

MR03-K04 Leg.1

Preliminary  
Cruise Report

February, 2004

Edited by  
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# 1. Cruise Narrative (17 Feb '04)

## 1.1 Highlight

WOCE P6W & C, R/V MIRAI Cruise MR03-K04 in the South Atlantic

Cruise Code : MR03-K04 Leg.1

Chief Scientist : Masao Fukasawa  
Ocean Observation and Research Department Japan Marine Science and  
Technology Center 2-15, Natsushima, Yokosuka, Japan 237-0061

Ship : R/V MIRAI

Ports of Call : Brisbane - Papeete

Cruise Date : August 3, 2003 – September 5, 2003

## 1.2 Cruise Summary

### Cruise Track

Cruise Track and station locations are shown in Fig.1.1.

### Number of Stations

A total of 121 stations were occupied using a Sea-Bird Electronics 36 bottle Carousel equipped with 36 12 liter Niskin X water sample bottles, a SBE911plus equipped with SBE35 deep ocean standards thermometer, SBE43 oxygen sensor, Seapoint sensors Inc. Chlorophyll Fluorometer and Benthos Inc. Altimeter and RDI Monitor ADCP.

### Sampling and measurements

- 1) Measurements of temperature, salinity, oxygen, current profile, fluorescence and using CTD/O<sub>2</sub> with LADCP, fluorescence meter.
- 2) RMS water sampling and analysis of salinity, oxygen, nutrients, CFC11,12, 113, total alkalinity, DIC and pH. The sampling depth in db were 10, 50, 100, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2600, 2800, 3000, 3250, 3500, 3750, 4000, 4250, 4500, 4750, 5000, 5250, 5500, 5750 and bottom(minus 10m).
- 3) Sample water collection for Ar, <sup>14</sup>C, <sup>13</sup>C, <sup>3</sup>He/<sup>4</sup>He, <sup>137</sup>Cs, Plutonium and <sup>3</sup>H, TOC.
- 4) Measurements of autotrophic biomass (epifluorescence and chlorophyll a) by surface LV.
- 5) Bio-Optical measurement (scatter and transfer).

6) Underway measurements of pCO<sub>2</sub>, temperature, salinity, nutrients, surface current, bathymetry and meteorological parameters

### Floats, Drifters

10 ARGO floats (4 SOLO floats and 6 APEX floats) were launched.

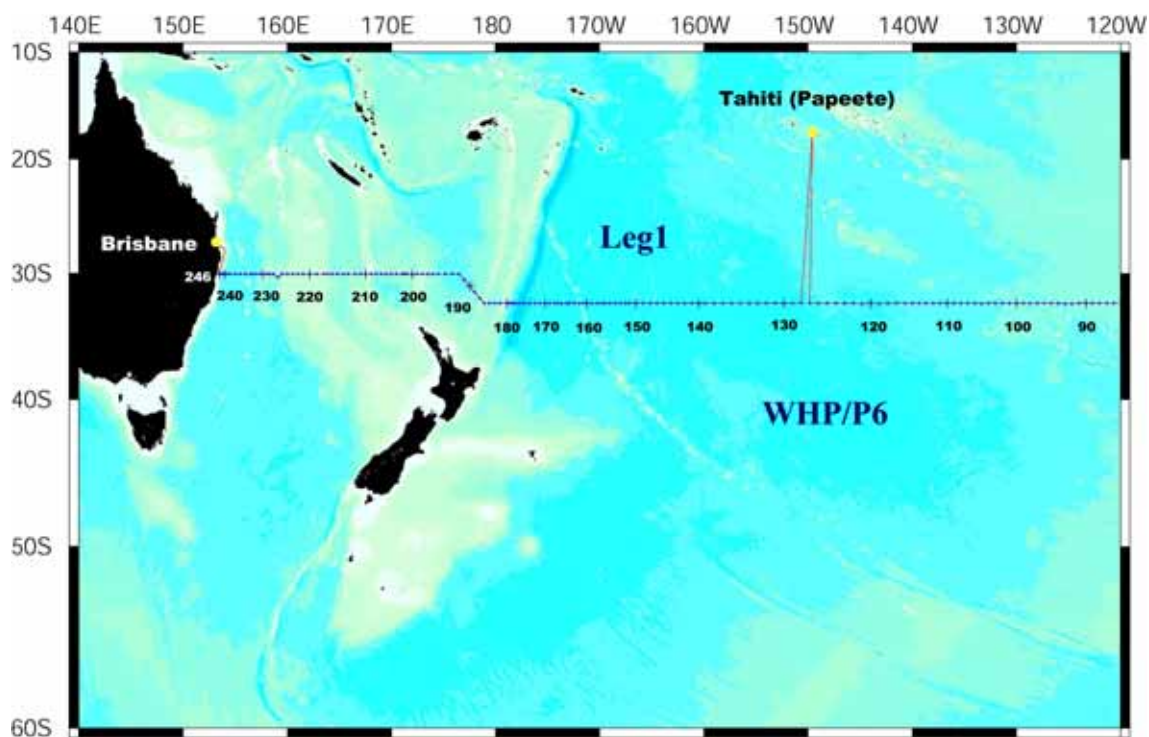


Fig.1.1 Cruise Track

### 1.3 Responsibility

The principal investigators responsible for major parameters are listed in Table.1.1.

### 1.4 Objective of the Cruise

#### Objectives

- To detect and quantify temporal changes in the Antarctic Overturn System corresponding to the global ocean and the Southern Ocean warming during this century through high quality and spatially dense observation along old WHP (World Ocean Circulation Experiment Hydrographic Program: 1991- 2002) lines.
- To estimate the amount of anthropogenic carbon uptaken by the Antarctic Ocean.

Selected scientific priorities which lead to above interest are:

# Changes in inventories of heat and freshwater

# Carbon and nutrients transport

# Data base for model validation

# ARGO sensor calibration and its deployment in the south Atlantic.

**Table.1.1 List of principal investigators and person in charge on the ship**

**Chief Scientist : Masao Fukasawa**

**Chief Technologist : Masayuki Fujisaki**

<b>Item</b>	<b>Principal Scientists</b>	<b>Person in Charge on the Ship</b>
<b>Hydrography</b>		
CTDO	Hiroshi Uchida Masao Fukasawa	Mark Rosenberg Satoshi Ozawa
LADCP	Yasushi Yoshikawa	Satoshi Ozawa
Fluorescence	Bryan Irwin	Takeshi Kawano
BTL Salinity	Takeshi Kawano	Naoko Takahashi
BTL Oxygen	Shuichi Watanabe	Takayoshi Seike
Nutrients	Michio Aoyama	Junko Hamanaka
TCO <sub>2</sub>	Akihiko Murata	Minoru Kamata
Alkalinity	Akihiko Murata	Fuyuki Shibata
pH	Akihiko Murata	Toru Fujiki
CFC's	Yutaka Watanabe	Ken-ichi Sasaki
<sup>14</sup> C	Yuichiro Kumamoto	Same as PI (collection only)
TOC	Akihiko Murata	Same as PI (collection only)
<sup>3</sup> He/ <sup>4</sup> He	Shuichi Watanabe	Y. Kumamoto (collection only)
Cs,Pu, <sup>3</sup> H,Sr	Michio Aoyama	A. Takeuchi (collection only)
Ar/N <sub>2</sub>	Yutaka Watanabe	S. Tanaka (collection only)
Primary Productivity	Bryan Irwin	Bryan Irwin
Argo float	Kensuke Takeuchi Dean Roemmich	Tomoyuki Takamori Masao Fukasawa
<b>Underway</b>		
ADCP	Yasushi Yoshikawa	Sou-ichiro Sueyoshi
Bathymetry	Toshiya Fujiwara	Sou-ichiro Sueyoshi
Meteorology	Kunio Yoneyama	Sou-ichiro Sueyoshi
Thermo-Salinograph	Takeshi Kawano	Takayoshi Seike
pCO <sub>2</sub>	Akihiko Murata	Minoru Kamata
Fluorescence	Bryan Irwin	Takayoshi Seike

## Data Policy

All data obtained during Leg1, Leg2, Leg4 and Leg5 along WHP lines have to be quality controlled and opened through WHPO and JAMSTEC *within two years after all legs*.

## 1.5 List of Cruise Participants

Cruise participants are listed in Table.1.2

## 2. Underway Measurements

### 2.1 Meteorological observation

#### 2.1.1 Surface Meteorological Observation

Souichiro Sueyoshi (Global Ocean Development Inc.)

Shinya Okumura (GODI)

Katsuhisa Maeno (GODI)

Not on-board: Kunio Yoneyama (JAMSTEC) Principal Investigator

#### (1) Objectives

The surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters bring us the information about the temporal variation of the meteorological condition surrounding the ship.

#### (2) Methods

The surface meteorological parameters were observed throughout the MR03-K04 Leg1 cruise from the departure of Brisbane on 3 August 2003 to arrival of Papeete on 5 September 2003. At this cruise, we used two systems for the surface meteorological observation.

#### (2-1) Mirai meteorological observation system

Instruments of Mirai meteorological system (SMET) are listed in Table 2.1-1 and measured parameters are listed in Table 2.1-2. Data was collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set has 6-second averaged.

#### (2-2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

SOAR system designed by BNL consists of major 3 parts.

-Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.

-Zeno meteorological system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.

-Scientific Computer System (SCS) designed by NOAA (National Oceanic and Atmospheric Administration, USA)- centralized data acquisition and logging of all data sets.

SCS recorded PRP data every 6 seconds, Zeno/met data every 10 seconds. Instruments and their locations are listed in Table 2.1-3 and measured parameters are listed in Table 2.1-4.

**Table 1.2 Cruise Participants**

A. Albertino	Sampling	Bogor Agricultural University
E. Barberi	Sampling	Estación de Fotobiología Playa Unión
T. Fujiki	TCO2	MWJ
M. Fujisaki	CTD	MWJ
M. Fukasawa	LADCP, Thermosalinograph, ARGO	JAMSTEC
J. Hamanaka	Nutrients	MWJ
Y. Iribe	Sampling	MWJ
B. Irwin	Bio-Optics	BIO
M. Kamata	TCO2	MWJ
T. Kawano	Salinity	JAMSTEC
A. Kubo	Nutrients	MWJ
Y. Kumamoto	DO, C-14	JAMSTEC
K. Maeno	ADCP, Bathymetry, Meteorology	GODI
A. Murata	pH, Alkalinity, TCO2, pCO2, TOC	JAMSTEC
T. Nishihashi	Sampling	MWJ
S. Okumura	ADCP, Bathymetry, Meteorology	GODI
Y. Oyama	Sampling	MWJ
S. Ozawa	CTD	MWJ
M. Rosenberg	CTD Data Processing	ACE CRC
K. Sagishima	CFC	MWJ
K. Sasaki	CFC	JAMSTEC
T. Seike	DO	JAMSTEC
F. Shibata	pH, Alkalinity	MWJ
A. Shioya	Sampling	MWJ
S. Sueyoshi	ADCP, Bathymetry, Meteorology	GODI
N. Takahashi	Salinity	MWJ
T. Takamori	CTD Operation	MWJ
A. Takeuchi	Sampling	KANSO
S. Tanaka	Ar, N2, CFC	Hokkaido Univ.
T. Tanaka	Sampling, Salinity	MWJ
A. Wada	Sampling, CFC	MWJ
M. Wakita	CFC	JAMSTEC
K. Wataki	CFC	MWJ
H. Yamazaki	Sampling	MWJ
I. Yamazaki	DO	MWJ
K. Yapa	Sampling	Univ. of Ruhuna, Matara, Sri Lanka
S. Yokogawa	Nutrients	MWJ
M. Yokota	Sampling, CFC	MWJ
Y. Yoshikawa	ADCP, LADCP	JAMSTEC

ACE CRC	Antarctic Climate and Ecosystems Cooperative Research Centre, Australia
BIO	Bedford Institute of Oceanography, Canada
GODI	Global Ocean Development Inc.
JAMSTEC	Japan Marine Science and Technology Center
KANSO	Kansai Environmental Engineering Center Co., LTD
MWJ	Marine Works Japan, Ltd.

-Mirai meteorological observation system

-Shipboard Oceanographic and Atmospheric Radiation (SOAR) System

### (3) Preliminary results

Figures 2.1-1 show the time series of the following parameters; Wind (SOAR), air temperature (SOAR), relative humidity (SOAR), precipitation (SOAR), short/long wave radiation (SOAR), pressure (SOAR) and significant wave height (SMET).

### (4) Data archives

The raw data obtained during this cruise will be submitted to JAMSTEC Data Management

Division. Corrected data sets will also be available from K. Yoneyama of JAMSTEC.

#### Remarks

1. Radiometers for the upwelling radiation measurement of R/V Mirai meteorological observation system were not installed during this cruise.
2. FRSR ch.4 (wave length: 680 nm) data was not collected from 17 August to arrival on Papeete because of poor contact of connector.
3. PIR data was not collected from 2153 UTC 20 August to 0020 UTC 21 August because of processing software trouble.

**Table 2.1-1 Instruments and installations of Mirai meteorological system**

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24m)
Thermometer	HMP45A	Vaisala, Finland	compass deck (21m)
	with 43408 Gill aspirated radiation shield (R.M. Young)		
	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m) SST
Barometer	F-451	Yokogawa, Japan	weather observation room captain deck (13m)
Rain gauge	50202	R. M. Young, USA	compass deck (19m)
Optical rain gauge	ORG-115DR	ScTi, USA	compass deck (19m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28m)
Radiometer (long wave)	MS-202	Eiko Seiki, Japan	radar mast (28m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10m)

**Table 2.1-2 Parameters of Mirai meteorological observation system**

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's speed	knot	Mirai log, DS-30 Furuno
4 Ship's heading	degree	Mirai gyro, TG-6000, Tokimec
5 Relative wind speed	m/s	6sec./10min. averaged
6 Relative wind direction	degree	6sec./10min. averaged
7 True wind speed	m/s	6sec./10min. averaged
8 True wind direction	degree	6sec./10min. averaged
9 Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10 Air temperature (starboard side)	degC	6sec. averaged
11 Air temperature (port side)	degC	6sec. averaged
12 Dewpoint temperature (starboard side)	degC	6sec. averaged
13 Dewpoint temperature (port side)	degC	6sec. averaged
14 Relative humidity (starboard side)	%	6sec. averaged
15 Relative humidity (port side)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18 Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19 Down welling shortwave radiation	W/m <sup>2</sup>	6sec. averaged



20	Down welling infra-red radiation	W/m <sup>2</sup>	6sec. averaged
21	Significant wave height (fore)	m	hourly
22	Significant wave height (aft)	m	hourly
23	Significant wave period	second	hourly
24	Significant wave period	second	hourly

**Table 2.1-3 Instrument and installation locations of SOAR system**

<u>Sensors</u>	<u>Type</u>	<u>Manufacturer</u>	<u>Location (altitude from surface)</u>
<i>Zeno/Met</i>			
Anemometer	05106	R.M. Young, USA	foremast (25m)
Tair/RH	HMP45A	Vaisala, Finland	foremast (24m)
	with 43408	Gill aspirated radiation shield (R.M. Young)	
Barometer	61201	R.M. Young, USA	foremast (24m)
	with 61002	Gill pressure port (R.M. Young)	
Rain gauge	50202	R. M. Young, USA	foremast (24m)
Optical rain gauge	ORG-815DA	ScTi, USA	foremast (24m)
<i>PRP</i>			
Radiometer (short wave)	PSP	Epply Labs, USA	foremast (25m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (25m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25m)

**Table 2.1-4 Parameters of SOAR system**

<u>Parameter</u>	<u>Units</u>	<u>Remarks</u>
1 Latitude	degree	
2 Longitude	degree	
3 Sog	knot	
4 Cog	degree	
5 Relative wind speed	m/s	
6 Relative wind direction	degree	
7 Barometric pressure	hPa	
8 Air temperature	degC	
9 Relative humidity	%	
10 Rain rate (optical rain gauge)	mm/hr	reset at 50mm
11 Precipitation (capacitive rain gauge)	mm	
12 Down welling shortwave radiation	W/m <sup>2</sup>	
13 Down welling infra-red radiation	W/m <sup>2</sup>	
14 Defuse irradiance	W/m <sup>2</sup>	

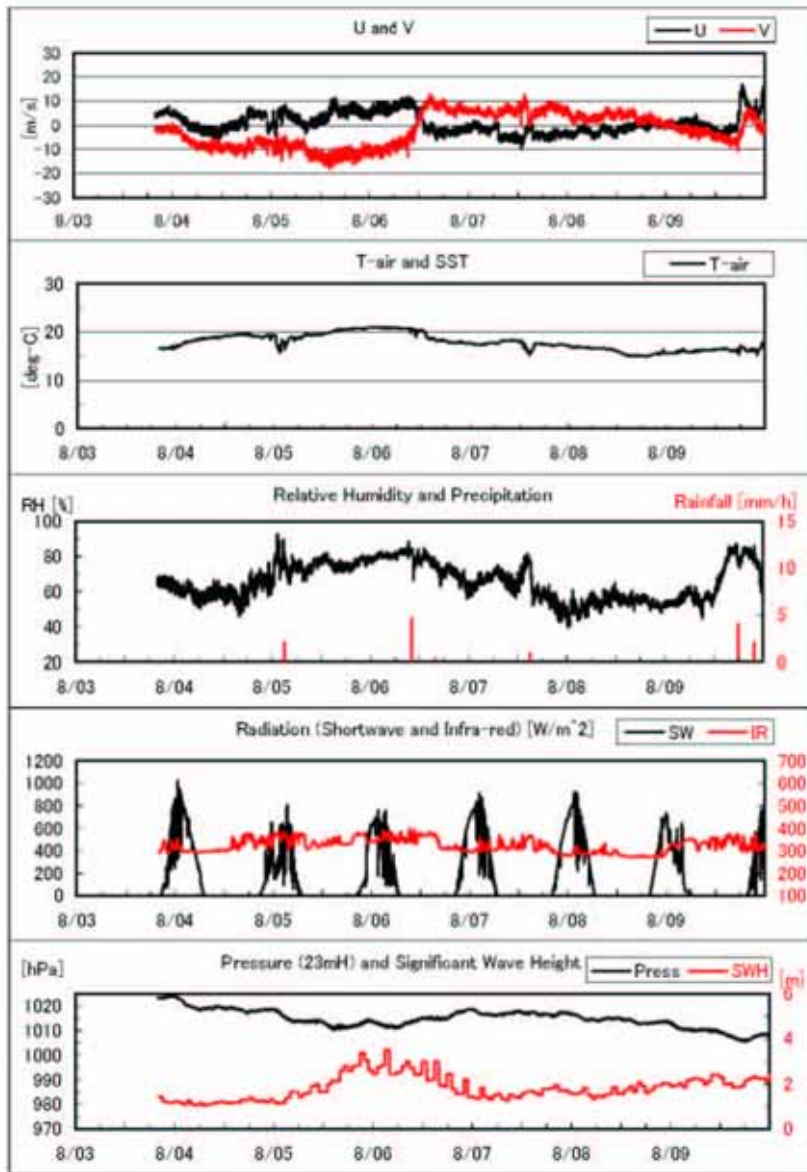


Fig.2.1-1 Time series of surface meteorological parameters during the cruise.

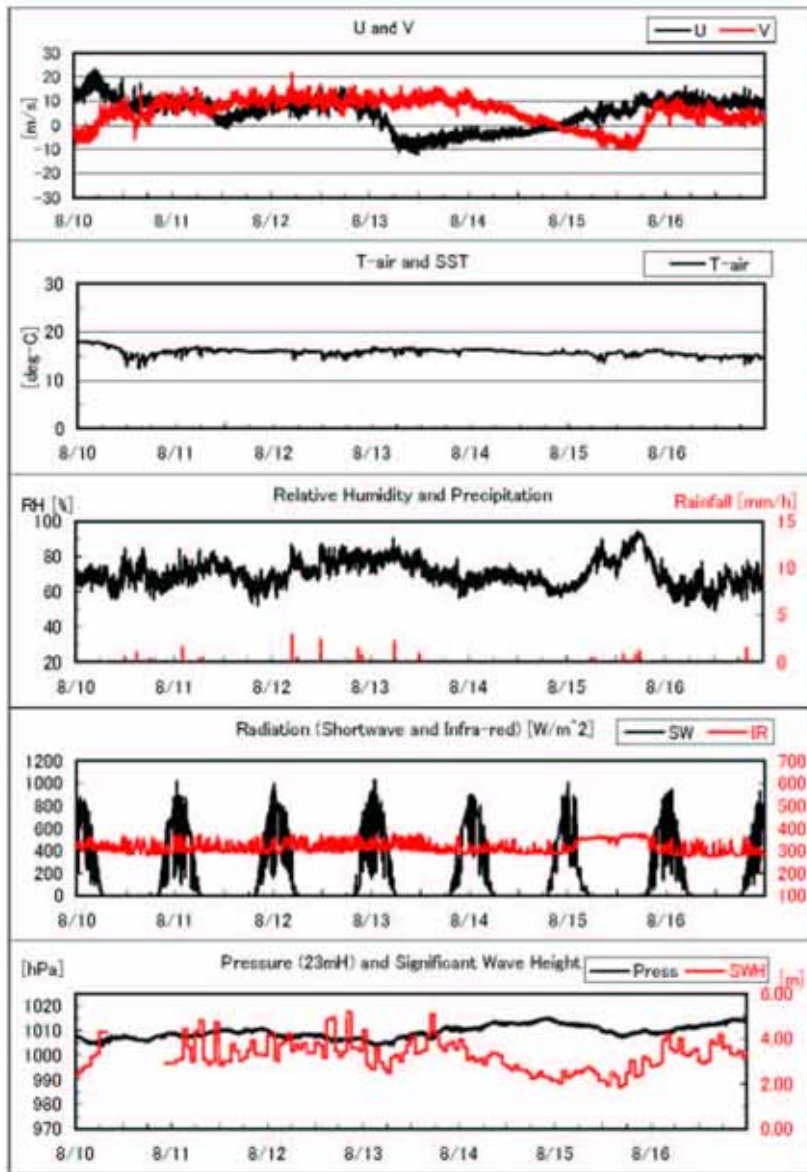


Fig.2.1-1 Continued

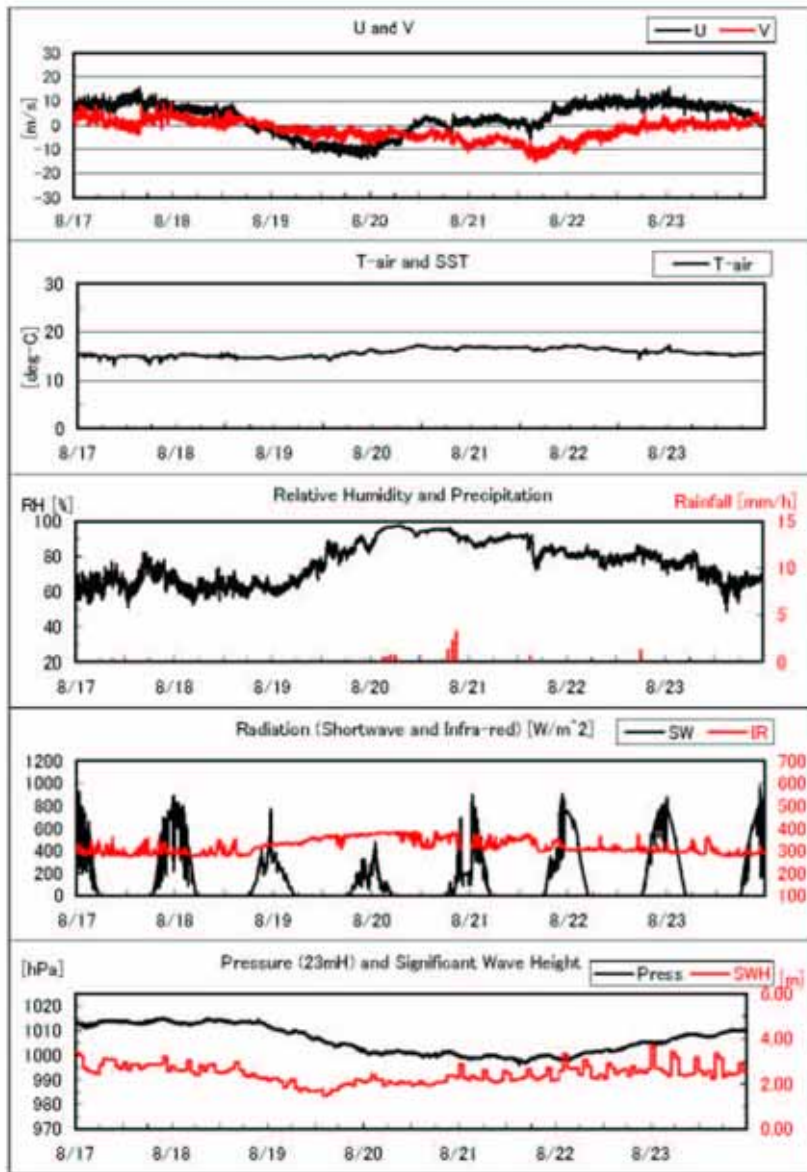


Fig.2.1-1 Continued

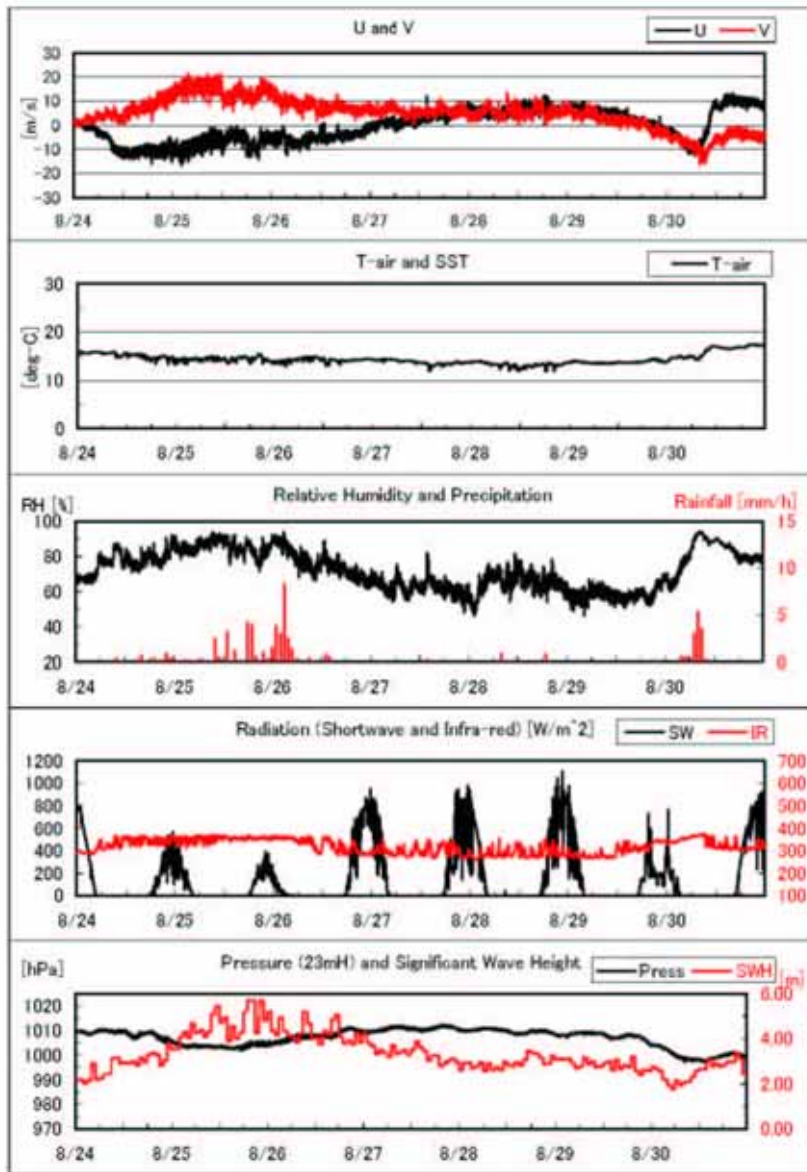


Fig.2.1-1 Continued

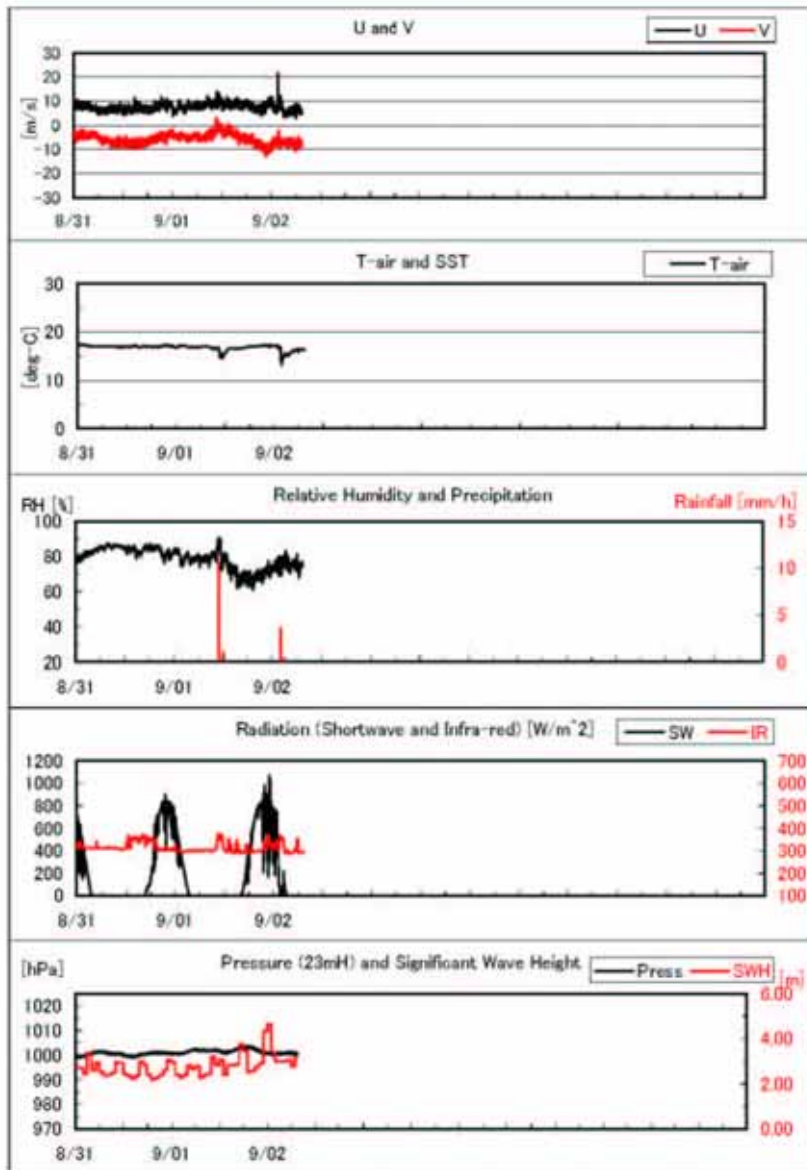


Fig.2.1-1 Continued

### 2.1.2 Ceilometer Observation

Souichiro Sueyoshi (Global Ocean Development Inc.)

