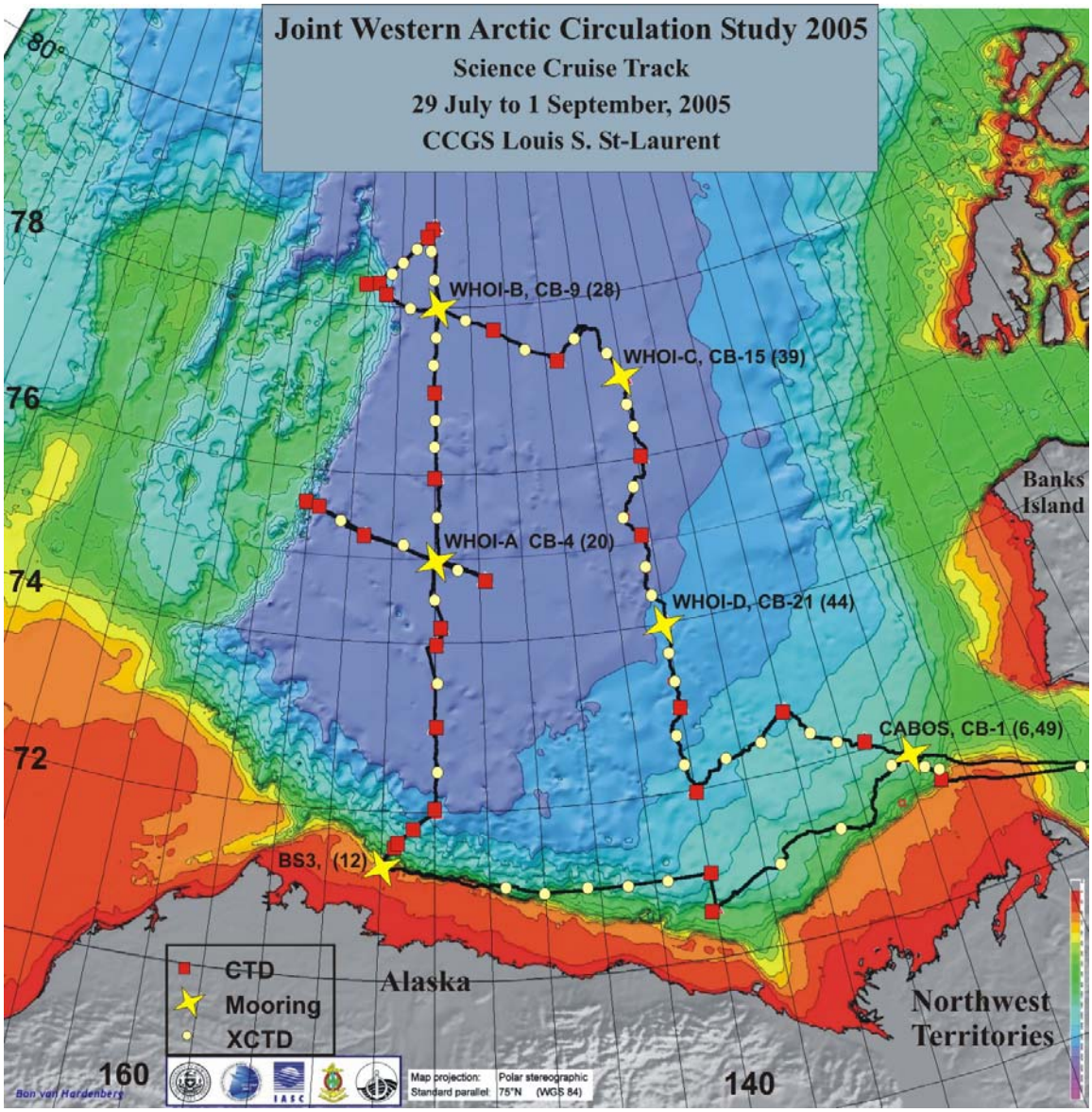

Figure 2. Cruise track with CTD and Moorings shown. Locations are in the appendices. Boxes denote CTD/Rosette stations, circles show XCTD deployments and stars show mooring locations. Labels show mooring name, station name and cast number.

4. Methods

The cruise followed last year's track, retracing the four lines that criss-cross the Canada Basin. The route is predefined by the moorings already in place. The intent is to repeat this track in successive years building a 6 year time-series for these transects.

4.1 Moorings

Mooring operations were performed from the ship's foredeck using the starboard A-frame and WHOI provided LEBUS winch. Typical recovery procedure was to confirm the mooring's location at the mooring site, determine the ship's drift, open an ice free area and recover the mooring. A rosette cast performed at the site would help for calibration of the mooring's CTD. The set up for the mooring operation typically began in the morning with the actual release/deployment starting late morning. Three or more survey positions were obtained to pinpoint the mooring's location. WHOI installed a GPS antenna on the corner of the foredeck lab container and used these positions with the range obtained from their over-the-side tranducer. The ship then broke ice for 1 to 2 hours over the mooring region, taking into account the predicted ice drift. After creating an ice free area over the given location the bridge would signal the deck team to release the mooring. The top float, only 50m below the surface, would appear within 30 seconds of being released. The float was hooked using the foredeck crane, brought on board and the line brought through the A-frame for recovery.

