CRUISE REPORT

HUDSON 98023

LABRADOR SEA

WOCE LINE AR7W

22 June - 9 July, 1998

A. CRUISE NARRATIVE

1. Highlights

a. WOCE Designation: WOCE Line AR7W
Atlantic Circulation Experiment

b. Expedition Designation: Hudson 98023

c. Chief Scientist:
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d. Ship: CCGS Hudson

e. Ports of Call:
June 22 BIO, Dartmouth, NS, Canada
July 9 BIO, Dartmouth, NS, Canada

f. Cruise Dates: June 22 to July 9, 1998

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.

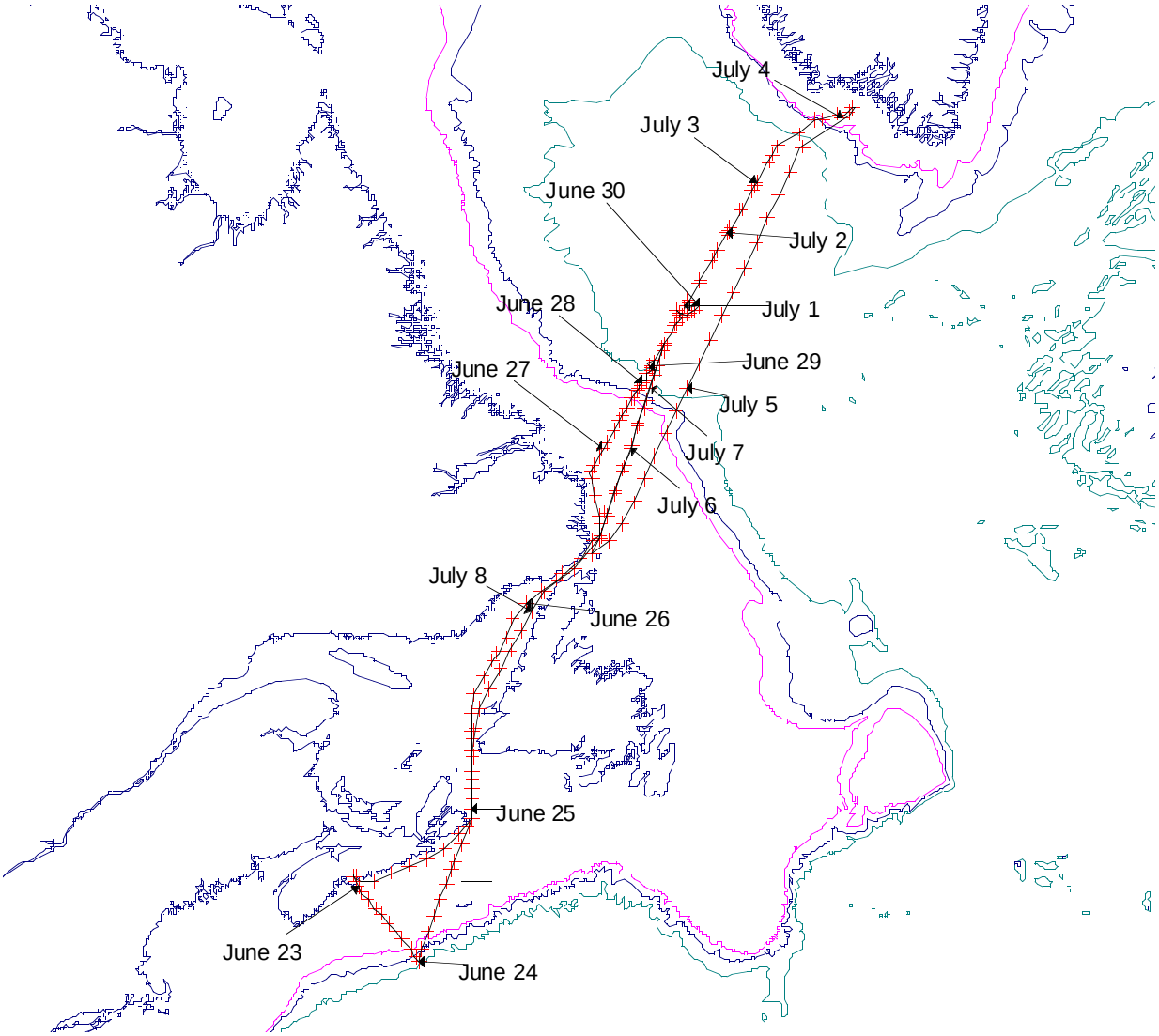

Figure 1. Cruise track for 18HU98023/1. The date labels indicate the ships position at 0000Z.

