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MR07-06

Cruise Report

January, 2008

Edited by

Dr.   Takeshi Kawano

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1. Cruise Narrative

January 11, 2008

1.1 Highlight

Cruise Code : MR07-06
GHPO Section designation: P01W and P14
Chief Scientist : Leg. 1 : Takeshi Kawano (kawnaot@jamstec.go.jp)
Leg.2 : Akihiko Murata (akihiko.murata@jamstec.go.jp)

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Ship : R/V MIRAI
Ports of Call : Sekinehama – Hachinohe – Majuro – Auckland

Cruise Date : October 8, 2008 – December 26, 2008

1.2 Cruise Summary

Cruise Track

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

Number of Stations

A total of 143 stations for Leg.1 and 129 stations for Leg.2 were occupied using a Sea Bird Electronics 36 bottle carousel equipped with 12 liter Niskin X water sample bottles, a SBE911plus equipped with SBE35 deep ocean standards thermometer, SBE43 oxygen sensor, AANDERAA “optode” oxgen sensor and Benthos Inc. Altimeter and RDI Monitor ADCP.

Sampling and measurements

1) Measurements of temperature, salinity, oxygen ,current profile, fluorescence using CTD/O_2 with LADCP.
2) Water sampling and analysis of salinity, oxygen, nutrients, CFC11,12, 113, total alkalinity, DIC, and pH.
3) Water sampling of POC, ^{14}C, ^{13}C, ^{137}Cs, Pu, Noble gases, stable isotopes of O_2
4) Water sampling for a biological study.
5) Underway measurements and sampling for pCO_2, temperature, salinity, nutrients, surface current, bathymetry and meteorological parameters
6) Air sampling for volatile organic matters

Floats, Drifters and Moorings

A total of 14 Argo floats were deployed.

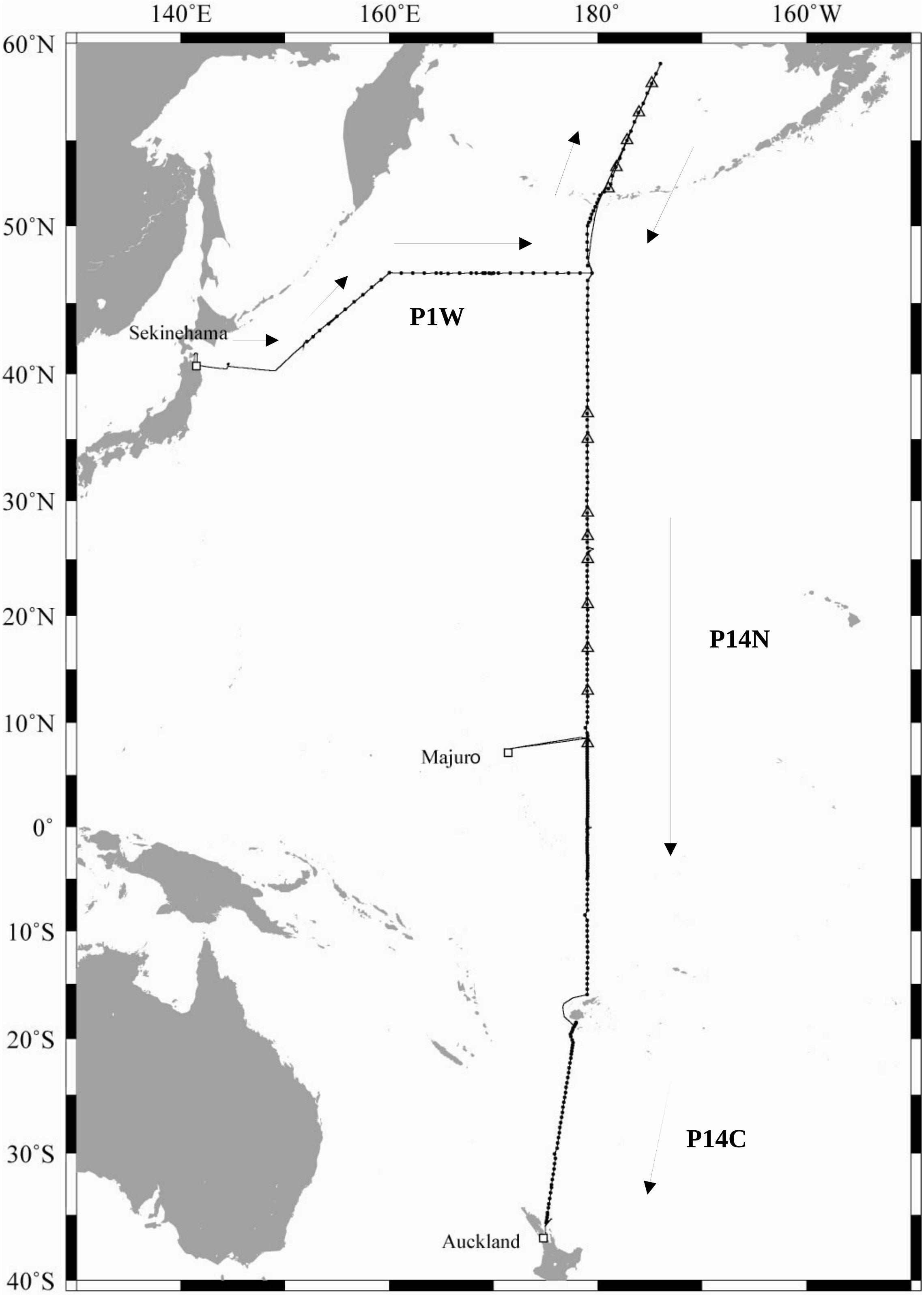


Fig.1.1 Cruise Track and station locations

1.3 Responsibility

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

1.4 Objective of the Cruise

(1) Objectives

It is well known that the oceans play a central role in determining global climate. However heat and material transports in the ocean and their temporal changes have not yet been sufficiently quantified. Therefore, global climate change is not understood satisfactorily. The purposes of this research are to evaluate heat and material transports such as carbon, nutrients, etc. in the Pacific and to detect their long term changes and basin-scale biogeochemical changes since the 1990s. This cruise is a reoccupation of the hydrographic section called 'WHP-P14', which was observed by an ocean science group of USA (United States of America) in 1993 as a part of WOCE (World Ocean Circulation Experiment). The data-set is included in the data base of CLIVAR (Climate Variability and Predictability) and Carbon Hydrographic Data Office (http://whpo.ucsd.edu/). We will compare physical and chemical properties along section WHP-P14 with those obtained in 1993 to detect and evaluate long term changes of the marine environment in the Pacific. The western stations of the hydrographic section called 'WHP-P01', which were not occupied in MR07-04 due to a trouble of ship's propellers, were also observed.

Reoccupations of the WOCE hydrographic sections are now in progress by international cooperation in ocean science community, named 'International Repeat Hydrography and Carbon Projec't, within the framework of CLIVAR, which is as part of WCRP (World Climate Research Programme) and IOCCP (International Ocean Carbon Coordination Project). Our research is planned as a contribution to this international projects supported by WMO (The World Meteorological Organization), ICSU (The International Council for Science)/SCOR (The Scientific Committee on Oceanic Research) and UNESCO (The United Nations Educational, Scientific and Cultural Organization)/IOC (The Intergovernmental Oceanographic Commission), and theresults and data will be published by 2009 for worldwide use.

The other purposes of this cruise are as follows:

1) to observe surface meteorological and hydrological parameters as a basic data of meteorology and oceanography such as studies on flux exchange, air-sea interaction and so on,

2) to observe sea bottom topography, gravity and magnetic fields along the cruise track to understand the dynamics of ocean plate and accompanying geophysical activities,

3) to observe bio-geochemical parameters to study material (carbon, nitrate, etc) cycle in the ocean,

4) to observe green house gasses in the atmosphere and the ocean to study their cycle from bio-geochemical aspect.

(2) Data Policy

Obtained data will be quality controlled and opened through GHPO and JAMSTEC within two years .

1.5 List of Cruise Participants

Cruise participants for each leg are listed in Table 2.

1.6 Major Problems

(1) Mistrip

The carousel water sampler mistripped at following stations;

Stn. P01-040 (Niskin Bottle #10)
Stn. P01-054 (Niskin Bottle #10)
Stn. P01-077 (Niskin Bottle #27)
Stn. P14N-054 (Niskin Bottle #11)
Stn. P14N-060 (Niskin Bottle #26)
Stn. P14N-063 (Niskin Bottle #11)
Stn. P14N-064 (Niskin Bottle #11)
Stn. P14N-071 (Niskin Bottle #31)
Stn. P14N-092 (Niskin Bottle #24)
Stn. P14N-099 (Niskin Bottle #18)
Stn. P14N-101 (Niskin Bottle #16)
Stn. P14N-103 (Niskin Bottle #5)
Stn. P14N-107 (Niskin Bottle #3 and #12)
Stn. P14N-126(Niskin Bottle＃30)
Stn.P14N-127(Niskin Bottle＃28)
Stn. P14C-007(Niskin Bottle #22)

(2) CTD sensor replacement

We encountered to several problems (crack, drift, shift, noise) of CTD sensors and replaced them after the following stations:

Sta. P01_46: secondary cnductivity sensor
Sta. P14N_4: primary and secondary temperature sensors
Sta. P14N_33: secondary temperature sensor
Sta. P14N_51: secondary conductivity sensor
Sta. P14N_74 cast 1: primary and secondary conductivity, and secondary temperature sensors*
Sta. P14N_99: primary conductivity sensor
Sta. P14N_108: primary conductivity sensor**
Sta. P14N_171: secondary conductivity sensor

* without secondary temperature and conductivity sensors for Sta. P14N_74 cast 2, and secondary conductivity sensor for Stas. from P14N_75 to P14N_79.

** the broken primary conductivity sensor was replaced after the station P14N_109 cast 1.

(3)Thermosalinograph

Salinity data from 2007/10/30 3:36 to 2007/11/6 4:34 was lost due to stuffed antifouling devices.

Table 1.1.1 List of principal investigator and person in charge on the ship

Chief Scientist : **Takeshi Kawano**
Chief Technologist : **Fuyuki Shibata**

Item	**Principal Investigator**	**Person in Charge on the Ship**
Hydrography		
CTDO	Hiroshi Uchida	Kenichi Katayama
LADCP	Shinya Kouketsu	Hiroshi Uchida
BTL Salinity	Takeshi Kawano	Naoko Takahashi
BTL Oxygen	Yuichiro Kumamoto	Kimiko Nishijima
Nutrients	Michio Aoyama	Ayumi Takeuchi
DIC	Akihiko Murata	Yoshiko Ishikawa
Alkalinity	Akihiko Murata	Ayaka Hatsuyama
pH	Akihiko Murata	Ayaka Hatsuyama
CFCs	Kenichi Sasaki	Kenichi Sasaki
$\Delta^{14}C$	Yuichiro Kumamoto	Yuichiro Kumamoto
Radionuclides	Michio Aoyama	Hideki Yamamoto
Noble Gasses	Tishiro Saino	Charles Stump
Biology	Takuhei Shiozaki	Ken Furuya
Underway		
ADCP	Shinya Kouketsu	Soichiro Sueyoshi
Bathymetry	Takeshi Matsumoto	Soichiro Sueyoshi
Gravity	Takeshi Matsumoto	Soichiro Sueyoshi
Geomagnetic Measurement	Takeshi Matsumoto	Soichiro Sueyoshi
Meteorology	Kunio Yoneyama	Soichiro Sueyoshi
Thermo-Salinograph	Yuichiro Kumamoto	Masanori Enoki
Volatile Organic Matter	Yoko Yokouchi	Soichiro Sueyoshi
Stable Isotopes in rain	Kimpei Ichiyanagi	Soichiro Sueyoshi
Air-Sea Turbulent CO_2 Flux	Osamu Tsukamoto	Fumiyoshi Kondo
Laser Radar	Nobuo Sugimoto	Soichiro Sueyoshi
pCO_2	Akihiko Murata	Yoshiko Ishikawa
Organic & inorganic carbon	Masao Uchida	Chie Sato
Floats, Drifters		
Argo float	Toshio Suga	Shinsuke Toyoda

Table 1.1.2 List of principal investigator and person in charge on the ship

Chief Scientist :	**Akihiko Murata**
Chief Technologist :	**Satoshi Ozawa**

Item	**Principal Investigator**	**Person in Charge on the Ship**
Hydrography		
CTDO	Hiroshi Uchida	Tomoyuki Takamori
LADCP	Shinya Kouketsu	Hiroshi Uchida
BTL Salinity	Takeshi Kawano	Naoko Takahashi
BTL Oxygen	Yuichiro Kumamoto	Kimiko Nishijima
Nutrients	Michio Aoyama	Kenichiro Sato
DIC	Akihiko Murata	Yoshiko Ishikawa
Alkalinity	Akihiko Murata	Minoru Kamata
pH	Akihiko Murata	Minoru Kamata
CFCs	Kenichi Sasaki	Kenichi Sasaki
$\Delta^{14}C$	Yuichiro Kumamoto	Akihiko Murata
Radionuclides	Michio Aoyama	Junji Matsushita
Biology	Takuhei Shiozaki	Ken Furuya
Underway		
ADCP	Shinya Kouketsu	Shinya Okumura
Bathymetry	Takeshi Matsumoto	Shinya Okumura
Gravity	Takeshi Matsumoto	Shinya Okumura
Geomagnetic Measurement	Takeshi Matsumoto	Shinya Okumura
Meteorology	Kunio Yoneyama	Shinya Okumura
Thermo-Salinograph	Yuichiro Kumamoto	Masanori Enoki
Volatile Organic Matter	Yoko Yokouchi	Shinya Okumura
Stable Isotopes in rain	Kimpei Ichiyanagi	Shinya Okumura
Air-Sea Turbulent CO_2 Flux	Osamu Tsukamoto	Shinya Okumura
Laser Radar	Nobuo Sugimoto	Shinya Okumura
pCO_2	Akihiko Murata	Yoshiko Ishikawa
Organic & inorganic carbon	Masao Uchida	Yukiko Kuroki
Floats, Drifters		
Argo float	Toshio Suga	Tomoyuki Takamori

Table 1.2.1 List of Cruise Participants for Leg.1

Name	Responsibility	Affiliation
Yasuhiro Arii	Carbon	MWJ
Masanori Enoki	Dissolved Oxygen/Thermosalinograph	MWJ
Hironobu Furuya	Biology	The University of Tokyo
Ayaka Hatsuyama	Carbon	MWJ
Mana Hikami	Water Sampling	MWJ
Miyo Ikeda	Dissolved Oxygen/Water Sampling	MWJ
Yoichi Imai	Water Sampling	JMA
Yoshiko Ishikawa	Carbon	MWJ
Kenichi Katayama	CTD	MWJ
Yoshimi Kawai	LADCP/Water Sampling	IORGC/JAMSTEC
Takeshi Kawano	Chief Scientist/Salinity/Water Sampling	IORGC/JAMSTEC
Fujio Kobayashi	Salinity	MWJ
Taketoshi Kodama	Biology	The University of Tokyo
Fumiyoshi Kondo	Air-Sea Turbulent CO_2 Flux	Okayama University
Yuichiro Kumamoto	Dissolved Oxygen/Water Sampling/C-1	IORGC/JAMSTEC
Nagi Masuda	Water Sampling	MWJ
Junji Matsushita	Nutrients	MWJ
Hiroshi Matsunaga	CTD	MWJ
Kohei Miura	Nutrients	MWJ
Takumi Miyahara	Water Sampling	MWJ
Dai Motomura	Water Sampling	MWJ
Nguyen Van Nguyen	Biology	The University of Tokyo
Kimiko Nishijima	Dissolved Oxygen/Water Sampling	MWJ
Satoshi Okumura	Meteorological/geological measurement	GODI
Harumi Ota	Meteorological/geological measurement	GODI
Kentaro Oyama	CTD	MWJ
Katsunori Sagishima	CFCs	MWJ
Kenichi Sasaki	CFCs	MIO/JAMSTEC
Chie Sato	POC and Bacteria	University of Tsukuba
Fuyuki Shibata	Chief Technologist/Carbon	MWJ
Takuhei Shiozaki	Biology	The University of Tokyo
Charles Stump	Noble Gasses	University of Washington
Soichiro Sueyoshi	Meteorological/geological measurement	GODI
Takeshi Suzuki	Water Sampling	MWJ
Naoko Takahashi	Salinity	MWJ
Ayumi Takeuchi	Nutrients	MWJ
Shoko Tatamisashi	CFCs	MWJ
Shinsuke Toyoda	CTD	MWJ
Hiroshi Uchida	CTD/LADCP/ADCP	IORGC/JAMSTEC
Masahide Wakita	CFCs	MIO/JAMSTEC
Koshi Yamaguchi	Water Sampling	MWJ
Hideki Yamamoto	Radionuclides/Water Sampling	MWJ
Kazuo Yamamoto	Water Sampling	MWJ

GODI	Global Ocean Development Inc.
IORGC	Institute of Observational Research for Global Change
JAMSTEC	Japan Agency for Marine-earth Sceinece and Technology
JMA	Japan Meteorological Agency
MIO	Mutsu Institute of Oceanography
MWJ	Marine Works Japan Ltd.

Table 1.2.2 List of Cruise Participants for Leg.2

Name	Responsibility	Affiliation
Toshimasa Doi	LADCP/Water Sampling	IORGC/JAMSTEC
Masanori Enoki	Dissolved Oxygen/Thermosalinograph	MWJ
Tsutomu Fujii	CTD	MWJ
Hironobu Furuya	Biology	The University of Tokyo
Ayaka Hatsuyama	Carbon	MWJ
Yukiko Hayakawa	Dissolved Oxygen/Water Sampling	MWJ
Yoichi Imai	Water Sampling	JMA
Yoshiko Ishikawa	Carbon	MWJ
Ryota Ito	Water Sampling	MWJ
Minoru Kamata	Carbon	MWJ
Katsuro Katsumata	LADCP/Water Sampling	IORGC/JAMSTEC
Mikio Kitada	Carbon	MWJ
Taketoshi Kodama	Biology	The University of Tokyo
Misato Koide	Water Sampling	MWJ
Atsushi Kubo	Water Sampling	MWJ
Yukiko Kuroki	POC	University of Tsukuba
Junji Matsushita	Radionuclides/Water Sampling	MWJ
Kohei Miura	Nutrients	MWJ
Akihiko Murata	Chief Scientist/Carbon/Water Sampling	IORGC/JAMSTEC
Nguyen Van Nguyen	Biology	The University of Tokyo
Kimiko Nishijima	Dissolved Oxygen/Thermosalinograph	MWJ
Haruka Nishimura	Water Sampling	MWJ
Ayumi Nomura	Water Sampling	MWJ
Takanori Ojima	Water Sampling	MWJ
Shinya Okumura	Meteorological/Geological measurement	GODI
Ryo Oyama	Meteorological/Geological measurement	GODI
Satoshi Ozawa	Chief Technologist/CTD	MWJ
Katsunori Sagishima	CFCs	MWJ
Kenichi Sasaki	CFCs	MIO/JAMSTEC
Kenichiro Sato	Nutrients	MWJ
Takayoshi Seike	Nutrients	MWJ
Takuhei Shiozaki	Biology	The University of Tokyo
Yuichi Sonoyama	CFCs	MWJ
Naoko Takahashi	Salinity	MWJ
Shoko Tatamisashi	CFCs	MWJ
Tomoyuki Takamori	CTD/ARGO	MWJ
Tatsuya Tanaka	Salinity	MWJ
Hiroshi Uchida	CTD/LADCP/Water Sampling	IORGC/JAMSTEC
Hirokatsu Uno	CTD	MWJ
Kazuho Yoshida	Meteorological/Geological measurement	GODI

GODI	Global Ocean Development Inc.
IORGC	Institute of Observational Research for Global Change
JAMSTEC	Japan Agency for Marine-earth Sceinece and Technology
JMA	Japan Meteorological Agency
MIO	Mutsu Institute of Oceanography
MWJ	Marine Works Japan Ltd.

2. Underway Measurements

2.1 Meteorological observation

2.1.1 Surface Meteorological Observation

December 27, 2007

(1) Personnel

Kunio Yoneyama	***(JAMSTEC) Principal Investigator / Not on-board***	
Souichiro Sueyoshi	***(Global Ocean Development Inc., GODI)***	***-leg1-***
Satoshi Okumura	***(GODI)***	***-leg1-***
Harumi Ohta	***(GODI)***	***-leg1-***
Shinya Okumura	***(GODI)***	***-leg2-***
Kazuho Yoshida	***(GODI)***	***-leg2-***
Ryo Ohyama	***(GODI)***	***-leg2***

(2) 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.

(3) Methods

The surface meteorological parameters were observed throughout the MR07-06 cruise. During this cruise, we used two systems for the observation.

i.. MIRAI Surface Meteorological observation (SMET) system

ii.. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

i. MIRAI Surface Meteorological observation (SMET) system

Instruments of SMET system are listed in Table.2.1.1-1 and measured parameters are listed in Table.2.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

ii. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

SOAR system designed by BNL (Brookhaven National Laboratory, USA) consists of major three parts.

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

b) Zeno Meteorological (Zeno/Met) system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.

c) 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.2.1.1-3 and measured parameters are listed in Table.2.1.1-4.

We have checked the following sensors, before and after the cruise for the quality control as post processing.

i. Young Rain gauge (SMET and SOAR)

Inspect of the linearity of output value from the rain gauge sensor to change Input value by adding fixed quantity of test water.

ii. Barometer(SMET and SOAR)

Comparison with the portable barometer value, PTB220CASE, VAISALA.

iii. Thermometer (air temperature and relative humidity) (SMET and SOAR)

Comparison with the portable thermometer value, HMP41/45, VAISALA.

(4) Preliminary results

Figures2.1.1-1 to 2.1.1-4 show the time series of the following parameters;

Wind (SOAR)
Air temperature (SOAR)
Relative humidity (SOAR)
Precipitation (SOAR, Optical rain gauge)
Short/long wave radiation (SOAR)
Pressure (SOAR)
Sea surface temperature (SMET)
Significant wave height (SMET)

(5) Data archives

These meteorological data will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC just after the cruise. Corrected data sets will be available from K. Yoneyama of JAMSTEC.

(6) Remarks

i. From 16:54, 17 Nov. to 20:35 18 Nov., Rain rate of SMET ORG is not available because of the sensor trouble. The sensor was replaced from ORG-815DR to ORG-115DR at 20:35, 18 Nov..

ii. SST(Sea Surface Temperature) data are available in the following periods.

00:58, 09 Oct. – 07:36, 19 Nov.
01:00, 23 Nov. – 01:29, 23 Dec.

iii. PRP data of SOAR system are not available due to the maintenance in the following periods.

01:00, 05 Dec. – 02:23, 05 Dec.
20:40, 06 Dec. – 22:15, 06 Dec.

iv. From 05:06, 09 Oct. to 23:46 15 Oct., Precipitation data of SOAR Capacitive rain gauge are not available because of the sensor trouble.

v. SOAR sensor cleaning

(PRP)	23:48, 15 Oct.
	20:55, 08 Nov.
	21:09, 26 Nov.
	23:28, 18 Dec.
(ORG)	20:56, 08 Nov.
	21:10, 26 Nov.
	01:45, 05 Dec.
	23:27, 18 Dec.

vi. Occasionally, SOAR ORG data at noon included error caused by blowing of the ship whistle at the foremast.

vii. SOAR short wave radiation data had a bias about 10W/m2 throughout the cruise. In addition, from the beginning of the second leg, an increasing linear trend of 1-2 W/m2 per one day was observed. These data will be corrected after the cruise.

Table.2.1.1-1 Instruments and installations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side and port side
Thermometer: SST	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	AP370	Koshin Denki, Japan	captain deck (13 m) weather observation room
Rain gauge	50202	R. M. Young, USA	compass deck (19 m)
Optical rain gauge	ORG-815DR	Osi, USA	
after 18 November	ORG-115DR	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table.2.1.1-2 Parameters of MIRAI Surface 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^2	6sec. averaged
20	Down welling infra-red radiation	W/m^2	6sec. averaged
21	Significant wave height (bow)	m	hourly
22	Significant wave height (aft)	m	hourly
23	Significant wave period (bow)	second	hourly
24	Significant wave period (aft)	second	hourly

Table.2.1.1-3 Instruments and installation locations of SOAR system

Sensors(*Zeno/Met*)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Barometer	61201	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (22 m)
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-115DA	Osi, USA	foremast (24 m)

Sensors (*PRP*)	Type	Manufacturer	Location (altitude from surface)
Radiometer (short wave)	PSP	Epply Labs, USA	foremast (24 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (24m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (24 m)

Table.2.1.1-4 Parameters of SOAR system

	Parameter	Units	Remarks
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	
11	Precipitation (capacitive rain gauge)	mm	reset at 50 mm
12	Down welling shortwave radiation	W/m^2	
13	Down welling infra-red radiation	W/m^2	
14	Defuse irradiance	W/m^2	

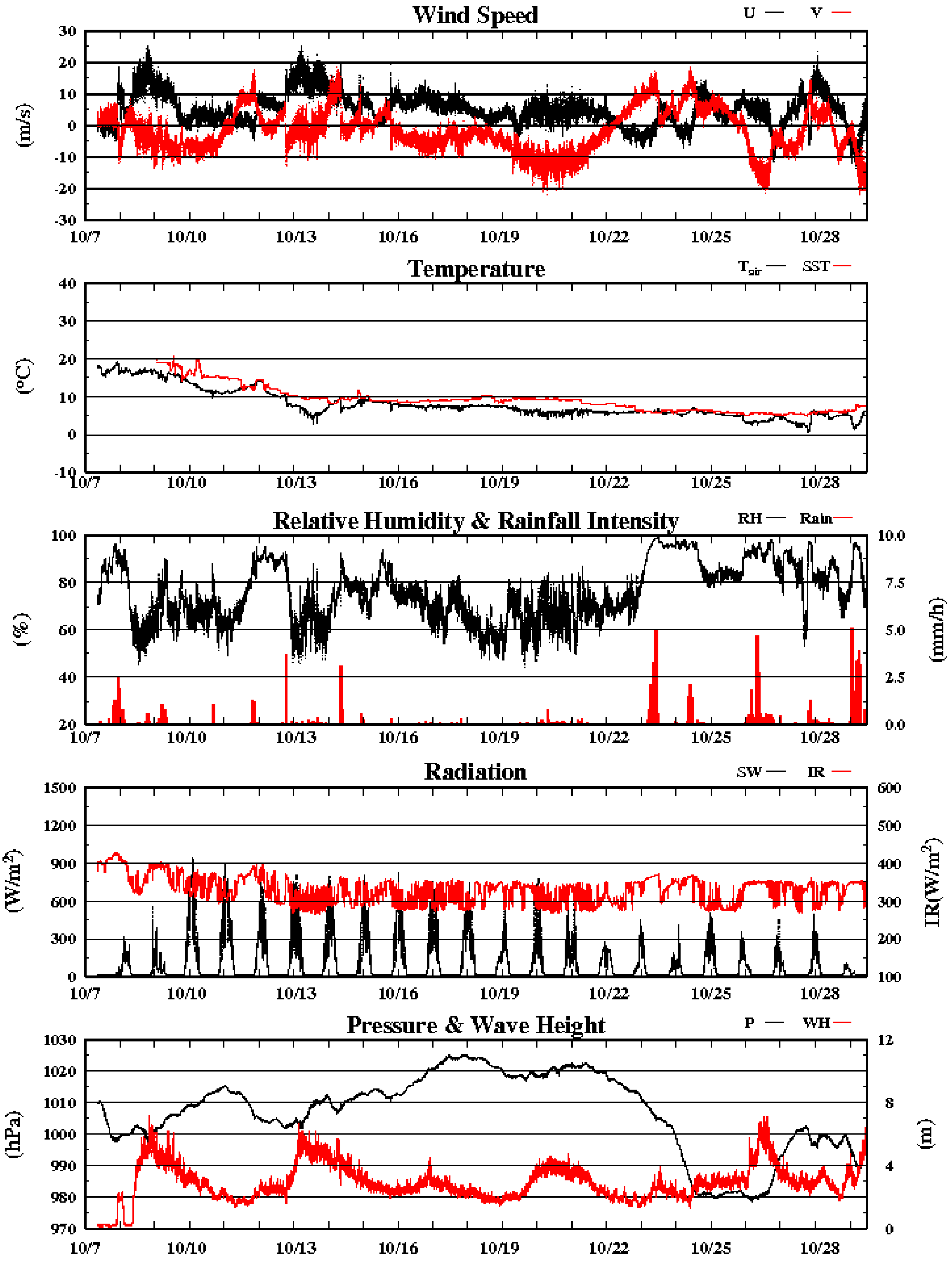


Fig.2.1.1-1 Time series of surface meteorological parameters during the MR07-06 cruise (Leg1)

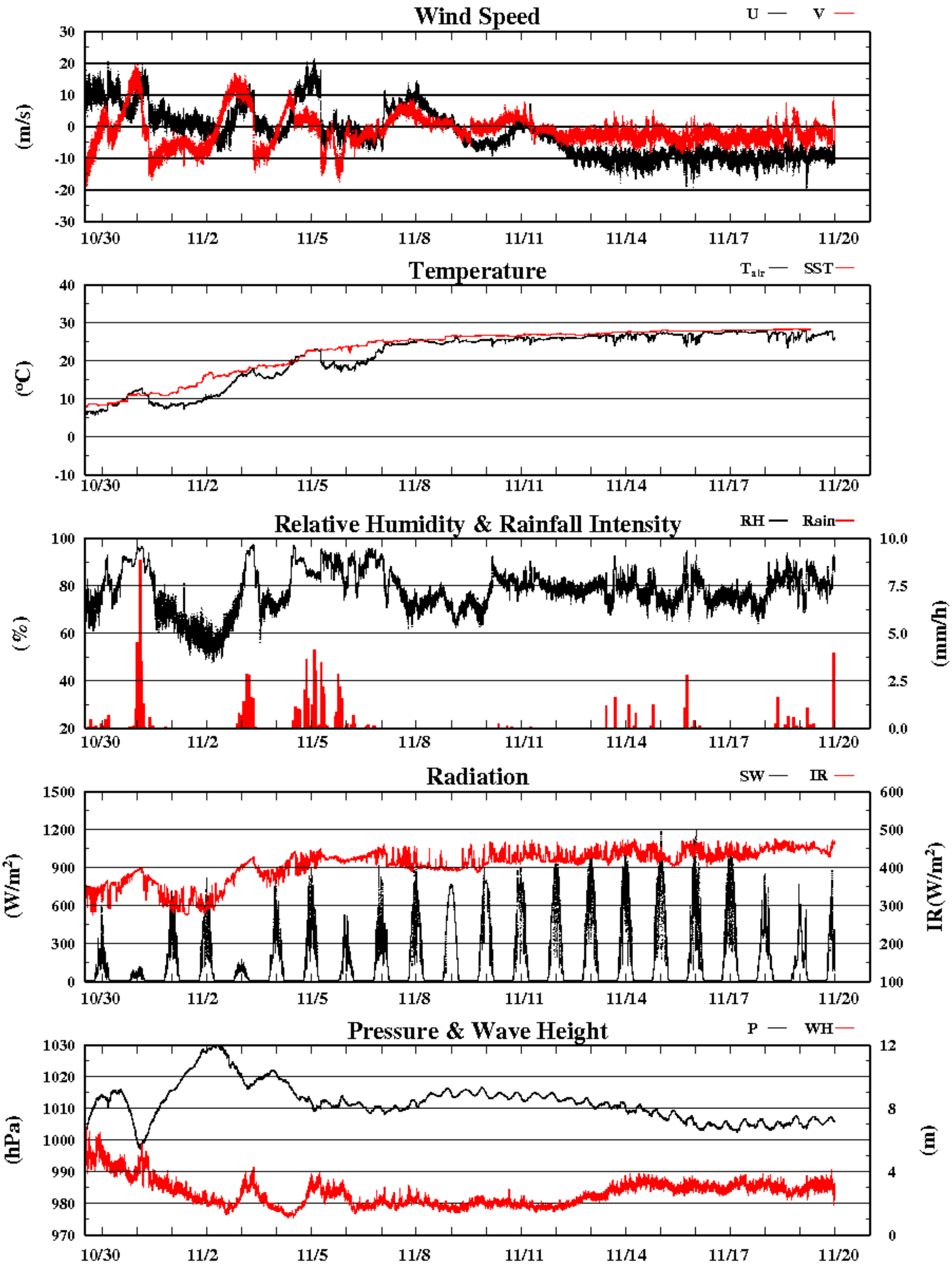


Fig.2.1.1-2 Time series of surface meteorological parameters during the MR07-06 cruise (Leg1)

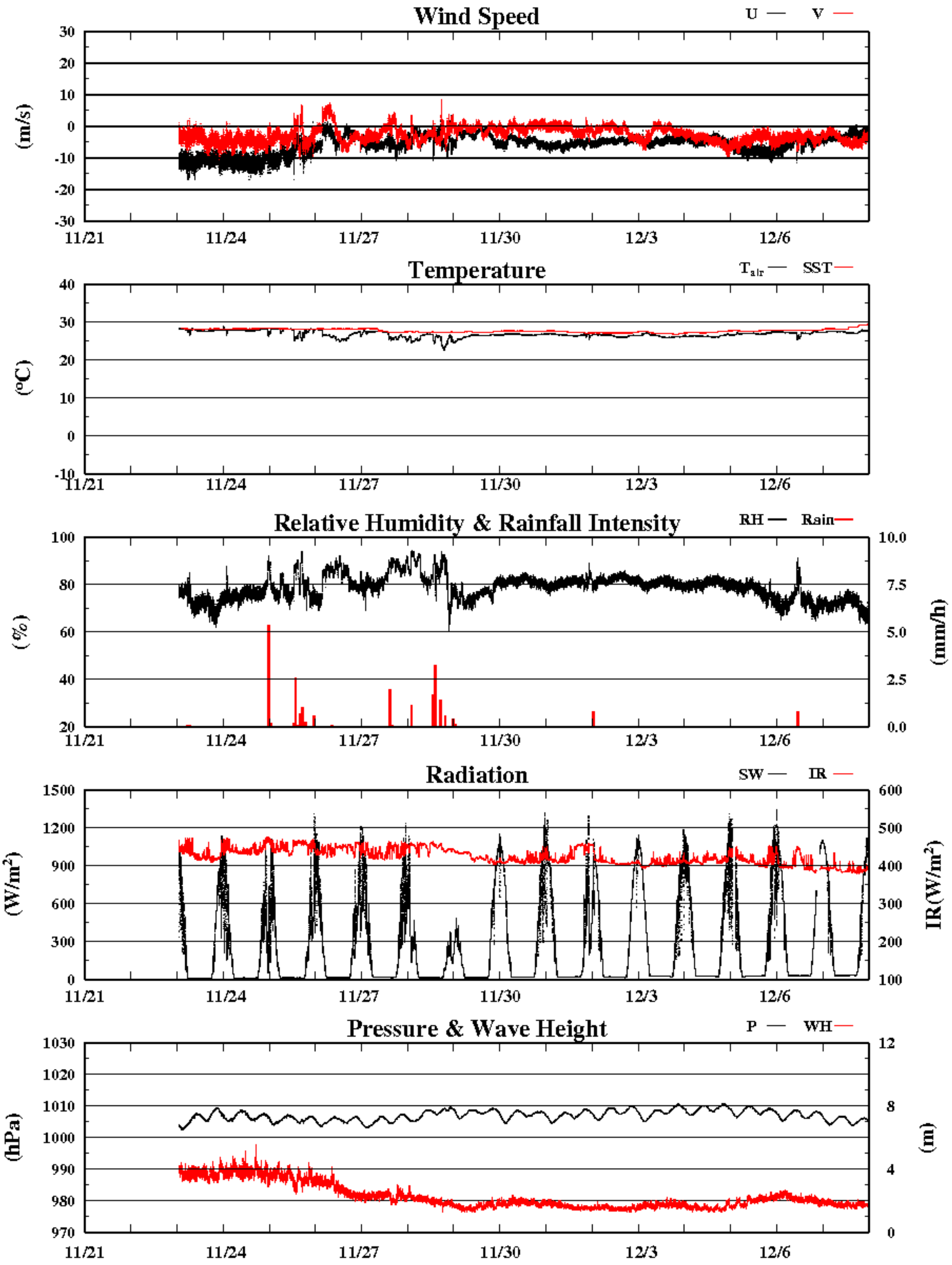


Fig.2.1.1-3 Time series of surface meteorological parameters during the MR07-06 cruise (Leg2)

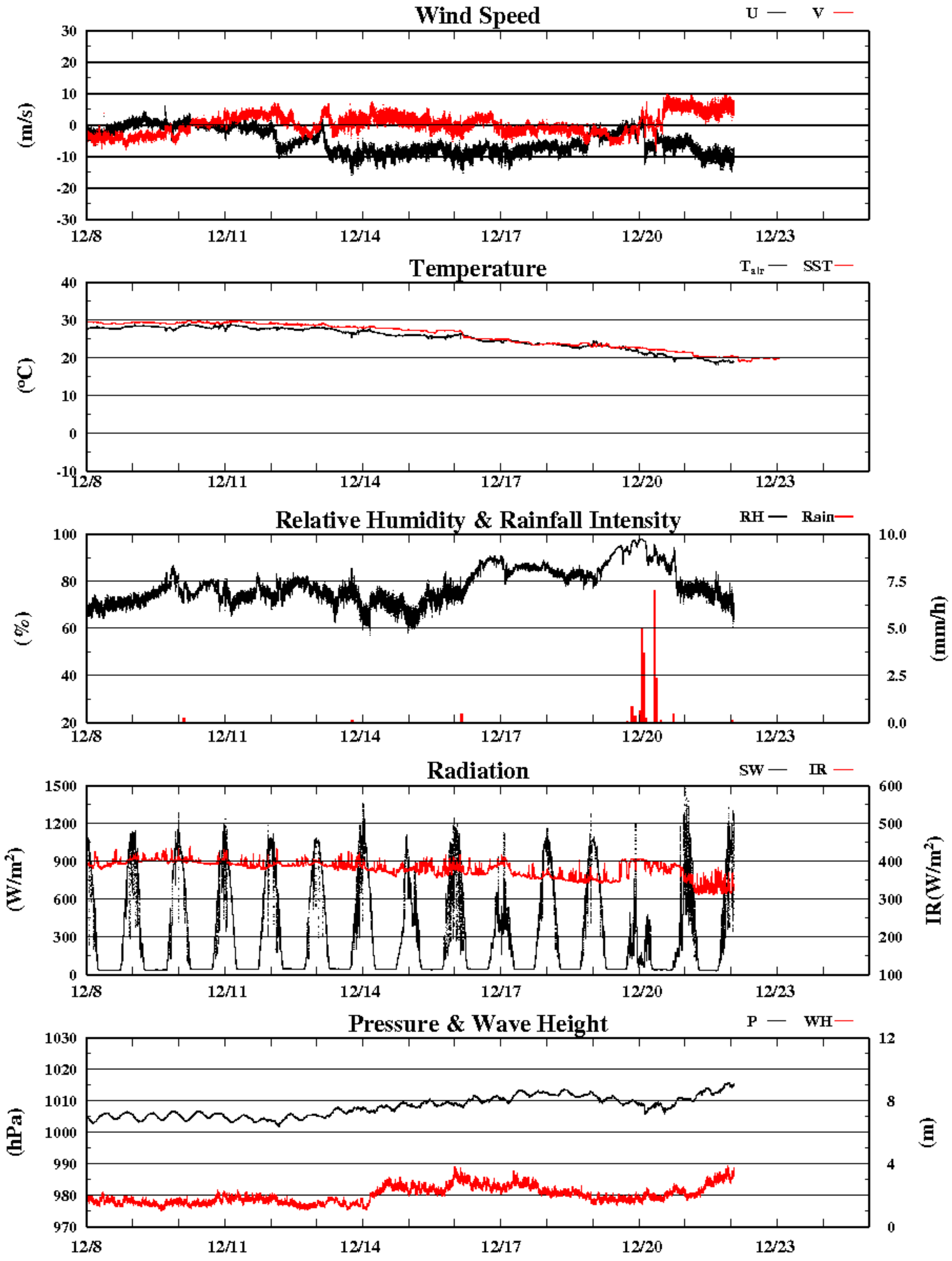


Fig.2.1.1-4 Time series of surface meteorological parameters during the MR07-06 cruise (Leg2)

2.1.2 Ceilometer Observation

December 27, 2007

(1) Personnel

Kunio Yoneyama	***(JAMSTEC) Principal Investigator / Not on-board***	
Souichiro Sueyoshi	***(Global Ocean Development Inc., GODI)***	***-leg1-***
Satoshi Okumura	***(GODI)***	***-leg1-***
Harumi Ohta	***(GODI)***	***-leg1-***
Shinya Okumura	***(GODI)***	***-leg2-***
Kazuho Yoshida	***(GODI)***	***-leg2-***
Ryo Ohyama	***(GODI)***	***-leg2-***

(2) 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.