Figure 3. CTD and current meter on the McLane Moored Profiler (MMP)

Deployment procedures began with a confirmation of the bottom depth or in the case of deploying in a new region, performing a short bottom survey. Ice was broken in the region and the mooring deployed, anchor first, from the starboard A-frame. It was useful to have a large enough area of broken ice so the bubbler system could be used to keep the deployment area ice free until the operation was finished. Following the deployment the mooring would be ranged on to confirm it final position.

WHOI moorings A, B and C and the University of Alaska Fairbanks CABOS mooring were deployed in August 2004, each carrying a profiling CTD and current meter (McLane Moored Profiler, MMP). These moorings were recovered, serviced, and redeployed. Servicing included replacing the CTDs and batteries. Two new moorings were deployed this year. WHOI–D, the same configuration as WHOI-A, B, C, was deployed in deep water, completing the 'box' pattern over the Canada Basin. WHOI's BS-3 was deployed on the Beaufort shelf-break in 150m of water to measure the shallow boundary current of Pacific water. BS3 had a profiling CTD but no current meter. All mooring operations were performed in the presence of ice. **See WHOI and CABOS mooring reports for more operation details**

Figure 4. Profiling CTD on BS3 mooring.

4.2 Ice Buoys

Two sets of bouys were deployed this year, in the northwest and northeast corners of our cruise track. It is hoped the northwest set will stay fairly stationary in the center of the sea-ice gyre while the northeast set will drift southwest through the Canada Basin. The sets consist of an Ice Tethered Profiler (ITP) and an Ice Mass Balance Buoy (IMBB).

Figure 5. Looking for a suitable ice-buoy location.

The ITP is a CTD, set up to profile between 5 and 800m. The IMBB measures ice thickness and temperature, and surface air temperature, pressure and snow accumulation. Both relay data daily to satellite. The first set were deployed 400m from the ship, with equipment and workers flown to the ice by helicopter. The gear was brought back by workboat. The two buoys were anchored into approximately 4m thick ice and by the following day we heard from the shore-based labs that both buoys were successfully transmitting data via satellite to shore. The second set was also deployed about 400m from the ship. The equipment was brought by sled to the site. The operation was temporarily stopped during the hole drilling due to ice leads developing nearby. The operation was completed the next day with confirmation the instruments were working the day after. **See WHOI mooring report for more operation details.**

4.3 Rosette/CTD Casts

Figure 6. Rosette deployment.

Rosette casts were taken with a Seabird SBE911+ CTD, equipped with dual temperature sensors, dual conductivity sensors, SBE43 oxygen probe, transmissometer, pumped fluorometer, bottom contact warning device and an altimeter. In addition, an RDI lowered acoustic doppler profiler (LADCP) was mounted on the frame to measure ocean current. The rosette water sampler, SBE32, was configured with 24 10-liter Niskin bottles to take chemistry samples: Salinity, Dissolved Oxygen, Nitrate (NO3), Silicate (SiO4), Phosphate (PO4), Freon (11, 12, 113 and carbon-tetrachloride), Chlorophyll-a (filtered at 0.7 um with chlorophyll-a and phaeopigment values for each), Alkalinity, Oxygen-18 isotope (O18), Barium, and Bacteria. On selected casts we sampled Cesium-137, Iodine-129, Cored Dissolved Organic Matter (CDOM), Total

Organic Carbon (TOC), Dissolved Inorganic Carbon (DIC), Carbon-13 isotope (C-13) and Ammonium.

The CTD was powered on while still on the deck. The rosette package was lowered to 10m, the sensor pumps turned on and the package soaked for 3 minutes to equilibrate the oxygen sensor. The package was then raised to just below the surface and then lowered at 60m/minute to within 15m of the ocean floor. After closing the first bottle at the bottom of the cast, the package was raised at 60m/minute then slowed to 30m/minute for the upper 400m. Bottles were closed on the upcast without changing the ascent speed with the thought that this will capture water with a uniform vertical offset (approximately 1 m) instead of stopping the package for bottle closures which can result in variable 0 to 5m offsets, depending on the flow dynamics around the bottles. The bottle flushing around a stopped package is thought to be dependant on the ship rock and relative drift, which are both less favorable for bottle flushing when a ship is in ice.

Figure 7. Neil Jollymore operates the CTD winch.

Figure 8. Nes Sutherland with the CFC sampling apparatus.

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.

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 temporal changes first.

