WHP Cruise Summary Information

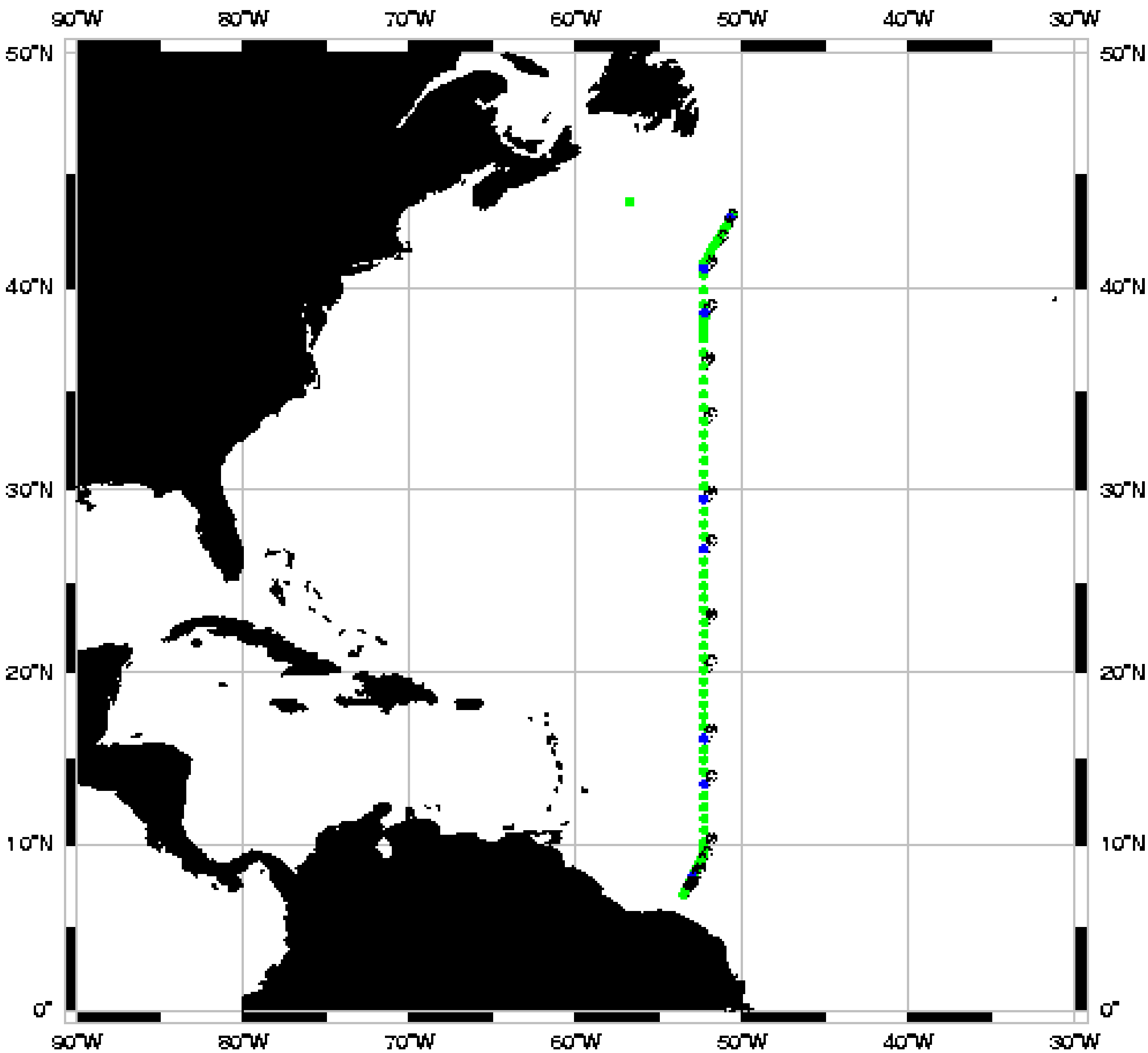
WOCE section designation	A20
Expedition designation (EXPOCODE)	316N151_3
Chief Scientist(s) and their affiliation	Robert Pickart, WHOI
Dates	1997.07.17 – 1997.08.10
Ship	KNORR
Ports of call	Halifax to Trinidad
Number of stations	95
Geographic boundaries of the stations	43°57.94''N 56°48.62''W 50°36.98''W 06°58.13''N
Floats and drifters deployed	11 Floats
Moorings deployed or recovered	4
Contributing Authors	none

WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

Cruise Summary Information	Hydrographic Measurements
Description of scientific program	CTD - general
	CTD - pressure
	CTD - temperature
Cruise track (figure)	CTD - conductivity/salinity
Description of stations	
Description of parameters sampled	
Floats and drifters deployed	
Moorings deployed or recovered	Nutrients
Principal Investigators for all measurements	
Cruise Participants	

Station locations for A20



Produced from .SUM files by WHPO.

KNORR 151 LEG-III CRUISE SUMMARY: A20

Robert S. Pickart, Chief Scientist (WHOI)

From 17 July - 10 August 1997 the research vessel KNORR occupied a hydrographic section extending from the Newfoundland shelf to the Suriname shelf, nominally along 52°W. This section, known as A20, is part of the Atlantic Circulation and Climate Experiment (ACCE), and one of two North Atlantic WOCE "Meridional Long-lines". The other meridional line, at 66°W, was occupied during the subsequent leg (T. Joyce, chief scientist). Thirty-one scientists representing 10 different projects participated on the cruise (Table 1).

Due to wonderful weather and excellent cooperation among the different groups, we ended up occupying more stations than originally planned for a total of 95 (Figure 1). At both ends the resolution on the shelf break was 3 mi, increasing to 10-15 mi on the continental slope, and finally 40 mi in the interior (except for the Gulf Stream where the spacing was 15-25 mi). A typical deep water station included a NBIS Mark-III CTD with oxygen sensor, lowered ADCP, and 33 10-liter Niskin bottle samples. Depending on the station up to 9 different WOCE quantities were measured: CFCs, Tritium/Helium, Oxygen, PCO_2, TCO_2, C14, Alkalinities, Nutrients, and Salts. On selected stations (such as TTO and GEOSECS repeat stations) all of the quantities were measured; more often a subset of them was collected. Table 2 gives the position/depth of each station and indicates which tracers (including numbers of samples) were drawn. Note that Oxygen, Nutrients and Salts were collected on every station (with the exception of the shelf break crossings where limited sampling was done).

In addition to the WOCE variables, Halocarbon measurements were made nominally once per day in the upper 200 m (usually from the shallowest 10 Niskin bottles, see Table 2). Underway measurements included PCO_2, Halocarbons, ADCP, and thermosalinograph (which was calibrated daily using surface salinity samples). A bio-optical cast was made once per day using a self contained winch and CTD package. This was done during the CTD cast falling closest to the noon hour. Eleven ALACE floats were launched in the Sargasso Sea, corresponding to CTD sites.

Brief Narrative

After occupying a test station in 3000 m of water near 57°W, we steamed to the 1000 m isobath along the northern dog-leg (Figure 1) and commenced dropping XBTs onto the shelf. This enabled us to identify the configuration of the Labrador Current prior to the CTD work (allowing us to optimally place the shelf break stations). This turned out to be quite useful as the Labrador Current contained an anomalous, large intrusion of warm water (Figure 2). For the shelf break work we used a 24-position 3.3-liter frame with a separate Mark-III, and collected water samples only within the core of the Labrador Current. At the 1000 m isobath we switched to the larger 36-position 10-liter package, which included the lowered ADCP. Water samples were taken according to the scheme described above. The dogleg portion of the section nicely sampled the slope water, including the Labrador Current, slope water front/jet, Labrador Sea Water, and Deep Western Boundary Current (DWBC, Figure 3). It should be noted that there were four current meter moorings located along the dogleg as part of a separate experiment.

A Gulf Stream warm core ring was located near the seaward edge of the dogleg, and we seem to have crossed through the center of it. Shortly after this we encountered the Gulf Stream front. XBTs were used to identify the precise position of the north wall, and CTDs were subsequently placed in order to properly resolve the current. Interestingly the Gulf Stream was a factor of two narrower than normal at this longitude (only 80-90 km wide).

Upon reaching the Sargasso Sea we began the 40 mi spacing, which was maintained until the southern boundary. After crossing the Corner Seamounts (near 35°N) we skirted along the outer flank of the Mid-Atlantic Ridge until roughly 15°N (Figure 1). During this part of the survey we consistently steamed at 12-13 knots. This enabled us to make up time lost on the northern boundary (due to fog near the Grand Banks). Near 10°N we doglegged into the southern boundary, again sampling the boundary current system with more detailed measurements. As in the north, we changed to the small package at the 1000 m isobath (this time including the lowered ADCP) and took measurements onto the shelf across the North Brazil Current system.

Our section contains some familiar and expected features, as well as some surprises and puzzles. It is the third long line occupied near this longitude, the other two being an IGY line in 1956 and a high-quality CTD section occupied in 1983 (Figure 1). A major aim of our study is to use the 1997 ACCE lines in conjunction with the past data sets to investigate ocean climate change. The A20 salinity section (Figure 4a) shows many of the major water mass/circulation features. On the northern side note the high-salinity warm core ring and Gulf Stream front. Inshore of this, within the DWBC, resides the Labrador Sea Water whose low-salinity signal extends south of the Gulf Stream and is the cause of significant freshening at mid-depths. In the bottom-most layer the Antarctic Bottom Water becomes progressively fresher toward the southern boundary. In the upper 1000 m there is a pronounced core of Antarctic Intermediate Water extending from the southern boundary.