b. Total Number of Stations Occupied

The CTD and ROS station positions are shown in Figure 2 (Scotian Shelf) and Figure 3 (WOCE Line AR7W). Some station numbers are indicated for clarity. The WHP stations are all contained in the box defined by 50-62°N and 43-60°W (Figure 3).

Table 1 lists the science operations for 98023.

Cast Type	Number of Operations	Detailed Division	Operation Numbers
ROS	41	22 AR7W Sites	see Table 2
		7 Halifax Line Sites	see Table 3
		5 Biology Casts	22, 42, 55, 87, 103
		1 Chemistry Equipment Test	20
		1 Oxygen sampling Test	24
		1 Seacat Calibration	69
		1 ^{13}C cast	100
		1 no samples due to mistrips	82
		1 aborted	15
		1 Basin test	1
CTD	1	1 test of replacement CTD probe	83
FLT	2		51, 58
MOR	11	7 operations to recover 6 moorings	38, 45, 52, 63(98), 67, 79
		2 deployments	40, 71
		2 release tests	39, 70
BIO	49	41 shallow net tows	
		2 deep net tows	47, 76
		6 light meter	43, 56, 68, 88, 101, 104

Table 1. Science operations conducted on 18HU98023/1.

AR7W Site Number	98023 ROS Operation Number
1	26
2	28
3	30
4	32
5	33
6	35
7	37
8	44
9	50
10	48
11	57
12	61
13	62
14	66
15	74
16	77
17	78
18	84
19	89
20	92
21	95
22	97

Table 2. AR7W sites and rosette operation numbers for 18HU98023/1.

Halifax Line Number	98023 ROS Operation Number
1	3
2	5
3	8
4	10
5	12
6	16
7	19

Table 3. Halifax Line sites and rosette operation numbers for 18HU98023/1.

