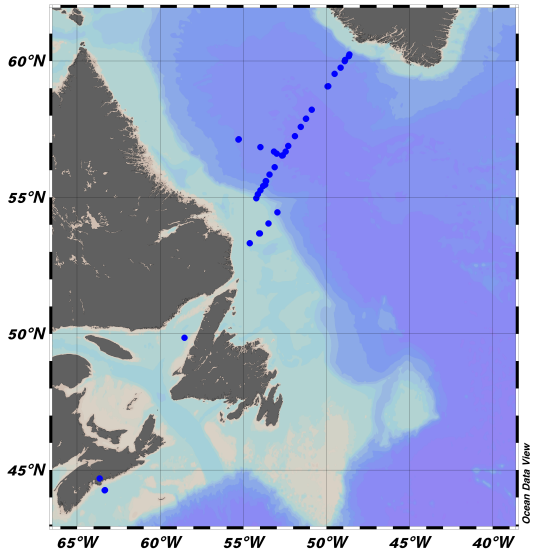
CRUISE REPORT: AR7W

Created: August 24



Highlights

Cruise Summary Information

Section Designation	**AR7W**
Expedition Designation (ExpoCode)	**18HU20000520**
Aliases	18HU2000009, HUD2000009
Chief Scientist	**Glen Harrison / BIO**
Dates	20 May – 8 June 2000
Ship	CCGS Hudson
Ports of Call	Dartmouth, NS, Canada – Dartmouth, NS, Canada
Geographic Boundaries	60° 24”N 63° 64”W 48° 63”W 44° 26”N
Stations	46
Floats and Drifters Deployed	3
Moorings Deployed and Recovered	35 total: 15 recoveries, 16 deployments, 4 release tests

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

CRUISE REPORT

HUDSON 2000009

LABRADOR SEA

WOCE LINE AR7W

20 May - 8 June, 2000

A. CRUISE NARRATIVE

1. Highlights

a. WOCE Designation:	WOCE Line AR7W Atlantic Circulation Experiment
b. Expedition Designation:	HUD2000009
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 FAX 902 426 9388 Internet harrisong@mar.dfo-mpo.gc.ca
d. Ship:	CCGS Hudson
e. Ports of Call:	May 20 BIO, Dartmouth, NS, Canada June 8 BIO, Dartmouth, NS, Canada
f. Cruise Dates:	May 20 to June 8, 2000

2. Cruise Summary Information

a. Cruise Track

A cruise track is shown in Figure 1. Ship position at 0000Z on each day of the cruise is indicated with a date label.

The WOCE cruise station summary file outlines the science operations conducted during the cruise. Note that additional cast types have been defined as: NET – Biological net tow; AGT – alongtrack temperature-salinity measurements; SAP – alongtrack shipboard ADCP measurements. As well, additional time codes have been defined as: BD – Begin Descent; EA – End Ascent. These codes are used during Lowered ADCP casts. Finally, in the Comment section of the SUM file there is frequent mention of operation notes indicated by “Op Note”. These notes will be included in the final cruise report.

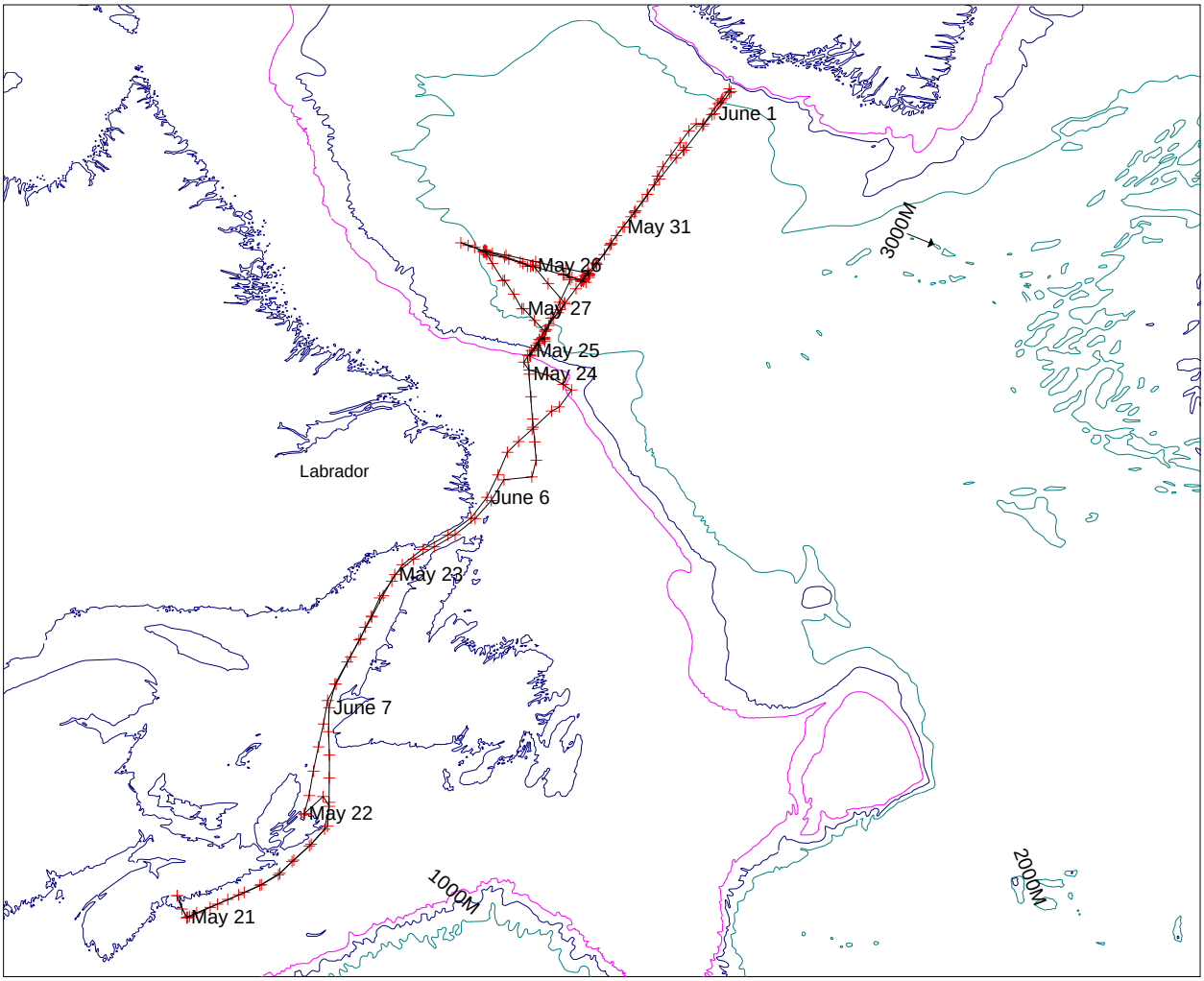

Figure 1. Cruise track for HUD2000009. The date labels indicate the ships position at 0000Z.

Additional parameter codes have also been defined and appear in the parameter column of the WOCE SUM file. These codes are: 510 – extracted chlorophyll; 511 – phytoplankton count; 512 – High Pressure Liquid Chromatography (HPLC); and 513 – Absorption Spectra. Sections that follow in the cruise report describe these measurements.

b. Total Number of Stations Occupied

The CTD and ROS station positions are shown in Figure 2. The WHP stations are all contained in the box defined by 50-62°N and 43-60°W. Table 1 lists the science operations for HUD2000009.

Cast Type	Number of Operations	Detailed Division	Operation Numbers
Rosette & CTD	46	20 AR7W Sites	see Table 2
		2 Halifax Line Sites	see Table 3
		4 Seacat Calibrations	60, 124 (BIO) 85, 97 (Kiel) (2 in Table 2)
		10 Biology Casts	see Table 2 plus 59,77,148
		12 Other Deep Casts	12,36,39,46,47,48,50,66,93 95,123,138
		1 Basin test	1
Moorings	35	15 recoveries	17,18,19,20,22,29,30,31,33,34, 35,53,54,55,68
		16 deployments (K31 recovery had two operation numbers assigned. See Note for Operation ID 29).	25,51,52,61,62,63,67,74,113, 116,117,118,125,126,127,128
		4 Release tests	23,73, 108,109
Biology	69	48 shallow net tows	5,6,10,11,13,14,15,27,28,37,38, 40,42,56,57,64,65,69,70,71,76, 78,79,81,83,84,88,89,91,92,94, 96,100,102,106,107,111,121, 122,132,133,135,137,139,141, 146,151,152
		20 Light related measurements 1 test station	2, 8,9,21,24,32,44,49,58,75,86, 99,104,114,115,130,131,143, 144,149,150
Other	3	1 Ship Board ADCP	4
		1 Along track t, s, and fluorescence	3
		3 floats deployed	120 **

Table 1. Science operations conducted on HUD2000009. ** All three floats were deployed at the same location with a single operation ID number.

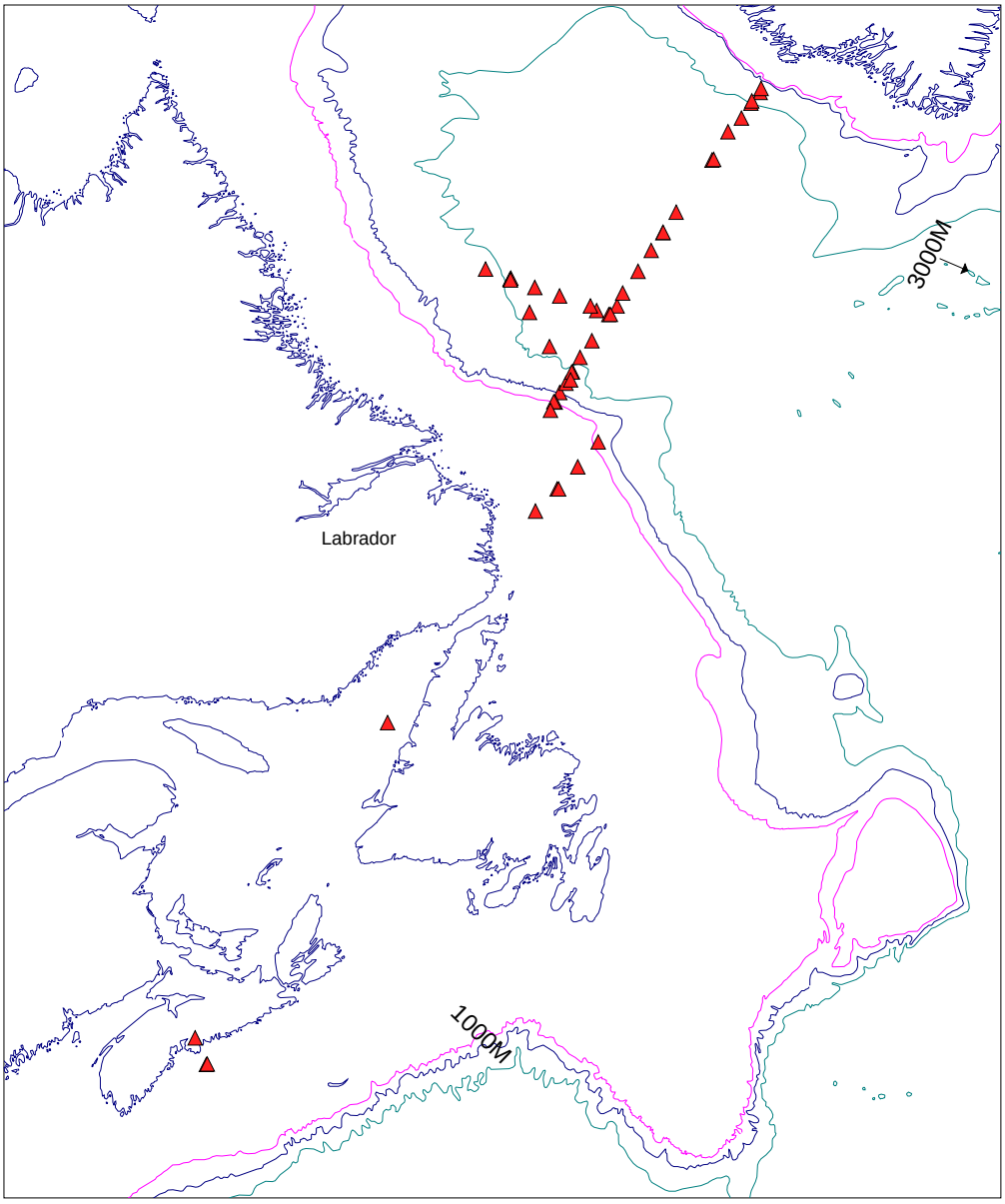

Figure 2. CTD, rosette and LADCP station positions on for Hudson HUD2000009.

AR7W Site Number	HUD2000009 Deep Cast Operation Number	HUD2000009 Biology Cast Operation Number
1	not occupied	
2	not occupied	
3	not occupied	
~ 4	147	
~ 5	145	142
~ 6	140	
7	136	
8	26	
9	134	
10	16	129
11	45	43
12	41	
13	not occupied	
14	72	119
15	112	
16	110	
16.5	80	
17	105	103
18	82	
19	not occupied	
20	85	87
21	101	
22	90	
23	97	
23.5	not occupied	98
24	93	not occupied
25	not occupied	not occupied
26	not occupied	not occupied
27	not occupied	not occupied
28	not occupied	not occupied

Table 2. AR7W sites and rosette operation numbers for HUD2000009.