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR07-06 cruise. Major parameters to be measured are
i. cloud base height in meters, ii. backscatter profiles, and iii. estimated cloud amount in octas.

Specifications of the system are as follows.

Laser source:	Indium Gallium Arsenide Diode
Transmitting wavelength:	905±5 mm 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 octas (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).

(4) Preliminary results

Figure.2.1.2 shows the time series of the first, second and third lowest cloud base height during the cruise.

(5) Data archives

Ceilometer data obtained during this cruise will be submitted to and archived by the Marine-Earth Data and Information Department (MEDID) of JAMSTEC.

(6) Remarks

Window Cleaning (UTC):	16 Oct.	03:01
	29 Oct.	01:27
	01 Nov.	01:47
	08 Nov.	21:05
	18 Nov.	03:18
	26 Nov.	21:05
	04 Dec.	01:55

11 Dec. 03:15
18 Dec. 22:45

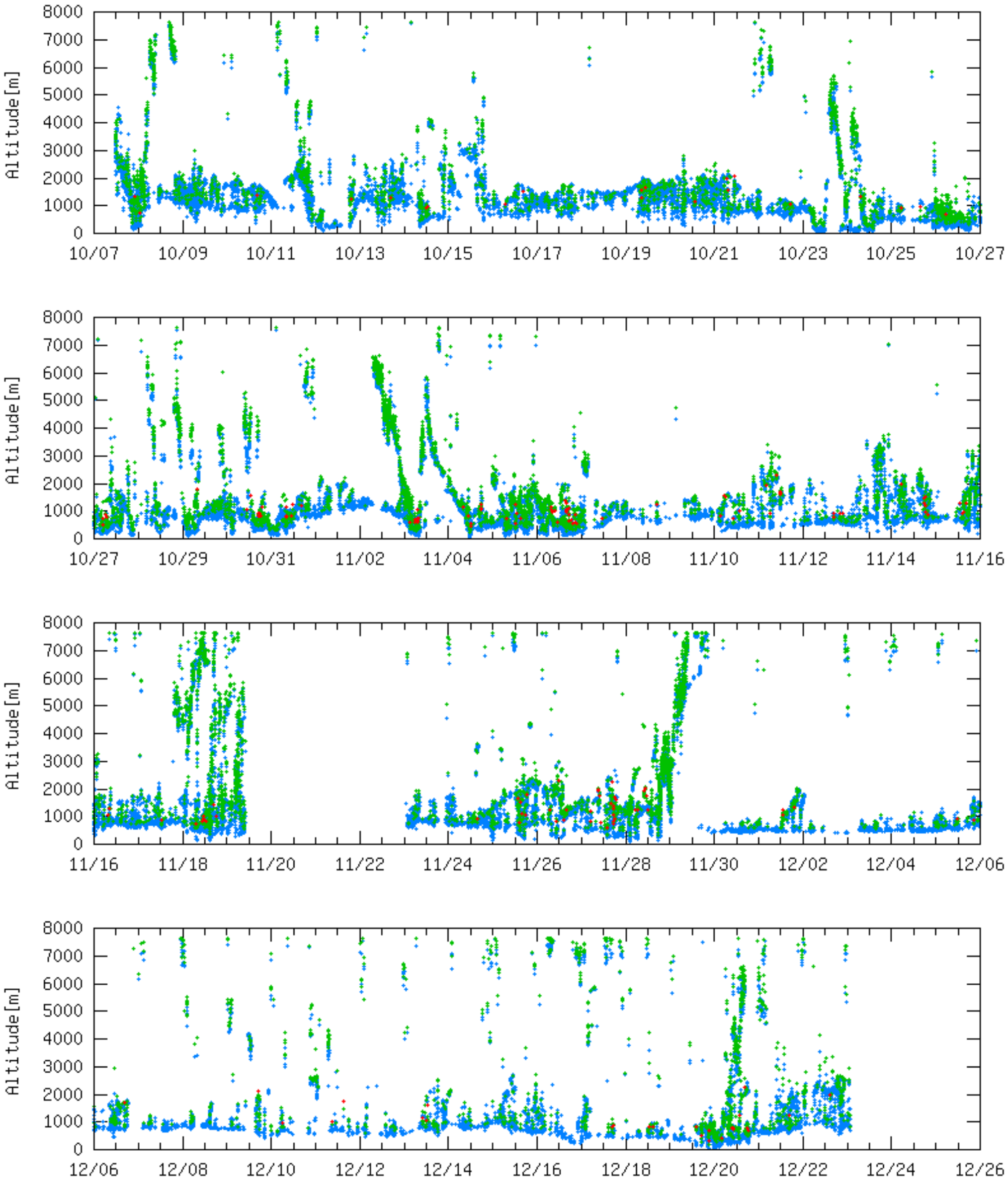


Fig.2.1.2 1st (blue) 2nd (green) and 3rd (red) lowest cloud base height during MR07-06 cruise.

2.1.3 Air-Sea Turbulent CO_2 Flux by Eddy Covariance Technique

November 15, 2007

(1) Personnel: ***Fumiyoshi Kondo (Okayama University): Operation Leader***

On-shore Scientists: Osamu Tsukamoto (Okayama University): Principal Investigator
Hiroshi Ishida (Kobe University)
Kunio Yoneyama (JAMSTEC)

(2) Objective

The ocean is one of the main sinks of anthropogenic CO_2. Precise measurements of the CO_2 gas flux across the air-sea interface provide a better understanding of the global carbon cycle. Eddy covariance technique is the only direct measurement of air-sea CO_2 flux. This technique has little assumption (constant flux layer and steady state), and may evaluate small spatial and temporal CO_2 flux as compared with mass balance technique. For these reasons, we hope that eddy covariance technique can understand uncertain processes that control air-sea CO_2 flux.

(3) Method

We installed the turbulent flux and ship motion correction systems on the top of the foremast (Fig. 1). The turbulent flux system consisted of a sonic anemometer-thermometer (KAIJO, DA-600-3TV) and an infrared CO_2/H_2O gas analyzer (LI-COR, LI-7500). LI-7500 is an open-path analyzer that measures directly turbulent fluctuations of carbon dioxide and water vapor densities in the air. In this cruise, a closed-path CO_2/H_2O gas analyzer (LI-COR, LI-7000) is installed at the top of the foremast. The sample air is drawn into a sample cell in this closed-path analyzer through a sampling tube and a diaphragm air pump.

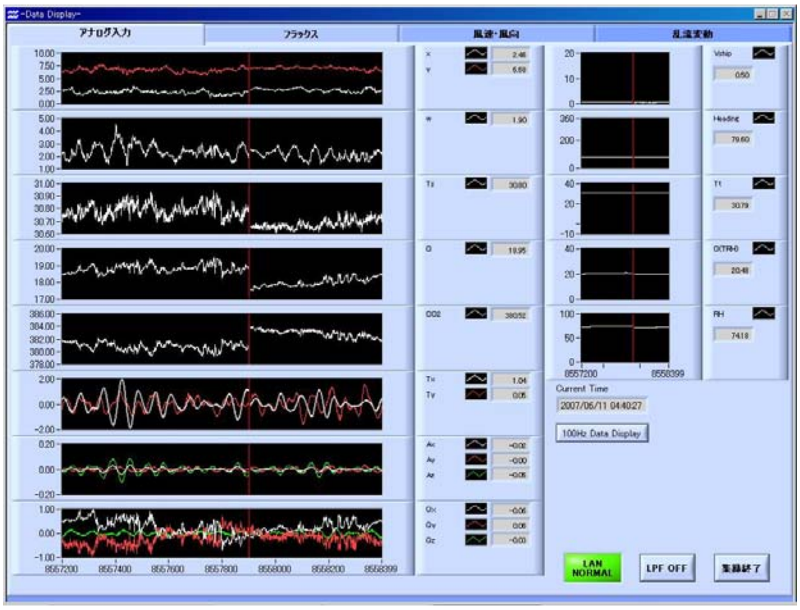
The sonic anemometer measures three-dimensional wind components relative to the ship including apparent wind velocity due to the ship motion. Then, the ship motion correction system measures the ship motions. This ship motion correction system consisted of a two-axis inclinometer (Applied Geomechanics, MD-900-T), a three-axis accelerometer (Applied Signals, QA-700-020), and a three-axis rate gyro (Systron Donner, QRS11-0050-100).

Analog output signals from these both systems are sampled at 100 Hz by a PC-based data logging system (National Instruments Co., Ltd., LabVIEW8). This system is connected to the Mirai network system to obtain ship speed and heading data that are used to derive absolute wind components relative to the ground. Combining these data, turbulent fluxes and statistics are calculated in a real-time basis and displayed on the PC (Fig. 2).

(4) Data Archive

All the data obtained during this cruise are archived at Okayama University, and will be open to public after quality checks and corrections. The corrected data and inventory information will be submitted to JAMSTEC Data Management Office.

Fig.1. Installation of the turbulent flux and ship motion correction systems on the top of the foremast.



x 2.46
y 6.69
w 1.90
Ts 30.80
Q 19.95
CO2 380.52
Tx 1.04
Ty 0.05
Ax -0.02
Ay -0.00
Az -0.06
Qx -0.06
Qy 0.06
Qz -0.00
Vship 0.50
Heading 79.60
T1 30.79
O(TRH) 20.48
RH 74.18

Current Time
2007/06/11 04:40:27

Fig.2. PC-based real time logging and monitoring system using LabVIEW8 software.

2.1.4 Lidar observations of clouds and aerosols

December 27, 2007

(1) Personnel

Nobuo Sugimoto, Ichiro Matsui, Atsushi Shimizu (National Institute for Environmental Studies, not on board), lidar operation was supported by GODI.

(2) Objectives

Objectives of the observations in this cruise is to study distribution and optical characteristics of ice/water clouds and marine aerosols using a two-wavelength lidar.

(3) Measured parameters

- Vertical profiles of backscattering coefficient at 532 nm
- Vertical profiles of backscattering coefficient at 1064 nm
- Depolarization ratio at 532 nm

(4) Method

Vertical profiles of aerosols and clouds were measured with a two-wavelength lidar. The lidar employs a Nd:YAG laser as a light source which generates the fundamental output at 1064 nm and the second harmonic at 532 nm. Transmitted laser energy is typically 30 mJ per pulse at both of 1064 and 532 nm. The pulse repetition rate is 10 Hz. The receiver telescope has a diameter of 20 cm. The receiver has three detection channels to receive the lidar signals at 1064 nm and the parallel and perpendicular polarization components at 532 nm. An analog-mode avalanche photo diode (APD) is used as a detector for 1064 nm, and photomultiplier tubes (PMTs) are used for 532 nm. The detected signals are recorded with a transient recorder and stored on a hard disk with a computer. The lidar system was installed in the radiosonde container on the compass deck. The container has a glass window on the roof, and the lidar was operated continuously regardless of weather. Every 15 minutes vertical profiles of four channels (532 parallel, 532 perpendicular, 1064, 532 near range) are recorded.

(5) Results

Lidar raw data have not been collected by NIES researchers because this is unattended subject. So we show here only sample vertical profiles of backscattering intensity which was automatically generated onboard and transferred to NIES by e-mail. Figure 1 shows an atmospheric structure revealed by lidar on October 17, 2007. There was a cloud layer around 8.5 km. High depolarization ratio (perpendicular to parallel at 532 nm) indicates this layer is consist of non-spherical ice particles. Below the cloud, some structure of aerosol layers was evident. A typical aerosol mixing layer was located blow 500m, but weak aerosol signal was detected between 1 – 2.5 km. Similar profiles are obtained every 15 minutes, and three dimensional structure of atmospheric scatterers (clouds and aerosols) are revealed in whole troposphere.

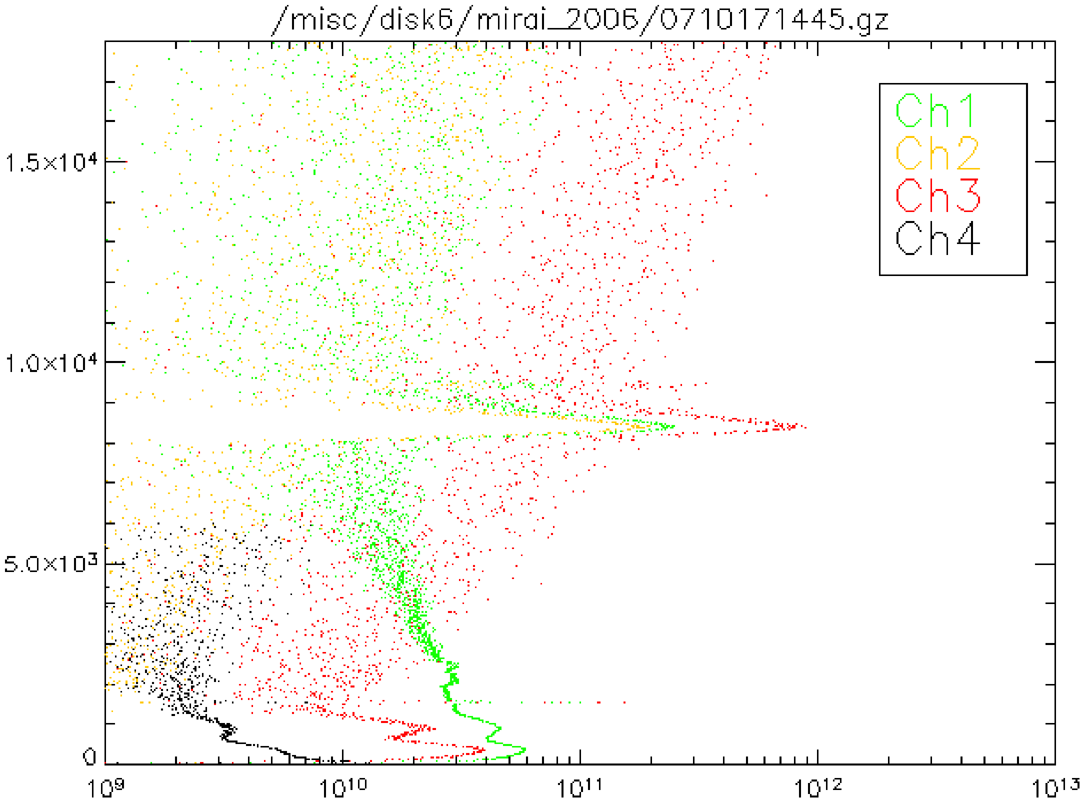


Figure 1 : Vertical profiles of backscattering intensity at 532 nm parallel (green), 532 nm perpendicular (yellow), 1064 nm (red) at UTC1445 on October 17, 2007. Black indicates signal from near field telescope (532nm)

(6) Data archive

- raw data
  - lidar signal at 532 nm
  - lidar signal at 1064 nm
  - depolarization ratio at 532 nm
  - temporal resolution 15min/ vertical resolution 6 m
  - data period : October 8 -- November 18 and November 23 – December 23, 2007
- processed data
  - cloud base height, apparent cloud top height
  - phase of clouds (ice/water)
  - cloud fraction
  - boundary layer height (aerosol layer upper boundary height)
  - backscatter coefficient of aerosols
  - particle depolarization ratio of aerosols

2.1.5 Rain Sampling for Stable Isotopes

December 27, 2007

(1) Personnel

Kimpei Ichiyanagi (JAMSTEC) (Not on board)

(2) Objective

To determine the spatial distribution of isotopic composition of rainfall on the Ocean

(3) Method

Rainfall samples are collected in 6cc glass bottle with plastic cap. Isotopic compositions for hydrogen and oxygen in rainfall are determined by the Isotope Ratio Mass Spectrometry (IRMS).

(4) Preliminary results

During this cruise, we collected 42 samples in total. Table 1 lists the date and location of rainfall samples. Analysis will be done after the cruise.

(5) Data archive

Original samples will be analyzed by IORGC. Inventory and analyzed digital data will be submitted to JAMSTEC Data Management Office.

Table 1 Dates and locations to show when and where rain water were sampled.

Sample No.	Date (UTC)		Location (lat/lon)			Rain (mm)
001	02:45,	October 08	40-34.3N	/	141-32.0E	18.2
002	08:55,	October 09	40-29.4N	/	145-03.5E	3.6
003	21:41,	October 11	43-37.4N	/	154-16.4E	3.5
004	09:35,	October 14	47-00.6N	/	161-08.8E	8.6
005	21:15,	October 15	46-58.8N	/	165-38.3E	0.4
006	23:32,	October 21	49-31.0N	/	178-58.3E	0.4
007	12:10,	October 23	51-24.1N	/	179-55.5E	2.9
008	19:38,	October 24	53-38.5N	/	178-07.8W	1.6
009	05:37,	October 26	56-58.8N	/	175-40.3W	2.7
010	02:56,	October 27	58-29.9N	/	174-24.9W	2.9
011	20:56,	October 28	50-40.8N	/	179-44.6E	0.5
012	03:52,	October 29	50-16.1N	/	179-37.6E	4.0
013	08:07,	October 29	49-15.6N	/	179-21.8E	9.1
014	09:17,	October 31	44-47.5N	/	179-01.8E	2.7
015	03:35,	November 03	39-23.8N	/	179-02.6E	2.8
016	12:30,	November 03	38-28.4N	/	179-00.1E	5.7
017	14:50,	November 04	36-13.6N	/	179-00.5E	1.4
018	09:33,	November 05	34-29.5N	/	178-59.3E	11.4
019	21:49,	November 05	32-58.7N	/	178-59.3E	7.2
020	07:52,	November 06	32-16.3N	/	179-00.8E	0.7
021	16:35,	November 13	19-31.1N	/	179-00.0E	2.9
022	19:57,	November 14	17-00.7N	/	178-59.5E	2.2
023	19:20,	November 15	15-00.7N	/	178-59.4E	1.8

024	18:17,	November 18	09-08.1N	/	178-57.2E	24.0
025	22:57,	November 18	08-59.8N	/	178-59.6E	0.4
026	10:02,	November 19	08-30.4N	/	178-54.9E	0.4
027	01:40,	November 25	07-14.1N	/	179-00.2E	0.6
028	20:15,	November 25	06-29.5N	/	178-59.8E	4.2
029	00:32,	November 26	06-14.4N	/	178-59.9E	1.0
030	05:29,	November 28	03-59.6N	/	178-59.6E	3.0
031	16:18,	November 28	03-30.3N	/	179-00.0E	3.4
032	19:28,	November 28	03-14.9N	/	178-59.8E	14.4
033	01:21,	November 29	02-59.9N	/	179-00.5E	0.8
034	23:59,	December 01	00-00.1N	/	179-00.1E	0.6
035	14:42,	December 06	04-00.4S	/	179-00.3E	1.4
036	18:25,	December 09	09-26.3S	/	178-59.9E	0.2
037	02:57,	December 16	21-25.6S	/	177-28.2E	0.8
038	22:12,	December 19	29-19.5S	/	176-07.4E	0.4
039	01:53,	December 20	29-34.4S	/	176-05.0E	28.9
040	05:27,	December 20	29-34.5S	/	176-05.1E	4.6
041	09:50,	December 20	29-34.6S	/	176-05.2E	14.0
042	19:50,	December 20	29-34.7S	/	176-05.3E	0.2

2.1.6 Volatile Organic Matter

December 25, 2007

(1) Personnel

Yoko Yokouchi (National Institute for Environmental Studies)

(2) Objectives

To know the distribution of volatile organic compounds emitted from marine biota.

(3) Measured compounds

- Dibromomethane
- Methyl iodide
- Methyl chloride
- Methyl bromide
- Dimethyl sulfide
- Carbonyl sulfide
- Isoprene
- Chloroform

(4) Methods

Air samples were taken on board forward of any potential contamination from the stack, at the front of the uppermost deck on the Mirai. Pressurized air sample was collected in an evacuated 6-L canister every 2.5 degree latitude between 49°N and 36°S. Sampling information is summarized in Table. 1.

Samples will be analyzed using a preconcentration/capillary gas chromatographic/mass spectrometer (GC/MS) after the cruise.

Table 1. Air samples collected during the MR-7-06 cruise.

	Stn. NO	SamplingTime		Sampling Position		Cannister No.	Wind		Air Temp. (degC)	SST (degC)
		Date	Time (UTC)	LAT (deg-min)	LON (deg-min)		Dir. (deg)	Speed (m/s)		
Leg.1	P14N-27	2007/10/21	14:22	48-59.62N	178-59.51E	1312	294	8.6	6.1	8.034
	P14N-19	2007/10/23	12:01	52-34.11N	179-55.46E	4969	238	7.5	6.4	5.828
	P14N-11	2007/10/24	21:42	54-00.02N	177-54.05W	5491	235	11.4	6.0	6.290
	P14N-06	2007/10/25	23:30	56-30.08N	176-05.65W	H1245	286	8.2	3.3	5.253
	P14N-01	2007/10/27	0:23	59-00.01N	173-59.85W	H1018	313	3.3	4.3	5.434
	P14N-32	2007/10/30	6:13	46-29.68N	179-00.30E	7069	276	11.7	8.8	8.892
	P14N-37	2007/10/31	17:33	43-59.62N	178-59.25E	H1028	309	8.9	8.3	10.948
	P14N-42	2007/11/1	23:43	41-29.54N	178-59.69E	5999	352	5.8	10.3	16.457
	P14N-47	2007/11/3	7:50	38-57.79N	179-01.63E	7221	238	9.3	18.0	18.162
	P14N-52	2007/11/4	10:53	36-30.0N	179-00.1E	5394	202	7.5	19.9	19.999
	P14N-57	2007/11/5	13:20	33-59.4N	178-59.8E	5238	330	3.0	19.1	23.125
	P14N-62	2007/11/6	15:31	31-30.0N	179-00.9E	1154	53	5.1	20.4	25.066
	P14N-67	2007/11/7	20:38	28-59.6N	179-00.1E	H1033	231	11.6	25.0	25.786
	P14N-72	2007/11/9	2:51	26-29.9N	179-00.0E	6000	20	0.1	26.5	26.476
	P14N-77	2007/11/11	14:35	24-00.1N	178-59.6E	2219	90	3.8	25.8	26.948
	P14N-82	2007/11/12	20:11	21-30.2N	178-59.4E	1879	64	9.8	26.4	26.991
	P14N-87	2007/11/13	20:40	19-00.4N	178-59.7E	H1005	65	8.9	26.5	27.607
	P14N-92	2007/11/15	0:30	16-30.2N	178-59.7E	5423	75	7.4	27.5	28.043
	P14N-97	2007/11/16	6:06	14-00.3N	178-59.7E	2163	68	9.4	27.6	27.966
	P14N-102	2007/11/17	13:31	11-30.6N	178-59.9E	H1261	61	9.5	27.4	28.197
	P14N-107	2007/11/18	20:37	9-00.4N	178-59.8E	4966	95	10.3	26.5	28.407
Leg.2	P14N-117	2007/11/25	19:23	6-29.55N	178-59.90E	1309	53	10.4	27.7	28.176
	P14N-127	2007/11/28	2:20	3-58.60N	179-00.43E	1017	81	4.1	24.7	27.482
	P14N-137	2007/11/30	10:11	1-30.14N	179-00.00E	1041	78	5.3	26.9	27.768
	P14N-147	2007/12/3	19:58	0-59.79S	179-00.06E	1294	68	4.7	26.4	26.927
	P14N-157	2007/12/6	4:00	3-29.81S	179-00.23E	1239	56	7.5	27.5	27.995
	P14N-165	2007/12/8	3:33	6-00.49S	179-00.47E	H1020	12	4.4	28.1	29.587
	P14N-170	2007/12/9	7:38	8-30.15S	178-44.93E	7215	329	4.5	28.5	29.486
	P14N-175	2007/12/10	12:21	11-00.28S	179-00.04E	5384	136	1.0	28.5	19.430
	P14N-180	2007/12/11	12:39	13-29.61S	179-00.14E	1306	167	4.1	28.0	29.408
	P14N-185	2007/12/12	9:02	15-58.53S	178-59.86E	5422	157	4.3	28.0	29.365
	P14C-52	2007/12/13	19:27	18-32.19S	177-55.72E	H1024	97	10.4	26.3	28.324
	P14C-38	2007/12/15	20:05	21-07.02S	177-30.86E	1293	82	7.6	26.0	27.382
	P14C-32	2007/12/17	1:17	23-29.17S	177-06.82E	1284	72	8.2	24.4	24.974
	P14C-26	2007/12/18	8:10	26-06.27S	176-39.91E	1151	84	8.1	23.4	23.666
	P14C-21	2007/12/19	9:35	28-16.49S	176-17.82E	1275	37	6.7	22.9	22.729
	P14C-15	2007/12/20	15:44	30-52.80S	175-51.50E	5494	138	8.9	20.4	21.879
	P14C-8	2007/12/22	1:51	33-42.22S	175-23.19E	5278	116	10.5	19.1	20.394
	P14C-1	2007/12/22	22:50	35-38.07S	175-02.07E	1114	94	10.1	18.7	19.647
	P14C-1	2007/12/22	22:56	35-38.07S	175-02.07E	1155	84	8.7	18.8	19.645

2.2 Navigation and Bathymetry

2.2.1 Navigation

December 27, 2007

(1) Personnel

Souichiro Sueyoshi	***(Global Ocean Development Inc., GODI)***	***-leg1-***
Satoshi Okumura	***(GODI)***	***-leg1-***
Harumi Ohta	***(GODI)***	***-leg1-***
Shinya Okumura	***(GODI)***	***-leg2-***
Kazuho Yoshida	***(GODI)***	***-leg2-***
Ryo Ohyama	***(GODI)***	***-leg2-***

(2) System description

Ship’s position and velocity were provided by Radio Navigation System on R/V Mirai. This system integrates GPS position, log speed, gyro compass heading and other basic data for navigation, and calculated speed/course over ground on HP workstation. Radio navigation System also distributed ship’s standard time synchronized to GPS time server via Network Time Protocol. These data were logged on the network server as “SOJ” data every 60 seconds.

Sensors for navigation data are listed below;

i) GPS receiver: Trimble DS-4000 with two GPS antennas located on navigation deck, starboard and port side, manually switched as to GPS receiving state and offset to radar-mast position, datum point.

ii) Dopplar log: Furuno DS-300, which use three acoustic beam for current measurement under the hull.

iii) Gyrocompass: Tokimec TG-6000, sperry type mechanical gyrocompass.

iv) GPS time server: Datum Tymserv 2100, NTP server synchronizing to GPS satellite every 1 second.

2.2.2 Swath Bathymetry

December 27, 2007

(1) Personnel

Takeshi Matsumoto	***(University of the Ryukyus)***	***Principal Investigator (Not on-board)***
Souichiro Sueyoshi	***(Global Ocean Development Inc., GODI)***	***-leg1-***
Satoshi Okumura	***(GODI)***	***-leg1-***
Harumi Ohta	***(GODI)***	***-leg1-***
Shinya Okumura	***(GODI)***	***-leg2-***
Kazuho Yoshida	***(GODI)***	***-leg2-***
Ryo Ohyama	***(GODI)***	***-leg2-***

(2) Introduction

R/V MIRAI is equipped with 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.

(3) Data Acquisition

We operated MNBES system during the MR07-06 Leg-1 cruise from Sekinehama on 7th October 2007 to fulfillment point of observation on 19th November 2007, and the Leg-2 cruise from starting point of observation on 23th November 2007 to Auckland on 26th December 2007. To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data for the surface (6.2m) sound velocity, and below that the sound velocity profile calculated from temperature and salinity profiles by CTD data by the equation in Mackenzie (1981) during the cruise. And also, we applied these calculated sound velocity profiles to each raw data in place, recalculated swath bathymetry data. Table 2.2.2-1 shows system configuration and performance of SEABEAM 2112.004 system.

Table 2.2.2-1 System configuration and performance

SEABEAM 2112.004 (12kHz system)	
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)

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

Bathymetric data obtained during this will be submitted to the Marine-Earth Data and Information Department （MEDID） of JAMSTEC.

(6) Remarks

i. Following the periods, we did not acquire data because system trouble.

14 Oct. 2007, 05:54 to 06:23

30 Oct. 2007, 09:33 to 10:57

ii. Following the period, we used PHINS motion sensor because the trouble of default motion sensor (TSS).

15 Dec. 2007, 05:14 to 17 Dec. 2007, 07:21

2.2.3 Sea Surface Gravity

January 10, 2008

(1) Personnel

Takeshi Matsumoto	***(University of the Ryukyus)***	***Principal Investigator (Not on-board)***
Souichiro Sueyoshi	***(Global Ocean Development Inc., GODI)***	***-leg1-***
Satoshi Okumura	***(GODI)***	***-leg1-***
Harumi Ohta	***(GODI)***	***-leg1-***
Shinya Okumura	***(GODI)***	***-leg2-***
Kazuho Yoshida	***(GODI)***	***-leg2-***
Ryo Ohyama	***(GODI)***	***-leg2-***

(2) Introduction

The distribution of local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR07-06 Leg-1 cruise from Sekinehama on 7th October 2007 to fulfillment point of observation on 19th November 2007, and the Leg-2 cruise from starting point of observation on 23rd November 2007 to fulfillment point of observation on 23rd December 2007.

(3) Parameters

Relative Gravity [CU: Counter Unit]

[mGal] = (coef1: 0.9946) * [CU]

(4) Data Acquisition

We have measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during this cruise. To convert the relative gravity to absolute one, we measured gravity using portable gravity meter (Scintrex gravity meter CG-3M) at Sekinehama.

(5) Preliminary Results

Absolute gravity shown in Table 2.2.3-1

Table 2.2.3-1

No.Date	U.T.C.	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at L&R *[2] Sensor *[1] [mGal]	Gravity at L&R *[2] Gravity [mGal]
2007 Oct/07	00:29	Sekinehama	980371.93	281	628	980372.84	12644.04

*[1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431

*[2]: LaCoste and Romberg air-sea gravity meter S-116

(6) Data Archives

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department （MEDID） of JAMSTEC.

2.2.4 On-board geomagnetic measurement

December 27, 2007

(1) Personnel

Takeshi Matsumoto	***(University of the Ryukyus)***	***Principal Investigator (Not on-board)***
Souichiro Sueyoshi	***(Global Ocean Development Inc., GODI)***	***-leg1-***
Satoshi Okumura	***(GODI)***	***-leg1-***
Harumi Ohta	***(GODI)***	***-leg1-***
Shinya Okumura	***(GODI)***	***-leg2-***
Kazuho Yoshida	***(GODI)***	***-leg2-***
Ryo Ohyama	***(GODI)***	***-leg2-***

(2) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR07-06 Leg-1 cruise from Sekinehama on 7th October 2007 to fulfillment point of observation on 19th November 2007, and the Leg-2 cruise from starting point of observation on 23th November 2007 to Auckland on 26th December 2007.

(3) Parameters

Three-component magnetic force [nT]
Ship’s attitude [1/100 deg]

(4) Method of Data Acquisition

A sensor of three-component fluxgate magnetometer is set on the top of foremast. Sampling is controlled by 1pps (pulse per second) standard clock of GPS signals. Navigation information, 8 Hz three-component of magnetic force, and VRU (Vertical Reference Unit) data are recorded every one second.

For calibration of the ship’s magnetic effect, we made a “figure-eight” turn (a pair of clockwise and anti-clockwise rotation). This calibration was carried out as below.

03 Dec. 2007, 02:03 to 02:24 about at 00-03S, 179-20E

(5) Preliminary Results

The results will be published after primary processing.

(6) Data Archives

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department （MEDID） of JAMSTEC.

2.3 Acoustic Doppler Current Profiler (ADCP)

December 27, 2007

(1) Personnel

Hiroshi Uchida (JAMSTEC)
Leg 1
Souichiro Sueyoshi (Global Ocean Development Inc., GODI)
Satoshi Okumura (GODI)
Harumi Ohta (GODI)
Leg 2
Shinya Okumura (GODI)
Kazuho Yoshida (GODI)
Ryo Ohyama (GODI)

(2) Overview of the equipment

Upper ocean current measurements were made throughout MR07-06 cruise, using a hull-mounted acoustic Doppler current profiler (ADCP) system up to 800 m depth. The instrument was configured for water-tracking mode, except for shallow water region in which the instrument was configured for bottom-tracking mode (interleaved bottom-ping with water-ping) to obtain calibration data for evaluation of transducer misalignment angle. The ADCP system is composed of following components;

(i) A 75 kHz broadband (coded-pulse) profiler with 4-beams Doppler sonar (Teledyne RD Instruments, San Diego, California, USA) is mounted on bottom of the ship with 30-degree beam angles and 45 degrees azimuth from the keel.

(ii) The ship’s heading is continuously provided by the ship’s gyro compass (Tokimec TG-6000, sperry type mechanical gyro compass).

(iii) The ship’s position is provided by a GPS navigation receiver (Trimble DS-4000 with two GPS antennas located on navigation deck).

(iv) Data is acquired using a personal computer with a software, VmDas version 1.4.0 (Teledyne RD Instruments). Clock of the personal computer is adjusted to GPS time every 3 minutes.

(v) High-precision attitude information, heading, pitch and roll, are obtained by an Inertial Navigation System (PHINS, iXSea, France) and also stored in N2R data files with a time stamp. The PHINS is the assembly of three high class (0.01 deg/h) fiber optic gyroscopes (FOG) and three high precision pendulum-type accelerometers.

(3) Data collection

Major parameters for the ADCP measurement were listed in Table 2.3.1. The ADCP was configured for 8 m processing bin with first 8 m blank distance. Data were obtained at 8 m intervals from 16.5 m depth. The sound speed at the transducer was calculated from temperature, salinity (constant value of 35.0 PSU) and transducer depth (6.5 m) using an equation of Medwin (1975). Data from each ping were recorded as raw ensemble data (.ENR file). In addition, data averaged over 60 and 300 seconds were recorded as short term average (.STA file) and long term average (.LTA file) data, respectively.

Table 2.3.1. List of major parameters.

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1000 m depth)
BP = 000	Disable bottom-track ping (almost over 1000 m depth)
Environmental Sensor Commands	
EA = +00000	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +0001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coordinate Transformation (Xform:Type; Tilts; 3Bm; Map)
EZ = 1020001	Sensor Source (C; D; H; P; R; S; T)
	C (1): Sound velocity calculates using ED, ES, ET (temp.)
	D (0): Manual ED
	H (2): External synchro
	P (0), R (0): Manual EP, ER (0 degree)
	S (0): Manual ES
	T (1): Internal transducer sensor
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 064	Low Correlation Threshold (0-255)
WD = 111 110 000	Data Out (V; C; A PG; St; Vsum; Vsum^2;#G;P0)
WE = 5000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0 = OFF, 1 = ON)
WJ = 1	Rcvr Gain Select (0 = Low, 1 = High)
WM = 1	Profiling Mode (1-8)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 999	Mode 1 Ambiguity Velocity (cm/s radial)

(4) Preliminary results

Figures 2.3.1 and 2.3.2 show surface (vertically averaged from 50 to 100 m depth) current vector averaged over one hour along the cruise track. The long term average (LTA) data was used in a software CODAS (Common Oceanographic Data Access System) developed by the University of Hawaii.

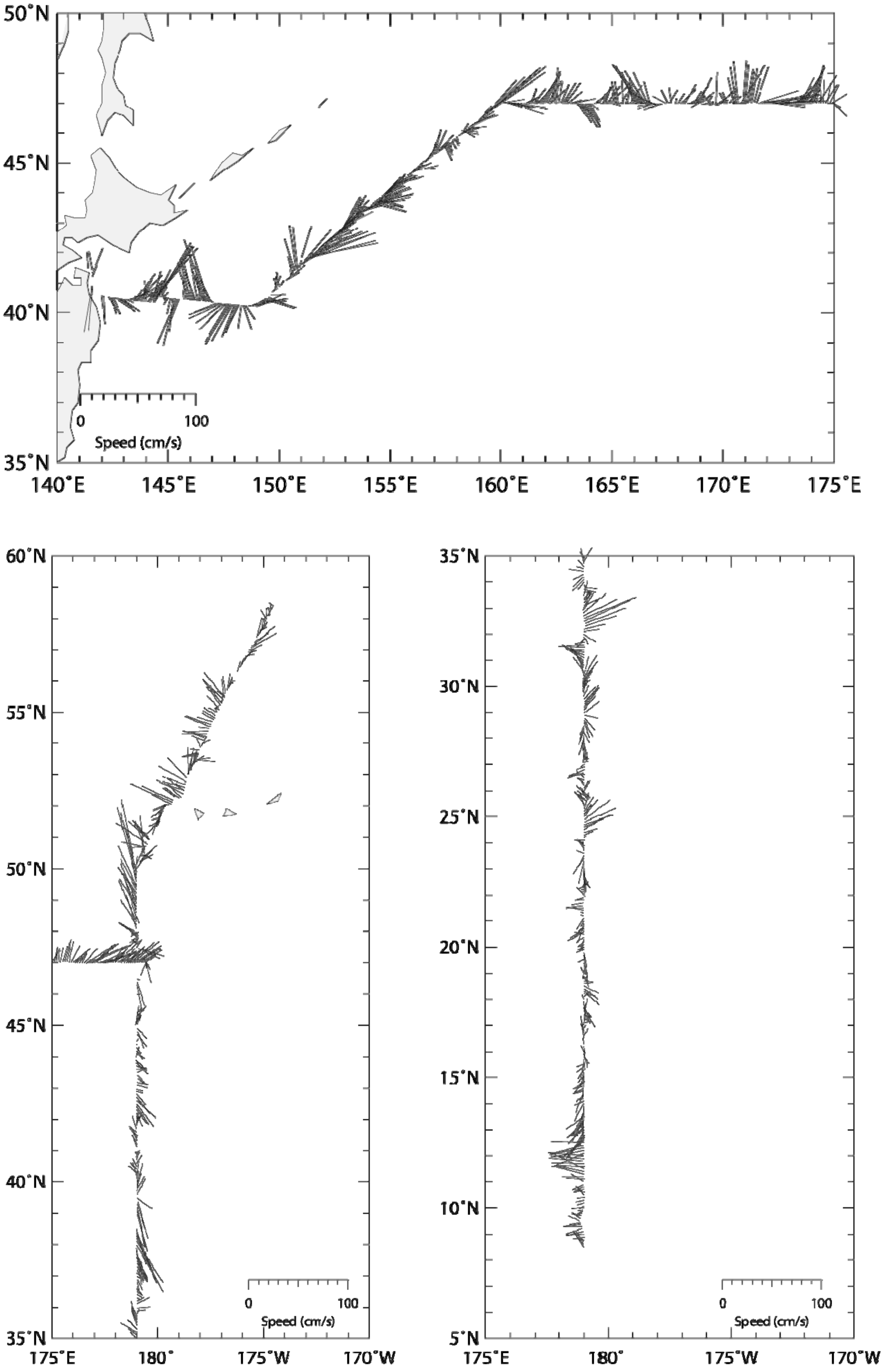


Fig. 2.3.1 Current vector along the cruise track for leg 1.