Dissolved Oxygen, Nutrients, Salinity, Chlorophyll-a and Phaeopigments, Freons, Alkalinity, and Ammonium were measured in laboratories on board. All other samples were prepared and stored for analysis on shore. Real-time analysis was critical for oxygen and ammonium and important for the others due to the higher accuracy achieved from the methods used with fresh samples. Analysis at sea also allows time to respond to problems with equipment or sampling methods that may only be noticed after looking at results.

4.4 XCTD

XCTD (eXpendable Conductivity Temperature Depth) probes provided quick water profiles between more time intensive CTD casts. The probes were provided by JAMSTEC (Type XCTD-1 made by Tsurumi Seiki) and WHOI (Type XCTD-3). The probes were deployed from the stern of the ship, falling freely through the water and measuring temperature and conductivity every 0.15 m from the surface to 1100 m. Data were transmitted to the ship during the freefall by a thin conducting wire extending from the XCTD to an onboard computer. To prevent sea ice from cutting the wire of the XCTD, the ship slowed to 12 knots for the deployment in open water areas and completely stopped in heavy ice areas.

Figure 9. Masuo Hosono launches an XCTD. (Photo curtesy Chris Linder)

It took 5 minutes for the XCTD to descend from the surface to 1100m. In Baffin Bay, during the ship's transit north, 31 probes were deployed at 30 sites. In the Canada Basin, 53 casts were conducted. Locations are listed in the appendix. Accuracy of the XCTDs are ±0.02 degrees in temperature, ±0.03 mS/cm in conductivity (approximately ±0.04psu in salinity) and ±5-20 m in depth. The salinity accuracy of XCTDs are initially poor but are improved to ±0.01psu by calibration to the cruise's CTD (Conductivity Temperature Depth) data.

4.5 Vertical Net Tows

Zooplankton sampling was performed using a modified Bongo net system. Two large bongo hoops were fitted with coarse mesh nets of 150µm and 236µm. A second set of smaller hoops were fitted perpendicular to the large hoops. These smaller hoops were fitted with finer 53µm mesh nets. The four nets were fitted with unidirectional flowmeters which measure the amount of water flowing through the hoops. Between cast the nets were stored on the foredeck in a box, built by the ship specifically to accommodate the bongo net. The vertical net tows were all to 100m.

Figure 10. Zooplankton nets.

Two casts to 100m were performed per station to collect enough samples for identification, DNA analysis and biomass measurements. The samples from the first cast were preserved in formalin with the 53µm samples combined to form one sample. From the second cast, the samples from the 236µm and combined 53µm nets were preserved in 100% ethanol, and the 150µm sample was washed with 4% ammonium formate and dried at 50^{o}C for 24 hours. 10 casts were performed at 4 stations. Locations are listed in the appendix.

4.6 LADCP (Waldemar Walczowski)

During the 2005_04 cruise of CCGS Louis S. St- Laurent, measurements by means of a Lowered Acoustic Doppler Current Profiler (LADCP) were performed. Measurements were conducted together with the CTD casts. The self recording RDI, 307.2 kHz device nr 3313 were attached to the rosette frame. The down-looking LADCP measured currents in 20 depth cells, each cell 10 m thick. In vicinity of the bottom, bottom track were used. Vertical speed rate of the rosette was always less than 1 m s^{-1}. LADCP data were read directly after profiling. CTD records from Seabird 9/11 device were used to determine the ship position (from NMEA protocol registered every scan) and LADCP depth (from CTD pressure and time records). LADCP data were processed using LDEO software. In the period of 04.08.2005- 30.08.2005, 42 LADCP casts were performed. **See LADCP report for more operation details and preliminary results.**

5. Personnel

The research team includes both shore and ship components. The principle investigators of this project are Eddy Carmack, Fiona McLaughlin, Andrey Proshutinsky and Koji Shimada.

Table 1. Science Personnel on Board

	Name	Affiliation	Responsibility
1	Sarah Zimmermann	IOS	Chief Scientist
2	Doug Sieberg	IOS	Chief Technician
3	Hugh Maclean	IOS	CTD watch leader
4	Jane Eert	IOS	CTD watchstander/ Data manager
5	Mary Steel	IOS	Oxygen Analysis
6	Linda White	IOS	Nutrient Analysis
7	Nes Sutherland	IOS	CFC Analysis
8	Wendy Richardson	IOS	CFC Analysis
9	Jeffrey Carpenter	IOS	CTD Watchstander/ Chlorophyll Analysis
10	Ryan North	IOS	CTD Watchstander/ Ammonium Analysis
11	William Burt	IOS	CTD Watchstander/ Bacteria Collection
12	Masuo Hosono	JAMSTEC	CTD Watchstander/ XCTD Technician
13	Michiyo Kawai	IOS	Alkalinity Analysis