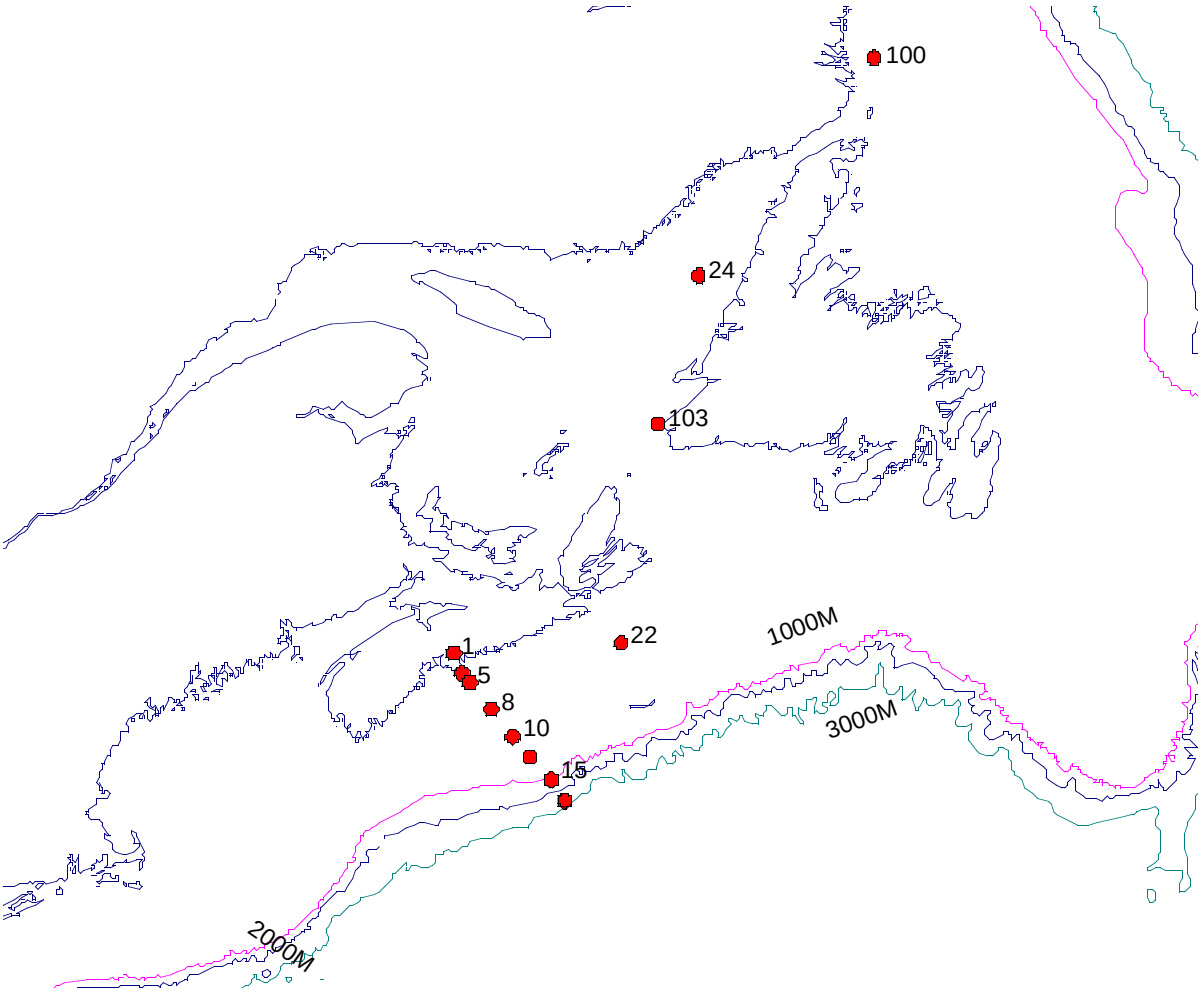

Figure 2. CTD/ROS station positions on the Scotian Shelf for Hudson 18HU98023/1.

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, nutrients, oxygen isotopes, helium and tritium.

c. Floats and Drifters deployed

The deployment sites for PALACE floats are shown in Figure 4. Two profiling ALACE floats were launched at stations 51 and 58.

