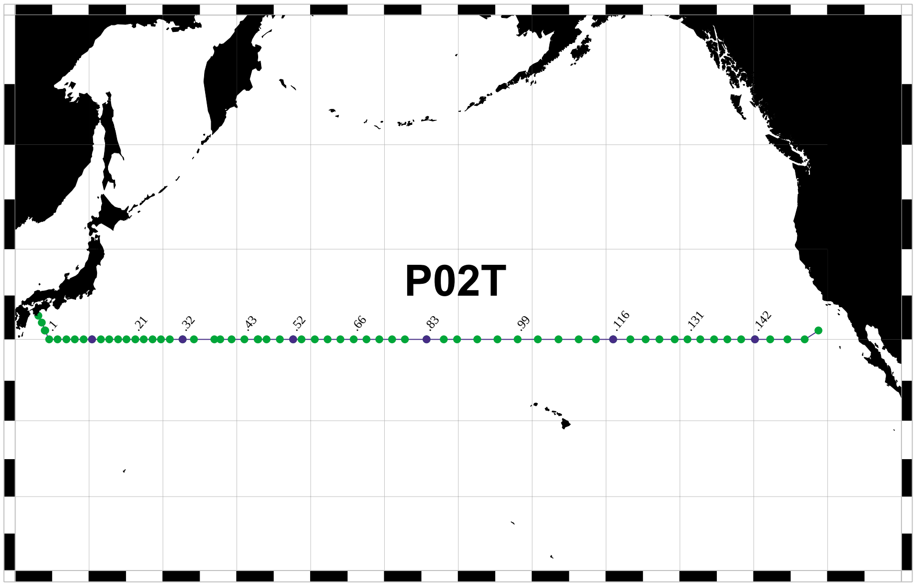
A. Cruise Narrative: P02T



A.1. Highlights

WHP Cruise Summary Information

WOCE section designation	**P02T**
Expedition designation (EXPOCODE)	**49K6KY9401_1**
Chief Scientist(s) and their affiliation	**Kuniaki Okuda/NRIFS***
Dates	1994.JAN.07 - 1994.FEB.10
Ship	R/V KAIYO-MARU
Ports of call	Tokyo, Japan to Longbeach, USA
Geographic boundaries of the stations	32° 44.98' N 133° 6.85' E 121° 11.97' W 29° 55.87' N
Number of stations	59
Floats and drifters deployed	unknown
Moorings deployed or recovered	unknown
Contributing Authors:	Kuniaki Okuda, Ichiro Yasuda, Tadashi Kamano, Chizuru Saito,

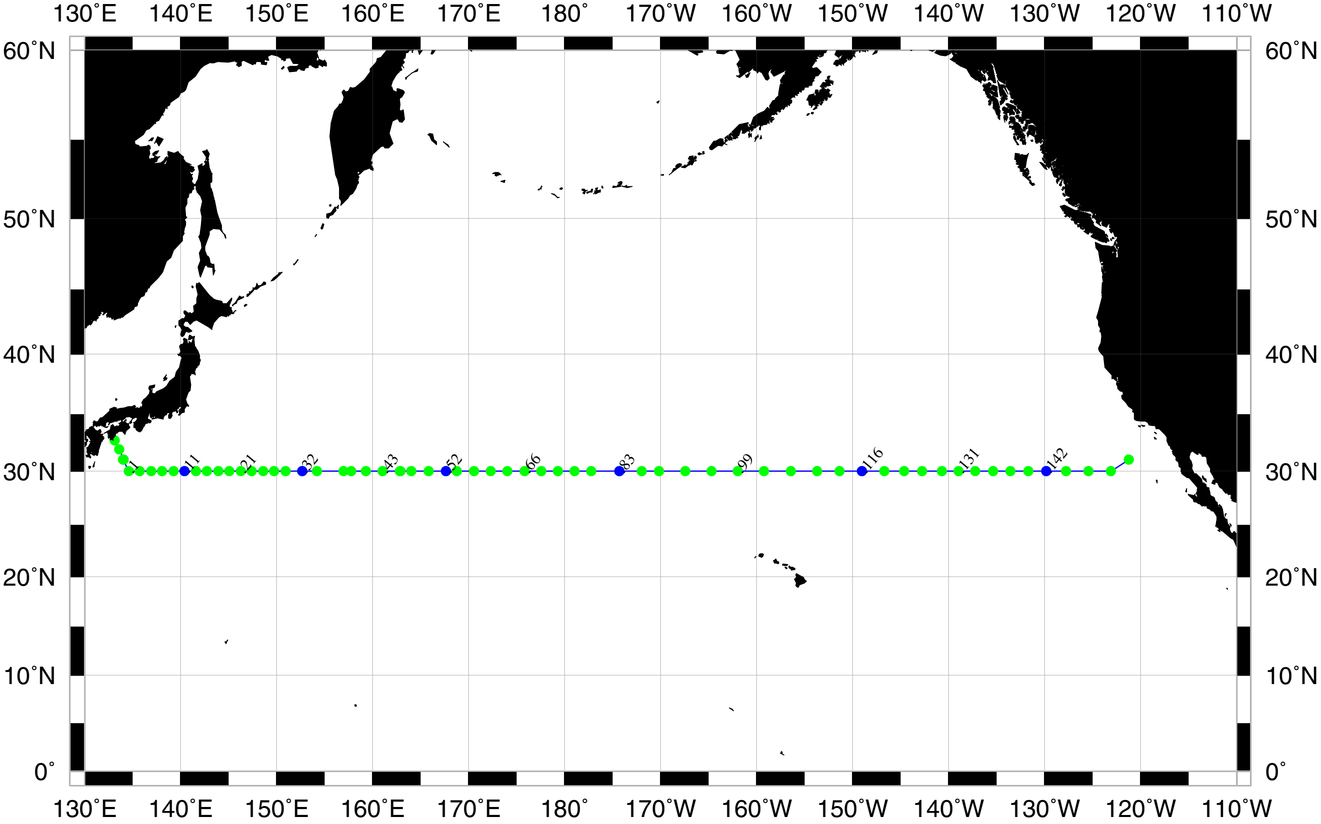
*Chief Scientist
Tohoku National Fisheries Research Institute
3-27-5 Shinhama-cho
Shiogama, Miyagi 985-0001 Japan
Phone: 81-22-365-9927 Fax: 81-22-367-1250 Email: kokuda@myg.affrc.go.jp