Halifax Line Number	HUD2000009 Deep Cast Operation Number
1	not occupied
2	7, 153
3	not occupied
4	not occupied
5	not occupied
6	not occupied
7	not occupied

Table 3. Halifax Line sites and rosette operation numbers for HUD2000009.

Along AR7W, the stations were full depth WHP small volume rosette casts with up to 24 rosette bottles. Depending on the station, water samples were analyzed for CFC's, carbon tetrachloride, methyl chloroform, total carbonate, alkalinity, oxygen, salinity, and nutrients.

c. Floats and Drifters deployed

A total of three floats were deployed as part of a test involving the tomographic sound source array. The three floats, deployed near mooring K41 (Operation ID #120), will park on the bottom until March 2001, when they are programmed to ascend to 700m and start their float mission. The three floats have serial numbers as follows:

IFM #	Manufacture #
518	#RF19
519	#RF20
520	#RF21

d. Moorings deployed or recovered

The Kiel mooring operations dealt with the recovery and servicing of 4 acoustic tomography moorings (K30, K31, K32 and K33) and their related set of 3 acoustic transponders for each tomography mooring. These mooring were serviced and replaced with similar moorings K40, K41, K42 and K43. In all, 29 operations were conducted during HUD2000009 related to the recovery and placement of the Kiel moorings (Figure 3).

A total of 6 BIO mooring related operations, consisting of 2 deployments, 2 recoveries and 2 release tests were conducted at various sites (see Figure 3). The following summarizes the mooring operations.

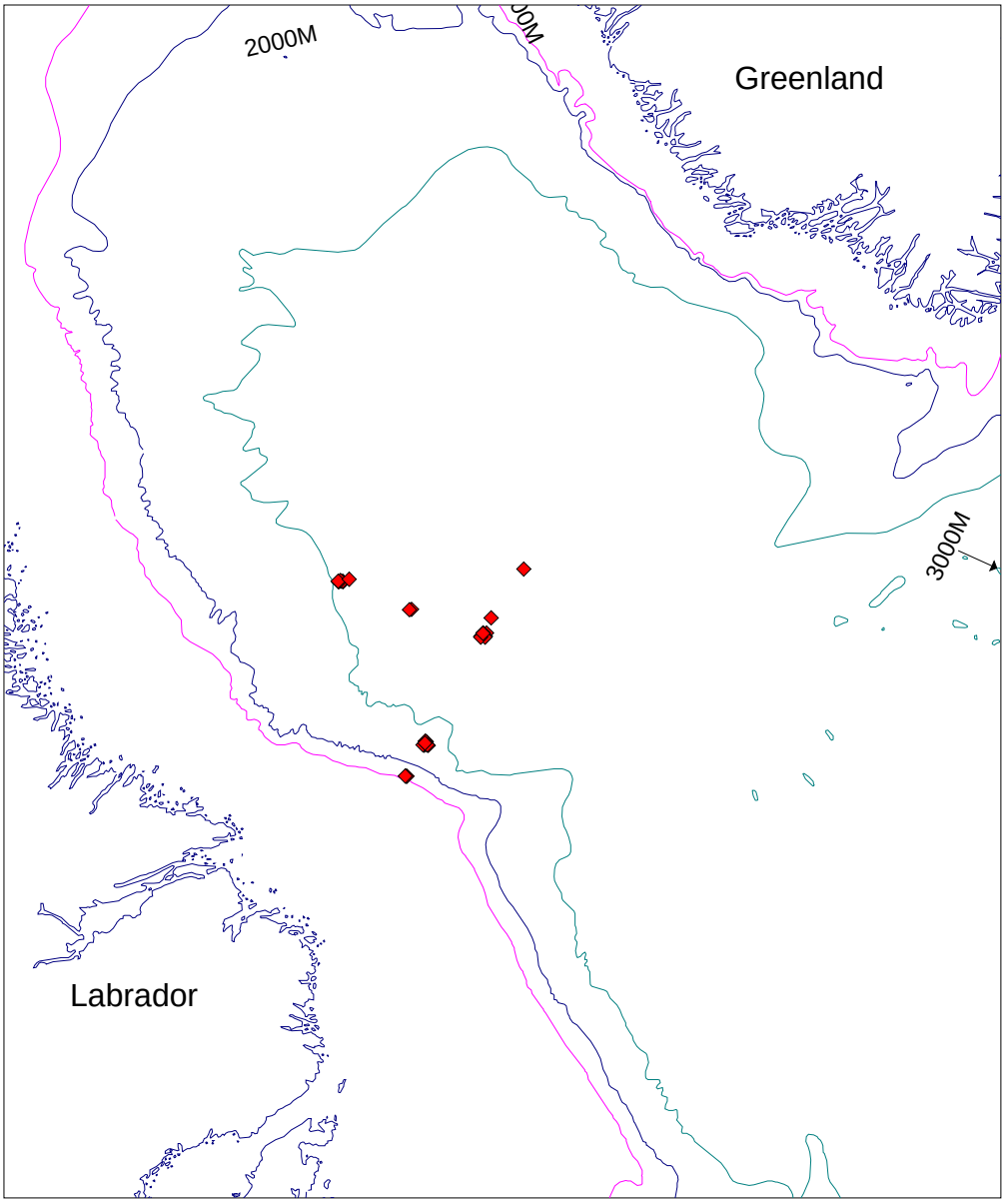

Figure 3. Mooring deployment and recovery positions for HUD2000009.

Deployments:

1 M1350 standard mooring consisting of one current meter positioned 20m off bottom along AR7W on the Labrador Slope (12 month deployment) along the 1000m isobath.

1 M1349 multi-instrument mooring near OWS Bravo on AR7W. This mooring consisted of 7 Seacat temperature/conductivity recorders, 6 Aanderaa current meters, 2 sediment traps and 3 acoustic releases.

3 Acoustic tomography moorings (K41, K42, K43), each with 3 acoustic transponders (12 operations plus 2 release tests for a total of 14 operations)

1 Traditional instrumentation mooring (K40) (1 operation)

Recoveries:

1 M1326 standard mooring consisting of one current meter positioned 20m off bottom along AR7W on the Labrador Slope (12 month deployment) along the 1000m isobath. This mooring was deployed on 18HU99022.

1 M1325 multi-instrument mooring near OWS Bravo on AR7W. This mooring consisted of 3 Seacat temperature/conductivity recorders, 6 Aanderaa current meters, and 4 Microcats SBE37 (two with temperature, and one with temperature and pressure). This mooring was deployed on 18HU99022.

3 Acoustic tomography moorings (K31, K32, K33), each with 3 acoustic transponders (12 operations)

1 Traditional instrumentation mooring (K30) (1 operation)

3. List of Principal Investigators

Name	Affiliation	Responsibility
Allyn Clarke	BIO clarkea@mar.dfo-mpo.gc.ca	senior scientist overall co-ordination
Glen Cota	ODU cota@ccpo.odu.edu	ocean optics
Bob Gershey	BDR Research rgershey@fox.nstn.ns.ca	Alkalinity, carbonate, CFC's
Glen Harrison	BIO harrisong@mar.dfo-mpo.gc.ca	Co-ordinator biological program nitrate and ammonium utilization by phytoplankton
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
Robert Pickart	WHOI pickart@rsp.whoi.edu	lowered ADCP
Trevor Platt	BIO plattt@mar.dfo-mpo.gc.ca	primary production, ocean colour
Peter Rhines	UW rhines@killer.ocean.washington.edu	moored instrument data
Uwe Send	Kiel usend@ifm.uni-kiel.de	Tomography Moorings

Table 4. List of Principal Investigators. See Section 7 for addresses.

4. Scientific Program and Methods

4.1 Physical - Chemical Program

a. Narrative

This expedition was conducting operations in support of three ongoing DFO scientific initiatives and a collaborative project with IFM, Kiel.

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 and replacement of the two Labrador Sea moorings provide a measure of the winter cooling and water mass transformations over the winters of 1999/2000 and 2000/2001.

Related recovery and replacement mooring work conducted by Kiel personnel consisted of servicing four tomography moorings as part of the German initiative 'Dynamics of Thermohaline Circulation Variability'. These moorings address the convection activity in the Labrador Sea and its connection to deep water formation, export and transport.

The second initiative is the Labrador Sea project in support of DFO's greenhouse gas (GHG) research. This biological program is designed to characterize the late spring biological processes in the Labrador Sea and its shelf regions both to determine the role of the biological pump to sequester carbon and to develop the regional algorithms that will allow primary productivity estimates to be made using data from Ocean Colour satellite sensors such as SeaWiFS and MODIS. The chemical oceanographic program is observing total carbonate, alkalinity and CFC's over the entire water column to determine the sequestration of anthropogenic carbon.

The third objective is to occupy station #2 on the Halifax Section in support of DFO's Atlantic Zonal Monitoring Program (AZMP).

During this cruise, an ADCP was added to the CTD/rosette package to provide an estimate of the full depth velocity profile at each CTD station. This data will be useful for the detection and definition of various subsurface currents such as the deep western boundary undercurrents.

The hydrographic program consisted of three full depth sections in the Labrador Sea, station #2 on the Halifax line and daily stations in support of biological observations. One task of the program was to occupy the section across the Labrador Sea, surveyed by the Bedford Institute of Oceanography since 1990, which is known as the WOCE AR7W line.

The oceanographic data collected in the cruise reveal significant changes in the water mass structure and properties since the last occupation of the Labrador Sea line in 1999. The following summarized the unique features of the sea water properties of the Labrador Sea as it was seen in the first cruise of the XXI century:

Labrador Sea Water (LSW) formed as the result of deep convection due to a series of severe winters between 1988 and 1993 is still present in 2000. However, since 1994 the core of this water is steadily getting warmer and saltier with a rate about 0.07 °C/year and 0.008, respectfully. In 2000 it was warmer and saltier than in the previous years (2.9 °C and 34.86).

The Northeast Atlantic Deep Water (NEADW, underlying the deep LSW) and Denmark Straight Overflow (DSOW, bottom water) substantially freshened and became colder over the last four years. Noteworthy that this tendency was steady through the years. DSOW is the freshest (34.86) and coldest (at places below 1.1 °C) in the history of deep observations in the Labrador

Sea. Due to the opposite tendencies in the deep LSW and NEADW the difference between properties of these waters is the smallest since the late 1980's.

The convection that took place in the winter (Feb-Mar) of 2000 wasn't as intense as that in the early 1990's. Nevertheless, the water originating as the result of the 2000 convection dominates the layer between 200 m and 1000 m, indicating that the convection of the last winter penetrated on average 300 m deeper than that of the winter before. This resulted in the further reduction of the volume of the deep LSW. The recent formation of the LSW is 0.02 fresher than its analogue found the previous year (1999).

On *site 16* (the central Labrador Sea) we found the most recent formation of the LSW about 600 m deeper than the neighbouring stations, spanning between 1000 m to 1600 m. High horizontal density gradient around the station suggests that this structure is associated with an intense anticyclonic eddy. There was another relatively homogeneous mixed layer between 100 m and 900 m with temperature and salinity -3.3 °C and 34.83, respectfully. This layer was not typical for the other stations. It could be produced at the time when the eddy was formed as the result of convergence and mixing of relatively warm and salty water (presumable from the eastern part of the region) with the fresher surface water. This extends to the bottom, causing temperature near the bottom to increase. However, the eddy didn't have a significant affect on the deep LSW.

4.2 Biological Program

a. Narrative

The biological program was a continuation of studies begun in 1994 to describe the large-scale (spatial and temporal) variability in plankton biomass and productivity in the Labrador Sea.

The program has consisted of essentially four elements:
(1) a phytoplankton biomass/primary productivity project - conducted by G. Harrison, and J. Anning and B. Irwin (for Trevor Platt),
(2) a bacterial metabolism project - conducted by P. Dickie (for Bill Li),
(3) a mesozooplankton project - conducted by L. Harris (for Erica Head) and
(4) a dissolved organic carbon/community respiration project - conducted by J. Bugden (for Paul Kepkay).

The objectives of these studies are two-fold:
(1) to provide a description of the inventories of biogenic carbon in the Labrador Sea, their turnover rates and variability in space and time as part of DFO'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 ecosystem-fisheries research.

A new project was begun this year (G. Harrison, J. Anning, B. Irwin) to investigate the vertical flux of biogenic particulate matter in the central Labrador Sea using time-series sediment traps deployed on the "BRAVO" mooring.