Shinya Okumura (GODI)

Katsuhisa Maeno (GODI)

Not on-board:

Kunio Yoneyama (JAMSTEC) Principal Investigator

#### (1) Objectives

The information of cloud base height and the liquid water amount around cloud base is important to understand the process on formation of the cloud. As one of the methods to measure them, the ceilometer observation was carried out.

#### (2) Parameters

Cloud base height [m].

Backscatter profile, sensitivity and range normalized at 30 m resolution.

Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

#### (3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR03-K04 Leg.1 cruise from CTD station P06W-246 on 4 August 2003 to CTD station P06C-121 on 2 September 2003.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wavelength:	905±5 nm at 25 degC
Transmitting average power:	8.9 mW
Repetition rate:	5.57 kHz
Detector:	Silicon avalanche photodiode (APD) Responsibility at 905 nm: 65 A/W
Measurement range:	0 ~ 7.5 km
Resolution:	50 ft in full range
Sampling rate:	60 sec
Sky Condition	0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility)
	(0: Sky Clear, 1:Few, 3:Scattered, 5-7: Broken, 8: Overcast)

On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 30 m (100 ft).

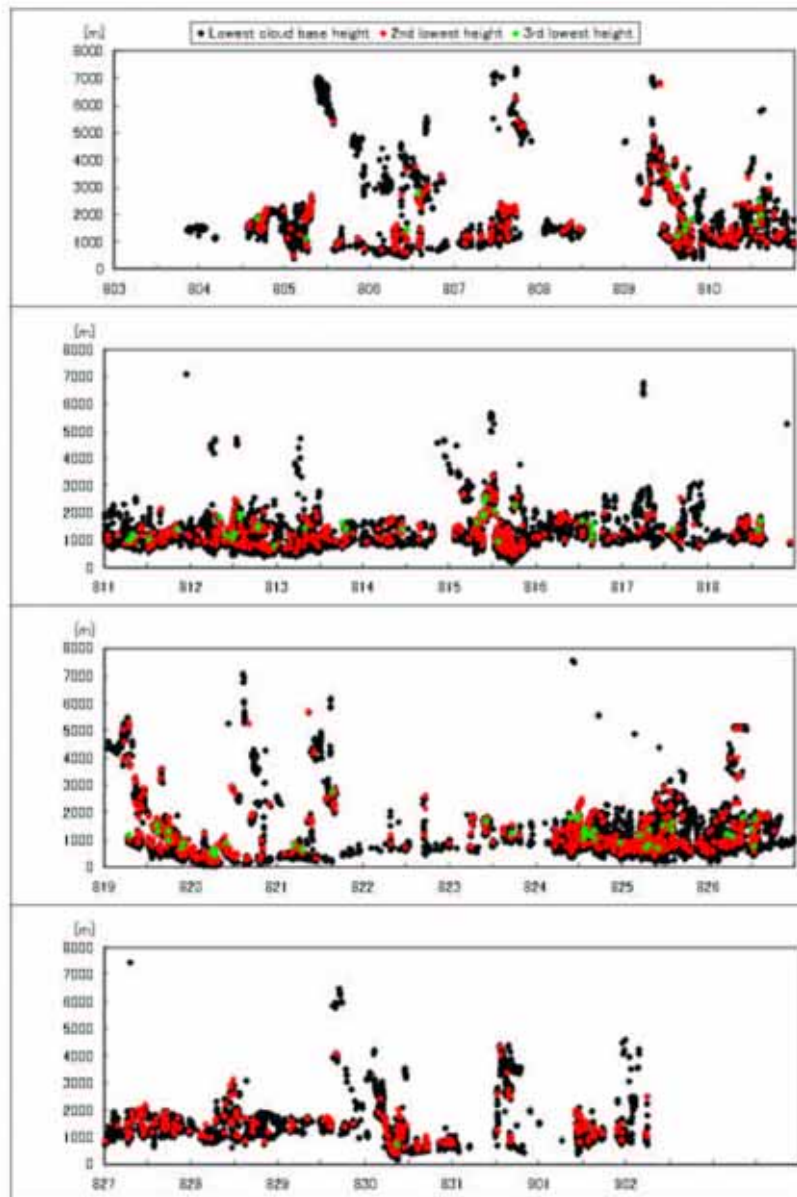


Figure 2.1-2 1st, 2nd and 3rd lowest cloud base height during the cruise.



#### (4)Preliminary results

The figure 2.1-2 shows the time series of the first, second and third lowest cloud base height.

#### (5)Data archives

The raw data obtained during this cruise will be submitted to JAMSTEC Data Management Division.

### 2.1.3 Surface atmospheric turbulent flux measurement

Not on-board

Kunio Yoneyama (JAMSTEC)

Osamu Tsukamoto (Okayama Univ.)

Hiroshi Ishida (Kobe Univ. of Mercantile Marine)

#### (1)Objective

To better understand the air-sea interaction, accurate measurements of surface heat and fresh water budgets are necessary as well as momentum exchange through the sea surface. In addition, the evaluation of surface flux of carbon dioxide is also indispensable for the study of global warming. Sea surface turbulent fluxes of momentum, sensible heat, latent heat, and carbon dioxide were measured by using the eddy correlation method that is thought to be most accurate and free from assumptions. These surface heat flux data are combined with radiation fluxes and water temperature profiles to derive the surface energy budget.

#### (2)Apparatus and Performance

The surface turbulent flux measurement system consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). Details of each sensor are as follows. All sensors are equipped at 25 m height from sea surface.

Sensor	Type / Manufacturer
Three-dimensional sonic anemometer-thermometer	Kaijo, DA-600
Infrared hygrometer	LICOR, LI-7500
Two-axis inclinometer	Applied Geomechanics, MD-900-T
Three-axis accelerometer	Applied Signal Inc., QA-700-020
Three-axis rate gyro	Systron Donner, QRS-0050-100

These signals are sampled at 10 Hz by a PC-based data logging system (Labview, National Instruments Co., Ltd.). By obtaining the ship speed and heading information through the Mirai network system it yields the absolute wind components relative to the ground. Combining wind data with the turbulence data, turbulent fluxes and statistics are calculated in a real-time basis.

#### (3)Calibration

All sensors were calibrated at the manufacturer (Kaijo Co. Ltd.) in April 2003.

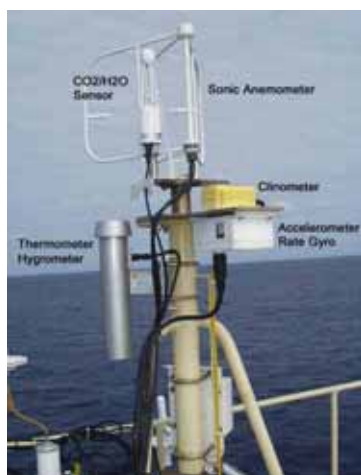
After the cruise, these data will be compared with surface meteorological data obtained by another system (SOAR) to exclude unreliable data.

#### (4)Preliminary results

Data will be processed after the cruise at Okayama University.

#### (5)Data Archive

All data are archived at Okayama University, and will be open to public after quality checks and corrections. Corrected data will be submitted to JAMSTEC Data Management Division.



**Fig.2.1.3 Turbulent flux measurement system on the top deck of the foremast.**

## 2.2 Navigation and Bathymetry

Souichiro Sueyoshi (Global Ocean Development Inc.)  
Shinya Okumura (GODI)  
Katsuhisa Maeno (GODI)

### (1) Introduction

Navigation: Ship's position was measured by GPS navigation system, manufactured by Sena Co. Ltd, Japan.

Bathymetry: R/V MIRAI equipped a Multi Narrow Beam Echo Sounding system (MNBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.) The main objective of MNBES survey is collecting continuous bathymetry data along ship's track to make a contribution to geological and geophysical investigations and global datasets. We had carried out bathymetric survey during the MR03-K04 Leg1 cruise from CTD station P06W-246 on 4 August 2003 to CTD station P06C-121 on 2 September 2003.

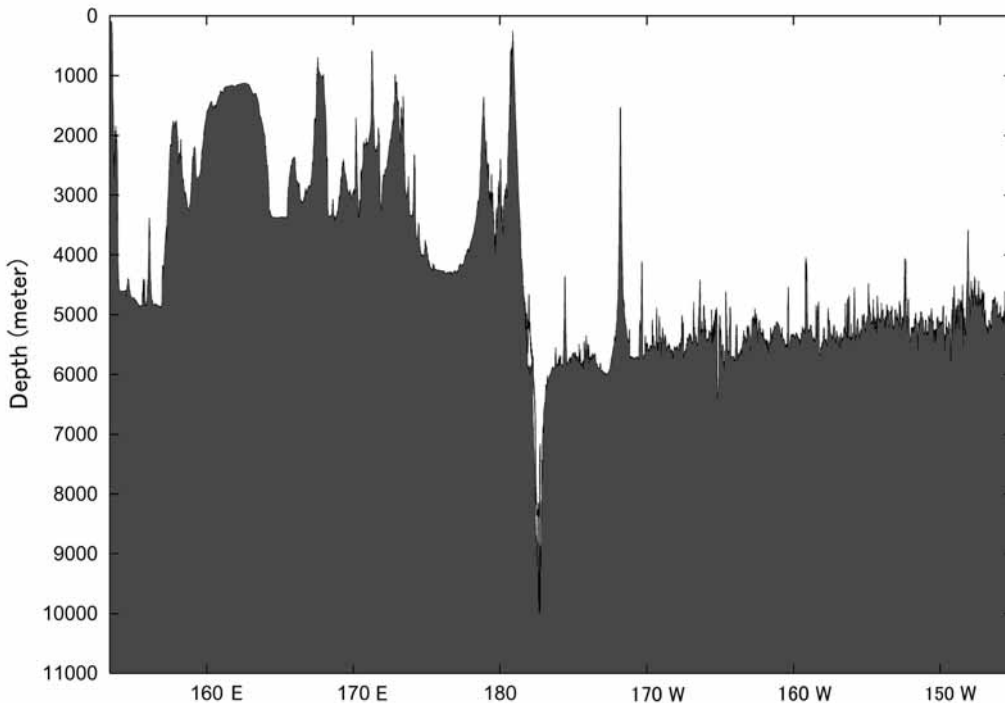
### (2) Data Acquisition

Navigation: The navigation system has two 12-channel GPS receivers (Leica MX9400N). GPS antennas located at Navigation deck aft bridge. The position determined by GPS was converted to the position of radar mast. The system gathered other navigation devices data (gyro heading and log speed). Navigation data was generated every second and was recorded every 60 seconds.

Bathymetry: The “SEABEAM 2100” on R/V MIRAI was used for bathymetry mapping during the cruise. To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data at the surface (6.2m) sound velocity, and the others depth sound velocity calculated temperature and salinity profiles from CTD data by the equation in Mackenzie (1981) during the cruise.

System configuration and performance of SEABEAM 2112.004,

Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or +/-1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or +/-1m, whichever is greater)



**Fig 2.2 Bathymetry**

### (3) Preliminary Results

The results will be published after primary processing.

### (4) Data Archives

Data obtained during this cruise will be submitted to the JAMSTEC Data Management Division, and archived there.

### (5) Remarks

Bathymetry: We could not collect data from 1605UTC to 1642UTC 26 August, due to system freeze.

## 2.3 Acoustic Doppler Current Profiler (ADCP)

Y. Yoshikawa (JAMSTEC)

S. Sueyoshi (GODI)

The instrument used was an RDI 76.8 kHz unit, hull-mounted on the centerline and approximately 23 m aft of the bow at the water line. On this cruise the firmware version was 5.59 and the data acquisition software was VM-DAS. Operation was made from the first CTD station (246) to the last CTD station (121). For most of its operation the instrument was used in the water-tracking mode, recording each 1 ping raw data in 100 bins x 8 m/bin from 17 m to 817 m. Sampling interval is 9.01 second. Bottom track mode was added in the westernmost shallow water region, giving the data to evaluate the alignment of the transducer on the hull. In the course the scale factor of ADCP was also evaluated. Compass we used was INU instead of ship's gyrocompass. Its accuracy was 0.01 degree and had already set on zero bias. At the interval of 8 Hz heading, pitch, and roll angles were recorded to another PC. Thus we had to combine both recorded data.

The performance of the ADCP instrument was good throughout the cruise: on steaming, profiles were almost always recorded to 500m except in heaviest weather and rough sea status. On station, profiles were not good because of the babbles from stabilizer. Echo intensity was relatively weak in the sea east of 160W. The INU instrument worked well except a recorder trouble. The trouble occurred and continued about 2 hours from 2226 on 5 August to 0007 on 6 August, when the CTD operation was carried on.

The first processing was evaluation both of scale factor and transducer misalignment by using the bottom track mode data between stations 246 and 244. Using good quality data in which the error velocity was less than 1cm/s, ratio ADCP/Navigation was calculated as 1.0259. The scale factor 0.9748 (=1/1.0259) is to be adapted to velocity magnitude of each ping. Misalignment was also calculated and corrected angle to be added to the velocity direction of each ping was -0.14

degree.

The second processing is applying misalignment correction to raw data and calculating flow field on grid as a preliminary result that would make us overview. Every ping data, both on steaming and on station, those error velocity less than 2 cm/s and correlation value higher than 100 were used to this averaging on the grid of 0.1 degree longitude.

On the next processing we will adapt a roll and pitch data of INU to profiles of each ping. They would correct a shear of each velocity profile, which could be occurred in the tilt motion of the transducer. Depth correction will be also made using CTD data.

## 2.4 Thermo-salinograph

Takayoshi Seike : Marine Works Japan Co. Ltd.

Masao Fukasawa : Ocean Observation and Research Department, JAMSTEC

### (1)Objective

To measure salinity, temperature, dissolved oxygen, and fluorescence of near-sea surface water.

### (2)Methods

The Continuous Sea Surface Water Monitoring System (Nippon Kaiyo co.,Ltd.) has six kind of sensors and can automatically measure salinity, temperature, dissolved oxygen, fluorescence and particle size of plankton in near-sea surface water continuously, every 1-minute. This system is located in the “sea surface monitoring laboratory” on R/V Mirai. This system is connected to shipboard LAN-system. Measured data is stored in a hard disk of PC every 1-minute together with time and position of ship, and displayed in the data management PC machine.

Near-surface water was continuously pumped up to the laboratory and flowed into the Continuous Sea Surface Water Monitoring System through a vinyl-chloride pipe. The flow rate for the system is controlled by several valves and was 12 L/min except with fluorometer (about 0.3 L/min). The flow rate is measured with two flow meters.

Specification of the each sensor in this system of listed below.

#### a) Temperature and Salinity sensor

SEACAT THERMOSALINOGRAPH

Model: SBE-21, SEA-BIRD ELECTRONICS, INC.

Serial number: 2118859-2641

Measurement range: Temperature -5 to +35 degC, Conductivity 0 to 6.5 S m<sup>-1</sup>  
Accuracy: Temperature 0.01 degC 6month<sup>-1</sup>, Conductivity 0.001 S m<sup>-1</sup> month<sup>-1</sup>  
Resolution: Temperatures 0.001degC, Conductivity 0.0001 S m<sup>-1</sup>

b) Bottom of ship thermometer

Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.  
Serial number: 032175  
Measurement range: -5 to +35 degC  
Resolution: ±0.001 degC  
Stability: 0.002 degC year<sup>-1</sup>

c) Dissolved oxygen sensor

Model: 2127A, Oubisufair Laboratories Japan INC.  
Serial number: 44733  
Measurement range: 0 to 14 ppm  
Accuracy: ±1% at 5 degC of correction range  
Stability: 1% month<sup>-1</sup>

d) Fluorometer

Model: 10-AU-005, TURNER DESIGNS  
Serial number: 5562 FRXX  
Detection limit: 5 ppt or less for chlorophyl a  
Stability: 0.5% month-1 of full scale

e) Particle Size sensor

Model: P-05, Nippon Kaiyo LTD.  
Serial number: P5024  
Measurement range: 0.02681 mmt to 6.666 mm  
Accuracy: ±10% of range  
Reproducibility: ±5%  
Stability: 5% week<sup>-1</sup>

f) Flow meter

Model: EMARG2W, Aichi Watch Electronics LTD.  
Serial number: 8672  
Measurement range: 0 to 30 l min<sup>-1</sup>

Accuracy:  $\pm 1\%$   
Stability:  $\pm 1\% \text{ day}^{-1}$

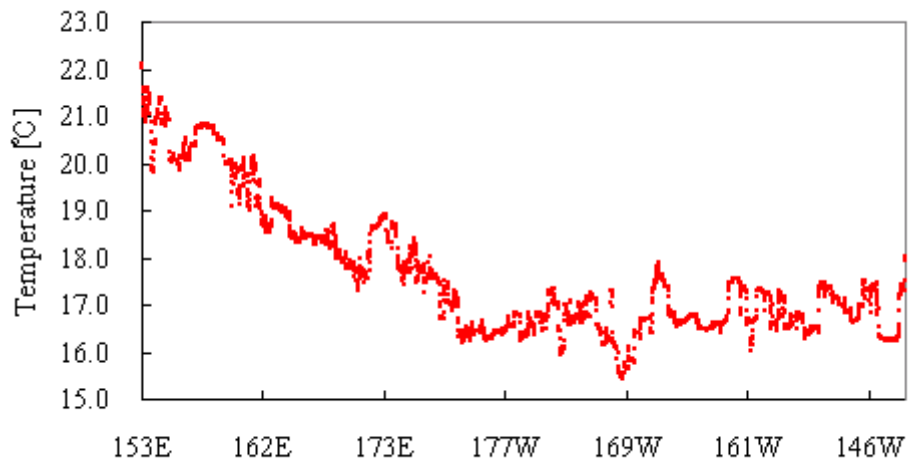
The monitoring Periods (UTC) during this cruise are listed below.

11:00 of August 3 , 2003 to 2:00 of September 3 , 2003

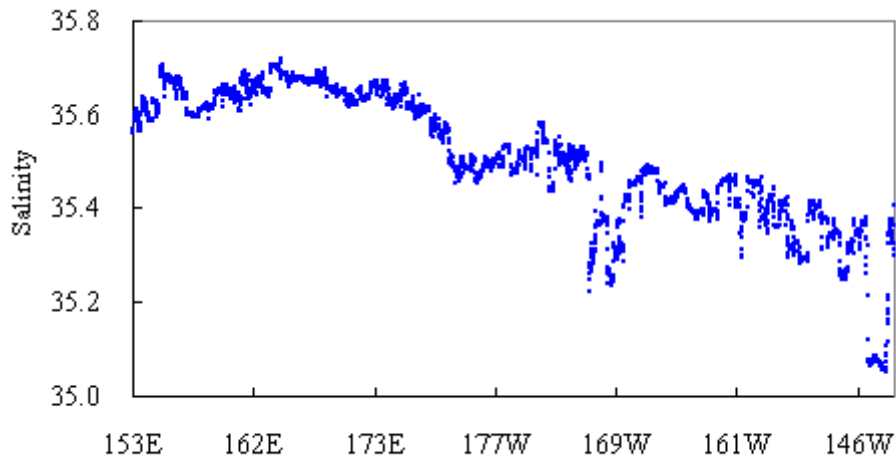
### (3)Preliminary Result

Preliminary data of temperature (Bottom of ship thermometer), salinity at sea surface between this cruise are shown in Fig.2.4.1, 2.4.2. They show the respective trend of each distribution on the ship's track every ten minutes.

We sampled about three times every day for salinity sensor calibration. All salinity samples were collected from the course of the system while on station or from regions with weak horizontal gradients. All samples were analyzed on the Guildline 8400B. The results were shown in Table 2.4.1.



**Fig.2.4.1 Time series of temperature in the sea surface water.**



**Fig.2.4.2 Time series of salinity in the sea surface water.**

(4)Date archive

The data were stored on a magnetic optical disk, which will be submitted to the Data Management Office (DMO) JAMSTEC, and will be opened to public via “R/V MIRAI Data Web Page” in JAMSTEC homepage.

**Table.2.4.1 Comparison between salinity data from *Continuous Sea Surface Water Monitoring* and bottle salinity.**

Date [UTC]	Time [UTC]	Salinity data	Bottle Salinity [PSS-78]
3-Aug-03	18:54	35.5879	35.5776
4-Aug-03	2:25	35.6021	35.5977
4-Aug-03	9:59	35.6077	35.6023
4-Aug-03	18:01	35.6732	35.7100
5-Aug-03	1:54	35.6752	35.7049
5-Aug-03	9:50	35.6532	35.6842
5-Aug-03	18:01	35.6003	35.6289
6-Aug-03	1:51	35.5960	35.6247
6-Aug-03	10:27	35.6214	35.6512
6-Aug-03	20:40	35.6474	35.6757
6-Aug-03	21:50	35.6564	35.6859
7-Aug-03	6:14	35.6663	35.6854
7-Aug-03	15:20	35.6338	35.6642



7-Aug-03	22:00	35.6880	35.7229
8-Aug-03	6:01	35.6572	35.6895
8-Aug-03	21:10	35.6394	35.6733
9-Aug-03	5:05	35.7028	35.7333
9-Aug-03	12:57	35.6875	35.7201
9-Aug-03	20:58	35.6833	35.7181
10-Aug-03	5:00	35.6743	35.7086
10-Aug-03	21:54	35.6847	35.7183
11-Aug-03	4:50	35.6789	35.7130
11-Aug-03	17:09	35.6461	35.6810
11-Aug-03	20:55	35.6490	35.6857
12-Aug-03	5:03	35.6290	35.6705
12-Aug-03	12:55	35.6526	35.6881
12-Aug-03	20:54	35.6345	35.6703
13-Aug-03	5:04	35.6611	35.6964
13-Aug-03	11:57	35.6644	35.7019
13-Aug-03	20:58	35.6236	35.6593
14-Aug-03	4:11	35.6377	35.6739
14-Aug-03	12:04	35.6180	35.6571
14-Aug-03	20:08	35.6064	35.6447
15-Aug-03	3:57	35.6112	35.6496
15-Aug-03	12:15	35.5664	35.6030
15-Aug-03	20:18	35.5552	35.5950
16-Aug-03	7:48	35.4951	35.5322
16-Aug-03	16:16	35.4935	35.5294
16-Aug-03	23:56	35.4875	35.5251
17-Aug-03	7:55	35.4698	35.5070
17-Aug-03	15:40	35.5015	35.5427
18-Aug-03	0:33	35.4962	35.5350
18-Aug-03	8:14	35.4878	35.5273
18-Aug-03	16:05	35.4888	35.5312
19-Aug-03	0:05	35.5214	35.5527
19-Aug-03	7:54	35.5274	35.5679
19-Aug-03	16:00	35.5244	35.5650
19-Aug-03	23:56	35.5482	35.5841

20-Aug-03	8:08	35.4433	35.4880
20-Aug-03	16:08	35.5156	35.5571
20-Aug-03	19:58	35.4993	35.5407
21-Aug-03	3:58	35.5171	35.5598
21-Aug-03	11:33	35.5097	35.5511
21-Aug-03	18:55	35.4674	35.5105
22-Aug-03	2:57	35.3707	35.4655
22-Aug-03	10:50	35.3744	35.4391
22-Aug-03	18:56	35.2718	35.3405
23-Aug-03	2:48	35.3186	35.3660
23-Aug-03	10:51	35.4549	35.5079
23-Aug-03	18:44	35.4632	35.5062
24-Aug-03	3:01	35.4781	35.5308
24-Aug-03	10:57	35.4741	35.5188
24-Aug-03	18:58	35.4474	35.4910
25-Aug-03	3:05	35.4212	35.4646
25-Aug-03	11:09	35.4394	35.4823
25-Aug-03	18:54	35.4106	35.4549
26-Aug-03	2:54	35.3799	35.4229
26-Aug-03	11:31	35.4319	35.4754
27-Aug-03	7:00	35.4600	35.5030
27-Aug-03	14:57	35.4578	35.5008
27-Aug-03	23:07	35.3555	35.4095
28-Aug-03	6:58	35.4548	35.4993
28-Aug-03	15:09	35.4504	35.4941
28-Aug-03	23:00	35.3639	35.4040
29-Aug-03	6:54	35.3661	35.4016
29-Aug-03	15:27	35.4121	35.4533
29-Aug-03	23:05	35.3417	35.3944
30-Aug-03	11:23	35.2927	35.3342
30-Aug-03	15:00	35.2908	35.3325
30-Aug-03	22:58	35.4069	35.4482
31-Aug-03	6:58	35.3776	35.4200
31-Aug-03	23:04	35.2608	35.3023
1-Sep-03	7:00	35.3240	35.3648

1-Sep-03	14:55	35.3516	35.3940
1-Sep-03	22:57	35.3651	35.4015
2-Sep-03	6:56	35.0834	35.1256
2-Sep-03	21:59	35.3719	35.4129

## 2.5 pCO<sub>2</sub>

Akihiko Murata (JAMSTEC)

Minoru Kamata (MWJ)

Toru Fujiki (MWJ)

### 2.5.1 Objective

Concentrations of CO<sub>2</sub> in the atmosphere are now increasing at a rate of 1.5 ppmv y<sup>-1</sup> owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO<sub>2</sub>, and to clarify the mechanism of the CO<sub>2</sub> absorption, because the magnitude of the anticipated global warming depends on the levels of CO<sub>2</sub> in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise, we are aimed at quantifying how much anthropogenic CO<sub>2</sub> absorbed in the surface ocean in the Southern Hemisphere, where data for CO<sub>2</sub> are sparse. For the purpose, we measured pCO<sub>2</sub> (partial pressure of CO<sub>2</sub>) in the atmosphere and surface seawater.

### 2.5.2 Apparatus and performance

Concentrations of CO<sub>2</sub> in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (BINOS<sup>TM</sup>). The automated system was operated by on one and a half hour cycle. In one cycle, standard gasses, marine air and an air in a headspace of an equilibrator were analyzed subsequently. The concentrations of the standard gas were 270.09, 328.86, 359.10 and 409.22 ppm. The standard gases will be recalibrated after the cruise.

The marine air taken from the bow was introduced into the NDIR by passing through a mass flow controller which controlled the air flow rate at about 0.5 L/min, a cooling unit, a perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing Mg(ClO<sub>4</sub>)<sub>2</sub>.

A fixed volume of the marine air taken from the bow was equilibrated with a stream of seawater that flowed at a rate of 5-6 L/min in the equilibrator. The air in the equilibrator was circulated with a pump at 0.7-0.8 L/min in a closed loop passing through two cooling units, a

perma-pure dryer (GL Science Inc.) and a desiccant holder containing  $Mg(ClO_4)_2$ .

### 2.5.3 Results

Concentrations of  $CO_2$  ( $xCO_2$ ) of marine air and surface seawater are shown in Fig. 2.5.1. From this figure, it is found that the area acted as a sink for atmospheric  $CO_2$ .

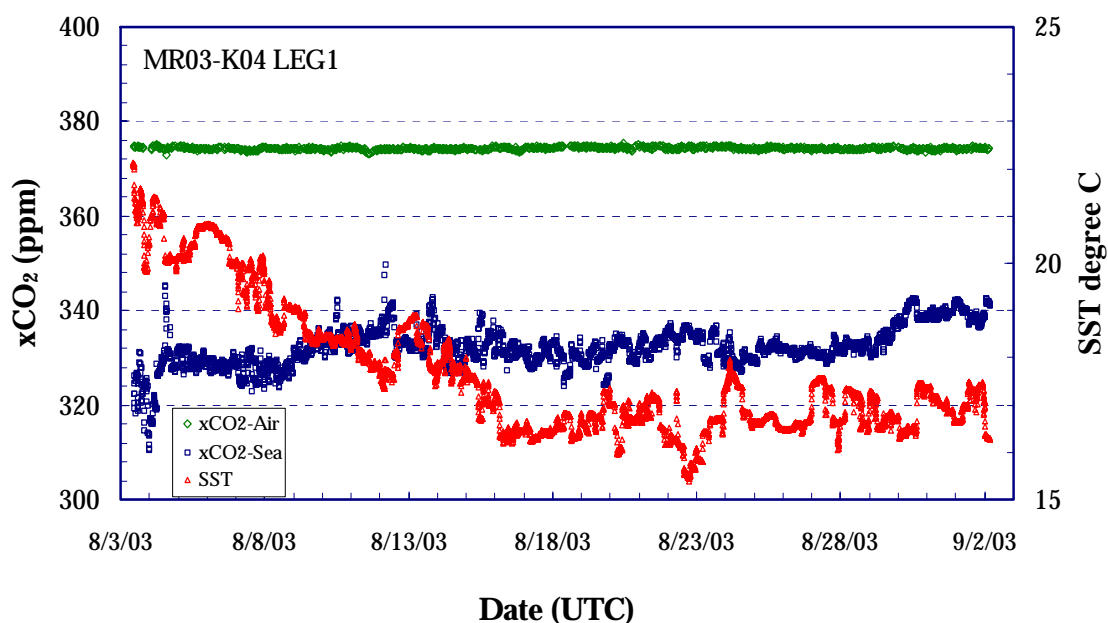


Figure 2.5.1 Concentrations of  $CO_2$  ( $xCO_2$ ) in atmosphere and surface seawater

## 3. Hydrography

### 3.1. CTDO-Sampler

Masao Fukasawa (JAMSTEC)

Mark Andrew Rosenberg (ACE CRC)

Masayuki Fujisaki (MWJ)

Satoshi Ozawa (MWJ)

Tomoyuki Takamori (MWJ)

### **3.1.1 Winch arrangements**

The CTD package was deployed using a 4.5 Ton Traction Winch System (Dynacon, Inc., USA) which was installed on the R/V Mirai in April 2001. The CTD Traction Winch System with the Heave Compensation Systems (Dynacon, Inc., USA) is designed to reduce cable stress resulting from load variation caused by wave or vessel motion. The system is operated passively by providing a nodding boom crane that moves up or down in response to line tension variations. Primary system components include a complete CTD Traction Winch System with 7000m of 9.5 mm armored cable rocker and Electro-Hydraulic Power Unit, nodding-boom crane assembly, two hydraulic cylinders and two hydraulic oil/nitrogen accumulators mounted within a single frame assembly. The system also contains related electronic hardware interface and a heave compensation computer control program.

