MR99-K07

Preliminary Cruise Report

January 2000

Japan Marine Science and Technology Center

Contents

4. Acknowledgements

1. Introduction

The equatorial Pacific has distinguished characteristics, those are it occupies a large region of the world's ocean and the warmest water of the planet exists there. The western equatorial Pacific contains so-called warm water pool. Nitrate is depleted there and primary production is small. In the central and eastern equatorial Pacific, vertical flux of nutrients is enhance due to Quasi-stationary upwelling caused by equatorial divergence and consequently chlorophyll a concentration and primary production rate increased along the equator. However, primary production and biomass are not as high as would be expected from the flux of nutrients could support. This is called high nutrient low chlorophyll situation. Since this east to west asymmetry is affected by ENSO event, there is a significant variability in physical characters on seasonal-interannual scale with impact to biogeochemistry, as well potentially with the similar scale of variability.

In order to investigate the mechanism of this biogeochemical variavility, Japan Marine Science and Technology Center (JAMSTEC) conducted biogeochemical observation cruise in the equatorial Pacific. Participants are from ;

- Central Research Institute of Erectric Power Industry
- Dalhousie University
- Geological Survey of Japan
- Global Ocean Development (Technicians)
- Hokkaido University
- Kansai Environmental Engineering Center
- Kumamoto University
- Kyushu University
- Marine Works Japan (Technicians)
- Meteorological Research Institute
- Nagoya University
- National Institute of Radiological Sciences
- Nara University of Education
- Seikai National Fisheries Research Institute
- Tokyo University

We made a comprehensive observation to investigate carbon cycle especially in a biological aspect. Our observation includes ;

- Hydrocast for physical, chemical and biological parameters such as saliniy, nutrients, dissolved inorganic carbon, plant pigments and so on..
- Atmospheric and oceanic CO_2 measurements.
- In situ and simulated in situ incubation for primary productivity and new productivity.
- Sediment trap moorings to observe export production.

- Distribution of phytoplankton and zooplankton.
- Etc.

We will conduct periodical and repeating observation to resolve a biogeochemical variation in a seasonal and inter-annual scale.

2. Outline of the cruise

2.1 Cruise summary

Ship : MIRAI

Chief Scientist :Takeshi KAWANO, Ocean Research Department, JAMSTEC

Cruise Code : MR99-K07

Project title : Biogeochemical and optical research

Period : Nov. 21, 1999 - Dec. 27, 1999

Ports of call : 1) Guam, U.S.A.

2) Shimonoseki, Japan

2.2 Cruise Log and cruise Track

See tables and figure attached.
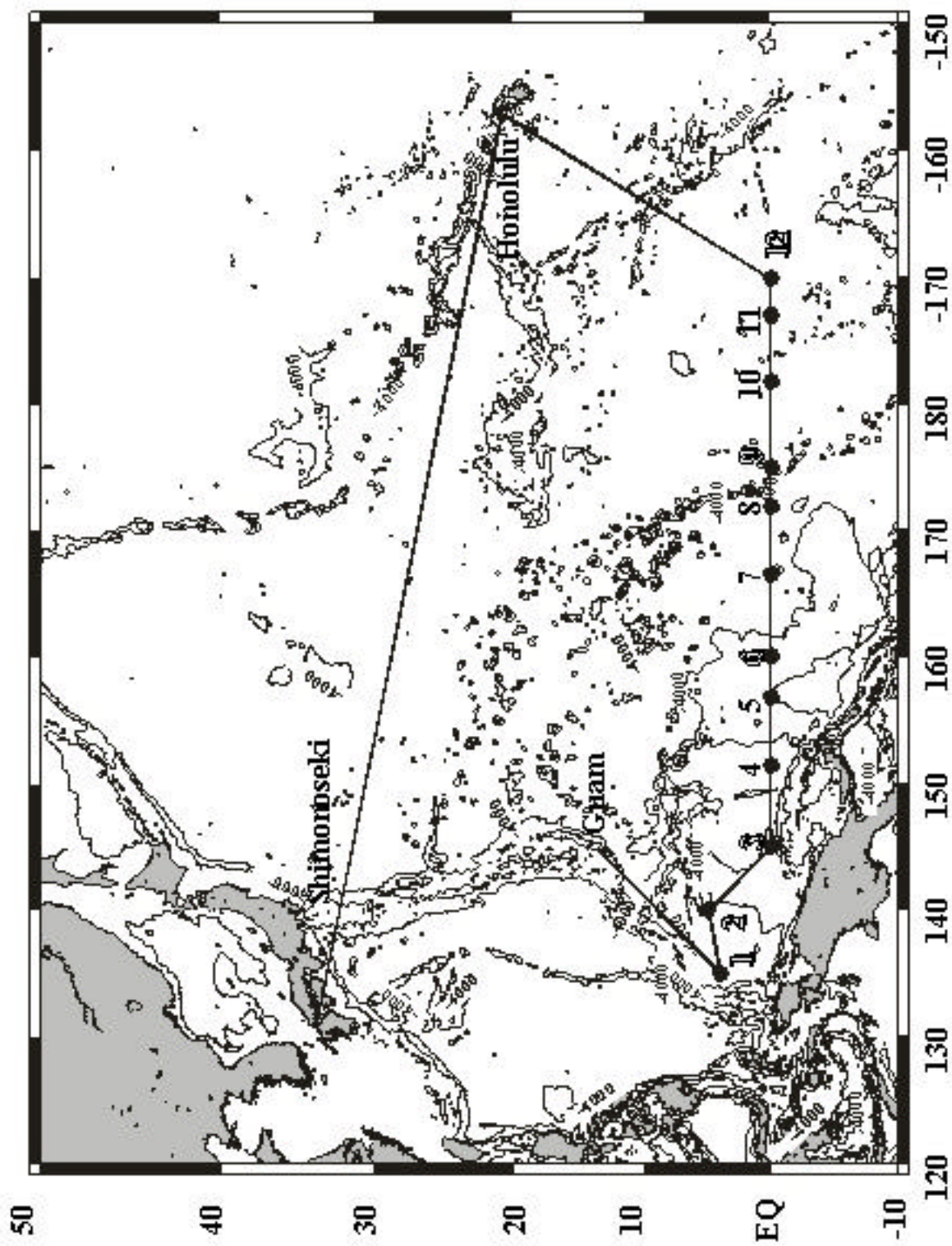
MR99-K07 Cruise Track

2.3 List of Participants

	NAME	ORGANIZATION	POSITION	ADDRESS
1	Takeshi Kawano	JAMSTEC	CHIEF SCIENTIST	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
2	Kazuhiko Matsumoto	JAMSTEC	SCIENTIST	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
3	Hirofumi Okano	JAMSTEC	SCIENTIST	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
4	Masatoshi Yamada	NIRS	SENIOR RESEARCHER	3609 Isozaki-cho Hitachinaka Ibaraki 311-1202 JAPAN
5	Tatsuo Aono	NIRS	SENIOR RESEARCHER	3609 Isozaki-cho Hitachinaka Ibaraki 311-1202 JAPAN
6	Yuichiro Tanaka	GSJ	SENIOR RESEARCHER	1-1-3 Higashi Tsukuba Ibaraki 305-0046 JAPAN
7	Nobuharu Komai	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN Phone +81-468-65-6803
8	Masayuki Fujisaki	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
9	Hiroaki Muraki	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
10	Keisuke Wataki	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
11	Ai Yasuda	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
12	Tsutomu Iwashita	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
13	Shu Saito	MRI	SCIENTIST	1-1 Nagamine Tsukuba Ibaraki 305-0052 JAPAN
14	Takanori Akiyoshi	NHE	TECHNICIAN	2-41-1 Higashikanagawa kanagawa-ku Yokohama Kanagawa 221-0044 JAPAN Phone +81-45-453-6911, Fax +81-45-453-6910
15	Masahiro Imamura	CRIEPI	SENIOR RESEARCHER	1646 Abiko Abiko Chiba 270-1166 JAPAN Phone +81-471-82-1181, Fax +81-471-83-2966

16	Cyril Dempsy	Dalhousie Univ.	TECHNICIAN	Pier 9 Richmond Terminals 3295 Barringtor St./Halifax. NS
17	Geoff Macintyre	Dalhousie Univ.	TECHNICIAN	1355 Oxford ST. Halifax N.S. CANADA B3H4J1
18	Hidekazu Ohta	KANSO	TECHNICIAN	1-3-5 Azuti-machi Chuo-ku Osaka 541-0052 JAPAN
19	Munehito Kimura	KANSO	TECHNICIAN	1-3-5 Azuti-machi Chuo-ku Osaka 541-0052 JAPAN
20	Kenichiro Masaki	KANSO	TECHNICIAN	1-3-5 Azuti-machi Chuo-ku Osaka 541-0052 JAPAN
21	Atsushi Yamaguchi	KANSO	TECHNICIAN	1-3-5 Azuti-machi Chuo-ku Osaka 541-0052 JAPAN
22	Akifumi Shimamoto	KANSO	TECHNICIAN	1-3-5 Azuti-machi Chuo-ku Osaka 541-0052 JAPAN
23	Fumitaka Yoshiura	GODI	TECHNICIAN	3-65 Oppamahigashi-cho Yokosuka Kanagawa 237-0065 JAPAN
24	Kei Okamura	Nagoya Univ.	Lecture	Furo-cho Chikusa-ku Nagoya Aichi 464-8601 JAPAN
25	Kyoko Tomioka	Hokkaido Univ.	Graduate Studente	N10 W8 Kita-ku Sapporo Hokkaido 060-0810 JAPAN Phone +81-11-716-2111
26	Yasuyuki Kitamori	Hokkaido Univ.	Graduate Studente	N19 W8 Kita-ku Sapporo Hokkaido 060-0819 JAPAN
27	Masako Iida	Hokkaido Tokai Univ.	Student	1-1-1 5jo Minaminosawa Minami-ku Sapporo Hokkaido 005-8801 JAPAN Phone +81-11-571-5111, Fax +81-11-571-7879
28	Yusuke Okazaki	Kyushu Univ.	Graduate Studente	6-10-1 Hakozaki Fukuoka 812-8581 JAPAN
29	Hanako Domitsu	Kumamoto Univ.	Graduate Studente	2-39-1 Kurokami Kumamoto 860-8555 JAPAN Phone +81-96-344-2111
30	Isao Tamamushi	Tohoku Institute of Univ.	Graduate Studente	35-1 Kasumi-cho Yagiyama Taihaku-ku Sendai Miyagi 982-8577 JAPAN
31	Shiro Nishida	Nara Univ. of Education	Professor	Takabatake-cho Nara 630-8528 JAPAN
32	Hideto Tsutsui	Kanazawa Univ.	Graduate Studente	Kakuma-cho Kanazawa Ishikawa 920-1192 JAPAN
33	Hitoshi Takamaru	Univ. of Tokyo	Studente	1-1-1 Yayoi Bunkyo-ku 106-0032 JAPAN
34	Shigeki Watanabe	Univ. of Tokyo	Studente	1-1-1 Yayoi Bunkyo-ku 106-0032 JAPAN
35	Chie Minami	Nagoya Univ.	Graduate Studente	Furo-cho Chikusa-ku Nagoya Aichi 464-8601 JAPAN
36	Mitsuru Yamamura	Tohoku Univ.	Studente	1-1-3 Higashi Tsukuba Ibaraki 305-8567 JAPN

37	Nakahito Nishikawa	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
38	Yuichiro Kondo	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
39	Shigeyoshi Araki	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
40	Kotoe Yamauchi	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN
41	Kenta Ogawa	MWJ	TECHNICIAN	2-15 Natsushima-cho Yokosuka 237-0061 JAPAN

JAMSTEC:Japan Marine Science and Technology Center

MRI: Meteorological Research Institute

NHE: Nippon Hakuyo Engineering

KANSO: Kansai Environmentral Engineering Center CO. , LTD

NIRS: National Institute of Radiological Sciences

MWJ: Marine Works Japan

CRIEPI: Central Research Institute of Electric Power Industry

GODI: Global Ocean Development. Inc

GSJ: Geological Survey of Japan

3.1 Meteorological Observation

3.1.1 Meteorological Station

(1) Personnel

   Fumitaka　Yoshiura (GODI)　　　　: Operation Leader

(2) Objective

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

(3) Measured Parameters

        The surface meteorological parameters were observed throughout MR99-K07 cruise from the departure of Guam　U.S.A. on 21 November 1999 to the arrival of Shimonoseki　Japan on 25 December 1999.

        Measured parameters are:

Name	Sampling Interval	Acronyms
Wind direction	6 sec./10 min. averaged	WD
Wind speed	6 sec./10 min. averaged	WS
Weather	3 hourly	Weather
Pressure (adjusted to the sea surface level)		
	6 sec./10 min. averaged	P
Air temperature	6 sec./10 min. averaged	T
Dewpoint temperature	6 sec./10 min. averaged	DPT
Relative humidity	6 sec./10 min. averaged	RH
Sea surface temperature	6 sec./10 min. averaged	SST
Rainfall amount	1 hourly (accumulated)	Rain
Significant wave height	3 hourly (20 min. averaged)	Wv. Ht.
Significant wave period	3 hourly (20 min. averaged)	Wv. Pd.

(4) Methods

        The meteorological sensors onboard R/V Mirai are listed in Table 3.1.1.1. Surface meteorological data were collected and processed by KOAC-7800 weather data processor and some sensors assembled by Koshin Denki, Japan.

Table 3.1.1.1

Sensors	Type	Maker	Location(Altitude from surface)
Anemometer:	KE-500	Koshin Denki, Japan	Foremast 24m
Thermometer:	FT	Koshin Denki, Japan	Compass Deck 19m
Dew point meter:	DW-1	Koshin Denki, Japan	Compass Deck 19m
Barometer:	F-451	Yokogawa, Japan	Weather observation room, Captain Deck 13m
Rain gauge:	50202	Young, U.S.A.	Compass Deck 19m
Optical Rain gauge:	ORG-115DR	SCTI, U.S.A.	Compass Deck 19m
Radiometer:	MS-801 (short wave) MS-200 (long wave)	Eiko Seiki, Japan	Radar mast (28m)
Wave height meter:	MW-2	Tsurumi-seiki, Japan	Bow

(5) Preliminary Results

Fig 3.1.1.1, 2 and 3 shows the part of the observation results for the permanent sensors.

(6) Data Archive

The dataset with 6 seconds 10 minutes and 1 hour interval are available in the 3.5" magnetic optical (MO) disk. The dataset will be submitted to the DMO (Data Management Office), JAMSTEC and will be under their control.
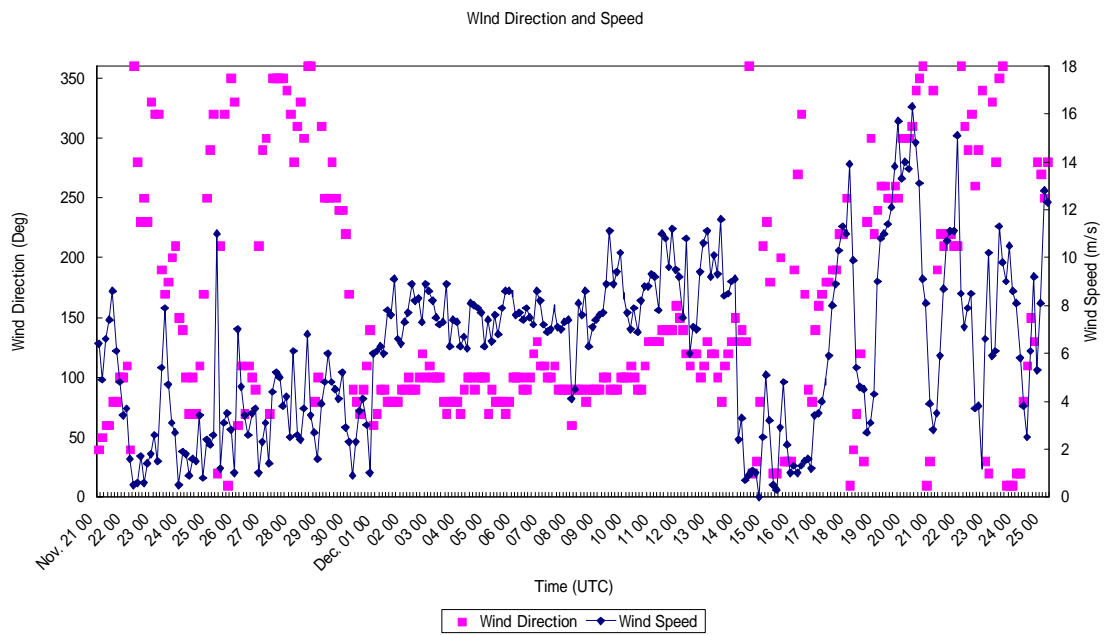
Fig.3.1.1.1 Wind Speed and Direction

Pressure
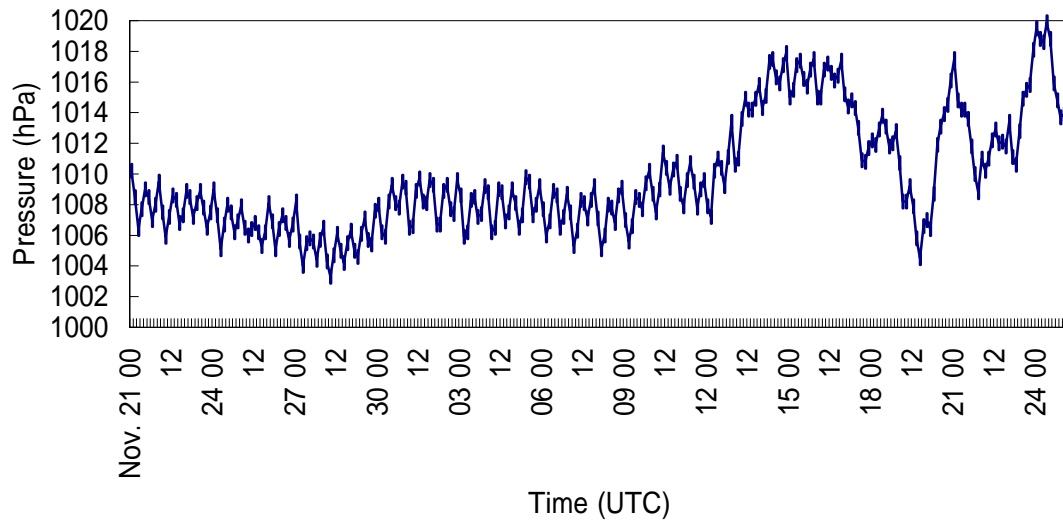
Fig.3.1.1.2 Pressure

Temperature and Relative Humidity
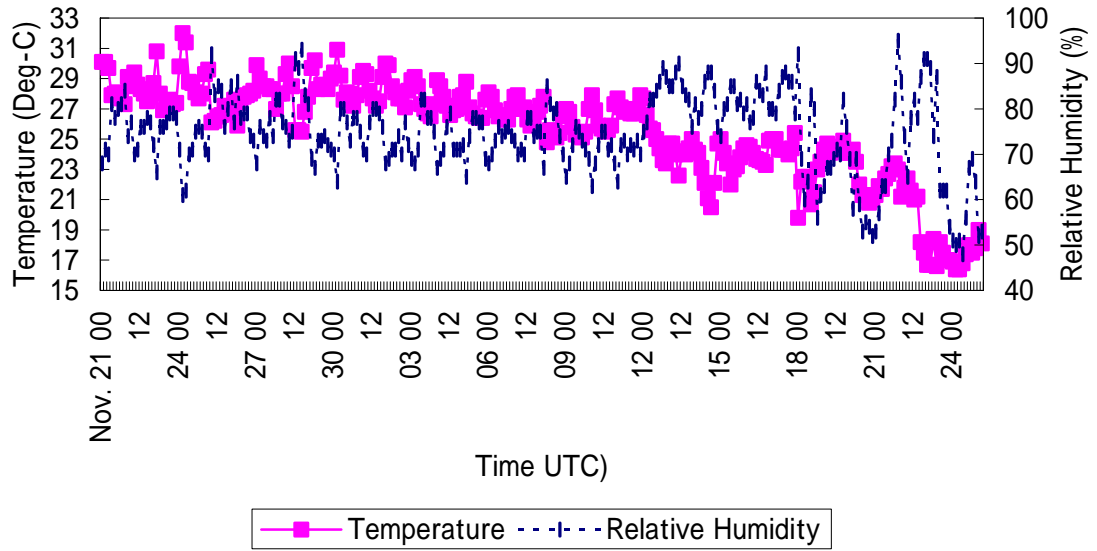
Fig.3.1.1.3 Temperature and Relative Humidity

3.1.2 Ceilometer

(1) Personnel

    Fumitaka   Yoshiura (GODI)   : Operation Leader

(2) Parameters

    (2.1)   Cloud base height [m]

    (2.2)   Backscatter profile, sensitivity and range normalized at 30m resolution

(3) Methods

        We measured cloud base height and backscatter profiles using CT-25K (Vaisala, Finland) ceilometer throughout MR99-K07 cruise from the departure of Guam, U.S.A. on 21 November 1999 to the arrival of Shimonoseki, Japan on 25 December 1999.

        Major parameters for the measurement configuration are as follows;

Laser source :	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wave length :	905 +-5 nm at 25deg-C
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

(4) Preliminary results

        The results will be public after the analysis.

(5) Data archives

        Ceilometer data obtained during this cruise will be submitted to the DMO (Data Management Office), JAMSTEC and will be under their control.

3.2 Physical Parameters

3.2.1 CTD/Carousel Observation with Fluorometer, Transmissometer.

Masayuki Fujisaki 1), Nobuharu Komai 1), Hiroaki Muraki 1), Tsutomu Iwashita 1)

Tak Kawano 2)

1) Marine Works Japan Ltd.

2) Japan Marine Science and Technology Center (JAMSTEC)

a) Objectives:

To measure vertical profiles of temperature, salinity, fluorescence, active fluorescence and PAR in the central equatorial Pacific using by CTD with Fluorometer and FRRF(Fast Repetion Rate Fluorometer) and PAR(Photocynthesis Available Radiation) sensor.

b) Method:

b-1) **SBE911plus shallow cast to 200 meters depth with fluorometer, FRRF and PAR sensor.**

We observed vertical profile of conductivity, temperature, fluorescence, and active fluorescence and PAR from surface to 200m by CTD system with Carousel water sampling System. FRRF and PAR sensor were attached on the CTD/Carousel frame.

24 places Carousel sampler with 30 liters Niskin bottle were deployed at each station for the chemical analysis of general water properties. Water sampling were made during up cast by sending command from computer.

CTD/Carousel were deployed and recovered from the stern of R/V MIRAI using A-frame. The decent rate was 0.5 m/s. After a cast, CTD/Carousel was lifted down from upper deck to the Water Drawing Room on 2nd deck and sea water was drawn from each bottle.

The TS data was processed by DATCNV, ROSSUM, SECTION, WILDEDIT and BINAVG version 4.232 provided by Sea-Bird Electronics, Inc. We made 1 meter averaged bin data for down cast and up cast.

b-2) **SBE911plus full depth cast**

Deep cast were conducted by the same SBE911plus underwater unit without FRRF and PAR sensor from the stern. At five stations, stn.01, stn.03, stn.06, stn.09, stn.12, the CTD was deployed to 10 meters above sea floor. In case that it was deeper than 4500m, we deployed to 4500m, so it was maximum wire length.

The operation and data processing were also same as the shallow cast as stated above. The decent rate ranged 0.8 m/s to 1.5 m/s depending stability of decent rate.

c) Instruments

Specification of the sensors were listed below.

CTD:SBE 911plus CTD system

Under water unit: CTD 9plus (S/N 0280, Sea-Bird Electronics, Inc.)

Temperature sensor: SBE3-04/F Primary Sensor (S/N 031524, Sea-Bird Electronics, Inc.)

Conductivity sensor: SBE4-04/0 Primary Sensor (S/N 041202, Sea-Bird Electronics, Inc.)

Fluorometer: Seapoint Chlorophyll Fluorometer (S/N 2148 Seapoint Sensors, Inc.)

F.R.R.F.: F.R.R.F.(S/N 182026 CHELSEA INSTRUMENT LTD)

PAR sensor: PAR sensor (S/N 046036 CHELSEA INSTRUMENT LTD)

Deck unit: SBE11(Sea-Bird Electronics, Inc.)

Altimeter: MODEL 2110-2 (S/N 206, BENTHOS Inc.)

d) Result

Vertical profiles of temperature, salinity, density and fluorescence at each station were shown in Figures.

Sea surface temperature (SST) was ca. 30 deg-C at stn.01-06. SST decreased as going to eastward. And salinity in vicinity of surface exceed 35.0 PSU.

The maximum of fluorescence was distributed from 60m to 90m depth at stn.01 and stn.02. After stn.03, however, the maximum layer distributed widely.

e) **File Name List**

Stn.	Cast	File name	Start	Position	Start (UTC)	
		(raw data)	Latitude	Longitude	Date	Time
1	Deep	0001L01	04-03.88N	135-04.29E	1999/11/23	06:22
1	Shallow 1	0001L02	04-02.96N	135-00.14E	1999/11/23	18:02
1	Shallow 2	0001L03	04-02.88N	135-00.40E	1999/11/24	00:40
1	Shallow 3	0001L04	04-02.52N	134-59.99E	1999/11/24	7:28
2	Shallow 4	0002L01	05-02.71N	140-07.24E	1999/11/26	00:28
3	Deep	0003L01	00-00.34S	144-59.91E	1999/11/27	08:27
3	Shallow 1	0003L02	00-00.50S	145-06.07E	1999/11/27	17:54
3	Shallow 2	0003L03	00-00.62S	144-59.96E	1999/11/28	00:26
3	Shallow 3	0003L04	00-01.43S	145-00.46E	1999/11/28	08:48
4	Shallow 4	0004L01	00-00.18N	152-01.20E	1999/11/30	00:32
5	Shallow 4	0005L01	00-00.00N	157-20.60E	1999/11/30	23:34
6	Shallow 1	0006L01	00-00.46N	160-01.32E	1999/12/1	16:58
6	Shallow 2	0006L02	00-03.22N	159-56.74E	1999/12/1	23:27
6	Shallow 3	0006L03	00-02.63N	159-56.41E	1999/12/2	07:19
6	Deep	0006L04	00-02.78N	159-55.48E	1999/12/2	10:00
7	Shallow 4	0007L01	00-00.01N	166-32.91E	1999/12/3	23:34
8	Shallow 4	0008L01	00-00.01S	171-42.98E	1999/12/4	22:33
9	Shallow 1	0009L01	00-01.54N	174-42.77E	1999/12/5	15:04
9	Shallow 2	0009L02	00-03.05N	174-54.07E	1999/12/5	23:04
9	Deep	0009L03	00-02.75N	174-54.01E	1999/12/5	01:31
9	Shallow 3	0009L04	00-02.18N	174-55.58E	1999/12/6	06:45
10	Shallow 4	0010L01	00-02.24S	178-05.47E	1999/12/6	23:01
11	Shallow 4	0011L01	00-00.32S	176-41.70W	1999/12/7	23:00
12	Shallow 3	0012L01	00-03.72N	170-08.51W	1999/12/9	03:29
12	Deep	0012L02	00-04.15N	170-09.31W	1999/12/9	06:04
12	Shallow 1	0012L03	00-01.99N	170-07.60W	1999/12/9	14:58
12	Shallow 2	0012L04	00-00.18S	170-12.12W	1999/12/9	21:19
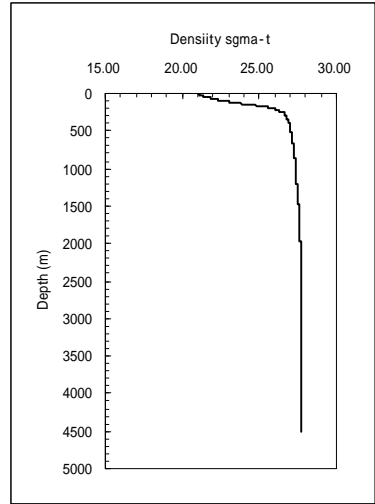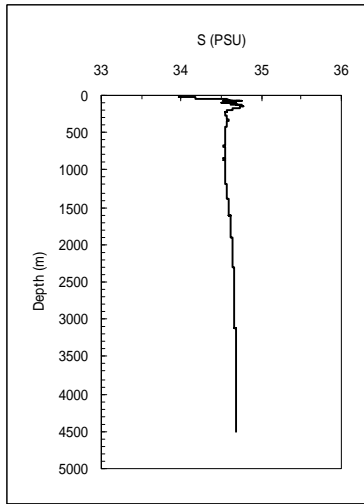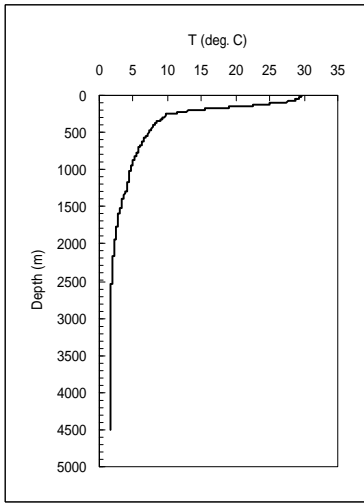
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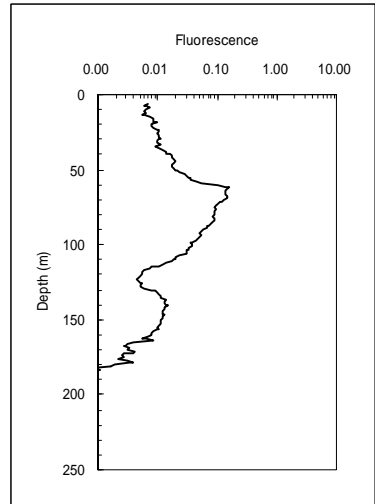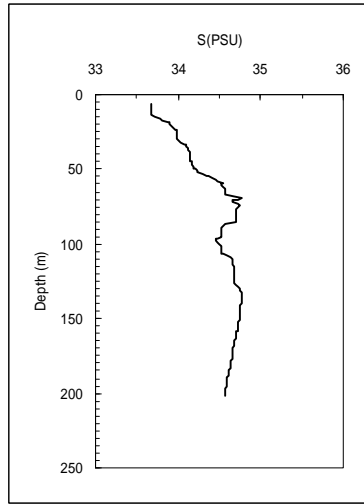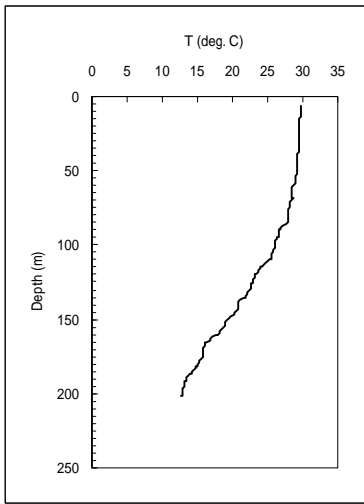
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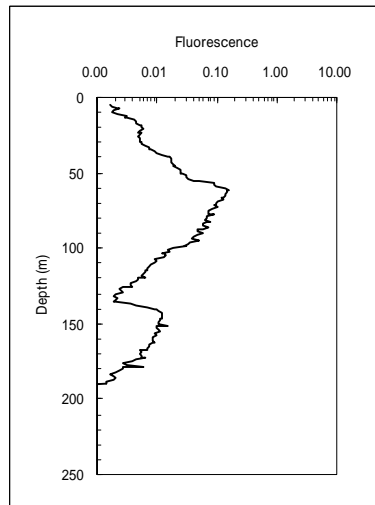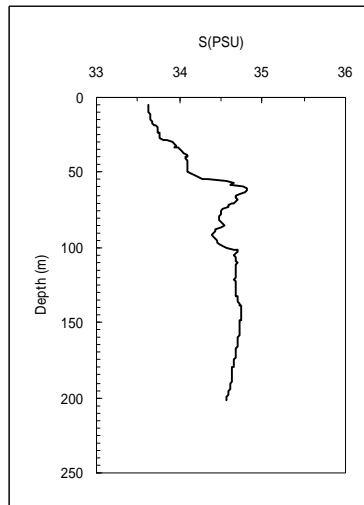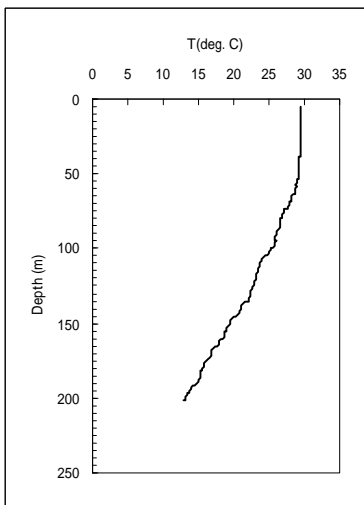
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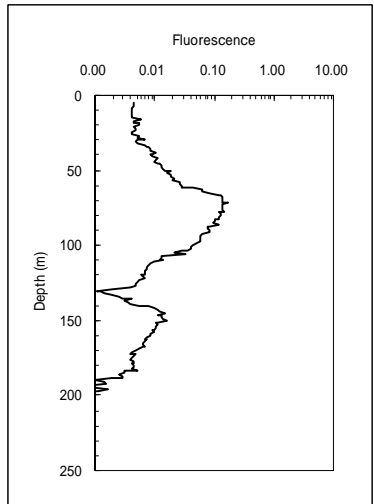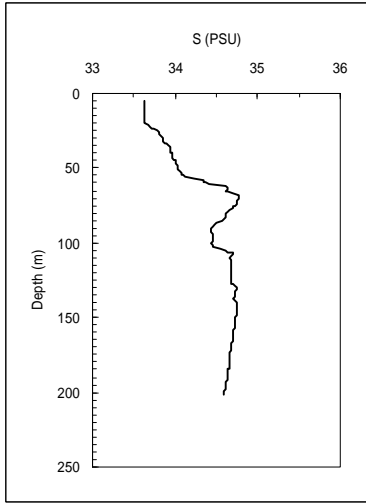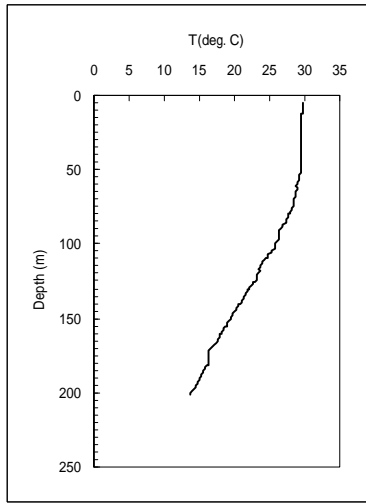
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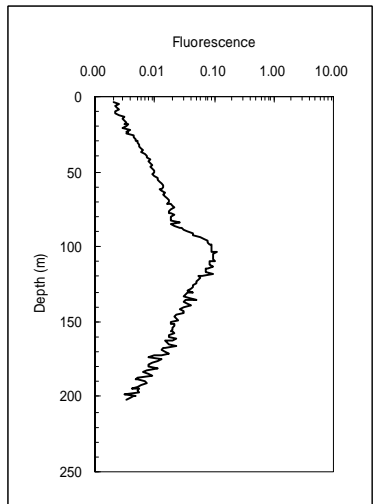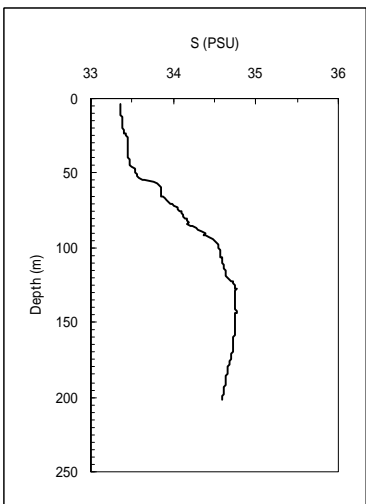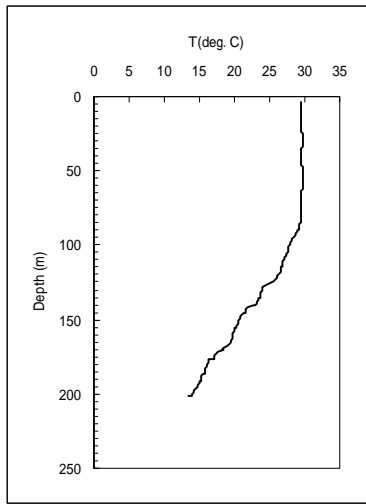
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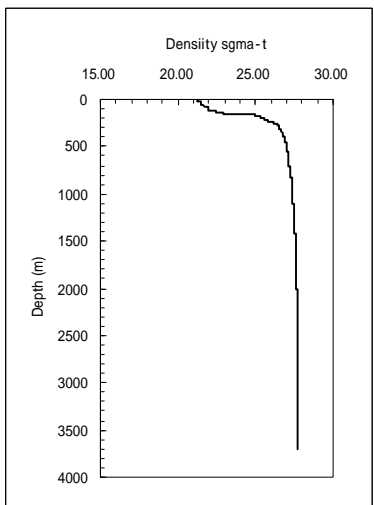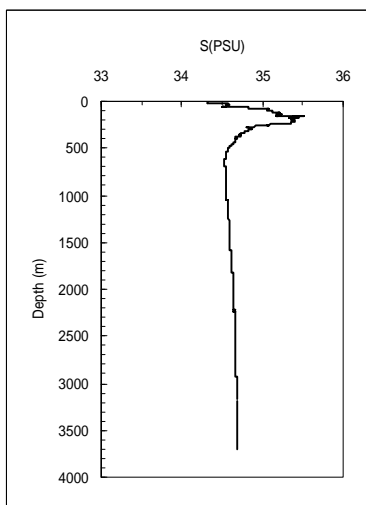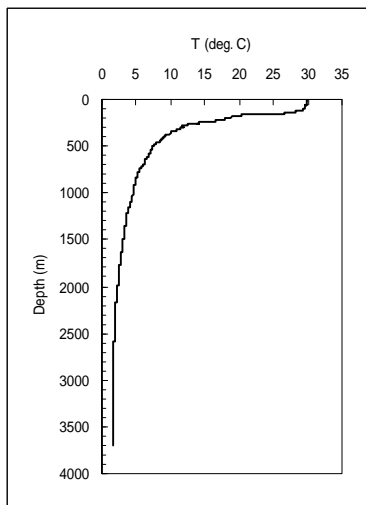
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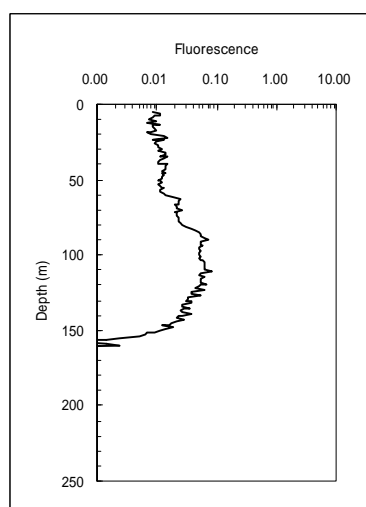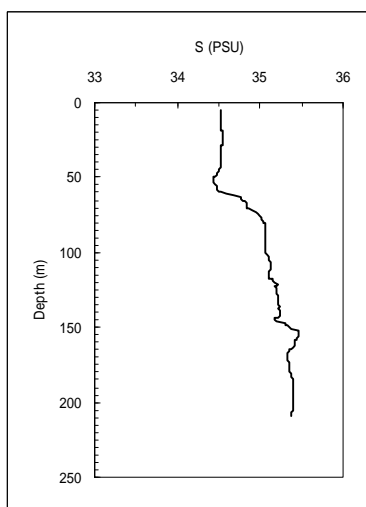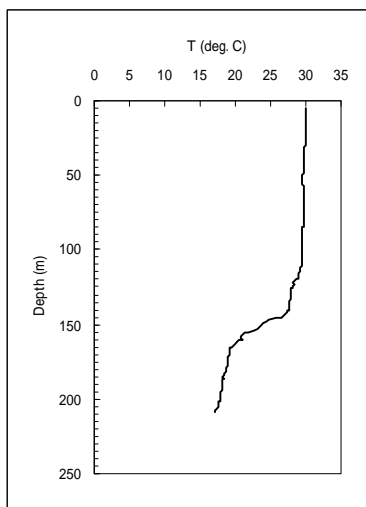
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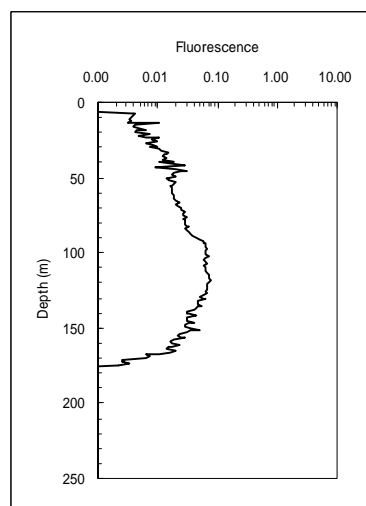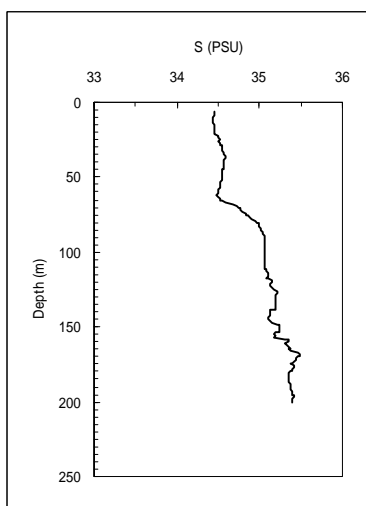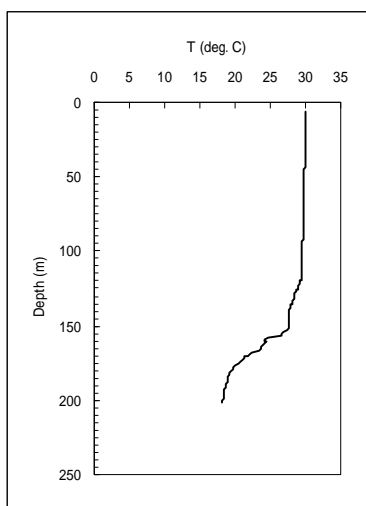
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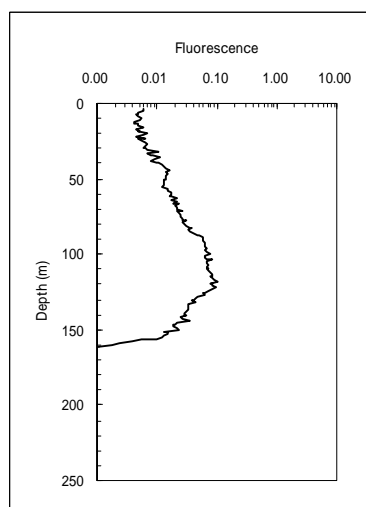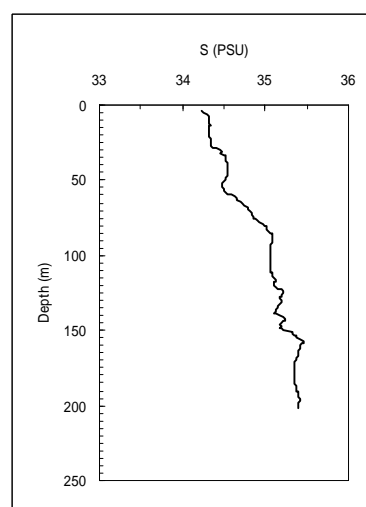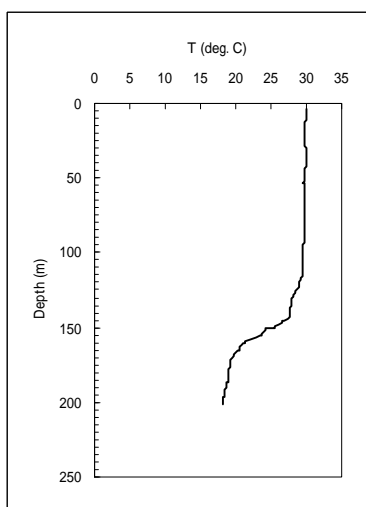
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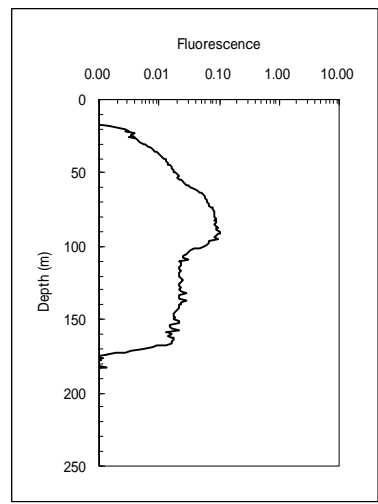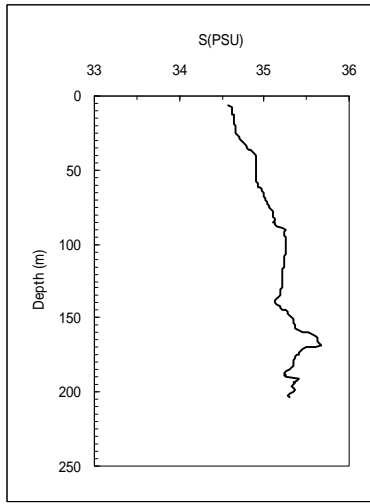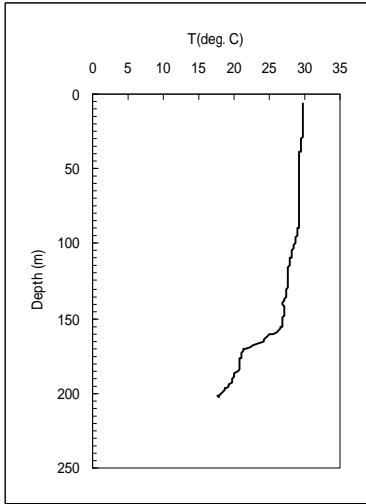
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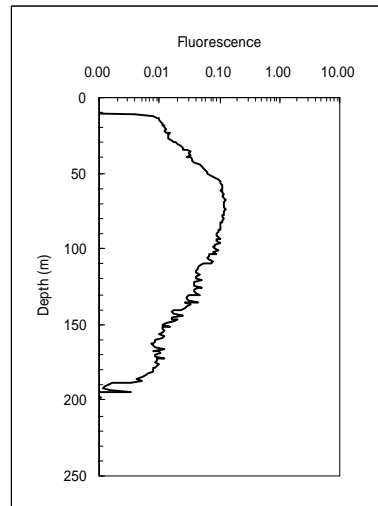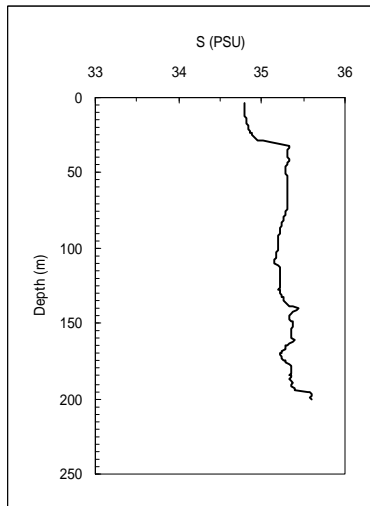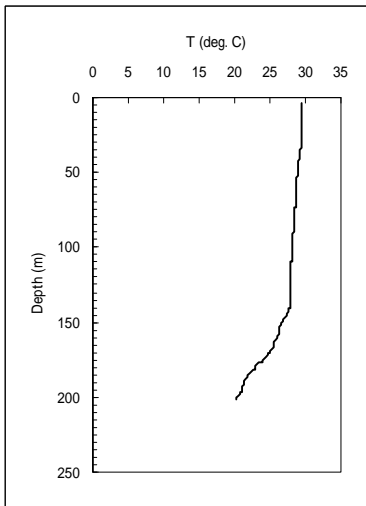
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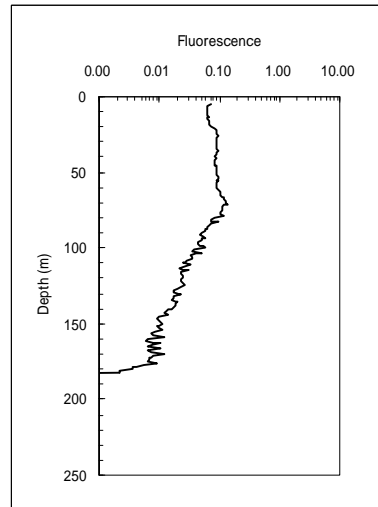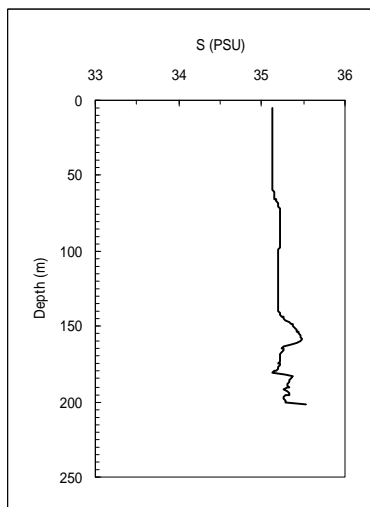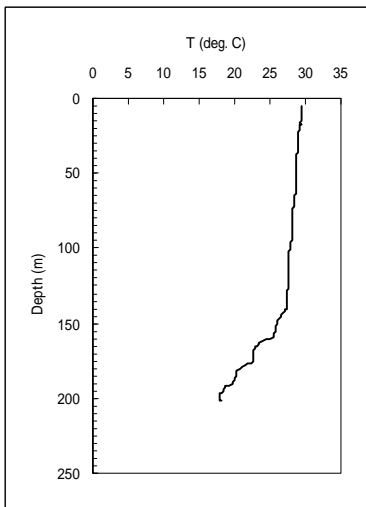
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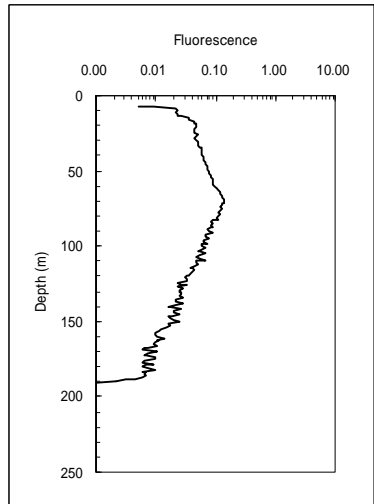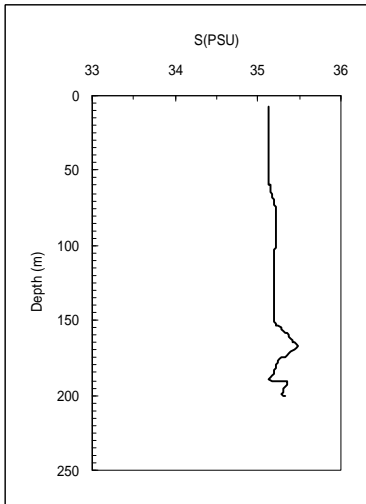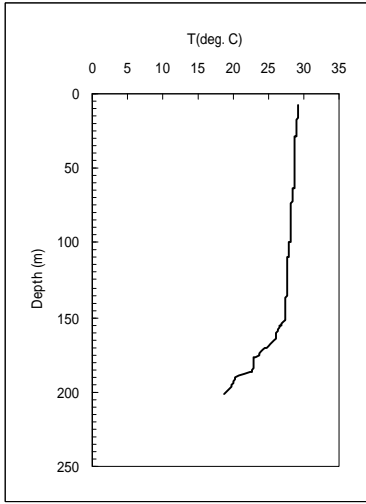
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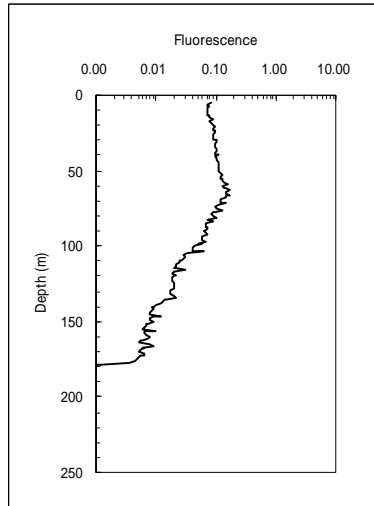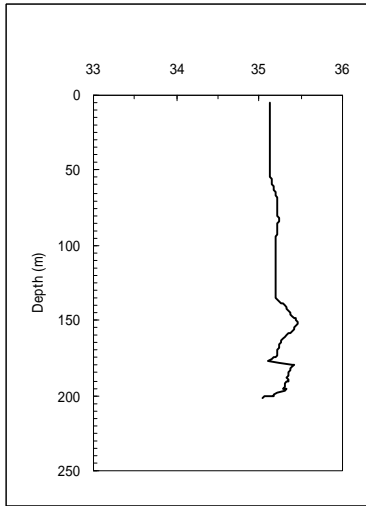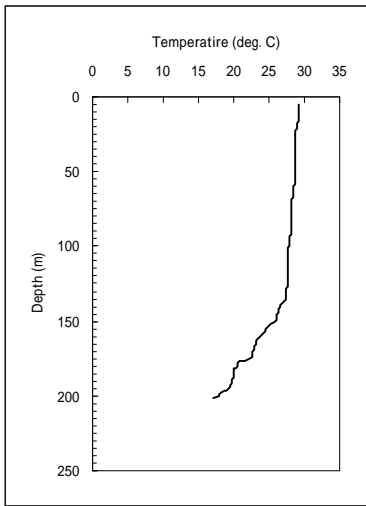
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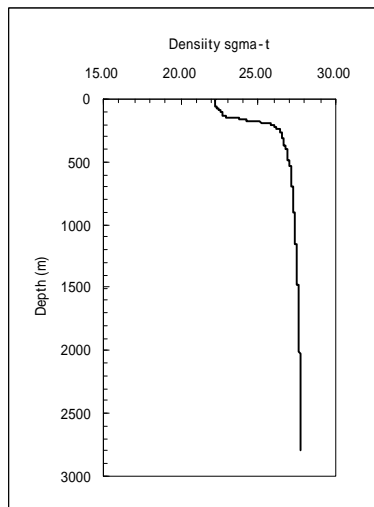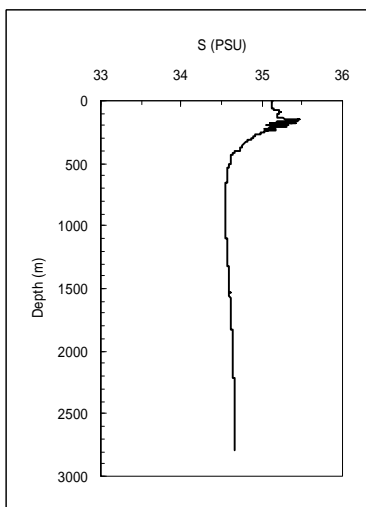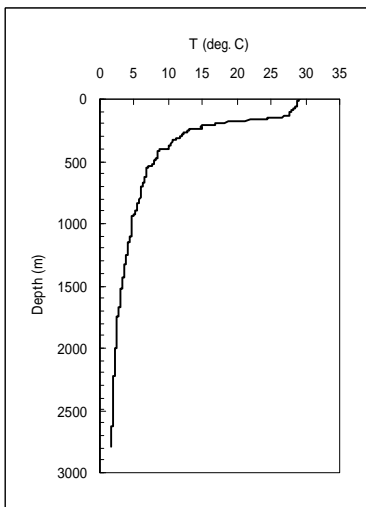
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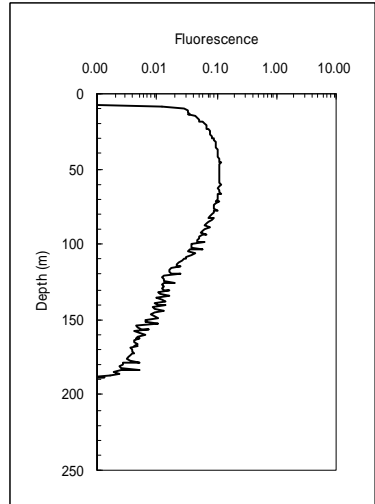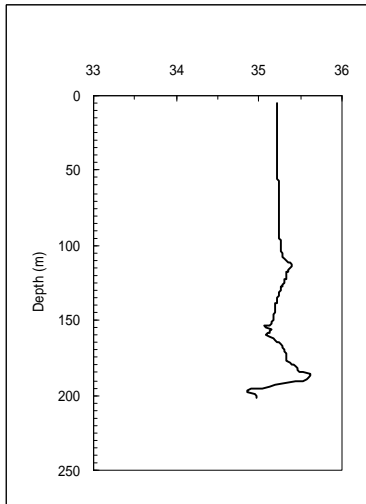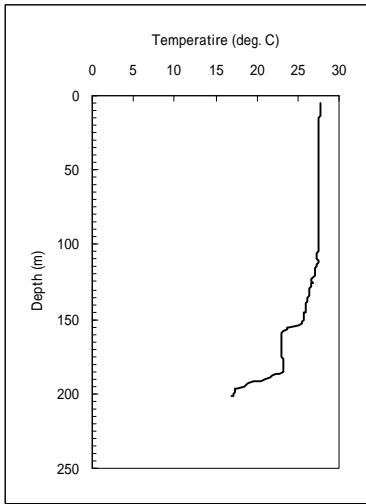
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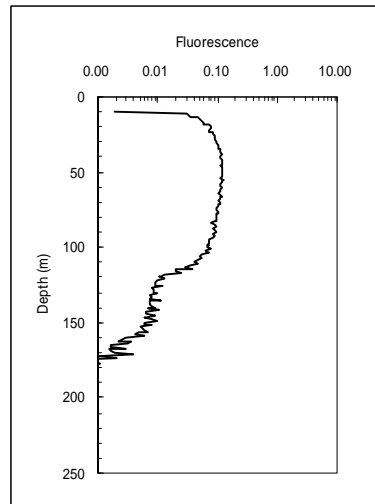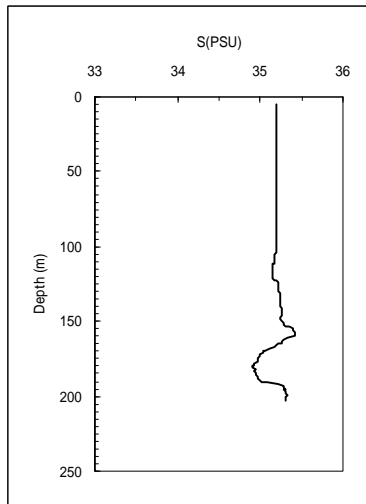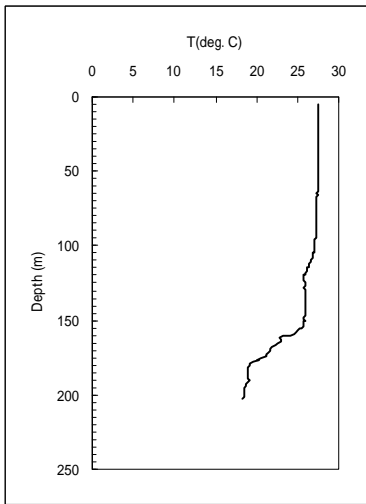
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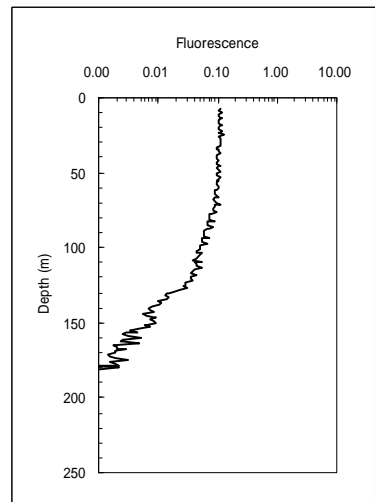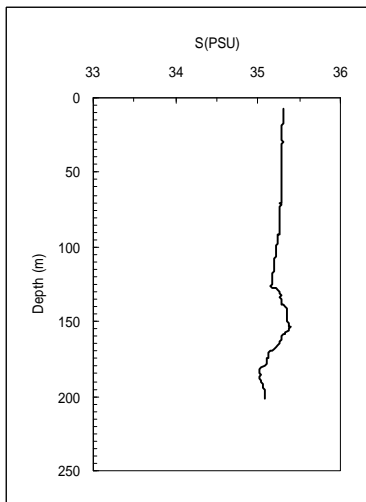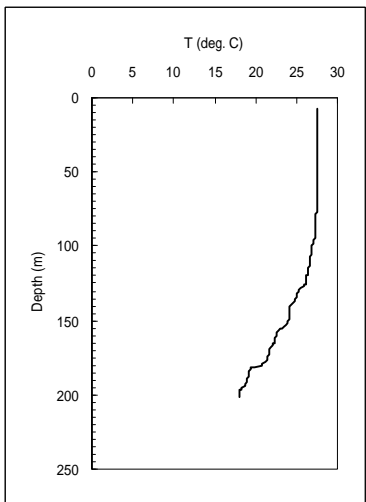
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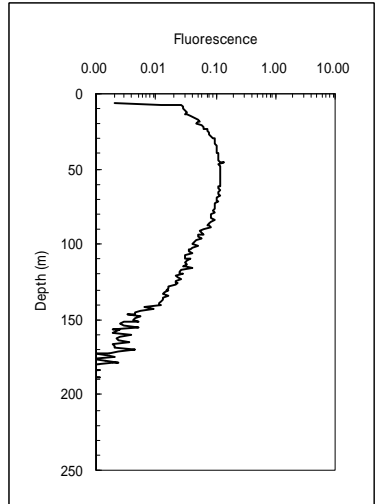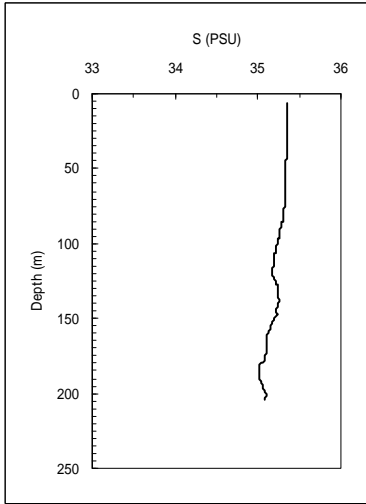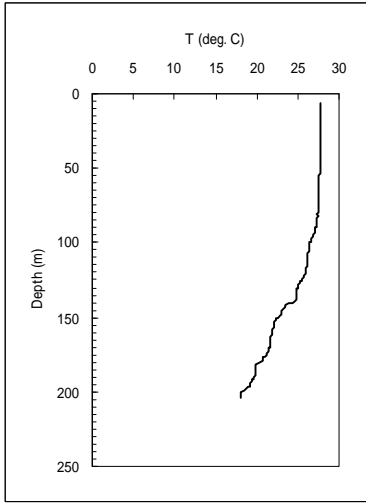
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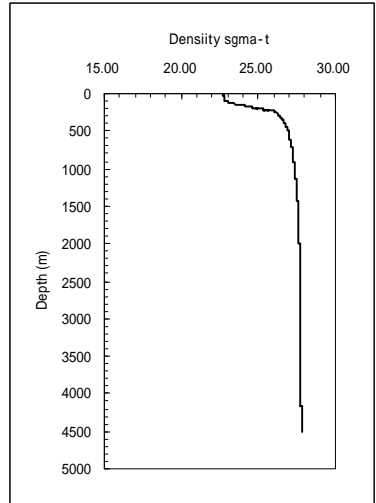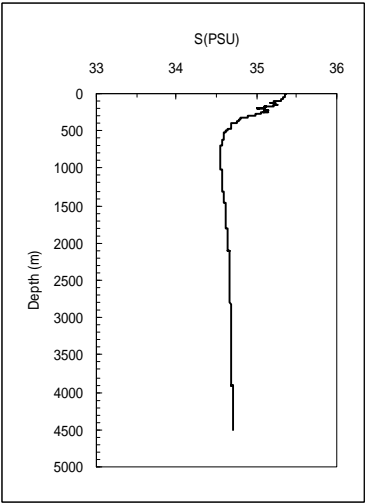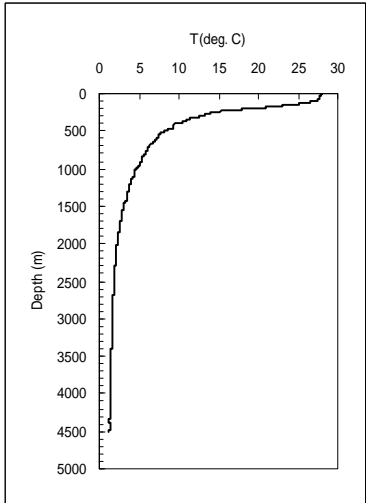
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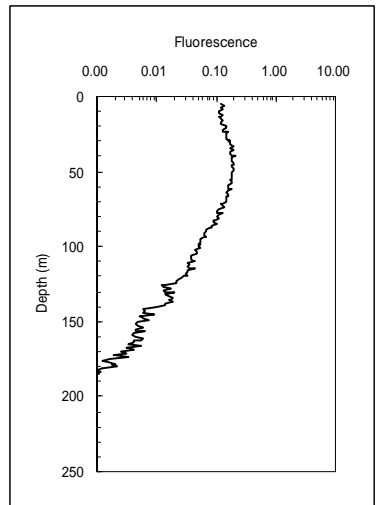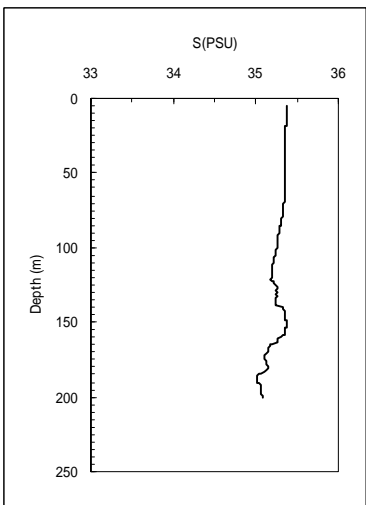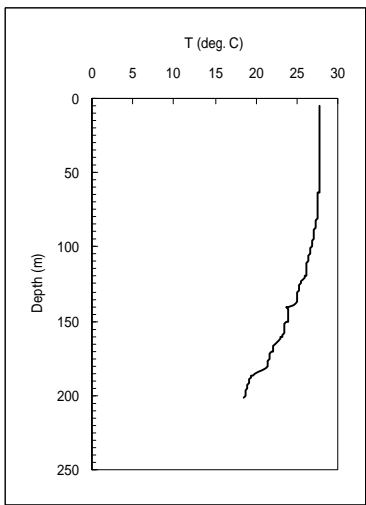
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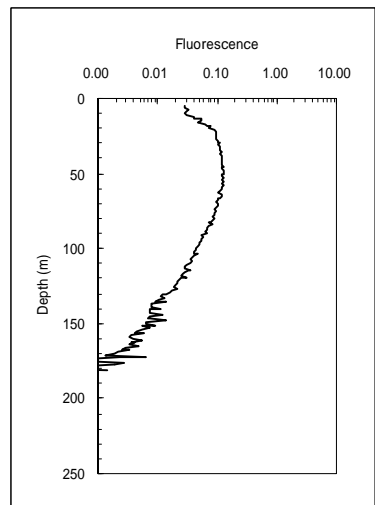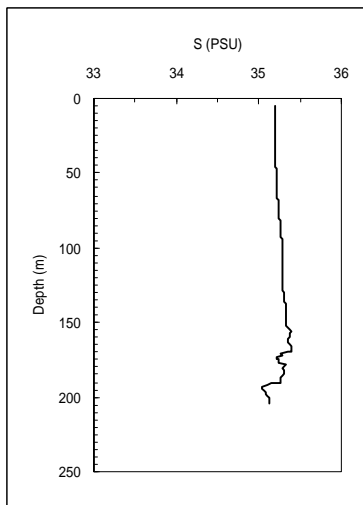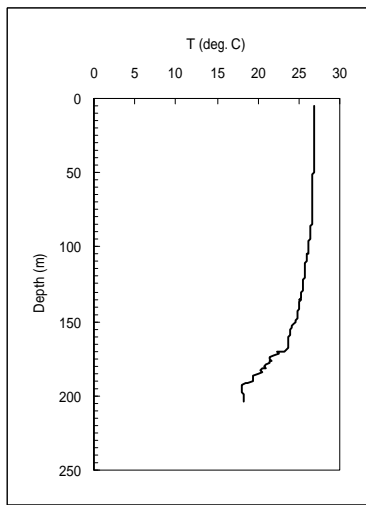
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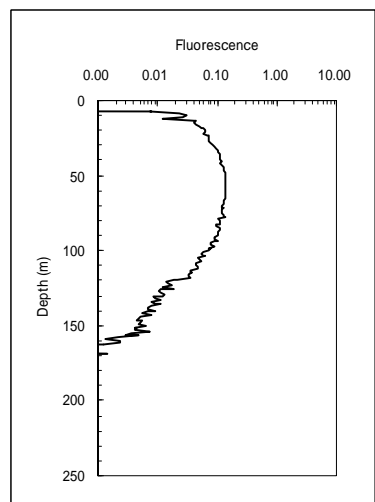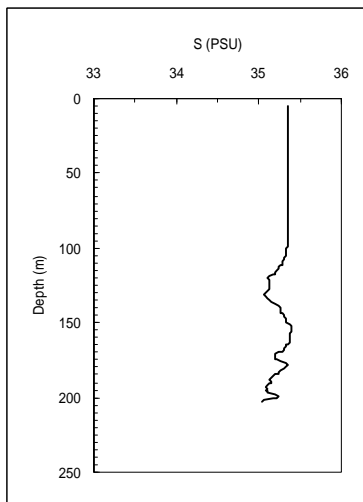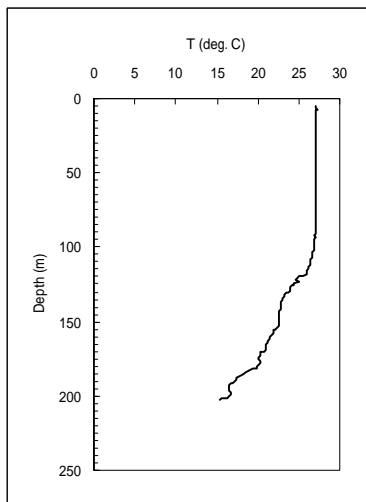
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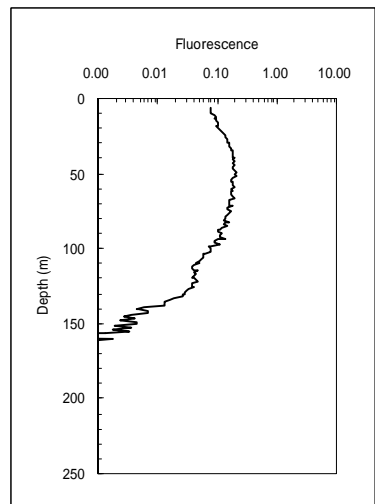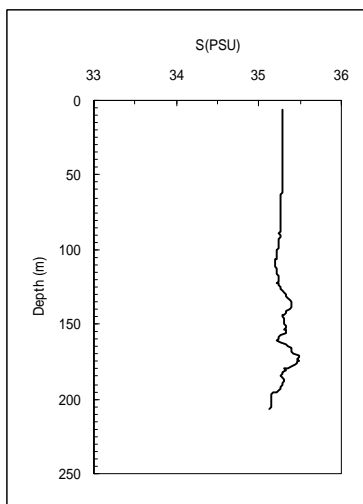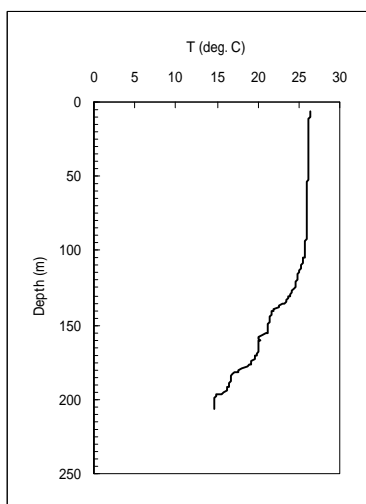
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T (deg C)
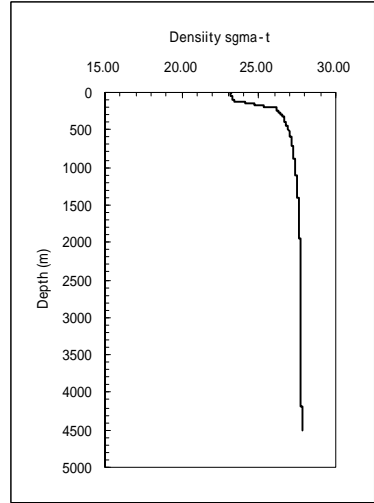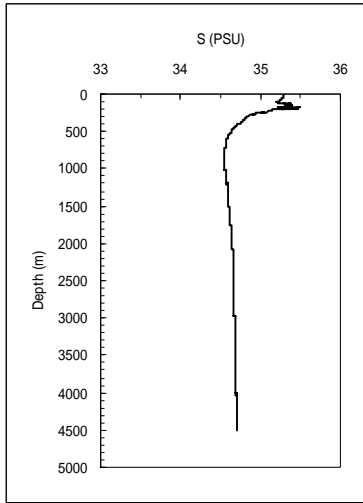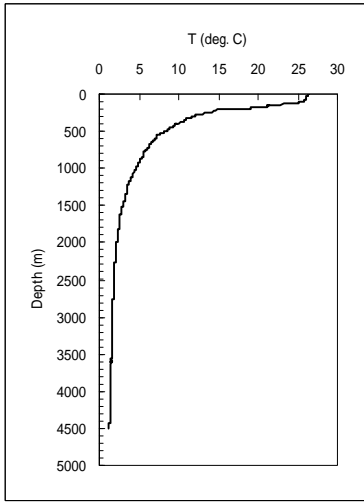
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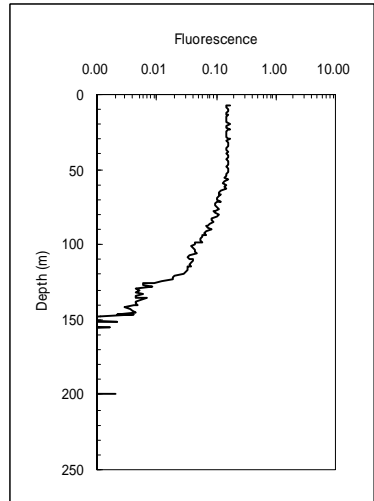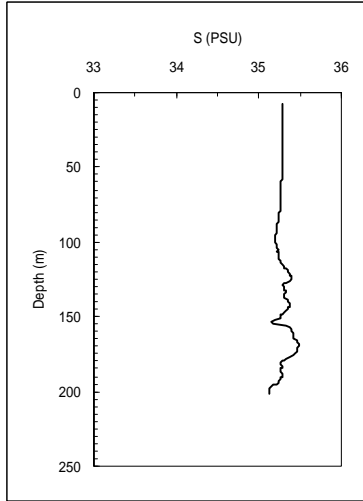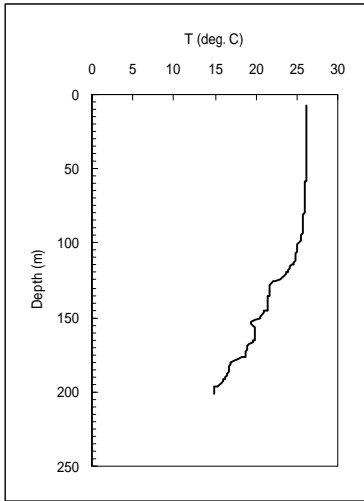
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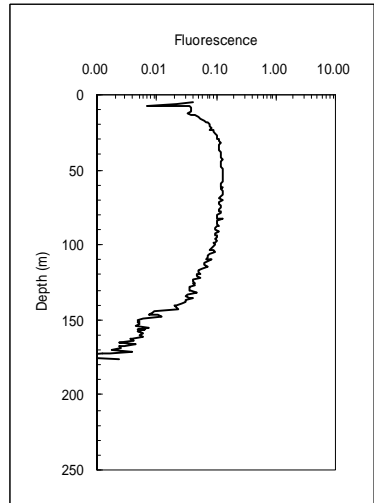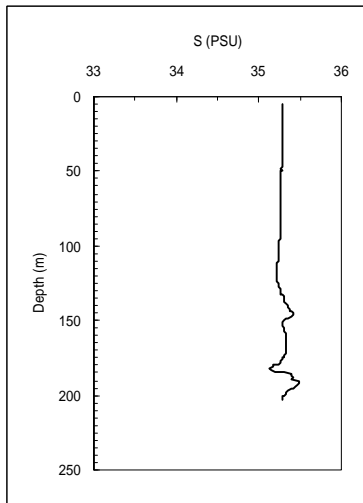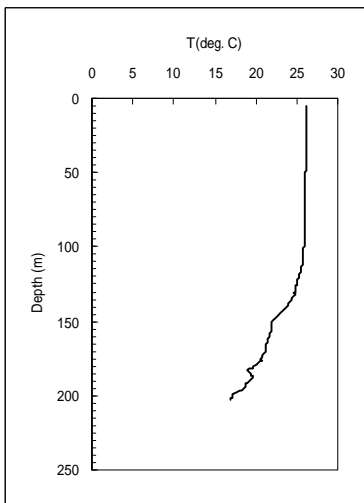
Stn.12 Shallow Cast 2