In addition to the DFO biological projects, a collaborative study with Dr. Glenn Cota (Old Dominion University, Norfolk, Virginia, USA) on the bio-optical properties of Labrador Sea waters was conducted. This information is being used in Dr. Cota's and Dr. Platt's laboratories for the development of algorithms to derive phytoplankton biomass and productivity from satellite-based ocean colour data.

b. Stable isotope studies of carbon and nitrogen (nitrate and ammonium) utilization by phytoplankton **Glen Harrison / Jeff Anning**

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 30-60 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. At a few stations, ^{14}C incubations were done in parallel for comparison. A total of 7 experiments were conducted (see Table 5); 6 stations were occupied along the AR7/W line and one at a Kiel mooring site (K33) NW of the line. Carbon and nitrogen-based primary productivity rates at these locations will be related to vertical fluxes of particulate biogenic carbon and nitrogen derived from our sediment traps deployed (175 & 1,053 m) on the "Bravo" mooring (M1349) during this mission and to be recovered next year.

Date	Site	Op#	LAT (N)	LON (W)	Photic Depth (m)	15N/13C	14C
28-May-00	K33	59	57.13	55.29	60	x	x
30-May-00	M1349	77	56.67	52.48	45	X	x
31-May-00	L3_20	87	59.06	49.95	30	X	x
01-Jun-00	L3_23	98	59.98	48.90	30	X	x
02-Jun-00	L3_17	103	57.87	51.25	50	X	
04-Jun-00	K42	129	55.45	53.72	60	X	
05-Jun-00	L3_05	142	53.68	54.05	55	X	

Table 5. Sampling of stable isotopes.

c. Sediment traps **Glen Harrison / Brian Irwin / Jeff Anning**

Supplemental funding was provided by DFO's Ocean Climate Program in 1999 for the fabrication and deployment of particle interceptor "traps" in the Labrador Sea during the 2000 field season. The trap design employed was developed at BIO (Bioflux traps), has a 24-cup capacity and internal Tattletale computer for programming particle collection intervals. Two

traps were built and deployed on the BIO "BRAVO" station mooring (M1349) at depths of 175m and 1053m. Cups were programmed to collect material for two-week intervals starting 12:01AM (GMT), 01 June, 2000. The traps will be recovered, refurbished or replaced and redeployed next spring to collect a follow-up year of data. The samples collected next spring will be processed back at BIO for particulate and dissolved biogenic (organic) carbon and nitrogen content as well as other constituents. These particle fluxes will provide the first direct estimates of seasonal variability and annual magnitude of the "Biological Pump" and its contribution to carbon sequestering in the region.

d. Zooplankton Sampling — L. Harris

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, who dominate the zooplankton in this region.

Vertical net tows were taken at 30 stations (2 on the Scotian Shelf and 28 from the Labrador Shelf/Labrador Sea) using a 3/4 meter 200 um mesh ring net. At all stations, tows were made from 100 meters to the surface. Additional deep tows (1500 meters to the surface) were taken at 2 of the stations. Samples will be analysed for species composition, copepod stage structure and biomass.

e. Measurements Of Copepod Metabolic Rates — L. Harris

Egg production rates of *Calanus finmarchicus*, the dominant copepod species, were measured at 14 stations in the Labrador Sea.

f. Dissolved Organic Carbon (DOC) and Microbial Community Respiration — Jay Bugden / Paul Kepkay

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

During CCGS Hudson cruise 2000-009 eight (8) stations were sampled, at a 10m and 40m depth, for gross microbial community respiration, and at 10m only ultrafiltrations were performed for size fractionation of DOC. The stations sampled are listed in Table 6. DOC depth profiles were also collected from twenty-three (23) stations listed below.

Station	Respiration	Ultrafiltration	DOC Profile
L3-4			X
L3-5	X	X	X
L3-6			X
L3-6A			X
AR7W site 7			X
AR7W site 8			X
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 16B			X
AR7W site 16.5			X
AR7W site 17	X	X	X
AR7W site 18			X
AR7W site 20	X	X	X
AR7W site 21			X
AR7W site 22			X
AR7W site 23	X	X	X
AR7W site 24			X
AR7W site 24.5			X
K32	X	X	
K33	X	X	
M1325	X	X	

Table 6. DOC sampling.

g. Primary Production Measurements **Brian Irwin / Jeff Anning**

Water samples for Photosynthesis/Irradiance experiments were collected from the rosette and from the flowthrough system (depth 4m) in the forward lab. A total of 21 samples were collected from the flow through system and 28 from the rosette (see Table 7). Aliquots of the samples were innoculated with 14C sodium bicarbonate and incubated for three hours in a temperature controlled incubator, at 30 different light levels, and then filtered onto glass fibre filters.

The level of radioactivity on each filter was measured on board with a scintillation counter. Aliquots were also filtered for chlorophyll, HPLC, absorption spectra and POC analysis. A filtered sample was frozen for DOC analysis. At biology CTD stations chlorophylls and CO2 samples were collected at 100, 80, 60, 50, 40, 30, 20, 10 and 1m.

Sample ID Number	Depth	Date	Latitude	Longitude
173049	4	May 21	44 55	61 15
173051	4	May 21	45 44	59 53
173053	4	May 22	48 06	59 36
173055	4	May 22	49 31	58 44
203367	4	May 23	52 26	54 55
203368	4	May 23	53 07	53 52
203369	4	May 24	55 26	53 43
203371	4	May 24	55 27	53 42
203373	4	May 25	56 34	52 38
203375	4	May 25	56 34	52 37
203378	4	May 26	55 50	53 24
229334	20	May 26	55 36	53 37
229336	10			
229337	20	May 27	57 06	55 18
229388	10			
203381	4	May 27	57 01	54 49
203383	4	May 28	57 07	55 17
229394	40	May 28	57 07	55 16
229397	20			
229399	10			
203386	4	May 29	57 03	55 14
203387	4	May 29	57 03	54 46
203389	4	May 30	56 41	52 30
229442	40	May 30	56 40	52 27
229445	20			
229447	10			
203392	4	May 31	58 38	50 25
229529	40	May 31	59 04	49 54
229532	20			
229534	10			
229640	40	June 1	60 02	48 53
229643	20			
229645	10			
173060	4	June 2	58 33	50 36
229679	40	June 2	57 52	51 14
229682	20			
229684	10			
173062	4	June 3	56 31	52 33
173063	4	June 3	56 33	52 38
229798	40	June 4	55 28	53 41
229801	20			
229803	10			

229883	40	June 5	53 40	54 02
229886	20			
229888	10			
173069	4	June 6	50 35	57 57
229916	40	June 6	49 51	58 32
229919	20			
229921	10			

Table 7. Primary production sampling.

h. Bio- Optical measurements **Dave Ruble / Jian Wang**

Instruments:
1. Satlantic SeaWIFS profiling Multichannel Radiometer (profiler and reference)
2. Satlantic SeaWIFS Aircraft Simulator (SAS)
3. MictroTops II Sunphotometer
4. SIMBAD Radiometer
5. Shimadzu UV-2401PC UV-Vis Recording Spectrotometer

Optical measurements of spectral light (radiance and irradiance) were made at 16 stations. Triplicate profiles were done at 9 of the stations with the SPMR Profiler (free falling) and Reference (13 channels, 400 to 700nm) to +80m in most cases. Above water records were done at all the stations with the SAS (13 channels, 380 to 865nm) for 10 minutes or longer. The SAS was mounted above the bridge over looking the profiling area. During SAS underway measurements the ship aligned with the sun and slowed to eliminate viewing of the ship's wake. This data will be processed to calculate values of the water-leaving radiance and remote sensing reflectance. Channel band ratios will be correlated with values of near surface chlorophyll to generate regional algorithms for remote sensing of biomass and production in the Labrador Sea. One or possibly two of the stations have a good possibility of being validation points. Additional spectral light measurements were made with a Microtops II Sunphotometer and SIMBAD radiometer.

Particulate (a_p), dissolved (a_s), and non-pigmented (a_n) absorption spectrum were run on discrete samples at 15 stations with a Shimadzu scanning spectrophotometer. Water samples were obtained from the forward lab's flow-through system (4m) and from CTD rosette (1,10,20, and 50m). Triplicates were run for surface samples.

i. Bacterial and Phytoplankton Enumeration and Uptake of Trititiated Leucine into Bacterial Protein **Paul Dickie**

Samples were collected from all CTD depths on all CTD profiles for enumeration of bacteria and viruses by Flow Cytometry. An indication of bacterial productivity with depth was obtained at 10 locations using a new micro method of tritiated leucine added to seawater and incubated in micro centrifuge tubes in a dark refrigerator. The uptake of leucine into protein (an indication of

increase in biomass) can then be obtained. Corresponding “leucine enrichment” and “predator dilution-time series” experiments were also performed. As well, integrated samples for each CTD profile were taken from surface to 50 meters for phytoplankton identification and counting by microscopy. These were preserved with acid Lugol.

5. Major Problems and Goals Not Achieved

Due to the 6.5 day delay in ship sailing date, a significant part of the Year 2000 enhanced program was not accomplished. This included 6 of the 7 biology stations on the Halifax Section, once daily biology stations on the transit to the Labrador Sea, 9 hydrographic stations on the Cape Farewell Section, 9 hydrographic stations on the Bonavista Section. In addition, 10 of the 28 standard hydrographic stations on the Labrador Sea Section were not sampled due to ice; 4 additional stations located south of the ice were added on the Labrador shelf side. The Halifax Section mooring was not ready at the time of sailing and thus was not deployed on this mission.

6. Other Incidents of Note

This was the second cruise to use the OSD Ocean Data and Information system (ODIN). ODIN is a shipboard database application for tracking and collecting the metadata and water sample data associated with an oceanographic cruise. ODIN was run in parallel with the historic system on 99022. As a natural implementation progression, ODIN was run as the sole system in the computer room during HUD2000009. Activities in the winch room were logged both within ODIN and on the historic decksheets.

7. List of Cruise Participants

Name	**Responsibility**	**Affiliation**
Jeff Anning	Underway Sampling, photosynthesis	BIO
Rick Boyce	Salts, Moorings	BIO
Jay Bugden	DOC Levels, respiration rates	BIO
Pierre Clement	Nutrients	BIO
Victoria Burdett-Coutts	CO_2, CFC’s, Alkalinity	BDR
Paul Dickie	Bacterial abundance and activity	BIO
Bob Gershey	Scientist, CO_2, CFC’s, Alkalinity	BDR
Les Harris	Zooplankton, Net Tows	BIO
Glen Harrison	Chief Scientist	BIO
Sabine Harms	Tomography Moorings	Kiel
Brian Irwin	Primary Production	BIO
Anthony Isenor	Data Manager	BIO
Detlef Kindler	Tomography Moorings	Kiel
Uwe Koy	Tomography Moorings	Kiel
Rudolf Link	Tomography Moorings	Kiel

Felix Morsdorf	Tomography Moorings	Kiel
Andreas Pinck	Tomography Moorings	Kiel
Dave Ruble	Optics	ODU
Bob Ryan	CTD Technician, Moorings	BIO
Murray Scotney	Moorings, instrumentation	BIO
Uwe Send	Tomography Moorings	Kiel
Jian Wang	Optics	ODU
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Frank Zemlyak	Technician, CO_2, CFC's, Alkalinity	BIO

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B. UNDERWAY MEASUREMENTS

1. Navigation and Bathymetry — Anthony W. Isenor

The navigation system onboard CCGS Hudson consists of a differential GPS receiver and AGCNAV. The receiver also broadcasts navigation NMEA strings throughout the ships network at about 1 Hz. The navigation data are then logged at one second intervals on a PC, while ship speed, direction, etc. data are logged at 1 minute intervals. This PC was running the AGCNAV software package, a PC based display, and way-point setting software package developed at the Atlantic Geoscience Centre at BIO. This software graphically displays ship position, way-points, 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 hull mounted 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. The transducer (serial number 177) had VM ADCP electronics (serial number 172). Logging, using Transect software on a 486 PC, was started on May 20th at 2355 Z in Halifax Harbour. Ten minute averages were logged for the duration of the mission. The configuration of the equipment results in a bin length of 4 metres and a total of 128 bins. The averaged data are stored to disk and backed up every few days. ADCP logging was stopped on June 8th at 0845Z in Halifax Harbour.

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

Water from approximately 4m was continuously pumped to the forward lab. The temperature, conductivity and fluorescence was measured and logged every 30 sec. Temperature and conductivity were measured with Seabird sensors and the fluorescence by a Wetlabs follow-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 every 15 minutes by an auto sampler for later analysis for nitrate and silicate. The computer also logged the time and position of these samples.

4. XBT and XCTD

No probes were used.

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. CTD Measurement — Anthony Isenor / Igor Yashayaev

a. Description of the Equipment and technique

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

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

BIO System Number	Sensor	Model	Serial Number
9	Temperature	3-02/F	03P2298
	Conductivity	4-02/0	041873
10	Temperature	3-02/F	03P2303
	Conductivity	4-02/0	041874

Table C1. System and sensor serial numbers used during HUD2000009.

Model	Serial Number
13-02	130267
13-02	130266
SBE-43	0071

Table C2. Oxygen sensors used during HUD2000009.

BIO Deck Unit Number	Model	Serial Number
2	11 plus	11P5676-0243

Table C3. Seabird deck unit used for HUD2000009.