### **3.1.2 Overview of the equipment**

The CTD system, SBE911plus system (Sea-Bird Electronics, Inc., USA), is a real time data system with the CTD data transmitted from a SBE 9plus underwater unit via a conducting cable to the SBE 11plus deck unit. The SBE 11plus deck unit is a rack-mountable interface which supplies DC power to the underwater unit, decodes the serial data stream, formats the data under microprocessor control, and passes the data to a companion computer. The serial data from the underwater unit is sent to the deck unit in RS-232 NRZ format using a 34560 Hz carrier-modulated differential-phase-shift-keying (DPSK) telemetry link. The deck unit decodes the serial data and sends them to a personal computer to display, at the same time, to storage in a disk file using SBE SEASOFT software.

The SBE 911plus system acquires data from primary, secondary and auxiliary sensors in the form of binary numbers corresponding to the frequency or voltage outputs from those sensors at 24 samples per second. The calculations required to convert from raw data to engineering units of the parameters are performed by the SBE SEASOFT in real-time. The same calculations can be carried out after the observation using data stored in a disk file.

The SBE 911plus system controls the 36-positions SBE 32 Carousel Water Sampler. The Carousel accepts 12 L water sample bottles. Bottles were fired through the RS-232C modem connector on the back of the SBE 11plus deck unit while acquiring real time data. The 12 L Niskin-X water sample bottle (General Oceanics, Inc., USA) is equipped externally with two stainless steel springs. The external springs are ideal for applications such as the trace metal

analysis because the inside of the sampler is free from contaminants from springs.

SBE's standard temperature (SBE 3F) and conductivity (SBE 4) sensor modules were used with the SBE 9plus underwater unit fixed by a single clamp and "L" bracket to the lower end cap. The conductivity cell entrance is co-planar with the tip of the temperature sensor's protective steel sheath. The pressure sensor is mounted in the main housing of the underwater unit and is ported to outside through the oil-filled plastic capillary tube. A compact, modular unit consisting of a centrifugal pump head and a brushless DC ball bearing motor contained in an aluminum underwater housing pump (SBE 5T) flushes water through sensor tubing at a constant rate independent of the CTD's motion. Motor speed and pumping rate (3000 rpm) remain nearly constant over the entire input voltage range of 12-18 volts DC.

**The system used in this cruise is summarized as follows:**

Under water unit:

*SBE, Inc., SBE 9plus, S/N 79492*

**Temperature sensor (primary):**

*SBE, Inc., SBE 3-plus, S/N 03P4188*

Temperature sensor (secondary):

*SBE, Inc., SBE 3-04/F, S/N 031464*

**Conductivity sensor (primary):**

*SBE, Inc., SBE 4-04/0, S/N 041088*

Conductivity sensor (secondary):

*SBE, Inc., SBE 4-04/0, S/N 041202*

Oxygen sensor (primary):

*SBE, Inc., SBE 43, S/N 430390*

Oxygen sensor (secondary):

*SBE, Inc., SBE 43, S/N 430205*

Pump (primary):

*SBE, Inc., SBE 5T, S/N 053575*

Pump (secondary):

*SBE, Inc., SBE 5T, S/N 050984*

Altimeter:

*Benthos Inc., PSA-900, S/N 1026 (exclude Stn. P06C148)*

Altimeter:

*Benthos Inc., 2110-2,, S/N 206 (only Stn. P06C148)*

Deep Ocean Standards Thermometer

*SBE, Inc., SBE 35, S/N 3528054-0022*

Fluorometer:

*Seapoint sensors, Inc., S/N 2148 (to Stn. P06C166)*

Deck unit:

*SBE, Inc., SBE 11plus, S/N 11P7030-0272*

Carousel Water Sampler:

*SBE, Inc., SBE 32, S/N 3221746-0278*

Water sample bottle:

*General Oceanics, Inc., 12-litre Niskin-X*

### **3.1.3 Pre-cruise calibration**

#### (1) Pressure

The Paroscientific series 4000 Digiquartz high pressure transducer (Paroscientific, Inc., USA) uses a quartz crystal resonator whose frequency of oscillation varies with pressure induced stress with 0.01 per million of resolution over the absolute pressure range of 0 to 15,000 psia (0 to 10,332 dbar). Also, a quartz crystal temperature signal is used to compensate for a wide range of temperature changes at the time of an observation. The pressure sensor (MODEL 415K-187) has a nominal accuracy of 0.015 % FS (1.5 dbar), typical stability of 0.0015 % FS/month (0.15 dbar/month) and resolution of 0.001 % FS (0.1 dbar).

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in the SEASOFT through software module SEACON:

S/N 79492 October 27, 1999

c1 = -65706.8

c2 = -0.1758329

c3 = 2.04245e-02

d1 = 0.027146

d2 = 0.0

t1 = 29.92375

t2 = -2.63869e-04

t3 = 3.92132e-06

$$t4 = 1.35947e-09$$

$$t5 = 4.49704e-12$$

(The coefficients c1, c2, t1 and t2 were changed on December 6, 1999.)

Pressure coefficients are first formulated into

$$c = c1 + c2 * U + c3 * U^2$$

$$d = d1 + d2 * U$$

$$t0 = t1 + t2 * U + t3 * U^2 + t4 * U^3 + t5 * U^4$$

where U is temperature in degrees Celsius. The pressure temperature, U, is determined according to

$$U \text{ (degC)} = M * (\text{12 bit pressure temperature compensation word}) - B$$

The following coefficients were used in SEASOFT through software module SEACON:

$$M = 1.284934e-2$$

$$B = -8.388034$$

(in the underwater unit system configuration sheet  
dated on November 30, 1999)

Finally, pressure is computed as

$$P \text{ (psi)} = c * [1 - (t0^2 / t^2)] * \{1 - d * [1 - (t0^2 / t^2)]\}$$

where t is pressure period (microsec). Since the pressure sensor measures the absolute value, it inherently includes atmospheric pressure (about 14.7 psi). SEASOFT subtracts 14.7 psi from computed pressure above automatically.

Pressure sensor calibrations against a dead-weight piston gauge are performed at Marine Works Japan Ltd. in Yokosuka, Kanagawa, JAPAN, usually once in a year in order to monitor sensor time drift and linearity. The pressure sensor drift is known to be primarily an offset drift at all pressures rather than a change of span slope. The pressure sensor hysteresis is typically 0.2 dbar.



The following coefficients for the sensor drift correction were also used in SEASOFT through the software module SEACON:

S/N 79492 April 24, 2001

slope = 0.9999235

offset = 2.4157361

The drift-corrected pressure is computed as

Drift-corrected pressure (dbar) = slope \* (computed pressure in dbar) + offset

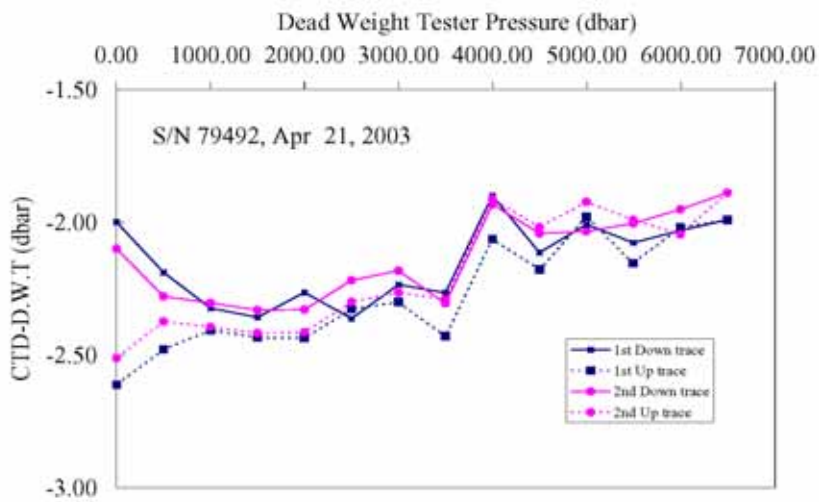
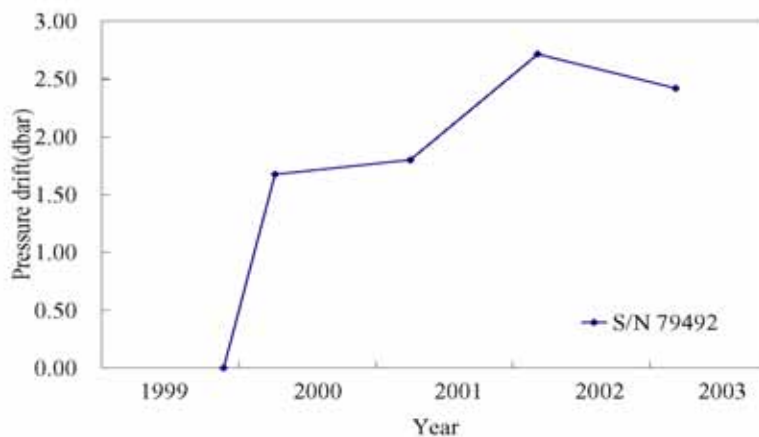


Fig.3.1.1 The residual pressures between the Dead Weight Tester and the CTD.



**Fig.3.1.2 Pressure sensor drift based calibrations on Dead-Weight Tester**

**(2) Temperature (SBE 3F)**

The temperature sensing element is a glass-coated thermistor bead in a stainless steel tube, providing a pressure-free measurement at depths up to 10,500 meters. The sensor output frequency ranges from approximately 5 to 13 kHz corresponding to temperature from  $-5$  to  $35$  degC. The output frequency is inversely proportional to the square root of the thermistor resistance, which controls the output of a patented Wien Bridge circuit. The thermistor resistance is exponentially related to temperature. The SBE 3F thermometer has a nominal accuracy of  $0.001$  degC, typical stability of  $0.0002$  degC/month and resolution of  $0.0002$  degC at 24 samples per second.

**Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in SEASOFT through the software module SEACON:**

S/N 03P4188(primary) June 25, 2003

$$g = 4.39868209e-03$$

$$h = 6.45272514e-04$$

$$i = 2.26066338e-05$$

$$j = 1.89127504e-06$$

$$f_0 = 1000.000$$

S/N 031464 (secondary) June 24, 2003

$$g = 4.84388979e-03$$

$$h = 6.80795615e-04$$

$$i = 2.70029675e-05$$

$$j = 2.13380253e-06$$

$$f_0 = 1000.000$$

Temperature (ITS-90) is computed according to

Temperature (ITS-90) =

$$1 / \{g + h * [\ln(f_0 / f)] + i * [\ln^2(f_0 / f)] + j * [\ln^3(f_0 / f)]\} - 273.15$$

where f is the instrument frequency (kHz).

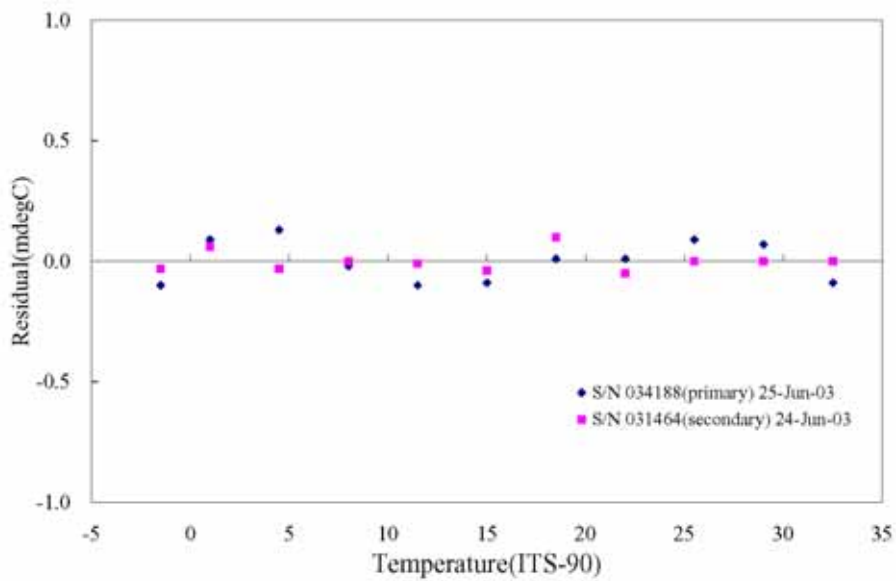
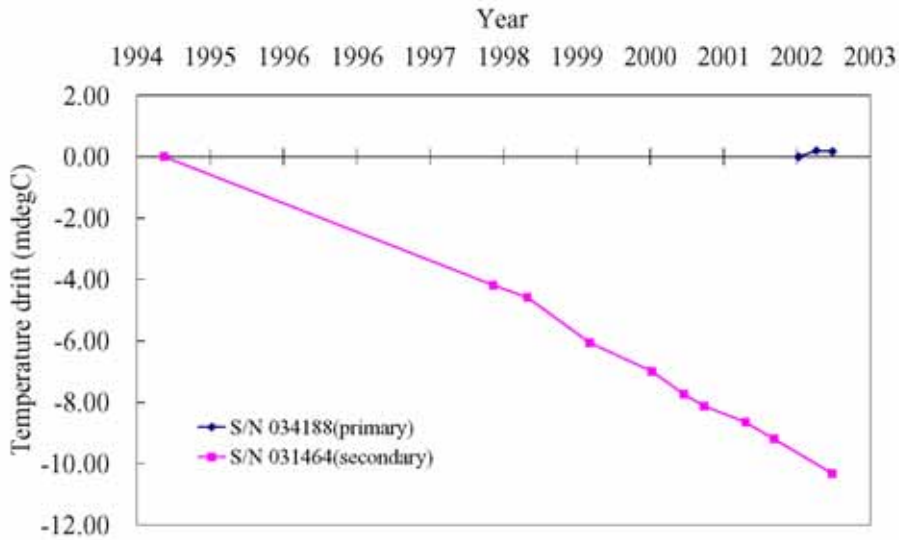


Fig.3.1.3 The residual between Bath temperature and Instrument temperature.



**Fig.3.1.4 Temperature sensor drift based on laboratory calibrations performed at SBE,Inc.**

(3) Conductivity (SBE 4)

The flow-through conductivity sensing element is a glass tube (cell) with three platinum electrodes to provide in-situ measurements at depths up to 10,500 meters. The impedance between the center and the end electrodes is determined by the cell geometry and the specific conductance of the fluid within the cell. The conductivity cell composes a Wien Bridge circuit with other electric elements of which frequency output is approximately 3 to 12 kHz corresponding to conductivity of the fluid of 0 to 7 S/m. The conductivity cell SBE 4 has a nominal accuracy of 0.0003 S/m, typical stability of 0.0003 S/m/month and resolution of 0.00004 S/m at 24 samples per second.

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in SEASOFT through the software module SEACON:

S/N 041088 (primary) July 03, 2003

$$g = -4.01946189e+00$$

h = 5.50802658e-01  
i = -1.68736617e-04  
j = 3.83962022e-05  
CPcor = -9.57e-08 (nominal)  
CTcor = 3.25e-06 (nominal)

S/N 041206 (secondary) July 03, 2003

g = -3.94210124e+00  
h = 4.38993142e-01  
i = -9.59762118e-06  
j = 2.09906225e-05  
CPcor = -9.57e-08 (nominal)  
CTcor = 3.25e-06 (nominal)

Conductivity of a fluid in the cell is expressed as:

$$C \text{ (S/m)} = (g + h * f^2 + i * f^3 + j * f^4) / [10 ( 1 + CTcor * t + CPcor * p)]$$

where f is the instrument frequency (kHz), t is the water temperature (degC) and p is the water pressure (dbar). The value of conductivity at salinity of 35, temperature of 15 degC (IPTS-68) and pressure of 0 dbar is 4.2914 S/m.

#### (4) Deep Ocean Standards Thermometer

The SBE35 is an accurate ocean-range temperature sensor that can be standardized against water triple point gallium melt cells as if it were an SPRT, but is also capable of measuring temperature in the ocean. When used with a SBE 911plus CTD and Carousel water sampler, the SBE35 makes a temperature measurement each time a bottle fire confirmation is received and stores the value in EEPROM.

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in SEATERM:

S/N 3528054-0022 July 03, 2003

#### LINEARIZATION CALIBRATION

$$A0 = 4.320725498 \text{ e-03}$$

$$A1 = -1.189839279 \text{ e-}03$$

$$A2 = 1.836299593 \text{ e-}04$$

$$A3 = -1.032916769 \text{ e-}05$$

$$A4 = 2.225491125 \text{ e-}07$$

#### FIXED POINT CALIBRATION

$$\text{Slope} = 1.000012$$

$$\text{Offset} = 0.000052$$

#### (5) Oxygen (SBE 43)

The SBE 43 oxygen sensor uses a Clark polarographic element to provide in-situ measurements at depths up to 7,000 meters. Calibration stability is improved by an order of magnitude and pressure hysteresis is largely eliminated in the upper ocean (1000 m). Continuous polarization eliminates the wait-time for stabilization after power-up. Signal resolution is increased by on-board temperature compensation. This sensor is also included in the path of pumped sea water. The oxygen sensor determines the dissolved oxygen concentration by counting the number of oxygen molecules per second (flux) that diffuse through a membrane, where the permeability of the membrane to oxygen is a function of temperature and ambient pressure. Computation of dissolved oxygen in engineering units is done in SEASOFT software through almost the same way as for the case of the SBE 13. The range for dissolved oxygen is 120 % of surface saturation in all natural waters; nominal accuracy is 2 % of saturation; typical stability is 2 % per 1000 hours.

The following coefficients were used in SEASOFT through the software module SEACON:

S/N 430390(primary) July 14, 2003

$$\text{Soc} = 0.3158$$

$$\text{Boc} = 0.0000$$

$$\text{TCor} = 0.0019$$

$$\text{PCor} = 1.350\text{e-}04$$

$$\text{Offset} = -0.5041$$

$$\text{tau} = 0$$

S/N 430205(secondary) June 18, 2003

Soc = 0.3982  
Boc = 0.0000  
TCor = 0.0003  
PCor = 1.350e-04  
Offset = -0.4885  
tau = 0

Oxygen (ml/L) is computed as

$$\begin{aligned} \text{Oxygen (ml/L)} &= [\text{Soc} * \{(\text{v} + \text{offset}) + (\text{tau} * \text{doc}/\text{dt})\} + \text{Boc} * \exp(-0.03 * \text{t})] \\ &\quad * \exp(\text{TCor} * \text{t} + \text{PCor} * \text{p}) * \text{Oxsat}(\text{t}, \text{s}) \\ \text{Oxsat}(\text{t}, \text{s}) &= \exp[\text{A1} + \text{A2} * (100 / \text{t}) + \text{A3} * \ln(\text{t} / 100) + \text{A4} * (\text{t} / 100) \\ &\quad + \text{s} * (\text{B1} + \text{B2} * (\text{t} / 100) + \text{B3} * (\text{t} / 100) * (\text{t} / 100))] \end{aligned}$$

where p is pressure in dbar, t is absolute temperature and s is salinity in psu. Oxsat is oxygen saturation value minus the volume of oxygen gas (STP) absorbed from humidity-saturated air. Its coefficients are as follows.

A1 = -173.4292  
A2 = 249.6339  
A3 = 143.3483  
A4 = -21.8482  
B1 = -0.033096  
B2 = -0.00170

#### (6) Altimeter

The Benthos PSA-900 Programmable Sonar Altimeter (Benthos, Inc., USA) determines the distance of the target from the unit in almost the same way as the Benthos 2110. PSA-900 also uses the nominal speed of sound of 1500 m/s. But, PSA-900 compensates for sound velocity errors due to temperature. In a PSA-900 operating at a 350 microsecond pulse at 200 kHz, the jitter of the detectors can be as small as 5 microseconds or approximately 0.4 centimeters total distance. Since the total travel time is divided by two, the jitter error is 0.25 centimeters. The unit is rated to a

depth of 6,000 meters.

The following scale factors were used in SEASOFT through the software module SEACON:

$$\text{FSVolt} * 300 / \text{FSRange} = 10$$

$$\text{Offset} = 0.0$$

#### (7) Fluorometer

The Seapoint Chlorophyll Fluorometer (Seapoint sensors, Inc., USA) is a high-performance, low power instrument to provide in-situ measurements of chlorophyll-a at depths up to 6,000 meters. The instrument uses modulated blue LED lamps and a blue excitation filter to excite chlorophyll-a. The fluorescent light emitted by the chlorophyll-a passes through a red emission filter and is detected by a silicon photodiode. The low level signal is then processed using synchronous demodulation circuitry which generates an output voltage proportional to chlorophyll-a concentration.

The following coefficients were used in SEASOFT through the software module SEACON as user defined polynomial:

S/N 2148 (unknown calibration date)

Gain setting :30X 0-5 ug/l

Offset :0.0

### **3.1.4 Data Collection and Processing**

#### 3.1.4-1 Data collection

CTD measurements were made using a SBE 9plus CTD equipped with two pumped temperature-conductivity (TC) sensors. The TC pairs were monitored to check drift and shifts by examining the differences between the two pairs.

The SBE 9plus CTD (sampling rate of 24 Hz) was mounted in a 36-positions Carousel frame. Auxiliary sensors included altimeter, dissolved oxygen sensor, fluorometer and Deep Ocean Standards Thermometer. Water samples were collected using a 36-positions SBE 32 Carousel Water



Sampler with 12 L Niskin-X bottles.

The package was lowered into the water from the starboard side and held 10 m beneath the surface for about one minute in order to activate the pump. After the pump was activated the package was lowered at a rate of 0.5 m/s to 100 m then the package was stopped in order to operate the heave compensator of the crane. The package was lowered again at a rate of 1.2 m/s to the bottom. The position of the package relative to the bottom was monitored by the altimeter reading. Also the bottom depth was monitored by the SEABEAM multibeam sounder on board. For the up cast, the package was lifted at a rate of 1.2 m/s except for bottle firing stops. At 100 m from the surface, the package was stopped in order to stop the heave compensator of the crane.

Niskin-X bottle samples were taken water for analysis of salinity, dissolved oxygen, nutrients, DIC, Total Alkalinity, pH, Freon, Radio Nuclear,  $^{14}\text{C}$ , N/Argon,  $^3\text{H}$ ,  $^3\text{He}/^4\text{He}$  and Bio Optical properties.

The SBE 11plus deck unit received the data signal from the CTD. Digitized data were forwarded to a personal computer running the SEASAVE module of the SEASOFT acquisition and processing software, version 4.25b. Temperature, salinity, oxygen and descent rate profiles were displayed in real-time with the package depth and altimeter reading.

#### 3.1.4-2 Data collection problems

At station P06W-X11, a fish was found in TC-duct(Primary) while washing the CTD after the cast. When the data were checked, abnormality was seen in the primary data of salinity and oxygen.

At station P06C-166, communication from the instrument failed at 1800 m depth during the up cast, and the cast was aborted. When the system was checked, the fluorometer was found to be leaking causing an electrical short. A second cast was done at the site with the fluorometer removed.

For stations P06C-126, 125, 123, 122 and 121, the SBE35 internal clock didn't work.

### 3.1.4-3 Data processing

SEASOFT consists of modular menu driven routines for acquisition, display, processing, and archiving of oceanographic data acquired with SBE equipment, and is designed to work with a compatible personal computer. Raw data are acquired from instruments and are stored as unmodified data. The conversion module DATCNV uses the instrument configuration and calibration coefficients to create a converted engineering unit data file that is operated on by all SEASOFT post processing modules. Each SEASOFT module that modifies the converted data file adds proper information to the header of the converted file permitting tracking of how the various oceanographic parameters were obtained. The converted data is stored in rows and columns of ascii numbers. The last data column is a flag field used to mark scans as good or bad.

The following are the SEASOFT-Win32 (Ver. 5.25b) processing module sequence and specifications used in the reduction of CTD data in this cruise. Some modules are originally developed for additional processing and post-cruise calibration.

DATCNV converted the raw data to scan number, pressure, depth, temperatures, conductivities, oxygen, oxygen voltage, chlorophyll-a concentration(to Stn. P06C-166), and altitude. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds.

ROSSUM created a summary of the bottle data. The bottle position, date, time were output as the first two columns. Scan number, pressure, depth, temperatures, conductivities, oxygen, oxygen voltage, chlorophyll-a concentration(to Stn. P06C-166), and altitude were averaged over 4.4 seconds.

ALIGNCTD converted the time-sequence of conductivity and oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. For a SBE 9plus CTD with the ducted temperature and conductivity sensors and a 3000 rpm pump, the typical net advance of the conductivity relative to the temperature is 0.073 seconds. So, the SBE 11plus deck unit was set to advance the primary conductivity for 1.73 scans ( $1.75/24 = 0.073$  seconds). As a result, the secondary conductivity was advanced 0.073 seconds relative to the temperature. Oxygen data are also systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing oxygen sensor outputs relative to the pressure.

WILDEDIT marked extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 48 scans. Data greater than two standard deviations were flagged. The second pass computed a standard deviation over the same 48 scans excluding the flagged values. Values greater than 10 standard deviations were marked bad. This process was applied to pressure, temperatures, conductivities, oxygen and altimeter outputs.

CELLTM used a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude  $\alpha = 0.03$  and the time constant  $1/\beta = 9.0$ .

FILTER performed a low pass filter on pressure with a time constant of 0.15 seconds. In order to produce zero phase lag (no time shift) the filter runs forward first then backwards.

WFILTER performed a median filter to remove spikes in the Fluorometer data. A median value was determined from a window of 49 scans.

WHPHEADER (original module) added information in header record correspond to the WHP CTD data (EXPCODE, WHP-ID, STNNBR, CASTNO, DATE, INSTRUMENT NO. and SAMPLING RATE).

SECTION selected a time span of data based on scan number in order to reduce a file size. The minimum number was set to be the starting time when the CTD package was beneath the sea-surface after activation of the pump. The maximum number was set to be the end time when the package came up from the surface. (Data to check the CTD pressure drift were prepared before SECTION.)

LOOPEDIT marked scans where the CTD was moving less than the minimum velocity of 0.0 m/s (traveling backwards due to ship roll).

BINAVG averaged the data into 1 dbar pressure bins. The center value of the first bin was set equal to the bin size. The bin minimum and maximum values are the center value plus and minus half the bin size. Scans with pressures greater than the minimum and less than or equal to the maximum were averaged. Scans were interpolated so that a data record exists every dbar.

DERIVE was re-used to compute salinity, potential temperature, and sigma-theta.

SPLIT was used to split data into the down cast and the up cast.

### 3.1.4-4 Data processing problem

Due to an error in altimeter coefficients in the configuration file, all CTD data were reprocessed using the correct altimeter coefficients.

### 3.1.5 Preliminary Results

The locations of CTD casts are attached in the SUMfile. In total, 122 castings were carried out. The section chart of all CTD cast are shown in Fig. 3.1.5.

Note that in these figures, the salinity data was not been calibrated by the in situ water sampled water.

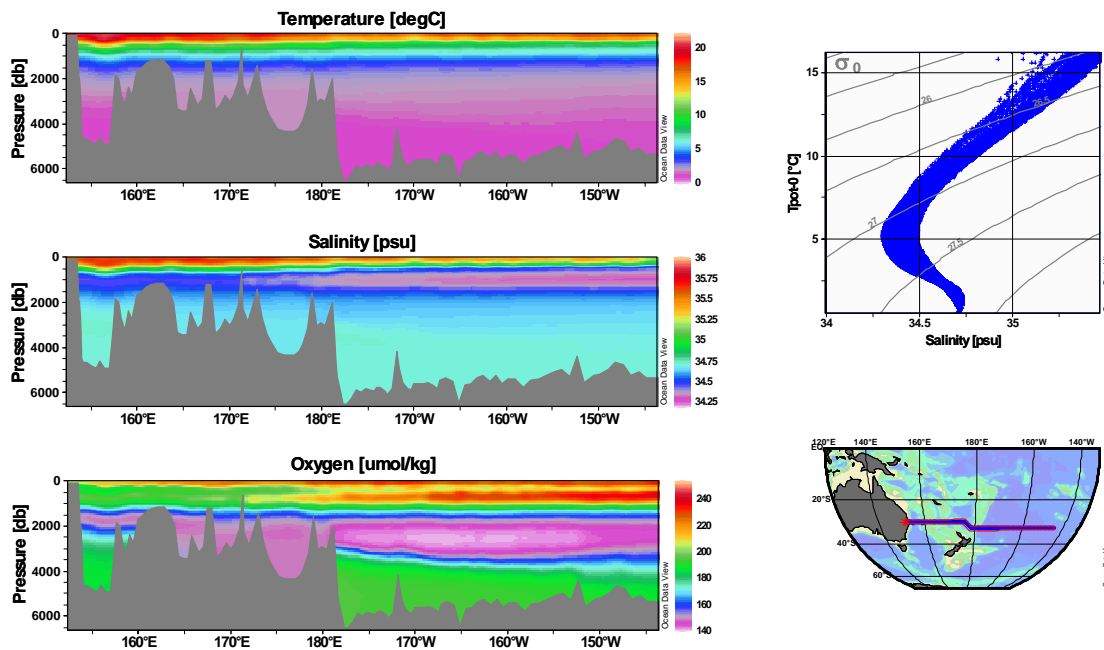


Fig.3.1.5 Section chart along 30°south

### 3.1.6 Necessary calibration

The post calibration schedules the following schedules.

S/N 03P4188	Sep. 2003
S/N 031464	Sep. 2003
S/N 041088	Oct. 2003
S/N 041202	Oct. 2003
S/N 430390	Oct. 2003
S/N 430205	Oct. 2003

### 3.1.7 Data archive

All raw and processed CTD data files were copied onto compact disks (CD) and submitted to JAMSTEC Data Management Office (DMO) and will be under their control.

## 3.2 Bottle Salinity

*Takeshi Kawano (JAMSTEC) and Naoko Takahashi (MWJ)*

### 3.2.1 Objectives

Bottle salinities were measured in order to be compared with CTD salinities to identify leaking bottles and calibrate CTD salinities.

### 3.2.2 Instrument and Method

#### 3.2.2-1 Salinity Sample Collection

The bottles in which the salinity samples are collected and stored are 250 ml Phoenix brown glass bottles with screw caps. Each bottle was rinsed three times with sample water and was filled to the shoulder of the bottle. The caps were also thoroughly rinsed. Salinity samples were stored for about 24 hours in the same laboratory as the salinity measurement was made.

