CRUISE REPORT

HUDSON 2008009

LABRADOR SEA

WOCE LINE AR7W

May 20 – June 4, 2008

A. CRUISE NARRATIVE

1. Highlights

a. WOCE Designation: WOCE Line AR7W

b. Expedition Designation: HUD2008009 or 18HU08009 (ISDM format)

c. Chief Scientist:
Glen Harrison
Ecosystem Research Division
Department of Fisheries and Oceans
Bedford Institute of Oceanography
PO Box 1006
Dartmouth, NS, Canada B2Y 2A4
Internet Glen.Harrison@dfo-mpo.gc.ca

d. Ship: CCGS Hudson

e. Ports of Call: May 20, 2008 St. John's, NL, Canada
June 4, 2008 BIO, Dartmouth, NS, Canada

f. Cruise Dates: May 20 to June 4, 2008

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.

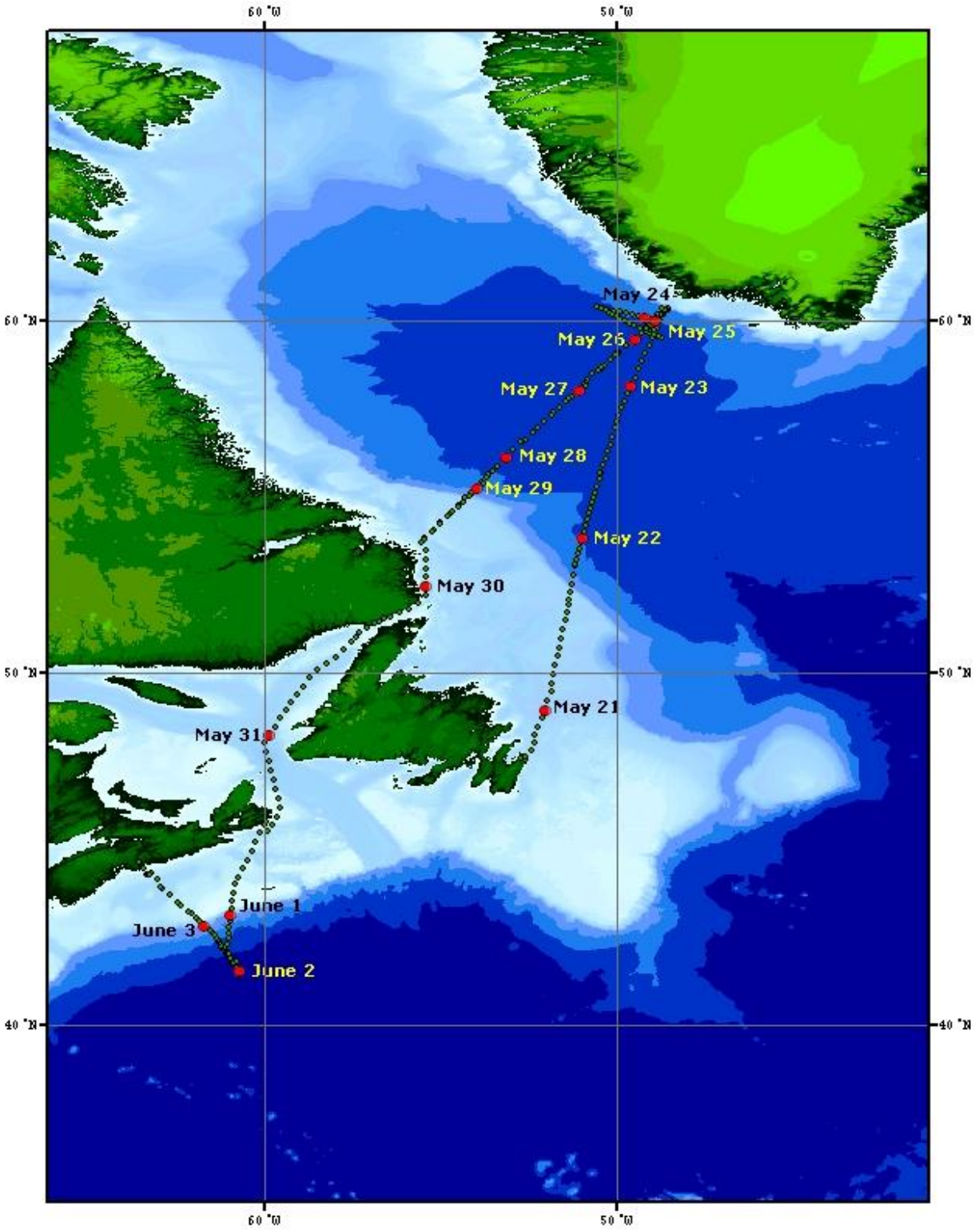

Figure A.2.1 Cruise track for HUD2008009. The date labels indicate the ship's position at 0000 UTC.

b. Total Number of Stations Occupied

The CTD / ROS station positions are shown in Figure A.2.2. Table A.2.1 lists the science operations for HUD2008009.

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 inorganic carbon (TIC), total alkalinity, oxygen, salinity, nutrients (nitrate, phosphate, and silicate), total organic carbon (TOC), and bacterial 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	27	25 of the 28 regular AR7W Sites (L3 line) plus sites 8.5 and 25.4	see Table A.2.2
	14	Halifax Line	225, 229, 231, 233, 235, 240, 242, 243, 245, 246, 248, 250, 252, 259
	7	Biology Casts not included in other tables	37, 68, 96, 139, 182, 227, 237
	1	Station 27	3
	1	Misc. Transit_01	17
	1	Unsuccessful CTD Operations	239
Moorings	5 4 1	Recoveries Deployments Release test	4, 188, 254, 255, 256 190, 253, 260, 261 189
Floats	8	APEX floats deployed	see Table A.2.3
Biology	33	200 micron net tows	2, 15, 35, 40, 43, 58, 66, 75, 85, 95, 106, 118, 128, 138, 150, 159, 167, 176, 179, 181, 192, 197, 202, 205, 209, 213, 216, 219, 222, 247, 249, 251, 258
	41	76 micron net tows	1, 14, 16, 34, 36, 42, 44, 57, 65, 67, 74, 76, 84, 94, 105, 107, 117, 119, 127, 137, 149, 151, 158, 160, 166, 175, 178, 180, 191, 193, 195, 201, 204, 206, 208, 210, 212, 215, 218, 221, 257
	7	Multi-net tows	226, 228, 232, 234, 236, 238, 244
	1	Unsuccessful NET Operations	196
Chemistry		^{129}I surface	
		^{129}I profile	
Other		~ 340 Hrs Ship Board ADCP	No number assigned
	110	XBT Deployments	5,6,7,8,9,10,11,12,13,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,47,48,49,50,51,52,53,54,55,56,61,62,63,64,70,71,72,73,78,79,80,81,82,83,87,88,89,90,91,92,93,99,100,101,102,103,104,109,110,111,112,113,114,115,116,121,122,123,124,125,126,131,132,133,134,135,136,141,142,143,144,145,146,147,148,153,154,155,156,157,162,163,164,165,169,170,171,172,173,174,185,186,187,199,200

Table A.2.1 Science operations conducted on HUD2008009.

AR7W Site Number	2008009 Deep Cast Operation Number
1	224
2	223
3	220
4	217
5	214
6	211
7	207
8	203
8.5	194
9	198
10	183
11	177
12	168
13	161
14	152
15	140
16	129
17	120
18	108
19	97
20	86
21	77
22	69
23	59
24	38
25	45
25.4	41
26	-
27	-
28	-

Table A.2.2. AR7W (L3) sites and rosette and CTD operation numbers for HUD2008009.