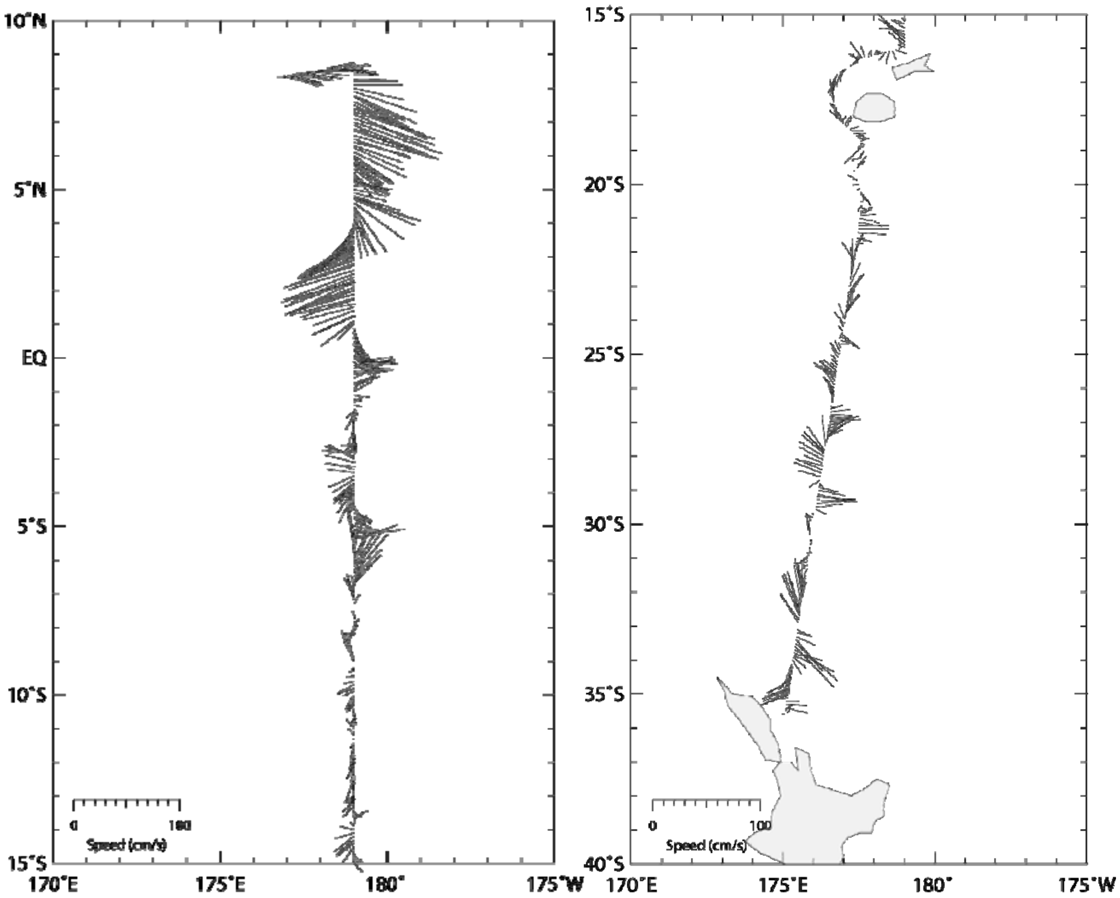


Fig. 2.3.2 Same as Fig. 2.3.1, but for leg 2.

(5) Data archive

Obtained data will be submitted to the Marine-Earth Data and Information Department （MEDID） of JAMSTEC, and will be available via "R/V MIRAI Data Web Page" in the JAMSTEC web site (http://www.jamstec.go.jp).

Reference

Medwin, H. (1975): Speed of sound in water: A simple equation for realistic parameters. *J. Acoust. Soc. Am.*, **58**, 1318-1319.

2.4 Thermo-salinograph and related measurements

January 17, 2008

(1) Personnel

Yuichiro KUMAMOTO **1), *Kimiko NISHIJIMA*** **2), *Masanori ENOKI*** **2), and *Miyo IKEDA*** **2)**
1) Japan Agency for Marine Earth Science and Technology (JAMSTEC)
2) Marine Works Japan Co. Ltd

(2) Objective

Our purpose is to obtain salinity, temperature, dissolved oxygen, and fluorescence data continuously in near-sea surface water during MR07-06 cruise.

(3) Methods

The Continuous Sea Surface Water Monitoring System (Nippon Kaiyo Co. Ltd.), including the thermo-salinograph, has five sensors and automatically measures salinity, temperature, dissolved oxygen, and fluorescence in near-sea surface water every one minute. This system is located in the sea surface monitoring laboratory on R/V MIRAI and connected to shipboard LAN system. Measured data, time, and location of the ship were displayed on a monitor and then stored in a data management PC (IBM NetVista 6826-CBJ).

The near-surface water was continuously pumped up to the laboratory from about 4 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was controlled by several valves and adjusted to be 12 dm^3/min except for a fluorometer (about 0.5 dm^3/min). The flow rate was measured by two flow meters.

Specifications of the each sensor in this system are listed below.

a) Temperature and salinity sensors
SEACAT THERMOSALINOGRAPH
Model: SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number: 2118859-2641 (Cal. Date: 9-Feb.-2007)
Measurement range: Temperature −5 to +35°C (ITS-90), Salinity 0 to 6.5 S m^{-1}
Accuracy: Temperature 0.01°C 6month^{-1}, Salinity 0.001 S m^{-1} month^{-1}
Resolution: Temperatures 0.001°C, Salinity0.0001 S m^{-1}

b) Bottom of ship thermometer (RMT)
Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number: 032607 (Cal. Date: 10-Aug.-2007)
Measurement range: −5 to +35°C (ITS-90)
Resolution: ±0.001°C
Stability: 0.002°C year^{-1}

c) Dissolved oxygen sensor
Model: 2127A, HACH ULTRA ANALYTICS JAPAN, INC.
Serial number: 47477
Measurement range: 0 to 14 ppm
Accuracy: ±1% at 5°C of correction range
Stability: 1% month^{-1}

d) Fluorometer

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

e) Flow meter

Model: EMARG2W, Aichi Watch Electronics LTD.
Serial number: 8672
Measurement range: 0 to 30 l min^{-1}
Accuracy: ±1%
Stability: ±1% day^{-1}

(4) Measurements

Periods of measurement, maintenance, and problems during MR07-06 are listed in Table 2.4.1. From October 10 to October 30, an antifoulant (antibiotic) device including TBTO (tributyltin oxide) was attached to the SBE-21 sensors to prevent growth of aquatic organisms on the sensors. The device was removed from the sensors after November 7 because of a problem.

Table 2.4.1 Events list of the thermo-salinograph during MR07-06

Date [UTC]	Time [UTC]	Event	Remarks
9-Oct.-07	02:17	All the measurements started.	Leg-1 start
05-Nov.-07	14:32	Lost of all the data.	Tripping of a circuit breaker
05-Nov.-07	14:34		
30-Oct.-07	03:36	Lost of salinity data.	A problem of the antibiotic device
07-Nov.-07	04:08		
07-Nov.-07	04:09	Lost of all the data.	Reboot of the data management PC
07-Nov.-07	05:04		
18-Nov.-07	04:35	Failure of RMT temp. data archive.	A noise on the data
19-Nov.-07	07:36	All the measurements stopped.	Leg-1 end
23-Nov.-07	02:00	All the measurements started.	Leg-2 start
23-Dec.-07	01:29	All the measurements stopped.	Leg-2 end

(5) Calibrations

i. Comparison with bottle data

We collected the surface seawater samples for salinity sensor calibration (Table 2.4.2). The seawater were collected approximately twice a day using a 250ml brown grass bottle. The samples were stored in the sea surface monitoring laboratory and then measured using the Guildline 8400B at the end of the legs after all the measurements of the hydrocast bottle samples (see section 3.2).

Table 2.4.2 Comparison of the sensor salinity with the bottle salinity

Date [UTC]	Time [UTC]	Latitude	Longitude	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Difference [Sen. - Bot.]
2007/10/9	5:25	40-32.06180N	144-33.13440E	33.8540	33.8458	0.0082
2007/10/9	14:12	40-22.40990N	146-42.40840E	33.6539	33.7204	-0.0665*
2007/10/10	2:55	41-05.85970N	150-18.13910E	33.0454	33.0327	0.0127
2007/10/10	17:23	42-20.76330N	152-09.03380E	33.0246	33.0196	0.0050
2007/10/11	6:36	43-04.88550N	153-19.58350E	32.8880	32.8815	0.0065
2007/10/11	18:27	44-04.74300N	154-59.84680E	32.6292	32.6202	0.0090
2007/10/12	6:42	44-20.23280N	155-24.25840E	32.6718	32.6882	-0.0164
2007/10/12	18:48	45-04.93350N	156-38.62630E	32.6208	32.6191	0.0017
2007/10/13	6:20	46-05.23470N	158-20.15860E	32.6245	32.6095	0.0150
2007/10/13	17:47	46-30.35720N	159-06.53620E	32.6256	32.6067	0.0189
2007/10/14	6:03	47-01.02970N	160-08.89530E	32.6805	32.6503	0.0302
2007/10/14	17:40	46-59.52310N	162-15.61480E	32.6576	32.6517	0.0059
2007/10/15	5:48	47-00.14140N	164-21.29860E	32.7218	32.7181	0.0037
2007/10/15	18:09	46-59.07380N	165-37.89780E	32.7204	32.7177	0.0027
2007/10/16	5:45	46-57.67950N	166-43.18590E	32.7198	32.7006	0.0192
2007/10/16	17:21	46-59.41470N	168-22.56610E	32.6269	32.6230	0.0039
2007/10/17	4:43	47-00.57730N	169-05.85870E	32.6415	32.6348	0.0067
2007/10/17	16:50	46-58.65870N	169-48.59680E	32.6433	32.6435	-0.0002
2007/10/18	4:37	46-59.83390N	170-28.31700E	32.6664	32.6637	0.0027
2007/10/18	17:37	47-00.36100N	172-11.21260E	32.6925	32.6908	0.0017
2007/10/19	4:00	47-00.24210N	173-49.77000E	32.6660	32.6612	0.0048
2007/10/19	17:22	46-59.80860N	176-05.82360E	32.6682	32.6711	-0.0029
2007/10/20	4:52	46-59.40840N	177-23.84440E	32.7044	32.6961	0.0083
2007/10/20	17:22	47-00.00850N	179-26.22310E	32.7052	32.6981	0.0071
2007/10/21	4:47	47-59.94950N	178-58.96240E	32.7126	32.7113	0.0013
2007/10/21	16:29	48-59.35410N	178-58.98940E	32.7462	32.7458	0.0004

Table 2.4.2 (continued)

Date [UTC]	Time [UTC]	Latitude	Longitude	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Difference [Sen. - Bot.]
2007/10/22	5:27	50-00.83360N	178-58.88290E	32.7591	32.7558	0.0033
2007/10/22	16:31	50-28.96300N	179-17.18900E	32.7410	32.7375	0.0035
2007/10/23	4:21	50-56.90210N	179-34.72020E	32.7865	32.7856	0.0009
2007/10/23	17:34	51-49.39240N	179-48.31570W	33.1172	33.0838	0.0334
2007/10/24	4:31	52-16.13690N	178-58.41500W	33.0384	33.0340	0.0044
2007/10/24	16:44	53-29.70310N	178-14.46000W	33.0212	32.9384	0.0828*
2007/10/25	4:14	54-29.63280N	177-33.24850W	32.9897	33.0030	-0.0133
2007/10/25	16:43	55-46.93320N	176-39.18100W	32.9090	32.8842	0.0248
2007/10/26	5:22	56-58.85310N	175-40.15170W	32.6355	32.6284	0.0071
2007/10/26	18:01	57-59.76550N	174-49.90480W	32.5895	32.5258	0.0637*
2007/10/27	4:57	58-08.08730N	174-44.48860W	32.5030	32.3429	0.1601*
2007/10/27	17:19	56-30.05810N	176-03.67350W	32.5951	32.7054	-0.1103*
2007/10/28	4:39	54-08.81850N	177-54.30220W	32.9045	32.9649	-0.0604*
2007/10/28	13:05	52-32.19380N	179-08.82310W	33.0417	33.0057	0.0360
2007/10/29	4:01	50-14.37020N	179-37.14930E	32.7248	32.7183	0.0065
2007/10/29	14:42	47-41.52110N	179-02.67540E	32.7274	32.6862	0.0412
2007/10/30	3:41	46-53.64970N	179-22.82010E	-	32.6969	-
2007/10/30	15:14	45-59.16150N	179-01.56400E	-	32.6628	-
2007/10/31	3:35	45-00.74700N	178-57.16110E	-	32.8870	-
2007/10/31	15:15	44-25.17970N	178-59.33940E	-	32.9982	-
2007/11/1	3:39	43-25.96290N	179-02.30580E	-	33.0939	-
2007/11/1	15:26	42-28.59190N	178-59.11440E	-	33.4875	-
2007/11/2	3:12	41-23.64650N	179-01.51310E	-	33.8685	-
2007/11/2	15:27	40-20.81390N	178-59.78120E	-	33.9810	-
2007/11/3	3:24	39-26.10410N	179-02.86940E	-	33.9847	-
2007/11/3	15:45	38-23.33390N	178-58.98450E	-	34.2733	-
2007/11/4	3:31	37-18.29470N	179-01.24320E	-	34.1793	-
2007/11/4	16:00	35-59.85240N	179-00.06330E	-	34.3576	-
2007/11/5	3:58	35-00.12920N	179-00.07790E	-	34.3425	-
2007/11/5	15:55	33-44.35400N	178-59.55440E	-	34.3342	-
2007/11/6	3:11	32-29.25280N	178-59.81090E	-	34.4613	-
2007/11/6	15:20	31-30.00990N	179-01.02830E	-	34.9858	-
2007/11/7	3:58	30-29.46880N	178-58.82510E	-	34.8471	-
2007/11/7	15:23	29-29.82960N	178-59.54800E	35.0656	35.0616	0.0040

Table 2.4.2 (continued)

Date [UTC]	Time [UTC]	Latitude	Longitude	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Difference [Sen. - Bot.]
2007/11/8	3:31	28-29.09130N	178-59.81260E	35.1072	35.1020	0.0052
2007/11/8	15:09	27-29.82050N	179-00.43770E	35.1408	35.1350	0.0058
2007/11/9	3:38	26-29.73090N	179-00.05290E	35.1328	35.1256	0.0072
2007/11/9	15:02	26-01.48300N	179-09.89370E	35.2352	35.2285	0.0067
2007/11/10	3:35	25-55.53690N	179-35.36160E	35.1871	35.1823	0.0048
2007/11/10	14:53	25-37.38100N	179-08.77730E	35.1945	35.1835	0.0110
2007/11/11	3:32	25-00.00200N	179-00.87020E	35.1259	35.1160	0.0099
2007/11/11	15:07	24-00.25110N	178-59.54920E	35.1751	35.1667	0.0084
2007/11/12	3:25	23-00.17370N	178-59.73550E	35.1788	35.1675	0.0113
2007/11/12	15:29	22-00.68720N	178-59.79810E	35.2859	35.2776	0.0083
2007/11/13	3:54	20-40.66570N	178-59.76420E	35.2590	35.2487	0.0103
2007/11/13	15:15	19-30.66360N	179-00.02710E	34.9384	34.9276	0.0108
2007/11/14	3:29	18-30.92670N	179-00.39380E	34.9828	34.9705	0.0123
2007/11/14	15:43	17-31.50610N	178-59.80200E	34.7915	34.7802	0.0113
2007/11/15	4:07	16-24.89740N	178-59.54480E	34.6641	34.6546	0.0095
2007/11/15	15:30	15-30.91970N	178-59.09970E	34.7727	34.7595	0.0132
2007/11/16	3:36	14-30.31750N	178-58.52030E	34.7215	34.7105	0.0110
2007/11/16	15:14	13-30.46350N	178-59.04190E	34.6934	34.6809	0.0125
2007/11/17	3:25	12-31.37000N	178-59.21560E	34.5697	34.5586	0.0111
2007/11/17	15:21	11-31.21370N	178-59.68420E	34.3699	34.3584	0.0115
2007/11/18	4:03	10-30.99360N	178-59.81610E	34.3508	34.3394	0.0114
2007/11/18	15:29	09-29.79300N	178-49.30000E	34.2541	34.2427	0.0114
2007/11/19	4:12	08-45.75560N	178-59.25940E	34.0907	34.0779	0.0128
2007/11/19	7:34	08-30.49010N	178-59.17670E	34.0624	34.0496	0.0128
2007/11/23	6:21	08-28.64970N	177-35.78940E	34.3121	34.2969	0.0152
2007/11/23	20:57	08-30.58210N	178-59.31190E	34.2402	34.2239	0.0163
2007/11/24	4:35	08-15.65310N	178-59.95810E	34.2931	34.2779	0.0152
2007/11/24	15:11	07-44.86660N	179-00.67490E	34.3735	34.3571	0.0164
2007/11/25	5:25	06-59.91330N	179-00.06250E	34.9224	34.9055	0.0169
2007/11/25	15:03	06-43.39460N	179-01.10810E	34.9023	34.8856	0.0167
2007/11/26	9:02	05-48.04660N	179-00.02110E	34.6940	34.6773	0.0167
2007/11/26	19:05	05-26.90940N	178-59.91100E	34.8380	34.8221	0.0159
2007/11/27	3:34	04-59.55490N	178-59.60990E	34.9097	34.8895	0.0202
2007/11/27	15:19	04-28.97130N	179-00.63150E	35.1440	35.1281	0.0159

Table 2.4.2 (continued)

Date [UTC]	Time [UTC]	Latitude	Longitude	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Difference [Sen. - Bot.]
2007/11/28	3:45	03-59.53280N	179-00.29860E	35.1021	35.0869	0.0152
2007/11/28	15:44	03-30.23710N	179-00.16020E	35.1012	35.0856	0.0156
2007/11/29	3:36	03-00.21240N	179-00.13510E	35.1367	35.1212	0.0155
2007/11/29	16:01	02-18.22210N	179-00.16430E	35.1347	35.1212	0.0135
2007/11/30	3:55	01-46.88070N	178-59.98650E	35.1377	35.1235	0.0142
2007/11/30	15:31	01-15.66770N	179-00.43110E	35.1435	35.1276	0.0159
2007/12/1	3:46	00-44.30730N	178-59.59540E	35.1914	35.1760	0.0154
2007/12/1	15:37	00-14.79480N	178-59.80660E	35.2090	35.1943	0.0147
2007/12/2	4:15	00-14.67970S	178-59.64810E	35.2218	35.2073	0.0145
2007/12/2	12:41	00-10.57770S	179-06.94120E	35.2325	35.2174	0.0151
2007/12/3	4:52	00-12.28510S	179-04.73820E	35.2249	35.2099	0.0150
2007/12/3	14:57	00-44.44420S	179-00.38430E	35.2623	35.2469	0.0154
2007/12/4	3:20	01-14.79930S	178-59.80360E	35.3369	35.3212	0.0157
2007/12/4	15:34	01-44.20500S	178-59.90450E	35.4360	35.4201	0.0159
2007/12/5	3:22	02-17.59460S	178-59.93920E	35.6036	35.5869	0.0167
2007/12/5	15:24	02-53.72300S	178-59.76740E	35.6056	35.5887	0.0169
2007/12/6	3:06	03-27.43530S	179-00.16390E	35.7017	35.6843	0.0174
2007/12/6	15:36	04-00.42580S	179-00.22410E	35.6937	35.6779	0.0158
2007/12/7	3:32	04-30.49320S	179-00.53770E	35.7250	35.7082	0.0168
2007/12/7	15:32	04-59.93530S	179-00.01310E	35.5754	35.5597	0.0157
2007/12/8	3:45	06-00.49190S	179-00.46560E	35.3242	35.3077	0.0165
2007/12/8	14:36	06-53.23310S	178-59.79630E	34.9645	34.9512	0.0133
2007/12/9	4:03	08-00.07870S	178-59.79360E	34.9440	34.9289	0.0151
2007/12/9	15:36	09-00.39210S	178-59.93910E	34.8335	34.8182	0.0153
2007/12/10	3:40	10-00.45970S	178-59.86400E	34.9014	34.8881	0.0133
2007/12/10	15:18	11-13.93150S	178-59.74590E	34.7253	34.7089	0.0164
2007/12/11	3:33	12-30.37470S	178-59.91460E	34.6997	34.7019	-0.0022
2007/12/11	15:51	13-46.37280S	179-00.26670E	34.7411	34.7252	0.0159
2007/12/12	4:00	15-22.73890S	178-59.73240E	34.5721	34.5526	0.0195
2007/12/12	15:19	16-12.74140S	177-54.43780E	34.4854	34.4725	0.0129
2007/12/13	4:35	18-00.97310S	176-45.86950E	34.5336	34.5170	0.0166
2007/12/13	14:24	18-50.60070S	177-46.34680E	34.6658	34.6499	0.0159
2007/12/14	3:17	18-55.97910S	177-42.97910E	34.6754	34.6600	0.0154
2007/12/14	15:33	19-28.61270S	177-27.00180E	34.6839	34.6687	0.0152

Table 2.4.2 (continued)

Date [UTC]	Time [UTC]	Latitude	Longitude	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Difference [Sen. - Bot.]
2007/12/15	3:23	20-07.58350S	177-31.91270E	34.8697	34.8541	0.0156
2007/12/15	14:34	20-49.63040S	177-33.64870E	34.7734	34.7594	0.0140
2007/12/16	3:13	21-27.06220S	177-28.28690E	34.7654	34.7500	0.0154
2007/12/16	14:27	22-35.48470S	177-15.81440E	35.1803	35.1668	0.0135
2007/12/17	3:34	23-28.79280S	177-06.59720E	35.2719	35.2571	0.0148
2007/12/17	15:22	24-33.84780S	176-55.51780E	35.3974	35.3832	0.0142
2007/12/18	3:14	25-40.20740S	176-44.22250E	35.3818	35.3685	0.0133
2007/12/18	15:32	26-32.00690S	176-35.73230E	35.5411	35.5272	0.0139
2007/12/19	3:17	27-42.58850S	176-23.83980E	35.3077	35.2935	0.0142
2007/12/19	14:58	28-42.40730S	176-13.37440E	35.4757	35.4621	0.0136
2007/12/20	3:33	29-47.61200S	175-58.31910E	35.5968	35.5770	0.0198
2007/12/20	15:37	30-52.84490S	175-51.55180E	35.6651	35.6505	0.0146
2007/12/21	3:21	31-44.20450S	175-43.19030E	35.6629	35.6484	0.0145
2007/12/21	15:40	32-49.34980S	175-32.03160E	35.7132	35.6991	0.0141
2007/12/22	3:07	33-42.10310S	175-23.62260E	35.6878	35.6729	0.0149
2007/12/22	15:06	35-01.27420S	175-09.08010E	35.7422	35.7286	0.0136
2007/12/23	1:20	35-33.05740S	175-08.87520E	35.6953	35.6812	0.0141

* Difference between the sensor and the bottle salinity is large.

ii. Sensor calibrations

The sensors for temperature and salinity were calibrated before the cruise. After the cruise the sensors will be calibrated again in order to evaluate drifts of measurements during the cruise. The results of the calibrations will be available via JAMSTEC MIRAI DATA Web, http://www.jamstec.go.jp/mirai/2007/.

(6) Date archive

Quality controlled data of temperature, salinity, dissolved oxygen, and fluorescence will be available via the JAMSTEC MIRAI DATA Web as shown above.

2.5. pCO_2

January 9, 2007

(1) Personnel

Akihiko Murata (JAMSTEC)
Yoshiko Ishikawa (MWJ)
Mikio Kitada (MWJ)
Yasuhiro Arii (MWJ)

(2) Objective

Concentrations of CO_2 in the atmosphere are now increasing at a rate of 1.5 ppmv y^{-1} 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_2, and to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 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_2 are absorbed in the surface ocean in the Pacific. For the purpose, we measured pCO_2 (partial pressure of CO_2) in the atmosphere and surface seawater along the WHP P1 line at 47°N and P14 line at 179°E.

(3) Apparatus

Concentrations of CO_2 in the atmosphere and the sea surface are measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (BINOS^{TM}). The automated system is operated by one and a half hour cycle. In one cycle, standard gasses, marine air and an air in a headspace of an equilibrator are analyzed subsequently. The concentrations of the standard gas are 270.02, 330.39, 369.28 and 419.69 ppmv. The standard gases will be recalibrated after the cruise.

The marine air taken from the bow is introduced into the NDIR by passing through a mass flow controller, which controls 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 $Mg(ClO_4)_2$.

A fixed volume of the marine air taken from the bow is equilibrated with a stream of seawater that flowed at a rate of 5-6L/min in the equilibrator. The air in the equilibrator is circulated with a pump at 0.7-0.8L/min in a closed loop passing through two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

(4) 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 ocean acted as a strong source close to Aleutian Islands (Date: 07/10/25) and the equatorial region (Date: 07/11/24 to 07/12/4) for atmospheric CO_2. The latter source is probably associated with the La Nina event.

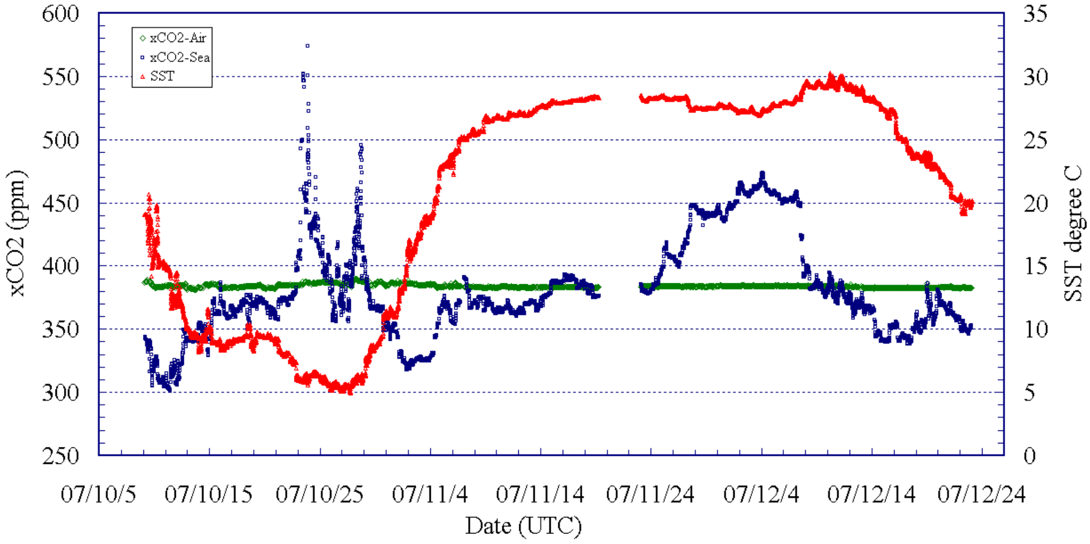


Fig. 2.5.1. Concentrations of CO_2 (xCO_2) in atmosphere (green) and surface seawater (blue), and SST (red).

2.6 Studies of marine organic carbon cycles associated with microbiological activity

December 27, 2007

(1) Personnel

Masao Uchida (NIES)
Yukiko Kuroki (University of Tsukuba)
Chie Sato (University of Tsukuba)
Motoo Utsumi (University of Tsukuba)

(2) Objectives

Marine microbes, especially Bacteria, are large and essential components of food webs and elemental cycles in the oceans. Marine bacteria include the two deepest divisions, or domains, Eubacteria and Archaea. These domains are identified by genetic distance in the composition of the 16S rRNA gene (Woose et al. 1990). Marine bacteria are morphologically simple: microscopic rods, spheres and filaments generally less than 1-2 µm in size, but bacteria are highly diverse in terms of both taxonomy and metabolism. There are many different varieties of bacteria existing in the oceans, but it has been long noted a discrepancy of several orders of magnitude between the number of bacterial cells that can be seen in the oceans by direct count (by epifluorescence microscopy) and the number of colonies that appear on agar plates (e.g. Jannasch and Jones, 1959). In terms of carbon cycling in marine systems, especially for dissolved organic carbon (DOC), one of the most important activities of bacteria is aerobic heterotrophy. Heterotrophic bacteria served primarily as a pathway for regeneration of organic nitrogen, phosphorus, and other bioactive elements, and represented a shunt of carbon and energy from the main phytoplankton-based food web.

In recent years, in addition, it is reported that nonthermophilic archaea represent up to 40% of the free-living prokaryotic community in the water column of the world’s oceans (ex. Delong, 1992), and some of their population is chemoautotrophy (ex. Pearson et al. 2001). Therefore, it is important to study the relationship between DOC cycling and bacterial community structure and their metabolic information in the marine systems. One difficult matter for studying these topics, however, it need so huge sea-water sample volume (c.a. 100,000 L) for analyzing the radioactive isotope ratio of specific organic material in POC, DOC and bacterial cell components.

The key aim of this study is to analyze the relationship between community structures and metabolic characteristics of microorganisms, and dissolved organic carbon cycling in the ocean water columns. The objectives of this study are as follow:

1) collect mega volume (from 50,000 to 100,000 L per each sample) of surface sea-water samples for measuring radioactive isotopic ratio of POC and bacterial cell membrane lipids, and for analyzing the composition of small size (less than 0.2 µm) organic carbon materials,

2) collect sea-water column samples (～100 L per each sample) for measuring stable and radioactive isotope ratio of POC, DOC and bacterial cell membrane lipids, and for analyzing the bacterial diversity and functional gene.

3) analyze the light elemental isotopic ratio and various types of organic compounds (including lipids).

We also collected sea-water samples for measuring the radioactive isotope ratio of DIC. One of the final goals of this study is making a mass balance model for dissolved carbon in the ocean.

(3) Instrument and Method

i. Mega volume filtration

To study the radioactive isotope ratio of POC and bacterial cell membrane lipid, and diversity of bacterial community, we filtered surface sea-water (12 samples, from 19,059 to 48141 L, see Table 2.6.1.a) continuously during the cruise. The filtration equipment is shown in Fig. 2.6.1. Each filter was exchanged new one when the filtration velocity declined under 5 L/min or the filtration period exceeded 5 day. The filters were frozen at -20^{o}C or -80^{o}C during the cruise.

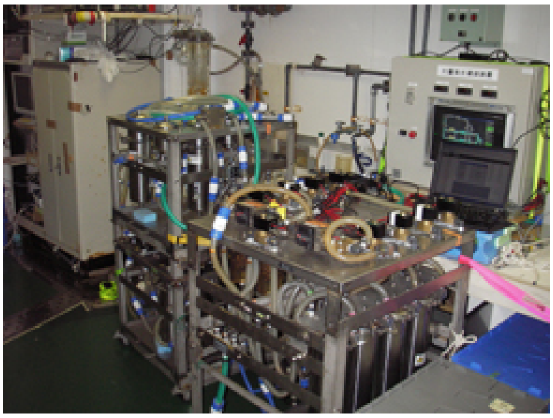


Figure 2.6.1 Mega volume filtration system setting up in the surface sea-water analysis room in “MIRAI”. The equipment is consist of a) steel-wool parts, b) 10 µm size filter parts, c) 1.0 µm size filter parts, d) 0.5µm size filter parts, e) 0.2µm size filter parts, and f) control units (control panel and data logger PC). The maximum filtration velocity is about 10 L/min.

ii. Sea-water column wataer sample collection

To study the diversity of bacterial community and functional gene, and stable and radioactive isotope ratio of POC, DOC and bacterial cell membrane lipids, we filtered 2-136 L sea-water at each sampling station. Water samples were collected from different depths at the stations with X-Niskin water samplers (12 L, General Oceanic) and immediately transferred to 2 or 10 L plastic canteens. Water samples also collected from surface sea-water supply system (100 to 200 L /each sampling time).

Each water sample was filtered with quartz fiber filters (Whatman QM-A, with a operational pore size of 0.6 µm, 110 mm and 47 mm in diameter) as soon as possible on board. The filters and filtrates were frozen at -20°C during the cruise.

During MR07-06 Leg.1, water column samples were collected from longitudinal transects in the Pacific Ocean to count the population density of bacteria in the water column. The sample (90 mL) were fixed with formalin (final concentration in the sample was 2.0%) immediately and stored at -80°C. Some water samples (800 to 1,000 mL) were filtered with 0.2 µm isopore membrane filter (Whatman, 47 mm in diameter) for comparing bacterial diversity form the quartz filters and doing FISH analysis, stored at -80°C (Table 6.2.1-f).

Table 2.6.1. List of filtrated sea-water samples during MR07-06.

a) Mega filtration samples of surface sea-water for POC, DOC and bacteria.

sampling date	site information	filtrate volume (L)
2007/10/09 07:24	40-31N, 144-35E	15,665
2007/11/01 02:42	43-29N, 179-02E	28,219
2007/11/04 20:34	35-41N, 179-01E	30,883
2007/11/09 26:19	26-00N, 179-12E	40,028
2007/11/13 10:54	20-00N, 178-59E	48,141
2007/11/23 01:15	06-14N, 179-00E	31,947
2007/11/30 06:38	01-45N, 178-59E	19,059
2007/12/04 05:35	01-25N, 178-60E	23,557
2007/12/09 06:00	08-16S, 178-51E	25,970
2007/12/17 12:00	24-22S, 176-57E	32,755
2007/12/19 21:38	29-10S, 176-09E	27,731
2007/12/22 23:30	35-37S, 175-03E	33,510

b) Large filtration samples of surface sea-water for POC.

sampling date	site information	filtrate volume (L)
2007.10.11	P01-32	100
2007.10.14	P01-38	100
2007.10.15	P01-X13	100
2007.10.17	P01-48	100
2007.10.19	P01-56	120
2007.10.20	P01-60	100
2007.10.22	P14N-23	100
2007.10.24	P14N-11	100
2007.10.26	P14N-05	100
2007.10.30	P14N-X01	100
2007.11.02	P14N-42	100
2007.11.04	P14N-50	100
2007.11.05	P14N-56	100
2007.11.07	P14N-X02	100
2007.11.11	P14N-77	100
2007.11.13	P14N-87	100
2007.11.16	P14N-97	100
2007.11.18	P14N-X04	100
2007.11.24	P14N-111	200
2007.11.26	P14N-120	200
2007.11.27	P14N-125	100
2007. 11.02	P14N-143	100
2007.12.06	P14N-160	100
2007.12.09	P14N-171	100

2007.12.11	P14N-180	100
2007.12.16	P14C-37	100
2007.12.17	P14C-28	100
2007.12.19	P14C-21	200
2007.12.19	P14C-20	200
2007.12.20	P14C-X06	100
2007.12.22	P14C-7	100

c) Filtration samples of surface sea-water for DOC.

sampling date	site information	filtrate volume (L)
2007.10.11	P01-32	2
2007.10.14	P01-38	2
2007.10.15	P01-X13	2
2007.10.17	P01-48	2
2007.10.19	P01-56	2
2007.10.20	P01-60	2
2007.10.22	P14N-23	2
2007.10.24	P14N-11	2
2007.10.26	P14N-05	2
2007.10.30	P14N-X01	2
2007.11.02	P14N-42	2
2007.11.04	P14N-50	2
2007.11.05	P14N-56	2
2007.11.07	P14N-X02	2
2007.11.11	P4N-77	2
2007.11.13	P14N-87	2
2007.11.16	P14N-97	2
2007.11.18	P14N-X04	2
2007.11.27	P14N-125	2
2007.12.02	P14N-143	2
2007.12.06	P14N-160	2
2007.12.09	P14N-171	2
2007.12.11	P14N-180	2
2007.12.16	P14C-37	2
2007.12.17	P14C-28	2
2007.12.20	P14C-X06	2
2007.12.22	P14C-7	2

d) Filtration samples of surface sea-water for DIC.

sampling date	site information	volume (L)
2007.10.11	P01-32	0.25
2007.10.14	P01-38	0.25
2007.10.15	P01-X13	0.25
2007.10.17	P01-48	0.25
2007.10.19	P01-56	0.25
2007.10.20	P01-60	0.25
2007.10.22	P14N-23	0.25
2007.10.24	P14N-11	0.25
2007.10.26	P14N-05	0.25
2007.10.30	P14N-X01	0.25
2007.11.02	P14N-42	0.25
2007.11.04	P14N-50	0.25
2007.11.05	P14N-56	0.25
2007.11.07	P14N-X02	0.25
2007.11.11	P4N-77	0.25
2007.11.13	P14N-87	0.25
2007.11.16	P14N-97	0.25
2007.11.18	P14N-X04	0.25
2007.11.27	P14N-125	0.25
2007.12.02	P14N-143	0.25
2007.12.06	P14N-160	0.25
2007.12.09	P14N-171	0.25
2007.12.11	P14N-180	0.25
2007.12.16	P14C-37	0.25
2007.12.17	P14C-28	0.25
2007.12.20	P14C-X06	0.25
2007.12.22	P14C-7	0.25

e) Filtration samples of CTD X-Niskin samplers for POC and bacteria.

sampling date	site information	total volume (L)
2007.10.14	P01-38	96
2007.10.17	P01-48	128
2007.10.19	P01-56	72
2007.10.24	P14N-11	136
2007/10/29-30	P14N-X01	80
2007/11/03-04	P14N-50	88
2007.11.5	P14N-56	160
2007.11.7	P14N-X02	110

2007.11.11	P4N-77	78
2007.11.16	P14N-97	72
2007.11.18	P14N-X04	80
2007.12.2	P14N-143	21
2007.12.6	P14N-160	8.5
2007.12.9	P14N-171	31.5
2007.12.17	P14C-28	52.5
2007.12.20	P14C-X06	70

f) Filtration samples of CTD X-Niskin samplers for DOC.

sampling date	site information	sampling layer	sampling volume (L)
2007.10.14	P01-38	33	2
2007.10.17	P01-48	29	2
2007.10.19	P01-56	36	2
2007.10.24	P14N-11	28	2
2007/10/29-30	P14N-X01	35	2
2007/11/03-04	P14N-50	34	2
2007.11.5	P14N-56	25	2
2007.11.7	P14N-X02	30	2
2007.11.11	P4N-77	34	2
2007.11.16	P14N-97	36	2
2007.11.18	P14N-X04	35	2
2007.11.27	P14N-125	35	2
2007.12.2	P14N-143	34	2
2007.12.6	P14N-160	35	2
2007.12.9	P14N-171	33	2
2007.12.17	P14C-28	31	2
2007.12.20	P14C-X06	29	2

g) Filtration samples of CTD X-Niskin samplers for bacterial counts.

