HLY-04-04, SBI Mooring Cruise. 2 Sep – 1 Oct, 2004
CTD and Water Sampling Summary

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Introduction

This report describes the hydrographic sampling program carried out on the 2004 Shelf-Basin Interactions (SBI) mooring cruise. This was the third in a series of cruises designed to study the manner in which the Arctic shelves and the open Arctic communicate with each other and how this might be influenced by climate variability. The cruise took place from 2 September through 11 October 2004. The principal investigator was Robert Pickart of the Woods Hole Oceanographic Institution (WHOI), Woods Hole, Massachusetts. Co-principal investigator was Tom Weingartner of the University of Alaska Fairbanks (UAF.) CTD data processing was carried out by WHOI, the water sample salinity and nutrients program was done by the Scripps Institution of Oceanography (SIO), chlorophyll measurements were taken by the University of Alaska, Fairbanks, and carbon measurements by the Rosenstiel School of Marine and Atmospheric Science, Miami, Florida.

A total of 157 CTD stations with bottom depths ranging from 30m-–2300m were collected from the Chukchi and western Beaufort Seas. Water samples were taken at 117 of these stations. Water sample measurements typically included dissolved oxygen, salinity, nutrients, chlorophyll and phaeopigments. In addition, Oxygen 18, dissolved organic carbon, particulate organic carbon, total carbon dioxide, alkalinity, and radium samples were collected during particular sections. CTD casts typically went to within 5m of the ocean floor; however, during the eddy survey and on comparison casts for the mooring sensors, it was not necessary to take the CTD to the ocean bottom.

CTD Package

CTD and water sample data were collected using the USCGC Healy's Seabird 911+ system operating at 24Hz scan rate, with a 24-position rosette package and 24 12-liter Niskin bottles. In addition to a dual set of pumped temperature and conductivity sensors, the CTD had a SBE43 oxygen sensor pumped in-line with the primary temperature and conductivity sensors, a WetLabs CST transmissometer, an Aquatraka fluorometer, and a Benthos altimeter. Fortunately, a backup frame, CTD and auxiliary sensors were also provided because we were required to change out the CTD and the altimeter during the cruise. See Appendix A for sensor serial numbers, calibration dates and position on frame.

Data Acquisition and Processing Procedures

Upon reaching the station, the rosette was brought out of the hanger, the CTD was powered on and data acquisition started. The transmissometer and fluorometer windows were cleaned immediately before each deployment. The sensors were soaked for three minutes at 10m after the pumps turned on. The CTD frame was then raised back to the near–surface (between 2m and 5m) and lowered at 30m/min to 100m and then at 60m/min. The descent rate was slowed to 30m/min approximately 60m off the ocean floor, and slowed further at 10m off the bottom. Depending on sea state, maximum CTD depths were within 1 to 5m of the ocean bottom. The bottom bottle was fired immediately and subsequent bottles were closed after waiting 30 seconds at each stop. The 'surface' bottle was taken at 10m to avoid the extremely large surface gradients and the change in water properties due to ship's presence (for example, the propeller wash). The CTD was turned off after the package was landed on deck, the water sampler rinsed with fresh water and the package returned to the heated hanger for sampling.

The CTD data were acquired and processed with Seabird software on a PC platform with further processing using routines written in Matlab® (The MathWorks Inc.). Acquisition occurred real -time through a conducting cable from the CTD to a PC running Seasave-Win32_V5_31a. The ship's GPS position was added to each data scan via the National Marine Electronics Association (NMEA) interface. Upon completion of the station, the data were copied via the ship's network to the processing PC. Seabird's windows-based processing software, SBEDataProcessing-Win32_V5_29b, was then used to produce 1-decibar averaged downcast and upcast profiles. The standard processing steps followed at sea were: sensor alignment through advancing conductivity; spike removal; a correction for the thermal mass of the temperature sensors; filtering; removal of pressure reversals; calculation of oxygen; averaging to 1 db levels; calculation of other derived properties; and separation of each station file into downcast and upcast profiles.

Next, conductivity and oxygen sensors were calibrated to the water samples and the calibration applied to both the downcasts and the upcasts using Matlab®.

Data Files

The file naming scheme starts with a 'd' or 'u' to indicate downcast or upcast and follows with five digits, 'dSSSCC.*', where SSSCC is a 3-digit station number (SSS) and 2-digit cast number (CC). Repeat casts (cast 2 and cast 3) were performed to collect radium samples. Occasionally the repeat cast would be performed out of sequence, i.e., we moved onto 4 new stations and then came back for the radium cast.

Raw CTD Acquisition Files from Seabird Sea-Save

SSSCC.dat	raw data
SSSCC.hdr	header file
SSSCC.bl	bottle trip scan numbers
SSSCC.con	configuration file

SSSCC.mrk	mark scan numbers, used to indicate start of down cast, bottom of cast, end of cast. Also used to mark the comparison stops during the CTD comparison casts where FSI EMCTDs and SBE Microcats were attached to the rosette frame.

Processed CTD Files

dSSSCC.cnv	down 1 db averaged file in Seabird format
dSSSCC_ct1.csv	down 1 db averaged file in JOSS format, comma delimited, and can be read using EXCEL
uSSSCC.cnv	up 1 db averaged file in Seabird format
uSSSCC_ct1.csv	up 1 db averaged file in JOSS format, comma delimited, and can be read using EXCEL
dSSSCC.dcc	final, edited (to remove density inversions) 1db averaged file in Seabird format.

Water Sample File

HLY0404_HY1.csv	water sample file with merged ctd data
DSSSCC.nut	merged nutrient and CTD (pressure, temperature, salinity, oxygen) at sample depths.

CTD Data Quality

Overview

The CTD, rosette and Niskin bottles performed well. The CTD temperature and conductivity sensors performed to their specified accuracy. The only equipment problems experienced were leaky connectors and the failure of the first altimeter. The auxiliary-4 CTD bulkhead connector leaked repeatedly even after the cable was changed out. Due to this, the CTD body was swapped out before station 61, but all the sensors were kept in their same configuration and plugged into the spare CTD. Removing the CTD with the bad auxiliary-4 connector revealed the modem bulkhead connector also had a slow leak. These connectors were replaced although we never needed to switch back to this CTD. The altimeter was changed out shortly afterwards for station 64. It was not reading full scale (~98.5m) when it was over 100m from the ocean floor and during the bottom approach of station 63 the altimeter was reading 4m as the package touched the bottom. The altimeter base appeared damaged although we had not experienced any event that would have caused this damage. It was surmised that the altimeter may have been damaged earlier but due to cycling in the cold and to greater pressure, the damage became obvious.

The CTD wire was reterminated once, after station 83. Since the CTD had swung strongly in the block and, prior to this high-tension event, had developed a kink, it was decided to reterminate the wire as a safety measure.

The CTD touched the bottom during stations 63 and 77, both at slow speed and without any change to the calibrations.

The pumps were frozen at the start of station 111, cast 2. The CTD was recovered and the pumps thawed before redeployment. After this the hangar door was lowered further and the gap between door and floor was covered to try and keep the floor at a warmer temperature. The pumps did not freeze again.

These were the major issues for the CTD; however, the complete list of station comments is included in Appendix B.

Pressure

On deck pressure was examined for stations 1 to 49 to determine if a mean pressure offset existed. Typically there was an offset of 0.3db before the cast and –0.2db after the cast. The CTD is powered up just before the cast, and typically the CTD pressure drifts from 0.4 towards 0 during the pre-cast time on deck. Based on this, it appears a longer warm-up period could be used and that there is no pressure bias.