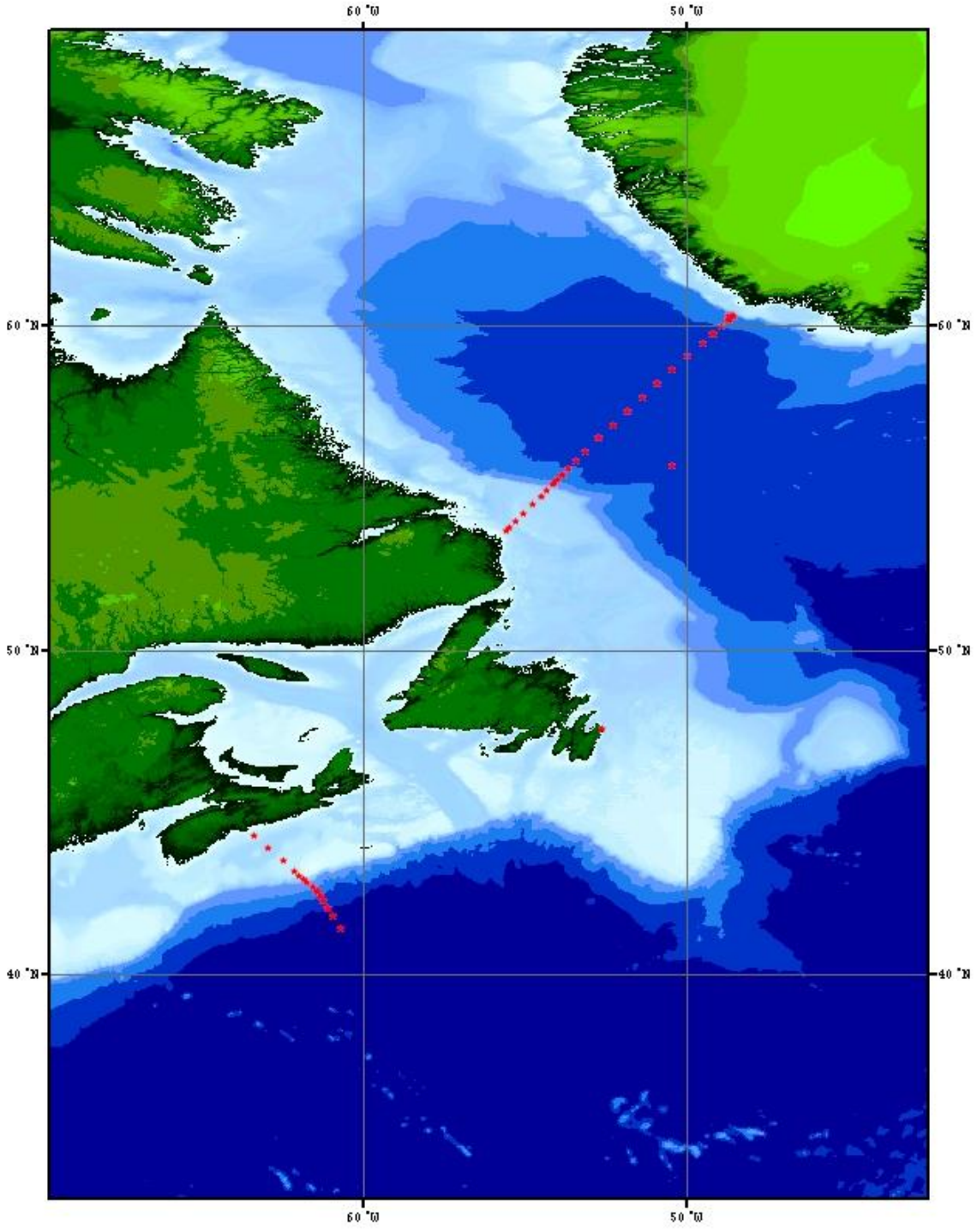

Figure A.2.2 This map shows the positions for all CTD operations (red-filled stars) for HUD2008009.

The AR7W Labrador Sea section and the extended Halifax Section were occupied during the HUD2008009 mission. These survey lines combined with Orphan Basin lines

occupied within the same four week period on HUD2008006 provide a comprehensive assessment of the oceanographic conditions in the Canadian sector of the Atlantic Ocean.

c. Floats and Drifters deployed

As a Canadian contribution to the international Argo project with the joint support of the Department of Fisheries and Oceans and Environment Canada, seven Webb Research Corporation Apex profiling floats equipped with Sea-Bird Electronics, Inc. Model 41 CTD sensors were deployed, five on the AR7W line and two on the Halifax line. Table A.2.3 gives details of the float deployments.

Apex Float		WMO #	Operation Number	Launch Position		Start Time	Launch Time
Type	SN			Latitude (N)	Longitude (W)		
APEX-SBE	3884	4901094	39	59.19	-48.75	23 May 2008 11:49	23 May 2008 12:56
APEX-SBE	3885	4901095	46	59.19	-48.71	23 May 2008 18:19	23 May 2008 19:58
APEX-SBE	3883	4901093	60	58.18	-48.93	25 May 2008 00:27	25 May 2008 01:26
pCO_2 drifting buoy (JAMSTEC)			98	58.66	-50.44		26 May 2008 15:25
APEX-SBE	3882	4901092	130	56.14	-51.80	27 May 2008 09:04	27 May 2008 09:36
APEX-SBE	3881	4901091	184	54.10	-53.78	28 May 2008 13:00	28 May 2008 13:50
APEX-SBE	3892	4901102	230	39.99	-60.89	01 Jun 2008 16:01	01 Jun 2008 16:47
APEX-SBE	3891	4901101	241	40.98	-61.40	02 Jun 2008 18:39	02 Jun 2008 19:30

Table A.2.3 APEX float deployments on HUD2008009.

d. Moorings deployed or recovered

Mooring operations are shown in Figure A.2.3. The Aanderaa current meter mooring near station L3-8 on the AR7W line was once again serviced on May 28, 2008. Mooring #1640 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 #1680 was deployed successfully on the same day.

Recovery:

M 1640	55º 07.14' N 54º 05.34' W	Standard mooring consisting of one current meter positioned 20m above bottom along AR7W on the Labrador Slope (12-month deployment) at the 1019 metres.

Deployment:

M 1680	55º 07.22' N 54º 05.36' W	Standard mooring consisting of one current meter positioned 20m above bottom along AR7W on the Labrador Slope (12-month deployment) at the 1018 metres.

A new software package called M-Cal (Mooring Calibrator) V 1.04 was used for the first time. M-Cal is a subset of a program called WorkBoat by James Illman of Software Engineering Associates. This enables the user to position the mooring once on the bottom. A computer is linked to the ship's navigation as well as, in this case, to the Benthos DS7000 deck unit. As the ship travels near the mooring, M-Cal transmits via transponder to the acoustic release and measures the time interval between the sent and reply pulses. This information combined with the navigation data enables the program to calculate the position of the release. As more and more data is gathered, the position continually updates. M-Cal also calculates a depth for the release.

This software is of great use if a mooring is off location for some reason. As M-Cal gives a position and not just a slant range, locating the mooring is much quicker. Communicating to a release via transponder only gives a slant range and not a direction. A ship has to randomly travel to minimize this slant range which could be time consuming. We did not have the opportunity on this mission to fine tune the program with inputs as "the speed of sound in water" for this location and the "turn around time of the acoustic release". However, as M-Cal saves the calibration, these inputs can be changed later to create a more accurate position.

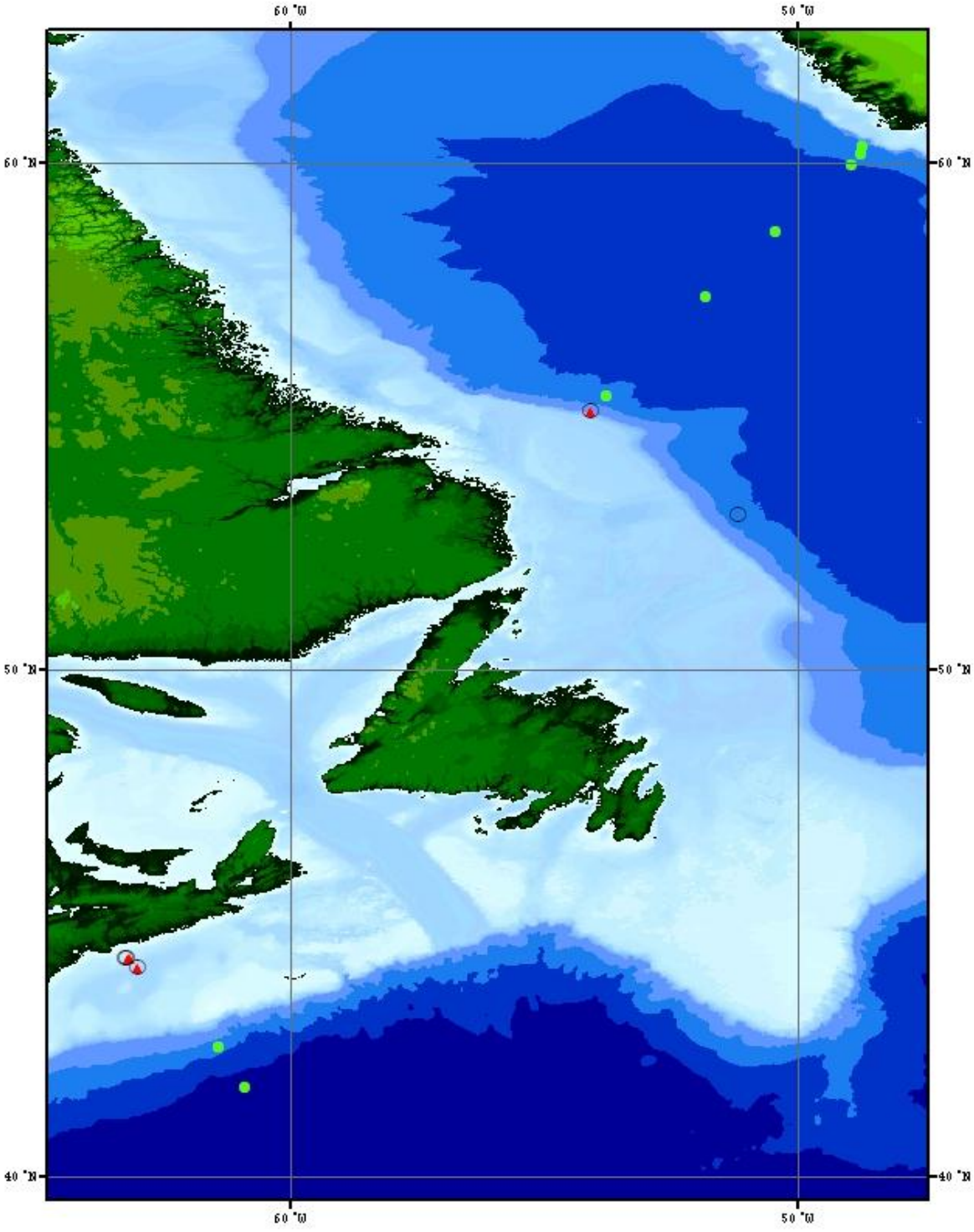

Figure A.2.3 Mooring operations (red-filled triangles are moorings deployed; black hollow circles are moorings recovered) and float deployment locations (green-filled circles) for HUD2008009.

