WHP Ref. No.: I01E/I01W
Last updated: 2000.09.14

A. Cruise Narrative:

A.1 Highlights

A.1.a WOCE designation: I01E/I01W

A.1.b Expedition Designation (EXPOCODE): 316N145_11-12

A.1.c Chief scientists:

Dr. John M. Morrison
Dept. of Marine, Earth and Atmospheric Science
North Carolina State University
1125 Jordan Hall
Raleigh, North Carolina
27695-8208
Phone: 919-515-7449
Email: John_Morrison@NCSU.EDU

Co-Chief scientists Dr. Harry L. Bryden
Southampton Oceanography Centre
Empress Dock
Southampton S014 3ZH, UK
Ph: 44-1703-596436
Fax: 44-1703-596204
Email: h.bryden@soc.soton.ac.uk

A.1.d Ship: R/V KNORR

A.1.e Ports of call: Muscat, Oman to Columbo, Sri Lanka to Singapore

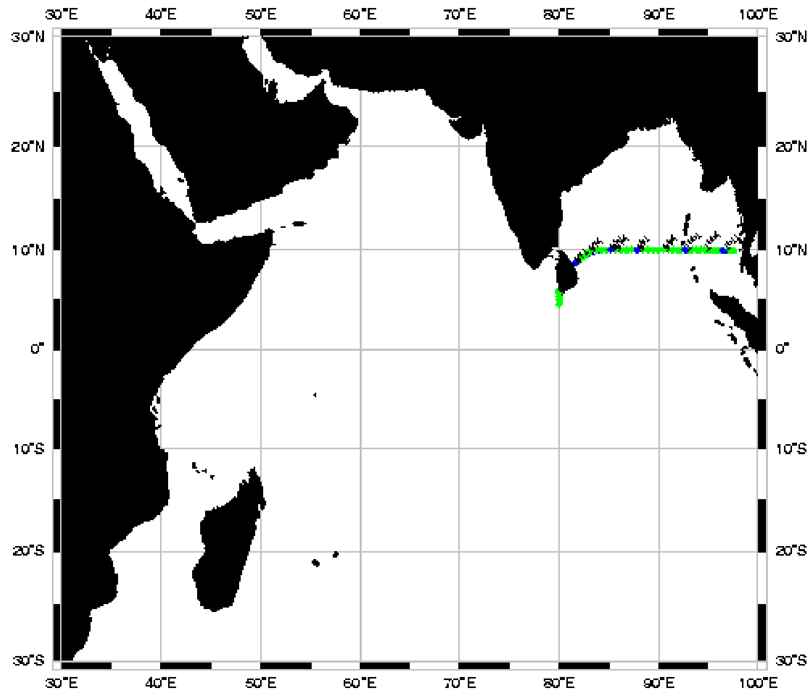
A.1.f Cruise dates: Aug. 29 - Sept. 28, 1995
Sept. 30 - Oct. 16, 1995

A.2 Cruise Summary

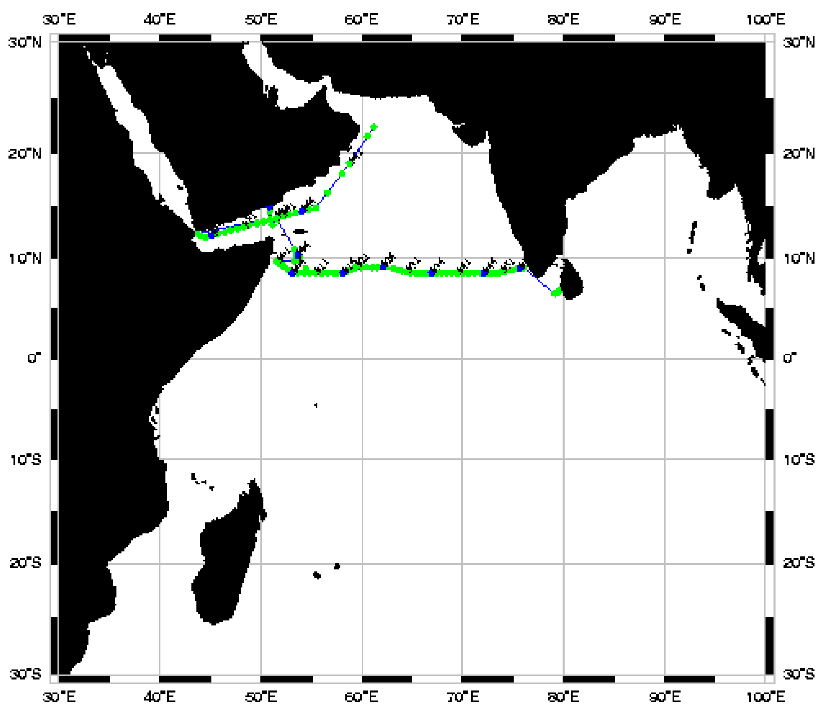
A.2.a Geographic boundaries

Cruise Track The cruise went across the North Indian Ocean at a nominal latitude of 8 N. From Muscat, the ship headed for the entrance to the Red Sea before starting the main section off the coast of Somalia. The section across the Arabian Sea ended on the continental shelf of India. After a brief port stop in Colombo, the section was continued from the Sri Lankan continental shelf across the Bay of Bengal and ended on the Myanmar continental shelf.

Station locations for I01E



Station locations for i01w



A.2.b Number of Stations

A total of 158 hydrographic stations were taken during the cruise, which includes three test stations to check instrument performance. A list of station positions including a brief chronology of notable events is in Table 1.

Sampling

On each hydrographic station, a continuous CTD profile of temperature, salinity and oxygen versus pressure is measured throughout the water column from the sea surface down to the ocean bottom; 36 water samples are then collected during the upcast and analysed in the laboratory for salinity, oxygen, nutrients (nitrate+nitrite, nitrite, silica and phosphate), chlorofluorocarbons (CFC-11, CFC-12), CO2 components (total CO2 and alkalinity); on selected stations water samples were collected for later analysis for helium, tritium, 14C, 13C and barium; finally, an LADCP was mounted on the CTD/Rosette frame on nearly every station to measure continuous profiles of horizontal velocity from the sea surface to the bottom and back to the sea surface. While underway and on station, continuous measurements were made of bottom depth, surface currents by a ship-mounted ADCP instrument with associated P-code GPS navigation, and meteorological variables with the ship-mounted IMET system.

Equipment used aboard KNORR for the basic CTD/Rosette system was provided by both Woods Hole Oceanographic Institution CTD Operations Group, and the Scripps Institution of Oceanography's Shipboard Technical Services/Ocean Data Facility (SIO STS/ODF). Four CTDs were brought for the cruise, two of which were used for the majority of the stations. Underwater equipment included:

Primary Sensors: Two Falmouth Scientific (FSI) ICTDs with Sensormedics oxygen sensors. Each has a Sensormedics oxygen sensor assembly and a titanium pressure transducer with temperature monitor.

Secondary Sensors: Two Neil Brown Mk-3 CTDs. Each has a Sensormedics oxygen sensor assembly and a titanium pressure transducer with temperature monitor.

In addition to the principal section across 8N-10N from Somalia to India, Sri Lanka to Myanmar, this station list contains:

1. a section along the axis of the Gulf of Aden
2. a meridional section across the Gulf of Aden from Yemen coastline
3. a section following German mooring line south of Socotra
4. a short section up onto the Sri Lanka continental shelf near Colombo
5. a short section south of the southern tip of Sri Lanka along 80 E to 4.5 N, repeating I8 stations 6 months later

Table 1. Hydrographic Station Positions and Brief Chronology for WOCE Section I1, R/V KNORR, 29 August to 16 October 1995, Muscat to Singapore

Sta #	WOCE #	Lat (N)	Lon (E)	Depth (m)	Comments	CTD Used
Start		23 37	58 38		Muscat Dep 8/29 0600	
1	857	22 28	61 12	3215	Station 841 on I7N	CTD38
2	858	22 28	61 12	3190	and	CTD09
3	859	22 28	61 12	3190	JGOFS station	CTD44
4	860	21 35	60 35		Water sample test 300m	
5	861	19 05	58 48	3285	Station 808 on I7N	
6	862	18 05	58 00	2815	JGOFS station	
7	863	16 16	56 33	3710	CTD test	CTD09
8	864	14 50	55 25	2440	CTD12	
9	865	14 40	54 45	2205	CTD44	
10	866	14 30	54 05	2595		
11	867	14 20	53 25	2970	Terminated at 700db	
12	868	14 20	53 25	2960	ALACE deployed	
13	869	14 10	52 45	1880	Terminated at 500bd	
14	870	14 10	52 45	1895		CTD38
15	871	14 00	52 10	2195		
16	872	13 50	51 30	1790	Repeated as 35	
17	873	12 22	43 42	300	Exit of Red Sea	
18	874	12 10	44 00	495		
19	875	12 00	44 30	1410		
20	876	12 10	45 05	815		
21	877	12 20	45 45	1390		
22	878	12 30	46 25	1770		
23	879	12 40	47 00	2005		
24	880	12 50	47 40	2350		
25	881	13 00	48 20	1995	ALACE deployment	
26	882	13 10	48 55	2640		
27	883	13 20	49 35	1950		
28	884	13 30	50 15	1955		
29	885	13 40	50 50	2470		
30	886	14 55	50 50	190	Yemen Shelf	
31	887	14 49	50 50	560		
32	888	14 40	50 50	1230	ALACE deployment	
33	889	14 30	50 50	1955		
34	890	14 10	51 10	2200		
35	891	13 50	51 30	1825		
36	892	13 43	51 34	4000	Proceed around Socotra	
37	893	10 48	53 22	3905	Pegasus German	CTD44
38	894	10 34.2	53 26	4020	mooring K14	
39	895	10 21	53 32	4185	Pegasus mooring	
40	896	10 09.9	53 38	4280	mooring K15	
41	897	9 54	53 48	4460	Pegasus line	
42	898	9 38.1	53 56	4580	mooring K16	
43	899	9 39	53 19	4580	Test station for	CTD12

Sta #	WOCE #	Lat (N)	Lon (E)	Depth (m)	Comments	CTD Used
43	900	9 42	51 30	760	Somalia	CTD44
44	901	9 35	51 40	1480	Fast ALACE deployment	
45	902	9 28	51 50	2325		
46	903	9 20	52 00	3650	Fast ALACE deployment	
47	904	9 06	52 17	4540		
48	905	8 48	52 41	4900	Fast ALACE deployment	
49	906	8 30	53 05	5035		
50	907	8 30	53 40	4970		
51	908	8 30	54 15	5025	mooring K17 8 43,54 20	
52	909	8 56	54 25	4800	Halfway between 908+909	
53	910	8 30	54 50	4660		
54	911	8 30	55 25	4730	Fast ALACE deployment	
55	912	8 30	56 00	3800		
56	913	8 30	56 35	4380		
57	914	8 30	57 10	4385		
58	915	8 30	57 34	3105		
59	916	8 30	58 06	3905	Section	
60	917	8 37	58 24	3700	Perpendicular to	
61	918	8 42	58 37	2305	Carlsberg Ridge	
62	919	8 51	59 00	3150	ALACE deployment	
63	920	8 57	59 14	3525		
64	921	9 01	59 25	3615		
65	922	9 01	59 57	3540		
66	923	9 01	60 29	3345		
67	924	9 01	61 01	3965		
68	925	9 01	61 33	4380		
69	926	9 01	62 05	4530		
70	927	9 01	62 37	4545	ALACE deployment	
71	928	8 54	63 08	4535		
72	929	8 48	63 34	4535	I7 station 782	
73	930	8 42	64 00	4530		
74	931	8 36	64 26	4560		
75	932	8 30	64 52	4550		
76	933	8 30	65 23	4535		
77	934	8 30	65 53	4525	ALACE deployment	
78	935	8 30	66 23	4530		
79	936	8 30	66 53	4555		
80	937	8 30	67 23	4560		
81	938	8 30	67 53	4575		
82	939	8 30	68 23	4575		
83	940	8 30	68 54	4590	ALACE deployment	
84	941	8 30	69 25	4615	Pick up Indian Officer	
85	942	8 30	70 00	4465		
86	943	8 30	70 35	4165		
87	944	8 30	71 10	3910		
87	945	8 30	71 45	3475		
88	946	8 30	72 05.7	2685	ALACE deployment	

Sta #	WOCE #	Lat (N)	Lon (E)	Depth (m)	Comments	CTD Used
89	947	8 30	72 26	2125		
90	948	8 30	72 47	2190		
91	949	8 30	73 08	2250		
92	950	8 30	73 28	1910		
93	951	8 34	73 50	2650		
94	952	8 39	74 15	2750		
95	953	8 44	74 40	2750		
96	954	8 48	75 00	2695		
97	955	8 52	75 20	1665		
98	956	8 56	75 40	345		
99	957	9 00	76 00	95		
Way	012	6 58	78 25		Disembark Indian Off	
100	958	6 25	79 06	2685	Baldridge station	
101	959	6 33	79 18	2345	Baldridge station	
102	960	6 42	79 30	1630	Baldridge station	
103	961	6 48	79 36	705	Baldridge station	
Colombo		6 55	79 52		Colombo Arr 9/28 0500	
Colombo		6 55	79 52		Colombo Dep 9/30 0300	
104	962	5 53	80 00	155	Short Section	
105	963	5 49	80 00	1110	Across Boundary	
106	964	5 45	80 00	2215	Current South of	
107	965	5 40	80 00	3235	Sri Lanka	
108	966	5 35	80 00	4030	I8 Station 284	
109	967	5 15	80 00	4135	Along 80 E	
110	968	4 55	80 00	4225	ALACE in 6C mode water	
111	969	4 30	80 00	4285	Down to 4.5¡N	
112	970	8 31	81 28	55		
113	971	8 37	81 36	2695		
114	972	8 46	81 48	3740	ALACE deployed	
115	973	8 58	82 04	3750		CTD38
116	974	9 13	82 24	3730		CTD44
117	975	9 28	82 44	3695		
118	976	9 43	83 04	3650		
119	977	9 58	83 24	3620		
120	978	9 58	83 51	3610		CTD38
121	979	9 58	84 18	3580	ALACE deployed	CTD44
122	980	9 58	84 45	3570		CTD38
123	981	9 58	85 12	3565		
124	982	9 13	82 24	3725	Redo 974	
125	983	9 28	82 44	3695	Redo 975	
126	984	9 43	83 04	3645	Redo 976	
127	985	9 58	84 18	3585	Redo 979	
128	986	9 58	85 39	3540		
129	987	9 58	86 12	3505		
130	988	9 58	86 45	3495		
131	989	9 50	86 47	3510	I9 station 268	
132	990	9 58	87 18	3480		

Sta #	WOCE #	Lat (N)	Lon (E)	Depth (m)	Comments	CTD Used
133	991	9 58	87 51	3425	ALACE	
134	992	9 58	88 24	3405		
135	993	9 58	88 57	3375		
136	994	9 58	89 28	3350		
137	995	9 58	89 59	3310		
138	996	9 58	90 30	3330	Pick up Ind. Navy Off	
139	997	9 58	91 00	3470	I9 station 234	
140	998	9 58	91 27	3405		
141	999	9 58	91 54	1285		
142	1000	9 58	92 16	845		
143	1001	9 58	92 38	990	Ten Degree Channel	
144	1002	9 58	93 00	1435		
145	1003	9 58	93 22	3065		
146	1004	9 58	93 46	4235		
147	1005	9 58	94 12	3180		
148	1006	9 58	94 38	2855		
149	1007	9 54	95 04	1775	Disembark Indian Off	
150	1008	9 50	95 30	2620		
151	1009	9 50	95 50	2475		
152	1010	9 50	96 10	1315		
153	1011	9 50	96 30	430		
154	1012	9 50	96 55	325		
155	1013	9 50	97 17	260		
156	1014	9 50	97 33	83		
End		1 20	103 50		Singapore Arr10/15 1100	

General Oceanics (GO) model 1016-36 pylon with 36-bottle frame with 10-liter bottles manufactured by SIO STS/ODF and Ocean Instrument Systems 10-kHz pinger.

A.2.c. Floats: ALACE Deployments

Autonomous Lagrangian Circulation Explorer (ALACE) floats are intended to map absolute velocity of large-scale currents for use with geostrophic shears from historical and WOCE Hydrographic Programme sampling. The floats drift at 800 to 1000 m depth, surfacing periodically to report their position by satellite. To avoid diffusion bias, the horizontal coverage is intended to be relatively uniform but the density for this cruise was augmented a bit near the western boundary of the Somalia coast

Two floats could not be launched as planned because they were in the territorial waters of India. Permission for such deployments had not been requested from the Government of India and the official Indian observer insisted that no ALACE deployments were allowed. One of the resulting two extra floats was deployed in a thermostad feature south of Sir Lanka at about 1000 m depth at 4 44 N, 80 E. Most of the ALACE floats have a 26-day cycle time, drifting for 26 days at 800 to 1000 m depth, then rising to the sea surface to report position to a satellite, before returning to depth to repeat the cycle for another 26 days. Design lifetime for these floats is 5 years. Four of the ALACE floats deployed in the region of the Somali Current (denoted by ÒFÓ) have 15-day cycle times. Each ALACE float was prepared in the laboratory during the downcast of a CTD station and launched from the stern of KNORR at the completion of a hydrographic station just as the ship set out for the next station. The launch information is shown in Table 2.

TABLE 2: WOCE I1 ALACE FLOAT LAUNCH INFORMATION

S/N	START TIME OF LAST SELFTEST	DEPLOYMENT TIME	DEPLOYMENT POSITION
536	950903 0230Z	950903 0357Z	14:20.03N, 53:25.11E
534	950907 0413Z	950907 0557Z	13:00.34N, 48:19.81E
539	950908 0912Z	950908 1302Z	14:38,08N, 50:49.52E
523F	950912 0944Z	950912 1126Z	09:36,95N, 51:40.11E
521F	950912 1547Z	950912 1944Z	09:21.39N, 51:58.86E
522F	950913 0527Z	950913 0857Z	08:50.95N, 52:41.39E
524F	950914 1555Z	950915 0234Z	08:27.02N, 55:24.39E
540	950916 1452Z	950916 2328Z	09:49.95N, 59:00.22E
546	950918 2142Z	950919 0148Z	09:00.87N, 62:36.73E
545	950921 0131Z	950921 0323Z	08:29.95N, 65:53.15E
542	950922 1955Z	950922 2217Z	08:29.80E, 68:53.85E
541	950924 0841Z	950924 1022Z	08:30.14N, 72:04.99E
543	951001 1615Z	951001 1940Z	04:55.10N, 79:59.93E
544	951003 0318Z	951003 0530Z	08:35.22N, 81:36.64E
533	951005 0413Z	951005 0626Z	09:58.81N, 84:17.46E
532	951008 2001Z	951008 2206Z	09:58.18N, 87:51.67E

A.2.d Mooring deployed or recovered

A.3 List of Principle Investigators

The list of Principal Investigators, their institution and the measurement program that they are responsible for is shown in Table 3.

Table 3: WOCE I1 Principal Investigators

Measurement	Principal Investigator	Institution
Chief Scientist	John M. Morrison	North Carolina State University
co-Chief Scientist	Harry Bryden	Southampton Oceanography Centre
Salinity, oxygen, CTD/O2	John Toole	Wood Hole Oceanographic Institution
Nutrients	Louis Gordon	Oregon State University
Chlorofluorocarbons	Mark Warner	University of Washington
Shallow He/Tr	William Jenkins	Wood Hole Oceanographic Institution
Deep He/Tr	Zafer Top	University of Miami
AMS C-14	Robert Key	Princeton University
Barium	Kelly Falkner	Oregon State University
TCO2	Catherine Goyet	Wood Hole Oceanographic Institution
ADCP/LADCP	Teresa Chereskin	Scripps Institution of Oceanography

Underway PCO2	Robert Key	Princeton University
IMET	Barrie Walden	Wood Hole Oceanographic Institution
Thermosalinograph	Barrie Walden	Wood Hole Oceanographic Institution
ALACE Floats	Russ Davis	Scripps Institution of Oceanography

A.4 Scientific Programme and Methods

The transindian hydrographic section I1 is the northernmost of the zonal sections to be carried out during the US WOCE Indian Ocean Expedition in 1994-1996. It crosses the southern boundaries of both the Bay of Bengal in the east and the Arabian Sea in the west. This section effectively completes the circumnavigation of the ocean with high quality hydrographic sections at latitudes between 8 N and 11 N, started by the 10 N transpacific and the 11 N transatlantic section carried out in 1989.