WHP Cruise and Data Information

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

Cruise Summary Information	**Hydrographic Measurements**
Description of scientific program	CTD - general
	CTD - pressure
Geographic boundaries of the survey	CTD - temperature
Cruise track (figure)	CTD - conductivity/salinity
Description of stations	CTD - dissolved oxygen
Description of parameters sampled	
	Salinity
	Oxygen
	Nutrients
Principal Investigators for all measurements	**Acknowledgments**
Cruise Participants	
	References (see sections)
Problems and goals not achieved	
	DQE Reports
	CTD
	CFCs
	Data Status Notes

Station locations for P02T



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A.2. Cruise Summary

P02 was composed of four different cruises which were carried out during the period from October 14, 1993 to November 14, 1994 utilizing three different observation ships. No large volume sampling was carried out. Most of the observation line is located on 30°N. But west of 134.5 E, the line goes northwest toward Cape Ashizuri along the PCM5 line. Also, east of 123°W the line bends northeast to avoid Mexican territory.

Two of the four cruise were intended to get high-quality CTD data on high density observation stations. For example, the shortest interval between stations is 30 nautical miles around some topographic features, with small volume water sampling for nutrient analysis (Salinity, Dissolved oxygen, Silicate, Phosphate, Nitrate, (Nitrite) and pH). These two cruises compose the central and eastern part of P02, and the western most part of P02, respectively. The first cruise began on 14 October 1993 and the latter began on the 15th of January, 1994. The third cruise planned to get nutrient and chemical tracers data (Freon, Total Carbon, Tritium, Radioactive carbon/sampling only, pC02) mainly at 32 depths with CTD-ROSSETE 101 system. This cruise started on the 7th January, 1994. The fourth and final cruise, which measured ctd data as well as discreet salinity and oxygen data, began on November 1, 1994.

Standards for nutrient is controlled by PIs among these three cruises. Standards used for these cruise was re-standardized at Scripps institution of Oceanography in the course of first cruise.

A.3. List of Principal Investigators

Parameter	Principal Investigator(s)	Affiliation
CTD02/rosette	Masao Fukasawa	School of Marine Science, Tokai Univ.
	Ichiro Yasuda	Tohoku Regional Fisheries Research Laboratory
	Hiroyuki Yoritaka	Hydrographic Department, MSA
T,S	Hiroyuki Yoritaka	Hydrographic Department, MSA
02	Yoshihisa Kato	School of Marine Science, Tokai Univ.
	Katsumi Yokouchi	Tohoku Regional Fisheries Research Laboratory
N03, NO2, NH4	Hiromi Kasai	Hokkaido Regional Fisheries Research Laboratory
P04, SiO2	Chizuru Saito	National Institute for Environmental Studies
3H, Δ14C, CFC	Yutaka Watanabe	National Institute for Resources and Environment
∑C02, pH, Alkali., pCO2	Tsuneo Ono	Faculty of Fisheries, Hokkaido University
T (underway), ADCP	Ichiro Yasuda	Tohoku Regional Fisheries Research Laboratory
S (underway)	Masao Fukasawa	School of Marine Science, Tokai Univ.
XBT	Hiroyuki Yoritaka	Hydrographic Department, MSA
Moorings	Masao Fukasawa	School of Marine Science, Tokai Univ.
Surface Drifters	Yutaka Michida	Hydrographic Department, MSA

A.4. Scientific Goals

To get reliable dataset to estimate meridional transport of physical and chemical mass across 30°N. Especially, at relatively shallow depths, the zonal transport of total carbon and CFCs included in NPIW-corresponding layer and NPSTMW are object to be estimated. Also heat and fresh water (and/or salinity) fluxes across 30°N are subject to be estimated.

From 1991, WOCE-like observation programmes have been carried out along 32.5° N by the Hydrographic Department, Maritime Safety Agency and School of Marine Science, Tokai University. In these programmes current variations were checked by current meter moorings around the Shatsky Rise. Also, nutrient variations were examined through 5 different cruises. Results from these programmes show that eddies which are associated with the Shatsky Rise give so large effects on oceanic conditions around the region. The variation of nutrient profiles excess 20% of their mean structure at the intermediate depth in magnitude.

In P02 cross section, we encounter three large topographic features, the Shatsky Rise, the Emperor Seamount and the Hess Rise. As explained in foregoing section, same P02 line was repeated twice within three months. This strategy of operation will help us to know some standard errors in estimated fluxes through information about time-dependent oceanic structures.

A.5 Water Sampling Equipment and Underway Measurements

Small Volume Sampling:	24-place rosettes with 10-liter bottles.
Large Volume Sampling:	None
CTD System:	NBIS Mark III CTD, with 02 sensor
Salinometer:	Guildline Autosals.
Nutrient Analysis:	Auto-analyzer 11
Oxygen Analysis:	Carpenter method (automatic titration)
Underway Sampling:	75 kHz ADCP manufactured by RD

A.6 Cruise Track and Stations

Station positions are shown on Figure 1, where solid circles show stations for small volume sampling (Kaiyo-Maru). Stations are fundamentally spaced at 30 nm interval, and spaced at 48 nm interval over flat bottom region, along 30°N. In western boundary, stations are spaced at 10-15 nm interval along PCM5 line. In eastern boundary, stations are spaced at 28 nm interval. Small volume sampling (CFCs, Tritium, Radioactive Carbon) were be carried out every 2 or 3 stations (at 60-96 nm interval).

