CRUISE REPORT

HUDSON 2010014

LABRADOR SEA

WOCE LINE AR7W

May 13 – May 30, 2010

A. CRUISE NARRATIVE

1. Highlights

a. WOCE Designation:	WOCE Line AR7W
b. Expedition Designation:	HUD2010014 or 18HU10014 (ISDM format)
c. Chief Scientist:	Glen Harrison Ocean Sciences Division Department of Fisheries and Oceans Bedford Institute of Oceanography PO Box 1006 Dartmouth, NS, Canada B2Y 2A4 Internet Glen.Harrison@dfo-mpo.gc.ca
d. Ship:	CCGS Hudson
e. Ports of Call:	May 13, 2010 St. John's, NL, Canada May 30, 2010 BIO, Dartmouth, NS, Canada
f. Cruise Dates:	May 13 to May 30, 2010

2. Cruise Summary Information

a. Cruise Track

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

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

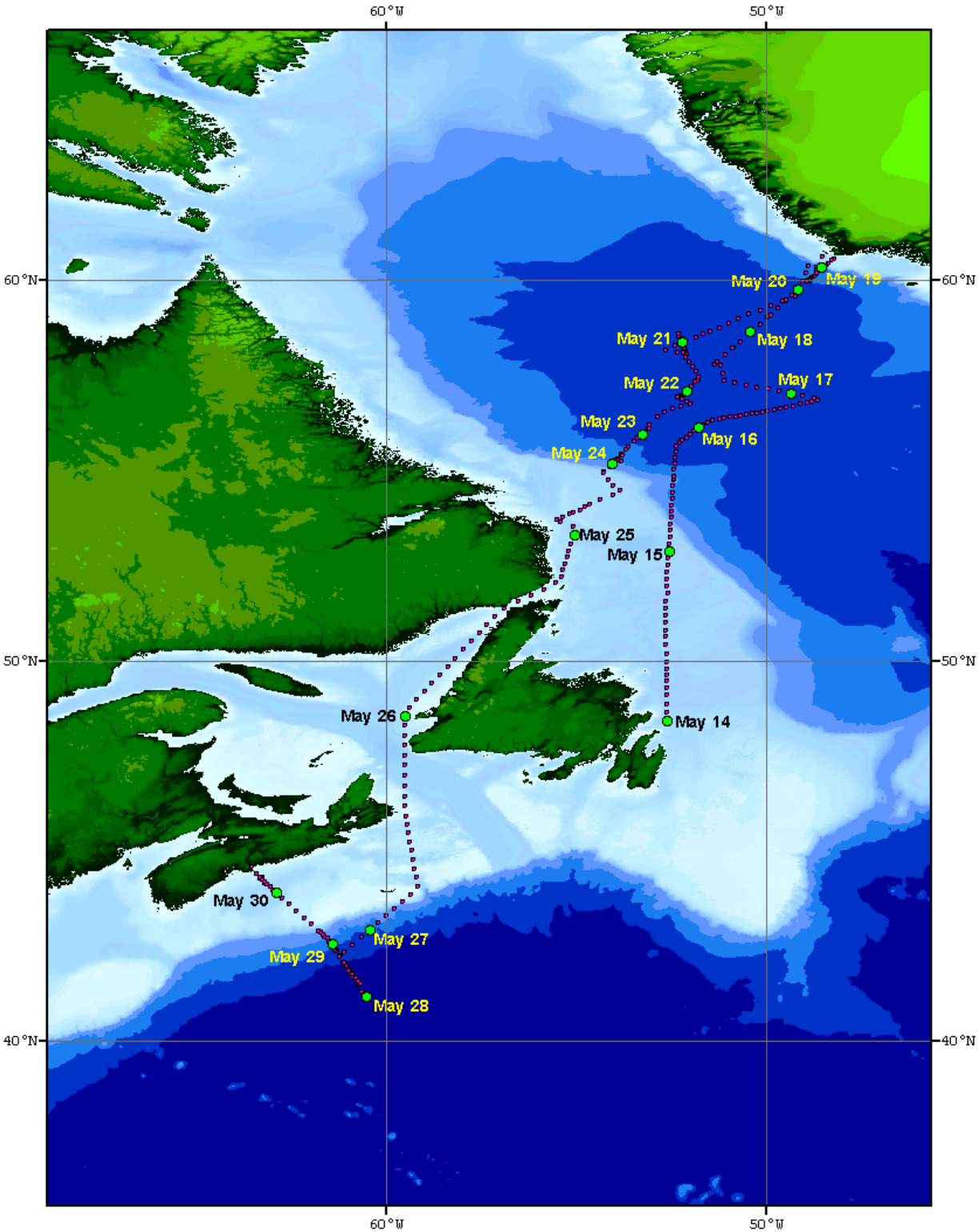

Figure A.2.1 Cruise track for HUD2010014. The pink dots indicate the ship's position for each hour of the voyage. The green dots and date labels indicate the ship's position at 0000 UTC for that particular date.

b. Total Number of Stations Occupied

The CTD / ROS station positions are shown in Figure A.2.2. Table A.2.1 lists the science operations for HUD2010014.

Along AR7W, the stations were full-depth WHP small volume rosette casts with up to 24 rosette bottles. Water samples were analyzed for CFCs, total inorganic carbon (TIC), total alkalinity, oxygen, salinity, nutrients (nitrate, phosphate, and silicate), total organic carbon (TOC), pH and bacterial abundance. Chlorophyll was analyzed at depths less than 200m at most stations. Samples were collected for ^{129}I (iodine-129) and O-18 (Oxygen-18) on selected casts.

Cast Type	Number of Operations	Detailed Division	Operation Numbers
Rosette & CTD	31	23 of the 28 regular AR7W Sites (L3 line) plus sites 2a, 3a, 4a, 5a, 6a, 8.5, 23.5 and 25.5	see Table A.2.2
	13	Halifax Line Sites 2, 3, 6, 6.3, 6.5, 6.7, and 7 - 13	267, 271, 274, 276, 277, 278, 281, 282, 283, 284, 286, 290, 293
	3	Mini Eddy Line just of AR7W (L3N4, L3N3, L3N2)	178, 181, 183
	3	Biology Casts not included in other tables	27, 202, 270
	1	Station 27	3
	2	Transit Stations	7, 13
	3	Aborted Operations	114, 245, 247
Moorings	2 * 1	Recovery Deployment	287 239
Floats	11	APEX floats deployed	17, 30, 48, 59, 87, 130, 179, 182, 184, 190, 197
Biology	42	200 micron net tows	1, 4, 6, 10, 12, 15, 24, 26, 45, 56, 70, 72, 77, 83, 96, 101, 111, 113, 119, 121, 127, 177, 180, 200, 201, 208, 210, 217, 223, 229, 242, 244, 250, 253, 255, 257, 260, 263, 280, 285, 288, 292
	22	76 micron net tows	2, 5, 11, 25, 46, 57, 71, 78, 97, 102, 112, 120, 128, 209, 218, 224, 230, 243, 254, 258, 261, 289
	6	Multi-net tows	213, 268, 275, 272, 279, 291
Chemistry	15	^{129}I surface	47, 73, 79, 85, 103, 129, 189, 196, 212, 219, 246, 251, 252, 264, 266
	9	^{129}I profile	16, 58, 115, 203, 225, 267, 271, 277, 278
Other		~ 400 Hrs Ship Board ADCP	No number assigned
	138	XBT Deployments	18 – 23, 31 – 39, 41 – 43, 49 – 55, 60 – 68, 74 – 76, 80 – 82, –86, 88, 90 – 95, 100, 104 – 106, 108, 109, 116 – 118, 123 – 126, 131 – 139, 141 – 150, 152 – 176, 185 – 188, 191 – 195, 198, 199, 204 – 207,

	6	MVP	214 – 216, 220 – 222, 226 – 228, 232 – 235, 237, 238, 240, 249 8, 9, 14, 69, 140, 241
	6	ASIP	29, 44, 110, 211, 236, 269

Table A.2.1 Science operations conducted on HUD2010014.

* For some reason no operation number was given to the recovering of mooring #1729 which was near station L3_08. The replacement mooring #1771 that was deployed was given the operation number 239. The mooring recovered for operation 287 was near station HL_02.

AR7W Site Number	2010014 Deep Cast Operation Number
1	266
2a	265
3a	264
4a	262
5a	259
6a	256
7	252
8	251
8.5	248
9	246
10	231
11	225
12	219
13	212
14	203
15	196
16	189
17	16
18	28
19	47
20	58
21	129
22	122
23	115
23.5	107
24	103
25	98
25.5	89
26	85
27	79
28	73

Table A.2.2. AR7W (L3) sites and rosette and CTD operation numbers for HUD2010014.

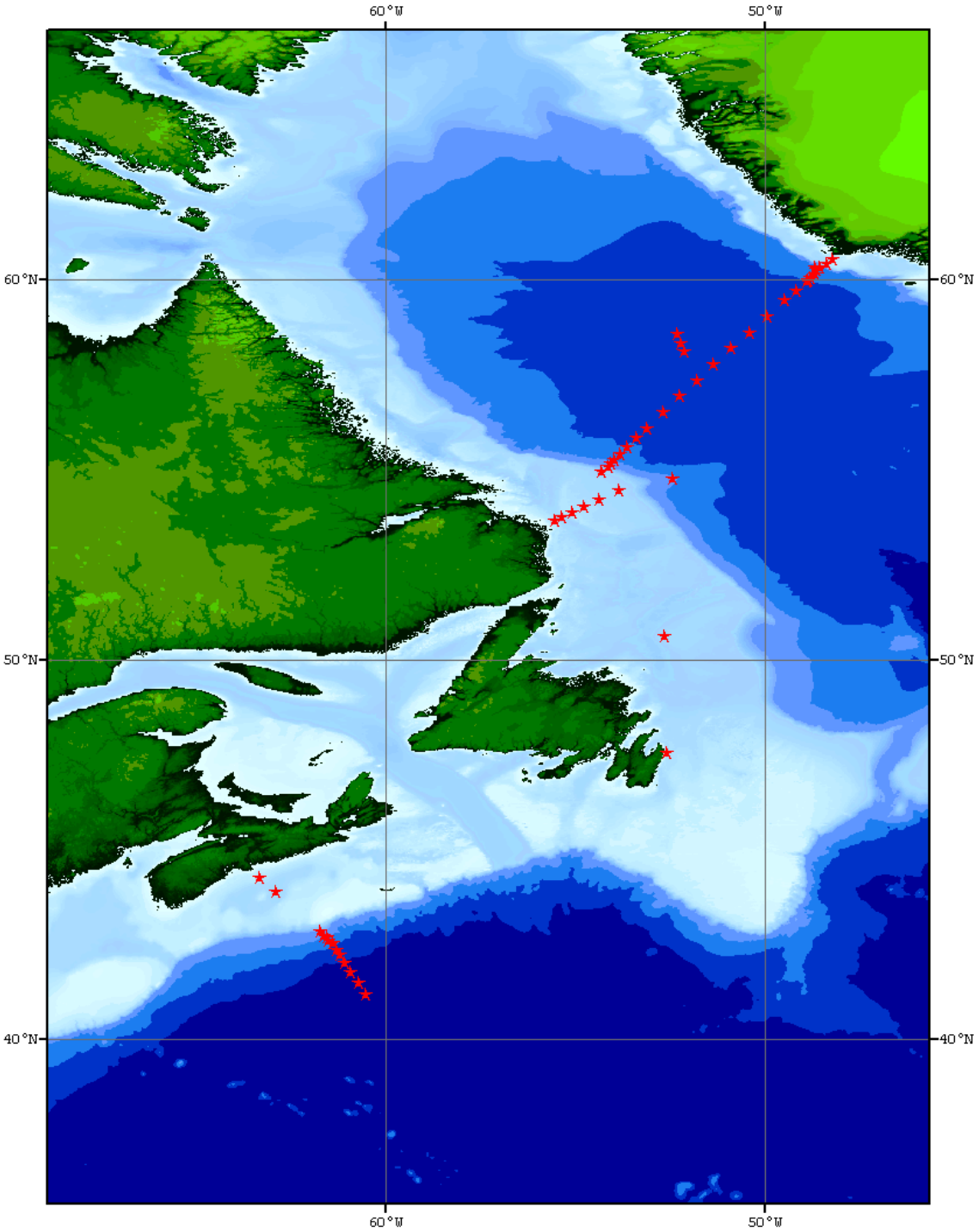

Figure A.2.2 HUD2010014 locations (red-filled stars) for operations involving one or more of the following data collection methods: Rosette, CTD and LADCP.

The AR7W Labrador Sea section and the extended Halifax Section were occupied during the HUD2010014 mission. These survey lines combined with the Orphan Basin lines occupied within the same four week period on HUD2009011 provide a comprehensive assessment of the oceanographic conditions in the Canadian sector of the Atlantic Ocean.

c. Floats and Drifters deployed

Eleven APEX profiling floats (Teledyne Webb Research, E. Falmouth, MA) equipped with SBE-41 temperature-conductivity sensors (Sea-Bird Electronics, Inc., Bellevue, WA) were deployed as a Canadian contribution to the international Argo project. This effort was jointly supported by Fisheries and Oceans Canada and the Canadian Ice Service of Environment Canada. Table A.2.3 gives details of the float deployments.

Apex Float		WMO	Event	Launch Position		Start Time	Launch Time
Type	SN			Latitude	Longitude	UTC	UTC
APEX-SBE APF9A	4962	4901156	17	57° 48.31' N	051° 22.45' W	17 May 2010 10:29	17 May 2010 11:36
APEX-SBE APF9A	4837	4901142	30	58° 14.74' N	050° 52.63' W	17 May 2010 19:40	17 May 2010 20:05
APEX-SBE APF9A	4956	4901150	48	58° 38.64' N	050° 24.68' W	18 May 2010 01:53	18 May 2010 03:50
APEX-SBE APF9A	4836	4901141	59	59º 03.87’ N	049° 54.48' W	18 May 2010 08:02	18 May 2010 09:39
APEX-SBE APF9A	5004	4901158	87	60º 19.93’ N	048° 36.51' W	19 May 2010 01:07	19 May 2010 02:01
APEX-SBE APF9A	4963	4901157	130	59° 29.45' N	049° 29.04' W	20 May 2010 05:47	20 May 2010 07:43
APEX-SBE APF9A	4960	4901154	179	58° 36.16' N	052° 17.41' W	21 May 2010 02:12	21 May 2010 04:10
APEX-SBE APF9A	4959	4901153	182	58° 21.84' N	052° 13.28' W	21 May 2010 06:21	21 May 2010 08:18
APEX-SBE APF9A	4983	4901159	184	58° 08.76' N	052° 12.69' W	21 May 2010 11:23	21 May 2010 12:27
APEX-SBE APF9A	4957	4901151	190	57° 22.72' N	051° 49.94' W	21 May 2010 20:19	21 May 2010 21:30
APEX-SBE APF9A	4958	4901152	197	56° 56.17' N	052° 13.29' W	22 May 2010 01:31	22 May 2010 03:49

Table A.2.3 APEX float deployments on HUD2010014.

d. Moorings deployed or recovered

Moorings deployed and recovered

The Aanderaa current meter mooring near station L3_08 on the AR7W line was once again serviced on May 23, 2010. Mooring #1729 was recovered successfully under good sea conditions. The RCM8 appeared to have worked properly and all mooring tackle was in good condition. The replacement mooring #1771 was deployed successfully on the same day.

Recovery:

M 1729 Anchor Drop MCal	55º 07.20’ N 54º 05.21’ W 55º 07.17’ N 54º 05.15’ W	Standard mooring consisting of one current meter positioned 20m above bottom along AR7W on the Labrador Slope (12-month deployment) at the 1029 metres.

Deployment:

M 1771 Anchor Drop MCal	55º 07.2120’ N 54º 05.3901’ W 55º 07.2018’ N 54º 05.3224’ W	Standard mooring consisting of one current meter positioned 20m above bottom along AR7W on the Labrador Slope (12-month deployment) at the 1029 metres.

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

This software is of great use if a mooring is off location for some reason. M-Cal gives a position so that locating the mooring is much quicker. Transponding to a release only gives a slant range and not a direction. A ship has to randomly travel to minimize this slant range which could be time consuming.

An engineering mooring deployed on April 9, 2010 was recovered on May 29, 2010. This mooring included a profiling instrument called the SeaHorse.