BIO CTD Probe Number	Model	Serial Number	Pressure Sensor
2	9 plus	9P5676-0249	49258
3	9 plus	09P7356-0289	51403

Table C4. Seabird CTD units for HUD2000009.

Operation	Circuit	Probe	Pressure	Temp.	Cond.	Oxygen
1-7	Primary	2	2	9	9	130267
	Secondary			10	10	130266
8-end	Primary	3	3	9	9	0071
	Secondary			10	10	130266

Table C5. CTD and sensor combinations used during HUD2000009.

Instrument	Serial Number
SBE Carousel	3215631-0168
Pinger	5098
Lowered ADCP	1359
Irradiance	SQPA327
Fluorometer	088172
Altimeter	222
Pump (Primary)	51775
Pump (Secondary)	51776

Table C6. Other instrumentation on the rosette frame.

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

One unique aspect of this frame is the adjustable legs. The base of the frame is circular with six vertical tubes, or legs, extending upward from the base. These legs end, and can slide within, a slightly larger tube at the base of a second circular frame. Each vertical leg has two fixed positions within the larger tube, and is held in these positions by stainless steel pins. In the deployment position, the legs are retracted. When personnel are drawing water samples, the legs are extended thus raising the frame by about 40 cm. This makes drawing the water samples much easier.

The Physical and Chemical Oceanographic Data Facility of the Scripps Institution of Oceanography (SIO) made the rosette bottles. Each bottle collects 10 litres of water.

This cruise also provided an opportunity to test the Seabird SBE 43 oxygen sensor. The SBE 43 is configured to work as a drop-in replacement for the standard SBE 13 sensor. The SBE 43 has a single output, oxygen current, that is internally corrected for temperature sensitivity.

b. Sampling Procedure and data processing techniques

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

The CTD data is recorded onto disk by a P300 computer using SEABIRD Seasave for Windows NT/95 version 1.15. Processing was conducted using Seasoft Version 4.243 software. The multiple plotting options of Seasave for Windows provided welcomed flexibility during CTD data logging.

At the end of each station, the Seasoft software is used to create 1 and 2 dbar processed data files. Other in-house software creates an inflection point file of the downcast T,S data which is later delivered to the Marine Environmental Data Service where it is converted to an IGOSS TESAC message and transmitted on the GTS. In-house software also produces a processed rosette trip file consisting of 3 seconds of averaged data immediately following the rosette trip. All the raw and processed data files associated with the station are then transferred to the ship's HP Servers for archive and subsequent access and distribution to various users on the vessel.

This field season used the revised Y2K compliant shipboard environment, in C++. All existing Turbo Pascal code was converted to C++ during the autumn of 1999. As well, an additional piece of code was developed to remove those CTD scans resulting from initial CTD contact with the water. The algorithm removes from the processing stream all scans while the primary pump is off. This removes the initial spiking of the sensor output resulting from water contact. As well, the program notes in the file header the sensor pressure at time of water contact (defined by the first of five consecutive scans with salinity > 10) and the pressure, temperature and salinity 24 scans after initial contact.

The data processing for this cruise was revised from the standard setup. The revisions processed both the dawn and up cast data, as well as compute derived parameters on the raw 24 Hz scans rather than the processed 1 and 2 dbar files. The processing takes the following steps:

Preprocessing	This removes all scans before the pump is activated, thus eliminating the initial startup spikes. As well, the pressure offset of the instrument at the time of water contact and the TS values one second after contact are wrote to the header of the processed file.
DATCNV	Converts the raw data to physical parameters.
WILDEDIT	For every block of 19 scans, flags all scans whose pressure, temperature, and conductivity values differ from the mean by more than 2 standard deviations. Recomputes mean and standard deviation from unflagged data then marks as bad all scans exceeding 4 standard deviations from these new values.

FILTER	Low pass filter pressure and conductivity channels. Time constant used for conductivity is 0.045 seconds, for pressure 0.150 seconds.
ALIGNCTD	Aligns the temperature, conductivity and oxygen values relative to the pressure values accounting for the time delays in the system. Time offsets for the primary sensors are: -0.010 secs for conductivity, 0.000 secs for temperature and 3.000 secs for oxygen. Time offsets for secondary sensors are: 0.035 seconds for conductivity, 0.000 seconds for temperature and 3.000 seconds for oxygen (NOTE: Primary conductivity is adjusted by 0.073 seconds in the Deck Unit while the secondary conductivity is not adjusted in the Deck Unit).
CELLTM	A recursive filter used to remove the thermal mass effects from the conductivity data. Thermal anomaly amplitude and time constants of 0.0300 and 9.0000 were used.
DERIVE	Computes oxygen values.
DERIVE	Computes salinity, potential temperature and $sigma_{theta}$.
SPLIT	Splits the data into DOWN and UP cast.
LOOPEDIT	Marks as bad, all cycles on the down trace for which the vertical velocity of the CTD unit is less than 0.1 metres/sec.
WILDEDIT	For every block of 19 scans, flags all scans salinity values differ from the mean by more than 2 standard deviations. Recomputes mean and standard deviation from unflagged data then marks as bad all scans exceeding 4 standard deviations from these new values.
BINAVG	Averages the down cast into 1 and 2 dbar pressure bins.
ROSSUM	Averages 3 seconds of CTD data after every bottle trip. Used in comparison with water sample data.

c. Calibration data

The CTD calibrations used during this cruise were supplied by Seabird Electronics. The applied calibrations are as follows:

BIO SEABIRD System # 9 Sensors ----------

Temperature Sensor 03P2298

$$T = 1/\{a + b[\ln(f_o/f)] + c[\ln^2[f_o/f] + d[\ln^3(f_o/f)]\} - 273.15$$

where ln indicates a natural logarithm, f is the frequency

a = 3.68017202 E-03
b = 6.00214054 E-04
c = 1.62501356 E-05
d = 2.2489128 E-06
f_o = 2918.321 (Seabird calibration dated December 3, 1997)
slope = 1, offset = 0

Conductivity Sensor 041873

$$\text{Conductivity} = (g + hf^2 + if^3 + jf^4)/[10(1 + \delta t + \varepsilon p)]$$

where f is the frequency, p is pressure in dbars, t is the temperature

g = -4.13982358
h = 5.40882425 E-01
i = -8.15812766 E-04
j = 6.91367207 E-05
δ = Ctcor = 3.25 E-06
ε = Cpcor = -9.5700 E-08 (Seabird calibration, February 21, 1997)
Slope = 1, offset = 0

BIO Probe # 3 Pressure Sensor ----------

Pressure Sensor 51403

$$\text{pressure} = c\,(1 - T_o^2/T^2)\,(1 - d[1 - T_o^2/T^2])$$

where T is the pressure period

$c = c_1 + c_2\,U + c_3\,U^2$
$d = d_1 + d_2\,U$
$T_o = T_1 + T_2\,U + T_3\,U^2 + T_4\,U^3 + T_5\,U^4$
U is the temperature
c_1 = -38625.88 psia
c_2 = 0.278422 psia/deg C
c_3 = 0.0140578 psia/deg C^2
d_1 = 0.038824
d_2 = 0
T_1 = 30.62824 micro sec
T_2 = -0.00017328 micro sec/deg C
T_3 = 4.7238e-006 micro sec/deg C^2
T_4 = 3.333e-009 micro sec/deg C^3
T_5 = 0
AD590M = 0.01142
AD590B = -9.117 (Seabird calibration, November 20, 1992)
slope = 1, offset = 0

BIO Probe # 2 Pressure Sensor ----------

Pressure Sensor 49258

$$\text{pressure} = c\,(1 - T_o^2/T^2)\,(1 - d[1 - T_o^2/T^2])$$

where T is the pressure period

$c = c_1 + c_2\,U + c_3\,U^2$
$d = d_1 + d_2\,U$
$T_o = T_1 + T_2\,U + T_3\,U^2 + T_4\,U^3 + T_5\,U^4$
U is the temperature
c_1 = -26446.08 psia
c_2 = -0.519681 psia/deg C
c_3 = 0.0081684 psia/deg C^2
d_1 = 0.033189
d_2 = 0

T_1 = 30.78782 micro sec
T_2 = -0.000531736 micro sec/deg C
T_3 = 4.68447e-006 micro sec/deg C^2
T_4 = -4.55823e-010 micro sec/deg C^3
T_5 = 0
AD590M = 0.01148
AD590B = -9.07248 (Seabird calibration, February 24, 1992)
slope = 1, offset = 0

BIO SEABIRD System # 10 Sensors ----------

Temperature Sensor 03P2303

$$T = 1/\{a + b[\ln(f_o/f)] + c[\ln^2[f_o/f] + d[\ln^3(f_o/f)]\} - 273.15$$

where ln indicates a natural logarithm, f is the frequency

a = 0.00368017216
b = 0.000598773888
c = 1.58179382e-005
d = 2.20940238e-006
f_o = 2896.732 (Seabird calibration, December 3, 1997)
slope = 1, offset = 0

Conductivity Sensor 041874

$$\text{Conductivity} = (g + hf^2 + if^3 + jf^4)/[10(1 + \delta t + \varepsilon p)]$$

where f is the frequency, p is pressure in dbars, t is the temperature

g = -4.08770679
h = 0.51586632
i = -0.00106080083
j = 7.93277368e-005
δ = Ctcor = 3.25e-006
ε = Cpcor = -9.57e-008 (Seabird calibration, February 21, 1997)
Slope = 1, offset = 0

Other Sensors ----------

Oxygen Sensor 130266

oxygen = A B C

where A = {Soc [oc + Tau d(oc)/dt] + Boc}

oc is the current from the oxygen sensor
d(oc)/dt is the time derivative of oc
Soc = 2.1015
Tau = 2.0
Boc = -0.0646

oc = Mv + b
m = 2.4692 E-07
b = -4.1977 E-10

B = OXYSAT(t,s)
t is temperature
s is salinity

$C = e^{\{tcor [T + wt (To-T)] + pcor p\}}$
e is natural log base
tcor = -0.033
pcor = 0.00015
p is the pressure
wt = 0.670
To oxygen sensor internal temperature
T is the water temperature, where T = kv + c
k = 8.8993
c = -7.0715
v is the oxygen temperature sensor voltage signal (calibrated on February 12, 1992)

Oxygen Sensor 130267

oxygen = A B C

where A = {Soc [oc + Tau d(oc)/dt] + Boc}

oc is the current from the oxygen sensor
d(oc)/dt is the time derivative of oc
Soc = 2.2144
Tau = 2.0
Boc = -0.0397

oc = Mv + b
m = 2.4624e-007
b = -4.9249e-010

B = OXYSAT(t,s)
t is temperature
s is salinity

$C = e^{\{tcor [T + wt (To-T)] + pcor p\}}$
e is natural log base
tcor = -0.033
pcor = 0.00015
p is the pressure
wt = 0.670
To oxygen sensor internal temperature
T is the water temperature, where T = kv + c
k = 8.9889
c = -6.8612
v is the oxygen temperature sensor voltage signal (calibrated on February 12, 1992)

Oxygen Sensor SBE43-0071

oxygen = A B C

where A = {Soc [oc + Tau d(oc)/dt] + Boc}

oc is the current from the oxygen sensor
d(oc)/dt is the time derivative of oc
Soc = 0.3411
Tau = 2.0
Boc = 0.0007

oc = Mv + b
m = 1e-006
b = 0

B = OXYSAT(t,s)
t is temperature
s is salinity

$C = e^{\{tcor [T + wt (To-T)] + pcor p\}}$
e is natural log base
tcor = 0.0004
pcor = 0.00013
p is the pressure
wt = 0
To oxygen sensor internal temperature
T is the water temperature, where T = kv + c
k = 8.9889
c = -6.8612
v is the oxygen temperature sensor voltage signal (calibration date, May 9, 2000)

Fluorometer 088172

VB = 0.212
V1 = 1.974
Vacetone = 0.334
Scale Factor = 1
Slope = 1
Offset = 0

Irradiance Sensor SPQA327

Log Amp LI193SB(SPQA327)/SBE90310(0002)
M = -0.773222
B = -3.536591
Calibration Constant = 4.37
Multiplier = 1

Altimeter 222

Scale factor = 15

2. 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 that were used for the first time on a similar mission approximately one year ago. However, new and different one-piece caps were used instead of the two piece caps tried last year. Once the sample bottle has been rinsed three times and filled to the shoulder, the neck and threads of the bottle was dried using paper towel and a new, unrinsed dry cap was installed. Once the bottles had reached room temperature, the caps were retighten. The drying of the neck of the bottle and installing an unrinsed cap is a new technique used for the first time for in-situ work although standard practice in the calibration laboratory.