A.7 Cruise Participants

Participant	Affiliation	Responsibilities
Kuniaki Okuda	NFRL, JFA	Chief Scientist
Ichiro Yasuda	Tohoku FRL, JFA	CTDO, T, S, 0_2
Makoto Okazaki	Far Sea FRL, JFA	CTDO, T, S, 0_2
Hiromi Kasai	Hokkaido FRL, JFA	0_2, NO3, PO4, SiO3, NO_2, NH4
Katsumi Yokouchi	Tohoku FRL, JFA	0_2, NO3, PO4, SiO3, NO_2, NH4
Chizuru Saito	NIES	NO3, PO4, SiO3
Ayako Nishina	Tokai Univ.	0_2, NO3, PO4, SiO3
Yutaka Watanabe	NIRE	CFC, 3H, Δ14C
Ken-ichoro Kuwahara	Tokai Univ.	CFC, 3H, Δ14C
Tsuneo Ono	Hokkaido Univ.	$\sum C0_2$, pH, pCO_2, Alkalinity
Kozo Okuda	Hokkaido Univ.	$\sum C0_2$, pH, pCO_2, Alkalinity
Mamoru Tamaki	Tokai Univ.	$\sum C0_2$, pH, pCO_2, Alkalinity

B. Underway Measurements

1) Navigation
2) Bathymetry
3) Acoustic Doppler Current Profiler (ADCP)
4) Thermosalinograph and related measurements
5) XBT and/or XCTD
6) Meteorological observations
7) **Atmospheric chemistry data**

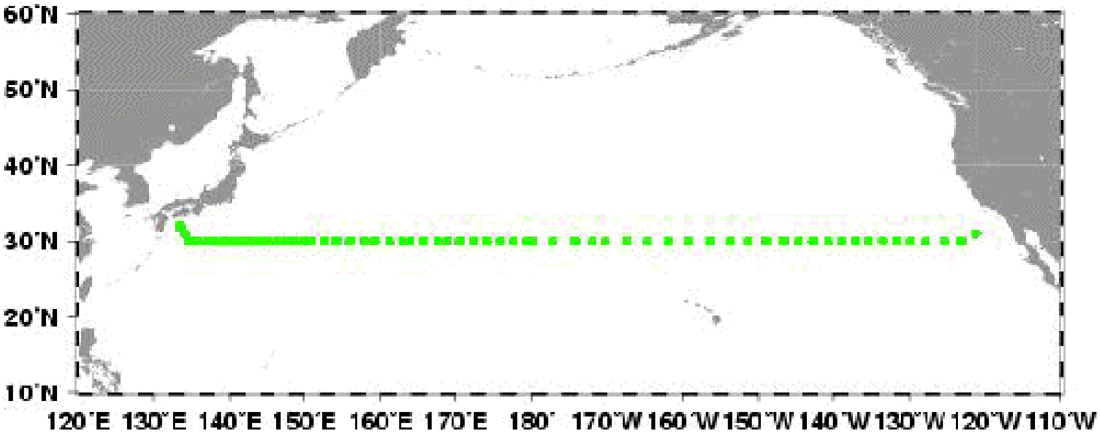
(no data)

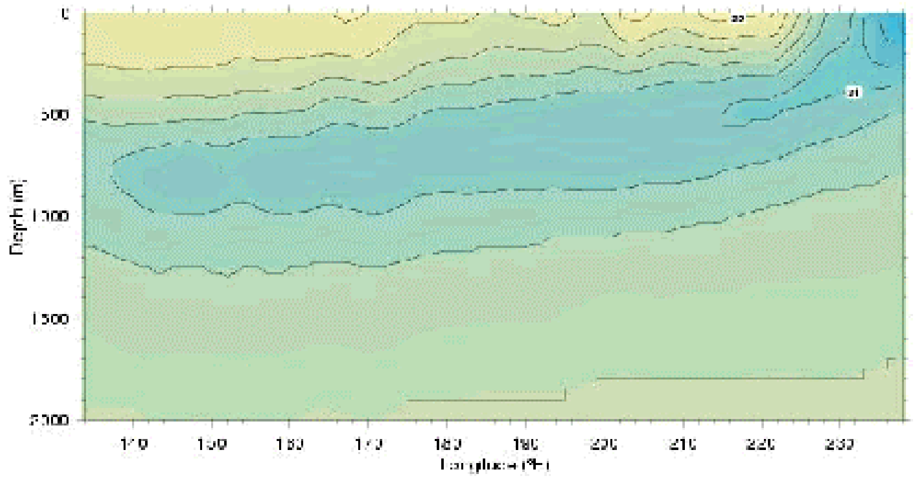
C.3 Hydrographic Measurement Techniques and Calibrations

C.3.1 Sample Salinity Measurements.

(Kuniaki Okuda, Ichiro Yasuda and Tadashi Kamano)
7 December, 1995

On R/V Kaiyo Maru cruise 3, the salinity analysis of samples was carried out on the two IOS DL Guildline Autosal salinometer model 8400. The one is on the Kaiyo Maru, and the other was brought from National Institute of Fisheries Science. The former instrument was used for Station K1 to K3. The sub-standard sample salinity drifted about 0.01psu. We decided to change room, and moved to the other room with air condition independent of the vessel one. However, the Autosal temperature regulation was broken down.





We used the other Autosal for all the stations after K3. The instrument was operated in the room temperature (24-25°C), and bath temperature was set to be 24.5°C. Every day, 2-3 station samples (50-80 samples) were measured. At each measurement, formal standardization by use of IAPSO Standard Seawater was performed, and was closed with the same batch of the Standard Seawater. Sub-standard measurements were performed about every 10 samples. The Autosal had not been very well. After about 100 sample measurements (4-5 hours measurement time), a drift of reading in conductivity ratio occurred. Then we have to stop the measurement and to turn off the power after substandard and standard measurements. For these reasons, we stopped the measurements in rather a short time (3-4 hours). Then the performance was satisfactory.

There were 101 pairs of replicate (i.e. from the same rosette bottle) samples drawn; and 14 pairs of duplicate (i.e., from different rosette bottles fired at the same depth) samples. The standard deviations of the groups of sample pairs are given in Table C.3.1 below.

TABLE C.3.1: Salinity replicate and duplicate statistics

Quantity	Mean difference	Number of pairs
Duplicates	0.0012 psu	14 for all layers
Duplicates	0.0020 psu	6 for halocline
Duplicates	0.0005 psu	8 for surface layer
Replicates	0.0005 psu	101

C.3.2 Oxygen Measurements (revised on July 15, 1997)

Equipment and techniques

Bottle oxygen samples were collected from Niskin bottles to calibrated glass bottles immediately after the drawing of samples for salinity as the first item. The subsampling bottles consists of the ordinary flask (ca.100ml) and glass stopper with long nipple. Overflow was carried out for 10 seconds during each sampling. The volume for overflow varied from 120 ml to 430 ml according to sampling persons. Potential temperature was used to allow corrections of sample density. Analysis followed whole bottle method. The thiosulfate titration was carried out in an air-conditioned laboratory. The same thiosulfate solution was used during this cruise. The standardization was done at the beginning, middle and end of the cruise. Duplicate samples were taken on every cast; usually these were from the bottles of number 1, 7, 13 and 19 of 24.