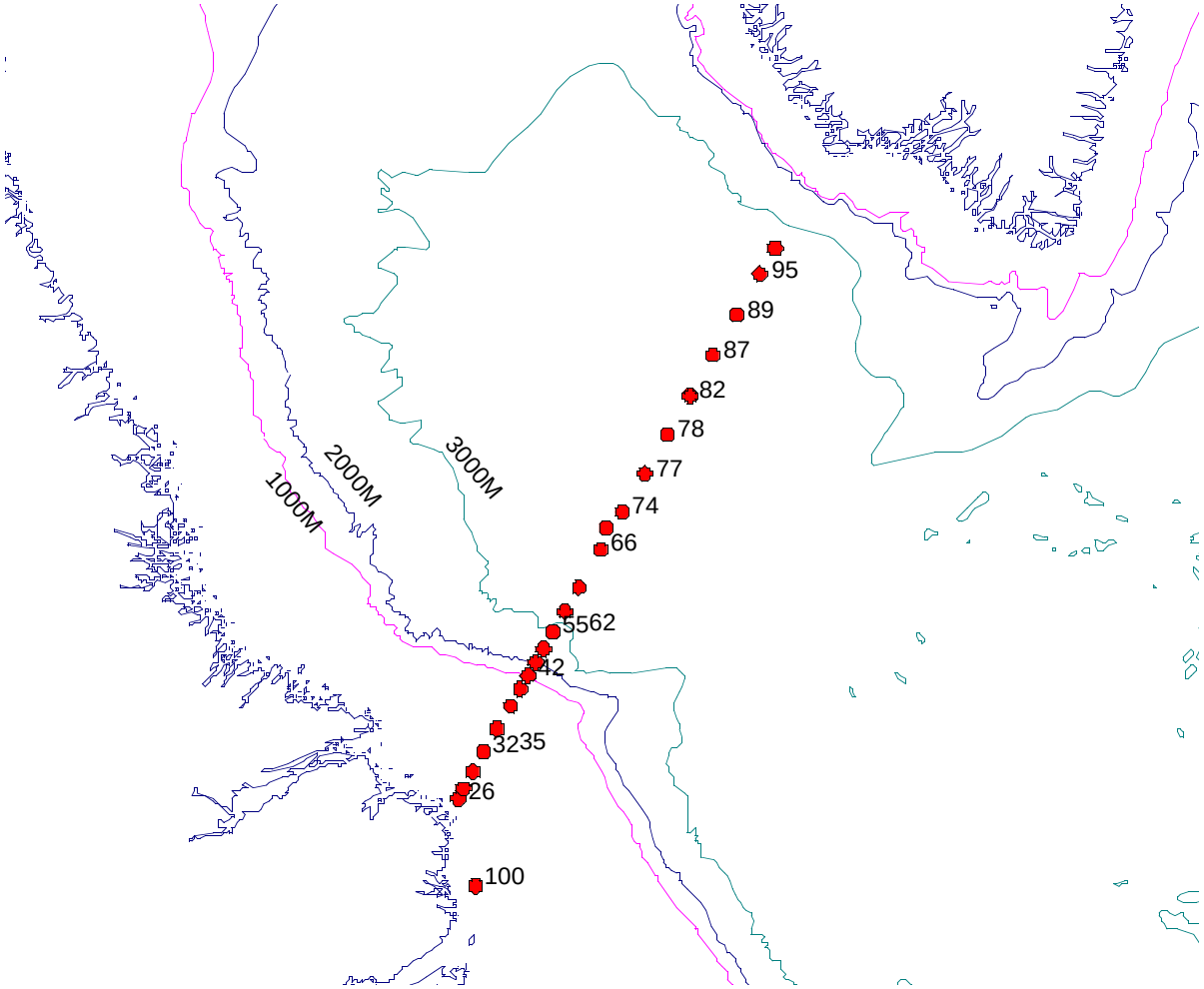

Figure 3. CTD/ROS station positions on the WOCE Line AR7W for Hudson 18HU98023/1.