14	Waldemar Walczowski	IOP	CTD Watchstander/ LADCP Analysis
15	Rick Krishfield	WHOI	WHOI Mooring Operations
16	John Kemp	WHOI	WHOI Mooring Operations
17	Kris Newhall	WHOI	WHOI Mooring Operations
18	Chris Linder	WHOI	Outreach

Table 2. Investigators on Shore

	Name	Affiliation	Program
1	Fiona McLaughlin	IOS	CTD and chemistry
2	Eddy Carmack	IOS	CTD and chemistry
3	Andrey Proshutinsky	WHOI	WHOI moorings
4	Koji Shimada	JAMSTEC	XCTD
5	Chris Guay	OSU	Barium samples
6	C.S. Wong	IOS	DIC, C13 samples
7	Bill Li	BIO	Bacteria samples
8	Celine Guegen	UBC	CDOM samples
9	John Smith	BIO	Cs-137 and I-129 samples
9	Russ Hopcroft	UAF	Zooplankton net tows
10	John Nelson	UVic/DFO	Zooplankton net tows
11	Igor Polyakov	IARC	CABOS mooring
12	Rob Chadwell	IARC	CABOS mooring technician
13	Robert Pickart	WHOI	BS-3 mooring

Affiliation Abbreviation

BIO	Bedford Institute of Oceanography, NS
DFO	Department of Fisheries and Oceans, Canada
IARC	International Arctic Research Center, Alaska
IOPAN	Institute of Oceanology Polish Academy of Sciences, Poland
IOS	Institute of Ocean Sciences, BC
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
UAF	University of Alaska Fairbanks, Alaska
UBC	Univerisity of British Columbia, BC
UVic	University of Victoria, BC
WHOI	Woods Hole Oceanographic Institution, Massachusetts

6. Goals Not Completed

JAMSTEC Stations and mooring in the western Beaufort Sea.

The provisional list of CTD stations at the start of the cruise included a collection in the southwest Beaufort Sea that was removed due to restrictions on time and fuel. During the planning stage, it was understood the timing would be tight, and the work would only be possible if we were making faster than planned progress. Ice conditions were similar to the previous year which meant there was no extra time for these stations. There was also the hesitation to use extra time at the beginning of the cruise that might be needed to complete the higher priority CTD casts and mooring work at the end of the cruise. Unfortunately this turned out to be true so it was to our benefit that these lower priority CTD casts were removed. Fuel consumption was also an issue. The balance between speed and fuel efficiency meant that it was not practical to try for a quick transit to collect these stations.

CTD Casts in the southeastern Canada Basin

The loss of 6 days while the ship's shaft bearings were repaired took a toll on the planned science however the impact was greatly moderated by the quick turnaround of the mooring work, the use of overtime and increased ship speed. All mooring work was completed as well as the key CTD stations. Only four of the planned CTD stations in the southeast Canada Basin were not accomplished and two CTD casts were not full depth to save time. By completing the majority of this work we were able to maintain the time-series and add new sample analysis (CFC, alkalinity, CS-137, I-129) to the 140W line. Again, many thanks to the dedicated engine department for taking on this repair job at sea, giving science the opportunity to complete our work.

7. Acknowledgements

We would like to thank the ship's captains and crew for all the work put into the trip and its preparation. The extra effort to make it a successful and enjoyable trip, from the engine repair to the assistance with river sample collection, was greatly appreciated. In addition we would like to thank: The Canadian Ice Service for their support with the ice and weather information; the CGCS Amundsen for the use of their helicopter during our offloading; and to the CGCS Sir Wilfred Laurier for accepting a transfer of science equipment and samples to be brought back to Victoria, BC.

8. Lists of Operations, Positions and Times

Table 3. Mooring Locations

Mooring Designation	Investigator	Water Depth (m)	Recovery Time	Recovery Location	Deployment Time	Deployment Location
CABOS	IARC I. Polyakov	1112	4-Aug-05 14:46 UTC	71° 46.506'N 131° 52.711'W	30-Aug-05 21:12 UTC	71° 49.676'N 131° 45.663'W
BS-3	WHOI R. Pickart	149	Na	na	6-Aug-05 22:12 UTC	71° 23.732'N 152° 02.175'W
BGOS-A	WHOI A. Proshutinsky	3825	9-Aug-05 18:40 UTC	75° 00.251' N 149° 58.108'W	12-Aug-05 20:05 UTC	75° 00.304' N 149° 53.413'W
BGOS-B	WHOI A. Proshutinsky	3821	14-Aug-05 15:08 UTC	78° 01.084'N 149° 52.459'W	17-Aug-05 19:25 UTC	77° 59.585'N 149° 57.866'W
BGOS-C	WHOI A. Proshutinsky	3722	26-Aug-05 00:01 UTC	76° 59.452'N 139° 58.307'W	26-Aug-05 20:50 UTC	76° 58.251'N 139° 59.539'W
BGOS-D	WHOI A. Proshutinsky	3510	Na	na	28-Aug-05 21:10 UTC	74° 00.146'N 139° 58.985'W
ITP1 & IMB 07949	WHOI A. Proshutinsky	3830	Na	na	15-Aug-05 22:00 UTC	78° 51.1'N 150° 15.9'W