The pure water blanks was determined to be 0.0083 ml in average with a standard deviation of 0.0051 ml according to Carpenter (1965), after Drs. T. Joyce and M. Aoyama pointed out serious shift of our values through WHP property inter-comparisons from crossing lines in North Pacific. The volume of oxygen added with the reagents was 0.0017ml (Murray et al., 1968). The analytical method and the preparation of reagents were fundamentally done according to the WHP Operations and Methods (Culberson, 1991).

The end point was detected at a wavelength of 372nm by an automatic photometric titrator (Model ART-3DO-1) manufactured by Hirama Laboratories, Japan. Because endpoint readings were erroneous for the early stations K1 to K14 due to too fast speed of piston buret, these samples were flagged as suspect. The volume of oxygen dissolved in the water was converted to mass fraction by use of the factor 44.66 and an appropriate value of the density.

Reproducibility of measurements

Approximately 1400 samples were taken during the cruise; in addition, 198 duplicates (14%) were taken from the same bottle in almost range of oxygen concentrations. Statistics on the duplicates are given in Table C.3.2.

Table C.3.2: Statistics of duplicates.

		Oxygen concentration difference (µmol/kg)		
Stations	**Number**	**Mean**	**Std.dev.**	**mean**
K1-K14	12	2.85	2.37	2.25
K15-K62	181	1.10	1.24	1.71

Duplicates from 181 pairs of samples taken from stations K15 to K62 had a mean difference of 1.10 µmol/kg with a standard deviation of 1.24 µmol/kg (1.71%), while 12 pairs of samples from stations K1 to K14 gave a mean difference of 2.85 µmol/kg with a standard deviation of 2.37 µmol/kg (2.25%, Table 1).

References

Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. Limnol. Oceanogr., 10: 141-143.

Culberson, C.H. 1991. 15 pp in the WOCE Operations Manual (WHP Operations and Methods) WHPO 91/1, Woods Hole.

Murray, N., J.P. Riley and T.R.S. Wilson 1968. The solubility of oxygen in Winkler reagents used for the determination of dissolved oxygen. Deep-Sea Res., 15: 237-238.

C.3.3 Nutrients, Kaiyo Maru

(Chizuru Saito)

Equipment and Technique

The nutrient analyses were performed on an AutoAnalyzer-IITM. The methods for silicic acid, nitrate plus nitrite and phosphate were those given in the WOCE and JGOFS manual (Gordon et al.,1992). Just for phosphate measurement, cool down process was insufficient so one more 10 turn coil joined after first one. The room temperature was maintained between 22 and 25 °C.

Sampling Procedure

Sampling of nutrients followed that for CFCs, pH, TA, C-14 and dissolved oxygen on average 45-60 minutes after the casts were on deck. Samples were drawn into 250 cm3 polyethylene, narrow mouth, screw-capped bottles. They were immediately introduced into the AA-II sampler by pouring into 4 cm3 polyethylene cups which fit the sampler tray. Both the 250 cm3 bottles and 4 cm3 cups were rinsed more than twice. Samples were analyzed as rapidly as possible after sampling. Polyethylene sample cups were soaked in 0.1 N HCl solution until next measurement began.

Standard

For silicate standard, we used Na2SiF6 standard solution in P2 cruise and after this cruise the standard solution was calibrated by SiO2 solution. This purity was 97.22% but silicate concentrations in this report were not recalculated. Other elements standards were prepared as WOCE manual's methods (Gordon et al.,1992).

Low nutrient seawater

Surface seawater was collected in Kuroshio Extension Area as low nutrient seawater (LNSW). Collected seawater was stored in the 20 liter container for a few months and then filtered with 0.45 mm pore size filter to prepare the working standard solution. The concentration of nutrients in each batch of LNSW were determined carefully.

Short term precision

During this cruise we monitored short-term precision by analyzing replicate samples taken from the same sample bottle and duplicate samples taken from the same Niskin bottle. Duplicate samples were drawn from two water samplers at each station. One pair was drawn from the deepest depth, the other pair from the near nitrate/phosphate maximum.

Measured samples were totally ca. 1500, duplicate samples were about 110 and replicate analysis were about 120 samples. The precision of duplicate samples of nitrate plus nitrite, phosphate and silicate were 1.0, 0.58 and 0.96 %, respectively. On the other hand, each replicate precisions were 0.81, 0.44 and 0.98%. Unfortunately, these values did not satisfy the WOCE requirements thought they should indicate the trend of regional concentrations of nutrients included these dispersions.

References

Gordon, L.I., Jennings, Jr. J.C., Ross, A.A. and Krest, J.M., 1992, An suggested protocol for Continuous Flow Automated Analysis of seawater nutrients (Phosphate, Nitrate, Nitrite and Silicic Acid) in the WOCE Hydrographic Program and the Joint Global Ocean Fluxes Study. OSU Coll. of Oc. Descr. Chem. Oc. Grp. Tech. Rpt. 92-1.

C.3.6 CTD Measurements, Kaiyo Maru

(Ichiro Yasuda)

December 22, 1995

Gantry and Winch Arrangements

The gantry of R/V Kaiyo Maru consists of A-frame and equipment of fixing of the CTD package. In the deployment, the winch winds up the 7.4mm armored cable and the CTD package goes up. When the top of the CTD package is at the A-frame (about 3m from the deck), the CTD package is fixed by a stopper. Then the A-frame brings the CTD over the sea (about 5m from the sea surface and about 2m from the side of the ship). After the stopper is released, the CTD goes into the sea. The employment is the reverse operation. The operation is safe and all right through the cruise. Every time after the CTD operation and water samples are drawn out from Niskin bottles, the CTD package is come into the CTD room.

The winch system is driven by oil-pressure. The wire tension, the wire length and the pressure from CTD is monitored at the winch and in a CTD operation room. During the cruise, the weather was always severe. Thus the wire speed had to be slow down so as to be enough tension on the wire, especially near the sea-surface (from 100m to surface). This is for preventing the wire from kink. As will be reported in the performance section, the wire kinks frequently occurred in the early stage of the cruise. In the bad weather conditions, one CTD down-up cast took more than 6 hours. For example, at Sta. K11, the cast took 8 hours which was the longest. In a good condition, one cast took about 4 hours for 6000m cast. The wire sometimes was wound not orderly around the drum. This caused further delay of the cast. To avoid the rough winding, shifter was replaced two times during the cruise.