Temperature

The primary and secondary temperature sensors were compared using the data from the bottle stops. They show a mean difference of less than 0.0005 °C. This inter-comparison supports the stated instrument accuracy of 0.001°C without requiring a post-cruise calibration.

Conductivity

The conductivity sensors were very stable, requiring only one calibration during the cruise and providing the stated accuracy of 0.002 PSU. Stations 1 to 111 were used in the fit. Surface values were used in the fit to obtain a slope over the range of conductivities; however, the majority of observations discarded by the iterative fitting routine (acceptable residual criteria was less than 2.5 * standard deviation (STD)) were from the high salinity gradient water in the upper 50m. Therefore, the accuracy quoted above should apply to the deeper water column only, while an accuracy of .007 is more appropriate for the upper layer (see the AWS02 CTD data report for a complete explanation.)

Sensor	Slope	Bias	STD mS/cm	Number of Observations
Primary	1.00016	-0.00358	0.0012	306 of 555
Secondary	0.99959	0.01003	0.0011	284 of 555

Oxygen

The oxygen sensor was also quite stable with one calibration performed for the cruise. The data were calibrated to the water samples, using stations 1 to 96. The calibration method followed the Seabird Application Note Number 64-2. This method determines two of the six coefficients, Soc and Voffset. The other coefficients were left at their laboratory calibration settings. All water samples were used in an iterative fitting routine (acceptable residual criteria was less than 2.5 x STD). The standard deviation of the calculated oxygen (using the same observations that passed the fitting criteria) was 0.05 ml/l.

Sensor	Soc	Voffset	STD	Number of Observations
Oxygen	4.0268e-01	–0.4434	0.006 oxy/phi	422 out of 560
			0.05 ml/l	422 out of 560

Fluorometer

The fluorometer data were not processed.

Transmissometer

The transmissometer data were not processed. A log of the full scale in-air and blocked in-air readings were measured from 7 September to 16 September. They show little change over this period. The full-scale in-air reading had a range from 4.56 to 4.8 volts with a more consistent reading after the transmissometer had been powered on for a few minutes. The blocked reading had a range of 0.048 to 0.056 volts. The window was cleaned with de-ionized water prior to each cast.

Density Inversions

Plots of density versus pressure for each station were created to identify spikes and density inversions in the downcast. For the first pass, an increase of 0.004 kg/m^3 was used to define density inversions at depths over 10m. Primary temperature and conductivity sensor data were interpolated at the location of the inversions, and the derived properties (salinity, density, theta) were recalculated. A detailed list of the interpolated points can be found in Table 1.

Table 1. First Pass Interpolation List

This list contains the pressure intervals over which the primary temperature and conductivity data were linearly interpolated.

```
%SBI04 List of pressure values where properties were interpolated
%Property Key:
%(1) Temperature
%(2) Conductivity
%(3) Temperature and Conductivity
%(4) Oxygen
%(5) Transmission
%(6) Fluorescence
%Station  Start (db)   End(db)  Property
%*******  **********  ********  ********
    101           0         9         3
    201           0         8         3
    501         128       130         3
    601           8        10         3
    601          19        21         3
    603           0         3         3
    603         196       197         3
    701           5         9         3
    701         249       251         3
    701         278       280         3
    702          14        23         3
    702         206       209         3
    703           0         5         3
    703          48        50         3
    801         104       106         3
    901         327       330         3
    902         339       341         3
   1001          28        31         3
   1001          38        40         3
   1301         153       155         3
   1401         456       458         3
   1502           7         9         3
   1502          71        74         3
   1801         771       773         3
   2101          13        18         3
   2201         308       310         3
   2301          33        34         3
   2301           9        11         3
   3101          11        14         3
   4201           4         6         3
```

4601	11	15	3
4601	35	37	3
4701	52	53	3
4702	21	23	3
4702	50	51	3
4901	30	33	3
4901	34	35	3
4902	33	34	3
5602	0	12	3
5901	10	12	3
5901	19	25	3
6001	6	9	3
6001	10	12	3
6001	17	21	3
6002	5	7	3
6002	9	11	3
6201	4	6	3
6201	66	68	3
6301	9	11	3
6301	67	68	3
6501	4	15	3
6902	11	13	3
6902	16	18	3
7001	180	182	3
7001	194	196	3
7101	160	162	3
7101	206	208	3
7501	358	360	3
7701	478	481	3
7901	39	41	3
8001	5	7	3
8001	61	63	3
8001	23	26	5
8101	12	14	3
8101	45	47	3
8201	4	7	3
8301	19	21	3
8301	42	44	3
8301	45	47	3
8304	8	10	3
8701	55	57	3
8701	62	65	5
8902	6	12	3
9101	8	12	3
9101	111	112	3
9301	119	121	3
9501	15	17	3
9501	135	137	3
9601	7	12	3
9601	16	18	3
9601	46	48	3
9701	66	68	3
9701	69	71	3
9701	89	91	3
9801	32	35	3
9801	45	47	3
9801	144	146	3

9801	241	243	3
9901	29	31	3
9901	32	34	3
9901	36	38	3
9901	40	42	3
10201	171	173	3
10301	10	12	3
10401	33	35	3
10401	36	38	3
10401	39	41	3
10401	42	44	3
10701	10	12	3
10701	588	591	3
10801	11	13	3
11102	10	16	3
11201	213	216	3
11401	10	13	3
11401	19	21	3
11401	130	132	3
11401	180	182	3
11401	187	189	3
11401	119	121	3
11401	126	128	3
11401	234	236	3
11401	243	245	3
11401	258	260	3
11501	117	120	3
11501	125	129	3
11501	132	136	3
11501	141	143	3
11501	149	152	3
11501	175	177	3
11501	228	230	3
11801	212	214	3
11901	175	180	3
11901	210	212	3
11901	283	285	3
11901	290	292	3
12102	11	16	3
12102	227	229	3
12102	280	282	3
12301	43	46	3
12301	58	60	3
12301	62	64	3
12301	80	82	3
12301	85	87	3
12301	89	91	3
12301	105	110	3
12301	237	239	3
12301	245	248	3
12302	45	47	3
12302	52	54	3
12302	56	58	3
12302	302	303	3
12501	61	63	3
12501	65	67	3
12501	69	71	3

12701	14	16	3
12701	38	40	3
12801	51	54	3
13301	18	20	3
13301	20	22	3
13301	24	26	3
13401	23	25	3
13501	9	16	3
13501	16	21	3
13601	10	12	3
13601	23	26	3
13801	35	38	3
13901	28	30	3
13901	40	42	3
13901	43	45	3
14001	38	40	3
14201	34	36	3
14301	34	36	3
14301	32	34	3
14401	34	36	3
14601	37	39	3
14901	41	42	3

After the cruise, the criteria for interpolating density inversions in the primary sensors of the downcast profiles were refined. Inversions greater than .002 kg/m^3 over the entire water column, including the upper 10 m, were identified. Where an inversion was detected, salinity derived from the primary conductivity sensor was linearly interpolated between the bounding good salinity values. Density was recalculated and plotted, and, if inversions were still detected, temperature from the primary temperature sensor was analogously interpolated. In cases where a good bounding salinity did not exist (inversions at the surface), the first one or several records were deleted up to the point where a reasonable density profile began. Secondary temperature and salinity were left unedited. A detailed list of these interpolations can be found in Table 2. The WOCE quality code for interpolated values was set to 7. An additional data set was created where quality codes were set to 7, but values were simply filled with a missing data value of –9.000.

