CRUISE REPORT: Hudson 2006019

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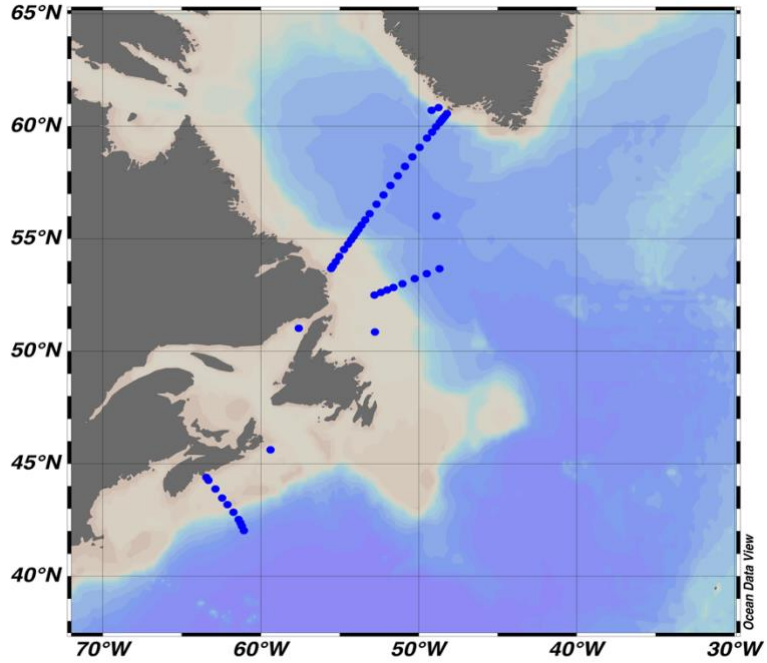

Highlights

Cruise Summary Information

Section Designation	AR7W
Expedition Designation (ExpoCode)	**18HU20060524**
Chief Scientist	**Ross Hendry**
Dates	24 May – 8 June, 2005
Ship	CCGS Hudson
Ports of Call	St John's, Canada – Dartmouth, Canada
Geographic Boundaries	60° 83"N 63° 45"W 48° 23"W 42° 03"N
Stations	59
Floats and Drifters Deployed	5 APEX floats
Moorings Deployed and Recovered	1 recovery, 1 deployment

Contact Information:

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Report assembled by Savannah Lewis

Links to Selected Topics
Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Cruise Summary Information	**Hydrographic Measurements**
Description of Scientific Program	**CTD Data:**
Geographic Boundaries	Acquisition
Cruise Track (Figure): PI CCHDO	Processing
Description of Stations	Calibration
Description of Parameters Sampled	Temperature Pressure
Bottle Depth Distribution (figure)	Conductivity Oxygen
Deployments	**Bottle Data**
Moorings Deployed or Recovered	Salinity
	Oxygen
Programs and Principal Investigators	Nutrients
Scientific Personnel	Total CO_2
	CFCs and SF_6
Problems and Goals Not Achieved	Total Alkalinity
	pH
	Total Organic Carbon
Underway Data Information	Bacterial Abundance
Navigation Bathymetry	
Acoustic Doppler Current Profiler	Lowered Acoustic Doppler Current Profiler
Thermosalinograph	
XBT and/or XCTD	
pCO_2	**Acknowledgements**
Atmospheric Chemistry Data	
Meteorological Observations	

CRUISE REPORT

HUDSON 2006019

LABRADOR SEA

WOCE LINE AR7W

May 24 – June 8, 2006

A. CRUISE NARRATIVE

1. Highlights

a. WOCE Designation:	WOCE Line AR7W Atlantic Circulation Experiment
b. Expedition Designation:	Hudson 2006019
c. Chief Scientist:	Ross Hendry Ocean Science Division Department of Fisheries and Oceans Bedford Institute of Oceanography PO Box 1006 Dartmouth, NS, Canada B2Y 2A4 Internet hendryr@mar.dfo-mpo.gc.ca
d. Ship:	CCGS Hudson
e. Ports of Call:	May 24 St. John's, NL, Canada June 8 BIO, Dartmouth, NS, Canada
f. Cruise Dates:	May 24 to June 8, 2005

2. Cruise Summary Information

a. Cruise Track

A cruise track is shown in Figure A.2.1. The ship's position at 0000 UTC on each day of the cruise is indicated with a date label.

The World Ocean Circulation Experiment (WOCE) -format cruise station summary file (SUM) outlines the science operations conducted during the cruise.

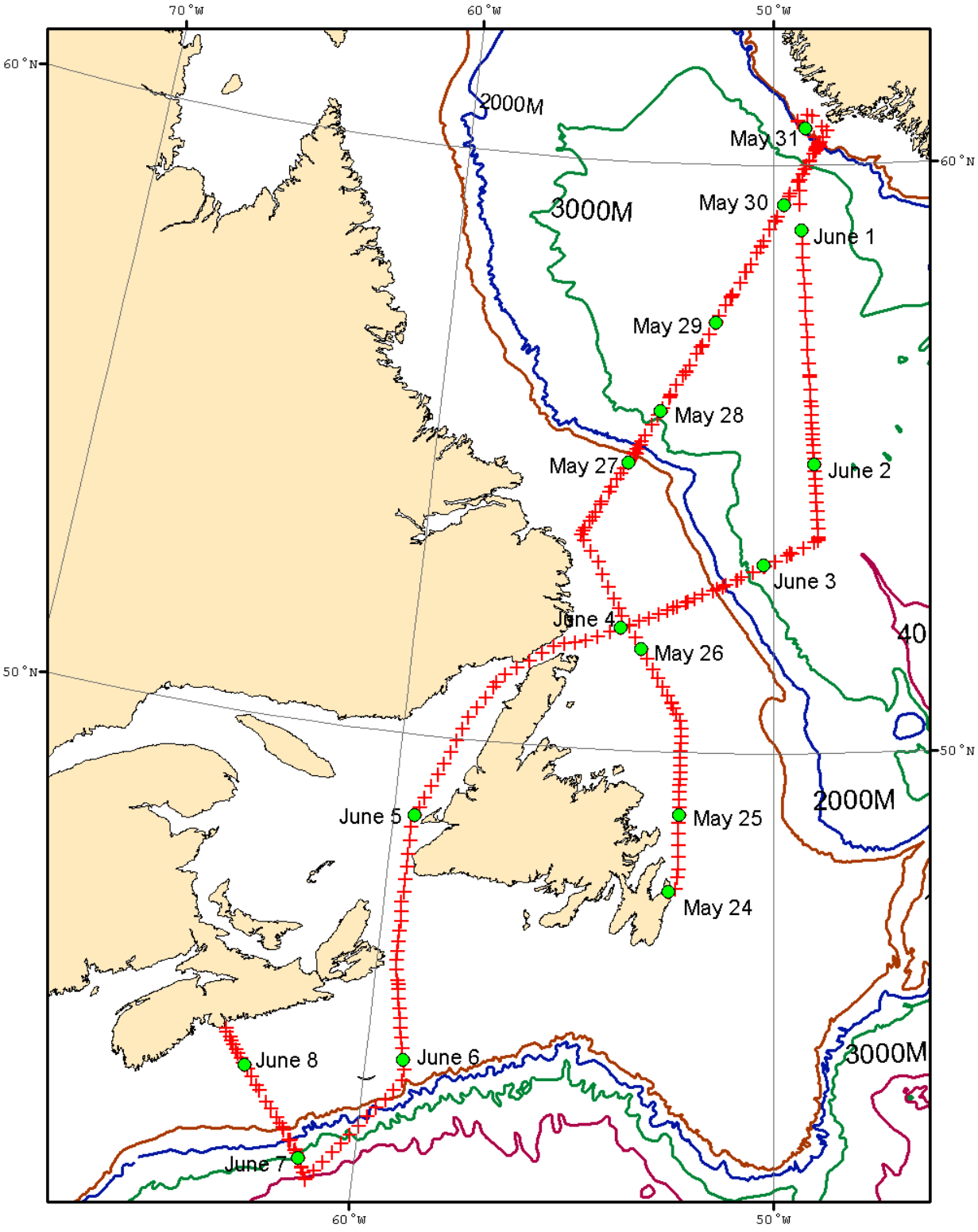


Figure A.2.1 Cruise track for 18HU2006019/1. The date labels indicate the ship's position at 0000Z.

b. Total Number of Stations Occupied

The CTD / ROS station positions are shown in Figure A.2.2. The WOCE Hydrographic Program (WHP) -style stations are all contained in the box defined by 44-61°N and 54-64°W. Table A.2.1 lists the science operations for 18HU2006019.

Along AR7W, the stations were full-depth WHP small volume rosette casts with up to 24 rosette bottles. Water samples were analyzed for CFCs, total carbonate, alkalinity, oxygen, salinity, nutrients (nitrate, phosphate, and silicate), total organic carbon (TOC), and bacteria abundance. Chlorophyll was analyzed at depths less than 200 m at most stations. Samples were collected for ^{129}I (iodine-129) on selected casts.

Cast Type	Number of Operations	Detailed Division	Operation Numbers
Rosette & CTD	32	28 regular AR7W Sites (L3 line) plus Sites 8.5, 25.3, 25.5 and 25.7	see Table A.2.2
	12	7 regular Halifax Line plus sites 5.5, 6.5, 8 – 10	256, 264, 269, 275, 281, 287, 292, 300, 310, 320, 326, 327
	11	Biology Casts not included in other tables	56, 91, 135, 190, 211, 221 (failed operation), 222, 228, 250, 253, 255
	3	Misc. CD01, CD02 and LS	5, 198, 200
	9	L4N Line (3, 4, 5, 5.9, 6.2, 7.1, 8.5,10 and 11)	225, 229, 233, 236, 237, 240, 243, 246, 249
Moorings	2 1	1 recovery, 1 deployment Release test	52, 53 4
Floats	5	APEX floats deployed	68, 114, 192, 213, 226
Biology	108	71 (75 cm 200 micron net tows)	1, 3, 6, 8, 11, 17, 19, 24, 26, 31, 35, 39, 44, 49, 51, 54, 59, 64, 66, 73, 79, 88, 90, 99, 101, 110, 112, 123, 132, 134, 141, 143, 151, 164, 166, 178, 180, 187, 189, 193, 195, 197, 199, 201, 202, 206, 207, 209, 215, 217, 219, 223, 227, 230, 232, 234, 238, 241, 244, 247, 251, 254, 263, 268, 274, 280, 286, 291, 299, 309, 319
		37 (30 cm 64 micron net tows)	2, 7, 12, 18, 25, 32, 36, 40, 45, 50, 55, 60, 65, 74, 80, 89, 100, 111, 124, 133, 142, 152, 165, 179, 188, 202, 210, 216, 220, 224, 231, 235, 239, 242, 245, 248, 252,
Chemistry		^{129}I surface	13, 20, 41, 56, 102, 136, 167, 194, 196, 198, 204
		^{129}I profile	67, 92, 125, 153, 212, 256, 269
Other		358.25 Hrs Ship Board ADCP	No number assigned
	144	XBT Deployments	10, 14 - 16, 21 – 23, 28 – 30, 34, 38, 42, 43, 57, 58, 62, 63, 69 – 72, 76 – 78, 82 – 87, 93 – 98, 103 – 109, 115 – 122, 126 – 131, 137 – 140, 145 – 150, 154 – 163, 168 – 177, 182 – 186, 257 – 262, 265 – 267, 270 – 273, 276 – 279, 282 – 285, 288 – 290, 293 – 298, 301 – 308, 311 – 318, 321 - 325

Table A.2.1 Science operations conducted on 18HU2006019/1.

AR7W Site Number	2006019 Deep Cast Operation Number
1	9
2	13
3	20
4	27
5	33
6	37
7	41
8	46
8.5	48
9	47
10	61
11	67
12	75
13	81
14	92
15	102
16	113
17	125
18	136
19	144
20	153
21	167
22	218
23	181
24	212
25	191
25.3	205
25.5	214
25.7	208
26	204
27	194
28	196

Table A.2.2. AR7W (L3) sites and rosette and CTD operation numbers for 18HU2006019/1.

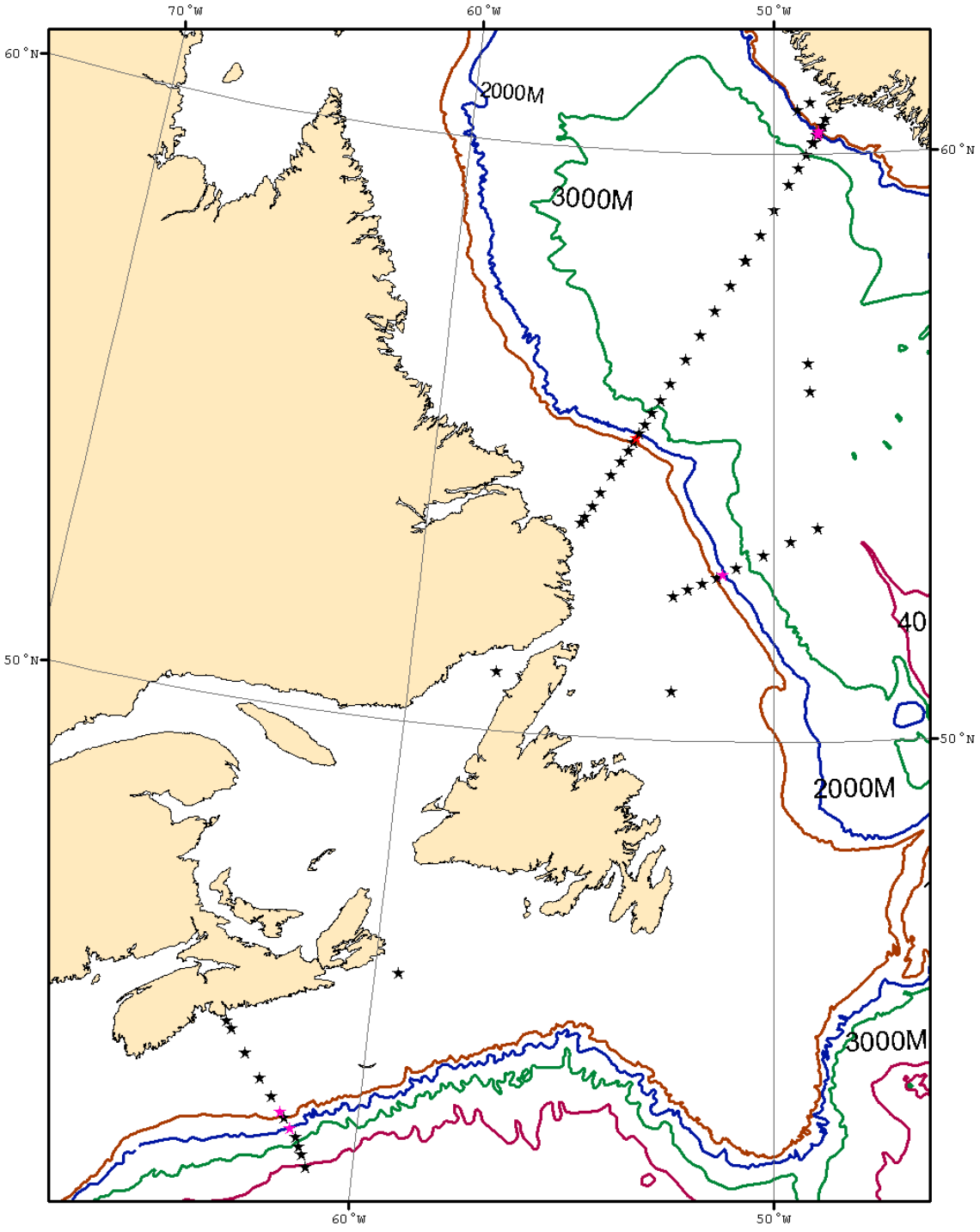


Figure A.2.2 This map shows the station positions for CTD only operations (red-filled stars) and rosette/CTD operations (black-filled star) for Hudson 18HU2006019/1.

Two full depth hydrographic sections were occupied in the Labrador Sea during the 18HU2006019 mission. These survey lines (shown in figure A.2.3 of appendix 1) combined with the Orphan Basin, Laurentian Fan and Halifax lines all occupied within the same four week period, provide a comprehensive assessment of the oceanographic conditions in the Canadian sector of the Atlantic Ocean.

Temperature, salinity and density sections along the L3 and L4 lines are shown in figures A.2.4 – A.2.6 of Appendix 1. A quick comparison of these sections with earlier occupations revealed a further increase in temperature and salinity at the mid depths (Labrador Se water). Salinity increased in the Northeast Atlantic Deep Water (NEADW – salinity maximum between 2500 and 3000 m) and temperature and salinity increased in the near-bottom layer, occupied by the Denmark Strait overflow water (DSOW). These specified changes agree with the changes seen in the DSOW at upstream locations (the UK and German mooring to southeast of Greenland). The 2005 occupation of the L3 line showed the freshest and coldest DSOW since 2002. The 2006 L3 occupation just completed indicates that this fresh and cold mass of DSOW has moved out of the central Labrador Sea. It is worth noting that the measurements at the deep L4 locations revealed fresher and colder DSOW than that found along the L3 line. This supports the expected southerly drift of the anomalous cold and fresh water mass seen in 2005.

The other remarkable tendency seen in these two sections is a slight increase in the NEADW salinities (>34.91 between 2500 and 3000 m) and a general broadening of salinity maximum toward the Greenland slope. This agrees with the predicted increase in the NEADW salinity and increase in the dominance of saltier waters as a part of the large scale response to the weakening of winter convection in the Labrador Sea. Our on-going research revealed a recent increase in the NEADW salinities in the Irminger Sea.

