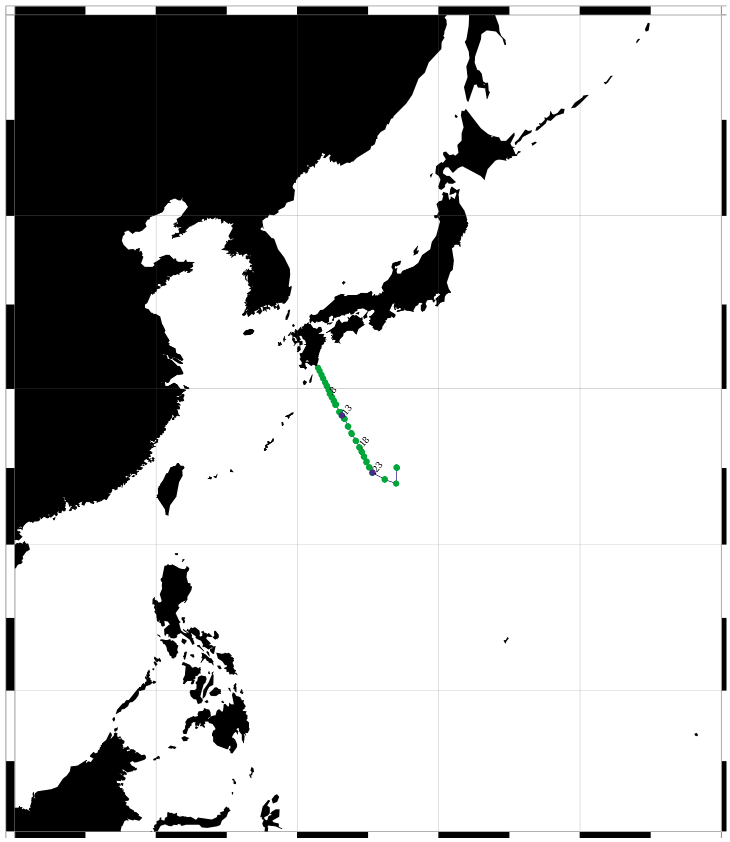
A. Cruise Narrative: P24



A.1. Highlights

WHP Cruise Summary Information

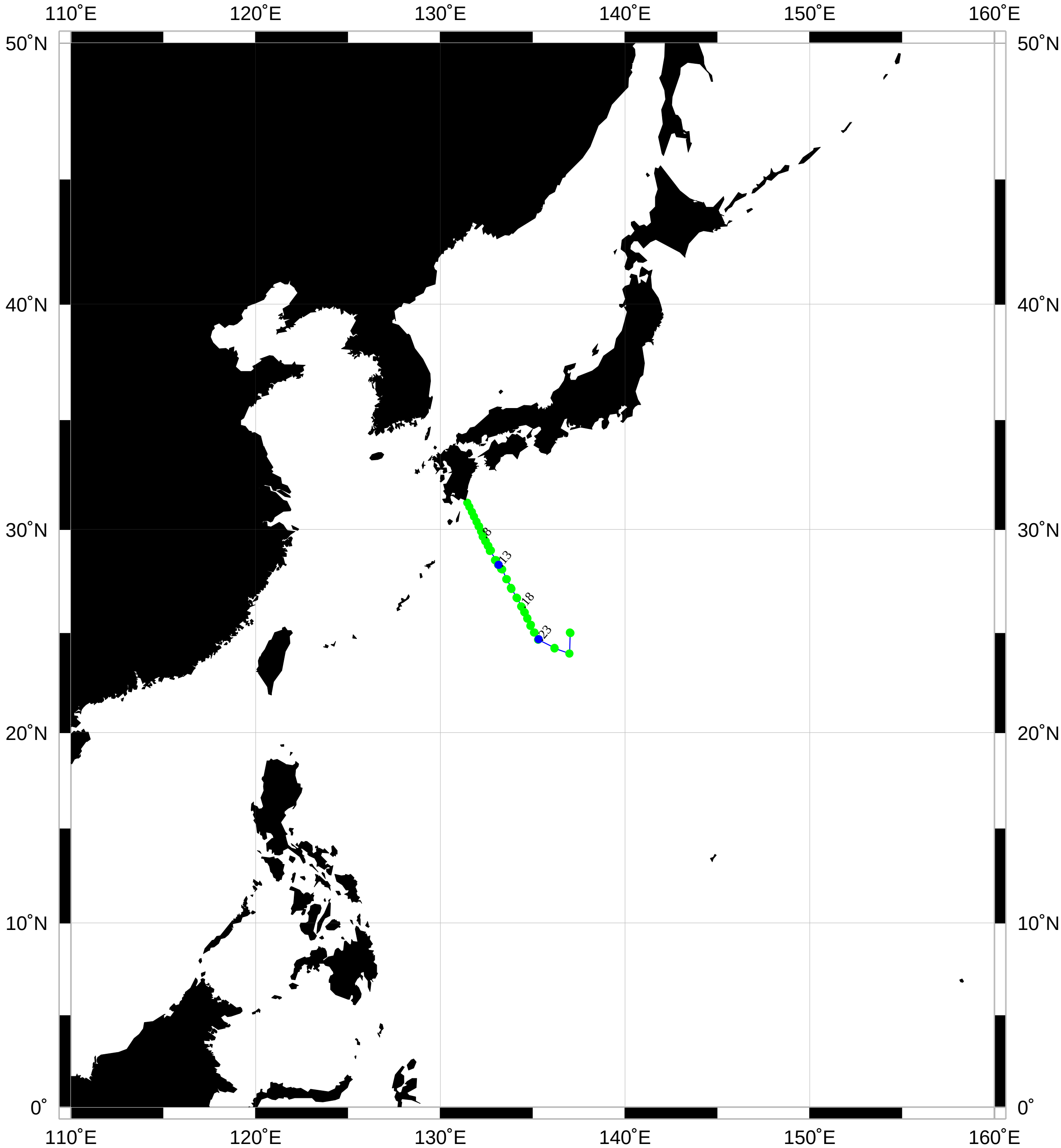
WOCE section designation	**P24**
Expedition designation (EXPOCODE)	**49RY9511_2**
Chief Scientist(s) and their affiliation	**Masahiko Fujimura**, JMA/MD
Dates	1995.11.15 – 1995.11.30
Ship	RYOFU MARU
Ports of call	Nagoya, Japan to Naha, Japan
Number of stations	26
Geographic boundaries of the stations	31°15.48'N 131°28.19'E 137°04.41'E 23°57.99'N
Floats and drifters deployed	none
Moorings deployed or recovered	none
Contributing Authors	Y. Takatsuki
(in order of appearance)	H. Kamiya
	K. Nemoto
	I. Kaneko

WHP Cruise and Data Information

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

Cruise Summary Information	**Hydrographic Measurements**
Description of scientific program	CTD - general
	CTD - pressure
	CTD - temperature
Cruise track (figure)	
Description of stations	
Description of parameters sampled	
Bottle depth distributions (figure)	Salinity
Floats and drifters deployed	Oxygen
Moorings deployed or recovered	Nutrients
	CFCs
Principal Investigators for all measurements	CFC DQE
Cruise Participants	CTD Data Consistency Check
Problems and goals not achieved	WHPO Data Processing Notes

Station locations for P24



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Cruise Report of RY9511, Leg-2 (WHP-P24)

Oceanographical Division
Climate and Marine Department
Japan Meteorological Agency

November 1999

1 Cruise Narrative

1.1 Highlights

WOCE section designation:	WOCE WHP P24
Expedition Designation (EXPOCODE):	49RY9511/2 (Ryofu Maru 95-11 cruise, leg 2)
Ship:	R/V Ryofu Maru
Ports of Call:	Nagoya, Japan to Naha, Japan
Cruise Dates:	November 15 to November 30, 1995.
Chief Scientist:	Masahiko Fujimura[1] Oceanographical Division Marine Department Japan Meteorological Agency 1-3-4 Otemachi, Chiyoda-ku, Tokyo 100, JAPAN E-mail: attention seadata@hq.kishou.go.jp

1.2 Cruise Summary

Cruise Track

The station locations along the WHP P24 section are shown in Figure 1.

Number of Stations

26 stations of CTD/Rosette casts were completed and pre- and post- CTD/Rosette casts for CFC bottle blank measurements were also occupied.