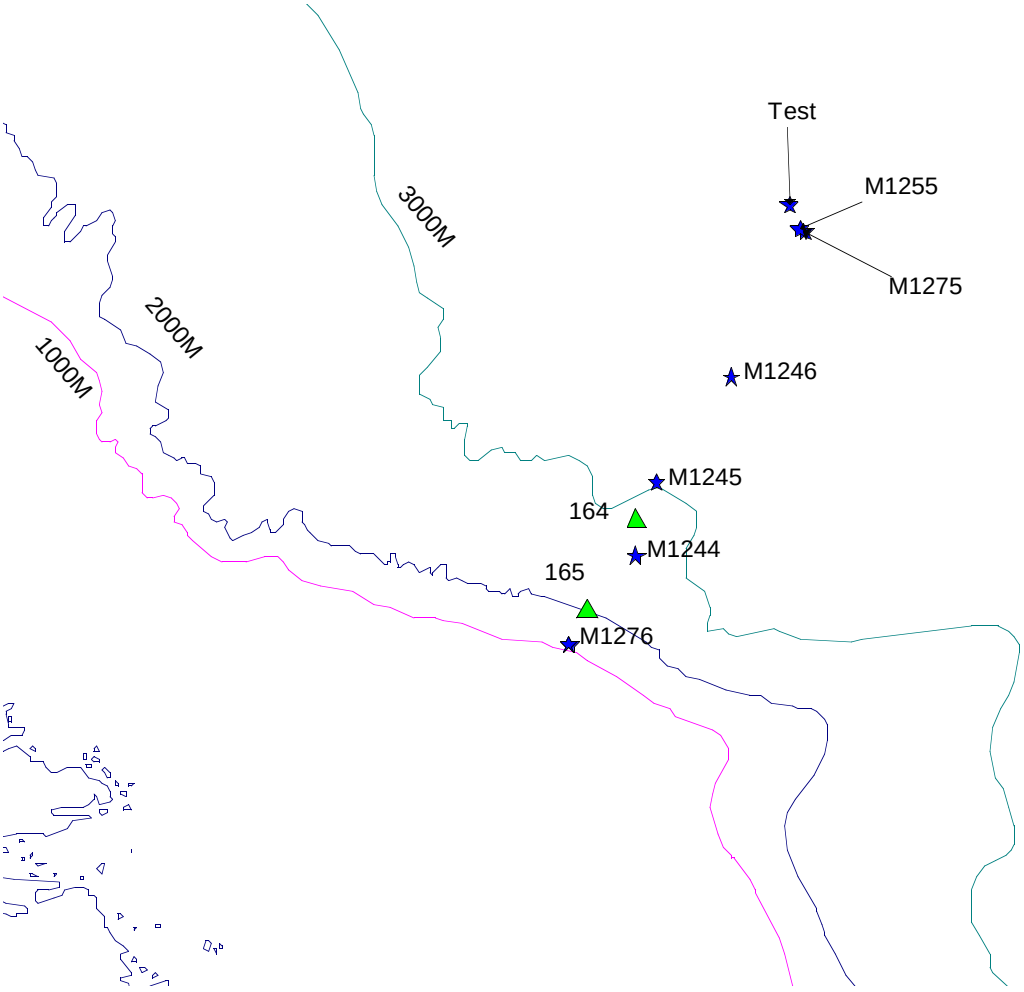

Figure 4. PALACE float deployment positions ($) and mooring positions (#) during Hudson 18HU98023/1. The float serial numbers and BIO Mooring numbers are also indicated.

d. Moorings deployed or recovered

A total of 11 mooring related operations, consisting of deployments, recoveries and release tests were conducted at various sites as shown in Figure 4. The following summarizes the mooring operations and provides a legend for Figure 4.

Deployments:

1 M1276 standard mooring consisting of one current meter positioned 20m off bottom was set across the Labrador Slope along AR7W (12 month deployment) along the 1000m isobath

1 M1275 multi-instrument mooring was set near OWS Bravo on AR7W replacing the mooring M1255 set in 1997 (WOCE Expocode 18HU97009/1). The deployed mooring consisted of 7 Seacat temperature/conductivity recorders, 6 Aanderaa current meters, and 3 SBE39 (two with temperature, and one with temperature and pressure)

Recoveries:

1 SSN (Sound Source North) mooring for RAFOS floats was recovered (not shown in Figure 4)

1 M1255 was partially recovered. Retrieved 2 Seacats and 3 Aanderaa current meters. Lost were 3 Aanderaa current meters, 4 Seacats, 1 WOTAN and 3 WADAR (TSKA water data recorders).

1 M1256 recovered consisting of 1 current meter moored at 20m off bottom along the 1000m isobath (same position as M1276 in Figure 4).

1 M1244 recovered all instruments, which consisted of 5 Aanderaa current meters.

1 M1245 attempted to contact both releases. Neither release responded. This mooring consisted of 5 Aanderaa current meters.

1 M1246 was released at station 63. The release indicated that it had released, but it did not move off the bottom. We assume that the mooring line is tangled in the anchor. The main float and top current meter had been previously found in Iceland. Hudson returned to the mooring site at station 98 and commenced dragging operations. This was successful, with the retrieval of 2 acoustic releases, 3 current meters and one current meter vane.

3. List of Principal Investigators

Name	Affiliation	Responsibility
Allyn Clarke	BIO clarkea@mar.dfo-mpo.gc.ca	scientist overall co-ordination
Glenn Cota	Old Dominion University cota@ccpo.odu.edu	Bio-Optical properties of the upper ocean
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
Robert Houghton	LDEO houghton@ldeo.columbia.edu	oxygen isotopes
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	senior scientist 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
Robert Pickart	WHOI pickart@rsp.whoi.edu	lowered ADCP
Peter Rhines	UW rhines@killer.ocean.washington.edu	moored instrument data
Fritz Schott	IFM Kiel fschott@ifm.uni-kie.de	PALACE floats

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 physical and chemical oceanographic operations in support of two ongoing scientific initiatives.