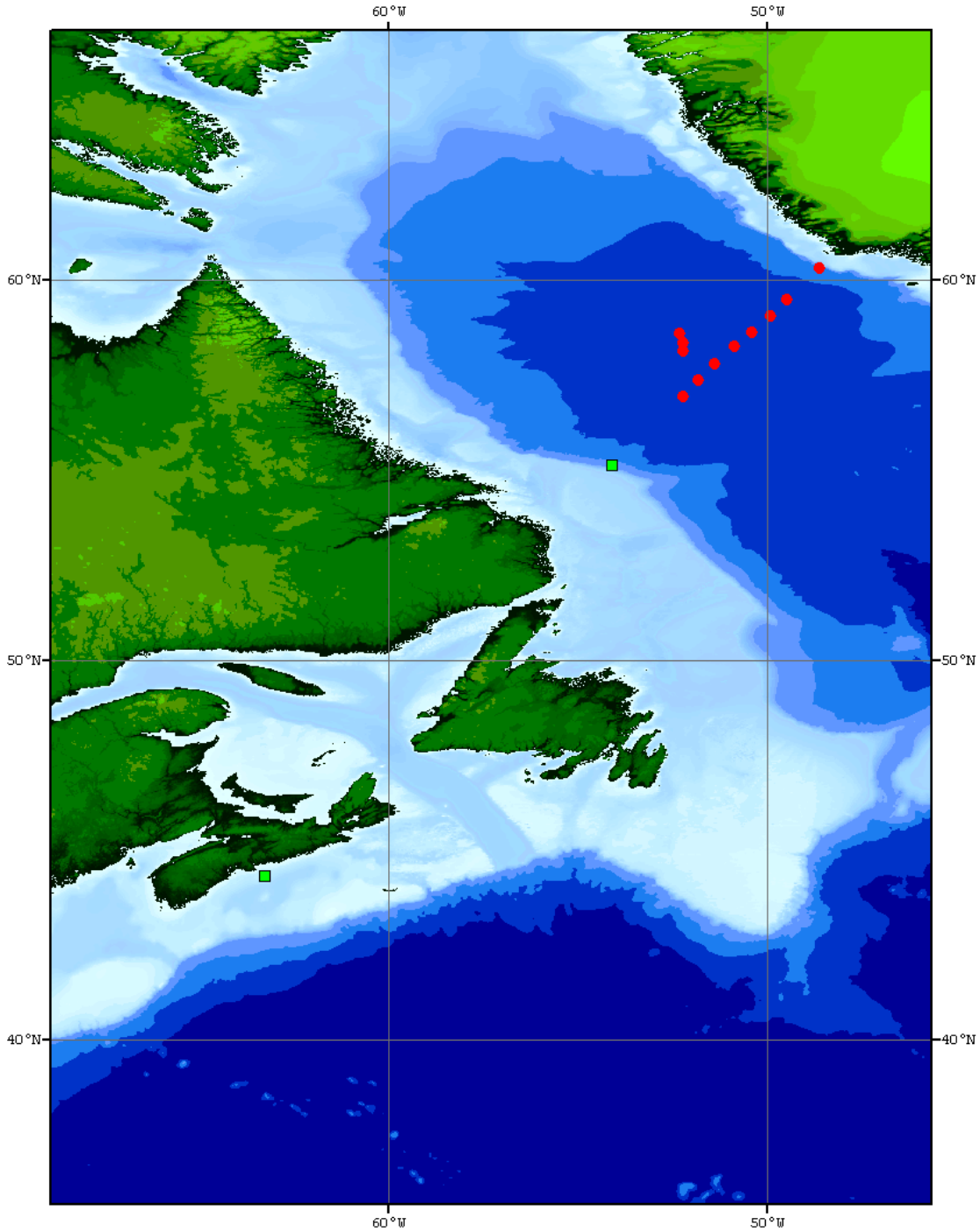

Figure A.2.3 HUD2010014 mooring location (green-filled square - a mooring was recovered and a new one deployed in the same location) and float deployment locations (red-filled circles).

3. List of Principal Investigators

Name	Affiliation	Responsibility
Kumiko Azetsu-Scott	BIO Azetsu-ScottK@mar.dfo-mpo.gc.ca	Chemistry program coordination, Alkalinity, CO2, CFCs, O^{18}, and pH.
Carina Gjerdrum	CWS Carina.Gjerdrum@ec.gc.ca	Sea bird program
Glen Harrison	BIO HarrisonG@mar.dfo-mpo.gc.ca	Senior Scientist, Biological program coordination
Erica Head	BIO HeadE@mar.dfo-mpo.gc.ca	Macrozooplankton distribution, abundance and metabolism
Paul Kepkay	BIO KepkayP@mar.dfo-mpo.gc.ca	Dissolved organic carbon, colloid chemistry and plankton respiration
Bill Li	BIO LiB@mar.dfo-mpo.gc.ca	Pico-plankton distribution and abundance, bacterial abundance and productivity
John Smith	BIO SmithJN@mar.dfo-mpo.gc.ca	Radioisotope sampling program
Igor Yashayaev	BIO YashayaevI@mar.dfo-mpo.gc.ca	Associate Senior Scientist, CTD program coordination, XBTs

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

4.1 Physical - Chemical Program

a. Narrative

The physical and chemical program on Hudson 2010014 continued an annual series of measurements in the Labrador Sea that began in 1990 as a contribution to the World Climate Research Programme and has evolved into a component of a multidisciplinary regional monitoring effort. The broad goals are to investigate interannual and long-term changes in the physical and chemical properties of the Labrador Sea and better understand the mechanisms that cause these changes. A particular focus is on changes in the intensity of winter overturning of surface and intermediate-depth waters and the resulting formation of Labrador Sea Water with varying temperature and salinity properties. This overturning is part of the thermohaline circulation that plays a role in the global climate system. Convection also transfers atmospheric gases such as oxygen and carbon dioxide from the surface layers to intermediate depths. The resulting oceanic storage of anthropogenic carbon reduces the rate of increase of carbon dioxide in the atmosphere but also increases the acidity of oceanic waters. The physical-chemical

investigations are part of a larger multidisciplinary effort seeking a better understanding of interannual and long-term changes in regional ecosystems.

Hudson 2010014 program elements included:

1. CTD profile measurements of pressure, temperature, salinity, dissolved oxygen, pH, fluorescence, and light intensity at a fixed set of stations (L3 line) spanning the Labrador Sea from Hamilton Bank on the Labrador Shelf to Cape Desolation Island on the West Greenland Shelf;
2. Measurements of salinity, dissolved oxygen, nutrients (nitrate/nitrite, phosphate, silicate), CFCs, dissolved inorganic carbon, alkalinity, and Iodine-129 from discrete water samples from a rosette sampler on the CTD package;
3. Recovery and redeployment of a current meter mooring providing near-bottom current and temperature measurements on the Labrador Slope in 1000 m water depth;
4. Current measurements from a ship-mounted acoustic current profiler;
5. Current measurements at CTD stations from a lowered acoustic current profiler (Woods Hole Oceanographic Institution);
6. Temperature profile measurements from Expendable Bathythermographs (XBTs) at selected points between CTD stations;
7. Autonomous float deployments as part of the Canadian Argo Program and the international Argo Project;
8. Physical and chemical measurements at Station 27 on the Newfoundland Shelf and on the Halifax Line on the Scotian Shelf in support of the Atlantic Zone Monitoring Program (AZMP);
9. Physical and chemical measurements on the Scotian Slope in support of an expanded offshore monitoring program and a joint study with the UK Proudman Oceanographic Laboratory;
10. Measurements of light carbonyl compounds in surface waters and marine air and associated measurements of atmospheric ozone, nitrogen oxides, and non-methane hydrocarbons (McGill University).

Station 27 off St. John's was occupied as a contribution to the AZMP. Problems with the connector on a pH sensor that disrupted the first shallow CTD stations on the outward transit were resolved. Operations on the outward transit to the L3 line included 7 shallow CTD casts, 3 ring net hauls, 9 XBT drops, and 2 float deployments.

The Labrador Sea station work went well except that unusually heavy sea ice on the western side of the Labrador Sea prevented access to stations L3_1 to L3_7 on the Labrador Slope and Shelf. Favourable ice conditions on the eastern side of the Labrador Sea at the time of our survey allowed the occupation of all planned stations on the West Greenland shelf. High winds interrupted over-the-side operations in the western Labrador Sea for approximately 12h. Operations on the L3 line included 25 full-depth CTD casts, 5 shallow CTD casts, 35 ring net hauls, 81 XBT drops, 6 float deployments, and 9 air samples.

A Net haul and CTD cast were carried out near the ice edge on the Newfoundland Shelf in 320 m water depth as a proxy for missed stations on the Labrador Shelf.

Ice conditions made it necessary to return via Cape Race rather than take the shorter route through Belle Isle Strait and the Gulf of St. Lawrence.

The combined Halifax Line/offshore Halifax Line (HL) was surveyed with 8 CTD casts, 4 Multinet hauls with 5 sampling levels down to 1000 m (HL_6 – HL_9), and 5 vertical ring net tows (HL_3–HL_5). The offshore survey stopped at HL_9 because of time constraints. HL_6.5 and all AZMP Halifax Line stations except Stations 1 and 2 were occupied. An Apex profiling float was deployed at HL_9.

Researchers from McGill University analyzed 39 water samples from 31 stations for light carbonyl compounds (formaldehydes, acetone, etc.) and collected 13 underway air samples close to 7 of these stations.

Weather and ice presented challenges to time management on this mission. Sea ice on the Labrador Coast was late in withdrawing, necessitating detours on transit and a longer return via Cape Race. Weather interrupted operations in the western Labrador Sea for approximately 12h. The formal mission plan allowed for a return to BIO as late as 05:00 UTC (08:00 ADT) on 1 June 2010 but nearing the offshore end of the Halifax Line on 29 May 2010 we made a considered commitment to return to BIO late on the afternoon of Sunday, 31 May 2010 to facilitate unloading from HUD2010014 and loading for the following mission, based on a short turnaround time and an assessment that we were in a position to do this and still complete the priority Halifax Line objectives. Arrangements were then made to have a working party and crane on the BIO jetty waiting for our arrival. Subsequently we were obliged to detour inshore to Halifax Line Station 6 to avoid a tropical depression approaching the offshore end of the Extended Halifax Line. This doubled the steaming time to occupy the offshore stations. Persistent fog made it necessary to reduce steaming speed and further cut into our station time. We occupied stations on the Extended Halifax Line out to site HL_9 but time constraints prevented the planned occupation of HL_10. On the return to BIO we occupied Stations 6.5 to 3 on the AZMP Halifax Line, still hampered by persistent fog. We had to bypass the AZMP time series at Halifax Line Station 2 because of poor time management over the final hours of the mission, which we particularly regret.

Summary log (all times are UTC)

17 May 2010 12:40 Depart St. John's harbour.
17 May 2010 13:40 2 Net hauls, CTD at Station 27 about 7 km from St. John’s harbour. Events 1–3. Transit to site L3_22 to start work on the eastern end of the L3 line.
17 May 2010 23:15 Deviated ~60 nm east of planned track near 49°20'N to avoid ice. Ice also prevented an approach to the Notre Dame Trough for a planned brief sub-bottom survey for colleagues in the Atlantic Geosciences Centre with the 3.5 kHz Knudsen Chirp 3260 sounder.
18 May 2010 11:20 Transit_01a Net haul, shallow CTD Event 5. The CTD failed on the downcast. The SBE18 pH sensor installed for the first time on this station had a fault in its connecting cable that was eventually identified as the cause of the problem. Transit_01b shallow CTD Event 6 at same location after removing the depth-limited biological sensors (Licor PAR sensor and WetLabs fluorometer) was also aborted at 58 dbar on the downcast. Trial Transit_02a shallow CTD Event 7 again without the shallow biological sensors was aborted after a partial downcast. Transit_02b shallow CTD Event 8 without the pH sensor

was completed without incident. 15:35 Steamed south in response to a SAR call; called off about 3 hours later, resumed steam north. Transit_03 shallow CTD Event 9.
19 May 2010 Transit to L3_22. Transit_04 Net haul, shallow CTD, 2 float deployments, 8 XBT drops. Events 10–21.
20 May 2010 Transit to L3_22. Transit_05 Net haul, shallow CTD including pH measurements with the repaired SBE18 pH sensor, XBT drop. Events 22–24. 20:00 Start L3 line. 2 Net hauls, CTD, 2 XBT drops, air sample. Events 25–30.
21 May 2010 L3 line. 5 Net hauls, 7 CTD casts, float deployment, 8 XBT drops. Events 31–53.
22 May 2010 L3 line. 6 Net hauls, shallow CTD, 4 full-depth CTD casts, 22 XBT drops, 3 air samples. Events 54–88.
23 May 2010 L3 line. 6 Net hauls, shallow CTD, 4 full-depth CTD casts, 19 XBT drops, 2 air samples. Events 89–120. 23 May 2010 20:25 High winds, break off work and run into the wind to the NW and W.
24 May 2010 08:45 Begin steam SE 25 nm to rejoin L3 line at L3_15. 2 Net hauls, shallow CTD, 2 full-depth CTD casts, 2 float deployments, 9 XBT drops. Events 121–136.
25 May 2010 L3 line. Moved from site L3_11 to mooring site on Labrador slope in mid-day to allow recovery in daylight hours. Recovered and redeployed slope mooring. Ice edge approximately 5 nm southwest of mooring site prevented further access to the Labrador Slope and Shelf. Occupied station L3_7.5 at ice edge in approximately 600 m water depth.
9 Net hauls, 5 CTD casts, release test, mooring recovery and redeployment, 2 float deployments, 17 XBT drops, 2 air samples. Events 137–174. It was reported that the hoses connected to the CTD sensors to keep them wet while the CTD is on deck between stations were left on the sensors during Event 174 (L3_7.5).
26 May 2010 L3 line. Occupied stations between ice edge and site L3_10. 5 Net hauls, shallow CTD, 4 full-depth CTD casts, 4 XBT drops. Events 175–188. End of L3 line work
27 May 2010 Transit south along edge of ice edge. Ice conditions at the entrance to Belle Isle Strait blocked the shorter route to the Halifax Line through the Gulf of St. Lawrence.
28 May 2010 02:35 BON_BAY Net haul, CTD in 320 m water depth about 20 nm SE of AZMP Bonavista Line Station 6 at the southern limit of sea ice to sample winter water as a proxy for missed stations on the Labrador Shelf. Events 189–190. Transit around Cape Race to site HL_10 on the extended Halifax Line.
29 May 2010 15:00 Altered course toward site HL_6 to avoid a forecast tropical depression.
30 May 2010 Occupied stations seaward from HL_6 to extended Halifax Line HL_9. 4 Multinet hauls, 4 CTD casts, float deployment, 4 air samples. Events 191–203.
31 May 2010 Occupied Halifax Line stations shoreward HL_6.5 to HL_3. 5 Net hauls, 4 CTD casts. Events 204–212. Final transit to BIO. 19:45 Alongside BIO jetty.

b. Chemical Oceanography

We have measured carbonate system (dissolved inorganic carbon and total alkalinity), Transient tracers (Halocarbons-CFCs), nutrients and dissolved oxygen in the GP Lab during 2010-014. Water samples for pH and oxygen isotope composition were also collected, preserved and stored.