Sampling

Measured parameters and numbers of samples are as follows:
Numbers of water samples analyzed:

salinity	815 samples at 26 stations
oxygen	691 layers at 26 stations
nutrients	691 layers at 26 stations
CFCs	147 layers at 9 stations

Numbers of water samples collected for shore-based analysis:

[1]present affiliation: Maritime Meteorological Division, Climate and Marine Department, Japan Meteorological Agency

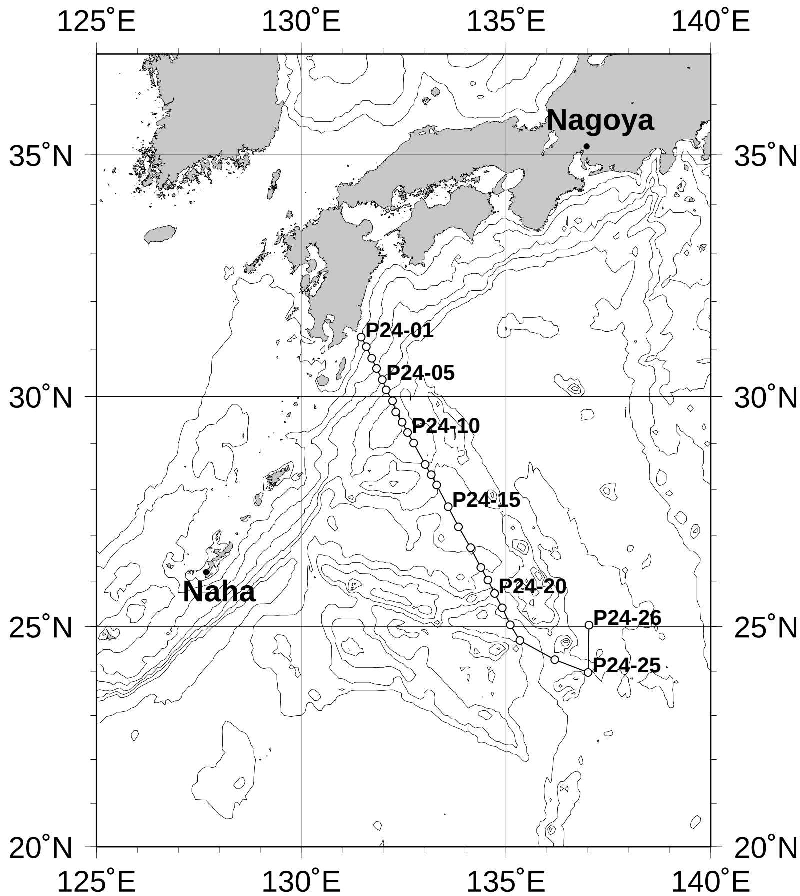

Figure 1: WHP-P24 station locations.
Contour level of the water depth: 200, 1000, 2000, 3000, 4000, 5000, 6000m.

helium-3 (^{3}He)	89 layers at 6 stations
tritium (^{3}H)	89 layers at 6 stations
AMS radiocarbon	159 layers at 6 stations plus ca. 160 samples for the forthcoming Pacific radiocarbon intercomparison.

Floats, Drifters, and Moorings

No floats, drifters, or moorings were deployed on this leg of the cruise.

1.3 List of Principal Investigators

The principal investigators responsible for the major parameters measured on the cruise and their E-mail address are listed in Table 1 and Table 2, respectively.

1.4 Scientific Programme and Methods

Narrative

Primary goal of the cruise is to obtain a high-quality standard dataset along P24 section, where the Kobe Marine Observatory of the Japan Meteorological Agency (JMA) will continue to carry out repeat hydrographic observations (PR17) and compare their data with the present standard data to detect long-term variations from sea surface to deep ocean. Another goal is to obtain detailed structure of deep circulation in the Shikoku and Northern Philippine Basins from deep density structure and property field along the section.

Since most of the instruments and equipments worked properly and the weather during the casts was not so severe, CTD observations, measurements of sample water salinity, dissolved oxygen and nutrients were carried out as intended. We also measured CFCs and collected water samples for shore-based analysis for 3He/3H, radiocarbon.

The cruise track is shown in Figure 1. After leaving Nagoya, the section began at (31-15N, 131-28E) off the coast of Kyushu. The Ryofu Maru headed southeastward along WOCE WHP P24. The distances between the neighboring stations were around 30 NM over some Basin, less than 30 NM over steep bathymetry in the Daito Ridge, between 10 and 20 NM over the continental slope. The last station was settled at (25-00N, 137-00E) which is the station WOCE P9-31. This section was not from coast to coast, however, three revisited stations were occupied at (24-15N, 136-12E: P3-322), (24-00N, 137-00E: P9-33), and (25-00N, 137-00E: P9-31) to confirm the traceability of the measurements.

Preliminary Results

Figure 2 shows the distribution of sample observations made on the P24 section. The preliminary results comparing the data this cruise and previous P3 and P9 cruises at three revisited stations showed in good agreements within the WOCE onetime standard of water samples.

Salinity We had three revisited stations on WHP P3 and P9. Salinity values interpolated with potential temperature below 1.6 degree C and differences are shown in Table 3. The deep water salinity values at the station P3-224 in 1985 are slightly lower (about 0.002 or 0.003) than those at the present station P24-24. While the salinity values at the stations P9-33 and P9-31 in 1994 are almost the same (almost within 0.002) with our P24-25 and P24-26.

Table 1: List of the parameters to be measured, the sampling groups responsible for each, and the principal investigator for each.

Chief Scientist: Masahiko Fujimura

Parameter	Sampling group	Principal Investigator
CTD/Rosette	JMA/MD	Yasushi Takatsuki
Salinity	JMA/MD	Yasushi Takatsuki
O_2, NO_3, NO_2, PO_4, SiO_2	JMA/MD	Hitomi Kamiya
Chlorofluorocarbons	JMA/MD	Kazuhiro Nemoto
$^3H/^3He$	JMA/MRI	Michio Aoyama
Radiocarbon	JMA/MRI	Michio Aoyama
ADCP	JMA/MD	Masahiko Fujimura

JMA/MD Marine Department, Japan Meteorological Agency
JMA/MRI Meteorological Research Institute, JMA

Table 2: List of E-mail address of each PI.

Masahiko Fujimura	fujimura.ma@met.kishou.go.jp
Yasushi Takatsuki	attention seadata@hq.kishou.go.jp
Hitomi Kamiya	attention seadata@hq.kishou.go.jp
Kazuhiro Nemoto	k-nemoto@met.kishou.go.jp
Michio Aoyama	maoyama@mri-jma.go.jp

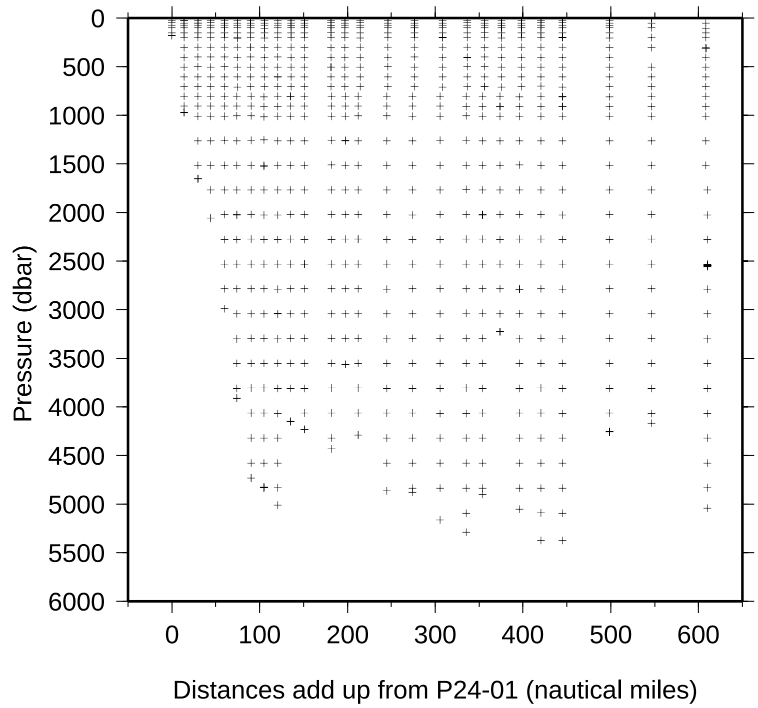

Figure 2: Location of 12-liter water samples collected on P24.

Oxygen Accuracy was checked by comparison with P3 and P9 data. Data taken at stations 24, 25 and 26 were compared with P3 station 322, P9 stations 33 and 31 respectively. Our data agrees with the old data within 1% of reproducibility in all cases. Comparison with data of P24 and P9 (Stn. 30–34) is given in Figure 4.

Table 3: Salinity values and differences on isotherms of P24, P3 and P9.

Potential Temp. (Depth ca.)	1.20 (4000m)	1.30 (3400m)	1.40 (3000m)	1.50 (2750m)	1.60 (2500m)
24-15N, 136-12E					
P24-24	–	34.672	34.662	34.652	34.640
P3-322	–	34.669	34.660	34.649	34.638
diff.	–	+0.003	+0.002	+0.003	+0.002
24-00N, 137-00E					
P24-25	–	34.671	34.663	34.653	34.642
P9-33	34.681	34.672	34.663	34.654	34.642
diff.	–	−0.001	0.000	−0.001	0.000
25-00N, 137-00E					
P24-26	34.681	34.671	34.662	34.652	34.643
P9-31	34.679	34.672	34.665	34.652	34.642
diff.	+0.002	−0.001	−0.003	0.000	+0.001

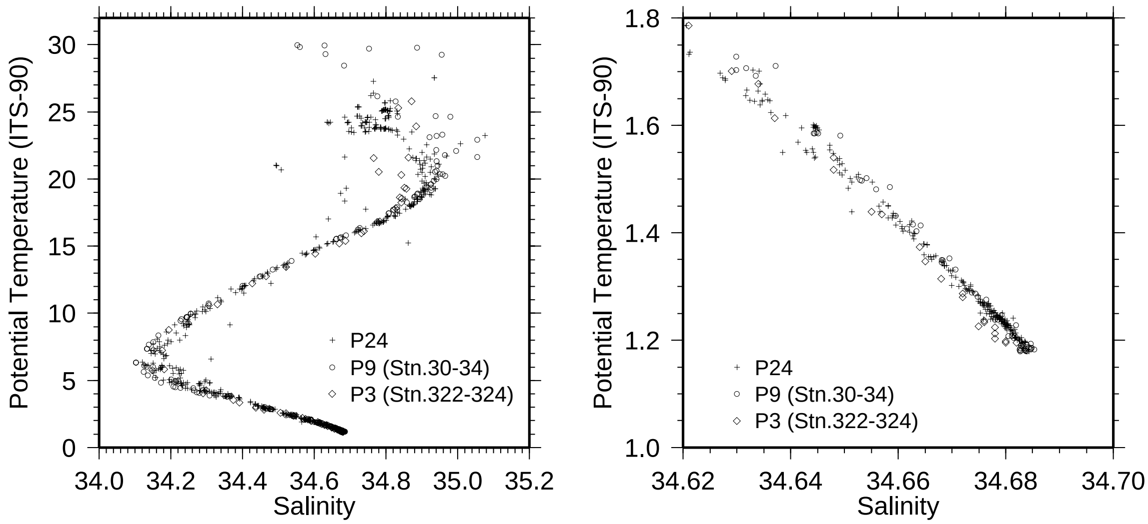

Figure 3: Salinity vs. potential temperature for P24 (+), P9 (Stn. 30–34; ◦) and P3 (Stn. 322–324; ⋄) data.