Section I1 encloses two areas of the northern Indian Ocean, the Arabian Sea and the Bay of Bengal. From I1 we should be able to compute separate heat, salt and water-mass budgets for each of these basins. This is of interest because the Arabian Sea is an important source of salt to the world ocean, while the Bay of Bengal is an important source of fresh water. In addition to helping define the thermohaline circulation of the Indian Ocean in conjunction with the overall survey of the Indian Ocean Expedition, the specific objectives of the Principal Investigators (PIs) are:

1. To determine the meridional heat and freshwater transports across 8 N in the Indian Ocean and to combine the new estimates with existing Atlantic and Pacific estimates in order to determine the total global ocean heat and freshwater transports across 10 N for comparison with the atmospheric and satellite-based estimates of energy transport;

2. To make a detailed analysis of the freshwater budget of the Bay of Bengal, into which 2 of the world's largest rivers empty, in order to understand the effects of this freshwater source on the Indian Ocean circulation;

3. To estimate the nutrient (and possibly the carbon transport) into and out of the Arabian Sea across its southern boundary at 8¡N in order to estimate the size of the overall biological productivity and of the "biological pump" in the Arabian Sea for comparison with JGOFS results.

4. To cooperate with the PIs of the other WOCE Indian Ocean Expedition on the preparation of a new "atlas" describing the first order circulation of the basin and to present and catalog the data collected in a systematic fashion.

5. To coordinate the results of our survey with the JGOFS Arabian Sea Process Study. JGOFS is carrying out 7 cruises within the Arabian Sea, encompassing an entire monsoonal cycle. The JGOFS data will be used to investigate the representativeness of the WOCE sections in the Arabian Sea, where there is large seasonal variability associated with monsoonal forcing. In addition, comparison of data collected during the JGOFS efforts near the mouth of the Arabian Sea with the hydrographic properties at

Section I1 may allow us to estimate the percentage of Persian Gulf Water that actually escapes into the Indian Ocean. Finally, estimates of the amount of Arabian Sea Water leaving the basin at the end of the Southwest Monsoon will be made.

6. To determine the extent of eastward penetration of high salinity Arabian Sea waters during the boreal winter that displace the low salinity waters normally carried westward by the North Equatorial Current (NEC).

7. To describe the deep water properties of the Adaman Basin, which is an enclosed basin below approximately 1500 m depth.

In addition, there are a number of questions that will be addressed using data from a combination of multiple sections, VOS XBT data, Lagrangian drifter data, etc. We will actively share the I1 measurements with other scientists working on such objectives and questions.

Preliminary Results

KNORR departed Muscat, Oman, on schedule on 29 August 1995. We proceeded westward down the coast of Oman, reoccupying a joint JGOFS and I7 station (841) at 22 28 N, 61 12 E, an I7 station (808) at 19 05 N, 58 48 E and a JGOFS station at 18 05 N, 58 00 E. Preliminary inter-comparisons of the data show excellent agreement. We then proceeded to carry out our Gulf of Aden Section. This section has 20 stations along a line from 12 22 N, 43 44 E to 14 50 N, 55 22 E. This section shows considerable variability, but gives us a good endpoint for Red Sea Water for water mass analysis. Satellite imagery from the JGOFS receiving station in Oman will aid in interpreting this data.

Because of the threat of pirates, we were forced to cancel the southern half of our planned section across the mouth of the Gulf of Aden. Instead, we proceeded to the position of a German current meter array south of Socotra. Once again because of the threat of pirates, we were forced to cancel any work around the moorings within 60 nm of Socotra. In discussions with Dr. F. Schott via Imarsat, we determined that we were just ahead of METEOR on this section. We coordinated our efforts with Schott to make a more densely spaced section along his array. In addition, we occupied 3 of his Pegasus sites for intercomparison of our LADCP velocities with his Pegasus velocity profiles.

We then proceeded to 9 42 N, 51 30 E to begin the main I1 line across the Arabian Sea. We took 6 closely spaced stations across the Somali Current, angling down to our main section latitude of 8 30 N. The main section is across the basin at 8 30 N, except for a short diagonal section perpendicular to the Carlsberg Ridge at about 58 E and a diversion to reoccupy another I7 station (782) at 8 48 N, 63 54'E.

On Monday, 18 September, we received word that the Government of India has decided to give a one-time exemption to carry out work in their waters at 20 nm spacing and to allow use of the ADCP and LADCP. Fortunately, the State Department and WOCE Office had been able to give us a heads-up on the clearance about a week earlier. We picked up the

Indian Observer at 8 30 N, 69 25 E on Saturday, 23 September. We then continued our line through the Laccadive Islands at the 8 Degree Channel and into the coast at 9 00 N, 76 00 E. In all we took 58 stations along the main I1 section of which 17 stations were within the Indian EEZ.

From the end of the main section, we disembarked the Indian Observer while transiting to Sri Lankan waters. We then reoccupied the 4 inshore stations of the BALDRIDGE I1 Pre-peat section onto the Sri Lankan shelf. We arrived in Colombo, Sri Lanka, on the morning of 28 September, having completed 103 stations on Leg 1. The final station on this leg was WOCE station 961.

KNORR departed Colombo, Sri Lanka, on schedule at 0800 on 30 September 1995 and proceeded south of Sri Lanka where 8 stations of Section I8 was reoccupied along 80 E to 4 30 N. Currents were weak along this section, showing little sign of the Indian Monsoon Current. Time had been scheduled time to occupy 2 stations in the Trincomalee Canyon at about 8 30 N, 81 20 E on the coast of Sri Lanka at the request of Kamal Tennakoon of National Aquatic Resources Agency in Sri Lanka. The Sri Lankan Naval Observer informed us that the Tamal Tigers were active in this area and advised us not to take these stations. KNORR then proceeded to the endpoint of the main line at 8 31 N , 81 28 E (just off the coast of Sri Lanka). Even though this station was in sight of land in the vicinity of the city of Trincomalee (where there is a major Sri Lankan Naval Base), the Sri Lankan Navy was so concerned about the potential threat of the Tamal Tigers, that they requested that we occupy this station during the daylight hours. They also escorted us with 4 gunboats as we came up the coast from the south to the location of this station. KNORR began the main line across the Bay of Bengal without incident. The first 8 stations were along a SW to NE line from the coast of Sri Lanka to the latitude of the proposed section, 9 58 N, across the Bay of Bengal. As KNORR proceeded along the main line, a 2 - 3 knot current flowing to the south out to about 75 nm (at least to the 4000 m isobath) was observed in the shipboard ADCP record. We then proceeded along the main line to 9 58 N, 85 12 E, where a problem with the CTD occurred. Fortunately, we had been processing the data with about a 24 hour delay. Because we had time, we decided to backtrack and redo 4 of the stations along the main line. We proceeded back to 9 58 N, 85 12 E, and continued to the east along the main line. We diverted slightly off the main line to reoccupy I9 Station 268. We picked up the Indian Naval Observer at 9 58 N, 88 58 E on Monday morning, 9 October 1995. We then proceeded with our section across the Adaman Sea. The Indian observer disembarked just prior to our entry into the waters of Myanmar. The last 4 stations of the line were within the waters of Myanmar. We completed the section at station 1014 and deadheaded to Singapore, anchoring in the harbour for the night of 15 October 1995 before docking on 16 October.

A.5 Major Problems Encountered on the Cruise

Because of the threat of pirates, we were forced to cancel the southern half of our planned section across the mouth of the Gulf of Aden. Also, because of the threat of pirates, we were forced to cancel any work around the German current meter moorings within 60 nm of Socotra. Finally, because of the threat of pirates we were not able to begin the section as close to Somalia as we would have liked; our most inshore station was in about 850 meters of water; the ADCP data shows that the most inshore hydrographic station was in the core of the Somali Current; hence we were not able to sample completely across to the inshore side of the Somali Current.

Potential problem with Standard Seawater Batch P-124.

Suspicion that salinity samples drawn after long times on deck might be changed due to condensation in the warm moist air in the head space of cold, deep-water bottles.

LADCP equipment failure for a section of the first leg leaves a portion of the section across the mouth of the Arabian Sea without absolute velocities.

A.6 Other Observations of Note

Preliminary data were supplied to the foreign observers of India, Sri Lanka and Myanmar prior to their departure from the ship.

A.7 List of Cruise Participants

I01 Crew List:	**Leg 1**	**Leg 2**
1. Dr. John Morrison, Co-Chief Scientist	CTD Watch	CTD Watch

North Carolina State University
MEAS Box 8208
Raleigh, NC 27695-8208
U. S. Citizen
Ph: (919) 515-7449
Fax: (919) 515-7802
Email: John_Morrison@ncsu.edu
(PI: Morrison)

2. Vijayakumar Manghnani	CTD Watch	CTD Watch

North Carolina State University
MEAS Box 8208
Raleigh, NC 27695-8208
Ph: (919) 515-7449
Fax: (919) 515-7802
Email: vijay@meadsp.nrrc.ncsu.edu
(PI: Morrison)

3a. L. V. Gangadhara Rao — CTD Watch
Physical Oceanography Division
National Institute of Oceanography
Dona Paula, Goa - 403 004, India
Indian Citizen
Ph: 91-832-226253 - 56 (O)
91-832-221848 (R)
Fax: 91-832-223340
Email: lvgrao@bcgoa.ernet.in
Telex: 0194-216 NIO IN
(PI: Morrison)

3b. M. T. Babu — CTD Watch
Physical Oceanography Division
National Institute of Oceanography
Dona Paula, Goa - 403 004, India
Indian Citizen
Ph: 91-832-221323
Fax: 91-832-223340
Email:
(PI: Morrison)

4. Dr. Harry L. Bryden, Co-Chief Scientist — CTD Watch — CTD Watch
Southampton Oceanography Centre
Empress Dock
Southampton S014 3ZH, UK
U. S. Citizen
Ph: 44-1703-596436
Fax: 44-1703-596204
Email: h.bryden@soc.soton.ac.uk
(PI: Bryden)

5a. Lisa M. Beal — CTD Watch
Southampton Oceanography Centre
Empress Dock
Southampton S014 3ZH, UK
U. K. Citizen
Ph: 44-1703-596436
Fax: 44-1703-596204
Email: lmb@soc.soton.ac.uk
(PI: Bryden)

5b. Dr. Michael N. Tsimplis CTD Watch
Southampton Oceanography Centre
Empress Dock
Southampton S014 3ZH, UK
Greek Citizen
Ph: 44-1703-596441
Fax: 44-1703-596204
Email: mnt@soc.soton.ac.uk
(PI: Bryden)

6a. Alison Scoon CTD Watch
26a Gibbon Road
Kingston Upon Thames
KT2 6AB, UK
Ph: 0181 5415025
or
Southampton Oceanography Centre
Empress Dock
Southampton S014 3ZH, UK
c/o Ian Robinson

6b. Michael J. Griffiths CTD Watch
Southampton Oceanography Centre
Empress Dock
Southampton S014 3ZH, UK
U. K. Citizen
Ph: 44-1703-596436
Fax: 44-1703-596204
Email: m.griffiths@soc.soton.ac.uk
(PI: Bryden)

7. Craig Harris CTD Watch CTD Watch
Oceanography Laboratories
Department of Earth Sciences
Liverpool University
Liverpool L693BX, UK
U. K. Citizen
Ph: 44-151-7944097
Email:
(PI: Bryden)

8. Marshall Swartz Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-2246 Fax: (508) 457-2165 Email: mswartz@whoi.edu (PI: Toole)	CTD W Leader	CTD W Leader
9. Paul Robbins Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-2918 Fax: (508) 457-2181 Email: probbins@whoi.edu (PI: Toole)	CTD W Leader	CTD W Leader
10. Laura Goepfert Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-2937 Fax: (508) 457-2165 Email: lgoepfert@whoi.edu (PI: Toole)	CTD Data Anal	CTD Data Anal
11. Paul Bouchard Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-3277 Fax: (508) 457-2165 Email: pbouchard@whoi.edu (PI: Toole)	CTD Watch	CTD Watch
12. George Tupper Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-2693 Fax: (508) 457-2165 Email: gtupper@whoi.edu (PI: Toole)	Salts	Salts

13. Dave Wellwood Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-2657 Fax: (508) 457-2165 Email: dwellwood@whoi.edu (PI: Toole)	Dissolved Oxygens	Dissolved Oxygens
14. Joe C. Jennings, Jr. Oregon State University U. S. Citizen Ph: (503) 737-4365 Fax: (503) 737-2064 Email: jenningj@oce.orst.edu (PI: Gordon)	Nutrients	Nutrients
15. Stanley Moore, Jr. Oregon State University U. S. Citizen Ph: (503) 737-3961 Fax: (503)737-2064 Email: moores@ucs.orst.edu (PI: Gordon)	Nutrients	Nutrients
16. Greg Eischeid Woods Hole Oceanographic Institution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-3410 Fax: (508) 289-2193 Email: geischeid@whoi.edu (PI: Goyet)	CO2	CO2
17. Philip Ording Woods Hole Oceanographic Institution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 457-2000-3553 Fax: (508) 289-2193 Email: cathy@co2.whoi.edu (PI: Goyet)	CO2	CO2

18. Toshitaka Amaoka   CO2   CO2
Marine and Atmospheric Geochemistry
Graduate School of Environmental Earth Science
Hokkaido University
Sapporo 060, Japan
Japanese Citizen
Ph: 81-11-706-2371
Fax: 81-11-726-6234
Email: f063411@eoas.hokudai.ac.jp
(PI: Goyet)

19. Kozo Okuda   CO2   CO2
Marine and Atmospheric Geochemistry
Graduate School of Environmental Earth Science
Hokkaido University
Sapporo 060, Japan
Japanese Citizen
Ph: 81-11-706-2371
Fax: 81-11-726-6234
Email: f053305@eoas.hokudai.ac.jp
(PI: Goyet)

20a. Teri Chereskin   ADCP/LADCP
Scripps Institute of Oceanography
Mail Code 0230
9500 Gilman Drive
La Jolla, CA 92093-0230
U. S. Citizen
Ph: (619) 543-6368
Fax:
Email: teri@scafell.ucsd.edu
(PI: Chereskin)

20b. Matthew Trunnell   ADCP/LADCP
Scripps Institute of Oceanography
Mail Code 0230
9500 Gilman Drive
La Jolla, CA 92093-0230
U. S. Citizen
Ph: (619) 543-5996
Fax: (619) 534-0704
Email: matter@ucsd.edu
(PI: Chereskin)

21. Peter Landry Woods Hole Oceanographic Insitution Woods Hole, MA 02543 U. S. Citizen Ph: (508) 289-2918 Fax: (508) 457-2000-2165 Email: plandry@whoi.edu (PI: Jenkins)	He/Tr	He/Tr
22. Murat Aydin c/o Zafer Top RSMAS Univ of Miami 4600 Rickenbaker Causeway Miami, FL 33149 Turkish Citizen Ph: (305) 361-4110 Fax: (305) 361-4112 Email: maydin@rsmas.miami.edu (PI: Top)	Deep He	Deep He
23. Steven Covey University of Washington School of Oceanography Box 357940 Seattle, WA 98195-7940 U. S. Citizen Ph: (206) 543-5059 Email: scovey@ocean.washington.edu (PI: Warner)	CFC	CFC
24a. Sabine Mecking University of Washington School of Oceanography Box 357940 Seattle, WA 98195-7940 German Citizen Email: mecking@ocean.washington.edu (PI: Warner)	CFC	

24b. Welin Huang University of Washington School of Oceanography Box 357940 Seattle, WA 98195-7940 Email: mwarner@ocean.washington.edu (PI: Warner)		CFC
25. Richard Rotter Princeton University U. S. Citizen Ph: (609) 258-3222 Fax: (609) 258-1274 Email: rotter@wiggler.princeton.edu (PI: Key)	C14	C14
26a. CDR M. Sarangapani Oceanographic Forecasting Cell Headquarters Southern Naval Command Naval Base Cochin --- 682004 India Ph: 0484-662472 (O) 0484-662815 (R) (Indian Observer)	Observer	
26b. LCDR S. Murali Indian Navy Met Officer INS JARAWA c/o Navy Office Port Blair (Observer)		Observer
27a. LCDR S. Jayakody Naval Headquarters P. O. Box 593 Colombo Sri Lanka Ph: 94-1-421151 (Sri Lankan Observer)	Observer/CTD	

27b. LCDR M.R.A.R.B. Mapa Observer/CTD
Naval Headquarters
P. O. Box 593
Colombo
Sri Lanka
Ph: 94-1-421151
Fax: 94-1-433896
(Sri Lankan Observer)

28. Tilak Dharmaratne Observer/CO2
Research Officer
National Aquatic Resources Agency (NARA)
Crow Island
Colombo-15
Sri Lanka
Ph: 94-1-522932
Fax: 94-1-522932
(Sri Lankan Observer)

29. Dr. San Hla Thaw Observer/CTD
Research Officer
Department of Meteorology and Hydrology
Yangon, Myanmar
Ph: 95-1-65669
Fax: 95-1-65944
(Myanmar Observer)

30. Lt. Win Thein Observer/CTD
Oceanographic Survey Officer
Naval Hydrographic Office
Myanmar Navy
55/61 Strand Road
Yangon
Myanmar
Ph: 95-1-95256
(Myanmar Observer)

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WOCE EXPOCODES 316N145-11 (West leg), 316N145-12 (East leg);
Knorr Cruise 145 Leg 11; WHOI Internal code "KA45".
Document written by Sarah Zimmerman -July 1998; Document revised by Maggie Cook – December 1998.
Final version revised by Marshall Swartz - July 1999.

INTRODUCTION

The WHOI CTD Group supported PIs Harry Bryden and John Morrison in the occupation of WOCE Hydrographic Program line I1 across the N. Indian Ocean from 8/29/95 to 10/16/95. The cruise was conducted as two legs, with stations 857 to 961 done on leg 1 and stations 962 to 1014 occupied on leg 2. Although the cruise completed the planned set of stations, multiple instrumental difficulties and failures plagued the voyage. This report summarizes those problems and outlines the steps taken in the data reduction effort.

A synopsis of the instrument problems is given in the appendix. Instrument failures meant that ICTDs from FSI constituted the primary instruments on the I1 cruise, the first time they have been so used by the WHOI Group. In some respects, this cruise highlighted shortcomings in this new instrument. Despite the difficulties, the data set produced by cruise end is of fair quality. Pre-to-post laboratory temperature calibration analyses were quite consistent (differences of only 0.002 C) suggesting the absolute temperatures in the data are reasonable. Calibrated CTD salinity profiles are quite consistent with the water sample salts, with residual salinity discrepancies with pressure between bottles and the profile data ranging between about +0.004 to -0.001 pss with depth. CTD oxygen calibrations are not as good, owing in large part to bad sensor units (that were changed repeatedly during the cruise in search of a well-functioning sensor. The sensor problems have been traced to manufacturing difficulties experienced by the producer combined with the company’s poor quality control.) Noise levels in the dataset are somewhat larger than scientists are used to working with. A general 0.002 pss salt noise level is present, about a factor of 2 larger than the norm. CTD oxygen noise levels are 0.04ml/l, worsening to 0.06 for individual stations (ship roll/weather or bad sensor?). Between legs 1 and 2, modifications were made to the ICTD giving the oxygen current more resolution. The general noise level was reduced to 0.03ml/l; better, but still slightly higher than the 0.02ml/l noise level typical of the MKIII CTD.

DATA DOCUMENTATION

Table of CTDs used by station number:
ICTD1338: stations 857, 863, 870 through 892, 978, 980 through 1014.
ICTD1344: stations 859 through 862, 865 through 869, 893 through 898, 900 through 977 and 979.
CTD09: station 858.
CTD12: stations 864 and 899.

There are no bottle files for stations 858, 867 and 869 due to the pressure signal having dropped out requiring the cast to be aborted. Station 859 has bottles up to 800 dbars only due to fouling of the pylon. Other station by station events are noted in the station by station log (file ATSEA.RPT submitted along with this document).

