CRUISE REPORT

HUDSON 2004016

LABRADOR SEA

WOCE LINE AR7W

15 May - 30 May, 2004

A. CRUISE NARRATIVE

1. Highlights

a. WOCE Designation:	WOCE Line AR7W Atlantic Circulation Experiment
b. Expedition Designation:	Hudson 2004016
c. Chief Scientist:	Glen Harrison Ocean Sciences Division Department of Fisheries and Oceans Bedford Institute of Oceanography PO Box 1006 Dartmouth, NS, Canada B2Y 2A4 Internet harrisong@mar.dfo-mpo.gc.ca
d. Ship:	CCGS Hudson
e. Ports of Call:	May 15 BIO, Dartmouth, NS, Canada May 30 St. John's, NL, Canada
f. Cruise Dates:	May 15 to May 30, 2004

2. Cruise Summary Information

a. Cruise Track

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

The WOCE cruise station summary file (SUM) outlines the science operations conducted during the cruise. In the Comment section of the SUM file there is frequent mention of operation notes indicated by "Op Note". These notes are included in Appendix 1.

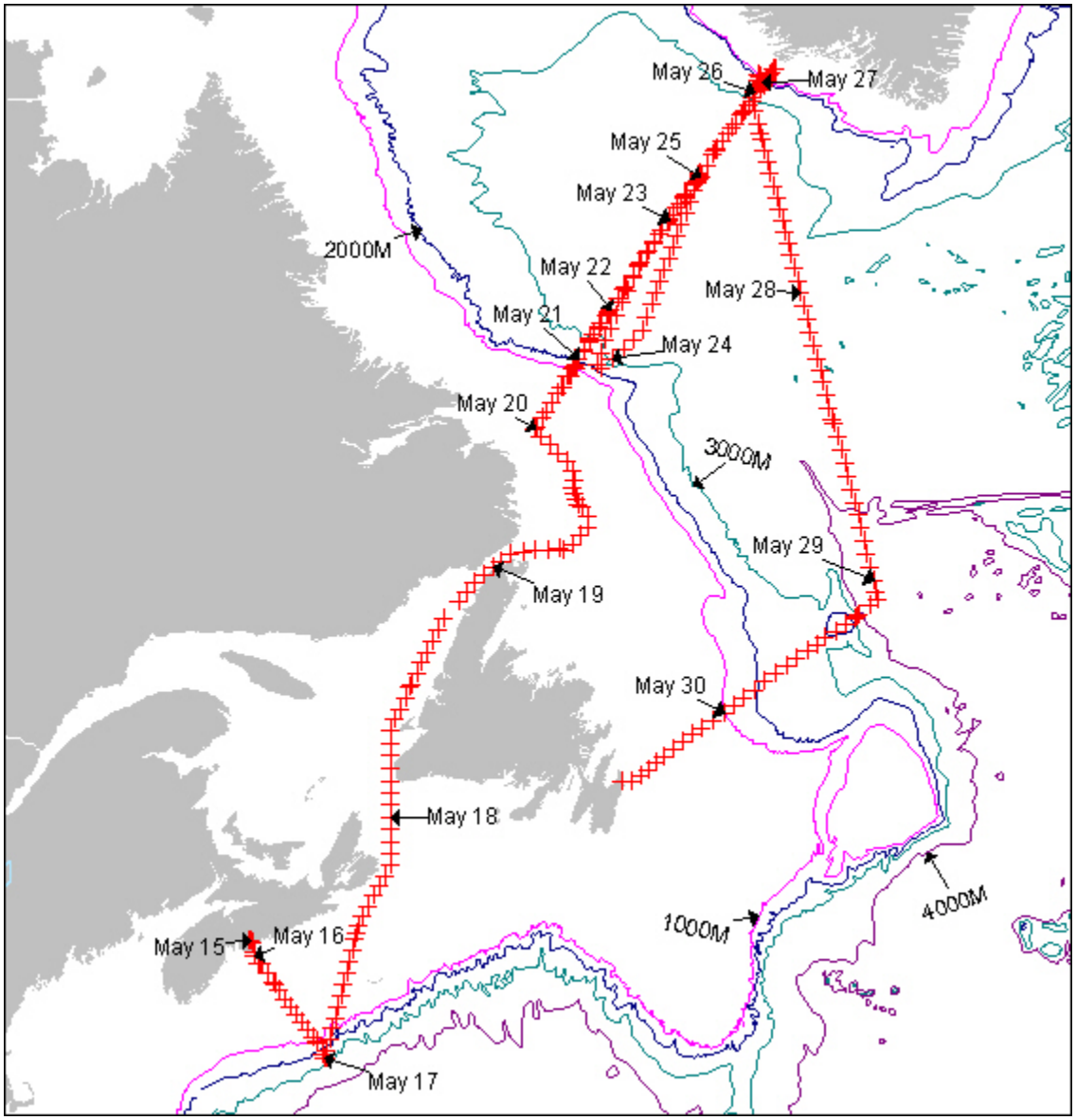

Figure A.2.1 Cruise track for 18HU2004016/1. The date labels indicate the ship's position at 0000Z.

b. Total Number of Stations Occupied

The CTD and ROS station positions are shown in Figure A.2.2. The WHP stations are all contained in the box defined by 50-62°N and 40-60°W. Table A.2.1 lists the science operations for 18HU2004016.

Cast Type	Number of Operations	Detailed Division	Operation Numbers
Rosette & CTD	27	26 regular AR7W Sites (L3 line) plus Sites 8.5	see Table A.2.2
	1	1 to profile warm LS Eddy	315
	7	Halifax Line Sites	See Table A.2.3
	2	Orphan Basin	287, 289
	7	Biology Casts not included in other tables	26, 27, 81, 133, 237, 280, 283
	1	Basin test	1
	1	Failed Cast	35
Moorings	2 1	1 recovery, 1 deployment Release test	54, 56 55
Floats	10	PROVOR floats deployed	91, 135, 214, 247, 267, 281, 282, 288, 290, 291
Biology	104	76, 200 μm net tows	3, 4, 6, 10, 11, 12, 15, 17, 18, 21, 22, 24, 25, 28, 29, 31, 32, 34, 37, 39, 41, 43, 45, 47, 49, 51, 57, 59, 61, 64, 66, 70, 72, 76, 78, 80, 87, 89, 97, 99, 118, 120, 122, 130, 132, 144, 146, 148, 160, 161, 204, 206, 209, 211, 212, 232, 234, 235, 236, 243, 244, 245, 252, 253, 255, 256, 258, 259, 261, 263, 265, 276, 278, 284, 285, 286
		28, 76 μm net tows	5, 7, 16, 23, 30, 33, 38, 42, 46, 50, 58, 60, 65, 71, 77, 79, 88, 98, 119, 121, 131, 145, 147, 205, 210, 233, 264, 277
Chemistry		^{129}I surface	36, 53, 67, 90, 100, 123, 134, 162, 213, 238, 246, 254, 266, 257, 262, 260
		^{129}I profile	82, 110, 149, 223, 279
Other		330 hrs Ship Board ADCP	No number assigned
		360 hrs. along-track T, S, and fluorescence	No number assigned
	127	XBT Deployments	68, 69, 74, 75, 83 – 86, 92 – 96, 101 – 109, 111 – 117, 124 – 129, 136 – 143, 150 – 159, 163 – 202, 207, 208, 215 – 222, 224 – 231, 239 – 242, 248 – 251, 268 - 275

Table A.2.1 Science operations conducted on 18HU2004016/1.

AR7W Site Number	2004016 Deep Cast Operation Number
1	-
2	-
3	36
4	40
5	44
6	48
7	53
8	62
8.5	63
9	67
10	73
11	82
12	90
13	100
14	110
15	123
16	134
17	149
18	162
19	213
20	223
21	238
22	246
23	279
24	254
25	266
25.3	-
25.7	-
26	257
27	262
28	260

Table A.2.2. AR7W sites and rosette and CTD operation numbers for 18HU2004016/1. Note that sites 1 and 2 could not be occupied due to ice and sites 25.3 and 25.7 were not occupied due to time constraints.

