C3O East 2008
Cruise Report

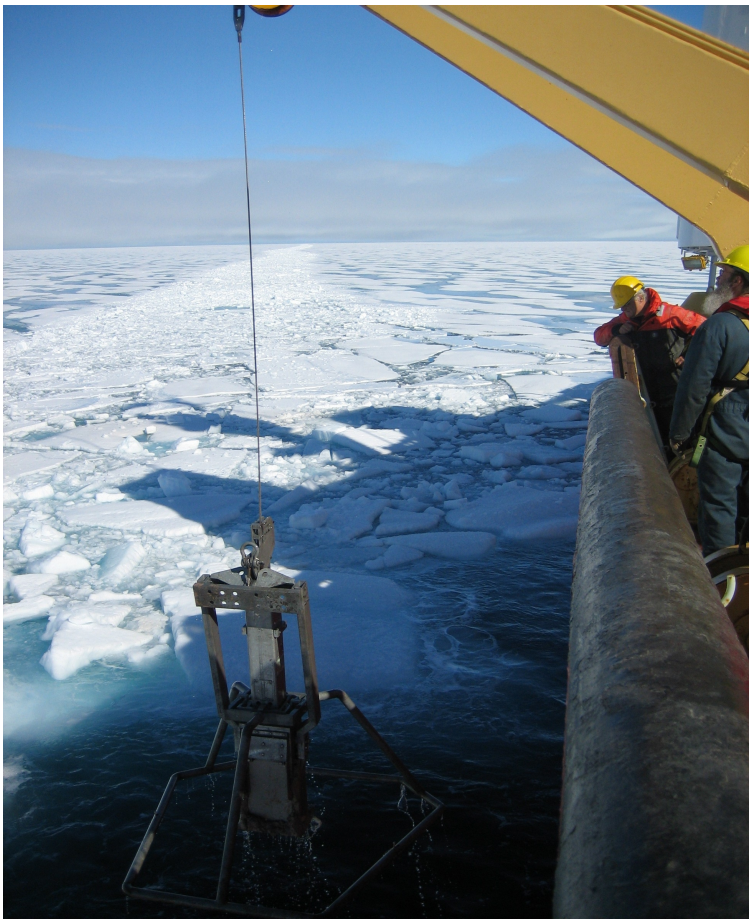

Photo: Jane Eert

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,* July 4 to 17, 2008

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Introduction

The Canada Three Oceans project "C3O" is part of Canada's contribution to International Polar Year research efforts. The focus of this collaboration between government institutes and universities is to study impacts of climate variability on the sub-arctic and Arctic water circulation and on the associated ecosystems.

Objectives:

This science program onboard the *CCGS Louis S St-Laurent* took place between July 4th and 17th along the ship's track on her northward voyage from Dartmouth, NS to Cambridge Bay, NU. A science group with members from DFO, Environment Canada, Canadian Universities and international institutions carried out multi-disciplinary observations of the seafloor, ocean and bird life. As well, members of the media, international scientists and personnel from DFO Communications Branch were on board and the ship was an integral part of the Polar Continental Shelf Project's 50th Anniversary Open House on July 12 in Resolute, NU.

The shipboard data collection included physical, biological, geochemical and benthic sampling:

- Profiles of water temperature and salinity were obtained with the main CTD, and with expendable CTD or bathythermograph (XCTD and XBT) probes,
- Additional sensors on the CTD profiler collected in situ data on phytoplankton concentrations (fluorometer), optical clarity (transmissometer), dissolved oxygen, photoactive radiation (PAR),
- A rosette was used with the CTD to obtain water samples from discrete depths for a broad suite of biological and geochemical parameters, some for onboard analysis, others to be stored for later analysis in shore-based laboratories,
- bio-acoustic backscatter data were collected with ADCP at all science stations,
- plankton samples were obtained in vertical hauls by bongo-net,
- benthic cores were obtained with a Pouliet box corer,
- continuous underway sampling of near-surface seawater temperature, salinity and phytoplankton (fluorescence), chromophoric dissolved organic matter, and dissolved gases,
- continuous recording of meteorological data (wind speed, air temperature, etc), navigation data, and soundings
- on board analysis of samples for chlorophyll, dissolved oxygen, plankton species and abundance,

DAYS ALLOCATED: 5 **DAYS OF OPERATION:** 2

SCIENTIFIC PERSONNEL: In Dartmouth, 15 scientists embarked for the leg to Resolute. At Resolute, 2 disembarked and 13 came aboard as part of the science group, with this science leg ending at Cambridge Bay.