Table 2 Second Pass Quality Control Interpolation List

This list contains the pressure values at which the primary temperature and conductivity data were linearly interpolated (for one data set) or filled with the missing data value of –9.000. For both final data sets, the WOCE quality code at these pressures was set to 7.

Station	Pressure
00202	8-11,47
00301	12
00401	4,5,6,7,57
00402	4,5,9
00501	5,6,131,132,133,136
00601	5,6,7,8,9,10
00702	3,4,5
00801	3,4,5,6,7,8,9,10,11
00901	3,4,6,8,9,10,11,
00902	3
00903	6,7
01001	5,9,10,11
01101	3,4,5,6
01301	8,9
01501	50
01502	3,4,5,6,7,62
01503	7,8,9
01601	6,7,8,9
01701	8,9,10
01801	7,8
02101	4,5,6,7,8,9,10
02201	4,5,6,7,8,9
02501	4,5,6,7,8
02801	3,4,5,6
02901	6,7,8
03001	4,5,6,7,8,29,30
03101	6,7,8
03201	2,4,5
03401	8
04101	7,8,9,10,11
04201	5,6
04402	9
04702	3,4,5,6,7
04801	6,7,8,9
04902	6,7,8,9,10,11,12
05101	3,5,6,7,8
05201	3,4,5,6,7
05301	3,4
05401	3,4,6,8
05501	5,6,7,8,9,10
05601	7,8,9
05603	7,8,9,10
05701	6,7,8
05901	5,6,7,8,9,10,11
06101	3,74
06601	9,10,11,12
06901	4,5,6,7,8,9,10
06902	3,5,6,7

06903	4,5,6,7,8,9
07001	5,6,7,8,9,10
07101	3
07201	4
07401	4,5,6,7,8,9
07501	8
07601	5,8
07701	3,4,5,6
07801	3,4,5
07901	5,6,7,8,9
08001	60
08101	3
08301	11,12,13,14,15,16,17
08304	7
08401	42
08601	6,7,9
08701	8
08801	4,5,6,7,8
09001	7,8,9,10
09101	6
09201	10,11,12
09501	7,8
09601	5
09901	5,7,8,9,14
10501	5,6,7,8,9,10
10701	3,4,5,6
10801	8
11001	5
11101	3,4,5,6,7
11102	9,10,11,12
11201	60
11401	220,227
11701	13
11901	10,11,12,13
11901	13
12001	244
12301	68,69
12502	8
13001	10,11
13701	38
14301	31

Final Data Product

For ease of distribution, it was decided that quality –controlled final data files would be converted to WOCE Hydrographic Programme format. For these data, bad data flags were inserted and the quality word set to 9 to indicate despiked. Oxygen units were converted from ml/l to umol/kg. See the document "Final Data Description.pdf" for a complete description.

Water Sample Acquisition and Analyses

Salts, Nutrients, Oxygen, and Water Sample File Preparation

See Appendix D. Hydrographic Team Activity Report (Healy 04-04), Daniel Schuller, Scripps Institute of Oceanography, San Diego, California.

Chlorophyll

Dean Stockwell, University of Alaska, Fairbanks, Alaska.

Chlorophyll samples were collected from casts covering 106 of the stations occupied during the 2004 SBI Mooring cruise. Six to nine depths per cast were sampled and processed. In addition, samples were processed from 8 stations, that were collected during underway analysis (Sharon Smith). Data entry into the data server was performed following quality control checks on spreadsheet information. Highest chlorophyll concentrations for the cruise (8.2 μg Chl/l) occurred at station 36. Chlorophyll samples were filtered onto 25 mm GF/F filters and extracted for 24 hours in 90% acetone and determined fluorometrically (Evans and O'Reilly, 1983; Holm-Hansen *et al*., 1965).

Evans, C.A. and J.E. O'Reilly. 1983. A Handbook for the Measurement of Chlorophyll *a* in Netplankton and Nannoplankton. Biomass Handbook No. 9. N.O.A.A.

Holm-Hansen, O., C.J. Lorenzen, R.W. Holmes, and J. D. Strickland. 1965. Fluorometric determination of chlorophyll. J. Cons. Cons. Int. Explor. Mer 30:3-15.

DOC,POC,TCO2,Alkalinity

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Dissolved organic carbon (DOC) samples were taken on all CTD lines and during the eddy survey. Full depth profiles were conducted with 375 total samples taken. These samples were frozen and stored to be analyzed in the laboratory upon return. Total CO2 and alkalinity samples were taken on all lines at the surface only, with the exception of the eddy profile in which full depth profiles were taken for both. 210 samples were taken for TCO2 and Alkalinity. Particulate Organic Carbon (POC) samples were taken during the eddy survey. 120 samples were taken at full depth ranges throughout the eddy work and will be analyzed upon return along with the DOC, TCO2 and alkalinity samples. The main objective of the cruise was to quantify the total carbon transport that occurs in an eddy moving from the shelf break into the Canada Basin. The high- resolution sampling that was conducted in the eddy is expected to accomplish this objective.

Appendix A. CTD Configuration

Main CTD	S/N	Last Cal	Stations
SBE 9+			
Pressure	0639		001 to 060
Primary Temperature	2796	02Jul04	001 to 157
Primary Conductivity	2545	02Jul04	001 to 157
Secondary Temperature	2824	02Jul04	001 to 157
Secondary Conductivity	2568	02Jul04	001 to 157
Oxygen SBE43	459	30Jun04	001 to 157
Trans. Wetlabs CST	CST-390-DR	20Nov03	001 to 157
Fluor. MKIII Aquatracka	088233	21Jan04	001 to 157
Benthos Alt. PSA-916D	872	default	001 to 064
Change outs:			
Pressure	0638	5Mar04	061 to 157
Benthos Alt. PSA-916D	843	default	064 to 157

Main CTD was horizontally mounted at base of CTD frame. The package included a 24 bottle rosette with 12-liter Niskin bottles and SBE Rosette. Oxygen was in line with primary temperature and conductivity. Both Temperature and Conductivity pairs have pumped flow. Fluorometer and transmissometer are not pumped systems.

After swapping out CTD 0639, Jim Schmidt replaced the modem and auxiliary-4 (v6 and v7 channel) bulkhead connectors. The swap was made because auxiliary-4 connector was leaking, but it was discovered after the swap that the modem connector had also leaked.