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
Robert Ronconi	CWS Carina.Gjerdrum@ec.gc.ca	Sea bird program
Glen Harrison	BIO HarrisonG@mar.dfo-mpo.gc.ca	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	Associate 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
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	Ross Hendry

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 2006/2007 winter. The resetting of the mooring on

the 1000m 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. A surface drifting pCO_2 buoy, which was developed and supplied by JAMSTEC, was deployed at station 19 of L3 line. This drifting sensor will measure partial pressure of CO_2 once every 6 days and return data to the laboratory together with its position, salinity and temperature through the satellite.

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	Glen Harrison

The biological program conducted as part of cruise 20080009, 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)

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 extended Halifax Section in support of ERD/OSD's obligations to the Atlantic Zone Monitoring Program (AZMP) and the new climate component.

A pelagic bird survey was carried out by Rob Ronconi, contractor for Environment Canada's Canadian Wildlife Service (Dartmouth, NS) supporting CWS's work 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 32 stations (Station 27, Transit_01, 26 on the L3 line, and 4 on the Halifax Line). At all stations, tows were made from 100 meters to the surface using a ¾ m 200 micron mesh ring net, except at Station 27 and those on the Halifax Line where tows were from the bottom. An additional tow was made using a using a 30 cm 76 micron mesh ring net at all stations except L3-25.5, HL5, HL4 and HL3. See Table A.4.2.2 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 12 stations on the L3 Line and Transit_01. See Table A.4.2.2 below.

d. Depth Distribution of *Calanus finmarchicus* in the Slope Water off the Scotian Shelf **L. Harris / E. Head**

The vertical depth distribution of *Calanus finmarchicus* in the Slope Water off the Scotian Shelf was investigated. At 7 stations, HL 6-12, five depth strata (1000-800, 800-600, 600-400, 400-200, 200-0 meters) were sampled using a ¼ meter multi-net fitted with five 200 micron mesh nets. See Table A.4.2.2 below.

Station	Ring Net 200u	Ring Net 76u	Egg Production	Multi-Net
Station 27	Y	Y		
Transit_01	Y	Y	Y	
L3-24	Y	Y	Y	
L3-25.5	Y			
L3-25	Y	Y	Y	
L3-23	Y	Y		
L3-22	Y	Y	Y	
L3-21	Y	Y	Y	
L3-20	Y	Y		
L3-19	Y	Y		
L3-18	Y	Y	Y	
L3-17	Y	Y	Y	
L3-16	Y	Y		
L3-15	Y	Y		
L3-14	Y	Y	Y	
L3-13	Y	Y	Y	
L3-12	Y	Y		
L3-11	Y	Y		

L3-10	Y	Y	Y	
L3-8.5	Y	Y	Y	
L3-9	Y	Y		
L3-8	Y	Y		
L3-7	Y	Y		
L3-6	Y	Y	Y	
L3-5	Y	Y		
L3-4	Y	Y		
L3-3	Y	Y		
L3-2	Y	Y		
HL-10				Y
HL-11				Y
HL-12				Y
HL-9				Y
HL-8				Y
HL-7				Y
HL-6				Y
HL-5	Y			
HL-4	Y			
HL-3	Y			
HL-2	Y	Y		

Table A.4.2.1 The net related operation(s) performed at each of the listed stations for HUD2008009.

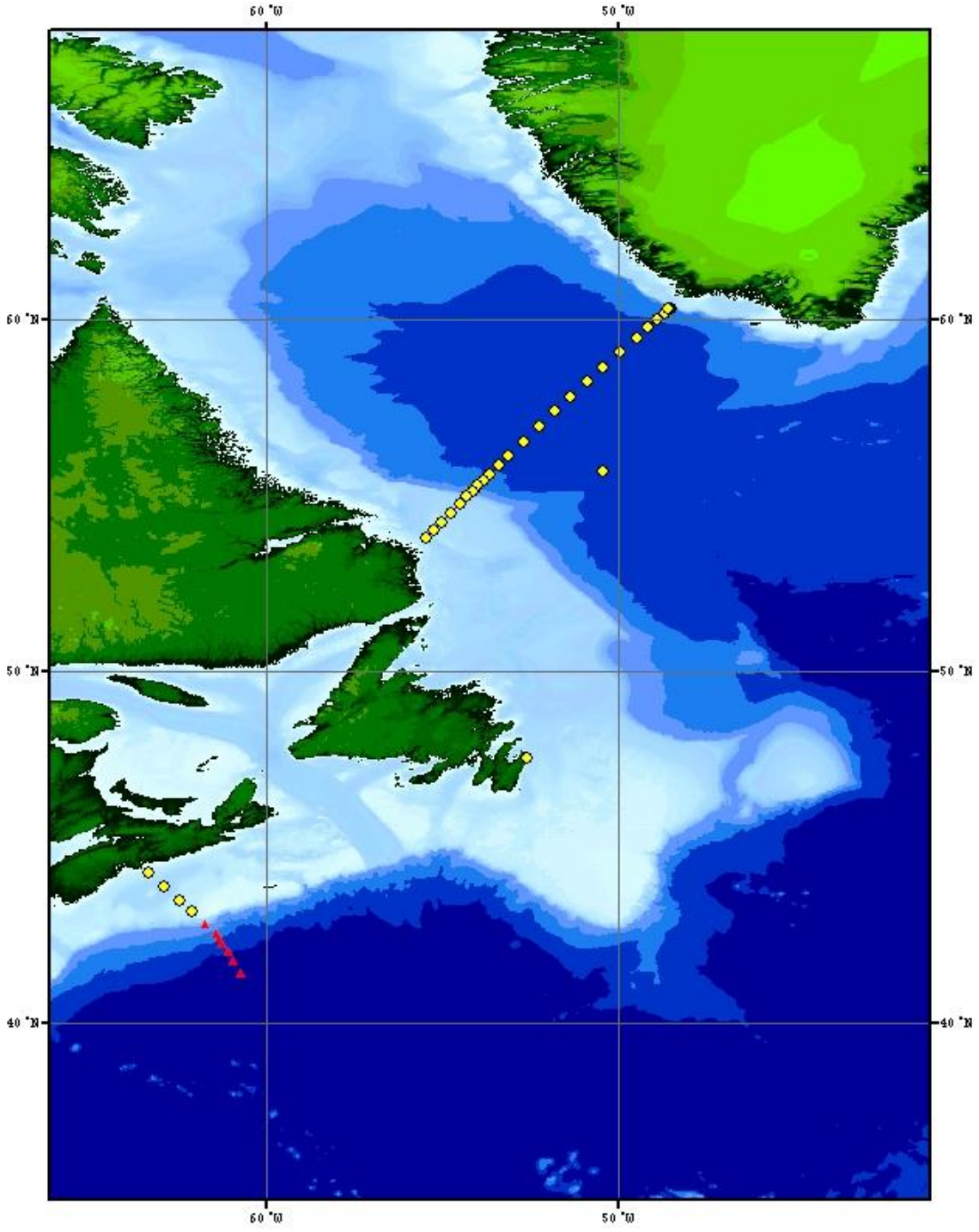

Figure A.4.2.1 Ring net tows (yellow-filled circles) and multi-net tows (red-filled triangles) locations for HUD2008009.

e. 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 HUD2008009, TOC depth profiles were collected from the following stations on 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	Not sampled due to ice
AR7W site 27	Not sampled due to ice
AR7W site 28	Not sampled due to ice

Table A.4.2.2 TOC sampling on HUD2008009.

f. Primary Production Measurements — Jeff Anning / Glen Harrison

Water samples for photosynthesis-irradiance (P-I) experiments were collected from the rosette at 12 stations. For each incubation experiment, 33 aliquots were inoculated with ^{14}C labelled 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. Duplicate chlorophyll, duplicate particulate organic carbon, one HPLC, and one Absorption Spectra sample were collected for each incubation experiment.

