Cruise Report C3O/IPY 2008-02

Pacific Region Vessel CCGS *Sir Wilfrid Laurier*

DATE: **FROM:** 2 July 2008 **TO:** 29 July 2008

SCIENCE CRUISE NUMBER: 2008-02 **SHIP'S PATROL NUMBER:**

CHIEF SCIENTISTS: Bon van Hardenberg / Svein Vagle

INTRODUCTION/PROGRAM BACKGROUND:

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.

CRUISE OBJECTIVES:

During this cruise aboard the CCGS Sir Wilfrid Laurier data were collected on the physical, biological and geochemical properties of ocean waters across the North Pacific Ocean, the shelf regions of the Bering and Chukchi Seas, the shelf and shelf-break along the Beaufort Sea, and the Amundsen Gulf region of the Canadian Arctic Archipelago, and on the benthic ecosystems in the Bering & Chukchi Seas.

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

- Profiles of water temperature and salinity were obtained with CTD, underway towed UCTD, and with expendable XCTD & XBT probes,
- Additional sensors on the CTD profiler collected in situ data on phyto plankton concentrations (fluorometer), optical clarity (transmissometer), dissolved oxygen, photoactive radiation (PAR), and nitrate,
- 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 towed transducers, from ADCP at all science stations and with a side-looking acoustic transducer mounted on a multi-net plankton sampler,
- plankton samples were obtained in vertical hauls by bongo-net and with a multi-net,
- benthic sampling was done with mud grabs and small cores,
- continuous underway sampling of near-surface seawater temperature, salinity and dissolved gases,
- incubation experiments on deck,
- on board analysis of samples for chlorophyll, dissolved oxygen, plankton species and abundance, flow cytometry,
- lab sediment incubation experiments, and
- video footage of the sea bottom taken at the benthic stations.

DAYS ALLOCATED: 34 **DAYS OF OPERATION:** 26

SCIENTIFIC PERSONNEL: In Victoria (VIC), 16 scientists embarked for the North Pacific leg. At Dutch Harbor (DUT) 3 disembarked, and an additional 5 joined the team. In Barrow (BAR) 6 left, and 1 joined. At Cambridge Bay (CAM) 12 disembarked, 1 stayed until crew change at Kugluktuk (KUG).

Name	Tasks	Affiliation	from	To
Bon van Hardenberg	Chief Scientist / Subsea Video	DFO-IOS	VIC	Cam
Svein Vagle	Co-chief & Bio-acoustics	DFO-IOS	VIC	Bar
Bill Williams	UCTD underway watch	DFO-IOS	VIC	Dut
Bill Crawford	Underway watch	DFO-IOS	VIC	Bar
John Nelson	Plankton diversity	DFO - IOS	VIC	Cam
Stephanie King	CTD / sampling	DFO - IOS	VIC	Dut
Helen Drost	CTD / sampling	DFO-IOS	VIC	Cam
Nina Nemcek	oxygen analysis	DFO-IOS	VIC	Cam
Liusen Xie	data /CTD processing	DFO-IOS	VIC	Cam
Corinne Pomerleau	Zooplankton	DFO-IML	VIC	Cam
Mike Bentley	Bird Observer	CWS	VIC	Kug
Ian Wrohan	Productivity	U.Vic	VIC	Cam
Akash Sastri	Plankton	U.Vic	VIC	Bar
Flavio Paparazzo	Productivity	U.Vic	VIC	Dut
Karen Scarcella	Virus diversity	U.Laval	VIC	Cam
Caroline Chenard	Virus	UBC	VIC	Cam
Jackie Grebmeier	Benthic	U.Maryland	Dut	Bar
Lee Cooper	Benthic	U.Maryland	Dut	Bar
Darren Tuele	CTD / instrumentation	DFO-IOS	Dut	Cam
Diana Varela	Productivity	Uvic	Dut	Cam
Markus Janout	sampling / underway	UAF	Dut	Bar
Bren MacKenzie	sampling / underway	DFO-IOS	Bar	Cam

SUMMARY of RESULTS:

During the stops at 77 science stations, the following science tasks were completed

- 107 CTD/Rosette casts,
- 72 ADCP deployments,
- 130 Bongo plankton net hauls,
- 13 Multi-net hauls,
- 74 Van Veen sediment grabs,
- 48 Sediment HAPS cores,
- 27 bottom video camera deployments,
- and 2 Argo floats were deployed.

Underway data collection included

- obtaining profile data with 18 UCTD casts, 28 XCTD and 104 XBT probes,
- towing of bio-acoustic backscatter sensors to acquire near-surface data,
- continuous monitoring of surface water properties both with electronic sensors and by sampling at discrete intervals from the seawater loop in the main lab on board,
- gathering PAR light intensity data, soundings along the ship's track, and weather data.

AREAS OF OPERATION:

North Pacific, Bering Sea, Chukchi Sea, Beaufort Sea, Amundsen Gulf, Coronation Gulf.
The map below (Figure 1) shows the ship's track from Victoria to Cambridge Bay and the science stations occupied along the route. A list of science station locations, dates and activities is included in appendix 1.

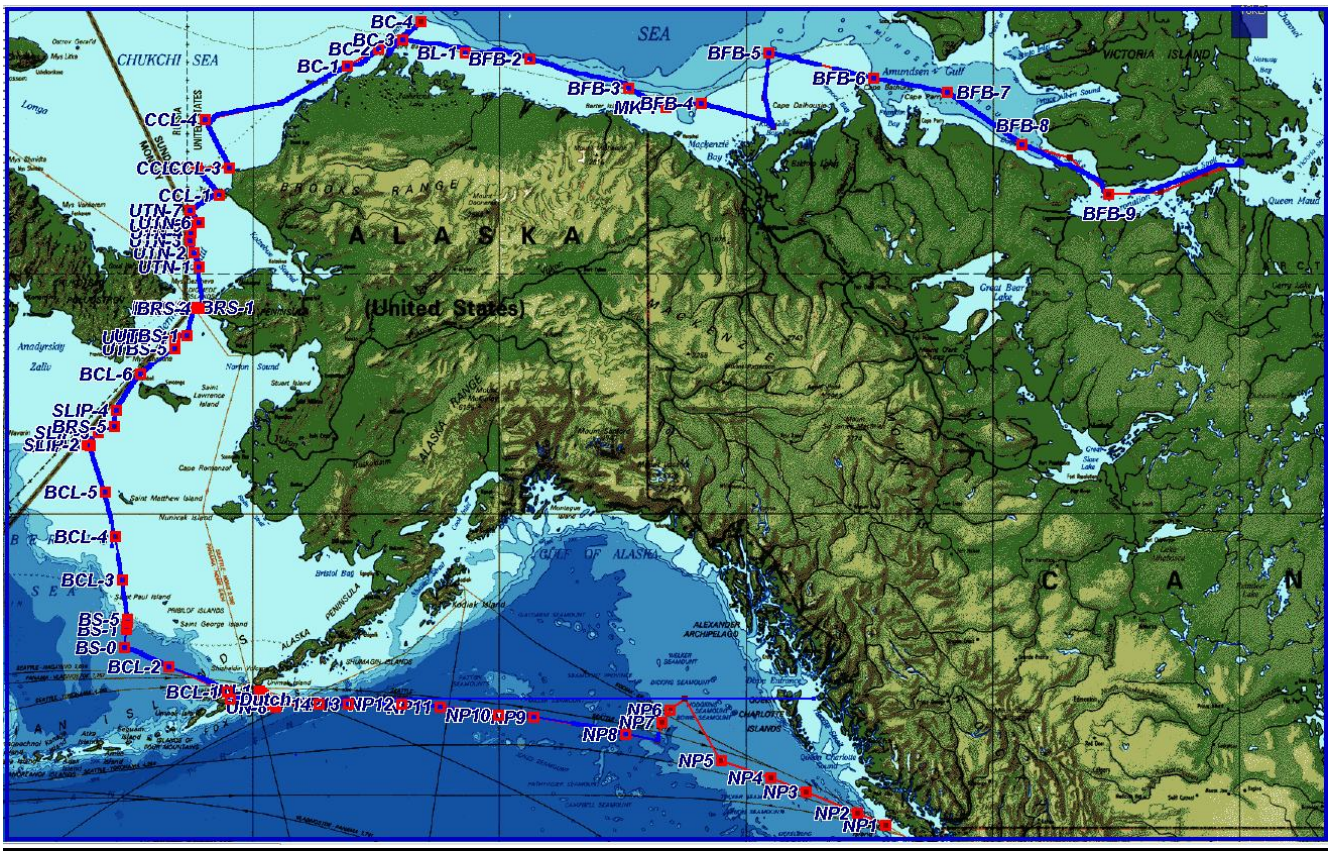


Figure 1. Map showing ship's track and location of science stations.

