doi : 10.17596/0003572

MR06-03

(18 May – 25 July 2006)

Preliminary Cruise Report

September 2006

JAMSTEC

Note

This cruise report is a preliminary documentation as of the end of this cruise. It may not be corrected even if changes on contents are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the principal investigator and parsons in charge of respective observations for the latest information and permission before using. Users of data are requested to submit their results to JAMSTEC.

Contents of MR06-03 Preliminary Cruise Report

Cover sheet

The 1st prize of "MR06-03 Cruise Report Cover sheet Competition designed by Tetsuya Nakamura (Nichiyu Gigen Kogyo).

A. Cruise summary

1. Cruise information

(1) Cruise designation (research vessel)

MR06-03 (R/V MIRAI)

(2) Cruise title

Biogeochemical study in the western North Pacific

Principal Investigator (PI); Shuichi Watanabe and Makio Honda,

JAMSTEC Mutsu Institute for Oceanography (MIO)

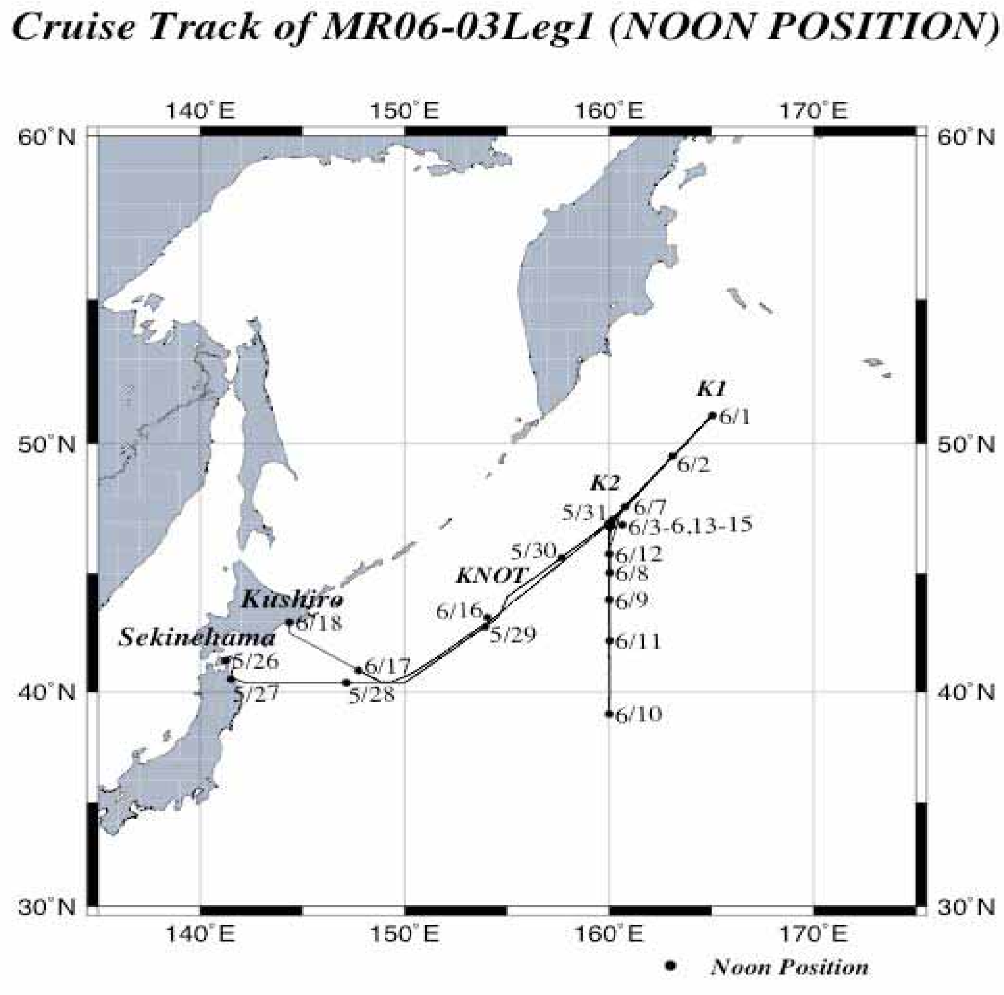
(3) Science proposals of cruise

S/N	Affiliation	PI	Proposal titles
MR06-1	Toyama Univ.	Kazumasa Aoki	Characteristics of spatial variation of aerosol physical properties over the ocean measured by solar aureole
MR06-2	JAMSTEC IORGC	Kunio Yoneyama	Continuous surface meteorological measurements as a basic dataset.