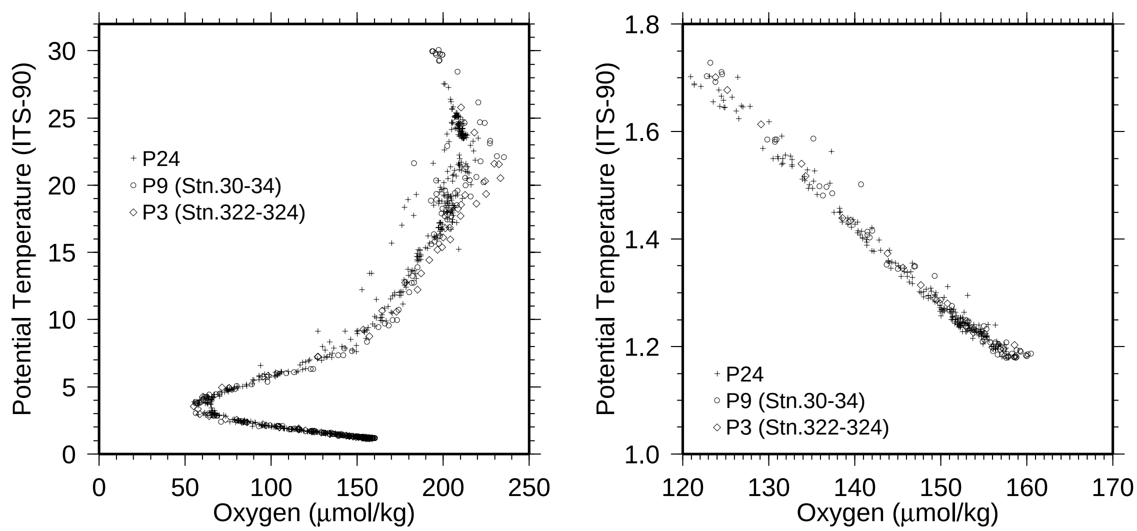

Figure 4: Dissolved oxygen concentration vs. potential temperature for P24 (+), P9 (Stn. 30–34; ◦) and P3 (Stn. 322–324; ⋄) data.

Nutrients Accuracy was checked by comparison with P3 and P9 data. Data taken at stations 24, 25 and 26 were compared with P3 station 322, P9 stations 33 and 31 respectively. Some comparisons are given in Figure 5. Our data agrees with the P9 data within 1% of reproducibility in all cases. On the other hand, our deep silicate concentrations were ca. 4.3 μmol/kg lower and deep phosphate data were ca. 0.1 μmol/kg higher on average than the P3 data.

1.5 Major Problems Encountered on the Cruise

A major problem was the unstable cold welder for Helium samples. It caused 25 percent losses of the samples.

1.6 List of Cruise Participants

The members of the scientific party are listed in Table 4, along with their responsibilities.

Table 4: Cruise participants

Name	Affiliation and Responsibilities
Masahiko Fujimura	Chief Scientist (JMA/MD ADCP)
Yasushi Takatsuki	(JMA/MD CTD/Rosette, Salinity)
Yoshiaki Kanno	(JMA/MD CTD/Rosette, Salinity)
Tetsuya Nakamura	(JMA/MD CTD/Rosette, Salinity)
Sinji Masuda	(JMA/MD CTD/Rosette, Salinity, Oxygen)
Ichiro Terashima	(JMA/MD Oxygen)
Hitomi Kamiya	(JMA/MD Oxygen, Nutrients)
Sonoki Iwano	(JMA/MD Nutrients)
Yoshisuke Takatani	(JMA/MD Nutrients)
Takafumi Umeda	(JMA/MD Oxygen)
Ikuo Kaneko	(JMA/MD CFCs)
Kazuhiro Nemoto	(JMA/MD CFCs)
Shu Saito	(JMA/MD CFCs)
Michio Aoyama	(JMA/MRI Radiocarbon, $^{3}H/^{3}He$)

JMA/MD	Marine Department, Japan Meteorological Agency
JMA/MRI	Meteorological Research Institute, JMA

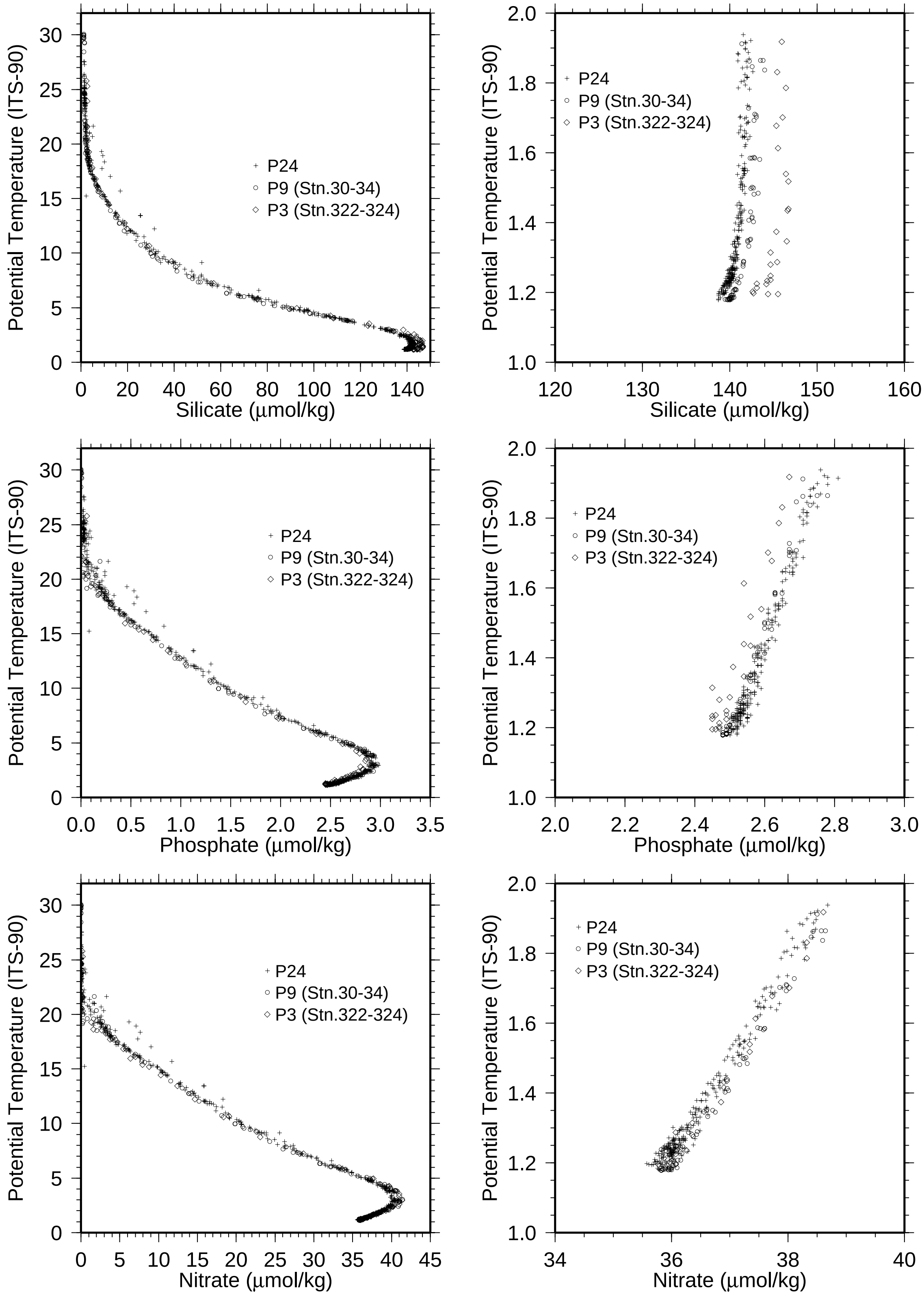

Figure 5: Silicate (upper), phosphate (middle), and nitrate (bottom) concentration vs. potential temperature for P24 (+), P9 (Stn. 30–34; ○) and P3 (Stn. 322–324; ◇) data.