Final processed WOCE-format CTD files are named in the form KA45Dnnn.WC1, where nnn is the station number. Note that stations 000 to 014 are actually stations 1000 through 1014 respectively.

Documentation files for this cruise are listed below:

I1FINAL.DOC this report.
INTERP.DOC list of linear interpolations performed in final processing of the data.
ATSEA.DOC a station by station description of CTD issues.

Final-revision CTD data files have been submitted with this data report.

INSTRUMENT CONFIGURATION:

Four CTDs were available on the cruise: two MkIII (CTDs 9 and 12) and two FSI ICTDs (1338 and 1344), with multiple deck units (MkIII and FSI). The CTDs were mounted in an SIO-designed 36-bottle frame fitted with a General Oceanics model 1016-36 36-position rosette pylon, driven through an SIO-modified controller.

The MkIII CTDs both experienced failures early in the cruise, making the two FSI ICTDs the primary instruments by default. Roughly 100 stations were made with ICTD 1344 as primary CTD and 50 stations with ICTD 1338 as primary CTD. Most commonly, the underwater frame was set up with two ICTD instruments: one sending data up the wire using its normal FSK configuration, and one set to record data internally, so that at the end of the station the data could be downloaded.

Significant signal interaction problems were encountered with the ICTDs and the General Oceanics pylon operating on a 10-km seacable, which resulted in data dropouts from the CTD and loss of confirmation of bottle closure from the pylon. A temporary solution was achieved through electrical modifications to both the CTDs and the pylon deck controller to accommodate the long seacable, and data quality improved substantially.

ACQUISITION AND PROCESSING METHODS

Data from ICTD1338 were acquired at 26.0 Hz and processed with a temperature lag of 630 ms. Data from ICTD 1344 were acquired at 26.0 Hz and with a temperature lag of 500 ms. The temperature lag was checked by comparing density reversals in theta salinity (TS) plots (Giles and McDonald, 1986). It was found that the aforementioned lags showed the least amount of looping or density reversals.

For the first 9 stations (857-865) CTD data were acquired using an FSI DT-1050 deck unit to demodulate the data. From station 866 and beyond, data were acquired by an EG&G Mk-III deck unit to demodulate the data. The deck units fed serial data to two personal computers running EG&G version 5.2 rev. 2 CTD acquisition software (EG&G, Oceansoft Acquisition Manual, 1990), one providing graphical data to screen and plotter, and the other a running listing output. Approach to seafloor of the CTD package was controlled by monitoring the pinger trace made by the direct and bottom return signals on the ship-provided PDR.

After each station, the CTD data were forwarded to another set of personal computers running both EG&G CTD post-processing 5.2 rev. 2 software and custom-built software from WHOI (Millard and Yang, 1993). The data were first-differenced, lag corrected, pressure sorted, and centered into 2 dbar bins for final data quality control and analysis, including fitting to water sample salinity and oxygen results.

SUMMARY OF LABORATORY CALIBRATIONS FOR CTDs

Maren Tracy Plueddemann and Marshall Swartz calibrated the pressure, temperature, and conductivity sensors at the Woods Hole Oceanographic Institution CTD Calibration Laboratory pre and post-cruise. The results are given below.

LABORATORY PRESSURE CALIBRATIONS

ICTD 1338:

PRE CRUISE CAL

Date: August 1995

Notes: 1338 and 1344 kept together in cold bath for pressure calibration.
1338, 1344 and CTD1 received temperature calibration at same time.

Bath temperature during pressure calibration = 1.85 deg C

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = 0.337188E+01
B = 0.100040E+00
C = -0.989186E-08
D = 0.121806E-12
Standard deviation of fit = 0.757851E+00

POST CRUISE CAL

Date: November 1995

Notes: 1338 and 1344 received pressure and temperature calibrations at the same time.

Bath temperature during pressure calibration = 1.67 deg C

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = 0.299558E+01
B = 0.999477E-01
C = -0.646358E-08
D = 0.900392E-13
Standard deviation of fit = 0.635441E+00

Bath temperature during pressure calibration = 29.80 deg C

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = 0.300466E+01
B = 0.999851E-01
C = -0.785380E-08
D = 0.103497E-12
Standard deviation of fit = 0.740938E+00

COMBINED PRE- and POST-CRUISE CAL

- Due to pressure bias shifts, a combination of the pre- and post-cruise pressure calibrations was selected for post cruise processing.

Bath temperature during pressure calibrations were 1.85 and 1.67 deg C

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = 0.326823E+01
B = 0.999882E-01
C = -0.798407E-08
D = 0.103679E-12
Standard deviation of fit = 0.766984E+00

ICTD 1344:

PRE CRUISE CAL

Date: August 1995
Notes: 1338 and 1344 kept together in cold bath for pressure calibration.
1338, 1344 and CTD1 received temperature calibration at same time.
Bath temperature during pressure calibration = 1.85 deg C
Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = 0.203003E+01
B = 0.999794E-01
C = -0.166617E-08
D = 0.175895E-13
Standard deviation of fit = 0.490572E+00

POST CRUISE CAL

Date: November 1995

- This post cruise calibration was selected for post-cruise processing.

Notes: 1338 and 1344 received pressure and temperature calibrations at the same time.
Bath temperature during pressure calibration = 1.67 deg C
Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = 0.162374E+01
B = 0.999549E-01
C = -0.293230E-09
D = 0.372714E-14
Standard deviation of fit = 0.341575E+00

Bath temperature during pressure calibration = 29.80 deg C
Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = 0.167806E+01
B = 0.999615E-01
C = -0.720102E-09
D = 0.938970E-14
Standard deviation of fit = 0.462750E+00

PRESSURE BIAS BY STATION NUMBER:

The following table summarizes the pressure bias applied during post-cruise data-processing, based upon the pressure measured by the CTD immediately prior to entering the water and immediately following recovery from the water.

sta	ctd#	bias_down	bias_up
857	1338	0.296823E+01	0.296823E+01
858	09	-.452144E+01	-.452144E+01
859	1344	0.183003E+01	0.183003E+01
860	1344	0.223003E+01	0.223003E+01
861	1344	0.243003E+01	0.243003E+01
862	1344	0.233003E+01	0.233003E+01
863	1338	-.442144E+01	-.442144E+01
864	12	-.391194E+02	-.391194E+02
865	1344	0.233003E+01	0.233003E+01
866	1344	0.203003E+01	0.203003E+01
867	1344	0.223003E+01	0.223003E+01
868	1344	0.193003E+01	0.193003E+01
869	1344	0.213003E+01	0.213003E+01
870	1338	0.216823E+01	0.216823E+01
871	1338	0.266823E+01	0.266823E+01
872	1338	0.256823E+01	0.256823E+01
873	1338	0.246823E+01	0.246823E+01
874	1338	0.256823E+01	0.256823E+01
875	1338	0.276823E+01	0.276823E+01
876	1338	0.246823E+01	0.246823E+01
877	1338	0.256823E+01	0.256823E+01
878	1338	0.246823E+01	0.246823E+01
879	1338	0.276823E+01	0.276823E+01
880	1338	0.226823E+01	0.226823E+01
881	1338	0.246823E+01	0.246823E+01
882	1338	0.276823E+01	0.276823E+01
883	1338	0.226823E+01	0.226823E+01
884	1338	0.206823E+01	0.206823E+01
885	1338	0.196823E+01	0.196823E+01
886	1338	0.266823E+01	0.266823E+01
887	1338	0.226823E+01	0.226823E+01
888	1338	0.216823E+01	0.216823E+01
889	1338	0.216823E+01	0.216823E+01
890	1338	0.196823E+01	0.196823E+01
891	1338	0.196823E+01	0.196823E+01
892	1338	0.196823E+01	0.196823E+01
893	1344	0.183003E+01	0.183003E+01
894	1344	0.163003E+01	0.163003E+01
895	1344	0.123003E+01	0.123003E+01
896	1344	0.103003E+01	0.103003E+01
897	1344	0.143003E+01	0.143003E+01
898	1344	0.113003E+01	0.113003E+01
899	12	-.381194E+02	-.381194E+02

sta	ctd#	bias_down	bias_up
900	1344	0.133003E+01	0.133003E+01
901	1344	0.153003E+01	0.153003E+01
902	1344	0.143003E+01	0.143003E+01
903	1344	0.153003E+01	0.153003E+01
904	1344	0.143003E+01	0.143003E+01
905	1344	0.123003E+01	0.123003E+01
906	1344	0.113003E+01	0.113003E+01
907	1344	0.113003E+01	0.113003E+01
908	1344	0.123003E+01	0.123003E+01
909	1344	0.300300E-01	0.300300E-01
910	1344	0.133003E+01	0.133003E+01
911	1344	0.930030E+00	0.930030E+00
912	1344	0.113003E+01	0.113003E+01
913	1344	0.830030E+00	0.830030E+00
914	1344	0.830030E+00	0.830030E+00
915	1344	0.830030E+00	0.830030E+00
916	1344	0.113003E+01	0.113003E+01
917	1344	0.123003E+01	0.123003E+01
918	1344	0.930030E+00	0.930030E+00
919	1344	0.123003E+01	0.123003E+01
920	1344	0.123003E+01	0.123003E+01
921	1344	0.630030E+00	0.630030E+00
922	1344	0.113003E+01	0.113003E+01
923	1344	0.113003E+01	0.113003E+01
924	1344	0.630030E+00	0.630030E+00
925	1344	0.630030E+00	0.630030E+00
926	1344	0.730030E+00	0.730030E+00
927	1344	0.630030E+00	0.630030E+00
928	1344	0.730030E+00	0.730030E+00
929	1344	0.830030E+00	0.830030E+00
930	1344	0.930030E+00	0.930030E+00
931	1344	0.930030E+00	0.930030E+00
932	1344	0.930030E+00	0.930030E+00
933	1344	0.430030E+00	0.430030E+00
934	1344	0.630030E+00	0.630030E+00
935	1344	0.630030E+00	0.630030E+00
936	1344	0.630030E+00	0.630030E+00
937	1344	0.330030E+00	0.330030E+00
938	1344	0.630030E+00	0.630030E+00
939	1344	0.830030E+00	0.830030E+00
940	1344	0.730030E+00	0.730030E+00
941	1344	0.730030E+00	0.730030E+00
942	1344	0.830030E+00	0.830030E+00

sta	ctd#	bias_down	bias_up
943	1344	0.830030E+00	0.830030E+00
944	1344	0.730030E+00	0.730030E+00
945	1344	0.830030E+00	0.830030E+00
946	1344	0.630030E+00	0.630030E+00
947	1344	0.230030E+00	0.230030E+00
948	1344	0.630030E+00	0.630030E+00
949	1344	0.530030E+00	0.530030E+00
950	1344	0.430030E+00	0.430030E+00
951	1344	0.930030E+00	0.930030E+00
952	1344	0.930030E+00	0.930030E+00
953	1344	0.103003E+01	0.103003E+01
954	1344	0.113003E+01	0.113003E+01
955	1344	0.730030E+00	0.730030E+00
956	1344	0.930030E+00	0.930030E+00
957	1344	0.113003E+01	0.113003E+01
958	1344	0.103003E+01	0.103003E+01
959	1344	0.930030E+00	0.930030E+00
960	1344	0.113003E+01	0.113003E+01
961	1344	0.530030E+00	0.530030E+00
962	1344	0.143003E+01	0.143003E+01
963	1344	0.103003E+01	0.103003E+01
964	1344	0.133003E+01	0.133003E+01
965	1344	0.103003E+01	0.103003E+01
966	1344	0.133003E+01	0.133003E+01
967	1344	0.930030E+00	0.930030E+00
968	1344	0.830030E+00	0.830030E+00
969	1344	0.830030E+00	0.830030E+00
970	1344	0.133003E+01	0.133003E+01
971	1344	0.143003E+01	0.143003E+01
972	1344	0.153003E+01	0.153003E+01
973	1344	0.430030E+00	0.430030E+00
974	1344	0.133003E+01	0.133003E+01
975	1344	0.103003E+01	0.103003E+01
976	1344	0.730030E+00	0.730030E+00
977	1344	0.103003E+01	0.103003E+01
978	1338	0.266823E+01	0.266823E+01
979	1344	0.133003E+01	0.133003E+01
980	1338	0.296823E+01	0.296823E+01
981	1338	0.206823E+01	0.206823E+01
982	1338	0.276823E+01	0.276823E+01
983	1338	0.276823E+01	0.276823E+01
984	1338	0.276823E+01	0.276823E+01
985	1338	0.256823E+01	0.256823E+01
986	1338	0.226823E+01	0.226823E+01
987	1338	0.176823E+01	0.176823E+01
988	1338	0.266823E+01	0.266823E+01
989	1338	0.256823E+01	0.256823E+01
990	1338	0.266823E+01	0.266823E+01
991	1338	0.256823E+01	0.256823E+01
992	1338	0.256823E+01	0.256823E+01

sta	ctd#	bias_down	bias_up
993	1338	0.256823E+01	0.256823E+01
994	1338	0.246823E+01	0.246823E+01
995	1338	0.246823E+01	0.246823E+01
996	1338	0.246823E+01	0.246823E+01
997	1338	0.246823E+01	0.246823E+01
998	1338	0.236823E+01	0.236823E+01
999	1338	0.236823E+01	0.236823E+01
000	1338	0.236823E+01	0.236823E+01
001	1338	0.246823E+01	0.246823E+01
002	1338	0.256823E+01	0.256823E+01
003	1338	0.256823E+01	0.256823E+01
004	1338	0.256823E+01	0.256823E+01
005	1338	0.196823E+01	0.196823E+01
006	1338	0.186823E+01	0.186823E+01
007	1338	0.196823E+01	0.196823E+01
008	1338	0.206823E+01	0.206823E+01
009	1338	0.196823E+01	0.196823E+01
010	1338	0.196823E+01	0.196823E+01
011	1338	0.196823E+01	0.196823E+01
012	1338	0.196823E+01	0.196823E+01
013	1338	0.196823E+01	0.196823E+01
014	1338	0.196823E+01	0.196823E+01

LABORATORY TEMPERATURE CALIBRATIONS

ICTD 1338 had a small change, less than 0.002 deg C. The pre and post temperature calibrations were averaged to be used with the post cruise processing. The ICTD 1344 temperature calibration changed pre to post cruise with a bias shift of +0.002 deg C. CTD reading warmer at the post cruise calibration. The point at where the temperature shift occurred was looked for but not found. The most reliable search was to look at data from the same station where both primary and internal recording CTDs were used. They did not show where the jump occurred. The fast thermistor channel data were also compared at points where the salinity calibration changed. There was not enough proof to point to a spot where the jump occurred, so an average of the pre and post cruise calibrations was used to process the data.

ICTD 1338 SLOW PLATINUM THERMOMETER CHANNEL

PRE CRUISE CAL

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = 0.285975E-02
B = 0.500231E-03
C = -0.177714E-10
D = 0.194501E-15
Standard deviation of fit = 0.373642E-03

POST CRUISE CAL

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = 0.918509E-03
B = 0.500358E-03
C = -0.190649E-10
D = 0.192328E-15
Standard deviation of fit = 0.352686E-03

COMBINED PRE AND POST CRUISE CAL

- A combined calibration was used for post cruise processing as noted above.

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = 0.186857E-02
B = 0.500298E-03
C = -0.185827E-10
D = 0.195224E-15
Standard deviation of fit = 0.594841E-03

ICTD 1338 FAST THERMISTOR CHANNEL

Note: ICTD1338 fast thermistor temperature data was used to check for temperature shifts during cruise, but did not contribute to the final processed temperature data.

PRE CRUISE CAL

Note: the second order fit was used during the cruise. The third order fit was used post cruise to compare changes pre to post cruise for the fast thermistor channel.

Resulting polynomial coefficients for a second order fit: (A+Bx+Cx^2):

A = 0.915609E-01
B = 0.495852E-03
C = 0.333829E-10
Standard deviation of fit = 0.693632E-01

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = -0.187870E-01
B = 0.524023E-03
C = -0.116195E-08
D = 0.129201E-13
Standard deviation of fit = 0.168422E-02

POST CRUISE CAL

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = -0.186425E-01
B = 0.524085E-03
C = -0.116322E-08
D = 0.129201E-13
Standard deviation of fit = 0.175345E-02

ICTD 1338 OXYGEN TEMPERATURE CHANNEL

PRE CRUISE CAL

Resulting polynomial coefficients for a second order fit: (A+Bx+Cx^2):

A = -0.216281E+01
B = 0.160633E+00
C = -0.121723E-03
Standard deviation of fit = 0.158769E+00

POST CRUISE CAL

- This post-cruise calibration was used with the oxygen algorithms to produce the final dataset.

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = -0.277188E+01
B = 0.183254E+00
C = -0.324103E-03
D = 0.503239E-06
Standard deviation of fit = 0.361886E-01

ICTD 1344 SLOW PLATINUM THERMOMETER

PRE CRUISE CAL

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = -0.639595E-02
B = 0.500576E-03
C = -0.219271E-10
D = 0.227245E-15
Standard deviation of fit = 0.260050E-03

POST CRUISE CAL

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A =-0.853971E-02
B = 0.500625E-03
C = -0.235555E-10
D = 0.243046E-15
Standard deviation of fit = 0.668181E-03

COMBINED PRE AND POST CRUISE CAL

- A combined calibration was used for final post cruise processing.

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = -0.748166E-02
B = 0.500600E-03
C = -0.226875E-10
D = 0.234567E-15
Standard deviation of fit = 0.940009E-03

ICTD 1344 FAST PLATINUM THERMOMETER CHANNEL
Note: The fast platinum thermometer channel was used as a secondary reference to judge changes to the ICTD 1344 slow platinum thermometer channel during the cruise. These measurements did not contribute to the final processed data.

PRE CRUISE CAL
Resulting polynomial coefficients for a second order fit: (A+Bx+Cx^2):
A = -0.164421E-02
B = 0.499960E-03
C = 0.832749E-12
Standard deviation of fit = 0.146257E-02

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = -0.390910E-02
B = 0.500535E-03
C = -0.235454E-10
D = 0.263094E-15
Standard deviation of fit = 0.356128E-03

POST CRUISE CAL
Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = -0.707179E-02
B = 0.500630E-03
C = -0.267632E-10
D = 0.294216E-15
Standard deviation of fit = 0.585656E-03

ICTD 1344 FAST THERMISTOR CHANNEL
Note: ICTD1344 fast thermistor temperature data was used to check for temperature shifts during cruise, but did not contribute to the final processed temperature data.

PRE CRUISE CAL
Resulting polynomial coefficients for a second order fit: (A+Bx+Cx^2):
A = 0.889859E-01
B = 0.496237E-03
C = 0.282361E-10
Standard deviation of fit = 0.677849E-01

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):
A = -0.188737E-01
B = 0.523767E-03
C = -0.113985E-08
D = 0.126255E-13
Standard deviation of fit = 0.182910E-02**POST CRUISE CAL**

Resulting polynomial coefficients for a third order fit: (A+Bx+Cx^2+Dx^3):

A = -0.181959E-01
B = 0.523798E-03
C = -0.113971E-08
D = 0.126209E-13
Standard deviation of fit = 0.171024E-02

ICTD 1344 OXYGEN TEMPERATURE CHANNEL

PRE CRUISE CAL

Resulting polynomial coefficients for a <u>second</u> order fit: (A+Bx+Cx^2):

A = -0.336502E+01
B = 0.146252E+00
C = -0.637599E-04
Standard deviation of fit = 0.293626E+00

POST CRUISE CAL

- The post-cruise oxygen temperature calibration was used with the oxygen algorithms for the final dataset.

Resulting polynomial coefficients for a <u>third</u> order fit: (A+Bx+Cx^2+Dx^3):

A = -0.477833E+01
B = 0.194995E+00
C = -0.466521E-03
D = 0.921395E-06
Standard deviation of fit = 0.714265E-01

SALINITY CALIBRATIONS

The CTD conductivity sensor data were fit to the water sample conductivity as described in Millard and Yang (1993). The stations were fit by groups according to the drift of the conductivity sensor over time.

Plot results of deep water theta/S revealed that there was a difference between CTDs:

1338: *.PRS CTD salt read too high ~0.002 psu or temperature was too low compared to *.SEA file.
1344: *.PRS CTD salt read too low ~0.001 psu or temperature was too high compared to *.SEA file.