The salinometer cell is filled and rinsed numerous times with sample water before readings are recorded. When three consecutive readings of conductivity agree to within 0.00001, this value is recorded for the sample. This value is 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 (See Appendix **) database. Conductivities were used to compute salinities using 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 are assumed to have occurred as a linear drift of the instrument. Thus, the program applies a correction to the ratios, which varies linearly with the samples analyzed. An offset is also applied if the initial standardization is different from the quoted value given on the ampoule label. The computed salinity data is 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 lab temperature during a particular run of samples was exceptionally stable which has been a problem on previous missions. However, a temperature span of the GP lab of 21º to 24 ºC was common throughout the mission. For one day, the bath temperature of the salinometer was changed from 24º to 21º as the lab temperature dipped to 20 ºC. These samples were identified as 229611 to 229673.

d. Replicate Analysis **(This section to be revised at a later date)**

A total of ** 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	
Median	
Mean	
Minimum	
Maximum	
Standard Deviation	

Also, a total of 29 extra samples, usually two per cast, were drawn, set aside and run as a group at the end of the mission. …….

e. Standards Used

The salinomometer was standardized during the mission using IAPSO standard water, Batch P136 dated April 16, 1999 having a K15 value of 0.99996 and a salinity of 34.999. Typically, a check of standardization was

performed at the beginning of a run and after 25 samples were analyzed. A sub-standard was sometimes used to check the performance of the instrument any time during a run.

f. Performance of the Autosal salinometer

Overall the salinometer worked well during the mission. The lab temperature was stable during any particular run which is an important factor if trying to optimize the performance of the instrument. Sample values stabilized quickly without any "hunting around" for a stable value. However, the drift of the instrument at times was not typical of a well running Autosal. At the start of a day the salinometer would drift about 10 units for the first 25 samples but appeared to drift much less or none at all for the remaining samples. As the salinometer has not been serviced for quite sometime this should be made a priority item.

3. Oxygen — Frank Zemlyak

a. General

Samples for the determination of dissolved oxygen were drawn from each rosette water sampling bottle on most casts. The samples were analyzed using the Winkler titration technique with a computer driven automated system developed at the Scripps Institute of Oceanography.

In total 407 samples were run, of which 21 were duplicates. Although some figures are presented in this summary, they are preliminary.

b. Description of Equipment and Technique

The oxygen samples are analyzed using an automated procedure developed by the Ocean Data Facility of the Scripps Institute of Oceanography. This procedure is a modified Winkler titration from Carritt and Carpenter (1966), using a whole bottle titration. To maintain historical records, the same Fisher Scientific Potassium Iodate standard was used as the working standard.

Standards and blanks are run at least once a day and whenever the system has been idle for a number of hours.

Before titrating, the top of the oxygen flask is washed a minimum of two times with deionized water before the glass stopper is withdrawn. At that point, a 1.5ml aliquot of sulphuric acid is added to the sample, a magnetic stir bar inserted, the sample is then titrated immediately.

During the titration, the oxygen flask is immersed in a water bath and is held firm in the centre of the 365nm UV light path. Starch as an indicator is not needed and the addition of a wetting agent to minimize the formation of micro bubbles is unnecessary.

c. Sampling Procedure and Data Processing Technique

The sampling bottles are calibrated 125ml Iodine flasks with Pennyhead stoppers. The flask volumes are determined gravimetrically. The matched flasks and stoppers have been etched with identification numbers and entered into the Oxygen program database.

During this cruise, 10 litre rosette bottles were used to obtain the original sample. The oxygen samples are drawn following the drawing of the CFC's and DOCsamples. The oxygen samples are drawn through the bottle spigots with a silicone tube attached so as to introduce the water to the bottom of the flask. The flask and its stopper are thoroughly rinsed and filled to overflowing. The flow is allowed to continue until at least two to three flask volumes overflowed. The flask is then slowly retracted with continuous low flow to ensure that no air gets trapped in the flask. Immediately thereafter, one ml each of the alkaline iodide and manganous chloride reagents are added, the stoppers carefully inserted, ensuring that no air gets into the flasks. The flasks are thoroughly shaken, then carried to the lab for analysis.

d. Replicate Analysis

The series of 21 duplicate samples taken throughout the cruise had a maximum difference of -0.416 to 0.085 ml/l, however, 86% of the values fell within -0.024 and +0.022 ml/l.

Many more standards and blanks were run during this cruise than in the past. Of the 124 blanks analyzed, the standard deviation was 0.00425 ml/l, of the 78 standards, 0.0011 ml/l of thiosulphate.

e. Conclusions

Although this is an automated computer controlled titration system, this cruise has shown that with operator care, the precision of titrations can be improved. This was demonstrated by the primary operator who had never been to sea, and had never used the system before. For example, in the case of the duplicate samples, 86% of the values fell within -0.024 and +0.022 ml/l. During the 1999 cruise 89% of the values fell between -.05 to +0.05 ml/l.

A very strong effort should be made to adopt a universal Oxygen Titration Standard to ensure more accurate oxygen determinations from year to year and institution to institution. The benefits of such a standard are obvious when one looks at other commonly measured parameters, such as salinity, nutrients, CFC'S, and carbonate.

4. Nutrients — Pierre Clement

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 10 L Niskins. The bottles are 10% HCL washed, rinsed three times with Super-Q and oven dried at >100 Degrees F.

A sample run includes six Working 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, S9888) as is the wash water. The Standards are tested against CSK Solution Standards (Sagami Chemical Center, Japan).

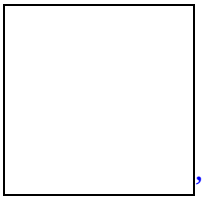
Analog data is converted to digital, processed and statistics calculated by a Pascal 7.0 in house program (Logger) on a PC. Chart recordings, hard copy and disk copies of the data are kept for reference.

c. Replicate Analysis **(This section to be revised at a later date)**

A duplicate sample is drawn from every Niskin. This has resulted in a total of 1158 duplicate samples for the nutrients.

Samples were collected in duplicate from the rosette bottles into 30 ml acid washed HDPE screw-capped bottles. 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.

Precision is a measure of the variability of individual measurements and in the following analysis two categories of precision are determined; field and analytical precision. Analytical precision is based on the pooled estimate of the standard deviation of the check standards over the course of a complete autoanalyzer run and is a measure of the greatest precision possible for a particular analysis. Field precision is based on the analysis of two or more water samples taken from a single Niskin sampling bottle and has an added component of variance due to subsampling, storage and natural sample variability.

Both categories of precision are determined by computing the variance,  , of each replicate set, where i is the index of the replicate set. In the case of analytical (field) precision, a

replicate set consists of all the check standards (duplicate samples). Given p replicate sets and n samples within any replicate set, the mean standard deviation, $\overline{\sigma}$, is determined from

$$\overline{\sigma} = \sqrt{\frac{\sum_{i=1}^{p}(n-1)_i \sigma_i^2}{\sum_{i=1}^{p}(n-1)_i}}$$

The precison expressed in percent is based on the mean concentration, M, of the check standards (analytical precision) or water samples (field precision) and is given by

$$P_{\%} = \frac{\overline{\sigma}}{M}$$

The following table indicates the analytical and field precision obtained for this cruise.

	Silicate	Phosphate	NO2+NO3
Number of Samples			
Number of Duplicates			
Mean concentration (μ moles/kg)			
Field Precision (μ moles/kg)			
Field Precision (%)			
Analytical Precision (μ moles/kg)			
Analytical Precision (%)			
Detection Limit (μ moles/kg)			

The laboratory temperature during all analyses was between 16 and 22 °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 above table were applied to the dataset. All values at or below the detection limits were set to zero.

The following duplicate measurements were used to compute the values given in the SEA file. All values that follow are in micro moles/kg. Conversion to micro moles/kg used a sample temperature of 15°C.

5. Dissolved Inorganic Carbon in Seawater **Bob Gershey**

a. Description of Equipment and Technique

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

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

b. Sampling Procedure and Data Processing Technique

Samples 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. These samples are treated in the same manner as a seawater sample. Values are reported in units of μmol/kg. The overall precision of the analysis should be at least 1.5 μmol/kg for samples with concentrations in the range of 1800-2300 μmol/kg.

6. Alkalinity — Bob Gershey

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 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. 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.

7. Halocarbons — Bob Gershey

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 at least 170°C. The contents of the trap are then passed through a 75m DB-624 megabore column. The resolved components exiting the column are quanitified using electron capture detection.

b. Sampling Procedure and Data Processing Technique

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 gas standards made up at Brookhaven National Laboratories. The Brookhaven standard has been calibrated against a reference air standard prepared by NOAA/CMDL at 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.

8. Reversing Thermometers

Reversing thermometers were not used since the dual temperature sensors on the Seabird CTD provide a better in the field temperature calibration.

D. MOORED MEASUREMENTS - DESCRIPTIONS, TECHNIQUES AND CALIBRATIONS

1. IFM/Kiel Tomography Moorings — Uwe Send

The IfM/Kiel work on the cruise consisted of servicing four moorings deployed in the central Labrador Sea. These were moorings K30 through K33 that had been deployed from the German RV 'Meteor' in the summer of 1999 (cruise designation Meteor M45/3). The moored measurements are part of a national special research initiative ('SFB') called 'Dynamics of Thermohaline Circulation Variability'. The particular subproject here addresses the convection activity in the Labrador Sea, its connection to deep water generation, export, and transports, its forcing and variability, and in general its role in the climate system. The year 1999-2000 was the fourth period of measurements.

The moorings contain point sensors for observing convection activity (microcats, pressure-temperature recorders, ADCPs) and traditional current meters, three of them carry acoustic tomography instruments, and one a profiling CTD. The tomography approach uses horizontal sound transmission between the moorings for obtaining large-scale averages of heat content and temperature stratification. This technique requires correction of mooring motion to within a few meters, which necessitates the deployment of 3 acoustic transponders around each mooring. The total work thus required the recovery of three ADCP's, three tomography systems, 11 microcats, 5 current meters, two 400m-thermistor chains, eight T-P recorders, one profiling CTD, nine transponders, and as accessories eight acoustic releases, four Argos and other radio transmitters. Many of these required servicing, including data download, inspection, re-batteried, and prepared for re-deployment. Microcats and T-P recorders were also calibrated by mounting them on the CTD rosette.

The new moorings deployed in place of the recovered ones were K40 through K43 in the same places and with similar configurations. Important additions were a surface telemetry system plus a CO_2 sensor on mooring K41. New transponders were also deployed and required surveying in, in order to determine their positions to a few meters accuracy. Since the deployments needed to take place from the stern, while the recoveries were carried out on the bow, the equipment needed to be transferred aft. For the large and heavy tomography instruments, as well as the ADCP floatation spheres, this could only be done over the side, floating the equipment to the stern of the ship. The larger instruments were serviced in the helicopter hangar and stored on the flight deck.

Another new aspect of this years deployment was the trial for dual usage of our tomography sound sources. They had been modified to also transmit RAFOS float signals. For testing this, three RAFOS floats were deployed near mooring site K41. These will park on the bottom until March 2001, when they are programmed to ascend to 700m and start their float mission.

In spite of the very short time available, all operations were carried out successfully. The moorings and instruments were recovered intact, and most had excellent data return. Immediate inspection revealed convection activity in excess of 1000m depth, and downward moving plumes

with vertical velocities of order 10cm/s. The tomography data are in the process of being analyzed at the time of writing.

2. BIO Current Meter Moorings — Rick Boyce

a. Description of the Equipment and Technique

Description of the Moorings

The standard BIO deep sea mooring consists of a large main streamlined subsurface float having 2000 pounds buoyancy holding the mooring as vertical as possible in the water column with minimal drag. Back-up buoyancy is provided throughout the mooring length to float the remaining sections of the mooring should it part at any location. The mooring line consists of 3/16" galvanized wire which has been impregnated with a yellow plastic coating to a nominal outside diameter of ¼". The wire is terminated at selected locations to allow instruments to be inserted into the mooring. Instruments such as Aanderaa Current Meters, SBE CTD instruments and Benthos 965A deep-sea acoustic releases are installed on the mooring.

The upper two subsurface buoyancy packages are constructed using 17-inch glass balls supported in a streamlined shell. The lower buoyancy package contains similar glass balls in standard "yellow hardhats". Stainless steel shackles and swivels are used to connect the instruments and backup buoyancy packages to the wire lengths. All shackles are secured with a piece of jacketed seizing wire as the mooring is assembled and deployed except for the shackles between the BUB package which are secured with cotter pins. The moorings have been designed for a 12-month deployment.

The mooring is designed to ensure the lower release will remain on location for recovery if any part of the mooring fails and breaks away. Fishing activity, iceberg, or other mechanical failure of the mooring hardware are typical causes of mooring loss. Chain is used below the release to ensure that the mooring wire will part first leaving the release on site. Sufficient Backup buoyancy is provided at the release for recovery. This ensures that parts of the mooring can be recovered for post-mortem analysis of the problems and redesign of future moorings preventing other mooring losses.

A Siemac Argos Mooring Relocation beacon has been installed on the main float for tracking purposes if the mooring should part during the deployment.

The BRAVO mooring #1349, for the first time, included two Sediment Traps at 175 and 1073 meters.

b. Sampling Procedure and Data Processing Techniques

The Aanderaa current meters are set with a sampling interval of one hour; the four SEACAT temperature / conductivity recorders were set to 30 minutes, while the three SEACATs with

temperature / conductivity / pressure recorders were set to 30 minutes. On recovery, the data is processed using standard software packages within the BIO Oceans suite of programs.

c. Calibration Data

The temperature and direction sensors of the Aanderaa current meters are calibrated in the laboratory prior to deployment. The SEACAT instruments are calibrated before and after deployment. These calibrations will not be included in this cruise report.