2 Hydrographic Measurement Techniques and Calibrations

2.1 Sample Salinity Measurements

by Y. Takatsuki (April 26, 1999)

Equipment and Technique

Salinity samples were collected in 150 ml amber glass bottles with rubber caps and stored in an air-conditioned laboratory for more than 24 hours before salinity measurements. The salinities were measured with two Guildline^{TM} Autosal^{TM} Model 8400B salinometer (S/N 60,027 and 61,282) with an Ocean Scientific International peristaltic-type sample intake pump. The salinometer was standardized with IAPSO Standard Seawater (SSW) batch P124 (18 Jan. 1994, K_{15}=0.99990) every day when it was used for sample measurements. The instruments were operated in the ship's separate laboratory at a bath temperature of 27 degree C with the laboratory temperature between 24 degree C and 26 degree C. We made efforts to keep the variation of laboratory temperature within 1 degree C between two standardizations before and after a series of salinity measurements, though the variation sometimes exceeded the limit and reached 2 degree C at the maximum.

During the cruise, we regularly took a batch of deep water below 1000 m depth, sealed in a polyethylene rectangular bag and used as a sub-standard water to monitor instrument drifts. We kept a batch of sub-standard sea water being isolated from air and stirred with a magnet stirrer so as to maintain its constancy of salinity during salinity sample measurements. A batch of sub-standard sea water was replaced by new one when the bag decreased in volume by half. This is because salinity of the sub-standard sea water tended to increase by about 0.0004 when its volume decreased largely.

31 outputs of conductivity ratio from the Autosal were taken by a PC at each reading, and their median and standard deviation were calculated and recorded.

There were 30 pairs of replicate samples drawn; and 40 pairs of duplicate samples. Of the duplicate pairs, 30 were from below 400m. The standard deviations of the three groups of sample pairs are given in Table 5 below. The precision of salinity measurements deeper than 400m depths is estimated at 0.0006.

Table 5: Salinity duplicate and replicate statistics

Quantity	Standard Deviation	Number of pairs
Replicates	0.0003	30
Duplicates (All)	0.0030	40
Duplicates (>400m)	0.0006	30

2.2 Sample Oxygen Measurements

by H. Kamiya (March 11, 1999)

Equipment and Technique

The dissolved oxygen samples were analyzed with an automated titration system. The titrator used in the P24 cruise, Model ART-3^{TM}, was a photometric type (372nm), which has been manufactured by Hirama Riken Inc. The volume of burette is 5 ml, and the resolution of titration is 0.0025 ml.

The dissolved oxygen samples were collected in 120 ml borosilicate glass bottles immediately following the drawing of samples for CFCs. Our bottle has a collar on its mouth and its round glass stopper contains a long nipple, which is inserted into the bottle, displacing ca. 30 ml of sample water. The temperature of a sample was measured with a thermistor probe being inserted into seawater after adding reagents.

The reagents were prepared according to the recipes by Carpenter (1965) and Culberson (1991) though normality of sodium thiosulfate for titration was selected about 0.05 in order that a titration for the highest oxygen concentration would be finished within a volume of the burette.

Titration blank was measured during cruise, determined as −0.0075 ml, and subtracted from all of thiosulfate titers of the samples.

Precision of measurements

During the cruise we monitored precision by analyzing duplicate samples taken from the samplers (Niskin bottles); both from the same sampler (replicate) and from two samplers tripped together at the same depth (duplicate). Replicate/duplicate samples were taken on every cast. The standard deviation of the difference were 0.81 (replicate) and 1.01 (duplicate) μmol/kg indicates the precision is about 0.4%. The results of comparisons between replicate/duplicate samples are shown in Table 6.

Table 6: Statistics of duplicates and Replicate for dissolved oxygen

	Standard Deviation		
Case	μmol/kg	(% of F.S.)	Number of data
Replicates	0.81	(0.37)	80
Duplicates	1.01	(0.46)	32
Full Scale	220		

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): Dissolved Oxygen. *in WHP Operations and Methods – July 1991.*

2.3 Nutrients

by H. Kamiya (March 11, 1999)

Equipment and techniques

The nutrient analyses were performed on a Technicon AutoAnalyzer™-II (AA-II). We prepared the regents and flow lines referred to the manual by L.I. Gordon *et. al.* (1993). However, as for phosphate and silicate analyses, we introduced the ascorbic acid method for convenience of reagent handling. Our system heated silicate and phosphate samples up to 37 degree C so as to keep coloration rate stable. The laboratory temperature was maintained from 23.5 to 25 degree C.

Sampling of nutrients followed that for the trace gases and dissolved oxygen. Samples were drawn into 12 ml polymethylpentene test tubes with silicone caps which fit the AA-II sampler tray. Both the test tubes and caps were rinsed with 10% HCl and deionized water before sampling at every stations.

The analysis routinely were started within half an hour after sampling on deck. Samples were introduced to the manifolds through the cycle of 80 seconds sampling and 45 seconds washing with artificial seawater of salinity ca. 34.7.

Calibrations and Standards

Nominal concentrations of standard are given in Table 7. All volumetric flasks and pipettors used on this work were calibrated before the cruise.

Linearity was checked beginning of leg and again at the end of station work and 9 sets of data were taken. Standards concentrations (μmol/kg) were : silicate 160, 80, 40, 20, 0; nitrate 40, 30, 20, 10, 0; phosphate 3, 2.25, 1.5, 0.75, 0. The mean difference (μmol/kg) of the mid-scale offset from straight lines were silicate 0.57, nitrate 0.19, phosphate 0.004, the standard deviations (μmol/kg) were 0.25, 0.03, 0.010 respectively.

For the reproducibility we measured 93 standards. The means (μmol/kg) were: silicate 82.45,, nitrate 21.71, phosphate 1.57, the standard deviations (μmol/kg) were 0.74, 0.19, 0.033 respectively.

During the cruise we monitored precision by analyzing replicate/duplicate samples taken from the Sampler. Replicate/duplicate samples were taken on every cast. The results of comparisons between replicate/duplicate samples are shown in Table 8.

Table 7: Concentrations of nutrients standard

(Unit:μmol/kg).

	Silicate	Nitrate	NO3+NO2	Nitrite	Phosphate
A standard	66454	25000		12500	1875
B standard	1993.6	500		500	37.5
C standard	159.5	40	41	1	3

Table 8: Statistics of duplicates and replicates for nutrients

(Unit:upper:μmol/kg lower: % of full scale).

Case	Silicate	Nitrate	Nitrite	Phosphate	Number of data
Replicates	0.214	0.080	0.002	0.010	97
	(0.13)	(0.20)	(0.18)	(0.35)	
Duplicates	0.175	0.064	0.006	0.013	33
	(0.11)	(0.16)	(0.65)	(0.44)	
Full Scale	159	41	1	3	

References

Gordon, L. I., J. C. Jennings, Jr., A. A. Ross, and J. M. Krest (1993): 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. *in WOCE Hydrographic Program Office, Method Manual, 91-1.*

2.4 CFC-11 and CFC-12 measurements

by K. Nemoto and I. Kaneko (March 18, 1998)

Equipment and Technique

Concentrations of the dissolved chlorofluorocarbons (CFCs) F-11 and F-12 were measured by shipboard electron-capture (ECD) gas chromatography, according to the methods described by Bullister and Weiss (1988). Our extraction and analysis system was assembled by GL Science Corp. The ECD gas chromatograph is Hitachi Corp., Model 263-30. CFCs samples were analyzed at 153 layers of 9 stations along the WHP-P24 section. Replicate samples were drawn and analyzed at each station, except the first station (P24-01, RF-0069).

Water Sampling and Data Processing

We used a 12-liter (Niskin bottle) x 24 rosette system (General Oceanic Co. Ltd.) for water sampling. The inner walls of the Niskin bottles and stainless springs had been coated with epoxy. According to Bullister and Weiss (1988), the O-rings of the bottle caps were heated to 60 degrees Celsius in a purged vacuum oven for two days to degas them, stored in a gas tight container and installed on the bottles just before the first station for CFCs sampling. CFCs samples were always drawn firstly by using 100 ml glass syringes. The samples were injected in the system and processed within 12 hours after sampling. Approximately 30 ml of samples was flushed, and 30 ml was transferred to the stripping chamber.

The volumes of our gas sample loop and water sample cylinder were determined after the cruise by the method to fill the sample loop/cylinder with distilled water and measure its weight increase. The volumes of the gas sample loop and water sample cylinder were determined to 1.152 ml and 29.84 ml, respectively.

Calibration curves used for converting output peak areas to CFCs concentrations are generated by multiple (up to seven, if necessary) injections of the known volume of standard gas. The coefficients of polynomial expressions used at each station are shown in Table 9.

On the basis of several stripping test during the cruise, we determined the stripping efficiencies to 0.996 for F-11 and 0.990 for F-12. We divide output peak area by these factors to estimate total amounts of F-11/F-12 dissolved in seawater samples.

Sample blanks

Sample blanks of F-11 and F-12 for each bottle were obtained before and after the observations along the P24 section, at 2500 m depth of Station RF-0068 (31-25N, 133-03E; Nov. 16, 1995) and RF-0095 (25-49N, 129-49E; Nov. 27, 1995). The results are shown in Table 10. The mean and standard deviation of F-11/F-12 blanks are approximately 0.02+/−0.005 pmol/kg, and no bottle seriously contaminated was found. During the observation, samples drawn from the deepest bottle were analyzed to monitor contamination of the system. The results (Table 11) shows that the system was not seriously contaminated during the observation.