Name	Affiliation	Tasks	Leg
Jane Eert	DFO - IOS	Chief Scientist/ data	Darrtmouth-CB
Robie MacDonald	DFO - IOS	Sediment coring	Darrtmouth-CB
Charles Gobeil	INRS	Sediment coring	Darrtmouth-CB
Marie-Ève Randlett	INRS	Sediment coring	Darrtmouth-CB
Danielle Dubien	INRS	Sediment coring	Darrtmouth-CB
Glenn Cooper	University of Victoria	Technical deck support/Nets	Darrtmouth-CB
Will Burt	DFO - IOS	Underway/deck/subsea video	Darrtmouth-CB
Sheila Sloman	DFO - IOS	oxygen/sampling	Darrtmouth-CB
David Fifield	EC	bird observer	Darrtmouth-CB
Waldek Walczowski	Poland	ADCP	Darrtmouth-CB
Marty Davelaar	DFO - IOS	sampling/CTD/Alkalinity analysis	Darrtmouth-CB
Adam Shahan	Sea-bird Electronics	CTD	Darrtmouth-CB
Donovan Hohn	USA	Science outreach	Darrtmouth-CB
Phil Benoit	University of Victoria	Acoustics	Dartmouth-Res
Jill Watkins	DFO-NHQ	sampling	Dartmouth-Res
Sarah Zimmermann	DFO - IOS	CTD	Res-CB
Edmand Fok	DFO - IOS	Computers/networking	Res-CB
Eddy Carmack	DFO - IOS	big picture	Res-CB
Erin Freeland Ballantyne	McGill/Oxford University	student	Res-CB
Mike Wallace	University of Washington	invitee	Res-CB
Paul Sprout	DFO-PAC	invitee	Res-CB
Laura Richards	DFO-PAC	invitee	Res-CB
David Hik	University of Alberta	invitee	Res-CB
Bill Li	DFO-BIO	invitee	Res-CB
Celine Gueguen	Trent University	CDOM	Res-CB
Chad Cuss	Trent University	CDOM	Res-CB
Mike Dempsey	DFO - IOS	Moorings	Res-CB
Oksana Schimnowski	DFO - NCAARE	Science Liaison	Res-CB

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Voyage overview:

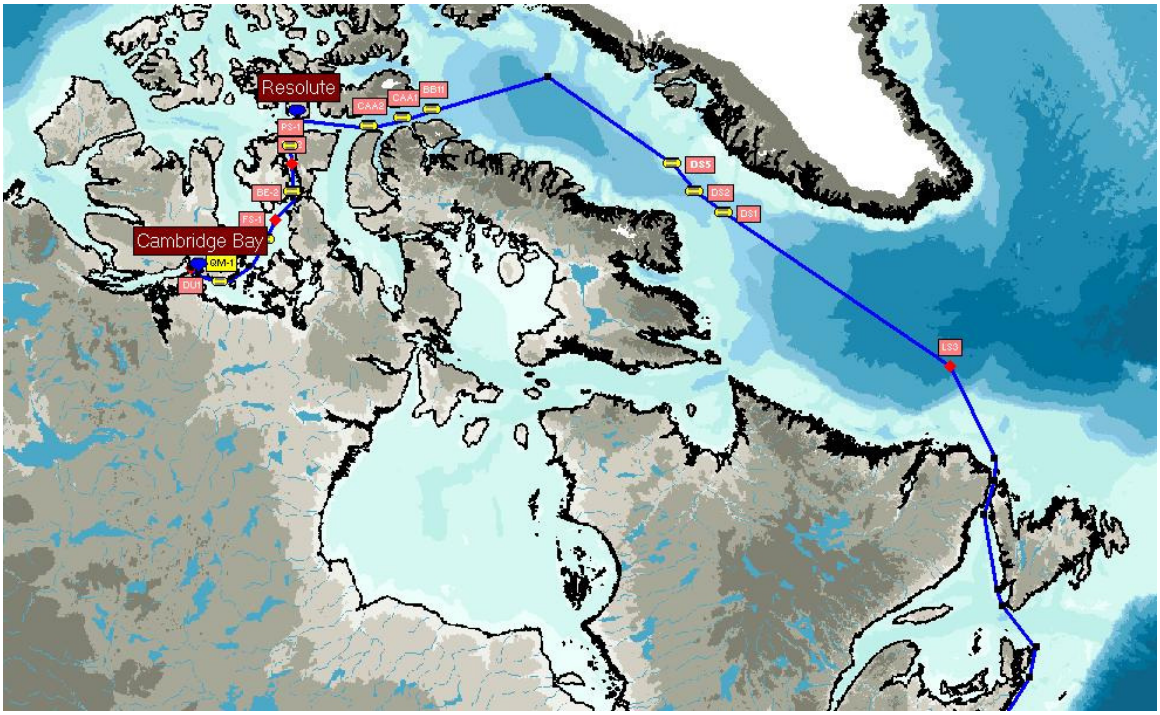

Figure 1. The cruise track for C3O East 2008 with science stations where physical and geochemical measurements were taken.