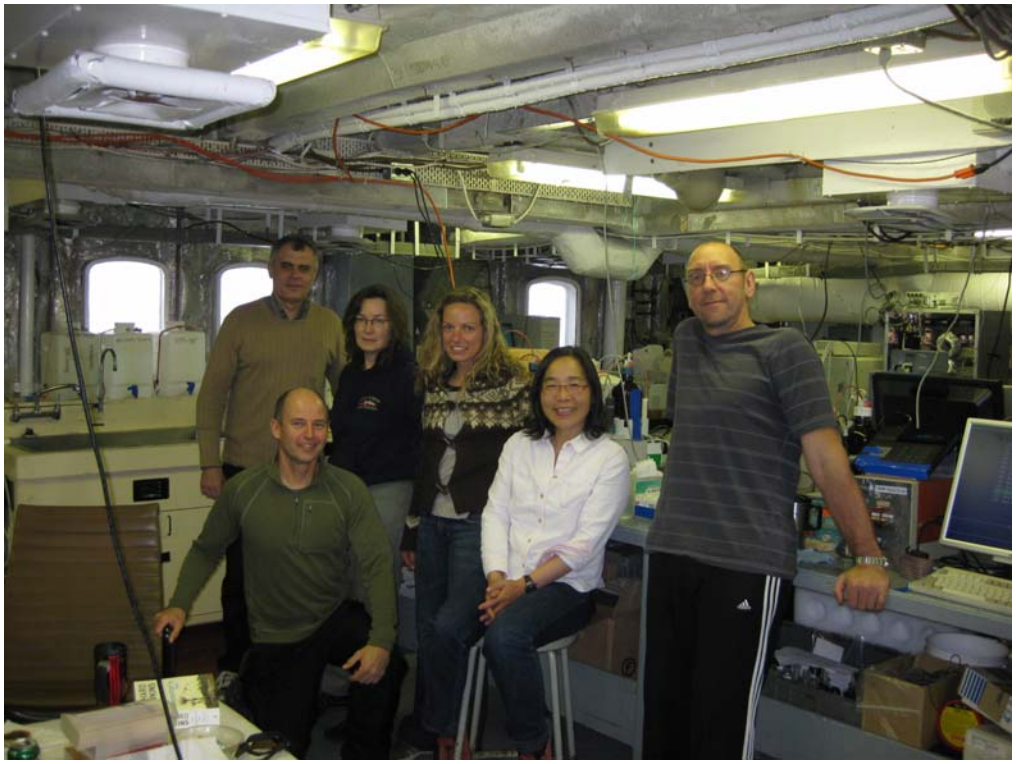

Figure A.4.1.1 The chemistry team from left to right: Yuri Geshelin, Richard Nelson, Carol Anstey, Darlene Brownell, Kumiko Azetsu-Scott, and Stephen Punshon.

b. Radioisotope Sampling Program **John Smith**

Water samples were collected for ^{129}I from a near surface rosette bottle at 15 stations on the L3 (AR7W) line. Fuller depth sampling for ^{129}I was carried out at five stations on the same section and four on the Halifax line. See table A.2.1 for the list of operations during which ^{129}I was sampled.

c. ASIP Measurements

Brian Ward & Adrian Callaghan
National University of Ireland

Jonathan Lilly
Earth & Space Research

ASIP is an autonomous vertically-moving profiling platform that is equipped with a suite of instruments that make measurements of the physical properties of the ocean from a maximum depth of 100m up to the air-sea interface. ASIP is equipped to measure pressure, temperature, conductivity, shear, photosynthetically active radiation (PAR), oxygen concentration and saturation, turbidity and dissolved organic matter.

ASIP is ~2.5m in length and weighs approximately 100kg. Figure 1 shows ASIP in an upright position moments before deployment. The instruments are located at the top of ASIP and are protected by a guard. In addition there is an NBOSI temperature and

conductivity sensor located on the side of ASIP approximately 25 cm below the instruments that are protected by the guard.

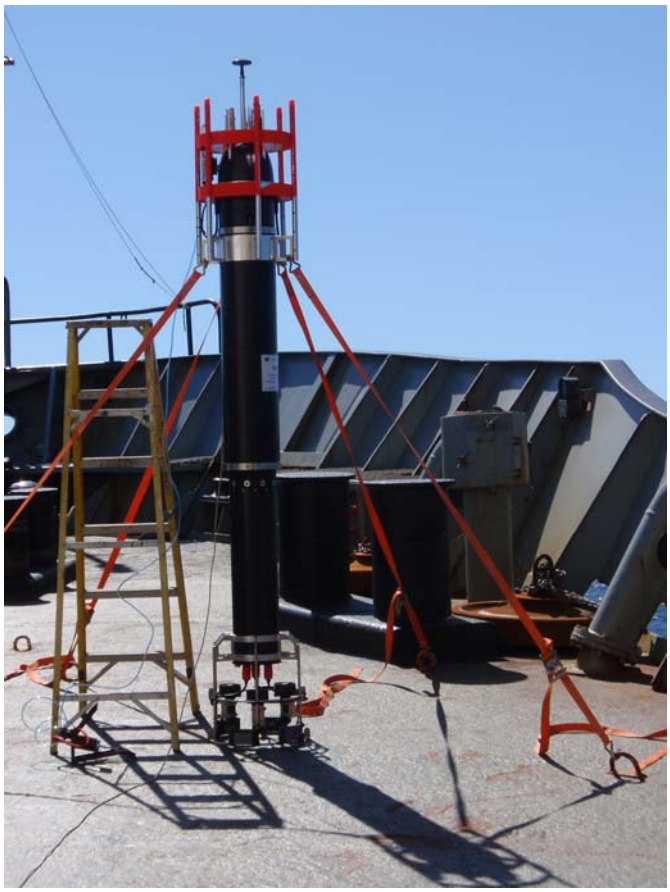

Figure A.4.1.2 A photo of ASIP while secured to CCGS Hudson's foredeck.

Before each deployment, ASIP's mission parameters are set in the lab. These include ASIP's maximum profiling depth, the time before ASIP performs its first profile and the time between all subsequent profiles. A maximum of approximately 100 profiles can be performed in a given deployment before ASIP needs to be recovered due to battery demands. Once deployed and after the initial wait period, ASIP turns on its thrusters which submerge ASIP to the mission depth. Once this depth has been reached the thrusters shut off and ASIP rises under its own positive buoyancy through the water column to the air-sea interface. Once at the surface ASIP gets a GPS fix and transmits its position via iridium satellite which is received on the boat. ASIP then goes into sleep mode until it makes its next profile. ASIP continues to profile until its batteries reach a preset level of depletion. Once deployed, as well as transmitting its position which is received on the research vessel, ASIP can also receive messages via iridium satellite. Therefore mission parameters such as profiling depth and interval can be changed mid deployment. Also, ASIP can be set into sleep mode to conserve battery power.

During the CCGS Hudson cruise in the Labrador Sea in May 201, ASIP was deployed a total of 6 times, summarised in the table below.

Deployment Number	Deployment Date/Time (UTC)	Recovery Date/Time (UTC)	Number of Profiles	Profile Depth (m)	Latitude (º)	Longitude (º)
1	May17 18:54	May17 19:34	5	15	58.218	50.898
2	May17 22:37	May18 00:36	20	60	58.638	50.419
3	May19 16:44	May19 21:15	33	75	60.003	48.888
4	May22 18:28	May22 22:50	30	100	56.109	53.111
5	May23 12:36	May23 19:53	50	100	55.264	53.976
6	May27 09:49	May27 17:16	60	100/40	41.773	60.911

Table A.4.1.1 List of ASIP deployments.

Deployment 1 was essentially a shakedown to see if the profiler was operating according to its programmed mission. It was also an opportunity to see if the data was being recorded correctly. As it turned out, the accurate CT sensor on ASIP was not being recorded and we had to contact the engineers to come up with a fix. After trying a software change, it was clear that this was not going to get solved in this way. The solution came after we were able to take the signal and re-route it to another port, but the data from this port was not available until deployment 4. We do have high-resolution (albeit less accurate) CT data for the other deployments.

Deployment 2 was another baby-sitting routine where we programmed ASIP to conduct 9 rapid profiles, followed by a satellite communication link. This “rapid” profiling technique was developed on the Hudson, and increased the number of profiles during a deployment by eliminating the computer turn-on and turn-off times, as well as bypassing the satellite link. This turned out to be a very successful feature for this cruise, as time was often limited and the objective was to maximise the data return.

Deployment 3 was the first time that ASIP was released, and the Fast Rescue Craft (FRC) returned to the ship without the instrument. It was successfully recovered after 4 hours, and conducted the programmed mission precisely. This provided enhanced confidence in ASIP’s ability to autonomously carry out its mission as well as call back with its position.

Deployment 4 was the first time ASIP was deployed to 100m, and again operated precisely according to the programmed mission.

Deployment 5 was again to 100m, but we acquired 50 this time. There was an issue with the antenna during deployment, and so the instrument was dismantled and a new antenna seal was installed, as there was concern that the o-ring seal was interfering with the antenna extension.

Finally deployment 6 was conducted in the highest wind conditions, with significant wave breaking at the surface. For this reason, we changed the mission programme in real-time by sending a message to ASIP while it was being deployed, and changed its measurement depth from 100 to 40m. This was to increase the turbulence data near the surface to improve our statistics. There was however a small bug in the mission code which resulted in ASIP doing rapid profiles only, which prevented any satellite communications. However, after the maximum number of profiles had expired ASIP stayed at the surface and transmitted its position every 2 minutes. Recovery was complicated by the 35 knot winds, and sight of the instrument was lost several times during the recovery operation.

In summary the cruise was very successful and we have some very valuable data of the upper ocean.

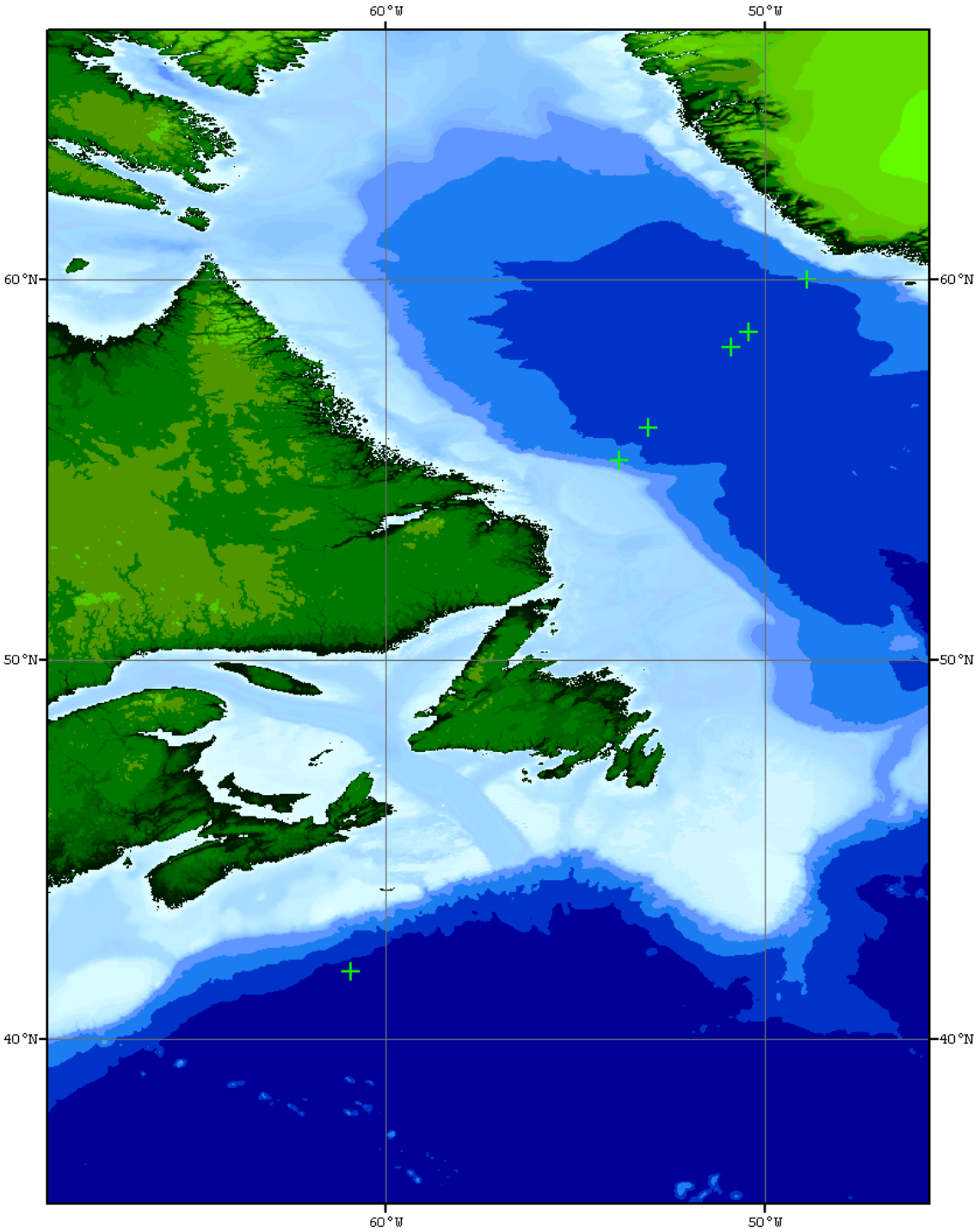

Figure A.4.1.3 HUD2010014 ASIP deployment locations (plus sign).

4.2 Biological Program

a. Narrative

The biological program conducted as part of cruise 2010014, with some modifications, was a continuation of studies began in 1994 to describe the large-scale (spatial and temporal) variability in plankton biomass, productivity and biogenic carbon inventories in the Labrador Sea.

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

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

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

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

b. Zooplankton Sampling — E. Head / M. Ringuette

The zooplankton sampling is part of an ongoing program, the aim of which is to investigate the distribution, abundance and life history of the major zooplankton groups found in the Labrador Sea and its associated shelf systems. Particular emphasis is placed on the copepod species of the *Calanus* genus, which dominate the zooplankton in this region.

Vertical net tows were taken at 30 stations (1 at Station 27, 2 in transit to the L3 line, 25 on the L3 line and 4 on the Halifax Line). At all stations, tows were made from 100

meters to the surface using a ¾ m diameter 200 µm mesh ring net, except at Station 27 and those on the Halifax Line where tows were from the 1000 m or bottom to the surface. An additional tow was made using a using a 30 cm 76 µm mesh ring net at 22 stations (21 on the L3 line and 1 at HL_02).

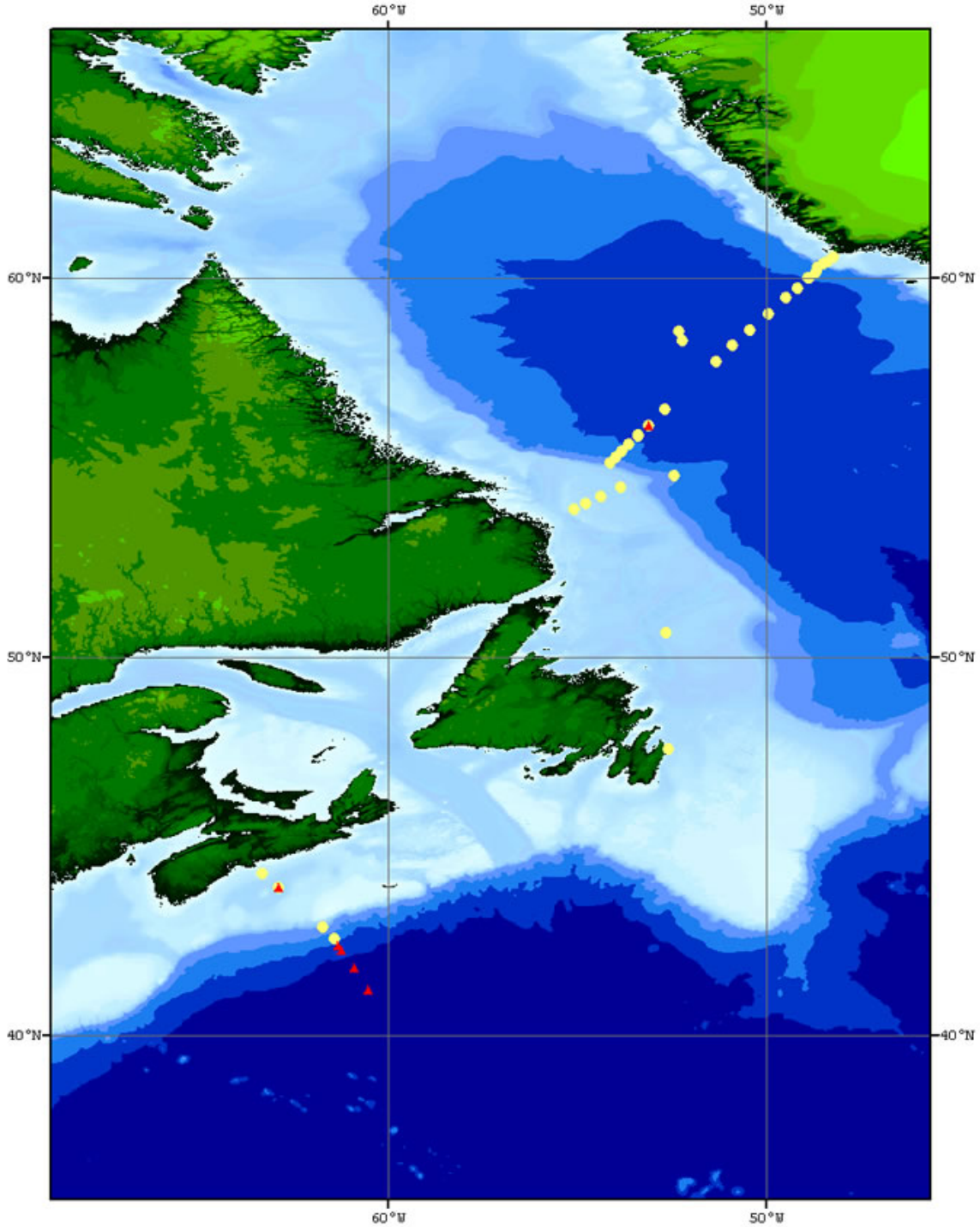

Figure A.4.2.1 HUD2010014 ring net tow (yellow-filled circles) and multi-net tow (red-filled triangles) locations.

c. Egg Production and developmental rates (EPR and DR) of *Calanus finmarchicus* in the Labrador Sea **E. Head / M. Ringuette**

EPRs were measured at 9 different stations the primary goal being to serve as a measure the secondary production. Egg production rates were monitored every 6 hours to determine the presence of a circadian cycle in egg production. The monitoring of a series of 24 vials containing 50 eggs each is being used to provide an estimate of the hatching rate of the population, and the time necessary to molt into subsequent naupliar stages up to N3. Replicate vials from each of 3 experiments are being preserved daily with formalin for subsequent laboratory counting. The experiments will continue in the laboratory, after the ship has docked. Development rates obtained in these experiments, together with estimates of EPRs and in situ levels of eggs and naupliar stages 1-3, will be used to determine mortality of the early life stages.