3.2.2 XCTD

(1) Personnel

       Takeshi Kawano (JAMSTEC): Principal Investigator

       Fumitaka   Yoshiura (GODI):   Operation Leader

       Naoto Morioka (Mirai crew)

(2) Parameters

       According to the manufacturer's information, the range and accuracy of parameters measured by the XCTD are as follows;

Parameter	Range	Accuracy
Conductivity	0 – 70 mS/cm	+/- 0.03 mS/cm
Temperature	-2 – 35 deg-C	+/- 0.02 deg-C
Depth	0 – 1000 m	

(3) Methods

       We observed the vertical profiles of the sea water measured by XCTD. The signal was converted by MK-100, Tsurumi Seiki and was recorded by WinXCTD software   Ver.1.02   made by Tsurumi Seiki.   Table 3.2.2-1 shows the summary of XCTD observation log.

Table 3.2.2-1 XCTD observation log

No.	Date	Lat.	Log.	Current Direction deg	Current Speed knt
1	1999/11/28 20:33	00-01.17S	145-01.31E	35	0.6
2	1999/11/29 0:25	00-01.06S	146-00.04E	168	0.2
3	1999/11/29 4:56	00-01.93S	147-00.58E	213	0.4
4	1999/11/29 8:52	00-00.45S	148-00.00E	264	0.5
5	1999/11/29 12:50	00-00.36S	149-00.01E	302	0.4
6	1999/11/29 16:44	00-00.05S	150-00.02E	328	0.3
7	1999/11/29 20:34	00-00.22N	151-00.03E	77	0.6
8	1999/11/30 0:21	00-00.08N	151-59.88E	66	0.5
9	1999/11/30 5:47	00-00.07N	153-00.00E	357	0.6
10	1999/11/30 9:49	00-00.06N	154-00.01E	328	0.5
11	1999/11/30 13:50	00-00.01S	155-00.01E	284	0.8
12	1999/11/30 17:55	00-00.26N	155-59.99E	325	0.8
13	1999/11/30 20:00	00-00.00N	156-59.99E	247	0.5
14	1999/12/1 3:40	00-00.00S	158-00.01E	289	0.7
15	1999/12/1 7:44	00-00.03S	159-00.01E	252	0.5
16	1999/12/2 20:15	00-01.03S	160-01.02E	220	0.7
17	1999/12/3 0:21	00-00.02S	161-00.02E	255	0.9
18	1999/12/3 4:36	00-00.10S	161-59.98E	256	0.8
19	1999/12/3 12:50	00-00.18N	164-00.02E	316	0.8
20	1999/12/3 21:07	00-00.36S	166-00.01E	264	0.7
21	1999/12/4 7:05	00-00.04S	168-00.01E	236	0.7
22	1999/12/4 15:20	00-00.03N	170-00.80E	274	0.8
23	1999/12/5 1:13	00-00.01S	172-00.00E	280	1.1
24	1999/12/5 9:44	00-00.08S	174-00.01E	299	0.8
25	1999/12/6 13:49	00-00.01S	176-00.65E	278	1.1
26	1999/12/6 22:24	00-00.05S	177-59.99E	246	1.5
27	1999/12/7 9:02	00-00.00N	179-59.99E	280	1.4
28	1999/12/7 17:33	00-00.05S	178-00.01W	300	0.7
29	1999/12/8 3:10	00-00.05S	175-59.99W	257	0.3
30	1999/12/8 11:16	00-00.20S	173-59.67W	210	0.6
31	1999/12/8 19:27	00-00.02S	172-00.05W	252	1.4
32	1999/12/10 5:31	00-06.61N	170-07.84W	331	1.1

(4) Preliminary results

   Some contour of XCTD data combined with CTD data are shown in the following figures.
Fig 3.2.2-1 and Fig 3.2.2-2 are temperature and salinity plots along the equator.

(5) Data archives

   XCTD data obtained during this cruise will be submitted to the DMO (Data Management
Office), JAMSTEC and will be under their control.

SALINITY (PSU)

MR99K7 1999/11/28 - 1999/12/10

Fig.3.2.2.1   Verical Section of Salinity

TEMPERATURE (C)

MR99K7 1999/11/28 - 1999/12/10
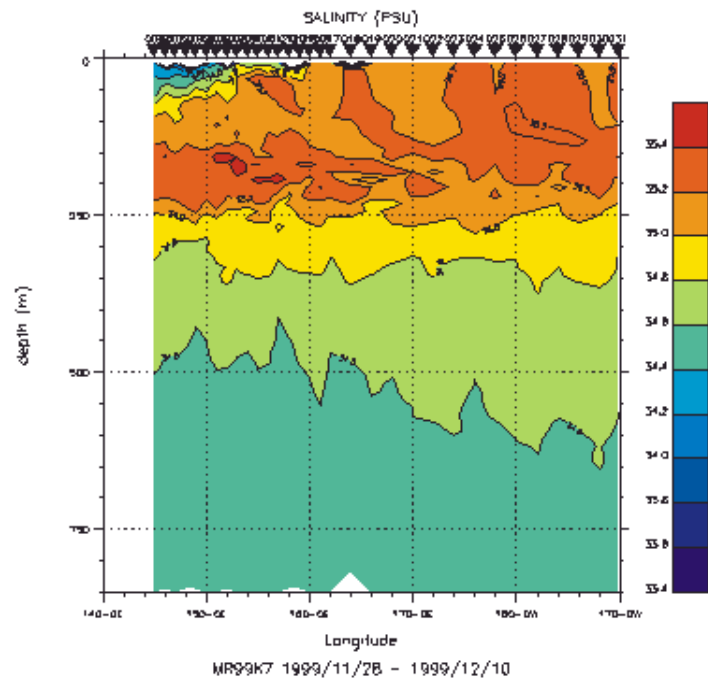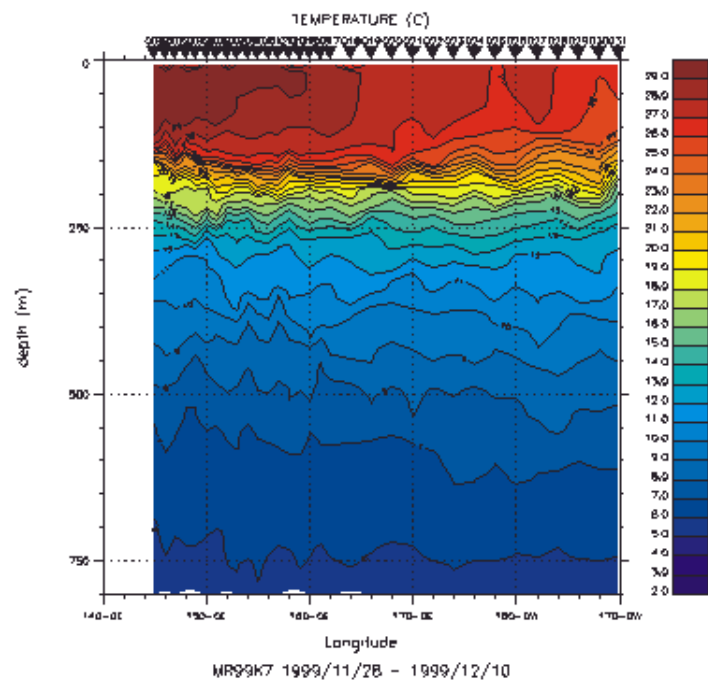
Fig.3.2.2.2 Vertical Section of Temperature

3.2.3 Shipboard ADCP

(1) Personnel

      Fumitaka Yoshiura (GODI): Operation Leader

(2) Parameters

  (2-1) N-S (North-South) and E-W (East-West) velocity components of each depth cell [cm/s]

  (2-2) Echo intensity of each depth cell [dB]

(3) Methods

      We measured current profiles by VM-75 (RD Instruments, Inc. U.S.A.) shipboard ADCP (Acoustic Doppler Current Profiler) throughout MR99-K07 cruise from the departure of Guam, U.S.A. on 21 November 1999 to the day before arrival of Shimonoseki, Japan on 25 December 1999.

      Major parameters for the measurement configuration are as follows;

Frequency :	75 kHz
Average :	every 300 sec
Depth cell length :	1600 cm
No. of depth cells :	40
First depth cell position :	30.9 m
Last depth cell position :	654.9 m
ADCP ensemble time :	32.4 sec
Ping per ADCP raw data :	16

(4) Preliminary results

      Two-hourly current vectors of 2-hour running mean averaged data are plotted (Fig3.2.3-1 and -2: from Guam to Honolulu; Fig 3.2.3-3 and -4: from Honolulu to Shimonoseki . We could not plot whole cruisedata in one sheet because of the software limitation.

(5) Data archives

      ADCP data obtained in this cruise will be submitted to the DMO (Data Management Office), JAMSTEC and will be under their control.
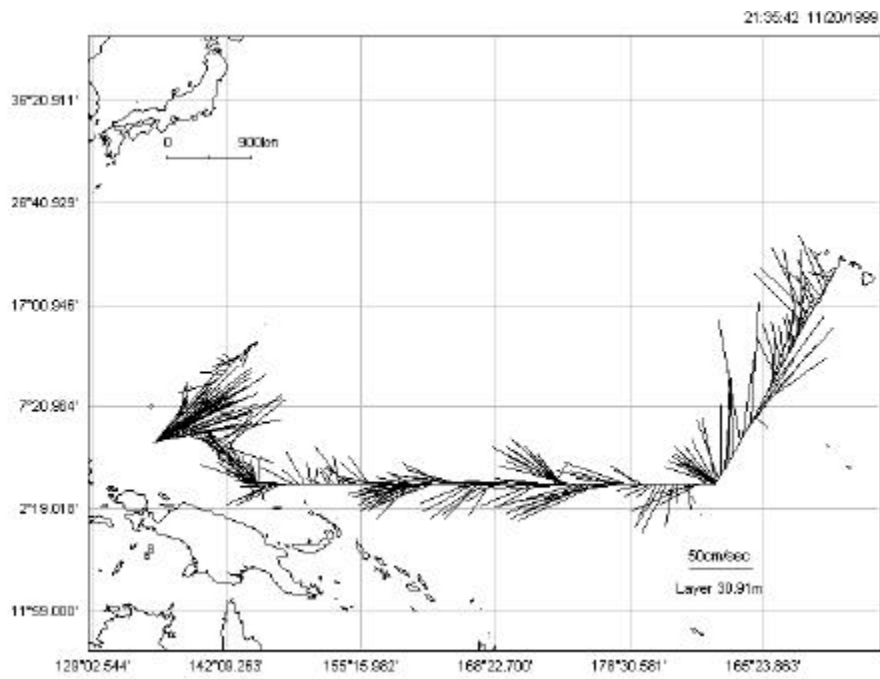
Fig.3.2.3.1 Current Velocity at 30m
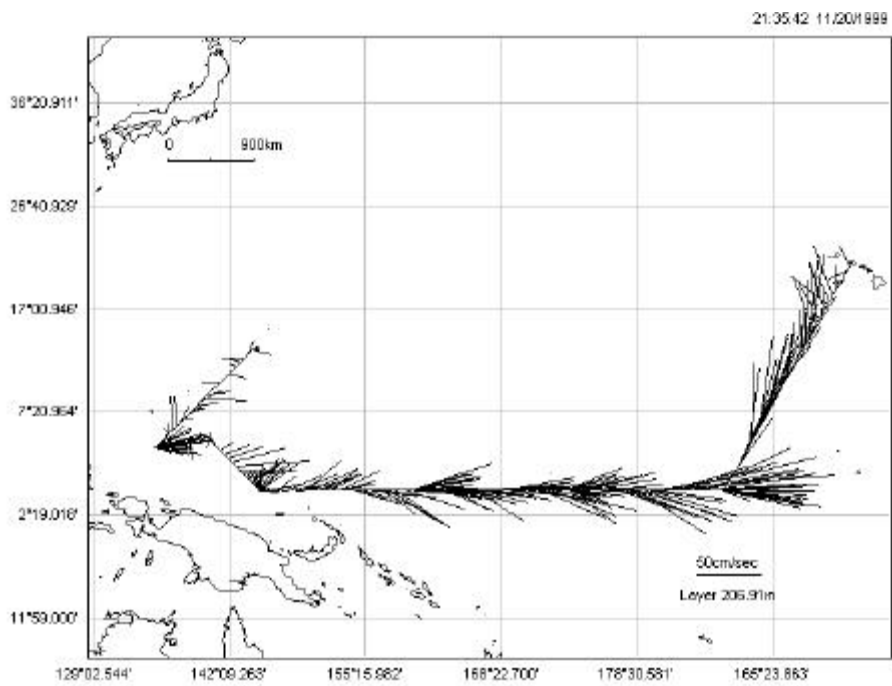
Fig.3.2.3.2 Current Velocity at 206m
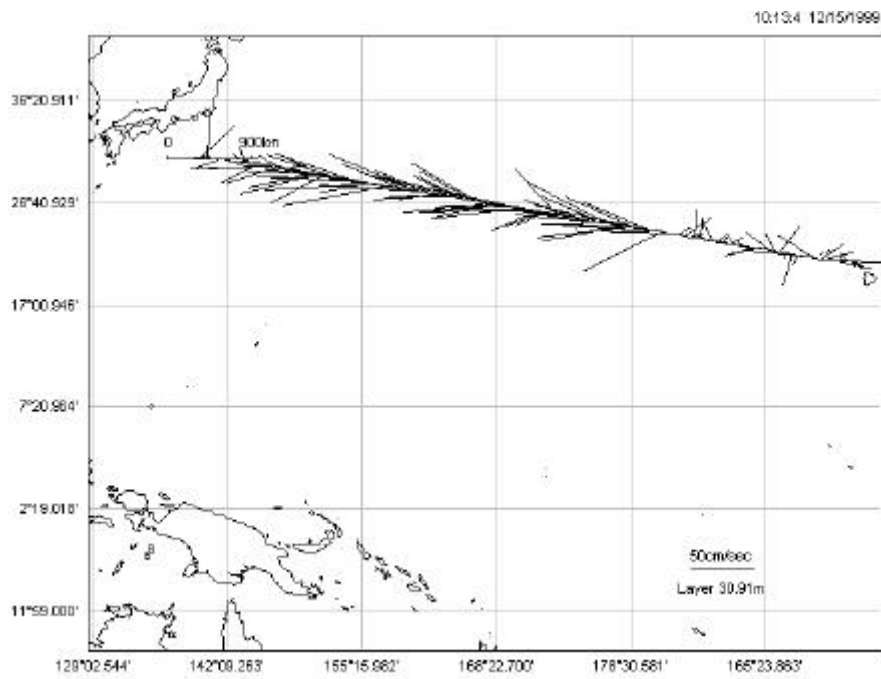
Fig.3.2.3.3 Current Velocity at 30m
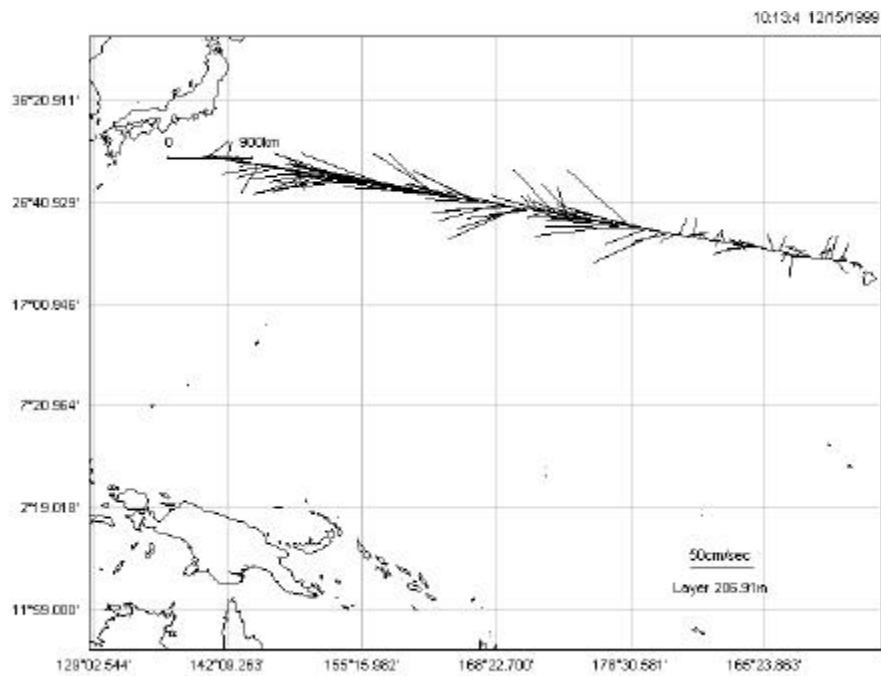
Fig.3.2.3.4 Current Velocity at 206m

3.3 Chemical Parameters

3.3.1 Dissolved Oxygen Measurement

Nobuharu Komai and Hiroaki Muraki

1-1-7 Mutsuura, Kanazawa-ku, Yokohama 236 Japan

(Marine Works Japan Ltd.)

Objective

 Precise determination of D.O. using the Winkler titraiton with potentiometric detection. Clarification of the vertical transection of D.O. concentration in the Western Equatorial Pacific.

Instruments and Methods

(a) Instruments and Apparatus

Glass bottle : Glass bottle for D.O. measurements consist of the ordinary BOD flask (ca.180ml) and glass stopper with long nipple, modified from the nipple presented in Green and Carritt (1966).

Dispenser : Eppendorf Comforpette 4800 / 1000µl (dispensed for the 1 ml of H_2SO_4 and standard KIO_3 solution)

OPTIFIX / 2 ml (dispensed for the picking reagents)

Metrohm Model 725 Multi Dosimat / 20 ml of titration vessel (dispensed for the standard KIO_3 solution)

Titrator : Metrom Model 716 DMS Titrino / 10 ml of titration vessel (resolution of titration is 0.001 ml)

Metrom Pt Electrode / 6.0403.100 (NC)

Software : Data acquisition and endpoint evaluation / Metrohm, METRODATA / 606013.000

(b) Methods

(b-1) Sampling

The preparation of reagents and the analytical method were fundamentally done according to the WHP Operation and Methods (Culberson, 1991, Dickson, 1994). Seawater samples for dissolved oxygen measurement were collected from 30 L Niskin bottles to calibrated dry glass bottles. During each sampling, 3 bottle volumes of seawater sample were overflowed to minimize contamination with atmospheric oxygen and the seawater temperature at the time of collection was measured for correction of the sample volume.

After the sampling, 1 ml each of the $MnCl_2$ and NaOH/NaI reagents was immediately added into the seawater and the sample bottle was capped and shaken vigorously. After the precipitation in the samples has settled, they were shaken a second time to ensure complete oxidation of the precipitant. The bottles were kept at a wood box in the laboratory until titration.

(b-2) D.O. analysis

The samples were analyzed by 2 sets of Metrohm titrators with 10 ml piston buret and Pt Electrode using whole bottle titration. Titration was determined by the potentiometric methods and the endpoint for titration was evaluated by the software of Metrohm, METRODATA (606013.000).

Concentration of D.O. was calculated by equation (8) and (9) of WHP Operations and Methods (Culberson, 1991). Salinity value of the equation (9) was used from the value of salinity of CTD. The amount of D.O. in the reagents was reported 0.0017 ml at 25.5 deg-C (Murray et al., 1968). However in this cruise, we used the value (=0.0027 ml at 21 deg-C) measured at 1995 WOCE cruise of R/V Kaiyo. D.O. concentrations we calculated were not corrected by seawater blank.

Preliminary Result

(a) Comparison of our KIO_3 standards to CSK standard solution

We prepared and used one batch of 5 liter of 0.07N thiosulfate solutions for titrant. And we also prepared two batches of 5 liter of 0.0100N standard KIO_3 solutions (Lot. JM991005 and JM991006) and used for the standardization.

Before this cruise, we compared our standards with CSK standard solution (Lot. DLG8365 and DLG8366) which is the commercially available standard solution prepared by Wako Pure Chemical Industries, Ltd. The results are shown in table 3.3.1-1.

Normality of our standard may be different 0.02 ~ 0.05% from nominal normality.

(b) Titration blanks and standardization

The blank determination and the standardizations have been performed each stations before the sample analysis. The value of thiosulfate standardization of titrator #1 was significantly changed at 21-Dec-99, so we didn't use a titrator #1 since that day.

The pure water blank (titration blank) was determined in deionized water by Milli-RX12, Millipore. The blank results from the presence of redox species apart from oxygen in the reagents which can behave equivalently to oxygen in the analysis. The results were shown in Fig. 3.3.1-1. The average of pure water blank was –0.007 ml (Titrator #1) and -0.008 ml (Titrator #2), respectively.

The results of standardization were shown in Fig. 3.3.1-2. The average of molarity of thiosulfate

solution was 0.07148 mol (Titrator #1) and 0.07127 mol (Titrator #2) with standard deviation was 0.00004 mol and 0.00006 mol, respectively. Titrant of the both titrators were used the same batch of thiosulfate solutions but the each molarity were a little different between the titrators. It may be caused that actual dispense volume of the each titrators were different.

(c) Reproducibility

In this cruise, 307 samples for D.O. samples were collected. 51 pairs (17%) of total samples were analyzed as "replicates" which were collected from same Niskin bottle. These results were shown in Table 3.3.1-2, Fig. 3.3.1-3 and Fig. 3.3.1-4.

Table 3.3.1-2 Result of replicate analysis

	Standard deviation (μmol/kg)	Number of pairs
All samples	0.39	51
Different titrator	0.62	17
Same titrator	0.22	34

In Fig 3.3.1-3, replicate samples whose number was below 21 were titrated by both titrators. So precision of these samples were relatively high (see table 3.3.1-2). The precision of this analysis was evaluated to be 0.39 μmol/kg (one sigma). This is corresponded to 0.19% of D.O. maximum concentration (205.37 μmol/kg) observed in this cruise.

Standard deviation was different when the pairs of replicates were titrated by the different titrator or the same titrator. It may be caused by the different of the calculated molarity between the each titrators.

(d) vertical profile

The vertical profile of D.O. were shown in Fig. 3.3.1-5.

References

Culberson, C.H. (1991) Dissolved Oxygen, in WHP Operations and Methods, Woods Hole., pp1-15

Culberson, C.H., G. Knapp, R.T. Williams and F. Zemlyak (1991) A comparison of methods for the determination of dissolved oxygen in seawater. (WHPO 91-2)

Dickson, A.G. (1994) Determination of dissolved oxygen in sea water by Winkler titration, in WHP Operations and Methods, Woods Hole., pp1-14.

Green, E.J. and D.E. Carritt (1966) An improved iodine determination flask for whole-bottle titrations, Analyst, 91, 207-208.

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

Table 3.3.1-1 Comparison of standards from different KIO3

Kind of KIO3	Nominal normality	Average titer	Standard deviation	n	Ratio to DLG8365	Calculated normality
CSK Lot. DLG8365	0.0100	1.4036	0.0010	9	1.0000	
Lot. 991005	0.010007	1.4049	0.0006	10		
	1.4049/1.0007=	1.4039			1.0002	0.010002
Lot. 991006	0.010000	1.4043	0.0009	10		
	1.4043/1.0000=	1.4043			1.0005	0.010005
Lot. 990715	0.010022	1.4058	0.0007	9		
	1.4058/1.0022=	1.4027			0.9994	0.009994
CSK Lot. DLG8366	0.0100	1.4051	0.0003	9		
	1.4051/1.00=	1.4051			1.0011	0.010011
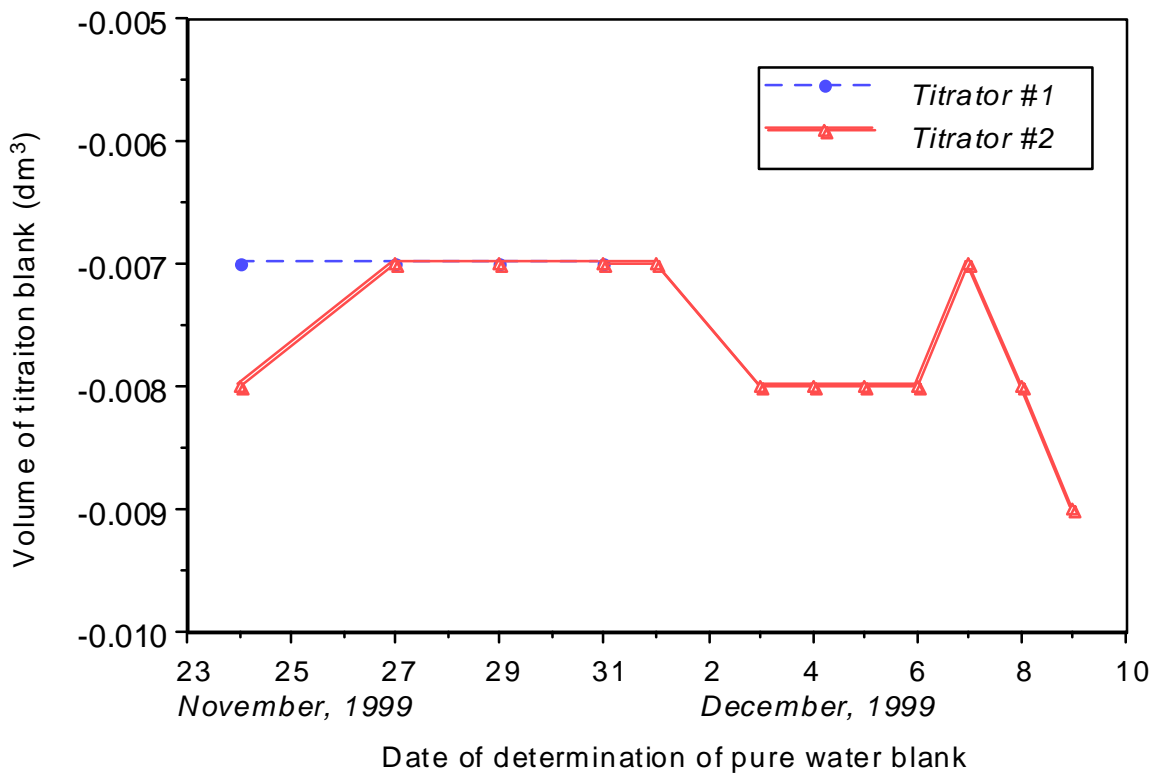
Fig. 3.3.1-1 Results of pure water blank at MR99-K07 cruise.
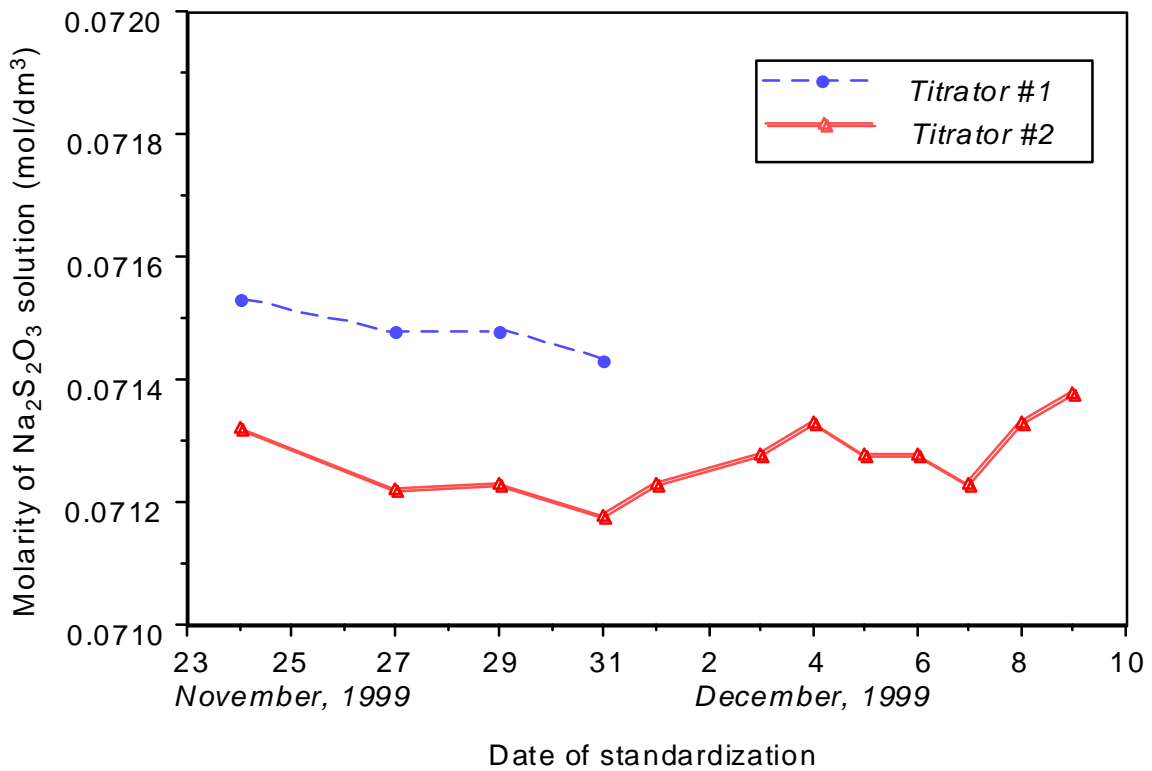
Fig. 3.3.1-2 Results of standardization at MR99-K07 cruise.
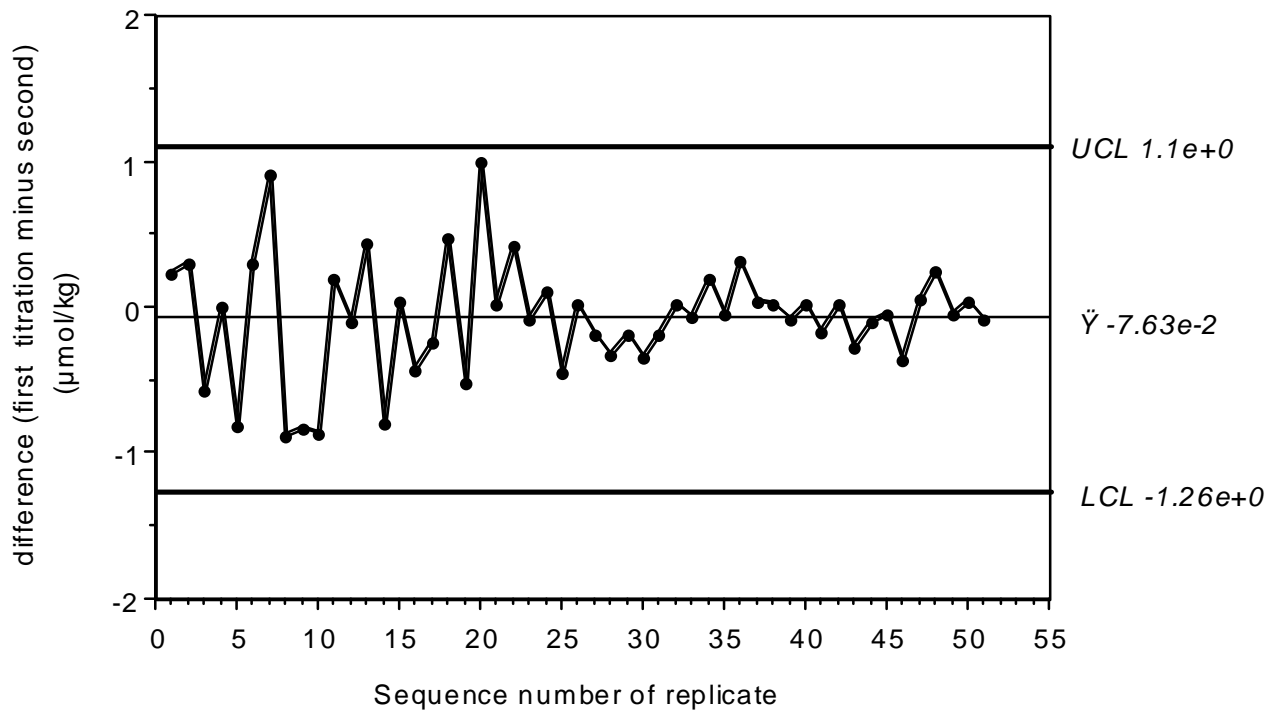
Fig. 3.3.1-3 Control chart of replicate sample at MR99-K07 cruise.
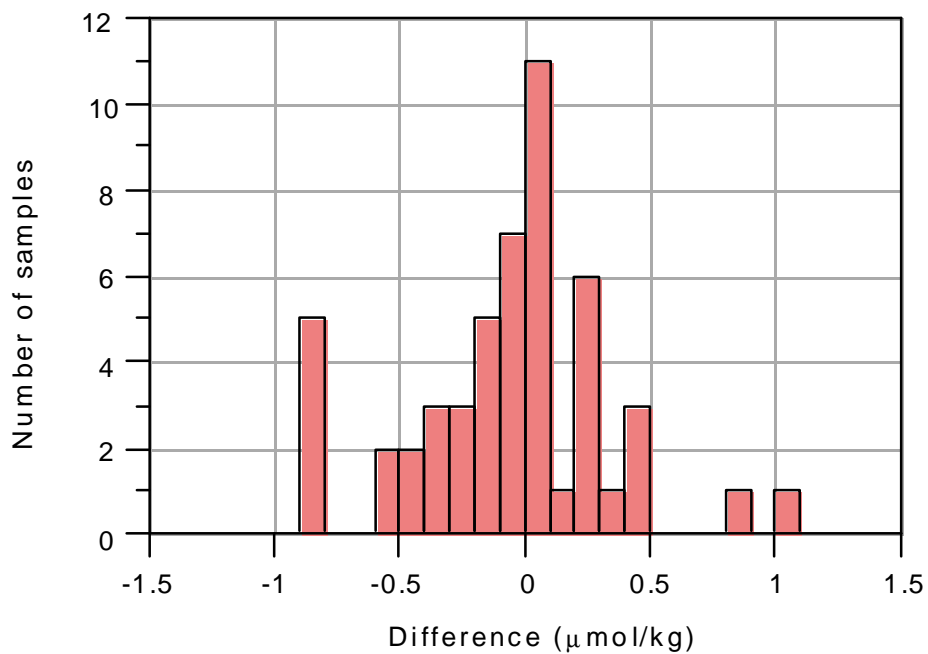
Fig. 3.3.1-4 Distribution of replilcates (first titration minus second) at MR99-K07 cruise.
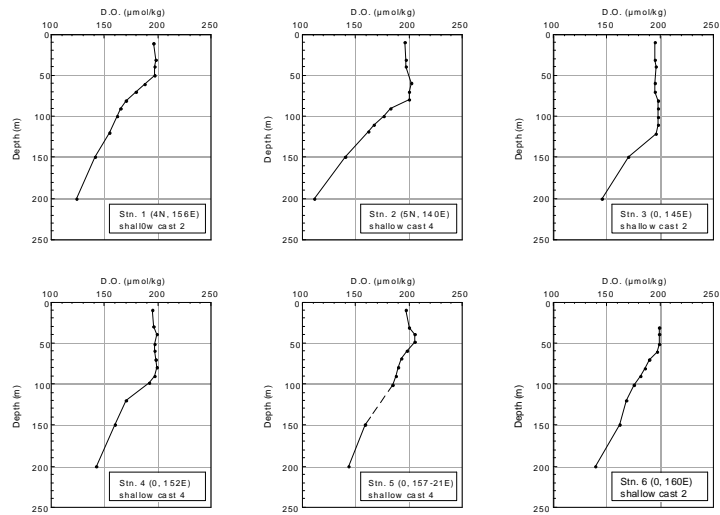
Fig. 3.3.1-5 Vertical profile of Dissolved Oxygen at MR99-K07 cruise. (continued)
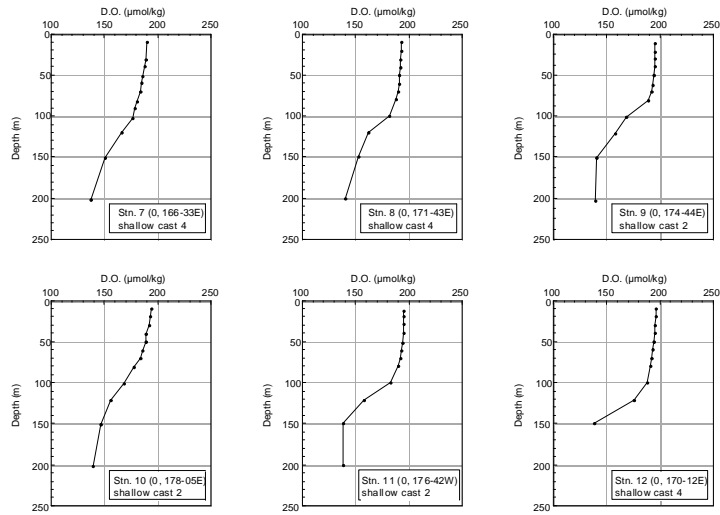
Fig 3.3.1-5 Vertical profile of Dissolved Oxygen at MR99-K07 cruise. (continued)
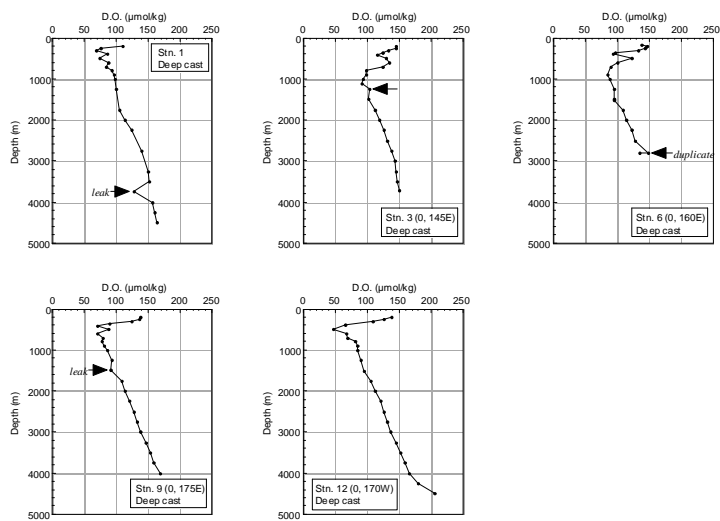
Fig 3.3.1-5 Vertical profile of Dissolved Oxygen at MR99-K07 cruise.