Auxiliary Sensor Configuration 1, Stations 1 to 59

Auxiliary 1	V0	Fluorometer
	V1	Free
Auxiliary 2	V2	Free
	V3	Free
Auxiliary 3	V4	Transmissometer
	V5	Free
Auxiliary 4	V6	Altimeter
	V7	Oxygen

Auxiliary Sensor Configuration 2, Stations 60 to 157

Auxiliary 1	V0	Fluorometer
	V1	Free
Auxiliary 2	V2	Altimeter
	V3	Free
Auxiliary 3	V4	Transmissometer
	V5	Free

Auxiliary 4	V6	Oxygen
	V7	Free

Configuration Files

Filename	Stations	Change
Hly0404_1.con	00101 to 05901	First setup
Hly0404_2.con	06001	Changed voltage channels
Hly0404_3.con	06101 to 06401	Changed pressure housing
Hly0404_4.con	06002 and 06501 to 15701	Changed altimeter

Height from bottom of frame

Pressure	7”
Primary Temperature	3.5”
Primary Conductivity	5.5”
Primary Pump	6.5”
Oxygen SBE43	6”
Secondary Temperature	3.5”
Secondary Conductivity	5.5”
Secondary Pump	6.5”
Trans. Wetlabs CST	2.75”
Fluor. Aquatracker	4”
Altimeter	2.5”
Bottle bottom	24.25”
Bottle mid-point	24.25”+19.5”

Distance between Temperature Sensors 7”

Tubing Lengths in Primary system:

Conductivity to Oxygen	2.5”
Oxygen to Pump	4.5”

Tubing Lengths in Secondary system:

Conductivity to Pump	6.5”

Appendix B. Individual Station Notes

Notes from station logsheets and processing:

1301 Did not get within altimeter range of bottom.
1401 Did not get within altimeter range of bottom.
1502 Radium and EMCTD comparison cast. EMCTDs s/n1313(BS7) and s/n1346(BS8).
1503 Radium and EMCTD comparison cast. EMCTDs s/n1313(BS7) and s/n1346(BS8).
1601 EMCTD comparison cast. EMCTDs s/n1355(BS3) and s/n1337(BS4).
1701 EMCTD comparison cast. EMCTDs s/n1337(BS2) and s/n1363(BS4).
1801 EMCTD comparison cast. EMCTDs s/n1355(BS3) and s/n1341(BS5).
1901 EMCTD comparison cast. EMCTDs s/n1337 (BS2) and s/n1341(BS5).
2001 MicroCat comparison cast. Microcats s/n 2131(BS1) and s/n 2132 (BS2).
2101 MicroCat comparison cast. Microcats s/n 2139(BS6).
Wire kinked while taking up slack prior to deployment.
2201 MicroCat comparison cast. Microcats s/n 2135(BS3), s/n2136(BS4), and s/n2137(BS5)
2301 Oxygen sensor not properly soaked. Only waited at 5m until pump turned on.
2401 Oxygen sensor not properly soaked. Only waited at 5m until pump turned on.
3001 Niskin 2 closed without waiting for 30-second wait so closed Niskin 3 at same depth. CTD tags will be left for both Niskins but water samples should be merged with Niskin 3 because they were drawn from this Niskin.
Surface mark is actually at 30db.
3301 T1-T2 difference looks larger than normal. May be due to jellyfish tentacles (seen on frame), or due to large swell in shallow water with large gradients. Later (station 45-47) a small blob of jelly-fish material freed from tubing between C2 and pump.
3401 Bottom mark is 5m off the bottom of cast.
3801 Did not wait 30 sec on Niskin 3
3901 Niskin1 was deployed with bottom cap closed. No samples from Niskin1, but tag is in file.
4501 Niskin 2 and 3, top vents not closed.
Gelatinous material removed from tubing between C2 and pump.
Software indicated pump was on while on deck prior to cast.
4601 Prior to cast flushed sensors again. This time a glob of gelatinous material appeared in tubing between secondary conductivity cell and pump. The material was removed, tube re-attached, and cast looked better.
4701 Quite a bit of jellyfish material on frame, including CTD intake.
5001 Originally named 05201. Filenames and *.hdr changed afterwards. Bottom depth also added to header file after the cast.
5201 Niskin1 did not close, not sampled.
5603 Mark taken 5 m above max CTD depth.

5801 Ryan noticed altimeter is not reading full scale anymore…off by 5m at surface and bottom depth (altimeter plus ctd depth) are 5m less than the bathymeter and Seabeam depth (however it does read +4 of the adcp depth). **Unplugged oxygen and altimeter cable from CTD and found connection had been leaking again.** Cleaned up, reattached and redeployed.

5901 No spare Y-cable available but since the Aux-2 bulkhead connector was free we removed Y-cable and plugged altimeter into the Aux-2, and left oxygen in aux-4. New configuration file made: HLY0404_2.con Altimeter is now changed from V6 to V2 and Oxygen is changed from V7 to V6.

6001 Oxygen data bad. Yes **connection leaked again (aux-4).** **Swapped out CTD body (s/n 638 for 639) but kept all the same sensors**. Turns out **the modem connection also had corrosion from leaking**. No clear problem seen on bulkhead connectors…pins on Aux-4 look slightly bent. New configuration file: HLY0404_3.con. The pressure casing we've switched to had a blown fuse and bulkhead connector during the last leg. Rob Palmeres could tell us what happened in particular. He got it back into working order with MSTs. Jim Schmidt replaced the aux-4 and modem bulkhead connectors in the removed CTD (s/n639).

6101 Data look good with new pressure housing.

6201 Pump on while on deck before cast.

6301 **Bottom contact (at slow speed)**. Altimeter read 4m and then touched bottom- altimeter was reading incorrectly.

6401 Careful bottom approach: flat bottom, no ship-rock, altimeter read 6m and then switched to 99. Did not touch bottom, but expect altimeter has ~ 4m offset. Altimeter changed out after cast.

6002 **First cast with spare altimeter**. Taken after 6401. Originally saved as 00602.* Changed back to 06002.* No bottles

6501 Altimeter reading fine.

6902 Originally saved file as 0690.* After cast files were renamed back to 06902.*

7401 **Auxiliary-4 connector cleaned after cast**. Pins were green, showing seawater had been leaking in. Connector was examined because V7 was reading non-zero (only oxygen is plugged into this connector so only V6 should have reading). However, there were no spikes in the data to indicate a problem.

7601 Niskin 3 was closed at an un-intended depth so was not sampled.

7701 **Bottom contact.** Ship lost power 8m above bottom. Ship drift/ wire angle change brought the CTD in contact with the bottom. The package may have even dragged along the bottom. Power was restored in ~2 minutes. Cast was restarted (?) bottom bottle tripped and continued with uptrace as normal. Primary and secondary conductivity differences were small- does not appear to shifted calibration.

7801 Altimeter went from 4.5 to 98 at bottom. Maybe due to slope, maybe altimeter problem? Altimeter was late in finding the bottom (28m off bottom).

8301 Wire stressed during wait at 5m. A big swell raised package and lowered tension of wire on block and then quickly released package, putting a shock on the wire. Data looks spiky and shows 5 m density inversion but this is most likely due to mixing by package/ ship prop in the high gradient water with big swells. Station

8401 performed next and then it was decided to reterminate wire (outer armor shows slight gaps and there is a kink from an earlier cast) and go back and repeat this station (calling the repeat 8304).

8304 Follows station 8401, back at station 83**. First cast with reterminated wire**. Looks fine. Seas have also calmed down slightly. Voltage channel 7 is free, but shows voltage on this cast. **Aux-4 connector (oxygen plugged in here: V6 and V7) cleaned after cast but does not appear noticeably wet**. Oxygen trace looks fine. Cast is named 04 to differentiate from naming scheme of radium casts (02 and 03), although there are no radium casts at this station.

8501 **Voltage channel 7 shows small noise**. Connector left as is, not checked.

8502 Voltage channel 7 reads 0 all cast but **voltage channel 5 now has small noise**. Connector left as is, not checked.

8601 **Voltage channel 5 shows small noise again**. Connector left as is, not checked.

8701 No more noise on any of the free channels (v1,v3,v5,v7).

9001 Niskin 1 not tripped at right depth (too early, ~10 off bottom). Not sampled. 2nd mark scan also not at bottom. 3rd mark scan is at bottom.