#### 3.2.2-2 Instruments and Method

The salinity analysis was carried out on Guildline Autosol salinometer model 8400B (S/N 62556), which was modified by addition of an Ocean Science International peristaltic-type sample intake pump and two Guildline platinum thermometers model 9450. One thermometer monitored an ambient temperature and the other monitored a bath temperature. The resolution of the thermometers was 0.001 degC. The measurement system was almost same as Aoyama et al (2003). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 degC. An ambient temperature varied from approximately 20 degC to 23 degC, while a bath temperature is

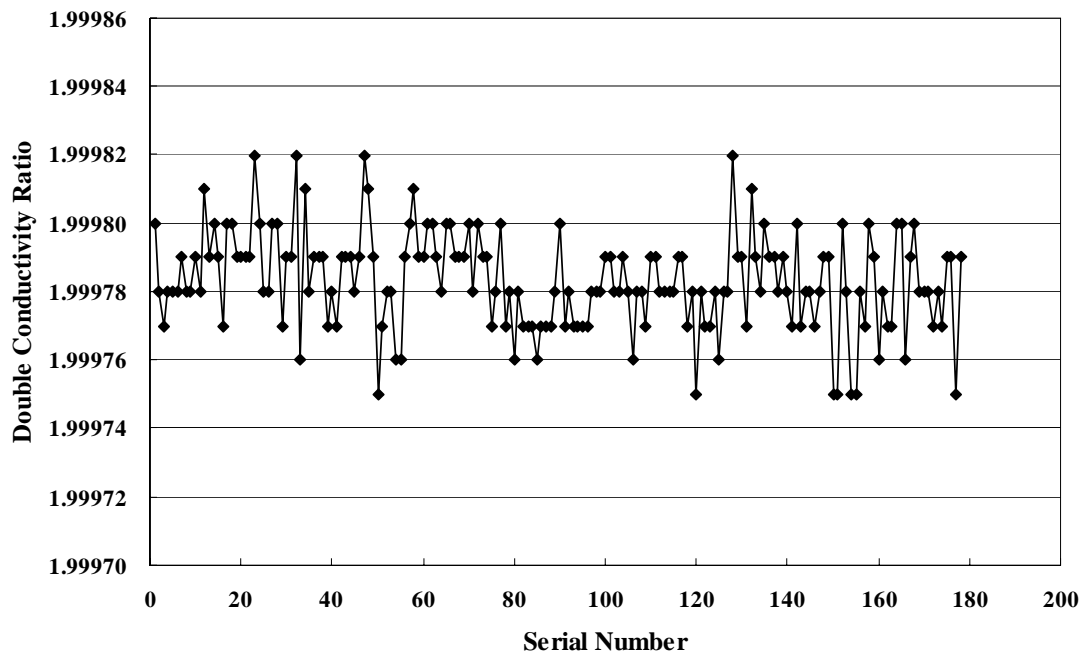
very stable and varied within  $\pm 0.002$  degC on rare occasion. A measure of a double conductivity ratio of a sample is taken as a median of thirty-one reading. Data collection was started after 5 seconds and it took about 10 seconds to collect 31 readings by a personal computer. Data were sampled for the sixth and seventh filling of the cell. In case the difference between the double conductivity ratio of this two fillings is smaller than 0.00003, the average value of the two double conductivity ratios was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to the 0.0003, we measured eighth filling of the cell. In case the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured ninth and tenth filling of the cell and the median of the double conductivity ratios of five fillings are used to calculate the bottle salinity.

The measurement was conducted 16hours per day (typically from noon to 04:00 in the next day) and the cell was rinsed by pure water every day and sometime cleaned by ethanol or soap or both after the measurement of the day.

### **3.2.3 Preliminary Result**

#### **3.2.3-1 Stand Seawater**

Standardization control was set to 638 and all the measurements were done by this setting. During the whole measurement, the STANDBY was 6107  $\pm$  0001 and ZERO was 0.00000 to 0.00001. We used IAPSO Standard Seawater batch P142 whose conductivity ratio was 0.99991 (double conductivity ratio is 1.99982) as the standard for salinity. We measured 178 ampoules of P142 and the average of the double conductivity ratio was 1.99978 and the standard deviation was 0.000014 which is equivalent to 0.0003 in salinity. Fig.3.2.1 shows the history of double conductivity ratio of the Standard Seawater batch P142. Since there was no significant trend in Fig.3.2.1 and the average of the double conductivity ratio was 1.99978, we add 0.00004 to all of the measured double conductivity ratio.



**Fig.3.2.1 The history of double conductivity ratio of the Standard Seawater batch P142**

**3.2.3-2. Sub-Standard Seawater**

We also used sub-standard seawater which was deep-sea water filtered by pore size of 0.45 micrometer and stored in a 20 liter cubitainer made of polyethylene and stirred for at least 24 hours before measuring. It was measured every six samples in order to check the possible sudden drift of the salinometer. During the whole measurements, there was no detectable sudden drift of the salinometer.

### 3.2.3-3 Replicate and Duplicate Samples

We took 692 pairs of replicate and 49 pairs of duplicate samples. Fig.3.2.2 (a) and (b) shows the histogram of the absolute difference between replicate samples and duplicate samples, respectively. There were seven bad measurements and six questionable measurements of replicate samples. As for questionable measurements, one of the pair is extremely high (more than 0.01 in salinity). This might be caused by insufficient seal of the sample bottles. Excluding these bad and questionable measurements, the standard deviation of the absolute difference of 679 pairs of replicate samples was 0.0002 in salinity and that of 49 pairs of duplicate samples was 0.0003 in salinity.

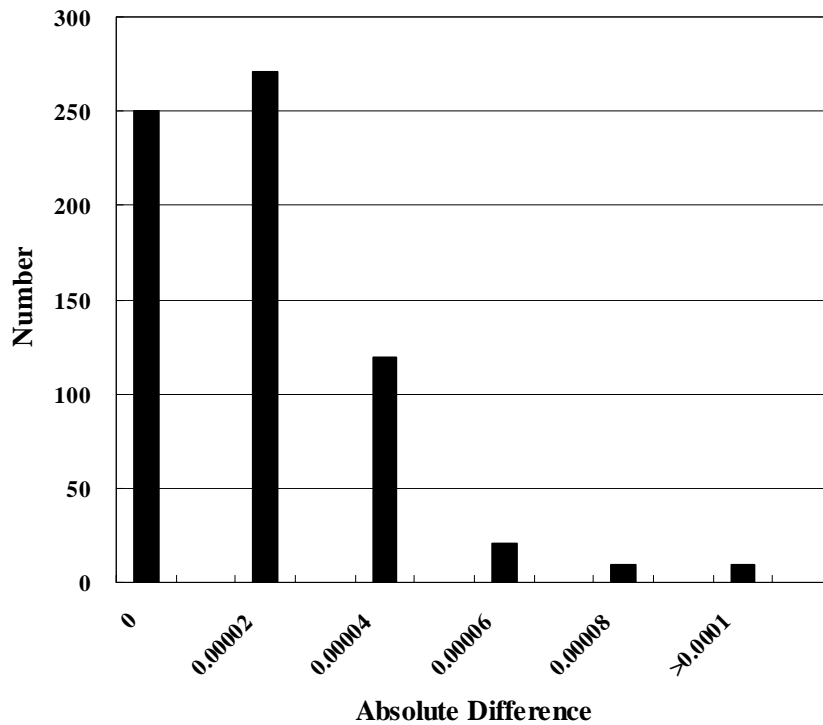
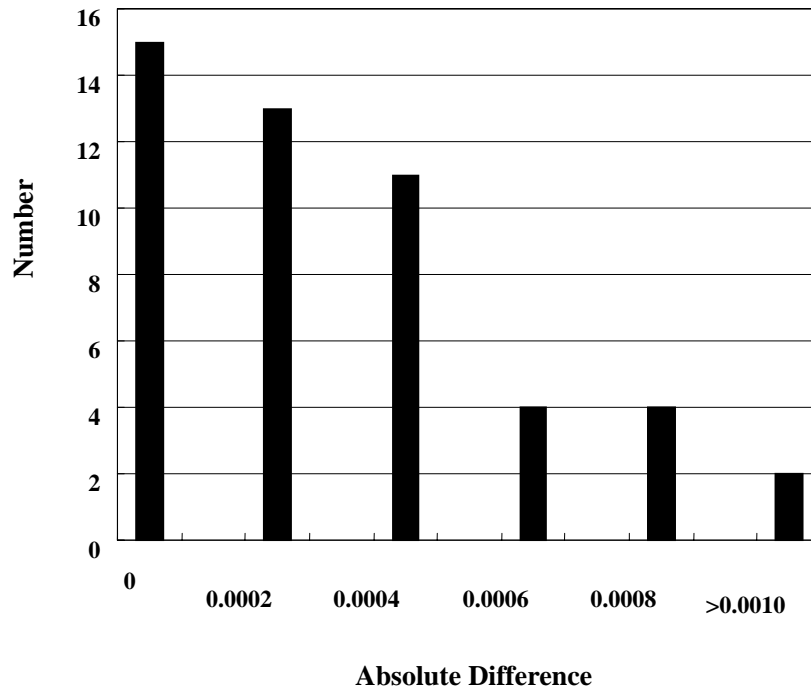


Fig.3.2-2 (a) The histogram of the absolute difference between replicate samples





**Fig.3.2.2 (b) The histogram of the absolute samples between duplicate samples.**

### 3.2.3-4 Figures

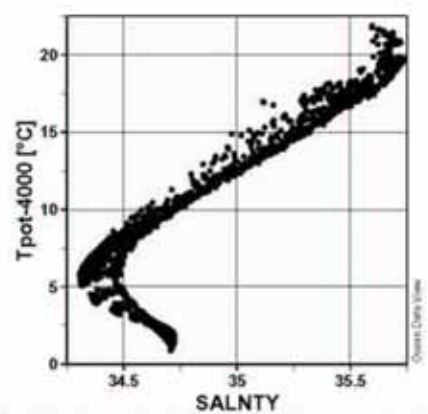
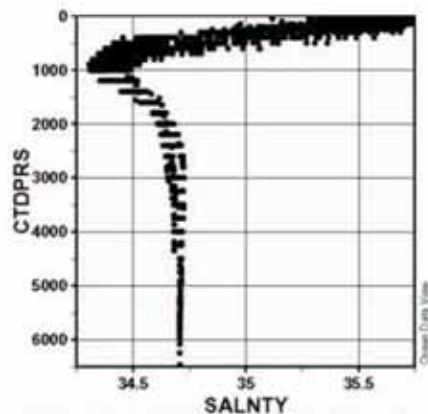
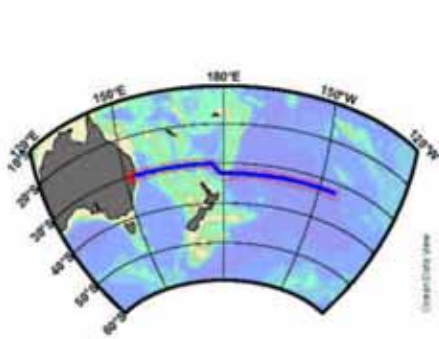
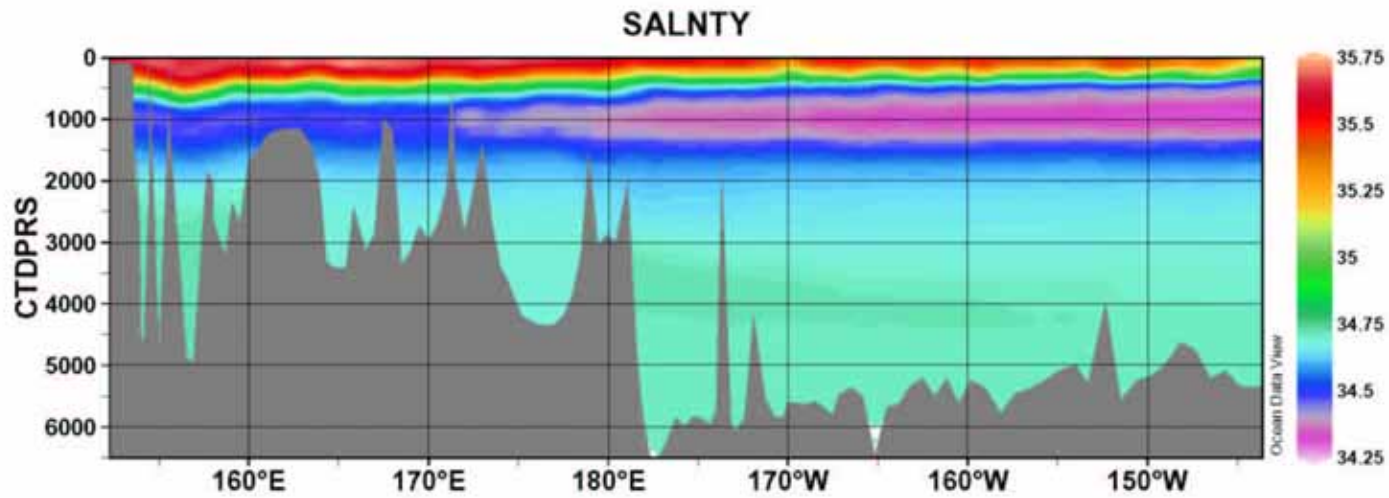
We measured about 4,200 samples in this leg. As a preliminary result, we will show a several figures without any interpretation. Fig.3.2.3 shows a vertical section of bottle salinity, vertical profile of bottle salinity and Sigma4-Salinity diagram produced by Ocean Data View. The same section, P06W and P06C, was observed in 1992. Fig.3.2.4 shows a vertical profile of bottle salinity in 1992 plotted with the profile obtained during this cruise (Bad and questionable measurements are not omitted).

### 3.2.4. Further data quality check

All the data will be checked once again in detail with other parameters such as dissolved oxygen and nutrients.

### 3.2.5. Reference

Aoyama, M., T. Joyce, T. Kawano and Y. Takatsuki : Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 49, 1103 ~ 1114, 2002  
 UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. UNESCO Tech. Papers in Mar. Sci., 36, 25 pp., 1981



C:\DOCUME~1\ADMINI~1\MYDOCU~1\MR23K9-10304E-1\NewCol; C:\DOCUME~1\ADMINI~1\MYDOCU~1\MR23K9-10304E-1\NewCol.dg; C:\DOCUME~1\ADMINI~1\MYDOCU~1\MR23K9-10304E-1\NewCol.doc; 5-ep05/2003 09)

Fig.3.2.3 vertical section, vertical profile of bottle salinity and Sigma4-Salinity diagram

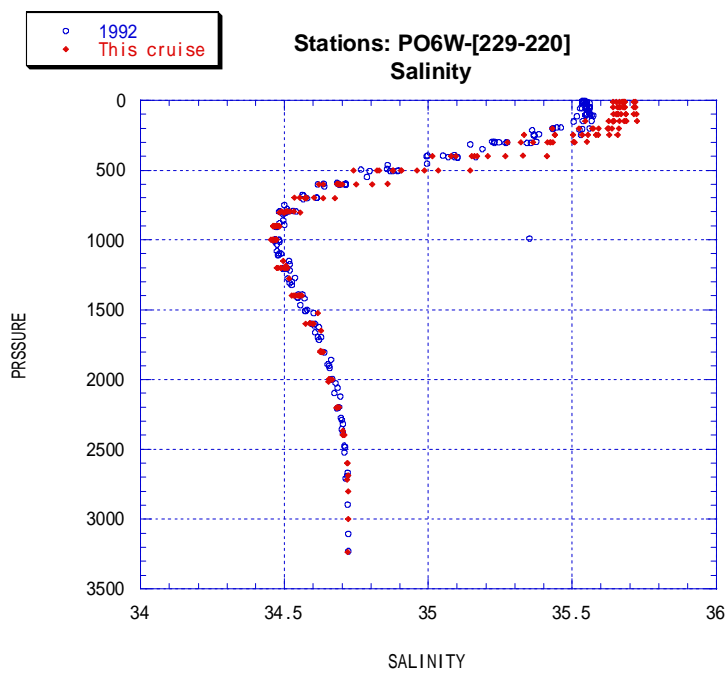
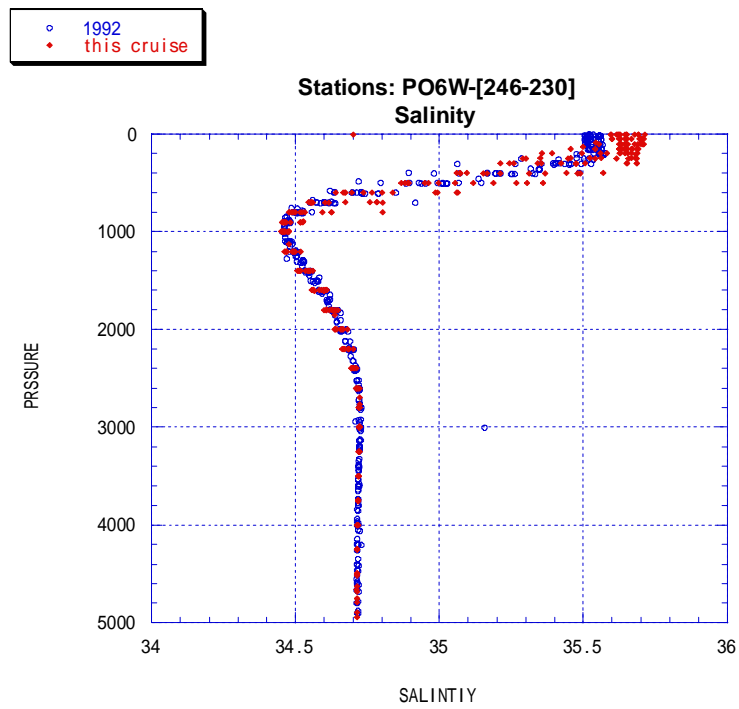


Fig.3.2.4 (a) Vertical Profile of salinity in 1992 (●) and this cruise (○).

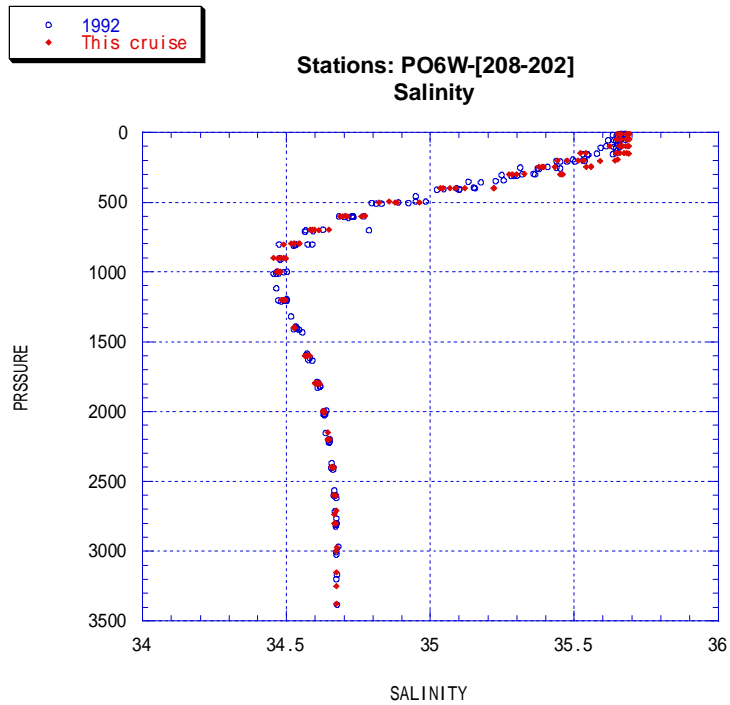
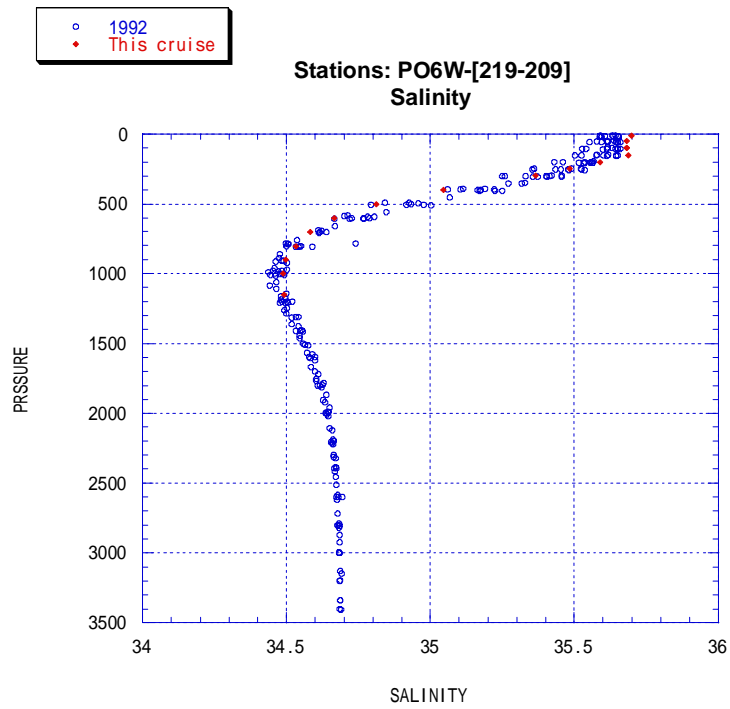


Fig.3.2.4 (b) Vertical Profile of salinity in 1992 (●) and this cruise ( ).

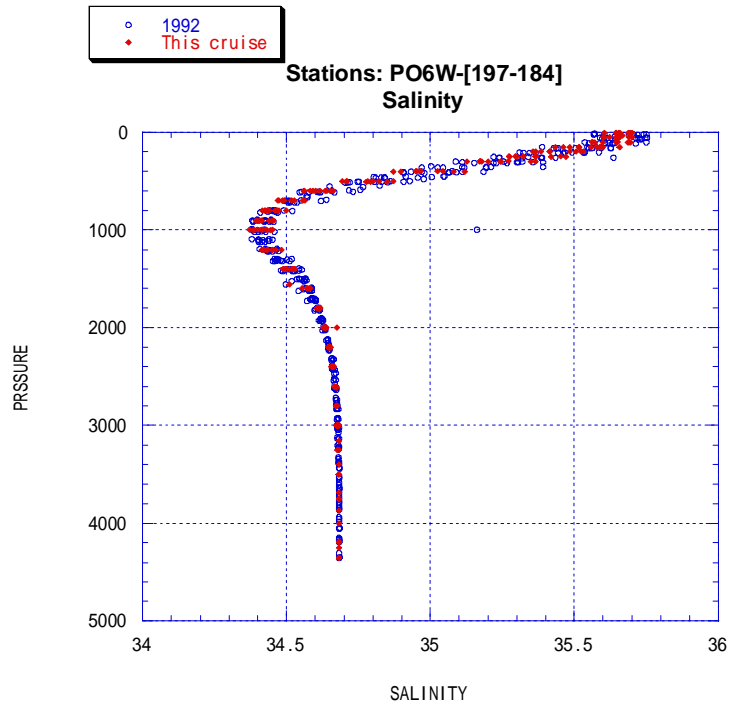
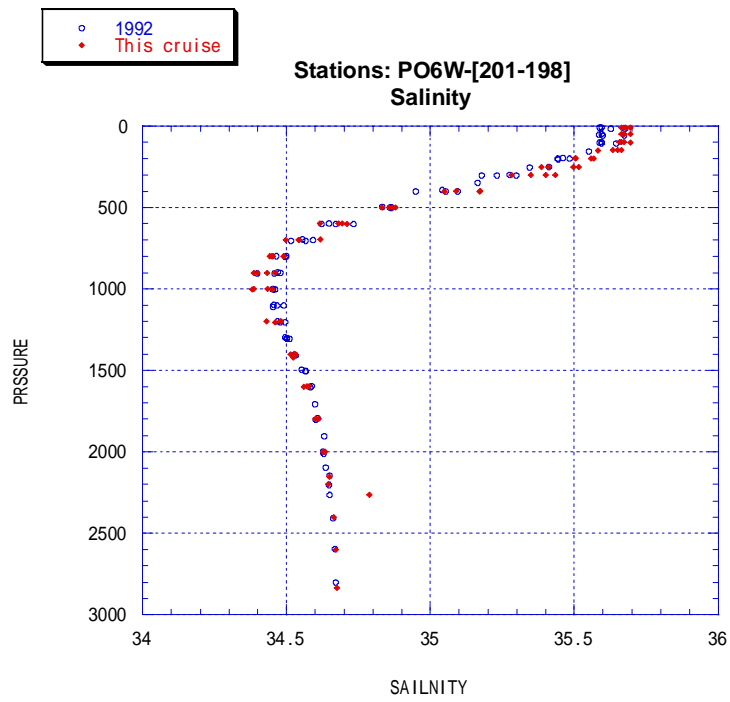


Fig.3.2.4 (c) Vertical Profile of salinity in 1992 (●) and this cruise ( ).

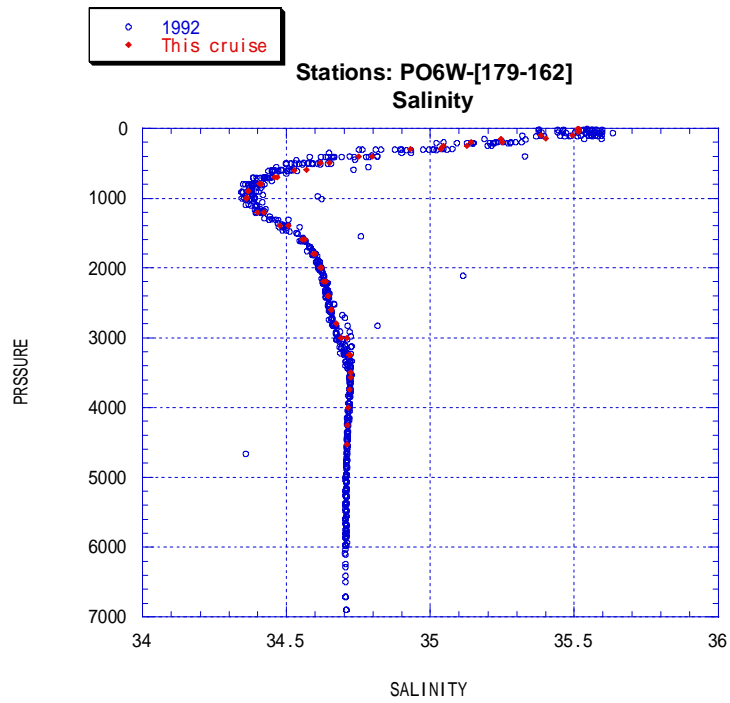
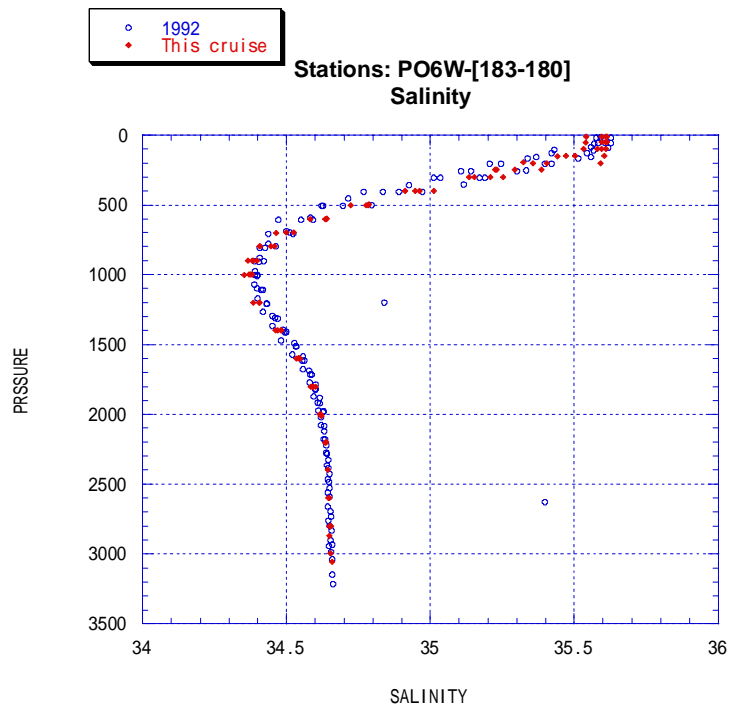


Fig.3.2.4 (d) Vertical Profile of salinity in 1992 (●) and this cruise ( ).

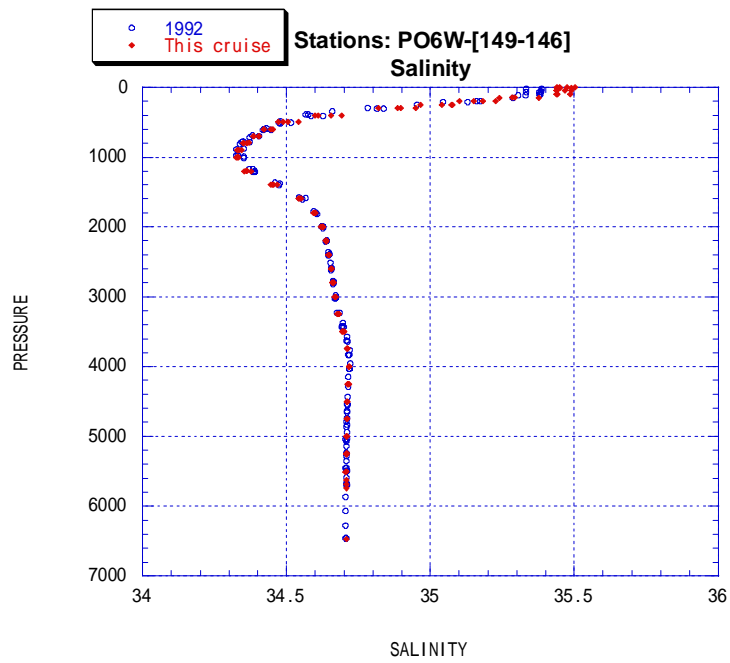
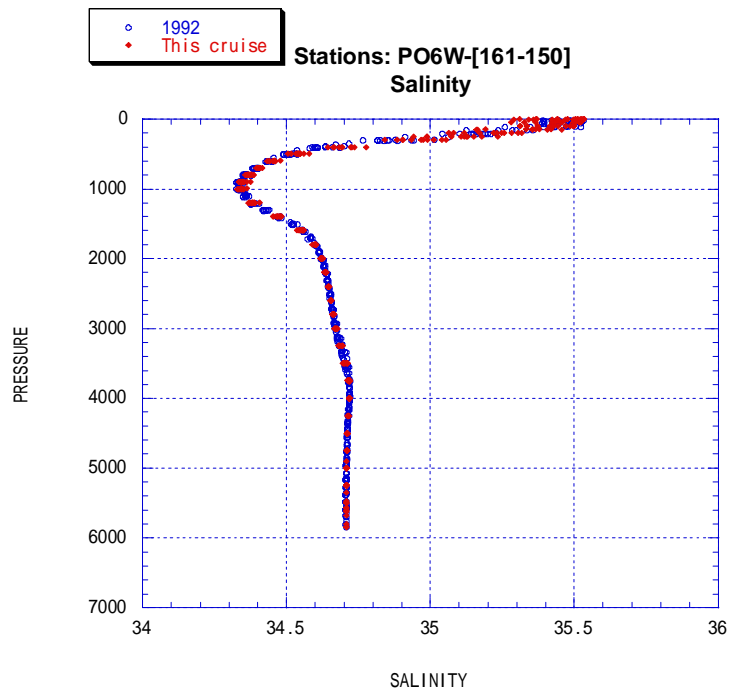


Fig.3.2.4 (e) Vertical Profile of salinity in 1992 (●) and this cruise (◆).