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

The vertical depth distribution of *Calanus finmarchicus* in the Slope Water off the Scotian Shelf was investigated. At four stations, HL 8-9-11 and 13, five depth strata (660-600, 600-400, 400-200, 200-100, 100-0 meters) were sampled using a square 0.5 x 0.5 m multi-net fitted with five 200 µm mesh nets. Limitation in the cable length explains the low depth reaches at these stations. See Table A.4.2.1 below.

Station	Date	Multi-net	Ring Net		EPR	Devel.
			200µm	76µm		Time
Station 27	13 May		X	X		
Biological cast #1	14 May		X	X	X	
Biological cast #2	15 May		X	X	X	
L3-17	17 May		X			
L3-18			X	X	X	X
L3-19			X	X		
L3-20	18 May		X	X		
L3-28			X	X		
L3-27			X	X		
L3-26			X			
L3-25	19 May		X	X		
L3-24			X	X		
L3-23			X	X	X	X
L3-22			X	X	X	
L3-21	20 May		X	X		
L3-N4			X			
L3-N3	21 May		X			
L3-14	22 May		X		X	X
L3-13		X	X	X	X	
L3-12			X	X		
L3-11	23 May		X	X		
L3-10			X	X		
L3-9			X	X	X	
L3-8	24 May		X			

L3-6A			X	X	X	
L3-5A			X	X		
L3-4A			X	X		
L3-3A			X			
HL-9	27 May	X				
HL-11		X				
HL-13		X				
HL-8	28 May	X				
HL-7			X			
HL-6	29 May		X			
HL-2			X	X		
HL-3		X	X			

Table A.4.2.1 Net tows performed on HUD2010014.

e. Total Organic Carbon (TOC)

Jeff Anning
(for Paul Kepkay)

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

During CCGS Hudson cruise 2010-014 TOC depth profiles were collected from stations of the AR7W line as indicated in the table below.

Station	TOC Profile
AR7W site 1	X
AR7W site 2A	X
AR7W site 3A	X
AR7W site 4A	X
AR7W site 5A	X
AR7W site 6A	X
AR7W site 7	X
AR7W site 8	X
AR7W site 9	X
AR7W site 10	X
AR7W site 11	X
AR7W site 12	X
AR7W site 13	X
AR7W site 14	X
AR7W site 15	X
AR7W site 16	X
AR7W site 17	X
AR7W site 18	X
AR7W site 19	X

AR7W site 20	X
AR7W site 21	X
AR7W site 22	X
AR7W site 23	X
AR7W site 24	X
AR7W site 25	X
AR7W site 26	X
AR7W site 27	X
AR7W site 28	X

Table A.4.2.2 TOC sampling on HUD2010014.

f. Primary Production Measurements — Jeff Anning

Water samples for photosynthesis-irradiance (P-I) experiments were collected from the rosette at 6 stations. For each incubation experiment, 33 aliquots were inoculated with ^{14}C labelled sodium bicarbonate and then incubated at in situ temperatures at 30 light levels (+ 3 dark bottles) for approximately 3 hours. At the end of the incubation period the cells were harvested onto GF/F glass fibre filters for later counting in a scintillation counter. Duplicate chlorophyll, duplicate particulate organic carbon, one particulate inorganic carbon, one HPLC, and one Absorption Spectra sample were collected for each incubation experiment.

Station	Event	Lat.	Long.	Date	Time	Depth	ID
L3_18 Bio	27	58.2188	-50.8833	"May 17 2010"	"15:22:56"	30	369182
	27	58.2188	-50.8833	"May 17 2010"	"15:26:53"	2	369185
L3_23 Bio	114	60.0057	-48.8717	"May 19 2010"	"17:58:39"	30	369351
	114	60.0057	-48.8717	"May 19 2010"	"18:00:56"	2	369355
L3_14 Bio	202	56.5405	-52.6718	"May 22 2010"	"12:08:54"	31	369507
	202	56.5405	-52.6718	"May 22 2010"	"12:11:28"	4	369511
L3_10	231	55.4198	-53.826	"May 23 2010"	"11:21:15"	30	369630
	231	55.4198	-53.826	"May 23 2010"	"11:22:27"	4	369631
L3_06a	256	54.4698	-53.8422	"May 24 2010"	"11:02:32"	31	369694
	256	54.4698	-53.8422	"May 24 2010"	"11:05:07"	3	369698
HL_11 Bio	270	41.7772	-60.908	"May 27 2010"	"10:31:21"	30	369790
	270	41.7772	-60.908	"May 27 2010"	"10:34:02"	3	369794
L3_18 Bio	27	58.2188	-50.8833	"May 17 2010"	"15:22:56"	30	369182
	27	58.2188	-50.8833	"May 17 2010"	"15:26:53"	2	369185
L3_23 Bio	114	60.0057	-48.8717	"May 19 2010"	"17:58:39"	30	369351
	114	60.0057	-48.8717	"May 19 2010"	"18:00:56"	2	369355
L3_14 Bio	202	56.5405	-52.6718	"May 22 2010"	"12:08:54"	31	369507

	202	56.5405	-52.6718	"May 22 2010"	"12:11:28"	4	369511
L3_10	231	55.4198	-53.826	"May 23 2010"	"11:21:15"	30	369630
	231	55.4198	-53.826	"May 23 2010"	"11:22:27"	4	369631
L3_06a	256	54.4698	-53.8422	"May 24 2010"	"11:02:32"	31	369694

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

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

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

Water samples were collected from all depths at 9 stations on the L3 line and incubated for between 3-24 hours after inoculation with ^{3}H labelled leucine. The cells were collected by centrifugation and prepared for scintillation counting back on shore.

Station	Event	Lat.	Long.	Date	Time
L3-18	28	5812.886	-5052.848	"May 17 2010"	"18:21:33"
L3-27	79	6027.000	-4822.221	"May 18 2010"	"22:27:34"
L3-24	103	6011.521	-4841.698	"May 19 2010"	"12:16:18"
L3-21	129	5929.066	-4928.745	"May 20 2010"	"07:35:40"
L3-14	203	5633.082	-5241.107	"May 22 2010"	"15:04:46"
L3-10	231	5524.802	-5346.965	"May 23 2010"	"11:23:06"
L3-08	251	5505.747	-5406.484	"May 24 2010"	"04:57:58"
L3-04a	262	5402.643	-5446.256	"May 24 2010"	"16:15:25"
L3-01	266	5340.527	-5533.011	"May 24 2010"	"21:36:24"

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

h. Pelagic Bird Survey — Carina Gjerdrum

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

Seabird Observer: Sarah Wong (snpwong@dal.ca)

Background
Our primary objective for the pelagic monitoring program is to map the relative abundance and distribution of pelagic birds in Atlantic Canada. We rely on ships-of-opportunity to carry seabird observers to offshore areas through the region, and prioritize areas that can be surveyed across multiple seasons and years. These data will provide

critical, and currently unavailable, information for environmental assessments for offshore developments, help identify areas where birds are at high risk for oil pollution and other human activities, identify critical marine habitat, and allow us to monitor trends in abundance and distribution of marine birds.

Protocol

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

Surveys are conducted while looking forward from the bridge, scanning ahead to a 90^0 angle from either the port or starboard side, limiting observations to a transect band 300m wide from the side of the platform. A survey consists of a series of five-minute observations periods, which are exclusively dedicated to detecting birds at sea. We conduct as many consecutive five-minute observation periods as possible, regardless if birds are present or not, and try to ensure consistent coverage throughout the day.

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

GENERAL RESULTS: Written by Sarah Wong

Seabird surveys were conducted from May 13 to May 29, 2010 from the bridge of the CCGS Hudson. A total of 1088 five-minute observation period were completed. During this time, 1014 birds from 6 different families were counted in transect (this does not include birds outside of the 300m wide transect, birds following the ship or birds in flight that were not captured during the instantaneous snapshots)(Table 1). In general, birds were widely distributed throughout the survey area, although higher densities were found over Newfoundland and Scotian slope waters.

Species from the family Alcidae were the most abundant group observed (45%), most of which were murres. Huge flocks of murres were observed through the Strait of Belle Isle (not included in the total as most were further than 300m away) and large numbers on the Scotian shelf. Dovekies were found mainly over the Greenland Slope waters, although some were observed in the Labrador Sea. Razorbills and Atlantic puffins were found mainly on off the coast of Newfoundland. Murres were most common off the coast of Newfoundland, but were also observed in the Labrador Sea.

Species observed in the family Procellariidae (accounting for 11%) were mainly Northern Fulmars. Fulmars followed the ship throughout the Labrador Sea. The total number given in Table 1 does not count ship followers, which sometimes numbered 400-500. Sooty and Greater Shearwaters were found on the Scotian Shelf and were first when we approached the Gully.

Storm-petrels accounted for 16% of the observations and were most numerous on the Scotian shelf and Slope. Gulls (Herring, Great Black-backed and Glaucus) also followed the ship in the Labrador Sea, though were more numerous closer to the shelf waters.

Non-seabirds observed included unidentified passerines (including sparrows and a thrush), 7 peregrin falcons and an osprey.

Acknowledgements
Our work could not occur without the generous support of DFO scientists and staff, and the Coast Guard officers and personnel.

Family	Species	Latin Name	Number Observed
Alcidae	Dovekie	*Alle alle*	88
	Thick-billed Murre	*Uria lomvia*	86
	Common Murre	*Uria aalge*	20
	Unknown Murre	*Uria* spp.	112
	Razorbill	*Alca torda*	19
	Murre or Razorbill		83
	Atlantic Puffin	*Fratercula artica*	46
	Black Guillemot	*Cepphus grylle*	2
	Unknown Alcid	*Alcidae*	5
Hydrobatidae	Wilson Storm-Petrel	*Oceanites oceanicus*	34
	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	44
	Unknown Storm-Petrel	*Oceanodroma* or *Oceanites*	89
Laridae	Herring Gull	*Larus argentatus*	26
	Great-Black-backed Gull	*Larus marinus*	5
	Glaucus Gull	*Larus hyperboreus*	11
	Black-legged Kittiwake	*Rissa trydactyla*	73
	Iceland Gull	*Larus glaucoides*	1
	Arctic Tern	*Sterna paradisaea*	3
	Unknown Tern	*Sterna* spp.	9
	Pomarine Jaeger	*Stercorarius pomarinus*	2
	Long-tailed Jaeger	*Stercorarius longicaudus*	2
	Parasitic Jaeger	*Stercorarius parasiticus*	1
	South Polar Skua	*Stercorarius maccormicki*	2
	Unknown Gull		1
Procellariidae	Northern Fulmar	*Fulmarus glacialis*	106
	Greater Shearwater	*Puffinus gravis*	6
	Sooty Shearwater	*Puffinus griseus*	4
Scolopacidae	Red Phalarope	*Phalaropus fulicaria*	82
	Red-necked Phalarope	*Phalaropus lobatus*	11
	Unknown Phalarope	*Phalaropus* spp.	7
Sulidae	Northern Gannet	*Morus bassanus*	34

Table A.4.2.5. List of species observed during the seabird survey. Total numbers include only those birds considered "in" transect.

They do not include birds following the ship, birds outside 300m and flying birds not captured during the "snapshot".

5. Major Problems and Goals Not Achieved

The only major problems were that a couple days were lost due to stormy weather and sea ice along the Labrador coast was encountered. The ship's speed was reduced during several periods of low visibility due to fog or tricky patches of sea ice. The presence of coastal sea ice prohibited the original occupation for stations 2 – 6 of the AR7W line, the 20th annual realization of this section by DFO Maritimes Science. Most of the full Halifax Line was occupied (stations 2, 3, 6, and 7); plus six additional deeper offshore stations.

6. Other Incidents of Note

There were none to report.

7. List of Cruise Participants

Name	Responsibility	Affiliation
Anning, Jeffrey	Biological	ERD, BIO
Anstey, Carol	Nutrients, Oxygens	ERD, BIO
Azetsu-Scott, Kumiko	Scientist, Carbonate, Alkalinity, O-18	OSD, BIO
Boyce, Richard	Salts, Mooring	OSD, BIO
Brownell, Darlene	CFCs	BDR
Callaghan, Adrian	ASIP	NUI
Dimerov, Entcho	Computer Room, XBTs	MUN
Geshelin, Yuri	Oxygens	OSD, BIO
Harrison, William Glen	Chief Scientist, Biological	ERD, BIO
Hartling, Adam	Winch Room, LADCP, VADCP	OSD, BIO
Head, Erica	Scientist, Biological, Net Tows	ERD, BIO
Jackson, Jeffrey	Data management, Computer Room	OSD, BIO
King, Randy	MVP	OSD, BIO
Lilly, Jonathan	ASIP, Computer Room	ESR
Nelson, Richard	CFCs	ERD, BIO
Perry, Timothy	Biological	ERD, BIO
Punshon, Stephen	Carbonate, Alkalinity	OSD, BIO
Ringuette, Marc	Biological, Net Tows	ERD, BIO
Ryan, Robert	CTD Tech., Winch Room	OSD, BIO
States, George	MVP	OSD, BIO
Ward, Brian	ASIP	NUI
Wong, Sarah	Sea bird observer	EC, CWS
Yashayaev, Igor	Associate Chief Scientist, Computer Room, XBTs	OSD, BIO

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

BDR BDR Research Ltd.
Box 652, Station 'M', Halifax, NS, Canada, B3J 2T3

EC, CWS Environment Canada, Canadian Wildlife Service
45 Alderney Drive, Dartmouth, Nova Scotia, Canada, B2Y 2N6

ERD Ecosystem Research Division

ESR Earth & Space Research
2101 Fourth Ave., Suite 1310
Seattle WA 98121 USA

MUN Fisheries and Marine Institute of Memorial University of Newfoundland
P.O. Box 4920 St. John's, NL Canada A1C 5R3

NUI National University of Ireland, Galway
University Road, Galway, Ireland.

OSD Ocean Sciences Division

B. UNDERWAY MEASUREMENTS

1. Navigation and Bathymetry — Jeff Jackson

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

AGCNAV is a PC-based display and waypoint setting software package, developed at the Atlantic Geoscience Centre at BIO. This software graphically displays ship position, waypoints, course, speed, etc. to the various science working areas. This has been the standard software package for years now. It was used on this mission to view the ship's position but it was not used to log the navigation data.