The suite of tracers measured on the cruise will provide valuable information in elucidating the water masses as well as understanding the climate signal. The oxygen section (Figure 4b) beautifully shows both the Labrador Sea Water and Norwegian-Greenland overflow water emanating from the northern boundary. Both these features appear again on the southern boundary. Note also the low oxygen of the Antarctic Bottom Water on the southern end of the section.

One of the surprises revealed by the tracers concerns the spreading of the Norwegian-Greenland overflow water from the northern boundary. The deep oxygen core extends into the Sargasso Sea centered near 3700 m (Figure 4b), whereas the analogous CFC core (not shown) is displaced roughly 500 m deeper. This perhaps reflects the difference in source functions of the two tracers in that CFCs have only entered the system in the last 50 years. Another unexpected feature is the complexity of the Labrador Sea Water signal along the northern boundary. It appears that discrete density layers are being ventilated, possibly the result of inter-annual variability in the formation of this water mass.

At the conclusion of the cruise the majority of the water sample data were merged into standard WOCE data files, and, aside from the post-cruise laboratory calibrations, the CTD data were nearly final. The combination of the 52°W and 66°W sections, along with the other ACCE fieldwork and previous hydrography, will provide a revealing look at the present state of the North Atlantic and its long-term variability.

Table 1: KN151-3 Cruise Participants

1.	Bob Pickart	WHOI	CTD (Chief Scientist)
2.	Marshall Swartz	WHOI	CTD-hardware/watchleader
3.	Daniel Torres	WHOI	CTD-LADCP
4.	Terry McKee	WHOI	CTD-Software
5.	Bob Millard	WHOI	CTD-Software
6.	George Tupper	WHOI	CTD-Hydrography
7.	Dave Wellwood	WHOI	CTD-Hydrography
8.	Shelley Ugstad	WHOI	CTD-watchleader
9.	Mindy Hall	WHOI	CTD-watchstander
10.	Avon Russell	WHOI	CTD-watchstander
11.	Brian Arbic	WHOI	CTD-watchstander
12.	Mark Davis	WHOI	CTD-watchstander
13.	Naomi Knoble	WHOI	CTD-watchstander
14.	Bill Smethie	LDEO	CFCs
15.	Eugene Gorman	LDEO	CFCs
16.	Damon Chaky	LDEO	CFCs
17.	Linda Baker	LDEO	CFCs
18.	Scott Birdwhistell	WHOI	Tritium/He
19.	Peter Landry	WHOI	Tritium/He
20.	Chris Sabine	Princeton	C14/Alkalinities
21.	Carrie Thomas	Princeton	C14/Alkalinities
22.	Rick Wilke	BNL	TCO2
23.	Ken Erikson	BNL	TCO2
24.	Angela Wilson	LDEO	PCO2
25.	Joe Jennings	OSU	Nutrients
26.	Barbara Sullivan	OSU	Nutrients
27.	Bob Moore	Dalhousie	Halocarbons
28.	Phil Morneau	Dalhousie	Halocarbons
29.	Wayne Groszko	Dalhousie	Halocarbons
30.	Carol Knudson	LDEO	Bio-optics
31.	Dana Swift	UW	PALACE floats

Table 2: RV Knorr KN151-3 Station Sampling Summary

Stn.	Lat (N)	Long (W)	Depth *	CFC	HC	He/Tr	Oxy	PCO_2	TCO_2	C14	Alk	Nut	Salt	Comment
1	43°14.80	50°37.01	81											"Small Frame, CTD #1088"
2	43°12.23	50°38.87	85											
3	43°07.54	50°43.01	95											
4	43°03.13	50°46.95	112											
5	43°00.56	50°48.95	156											
6	42°58.09	50°50.78	306	6		5	6	6	6		6	6	6	
7	42°55.80	50°52.73	673	10		10	10	10	10	8	10	9	9	
8	42°53.65	50°54.26	948	14	10	13	18	18	18		18	18	18	"Switch to Large Frame, CTD #9"
9	42°49.03	50°58.16	1387	18			18	4			1	18	18	
10	42°38.06	51°07.30	1990	21		20	21	21	21	16	21	21	21	Subsurface Mooring Site
11	42°24.85	51°17.95	2664	20			25		1		1	25	25	
12	42°11.70	51°29.20	3257	21	10	24	30	24	30	24	30	30	30	
13	42°00.41	51°38.50	3578	22			30	1			1	30	30	
14	41°49.48	51°47.59	4007	24		24	30	22	30		30	30	30	Subsurface Mooring Site
15	41°34.38	51°59.00	4565	8			10					10	10	Missing All But the Bottom 6 Btls
16	41°34.50	51°59.15	4560	18			23		1		1	23	23	Repeat of Station 15 to 3100 db
17	41°20.22	52°10.62	5068	24	10		30	24	30		30	30	30	
18	41°07.72	52°20.85	5145	26		24	30	1			1	30	30	Begin Dogleg South
19	40°53.03	52°21.38	5031	25		24	30	20	30		30	30	30	
20	40°33.24	52°21.36	5188	20			30		1		1	30	30	
21	39°53.22	52°21.54	5269	27	10		30	1	30	26	30	30	30	
22	39°12.88	52°20.96	5321	30			30	1			1	30	30	
23	38°49.43	52°20.05	5337	30		23	30	22	30		30	30	30	North Wall of Gulf Stream
24	38°35.95	52°20.96	5344	12	11		30	15	30		1	30	30	
25	38°20.00	52°21.28	5355	30			30	24	30		30	30	30	
26	37°59.92	52°21.32	5375	29		24	30	1			1	30	30	
27	37°35.08	52°21.45	5429	18			30	22	30		30	30	30	Begin 40-Mile Spacing
28	36°55.16	52°20.95	5447	30	10	8	30				1	30	30	
29	36°14.35	52°21.13	2763	22			30	18	30		30	30	30	Seamount
30	35°33.70	52°20.89	4997	30		24	30	20	30	27	30	30	30	ALACE 013
31	34°53.33	52°21.10	5517	30			30		1		1	30	30	
32	34°12.83	52°21.10	5558	30	11		30	23	30		30	30	30	

Stn.	Lat (N)	Long (W)	Depth *	CFC	HC	He/Tr	Oxy	PCO_2	TCO_2	C14	Alk	Nut	Salt	Comment
33	33°32.33	52°21.17	5565	30		8	30	15	30		30	30	30	ALACE 020
34	32°52.48	52°20.93	5632	31			33			32	1	33	33	
35	32°12.32	52°20.80	5360	33	11	23	33	20	33		33	33	33	ALACE 021
36	31°32.10	52°20.89	5498	30			33	4	33		33	33	33	
37	30°52.03	52°20.59	5165	31			33	15	1		1	33	33	ALACE 026
38	30°11.83	52°20.65	5676	32		8	32	22	32		32	32	32	
39	29°31.93	52°21.00	5380	30	11		33	21	33		33	33	33	ALACE 016
40	28°51.98	52°20.65	5639	32		25	33		1		?	33	33	
41	28°11.81	52°20.59	5478	33			33		33		33	33	33	ALACE 023
42	27°31.57	52°20.57	5899	30	11	8	33	33	33	27	33	33	33	
43	26°51.53	52°20.38	5405	33			33	1	1		1	33	33	ALACE 002
44	26°11.32	52°20.65	5909	33		23	33	?	33		33	33	33	
45	25°31.27	52°20.53	5782	29	14		33	20	33		33	33	33	ALACE 029
46	24°51.26	52°20.48	5127	33		8	33	1	1		1	33	33	
47	24°11.15	52°20.53	5450	33			33	21	33		33	33	33	ALACE 003
48	23°30.80	52°20.51	5028	29	12		33		33		33	33	33	
49	22°50.78	52°20.40	5090	33		24	33	1			1	33	33	ALACE 014
50	22°10.75	52°20.38	5016	33			33	22	33		33	33	28	
51	21°30.64	52°20.38	4907	32		16	32	24	32	27	32	32	32	
52	20°50.25	52°20.42	4391	33	13		33		1		1	33	33	ALACE 027
53	20°10.18	52°20.23	4881	33		24	33	22	33		33	33	33	
54	19°30.07	52°20.36	5363	33			33		33		33	33	33	
55	18°49.91	52°20.23	5137	31	12	4	33		1		1	33	33	
56	18°11.02	52°20.10	4851	33		8	33	24	33		33	33	33	
57	17°31.95	52°20.17	5690	33			33	11	33		33	33	33	
58	16°53.08	52°20.06	4825	33		23	33		1		1	33	33	
59	16°13.87	52°20.10	4987	31	12		33		33		33	33	33	
60	15°34.93	52°19.97	5115	17		8	33	24	33		33	33	33	
61	14°59.90	52°20.03	4521	33			33	14	33	27	33	33	33	
62	14°14.96	52°20.20	5187	33		24	33				1	33	33	
63	13°33.88	52°20.02	5231	29	12		33	24	33		33	33	33	
64	12°52.91	52°19.97	5231	33		8	33	12	33		33	33	33	
65	12°12.04	52°20.03	5068	33			33		1		1	33	33	
66	11°31.12	52°19.95	5005	31	12	23	33		33		33	33	33	