Station No.	Date (UTC)	Volum（L）
P01-38	2007/10/14	1.0
P01-48	2007/10/17	0.9
P01-56	2007/10/19	1.0
P14N-X01	2007/10/29-30	1.0
P14N-50	2007/11/03-04	1.0
P14N-56	2007/11/5	0.8
P4N-77	2007/11/11	1.0
P14N-97	2007/11/16	1.0
P14N-X04	2007/11/18	1.0

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3. Hydrography

3.1 CTDO$_2$ Measurements

January 23, 2008

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Leg 2
Satoshi Ozawa (MWJ)
Hirokatsu Uno (MWJ)
Tomoyuki Takamori (MWJ)
Tsutomu Fujii (MWJ)

(2) Winch arrangements

The CTD package was deployed by using 4.5 Ton Traction Winch System (Dynacon, Inc., Bryan, Texas, USA), which was installed on the R/V Mirai in April 2001 (Fukasawa et al., 2004). Primary system components include a complete CTD Traction Winch System with up to 8000 m of 9.53 mm armored cable (Ocean Cable and Communications Co., Yokohama, Kanagawa, Japan).

(3) Overview of the equipment

The CTD system was SBE 911plus system (Sea-Bird Electronics, Inc., Bellevue, Washington, USA). The SBE 911plus system controls 36-position SBE 32 Carousel Water Sampler. The Carousel accepts 12-litre Niskin-X water sample bottles (General Oceanics, Inc., Miami, Florida, USA). The SBE 9plus was mounted horizontally in a 36-position carousel frame. SBE's temperature (SBE 3) and conductivity (SBE 4) sensor modules were used with the SBE 9plus underwater unit. 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 modular unit of underwater housing pump (SBE 5T) flushes water through sensor tubing at a constant rate independent of the CTD's motion, and pumping rate (3000 rpm) remain nearly constant over the entire input voltage range of 12-18 volts DC. Flow speed of pumped water in standard TC duct is about 2.4 m/s. Two sets of temperature and conductivity modules were used. An SBE's dissolved oxygen sensor (SBE 43) was placed between the primary conductivity sensor and the pump module. Auxiliary sensors, a Deep Ocean Standards Thermometer (SBE 35), an altimeter (PSA-916T; Teledyne Benthos, Inc., North Falmous, Massachusetts, USA), an oxygen optode (Oxygen Optode 3830; Aanderaa Data Instruments AS, Bergen, Norway), and a fluorometer (Seapoint sensors, Inc., Kingston, New Hampshire, USA) were also used with the SBE 9plus underwater unit. In addition, two prototypes of oxygen optode (RINKO and RINKO2; Alec Electronics Co. Ltd., Kobe, Hyogo, Japan) were also used. To minimize motion of the CTD package, a heavy stainless frame (total weight of the CTD package without sea water in the bottles is about 1000 kg) was used with an aluminum plate (54 × 90 cm).

Summary of the system used in this cruise

Deck unit:

SBE 11plus, S/N 0272

Under water unit:

SBE 9plus, S/N 79492 (Pressure sensor: S/N 0575)

Temperature sensor:

SBE 3plus, S/N 4188 (primary: stations from P01_28_2 to P14N_4_1)
SBE 3, S/N 1525 (secondary: stations from P01_28_2 to P14N_4_1,
primary: stations from P14N_30_1 to P14C_1_1)
SBE3plus, S/N 4421 (secondary: stations from P14N_30_1 to P14N_33_1)
SBE 3plus, S/N 4188 (secondary: stations from P14N_34_1 to P14N_73_1)
SBE 3plus, S/N 4216 (secondary: stations from P14N_75_1 to P14C_1_1)
* without secondary temperature sensor for station P14N_74_2

Conductivity sensor:

SBE 4, S/N 3064 (primary: stations from P01_28_2 to P14N_74_1)
SBE 4, S/N 1206 (primary: stations from P14N_74_2 to P14N_99_1)
SBE 4, S/N 3116 (primary: stations from P14N_100_1 to P14N_109_1)
SBE 4, S/N 3124 (primary: stations from P14N_109_2 to P14C_1_1)
SBE 4, S/N 2240 (secondary: stations from P01_28_2 to P01_46_1)
SBE 4, S/N 3036 (secondary: stations from P01_47_1 to P14N_51_1)
SBE 4, S/N 2854 (secondary: stations from P14N_52_1 to P14N_74_1)
SBE 4, S/N 2435 (secondary: stations from P14N_80_1 to P14N_171_1)
SBE 4, S/N 1172 (secondary: stations from P14N_172_1 to P14C_1_1)
* without secondary conductivity sensor for stations from P14N_74_2 to P14N_79_1

Oxygen sensor:

SBE 43, S/N 0394
AANDERAA Oxygen Optode 3830, S/N 612
ALEC Oxygen Optode (RINKO, prototype) (stations from P01_28_2 to P14C_48_1)
ALEC Oxygen Optode (RINKO2, prototype) (stations from P14N_109_2 to P14C_1_1 (leg 2))

Pump:

SBE 5T, S/N 4595 (primary)
SBE 5T, S/N 4598 (secondary)

Altimeter:

PSA-916T, S/N 1157

Deep Ocean Standards Thermometer:

SBE 35, S/N 0045

Fluorometer:

Seapoint Sensors, Inc., S/N 2579
* without fluorometer for the following stations,
because the maximum pressure was beyond the pressure-proof
stations from P01_44_2 to P01_46_1
stations from P01_53_1 to P01_54_1
stations from P14N_24_1 to P14N_23_1
stations from P14N_100_1 to P14N_101_1
stations from P14N_107_1 to P14N_109_2

station P14N_123_1

Carousel Water Sampler:

SBE 32, S/N 0391

Water sample bottle:

12-litre Niskin-X (no TEFLON coating)

(4) Pre-cruise calibration

i. Pressure

The Paroscientific series 4000 Digiquartz high pressure transducer (Model 415K-187: Paroscientific, Inc., Redmond, Washington, 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 15000 psia (0 to 10332 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 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). 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 automatically.

Pre-cruise sensor calibrations for linearization were performed at SBE, Inc.

S/N 0575, 27 October 1999

The time drift of the pressure sensor is adjusted by periodic recertification corrections against a dead-weight piston gauge (Model 480DA, S/N 23906; Bundenberg Gauge Co. Ltd., Irlam, Manchester, UK). The corrections are performed at JAMSTEC, Yokosuka, Kanagawa, Japan by Marine Works Japan Ltd. (MWJ), Yokohama, Kanagawa, Japan, usually once in a year in order to monitor sensor time drift and linearity.

S/N 0575, 5 July 2007

slope = 0.99980507

offset = 2.33363

Result of the pre-cruise pressure sensor calibration against the dead-weight piston gauge is shown in Fig. 3.1.1.

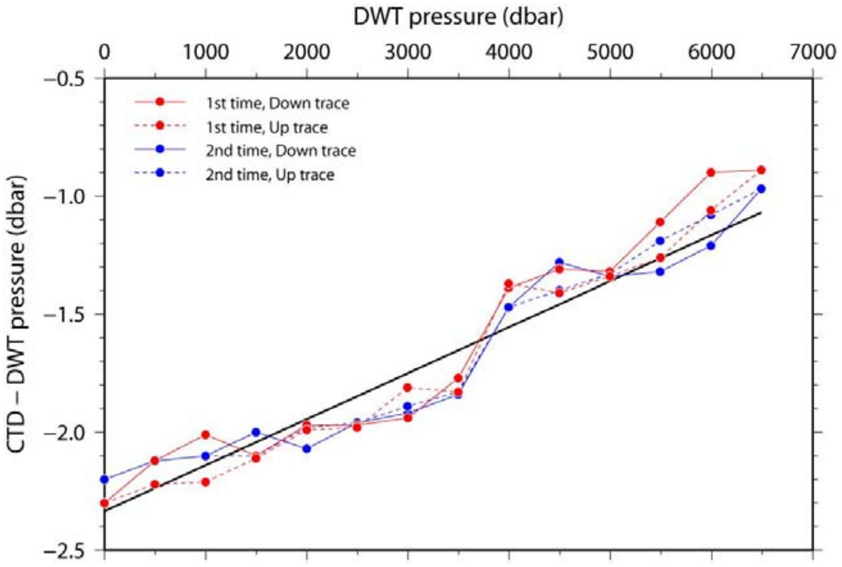

Fig. 3.1.1 Difference between the dead-weight piston gauge and the CTD pressure. The calibration line (black line) is also shown.

ii. Temperature (SBE 3)

The temperature sensing element is a glass-coated thermistor bead in a stainless steel tube, providing a pressure-free measurement at depths up to 10500 (6800) m by titanium (aluminum) housing. The SBE 3 thermometer has a nominal accuracy of 1 mK, typical stability of 0.2 mK/month, and resolution of 0.2 mK at 24 samples per second. The premium temperature sensor, SBE 3plus, is a more rigorously tested and calibrated version of standard temperature sensor (SBE 3).

Pre-cruise sensor calibrations were performed at SBE, Inc.

S/N 4188, 16 May 2007
S/N 4216, 16 May 2007
S/N 1525, 14 June 2007
S/N 4421, 14 June 2007

Pressure sensitivity of SBE 3 was corrected according to a method by Uchida et al. (2007), for the following sensor.

S/N 4188, –2.946675e–7 [°C/dbar]

Time drift of the SBE 3 temperature sensors based on the laboratory calibrations is shown in Fig. 3.1.2.

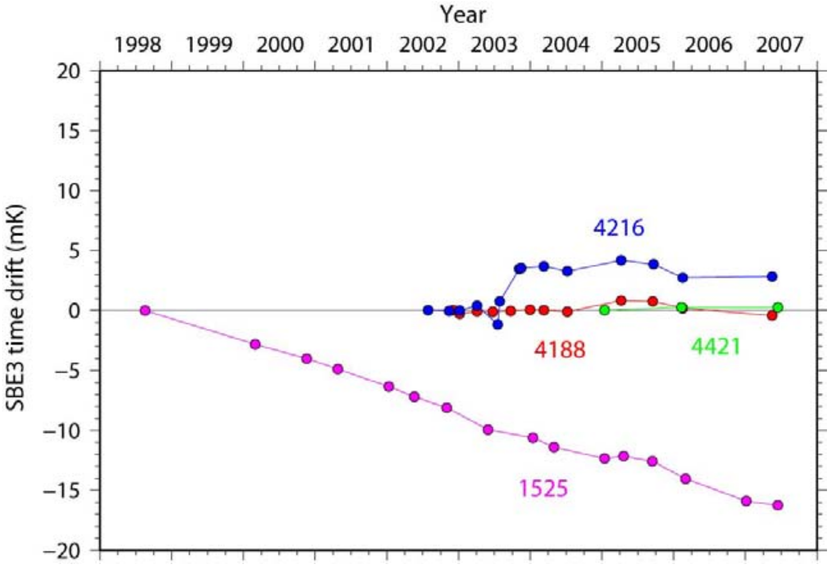

Fig. 3.1.2 Time drift of SBE 3 temperature sensors based on laboratory calibrations.

iii. 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 10500 (6800) m by titanium (aluminum) housing. The 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.

S/N 3064, 14 June 2007
S/N 2240, 10 August 2007
S/N 3036, 10 May 2007
S/N 2854, 10 August 2007
S/N 1206, 10 May 2007

S/N 2435, 10 August 2007
S/N 3116, 16 May 2007
S/N 3124, 16 May 2007
S/N 1172, 14 June 2007

The value of conductivity at salinity of 35, temperature of 15 °C (IPTS-68) and pressure of 0 dbar is 4.2914 S/m.

iv. Oxygen (SBE 43)

The SBE 43 oxygen sensor uses a Clark polarographic element to provide in-situ measurements at depths up to 7000 m. The range for dissolved oxygen is 120 % of surface saturation in all natural waters, nominal accuracy is 2 % of saturation, and typical stability is 2 % per 1000 hours.

Pre-cruise sensor calibrations were performed at SBE, Inc.

S/N 0394, 23 June 2007

v. Deep Ocean Standards Thermometer

Deep Ocean Standards Thermometer (SBE 35) is an accurate, ocean-range temperature sensor that can be standardized against Triple Point of Water and Gallium Melt Point cells and is also capable of measuring temperature in the ocean to depths of 6800 m. The SBE 35 was used to calibrate the SBE 3 temperature sensors in situ (Uchida et al., 2007).

Pre-cruise sensor linearization was performed at SBE, Inc.

S/N 0045, 27 October 2002

Then the SBE 35 is certified by measurements in thermodynamic fixed-point cells of the TPW (0.0100 °C) and GaMP (29.7646 °C). The slow time drift of the SBE 35 is adjusted by periodic recertification corrections. Pre-cruise sensor calibration was performed at SBE, Inc.

S/N 0045, 29 May 2007 (slope and offset correction)

The time required per sample = 1.1 × NCYCLES + 2.7 seconds. The 1.1 seconds is total time per an acquisition cycle. NCYCLES is the number of acquisition cycles per sample and was set to 4. The 2.7 seconds is required for converting the measured values to temperature and storing average in EEPROM.

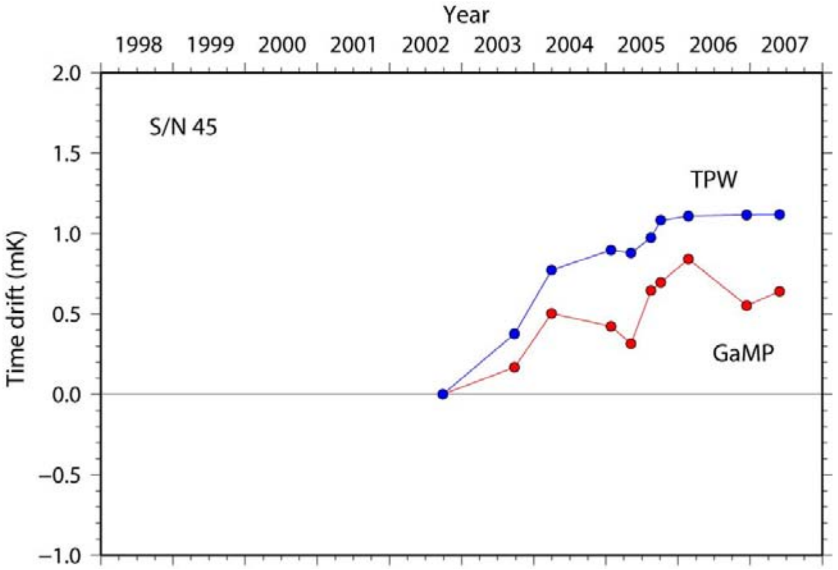

Fig. 3.1.3 SBE35 time drift based on laboratory fixed point calibrations

(triple point of water, TPW and gallium melt point, GaMP) performed by SBE, Inc.

When using the SBE 911 system with SBE 35, the deck unit receives incorrect signal from the under water unit for confirmation of firing bottle #16. In order to correct the signal, a module (Yoshi Ver. 1; EMS Co. Ltd., Kobe, Hyogo, Japan) was used between the under water unit and the deck unit.

Time drift of the SBE 35 based on the fixed point calibrations is shown in Fig. 3.1.3.

vi. Altimeter

Benthos PSA-916T Sonar Altimeter (Teledyne Benthos, Inc.) determines the distance of the target from the unit by generating a narrow beam acoustic pulse and measuring the travel time for the pulse to bounce back from the target surface. It is rated for operation in water depths up to 10000 m. The PSA-916T uses the nominal speed of sound of 1500 m/s.

vii. Oxygen Optode

Oxygen Optode 3830 (Aanderaa Instruments AS) is based on the ability of selected substances to act as dynamic fluorescence quenchers. In order to use with the SBE 911plus CTD system, an analog adaptor (3966) is connected to the oxygen optode (3830). The analog adaptor is packed into titanium housing made by Alec Electronics Co. Ltd., Kobe, Hyogo, Japan. The sensor is designed to operate down to 6000 m. The range for dissolved oxygen is 120 % of surface saturation in all natural waters, nominal accuracy is less than 5 % of saturation, and setting time (68%) is shorter than 25 seconds.

Outputs from the sensor are the raw phase shift and temperature. The optode oxygen can be calibrated by the Stern-Volmer equation, according to a method by Uchida et al. (submitted manuscript):

$$O_2\ (\mu\text{mol/l}) = (P_0 / P - 1) / K_{sv}$$

where P is phase shift, P_0 is phase shift in the absence of oxygen and K_{sv} is Stern-Volmer constant. The P_0 and the K_{sv} are assumed to be functions of temperature as follows.

$$K_{sv} = C_{11} + C_{12} \times t + C_{13} \times t^2$$

$$P_0 = C_{21} + C_{22} \times t$$

$$P = C_{31} + C_{32} \times P_b$$

where t is CTD temperature (°C) and P_b is raw phase measurement (degrees). The oxygen concentration is calculated using temperature data from the first responding CTD temperature sensor instead of temperature data from slow responding optode temperature sensor. The following calibration coefficients were preliminary determined and used during the cruise.

C_{11} = 2.524333849859047e-03
C_{12} = 1.040512483437119e-04
C_{13} =2.031782279102085e-06
C_{21} =60.12602843004201
C_{22} = 5.373515544568493e-02
C_{31} = –4.120804165979808
C_{32} = 1.065098754485088

viii. Fluorometer

The Seapoint Chlorophyll Fluorometer (Seapoint Sensors, Inc., Kingston, New Hampshire, USA) provides in-situ measurements of chlorophyll-a at depths up to 6000 m. 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.

ix. Prototype oxygen optode

The prototype of oxygen optodes (RINKO and RINKO2: Alec Electronics Co. Ltd.) provides the raw phase shift and temperature at depths up to 7000 m. Pre-cruise calibration was not performed for the prototype sensors.

(5) Data collection and processing

i. Data collection

CTD system was powered on at least 20 minutes in advance of the data acquisition and was powered off at least two minutes after the operation in order to acquire pressure data on the ship's deck.

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 lifted to the surface and lowered at a rate of 1.0 m/s to 200 m (or 300 m when significant wave height is high) then the package was stopped to operate the heave compensator of the crane. The package was lowered again at a rate of 1.2 m/s to the bottom. For the up cast, the package was lifted at a rate of 1.1 m/s except for bottle firing stops. At each bottle firing stops, the bottle was fired after waiting from the stop for 30 seconds and the package was stayed at least 5 seconds for measurement of the SBE 35. At 200 m (or 300 m) from the surface, the package was stopped to stop the heave compensator of the crane.

Water samples were collected using a 36-bottle SBE 32 Carousel Water Sampler with 12-litre Niskin-X bottles. Before a cast taken water for CFCs, the 36-bottle frame and Niskin-X bottles were wiped with acetone.

Data acquisition software:	SEASAVE-Win32, version 5.27b

ii. Data collection problems

Temperature sensor

Difference between the primary temperature sensor S/N 4188 and the SBE 35 was slightly greater than that between the secondary temperature sensor S/N 1525 and the SBE 35. Therefore the temperature sensor S/N 1525 was used as primary temperature sensor and the temperature sensor S/N 4421 was used as secondary temperature sensor after the station P14N_4_1. The secondary temperature sensor S/N 4421, however, showed large discrepancy (about 0.5 mK) between the down- and up-casts. Therefore the secondary temperature sensor was replaced with the temperature sensor S/N 4188 after the station P14N_33_1.

Scattering of difference between the secondary temperature sensor S/N 4188 and the SBE 35 was gradually became large. Therefore the secondary temperature sensor S/N 4188 was replaced with the temperature sensor S/N 4216 after the station P14N_73_1.

At the stations from P14N_75_1 to P14N_79_1, the secondary temperature sensor was used without the secondary conductivity sensor. The temperature sensor was directly connected with the pump by a tube. The temperature sensor reading was about 1 mK higher than usual for the stations.

Conductivity sensor

The secondary conductivity sensor S/N 2240 was broken near the bottom of the station P01_45_1. Therefore the secondary conductivity sensor was replaced with the conductivity sensor S/N 3036 after the station P01_46_1. The secondary conductivity sensor S/N 3036 was broken near the bottom of the station P14N_51_1. Therefore the secondary conductivity sensor was replaced with the conductivity sensor S/N 2854 after the station. The primary and secondary conductivity sensors S/N 3064 and S/N 2854 were broken near the bottom of the station P14N_74_1. Therefore the primary conductivity sensor was replaced with the conductivity sensor S/N 1206 and the secondary temperature and conductivity sensors were removed from the CTD system after the station. At the station P14N_80_1, the secondary conductivity sensor S/N 2435 was attached to the CTD system. The primary conductivity sensor S/N 3116 was broken near the bottom of the station P14N_108_1. Because the secondary conductivity sensor was in normal condition and the remaining station was only one station for the leg 1, the broken conductivity sensor was left for the station P14N_109_1. At the beginning of the leg 2, the primary conductivity was replaced with the conductivity sensor S/N 3124. The secondary conductivity sensor S/N 2435 was broken near the bottom of the station P14N_171_1. Therefore the secondary conductivity sensor was replaced with the conductivity sensor S/N 1172 after the station.

Because the conductivity sensor reading from the primary conductivity sensor S/N 1206 was slightly shifted during a long stop due to the winch trouble during the station P14N_98_1, the primary conductivity sensor was replaced with the conductivity sensor S/N 3116 after the station P14N_99_1.

Prototype oxygen optode

At the station P14N_181_1, the sensor reading from RINKO was unstable during the down-cast, although the sensor reading was normal during the up-cast. At the station P14N_182_1, RINKO did not work during the cast due to leakage. Therefore RINKO was removed after the cast.

Winch troubles

At the station P01_34_1, a sensor in the hydraulic actuator of the crane broke at about 864 dbar of the up-cast. Therefore CTD was operated without heave motion of the crane at the station P01_35_1.

At the station P14N_98_1, a chain rotating the cable drum broke at about 713 dbar of the down-cast and the CTD package was stopped at the depth for about 110 minutes during repair.

At the station P14N_178_1, distance between the CTD package and the bottom was rapidly shorten at the bottom before firing the bottle #1, and the neatly arranged cable on the winch drum broke down in disorder, because the CTD package was quickly upped. Therefore the cast was quitted. The station location was changed about one mile from the original location and the second cast was carried out.

Miss trip and miss fire

Niskin bottles did not trip correctly at the following stations.

Miss trip	Miss fire
P01_40_2, #10	P14N_60_1, #26
P01_54_1, #10	P14N_71_1, #31
P14N_54_1, #11	P14C_35_1, #11
P14N_63_1, #11	
P14N_64_1, #11	
P14N_77 _1, #27	
P14N_92_1, #24	
P14N_99_1, #18	
P14N_101_1, #16	
P14N_103_1, #5	
P14N_107_1, #3 and #12	
P14N_110_1, #2	
P14N_126_1, #30	
P14N_127_1, #28	
P14C_50_1, #24	

P14C_7_1, #22

Other incidents of note

At the station P01_47_1, the secondary temperature and conductivity data were noisy.

At the station P14N_55_1, the SBE 35 data of bottle #8 was lost, because the next bottle firing command was sent before storing the SBE 35 data in the internal memory.

At the station P14N_140_1, the secondary salinity data did not change from zero. Therefore the cast was quitted. The secondary sensors were flushed with water and the second cast was carried out.

iii. Data processing

SEASOFT consists of modular menu driven routines for acquisition, display, processing, and archiving of oceanographic data acquired with SBE equipment. Raw data are acquired from instruments and are stored as unmodified data. The conversion module DATCNV uses instrument configuration and calibration coefficients to create a converted engineering unit data file that is operated on by all SEASOFT post processing modules. The following are the SEASOFT and original software data processing module sequence and specifications used in the reduction of CTD data in this cruise.

Data processing software

SEASOFT-Win32, version 5.27b

DATCNV converted the raw data to engineering unit data. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds, and the offset was set to 0.0 second.

TCORP (original module, version 1.0) corrected the pressure sensitivity of the SBE 3 for both profile and bottle information data. One SBE 3 (S/N 4188) was corrected because it had relatively large pressure sensitivity (about +1.8 mK per 6000 dbar).

ROSSUM created a summary of the bottle data. The data were averaged over 4.4 seconds.

ALIGNCTD converted the time-sequence of 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 and the secondary conductivity for 1.73 scans (1.75/24 = 0.073 seconds). 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 output (oxygen voltage) relative to the temperature data. Prototype of the oxygen optode data (RINKO and RINKO2) are also delayed by slightly slow response time of the sensor. The delay was compensated by 2 seconds advancing sensor output relative to the temperature data.

ALIGNOPT (original module, version 0.1) also compensated the delay of the AANDERAA optode sensor by advancing relative to the CTD temperature data as a function of temperature (t).

$$\text{align (sec)} = 25 \times \exp(-0.13 \times t) \quad (\text{for } 0 \le t \le 16.3\ {}^\circ\text{C})$$
$$= 25 \quad (\text{for } t < 0\ {}^\circ\text{C})$$
$$= 3 \quad (\text{for } t > 16.3\ {}^\circ\text{C})$$

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 1000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to all variables.

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 = 7.0.

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 as a median filter to remove spikes in fluorometer data. A median value was determined by 49 scans of the window.

SECTION (or original module of SECTIONU, version 1.0) 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 start 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 for estimation of 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).

DESPIKE (original module, version 1.0) removed spikes of the data. A median and mean absolute deviation was calculated in 1-dbar pressure bins for both down- and up-cast, excluding the flagged values. Values greater than 4 mean absolute deviations from the median were marked bad for each bin. This process was performed 2 times for temperature, conductivity, oxygen voltage (SBE 43) and optode oxygen (AANDERAA) data.

DERIVE was used to compute oxygen (SBE 43).

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 exist every dbar.

DERIVE was re-used to compute salinity, potential temperature, and density (σ_θ).

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

For the station P14N_36_1, bad quality data of the primary temperature and conductivity between 37 and 78 dbar of the down-cast were corrected by using original module SWAP. The bad quality data were replaced with the secondary temperature and conductivity data for the depths. Offsets of the secondary temperature and conductivity data relative to the primary temperature and conductivity data at the depths were estimated from the upper and lower data and were subtracted from the secondary data.

Remaining spikes in temperature and salinity data were manually eliminated from the 1-dbar-averaged data. The following data gaps over 1-dbar were linearly interpolated with a quality flag of 6.

Station	Pressure (dbar)	Parameters
P01_28_2	99	Salinity
P01_33_1	480	Salinity
P01_57_1	73	Salinity
P14N_110_1	300	Temperature
P14N_111_1	139, 199	Temperature
P14N_154_1	201	Temperature
P14N_164_1	627	Salinity
P14N_170_1	1387	Salinity
P14C_10_1	50	Temperature
P14C_10_1	49-50	Salinity

P14C_6_1	1520	Salinity

(6) Post-cruise calibration

i. Pressure

The CTD pressure sensor offset in the period of the cruise was estimated from the pressure readings on the ship deck. For best results the Paroscientific sensor was powered on for at least 20 minutes before the operation. In order to get the calibration data for the pre- and post-cast pressure sensor drift, the CTD deck pressure was averaged over first and last one minute, respectively. Then the atmospheric pressure deviation from a standard atmospheric pressure (14.7 psi) was subtracted from the CTD deck pressure. The atmospheric pressure was measured at the captain deck (20 m high from the base line) and sub-sampled one-minute interval as a meteorological data. Time series of the CTD deck pressure is shown in Figs. 3.1.4 and 3.1.5.

The CTD pressure sensor offset was estimated from the deck pressure obtained above. Mean of the pre- and the post-casts data over the whole period gave an estimation of the pressure sensor offset from the pre-cruise calibration. Mean residual pressure between the dead-weight piston gauge and the calibrated CTD data at 0 dbar of the pre-cruise calibration was subtracted from the mean deck pressure. Estimated mean offset of the pressure data is listed in Table 3.1.1. The post-cruise correction of the pressure data is not deemed necessary for the pressure sensor.

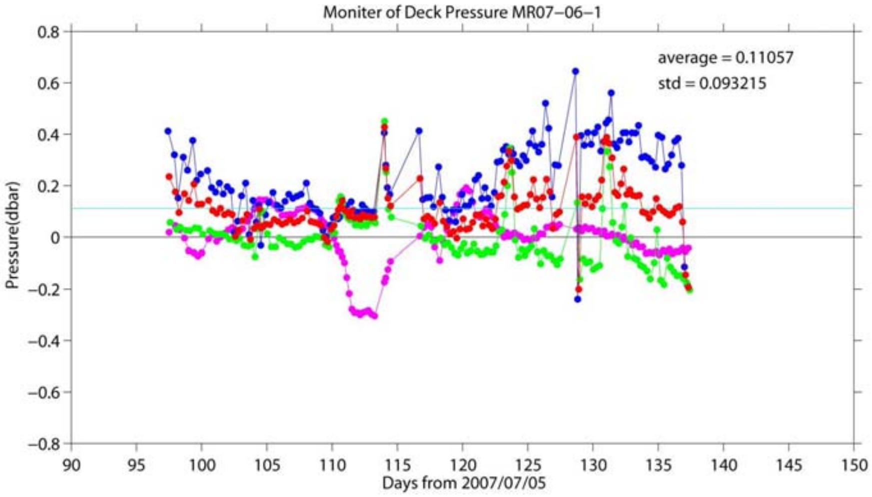

Fig. 3.1.4 Time series of the CTD deck pressure for leg 1. Pink dot indicates atmospheric pressure anomaly. Blue and green dots indicate pre- and post-cast deck pressures, respectively. Red dot indicates an average of the pre- and the post-cast deck pressures.

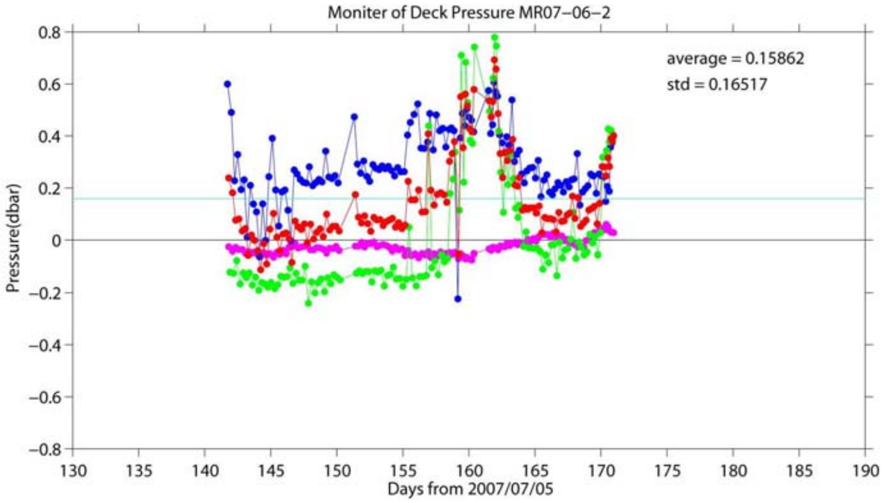

Fig. 3.1.5 Same as Fig. 3.1.4, but for leg 2.

Table 3.1.1 Offset of the pressure data. Mean and standard deviation are calculated from time series of the average of the pre- and the post-cast deck pressures.

Leg	Mean deck pressure	Standard deviation	Residual pressure	Estimated offset
1	0.11 dbar	0.09 dbar	0.06 dbar	0.05 dbar
2	0.16 dbar	0.17 dbar	0.06 dbar	0.10 dbar

ii. Temperature

The CTD temperature sensors (SBE 3) were calibrated with the SBE 35 under the assumption that discrepancies between SBE 3 and SBE 35 data were due to pressure sensitivity, the viscous heating effect, and time drift of the SBE 3, according to a method by Uchida et al. (2007).

Post-cruise sensor calibration for the SBE 35 will be performed at SBE, Inc., after MR07-06 cruise.

The CTD temperature was preliminary calibrated as

$$\text{Calibrated temperature} = T - (c_0 \times P + c_1 \times t + c_2)$$

where T is CTD temperature in °C, P is pressure in dbar, t is time in days from pre-cruise calibration date of CTD temperature and c_0, c_1, and c_2 are calibration coefficients. The coefficients were determined using the data for the depths deeper than 1950 dbar.

The primary temperature data were basically used for the post-cruise calibration. For the stations P14N_108_1 and P14N_109_1, the secondary temperature sensor was also calibrated and used instead of the primary temperature data, because the primary conductivity data was not able to be used for the stations. The number of data used for the calibration and the mean absolute deviation from the SBE 35 are listed in Table 3.1.2 and the calibration coefficients are listed in Table 3.1.3. The results of the post-cruise calibration for the CTD temperature are summarized in Table 3.1.4 and shown in Figs. 3.1.6 and 3.1.7.

Table 3.1.2 Number of data used for the calibration (pressure ≥ 1950 dbar) and mean absolute deviation between the CTD

temperature and the SBE 35. Serial number 4216 for leg 1 is secondary temperature sensor.

Serial number	Number	Mean absolute deviation	Note
Leg 1			
4188	825	0.1 mK	Stns. P01_28_2 to P14N_4_1
1525	1210	0.1 mK	Stns. P14N_30_1 to P14N_109_1
4216	421	0.1 mK	Stns. P14N_80_1 to P14N_109_1
Leg 2			
1525	1528	0.1 mK	

Table 3.1.3 Calibration coefficients for the CTD temperature sensors. Serial number 4216 for leg 1 is secondary temperature sensor.

Serial number	c_0 (°C/dbar)	c_1 (°C/day)	c_2 (°C)
Leg 1			
4188	3.85600e–8	1.54264e–5	–0.0013
1525	–6.56477e–9	1.76679e–5	–0.0018
4216	4.66846e–8	–6.65040e–5	–0.0129
Leg 2			
1525	8.24860e–9	–1.23300e–5	0.0028

Table 3.1.4 Difference between the CTD temperature and the SBE 35 after the post-cruise calibration. Mean and standard deviation (Sdev) are calculated for the data below and above 1950 dbar. Number of data used is also shown.

	Pressure ≥ 1950 dbar			Pressure < 1950 dbar	
Number	Mean (mK)	Sdev (mK)	Number	Mean (mK)	Sdev (mK)
Leg 1					
1570	0.00	0.2	2962	0.01	6.9
Leg 2					
2121	0.00	0.1	3007	–0.15	8.4

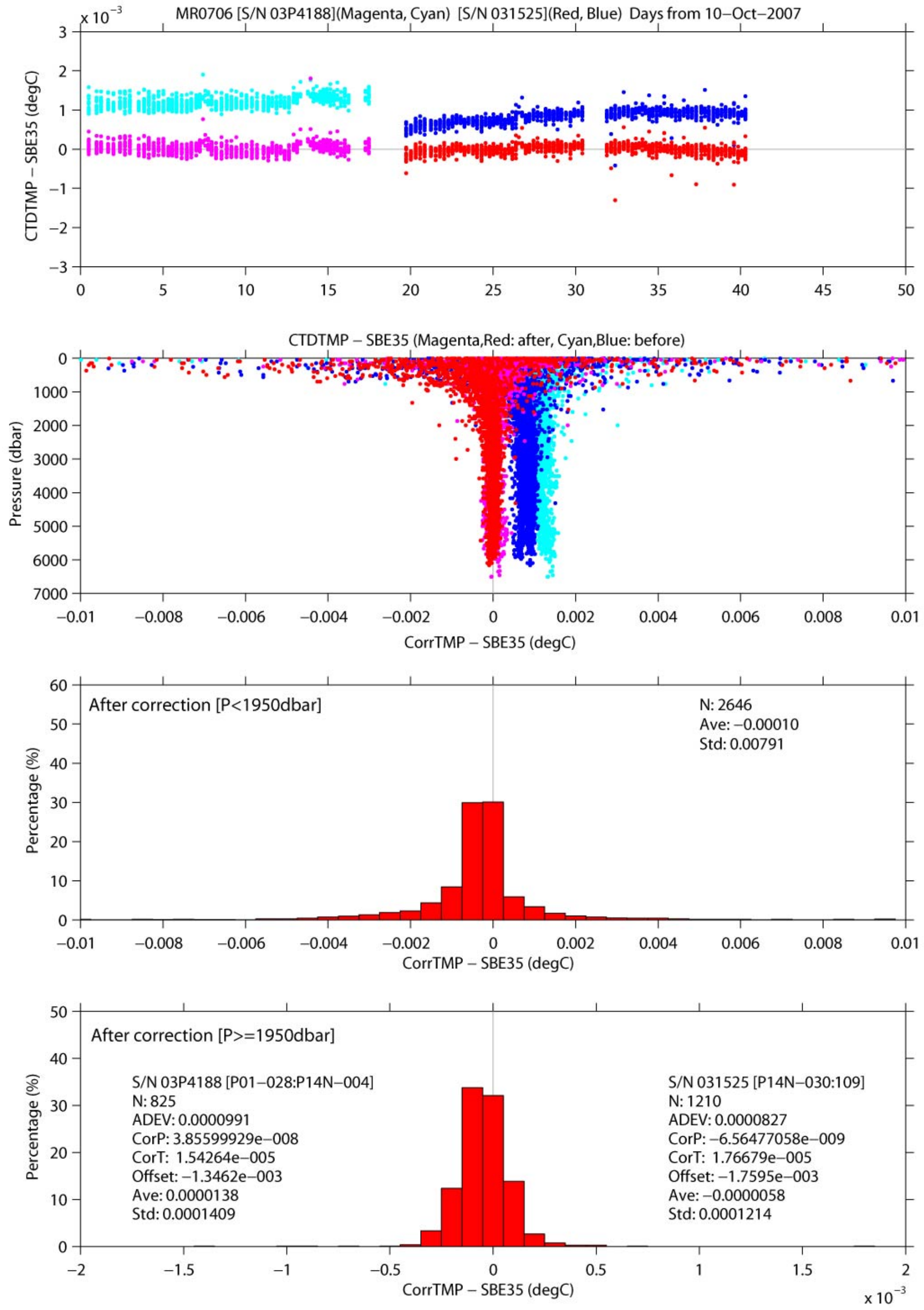

Fig. 3.1.6 Difference between the CTD temperature and the SBE 35 for leg 1. Blue/cyan and red/magenta dots indicate before and after the post-cruise calibration using the SBE 35 data, respectively. Top panel shows for P ≥ 1950 dbar. Lower two panels show histogram of the difference after the calibration.