The first initiative is the Atlantic Circulation Experiment of the World Ocean Circulation Experiment (WOCE). One element of this experiment seeks to map the hydrographic and tracer fields of the subpolar gyre of the North Atlantic to provide a measure of the winter cooling and water mass transformations over the entire region. Hudson 98023 was planned to map the Labrador Sea part of the sub-polar gyre as well as to deploy current meter moorings and profiling ALACE floats, which will measure the changes in the hydrographic structure and the gyre circulation over the coming 12 months. This cruise is the continuation of the program to occupy the WOCE line AR7W annually and seasonally to study deep convection and variability in the Labrador Sea in the context of thermohaline circulation in this key region of the North Atlantic subpolar gyre.

The second initiative is the Labrador Sea project of the Canadian Joint Global Fluxes Study (JGOFS). This project seeks to measure the vertical fluxes of carbon from the atmosphere to the deep ocean and its sediments. The biological program on Hudson 98023 was designed to characterize late spring-summer biological processes in the Labrador Sea and its shelf regions. The program also includes collecting light measurements, which will be used to develop the regional algorithms that will allow primary productivity estimates to be made using data from Ocean Color satellite sensors such as Sea WIFS. The physical oceanographic program is observing total carbonate, alkalinity and CFCs over the entire water column in support of these JGOFS objectives.

During this cruise, an ADCP was added to the CTD/rosette package to provide a 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.

A total of 2 PALACE floats were deployed throughout the Labrador Sea. These instruments should provide weekly information on the changes in the heat and salt distributions of the upper 1500 m of the water column throughout the cooling season.

4.2 Biological Program

a. Narrative

The biological program studied the distribution and physiology of the major plankton groups; bacterioplankton, phytoplankton and zooplankton. The spectral distribution of light in the water column was also examined.

b. Phytoplankton Program

All stations on the Halifax line and some of the stations on the Labrador Sea line were sampled every 10 m to 100 m for chlorophyll, nutrients, and CO_2 (Table 5). Integrated collections through the upper 50m were also taken for phytoplankton and microzooplankton.

Station	Operation	Lat	Long
HL 1	3	44.40	63.47
HL 2	5	44.27	63.32
HL 3	8	43.88	62.88
HL 4	10	43.48	62.45
HL 5	12	43.18	62.10
HL 6	16	42.85	61.68
HL 7	19	42.53	61.40
SABLE	22	44.83	60.27
GULF	24	49.85	58.72
Site 1	26	53.68	55.55
Site 2	28	53.80	55.44
Site 3	30	53.99	55.25
Site 4	32	54.22	55.02
Site 6	35	54.76	54.49
Site 7	37	54.95	54.29
Site 8	42	55.11	54.14
Site 11	55	55.61	53.63
Site 15	69	56.95	52.24
Site 19	87	58.64	50.42

Table 5. Phytoplankton sampling.

When it was possible to obtain larger volumes of water during the daylight hours Photosynthesis-Irradiance experiments (Table 6) were conducted on populations from two depths.

Station	Operation	Lat	Long
NE SABLE IS.	22	44.83	60.27
GULF	24	49.85	58.72
Site 8	42	55.11	54.14
Site 11	55	55.61	53.63
Site 15	69	56.95	52.24
Site 19	87	58.64	50.42

Table 6. Photosynthesis-Irradiance experiments.

c. 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 28 stations (8 on or near the Scotian Shelf, 1 in the Gulf and 19 from the Labrador Shelf/Labrador Sea) using a 3/4 m 200 Tm mesh ring net. At all stations, tows were made from 100 m to the surface. Additional deep tows (2500 m to the surface) were taken at two of the stations in the Labrador Sea . Samples will be analyzed for species composition, copepod stage structure and biomass.

d. Measurements Of Copepod Metabolic Rates

Respiration rates (CO_2 production) of the copepod communities were determined at 6 stations in the Labrador Sea.

e. Microbiological Samples

Bob Whalen, Michael Hanson and Robin Anderson

Microbiological samples were collected and experiments were conducted at stations on the AR7W line. Depth profiles were collected at 9 sites. Samples for bacteria enumeration were collected from 11 depths (1, 10, 20, 30,...100m) for a total of 99 samples.