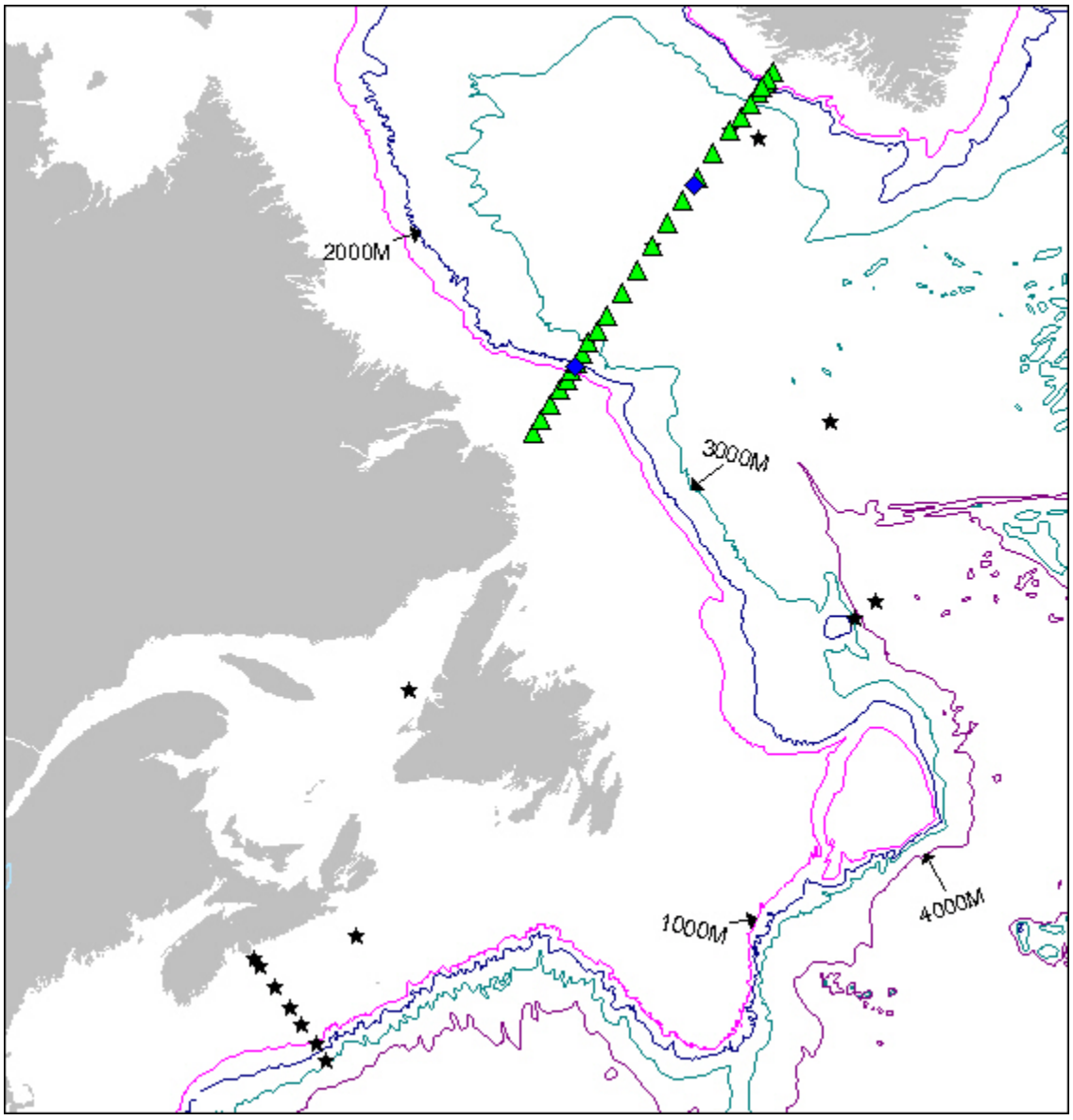

Figure A.2.2 This map shows the station positions for CTD only operations (blue solid diamonds); rosette, CTD and LADCP operations (green filled triangles); rosette and CTD operations (black star) for Hudson 18HU2004016/1.

Halifax Line Number	2004016 Deep Cast Operation Number
1	2
2	8
3	9
4	13
5	14
6	19
7	20

Table A.2.3. Halifax Line sites and rosette operation numbers for 18HU2004016/1.

Along AR7W, the stations were full-depth WHP small volume rosette casts with up to 24 rosette bottles. Water samples were analyzed for CFCs, carbon tetrachloride, total carbonate, alkalinity, oxygen, salinity, and nutrients. On some casts, samples were collected for ^{129}I (iodine-129).

c. Floats and Drifters deployed

Listed in table A.2.5 are the 10 PROVOR floats that were deployed. The deployment logs are given in Appendix 2.

PROVOR Float #	WMO #	Event Number	Launch Position		Start Date / Time	Launch Date / Time
			Latitude	Longitude		
MT-157	4900528	91	55 52.3 N	53 24.0 W	21 May 2004 18:48	21 May 2004 19:32
MT-155	4900526	135	57 22.4 N	51 45.7 W	22 May 2004 17:05	22 May 2004 18:06
MT-163	4900534	214	58 34.9 N	50 24.4 W	25 May 2004 02:06	25 May 2004 02:48
APEX-1392	4900494	247	59 45.7 N	49 06.6 W	25 May 2004 19:58	25 May 2004 21:50
APEX-1393	4900495	267	60 18.4 N	48 37.1 W	26 May 2004 23:22	27 May 2004 01:50
MT-160	4900531	281	57 30.1 N	47 53.4 W	27 May 2004 19:05	27 May 2004 20:29
MT-168	4900539	282	54 59.7 N	46 52.0 W	28 May 2004 05:47	28 May 2004 07:21
MT-108	4900418	288	50 53.6 N	45 12.4 W	29 May 2004 04:47	29 May 2004 06:08
MT-161	4900532	290	50 35.4 N	45 48.5 W	29 May 2004 10:18	29 May 2004 11:45
MT-164	4900535	291	50 10.0 N	46 49.1 W	29 May 2004 13:54	29 May 2004 15:18

Table A.2.5 PROVOR float deployments on Hudson 2004016

d. Moorings deployed or recovered

There were two mooring related operations conducted. Mooring M1475 was recovered in the Labrador Sea and mooring M1514 was deployed in the same area. The following summarizes the mooring operations. The mooring logs are attached as Appendix 3.

Deployment:

M 1514	55 07.171 N 54 05.554 W	Standard mooring consisting of one current meter positioned 20m off bottom along AR7W on the Labrador Slope (12-month deployment) at the 1032 metres.

Recovery:

M 1475	56 07.171 N 54 05.554 W	Standard mooring consisting of one current meter positioned 20m off bottom along AR7W on the Labrador Slope (12-month deployment) at the 1032 metres.

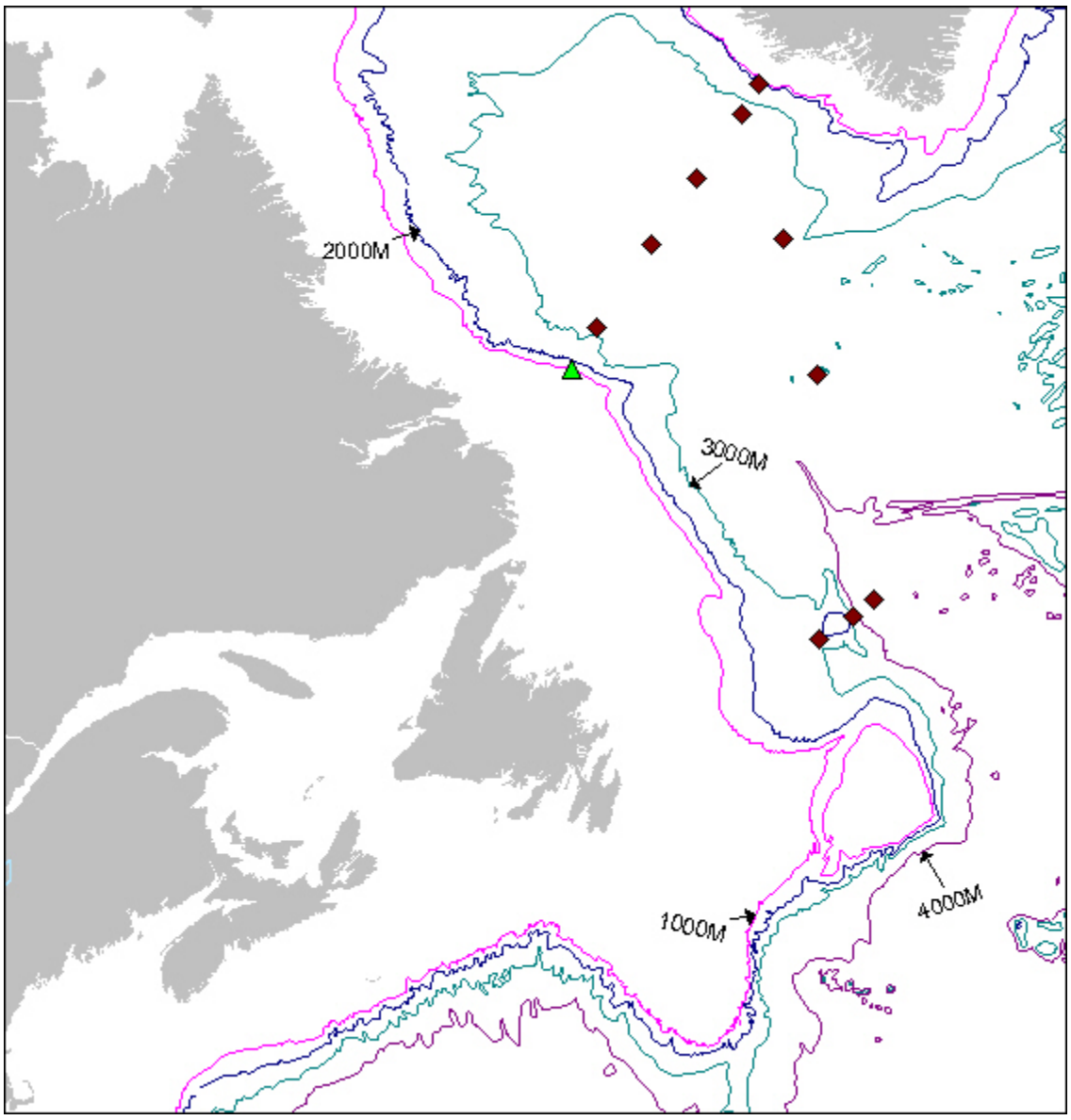

Figure A.2.3 Mooring operations (green filled triangle - a mooring was recovered and a new one deployed in the same location) and float deployment locations (burgundy filled diamonds) for Hudson 18HU2004016/1.