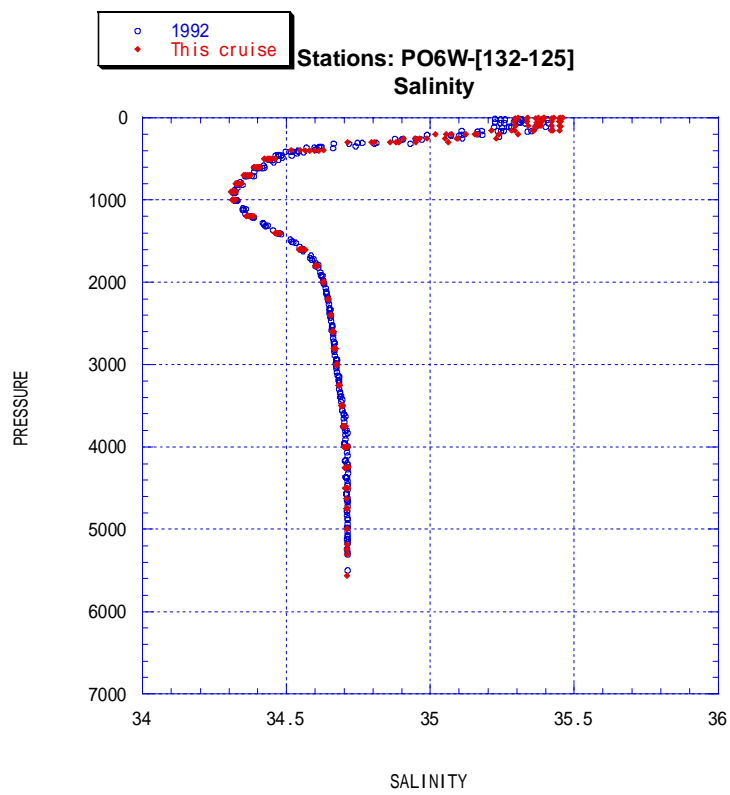
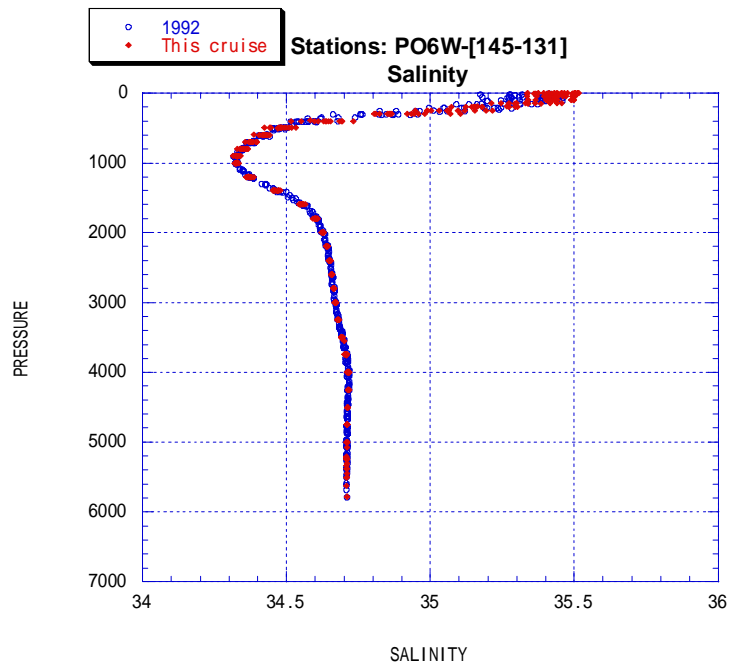


Fig.3.2.4 (f) Vertical Profile of salinity in 1992 (●) and this cruise (●).



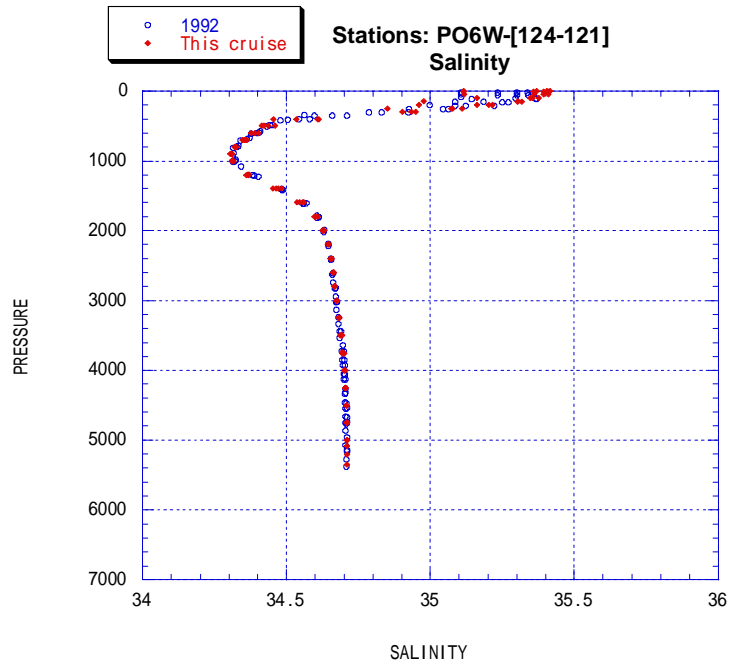


Fig3.2.4 (g) Vertical Profile of salinity in 1992 (●) and this cruise ( ).

### 3.3 Oxygen (Sep. 04, 2003)

Takayoshi Seike : Marine Works Japan Co. Ltd..

Ichiro Yamazaki : MWJ

Yuichiro Kumamoto : Ocean Observation and Research Department, JAMSTEC

#### 3.3.1 Objectives

Dissolved oxygen is one of the most significant tracer for the ocean circulation study. During the past decades, dissolved oxygen concentration in intermediate layers has decreased in the North Pacific. The causes of the decrease, however, are still unclear. In this cruise (MR03-K04 Leg.1), we measured dissolved oxygen concentration at all the stations along WHP P06W and P06C from 153.5°E to 144.8°W in the South Pacific. Our purposes are to compare our oxygen data in 2003 and those of WHP P06 in 1992.

#### 3.3.2 Methods

Reagents:

Pickling Reagent I: Manganous chloride solution (3M)

Pickling Reagent II: Sodium hydroxide (8M) / sodium iodide solution (4M)

Sulfuric acid solution (5M)

Sodium thiosulfate (0.025M)

Potassium iodate (0.001667M)

Instruments:

Burette for sodium thiosulfate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm<sup>3</sup> of titration vessel

Burette for potassium iodate;

APB-410 manufactured by Kyoto Electronic Co. Ltd. / 20 cm<sup>3</sup> of titration vessel

Detector and Software; Automatic photometric titrator manufactured by Kimoto Electronic Co. Ltd.

Sampling

Following procedure is based on the WHP Operations and Methods (Dickson, 1996).

Seawater samples were collected with Niskin bottle attached to the CTD-system. Seawater for oxygen measurement was transferred from Niskin sampler bottle to a volume calibrated flask (ca. 100 cm<sup>3</sup>). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent

I, II) of 0.5 cm<sup>3</sup> each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

#### Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. A magnetic stirrer bar and 1 cm<sup>3</sup> sulfuric acid solution were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose molarity was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise we measured dissolved oxygen concentration using two sets of the titration apparatus (DOT-1 and DOT-2). Dissolved oxygen concentration ( $\mu\text{mol kg}^{-1}$ ) was calculated by sample temperature during seawater sampling, salinity of the sample, and titrated volume of sodium thiosulfate solution without the blank.

#### Standardization and determination of the blank

Concentration of sodium thiosulfate titrant (ca. 0.025M) was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130°C. 1.7835 g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm<sup>3</sup> in a calibrated volumetric flask (0.001667M). 10 cm<sup>3</sup> of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 90 cm<sup>3</sup> of deionized water, 1 cm<sup>3</sup> of sulfuric acid solution, and 0.5 cm<sup>3</sup> of pickling reagent solution II and I were added into the flask in order. Amount of sodium thiosulfate titrated gave the molarity of sodium thiosulfate titrant.

The blank from the presence of redox species apart from oxygen in the reagents was determined as follows. 1 cm<sup>3</sup> of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 100 cm<sup>3</sup> of deionized water, 1 cm<sup>3</sup> of sulfuric acid solution, and 0.5 cm<sup>3</sup> of pickling reagent solution II and I were added into the flask in order. Just after titration of the first potassium iodate, a further 1 cm<sup>3</sup> of standard potassium iodate was added and titrated. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate. The oxygen in the pickling reagents I (0.5 cm<sup>3</sup>) and II (0.5 cm<sup>3</sup>) was assumed to be  $3.8 \times 10^{-8}$  mol (Dickson, 1996).

Table 3.3.1 shows results of the standardization and the blank determination during this cruise. The blank was less than 0.3  $\mu\text{mol/kg}$ . Reproducibility (C.V.) of standardization was less than 0.08 % (n = 5).

**Table 3.3.1 Results of the standardization and the blank determinations during MR03-K04 Leg.1**

Date (UTC)	Time (UTC)	KIO <sub>3</sub>		DOT-1 (cm <sup>3</sup> )			DOT-2 (cm <sup>3</sup> )			Samples (Stations)
		#	Bottle	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	E.P.	blank	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	E.P.	blank	
08-03-03	18:44	#1	030414-31	030411-7	3.969	0.006	030411-8	3.969	0.007	246,245,244
08-04-03	09:43		030414-32	030411-7	3.967	0.002	030411-8	3.967	0.008	243,242
08-04-03	15:57		030414-33	030411-7	3.964	0.005	030411-8	3.968	0.007	241
08-04-03	22:38		030414-34	030804-1	3.971	0.004	030804-2	3.968	0.004	240
08-05-03	05:09		030414-35	030804-1	3.968	0.007	030804-2	3.966	0.006	239
08-05-03	11:07		030414-36	030804-1	3.968	0.007	030804-2	3.968	0.007	238
08-05-03	16:53		030414-37	030804-1	3.966	0.005	030804-2	3.968	0.005	237
08-05-03	21:18		030414-38	030804-1	3.965	0.005	030804-2	3.970	0.006	X11
08-06-03	02:44		030414-39	030804-1	3.965	0.008	030804-2	3.968	0.005	235
08-06-03	09:50		030414-40	030804-3	3.970	0.007	030804-4	3.971	0.006	234,232
08-06-03	18:02		030414-41	030804-3	3.970	0.005	030804-4	3.969	0.005	231,230
08-06-03	23:48		030414-42	030804-3	3.967	0.005	030804-4	3.969	0.007	229,228
08-07-03	05:04		030414-43	030804-3	3.962	0.004	030804-4	3.965	0.006	227,226
08-07-03	14:14		030415-1	030804-5	3.968	0.007	030807-1	3.958	0.006	225,224,223
08-07-03	23:10	030415-2	030804-5	3.968	0.002	030807-1	3.957	0.005	222,221,220	
08-08-03	07:11	030415-3	030804-5	3.965	0.006	030807-1	3.957	0.005	219,218	
08-08-03	16:21	030415-4	030804-5	3.963	0.003	030807-1	3.956	0.005	217,216	
08-09-03	01:30	030415-5	030804-5	3.963	0.003	030807-1	3.951	0.007	216	
08-09-03	05:17	030415-6	030807-2	3.957	0.004	030807-3	3.958	0.006	215,214,213	
08-10-03	13:48	030415-7	030807-2	3.954	0.004	030807-3	3.956	0.005	212,211	
08-11-03	02:49	030415-8	030807-2	3.953	0.005	030807-3	3.950	0.007	210	
08-11-03	06:31	030415-9	030807-2	3.953	0.005	030807-3	3.951	0.007	209,208	
08-11-03	15:28	030415-10	030807-2	3.954	0.003	030807-3	3.953	0.007	207	
08-11-03	21:44	030415-11	030807-4	3.957	0.004	030807-5	3.959	0.007	206,205	
08-12-03	04:55	030415-12	030807-4	3.957	0.002	030807-5	3.956	0.008	204,203	
08-12-03	12:36	030415-13	030807-4	3.954	0.003	030807-5	3.955	0.007	202,201	
08-12-03	22:14	030415-16	030810-1	3.960	0.002	030810-2	3.961	0.007	200,199	
08-13-03	04:12	030415-17	030810-1	3.959	0.003	030810-2	3.958	0.006	198,197	
08-13-03	12:43	030415-18	030810-1	3.958	0.003	030810-2	3.958	0.008	196,195	
08-13-03	23:12	030415-19	030810-1	3.958	0.003	030810-2	3.959	0.007	194,X14	
08-14-03	12:08	030415-20	030810-3	3.961	0.005	030810-4	3.961	0.008	192,191	

Table 3.3.1 continued

Date (UTC)	Time (UTC)	KIO <sub>3</sub>		DOT-1 (cm <sup>3</sup> )			DOT-2 (cm <sup>3</sup> )			Samples (Stations)
		#	Bottle	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	E.P.	blank	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	E.P.	blank	
08-15-03	00:50		030415-21	030810-3	3.960	0.003	030810-4	3.959	0.008	190,186
08-15-03	10:32		030415-22	030810-3	3.960	0.004	030810-4	3.959	0.009	185,184
08-15-03	19:00		030415-23	030810-3	3.961	0.004	030810-4	3.959	0.008	183,182
08-16-03	05:06		030415-24	030810-5	3.963	0.008	030815-1	3.960	0.008	181,180
08-16-03	11:14		030415-25	030810-5	3.960	0.004	030815-1	3.957	0.008	179,178
08-17-03	23:02		030415-26	030810-5	3.960	0.003	030815-1	3.953	0.011	177
08-18-03	04:19		030415-27	030810-5	3.960	0.006	030815-1	3.951	0.007	176
08-18-03	12:31		030415-31	030815-2	3.959	0.003	030815-3	3.959	0.007	175
08-18-03	17:45		030415-32	030815-2	3.960	0.005	030815-3	3.955	0.009	174
08-19-03	03:37		030415-33	030815-2	3.958	0.004	030815-3	3.958	0.009	173,172
08-19-03	18:00		030415-34	030815-2	3.958	0.005	030815-3	3.958	0.009	171
08-20-03	02:09		030415-35	030815-4	3.946	0.006	030815-5	3.945	0.009	170,169
08-20-03	11:12		030415-36	030815-4	3.958	0.005	030815-5	3.959	0.008	168,167
08-20-03	21:21	#4	030415-37	030815-4	3.960	0.004	030815-5	3.960	0.011	166-1,2
08-21-03	03:54		030815-38	030815-4	3.960	0.006	030815-5	3.959	0.011	165
08-21-03	12:46		030415-39	030819-1	3.960	0.004	030819-2	3.961	0.010	164,163,162
08-22-03	03:43		030415-41	030819-1	3.957	0.002	030819-2	3.958	0.009	161,160
08-22-03	13:35		030415-42	030819-1	3.958	0.002	030819-2	3.960	0.009	159
08-22-03	19:24		030415-43	030819-1	3.959	0.002	030819-2	3.958	0.009	158
08-23-03	05:01		030417-1	030819-3	3.960	0.004	030819-4	3.961	0.010	X15,156
08-23-03	12:01		030417-2	030819-3	3.961	0.005	030819-4	3.961	0.010	155,154
08-24-03	23:08		030417-3	030819-3	3.960	0.004	030819-4	3.961	0.011	153,152
08-24-03	09:21		030417-4	030819-3	3.959	0.004	030819-4	3.960	0.011	151
08-24-03	17:22		030417-5	030819-5	3.959	0.002	030823-1	3.960	0.012	150,149
08-26-03	05:30		030417-6	030819-5	3.959	0.003	030823-1	3.959	0.008	148
08-26-03	16:05	#5	030417-7	030819-5	3.957	0.004	030823-1	3.959	0.010	147
08-26-03	22:48		030417-8	030819-5	3.958	0.004	030823-1	3.960	0.010	146
08-27-03	05:13		030417-9	030819-5	3.957	0.005	030823-1	3.956	0.012	145
08-27-03	12:49		030417-10	030823-2	3.959	0.003	030823-3	3.957	0.005	144,143
08-27-03	23:51		030417-11	030823-2	3.959	0.003	030823-3	3.960	0.006	142
08-28-03	04:50		030417-12	030823-2	3.959	0.004	030823-3	3.958	0.004	140

Table 3.3.1 continued

Date (UTC)	Time (UTC)	KIO <sub>3</sub>		DOT-1 (cm <sup>3</sup> )			DOT-2 (cm <sup>3</sup> )			Samples (Stations)
		#	Bottle	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	E.P.	blank	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	E.P.	blank	
08-28-03	10:06		030417-13	030823-2	3.958	0.006	030823-3	3.957	0.006	139,138
08-28-03	02:25	#6	030417-16	030823-4	3.961	0.005	030823-5	3.962	0.008	137,136
08-29-03	11:54		030417-17	030823-4	3.959	0.005	030823-5	3.960	0.007	135
08-29-03	19:00		030417-18	030823-4	3.961	0.002	030823-5	3.963	0.011	134,133
08-30-03	06:30		030417-19	030823-4	3.959	0.004	030823-5	3.960	0.009	132,131
08-30-03	21:51		030417-20	030828-1	3.960	0.005	030828-2	3.962	0.007	130,129
08-31-03	07:44		030417-21	030828-1	3.960	0.004	030828-2	3.963	0.009	X16
08-31-03	15:51		030417-22	030828-1	3.961	0.005	030828-2	3.962	0.009	127
08-31-03	22:59		030417-23	030828-1	3.961	0.005	030828-2	3.963	0.009	126
09-01-03	04:50		030417-24	030828-1	3.962	0.005	030828-2	3.963	0.009	125
09-01-03	11:54		030417-25	030828-3	3.958	0.003	030828-4	3.961	0.008	124,123
09-02-03	00:17		030417-26	030828-3	3.959	0.003	030828-4	3.962	0.010	122
09-02-03	06:12		030417-27	030828-3	3.958	0.003	030828-4	3.958	0.008	121

### 3.3.3 Reproducibility of sample measurement

Replicate samples were taken at every CTD cast; usually these were 5 - 10 % of seawater samples of each cast during this cruise. Results of the replicate samples were shown in Table 2. The standard deviation was calculated by a procedure (SOP23) in DOE (1994).

**Table 2 Results of the replicate sample measurements**

Number of replicate sample pairs	Oxygen concentration (μmol/kg)
	Standard Deviation.
194	0.09

### 3.3.4 Post-cruise calibrations

We will calibrate oxygen data that obtained on board using results of the CSK standard solution (potassium iodate solution, 0.001667M) and reassess the standardizations and the blank determinations.

### 3.3.5 Preliminary results

During this cruise we measured oxygen concentration in 3,411 seawater samples. Distribution of dissolved oxygen (30 ~ 32°S, 153.5°E ~ 144.8°W) were shown in Fig.3.3.1 that obviously shows three water mass; Antarctic Intermediate Water (AAIW), Pacific Deep Water (PDW), and Antarctic Bottom Water (ABW) in the east of the date line. We compared our oxygen data in 2003 and those of WHP P06 in 1992. Below 4000 m depth, the oxygen concentration difference between two cruises is less than  $1 \mu\text{mol kg}^{-1}$  approximately. Thus we believe that there is not “offset” of oxygen measurements between the cruises in 1992 and 2003. In shallower depths including AAIW (400 – 1000 m dept), significant oxygen change between 1992 and 2003 was not found. This contrasts well with recent decrease of oxygen concentration in intermediate water in the North Pacific (Emerson *et al.*, 2001; Watanabe *et al.*, 2001). Although we found slight oxygen increase (less than  $10 \mu\text{mol kg}^{-1}$ ) in lower AAIW at some stations, it is unknown whether the increase is decadal change of intermediate oxygen concentration or not.

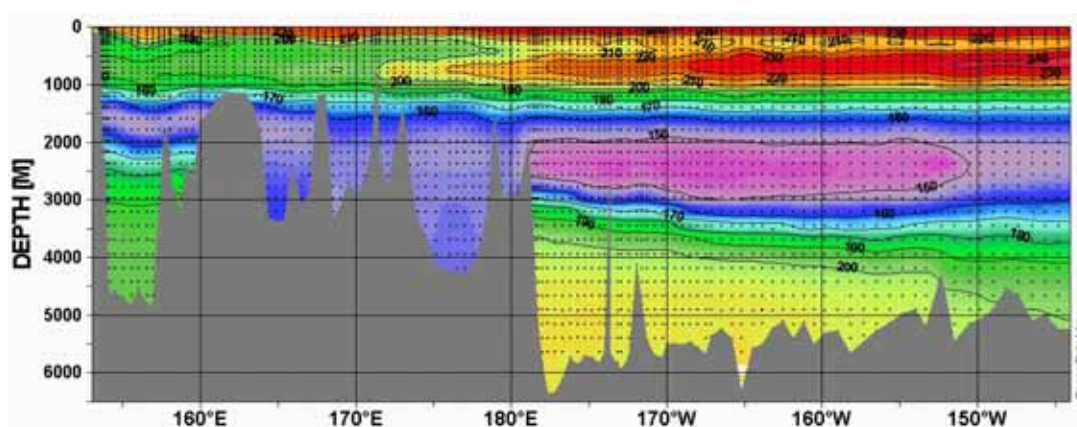


Fig.3.3.1 Dissolved oxygen concentration ( $\mu\text{mol / kg}$ ) in 2003. This figure was drawn using Ocean Data View (R. Schlitzer, <http://www.awi-bremerhaven.de/GEO/ODV>, 2002).

### 3.3.5 References:

- Dickson, A. (1996) Dissolved Oxygen, in WHP Operations and Methods, Woods Hole, pp1-13.
- DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2. A.G Dickson and C. Goyet (eds), ORNL/CDIAC-74.
- Emerson, S, S. Mecking and J.Abell (2001) The biological pump in the subtropical North Pacific Ocean: nutrient sources, redfield ratios, and recent changes. *Global Biogeochem. Cycles*, 15, 535-554.
- Watanabe, Y. W., T. Ono, A. Shimamoto, T. Sugimoto, M. Wakita and S. Watanabe (2001) Probability of a reduction in the formation rate of subsurface water in the North Pacific during the 1980s and 1990s. *Geophys. Res. Letts.*, 28, 3298-3292.

**3.4 Nutrients** (Ver. 1.0, 2 Sept. 2003 ; Ver. 2.3, 3 Sept. 2003 ; Ver. 2.4, 15 Sept. 2003 ; Ver. 3.0, 16 Oct. 2003 ; Ver.4.0, 26 Oct. 2003 ; Ver. 4.1, 24 Nov. 2003)

Michio AOYAMA :Geochemical Res. Dep., Meteorological Res. Inst., Japan

Junko HAMANAKA, Asako KUBO, Shinichiro YOKOGAWA : Marine Works Japan Co. Ltd.

### **3.4.1 Objectives**

The objectives of nutrients analyses during the R/V Mirai around the world cruises along ca. 30 deg. S in the Southern Hemisphere are as follows;

- 1) Describe the present status of nutrients in 2003-2004 in good traceability throughout the cruises. The target nutrients are nitrate, nitrite, phosphate and silicate (Although acid is correct, we use silicate because silicate is widely used in oceanographic community.).
- 2) Study the temporal and spatial variation of nutrients based on the previous high quality experiments data of WOCE, GOSECS , IGY and so on.
- 3) Study of temporal and spatial variation of nitrate:phosphate ratio, so called Redfield ratio.
- 4) Obtain more accurate estimation of total amount of nitrate, phosphate and silicate silicic acid? in the interested area.
- 5) Provide more accurate nutrients data for physical oceanographers to use as tracers of water mass movement.

### **3.4.2 Equipment and techniques**

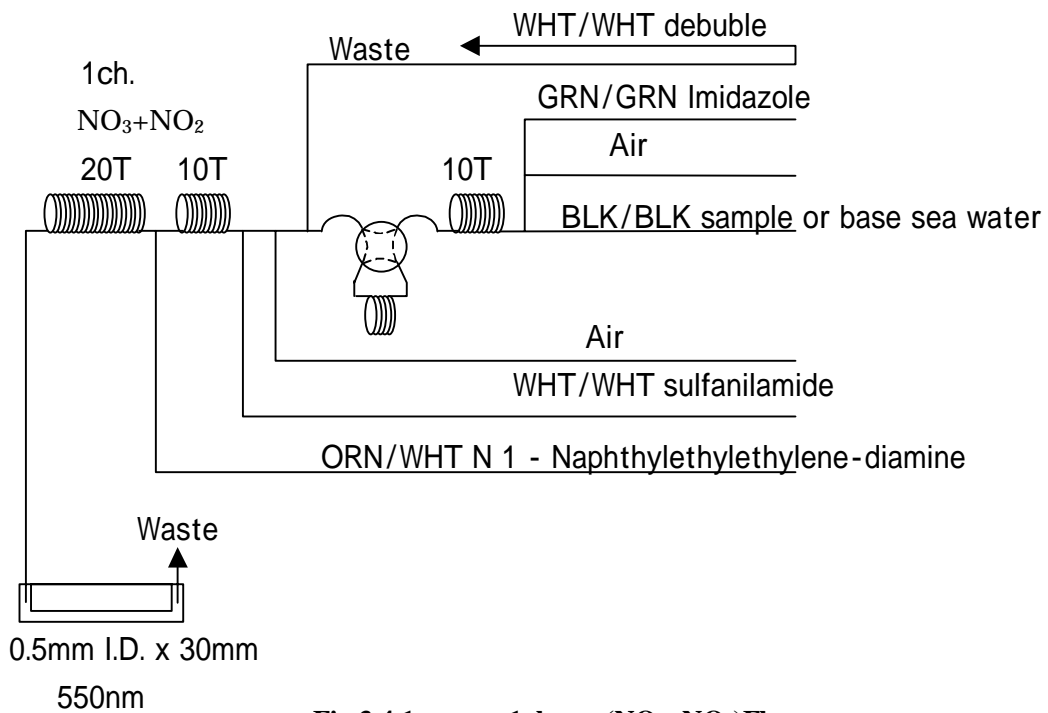
#### **3.4.2-1 Analytical detail using TRAACS 800 systems (BRAN+LUEBBE)**

The phosphate analysis is a modification of the procedure of Murphy and Riley (1962). Molybdic acid is added to the seawater sample to form phosphomolybdic acid which is in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

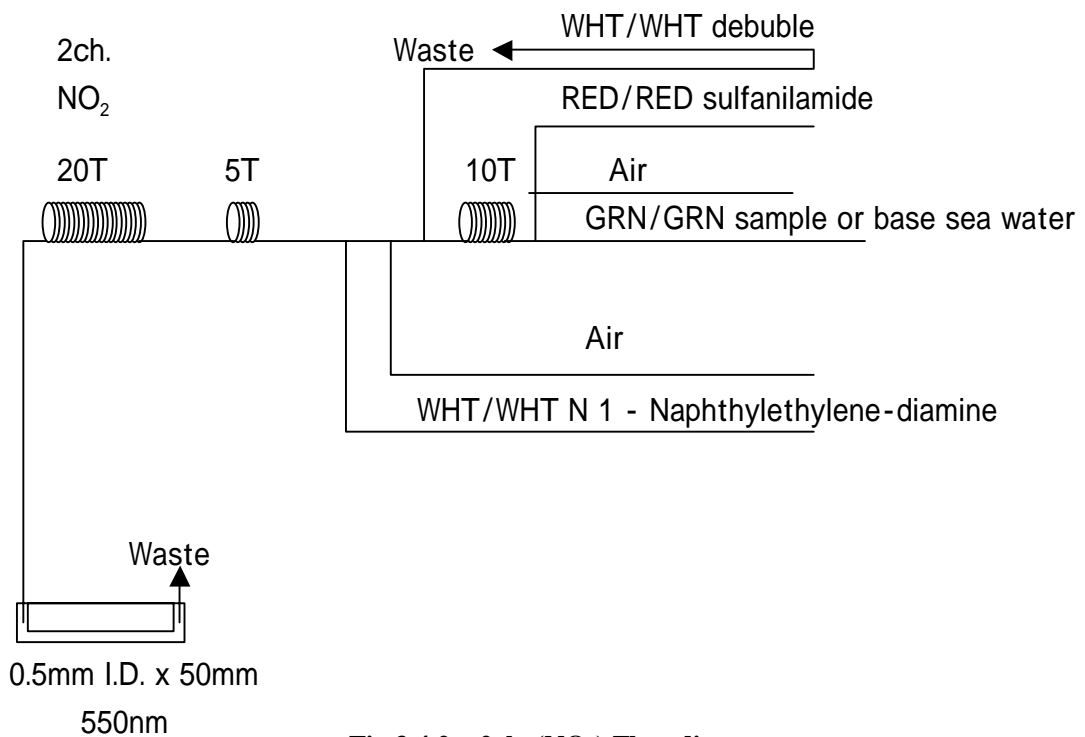
Nitrate + nitrite and nitrite are analyzed according to the modification method of Grasshoff (1970).

The sample nitrate is reduced to nitrite in a cadmium tube inside of which is coated with metallic copper. The sample stream with its equivalent nitrite is treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacts with the sulfanilamide to produce a diazonium ion. N1-Naphthylethylene-diamine added to the sample stream then couples with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite react and are measured; without reduction, only nitrite reacts. Thus, for the nitrite analysis, no reduction is performed and the alkaline buffer is not necessary. Nitrate is computed by difference.