3.3.2 Salinity Measurement

(1) Personnel

  Masayuki Fujisaki (MWJ)

  Nobuharu Komai (MWJ)

  Tsutomu Iwashita (MWJ)

(2) Objectives

  To check the quality of CTD salinity.

(3) Parameters

  Salinity of sampled water

(4) Method

Seawater samples were collected with 30 liter Niskin bottles. They were stored in 250 ml Phoenix brown glass bottles. The salinity measurements were carried out using the laboratory salinometer (Model 8400B AUTOSAL; Guildline Instruments Ltd.), which was modified by addition of an Ocean Scientific International peristaltic-type sample intake pump, with a bath temperature 24 deg-C. The instrument was operated in the "AUTOSAL Room" of R/V Mirai. A double conductivity ratio was defined as a median of 31 readings of the salinometer. Data collection was started after 5 seconds and it took about 10 seconds to collect 31 readings by a personal computer. The salinometer standardizations were made with IAPSO Standard Seawater batch P135 (Ocean Scientific International Ltd.) whose conductivity is 0.99992 (salinity 34.9969). Sub-standard seawater was used to check the drift of the Autosal .

(5) Results

The average of difference between CTD data and Autosal data with each cast ware almost less than +/- 0.0045.

3.3.3 Nutrients Analysis(Sample water nutrients measurements)

(1) Personnel

    Munehito KIMURA (KANSO Co., Ltd.)

    Ken-ichiro MASAKI (KANSO Co., Ltd.)

    Hirofumi OKANO (Japan Marine Science and Technology Center)

(2) Objectives

    The vertical and horizontal distributions of nutrients are one of the important factors on the study of primary production, ocean circulation and seawater upwelling. During this cruise, the objectives of nutrients (NO_3, NO_2, SiO_2, PO_4 and NH_3) measurement were to obtain the important and basic information on these studies.

(3) Instruments and Methods

    The nutrients analysis were performed on two pieces of Bran + Luebbe continuous flow analytical system Model TRAACS 800 (4 channels types) and one of it's TRAACS 800 (2 channels types). The manifolds are shown in Figures 1-(a), (b), (c) and (d). The TRAACS 800s (4 channels types) were located at bio-chemical laboratory in the R/V MIRAI. The TRAACS 800 (2 channels types) was located at surface seawater monitoring laboratory in the R/V MIRAI. The monitoring of bio-chemical laboratory's temperature and humidity were done at intervals of five minutes at the laboratory for this cruise. The temperature and humidity maintained between 15.8 – 27.1 degree C (average 21.4 degree C) and 34 - 90 % (average 65.6 %), respectively.

    The analytical methods were as follows:

A. By one the TRAACS 800 of 4 channels types.

    Nitrate (ch.1A): Nitrate in seawater was reduced to nitrite by reduction tube (Cd - Cu tube), and the nitrite produced was determined by the nitrite method described to next, but the flow cell used in nitrate analysis was 3 cm length type. Nitrite initially present in the sample, was corrected by nitrite analytical data after this measurement.

    Nitrite (ch.2A): Nitrite was determined by diazotizing with sulfanilamide, by coupling with N-1-naphthyl- ethylenediamine (NED) to form a colored azo compound and by being measured the absorbance of 550 nm using 5 cm length flow cell, in the system.

    Silicate (ch.3A): Silicate was determined by complexing with molybdate, by reducing with ascorbic acid to form a colored complex and by being measured the absorbance of 630 nm using 3 cm length flow cell, in the system.

    Phosphate (ch.4A): Phosphate was determined by complexing with molybdate, by reducing with ascorbic acid to form a colored complex and by being measured the absorbance of 880 nm using 5 cm length flow cell, in the system.

B. By the other TRAACS 800 of 4 channels types;

    Ammonia (ch.3B): Ammonia in seawater was determined by couplying with phenol and sodium hypochlorite to form a colored indophenol blue and by being measured the absorbance of

630 nm using 5 cm length flow cell in the system.

In this system, ammonia in sample was done to react with the reagent directly without separeting from magunecium coexisted in sample, that is formed a precipitation.   Thus we named this method "a direct method (DM)", for differentiating with the last ammonia analysis method of Ch.2C.

Ammonia (ch.4B): The same as above ch.3B.

C. By one the TRAACS 800 of 2 channels types;

Ammonia (ch.2C): Sample seawater was mixed with an alkaline solution containing citrate as masking agent, ammonia as gas state was formed from sample.   The ammonia(gas) was absorbed in sulfuric acid solution by pathing a porous teflon membrane (pore-size 0.5um) at the dialyzer attached to analytical system.   The ammonia absorbed in acidic solution was determined by couplying with   salycilate and hypochlorite to form a colored compound and by being measured the absorbance of 660 nm using 5 cm length flow cell in the system.

In this system, ammonia in sample was done to react with the reagent after separeting from magunecium coexisted in sample.   Thus we named this method "a gas diffusion method (GDM)".

(4) Sampling Procedures

Samples were drawn into polypropylene 100 ml small mouth bottles from Niskin bottles mouth by directly or from bucket with a silicon tube.   These were rinsed twice before filling. The samples were analyzed as soon as possible.

As analyzing by the TRAACS 800, glassy 7 ml sample cups were used.   Before this cruise, all the glass sample cups had been washed with a detergent solution (Contaminon L solution, Wako Pure Chem. Indus, Ltd.), had been rinsed by fresh water, had been rinsed by deionized water, had kept in some packing container with deionized water.   These were rinsed twice with sample before being made to analyze.

(5) Calibration of volumetric utensil

The calibration of all volumetric flasks and micropipettes used for the cruise had been checked before this cruise.

(6) Nutrient standards

According to Gordon et al., reported "an suggested protocol for continuous flow automated analysis of seawater nutrients" in 1992, standards of nitrate, nitrite and phosphate were prepared. Their nutrients primary standards (stock solution) were prepared from salts (KNO_3, $NaNO_2$ and KH_2PO_4), that dried on oven at 110 degree C and cooled over silica gel in desiccator before weighing, respectively.   The precision of the weighing was ca. 0.1 %.   Concentration of the nutrients in the stock solutions was 40,000 umol/L (=uM) for nitrate, 4,000 uM for nitrite and 2,500 uM for phosphate, respectively.   Each the stock solution of nitrate, nitrite and phosphate were named to A-1N, A-2, and A-1P standard solution.

Silicate primary standard (stock solution) was prepared by an ampoule of J.T.Baker Chem. Co. Ltd., was containing one gram of SiO_2 in one ampoule.   Concentration of silicate in the stock

solution was 33,286.5 uM.   The stock solution of silicate was named to A-3 standard solution.

Ammonia primary standard (stock solution) was prepared from ammonium sulfate ($(NH_4)_2SO_4$), that dried on oven at 110 degree C and cooled over silica gel in desiccator before weighing. The precision of the weighing was ca. 0.1 ％.   Concentration of ammonia in the stock solutions was 4,000 uM for ammonium.   The stock solution of ammonium was named to A-4 standard solution.

When the sample of the shallow casting was analyzed, these stock solutions were mixed all together and were diluted to 800 uM for nitrate, 40 uM for nitrite, 998.595 uM for silicate, 50 uM for phosphate and 40 uM for ammonia.   The diluted standard solution was named to SB standard solution.

The SB standard solution was diluted to the working standard solution of six types with low nutrient seawater (LNSW).   The working standards solution have the six types of difference nutrients concentration as follows: nitrate 24.0, 9.6, 4.8, 3.2, 1.6 and 0.0 uM; nitrite 1.20, 0.48, 0.24, 0.16, 0.08 and 0.00 uM; silicate 29.96, 11.98, 5.99, 3.99, 2.00 and 0.00 uM; phosphate 1.5, 0.6, 0.3, 0.2, 0.1 and 0.0 uM; ammonia 1.20, 0.48, 0.24, 0.16, 0.08 and 0.00 uM (These values are all about, because of some correction have been done after preparing.).   These working standards were named to SC-6, 5, 4, 3, 2 and 1.

When the sample of the Deep casting was analyzed, these stock solutions were mixed all together and were diluted to 800 uM for nitrate, 24 uM for nitrite, 3328.65 uM for silicate, 65 uM for phosphate and 24 uM for ammonia.   The diluted standard solution was named to DB standard solution.

The DB standard solution was diluted to the working standard solution of six types with LNSW.   The working standards solution have the six types of difference nutrients concentration as follows: nitrate 44.8, 32.0, 19.2, 12.8, 6.4 and 0.0 uM; nitrite 1.34, 0.96, 0.58, 0.38, 0.19 and 0.00 uM; silicate 186.40, 133.15, 79.89, 53.26, 26.63 and 0.00 uM; phosphate 3.64, 2.60, 1.56, 1.04, 0.52 and 0.00 uM; ammonia 1.34, 0.96, 0.58, 0.38, 0.19 and 0.00 uM (These values are all about, because of some correction have been done after preparing.).   These working standards were named to DC-6, 5, 4, 3, 2 and 1.

(7) The check of standard

As the stock solutions were prepared, we separated the stock solutions to two bottles each A types of standard solution.   One bottle was used to prepare for SB or DB standard solution during the cruise, was named 'stock A'.   The other was stocking as reference standard solution, was named 'stock B'.   The comparison of the stocks was done once during this cruise.

The concentration ratio between stock A and stock B calculated from the following formula: R = (MW/MR)/(CW/CR), R; concentration ratio, MW; measured working STD, MR; measured reference STD, CW; calculated working STD, CR; calculated reference STD.   The result of comparison is shown in Table 1.

(8) Low nutrient seawater (LNSW)

The surface seawater as LNSW, was collected at point of 00 - 00 N and 160 - 00 E in the equator on Jan. 8, 1999.   The collected seawater was stocked in the 20-liters polyethylene container for several month, filtered with 0.45 um pore size membrane filter (Millipore HA), was restored in the 20-liters container.   The concentration of nutrient was determined in each batch of container.   The results are shown in Table 2.

(9) The comparison between working standard and CSK standard

The comparison between working standard solution and CSK standard were carried out during the cruise on board.   In the case of this comparison analysis, it has a problem against difference matrix between working standard solution (LNSW base) and CSK standard (NaCl 3.05 % base), but in here, it reports the measurement values against the LNSW.   The results are shown in Table 3.

(10) Precision check on each analysis

On each analysis, precision check was done with the sample and two of the working standard solution.   The used sample was the sample of the deepest layer in the casting.   One working standard solution is the maximum concentration in the working standard used, the other is the second minimum concentration in the working.   For being to obtain the precision, samples were analyzed several times by repeating.   The results of the repeat analysis are summarized in the percent of the concentration level in Table 4-(a) and (b).

(11) Inter cruise calibration

For obtaining inter cruise calibration data, it was done the comparison analysis between the stock standards of leg.2 in MR99K05 and the standards of this cruise (MR99K07) on board during the cruise.   The results of the comparison analysis stood for as the concentration ratio.   The concentration ratio were calculated with the following formula: R = (M1/C1)/(M2/C2), R; concentration ratio, M1; measured concentration (working STD of Leg.2 in MR99K05), M2; measured conc. (working STD of MR99K07), C1; calculated conc. (working STD of Leg.2 in MR99K05), C2; calculated conc. (working STD of MR99K07).   The results are shown in Table 5.

 (12) Preliminary results
Vertical profiles of nutrients

Vertical profiles of nutrients each station are shown in Figure.2 - (a)- (k).
Vertical distribution of nutrients on the eqator.

Vertical distribution of nutrients on the eqator in the Western Pacific Ocean are shown in Figure.3 - (a)-(c).

(13) Data archive

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

Table 1. The result of comparing between the stock standard for preparing the working standard (stock A) and the stock standard for the reference (stock B)

Date	Nitrate (ratio)	Nitrite (ratio)	Silicate (ratio)	Phosphate (ratio)	Ammonia (ratio)	Matrix base	Analytical style *)
Nov. 24, 1999	0.997	1.000	1.004	0.983		LNSW	High
Nov. 24, 1999	1.028	1.032	1.032	1.035		LNSW	Low
Dec. 10, 1999	0.985	0.971	1.028	0.972		LNSW	High
Dec. 10, 1999	1.019	0.977	1.068	0.995		LNSW	Low

*) Analytical style stands for the used working standard as analyzing, the 'High' represents the working standards for deep casting's samples, the 'low' represents the working standards for shallow casting.'s sample.

Table 2. The results of measuring nutrients in low nutrients seawater (LNSW).

Batch No.	Nitrate (umol/L)	Nitrite (umol/L)	Silicate (umol/L)	Phosphate (umol/L)	Ammonia (umol/L)
S-01	0.000	0.039	1.323	0.244	0.000
S-02	0.000	0.038	1.325	0.281	0.000
S-03	0.000	0.039	1.318	0.269	0.000
S-04	0.000	0.035	1.352	0.295	0.000
S-05	0.000	0.037	1.365	0.273	0.000
S-06	0.000	0.035	1.311	0.272	0.000
S-07	0.000	0.038	1.305	0.260	0.000
S-08	0.000	0.035	1.334	0.250	0.000
S-09	0.000	0.040	1.348	0.247	0.000
S-10	0.000	0.039	1.328	0.269	0.000

Table 3. The results of measuring the CSK standard on the working standard.

*) Analytical style stands for the used working standard as analyzing, the 'High' represents the working standards for deep casting's samples, the 'low' represents the working standards for shallow casting.'s sample.

Date	Anal Style *)	Sample	Nitrate uM	Nitrite uM	Silicate uM	Phosphate uM	Ammonia uM
Nov. 24, 1999	high	CSK SiO2 100uM	0.017	0.053	99.848	0.240	1.012
		CSK SiO2 50uM	0.021	0.049	49.464	0.176	1.056
		CSK SiO2 10uM	0.074	0.049	9.973	0.179	0.761
		CSK SiO2 0uM	0.040	0.045	0.502	0.165	1.008

Table 3. Continue.

Date	Anal Style *)	Sample		Nitrate uM	Nitrite uM	Silicate uM	Phosphate uM	Ammonia uM
Nov. 24, 1999	high	CSK PO4	3.0uM	0.212	0.068	14.450	3.005	0.884
		CSK PO4	2.0uM	0.190	0.414	24.192	1.983	0.878
		CSK NO3	40uM	39.716	0.046	18.528	0.205	1.063
		CSK NO2	1.0uM	0.000	1.137	41.074	0.460	1.286
		CSK NO2	0.5uM	0.000	0.540	15.876	0.436	1.279
	low	CSK SiO2	10uM	0.032	0.064	10.064	0.195	-
		CSK SiO2	0uM	0.000	0.065	0.236	0.120	-
		CSK NO2	1.0uM	0.000	1.126	35.821	0.389	-
		CSK NO2	0.5uM	0.000	0.535	23.282	0.353	-
Dec. 20, 1999	high	CSK SiO2	100uM	-	-	99.352	0.272	1.066
		CSK SiO2	50uM	-	-	48.537	0.210	1.008
		CSK SiO2	10uM	-	-	9.982	0.246	1.622
		CSK SiO2	0uM	-	-	0.787	0.238	0.942
		CSK PO4	3.0uM	-	-	63.988	3.010	0.749
		CSK PO4	2.0uM	-	-	18.996	2.024	0.689
		CSK NO2	1.0uM	-	-	17.120	0.335	1.965
		CSK NO2	0.5uM	-	-	22.999	0.481	2.519
		CSK NO2	0.0uM	-	-	12.314	0.479	1.872
		CSK NO3	40uM	-	-	22.372	0.218	0.963
		CSK NO3	0uM	-	-	36.364	0.238	1.394
		CSK NO2	1.0uM	0.000	1.067	-	-	-
		CSK NO2	0.5uM	0.016	0.543	-	-	-
		CSK NO3	40uM	39.734	0.071	-	-	-
		CSK NO3	0uM	0.056	0.054	-	-	-
	low	CSK SiO2	10uM	0.010	0.089	10.181	0.306	1.257
		CSK SiO2	0uM	0.047	0.084	0.012	0.269	0.937
		CSK NO2	1.0uM	0.000	1.100	16.517	0.517	0.737
		CSK NO2	0.5uM	0.006	0.563	22.799	0.474	1.079
		CSK NO2	0.0uM	0.000	0.195	12.747	0.479	1.146

Table 4-(a). The results of repeat analysis for checking the precision each analysis.
In Sample I.D., the 'DC' represents the working standards for analyzing the deep casting samples, the 'SC' represents the working standards for analyzing the shallow casting samples, the figure only (such as 0 or 24) stands for the Niskin's bottle No., respectively.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.1	Deep	DC-1	Avg(uM)	0.025	0.044	1.305	0.214	-0.055	0.075
			SD(uM)	0.011	0.005	0.078	0.010	0.054	0.017
			RSD(%)	43.0	11.6	5.9	4.8	98.0	22.7
			n	5	5	5	5	5	5
		DC-2	Avg(uM)	6.485	0.208	27.751	0.747	0.359	0.291
			SD(uM)	0.014	0.004	0.113	0.006	0.053	0.018
			RSD(%)	0.2	1.7	0.4	0.8	14.9	6.2
			n	5	5	5	5	5	5
		24	Avg(uM)	20.459	0.045	21.200	1.577	-0.073	0.050
			SD(uM)	0.041	0.006	0.049	0.014	0.042	0.037
			RSD(%)	0.2	12.3	0.2	0.9	57.4	74.6
			n	5	5	5	5	5	5
		DC-6	Avg(uM)	45.745	1.298	186.596	3.743	1.185	1.058
			SD(uM)	0.200	0.012	0.612	0.017	0.041	0.054
			RSD(%)	0.4	0.9	0.3	0.4	3.5	5.1
			n	5	5	5	5	5	5
	Shallow 1 & 2	SC-2	Avg(uM)	1.653	0.119	3.399	0.239	-	-
			SD(uM)	0.009	0.004	0.047	0.006	-	-
			RSD(%)	0.5	3.6	1.4	2.4	-	-
			n	5	5	5	5	-	-
		0 (Shallow 2)	Avg(uM)	0.058	0.063	1.313	0.077	-	-
			SD(uM)	0.006	0.003	0.064	0.009	-	-
			RSD(%)	10.7	4.7	4.9	12.2	-	-
			n	5	5	5	5	-	-
		SC-1	Avg(uM)	0.056	0.059	1.425	0.192	-	-
			SD(uM)	0.005	0.002	0.053	0.012	-	-
			RSD(%)	9.5	3.3	3.7	6.4	-	-
			n	2	2	2	2	-	-
		SC-6	Avg(uM)	25.913	1.217	31.317	1.715	-	-
			SD(uM)	0.110	0.003	0.091	0.010	-	-
			RSD(%)	0.4	0.3	0.3	0.6	-	-
			n	5	5	5	5	-	-

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.2	Shallow 4	SC-2	Avg(uM)	1.696	0.111	3.504	0.340	0.166	0.124
			SD(uM)	0.007	0.006	0.093	0.010	0.017	0.012
			RSD(%)	0.4	5.8	2.6	3.1	10.3	9.3
			n	5	5	5	5	5	5
		0	Avg(uM)	0.145	0.061	1.650	0.090	0.581	0.566
			SD(uM)	0.008	0.006	0.070	0.066	0.285	0.313
			RSD(%)	5.3	10.0	4.2	73.1	49.1	55.3
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.080	0.037	1.561	0.223	0.112	0.105
			SD(uM)	0.006	0.002	0.094	0.010	0.037	0.025
			RSD(%)	7.9	4.6	6.0	4.3	33.4	23.8
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.453	1.170	31.226	1.759	0.972	0.984
			SD(uM)	0.057	0.006	0.275	0.012	0.024	0.027
			RSD(%)	0.2	0.5	0.9	0.7	2.5	2.7
			n	5	5	5	5	5	5
St.3	Deep	DC-2	Avg(uM)	6.433	0.222	27.440	0.753	0.224	0.213
			SD(uM)	0.018	0.005	0.096	0.010	0.050	0.051
			RSD(%)	0.3	2.2	0.3	1.3	22.3	23.7
			n	5	5	5	5	5	5
		24	Avg(uM)	11.061	0.054	6.594	0.935	0.019	0.065
			SD(uM)	0.027	0.005	0.048	0.008	0.046	0.017
			RSD(%)	0.2	9.2	0.7	0.9	243.9	25.5
			n	5	5	5	5	5	5
		DC-1	Avg(uM)	0.129	0.042	1.798	0.279	0.109	0.107
			SD(uM)	0.017	0.005	0.048	0.015	0.161	0.141
			RSD(%)	13.4	12.5	2.7	5.4	147.5	131.5
			n	5	5	5	5	5	5
		DC-6	Avg(uM)	47.551	1.304	184.166	3.843	1.240	1.124
			SD(uM)	0.096	0.002	0.722	0.010	0.038	0.025
			RSD(%)	0.2	0.2	0.4	0.3	3.1	2.2
			n	5	5	5	5	5	5
	Shallow 1 & 2	SC-2	Avg(uM)	1.719	0.120	3.293	0.361	0.126	0.204
			SD(uM)	0.013	0.006	0.029	0.002	0.044	0.031
			RSD(%)	0.7	5.2	0.9	0.7	35.3	15.2
			n	5	5	5	5	5	5

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.3	Shallow 1 & 2	0 (Shallow 2)	Avg(uM)	0.198	0.069	1.368	0.223	0.337	0.444
			SD(uM)	0.036	0.007	0.091	0.021	0.085	0.089
			RSD(%)	18.1	9.4	6.7	9.3	25.2	20.0
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.146	0.062	1.582	0.267	0.094	0.275
			SD(uM)	0.003	0.012	0.034	0.005	0.067	0.045
			RSD(%)	2.3	18.7	2.1	1.9	71.3	16.3
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	26.524	1.203	31.430	1.760	0.966	1.244
			SD(uM)	0.052	0.003	0.194	0.006	0.014	0.029
			RSD(%)	0.2	0.3	0.6	0.3	1.4	2.4
			n	5	5	5	5	5	5
St.4	Shallow 4	SC-2	Avg(uM)	1.732	0.118	3.308	0.363	0.105	0.111
			SD(uM)	0.007	0.009	0.063	0.008	0.006	0.003
			RSD(%)	0.4	7.3	1.9	2.3	5.4	3.1
			n	5	5	5	5	5	5
		0	Avg(uM)	0.079	0.037	1.671	0.209	0.099	0.119
			SD(uM)	0.009	0.005	0.044	0.006	0.008	0.009
			RSD(%)	10.8	14.3	2.6	2.7	8.4	7.6
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.048	0.033	1.619	0.278	0.128	0.112
			SD(uM)	0.013	0.013	0.029	0.012	0.023	0.006
			RSD(%)	26.9	37.9	1.8	4.4	17.7	5.4
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	26.490	1.178	31.369	1.751	1.245	1.410
			SD(uM)	0.096	0.007	0.181	0.010	0.176	0.070
			RSD(%)	0.4	0.6	0.6	0.6	14.1	5.0
			n	5	5	5	5	5	5
St.5	Shallow 4	SC-2	Avg(uM)	1.689	0.109	3.623	0.364	0.210	0.261
			SD(uM)	0.004	0.003	0.065	0.001	0.061	0.081
			RSD(%)	0.2	2.9	1.8	0.3	29.0	31.1
			n	5	5	5	5	5	5
		0	Avg(uM)	0.136	0.045	1.841	0.263	0.111	0.242
			SD(uM)	0.006	0.005	0.035	0.005	0.033	0.035
			RSD(%)	4.6	11.7	1.9	2.0	29.5	14.4
			n	5	5	5	5	5	5

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.5	Shallow 4	SC-1	Avg(uM)	0.131	0.041	1.602	0.265	0.159	0.209
			SD(uM)	0.004	0.003	0.028	0.003	0.036	0.032
			RSD(%)	3.1	7.7	1.7	1.2	22.4	15.2
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.116	1.179	31.782	1.709	1.502	1.498
			SD(uM)	0.038	0.002	0.367	0.004	0.025	0.073
			RSD(%)	0.2	0.2	1.2	0.2	1.7	4.9
			n	5	5	5	5	5	5
St.6	Shallow 1 & 2	SC-2	Avg(uM)	1.683	0.118	3.383	0.341	0.957	0.071
			SD(uM)	0.006	0.003	0.035	0.003	0.094	0.022
			RSD(%)	0.4	2.4	1.0	0.9	9.8	30.8
			n	5	5	5	5	5	5
		0 (Shallow 2)	Avg(uM)	0.092	0.055	1.599	0.275	1.112	0.237
			SD(uM)	0.004	0.003	0.035	0.008	0.073	0.051
			RSD(%)	4.2	5.7	2.2	2.8	6.6	21.4
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.052	0.049	1.164	0.250	1.007	0.045
			SD(uM)	0.005	0.003	0.007	0.003	0.183	0.039
			RSD(%)	9.6	6.7	0.6	1.1	18.1	85.6
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.139	1.203	33.920	1.761	2.242	0.828
			SD(uM)	0.041	0.004	0.160	0.007	0.186	0.018
			RSD(%)	0.2	0.4	0.5	0.4	8.3	2.1
			n	5	5	5	5	5	5
	Deep	DC-2	Avg(uM)	6.517	0.233	27.304	0.752	0.156	0.020
			SD(uM)	0.021	0.006	0.031	0.006	0.066	0.158
			RSD(%)	0.3	2.6	0.1	0.8	42.0	792.1
			n	5	5	5	5	5	5
		24	Avg(uM)	12.642	0.049	9.965	1.057	0.057	-0.215
			SD(uM)	0.031	0.003	0.116	0.008	0.038	-0.084
			RSD(%)	0.2	5.2	1.2	0.7	67.2	39.3
			n	5	5	5	5	5	5
		DC-1	Avg(uM)	-0.063	0.039	0.883	0.227	0.093	-0.294
			SD(uM)	-0.009	0.007	0.031	0.005	0.073	-0.047
			RSD(%)	14.9	16.7	3.5	2.2	78.9	16.1
			n	5	5	5	5	5	5

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.6	Deep	DC-6	Avg(uM)	45.695	1.323	185.830	3.873	1.073	1.211
			SD(uM)	0.072	0.003	0.656	0.010	0.091	0.054
			RSD(%)	0.2	0.2	0.4	0.3	8.5	4.4
			n	5	5	5	5	5	5
St.7	Shallow 4	SC-2	Avg(uM)	1.667	0.125	3.386	0.388	-	-
			SD(uM)	0.010	0.003	0.056	0.009	-	-
			RSD(%)	0.6	2.6	1.7	2.4	-	-
			n	5	5	5	5	-	-
		0	Avg(uM)	3.132	0.627	2.440	0.493	-	-
			SD(uM)	0.005	0.004	0.063	0.002	-	-
			RSD(%)	0.2	0.7	2.6	0.5	-	-
			n	5	5	5	5	-	-
		SC-1	Avg(uM)	0.091	0.040	1.386	0.299	-	-
			SD(uM)	0.003	0.002	0.056	0.005	-	-
			RSD(%)	3.8	6.1	4.0	1.8	-	-
			n	5	5	5	5	-	-
		SC-6	Avg(uM)	24.892	1.130	32.361	1.760	-	-
			SD(uM)	0.070	0.002	0.300	0.013	-	-
			RSD(%)	0.3	0.2	0.9	0.7	-	-
			n	5	5	5	5	-	-
St.8	Shallow 4	SC-2	Avg(uM)	1.698	0.118	3.626	0.386	0.574	-
			SD(uM)	0.007	0.002	0.035	0.006	0.158	-
			RSD(%)	0.4	1.6	1.0	1.5	27.6	-
			n	5	5	5	5	5	-
		0	Avg(uM)	2.899	0.411	2.418	0.488	0.755	-
			SD(uM)	0.003	0.002	0.017	0.007	0.218	-
			RSD(%)	0.1	0.4	0.7	1.5	28.9	-
			n	5	5	5	5	5	-
		SC-1	Avg(uM)	0.052	0.039	1.524	0.296	0.322	-
			SD(uM)	0.006	0.003	0.047	0.003	0.162	-
			RSD(%)	12.4	8.5	3.1	0.9	50.5	-
			n	5	5	5	5	5	-
		SC-6	Avg(uM)	25.287	1.195	31.202	1.772	1.372	-
			SD(uM)	0.039	0.013	0.311	0.013	0.023	-
			RSD(%)	0.2	1.1	1.0	0.7	1.7	-
			n	5	5	5	5	5	-

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.9	Shallow 1	SC-2	Avg(uM)	1.681	0.110	3.486	0.358	0.264	0.213
			SD(uM)	0.008	0.002	0.126	0.020	0.068	0.064
			RSD(%)	0.5	2.1	3.6	5.5	25.7	30.2
			n	5	5	5	5	5	5
		0	Avg(uM)	2.851	0.378	2.308	0.480	0.363	0.269
			SD(uM)	0.009	0.004	0.033	0.005	0.181	0.031
			RSD(%)	0.3	1.1	1.4	1.0	49.8	11.4
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.055	0.043	1.401	0.269	0.238	0.177
			SD(uM)	0.004	0.004	0.087	0.010	0.164	0.072
			RSD(%)	6.4	10.1	6.2	3.9	69.0	40.8
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.109	1.173	31.688	1.766	4.881	1.355
			SD(uM)	0.025	0.003	0.186	0.019	1.675	0.061
			RSD(%)	0.1	0.3	0.6	1.1	34.3	4.5
			n	5	5	5	5	5	5
	Shallow 2	SC-2	Avg(uM)	1.667	0.115	3.324	0.344	0.174	0.096
			SD(uM)	0.011	0.003	0.075	0.006	0.027	0.114
			RSD(%)	0.7	3.0	2.3	1.8	15.3	119.1
			n	5	5	5	5	5	5
		0	Avg(uM)	2.602	0.347	2.060	0.438	0.448	0.553
			SD(uM)	0.007	0.003	0.038	0.006	0.303	0.316
			RSD(%)	0.3	0.9	1.8	1.3	67.7	57.2
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.035	0.044	1.265	0.254	0.249	0.268
			SD(uM)	0.004	0.005	0.039	0.006	0.045	0.063
			RSD(%)	11.7	10.3	3.1	2.5	18.0	23.6
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.015	1.172	31.755	1.777	1.201	1.268
			SD(uM)	0.053	0.004	0.202	0.006	0.103	0.103
			RSD(%)	0.2	0.3	0.6	0.3	8.6	8.1
			n	5	5	5	5	5	5
	Deep	DC-2	Avg(uM)	6.461	0.222	27.972	0.743	0.223	0.221
			SD(uM)	0.013	0.005	0.136	0.003	0.084	0.445
			RSD(%)	0.2	2.3	0.5	0.4	37.8	201.3
			n	5	5	5	5	5	5

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.9	Deep	24	Avg(uM)	12.992	0.050	10.345	1.068	0.192	0.560
			SD(uM)	0.036	0.005	0.049	0.005	0.075	0.775
			RSD(%)	0.3	9.8	0.5	0.5	38.9	138.5
			n	5	5	5	5	5	5
		DC-1	Avg(uM)	0.069	0.035	1.579	0.263	-0.029	0.914
			SD(uM)	0.009	0.007	0.026	0.009	-0.083	0.734
			RSD(%)	13.7	19.4	1.7	3.3	286.6	80.3
			n	5	5	5	5	5	5
		DC-6	Avg(uM)	45.937	1.306	187.589	3.922	1.369	0.661
			SD(uM)	0.060	0.003	2.137	0.011	0.020	0.905
			RSD(%)	0.1	0.2	1.1	0.3	1.4	136.9
			n	5	5	5	5	5	5
St.10	Shallow 4	SC-2	Avg(uM)	1.701	0.118	3.649	0.362	-0.028	0.129
			SD(uM)	0.005	0.003	0.055	0.003	-0.063	0.033
			RSD(%)	0.3	2.5	1.5	0.8	226.2	25.7
			n	5	5	5	5	5	5
		0	Avg(uM)	4.298	0.492	2.739	0.583	0.365	0.509
			SD(uM)	0.007	0.005	0.033	0.010	0.181	0.177
			RSD(%)	0.2	1.1	1.2	1.8	49.7	34.8
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.002	0.048	1.404	0.277	0.031	0.081
			SD(uM)	0.003	0.002	0.043	0.004	0.063	0.057
			RSD(%)	158.6	4.8	3.0	1.5	203.8	70.0
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.202	1.179	31.124	1.776	1.230	1.294
			SD(uM)	0.028	0.003	0.044	0.005	0.104	0.065
			RSD(%)	0.1	0.2	0.1	0.3	8.4	5.0
			n	5	5	5	5	5	5
St.11	Shallow 4	SC-2	Avg(uM)	1.686	0.107	3.391	0.359	-	0.066
			SD(uM)	0.013	0.004	0.052	0.007	-	0.072
			RSD(%)	0.8	3.8	1.5	2.0	-	109.4
			n	5	5	5	5	-	5
		0	Avg(uM)	3.961	0.315	2.468	0.549	-	0.273
			SD(uM)	0.019	0.001	0.029	0.006	-	0.044
			RSD(%)	0.5	0.3	1.2	1.2	-	15.9
			n	5	5	5	5	-	5

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.11	Shallow 4	SC-1	Avg(uM)	0.074	0.033	1.448	0.238	-	0.143
			SD(uM)	0.010	0.006	0.084	0.027	-	0.081
			RSD(%)	13.1	19.0	5.8	11.2	-	56.4
			n	5	5	5	5	-	5
		SC-6	Avg(uM)	25.332	1.187	31.614	1.753	-	1.189
			SD(uM)	0.039	0.002	0.151	0.008	-	0.123
			RSD(%)	0.2	0.2	0.5	0.5	-	10.4
			n	5	5	5	5	-	5
St.12	Deep	DC-1	Avg(uM)	0.095	0.040	1.440	0.245	0.008	0.050
			SD(uM)	0.007	0.005	0.048	0.006	0.072	0.106
			RSD(%)	7.7	11.5	3.4	2.6	901.2	212.5
			n	5	5	5	5	5	5
		DC-2	Avg(uM)	6.477	0.207	26.282	0.766	0.035	0.177
			SD(uM)	0.015	0.002	0.105	0.009	0.052	0.118
			RSD(%)	0.2	1.1	0.4	1.2	148.5	66.6
			n	5	5	5	5	5	5
		22	Avg(uM)	23.947	0.039	8.709	1.171	-0.013	0.169
			SD(uM)	0.029	0.007	0.077	0.007	0.222	0.220
			RSD(%)	0.1	18.0	0.9	0.6	1708.8	130.4
			n	5	5	5	5	5	5
		DC-6	Avg(uM)	45.723	1.309	193.684	3.822	2.222	1.504
			SD(uM)	0.090	0.005	0.564	0.008	0.642	0.368
			RSD(%)	0.2	0.4	0.3	0.2	28.9	24.5
			n	5	5	5	5	5	5
	Shallow 1	SC-2	Avg(uM)	1.660	0.104	3.486	0.348	-	0.205
			SD(uM)	0.023	0.004	0.081	0.007	-	0.067
			RSD(%)	1.4	4.3	2.3	1.9	-	32.8
			n	5	5	5	5	-	5
		0	Avg(uM)	5.312	0.364	3.083	0.590	-	0.588
			SD(uM)	0.015	0.003	0.057	0.010	-	0.286
			RSD(%)	0.3	0.9	1.9	1.6	-	48.7
			n	5	5	5	5	-	5
		SC-1	Avg(uM)	0.072	0.032	1.400	0.272	-	0.318
			SD(uM)	0.008	0.006	0.045	0.006	-	0.241
			RSD(%)	10.8	17.6	3.2	2.2	-	75.7
			n	5	5	5	5	-	5

Table 4-(a). Continue.

St. No.	Anal. Group	Sample I.D.	Items	Nitrate+Nitrite (Ch.1A)	Nitrite (Ch.2A)	Silicate (Ch.3A)	Phosphate (Ch.4A)	Ammonia (Ch.3B)	Ammonia (Ch.4B)
St.12	Shallow 1	SC-6	Avg(uM)	25.144	1.168	32.227	1.748	-	1.133
			SD(uM)	0.053	0.004	0.097	0.010	-	0.087
			RSD(%)	0.2	0.4	0.3	0.5	-	7.6
			n	5	5	5	5	-	5
	Shallow 2	SC-2	Avg(uM)	1.672	0.134	3.427	0.342	1.109	0.142
			SD(uM)	0.006	0.004	0.039	0.007	0.132	0.036
			RSD(%)	0.3	2.6	1.1	2.2	11.9	25.2
			n	5	5	5	5	5	5
		0	Avg(uM)	5.321	0.392	3.062	0.581	1.303	0.247
			SD(uM)	0.024	0.003	0.091	0.004	0.128	0.104
			RSD(%)	0.4	0.8	3.0	0.7	9.8	42.3
			n	5	5	5	5	5	5
		SC-1	Avg(uM)	0.070	0.063	1.361	0.256	0.991	0.085
			SD(uM)	0.007	0.007	0.026	0.009	0.036	0.032
			RSD(%)	9.3	11.2	1.9	3.7	3.7	38.0
			n	5	5	5	5	5	5
		SC-6	Avg(uM)	25.121	1.182	32.369	1.774	2.847	1.379
			SD(uM)	0.047	0.004	0.215	0.015	0.263	0.198
			RSD(%)	0.2	0.3	0.7	0.8	9.2	14.4
			n	5	5	5	5	5	5

Table 4-(b). The results of repeat ammonia analysis (NH_3:Ch.2C) for checking the precision each analysis by gas diffusion method (GDM).   In this table, "W-blank" represents the working blank. The W-blank was made to used of as the blank, was put into the sample cup on an autosampler.

St. No.	Anal. Group	Items	Analyzed samples						
			C-5	C-1	baseline	20	ref C-5	W-blank	C-4
St.1	Deep	Avg(uM)	0.816	0.063	0.026	0.185	0.804	-	-
		SD(uM)	0.038	0.016	0.035	0.051	0.009	-	-
		RSD(%)	4.61	25.34	133.5	27.6	1.09	-	-
		n	5	5	5	5	5	-	-
	Shallow 1	Avg(uM)	0.791	0.052	-0.014	0.061	-	-	-
		SD(uM)	0.013	0.013	-0.005	0.075	-	-	-
		RSD(%)	1.65	25.93	34.83	122.15	-	-	-
		n	5	5	5	5	-	-	-

Table 4-(b). Continue.

St. No.	Anal. Group	Items	C-5	C-1	baseline	20	ref C-5	W-blank	C-4
					Analyzed samples				
	Shallow 2	Avg(uM)	0.806	0.053	0.021	0.043	-	-	-
		SD(uM)	0.012	0.012	0.004	0.014	-	-	-
		RSD(%)	1.52	23.58	18.13	32.5	-	-	-
		n	4	4	5	5	-	-	-
St.2	Shallow 4	Avg(uM)	0.810	0.043	-0.007	0.074	-	-	-
		SD(uM)	0.026	0.004	-0.004	0.061	-	-	-
		RSD(%)	3.17	9.7	56.84	82.78	-	-	-
		n	5	4	5	5	-	-	-
St.4	Shallow 4	Avg(uM)	0.815	0.026	-0.033	0.511	-	-	-
		SD(uM)	0.050	0.011	-0.007	0.043	-	-	-
		RSD(%)	6.14	41.31	21.51	8.32	-	-	-
		n	5	4	5	5	-	-	-
St.5	Shallow 4	Avg(uM)	0.938	0.047	-0.011	0.052	-	-	0.430
		SD(uM)	0.078	0.002	-0.002	0.004	-	-	0.045
		RSD(%)	8.27	3.3	19.04	7.13	-	-	10.48
		n	5	5	4	4	-	-	5
St.6	Shallow 1	Avg(uM)	0.786	0.045	0.037	0.260	-	-	-
		SD(uM)	0.023	0.004	0.007	0.012	-	-	-
		RSD(%)	2.96	8.62	19.02	4.67	-	-	-
		n	5	4	5	5	-	-	-
	Shallow.2	Avg(uM)	0.812	0.043	-0.014	0.056	-	-	-
		SD(uM)	0.080	0.005	-0.011	0.022	-	-	-
		RSD(%)	9.80	10.63	75.83	39.82	-	-	-
		n	5	5	3	5	-	-	-
	Deep	Avg(uM)	0.817	0.040	0.012	0.035	-	-	-
		SD(uM)	0.016	0.004	0.005	0.007	-	-	-
		RSD(%)	2.01	10.9	44.28	19.66	-	-	-
		n	5	5	5	5	-	-	-
St.7	Shallow 4	Avg(uM)	0.782	0.063	-0.006	0.248	-	0.006	-
		SD(uM)	0.016	0.011	-0.002	0.038	-	0.003	-
		RSD(%)	2.00	17.50	34.31	15.17	-	58.30	-
		n	4	4	5	4	-	4	-
St.8	Shallow 4	Avg(uM)	0.807	0.044	0.014	0.107	-	0.024	-
		SD(uM)	0.015	0.004	0.003	0.031	-	0.020	-
		RSD(%)	1.84	9.84	19.47	29.39	-	82.94	-
		n	4	4	4	4	-	5	-

Table 4-(b). Continue.

St. No.	Anal. Group	Items	Analyzed samples						
			C-5	C-1	baseline	20	ref C-5	W-blank	C-4
St.9	Shallow 1 & 2	Avg(uM)	0.787	0.043	-0.016	-	-	-0.020	-
		SD(uM)	0.005	0.006	-0.003	-	-	-0.006	-
		RSD(%)	0.66	13.54	18.8	-	-	31.85	-
		n	4	4	5	-	-	5	-
	Deep	Avg(uM)	0.807	0.044	-0.019	0.013	-	0.019	-
		SD(uM)	0.034	0.002	-0.010	0.006	-	0.013	-
		RSD(%)	4.26	5.31	53.98	47.79	-	67.88	-
		n	5	4	5	3	-	5	-
St.10	Shallow 4	Avg(uM)	0.812	0.035	-0.032	0.153	-	-0.013	-
		SD(uM)	0.028	0.011	-0.007	0.034	-	-0.007	-
		RSD(%)	3.44	30.58	20.91	21.98	-	54.76	-
		n	5	4	5	5	-	5	-
St.11	Shallow 4	Avg(uM)	0.791	0.033	-0.033	0.130	-	-0.015	-
		SD(uM)	0.048	0.004	-0.004	0.021	-	-0.007	-
		RSD(%)	6.01	13.18	10.89	16.07	-	45.14	-
		n	5	4	5	4	-	5	-
St.12	Shallow 1 & 2	Avg(uM)	0.799	0.041	-0.012	0.125	-	0.022	-
		SD(uM)	0.020	0.014	-0.004	0.024	-	0.007	-
		RSD(%)	2.47	34.42	33.53	19.57	-	30.52	-
		n	5	3	5	5	-	4	-
	Deep	Avg(uM)	0.791	0.045	-0.007	0.026	-	0.046	-
		SD(uM)	0.042	0.004	-0.006	0.020	-	0.039	-
		RSD(%)	5.27	7.93	84.93	77.58	-	84.1	-
		n	5	5	3	4	-	4	-

Table 5. The result of comparing analysis between the standards of leg.2 in MR99K05 and the standards of MR99K07, for the inter cruise calibration.

Analytical Group	Nitrate (ratio)	Nitrite (ratio)	Silicate (ratio)	Phosphate (ratio)	Ammonia (ratio)
St.12-SC2	0.99	1.02	1.06	1.00	1.02
St.12-DC	1.03	1.00	1.04	1.00	1.15
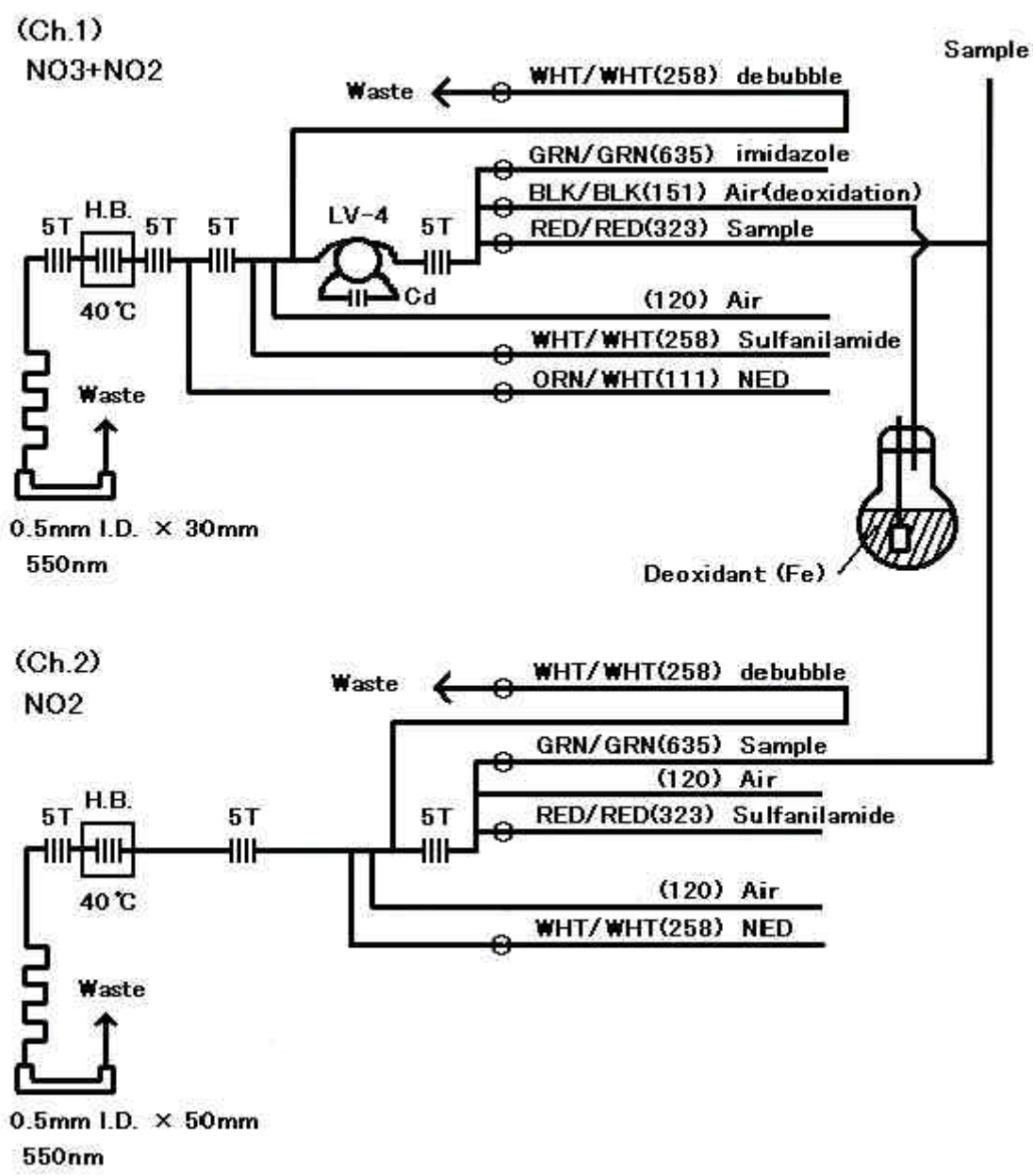
Figure 1-(a). Flow diagrams of nitrate + nitrite and nitrite analysis.

(Ch.3)
SiO2

Sample

WHT/WHT(258) debubble — Waste ←

GRN/GRN(635) Molybdate(VI)

(120) Air

RED/RED(323) Sample

(120) Air

WHT/WHT(258) Oxalic acid

ORN/WHT(111) L-Ascorbic acid

5T H.B. 5T 5T 5T

45℃

Waste

0.5mm I.D. × 30mm

630nm

(Ch.4)
PO4

WHT/WHT(258) debubble — Waste ←

GRN/GRN(635) Sample

(120) Air

RED/RED(323) PO4 diluent water

(120) Air

WHT/WHT(258) PO4 mixed reagent

5T H.B. 5T 5T

40℃

Waste

0.5mm I.D. × 50mm

880nm
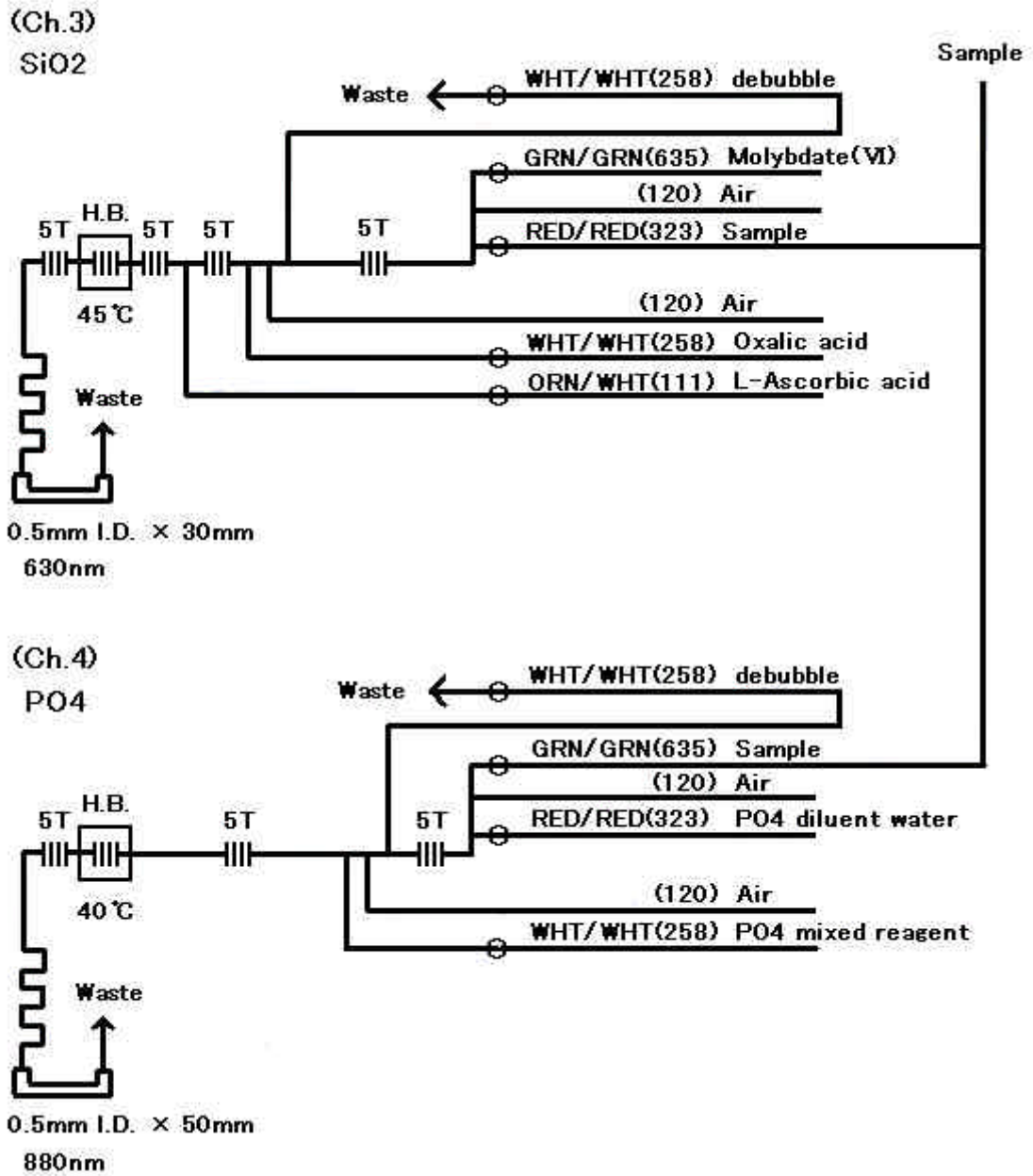
Figure 1-(b). Flow diagrams of silicate and phosphate analysis.

(CH.3B and CH.4B)

NH3 : direct method
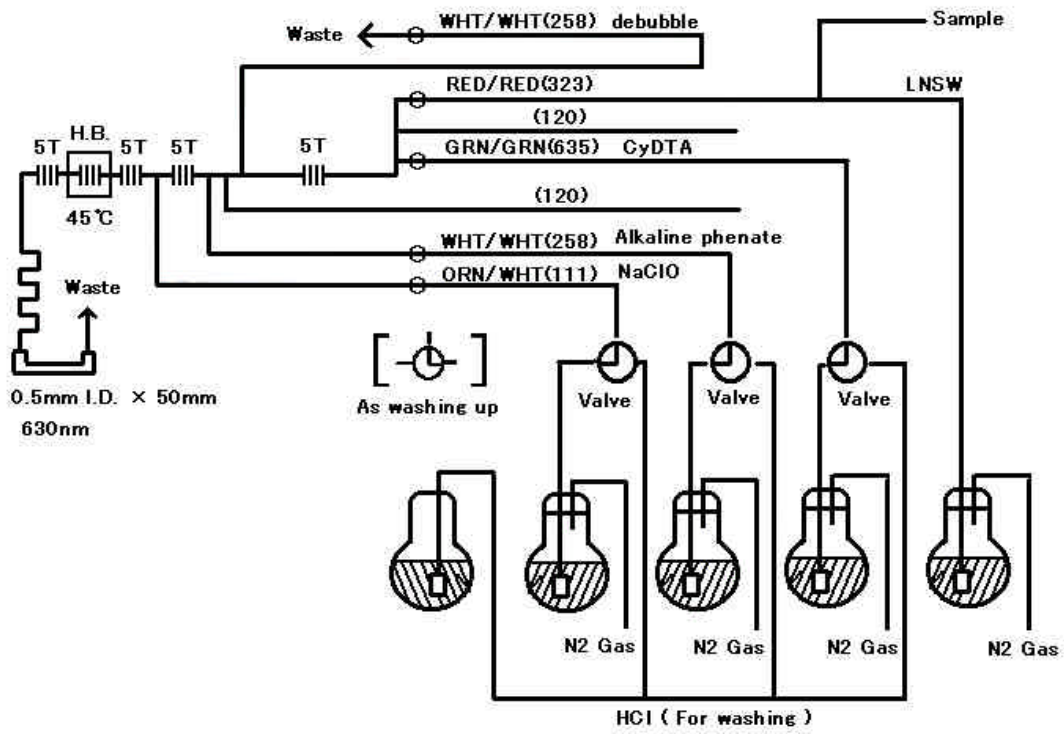
Figure 1-(c). Flow diagrams of ammonium analysis (direct method).

(CH.2C)

NH3 : Gas diffusion method

to sampler ← GRN/GRN(2.00) Sampler washing sol.

BLU/BLU(1.60) Sample
ORN/ORN(0.42) Citrate

24 inch dialyzer

10T 5T

RED/RED(0.80) Air (no airbar)
ORN/WHT(0.23) Citrate/NaOH

Waste ←

teflon membrane
0.5 μm

H.B.