Sample blanks which should be subtracted from measurement values are determined so that F-11/F-12 concentrations are zero below 2000 m depth at each station. The values are shown in Table 12.

Precision

The reproducibility was estimated from replicate analyses of 100-500m depths water at 8 stations (Table 13). It was approximately less than 2 % for F-11 and F-12, but at two stations (RF-0085 and RF-0091) the F-12 differences showed extraordinary large values.

Air Sampling

At 25-39 N, 131-11 E after the observations along the P24 section, on November 26 of 1995, we took marine air samples with a 300 ml syringe and injected them in the system to analyze

Table 9: CFC scaling factors.

CFC concentration $= A + BX + CX^2 + DX^3$, X: Area

F12	RF-0070 P24-02	RF-0072 P24-04	RF-0074 P24-06	RF-0078 P24-10	RF-0082 P24-14
A	−9.38E−15	−2.19E−15	8.48E−15	−6.64E−15	2.42E−15
B	1.29E−04	1.19E−04	1.22E−04	1.11E−04	1.18E−04
C	−2.84E−10	6.10E−10	4.29E−10	1.24E−09	5.20E−10
D	2.58E−14	−1.68E−15	3.17E−15	−1.57E−14	−2.16E−15

F12	RF-0085 P24-17	RF-0088 P24-20	RF-0091 P24-23	RF-0093 P24-25	RF-0095 Blank test
A	−1.86E−14	7.48E−15	5.14E−16	6.10E−15	6.63E−17
B	1.19E−04	1.16E−04	1.20E−04	1.09E−04	1.08E−04
C	2.16E−10	6.57E−10	1.99E−10	1.26E−09	8.97E−10
D	7.27E−15	−4.75E−15	4.31E−15	−1.75E−14	0.00E+00

F11	RF-0070 P24-02	RF-0072 P24-04	RF-0074 P24-06	RF-0078 P24-10	RF-0082 P24-14
A	−8.05E−15	2.25E−15	3.85E−15	1.22E−15	0.00E+00
B	1.91E−05	1.81E−05	1.87E−05	1.78E−05	1.95E−05
C	−2.46E−11	6.66E−12	−1.38E−11	9.36E−14	−1.99E−11
D	1.38E−16	−5.66E−17	4.47E−17	−9.09E−18	9.87E−17

F11	RF-0085 P24-17	RF-0088 P24-20	RF-0091 P24-23	RF-0093 P24-25	RF-0095 Blank test
A	−2.98E−15	−6.85E−16	2.30E−15	−1.65E−15	1.11E−17
B	1.98E−05	2.11E−05	2.19E−05	1.81E−05	1.97E−05
C	−3.75E−11	−3.79E−11	−6.19E−11	−1.59E−11	1.69E−11
D	1.71E−16	1.52E−16	2.72E−16	5.27E−17	0.00E+00

CFCs. The results are shown in Table 6 with the CFCs concentration of the laboratory air simultaneously analyzed.

Standard Gas

A standard gas used in our cruise was made by Nippon Sanso Inc. Concentrations of F-11 and F-12 contained in our standard gas were calibrated by Dr. Yutaka Watanabe of National Research Institute for Resources (NIRE) on October 25, about twenty days before the WHP-P24 observations. F-11 and F-12 concentrations of our standard gas referred to a NIRE standard gas were 288.0+/−2.8 pptv and 482.4+/−5.7 pptv, respectively. We used these values to calculate the F-11 and F-12 concentrations of seawater/air samples obtained during the cruise. The NIRE standard gas has been scaled by a SIO standard gas used in the Hokkaido University. Therefore, our values determined via NIRE standard gas ought to have consistency with data scaled with SIO standards.

Table 10: Sample blanks at the test stations.

(1) Before P24 section

Station	Bottle	Syringe	Depth(m)	F12(pmol/kg)	F11(pmol/kg)
RF-0068	1	1	2500	0.030	0.028
Blank	2	2	2500	0.019	0.029
Test	3	3	2500	0.036	0.037
	4	4	2500	0.023	0.025
	5	5	2500	0.032	0.025
	6	6	2500	0.014	0.028
	7	7	2500	0.024	0.030
	8	8	2500	0.025	0.030
	9	9	2500	0.027	0.021
	10	10	2500	0.027	0.028
	18	18	2500	0.020	0.022
	19	19	2500	0.021	0.024
	11	11	2500	0.020	0.026
	12	12	2500	0.021	0.031
	13	13	2500	0.021	0.022
	15	15	2500	0.019	0.023
	14	14	2500	0.026	0.029
	16	16	2500	0.015	0.023
	17	17	2500	0.021	0.024
	20	20	2500	0.014	0.022
	21	21	2500	0.023	0.023
	22	22	2500	0.011	0.023
	23	23	2500	0.023	0.024
	24	24	2500	0.018	0.038
			MEAN	0.022	0.026
			S.D.	0.006	0.005

(2) After P24 section

Station	Bottle	Syringe	Depth(m)	F12(pmol/kg)	F11(pmol/kg)
RF-0095	1	1	2500	0.017	0.014
Blank	2	2	2500	0.008	0.014
Test	3	3	2500	0.013	0.014
	4	4	2500	0.014	0.019
	5	5	2500	0.012	0.016
	6	6	2500	0.013	0.016
	7	7	2500	0.013	0.015
	8	8	2500	0.011	0.014
	9	9	2500	0.019*	0.024*
	10	10	2500	0.013	0.016
	11	11	2500	0.017	0.018
	12	12	2500	0.015	0.018
	13	13	2500	0.011	0.014
	14	14	2500	0.010	0.012
	15	15	2500	0.012	0.014
	16	16	2500	0.010	0.014
	17	17	2500	0.031	0.026
	18	18	2500	0.016	0.014
	19	19	2500	0.018	0.017
	20	20	2500	0.014	0.015
	21	21	2500	0.014	0.014
	22	22	2500	0.013*	0.029*
	23	23	2500	0.014	0.021
	27	24	2500	0.023*	0.027*
			MEAN	0.015	0.017
			S.D.	0.005	0.005

* : bad measurement

Table 11: Sample blanks of the deepest bottles.

Station	Cast	Bottle	Depth (m)	F12 (pmol/kg)	F11 (pmol/kg)
RF-0072 (P24-04)	1	1	2058	0.019	0.038
RF-0074 (P24-06)	1	1	3909	0.017	0.030
		1	3909	0.029	0.035
RF-0076 (P24-08)	1	1	4833	0.010	0.021
		24	4834	0.017	0.023
		1	4833	0.023	0.027
		24	4834	0.016	0.023
RF-0077 (P24-09)	1	1	5009	0.023	0.026
		1	5009	0.029	0.022
		1	5009	0.026	0.025
		1	5009	0.023	0.020
RF-0078 (P24-10)	1	1	4152	0.019	0.025
		1	4152	0.022	0.022
RF-0082 (P24-14)	1	1	4290	0.017	0.022
RF-0084 (P24-16)	1	1	4881	0.022	0.029
		1	4881	0.020	0.022
		1	4881	0.018	0.017
RF-0085 (P24-17)	1	1	5164	0.020	0.025
RF-0091 (P24-23)	1	1	5376	0.027	0.034
RF-0093 (P24-25)	1	1	4170	0.018	0.024
		1	4170	0.016	0.025

Table 12: Sample blanks determined at each station.

Station	F-12 (pmol/kg)	F-11 (pmol/kg)
RF0070 (P24-02)	0.019	0.038
RF0072 (P24-04)	0.019	0.038
RF0074 (P24-06)	0.018	0.027
RF0078 (P24-10)	0.011	0.026
RF0082 (P24-14)	0.016	0.016
RF0085 (P24-17)	0.025	0.020
RF0088 (P24-20)	0.008	0.019
RF0091 (P24-23)	0.013	0.031
RF0093 (P24-25)	0.009	0.023

References

Bullister, J.L. and R.F. Weiss, 1988: Determination of CCl_3F and CCl_2F_2 in sea water and air. *Deep Sea Research*, **35**, 839–853.

Table 13: Reproducibility estimated by replicate analyses.

Station	Cast	Bottle	Syringe	Depth (m)	F-12 (pmol/kg)	F-11 (pmol/kg)	F12 Diff (%)	F11 Diff (%)
RF-0072	1	15	15	200	1.291	2.364	0.07	0.30
P24-04		15	15	200	1.292	2.357		
		20	20	49	1.061	1.886	3.41	0.83
		20	20	49	1.098	1.901		
RF-0074	1	6	14	204	1.292	2.385	0.53	0.36
P24-06		6	14	204	1.299	2.376		
RF-0078	1	6	14	201	1.187	2.119	0.53	0.43
P24-10		6	14	201	1.180	2.110		
		8	16	101	1.090	1.791	2.30	1.88
		8	16	101	1.066	1.758		
RF-0082	1	6	14	203	1.359	2.486	0.97	0.79
P24-14		6	15	203	1.345	2.466		
RF-0085	1	6	14	202	1.297	2.525	0.44	14.69
P24-17		6	15	202	1.291	2.179		
RF-0088	1	6	14	203	1.365	2.458	0.71	2.68
P24-20		6	15	203	1.356	2.393		
RF-0091		6	16	201	1.373	2.640	1.11	13.58
P24-23		6	17	201	1.358	2.304		
		3	12	504	0.941	1.708	2.00	1.84
		3	13	504	0.922	1.676		
RF-0093	1	19	13	504	1.069	2.048	0.00	1.68
P24-25		19	14	504	1.069	2.082		
		21	16	201	1.311	2.224	1.82	4.07
		21	17	201	1.288	2.135		

Table 14: Air measurements at 25-39 N, 131-11 E.