Station	Event	Lat.	Long.	Date	Time	Depth	ID
Bio Cast	17	55.6787	-50.4415	"May 22 2008"	11:50:09"	20.31	331555
L3-24 Bio	37	60.175	-48.6835	"May 23 2008"	10:04:04"	3.13	331570
L3-24 Bio	37	60.175	-48.6835	"May 23 2008"	09:59:09"	16.18	331568
L3-22 Bio	68	59.756	-49.1682	"May 25 2008"	19:08:38"	3.937	331652
L3-22 Bio	68	59.756	-49.1682	"May 25 2008"	19:08:38"	27.602	331648
L3-19 Bio	96	58.6398	-50.4125	"May 26 2008"	12:19:13"	3.216	331737
L3-19 Bio	96	58.6398	-50.4125	"May 26 2008"	12:16:00"	29.618	331733
L3-15 Bio	139	56.9563	-52.2368	"May 27 2008"	12:38:33"	2.904	331846
L3-15 Bio	139	56.9563	-52.2368	"May 27 2008"	12:35:23"	29.89	331842
L3-10 Bio	182	55.4183	-53.821	"May 28 2008"	11:16:01"	2.509	331979
L3-10 Bio	182	55.4183	-53.821	"May 28 2008"	11:13:35"	30.109	331975
L3-4	217	54.2228	-55.0198	"May 29 2008"	14:00:34"	2.795	332092
L3-4	217	54.2228	-55.0198	"May 29 2008"	13:57:22"	29.495	332088
HL-11 Bio	227	41.7787	-60.9077	"Jun 01 2008"	12:09:32"	2.54	332164
HL-11 Bio	227	41.7787	-60.9077	"Jun 01 2008"	12:06:13"	30.462	332160
HL-7 Bio	237	42.544	-61.383	"Jun 02 2008"	13:52:53"	2.484	332273
HL-7 Bio	237	42.544	-61.383	"Jun 02 2008"	13:50:12"	29.945	332269
HL-2	259	44.2663	-63.3175	"Jun 03 2008"	13:44:03"	3.076	332355
HL-2	259	44.2663	-63.3175	"Jun 03 2008"	"13:40:43"	30.457	332351

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

g. Bacterial Abundance and Production of Microbial Plankton — Tim Perry / Bill Li

At every depth at every station on the L3 line and stations sampled on the HL line a sample was collected for bacterial counting by flow cytometry.

Water samples were collected from all depths at 7 stations on the L3 line and incubated for between 3-24 hours after inoculation with ^{3}H labelled leucine. The cells were collected by centrifugation and prepared for scintillation counting back on shore.

Station	Event	Lat.	Long.	Date	Time
L3-24	38	6010.551	-4843.886	"May 23 2008"	"12:44:05"
L3-18	108	5814.603	-5053.833	"May 26 2008"	"21:24:43"
L3-14	152	5632.395	-5242.832	""May 27 2008""	"20:01:26"
L3-11	177	5537.003	-5337.839	""May 28 2008""	"08:26:23"
L3-08	203	5506.443	-5406.606	""May 28 2008""	"02:47:08"
L4-04	217	5413.368	-5501.188	""May 29 2008""	"13:49:10"
L4-01	224	5340.722	-5533.132	""May 29 2008""	"18:51:43"

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

h. Pelagic Bird Survey — Carina Gjerdrum / Robert Ronconi

Carina Gjerdrum, Environment Canada
45 Alderney Drive, Dartmouth, N.S., B2Y 2N6
(902) 426-9641
carina.gjerdrum@ec.gc.ca

Seabird Observer: Robert Ronconi
20 May – 4 June, 2008

BACKGROUND

Our primary objective for the pelagic monitoring program is to map the relative abundance and distribution of pelagic birds in Atlantic Canada. We rely on ships-of-opportunity to carry seabird observers to offshore areas throughout the region, and prioritise areas that can be surveyed across multiple seasons and years. These data will provide critical, and currently unavailable, information for environmental assessments for offshore developments, help identify areas where birds are at high risk for oil pollution and other human activities, identify critical marine habitat, and allow us to monitor trends in abundance and distribution of marine birds.

Protocol

The main objective of our protocol is to ensure that observers conducting surveys at sea from a moving platform are recording data in a consistent, unbiased fashion that permit subsequent conversion into seabird densities. This protocol is consistent with methods used elsewhere in the world, making these data comparable to other geographic areas.

Surveys are conducted while looking forward from the bridge, scanning ahead to a 90^{o} angle from either the port or starboard side, limiting observations to a transect band 300m wide from the side of the platform. A survey consists of a series of five-minute

observation periods, which are exclusively dedicated to detecting birds at sea. We conduct as many consecutive five-minute observation periods as possible, regardless if birds are present or not, and try to ensure consistent coverage throughout the day.

We scan the transect continuously by eye, to count and identify birds present in air or on water. Binoculars are used to confirm the species identification, and other details, such as age, moult, carrying fish, etc. We continuously record all birds observed on the sea surface and estimate their distance from the platform. Flying birds are not recorded continuously as this would overestimate bird density. Instead, we record flying birds using instantaneous counts, or "snapshots", at regular intervals throughout the observation period. The number of snapshots conducted depends on the speed of the platform.

GENERAL RESULTS

From 20 May – 4 June, 1509 km of ocean track were surveyed from the bridge of the CCG Hudson. During this time, 1538 birds from 6 different families were counted (Table A.4.2.5). In general, birds were widely distributed throughout the survey area, although higher densities occurred just outside Halifax Harbour, on the Sable Bank, through the Strait of Belle Isle, off the north coast of the Avalon Peninsula, and near the Greenland coast (Figure A.4.2.2).

Species from the family Procellariidae were the most abundant group observed (37%), 26% of which were Northern Fulmar. Northern Fulmar were observed throughout the survey area, but were most common over the Labrador and Greenland slope waters. Additional members of this family include the Sooty and Greater Shearwaters, both summer migrants from the southern hemisphere, which were observed almost exclusively on the Scotian Shelf. Birds from the family Alcidae accounted for 21% of the observations. Most of these were Murres, which were common through the Strait of Belle Isle, near breeding colonies on the Avalon Peninsula, and near the Greenland coast. Dovekie and Puffins were relatively common in these same areas.

Storm-petrels accounted for 17% of the observations and were especially numerous off Baccalieu Island, which is the largest Leach's Storm-Petrel colony in the world. Wilson's Storm-Petrels were more common on the Scotian Shelf where they have recently arrived from breeding colonies in the southern hemisphere. Flocks of phalaropes (mostly Red Phalarope) were common (14%) on the eastern Scotian Shelf, through the Strait of Belle Isle, and in the western Labrador Sea. These birds are migrating towards breeding colonies in the high Arctic. Observations also included a few Red-necked Phalaropes. Black-legged Kittiwakes were the most commonly encountered gull in the survey (5%), and often followed the vessel with the fulmars. Arctic-breeding gulls such as Iceland, Sabine's, and Glaucous Gulls were notably absent from the surveys this year.

ACKNOWLEDGEMENTS

Our work could not occur without the generous support of DFO scientists and staff, and the Coast Guard officers and personnel. Thank you for giving me the opportunity to join this cruise.

Family	Species		Number observed
Procellariidae	Northern Fulmar	*Fulmarus glacialis*	405
	Sooty Shearwater	*Puffinus griseus*	40
	Greater Shearwater	*P. gravis*	125
	Manx Shearwater	*P. puffinus*	1
	Unknown Shearwater	*Puffinus* spp.	1
Hydrobatidae	Leach's Storm-petrel	*Oceanodroma leucorhoa*	142
	Wilson's Storm-petrel	*Oceanites oceanicus*	56
	Unknown Storm-petrel	*Oceanodroma* or *Oceanites*	61
Sulidae	Northern Gannet	*Morus bassanus*	35
Scolopacidae	Red-necked Phalarope	*Phalaropus lobatus*	6
	Red Phalarope	*P.fulicaria*	200
	Unknown Phalarope	*Phalaropus* spp.	14
Laridae	Unknown Jaeger	*Stercorarius* spp.	1
	South Polar Skua	*S. maccormicki*	1
	Herring Gull	*Larus argentatus*	29
	Great Black-backed Gull	*L. marinus*	13
	Black-legged Kittiwake	*Rissa trydactyla*	71
	Arctic Tern	*Sterna paradisaea*	1
	Unknown Tern	*Sterna* spp.	8
Alcidae	Dovekie	*Alle alle*	52
	Thick-billed Murre	*Uria lomvia*	31
	Common Murre	*U. aalge*	46
	Unknown Murre	*Uria* spp.	111
	Razorbill	*Alca torda*	18
	Atlantic Puffin	*Fratercula arctica*	66
	Unknown Alcidae	Alcidae	4
Total number observed within transect			1538

Table A.4.2.5 Numbers of birds observed within the 300 m transect during the spring 2008 Labrador Sea survey.