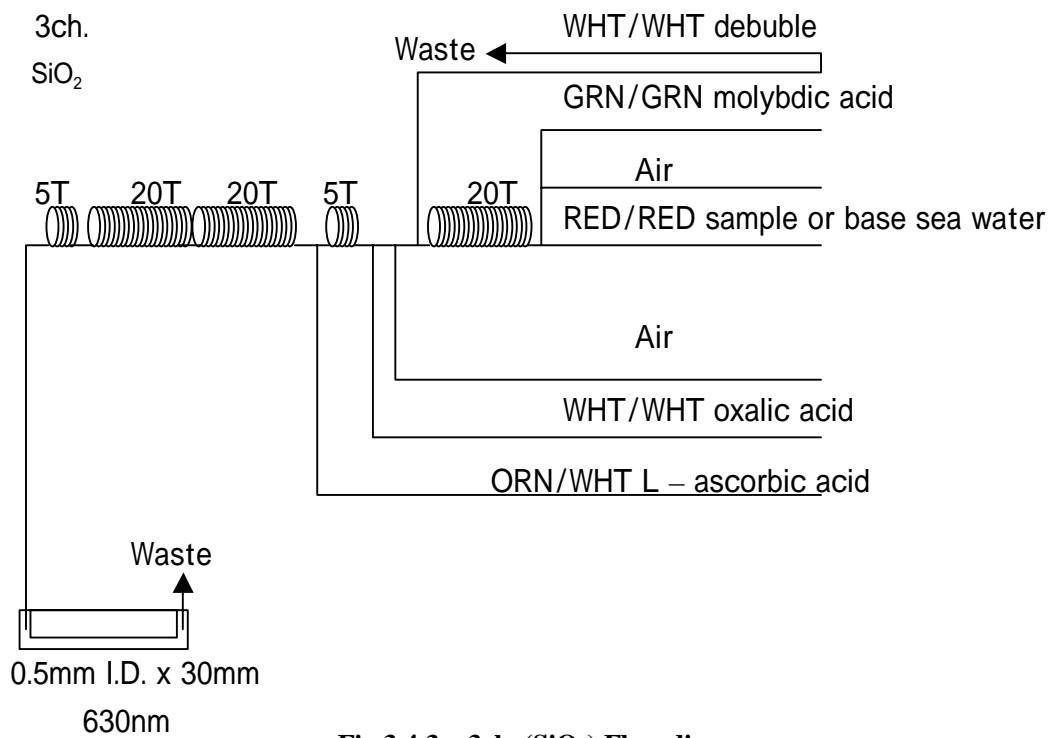




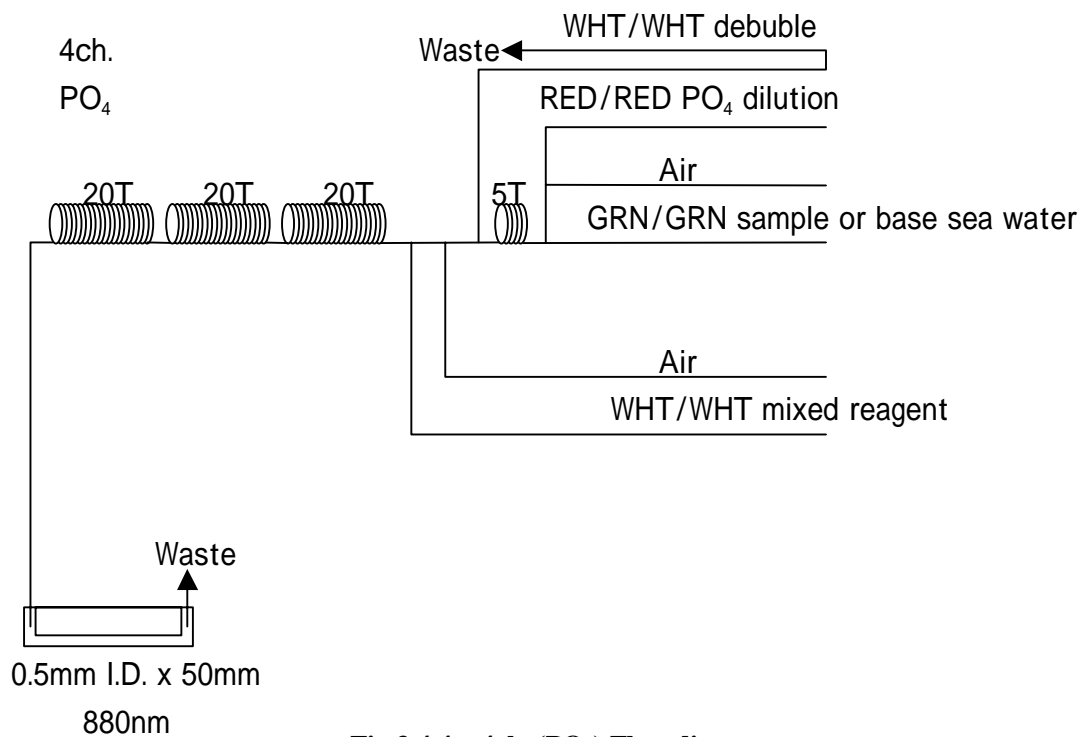
**Fig.3.4.1 1ch. (NO<sub>3</sub>+NO<sub>2</sub>)Flow**



**Fig.3.4.2 2ch. (NO<sub>2</sub>) Flow diagram.**



**Fig.3.4.3 3ch. (SiO<sub>2</sub>) Flow diagram.**



**Fig.3.4.4 4ch. (PO<sub>4</sub>) Flow diagram.**

The silicic acid (hereafter silicate) method is analogous to that described for phosphate. The method used is essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid is first formed from the silicic acid in the sample and added molybdic acid; then the silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using ascorbic acid as the reductant.

The flow diagrams for each parameter are shown in Fig.3.4.

### **3.4.2-2 Sampling procedures**

Sampling of nutrients followed that oxygen, trace gases and salinity. Samples were drawn into two of virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials are put into water bath at 22 degC in 10 minutes before use to stabilize the temperature of samples.

No transfer was made and the vials were set an auto sampler tray directly. Samples were analyzed as rapidly as possible after collection, and then the samples were analyzed within 5 hours. Several samples were stored longer than usual and analyzed within 7-8 hours after collection.

### **3.4.2-3 Data processing.**

Raw data from TRAACS800 were treated as follows;

Check baseline shift.

Check the shape of each peak and positions of peak values taken, then change the positions of peak values taken if necessary.

Load pressure and salinity from CTD data.

Calibration curves were assumed second order equations.

### **3.4.3 Nutrients standards**

#### **3.4.3-1 In-house standards**

##### **3.4.3-1.1 Volumetric Laboratory Ware.**

All volumetric glass- and plastic(PMP)-ware used were gravimetrically calibrated. Plastic volumetric flasks were gravimetrically calibrated at the temperature of use within 2-3 K

##### **3.4.3-1.1.1. Volumetric flasks.**

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05% or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicic acid from the glass. High quality plastic (polymethylpentene, PMP, or polypropylene) volumetric flasks were gravimetrically calibrated and used only within 2-3 K of the calibration

temperature.

The computation of volume contained by glass flasks at various temperatures other than the calibration temperatures were done by using the coefficient of linear expansion of borosilicate crown glass.

Because of their larger temperature coefficients of cubical expansion and lack of tables constructed for these materials, the plastic volumetric flasks were gravimetrically calibrated over the temperature range of intended use and used at the temperature of calibration within 2 K . The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

#### 3.4.3-1.2.2. Pipettes and pipettors.

All pipettes have nominal calibration tolerances of 0.1% or better. These were gravimetrically calibrated in order to verify and improve upon this nominal tolerance.

### 3.4.3-1.2 REAGENTS, GENERAL CONSIDERATIONS

#### 3.4.3-1.2.1 General Specifications.

All reagents were of very high purity such as "Analytical Grade," "Analyzed Reagent Grade" and others. And assay of nitrite was determined according JISK8019 and assays of nitrite salts was 98.9%. We use that value to adjust the weights taken.

#### 3.4.3-1.2.2 Ultra pure water.

Ultra pure water (MilliQ water) freshly drawn was used for preparation of reagents, higher concentration standards and for measurement of reagent and system blanks.

#### 3.1.3-1.3.1.2.3 Low-Nutrient Seawater (LNSW).

Surface water having low nutrient concentration was taken and filtered using 0.45  $\mu\text{m}$  pore size membrane filter. This water is stored in 20 liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in May 2003.

#### 3.4.3-1.3.1.3 Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards are set as shown in Table 3.4.1 The C standard are prepared according recipes as shown in Table 3.4.2 All volumetric laboratory tools were calibrated prior the cruise as stated in chapter 3.1.1. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric lab. Wares.

**Table 3.4.1 Nominal concentrations of nutrients for A, B and C standards**

	A	B	C-1	C-2	C-3	C-4	C-5
NO <sub>3</sub> ( $\mu$ M)	45000	1350	0.0	13.5	27.0	40.5	54.0
NO <sub>2</sub> ( $\mu$ M)	4000	40	0.0	0.4	0.8	1.2	1.6
SiO <sub>2</sub> ( $\mu$ M)	36000	5040	0.0	50	100	150	200
PO <sub>4</sub> ( $\mu$ M)	4500	90	0.0	0.9	1.8	2.7	3.6

**Table 3.4.2 Working calibration standard recipes**

C-STD	B-1 STD	B-2 STD	MAT
C-1	0 ml	0 ml	40 ml
C-2	5 ml	5 ml	30 ml
C-3	10 ml	10 ml	20 ml
C-4	15 ml	15 ml	10 ml
C-5	20 ml	20 ml	0 ml

3.4.3-1.4 Renewal of in-house standard solutions.

In-house standard solutions as stated in 3.4.3 were renewed as shown in Table 3.4.3

### 3.4.3-2 RMNS

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge number of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., submitted). In the previous world wide expeditions, such as WOCE cruises, the higher reproducibility and precision of nutrients measurements were required (Joyce and Corry, 1994). Since no standards were available for the measurement of nutrients in seawater at that time, the

requirements were described in term of reproducibility. The required reproducibility was 1%, 1-2%, 1-3% for nitrate, phosphate and silicate, respectively. Although nutrient data from the WOCE one-time survey was of unprecedented quality and coverage due to much care in sampling and measurements, the differences of nutrients concentration at crossover points are still found among the expeditions (Aoyama and Joyce, 1996, Mordy et al., 2000, Gouretski and Jancke, 2001). For instance, the mean offset of nitrate concentration at deep waters was 0.5  $\mu$ mol kg<sup>-1</sup> for 345 crossovers at world oceans, though the maximum was 1.7  $\mu$ mol kg<sup>-1</sup> (Gouretski and Jancke, 2001). At the 31 crossover points in the Pacific WHP one-time lines, the WOCE standard of reproducibility

for nitrate of 1% was fulfilled at about half of the crossover points and the maximum difference was 7% at deeper layers below 1.6 deg C in potential temperature (Aoyama and Joyce, 1996).

**Table 3.4.3 Timing of renewal of in-house standards.**

NO <sub>3</sub> , SiO <sub>2</sub> , PO <sub>4</sub>	Renewal
A-1S t d. (NO <sub>3</sub> )	maximum 10 days
A-3S t d. (SiO <sub>2</sub> )	comercial prepared solution
A-4S t d. (PO <sub>4</sub> )	maximum 14 days
B-1S t d. (mixture of A-1,3 and 4 Std. )	2 days

NO <sub>2</sub>	Renewal
A-2S t d. (NO <sub>2</sub> )	maximum 14 days
B-2S t d. (NO <sub>2</sub> )	maximum 14 days

C Std	Renewal
C1 ~ C5 Std ( mixture of B1 and B2 Std. )	24 hours

Reduction estimation	Renewal
D-1S t d.	when A-1renewed
44μM NO <sub>3</sub>	when C-std renewed
47μM NO <sub>2</sub>	when C-std renewed

### 3.4.3-2.1 RMNS preparation

#### 3.4.3-2.1.1 RMNS preparation and homogeneity for previous lots.

The study on reference material for nutrients in seawater (RMNS) on the seawater base has been carried out to establish traceability on nutrient analyses in seawater since 1994 in Japan. Autoclaving to produce RMNS has been studied (Aminot and Kerouel, 1991, 1995) and autoclaving was used to stabilize the samples for the 5th intercompariosn exercise in 1992/1993 (Aminot and Kirkwood, 1995). Aminot and Kerouel (1995) concluded that nitrate and nitrite were extremely

stable throughout their 27 months storage experiment with overall standard deviations lower than 0.3% (range 5-50  $\mu\text{mol l}^{-1}$ ) and 0.8% (range 0.5-5  $\mu\text{mol l}^{-1}$ ), respectively. For phosphate, slight increase by 0.02-0.07  $\mu\text{mol l}^{-1}$  per year was observed due to the leaching from the container glass.

The main source of nutrient variation in seawater is believed to be microorganism activity, hence, production of RMNS depends on biological inactivation of samples. In this point of view, previous study showed that autoclaving to inactivate the biological activity is acceptable for RMNS preparation.

The seawater for RMNS production was sampled in the North Pacific Ocean at the depths of surface where the nutrients are almost depleted and 1500-2000 meters depth where the nutrients concentrations are the maximum. The seawater was gravity-filtered through a membrane filter with a pore size of 0.45  $\mu\text{m}$  (Millipore HA). The latest procedure of autoclaving for RMNS preparation is that the seawater in a stainless steel container of 40 liters was autoclaved at 120 degC, 2 hours, 2 times during two days. The filling procedure of autoclaved seawater was basically same throughout our study. Following cooling at room temperature in two days, polypropylene bottle of 100 ml capacity were filled by the autoclaved seawater of 90 ml through a membrane filter with a pore size of 0.2  $\mu\text{m}$  (Millipore HA) at a clean bench in a clean room. The polypropylene caps were immediately tightly screwed on and a label containing lot number and serial number of the bottle was attached on all of the bottles. Then the bottles were vacuum-sealed to avoid potential contamination from the environment.

#### 3.4.3-2.1.2. 180 RMNS packages and 500 bottles of lot AH for this cruise

RMNS lots T, AN, AK, AM and O are prepared to cover the nutrients concentrations in the interested sea area. About 180 sets of 5 RMNS lots are prepared. These packages will be used daily when in-house standard solutions renewed daily. 500 bottles of RMNS lot AH are prepared to use every analysis at every hydrographic stations planned about 500 during the cruise. These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room, REGENT STORE, where the temperature was maintained between 21.7 degC and 23.2 degC.

#### 3.4.3-2.2 The homogeneity of RMNS and consensus values of the lot AH

The homogeneity of lot AH and analytical precision are shown in Table 3.4.4 These are for the assessment of the magnitude of homogeneity of the RMNS bottles those are used during the cruise. As shown in Table 3.4.4 the homogeneity of RMNS lot AH for nitrate and silicate are the same magnitude of analytical precision derived from fresh raw seawater. The homogeneity for phosphate, however, exceeded the analytical precision at about factor two. The homogeneity for lot AH is same order of magnitude for previous RMNS of lot K.

**Table 3.4.4 Homogeneity of lot AH derived from 30 samples measurements and analytical precision onboard R/V Mirai in May 2003.**

	Phosphate CV%	Nitrate	Silicate
RMNS			
AH	0.83%	0.39%	0.13%
(K)	(1.0%)	(0.3%)	(0.2%)
Precision	0.39%	0.36%	0.13%

note: N=30 x 2

### 3.4.4 Quality control

#### 3.4.4-1 Precision of nutrients analyses during the cruise

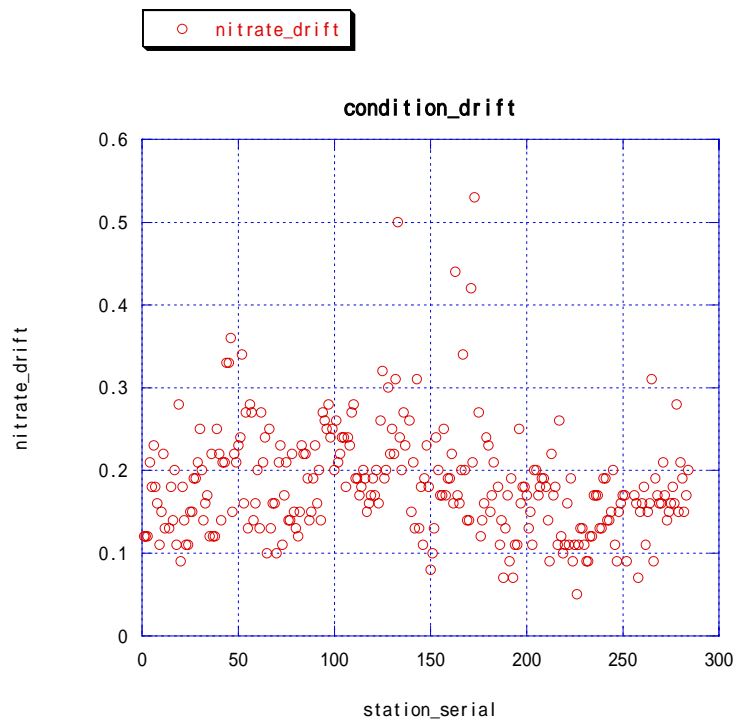
Precision of nutrients analyses during the cruise was evaluated based on the 13 measurements, which are measured every 10-15 samples, during a run at the concentration of C-5. We also evaluated the reproducibility based on the replicate analyses of five samples in each run. Summary of precisions are shown in Table 4.1. As shown in Table 3.4.5 and Fig.3.4.5-3.4.7 the precisions for each parameters are generally good considering the analytical precisions estimated from the simultaneous analyses of 60 samples in May 2003. Analytical precisions previously evaluated were 0.39% for phosphate, 0.36% for nitrate and 0.13% for silicate, respectively. Then we can conclude that the analytical precisions for phosphate, nitrate and silicate were maintained throughout leg 1 except a few outliers.



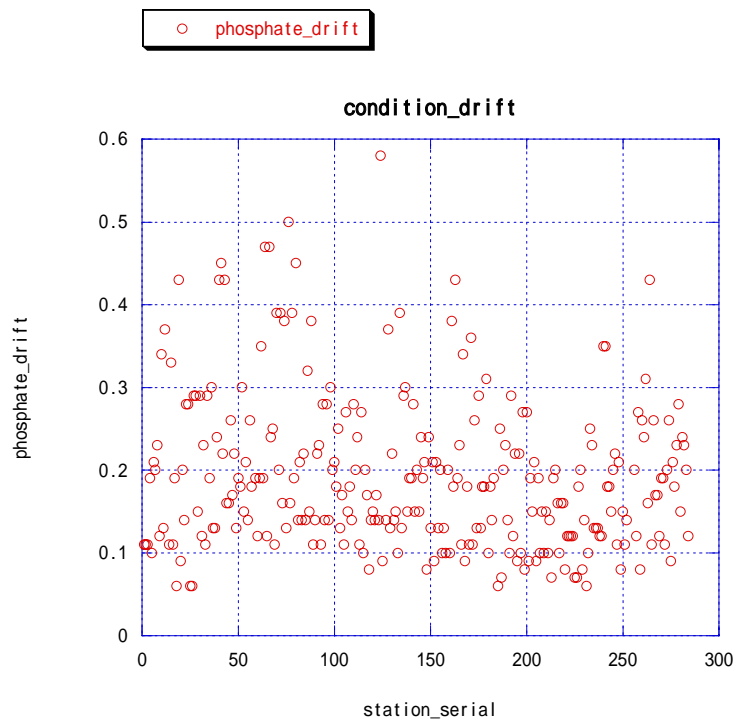
**Table 3.4.5 Summary of precision based on the replicate analyses of 13 samples in each run during leg 1**

	Nitrate CV%	Phosphate CV%	Silicate CV%
Median	0.19	0.19	0.23
Mean	0.19	0.21	0.24
Maximum	0.36	0.50	0.39
Minimum	0.09	0.06	0.07
N	121	120	120

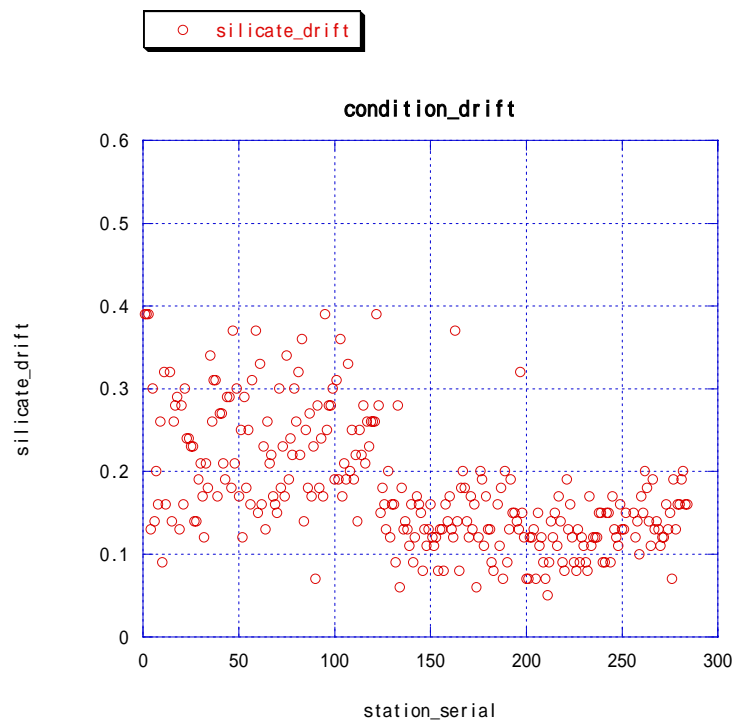
The time series of precision are shown in Fig.3.4.5-3.4.7



**Fig.3.4.5**



**Fig.3.4.6**



**Fig.3.4.7**

We also obtained same results from the values of reproducibility of five samples measurements as shown in Table 3.4.6

**Table 3.4.6 Summary of precision based on the replicate analyses of five samples in each run.**

	Nitrate CV%	Phosphate CV%	Silicate CV%
Mean	0.240	.28	0.16
Maximum	0.49	0.69	0.38
Minimum	0.05	0.0	0.04
N	731	69	71

The concentrations of replicate samples were 2.2-2.7  $\mu\text{mol kg}^{-1}$  for phosphate, 34-38  $\mu\text{mol kg}^{-1}$  for nitrate and 85-120  $\mu\text{mol kg}^{-1}$  for silicate, respectively.

### 3.4.4-2 Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are as shown in Table 3.4.7 The average of carry over for nitrate was 0.47, which is relatively high rather than those of Phosphate and Silicate.

**Table 3.4.7 Summary of carry over during leg 1.**

	Nitrate CV%	Phosphate CV%	Silicate CV%
Median	0.39	0.19	0.15
Mean	0.43	0.25	0.15
Maximum	0.90	1.25	0.47
Minimum	0.03	0.00	0.00
N	121	120	120

### 3.4.3, Concentrations of low nutrients seawater.

Concentrations of low nutrients seawater obtained from each measurements were summarized in Table 3.4.8 As shown in table 4.4, the concentrations of low nutrients seawater used in this cruise are well reproduced against nominal concentrations given in May 2003.

**Table 3.4.8 Summary of low nutrients seawater during leg 1 .**

	Nitrate micro mol kg <sup>-1</sup>	Phosphate micro mol kg <sup>-1</sup>	Silicate micro mol kg <sup>-1</sup>
Median	- 0.02	0.15	1.01
Mean	-0.01	0.15	0.98
Maximum	0.11	0.18	1.29
Minimum	-0.13	0.10	0.01
Nominal	0.00	0.16	1.01

The numbers of analysis were 121 for three parameters.

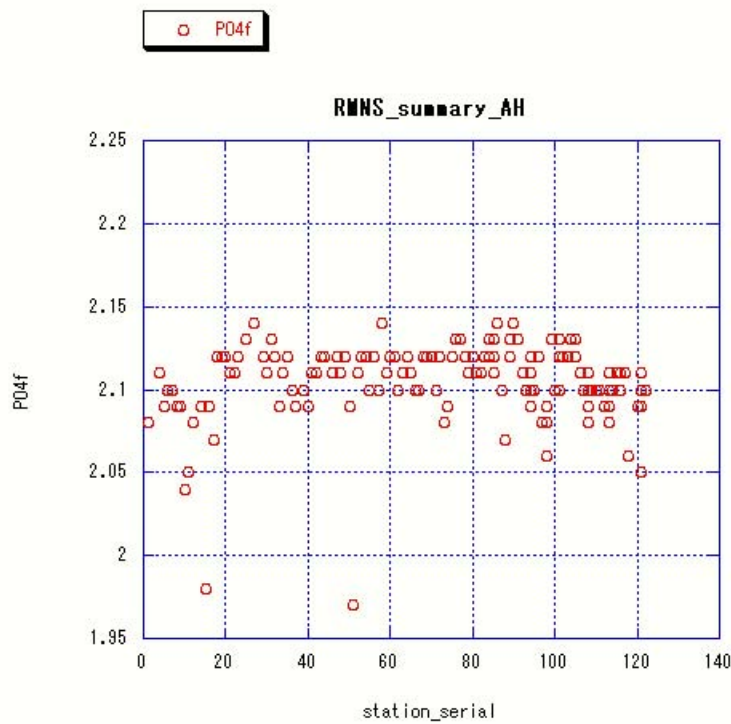
### 3.4.5 Evaluation of trueness of nutrients concentrations using RMNSs

We have been using RMNS for all runs, then, we can evaluate the trueness of nutrients concentration throughout leg 1. The details were discussed post leg meeting at Tsukuba on 16-17 Sept. 2003. Preliminary results are shown in Fig.3.4.8-3.4.10

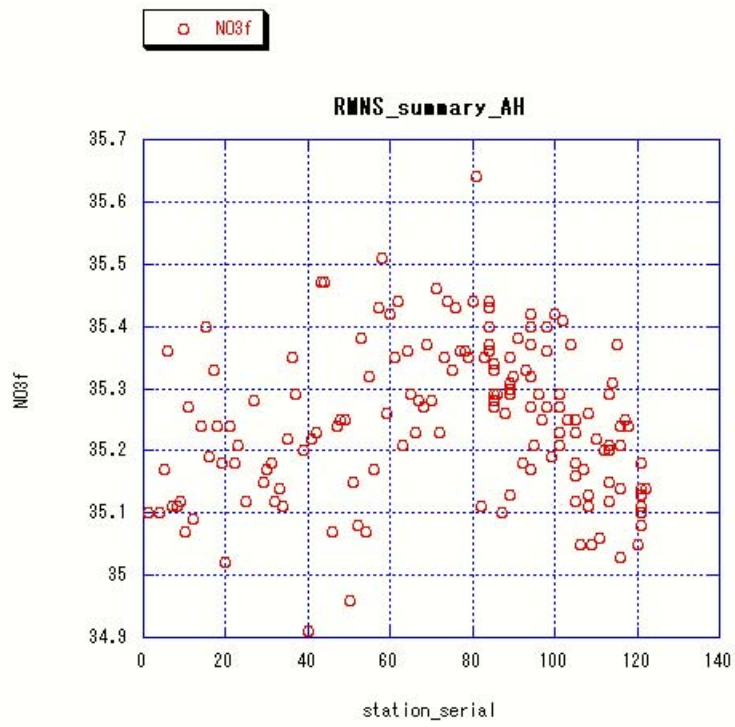
For the phosphate, we can observe no trend of concentration of AH. We, however, see several outliers in lower concentration side. The reason is unknown now, however, this may come from the nature of RMNS itself not caused of analytical procedure.

For the nitrate, we discussed the observed tendency in 3.4.6 We might have to compensate this tendency later.

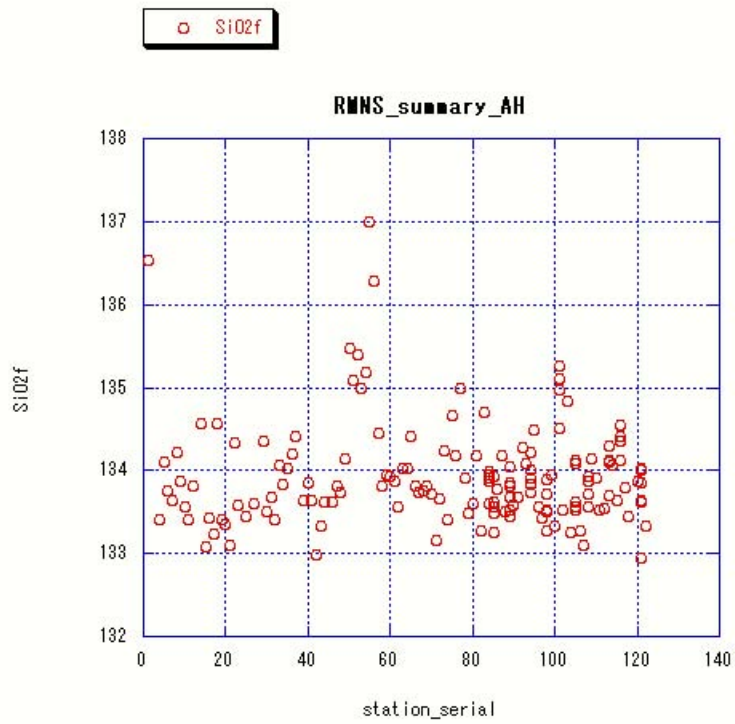
For the silicate, several outliers at higher concentration side were observed. We also discuss this issue in 3.4.6.



**Fig.3.4.8**



**Fig.3.4.9**



**Fig.3.4.10**

### **3.4.6 Problem occurred and solutions.**

#### 1) Silicate concentration decrease in 3-4 days in B-standard solution

A decrease of silicate concentration in B-standard solution was found three to four days after its renewal. This was found by the apparent change of RMNS-AH silicate concentrations.

We, then, decided to renew B-std solution of silicate every two days from the measurements of the sample at station P06C-166. We, also, did additional measurements of RM-AH to monitor the stability of B-std. After introducing this new procedure, the apparent stability of RMNS-AH silicate concentration becomes better.

#### 2) Base line shift at 3 and 4 ch, silicate and phosphate channels, of #2 machine of TRAACS800.

Base line shift at 3 and 4 ch, silicate and phosphate channels, of #2 machine of TRAACS800 were observed during leg.1. From station P06C-123, we had stopped to use #2 machine of TRAACS800. The measurements were continued using #1 machine of TRAACS800 until the station P06C-121.

At Tahiti, #2 machine of TRAACS800 were checked and a board and two cables were replaced.

#### 3) Silicate concentration drift related with the direct flow from air conditioner in the laboratory

Silicate concentration drift related with the direct flow from air conditioner in the laboratory were observed in the results of #1 TRAACS. We, then, put temporally shield from the measurements of the sample at station P06C-160. The drift of the results of #1 TRAACS, however, did not become smaller after station P06X-160 during Leg. 1.

#### 4) Nitrate concentration might decrease within a few weeks in A-standard solution after preparation.

A decrease of nitrate concentration in A-standard solution was found within a few weeks after its renewal. This was found by the apparent change of RMNS-AH nitrate concentrations.

We, then, decided to renew A-std solution of nitrate every 10 days.

### **3.5 Freons**

Ken-ichi Sasaki : Ocean Observation and Research Department, JAMSTEC

Masahide Wakita : Ocean Observation and Research Department, JAMSTEC

Katsunori Sagishima : Marine Works Japan Co. Ltd.