35°C

5T 5T

ORN/GRN(0.10) Air
RED/RED(0.80) Nitroprussiate/H2SO4

ORN/WHT(0.23) Salycilate
ORN/GRN(0.10) 0.4% NaClO

0.5mm I.D. × 50mm
660nm

BLK/BLK(0.32) Air

Waste ← BLU/BLU(1.60) Waste control

Gas washing bottle

Figure 1-(d). Flow diagrams of ammonia analysis (gas diffusion method).
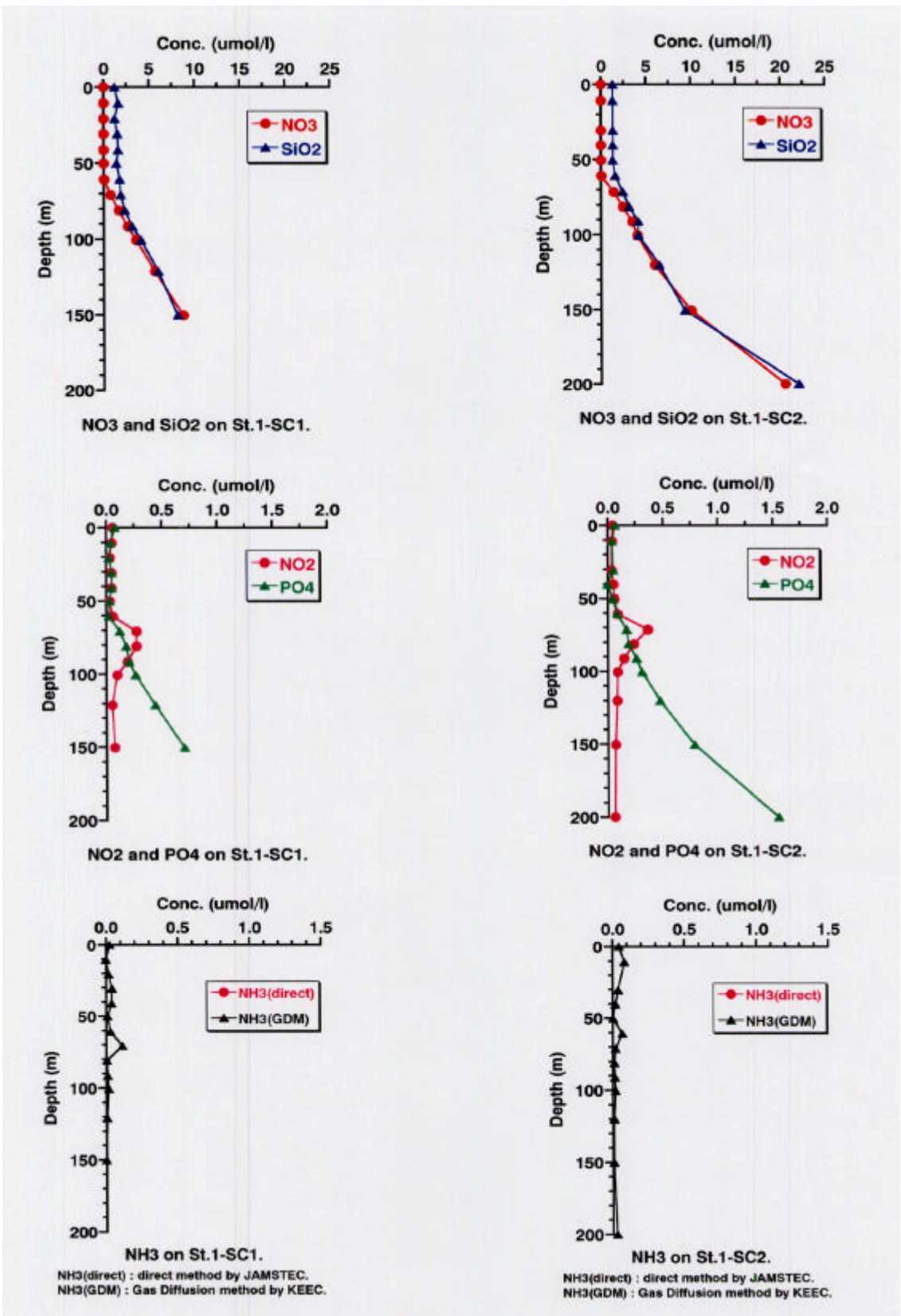
Figure 2-(a). Vertical profiles of nutrients in MR99K07 cruise.
The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
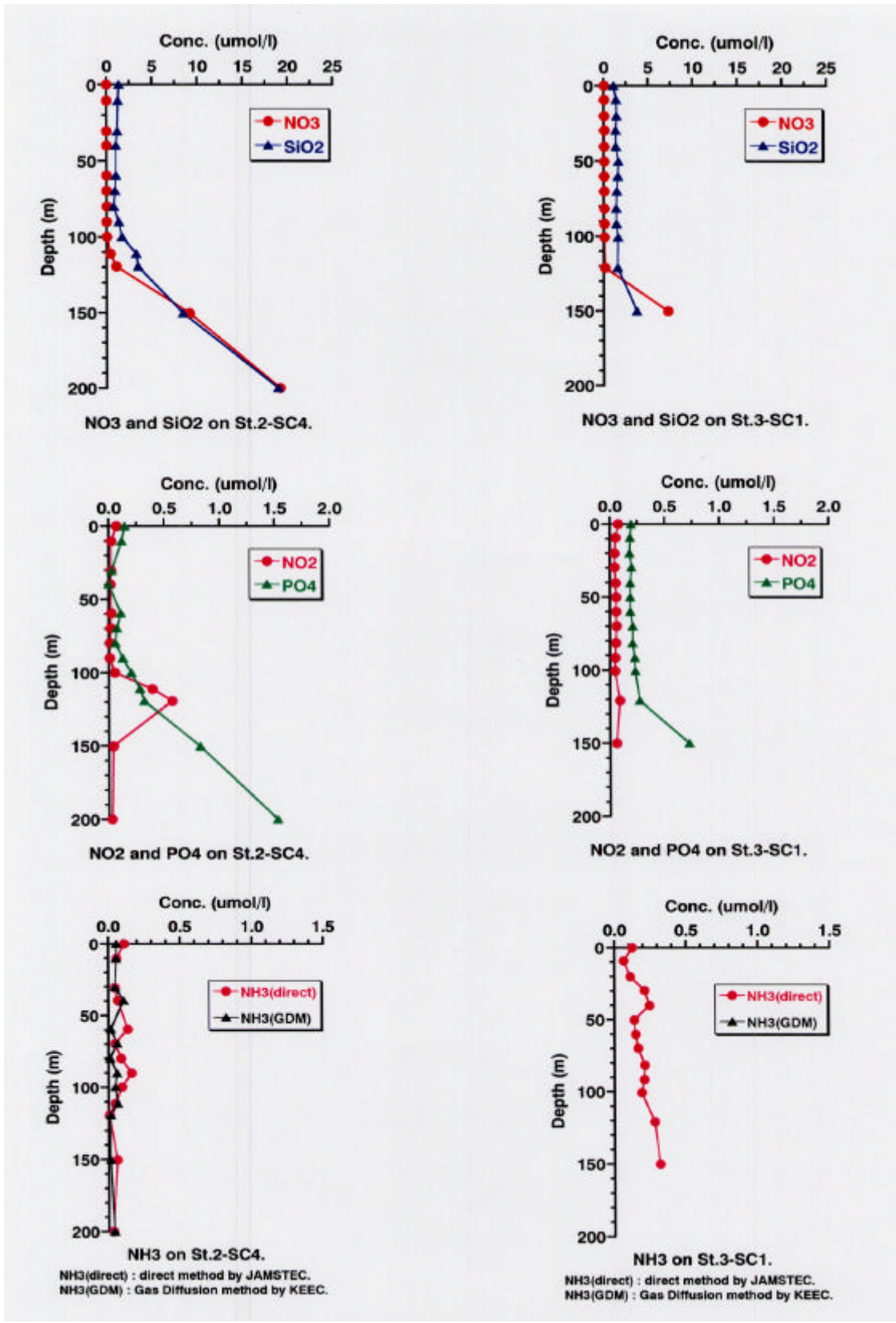
Figure 2-(b). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
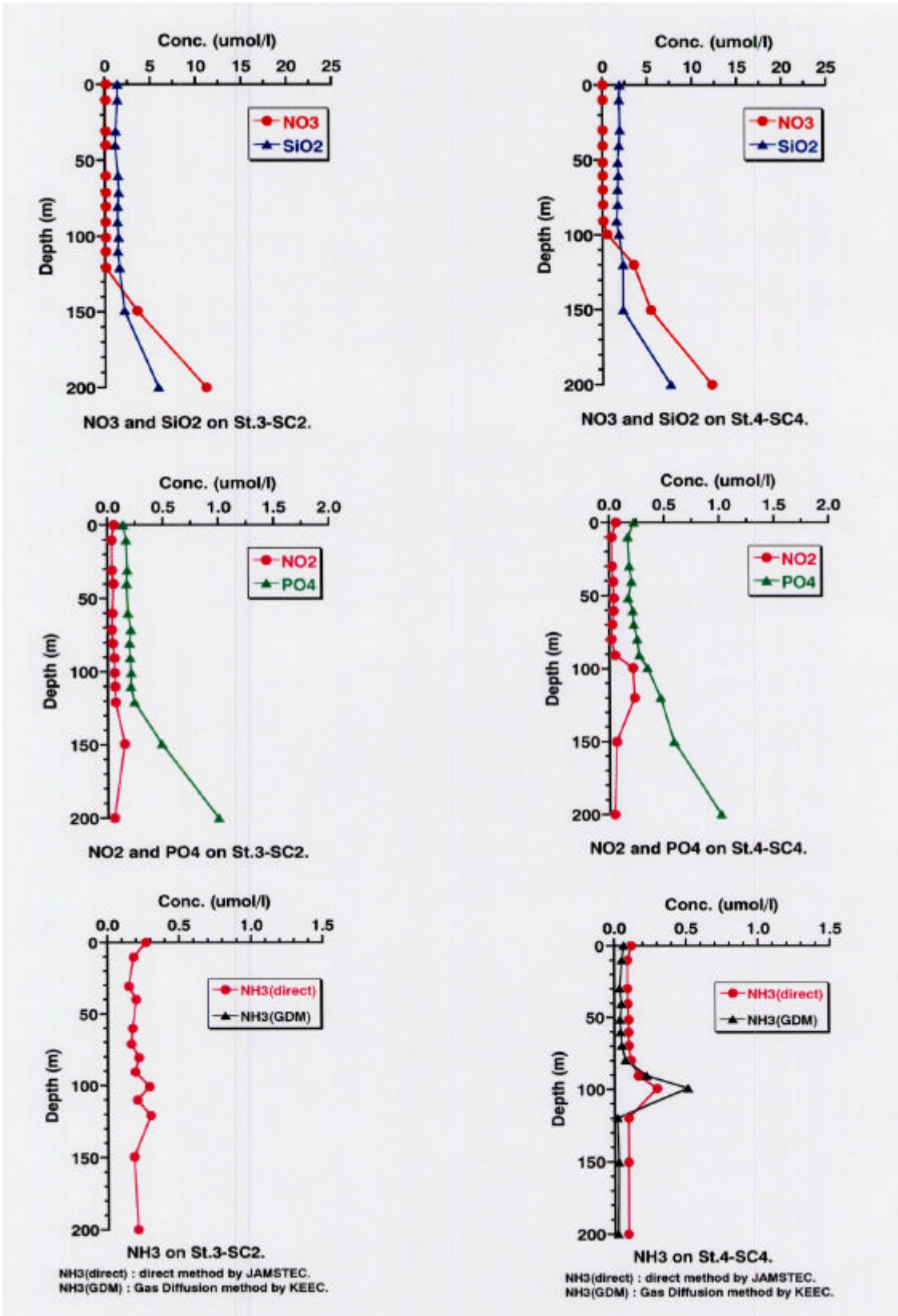
Figure 2-(c). Vertical profiles of nutrients in MR99K07 cruise.
The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
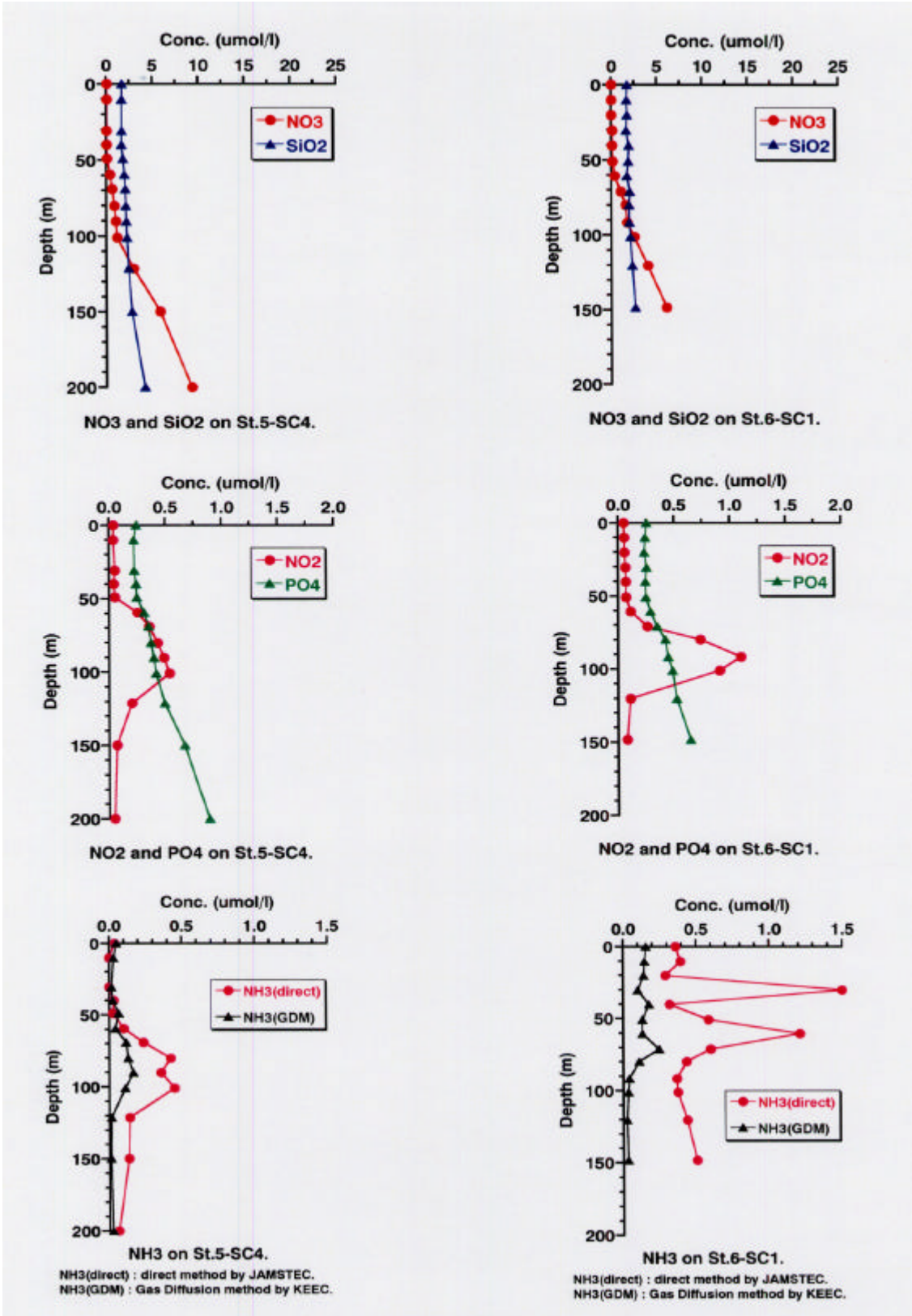
Figure 2-(d). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
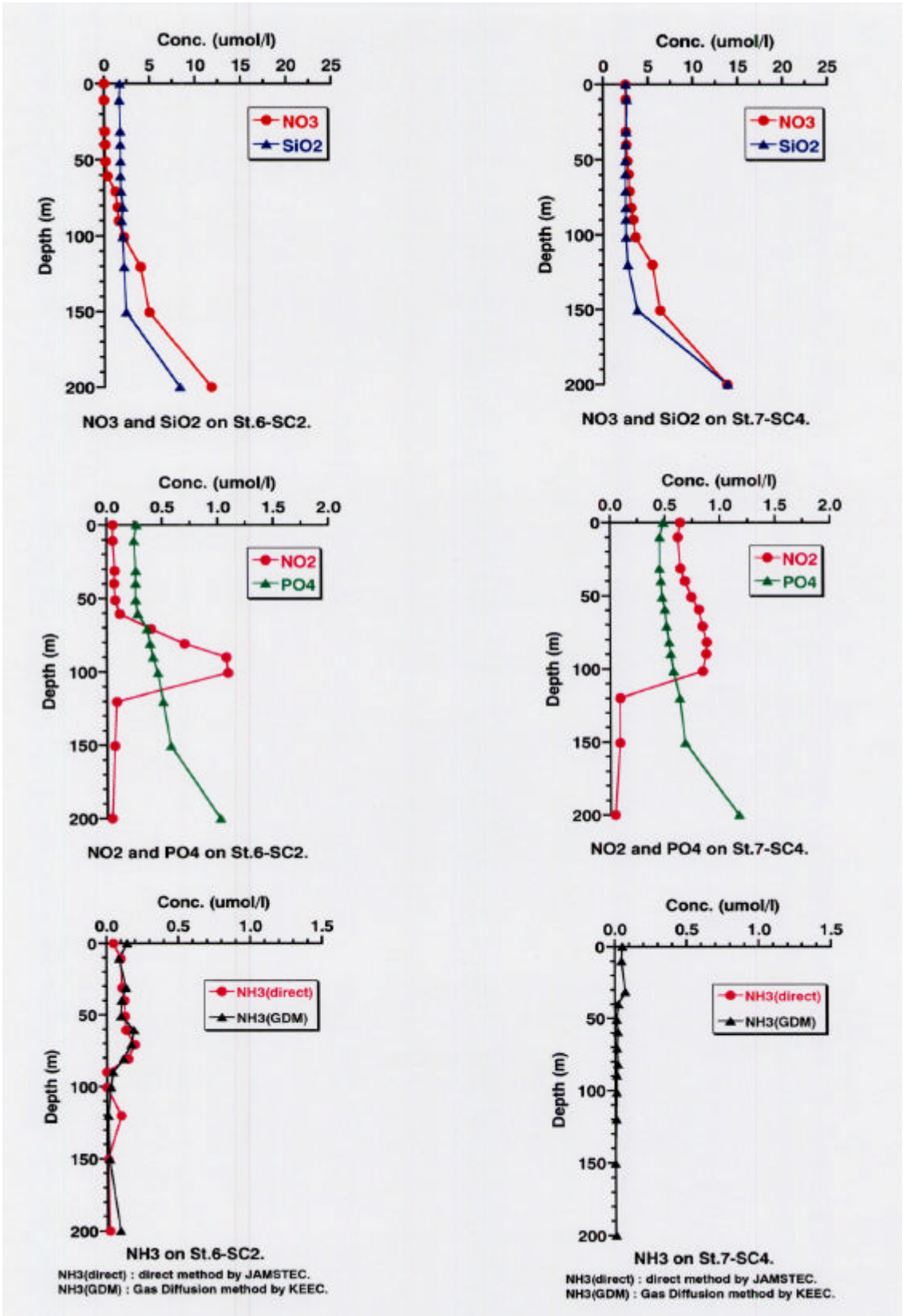
Figure 2-(e). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting., the 'DC' stands for deep casting.
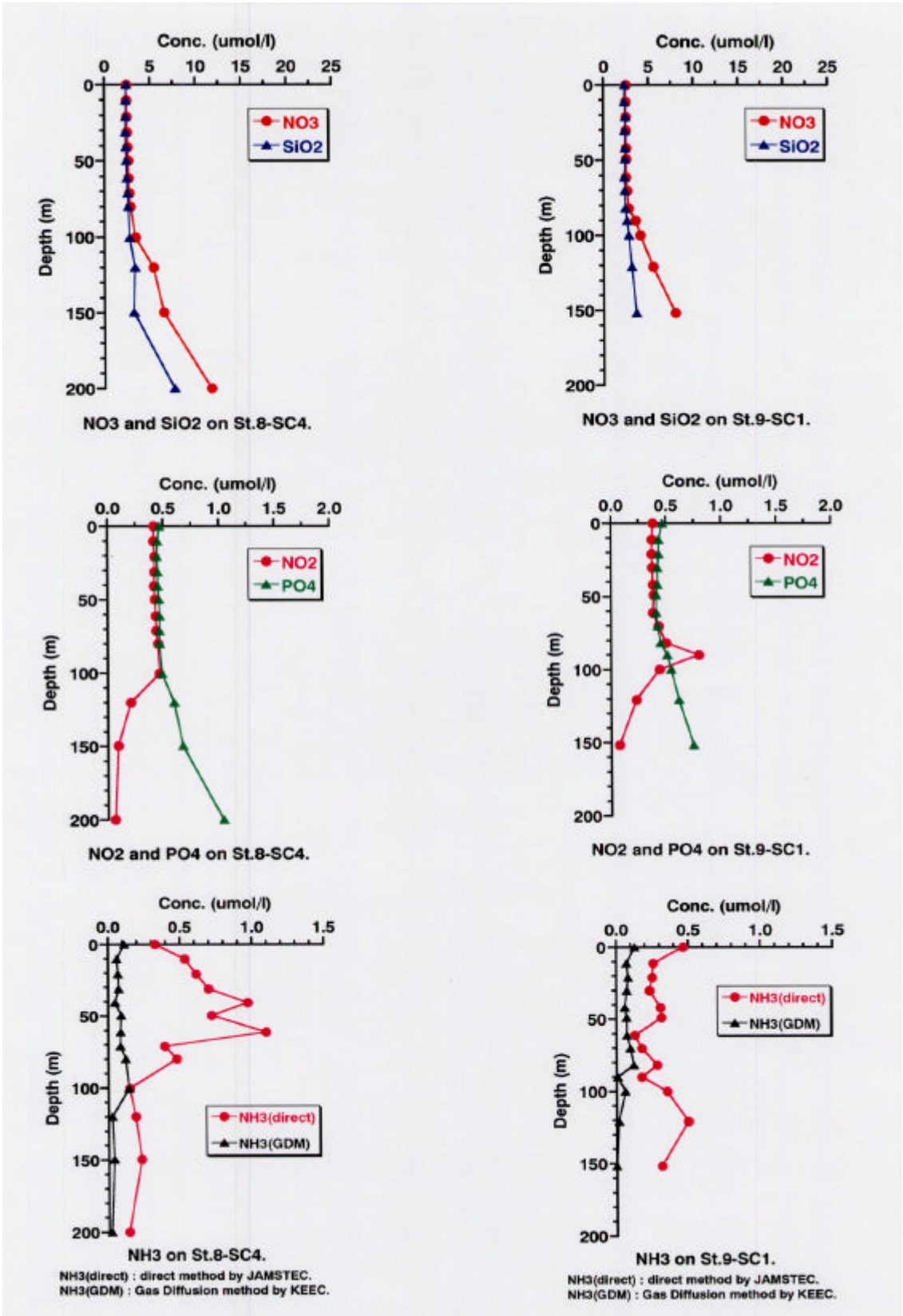
Figure 2-(f). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
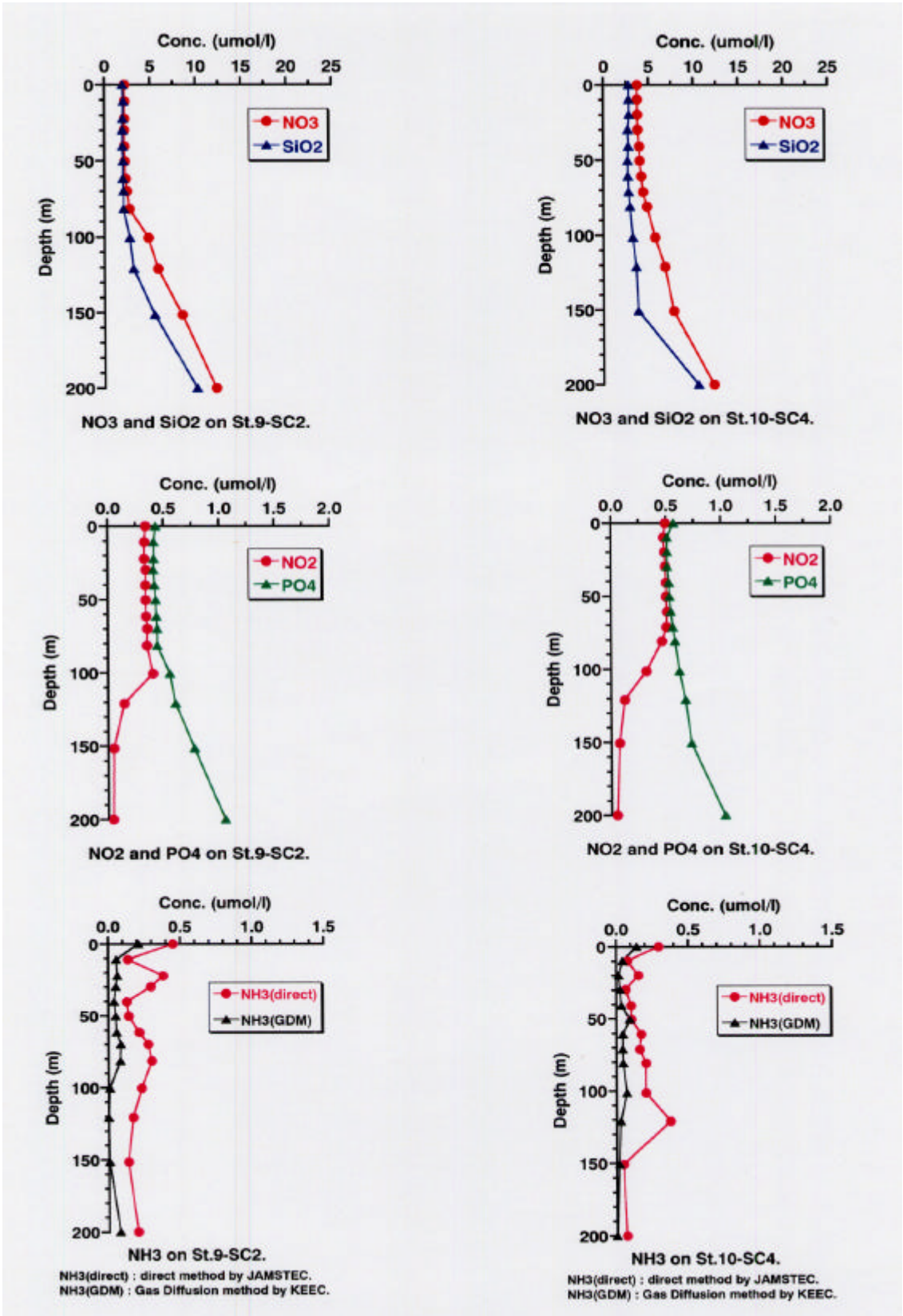
Figure 2-(g). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.

NO3 and SiO2 on St.11-SC4.

NO3 and SiO2 on St.12-SC1.

NO2 and PO4 on St.11-SC4.

NO2 and PO4 on St.12-SC1.

NH3 on St.11-SC4.

NH3(direct) : direct method by JAMSTEC.
NH3(GDM) : Gas Diffusion method by KEEC.

NH3 on St.12-SC1.

NH3(direct) : direct method by JAMSTEC.
NH3(GDM) : Gas Diffusion method by KEEC.
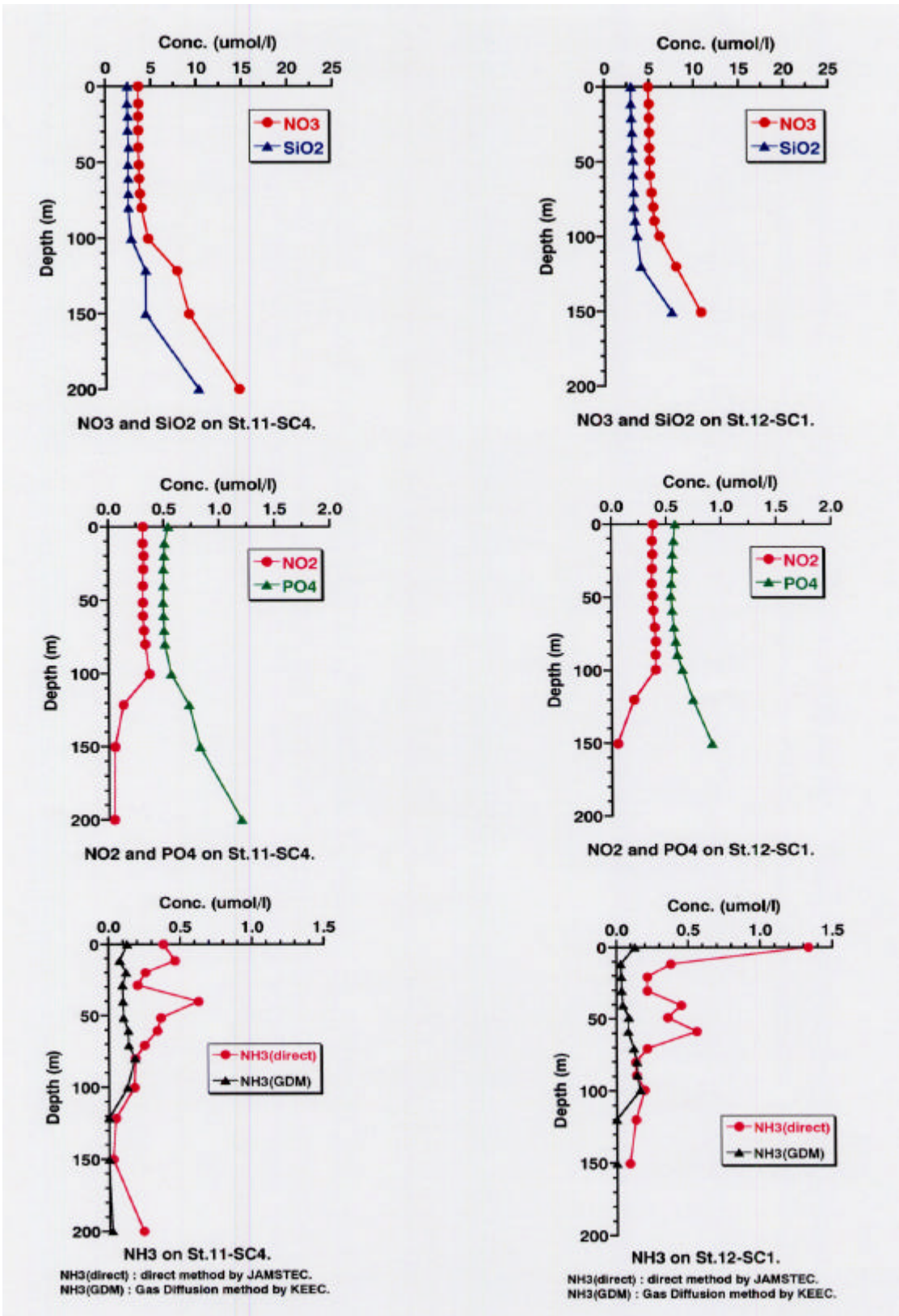
Figure 2-(h). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.

Conc. (umol/l)

NO3 and SiO2 on St.12-SC2.

Conc. (umol/l)

NO3 and SiO2 on St.1-DC.

Conc. (umol/l)

NO2 and PO4 on St.12-SC2.

Conc. (umol/l)

NO2 and PO4 on St.1-DC.

Conc. (umol/l)

NH3 on St.12-SC2.
NH3(direct) : direct method by JAMSTEC.
NH3(GDM) : Gas Diffusion method by KEEC.

Conc. (umol/l)

NH3 on St.1-DC.
NH3(direct) : direct method by JAMSTEC.
NH3(GDM) : Gas Diffusion method by KEEC.
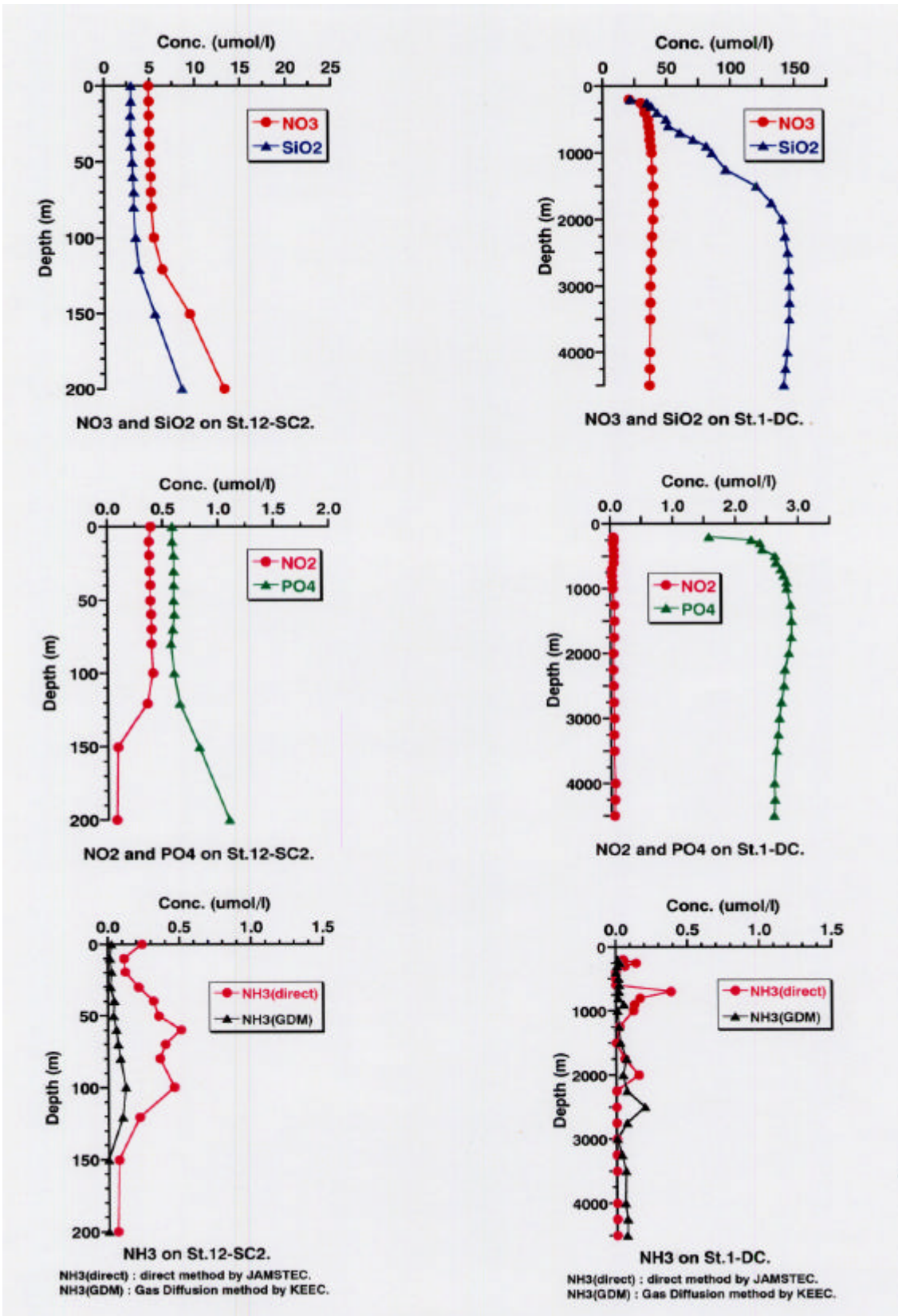
Figure 2-(i). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
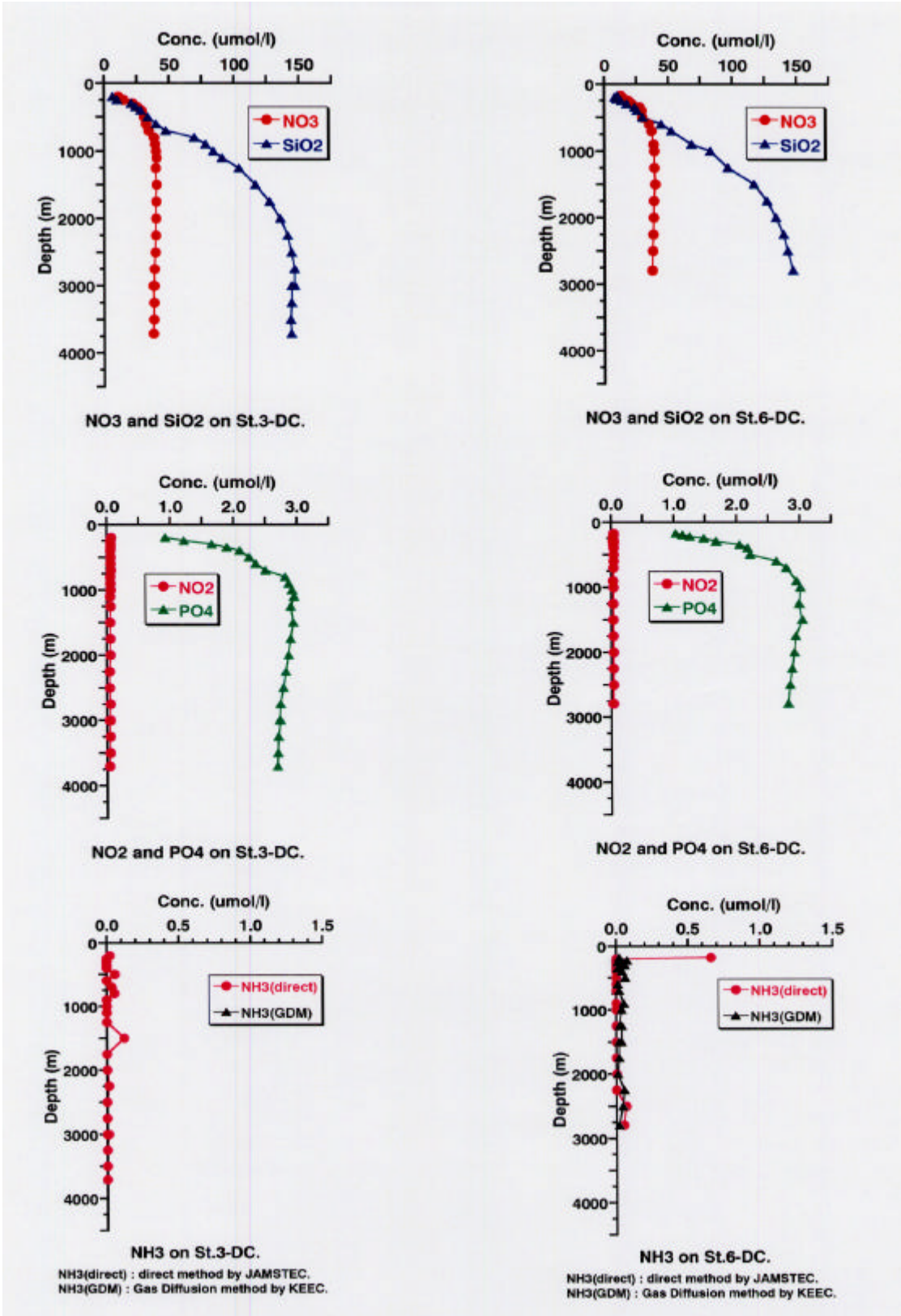
Figure 2-(j). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting,, the 'DC' stands for deep casting.
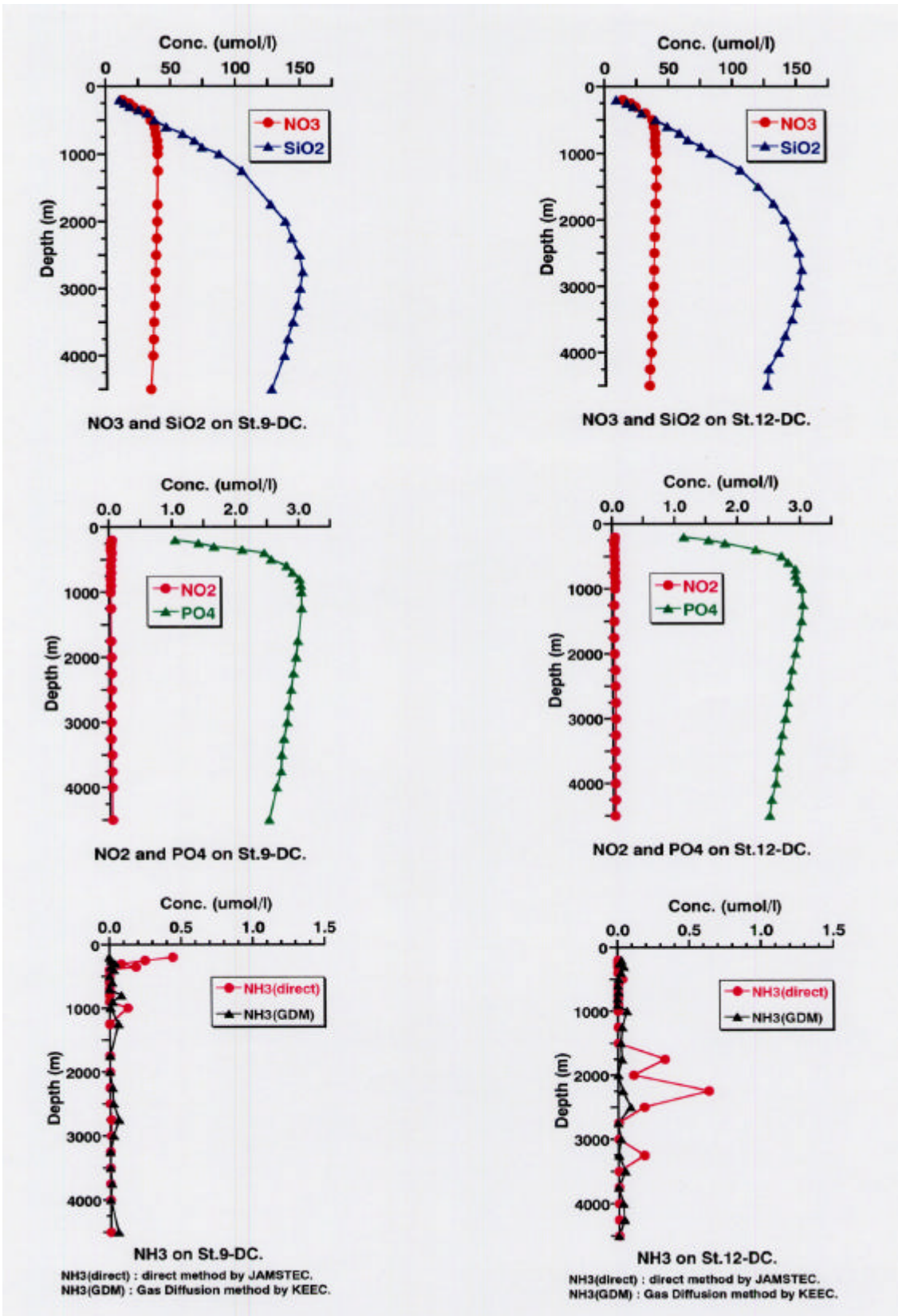
Figure 2-(k). Vertical profiles of nutrients in MR99K07 cruise.

The 'SC' stands for shallow casting., the 'DC' stands for deep casting.
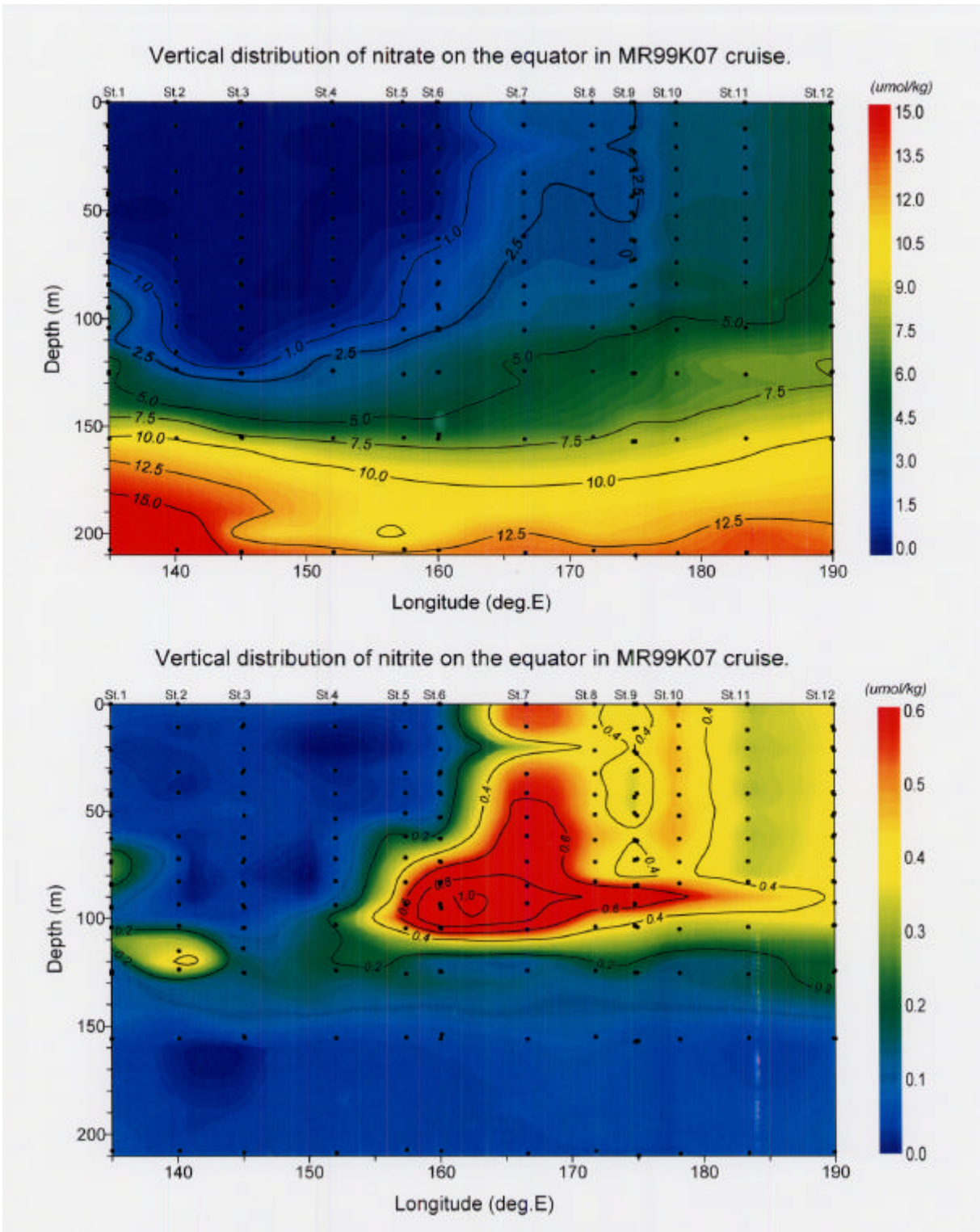
Figure 3-(a). Vertical distribution of nitrate and nitrite on the equator in MR99K07 cruise.
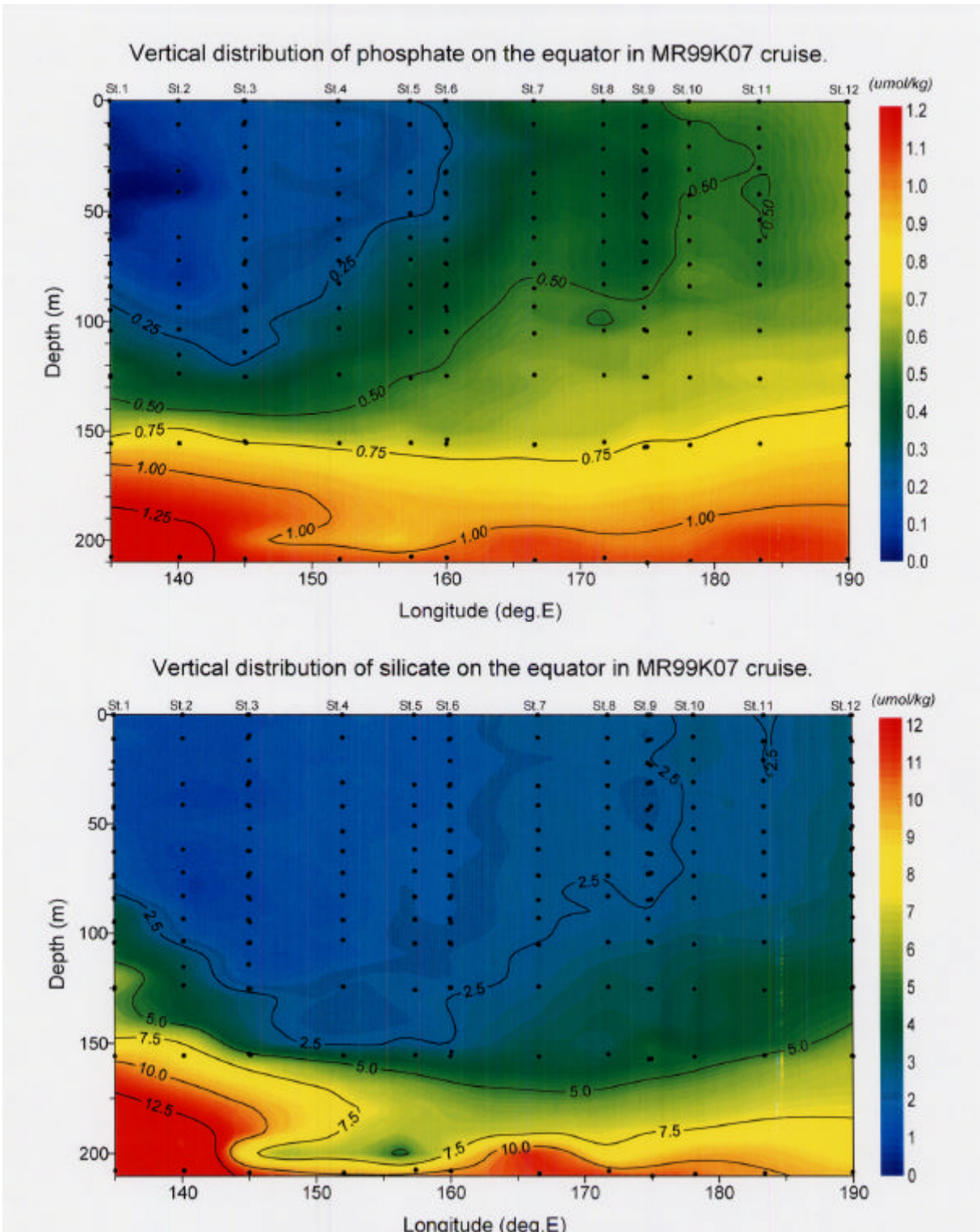
Figure 3-(b). Vertical distribution of phosphate and silicate on the equator in MR99K07 cruise.
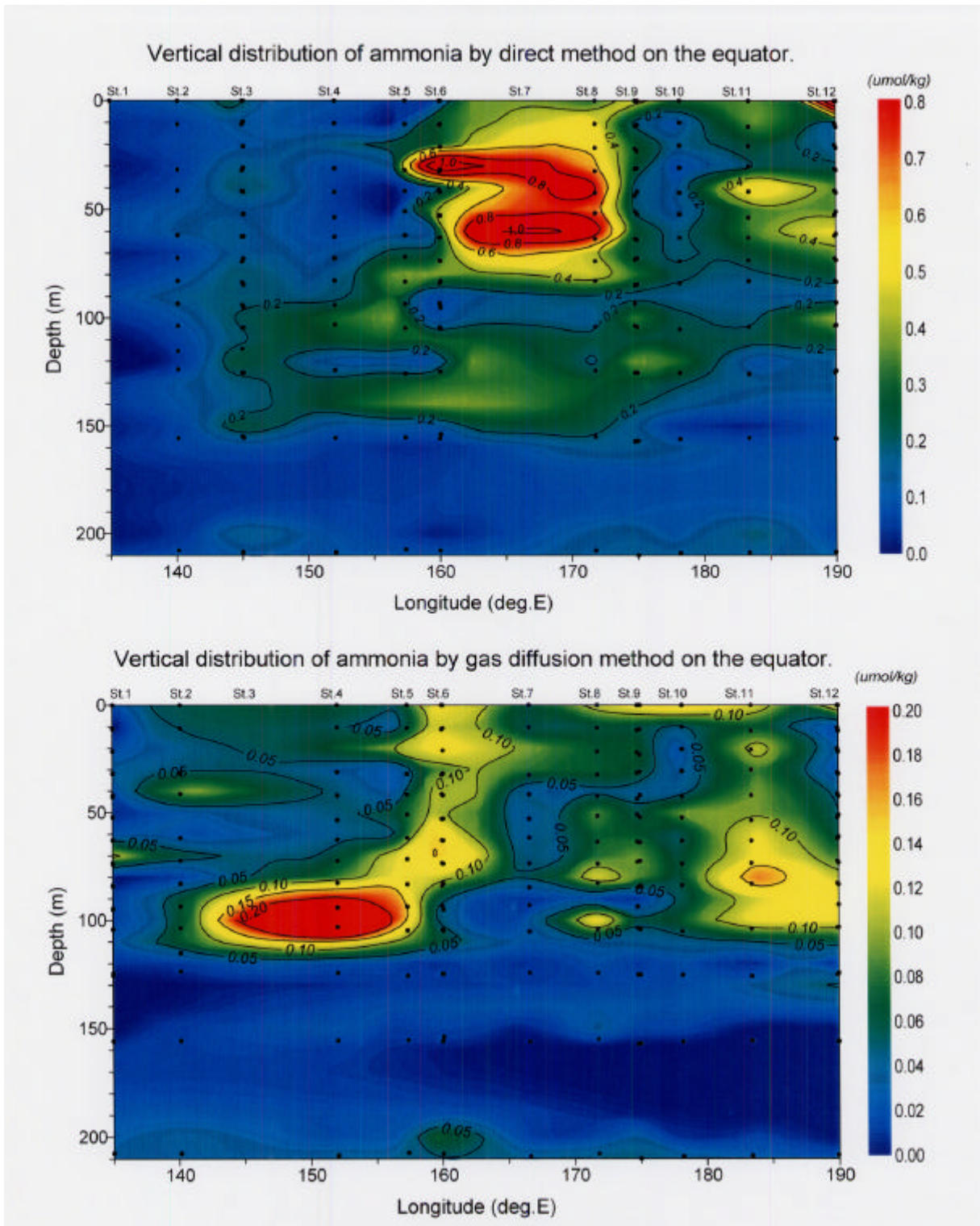
Figure 3-(c). Vertical distribution of ammonia (DM) and ammonia (GDM) on the equator
in MR99K07 cruise.

3.4 Pigment Analysis

3.4.1 Chlorophyll *a* measurements of phytoplankton pigment by fluorometric analysis

Kazuhiko Matsumoto (JAMSTEC), Keisuke WATAKI (MWJ), Yuichiro KONDO (MWJ), Nakahito NISHIKAWA (MWJ), Shigeyoshi ARAKI (MWJ) and Kotoe YAMAUCHI (MWJ)

JAMSTEC: Japan Marine Science and Technology Center
MWJ: Marine Works Japan Ltd.

Objectives

　　　　The purpose of this study is to estimate the distributions of chlorophyll-a in the equatorial Pacific by fluorometric analysis. Chlorophyll-a measurements are carried out with three different type fluorometers (broadband filter type, narrowband filter type and wavelength selectable type). Broadband filter type fluorometer is used in common, but it is recognized the errors related to the acidification technique when chlorophyll-b is present. Welschmeyer (1994) developed the new non-acidification method with narrowband filter type fluorometer to eliminate the effect of acidification error. Narrowband filter type fluorometer is the same equipment as broadband filter type fluorometer, just changed excitation-emission filters. A new non-acidification method is not need to consider the acidification error, but the new method yield some overestimate of the true chlorophyll-a concentration, especially when chlorophyll-b is present. We attempted to divide the chlorophyll-b from chlorophyll-a to reduce the overestimate of chlorophyll-a value by the new non-acidification method with wavelength selectable spectrofluorophotometer.

Materials and Method

　　　　Seawater samples were collected at twelve sampling sites between longitude 135E and 170W in the equatorial Pacific. The samples were collected at 13 depths from the depth of surface to 200m with Niskin bottles, except for the surface water, which was taken by the bucket. The samples (sample volume of 1 liter for Shimadzu spectrofluorophotometer and 0.5 liter for Turner fluorometer) were gently vacuum-filtered (<20 cmHg) through Nuclepore filters (pore size: 0.4 µm; diameter: 47 mm) in the dark room. The chlorophylls on the filters were immediately extracted in the N, N-dimethylformamide (6 ml) and then, the samples were stored at –30 degC until the analysis of chlorophylls. Fluorescence measurements were performed at room temperature (25+/-2 degC) after the samples were taken out of the freezer.