The approximate total distance travelled from Victoria to Cambridge Bay was about 4600 nautical miles, and the estimated incremental time required for all science stations is 160 hours, just over 6.5 days. Of this total time, 5.8 days is carried out west of Demarcation Point, and 0.8 days east of there in the Canadian Arctic.

FIELDWORK:

The first leg of the C3O science program aboard the Sir Wilfrid Laurier this year had an expanded biological component, similar to that done the previous year aboard the Louis S. St. Laurent. This included extensive water column sampling with multiple rosette casts at many stations; plankton net hauls with bongos and a Multi-net; acoustic back-scatter data collection both with towed sensors during transit, with a downward-looking ADCP when on stations, and with a side-looking sensor on the multi-net.

Science activities aboard the CCGS Sir Wilfrid Laurier for the July leg of the program covered three distinct segments:

1. Across the North Pacific from Victoria, BC to Dutch Harbor, Alaska:
   - twice daily stops were made at major science stations: the morning stations had up to three CTD/rosette casts, the first a shallow high-volume cast for biology, the second to 1000 m depth for water column

profiling and geochemistry sampling; while water was drawn from this second cast, a multi-net haul was done to about 1000m, with a side-looking acoustic transducer mounted on it to look for layers of strong backscatter; 2 to 4 bongo net hauls to 100m and 200m or as limited by water depth were done; a final rosette cast was done to get water samples from specific light-level depths for primary productivity incubation experiments; an ADCP was hung over the side at each station stop to collect both a profile of upper layer currents below the ship, as well as backscatter intensity data;

- underway data were collected between stations with UCTD, XCTD and XBT, and bio-acoustic tows; continuous seawater loop sampling was done during the whole cruise. The evening stations generally had only a single rosette cast for bio-geochemistry sampling and several vertical hauls with plankton nets.
- Profile data and bio-geochemical samples were collected at a section of closely spaced stations from deep water onto the shelf across the Alaska Shelf into Unimak Pass and onto the shelf in the central Bering Sea.

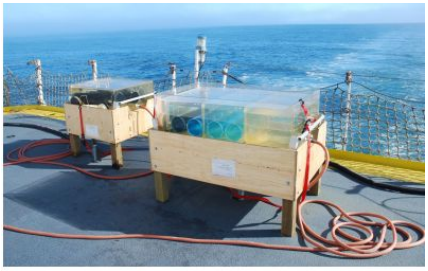
2. In the Bering/Chukchi Seas segment from Dutch Harbor to Barrow, Alaska, the twice daily station stops were continued in the southern deep part of the Bering, then in transit across the shelf areas more frequent stations were occupied at repeat benthic locations and the science team worked in shifts to accommodate this whenever stations were reached. At these benthic locations:
   - Several rosette casts were done to get samples from the overlying water column for the biology and geochemistry groups;
   - sediment samples were collected in 5 Van Veen bottom grabs and small cores were obtained with the HAPS corer.
   - 2 to 4 plankton net hauls were done at most benthic stations,
   - Bottom video footage was taken with the subsea camera system,
   - ADCP data on currents and acoustic backscatter.

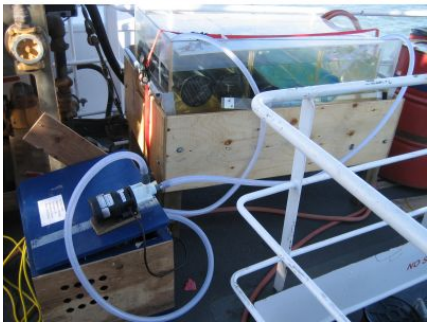
3. Over the Arctic segment from Barrow along the Beaufort Shelf and into the Canadian Arctic Archipelago to Cambridge Bay, Nunavut, a return to twice daily science stations, but including some repeats of Louis St-Laurent stations, and stopping at different station depths alternating between continental shelf, and deeper shelf-break locations.

Shipboard labs

Laboratory spaces on board were used to:

- collect samples and electronic sensor data from the seawater loop,
- filter rosette samples for chlorophyll, bacteria & virus content,
- analyze dissolved oxygen concentrations in water samples,
- microscope inspection of plankton samples,
- flow-cam imaging to analyze and inventory microscopic particles in fluids.





Deck space was used by science for launch and retrieval of equipment and instrumentation, including CTD/rosette for profiling & water sampling, the launching and data acquisition of UCTD, XCTD,XBT, deployment of ARGO floats, ADCP for acoustic current meter measurements, backscatter tow-fish, sediment sieving, subsea camera work, plankton multinet and nets, and conducting incubation experiments.

To facilitate the science, three container labs were installed:

- the usual 20-ft green container, with a new man-door in the wall opposite the cargo doors, for use by the plankton net people in sample preparations, and for the subsea camera systems components,
- the 10-ft blue one on the well deck, for set-up of the tow-fish, and later for use by the benthic group to prepare the sediment samples, and
- the 20-ft aluminium one on the boat deck provided much needed lab space for the primary productivity group to do sample filtering, preparation for incubators and sample analysis.

The container labs were well suited for lab duties, outfitted with counter space, shelving, simple sink, heat and power for instruments, but are lacking in ventilation. All were hooked up to electrical power for lights, heat and to run small pumps and electronic instrumentation, the two 20-ft ones also had phone, ship's intercom and network connections. Without these extra work spaces there would not have been room for the many extra on-board science activities during this cruise.

SUCCESSES AND PROBLEMS [SCIENTIFIC]:

All of the science instrumentation provided exciting new data, and will help to combine biological findings with measurements of the physical characteristics of the ocean. Most equipment performed well all the time, but problems were experienced with some of the science gear, as is to be expected with newly developed instruments. The combined data should provide unique opportunities to interpret interactions between the biological conditions and the physical parameters that govern their environment.

CTD/rosette system

A Seabird SBE-9 profiling CTD was used with a new custom built compact 24-bottle rosette water sampler. The CTD was equipped with the standard suite of pressure, temperature and conductivity sensors, and additional external sensors: a fluorometer to measure chlorophyll-a concentrations, a transmissometer to measure water clarity, a dissolved oxygen probe, an ISUS nitrate sensor, a PAR ambient light sensor, and an acoustic altimeter to get accurate height above the bottom.

The new 24-bottle rosette system was equipped with a Seabird Carousel pylon to remotely trigger the 10-litre sample bottles. An SBE-11 deck unit was used with Seasave software to acquire real-time data from the CTD and to close the bottles at depths selected before and/or during the cast. The deck unit included a NMEA board to automatically add GPS position into the header of the data file, and a PAR board to add data from the in-air reference PAR light sensor to the data stream. Some of the bottle lanyards were shorter than others, making them hard to set-up before casts. The staggered bottles make a tight package, and bottle numbers in a large font should be added near the valves to prevent errors in sampling.

The Hawboldt CTD winch experienced problems in several casts during retrieval when the CTD/rosette system was nearly back at the surface. There seems to be a flaw in the design of the remote control unit at the rail. Ship's engineering spend a number of hours diagnosing and fixing the problems, related to the failure of micro-switches in the manual outboard control station affecting the break release system. The problems were resolved without serious loss of time, but could recur.

The CTD conducting cable was shedding black grease from the main block and the winch guide rollers. Part of this dripped onto the top of the rosette and on the deck in the rosette landing area, and this tended to spread across the sampling equipment and be tracked down the hallways. The rosette system will need a thorough inspection and cleaning to avoid contaminating samples or problems with the rosette lanyards and triggering.

The ISUS nitrogen sensor on the CTD did not give consistently good data. Some of the problems were caused by incorrect installation of batteries in the external power pack, and an incorrect dummy plug allowed seawater to seep into and corrode on of the connectors. Ship's electronics created a temporary patch that allowed more data to be collected.