Keisuke Wataki : MWJ

Shinichi Tanaka : Graduate School of Environmental Earth Science, Hokkaido University

### 3.5.1 Objectives

Freons (Chlorofluorocarbons, hereafter CFCs) are the artificially formed gas. CFC-11 ( $\text{CCl}_3\text{F}$ ), CFC-12 ( $\text{CCl}_2\text{F}_2$ ), CFC-113 ( $\text{C}_2\text{Cl}_3\text{F}_3$ ) are very useful chemical tracers to clarify the water movement. We determined dissolved CFC-11, CFC-12, CFC-113 concentrations in seawater on board.

### 3.5.2 Apparatus

Dissolved CFCs concentrations in seawater were determined with an electron capture detector - gas chromatograph (ECD-GC) attached the purge and trapping system.

**Table 3.5.1 Instruments and analytical conditions**

Instruments	
Gas Chromatograph:	GC-14B (Shimadzu Ltd.)
Detector:	ECD-14 (Shimadzu Ltd)
Column:	
Pre column:	Pola PLOT – QHT (i. d.: 0.53mm, length: 2m, tick: 6.0 $\mu\text{m}$ )
Main column:	Pola PLOT – QHT (i. d.: 0.53mm, length: 25m, tick: 6.0 $\mu\text{m}$ )
Temperature	
Oven:	75(or 100) to 140 deg-C
Detector:	200 or 250 deg-C
Trapping & desorbing:	-45 deg-C & 130 deg-C
Gas flow rate	
Carrier gas:	3 – 7ml/min
Detector Make UP:	~ 17 ml/min
Column Purge:	>10 ml/min
Sample purge:	~ 100ml/min

### 3.5.3 Procedures

#### (3-1) Sampling

Seawater samples for CFCs measurement were collected from 12 liter Niskin bottles to N2 purged 300ml glass bottle with specially ordered Swagelok unions. Two times bottle volumes of seawater sample were overflowed to minimize contamination with atmospheric CFCs.

Air samples for CFCs measurement were collected to 100ml glass cylinder at the navigation deck on R/V “MIRAI”.



### (3-2) Analysis

The CFCs analytical system was modified from the original design of Bullister and Weiss (1988). Sample volume was 150ml. The trap used to hold CFCs consists of a length of 1/8 in. o.d. SS tubing packed with 5 cm of Porapak T (80/100 mesh). Trapping and desorbing temperature were – 45 deg-C and 130 deg –C, respectively. The trapped gas was transformed to GC system directly. Analytical conditions were bellow.

### 3.5.4 Performance

At measurement of standard gas (that the concentrations are surface seawater level), repeatability of CFC-11, CFC-12 and CFC-113 is less than 1 %, 1 %, 3 % (n = 5), respectively. The standard gases used in this cruise will be calibrated to SIO scale standard gases after the cruise, and then the data will be corrected.

### 3.5.5 Results

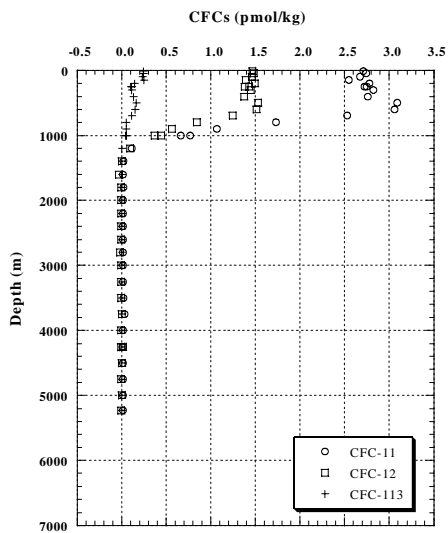
In this region, there had been little CFC-11 and -12 data in water column deeper than 1000 m water depth, and no CFC-113 data in any layers. We determined the CFC-11, -12 and -113 concentrations from surface to bottom layer, and found that CFC-11 and -12 penetrated up to 1200 m water depth (see figures). Further description and discussions will be done after calibration of standard gases and quality controls of the data.

### 3.5.6 Data archive

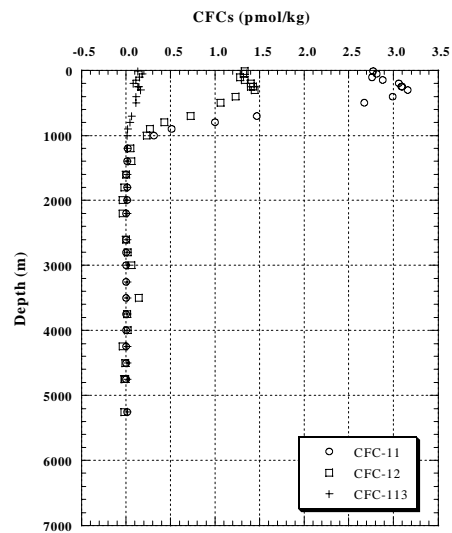
All data will be submitted to JAMSTEC Data Management office (DMO) and under its control.

### 3.5.7 Reference

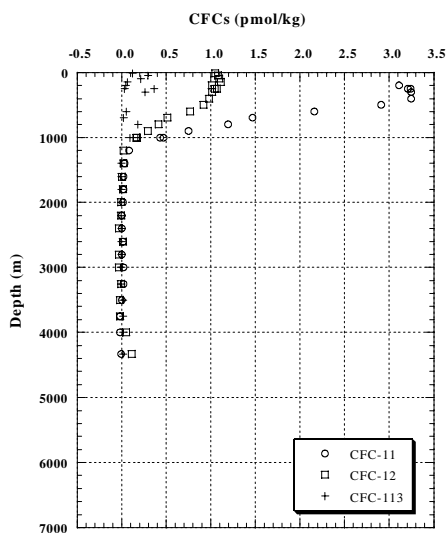
Bullister, J.L and Weiss R.F. 1988. Determination of  $\text{CCl}_3\text{F}$  and  $\text{CCl}_2\text{F}_2$  in seawater and air. Deep Sea Research, 35, 839-853.



P06W-X14

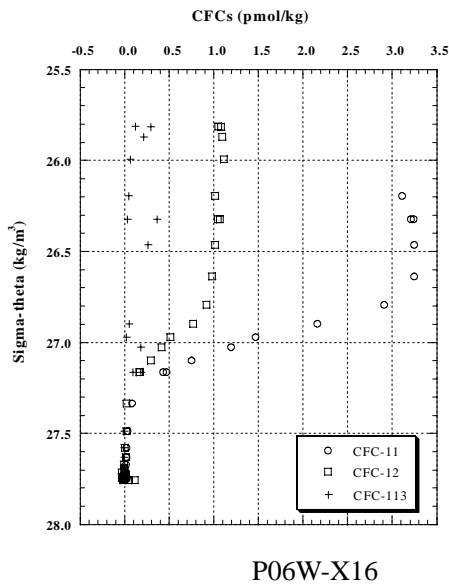
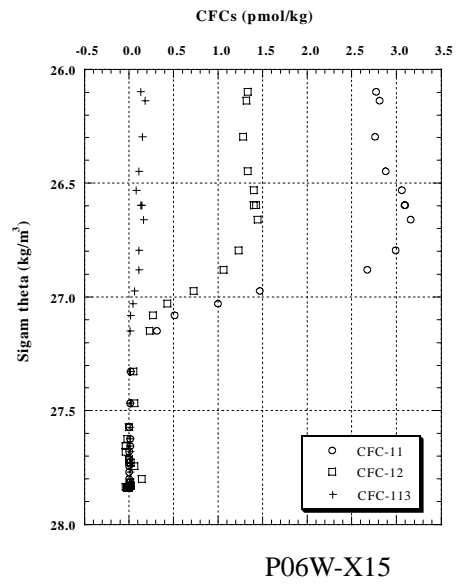
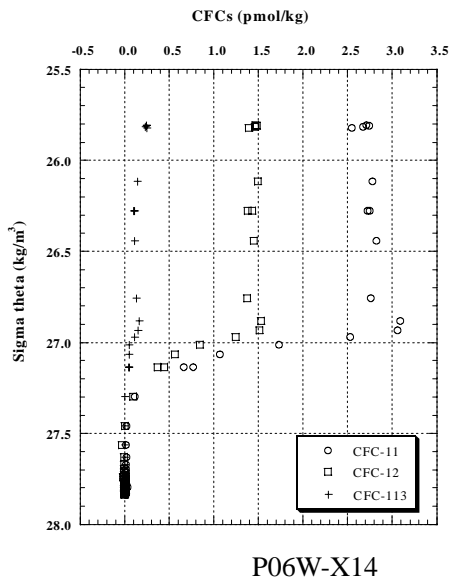


P06C-X15



P06C-X16

Fig. 3.5.1 Examples of vertical profiles of dissolved CFCs concentrations observed at P06W-X14, X15, X16. Circle, square and crosses symbols mean CFC-11, CFC-12 and CFC-113, respectively.



**Fig. 3.5.2** Same as Fig. 3.5.1 but vertical axes are sigma theta.

### 3.6 Carbon items

Akihiko Murata (JAMSTEC)

Fuyuki Shibata (MWJ)

Minoru Kamata (MWJ)

Toru Fujiki (MWJ)

Saika Wada (MWJ)

#### 3.6.1 Objectives

Concentrations of CO<sub>2</sub> in the atmosphere are now increasing at a rate of 1.5 ppmv y<sup>-1</sup> owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO<sub>2</sub>, and to clarify the mechanism of the CO<sub>2</sub> absorption, because the magnitude of the anticipated global warming depends on the levels of CO<sub>2</sub> in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise, we are aimed at quantifying how much anthropogenic CO<sub>2</sub> absorbed in the Southern Oceans, where intermediate and deep waters are formed, are transported and redistributed in the Pacific, Atlantic and Indian Oceans. For the purpose, we measured CO<sub>2</sub>-system parameters such as dissolved inorganic carbon (C<sub>T</sub>), total alkalinity (A<sub>T</sub>) and pH. For a carbon budget study, we also collected seawater samples for total organic carbon (TOC).

#### 3.6.2 Apparatus

##### (1) C<sub>T</sub>

Measurements of C<sub>T</sub> was made with two total CO<sub>2</sub> measuring systems (systems A and B; Nippon ANS, Inc.), which are slightly different from each other. The systems comprise of a sea water dispensing system, a CO<sub>2</sub> extraction system and a coulometer (Model 5012, UIC Inc.).

The sea water dispensing system has an auto-sampler (6 ports), which takes sea water in a 300 ml borosilicate glass bottle and dispenses the sea water to a pipette of nominal 20 ml volume by PC control. The pipette was kept at 20 °C by a water jacket, in which water from a water bath set at 20 °C is circulated.

CO<sub>2</sub> dissolved in a sea water sample is extracted in a stripping chamber of the CO<sub>2</sub> extraction system by adding phosphoric acid (10 % v/v). The stripping chamber is made approx. 25 cm long and has a fine frit at the bottom. To degass CO<sub>2</sub> as quickly as possible, a heating wire kept at 40 °C was rolled from the bottom to a 1/3 height of the stripping chamber. The acid is added to the stripping chamber from the bottom of the chamber by pressurizing an acid bottle for a given time to push out the right amount of acid. The pressurizing is made with nitrogen gas (99.9999 %). After the

acid is transferred to the stripping chamber, a sea water sample kept in a pipette is introduced to the stripping chamber by the same method as in adding an acid. The sea water reacted with phosphoric acid is stripped of CO<sub>2</sub> by bubbling the nitrogen gas through a fine frit at the bottom of the stripping chamber. The CO<sub>2</sub> stripped in the chamber is carried by the nitrogen gas (flow rates of 130 ml min<sup>-1</sup> and 140 ml min<sup>-1</sup> for systems A and B, respectively) to the coulometer through a dehydrating module. For system A, the module consists of two electric dehumidifiers (kept at 1 °C) and a chemical desiccant (Mg(ClO<sub>4</sub>)<sub>2</sub>). For system B, it consists of three electric dehumidifiers, but no chemical desiccants.

The measurement sequence such as system blank (phosphoric acid blank), 2 % CO<sub>2</sub> gas in a nitrogen base, sea water samples (6) was programmed to repeat. The measurement of 2 % CO<sub>2</sub> gas was made to monitor response of coulometer solutions (from UIC, Inc.).

## (2) A<sub>T</sub>

Measurement of A<sub>T</sub> was made using two titration systems (systems A and B; Nippon ANS, Inc.). The systems comprise of a water dispensing unit, an auto-burette (Metrohm) and a pH meter (Thermo Orion), which are automatically controlled by a PC.

A seawater of approx. 40 ml is transferred from a sample bottle (borosilicate glass bottle; 130 ml) into a water-jacketed (25 °C), and is introduced into a water-jacketed (25 °C) titration cell. The seawaters are titrated by an acid titrant, which was 0.05 M HCl in 0.65 M NaCl in this cruise.

Calibration of the acid titrant was made by measuring A<sub>T</sub> of 5 solutions of Na<sub>2</sub>CO<sub>3</sub> in 0.7 M NaCl solutions. The computed A<sub>T</sub>s were approx. 0, 100, 1000, 2000 and 2500 μmol kg<sup>-1</sup>. The measured values of A<sub>T</sub> (calculated by assuming 0.05 M) should be a linear function of the A<sub>T</sub> contributed by the Na<sub>2</sub>CO<sub>3</sub>. The line was fitted by the method of least squares. Theoretically, the slope should be unity. If the measured slope is not equal to one, the acid normality should be adjusted by dividing initial normality by the slope, and the whole set of calculations is repeated until the slope = 1

Calculation of A<sub>T</sub> was made based on a modified Gran approach.

## (3) pH

Measurement of pH was made by a pH measuring system (Nippon ANS, Inc.), which adopts a method for the spectrophotometric determination. The system comprises of a water dispensing unit and a spectrophotometer (Carry 50 Scan, Varian). For an indicator, *m*-cresol purple (2 mM) was used.

Seawater was transferred from borosilicate glass bottle (300 ml) to a sample cell in the spectrophotometer. The length and volume of the cell are 8 cm and 13 ml, respectively, and the sample cell was kept at 25.00 ± 0.05 °C in a thermostated compartment. First, absorbances of

seawater only were measured at three wavelengths (730, 578 and 434 nm). Then the indicator was injected and circulated for about 4 minutes. to mix the indicator and seawater sufficiently. After the pump was stopped, the absorbances of seawater + indicator were measured at the same wavelengths. The pH was calculated based on the following equation (Clayton and Byrne, 1993):

$$pH = pK_2 + \log\left(\frac{A_1 / A_2 - 0.00691}{2.2220 - 0.1331(A_1 / A_2)}\right),$$

where  $A_1$  and  $A_2$  indicate absorbances at 578 and 434 nm, respectively, and  $pK_2$  is calculated as a function of water temperature and salinity.

#### Reference

Clayton T.D. & R.H. Byrne (1993) Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results. *Deep-Sea Research* 40, 2115-2129.

#### (4) TOC

Seawaters for TOC measurement were collected at every 4th to 5th stations.

The seawater was collected into a test tube from Niskin bottles (approx. 50 ml) without a drawing tube. The seawater was frozen at approx.  $-20\text{ }^{\circ}\text{C}$  as soon as possible after the water sampling.

TOC will be measured in a laboratory on land.

### 3.6.3 Performances

#### (1) $C_T$

The two systems had worked well during the leg without a major malfunction. Replicate analysis was made on every 9th seawater sample. The average of the differences was  $1.6\text{ }\mu\text{mol kg}^{-1}$  ( $n = 206$ ).

#### (2) $A_T$

The systems conducted a high speed titration (5-6 min.) compared to systems used in previous studies. Thus we decided to measure  $A_T$  by one system (system A), and leave the other for a backup. A few replicate samples were taken on every station. The averages of absolute differences between the replicate samples of systems A and B were  $2.0$  ( $n = 132$ ) and  $1.7\text{ }\mu\text{mol kg}^{-1}$  ( $n = 58$ ), respectively.

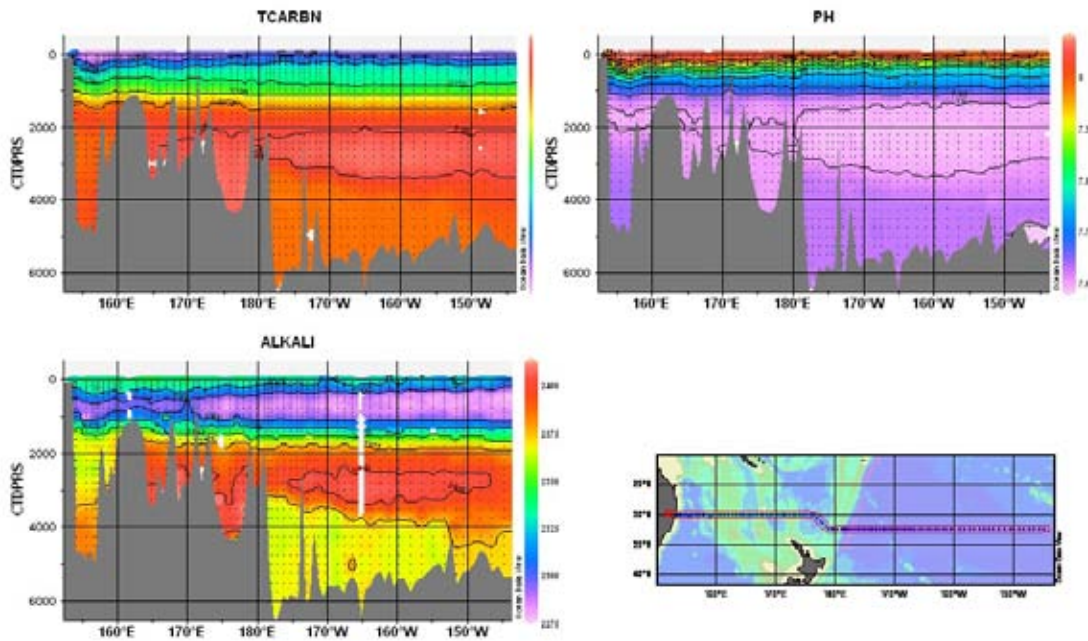
(3) pH

The system had worked well with no troubles. The average of absolute differences between replicate samples were 0.0012 pH unit (n = 139).

**3.6.4 Results**

Cross sections of  $C_T$ ,  $A_T$  and pH are illustrated in Fig. 3.6.1

Distributions of  $C_T$  were different from basin to basin. However, the maximum of  $C_T$  (> 2300) existed in the layers from 2000 to 3000 m. For  $A_T$ , the maximum and minimum were found in the layers 500 to 1000 m and 2800 to 3200 m, respectively. The pH showed the minimum (approx. 7.58) in the layers from 1500 to 3000 m.



**Fig.3.6.1** Cross sections of  $C_T$ ,  $A_T$  and pH along the western half of WOCE P06 line.

## 3.7 Samples taken for other chemical measurement

### 3.7.1 Nitrogen/Argon

Shinichi Tanaka and Yutaka Watanabe

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Graduate School of Environmental Earth Science, Hokkaido University

#### 1 Objective

##### (a) Detect to climate change evidence

Recently, It is estimated that Climate will be changing by human activity. To detect for Climate change signals in the ocean, we use air sea gases exchange. Middle and Deep seawater is almost made by vertical convection at the winter surface. If clear to time series gases concentrations change of each water mass, we can detect to climate change evidence apply to air sea gases exchange process. Therefore, we choice dissolved  $N_2$ , Ar concentration because there is main gasses and non reactive, it is appropriate for this study.

##### (b) Estimate to more accurate oxygen utility's in the middle and deep sea

Dissolved oxygen is regarded to estimate baio activity in middle and deep sea. Usually, it's calculation method used apparent oxygen utility(AOU), but this calculation method has uncertainty, because this method defined that DO was saturated when water mass stayed surface. If we can estimate that's saturation ratio, it is possible to calculate more accurate oxygen utility.

To estimate accurate oxygen utility, we use  $N_2$ , Ar.  $N_2$ , Ar and  $O_2$  is main component of atmosphere and same solubility.  $N_2$ , Ar is non reactive in the seawater,. And middle and deep sea almost made vertical mixing and convection at winter. If DO and  $N_2$ , Ar concentrations in the winter surface determined air sea gases exchange, it is possible to estimate more accurate oxygen utility used by  $N_2$  and Ar concentrations.

#### 2 Method

##### (a) Sampling

Water samples were collected at 15 stations.,

StationP06W-239,234,228,221,213,201,X14,P06C-180,174,168,X15,150,142,133,125.

Seawater samples were collected with Niskin Bottle. Each sample was collected in a 50ml-glass bottle. At the sampling, seawater was allowed to overflow more than four times the bottle volume. A 50 $\mu$ L aliquot of saturated  $HgCl_2$  solution was added to each sample to avoid biological change after sampling and it was stored in refrigerator.

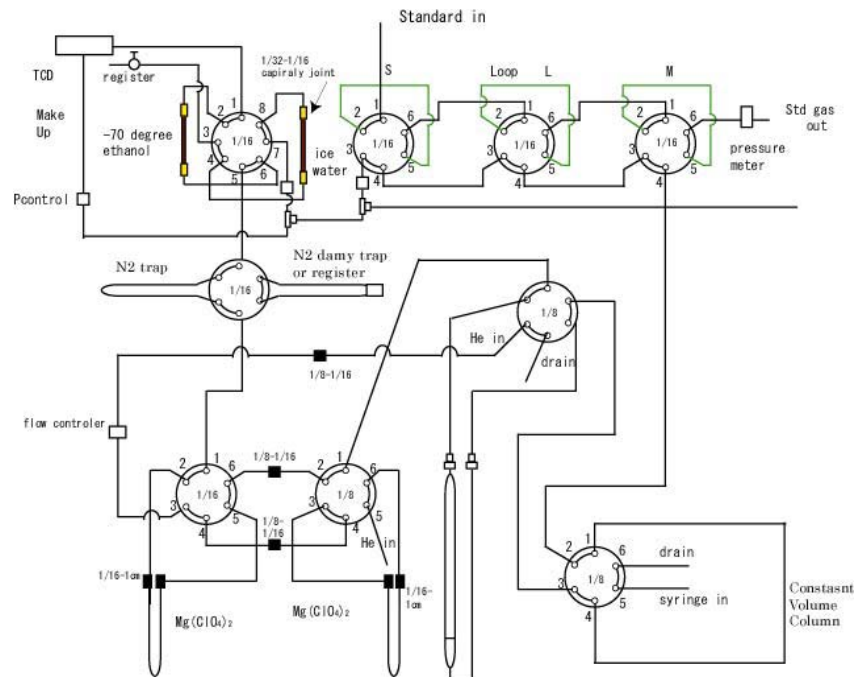
##### (b) Analysis



Analysis will be determined onshore laboratory use by TCD-GC system. (Fig.3.7.1). Each gases analytical precision has below 0.1%.

(3) Result

After finish this creuse, Sample analysis and data adjustment.



**Fig.3.7.1 TCD-GC system**

**3.7.2 Carbon-14, carbon-13 (Sep. 04, 2003)**

Yuichiro Kumamoto : Ocean Observation and Research Department, JAMSTEC

(1) Objective

In order to investigate water circulation and carbon cycle in the south Pacific, seawater for carbon-14 (radiocarbon) and carbon-13 (stable carbon isotope) of total dissolved inorganic carbon (TDIC) was collected by the hydrocasts from surface to bottom.

(2) Sample collection

The sampling stations and number of samples are summarized in Table 3.7.1 All samples for carbon isotope ratios were collected at 23 stations using 12 L Niskin bottles. The seawater sample

was siphoned into a 250 cm<sup>3</sup> glass bottle with enough seawater to fill the glass bottle 3 times. Immediately after sampling, 10 cm<sup>3</sup> of seawater was removed from the bottle and poisoned by 0.05 cm<sup>3</sup> μl of saturated HgCl<sub>2</sub> solution. Then the bottle was sealed by a glass stopper with Apiezon M grease and stored in a cool and dark space on board.

(3) Sample preparation and measurements

In our laboratory, dissolved inorganic carbon in the seawater samples will be stripped cryogenically and split into three aliquots: radiocarbon measurement (about 200 μmol), carbon-13 measurement (about 100 μmol), and archive (about 200 μmol). The extracted CO<sub>2</sub> gas for radiocarbon will be then converted to graphite catalytically on iron powder with pure hydrogen gas. The carbon-13 of the extracted CO<sub>2</sub> gas will be measured using Finnigan MAT252 mass spectrometer. The carbon-14 in the graphite sample will be measured by Accelerator Mass Spectrometry (AMS).

**Table 3.7.1 The sampling stations and number of samples for carbon isotope ratios.**

Station	No. samples	No. replicate samples	Max. sampling pressure /db
P06W-239	31	3	4,680
P06W-234	32	3	4,898
P06W-227	24	3	3,235
P06W-221	15	1	1,185
P06W-215	26	3	3,419
P06W-211	23	2	2,873
P06W-207	25	3	3,153
P06W-201	20	2	2,264
P06W-195	27	3	3,689
P06W-191	30	3	4,353
P06C-182	24	2	2,872
P06C-174	36	3	6,503
P06C-168	36	3	5,958
P06C-162	29	3	4,200
P06C-X15	34	3	5,610
P06C-150	33	3	5,357
P06C-146	34	3	5,630
P06C-142	33	3	5,221

P06C-137	35	3	5,781
P06C-133	32	3	5,076
P06C-X16	33	3	5,234
P06C-125	30	3	4,626
P06C-121	33	3	5,354
Total	675	64	

### 3.7.3 Radionuclides (4 Sept. 2003)

Michio Aoyama : Geochemical Res. Dep., Meteorological Res. Inst., Japan

Akira Takeuchi : KANSO, Japan

#### (1) Objectives

Study more about present distribution of artificial radioactivity originated mainly from atmospheric nuclear weapons tests in the 1960s in the world oceans. Provide detail artificial radionuclides database for general circulation model validation

#### (2) Target radionuclides

Main target radionuclides are  $^{137}\text{Cs}$ , Pu and tritium. For some samples, the other parameters such as  $^{90}\text{Sr}$  and  $^{129}\text{I}$  will be measured.

#### (3) Sampling procedures

Sampling of seawater samples of radionuclides in water column were done followed that all parameters. The additional bottles were available by chance, then, the samples volumes for water column varied from 6 liter to 20 liter. Samples were drawn into 20 L cubitainers from the Niskin bottles. These samples were filtered using 0.45  $\mu\text{m}$  pore size filter and filled into appropriate size of tanks, cubitainers and bottle. Filters were also archived. Concentrated Nitric Acid was added to the samples to keep pH1.6 except for tritium samples.

Surface water samples were drawn through intake pump below several meter from the surface. Seawater of 85 liter were collected for  $^{137}\text{Cs}$ , Pu and so on. For the tritium, seawater of 1 liter was collected.