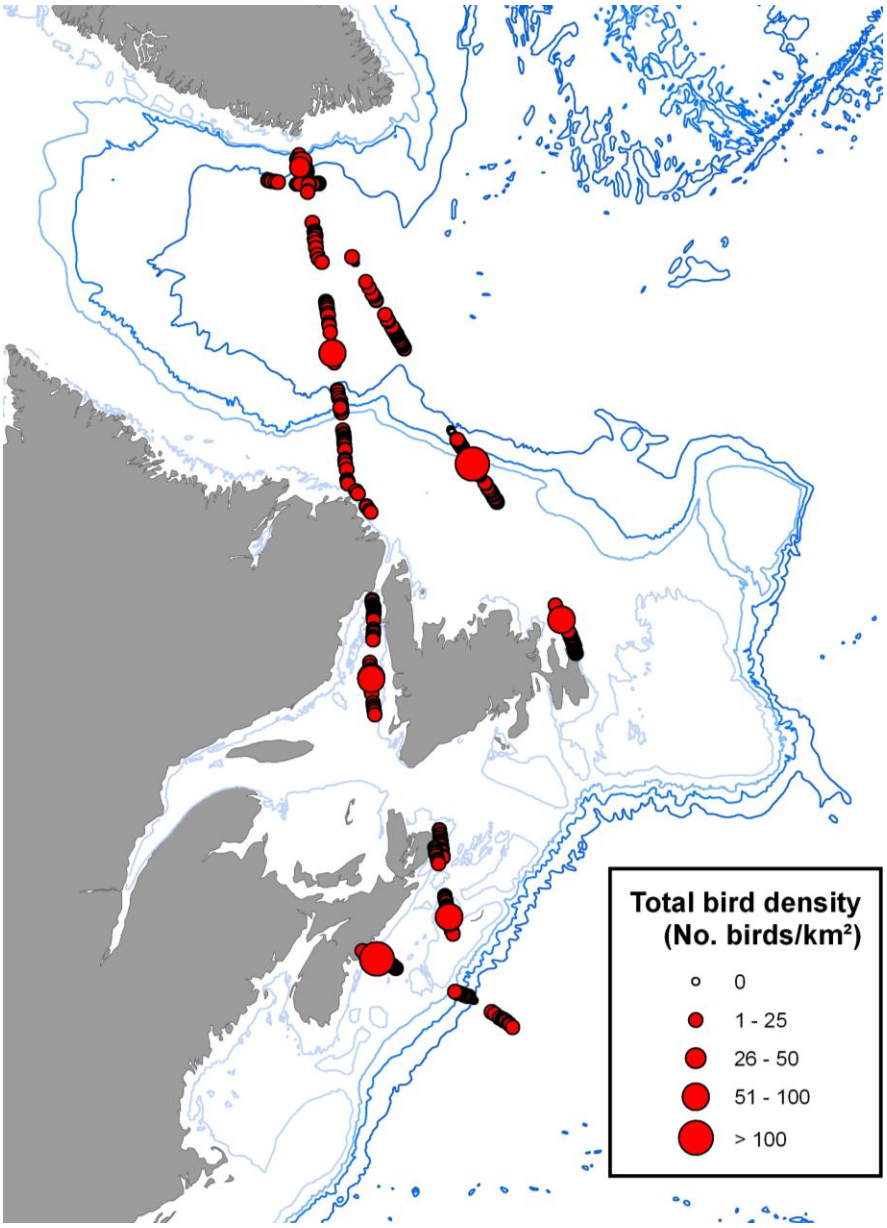

Figure A.4.2.2 Bird densities (number of birds km^{-2}) observed during spring 2008 Labrador Sea surveys.

5. Major Problems and Goals Not Achieved

6. Other Incidents of Note

7. List of Cruise Participants

Name	Responsibility	Affiliation
Jeffrey Anning	Biological, Primary Production	ERD, BIO
Carol Anstey	Nutrients, Oxygens	ERD, BIO
Kumiko Azetsu-Scott	Scientist, Carbonate, Alkalinity	OSD, BIO
Richard Boyce	Salts, Mooring, Floats	OSD, BIO
John (Jay) Bugden	TOC Levels	ERD, BIO
Rob Ronconi	Sea bird observer	EC, CWS
Yuri Geshelin	Computer Room	OSD, BIO
Susan Hannan	Carbonate, Alkalinity	BDR
Leslie Harris	Biological, Net Tows	ERD, BIO
Glen Harrison	Chief Scientist, Biological	ERD, BIO
Adam Hartling	Winch Room, LADCP	OSD, BIO
Ross Hendry	Associate Chief Scientist, Oxygens	OSD, BIO
Jeffrey Jackson	Data management, Computer Room	OSD, BIO
Richard Nelson	CFC	ERD, BIO
Timothy Perry	Biological, Bacteria	ERD, BIO
Brian Robinson	Carbonate, Alkalinity	BDR
Robert Ryan	CTD Tech., Winch Room	OSD, BIO
David Slauenwhite	CFC	OSD, BIO
Igor Yashayaev	Scientist, XBT	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

ERD Ecosystem Research Division

DAL Dalhousie University
Halifax, NS, Canada, B3H 4R2

OSD Ocean Sciences Division

B. UNDERWAY MEASUREMENTS

1. Navigation and Bathymetry — Jeff Jackson

The navigation system onboard CCGS Hudson consists of one differential GPS receiver and navigation software. 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 running the navigation software, then rebroadcasts the NMEA strings to distribution units in the computer room, which provide many output lines for the working labs. The resulting broadcast navigation strings are ~ 1 Hz. The navigation data are then logged at specified intervals on a PC. For this cruise the navigation was logged approximately 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. This has been the standard software package for years now and we used it again on this mission.

New to the navigation acquisition arena is the Geological Survey of Canada's (GSC) Survey Suite navigational software. This is a windows package which grabs every NMEA string broadcast over the network. It adds a date/time stamp to every data record acquired. It was tested on this cruise and it seemed to work very well without any problems. It is easier to configure and operate than AGCNAV. The only negative observation that can be made is that it does not have a waypoint viewer.

The echo sounder system used for collecting bathymetric data at station locations consisted of a 12 KHz Raytheon PTR echo sounder that created an analog trace on a Raytheon Line Scan Recorder located in the forward laboratory. The transducer beam width is 15 degrees. The sweep rate of the recorder 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 — Adam Hartling

Ocean Surveyor II vessel mounted acoustic Doppler current profiler system consists of a 75 kHz phased array transducer assembly mounted in a well in the ship's hull. The deck unit and computer are located in the forward lab.

The transducer assembly is mounted on a ram penetrating the ships hull that can be lowered if necessary. Transducer remained in the retracted position for the duration of the cruise. It was determined during sea acceptance testing that lowering the transducer did not effect the operation of the system. The transducer is located approximately 6m below the waterline.

The system is capable of collecting bottom track data to 1000m and profile data to 650m. Setup includes 100-8m bins. The Ocean Surveyor was set to operate in the narrow band single ping mode with 2 sec ensemble time. Position, heading, pitch and roll data is provided by the ADU5 attitude determination unit at a 5Hz rate. Ships gyro heading data is connected directly to the OSII deck unit. The Ocean Surveyor also includes a temperature sensor for sound speed calculations.

WinADCP software package used monitor profile data in real time. WinADCP is set to display times series of short-term averaged profile and attitude data. VmDas Software package used to deploy OSII and log raw data, VmDas option files, intermediate and processed files. Data back-up on external hard-drive. Data back-up includes only raw data and VmDas option files.

All NMEA strings are logged during data collection. The gyro heading is included in the raw data. Raw data is processed in real time for a short term average of 30sec and a long term average of 300sec.

Data will have to be reprocessed using gyro heading during periods with low quality or no attitude solution. Raw data can be reprocessed using VmDas.

There was a significant increase in the noise floor caused by bow thrusters while on station, during high sea states, or during travel at speeds in excess of 12 knots in rough conditions. An increase in the noise floor results in a significant decrease in the data quality and reduction in the profile range. The attitude solution also seemed to degrade occasionally when the ship is in a very low motion state with no heading or location change.

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 60 sec. The temperature and conductivity were measured with Sea-Bird 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 the ships 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 HUD2008009 mission. 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 1900m at the cruising speed of 6 knots, T7s record temperature to 800m at the cruising speed 15 knots and T10s to 200m. The vertical resolution of the measurements was about 0.6-0.8m. 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).