MR06-3	JAMSTEC IORGC	Kinpei Ichiyanagi	Rain Sampling for Stable Isotopes
MR06-4	Tokyo Univ.	Ichiro Yasuda	Studies on the transport and variation of the North Pacific western subarctic water-masses
MR06-5	NIES	Nobuo Sugimoto	Study of distribution and optical characteristics of ice/water clouds and marine aerosols
MR06-6	AIST	Nobuo Tsurushima	Cancel
MR06-7	JAMSTEC IFREE	Takashi Toyofuku	Genetic diversity of planktonic foraminifera in northern Northwest Pacific and its relationship to Quaternary paleo-environmental changes.
MR06-8	Ryukyu Univ.	Takeshi Matsumoto	Standardisation of marine geophysical data and its application to the ocean floor geodynamics studies
MR06-9	JAMSTEC XBR	Minoru Kitamura	Studies of zooplankton community in the time series observation station, K2
MR06-10	Hokkaido Univ.	Seiichi Saito	Study of primary productivity observed by remotely sensing data of ocean color.
MR06-11	Nagoya Univ.	Toshiro Saino	Air-sea gas exchange rate from oxygen-17 anomaly of dissolved oxygen
MR06-12	Tokyo Met. Univ.	Katsuyoshi Kajii	Cancel

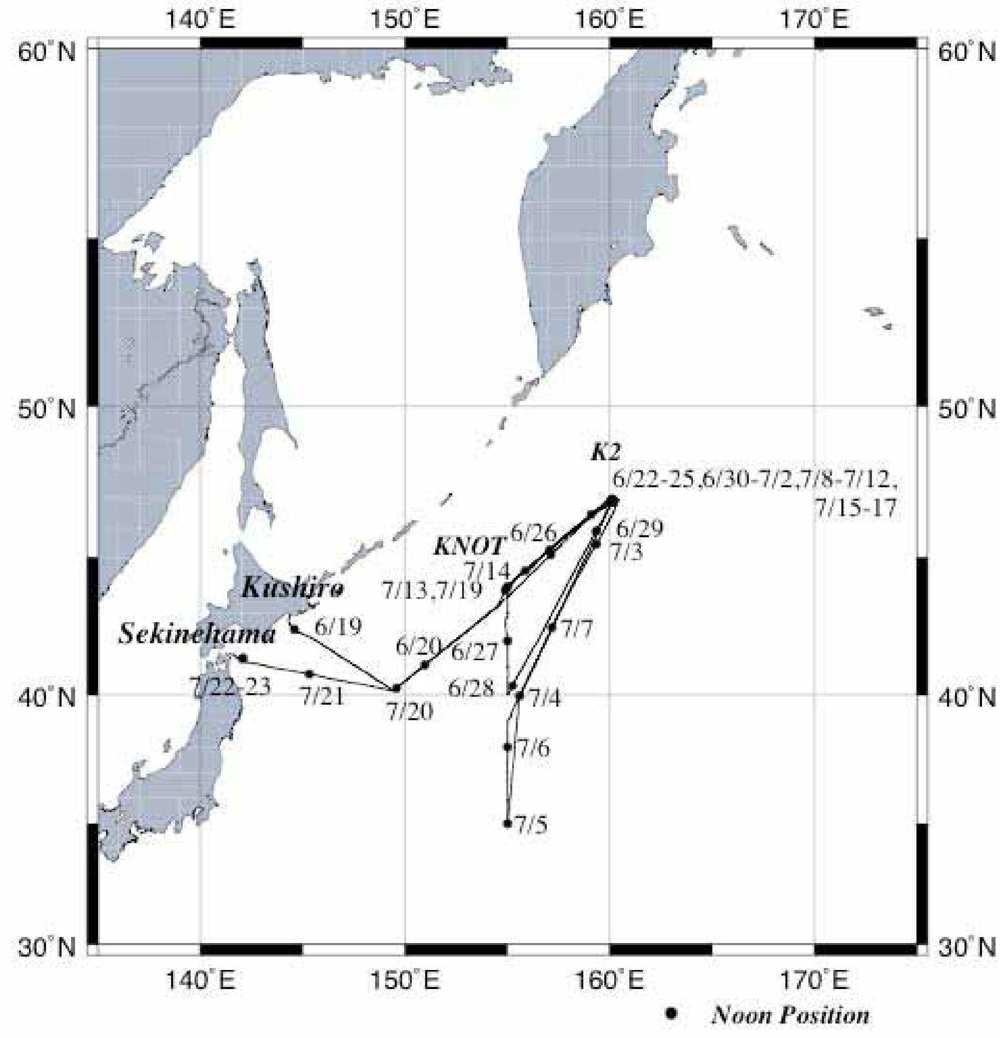
(4) Cruise period (port call)
Leg.1: 28 June 2005 (Sekinehama) – 18 June 2005 (Kushiro)
Leg.2: 19 June 2005 (Kushiro) – 25 July 2005 (Sekinehama)