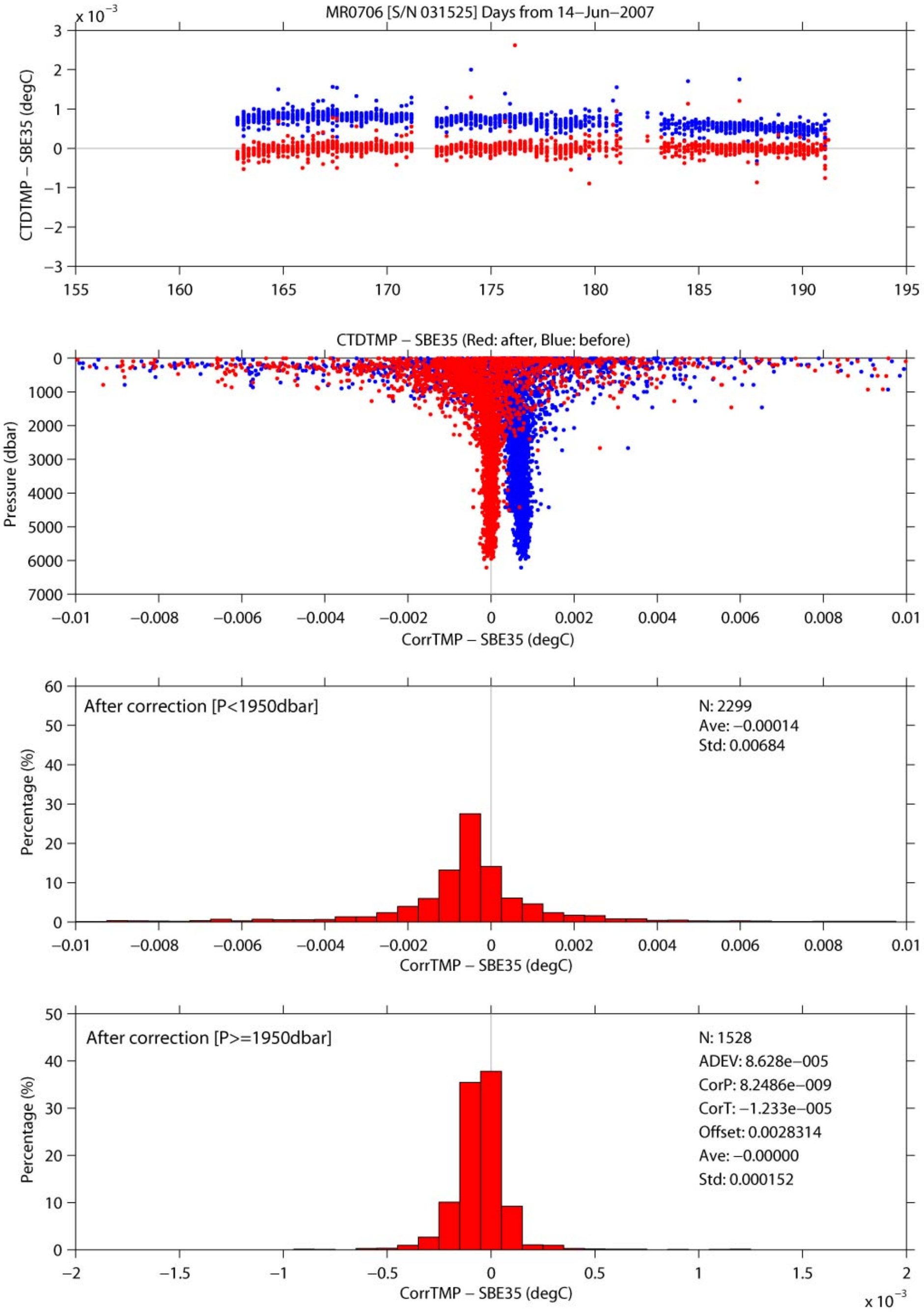

Fig. 3.1.7 Same as Fig. 3.1.6, but for leg 2.

iii. Salinity

The discrepancy between the CTD salinity and the bottle salinity is considered to be a function of conductivity and pressure. The CTD salinity was calibrated as

$$\text{Calibrated salinity} = S - (c_0 \times P + c_1 \times C + c_2 \times C \times P + c_3)$$

where S is CTD salinity, P is pressure in dbar, C is conductivity in S/m and c_0, c_1, c_2 and c_3 are calibration coefficients. The best fit sets of coefficients were determined by minimizing the sum of absolute deviation with a weight from the bottle salinity data. The MATLAB® function FMINSEARCH was used to determine the sets. The weight was given as a function of vertical salinity gradient and pressure as

$$\mathrm{Weight} = \min[4, \exp\{\log(4) \times \mathrm{Gr} / \mathrm{Grad}\}] \times \min[4, \exp\{\log(4) \times P^2 / \mathrm{PR}^2\}]$$

where Grad is vertical salinity gradient in PSU dbar^{-1}, and P is pressure in dbar. Gr and PR are threshold of the salinity gradient (0.5 mPSU dbar^{-1}) and pressure (1000 dbar), respectively. When salinity gradient is small (large) and pressure is large (small), the weight is large (small) at maximum (minimum) value of 16 (1). The salinity gradient was calculated using up cast CTD salinity data. The up cast CTD salinity data was low-pass filtered with a 3-point (weights are 1/4, 1/2, 1/4) triangle filter before the calculation.

The primary conductivity data created by the software module ROSSUM were basically used after the post-cruise calibration for the temperature data. For the stations P14N_108_1 and P14N_109_1, the secondary conductivity data was used, because the primary conductivity data was not able to be used for the stations. The coefficients were determined for some groups of the CTD stations. The results of the post-cruise calibration for the CTD salinity are summarized in Table 3.1.5 and shown in Figs. 3.1.8 and 3.1.9. And the calibration coefficients and number of data used for the calibration are listed in Table 3.1.6.

Table 3.1.5 Difference between the CTD salinity and the bottle salinity after the post-cruise calibration. Mean and standard deviation (Sdev) are calculated for the data below and above 950 dbar. Number of data used is also shown.

Pressure ≥ 950 dbar			Pressure < 950 dbar		
Number	Mean (mPSU)	Sdev (mPSU)	Number	Mean (mPSU)	Sdev (mPSU)
Leg 1					
2672	0.0	0.4	1870	0.0	4.3
Leg 2					
2067	–0.1	0.5	1647	1.1	8.8

Table 3.1.6 Calibration coefficients for the CTD salinity. Number of data used is also listed.

Station	Number	c_0	c_1	c_2	c_3
Leg 1					
P01 28	33	1.2366877766e-5	-3.1864710265e-3	-3.7410180073e-6	8.3092359251e-3
P01 29	34	1.4429501944e-5	-1.7179786902e-3	-4.3563216655e-6	3.8109547807e-3
P01 30	33	8.0524469712e-6	-4.6347655243e-3	-2.3595978265e-6	1.2938880900e-2
P01 32-33	101	1.1753176804e-5	-2.5920297513e-3	-3.5208528038e-6	6.0330712832e-3
P01 34-41	261	5.2675994458e-6	-4.3909897182e-3	-1.5450824887e-6	1.1719014146e-2
P01 42-46	216	7.0309692113e-6	-4.3031061185e-3	-2.0723214458e-6	1.0888896417e-2
P01 47-57	341	1.1092775540e-5	-2.3272648509e-3	-3.3053060435e-6	3.5700887850e-3
P01 58-59	71	3.2310197116e-6	-4.4057460257e-3	-9.2624113598e-7	1.0830447326e-2
P01 60-4	826	6.7400531759e-6	-2.7670250955e-3	-1.9631840097e-6	4.1271223241e-3
P14N 30-39	356	6.2991911918e-6	-1.7666229796e-3	-1.8995982920e-6	1.7562568508e-3
P14N 40-53	477	5.0547425123e-6	-7.9209509292e-4	-1.5177307189e-6	-1.9611923558e-3
P14N 54-73	633	3.1759512104e-6	-1.0157437278e-3	-9.4764638711e-7	-1.4232704966e-3
P14N 74-77	34	2.4469862353e-6	6.4594035205e-4	-7.2598062391e-7	-8.8654546715e-4
P14N 78-81	133	4.7865965493e-6	1.6054792872e-4	-1.4517360658e-6	-1.5497727834e-4
P14N 82-99	545	4.3956514692e-7	1.0331301338e-4	-1.1130619565e-7	1.0822581183e-4
P14N 100-107	271	4.2884569782e-6	-1.7427574735e-3	-1.2594920500e-6	8.5148058572e-3
P14N 108-109	70	6.0865582513e-6	-4.5049125413e-4	-1.7802113940e-6	2.1856744398e-3
Leg 2					
P14N 109-115	232	2.3777541759e-6	-1.3933958135e-3	-6.6273977628e-7	8.1764782233e-3
P14N 116-127	417	3.5670485696e-6	-1.1006125106e-3	-1.0346847842e-6	6.8622137886e-3
P14N 128-138	377	1.3987382078e-6	-1.4065398654e-3	-3.4347529939e-7	7.5351833539e-3
P14N 139-144	205	2.8354655464e-6	-1.2215836660e-3	-7.9541774815e-7	6.5351513653e-3
P14N 145-149	170	3.1542072660e-6	-2.0613822363e-3	-8.9077088694e-7	8.8717976083e-3
P14N 150-158	301	4.8230368910e-6	-1.2147005582e-3	-1.4092637192e-6	5.5797896292e-3
P14N 159-174	505	1.6174979975e-6	-1.1887433192e-3	-3.8999095831e-7	4.4287286499e-3
P14N 175- P14C1	1484	-1.2626975255e-6	-1.0905094466e-3	5.9573995339e-7	2.4361456298e-3

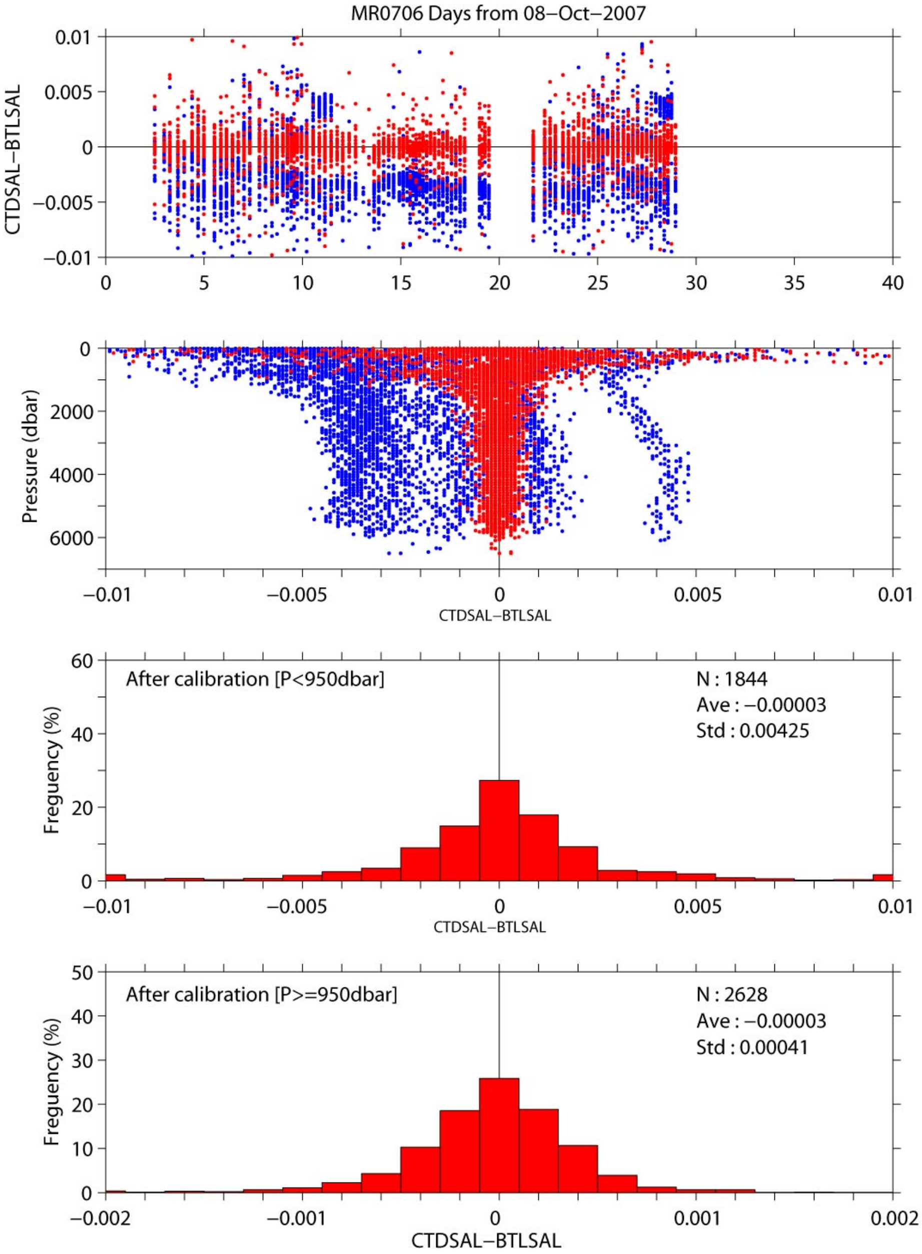

Fig. 3.1.8 Difference between the CTD salinity and the bottle salinity for leg 1. Blue and red dots indicate before and after the post-cruise calibration using the bottle salinity data, respectively. Top panel shows for P ≥ 950 dbar. Lower two panels show histogram of the difference after the calibration.

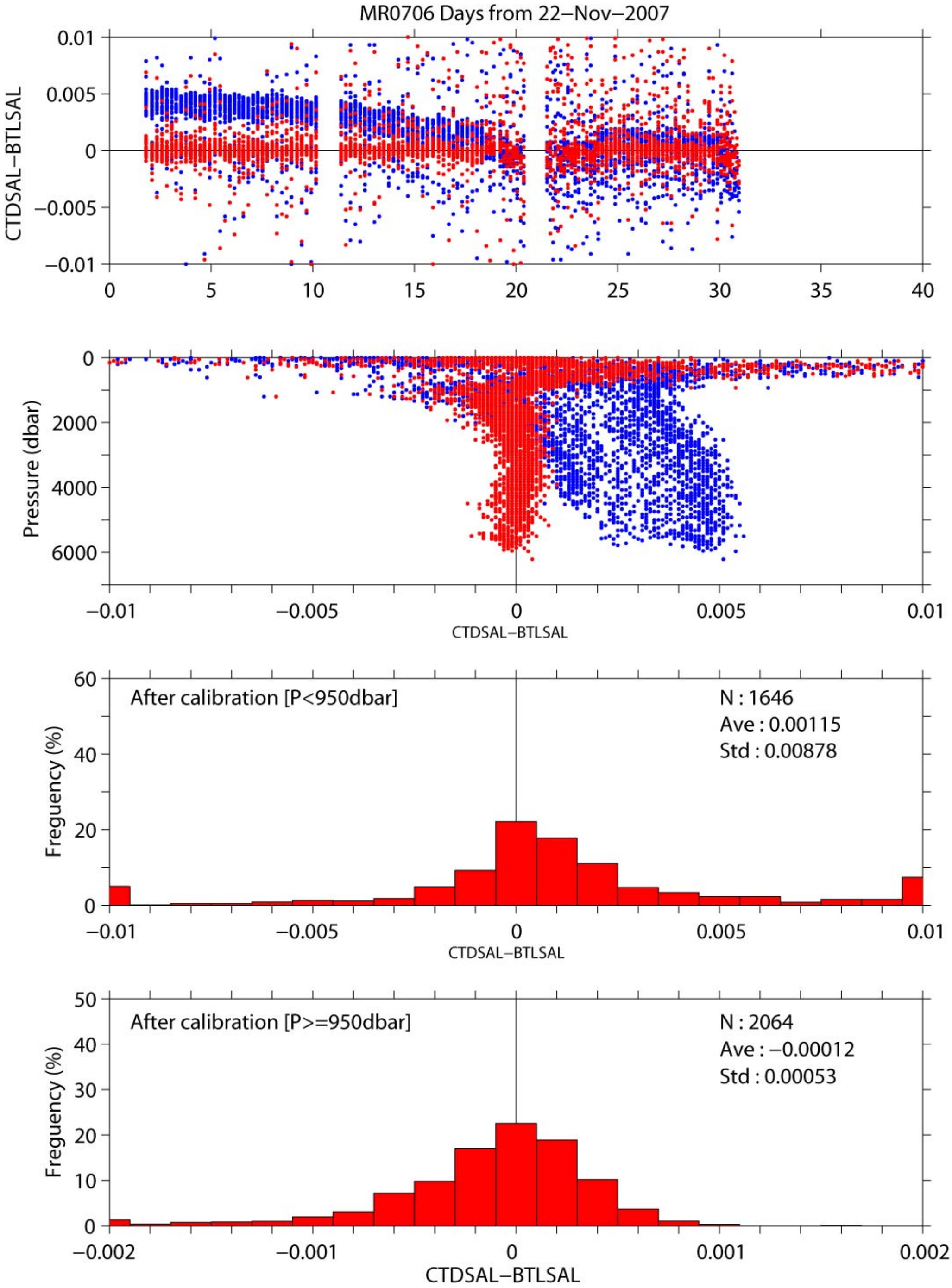

Fig. 3.1.9 Same as Fig. 3.1.8, but for leg 2.

iv. Oxygen

Post-cruise calibration for the CTD oxygen sensor is not finished yet and the oxygen sensor will be calibrated by the Stern-Volmer equation, according to a method by Uchida et al. (submitted manuscript), by using bottle sampled oxygen data.

(7) Preliminary results

Vertical sections for potential temperature, salinity and oxygen are shown in Figs. 3.1.10 to 3.1.12.

References

Fukasawa, M., T. Kawano and H. Uchida (2004): Blue Earth Global Expedition collects CTD data aboard Mirai, BEAGLE 2003 conducted using a Dynacon CTD traction winch and motion-compensated crane, *Sea Technology*, 45, 14-18.

Uchida, H., K. Ohyama, S. Ozawa, and M. Fukasawa (2007): In-situ calibration of the Sea-Bird 9plus CTD thermometer, *J. Atmos. Oceanic Technol.*, 24, 1961-1967.

Uchida, H., T. Kawano, I. Kaneko, and M. Fukasawa: In-situ calibration of optode-based oxygen sensors, submitted to *J. Atmos. Oceanic Technol.*

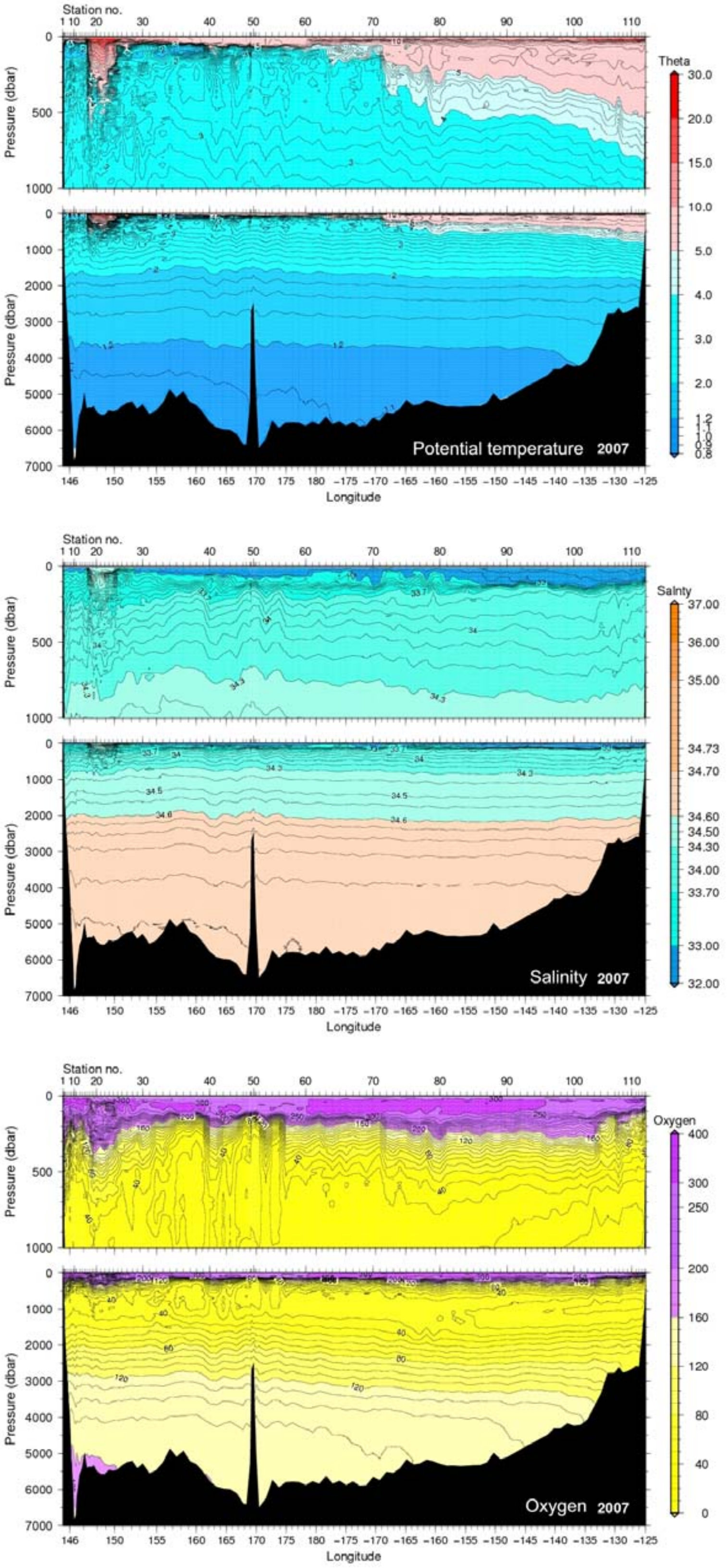

Fig. 3.1.10 Vertical section of temperature (upper), salinity (middle) and oxygen (lower) for WHP P01 line. Data of stations 29 to 60 are obtained in leg 1 and the other are obtained in MR07-04 cruise.

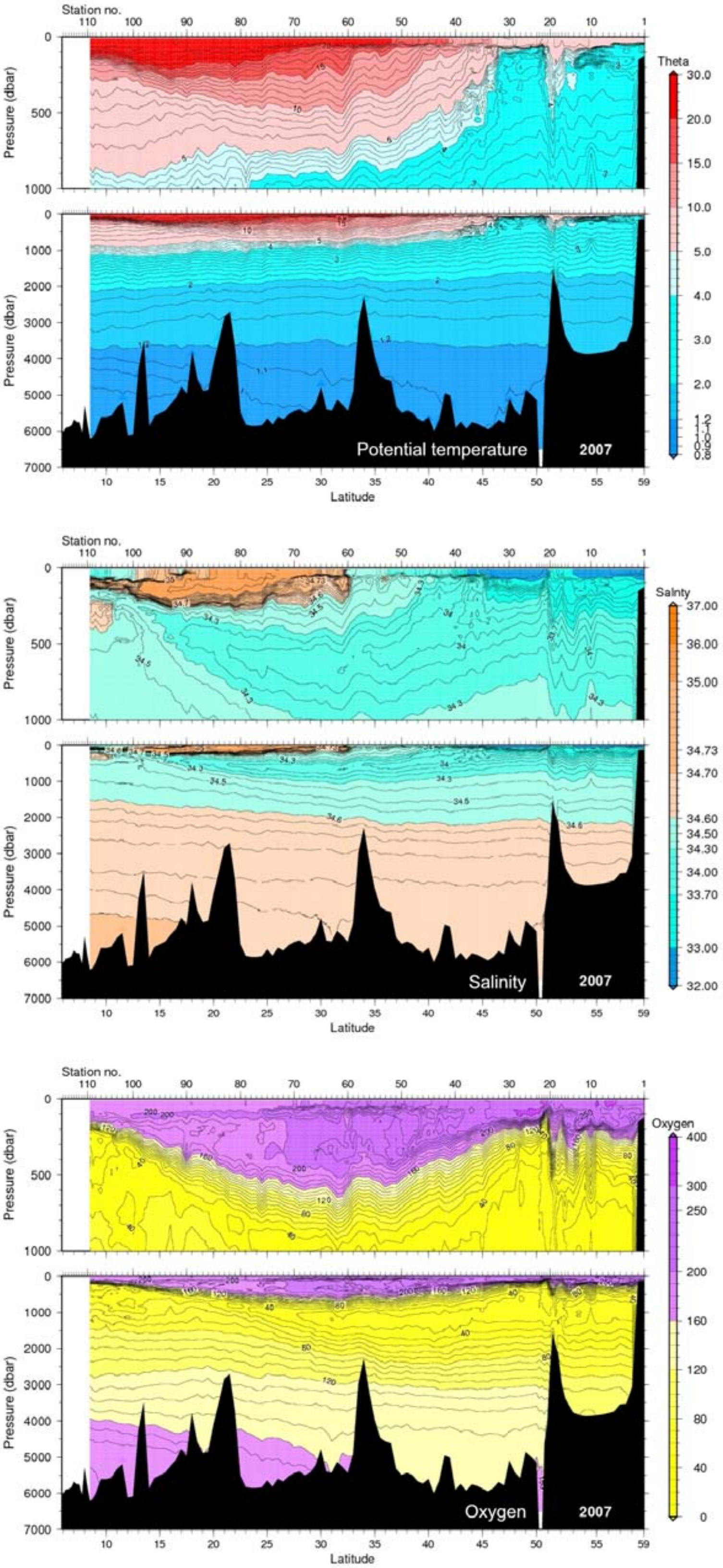

Fig. 3.1.11 Same as Fig. 3.1.10, but for WHP P14 line (leg 1).

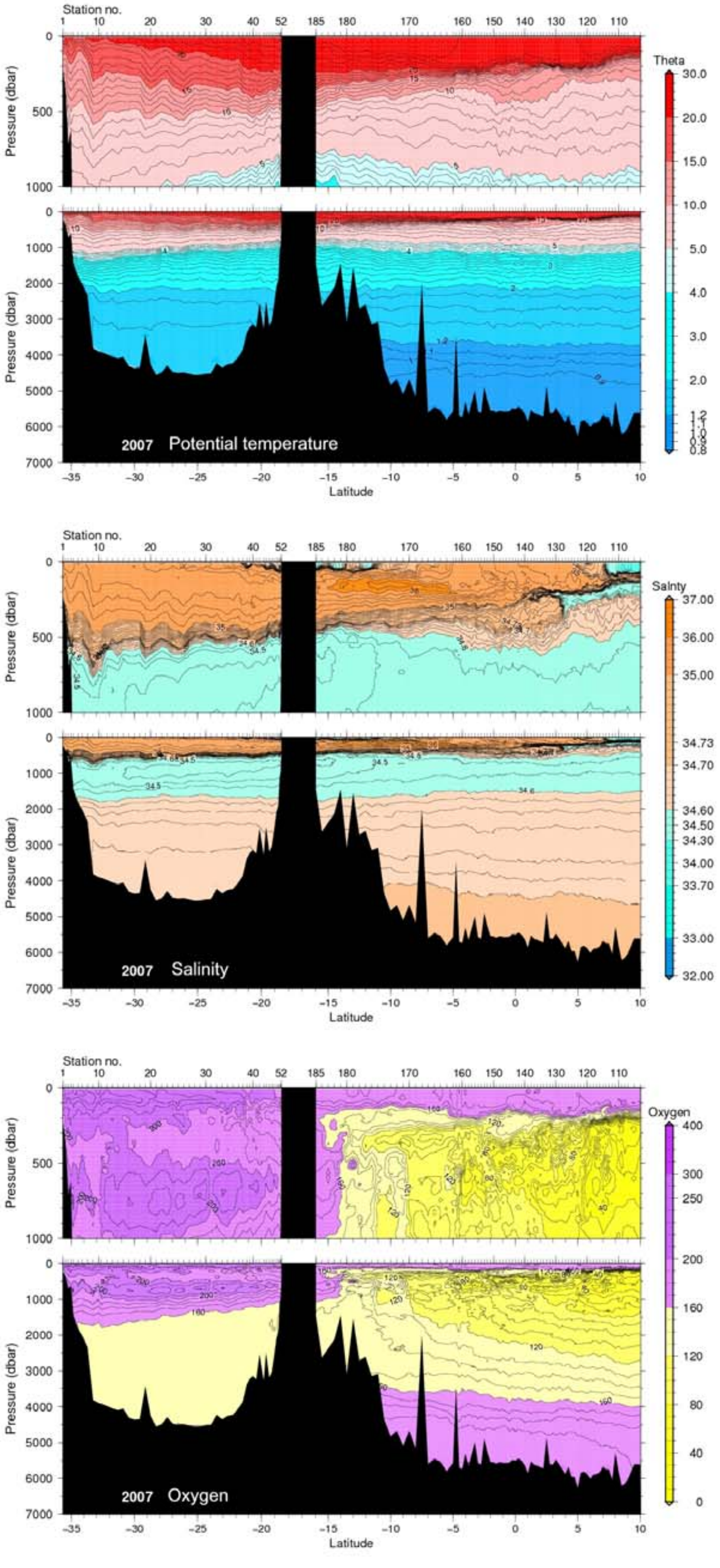

Fig. 3.1.12 Same as Fig. 3.1.10, but for WHP P14 line (leg 2).

3.2 Bottle Salinity

January 17, 2008

(1) Personnel

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Tatsuya Tanaka (MWJ)

(2) Objectives

Bottle salinities were measured to compare with CTD salinities for calibrating CTD salinities and for identifying leaking bottles

(3) Instrument and Method

i. 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 more than 12 hours in the same laboratory as where the salinity measurement was made.

ii. Instruments and Method

The salinity analysis was carried out on Guildline Autosal salinometer model 8400B (S/N 62827), which was modified by adding 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 ºC. The measurement system was almost same as Aoyama et al (2003). The salinometer was operated in an air-conditioned laboratory of the ship at a bath temperature of 24 ºC.

An ambient temperature varied from approximately 21 ºC to 24 ºC while a bath temperature was very stable and varied within +/- 0.002 ºC 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 for Leg.1 and the eighth and ninth filling for Leg.2 and Leg.3. In the case where the difference between the double conductivity ratio of this two fillings is smaller than 0.00002, the average value of the two double conductivity ratios is used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference ~~was~~ is greater than or equal to 0.00003, we measure another additional filling of the cell. In the case where the double conductivity ratio of the additional filling does not satisfy the criteria above, we measure~~d~~ two other fillings 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 for about 10 to 18 hours per day and the cell was cleaned with ethanol or soap or both after the measurement of the day. We measured more than 9,900 samples in total.

(4) Preliminary Result

i. Stand Seawater

Leg.1

Standardization control was set to 460 and all measurements were done by this setting. STNBY was 5402 +/- 0001 and ZERO was 0.00001 +/- 0.00001. We used IAPSO Standard Seawater batch P148 whose conductivity ratio was 0.99982 (double conductivity ratio is 1.99964) as the standard for salinity. We measured 146 bottles of P148 during routine measurement. Fig.3.2.1 shows the history of double conductivity ratio of the Standard Seawater batch P148.

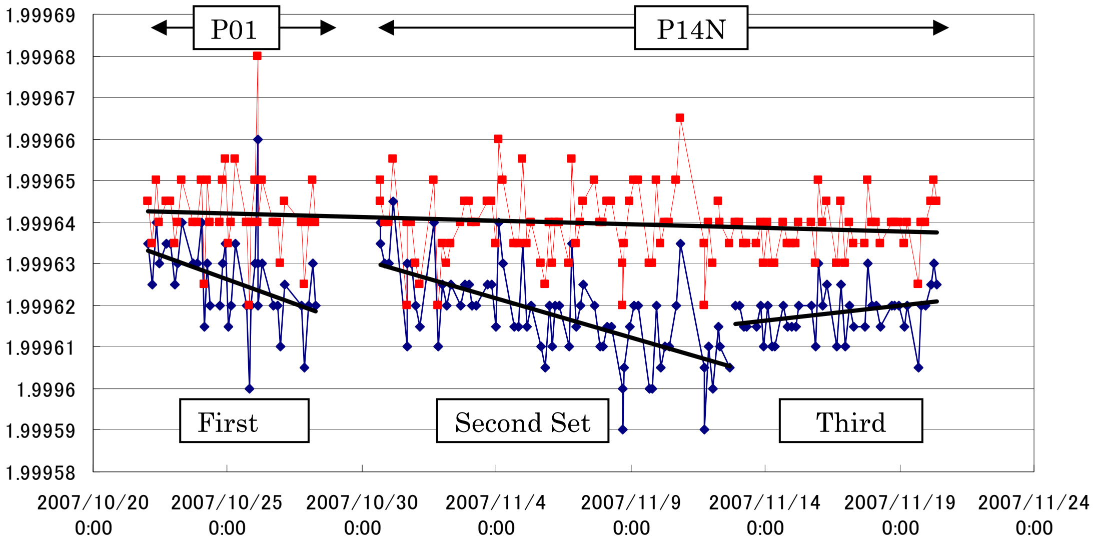

Fig.3.2.1 History of Double conductivity ratio of P148 during Leg.1. X and Y axes represents date and double conductivity ratio, respectively. Blue triangle is raw data and red rectangular is corrected data.

Drifts were calculated by fitting data from P148 to the equation obtained by the least square method (solid lines). Correction for the double conductivity ratio of the sample was made to compensate for the drift. After the drift correction, we add 0.00001 for the first and second set and 0.00002 for the third set to make the average to 1.99964. After these corrections, the standard deviation of 146 bottles becomes 0.000009, which is equivalent to 0.0002 in saliniy.

Leg.2

Standardization control was set to 464 and all measurements were done by this setting. STNBY was 5402 +/- 0001 and ZERO was 0.00001 +/- 0.00001.We used IAPSO Standard Seawater batch P148 as the standard for salinity. We measured 160 bottles of P148 during routine measurement. There were 2 bad bottles whose conductivities were extremely high. Data of these 2 bottles are not taken into consideration hereafter. Fig.3.2.2 shows the history of double conductivity ratio of the Standard Seawater batch P148. Drifts were calculated by fitting data from P148 to the equation obtained by the least square method (solid lines). Correction for the double conductivity ratio of the sample was made to compensate for the drift. After correction, the average of double conductivity ratio became 1.999625 and the standard deviation was 0.00008, which is equivalent to 0.0002 in salinity. We added 0.000015 to make an average to 1.99964.

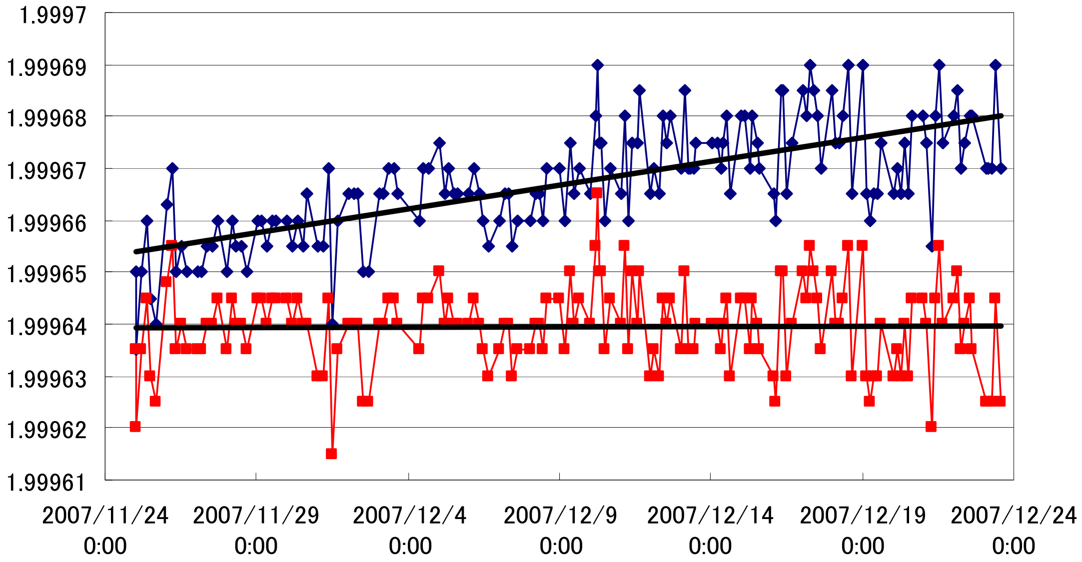

Fig.3.2.2 History of Double conductivity ratio of P148 during Leg.2. X and Y axes represents date and double conductivity ratio, respectively.

ii. Sub-Standard Seawater

We also used sub-standard seawater which was deep-sea water filtered by pore size of 0.45 micrometer and was 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 possible sudden drift of the salinometer. During the whole measurements, there was no detectable sudden drift of the salinometer.

iii. Replicate and Duplicate Samples

Leg.1

We took 840 pairs of replicate. Fig.3.2.3 shows the histogram of the absolute difference between each pair of the replicate samples. There were 6 bad measurements in the replicate samples. Excluding these bad measurements, the standard deviation of the absolute difference in 834 pairs of the replicate samples was 0.00017 in salinity.

Leg.2

We took 749 pairs of replicate samples. Fig.3.2.4 shows the histogram of the absolute difference between each pair of the replicate samples. There were 4 questionable measurements in the replicate samples. Excluding these questionable measurements, the standard deviation of the absolute difference in 745 pairs of the replicate samples was 0.00016 in salinity.

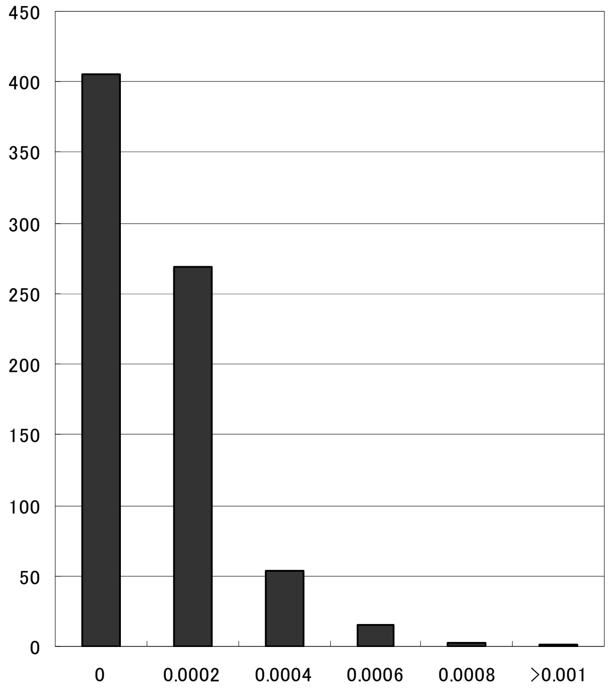

Fig.3.2.3 The histogram of the absolute difference between each pair of replicate samples in Leg.1. X axis is absolute difference in salinity and Y axis is fequency.