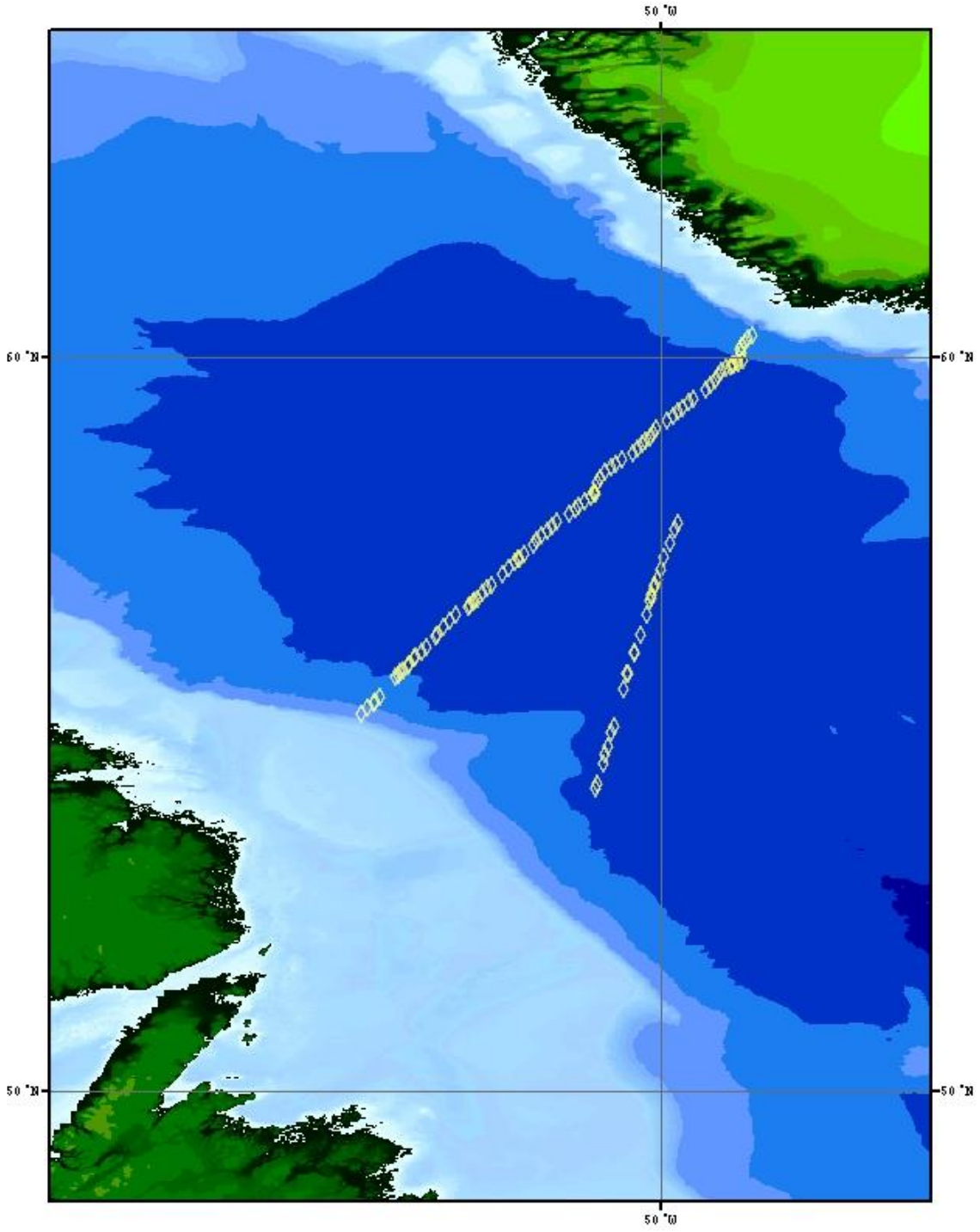

Figure B.4.1 XBT sites (indicated by blue open circles) during HUD2008009.

5. Thales Navigation ADU5 Attitude Determination Unit **Adam Hartling**

4-antenna receiver configuration uses differential carrier phase measurements to compute heading, roll, and pitch in real-time at a 5-Hz update rate.

Position and velocities are computed only for Antenna 1. The remaining antennas provide carrier phase data for attitude determination. Antenna 1 is a Beacon antenna providing differential position when in range of a base station. Beacon corrections were available for all but the most north – east portion of the cruise.

Antenna separations in a normal multipath environment determine the level of solution accuracy. Fore - aft antenna separation is 3m provides potential heading accuracy of 0.2 degrees. Port – starboard antenna separation of 1m provides potential pitch/roll accuracy of 0.6 degrees.

User configurable data is output on two serial ports. Output Port A provides position data for ship wide NMEA Mux including strings
GGA,GLL,VTG,ZDA

Output Port B, 115200, 5Hz update rate, provides position and attitude data for Ocean Surveyor II
GGA,VTG, and PASHR,AT2 (heading, pitch, roll)

When the receiver is searching for the ambiguities, or when a valid solution has not been found code phase estimate of heading appears in the PASHR,AT2 string and pitch and roll are displayed as exactly 0.00. Heading may also be displayed as 0.00 if no estimate is available. In extreme cases the position may also be lost.

When either of these situations exist, the attitude reset flag is set to 1 in the attitude output message (a 0 for the attitude reset flag indicates a good attitude solution).

If noisy or bad satellite measurement data was received by the ADU5 the Kalman filters sometimes get lost. This results in no valid solution. This often is the result of high multipath interference. BRMS and MRMS fields in the PASHR,AT2 string will exceed maximum noise levels, and the PDOP will become large. For a good solution PDOP should be less than 6.

ADU5 was reset on a few occasions when the attitude solution was lost. No loss of position resulted. If the interference is not prolonged the unit can recover on its own. The PASHR, AT2 string contains a quality flag which indicated the quality of the solution.

In the presence of multipath the attitude solution suffers degradation in accuracy and an increase in processing time is required to regain a lost solution. To reduce outages for the 2008 cruise season the array was moved to the port side and raised to a height of 2.5 m off the deck. The port side was chosen to increase the distance from the ships radar antenna. This arrangement seemed to improve the reliability of the motion sensor.

Solution quality was monitored on a daily basis with the aid of the Teledyne RDI VMDAS and WinADCP software packages used to log and monitor the OSII ADCP current profile data.

6. Meteorological observations

The officer of the watch manually logged meteorological variables at regular intervals. Negotiations are ongoing with the Meteorological Service of Canada to install an automated weather reporting system on Hudson.

7. Atmospheric Chemistry

There was no atmospheric chemistry program.

C. HYDROGRAPHIC MEASUREMENTS - DESCRIPTIONS, TECHNIQUES AND CALIBRATIONS

1. 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 Drawing Office where they were left for a period of at least 10 hours to equilibrate to room temperature before being analyzed. The temperature in this area ranged between 23º to 25 ºC. The bath temperature was maintained at 24º for all samples.

d. Standards Used

The salinometer was standardized during the mission using IAPSO standard water, Batch P147 dated June 6, 2006 having a K15 value of 0.99982 and a salinity of 34.993. 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. Historically the Autosal was setup in the General Purpose (GP) lab onboard Hudson. Air temperature was difficult to control in this area. For this mission the Autosal was installed in the Drawing Office where the operator can control the ambient air temperature much better than in the GP lab.

2. Oxygen — Carol Anstey / Ross Hendry

a. General

This report concerns data from the combined cruises HUD2008-006 Orphan Basin and HUD2008-009 Labrador Sea. Samples for the determination of dissolved oxygen were collected along two transects crisscrossing the Orphan Basin, the Newfoundland monitoring station 27, AR7W L3 and the Halifax Line on the Scotian Shelf. Samples were drawn from all depths at each station. One replicate sample per station was collected usually at the bottom depth or maximum oxygen depth as determined by the CTD trace.

The samples were analyzed using an automated system developed at the Scripps Institute of Oceanography based on a modified Winkler titration technique.

b. Sampling Procedures

Oxygen sub-samples were drawn after chlorofluorocarbon (CFC) and total organic carbon (TOC) samples from 10L bottles attached to a 24-bottle Rosette Sampler. The oxygen sampling bottles were 125 mL Iodine flasks with matched custom ground stoppers (Levy et al., 1977). The flask volumes were predetermined gravimetrically (volume data saved to titration program). The matched flasks and stoppers are etched with identification numbers.

Each oxygen sub-sample was drawn via a silicone tube attached to the spigot of the Rosette bottle. The flask and cap were thoroughly rinsed and the flask filled to overflowing. The flow was then allowed to continue until two to three flask volumes overflowed. The sampling tube was slowly removed with continuous low flow to ensure that no air was trapped in the flask and the sample volume kept to the brim of the flask. As in the previous year, the draw temperature of each sample was taken by a digital thermometer in the winch room. This method had to be abandoned twice during the cruise as several thermometers failed. In these cases, the CTD recorded temperature obtained from the QAT file was used as draw temperature. Samples were oxidized immediately with the addition of 1.0 mL each Alkaline Iodide and Manganous Chloride. The flask stopper was carefully inserted to avoid introducing air. The flask was then thoroughly shaken. The resulting precipitate was allowed to settle for approximately 30 minutes before analysis once the bottles reached the GP lab.

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). On the addition of 1.0 mL each Manganous Chloride and Alkaline Iodide, a manganous hydroxide precipitate forms reacting with the dissolved oxygen to form a hydrated tetravalent oxide of manganese. Once the resulting precipitate has settled, it is dissolved by the addition of 1.5 mL of 5M sulphuric acid forming acidic $MnO(OH)_{2,}$ which acts as an oxidizing agent liberating free iodine from the iodide solution equivalent to the dissolved oxygen in the water. The free iodine was titrated with standardized thiosulfate solution and the amount of dissolved oxygen calculated. A 350 nm UV detector was used to determine the 100% transmission endpoint. A Potassium Iodate solution was used as the working standard. The temperatures of the samples, potassium iodate and thiosulphate (taken by temperature probe integrated with titration system) were logged in the program for each determination to allow for temperature related volume corrections.