Equipment, calibrations and standards

1) Neil Brown MK3B CTD with Beckman oxygen sensor which was the property of SEA company and was leased to National Research Institute of Fisheries Science. Identification S/N #01-1156.
2) General Oceanics 10 liter 24 bottle rosette which was modified from 2.5L 24 bottle rosette. The 10-liter bottles consisted from Niskin bottles and lever-action-type bottles.
3) Seven digital reversing thermometers and two digital reversing pressure meters.
4) Benthos 12kHz pinger 2216.

Backup equipment consisted of spare CTD-DO sensor (owned by Kaiyo Maru), Niskin bottles and underwater unit for 2.5L 24bottle rosette.

The shipboard equipment consisted of two complete integral systems for demodulating and displaying the CTD data as well as controlling the rosette multisampler. Each system included the following major units:

1. FSI (Falmouth Scientific Inc.) demodulator deck unit data terminal. Model DT-1050.
2. DECpc 466D2LP system which is compatible with IBM/DOS machine.
3. Neil Brown data interrupt-type rosette firing module.

The data was backed up also in the NEC PC computer disk and DAT cassette data recorder through Neil-Brown Deck Terminal 1150.

Laboratory calibration of the Mk III CTD temperature, pressure and conductivity sensors was carried out at Woods Hole Oceanographic Institution just before (December 6, 10, 15 in 1993) and after (April 1994) the Kaiyo-P2 cruise by FSI.

Temperature sensor was adjusted to error-free by the pre-calibration, and then it was calibrated at five temperatures. According to the pre-calibration dataset (Table C.3.3), temperature was corrected as :

$$T=1.000056 \times T_{raw} - 1.919476E\text{-}6 \times T_{raw}*T_{raw} + 0.738327E\text{-}3$$

with the standard deviation of the error is 0.6368E-3 C.

This temperature calibration factor was used throughout the cruise and the CTD dataset.

Table C.3.3. Pre-cruise Temperature calibration in unit of degrees Celsius.

Standard Temp.	CTD-Temp.	Difference
.39238	.3920	-0.00038
7.65324	7.6512	-0.00204
15.06606	15.0656	-0.00046
22.29096	22.2900	-0.00096
28.99132	28.9904	-0.00092

Table C.3.4. Post-cruise temperature calibration.

Standard Temp. (TSTD)	TCTD-TSTD °C
0.43501	+0.002
0.43526	+0.002
7.69441	+0.002
7.69466	+0.002
15.14306	+0.004
15.14306	+0.005
15.14356	+0.004
22.44979	+0.007
22.44979	+0.007
22.45004	+0.007
29.32793	+0.008
29.32793	+0.008

From the pre- and post-cruise temperature calibrations, temperature sensor errors during the cruise are estimated to be 0.002°C for 0-8°C, 0.004°C at 15°C, 0.007°C at 22°C and

0.008°C at 29°C. The temperature error below the thermocline ($T<8°C$) is within the WOCE requirement.

From the pressure sensor calibration data with a deadweight tester, the following fit for the CTD pressure was found at an ambient temperature of ice-point, with a rms. error of 0.8 dbar.

$$P = -0.645806E\text{-}10 \times P_{raw}{**}3 + 0.653211E\text{-}06 \times P_{raw}{**}2 + 0.999061 \times P_{RAW} + 0.59$$

Further corrections were applied during data processing for variation of offset (on-deck pressure just before and after each sampling, and up/down hysteresis).

Equipment performance

General

In the CTD-rosette deployment and employment, problems arose almost from the wire-kink, miss-fire of rosette and bottle-leak from the lever-action-type bottles. The wire-kink occurred 5 times from Sta. AS12 to Sta. K10 (Sta. AS12, AS13, just before K4, K4, K10) because the CTD-package was too light in weight to be stable in rough sea conditions. This was recovered by attaching 6x20kg weight at the package at Sta. K4. The deficiency of the lever-action-type bottles caused miss-fire of the rosette system. This was from the difficulty in the setting of the bottle. Too much tension pulls the rosette-release pin, which results in no-release of the bottle. Weak tension causes insufficient coverage of the bottle, resulting in leak. We replaced the lever-action-type bottles to the Niskin bottles as much as possible. Then, the miss-fire was considerably reduced.

CTD

CTD performance had been almost nice through the cruise. We were calibrating the CTD data with comparison with water sampled data on the course of the cruise. We also compared the CTD data with historical NODC and Levitus dataset by superimposing the CTD data on the data points around 10x10 degree mesh data (vertical profiles, T-S, T-DO, S-DO diagrams) in order to detect sensor failure. This comparison routine was provided by Dr. Tomowo Watanabe in Far Seas Fisheries Research Institute.

Problems concerning CTD are summarized as follows:

Sta. AS4

At Sta. AS4, the CTD- package was deployed without removing sensor covers of conductivity and dissolved oxygen. This miss-operation lead to DO-sensor broken. We replaced a new oxygen sensor just before Sta. K2. Since the measurements of water sample oxygen was not good from Sta. K1 to K14, the oxygen data by the old DO sensor [Sta. K1, AS2, AS3, AS4 and AS5] cannot be used. We cannot use the conductivity (thus salinity) data of Sta. AS4.

Sta. K61

Just before Sta. K61, the deck-unit terminal DT-1050 broken down probably because of the failure of power supply parts. The back-up unit consisting of Neil-Brown Deck Terminal 1150 and NEC-PC98 Personal Computer system was used to obtain the CTD data only at Sta. K61. The data storage routine was provided by Dr. Kiyoshi Kawasaki in National Research Institute of Fisheries Science, who also largely helped the data processing at the station. The data format of the original data at K61 was converted to the one which corresponds to the formal format, and then we used the same data processing procedure as used in the other stations. At the final station, Sta. K62, the back-up Terminal 1050 was used for data acquisition.

24-Bottle Rosette System

As noted earlier, this system gave many problems, non-closing of bottles and double bottle closing.

12kHz Pinger

The performance of the pinger was satisfactory during the cruise.

C.3.7 CTD Data Collection and Processing

Data Capture and Reporting

Every time CTD deployment, the CTD-package was stopped near the sea-surface for about 1 minute in order to make sensors adjusted in the sea-water. Then, the cable was released.