The navigation data was logged using the Geological Survey of Canada's (GSC) Survey Suite navigational software. This is a windows package which grabs every NMEA string broadcast over the network. It adds a date/time stamp to every data record acquired. It is much easier to configure and operate than AGCNAV. The only negative observation is that it does not have a waypoint viewer.

The echo sounder system used for collecting bathymetric data at station locations consisted of a 12 KHz Raytheon PTR echo sounder that created an analog trace on a Raytheon Line Scan Recorder located in the forward laboratory. The transducer beam width is 15 degrees. The sweep rate of the recorder was adjusted throughout the course of data collection to aid in identifying the bottom signal. One transducer is positioned on a Ram that can be lowered or raised depending on conditions. When the ram is up, the waterline to transducer offset is 6 m. When the ram is down, the offset is 8 m.

2. Vessel Mounted Acoustic Doppler Current Profiler — Adam Hartling

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

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

The system is capable of collecting bottom track data to 1000m and profile data to 650m. Setup includes 100-8m bins. The Ocean Surveyor was set to operate in the narrow band single ping mode with 3 sec ensemble time. Position, heading, pitch and roll data is

provided by the ADU5 attitude determination unit at a 1Hz rate. Ships gyro heading data is connected directly to the OSII deck unit. The Ocean Surveyor also includes a temperature sensor for sound speed calculations.

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

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

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

Significant increase in noise floor caused by bow thrusters while on station, during high sea states, or during travel at speeds in excess of 12 knots. Increase in noise floor results in significant decrease in data quality and reduction in profile range.

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

Water from approximately 4m was continuously pumped to the forward lab. The temperature, conductivity and fluorescence were measured and logged every 15 sec. The temperature and conductivity were measured with Sea-Bird Thermosalinograpgh and the fluorescence by a Wetlabs flow through fluorometer. Incident Photosynthetically Active Radiation was measured with a Li-Cor Spherical Quantum Sensor and this data was collected as hourly means. Exact time and positions were provided by the ships GPS and logged with the other data.

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

Expendable Bathythermographs were routinely deployed during the HUD2010014 mission. See Fig. B.4.1 for a map with the XBT drops indicated. We used three different models of XBTs: Sparton T5, Sippican T7 and Sippican T10. T5s are capable of measuring to maximum depths of 1900m at the cruising speed of 6 knots, T7s record temperature to 800m at the cruising speed 15 knots and T10s to 200m. The vertical resolution of the measurements was about 0.6-0.8m. There were 24 T5, 45 T7 and 27 T10 XBTs launched during the cruise (Table A.2.1 lists the operation numbers when these were deployed).

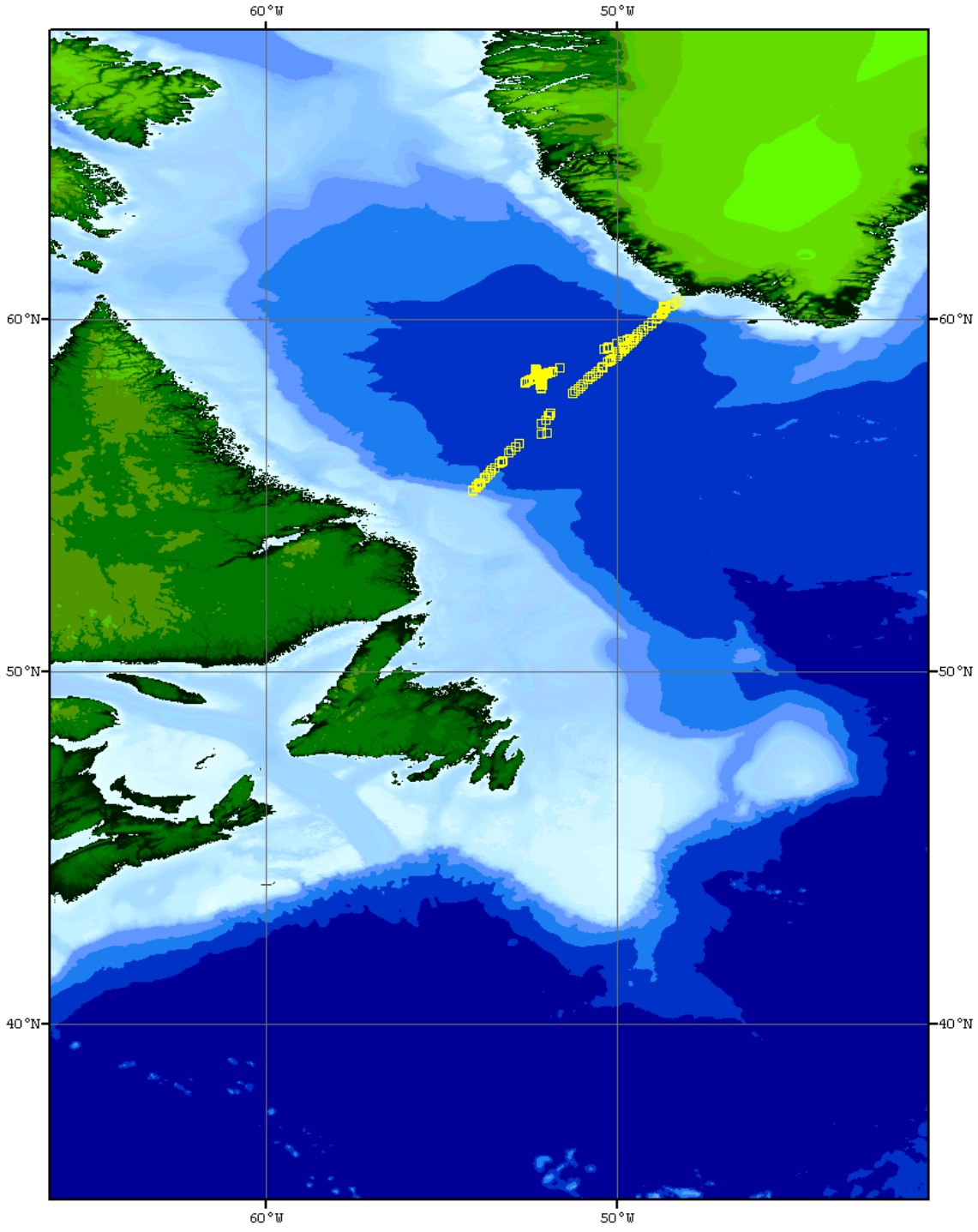

Figure B.4.1 XBT sites (indicated by yellow open squares) during HUD2010014.

5. Ashtec ADU5 Attitude Determination Unit — Adam Hartling

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

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

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

When the receiver is searching for the ambiguities, or when a valid solution has not been found code phase estimate of heading appears in the PASHR,AT2 string and pitch and roll are displayed as exactly 0.00. Heading may also be displayed as 0.00 if no estimate is available.
The PASHR, AT2 string contains a quality flag which indicated the quality of the solution.
When either of these situations exist, the attitude reset flag is set to 1 in the attitude output message (a 0 for the attitude reset flag indicates a good attitude solution).

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

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

6. Meteorological observations

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

7. Atmospheric Chemistry

There was no atmospheric chemistry program.

C. HYDROGRAPHIC MEASUREMENTS - DESCRIPTIONS, TECHNIQUES AND CALIBRATIONS

1. Salinity — Rick Boyce

a. Description of Equipment and Technique

595 salinity samples were analyzed using a Guildline Autosal 8400B salinometer, serial number 69780. Samples were drawn into 200 ml bottles. Once the sample bottle was rinsed three times and filled to the shoulder, the neck and threads of the bottle were dried using paper towel and a new dry cap was installed. Once the bottles reached room temperature, the caps should be retightened. The drying of the neck of the bottle and installing a dry cap has been a technique used since the HUD2000009 cruise and prevents salt crystals from forming under the cap if samples are left for a long period of time before analysis.

The samples are placed into a constant temperature water bath set to 23.5º C with the Autosal running at 24ºC. The cell of the salinometer was filled and rinsed three times with sample water. A fourth sample was introduced into the cell and readings were averaged over a 10 to 15 second interval until the operator was satisfied that the correct value was attained. If there was any doubt in this value, subsequent refills were performed and readings averaged as above. Once satisfied, a sample ID number and Conductivity Ratio was recorded onto the Salinity Log Sheet. Periodically, the room temperature was recorded constantly.

b. Data Processing Technique

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

c. Laboratory and Sample Temperatures

Full cases of samples were taken from the Winch Room to the Drawing Office. Cases of 24 salinity bottles were placed into water baths set at 23.5º C and allowed to equilibrate before analyzing. During this particular Mission, the room temperature in this area ranged remained quite stable hovering near 24 ºC. The Autosal bath temperature was set to 23.5ºC for all samples.

d. Standards Used

The salinometer was standardized during the mission using IAPSO standard water, Batch P150 dated May 22/08 having a K15 value of 0.99978, salinity of 34.991. Typically, standardization checks were performed at the beginning and end of a run. After ID# 396652, the standard changed to Batch P151, expiry date May 22/10 having a K15 value of 0.99994, salinity of 34.999. Typically, standardization checks were performed at the beginning and end of a run.

e. Performance of the Autosal salinometer

Overall, the Autosal salinometer worked well during the mission except for a run #6 stating with ID# 396652 and ending with ID# 369746. There was some drift in the standards over the cruise period. The introduction of water baths to bring the samples close to the temperature of the Autosal bath has made the analysis much better. The instrument spends very little time in bringing the sample to the temperature of the bath thus reducing bath fluctuations. The lab temperature was stable during all runs which is an important factor when trying to optimize the performance of the instrument. Historically the Autosal was setup in the General Purpose (GP) lab onboard Hudson. Air temperature was difficult to control in this area. For this mission the Autosal was installed in the Drawing Office where the operator could control the ambient air temperature much better than in the GP lab.

2. Measuring Dissolved Oxygen Concentration and calibration of Sea-Bird oxygen primary sensor on the Hudson 2010-009 and 2010-014 missions.

Carol Anstey / Yuri Geshelin

1. Introduction

In the spring of 2010, the CCGS Hudson carried out two field missions: 2010-009 (5-13 May 2010, Orphan Basin) and 2010-014 (14-30 May 2010, the annual occupation of the AR7W / L3 line across the Labrador Sea). On both missions, samples and standard measurements of dissolved oxygen (DO) were taken at various depths as part of the cruise program with the use of titration methods and by means of Sea-Bird DO primary and secondary sensors. Attempts at calibration of the primary sensor were made during the missions[1]. The purposes of this note are (a) to describe the methods of collecting samples, data acquisition and processing; (b) outline the problems and provide recommendations for improving the future work; (c) to provide some preliminary results of the expedition in the form of quantitative estimates.

Section 4 of the report is divided in two parts, each of which corresponds to one of the two missions. This is done not due to climatological or geographical considerations, but because of the transition to a newer titration system, which took place at the beginning of the second mission. The system used on the 2010-009 mission was developed at the Scripps Institute of Oceanography and is based on a modified Winkler titration technique. The system used on the 2010-014 mission was based on the colorimeter principle, and its Matlab-based software was developed at the Maurice Lamontagne Institute, Quebec and referred to as BOB in this writing.

The replacement had to be done because of the failure of the Scripps system. This change had impact on both the protocol of work and results. While both systems have problems, the newer one proved to be more efficient and in general, capable of producing consistent results.

2. Procedures and methods

Oxygen sub-samples were drawn from 10L bottles attached to a 24-bottle Rosette Sampler. To reduce air contamination of the samples to a possible minimum, the sampling was done immediately after the dissolved organic carbon (DOC) and chlorofluorocarbon (CFC) sampling[2]. On the 2010-009 mission, no replicate samples were taken. During the 2010-014 mission, on most oceanographic stations, replicate samples were collected at least at one depth. Normally, these depths were chosen to be at the minima and maxima of the DO vertical profile as determined from the CTD cast in the computer room. This strategy ensues from the calibration purpose: we strived for the

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[1] The data logged by the Sea-Bird secondary dissolved oxygen sensor were incorrect during most of the mission due to the wrong calibration coefficients and / or wrong equation; therefore, the secondary oxygen channel has not been given much attention up to this point.

[2] In some instances, only CFC sampling preceded the DO sampling.

maximum range of the calibration curve. Another characteristic point on the oxygen vertical profile, where, in most cases, duplicate samples were taken, is the bottom (i.e. the deepest observation).

The oxygen sampling bottles were 125 mL Iodine flasks with matched custom ground stoppers. The volumes of flasks with the corresponding stoppers were predetermined gravimetrically, and volume data were saved to titration programs prior to the mission. The matched flasks and stoppers are etched with identification numbers.

Each oxygen sub-sample was drawn through a silicone tube attached to the spigot of the Rosette bottle. The flask and stopper were thoroughly rinsed. The flow was then allowed to continue until two to three flask volumes overflowed. The sampling tube was slowly removed with continuous low flow to ensure that no air was trapped in the flask and the volume kept to the brim until the stopper was added.

On the 2010-009 mission, the draw temperature of each sample was taken by a digital thermometer in the winch room. That temperature was subsequently entered in the processing software. Several discussions were held on whether this procedure is mandatory, or the time-binned *in situ* temperature from Sea-bird can be used instead, as in the previous years. As seen from Figure C.3.1, there is a good agreement between the two temperatures (the correlation coefficient is 0.98). A few outliers are probably due to the errors made by the sample collector. As pointed out by Stephen Punshon, such discrepancy between the two temperatures is too negligible to cause any effect on the titration process.

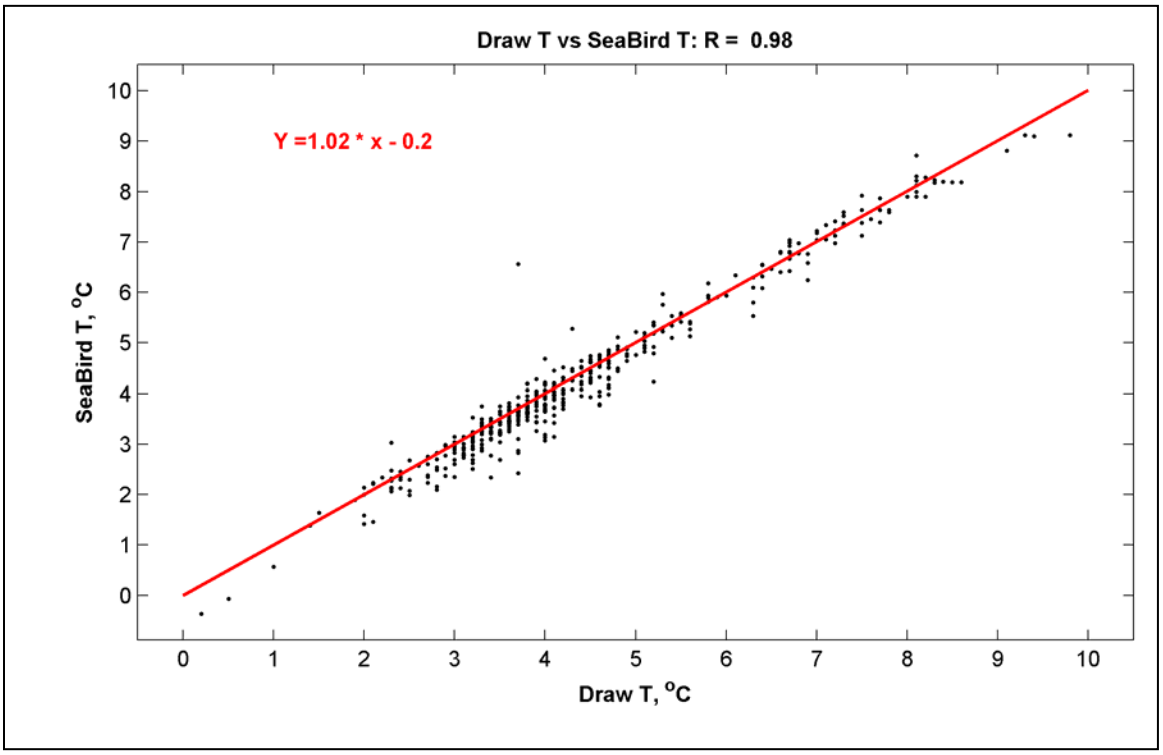


Figure C.3.1. Draw temperature of samples taken in the winch room vs the *in situ* temperature.