Stn.	Lat (N)	Long (W)	Depth *	CFC	HC	He/Tr	Oxy	PCO_2	TCO_2	C14	Alk	Nut	Salt	Comment
67	10˚50.02	52˚19.85	4954	24			33	24	33		33	33	33	
68	10˚09.10	52˚19.72	4944	33		8	33		1	26	1	33	33	End 40-Mile Spacing
69	9˚53.08	52˚20.90	4921	4			33	24	33		33	33	33	
70	9˚38.28	52˚21.41	4892	31	12		33		33		33	33	33	
71	9˚23.07	52˚21.94	4836	24		24	33	13	1		1	33	33	Begin Dogleg West
72	9˚11.15	52˚27.80	4770	20			33		33		33	33	33	
73	8˚58.50	52˚33.98	4686	31			33		1		1	33	33	
74	8˚47.05	52˚39.86	4631	33		24	33		33		33	33	33	
75	8˚38.08	52˚43.90	4737	29	11		33	4	1		2	33	33	
76	8˚28.87	52˚49.03	3302	30	7	24	33	19	33	24	33	33	32	
77	8˚19.97	52˚53.27	2421	25			33	1	1		1	33	33	
78	8˚10.93	52˚57.47	1609	17		16	21	16	21	16	21	21	21	
79	8˚03.47	53˚01.25	1285	6			18		1		1	18	18	
80	7˚55.93	53˚04.95	1229	14			18		18		18	18	18	
81	7˚49.00	53˚08.57	1197	6			17		1		1	17	17	
82	7˚41.57	53˚12.11	999	14	12	13	18	18	18	8	18	18	18	
83	7˚36.10	53˚15.00	833				18		1		1	18	18	"Switch to Small Frame, CTD #1088"
84	7˚30.90	53˚17.18	682	11			12	4	12		12	12	12	
85	7˚25.22	53˚20.15	475	11			11		1		1	11	11	
86	7˚22.48	53˚21.40	399	10		8	10	1	1		1	10	10	
87	7˚19.72	53˚22.67	334		3		9	9	9		9	9	9	
88	7˚17.03	53˚24.00	282	7	1		7		1		1	7	7	
89	7˚14.32	53˚25.35	238				7		1		1	7	7	
90	7˚11.60	53˚26.68	208	6			6	6	6		6	6	6	
91	7˚08.92	53˚28.05	181				6		1		1	6	6	
92	7˚06.18	53˚29.30	131	11		3	7		1		1	7	7	
93	7˚03.55	53˚30.60	93				5		5		5	5	5	
94	7˚00.82	53˚32.00	85	5			5		1		1	5	5	
95	6˚58.12	53˚33.25	76				5		5		5	5	5	
Total				2066	238	608	2381	788	1488	288	1468	2380	2374	
Percent				15	2	4	17	6	11	2	10	17	17	
14079 Samples Taken														

Figure 1: A20 Station Positions

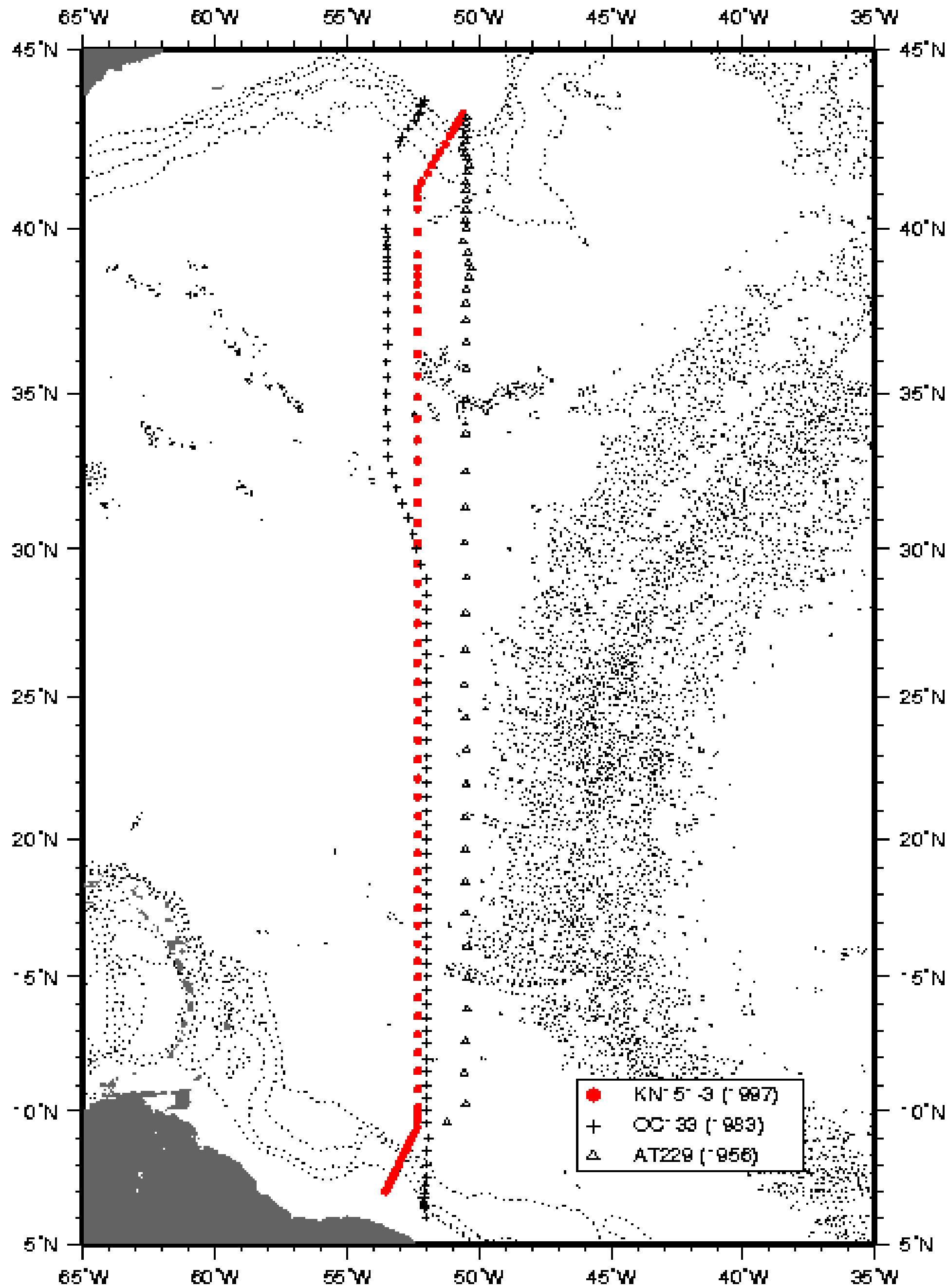


Figure 2: KN151 Labrador Current Theta (C)