Nov. 26, 1995	F12 (ppt)	F11 (ppt)
the open air	557.7	284.0
	569.4	286.4
	556.7	281.6
	570.8	297.2
the air inside ship	582.2	426.1
(in the laboratory)	571.1	360.1

2.5 CTD measurements

by Y. Takatsuki (April 30, 1999)

Equipment, calibrations and standards

The CTD equipment used on this cruise was the property of JMA. The following equipment was deployed on the CTD/rosette underwater frame:

1. Falmouth Scientific, Inc. (FSI) Triton ICTD$^{\mathrm{TM}}$ (#1316).
2. General Oceanics 12 liter 24 bottle rosette multi-bottle sampler Model 1015.
3. Benthos Altimeter Model 2110-1.
4. Preussag 10 KHz pinger Model TBB.
5. One SIS (Sensoren Instrumente Systeme) digital reversing thermometer (RTM) and two SIS digital reversing pressure meters (RPM).

The shipboard equipment consisted of complete integral system for demodulating and displaying the CTD data as well as controlling the rosette multi-bottle sampler. The system included the following major units:

1. FSI deck terminal Model 1050.
2. Compaq Deskpro$^{\mathrm{TM}}$ PC system with 128 Mbytes 3.5 inch Magneto-optical (MO) disk drive.
3. General Oceanics rosette firing module for Model 1015.

Pre-cruise temperature and pressure calibrations for CTD #1316 was carried out by S.E.A. corporation in October/November, 1995. Correction on RTM and RPMs data were done according to the correction tables, which attached at shipping.

Pre- and post- cruise calibrations of the conductivity sensors were not carried out, so the calibration constants were calculated from a fit to the salinities measured from the water samples collected at each station.

CTD temperature calibration CTD temperature was calibrated on 30 October 1995 in degrees Centigrade in the IPTS-68 scale at fifteen temperatures ranging from 0.99 to 30.1 degress by the S.E.A. corporation. The transfer standard had been calibrated on 20 October 1995 at the triple point of water. The following linear fit for CTD temperature was used, with a rms error of 0.3 millidegrees.

$$T_{68} = 0.9999239 \times T_{raw} - 0.0111757$$

CTD pressure calibration CTD pressure was calibrated on 2 November 1995 with a dead-weight tester at ten point pressures ranging from 0.0 to 5878.2 dbar by the S.E.A. corporation. The following equations for CTD pressure for down-cast and up-cast were used, with a rms error of 0.11 dbar and 0.08 dbar, respectively.

$$\begin{aligned} P_{down} &= 0.219960 + 1.000173 \times P_{raw} \\ & \quad -1.174592\mathrm{E}-7 \times {P_{raw}}^2 + 1.68155\mathrm{E}-11 \times {P_{raw}}^3 \quad (\text{down cast, full scale}) \\ {P_{up}}' &= -0.2453189 + 0.9999456 \times P_{raw} \\ & \quad -7.525608\mathrm{E}-8 \times {P_{raw}}^2 + 1.860992\mathrm{E}-11 \times {P_{raw}}^3 \quad (\text{up cast, full scale}) \end{aligned}$$

Digital RTM calibration RTM was calibrated by SIS before shipping. Correction values for RTM are listed in Table 15.

Table 15: Digital RTM correction value 'c'.

$$T_{cal} = T_{raw} + c$$

T777 (date of calibration: 3 Nov. 1993)

Temperature	-2	0	5	10	15	19.5	20
c	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

Digital RPM calibration We used three RPMs, P6184, P6299H, and P6300H. Two of them were calibrated by SIS before shipping. P6184 has no calibration data, hence we have done no corrections on data from P6184. Correction values for RPMs are listed in Table 16.

Table 16: Digital RPM correction value 'c' at 3 degree C.

$$P_{cal} = P_{raw} + c$$

P6299H (date of calibration: 10 Sep. 1993)

Pressure	-10	1000	2007	3008	4009	5005	5999
c	$+10$	$+1$	-5	-5	-5	0	$+6$

P6300H (date of calibration: 10 Sep. 1993)

Pressure	-5	1001	2006	3008	4008	5007	6003
c	$+5$	0	-4	-5	-4	-2	$+2$

CTD Data Collection and Processing

The RS-232C signal from a FSI 1050 deck terminal was taken by a Compaq Deskpro$^{\mathrm{TM}}$ PC to log and process data. The CTD data at down- and up- casts were fully logged in real time to the RAM disk, and were copied to MO disks after CTD recovery. Data were processed on the PC with the software programmed by the members of Nagasaki Marine Observatory, according to the method by Millard and Yang (1993).

A time-constant difference between the temperature and conductivity sensors, which is necessary for salinity despiking, was determined $\tau = 0.250$ seconds so as to minimize fluctuations of salinity profile (Kawabe and Kawasaki, 1993).

The calibration for CTD #1316 was done according to the IPTS-68 scale, temperature was converted to the ITS-90 scale by following equation:

$$T_{90} = 0.99976 \times T_{68}.$$

Owing to pressure sensor hysteresis, pressure for up-cast (P_{up}) were calculated with following equations according to Millard and Yang(1993):

$$\begin{aligned} P_{up} &= {P_{up}}' \cdot (1 - W) + P_{down} \cdot W \\ W &= \exp(-(P_{bottom} - P_{down})/Z_0), \end{aligned}$$

where, P_{bottom} is the maximum pressure for the cast, and Z_0 is scaling factor, which is 300 dbar for ICTD.

Table 17: Position on rosette of RTM and RPMs.

Inst #	position
T777	3
P6184	3
P6300H	9
P6299H	13

Condition of the temperature and pressure sensors during the cruise were monitored to some extent through comparisons of CTD measurements with Digital RTM and Digital RPM at the time the water bottle was tripped. The position on rosette of RTM and RPMs were set are tabulated in Table 17. Any drift exceeding a nominal precision of RTM and RPM were not detected for the CTD (Figure 6 and 7).

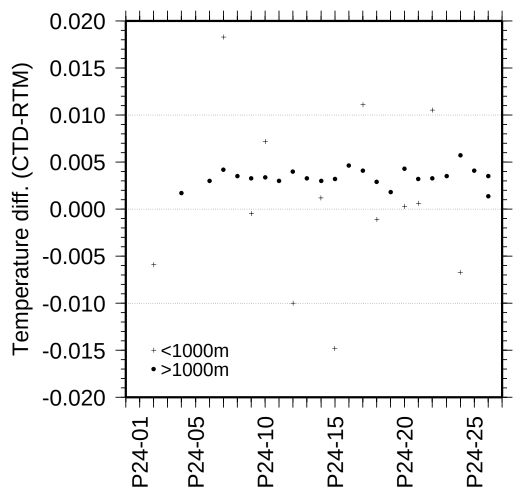

Figure 6: Temperature differences between CTD and Reversing Temperature Meter (RTM)

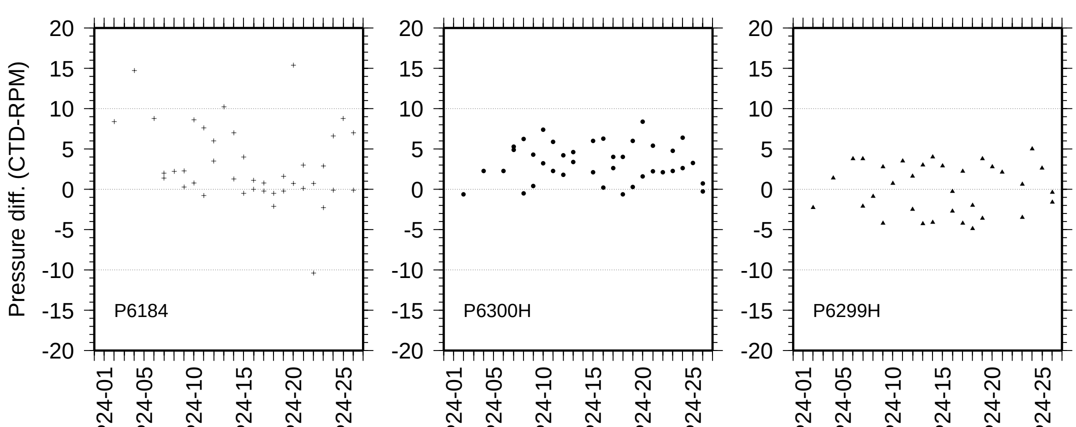

Figure 7: Pressure differences between CTD and Reversing Pressure Meter (RPM)

As mentioned above, we could not carry out pre- and post- cruise calibrations of the conduc-

Table 18: Correction coefficients for conductivity sensor of CTD #1316

$$C = A \times {C_{raw}}' + B$$

Station	A	B
P24-01 – P24-02	1.000626	-0.0110
P24-03 – P24-09	1.000700	-0.0110
P24-10 – P24-18	1.000687	-0.0110
P24-19 – P24-26	1.000701	-0.0110

tivity sensors. The conductivity data were converted for cell material deformation correction at first:

$$\begin{aligned} {C_{raw}}' &= (1 + \alpha(P - P_0) + \beta(T - T_0)) \cdot C_{raw} \\ \alpha &= -3.0\mathrm{E} - 5 \\ \beta &= 1.5\mathrm{E} - 8 \\ T_0 &= 2.8 \\ P_0 &= 0.0. \end{aligned}$$

The bias was assumed in advance, and then, the slope was determined from a linear-fit to the salinities measured from the water samples collected at each station. The coefficients for correction finally adopted for the data processing are listed in Table 18.