Bio-acoustic towfish

The bio-acoustic towfish provided many hours of backscatter data while crossing the North Pacific, but posed serious technical challenges. To protect the conducting cable attached to the transducers, a new steel-jacketed cable was installed. The weight and size of the mechanical connector that attached it to the towing body made it unstable for towing at ship's cruising speed.

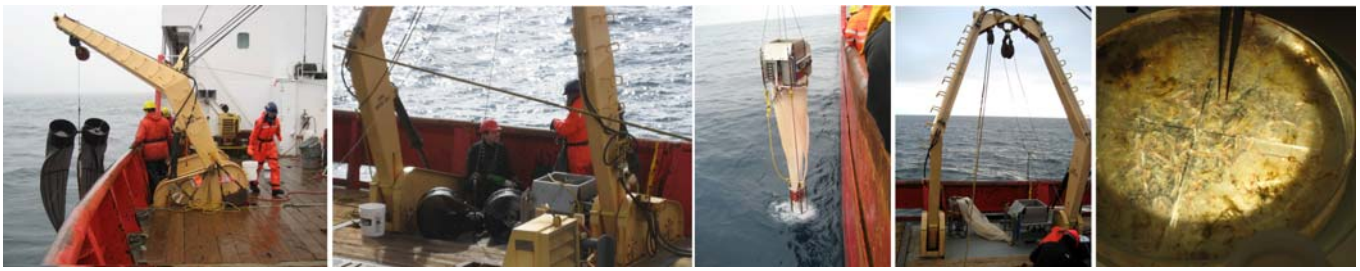
Many hours were spent in efforts to improve the design by adjusting trim tabs and tail wing, and repositioning cable attachment points, but attempts to resolve the problems were abandoned in the later part of the cruise. Images below show some of the cable-to-towfish configurations tested.

UCTD underway profiling

Ship's engineering built a splendid towing post on the aft deck for the underway UCTD, but the system still suffered from spooling problems, and the CTD-towfish probe was lost during the recovery phase of a cast, after only a few days of operation in which 18 casts were done.

After that, 28 underway CTD profiles were obtained using expendable XCTD probes, and in areas of special interest, such as the sub-arctic front in the North Pacific and the pool of cold water in the Bering Sea south of St. Lawrence island, densely spaced water temperature profiles were acquired by launching 104 XBT probes.

Plankton nets



Multiple plankton net hauls were done at most stations, using the hydro winch and A-frame on the well-deck. Bongo nets were lowered to 100m and 200m depth, or as water depth allowed. This was generally done during the time needed to draw water samples between successive rosette casts. A Multi-net was used at deep stations down to 1000m to collect samples from five pre-programmed levels. The multi-net performed well and was relatively easy to deploy using a second block rigged in the A-frame, with a rope that clipped to the tag-line (yellow rope in middle photo) and employed a multi-part block & tackle (on deck) to lift the cage with the 5 cod-ends over the side.

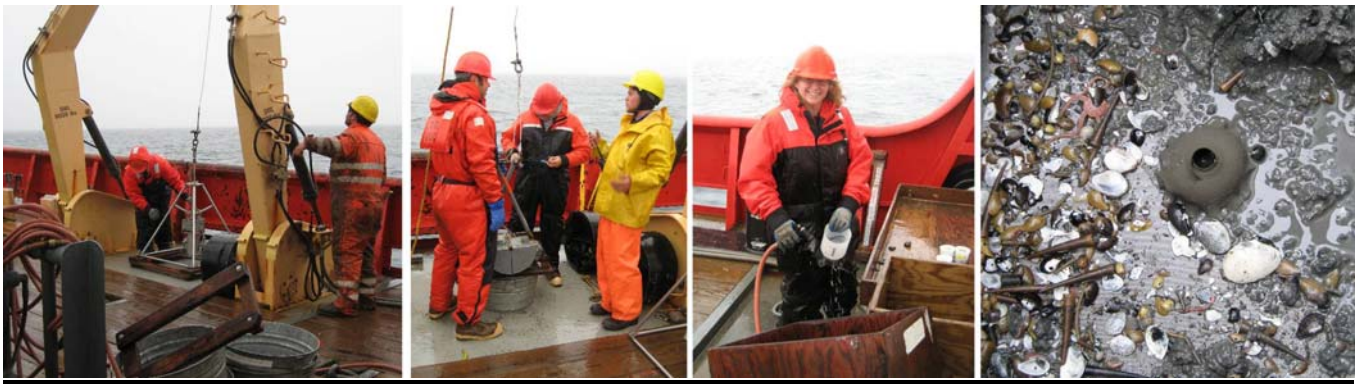
The side-looking acoustic backscatter instrumentation on the multi-net did fail a number of times, possibly due to battery power, connector problems or software settings.

Subsea video system

Video footage was acquired at most benthic stations, mostly from the lower resolution camera system. Some excellent bottom video footage was obtained with the new HD camera in the pressure housing, but the

electronics for this system kept shutting off the recorder, and the auto-focus tended to lock onto small bubbles on the pressure case window. The heavier cable for the more powerful lights failed to return a video signal for the topside monitor and the ship's electronics technician did extensive diagnostic tests and repair efforts. A limited amount of HD footage was obtained in several casts with the old and new camera systems strapped together. This was difficult to handle, so in later casts the housing with the HD camera was strapped onto the low resolution system. The images above show the two systems lashed together for several casts, screen captures from both cameras recorded simultaneously at the same location, and adjusting camera depth while watching the video signal on deck on the topside monitor.

Benthic sediments



Sediments were collected at benthic stations to determine total organic carbon and C/N ratios. Short surface cores were obtained with a HAPS corer (left image) and the cores were used in incubation experiments in the lab on board to measure respiration and chlorophyll present in sediments. Surface sediments brought up with multiple Van Veen grabs were sieved (right 2 images) to determine species distributions and abundance of biological content, and one sediment grab was used to analyze for grain size distribution.

Drift bottles

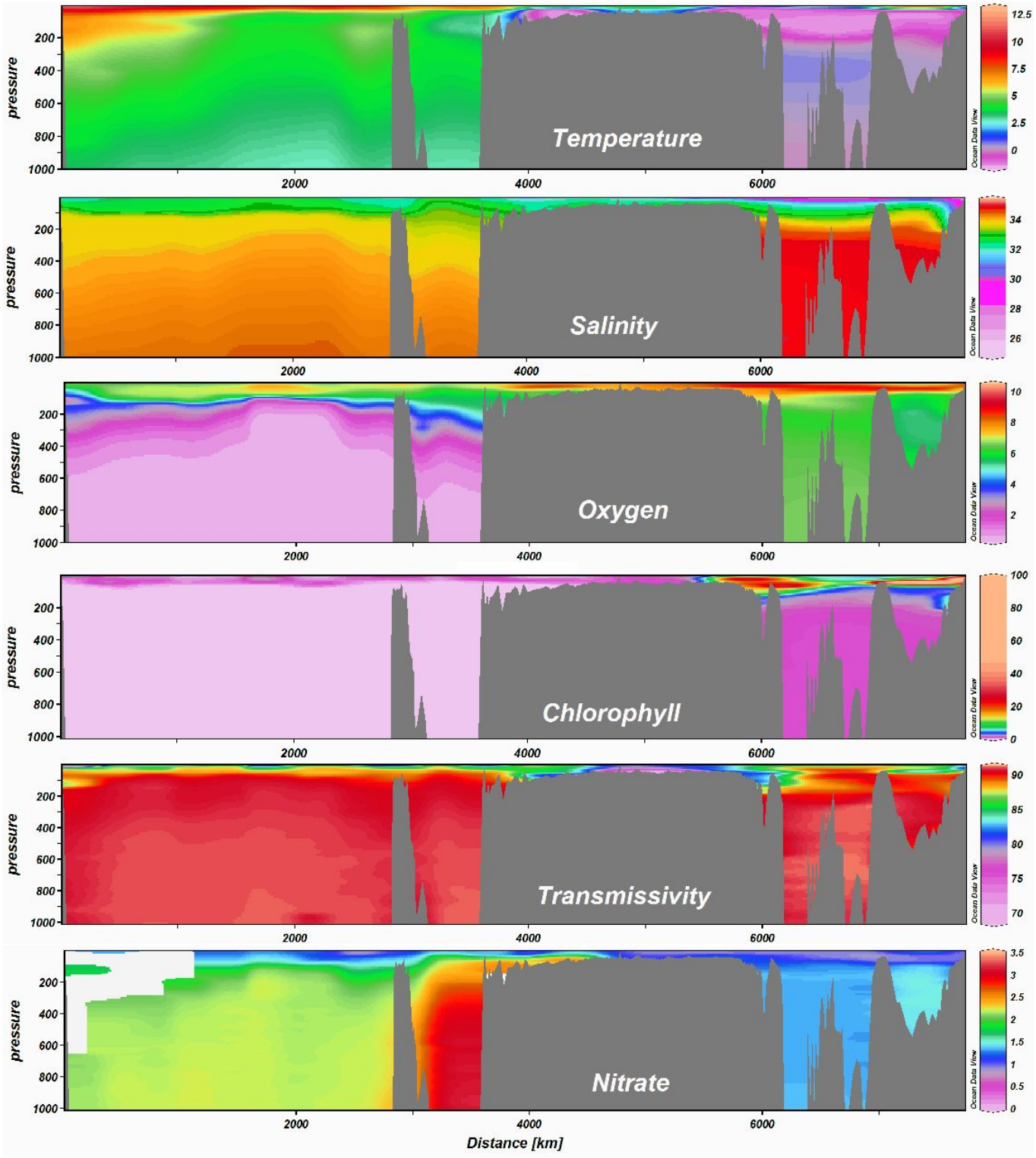
As part of a project started in 2000, a number of drift bottles, each containing a message with serial number and reporting contact information, were launched at selected locations along the ship's track. The drop locations are logged, and when finds are reported this provides information on ocean surface drift trajectories. A website is maintained to document all drops and finds, and map the results.