3. List of Principal Investigators

Name	Affiliation	Responsibility
Allyn Clarke	BIO clarkea@mar.dfo-mpo.gc.ca	Senior scientist Overall co-ordination
Bob Gershey	BDR Research rgershey@fox.nstn.ns.ca	Alkalinity, carbonate, CFCs
Glen Harrison	BIO harrisong@mar.dfo-mpo.gc.ca	Coordinator biological program nitrate and ammonium utilization by phytoplankton, sediment traps Labrador Sea.
Erica Head	BIO heade@mar.dfo-mpo.gc.ca	Macrozooplankton distribution, abundance and metabolism
Paul Kepkay	BIO kepkayp@mar.dfo-mpo.gc.ca	Dissolved organic carbon, colloid chemistry and plankton respiration
Peter Jones	BIO jonesp@mar.dfo-mpo.gc.ca	Alkalinity, carbonate, CFC's
John Lazier	BIO lazierj@mar.dfo-mpo.gc.ca	CTD data, moored instrument data
Bill Li	BIO lib@mar.dfo-mpo.gc.ca	Pico-plankton distribution and abundance, bacteria
John Loder	BIO LoderJ@mar.dfo-mpo.gc.ca	Moorings, Scotian Slope and Flemish Pass
Robert Pickart	WHOI pickart@rsp.whoi.edu	Lowered ADCP
John Smith	BIO smithjn@mar.dfo-mpo.gc.ca	Chemistry isotopes
Igor Yashayaev	BIO YashayaevI@mar.dfo-mpo.gc.ca	Hydrography and 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.

The first initiative is in support of the North Atlantic Oscillation and the Atlantic Thermohaline Circulation Principal Research Areas of the Climate Variability and Predictability (CLIVAR) project of the World Climate Research Programme (WCRP). 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

winters of 2003/2004. The resetting of the mooring on the 1000 metre isobath on the Labrador slope continues a 20+ year observation program of the Labrador Current.

The second initiative is the continuation of the Labrador Sea project of the Canadian Joint Global Ocean Flux Study (JGOFS). 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 CFCs over the entire water column in order to document the vertical transport of carbon via winter convection in the Labrador Sea as well as the changes in carbon storage in the deep waters of the North Atlantic.

The third initiative is to observe the physical and chemical parameters at the various stations of the Halifax Section in support of DFO's Atlantic Zonal Monitoring Program.

The fourth initiative was to deploy profiling floats as a Canadian contribution to the International GODAE/Argo program. Ten floats were deployed; seven in the Labrador Sea proper and three in its outflow region around Orphan Knoll.

b. Radioisotope Sampling Program **John Smith**

Near surface water samples were collected for ^{129}I from a near surface rosette bottle at 16 stations on the L3 (AR7W) line. Full depth sampling for ^{129}I was carried out at 5 stations on the same section. 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 2004016, 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 five elements:
1) a phytoplankton biomass/primary productivity program conducted by Glen Harrison and Jeff Anning with assistance from Tim Perry,
2) a microbial program conducted by Paul Dickie (for Bill Li),
3) a mesozooplankton program conducted by Les Harris and Tim Perry (for Erica Head),
4) a dissolved organic carbon/community respiration program conducted by Jay Bugden (for Paul Kepkay), and

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 OSD's 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 OSD's fisheries-related research.

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

b. Stable Isotope Studies of Carbon and Nitrogen (nitrate and ammonium) Utilization by Phytoplankton — **Glen Harrison / Tim Perry**

This work represents a continuation of research begun in 1994 to determine the primary productivity (in terms of carbon and nitrogen) of phytoplankton in the Labrador Sea. Carbon dioxide (CO_2), nitrate (NO_3) and ammonium (NH_4) utilization rates from eight depths in the photic zone (i.e. the 1% light level ranged from 31-71 m) were determined using stable isotope tracer (^{13}C and ^{15}N) methods. Incubations experiments were carried out in on-deck 'simulated in-situ' incubators. A total of 7 experiments were conducted (see Table A.4.2.1). In addition to isotope tracer experiments, particulate organic matter (nitrogen and carbon) were determined at the productivity depths and ammonium concentrations were measured at 11 depths in the upper 200m.

Date	Site	Event #	Photic Depth (m)	$^{15}N/^{13}C$	POC/ PON
20-May-04	L3_07	53	71	x	x
21-May-04	L3_11	181	68	x	x
22-May-04	L3_16	133	35	x	x
25-May-04	L3_21	237	39	x	x
26-May-04	L3_26	257	30	x	x
27-May-03	Transit	280	33	x	x
28-May-04	Transit	283	56	x	x

Table A.4.2.1. Sampling for stable isotopes.

c. 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 34 stations (7 on the Halifax Line, 2 in transit and 25 on the L3 line). At all stations, tows were made from 100 meters to the surface using a ¾ meter, 200 μ ring net. At nine of these stations an additional tow was made using a ½ meter, 76 μ ring net. See Figure A.4.2.1 below for station locations where nets were used.

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

Egg production rates of *Calanus finmarchicus*, the dominant copepod species, were measured at 9 stations in the Labrador Shelf.

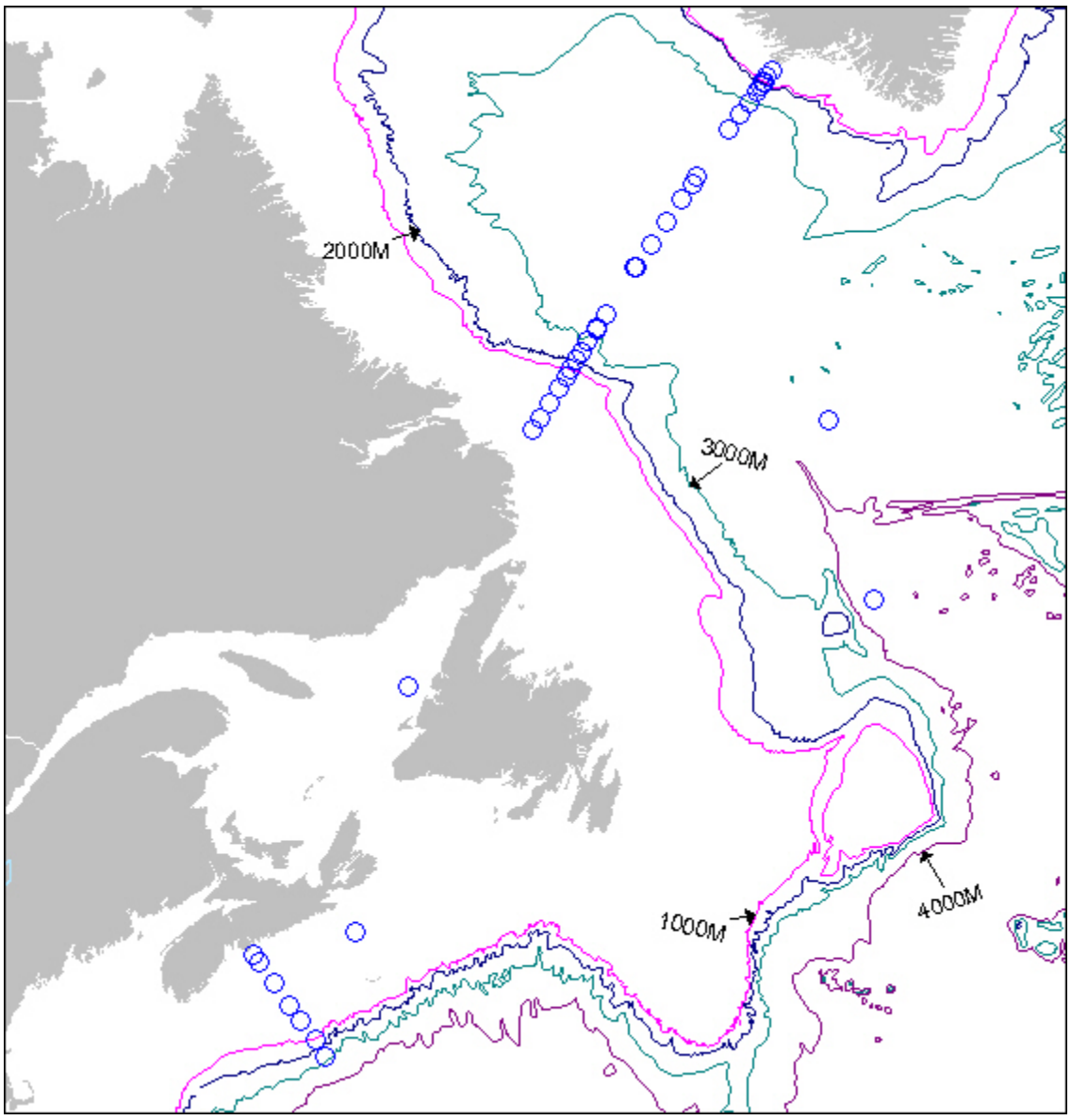

Figure A.4.2.1 Net tow (blue open circle) locations for 18HU2004016/1.

e. Total Organic Carbon (TOC) and Microbial Community Respiration

Jay Bugden / Paul Kepkay

In order to better understand the cycling of carbon and the mechanisms controlling it in the Labrador Sea, it is necessary to examine the pool of total organic carbon (TOC), and look at the activity of the microbial community in the water column. By examining the rate of respiration and size fractionating the TOC, information on the fate of carbon in this marine environment may be elucidated.

During CCGS Hudson cruise 2004-016 five (5) stations were sampled at the surface and at the chlorophyll maximum (usually between 10 and 50m depth) for gross microbial

community respiration, and for the same stations only the surface was sampled for size fractionation of TOC (ultrafiltration). The stations sampled are listed below. TOC depth profiles were also collected from the stations indicated in the table below.