The deployed Seacats were calibrated on station 60. The recovered Seacats and Microcats were calibrated on station 124.

d. Recovery of Moorings

Moorings 1325 & 1326 were both completely recovered in good shape. Mooring 1325 was found over 3 miles away from its documented position as written in the mooring log. All the Aanderaa current meters and Seabird CTD's have full records and appear to functioned properly. The Argos beacon did not work as the battery voltage was low. Once new batteries were installed, the beacon functioned properly.

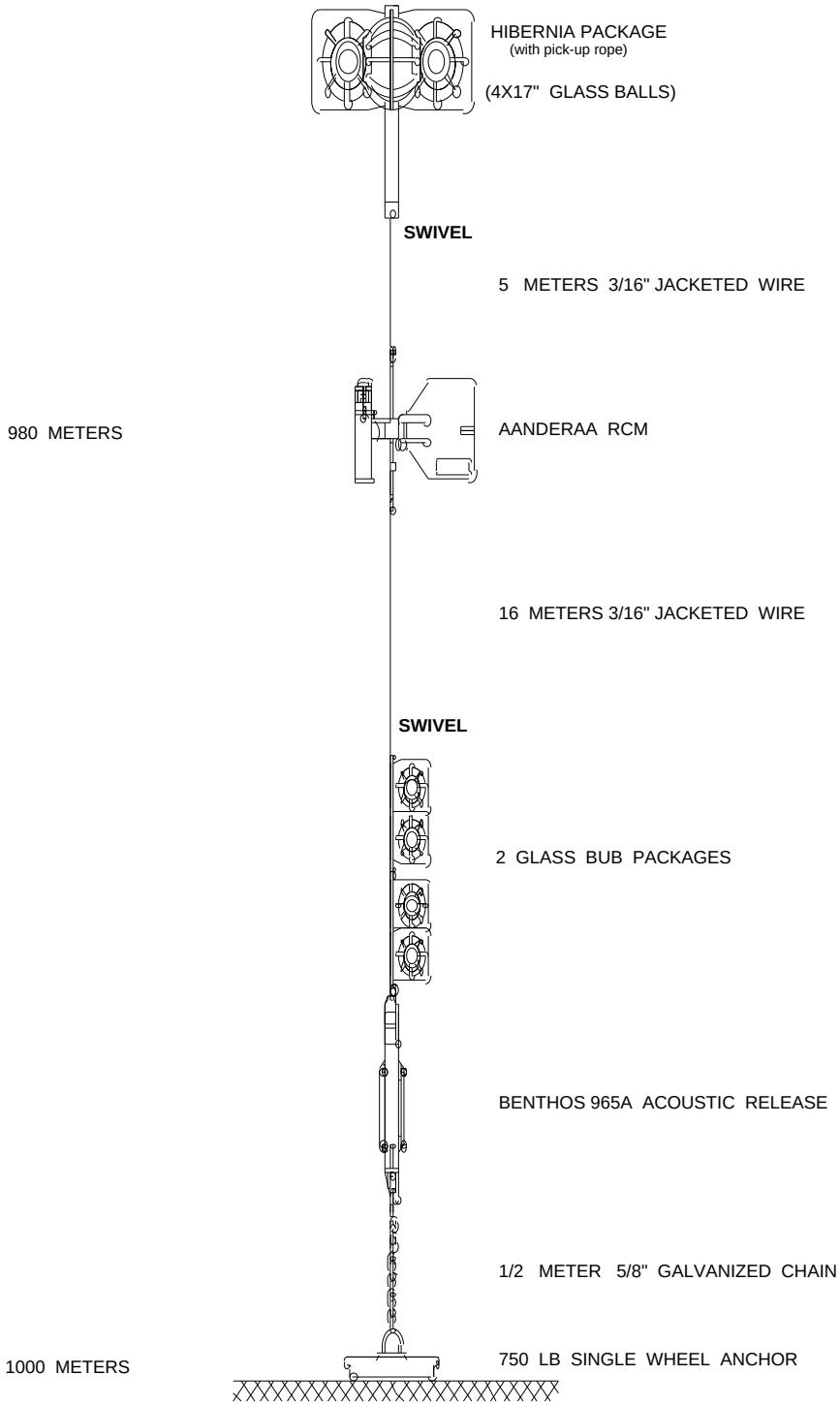
e. Deployment of Moorings

Mooring 1349 incorporated two sediment traps. Conditions were excellent and the attempts to moor the traps upright were successful. When all the mooring line was payed out, the ship was about one mile from the designated mooring position. As the bottom topography was consistently flat and the water depth was correct, the anchor was dropped. It was decided that dragging the traps and the mooring across the surface was not a good idea especially when the actual mooring site is not that critical. Between the BUB packages, ½" stainless pinned shackles were used and not the safety shackles. Safety straps were not used. The batteries in the Argos beacon were changed (11 volts), the beacon tested and then attached to the syntactic foam buoy.

Mooring 1350 was deployed on May 24th. A light was not used and ½" stainless pinned shackles were incorporated between the BUB packages.

d. Deployment and Recovery Logs

MOORING # 1326 LAZIER LAB SEA JULY 1999



Recovery

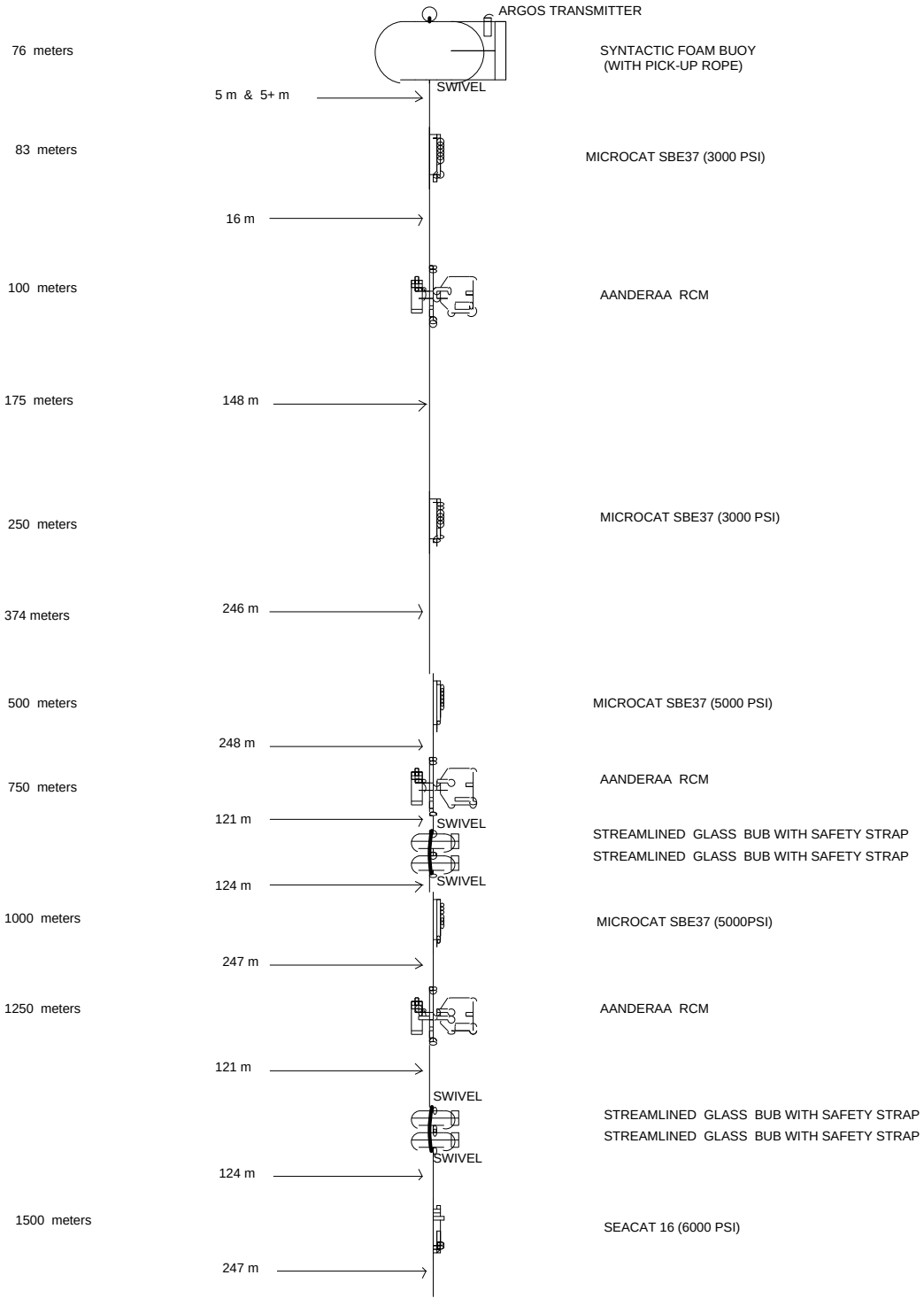
Mooring No. M1326

Ship: Hudson
Mooring Technician: Scotney/Boyce
Type of Nav: GPS
Sea State: very calm, <1 metre sea, ~1m swell
Cancel Notship: Yes _____ No _____

Cruise No: 2000009
Date: 24 May 2000
Weather Conditions: sunny, clear, beautiful day

Time (Z)	Instrument	Remarks
19:02		Release command sent and accepted
19:17		Packages sighted on surface
19:25		Package hooked with small hook
19:26		Grapel on package
19:27	CM4208	CM out of water
19:27		Upper buoyancy on deck
19:30	CM4208	CM on deck. Rotor spinning.
19:32	890	Release and lower buoyancy package onboard.

MOORING # 1325 LAZIER LAB SEA WOCE JULY 1999



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MOORING # 1325 LAZIER LAB SEA WOCE JULY 1999

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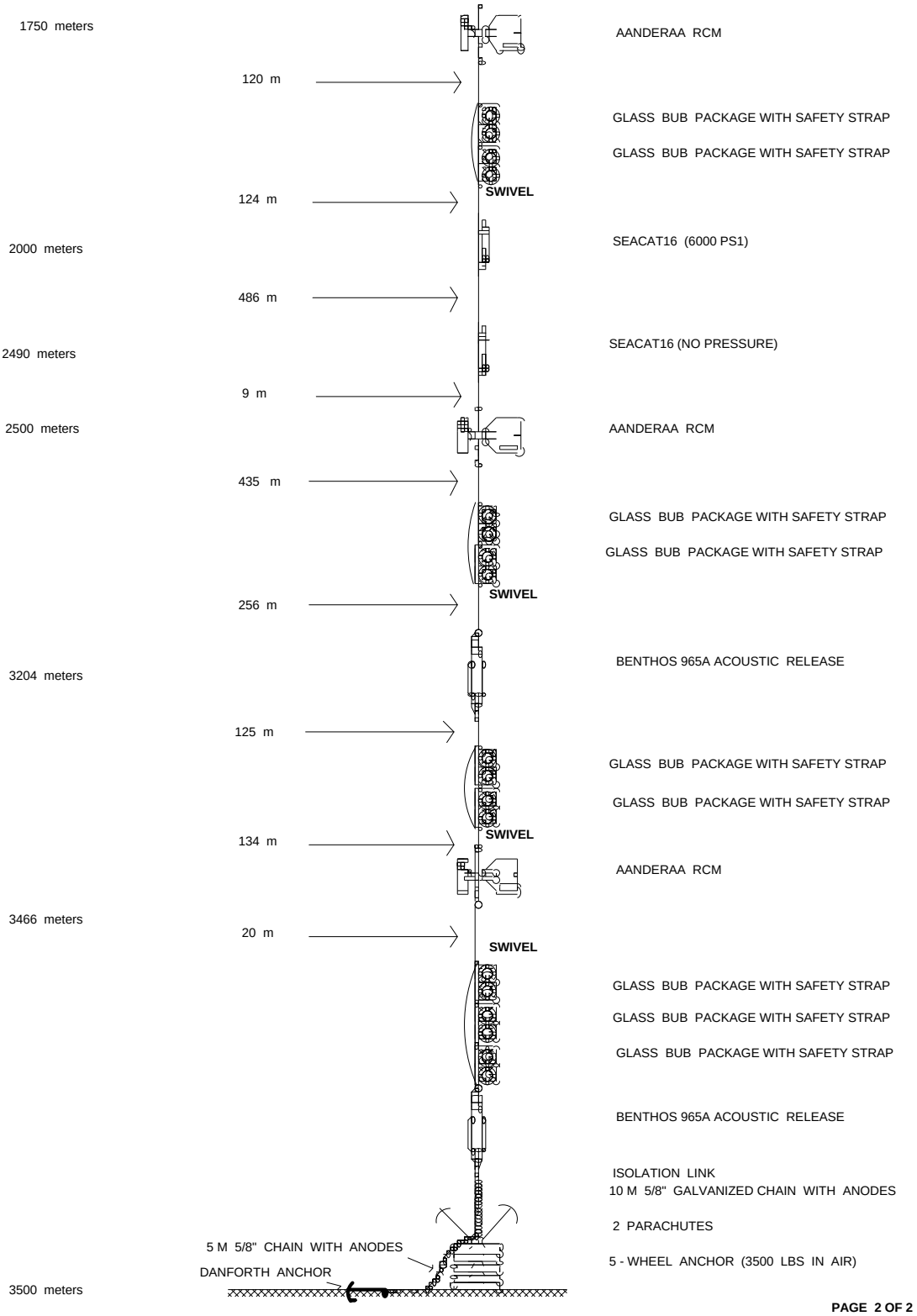