9601 Did not wait 30 seconds before tripping surface bottle.

11101 Extra tag (24th niskin) not sampled- remove tag.

11102 **First dunking the pumps never came on due to freezing. CTD was brought back into hanger and flushed with warm water and then with warm saline water. CTD was then redeployed, leaving syringes full of warm saline water on as long as possible, removing just before it was lowered into the water. Initially this was called 11103 but was renamed to 11102.**

11201 Paused at 210m for a few minutes on downcast because wire was rubbing side on A-frame.

11601 Initially put into water with syringes still attached. Brought out, syringes taken off and restarted.

12101 Thermometer for measuring oxygen temperature out of range on very cold water

12502 CTD drifted lower while tripping all the bottles for radium samples. Niskins 13 and 14 not sampled due to change in depth. CTD depth readjusted after Niskin 14.

12902 Niskin 10 leaking.

14401 Large number of jellyfish-parts on CTD frame. May have affected transmissometer.

Notes on Bottles

00101	3	Did not wait 30 seconds before closing Niskin
00201	1	Did not close. Lanyard hooked over pin 1 and 24
00201	14	Did not close. But closed after tugging on lanyard.
00601	1	Mistake: wrong depth, no samples drawn.
01201	2	Mistake: wrong depth, no samples drawn.
03801	3	Did not wait 30 seconds before closing Niskin
03901	1	Deployed with bottom endcap closed
04501	2	Top vent not closed

04501 3	Top vent not closed
05201 1	Tripped but did not close.
09601 9	Did not wait 30 seconds before closing Niskin
12101	Thermometer for measuring oxygen temperature out of range on very cold water
12902 10	Niskin leaking

Appendix C. Seabird Processing Settings

Program/ Module   Function

1 **SEASAVE** Acquire raw data.

2 **Data Conversion** Convert raw data (*.dat), using the *.con file, selecting ASCII as data conversion format.

sbi04_datcnv.psu
*Start at scan number of downcast, after the soak. Store files in processed/datcnv For the *.ros files, use scans marked with bottle confirm bit, 0 sec offset, 2 sec range duration.*

3 **Rossete Summary** Average the scans associated with each bottle trip to create CTD bottle stop information.

sbi04_rossum.psu
Averaged all values. Derived Oxygen, Oxygen Saturation, Salinity 1 and Salinity 2. Found min/max and STD although this info is not being used in water sample data.

4 **Align CTD** Advance sensors relative to pressure, depending on sensor response time. Typically secondary conductivity is advanced 0.073seconds and oxygen is advanced +2 to +5 seconds. The primary conductivity is typically already advanced 0.073 seconds by the deck unit.

sbi04_alignctd.psu
Confirmed SBE11 deckunit was already advancing both primary and secondary conductivity by 0.073 seconds so only using align to advance oxygen. Advanced oxygen voltage by 3 seconds.

5 **Cell Thermal Mass** Perform conductivity cell thermal mass correction to achieve higher salinity accuracy. This step is necessary when salinity accuracy better than 0.01 PSU is desired in regions with steep gradients. Typical values are alpha = 0.03 and 1/beta = 7.0.

sbi04_celltm.psu
Chose to adjust Primary Conductivity with Primary Temperature and to adjust Secondary Conductivity with Secondary Temperature. Used suggested corrections of alpha=0.03 and 1/beta= 7.0

6 **Wild Edit** Identify scans that have very different values from their neighboring scans.

sbi04_wildedit.psu
*Chose first pass of 10*STD and second pass of 20*STD using 100 scans per block (about 4 seconds). All scans are used for STD calculation (after loopedit is run,*

could exclude those flagged data from the STD calculation). Pressure, T1, T2, C1, C2, OxV, Alt, S1, S2, SndVel, Depth were tested. Did not run procedure on transmissometer, fluorometer or latitude and longitude.

7 **Filter** Low-pass filter pressure with time constant of 0.15 seconds to increase pressure resolution for Loop Edit. Typically pressure is low passed filtered with 0.15 seconds and conductivity is filtered with 0.03

sbi04_filter.psu
Applied 0.1- second filter to pressure and 0.03-second filter to conductivities.

8 **Loop Edit** Mark scans where CTD is moving less than minimum velocity or traveling backwards due to ship roll.

sbi04_loopedit.psu
Scans with speeds less than 0 m/s are marked bad.
Store files in processed/loopedit.
'Exclude marked scans' is checked, meaning scans previously flagged bad will not be used in loopedit calculation.

9 **Derive** Compute oxygen from oxygen signal (SBE 43); also need conductivity (or salinity), temperature, and pressure.

sbi04_deriveox.psu
Derive Oxygen ml/l with 1.0-second window size

10 **Bin Average** Average data into desired pressure or depth bins.

sbi04_binavg.psu
Pressure averaging, 1db, with interpolation to center the output. Exclude scans marked bad (wildedit, loopedit)t. Output the number of scans in each averaged bin. Process the whole cast, not just the downcast.

11 **Derive** Compute salinity, density, and other parameters.

sbi04_derivefull.psu
Compute salinity 1 and salinity 2, sound velocity, and depth (using 71 Lat).
Store files in processed/derivefull

10 **Strip** Remove extra columns.

sbi04_strip.psu
Reduce file to P,T1, T2, C1, C2, OxV, Fl, Tr, Alt, Oxy, Scans per bin, S1, S2, Fl, Alt. Do not include Latitude, Longitude, SoundSpeed, and Depth

11 **Split** Create a separate file for down and up cast.

sbi04_split.psu
Split files into down and uptrace. Exclude scans marked bad is checked, meaning a scan identified bad in loopedit will not be used to separate the downtrace from the uptrace.

Appendix D. Hydrographic Team Activity Report

Cruise ID: (Healy 04-04)
Dates: 2 September to 1 October 2004
Ports: Dutch Harbor, Alaska to Nome, Alaska
Dr. James Swift (PI)
On board team: Daniel Schuller, Erik Quiroz, James Schmitt, Dean Stockwell

Bottle Data

There were two generic types of casts performed with differing sampling protocols. Generally speaking, the samplings associated with these casts were as follows, but there is some cast-to-cast variation.

- **Hydrographic**
  - ***Oxygen***
  - ***Total CO2***
  - ***Total Alkalinity***
  - ***Nutrients***
  - ***Chlorophyll/Phaeophytin***
  - ***Salinity***
  - ***O18/O16***
  - ***Dissolved Organic Matter/Particulate Organic Matter***
- **Radium**
  - ***Radium***
  - ***Salinity***
  - ***O18/O16***

The correspondence between individual sample containers and the rosette bottle from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles.

Normal sampling practice included opening the drain valve before the air vent on the bottle, to check for air leaks. This observation together with other diagnostic comments (e.g., "lanyard caught in lid", "valve left open") that might later prove useful in determining sample integrity was noted on the sample log.

Bottle Data Processing

After the samples were drawn and analyzed, the next stage of processing involved merging the different data streams into a common file. The rosette cast and bottle numbers were the primary identification for all ODF-analyzed samples taken from the bottle, and were used to merge the analytical results with the CTD data associated with that bottle.

Diagnostic comments from the sample log, and notes from analysts and/or bottle data processors were entered into a computer file associated with each station (the "quality" file) as part of the quality control procedure. WHP water sample codes were selected to indicate the reliability of the individual parameters affected by the comments. WHP bottle codes were assigned where evidence showed the entire bottle was affected, as in the case of a leak, or a bottle trip at other than the intended depth.

Specific data processing and techniques and additional quality control are included with the parameter write-up.