The consistency of the bias between stations indicates it was probably not a real ocean measurement such as measuring internal waves, but some kind of instrument, package dynamic or bottle artifact. All ICTD 1338 stations have a significant bias, with the downtrace always saltier than the bottles. The uptrace has been fit well, but the uptrace is fresher than the downtrace. To correct for the difference, the downtrace salinity data for the group of stations 978 and 980 through 1014 were fit to the bottle data. This was accomplished by processing the 2-decibar averaged downtrace CTD data against the bottle data, and provided a more acceptable fit for these stations. Figures 1 and 2 demonstrate the CTD salt to bottle salt fits for stations 982 through 1000 using downtrace data, and figures 3 and 4 demonstrate the same fits using uptrace data as is normally done.

ICTD 1338 stations 870 through 892 seemed to fit well after forcing the CTD salt data to agree with the bottom bottle data, and so were not refit using the downtrace. ICTD 1344 downtraces trend toward being fresher than the bottles. The uptrace and downtrace agree, but the fits were not working well. Some of the fits were recalculated, with emphasis on matching up the CTD and salts in the bottom water.

CTD comparisons were made with the primary CTD and memory CTD data from the same stations. Pressure agreed very well, with bottom depths agreeing within 1dbar on the stations checked. Temperature would stray, +/-.002 at the bottom, sometimes ICTD 1338 being warmer, and sometimes ICTD 1344 was warmer. This is most likely a factor of the location of the telemetering CTD on the sampler frame being different than the position of the memory mode CTD and thus in a different waterpath. Both CTDs could have thermal contamination of the temperature signal from the frame while sampling at a bottle stop.

Notes for particular stations' salinity calibrations

Stations 936-938, 940-941:
A pressure dependent difference between bottle and CTD salinities could not be removed without changing the conductivity cell gemoetry correction terms for pressure (ALPHA) and temperature (BETA). After station 942, the conductivity cell was cleaned due to slime buildup. The difficult calibrations from station 936 to 942 could have been induced by fouling or buildup of slime on the conductivity cell.

Stations 936, 937 and 938:
BETA was changed from 1.5e-8 to 0.75e-8
Stations 940 and 941 have BETA changed from 1.5e-8 to 0.75e-8, and
ALPHA changed from -6.5e-6 to -9.75e-6.

Station 923 and 954:
Salt changes that looked questionable until the uptrace was overlaid and followed the shape of the downtrace. Station 923 freshens around 2 deg C.

Station 954 has spikes and a shift at 1750dbar, 1900dbar and 2250 dbar that are clearly repeated in the uptrace.

Table 1. Final conductivity coefficients applied by station number

The coefficients used to scale <u>downtrace</u> conductivity data for the I1 stations are listed below.

stn	bias	slope	stn	bias	slope
857	0.269148E-02	0.999756E-03	901	-0.823240E-03	0.999992E-03
858	0.148422E-01	0.997105E-03	902	-0.823240E-03	0.999992E-03
859	0.758850E-02	0.999569E-03	903	-0.823240E-03	0.999992E-03
860	0.758850E-02	0.999569E-03	904	-0.823240E-03	0.999992E-03
861	0.758850E-02	0.999569E-03	905	-0.823240E-03	0.999992E-03
862	0.758850E-02	0.999569E-03	906	-0.823240E-03	0.999992E-03
863	0.269148E-02	0.999816E-03	907	-0.823240E-03	0.999992E-03
864	0.187740E-01	0.100097E-02	908	-0.823240E-03	0.999992E-03
865	0.758850E-02	0.999569E-03	909	-.823240E-03	0.999989E-03
866	0.758850E-02	0.999569E-03	910	-.106344E-02	0.100004E-02
867	0.758850E-02	0.999569E-03	911	-.106344E-02	0.100004E-02
868	0.758850E-02	0.999649E-03	912	-.106344E-02	0.100004E-02
869	0.758850E-02	0.999569E-03	913	-.106344E-02	0.100004E-02
870	0.269148E-02	0.999795E-03	914	-.106344E-02	0.100004E-02
871	0.269148E-02	0.999795E-03	915	-.106344E-02	0.100004E-02
872	0.269148E-02	0.999795E-03	916	-.106344E-02	0.100004E-02
873	0.269148E-02	0.999795E-03	917	-.106344E-02	0.100004E-02
874	0.269148E-02	0.999795E-03	918	-.128407E-03	0.100004E-02
875	0.269148E-02	0.999795E-03	919	-.128407E-03	0.100004E-02
876	0.269148E-02	0.999795E-03	920	-.128407E-03	0.100004E-02
877	0.269148E-02	0.999795E-03	921	-.128407E-03	0.100004E-02
878	0.269148E-02	0.999795E-03	922	-.128407E-03	0.100004E-02
879	0.269148E-02	0.999795E-03	923	-.128407E-03	0.100004E-02
880	0.269148E-02	0.999795E-03	924	-.128407E-03	0.100004E-02
881	0.269148E-02	0.999795E-03	925	-.128407E-03	0.100004E-02
882	0.269148E-02	0.999795E-03	926	-.128407E-03	0.100004E-02
883	0.269148E-02	0.999795E-03	927	-.128407E-03	0.100004E-02
884	0.269148E-02	0.999795E-03	928	-.128407E-03	0.100004E-02
885	0.269148E-02	0.999795E-03	929	-.296800E-03	0.100006E-02
886	0.269148E-02	0.999795E-03	930	-.296800E-03	0.100006E-02
887	0.269148E-02	0.999795E-03	931	-.296800E-03	0.100006E-02
888	0.269148E-02	0.999795E-03	932	-.296800E-03	0.100006E-02
889	0.269148E-02	0.999795E-03	933	-.296800E-03	0.100006E-02
890	0.269148E-02	0.999795E-03	934	-.296800E-03	0.100014E-02
891	0.269148E-02	0.999795E-03	935	-.296800E-03	0.100006E-02
892	0.269148E-02	0.999795E-03	936	0.141056E-02	0.100005E-02
893	-.823240E-03	0.999989E-03	937	0.141056E-02	0.100005E-02
894	-.823240E-03	0.999989E-03	938	0.141056E-02	0.100005E-02
895	-.823240E-03	0.999989E-03	939	0.141056E-02	0.100005E-02
896	-.823240E-03	0.999989E-03	940	-.514493E-02	0.100032E-02
897	-.823240E-03	0.999989E-03	941	-.514493E-02	0.100032E-02
898	-.823240E-03	0.999989E-03	942	-.514493E-02	0.100030E-02
899	0.187740E-01	0.100097E-02	943	-.891709E-03	0.100003E-02
900	-0.823240E-03	0.999992E-03	944	-.891709E-03	0.100003E-02

stn	bias	slope	stn	bias	slope
945	-.891709E-03	0.100003E-02	980	0.419290E-03	0.999994E-03
946	-.891709E-03	0.100004E-02	981	0.419290E-03	0.999994E-03
947	-.891709E-03	0.100004E-02	982	0.419290E-03	0.999994E-03
948	-.891709E-03	0.100004E-02	983	0.419290E-03	0.999994E-03
949	-.891709E-03	0.100004E-02	984	0.419290E-03	0.999994E-03
950	-.891709E-03	0.100004E-02	985	0.419290E-03	0.999994E-03
951	-.891709E-03	0.999983E-03	986	0.419290E-03	0.999994E-03
952	-.891709E-03	0.100004E-02	987	0.419290E-03	0.999994E-03
953	-.891709E-03	0.100004E-02	988	0.419290E-03	0.999994E-03
954	-.891709E-03	0.100004E-02	989	0.419290E-03	0.999994E-03
955	-.891709E-03	0.100004E-02	990	0.419290E-03	0.999994E-03
956	-.891709E-03	0.100004E-02	991	0.419290E-03	0.999994E-03
957	-.891709E-03	0.100004E-02	992	0.419290E-03	0.999994E-03
958	-.891709E-03	0.999997E-03	993	0.419290E-03	0.999994E-03
959	-.891709E-03	0.100004E-02	994	0.419290E-03	0.999994E-03
960	-.891709E-03	0.100008E-02	995	0.419290E-03	0.999994E-03
961	-.891709E-03	0.100008E-02	996	0.419290E-03	0.999994E-03
962	-.390173E-02	0.100009E-02	997	0.419290E-03	0.999994E-03
963	-.390173E-02	0.100009E-02	998	0.419290E-03	0.999994E-03
964	-.519660E-02	0.100021E-02	999	0.419290E-03	0.999994E-03
965	-.519660E-02	0.100021E-02	000	0.419290E-03	0.999994E-03
966	-.519660E-02	0.100021E-02	001	0.419290E-03	0.999994E-03
967	-.519660E-02	0.100021E-02	002	0.419290E-03	0.999994E-03
968	-.519660E-02	0.100021E-02	003	0.419290E-03	0.999994E-03
969	-.519660E-02	0.100021E-02	004	0.419290E-03	0.999994E-03
970	-.519660E-02	0.100019E-02	005	0.419290E-03	0.999994E-03
971	-.519660E-02	0.100019E-02	006	0.419290E-03	0.999994E-03
972	-.519660E-02	0.100019E-02	007	0.419290E-03	0.999994E-03
973	-.519660E-02	0.100019E-02	008	0.419290E-03	0.999994E-03
974	-.519660E-02	0.100019E-02	009	0.419290E-03	0.999994E-03
975	-.519660E-02	0.100019E-02	010	0.419290E-03	0.999994E-03
976	-.519660E-02	0.100019E-02	011	0.419290E-03	0.999994E-03
977	-.390173E-02	0.100007E-02	012	0.419290E-03	0.999994E-03
978	0.419290E-03	0.999988E-03	013	0.419290E-03	0.999994E-03
979	-.390173E-02	0.100015E-02	014	0.419290E-03	0.999994E-03

The coefficients used to scale uptrace conductivity data for selected I1 stations are listed below.

stn	bias	slope
978	0.216462E-02	0.999940E-03
980	0.216462E-02	0.999940E-03
981	0.216462E-02	0.999940E-03
982	0.216462E-02	0.999940E-03
983	0.216462E-02	0.999975E-03
984	0.216462E-02	0.999975E-03
985	0.216462E-02	0.999975E-03
986	0.216462E-02	0.999975E-03
987	0.216462E-02	0.999975E-03
988	0.216462E-02	0.999975E-03
989	0.216462E-02	0.999975E-03
990	0.216462E-02	0.999975E-03
991	0.216462E-02	0.999975E-03
992	0.216462E-02	0.999975E-03
993	0.216462E-02	0.999975E-03
994	0.216462E-02	0.999975E-03
995	0.216462E-02	0.999975E-03
996	0.216462E-02	0.999975E-03
997	0.216462E-02	0.999975E-03
998	0.216462E-02	0.999975E-03
999	0.216462E-02	0.999975E-03
000	0.216462E-02	0.999975E-03
001	0.216462E-02	0.999975E-03
002	0.216462E-02	0.999975E-03
003	0.216462E-02	0.999975E-03
004	0.216462E-02	0.999975E-03
005	0.216462E-02	0.999975E-03
006	0.216462E-02	0.999975E-03
007	0.216462E-02	0.999975E-03
008	0.216462E-02	0.999975E-03
009	0.216462E-02	0.999975E-03
010	0.216462E-02	0.999975E-03
011	0.216462E-02	0.999975E-03
012	0.216462E-02	0.999975E-03
013	0.216462E-02	0.999975E-03
014	0.216462E-02	0.999975E-03

Note: Uptrace CTD conductivity data was fit to the bottle salts for stations 978 and 980 through 1014 as described in the preceding documentation to achieve a better fit.

SALINITY FITTING RESULTS:

The following plots show the differences between the rosette and CTD salts across legs one and two. It is important to note that these plots cover both CTDs, each of which were opened on several occasions potentially causing calibration changes. In the beginning of the cruise many mechanical problems were encountered. (see appendix of ATSEA.doc).

Figure 1: Leg 1 - Difference between calibrated downtrace CTD salts and the rosette salinity data

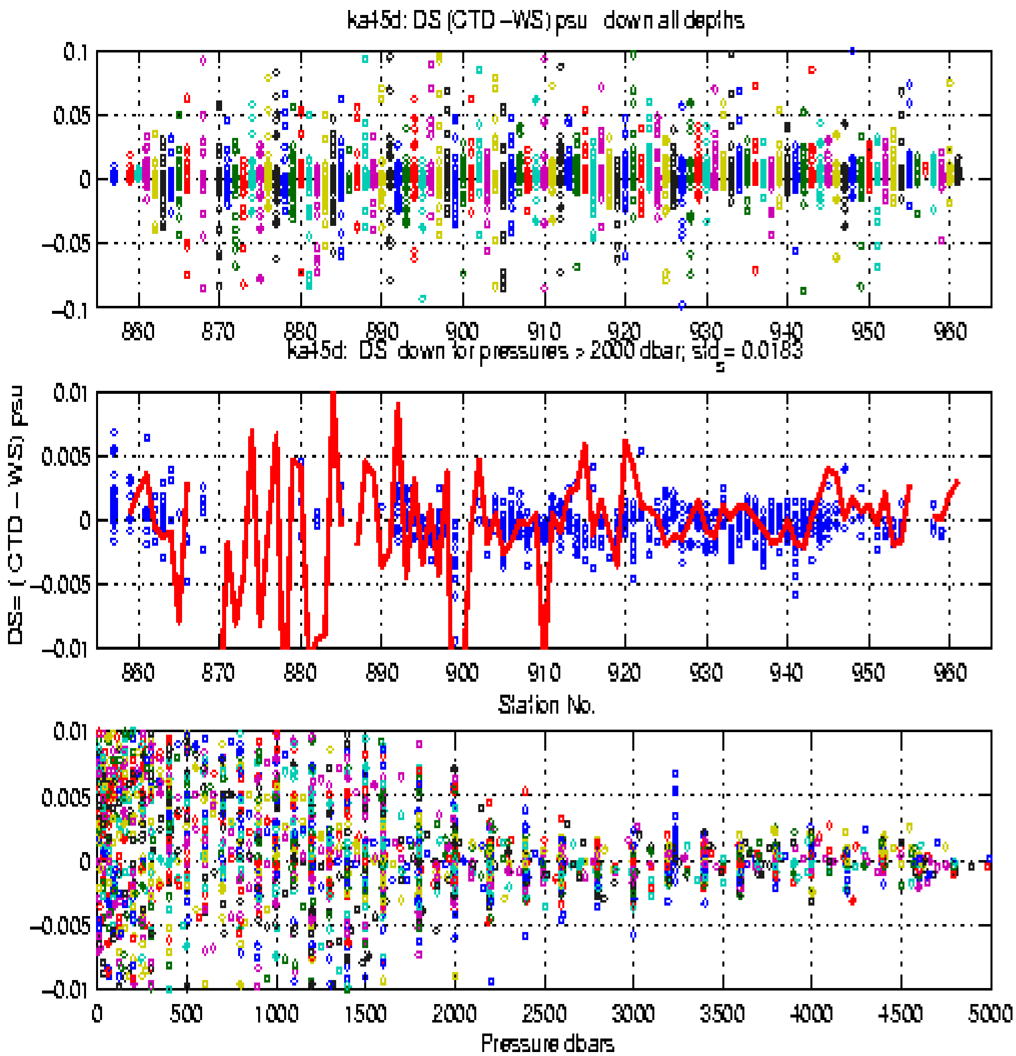


Figure 2: Leg 2 - Difference between calibrated downtrace CTD salts and rosette salinity data

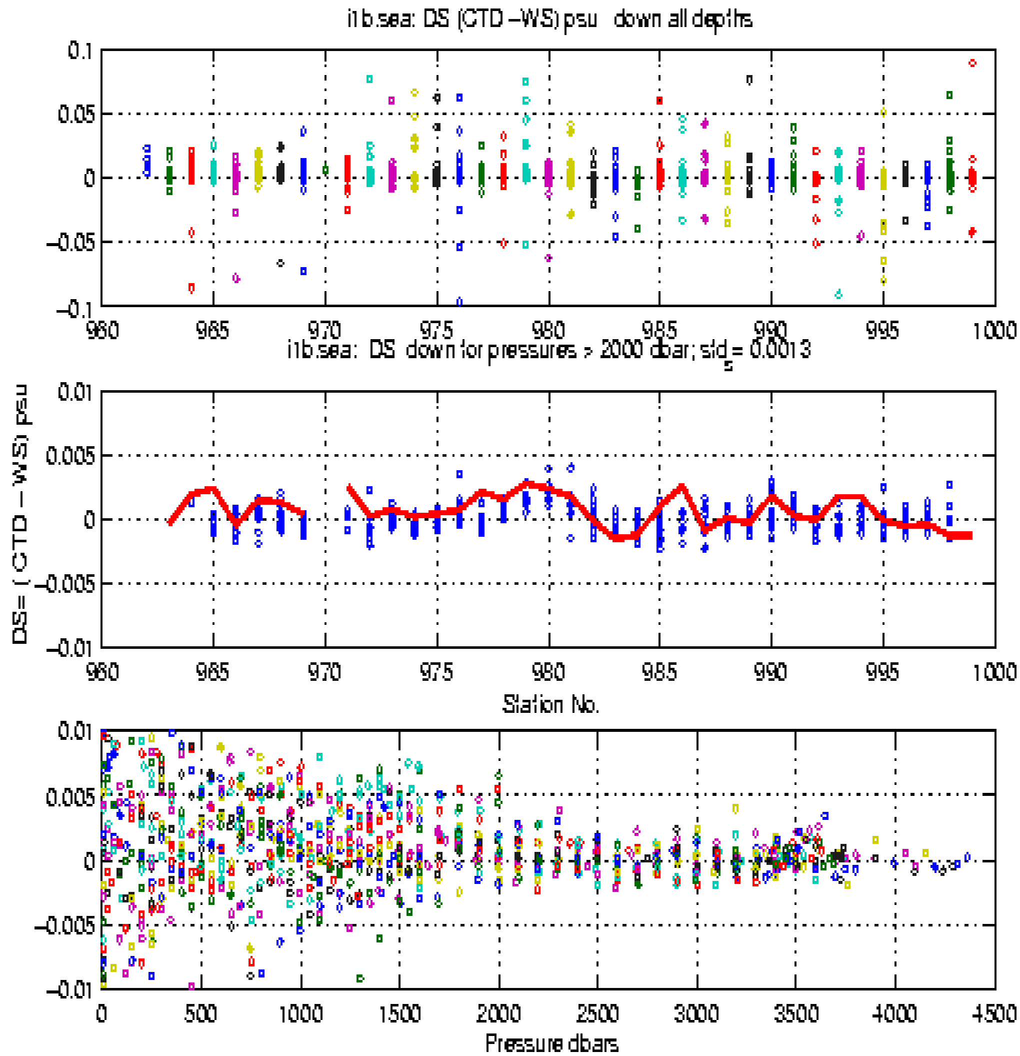


Figure 3: Leg 1 Differences between calibrated uptrace CTD salts in rosette file (scaled with separate multiple regression fit from down salinities) and rosette salts. Note that the residuals are significantly better for the uptrace data. Fits to the uptrace data were applied to the uptrace CTD data in the rosette file. Due to hysteresis, fits to the downtrace data needed to be applied to the downtrace CTD data files for stations 978 to 1014.