Although the L4 line is only 200-400 km away from the L3 line we can note significant differences in water mass properties. Contrasting with the fresher and colder DSOW at L4, the version of NEAW found at the same locations is saltier than that at L3. This can be regarded as an evidence of one of the suggestions we are making in our study in progress about deflection of a significant portion of NEADW west and than south before it enters the central Labrador Sea. This alteration in the pathway is likely a result of the topographic futures extending from Greenland and Labrador toward the deeper basins (clearly seen between the L3 and L4 sections in figures A.2.7 – A.2.9 of Appendix 1).

A strong mesoscale (425 km) is clearly seen in temperature, salinity and dissolved oxygen profiles. Even if the eddy's cold and fresh center was at least 10 km away from the closest CTD station (as shown in the next section of the report), it has a distinctive anticyclonic circulation penetrating to the bottom. Noteworthy, the eddy found inside the Orphan Basin also had a fresh and cold core; however its rotation was opposite to the eddy seen near the L3 line.

The set of high quality hydrographic sections occupied in the spring 2006 Hudson missions (2006011 and 2006019) to the northwest Atlantic ocean will be used in an observational synthesis on the large scale evolution of the deep and dense overflows entering the North Atlantic across the Greenland-Scotland Ridge (demoted here as NEADW and DSOW).

c. Floats and Drifters deployed

As a contribution to the international Argo project, five Webb Research Corporation Apex profiling floats equipped with Sea-Bird Electronics, Inc. model 41 CTD sensors were deployed, four on the AR7W line and one at the most offshore station on the L4.line Two of the floats deployed on the AR7W line were equipped with Aanderaa Instruments Corporation Oxygen Optode 3830 dissolved oxygen sensors. One of the newer non-Optode floats was configured to do a deep profile immediately after deployment (deep profile first feature). A sixth float that was scheduled for deployment failed a pre-deployment test and was not available for use. Our float inventory is fully committed so no backup was available. Table A.2.3 gives details of the float deployments. Copies of the deployment log sheets are found in Appendix 6.

Apex Float		WMO #	Operation Number	Launch Position		Start Time	Launch Time
Type	SN			Latitude (N)	Longitude (W)		
APEX-SBE	2068	4900682	68	55.590045	-53.64622667	27/05/2006 21:09:00	27/05/2006 22:05:00
APEX-SBE	2069	4900683	226	52.69595167	-48.702615	02/06/2006 11:21:00	02/06/2006 12:34:00
APEX-SBE	2679	4900876	114	57.36539667	-51.781645	28/05/2006 22:01:00	29/05/2006 00:21:00
APEX-SBE-Aanderaa	2688	4900879	213	60.1848	-48.68579833	31/05/2006 10:31:52	31/05/2006 11:35:00
APEX-SBE-Aanderaa	2689	4900880	192	60.296965	-48.58461833	30/05/2006 13:51:00	30/05/2006 15:32:00

Table A.2.3 APEX float deployments on Hudson 2006019.

d. Moorings deployed or recovered

The current meter mooring on the 1000 m depth contour off Hamilton Bank near AR7W station L3-8 was once again serviced on May 27, 2006. Mooring 1555 was recovered successfully under good sea conditions. The RCM8 appeared to have worked properly and all mooring tackle was in good condition. The replacement mooring 1601 was deployed without incident. A post-deployment positioning survey was carried out to provide a precise location for mooring 1601.

Deployment:

M 1601	55 07.2036 N 54 05.4142 W	Standard mooring consisting of one current meter positioned 20m below surface along AR7W on the Labrador Slope (12-month deployment) at 1130 metres.

Recovery:

M 1555	55 07.1772 N 54 05.3113 W	Standard mooring consisting of one current meter positioned 20m below surface along AR7W on the Labrador Slope (12-month deployment) at 1010 metres.

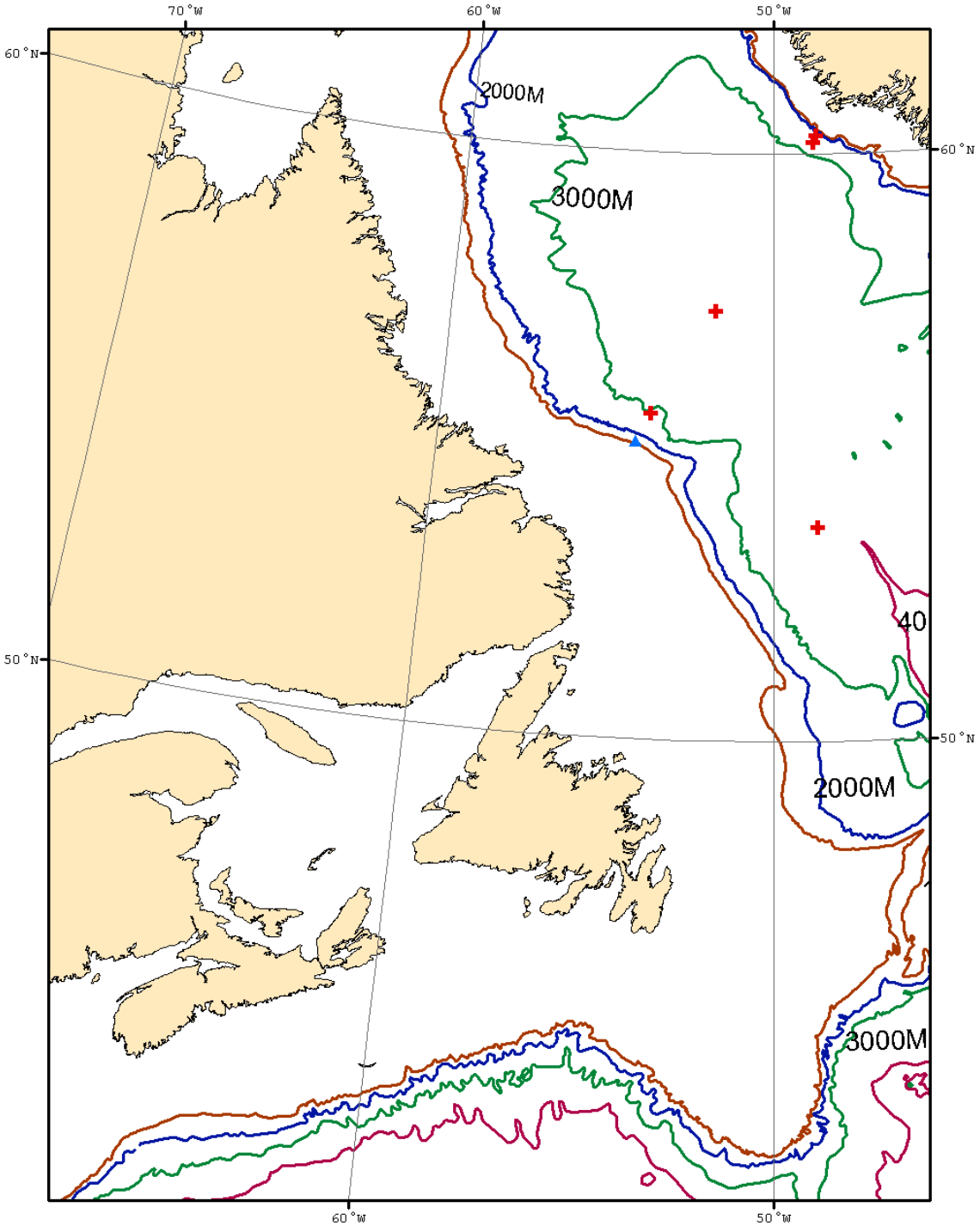


Figure A.2.10 Mooring operation (blue-filled triangle - a mooring was recovered and a new one deployed in the same location) and float deployment locations (red-filled crosses) for Hudson 18HU2006019/1.

3. List of Principal Investigators

Name	Affiliation	Responsibility
Kumiko Azetsu-Scott	BIO Azetsu-ScottK@mar.dfo-mpo.gc.ca	Chemistry program coordination, Alkalinity, CO2, CFCs
Carina Gjerdrum	CWS Carina.Gjerdrum@ec.gc.ca	Sea bird program
Glen Harrison	BIO HarrisonG@mar.dfo-mpo.gc.ca	Associate Senior Scientist, Biological program coordination
Erica Head	BIO HeadE@mar.dfo-mpo.gc.ca	Macrozooplankton distribution, abundance and metabolism
Ross Hendry	BIO HendryR@mar.dfo-mpo.gc.ca	Senior scientist Overall co-ordination
Paul Kepkay	BIO KepkayP@mar.dfo-mpo.gc.ca	Dissolved organic carbon, colloid chemistry and plankton respiration
Bill Li	BIO LiB@mar.dfo-mpo.gc.ca	Pico-plankton distribution and abundance, bacterial abundance and productivity
Ryan Murphy	MUN RMMurphy@mta.ca	Prokaryotic microbial community studies
Robert Pickart	WHOI Pickart@rsp.whoi.edu	Lowered ADCP
John Smith	BIO SmithJN@mar.dfo-mpo.gc.ca	Radioisotope sampling program
Igor Yashayaev	BIO YashayaevI@mar.dfo-mpo.gc.ca	CTD program coordination, XBTs

Table A.3.1. List of Principal Investigators (see Section 7 for addresses).

4.1 Physical - Chemical Program

a. Narrative

This expedition was conducting operations in support of four ongoing scientific initiatives.

Since 1990, Maritimes Science Branch at the Bedford Institute of Oceanography has carried out annual occupations of a hydrographic section across the Labrador Sea. The section was designated AR7W (Atlantic Repeat Hydrography Line 7) in the World Ocean Circulation Experiment (WOCE). This effort continues as a regional monitoring and research program that contributes to the Climate Variability (CLIVAR) component of the World Climate Research Programme (WCRP) and the international Global Climate

Observing System (GCOS). The work also contributes to the international Arctic and Subarctic Ocean Fluxes (ASOF) programme. The occupation of the Labrador Sea section and the recovery of the one Labrador Sea mooring provide a measure of the winter cooling and water mass transformations over the 2005/2006 winter. The resetting of the mooring on the 1000 metre isobath on the Labrador slope continues a 20+ year observation program of the Labrador Current.

Maritimes Region of DFO has designated the AR7W surveys as a core element of our regional ocean monitoring program. As such, they will continue to contribute both to a better scientific understanding of this region and its links to processes in eastern Canadian waters, and to the monitoring mandate of the international Global Climate Observing System.

The second initiative is the continuation of the Labrador Sea project concerned with the natural and anthropogenic carbon cycles. The biological program is designed to characterize the late spring biological processes in the Labrador Sea and its shelf regions and is discussed in a later section of this document. The physical/chemical oceanographic program observes nutrients, total carbonate, alkalinity, and chlorofluorocarbons (CFCs) over the entire water column in order to document the vertical transport of carbon via winter convection in the Labrador Sea and changes in carbon storage in the deep waters of the North Atlantic.

DFO chemical and biological research programs associated with the AR7W surveys have contributed to a better understanding of the carbon cycle within the international Joint Global Ocean Flux (JGOFS) research program and the Canadian program on Enhancement of Greenhouse Gas Sinks (EGGS).

The third initiative is to observe the physical and chemical parameters at the Halifax Section fixed-station monitoring site in support of DFO's Atlantic Zonal Monitoring Program (AZMP). Additional stations in the offshore zone to depths of 4000 m were made as a pilot version of a possible enhancement of this monitoring effort.

The fourth initiative was to deploy profiling floats as part of Canadian Argo, a contributor to the international Argo Project. Five Apex profiling floats were deployed in the Labrador Sea.

b. Radioisotope Sampling Program **John Smith**

Water samples were collected for ^{129}I from a near surface rosette bottle at 11 stations on the L3 (AR7W) line. Full depth sampling for ^{129}I was carried out at five stations on the same section and two on the Halifax line. See table A.2.1 for the list of operations during which ^{129}I was sampled.

4.2 Biological Program

a. Narrative

The biological program conducted as part of cruise 2006019, with some modifications, was a continuation of studies began in 1994 to describe the large-scale (spatial and temporal) variability in plankton biomass, productivity and biogenic carbon inventories in the Labrador Sea.

The program has consisted of essentially four elements:
1) a phytoplankton biomass/primary productivity program conducted by Jeff Anning (for Glen Harrison),
2) a microbial program conducted by Tim Perry (for Bill Li),
3) a mesozooplankton program conducted by Les Harris (for Erica Head), and
4) a dissolved organic carbon program conducted by Jay Bugden (for Paul Kepkay)

An additional program, investigating the relationship between (prokaryotic) microbial community structure and its ecological and biogeochemical function in the Labrador Sea, was conducted by Ryan Murphy, a graduate student at Memorial University working under the supervision of Professor Richard Rivkin.

The ultimate aim of these studies is twofold:
1) to provide a description of the inventories in and export of biogenic carbon from the Labrador Sea, their turnover rates and variability in space and time as part of Ecosystem Research Division's (ERD) continuing climate-studies and
2) to provide a description of plankton life-cycles and productivity in the Labrador Sea and its influence or contribution to ecosystems downstream in support of ERD's ecosystem-related research.

In addition to the Labrador Sea study, phytoplankton, mesozooplankton and nutrient samples were collected along the Halifax Section in support of ERD/OSD's obligations to the Atlantic Zone Monitoring Program (AZMP).

A pelagic bird survey was carried out by Carina Gjerdrum. She is a wildlife biologist with Environment Canada's Canadian Wildlife Service (Dartmouth, NS) working on seabird issues. The goal of this survey was to gather data on the offshore distribution and abundance of marine birds in order to identify and minimize the impacts of human activities at sea on birds. These data will provide critical, and currently unavailable, information for environmental assessments for offshore developments, and will help identify areas where birds are at high risk from oil pollution, and other human activities.

b. Zooplankton Sampling — L. Harris / E. Head

The zooplankton sampling is part of an ongoing program, the aim of which is to investigate the distribution, abundance and life history of the major zooplankton groups

found in the Labrador Sea and its associated shelf systems. Particular emphasis is placed on the copepod species of the *Calanus* genus, which dominate the zooplankton in this region.

Vertical net tows were taken at 53 stations (9 on the Halifax Line, 31 on the L3 line, 8 on the L4 line, 2 on the CD line and 3 transit locations). At all stations, tows were made from 100 meters to the surface using a 200 μmeter ring net, except on the Halifax Line where tows were from 1000 meters or the bottom, whichever came first. An additional tow was made using a using a 76 μmeter ring net at 27 stations on the L3 line, 7 stations on the L4 line and 3 at transit locations. See Figure A.4.2.1 below for station locations where nets were used.

c. Measurements Of Copepod Reproduction Rates **L. Harris / E. Head**

Egg production rates of *Calanus finmarchicus*, the dominant copepod species, were measured at 11 stations on the L3 Line, 2 stations on the L4 Line and Transit_01.

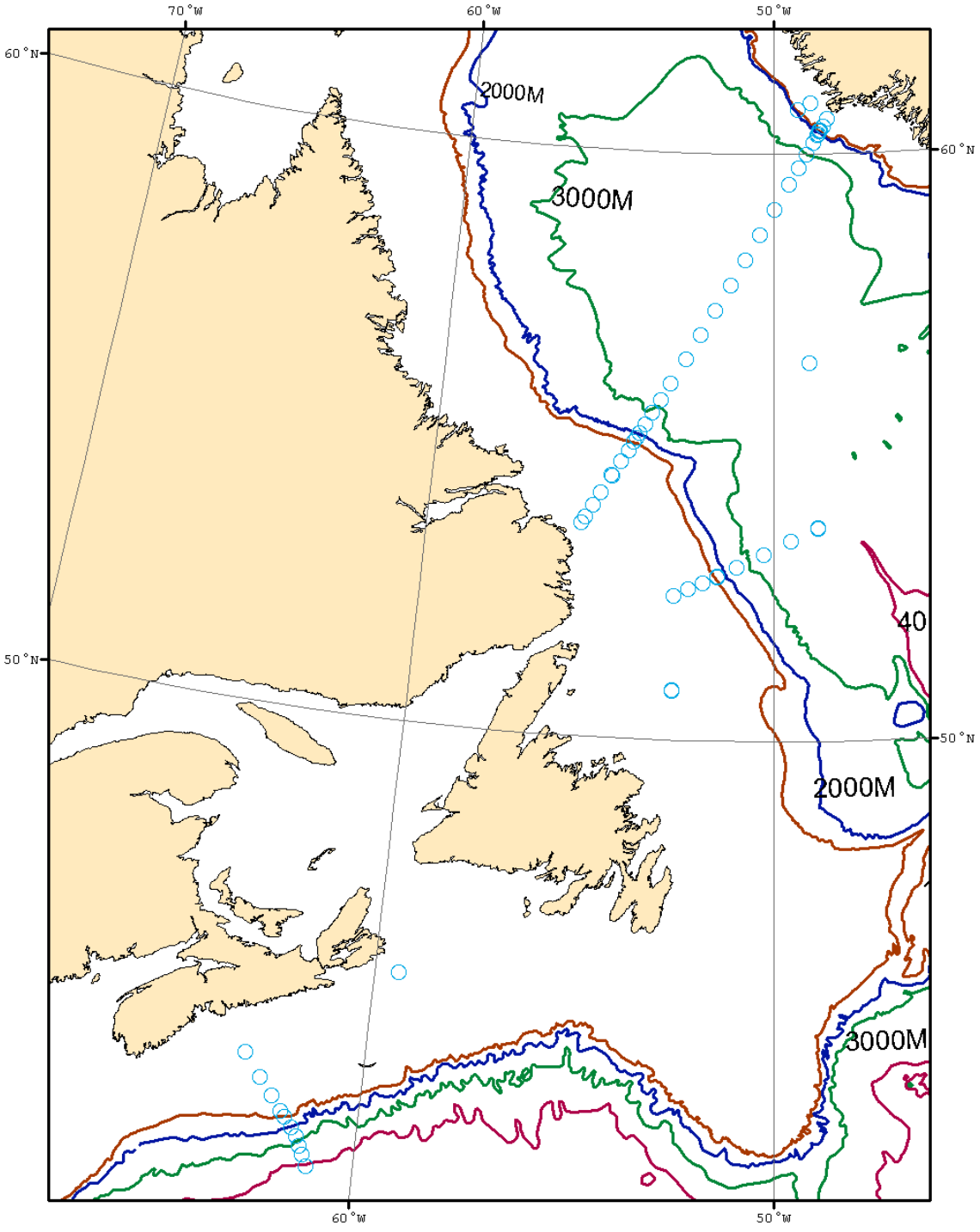


Figure A.4.2.1 Net tow (blue open circle) locations for 18HU2006019/1.

d. Total Organic Carbon (TOC) **Jay Bugden / Paul Kepkay**

In order to better understand the cycling of carbon in the Labrador Sea, it is necessary to examine the pool of total organic carbon (TOC). Obtaining a profile of TOC concentration in the water column can help determine the fate of organic carbon. Elevated concentrations of TOC at depth are indicative of transport of carbon to the deep ocean, which basically removes it from the effects of biological re-mineralization. This can result in the long term storage of organic carbon in the deep ocean. Such information can be applied to models that track the fate of carbon in the environment and its potential effects on climate change.