ARGO profiling floats

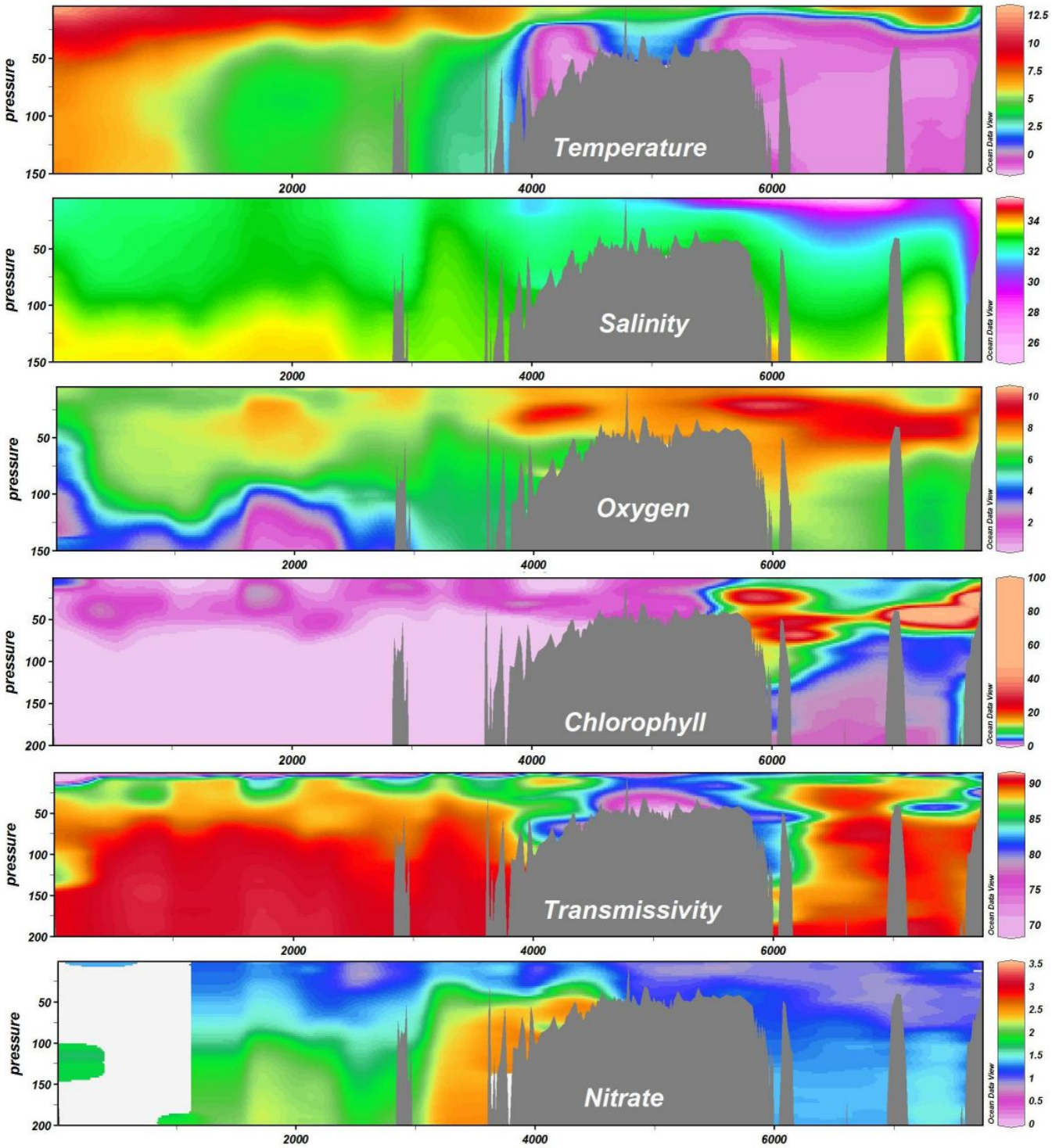
Two ARGO deep-profiling floats were deployed in the North Pacific at pre-selected locations to improve the coverage of the array in the Gulf of Alaska. The images above show the deployment method used to launch them.

PRELIMINARY RESULTS FROM PROFILING INSTRUMENTS:

The plots below show preliminary sections of data obtained with the profiling instruments (CTD, UCTD, XCTD and XBT) along the ship's track. The map shows all locations where profiles were obtained. Initial data processing was done on board to remove obviously bad data and to correct for sensor response characteristics. The first set of plots show sections of measured parameters to 1000 meters depth, and a second set is an enlargement of the upper 200 meters.



Sections of profile data collected from sensors both at science stations and underway.



Sections of upper 200 meters of profile data from sensors both at science stations and underway.

PROBLEMS [SHIP'S EQUIPMENT/OPERATIONS/PLATFORM SUITABILITY]:

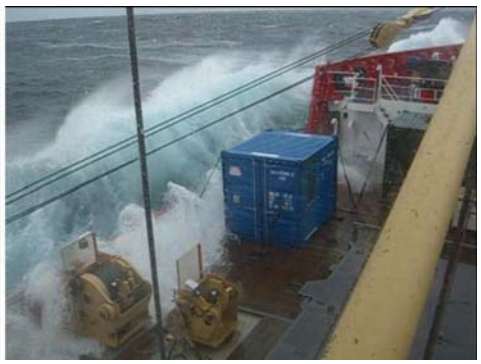
While in the Canadian Arctic, the operational demands on Coast Guard for support to northern shipping (servicing of aids to navigation and assisting tugs and barges facing remnants of winter ice) necessitated flexibility in scheduling of date and location for the termination of the science program. The presence of sea ice in the Archipelago made it difficult to determine where and when the cruise would end. Cambridge Bay or alternately Kugluktuk were considered as final destination. Schedules and seats on flights from small northern communities are limited, and so is space in hotels on shore. While old hands are familiar with the concept of northern time, it caused a lot of stress for participants who had other time commitments after this cruise. It would ease tensions to get return travel arrangements confirmed somewhat earlier before the end of the cruise.

SUCCESSES [SHIP]:

Internet access during much of the cruise provided good access to shore based institutes and for technical support with instrumentation, and the frequent email exchange provided a welcome way to stay in touch with colleagues and family.

DAYS LOST DUE TO WEATHER:

Less than 1 day total was lost in skipped science activities at 3 planned stations due to hight winds & rough sea-state.