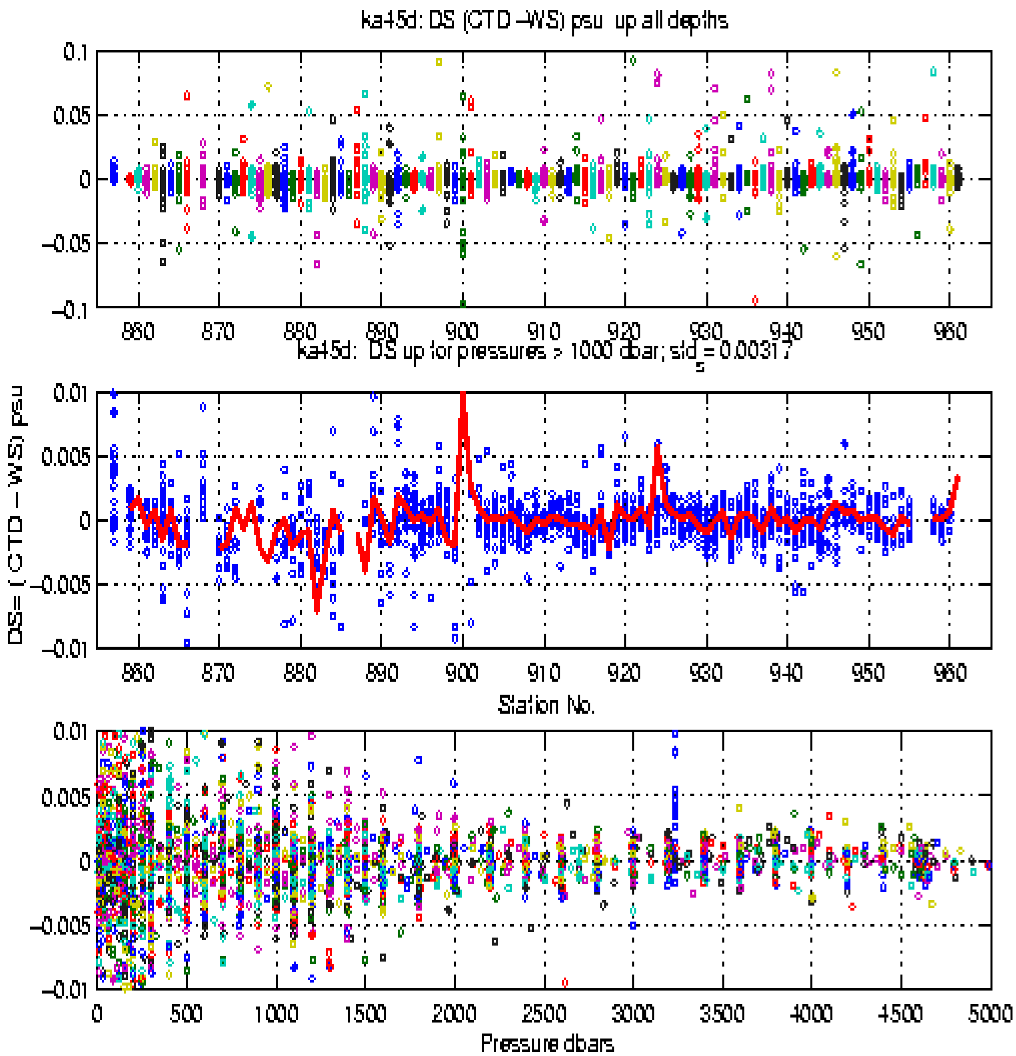
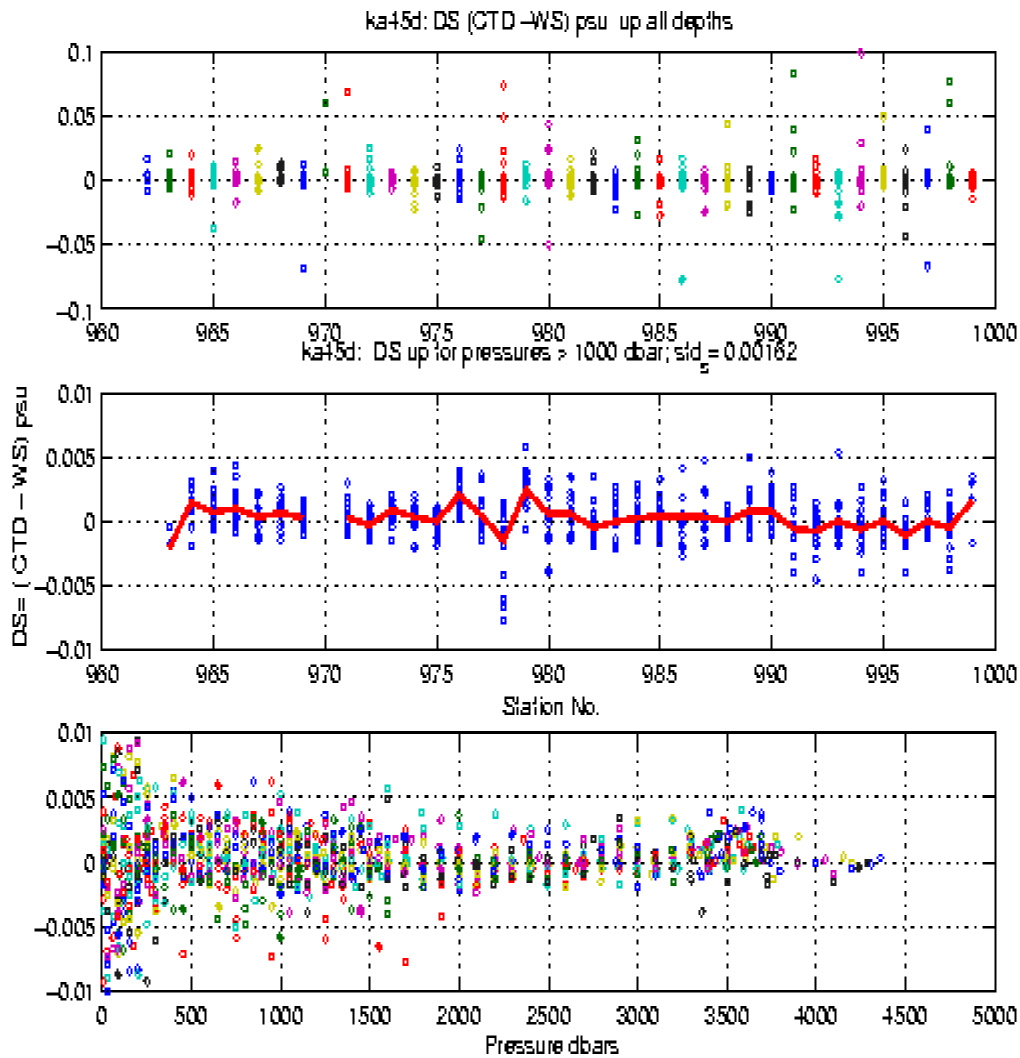


Figure 4: Leg 2: Differences between scaled uptrace CTD salts in the rosette file (separate multiple regression fit from down salinities) and the rosette salt data.



OXYGEN CALIBRATIONS:

SENSOR FAILURES

The CTD oxygen data presented special problems from the beginning. While all four CTDs were initially fitted with new oxygen sensors, and spares were brought on the cruise, the stations were plagued with sensor failures and erratic sensor data. The CTDs all used Sensormedics brand polarographic oxygen sensors, and due to recent experience of failures, it was expected that sensor changes would have to be made. However, the failure rate exceeded our low expectations, with seven replacement sensors being used.

Oxygen sensors were replaced following the stations listed below:

Station	CTD	Sensor s/n
865	1344	5-06-03
910	1344	5-06-02
923	1344	5-07-02
930	1344	4-10-2
980	1344	4-12-04
991	1344	5-06-01

The CTDs used interchangeable sensor assemblies, which permitted the oxygen thermistor and sensor module to simply be unplugged and a new one installed if a problem was found. This speeded up the changeout of failed oxygen sensors. However, since each CTD's oxygen temperature channel is calibrated to a specific module, swapping a module out changes the oxygen temperature calibration. Due to the large number of failures of sensors, modules were interchanged between the ICTDs on several occasions, and necessitated special attention to fitting of the data.

OXYGEN DATA FITTING

Some stations fit well using normal fitting routines, while others had a definite pressure dependent shape in the residuals. A similar shape recurred in different groups. The shape was more pronounced in some groups than others. A weight of 0.8 and lag of 1 was consistent from a few of the larger groups. Most of the groups had this weight and lag held during the fits since many groups came up with weights over 1 and lags below 0 when allowed to fit for those parameters. For the groups with the pressure dependent shape in the residuals, tcor was held at some value lower than the fit originally came up with. Usually tcor was adjusted by -0.002 and the group refit. The resulting residuals between 2000 to 5000 dbars would be centered around 0 with a spread reduced from +/-0.1 to +/-0.04 but the shape would remain in the upper 2000 dbars.

Special notes for fitting oxygen data for particular stations:

The oxygen temperature (OT) coefficients were changed for the post processing. There were several instances of the CTD profile not reaching the oxygen minimum, or overshooting the minimum. This may have been due to not having the proper OT coefficients in the at-sea station header files. These were corrected during post-processing so all calibration files now have the proper OT coefficients for each CTD.

OT coefficient changes:

Station applied to	Change made
857, 870-892	replaced wrong 38 bias with right 38 bias.
859-862	replaced 38 OT cal with 44 OT cal.
865-869	left as is.
893-979, 899, 978	replaced 38 OT wrong bias with 44 OT cal.
979	replaced wrong 38 bias with right 38 bias.
980	replaced wrong 38 bias with right 38 bias.
981-004	replaced wrong 38 bias with right 38 bias.
005-014	replaced wrong 38 bias with right 38 bias.

Stations 859 to 862 were taken with ICTD 1344 but used ICTD1338's oxygen assembly. 1344's OT calibration terms were put into the cal file.

Stations 877, 878, 879 and 004 were scaled using the at-sea OT and oxygen current (OC) terms. With the new OT terms, it was not possible to get as good a fit as the at-sea results. The terms arrived at had unrealistic numbers such as a negative lag but was used anyway for the resulting good fit.

Stations 857 and 858, test stations, had the oxygen quality word flagged '4' (bad) in the downtrace. All the bottles were deep and not useful for finding a fit for the whole profile.

Station 859, the next station in the same locations as 857 and 858, had bottles except for the top 800dbar due to a pylon failure. Even with a better fit this top should be labeled '3' (questionable).

Station 860, a test station for water sampling. The downtrace oxygen was labeled '4' due to all bottles fired deep.

Stations 906 to 904 have clear shape in the bottom water that may or may not be real. The uptrace looks as if it follows the shapes loosely, not really until the larger features around 2000dbar does it really follow the downtrace. Station 937 had extra bottles taken deep to watch the +/- 0.05ml/l variation in oxygen. The bottles do look like they agree with the oxygen.

Station 987, a -0.04 ml/l shift in oxygen at 2711dbar does not look real, and does not agree with bottle or following stations. It has been flagged '3' (questionable).

TABLE 2 OXYGEN FITTING COEFFICIENTS FOR STATIONS WITH NORMAL ALGORITHM

Below is a list of the coefficients used to scale the oxygen data for all but 53 stations that have a special fitting routine applied (noted as "special fit").

stn	bias	slope	pcor	tcor	wt	lag
857	-0.011	0.2915E-03	0.6243E-03	0.0156	0.60	3.00
858	-0.023	0.1192E-02	0.1798E-03	-0.0300	0.80	1.00
859	-0.023	0.1192E-02	0.1798E-03	-0.0300	0.80	1.00
860 - 862 special fit.						
863	0.004	0.1296E-02	0.1407E-03	-0.0524	0.60	0.30
864	-1.375	0.1136E-03	0.2034E-03	-0.0522	0.60	1.00
865 - 869 special fit.						
870	0.006	0.3862E-03	0.6243E-03	0.0156	0.60	3.00
871	0.009	0.6467E-03	0.3590E-03	0.0064	0.60	3.00
872	0.009	0.6467E-03	0.3590E-03	0.0064	0.60	3.00
873	0.039	0.8729E-03	0.1179E-03	-0.0155	0.60	3.00
874	0.039	0.8729E-03	0.1179E-03	-0.0155	0.60	3.00
875	0.022	0.1472E-02	-0.1200E-03	-0.0397	0.60	3.00
876	0.022	0.1472E-02	-0.1200E-03	-0.0397	0.60	3.00
877	0.004	0.1318E-02	-0.4643E-05	-0.0341	0.10	4.00
878	-0.018	0.4243E-02	-0.2527E-03	-0.0677	1.32	-0.3
879	-0.018	0.4243E-02	-0.2527E-03	-0.0677	1.32	-0.3
880-892 special fit.						
893	0.005	0.1170E-02	0.1499E-03	-0.0272	0.80	1.00
894	0.022	0.1141E-02	0.1508E-03	-0.0271	0.80	1.00
895	0.009	0.1273E-02	0.1416E-03	-0.0298	0.80	1.00
896	0.017	0.1281E-02	0.1444E-03	-0.0275	0.80	1.00
897	0.017	0.1281E-02	0.1444E-03	-0.0275	0.80	1.00
898	0.019	0.1316E-02	0.1398E-03	-0.0275	0.80	1.00
899	-1.427	0.1162E-03	0.1901E-03	-0.0283	0.60	1.00
900	0.017	0.1281E-02	0.1444E-03	-0.0275	0.80	1.00
901	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
902	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
903	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
904	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
905	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
906	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
907	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
908	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
909	0.011	0.1376E-02	0.1469E-03	-0.0294	0.80	1.23
910	0.036	0.1149E-02	0.1427E-03	-0.0270	0.80	1.00
911	0.003	0.1214E-02	0.1503E-03	-0.0280	0.80	1.00
912 - 922 special fit.						
923	-0.006	0.1045E-02	0.1665E-03	-0.0243	0.74	9.34
924	-0.006	0.1045E-02	0.1665E-03	-0.0243	0.74	9.34
925	0.000	0.1080E-02	0.1463E-03	-0.0240	0.80	1.00
926	0.000	0.1080E-02	0.1463E-03	-0.0240	0.80	1.00
927	0.000	0.1080E-02	0.1463E-03	-0.0240	0.80	1.00
928	0.000	0.1080E-02	0.1463E-03	-0.0240	0.80	1.00
929	0.000	0.1080E-02	0.1463E-03	-0.0240	0.80	1.00
930 - 933 special fit.						
934	-0.014	0.1582E-02	0.1336E-03	-0.0297	0.80	1.00
935	-0.024	0.1664E-02	0.1146E-03	-0.0304	0.80	1.00
936	-0.024	0.1664E-02	0.1146E-03	-0.0304	0.80	1.00
937	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
938	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
939	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
940	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
941	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
942	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
943	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
944	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
945	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
946	-0.020	0.1612E-02	0.1419E-03	-0.0300	0.80	1.00
947	-0.006	0.1296E-02	0.2061E-03	-0.0236	0.80	1.00
948	-0.005	0.1300E-02	0.2061E-03	-0.0236	0.80	1.00
949	-0.005	0.1300E-02	0.2061E-03	-0.0236	0.80	1.00
950	0.007	0.9440E-03	0.3342E-03	-0.0105	0.80	1.00
951	-0.011	0.1433E-02	0.1654E-03	-0.0278	0.80	1.00
952	-0.011	0.1433E-02	0.1654E-03	-0.0278	0.80	1.00
953	-0.011	0.1433E-02	0.1654E-03	-0.0278	0.80	1.00
954	-0.011	0.1433E-02	0.1654E-03	-0.0278	0.80	1.00
955	-0.011	0.1433E-02	0.1654E-03	-0.0278	0.80	1.00
956	-0.011	0.1433E-02	0.1654E-03	-0.0278	0.80	1.00
957	-0.154	0.1608E-02	0.5058E-03	-0.0163	0.70	1.00
958	-0.014	0.1477E-02	0.1318E-03	-0.0289	0.80	1.00
959	-0.014	0.1477E-02	0.1318E-03	-0.0289	0.80	1.00
960	-0.014	0.1477E-02	0.1318E-03	-0.0289	0.80	1.00
961	-0.014	0.1477E-02	0.1318E-03	-0.0289	0.80	1.00
962	-0.019	0.1310E-02	0.1542E-03	-0.0240	0.80	1.00
963 - 969 special fit.						
970	0.131	0.13908E-02	-0.9363E-03	-0.0277	0.80	1.00
971 - 979 special fit.						
980	0.005	0.3081E-03	0.1529E-03	-0.0294	0.60	3.00
981	0.011	0.2968E-03	0.1529E-03	-0.0294	0.60	3.00
982	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
983	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
984	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
985	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
986	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
987	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
988	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
989	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
990	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
991	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
992	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
993	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
994	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
995	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
996	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
997	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
998	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
999	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
000	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
001	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
002	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
003	0.001	0.3028E-03	0.1569E-03	-0.0258	0.60	3.00
004	0.0082	0.3217E-03	0.1485E-03	-0.0277	0.90	1.00
005	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
006	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
007	0.018	0.2455E-03	0.2161E-03	-0.0205	0.60	3.00
008	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
009	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
010	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
011	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
012	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
013	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00
014	0.009	0.2903E-03	0.1476E-03	-0.0265	0.71	3.00

"Special fit" indicates that a revised oxygen fitting algorithm was used for these stations. See next section for details.

SPECIAL OXYGEN ALGORITHM FITTING

Fifty-three stations had the problem of fitting the CTD oxygen profile to the bottle data. Bob Millard revised the oxygen algorithm in an attempt to improve the oxygen data from ICTD stations with pressure dependent oxygen residuals using the original Owens & Millard oxygen algorithm:

oc = (ocr+lag*docr/dt)*slope+bias

Two changes to the oxygen algorithm of Owens & Millard (1985) result in the equation below:

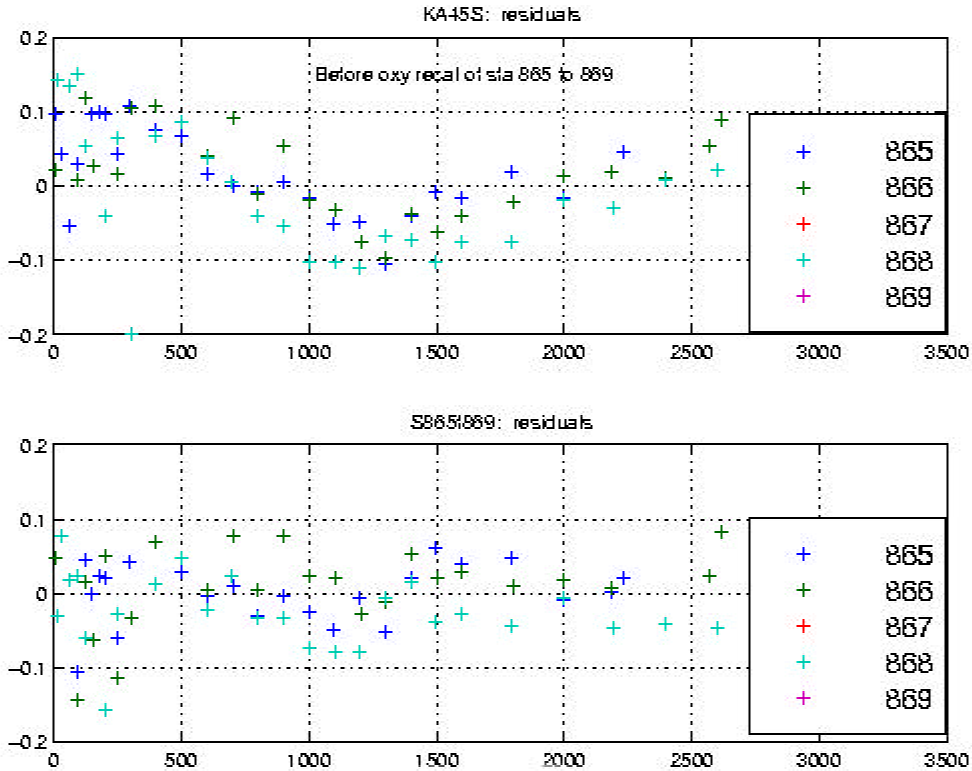
ox = oc*oxsat* exp(tcor*(T+wt*(OT-T)+pcor*P)

First is the uncoupling of the temperature parameters in the exponential of the algorithm (tcor*wt). This becomes particularly helpful if the oxygen temperature (OT) term does not have a valid calibration. A new term involving the cross-term between pressure and temperature has been added to the algorithm as it picks up additional variance. Note that the oxygen lag term is negative for a number of station groups listed in table I below. In recognition of the inadequate performance of the oxygen sensor modules used for these stations, we opted for the best fit to the water sample oxygen data even though the terms may not be physically realistic.

ox = oc*oxsat* exp(tcor1*T+tcor2*OT+pcor*P+ptcor*P*T)

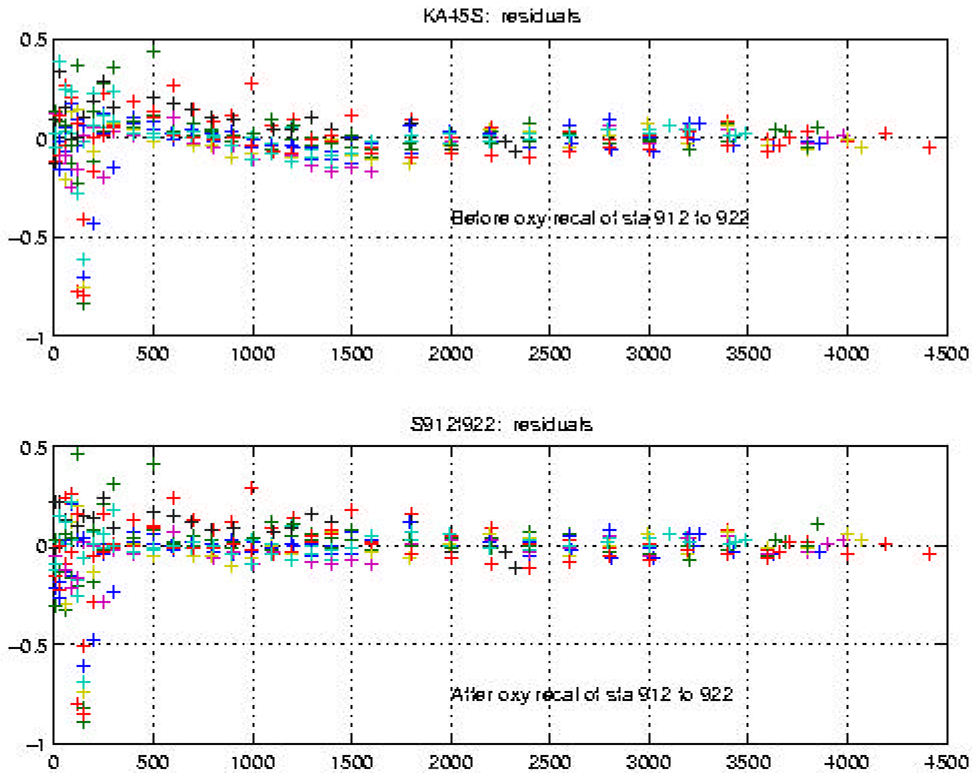
The following figures demonstrate how well the adjusted algorithm has done in fitting two station groups that could not be fit with the original algorithm.