During CCGS Hudson cruise 2006-019 TOC depth profiles were also collected from all stations of the AR7W line as indicated in the table below.

Station	TOC Profile
AR7W site 1	X
AR7W site 2	X
AR7W site 3	X
AR7W site 4	X
AR7W site 5	X
AR7W site 6	X
AR7W site 7	X
AR7W site 8	X
AR7W site 9	X
AR7W site 10	X
AR7W site 11	X
AR7W site 12	X
AR7W site 13	X
AR7W site 14	X
AR7W site 15	X
AR7W site 16	X
AR7W site 17	X
AR7W site 18	X
AR7W site 19	X
AR7W site 20	X
AR7W site 21	X
AR7W site 22	X
AR7W site 23	X
AR7W site 24	X
AR7W site 25	X
AR7W site 26	X
AR7W site 27	X
AR7W site 28	X

Table A.4.2.2 TOC sampling on CCGS Hudson cruise 2006019.

e. Primary Production Measurements **Jeff Anning / Glen Harrison**

Water samples for phytosynthesis-irradiance (P-I) experiments were collected from the rosette at 10 stations. For each incubation experiment, 33 aliquots were inoculated with ^{14}C of sodium bicarbonate and then incubated at in situ temperatures at 30 light levels (+ 3 dark bottles) for approximately 3 hours. At the end of the incubation period the cells were harvested onto GF/F glass fibre filters for later counting in a scintillation counter. On three occasions (transit stations), parallel P-I experiments from a single depth were done using the stable isotope 13C instead of the radioisotope, for comparison. Duplicate chlorophyll, duplicate particulate organic carbon, one HPLC, and one Absorption Spectra sample were collected for each incubation experiment. At stations L3_01, L3-09, L3-14, L3-18 and L3-24, additional samples for taken for particulates at 2-9 selected depths (surface to bottom) for analysis of stable isotope abundances of ^{13}C and ^{15}N back at BIO to evaluate the capabilities of ERD's new isotope mass spectrometer.

Station	Event	Lat.	Long.	Date	Time	Depth	ID
CTD Test	5	50.857	-52.787	"May 25 2006"	"17:48:57"	4	298742
L3-01	9	53.683	-55.557	"May 26 2006"	"11:27:33"	31	298750
L3-01	9	53.683	-55.557	"May 26 2006"	"11:31:23"	2	298754
L3-04	27	54.224	-55.038	"May 26 2006"	"17:40:25"	31	298790
L3-04	27	54.224	-55.038	"May 26 2006"	"17:42:16"	5	298795
L3-09	56	55.263	-53.979	"May 27 2006"	"14:32:15"	20	298881
L3-09	56	55.263	-53.979	"May 27 2006"	"14:33:45"	4	298884
L3-14	91	56.537	-52.679	"May 28 2006"	"10:19:08"	30	298989
L3-14	91	56.537	-52.679	"May 28 2006"	"10:21:10"	3	298993
L3-18	135	58.221	-50.869	"May 29 2006"	"08:53:32"	31	299100
L3-18	135	58.221	-50.869	"May 29 2006"	"08:55:54"	3	299104
L3-25	190	60.291	-48.550	"May 30 2006"	"13:05:31"	29	299235
L3-25	190	60.291	-48.550	"May 30 2006"	"13:07:35"	3	299239
L3-24	211	60.179	-48.677	"May 31 2006"	"09:00:43"	30	299326
L3-24	211	60.179	-48.677	"May 31 2006"	"09:02:38"	3	299330
Bio 1_JUN	222	56.021	-48.877	"Jun 01 2006"	"14:27:39"	30	299388
Bio 1_JUN	222	56.021	-48.877	"Jun 01 2006"	"14:29:18"	2	299392
L4-10	228	53.456	-49.504	"Jun 02 2006"	"15:40:36"	29	299427
L4-10	228	53.456	-49.504	"Jun 02 2006"	"15:43:03"	3	299431
L4-05	243	52.732	-52.000	"Jun 03 2006"	"12:53:01"	20	299534
L4-05	243	52.732	-52.000	"Jun 03 2006"	"12:54:28"	3	299537
Bio 4_JUN	250	51.029	-57.604	"Jun 04 2006"	"11:12:03"	23	299573
Bio 4_JUN	250	51.029	-57.604	"Jun 04 2006"	"11:14:44"	2	299577
HL-10	255	42.029	-61.078	"Jun 06 2006"	"14:13:48"	30	299599
HL-10	255	42.029	-61.078	"Jun 06 2006"	"14:15:21"	2	299603

Table A.4.2.3. Photosynthesis/Irradiance incubations were conducted at the above stations.

f. Bacterial Abundance and Production of Microbial Plankton **Tim Perry**

At every depth a sample was collected for bacterial counting by flow cytometer. Duplicate chlorophyll samples were collected in the surface waters (100m to surface) and a single sample for both HPLC and Absorption spectrum analysis were collected from the surface.

Water samples were collected from all depths at 7 stations and incubated for between 1-3 hours after inoculation with 3H labeled leucine. The cells were collected by centrifugation and prepared for scintillation counting back on shore.

Station	Event	Lat.	Long.	Date	Time
L3-01	9	53.683	-55.557	"May 26 2006"	"11:27:33"
L3-08	46	55.110	-54.133	"May 27 2006"	"02:32:58"
L3-14	91	56.537	-52.679	"May 28 2006"	"10:19:08"
L3-24	211	60.179	-48.677	"May 31 2006"	"09:00:43"
L3-27	194	60.448	-48.361	"May 30 2006"	"17:16:53"
L4-10	228	53.456	-49.504	"Jun 02 2006"	"15:40:36"
L4-05	243	52.732	-52.000	"Jun 03 2006"	"12:53:01"

Table A.4.2.4. Microbial production incubations were conducted at the above stations.

g. Prokaryotic Microbial Community Studies **Ryan Murphy**

This project consisted of two sampling schemes to investigate the ecosystem processes of phylogenetically-defined prokaryotic populations. These samples make up the first half of my master's project in which I will optimize the qPCR technique to detect and quantify members of the Euryarchaea, SAR11 and SAR 86 clusters, β-proteobacteria, and the CFB group.

The first sampling scheme used samples collected from 1-2m, 10m, 20m, and 30m on the AR7W line to measure stratification of prokaryotic community structure with qPCR. The second sampling scheme used water samples collected from the surface (1-2m) layer of 7 stations—mostly on the AR7W line—and incubated for 96 hours as part of nutrient enrichment, temperature-shift, and grazing experiments. Samples for bacterial abundance (Acridine Orange: t=0, 24, 48, 72, 96 and FCM: t=0, 24, 96), and community structure (qPCR: t=0, 96 and CARD-FISH: t=96) measures were collected from these experiments for analysis at the OSC in Logy Bay.

5. Major Problems and Goals Not Achieved

No major problems were encountered and all scientific goals were achieved. The ship's speed was reduced during several periods of low visibility due to fog, but operation on

three engines during extended transits in favourable conditions made up for any time lost. The absence of coastal sea allowed a full occupation of the AR7W line, the 17th annual realization of this section by DFO Maritimes Science. Two inshore stations on the neighbouring Cape Desolation line on the West Greenland shelf and slope were also occupied. Favourable weather and lack of any major equipment problems allowed most of the planned contingency work to be completed. The L4 line off the northern Newfoundland slope was surveyed with nine CTD stations. The full Halifax Line was occupied and enhanced with five additional stations, including three in deeper waters offshore.

6. Other Incidents of Note

The AutoAnalyser used for nutrient analyses failed just before the start of the Halifax Line due to a short circuit in one of the colorimeters. Samples from the Halifax Line were frozen for analysis on shore.

7. List of Cruise Participants

Name	Responsibility	Affiliation
Jeffrey Anning	Biological	ERD, BIO
Carol Anstey	Nutrients, Oxygens	ERD, BIO
Andres Antico	Winch Room, XBT	McGill
Kumiko Azetsu-Scott	Scientist, Carbonate, Alkalinity	OSD, BIO
Richard Boyce	Salts, Mooring	OSD, BIO
John (Jay) Bugden	TOC Levels	ERD, BIO
Michael Dunphy	Winch Room	DAL
Carina Gjerdrum	Sea bird observer	EC, CWS
Leslie Harris	Biological, Net Tows	ERD, BIO
William Glen Harrison	Associate Chief Scientist, Biological	ERD, BIO
Adam Hartling	Winch Room	OSD, BIO
Ross Hendry	Chief Scientist	OSD, BIO
Jeffrey Jackson	Data management, Computer Room	OSD, BIO
David Kellow	Oxygens	OSD, BIO
Ryan Murphy	Biological	MUN
Richard Nelson	CFCs	ERD, BIO
Timothy Perry	Biological	ERD, BIO
A. E. Friederike Prowe	Carbonate, Alkalinity	DAL
Brian Robinson	CFCs	BDR
Robert Ryan	CTD Tech., Winch Room	OSD, BIO
Igor Yashayaev	Scientist, Computer Room	OSD, BIO

BIO Bedford Institute of Oceanography
PO Box 1006
Dartmouth, NS, Canada, B2Y 2A4

BDR	BDR Research Ltd. Box 652, Station 'M' Halifax, NS, Canada, B3J 2T3
EC, CWS	Environment Canada, Canadian Wildlife Service 45 Alderney Drive Dartmouth, Nova Scotia, Canada, B2Y 2N6
DAL	Dalhousie University Halifax, NS, Canada, B3H 4R2
McGill	McGill University 845 Sherbrooke St. W. Montreal, Quebec, Canada, H3A 2T5
MUN	Memorial University of Newfoundland St. John's, NL A1C 5S7 P.O. Box 4200, Canada

B. UNDERWAY MEASUREMENTS

1. Navigation and Bathymetry — Jeff Jackson

The navigation system onboard CCGS Hudson consists of a differential GPS receiver and AGCNAV. The receiver is one of many NMEA feeds into a multiplexer that provides all the NMEA strings to a PC on the bridge. The PC, which is running AGCNAV software, then rebroadcasts the NMEA strings to distribution units in the computer room, which provide 16 output lines for the working labs. The resulting broadcast navigation strings are at about 1 Hz. The navigation data are then logged at specified intervals on a PC. For this cruise the navigation was logged every second.

AGCNAV is a PC based display and waypoint setting software package, developed at the Atlantic Geoscience Centre at BIO. This software graphically displays ship position, waypoints, course, speed, etc. to the various science working areas.

The echo sounder system used for collecting bathymetric data at station locations consisted of a Raytheon Line Scan Recorder, Model LSR 1811-1 (serial number A101) connected to a 12kHz transducer. The transducer beam width is 15 degrees. The sweep rate of the record was adjusted throughout the course of data collection to aid in identifying the bottom signal. One transducer is positioned on a Ram that can be lowered or raised depending on conditions. When the ram is up, the waterline to transducer offset is 6 m. When the ram is down, the offset is 8 m.

2. Vessel Mounted Acoustic Doppler Current Profiler — Murray Scotney

The Hudson was equipped with a hull mounted RDI Acoustic Doppler Current Profiler (ADCP). The transducer (serial number 177) had VM ADCP electronics (serial number 172). Logging, using Transect software on a 486 PC, was started on May 24 at 1345 Z leaving the St. John's Harbour.

The configuration used for logging resulted in 5-minute averages in 4 meter bins. The averaged data are stored to disk and backed up every few days. ADCP logging was stopped on June 9 at 12:04 Z in Halifax Harbour.

3. Continuous Flow Multisensor Package (CFMP) — Jeff Anning

Water from approximately 4m was continuously pumped to the forward lab. The temperature, conductivity and fluorescence were measured and logged every 30 sec. The temperature and conductivity were measured with Seabird sensors and the fluorescence by a Wetlabs flow through fluorometer. Incident Photosynthetically Active Radiation was measured with a Li-Cor Spherical Quantum Sensor and this data was merged with the sea

water parameters. Exact time and positions were provided by a Northstar GPS and logged with the other data.

4. XBT measurements and high-resolution mapping of the thermal structure of the upper layer

Igor Yashayaev

Expendable Bathythermographs were routinely deployed during the HUD2006019 missiong. See Fig. B.4.1 for a map with the XBT drops indicated. We used three different models of XBTs: *Sparton* T5, *Sippican* T7 and *Sippican* T10. T5s are capable of measuring to maximum depths of 1900 m at the cruising speed of 6 knots, T7s record temperature to 800 m at the cruising speed 15 knots and T10s to 200 m. The vertical resolution of the measurements was about 0.6-0.8 m. There were 24 T5, 45 T7 and 27 T10 XBTs launched during the cruise (Table A.2.1 lists the operation numbers when these were deployed).

The XBT and CTD composite transect features a strong cold mesoscale eddy centered about 10 km to the west of the closest CTD station. The top 1200 m of this eddy are filled with well mixed relatively cold and fresh water. The XBT AR7W section provides a detailed account of smaller scale irregularities potentially introducing sampling error to the estimates based on CTD profiles only. In addition the XBT profiles help to increase spatial resolution near the ocean fronts and strong currents. In the eastern part of the section, the XBT profiles help to interpret sparser CTD measurements – the cold structure found above the warm and salty core off the Greenland slope is a filament, patch or shallow eddy formed by the fresh and cold shelf break current known as the West Greenland Current.

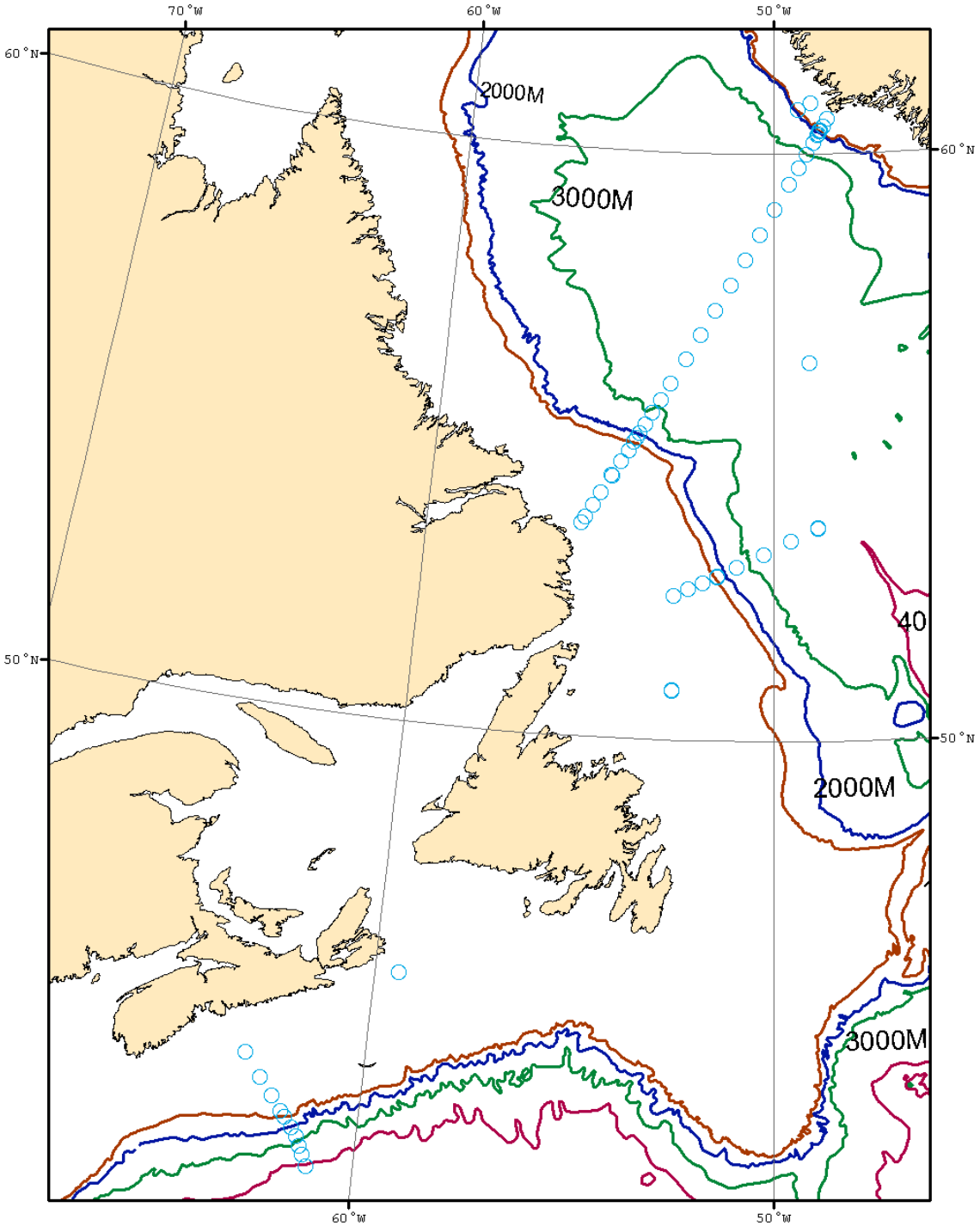


Figure B.4.1 XBT drop sites (indicated by blue hollow circles) during HUD2006019.