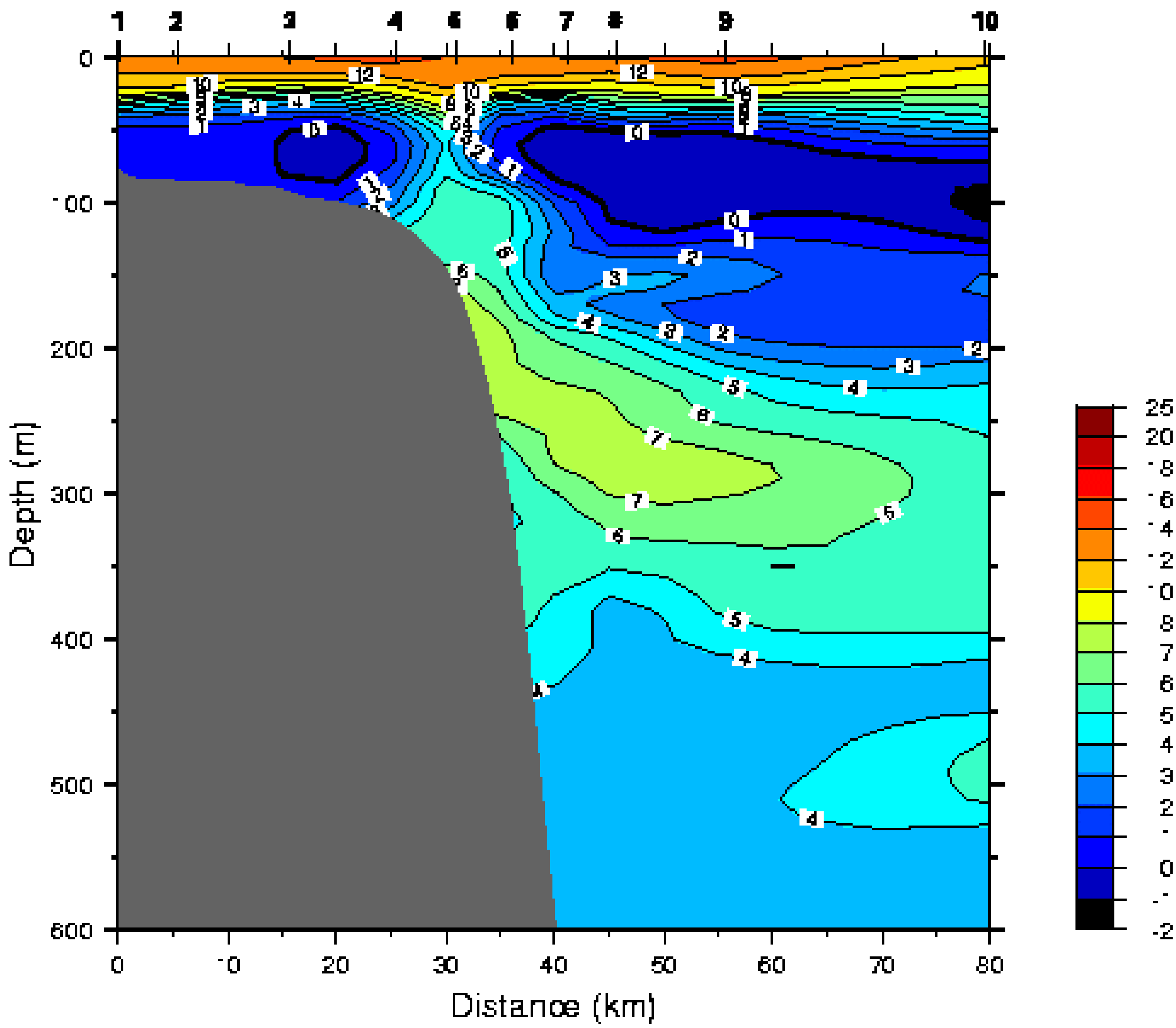


Figure 3: KN151 Northern Boundary Salinity (PSU)

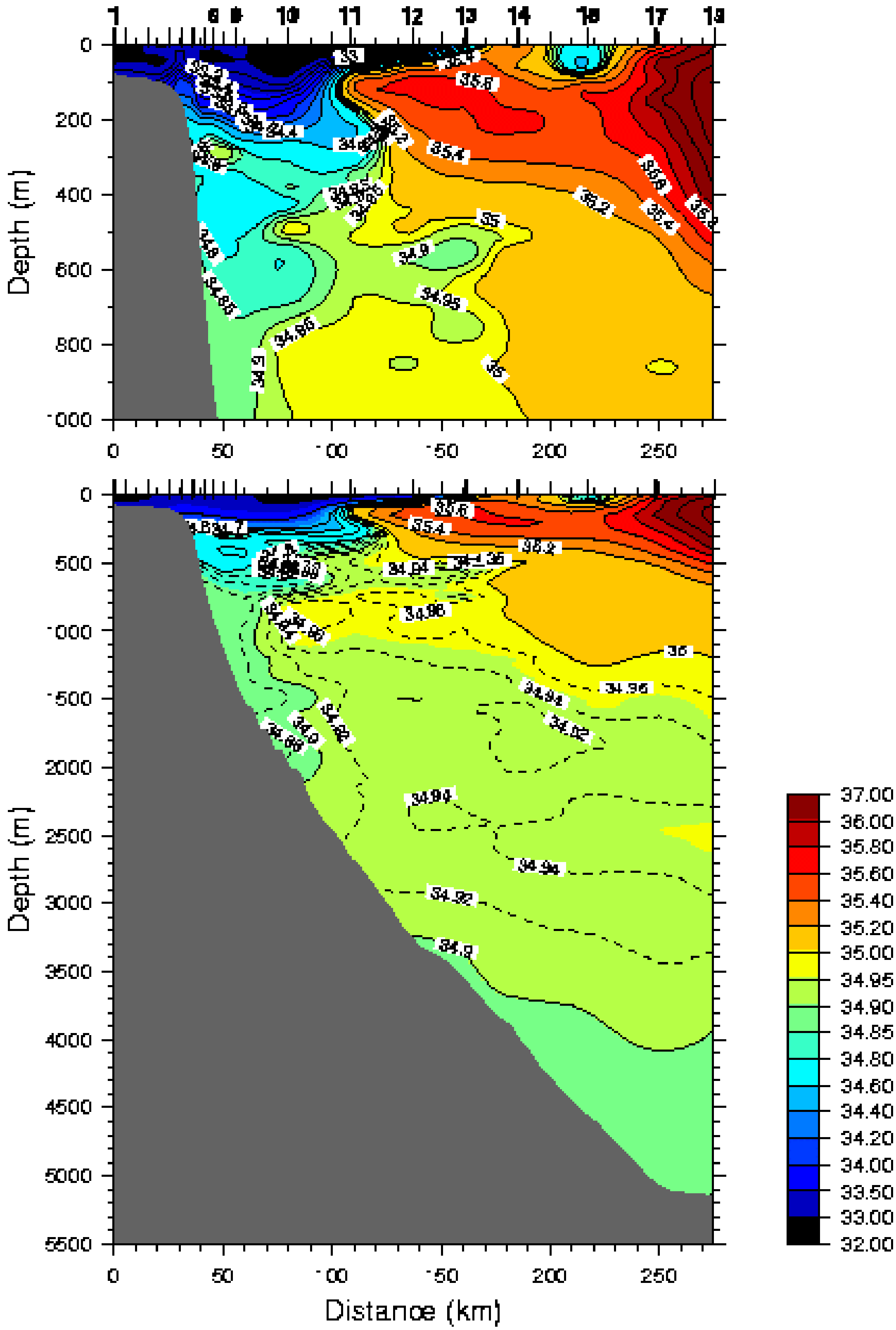


Figure 4a: KN151-III Salinity (PSU)

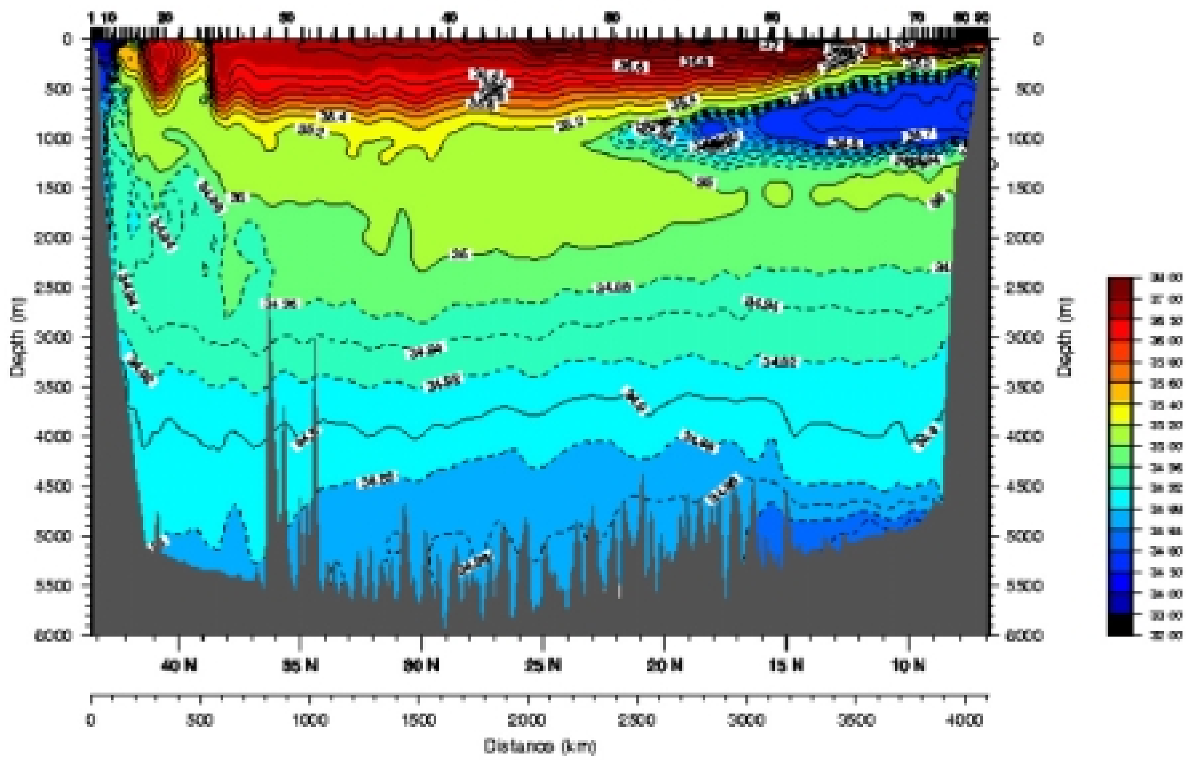
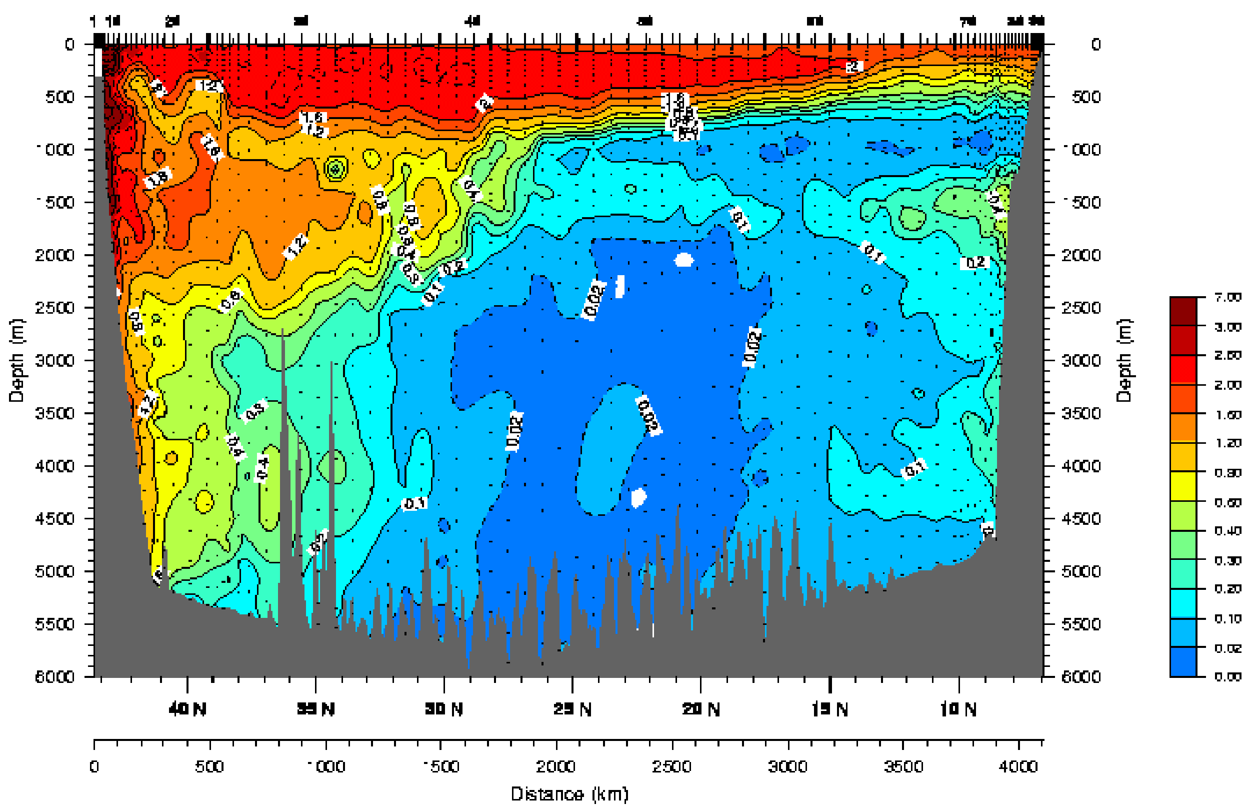