At the end of the 2010-009 mission, upon consideration, a decision was made to discontinue taking the draw temperature. Another simple reason for not taking it on the 2010-014 mission was the fact that the colorimeter software does not request the draw temperature at all (see the Introduction about the replacement of the titration system).

Samples were oxidized immediately with the addition of 1.0 mL each Alkaline Iodide and Manganous Chloride. A discussion was held on whether or not the tip of the spout should be submerged under the surface of the sample during this procedure, and the decision was made to submerge. The flask stopper was carefully inserted to avoid introducing air and the flask was thoroughly shaken.

The procedures for storing samples were different on the 2010-009 and 2010-014 missions. On the first one, the samples were stored immediately after collection for at least 30 minutes to allow the precipitate to settle in a 4°C refrigerator located in the GP lab as per original protocols: store cool and in the dark to prevent undesirable photochemical reactions. In the middle of the 2010-014 mission, upon having numerous problems with the colorimeter probe, it was believed that the problems were caused by tiny nitrogen bubbles, which form at low temperatures. Consequently, the decision was made to store samples in a dark place (also immediately) at room temperature, but no longer than for 2 hours, to avoid problems with bubbles due to higher temperatures.

3. Replicate analysis (time series)

As mentioned, during the 2010-014 mission, replicate samples were collected at least at some depths. Normally, two samples (duplicates) were taken; on two occasions, triple samples (triplicates) were taken. Figure C.3.2 presents the time series of the difference between the DO concentrations sampled at the same depth. As seen from the figure, most of the large differences occurred at the beginning of the 2010-014 mission, at the stage when the new Winkler system was poorly known. A few of them, however, happened at a later stage. The reasons for these discrepancies are not well understood, but we believe they are due to the formation of the bubbles on the colorimeter.

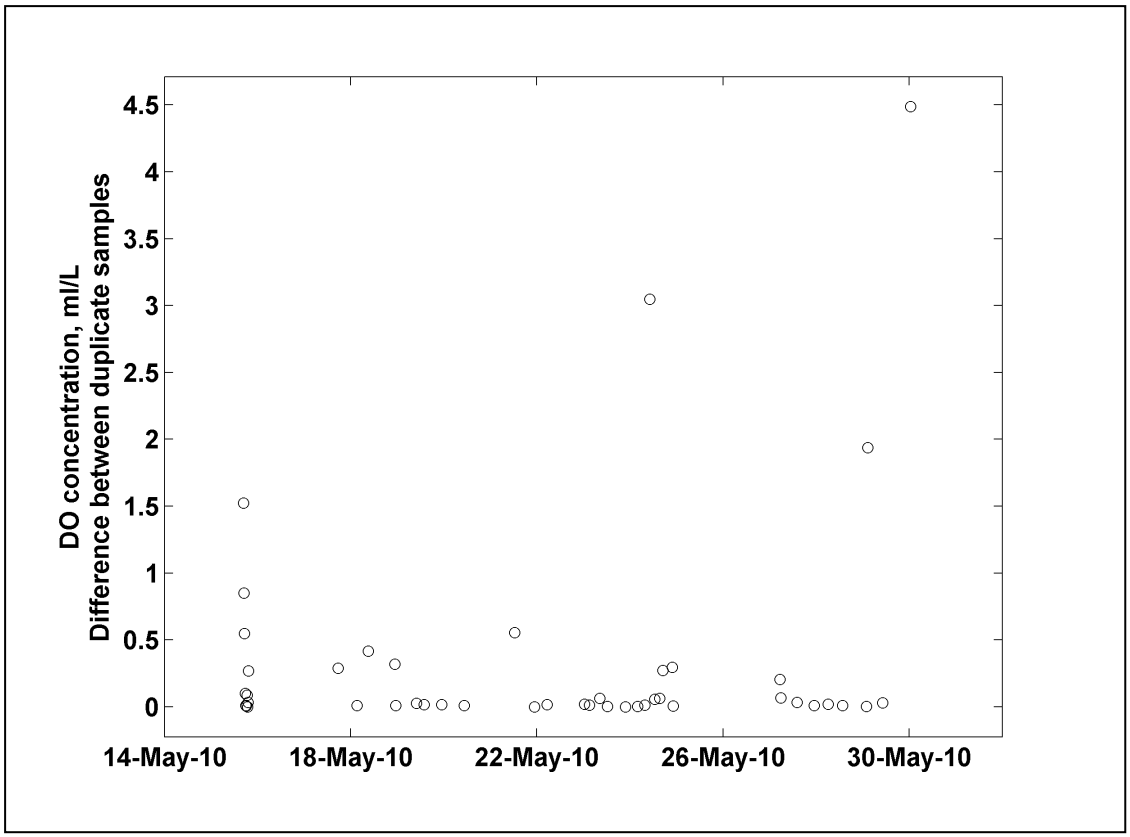


Figure C.3.2. Difference between the DO concentrations sampled at the same

4. Sea-Bird – Winkler comparisons

On both the 2010-009 and 2010-014 missions, the secondary CTD oxygen channel was logging spurious values because of the equation and calibration coefficients were wrong. This was fixed at the end of the cruise by Jeff Jackson. For this reason, this report covers only the results obtained for the primary oxygen channel.

4.1. Cruise 2010-009, Scripps Winkler system

The scatter plot of Sea-Bird vs Winkler O2 concentration is presented in Figure C.3.3. The left panel of that plot presents the scatter plot of the two values. The correlation coefficient is fairly small, almost negligible: R = 0.26. Nevertheless, at high end the cluster of points seems to be reasonably well aligned along the one-to-one correspondence line. This suggests that the problems at low end can be accounted for by poor sampling technique. The samples were taken by new people.

Plotted on the right panel of Figure C.3.3 is the relationship between the difference between the two values and pressure. The apparent slope is an indication that something was not right with the calibration coefficients used by the Sea-Bird processing software.

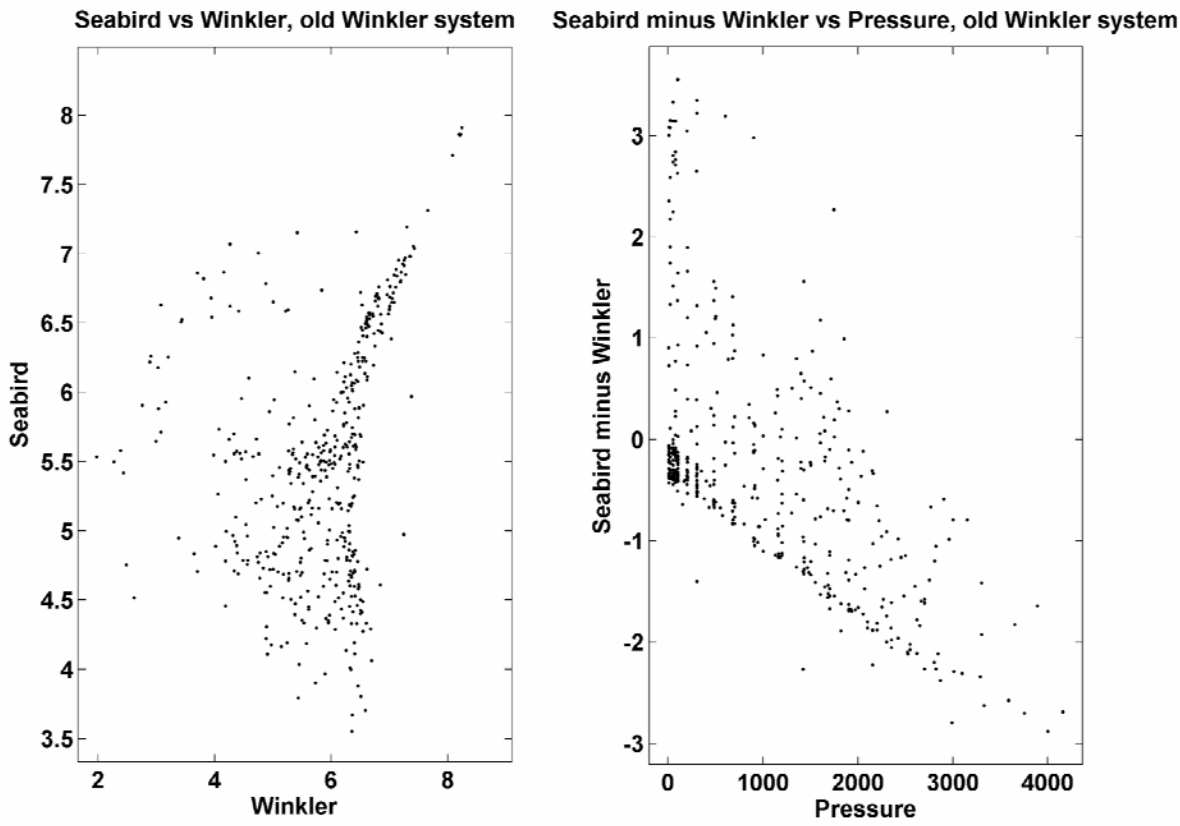


Figure C.3.3. Scatter plot of Sea-Bird vs Winkler O2 concentrations depth.

4.2. Cruise 2010-014, BOB system

The scatter plot of Sea-Bird vs BOB O2 concentration is presented in Figure C.3.4. The date when Jeff Jackson fixed the Sea-Bird calibration coefficients (20 May 2010) is used for the color-coding of the data points. Apparently, most of the red points are grouped along the one-to-one correspondence line, while most of the blue ones are off that line. Exceptions to this rule exist, however there are obvious outliers in both groups. The overall correlation coefficient is 0.46, although the removal of outliers would result in a successful calibration.

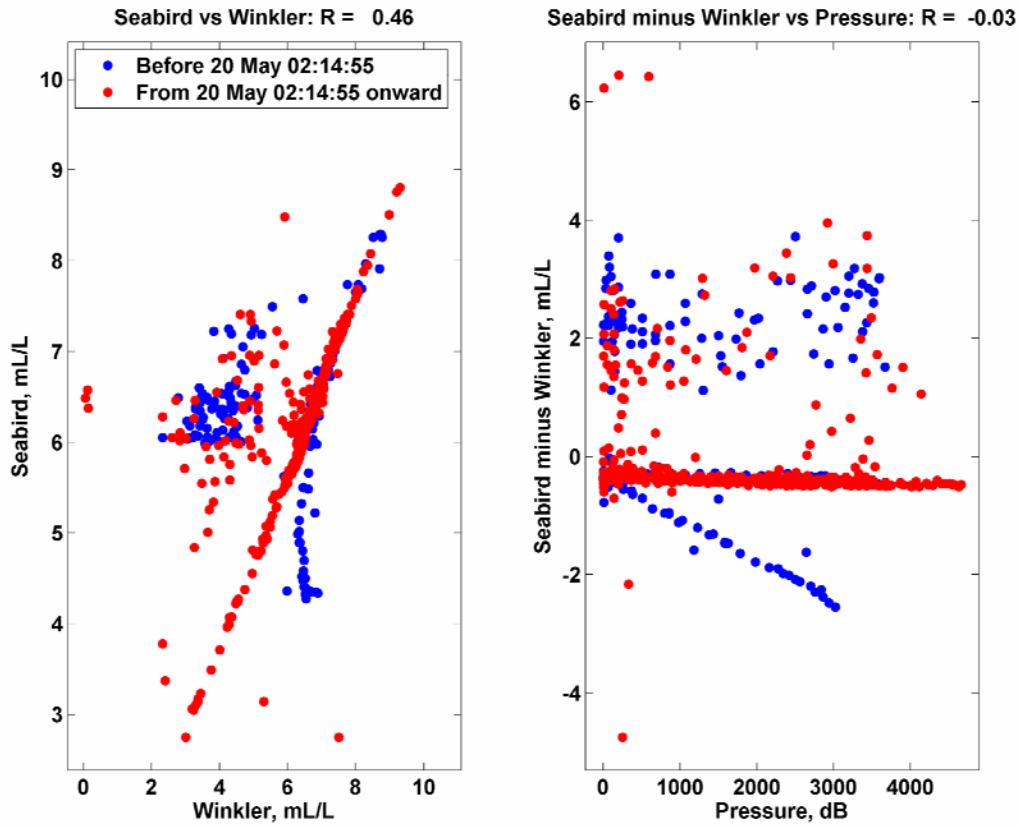


Figure C.3.4. Scatter plot of SeaBird vs Winkler O2 concentrations

5. Conclusions and recommendations

We have summarized the procedures for sampling, measuring and calibrating the DO concentrations on two Hudson missions in the spring of 2010. The two main problems encountered at sea were:

- Poor sampling practices were exercised (the 2010-009 mission only). The air bubbles in the samples caused some overestimation of the DO concentration at the low end of the calibration curve (see the lower part of the left panel in Figure C.3.3).
- The Sea-Bird calibration coefficients were incorrect for the majority of both missions.
- The BOB titration system was at times out of order. In such cases, the software produced the “PROBLEM” message. As a result, about 10 samples were lost.

In the future, we need to gain more understanding about the BOB titration system. Consultations with the software developers at IML are needed. In the future, we also need to ensure that the Sea-Bird calibration coefficients and equations used at sea are correct. This needs to be done prior to the missions.

3. Nutrients **Carol Anstey**

a. Description of Equipment and Technique

Samples were analyzed for silicate, phosphate, nitrate (nitrate plus nitrite) and ammonia using a Technicon Autoanalyzer II. The methods were standard Technicon for Seawater Analysis (Silicate 186-72W, Phosphate 155-71W, Nitrate/Nitrite 158-71W) except for Phosphate which has been modified by separating the Ascorbic Acid (4.0 gm/l) from the Mixed Reagent. The modified Mixed Reagent instead of water was introduced at the start of the sample stream (0.23 ml/min.) and the Ascorbic Acid was introduced separately between the two mixing coils (0.32 ml/min.) (Strain and Clement, 1996). Ammonia was determined by a method developed by R. Kerouel and A. Aminot; *'Fluorometric determination of ammonia in sea and estuarine waters by direct segmented flow analysis.'* Marine Chemistry 57 (1997) 265-275.

b. Sampling Procedure and Data Processing Technique

Duplicate nutrient samples were drawn into 30 ml HDPE (Nalgene) wide mouth sample bottles from the 10 L Rosette bottles. The sample bottles were pre-washed in 10% HCL, rinsed three times with Alpha-Q (de-ionized water) and oven dried at >100 Degrees F.

A sample run included six Calibration Standards, analyzed in duplicate, at the beginning and end of each shift's analysis. The standards, wash water and blanks for phosphate, silicate and nitrate/nitrite were made up in 33 ppt NaCl (Sigma, ACS Reagent); for ammonia, Alpha-Q water only. The second most concentrated Calibration Standard was used as a Check Standard every 16 samples, followed by blanks as a baseline check. The quality of analysis was checked by analyzing an Intercalibration Reference Material MOOS-1 for nutrients produced by NRC, Ottawa. There was no existing ammonia Reference Material.

The raw analog data was converted to digital data, processed and concentrations calculated using Michaelis-Menton Regression, including statistics, by an in-house Pascal 7.0 program (AAII) on a PC. Chart recordings, hard copy and disk copies of the data were archived.

c. Replicate Analysis

Total number of duplicate samples analyzed for Orphan Basin HUD2010-009: 892 and AR7W Labrador Sea HUD2010-014: 1476. Samples were analyzed as soon as possible after collection. Any samples collected off watch were kept refrigerated (4ºC) and analyzed within eight hours of collection.