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1. PROGRAM COMPONENTS

Measurements:

- 13 CTD/Rosette Casts at 13 Stations
- Upper ocean current measurements from Acoustic Doppler Current Profiler during 6 CTD casts in relatively ice-free waters. Once past Resolute, there was too much ice to deploy the ADCP.
- 179 Water Samples
  At all stations: Salinity, Oxygen, Nutrients, Barium, O-18, Bacteria, Alkalinity, Colored Dissolved Organic Matter, Chlorophyll-a.
- 11 Pouliot box cores,
- Underway data collection of ship's meteorological, depth, sea surface, and navigation sensors as well as a photosythetically active radiation sensor.
- 24 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1100m depth or full water column if water is shallower than 1100m
- 13 Vertical Net Casts to 100m depth
- 144 Drift Bottles Deployed

Other:

- The Louis St-Luarent hosted a component of the Polar Continental Shelf Project's 50'th Anniversary Open House July 12 at Resolute

2. PROGRAM COMPONENT DESCRIPTIONS

a. Rosette/CTD Casts: Eddy Carmack (IOS) PI, Jane Eert

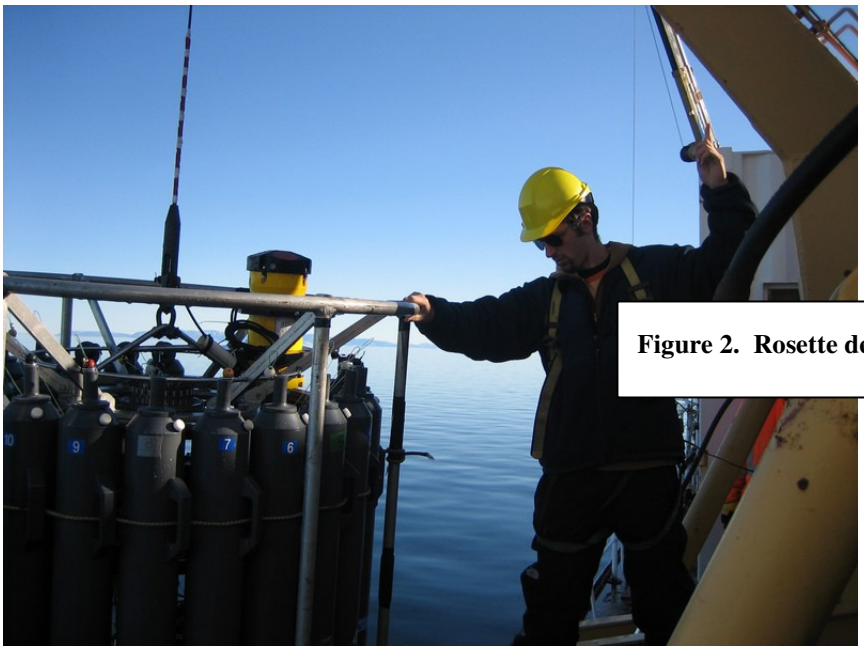

Figure 2. Rosette deployment.

The primary CTD system used on board was a Seabird SBE9+ CTD configured with a 24- position SBE-32 pylon and ice-strengthened rosette frame with 10L Niskin bottles fitted with internal stainless steel springs. The data were collected real-time using the SBE 11+ deckunit and computer running Seasave Win32 V 5.37d acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, two oxygen sensors, fluorometer, transmissometer, altimeter, a bottom contact switch and surface reference PAR.

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), Coloured Dissolved Organic Matter (CDOM), Alkalinity, Oxygen-18 isotope (O18), Barium, and Bacteria.