Full CTD data with 31.25 per second are passed from the CTD Deck Unit to the DEC-PC and are processed with a CTD processing software provided by EG&G. All the raw data are archived in the PC. The data processing procedure almost exactly follows the method by Millard & Yang (1993: CTD Calibration and processing methods used at Woods Hole Oceanographic Institution). Firstly, we perform first difference check in which if a data value jumps more than a certain critical value, the data was marked and discarded. The critical values are as follows:

Pressure Level (dbar)	P	T	C	Oc	Ot
0-100	1.0	0.5	0.5	1.0	1.0
100-500	1.0	0.1	0.1	0.5	1.0
500-1000	1.0	0.05	0.05	0.25	1.0
1000-3000	1.0	0.02	0.02	0.1	1.0
3000-5000	1.0	0.015	0.015	0.05	1.0
5000-6500	1.0	0.015	0.015	0.025	1.0

The remaining downcast data are averaged in the 2db-pressure interval. In this process, calibrations of pressure, temperature, conductivity and time-constant mismatch are applied. CTD salinity and dissolved oxygen concentrations are reconciled with sample values, and any necessary adjustments made. The downcast data are extracted, sorted on pressure and averaged to 2dbar intervals: any gaps in the averaged data are filled by linear interpolation.

Temperature calibration

The following calibration was applied to the CTD temperature data:

$$T=1.000056 \text{ x } T_{raw} - 1.919476E\text{-}6 \text{ x } T_{raw}{*}T_{raw} + 0.738327E\text{-}3$$

This calibration was in C on the ITS68 scale, which was used for all temperature data reported from this cruise. For the purpose of computing derived oceanographic variables, temperature were converted to the 1968 scale, using T68 = 1.00024 T90 as suggested by Saunders (1990). In order to allow for the mismatch between the time constants of the temperature and conductivity sensors, the temperature were corrected. The time constant was estimated to be 0.303719 seconds, which was determined to minimize fine-scale salinity fluctuations (Dr. Kiyoshi Kawasaki, National Research Institute of Fisheries Science, provided the processing programs).

Pressure Calibration

The following calibration was applied to the downcast CTD pressure data:

$$P = -0.645806E\text{-}10 \text{ x } P_{raw}{**}3 + 0.653211E\text{-}06 \text{ x } P_{raw}{**}2 + 0.999061 \text{ x } P_{raw} - P_{deck}$$

where P_{deck} is a pressure reading when the CTD is on deck just before the cast.

A final adjustment to pressure is to make a correction to upcast pressures for hysteresis in the sensor. This is calculated on the basis of laboratory measurements of the hysteresis. The hysteresis after a cast of 5863dbar (denoted by dp5863(p)) is given in Table C.3.5.

Table C.3.5. Laboratory measurements of hysteresis in pressure sensor dp5863 (p)=(upcast-downcast) pressure at various pressures, P (from deadweight tester), in a simulated 5863 dbar cast.

P (dbar)	dp5500(p) (dbar)
5863	0.0
5518	0.3
4138	1.24
2758	2.4
1378	4.4
689	5.4
0	0.2

The following calibration was applied to the upcast pressure calibration:

$$P = -0.29655E\text{-}9 \text{ x } P_{raw}{**}3 + 0.296207E\text{-}05 \text{ x } P_{raw}{**}2 + 0.992595 \text{ x } P_{raw} - P_{deck}$$

where P_{deck} is a pressure reading when the CTD is on deck just after the cast.

The hysteresis is compensated for by matching the uptrace water samples and downtrace CTD profile using the following equation:

$$P = P_{up} \times (1-W) + P_{dn} \times W$$

$$W = \exp[-(P_{bottom} - P_{dn})/Z0]$$

where P is the adjusted pressure, P_{up} is the pressure value scaled with the uptrace calibration, P_{dn} is the pressure value scaled with the downtrace calibration, P_{bottom} is the maximum pressure of the station, and Z0=500dbar.

Salinity calibration

Salinity was calibrated by comparison with sample salinities. The laboratory calibration of the conductivity sensor showed that

$$C = C_{raw}*1.00028 - 0.408124E-2$$

with the 6 points (the points are around C=60.02142, 37.42179) and the standard deviation of 0.61E-3.

This was applied to station data as an initial calibration. The initial calibration was followed by the correction to conductivity ratio

$$C = G \times [1 - 6.5E-6 \times (T-2.8) + 1.5E-8 \times (P-3000)]$$

In-situ salinity calibration

Cell Factor Estimation

We compared all CTD conductivity data with those of water samples which was converted from salinity with temperature and pressure at the points bottles closed. We fitted a linear regression equation of

$$C = a \times C_{ctd} + b$$

with minimizing RMS error. The water sample data whose values are beyond 2.8 x sigma (standard deviation) criterion are rejected. This rejection and fitting procedure is repeated until all data are within the 2.8 x sigma criterion. This procedure follows Millard and Yang (1993). By using the CTD salinity determined with the cell factors determined by the above procedure, we again compared the CTD salinity and sample salinities. In this process, we detected bottle leak, miss-fire bottles and bottles taken at different depth. With the information of bottle rearrangements and rejection of questionable sample data, we again determined the cell factor as

$$a=1.0009114; \quad b=-0.03172988$$

For all, 1328 set of water sample and CTD data, from Sta. K1-K62, we determined one set of cell factor. In the process of rejections of beyond-2.8-sigma data, 333 set of data were rejected, and the standard deviation of the difference between CTD and water sample salinities for the remaining data was 0.002461mmho/cm. These data in the above process are reported in text files of all.his (cell factor determination), all.rej (list of rejected data) and all.res (list of remaining data).

With the cell factor determined by the above procedure, mean difference between CTD and water sample and standard deviations for depth ranges in the deep part are in the Table C.3.6.

Table C.3.6.

Depth Range	**Mean Salinity Difference $S_{sample} - S_{ctd}$ (mmho/cm)**	**Standard Deviation (mmho/cm)**
>=1000dba	@0.000179	0.002188
>=2000dbar	@0.0009017	0.00143
>=3000dbar	0.001136	0.00128
>=4000dbar	0.001285	0.00125

Since data number is larger in shallow part than in deep part, a systematic error (bias) tends to increase with depth. For the depth >= 3000dbar, there is a bias of about 0.001. To remove this bias, the bias part of the cell factor, we set b=-0.03172988 + 0.001= -0.03072988. With this operation, almost no bias is present for d>=2000dbar; while there exits a bias of about 0.001 for near surface data (d<1000dbar).