This year it was decided to attempt to run all 5 nutrients at sea: nitrate/nitrite, silicate, phosphate, ammonia and nitrite. There were problems with a very erratic baseline and contamination for phosphate on the first shift of analysis. Samples from stations OB 2, 3, 7 and 9 had to be frozen until the sources of the problems could be repaired. All tubing was replaced, reagent bottles were acid washed and new reagent made up. Also, a double amount of surfactant was added to phosphate ascorbic acid; problems solved. Rough seas on May 5th to May 9th caused several mechanical problems. The sampling arm on the carousel for ammonia and nitrite would not swing. This was caused by the outer casing pushing against the swing arm mechanism where the instrument was tied down too tight. The older silicate colorimeter broke down possibly due to extra violent shaking breaking the A/D board or internal data cable connection. Data was collected on the strip chart but none in the voltage file on the computer. Data for calculations were entered manually from peak height measured from strip chart (OB-368536-368653). The spare that was brought along was a newer type that was not compatible with the older style data cables. Instead, the nitrite colorimeter was converted for use as silicate and no nitrite data was collected. Both of the older Kipp and Zonen chart recorders failed. Two new ones brought as spares were used allowing data collection for only four channels, silicate, phosphate, nitrate and ammonia. The peristaltic pump seized for silicate, phosphate and nitrate May 11 (368861-368900 analyzed; 368885-368900 frozen and reanalyzed next day). Extensive data editing had to be done before data could be reported. May 15, (369124-369134), silicate and phosphate channels collected data fine but ammonia and nitrate channels only collected on chart recorder; peak height data again had to be entered manually for calculation. Cause for this problem could not be found. A 'dummy' run was set up with standards only and all data collected fine. Extremely rough seas affected phosphate channel May 22; air bubbles kept getting caught in the flowcell. Unfortunately phosphate data had to be discarded (369437-369499). Frequent flushing of the entire system with 1N HCl followed by Alpha-Q water helped to prevent sample flow problems and build-up of molybdate coating of the flow cells.

The ammonia system was initially set up following guidelines recommended by Malcolm Woodward, Plymouth Institute of Oceanography. He recommended using High Purity Nitrogen gas in Tedlar bags to replace the 'air' supply for the segmented flow and head space of the mixed reagent. Also, the Alpha-Q system was brought to re-sieve Alpha-Q water brought on board in acid washed carboys. The Tedlar bags of gas were a dismal failure; difficult to fill and leaked very badly. The pump brought to push water back through the Alpha-Q system was inadequate. Ammonia data was not collected for the first few shifts. In the end, the air supply and reagent bottle were both fitted with a homemade gas trap consisting of a 10cc syringe filled with Sicacide (sulphuric acid coated molecular sieve) to absorb any ammonia from the air. Standards and samples were covered with Parafilm as soon as the sample cups were poured. These measures turned out to be perfectly adequate for avoiding any ammonia contamination. There was no increase in baseline or check standards throughout run and fluorometer settings did not change from normal lab settings for gain or sensitivity. The mixed reagent did not pick up ammonia and could be used over two days with no problem. Data for sample runs were excellent: stable baselines and very good calibration RMS – 'fit to curve'.

Again this year the GP lab temperature remained very warm: 24°C to 30°C. A fan was used to circulate air from an open porthole but doors were kept shut to maintain warm temperatures for the pH and alkalinity analysis. It helped that the Autoanalyzer was run at night when the ambient temperatures were cooler preventing degassing of molybdate reagents and build-up of precipitate in the nitrate colour reagent line but the warmer temperatures caused problems with degassing the dissolved oxygen samples coating the new colorimetric method cell window with fine bubbles.

All raw data had to be brought back to the Institute for editing and final calculations. The computer for this purpose cannot be used as a 'stand alone' but must be tied into the BIO Intranet. The old computer cannot be uploaded with an excel program adequate to edit and sort data. This problem must be solved before the next cruise so that data can be calculated, edited and reported on board.

The data quality parameters, determined with check standards and RMS offset from the calibration curve, came well within accepted values. However the MOOS-1 Intercalibration Reference Standard gave consistently high results. A summary of QC/QA MOOS-1 data as follows:

QC/QA		**Silicate µM**	**Phosphate µM**	**Nitrate µM**
Accepted Values	**from**	**25.00**	**1.490**	**22.80**
	to	**27.00**	**1.630**	**24.60**
Analytical Results MOOS-1		27.16	1.852	24.93
		27.44	1.828	25.41
		28.41	1.881	27.76
		28.39	1.912	27.25
		26.94	1.822	27.00
		26.94	1.797	25.46
		27.46	1.818	27.15
		27.50	1.790	27.04
		27.34	1.788	25.76
		27.16	1.790	26.20
		27.03	1.786	26.07
		26.97	1.771	25.56
		26.92	no data	26.37
		26.81	no data	25.62
		27.44	1.837	25.39
		27.40	1.838	25.62
		26.66	1.824	25.47
		27.01	1.832	25.56
		27.07	1.995	27.71
		26.96	1.839	27.88
		26.91	1.877	27.06
		26.96	1.791	26.99
		27.52	1.819	27.11
		27.67	1.754	27.11

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

RMS Offset from Curve:

	SILICATE	PHOSPHATE	NITRATE	AMMONIA
Mean (µM) (n=34)	0.115	0.042	0.089	0.080
Std. Deviation (µM)	0.115	0.020	0.043	0.032
Maximum (µM)	0.695	0.111	0.271	0.132
Cruise Average:				
Orphan Basin (n=7)	0.108	0.009	0.074	0.125
Std. Deviation (µM)	0.083	0.004	0.072	0.035
Labrador Sea (n=36)	0.075	0.018	0.175	0.139
Std. Deviation (µM)	0.044	0.007	0.131	0.052

The nutrient detection limits are an average of all analytical runs from both the Orphan Basin and Labrador Sea legs of the cruise.

	Silicate	Phosphate	Nitrate	Ammonia
Number of Samples (both legs)	2368	2244	2368	2010
Number of Duplicates	4736	4488	4736	4020
Detection Limit (µ moles/L)	0.19 ±0.16	0.039 ±0.033	0.11 ±0.06	0.10 ±0.09

Analytical Precision: Standard Deviation of Check Standards

Silicate	Phosphate	Nitrate	Ammonia
0.047	0.008	0.039	0.027
0.195	0.010	0.098	0.082
0.255	0.015	0.003	0.751
0.303	0.031	0.141	0.019
0.016	0.016	0.202	0.130
1.615	0.024	0.417	0.075
0.420	0.020	0.253	no data
0.469	0.015	0.205	0.155
0.204	0.017	0.090	0.135
0.302	no data	0.329	0.116
0.385	0.032	0.156	0.129
0.513	0.051	0.246	0.080
0.571	0.029	0.185	0.082
0.220	0.032	0.183	0.090
0.714	0.041	0.465	0.075

0.197	0.047	0.321	0.074
0.217	0.050	0.225	0.137
0.143	0.035	0.160	0.090
0.202	0.017	0.153	no data
0.223	0.013	0.189	no data
0.250	0.022	0.227	0.123
0.504	0.023	0.765	0.104
0.272	0.028	0.218	1.296
0.120	0.041	0.104	0.113
0.242	0.020	0.246	0.146

5. Dissolved Inorganic Carbon (DIC), Total Alkalinity (TA) and pH in Seawater

Kumiko Azetsu-Scott / Stephen Punshon

Samples for dissolved inorganic carbon (DIC) and total alkalinity (TA) were collected at standard hydrographic depths at the whole-number stations 1-28 on the AR7/W Line, with the exception of station 22 where no bottles were fired due to a malfunctioning rosette/CTD, and at stations 2, 3 and 6-13 on the Halifax Line.

Seawater samples were collected in 500 mL borosilicate glass bottles and analyzed for DIC followed by TA typically within 12 hours of collection following the methods prescribed in "Guide to Best Practices for Ocean CO2 Measurements" by Dickson et al. (2007). Water samples from stations 14 and 11 on the AR7/W were poisoned with 100µl of mercuric chloride to stop microbial activity and stored prior to analysis during the transit from the AR/7W to Halifax line. This preservation procedure was necessary due to a valve failure on the SOMMA instrument at the end of Station 15 and because of lack of analysis time between stations. A total of 475 samples for AR7/W and 206 samples for the Halifax Line were analyzed.

DIC was determined using gas extraction and coulometric titration with photometric endpoint detection (Johnson, et al., 1985). Total alkalinity was measured by open-cell potentiometric titration with a five-point method (Haraldsson et al., 1997). Bottles of Batch 99 Certified Reference Material (CRM) (supplied by Professor Andrew Dickson, Scripps Institution of Oceanography, San Diego, USA) were analyzed in duplicate every 20 samples to evaluate accuracy.

Samples for pH measurements were also collected at the same stations and depths as DIC/TA with additional samples taken at the biological stations. pH samples were collected in 60 mL amber "Boston Round" glass bottles with poly-seal lined closures and poisoned by adding 20 µL of saturated mercuric chloride solution within one hour of collection. A small air space of ~1 mL allowed for expansion of the sample due to temperature changes. These samples are stored at room temperature for later analysis using a spectrophotometric method at the Bedford Institute of Oceanography.

The SOMMA system for DIC was updated for 2010 with a new electronic valve interface control system, new software and a modern computer, and generally worked very well with excellent precision of around ± 1-2 µmol kg -1. Unfortunately, the failure of an old

Bio-Chem pinch valve (Valve #9) at the penultimate analysis of the Station 15 samples required preservation of the Station 14 samples so that a repair could be made. Valve #8 occasionally did not close completely, allowing excessive phosphoric acid to be delivered to the stripping chamber. The thermostat for the DIC sample water bath failed at the start of the Halifax Line requiring the cooler to be turned on and off manually. Consequently, the SOMMA water jacket temperature fluctuated in the range of 7-13 º C throughout the Halifax Line measurements.

In the case of the TA analytical system, there was an initial tendency for the stirrer motor to stick due to the titration cup support warping. This was rectified by applying a downward pressure on the support with an elastic cord. A slow leak of hydrochloric acid from the anti-diffusion delivery tip was noticed after filling the acid reservoir on May 20th and this may have caused some low TA values and poor precision especially for Stations 15 and 16. Efforts were made to wipe the delivery tip immediately prior to titration and the precision subsequently improved. It is likely that a leaking rotary valve on the Dosimat 655 titrator is the cause of this problem.

6. Oxygen isotope composition (δ18O) Kumiko Azetsu-Scott / Stephen Punshon

Water samples were collected in 60 mL amber "Boston Round" glass bottles with poly-seal lined closures at the surface three depths for the every station along AR7W line. For the station 17, the bottom three bottles were sampled instead of surface three samples. Entire depths were sampled at station 5, 16 and 28.

7. Halocarbons (CFCs) Darlene Brownell / Richard Nelson

Concentrations of chlorofluorocarbons, CFC-12, CFC-11, CFC-113, carbon tetrachloride and methyl chloroform were measured along transect lines, L3 and the Halifax line from May 13th to May 30st 2010. Overall, 32 stations were sampled, 564 and 10 sea water and air samples were collected and analysed, respectively.

a. Description of Equipment and Technique

To avoid atmospheric contamination, CFC water samples were drawn first, directly from the spigots of the PVC bottles on the rosette sampler directly into 100-ml glass syringes. Syringes were rinsed three times before they were filled. The samples were stored in a water bath of continuously flowing surface seawater until analysis (0°C – 10°C), less than 24 hours.

Halocarbons were stripped from seawater using an automated purge and trap system. Water samples were injected directly into the systems from a 100-ml glass syringe. A measured volume of seawater sample was transferred to a purge chamber, warmed to 80°C, and purged with a stream of UHP Nitrogen (80 ml/min) for 10 minutes. The analytes were trapped on a chromatographic absorbent (Porapak-N) packed in stainless steel tubing (3 mm x 17 cm) maintained at 10°C, the compounds were then desorbed by heating the trap to 170°C. A Varian 3300 Gas Chromatograph equipped with a 75m DB-624 megabore column and electron capture detection was used for the separation and quantification of the halocarbons.

The purge and trap system was susceptible to contamination whenever it was open for maintenance and repairs. For this reason, blanks are run after the system has been open until a stable baseline could be achieved.

b. Calibration

Results were calibrated using working standards prepared gravimetrically at Brookhaven National Laboratories, which was calibrated against a standard air sample certified by CMDL/NOAA, Boulder, Colorado. Analytical precision calculated from replicate measurements for CFCs was 1-3% and for CCl_4 4%.

c. Problems Encountered

There were minimum problems encountered with the instrumentation during the cruise. One of the computers (486 model) over heated and needed to be replaced. Another computer was re-built using spare parts and other similar computers and was used as a new back up computer.

c. Future work

Atmospheric CFC's have stopped increasing as a result of the restrictions enacted in the 1980s on the production and release of CFCs. Using CFCs as tracers to estimate the age of water masses have become more problematic encouraging the use of a new transient tracer. Currently, a new system is being built which will measure sulphur hexafluoride (SF_6), a new chemical tracer as well as CFC-12. This system is expected to be ready for the Labrador Sea 2011 cruise.

F. APPENDICES

Appendix 1. Operation Notes Report — Jeff Jackson

Note Number: 1	**Entry Time:** 19/May/2010 21:35:56	**Note Made By:** Jeff Jackson	**Operation ID**: 115
The CTD and rosette bottles stopped working at around 250 m during the upcast. The last 5 bottles could not be fired (369376 - 369380). The termination/splice was redone after this station.			

Note Number: 2	**Entry Time:** 23/May/2010 19:22:07	**Note Made By:** Jeff Jackson	**Operation ID**: 245
This CTD operation failed.			

Note Number: 3	**Entry Time:** 23/May/2010 23:13:13	**Note Made By:** Jeff Jackson	**Operation ID**: 247
CTD failed at 926 db. Piercing noise and error light flashing on deck unit.			

Note Number: 4	**Entry Time:** 26/May/2010 02:11:10	**Note Made By:** Jeff Jackson	**Operation ID**: 69
Original MVP was lost due to the line being snagged on something in the water.			

Note Number: 5	**Entry Time:** 26/May/2010 02:19:56	**Note Made By:** Jeff Jackson	**Operation ID**: 84
Net was cancelled but the operation was entered in the database when it should not have been.			

Note Number: 6	**Entry Time:** 26/May/2010 02:49:41	**Note Made By:** Jeff Jackson	**Operation ID**: 151
This was assigned to an XBT but the XBT was never launched and this operation was entered in the database but should not have been.			

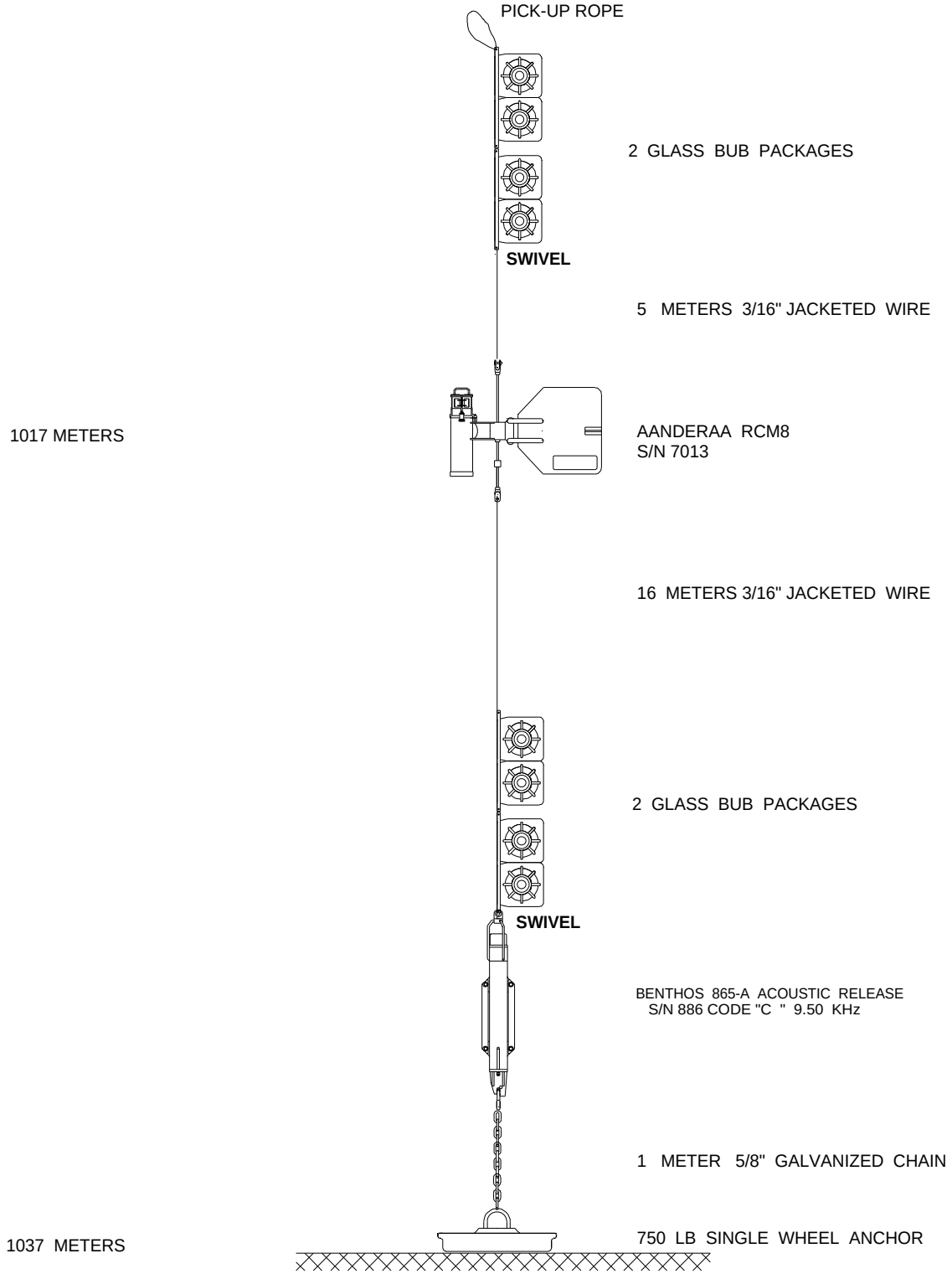
Recovery

Mooring No: M1729
Ship: HUDSON Cruise No: 2010-014 Date: MAY 23, 2010
Mooring Tech: BOYCE / HAMLING
Type of Nav:
Weather Conditions: CLEAR CALM
Cancel Notship: Yes____ No ____

Recovery Log

Time(Z)	Instrument	Remarks
1331		ENABLED ~ 1.7 MILES AWAY WHILE STEAMING
1353		RELEASE COMMAND SENT OK
14:25		On Board.