Figure 4b: KN151-III F-11 (pM/kg)



A20 CTD PROCESSING and CALIBRATIONS

CTD CALIBRATIONS AND AT-SEA PROCESSING:

CTD 9 Cal files

Station 999 was a test station and was taken using CTD 9 and cal file: kn51d999.c00 taken from cal file sent out for CTD 9: im09kn51.cal

kn51d999.c00 was updated with new conductivity terms and Pressure bias by RMillard to kn51d999.c01

Differences in cal extensions:		
	.c00	.c01
conductivity		
slope	0.972844e-03	.99569966E-3
bias	-0.416258e-01	.22897E-1
oxygen current		
slope	1.310000e-004	.0015
bias	8.540000e-001	0.0000
pcor	-1.177000e-005	.00015
tcor	-3.900000e-003	-.03
Pressure Temperature		
D1	-2.9015	-290.15

For CTD 9 im09kn51.c01 -- cal used for station 8

.c02 - was created but seemingly never used for ACQuistion.
Differences between .c002 and .c03 are:

diff im09kn51.c02 im09kn51.c03 (< = .c02 > = .c03)

Oxygen Current
SENSOR S/N ; New Sensor Installed 5 Oct 93
SENSOR S/N ; New Sensor Installed July 97
LAG ; 5.0
LAG ; 8.000000e+000

970720-MS: IM09kn51.c03 file updated from *.c01 modified by Millard.
.c01 used only for stn 008.
Oxygen current and conductivity values were changed from previous version.

Comments on cal files:

.c03 > 970720-MS: IM09kn51.c03 file updated from *.c01 modified by Millard. .c01 used only for stn 008. Oxygen current and conductivity values were changed from previous version.
.c04 > 970725-TKM: im09kn51.c04 file updated from *.c03 using new cals provided by Bob Millard. New conductivities from stations 14 - 18(?) and O2 cal from stations 11 - 14.
.c05 > 970728-TKM: im09kn51.c05 New pressure bias applied and new Oxygen cals provided by Bob Millard based on stations 20 - 36. Conductivity cal for stations xx - xx.
.c06 > 970801-TKM im09kn51.c06 New pressure bias applied and new Oxygen cals based on stations 24 - 41

Sta.	**CTD**	**Cal**
1-7	CTD 1088	im88kn51.cal (attached)
	CTD 9	im09kn51.c01
9 – 29	CTD 9	im09kn51.c03
30-39	CTD 9	im09kn51.c04
40-53	CTD 9	im09kn51.c05
54-83	CTD 9	im09kn51.c06
83-95	CTD 1088	im88kn51.c01
(Oxygen current params zeroed)		

CTD 1088 cal files:

PRESSURE	
quadratic	-.131851E-09
slope	0.107562
bias	-.435024E+02
lag	0
ACQLAG	0.200

STANDARD TEMPERATURE	
Quadratic	0.545757E-12
slope	0.496728E-03
bias	-.164305E+01
lag	250.0

CONDUCTIVITY	
slope	0.100263E-02
bias	-.108491E-01
lag	0
ACQLAG	0.100
ALPHA	-6.5E-6
BETA	1.5E-8
TO	2.8
PO	3000.0

OXYGEN CURRENT;
A ; 9.658398926872436D-17
B ;-1.412062274713116D-11
C ; 7.68213574439594D-07
D ;-1.834161650101719D-02
E ; 162.4567809569779
LAG ; 7.50
PCOR ; 0.00015
TCOR ;-0.036
C2 ; 0.75
TAU ; 0.0

OXYGEN TEMPERATURE;
A ; 0
B ; 0.0
C ; -.198691E-08
D ; 0.871938E-03
E ; -.110374E+02
LAG ; 0

PRESSURE TEMPERATURE
A ; 0
B ; 0
C ; 0
D ; -.255382E-02
E ; 0.107186E+03
LAG ; 0
ACQLAG ; 0.225
S1 ;-2.6778E-06
S2 ;-0.36463
T0 ; 1.4
D1 ; 0.218169

******************changes to o2 cal file ****************
ctd9
OXYGEN CURRENT ;
D ; 0.2325E-04
E ; 0.0
LAG ; 7.50
PCOR ; 0.00015
TCOR ;-0.036
C2 ; 0.75
TAU ; 0.0

At-sea processing:

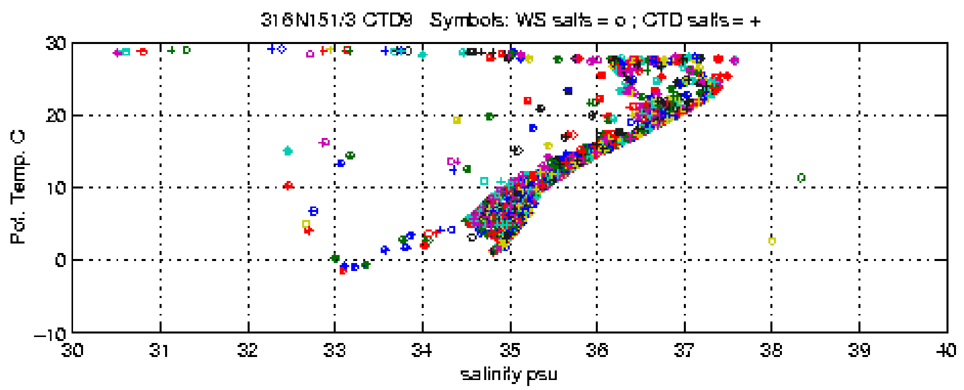
For CTD 9, conductivity sensor was very stable and required little adjusting. Terry McKee processed the data and Bob Millard provided calibration. Pressure bias required some adjusting at station 40 to make instrument measure 0 for on-deck pressure and to minimize the difference between on-deck pressure for the downcast and the upcast.

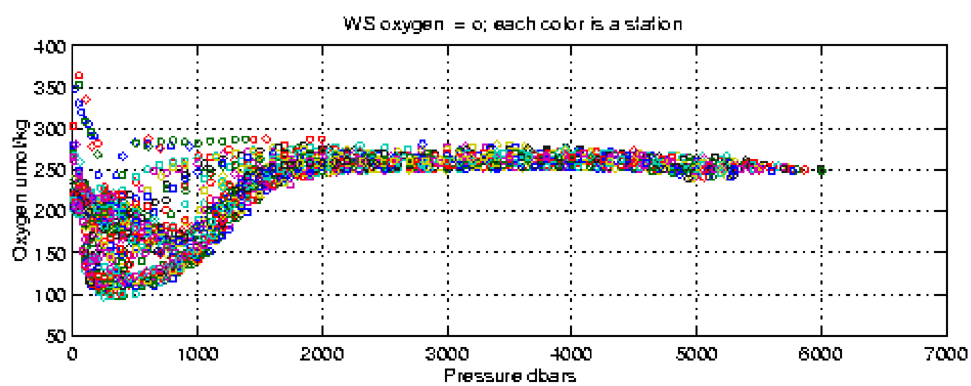
Shore-based Processing:

Calibrations were done by R. Millard , and processing by J. Dunworth-Baker

Extensive plotting and comparing led to converting the D1 term in pressure to -400 for CTD9

CTD9
Matlab routines were developed to better fit the data in station groups. Conductivity cals were refined. Oxygen fitting programs/routines were modified to allow for 2 different cals for each station...0-1500 dbars and 1500-bottom. The two cals were feathered together over 200 dbars. Bad surface values were smoothed or eliminated. The ctd data were extracted from the matlab workspace into the woce format, using wct_wrt2. Corrected ctdsal and ctdoxy at bottle levels were also extracted from the workspace into a sea file template, and merged into the final sea file (316N151_3.sea).