Microzooplankton dilution grazing experiments were conducted at sites 2, 8, 14A, and 19.
Samples for Total Chl A, 5 µm Chl A, bacteria, and protozoa were collected prior to the experiment. Samples taken at time points include total Chl A, bacteria, and picoplankton. The total number of grazing experiments was 4.

A total of 6 experiments on temperature dependent and nutrient dependent bacteria growth were carried out at the sites of the grazing experiments.

f. Dissolved Organic Carbon (DOC) and Microbial Community Respiration

Jay Bugden and Paul Kepkay

Samples for DOC profiles, size fractionation of DOC (ultrafiltration) and microbial community respiration were collected at 15 stations on the AR7W line (see Table 7). Ultrafiltration and rates of respiration of seawater samples were carried out at the

time of collection (the ultrafiltration samples were frozen for later laboratory analysis), while samples for the DOC profiles were filtered and frozen for later analysis.

Station	Respiration	Ultrafiltration	DOC Profile
Site 1 (AR7W Line)	X	X	X
Site 4	X	X	X
Site 6			X
Site 7			X
Site 8	X	X	
Site 9			X
Site 11	X	X	
Site 12			X
Site 14			X
Site 16			X
Site 18			X
Site 19	X	X	
Site 19 Deep (2000m)	X	X	
Site 20			X
Site 21			X
M1255 Mooring Site	X	X	

Table 7. DOC sample collection.

g. Satlantic Profiling Multichannel Radiometer — Dave Ruble

Profiles of spectral light characteristics were taken at 6 stations from the surface to below 0.0001% surface PAR (in most cases >70m). Spectral profiles will be processed to calculate values of water-leaving radiance at 13 wavelengths. Two and three 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.

Initial problems with the Profiler occurred due to the wrong configuration of a new Power / Telemetry circuit board installed by Satlantic just prior to leaving. Satlantic was contacted and they faxed detailed instructions for disassembling the Profiler and rewiring of the Power / Telemetry circuit board. The first attempt did not work, however the second set of instructions did fix the problem and the Profiler has functioned normally for the remainder of the cruise.

h. Bacterial Abundance and Activity — Paul Dickie and Bill Li

Seawater from the CTD was sampled for phytoplankton and microzooplankton (identification and enumeration) by combining 50 ml aliquots of water from each

depth between the surface and 90 m and preserving with acid Lugol. Samples from individual depths were taken from the same water to count bacteria and autofluorescent cells by flow-cytometry. Stations (operation numbers) sampled: 3, 5, 8, 10, 12, 16, 19, 22, 24, 26, 28, 30, 32, 35, 37, 42, 55, 69, 87, 100, 103.

At several stations, experiments were performed on the marine micro-heterotrophic populations using tritiated thymidine and leucine to check reproductive and biomass growth rates vs. depth over the photic zone. Stations sampled were: 24, 26, 42, 55, 69, 87 and 103. One dilution experiment (stn. 87) and one enrichment experiment (stn.98) were conducted to test effects of predation and thymidine / leucine enrichment on the growth experiments.

5. Major Problems and Goals Not Achieved

5.1 Mooring Operations

There were major problems with three moorings. One, M1245, could not be located and is presumed lost. One, M1246, was known to have lost its top buoyancy. We located it but it failed to come up when the release command was sent. It was recovered subsequently by dragging and had lost only one of its current meters. The third, M1255, was recovered with about half of its instrumentation missing. Both M1246 and 1255 lost buoyancy very soon after they had been moored, and will thus provide almost no useful data. Why these three moorings failed will have to await further analysis, but a reevaluation of mooring design is essential and urgent.

5.2 Sites 23 to 28

Unfortunately, sites 23 to 28 on the Greenland side of the Labrador Sea were not occupied. A medical emergency required the discontinuation of the line after Site 22. Hudson attempted a port call at Julianehaab, Greenland, but due to heavy ice was routed across the Labrador Sea to St. Anthony, Newfoundland.