Standards, titre, acid and pickling agents were prepared just before the cruise. Both the voltage regulator and the lamp had to be replaced during analysis on this cruise. It has been recommended that a new detectors, voltage regulators and lamps be purchased.

d. Replicate Analysis

Replicate samples were drawn from one depth per station usually either the bottom depth or oxygen maximum as determined from the CTD sensor trace. The standard deviations (precision) of oxygen concentration for the replicate pairs are plotted for each day of analysis in Figure C.2.1. Average deviation for all replicate samples: ± 0.0806 mL/L.

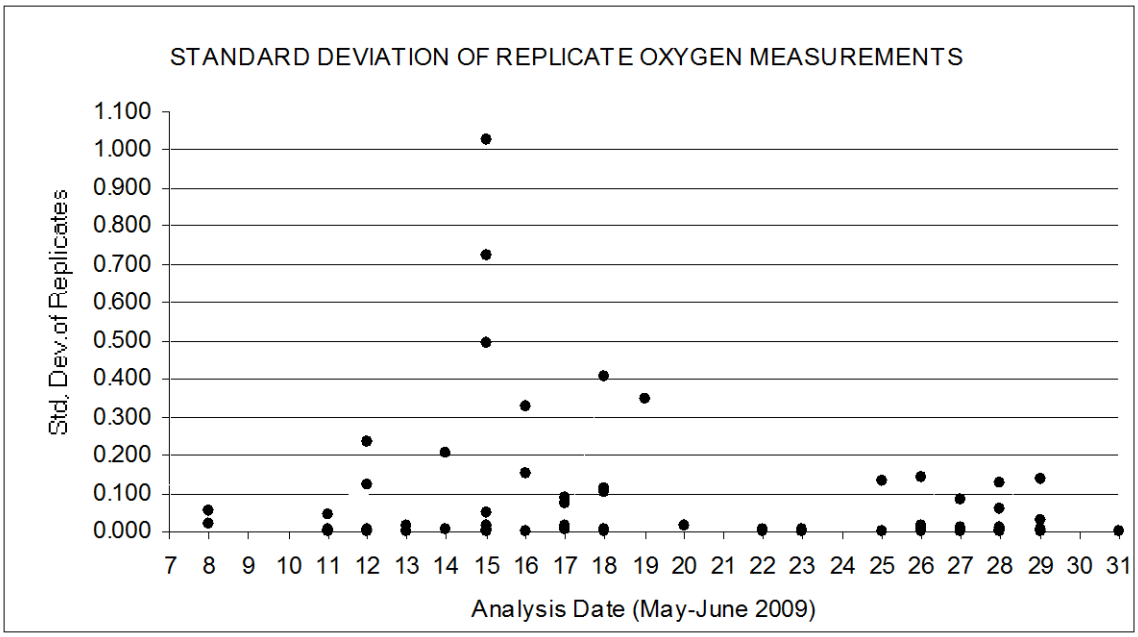

Figure C.2.1. Standard deviation of mean for the analysis of each replicate pair vs. date of analysis.

e. Standards and blanks

Standard calibrations and blanks were done at change of watch when the analysis was taken over by a change of staff. Standards are determined by the titration of 10.0 mL volume of KIO_3 solution. Blanks are determined by titration an initial 1.0 mL volume of KIO_3 followed by addition and titration of a second 1.0 mL volume. The blank is the difference between the two volumes. The protocol followed in previous years was to obtain at least three replicate standards and blanks within ±0.0003. As a change in an attempt to exclude bias, only five to six of each were done and accepted without discarding results outside a set precision limit. The oxygen analysis software does allow the operator to edit out any individual blank or standard titration considered an outlier and in some cases where results were obviously out of line, this was used. The average values of valid standards and blanks for each set of titrations were used to compute oxygen concentration. The individual titration volumes and auxiliary information are stored for possible re-processing. The averages of the daily accepted standard and blank values are plotted in Figures C.2.2 and C.2.3 below.

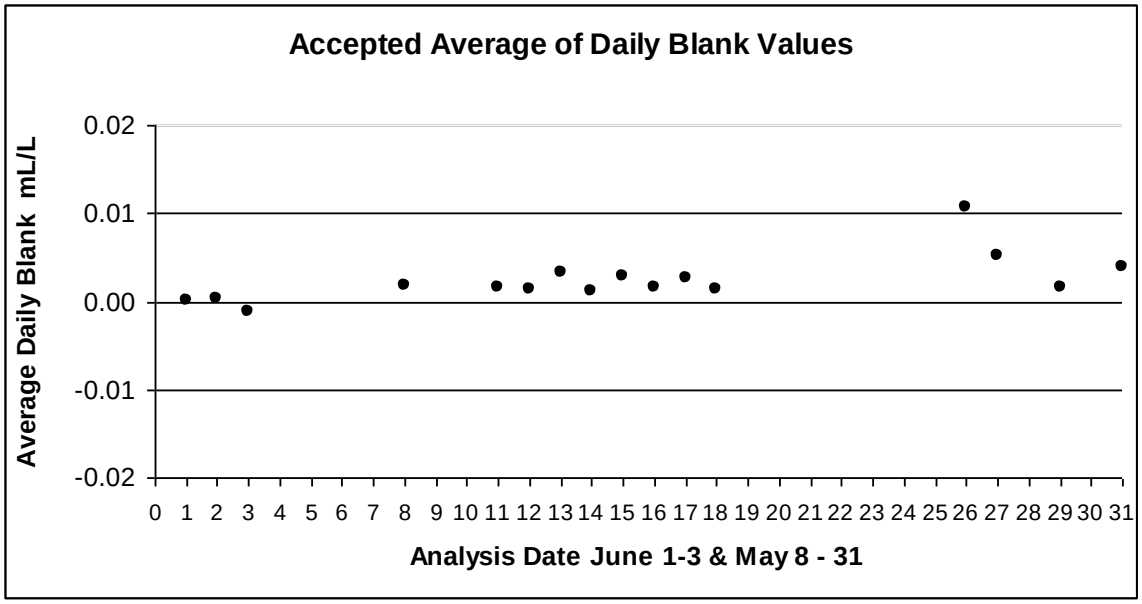

Figure C.2.2. Averages of accepted values for oxygen blanks for each analysis day.

The blank values in Figure C.2.2 have an overall average of 0.0024 mL/L and overall average deviation of 0.0023 mL/L.

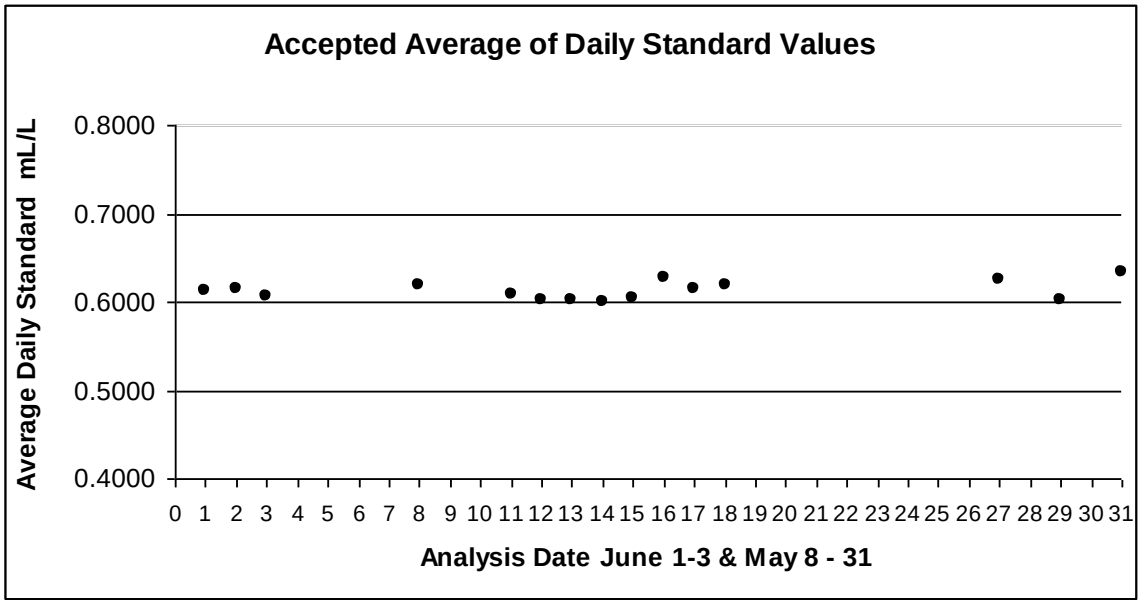

Figure C.2.3. Averages of accepted values for Potassium Iodate standards for each analysis day.