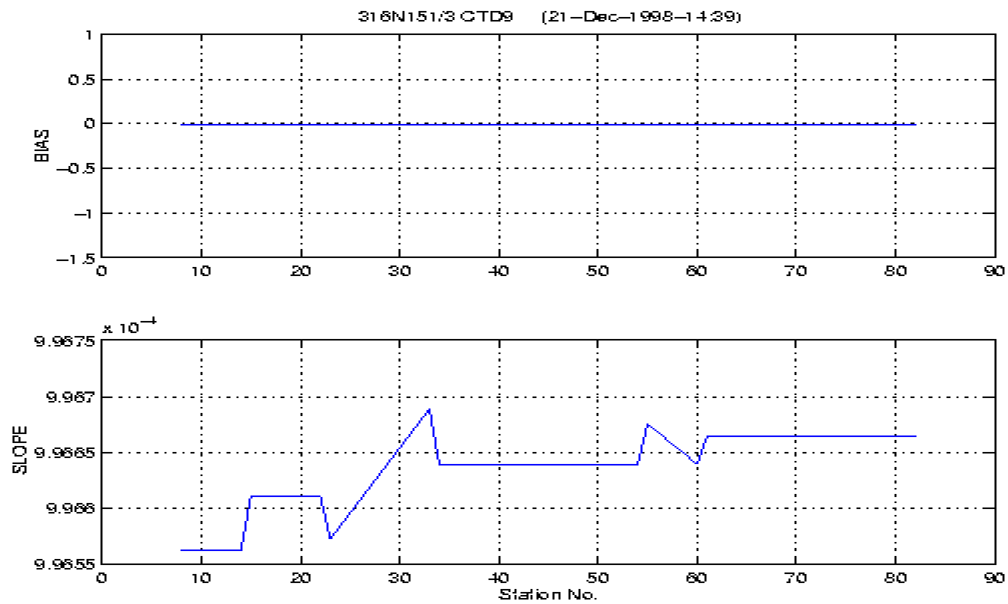




MATLAB FILE: kn151v3 CRUISE: 316N151/3
DATE: 17-Dec-1998
CTD9
Conductivity Calibrations

sta	slope	bias
8	0.000996561	-0.01
9	0.000996561	-0.01
10	0.000996561	-0.01
11	0.000996561	-0.01
12	0.000996561	-0.01
13	0.000996561	-0.01
14	0.000996561	-0.01
15	0.000996611	-0.01
16	0.000996611	-0.01
17	0.000996611	-0.01
18	0.000996611	-0.01
19	0.000996611	-0.01
20	0.000996611	-0.01
21	0.000996611	-0.01
22	0.000996611	-0.01
23	0.000996572	-0.01
24	0.000996584	-0.01
25	0.000996595	-0.01
26	0.000996607	-0.01
27	0.000996619	-0.01
28	0.00099663	-0.01
29	0.000996642	-0.01
30	0.000996654	-0.01
31	0.000996665	-0.01
32	0.000996677	-0.01
33	0.000996689	-0.01
34	0.000996639	-0.01
35	0.000996639	-0.01
36	0.000996639	-0.01
37	0.000996639	-0.01
38	0.000996639	-0.01
39	0.000996639	-0.01
40	0.000996639	-0.01
41	0.000996639	-0.01
42	0.000996639	-0.01
43	0.000996639	-0.01
44	0.000996639	-0.01
45	0.000996639	-0.01
46	0.000996639	-0.01

sta	slope	bias
47	0.000996639	-0.01
48	0.000996639	-0.01
49	0.000996639	-0.01
50	0.000996639	-0.01
51	0.000996639	-0.01
52	0.000996639	-0.01
53	0.000996639	-0.01
54	0.000996639	-0.01
55	0.000996675	-0.01
56	0.000996668	-0.01
57	0.000996661	-0.01
58	0.000996654	-0.01
59	0.000996646	-0.01
60	0.000996639	-0.01
61	0.000996664	-0.01
62	0.000996664	-0.01
63	0.000996664	-0.01
64	0.000996664	-0.01
65	0.000996664	-0.01
66	0.000996664	-0.01
67	0.000996664	-0.01
68	0.000996664	-0.01
69	0.000996664	-0.01
70	0.000996664	-0.01
71	0.000996664	-0.01
72	0.000996664	-0.01
73	0.000996664	-0.01
74	0.000996664	-0.01
75	0.000996664	-0.01
76	0.000996664	-0.01
77	0.000996664	-0.01
78	0.000996664	-0.01
79	0.000996664	-0.01
80	0.000996664	-0.01
81	0.000996664	-0.01
82	0.000996664	-0.01



MATLAB FILE: kn51v5 CRUISE: 316N151/3 DATE: 21-Dec-1998
Shallow OXYGEN calibrations

sta	bias	slope	pcor	tcor	wt	lag
8	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
9	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
10	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
11	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
12	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
13	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
14	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
15	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
16	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
17	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
18	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
19	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
20	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
21	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
22	0.04014	0.00139344	0.000148981	-0.03203	0.4331	3.7445
23	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
24	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
25	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
26	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
27	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
28	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
29	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445

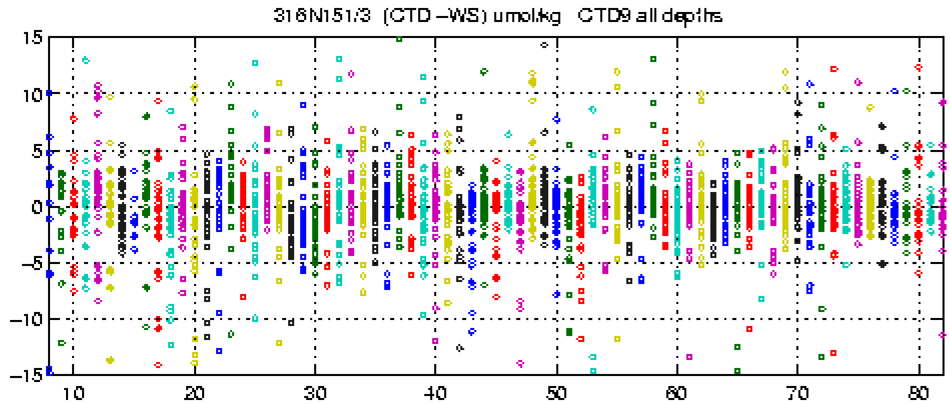
sta	bias	slope	pcor	tcor	wt	lag
30	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
31	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
32	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
33	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
34	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
35	0.01354	0.00133207	0.000198752	-0.02617	0.5241	3.7445
36	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
37	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
38	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
39	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
40	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
41	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
42	0.10237	0.00127476	0.000134255	-0.02508	0.7139	3.7445
43	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
44	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
45	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
46	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
47	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
48	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
49	0.08834	0.00104998	0.000239343	-0.01718	0.9557	3.7445
50	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
51	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
52	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
53	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
54	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
55	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
56	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
57	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
58	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
59	0.07287	0.000999973	0.000270196	-0.01557	0.8203	3.7445
60	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
61	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
62	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
63	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
64	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
65	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
66	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
67	0.09969	0.000772958	0.000351996	-0.00832	1.0417	3.7445
68	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
69	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
70	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
71	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
72	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
73	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
74	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445

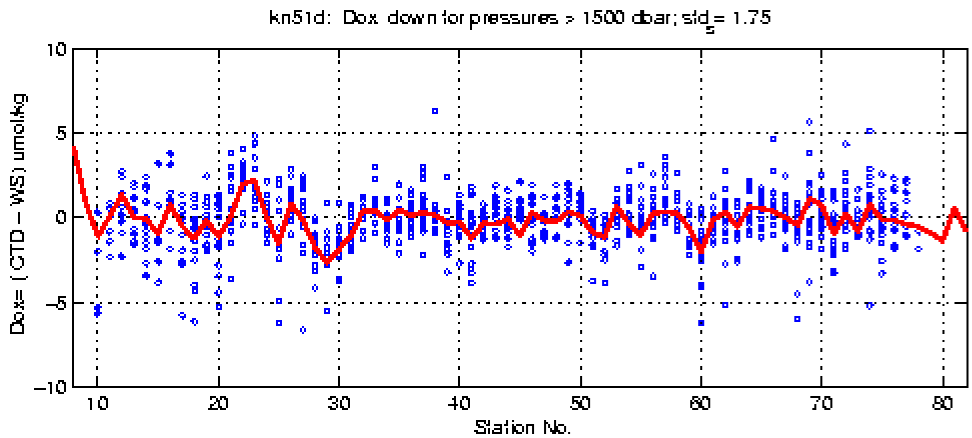
sta	bias	slope	pcor	tcor	wt	lag
75	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
76	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
77	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
78	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
79	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
80	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
81	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445
82	0.0374	0.00141479	0.000130707	-0.02767	0.6427	3.7445