MOORING # 1729 HENDRY LAB SEA MAY 2009



Placement

Mooring No. 1771
Geographic Area: LAB SEA Intended Duration 1 YEAR
Ship: HUDSON Mission No: 2010-014 Date: MAY 23, 2010
Weather/Sea Conditions: CALM, CLEAR
Mooring Technician: BOYLE Type of Navigation: DGPS
Latitude: 55° 07.2120'N Longitude: -054° 05.3901 Time of Fix: 1537 (RA106B)
Main Float: Type: BUB Markings: YELLOW
Beacon: Type: — I.D. # ~
Mooring Line: Type: JACKETED Colour: YELLOW
Release: Type: 965A S/N: 891 Release Code: C Frequency 10.75 KHZ
Sounding:

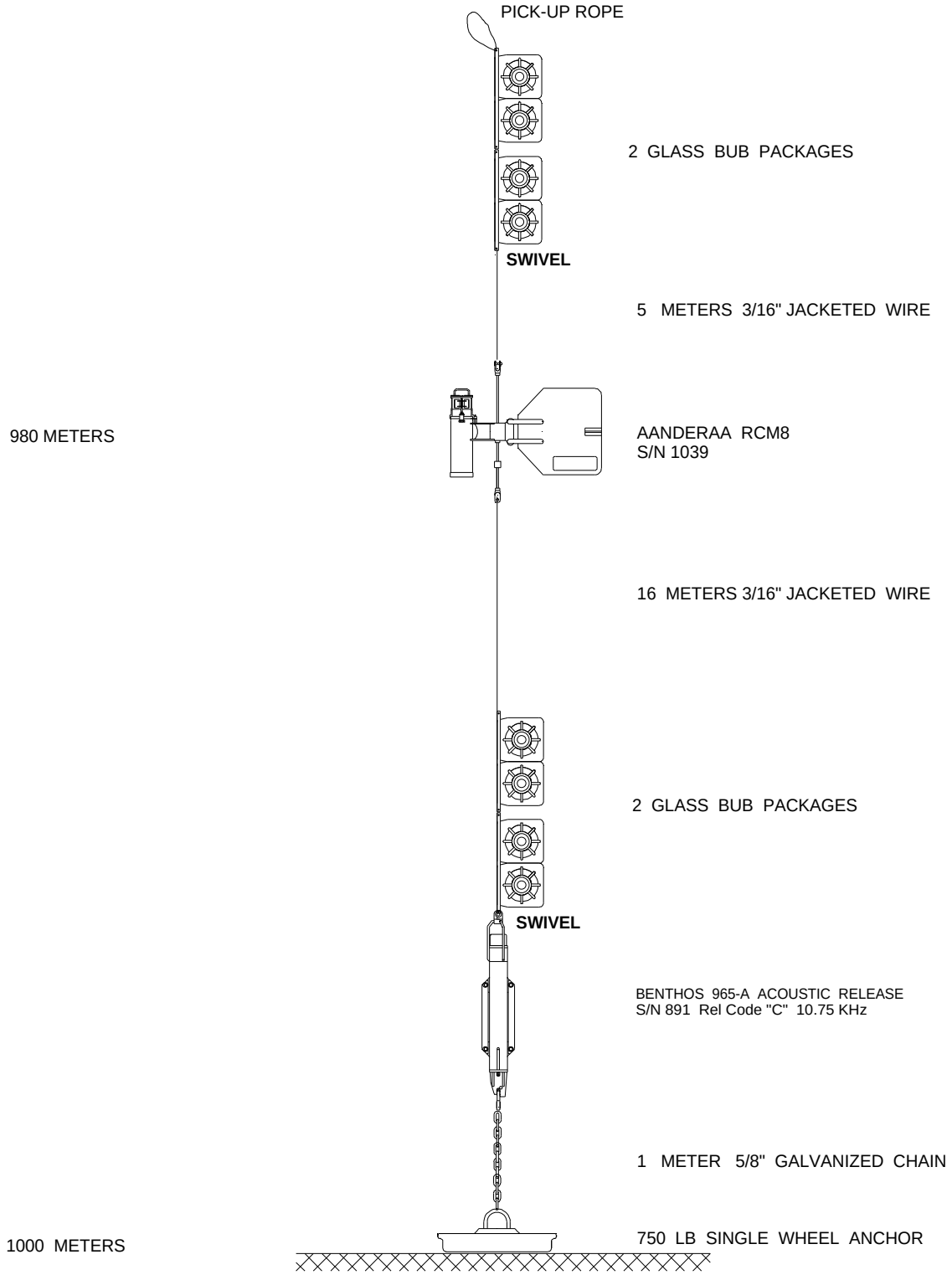
	LSR	Knudsen(12 khz)	Other
SV of Recorder	1463 m/s	1463 m/s	m/s
Initial Depth	fms	1024 m	m
Xducer Depth	m	INCLUDED m	m
Initial + xducer	m	1024 m	m
Depth Corrected	m	1031 m	m
@ SV =	m/s	@ SV = 1473.8 m/s	@ SV = m/s

Placement Log

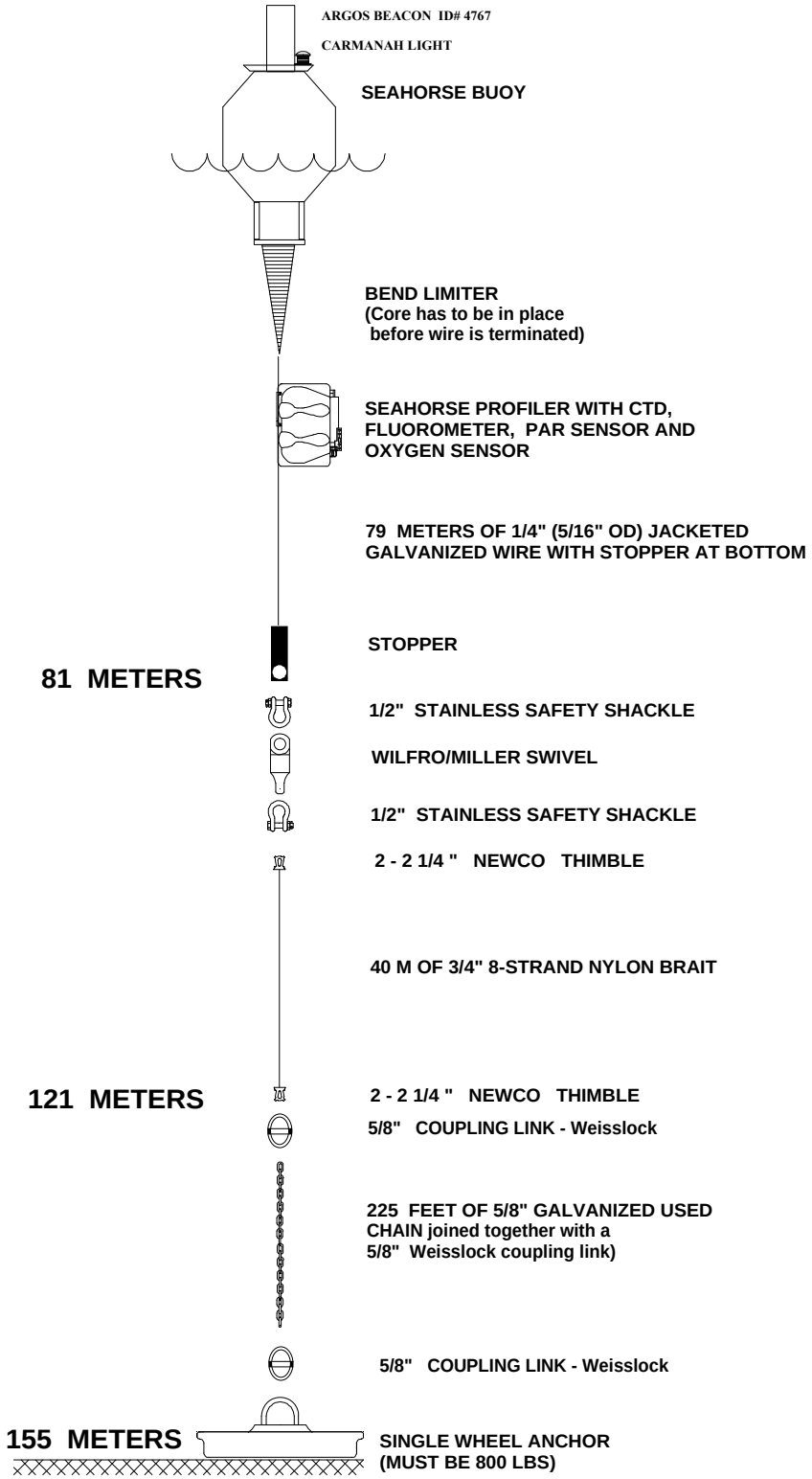
Time (Z)	Instrument	Remarks
1537		ANCHOR AWAY
ANCHOR	55° 07.2072'N	FIXED
	-054° 05.3758' W	
	@	1537 Z
		Mean Position
		N 55 07.2018
		W 54 05.3224
		Depth 1008.6 m
	FILE	HUD2010009\M1771.mcal

TARGET LOCATION
55° 7.20'N 54° 5.40'W

MOORING # 1771 HENDRY LAB SEA MAY 2010



MOORING# 1766 SEAHORSE HAMILTON HALIFAX STN #2 APRIL 2010



Appendix 3. CTD Initial Setup Information **Rick Boyce**

Original Request _X_ Update ___
Information Supplied By: ____Bob Ryan_____
Date: April 30, 2010

Mission: **HUD2010-014** Departure Date: **17 May, 2010**

Chief Scientist: **Hendry**

INSTRUMENT CONFIGURATION

Frequency channels suppressed = **0**
Voltage words Suppressed = **0**
Computer interface = **RS-232**
Scans to average = **1**
Surface PAR voltage added = **No X** Yes __
Scan time added= **No X** Yes __
NMEA position data added = **Yes**

Pri. Pump Serial Number: **051775**
Sec. Pump Serial Number: **051776**
Carousel Serial Number: **3240415-0624**

Channel Designation	Parameter	Model Number	Serial Number	Calibration Date	System Number
Frequency 0	Temperature - Primary	SBE3	035081	**8 April 2010**	**TS13**
Frequency 1	Conductivity - Primary	SBE4	**043561**	**8 April 2010**	**CS13**
Frequency 2	Pressure – SBE9*plus* s/n 9P7356-0289	410K-105	**69009**	**25 March 2010**	**PP06**
		Modulo 12P	**0362**	**31 Jan 1997**	
Frequency 3	Temperature - Secondary	SBE3	**035083**	**8 April 2010**	**TS14**
Frequency 4	Conductivity - Secondary	SBE4	**043562**	**8 April 2010**	**CS14**
Voltage 0	Altimeter	2110-2	**222**	**18 May 1999**	**AL01**
Voltage 1	Fluorometer Chelsea	AquaTracka Mk 3	**088172**	**10 February 1997**	**FC01**
Voltage 2	Oxygen	SBE43	**430042**	**06 January 2010**	**OX01**
Voltage 3	Oxygen	SBE43	**431588**	**06 March 2010**	**OX03**
Voltage 4	Irrandiance (PAR)	LI-193SA	**SPQA2711**	**17 June 1999**	**IR03**
		PN 90310	**0002-CH1**	**17 April 98**	**LA01**
Voltage 5	**Fluorometer, WetLabs**	CDOM WETStar	**WSCD-987P**	**18 August 2003**	**FL07**
Voltage 6	**pH Sensor**	**SBE18**	**180669**	**5 November 2008**	**PH01**
Voltage 7	Free	Free	Free	Free	

Additional Configure Information

ASCII Output: **Shared File – C:\CTDdata\shared.dat (refer to attached)**
Deck Unit Modem COMM Port = **COM ___** (selected in 'Realtime Data : Start Acquisition')
Water Sampler
- Number of Water Bottles = **24**
- Water Sampler Type = **SBE Carousel**
- Firing Sequence = **Sequential**
- Bottle Positions For Table Driven = < See CTD System Administrator if REQUIRED >

SPARES

Parameter	Model Number	Serial Number	Calibration Date	System Number
Temperature	SBE3	031256	23 February 2010	**TS06**
Temperature	SBE3	032303	13 March 2010	**TS10**
Temperature	SBE3	031376	9 February 2010	**TS03**
Temperature	SBE3	032298	13 February 2010	**TS09**
Conductivity	SBE4	040997	23 February 2010	**CS06**
Conductivity	SBE4	041874	13 March 2010	**CS10**
Conductivity	SBE4	041076	9 February 2010	**CS03**
Conductivity	SBE4	041873	13 February 2010	**CS09**
Pressure – SBE9*plus* s/n 9P5676-0249	410K-105	49258	18 March 2010	**PP02**
	Modulo 12P	0084	18 March 2010	
Pressure – SBE9*plus* s/n 9P9984-0370	410K-105	50601	18 March 2010	**PP05**
	Modulo 12P	0838	18 March 2010	

ASCII Output Setup (for shared file)

__X__ Generate Shared File

Shared File… **C:\Metering Sheave\shared.dat**

Number of seconds (data time) between ASCII updates: **0.5**

ASCII Output Variables

	Variable	Dec. Digits
Column #0	**scan number**	**0**
Column #1	**pressure**	**2**
Column #2	**altimeter**	**2**
Column #3	**none**	**3**
Column #4	**none**	**3**
Column #5	**none**	**3**
Column #6	**none**	**3**
Column #7	**none**	**3**

	Variable	Dec. Digits
Column #8	**none**	**3**
Column #9	**none**	**3**
Column #10	**none**	**3**
Column #11	**none**	**3**
Column #12	**none**	**3**
Column #13	**none**	**3**
Column #14	**none**	**3**

G. REFERENCES

Carritt, D. E. and J. H. Carpenter. 1966. Comparison and evaluation of currently employed modifications of the Winkler method for determining dissolved oxygen in seawater. Journal of Marine Research, 24, 268-318.

Culberson, C. H. 1991. WHP Operations and Methods. Dissolved Oxygen. (http://whpo.ucsd.edu/manuals/pdf/91_1/culber2.pdf)

Levy, E. M., C. C. Cunningham, C. D. W. Conrad and J. D. Moffatt. 1977. The determination of dissolved oxygen in sea water. Bedford Institute of Oceanography Report Series, BI-R-77-9, August 1977.

SIO/ODF. 2000. Oxygen titration manual. Scripps Institute of Oceanography, Ocean Data Facility. Version 22-Feb-2000.

Strain, P.M. and P.M. Clement. 1996. Nutrient and dissolved oxygen Concentrations in the Letang inlet, New Brunswick, in the summer of 1994. Can. Data Rep. Fish. Aquat. Sci. 1004: iv + 33p.

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