ITP3 & IMB 07950	WHOI A. Proshutinsky		Na	na	23-Aug-05 18:00 UTC	77° 36.1'N 142° 11.8'W

Table 4. Rosette Casts

Cast	Station	Latitude (N)	Longitude (E)	Date (UTC)	Time (UTC)	Water Depth (m)	Max CTD Depth (m)	Sample Numbers	Comment
1	1	74.2647	-95.3890	29-Jul-05	16:19	205	200	1-8	Northwest Passage
2	2	68.8733	-101.4435	31-Jul-05	14:14	46	40	9-13	Northwest Passage
3	3	68.7062	-102.7630	31-Jul-05	18:06	105	100	14-18	Northwest Passage
4	4	68.7000	-103.7700	31-Jul-05	21:04	105	100	19-24	Northwest Passage
5	AG5	70.5515	-122.9032	3-Aug-05	12:41	641	638	25-45	Northwest Passage
6	CB-1/ CABOS	71.7688	-131.8172	4-Aug-05	05:47	1098	1093	46-68	
7	CB-1/ CABOS	71.7710	-131.8670	4-Aug-05	10:31	1118	250	69-73	Repeat cast for bottle flushing test
8	CB-1/ CABOS	71.7657	-131.8603	4-Aug-05	11:25	1120	1000	74-91	Repeat cast for bottle flushing test
9	CB-28a	70.5850	-139.9967	5-Aug-05	15:04	866	871	92-112	
10	CB-28b	71.0000	-139.9997	5-Aug-05	17:33	2079	2073	113-136	
11	BS-3a	71.3650	-151.9708	6-Aug-05	20:21	97	90	na	CTD only, no bottles
12	BS-3	71.3977	-151.9948	7-Aug-05	01:37	150	151	137-146	
13	BS-3b	71.5802	-151.5175	7-Aug-05	04:52	>1500	1000	147-166	Repeat cast for Cesium/Iodine samples
14	BS-3b	71.6237	-151.4912	7-Aug-05	10:58	>1500	1513	167-187	
15	BS-3c	71.7958	-150.8415	7-Aug-05	14:44	2462	2456	188-210	
16	BS-3d	72.0035	-150.0002	7-Aug-05	19:18	3115	3108	211-234	
17	CB-2	73.0020	-149.9920	8-Aug-05	08:25	~3670	3564	235-258	
18	CB-3	74.0035	-149.9597	8-Aug-05	21:13	3830	1000	259-278	Repeat cast for Cesium/Iodine samples
19	CB-3	74.1898	-149.7422	9-Aug-05	03:42	3818	3812	279-302	
20	CB-4	74.9793	-149.9347	10-Aug-05	00:43	3830	3820	303-326	
21	CB-5	75.2777	-153.2465	10-Aug-05	10:13	3843	3838	327-337	
22	CB-5a	75.5718	-155.5615	10-Aug-05	17:46	3846	3836	338-361	
23	CB-5b	75.6188	-156.1637	10-Aug-05	23:20	2130	2094	na	CTD only, no bottles
24	CB-6	74.7533	-147.7518	11-Aug-05	19:39	3802	3796	362-385	
25	CB-4	74.9882	-149.8727	12-Aug-05	21:55	3840	850	386-409	Repeat cast for thermohaline intrusion study
26	CB-7	75.9878	-149.9657	13-Aug-05	08:07	3829	3821	410-433	
27	CB-8	76.9888	-150.0138	13-Aug-05	19:22	3830	3800	434-457	
28	CB-9	78.0018	-149.8377	14-Aug-05	07:33	3824	3816	458-481	