Station	Respiration	Ultrafiltration	TOC Profile
AR7W site 1	not sampled - ice covered		
AR7W site 2	not sampled - ice covered		
AR7W site 3			X
AR7W site 4			X
AR7W site 5			X
AR7W site 6			X
AR7W site 7	X	X	X
AR7W site 8			X
AR7W site 8.5			
AR7W site 9			X
AR7W site 10			X
AR7W site 11	X	X	X
AR7W site 12			X
AR7W site 13			X
AR7W site 14			X
AR7W site 15			X
AR7W site 16	X	X	X
AR7W site 17			X
AR7W site 18			X
AR7W site 19			X
AR7W site 20			X
AR7W site 21	X	X	X
AR7W site 22			X
AR7W site 23			X
AR7W site 24			X
AR7W site 25			X
AR7W site 26	X	X	X
AR7W site 27			X
AR7W site 28			X

Table A.4.2.2 Ultrafiltration, respiration and TOC sampling on CCGS Hudson cruise 2004016.

f. Primary Production Measurements — Jeff Anning

Water samples for primary production experiments were collected from the rosette at 10 stations. For each incubation, 33 aliquots were inoculated with 14C as 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.

Station	Event	Lat. (deg)	Lat. (min)	Long. (deg)	Long. (min)	Date	Time (GMT)	Depth	ID
HL5	14	43	11.16	62	5.883	16-May-04	1325	2.0	277046
BioCTD1	26	44	48.147	50	29.343	17-May-04	1250	2.0	277084
BioCTD2	27	49	17.978	58	54.749	18-May-04	1124	2.0	277098
BioCTD2	27	49	17.978	58	54.749	18-May-04	1124	50.0	277089
L3-7	53	54	57.513	54	15.112	20-May-04	1250	20.0	277154
L3-7	53	54	57.513	54	15.112	20-May-04	1250	3.0	277173
L3-11	81	55	37.455	53	38.036	21-May-04	1125	30.0	277245
L3-11	81	55	37.455	53	38.036	21-May-04	1125	3.0	277253
L3-16	133	57	22.926	51	46.329	22-May-04	1446	30.0	277385
L3-16	133	57	22.926	51	46.329	22-May-04	1446	3.0	277393
L3-21	237	59	29.695	49	29.475	25-May-04	1257	30.0	277525
L3-21	237	59	29.695	49	29.475	25-May-04	1257	3.0	277533
L3-26	257	60	22.128	48	28.663	26-May-04	1650	30.0	277621
L3-26	257	60	22.128	48	28.663	26-May-04	1650	3.0	277628
BioCTD3	280	59	21.962	48	37.902	27-May-04	1130	30.0	277706
BioCTD3	280	59	21.962	48	37.902	27-May-04	1130	3.0	277714
BioCTD4	283	54	10.721	46	32.382	28-May-04	1124	30.0	277726
BioCTD4	283	54	10.721	46	32.382	28-May-04	1124	3.0	277739

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

g. Bacterial Abundance and Production of Microbial Plankton — William Li / Paul Dickie

Seawater samples were collected from the water sample bottles at all stations and all depths for subsequent Flow Cytometric analysis. They were preserved with a final concentration of 1% filtered paraformaldehyde and frozen in liquid Nitrogen. Dr. Bill Li will look at these for enumeration of pico-phytoplankton, bacteria and viruses. At 17 stations on the Labrador- Greenland transect, incubations were conducted on water from the surface to 150 meters for uptake of tritiated leucine into bacterial cells. This gave an estimate of the rate of increase of marine heterotroph biomass in the photic zone. An additional experiment was performed at station L3-21 water depths from surface to 3499 meters (24 depths). Three additional transit stations were sampled for leucine uptake.

h. Zooplankton biomass and growth **Lidia Yebra / Sergio Alvarado**

WP2 nets (76 um and 200 um mesh) were used to collect ZP from 0-100 m, along line L3 (see list of stations below). On board, samples were fractionated by size: 63-200, 200-450, 450-1000 and >1000 um, and frozen in liquid Nitrogen. At PML, biomass and structural growth will be determined. Biomass will be estimated as protein content, following the method of Lowry *et al*. (1951), modified by Rutter (1967). Growth will be approached with the AARS method (Yebra & Hernández-León, 2004). Relationship between hydrography and growth will be studied and compared with previous data obtained in December 2002 along the same transect.

Calanus finmarchicus growth

Groups of 20 CV and females of *C. finmarchicus* were selected from vertical hauls inside and outside a warm eddy found next to line L3, and stored in liquid Nitrogen. At PML, biomass and growth rates of these copepods will be compared between them and also with the ones collected during the cruise HUD2002075.

On the Labrador shelf, young stages of *C. finmarchicus* (CI-III) were collected from vertical tows (0-100 m) and cultured under field Temperature and Chlorophyll concentrations to determine their growth rates (Exps. 1, 2 and 3). Growth rates assessed by individual weight increases (Heinle, 1966) and by the AARS method (Yebra & Hernández-León, 2004) will be compared at Plymouth Marine Laboratory.

Event	Station	Date	Zooplankton	CV & fem	Exps
	Hl-2	15/05/04			X
	Hl-5	16/05/04			X
	9-SOLAS	17/05/04			X
	18	18/05/04			X
	L3-03	19/05/04	X		
	L3-04	20/05/04	X		
	L3-05	20/05/04	X		
	L3-06	20/05/04	X		
	L3-07	20/05/04	X		
	L3-08	20/05/04	X		
	L3-09	20/05/04	X		
	L3-10	21/05/04	X		
	L3-11	21/05/04	X		
	L3-12	21/05/04	X		
	L3-13	21/05/04	X		X
	L3-15	22/05/04	X		
	L3-16	22/05/04	X		
	L3-17	22/05/04	X	X	
	L3-18	23/05/04	X		

	Eddy	24/05/04	X	X	
	L3-19	24/05/04	X	X	
	L3-21	25/05/04	X		
	L3-22	25/05/04	X		
252	L3-24	26/05/04	X		
	L3-26	26/05/04	----		
258	L3-28	26/05/04	X		
	In Transit	28/05/04			X

i. Marine Mammal Sightings **Wayne Ledwell**

Method

This cruise was conducted as part of a long term project to study physical and biological parameters of the Labrador Sea by the Bedford Institute of Technology from Halifax, Nova Scotia. A member of the Whale Release and Strandings group was onboard to photo identify and biopsy the northern bottlenose whale (Hyperoodon ampullatus). Results would be helpful in determining population structure of this whale with reference to a much smaller population of the northern bottlenose in the Gully off the Scotian Shelf. The ship worked from the Scotian shelf through the Cabot Strait to Hamilton Bank and on to Cape Desolation, Greenland. From Greenland the ship sailed to the Orphan Basin on the Grand Banks and onto St. John`s Newfoundland (see appendix a). The Labrador Sea leg started at shelf edge of the Hamilton Bank to position 6033.47N 4814.18W (8 N.M. from Cape Desolation). Sighting effort was continuous from the bridge by the officers on watch. In addition approximately 6 hours of coverage each day was conducted outside on the deck. The bridge is 12m from the deck with the capability to observe 6.8 nautical miles with the naked eye on either side and in front. A Bushnell 8x42 330 feet fov (field of view) @1000 yards was used. The ship worked day and night steaming and spending from one to five hours on various previously designated stations. An additional tract of 550 nautical miles round trip was undertaken for an emergency. This began at position 58 29N 5031W on 23 May to Hamilton Bank and back to position on 24 May. From Halifax the ship covered 2,850 nautical miles. A crossbow with sampling arrows and equipment was carried for biopsies.

Results

A total of five northern bottlenose whales (Hyperoodon ampullatus) were sighted; one off of the Hamilton Banks and a group of four off Cape Desolation, Greenland. Both sightings occurred when the ship was stopped with instruments in the water on station. The whales were very close to the ship and swam around the hull for about 20 minutes. Ten humpback whales (Megaptera novaengliae), 12 fin whales (Balaenoptera physalus), about 70 long-finned pilot whales (Globicephala melaena) and one minke whale (Balaenoptera acutostrata) were sighted. Three large unidentified large whale spp. were observed at distances of approximately 5 nautical miles from the ship. Three other

unidentified medium sized whales were sighted. Approximately 700 seals were sighted either swimming in the Strait of Belle Isle or on pack ice in the area of the Hamilton Banks. All the medium sized and beaked whales were sighted when the ship was stopped on station. All large whales were sighted when the ship was moving between stations. Pictures were taken during both sightings of the northern bottlenose whale. No biopsies were taken.

DATE	SIGHTING POSITION	SIGHTING EFFORT	WEATHER	RESULTS
15 May Bedford Basin		N\A	N\A	N\A
16 May Scotian shelf 43 11N 62 6W		N\A	HEAVY FOG ALL DAY	NO
17 May Gulf St. Lawrence 4454N 6027W TO 4639N 5929W	4512.86N 6013.27W	0600-1930	CLEAR 10-15 KNOTS	10 HUMPBACKS 12FINS 1 MINKE 1 SMALL UNIDENTIFIED (Canso Bank)
17 May	Gulf St. Lawrence 4533.8N 5954.12W		CLEAR	I Large whale, possible fin
18 MAY CABOT STRAIT 4901N5907W TO 5046.7N 5736.8W	5006N 5818W	ALL DAY	CLEAR	APPROX 150 SEALS SWIMMING IN HERDS
18 MAY	5006N 5818W			1 FIN OR BLUE@ 2-3MI ~400 SEALS SWIMMING IN HERDS
19 MAY BELLE ISLE	5256N 54507W	1200-1900	INTERMITTENT FOG	141 SEALS ON HEAVY PACK ICE *5 GREYS
20 MAY HAMILTON BANK	5507.06N 5405.2W	ALL DAY	CLEAR WIND 25NW	NORTHERN BOTTLENOSE DEPTH 1050M Greenish brown, around

				ship on station for 15 min. 3 pics taken
21 MAY	5607.4N 5306.9W	ALL DAY	20-25SW ALL DAY-CLEAR	3 PILOT WHALES 1 LARGE WHALE BY RADAR
22 MAY	5658.49N 524.63W	ALL DAY	10 KNOTS WEST-CLEAR	1 small unidentified whale-200m distant
DATE	SIGHTING POSITION	SIGHTING EFFORT	CONDITIONS	RESULTS
23 MAY	5528.5N 5235.9W	ALL DAY		1 large whale spp~3 mile distant
24 MAY morning			Strong 35-40 wind	Return to Greenland line
24 May 2004 1800	5829.78N 5031.12W	1400-2100	10-30 CLEAR	~15 pilots, males, females w/calves Depth at bottom 3600m
25 May	End position		Windy-heavy seas	No effort
26 May to 6032.47 N 4814.18W surface temp 1ºC	6022N 4827W	All day	35 a.m 15-20 p.m Clear	I unidentified medium sized whale spp. Depth 766m *
26 May	6018N.05N 4834.63W			4 bottlenose whales (1 large and 1 calf) Depth 2125 m-just beyond shelf. Whales circled ship twice at 2115 hours
27 May	5829.71N 4816.98W		CLEAR	1 medium sized beaked whale spp.
28 May				In transit to Orphan basin