　　　　Traditional acidification and Welschmeyer non-acidification methods were examined for the determinations of chlorophyll-a with Turner design model 10-AU-005 fluorometer. Traditional acidification method was performed at 1 minute later after adding the 1 M hydrochloric acid. Analytical conditions of two methods indicate in Table 1.

Table 1   Analytical conditions of traditional acidification and Welschmeyer non-acidification methods for chlorophyll-a with Turner fluorometer.

		Traditional method	Welschmeyer method
Excitation filter	/nm	5-60 (340-500nm)	436nm
Emission filter	/nm	2-64 (>665nm)	680nm
Optical kit		10-037R	10-040R
Lamp		Daylight White F4T5D	Blue F4T5, B2/BP
			(F4T4, 5B2 equiv.)

Shimadzu RF-5300PC spectrofluorophotometer was used for the determination of chlorophyll-a by the acidification method and non-acidification method, and for the chlorophyll-b estimation. Analytical conditions as follows;

SHIMADZU RF-5300PC analytical conditions:

Chlorophyll-a ;   Excitation wavelength : 433 nm / slit width 3.0nm
                   Emission wavelength : 668 nm / slit width 5.0nm

Chlorophyll-b ;   Excitation wavelength : 461 nm / slit width 3.0nm
                   Emission wavelength : 654 nm / slit width 5.0nm
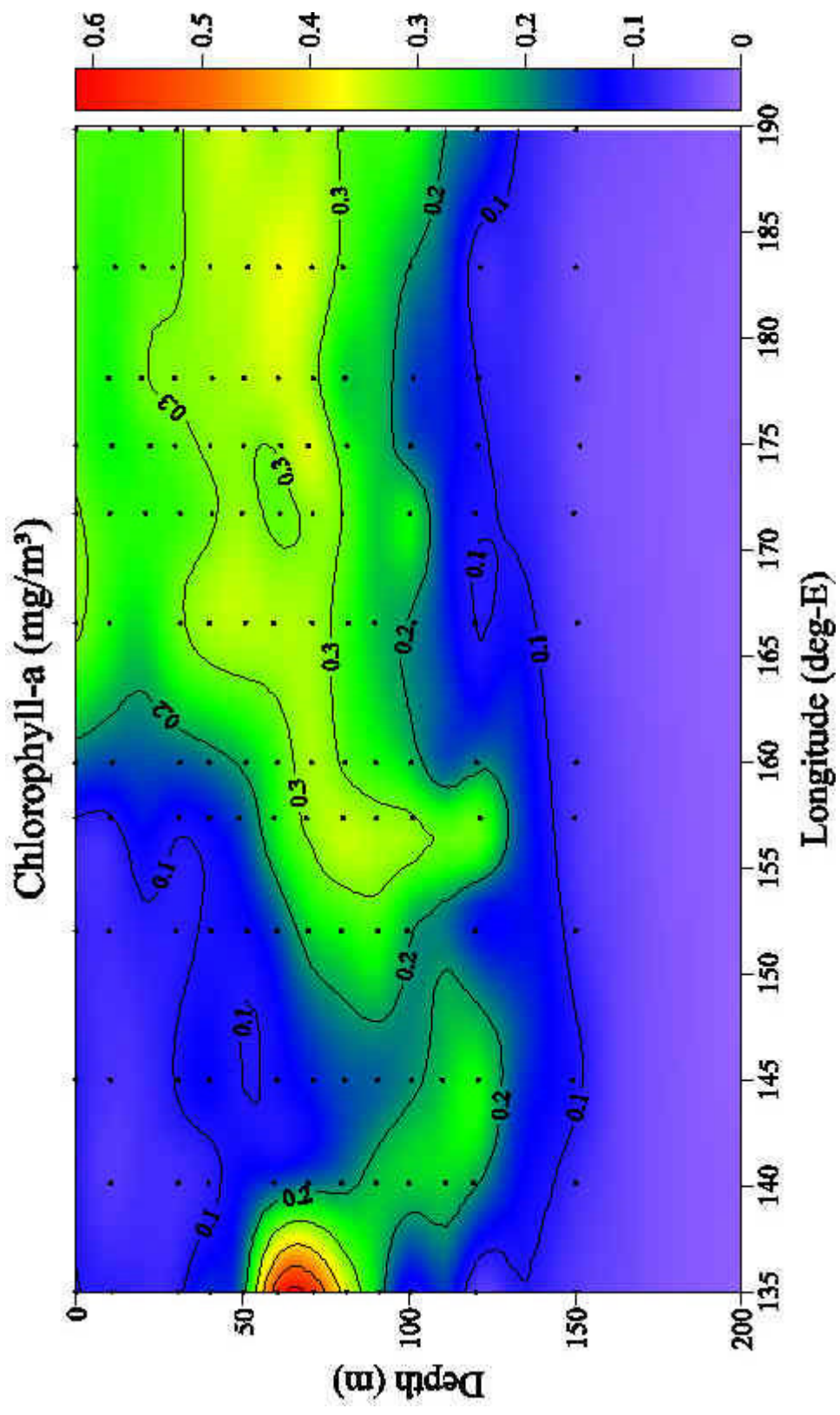
3.4.2 The measurement of phytoplankton pigment by HPLC

Keisuke WATAKI (MWJ) and Kazuhiko Matsumoto (JAMSTEC)

JAMSTEC: Japan Marine Science and Technology Center
MWJ: Marine Works Japan Ltd.

Objectives

       High-performance liquid chromatography (HPLC) analysis has been shown to be a conclusive method for separating and quantifying pigments in natural water. In this cruise, the phytoplankton pigments are analyzed, in order to compare the phytoplankton community structure.

Materials and Method

       Samples were filtered onto Whatman GF/F grass-fiber filters. The water remaining filters after filtration was removed by vacuum dry. Phytoplankton pigments were extracted in N,N-dimethylformamid over 24 hours in freezer (–20degC). Ultra pure water as the role of ion-pair reagent and the internal standard (canthaxanthin) are added to all samples before injection. Phytoplankton pigments are measured by two different HPLC methods. The one is showed as the following solvents and column system, which is modified method of Wright *et al.* (1991).

       Solvent A; 80:20 methanol : 0.5M ammonium acetate

       Solvent B; 90:10 acetonitrile:water

       Solvent C; ethyl acetate

       Column: C-18 (J'sphere ODS-H80; YMC, Inc.) 4.6x150mm I.D.

The other is showed as the following solvents and column system, which is modified method of Goericke and Repeta (1993).

       Solvent A; 75:25 methanol : 0.5M ammonium acetate

       Solvent B; methanol

       Column: C-8 (Pro C8; YMC, Inc.) 4.6x150mm I.D.

HPLC systems are consisted as follows.

       Detector: Waters 996 Photodiode Array

       Pump: Waters600

       Auto Sampler: Waters 717 plus

       Column temperature: 40degC

       The HPLC system is caliblated with commercially pigment standards (chlorophyll-a and -b from Sigma Chem.Co., and chlorophyll-c, diadinoxanthin, lutein, fucoxanthin, alpha-carotene, beta-carotene, neoxanthin, peridinin, prasinoxanthin, alloxanthin, violaxanthin, 19'-hexanoyloxyfucoxanthin, 19'-butanoyloxyfucoxanthin, canthaxanthin, zeaxanthin and

diatoxanthin from VKI). Concentrations of pigment standards are determined using spectrophotometer. Chlorophyll-a and -b are quantitatively evaluated by drawing the calibration curve using the amount of the standards and their respective peak areas. Other pigments are quantitatively evaluated using the formula of JGOFS Protocols (1994). Chlorophyll-a and -b peak areas are measured by Photodiode Array Detector at each blue maximum wavelength. Others are measured at 460nm.

Samples will be analyzed at JAMSTEC, Yokosuka.

3.4.3 Size fraction of phytoplankton by fluorometric analysis

Kazuhiko Matsumoto (JAMSTEC), Keisuke WATAKI (MWJ),
Yuichiro KONDO (MWJ) and Kotoe YAMAUCHI (MWJ)

JAMSTEC: Japan Marine Science and Technology Center
MWJ: Marine Works Japan Ltd.

Objectives

Phytoplankton are existed various species and sizes in the ocean. Phytoplankton species are roughly characterized by size. The object of this study is investigated the vertical distribution of phytoplankton after the size filtration procedure in the equatorial Pacific.

Materials and Method

Seawater samples were collected at twelve sampling sites between longitude 135E and 170W in the equatorial Pacific Ocean. The samples were collected at 13 depths from the depth of surface to 200m with Niskin bottles, except for the surface water, which was taken by the bucket. The samples (1 liter) were gently vacuum-filtered (< 20 cmHg) through the 47mm-diameter 10.0μm mesh filter and Nuclepore filters (pore size of 2.0μm, 1.0μm and 0.4μm) after sampling. At the Stns. 10 to 12, the samples were filtered without 10.0μm filter. Phytoplankton pigments on the filters were immediately extracted in 6 ml of N, N-dimethylformamide after filtration. Then, the extracted samples were stored in the freezer (-30 degC) for more than 24 hours before analysis. Chlorophyll-a was measured by the acidification (1 M-HCl) and non-acidification (modified Welschmeyer method 1994) method of a fluorometric determination using the spectrofluorophotometer (SHIMADZU RF-5300PC). Then, we attempted to measure the chlorophyll-b by fluorometric determination.

SHIMADZU RF-5300PC analytical conditions:

  Chlorophyll-a ; Excitation wavelength : 433 nm / slit width 3.0nm
         Emission wavelength : 668 nm / slit width 5.0nm
  Chlorophyll-b ; Excitation wavelength : 461 nm / slit width 3.0nm
         Emission wavelength : 654 nm / slit width 5.0nm

3.4.4 Characterization of light absorption coefficients of phytoplanktons in the equatorial Pacific Ocean

Chie MINAMI (Institute for Hydrosheric-Atmosheric Sciences, Nagoya university)
Kazu Matsumoto (JAMSTEC)

Objective

The spectral absorption coefficients of phytoplankton are used to calculate the light energy absorbed by phytoplankton (PUR; Photosynthetically usable radiation) and one of the essential parameter of studying primary productions in the ocean. So it is important to estimate the spectral absorption coefficients understanding the optical property in the sea.

Method

Seawater samples were collected approximately 5 litters at 13 depths (shallow 1 cast) or 12depths (shallow 2 and 4 cast) from surface to 150m using Niskin bottles and bucket at station1-12. The samples were filtrated Whatman GF/F glass fiber filters (diameter; 25mm) at pressure of <150mHg. The sample filters were measured the optical density of particles retained on the filter (OD_{fp}) by using a spectrophotometer (Shimadzu MPS240-PC). After that the sample filters were bleached with1% NaClO solution for ten minutes, then the optical density of the decolorized particles (OD_f) were measured again. The optical density of particles retained on the filter (OD_{fp} / OD_f) needs to convert to aqueous value (OD   / OD   ). We applied the correlation of Cleveland and Weidemann (1993) In this study.

$$OD_s (\ ) = 0.378\, OD_f (\ ) + 0.523\, OD_f (\ )^2$$

The absorption coefficient of particles (a_p) and decolorized particulate matter (a_d) are calculated as following equation:

$$a(\ ) = 2.3 * OD\ (\ ) / L;\ (L = V / S)$$

Where, S is the clearance area of the filter (m^2) and V is the volume of filtered water (m^3).

The subtraction of a_d from a_p shows the light absorption coefficient of the living phytoplankton (a_{ph}).

$$a_{ph} = a_p - a_d$$

3.4.5 Distribution and abundance of picophytoplankton in the equator of Pacific Ocean: Results of flow cytometry analysis

Atsushi Yamaguchi[1] and Kazuhiko Matsumoto[2]

[1]: KANSO (Kansai environmental engineering center)
[2]: JAMSTEC (Japan marine science technology center)

Abstract

Distribution and abundance of picophytoplankton populations were investigated along the equator of Pacific Ocean during the MR99-K07 cruise.   Cell density, fluorescence, and size of picophytoplankton were analyzed using flow cytometry.   Large regional difference was observed in distribution of picophytoplankton.   Vertical distribution of picophytoplankton was deeper (peak was ca. 100 m) in the western stations (St. 1-4, 135° E to 152° E), and was shallower in the eastern stations (St. 5-12, 157° 20'E to 170° W).   Regional difference in abundance was smaller than that of distribution pattern (integrated cell density was same order [4-9 x 10^{12} cells m^{-2}: 0-200 m] in all the station).   Cell density at maximum layer ranged from 40-180 x 10^3 cells ml^{-1}.   Prochlorophytes (*Prochlorococcus*) was the most dominant taxon in picophytoplankton population throughout the layer or region.   However, the taxonomic contribution in density, fluorescence, and size of picophytoplankton was different each other.   Additional information about fluorescence and size of picophytoplankton, and effect of preservation or storage of sample was mentioned.

Introduction

The structure of the pelagic ecosystem has been reconsidered after the discovery of the widespread occurrence of picophytoplankton (Waterbury et al. 1979), which are smaller than 2um.   Primary production in subtropical and tropical open waters is largely attributed by picophytoplankton. Picophytoplankton community is composed of prokaryotic cyanobacteria (*Synechococcus* spp.) and eukaryotic microalgae (Takahashi et al. 1985, Blanchot et al. 1992, Campbell and Vaulot 1993).   Li and Wood (1988) also found very small red-fluorescing bodies by flow cytometry in the North Atlantic Ocean.   They considered that the very small red-fluorescing bodies corresponded to prochlorophyte described by Chisholm et al. (1988).   More recently, the prokaryotic alga was isolated and named *Prochlorococcus marinus* (Chisholm et al. 1992).

Picophytoplankton communities are well suited for analysis by using flow cytometry. Flow cytometry can count small particle rapidly, and measure type of fluorescence and size of particle.   Three taxon of picophytoplankton can divide based on their fluorescence (Table I). Flow cytometry can detect these three picophytoplankton.   The present study aims to reveal features of distribution and community structure of picophytoplankton along the equator Pacific Ocean.   Additional information about fluorescence and size of picophytoplankton, and effect of

preservation or storage of sample will be mentioned.

Table I. Three taxon of picophytoplankton and their fluorescence.

Name of taxon	Type of fluorescence
Cyanobacteria (*Synechococcus* spp.)	Orange (Phycoerythrin) and Red (Chlorophyll *a*)
Prochlorophytes (*Prochlorococcus*)	Red (Chlorophyll, but mostly divinyl-chlorophyll *a*)
Picoeukaryotes	Red (Chlorophyll, mostly Chlorophyll *a*)

Material and methods

Equipment

The flow cytometer system used in this research was BRYTE HS system Bio-Rad Laboratories Inc.
System specification were follows:

Light source: 75W Xenon arc or 75W Xenon/Mercury arc

Excitation wavelength: 350-650 nm

Selectable by changing filter block

Scatter sensitivity: approximately 0.2 um, resolution: 0.02 um

Fluorescence detection: 3-colour (1 option) wavelength selectable by changing filter block

Detector: high-performance PMT

Analyzed volume: max 75 ul

Flow rate: 0.5-50 ul min^{-1}

As sheath fluid, high quality DW (milli-Q) was used. To detect fluorescence of chlorophyll and phycoerythrin, we selected B2 as excitation filter block and OR1 as fluorescence separator block. B2 and OR1 have ability as follows:

B2:	Excitation filter	390-490 nm
	Beam-splitter	510 nm
	Emission filter	515-720 nm
OR1:	Emission filter 1	565-605 nm
	Beam-splitter	600 nm
	Emission filter 2	>615 nm

Because of the size of picophytoplankton (smaller than 2 um), we changed voltage of PMT (photomultiplier tube) and gain as follow:

Parameter	PMT	Gain	Threshold
LS1	300	Log	19
LS2	350	Log	
FL1	500	Log	
FL2	500	Log	

Flow rate of sample was 0.7Bar 15 ul min^{-1}.

Sampling

Water samples were collected using Niskin sampler mounted on CTD. The surface water (0 m) was collected by bucket. After the capture, water samples was immediately filtered with 10 um filter which mounted with filter holder, and placed in 50 ml poly-carbonate bottle, and stored in freezer (ca. 4degC) for one hour until measurement.

Measurement

Before 10 min of measurement, the power of flow cytometer was turned on (for warm up). Water sample (75 ul) was run on the flow cytometer (e.g. it takes 5 min to measure 1 sample each [75/15=5]). Triplicate measurement was carried out for each water sample. Result was shown as mean of triplicate (for detail data of triplicate, refer the Appendix after). After the measurement, the sample was fixed with glutaraldehyde (1% final concentration) for 10 min, then frozen in deep freezer (-20degC).

Data analysis

Analyzing a typical sample was as follows. In a scatter-plot of FL1 (orange fluorescence: phycoerythrin) vs. FL2 (red fluorescence: chlorophyll), there could be discriminated classify the cells into three groups: cyanobacteria (*Synechococcus*), prochlorophytes (*Prochlorococcus*), and picoeukaryotes (Fig. 1). Left under corner of scatter-plot was low fluorescence group where could not identify from noise, and this fraction was abandoned as noise. In the software of BRYTE-HS, cell density (count per ul) and mean of fluorescence (FL1 or FL2) and size (LS1 or LS2) were calculated for each gated group. The raw data of each fluorescence and size was shown in Appendix.
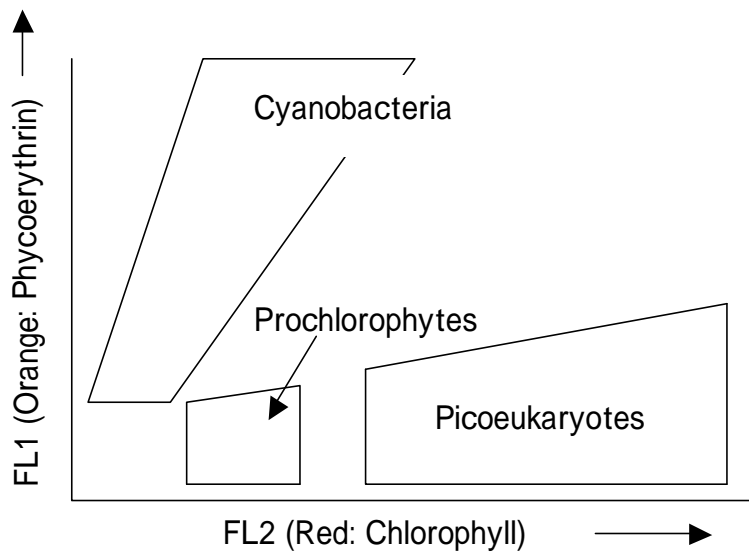
Fig. 1. Schematic diagram of scatter-plot of FL1 (orange fluorescence) vs. FL2 (red fluorescence). Three picophytoplankton (cyanobacteria, prochloro- phytes, and picoeukaryotes) were separated as subpopulation in this plot.

Size of cell

Size of cell was estimated from LS1 or LS2 (LS means light-scattering). Relationship between LS1 and diameter of beads was shown in Fig. 2.
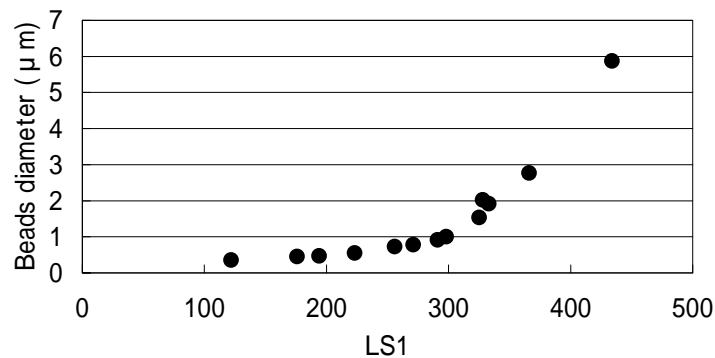
Fig. 2. Relationship between LS1 and beads diameter (um).

Relationship between beads diameter and LS1 was fitted by equation: $\text{Log}_{10}\ Y=a+bX$, where *a* and *b* were constant.

$\text{Log}_{10}Y=1.9095+0.004099X$ ($r=0.97$)

Where *Y* means diameter of beads (nm: 1000 x um) and *X* is LS1.   Assuming shape of cell as a sphere, using this equation, data of LS1 for cell was converted to diameter.   However, calculated cell diameter in this research was unfortunately smaller than that of previously reported (see "Results-size of cell").   It seems clear that the shape of cell was different from a sphere (might be oval shape), and note the diameter in the present study is underestimate ones.

Effect of preservation and storage

After the measurement, samples were preserved with glutaraldehyde (1% final concentration).   To observe the effect of preservation and storage, additional measurement was carried out based on the samples at St. 12 cast 2.   Samples were measured twice, one was in fresh and the other was in 9 days after of preservation.   Cell density, fluorescence, and cell size of both data were compared.

Results

Results shown in this section was based on the mean of triplicate measurements.   The raw data of density, fluorescence, and size of three measurements at each sampling layer were shown in Appendix.

Distribution and abundance

Picophytoplankton cell density at the maximum layer was varied from 52 x 10^3 cells ml^{-1} at 50 m of St. 9 (cast 1) to 195 x 10^3 cells ml^{-1} at 60 m of St. 1 (cast 2) (Fig. 3).   Thus the order of picophytoplankton cell density at maximum layer was ranged from 10^4 to 10^5 cells ml^{-1}.   Vertical distribution was different with station.   At first three station (St. 1 to 3), cell density between 0 and 50 m was very small (<10 x 10^3 cells ml^{-1}), and increased rapidly below 50 m (the maximum depth was ca. 90 m) (Fig. 3).   This sharp maximum below 50 m became smooth after St. 4, and the maximum layer became shallower (ca. 70 m).   The maximum layer was shallow during St. 7 to 12 (ranged between 30 and 50 m, see Fig. 3).

Regional difference in abundance was insignificant.   In terms of standing stock (or integrated cell density, cells m^{-2}: 0-200 m), there ranged from 4 to 9 x 10^{12} cells m^{-2} (all the station was in same order, Table II).

Throughout the layer and station, Prochlorophytes (*Prochlorococcus*) was the most dominant taxon (ranged 77-94% of the picophytoplankton, see Table II).   Cyanobacteria (*Synechococcus*) was the second (2-17%) and Picoeukaryotes was the least (3-9%).   The taxonomic composition was different with depth.   Contribution of Cyanobacteria was larger in the surface layer (especially 0 to 30 m), and Prochlorophytes was larger in the deeper layer (below of 100 m) (Fig. 3).

Table II. Standing stock ($\times 10^{12}$ cells m^{-2}) and taxonomic composition of picophytoplankton at St. 1 to 12.

Station (cast)	1 (2)	2	3 (1)	3 (2)	4	5	6 (1)	6 (2)
Cyanobacteria	0.41	0.10	0.26	0.28	0.44	0.44	1.07	0.90
(%)	8	2	5	5	6	6	17	13
Prochlorophytes	4.31	4.35	4.35	5.70	7.20	6.20	4.82	5.43
(%)	86	94	91	92	92	89	77	82
Picoeukaryotes	0.27	0.16	0.16	0.20	0.20	0.32	0.38	0.33
(%)	5	3	3	3	3	5	6	5
Total	4.99	4.62	4.77	6.18	7.83	6.96	6.26	6.66

Table II.　(Continued)

Station (cast)	7	8	9 (1)	9 (2)	10	11	12 (1)	12 (2)
Cyanobacteria	0.84	0.71	0.78	0.74	0.46	0.57	0.99	0.89
(%)	11	10	15	13	9	11	11	11
Prochlorophytes	6.27	5.98	3.83	4.48	4.09	4.26	7.28	6.24
(%)	83	82	76	79	83	81	81	79
Picoeukaryotes	0.47	0.56	0.44	0.47	0.38	0.41	0.73	0.73
(%)	6	8	9	8	8	8	8	9
Total	7.58	7.25	5.05	5.69	4.92	5.23	9.00	7.86

Fluorescence

BRYTE-HS could measure the brightness of fluorescence.　Two type of fluorescence were measured in this study: phycoerythrin (orange fluorescence, FL1) and chlorophyll (red fluorescence, FL2).　Phycoerythrin was observed only for cyanobacteria, while chlorophyll was observed all the picophytoplankton (see Table I).　Vertical changes in fluorescence of each picophytoplankton were shown in Fig. 4.　All the fluorescence increased with increasing depth (Fig. 4).　As only exception was seen for cyanobacteria at St. 9 cast 2, which was partly because there included two *Synechococcus* species.　In the scatter plot, high- and low-fluorescence species was identified for *Synechococcus*, and the vertical distribution of high-fluorescence species was shallower than low-fluorescence species.

Relationship between fluorescence and depth was fitted with liner equation: $Y=a+bX$, where *a* and *b* were constant, and *Y* was relative fluorescence (peak of fluorescence as 1) and *X* was depth in m.　Each fluorescence showed significant correlation with depth and liner equation was yield (Table III).

Table III. Liner equation between relative fluorescence (*Y*, peak of fluorescence as 1) and depth (*X* depth in m).

		Equation: $Y=a+bX$	
Taxon.	Fluorescence	*a*	*b*
Cyanobacteria	Phycoerythrin	0.7187	0.00205
Cyanobacteria	Chlorophyll	0.6781	0.00268
Prochlorophytes	Chlorophyll	0.6729	0.00274
Picoeukaryotes	Chlorophyll	0.8210	0.00154

The intercept of this equation (*a*) indicated relative fluorescence of each taxon at sea surface (0 m). Decreasing of fluorescence near the surface layer was larger in chlorophyll of prokaryotes (0.68 for cyanobacteria and 0.67 for prochlorophytes). Decreasing was small for chlorophyll of eukaryotes (0.82 at surface) and phycoerythrin of cyanobacteria was middle of them (Fig. 5).
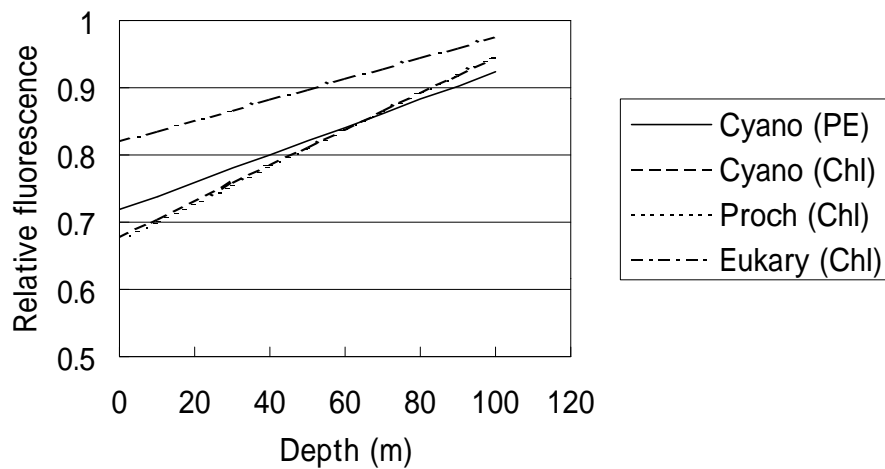
Fig. 5. Relationship between relative fluorescence and depth. Cyano (PE): phycoerythrin of cyanobacteria, Cyano (CHL): chlorophyll of cyanobacteria, Proch (CHL): chlorophyll of prochlorophytes, Eukary (CHL): chlorophyll of picoeukaryotes.

Size

Assuming the shape of cell as a sphere, cell size was estimated from LS1 data. The estimated cell size was smaller than that of previously reported ones (see Morel et al. 1993). It was partly because the shape of cell was not a sphere (see Material and methods). Note that size of cell in the present study was underestimated data. Because of this limitation, only the relative changes between taxon and/or depth was mentioned here.

In the relative sense, numerical minority picoeukaryotes had the largest cell size, and numerical dominant prochlorophytes was the smallest (cyanobacteria was the middle both in number and size) (Fig. 6). This reverse order was also the case of fluorescence (e.g. picoeukaryotes >cyanobacteria>prochlorophytes). It indicated that taxonomic contribution to cell density, fluorescence, and size was different each other.

Relationship between cell size and depth was uncertain.   In some station, the smaller cell was occurred between 50 and 100 m (see St. 8 or 11 in Fig. 6), but was not the case of all stations (see St. 5).   The vertical changes in cell size might be occurred, but to generalize some relationship with depth, the data available in this study was limited.

Effect of preservation and storage

Effect of preservation and storage was observed for samples at St. 12 cast 2 (Fig. 7).   Changes in cell density were the largest (Fig. 7a).   Cell density of cyanobacteria and picoeukaryotes were decreased by preservation, while prochlorophytes was increased near surface layer (0-20 m), and was decreased markedly below that layer.   Cell densities after preservation were decreased from that of fresh samples in factor of 0.80 (compared fresh sample as 1, mean of all samples) for cyanobacteria, 0.92 for prochlorophytes, and 0.70 for picoeukaryotes.

Fluorescence was also decreased by preservation and storage (Fig. 7b).   The decreasing of cell density might cause decreasing fluorescence of cell after preservation.   Decreasing in fluorescence was not observed for prochlorophytes near surface layer (0-20 m), while was observed below of that layer (Fig. 7b).   There observed no difference in phycoerythrin of cyanobacteria (preserved sample was 0.99 of fresh sample).   The other fluorescence (chlorophyll) decreased after preservation, in factor 0.89 of fresh sample for cyanobacteria, 0.93 for prochlorophytes, and 0.91 for picoeukaryotes.

While cell density and fluorescence were decreased after the preservation, size of cell was the only parameter which increased after the preservation (Fig. 7c).   Increasing in size from fresh sample was 1.12 (mean of all samples) for cyanobacteria, 1.27 for prochlorophytes, and 1.13 for picoeukaryotes.

Discussion

Distribution and abundance

Vertical distribution pattern is different between western stations (St. 1-4) and eastern stations (St. 5-12) (Fig. 3).   In the western (135° E to 152° E), cell density in the upper 50 m is extremely small, while below of 50 m, cell number rapidly increase and show prominent peak near 90 m (Fig. 8).   In the eastern (157° 20'E to 170° W), certain density is occurred at surface layer and have flat peak ca. 40 m (Fig. 8).   However, this regional difference is limited only for distribution pattern (i.e. shape of vertical distribution [sharp eastern and flat western] or depth of maximum [90 m in the eastern and 40 m in the western]).

Integrated cell density (cells m^{-2}: =standing stock) at all the station are in the same order (x 10^{12} cells m^{-2}) (Table II).   Taxonomic composition is also the same (prochlorophytes: cyanobacteria: picoeukaryotes=85:10:5) throughout the equator (Table II).   The cell density of prochlorophytes in the present study (10^3-10^5 cells ml^{-1}) is similar to previously reported in the open waters of the Pacific Ocean (Campbell and Vault 1993, Shimada et al. 1993).   The order of density of cyanobacteria in the present study (10^2-10^4 cells ml^{-1}) is also consistent with reported in the

tropical waters of the Pacific Ocean (Blanchot et al. 1992).

Regional difference observed for vertical distribution of picophytoplankton may related with vertical distribution of nutrient.   Nutrient especially NO_2 and PO_4 is limited (nearly zero) in the upper 100 m in the western stations, while is increased to 0.3-0.4 uM in the eastern stations (refer report on nutrient in this cruise).   In the western equator Pacific Ocean, Blanchot et al. (1992) found large differences between non-El Nino and El Nino conditions because upwelling bring nutrients to the surface
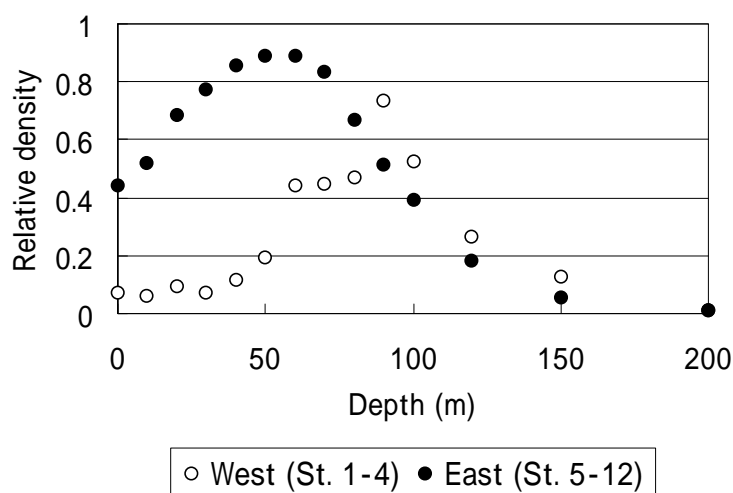
Fig. 8.   Vertical distribution of relative density of picophytoplankton
  (peak of density is considered as 1) in the western (135° E to 152° E ,
  open) and the eastern (157° 20'E to 170° W, solid).   Value at each
  depth represents mean of the listed station (St. 1-4 for the west and
  St. 5-12 for the east).

layer during non-El Nino year whereas surface nitrate is depleted when El Nino weakens or stop the upwelling.   In the present study, the western stations (St. 1-4, 135° E to 152° E) are considered as El Nino type while the eastern (St. 5-12, 157° 20'E to 170° W) are considered as non-El Nino type.

Fluorescence and size of cell
The low chlorophyll content per cell occurs in near-surface water (Prezelin et al. 1986) since the chlorophyll content becomes low at high incident irradiance (Kana and Glibert 1987, Morel et al. 1993).   Theoretical solar radiation received at the sea surface is calculated as about 2,000 uE m^{-2} s^{-1} between 10° N and 10° S in November and December (Lalli and Parsons 1993).   Under such the high irradiance, the chlorophyll content becomes less than 2 fg cell^{-1} (Kana and Glibert 1987). Moreover, nitrate-depletion also makes it smaller in the surface water (ca. 0.5 fg cell^{-1}) (Glover et al. 1988).   These environmental factors may result in the relatively little fluorescence content per cell observed at the shallow layers in the present study.

As mentioned before, the cell size data in the present study is underestimated one. We shall do re-calculation or analyzing the data in land laboratory, and have nothing to comment related with size.

Effect of preservation and storage

Compared with fresh sample, the preserved-storage sample has weak fluorescence per cell, it causes diminish detective number of cell and low cell density of the preserved-storage sample (Fig. 7). Effects of preservation may be different with that of storage. However, they could not divide in the present study. Thus the low-fluorescence and low-density phenomenon observed in the present study is a combined effect of preservation and storage. To observe "real" effects of both preservation and storage, another method is needed.

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3.5 Primary and new productivity

Ai YASUDA 1), Kenta OGAWA 1), Hirofumi OKANO 2), Takeshi KAWANO 2),Chie MINAMI3)
1) Marine Works Japan LTD
2) Japan Marine Science and Technology Center
3) Nagoya University

Objectives

The objective of this study is to known the mechanism of primary production at the open sea on the equator.

(1) In-situ Incubation

Bottles for incubation and filters

Bottles for incubation are ca. 1 liter Nalgen polycarbonate bottles with screw caps. Grass fiber filters (Wattman GF/F 25mm) pre-combusted under 420 degree C of temperature for at least 4 hours, were used for a filtration.

Incubation

In-situ incubation for 24 hours was executed at station 1,3,6 and 12.   We took two transparent bottles and one dark bottle samples from 13 layers (every 10m from surface to 100m, 120m and 150m depth and moored these samples at each depth for 24 hours (Fig.1).   All the samples were spiked with 0.2 mmoles/ L of NaH^{13}CO$_3$ solution just before mooring. Samples were filtered immediately after the incubation and the filters were kept frozen till the end of cruise. After that, the filters were dried on the oven of 45 degree C.

Measurement

After the cruise, all samples will be made to measure by a mass spectrometer ANCA-SL system at JAMSTEC.

In-Situ Incubation Plan for MR99-K07(Nov.-Dec.'99)

Incubation period
24 hours

Flash Light

GPS Bouy

10m interval

Sinker 10kg
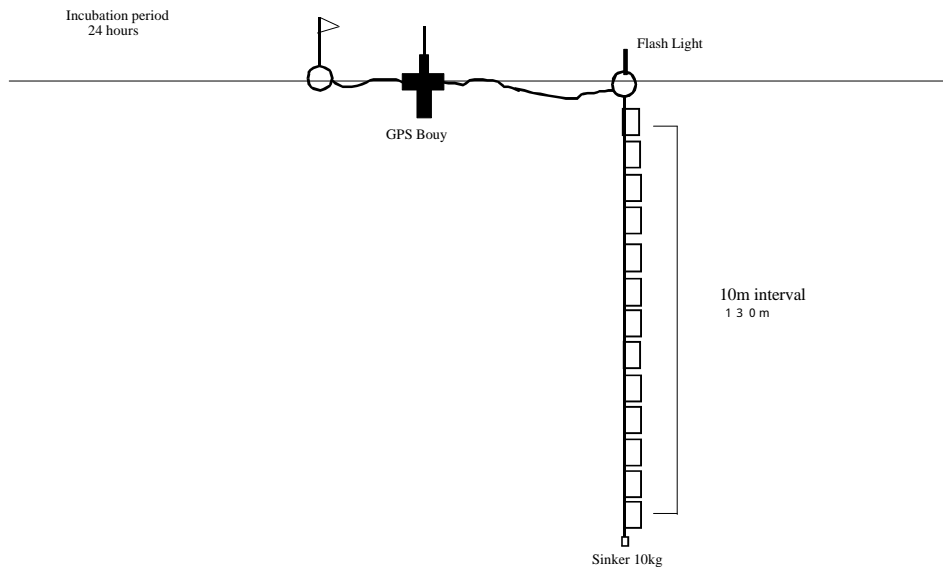
Fig.1 In-situ incubation

(2) Photosynthesis and irradiation curve measurement
Bottles for incubation and filters

Bottles for incubation (ca.1 liter) was done to cut off the light on bottle's side, upper and bottom, which did not pass the light from a 500W halogen lamp (light source). These bottles were numbered from No.1 to 8, on the lamp. All bottles were shield with a film on lamp side. Grass fiber filters(Wattman GF/F 25mm) pre-combusted under 420 degree C of temperature condition for at least 4 hours, were used for a filtration.

Incubation

Photosynthesis and irradiation curve measurements were carried out at all stations. Sampling was made at surface, chlorophyll maximum layer and 120m depth.

The bottles were spiked with 0.2 mmoles/L of $NaH^{13}CO_3$ solution, and incubated for 3 hours at temperature- controlled bath in a laboratory. The light intensity was shown in table 1.

Table.1 Light Intensity of P-I measurements

Bottle No.	Light Intensity (uE/cm2/sec)
1	1550
2	870
3	450
4	250
5	135
6	60
7	35
8	18.5

Samples were filtered immediately after the incubation and the filters were kept to freeze till the end of cruise. After that, filters were dried on the oven of 45 degree C.
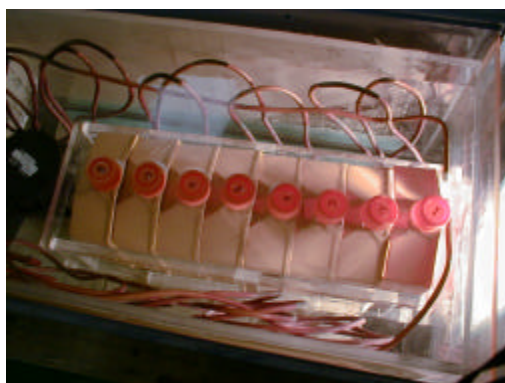
Fig.2   P-I measurement

Measurement

After the cruise, all samples will be made to measure by a mass spectrometer ANCA-SL system at JAMSTEC.

(3) Simulated in-situ incubation

Bottles for incubation and filters

Bottles for incubation are ca. 1 liter Nalgen polycarbonate bottles with screw caps.   Grass fiber filters (Wattman GF/F 25mm) pre-combusted under 420 degree C of temperature for at least 4 hours, were used for a filtration.

Simulated in-situ incubation

We took triplicate samples from the surface, 10m, 30m, 40m, 60m and 80m layer by a bucket and Niskin bottles at all station. All samples were spiked with 0.2 mmoles/L of $NaH^{13}CO_3$ solution and with 0.1 umoles/L of $K^{15}NO_3$ solution.

These bottles were placed into the covered sheet back, corresponding to nominal light levels at the depth at which samples, were taken. Samples were incubated in a temperature-controlled bath for 3 hours.

Samples were filtered immediately after the incubation and the filters were kept frozen till the end of cruise. After that, filters were dried on the oven of 45 degree C.

Measurement

After the cruise, all samples will be made to measure by a mass spectrometer ANCA-SL system at JAMSTEC.

3.6 Continuous measurement of surface seawater
3.6.1. Integrated monitoring system of surface water

Kazuhiko Matsumoto (JAMSTEC): Principal Investigator
2-15 Natsushima-cho, Yokosuka 237-0061 Japan

Nobuharu Komai, Hiroaki Muraki and Keisuke Wataki ((Marine Works Japan Ltd.)
1-1-7 Mutsuura, Kanazawa-ku, Yokohama 236-0031 Japan

Objectives
   To monitor continuously the physical, chemical and biological characteristics of near-sea surface water.

Parameters
   Temperature, salinity, dissolved oxygen, fluorescence, particle size of plankton in the near-surface water.

Instruments and Methods
   The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo co., Ltd.) is located in the "*sea surface monitoring laboratory*" on R/V Mirai. It can automatically measure temperature, salinity, dissolved oxygen, fluorescence and particle size of plankton in the near-surface water every 1-minute. Measured data are saved every one-minute together with time and the position of ship, and displayed in the data management PC machine. This system is connected to shipboard LAN-system and provides the acquired data for p-CO_2 measurement system, etc. Geodetic reference system for the positioning was used by WGS 84 at this cruise.
   The uncontaminated seawater intake is 4.5m below the sea surface. Near-surface water was continuously pumped up about 200L/min from the intake to the laboratory and then flowed into *the Continuous Sea Surface Water Monitoring System* and p-CO_2 measurement system etc. through a steel pipe. The flow rate of surface water for this system was 12L/min, which controlled by some valves and passed through some sensors except with fluorometer (about 0.3L/min) through vinyl-chloride pipes.
   The Continuous Sea Surface Water Monitoring System has six kinds of sensors, which TSG comprises of two SBE sensor modules. Sea surface temperature is measured by a ship bottom oceanographic thermometer situated on the suction side of the uncontaminated seawater supply in the forward hold. Specification and calibration date of the each sensor in this system are listed below.

a-1) Temperature and salinity sensors
          SEACAT THERMOSALINOGRAPH
          Model: SBE-21, SEA-BIRD ELECTRONICS, INC.
          Serial number: 2113117-2641
          Measurement range: Temperature -5 to +35 deg-C,   Salinity 0 to 6.5 S/m
          Accuracy: Temperature 0.01 deg-C/6month, Salinity 0.001 S/m/month
          Resolution: Temperature 0.001 deg-C,   Salinity 0.0001 S/m
          Calibration date: 08-Sep-99 (mounted on 15-Oct-99 in this system)

a-2) Ship bottom oceanographic thermometer (mounted at the back of the pump for surface water)
          Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.
          Serial number: 032607
          Measurement range: -5 to +35 deg-C
          Initial Accuracy: 0.001 deg-C per year typical
          Stability: 0.002 deg-C per year typical
          Calibration date: 29-Apr-99 (mounted on 24-Aug-99 in this system)

b) Dissolved oxygen sensor
          Model: 2127, Oubisufair Laboratories Japan INC.
          Serial number: 31757
          Measurement range: 0 to 14 ppm
          Accuracy: +/- 1% at 5 deg-C of correction range
          Stability: 1% per month
          Calibration date: 20-Dec-99

c) Fluorometer

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

d) Particle size sensor

Model:	P-05, Nippon Kaiyo LTD.
Serial number:	P5024
Accuracy:	+/- 10% of range
Measurement range:	0.02681mm to 6.666mm
Reproducibility:	+/- 5%
Stability:	5% per week

e) Flowmeter

Model:	EMARG2W, Aichi Watch Electronics LTD.
Serial number:	8672
Measurement range:	0 to 30 L/min
Accuracy:	+/- 1%
Stability:	+/- 1% per day

Preliminary Result
Calibration
(a) Salinity sensor

We cleaned the conductivity cell at Guam port just before this cruise. We sampled each day for salinity validation and in situ salinity calibration during this cruise. All salinity samples were collected from the course of the system while on station or from regions with weak horizontal gradients. All samples were analyzed on the Guildline 8400B using standard seawater batch P135 (see section of salinity measurement).

To estimate the accuracy of the conductivity, we calculated the conductivity from bottle samples and the conductivity sensor at the same sampling time. We calculated the conductivity at a pressure of 0dbar and at the temperature of the CT sensor. The results were shown in table 3.6.1-1 and Figure 3.6.1-1 and Figure 3.6.1-2, and the results were shown in table 3.6.1-2.

Table 3.6.1-2 Precision of Salinity and Conductivity of TSG at MR99-K07

	Sctd-Ssal	Cctd-Csal
Average	0.0026	0.0004
Standard Deviation	0.0039	0.0006
Average of absolute difference	0.0037	0.0005
Standard Deviation of absolute difference	0.0028	0.0004
R.M.S.	0.0033	0.0005
Min	-0.0090	-0.0013
Max	0.0134	0.0018
N	36	36

We calculated the Root Mean Squares (R.M.S.) of difference of salinity and conductivity value for 36 samples. R.M.S. of salinity and conductivity (one sigma) were 0.0033 and 0.0005, respectively. There were 3 samples which difference of salinity was higher than two times of standard deviation at this cruise (Figure 3.6.1-1). We suspected that these differences may be caused by the sampling water and TSG measurement. The final results omitted the three samples were shown in Table 3.6.1-3.

Table 3.6.1-3 Precision of Salinity and Conductivity at TSG omitted 3 samples

	Sctd-Ssal	Cctd-Csal
Average	0.0030	0.0004
Standard Deviation	0.0023	0.0003
Average of absolute difference	0.0032	0.0005
Standard Deviation of absolute difference	0.0020	0.0003
R.M.S.	0.0026	0.0004
Min	-0.0017	-0.0003
Max	0.0068	0.0009
N	33	33

Our final results showed that the validation of salinity of TSG was about 0.005 PSU (two sigma of standard deviation) during this cruise.

(b) Dissolved Oxygen (D.O.) sensor

D.O. sensor of this system was calibrated just before this cruise. To estimate of accuracy of the sensor, we collected the 23 samples from the course of the system and analyzed by Winkler method. The samples for the titration method were analyzed by Metrohm piston burette of 10ml with Pt Electrode using Whole bottle titration. The standardization and pure water blank determination have been performed before the sample titration. Concentration of D.O. was calculated by equation (8) of WHP Operations and Methods (Culberson, 1991). The amount of D.O. in the reagents was used the value (=0.0027 ml at 21 deg-C) measured at 1995 WOCE cruise (see section 3.3.1).

The results were shown in table 6.3.1-2 and Figure 6.3.1-2 and 6.3.1-3. D.O. value of the sensor was always higher than the values analyzed by the Winkler method. The average and standard deviation of differences was 0.937 ml/l and 0.062 ml/l (one sigma), respectively. This value was similar to the value at the MR99-K06 cruise (0.903+/-0.039 ml/l). So we wondered if we made a mistake in the procedure of calibration of sensor or the sensor was not in good condition during last and this cruise. The reason is not unclear.

(c) Fluorometer

We cleaned the flow cell of fluorometer at Guam port just before this cruise. We also cleaned the flow cell 6 times (26-Nov-99, 2-Dec-99, 6-Dec-99, 10-Dec-99, 13-Dec-99, 19-Dec-99) during this cruise.

In order to calibrate the data of fluorescence from this system, we collected surface seawater samples which pumped up from the ship's bottom three times each day. We determined the concentrations of chlorophyll *a* and chlorophyll *b* on board. The method and the results of each measurements were shown in another section.

Result

Preliminary data every 10 minutes from Guam to Stn. 1, Stn. 1 to Stn. 3, Stn. 3 to Stn. 12, Stn. 12 to Honolulu and Honolulu to Shimonoseki were shown in Figure 3.6.1-4　Figure 3.6.1-7, respectively. They showed the respective trend of temperature, salinity, D.O. and fluorescence distributions on the ship's track.

In Fig. 3.6.1-4, there was a region where salinity was low (below 34PSU) but temperature was high. At the equator line, there was the warm water pool from 145E to 160E. There was a front of temperature at about 160E. The temperature was getting lower but salinity was getting higher eastward (Fig. 3.6.1-5). In Figure 3.6.1-5, several of significant peaks of fluorescence were found from 159E to 170W. We seemed that the equatorial upwelling was caused around these regions.

In Fig. 3.6.1-6, there was a fluorescence peak from 5N to 8N where corresponded to the front of temperature.

Other remarks
Data archive

All the files of raw data, Microsoft excel files of raw data, excel files divided into each 10minutes data were stored on a magnetic optical disk. All the data will be submitted to the DMO at JAMSTEC.

References

T. J. Muller and H. -W. Schenk (1991) Near-Surface Temperature, salinity, and Bathmetry Measurements, in WHP Operations Methods, Woods Hole, pp.1-4.

Culberson, C. H. (1991) Dissolved Oxygen, in WHP Operations Methods, Woods Hole, pp.1-15.

Porra R. J., W. A. Thompson and P. E. Kriedemann (1989) Biochem. Biophys. Acta, 975, 384 – 394.

Table 3.6.1-1 Comparison of salinity between salinity sensor of Sea Surface Monitoring System and samples analyzed by Autosal salinometer.

Sampling Date (UTC)	Sampling Time (UTC)	Sampling Position latitude	longitude	Tctd (IPTS-68)	Sctd (PSS78)	Ssal (PSS78)	Sctd-Ssal (PSS78)	Cctd (S/m)	Csal (S/m)	Cctd-Csal (S/m)	Remarks
11/21/99	07:25	11-42.849N	142-49.258E	29.5072	34.7533	34.7473	0.0060	5.7460	5.7452	0.0008	stoppage
11/22/99	14:56	05-50.982N	136-50.565E	29.7677	33.7010	33.6964	0.0046	5.6181	5.6174	0.0007	stoppage
11/23/99	14:14	04-02.356N	135-00.185E	29.7511	33.6692	33.6652	0.0040	5.6118	5.6111	0.0007	stoppage
11/24/99	04:45	04-02.762N	134-59.773E	29.8718	33.6429	33.6379	0.0050	5.6203	5.6195	0.0008	stoppage
11/25/99	22:32	05-03.037N	140-07.069E	29.5463	33.3417	33.3381	0.0036	5.5423	5.5417	0.0006	stoppage
11/26/99	04:14	05-01.949N	140-08.696E	29.6001	33.3624	33.3714	-0.0090	5.5508	5.5521	-0.0013	stoppage
11/27/99	09:23	00-00.568S	144-59.905E	29.9005	34.3104	34.3041	0.0063	5.7222	5.7213	0.0009	stoppage
11/28/99	08:08	00-00.423S	145-00.978E	29.9496	34.2763	34.2761	0.0002	5.7224	5.7223	0.0001	stoppage
11/29/99	23:13	00-00.000N	151-41.784E	29.9005	34.5912	34.5865	0.0047	5.7638	5.7631	0.0007	stoppage
11/30/99	09:40	00-00.076N	153-58.996E	29.7652	34.7319	34.7288	0.0031	5.7702	5.7698	0.0004	stoppage
11/30/99	23:46	00-00.022S	157-20.569E	29.4360	34.8004	34.7947	0.0057	5.7453	5.7445	0.0008	stoppage
12/1/99	19:26	00-03.125N	159-56.577E	29.3352	35.1023	35.0990	0.0033	5.7788	5.7783	0.0005	stoppage
12/2/99	03:16	00-03.193N	159-55.336E	29.5066	35.1301	35.1241	0.0060	5.8012	5.8003	0.0009	stoppage
12/3/99	11:49	00-00.109N	163-45.235E	28.2979	35.2868	35.2823	0.0045	5.6947	5.6940	0.0007	stoppage
12/4/99	02:44	00-00.011N	166-56.848E	27.9583	35.2188	35.2138	0.0050	5.6487	5.6480	0.0007	stoppage
12/4/99	22:40	00-00.040S	171-42.928E	27.5585	35.2016	35.1976	0.0040	5.6037	5.6031	0.0006	stoppage
12/5/99	08:32	00-00.094S	173-43.025E	27.7833	35.2294	35.2226	0.0068	5.6315	5.6306	0.0009	stoppage
12/6/99	02:41	00-02.711N	174-54.104E	27.9733	35.3588	35.3577	0.0011	5.6702	5.6701	0.0001	stoppage
12/6/99	23:15	00-02.278S	178-05.268E	26.9412	35.1892	35.1860	0.0032	5.5365	5.5360	0.0005	stoppage
12/8/99	00:21	00-00.233S	176-41.042W	27.3014	35.3532	35.3485	0.0047	5.5977	5.5970	0.0007	stoppage
12/9/99	12:08	00-02.726N	170-08.008W	26.2196	35.2815	35.2808	0.0007	5.4729	5.4728	0.0001	stoppage
12/10/99	04:49	00-05.563N	170-07.231W	26.3414	35.2780	35.2781	-0.0001	5.4853	5.4854	-0.0001	stoppage
12/11/99	02:14	04-44.049N	167-22.327W	27.1069	34.9990	34.9974	0.0016	5.5274	5.5272	0.0002	stoppage
12/12/99	11:22	12-29.045N	162-58.862W	26.0283	34.5364	34.5351	0.0013	5.3502	5.3500	0.0002	stoppage
12/13/99	06:27	16-41.628N	160-35.593W	25.1637	34.5344	34.5357	-0.0013	5.2604	5.2607	-0.0003	stoppage
12/15/99	23:56	21-36.852N	161-39.392W	25.1896	35.1330	35.1315	0.0016	5.3442	5.3439	0.0003	stoppage
12/16/99	09:03	22-04.251N	164-07.934W	25.4643	35.3131	35.3130	0.0001	5.3974	5.3974	0.0000	stoppage
12/17/99	15:47	23-28.185N	172-38.080W	26.0431	35.1859	35.1826	0.0033	5.4411	5.4406	0.0005	stoppage
12/18/99	12:33	24-22.896N	178-06.195W	24.7498	35.3947	35.3964	-0.0017	5.3331	5.3334	-0.0003	stoppage
12/19/99	06:57	25-09.855N	177-04.071E	25.2147	35.4676	35.4757	-0.0081	5.3920	5.3931	-0.0011	stoppage
12/20/99	06:43	26-03.568N	171-38.131E	25.7698	35.4572	35.4438	0.0134	5.4493	5.4475	0.0018	stoppage
12/21/99	02:32	26-49.023N	166-53.221E	25.0889	35.2605	35.2597	0.0008	5.3508	5.3507	0.0001	stoppage
12/22/99	10:38	28-14.676N	157-57.860E	23.9998	35.0621	35.0612	0.0009	5.2104	5.2103	0.0001	stoppage
12/23/99	15:51	29-32.757N	149-45.492E	21.2875	34.5731	34.5690	0.0041	4.8690	4.8685	0.0005	stoppage
12/24/99	05:14	30-09.021N	145-54.948E	21.0856	34.6383	34.6355	0.0028	4.8567	4.8563	0.0004	stoppage
12/25/99	03:59	31-13.216N	139-09.651E	21.2201	34.7267	34.7243	0.0024	4.8814	4.8811	0.0003	stoppage

Table 6.3.1-2 Comparison of D.O. values between a D.O. sensor of Sea Surface Monitoring System and water samples from the system using Winkler method.