PAGE 2 OF 2

Recovery

Mooring No. M1325

Ship: Hudson
Mooring Technician: Scotney/Boyce
Type of Nav: GPS
Sea State: sea < 1m, swell ~1 m
Cancel Notship: Yes _____ No _____

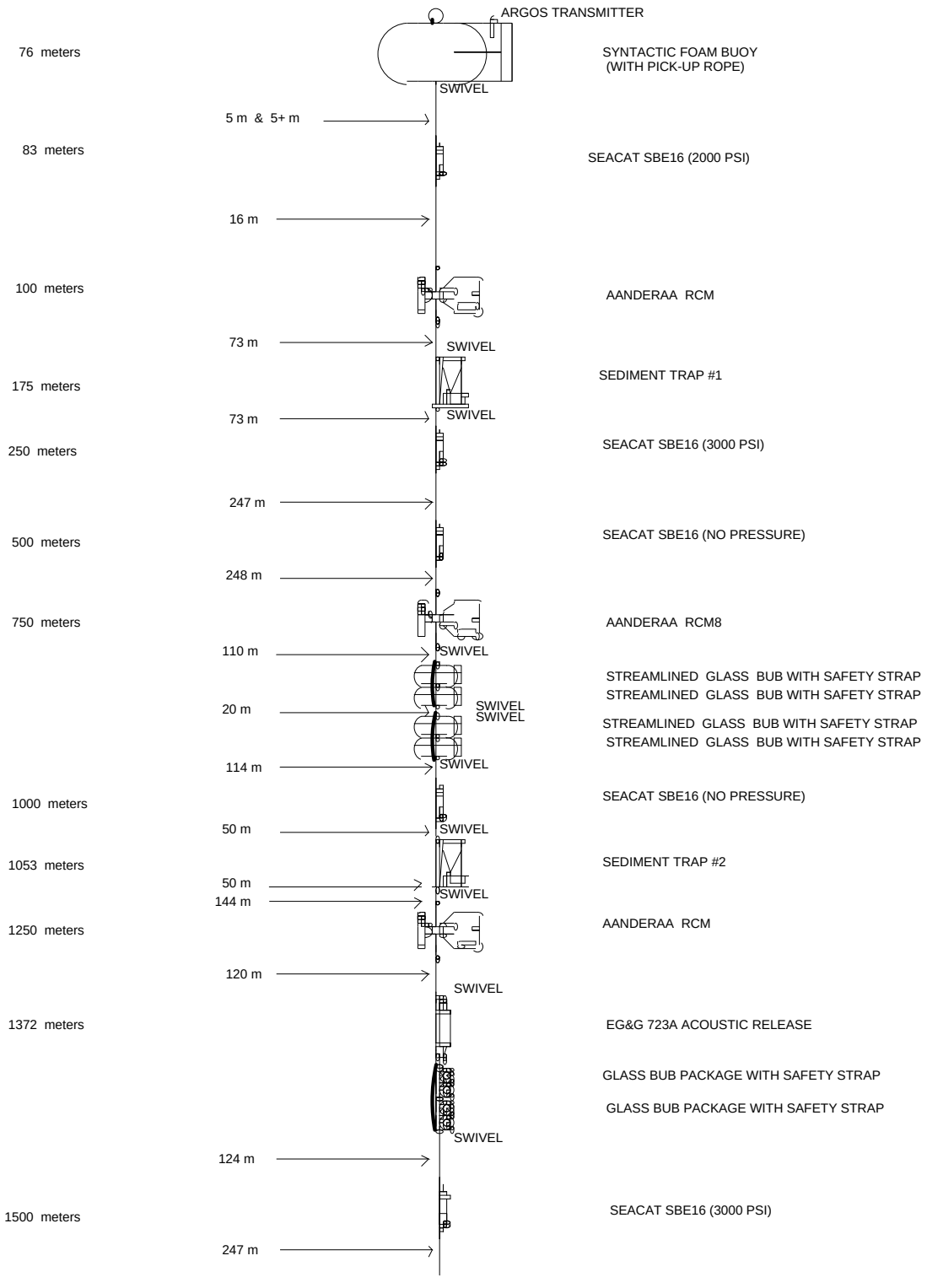
Cruise No: 2000009
Date: 29 May 2000
Weather Conditions: overcast

Recovery Log

Time (Z)	Instrument	Remarks
21:38		Attempting to communicate with bottom release.
21:54		Communicating with upper release. Sounds far away.
21:55		Could not range off of bottom release. Now, range off of upper release is ~ 7200 m
22:20		Gave bridge positions obtained from Allyn's spearsheet. Now moving toward 56 ° 44.6 'N 52° 26.6' W. Range decreasing.
22:29		Range starting to increase. Changing course toward north.
22:47		Slant range 3649 m at 56° 44.77'N 52° 30.07'W which is 5.5 cables away.
22:52	883	Release command sent to release 883.
22:54		Release command send 2nd time
22:54		Release command accepted.
22:55		Sighted off starboard beam, ~200 m at 56° 44.625'N 52° 30.437'W (this is ships position)
23:37		Yellow floats sighted.
23:41		Second set of yellow floats sighted
23:42		A red set of buoyancy sighted
23:48		Upper float hooked.
23:51		Upper float rope attached to boom.
23:53		Upper float on deck.
23:57	0861	Microcat on deck.
00:00 (May 30)	CM 2663	Aanderaa RCM on deck.
00:03	0862	Microcat on deck.
00:08	0863	Microcat on deck.
00:13	CM 3300	Aanderaa RCM on deck.
00:16		2 streamlined BUB on deck.
00:20	0864	Microcat on deck.
00:25	CM 4406 and Seacat	RCM and Seacat in a trangle of wire. On deck.
00:30	2 BUB	On deck.
00:37	CM4600 and Seacat	RCM and Seacat in a tangle of wire. On deck.
00:46	Seacat	Seacat on deck.
00:49	CM 4998	RCM on deck.
01:00	2 BUB	On deck.
01:06	2 BUB	Massive tangle. There are seven lines off the BUB.
01:07		3 pair of BUB next to the ship, other BUB well away from the ship.
01:09	CM 7134	On deck.
01:13		Lower release and 3 BUB on deck.
01:18		2 BUB on deck.

01:24		Release on deck. Recovery Completed.
01:31		Checked all 6 RCM. All rotors spinning freely.

MOORING # 1349 LAZIER LAB SEA WOCE MAY 2000



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MOORING # 1349 LAZIER LAB SEA WOCE MAY 2000

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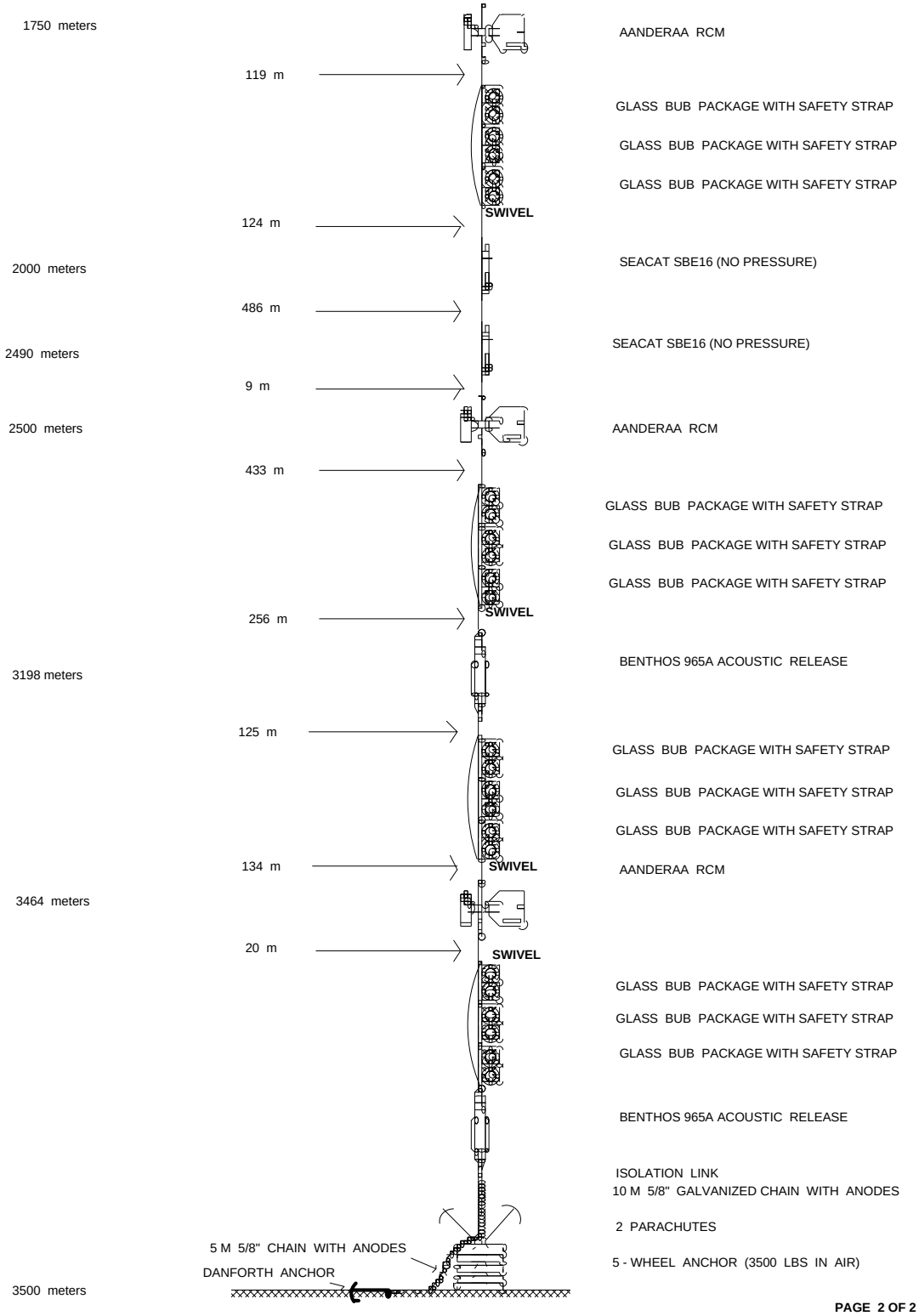


Placement

Mooring No. 1349

Geographic Area:	Labrador Sea	Intended Duration:	1 year		
Ship:	Hudson	Cruise No:	2000009	Date:	30 May 2000
Sea State:	swell <1m, sea <1m	Weather Conditions:	overcast		
Mooring Technician:	Scotney/Boyce	Navigation Inst:	GPS		
Notship #	(Maritimes 902-426-6030, Nfld 709-772-2083, Laurentian 418-648-5410)				
Latitude:	56° 40.4516 N	Longitude:	52 ° 29.2068 W	Time of Fix:	1615 Z
Depth: Raw:	1880 fths	Corrected:	3511 m (speed of sound 1491 m/s, ram up - 6m)		
Main Float:	Type:	syntactic foam	Markings:	orange	
Radio Beacon:	Type:	none	Freq.		
Light:	Type:	none	Colour/Rate:		
Mooring Line:	Type:	3/16 inch jacketed	Colour:	yellow	

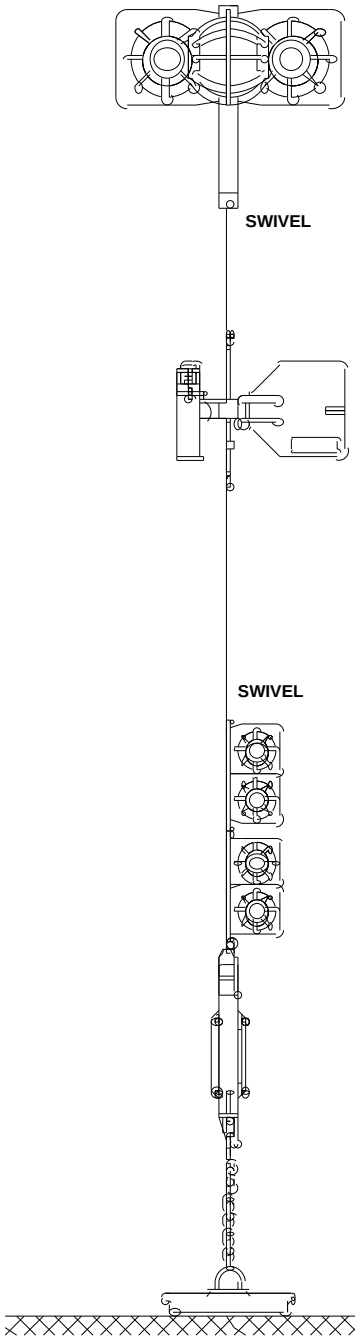
Release:	Type:	EG&G	S/N:	107002	Release Code: 0134
	Type:	Benthos	S/N:	889	Release Code: C, 10.25 kHz, ID=20
	Type:	Benthos	S/N:	891	Release Code: C, 10.75 kHz, ID=22

Placement Log

Time (Z)	Instrument	Remarks
09:35	Release 891	Release test to 200 m.
09:41		Release command sent and accepted.
09:51	Release 889	Release test to 200 m.
09:55		Release command sent and accepted.
10:04	EG&G 107002	Start release test to 200 m.
10:11		Release command sent and accepted.
11:22		Ordered Seacats. Checked BUB. Found 1 missing cotter pin. Deck crew fixed it.
12:28		Main float and Seacat in the water.
12:35	RCM 3299	Rotor spinning. In the water.
12:47		Sediment trap in the water.
12:51	1623	Seacat in the water.
12:58	1625	Seacat in the water.
13:04	RCM 6401	In the water.
13:10		Streamlined BUB package of 2 in the water.
13:14		Streamlined BUB package of 2 in the water.
13:27	1626	Seacat in the water. Had to turn the Seacat around because the swivel was hitting the cell.
13:34		Sediment trap in the water.
13:42	CM 6409	RCM in the water.
13:44		Found yellow jacket off wire ~ 1 cm. Taped it.
13:52	107002	Release and 2 BUB in the water.
13:57	1624	Seacat in the water.
	6410	RCM in the water. Rotor spinning.
14:10		3 pack of BUB in the water.
	1627	Seacat in the water.
14:25	1896	Seacat in the water.