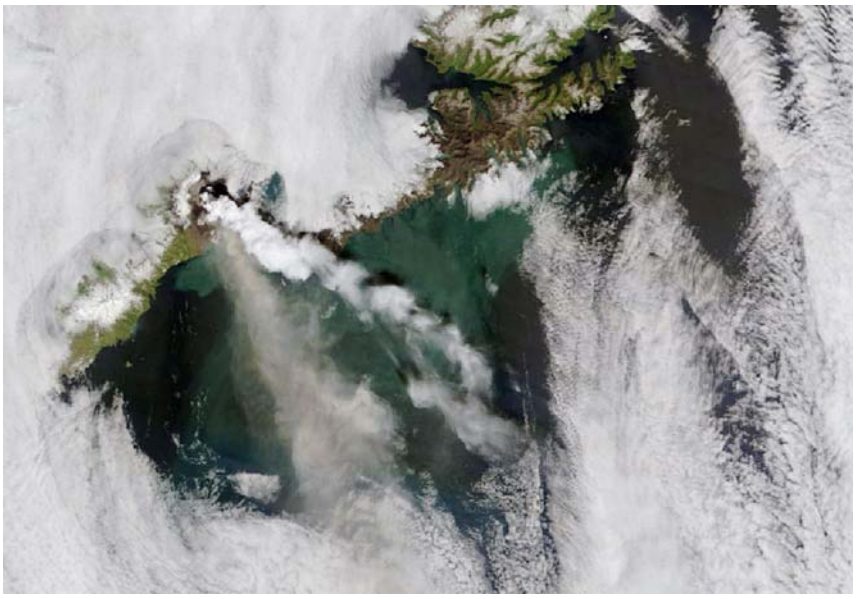
DELAYS [OTHER THAN WEATHER]:

At Barrow, stress cracks were found in the helicopter tail boom, which required a detour to Tuktoyaktuk for repairs.

SAFETY CONCERNS:

While handling of chemicals used in lab analysis was generally done with due care, some concern was expressed over possible hazards in the handling of toxic chemicals used to fix biological activity in water samples. No harmful incidents were reported and procedures were reviewed to avoid the possibility of hazards.

Okmok volcano eruption



On 12 July 2008 at 11:43 ADT Okmok volcano on Umnak Island just west of Dutch Harbor started to erupt, around the time that the ship left from Dutch Harbor. Heavy clouds obscured the view, and the first sign of the eruption was ash raining down on the decks and coating exterior surfaces on the ship. The satellite image shows the separate steam and ash plumes.

Besides the usual few nicks or bruises, and a few sore backs (!), no instances of a serious nature were reported by science participants.

SUMMARY/FINAL COMMENTS:

We want to express our heartfelt thanks to the officers and crew of the Sir Wilfrid Laurier for their help in making this cruise a success. Many hours were spent assisting with the operation of science gear, and in technical assistance with a variety of different projects. Thank you for your willing and eager support, for your patience in dealing with the challenges we presented, and for the warm welcome we received during our stay on board.

Appendix 1 Science Stations

Explanation of listed tasks:
-ADCP is the down-looking Doppler current profiler which also collected acoustic backscatter intensity data,
-CTDR is the CTD/Rosette electronic profiling and water sampling instrumentation,
-Bongo is the dual plankton net vertical haul from depths of 100m or 200m or less at the shallower stations,
-MultiNet is the package of 5 nets that open at successive programmed depths and includes pressure & temperature sensors and side-looking acoustic backscatter sensor,
-Grab refers to the van-Veen sediment grab and Core to the HAPS bottom corer,
-Camera is the subsea video camera system used to collect bottom footage.
The number in front of each task indicates how many repeats were done (either for multiple volumes or to different depths.

Station Name	Date	Start (PDT)	Lat. North (deg)	Lat (min)	Long. West (deg)	Long (min)	Science Tasks
Victoria	7/2/2008	18:00	48	25.215	123	23.343	Depart for Arctic
NP1	7/3/2008	8:22	49	6.951	126	41.096	ADCP, 5CTDR, 4Bongo
NP2	7/3/2008	18:08	49	37.743	128	22.263	ADCP, 1CTDR, 2Bongo
NP3	7/4/2008	07:33	50	28.040	131	29.665	ADCP, 1CTDR, 4Bongo
NP4	7/4/2008	18:05	50	58.991	133	37.672	ADCP, 1CTDR, 3Bongo
NP5	7/5/2008	7:10	51	38.815	136	39.573	ADCP, 3CTDR, 3Bongo
NP6	7/6/2008	10:44	53	29.830	139	45.710	ADCP, 3CTDR, 4Bongo
NP7	7/6/2008	17:33	53	2.445	140	13.501	ADCP, 1CTDR, MultiNet
NP8	7/7/2008	7:06	52	37.227	142	28.801	ADCP, 4CTDR, 3Bongo
NP9	7/8/2008	7:02	53	15.563	148	3.215	ADCP, 4CTDR, 3Bongo
NP10	7/8/2008	17:30	53	19.430	150	11.150	ADCP, 1CTDR, MultiNet
NP11	7/9/2008	7:06	53	38.100	153	45.700	ADCP, 1CTDR, 4Bongo
NP12	7/9/2008	17:30	53	42.726	156	7.550	2CTDR, 3Bongo, MultiNet
ARGO		16:00	53	40.700	155	40.330	Float deploy
NP13	7/10/2008	6:58	53	43.297	159	20.212	ADCP, 3CTDR, 4Bongo, MultiNet
NP14	7/10/2008	17:30	53	43.406	161	6.557	ADCP, 2CTDR, 3Bongo, MultiNet
ARGO	7/11/2008	0:40	53	40.637	162	32.170	Float deploy
UN8	7/11/2008	4:35	53	38.480	163	45.200	ADCP, 1CTDR
UN-7	7/11/2008	6:34	53	44.027	163	55.769	ADCP, 1CTDR
UN-6	7/11/2008	8:17	53	48.398	164	3.718	ADCP, 1CTDR, 3Bongo
UN-5	7/11/2008	09:53	53	53.083	164	16.898	ADCP, 1CTDR
UN-4	7/11/2008	10:57	53	57.547	164	19.882	ADCP, 1CTDR
UN-3	7/11/2008	12:04	54	8.040	164	13.900	ADCP, 1CTDR
UN-2	7/11/2008	13:02	54	6.700	164	35.700	ADCP, 1CTDR
UN-1	7/11/2008	14:06	54	11.300	164	43.600	ADCP, 1CTDR
Dutch Harbor	7/11/2008	20:00	53	53.620	166	31.000	Science personnel
BCL-1	7/12/2008	17:10	54	10.500	166	40.600	ADCP, 1CTDR, 2Bongo, MultiNet
BCL-2	7/13/2008	08:00	55	3.594	170	12.582	ADCP, 3CTDR, 4Bongo, MultiNet