Problem in CTD salinity data

1) CTD salinity data at Sta. AS4 (filename=ka03d004.prs) is not good because of the sensor failure.

2) A large part of the data which are rejected when the present cell factor is near a intermediate salinity minimum (North Pacific Intermediate Water) for 200-1000dbar and in sharp thermocline and halocline. There is a tendency that a salinity difference, delta-S (S_{ctd}-S_{sample}) is positive (negative) for the depth larger (less) than in salinity minimum. This suggests that the CTD sensor traveled upward at the time when the bottle was closed after CTD data (average of 30 data) was obtained (5-10 seconds in advance of bottle closing). The rosette system is not non-interrupt type, this difference is inevitable. By these reasons, we keep the Bottle File data even when the salinity is somewhat (|delta-S|<0.02) different from the corresponding sample salinity data. A data user would be better to refer to the water sample salinity data when he or she uses the salinity data with combination of other water sampled data as nutrients and Freon.

3) As a course of the cruise, there is a tendency that conductivity difference delta-C (=C_{ctd}-C_{sample}) increases after Sta. K33. The delta-C averaged for 1000-6500dbar data

is -0.0005}0.0005mmho/cm in Sta. K4-K33; while the delta-C is increasing as station and at Sta. K62 delta-C is +0.0015mmho/cm. The increase of delta-C is almost linear with station. It is possible to remove this station-dependent change; but we have not done that because overall accuracy is within the WOCE requirement. This station dependent change in conductivity might arise from the CTD temperature increase found between pre- and post-cruise temperature calibration (delta-T=0.002C for 0-8C) as already reported.

Oxygen Calibration

CTD oxygen were calibrated by fitting to sample values using the following formula (Owens and Millard, 1985):

$$Oxm = [A \text{ x } (O_c + B \text{ x } dO_c/dt) + C] \text{ x } oxsat(T,S) \text{ x } \exp[t_{cor} \text{ x } (T_{ctd} + Wt \text{ x } (T_{ctd} - Ot) + p_{co}r \text{ x } p)$$

where one set of the coefficients A, B, C, t_{cor}, Wt and p_{cor} were chosen for the whole cruise, and O_c, T_{ctd} and Ot are Oxygen current, temperature by CTD and temperature in the oxygen sensor, respectively. Water sample oxygen data for Sta. K1-K15 are excluded from the calibration dataset because the oxygen measurement was not good for those stations. At Sta. AS4 (CTD file name= ka03d004.prs), CTD oxygen sensor was broken down, and was replaced just before the station K2. Since neither the CTD oxygen nor the water sample data are available for Sta. AS1-AS5 and K1, oxygen data are not present for these stations. The CTD oxygen data are almost all right, but there is high frequency noise for 0-300dbar that makes the measurement accuracy lower.

For oxygen data available in Sta. K16-K62, one set of calibration parameters is determined as:

C = 0.019 non-dimensional
A = 0.9778
$P_{co\ r}$ = 0.1363E-3 /dbar
T_{cor} = -0.03165 /C
Wt = 0.8680 non-dimensional
B = -2.147 seconds

For this fitting, standard deviation is 0.064ml/l. This large error arise from the high-frequency noise in 0-500dbar. In deep water, CTD oxygen measurements are within WOCE requirement as following Table:

Pressure Range	Standard Deviation (ml/l)	Data Number
0 =< <100	0.093	51
100 200	0.089	58
200 300	0.081	41
300 500	0.083	74
500 700	0.089	64
700 1000	0.064	99
1000 1500	0.049	83
1500 2000	0.048	87
2000 3000	0.047	43
3000 - 6500	0.040	251

The CTD oxygen sensor is stable for Sta. K16-K62, so that we applied the above one set of calibration parameter for the whole CTD data for Sta. K2-K62.

The average of the difference $O_{res}=O_{ctd}-O_{sample}$ for each station fluctuates from station to station but is within } 0.05ml/l for Sta. K16-K62. The standard deviation is less than 0.025ml/l, which is comparable with or less than the standard deviation of Ores for each station. The oxygen calibration history, rejected data list and remaining data list are contained in file "37-90ox.his", 37-90ox.rej" and "37-90ox.res".

We estimated the fitting parameters for several sets of station groups as follows:

station	(ml/L) sigma	data# (rej.#)	bias	slope	(e-2) Pcor	(e-3) Tcor	(e-1) Wt	Lag
K15-K21	0.0598	147 (8)	0.000	0.1055	0.1367	-0.3521	0.9657	0.1856
K22-K28	0.0531	136 (17)	0.005	0.09999	0.1403	-0.3314	0.9337	6.171
K29-K33	0.0636	107 (5)	0.010	0.09962	0.1413	-0.3142	1.085	-2.603
K34-K40	0.0514	129 (14)	0.006	0.09848	0.1392	-0.3376	0.7285	-1.462
K41-K47	0.0574	132 (20)	0.011	0.09376	0.1400	-0.3094	0.6607	-6.838
K48-K55	0.0684	171 (6)	0.010	0.09782	0.1388	-0.3177	0.8137	-4.093
K56-K62	0.0565	136 (13)	0.009	0.1036	0.1342	-0.3564	0.9349	-2.756

We applied the above sets of calibration parameters for each station group. For K2-K14, the first set of parameters were applied to obtain downcast CTD oxygen data. Thus the CTD-oxygen data for K2-K14 were not directly calibrated with water sample data. This fact should be noted for data users. However, judging from that the oxygen sensor is fairly stable for the course of the cruise, it is possible to use the CTD oxygen data of sta. K2-K14.

Station number and CTD file number comparison List

station #	File name
K1(AS1)	KA03d001.prs
AS2	02
AS3	03
AS4	04
AS5	05
K2	06
AS7	07
AS8	08
AS9	09
K3	10 (1ST CAST) 11 (2ND)
AS11	12
AS12	13
AS13	14
K4	15
St.2	16
K5	17
St.4	18
K6	19
St.6	20
K7	21
St.8	22
K8	23
St.10	24
K9	25
St.12	26
K10	27
St.14	28
K11	29
St.16	30
K12	31
St.18	32
K13	34
K14	35
K15	36
K16	37
K17	38
K18	39
K19	40
K20	41
K21	42
K22	43

station #	File name
K23	44
K24	45
K25	46, 47
K26	48
K27	49
K28	50
K29	51
K30	52
K31	53
K32	54
K33	55
K34	56
K35	57
K36	58
K37	59
K38	61
K39	62
K40	63
K41	64
K42	65
K43	66
K44	67
K45	68
K46	69
K47	70
K48	71
K49	72
K50	73
K51	74
K52	75
K53	76
K54	77
K55	78
K56	79
K57	80
K58	82
K59	83
K60	84
K61	90
K62	85

Final CFC Data Quality Evaluation (DQE) Comments on P02T.