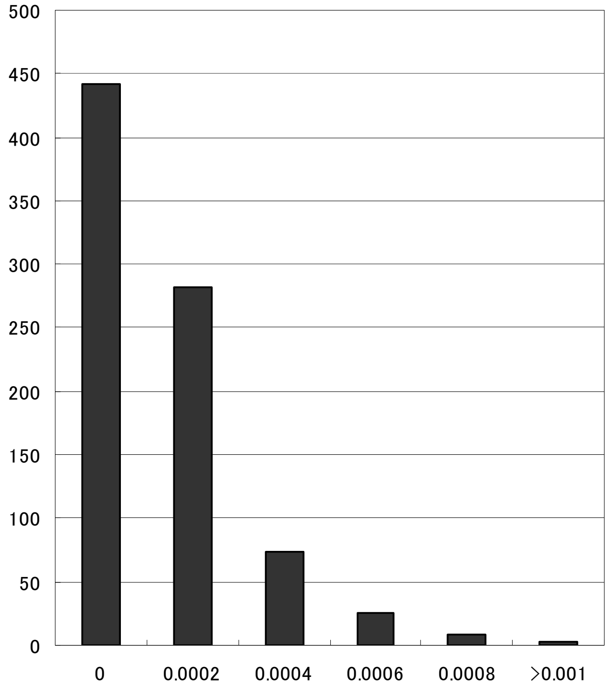

Fig.3.2.4 The histogram of the absolute difference between each pair of replicate samples in Leg.2. X axis is absolute difference in salinity and Y axis is fequency.

3.2.3. Further data quality check

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

3.2.4 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., 1

3.3 Bottle Oxygen

January 17, 2008

(1) Personnel

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2) Marine Works Japan Co. Ltd

(2) Objectives

Dissolved oxygen is one of good tracers for the ocean circulation. Recent studies in the North Pacific indicated that dissolved oxygen concentration in intermediate layers decreased in basin wide scale during the past decades. The causes of the decrease, however, are still unclear. During MR07-06, we measured dissolved oxygen concentration from surface to bottom layers at all the hydrocast stations along around 47°N in the western North Pacific and along 179°E in the central Pacific. These stations reoccupied the WHP-P01 (1985 and 1999) and WHP-P14N (1993) and -P14C (1992) stations. Our purpose is to evaluate temporal changes in dissolved oxygen in the Pacific Ocean between the 1990s and 2007.

(3) 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)
CSK standard of potassium iodate: Lot EWL3818, Wako Pure Chemical Industries Ltd., 0.0100N

(4) Instruments

Burette for sodium thiosulfate and potassium iodate;
    APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel
Detector;
    Automatic photometric titrator, DOT-01 manufactured by Kimoto Electronic Co. Ltd.

(5) Seawater sampling

Following procedure is based on a determination method in the WHP Operations Manual (Dickson, 1996). Seawater samples were collected from 12-liters Niskin sampler bottles attached to the CTD-system. Seawater for bottle oxygen measurement was transferred from the Niskin sampler bottle to a volume calibrated glass flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Sample temperature was measured by a thermometer during the overflowing. Then two reagent solutions (Reagent I, II) of 0.5 cm^3 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 to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

(6) Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. A magnetic stirrer bar and 1 cm^3 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 thermometer. We measured dissolved oxygen concentration using two sets of the titration apparatus, named DOT-1 and DOT-3. Dissolved oxygen concentration ($\mu mol\ kg^{-1}$) was calculated by the sample temperature during the sampling, CTD salinity, flask volume, and titrated volume of the sodium thiosulfate solution.

(7) Standardization

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^3 in a calibrated volumetric flask (0.001667M). 10 cm^3 of the standard potassium iodate solution was added to a flask using a volume-calibrated dispenser. Then 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the molarity of the sodium thiosulfate titrant. Table 3.3.1 shows result of the standardization during this cruise. Error (C.V.) of the standardization was 0.02±0.01 %, c.a. 0.05 $\mu mol\ kg^{-1}$.

(8) Determination of the blank

The oxygen in the pickling reagents I (0.5 cm^3) and II (0.5 cm^3) was assumed to be 3.8×10^{-8} mol (Murray *et al.*, 1968). The blank from the presence of redox species apart from oxygen in the reagents (the pickling reagents I, II, and the sulfuric acid solution) was determined as follows. 1 and 2 cm^3 of the standard potassium iodate solution were added to two flasks respectively. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I each were added into the two flasks in order. The blank was determined by difference between the two times of the first (1 cm^3 of KIO_3) titrated volume of the sodium thiosulfate and the second (2 cm^3 of KIO_3) one. The results of 3 times blank determinations were averaged (Table 3.3.1). On December 20, we changed the pickling reagents II solution. After that, the values of the blank increased by about 0.005 cm^3 in the sample measurements for P14C-001～-009. The averaged blank values for DOT-1 and DOT-3 before the reagent change were –0.007±0.001 (S.D., n=30) and –0.007±0.001 (S.D., n=29) cm^3, respectively.

Table 3.3.1 Results of the standardization and the blank determinations during MR07-06.

Date	KIO_3		DOT-1 (cm^3)			DOT-3 (cm^3)			Samples
(UTC)	#	ID No.	$Na_2S_2O_3$	E.P.	blank	$Na_2S_2O_3$	E.P.	blank	(Stations)
2007/10/09	1	20070619-09-02	20070613-03	3.951	-0.008	20070613-03	3.952	-0.007	P01_028,029,030,032
2007/10/12		20070619-09-03	20070613-03	3.951	-0.007	20070613-03	3.952	-0.007	P01_031,033,034,035,036,037
2007/10/14		20070619-09-04	20070613-05-01	3.954	-0.006	20070613-05-02	3.952	-0.005	P01_038,039,040,041,042,X13,043
2007/10/16		20070619-09-05	20070613-05-01	3.954	-0.006	20070613-05-02	3.954	-0.007	P01_044,045,046,047
2007/10/17		20070619-09-06	20070613-05-03	3.954	-0.006	20070613-05-04	3.951	-0.008	P01_048,049,050,051,052,053,054
2007/10/18		20070619-09-07	20070613-05-03	3.952	-0.007	20070613-05-04	3.952	-0.008	P01_055,056,057,058,059,060
2007/10/20		20070619-09-08	20070613-06-01	3.957	-0.009	20070613-06-02	3.956	-0.009	P01_061,P14N_029,028,027,026,025,024
2007/10/22	2	20070619-10-01	20070613-06-01	3.957	-0.005	20070613-06-02	3.957	-0.007	P14N_023,022,021,020,019
2007/10/23		20070619-10-02	20070613-06-03	3.957	-0.006	20070613-06-04	3.956	-0.006	P14N_018,017,016,015,014,013,012,011,010,009,008,007,006,005,004,003,002,001
2007/10/29		20070619-10-04	20070613-07-01	3.957	-0.007	20070613-07-02	3.957	-0.008	P14N_030,X01,032,033,034,035,036,037,038,039,040
2007/11/01		20070619-10-06	20070613-07-03	3.957	-0.007	20070613-07-04	3.957	-0.007	P14N_041,042,043,044,045,046,047,048,049,051,052
2007/11/04		20070619-10-08	20070613-08-01	3.955	-0.007	20070613-08-02	3.956	-0.008	P14N_053,054,055,056,057,058,059,060,061
2007/11/06	3	20070911-11-01	20070613-08-01	3.959	-0.006	20070613-08-02	3.960	-0.006	P14N_062,063,064,X02
2007/11/07		20070911-11-02	20070613-08-03	3.957	-0.004	20070613-08-04	3.957	-0.008	P14N_066,067,068,069,070,071,072,073
2007/11/11		20070911-11-03	20070613-08-03	3.959	-0.004	20070613-08-04	3.959	-0.008	P14N_074,075,076,077
2007/11/12		20070911-11-04	20070613-09-01	3.956	-0.009	20070613-09-02	3.958	-0.007	P14N_078,079,080,081,082,083,084,085,086,087,089,090
2007/11/14		20070911-11-06	20070613-09-03	3.955	-0.008	20070613-09-04	3.957	-0.008	P14N_091,092,093,094,095,096,097,098,099,100,101,102
2007/11/18		20070911-11-08	20070613-10-01	3.956	-0.010	20070613-10-02	3.958	-0.008	P14N_103,104,105,X04,107,108,109

Table 3.3.1 continued.

Date (UTC)	KIO$_3$		DOT-1 (cm^3)			DOT-3 (cm^3)			Samples (Stations)
	#	ID No.	$Na_2S_2O_3$	E.P.	blank	$Na_2S_2O_3$	E.P.	blank	
2007/11/23	4	20070911-12-02	20070613-10-03	3.960	-0.007	20070613-10-04	3.959	-0.010	P14N_109(2),110,111,112,113,114,115,116,117
2007/11/26		20070911-12-04	20070613-11-01	3.956	-0.007	20070613-11-02	3.955	-0.009	P14N_118,119,120,121,122,123,124,125,126,127,128,129
2007/11/28		20070911-12-06	20070613-11-03	3.956	-0.007	20070613-11-04	3.957	-0.006	P14N_130,131,132,133,134,135,136,137,138,139,140,141
2007/12/01		20070911-12-08	20070613-12-03	3.953	-0.006	20070613-12-01	3.956	-0.005	P14N_142,143,144
2007/12/03	5	20070911-13-02	20070613-12-03	3.954	-0.007	20070613-12-01	3.956	-0.006	P14N_145,146,147,148,149,150
2007/12/04		20070911-13-03	20070613-12-02	3.953	-0.006	20070613-12-04	3.956	-0.005	P14N_151,152,153,154,155,156,157,158,159,160,161,162,163
2007/12/08		20070911-13-06	20070613-13-01	3.949	-0.006	20070613-13-02	3.952	-0.007	P14N_164,165,166,167,168,169,170,171,172,173,174,175,176
2007/12/11		20070911-13-08	20070613-13-03	3.952	-0.004	20070613-13-04	3.952	-0.008	P14N_177,178,179,180,181,182,183,184,185
2007/12/12	6	20070911-14-01	20070613-13-03	3.944	-0.006	-	-	-	P14N_184,185
2007/12/13		20070911-14-02	20070613-13-03	3.951	-0.007	20070613-13-04	3.950	-0.008	P14C_049,048,052,051,050,047,046,045,044
2007/12/14		20070911-14-03	20070613-14-01	3.957	-0.006	20070613-14-02	3.958	-0.007	P14C_043,042,041,040,039,038,037,036
2007/12/17		20070911-14-05	20070613-14-03	3.955	-0.008	20070613-14-04	3.956	-0.009	P14C_032,031,030,029,028,027,026,025,024,023,022,021,020,019
2007/12/22	7	20070911-15-01	20070613-15-01	3.967	0.002	20070613-15-02	3.967	0.004	P14C_009,008,007
2007/12/22		20070911-15-02	20070613-15-03	3.967	0.001	20070613-15-04	3.965	-0.001	P14C_006,005,004,003,002,001

Batch number of the KIO$_3$ standard solution

(9) Replicate sample measurement

Replicate samples were taken from every CTD cast. Total amount of the replicate sample pairs of good measurement (flagged 2) was 739. The standard deviation of the replicate measurement was 0.08 μmol kg^{-1} that was calculated by a procedure (SOP23) in DOE (1994). Although there are two outlying data, relation between the difference and sampling depth was not clear (Fig. 3.3.1). The differences did not depend on measurement date (Fig. 3.3.2). In the hydrographic data sheet, a mean of replicate sample pairs will be presented with the flag 2 (see section 11).

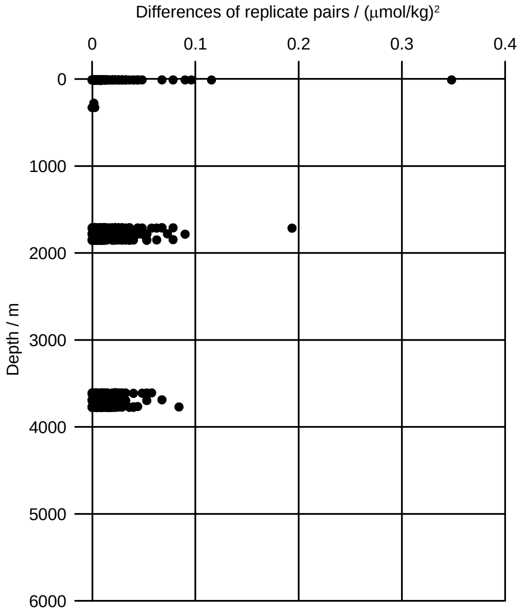


Figure 3.3.1　Differences of replicate pairs against sampling depth.

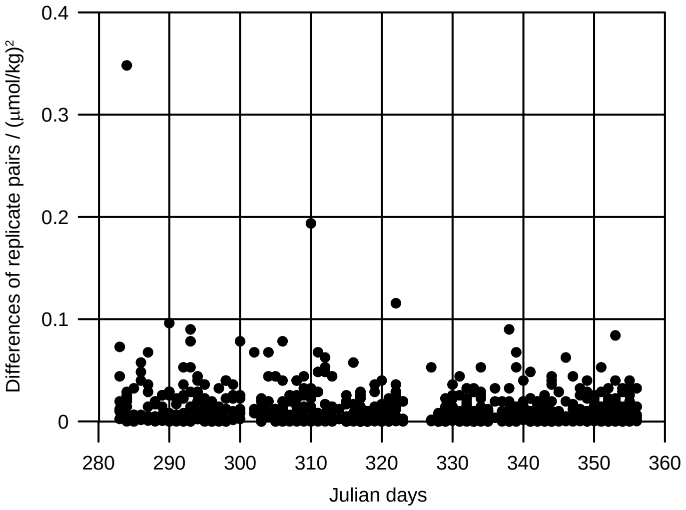


Figure 3.3.2　Differences of replicate pairs against measurement date (Julian days).

(10) CSK standard measurements

The CSK standard is a commercial potassium iodate solution (0.0100 N) for analysis of dissolved oxygen. In this cruise, we measured four bottles of the CSK standard solutions (Lot EWL3818) against our KIO_3 standards as samples (Table 3.3.2). A good agreement among them confirms that there was no systematic shift in our oxygen measurements during this cruise. These values also agree with those measured in our previous cruises, MR07-03 and MR07-04, suggesting comparability in the oxygen measurements among the three cruises.

Table 3.3.2 Results of the CSK standard (Lot EWL3818) measurements on board.

Date (UTC)	KIO$_3$ ID No.	DOT-1		DOT-3		Remarks
		Conc. (N)	error (N)	Conc. (N)	error (N)	
2007/10/07	20070619-08-05	0.010009	0.000002	-	-	MR07-06
2007/11/19	20070911-12-01	0.010003	0.000001	0.010000	0.000001	
2007/11/23	20070911-12-02	0.010000	0.000001	0.010003	0.000002	
2007/12/23	20070911-15-09	0.010006	0.000002	0.010007	0.000001	
2007/07/23	20070619-05-01	0.009999	0.000001	0.010002	0.000002	MR07-04
2007/08/29	20070619-07-04	0.010004	0.000001	0.010006	0.000003	
2007/06/10	20070424-01-08	−	−	0.010006	0.000002	MR07-03
2007/07/24	20070425-01-06	0.010006	0.000003	0.010005	0.000002	

(11) Quality control flag assignment

Quality flag values were assigned to oxygen measurements using the code defined in Table 0.2 of WHP Office Report WHPO 91-1 Rev.2 section 4.5.2 (Joyce *et al*., 1994). Measurement flags of 2 (good), 3 (questionable), 4 (bad), and 5 (missing) have been assigned (Table 3.3.3). The replicate data were averaged and flagged 2 if both of them were flagged 2. If either of them was flagged 3 or 4, a datum with "younger" flag was selected. Thus we did not use flag of 6 (replicate measurements). For the choice between 2, 3, or 4, we basically followed a flagging procedure as listed below:

a. Bottle oxygen concentration and difference between bottle oxygen and CTD oxygen at the sampling layer were plotted against CTD pressure. Any points not lying on a generally smooth trend were noted.

b. Dissolved oxygen was then plotted against sigma-theta. If a datum deviated from a group of plots, it was flagged 3.

c. Vertical sections against pressure and potential density were drawn. If a datum was anomalous on the section plots, datum flag was degraded from 2 to 3, or from 3 to 4.

d. If the bottle flag was 4 (did not trip correctly), a datum was flagged 4 (bad). In case of the bottle flag 3 (leaking) or 5 (unknown problem), a datum was flagged based on steps a, b, and c.

Table 3.3.3 Summary of assigned quality control flags.

Flag	Definition	
2	Good	8,312
3	Questionable	19
4	Bad	17
5	Not report (missing)	2
	Total	8,350

(12) Preliminary Results

i. Comparison with Winkler oxygen measurements by University of Washington on board

At station P01-035, we conducted an inter-comparison of Winkler oxygen measurements between University of Washington (UW) and JAMSTEC on board. Seawater sample for UW was collected just after the oxygen sampling for JAMSTEC. The bottle oxygen concentrations in the samples from 15 Niskin bottles were analyzed separately by UW and JAMSTEC and compared each other. We got a very good agreement between UW and JAMSTEC results (Fig. 3.3.3).

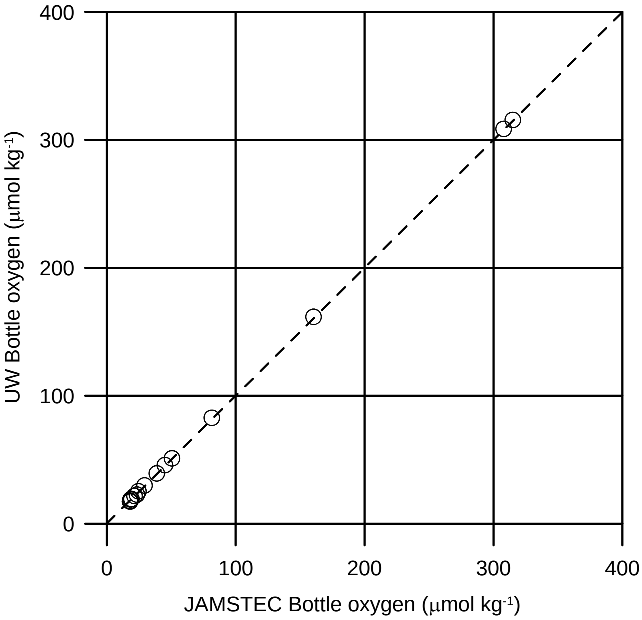


Figure 3.3.3 Comparison of bottle oxygen measurement between UW and JAMSTEC. A broken line shows a linear regression line whose correlation coefficient (r^2) and standard error are 0.99997 and 0.567, respectively.

ii. Comparison of oxygen measurements at a cross point.

During this cruise, we compared two profiles of bottle oxygen at a cross point, 47.0°N/179.5°E. The first and second casts were conducted on 20-Oct.-2007 (MR07-06_P01-061) and 30-Oct.-2007 (MR07-06_ P14N-X01), respectively. Below 1200 dbar, we got a good agreement between the first and second measurements (Fig. 3.3.4). We had also measured bottle oxygen at the cross point during our previous cruise, MR07-04 (P01-061, 14-Aug.-2007). The oxygen profile in deep waters at the cross point of MR07-04 well agreed with those of MR07-06 (Fig. 3.3.4).

iii. Decadal changes in dissolved oxygen along WHP-P01.

Figure 3.3.5 shows zonal transects of dissolved oxygen along WHP-P01 in 2007. From 152°E (P01-028) to 179°E (P01-061), we re-occupied during this cruise, MR07-06 in October. The rest of the WHP-P01 stations were revisited during our previous cruise, MR07-04 in July and August of 2007. Difference in dissolved oxygen distribution between the eastern and western North Pacific can be distinguished. The boundary between the east and west is likely to be lying around 160°W. Dissolved oxygen concentrations in bottom waters in the west are higher than those in the east. The minimum concentration around 1000 m depth in the east was lower than that in the west.

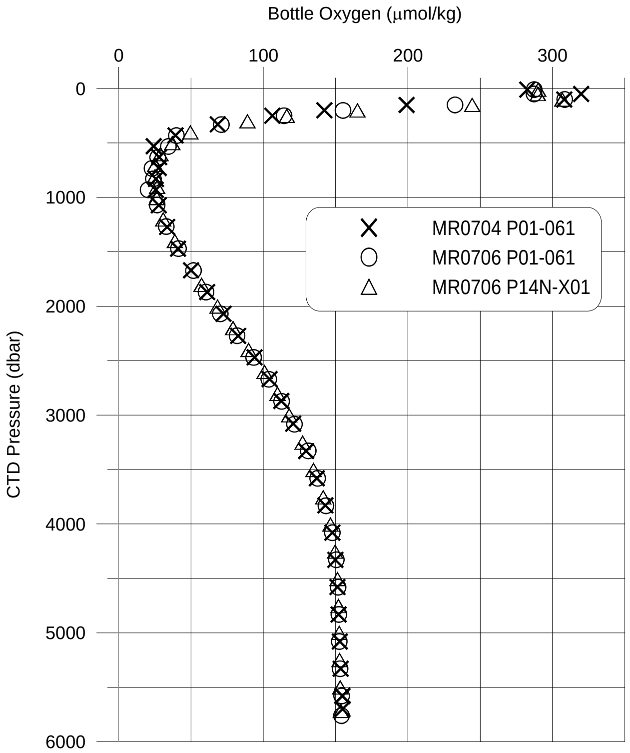


Figure 3.3.4 Vertical profiles of bottle oxygen concentration at a cross point (47.0°N/179.5°E) during MR07-06 and MR07-04 cruises.

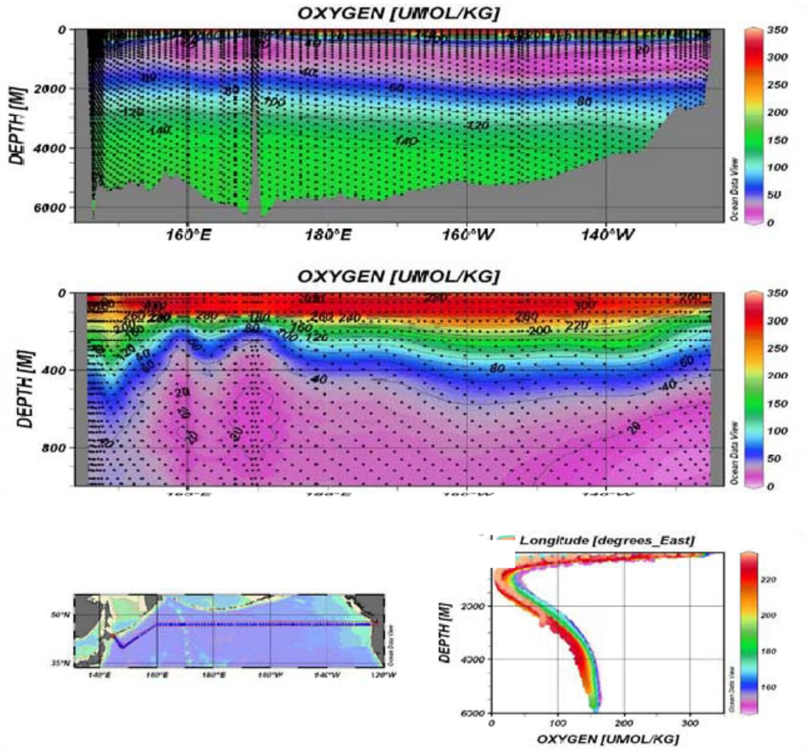
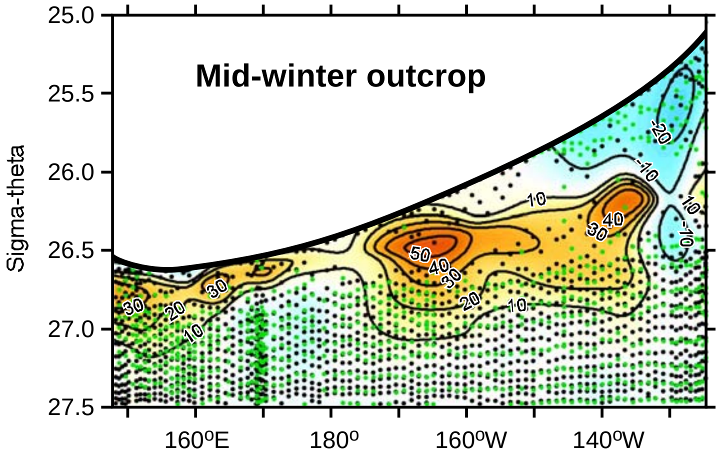


Figure 3.3.5 Zonal transects of dissolved oxygen along WHP-P01 in 2007.

We compared dissolved oxygen in deep waters below 4000 m depth in 2007 with those in 1985 and 1999 along WHP-P01. The oxygen concentration in 2007 were slightly lower than those in 1985 and 1999 by 1.9 ± 0.8 (n=641) and 1.1 ± 1.2 (n=628) μmol kg^{-1}, respectively. Despite of these small offsets in the deep layers, dissolved oxygen concentrations in the thermocline in 2007 were significantly higher than those in 1999. Distribution of differences in Apparent Oxygen Utilization (AOU) against water density between 1999 and 2007 (Fig. 3.3.6b) indicates that AOU (dissolved oxygen) decreased (increased) in waters just below seasonal mixing layer from 1999 to 2007. The maximum AOU decrease (about −50 μmol kg^{-1}) was found in 26.6 σ_θ layer between 180° and 140°W approximately. This AOU change between 1999 and 2007 is completely opposite to that between 1985 and 1999 (Fig. 3.3.6a).

(a) ΔAOU / μmol kg^{-1} WHP-P01 (47^{o}N) 1999 - 1985



(b) ΔAOU / μmol kg^{-1} WHP-P01 (47^{o}N) 2007 - 1999

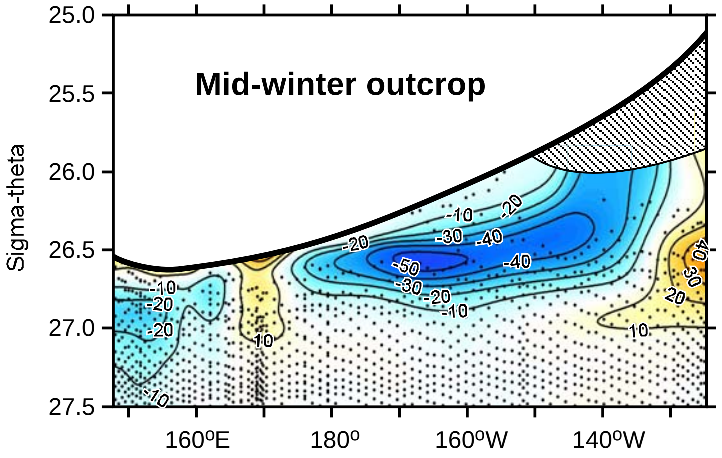


Figure 3.3.6 Distributions of differences of Apparent Oxygen Utilization, AOU (μmol kg^{-1}) against density (σ_θ) between 1985 and 1999 (a) and between 1999 and 2007 (b). Contour intervals are 10 μmol kg^{-1}. Small dots indicate sampling layers for bottle oxygen. Sparse data hinder the comparison between 1999 and 2007 in shallow layers in the area to the east of 150°W (shaded area).

iv. Decadal changes in dissolved oxygen along WHP-P14N/C.

Figure 3.3.7 shows meridional transects of dissolved oxygen along WHP-P14N/C in 2007. WHP-P14N and P14C lines are lying from the Bering Sea to the Fiji Island and from the Fiji Islands to New Zealand (the South Fuji Basin), respectively. The transect of WHP-P14N is characterized by an oxygen minimum in mid-layers from the Bering Sea to the equator. In the Central Pacific Basin from 20^{o}N to 10^{o}S, dissolved oxygen concentration in bottom water (Circumpolar Deep Water) is slightly high. In the South Fiji Basin, dissolved oxygen maximum is found in mid-layers and oxygen concentration below 2000 m depth is uniform.

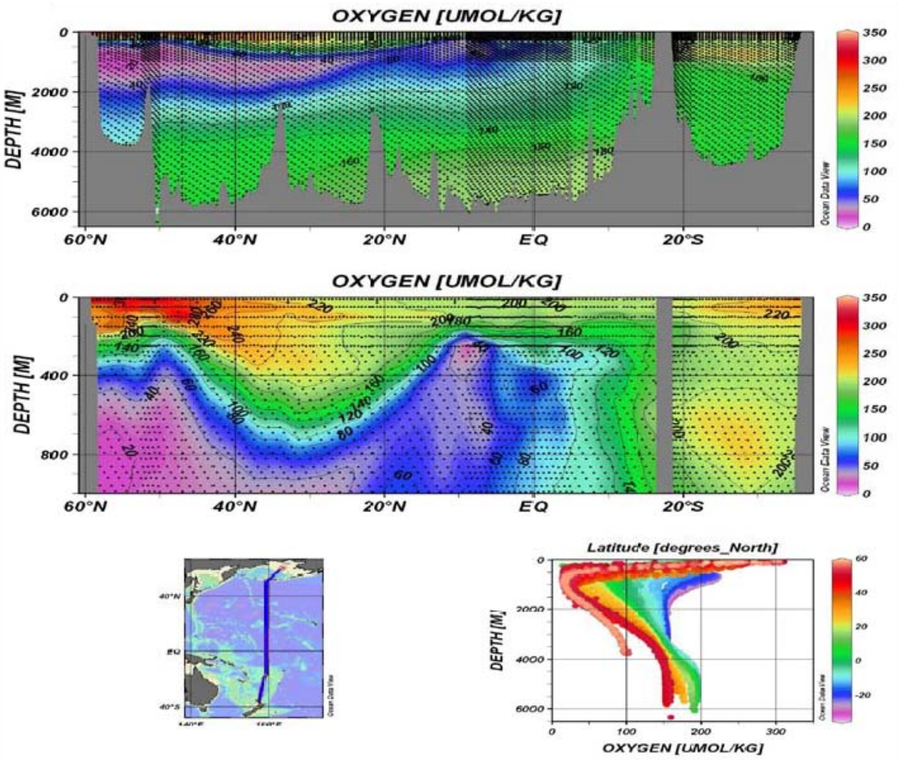


Figure 3.3.7 Meridional transects of dissolved oxygen along WHP-P14N/C in 2007.

We compared dissolved oxygen in deep waters below 4000 m depth in 2007 with those in 1992/93 along WHP-P14N/C. The oxygen data in 2007 were slightly lower than those in 1992/93 by 1.3 ± 2.0 (n=1106). Except in the Bering Sea there was not large change in dissolved oxygen or AOU. Figure 3.3.8 shows distribution of differences in AOU against water density between 1992/93 and 2007. The maximum AOU increase (about 40 µmol kg^{-1}) was found in 26.6 σ_{θ} layer in the Bering Sea. Small temporal changes in the tropical region between 20^{o}N and 20^{o}S may be caused by transition of mesoscale eddies. Smaller decrease (about −10 µmol kg^{-1}) in the mid layer at 47^{o}N/179^{o}E between 1993 and 2007 than that (～−30 µmol kg^{-1}) between 1999 and 2007 (see Fig. 3.3.6b) indicates that AOU (dissolved oxygen) was highest (lowest) in 1999 at the cross point in the subarctic North Pacific.

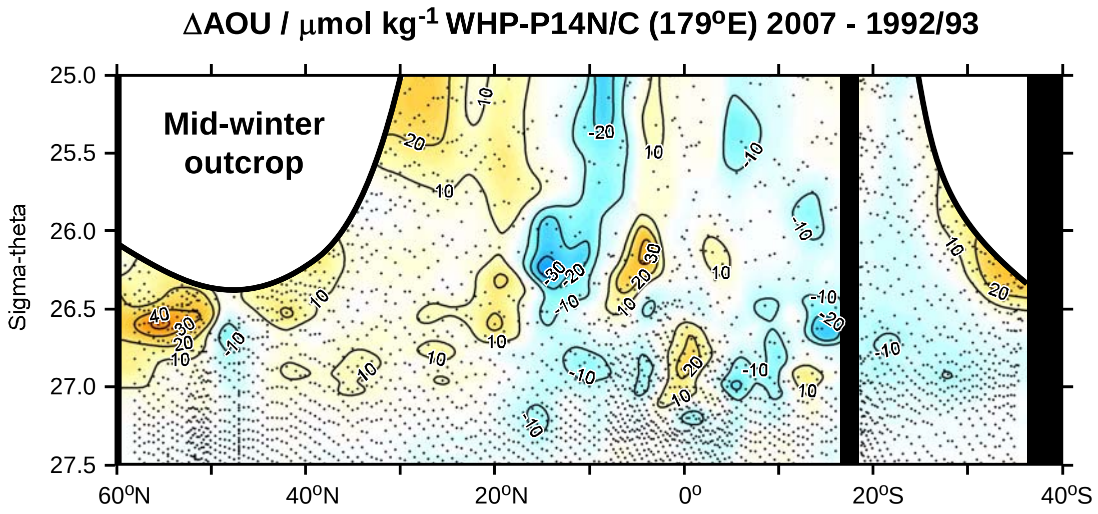


Figure 3.3.8 Distributions of differences of AOU (μmol kg^{-1}) against density (σ_θ) between 1992/93 and 2007. Contour intervals are 10 μmol kg^{-1}. Small dots indicate sampling layers of dissolved oxygen in 2007.

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3.4 Nutrients

December 27, 2007

(1) Personnel

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(2) Objectives

The objectives of nutrients analyses during the R/V Mirai MR0706 cruise, WOCE P1 and P14 revisited cruise in 2007, in the North Pacific are as follows;

Describe the present status of nutrients concentration with excellent comparability.

The determinants are nitrate, nitrite, phosphate and silicate. (Although silicic acid is correct, we use silicate because a term of silicate is widely used in oceanographic community.)

Study the temporal and spatial variation of nutrients concentration based on the previous high quality experiments data of WOCE previous P1 cruises in 1985 and 1999, GOESECS, IGY and so on.

Study of temporal and spatial variation of nitrate: phosphate ratio, so called Redfield ratio.

Obtain more accurate estimation of total amount of nitrate, phosphate and silicate in the interested area.

Provide more accurate nutrients data for physical oceanographers to use as tracers of water mass movement.

(3) Equipment and techniques

i. 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.

The 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 analytical methods of the nutrients during this cruise are similar with previous cruises (Uchida and Fukasawa, 2005).

The flow diagrams and reagents for each parameter are shown in Figures 3.4.1-3.4.4.

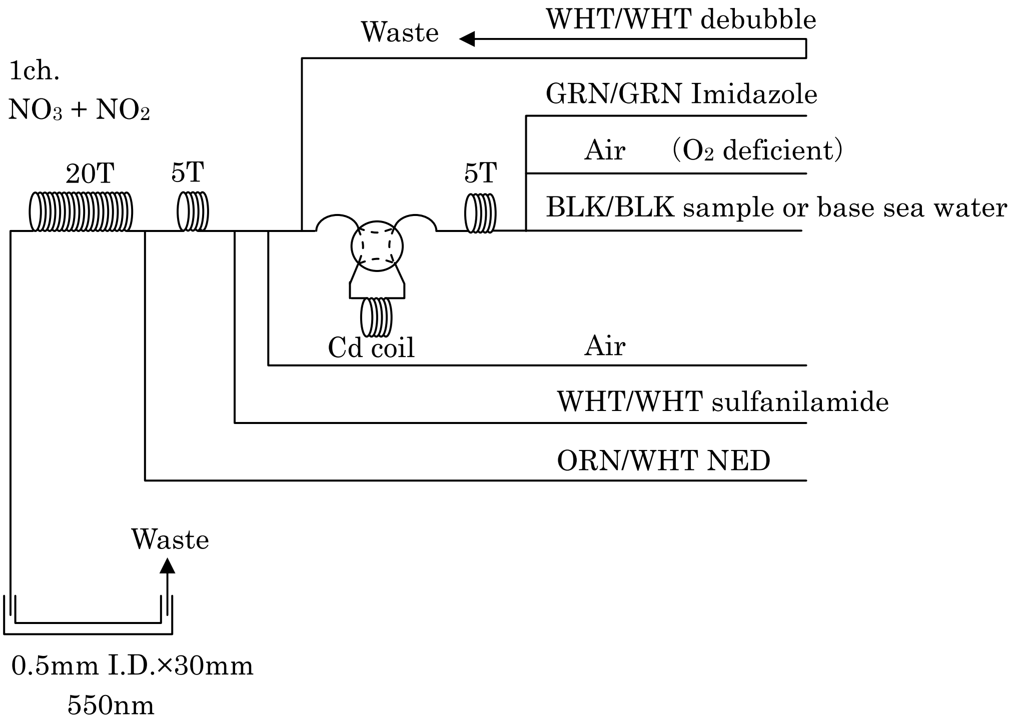

Figure3.4.1: 1ch. (NO_3+NO_2) Flow diagram.

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ii. Nitrate Reagents

Imidazole (buffer), 0.06M (0.4% w/v)

Dissolve 4g imidazole, $C_3H_4N_2$, in ca. 900ml DIW; add 2ml concentrated HCl; make up to 1000ml with DIW. After mixing, 1ml Triton(R)X-100 (50% solution in ethanol) is added.

Sulfanilamide, 0.06M (1% w/v) in 1.2M HCl

Dissolve 10g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 1000ml of 1.2M (10%) HCl. After mixing, 2ml Triton$^{®}$X-100 (50% solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1% w/v)

Dissolve 1 g NEDA, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000ml of DIW; containing 10ml concentrated HCl. Stored in a dark bottle.

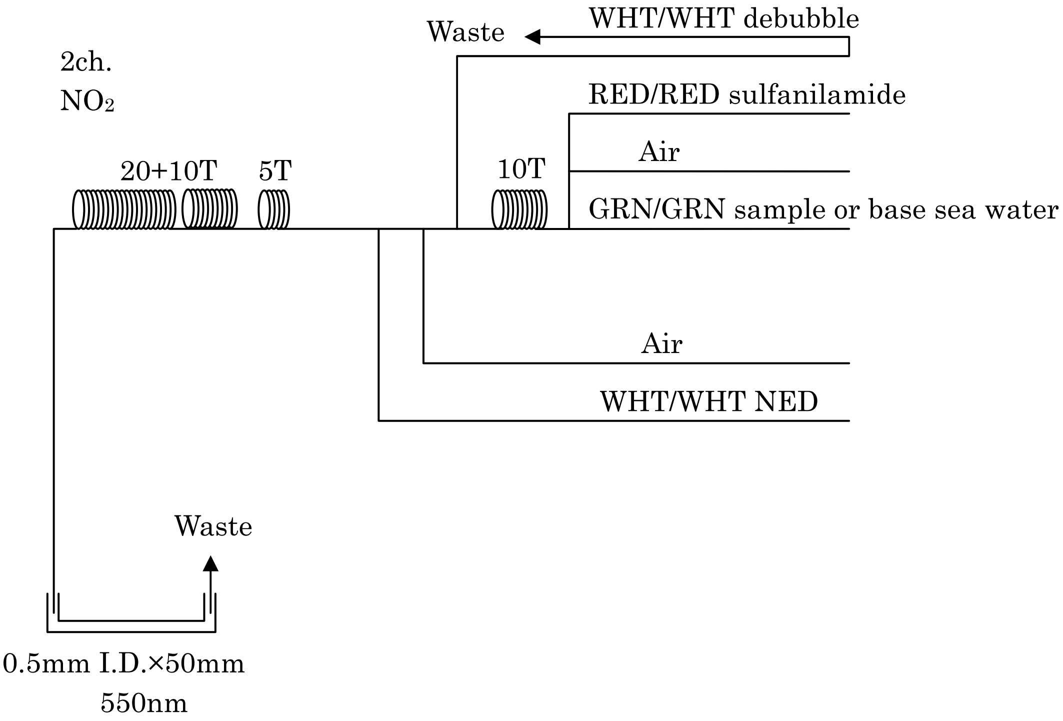

Figure 3.4.2: 2ch. (NO_2) Flow diagram.