5. Thales Navigation ADU5 Attitude Determination Unit — Adam Hartling

Thales Navigation ADU5 Attitude Determination Unit, Model # 800952

The ADU5 provides accurate real time heading, pitch, roll, velocity and three dimensional position measurements at data rates of up to 5Hz.

The ADU5 unit incorporates four GPS receivers mounted in a fixed portable antenna array provided by Thales Navigation. The array provides 1m separation between the GPS receivers.

The Antenna array was mounted on the wheelhouse deck behind the mast approximately 1.5m above the deck. The array is mounted with antenna 1 to the bow of the ship. Antenna one and two must be parallel to the centerline of the ship. The vertical pipe supporting the array was bolted to the deck with one angled support to ensure a rigid platform.

Four separate coaxial cables connect the ADU5 Unit to the GPS antennas. The cables were run from the antenna array across the deck and connected to the ADU5 unit mounted in the computer room.

Measurement data is output from two RS-232 ports capable of baud rates up to 115200. Port A and Port B are identical except for Pin 9. Port A pin 9 functions as a 1pps output. Port B pin 9 functions as an event trigger input.

The ADU5 unit requires a 10-29V DC regulated power supply. Power to the unit was supplied with a 6200B HP bench top dc power supply set at 15V DC.

A PC located in the computer room was connected to the ADU5 unit. Two com ports were used to connect to both Port A and Port B on the ADU5. Communication with the unit was accomplished using the Thales Navigation EVALUATE software package.

The attitude determination is calculated based on differential carrier phase measurements between the four receivers. An initial calibration procedure is used to calculate the relative positions of the receivers for each installation. The calibration process is time consuming (An hour minimum if conditions are good) and requires at least six GPS satellites to be continually available during the logging process. After this procedure the calibration data is downloaded to the ADU5 unit. Calibration is performed using CalibADU Software supplied with the ADU5 unit. Static calibration was completed while along side in St. Johns. Dynamic calibration was attempted previously while under way and was found to be error prone and required over a day of data logging to obtain suitable data. This is attributed to the continual motion of the ship in conjunction with the mast and other fixtures on the wheelhouse deck causing temporary loss of lock.

Error in the pitch and roll calculation was seen to increase in rough weather. This may be a result of the environment on the wheelhouse including the mast and other reflective objects.

Using The EVALUATE software package data was logged at a 1hz rate from St. Johns to the end of the AR7W Line. Logging was implemented using the standard data strings required by the EVALUATE software. Both Raw Data and NMEA standard outputs were recorded. New files were created every 1000sec requiring approximately 730KB per file, or 447MB in total.

Raw Data	AT2 : Attitude, Flags, PDOP data
NMEA Output	POS : Position message SAT : Satellite information message SA4 : Satellite status message

Identical attitude and position data was also collected for the L4 Line.

Data logging was also attempted at rates up to 5Hz using the EVALUTE software. In general logging was unreliable due to the poor performance of the software package. The desired output would also be changed by the software if any of the real-time virtual instruments or displays were selected.

To allow experimentation with data formats and output rates the EVALUATE software was connected through COM1 to PORT A of the ADU5 unit. Hyper-Terminal was connected through COM2 to PORT B. Using the EVALUATE terminal commands were sent to the ADU5 unit to modify the output stream on PORT B. The PORT B output could then be logged and monitored using Hyper-Terminal. Hyper-Terminal does not feature a convenient means of sending commands. The use of EVALUATE on PORT A provided a very user friendly solution.

Output rates of 5Hz were successful using the Hyper-Terminal software at baud rates of 9600 and 115200. Hyper-Terminal does not allow new data files to be created at regular user defined intervals. Data was logged using standard NMEA outputs. 15 hours of logging required approximately 67MB of disk space.

PAT : Position and attitude message
ZDA : Time-Date Message
POS : Position Message

To this point the performance has only been investigated using ASCII output messages. Binary output is also available and may be used in the future for data output to an ADCP deck unit. No problems are predicted for this application concerning the ADU5 receiver.

References

Thales Navigation, ADU5 Operation and Reference Manual, 2004

6. Meteorological observations

The ship's crew logged routine reporting of meteorological variables.

7. Atmospheric Chemistry

There was no atmospheric chemistry program.

C. HYDROGRAPHIC MEASUREMENTS - DESCRIPTIONS, TECHNIQUES AND CALIBRATIONS

1. CTD Measurement — Igor Yashayaev

a. Description of the Equipment and technique

The CTD measurements were made with a standard SEABIRD model 11 Plus deck unit and model 9 Plus CTD equipped with two temperature sensors, two conductivity sensors, a paroscientific digiquartz model 410K-105 pressure sensor, two dissolved oxygen sensors, an altimeter sensor, par/irradiance sensor and a fluorometer sensor. All but the pressure sensor are mounted in one of two ducts through which separate pumps pull seawater. Hence the water flow past the actual sensors is independent of the lowering rate. This simplifies the data processing considerably.

The sensors used for the various Systems and the sensor arrangement for each station is listed below.

BIO System Number	Sensor	Model	Serial Number
8	Temperature	3-02/F	03P2129
	Conductivity	4-02/0	041730
10	Temperature	3-02/F	03P2303
	Conductivity	4-02/0	041874

Table C.1.1. System numbers and sensor serial numbers.

Model	Serial Number
SBE43	430133, Cal. 21-Jan-2006
SBE43	430042, Cal. 29-Dec-2005

Table C.1.2. Oxygen sensors used during 2006019.

BIO Deck Unit Number	Model	Serial Number
3	11 plus	11P7032-0267
2 (spare, never used)	11 plus	11P5676-0243

Table C.1.3. Seabird deck units for 2006019.

BIO CTD Probe Number	Model	Serial Number	Pressure Sensor
6	9 plus	MOD12P-0362	69009

Table C.1.4. Seabird CTD units for 2006019.

Stations	Circuit	Probe	Pressure	Temp.	Cond.	Oxygen	Pump
All	Primary	6	6	8	8	430133	051775
	Secondary			10	10	430042	051776

Table C.1.5. CTD and sensor configurations used during 2006019.

Instrument	Serial Number
SBE Carousel	3215631-0165
Pinger	Unknown
Lowered ADCP	1576
Irradiance	SPQA280-LI-193SA/0002-PN90310-CH1
Fluorometer	088172
Altimeter	222

Table C.1.6. Other instrumentation on the rosette frame.

The Seabird CTD was mounted vertically within a custom designed and built CTD/Rosette frame. All the pressure cases as well as the sample bottles are mounted vertically to improve the package's stability as it descends through the water column. In the centre of the frame is an aluminum tube, which contains at its upper end a Seabird Carousel 24 bottle rosette unit. The frame itself is subdivided into four quadrants. In one quadrant is a RDI 150 kHz Broadband ADCP in a shortened pressure case. In the next quadrant is the pressure case for the Seabird CTD and fluorometer. The third quadrant contains the battery pack for the LADCP, the Benthos altimeter and a General Oceanics model 6000 12 kHz pinger unit. The last quadrant contains the dual CTD sensors and pumps.

b. Sampling Procedure and data processing techniques

The rosette frame and CTD were deployed with a lowering rate of 60 meters/min (40 meters/min in the upper 200 meters). The package was recovered at a rate of 75 meters/min depending on the wire tension.

The CTD data is recorded onto disk by a PC computer using SEABIRD Seasave for Windows. Processing was conducted using Seasoft Version 4.999 software. IMS software was used for communication with the winch operator and for providing CTD readout to the metering block display.

After each station we process the recorded data files (raw data – *019a###.dat*, instrument configuration - *019a###.con*, header file - *019a###.hdr*, bottle position file containing scan of the records when each bottle was tripped - *019a###.bl*) to create 1 and 2 dbar processed data files and other CTD-derived files designed for specific tasks, like the *.qat* files, which are based on the rosette summary files merged with unique for each bottle trip identifiers of sea water samples.

All the raw and processed data files associated with the station are then transferred to the ship's file servers for archive and subsequent access and distribution to various users on the vessel.

Over the past ten years we developed, tuned and used a set of processing scripts to generate high quality CTD profiles during and after WOCE and CLIVAR cruises (*processing scripts and algorithms of additional modules are available from Igor Yashayaev*). This processing was executed in Command Prompt window (MS-DOS-compatible) and provided flexible capabilities for multiple file processing, producing up and down trace fully processed profiles. It also provided operational stability avoiding processing errors caused by insufficiency in file structure, etc. However, with Seabird Electronics switching to windows based processing and trying to take advantage of a better resource management provided by Windows, the CTD support group (BIO) has developed a Windows based CTD data processing system. The ship board version of this system that will be used as the BIO standard uses our MS-DOS version as its prototype and a model. We worked in contact with the informatics support group providing this development to accommodate all of our processing needs in this system and provide an efficient and reliable working environment. The Windows based processing system that was used in 2006-011 and 2006-019 Hudson missions was released shortly before the cruises and installed on the CTD acquisition and processing computer. It was routinely used through both trips for after-station processing and batch reprocessing. There were many comments and suggestion brought up in the course of operations.
The major inconveniences of the existing package are:
1) Redundancy in the multiple windows and menu collections, causing the operator to repeat the same confirmations and filling up the same queries with the same answers; the windows should be redesigned / restructured to provide simplicity and logic.
2) Inability to “memorize” the working pathways – working on the same project implies that we use the same folder, use the same file with sample IDs, I would suggest to improve a system of hints – e.g. use some predefined names or extensions for first bottle sample Ids – if the file exists and there is a sample ID typed in already – provide automatic retrieval of such, would be nice to have an *.ini* or *.cfg* or other configuration or setup files remembering last station processed. Also if the system can find newer data files then they show up into the processing list or scan the folder of completed files and check which are yet to be processed. This would add some intuitive intelligence to the system, save time and provide a neat way to control accomplished tasks.
3) I didn’t like the instrument configuration on the first panel – this file has nothing else but sensor settings and we have a *.con* file supplied with each data file. It is an unusual case when the processing will be done with some external *.con* file when there is a real

file accompanying each *.dat* file – sometimes we simply don't have this one for all *.con* files. The other point is that we usually store this group-specific *.con* outside of the main data folder, so you need to switch folders at each query – this is time consuming and you must concentrate every time so to not make mistakes.
3) Its inability to mix different configurations of CTD sensors in the same batch process, even if it may be possible this is a big "NO" in the system simply because you need to enter a specific *.con* file at the start of each session. It is kind of tricky to tell it to use sensor systems 9 & 10 for all stations but some have different configurations.
4) We had a station when the CTD connection shorted and so the cast stopped before we reached the bottom; so only the down trace was produced. The default file version caused an error, so I had to manually turn off the up-cast processing part. It would be nice to implement more flexible conditional logic.
5) The system sometimes froze – the cause was unknown – after restart it worked fine on the same file.
6) Leave the "Zip file" option unchecked as the default.
7) Very slow file exchange – in the MS-DOS version it was never an issue.
8) Redundant confirmation buttons appear in the middle of processing.
9) Text box – I never read it and I am not sure if anybody read it – I am not saying we don't need it – just put it on a button somewhere.
10) Files are not removed from CTDDATA.
11) Most of the checkboxes can be hidden under "options" button – the whole process can be well places at the same level with buttons for tuning up Seabird and BIO modules.
12) Oxygen sensor delay times are not 5 seconds – my crude estimate is close to 8.
There were other comments, some of which I forgot but will provide as soon as recall. There are definite advantages in the system – but for now we want to boil it down to the level when the processing can be done easy, quickly and somehow in a more intuitive way – I am very enthusiastic about it and put trust into it – the fact that I never considered switching back to quick and simple DOS talks for itself.

c. Pre-mission tune-up of the CTD sensors

There are two types of coefficients used in instrument configuration files – one is sensor specific supplied by Seabird Electronics and applied to raw frequency and/or voltage readings (I call these hardware coefficients). The other set of coefficients is determined by external processes affecting the sensors – aging, drift, pressurizing, etc. (I call these dynamic coefficients). Although there is no strict separation between these groups (if we send a sensor back to Seabird they recalibrate it and derive new hardware coefficients – turning optimal slope and offset to 1 and 0), I only play with the dynamic coefficients. All coefficients used to calculate CTD physical values from sensors readouts are stored in stations specific .con files and can be easily viewed or change by using *Seacon*. Before I accumulate enough values water sample salinity, I use the previous history of laboratory and in-situ calibrations. Using most recent laboratory calibrations and coefficients determined for the previous year data I determine the values for slope and offset in each sensor reading and apply this numbers directly to the *.con* files.
The following table and screenshot are examples of output of the program that I developed for handling laboratory calibrations.
System 9 conductivity sensor failed during 2006-011 we decided to replace it with system 8. Since we don't have consistent in-situ trial for this system (8) I used the slope and offset values based on laboratory calibrations. For system 10 I used the slope and offset valued that were found as the best choice for 2005 data processing.

Output of Laboratory Calibration management and analysis software (sensors' statistics):

```
--------------------------------------------------------------------------------
  Request #9 of 20-May-2006, 17:14:30
  C sensor #8
  Calibration History:    2005 - 2006
  C CTD values range:     2.74 - 4.83
  C Bath-CTD values range: 0.0014 - 0.0035
--------------------------------------------------------------------------------
  File_Name, YYYY, MM, ##,    Slope,   Offset,     Mean,      StD,   Median
2005_MAR_S08, 2005,  3, 16,  0.000929, -0.001031,  0.002198,  0.000689,  0.001992
2006_JAN_S08, 2006,  1, 16,  0.000993, -0.001153,  0.002270,  0.000727,  0.001968
--------------------------------------------------------------------------------


--------------------------------------------------------------------------------
  Request #11 of 20-May-2006, 17:15:23
  T sensor #8
  Calibration History:    2005 - 2006
  T CTD values range:     -1.75 - 20.17
  T Bath-CTD values range: -0.0004 - 0.0009
--------------------------------------------------------------------------------
  File_Name, YYYY, MM, ##,    Slope,   Offset,     Mean,      StD,   Median
2005_MAR_S08, 2005,  3, 16,  0.000025,  0.000148,  0.000300,  0.000378,  0.000400
2006_JAN_S08, 2006,  1, 16, -0.000002,  0.000580,  0.000569,  0.000130,  0.000550
--------------------------------------------------------------------------------
```

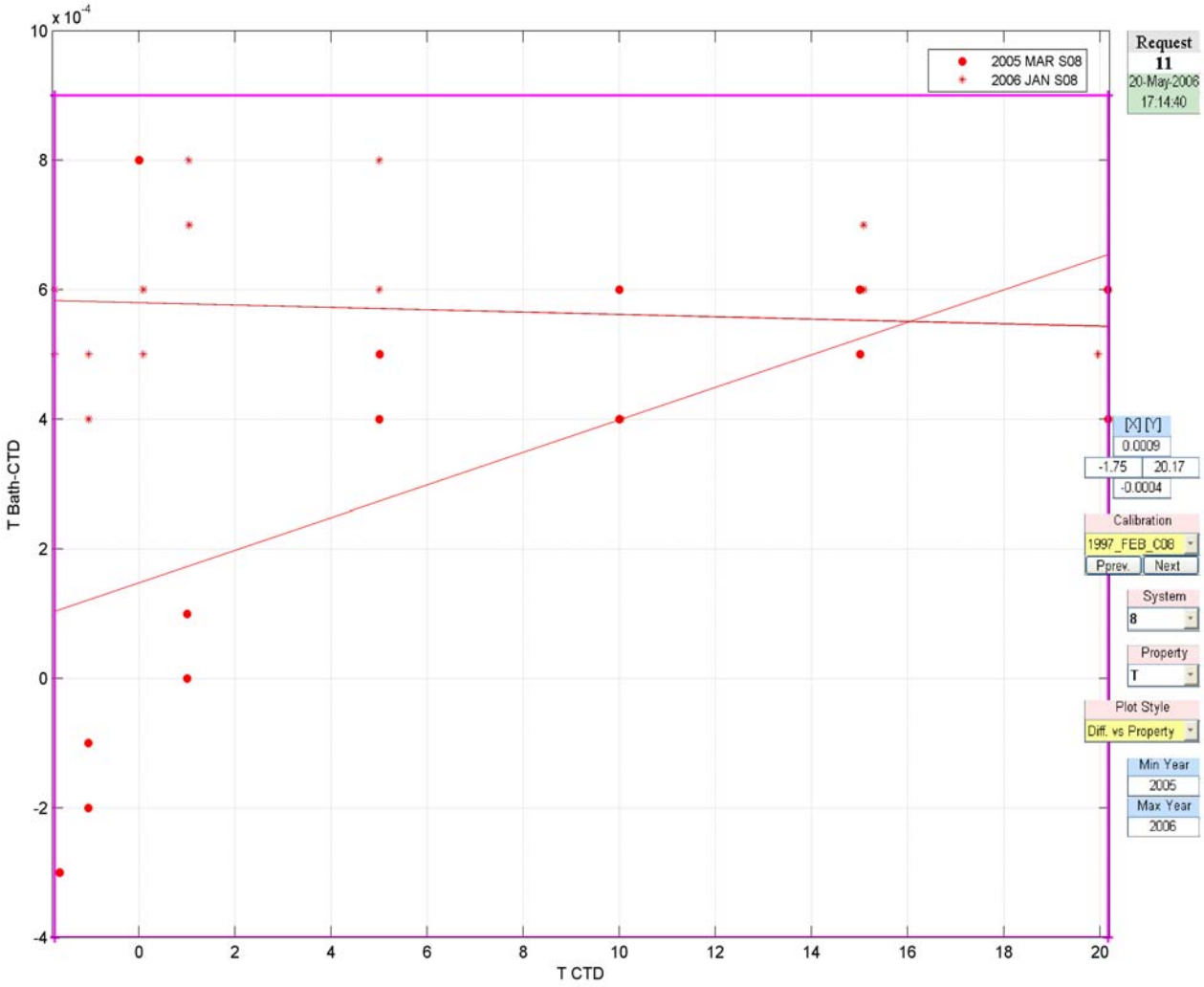


Figure C.1.1. Output of Laboratory Calibration management and analysis software: Laboratory calibrations of system #8 temperature sensor