29 May Orphan Basin	5035.24N 4548.74W		CLEAR	~50 pilot whales-mixed herd of large and small whales @ 0735. Depth 3672m
30 May				In transit St. John`s, NL

*Larval squid were picked up in plankton net on three occasions on Greenland side of the shelf

Discussion

Sightings of the northern bottlenose whale occurred just beyond the shelf on both sides of the Labrador Sea. This is consistent with previous sightings of this whale by scientists and crew over the past 10 years. Sightings vary but are always found when the ship is on station. It is suspected that bottlenose whales are curious and attracted to noises generated by the ship. A dedicated effort to locate this whale should follow the Labrador shelf north into the Davis Strait and down the Greenland shelf side. Periodic stops should accompany any survey. This would allow the whale time to locate the ship.

Acknowledgements

I would like to thank the chief scientist, Glen Harrison, for having me on this cruise and to all the ships officers, crew and scientific staff of the CCGS Hudson for their generosity to me and for their assistance in locating whales.

5. Major Problems and Goals Not Achieved

Four factors contributed to the loss of station time and the inability to complete the hydrographic program as planned, (1) fuelling of the ship could not be done prior to sailing date – ca. 8h of program time were lost in fuelling, (2) heavy ice conditions on the southern Labrador coast and fog slowed progress to the inshore stations of the L3 line – ca. 6h of program time were lost and the two innermost stations were not sampled, (3) an unexpected medical evacuation required return of the ship to with 200 nautical miles of the Labrador coast (550 nautical miles round trip) – 36h of program time were lost, and (4) a storm off the Greenland coast on 25/26May with accompanying strong winds (35-50 knots) suspended over-the-side operations for ca. 9h. Thirteen stations in the Orphan Basin (42h of work) could not be sampled.

6. Other Incidents of Note

Some minor problems (software) with the CTD metering block display were encountered but correctable. Some of the elevator supports for the rosette frame were bent during operations. The plan is to weld and reattach while alongside in St John's.

7. List of Cruise Participants

Name	Responsibility	Affiliation
Sergio Alvarado	Scientist, Biologist	PML
Jeff Anning	Primary Production	BIO
Carol Anstey	Nutrients	BIO
Christine Ward-Paige	Student, CO_2, Alkalinity	BIO
Jay Bugden	TOC Levels, respiration rates	BIO
Rick Boyce	Salts, moorings	BIO
Derek Brittain	MVP, moorings	BIO
Paul Dickie	Bacterial activity	BIO
Bob Gershey	Scientist, CO_2, CFCs, Alkalinity	BDR
Les Harris	Zooplankton, Net Tows	BIO
Glen Harrison	Senior Scientist	BIO
Ross Hendry	Scientist, O_2, Computer Room	BIO
Jeff Jackson	Data management, Computer Room	BIO
Tim Perry	Zooplankton, vertical net hauls	BIO
Murray Scotney	Moorings, instrumentation	BIO
Igor Yashayaev	Assistant Scientist, Computer Room	BIO
Lidia Yebra Mora	Scientist, Biologist	PML
Frank Zemlyak	Technician, CO_2, O_2, CFCs, Alkalinity	BIO

BIO	Bedford Institute of Oceanography PO Box 1006 Dartmouth, NS, B2Y 2A4 Canada
BDR	BDR Research Ltd. Box 652, Station 'M' Halifax, NS, B3J 2T3 Canada
PML	Plymouth Marine Laboratory Prospect Place, The Hoe PL1 3DH, United Kingdom

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 at 1 second, 10 seconds and 1 minute intervals during the cruise due to operator oversight. It usually is logged at a 10 second interval throughout the cruise.

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 15 at 1710 Z leaving Halifax 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 May 30 at 11:15 Z in St. John's 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 was measured and logged every 30 seconds. 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. In addition, discrete water samples were collected at regular intervals by an auto sampler for later analysis for nitrate and silicate. Time and position of these discrete samples were logged by the computer.

4. XBT and XCTD — Igor Yashayaev

Expendable Bathythermographs were routinely deployed along the AR7W line on the way from Labrador to Greenland. See figure B.4.1 for a map with the XBT drops indicated. The XBTs were model T7 from Sparton of Canada. These types of probes are capable of measuring to maximum depths of 800 m (T7) at the full cruising speed 15 knots. The vertical resolution of the measurements was about 0.6-0.8 m. 127 XBTs were launched during the cruise (Table A.2.1 lists the operation numbers when these were deployed).

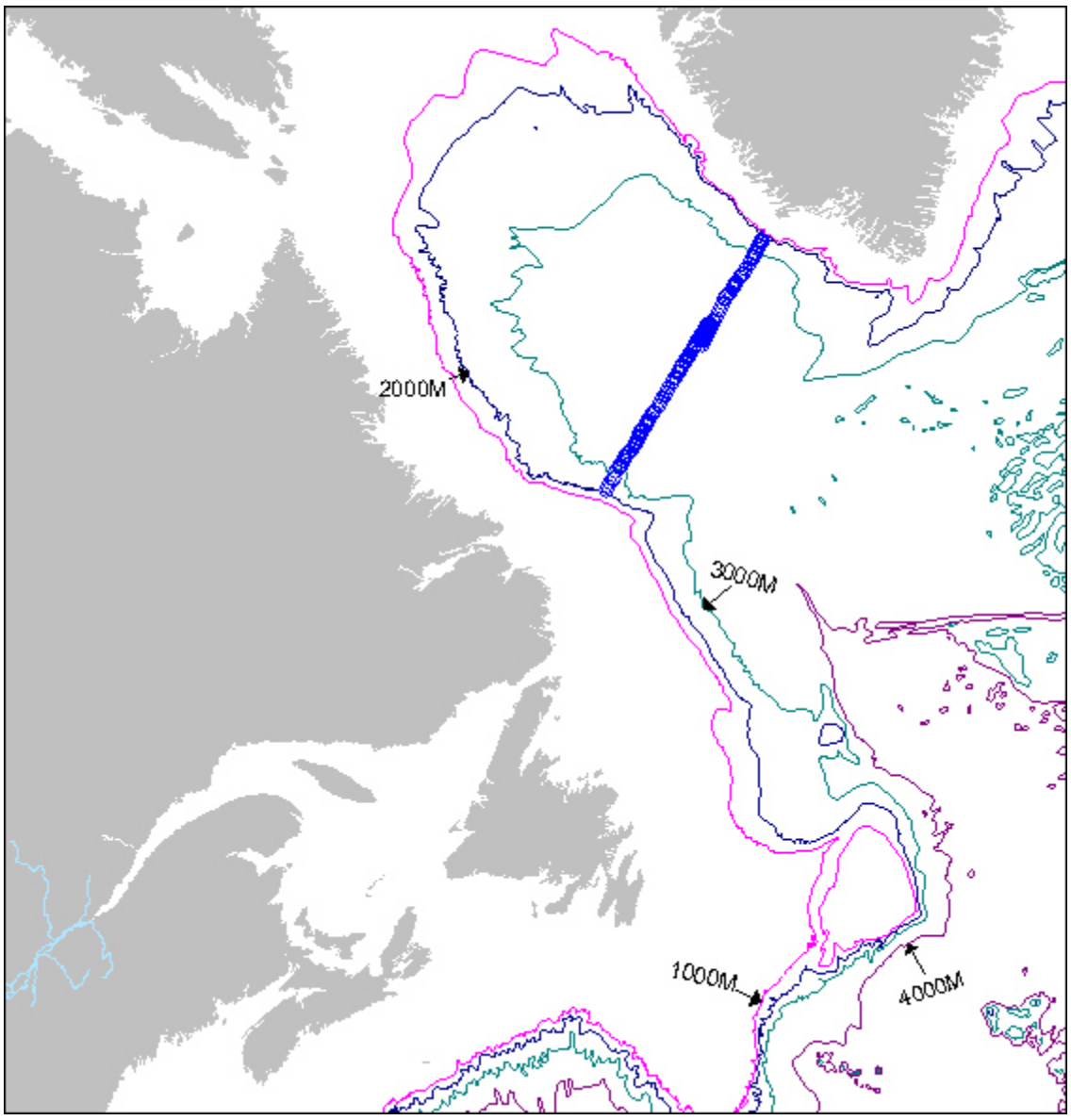

Figure B.4.1 XBT drop sites along the AR7W section (indicated by blue hollow circles).

5. Meteorological observations

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

6. 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 61083. 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.