29	CB-11	78.9722	-149.9947	15-Aug-05	03:31	3831	800	481-492	Repeat cast for Cesium/Iodine samples
30	CB-11	78.9750	-149.9952	15-Aug-05	04:48	3831	3812	493-516	
31	Ice_floe	78.8655	-150.4713	15-Aug-05	10:10	3830	3810	na	Cast at Ice Buoy deployment; CTD only, no bottles
32	CB-10	78.2875	-153.2477	16-Aug-05	08:52	2450	800	517-528	Repeat cast for Cesium/Iodine samples
33	CB-10	78.2852	-153.2527	16-Aug-05	10:19	2504	2436	529-552	
34	CB-10a	78.2615	-153.9487	16-Aug-05	16:09	946	937	na	CTD only, no bottles
35	CB-10b	78.1778	-152.8525	16-Aug-05	19:21	3123	3095	na	CTD only, no bottles
36	CB-9	77.9822	-150.0460	17-Aug-05	10:23	~3800	1580	553-572	Repeat cast thermohaline intrusion study
37	CB-12	77.7020	-146.7030	18-Aug-05	01:59	3814	3802	573-596	
38	CB-13	77.2982	-143.3703	18-Aug-05	13:19	3782	3776	597-620	
39	CB-15	76.9850	-139.9865	26-Aug-05	07:04	3725	3719	628-651	
40	CB-15	76.9810	-139.9955	26-Aug-05	12:54	3725	800	652-671	Repeat cast for Cesium/Iodine samples
41	CB-15	76.9652	-139.9618	26-Aug-05	21:59	3732	600	672-691	Repeat cast for thermohaline intrusion study
42	CB-17	75.9977	-139.7845	27-Aug-05	11:18	~3700	1004	692-715	Shortened cast to save time
43	CB-18	75.0633	-140.3732	27-Aug-05	21:59	3660	3644	716-739	
44	CB-21	74.0343	-140.0165	28-Aug-05	11:05	3520	3514	740-763	
45	CB-27	73.0067	-139.9983	29-Aug-05	05:15	3234	2000	764-787	Shortened cast to save time
46	CB-29	71.9972	-139.9877	29-Aug-05	15:08	2680	2673	788-811	
47	CB-23a	72.7005	-135.9668	30-Aug-05	03:39	2630	2624	812-835	
48	CB-31a	72.1098	-133.2298	30-Aug-05	13:39	1767	1761	836-859	
49	CB-1/CABOS	71.7558	-131.7378	30-Aug-05	18:10	1061	1055	860-883	
50	CB-1a	71.3938	-130.9020	31-Aug-05	00:11	248	243	884-895	

Table 5. XCTD Casts in Baffin Bay

XCTD Cast	Latitude (N)	Longitude (W)	Date (UTC)	Time (UTC)	Water Depth (m) [Depth with * is from chart]	Max XCTD Depth (m)	Note	Probe s/n	File name
1	64.0038	54.9979	24-Jul-05	04:05	1280			05022376	0507240401
2	64.3406	55.5441	24-Jul-05	06:08	1140	bottom		05022377	0507240605
3	64.6695	56.0708	24-Jul-05	08:00	780	bottom		05022378	0507240755
4	64.9984	56.6014	24-Jul-05	09:45	650	bottom		05022379	0507240942
5	65.3352	57.1384	24-Jul-05	11:30	600	bottom		05022380	0507241126
6	65.6689	57.6720	24-Jul-05	13:20	580	bottom		05022381	0507241314
7	66.0027	58.1984	24-Jul-05	15:43	555	bottom		05022382	0507241538

7	66.0256	58.2360	24-Jul-05	15:50	566	bottom	Repeat cast; both casts good	05022383	0507241548
8	66.3372	58.7322	24-Jul-05	17:31	626	bottom		05022384	0507241725
9	66.6680	59.2732	24-Jul-05	19:25	907	bottom		05022385	0507241919
10	67.0076	59.7911	24-Jul-05	21:53	990	bottom		05022386	0507242152
11	67.3358	60.3316	25-Jul-05	00:05	1000 *			05022387	0507250003
12	67.6675	60.3710	25-Jul-05	01:47	1767 *			05022388	0507250141
13	68.3335	60.3498	25-Jul-05	06:39	1540 *			05022389	0507250639
14	69.0024	60.7204	25-Jul-05	10:27	1700 *			05022390	0507251020
15	69.6684	60.8636	25-Jul-05	13:40	1880 *			05022391	0507251330
16	70.3499	61.1993	25-Jul-05	17:03	1118 *			05022392	0507251658
17	71.0109	61.8643	25-Jul-05	20:01	1920 *			05022393	0507251955
18	71.6818	62.0694	25-Jul-05	22:56	2260 *			05022394	0507252251
19	72.3289	62.5271	26-Jul-05	01:53	625 *			05022395	0507260149
20	72.9966	61.8441	26-Jul-05	04:55	1120 *	bottom		05022396	0507260542
21	74.7168	68.4999	26-Jul-05	19:27	1525 *			05022397	0507261926
22	74.6158	69.9836	26-Jul-05	21:50	1000 *			05022399	0507272146
23	73.8176	70.9999	27-Jul-05	01:29	1250 *	bottom		05022398	0507270122
24	73.8007	71.9969	27-Jul-05	03:00	1095 *	wire cut 1035		05032436	0507270300
25	73.8363	73.0689	27-Jul-05	04:42	865 *	bottom		05032437	0507270436
26	73.9022	73.9971	27-Jul-05	06:05	833 *	bottom		05032438	0507270558
27	74.0040	75.0726	27-Jul-05	07:22	806 *	bottom		05032439	0507270715
28	74.0849	80.0133	27-Jul-05	13:15	803 *	wire cut 607		05032440	0507271303
29	74.2015	84.9995	27-Jul-05	19:15	534 *	bottom		05032441	0507271913
30	74.3331	90.0055	28-Jul-05	00:57	284	bottom		05032442	0507280051