Figure 5: Oxygen fitting with new algorithm: Stations 865 to 869: Original fit shows distinct pressure dependent shape as opposed to fit with new algorithm.



Above plots display differences of bottle to CTD oxygen ml/l by pressure in decibars.

Figure 6: Oxygen fitting with new algorithm: Stations 912 to 922: Fit with new algorithm removes pressure dependent shape of residuals.



Above plots display differences of bottle to CTD oxygen ml/l by pressure in decibars.

Figure 7: Refit of station group 912 to 922 (notice that shallow station 918 rosette data are bad).

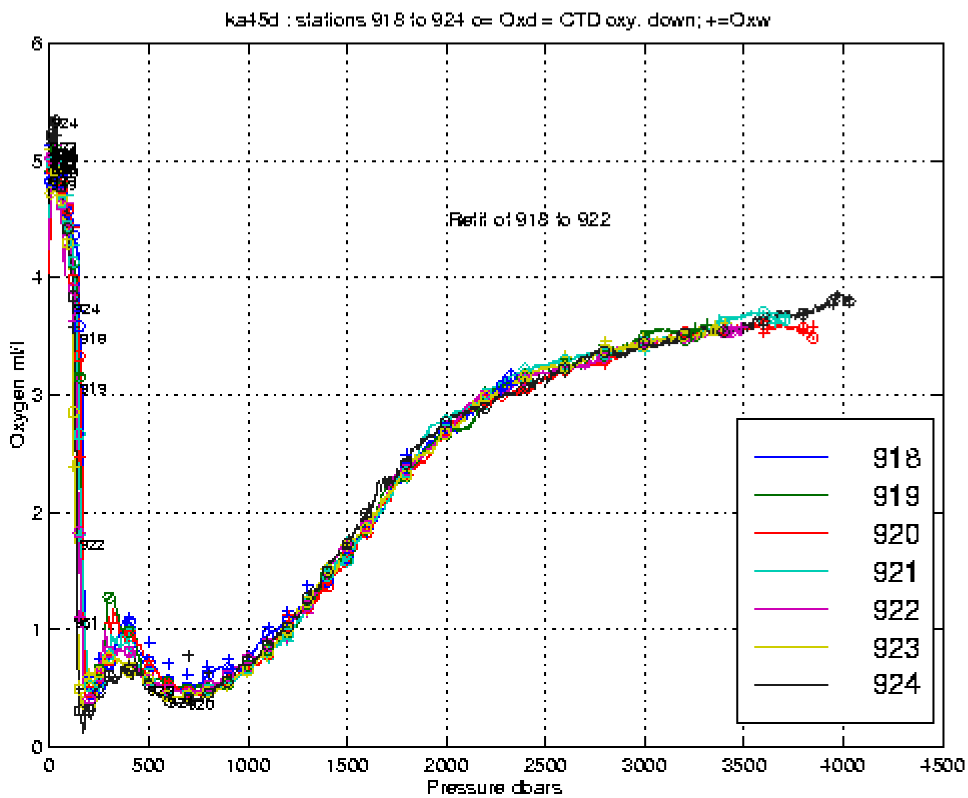


Figure 8: Refit of stations 930 to 933 in comparison to surrounding stations.

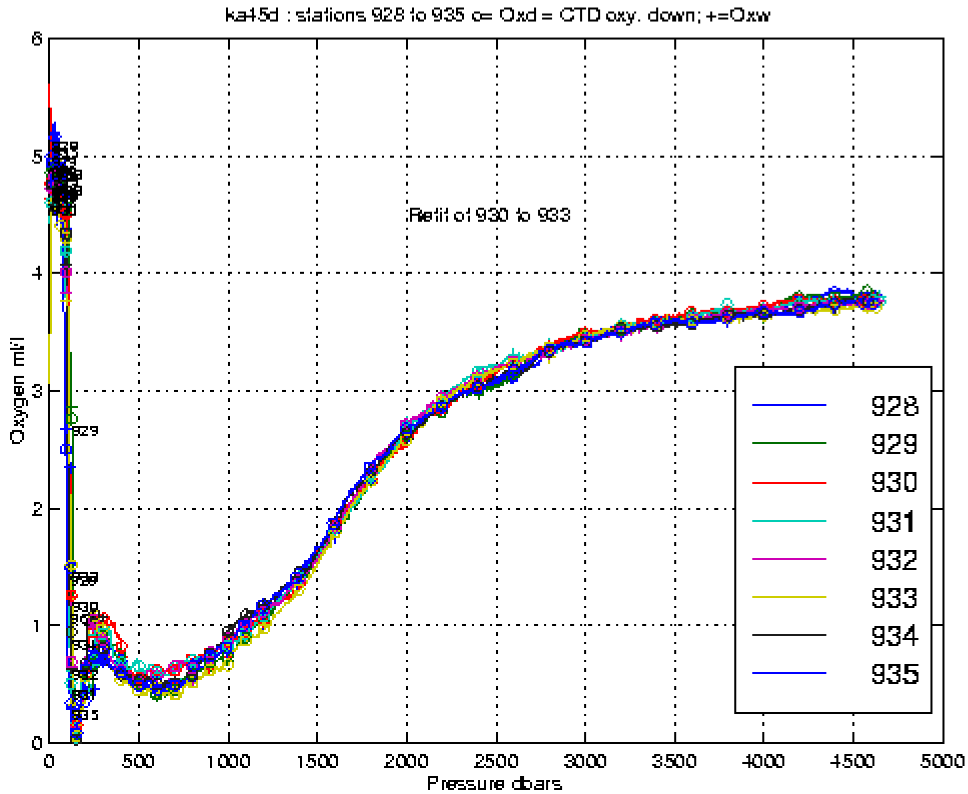


Table 3: Oxygen data fitting coefficients for revised algorithm

The following is a table of coefficients used to scale the oxygen data in the 53 stations that exhibited oxygen fitting problems. Note that some of the terms (i.e. lag) are unrealistic; they do, however, allow these data to be fit to the rosette water sample values. These are the data that could not be fit with the standard oxygen algorithm.

stn	bias	slope	pcor	tcor1	tcor2	lag	ptcor
860	-0.007971	0.001741	0.000156	-0.118095	0.050579	-4.17	-0.00006604
861	-0.007971	0.001741	0.000156	-0.118095	0.050579	-4.17	-0.00006604
862	-0.007971	0.001741	0.000156	-0.118095	0.050579	-4.17	-0.00006604
865	0.016388	0.001236	0.000163	-0.027216	-0.007340	-0.82	-0.00003362
866	0.016388	0.001236	0.000163	-0.027216	-0.007340	-0.82	-0.00003362
867	0.016388	0.001236	0.000163	-0.027216	-0.007340	-0.82	-0.00003362
868	0.016388	0.001236	0.000163	-0.027216	-0.007340	-0.82	-0.00003362
869	0.016388	0.001236	0.000163	-0.027216	-0.007340	-0.82	-0.00003362
880	0.157432	0.000496	0.000439	0.077879	-0.080973	-3.74	-0.00011072
881	0.052984	0.000207	0.001009	0.073267	-0.044510	-11.85	-0.00010797
882	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
883	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
884	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
885	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
886	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
887	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
888	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
889	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
890	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
891	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
892	0.046955	0.001134	0.000207	-0.011526	-0.015070	0.03	-0.00004038
912	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
913	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
914	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
915	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
916	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
917	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
918	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
919	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
920	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
921	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
922	0.018098	0.001265	0.000161	-0.011542	-0.016859	-0.84	-0.00002167
930	-0.028873	0.001555	0.000177	-0.016931	-0.010603	-5.01	-0.00003549
931	-0.028873	0.001555	0.000177	-0.016931	-0.010603	-5.01	-0.00003549
932	-0.028873	0.001555	0.000177	-0.016931	-0.010603	-5.01	-0.00003549

stn	bias	slope	pcor	tcor1	tcor2	lag	ptcor
933	-0.028873	0.001555	0.000177	-0.016931	-0.010603	-5.01	-0.00003549
963	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
964	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
965	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
966	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
967	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
968	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
969	-0.013299	0.001418	0.000157	-0.009204	-0.015968	1.10	-0.00002067
971	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
972	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
973	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
974	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
975	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
976	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
977	-0.019304	0.001652	0.000148	-0.011510	-0.019372	1.83	-0.00004173
978	0.411273	0.000324	0.000045	0.266932	-0.283316	102.98	-0.00008445
979	-0.035108	0.001632	0.000151	-0.018120	-0.012538	-2.50	-0.00003505

The quality of the final oxygen data is documented by the residual plots below:

Figure 9: Leg 1: Differences between final calibrated down oxygen data and rosette water sample data.

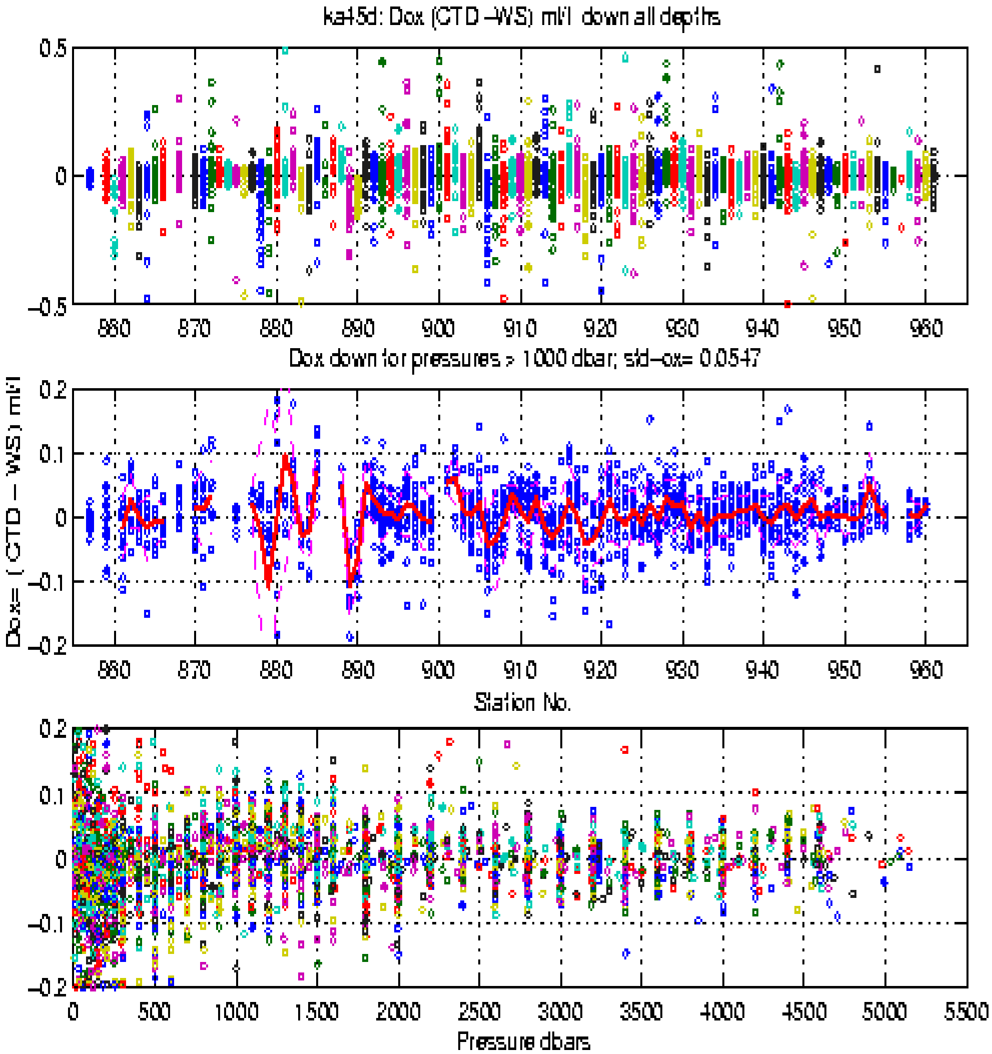


Figure 10: Leg 2: Differences between calibrated down oxygen data and rosette water sample data

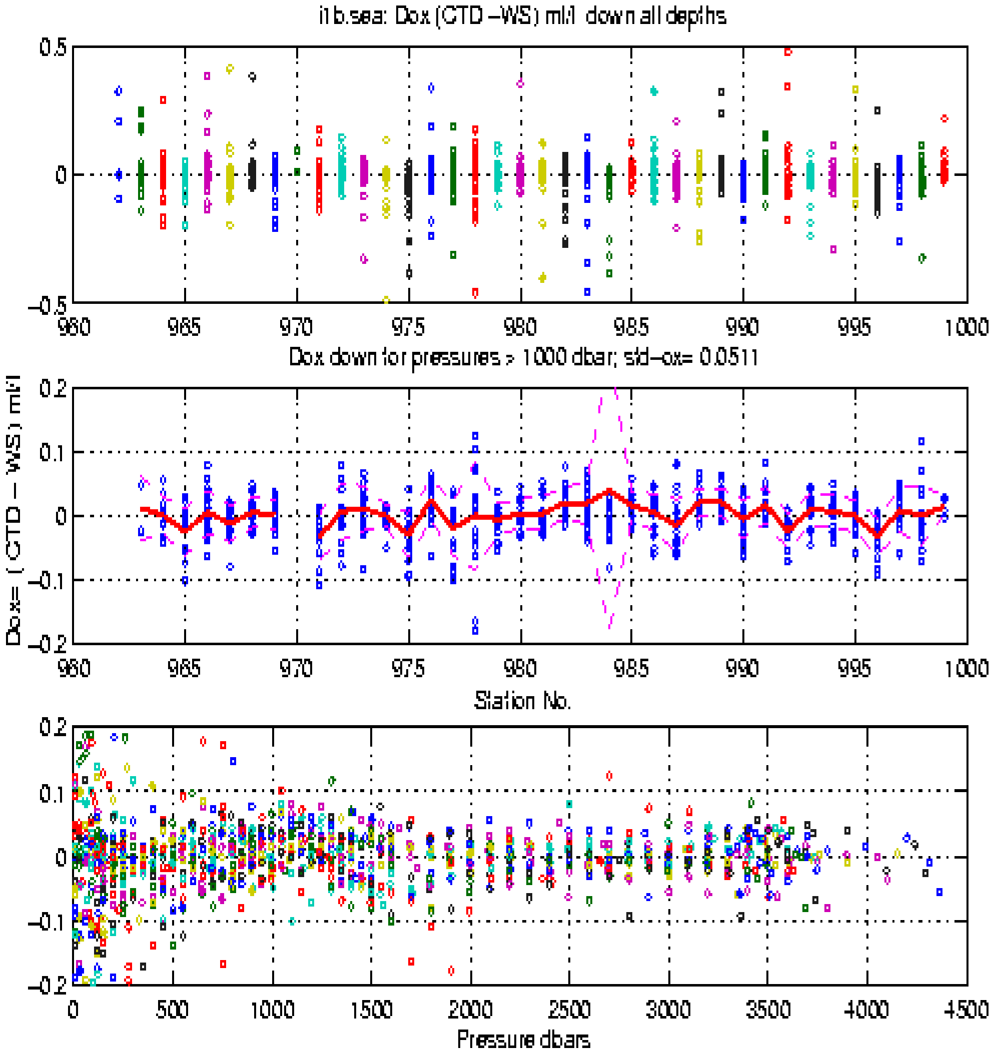
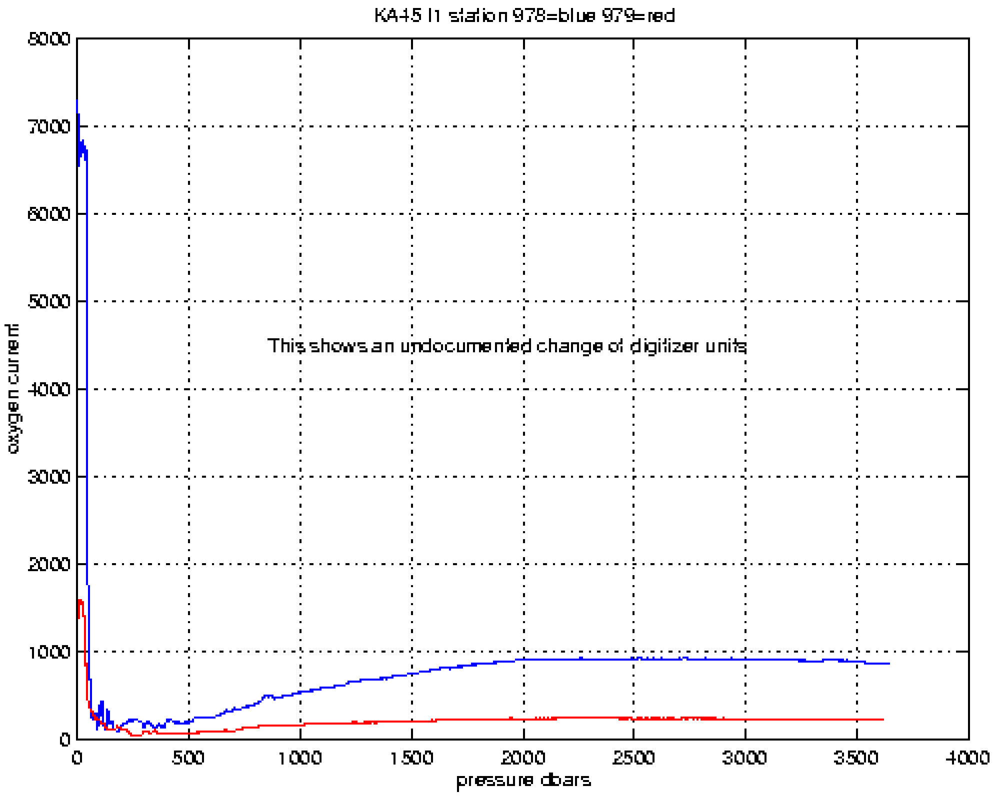


Figure 11: Stations 978 and 979 demonstrate that there were times during the cruise when the CTD was opened up and the oxygen current digitizer changed, resulting in a scaling change.



The following notes document instances where the quality word flag of the CTD oxygen in the CTD downtrace files was changed to 4 to signify bad data.