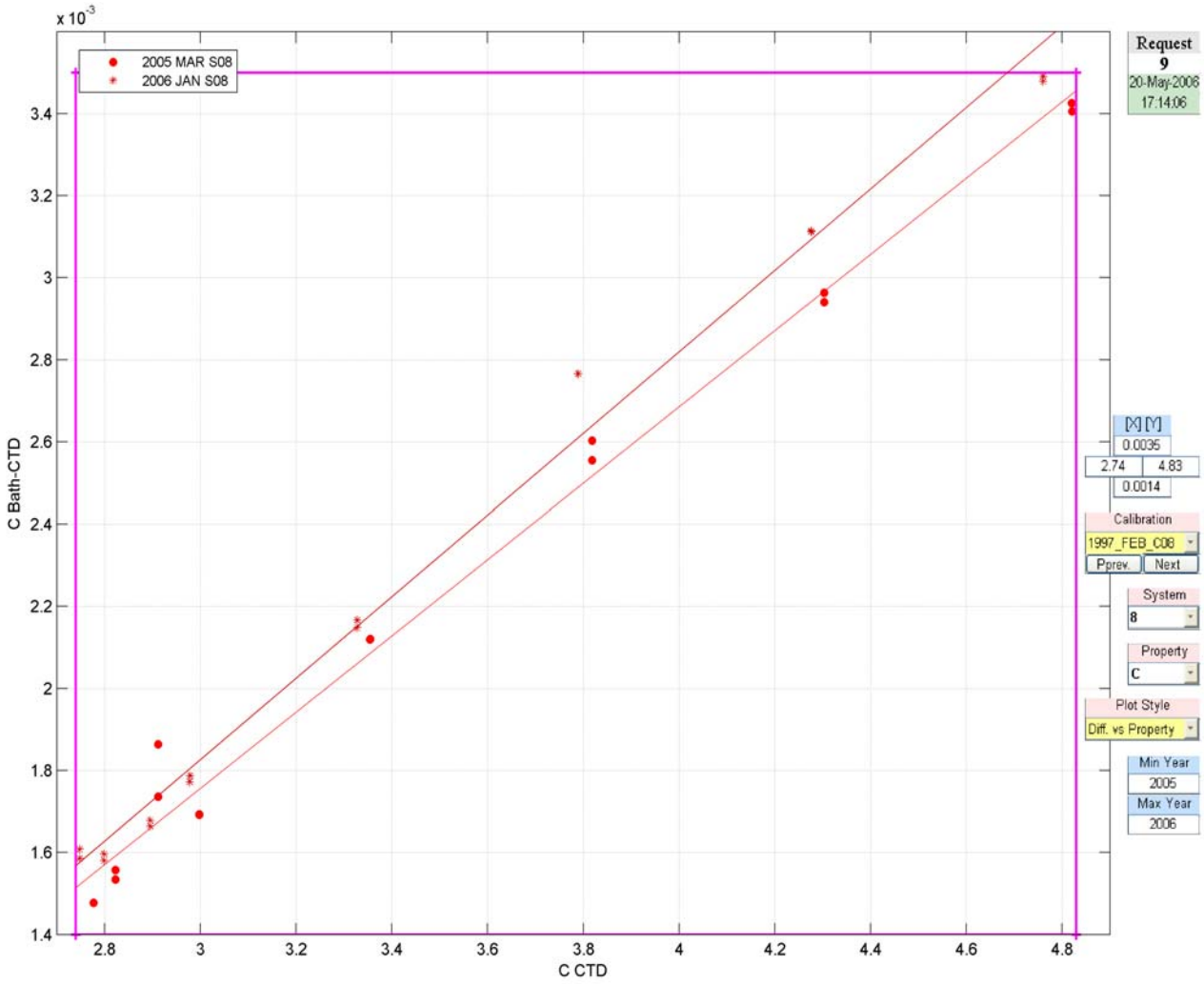


Figure C.1.2. Output of Laboratory Calibration management and analysis software: Laboratory calibrations of system #8 conductivity sensor

2. Salinity — Rick Boyce

a. Description of Equipment and Technique

Salinity samples were analyzed using a Guildline Autosal 8400B salinometer, serial number 60968. Samples were drawn into 200 ml bottles. Once the sample bottle was rinsed three times and filled to the shoulder, the neck and threads of the bottle were dried using paper towel and a new dry cap was installed. Once the bottles reached room temperature, the caps were retightened. The drying of the neck of the bottle and installing a dry cap has been a technique used since the HUD2000009 cruise and prevents salt crystals from forming under the cap.

The salinometer cell was filled and rinsed numerous times with sample water before readings were recorded. When three consecutive readings of conductivity agree to within 0.00001,

this value was recorded for the sample. This value was then entered into the water sample database as the conductivity ratio for the water sample.

b. Data Processing Technique

Conductivities were entered into the ODIN database. Conductivities were used to compute salinities using the water sample conductivity ratio and the standard IAPSO formula applied in an ODIN module. Any changes in the salinometer readings between successive standardizations were assumed to have occurred as a linear drift of the instrument. Thus, the program applied a correction to the ratios, which varied linearly with the samples analyzed. An offset was also applied if the initial standardization was different from the quoted value given on the ampoule label. The computed salinity data was then placed in the water sample database.

c. Laboratory and Sample Temperatures

Full cases of samples were taken from the winch room to the GP lab where they were left for a period of at least 10 hours to equilibrate to room temperature before being analyzed. The temperature range in the GP lab of 19º to 23 ºC was common throughout the mission. The bath temperature was maintained at 21º for all samples.

d. Standards Used

The salinometer was standardized during the mission using IAPSO standard water, Batch P146 dated May 12, 2005 having a K15 value of 0.99979 and a salinity of 34.992. Typically, standardization checks were performed at the beginning and end of a run. A sub-standard was used to check the performance of the instrument at some times during a run.

e. Performance of the Autosal salinometer

Overall the salinometer worked well during the mission. The lab temperature was stable during all runs which is an important factor when trying to optimize the performance of the instrument. During previous missions, the bath temperature of the Autosal had been set at 24º C. During this mission, the lab temperature was kept cooler forcing the Autosal bath temperature to be set at 21ºC. Temperature control of the ambient air is crucial to the operation of the Autosal. The air temperature in the General Purpose Lab on board the Hudson during the mission was adequate but did fluctuate significantly at times. For the next mission, the Autosal will be set up in a different location.

3. Oxygen — Dave Kellow / Carol Anstey

a. General

Samples for the determination of dissolved oxygen were drawn from approximately 68% of the rosette water sampling bottles (601 of 873 bottles). Replicate samples were drawn and analyzed for 60 bottles, or about 7% of the bottles analyzed. These were drawn along the AR7W and L4 lines.

The samples were analyzed using the Winkler titration technique with a computer-driven automated system developed at the Scripps Institute of Oceanography.

b. Sampling Procedures

For this cruise 10 L bottles attached to a 24-bottle Rosette Sampler were used for water sampling. Oxygen sub-samples were drawn after chlorofluorocarbon (CFC) and total organic carbon (TOC) sub-samples. The oxygen sampling bottles are 125 mL Iodine flasks with custom ground stoppers (Levy et al., 1977). The flask volumes are determined gravimetrically. The matched flasks and stoppers are etched with identification numbers.

All members of the CTD watches participated in the drawing of oxygen samples. Each oxygen sub-sample was drawn through a silicone rubber tube attached to the bottle spigot of the Rosette bottle. The flask was thoroughly rinsed and filled to overflowing; the flow was then allowed to continue until two to three flask volumes overflowed. The sampling tube was slowly retracted with continuous low flow to ensure that no air was trapped in the flask. The flask stopper was also rinsed.

Immediately thereafter, one mL each of alkaline iodide and manganous chloride was added from a dispenser in the winch room. The flask stopper was carefully inserted to avoid introducing air. The flask was then thoroughly shaken.

The oxygen samples were removed from the winch room to the General Purpose (GP) laboratory. The flasks were shaken a second time in the GP laboratory.

c. Analysis Equipment and Technique

The oxygen samples were analyzed using an automated procedure developed by the Ocean Data Facility of the Scripps Institute of Oceanography (OSD/SIO, 2000). This procedure is a modified Winkler titration from Carritt and Carpenter (1966). The samples are acidified by the addition of 1.5 mL of sulphuric acid. Dissolved oxygen content is determined by an automated whole bottle titration using sodium thiosulphate and a UV end-point detection. A potassium iodate (KIO3) solution was used as the working standard. The temperatures of the KIO3 and thiosulphate are logged to allow for temperature-related corrections.

Experienced personnel prepared the standard solutions and set up of the titration apparatus. Two operators shared the oxygen titrations in addition to their general watch-standing duties. Both operators were new to the procedure and encountered some difficulty during processing.

d. Replicate Analysis

Replicate samples were drawn and analyzed from 60 rosette bottles, about 7% of the total number. Absolute differences in oxygen concentration for the replicate pairs are plotted as a function of titration time in Figure 1 below. Excluding outliers with absolute differences greater than 0.1 mL/L, the maximum absolute difference was 0.053 mL/L and the root-mean-square difference of replicates was 0.016 mL/L. If the replicates were independent, this would imply a sampling and analysis precision of $0.016/\sqrt{2} = 0.012$ mL/L (standard deviation).

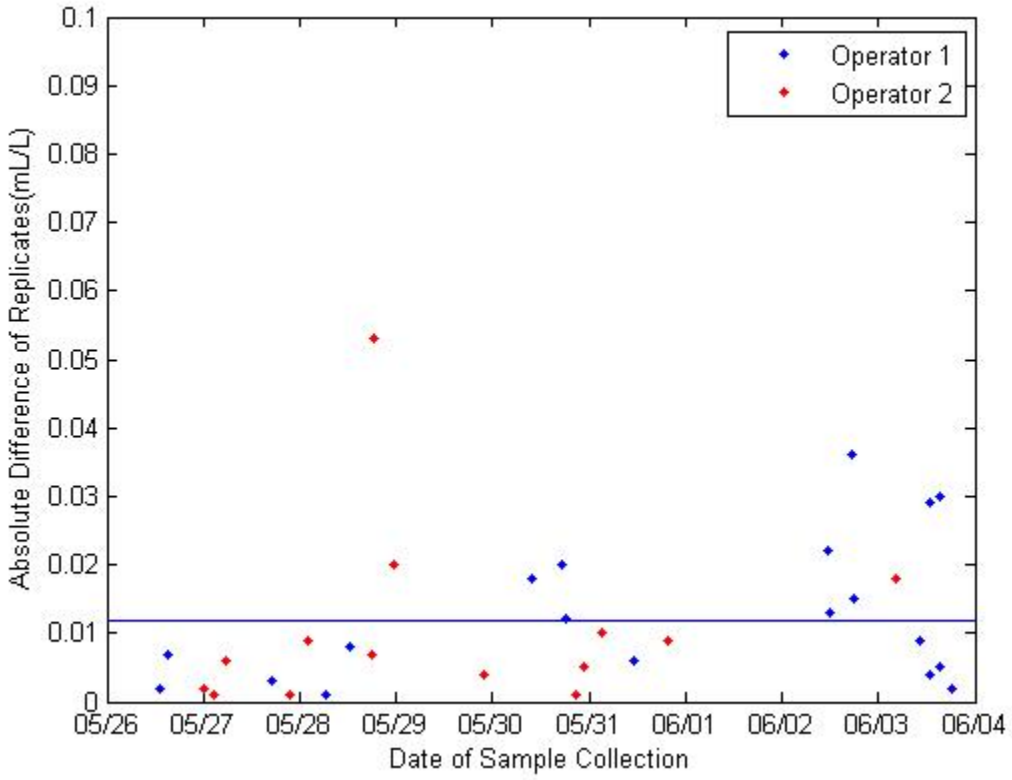


Figure C.3.1 Absolute differences of oxygen replicates as a function of sample collection time. The solid line marks the mean value of 0.012 mL/L excluding outliers that are not shown.

e. Standards and blanks

A total of approximately 168 standards and blanks divided into 17 sets were run at intervals during the cruise. Standards are determined by the titration of a precisely known volume (~10 mL) of KIO3 solution. The procedure followed was to obtain at least three self-consistent standards and blanks before each batch of samples was run. The oxygen analysis software allows the operator to subjectively flag a suspect individual titration as invalid. The average values of valid standards and blanks for each such set of titrations are used by the analysis program to compute oxygen concentration after each titration. The individual titration volumes and auxiliary information are stored for possible re-processing. Each of the 17 sets of standard and blank determinations involved between 3 and 15 individual titrations. The root-mean-square (rms) of the sample standard deviations for the 15 sets was approximately 0.005 mL for standards and 0.001 mL for

blanks. The mean standard and blank values and the associated standard errors of the mean for the 15 runs are plotted as a function of titration time in Figures 2 and 3 below.

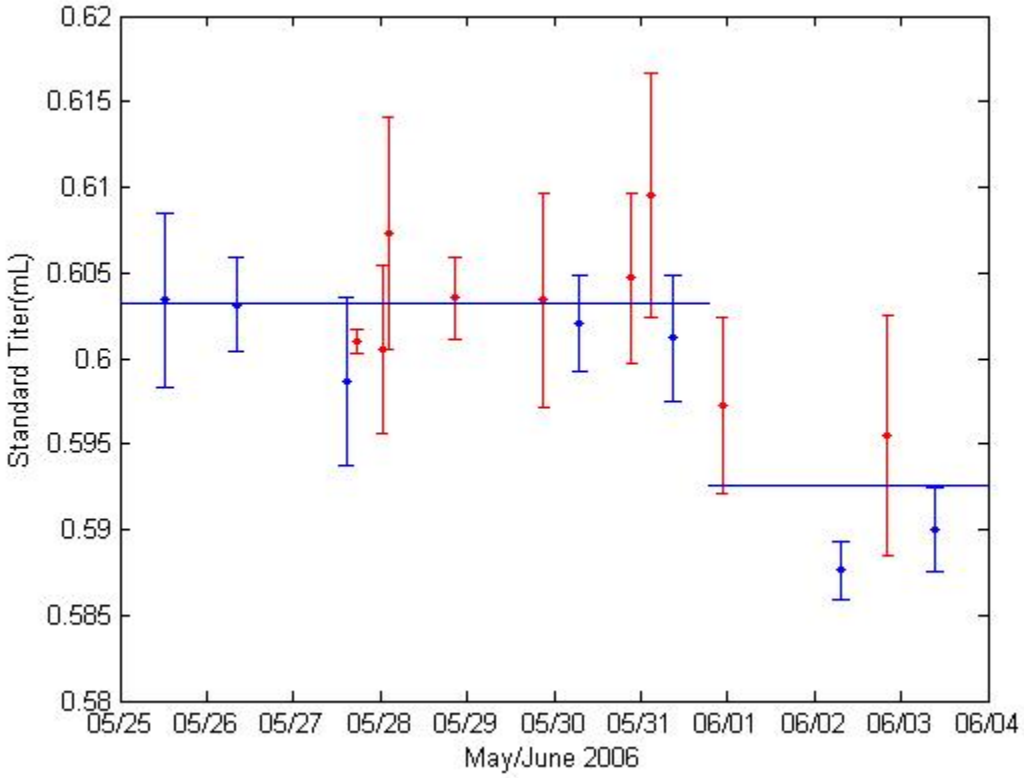


Figure C.3.2 Set-mean standard titer as a function of titration time. The standard error of the mean and the number of individual titrations for each set are indicated. The solid lines mark the mean value of the set means before and after the change of KIO_3 solution.

In principal, these values should not change appreciably during a cruise period. However, the supply of KIO_3 solution was divided up into two bottles, each with a slightly different normalization. When the first amount was used up, a switch to the second was made, and the change is noted in figure 2.

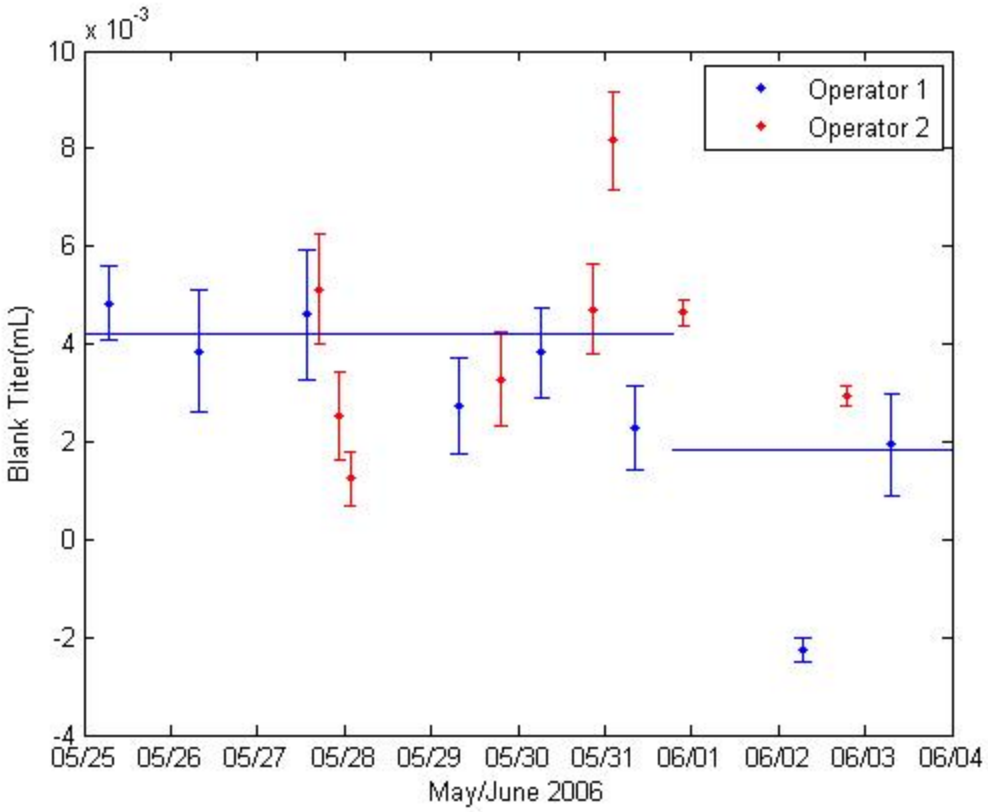


Figure C.3.3 Set-mean blank titer as a function of titration time. The standard error of the mean and the number of individual titrations for each set are indicated. The solid lines mark the mean value of the set means before and after the change in KIO_3 solution.