Pressure and Temperatures

All pressures and temperatures for the bottle data tabulation were obtained by averaging CTD data for a brief interval at the time the bottle was closed and then applying the appropriate calibration data.

The temperatures are reported using the International Temperature Scale of 1990.

Bottle Data Footnoting

WHP water bottle quality flags were assigned as defined in the WOCE Operations Manual [Joyce].

WHP water sample quality flags were assigned to the water samples using the following criteria:

1 The sample for this measurement was drawn from the water bottle, but the results of the analysis were not received.

2 Acceptable measurement.

3 Questionable measurement. *The data did not fit the station profile or adjacent station comparisons (or possibly CTD data comparisons). No notes from the analyst indicated a problem. The data could be acceptable, but are open to interpretation.*

4 Bad measurement. *The data did not fit the station profile, adjacent stations or CTD data. There were analytical notes indicating a problem, but data values were reported. Sampling and analytical errors were also flagged as 4.*

5 Not reported. *The sample was lost, contaminated or rendered unusable.*

9 The sample for this measurement was not drawn.

Not all of the quality flags are necessarily used on this data set.

Salinity

730 salinity samples were analyzed, including thermosalinograph check samples.

Sampling and Data Processing

Salinity samples were drawn into 200 ml high alumina borosilicate bottles, which were rinsed three times with sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This container provides very low container dissolution and sample evaporation.

Equipment and Techniques

A Guildline Autosal 8400B #65-715, standardized with IAPSO Standard Seawater (SSW) batch P-144, was used to measure the salinities. Prior to the analyses, the samples were stored to permit equilibration to laboratory temperature, usually 8-20 hours. The salinometer was outfitted with an Ocean Scientific International interface for computer-aided measurement. The salinometer was standardized with a fresh vial of standard seawater (SSW) at the beginning of each analysis run. Instrument drift was determined by running a SSW vial after the last sample was run through the autosal. The salinometer cell was flushed until two successive readings met software criteria for consistency; these were then averaged for a final result. The estimated accuracy of bottle salinities run at sea is usually better than 0.002 PSU relative to the particular standard seawater batch used.

Laboratory Temperature

The temperature stability in the salinometer laboratory was moderate; variation was no more than 3° C during a run of samples. The laboratory temperature was generally 2-3ºC lower than the Autosal bath temperature.

Oxygen

790 samples were analyzed for oxygen.

Sampling and Data Processing

Samples were collected for dissolved oxygen analyses as the first sample after the rosette was brought on board. Using a Tygon drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed three times then filled and allowed to overflow for approximately three flask volumes. The sample draw temperature was measured with a small platinum resistance thermometer embedded in the drawing tube. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice to assure thorough dispersion of the precipitate, once immediately after drawing, and then again after about 20 minutes. The samples were usually analyzed within several hours of collection. Thiosulfate normalities were calculated from each standardization and corrected to 20ºC. Periodically, the 20ºC normalities and the blanks were plotted versus time and were reviewed for possible problems. New thiosulfate normalities were recalculated as a linear function of time, if warranted. The oxygen data were recalculated using the smoothed normality and an averaged reagent blank. Oxygens were converted from milliliters per liter to micromoles per kilogram using the sampling draw temperature and the sample’s salinity.

It was noted part way through the cruise that sample draw temperatures were not being reported as negative. Sample draw temperatures were plotted versus CTD bottle temperatures and “sign”-corrected where appropriate for stations 00601 through 07801. Sample draw temperatures after 07801 were read and recorded correctly on the sample log sheets.

Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. The ODF method used a whole-bottle modified-Winkler titration following the technique of Carpenter (1965) with modifications by Culberson (1991), but with higher concentrations of potassium iodate standard (approximately 0.012N) and thiosulfate solution (55 g/l). Standard KIO3 solutions prepared ashore were run at the beginning of each run. Reagent and distilled water blanks were determined, to account for presence of oxidizing or reducing materials.

Volumetric Calibration

Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at ODF's chemistry laboratory. This was done once before using flasks for the first time and periodically thereafter when a suspect bottle volume was detected. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

Standards

Potassium iodate was obtained from Johnson Matthey Chemical Co. and was reported by the supplier to be >99.4% pure.

Nutrients

849 samples were analyzed for nutrients.

Sampling and Data Processing

Nutrient samples were drawn into 45 ml polypropylene, screw-capped "oak-ridge type" centrifuge tubes. The tubes were rinsed with 10% HCl and then with sample three times before filling. Standardizations were performed at the beginning and end of each group of analyses (10-36 samples) with an intermediate concentration of mixed nutrient standard in a low nutrient seawater matrix. This standard was prepared from a secondary standard immediately prior to each run. The secondary standards were prepared aboard ship by dilution from primary standard solutions. Dry standards were pre-weighed at the laboratory at ODF, and transported to the vessel for dilution to the primary standard. Sets of 7 different standard concentrations covering the range of sample concentrations were analyzed periodically to determine the deviation from linearity, if any, as a function of absorbance for each nutrient analysis. A correction for non-linearity was applied to the final nutrient concentrations when necessary. After each group of samples was analyzed, the raw data file was processed to produce another file of response factors, baseline values, and absorbances. Suspect values were checked for accuracy against values taken from strip chart recordings.

Nutrients, when reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in situ* salinity, and the sample temperature measured at the time of analysis.

Equipment and Techniques

Nutrient analyses (nitrate+nitrite, nitrite, phosphate, and silicate) were performed on an ODF-modified 4-channel Technicon AutoAnalyzer II, generally within a few hours after sample collection. The samples were kept in the dark by covering with tin foil or refrigerated at 4°C, if necessary, but brought to within 5°C of lab temperature before analysis. The analog outputs from each of the six channels were digitized and logged automatically by computer (PC) at 2-second intervals.

A modification of the Armstrong *et al*. (Armstrong 1967) procedure was used for the analysis of nitrate and nitrite. For the nitrate plus nitrite analysis, the seawater sample was passed through a cadmium reduction column where nitrate was quantitatively reduced to nitrite. The stream was then passed through a 15mm flowcell and the absorbance measured at 540nm. The same technique was employed for nitrite analysis, except the cadmium column was bypassed, and a 50mm flowcell was used for measurement. Periodic checks of the column efficiency were made by running alternate equal concentrations of NO2 and NO3 through the NO3 channel to ensure that column efficiencies were high (> 95%). Nitrite concentrations were subtracted from the nitrate+nitrite values to obtain nitrate concentrations.

Phosphate was analyzed using a modification of the Bernhardt and Wilhelms [Bernhardt 1967.] technique. The reaction product was heated to ~55ºC to enhance color development, then passed through a 50mm flowcell and the absorbance measured at 820m.

Silicate was analyzed using the technique of Armstrong *et al*., (Armstrong, 1967). The sample was passed through a 15mm flowcell and the absorbance measured at 660nm.

Nutrient Standards

Primary standards for nitrate (KNO3), nitrite ($NaNO_2$), and phosphate (KH_2PO_4) were obtained from Johnson Matthey Chemical Company, and the supplier reported purities of 99.999%, 97%, and 99.999%, respectively. Na_2SiF_6, the silicate primary standard, was obtained from Johnson Matthey Company and Fisher Scientific and was reported by the suppliers to be >98% pure.

References

Armstrong, F. A. J., Stearns, C. R., and Strickland, D. H., “The measurement of upwelling and subsequent biological processes by means of the Technicon AutoAnalyzer and associated equipment,” *Deep-Sea Research*, 14, pp. 381-389, (1967).