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 21º to 25 ºC was common throughout the mission. The bath temperature was maintained at 24º for all samples.

d. Replicate Analysis

A total of 14 (total of 28) duplicate salinity samples were drawn and processed within the normal time frame. The statistics of the differences between these duplicates are as follows:

Statistic	Value
Number of Points	14
Median	0.0001

Mean	0.00001
Minimum	0
Maximum	-0.000984
Standard Deviation	0.00036

Also, a total of 17 extra samples were drawn, set aside and run as a group at the end of the mission.

e. Standards Used

The salinometer was standardized during the mission using IAPSO standard water, Batch P141 dated June 12, 2002 having a K15 value of 0.99993 and a salinity of 34.997. Typically, standardization checks were performed at the beginning of a run and then after 25 samples were analyzed. A sub-standard was sometimes used to check the performance of the instrument at some time during a run.

f. 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.

2. Oxygen — Rick Boyce / Ross Hendry

a. General

Samples for the determination of dissolved oxygen were drawn from approximately 66% of the rosette water sampling bottles (516 of 785 bottles). Essentially complete coverage was obtained for the primary AR7W line: for those stations, 86% (459 of 536) of all rosette bottles including all bottles for stations in water depths greater than 2000 m were sub-sampled and analyzed for oxygen. No water samples were taken at Event 63 (Site L3_8.5) or at Event 203 (a CTD station taken between Sites L3_18 and L3_19 to better resolve an eddy). Replicate samples were drawn and analyzed for 30 bottles, or about 6% of the bottles analyzed.

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

There were major problems with the standardization of the oxygen titration system. These problems will have to be resolved before useful bottle oxygen values can be produced

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. The tops of the stoppers were sealed with distilled water while the precipitate settled prior to analysis.

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. One of the operators was completely new to the procedure and had to be trained on the job.

Most of the samples were titrated between four and sixteen hours after the drawing of samples. The exceptions were twelve samples including two replicates from Events 36 and 40 (shallow Sites L3_03 and L3_04) that were analyzed approximately two hours after the second shaking.

d. Replicate Analysis

Replicate samples were drawn and analyzed from 30 rosette bottles, about 6% 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 two outliers with absolute

differences greater than 0.1 mL/L, the maximum absolute difference was 0.018 mL/L and the root-mean-square difference of replicates was 0.008 mL/L. If the replicates were independent, this would imply a sampling and analysis precision of 0.008/√2 = 0.006 mL/L (standard deviation). The replicate statistics for samples run by the two operators were identical.

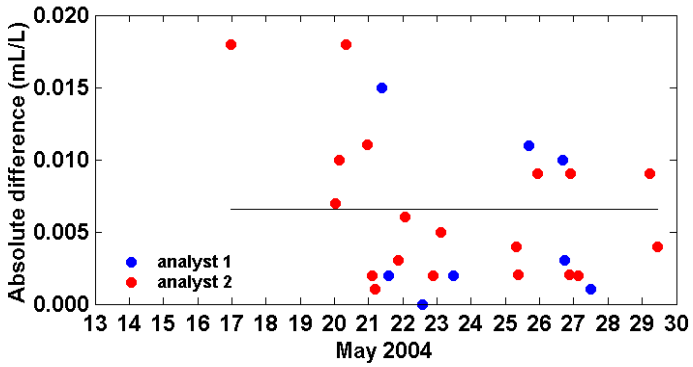

Figure 1 Absolute differences of oxygen replicates as a function of titration time. The solid line marks the mean value of 0.006 mL/L excluding two outliers that are not shown.

e. Standards and blanks

A total of approximately 60 standards and blanks divided into 15 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 15 sets of standard and blank determinations involved between 3 and 14 individual titrations. The root-mean-square (rms) of the sample standard deviations for the 15 sets was approximately 0.002 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.

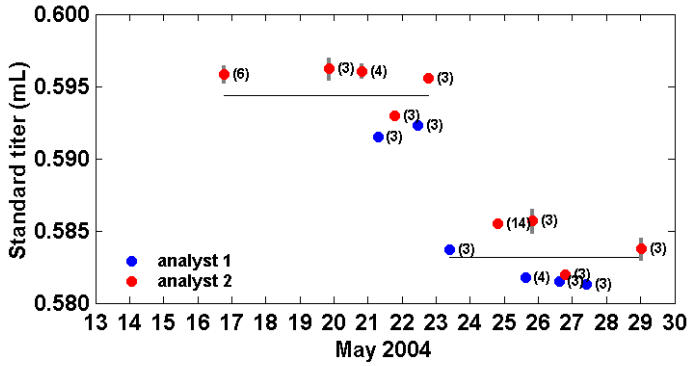

Figure 2 Set-mean standard titer as a function of titration time. The standard error of the mean and the number of individual titrations for each set are indicated. The solid lines mark the mean value of the set means before and after the shift in standard titers.

In principal, these values should not change appreciably during a cruise period. However, Figure 2 shows an abrupt shift in the standard from approximately 0.594 mL to 0.583 mL between early evening May 22 and mid-morning the following day. This 2% decrease in standard gives an increase in calculated oxygen concentration of 2%, or 0.12 mL/L for a nominal concentration of 6 mL/L. The standard values before and after the shift are self-consistent. The standard deviations for the run-average standards shown in Figure 2 before and after the shift are identical at 0.002 mL. The group includes seven values before the shift and eight values after the shift.

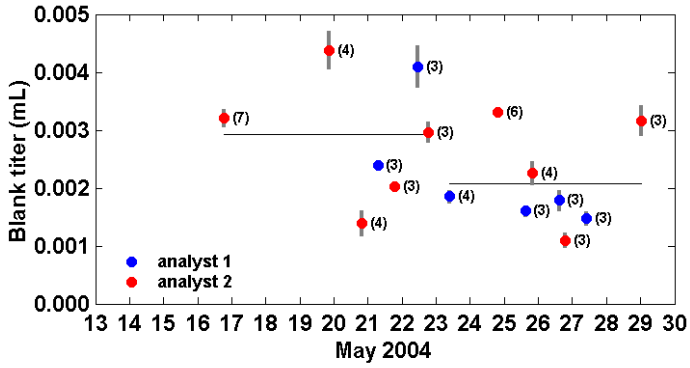

Figure 3 Set-mean blank titer as a function of titration time. The standard error of the mean and the number of individual titrations for each set are indicated. The solid lines mark the mean value of the set means before and after the shift in standard titers.

A post-cruise comparison of the Hudson 2004-016 bottle oxygen values reported by the oxygen analysis program for the AR7W sites with bottle oxygen values from the 2003 AR7W occupation on Hudson 2003-038 suggests that neither the of the internally-consistent groups of standards from the 2004 survey gives accurate results. The pre-shift 2004 oxygen concentrations are systematically 0.2 mL/L lower than the 2003 results and

post-shift 2004 oxygen concentrations systematically 0.1 mL/L lower than the 2003 results.

The standardization issues will need to be resolved to realize any useful bottle oxygen results. This problem is under investigation.

The 15 blank values in Figure 3 have an overall average of 0.0025 mL and overall standard deviation of 0.001 mL. The averages before and after the shift in standards are 0.0029 and 0.0021 mL respectively. The difference between the mean blank before and after the shift in standards is not statistically different from zero at the 95% confidence level.

f. Comments

The number of replicate samples was somewhat less than the 10% minimum recommended by the WOCE Hydrographic Program (WHP) Operations and Methods Manual for dissolved oxygen (Culberson, 1991). The WHP manual suggests as a minimum requirement that two times the root-mean-square (rms) difference in replicates should be less than 0.5% of the highest oxygen concentrations encountered. For the present cruise, this gives 0.044 mL/L for a maximum observed oxygen concentration of 8.9 mL/L. The two-times-rms statistic for the 28 replicates was 0.016 mL/L. This suggests a reasonable standard of sample drawing and analysis was achieved on the cruise.

In several 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 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.

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.

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. Thanks are owing to Frank Zemlyak for setting up the oxygen titration system and for his help with maintaining it on the cruise even though his other responsibilities left him with little time.

3. Nutrients — Carol Anstey

a. Description of Equipment and Technique

Samples were analyzed for silicate, phosphate, and total nitrate (nitrate plus nitrite) using a Technicon Autoanalyser 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 gms/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 the Ascorbic Acid is pumped 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 subsamples are drawn into 30 ml HDPE (Nalge) wide mouth sample bottles from the 10 L rosette bottles. The bottles are 10% HCL washed, rinsed three times with Super-Q and oven dried at >100 Degrees F.

A sample run includes six Calibration Standards run at the beginning and end. Duplicate Check Standards are run every 16 samples followed by blanks as a Baseline Check. These Standards are made up in 33 ppt NaCl (Sigma, ACS Reagent) as is the wash water. The standards are checked against reference standards: WAKO CSK Standards (Sagami Chemical Center, Japan) and NRC Intercalibration Reference Standard MOOS-1.

Analog data is converted to digital, processed and has statistics calculated on them by an in-house Pascal 7.0 program (AAII) on a PC. Chart recordings, hard copy and disk copies of the data are kept for reference.

c. Replicate Analysis

Samples were collected in duplicate from every bottle on the rosette into 30 ml acid washed HDPE screw-capped bottles. Total number of duplicate samples analyzed: 1398. These were refrigerated until analysis, typically within 12 hours of collection. The water samples were transferred to acid washed 7 ml cups for analysis with the AutoAnalyzer.

There were two technical problems encountered during analysis of the samples. Two days into the cruise, the PC hard drive used in acquisition of the data “crashed” and had to be replaced. This was done in a timely fashion thanks to the ship’s technician so as not to leave samples refrigerated for too long ~ 6 hours. Three days later, rough weather

shook the data acquisition board loose in the computer. That day's samples were frozen until the problem could be fixed. The affected samples were: 277237 – 277261 and 277278 – 277325. These samples were thawed at room temperature and run the following shift.