The 18 blank values in Figure 3 have an overall average of 0.0037 mL and overall standard deviation of 0.0023 mL. The averages before and after the shift in standards are 0.0042 and 0.0018 mL respectively.

f. Comments

In three instances, oxygen flasks presented for titration were found to have the wrong stoppers. Since each pair is individually calibrated, the sample volumes for the mismatched flask/stopper combinations must be recalibrated before these results can be used. All such instances were noted in the oxygen system log. However, it may not be obvious when switch was made.

Procedures for drawing and handling oxygen samples were not specifically reviewed with winch room personnel at the start of the cruise. In principle, it would be useful to do so. The data from L3_Station 1 was compromised because the samples were improperly drawn.

The clamp that holds the oxygen flask for titration is awkward to manipulate. Although the operation improves with practice, a better design would make it easier on the operator

and might improve the titration results. Sometimes a splash would occur, and a droplet or two of the sample would be lost.

The thiosulphate Dosimat failed to stop dispensing several times when the flushing function was invoked. The Dosimat had to be turned off and on and the PC titration system restarted when this happened. Before this was recognized as a software problem, the Dosimats were switched.

Figure 3 shows that at one point, a negative mean blank was reached. This would indicate some sort of impurity in the blanking solution that contributed more to the solution than the pickling solutions. Re-calculation may need to be done here to correctly determine the given concentrations.

The software package is very limited in capabilities, and depends on a very old PC as its operating platform. A new software package with expanded logging capabilities, network integration and a higher rate of sampling should be generated to improve data integrity.

The software package also only yields a result after the scientist has accepted the slope and endpoint. Sometimes it is necessary to see the actual derived concentration before one can accept it as a correct answer. It would be useful to see all derived results before accepting them (or over-titrating).

Over-titration should be an option more than once if necessary, and all derived concentration values should be noted and logged.

For best results, the oxygen analyses should be done by a trained operator. The system is simple enough to use that inexperienced operators can achieve reasonable results under good conditions. Untrained personnel are less able to recognize and diagnose problems when they occur.

4. Nutrients — Carol Anstey

a. Description of Equipment and Technique

Samples were analyzed for silicate, phosphate, and total nitrate (nitrate plus nitrite) using a Technicon Autoanalyzer II. The chemistries are standard Technicon (Silicate 186-72W, Phosphate 155-71W, Nitrate/Nitrite 158-71W) except for Phosphate which is modified by separating the Ascorbic Acid (4.0 gm/l) from the Mixed Reagent. This alteration is achieved by introducing the modified Mixed Reagent instead of water at the start of the sample stream at 0.23 ml/min. and introducing Ascorbic Acid into the stream between the two mixing coils at 0.32 ml/min. (Strain and Clement, 1996).

b. Sampling Procedure and Data Processing Technique

Duplicate nutrient samples are drawn into 30 ml HDPE (Nalge) wide mouth sample bottles from the 10 L rosette bottles. The bottles are prewashed in 10% HCL, rinsed three times with Super-Q and oven dried at >100 Degrees F.

A sample run includes six Calibration Standards, analyzed in duplicate, at the beginning and end. The second most concentrated Calibration Standard used as a Check Standard every 16 samples followed by blanks as baseline check. These standards are made up in 33 ppt NaCl (Sigma, ACS Reagent), as is the wash water. The standards are checked against an Intercalibration Reference Material MOOS-1 produced by NRC.

The raw analog data is converted to digital data, processed and concentrations calculated, including statistics, by an in-house Pascal 7.0 program (AAII) on a PC. Chart recordings, hard copy and disk copies of the data are kept on file.

c. Replicate Analysis

Total number of duplicate samples analyzed for HUD2006-019: 1546. These were refrigerated until analysis, typically within 8 hours of collection. The water samples were transferred to acid washed 7 ml cups for analysis with the AutoAnalyzer.

There were several technical problems encountered during the cruise. The fridge used to store samples and standards on board broke down but fortunately could be replaced with one owned by Jeff Anning not currently in use.

A white Azo-dye precipitate continuously built up in the Nitrate line during the longer analysis runs. Analysis had to be stopped, (final calibration was run to allow proper processing of data) and the precipitate cleaned out before restarting the analysis for that day. The Ascorbic Acid reagent for Silicate would degas and form bubbles which would get caught in the flowcell interfering with the analysis. High lab temperatures which were difficult to control may have contributed to these problems. A fan was used to help cool the area around the autoanalyzer and seemed to help.

The power connection for the Nitrate colorimeter was very loose causing loss of power if the ship was rolling very much. The plug was removed several times for repair. The final time the power was reconnected, the voltage regulator failed and the plug blew, burning out the Log Ratio board in the colorimeter and the IO board in the computer. The computer board was replaced with a spare but there are no replacements for the colorimeter boards; they can no longer be purchased. This emphasizes the age and fragility of the equipment being used. Sample analyses were fortunately completed for both the AR7W-L3 and L4 lines (298730 – 299561). Samples collected for the Biological Station June 4 and the extended Halifax Line were frozen immediately and taken back to BIO. Fortunately this is not a change in protocol for this line as samples collected from this line for AZMP are routinely frozen.

The data quality parameters, determined with check standards, MOOS-1 Intercalibration Reference Standard and RMS offset from the calibration curve, came well within accepted values. Frequent flushing of the system with 1N HCl followed by Alpha-Q water helped to prevent sample flow problems and build-up of molybdate coating of the flow cells.

The laboratory temperature during all analyses was between 18 and 25 °C.

The conversion to mass units for the analytical precision and detection limits used a standard density corresponding to 33 ppt and 15°C.

The nutrient detection limits noted in the table below were applied to the dataset. All values at or below the detection limits were set to zero.

	Silicate	Phosphate	NO2+NO3
Number of Samples	773	773	773
Number of Duplicates	1546	1546	1546
Detection Limit (μ moles/kg)	0.438	0.038	0.15

5. Total Inorganic Carbon in Seawater — Kumiko Azetsu-Scott

a. Description of Equipment and Technique

The total dissolved inorganic carbon content of seawater is defined as the total concentration of carbonate ion, bicarbonate ion and unionized species of carbon dioxide. Before analysis, the sample is treated with acid to convert all ionized species to the unionized form, which is then separated from the liquid phase and subsequently measured using a coulometric titration technique. This involves the reaction of carbon dioxide gas with a dimethysulfoxide solution of ethanolamine to produce hydroxyethylcarbamic acid. The acidic solution is titrated with hydroxide ion formed by the electrolytic decomposition of water. The progress of the titration is followed through colorimetric measurement of the absorbance of a pH indicator dye (thymolphthalein) in the ethanolamine solution.

A known volume of seawater is dispensed into a stripping chamber from a pipet of known volume and temperature controlled to within 0.4 °C. It is then acidified with ten percent its volume of an 10% solution of carbon dioxide-free phosphoric acid. The solution in stripped of carbon dioxide gas by bubbling with a stream of nitrogen gas directed through a glass frit. The carrier gas exiting the stripper passes through a magnesium perchlorate trap to remove water vapour and acidic water droplets. The gas stream is then directed into the coulometric titrator where the total amount of carbon dioxide gas is quantified.

b. Sampling Procedure and Data Processing Technique

Samples for total inorganic carbon were collected and analyzed from all bottles tripped at standard hydrographic depths on whole-number sites on the AR7/W, on L-4 line stations 3, 4, 5.9, 7.1, 8.5 and 11 and on Halifax line stations xxxxx.

Samples are drawn from the rosette immediately following the drawing of the oxygen samples in order to minimize exchange of carbon dioxide gas with the head space in the sampler. This exchange will typically result in a loss of carbon dioxide. It is desirable that the samples be drawn before half the sampler is emptied and within ten minutes of recovery. Clean borosilicate glass bottles are rinsed twice with 30 - 50 ml of the sample. The bottle is then filled from the bottom using a length of vinyl tubing attached to the spigot of the sampler. The sample is overflowed by at least a half of the volume of the bottle (typically 250 ml). A head space of 1% is left to allow for expansion without leakage.

Theoretically, the coulometer should give a direct measurement of the amount of carbon titrated based on calculations using the Nernst equation. In practice, the coulometer's calibration is checked using Certified Reference Materials obtained from the Scripps Institute of Oceanography, LaJolla, California. These samples are treated in the same manner as a seawater sample. Values are reported in units of μmol/kg. The overall precision of the analysis should be at least 1.5 μmol/kg for samples with concentrations in the range of 1800-2300 μmol/kg.

6. Alkalinity — Kumiko Azetsu-Scott

a. Description of Equipment and Technique

The total alkalinity of seawater is defined as the number of moles of hydrogen ion equivalent to the excess of proton acceptors (bases formed from weak acids with dissociation constants of less than $K=10^{-4.5}$) over proton donors (acids with $K>10^{-4.5}$) in a one kilogram sample. An automated potentiometric titration system is used to determine this quantity. During the course of the titration the pH is measured using a Ross combination electrode standardized using a Hansson seawater buffer. A known volume (~25ml) of sample is measured in a calibrated, thermostated pipette and dispensed in to an open cup. The alkalinity of the sample is estimated from its salinity and acid equivalent to 0.7 of this amount is added and the pH measured. A further three aliquots of acids are added to bring the titration to 90% completion. The Gran Function F3 (Stumm and Morgan) is then applied to these points to obtain a more refined estimate of the alkalinity. Five additional aliquots are then added to complete the titration.

b. Sampling Procedure and Data Processing Technique

Samples for alkalinity were collected and analyzed from all bottles tripped at standard hydrographic depths on whole-number sites on the AR7/W line with the exception of station L3-19 (no bottles available for alkalinity measurements), stations 3, 4, 5.9, 7.1, 8.5 and 11 and on L-4 line and stations xxxxx on Halifax line. Samples are collected using the same procedure as for Dissolved Inorganic Carbon (see Section 5b).

The pH values for the last five points of the titration are used to evaluate the Gran Function F1 from which the final estimate of the equivalence point is obtained. Hydrochloric acid used in the titrations is calibrated is two ways: against a standard solution of sodium borate using an acid base titration and against postassium iodate using an iodometric titration with sodium thiosulphate. In addition, the calibration is checked using Certified Reference Materials obtained from the Scripps Institute of Oceanography, LaJolla, California. Values are reported in units of μmol/kg. The precision of the analysis was not good at the beginning of the cruise (suspected acid problem and laboratory temperature fluctuation), but after modification it improved to be 0.1% for samples with concentrations in the range of 1900-2400 μmol/kg.

7. Halocarbons — Brian Robinson / Rick Nelson

a. Description of Equipment and Technique

The series of halocarbon compounds that are analysed includes the chlorofluorocarbons CFC-12, CFC-11, CFC-113 and the halocarbons carbon tetrachloride and methyl chloroform. The analyses are carried out on two identical purge and trap systems developed at the Bedford Institute of Oceanography. Water samples are injected into the systems directly from the syringes used to collect the samples. The sample pipette is rinsed with a minimum of two volumes of water before the sample passes into the purge chamber that is held at 80°C. The halocarbons are purged from the sample for four minutes with ultra high purity nitrogen at a flow rate of 80 ml/min. The purged gasses are trapped in a Porapak-N trap that is cooled to a temperature of less than 10°C. The halocarbons are then desorbed by heating the trap to 170°C. A Varian 3300 Gas Chromatograph equipped with a 75m DB-624 megabore column and electron capture detection is used for the separation and quantification of the halocarbons.

b. Sampling Procedure and Data Processing Technique

Due to the length of time required for a single sample analysis (approx. 25min) and the frequency at which the deep stations were sampled (every 4-6 hours), it was not possible to collect halocarbon samples at all stations during the cruise. On AR7/W line, halocarbons were sampled at all stations except for L3-12, L3-16, L3-18, L3-19 and L3-23. On the L4 line, samples were taken at stations 3, 4, 5.9, 7.1, 8 and 11, while on the Halifax Line samples were taken at stations…

Samples are collected directly from the rosette using 100 ml syringes to avoid contact of the sample with the atmosphere. The syringes are rinsed three times before they are filled. To prevent contamination, the CFC samples are the first samples collected from the bottles. The samples are then stored in a water bath of continuously flowing surface seawater until analysis. The analysis of the samples is always completed within 24 hours after they have been drawn. The purge and trap system is also susceptible to contamination whenever it is open for maintenance and repairs. For this reason, blanks are run after the system has been open until a stable baseline can be achieved.

Chromatograms are analyzed using a commercial software package. Concentrations of the various components are evaluated from baseline-corrected peak areas. Calibration is carried out using working gas standards made up at Brookhaven National Laboratories. These standards have been calibrated in turn against a standard air sample ALM-64975 provided by CMDL/NOAA, Boulder Colorado. Standard volumes are corrected for lab temperature and pressure. Results are reported in units of pmol/kg of seawater. Clean air samples are also analyzed at several stations as a check on the standardization.

F. APPENDICES

Appendix 1. Cruise Report Images

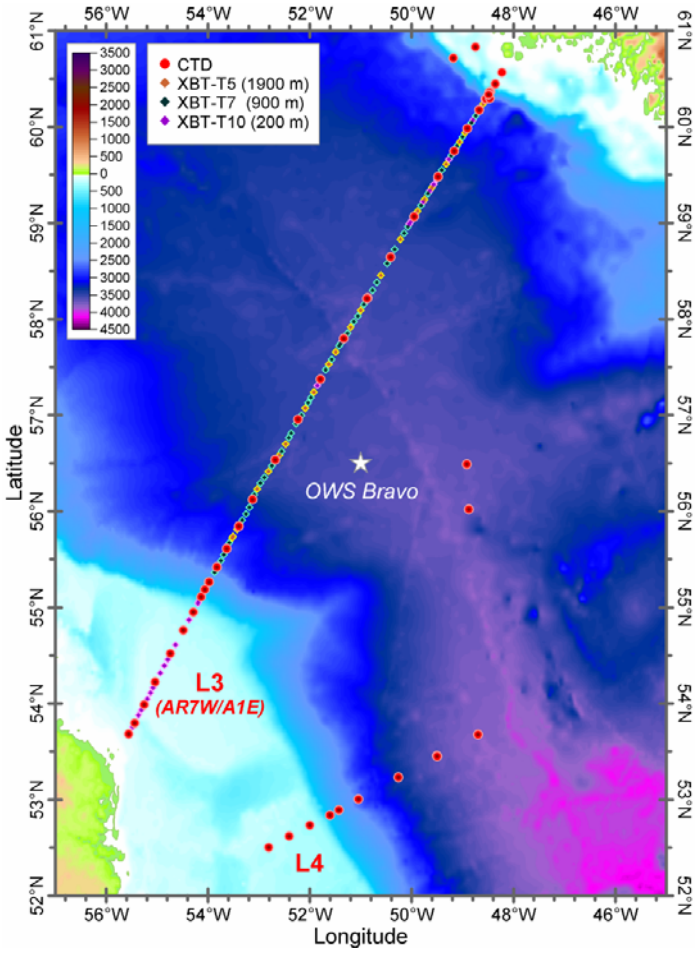


Figure A.2.3. CTD stations and XBT drop sites along the L3 (AR7W) and L4 sections (*red circles – CTD, diamonds - XBT*).

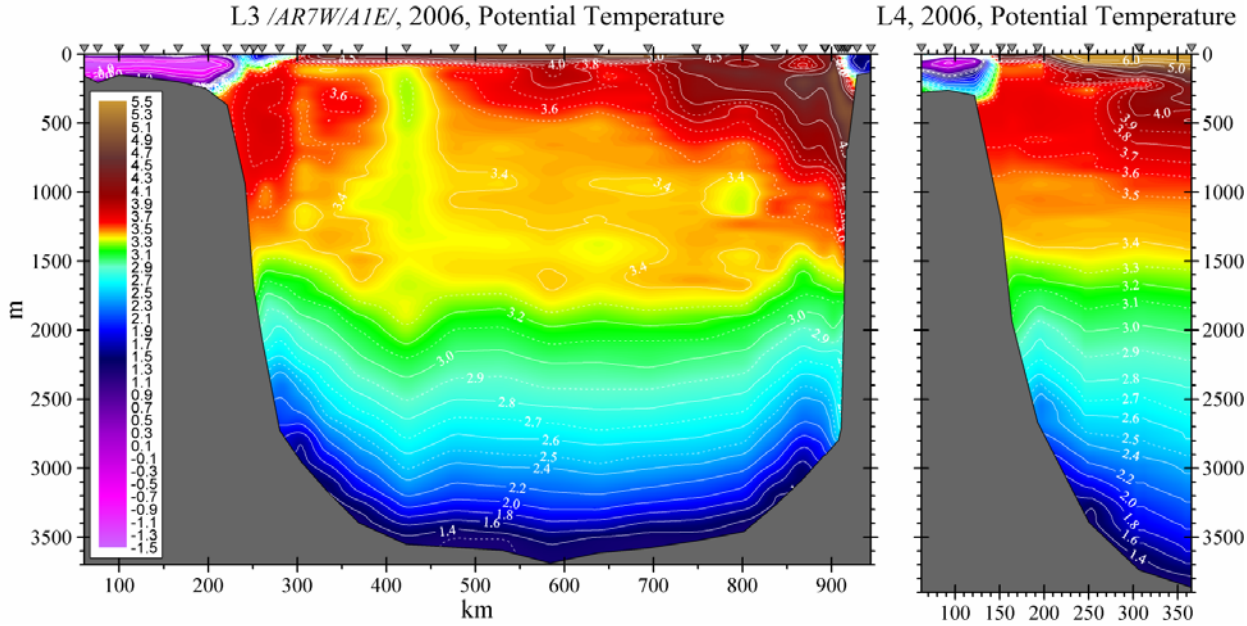


Figure A.2.4. Displayed are vertical sections of potential temperature (°C). The section lines are L3 and L4 shown in figure A.2.3. The Labrador shelf is on the left side of the plots.