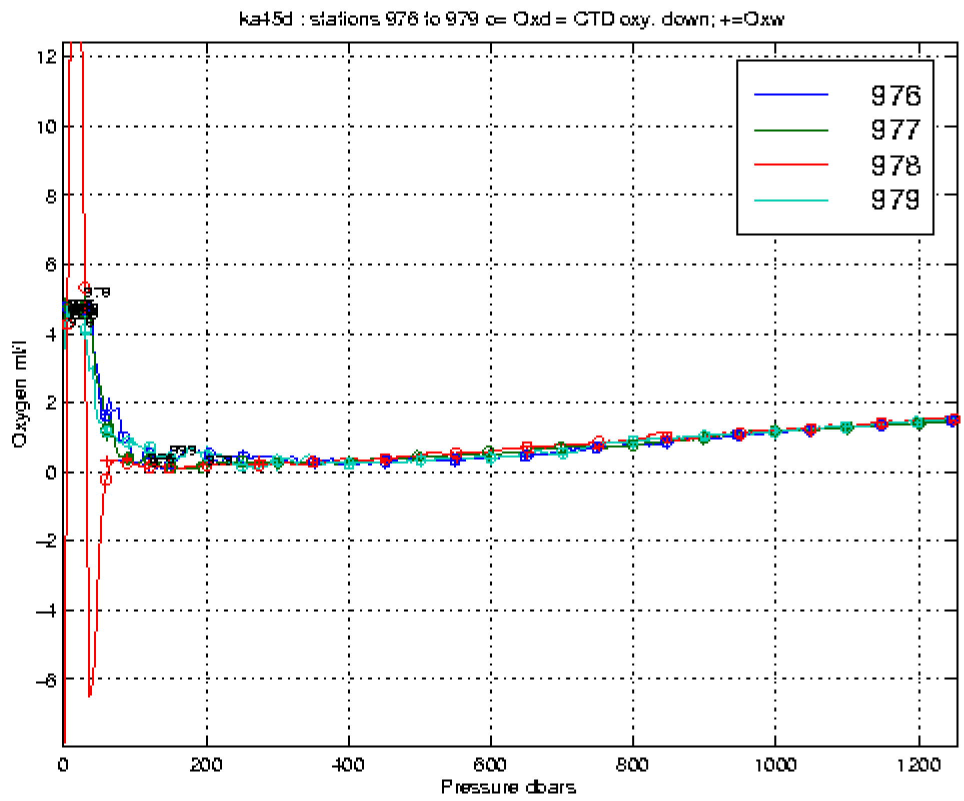
Stations 920-922, 915, 918

Set flag of 1 st oxygen value to 4 because oxygen current value is low by 0.8 ml/l.

Station 858: Oxygen bad between 237 to 241 and 275 dbars; set quality word =4.

Station 978: From the surface to 71 dbars the CTD oxygen is flagged bad.

Figure 12: Station 978 oxygen data unsalvageable above 71 dbar.



CFC-11 and CFC-12 Measurements - WOCE I1

Leg 1: Muscat, Oman to Colombo, Sri Lanka

Analysts:Mr. Steven Covey, University of Washington
Ms. Sabine Mecking, University of Washington

Leg 2: Colombo, Sri Lanka to Singapore

Analysts:Mr. Steven Covey, University of Washington
Ms. Wenlin Huang, University of Washington

Sample Collection and Analysis

Samples for CFC analysis were drawn from the 10-liter Niskins into100-cc ground glass syringes fitted with plastic stopcocks. These sampleswere the first aliquots drawn from the particular Niskins. The samples were analyzed using a CFC extraction and analysis system ofDr. Ray F. Weiss of Scripps Institution of Oceanography. The analyticalsystem was set up in a portable laboratory, belong to Dr. John Bullister, onthe fantail of the R/V Knorr. The analytical procedure and data analysisare described by Bullister and Weiss (1988). One syringe, Becton-Dickinson9882, was found to be a source of contamination for CFC-11. A separate samplingblank was applied to this syringe. These samples have been flagged as "questionable"(WOCE flag 3) and are listed below (Table 4). The CFC concentrations in air (Table 3) were measured approximately every twodays during this expedition. Air was pumped to the portable laboratory fromthe bow through Dekabon tubing. Calibration

A working standard, calibrated on the SIO1993 scale, was used to calibrate theresponse of the electron capture detector of the Shimadzu Mini-2 GC to the CFCs.This standard, Airco cylinder CC88110, contained gas with CFC-11 and CFC-12concentrations of 275.61 parts per trillion (ppt) and 496.49 ppt, respectively.

Sampling Blanks

We have attempted to estimate the level of contamination by taking the mode ofmeasured CFC concentration in samples which should be CFC-free. In this region,measurements of other transient tracers such as carbon-14 indicate that the deepwaters are much older than the CFC transient. We have used all samples deeper thanthan 2000 meters to determine the blanks of 0.002 picomoles per kilogram (pmol/kg)for CFC-12 and 0.004 pmol/kg for CFC-11. These concentrations have been subtractedfrom all the reported dissolved CFC concentrations. Syringe 9882 had a much higher sampling blank for CFC-11 (0.010 +/- 0.010 pmol/kg)based on the mean of a few samples. Since there is a large uncertainty in thecontamination level, all of the samples collected using this syringe during the firstleg have been flagged as questionable. The stopcock (likely source of the contamination)appears to have been changed for leg 2.

Data

In addition to the CFC concentrations which have merged with the .hyd file, thefollowing three tables have been included to complete the data set. The first twoare tables of the duplicate samples. The third is a table of the measured atmosphericCFC concentrations listed with time and position.

Table 1: CFC-11 Concentrations in Replicate Samples

STATION NUMBER	**SAMP NO.**	**CFC-11 pM/kg**	**WOCE Flag**
859	1	10 0.003	2
859	1	10 0.007	2
862	1	24 0.812	2
862	1	24 0.822	2
863	1	25 0.100	2
863	1	25 0.098	2
864	1	15 0.135	2
864	1	15 0.136	2
866	1	25 0.972	2
866	1	25 0.965	2
870	1	12 0.071	2
870	1	12 0.072	2
871	1	19 0.402	2
871	1	19 0.410	2
872	1	20 0.816	2
872	1	20 0.830	2
873	1	1 0.661	2
873	1	1 0.670	2
877	1	17 0.701	2
877	1	17 0.703	2
885	1	20 0.501	2
885	1	20 0.492	2
889	1	15 0.147	2
889	1	15 0.146	2
899	1	1 0.002	2
899	1	1 0.003	2
902	1	16 0.208	2
902	1	16 0.211	2
909	1	21 0.026	2
909	1	21 0.025	2
912	1	9 -0.004	2
912	1	9 -0.001	2
925	1	2 0.000	2
925	1	2 0.000	2

STATION NUMBER	SAMP NO.	CFC-11 pM/kg	WOCE Flag
925	1	21 0.005	2
925	1	21 0.003	2
929	1	1 0.008	2
929	1	1 0.008	2
936	1	24 0.010	2
936	1	24 0.013	2
940	1	29 0.355	2
940	1	29 0.348	2
941	1	1 0.000	2
941	1	1 0.002	2
952	1	16 0.010	2
952	1	16 0.014	2
954	1	5 -0.002	2
954	1	5 -0.003	2
1012	1	7 1.441	2
1012	1	7 1.425	2

Table 2: CFC-12 Concentrations in Replicate Samples

STATION NUMBER	SAMP NO.	CFC-11 pM/kg	WOCE Flag
859	1	10 0.005	2
859	1	10 0.011	2
862	1	24 0.476	2
862	1	24 0.482	2
863	1	25 0.054	2
863	1	25 0.044	2
864	1	15 0.070	2
864	1	15 0.070	2
866	1	25 0.543	2
866	1	25 0.545	2
868	1	22 0.186	2
868	1	22 0.172	2
870	1	12 0.034	2
870	1	12 0.038	2
871	1	19 0.220	2
871	1	19 0.224	2
872	1	20 0.429	2
872	1	20 0.427	2
873	1	1 0.370	2
873	1	1 0.380	2
877	1	17 0.395	2
877	1	17 0.392	2
885	1	20 0.275	2
885	1	20 0.266	2
889	1	15 0.080	2

STATION NUMBER	SAMP NO.	CFC-11 pM/kg	WOCE Flag
889	1	15 0.078	2
896	1	33 1.006	2
896	1	33 1.012	2
899	1	1 -0.002	2
899	1	1 -0.002	2
902	1	16 0.111	2
902	1	16 0.111	2
909	1	21 0.014	2
909	1	21 0.013	2
912	1	9 0.000	2
912	1	9 -0.002	2
925	1	2 0.002	2
925	1	2 0.002	2
925	1	21 0.004	2
925	1	21 0.000	2
929	1	1 0.003	2
929	1	1 0.001	2
936	1	24 0.004	2
936	1	24 0.007	2
940	1	29 0.188	2
940	1	29 0.184	2
941	1	1 0.001	2
941	1	1 0.000	2
952	1	16 0.006	2
952	1	16 0.006	2
954	1	5 0.001	2
954	1	5 -0.001	2
1012	1	7 0.840	2
1012	1	7 0.831	2

Table 3: Atmospheric CFC Concentrations

AIRNBR	LAT N	LON E	DATE	TIME	CFC-11	CFC-12	STNNBR
	dec deg	dec deg	gmt	gmt	ppt	ppt	(approx.)
1	19.082	58.797	950831	657	262.0	526.2	861
1	19.082	58.797	950831	707	261.9	523.8	861
1	19.082	58.797	950831	717	261.5	527.3	861
1	19.082	58.797	950831	726	262.1	528.8	861
2	16.267	56.555	950901	825	262.2	527.0	863
2	16.267	56.555	950901	840	262.6	527.3	863
2	16.267	56.555	950901	850	262.6	525.8	863
2	16.267	56.555	950901	900	262.4	523.7	863
2	16.267	56.555	950901	918	262.1	522.5	863
3	14.167	52.753	950903	1001	262.0	523.9	870
3	14.167	52.753	950903	1010	262.0	521.4	870

AIRNBR	LAT N	LON E	DATE	TIME	CFC-11	CFC-12	STNNBR
	dec deg	dec deg	gmt	gmt	ppt	ppt	(approx.)
3	14.167	52.753	950903	1020	261.9	523.3	870
3	14.167	52.753	950903	1029	261.8	523.5	870
4	12.375	43.812	950905	1721	266.0	531.1	873
4	12.375	43.812	950905	1730	264.8	531.2	873
4	12.375	43.812	950905	1740	265.2	529.7	873
4	12.375	43.812	950905	1749	265.1	532.7	873
5	12.333	45.753	950906	904	263.9	531.0	877
5	12.333	45.753	950906	914	263.6	530.9	877
5	12.333	45.753	950906	923	263.7	529.3	877
5	12.333	45.753	950906	933	263.7	528.5	877
6	13.065	48.568	950907	1701	265.3	536.2	883
6	13.065	48.568	950907	1711	264.6	536.0	883
6	13.065	48.568	950907	1720	264.7	533.4	883
7	13.717	51.568	950909	1118	262.6	523.5	892
7	13.717	51.568	950909	1128	261.6	523.1	892
7	13.717	51.568	950909	1137	262.7	522.5	892
7	13.717	51.568	950909	1147	262.3	523.4	892
8	9.898	53.800	950911	32	262.8	524.7	897
8	9.898	53.800	950911	43	261.5	521.1	897
8	9.898	53.800	950911	52	261.9	522.3	897
8	9.898	53.800	950911	102	261.4	521.8	897
9	8.823	52.690	950913	802	261.9	525.6	904
9	8.823	52.690	950913	812	261.8	525.0	904
9	8.823	52.690	950913	822	261.6	523.9	904
9	8.823	52.690	950913	832	262.3	524.4	904
10	8.930	54.417	950914	1151	262.6	523.6	908
10	8.930	54.417	950914	1201	262.5	523.8	908
10	8.930	54.417	950914	1212	262.3	524.7	908
11	8.490	58.110	950916	603	262.0	525.5	916
11	8.490	58.110	950916	613	262.1	523.6	916
11	8.490	58.110	950916	624	262.3	523.4	916
11	8.490	58.110	950916	634	262.2	523.1	916
12	9.008	61.552	950918	941	262.4	524.5	925
12	9.008	61.552	950918	951	263.1	525.6	925
12	9.008	61.552	950918	1001	263.1	525.7	925
12	9.008	61.552	950918	1010	263.5	524.9	925
13	8.500	65.883	950921	258	262.9	528.6	934
13	8.500	65.883	950921	308	263.1	528.5	934
13	8.500	65.883	950921	318	263.1	526.4	934
13	8.500	65.883	950921	328	262.8	528.8	934
14	8.497	68.900	950922	2130	263.9	526.4	940
14	8.497	68.900	950922	2140	262.7	524.3	940
14	8.497	68.900	950922	2151	263.7	525.1	940
14	8.497	68.900	950922	2202	262.5	525.4	940
14	8.497	68.900	950924	40	261.9	520.6	940
14	8.497	68.900	950924	55	260.2	522.8	940
15	8.503	71.215	950924	130	262.7	528.6	944

AIRNBR	LAT N	LON E	DATE	TIME	CFC-11	CFC-12	STNNBR
	dec deg	dec deg	gmt	gmt	ppt	ppt	(approx.)
15	8.503	71.215	950924	140	262.2	526.8	944
15	8.503	71.215	950924	149	262.0	525.0	944
15	8.503	71.215	950924	200	262.9	526.5	944
16	8.568	73.832	950925	906	262.9	525.4	951
16	8.568	73.832	950925	916	263.0	523.7	951
16	8.568	73.832	950925	926	262.7	526.5	951
17	6.417	79.100	950927	1418	263.7	527.1	958
17	6.417	79.100	950927	1428	263.7	526.7	958
17	6.417	79.100	950927	1438	264.0	526.7	958
18	5.633	79.997	950930	1242	262.9	529.2	963
18	5.633	79.997	950930	1251	261.5	528.3	963
18	5.633	79.997	950930	1301	262.7	526.9	963
19	9.963	83.847	951004	2220	265.1	532.5	978
19	9.963	83.847	951004	2231	264.8	530.5	978
19	9.963	83.847	951004	2241	265.0	528.9	978
19	9.963	83.847	951004	2252	264.4	530.6	978
20	9.828	86.788	951008	920	262.5	529.3	989
20	9.828	86.788	951008	930	264.1	531.8	989
20	9.828	86.788	951008	940	263.8	528.7	989
21	9.855	95.332	951012	230	263.2	526.8	1008
21	9.855	95.332	951012	239	263.6	526.2	1008
21	9.855	95.332	951012	250	262.8	525.0	1008
21	9.855	95.332	951012	302	263.1	526.2	1008
22	9.627	97.442	951013	21	263.9	530.7	1014
22	9.627	97.442	951013	30	263.9	528.9	1014
22	9.627	97.442	951013	41	264.1	527.8	1014
22	9.627	97.442	951013	53	263.8	526.7	1014

Table 4 - Samples Collected Using Syringe 9882

The following samples were collected with syringe 9882. Since deep samples taken with this syringe showed some contamination, a higher blank of 0.01 pmol/kg is subtracted from the samples collected during the first leg of the cruise (up to station 861). All of the samples from the first leg are also flagged as questionable (3) or bad (4).

NOTE: The sample number is 100*Cast plus the bottle number.

STA NBR	SAMPLE	Nominal Depth	
857	127	3195	
861	106	2600	
862	106	2000	
863	123	800	
864	120	250	
868	122	300	% part of dupl.
874	114	120	
879	127	30	
881	110	1000	
882	126	90	
883	121	180	
884	114	600	
885	122	200	
887	116	20	
889	128	0	
891	112	700	
892	136	5	
893	110	2400	
894	110	2600	
895	128	300	
896	133	90	% part of dupl.
898	111	2800	
899	109	3200	
900	119	60	
902	110	1100	
903	123	600	
904	126	500	
905	110	3400	% depth may be off
906	109	3800	
907	109	3600	
908	109	3800	
909	130	200	
910	124	700	
911	109	3400	
912	122	700	
913	126	400	

STA NBR	SAMPLE	Nominal Depth	
914	112	2400	
915	123	250	
917	110	2600	
918	114	800	
919	116	1100	
920	131	90	
921	124	500	
922	136	5	
923	119	800	
924	119	1100	
925	101	4450	
926	120	1100	
927	121	100	
928	101	4625	
929	115	2000	
930	116	1800	
931	119	1200	
932	104	4200	
933	125	600	
934	124	700	
935	108	3400	
936	108	3700	
937	123	900	
938	107	3700	
941	135	30	
948	124	165	
949	126	30	
950	122	90	
951	127	250	
952	108	1550	
953	126	90	
955	110	800	
958	127	30	
964	108	1350	
965	128	90	
966	128	350	
967	128	300	
968	128	350	
969	123	800	
971	124	150	
972	125	450	
974	128	150	
975	114	1500	
976	129	250	
977	126	300	
979	129	150	
980	125	350	

STA NBR	SAMPLE	Nominal Depth	
981	125	300	
986	110	2100	
987	126	250	
989	131	120	
990	114	1900	
991	128	120	
992	128	100	
993	126	200	
994	122	450	
995	129	90	
996	122	450	
997	122	600	
998	126	200	
1000	112	150	
1002	113	350	
1003	128	90	
1004	126	500	
1005	127	120	
1008	121	200	
1009	116	650	

DATA PROCESSING DETAIL NOTES:

STATION 863:
Made the internally recording (IR) backup CTD, CTD 1338, the primary data for the station instead of CTD 9. CTD9's oxygen and salinity in the down profile were bad due to noisy pressure requiring heavy interpolation. ICTD 1338 data were used to make the down 2-dbar file. CTD 9's info was left with the bottle file. There were problems making the bottle file from the IR CTD. Note, there aredifferent up and down cals, one for CTD1338, the other for CTD9.

STATION 909:
ICTD1344 jumped in salinity by -0.002psu at 3453dbar. Profile continued down at this lower salinity until reaching the bottom when it jumped back +0.001psu. The uptrace bottles and surrounding stations did not support this feature. The salinity below 3453 was replaced with the uptrace salinity.

STATIONS 973 to 979:
ICTD 1344 conductivity sensor was jumping low, away from the profile and then back to the real value over these set of stations. The problem appeared to be a loose mounting on the conductivity sensor that was epoxied into place after station 981.

STATION 973:
Replaced the bad downtrace salinity with uptrace salinity over the pressure ranges 1191 to 1641 dbar and 1707 to 2747 dbar.

STATION 974:
Replaced the bad downtrace salinity with uptrace salinity over the pressure range 1921 to 3773 dbar (bottom).

STATION 975:
Large interpolations over bad sections. The ranges are listed in the interpolation file:Station, Start pressure, 3=salinity, Ending pressure

975,939,3,1127
975,1447,3,1453
975,1455,3,1457
975,1479,3,1485
975,1781,3,1833
975,2083,3,2157

STATION 976:
Interpolate over the bad section. The range is listed in the interpolation file:
Station, Start pressure, 3=salinity, Ending pressure
976,2191,3,2251

STATION 977:
Leave as is, there is some odd shape in the 900 to 1100 dbar range but it is loosely mimicked by the uptrace.

STATION 979:
Interpolate over bad section. The range is 2683 to 3151 dbar. There is some shape in the 800 to 1200 dbar section but again, it is loosely copied by the uptrace data.

STATION 978, 980 to 014:
ICTD1338 downtrace salinity was fit to bottles for downtrace scaling term. Uptrace left as it was. There are two cal files for each station, one for uptrace data *.CU8 and one for downtrace data *.C08.

The *.CTD files of 2 dbar pressure averaged and centered downtrace profiles and the *.SEA bottle file both refer to stations 1000 to 1014 as 0 to 14.

The *.SEA files (one for leg1 and one for leg2) have been updated with new CTD pressure, temperature, potential temperature, salinity and oxygen data produced from the latest set of calibration coefficients.

Final nutrient data has been merged into the *.SEA files as well.

A distinct processing sequence of events occurred after rescaling oxygen data for the 53 "problem oxygen " stations.