Sampling Date and Time (UTC)		Sampling Positon Latitude	Longitude	Salinity	T of SBE21 (deg-C)	D.O. sensor (ml/l)	Winkler (ml/l)	Difference (ml/l)	Remarks
11/23/99	14:32	04-02.425N	135-00.413E	33.679	29.8122	5.29	4.47	0.82	
11/24/99	04:43	04-02.788N	134-59.819E	33.641	29.8562	5.31	4.47	0.83	
11/26/99	04:19	05-01.883N	140-08.697E	33.360	29.5853	5.35	4.49	0.86	
11/26/99	04:20	05-01.872N	140-08.698E	33.360	29.5853	5.35	4.51	0.84	
11/27/99	09:32	00-00.637S	144-59.910E	34.301	29.8849	5.34	4.46	0.88	
11/27/99	09:35	00-00.654S	144-59.909E	34.300	29.8837	5.33	4.45	0.89	
11/30/99	04:30	00-00.620N	152-40.377E	34.809	30.3196	5.40	4.45	0.95	
11/30/99	04:36	00-00.599N	152-41.905E	34.838	30.1458	5.36	4.45	0.91	
11/30/99	23:56	00-00.052S	157-20.582E	34.803	29.4392	5.46	4.50	0.96	
12/2/99	03:23	00-03.193N	159-55.340E	35.129	29.4917	5.48	4.52	0.95	
12/2/99	03:26	00-03.192N	159-55.349E	35.130	29.4892	5.48	4.53	0.95	
12/4/99	02:55	00-00.012S	166-59.528E	35.214	27.9422	5.31	4.39	0.92	
12/4/99	02:58	00-00.020S	167-00.258E	35.220	27.9507	5.32	4.40	0.92	
12/4/99	23:57	00-00.063S	171-43.360E	35.203	27.6268	5.37	4.42	0.95	
12/4/99	23:59	00-00.071S	171-43.437E	35.204	27.6274	5.37	4.42	0.95	
12/6/99	02:48	00-02.736N	174-54.106E	35.360	27.9638	5.51	4.50	1.01	
12/6/99	02:55	00-02.760N	174-54.136E	35.360	27.9599	5.51	4.50	1.00	A buble from the dispense
12/6/99	23:22	00-02.315S	178-05.274E	35.190	26.9316	5.39	4.42	0.97	
12/6/99	23:24	00-02.323S	178-05.276E	35.189	26.9343	5.39	4.42	0.96	
12/8/99	00:26	00-00.184S	176-40.300W	35.351	27.3734	5.46	4.46	1.00	
12/8/99	00:28	00-00.159S	176-39.923W	35.351	27.3931	5.46	4.47	0.99	
12/9/99	12:12	00-02.715N	170-08.010W	35.281	26.2063	5.55	4.51	1.03	
12/9/99	12:15	00-02.663N	170-08.046W	35.282	26.2050	5.54	4.52	1.03	
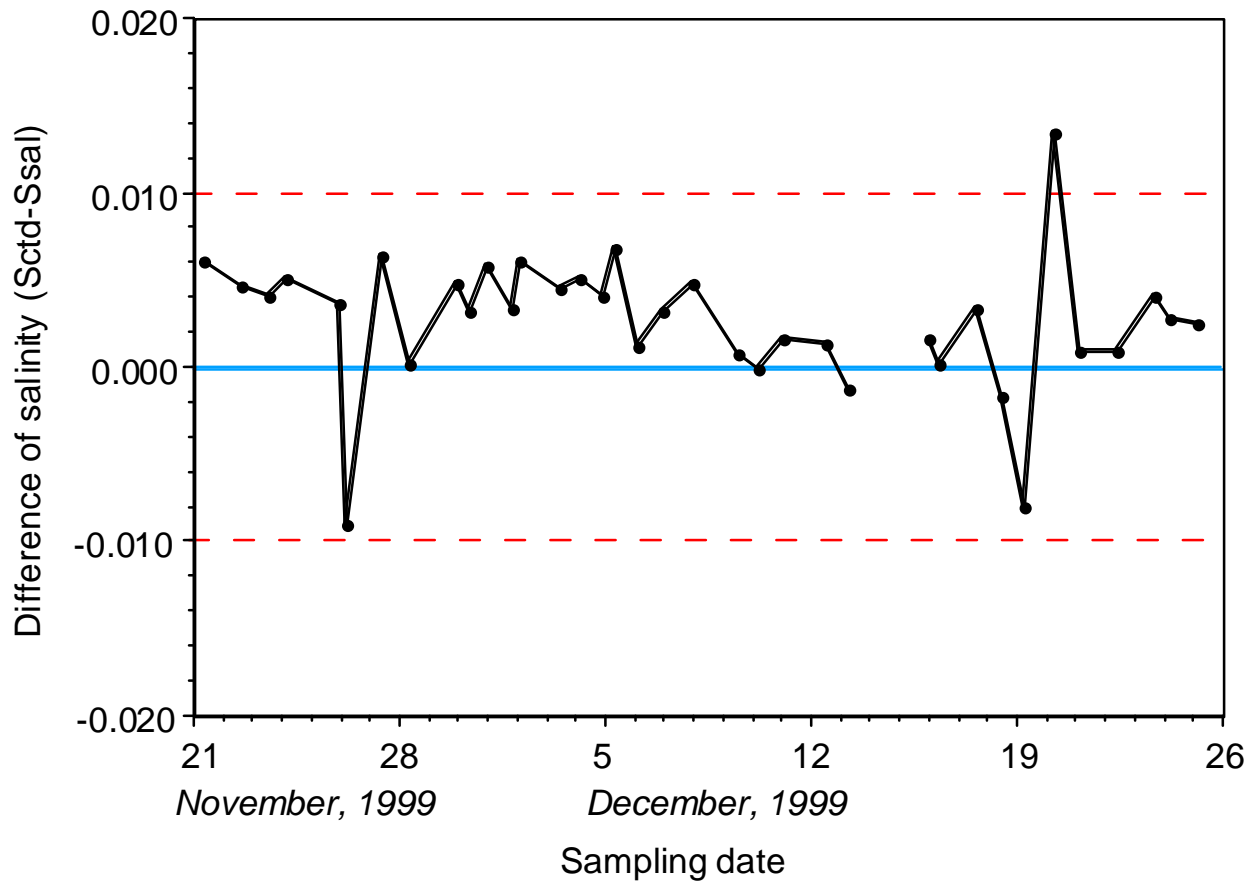
Figure 3.6.1-1 difference between the salinity values measured by TSG (Sctd) of *the Sea Suraface Monitoring System* and by Autosal salinometer (Ssal) for 36 samples.
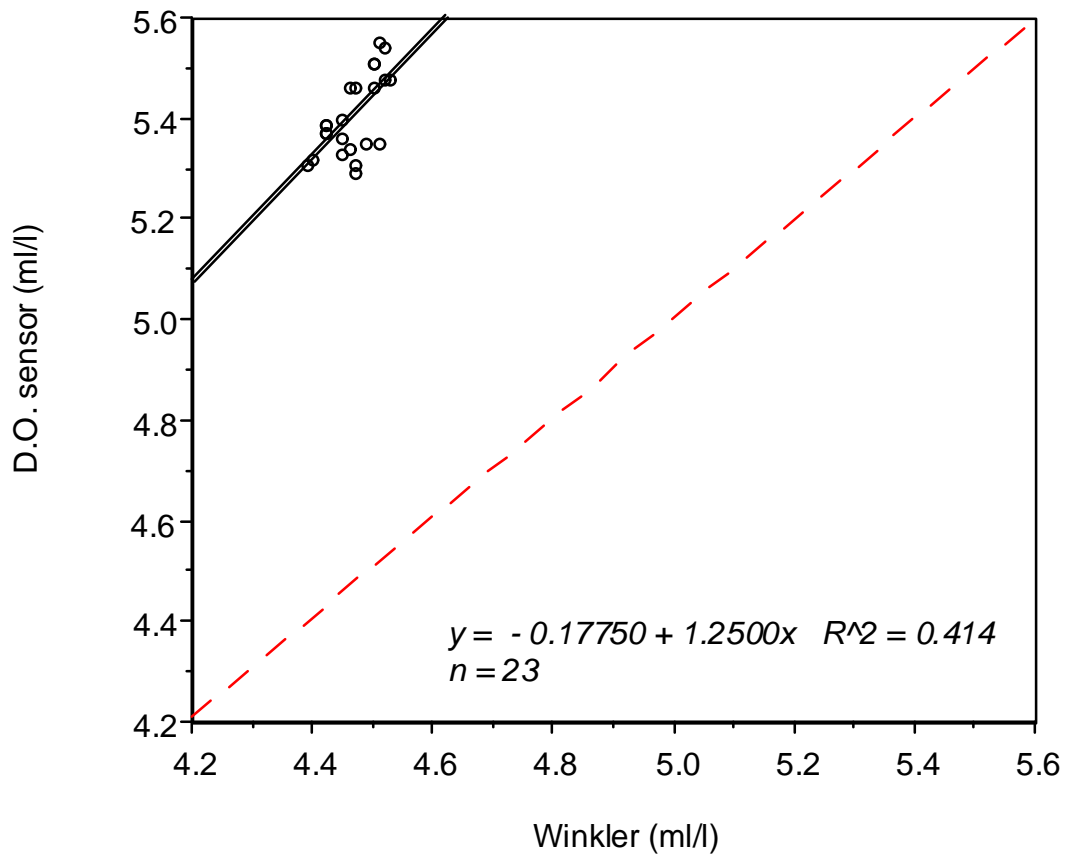
Figure 3.6.1-2 Comparison between the D.O. value measured by D.O. sensor of *Sea Surface Monitoring System* and by the Winkler method for 23 samples during MR99-K07 Cruise.
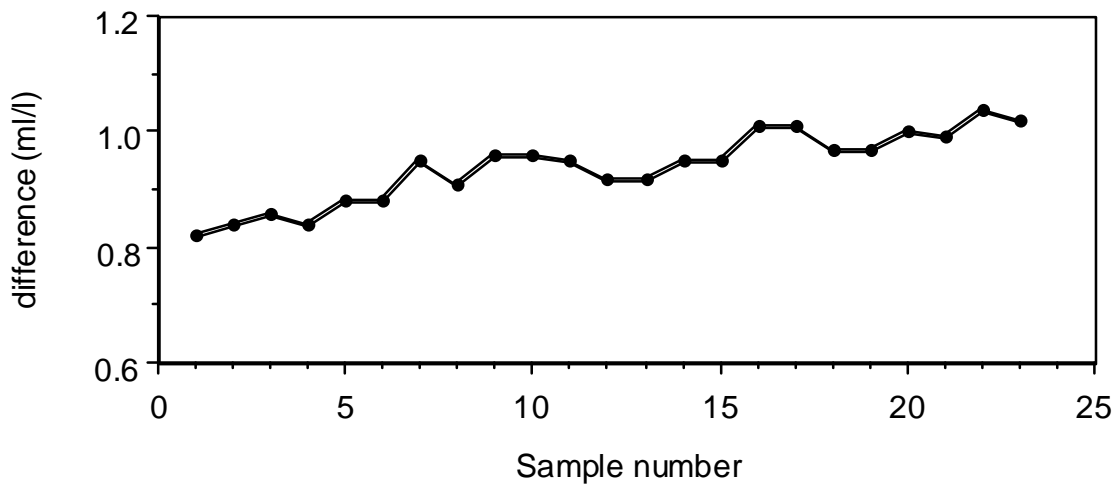
Figure 3.6.1-3 difference of D.O. value between D.O. sensor of *sea Surface Monitoring System* and the Winlkler method during MR99-K07 Cruise.
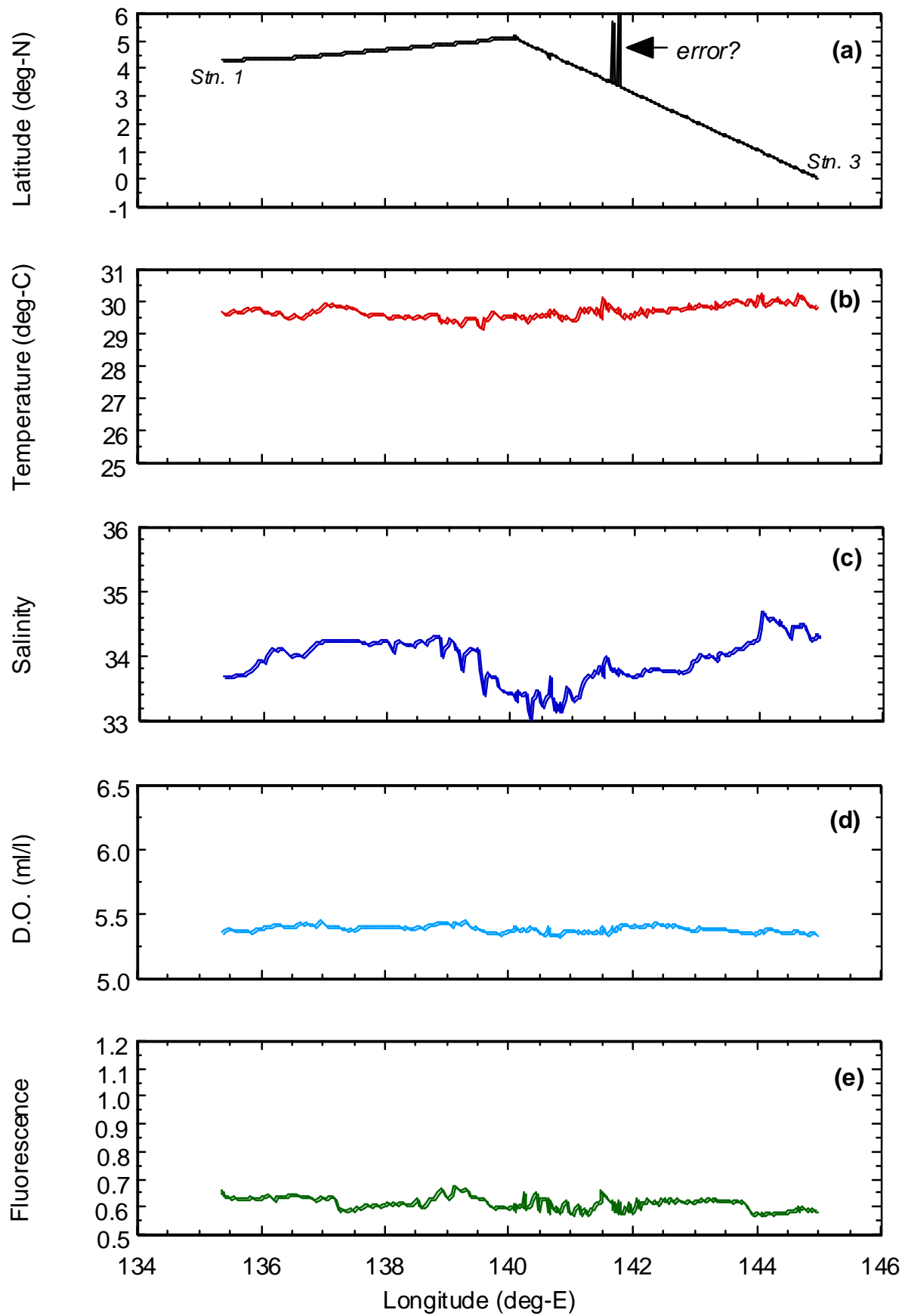
Fig 3.6.1-4 Ship's track (a), temperature (b), salinity (c), D.O. (d) and fluorescence (e) of suface water from Stn. 1 to Stn. 3.
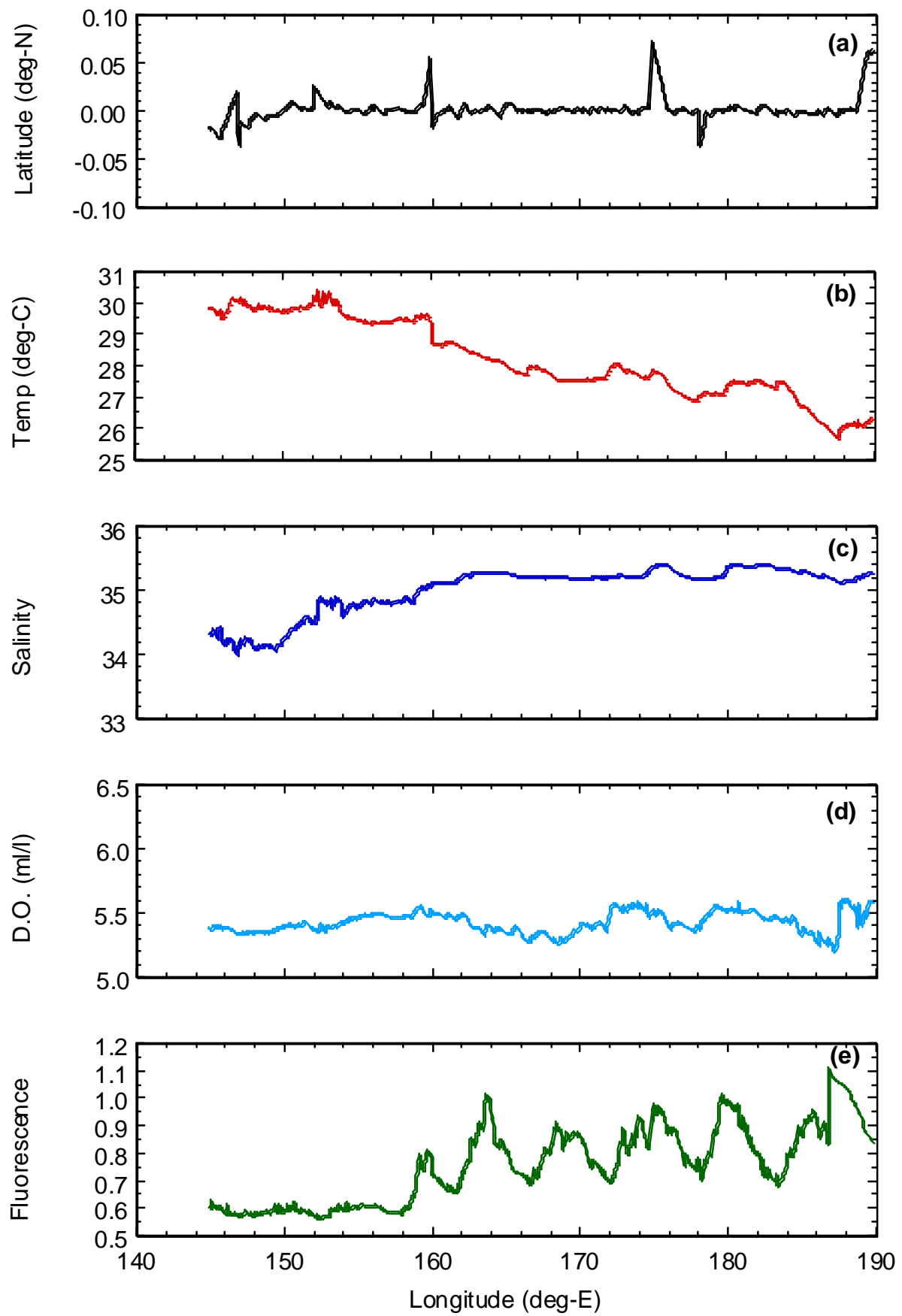
Fig 3.6.1-5 Ship's track (a), temperature (b), salinity (c), D.O. (d) and fluorescence (e) of suface water from Stn. 3 to Stn. 12 along the equator line.
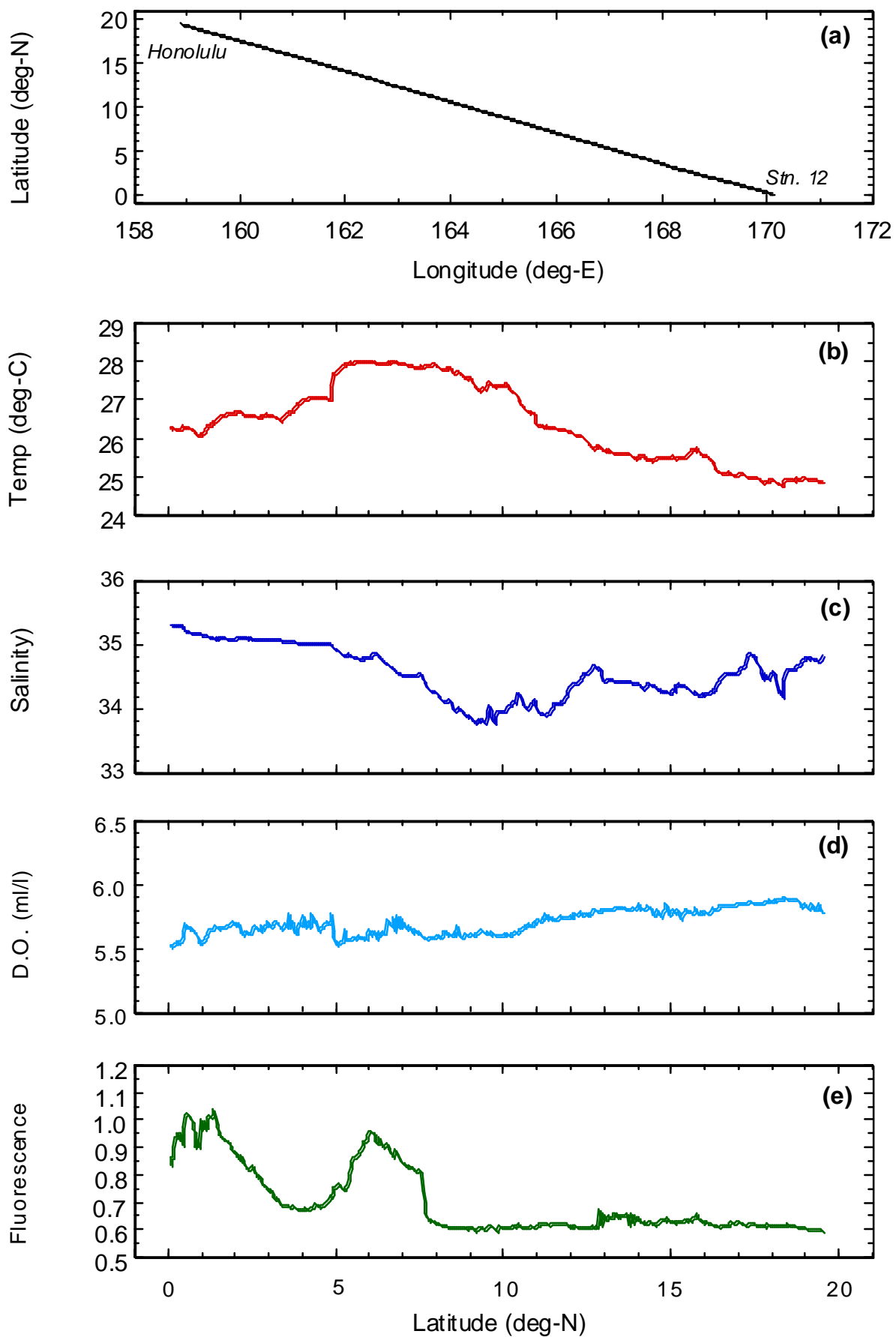
Fig 3.6.1-6 Ship's track (a), temperature (b), salinity (c), D.O. (d) and fluorescence (e) of suface water from Stn. 12 to Honolulu.
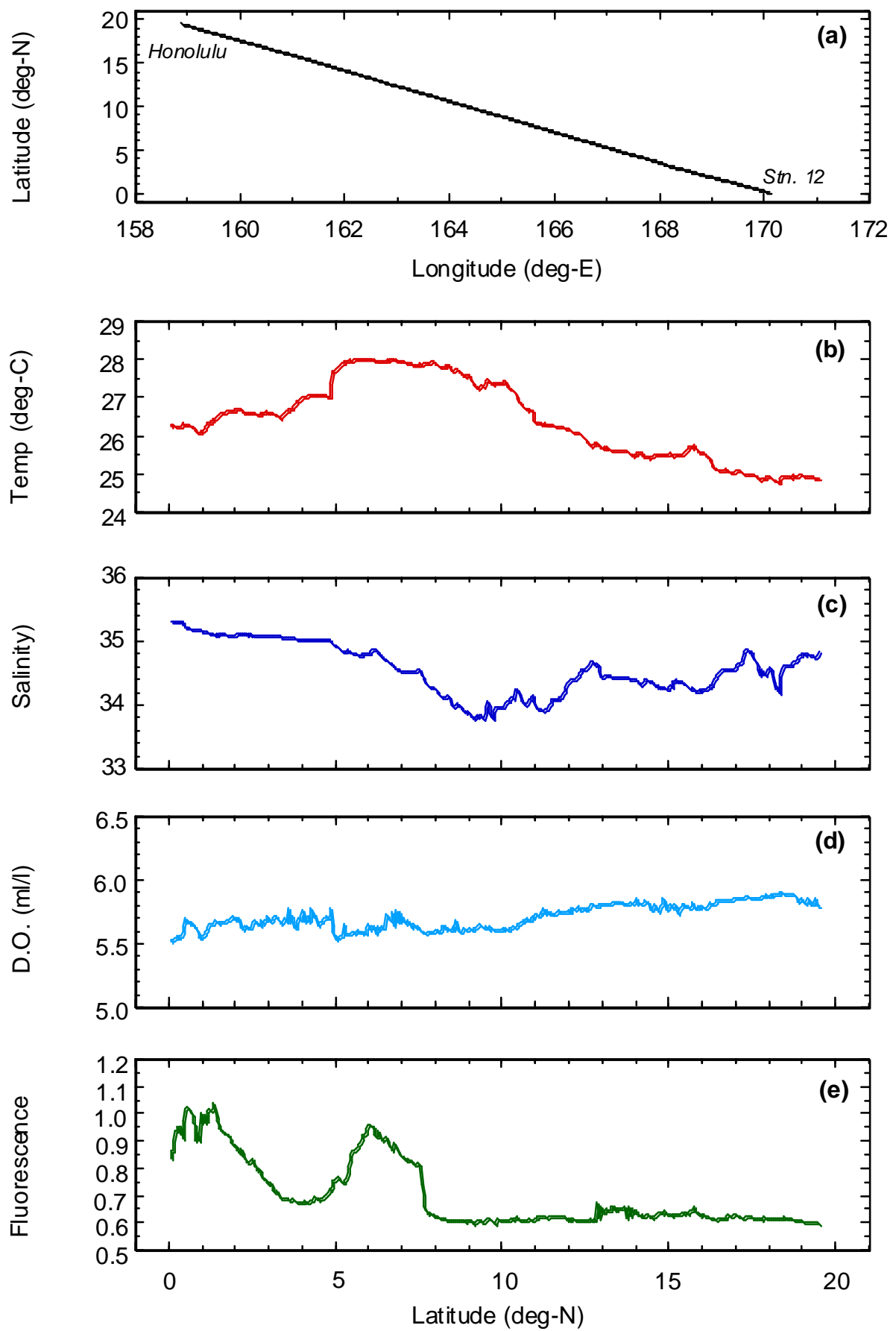
Fig 3.6.1-7 Ship's track (a), temperature (b), salinity (c), D.O. (d) and fluorescence (e) of suface water from Stn. 12 to Stn. Honolulu.

3.6.2 Nutrients Monitoring in Surface Seawater

(1) Personnel
   Munehito KIMURA (KANSO Co., Ltd.)
   Ken-ichiro MASAKI (KANSO Co., Ltd.)
   Hirofumi OKANO (Japan Marine Science and Technology Center)

(2) Objectives
   The horizontal distributions of nutrients in surface seawater are one of the important factors on the study of primary production, ocean circulation and seawater upwelling.   During this cruise, the objectives of nutrients monitoring in surface seawater were to obtain the important and basic data on these studies.

(3) Instruments and methods
   The nutrients monitoring was performed on Bran + Luebbe continuous monitoring system Model TRAACS 800 (4 channels).   The flow diagram of monitoring system is shown in Figure 1.   The TRAACS 800 was located at the surface seawater laboratory for monitoring in the R/V MIRAI.   The analytical methods are as follows:
   Nitrate (ch.1): Nitrate in seawater was reduced to nitrite by reduction tube (Cd - Cu tube) and the nitrite reduced was determined by the nitrite method described to next, but the flow cell used in nitrate analysis was 3 cm length type.   Nitrite initially present in the seawater was corrected after measuring.
   Silicate (ch.2): Silicate was determined by molybdate-ascorbic acid method.   The silicate was produced silicomolybdate with molybdate, was reduced by ascorbic acid in order to form a colored complex.   The complex was made to measure the absorbance of 630 nm using 3 cm length flow cell.
   Nitrite (ch.3): Nitrite was determined by diazotizing with sulfanilamide, by coupling with N-1-naphthyl-ethylenediamine (NED) to form a colored azo compound and by being measured the absorbance of 550 nm using 5 cm length flow cell.
   Phosphate (ch.4): Phosphate was determined by molybdate-ascorbic acid method.   The phosphate was produced phosphomolybdate by molybdate, was reduced by ascorbic acid in order to form a colored complex. The complex was made to measure the absorbance of 880 nm using 5 cm length flow cell.

(4) Sampling procedures
   Seawater of 4 m depth under ocean surface was pumped up to laboratory inner R/V MIRAI continuously, was poured in 3 litter (L) of polypropylene beaker through a faucet of the laboratory, was introduced direct to monitoring system by narrow tube which was attached a plankton net filter, continuously.

(5) Preliminary results
   The nutrients monitoring was made the period of Guam (U.S.A.) to Hawaii (USA) and Hawaii to Kuroshio Area (adjacent area to JAPAN).   During monitoring period, monitoring cycle was 6 hour containing 1 hour for calibrating and copper-coating to the Cd - Cu reduction tube.   Then monitoring data was obtained every 1 minute.   The preliminary results of monitoring are shown in Figure 2-(a) and (b).

(6) Data archive
   All data will be submitted to JAMSTEC data management office (DMO) and under its control.
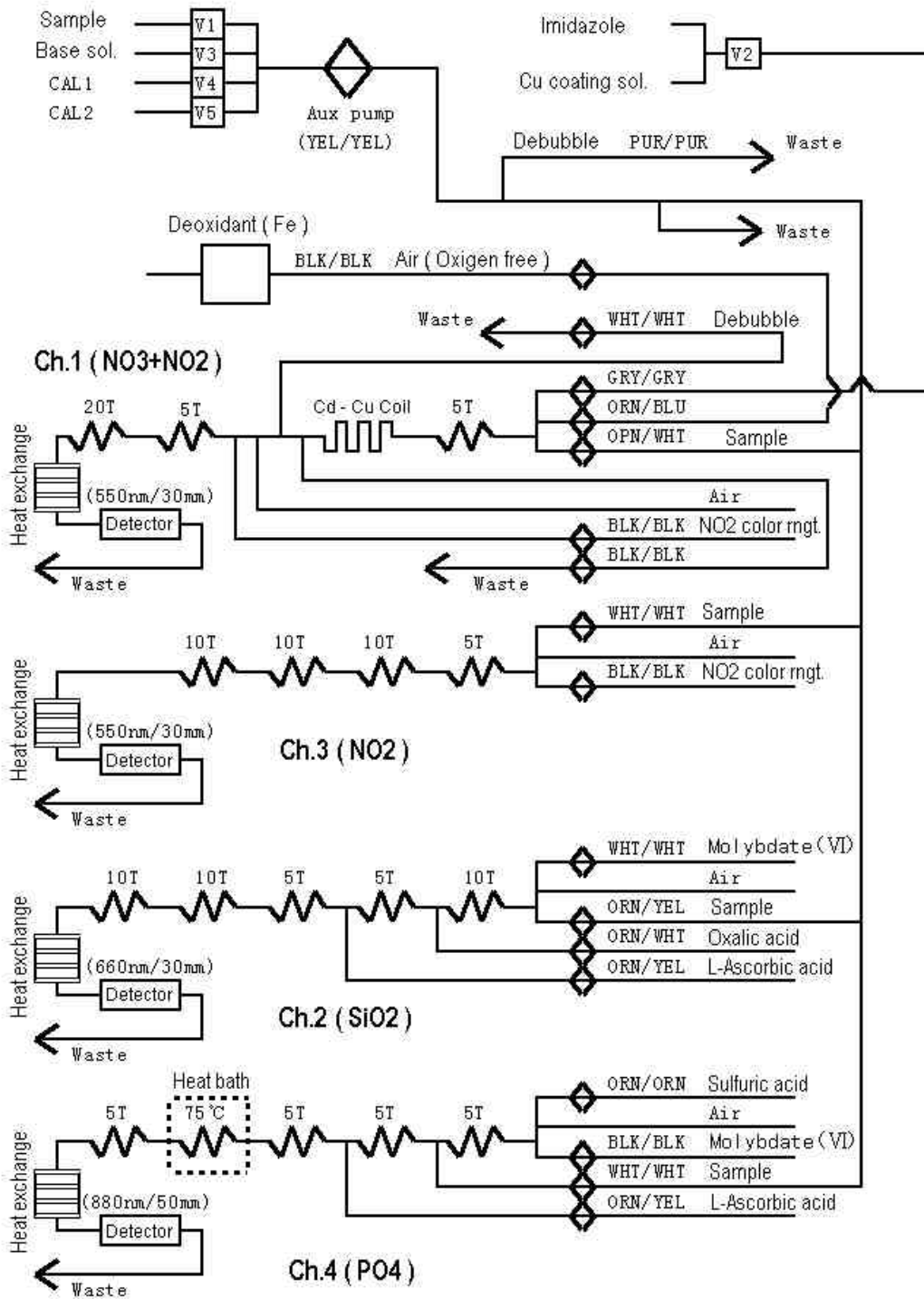
Figure 1. Flow diagram of nutrients monitoring system.
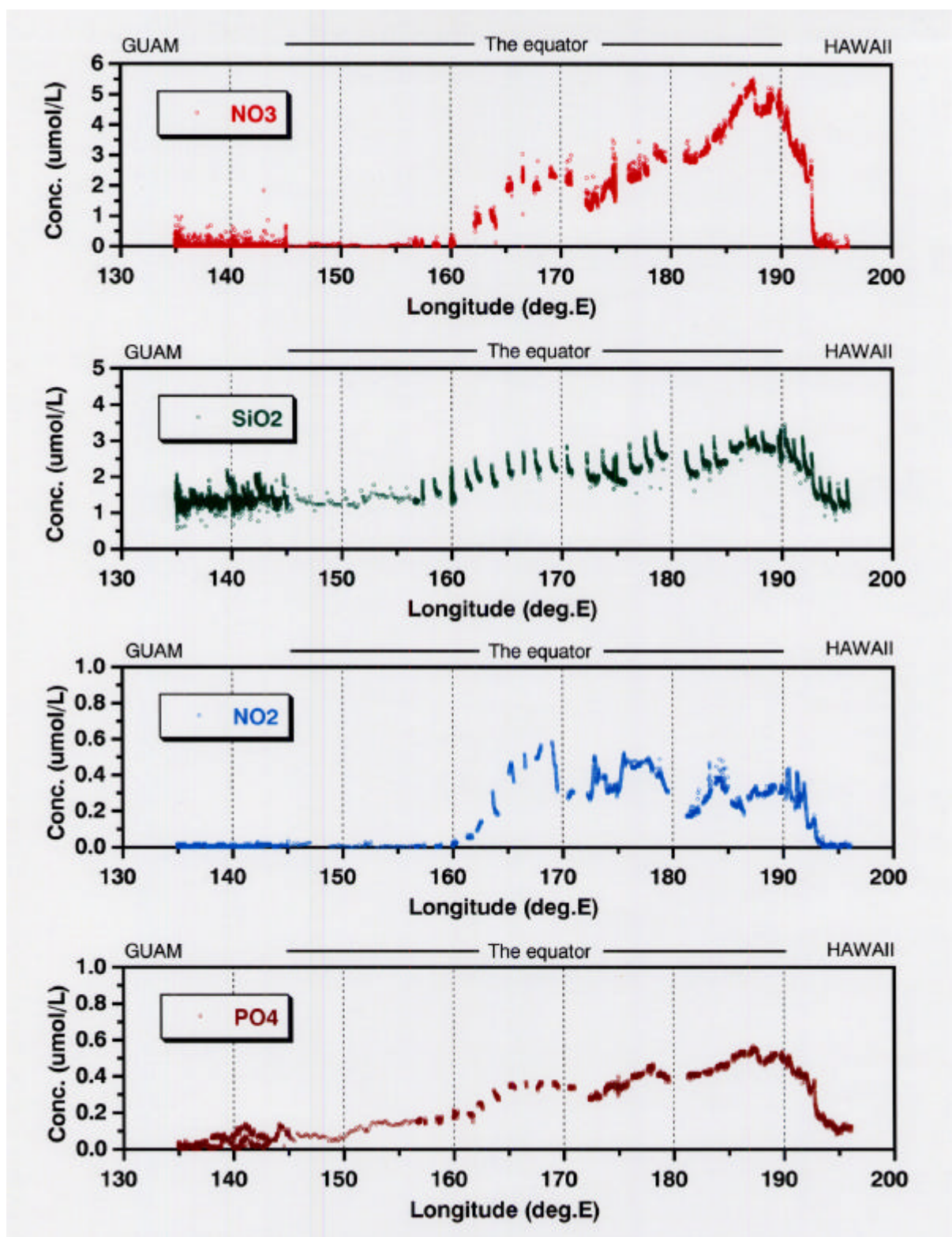
Figure 2-(a).　Results of nutrients (NO3, SiO2, NO2 and PO4) monitoring from GUAM to HAWAII in MR99K07 cruise.
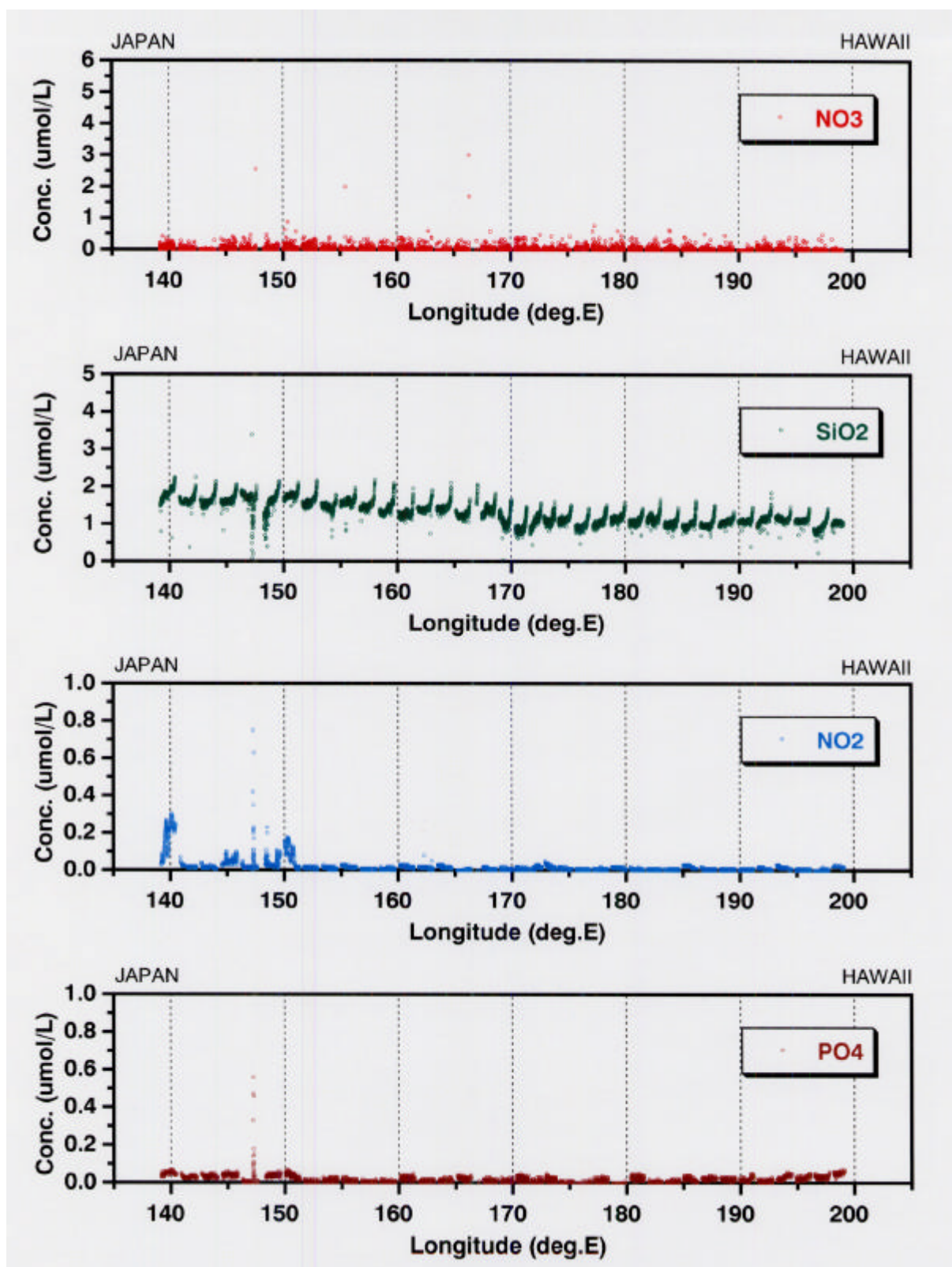
Figure 2-(b).   Results of nutrients (NO3, SiO2, NO2 and PO4) monitoring
from HAWAII to JAPAN in MR99K07 cruise.

3.7 Distribution of heterotrophic microflagellates and ciliates in the equatorial Pacific

Kazuhiko MATSUMOTO (JAMSTEC) and Nakahito NISHIKAWA (MWJ)

JAMSTEC: Japan Marine Science and Technology Center
MWJ: Marine Works Japan Ltd**.**

Objectives
    Picoplankton (0.2-2.0µm) and nanoplankton (2.0-20µm) are major contributors to phytoplankton biomass and primary production in the equatorial Pacific. Heterotrophic microflagellates and ciliates play important role in the microbial food web as grazer of picoplankton and nanoplankton. The purpose of this study is to estimate the abundance of heterotrophic microflagellates and ciliates as grazer of phytoplankton by using fluorescence microscopy.

Materials and Method
    Seawater samples were collected at twelve sampling sites between longitude 135E and 170W in the equatorial Pacific. The samples were collected at 13 depths from the depth of surface to 200m. Seawater samples were immediately treated with the final concentration of 1 % glutaraldehyde and were kept at room temperature (1 hour). Seawater samples were filtered through a 1 µm pore size Nuclepore filter, pre-stained by irgalan black, stacked on membrane filters (Millipore, pore size: 8.0 µm) at the low vacuum of < 20 cmHg. Seawater samples were double-stained with DAPI (4'6-diamidino-2-phenylindole dihydrochloride) for the staining of DNA, and proflavine (3-6-diamidino-acridine hemisulfate) for the staining of flagella. The working solution of DAPI (10 µg/ml) and proflavine (0.033 %) were pre-filtrated through 0.22 µm pore size of non-pyrogenic Durapore membrane filter (Millipore, Millex-GX). At the fluorescence microscopy, heterotrophic plankton are distinguished with autotrophic plankton, because cells of autotrophic plankton are seen as orange and /or red by the autofluorescence of pigments.
    The staining method was as follows;
When the seawater remained approximately 10 ml in the funnel on the filtration procedure, seawater samples were stained with the working solution of DAPI (1 ml). After five minutes, that were stained with the working solution of proflavine (0.4 ml) for 5 minutes. Then, seawater samples were filtered. Sample filters were put on a slide-glass with one drop of immersion oil, and covered with micro cover glass, which were stored in the deep freezer (–85   ) until the observation

Analysis will be scheduled at the laboratory (Marine Biological Research Institute of Japan Co., LTD.).

3.8 Relationship between Cd and phosphate in the equatorial western Pacific.

Kazuo Abe
(Ishigaki Tropical Station, Seikai National Fisheries Research Institute)

Objective

The distribution of Cd in the ocean is strongly correlated with the behavior of phosphate, which indficates that the behavior of Cd in seawater is regulated by marine biogeochemical processes, namely the uptake by phytoplankton in surface waters, consequential decomposition of the produced organic matter and remineralization in deep waters.   Generally, the plot of dissolved Cd against phosphate shows a good linearity and the slope varies from basin to basin.   These variations of the relationship in the Cd-phosphate plots in the world oceans are considered to be caused by multiple factors that affect the distributional patterns in each oceans, namely biogeochemical processes, biomass composition, preformed concentrations, atmospheric deposition, benthic input or hydrographical conditions.   The main purpose of this study in this cruise is to investigate the distributional features of Cd and to examine the relationship between Cd and phosphate in the western equatorial Pacific Ocean.

Methods

Surface water samples were collected at 12 stations with a plastic bucket aboard R/V Mirai.   The water samples for dissolved Cd were transfered to acid-cleaned polyethylene bottles and kept in a freezer until analysis. Cd in samples filtered through 0.4 um Nuclepore filter will be concentrated by the modified APDC co-precipitation of Boyle and Edmond (1977) in a clean ventilation system.   The determination of Cd will be carried out by flameless-AAS (Atomic Absorption Spectrophotometer).

3.9 ^{234}Th/^{238}U and ^{210}Po/^{210}Pb disequilibria as indicators of removal rates and particulate organic carbon fluxes in the western and central equatorial Pacific

Tatsuo AONO and Masatoshi YAMADA

Research Center for Radioecology, National Institute of Radiological Sciences
3609 Isozaki, Hitachinaka, Ibaraki 311-1202, JAPAN

These nuclides, thorium-234($t_{1/2}$ = 24.1 day), lead-210($t_{1/2}$ = 22.3 yr) and polonium-210($t_{1/2}$ = 138 days) in seawater, are especially useful for studies on material transport scavenging processes within relatively short times and on the mechanism of material transport from the surface ocean, because they are highly reactive to particulate matter and its rapid removal from the water column. The aim of this study is to investigate the removal rates of these radionuclides from the water column in the equatorial Pacific through understanding of the distributions of radionuclides in seawater and particle matter. And, the goal of this study is to clarify the material transport and the implications for POC export in the equatorial Pacific.

The study of the disequilibria of lead-210 and polonium-210 in seawater can be used to observe relatively short term oceanic particle flux processes. The seawater samples were collected at Stns. 1, 3, 6, 9 and 12 with the CTD/RMS. The collected samples will be analyzed for activities of ^{210}Po and ^{210}Pb by an alpha spectrometry in the laboratory.

Thorium-234 produced by decay of uranium-238 in seawater, has been used to studies on removal rates and transport processes of marine particles. The seawater samples were collected at Stns. 1, 3, 6, 9 and 12 using the CTD/RMS. The collected samples has been analyzed for ^{234}Th activity at sea and for POC in the laboratory.

The settling particles were collected using a combined drifting trap. The trap array was deployed at the depth of 210m at Stns. 1, 3, 6 and 12. Upon recovery of the sediment traps, the sample bottles were stored under refrigeration. The collected samples have been analyzed for radioactivity of ^{234}Th and POC in the laboratory.

3.10 Radionuclides in settling particles, deep-sea sediments and surface seawater.

Masatoshi Yamada and Tatsuo Aono
Geochemical Research Section, Research Center for Radioecology,
National Institute of Radiological Sciences
Isozaki 3609, Hitachinaka, Ibaraki 311-1202, Japan

Introduction

Naturally occurring radionuclides ^{230}Th ($T_{1/2}$=7.52 x 10^4 yr), ^{231}Pa ($T_{1/2}$=3.28 x 10^4 yr), and ^{210}Pb ($T_{1/2}$=22.3 yr) can be classified into nuclides which associate with particles and are removed from seawater by scavenging or biological processes. These nuclides provide useful chronometers to determine the important rates of material transport processes in the marine environment. It is well known that ^{234}U and ^{235}U are dissolved uniformly in seawater. The production rate of ^{230}Th and ^{231}Pa in the seawater is fixed because the radioactive decay of ^{234}U and ^{235}U is the significant source. Yang et al.(1986) have reported that a fractionation between ^{230}Th and ^{231}Pa took place in the ocean. A significant fraction of ^{231}Pa relative to ^{230}Th may be transported laterally from the open ocean to the ocean margins. ^{210}Pb is transported to oceanic areas of high productivity and particle flux and scavenging by particles is a major mechanism of ^{210}Pb removal from seawater. The main purpose of this investigation is to determine the concentrations of ^{230}Th, ^{231}Pa, and ^{210}Pb in settling particles and deep-sea sediments and to discuss the scavenging process by measuring the behavior of ^{230}Th, ^{231}Pa, and ^{210}Pb in the western equatorial Pacific.

Artificial long-lived radionuclides ^{239}Pu ($T_{1/2}$=2.44 x 10^4 yr) and ^{240}Pu ($T_{1/2}$=6.58 x 10^3 yr) have been mainly delivered to the environment by global fallout as a result of release from atmospheric weapons testing, which took place mostly during the 1950s and early 1960s. The purpose of this investigation is to determine the current level of $^{239+240}$Pu contamination in surface seawater in the western equatorial Pacific.

Materials and Methods

Settling particle samples were collected at Stns. 1, 2, 3, and 9 by using time-series sediment traps. Sampling information has been described in detail elsewhere in this cruise report (Shimamoto and Tanaka). Settling particle samples will be analyzed for their radioactivities on land laboratory after radiochemical separations.

Five long-term moorings of time-series sediment traps were deployed at Stns. 1, 3, 6, 9, and 12 in the western equatorial Pacific during the MR99-K07 cruise.

The marine sediment samples were collected at Stns. 1, 2, 3, 6, 9, and 12 in the western equatorial Pacific. The samples were collected with a multiple corer, which was used to get relatively undisturbed surface sediments. Sampling information has been described in detail elsewhere in this cruise report (Tanaka). The cores were cut into 1 cm segments on shipboard and brought back to land laboratory for radionuclides analysis.

Surface seawater samples were collected at 19 locations in the western equatorial Pacific. The amount of surface seawater sample was usually 250 liters. The surface water was acidified with HCl and then appropriate amount of Fe was added. Radionuclides in seawater were coprecipitated with iron hydroxide by neutralizing the water with ammonia. The iron hydroxide was brought back to land laboratory for analysis.

3.11 The spatial and depth-wise variation in the concentration of TEP
Shigeki WATANABE, Neelam RAMAIAH, Ken FURUYA
University of Tokyo

Objective:
TEP(transparent exopolymer particles) are a group of polysaccharide particles formed largely from the dissolved extracellular exudates released by phytoplankton. These particulates are important as a source of nutrition for micro heterotrophs and play an important role in microbial food web, organic matter flux and transformation of dissolved to particulate organic matter. Our objective in this cruise is to study the spatial and depth-wise variation in the concentration of TEP in relation to existing phytoplankton biomass and bacterial abundance in the Equatorial Pacific Ocean.

Parameters:
Water samples from surface + 11 depths of all the 12 shallow cast, and 12 depths of the deep cast stations were collected for estimation of following parameters:
Ambient concentration of TEP
TEP abundance (number and size)
Total bacterial counts

Methods:
100ml seawater samples were filtered through 0.4um nucrepore filters. Particles on the filters were stained with alcian blue. The filters were preserved at –20 . TEP concentrations will be determined spectrophotometrically, and size and numbers of TEP will be determined observing under light microscope.
For the determination of bacterial counts, samples were fixed in 1% glutaraldehyde. Bacteria will be counted using epiflourecence microscope after staining the cells with DAPI.

3.12 Distribution of Phycoerythrin in the Equatorial Pacific Ocean

Hitoshi TAKAMARU , Erina HATAKEYAMA , Ken FURUYA
University of Tokyo

Objective

Phycoerythrin(PE) is the one of the light-harvesting phycobiliproteins in the three algal crasses: cyanophyta, cryptophyta and rhodophyta. Small coccoid cyanobacteria, synechococcus spp., contain high concentration of phycobiliproteins and seem to use them as nitrogen reserves as well as light-harvesting pigments. Although ecologically important, simple and standardized method for estimation of Phycobiliproteins has not been established yet mainly due to the difficulty involved in the extraction of these pigments. This had led to a lack of information on the natural concentration of phycobiliprotein, which is important to study the distribution and physiology of cyanobacteria.

Recently some simple methods were proposed for the estimation of PE. Our objective in this cruise is to measure the natural concentrations of PE in the equatorial pacific ocean using these methods, and to study the natural abundance and physiology of cianobacteria.

Method

Seawater sample were collected from 13 depths in the upper 200m water column. One liter samples were filtered through 0.4um pore sized Nuclepore filters to collect particles, and the materials were resuspended in 50% glycerol. Fluorescence excitation spectra of the samples were measured by Hitachi spectrofluorometer(emission:570nm), and emission spectra were measured.

Synechococcus spp. Cells will be counted in the concentrated glycerous suspension and in untreated natural seawater sample by epifluorescence microscopy.

3.13 Atmospheric and oceanic CO_2 measurements

(1) Personnel

   Masao Ishii, Hisayuki Y. Inoue, and Shu Saito*

   Geochemical Research Department, Meteorological Research Institute,

   Nagamine 1-1, Tsukuba, Ibaraki 305-0052, Japan

   Hidekazu Ota*

   Kansai Environmental Engineering Center Co. LTD.

   Azuchimachi 1-3-5, Chuo-ku, Osaka 541-0052, Japan

   * on board personnel

(2) Objectives

Carbon dioxide (CO_2), known as a major greenhouse gas, has been increasing in the atmosphere as a result of the anthropogenic emission. Its current concentration is approximately 30% higher than that in the preindustrial era (280 ppm).   In order to predict the future atmospheric CO_2 variation due to the anthropogenic emission and the potential alteration of the carbon cycle as a result of the climate change, it is necessary to understand the processes which are controlling the fluxes among the global carbon reservoirs, the atmosphere, the terrestrial biosphere and the ocean, as well as to estimate the present CO_2 inventory among these reservoirs.

The eastern and the central equatorial Pacific is now known to act as a significant source of the CO_2 to the atmosphere due primarily to the equatorial upwelling. The western equatorial Pacific, where warm water prevails in the surface layer, also occasionally exhibits a large CO_2 emission from the sea to the atmosphere.   Flux of CO_2 from the equatorial Pacific has been reported to show a significant interannual variability that is associated with the ENSO event. However, the temporal and spatial variation in the whole CO_2 system in seawater enough to elucidate its controlling mechanism has not been well documented.

In this cruise, we made concurrent underway measurements of CO_2 concentration in the atmosphere and in surface seawater and total inorganic carbon (TCO_2) in surface seawater. We also measured TCO_2 and pH in water columns at hydrographic stations.   The purpose of these observations is to describe the oceanic CO_2 system in the western equatorial Pacific and to clarify the controlling factors that are responsible for its variation in space and time as well as to investigate the air-sea CO_2 flux in this region.

(3) Parameters
  (a) CO_2 concentration (xCO_2) in marine boundary air and in the air equilibrated with surface seawater.
  (b) Total inorganic carbon (TCO_2) in surface seawater.
  (c) Total inorganic carbon (TCO_2) in the water column above the depth of 4500 m.
  (d) pH (total hydrogen ion scale) in the water column above the depth of 4500 m.
  (e) pH (total hydrogen ion scale) in surface seawater.

(4) Methods

(a) Underway measurements of CO_2 concentration in marine boundary air and in the air equilibrated with surface seawater:

We made measurements of the CO_2 concentration (mole fraction of CO_2 in air; xCO_2) in marine boundary air twice every 1.5 hour and that in the air equilibrated with the great excess of surface seawater four times every 1.5 hour during the whole cruise using the automated CO_2 measuring system (Nippon ANS Co.).   Marine boundary air was taken continuously from the foremast.   Seawater was taken continuously from the bottom of the ship located ca.5 m below the sea level and introduced into the MRI-shower-type equilibrator. Non-dispersive infrared (NDIR) gas analyzer (BINOS 4) was used as a detector. It was calibrated with four CO_2 reference gases (306ppm, 356ppm, 405ppm, 456ppm in air, Nippon Sanso Co.) once every 1.5 hour. Concentration of CO_2 will be published on the basis of the WMO X85 mole fraction scale after the cruise. Corrections for the temperature-rise from the bottom of the ship to the equilibrator and the drift of CO_2 concentration in reference gases are also to be made. Partial pressure of CO_2 will be calculated from xCO_2 by taking the water vapor pressure and the atmospheric pressure into account.

 (b) Underway measurement of total inorganic carbon (TCO_2) in surface seawater:

We made underway measurement of TCO_2 in surface seawater using the automated TCO_2 analyzer (Nippon ANS Co.) equipped with carbon coulometer 5012 (UIC Co.).   Seawater was taken continuously from the bottom of the ship and a portion of the seawater (~ 22 cm^3) was introduced into the water-jacketed pipette of the analyzer twice every 1.5 hour for the analysis. We also analyzed TCO_2 in the reference seawater prepared in MRI that is traceable to the CRM provided by Dr. A. Dickson in Scripps Institution of Oceanography. The analysis of the reference seawater was made at least once during the each run of the coulometric cathode- and anode-solutions.

(c)(d) Measurement of TCO_2 and pH (total hydrogen ion scale) in the water column:

Discrete samples for TCO_2 and pH analyses were taken from Niskin bottles on CTD/carousel sampler and from a bucket for surface seawater at the total of 12 hydrographic stations.

Samples for TCO_2 analysis were collected in $250cm^3$ borosilicate glass bottles (Sibata) with ground-glass stopcock lubricated with Apiezon L grease, and were poisoned with 0.2 cm^3 of saturated $HgCl_2$ solution. Duplicate samples were routinely taken from surface seawater in a bucket. TCO_2 was determined by coulometry at 20 deg-C using a automated TCO_2 sampling system (MRI-Nippon ANS) equipped with carbon coulometer 5012 (UIC Co.). It was standardized using a suite of Na_2CO_3 solution and the reference seawater prepared in MRI that is traceable to the CRM provided by Dr. A. Dickson in Scripps Institution of Oceanography. The analysis of the reference seawater was made twice during the each run of the coulometric cathode- and anode-solutions. All samples were analyzed within 11 h after the CTD/carousel arrived on deck. A correction for the addition of $HgCl_2$ solution is to be made.