14:27	8695	RCM in the water.
14:37		3 BUB packages in the water.
14:44	889	Release in the water.
14:47		Chipped the yellow jacket near the end of the 125m piece. Taped it.
14:50		3 BUB in the water.
14:55	9328	RCM in the water rotor spinning.
14:57		Replacing middle BUB because of broken hard hats.
15:01	891	Attaching release.
15:07	891	3 BUB and release attached to line. Chain attached to release.
15:08	891	3 BUB and release over the side
15:16:52		Anchor away at 56° 40.3897 N 52° 29.2831 W. This is 1 nautical mile away from the intended drop point. Took 3 miles to deploy.
15:21		Sounding 1882 ftm = 3515 m
15:58		Bridge saw surface buoy go under at 56° 39.6976' N 52° 28.7053' W
16:12		Slant range 3581 m. So ~ 4 cables away.
16:15		Slant range 3550 m. So ~ 3 cables away. 56° 40.4516'N 52° 29.2068'W Best fix. This is within 2 cables of the drop anchor point.

MOORING # 1350 LAZIER LAB SEA WOCE MAY 2000



Placement

Mooring No. 1350

Geographic Area:	Labrador Sea	Intended Duration:	1 year		
Ship:	Hudson	Cruise No:	2000009	Date:	30 May 2000
Sea State:	swell ~1 m, sea < 1 m	Weather Conditions:	sunny beautiful day		
Mooring Technician:	Scotney/Boyce	Navigation Inst:	GPS		
Notship #	(Maritimes 902-426-6030, Nfld 709-772-2083, Laurentian 418-648-5410)				
Latitude:	55° 7.2132 N	Longitude:	54° 5.5457 W	Time of Fix:	22:05 Z
Depth: Raw:	570 fths	Corrected:	1070 m (using 1491 m/s sound speed, ram down + 8m		
Main Float:	Type:	Hibernia	Markings:	none	
Radio Beacon:	Type:	none	Freq.		
Light:	Type:	none	Colour/Rate:		
Mooring Line:	Type:	3/16 inch jacketed	Colour:	yellow	
Release:	Type: Benthos	S/N: 885	Release Code: C freq. 9.25 kHz ID=16		

Placement Log

Time (Z)	Instrument	Remarks
20:01	Release	Test completed. Release functioned properly.
		Anchor secured over rail.
21:15		Lower buoyancy package over rail.
21:20		Lower buoyancy package released.
21:23	CM 3584	CM on deck. Rotor spinning. Mooring all hooked together on deck.
21:30		Raising upper buoyancy and CM off deck.
21:31		CM in water.
21:34:59		Anchor away. 55° 7.217' N 54° 5.614' W 570 ftms = 1070 m
22:05		Repositioning of mooring: 55° 7.2132'N 54° 5.5457'W within 0.5 cable of drop point. This was at closest approach slant range 1075 m.

E. ACKNOWLEDGEMENTS

F. APPENDICES (This section to be revised at a later date)

Appendix 1: Along Track CTD Calibration Information

BSB SEABIRD Model 25-03 Serial Number 258917-0116

Temperature Sensor 031548

$$T = 1/\{a + b[\ln(f_o/f)] + c[\ln^2[f_o/f] + d[\ln^3(f_o/f)]\} - 273.15$$

where ln indicates a natural logarithm, f is the frequency

a = 3.68120903 E-03
b = 6.05726873 E-04
c = 1.57453931 E-05
d = 2.37605653 E-06
f_o = 6145.410
slope = 1, offset = 0(Seabird calibration dated November 2, 1993)

Conductivity Sensor 041124

$$\text{Conductivity} = (af^m + bf^2 + c + dt)/[10(1-9.57(10^{-8})p)]$$

where f is the frequency, p is pressure in dbars, t is the temperature

m = 4.4
a = 7.91164000 E-06
b = 4.91698742 E-01
c = -4.03526125 E+00
d = 6.64743265 E-05
Slope = 1.00000000
Offset = 0.000

Irradiance Sensor 1567

where

m = -0.7558000
b = -3.4702000
Calibration Constant = 3.34000
Multiplier = 1.000

Fluorometer Sensor 304

where

Scale Factor = 10.000
Offset = 0.000

Appendix 2. Software/Hardware Report — Anthony W. Isenor

ODIN

The Ocean Data and Information system (ODIN) is a shipboard database application for tracking and collecting the metadata and water sample data associated with an oceanographic cruise. ODIN has been beta tested in the past, during 98023 and 99022, in the Labrador Sea. The system was implemented on HUD2000009 as an operational system. Our standard paper based system for the winch room was maintained in parallel to ODIN. In the computer room, the traditional paper based system was not used. Our traditional dry deck sheets were produced using ODIN after the completion of the operation.

This ODIN implementation continued to uncover technical issues related to operational use. However, the difference this year was in both the number of comments (from 50 down to 20) and the complexity. Comments requiring code modifications were typically addressed in the same day, indicating very minimal code modifications.

ODIN has the capacity to provide staff with improved information related to the science activities and data on a research cruise. It provides a “complete cruise” representation of activities, rather than a group or program perspective. Considering the evolution of the beta testing over the last three years, the next natural step for ODIN is complete implementation.

Appendix 3. Operation Notes

Operation Notes Report
As Completed On: 12/Jul/2000
Cruise Number: 2000009
(sorted by Operation ID Number)

Note Number: 1	**Entry Time:** 06/Jun/2000 18:52:05	**Note Made By:** Anthony Isenor	**Operation ID**: 7
After 7 was completed, the CTD probe and oxygen sensor were changed. The probe was changed from probe 2 (SN 49258) to probe 3 (SN 51403). The change was made due to the c.a. 2.2 dbar offset that probe 2 had while on deck. We wired up and examined the ondeck offset and time decay for probes 3 and 6. These two probes were used in the Labrador Sea during the 1999 and 1998 occupations. Examining the time decay, the noise, the past history of the lab calibration and the stable offset of the unit, we decided on probe 3. The following was determined (decay time is the time to a c.a. constant reading) probe noise decay offset 2 +- 0.05 20 min 2 3 +- 0.7 5 min 0 6 +- 0.05 10 min -0.4 However, after we actually had probe 3 in place on the rosette, the offset was noted to be 0.85 dbar. We cannot explain why the offset has changed. The oxygen sensor was changed to the new deep ocean sensor from Seabird. We put this on the primary circuit.			
Note Number: 3	**Entry Time:** 24/May/2000 09:38:20	**Note Made By**: Igor Yashayaev	**Operation ID**: 12
On deck before cast p = 0.62 - 0.72 On deck after cast p = 0.3			
Note Number: 2	**Entry Time:** 24/May/2000 09:37:20	**Note Made By:** Igor Yashayaev	**Operation ID**: 16
On deck before cast p = 0.37 Just out of water after cast p = 0.27			
Note Number: 4	**Entry Time:** 24/May/2000 11:57:26	**Note Made By:** Anthony Isenor	**Operation ID**: 16
The sampling start times are correct. The salinity samples were drawn by rinsing 3 times without a cap, then filling the bottle to the rim, then wiping the treads on the bottle with a kim wipe, then placing a no-liner, dry cap on the bottle.			
Note Number: 19	**Entry Time:** 18/Jul/2000 08:11:17	**Note Made By:** Anthony Isenor	**Operation ID**: 29
Started recovery by hooking surface floats. Surface floats parted. Completed recovery using next operation number 30.			
Note Number: 5	**Entry Time:** 26/May/2000 09:49:22	**Note Made By:** Anthony Isenor	**Operation ID**: 37
The winch needed oil so the engineers started caring buckets of oil to the winch room. Start sampling times are good on this cast. The note time here is when they started caring the oil to the winch room.			
Note Number: 6	**Entry Time:** 26/May/2000 12:18:44	**Note Made By:** Anthony Isenor	**Operation ID**: 41
On deck pressure was 0.33 dbar before the cast. CTD decent stopped at 1375 dbar to inspect block. Stopped about 4 minutes. Started again, then stopped a second time immediatly after starting. Started down again, 8 minutes after initial stop.			
Note Number: 7	**Entry Time:** 27/May/2000 14:33:33	**Note Made By:** Anthony Isenor	**Operation ID**: 48

Bottle 19 (OC79) imploded and is gone, only the end caps remained. This bottle is on the inside circle of the rosette. Adjacent bottles, 17 (OC55) 20 (OC52) and 21 (OC87) were missing spigots. Spigots were replaced.			
Note Number: 18	**Entry Time:** 06/Jun/2000 20:01:29	**Note Made By:** Igor Yashayaev	**Operation ID**: 59
Nutrients were not delivered to fridge in GPlab. They were found in winch room on May 30. Pierre Clemente advised us to discard them as they were to long before processing or freezing.			
Note Number: 8	**Entry Time:** 28/May/2000 20:54:31	**Note Made By:** Anthony Isenor	**Operation ID**: 60
The cast decent and ascent was at 40m/minute. The following time is based on the Seacat clock, and associated with this is the scan number from the CTD. 20:41:00 GMT = 21961 (scan number) 20:42:00 GMT = 23401 20:44:00 GMT = 26269			
Note Number: 9	**Entry Time:** 28/May/2000 22:50:35	**Note Made By:** Anthony Isenor	**Operation ID**: 60
After the cast, I corrected an error in the ODIN database. I missed one operation at 55, and needed to insert at that number. So operations 55 to 59 became 56 to 60.			
Note Number: 10	**Entry Time:** 28/May/2000 22:53:18	**Note Made By**: Anthony Isenor	**Operation ID**: 60
The Seacat calibration cast calibrated Seacats SN 1628, 1625, 1623, 1626, 1624, 1627, and 1896.			
Note Number: 11	**Entry Time:** 31/May/2000 13:56:45	**Note Made By:** Anthony Isenor	**Operation ID**: 85
Second calibration cast for the German's Seacats.			
Note Number: 12	**Entry Time:** 01/Jun/2000 12:33:35	**Note Made By:** Anthony Isenor	**Operation ID**: 97
Calibration cast for the German seacats			
Note Number: 13	**Entry Time:** 03/Jun/2000 06:17:52	**Note Made By:** Igor Yashayaev	**Operation ID**: 112
Event 112: Primary Salinity became noisy.			
Note Number: 14	**Entry Time:** 06/Jun/2000 18:52:05	**Note Made By:** Igor Yashayaev	**Operation ID**: 112
Primary salinity at times getting wild. Primary oxygen has gone wild. My guess: partial pump failure (1) CTD got water (2). Didn't terminate the cast. Switched to display of secondary salinity. From 2800 db the primary system started to function normally.			
Note Number: 15	**Entry Time:** 03/Jun/2000 20:26:44	**Note Made By:** Anthony Isenor	**Operation ID**: 119
This was the cast with CO2 samples for Doug Wallace.			
Note Number: 17	**Entry Time:** 06/Jun/2000 18:52:05	**Note Made By:** Anthony Isenor	**Operation ID**: 120
This operation involved the deployment of three RAFOS floats, all at the same location. The floats are identifed by the IMF number and the manufacturer SN. IMF No. Manufacturer SN 518 #RF19 519 #RF20 520 #RF21			
Note Number: 16	**Entry Time:** 04/Jun/2000 02:49:04	**Note Made By:** Igor Yashayaev	**Operation ID**: 124
Mooring #1325 Seacat/Microcat post-calibrations.			

G. REFERENCES

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