The following was done using Matlab:

1. The WOCE format files submitted in July 1998 were the starting point.
2. For those stations requiring revised CTD oxygen data, the new oxygen data were overwritten into the original files.
3. The original CTD oxygen data in the SEA file were also overwritten with the newest oxygen data.

The bottle file pressures were used to merge the 2 dbar down-profile CTD oxygen data from the stations reprocessed into the bottle file.

The SEA file was also put through an initial pass at setting quality flags for both CTD salt and oxygen:

The quality word of both the CTD oxygen and CTD salinity were compared to the bottle values using a screening criteria that varied with pressure.

Within the following pressure levels, differences abs(Oxw-Oxcw) exceeding the value given are marked questionable.

Pressure less than 500 dbars Dox > 0.5 ml/l.
Pressure between 500 and 1500 dbars Dox > 0.2 ml/l.
Pressure greater than 1500 dbars and Dox > 0.1 ml/l.

All CTD oxygen values equal to -9.0 have had their quality word set equal to 9.

The original bottle file I1A.SEA had newly calibrated down CTD oxygen data merged into it and CTD salinity and oxygen data quality control edited. The resultant file is I1AA.SEA.

The original bottle file I1B.SEA was output to file I1BB.SEA.
The file I1B.SEA had a second set of four header records that were found to be inserted between station 999 and 0 (ie, station 1000). These headers were removed from file I1aa.SEA.

RESOLVED DATA ISSUES:

<u>Concern over possible pressure hysteresis in ICTD 1338 found to be caused by internal wave signal</u>.

> Issue was looked at by Bob Millard and determined not to be instrumental hysteresis but the signal of vertical heaving by internal waves.

<u>Non-compliant IOS standard water, batch P-124 from box 2</u>.

Standard water believed to be .002 fresh. Problem recognized immediately, only two stations resulted in questionable water sample salts from using this batch of standard water.

Spikes and jumps in all data fields throughout the cruise caused extensive editing.

The entire dataset has been edited and spikes, jumps, etc have been removed.

Pre- to post-cruise laboratory temperature calibrations of CTD 1344 and CTD 1338 showed changes.

A combined pre and post cruise temperature calibration has been selected for the ICTDs as described in the calibration summary section.

Oxygen fitting problems due to oxygen sensor failures and change-outs.

Several factors slowed the CTD oxygen fitting. Poor quality oxygen sensors necessitated frequent changes of sensors: 7 changes total. This resulted in at least as frequent changes in oxygen calibration coefficients. Swapped oxygen assemblies for stations 859 to 862 altered the oxygen temperature calibrations, another complication to the data fitting. Concentrations at the oxygen minimum come close to zero for 35 stations. It took substantially more time than usual to find a calibration that resulted in CTD oxygen data consistent with the water sample data but without going negative.

As noted in the oxygen calibration section, a revision to the Owens-Millard algorithm was tried and found to provide an acceptable fit for the oxygen data for 53 stations that were previously not able to be fit with the original algorithm.

CTD equipment failures caused extra processing to fit data to water samples and improve data.

Stations that had trouble with the primary instrument took extra time to correct. Such trouble includes segments of unreadable data or individual sensors not responding. Because two CTDs were usually on the frame, along with a second, independent temperature sensor, these problem stations were recovered by using data from the other instrumentation. For example, in the case of station 973, data from both primary and backup was used to construct the final hydrographic profile.

Reference:

Owens, W. B. and R. C. Millard Jr. (1985). A new algorithm for CTD oxygen calibration. Journal of Physical Oceanography, 15, 621-631.

APPENDIX 1:
NOTES ON WORK DONE TO PARTICULAR STATIONS: EXTRACTS FROM AT-SEA WATCHSTANDER'S LOG HIGHLIGHTING DATA PROBLEMS AND FIXES.

Station 858: CTD 9

Pressure drop-out and cast aborted- no water samples. CTD9 subsequently found to have failed pressure sensor, apparently due to corrosion in sensing element. CTD cannot be fixed at sea.

Station 859: ICTD1344.

Pylon failure, at bottle 18 pylon homed itself with message error was 242. Problem due to interfering telemetry of CTD and pylon.

AFTER Station 862: ICTD1338

ICTD1338 opened to switch from FSK to memory mode, and will be used as second CTD on frame.

Station 863: CTD9 with ICTD1338 in Memory mode.

After Test station for CTD9, CTD 9 opened and found dessicant packs to be caught btw boards, causing components on board to short out. Thought was fixed, but everything dropped out twice during this station.
-USE ICTD1338 DATA FOR THIS STATION

Station 864:CTD12,

Test station for CTD12, after shipping got complete garbage trying to run through seacable at 180 ma, switched to running at 250 ma seemed to run fine on deck, so tried a test station.
-down trace- cond jumps
-uptrace- large TMR error that was counted as btl tags scan # 47614, 1297 dbar 55 btl tags 11-37 taken out, and 12

Station 865: ICTD1344

with new oxygen sensor 5-06-03.
CHANGED TO MKIII DECK UNIT ON UP CAST
-a lot of noise in cast, changed over deckunit to MarkIII from FSI DT-1050, seemed to cleanup data.

Station 867:ICTD1344

loss of signal during down cast, fsk was still there but pressure pegged out at 6552. Put power supply in standby and switched to DT1050, no response. Put power supply back in standby, swapped back to MKIII DU and voila data returned.
CAST ABORTED
Down trace- weird pressure jump in beggining of cast complete pressure dropout at scans 26466-29569, 647 dbar

Station 869:ICTD1344

on down trace pressure pegged at 6552, FSK ok. Tried powering down for 5 min then back up- no luck, package brought back to 400m powered down then back up- no luck. Brought package to 200m powered down then backup - no luck, Tried firing 3 btl- no effect.
CAST ABORTED- BROUGHT BACK TO SURFACE
downcast- complete pressure drop out at 27832 used this as cut off scan number in header.

After station 869:

ICTD1338 OPENED TO CHANGE TO FSK MODE

After station 870:

I ICTD1344 opened up, found uninsulated wires, sloppy wiring.
Problems repaired. ICTD1344 memory card now installed.

SALINOMETER 10 BLEW POWER SUPPLY, CHANGED OUT OK

After station 872: ICTD1338, ICTD1344 memory.

ICTD1344 SURGERY, ICTD OPENED . Power board replaced with spare.

Station 875:ICTD1338

fter finished station tried to send pylon home, recieved
comm errors, pylon draws .280 A, pylon trying to move
to home, but seemed stuck, helped move and washed out,
pylon them seemed to be ok, drew .1 A.

Station 884:ICTD1338

-down trace PRESSURE JUMP
pressure jumped from 5.9 to 7.7 and did not jump back. scan # 14458
interped btw 5.9 dbar.
-uptrace- cast started on deck and not erased
fast temperature jump

Station 886:ICTD1338

-Pylon problems- computer return after firing 1 01 7
2 02
7
tried to position to 3- comm error
reinitialized and positioned to 2 success
-CTD powered up at 0725

After station 888:

******ICTD1344 OPENED ******
ICTD not used since last opening to replace power board.

After station 892:
******ICTD1344 AND ICTD1338 BOTH OPENED TO SWAP OUTMEMORY CARD*********

Station 900:ICTD1344, P1484, SIOSCI, MKIII DU, FRAME B
ICTD 1338 INTERNALLY RECORDING
Cast one aborted, sensor covers left on package
CTD harness replaced and connectors regreased, still
a problem- alot of synch errors from CTD
Problem found to be in termination, swapped to port sea cable
problem still continued. Turned off pylon power and synch error
went away.

Station 907:ICTD1344
MODEM CARD ON SIOSCI MODIFIED TO REDUCE
TRANSMIT LEVEL, HOPING
TO AVOID SYNCH ERRORS- lower surf xmit

Station 910:ICTD1344
NEW OXYGEN SENSOR 5-06-02

Station 913:BACKUP ICTD1338 ON FRAME, BUT NOT RECORDING
IN MEM MODE-
bat died

Station 915:BACKUP ICTD1338 INTERNALLY RECORDING- new
battery
-down trace-clean

Station 923:ICTD1344
NEW OXYGEN SENSOR (5-07-02)
FAWL CONNECTOR ON IRICTD1338 FAILED, ICTD1338
WAS REMOVED AND
A 3 PIN BULKHEAD CONNECTOR WAS PUT IN PLACE.

Station 925:ICTD1344
ICTD1338 INTERNALLY RECORDING, POWERED DOWN
SEACABLE
PORT SEACABLE
lots o' synch errors, pylon turned off during down trace
winch stopped at 4350 dbar to check level wind of winch

pylon problems trying to fire bottle 35, tried turning off and on pylon, reinitializing it, kept saying 02 7. When brought on deck found pylon to be at position 7. Reinitialized on deck and seemed to work fine.
-down trace- very noisy in conductivity, fast temp, oxtemp jumps
pressure -150 jumps
synch errors- 55 errors
-uptrace- cleaned up only around btl tags
took out btl tag 33.

Station 903:ICTD1344
NEW OXYGEN SENSOR 4-10-2

After station 942:
*******CONDUCTIVITY SENSOR ON BOTH ICTD1338 AND 1344 WERE CLEANED*****

Station 948:ICTD1344
pylon problems in beggining of cast, reinitialized, retried reinitialized and retried again, worked on third attempt.

After station 955:
*****PROBLEMS WITH INTERNALLY RECORDING ICTD 1338*********

Station 958:ICTD1344
BOTTOM CONTACT WITH PACKAGE
pylon problems, comm errors with pylon, however all bottles were fired

After station 961:
************ICTD1338 UPDATED EEPROM VERSION 1.9SMF *********
***********CHANGED OUT POWER SUPPLY AND PUT A NEW ONE IN*********

Station 973:ICTD1344
PRIOR TO STATION TOOK OUT MECCA WYE, AND 2 PIN CONNECTOR TO MECCA, CHANGED OUT THE HARNESS
****IN FINAL DATA USE ICTD1344 OXYGEN TRACE w/ ICTD1338 CONDUCTIVITY TRACE***
STATION 973 *.prs file currently has oxygens from iCTD1344 and salts
from IRICTD1338. M-file s973sal.m can be used to replace the the salt column from kj45d973.prs.

Station 975:ICTD1344

PRIOR TO STATION, SWAPPED FSKICTD CONDUCTOR TO MEM ICTD CONDUCTOR

Station 977:ICTD1344
CLEANED CONDUCTIVITY SENSOR ON ICTD1344, CHECKED FOR ROTATION

Station 978: ICTD1344
*****IN FINAL DATA SET USE IRICTD1338 DATA, THIS WAS DONE OCT95****
**** ICTD1344 DATA BACKED UP ONTO POSTPROC DISKS AS WELL AS ****
**** ICTD1338 DATA ****

Station 980: ICTD1344, ICTD1338 in Memory mode.
New oxgen sensor on ICTD1344 #4-12-04
ICTD1338 IN MEMORY w/ OTM 1372, POWER DOWN SEA CABLE.
For final dataset use ICTD1338 data - note this was done in Oct95.
ICTD1338 data backed up in POSTPR data, ICTD1344 only backed up raw data.
Water sample salts flagged as 3, appear to be .002 fresh, problem with standard water.

Station 981: ICTD1338
Water sample salts flagged as 3, appear to be 0.002 fresh, problem with standard water was subsequently found to be cause.

After station 981: ICTD1344
ICTD1344 FIRMWARE UPGRADED to version 1.9SMF providing 14 bits of oxygen digitization.
CONDUCTIVITY SENSOR STEM EPOXIED IN PLACE SO IT WILL NOT ROTATE.
OTM CHANGED TO VARIABLE 16, AND REDUNDANT TEMP TO VARIABLE 17, TO MATCH PAST CRUISES.

Station 991: ICTD1344
IN MEMORY w/ OTM 1372- new oxygen sensor (5-06-01)

Station 1005:ICTD1338
*****RECORD LAYOUT CHANGED TO INCLUDE PRSTEMP VAR#14****
Stopped cast at 1000m on down cast to see how pressure temp reacts, also stopped at approx 2750m.

Station 1012:ICTD1338,

Fast thermistor stem is not tight, tech did not repair anything; damage might result.

= end of Watchstander's log =

APPENDIX 2:
CRUISE INTERPOLATION DOCUMENTATION

List of interpolations applied after the pressure averaging and centering. The columns are for station number, the starting bad pressure, the column to be interpolated over (3=salinity, 4=oxygen), and the ending bad pressure. This does not list the edits done to the raw data using the EG&G software's ctdpost editor.

SALINITY INTERPOLATIONS

002,1291,3,1297
002,1353,3,1367
002,1405,3,1413
005,2773,3,2779
005,1001,3,1015
005,881,3,885
864,2407,3,2413
872,9,3,9
964,1995,3,1999
964,2243,3,2255
964,1127,3,1137
964,1429,3,1435
975,939,3,1127
975,1447,3,1453
975,1455,3,1457
975,1479,3,1485
975,1781,3,1833
975,2083,3,2157
976,2191,3,2251
979,2683,3,3151
986,1535,3,1545
987,671,3,697
987,1043,3,1051
987,1395,3,1399
988,1321,3,1328
988,1419,3,1423
990,1187,5,1195
991,1241,3,1245
995,937,3,947
997,1755,3,1771
999,921,3,931

999,1063,3,1081

OXYGEN INTERPOLATIONS

984,2321,4,2341
984,2559,4,2575
984,2871,4,2885
984,2981,4,2991
984,3087,4,3091
987,2717,4,2725
988,2125,4,2131
988,3357,4,3361
989,2977,4,2983
990,3353,4,3357

Data Processing Notes:

i01wsu.txt - Changed first header from R/V KNORR, I1,KN145, 11 to:
R/V KNORR CR. KN145, LEG 11 WHP-ID I01W

Added time stamp

changed EXPOCODE from 316N145/11a to 316N145_11

changed WOCE SECT from I1 to I01W

latitude was not left justified, corrected this

The following records had the wrong date. The cast started before midnight and ended after midnight according to the time but the date used was the same for the BE, BO, and EN event codes.

Sta. #	Event Code	Original Date	Changed to Date
857	BO	082995	083095
862	EN	083195	090195
880	EN	090695	090795
885	BO	090795	090895
885	EN	090795	090895
891	EN	090895	090995
897	EN	091095	091195
904	EN	091295	091395
911	BO	091495	091595
911	EN	091495	091595
915	BO	091595	091695
915	EN	091595	091695
927	EN	091895	091995
934	BO	092095	092195
934	EN	092095	092195
937	EN	092195	092295
944	EN	092395	092495
954	BO	092595	092695
954	EN	092595	902695

i1a.sea - Changed first header EXPOCODE and WHP-ID to conform with .sum file.
EXPOCODE 31ka45 to 316N145_11, and WHP-ID WOCE to I01W.
Changed CRUISE DATES 082995-101695 to 082995-092895
Added time stamp

Deleted last record in file, it only had

CHANGED FILE NAME TO i01why.txt

i01esu.txt - Changed first header from R/V KNORR, I1,KN145, 11 to
R/V KNORR CR. KN145, LEG 12 WHP-ID I01E
Added time stamp
changed EXPOCODE from 316N145/11b to 316N145_12
changed WOCE SECT from I1 to I01E
latitude was not left justified, corrected this
deleted last record in file, it only had

The following stations had the wrong date. The cast started beforemidnight and ended after midnight according to the time but the date used was the same for the BE, BO, and EN event codes.

Sta. #	Event Code	Original Date	Changed to Date
966	EN	093095	100195
987	EN	100795	100895
996	EN	100995	101095
1002	EN	101095	101195

i1b.sea - Changed first header EXPOCODE and WHP-ID to conform with .sum file.
EXPOCODE 31ka45 to 316N145_12, and WHP-ID WOCE to I01E.
Changed CRUISE DATES 082995-101695 to 093095-101695
Added time stamp
Deleted last record in file, in only had

CHANGED FILE NAME TO i01ehy.txt

Sarilee Anderson
4 Feb. 1998

Jerry and Steve - here is John Morrison's reply - it looks like he didn't copy it to you. I answered him back - that it probably would make most sense for him to look over his finalized data set before submitting it. So we can go ahead and make the small changes I suggested to the preliminary bottle data set. I am not making any changes to the sum and ctd files.

I will ftp the i01hy.txt file to you in a minute. Please acknowledge receipt and please replace the file that is on the website (of course saving the old one in your archive!!) Lynne

>From John_Morrison@ncsu.edu Tue Sep 29 04:44 PDT 1998
X-Sender: morrison@pop-0.foamv.ncsu.edu
Mime-Version: 1.0
To: Lynne Talley <lynne@gyre.ucsd.edu>
Subject: Re: i01 bottle questions
Content-Type: text/plain; charset="us-ascii" Content-Length: 3780

Hi Lynn:

I told Steve Diggs last week that you only have the preliminary dataset at SIO. I received the edited data from Sarah just a couple of weeks ago and have not had the chance to go through them yet. I was planning on doing this as soon as I return from Oman and India (will be gone from 4 Oct - 18 Oct).

I know that there are 50 stations that have "bad" ctd O2 that Bob Millard was going to take another look at!!!!!

If you would like, I can make the files that I have available now accessible to you or you can wait until I have a chance to look at them.

Let me know what you want to do!!!! I hate to waste your time until I have had a chance to go over the data!!!!! I would suspect that most of the changes are in the CTD and not hydro data, but you never know!!!!

john
(see more below)

On you suggestions:

>John - good to see you last week! I'm going through data sets and plots before we release the cdrom in a couple of weeks. I have three questions about I01 - if you're around could you let me know what you want us to do about them?

>1. We have I01E and I01W listed separately, but it looks like the data files had been combined. Do you have a preference for whether they are separated or together? It might be easier in general to have them together here.

I really have no preference. They were seperated for convenience of the folks aboard ship --- we finalized the first leg when going into Sri Lanka
>2. bottle data file - I suggest two changes - let me know what you think:

>Line 1: (header)

>expocode changed to 316N145 (as listed in sum file)

already changed to 316N145/I1a for each of the samples in the sum file.

>added the WHP-ID of I01
>added date stamp (new WHPO practice so we know which version of a file
>we are using)

>Old line:
>EXPOCODE 31ka45 WHP-ID WOCE CRUISE DATES 082995-101695

>New line:
>EXPOCODE 316N145 WHP-ID WOCE I01 CRUISE DATES 082995-101695 WHPOSIO19980928LDT

I have no problem with this change. It actually makes more sense.

>-----------------------------

>Line 4423:
>Bottle flag for station 1005, 1, 23 at 349.7 dbar is 3 and salinity is 4. It looks like all nutrients are bad here as well. I suggest that
>they all be flagged 4. Oxygen doesn't look out of place, but maybe for consistency, it should be flagged 3.

Once again, no problem here. I may also be more that should be changed in the data set that you have there.

>Old line plus one level above and one level below:
>1005 1 24 SIH036 2474.1 249.7 12.8941 34.9775 0.462
>12.8599
>34.9754 0.431 36.81 32.70 0.00 2.359 0.31 0.16 -9.000 -9.0000
>-9.0 2233.18 2320.96 -9.0 23322222222111111 1005 1 23 SIH001 3473.6 349.7 11.1018 35.0139 0.602
>11.0581
>33.5454 0.558 17.17 14.19 0.04 1.047 -9.00 -9.00 -9.000 -9.0000
>-9.0 2247.63 2330.83 -9.0 33342222299111111 1005 1 22 SIH019 4479.6 450.2 10.0980 35.0309 0.733
>10.0448
>35.0301 0.735 46.06 35.17 -0.00 2.522 0.10 0.05 -9.000 -9.0000
>-9.0 -9.0 -9.0 -9.0 23322222222111111
>Proposed new line:
>1005 1 23 SIH001 3473.6 349.7 11.1018 35.0139 0.602
>11.0581

>33.5454 0.558 17.17 14.19 0.04 1.047 -9.00 -9.00 -9.000 -9.0000
>-9.0 2247.63 2330.83 -9.0 33343444499111111

>Thanks - Lynne
9/29/98

6/27/99

The WHOI processing programs could not handle 4 digit station numbers, therefore the processed data as passed to me for final approval had files with station numbers 857 - 999 and 00 - 14. I changed the names of theCTD files and the stations numbers in the CTD, SEA and SUM files to reflect the actual WOCE stations numbers: 857 - 1014.

John M. Morrison, Chief Scientist, WOCE I1