Station Name	Date	Start (PDT)	Lat. North (deg)	Lat (min)	Long. West (deg)	Long (min)	Science Tasks
BS-0	7/13/2008	21:33	55	42.420	172	56.990	ADCP, 1CTDR, MultiNet
BS-1	7/14/2008	03:51	56	18.868	172	49.458	ADCP, 1CTDR
BS-2	7/14/2008	05:46	56	25.218	172	47.679	ADCP, 1CTDR
BS-3	7/14/2008	07:09	56	28.600	172	46.800	ADCP, 1CTDR, MultiNet
BS-4	7/14/2008	9:00	56	32.856	172	45.222	ADCP, 1CTDR
BS-5	7/14/2008	10:03	56	38.748	172	43.925	ADCP, 3CTDR, 4Bongo
BCL-3	7/14/2008	20:10	57	57.623	173	5.531	ADCP, 1CTDR, Camera
BCL-4	7/15/2008	4:48	59	19.220	173	30.011	ADCP, 1CTDR
BCL-5	7/15/2008	12:50	60	38.860	174	8.990	ADCP, 1CTDR, 2Bongo, Camera
SLIP-1	7/15/2008	22:00	62	0.800	175	3.000	ADCP, 1CTDR, 2Bongo, Camera 5Grab, 2Core
SLIP-2	7/16/2008	1:19	62	2.998	175	12.262	ADCP, 1CTDR, Camera 7Grab, 3Core
SLIP-3	7/16/2008	5:48	62	23.609	174	34.243	ADCP, 1CTDR, Camera 6Grab, 3Core
SLIP-5	7/16/2008	10:12	63	33.794	173	33.376	ADCP, 1CTDR, Camera 4Grab, 4Core
SLIP-4	7/16/2008	14:15	63	1.700	173	27.400	ADCP, 2CTDR, 4Bongo, Camera 4Grab, 4Core
BCL-6	7/16/2008	23:30	64	6.070	172	16.860	ADCP, 1CTDR, Camera 2Bongo
UTBS-5	7/17/2008	6:10	64	39.939	172	55.351	ADCP, 1CTDR, 2Bongo, Camera 4Grab, 4Core
UTBS-4	7/17/2008	9:37	64	57.531	169	53.107	ADCP, 1CTDR, Camera 5Grab, 3Core
UTBS-1	7/17/2008	12:30	64	59.500	169	8.300	ADCP, 2CTDR, 4Bongo, Camera 5Grab, 2Core
BRS-1	7/17/2008	22:20	65	43.000	168	53.900	ADCP, 1CTDR, Camera 2Bongo
BRS-2	7/17/2008	23:45	65	43.000	168	53.900	ADCP, 1CTDR
BRS-3	7/18/2008	0:43	65	40.445	168	33.967	ADCP, 1CTDR, Camera 2Bongo
BRS-4	7/18/2008	2:21	65	40.445	168	24.177	ADCP, 1CTDR
BRS-5	7/18/2008	3:57	65	39.096	168	13.098	ADCP, 1CTDR, Camera 2Bongo
UTN-1	7/18/2008	10:28	66	42.470	168	23.780	ADCP, 1CTDR, 2Bongo, Camera 6Grab, 3Core
UTN-2	7/18/2008	14:25	67	2.900	168	43.800	ADCP, 1CTDR, Camera 5Grab, 4Core
UTN-3	7/18/2008	17:51	67	20.100	168	57.500	ADCP, 1CTDR, Camera 4Grab, 4Core
UTN-4	7/18/2008	20:30	67	30.050	168	54.470	ADCP, 2CTDR, 4Bongo, Camera 4Grab, 3Core
UTN-5	7/18/2008	23:46	67	33.610	169	0.600	ADCP, 1CTDR, Camera 4Grab, 4Core

UTN-6	7/19/2008	2:19	67	44.217	168	26.359	ADCP, 1CTDR, Camera 5Grab, 3Core
Station Name	**Date**	**Start (PDT)**	**Lat. North (deg)**	**Lat (min)**	**Long. West (deg)**	**Long (min)**	**Science Tasks**
UTN-7	7/19/2008	5:26	68	0.030	168	55.000	ADCP, 1CTDR, Camera 6Grab, 3Core
CCL-1	7/19/2008	12:24	68	22.020	167	10.930	ADCP, 2CTDR, 2Bongo, Camera
CCL-2	7/19/2008	19:10	68	57.400	168	31.400	ADCP, 1CTDR, 2Bongo, Camera
CCL-5	7/19/2008	23:05	70	18.900	163	25.800	2Bongo only
CCL-3	7/20/2008	0:03	68	57.940	166	32.120	ADCP, 1CTDR, 2Bongo, Camera
CCL-4	7/20/2008	9:50	70	0.058	168	2.363	2-ADCP, 2CTDR, 4Bongo, Camera
BC-1	7/21/2008	7:01	71	4.006	159	21.380	ADCP, 1CTDR, 3Bongo, Camera
BCL-2	7/21/2008	12:48	71	24.400	157	19.800	ADCP, 1CTDR, 2Bongo, Camera
BC-3	7/21/2008	17:35	71	34.600	156	1.500	ADCP, 1CTDR, 2Bongo
BC-4	7/21/2008	22:20	71	55.705	154	53.460	ADCP, 1CTDR, 1Bongo
Barrow	7/22/2008	**Change to MDT**	71	20.150	156	48.000	Science team & Helo
BL-2	7/23/2008	8:04	71	19.504	152	13.002	ADCP, 3CTDR, Camera 4Bongo Multinet
BFB-2	7/23/2008	17:35	71	12.400	148	17.530	ADCP, 1CTDR, 2Bongo Multinet
BFB-3	7/24/2008	7:08	70	58.110	142	15.840	ADCP, 2CTDR, 2Bongo Multinet
MK-1	7/24/2008	15:25	70	13.810	140	0.510	ADCP, 41CTDR, 4Bongo
BFB-4	7/24/2008	22:10	70	19.120	137	50.200	ADCP, 1CTDR, 2Bongo
whales	7/25/2008	14:45	70	3.730	133	43.750	2Bongo
BFB-5	7/25/2008	22:05	71	19.900	133	44.800	ADCP, 2CTDR, 4Bongo Multinet
BFB-6	7/26/2008	12:10	70	49.500	127	25.350	ADCP, 1CTDR, 2Bongo
BFB-7	7/26/2008	21:55	70	39.130	122	46.280	ADCP, 3CTDR, 4Bongo Multinet
BFB-8	7/27/2008	9:40	69	27.850	118	19.940	ADCP, 1CTDR, 2Bongo
BFB-9	7/27/2008	22:20	68	23.100	113	7.400	ADCP, 1CTDR, 1Bongo
Cambridge Bay	7/28/2008	12:00	69	4.800	105	1.900	End of science program

Appendix 2. Weather conditions along the ships track.

Plots of weather parameters along the ships track were constructed from the data submitted by the ship's AVOS automated weather reporting station to the global weather network. The data was downloaded from the internet website http://sailwx.info/shiptrack/researchships.phtml which tracks reporting ship locations and conditions.

The figures below show the wind speed and direction, barometric pressure, and the air-, dewpoint- and seawater temperatures along the track in time series plots.