Figure 8 shows the differences between CTD salinity and salinity of water samples. Statistical analysis of the difference between the CTD and water sample salinities deeper than 2000 m showed a standard deviation less than 0.0023 (all data) and less than 0.0008 (exclude three doubtful data, that is, 2275.8 dbar at P24-07, 2787.1 dbar and 2530.9 dbar at P24-09).

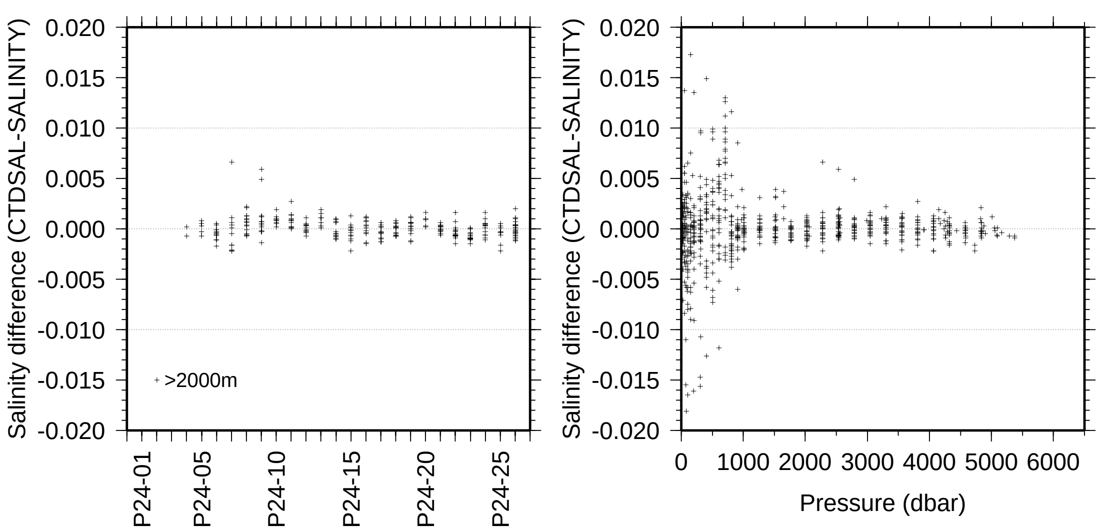

Figure 8: Differences between CTD salinity and salinity of water samples. Station number vs. salinity difference (deeper than 2000m; left), Pressure vs. salinity difference (right).

References

Kawabe, and Kawasaki, 1993: CTD Data Calibration. *JODC manual guide* **JP013-93-1**, 73 pp (in Japanese).

Millard, R. C. and K. Yang, 1993: CTD Calibration and Processing Methods used at Woods Hole Oceanographic Institution. *WHOI Techonical Report* **WHOI-93-44**, 104 pp.

Final CFC Data Quality Evaluation (DQE) Comments on P24.
(David Wisegarver)
Dec 2000 by

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

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or
David Wisegarver (wise@pmel.noaa.gov).

More information may be available at 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.
****

WHPO CTD DATA CONSISTENCY CHECK
2002.JAN.15

The WHP-Exchange format bottle and/or CTD data from this cruise have been examined by a computer application for contents and consistency. The parameters found for the files are listed, a check is made to see if all CTD files for this cruise contain the same CTD parameters, a check is made to see if there is a one-to-one correspondence between bottle station numbers and CTD station numbers, a check is made to see that pressures increase through each file for each station, and a check is made to locate multiple casts for the same station number in the bottle data. Results of those checks are reported in this '_check.txt' file.

When both bottle and CTD data are available, the CTD salinity data (and, if available, CTD oxygen data) reported in the bottle data file are subtracted from the corresponding bottle data and the differences are plotted for the entire cruise. Those plots are the' _sal.ps' and '_oxy.ps' files.

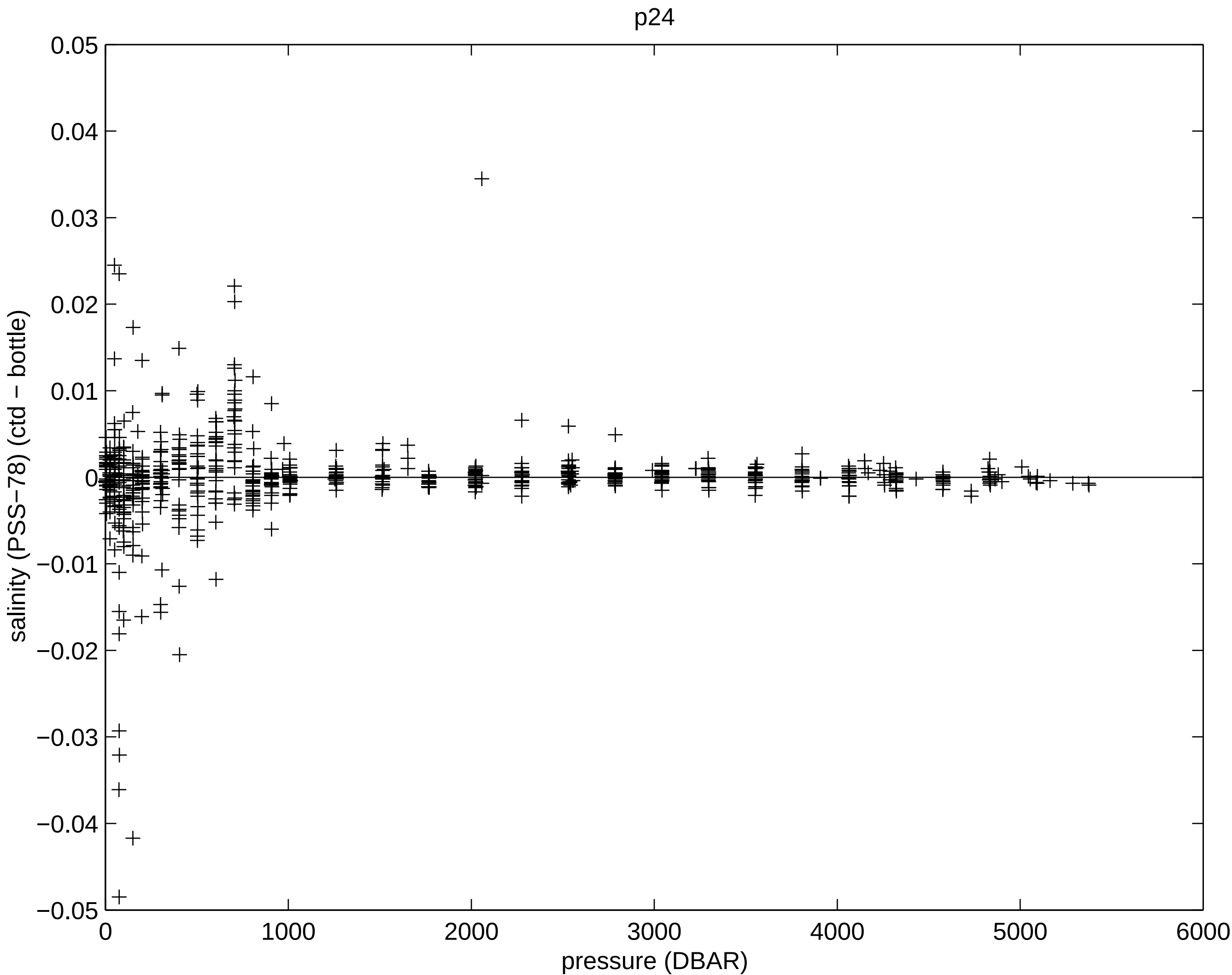
Following parameters found for bottle file:

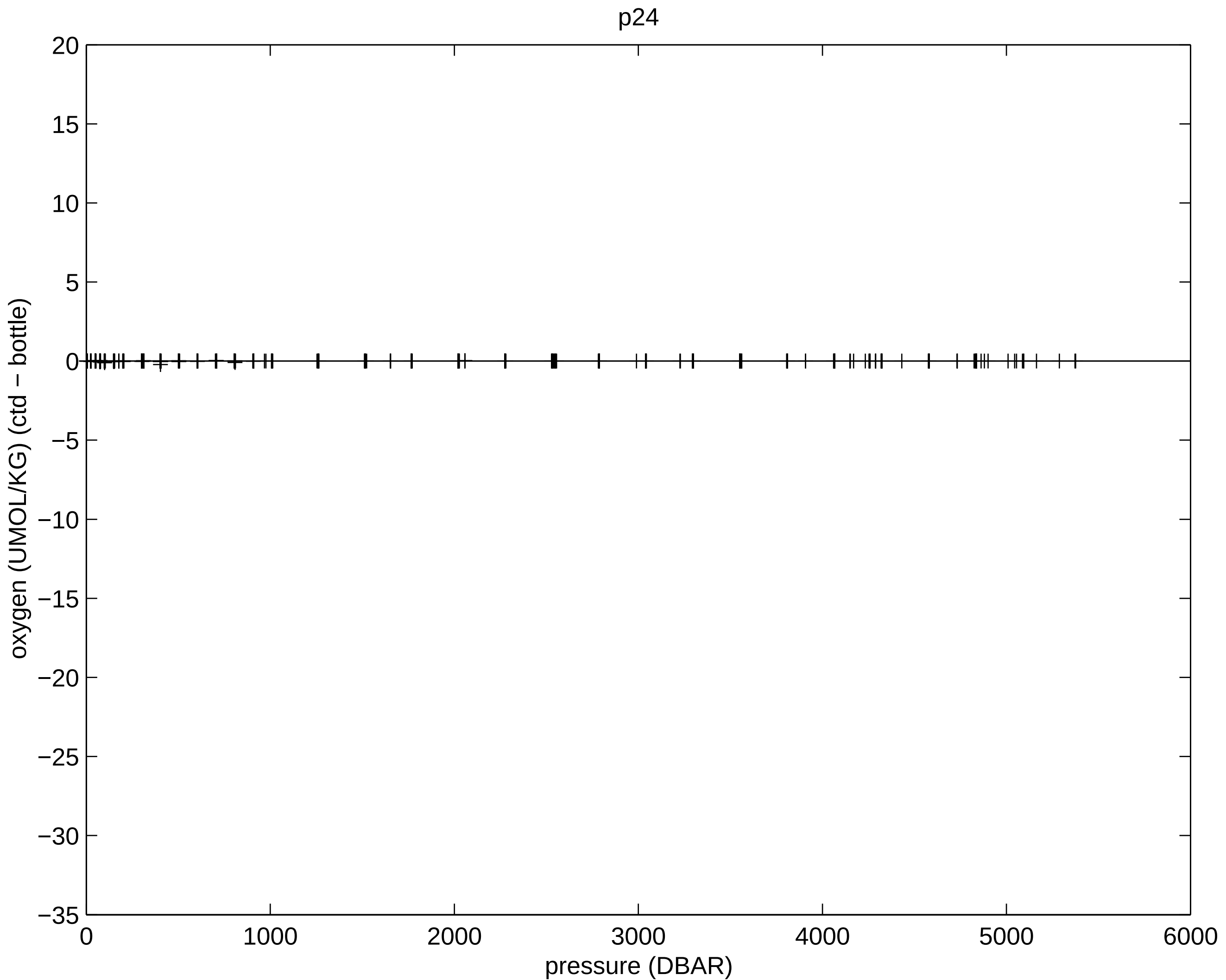
EXPOCODE	DEPTH	SILCAT	CFC-12_FLAG_W
SECT_ID	CTDPRS	SILCAT_FLAG_W	TRITUM
STNNBR	CTDTMP	NITRAT	TRITUM_FLAG_W
CASTNO	CTDSAL	NITRAT_FLAG_W	HELIUM
SAMPNO	CTDSAL_FLAG_W	NITRIT	HELIUM_FLAG_W
BTLNBR	SALNTY	NITRIT_FLAG_W	DELHE3
BTLNBR_FLAG_W	SALNTY_FLAG_W	PHSPHT	DELHE3_FLAG_W
DATE	CTDOXY	PHSPHT_FLAG_W	DELC14
TIME	CTDOXY_FLAG_W	CFC-11	DELC14_FLAG_W
LATITUDE	OXYGEN	CFC-11_FLAG_W	
LONGITUDE	OXYGEN_FLAG_W	CFC-12	

- All ctd parameters match the parameters in the reference station.
- All stations correspond among all given files.
- No bottle pressure inversions found.
- Bottle file pressures are increasing.

p24_hy1.csv -> contains stations with multiple casts:

station -> 10: 2 casts.	station -> 15: 2 casts.	station -> 20: 2 casts.	station -> 26: 2 casts.
station -> 11: 2 casts.	station -> 16: 2 casts.	station -> 21: 2 casts.	station -> 6: 2 casts.
station -> 12: 2 casts.	station -> 17: 2 casts.	station -> 22: 2 casts.	station -> 7: 2 casts.
station -> 13: 2 casts.	station -> 18: 2 casts.	station -> 23: 2 casts.	station -> 8: 2 casts.
station -> 14: 2 casts.	station -> 19: 2 casts.	station -> 24: 2 casts.	station -> 9: 2 casts.


p24
0.05
0.04
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
−0.05
salinity (PSS−78) (ctd − bottle)
0
1000
2000
3000
4000
5000
6000
pressure (DBAR)


p24
oxygen (UMOL/KG) (ctd − bottle)
pressure (DBAR)
20
15
10
5
0
−5
−10
−15
−20
−25
−30
−35
0
1000
2000
3000
4000
5000
6000

WHPO DATA PROCESSING NOTES

Date	Contact	Data Type	Data Status Summary	
2/28/96	Fujimura	DOC	Cruise Rpt Rcvd @ WHPO	
2/28/96	Fujimura	SUM	Submitted	
10/16/97	Fujimura	CTD/BTL	Submitted for DQE	
8/7/98	Diggs	CTD	Website Updated	
12/6/99	Huynh	CTD/BTL/SUM	Data Update	New data files received
12/6/99	Diggs	DOC	Submitted	Hard copy only
4/20/00	Key	DELC14	No Data Submitted	

Unfortunately, I can provide no new information on the C14 status for cruises P15N and P24. I do know that acquiring data from CS Wong (P15N) has been very difficult. I'll try to investigate.

Date	Contact	Data Type	Data Status Summary	
7/7/00	Huynh	DOC	Website Updated	pdf, txt versions online
8/4/00	Saiki	CTD/BTL	SALNTY, OXYGEN, NUTs, CFCs & CTD now public	

I am pleased to inform you that the PIs and participants of the one-time and repeat cruises conducted by the Japan Meteorological Agency's vessels agreed to change most of the data status to public. The only exception is the He/Tr of P09 and He/Tr, C-14 of P24.

In this respect, a list of the cruises which we wish to change the status from non-public to public follows for confirmation.

Date	Contact	Data Type	Data Status Summary	
8/8/00	Diggs	CTD/BTL	Website Updated	data unencryted

JMA just released these data and Dave Muus and Jim Swift requested that the data be correctly pressure sorted. That is now done and the files are unencrypted and online.

CTD files are now unencrypted and online as well.

All tables and files associated with this cruise have been updated as well.

Date	Contact	Data Type	Data Status Summary
7/3/01	Wisegarver	CFCs	DQE Complete; precision meets 'relaxed' standard

In regards to P24, the surface saturation of CFC-12 is about 100% while that of CFC-11 is about 90% at stations 2, 10, 20, 23, and 25. THis difference is greater than normally expected. Typically, an undersaturation of 10% can be associated with upwelling, deep mixing or convection, but even then, the two gasses are usually close in saturation.

In light of this, CFC-11 QUALT1 flags of '2' (good) for stations 2 and 23 have been given QUALT2 flags if '3' (questionable) as well as the shallow low ratio values at stations 10, 17, 20 and 25. With these additional flags, P24 meets the 'relaxed' standard. We will forward our QUALT2 DQE flag recommendations to the WHP Office. We will not alter any of the original CFC data or flags sent by your group to the WOCE office for P24.

Date	Contact	Data Type	Data Status Summary
11/16/01	Bartolacci	CFCs	Updated CFCs ready to be merged

I have placed the updated CFC data file sent by Wisegarver into the P24 original directory in a subdirectory called 2001.07.09_P24_CFC_UPDT_WISEGARVER. This directory contains data, documentation and readme files. data are ready for merging

Date	Contact	Data Type	Data Status Summary
1/7/02	Uribe	CTD	Website Updated; CSV File Added

CTD has been converted to exchange using the new code and put online.

Date	Contact	Data Type	Data Status Summary
1/17/02	Hajrasuliha	CTD	Internal DQE completed; See Note:

created .ps files, check with gs viewer. Created *check.txt file.

2/13/02	Swift	He/Tr	Data Update

Please update the records for P24 (49RY9511_2). He/Tr will not be processed due to lack of funds. Swift talked to Aoyama at the Ocean Sciences meeting yesterday and reminded him of that fact.

2/16/02	Diggs	C14	Data ready to be merged

I have recently located the Radiocarbons for P24 (Aoyama). They are in the following directory and are ready to merge:

data/onetime/pacific/p24/original/20011129_P24_C14_AOYAMA

I did some refomatting to get them into WOCE format and should merge without problems.

2/26/02	Muus	DELC14	Data Merged into new online BTL and CSV files

1. Merged DELC14 and C14ERR into web bottle file
2. Added QUALT2 same as QUALT1.
3. Put new woce format and exchange format bottle files on-line.

Notes on P24 merging Feb 26, 2002 D.Muus

1. Merged DELC14 and C14ERR from:
   File p24hy.mao received from M. Aoyama Nov 29, 2001.
   into bottle file from web (20010327WHPOSIOKJU)
2. SUMMARY file has parameter code 12 (C14) on Stations
   2/1, 6/1, 6/2, 14/1, 14/2, 17/1, 17/2, 23/1, 23/2, 26/1 and 26/2.
   New data file (p24hy.mao) has C14 data for Stations
   17/1, 17/2, 23/1 and 23/2 only.
   Left SUMMARY file unchanged.
3. Changed all remaining quality code "1"s to "9"s and made QUALT2 word same as QUALT1.
4. Made new exchange file for Bottle data.
5. Checked new bottle file with Java Ocean Atlas.

6/25/02	Kappa	DOC	Cruise Report updated

Added CFC DQE Report, CTD Data Consistency Check, and WHPO Data Processing Notes to both PDF and TXT documents.