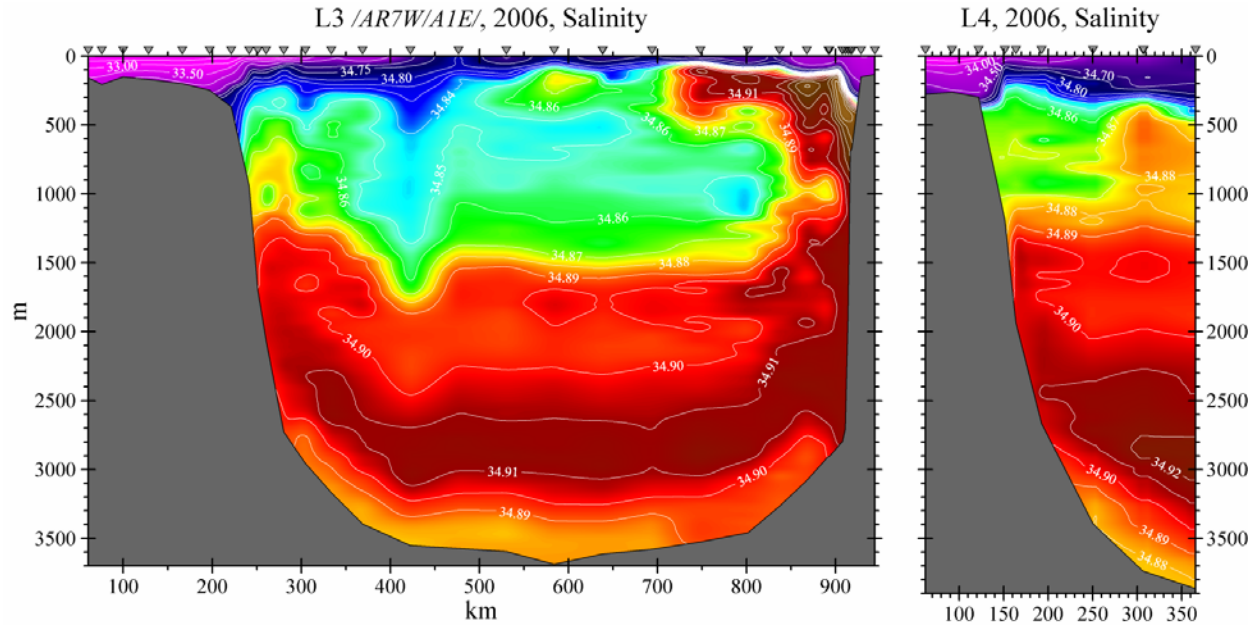


Figure A.2.5. Vertical sections of salinity. The section lines are L3 and L4 shown in Fig. 1. The Labrador shelf is on the left side of the plots.

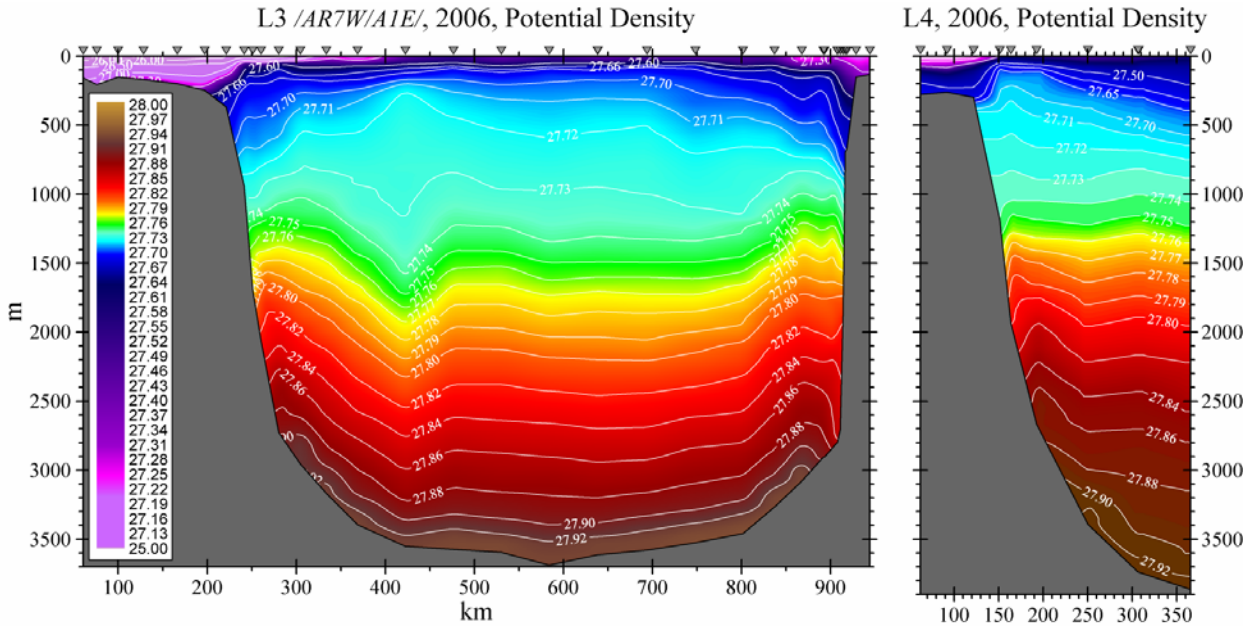


Figure A.2.6. Vertical sections of potential density. The section lines are L3 and L4 shown in Figure A.2.3. The Labrador shelf is on the left side of the plots.

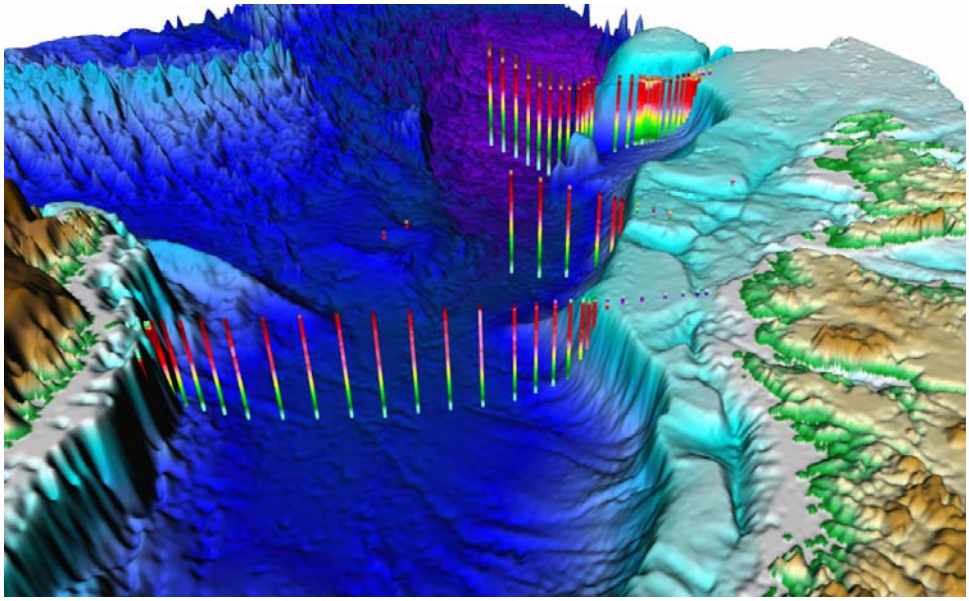


Figure A.2.7. Vertical profiles of potential temperature from the CTD stations occupied in the 2006 spring cruises to the Labrador Sea and Orphan Basin regions. Perspective view in the southward direction with Greenland on the left side and Labrador on the right side. In 2006 the thin near-bottom layer was colder than ^{o}C. Shallow stations on the Labrador side exhibit sub-zero temperatures associated with the cold intermediate layer. The highest temperatures recorded in these 2006-011 and 2006-019 Hudson missions are seen in the upper 200 m layer over the offshore part of the Orphan Basin line (furthest in the view).

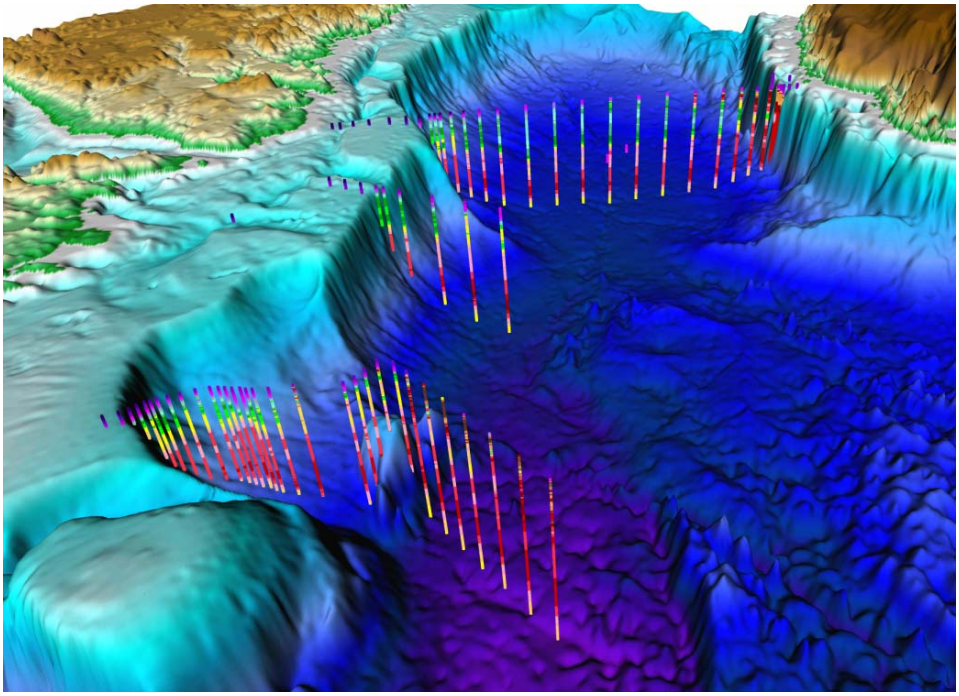


Figure A.2.8. Vertical profiles of salinity from the CTD stations occupied in the 2006 spring cruises to the Labrador Sea and Orphan Basin regions. Perspective view in the northward direction with Greenland on the right side and Labrador on the left side. The less-salty near-bottom layer is the Denmark Strait Overflow water (DSOW). The saltier water above is the Northeast Atlantic Deep Water (NEADW). The near surface and Labrador shelf waters have a larger fraction of freshwater (low salinities).

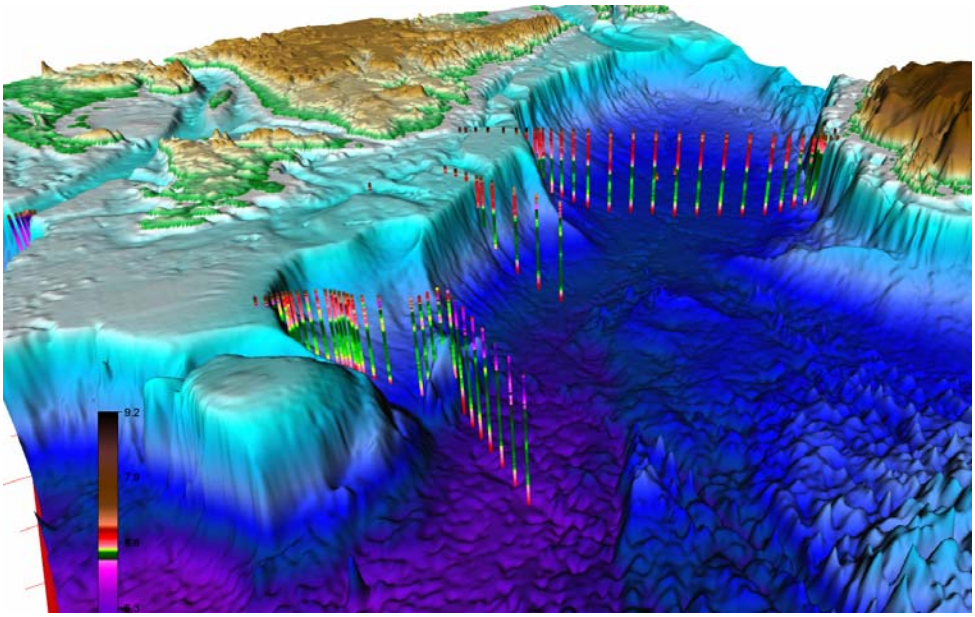


Figure A.2.9. Vertical profiles of oxygen from the CTD stations occupied in the 2006 spring cruises to the Labrador Sea and Orphan Basin regions. Perspective view in the northward direction with Greenland on the right side and Labrador on the left side. The stations at the far left side are the Laurentian Fan CTDs occupied earlier in 2006-011 Hudson mission. These profiles show extremely low concentration of dissolved oxygen (purple) in the slope waters.

The upper offshore layer in the Orphan Basin line (closest) also indicates a relatively low oxygen concentrations – this is a typical signature of central North Atlantic or North Atlantic Current waters. Note the fresh (Fig. 6), cold (Fig. 5) and oxygen rich core eddy in the Orphan Basin. NEADW has relatively low oxygen concentrations (green), while the near-bottom layer (DSOW) is rich in oxygen (red) – indicating a short age and fast spreading of these waters.

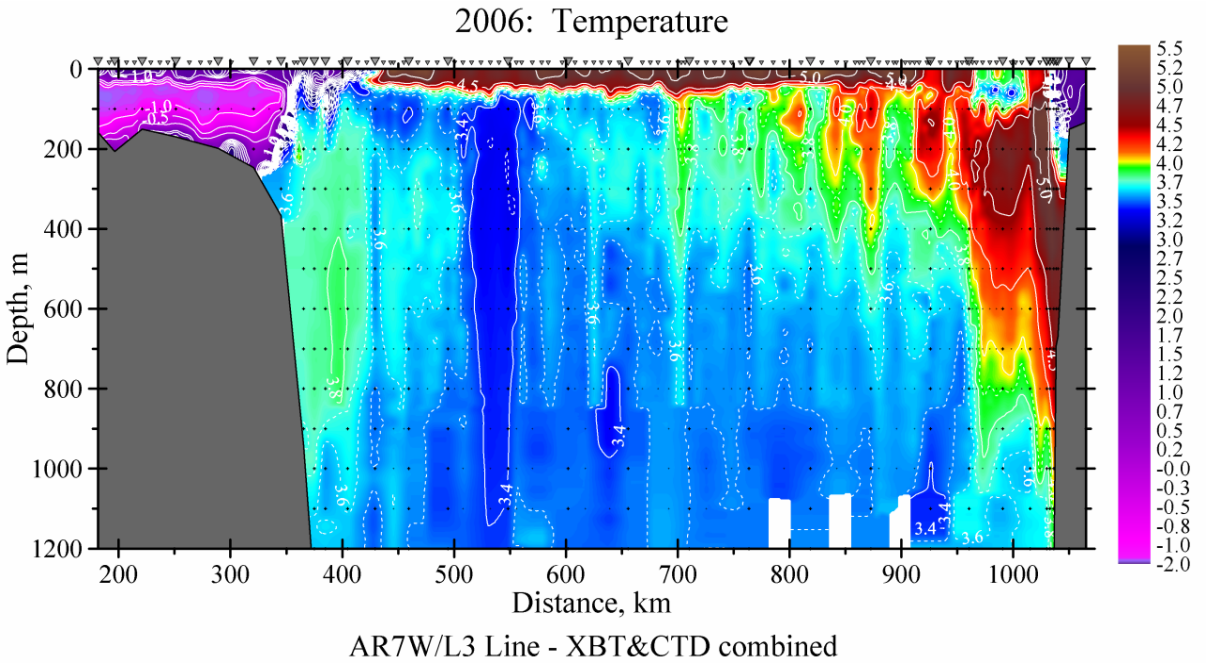


Figure B.4.2. Temperature (°C) section along the L3 line (Fig. 1) based on XBT (indicated by thinner markers) and CTD (indicated by thicker markers) profiles. The Labrador shelf is on the left side of the plots. Both CTD and XBT measurements were averaged in the nodes of 1 m vertical grid.

Appendix 2. Operation Notes Report **Jeff Jackson**

(sorted by Operation ID Number)

Note Number: 1	**Entry Time:** 04/Jun/2006 23:04:25	**Note Made By:** Jeff Jackson	**Operation ID**: 221
Biology CTD cast was aborted due to CTD system freeze. Package was brought back on board. The problem was a lose connection from a faulty splice.			
Note Number: 2	**Entry Time:**	**Note Made By**:	**Operation ID**:

Appendix 3. Some operational recommendations **Igor Yashayaev**

These are some of my other suggestions raised in the course of CTD operations of 2006-011 and 2006-019 missions:

1) Sounding

   Record the bottom track on all new lines and check the time marks and performance every 10 (20?) minutes.