For a typical cast, the CTD was powered on while still on the deck. The transmissometer windows were wiped with deionized water soaked kimwipe or q-tip prior to each deployment. 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 the surface and lowered at 60m/minute to 1000m or, in water shallower that 1000m, to within 5m of the ocean floor. After closing the first bottle at the bottom of the cast, the package was raised at 60m/minute to the surface with 30s stops for bottle closing on the first 6 casts, in open water. On the remaining 8 casts, conductied in 8+ 10ths ice cover, 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 dependant on the ship rock and relative drift, which are both less favourable for bottle flushing when a ship is in ice.

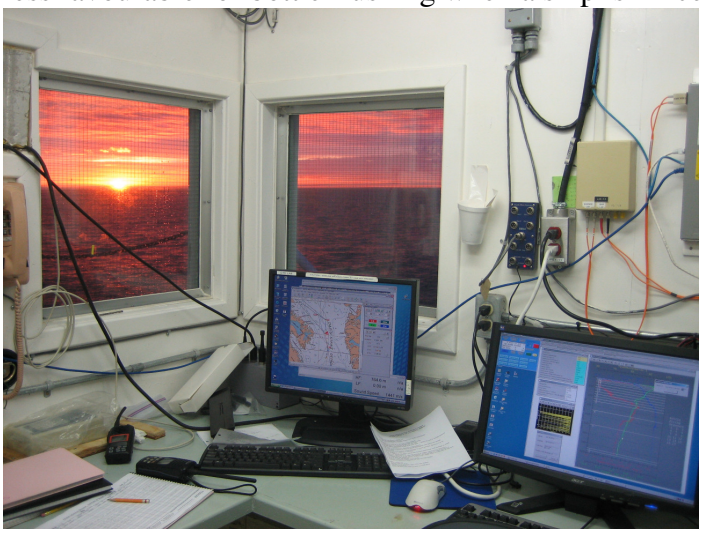

Figure 3 Looking out the window of the CTD control room.

Standard bottle closing depths were used throughout the cruise.

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.

The CTD's six-pin bulkhead connectors were replaced prior to the cruise with wet-pluggable connectors with great results. For the first time, this CTD was used on an Arctic cruise with no leaking connections to the CTD body. Unlike last year, we had less trouble with Niskin bottles not closing. The reason may be to that there was less grease falling off the wire onto the CTD frame and that the pylons had been serviced prior to the cruise.

The 13 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 temporal changes first. Dissolved Oxygen and Alkalinity were analysed on board. All other samples were prepared and stored for analysis on shore.

In conjunction with the first 6 CTD/Rosette Casts, an acoustic doppler current profiler (ADCP) measuring currents of the upper 60m and two backscatter transducers looking for layers of zooplankton were lowered over the side. The package was lowered by crane from the boat deck to approximately 5m beneath the surface and left in place until the completion of the CTD cast. Once the ship moved into ice-covered waters, the ADCP was not deployed due to the risk of losing it in the difficult conditions.

b. Sediment coring programme (Gobiel/Macdonald PIs)

The 2008 mission concentrated on collecting sediment cores for the Eastern Arctic including Baffin Bay and the Arctic Archipelago. The coring team included Drs. Charles Gobeil (INRS) and Robie Macdonald (IOS), and Danielle Dubien and Marie-Eve Randlett (grad students). In total, 11 sites were cored, which together with the 2007 mission provides the project with 25 cores for examination of elemental/organic biomarker distributions (Figure 1). All cores were collected using a Pouliot box core (20 cm × 30 cm × ~50cm (depth)) and coring operations took from 0.5 to ~1 hour over-the-side time. Once recovered each core was transported to a small container lab on the foredeck where it was sectioned from top to bottom. Section intervals were narrow near the surface (0.5cm), to capture fine structure in recent sediments, and at wider intervals (5cm) near the bottom of the core, where changes are less dynamic. In addition to the elemental/organic biomarker sampling, small tubes (2) were inserted into each box core to collect a vertical profile for meiofaunal analysis (Dr. P. Buat, FWI).

Sediment subsections were immediately frozen and then transported home in coolers to respective laboratories (INRS, Quebec, IOS, BC) along with personal luggage. The sediment cores are presently undergoing elemental analyses at INRS including important redox elements (Fe, Mn, Cd, S, Mo, Re, U, As) and many other metals; these data will form the primary resource to understand the cycling of elements such as Fe, As, S and Mo and how such cycling relates to modern organic carbon forcing along Arctic, Pacific and Atlantic margins. The distribution of core locations will provide a contrast between regions that have no seasonal ice cover and those presently experiencing a variety in the length and intensity of seasonal ice cover.