Table 6. XCTD Casts in the Canada Basin

XCTD Cast	Latitude (N)	Longitude (W)	Date(UTC)	TIME (UTC)	Water Depth (m) Depth with * is from chart	Max XCTD Depth (m)	Probe Type (XCTD-1 or XCTD-3)	File name
1	71.7005	132.5667	4-Aug-05	17:33	1200	1100	3	0508041724
2	71.1846	134.9633	5-Aug-05	03:08	750	bottom	1	0508050305
3	70.9430	137.3866	5-Aug-05	08:38	1450	1100	1	0508050838
4	70.9996	141.4992	5-Aug-05	21:06	2526*	1100	1	0508052101
5	71.0002	142.9968	5-Aug-05	23:31	1400*	1100	1	0508052325
6	70.9983	144.4999	6-Aug-05	01:47	600*	bottom	1	0508060146
7	70.9983	146.0329	6-Aug-05	04:19	1400*	1100	3	0508060414
8	71.1109	147.4928	6-Aug-05	06:56	1050	1100	3	0508060653
9	72.4806	149.8959	8-Aug-05	02:39	3600*	1100	3	0508080238
10	73.4987	150.0078	8-Aug-05	14:40	3800*	1100	3	0508081438
11	74.4993	150.0020	9-Aug-05	08:50	3800*	1100	3	0508090849

12	75.1452	151.5512	10-Aug-05	06:47	3800*	wire cut 1020	3	0508100647
13	75.4499	154.4839	11-Aug-05	04:31	3800*	1100	3	0508110428
14	74.8810	148.9973	12-Aug-05	09:13	3800*	1100	3	0508120913
15	75.4892	149.8986	13-Aug-05	03:04	3800*	1100	3	0508130255
16	76.3315	149.9918	13-Aug-05	13:29	3800*	1100	3	0508131330
17	76.6627	149.9740	13-Aug-05	16:23	3800*	1100	3	0508131624
18	77.3285	150.0328	14-Aug-05	00:40	3800*	1100	3	0508140038
19	77.6408	150.0573	14-Aug-05	03:42	3800*	1100	3	0508140341
20	78.3237	150.0135	14-Aug-05	21:36	3800*	1100	3	0508141234
21	78.6488	150.1135	15-Aug-05	00:58	3800*	1100	3	0508150055
22	78.7108	151.1083	16-Aug-05	02:17	3500*	1100	3	0508160214
23	78.5699	151.7807	16-Aug-05	04:48	3835	1100	3	0508160444
24	78.4211	152.6110	16-Aug-05	06:58	3840	1100	3	0508160658
25	77.9842	151.4705	17-Aug-05	00:31	3840	1100	3	0508170024
26	77.8563	148.3788	17-Aug-05	22:30	3800*	1100	3	0508172230
27	77.4613	145.0493	18-Aug-05	09:13	3800*	1100	3	0508180913
28	77.5228	142.1789	18-Aug-05	20:20	3700*	1100	3	0508182019
29	77.9735	141.5782	19-Aug-05	20:59	3700*	1100	3	0508192102
30	77.2933	140.6195	25-Aug-05	15:40	3700*	1100	1	0508251537
31	76.6651	140.0708	27-Aug-05	03:19	3500*	1100	1	0508270317
32	76.3713	139.8372	27-Aug-05	06:50	3500*	1100	1	0508270647
33	75.6632	140.4230	27-Aug-05	16:12	3500*	wire cut 1043	1	0508271610
34	75.3342	141.0020	27-Aug-05	19:04	3500*	1100	1	0508271901
35	74.6724	140.4287	28-Aug-05	05:04	3600*	1100	1	0508280503
36	74.3403	140.3605	28-Aug-05	07:57	3500*	1100	1	0508280756
37	73.6656	140.0901	28-Aug-05	23:53	3400*	1100	1	0508282351
38	73.3151	140.1932	29-Aug-05	02:30	3300*	wire cut 755	1	0508290230
39	73.3140	140.1941	29-Aug-05	02:37	3300*	1100	1	0508290237
40	72.6638	140.3997	29-Aug-05	09:30	2900*	1100	1	0508290927
41	72.3337	140.1768	29-Aug-05	11:51	2700*	1100	1	0508291150
42	72.3084	138.6368	29-Aug-05	20:14	2700*	1100	3	0508292012
43	72.4264	137.1248	29-Aug-05	23:15	2500*	1100	3	0508292314
44	72.3647	135.1958	30-Aug-05	09:01	2250*	1100	3	0508300901
45	72.1955	134.2690	30-Aug-05	11:19	2000*	1100	3	0508301118
46	71.2668	132.5862	30-Aug-05	16:12	1200*	1100	3	0508301611
47	71.5878	131.3183	30-Aug-05	22:33	727	bottom	3	0508302235
48	71.5027	130.9598	30-Aug-05	23:33	441	bottom	3	0508302332
49	71.3471	130.7453	31-Aug-05	01:07	152	bottom	3	0508310106
50	70.9200	126.0093	31-Aug-05	06:58	389	bottom	3	0508310657
51	70.3736	122.0011	31-Aug-05	12:02	455	bottom	3	0508311200
52	69.5788	118.0053	31-Aug-05	18:50	400	bottom	3	0508311849
53	68.8506	114.4962	1-Sep-05	00:55	86	bottom	1	0509010054