Bernhardt, Wilhelms A., “The continuous determination of low level iron, soluble phosphate and total phosphate with the AutoAnalyzer”, *Technicon Symposia*, **I**, pp. 385-389 (1967).

Carpenter, J. H., “The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method,” *Limnology and Oceanography*, 10, pp. 141-143 (1965).

Culberson, C. H., Knapp, G., Stalcup, M., Williams, R.T., and Zemlyak, F., “A comparison of methods for the determination of dissolved oxygen in seawater,” Report WHPO 91-2, WOCE Hydrographic Programme Office (Aug 1991).

Joyce, T. ed., and Corry, C. ed., “Requirements for WOCE Hydrographic Programme Data Reporting,” Report WHPO 90-1, WOCE Report No. 67/91 3.1, pp. 52-55, WOCE

Hydrographic Programme Office, Woods Hole, MA, USA (May 1994, Rev. 2),
UNPUBLISHED MANUSCRIPT

Appendix E. CTD Station Log

SECTION 1

Station	Latitude		Longitude		Corr Depth
1	71	13.49	152	13.38	39
2	71	16.29	152	11.28	48
3	71	18.86	152	7.62	56
4	71	21.91	152	6.72	67
5	71	24.00	152	3.78	155
6	71	26.86	152	1.56	212
7	71	29.68	151	59.28	301
8	71	32.00	151	56.82	598
9	71	34.51	151	55.98	763
10	71	37.53	151	53.52	998
11	71	39.51	151	50.82	1350
12	71	42.16	151	49.14	1569
13	71	45.32	151	46.44	1775
14	71	47.54	151	43.50	2001
15	71	50.81	151	42.96	2131

SECTION 2

Station	Latitude		Longitude		Corr Depth
23	71	57.72	161	17.10	35
24	71	53.79	161	9.78	49
25	71	50.62	161	3.48	52
26	71	47.06	160	55.74	65
27	71	43.73	160	49.38	69
28	71	40.22	160	43.02	70
29	71	36.53	160	35.94	55
30	71	33.18	160	28.92	56
31	71	29.77	160	22.38	76
32	71	26.23	160	16.08	53
33	71	22.93	160	9.42	50
34	71	21.23	160	7.26	52
35	71	19.67	160	3.06	52
36	71	18.04	159	59.40	45
37	71	16.25	159	55.86	45
38	71	14.45	159	52.62	44
39	71	12.74	159	49.98	44
40	71	10.95	159	46.98	46
41	71	9.54	159	44.52	46
42	71	7.68	159	40.80	47
43	71	5.99	159	37.98	48
44	71	4.30	159	35.04	45

45	71	2.81	159	30.24	42
46	71	1.01	159	27.42	42
47	70	59.43	159	24.60	40
48	70	57.79	159	21.84	37
49	70	55.95	159	19.56	34

SECTION 3

Station	Latitude		Longitude		Corr Depth
50	71	31.29	155	26.76	31
51	71	31.79	155	29.88	45
52	71	32.41	155	34.44	61
53	71	33.61	155	36.78	112
54	71	34.67	155	40.02	152
55	71	35.74	155	42.78	183
56	71	36.95	155	44.64	223
57	71	39.14	155	49.08	154
58	71	41.38	155	53.88	110
59	71	43.61	155	59.22	101
60	71	46.01	156	3.12	94
61	71	48.04	156	8.58	85
62	71	50.33	156	13.68	76
63	71	52.39	156	18.42	67
64	71	54.89	156	23.10	59
65	71	57.41	156	25.92	60
66	72	0.09	156	28.50	83
67	72	2.47	156	30.48	113
68	72	5.28	156	33.66	148
69	72	7.73	156	35.82	173
70	72	10.43	156	37.92	203
71	72	12.88	156	41.46	215
72	72	15.56	156	42.78	241
73	72	18.16	156	46.14	247
74	72	20.70	156	42.90	291
75	72	23.13	156	38.76	373
76	72	25.56	156	36.06	749
77	72	28.12	156	32.82	957
78	72	30.71	156	28.74	1029

SECTION 4

Station	Latitude		Longitude		Corr Depth
86	72	50.90	166	1.08	50
85	72	56.01	165	58.74	52
84	73	0.81	165	59.94	57
83	73	5.80	166	0.36	57

82	73	10.78	166	0.12	59
81	73	15.30	166	0.60	63
87	73	20.26	165	59.94	67
80	73	20.60	166	3.24	67
88	73	25.54	166	0.00	76
89	73	30.36	165	58.98	88
79	73	36.68	166	1.38	105
90	73	36.73	165	59.28	103
91	73	40.84	166	0.12	111
92	73	45.37	165	59.76	119
93	73	50.30	166	0.24	135
94	73	55.28	166	0.36	147
95	74	0.25	166	0.06	178
96	74	5.20	166	0.12	205
97	74	10.46	166	0.78	245
98	74	16.24	165	59.28	278
99	74	27.20	165	58.74	338

SECTION 5

Station	Latitude		Longitude		Corr Depth
101	75	30.71	167	53.34	180
102	75	35.91	167	58.32	176
103	75	41.07	168	4.32	194
104	75	46.46	168	8.40	217
105	75	51.56	168	16.02	254
106	75	56.90	168	19.68	350
107	76	2.07	168	26.04	594
108	76	7.35	168	31.14	1311
109	76	12.70	168	37.92	1781
110	76	17.57	168	43.20	1944
111	76	22.80	168	46.32	2035

SECTION 6

Station	Latitude		Longitude		Corr Depth
133	70	41.93	168	48.90	23
134	70	41.90	168	34.86	24
135	70	41.73	168	17.82	29
136	70	41.84	168	1.26	34
137	70	41.94	167	44.88	34
138	70	41.87	167	28.14	37
139	70	41.92	167	11.70	39
140	70	41.90	166	55.32	41
141	70	42.03	166	39.06	42
142	70	41.88	166	23.16	41
143	70	41.74	166	7.08	38
144	70	41.83	165	50.58	37

145	70	41.89	165	34.62	36
148	70	37.31	165	16.80	36
149	70	32.81	164	59.22	43
150	70	27.71	164	40.86	46
151	70	22.89	164	22.98	51
152	70	20.71	164	14.76	49
153	70	18.26	164	6.06	48
154	70	15.65	163	57.18	41
155	70	13.31	163	48.12	37
156	70	10.99	163	39.78	33
157	70	8.66	163	30.66	27

SECTION EDDY-1

Station	Latitude		Longitude		Corr Depth
112	73	15.77	160	16.56	707
113	73	17.85	160	17.10	1037
114	73	20.65	160	16.92	1152
115	73	23.45	160	16.68	1337
116	73	25.99	160	18.00	1386
117	73	28.79	160	17.04	1595
118	73	31.48	160	16.68	1922

SECTION EDDY-8

Station	Latitude		Longitude		Corr Depth
121	73	31.42	160	30.42	1470
122	73	29.77	160	30.30	1580
123	73	28.21	160	30.30	1473
124	73	26.61	160	29.94	1029
125	73	24.84	160	30.24	1068
126	73	23.45	160	29.82	1099
127	73	21.71	160	29.76	990
128	73	20.10	160	29.16	918
129	73	18.42	160	29.76	937
130	73	16.68	160	29.82	760
131	73	15.44	160	29.04	625