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iii. Nitrite Reagents

Sulfanilamide, 0.06M (1% w/v) in 1.2M HCl

Dissolve 10g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 1000ml of 1.2M (10%) HCl. After mixing, 2ml Triton$^{®}$X-100 (50% solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride , 0.004 M (0.1% w/v)

Dissolve 1 g NEDA, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000ml of DIW; containing 10ml concentrated HCl. Stored in a dark bottle.

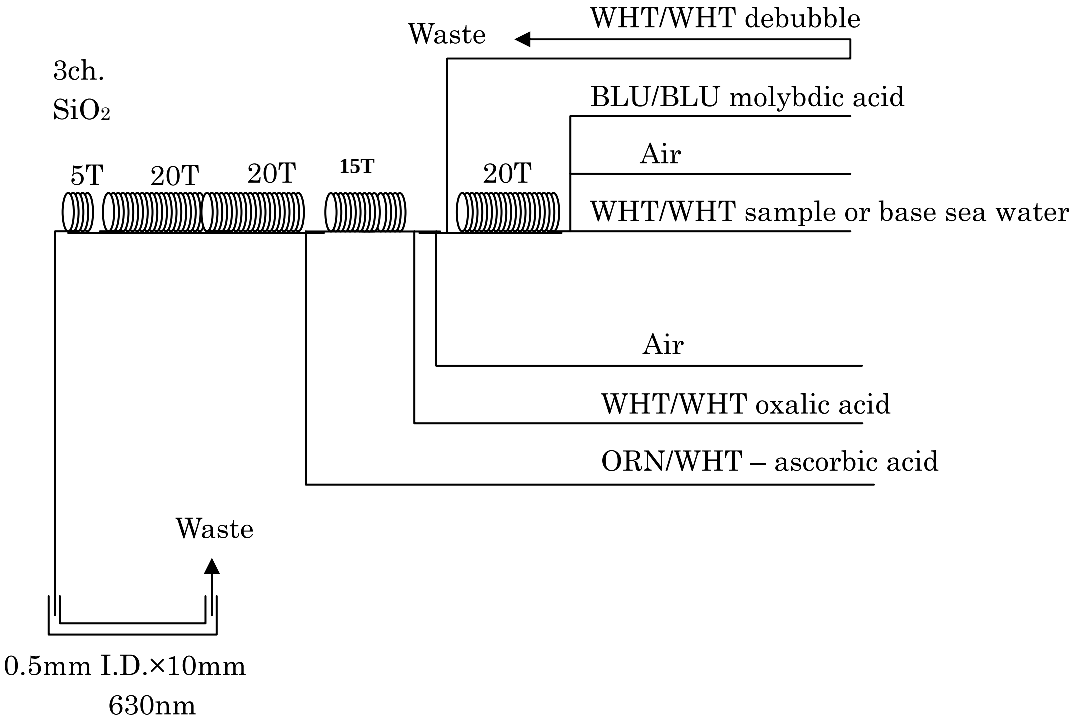

Figure 3.4.3: 3ch. (SiO_2) Flow diagram.

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iv. Silicic Acid Reagents

Molybdic acid, 0.06M (2% w/v)

Dissolve 15g Disodium Molybdate(VI) Dihydrate, $Na_2MoO_4 \cdot 2H_2O$, in 1000ml DIW containing 8ml H_2SO_4. After mixing, 20ml sodium dodecyl sulphate (15% solution in water) is added.

Oxalic acid, 0.6M (5% w/v)

Dissolve 50g Oxalic Acid Anhydrous, HOOC: COOH, in 950ml of DIW.

Ascorbic acid, 0.01M (3% w/v)

Dissolve 2.5g L (+)-Ascorbic Acid, $C_6H_8O_6$, in 100ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

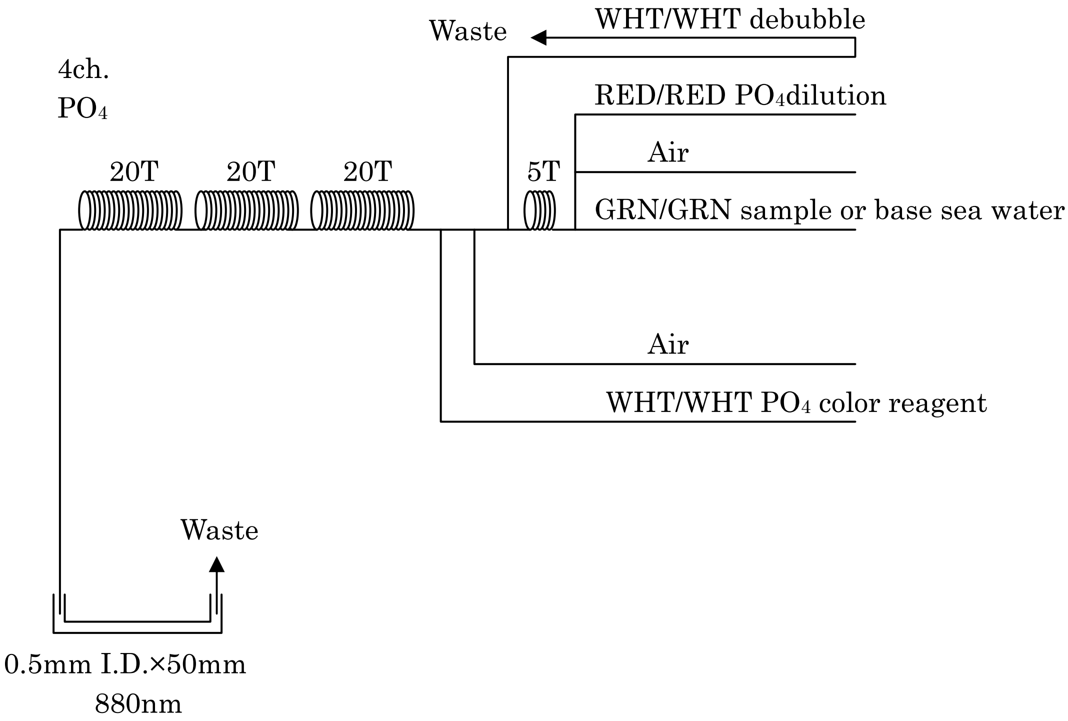

Figure 3.4.4: 4ch. (PO_4) Flow diagram.

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v. Phosphate Reagents

Stock molybdate solution, 0.03M (0.8% w/v)

Dissolve 8g Disodium Molybdate(VI) Dihydrate, $Na_2MoO_4 \cdot 2H_2O$, and 0.17g Antimony Potassium Tartrate, $C_8H_4K_2O_{12}Sb_2 \cdot 3H_2O$, in 1000ml of DIW containing 50ml concentrated H_2SO_4.

Mixed Reagent

Dissolve 0.8g L (+)-Ascorbic Acid, $C_6H_8O_6$, in 100ml of stock molybdate solution. After mixing, 2ml sodium dodecyl sulphate (15% solution in water) is added. Stored in a dark bottle and freshly prepared before every measurement.

PO4 dilution

Dissolve Sodium Hydrate, NaCl, 10g in ca. 900ml, add 50ml Acetone and 4ml concentrated H_2SO_4, make up to 1000ml. After mixing, 5ml sodium dodecyl sulphate (15% solution in water) is added.

vi. 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 25 +-1deg. C 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 after collection basically within 14 hours.

vii. 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, and then change the positions of peak values taken if necessary.

Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.

Baseline correction and sensitivity correction were done basically using liner regression.

Load pressure and salinity from CTD data to calculate density of seawater.

Calibration curves to get nutrients concentration were assumed second order equations.

(4) Nutrients standards

i. Volumetric Laboratory Ware of in-house standards

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

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 3-4 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 3-4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

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.

ii. Reagents, general considerations

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 JIS K8019 and assays of nitrite salts were 99.1%. We use that value to adjust the weights taken.

For the silicate standards solution, we use Merck HC623465 solution. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.5%. For nitrate and phosphate, we use Merck 99.999% powders.

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.

Low-Nutrient Seawater (LNSW).

Surface water having low nutrient concentration was taken and filtered using 0.45 μm 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 2007.

iii. 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 is prepared according recipes as shown in Table 3.4.2. All volumetric laboratory tools were calibrated prior the cruise as stated in chapter (i). 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	C-6	C-7
NO_3(μM)	45000	900	0	BA	AY	AX	AV	BF	55	BG
NO_2(μM)	4000	20	0	BA	AY	AX	AV	BF	1.2	BG
SiO_2(μM)	36000	2880	0	BA	AY	AX	AV	BF	170	BG
PO_4(μM)	3000	60	0	BA	AY	AX	AV	BF	3.6	BG

Table 3.4.2: Working calibration standard recipes

C-STD	B-1 STD	B-2 STD
C-6	30 ml	30 ml

B-1 STD: Mixture of nitrate, silicate and phosphate
B-2 STD: Nitrite

iv. Renewal of in-house standard solutions.

In-house standard solutions as stated in (iii) were renewed as shown in Table 3.4.3.

(5) Reference material of nutrients in seawater

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., submitted ;Aoyama et al.,2007). 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 μmol kg^{-1} for 345 crossovers at world oceans, though the maximum was 1.7 μmol kg^{-1} (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_3, NO_2, SiO_2, PO_4	Renewal
A-1 Std. (NO_3)	maximum 1 month
A-2 Std. (NO_2)	maximum 1 month
A-3 Std. (SiO_2)	commercial prepared solution
A-4 Std. (PO_4)	maximum 1 month
B-1 Std. (mixture of NO_3, SiO_2, PO_4)	8 days
B-2 Std. (NO_2)	8 days

C Std	Renewal
C-6 Std (mixture of B1 and B2 Std.)	24 hours

Reduction estimation	Renewal
D-1 Std. (7200µM NO_3)	when A-1renewed
43µM NO_3	when C-std renewed
47µM NO_2	when C-std renewed

i. RMNSs for this cruise

RMNS lots BA, AY, AX, AV and BF, which covers full range of nutrients concentrations in the western North Pacific Ocean are prepared. 40 sets of BA,AY,AX,AV and BF are prepared.

Since silicate concentration along P1 section was expected to be very high, we also prepared RMNS lot BG, of which silicate concentration is 255 µmol kg^{-1}. When silicate concentration expected to exceed 170 µmol kg^{-1}, we add RMNS lot BG as an additional standard as C7. These RMNSs were renewed daily and analyzed every 2 runs on the same day.

150 bottles of RMNS lot BC are prepared to use every analysis at every hydrographic station. These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 24-26 deg. C.

ii. Assigned concentration for RMNSs

We assigned nutrients concentrations for RMNS lots BA, AY, AX, AV, BF, BC and BG as shown in table 3.4.4.

iii. The homogeneity of RMNSs

The homogeneity of lot BC and analytical precisions are shown in table 3.4.5. These are for the assessment of the magnitude of homogeneity of the RMNS bottles those are used during the cruise. As shown in table3.4.5 and table 3.4.6 the homogeneity of RMNS lot BC for nitrate and silicate are the same magnitude of analytical precision derived from fresh raw seawater in May2005. The homogeneity for phosphate, however, exceeded the analytical precision at some extent. In May 2007, analytical precisions become better less than 0.1% and the homogeneity at lot BF and BG for nitrate, phosphate and silicate were 0.11-0.14%, 0.17-0.21%, 0.08-0.10%, respectively.

Table 3.4.4 Assigned concentration of RMNSs

unit: micro mol kg-1

	Phosphate	Nitrate	Silicate	Nitrite
AH	2.114	35.31	132.20	
BA	0.068	0.07	1.60	0.02
AY	0.516	5.60	29.42	0.62
AX	1.619	21.42	58.06	0.35
AV	2.516	33.36	154.14	0.10
BF	2.797	41.28	150.23	0.01
BC	2.782	40.71	156.13	0.02
BG	2.562	36.72	254.70	0.06

Table 3.4.5: Homogeneity of lot BC and previous lots derived from simultaneous 30 samples measurements and analytical precision onboard R/V Mirai in May 2005.

	Nitrate CV%	Phosphate CV%	Silicate CV%
BC	0.22	0.32	0.19
(AH)	(0.39%)	(0.83%)	(0.13)
(K)	(0.3%)	(1.0%)	(0.2%)
Precision	0.22%	0.22%	0.12%

Note: N=30 x 2

Table 3.4.6 Homogeneity of lot BF and BG derived from simultaneous 7 samples measurements and analytical precision onboard R/V Mirai in May 2007.

	Nitrate CV%	Phosphate CV%	Silicate CV%
BF	0.11	0.21	0.10
BG	0.14	0.17	0.08
Precision	0.05	0.07	0.06

Note: N=7 x 4

iv. Comparability of RMNSs during the periods from 2003 to 2007

Cruise-to-cruise comparability has examined based on the results of the previous results of RMNSs measurements obtained among cruises, and RMNS international comparison experiments in 2003 and 2007. As shown in Table 3.4.7, the nutrients concentration of RMNSs were in good agreement among the measurements during the period from 2003 to 2007. For the silicate measurements, we show lot numbers and chemical company names of each cruise/measurement in the footnote. As shown in table 3.4.7, there is less comparability among the measurements due to less comparability among the standard solutions provided by chemical companies in the silicate measurements.

Table 3.4.7 Comparability for phosphate, nitrate and silicate

Cruise/Lab	year	RM Lots							
		AH	BA	AY	AX	AV	BF	BC	BG
					Nitrate				
MR03-K01	2003	35.27							
MR03-ENG	2003	35.23							
MR03-K02	2003	35.28							
MR03-K04 Leg1	2003	35.25							
MR03-K04 Leg2	2003	35.37							
MR03-K04 Leg4	2003	35.37							
MR03-K04 Leg5	2003	35.34							
MR03-K04 Leg6	2003	35.31							
2003intercomparison	2003	35.23			21.39				
MR05-01	2005	35.53	0.10		21.50	33.40			
MR05-ENG	2005							40.80	
MR05-02	2005		0.10	5.60	21.40	33.30		40.70	
MR05-05_1 precruise	2005	35.70	0.10	5.60	21.40	33.40		40.70	
MR05-05_1	2005		0.07	5.61	21.43	33.36		40.62	
MR05-05_2 precruise	2005		0.08	5.58	21.39	33.36		40.72	
MR05-05_2	2005		0.07	5.62	21.44	33.36		40.73	
MR05-05_3 precruise	2005		0.06	5.62	21.49	33.39		40.79	
MR05-05_3	2005		0.07	5.62	21.45	33.37		40.74	
MR06-02	2006			5.62		33.36			
MR06-03 precruise	2006			5.59		33.42			
MR06-03_2precruise	2006			5.62		33.24			
MR06-04_1precruise	2006			5.60		33.33			
MR06-04_2	2006			5.63		33.12			
MR06-05_1	2006		0.04	5.58	21.40	33.32		40.63	
2006intercompariosn	2006		0.04	5.58	21.40	33.32		40.63	
2003intercomp_revisit	2006	35.40							
MR07-02	2007		0.04	5.62	21.44	33.40	41.36		36.85
MR0704_precruise_1	2007	35.75	0.08	5.66	21.57	33.49	41.50	40.85	36.91
MR0704_precruise_2	2007	35.85	0.08	5.66	21.63	33.54	41.61	40.98	37.02
					Phosphate				
MR03-K01	2003	2.100							
MR03-ENG	2003	2.117							
MR03-K02	2003	2.104							
MR03-K04 Leg1	2003	2.110							
MR03-K04 Leg2	2003	2.110							
MR03-K04 Leg4	2003	2.110							
MR03-K04 Leg5	2003	2.110							
MR03-K04 Leg6	2003	2.100							
2003intercomp	2003	2.100							
MR05-01	2005	2.126	0.070		1.620	2.520			
MR05-02	2005		0.070	0.520	1.620	2.520		2.770	
MR05-05_1 precruise	2005	2.140	0.050	0.510	1.620	2.520		2.780	
MR05-05_1	2005		0.062	0.515	1.614	2.515		2.774	
MR05-05_2 precruise	2005		0.066	0.519	1.608	2.510		2.784	
MR05-05_2	2005		0.064	0.517	1.614	2.516		2.781	

MR05-05_3 precruise	**2005**		**0.060**	**0.519**	**1.620**	**2.517**		**2.788**	
MR05-05_3	**2005**		**0.061**	**0.515**	**1.615**	**2.515**		**2.778**	
MR06-02	**2006**			**0.516**		**2.515**			
MR06-03 precruise	**2006**			**0.496**		**2.499**			
MR06-03_2 precruise	**2006**			**0.504**		**2.515**			
MR06-04_1precruise	**2006**			**0.502**		**2.501**			
MR06-04_2	**2006**			**0.510**		**2.507**			
MR06-05_1	**2006**		**0.071**	**0.527**	**1.623**			**2.791**	
2006intercomparison	**2006**		**0.071**	**0.524**	**1.623**	**2.515**		**2.791**	
2003intercomp_revisit	**2006**	**2.141**							
MR07-01	**2007**			**0.524**		**2.521**			
MR07-02	**2007**		**0.080**	**0.593**	**1.646**	**2.553**	**2.832**		**2.599**
MR0704_pre_test1	**2007**	**2.143**	**0.062**	**0.518**	**1.622**	**2.515**	**2.815**	**2.786**	**2.574**
MR0704_pre_test2	**2007**	**2.148**	**0.057**	**0.515**	**1.622**	**2.520**	**2.815**	**2.792**	**2.582**
					Silicate				
MR03-K01*	**2003**	**133.9**							
MR03-ENG**	**2003**	**134.1**							
MR03-K02**	**2003**	**133.9**							
MR03-K04 Leg1**	**2003**	**133.8**							
MR03-K04 Leg2**	**2003**	**134.0**							
MR03-K04 Leg4**	**2003**	**134.0**							
MR03-K04 Leg5**	**2003**	**133.9**							
MR03-K04 Leg6**	**2003**	**133.8**							
2003intercomparison**	**2003**	**133.97**							
MR05-01#	**2005**	**135.5**	**1.6**		**59.4**	**157.7**			
MR05-02#	**2005**		**1.6**	**30.1**	**59.5**	**157.9**		**159.9**	
MR05-05_1precruise##	**2005**	**135.9**	**1.6**	**30.1**	**59.5**	**157.9**		**160.1**	
MR05-05_1##	**2005**		**1.6**	**30.1**	**59.5**	**158.0**		**160.0**	
MR05-05_2 precruise##	**2005**		**1.6**	**30.1**	**59.5**	**158.0**		**160.2**	
MR05-05_2##	**2005**		**1.6**	**30.1**	**59.5**	**158.0**		**160.1**	
MR05-05_3 precruise##	**2005**		**1.6**	**30.1**	**59.5**	**158.0**		**160.1**	
MR05-05_3##	**2005**		**1.6**	**30.1**	**59.5**	**157.9**		**160.1**	
MR06-02##	**2006**			**30.1**		**157.9**			
MR06-03 precruise†	**2006**			**29.4**		**154.5**			
MR06-03_2precruise†	**2006**			**29.6**		**154.5**			
MR06-04_1precruise†	**2006**			**29.5**		**154.3**			
MR06-04_1†	**2006**								
MR06-04_2†	**2006**			**30.2**		**154.0**			
MR06-05_1***	**2006**		**1.61**	**29.5**	**58.20**	**154.16**		**156.31**	
2006intercomparison†	**2006**		**1.64**	**29.5**	**58.18**	**154.33**			
2003intercomp_revisit†	**2006**	**132.55**							
MR07-01†	**2007**			**29.4**		**154.53**			
MR07-02†	**2007**		**1.65**	**29.6**	**58.37**	**154.55**	**150.57**		**254.95**
MR0704_precruise_1$	**2007**	**133.41**	**1.63**	**29.52**	**58.36**	**154.92**	**151.11**	**157.08**	**256.15**
MR0704_precruise_2$	**2007**	**133.39**	**1.70**	**29.60**	**58.44**	**155.18**	**151.33**	**157.19**	**256.61**

List of lot numbers: *: Kanto 306F9235; **: Kanto 402F9041; #: Kanto 502F9205; ##: Kanto 609F9157; †Merck OC551722; ***: Merck HC694149, $: Merck HC623465

(6) Quality control

i. Precision of nutrients analyses during the cruise

Precision of nutrients analyses during the cruise was evaluated based on the 11 measurements, which are measured every 12 samples, during a run at the concentration of C-6. We also evaluated the reproducibility based on the replicate analyses of five samples in each run. Summary of precisions are shown in Table 3.4.8. As shown in Table 3.4.8 and Figures 3.4.5-3.4.7, the precisions for each parameter are generally good considering the analytical precisions estimated from the simultaneous analyses of 12 samples in May 2007. Analytical precisions previously evaluated were 0.07% for phosphate, 0.05% for nitrate and 0.06% for silicate, respectively. During this cruise, analytical precisions were 0.10% for phosphate, 0.06% for nitrate and 0.07% for silicate in terms of median of precision, respectively. Then we can conclude that the analytical precisions for phosphate, nitrate and silicate were maintained throughout this cruise. The time series of precision are shown in Figures 3.4.5-3.4.7.

Table 3.4.8: Summary of precision based on the replicate analyses of 11 samples in each run through out cruise.

	Nitrate CV%	Phosphate CV%	Silicate CV%
Median	**0.07**	**0.09**	**0.07**
Mean	**0.07**	**0.10**	**0.07**
Maximum	**0.15**	**0.20**	**0.16**
Minimum	**0.02**	**0.03**	**0.02**
N	**280**	**280**	**280**

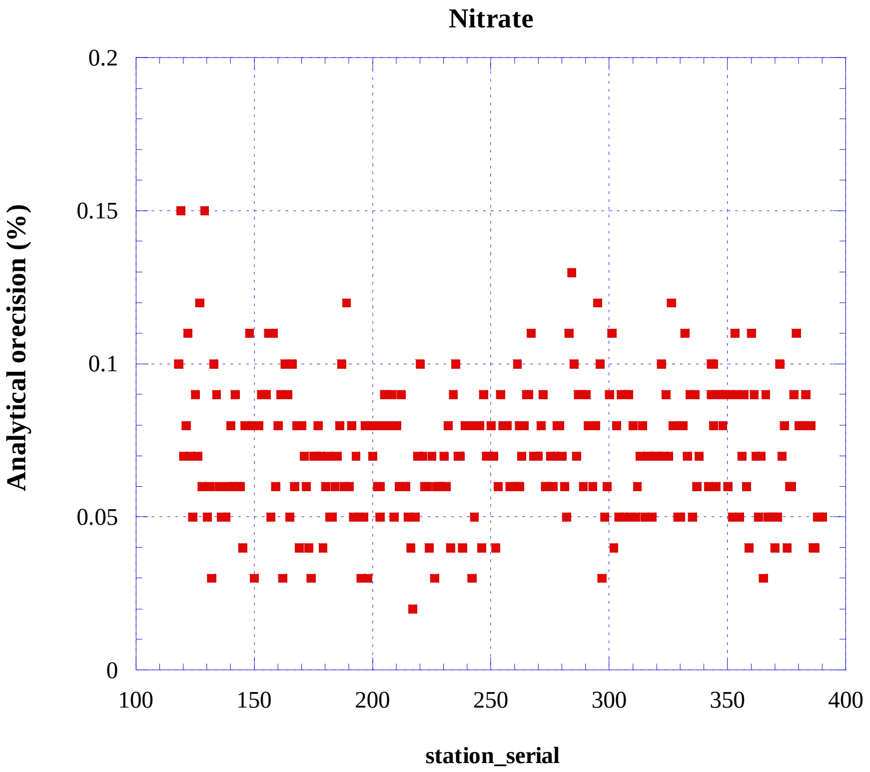

Figure: 3.4.5 Time series of precision of nitrate

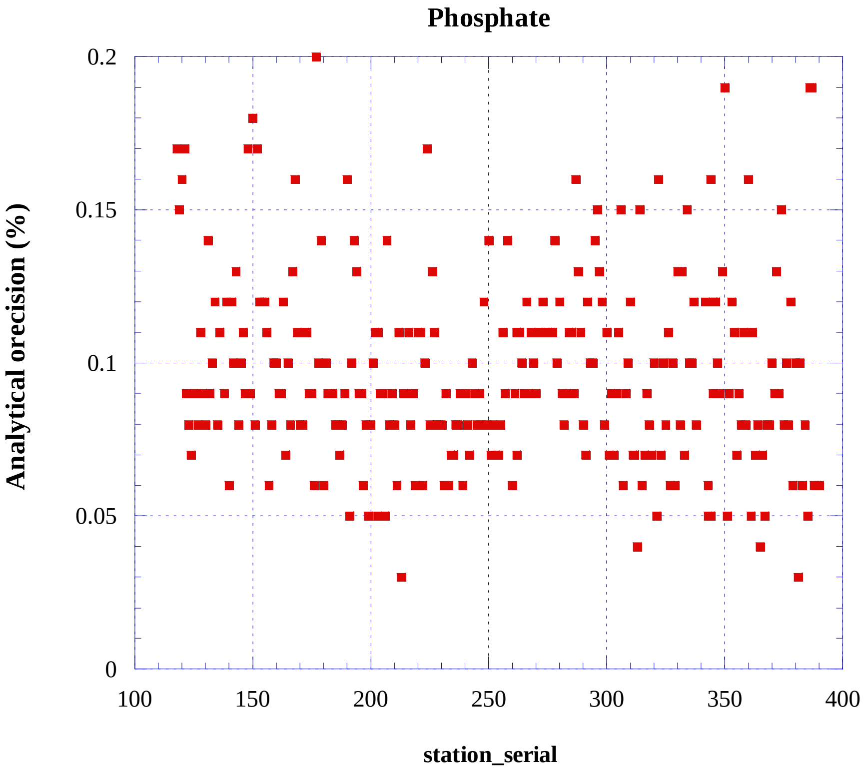

Figure: 3.4.6 Time series of precision of phosphate

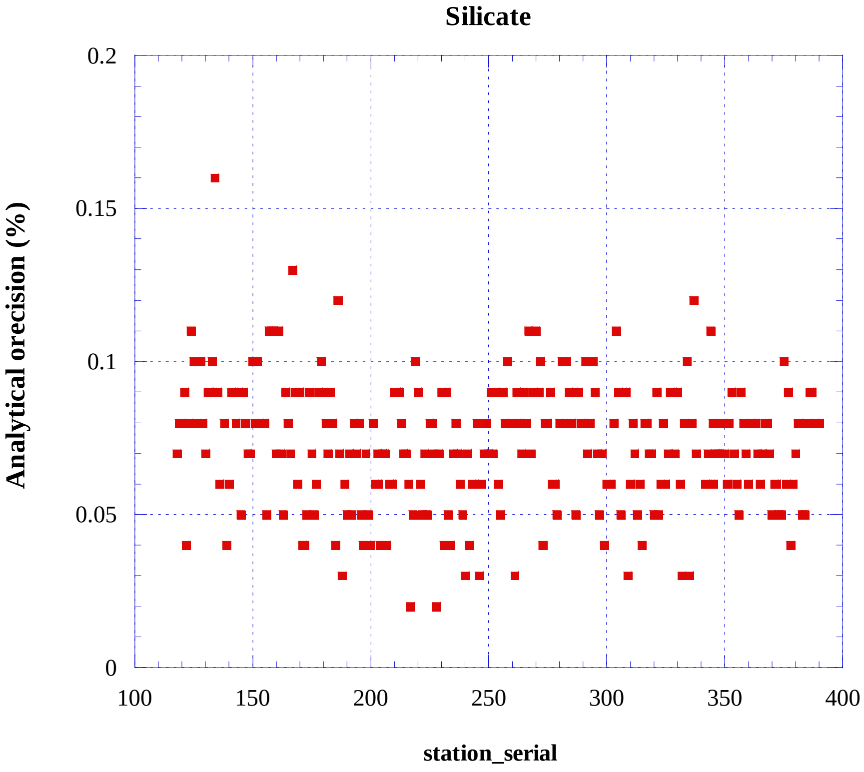

Figure: 3.4.7 Time series of precision of silicate

ii. Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are small enough within acceptable levels as shown in Table 3.4.9.

Table 3.4.9: Summary of carry over through out cruise.

	Nitrate CV%	Phosphate CV%	Silicate CV%
Median	**0.14**	**0.12**	**0.14**
Mean	**0.14**	**0.13**	**0.14**
Maximum	**0.33**	**0.29**	**0.40**
Minimum	**0.00**	**0.01**	**0.00**
N	**280**	**280**	**280**

(7) Problems/improvements occurred and solutions.

No problem occurred during this cruise.

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3.5 Chlorofluorocarbons

December 27, 2007

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(2) Objectives

Chlorofluorocarbons (CFCs) are chemically and biologically stable gases that have been artificially synthesized at 1930's or later. The atmospheric CFCs can slightly dissolve in sea surface water by air-sea gas exchange and then are spread into the ocean interior. Three chemical species of CFCs, namely CFC-11 (CCl3F), CFC-12 (CCl2F2), CFC-113 (C2Cl3F3), and CFCs like compound, carbon tetrachloride (CCl4) can be used as transient tracers for the decadal time scale ocean circulation. We measured these compounds in seawater on board.

(3) Instrument and Method

i. Instruments

Dissolved CFCs and CCl_4 are measured by an electron capture detector (ECD) – gas chromatograph attached with a purging & trapping system.

Table 3-5-1 Instruments for CFCs and CCl_4 analysis.

Gas Chromatograph:	GC-14B (Shimadzu Ltd.)
Detector:	ECD-14 (Shimadzu Ltd)
Analytical Columns:	
[For CFCs]:	
Pre-column:	Silica Plot capillary column [i.d.: 0.53mm, length: 8 m, thick: 0.25µm]
Main column:	Connected two capillary columns (Pola Bond-Q [i.d.: 0.53mm, length: 9 m, film thickness: 6.0µm] followed by Silica Plot [i. d.: 0.53mm, length: 15 m, film thickness: 0.25µm])
[For CCl_4]:	
Pre-column:	DB-624 capillary column [i.d.: 0.53mm, length: 30 m, film thickness: 3µm]
Main column:	DB-624 capillary column [i.d.: 0.53mm, length: 75 m, film thickness: 3µm]
Purging & trapping:	Developed in JAMSTEC. Cold trap columns are 1/16" SUS tubing packed Porpak N columns.

ii. Sample Collection

Seawater sub-samples for CFCs and CCl4 measurements were collected from 12 litter Niskin bottles to 300ml and 150 ml glass bottles (developed in JAMSTEC), respectively. The bottles were filled by nitrogen gas before sampling. Two times of the bottle volumes of seawater sample were overflowed. The seawater samples were kept in water bathes roughly controlled at in-situ sample temperature. The CFCs and CCl4 concentrations were determined as soon as possible after sampling.

In order to confirm CFC concentrations of standard gases and their stabilities and also to check CFC saturation levels in sea surface water with respect to overlying air, CFC mixing ratios in the background air were periodically analyzed. Air samples were continuously led into the Environmental Research Laboratory using 10 mm OD Dekaron® tubing. The end of the tubing was put on a head of the compass deck and another end was connected onto a macro air pump in the laboratory. The tubing was relayed by a T-type union which had a small stop cock. Air sample was collected from the flowing air into a 100ml glass cylinder attached on the cock.

iii. Analysis

The analytical system is modified from the original design of Bullister and Weiss (1988). Constant volume of sample water (50ml for CFCs and 30 ml for CCl4) is taken into the purging & trapping system. Dissolved CFCs and CCl4 are de-gassed from sample water by N2 gas purge and concentrated in a trap column cooled to -40 degree centigrade. The CFCs and CCl4 are desorbed by electrically heating the trap column, and lead into the pre-column. CFCs and CCl4 are roughly separated from other compounds in the pre-column and are sent to main analytical column. And then the pre-column is switched to another line and flushed buck by counter flow of pure nitrogen gas. CFCs and CCl4 sent into main column are separated further and detected by an electron capture detector (ECD). Nitrogen gases used in this system was filtered by N2 gas purifier (VICI) and gas purifier tube packed Molecular Sieve 13X (MS-13X).

Table 3-5-2 Analytical conditions of dissolved CFCs in seawater.

Temperature	
Analytical Column:	95 deg-C
Detector (ECD):	240 deg-C
Trap column:	-40 deg-C (at adsorbing) & 140 deg-C (at desorbing)
Mass flow rate of nitrogen gas (99.9999%)	
Carrier gas:	15 ml/min
Detector make-up gas:	22 ml/min
Back flush gas:	20 ml/min
Sample purge gas:	130 ml/min
Standard gas (Japan Fine Products co. ltd.)	
Base gas:	Nitrogen
CFC-11:	300 ppt (v/v)
CFC-12:	160 ppt (v/v)
CFC-113:	30 ppt (v/v)

Table 3-5-3 Analytical conditions of dissolved CCl$_4$ in seawater.

Temperature	
Analytical Column:	50 deg-C
Detector (ECD):	200 deg-C
Trap column:	-45 deg-C (at adsorbing) & 130 deg-C (at desorbing)
Mass flow rate of nitrogen gas (99.9999%)	
Carrier gas:	14 ml/min
Detector make-up gas:	23 ml/min
Back flush gas:	20 ml/min
Sample purge gas:	140 ml/min
Standard gas (Japan Fine Products co. ltd.)	
Base gas:	Nitrogen
CFC-10 (CCl4):	250 ppt (v/v)

(4) Preliminary Result

i. Precisions

The analytical precisions are estimated from replicate sample analyses. The precisions of CFCs and CCl4 in leg 1 were calculated to be ± 0.012 pmol/kg (n = 256), ± 0.009 pmol/kg (n = 257), ± 0.007 pmol/kg (n = 227) and 0.05 pmol/kg (n = 16) for CFC-11, -12 -113 and CCl4, respectively. These in leg 2 were computed to be± 0.004 pmol/kg (n = 206), ± 0.004 pmol/kg (n = 206), ± 0.002 pmol/kg (n = 112) and 0.04 pmol/kg (n = 23) for CFC-11, -12 -113 and CCl4, respectively. The sampling number for CCl4 is not enough to estimate statistical precision.

In the CCl4 analysis, we had some problems relating accuracy. Our measurements of CCl4 concentration in surface water and mixing ratio in background air were around 40-60 % higher than them expected values from the atmospheric CCl4 history (Walker et al., 2000). A possible cause of this discrepancy is problem on calibration of the standard gasses. The standard gases will be calibrated with respect to other gasses in near future.

(5) Further data quality check

Volumetric loops for seawater sample and standard gas (and air sample) will be re-calibrated after this cruise and CFC concentrations will be corrected. Variation of detector sensitivities will be taken into account. And then, all the data will be checked once again in detail by property to property plot and others.

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3.6. Carbon items

January 9, 2008

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Yasuhiro Arii (MWJ)

(2) Objectives

Concentrations of CO_2 in the atmosphere are now increasing at a rate of 1.5 ppmv y^{-1} 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_2, and to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 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_2 absorbed in the ocean are transported and redistributed in the Pacific. For the purpose, we measured CO_2-system parameters such as dissolved inorganic carbon (C_T), total alkalinity (A_T) and pH.

(3) Apparatus

i. C_T

Measurements of C_T was made with two total CO_2 measuring systems (systems A and C; Nippon ANS, Inc.), which are slightly different from each other. The systems comprise of a seawater dispensing system, a CO_2 extraction system and a coulometer (Model 5012, UIC Inc.).

The seawater dispensing system has an auto-sampler (6 ports), which takes seawater in a 300 ml borosilicate glass bottle and dispenses the seawater 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_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 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. 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 pressrizing is made with nitrogen gas (99.9999 %). After the acid is transferred to the stripping chamber, a seawater sample kept in a pipette is introduced to the stripping chamber by the same method as in adding an acid. The seawater reacted with phosphoric acid is stripped of CO_2 by bubbling the nigrogen gas through a fine frit at the bottom of the stripping chamber. The CO_2 stripped in the chamber is carried by the nitrogen gas (flow rates is 140 ml min^{-1}) to the coulometer through a dehydrating module. The modules of systems A and C consist of two electric dehumidifiers (kept at 1 - 2 °C) and a chemical desiccant ($Mg(ClO_4)_2$).

The measurement sequence such as system blank (phosphoric acid blank), 2 % CO_2 gas in a nitrogen base, sea water samples (6) was programmed to repeat. The measurement of 2 % CO_2 gas was made to monitor response of coulometer solutions (from UIC, Inc.).

ii. A_T

Measurement of A_T was made based on spectrophotometry using a custom-made system (Nippon ANS, Inc.). The system comprises of a water dispensing unit, an auto-burette (765 Dosimat, Metrohm), and a spectrophotometer (Carry 50 Bio, Varian), which are automatically controlled by a PC. The water dispensing unit has a water-jacketed pipette and a water-jacketed titration cell. The spectrophotometer has a water-jacketed quartz cell, length and volume of which are 8 cm and 13 ml, respectively. To circulate sample seawater between the titration and the quartz cells, PFA tubes are connected to the cells.

A seawater of approx. 40 ml is transferred from a sample bottle (borosilicate glass bottle; 130 ml) into the water-jacketed (25 ºC) pipette by pressurizing the sample bottle (nitrogen gas), and is introduced into the water-jacketed (25 ºC) titration cell. The seawater is circulated between the titration and the quartz cells by a peristaric pump to rinse the route. Then, Milli-Q water is introduced into the titration cell, and is circulated in the route twice to rinse the route. Next, a seawater of approx. 40 ml is weighted again by the pipette, and is transferred into the titration cell. The weighted seawater is introduced into the quartz cell. Then, for seawater blank, absorbances are measured at three wavelengths (750, 616 and 444 nm). After the measurement, an acid titrant, which is a mixture of approx. 0.05 M HCl in 0.65 M NaCl and bromocresol green (BCG) is added (about 2 ml) into the titration cell. The seawater + acid titrant solution is circulated for 6 minutes between the titration and the quartz cells, with stirring by a stirring tip and bubbling by wet nitrogen gas in the titration cell. Then, absorbances at the three wavelengths are measured again.

Calculation of A_T was made by the following equation:

$$A_T = (-[H^+]_T V_{SA} + M_A V_A) / V_S ,$$

where M_A is the molarity of the acid titrant added to the seawater sample, $[H^+]_T$ is the total excess hydrogen ion concentration in the seawater, and V_S, V_A and V_{SA} are the initial seawater volume, the added acid titrant volume, and the combined seawater plus acid titrant volume, respectively. $[H^+]_T$ is calculated from the measured absorbances based on the following equation (Yao and Byrne, 1998):

$$\begin{aligned} pH_T = -\log[H^+]_T &= 4.2699 + 0.002578(35 - S) + \log((R - 0.00131)/(2.3148 - 0.1299R)) \\ &\quad - \log(1 - 0.001005S), \end{aligned}$$

where S is the sample salinity, and R is the absorbance ratio calculated as:

$$R = (A_{616} - A_{750}) / (A_{444} - A_{750}) ,$$

where A_i is the absorbance at wavelength *i* nm.