Table 7. Zooplankton Casts

Net event	Station (CTD Cast)	Latitude (N)	Longitude (W)	Date (UTC)	Time (UTC)	Approx. Max Net Depth (m)	Approx. Water Depth (m)	Notes
1	CB-1 (6)	71.78	131.87	04-Aug-05	7:15	100	1100	
2	CB-1 (6)	71.78	131.87	04-Aug-05	7:31	100	1100	
3	CB-4 (20)	74.98	149.93	10-Aug-05	0:02	100	3830	Contamination: Rinsed inside net with seawater hose
4	CB-4 (20)	74.98	149.93	10-Aug-05	0:11	100	3830	Contamination: Rinsed inside net with seawater hose
5	CB-4 (20)	75.00	150.00	12-Aug-05	12:03	100	3830	Station CB-4 repeated. Location from Bridge Log
6	CB-4 (20)	75.00	150.00	12-Aug-05	12:20	100	3830	Station CB-4 repeated. Location from Bridge Log
7	CB-9 (28)	78.00	149.84	14-Aug-05	6:50	100	3824	
8	CB-9 (28)	78.01	149.84	14-Aug-05	7:07	100	3824	
9	CB-15 (39)	76.98	140.00	26-Aug-05	9:45	100	3700	
10	CB-15 (39)	76.98	140.00	26-Aug-05	10:01	100	3700	

Table 8. Bucket Samples for Surface Water

Station Name	Latitude (N)	Longitude (E)	Date (UTC)	Time (UTC)	Water Depth (m)
XCTD 30	77.2933	140.6195	25-Aug-05	15:41	3700+
XCTD 31	76.6651	140.0708	27-Aug-05	03:19	3500+
XCTD 32	76.3713	139.8372	27-Aug-05	06:50	3500+
XCTD 33	75.6632	140.4230	27-Aug-05	16:12	3500+
XCTD 34	75.3342	141.0020	27-Aug-05	19:04	3500+
XCTD 35	74.6724	140.4287	28-Aug-05	05:04	3600+
XCTD 36	74.3403	140.3605	28-Aug-05	07:57	3500+

XCTD 37	73.6656	140.0901	28-Aug-05	23:53	3400+
XCTD 40	72.6638	140.3997	29-Aug-05	09:30	~2900
XCTD 41	72.3337	140.1768	29-Aug-05	11:51	~2700
XCTD 42	72.3084	138.6368	29-Aug-05	20:14	2700+
XCTD 43	72.4264	137.1248	29-Aug-05	23:15	2500+
XCTD 44	72.2147	135.1958	30-Aug-05	09:01	2250
XCTD 45	72.1955	134.2690	30-Aug-05	11:19	2000
XCTD 46	71.2668	132.5862	30-Aug-05	16:12	1200
XCTD 47	71.5878	131.3183	30-Aug-05	22:33	715
XCTD 48	71.5027	130.9598	30-Aug-05	23:33	440
XCTD 49	71.3471	130.7453	31-Aug-05	01:07	152
XCTD 50	70.5867	126.0093	31-Aug-05	06:58	389
XCTD 51	70.3736	122.0011	31-Aug-05	12:02	455
XCTD 52	69.5788	118.0067	31-Aug-05	18:50	400
XCTD 53	68.8506	114.4962	1-Sep-05	00:55	86
Coppermine River 1	67.7206	115.4110	7-Sep-05	23:30	0.5
Coppermine River 2	67.7495	115.3583	8-Sep-05	00:15	0.5
Coppermine River 3	67.7603	115.2653	8-Sep-05	00:45	0.5
Coppermine River 4	67.7947	115.1241	8-Sep-05	01:00	0.5
East of Kugluktuk	68.3678	112.9308	9-Sep-05	03:00	138
West of Cambridge Bay	68.7833	107.9383	9-Sep-05	14:30	88
East of Cambridge Bay	68.8704	105.2838	10-Sep-05	01:00	70
Larsen Sound	70.3425	98.8450	10-Sep-05	15:00	199