Samples for pH analysis were collected in $400cm^3$ plastic bags covered with aluminum layer, and were poisoned with 0.3 cm^3 of saturated $HgCl_2$ solution. Duplicate samples were routinely taken from surface seawater in a bucket. pH was measured by spectrophotometry at 25.0 deg-C after adding a dye m-cresol purple using a MRI-Nippon ANS automated system equipped with spectrophotometer Cary 50 (Varian Co). The analysis of the reference seawater was made once at the end of a series of measurements at a station. All samples were analyzed within 11 h after the CTD/carousel arrived on deck. Corrections for the addition of $HgCl_2$ solution and m-cresol purple solution are to be made.

(e) Underway measurement of pH (total hydrogen ion scale) in surface seawater:

We tried underway measurement of pH in surface seawater using the instrument described above (d). Seawater was taken continuously from the bottom of the ship. A portion of seawater (~ 20 cm^3) was introduced into the water-jacketed quartz flow cell of the spectrophotometer. The cell is custom-made and has 8cm light path length. The measurement was made every half an hour synchronized with pCO_2 and TCO_2 measurement. When discrete samples were measured, we set the measurement interval as 1.5 h.

(5) Results

Data analyses will be made soon.

(6) Data archive

The original data will be archived at Geochemical Research Department, Meteorological Research Institute. Data will be also submitted to Data Management Office at JAMSTEC within 3 years.

3.14 Determination of carbonate (total dissolved inorganic carbon, alkalinity and pH), sulfur hexafluoride (SF6) and nitrous oxide (N2O) in sea water at the equatorial area

Central Research Institute of Electric Power Industry
Masahiro IMAMURA

1. OBJECTIVES

In the view of the problem of the global warming, it is important to know the concentration level of green house effect gases in the ocean and the penetration rate of the gases trough air-sea surface interface. Our purpose of this cruise is to collect the date of carbonate (total carbon dioxide and alkalinity), sulfur hexafluoride (SF_6) and nitrogen oxide (N_2O) at the equator area. We will estimate the flux of antholopogenic carbon dioxide in this area using the obtained data.

2. DESCRIPTION OF METHODS

< Total Alkalinity>

Total Alkalinity samples were collected in 250ml polyethylene bottles with inner caps from Niskin-type water samplers and capped after an overflow of about 150ml of sea water. All samples were stored at room temperature after sampling and analyzed within a few hours. Samples were transferred into a glass titration cell using a 50ml transfer pipette and titrated at 25ºC$\pm$0.1ºC with 0.1 M HCl containing 0.6M NaCl within 10 min. The electric potential and temperature of the sample were followed with a Ag/AgCl combined electrode (Radiometer Analytical A/S, GK2401C) and a temperature sensor (Radiometer Analytical A/S, T901) connected to a TitraLab^{TM} (Radiometer Analytical A/S) system. The titration was controlled automatically and the titration curve was analyzed with the inflection point titration method by the system. The precision of the method was determined to be $\pm$0.0047mmol/kg (n=8) from replicate analysis of the Certified Reference Solutions (CRMs) (batch 44) supplied by Dr. Andrew Dickson of Scripps Institution of Oceanography (SIO)). Standardization of the titrant (0.1 M HCl) was accomplished with Na_2CO_3 (99.99% pure; Asahi Grass) standards.

<Total dissolved inorganic carbon (T-CO$_2$)>

The T-CO_2 concentration in seawater samples were determined by using the coulometric titration system (UIC Inc., Carbon Coulometer model 5011) described by Jhonson et al. (1985) with the modified CO_2 extraction system described by Shitashima et al. (1996). Samples for T-CO_2 analysis were drawn from the Niskin samplers into 125ml glass vial bottles after an overflow of about 100ml of the sea water. The samples were immediately poisoned with 50µl of 50% saturated $HgCl_2$ in order to restrict biological alteration prior to sealing the bottles. All samples were stored at room temperature after sampling and analyzed within a few hours.

Seawater was introduced manually into the thermostated (25ºC$\pm$0.1ºC) measuring pipette with a volume of ~30ml by a pressurized headspace CO_2-free air that had been passed through the KOH scrubber. The measured volume was then transferred to the extraction vessel. The seawater sample in the extraction vessel was acidified with 1.5 ml of 3.8% phosphoric acid and the CO_2 was extracted from the sample for 10 minutes by bubbling with the CO_2-free air. After passing through the Ag_2SO_4 scrubber and polywool to remove sea salts and water vapor, the evolved CO_2 gas was continuously induced to the coulometric titration cell by the stream of the CO_2-free air. All reagents were renewed every day. The T-CO_2 concentration in seawater was calculated using a calibration carve constructed by measuring five to six different concentrations of dissolved Na_2CO_3 (99.99% pure; Asahi Grass) used as a standard solutions (Dickson and Goyet, 1994). The precision of the T-CO_2 measurements was tested by analyzing CRMs (batch 44) at the start of the measurement of samples every day. Figure 2 shows a comparison between the results of our shipboard measurements of these CRMs during the cruise and certified values provided by Dr. Andrew Dickson. Our shipboard measurements yielded a mean value of 1995.6$\pm$2.8 µmol/kg (n=40), which compares with 1997.6$\pm$1.4 µmol/kg (n=9) certified by SIO. We also prepared and analyzed sub-standards that were bottled into 125ml glass vial bottles from a 20l bottle of filtered and poisoned offshore surface water in order to check the condition of the system and the stability of measurements every day. The resulting standard deviation form replicate analysis of 19 sub-standards was $\pm$1.8 µmol/kg.

<Sulfur hexafluoride (SF$_6$)>

SF_6 Sample was drawn from the Niskin samplers into 500ml DURAN glass bottles after an overflow of about 250ml of the sea water. The bottle was sealed tightly and stored at room temperature. The analysis of SF_6 will be carried out on land laboratory. The SF_6 gas in seawater is concentrated by a purge-and-trap method and measure by gas chromatography with electron capture detector. Seawater sample (480ml) is transferred into the extraction vessel and bubble (flow rate : 220ml/min) for 10 minuets with nitrogen gas in order to extract SF_6 gas from seawater and the SF_6 is trapped by using the Porapak Q (80-100µm) column. The column is heated at about 80ºC for disorption of SF_6 and the SF_6 is introduced to gas chromatography (HP 5890 series II, column : HP Molecular Sieve 5A (80-100µm) 30m x 0.53mm) and detecte with non-radioactive electron capture detector (VICI, Pulsed discharge Detector (ECD mode)).

<Nitrogen Oxide (N_2O)>

Samples for N_2O analysis were drawn from the Niskin samplers into 125ml glass vial bottles after an overflow of about 100ml of the sea water. The samples were immediately poisoned with 50µl of 50% saturated $HgCl_2$ in order to restrict biological alteration prior to sealing the bottles. All samples were stored in a refrigerator before measurement, and were analyzed within 12 hours of collection. The N_2O gas in seawater was measured by gas chromatography with electron capture detector on board. About 15ml of headspace gas (N_2) was introduced into a glass vial bottle by removing seawater with syringe. Subsequently, samples were stand in thermostatic water bath (40 +/- 0.5℃) for at least 2 hours in order to make a gas-liquid equilibration. The N_2O in headspeas gas was took with a gas syringe and injected to gas chromatograph (column : Molecular Sieve 5A 60/80 2m× 3Ø) with [63]Ni electron capture detector (SHIMADZU GC-14B ECD).

3. REFERENCES

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3.15 The measurement for active fluorescence by FRRF (Fast Repetitation Rate Fluorometer) to estimate primary productions *in situ* and variation of photosystem II parameter.

Minami Chie, Saino Toshiro,
Institute for Hydrosheric-Atomospheric Scineces, Nagoya University

Objective

In order to understand regional primary productions in the equatorial Pacific Ocean, it is important to evaluate phytoplankton physiological status and its relation to environmental conditions. So we measured photosynthetic parameters by FRRF to estimate primary productions. This parameters are calculated from the in vivo fluorescence of chlorophyll is induced by excitation light energy.

1. Estimate of primary productions *in situ*

We fixed FRRF to CTD at every Shallow Cast (depth of about 200m) and measured photosynthetic parameters by FRR method based on active fluorescence. We will calculate the photosynthesis rate of phytoplankton from the vertical profiles of fluorescence yield.

2. Variation of photosystem II parameter

To evaluate the photochemical potential, surface seawater were flowed continuatively through the flowcell of FRRF during the ship was sailing. The absorption cross section of PSII, the efficiency of photochemical conversion and the rate of electron transport from PSII toPSI were measured at intervals of fifteen minutes. We also collected surface seawater sample, to evaluate phytoplankton communities by HPLC pigment analysis, from one time at day and night. We will evaluate the dynamics of phytoplankton from horizontal profiles.

3.16 Study on the biogeography of the coccolithophorid assemblage in the Western and Central Equatorial Pacific Ocean

Yuichiro TANAKA[1] and Kyoko TOMIOKA[2]

1: Marine Geology Department, Geological Survey of Japan
2: Graduate School of Science, Hokkaido University

Introduction

Coccolithophorids are one of the important primary producers in the tropical warm ocean. Due to the production of extra cellular calcium carbonate scales (coccoliths), coccolithophorids contribute to the export flux of calcium carbonate from the sea surface to the sea floor. The standing crop and the floral composition of coccolithophorids are controlled by the topography and surface water circulation.

Surface currents of the Equatorial Pacific Ocean is characterized by the westward North and South Equatorial Currents and the eastward Equatorial Counter Current. Strength of the westward transportation and the oceanographic setting are controlled by Asian Monsoon and El Niño and the Southern Oscillations (ENSO)

In the Normal and La Niña phases of ENSO, stratified Western Pacific Warm Pool (WPWP) develop in the Western Equatorial Pacific due to the strong westward transportation of surface warm waters by the North and South Equatorial Currents. In the Eastern Equatorial Pacific, deep water upwells to replace the lost surface water. Therefore, strength of stratification is different between the Eastern and Western Equatorial Pacific Ocean.

In the El Niño phase of ENSO, westward surface transportation is weakened, and the warm surface waters that piled up in the western Pacific during the Normal and La Niña phase flow back to the east. As a result, Central and Eastern Equatorial Pacific get stratified as well as Western Equatorial Pacific.

Coccolithophorids in the Equatorial Pacific Ocean has been studied by several researchers, however, effect of environmental changes caused by ENSO on the coccolithophorid flora has not been revealed, yet. In this study, we will try to clarify the environmental control on the primary production and floral composition of coccolithophorid assemblage.

Materials and Method

For the study of the standing crop and floral composition of the coccolithophorid assemblage, surface water samples were taken during the cruises from the st. 1 to Japan by using a water pump, and subsurface water samples were collected in the 12 stations by using Niskin bottles (Table 1). Immediately after sampling, 5.4 to 8 liter of water samples were filtered onto Millipore filter with a pore size of 0.45 µm. Filters were then air-dried.

Table.1

Filter No.	Date & Time (LST)	Latitude	Longitude	St.	Cast Code	Depth (m)	Volume (l)	Sampling tool
1	99/11/24			1	Shallow 3	0	8	bucket
2				1	Shallow 3	chl.max	8	Niskin Bottle
3				1	Shallow 3	20	8	Niskin Bottle
4				1	Shallow 3	40	8	Niskin Bottle
5				1	Shallow 3	60	8	Niskin Bottle
6				1	Shallow 3	80	8	Niskin Bottle
7				1	Shallow 3	100	8	Niskin Bottle
8				1	Shallow 3	120	8	Niskin Bottle
9				1	Shallow 3	140	8	Niskin Bottle
10				1	Shallow 3	160	8	Niskin Bottle
11				1	Shallow 3	180	8	Niskin Bottle
12				1	Shallow 3	200	8	Niskin Bottle
13	99/11/25 12:00	4 23.21 N	136 42.00 E	-	-	ca.5m	8	pump
14	99/11/25 16:00	4 36.08 N	137 48.97 E	-	-	ca.5m	8	pump
15	99/11/25 19:55	4 49.01 N	138 53.89 E	-	-	ca.5m	8	pump
16	99/11/25 23:00	5 01.18 N	139 43.70 E	-	-	ca.5m	8	pump
17	99/11/26			2	Shallow 4	0	8	bucket
18				2	Shallow 4	10	8	Niskin Bottle
19				2	Shallow 4	30	8	Niskin Bottle
20				2	Shallow 4	40	8	Niskin Bottle
21				2	Shallow 4	60	8	Niskin Bottle
22				2	Shallow 4	70	8	Niskin Bottle
23				2	Shallow 4	80	8	Niskin Bottle
24				2	Shallow 4	90	8	Niskin Bottle

25					2	Shallow 4	100	8	Niskin Bottle
26					2	Shallow 4	110	8	Niskin Bottle
27					2	Shallow 4	120	8	Niskin Bottle
28					2	Shallow 4	150	8	Niskin Bottle
29					2	Shallow 4	200	8	Niskin Bottle
30	99/11/26 23:00	6 21.66 N	140 47.31 E	-	-	ca.5m	8	pump
31	99/11/27 0:15			-	-	ca.5m	8	pump
32	99/11/27 4:10	2 47.08 N	142 28.06 E	-	-	ca.5m	8	pump
33	99/11/27 8:10	1 51.53 N	143 12.30 E	-	-	ca.5m	8	pump
34	99/11/27 12:00	1 06.87 N	143 56.21 E	-	-	ca.5m	8	pump
35	99/11/27 16:00	0 22.33 N	144 38.55 E	-	-	ca.5m	8	pump
36	99/11/28			3	Shallow 3	0	8	bucket
37				3	Shallow 3	chl.max	8	Niskin Bottle
38				3	Shallow 3	20	8	Niskin Bottle
39				3	Shallow 3	40	8	Niskin Bottle
40				3	Shallow 3	60	8	Niskin Bottle
41				3	Shallow 3	80	8	Niskin Bottle
42				3	Shallow 3	100	8	Niskin Bottle
43				3	Shallow 3	120	8	Niskin Bottle
44				3	Shallow 3	140	8	Niskin Bottle
45				3	Shallow 3	160	8	Niskin Bottle
46				3	Shallow 3	180	8	Niskin Bottle
47				3	Shallow 3	200	8	Niskin Bottle
48	99/11/29 11:55	0 00.03 S	146 22.87 E	-	-	ca.5m	8	pump
49	99/11/29 16:06	0 00.98 S	147 18.33 E	-	-	ca.5m	8	pump
50	99/11/29 19:05	0 00.04 S	148 03.82 E	-	-	ca.5m	8	pump
51	99/11/29 23:00			-	-	ca.5m	8	pump
52	99/11/30 4:10	0 00.27 S	150 21.92 E	-	-	ca.5m	8	pump
53	99/11/30 7:55	0 00.12 N	151 21.77 E	-	-	ca.5m	8	pump
54	99/11/30			4	Shallow 4	0	8	bucket
55				4	Shallow 4	10	8	Niskin Bottle
56				4	Shallow 4	30	8	Niskin Bottle
57				4	Shallow 4	40	8	Niskin Bottle
58				4	Shallow 4	60	8	Niskin Bottle
59				4	Shallow 4	80	8	Niskin Bottle
60				4	Shallow 4	90	8	Niskin Bottle
61				4	Shallow 4	100	8	Niskin Bottle
62				4	Shallow 4	120	8	Niskin Bottle
63				4	Shallow 4	140	8	Niskin Bottle
64				4	Shallow 4	170	8	Niskin Bottle
65				4	Shallow 4	200	8	Niskin Bottle
66	99/11/30 13:40	0 00.86 N	152 28.63 E	-	-	ca.5m	8	pump
67	99/11/30 14:39	0 00.58 N	152 42.89 E	-	-	ca.5m	8	pump
68	99/11/30 16:00	0 00.20 N	153 04.00 E	-	-	ca.5m	8	pump
69	99/11/30 19:00	0 00.21 N	153 51.63 E	-	-	ca.5m	8	pump
70	99/12/1 4:33	0 00.10 N	155 54.81 E	-	-	ca.5m	8	pump
71	99/12/1 8:10	?	? ? E	-	-	ca.5m	8	pump
72	99/12/1			5	Shallow 4	0	8	bucket
73				5	Shallow 4	10	8	Niskin Bottle
74				5	Shallow 4	30	8	Niskin Bottle
75				5	Shallow 4	40	8	Niskin Bottle
76				5	Shallow 4		8	Niskin Bottle
77				5	Shallow 4		8	Niskin Bottle
78				5	Shallow 4		8	Niskin Bottle
79				5	Shallow 4		8	Niskin Bottle
80				5	Shallow 4		8	Niskin Bottle
81				5	Shallow 4	140	8	Niskin Bottle
82				5	Shallow 4	170	8	Niskin Bottle
83				5	Shallow 4	200	8	Niskin Bottle
84	99/12/1 16:00	0 00.07 S	158 19.12 E	-	-	ca.5m	8	pump
85	99/12/1 19:05	0 00.08 S	159 04.42 E	-	-	ca.5m	8	pump
86	99/12/2			6	Shallow 3	0	8	bucket
87				6	Shallow 3	chl.max	8	Niskin Bottle
88				6	Shallow 3	20	8	Niskin Bottle

89				6	Shallow 3	40	8	Niskin Bottle
90				6	Shallow 3	60	8	Niskin Bottle
91				6	Shallow 3	80	8	Niskin Bottle
92				6	Shallow 3	100	8	Niskin Bottle
93				6	Shallow 3	120	8	Niskin Bottle
94				6	Shallow 3	140	8	Niskin Bottle
95				6	Shallow 3	160	8	Niskin Bottle
96				6	Shallow 3	180	8	Niskin Bottle
97				6	Shallow 3	200	8	Niskin Bottle
98	99/12/3 11:50	0 00.03 N	161 06.49 E	-	-	ca.5m	8	pump
99	99/12/3 16:00	0 00.04 N	162 05.24 E	-	-	ca.5m	8	pump
100	99/12/3 19:05	0 00.08 N	162 51.03 E	-	-	ca.5m	8	pump
101	99/12/3 23:25	0 00.02 N	163 53.55 E	-	-	ca.5m	8	pump
102	99/12/4 4:05	0 00.03 N	165 02.31 E	-	-	ca.5m	8	pump
103	99/12/4 8:20	0 00.11 S	166 03.21 E	-	-	ca.5m	8	pump
104	99/12/4			7	Shallow 4	0	8	bucket
105				7	Shallow 4	10	8	Niskin Bottle
106				7	Shallow 4	30	8	Niskin Bottle
107				7	Shallow 4	40	8	Niskin Bottle
108				7	Shallow 4	50	8	Niskin Bottle
109				7	Shallow 4	60	8	Niskin Bottle
110				7	Shallow 4	80	8	Niskin Bottle
111				7	Shallow 4	100	8	Niskin Bottle
112				7	Shallow 4	120	8	Niskin Bottle
113				7	Shallow 4	140	8	Niskin Bottle
114				7	Shallow 4	170	8	Niskin Bottle
115				7	Shallow 4	200	8	Niskin Bottle
116	99/12/4 16:00	0 00.04 S	167 29.78 E	-	-	ca.5m	8	pump
117	99/12/4 18:55	0 00.09 S	168 12.24 E	-	-	ca.5m	8	pump
118	99/12/5 0:00	0 00.02 N	169 13.38 E	-	-	ca.5m	8	pump
119	99/12/5 4:15	0 00.01 S	170 13.75 E	-	-	ca.5m	8	pump
120	99/12/5 7:40	0 00.02 S	171 03.31 E	-	-	ca.5m	8	pump
121	99/12/5			8	Shallow 4	0	8	bucket
122				8	Shallow 4	10	8	Niskin Bottle
123				8	Shallow 4	30	8	Niskin Bottle
124				8	Shallow 4	40	8	Niskin Bottle
125				8	Shallow 4	50	8	Niskin Bottle
126				8	Shallow 4	60	8	Niskin Bottle
127				8	Shallow 4	80	8	Niskin Bottle
128				8	Shallow 4	100	8	Niskin Bottle
129				8	Shallow 4	120	8	Niskin Bottle
130				8	Shallow 4	140	8	Niskin Bottle
131				8	Shallow 4	170	8	Niskin Bottle
132				8	Shallow 4	200	8	Niskin Bottle
133	99/12/5 16:00	0 00.10 S	172 39.17 E	-	-	ca.5m	8	pump
134	99/12/5 19:00	0 00.05 S	173 21.00 E	-	-	ca.5m	8	pump
135	99/12/6 0:00	0 00.08 N	174 31.85 E	-	-	ca.5m	8	pump
136	99/12/6			9	Shallow 3	0	8	bucket
137				9	Shallow 3	chl.max	8	Niskin Bottle
138				9	Shallow 3	20	8	Niskin Bottle
139				9	Shallow 3	40	8	Niskin Bottle
140				9	Shallow 3	60	8	Niskin Bottle
141				9	Shallow 3	80	8	Niskin Bottle
142				9	Shallow 3	100	8	Niskin Bottle
143				9	Shallow 3	120	8	Niskin Bottle
144				9	Shallow 3	140	8	Niskin Bottle
145				9	Shallow 3	160	8	Niskin Bottle
146				9	Shallow 3	180	8	Niskin Bottle
147				9	Shallow 3	200	8	Niskin Bottle
148	99/12/6 23:55	0 01.74 N	175 33.92 E	-	-	ca.5m	8	pump
149	1999/12/7a 4:15	0 00.07 N	176 34.45 E	-	-	ca.5m	8	pump
150	1999/12/7a 7:35	0 00.84 S	177 21.46 E	-	-	ca.5m	8	pump
151	1999/12/7a			10	Shallow 4	0	8	bucket
152				10	Shallow 4	10	8	Niskin Bottle

No.	Date/Time	Lat °	Lat ′	N/S	Lon °	Lon ′	E/W	St.	Layer	Depth		Method
153								10	Shallow 4	30	8	Niskin Bottle
154								10	Shallow 4	40	8	Niskin Bottle
155								10	Shallow 4	50	8	Niskin Bottle
156								10	Shallow 4	60	8	Niskin Bottle
157								10	Shallow 4	80	8	Niskin Bottle
158								10	Shallow 4	100	8	Niskin Bottle
159								10	Shallow 4	120	8	Niskin Bottle
160								10	Shallow 4	140	8	Niskin Bottle
161								10	Shallow 4	170	8	Niskin Bottle
162								10	Shallow 4	200	8	Niskin Bottle
163	1999/12/7a 16:15	0	00.31	S	178	56.39	E	-	-	ca.5m	8	pump
164	1999/12/7a 19:05	0	00.06	S	179	32.99	E	-	-	ca.5m	8	pump
165	1999/12/7b 0:00	0	00.28	S	179	18.87	W	-	-	ca.5m	8	pump
166	1999/12/7b 4:10	0	00.14	S	178	19.42	W	-	-	ca.5m	8	pump
167	1999/12/7b 7:40	0	00.24	N	177	28.68	W	-	-	ca.5m	8	pump
168	1999/12/7b							11	-	0	8	bucket
169								11	Shallow 4	10	8	Niskin Bottle
170								11	Shallow 4	30	8	Niskin Bottle
171								11	Shallow 4	40	8	Niskin Bottle
172								11	Shallow 4	50	8	Niskin Bottle
173								11	Shallow 4	60	8	Niskin Bottle
174								11	Shallow 4	80	8	Niskin Bottle
175								11	Shallow 4	100	8	Niskin Bottle
176								11	Shallow 4	120	8	Niskin Bottle
177								11	Shallow 4	140	8	Niskin Bottle
178								11	Shallow 4	170	8	Niskin Bottle
179								11	Shallow 4	200	8	Niskin Bottle
180	1999/12/7b 16:00	0	00.11	S	175	47.79	W	-	-	ca.5m	8	pump
181	1999/12/7b 19:05	0	00.12	S	175	01.76	W	-	-	ca.5m	8	pump
182	99/12/8 0:02	0	00.23	S	174	02.86	W	-	-	ca.5m	8	pump
183	99/12/8 4:53	0	00.07	N	173	05.56	W	-	-	ca.5m	8	pump
184	99/12/8 8:10	0	00.34	S	172	63.92	W	-	-	ca.5m	8	pump
185	99/12/8 12:00	0	00.29	N	171	10.39	W	-	-	ca.5m	8	pump
186	99/12/8							12	Shallow 3	0	8	bucket
187								12	Shallow 3	chl.max	8	Niskin Bottle
188								12	Shallow 3	20	8	Niskin Bottle
189								12	Shallow 3	40	8	Niskin Bottle
190								12	Shallow 3	60	8	Niskin Bottle
191								12	Shallow 3	80	8	Niskin Bottle
192								12	Shallow 3	100	8	Niskin Bottle
193								12	Shallow 3	120	8	Niskin Bottle
194								12	Shallow 3	140	8	Niskin Bottle
195								12	Shallow 3	160	8	Niskin Bottle
196								12	Shallow 3	180	8	Niskin Bottle
197								12	Shallow 3	200	8	Niskin Bottle
198	99/12/9 20:00	0	25.96	N	169	56.84	W	-	-	ca.5m	8	pump
199	99/12/10 0:02	1	18.85	N	169	24.39	W	-	-	ca.5m	8	pump
200	99/12/10 4:07	2	11.24	N	168	50.52	W	-	-	ca.5m	8	pump
201	99/12/10 8:05	3	03.35	N	168	18.37	W	-	-	ca.5m	8	pump
202	99/12/10 11:59	3	58.92	N	167	49.32	W	-	-	ca.5m	8	pump
203	99/12/10 15:53	4	53.35	N	167	16.79	W	-	-	ca.5m	8	pump
204	99/12/10 19:05	5	36.98	N	166	52.55	W	-	-	ca.5m	8	pump
205	99/12/11 0:20	6	38.45	N	166	17.07	W	-	-	ca.5m	8	pump
206	99/12/11 4:20	7	37.02	N	165	44.29	W	-	-	ca.5m	8	pump
207	99/12/11 8:16	8	34.12	N	165	13.44	W	-	-	ca.5m	8	pump
208	99/12/11 11:55	9	25.53	N	164	43.34	W	-	-	ca.5m	8	pump
209	99/12/11 16:16	10	23.94	N	164	10.41	W	-	-	ca.5m	8	pump
210	99/12/11 19:15	11	06.22	N	163	46.76	W	-	-	ca.5m	8	pump
211	99/12/12 0:01	12	11.23	N	163	09.41	W	-	-	ca.5m	8	pump
212	99/12/12 4:27	13	10.18	N	162	36.03	W	-	-	ca.5m	8	pump
213	99/12/12 8:20	14	01.15	N	162	07.79	W	-	-	ca.5m	8	pump
214	99/12/12 12:00	14	50.70	N	161	40.34	W	-	-	ca.5m	8	pump
215	99/12/12 16:05	15	44.69	N	161	10.62	W	-	-	ca.5m	8	pump
216	99/12/12 18:55	16	21.37	N	160	47.59	W	-	-	ca.5m	8	pump

217	99/12/13 0:11	17 31.44 N	160 06.25 W	-	-	ca.5m	8	pump
218	99/12/13 4:05	18 25.03 N	159 34.86 W	-	-	ca.5m	8	pump
219	99/12/13 8:41	19 29.07 N	158 56.88 W	-	-	ca.5m	8	pump
220	99/12/15 16:04	21 43.03 N	162 14.87 W	-	-	ca.5m	8	pump
221	99/12/15 20:09	21 55.42 N	163 21.39 W	-	-	ca.5m	8	pump
222	99/12/15 23:04	22 08.89 N	164 41.30 W	-	-	ca.5m	8	pump
223	99/12/16 4:00	22 19.89 N	165 47.05 W	-	-	ca.5m	8	pump
224	99/12/16 8:00	22 30.36 N	166 53.67 W	-	-	ca.5m	8	pump
225	99/12/16 12:07	22 42.51 N	168 02.61 W	-	-	ca.5m	8	pump
226	99/12/16 15:58	22 53.04 N	169 05.52 W	-	-	ca.5m	8	pump
227	99/12/16 19:54	23 03.47 N	170 10.64 W	-	-	ca.5m	8	pump
228	99/12/17 0:28	23 18.30 N	171 43.42 W	-	-	ca.5m	8	pump
229	99/12/17 4:00	23 28.86 N	172 41.68 W	-	-	ca.5m	8	pump
230	99/12/17 8:00	23 39.60 N	173 47.11 W	-	-	ca.5m	8	pump
231	99/12/17 12:00	23 49.39 N	174 40.36 W	-	-	ca.5m	8	pump
232	99/12/17 15:57	24 00.28 N	175 53.55 W	-	-	ca.5m	8	pump
233	99/12/17 19:59	24 11.12 N	176 56.28 W	-	-	ca.5m	8	pump
234	99/12/19 0:00	24 21.65 N	177 58.13 W	-	-	ca.5m	8	pump
235	99/12/19 4:16	24 31.75 N	179 03.21 W	-	-	ca.5m	8	pump
236	99/12/19 8:01	24 41.47 N	179 58.05 E	-	-	ca.5m	8	pump
237	99/12/19 12:03	24 52.43 N	178 53.07 E	-	-	ca.5m	8	pump
238	99/12/19 15:58	25 02.28 N	177 49.47 E	-	-	ca.5m	8	pump
239	99/12/19 19:56	25 12.41 N	176 48.60 E	-	-	ca.5m	8	pump
240	99/12/19 23:56	25 25.08 N	175 32.04 E	-	-	ca.5m	8	pump
241	99/12/20 4:05	25 35.63 N	174 28.56 E	-	-	ca.5m	8	pump
242	99/12/20 8:06	25 43.87 N	173 33.74 E	-	-	ca.5m	8	pump
243	99/12/20 12:01	25 51.83 N	172 47.08 E	-	-	ca.5m	8	pump
244	99/12/20 16:02	25 59.97 N	171 59.02 E	-	-	ca.5m	8	pump
245	99/12/20 19:55	26 07.35 N	171 09.46 E	-	-	ca.5m	8	pump
246	99/12/21 0:01	26 16.44 N	170 15.04 E	-	-	ca.5m	8	pump
247	99/12/21 4:05	26 25.98 N	169 18.43 E	-	-	ca.5m	8	pump
248	99/12/21 8:06	26 35.59 N	168 19.96 E	-	-	ca.5m	8	pump
249	99/12/21 12:04	26 45.07 N	167 16.98 E	-	-	ca.5m	8	pump
250	99/12/21 16:02	26 56.12 N	166 11.60 E	-	-	ca.5m	8	pump
251	99/12/21 19:55	27 06.33 N	165 07.31 E	-	-	ca.5m	8	pump
252	99/12/22 0:21	27 20.29 N	163 37.57 E	-	-	ca.5m	8	pump
253	99/12/22 4:10	27 30.72 N	162 34.19 E	-	-	ca.5m	8	pump
254	99/12/22 8:05	27 41.98 N	161 28.64 E	-	-	ca.5m	8	pump
255	99/12/22 12:05	27 51.88 N	160 21.47 E	-	-	ca.5m	8	pump
256	99/12/22 16:00	28 02.84 N	159 15.79 E	-	-	ca.5m	8	pump
257	99/12/22 19:55	28 12.92 N	158 09.49 E	-	-	ca.5m	8	pump
258	99/12/23 0:07	28 26.71 N	156 41.17 E	-	-	ca.5m	8	pump
259	99/12/23 4:07	28 38.41 N	155 32.68 E	-	-	ca.5m	8	pump
260	99/12/23 8:03	28 48.73 N	154 25.89 E	-	-	ca.5m	8	pump
261	99/12/23 12:05	28 59.67 N	153 19.26 E	-	-	ca.5m	8	pump
262	99/12/23 16:02	29 09.86 N	152 13.82 E	-	-	ca.5m	8	pump
263	99/12/23 20:01	29 19.59 N	151 07.84 E	-	-	ca.5m	8	pump
264	99/12/23 23:55	29 30.18 N	150 01.36 E	-	-	ca.5m	8	pump
265	99/12/24 4:13	29 42.04 N	148 48.20 E	-	-	ca.5m	8	pump
266	99/12/24 8:07	29 52.38 N	147 41.54 E	-	-	ca.5m	8	pump
267	99/12/24 12:12	30 03.77 N	146 30.29 E	-	-	ca.5m	8	pump
268	99/12/24 16:05	30 14.02 N	145 22.56 E	-	-	ca.5m	8	pump
269	99/12/24 20:04	30 26.35 N	144 09.57 E	-	-	ca.5m	8	pump
270	99/12/25 0:09	30 37.49 N	142 56.14 E	-	-	ca.5m	8	pump
271	99/12/25 4:17	30 48.18 N	141 42.58 E	-	-	ca.5m	8	pump
272	99/12/25 8:10	30 59.73 N	140 31.74 E	-	-	ca.5m	8	pump
273	99/12/25 0:00	31 10.83 N	139 26.93 E	-	-	ca.5m	8	pump

In the laboratory, the absolute abundance and floral composition of coccolithophorid assemblage will be studied under a cross-polarized light microscope and SEM, respectively.

For the observation of the protoplasm of coccolithophorids, selected 64 filter samples were dyed by the Rose Bengal solution (Table 2). After filtration, ca. 5 ml of 0.5 permill Rose Bengal solution was immidiately dropped onto the filter samples. Filteres were then stored in the plastic petridishes about 24 hours and were washed out by ca. 500 ml. of boiled filtered sea water. And then, filters were air-dried.

Table.2

Filter No.	Date & Time (LST)	St.	Cast Code	Depth (m)	Volume (l)	sampling tool
R-1	99/11/23 8:45	-	-	ca.5m	7.66	pump
R-2	99/11/23 9:30	-	-	ca.5m	8	pump
R-3	99/11/24 10:40	1	shallow 1	0	5.7	bucket
R-4		1	shallow 1	10	8	Niskin Bottle
R-5		1	shallow 1	20	8	Niskin Bottle
R-6		1	shallow 1	30	8	Niskin Bottle
R-7		1	shallow 1	40	8	Niskin Bottle
R-8		1	shallow 1	50	8	Niskin Bottle
R-9		1	shallow 1	60	8	Niskin Bottle
R-10		1	shallow 1	70	8	Niskin Bottle
R-11		1	shallow 1	80	8	Niskin Bottle
R-12		1	shallow 1	90	8	Niskin Bottle
R-13		1	shallow 1	100	8	Niskin Bottle
R-14		1	shallow 1	120	8	Niskin Bottle
R-15		1	shallow 1	150	8	Niskin Bottle
R-16	99/11/28	3	shallow 1	0	8	bucket
R-17		3	shallow 1	10	8	Niskin Bottle
R-18		3	shallow 1	20	8	Niskin Bottle
R-19		3	shallow 1	30	8	Niskin Bottle
R-20		3	shallow 1	40	8	Niskin Bottle
R-21		3	shallow 1	50	8	Niskin Bottle
R-22		3	shallow 1	60	8	Niskin Bottle
R-23		3	shallow 1	70	8	Niskin Bottle
R-24		3	shallow 1	80	8	Niskin Bottle
R-25		3	shallow 1	90	8	Niskin Bottle
R-26		3	shallow 1	100	8	Niskin Bottle
R-27		3	shallow 1	120	8	Niskin Bottle
R-28		3	shallow 1	150	8	Niskin Bottle
R-29	99/12/2	6	shallow 1	0	8	bucket
R-30		6	shallow 1	10	8	Niskin Bottle
R-31		6	shallow 1	30	8	Niskin Bottle
R-32		6	shallow 1	40	8	Niskin Bottle
R-33		6	shallow 1	60	8	Niskin Bottle
R-34		6	shallow 1	70	8	Niskin Bottle
R-35		6	shallow 1	80	8	Niskin Bottle
R-36		6	shallow 1	100	8	Niskin Bottle
R-37		6	shallow 1	120	8	Niskin Bottle
R-38		6	shallow 1	140	8	Niskin Bottle
R-39		6	shallow 1	170	8	Niskin Bottle
R-40		6	shallow 1	200	8	Niskin Bottle
R-41	99/12/6	9	shallow 1	0	8	bucket
R-42		9	shallow 1	10	8	Niskin Bottle
R-43		9	shallow 1	30	8	Niskin Bottle
R-44		9	shallow 1	40	8	Niskin Bottle
R-45		9	shallow 1	60	8	Niskin Bottle
R-46		9	shallow 1	70	8	Niskin Bottle
R-47		9	shallow 1	80	8	Niskin Bottle
R-48		9	shallow 1	100	8	Niskin Bottle
R-49		9	shallow 1	120	8	Niskin Bottle
R-50		9	shallow 1	140	8	Niskin Bottle
R-51		9	shallow 1	170	8	Niskin Bottle
R-52		9	shallow 1	200	8	Niskin Bottle
R-53	99/12/8	12	shallow 1	0	8	bucket
R-54		12	shallow 1	10	8	Niskin Bottle
R-55		12	shallow 1	30	8	Niskin Bottle
R-56		12	shallow 1	40	8	Niskin Bottle
R-57		12	shallow 1	60	8	Niskin Bottle
R-58		12	shallow 1	70	8	Niskin Bottle
R-59		12	shallow 1	80	8	Niskin Bottle
R-60		12	shallow 1	100	8	Niskin Bottle

R-61		12	shallow 1	120	8	Niskin Bottle
R-62		12	shallow 1	140	8	Niskin Bottle
R-63		12	shallow 1	170	8	Niskin Bottle
R-64		12	shallow 1	200	8	Niskin Bottle

3.17 Distribution of diatoms in the Equatorial Pacific

Yusuke Okazaki (Kyushu University)

Diatoms are ubiquitous siliceous phytoplankton living in the marine surface waters. Species distribution of the diatoms can be correlated to biological productivity, salinity and temperature conditions, allowing for us to reconstruct marine environments. The purpose of this study is to characterize the distribution of diatoms in the western warm water pool as well as outside of it in the Equatorial Pacific surface waters. In order to understand such baseline sea-surface environmental conditions as opposed to an El Nino condition, we plan to assess the distribution of diatom taxa and their standing stock.

Two liters of the surface waters were systematically sampled using a pump equipped on the ship. Then they were filterd using Gelman membrane filters (diameter: 25 mm, pore size: 0.4 µm) . Their sampling locations are Station 1-12 and which are located every 5 between 140 E to 170 W on the Equator. Beyond Station 12, two samples were collected daily, one in the morning and the other in the evening.

A shore based diatom distribution study employing taxon-enumeration will be conduced at the Kyushu University.

3.18 Distribution of radiolarians and planktonic foraminifers in the Equatorial Pacific

Yusuke Okazaki (Kyushu University) and Hanako Domitsu (Kumamoto University)

Knowledge on distributions of radiolarians, siliceous zooplankton, and planktonic foraminifers, calcareous zooplankton, is useful for understanding water mass structures, and climatic change together with studies on particle fluxes and sediments. The main purpose of the present study is to characterize the horizontal and vertical distributions of radiolarians and planktonic foraminifers in the Equatorial Pacific.

A plankton-net was towed at Station 1, 3, 6, 9 and 12. We used a closing type net (diameter: 1 m, length: 4.5 m, mesh size: 63 µm). This net can be closed at a designated depth by sending a messenger while towing upward, allowing us to collect samples at any depth intervals. Samples were preserved in seawater filtered through a screen with an opening of 63 µm with 4 % formalin solution buffered to pH 7.6 with sodium tetraborate. In order to stain protoplasm of plankton, we added Rose Bengal to the sample.   Sampling depth intervals were as follows: Station 1 and 6: 0-20 m, 20-40 m, 40-80 m, 80-120 m, 120-160 m, 160-200 m, 200-500 m and 500-1000 m; Station 3: 0-20 m, 20-40 m, 40-80 m, 80-120 m, 120-160 m, 160-200 m, 200-500 m, 500-1000 m and 50-100 m; Station 9 and 12: 0-20 m, 20-40 m, 40-80 m, 80-120 m, 120-160 m, 160-200 m and 200-500 m.

These samples will be studied in the shore-based laboratories.

3.19 Distribution of planktic foraminifera in the surface water in the Pacific Ocean.

Hanako DOMITSU (Kumamoto University) and Yuichiro TANAKA (Geological Survey of Japan)

Objective:

The purposes of this study are; (1) to reveal the distribution pattern of planktic foraminifera in the surface water in the Pacific Ocean, and (2) to investigate the intensity of upwelling or downwelling in the western Pacific Ocean by measuring the difference of oxygen isotope values of foraminiferal tests.
Method:

Plankton samples were collected from the 21th of November to the 25th of December 1999, during the R. V. MIRAI cruise MR99-K07. A continuous set of samples was obtained with a surface water pump of the R. V. MIRAI. The samples were filtered 1-2 m^3 of seawater through a screen with an opening of 75 µm in the morning and/or the evening, and were preserved in approximately 70 % Ethanol with a buffer of "pH BLOCK 8.2 (produced by GEX Co.)".

The planktic foraminiferal specimens will be identified, and then, their tests will be measured oxygen isotope in the laboratory.

3.20 Study on biophile trace elements in phytoplankton samples from the Equatorial Pacific

Kei OKAMURA(1), Masako IIDA(2) and Toshiyuki MASUZAWA(1)
(1) Research Center of Water and Biogeochemical Cycles,
Institute for Hydrospheric-Atmospheric Sciences, Nagoya University
(2) School of Engineering, Hokkaido Tokai University

Introduction

In addition to biophile major elements, such as, C, N, P, Si, etc., biophile trace elements are also included in the biogeochemical cycles of elements in marine environments and play an essential role in biological production as that of iron in HNLC areas. Primary production due to photosynthesis in the euphotic zone is the starting process of the biogeochemical cycles of elements but knowledge on them are quite limited The purpose of the present study is to sample phytoplankton fraction
materials and analyze chemical composition as one of the mother materials for settling particles and bottom sediments, and compare with their chemical compositions.

Sampling

Samples mainly composed of phytoplankton size were obtained vertically in the euphotic zone with a double structure NORPAC net at Stns. 1, 3, 6, 9 and 12. The NORPAC net is composed of a main net of 20 µm-opening attached with a pre-net of 335 µm-opening. Samples were treated with three methods by refrigerated centrifugation at 0ºC in a refrigerated room: only centrifugation,. washing several times with Milli-Q water and washing with 0.5M ammonium formate to remove sea salt for later chemical analysis in 50 ml PE centrifuge tubes. The centrifuged samples were stored in a deep freezer and carried back to the onshore laboratory for later vacuum-drying.

About 1500 ml of seawater samples collected with a CTD-RMS were filtered with a pre-weighed 0.4 µm nuclepore filter in a clean room on board to obtain suspended particles from 0 to 200 m depth. The filter was stored in a deep freezer and carried back to the onshore laboratory for later vacuum-drying.

Methods

Phytoplankton samples will be analyzed for about 20 major and trace elements by neutron activation analysis at Research Reactor Institute, Kyoto University. These phytoplankton samples will be subjected to stepwise chemical leaching to determine major components, that is, sea salts, calcium carbonate, organic matter, opaline silica and residual aluminosilicate, and also to measure minor and trace elements in each leachate by ICP-AES and/or MC-ICP-MS.

3.21 NANNOPLANKTON FLUX AND COMPOSITION

Shiro NISHIDA and Hideto TSUTSUI**
*Nara Univ. of Educ. & **Grad. Scholl of Nat. Sci., Kanazawa Univ.

We intend to clarify the nannoplankton flora especially concerned with coccolithophorids and silicoflagelletes in Pacific tropical sea area.

By the way nannoplankton is a comprehensive name which is given to minute plankton group ranging from about 1 to 74 micrometers in size. Almost nannoplankton taxa are phytoplankton and contribute as primary producers in pelagic ocean. Especially coccolithophorids are a large member of nannoplankton population and sometimes show blooming in ocean. The evaluation of its blooming is an important problem in world marine environments and ecosystems. Moreover coccolithophorid plays a role of calcium carbonate transporter from photic layer to deep sea and accumulate large amount of coccolith-ooze.

Our sampling works during the cruise are planned as following two ways.

1. Vertical profile of nannoplankton flux and composition in each station

    12 layers of water to the depth of 200 meters sampled by Niskin bottles, which arranged in rosette-multi-sampler system with CTD apparatus

    Station nos., filter sample nos., water depth and filtrated water volume are given in table 1.

2. Surface nannoplankton flux and composition along the cruise track

    Water sample is based on intake surface water for about 4-hour interval.

    Sample nos., sampling position, sample date and time, water temperature and filtrated water volume are given in table 2.

Water sample was filtrated with membrane filter, in this time we used Milipore filter type AAWP with 0.8um pore. Its effective diameter is 48 millimeters. After linseed with filtrated pure water, dried in room temperature and stored in plastic case.

On the shore laboratory a fix area of the filter sample will be cut out, treated with ordinary SEM preparation procedure and examined under a SEM. Under a SEM we can distinguish nannplankton species and count each numbers to obtain a flux data. Furthermore we can record nannoplankton figures through digital image processing apparatus.

3.22 Measurement of 15N/14N ratio of nitrate in sea water

Takeshi Nakatsuka and Yasuyuki Kitamori
Institute of Low Temperature Science, Hokkaido University, N19 W8, Kita-Ku, Sapporo 060-0819, Japan

Purpose

Nitrogen isotope ratios of nitrate vary in oceans, according to the nitrate uptake by phytoplankton and/or the denitrification/N2-fixation activities of marine micro-organisms. These isotopic informations can be further transferred into the nitrogen isotopic ratios of organic matter in sinking particles and sediments through photosynthetic nitrate uptake processes in surface water. Consequently, we can reconstruct the seasonal and interannual variations of nitrogen cycle in the upper ocean by measurements of nitrogen isotopic ratios of sinking particles and sediment cores. In these reconstruction procedures, the information of nitrogen isotopic ratios of nitrate are essentially important together with the nutrient variability in the concerned area of ocean.

Collection and Analysis

At each sampling station, one-liter water samples were collected from eight or nine subsurface water layers (Table 1). The water samples were quenched on board by adding of 5ml ultra-pure 20% HCl solution, and stored in refrigerators until the isotope measurement in the shore-based laboratory. In the laboratory, the nitrate in sample water is converted into the form of ammonium sulfate by a reduction-distillation method, and its isotopic ratio of nitrogen is measured by an isotopic ratio mass spectrometer.

3.23 A study of organic compounds in the marine aerosols collected from equatorial Pacific

Yasuyuki Kitamori and Kimitaka Kawamura
Institute of Low Temperature Science, Hokkaido University, N19 W8, Kita-ku, Sapporo 060-0819, Japan

Introduction
The equatorial Pacific is an interesting region from a viewpoint of marine organic aerosol study. Anthropogenic and natural terrestrial materials derived from Asian continental are long-range transported into the open ocean through the atmosphere. During early spring, the atmospheric transport is intensified in the Pacific Ocean. The transport of organic compounds over the marine environments as well as sea-to-air flux of volatile and particulate materials from the ocean change the atmospheric composition of marine aerosols. The terrestrial input to the remote marine environment may have influence on the primary productivity, and on the optical and microphysical properties of clouds in the equatorial Pacific, where vertical mixing and convection in the atmosphere is important. Because organic aerosols that contain water-soluble organic compounds alter hygroscopic properties of aerosol particles, they should play an important role in controlling cloud albedo by acting as cloud condensation nuclei (CCN). Previous studies on the marine organic aerosols have shown that water-soluble organic acids including low molecular weight dicarboxylic acids are abundant in the remote marine atmosphere. They comprise up to 18% of the total aerosol carbon in the equatorial Pacific. However, there is very few such a study in the remote marine atmosphere, especially on high molecular weight organic compounds including n-alkanes, fatty alcohols and fatty acids. These lipid compounds are very important because they provide useful information about their sources and source strength over the marine environment.
The behaviors of aerosol particles in the atmosphere largely depend on the size distribution as well as chemical composition. The purpose of this study is to clarify the particle size distribution of lipids in aerosols over the equatorial Pacific. This marine area is characterized by nutrient-poor water. Therefore it is expected that the aerosols derived from the Asian continent play an important role as the nutrient sources and have a considerable influence on the primary productivity and thus on the export flux to the deep ocean floor. So we will determine the spatial distribution of the concentration and compositions of organic aerosols at molecular. Furthermore, we will analyze the organic aerosols that have already been collected over the western North Pacific. The results will be compared in terms of their distributions in the marine atmosphere between the western North Pacific and the equatorial Pacific to better understand the long-range atmospheric transport of continental materials and its response to the marine biological productivity.

Samples and Analysis
Marine aerosol samples (Table 1) were collected on the compass deck of R/V Mirai during the cruise of MR99-K07 (November 19 to December 27, 1999) in the Pacific Ocean. The samples were collected using a high volume air sampler (Kimoto, Model-120F) on quartz fiber filters (Pallfex, 2500QAT-UP). Size-segregated aerosol samples (Table 1) were also collected using a MOUDI (micro-orifice uniform deposit impactor), with which size cut points of 18, 10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, 0.18, 0.1, 0.056 um are available (MSP, Model-110). The sampling was carried out using a wind sector / wind speed controller when the wind direction was within +/- 60 deg of the ship direction and the relative wind speed was > 5 m/s. All the filters were pre-combusted for 3 h at 450 degC prior to use in order to remove any absorbed organic materials. After the sample collection was completed (usually 24h or 7weeks), filter samples were stored in a pre-cleaned glass jar with a Teflon-lined screw cap at –20degC before the analysis.
Aliquots of the filter samples are extracted with organic solvents. The extracts are divided into neutral and acidic fractions. Neutrals are further fractionated into sub-fractions on a silica gel column. The acids fraction is treated with 14% BF3 in methanol to derive carboxylic acid methyl esters. Each fraction is determined with a capillary GC and GC/MS systems.

Expected results
The organic chemical analyses of the marine aerosols collected in this cruise (MR99-K07) will provide data base for the spatial distribution of lipid class compounds in the Pacific Ocean that will give an information of long-range atmospheric transport of continental materials over the remote ocean. Based on the particle size distribution of lipid compounds, we expect to obtain the information on what size of aerosols are more transported over the tropical Pacific from the continent. These results can be used to elucidate the results of biomarkers in sediment trap and surface sediment samples, which are also collected in this cruise for the study of carbon cycle in the Pacific Ocean.

3.24 Shipborne Mie scattering lidar observation of aerosols and clouds

(1)Personnel name and affiliation (* indicates on board personnel)
      Isao Tamamushi   (T.I.T.)*
      Ichiro Matsui   (NIES)
      Nobuo Sugimoto   (NIES)
      Kazuhiro Asai   (T.I.T.)

(2)Objectives
Shipborne Mie scattering lidar observation of aerosols and clouds have been started this year using R/V Mirai. The purposes of the observation are to obtain global distribution and optical characteristics of aerosols and clouds. These are used in the climatological study as well as in the study on the data reduction algorithms and data methods for space borne lidars.

(3)Parameters
      Aerosols: Density distribution, Backscatter coefficient,
                         Depolarization, Optical depth.
      Clouds: Height of cloud bottom, Backscatter coefficient,
                         Depolarization, Optical depth.

(4)Method
The lidar employs a compact flashlamp pumped second-harmonics Nd:YAG laser. Mie scattering at 1064 nm and 532 nm, and depolarization ratio at 532 nm were recorded. System parameters are as follows;
   Laser: Big Sky Laser CFR-200
      Output power: 532nm 50mJ/Pulse, 1064nm 100mJ/pulse
      Repetiton rate: 10Hz   Beam div.: 0.5mrad
   Receiver: Schmidt cassegrainian
      Diameter: 280mm   Field of view: 1mrad
   Detector: PMT(532nm) ,   APD(1064nm)
   Data collection: LeCroy LC574AL
      Measurement range: 0-30km   Range resolution: 6m
      Sampling rate: 10sec

(5)Results
Figure 1 shows a temporal variation of vertical profile. The range-corrected lidar signal at 532 nm is indicated with a gray scale. Maximum height of boundary layer is around 1km as seen in Fig.1. Diurnal variation of boundary layer is not significant. Low clouds are frequently observed at the top of the planetary boundary layer. Cirrus clouds are observed in an altitude range of 10 to 15 km.

MIRAI(MR99-K07) (UTC)
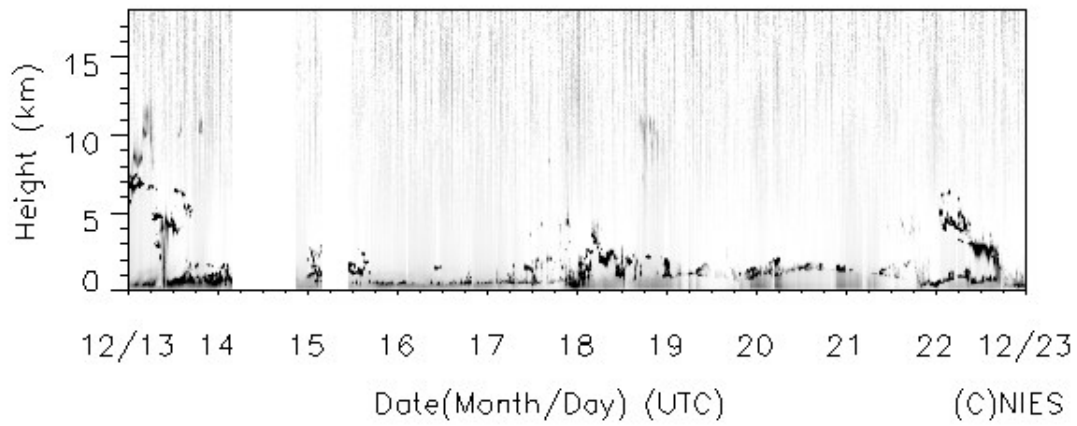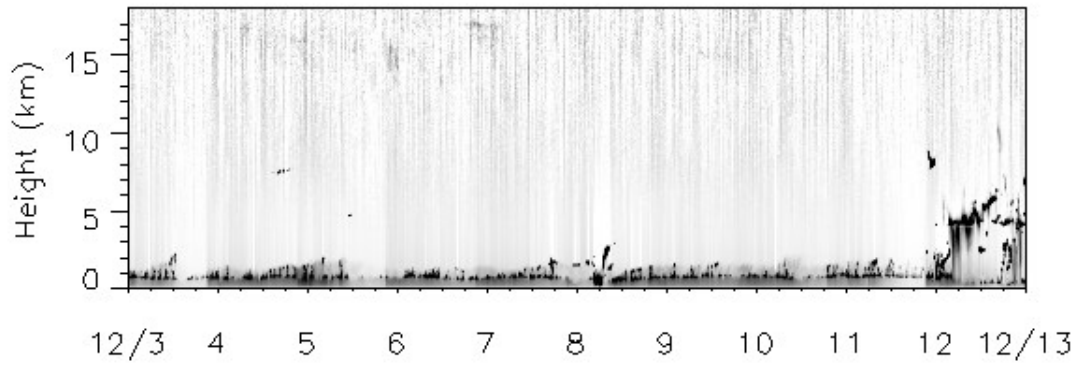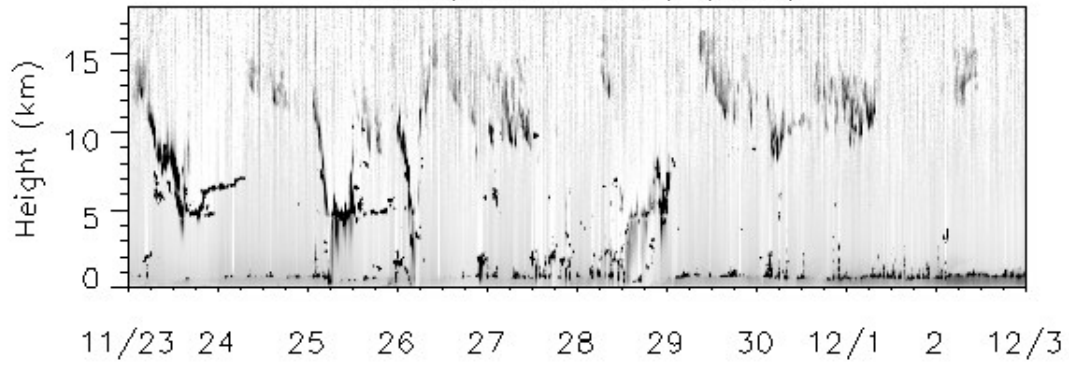
Date(Month/Day) (UTC)   (C)NIES

3.25 SEDIMENT TRAP EXPERIMENT

A. SHIMAMOTO[1], Y. Tanaka[2]

  1) Kansai environmental engineering center Co. Ltd.
    Envieonmental chemistry department ocean environmental survey team
  2) Geological Survey of Japan

OBJECT
    We are planning next items about how to use collected settling particles.
A) Total mass flux and main component
      To analyze total mass flux and main component (Opal, Carbonate, Organic carbon, Organic nitrogen).
B) Carbonate flux by calcareous nannoplankton.
      To analyze seasonal varieties of the coccolith species, and annual and vertical changes of the coccolith flux.
C) Planktonic foraminifera flux.
      To analyze planktonic foraminifera flux, and the dissolution process of settling foraminiferal shell in the water column.
D) Flux of silicoplankton (1.Diatom, 2.Radiolaria, 3.Silicofragellate, 4.Silicodinofragellate)
      To estimate vertical flux of the carbon and silica based on that analyzing each species flux of the time-series settling particles.
E) Radio-nuclide (U-238, Th-230, Pa-231, Pu-239+240, Pb-210, Po-210, etc.)
    To consider that settling particle flux, and horizontal and vertical transport process.