5.3 Profiling Radiometer

The Satlantic SeaWIFS Multichannel Profiling Radiometer was inoperative for about half of the cruise. It had been overhauled just before being put on board and checked out by the manufacturer prior to sailing. Nevertheless, an essential internal connection had not been made. After several contacts with the manufacturer, the ship's technician was able to get the instrument operative. This part of the biological program was, however, strongly impacted

6. Other Incidents of Note

none

7. List of Cruise Participants

Name	Responsibility	Affiliation
Jeff Anning	Underway Sampling, photosynthesis, pump	BIO
Rick Boyce	Technician, Moorings	BIO
Jay Bugden	DOC Levels, respiration rates	J&S Envirotech, Dartmouth
Pierre Clement	Nutrients	BIO
Paul Dickie	Bacterial abundance and activity	BIO
Jennifer Dixon	Oxygens	BDR
Mike Fougerousse	Bio-optical	ODU
Bob Gershey	Scientist, CO_2, CFC's, Alkalinity	BDR
Jean Hanley	Helium, Tritum	LDEO
Michael Hanson	bacteria growth	MUN
Les Harris	Zooplankton, Net Tows	BIO
Albert Hartling	Winch Room, moorings	BIO
Ross Hendry	Scientist, watchkeeper	BIO
Mike Hingston	Technician, CO_2, CFC's, Alkalinity	BDR
Anthony Isenor	Data Manager	BIO
Peter Jones	Senior Scientist	BIO
John Lazier	Assistant Scientist	BIO
Dave Ruble	Bio-optical	ODU
Murray Scotney	Moorings, instrumentation	BIO
Leif Thomas	Watchkeeper	UW
Bob Whalen	Microzooplankton	NWAFC
Frank Zemlyak	Technician, CO_2, CFC's, Alkalinity	BIO

BIO	Bedford Institute of Oceanography
	PO Box 1006
	Dartmouth, NS, B2Y 2A4
BDR	BDR Research Ltd.
	Box 652, Station 'M'
	Halifax, N.S., B3J 2T3
IFM-Kiel	Institut für Meereskunde an der Universität Kiel
	Düsternbrooker Weg 20
	D-24105 Kiel, Germany
LDEO	Lamont-Doherty Geological Observatory
	Columbia University
	Palisades, New York 10964
MUN	Memorial University of Newfoundland
NWAFC	Northwest Atlantic Fisheries Centre
	Newfoundland, Canada

ODU	CCPO
	Old Dominion University
	Norfolk, VA 23529
	USA
UW	University of Washington
	Seattle, WA 98195
WHOI	Woods Hole Oceanographic Institution
	Woods Hole, MA 02543

B. UNDERWAY MEASUREMENTS

1. Navigation and Bathymetry — Anthony W. Isenor

The navigation system onboard CCGS Hudson consists of a Trimble Navigation Loran-GPS 10X decoder and AGCNAV. The decoder receives the satellite fixes and decodes the signals to obtain latitude, longitude and time. The decoder signals are about 1 Hz. The navigation data were logged at one minute intervals on a PC. 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 consisted of a Raytheon Line Scan Recorder, Model LSR 1811-2 (serial number A117) 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. The recorder was also linked to a clock, and thus could indicate 5 minute intervals on the sounder paper. The system was used to collect bathymetric soundings at 5 minute intervals while underway between stations.

One transducer is positioned on a Ram that can be lowered or raised depending on conditions. The record of Ram position is as follows:

Ram up at beginning of trip
Ram down on 1100 Z June 27
Ram up at 1307 Z July 3
Ram down at 0910 Z July 6
Ram up at 1800 Z July 6

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 607). Logging, using Transect software on a 486 PC, was started on June 22 at 2228 Z in Halifax Harbour. The configuration of the equipment results in a bin length of 4 metres and a total of 128 bins. The 5 minute averaged data are stored to disk and backed up every few days. ADCP logging was stopped on July 9 at 1140 Z in Halifax Harbour.

3. Continuous Flow Multisensor Package (CFMP) Jeff Anning

Water from approximately 4m was continuously pumped to the forward lab. The temperature, conductivity and fluorescence 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 time and position of these samples was also logged by the computer.

4. XBT and XCTD

No probes were used

5. Meteorological observations

Routine reporting of meteorological variables was carried out by the ship's crew.

6. Atmospheric Chemistry

There was no atmospheric chemistry program.