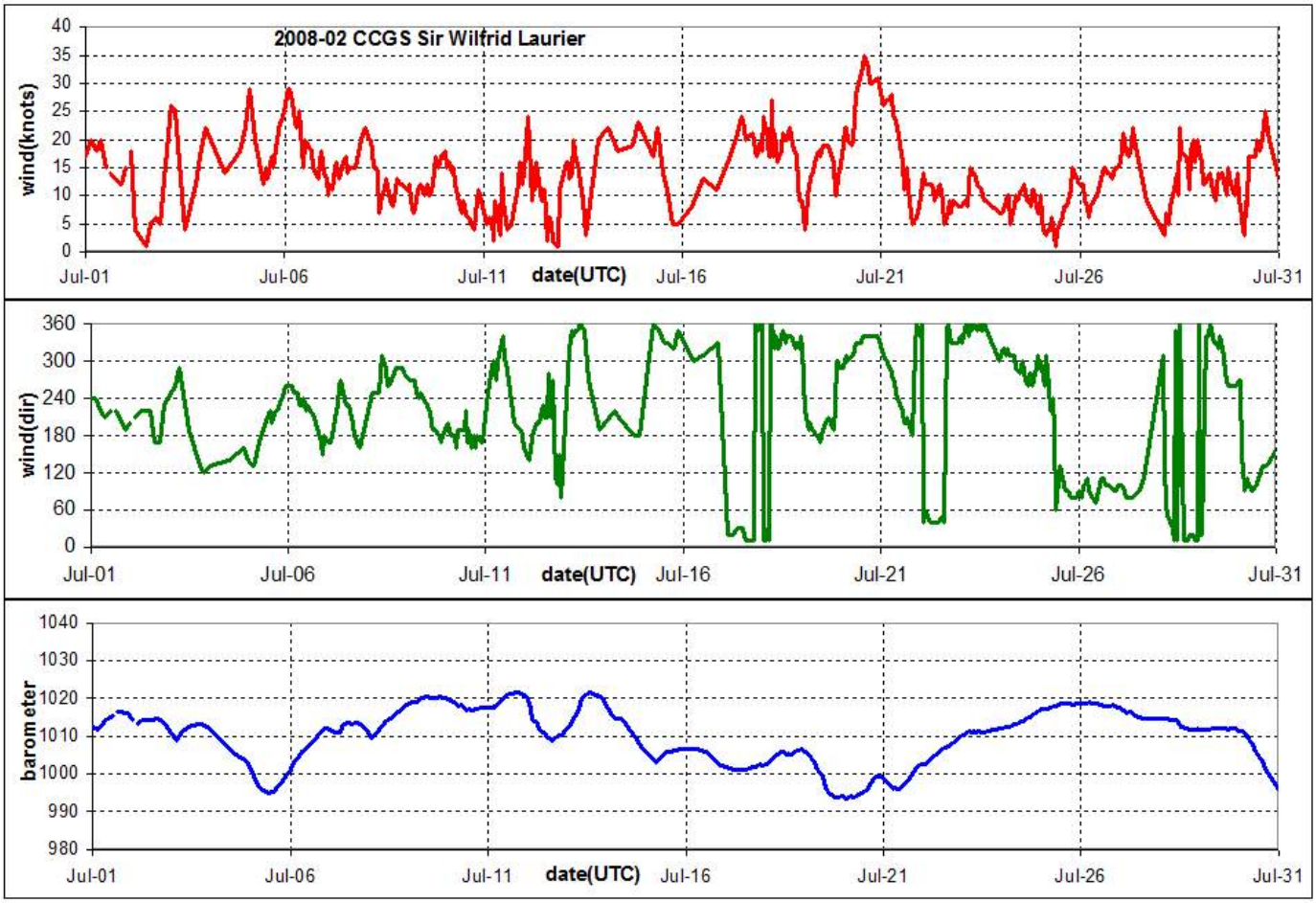


Figure A2-1. Time-series plots of wind speed (knots), direction (degrees true) and barometric pressure (millibar) along the track as reported by SWL.

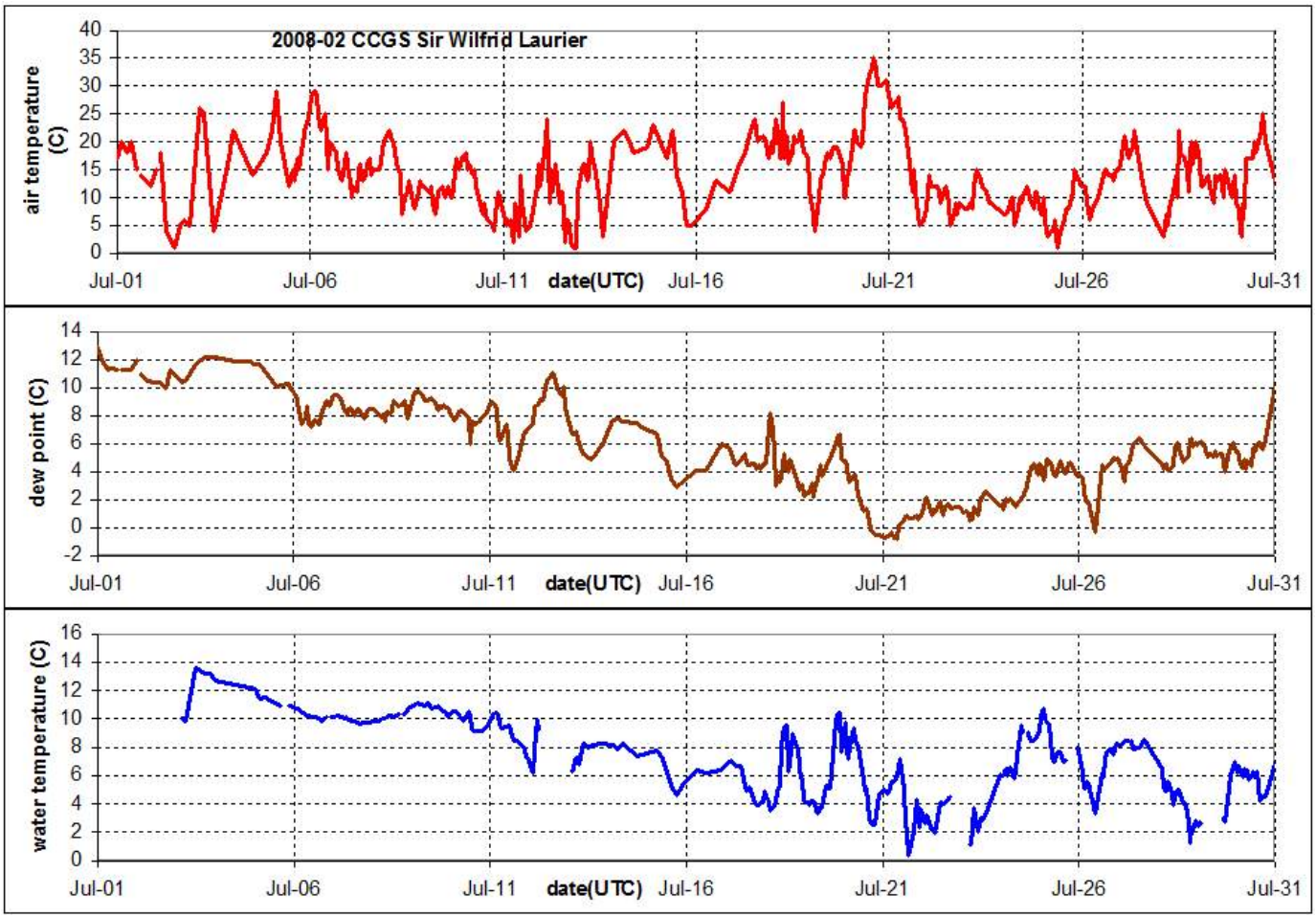


Figure A2-2. Time-series plots of air-, dewpoint-, and seawater temperatures (degrees C) along the track as reported by the SWL.

Karen Scarcella (Lovejoy Lab) RNA / DNA

At each BIO station that I sampled, generally samples were collected at 6 depths. Samples were collected for DNA analysis, Chlorophyll, Bacteria and DAPI (stained microscope slides) at all of those six depths and samples for RNA analysis were collected from the 4 shallowest depths among the 6 depths sampled. FISH samples were collected at all stations at the chlorophyll max and surface depths. Bacteria samples were also collected at almost every station (Geochem and Bio stations).

For chlorophyll, DNA and RNA the samples were fractionated. Therefore for each depth sampled there are 2 samples for each analysis (i.e DNA, RNA and chlorophyll). For chlorophyll, the total fraction is the seawater filtered directly through the GFF (7.5um) whereas for the small fraction the seawater is filtered through a 3um filter before being filtered through the GFF. For DNA and RNA, the seawater is first filtered through a 50um mesh to keep zooplankton out of our samples, secondly through a 3um polycarbonate filter and thirdly through a 0.2um polycarbonate filter. The portion retained on the 3um filter is labeled the "large fraction" and the portion retained on the 0.2um filter is labeled the "small fraction".

Stations sampled

North Pacific:	NP-1	NP-5	NP-6	NP-8	NP-9	NP-12	NP-13	NP-14
Bering Sea:	BCL-2	BS-5	SLIP-4	UTBS-1				
Chukchi Sea:	UTN-4	CCL-4						
Beaufort Sea:	BL-1	MK-1	BFB-5	BFB-7				

Corinne Pomerleau (DFO-IML / UQAR-ISMER) Zooplankton

Foraging Ecology and Habitat Selection of Bowhead Whales (*Balaena mysticetus*) in the Canadian High Arctic.

Project members: Corinne Pomerleau, PhD Candidate (DFO-IML and UQAR-ISMER) under the supervision of Steven H. Ferguson (DFO-FWI and U of Manitoba), Veronique Lesage (DFO-IML) and Gesche Winkler (UQAR-ISMER). This work is done in collaboration with Eddy Carmack (DFO-IOS) and John Nelson (DFO-IOS and U of Victoria).