METHOD & RESULT
    We deployed five systems of the sediment trap mooring arrays for about one year.　The detailed data is followed (Table-1).　All of used the sediment traps and releasers are SMD26S-6000 and Model-L (Nichiyu-Giken Co. Ltd.).　The sampling layer of a mooring array is about 1 and 2 or 3 km depth.
    We made preservative compounded seawater filtered with GF/F filter for neutralized Formalin.　Neutralized Formalin was filtered with 0.6uM Nucleporefilter after neutralized Formaldehyde solution to about pH=7.4-7.6 by Sodium tetraborate.
    Each collecting interval is divided a month the first and latter half.　Most of sampling schedules is synchronized (Table-2).

Table-1 Deployed mooring array data

Station	1	3	6	9	12
Start time (LST)	1998/11/24 16: 08	1999/11/28 16:00	1999/12/02 15:25	1999/12/06 16:30	1999/12/09 12:00
Mooring start point	4-03.59N 135-01.06E	00-00.21S 144-58.98E	00-03.17N 159-55.66E	00-02.75N 174-54.14E	00-00.20S 170-12.00W
Deployed sinker time and point	15:09 4-02.63N 134-59.50E 4,749m	17:13 00-01.04S 145-01.08E 3,676m	16:49 00-03.20N 159-57.29E 2,808m	17:52 00-02.25N 174-55.45E 4,820m	13:25 00-00.82S 170-09.75W 5,634m
Expected mooring point	4-02.39N 135-00.00E	00-00.84S 145-00.78E	00-03.15N 159-57.00E	00-02.25N 174-55.45E	00-00.71S 170-10.12W
Collecting layer	890m 2,890m	970m 2,030m	930m 1,990m	960m 2,970m	1,140m 3,040m
Sampling start time (JST)	1998/11/25 01: 00	1999/12/01 01:00		1999/12/16 01:00	
Sampling stop time (JST)	2000/10/23 01: 00	2001/01/01 01:00		2001/01/16 01:00	
Interval	c.a. 15days (see next time table)				
Preservative	Seawater and formalin neutralized with sodium tetraborate				
Recovery	MR00-K??	MR01-K02			

Table-2 Sampling schedule (JST)

EVENT #	Station#01	Station#03	Station#06	Station#09	Station#12
1	1998/11/25 01: 00	1999/12/01 01:00		1999/12/16 01:00	
2	1999/12/01 01:00	1999/12/16 01:00		2000/01/01 01:00	
3	1999/12/16 01:00	2000/01/01 01:00		2000/01/16 01:00	
4	2000/01/01 01:00	2000/01/16 01:00		2000/02/01 01:00	
5	2000/01/16 01:00	2000/02/01 01:00		2000/02/16 01:00	
6	2000/02/01 01:00	2000/02/16 01:00		2000/03/01 01:00	
7	2000/02/16 01:00	2000/03/01 01:00		2000/03/16 01:00	
8	2000/03/01 01:00	2000/03/16 01:00		2000/04/01 01:00	
9	2000/03/16 01:00	2000/04/01 01:00		2000/04/16 01:00	
10	2000/04/01 01:00	2000/04/16 01:00		2000/05/01 01:00	
11	2000/04/16 01:00	2000/05/01 01:00		2000/05/16 01:00	
12	2000/05/01 01:00	2000/05/16 01:00		2000/06/01 01:00	
13	2000/05/16 01:00	2000/06/01 01:00		2000/06/16 01:00	
14	2000/06/01 01:00	2000/06/16 01:00		2000/07/01 01:00	
15	2000/06/16 01:00	2000/07/01 01:00		2000/07/16 01:00	
16	2000/07/01 01:00	2000/07/16 01:00		2000/08/01 01:00	
17	2000/07/16 01:00	2000/08/01 01:00		2000/08/16 01:00	
18	2000/08/01 01:00	2000/08/16 01:00		2000/09/01 01:00	
19	2000/08/16 01:00	2000/09/01 01:00		2000/09/16 01:00	
20	2000/09/01 01:00	2000/09/16 01:00		2000/10/01 01:00	
21	2000/09/16 01:00	2000/10/01 01:00		2000/10/16 01:00	
22	2000/10/01 01:00	2000/10/16 01:00		2000/11/01 01:00	
23	2000/10/16 01:00	2000/11/01 01:00		2000/11/16 01:00	
24	2000/10/23 01:00	2000/11/16 01:00		2000/12/01 01:00	
25	-	2000/12/01 01:00		2000/12/16 01:00	
26	-	2000/12/16 01:00		2001/01/01 01:00	
27	-	2001/01/01 01:00		2001/01/16 01:00	
Bottle Name	C99M01S C99M01D	C99M03S C99M03D	C99M06S C99M06D	C99M09S C99M09D	C99M12S C99M12D

SEDIMENT TRAP MOORING RECOVERY

We tried the recovery of six sediment trap mooring arrays. All of these were deployed in January 1999 (MR98-K02).

At Station#12 the whole system were not able to recovery by non-response of the releaser though the others were to do.

At Station#01 the ATDS (Automatic temperature depth system: this equipment regularly makes a rope with a built-in itself longer, and does a little buoy risen to the surface. The temperature and depth sensors are measuring data during under the seawater.) which had arranged just under the euphotic zone was disappeared from the system.   At the top of the rope, a lot of longline (one kind of fishing longline) were gotten tangled instead of the ATDS.   And the top of the rope was cut by something cutting like a sharp edged tool.   It seems that a fishing boat made fishing longlines gotten caught in this system.

At Station#06 the both sediment traps had trouble.   The turning tables set sampling bottles did not run though both of them were able to register sensor data.   There are no samples for this reason.

At Station#06 the sample of bottle number "C98M09D06" was only lost from the turning table of the sediment trap.

We named sampling bottles as follows.

[Example]   "C98M01S01"

                C = Mission Name (Carbon Mapping)

                98 = deployed year

                M = Cruise Name (MIRAI)

                01 = Station Number

                S = Sampling Layer (Shallow or Deep)

                01 = Collecting Number

The working record on deck is followed as next table (Table-3).

The event schedule of collected samples is followed as next table (Table-4).

Table-3 Recovered mooring array data

Station	1	2	3	6	9	12
Released time (LST) and point	1999/11/231 2:06 No data	1999/11/26 6:33 5-03.37N 140-06.43E	1999/11/28 6:15 00-01.50S 145-10.22E	1999/12/2 6:26 00-03.13N 159-56.56E	1999/12/6 8:02 00-02.17N 174-55.10E	1999/12/9 13:47- No data
Recovery start time and point	13:25 No data	7:08 5-03.81N 140-06.41E	6:46 00-00.62S 145-01.03E	7:06 00-03.00N 159-56.91E	9:06 00-02.68N 174-56.32E	-
Recovery end time and point	15: 11 No data	8:45 5-02.90N 140-07.20E	6:46 00-00.21S 145-00.75E	8:22 00-03.19N 159-55.59E	10:21 00-02.34N 174-57.30E	-
Station	1	2	3	6	9	12
Collecting layer	970m 2,940m	1,000m 2,970m	1,020m 2,060m	970m 2,010m	1,040m 3,000m	1,020m 3,090m
Event start time (JST)	1999/1/1 1:00	1999/1/3 1:00	1999/1/5 1:00	1999/1/9 1:00	1999/1/13 1:00	1999/1/17 1:00
Event stop time (JST)	1999/11/21 1:00				1999/12/1 1:00	
Interval	c.a. 15 days (see next time table)					
Preservative	Seawater and formalin neutralized with sodium tetraborate					
Remarks	ATDS lost	-	-	No Sample	Sample# C98M09D06 lost	Whole array lost

Table-4 Sampling schedule (JST)

Event #	Station. 1	Station. 2	Station. 3	Station. 6	Station. 9	Station. 12
1	1999/1/1 1:00	1999/1/3 1:00	1999/1/5 1:00	1999/1/9 1:00	1999/1/13 1:00	No sample
2	1999/1/16 1:00					1999/1/17 1:00
3	1999/2/1 1:00					
4	1999/2/16 1:00					
5	1999/3/1 1:00					
6	1999/3/16 1:00					
7	1999/4/1 1:00					
8	1999/4/16 1:00					
9	1999/5/1 1:00					
10	1999/5/16 1:00					
11	1999/6/1 1:00					
12	1999/6/16 1:00					
13	1999/7/1 1:00					
14	1999/7/16 1:00					
15	1999/8/1 1:00					
16	1999/8/16 1:00					
17	1999/9/1 1:00					
18	1999/9/16 1:00					
19	1999/10/1 1:00					
20	1999/10/16 1:00					
21	1999/11/1 1:00					
22	1999/11/16 1:00					
23	1999/11/21 1:00				1999/12/1 1:00	

3.26 Multiple Corer

3.26.1 Sediment samples obtained in the western Equatorial Pacific ocean

Yuichiro Tanaka

Marine Geology Department, Geological Survey of Japan

The investigation of the surface sediments offers important information on the material flux about the process of the transportation of the floor in the sea and sedimentary environments. Sediment samples were collected with a multiple corer (attached eight cores). Eight core samples were distributed to eight laboratories.

Table 1 shows the sampling location.

Lithology

site 1. Dark brown silty clay. Upper part is composed of oxidized dark brown silty clay (upper 16 cm), and lower part is the bioturbated dull yellowish brown silt. (core length: 38 cm).

site 2. Brown to light yellow silt with foraminiferal patch. Upper part is composed of oxidized brown clay (upper 10 cm), middle part is bioturbated silt, and lower part is composed of light yellow calcareous silt. (core length: 37 cm) .

site 3. Dull yellow orange calcareous silt with oxidized dull yellowish brown silt in the top. (core length: 32 cm).

site 6. Dull yellow to light gray calcareous ooze. Bioturbated layer intercalates from 20 cm to 27 cm. (core length: 29cm).

site 9. Dull yellowish brown clay (upper 6 cm); dull yellow orange calcareous silt (lower 26 cm). (core length: 32 cm).

site 12. Dark brown to dull yellowish brown clay with foraminifera in the top. (core length: 41 cm)

Table 1. MR99-K07 Multiple Core Site

Site	Type	Date	Start		Hit the bottom				Leave the	Recovery	
			Time	Depth(m)	Time	Point	Depth(m)	Wire Length(m)	bottom	Time	Depth(m)
St.1	MC-1	11/24/99	6:32	4718	8:02	04-02.9767N 135-00.4900E	4703	4701	8:05	9:20	4722
St.2	MC-2	11/26/99	13:00	4168	14:20	05-01.6662N 140-08.7195E	4168	4186	14:22	15:50	4166
St.3	MC-3	11/28/99	13:20	3696	14:40	00-00.2509N 144-59.6391E	3699	3695	14:43	16:00	3710
St.6	MC-4	12/2/99	13:15	2824	14:14	00-03.2063N 159-55.3350E	2803	2802	14:17	15:02	2803
St.9	MC-5	12/6/99	4:30	4775	6:02	00-00.9645N 174-49.7791E	4773	4764	6:05	7:13	4773
St.12	MC-6	12/10/99	6:10	5526	8:00	00-00.4504N 170-09.1376E	5632	5640	8:03	9:30	5555

3.26.2 Planktic foraminifera in the multiple-cored sediments in the equatorial Pacific Ocean.

Hanako DOMITSU (Kumamoto University)

Objective:

Multiple-cored sediments were obtained at the site of St.1, St.2, St.3, St.6, St.9 and St.12 in the Equatorial Pacific. The purposes of this study are; (1) to clarify vertical changes of planktic foraminiferal assemblages and oxygen isotope ratios of foraminiferal tests in the cored sediments, (2) to compare the changes among the cored sediments, and (3) to construct palaeoclimatic and palaeoenvironmental changes of the equatorial part of the Pacific Ocean during the last 100,000 years.

Method (sample preparation procedures):

Cored sediment was cut first vertically into two halves by a stainless-steel spatula or a nylon fishing line. One of these half samples was processed for sedimentological investigation, and the other was for micropalaeontological investigation. The cutting surface of each half sample was shaved first by a stainless-steel spatula for detailed visual observations. After visual observations and core descriptions were made, quantitative sampling for sedimentological analysis was conducted on one of the half samples with a plastic cubic sampler, 1.9 cm in length and approximately 6.86 cm^3 in volume. The other half sample was sliced into 1 cm thick segment and then collected quantitatively with the plastic cubic sampler for analysis of planktic foraminifera, and the rest was archived with a vinyl pack.

Another cored sediment (for analysis of coccolis) was also cut vertically into two halves, an 8-mm thick and 20-cm long sliced sediment was cased in a plastic box from the cutting surface for soft X-ray radiograph observation through the sample. After this observation, the boxed samples can be sliced into segment samples thinner than 1 cm for further high resolution analysis of planktic foraminifera.

All samples had been kept at 4-5 ^{o}C after sampling.

Planktic foraminiferal specimens will be identified under a binocular microscope in the laboratory. Then, the tests of specimens will be measured oxygen isotope.

3.26.3 Measurement of nitrogen isotopic ratios and biomarker compositions in sediment cores

Takeshi Nakatsuka and Yasuyuki Kitamori

Institute of Low Temperature Science, Hokkaido University, N19 W8, Kita-Ku, Sapporo 060-0819, Japan

Purpose

Nitrogen isotopic ratios of sediment cores record the past change of nitrogen cycles in the surface ocean, and on the other hand, marine and terrestrial biomarker compositions in sediment can reflect the past change of biological productivities of ocean and atmosphere circulation intensities. Measurement of nitrogen isotopic ratios and biomarker compositions in sediment cores will be carried out for the reconstruction of these variations.

Collection and Analysis

At each sampling station (St.1, 3, 6, 9, 12), one of the multiple core was sub-divided into 1 cm intervals, and stored in pre-cleaned glass vials in freezers until the chemical analyses in the shore-based laboratory. The sediment samples are firstly analyzed for total nitrogen and their isotopic ratios by element analyzer-continuous flow-isotopic ratio mass spectrometer system, and then measured for biomarker compositions using GC, GC-MS, GC-C-IRMS systems.

3.26.4 Environmental changes assessed from diatoms and radiolarians in the Equatorial Pacific sediments

Yusuke Okazaki (Kyushu University)

Siliceous microplankton such as diatoms and radiolarians preserved in the sediments contains a significant amount of information about environmental and climatic change. Their taxonomic and quantitative changes are useful for understanding paleoenvironments. The Equatorial Pacific area can be characterized climatic events such as ENSO. The main purpose of this study is to examine paleoenvironmental changes using fossil diatoms and radiolarians in sediment cores.

A multiple corer was used to collect sediment cores at Station 1, 2, 3, 6, 9 and 12. Samples of 5 mm intervals were taken from the core-top to 2 cm depth and 1 cm intervals from 2 cm depth to the core-bottom, followed by packaging and refrigeration.

Detail shore based analysis wil be conducted at the Kyushu University.

3.26.5 Porewater geochemistry of deep-sea sediments from the Equatorial Pacific

Kei OKAMURA(1), Masako IIDA(2) and Toshiyuki MASUZAWA(1)

(1) Research Center of Water and Biogeochemical Cycles,

Institute for Hydrospheric-Atmospheric Sciences, Nagoya University

(2) School of Engineering, Hokkaido Tokai University

Introduction

Early diagenesis is the final stage of mineralization of biologically produced materials in the oceanic euphotic zone, that is, organic matter, calcium carbonate, opaline silica and others. In order to clarify the processes and to evaluate quantitatively the dynamic behaviors of carbon through the water column, the evaluation of vertical fluxes of these biological-production relating chemical species through sediment-water

interface is essential. There have been several reports on porewater geochemistry in the Equatorial Pacific but little on those including major diagenetic processes. We intend to evaluate these vertical fluxes through porewaters by obtaining porewater samples at several depths in multiple-core samples and analyze these chemical species to obtain the vertical profiles in porewaters of there chemical species. Based on these results we will evaluate early diagenetic processes including vertical fluxes of inorganic and organic carbon and compare them with primary productivity and also settling fluxes from sediment trap studies.

Sampling

Porewater samples were obtained from multiple-corer sediment samples at Stns. 1, 2, 3, 6, 9 and 12. Porewaters were squeezed by core barrel squeezing (Jahnke, 1988) from subcores sampled in specially designed multiple-core barrels by being filtered with 0.22 um Millex GV filters at 14 ports between 0 and 40 cm depth at maximum in a refrigerated room at 4-6ºC. Overlying bottom waters were also sampled. Obtained porewater samples were treated chemically and stored for appropriate analytical purposes of each chemical species.

Methods

Ammonia, phosphate, and silicate in porewaters as well as overlying bottom waters were analyzed by spectrophotometry and nitrate + nitrite by FIA on board ship after squeezing. Major anions and cations, alkalinity, DIC, DOC and Mn will be analyzed by ion chromatography, by acid titration, by NDIR, by HTC/DI and by FLAA, respectively, at the onshore laboratory.

Another subcore at each station was used to measure vertical change in formation resistivity factor with a four-electrode resistivity probe to evaluate vertical change in diffusivity of

each sediment core. After measurement, each core sample was sliced and stored in a refrigerator for the later measurement of sediment porosity based on sediment water content.

3.27 Bio-optical measurement

1.0   Scope.

This document summarizes scientific investigations carried out by JAMSTEC and Dalhousie University onboard the R/V Mirai in the equatorial Pacific during November and December of 1999. It represents work supported by JAMSTEC, Dalhousie University and the Office of Naval Research, HyCODE project.

2.0   Objectives.

The objectives of Dalhousie University during this cruise were several and included:

a.   Evaluate the net vertical transport of energy associated with penetrating irradiance, for comparison with the net surface heat flux along an equatorial transect.

b. Carry out a collaborative effort with JAMSTEC in the development and validation of bio – optical algorithms for use with the currently operating SeaWiFS satellite.

c. Test Satlantic optical equipment for prolonged stability in the field using the new SQMII (SeaWiFS Quality Monitor).

3.0   Participants:

Takeshi Kawano / Chief Scientist, JAMSTEC
Masayuki Fujisaki / Technician, Marine Works Japan Ltd.
Geoff MacIntyre M.Sc. / Research Associate, Dalhousie University
Cyril Dempsey / C.E.T., Satlantic Inc.

4.0   Cruise Summary.

The R/V Mirai departed Guam on November 21st 1999 for a transect along the equator from 143E to 170W, and finished in Honolulu Harbor   on Dec. 13th 1999.
A large number of optical, biological, physical and chemical measurements were taken, which can be found summarized in the overall MR99K07 cruise report.

5.0 Summary Description of Instruments Deployed

SPMR/SMSR

The primary instrument system deployed was the JAMSTEC SeaWiFS Profiling Multichannel Radiometer (SPMR) and SeaWiFS Multichannel Surface Reference (SMSR). The SPMR is deployed in a freefall mode through the water column while measuring the following physical and optical parameters.

The profiler carries both a 13 channel Irradiance sensor (Ed) and a 13 channel radiance sensor (Lu), as well as instrument tilt, fluorometry, conductivity and an external temperature probe. The SMSR or reference sensor has a 13 channel irradiance sensor (Es), tilt meter and a internal temperature sensor. This instrument suite is used for the derivation of the penetration of visible and ultra – violet light in the ocean, and for determination of the vertical distribution of apparent optical properties for comparison with in – situ pigment measurements. It is used to provide normalized water leaving radiance for SeaWiFS calibration and validation and the empirical development of radiative transfer algorithms for the further exploration of ocean color satellite data. To further aid in the collection and analysis of accurate SeaWiFS cal/val measurements, two digital pictures where taken at each station. The first picture documented the sea state and the second documented the sky state.

The profiler was deployed at least twice per station as close as possible to the SeaWiFS satellite overpass to a depth of 200 m. Care was taken to try to obtain a full cast without clouds fully or partially occluding the sun. The reference was mounted on the compass deck and was never shadowed from any ship structures. The profiler fell at an average rate of 1 m/s second with tilts of less than 2 degrees.

**Figure # 1 Profiler configuration**

Figure # 2 Profiler deployment
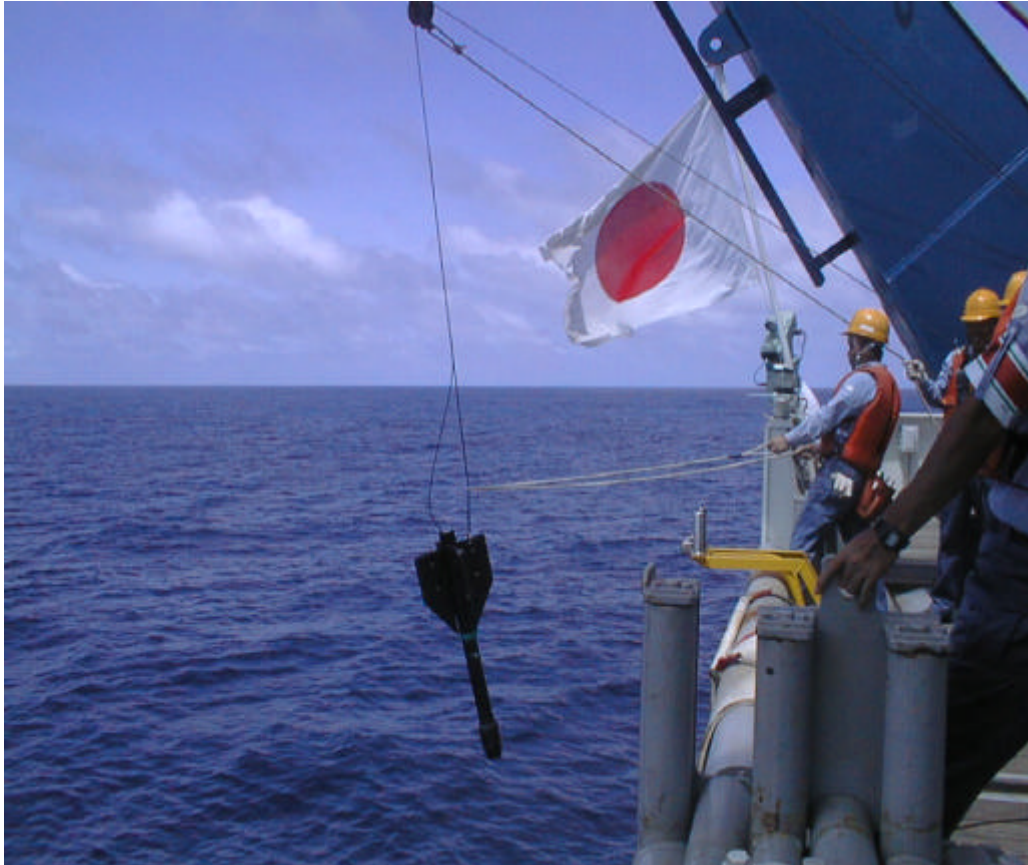
HyperSpectral TSRB

The second instrument deployed was the Dalhousie University Hyperstectral TSRB. This instrument has 80 downwelling irradiance channels and 80 upwelling radiance channels from 380 nm to 800 nm. This buoy type instrument floats at the surface with its irradiance sensor just above the sea surface and its radiance sensor at 65 cm's below the surface. This instrument also collects dark data every 5 seconds by using small shutters to block the incoming light. This allows the investigator to obtain real time dark correction. The hyper TSRB was deployed immediately after the last profiler cast at every station.

Figure # 3 Hyperspectral deployment
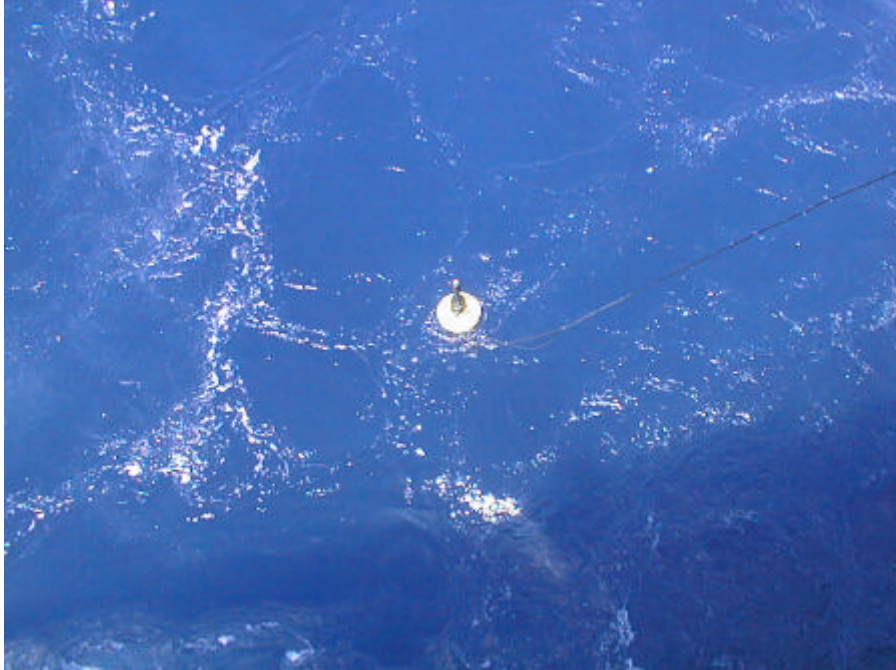
Figure # 4 Hyperspectral and profiler

MET 1000

The third instrument deployed was the Met 1000 meteorological station. This instrument package measures a wide range of physical and optical properties. In its present form, this instrument can measure physical properties such as gps location, relative ship speed and direction, temperature and relative humidity, wind speed and wind   direction and barometric pressure. It also measures solar radiation, sea surface skin temperature, downwelling irradiance (Es) and upwelling above surface radiance (Lt).The last set of optical properties were measured with two 7 channel Satlantic MVD instruments. These two instruments running in unison are also known as the SAS (SeaWiFS aircraft Simulator).

Figure # 5 SAS radiance Lt sensor

Figure # 6 Weather station

Figure # 7 Solar radiation sensor

The MET – 1000 was set up and started collecting data immediately upon departure from Guam. This instrument package ran 24 hours a day and the data was collected using Satview data logging software. These data files can become very large so it was decided after the first three days to collect one night file and then to collect data files at two hour intervals during the day. This will make data processing much easier.

MicroTops II Sunphotometer

The fourth instrument deployed on MR99K07 was the MicroTops II Sunphotometer. This instrument has the capability of measuring the direct solar radiation at 300, 305.5, 312.5, 940 and 1020nm. This data can then be used to determine optical thickness. A Garmen GPS was used in unison with the MicroTopsII and downloaded NMEA sentences to the sunphotometer in real time. The collected gps position and time is then used to determine the solar zenith angle. Measurements were taken by Masayuki Fujisaki at the same time as profiler observations (casts) were being performed. It is very important only to collect sunphotometer data while the sun is in direct view, ie. clouds and high cirrus do not obstruct the solar disc. Stations # 1,2,5 and 11 did not meet these criteria so no measurements were performed. The files were downloaded into a data.dbf file . The readings for that day were cut from this file and copied to an excel spreadsheet and named with a cruise i.d. and station #. Example mr99k07stn06.xls. Comments about sky conditions etc. are contained within these files.

SQMII   (SeaWiFS Quality Monitor)

The last instrument   used during this experiment was the Dalhousie University SQMII (SeaWiFS Quality Monitor). The SQMII is a device used to monitor optical instrument stability over time. This instrument emits a very stable diffuse light source. The optical instruments are inserted into the light chamber of the SQM and data is collected for that optical head for three minutes. Each instrument was monitored every second day for the duration of the cruise. This instrument also has its own internal detector to monitor its light source as the device under test is collecting data. In this way, the investigator has empirical evidence that all optical instruments collecting data remained stable for the duration of the cruise. If changes are indeed noticed because of inadvertent damage during deployment or for any other reason, a new calibration file can be produced, using another instrument as a reference, to correct for any deviation.

Figure # 8 SQM II   Front view

Figure # 9 SQM II rear view
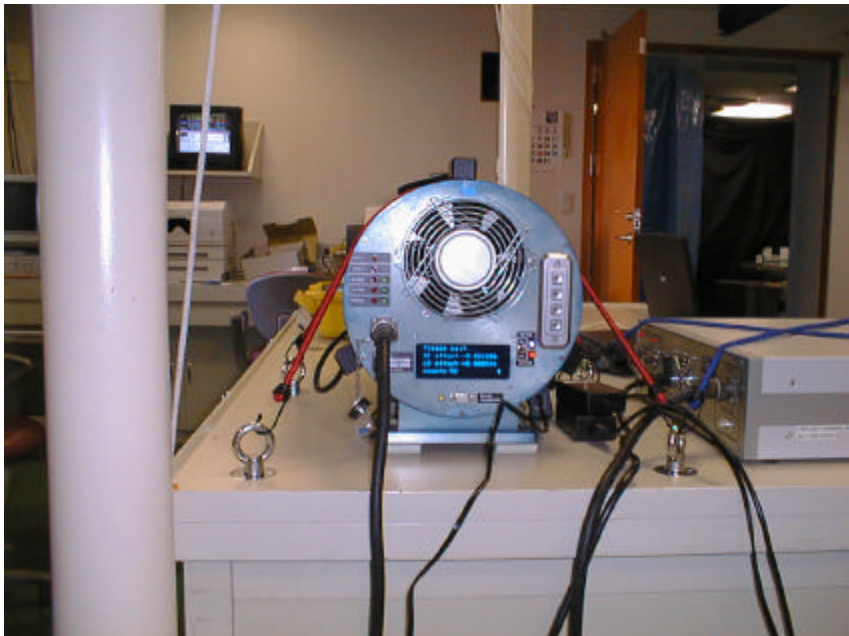
6.0 Cruise Station Summary

Location	Date	Position
Guam	*Nov 21 1999*	**13°00N 145°00E**
Stn01	**Nov 24 1999**	**04°02N 135°00E**
Stn02	**Nov 26 1999**	**05°00N 140°00E**
Stn03	**Nov 28 1999**	**0°00N 145°00E**
Stn04	**Nov 30 1999**	**0°00N 152°00E**
Stn05	**Dec 01 1999**	**0°00N 157°00E**
Stn06	**Dec 02 1999**	**0°00N 159°00E**
Stn07	**Dec 04 1999**	**0°00N 166°00E**
Stn08	**Dec 05 1999**	**0°00N 171°00E**
Stn09	**Dec 06 1999**	**0°00N 174°00E**
Stn10	**Dec 07a 1999**	**0°00N 178°00E**
Stn11	**Dec 07b 1999**	**0°00N 176°00W**
Stn12	**Dec 09 1999**	**00°00N 170°00W**

7.0 Instrument Calibration Summary

SPMR 036 b.cal

#SATPRO0036

SPMR 036 / CT & C / Project 99115

Calfile valid 18 March 1999

completed by Jennifer

INSTRUMENT SATPRO " 6 AS 0 NONE

SN 0036 " 4 AI 0 COUNT

RATE 6 'Hz' 0 BU 0 NONE

#LU sensor OCR-1000 S/N 048 calibrated for LO GAIN in IN SEAWATER

by JENN on 03/16/99 at 17:34:53

LO GAIN calibration LAMP: F539 TARGET: T05816A at DIST: 130.0cm

#LU sensor OCR-1000 S/N 048 calibrated for HI GAIN in IN SEAWATER

by JENN on 03/16/99 at 17:49:15

HI GAIN calibration LAMP: F539 TARGET: T05816A at DIST: 240.0cm

LU 380.3 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1

  8389419.3 1.3947e-007   1.77

  8389263.7 1.3606e-007   1.77

LU 399.8 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8389285.7 1.2945e-006   1.76
  8389151.8 1.2969e-007   1.76
LU 412.4 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8389158.4 1.3001e-006   1.76
  8391719.3 1.3497e-007   1.76
LU 442.8 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8389598.2 1.3029e-006   1.75
  8389375.2 1.3392e-007   1.75
LU 455.8 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8388892.1 1.2934e-006   1.75
  8388604.1 1.3467e-007   1.75

SPMR 036 b.cal cont.

LU 489.6 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8388994.2 1.3169e-006   1.75
  8388840.3 1.3661e-007   1.75
LU 519.3 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8389773.1 1.2675e-006   1.74
  8389644.3 1.3365e-007   1.74
LU 554.5 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8389469.9 1.2916e-006   1.74
  8389293.5 1.3408e-007   1.74
LU 564.6 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8389344.2 1.2707e-006   1.74
  8389018.3 1.3498e-007   1.74
LU 619.2 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8388585.0 1.2906e-006   1.73
  8388455.4 1.3185e-007   1.73
LU 665.6 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8388868.8 6.7810e-007   1.73
  8388623.5 3.3735e-008   1.73
LU 682.6 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8388262.1 6.9290e-007   1.73
  8388075.4 3.4491e-008   1.73

LU 704.5 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1

  8388379.6 6.4750e-007   1.73

8388143.7 3.3546e-008   1.73

LU DARK 'COUNTS' 3 BU 0 COUNT

#ED sensor OCI-1000 S/N 070 calibrated for LO GAIN in IN SEAWATER

by JENN on 03/17/99 at 16:51:52

LO GAIN calibration LAMP: F539 at DIST: 50.0cm

#ED sensor OCI-1000 S/N 070 calibrated for HI GAIN in IN SEAWATER

by JENN on 03/17/99 at 16:55:02

HI GAIN calibration LAMP: F539 at DIST: 120.0cm

ED 380.0 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8390461.9 1.6937e-005   1.42

  8390345.5 1.6665e-005   1.42

ED 399.7 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8388537.0 2.4567e-005   1.38

  8386183.6 8.6943e-007   1.38

ED 412.4 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8388970.7 2.2778e-005   1.52

  8387609.1 8.0565e-007   1.52

ED 442.9 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8389148.1 2.3616e-005   1.44

  8387858.2 8.1335e-007   1.44

ED 455.2 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8389908.2 2.4728e-005   1.45

  8388801.7 8.5912e-007   1.45

ED 489.4 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8389140.3 2.6170e-005   1.43

  8388075.4 9.0873e-007   1.43

ED 519.8 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8388959.8 2.4380e-005   1.42

  8387726.7 8.2643e-007   1.42

ED 554.9 'uW/cm^2/nm' 3 BU 2 OPTIC1

  8389335.0 2.4574e-005   1.39

  8388303.4 8.4383e-007   1.39

ED 565.1 'uW/cm^2/nm' 3 BU 2 OPTIC1

8390042.9 2.4122e-005   1.39

8389405.4 8.3462e-007   1.39

ED 619.3 'uW/cm^2/nm' 3 BU 2 OPTIC1

8388914.1 1.6123e-005   1.40

8387933.5 4.3536e-007   1.40

SPMR 036 b.cal cont.

ED 665.5 'uW/cm^2/nm' 3 BU 2 OPTIC1

8388608.7 1.7071e-005   1.40

8388064.3 4.2561e-007   1.40

ED 682.8 'uW/cm^2/nm' 3 BU 2 OPTIC1

8388566.4 1.7469e-005   1.38

8387625.1 4.2828e-007   1.38

ED 705.2 'uW/cm^2/nm' 3 BU 2 OPTIC1

8389786.4 1.6964e-005   1.36

8388580.5 4.3567e-007   1.36

ED DARK 'COUNTS' 3 BU 0 COUNT

Ancillary sensors

Processed by Darrell Adams

X-Y Tilts calibrated by Jim Foesenek on 15 March 1999

#

Tiltx Coeff

TILT X 'deg' 2 BU 1 POLYU

-8.3778200e+1   2.5258311e-3   2.9280142e-10

Tilty Coeff

TILT Y 'deg' 2 BU 1 POLYU

-8.3508032e+1   2.5364063e-3   1.5919118e-10

SATCAL THERMAL (SATPRO0036)

Bath run: SATCAL AT=16:55:46 1999-03-12, Darrell Adams

Analysis: SATANL AT=16:46:38 1999-03-15, Darrell Adams

T i 'C' 2 BU 1 POLYU

1.225042393e+4   -1.385780538   6.617435216e-5   -1.693830443e-9   2.441907125e-14

-1.876082248e-19 5.987521023e-25

T r 'C' 2 BU 1 POLYU

8.919577623e+3   -9.591290795e-1   4.344713360e-5   -1.049405611e-9   1.416129669e-14
-1.007021226e-19 2.925997564e-25

T w 'C' 2 BU 1 POLYU

-1.095124900e+1   1.331734229e-3   -1.757574369e-8   3.316125255e-13   -2.738835801e-18
1.860366496e-24 1.419814397e-28

Viatran 500 psi transducer 2224AU2AAE10 s/n 287114
Calibrated 2/1/1999

Pres none 'm' 2 BU 1 POLYF
0.0104453   33168

COND036A.cal
Ocean Sensors CT probe s/n 344 calibrated 1 March 1999
by Darrell Adams using POLYU fit order 6

COND NONE 'mmho/cm' 2 BU 1 POLYU
1.2877180238e+001   -1.2251451929e-003   1.7502078011e-007   -7.0118399936e-012
1.4938418229e-016 -1.6123497254e-021 6.9462925767e-027
#Fluorometer
WetStar S/N WS3S-504
Calibrated 04 February 1999
Chlorophyll in Thalassiosira weissflogii phytoplankton culture of
50 ug/l = 3.012volts, Pure water = 0.072volts
FLUOR none 'ug/l' 2 BU 1 POLYF
17.007e-333240
FRAME none '' 1 BU 0 COUNT
CRLF TERMINATOR '' 2 AS 0 NONE

SMSR 036A.CAL

Project 99115, CT&C
SMSR 036 with OCI1000 069

Calibration file valid March 3, 1999
completed by Jennifer
INSTRUMENT SATREF " 6 AS 0 NONE
SN 0036 " 4 AI 0 COUNT
RATE 6 'Hz' 0 BU 0 NONE

SPARE NONE " 42 BU 0 NONE

#ES sensor OCI-1000 S/N 069 calibrated for LO GAIN in IN AIR
by JENN on MON MAR 1, 1999 at 11:09:27
LO GAIN calibration LAMP: F539 at DIST: 50.0cm
#ES sensor OCI-1000 S/N 069 calibrated for HI GAIN in IN AIR
by JENN on MON MAR 1, 1999 at 11:13:37
HI GAIN calibration LAMP: F539 at DIST: 50.0cm
ES 377.0 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388780.0 2.4438e-005   1.00
   8388713.4 2.4505e-005   1.00
ES 399.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8389434.7 3.5714e-005   1.00
   8389244.6 2.3473e-006   1.00
ES 412.2 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388650.4 3.3102e-005   1.00
   8388076.4 2.4297e-006   1.00
ES 442.8 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8389713.9 3.5565e-005   1.00
   8389305.6 2.3745e-006   1.00
ES 456.1 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388709.7 3.4039e-005   1.00
   8388537.6 2.4000e-006   1.00
ES 490.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388381.3 3.5259e-005   1.00
   8388276.6 2.4365e-006   1.00
ES 519.0 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388633.7 3.4546e-005   1.00
   8388475.9 2.4451e-006   1.00
ES 554.3 'uW/cm^2/nm' 3 BU 2 OPTIC1

```
   8388585.0 3.3913e-005    1.00
   8388408.1 2.3997e-006    1.00
ES 564.5 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8387896.5 3.5143e-005    1.00
   8387843.6 2.5712e-006    1.00
ES 619.5 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8389043.7 3.5660e-005    1.00
   8388938.8 2.2347e-006    1.00
ES 665.6 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388309.0 3.6363e-005    1.00
   8388259.3 2.4292e-006    1.00
ES 683.0 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388239.7 3.7472e-005    1.00
   8388193.1 2.4443e-006    1.00
ES 705.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
   8388437.4 3.8101e-005    1.00
   8388408.1 2.4332e-006    1.00
ES DARK 'COUNTS' 3 BU 0 COUNT
```

SMSR 036A.CAL cont.

Ancillary sensors processed by Darrell Adams

Tilts calibrated by Jim Foesenek on March 3, 1999

```
TILT X 'deg' 2 BU 1 POLYU
   -8.1760632e+1      2.4826614e-3      3.5361855e-10
```

```
TILT Y 'deg' 2 BU 1 POLYU
   -8.1335704e+1      2.5000490e-3      -7.7113429e-11
```

SATCAL THERMAL (SATREF0036)
Bath run: SATCAL AT=14:49:49 1999-02-28, Darrell Adams
Analysis: SATANL AT=08:43:07 1999-03-03, Darrell Adams

T i 'C' 2 BU 1 POLYU

7.638041784e+3   -8.144797865e-1   3.677511267e-5   -8.891323361e-10   1.206102189e-14
-8.662945030e-20 2.557327995e-25

SAS4445D.CAL

Project 98122 CT&C (SAS2 S/N 007)
calfile valid 16 August, 1999
completed by Jennifer
INSTRUMENT SATSAS " 6 AS 0 NONE
RATE 10 'Hz' 0 BU 0 NONE

INSTRUMENT MVD " 3 AS 0 NONE
SN 0044 " 4 AI 0 NONE

#ES sensor OCI-200 S/N 117 calibrated for LO GAIN in IN AIR
by jenn on 08/16/99 at 14:36:47
LO GAIN calibration, LAMP: f562 at DIST: 50.0 cm
ES 412.0 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32763.8 9.48664e-003 1.00
ES 443.4 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32765.0 9.15063e-003 1.00
ES 488.8 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32773.5 8.95012e-003 1.00
ES 510.9 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32767.3 8.77857e-003 1.00
ES 554.7 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32769.9 8.93148e-003 1.00
ES 670.9 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32774.6 8.85296e-003 1.00
ES 781.6 'uW/cm^2/nm' 2 BU 1 OPTIC2
    32772.1 9.46906e-003 1.00
ES NONE " 2 BU 0 NONE

SAMPLES AVERAGED 'FRAMES' 1 BU 0 COUNT
FRAME COUNTER " 1 BU 0 COUNT

CHECK SUM " 1 BU 0 COUNT

SAS4445D.CAL cont.

INSTRUMENT MVD " 3 AS 0 NONE
SN 0045 " 4 AI 0 NONE

#LS sensor OCR-200   S/N 074 calibrated for LO GAIN in IN AIR
by JENN on 08/16/99 at 14:11:02
LO GAIN calibration LAMP: F562 TARGET: T26466A at DIST: 130.0cm
LS 411.6 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32771.0 6.0931e-004   1.00
LS 443.6 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32771.6 5.8849e-004   1.00
LS 491.2 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32776.6 5.8938e-004   1.00
LS 509.2 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32775.2 6.4776e-004   1.00
LS 554.6 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32776.9 5.8570e-004   1.00
LS 670.7 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32772.9 3.0278e-004   1.00
LS 782.2 'uW/cm^2/nm/sr' 2 BU 1 OPTIC2
    32774.0 2.9851e-004   1.00
#
HEITRONICS KT19.85 SN 1585
Output range set at -10to40C
#
AUX T_IR 'C' 2 BU 1 POLYU
-60.1 0.0015293

SAMPLES AVERAGED 'FRAMES' 1 BU 0 COUNT
FRAME COUNTER " 1 BU 0 COUNT
CHECK SUM " 1 BU 0 COUNT
CRLF TERMINATOR " 2 AS 0 NONE

Model HMP45C Temperature and Relative Humidity Sensor

Calibrated Aug. 1999

Setra Model SBP270 barometric pressure sensor

Calibrated Aug.1999

RM Young 05106 Marine Wind Monitor

Routine Maintaince Aug. 1999

Eppley PSP Pyranometer

Calibrated Aug. 1999

HST/HSD002n.cal

Calibrated Sept. 1999

See calibration file in MK99K07 data folder.

8.0   File Formats (SPMR/SMSR DATA)

8.1   LEVEL1 Data

All **.RAW** files are coded in binary and can only be read by ProSoft , Asciicon and HyperCon.

8.2   LEVEL2 Data

.PRO files are (large) ASCII files which contain only the data from the profiler instrument (SPMR). The data is tab delineated and can be read directly into EXCEL.   Check the file name (as listed above) to see if the file is the full data set or an edited one if you are trying to align the records. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.   The record beginning with # contains the id for each column in the file.   Time is not directly available in this data set but can be easily calculated using the header record SATHDR START_TIME   hh.hhhhhh (where hh.hhhhhh is in decimal hours) which represents the time the first record was written.   Time for each record can be calculated using

$$REC\_TIME = REC\_NUM*(1 / RATE / 3600) + START\_TIME$$

where RATE=6.000Hz

.REF files are (large) ASCII files which contain only the data from the reference instrument (SMSR). The data is tab delineated and can be read directly into EXCEL.   Check the file name (as listed above) to see if the file is the full data set or an edited one if you are trying to align the records. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.   The record beginning with # contains the id for each column in the file.   Time is not directly available in this data set but can be easily calculated using the header record SATHDR START_TIME   hh.hhhhhh (where hh.hhhhhh is in decimal hours) which represents the time the first record was written.   Time for each record can be calculated using

$$REC\_TIME = REC\_NUM*(1 / RATE / 3600) + START\_TIME$$

where RATE=6.000Hz

8.3   LEVEL3 Data

.BIN files are ASCII files which contain binned data from both the profiler and the reference.   The data is tab delineated and can be read directly into EXCEL.   The binning interval for these files is usually one meter.   .BIN file records are usually only computed for records in which   the profiler orientation is acceptable, however when the profiler is not under its own freefall descent, records in the middle of the cast may be contaminated.   It is prudent to check the tilt column if the data look unusual (tilts greater the 2-3 degrees are to be used with caution, above 5 are not acceptable)   Since this does not normally occur when the profiler is under its own descent, ProSoft does not flag it. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.   Note that there are three processing levels for .BIN data, check the header records for SATHDR PROCLVL 3x.

3A = binned data (no corrections)

3B = binned data with surface reference fluctuation corrections (not used)

3C = binned data with Ed/Lu depth corrections (ie Lu data shifted up to

Ed depth)

Only PROCLVL 3C data should be used.

The record beginning with # contains the id for each column in the file.

8.4   LEVEL 4

.PAR files are ASCII files which contain binned data from the profiler irradiance sensor integrated to calculate quanta/cm^2/sec.   The file also gives, in the comments, various selected % light levels which are referenced to the surface reference irradiance values.   The data is tab delineated and can be read directly into EXCEL.   The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.

The record beginning with # contains the id for each column in the file.

.K files are ASCII files which contain binned   data from   the profiler   optical sensors which have been used to calculate the attenuation coefficients Kd and Ku for each wavelength using the Smith and Baker method. The data is tab delineated and can be read directly into EXCEL.   The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.

Note that the first few bins of the profile have a K of zero, as does the end of the profile.   These values are considered invalid.   The first computed K value is at the start of the profile plus NUM_K_BINS/2.   The ones before this are zero so the rows match up with other binned and LEVEL4 products. The bottom of the profile is set to zero when a minimum threshold of Ed or Lu is detected.   This is only an estimate for general cases so it is possible the the K values in the file near the bottom are not valid and should be checked before using them.   Often if the darks used were too high, the K profile will shoot off to infinite K.   If the darks used were too low, the K profile may drop below the value for pure water at the end of the cast (it may also go to zero).Also the PAR profiles should be checked before using a K profile.   A 'bump' in the PAR reference profile indicates that a cloud passed during the cast which imparts a characteristic high spike and then a low

spike in the K profile.

The record beginning with # contains the id for each column in the file.

.FLX files are ASCII files which contain binned data from the profiler optical sensors which have been used to calculate the downward, upward and total flux (in W/m^2) at each bin. The data is tab delineated and can be read directly into EXCEL. The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.

The record beginning with # contains the id for each column in the file.

.RFL files are ASCII files which contain binned data from the profiler optical sensors which have been used to calculate the reflectance at each bin. Eu is estimated from Lu using a constant Q of 5. The data is tab delineated and can be read directly into EXCEL. The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.

The bottom of the profile is set to zero when a minimum threshold of Ed or Lu is detected. This is only an estimate for general cases so it is possible the the reflectance values in the file near the bottom are not valid and should be checked before using them. Often if the Ed darks used were too high, the reflectance profile will shoot off to infinite reflectance. If the Lu darks used were too high, the reflectance profile may drop to zero at the end of the cast.

The record beginning with # contains the id for each column in the file.

.RRS files are ASCII files which contain binned data from the profiler optical sensors which have been used to calculate the remote sensing reflectance at each bin. The data is tab delineated and can be read directly into EXCEL. The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.

The bottom of the profile is set to zero when a minimum threshold of Ed or Lu is detected. This is only an estimate for general cases so it is possible the the reflectance values in the file near the bottom are not valid and should be checked before using them. Often if the Ed darks used were too

high, the reflectance profile will shoot off to infinite reflectance.   If the Lu darks used were too high, the reflectance profile may drop to zero at the end of the cast.

The record beginning with # contains the id for each column in the file.

.PIG files are ASCII files which contain pigment estimates using binned data from Kd computed for each Ed sensor wavelength.   The algorithm used is from Morel's 1998 paper. Usually only the data from the 'blue' channels (400-500nm) give good estimates.   The data is tab delineated and can be read directly into EXCEL.   The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.   Since the data is generated by the K profiles, see the notes in that section before interpreting any pigment profiles.

The record beginning with # contains the id for each column in the file.

.LWN files are ASCII files which contain normalized water leaving radiance estimates using binned data from Kd and Ku data as well as binned Es and Lu data.   The algorithm used is from Mueller and Austin SeaWiFS Protocols Vol25.   The data is tab delineated and can be read directly into EXCEL.   The binning interval for these files is usually one meter. The file has a series of header records (which start with SATHDR) which contain various parameters which are used by ProSoft in data processing.

The LWN computation is very sensitive to a poor deployment.   This value depends on good reference values and good profile values.   Any problems with instrument tilts or clouds (particularly at the start of the cast) will have a serious impact on the results.   Make sure all ancillary parameters and K values are good before using this data.
The record beginning with # contains the id for each column in the file.

8.5   Processing program configurations

1.   SPMR / SMSR

         Pressure Tare performed with Ed sensor just below surface
         Ed – Lu distance (1.14m)
         Es distance to surface (0m)
         Darks, Calibration file for Ed and basement darks for Lu
         1 m binning interval
         Num_K_Bins = 5
         Pigments calculated using Morel 1998 model

2.   Hyperspectral   TSRB

         Es distance to surface (0m)
         Ls distance to surface (0.65cm's)
         Darks, shutter darks feature 6 dark correction menu
         Binning interval 10 seconds.

3.   Met 1000 data processed with Traksoft .21b

         .Dat files produced but no averaged files at this time.

3.28 Satellite observation

Ichio Asanuma, JAMSTEC

Takanori Akiyoshi, Nippon Hakuyo Electronics

Objectives

It is our objectives to monitor the ocean color and the sea surface temperature, to build the data set of those parameters, and to build the practical algorithm to estimate the primary production.

Methods

a) Ocean Color

We receive the down link HRPT signal from the OrbView-2 polar orbit satellite by the HRPT receiving station on the R/V Mirai.   Our receiving station is the TeraScan receiving system, which has the 1.2 m antenna in the redome, the down converter, the bit synchronizer, the frame synchronizer, and the workstation to control antenna and to process received data.

We generated the level-0 data from the pass disk of the receiving system with the function 'swlevel-0', which is a products of SeaSpace.   Then we generated the level-1a data by the function 'runl1a', which is a software of NASA.   Then we processed data into the geophysical values including chlorophyll-a by the function in the SeaDAS.

b). Sea Surface Temperature

We receive the down link HRPT signal from the NOAA polar orbit satellite by the same way as the signal of the OrbView-2.   We processed the HRPT signal with the inflight calibration and computed the sea surface temperature by the multi-channel sea surface temperature method.   We projected the data on the map, which covers 20S to 20N and 150E to 130W.   In the daily steps, we overlayed data of 6 to 8 passes to generate a daily composite.   Finally, we generated two images of the weekly composite for this cruise.

Data

Data will be analyzed after the cruise.

3.29 Geophysical Observation

　(The observations were carried out only in the EEZ of Japan and the public sea.)

3.29.1 Multi narrow beam echo sounding system

(1)Personnel

　　　　Fumitaka　Yoshiura (GODI)：Operation leader

　　　　Naoto Morioka(Mirai crew)

(2)Objective

　　　　R/V Mirai has installed a multi narrow beam echo sounding system manufactured by SeaBeam Inc., SeaBeam 2100 system.　This system utilized bathymetry mapping. The newest one can measure more than 120 degrees wider swath and available all depth of the world ocean floor.

　(3)Method

　　　　We carried out bathymetric survey from Honolulu U.S.A. to Shimonoseki Japan. And we made contour maps around sites of Station 1 2 3 6 9 and 12. We used post processing W/S for make contour maps. The post processing system furnished on this MNBES has two high performance W/S Indigo^2 which have "mb-system" software on the basis of the Genetic Mapping Tool (GMT) called SeaView. Consequently, measured data can easily be edited on W/S by automatically or manually to provide gridding data and map images.　Finally colored map from A to E size were used to decide to buoy deployment locations.

(4)Results

　　　　The bathymetrical contour maps have been utilize for deploy　the sediment　trap. The accuracy seems to be enough to deploy the　sediment　trap at any depth. It is, of course, required to keep high accuracy that precise correction of sound speed of the target area can be performed based on the temperature profiles of water column. During this cruise, CTD/XCTD casts have done at the deployment sites or very close to the sites, we could use the CTD/XCTD data to derive sound velocity. The newest system has continuously measured the surface water sound velocity in real time, because sound velocity at the hydrophone alley is a very important factor to determine the angle of acoustic ray path which affects the outer beam of wider swath. Unfortunately, the SSV meter had a trouble whole of the cruise, so we input the newest sound velocity data site by site.

(5)Data archives

Bathymetry data obtained during this cruise will be submitted to DMO (Data Management Office), JAMSTEC and will be under their control.

3.29.2 Sea Surface Gravity Measurement

(1) Personnel

Fumitaka   Yoshiura (GODI) :Operation leader

Naoto Morioka(Mirai crew)

(2) Method

We measured relative gravity values by LaCoste-Romberg onboard gravity meter S-116 throughout MR99-K07 cruise from the departure of Honolulu, U.S.A. on 14 November 1999 to the day before arrival of Shimonoseki   Japan on 27   December 1999.

To obtain absolute gravity values, we also measured relative value by portable gravity meter Scintrex gravity meter CG-3M) at comparable points, Sekinehama gravity base and Guam port reference points, already known absolute gravity values. Moreover, measured values are corrected based on the bathymetry (free-air) and ship movement (etoveth).   Consequently, the corrected gravity data should involve the information of crustal and upper mantle structures how they compensate the discrepancy from isostatic balance.

(3) Preliminary results

The absolute gravity values calculated in comparison with absolute values of reference points at Sekineham and Guam port are shown in Table 6.5.1-1.

(4)Data archives

Gravity data obtained in this cruise will be submitted to the DMO (Data Management Office), JAMSTEC and will be under their control.

3.29.3 Surface three component magnetometer

(1) Personnel

      Fumitaka　Yoshiura (GODI)　:Operation leader

(2) Objective

  In order to continuously obtain the geomagnetic field vectors on the sea surface, a three component magnetometer is a very useful equipment.　The magnetic force on the sea is affected by induction of magnetized body beneath the subbottom in addition to the earth dipole magnetic field. The magnetic measurement on the sea is, therefore, one of utilities for geophysical reconstruction of crustal structure and so on.　The geomagnetic field can be divided into three components, i.e., two horizontal (x & y)　and one vertical (z) moments.　Three-component observation instead of total force includes much information of magnetic structure of magnetized bodies.

(3) Method

     The sensor is a three axes fluxgate magnetometer on the top of foremast and sampling period is 8Hz.　The timing of sampling is controlled by the 1pps standard clock of GPS signal. Every one second data set which consists of 310 bytes; navigation information, 8 Hz three component of magnetic forces and VRU data were recorded in the external hard disk.

(4)Preliminary results

   During MR99-K07 cruise, the magnetic force is continuously measured from Honolulu U.S.A. to Shimonoseki　Japan .　Data obtained on the sea will be analyzed in near future. The procedure of quality control is mainly to eliminate the effect of ship's magnetized vector condition.

(5)Data archives

     Magnetic force data obtained during this cruise will be submitted to DMO (Data Management Office), JAMSTEC and will be under their control.

4. Acknowledgement

We thank Capt. Hashimoto, the commanding officer of MIRAI, and his crew for their skillful and diligent work..