(David Wisegarver)
Dec 2000

Based on the data quality evaluation, this data set meets the relaxed WOCE standard (3% or 0.015 pmol/kg overall precision) for CFC's. Detailed comments on the DQE process have been sent to the PI and to the WHPO.

The CFC concentrations have been adjusted to the SIO98 calibration Scale (Prinn et al. 2000) so that all of the Pacific WOCE CFC data will be on a common calibration scale. For further information, comments or questions, please, contact the CFC PI for this section (watanabe@nire.go.jp) or David Wisegarver (wise@pmel.noaa.gov). Additional information on WOCE CFC synthesis may be available at: http://www.pmel.noaa.gov/cfc.

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Prinn, R. G., R. F. Weiss, P. J. Fraser, P. G. Simmonds, D. M. Cunnold, F. N. Alyea, S. O'Doherty, P. Salameh, B. R. Miller, J. Huang, R. H. J. Wang, D. E. Hartley, C. Harth, L. P. Steele, G. Sturrock, P. M. Midgley, and A. McCulloch, A history of chemically and radiatively important gases in air deduced from ALE/GAGE/AGAGE J. Geophys. Res., 105, 17,751-17,792, 2000.

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Data Processing Notes

Date	Contact	Data Type	Data Status Summary	
09/09/97	Yasuda	CTD/BTL/SUM	Submitted for DQE	(also DOC)
10/15/97	Aoyama	NUTs	Submitted for DQE	(on disk}
10/17/97	Aoyama	NUTs/DOC	Submitted for DQE	
10/19/98	Thompson	DELC14	No Data Submitted	
	Masao Fukasawa/Tokai Univ. needs help processing C14 data			
06/29/99	Bartolacci	CTD/BTL/SUM	Data Update	
	I have updated the P02T (49K6KY9401_1) bottle, sum, and ctd files with the most recent reformatted files from Sarilee. The specifics on the reformatting can be found in "notes.p02t" in the original directory of p02t on the public site (you should be able to get to the file there, if not let me know and I'll just mail you a copy). The table has been updated to reflect the change. Danie			
05/09/00	Okuda	CTD/BTL	Data are Public	
	Of course, our data can be made "public/unencrypted".			
08/15/00	Diggs	CTD/BTL	Website Updated	data unencrypted
	All params in all files decrypted by me. Okuda sent a message to WHPO stating that all data could be public.			
11/17/00	Fukasawa	He/Tr	No Data Submitted; PI is Hirose/MRI-JMA	
12/18/00	Kappa	DOC	Doc Update	
	oxy, nuts, ctd reports combined into txt version			
02/17/01	Diggs	CFCs/CO2	Reformatting Needed; given to Dave Muus	

02/20/01 Okuda He/Tr Not Measured - Planned, not carried out

The sampling for helium/tritium might be planed for P2 at first and reported to WHP office, but actually did not made, I think.

02/21/01 Kappa NUTs/CFCs/CO2 Submitted

Downloaded data from public JODC website The Bottle File has the following parameters: SILCAT, NO2+NO3, NITRIT, PHSPHT, CFC-11, CFC-12, TCARBN, ALKALI, PH. The Bottle File contains: CastNumber StationNumber BottleNumber SampleNumber. And would like the following done to the data: reformat,merge,put online:Public

02/27/01 Diggs CTD PI update

Fukasawa & Yasuda/U Tokyo also responsible

03/07/01 Muus BTL Data Merged

- 20010306 merged file replaced by 20010307 file. Merged nutrients, freons, and carbon data from 2001.02.27_P02T_CFC_CARBON.DIR/P2_RUTIN_WOCEFMT.txt into the 19990616WHPOSIOSA web file and assumed the 1999 web SUMMARY file is correct.
- Station 11 cast 1 on new file seems to be the same as station 10 cast 2 on web file.
- No Sta 11/1 on web file and no Sta 10/2 on new file.
- Station 47 cast 1 on new file seems to be the same as station 47 cast 2 on web file.
- No Sta 47/1 on web file and no Sta 47/2 on new file. Summary file on web (dated 19990615) agrees with web .SEA file.
- Station 1 Cast 1 on web file but no Station 1 on new file. Successfully ran wocecvt on merged file (p02thy.txt dated 20010307).

03/12/01 Diggs S/O/NUTs/CFCs/C02 Website Updated

Data merged into online file Bottle: (salnty, oxygen, silcat, no2 no3, cfc-11, cfc-12, tcarbn, alkali) Placed new bottle data file online that Dave Muus Merged. "Merged nutrients, freons, and carbon data from 2001.02.27 _P02T_CFC_ CARBON.DIR/ P2_RUTIN_ WOCEFMT.txt into the 19990616 WHPOSIOSA web file and assumed the 1999 web SUMMARY file is correct."

04/04/01 Key DELC14 Data Request

It has just come to my attention that the C-14 results from the Japanese occupation of line P2T have been published. The number of stations is rather small, but the data are in an area which the U.S. did not cover (zonally). They should be willing to release the data since they consider it an official WOCE cruise. The reference is: Watanabe, et al., 1999, J. Oceanogr. Soc. Japan, A preliminary study of oceanic bomb radiocarbon inventory in the North Pacific during the last two decades, 55, 705-716. I will e-mail Watanabe today with an initial request for the data for inclusion in the atlas. If I have no luck, perhaps one of you can followup.

06/22/01 Uribe CTD/BTL Website Updated: CSV File Added

CTD and Bottle files in exchange format have been put online.

06/29/01 Wisegarver CFCs DQE Complete

precision outside orignal WOCE standards; meets "relaxed" stnds The calculated precision for CFC-12 based on replicate pars was 1.8%, Although the precison of measurements did not meet the original WOCE quality standards [1.9% or 0.002 pmol/kg for CFC-12], the data does fall within the relaxed standards of ±3% or 0.015 pmol/kg.

01/15/02 Kappa DOC Complied PDF and Text cruise Reports