The data quality parameters, determined with check standards, CSK Reference Standards and RMS offset from the calibration curve, came well within accepted values. Frequent flushing of the system with 1N NaOH 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
Detection Limit (μ moles/kg)	0.426	0.042	0.132

4. Total Inorganic Carbon in Seawater — Bob Gershey / Peter Jones

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 drawn from all bottles tripped at standard hydrographic depths on whole-number sites on the AR7/W line.

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. If samples are not to be analyzed within four to five hours, the sample is poisoned with 100 µl/250 ml of 50% saturated mercuric chloride solution. The bottle is tightly sealed and stored preferably at the temperature of collection in the dark.

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.

5. Alkalinity — Bob Gershey / Peter Jones

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 drawn from all bottles tripped at standard hydrographic depths on whole-number sites on the AR7/W 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 potassium 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 overall precision of the analysis is 1.5 μmol/kg for samples with concentrations in the range of 1900-2400 μmol/kg.

6. Halocarbons — Bob Gershey / Peter Jones

a. Description of Equipment and Technique

The suite of halocarbon compounds analyzed include the chlorofluorocarbons: CFC-12, CFC-11, CFC-113 and the halocarbons carbon tetrachloride and methyl chloroform. The analyses are carried out on two purge and trap systems developed at the Bedford Institute of Oceanography. The water samples are injected into the systems directly from the syringes used to collect the samples. A minimum of two volumes of water are used to rinse the sample pipette. The samples are purged for four minutes with ultra high purity nitrogen at a flow rate of 80 ml/min. The components are trapped in Porapak-N trap which is cooled to a temperature of less than 10°C. They are then desorbed by heating the trap up to 170°C. The contents of the trap are then passed through a 75m DB-624 megabore column. The resolved components exiting the column are quantified using electron capture detection.

b. Sampling Procedure and Data Processing Technique

Samples for halocarbons were drawn from all bottles tripped at standard hydrographic depths on whole-number sites on the AR7/W line, with the exception of location 14, which was not sampled.

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 which are collected from the bottles. The samples are then stored in a water bath of continuously flowing surface sea water until analysis. Air samples are taken in the winch room at the start of the cruise to ensure that it is not contaminated. The analysis of the samples is always completed within

24 hours after they have been drawn. Duplicates are taken at each station, with some of these being run on each system to ensure that the results are comparable.

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 sea water. Clean air samples are also analyzed with each station, as a check on the standardization.

F. APPENDICES

Appendix 1: Operation Notes Report
(sorted by Operation ID Number)

Note Number: 1	**Entry Time:** 16/May/2004 21:35:46	**Note Made By:** Jeff Jackson	**Operation ID**: 20
Sounding 2746 m			
Note Number: 2	**Entry Time:** 20/May/2004 1:31:16	**Note Made By**: Jeff Jackson	**Operation ID**: 35
Sent the rosette down to bottom, but there was a system malfunction which would not allow the bottles to fire. The cast was aborted and redone as operation 36.			
Note Number: 3	**Entry Time:** 22/May/2004 21:46:09	**Note Made By:** Jeff Jackson	**Operation ID**: 134
Igor ran into some troubles with this operation. The bottles in positions 10 - 24 were not accessible during the cast and thus were not filled in. Jeff filled in what he could from the CTD QAT file.			
Note Number: 4	**Entry Time:** 29/May/2004 8:43:41	**Note Made By:** Jeff Jackson	**Operation ID**: 289
For the second time on this cruise the metering sheave software is not working correctly. The CTD data line fails to show up. We are not sure if it is just a loose connection or a computer problem.			

Table F.1.1 Operation Notes

Appendix 2: PROVOR Float Logs

Serial No. 1392
APEX Float Launch **Argos No. 47700**

Float was started. Date: __May 25/04_ Time: __1958_____GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: __May 25/04_ Time: __2150_____ GMT
Float should be deployed within 6 hours of start time.

Deployed By: ___Derek Brittain_____

Vessel: __Hudson____ Event No. ___247____

Latitude __59 45.7253_____ Longitude __49 06.5567_____

Water Depth __3152 m__ Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. __246__

Date: __May 25/04____ Time: ___2020_____ GMT

Latitude __59 45.4781__ Longitude __49_08.8230____

Maximum Depth __3213 m__

Any problems associated with the start up and deployment operation
_____
_____
_____
_____
_____
_____

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

Allyn Clarke
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ClarkeA@mar.dfo-mpo.gc.ca

Serial No. 1393

APEX Float Launch **Argos No. 47701**

Float was started. Date: __May 26/04_ Time: __2322_____GMT
i.e. you sweep a magnet over the reset point and it beeps.

Float deployed. Date: __May_27/04_ Time: __0150_____ GMT
Float should be deployed within 6 hours of start time.

Deployed By: __Derek Brittain_____

Vessel: __Hudson____ Event No. __267_____

Latitude __60 18.4493_____ Longitude __48 37.0929_____

Water Depth __2694_m__ Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. __266___

Date: __May 26/04____ Time: ___2307_____ GMT

Latitude __60 17.5118__ Longitude __48 32.7692____

Maximum Depth __2747 m__

Any problems associated with the start up and deployment operation

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

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Serial No. MT-157

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 21/04 Time: 1848 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 21/04 Time: 1932 UT By:
_____

Vessel: Hudson Event No. 91

Latitude 55 52.2544 Longitude 53 23.9989

Water Depth 3069 m Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. 90 (L3-12)

Date: May 21/04 Time: 1810 GMT

Latitude 55 51.5531 Longitude 53 23.7638 Max Depth 3162 m

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

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Serial No. MT-155

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: __May 22/04_ Time: __1705_____UT Cycle Period _10 days

Drift Depth __1500 m.__ Profile Depth _2000 m.

Transmission Period __45___sec. Transmission Duration __9_____hrs

Deployment Date: _May 22/04__ Time: ___1806___ UT By: __M. Scotney_____

Vessel: __Hudson___ Event No. ___135____

Latitude __57 22.3773_____ Longitude __51 45.7050_____

Water Depth __3462 m__ Must be deeper than 2000 metres

Nearest CTD / XBT cast (circle one) Event No of cast. __134 (L3-16)_

Date: __May 22/04____ Time: ____1540_____ GMT

Latitude __57 22.6486__ Longitude __51 47.3631___ Max Depth __3580 m__

Any problems associated with the start up and deployment operation

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

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Serial No. MT-163

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 25/04 Time: 0206 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 25/04 Time: 0248 UT By: D. Brittain

Vessel: Hudson Event No. 214

Latitude 58 34.91 Longitude 50 24.40

Water Depth 3463 m Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. L3-19

Date: May 25/04 Time: 0000 GMT

Latitude 58 37.515 Longitude 50 25.057 Max Depth 3590 m

Any problems associated with the start up and deployment operation

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

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Serial No. MT-160

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 27/04 Time: 1905 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 27/04 Time: 2029 UT By: M. Scotney

Vessel: Hudson Event No. 281

Latitude 57 30.0695 Longitude 47 53.3581

Water Depth 3243 m Must be deeper than 2000 metres

Nearest CTD / XBT cast (circle one) Event No of cast. 280

Date: May 27/04 Time: 1120 GMT

Latitude 59 21.9694 Longitude 48 38.0978 Max Depth 3206 m
(Cast to 200m only)

Any problems associated with the start up and deployment operation

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

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Serial No. MT-168

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 28/04 Time: 0547 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 28/04 Time: 0721 UT By: _____

Vessel: Hudson Event No. 282

Latitude 54 59.68 Longitude 46 52.049

Water Depth 3389 m Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. 280

Date: May 27/04 Time: 1111 GMT

Latitude 59 21.98 Longitude 48 38.09 Max Depth 3206 m

Any problems associated with the start up and deployment operation

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

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Serial No. MT-108

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 29/04 Time: 0447 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 29/04 Time: 0608 UT By: _____

Vessel: Hudson Event No. 288

Latitude 50 53.5617 Longitude 45 12.4399

Water Depth 4030 m Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. 287

Date: May 29/04 Time: 0307 GMT

Latitude 50 53.8146 Longitude 45 12.0023 Max Depth 4170 m

Any problems associated with the start up and deployment operation

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

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Serial No. MT-161

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 29/04 Time: 1018 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 29/04 Time: 1145 UT By: _____

Vessel: Hudson Event No. 290

Latitude 50 35.4422 Longitude 45 48.4901

Water Depth 3517 m Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. 289

Date: May 29/04 Time: 1015 GMT

Latitude 50 35.3340 Longitude 45 48.7124 Max Depth 3627 m

Any problems associated with the start up and deployment operation

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

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Serial No. MT-164

PROVOR Float Launch

System Argos ID dec. **Hex**

Buoyancy ID **Sensor ID**
Argos PTT ID **Buoyancy Controller**
Software Version **SN1156 1.4**

Start Date: May 29/04 Time: 1354 UT Cycle Period 10 days

Drift Depth 1500 m. Profile Depth 2000 m.