   Winch room: To save time on each station and start it immediately after the ship is in position to deploy the CTD we need to make sure that there is no unnecessary delay cause by both computer and winch room CTD operators. One of such possible setbacks is sounding (sometime none provided or minutes after the bridge okayed beginning of the deployment). I suggest the following measures to improve our performance in station preparation – (a) if the echo sounder is not ON between stations, turn the echo sounder ON when the ship slows down for a station, better ~10 minute before; (b) since the ship drifts while keeping a station, we can use a sounding within 0.5 nm as an initial value typed in the station header with the same success as the value used at the point of CTD deployment - this will make the winch room staff available to help with CTD deployment. If the initial sounding is corrected or updated during the cast, please notify the computer room and winch operator.

   Computer room: Confirm readiness for the station, confirm event number with the bridge, start all required programs prior to deployment (open *Seasave* → *RealtimeData* → *Start Acquisition* → *File selection* → *Start*, but hold the confirmation until you know that the CTD is about to leave the deck. Use initial sounding value to feed into *Seasave* header.

2) CTD deployment

   Computer room: Be ready to start acquisition at any time, but since it is nice to have all station produced in the same fashion, please start logging before the package hits the water but as close to the deployment as possible.

   IMS software often causes halts in CTD acquisition, so make sure that it is off before you start a station and turn it on only after you see CTD values start changing on the screen!!!

   I suggest move IMS from CTD logging computer to the other PC, I call it – CTD operation support PC – this can ran both IMS and ODIN – the exchange with IMS can be established by sharing CTD file via the ship's server.

   If the station is deeper than 3000 m, first send the CTD down to 200 m off expected bottom depth. Near the rapidly changing bathymetry an extra caution is a good practice.

   Winch room: Would be nice to know when we start moving the package, so the acquisition could be started on time (we get confirmation that CTD is in the water, but nothing prior, the pre-deployment time varies, so it would be nice at least to send a beep).

3) Approaching the bottom.

Computer room: As soon as you see the altimeter readings drop below 100, notify the winch room and reconfirm every 25 m.

Winch room: At 60 m/min, the valid altimeter range is passed in about 1-1.5 min. Please rely on the sounder regardless of altimeter (we can also lose the computer feedback). The rule is simple – use the lesser value the distance to bottom. If the altimeter and sounder disagree by more than 50 m, get a third opinion before making a decision.

Appendix 4. Water Sampling schedules — Igor Yashayaev

To accommodate requirements fro water sample collection and provide operational directives to the hydrographic team, the following tables were distributed to all involved in water sample collection and sample analysis prior to beginning of each line (the delay in providing this forms could be caused by unforeseen changes in the planning and miscommunications).

Table 5.1. Water sampling strategy for L3 (AR7W/A1E) line (similar were designed for specific stations of the L4 and modified L4 lines)

Station#																															Station#
Notes																															Notes
Site#	1	2	3	4	5	6	7	8	+1/2	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	+1/3	+2/3	26	27	28	Site#
NumBot.	12	14	12	19	13	14	17	19	5	19	22	24	24	24	24	24	24	24	24	24	24	24	24	24	23	22			20	10	10	NumBot.
1	150	210	150	170	190	235	360	920	1500	2020	2650	2940	3160	3360	3530	3560	3570	3670	3590	3590	3510	3440	3260	3000	2900	2630			1300	135	135	1
2	125	180	125	140	150	200	330	860	1450	1970	2590	2890	3100	3300	3460	3490	3500	3590	3520	3520	3450	3380	3200	2940	2840	2590			1250	100	100	2
3	100	150	100	120	125	150	290	790	1350	1900	2510	2810	3020	3220	3380	3400	3410	3490	3430	3430	3370	3300	3120	2860	2760	2510			1170	80	80	3
4	80	125	80	100	100	125	250	700	1220	1810	2410	2690	2920	3120	3280	3290	3300	3380	3320	3320	3270	3200	3020	2760	2660	2410			1070	60	60	4
5	60	100	60	80	80	100	200	590	1100	1690	2290	2560	2810	3000	3160	3170	3180	3250	3200	3200	3150	3080	2900	2640	2540	2290			950	50	50	5
6	50	80	50	60	60	80	150	470		1550	2150	2430	2690	2860	3030	3030	3040	3120	3060	3060	3020	2950	2770	2500	2400	2150			820	40	40	6
7	40	60	40	50	50	60	100	360		1390	1990	2290	2560	2700	2860	2870	2880	2940	2900	2900	2860	2790	2620	2340	2240	1990			680	30	30	7
8	30	50	30	40	40	50	80	260		1210	1810	2150	2410	2520	2660	2680	2690	2740	2710	2710	2660	2610	2460	2160	2060	1810			520	20	20	8
9	20	40	20	30	30	40	60	170		1030	1610	1990	2230	2320	2440	2470	2480	2520	2500	2500	2440	2410	2260	1980	1860	1630			380	10	10	9
10	10	30	10	20	20	30	50	100		850	1410	1810	2010	2100	2210	2250	2250	2290	2270	2270	2210	2190	2060	1780	1660	1430			250	2	2	10
11	10	20	10	10	10	20	40	80		670	1210	1630	1790	1880	1970	2010	2010	2040	2020	2020	1970	1960	1850	1580	1460	1230			150			11
12	2	10	2	2	10	10	30	60		510	1030	1430	1550	1640	1730	1770	1770	1790	1770	1770	1730	1730	1640	1380	1260	1030			100			12
13		10			2	10	30	50		370	850	1230	1310	1400	1500	1530	1530	1550	1530	1530	1500	1500	1430	1180	1060	850			80			13
14		2				2	30	40		250	670	1030	1090	1180	1280	1290	1290	1300	1290	1290	1280	1280	1230	980	880	670			60			14
15							30	30		150	510	850	890	960	1070	1070	1070	1070	1070	1070	1070	1070	1030	800	720	510			50			15
16							30	20		100	370	670	710	760	870	870	870	870	870	870	870	870	840	640	580	370			40			16
17							30	10		50	250	510	550	580	680	680	680	680	680	680	680	680	660	500	460	250			30			17
18							20	10		20	150	370	400	430	510	510	510	510	510	510	510	510	480	380	340	150			20			18
19							10	2		2	100	250	290	310	360	360	360	360	360	360	360	360	330	260	240	100			10			19
20							1				50	150	190	200	240	240	240	240	240	240	240	240	210	160	140	50			2			20
21							1				20	100	110	120	140	140	140	140	140	140	140	140	110	100	80	20						21
22							1				2	50	50	60	70	70	70	70	70	70	70	70	50	50	35	2						22
23							1					20	20	30	35	35	35	35	35	35	35	35	25	20	2							23
24							1					2	2	2	2	2	2	2	2	2	2	2	2	2								24

n – collect nutrients

Salinity Duplicates

No Physics

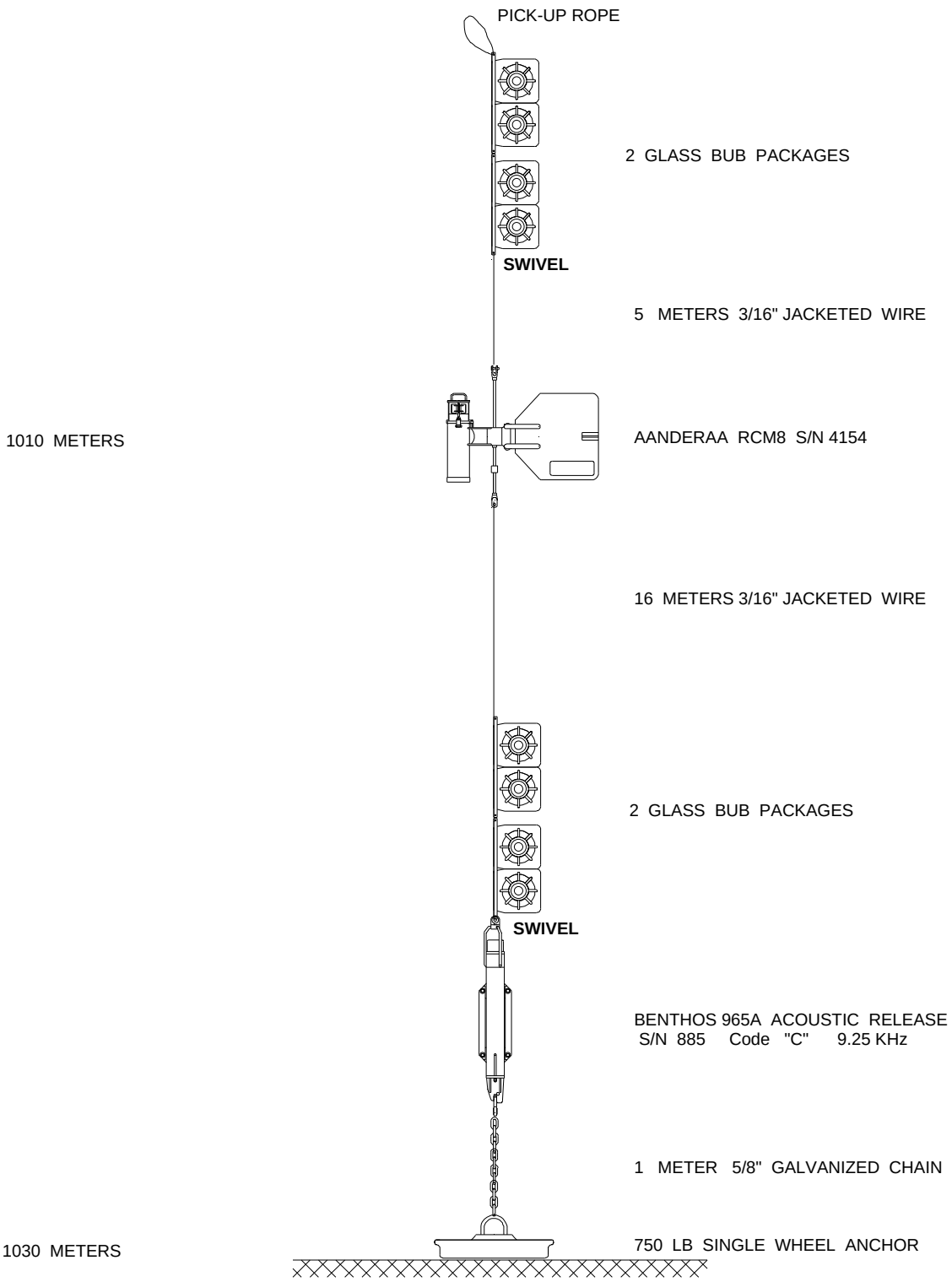
Aging Salinity Duplicates

Oxygen Duplicates

^{129}I

Appendix 5. Mooring Details **Rick Boyce**

MOORING # 1601 HENDRY LAB SEA MAY 2006



Placement

Mooring No. 1601
Geographic Area: Lab Sea Intended Duration 1 year
Ship: CCGS Hudson Cruise No: 06019 Date: May 27, 2006
Sea State: Calm Weather Conditions: Calm
Mooring Technician: REB Navigation Inst. GPS
Notship # N060874 Date Made May 31, 2006 Date Cancelled
Maritimes Tel: 902-426-6030 Nfld Tel: 709-772-2083 Laurentian Tel: 418-648-5410
Fax : 902-426-6334 Fax : 709-772-5369 Fax : 418-648-7244
Latitude: 55º 7.20 N Longitude: 54º 5.31 W Time of Fix: Survey see note
Depth: Raw: 556 Fms Corrected: 1130 meters
Main Float: Type: BUB Markings: Yellow
Argos Beacon: Type: N/A I.D. #
Mooring Line: Type: 3/16" Jacketed Colour: Yellow
Release: Type: Benthos 965A S/N: 885 Release Code: "C" 9.25 KHz

Placement Log

Time (Z)	Instrument	Remarks
1102		Mooring on surface
1104		Anchor slipped
		Sounding 556 Fms
		Speed of sound from nearby CTD cast = 1473 m/s
		Anchor drop position:
		55º 07.2036 N 54º 05.4142 W
		See attached not for info on survey performed at site
		to position the mooring.

Serial No.	**2068**
Argos ID	**37761**
Argos Hex	**10EF013**
WMO Code	**4900682**

Appendix 6. APEX Float Log Sheets — Rick Boyce

APEX Float Launch

Float was started. Date: __May 27/06_ Time: ___2109_____GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: __May 27/06_ Time: ___2205_____GMT
Float should be deployed within 6 hours of start time.

Deployed By: _____Richard Boyce_____

Mission: HUD2006019 Vessel: CCGS Hudson Event No __68_____

Latitude ___55° 35.4027N__ Longitude ____53° 38.7736___

Water Depth _2859 m_____ (must be deeper than 2000 metres)

Nearest **CTD** / XBT cast (circle one) Event No of cast. ___67___

Date: ___May 26/06___ Time: ___1959_____ GMT

Latitude __55° 36.6421_ Longitude __53° 37.9109___

Maximum Depth 2943 dbars

Any problems associated with the start up and deployment operation
_____All looks good
_____
_____
_____
_____
_____
_____
_____

Please Fax or email this information,
within 24 hours of launch if possible, to:

Howard Freeland	cc:	Ross Hendry
Institute of Ocean Sciences		Bedford Institute of Oceanography
Fax: (250) 363-6746		Fax: (902) 426-7827
Email: FreelandHJ@pac.dfo-mpo.gc.ca		Email: HendryR@mar.dfo-mpo.gc.ca

Serial No.	**2069**
Argos ID	**37763**
Argos Hex	**10EF035**
WMO Code	**4900683**

APEX Float Launch

Float was started. Date: ___June 2/06 Time: __1121_____GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: ___June 2/06 Time: __1234_____GMT
Float should be deployed within 6 hours of start time.

Deployed By: _____Richard Boyce_____

Mission: HUD2006019 Vessel: CCGS Hudson Event No __226____

Latitude ___53° 41.7571N__ Longitude ___48° 42.1569W___

Water Depth __3722 m___ (must be deeper than 2000 metres)

Nearest **CTD** / XBT cast (circle one) Event No of cast. 225 L4_11

Date: __June 2/06____ Time: ___0956_____ GMT

Latitude __53° 40.6533_ Longitude __48° 41.9688___

Maximum Depth 3860 dbars

Any problems associated with the start up and deployment operation
_____All looks good
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Please Fax or email this information,
within 24 hours of launch if possible, to:

Howard Freeland	cc:	Ross Hendry
Institute of Ocean Sciences		Bedford Institute of Oceanography
Fax: (250) 363-6746		Fax: (902) 426-7827
Email: FreelandHJ@pac.dfo-mpo.gc.ca		Email: HendryR@mar.dfo-mpo.gc.ca

Serial No.	**2679**
Argos ID	**62962**
Argos Hex	**324636A**
WMO Code	**4900876**

APEX Float Launch

Float was started. Date: __May 28/06_ Time: ___2201_____GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: __May 29/06_ Time: ___0021_____GMT
Float should be deployed within 6 hours of start time.

Deployed By: _____Richard Boyce_____

Mission: HUD2006019 Vessel: CCGS Hudson Event No __114____

Latitude ____57° 21.9283N_ Longitude __51° 46.8987W____

Water Depth __3463 m____ (must be deeper than 2000 metres)

Nearest **CTD** / XBT cast (circle one) Event No of cast. __113___

Date: __May 28/06____ Time: ___2144_____ GMT

Latitude _57° 22.4962__ Longitude __51° 47.6754___

Maximum Depth _3584 dbars

Any problems associated with the start up and deployment operation
_____All looks good
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Please Fax or email this information,
within 24 hours of launch if possible, to:

Howard Freeland	cc:	Ross Hendry
Institute of Ocean Sciences		Bedford Institute of Oceanography
Fax: (250) 363-6746		Fax: (902) 426-7827
Email: FreelandHJ@pac.dfo-mpo.gc.ca		Email: HendryR@mar.dfo-mpo.gc.ca

Serial No.	**2688**
Argos ID	**62965**
Argos Hex	**3246313**
WMO Code	**4900879**

APEX Float Launch

Float was started. Date: __May 31/06_ Time: __10:31:52__GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: __May 31/06_ Time: __1135_____GMT
Float should be deployed within 6 hours of start time.

Deployed By: _____Richard Boyce_____

Mission: HUD2006019 Vessel: CCGS Hudson Event No __213____

Latitude ___60^{o} 11.0880N__ Longitude ___48^{o} 41.1479W__

Water Depth __2904 m____ (must be deeper than 2000 metres)

Nearest **CTD** / XBT cast (circle one) Event No of cast. 212 L3_24

Date: __May 31, 2006_ Time: _____0934_____ GMT

Latitude _60^{o} 10.5134__ Longitude __48^{o} 40.5670___

Maximum Depth 2892 dbars

Any problems associated with the start up and deployment operation
_____
_____All looks good
_____
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_____
_____

Please Fax or email this information,
within 24 hours of launch if possible, to:

Howard Freeland	cc:	Ross Hendry
Institute of Ocean Sciences		Bedford Institute of Oceanography
Fax: (250) 363-6746		Fax: (902) 426-7827
Email: FreelandHJ@pac.dfo-mpo.gc.ca		Email: HendryR@mar.dfo-mpo.gc.ca

Serial No.	**2689**
Argos ID	**62966**
Argos Hex	**3246326**
WMO Code	**4900880**

APEX Float Launch

Float was started. Date: __May 30/06_ Time: ___1351_____GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: __May 30/06_ Time: ___1532_____GMT
Float should be deployed within 6 hours of start time.

Deployed By: _____Richard Boyce_____

Mission: HUD2006019 Vessel: CCGS Hudson Event No __192____

Latitude ___60° 17.8179N__ Longitude __48° 35.0771W____

Water Depth __2694 m____ (must be deeper than 2000 metres)

Nearest **CTD** / XBT cast (circle one) Event No of cast. 191 L3_25

Date: __May 30, 2006 Time: ____1337_____ GMT

Latitude _60° 17.5439__ Longitude __48° 32.4813___

Maximum Depth 2767 dbars

Any problems associated with the start up and deployment operation
_____
_____All looks good
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within 24 hours of launch if possible, to:

Howard Freeland	cc:	Ross Hendry
Institute of Ocean Sciences		Bedford Institute of Oceanography
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