**Table 3.7.2  
SAMPLING RESULTS**

(1/4)

Stn.	LATITUDE	LONGITUDE	SAMPLES		FILTER		REMARKS
			DEPTH	VOL	PORE SIZE	QUANTITY	
P06W-238	30° 05' S	154° 30' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
			100db	9L	0.45 µ m	1	Cs137,Pu,H3
			200db	21L	0.45 µ m	1	Cs137,Pu,H3
			400db	9L	0.45 µ m	1	Cs137,Pu,H3
			600db	21L	0.45 µ m	1	Cs137,Pu,H3
			800db	9L	0.45 µ m	1	Cs137,Pu,H3
			1000db	21L	0.45 µ m	1	Cs137,Pu,H3
			1200db	8L	0.45 µ m	1	Cs137,Pu,H3
			1400db	7L	0.45 µ m	1	Cs137,Pu,H3
			2000db	21L	0.45 µ m	1	Cs137,Pu,H3
			2400db	10L	0.45 µ m	1	Cs137,Pu
			3000db	10L	0.45 µ m	1	Cs137,Pu,H3
			3500db	10L	0.45 µ m	1	Cs137,Pu
			4000db	21L	0.45 µ m	1	Cs137,Pu,H3
			4664db	21L	0.45 µ m	1	Cs137,Pu,H3
P06W-234	30° 05' S	156° 32' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
P06W-228	30° 05' S	158° 20' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
			100db	7L	0.45 µ m	1	Cs137,Pu,H3
			200db	21L	0.45 µ m	1	Cs137,Pu,H3
			400db	8L	0.45 µ m	1	Cs137,Pu,H3
			600db	21L	0.45 µ m	1	Cs137,Pu,H3
			800db	21L	0.45 µ m	1	Cs137,Pu,H3
			1000db	21L	0.45 µ m	1	Cs137,Pu,H3
			1200db	6L	0.45 µ m	1	Cs137,Pu,H3
			1400db	8L	0.45 µ m	1	Cs137,Pu,H3
			2000db	21L	0.45 µ m	1	Cs137,Pu,H3
			2400db	7L	0.45 µ m	1	Cs137,Pu
			2687db	21L	0.45 µ m	1	Cs137,Pu,H3
			P06W-221	30° 05' S	161° 30' E	0db	86L
P06W-214	30° 04' S	165° 24' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
			100db	9L	0.45 µ m	1	Cs137,Pu,H3
			200db	21L	0.45 µ m	1	Cs137,Pu,H3
			400db	8L	0.45 µ m	1	Cs137,Pu,H3
			600db	21L	0.45 µ m	1	Cs137,Pu,H3
			800db	21L	0.45 µ m	1	Cs137,Pu,H3
			1000db	21L	0.45 µ m	1	Cs137,Pu,H3
			1200db	7L	0.45 µ m	1	Cs137,Pu,H3
			1400db	8L	0.45 µ m	1	Cs137,Pu,H3
			2000db	21L	0.45 µ m	1	Cs137,Pu,H3
			2400db	9L	0.45 µ m	1	Cs137,Pu
			3414db	21L	0.45 µ m	1	Cs137,Pu,H3
			P06W-211	30° 05' S	167° 00' E	0db	86L
P06W-206	30° 05' S	169° 30' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
			100db	8L	0.45 µ m	1	Cs137,Pu,H3
			200db	21L	0.45 µ m	1	Cs137,Pu,H3
			400db	7L	0.45 µ m	1	Cs137,Pu,H3
			600db	21L	0.45 µ m	1	Cs137,Pu,H3
			800db	21L	0.45 µ m	1	Cs137,Pu,H3
			1000db	21L	0.45 µ m	1	Cs137,Pu,H3
			1200db	8L	0.45 µ m	1	Cs137,Pu,H3
			1400db	9L	0.45 µ m	1	Cs137,Pu,H3
			2000db	21L	0.45 µ m	1	Cs137,Pu,H3
			2400db	8L	0.45 µ m	1	Cs137,Pu
			2739db	21L	0.45 µ m	1	Cs137,Pu,H3

## SAMPLING RESULTS

(2/4)

Stn.	LATITUDE	LONGITUDE	SAMPLES		FILTER		REMARKS
			DEPTH	VOL	PORE SIZE	QUANTITY	
P06W-200	30°05' S	172°00' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
			100db	8L	0.45 µ m	1	Cs137,Pu,H3
			200db	21L	0.45 µ m	1	Cs137,Pu,H3
			400db	8L	0.45 µ m	1	Cs137,Pu,H3
			600db	21L	0.45 µ m	1	Cs137,Pu,H3
			800db	21L	0.45 µ m	1	Cs137,Pu,H3
			1000db	21L	0.45 µ m	1	Cs137,Pu,H3
			1200db	11L	0.45 µ m	1	Cs137,Pu,H3
			1400db	8L	0.45 µ m	1	Cs137,Pu,H3
			2000db	21L	0.45 µ m	1	Cs137,Pu,H3
			2400db	10L	0.45 µ m	1	Cs137,Pu
			2834db	21L	0.45 µ m	1	Cs137,Pu,H3
			P06W-194	30°05' S	175°10' E	0db	86L
100db	7L	0.45 µ m				1	Cs137,Pu,H3
200db	21L	0.45 µ m				1	Cs137,Pu,H3
400db	7L	0.45 µ m				1	Cs137,Pu,H3
600db	21L	0.45 µ m				1	Cs137,Pu,H3
800db	8L	0.45 µ m				1	Cs137,Pu,H3
1000db	21L	0.45 µ m				1	Cs137,Pu,H3
1200db	8L	0.45 µ m				1	Cs137,Pu,H3
1400db	7L	0.45 µ m				1	Cs137,Pu,H3
2000db	21L	0.45 µ m				1	Cs137,Pu,H3
2400db	8L	0.45 µ m				1	Cs137,Pu
3000db	21L	0.45 µ m				1	Cs137,Pu,H3
3500db	8L	0.45 µ m				1	Cs137,Pu
P06W-191	30°35' S	177°00' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
P06C-182	32°30' S	179°55' E	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
P06C-175	32°30' S	177°40' W	0db	86L	0.45 µ m	1	Cs137,Pu,H3,Sr
			100db	7L	0.45 µ m	1	Cs137,Pu,H3
			200db	7L	0.45 µ m	1	Cs137,Pu,H3
			400db	7L	0.45 µ m	1	Cs137,Pu,H3
			600db	7L	0.45 µ m	1	Cs137,Pu,H3
			800db	8L	0.45 µ m	1	Cs137,Pu,H3
			1000db	7L	0.45 µ m	1	Cs137,Pu,H3
			1200db	8L	0.45 µ m	1	Cs137,Pu,H3
			1400db	8L	0.45 µ m	1	Cs137,Pu,H3
			2000db	8L	0.45 µ m	1	Cs137,Pu,H3
			2400db	8L	0.45 µ m	1	Cs137,Pu
			3000db	8L	0.45 µ m	1	Cs137,Pu,H3
			3500db	8L	0.45 µ m	1	Cs137,Pu
			4000db	7L	0.45 µ m	1	Cs137,Pu,H3
			4500db	7L	0.45 µ m	1	Cs137,Pu
5000db	7L	0.45 µ m	1	Cs137,Pu,H3			
5500db	8L	0.45 µ m	1	Cs137,Pu			
6500db	7L	0.45 µ m	1	Cs137,Pu,H3			

## SAMPLING RESULTS

(3/4)

Stn.	LATITUDE	LONGITUDE	SAMPLES		FILTER		REMARKS
			DEPTH	VOL	PORE SIZE	QUANTITY	
P06C-167	32 30' S	174 00' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
			100db	7L	0.45 μ m	1	Cs137,Pu,H3
			200db	7L	0.45 μ m	1	Cs137,Pu,H3
			400db	7L	0.45 μ m	1	Cs137,Pu,H3
			600db	7L	0.45 μ m	1	Cs137,Pu,H3
			800db	8L	0.45 μ m	1	Cs137,Pu,H3
			1000db	6L	0.45 μ m	1	Cs137,Pu,H3
			1200db	6L	0.45 μ m	1	Cs137,Pu,H3
			1400db	8L	0.45 μ m	1	Cs137,Pu,H3
			2000db	7L	0.45 μ m	1	Cs137,Pu,H3
			2400db	7L	0.45 μ m	1	Cs137,Pu
			3000db	8L	0.45 μ m	1	Cs137,Pu,H3
			3500db	7L	0.45 μ m	1	Cs137,Pu
			4000db	6L	0.45 μ m	1	Cs137,Pu,H3
			4500db	7L	0.45 μ m	1	Cs137,Pu
			5000db	7L	0.45 μ m	1	Cs137,Pu,H3
5500db	8L	0.45 μ m	1	Cs137,Pu			
5759db	8L	0.45 μ m	1	Cs137,Pu,H3			
P06C-162	32 30' S	171 55' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
P06C-156	32 30' S	169 30' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
			100db	6L	0.45 μ m	1	Cs137,Pu,H3
			200db	7L	0.45 μ m	1	Cs137,Pu,H3
			400db	7L	0.45 μ m	1	Cs137,Pu,H3
			600db	21L	0.45 μ m	1	Cs137,Pu,H3
			800db	8L	0.45 μ m	1	Cs137,Pu,H3
			1000db	7L	0.45 μ m	1	Cs137,Pu,H3
			1200db	7L	0.45 μ m	1	Cs137,Pu,H3
			1400db	8L	0.45 μ m	1	Cs137,Pu,H3
			2000db	8L	0.45 μ m	1	Cs137,Pu,H3
			2400db	7L	0.45 μ m	1	Cs137,Pu
			3000db	8L	0.45 μ m	1	Cs137,Pu,H3
			3500db	8L	0.45 μ m	1	Cs137,Pu
			4000db	7L	0.45 μ m	1	Cs137,Pu,H3
			4500db	8L	0.45 μ m	1	Cs137,Pu
			5000db	7L	0.45 μ m	1	Cs137,Pu,H3
5613db	21L	0.45 μ m	1	Cs137,Pu,H3			
P06C-150	32 30' S	166 30' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
P06C-145	32 30' S	163 10' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3
			100db	6L	0.45 μ m	1	Cs137,Pu,H3
			200db	8L	0.45 μ m	1	Cs137,Pu,H3
			400db	8L	0.45 μ m	1	Cs137,Pu,H3
			600db	21L	0.45 μ m	1	Cs137,Pu,H3
			800db	8L	0.45 μ m	1	Cs137,Pu,H3
			1000db	21L	0.45 μ m	1	Cs137,Pu,H3
			1200db	8L	0.45 μ m	1	Cs137,Pu,H3
			1400db	8L	0.45 μ m	1	Cs137,Pu,H3
			2000db	8L	0.45 μ m	1	Cs137,Pu,H3
			2400db	7L	0.45 μ m	1	Cs137,Pu
			3000db	8L	0.45 μ m	1	Cs137,Pu
			3550db	8L	0.45 μ m	1	Cs137,Pu,H3
			4000db	8L	0.45 μ m	1	Cs137,Pu,H3
			4500db	8L	0.45 μ m	1	Cs137,Pu
			5000db	8L	0.45 μ m	1	Cs137,Pu,H3
5330db	21L	0.45 μ m	1	Cs137,Pu,H3			

SAMPLING RESULTS							(4/4)
Stn.	LATITUDE	LONGITUDE	SAMPLES		FILTER		REMARKS
			DEPTH	VOL	PORE SIZE	QUANTITY	
P06C-142	32°30' S	161°10' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
P06C-136	32°30' S	157°20' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3
			100db	7L	0.45 μ m	1	Cs137,Pu,H3
			200db	8L	0.45 μ m	1	Cs137,Pu,H3
			400db	9L	0.45 μ m	1	Cs137,Pu,H3
			600db	21L	0.45 μ m	1	Cs137,Pu,H3
			800db	8L	0.45 μ m	1	Cs137,Pu,H3
			1000db	7L	0.45 μ m	1	Cs137,Pu,H3
			1200db	7L	0.45 μ m	1	Cs137,Pu,H3
			1400db	8L	0.45 μ m	1	Cs137,Pu,H3
			2000db	8L	0.45 μ m	1	Cs137,Pu,H3
			2400db	7L	0.45 μ m	1	Cs137,Pu
			3000db	8L	0.45 μ m	1	Cs137,Pu,H3
			3500db	8L	0.45 μ m	1	Cs137,Pu
			4000db	8L	0.45 μ m	1	Cs137,Pu,H3
			4500db	7L	0.45 μ m	1	Cs137,Pu
			5000db	8L	0.45 μ m	1	Cs137,Pu,H3
			5451db	21L	0.45 μ m	1	Cs137,Pu,H3
P06C-132	32°30' S	154°00' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
P06C-127	32°30' S	149°50' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3
			100db	8L	0.45 μ m	1	Cs137,Pu,H3
			200db	9L	0.45 μ m	1	Cs137,Pu,H3
			400db	8L	0.45 μ m	1	Cs137,Pu,H3
			600db	21L	0.45 μ m	1	Cs137,Pu,H3
			800db	8L	0.45 μ m	1	Cs137,Pu,H3
			1200db	8L	0.45 μ m	1	Cs137,Pu,H3
			1400db	8L	0.45 μ m	1	Cs137,Pu,H3
			2000db	8L	0.45 μ m	1	Cs137,Pu,H3
			2400db	8L	0.45 μ m	1	Cs137,Pu
			3000db	8L	0.45 μ m	1	Cs137,Pu,H3
			3500db	8L	0.45 μ m	1	Cs137,Pu
			4000db	7L	0.45 μ m	1	Cs137,Pu,H3
			4500db	8L	0.45 μ m	1	Cs137,Pu
			5000db	8L	0.45 μ m	1	Cs137,Pu,H3
P06C-124	32°30' S	147°21' W	0db	86L	0.45 μ m	1	Cs137,Pu,H3,Sr
		TOTAL	-	3809L	-	191	

(4) Samples accomplished during leg 1

A total of 22 samples were collected for surface sample. At the 12 stations, a total of 169 samples were collected for water column. A total amount of the weight of the samples is around 3800kg and stored in a store at temperate temperature.

(5) Problem occurred and solutions.

No problem occurred.

### 3.7.4 Helium Isotopes in seawater

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#### (1) Objective

Helium isotope ratio is one of important chemical tracers for discussion of water movement. Helium-3 is mainly diffused from earth interior and produced by decay of tritium (Clark, Beg and Craig, 1969). In southern hemisphere, former helium-3 is important. Distribution of helium-3 in mid-depth ocean indicates the source of helium-3 is hydrothermal activity in mid-ocean ridge and is spreading in the deep ocean waters (for example, Craig and Lupton, 1981, Lupton, 1998). Its distribution in the shallow ocean is related with tritium distribution. This helium is important to discuss mixing and transport to deeper ocean (for example, Jenkins, 1998).

During this leg, water samples for helium isotope analysis were collected at P06C-159 to discuss the lateral transport of deep ocean water in the South Pacific.

#### (2) Procedure

##### (2-1) Sampling method

Water sampling method is according to the WOCE Hydrographic Operation manual. Seawater samples were transferred from the Niskin bottle to the annealed copper tubing (o.d.: 3/8 inches, thickness: 1.5 mm, length: about 1 m) through plastic tubing. The seawater volume flushed through the copper tubing was about 6 times sample volume. During flushing, copper tubing was hit with wooden hammer and air bubbles were removed completely. Plastic tubing both side of copper tubing was clipped with stopper. The copper tubing was clamped both side with special clamps inside of laboratory on board and these samples were kept inside room.

##### (2-2) Analysis

Helium isotopes are analyzed with static mass spectrometer after dissolved helium is degassed from seawater and purified. The determination of helium isotopes will be ordered to specialist.

#### References

Clark, W., M. A. Beg and H. Craig (1969) Excess  $^3\text{He}$  in the sea: evidence for terrestrial primordial



helium. *Earth Planet. Sci. Lett.*, **6**, 213-220.

Craig, H. and J. E. Lupton (1981) Helium-3 and mantle volatiles in the ocean and the oceanic crust. *The Sea, 7: The Oceanic Lithosphere*. Ed. C. Emiliani, Wiley and Son, New York, 391-428.

Jenkins W. J.(1998) Studying subtropical thermocline ventilation and circulation using tritium and  $^3\text{He}$ . *J. Geophys. Res.*, **103**, 15817-15831.

Jenkins W. J., D. E. Lott, M. W. Davis, S. P. Birdwhistell and M. O. Matthewson (1991) Measuring Helium Isotopes and Tritium in Seawater Samples. In: *WOCE hydrographic Operations and Methods, WOCE Operations Manual*, 3, Section 3.1, Part 3.1.3, WHP Office Report WHPO 91-1, WOCE Report No. 68/91, 21pp.

Lupton, J. E. (1998) Hydrothermal Helium Plumes in the Pacific Ocean. *J. Geophys. Res.*, **103**, 15853-15863.

### **3.8 Lowered Acoustic Doppler Current Profiler**

Y. Yoshikawa : JAMSTEC

Direct flow measurement from sea surface to bottom was carried out by using an lowered acoustic Doppler current profiler (LADCP). The instrument used was an RDI Monitor 307.2 kHz unit (S/N 2553). The instrument was attached on CTD/RMS frame, and oriented downward. CPU firmware version was 16.20.

Total of 118 operations were made with the CTD observations. Because the depth was too deep, operation was not made at the CTD stations, 175, 174 and 148. One ping raw data were recorded in 32 bins. From station 246 to 232 we set bin length for 4m. From station 231 to 121 we set bin length for 8 m. Each sampling interval was 1.29 second. The accuracy of each ping was 3 cm/s in 4m-bin and 2 cm/s in 8m-bin, respectively. Bottom-tracking mode was used and it succeeded to capture the bottom. A pressure sensor was also added. For the calculation of sound speed, we set salinity as constant value, 34 psu.

The performance of the LADCP instrument was good in western stations. Profiles were obtained over 100 m distance in shallow depth and almost 60 m in deeper depth. On the other hand in eastern stations the performance was bad. In the deeper depth good quality data were obtained only 3 or 4 bins, which means the LADCP could observe only 25 m. It would be due to a weak echo intensity, which agreed with ship's ADCP.

The data will be analyzed by using the method of Visbeck (2002) with CTD and navigation data.

### 3.9 BIOLOGICAL OPTICAL PROGRAMME

Bryan Irwin : Bedford Institute of Oceanography

#### (1) PROGRAMME OBJECTIVES

The primary objectives were to collect near surface water samples for primary production measurements, pigment analysis, picoplankton cell counts and Coloured Dissolved Organic Matter. At each sampling station incident, sea surface and sky measurements of radiation were made when weather conditions permitted. Photosynthetically Active Radiation (PAR) was recorded each hour. A PAR sensor was mounted on gimbals above the Atmospheric observation laboratory. A Licor 1400 data logger took measurements every 60 seconds and averaged the readings over one hour. The hourly average was recorded.

**Table 3.9.1 Sampling station list – R/V Mirai Leg.1**

DATE	TIME GMT	STATION #	LATITUDE	LONGITUDE	ID#
4-Aug	01 00	PO6W-244	30 05.05S	153 35.90E	264001
4-Aug	23 10	PO6W-238	30 05.13S	154 29.80E	264003
5-Aug	22 00	PO6W-234	30 04.97S	156 31.78E	264005
6-Aug	03 15	PO6W-232	30 04.94S	156 55.26E	264006
6-Aug	22 10	PO6W-227	30 04.64S	158 40.96E	264008
7-Aug	02 30	PO6W-226	30 19.93S	159 04.98E	264009
7-Aug	20 50	PO6W-221	30 04.99S	161 30.26E	264011
8-Aug	00 30	PO6W-220	30 05.30S	162 10.00E	264012
8-Aug	21 10	PO6W-215	30 05.06S	164 49.90E	254014
9-Aug	01 45	PO6W-214	30 04.62S	165 24.50E	264015
9-Aug	24 00	PO6W-212**	30 04.65S	166 29.48E	264017
10-Aug	21 30	PO6W-210	30 04.92S	167 29.90E	264019
11-Aug	04 00	PO6W-209	30 04.92S	167 59.90E	264020
11-Aug	20 30	PO6W-205	30 04.82S	169 59.82E	264022
12-Aug	01 00	PO6W-204	30 05.70S	170 29.94E	264023
12-Aug	20 30	PO6W-199	30 04.98S	172 29.92E	264025
13-Aug	00 30	PO6W-198	30 05.06S	172 59.95E	264026
13-Aug	18 10	PO6W-194	30 04.86S	175 10.08E	264028
14-Aug	01 00	PO6W-X14	30 00.50S	176 00.60E	264029
14-Aug	19 30	PO6W-190	31 05.06S	177 32.25E	264031

15-Aug	01 30	PO6C-186	31 34.99S	177 59.20E	264032
15-Aug	19 30	PO6C-182	32 30.00S	179 55.06E	264034
15-Aug	23 20	PO6C-181	32 30.15S	179 34.98W	264035
16-Aug	18 00	XXXXXXXXX	31 56.04S	177 19.05W	264037
17-Aug	18 00	PO6C-177	32 30.00S	178 17.02W	264039
17-Aug	22 30	PO6C-176	32 30.05S	178 00.03W	264040
18-Aug	18 30	XXXXXXXXX	31 59.81S	177 19.76W	264042
19-Aug	00 30	PO6C-173	32 29.96S	176 45.08W	264043
19-Aug	18 10	PO6C-170	32 28.87S	175 15.29W	264045
19-Aug	24 00	PO6C-169	32 30.10S	174 50.13W	264046
20-Aug	18 40	PO6C-166	32 30.25S	173 39.97W	264048
21-Aug	01 10	PO6C-165	32 29.95S	173 10.39W	264049
21-Aug	17 40	PO6C-162	32 29.95S	171 55.03W	264056
21-Aug	22 00	PO6C-161	32 30.11S	171 35.07W	264062
22-Aug	19 10	PO6C-X15	32 30.15S	170 00.13W	264069
23-Aug	00 45	PO6C-156	32 30.02S	169 30.23W	264075
23-Aug	17 15	PO6C-153	32 30.11S	168 00.92W	264082
23-Aug	23 00	PO6C-152	32 30.15S	167 29.97W	264088
24-Aug	16 20	PO6C-149	32 29.87S	165 49.93W	264095
25-Aug	20 00	PO6C-148**	32 29.98S	165 09.97W	264101
26-Aug	02 00	PO6C-148**	32 29.98S	165 09.97W	264108
26-Aug	17 45	PO6C-146	32 30.05S	163 50.12W	264110
26-Aug	24 00	PO6C-145	32 29.94S	163 10.03W	264116
27-Aug	18 00	PO6C-142	32 29.94S	161 09.91W	264123
27-Aug	23 40	PO6C-140	32 29.72S	160 29.62W	264129
28-Aug	18 20	PO6C-137	32 30.04S	158 09.95W	264136
29-Aug	00 50	PO6C-136	32 29.73S	157 19.98W	264142
29-Aug	19 40	PO6C-133	32 30.17S	154 50.49W	264149
30-Aug	01 35	PO6C-132	32 30.00S	153 59.69W	264155
30-Aug	16 40	PO6C-130	32 29.95S	152 20.05W	264162
30-Aug	22 20	PO6C-129	32 29.92S	151 29.62W	264168
31-Aug	18 00	PO6C-126	32 29.98S	148 59.94W	264176
1-Sep	00 05	PO6C-125	32 30.13S	148 09.99W	264182
1-Sep	18 40	PO6C-122	32 29.97S	145 39.81W	264189
2-Sep	00 50	PO6C-121	32 30.35S	144 49.87W	264195

\*\*\* No CTD at this station

## (2) SAMPLES COLLECTED

**PI curves using  $^{13}\text{C}$  mass isotope:** An artificial light temperature controlled incubator was used to incubate the samples. The incubator held 42 x 125ml polycarbonate bottles. Water samples were spiked with 0.2 m mol of  $^{13}\text{C}$  Sodium Bicarbonate solution and incubated for three hours at in-situ temperature. At the end of the incubation period, groups of three bottles were filtered on to precombusted 25 mm GF/F glass fiber filters. Samples were dried and stored on board. Samples will be analyzed in a mass spectrometer in Concepcion, Chile

**HPLC:** Duplicates from each water sample were filtered on to precombusted 25 mm GF/F glass fiber filters. The volume was usually two liters. Samples were frozen in liquid nitrogen then stored at  $-80$  degC. Samples will be analyzed later using High Performance Liquid Chromatography (HPLC) in the laboratory.

**Absorption Spectra:** Duplicate samples from each water sample were filtered on to precombusted 25 mm GF/F glass fiber filters. The volume was usually two liters. One sample was frozen in liquid nitrogen then stored at  $-80$  degC. This will be analyzed later in the laboratory. The second sample was analyzed on board. A filter, through which pre-filtered seawater was passed, was used as the blank. Absorption was measured from 750 nm to 250 nm using a Carey Model 50 BIO UV/VIS Spectrophotometer.

**Pico Plankton Counts:** Duplicate samples ( 1.8 mls) from each water sample were fixed with paraformaldehyde and then frozen in liquid nitrogen and stored at  $-80$  degC. Samples will be analyzed later in the laboratory.

**Coloured Dissolved Organic Matter (CDOM):** Sample water was filtered through a 47mm 0.2 micron polycarbonate filter and the filtrate saved. CDOM was measured from 750 nm to 250 nm in 10 cm quartz cells using a Carey Model 50 BIO UV/VIS Spectrophotometer. MilliQ water was used as a blank.

**Turner chlorophylls:** Triplicate samples of 100 ml from each sample were filtered on to 25 mm GF/F glass fiber filters. Chlorophyll was extracted in to 10 ml of 85% acetone at  $-20$  degC in the dark for approximately 24 hours. Chlorophyll concentration was measured in a Turner Design 10 AU fluorometer.

**Chlorophyll Profiles:** The fluorometer on the rosette stopped functioning at station PO6C-166. At subsequent Bio Optical stations, water samples were collected from the rosette at 10, 50, 100, 150

and 200m. At each of those depths triplicate Turner chlorophylls were measured.

***Flow through:*** Once per day water was collected from the flow through system and the fluorescence was recorded. Triplicate Turner chlorophyll samples were filtered and analyzed on board.

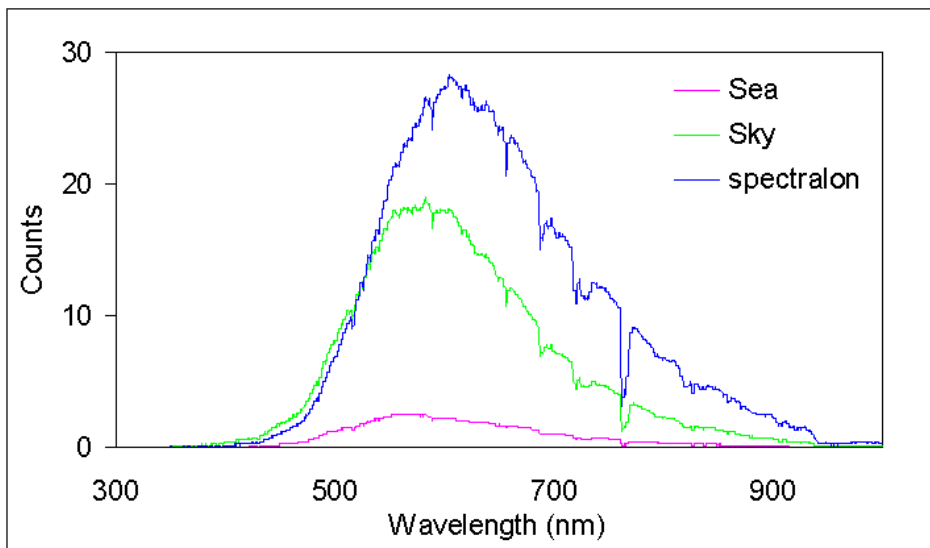
At each station where water was collected, incident, sea surface and sky measurements of radiation were measured using three different instruments. The instruments were SIMBAD-07, SIMBADA-21 and an OCEAN OPTICS HYPERSPECTRAL RADIOMETER.

SIMBAD-07 is a hand-held battery operated radiometer, which measures direct sunlight intensity by viewing the sun and water-leaving radiance at five spectral bands. Spectral bands are centered at 443, 490, 560, 670 and 870 nm. An external GPS antenna continuously acquires navigation data when the radiometer is in use.

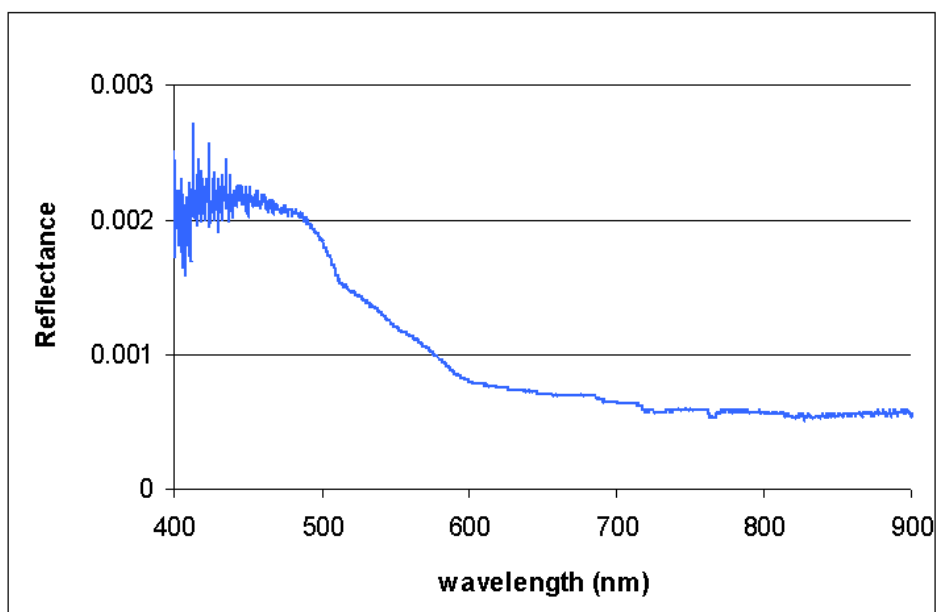
SIMBADA-21 is a similar instrument with a built-in GPS antenna and measures radiance at eleven spectral bands. Spectral bands are centered at 350, 380, 412, 443, 490, 510, 565, 620, 670, 750 and 870 nm.

The Ocean Optics Hyperspectral Radiometer measures the complete spectrum from 350 to 1000 nm at 0.5 nm intervals. A fiber optic probe is aimed at the sky and the sea surface to make the measurements.

Data from SIMBAD-07 and Ocean Optics were analyzed to verify that valid information had been collected. Detailed analysis will be done later in the laboratory. Software was not available to analyze the SIMBADA-21 data.



**Fig.3.9.1** Raw data from ocean optics hyperspectral radiometer on August 12th 2003.



**Fig.3.9.2** Reflectance calculated from raw data on August 12th 2003.

## **4. Floats and Drifters**

### **4.1 Argo float**

Nobie Shikama	(FORSGC): Principal Investigator (not on board)
Eitarou Oka	(FORSGC): not on board
Tomoyuki Takamori	(MWJ): Operation leader
Satoshi Ozawa	(MWJ): Technical staff

#### **4.1.1 Objectives**

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the subtropical South Pacific such as the South Pacific Eastern Subtropical Mode Water.

The profiling floats launched in this cruise obtain vertical profiles of temperature and salinity automatically every ten days. The data from the floats will enable us to understand the phenomenon mentioned above with time/spatial scales much smaller than those in the previous studies.

#### **4.1.2 Parameters**

Water temperature, salinity, and pressure

#### **4.1.3 Methods**

Profiling float deployment :

We launched 6 APEX floats of FORSGC and 4 SOLO floats of Scripps Institution of Oceanography (SIO). These floats equip an SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc.

The floats usually drift at a depth of 2000 dbar (called the parking depth), rising up to the sea surface every ten days by increasing their volume and thus changing the buoyancy. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately nine hours, transmitting their positions and the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The status of floats and their launches are shown in Table 4.1-1.

#### **4.1.4 Data archive**

All data acquired by the FORSGC floats through the ARGOS system is stored at FORSGC. The real-time data are provided to meteorological organizations via Global Telecommunication System (GTS) and utilized for analysis and forecasts of sea conditions.

**Table 4.1.1 Status of floats and their launches**

Float (FORSGC)

Float Type	APEX floats manufactured by Webb Research Ltd.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	10 days (approximately 9 hours at the sea surface)
ARGOS transmit interval	30 sec
Target Parking Pressure	2000 dbar
Sampling layers	71 (2000, 1900, 1800, 1700, 1600, 1500, 1400, 1300, 1250, 1200, 1150, 1100, 1050, 1000, 975, 950, 925, 900, 875, 850, 825, 800, 780, 760, 740, 720, 700, 680, 660, 640, 620, 600, 580, 560, 540, 520, 500, 480, 460, 440, 420, 400, 380, 360, 340, 320, 300, 280, 260, 240, 220, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20, 10 [dbar])

Float (SIO)

Float Type	SOLO floats manufactured by Scripps Institution of Oceanography
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	10 days
Target Parking Pressure	2000 dbar

Launches

Owner	Type	S/N	ARGOS PTT ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch
FORSGC	APEX	927	25184	19:36, Aug. 21	20:42, Aug. 21	32-30.74 S, 171-55.13 W
SIO	SOLO	2185	unknown	00:08, Jul. 31	09:56, Aug. 23	32-31.01 S, 168-59.49 W
FORSGC	APEX	928	25185	18:24, Aug. 24	00:08, Jul. 31	32-28.23 S, 165-48.00 W
SIO	SOLO	2199	unknown	00:08, Jul. 31	03:42, Aug. 27	32-29.45 S, 163-08.99 W
FORSGC	APEX	929	25186	07:22, Aug. 28	09:13, Aug. 28	32-30.21 S, 159-48.14 W
FORSGC	APEX	930	25187	03:21, Aug. 29	04:21, Aug. 29	32-30.38 S, 157-17.91 W
FORSGC	APEX	931	25263	02:58, Aug. 30	05:19, Aug. 30	32-28.46 S, 154-01.00 W
SIO	SOLO	2202	unknown	08:35, Jul. 31	09:02, Aug. 31	32-30.95 S, 150-30.71 W
FORSGC	APEX	932	25280	01:55, Sep. 01	03:25, Sep. 01	32-31.12 S, 148-08.70 W
SIO	SOLO	2203	unknown	00:11, Jul. 31	07:25, Sep. 02	32-31.12 S, 144-50.01 W