Samples returned to IOS are being analyzed for a suite of organic markers including alkanes, sterols, lignins and isotopic compositions ($\delta^{13}C$, $\delta^{15}N$). This data set will provide the primary resource to determine origins and burndown of organic constituents in the Arctic margin sediments.

Together the organic and elemental data sets will provide a baseline against which to evaluate future change, and the vertical profiles in sediments will provide a basis to

estimate fluxes and cycling of important elements in response to organic forcing. The distribution of sediment cores along the margins has been chosen because this region is likely to experience the greatest change in the near future. Indeed, within the redox elemental distributions, there may already be evidence of such change in non steady-state distributions between different elements. Accordingly, our data base may be applied to determining the effects of dynamic change in labile carbon flux to the bottom, and to understanding how the cycling is recorded in redox elemental distributions so that these latter may be applied to understanding the meaning of past records of elemental distributions in marginal sediments.

c. Zooplankton Vertical Net Haul

P.I. John Nelson(DFO), Glenn Cooper (University of Victoria)

Figure 4. Zooplakton Cast

A total of 13 Bongo net hauls were completed during 2008-29, at 13 of 14 oceanographic stations. The Bongo used comprised 4 nets, two 50cm hoops and two 15cm hoops. The large hoops were harnessed with 236 µm meshes, while the two smaller hoops were harnessed with 53 µm mesh.

Each net had its own flowmeter. The 53 µm and 236 µm nets were harnessed with MF-315 flowmeters. One of the MF-315 flowmeters had a permanent malfunction, leaving only three operational flowmeters.

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.

Routine sampling involved conducting one vertical haul to 100m depth.

d. 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 selected stations.

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.

e. 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, CDOM

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. 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.

3. COMPLETION OF PLANNED ACTIVITIES

Due to the late departure of the ship from Dartmouth, time available for science stations was significantly reduced from the planned programme. Thirty-one rosette stations had been planned, with box cores at 15 of them. Almost all the cutting of science stations occurred on the first leg, between Dartmouth and Resolute. Due to a fixed date for the PCSP Open House in Resolute, the late departure meant that the coring operations in Davis Strait and the rosette stations in the Labrador Sea and Baffin Bay were most affected. After Resolute, despite difficult ice conditions, only the optional (but highly desirable) detour into Bellot Strait was not achieved and the original station plan, minus Bellot Strait but with an additional 3 box cores, was carried out.

4. ACKNOWLEDGMENTS

The science team would like to thank the Coast Guard for their support, particularly Captain Rothwell and the crew of the *CCGS Louis S. St-Laurent*. We'd like to thank the Canadian Ice Service for their assistance with ice images and weather information as well as the helicopter pilot for his valuable help with ice reconnaissance

flights and transport. Thanks to the Staff of the Polar Continental Shelf project in Resolute for their help in making July 12th a very special day for many of the elders of Resolute and other dignitaries who had the chance to tour the Louis. Importantly, we'd like to acknowledge DFO and the Canadian International Polar Year Programme for their continued support of this program.

Quote from an Elder of the community of Resolute:
"*We have seen these ships go by every year and we always thought they were here to break up the ice. Now we see you are studying the ocean and that makes us very happy*"

Appendix: Station locations and activites:

CTD Cast #	Station	CAST START TIME (UTC)	Lat Deg N	Lat Min	Lon Deg W	Lon Min	Water Depth (m)	Nets?	Core?
1	LS3	07/08/2008 6:30	55	57.898	53	15.63	3090	x	
2	DS1	08/08/2008 20:38	65	28.91	57	44.886	580	x	x
3	DS2	09/08/2008 3:16	66	45.58	58	32.34	780	x	x
4	DS5	09/08/2008 10:18	68	2.198	57	32.201	330	x	x
	BB11	11/08/2008 6:04	73	56	77	55.8	850		x
5	CAA1	11/08/2008 10:58	73	56.052	81	49.867	640	x	x
6	CAA2	11/08/2008 16:48	73	55.981	86	9.74	356	x	failed
7	PS1	14/08/2008 7:45	73	35.838	96	17.714	245	x	x
8	PS2	14/08/2008 15:30	72	59.998	96	13.198	340	x	x
9	BE2	15/08/2008 2:58	71	58.454	95	59.906	420	x	x
10	FS1	15/08/2008 15:26	70	59.971	97	59.924	145	x	x
11	VS1	16/08/2008 5:48	70	14.962	98	55.792	209	x	x
12	QM1	17/08/2008 2:34	68	39.988	103	0.172	113	x	x
13	DU1	17/08/2008 12:29	69	0.025	106	9.371	130	x	