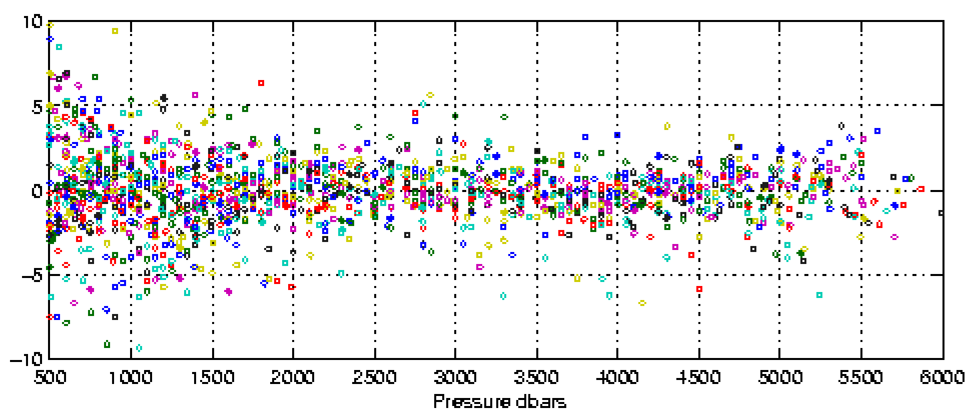
Deep Cals...

sta	bias	slope	pcor	tcor	wt	lag
8	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
9	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
10	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
11	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
12	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
13	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
14	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
15	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
16	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
17	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
18	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
19	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
20	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
21	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
22	0.85511	0.000391626	-1.51141e-005	-0.04796	0.2813	3.7445
23	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
24	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
25	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
26	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
27	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
28	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
29	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
30	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
31	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
32	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
33	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
34	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
35	0.05047	0.00156142	0.000127505	-0.0496	0.2164	3.7445
36	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445
37	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445
38	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445
39	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445

sta	bias	slope	pcor	tcor	wt	lag
40	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445
41	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445
42	0.02659	0.00158339	0.00013476	-0.05036	0.1415	3.7445
43	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
44	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
45	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
46	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
47	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
48	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
49	-0.05262	0.00152784	0.000173455	-0.02333	1.0655	3.7445
50	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
51	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
52	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
53	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
54	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
55	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
56	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
57	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
58	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
59	-0.00274	0.00149448	0.000153066	-0.02868	0.8203	3.7445
60	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
61	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
62	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
63	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
64	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
65	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
66	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
67	0.02911	0.00149021	0.000139251	-0.03213	1.0417	3.7445
68	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
69	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
70	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
71	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
72	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
73	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
74	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
75	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
76	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
77	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
78	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
79	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
80	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
81	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445
82	0.00492	0.00149473	0.000149884	-0.03184	1.0000	3.7445

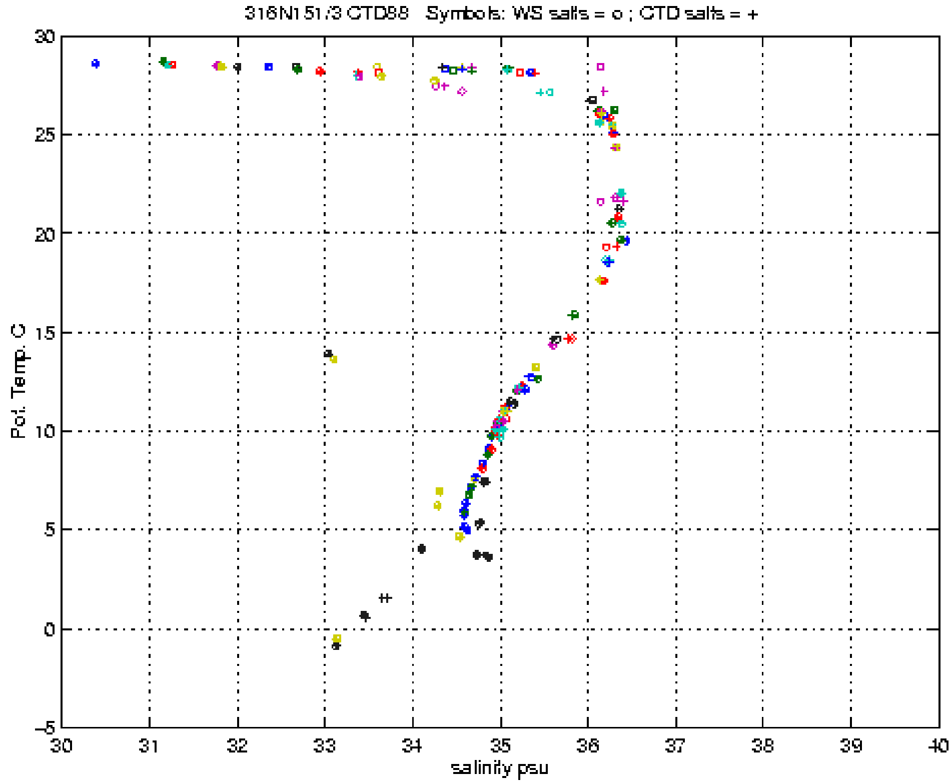




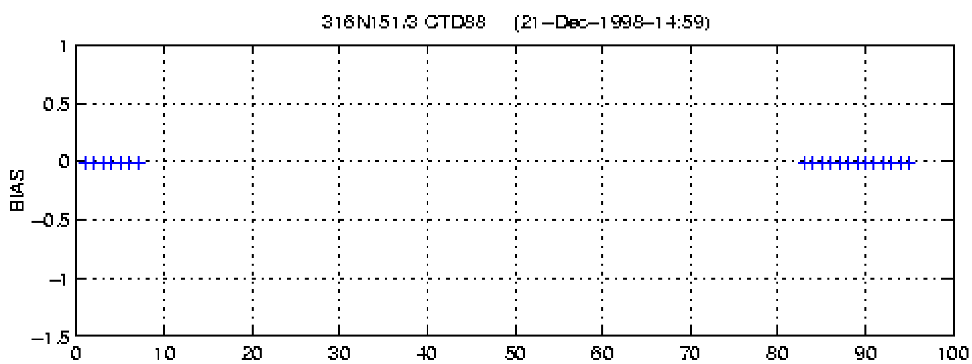


CTD88

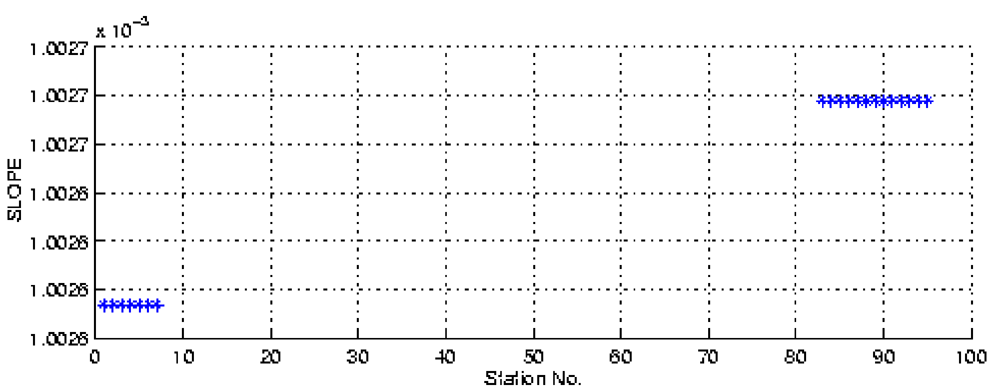
At sea co cals were checked and considered final. The ctdoxy was deemed un-fixable. Quality flags for ctdoxy in the ctd data and in the sea file are set to 4, and the quasi-calibrated ctdoxy are reported.



316N151/3 CTD88   Symbols: WS salts = o ; CTD salts = +
Pot. Temp. C
salinity psu



316N151/3 CTD88   (21−Dec−1998−14:59)
BIAS



x 10⁻³
SLOPE
Station No.

MATLAB FILE: kn51v88 CRUISE: 316N151/3
Conductivity Calibrations

sta	slope	bias
1	-0.011	0.00100259
2	-0.011	0.00100259
3	-0.011	0.00100259
4	-0.011	0.00100259
5	-0.011	0.00100259
6	-0.011	0.00100259
7	-0.011	0.00100259
83	-0.011	0.00100268
84	-0.011	0.00100268
85	-0.011	0.00100268
86	-0.011	0.00100268
87	-0.011	0.00100268
88	-0.011	0.00100268
89	-0.011	0.00100268
90	-0.011	0.00100268
91	-0.011	0.00100268
92	-0.011	0.00100268
93	-0.011	0.00100268
94	-0.011	0.00100268
95	-0.011	0.00100268

ACCE 52W Cruise Report Nutrient Analyses 8-Jun-98

Equipment and Techniques

Dissolved nutrient analyses were performed by J.C. Jennings, Jr. and B. E. Sullivan from Dr. L. I Gordon's group at Oregon State University (OSU). The analyses were performed using a Technicon AutoAnalyzerII (AAII) which is the property of Scripps Institution of Oceanography's Oceanographic Data Facility (ODF). This AutoAnalyzer has been used throughout the ACCE Program. For this 52W leg, we substituted an Alpkem Model 303 autosampler for the ODF autosampler. A Keithley model 575 data acquisition system was used in parallel with analog stripchart recorders to acquire the absorbance data for this leg. The software used to process the nutrient data was developed at OSU. OSU provided all of the reagent and standard materials. The analytical methods are described in Gordon et al (1994).