Transmission Period 45 sec. Transmission Duration 9 hrs

Deployment Date: May 29/04 Time: 1518 UT By: _____

Vessel: Hudson Event No. 291

Latitude 50 09.9730 Longitude 46 49.0796

Water Depth 2877 m Must be deeper than 2000 metres

Nearest **CTD** / XBT cast (circle one) Event No of cast. 289

Date: May 29/04 Time: 1015 GMT

Latitude 50 35.3340 Longitude 45 48.7124 Max Depth 3627 m

Any problems associated with the start up and deployment operation

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

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Appendix 3: Mooring Logs

Placement

Mooring No:		1514	Geographic Area:	Hamilton Bank
Intended Duration:		1 year	Ship:	CCGS Hudson
Cruise No:		HUD2004016	Date:	May 20, 2004
Sea State:		1.0 m swells	Weather Conditions:	clear
Mooring Tech:		Scotney / Boyce	Navigation Inst.	DGPS
Notship #		Maritimes 902-426-6030, Nfld 709-772-2083, Laurentian 418-648-5410		
Latitude:		55 07.0731 N	Longitude:	54 05.2760 W
Time of Fix:		1622 Z		
Depth: Raw:			Corrected:	
Main Float:	Type:	Hibernia	Markings:	yellow
Beacon:	Type:	N/A	ID: S/N	
Light:	Type:	N/A	Colour/Rate:	
Mooring Line:	Type:	jacketed wire	Colour:	yellow
Release:	Type:	965 A	S/N:	892
Release Code:		C	Frequency:	11.0 kHz

Placement Log

Time (Z)	Instrument	Remarks
1618		Hibernia package in water
1619	CM9328	In water
1622		Anchor away
		55 07.1014 N 54 05.4209 W
		Sounding 1035 m (Bridge Sounder)
		CPA1 55 07.0502 N 54 05.3392 W 1046 m range
		CPA2 55 07.0731 N 54 05.2760 W 1043 m range
		1029 m (bridge)
		550 fm 1012 m (winch room) not corrected for sound

MOORING # 1514 CLARKE LAB SEA MAY 2004

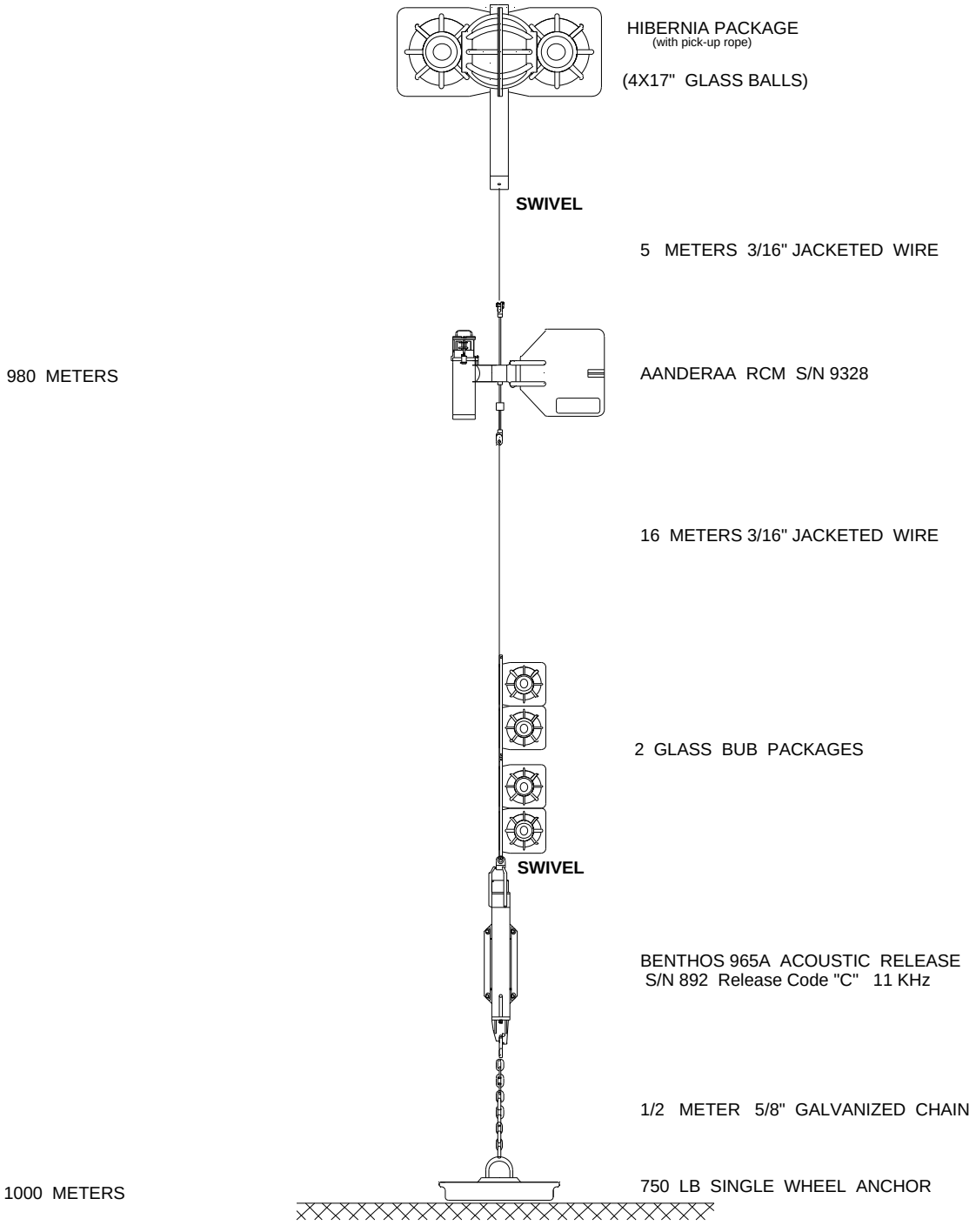

Figure F.3.1

Recovery

Mooring No:	1475	Ship:	CCGS Hudson
Cruise No:	HUD2004016	Date:	May 20, 2004
Mooring Tech:	Boyce / Scotney	Type of Nav:	
Sea State:	1 m waves		
Weather Conditions:	clear		
Cancel Notship:	Yes _____ No		

Recovery Log

Time (Z)	Instrument	Remarks
1400		Release command sent, range 1150 m
1408		Release command sent 3 attempts confirmation at 1411
1425		On surface
1432		BUB package hooked
1439		BUBs & release on board
1441		CM5002 on board
1443		Mainfloat on board
		1 blade of rotor broken on recovery?

MOORING # 1475 CLARKE LAB SEA JULY 2003

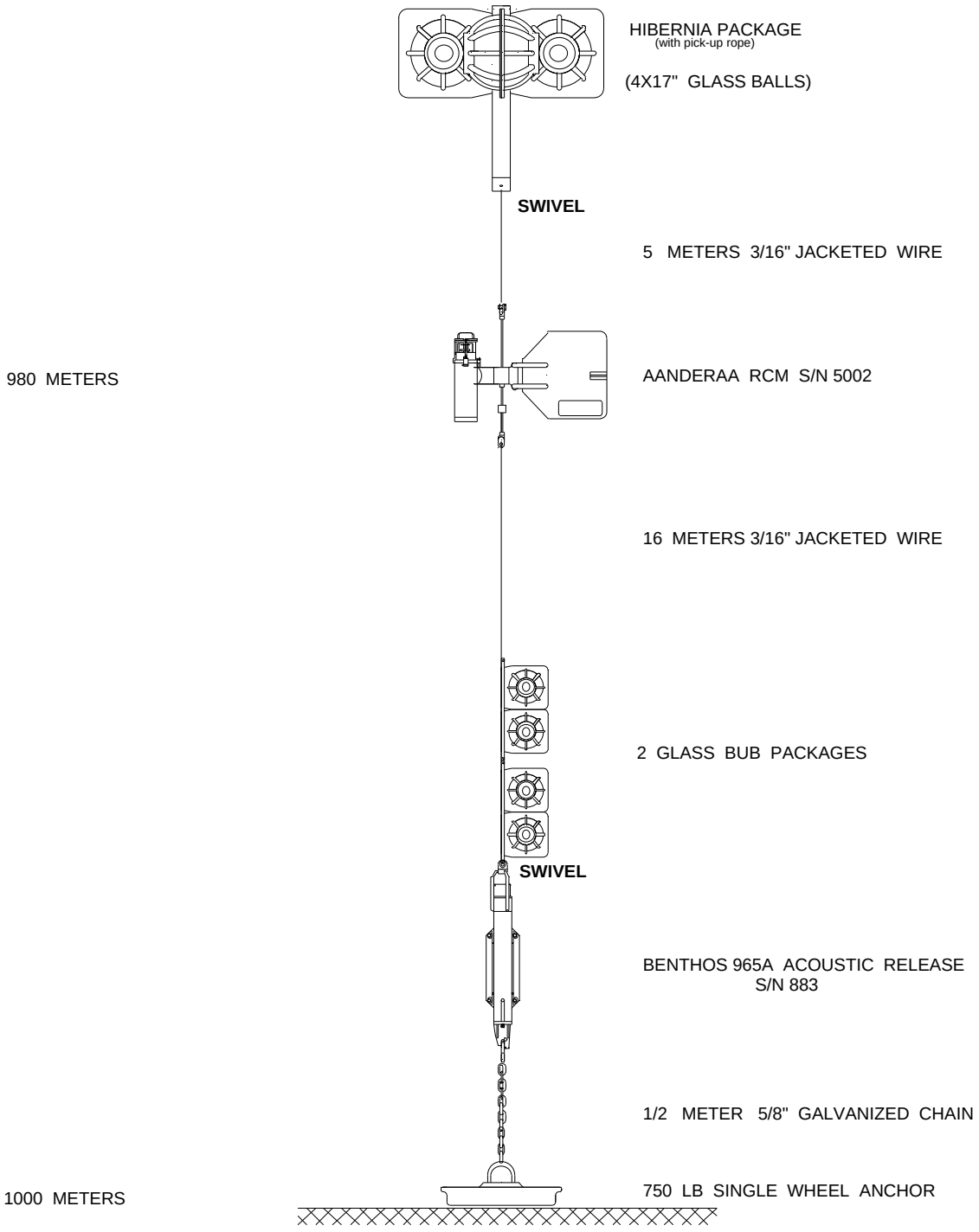

Figure F.3.2

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