MISCELLANEOUS

Station	Latitude		Longitude		Corr Depth	
16	71	54.15	153	3.72	1274	EMCTD cal
17	71	56.13	153	3.36	1579	EMCTD cal
18	71	56.82	153	4.98	1633	EMCTD cal
19	71	57.38	153	7.08	1411	EMCTD cal
20	72	23.30	154	43.80	2309	Micro cal
21	72	35.16	155	29.16	2016	Micro cal
22	72	55.80	156	50.88	2376	Micro cal
79	73	36.68	166	1.38	105	CS2 cal

80	73	20.60	166	3.24	67	CS1 cal
100	75	6.07	168	0.24	159	NOAA cal
119	73	31.60	160	26.82	1576	eddy surv
120	73	28.96	160	27.00	1653	eddy surv
132	70	40.03	167	3.00	51	CC cal
146	70	49.75	165	5.58	39	Chuk shelf
147	70	57.32	164	41.22	33	Chuk shelf

XCTD SECTION EDDY-2

Station	Latitude		Longitude		Corr Depth
126	73	28.95	160	27.54	780
127	73	25.67	160	27.24	976
3	73	23.77	160	27.18	1052
4	73	21.17	160	27.24	1043
5	73	18.48	160	27.18	1040
6	73	15.66	160	27.24	1670

SECTION EDDY-3

Station	Latitude		Longitude		Corr Depth
7	73	14.69	160	8.46	769
8	73	17.39	160	8.34	1189
9	73	20.02	160	8.34	1253
10	73	22.83	160	8.34	1362
11	73	25.50	160	8.28	1552
12	73	28.21	160	8.34	1620
12	73	31.19	160	8.34	1921

SECTION EDDY-4

Station	Latitude		Longitude		Corr Depth
14	73	31.71	160	36.54	515
15	73	29.24	160	36.60	685
16	73	26.38	160	36.60	750
17	73	23.81	160	36.60	897
18	73	21.09	160	36.60	743
19	73	18.32	160	36.60	1340
21	73	15.03	160	35.34	1377

XCTD SECTION EDDY-5

Station	Latitude		Longitude		Corr Depth
22	73	14.81	160	46.44	470
23	73	17.38	160	46.08	448
24	73	20.08	160	46.14	559
25	73	22.78	160	46.08	680
26	73	25.76	160	46.08	497
27	73	28.15	160	46.08	496
28	73	31.00	160	46.14	1093

XCTD SECTION EDDY-6

Station	Latitude		Longitude		Corr Depth
29	73	31.79	160	55.08	396
30	73	29.14	160	55.74	365
32	73	25.75	160	54.66	375
33	73	23.81	160	55.62	403
34	73	21.09	160	55.62	373
35	73	18.45	160	55.62	418
36	73	15.39	160	55.62	480

XCTD SECTION EDDY-7

Station	Latitude		Longitude		Corr Depth
37	73	14.63	161	5.04	375
39	73	20.03	161	5.04	325
40	73	22.85	161	5.04	307
41	73	25.54	161	5.04	315
43	73	29.63	161	5.04	350

XBT SECTION X1

XBT #	Latitude		Longitude		Corr Depth
7	73	33.97	159	40.74	56
8	73	29.62	159	48.48	66
9	73	25.36	159	56.04	78
10	73	23.00	160	0.42	146
11	73	20.62	160	4.62	176
12	73	18.23	160	9.00	209
13	73	15.82	160	13.32	265
14	73	13.44	160	17.52	319
15	73	10.99	160	21.84	438
16	73	8.57	160	26.10	887
17	73	5.81	160	30.96	1170
18	73	3.81	160	34.44	1352
19	73	1.40	160	38.64	1473
21	72	58.27	160	44.10	1643
22	72	56.36	160	47.34	1963
23	72	54.16	160	51.12	2265

XBT SECTION X2

XBT #	Latitude		Longitude		Corr Depth
24	72	46.66	160	17.46	62
25	72	48.92	160	12.66	64
26	72	51.25	160	7.98	75
27	72	53.54	160	3.48	96
28	72	55.90	159	58.80	136
29	72	58.16	159	54.18	187
30	73	0.26	159	49.98	236
31	73	2.80	159	44.82	279
32	73	5.18	159	40.14	332
33	73	7.51	159	35.40	424
34	73	9.82	159	30.66	847
35	73	12.13	159	25.98	1213
36	73	14.48	159	21.24	1474
37	73	16.79	159	16.50	1615
38	73	21.39	159	7.08	1844
39	73	26.15	158	57.30	2245

XBT SECTION X3

XBT #	Latitude		Longitude		Corr Depth
40	73	16.99	158	18.24	59
41	73	12.48	158	28.38	64
43	73	9.59	158	34.98	71
44	73	7.92	158	38.76	104
45	73	5.69	158	43.68	146

46	73	3.42	158	48.84	177
47	73	1.20	158	53.82	208
48	72	58.91	158	58.80	268
49	72	56.69	159	3.90	319
50	72	54.38	159	9.00	400
51	72	51.79	159	14.82	852
52	72	49.82	159	19.14	1279
53	72	47.53	159	24.12	1517
54	72	45.35	159	28.98	1670
56	72	43.06	159	33.96	1733
57	72	40.84	159	38.88	1930
58	72	38.50	159	43.92	2186

XBT SECTION X4

XBT #	Latitude		Longitude		Corr Depth
59	72	31.19	159	3.96	51
60	72	33.37	158	58.74	53
61	72	35.55	158	53.70	69
62	72	37.85	158	48.48	92
63	72	40.08	158	43.32	154
64	72	42.35	158	38.10	194
65	72	44.48	158	33.06	223
66	72	46.61	158	28.08	282
67	72	48.92	158	22.86	357
68	72	51.13	158	17.64	859
69	72	53.33	158	12.48	1223
70	72	55.55	158	7.26	1574
71	72	58.06	158	1.32	1862
72	72	59.96	157	56.94	2068
73	73	2.41	157	51.12	2113
74	73	4.44	157	46.32	2248

XBT SECTION X5

XBT #	Latitude		Longitude		Corr Depth
75	72	53.66	156	55.74	61
76	72	51.85	157	1.50	68
77	72	49.80	157	8.22	80
78	72	47.90	157	14.64	146
79	72	46.00	157	21.06	191
80	72	44.02	157	27.60	231
81	72	42.12	157	33.66	286
82	72	40.19	157	40.02	338
83	72	38.26	157	46.56	382
84	72	36.39	157	52.74	454
85	72	34.43	157	58.98	1027

86	72	32.51	158	5.28	1407
87	72	30.54	158	11.76	1738
88	72	28.60	158	17.88	1816
90	72	26.47	158	24.84	2133

XBT SECTION X6

XBT #	Latitude		Longitude		Corr Depth
93	73	18.95	159	16.38	1488
94	73	20.13	159	24.60	1648
95	73	21.41	159	33.00	1636
96	73	22.67	159	41.64	1725
97	73	23.83	159	49.74	1784
98	73	25.11	159	58.14	1604
99	73	26.33	160	6.48	1587
100	73	27.54	160	15.00	1328
101	73	28.81	160	23.40	1551
102	73	30.03	160	31.74	1550
103	73	31.38	160	40.74	1271

XBT SECTION X6b

XBT #	Latitude		Longitude		Corr Depth
104	73	27.18	160	34.62	1030
105	73	25.39	160	26.40	1126
106	73	23.24	160	17.70	1329
107	73	21.62	160	11.22	1240
108	73	19.97	160	4.38	1337