General objective:

The overriding question this project hopes to answer is the determination of bowhead whale habitat needs by focusing on (1) foraging ecology and (2) resource selection. First, to understand foraging ecology, archived and collected (July 2008) biopsy samples of eastern and western Arctic bowhead whales will be used to test for stable isotope (carbon, nitrogen and sulphur) and fatty acid chemical signals that can be compared to prey thereby differentiating seasonal food selection and prey composition. Second, using past and proposed (2008) satellite telemetry location data, resource selection functions will be modeled in conjunction with analyses of the temporally changing bowhead environment (e.g. primary productivity such as chlorophyll a) to understand habitat requirements. The proposed research aims to provide information necessary for the short-term recovery objective of identifying and protecting important whale habitat required for the Conservation Strategy for Eastern Canadian Arctic Bowhead Whales. There is very little information in the literature about the Bowhead whale needs for habitat and accurate foraging. We do not know which preys they are feeding on and what is driving their habitat selection versus movement patterns. We hope to provide a better understanding of their foraging pattern and behaviour in a context of climate change and the impact that this might have on the marine system they depend on.

Sampling Protocol:

Biological samples were collected at every basic and full stations along the cruise transect. Various zooplankton genus and species were collected with a vertically towed Bongo net, a set of 2 adjacent 1-m^2 frame nets, from 200 m (or near the bottom if sampling was done in a shallower area) to the surface (mesh size 2*236 um) hauling at 1 meter per second. Zooplankton samples were poured into a bucket filled with surface sea water in order to keep the samples alive as long as possible. Sorting of the samples were performed in the green container located on the ship foredeck. Identification to the lowest level possible (e.g. genus or specie) was done using a dissecting scope. Representative sub samples of individual zooplankton genus or species were placed into 4 ml glass vials for stable isotope analysis. The other portions of the samples were put into 30 ml plastic vials and whirl-pak bags and were kept frozen until further analysis for fatty acids. One or two vertical tows were performed at every sampling station.

42 stations were sampled for zooplankton including one opportunistic sampling done in the Beaufort Sea following Bowhead's sighting.

List of the stations: NP1,2,3,4,5,6,8,9,11,12,13,14, UN6, BCL2, BS5, BCL5, SLIP1, SLIP4, UTBS1, BRS1, BRS3, UTN1, UTN4, UTN7, CCL1,2,3,4,5, BS1, BS2, BS3, BL1, BFB2, BFB3, MK1, BFB4, 5,6,7,8.

Future collaborative work:

Taxonomy will be done on the preserved (4% formaline) samples collected in 2007 aboard the Louis St-Laurent and the 2008 samples collected on the Laurier. I will be coming to IOS at the beginning of 2009 to do the taxonomy work. This part of the project is very important as we will know which species were present when and where and in which proportion. We will also be able to calculate an estimate of the biomass at every station.

Dr. Diana Varela and Ian Wrohan (University of Victoria)

Phytoplankton Productivity and Nutrient Dynamics in Surface Waters of the Subarctic Pacific and Western Arctic

Introduction

Phytoplankton play a critical role in the cycling of elements in the ocean by taking up dissolved nutrients (e.g., C, N, Si, P) and returning them back to seawater upon their death and decomposition. Phytoplankton physiology is then responsible for changes in the C balance in the upper water column, which in turn influence atmospheric CO_2 concentrations and modify global climate.

The study of the nutrient physiology of phytoplankton contributes to the understanding of biogeochemical cycling and ecosystem dynamics in surface waters. Over spatio-temporal scales that approximate the residence time of water in the mixed layer, the rate of "new production" (nitrate-based primary productivity) can be used as an indicator of the vertical flux of organic matter out of the euphotic zone (i.e., export production). High rates of new production are normally attributed to diatoms. In contrast, high rates of "regenerate primary production" (ammonium and urea-based) are generally indicative of low export rates and the presence of phytoplankton assemblages characterized by small cells (less of a diatom contribution). The predominance of one phytoplankton group over another has a direct impact on food web structure in surface waters, and on the magnitude of primary and export production available for consumption at higher trophic levels.

Diatoms, a group of phytoplankton from the Class Bacillariophyceae, are major primary producers and key exporters of organic matter and opal in marine coastal waters and upwelling regions throughout the world's oceans. Diatoms have an absolute requirement for Si, which is precipitated as amorphous hydrated silica in their cell walls. Hence, diatoms control the cycling of Si and contribute significantly to the downward flux of biogenic silica, N and C in most oceanic regions. In the Southern Ocean, diatoms are responsible for as much as 75% of the annual primary production. In particular, the area between the Antarctic Polar Front and the northern extent of the marginal sea ice is the site of massive diatom blooms.

It is critical that comprehensive studies of phytoplankton process are carried out in surface waters of the subarctic Pacific and western Arctic in order to determine the potential effects of climatic changes on nutrient dynamics, autotrophic biomass and productivity, and export fluxes.

Overall Objective

The goals of our project are: (1) to investigate the dynamics of nutrient cycling and the rates of phytoplankton (total, new and regenerated) production and (2) to assess how variability in physical and chemical gradients affect phytoplankton dynamics in surface waters of the subarctic Pacific and western Arctic.

In order to achieve these goals, our **Specific Objectives** are:

(1) *The study of nutrient pools in surface waters*.

We collected samples for the measurement of dissolved nutrients (NH_4, N-urea, NO_3, $Si(OH)_4$, PO_4) and particulate C, N and Si.

(2) The determination of the structure of the phytoplankton community.

We collected samples for: the measurement of total and size-fractionated chlorophyll *a* (0.7 and 5 µm) and the composition of phytoplankton assemblages by light microscopy and Flow-Cam® (an imaging particle/size analyzer).

(3) The determination of the magnitude of total, new and regenerated production by phytoplankton.

We performed experiments with live phytoplankton assemblages by inoculating the cultures with ^{14}C, $^{15}NO_3$, $^{15}NH_4$ and ^{15}N-urea. Cultures were grown in on-deck incubators for 24 hs.

This work was carried out along a vertical profile throughout the euphotic zone (at up to 6 depths corresponding to 100, 50, 30, 12, 1 and 0.1% of surface irradiance) at selected stations, which were strategically chosen to identify extreme conditions or different ecosystems. The following is a list of stations and depths sampled:

- NP1: 2, 6, 25, 50, 61 and 79 m
- NP5: 5, 13, 43 and 100 m
- NP6: 2, 3, 7, 35 and 71 m
- NP8: 3, 10, 18, 31, 79 and 119 m
- NP9: 2, 4, 6, 11, 36 and 70 m
- NP12: 2, 20 and 102 m
- NP13: 3, 11 and 80 m
- NP14: 3, 21 and 100 m
- UN7: 6 m
- UN4: 3 m
- UN2: 3 m
- BCL2: 5, 15, 53 and 100 m
- BS1: 3 m
- BS3: 3 m
- BS5: 5, 9, 15, 33 and 50 m
- SLIP4: 3, 4, 5, 15, 30 and 59 m
- BCL6: 5 m
- UTBS1: 3, 6, 15, 32 and 44 m

- UTN4: 2, 5, 12, 25 and 42 m
- CCL4: 4, 8, 15 and 30 m
- BC2: 2, 6, 10, 19, 30 and 44 m
- BC4: 6 m
- BL1: 2, 4, 10, 23, 48 and 59 m
- MK1: 2, 4, 14, 45 and 97 m
- BFB5: 2, 4, 15, 44 and 90 m
- BFB6: 6 m
- BFB7: 2, 5, 11, 43 and 60 m

Lee Cooper and Jackie Grebmeier, University of Maryland Center for Environmental Science

Our efforts were centered on activities at 19 stations occupied between Dutch Harbor and Barrow. Water column Chlorophyll a was measured at all of these stations at a total of six depths using a Turner Design AU-40 shipboard fluorometer (Table 1). Surface sediments were sampled for total organic carbon and C/N ratios at each of these stations except in Bering Strait (data available at a later date), as were inventories of chlorophyll present in surface sediments and measured with the Turner Designs fluorometer (Table 2).

A total of 13 duplicate 133 cm2 sediment incubations were undertaken during the cruise. These shipboard incubations measure oxygen utilization and nutrient exchange between the sediments and the overlying water column and provide a measure of organic carbon supply to the benthos.

Finally, benthic organisms were collected using four van Veen grabs at each of 15 stations. A fifth grab was collected at each station for sediment measurements including grain size, C/N ratios and total organic carbon as discussed above. The biological samples were preserved for onboard and have been returned to the Chesapeake Biological Laboratory for species identification.

Tables were submitted with water-column and sediment chlorophyll readings from the benthic stations. These will be added in the data spreadsheets, and included in the data report for the cruise.

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