The potassium iodate standard values in Figure C.2.3 have an overall average of 0.6129 mL/L and overall average deviation of 0.0092 mL/L.

f. Comments

A log book was kept with a daily record of raw data results and any problems encountered. Unfortunately, for the Labrador Sea HUD2009-009 portion of the cruise, daily results for standards, blanks and replicates were not recorded as rigorously. This lack of recorded data caused problems when recalculating the data or calculating blank and standard performance statistics. A protocol has been set in place where all data will be recorded. There were constant problems with bubbles forming in the reagent lines; perhaps due to swings in GP lab temperatures. Results from standard and blank calibrations were erratic with very low precision. Also, there was an increasing problem with negative blanks, especially towards the end of the cruise. Protocol calls for precision to be ±0.0003; this was rarely achieved. This has been an ongoing problem. Alpha-Q, supplied by the nutrient lab, was used for calibrations and blanks in an attempt to improve precision and accuracy. However no difference in precision was noted. Again a computer or 'systems' crash occurred a several times, once due to water in the keyboard. A computer upgrade would be well recommended. The Dosimats did work smoothly other than the constant degassing problem. Problems with switched stoppers or draw bubbles in the samples were not noted. Unfortunately, during the Labrador Sea cruise portion, samples were left to sit at room temperature in the lab several times leading to the development of fine gas bubbles and degradation of precipitate (darkening of colour and dissolution of precipitate). Protocol used by the IOS lab (Sidney, BC) of storing the samples in a refrigerator set aside specifically for this use in the GP lab has been suggested. It has been reported that samples can be stored without photo degradation in this manner for up to 10 hours. This protocol will be adopted next year. Alkaline Iodide and Manganous Chloride dispensers were kept regularly rinsed out to prevent sticking.

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 were standard Technicon for Seawater Analysis (Silicate 186-72W, Phosphate 155-71W, Nitrate/Nitrite 158-71W) except for Phosphate which has been modified by separating the Ascorbic Acid (4.0 gm/l) from the Mixed Reagent. This modification was 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 were drawn into 30 ml HDPE (Nalge) wide mouth sample bottles from the 10 L Rosette bottles. The sample bottles were pre-washed in 10% HCL, rinsed three times with Alpha-Q (deionized water) and oven dried at >100 Degrees F.

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

The raw analog data was 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 were archived.

c. Replicate Analysis

Total number of duplicate samples analyzed for HUD2007-011: 1942. Samples were analyzed as soon as possible after collection. Any samples collected off watch were kept refrigerated (-4ºC) and analyzed within eight hours of collection.

There were no technical problems encountered during this cruise. All sample runs were excellent: stable baselines and very good calibration RMS – 'fit to curve'. Only the phosphate baseline for May 26, 2007 analysis was unstable. This was soon addressed by changing the pump tubes and an extra acid cleaning of the phosphate heater to remove molybdate build up. There were some problems during the first few analyses with air bubbles slipping into the flow cells causing erroneous air peaks. This was fixed by tilting the colorimeters by 20º. The air peaks did not interfere with the final voltage data as the program has been written to edit these out. Since the problems encountered last year on HUD2006-019, we have been able to replace old equipment. The nitrate and phosphate colorimeters have been replaced with rebuilds from Pulse Instrumentation. The voltage regulators replaced with new. Data was still being collected using the last spare IO board. The search for a replacement is ongoing. Last year's problems with white Azo-dye precipitate continuously building up in the nitrate line and the degassing of the ascorbic acid reagent for silicate forming bubbles which would get caught in the flowcell were not encountered. The high, and difficult to regulate, lab temperatures which may have contributed to these problems last year were much more stable and cooler. Average lab temperatures stayed between 22ºC to 26ºC as compared to sometimes 35ºC last year. This was probably due to cooler temperatures outside. Fans were still used to help cool the whole lab along with keeping portholes and deck doors open during calm weather.

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. A summary of QC/QA MOOS-1 data as follows:

QC/QA MOOS-1		Silicate (µM)	Phosphate (µM)	Nitrate (µM)
Accepted Values	**from**	**25.00**	**1.490**	**22.80**
	to	**27.00**	**1.630**	**24.60**
Analytical Results		27.01	1.607	24.70
		26.66	1.624	24.82
		27.47	1.651	25.45
		27.57	1.659	25.49
		27.07	1.666	25.84
		27.04	1.646	25.37
		27.37	1.653	25.22
		27.32	1.675	25.26
		26.83	1.623	25.49
		26.91	1.634	25.71
		26.45	1.622	25.67
		26.36	1.611	25.64
		27.01	1.607	24.70
		26.66	1.624	24.82
		26.71	1.634	24.77
		26.51	1.625	24.70
		26.91	1.607	25.14
		26.91	1.597	25.29

RMS offset from the predicted calibration curve is a measure of how acceptable the calibration was for a specific analysis run. There is no firm cutoff for ‘good’ or ‘bad’ data. The following table lists acceptable limits for RMS fit determined by averaging 34 runs of data deemed to be acceptable by peak shape, stability of the baseline and precision between duplicates.

RMS Offset from Curve:

STATISTIC	SILICATE (µM)	PHOSPHATE (µM)	NITRATE (µM)
Mean (n = 34)	0.115	0.042	0.089
Std. Deviation	0.115	0.020	0.043
Maximum	0.695	0.111	0.271
Cruise Average	0.080	0.017	0.082

RMS Values for Individual Analysis Runs:

Analysis Date	SILICATE		PHOSPHATE		NITRATE	
	Initial	Final	Initial	Final	Initial	Final
MAY0908	0.112	0.037	0.019	0.018	0.011	0.049
MAY1008	0.048	0.058	0.025	0.023	0.034	0.082
MAY1108	0.056	0.069	0.019	0.023	0.035	0.153
MAY1208	0.124	0.04	0.019	0.022	0.056	0.076
MAY1408	0.052	0.025	0.024	0.017	0.022	0.024
MAY2108	0.042	0.067	0.012	0.013	0.025	0.055
MAY2208	0.033	0.049	0.011	0.009	0.02	0.016
MAY2308	0.029	0.055	0.013	0.01	0.084	0.021
MAY2408	0.056	0.037	0.017	0.014	0.054	0.033
MAY2508	0.048	0.035	0.013	0.018	0.025	0.063
MY25B08	0.028	0.079	0.021	0.026	0.092	0.052
MAY2608	0.039	0.22	0.014	0.014	0.043	0.052
MAY2708	0.056	0.072	0.014	0.021	0.062	0.123
MAY2808	0.065	0.167	0.013	0.014	0.068	0.085
MAY2908	0.044	0.022	0.012	0.018	0.039	0.083
MAY3008	0.021	0.194	0.013	0.02	0.053	0.186
MAY3108	0.037	0.065	0.014	0.016	0.049	0.144
JUN0108	0.055	0.259	0.009	0.021	0.124	0.21
JUN1B08	0.236	0.185	0.028	0.025	0.221	0.266
JUN0208	0.058	0.149	0.008	0.023	0.108	0.218

The nutrient detection limits noted in the table below are an average of all analytical runs for the cruise. Individual daily detection limits were applied to the corresponding data set.

STATISTIC	Silicate	Phosphate	NO2+NO3
Number of Samples	779	779	779
Number of Duplicates	1558	1558	1558
Mean concentration (μmoles/L)	9.49	0.96	13.16
Detection Limit (μmoles/L)	0.228 ± 0.115	0.033 ± 0.029	0.106 ± 0.050

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 a 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 all sites on the AR7W and Halifax line except bottles for biological measurements. Because of the time constrain, samples from station 11 and 13 were preserved with $HgCl_2$ and analyzed later during the transit from AR7W to Halifax line. Other samples were analyzed within 4 hours of collection.

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. Samples from Station 11 and 13 were preserved with

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, La Jolla, 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 was 1.5 μmol/kg or better for samples with concentrations in the range of 1800-2300 μmol/kg.

We encountered break-down of a computer, which operates extraction system (SOMMA) and a coulometer on the 25th of May. A computer was re-built using pieces from several

existing computers by Brian Robinson. These computers are very old (486) and the reliability of using an old computer (pieces of old computers) is not good for the future operation. We need to build a control board based on the more recent computer.

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 the AR7W and Halifax lines with the exception of bottles for biological measurements. Samples are collected using the same procedure as for Dissolved Inorganic Carbon (see Section 5b). Because of the time constrain, samples from station 11 and 13 were preserved with $HgCl_2$ and analyzed later during the transit from AR7W to Halifax line.

Precision of measurements were less than 0.1% and most of the time less than 0.05%. Precision has improved since 2007. Problem of alkalinity measurements is a time. Processing time for alkalinity is over 15 minutes per sample. When the duration between stations is very short such as this year, we are pressed in time to process all the samples. Also, we did not have any problem in this cruise, a computer which control the system is very old (286), we need up-grade the system.

7. Halocarbons — Dave Slauenwhite / 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, it was not possible to collect halocarbon samples at all stations during the cruise. On AR7W line, halocarbons were sampled at all stations except for L3-12, L3-21 and L3-27. On the L2 line, samples were taken at stations 6, 8, 10, 12, 14, 15.5, and 18, while all stations were sampled on the Halifax Line.

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. Operation Notes Report **Jeff Jackson**

(sorted by Operation ID Number)

Note Number: 1	**Entry Time:** 28/May/2008 20:54:30	**Note Made By:** Jeff Jackson	**Operation ID**: 196
Part of the metering block came loose so this operation was cancelled so the block could be fixed.			

Note Number: 2	**Entry Time:** 29/Jul/2010 15:31:55	**Note Made By:** Jeff Jackson	**Operation ID**: 239
CTD operation aborted due to technical problems.			

G. REFERENCES

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