The HCl in the acid titrant was standardized on land. The concentrations of BCG were estimated to be approx. 2.0×10^{-6} M in the sample seawater, respectively.

iii. pH

Measurement of pH was made by a pH measuring system (Nippon ANS, Inc.). For the detection of pH, spectrophotometry was adopted. 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 is 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 is kept at 25.00 ± 0.05 ºC in a thermostated compartment. First, absorbances of seawater only are measured at three wavelengths (730, 578 and 434 nm). Then the indicator is injected and circulated for about 4 minutes. to mix the indicator and seawater sufficiently. After the pump is stopped, the absorbances of seawater + indicator are measured at the same wavelengths. The pH is calculated based on the following equation (Clayton and Byrne, 1993):

$$\mathrm{pH} = \mathrm{pK}_2 + \log\left(\frac{\mathrm{A}_1/\mathrm{A}_2 - 0.00691}{2.2220 - 0.1331(\mathrm{A}_1/\mathrm{A}_2)}\right),$$

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.

(4) Performances

i. C_T

The two systems worked well without a major malfunction. Replicate analysis was made approximately on every 9th seawater sample. During the leg 1, the repeatability for systems A and C were estimated to be 1.2 ± 1.1 (n = 106 pairs) and 1.2 ± 1.1 (n = 123 pairs) μmol kg^{-1}, respectively. The combined result was 1.2 ± 1.1 μmol kg^{-1} (n = 229 pairs). During the leg 2, they were 1.2 ± 1.0 (n = 116 pairs) and 1.2 ± 1.1 (n = 95 pairs) μmol kg^{-1}, respectively. The combined result was 1.2 ± 1.0 μmol kg^{-1} (n = 211 pairs).

ii. A_T

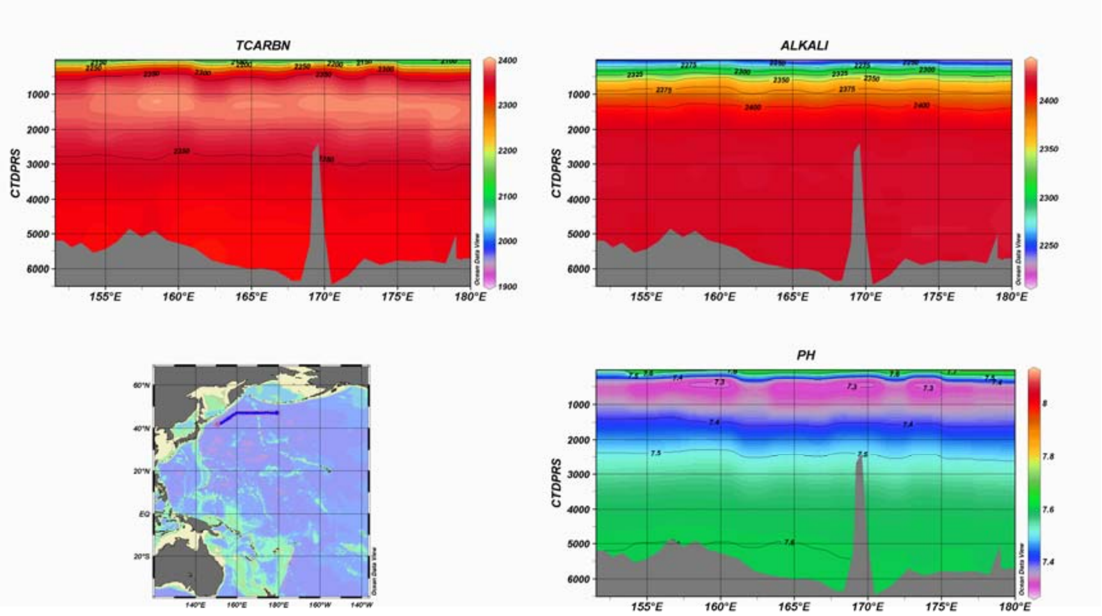
The system showed a very good precision compared to systems used in previous studies. A few replicate samples were taken on every stations. During the leg 1, the repeatability was estimated to be 0.6 ± 0.5 μmol kg^{-1} (n = 227 pairs), while during the leg 2, it was estimated to be 0.4 ± 0.4 μmol kg^{-1} (n = 211 pairs).

iii. pH

The system worked well with no troubles. The average of absolute differences between replicate samples were 0.0007 ± 0.0007 (n = 302 pairs) and 0.0003 ± 0.0003 pH unit for legs 1 and 2, respectively.

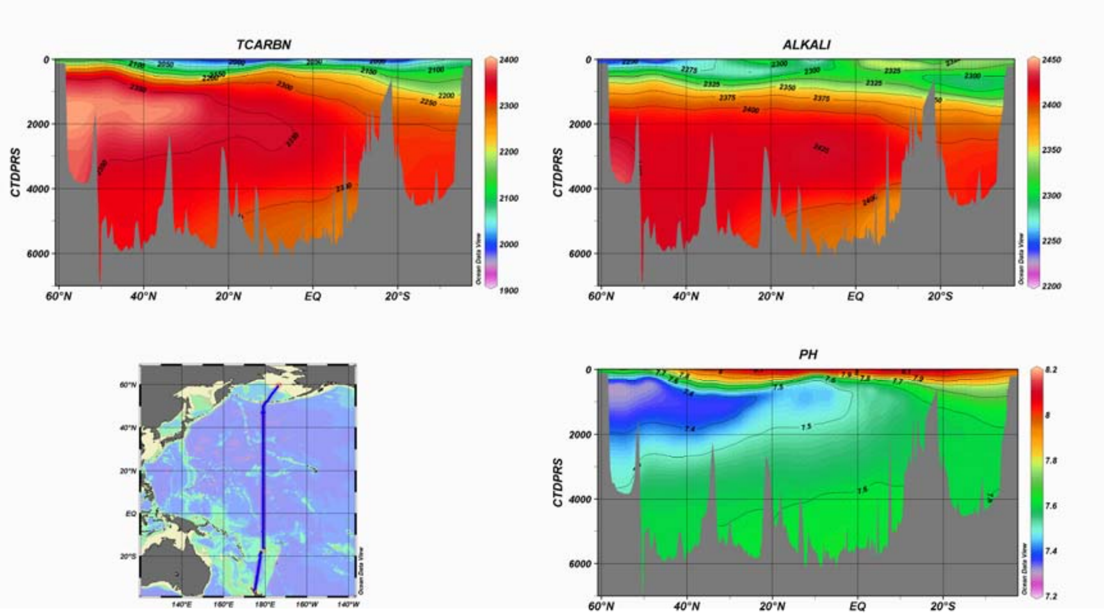
(5) Results

Cross sections of C_T, pH, and A_T along WOCE P01 and P14 lines are illustrated in Figs. 3.6.1. and 3.6.2., respectively.



P01 line

Fig. 3.6.1. Distributions of C_T (upper left), A_T (upper right), and pH (lower right) along the P01 line.



P14 line

Fig. 3.6.2. Distributions of C_T (upper left), A_T (upper right), and pH (lower right) along the P14 line.

References

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

Yao W. and R. H. Byrne (1998) Simplified seawater alkalinity analysis: Use of linear array spectrometers. Deep-Sea Research I 45, 1383-1392.

3.7 Samples taken for other chemical and biologicalmeasurement

3.7.1 Carbon-13, 14

January 11, 2008

(1) Personnel

Yuichiro KUMAMOTO

Japan Agency for Marine Earth Science and Technology (JAMSTEC)

(2) Objective

In order to investigate the water circulation and carbon cycle in the North Pacific, seawaters for carbon-14 (radiocarbon) and carbon-13 (stable carbon isotope) of total dissolved inorganic carbon (TDIC) were collected by the hydrocasts from surface to near bottom during MR07-06 cruise.

(3) Sample collection

The sampling stations and number of samples are summarized in Table 3.7.1.1. All samples for carbon isotope ratios were collected at 27 stations using 12-liter Niskin-X bottles. The seawater sample was siphoned into a 250 cm^3 glass bottle with enough seawater to fill the glass bottle 2 times. Immediately after sampling, 10 cm^3 of seawater was removed from the bottle and poisoned by 0.1 cm^3 μl of saturated $HgCl_2$ solution. Then the bottle was sealed by a glass stopper with Apiezon grease M and stored in a cool and dark space on board.

(4) 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_2 gas for radiocarbon will be then converted to graphite catalytically on iron powder with pure hydrogen gas. The carbon-13 of the extracted CO_2 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 3.7.1.1 The sampling stations and number of samples for carbon isotope ratios.

Station	No. samples	No. replicate sample	Max. sampling pressure /d
P01-032	34	2	5451
P01-038	33	2	5279
P01-X13	36	2	6008
P01-048	29	2	4255
P01-056	36	2	5904

P01-060	36	2	5737
P14N-005	26	2	3529
P14N-011	28	2	3852
P14N-023	36	2	6500
P14N-X01	35	2	5718
P14N-042	32	2	4970
P14N-050	34	2	5487
P14N-056	25	1	3194
P14N-X02	30	2	4625
P14N-077	34	2	5838
P14N-087	32	2	4890
P14N-097	36	2	5780
P14N-X04	35	2	5706
P14N-125	35	2	5765
P14N-143	34	2	5497
P14N-160	35	2	5724
P14N-171	33	2	5084
P14N-180	25	1	3087
P14C-037	28	2	3838
P14C-028	31	2	4538
P14C-X06	29	2	4310
P14C-007	20	1	2012
Total	857	51	

3.7.2 Radionuclides

December 27, 2007

Michio Aoyama
(Meteorological Research Institute / Japan Meteorological Agency, Principal Investigator)
LEG 1: Hideki Yamamoto (Department of Marine Science, Marine Works Japan Ltd.)
LEG 2: Junji Matsushita (Department of Marine Science, Marine Works Japan Ltd.)

(1) Objectives

Study more about present distribution of ^{137}Cs in the subpolar region in the North Pacific Ocean originated mainly from atmospheric nuclear weapons tests conducted in the 1960s.

Provide detail artificial radionuclides database for general circulation model validation.

(2) Target radionuclides

Main target radionuclides are ^{137}Cs, and Pu.

(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 7 liter to 40 liter. Samples were drawn into 10 or 20 liter cubitainers from the Niskin bottles. Concentrated Nitric Acid was added to the samples to keep pH1.6.

Surface water samples were drawn through intake pump below several meters from the surface. Seawater of 80 liter were collected for ^{137}Cs and Pu.

(4) Samples accomplished during the cruise

A total of 12 samples were collected for surface sample.

At the 15 stations, a total of 150 samples were collected for water column.

Table 3.7.2.1 Sampling Summary

Station#	Lat.	Long.	Sampling layer	Number of layers
004	35-01.25S	175-08.97E	Sur	1
008	33-42.16S	175-23.03E	Sur, 100, 200, 430, 630, 1070, 1000, 2070, 2276	9
012	32-10.63S	175-38.27E	Sur, 100, 200, 400, 600, 800, 1000, 2000, 3000, 3967	10
016	30-29.93S	175-56.02E	Sur, 100, 200, 370, 570, 770, 970, 1930, 2930, 3920, 4284	11
022	27-50.41S	176-22.22E	Sur, 100, 200, 370, 570, 770, 970, 1930, 2930, 3920, 4413	11
025	26-32.56S	176-35.85E	Sur	1
029	24-48.09S	176-53.17E	Sur, 100, 200, 430, 630, 830, 1070, 2070, 3080, 3330, 4080, 4524	12
032	23-29.20S	177-06.82E	Sur	1
036	21-46.03S	177-24.11E	Sur, 100, 200, 400, 600, 800, 1000, 2000, 3000, 4027	10
040	20-37.80S	177-35.58E	Sur	1
046	19-12.83S	177-34.70E	Sur, 100, 200, 370, 570, 770, 970, 1930, 3038	9
050	18-39.68S	177-52.53E	Sur	1
183	14-59.85S	178-59.53E	Sur, 100, 200, 370, 570, 770, 970, 1930, 2397	9
178_cast2	12-30.91S	179-01.06E	Sur, 100, 200, 400, 600, 800, 1000, 2000, 3046	9
178_cast1	12-30.35S	179-00.25E	Sur,	1
176	11-30.54S	178-59.74E	Sur,	1
172	9-29.86S	178-59.95E	Sur, 100, 200, 400, 600, 800, 1000, 2000, 3000, 4000, 4648	11
167	6-59.96S	179-00.06E	Sur	1
161	4-30.46S	179-00.53E	Sur, 100, 200, 430, 630, 830, 1070	7
153	2-30.08S	179-00.12E	Sur	1
144	0-14.90S	178-59.50E	Sur, 100, 200, 370, 570, 770, 970, (1730, 1930, 2130), (2730, 2930, 3170), (3670, 3920, 4170), (4670, 4920, 5170), 5545	12
134	2-14.70N	179-00.18E	Sur, 100, 200, 430, 630, 830, 1070, (1870,	12

			2070, 2270), (2870, 3080, 3330), (3830, 4080, 4330), (4830, 5080, 5330), 5719	
129	3-29.83N	179-00.24E	Sur	1
124	4-44.70N	178-59.99E	Sur, 100, 200, 400, 600, 800, 1000, (1800, 2000, 2200), (2800, 3000, 3250), (3750, 4000, 4250), (4750, 5000, 5250), 5750, 5925	13
119	6-00.33N	178-59.77E	Sur	1
116	6-44.70N	179-00.26E	Sur, 100, 200, 430, 630, 830, 1070, (1870, 2070, 2270), (2870, 3080, 3330), (3830, 4080, 4330), (4830, 5080, 5330), 5769	12
112	7-45.02N	179-00.62E	Sur	1

(5) Problem occurred and solutions.

No special problem occurred, except use of 0.65 micro meter pore size filter used to filter sea water samples at some stations.

3.7.3 Noble gas saturation

November 21, 2007

(1) Personnel

Charles Stump (University of Washington)
Steven Emerson (University of Washington) ***P.I.***
Roberta Hamme (University of Victoria) ***P.I.***

(2) Objectives

We are sampling the upper thermocline of the ocean to determine the degree of saturation of the noble gases: Ar, Xe and Kr. The degree of supersaturation for these noble gases is proportional the rate of diapycnal mixing as one travels from the outcrop area toward the interior of the gyre. Our goal is to determine the rate of diapycnal mixing using this geochemical technique.

(3) Instrument and Method

Seawater samples were collected for analysis of argon, krypton and xenon by mass spectrometry. All seawater samples were collected from depth using 12 liter Niskin bottles. Duplicate seawater samples were taken from each Niskin bottle following the sampling of oxygen and CFC. Two deep casts of 10 depths each were taken at the beginning and one cast at the end of the cruise transect. Six profiles of ten depths centered on Sigma t = 26.5 were collected at latitudes from 53N to 19N. Twenty-one duplicate surface seawater samples were also taken every ten degrees from 50N to 10N from the line located in the sea surface monitoring laboratory on the R/V Mirai. Dissolved oxygen was also collected at this time for Winkler titration analysis. The seawater samples were taken in evacuated 200 ml glass flasks with 4 O-ring Louwers-Hapert stopcocks. These evacuated flasks were stored with CO_2 gas in the dead space of the neck. A length of tygon tubing is attached to the flask and the neck is flushed with CO_2 gas using 1/16” O.D. nylon tubing. Another tube of 1/16” O.D. is attached to the Niskin bottle. This is inserted into the Tygon tubing and the CO_2 tube removed. The evacuated flask is opened and 100 ml of seawater is pulled into the flask. After cleaning the necks with distilled water, the necks are again filled with CO_2 gas for shipment. The oxygen samples were taken in standard 250 ml Kimax glass bottles with ground glass stoppers. The sampling stations and number of samples at each station are listed in Table 3.7.3-1.

Table 3.7.3-1

		CTD Samples					Underway Samples	
Station	**Date**	**Emerson**	**Hamme**	**Sarma**	**Latitude**	**Date**	**Emerson**	**Sarma**
P01-44	16-Oct-07	10			50N	29-Oct-07	2	1
P01-45	16-Oct-07	10			48N	29-Oct-07	2	1
P01-54	19-Oct-07	10			46N	30-Oct-07	2	1
P01-55	19-Oct-07	10			44N	31-Oct-07	2	1
P01-60	20-Oct-07		10		42N	1-Nov-07	2	1
P01-61	21-Oct-07		10		40N	2-Nov-07	2	1
P14-13	24-Oct-07	10			38N	3-Nov-07	2	1
P14-14	24-Oct-07	10			36N	4-Nov-07	2	1
P14-22	23-Oct-07			10	34N	5-Nov-07	2	1
P14-23	23-Oct-07			10	32N	6-Nov-07	2	1
P14-26	22-Oct-07	10			30N	7-Nov-07	2	1
P14-27	22-Oct-07	10			28N	8-Nov-07	2	1
P14-30	30-Oct-07		10		26N	9-Nov-07	2	1
P14-X01	30-Oct-07		10		24N	11-Nov-07	2	1
P14-34	31-Oct-07			10	22N	12-Nov-07	2	1
P14-35	31-Oct-07			10	20N	13-Nov-07	2	1
P14-37	1-Nov-07	10			18N	14-Nov-07	2	1
P14-38	1-Nov-07	10			16N	15-Nov-07	2	1
P14-41	2-Nov-07			10	14N	16-Nov-07	2	1
P14-42	2-Nov-07			10	12N	17-Nov-07	2	1
P14-45	3-Nov-07		10		10N	18-Nov-07	2	1
P14-46	3-Nov-07		10					
P14-53	5-Nov-07	10						
P14-54	5-Nov-07	10						
P14-58	6-Nov-07			10				
P14-59	6-Nov-07			10				
P14-62	7-Nov-07		10					
P14-63	7-Nov-07		10					
P14-66	8-Nov-07			10				
P14-67	8-Nov-07			10				
P14-70	9-Nov-07	10						
P14-71	9-Nov-07	10						
P14-78	12-Nov-07		10					
P14-79	12-Nov-07		10					
P14-82	13-Nov-07			10				
P14-83	13-Nov-07			10				
P14-87	14-Nov-07	10						
P14-88	14-Nov-07	10						
P14-94	16-Nov-07		10					
P14-95	16-Nov-07		10					
P14-99	17-Nov-07		10					
P14-100	17-Nov-07		10					
P14-103	18-Nov-07			10				
P14-104	18-Nov-07			10				
P14-107	19-Nov-07	10						
P14-108	19-Nov-07	10						
Total		180	140	140			42	21

3.7.4 Triple O2 gas measurement

November 21, 2007

(1) Personnel

Charles Stump (University of Washington)
V.V.S. Sarma (University of Colorado)   P.I.

(2) Objectives

Assessment of plankton metabolic processes, such as community gross, net production, and respiration, is very important in order to understand how biological processes influence carbon flux from the sunlit zone. The estimation of metabolic rates based on triple oxygen isotopic composition of dissolved oxygen would give time-integrated rates over the residence time of oxygen in the mixed layer. Our technique involves precise measurements of triple oxygen isotopes (^{16}O, ^{17}O and ^{18}O) in dissolved oxygen (O_2) in the surface mixed layer of the ocean, which is controlled by photosynthetic O_2 production, respiration, and exchange with atmosphere. The isotopic composition of O_2 produced during photosynthesis and fractionation during respiration is the primary controls on the ratios of stable oxygen isotopes in atmospheric O_2. Our aim is to examine spatial variations in the plankton metabolic processes in the North Pacific to understand how biological pump in this region influences carbon flux to the twilight zone.

(3) Instrument and Method

Seawater samples were collected for analysis of ^{16}O, ^{17}O and ^{18}O by mass spectrometry. All seawater samples were collected from depth using 12 liter Niskin bottles. Duplicate seawater samples were taken from each Niskin bottle following the sampling of oxygen and CFC. Seven profiles of ten depths were collected at latitudes from 50N to 10N. Twenty-one surface seawater samples were also taken every two degrees from 50N to 10N from the line located in the sea surface monitoring laboratory on the R/V Mirai. Dissolved oxygen was also collected at this time for Winkler titration analysis. The seawater samples were taken in evacuated 300 ml glass flasks with O-ring Louwers-Hapert stopcocks. These evacuated flasks were stored with water in the dead space of the neck. A length of tygon tubing is attached to the flask and the neck is flushed with CO_2 gas using 1/16" O.D. nylon tubing. Another tube of 1/16" O.D. is attached to the Niskin bottle. This is inserted into the Tygon tubing and the CO_2 tube removed. The evacuated flask is opened and 150 ml of seawater is pulled into the flask. After cleaning the necks with distilled water, the necks are again filled with water for shipment. The oxygen samples were taken in standard 250 ml Kimax glass bottles with ground glass stoppers. The sampling stations and number of samples at each station are listed in Table 3.7.3-1.

3.7.5 N_2 fixation activity and phytoplankton dynamics in the central Pacific

December 26, 2007

(1) Personnel

Takuhei Shiozaki (1, Nguyen Van Nguyen (1, Taketoshi Kodama (1, Hironobu Furuya (1, Yasuwo Fukuyo (2, Shigenobu Takeda (1, and Ken Furuya (1

1) Department of Aquatic Bioscience, Graduate School of Agricultural and Life Sciences,
The University of Tokyo
2) Asian Natural Environmental Science Center, The University of Tokyo

(2) Objectives

It has long been thought that nitrate in deepwater is the major source of new production. However, recent studies have shown that biological N_2 fixation has a critical role in supporting new production in the oligotrophic tropical and subtropical waters. To elucidate latitudinal variation of N_2 fixation activities and phytoplankton dynamics in the central Pacific, we conducted following experiments in this cruise.

(3)Methods, Apparatus and Performance

Semi-continuous measurement of nutrients, temperature and salinity on the surface water

Samples were collected from the ship's non-toxic seawater supply that pumped from the bottom of the ship. Concentrations of NO_3^-+NO_2^- (N+N), SRP, and ammonium were measured semi-continuously by a supersensitive colorimetric system that consists of Auto Analyzer II (Technicon) connecting to Liquid Waveguide Capillary Cell (LWCC, WPI) from 36.0°N to 4.2°N and from 3.0°S to 34.1°S. Temperature and salinity were measured continuously by Ocean Seven 301 (Idronaut) almost all the way through this cruise.

Distribution of phytoplankton assemblage, dissolved organic nitrogen (DON), dissolved organic phosphorus (DOP), $\delta^{15}N$, and a^*_{ph}

Samples for phytoplankton abundance, chlorophyll *a*, DON and DOP were collected almost every four degree-N by a bucket and Niskin samplers from the depths of 0, 10, 50, 100, 150, 200 m. The other samples for pigments for HPLC analysis, ^{15}N and a^*_{ph} were only collected from the surface waters. The samples for chlorophyll *a* were measured fluorometrically with a Turner Design 10-AU fluorometer after extraction with N, N-dimethylformamide on board. The other samples for phytoplankton abundance, DON and DOP, pigments, ^{15}N, and a^*_{ph} will be respectively analyzed by flow cytometry and microscopy, DON/DOP analyzer, HPLC, mass spectrometer, and spectrophotometer on land.

N_2 fixation activity, diversity of diazotrophs, and its relationship with the other nitrogen compounds

Samples for *nifH* gene were collected by a bucket and Niskin samplers almost every four degree-N from the depths of 0, 10, 50, 100, 150, 200 m. Replicate samples were collected in 1 L polyvinyl chloride bottles. They were size-fractionated by using 47-mm Nucleopore filters of two different pore sizes (0.2 and 10 μm) with gentle vacuum (<100 mmHg). After filtration, each filters placed in 2 ml centrifuge tubes containing 300 μl of Tris-EDTA (TE) (10 mM Tris- HCl at pH 7.4; 1 mM EDTA at pH 8.0). The tubes were immediately frozen in liquid nitrogen for nucleic acids extraction. Nucleic acids extraction was conducted on board. After extraction, samples were stored at -20°C until PCR analysis on land.

Samples for incubation experiments were collected by an acid-cleaned bucket from the surface waters at the same station where samples for *nifH* gene were collected. These samples were collected at dawn. N_2 fixation activities of whole waters or of <10 m fractions, and NO_3^- or NH_4^+ assimilations were evaluated using ^{15}N tracer. After addition of the tracers, the incubation bottles were placed into on-deck incubators cooled by flowing surface seawater. The incubations for NO_3^- or NH_4^+ assimilation were terminated by gentle vacuum filtration through precombusted GF/F filter within 2 hours. The incubations for N_2 fixation of whole waters were terminated in the same way, and that of < 10 m fractions were terminated after passage through a 10 m prefilter. The samples for N_2 fixation activities were incubated for 24 hours. These filters were kept frozen in a freezer (-20 ºC) for later analysis on land.

In addition, experiments for elucidating inhibitions of N_2 fixation by the other nitrogen compounds (NO_3^- or NH_4^+) were conducted in the N+N depleted region. Samples for these experiments were collected by an acid-cleaned bucket from the surface waters. The incubation bottles were spiked both $^{15}N_2$

(2 ml) and $^{14}NO_3^-$ (or $^{14}NH_4^+$) in the range of 0.05-10 M. These samples were incubated for 24 hours. These experiments were conducted in total 11 stations.

Morphological and genetic variations of dinophysoid dinoflagellates

Samples were collected by sieving the pumped-up seawater at 6 m depth through a plankton net with mesh size of 20 µm. Single cells of dinophysoids were microscopically isolated, pictured, examined for morphological characteristics and transferred to a 200µl PCR tube for PCR amplification. The first PCR amplified about 5 kilo base pairs of ribosomal DNA, from the small subunit (the 24S region) to the D6 region of the large subunit (the 28S region). The second PCR amplified approximately 700 base pairs of the D1- D2 regions of the large subunit using the first PCR products as templates. The successfully amplified DNA products (checked by electrophoresis) were purified using the Promega purification kit and stored at -20^{o}C for later sequencing when back to land.

3.8 Lowered Acoustic Doppler Current Profiler

December 24, 2007

(1) Personnel

Leg 1	
Hiroshi Uchida	***(JAMSTEC) (the person in charge on the cruise)***
Yoshimi Kawai	***(JAMSTEC)***
Leg 2	
Katsuro Katsumata	***(JAMSTEC)***
Toshimasa Doi	***(JAMSTEC)***
PI	
Shinya Kouketsu	***(JAMSTEC) (not on board)***

(2) Overview of the equipment

An acoustic Doppler current profiler (ADCP) was integrated with the CTD/RMS package. The lowered ADCP (LADCP), Workhorse Monitor WHM300 (Teledyne RD Instruments, San Diego, California, USA), which has 4 downward facing transducers with 20-degree beam angles, rated to 6000 m. The LADCP makes direct current measurements at the depth of the CTD, thus providing a full profile of velocity. The LADCP was powered during the CTD casts by a 50.4 volts rechargeable Ni-Cd battery pack. The LADCP unit was set for recording internally prior to each cast. After each cast the internally stored observed data was uploaded to the computer on-board. By combining the measured velocity of the sea water and bottom with respect to the instrument, and shipboard navigation data during the CTD cast, the absolute velocity profile can be obtained (e.g. Visbeck, 2002).

The instrument used in this cruise was as follows.

Teledyne RD Instruments, WHM300-I-UG27

S/N 8484 (CPU firmware ver. 16.28)

S/N 2553 (CPU firmware ver. 16.28) (with pressure sensor) *

* Serial number 2553 was used at stations from P14C_41 to P14C_32.

(3) Data collection

In this cruise, data were collected with the following configuration.

Bin size: 8.0 m
Number of bins: 14
Pings per ensemble: 1
Ping interval: 1.0 sec

At the following stations, the CTD cast was carried out without the LADCP, because the maximum pressure was beyond the pressure-proof of the LADCP (6000 m).

Stations from P01_44 to P01_46
Stations from P01_53 to P01_54
Stations from P14N_24 to P14N_23

(4) Data collection problems

Echo intensity of a transducer of serial number 8484 was found to become weak gradually. Echo intensity was recorded every second for each beam at every bin. Throughout a cast, statistical mode was calculated at each bin, and then the modes were averaged over the bins (Fig. 3.8.1). The peak after station P14N_140 results from enhanced reflections by the equatorial upwelling and that after P14C-52 from the substitution by anther sensor (serial number 2553). A part of data from the substituted sensor was missed by unknown reason at the following stations.

P14C_40: from 2920 m of down-cast to 2870 m of up-cast
P14C_33: from 2440 m of down-cast to 2680 m of up-cast
P14C_32: from 3540 m of down-cast to 3330 m of up-cast

Therefore the original sensor (serial number 8484) was used again after 10 casts from the substitution.

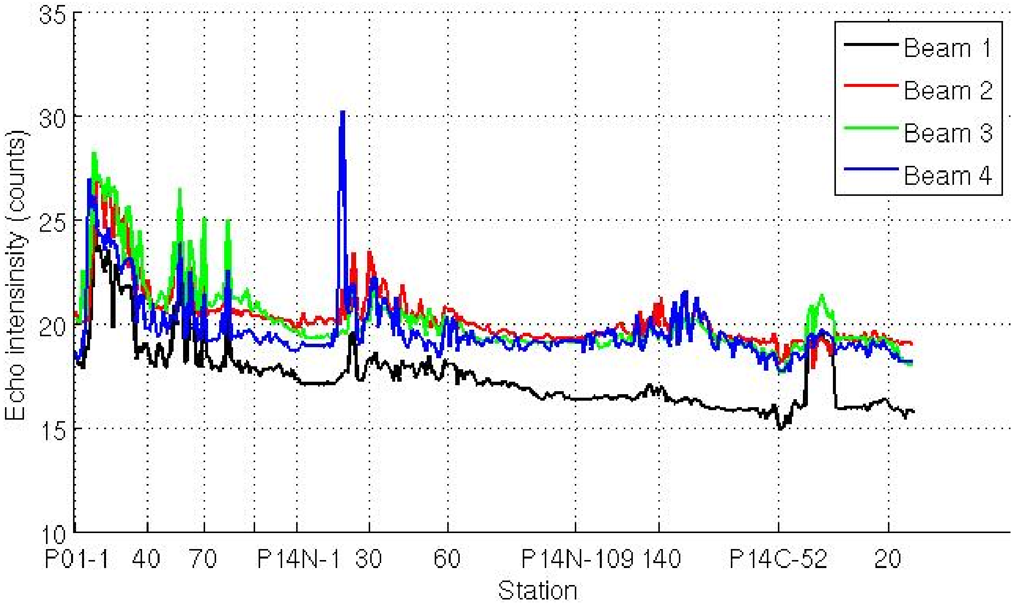


Fig. 3.8.1. Progress of echo intensity in each beam of the LADCP for MR07-04 and MR07-06 cruises.

Reference

Visbeck, M. (2002): Deep velocity profiling using Lowered Acoustic Doppler Current Profilers: Bottom track and inverse solutions. *J. Atmos. Oceanic Technol.*, **19**, 794-807.

4. Floats, Drifters and Moorings

4.1 Argo floats

December 20, 2007

(1) Personnel

Toshio Suga	***(JAMSTEC/IORGC):Principal Investigator (not on board)***
Nobuyuki Shikama	***(JAMSTEC/IORGC):not on board***
Kanako Sato	***(JAMSTEC/IORGC):not on board***
Mizue Hirano	***(JAMSTEC/IORGC):not on board***
Kenichi Katayama	***(MWJ):Technical Staff(Operation Leader of Leg 1)***
Shinsuke Toyoda	***(MWJ) :Technical Staff***
Kentaro Ohyama	***(MWJ) :Technical Staff***
Hiroshi Matusnaga	***(MWJ) :Technical Staff***
Tomoyuki Takamori	***(MWJ):Technical Staff(Operation Leader of Leg 2)***

(2)Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the North Pacific such as the North Pacific Intermediate Water and the North Pacific Tropical Water.The profiling floats launched in this cruise measure 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 in previous studies.

(3) Parameters

Water temperature, salinity, and pressure

(4) Methods

i. Profiling float deployment

We launched APEX floats manufactured by Webb Research Ltd. These floats equip an SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc.The floats usually drift at a depth of 1000 dbar (called the parking depth), diving to a depth of 2000 dbar and rising up to the sea surface by decreasing and increasing their volume and thus changing the buoyancy in ten-day cycles. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately nine hours, transmitting 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.

We also launched APEX floats owned by the Institute of Ocean Sciences (IOS) in Canada. Dr. Freeland belonging to IOS asked Dr. Fukasawa, who is the director of this cruise, to launch five floats in the Bering Sea and we launched these floats there shown in Table 4.1-2.

(5) Preliminary Result

The time series of vertical profiles of sea-water temperature and salinity observed by the JAMSTEC float are shown in Fig. 4.1-1. The salinity maximum is observed beneath the mixed layer. The salinity minimum is also observed in the intermediate layer between 400 and 800m. This salinity minimum water seems to be the North Pacific Intermediate Water.

The time series of vertical profiles observed by IOS float launched in the Bering Sea are also shown in Fig. 4.1-2. We can see the temperature minimum layer, called “dichothermal water”, at about 200-m depth. This temperature inversion is not shown in December 2007. The temporal change and horizontal/vertical structure of dichothermal water in the Bering Sea will be obtained by the IOS floats.

(6) Data archive

The real-time data are provided to meteorological organizations, research institutes, and universities via Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) and Global Telecommunication System (GTS), and utilized for analysis and forecasts of sea conditions.

Table 4.1-1 Status of JAMSTEC floats and their launches

Float

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	1000 dbar
Sampling layers	50, 1900, 1850, 1800, 1750, 1700, 1650, 1600, 1550, 1500, 1450, 1400, 1350, 1300, 1250, 1200, 1150, 1100, 1050, 1000, 980, 960, 940, 920, 900, 880, 860, 840, 820, 800, 780, 760, 740, 720, 700, 680, 660, 640, 620, 600, 580, 560, 540, 520, 500, 490, 480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370, 360, 350, 340, 330, 320, 310, 300, 290, 280, 270, 260, 250, 240, 230, 220,210, 200, 195, 190, 185, 180, 175, 170, 165, 160, 155, 150, 145, 140, 135, 130, 125, 120, 115, 110, 105, 100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, 15, 10, 4 or surface dbar)

Launches

Float S/N	ARGOS ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch	CTD St. No.
3331	75743	2007/11/04 07:05	2007/11/04 08:33	36-58.62[N] 179-01.88[E]	P14N-051
3330	75742	2007/11/0504:13	2007/11/05 05:56	34-59.89[N] 178-59.80[E]	P14N-055
3329	75741	2007/11/07 21:25	2007/11/07 23:52	28-58.83[N] 179-01.25[E]	P14N-067
3328	75740	2007/11/08 21:30	2007/11/09 00:21	26-59.79[N] 179-01.77[E]	P14N-071
3341	75753	2007/11/11 04:43	2007/11/110 5:54	25-00.27[N] 179-01.59[E]	P14N-075
3333	75745	2007/11/13 01:18	2007/11/13 02:28	21-00.66[N] 178-59.88[E]	P14N-083
3332	75744	2007/11/14 18:44	2007/11/14 21:36	17-01.42[N] 178-59.25[E]	P14N-091
3343	75755	2007/11/16 21:04	2007/11/16 21:59	13-00.39[N] 178-59.33[E]	P14N-099
3327	75739	2007/11/24 08:22	2007/11/24 10:05	08-00.17[N] 179-01.21[E]	P14N-111

Table 4.1-2 Launches of IOS floats

Float S/N	ARGOS ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch	CTD St. No.
3268	33318	2007/10/24 03:18	2007/10/24 04:34	52-16.13[N] 178-58.20[W]	P14N-015
3264	33314	2007/10/24 17:44	2007/10/24 18:55	53-29.833[N] 178-14.01[W]	P14N-012
3265	33315	2007/10/25 08:44	2007/10/25 10:18	54-59.59[N] 177-09.45[W]	P14N-009
3260	33306	2007/10/26 00:41	2007/10/26 01:55	56-29.22[N] 176-05.71[W]	P14N-006
3261	33307	2007/10/27 06:31	2007/10/27 08:01	57-59.70[N] 174-53.87[W]	P14N-003

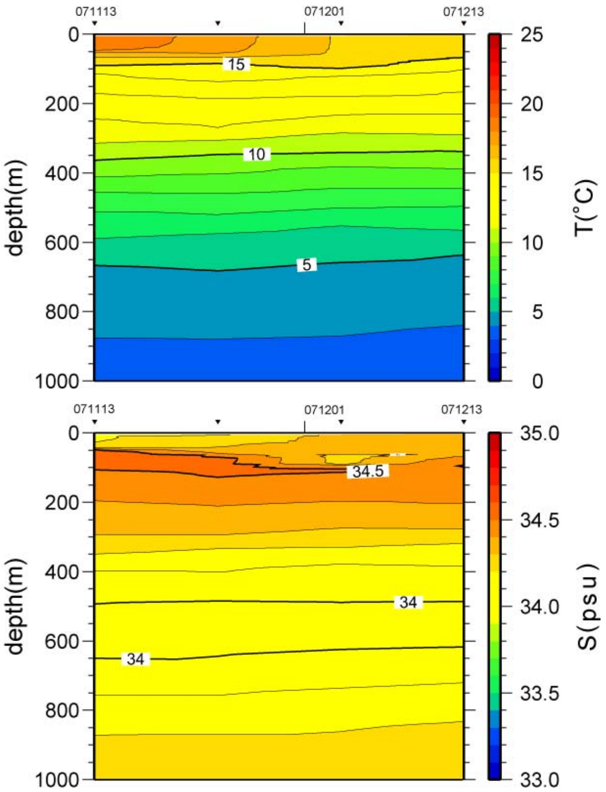


Figure 4.1-1 The time series of vertical profiles of sea-water temperature (top) and salinity (bottom) observed by the JAMSTEC floats whose WMO_ID is 2900702.

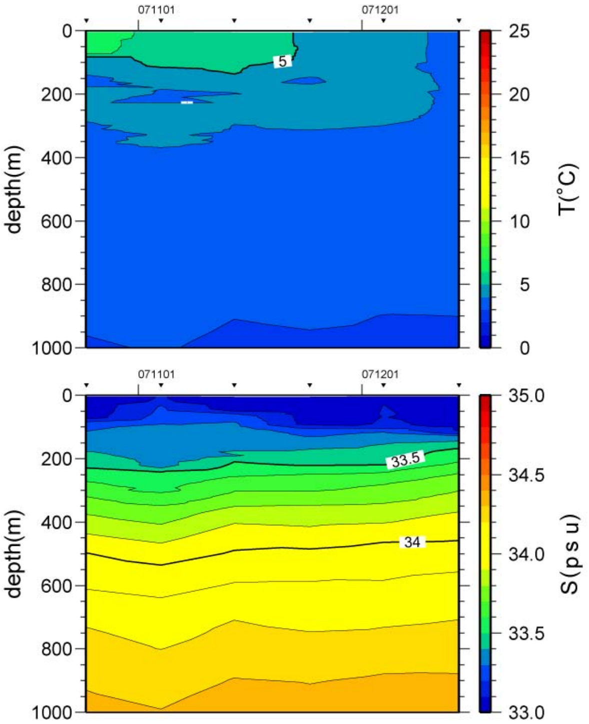


Figure 4.1-2 The time series of vertical profiles of sea-water temperature (top) and salinity (bottom) observed by the IOS floats whose WMO_ID is 4901074.