Sampling Procedures:

Nutrient samples were drawn from all sampled depths on CTD/rosette casts at stations 006 to 095. High-density polyethylene (HDPE) bottles of approximately 30-mL volume were used as sample containers, and these same bottles were positioned directly in the autosampler tray. These sample bottles were routinely rinsed at least 3 times with the sample seawater before filling. Sample bottles were rinsed twice with deionized water after sample runs, and were soaked in 10% HCl every other day. The nutrient samples were drawn following those for CFCs, helium, tritium, dissolved oxygen, carbon dioxide, alkalinity and salinity. At most stations, the AAII sample run was started before sampling was completed to reduce delay and minimize possible changes in nutrient concentration due to biological processes.

Calibration and Standardization:

Calibration standards for the nutrient analyses were prepared from high purity preweighed crystalline standard materials. The phosphate and nitrate standard materials had been compared in the OSU laboratory with NIST Standard Reference Materials and the silicofluoride with ultra high purity SiO_2 and silicon metal. The materials used were: Phosphate standard: JT Baker potassium di-hydrogen phosphate lot 39548. Nitrate standard: Mallinkrodt potassium nitrate lot VTA. Silicic acid standard: J. T. Baker sodium silicofluoride lot 21078 10A. Nitrite standard: MCB sodium nitrite lot 4205.

At the beginning of the cruise, six separate high concentration standards were prepared in deionized water; two silicic acid standards, two nitrite standards, and two mixed phosphate and nitrate standards. These duplicate standards were compared before use to ensure the accuracy of their preparation. Then more dilute mixed standards containing silicic acid, nitrate and phosphate were prepared from these high concentration standards. Similar mixed standards containing nitrate, phosphate, and silicic acid were prepared in duplicate at intervals of 7 to 10 days and kept refrigerated in HDPE bottles. For almost every station, a fresh "working standard" was prepared by adding aliquots of the high concentration mixed standard and the nitrite standard to low nutrient seawater. Working standards were not used if more than six hours had elapsed after their preparation. These working standards had nutrient concentrations similar to those found in Deep and Bottom waters.

The volumetric flasks and pipettors used to prepare standards were gravimetrically calibrated prior to the cruise. The Eppendorf Maxipettor adjustable pipettors used to prepare mixed standards typically have a standard deviation of less than 0.002 mL on repeated deliveries of 10-mL volumes. Corrections for the actual volumes of the flasks and pipettors were included in the preliminary data. The WOCE Operations Manual calls for nutrient concentrations to be reported in units of micromole/kg. Because the salinity information required to compute density is not usually available at the time of initial computation of the nutrient concentrations, our concentrations are always originally computed as micromole/L (uM). This unit conversion will be made using the corrected salinity data when it is available.

Measurement of Precision and Bias:

Short Term Precision and Bias:

Throughout the cruise, replicate samples drawn in different sample bottles from the same Niskin bottle were analyzed to assess the precision of the AAII analyses. These replicate samples were analyzed both as adjacent samples (one after the other) and at both the beginning and end of sample runs to monitor deterioration in the samples or uncompensated instrumental drift

We used a randomly selected subset of these replicate samples to estimate short-term (within run) precision. The average standard deviations of 26 sets of quadruplicate determinations are listed below. The deviation of the absolute values of the sample differences gives an estimate of short-term precision while the average difference with regard to sign is an estimate of uncompensated drift or bias.

Nutrient (uM)	**Avg. Stnd Dev. (uM)**	**Avg. Difference (wrt sign)**
Nitrate	0.043	0.014
Nitrite	0.002	0.002
Phosphate	0.003	0.002
Silicic acid	0.102	-0.070

Longer Term Precision:

In an attempt to assess the longer-term, between-station precision of the nutrient data, we fitted the deep nutrient data to sigma 4 data at several adjacent stations where natural background variability appeared to be small. We believe that the magnitude of the residuals can provide an estimate of station-to-station precision. The means of the absolute values of the residuals for several multi-station curves are presented below.

Sta Groups	#point used	Mean Silicic acid Residual (uM)	Mean Phosphate Residual (uM)	Mean Nitrate Residual (uM)
33 & 34	19	0.58 (1.16%)	0.010 (0.67%)	0.091 (0.45%)
45-47	36	0.37 (0.74%)	0.004 (0.26%)	0.054 (0.27%)
54 & 55	19	0.29 (0.58%)	0.005 (0.33%)	0.070 (0.35%)

Only data from depths greater than 2700m were used. Station pairs 54&55 and 33&34 were selected because high concentration mixed standards used changed at these stations. Stations 45 - 47 were selected because the deep-water variability appeared to be quite small at these locations. In all cases except the silicic acid fit for stations 33&34, the mean absolute value of the residuals expressed as a percentage of the deep-water concentration is <1.0%.

Nutrient Quality Control Notes:

During the 52W cruise, only limited flagging of the nutrient data was performed, except for those few bottles that were obvious leakers and for bottles whose values are average of replicate samples. (The relatively few Niskin bottles with obvious problems were usually not sampled.)

Nitrate values at 11 stations on the final day of sampling were flagged because of recognized problems. Unusually rapid declines in the efficiency of the Cd reduction column affected the nitrate determinations at stations occupied on 8 August 1997 despite repeated replacement of the columns. Our protocol of running calibration standards at both the start and end of each set of samples allows us to minimize the effect of linear changes in system response, but if the change in column efficiency is non-linear with time, some error will be introduced. We have carefully examined the nitrate data at the affected stations. Although we can find no clear effects on the accuracy of these data, we have flagged them as questionable because of the recognized analytical problem affecting these stations. Wherever possible, we compared replicate samples analyzed at both the beginning and end of the affected sample runs. In the worst cases (stations 082, 084, and 087) the replicate samples differ by 0.6-0.8 uM over the course of the run. (This is about 2.5% of the near bottom nitrate values.) This should provide a worst case estimate of the imprecision in these stations. Nitrate values were flagged at the following stations: 082, 084-087, and 091-095.

Post cruise QC summary:

All of the nutrient data has been re-examined for problems. A few typographical errors were discovered and corrected and several "questionable" values were identified and flagged. A summary of data flagging and other notes that may aid in DQE examination is given below:

Stations 1 - 5 were CTD only, no bottle samples were drawn.

Station 006: Odd numbered bottles sampled

Station 007: Odd numbered bottles sampled. No sample from #13, ran out of water.

Station 015: Only deep bottles tripped. All parameters shifted slightly relative to adjacent stations. The deepest two bottles (1 and 2) have very low silicic acid and high salinity, flagged as questionable.

Station 20: Kink in profiles at bottles 6 & 7, with 6 low and 7 high. No problems found in our raw data.

Station 021: Three low silicic acid values resulted from a typo (bottles 13, 14, and 15). Edited and recalculated

Station 022: Many nitrite values of -0.01. There was a problem with the DIW peaks and what looks like some non-linear drift. Flagged as 3's.

Station 028: High nitrite at the bottom. No obvious problem found in our raw data.

Station 038: 5648m. Low phosphate due to a typo in editing. Recalculated and edited.

Station 39: 1879m. Bottle 14 Slight low nutrient, high oxygen kink, no obvious problem.

Station 45: 2028m, Bottle 12 High silicic acid, flagged as questionable.

Station 51: 3941m. Bottle 6 High oxygen, low nut kink. Also present as a 2-bottle feature at Station 52. No problem obvious in our raw data.

Station 59: 4074m, Bottle 4 Low nutrient, high oxygen kink., No obvious problem found in our raw data. Flagged nitrate, phosphate, and silicic acid as questionable.

Station 60: Multiple nutrient/oxygen kinks at 4231,3251, and 2762 m. No obvious problems found

Stations 67-70: Lots of variability in nutrients and oxygen around theta range from 2.5 - 3 degrees. No obvious problems found.

Station 75: 26m, Bottle 32. High silicic acid in original data. Based on the low salinity/high silicic acid relationship of the Amazon outflow, we think that nutrient samples for bottles 32 and 33 were reversed and the high silicic acid belongs with the low salt. Edited accordingly.

Station 76: Bottles 12 - 16 Low phosphate (ca 0.03M). May be a temporary baseline shift. Flagged as questionable.

Station 77: 1485m. Phosphate shifted up with no change in nitrate or oxygen. This appeared to be a correctable baseline shift. Phosphate data for this station were edited and recalculated accordingly.

Nitrate values were flagged at stations: 082, 084-087, 091-095 due to Cd column problems discussed above.

References

Gordon, L. I., J. C. Jennings, Jr., A. A. Ross and J. M. Krest. 1994. A suggested protocol for continuous flow automated analysis of seawater nutrients (phosphate, nitrate, nitrite and silicic acid) in the WOCE Hydrographic Program and the Joint Global Ocean Fluxes Study. In WOCE Operations Manual, WOCE Report No. 68/91. Revision 1, 1994.