(5) Cruise region (geographical boundary)
The western North Pacific (51°N – 35°N, 155°E – 165°E)

(6) Cruise truck and stations



Cruise Track of MR06-03Leg2 (2006.6/19 - 7/25)



2. Cruise participants

Leg.		Name	Affiliation	Appointment	Tel
1	2				
○	○	Makio Honda (PI)	JAMSTEC MIO	Sub Leader	
○		Kazuhiko Matsumoto （Leg.1　Deputy PI）	Same as above	Researcher	
○		Hajime Kawakami	Same as above	Same as above	
○	○	Masahide Wakita （Leg.2 Deputy PI）	Same as above	Same as above	
	○	Yoshiyuki Nakano	Same as above	Same as above	
	○	Tetsuichi Fujiki	Same as above	Same as above	
○	○	Minoru Kitamura	JAMSTEC XBR	Same as above	
○		Masashi Tsuchiya	JAMSTEC IFREE	Same as above	
○		Atsushi Kurasawa	JAMSTEC IFREE	Graduated student	
○	○	Suguru Okamoto	Hokkaido Univ.	Graduated student	
○		Kazuhiko Ohishi	Same as above	Same as above	
	○	Takushi Hosaka	Nagoya Univ.	Technician	
	○	Vedula V. S. S. Sarma	Same as above	Researcher	
○		Tetsuya Nakamura	Nichiyu Giken Kogyo	Technician	
○		Satoshi Ozawa (Leg.1 Principal Marine Technician)	Marine Works Japan （MWJ）	Marine Technician	
○		Hirokatsu Uno	Same as above	Same as above	
○	○	Akinori Murata	Same as above	Same as above	
○		Tatsuya Tanaka	Same as above	Same as above	
○		Taiki Ushiromura	Same as above	Same as above	
○	○	Toru Idai	Same as above	Same as above	
○	○	Fuyuki Shibata	Same as above	Same as above	
○	○	Katsunori Sagishima	Same as above	Same as above	
○	○	Ai Yasuda	Same as above	Same as above	
○	○	Minoru Kamata (Leg.2 Principal Marine Technician)	Same as above	Same as above	
○		Takayoshi Seike	Same as above	Same as above	
○	○	Junko Hamanaka	Same as above	Same as above	
○	○	Yuishi Sonoyama	Same as above	Same as above	
○		Masanori Enoki	Same as above	Same as above	
○		Yoshiko Ishikawa	Same as above	Same as above	
○	○	Kimiko Nishijima	Same as above	Same as above	
○		Junji Matsushita	Same as above	Same as above	
○	○	Miyo Ikeda	Same as above	Same as above	
○	○	Ayaka Hatsuyama	Same as above	Same as above	
	○	Naoko Takahashi	Same as above	Same as above	
	○	Tomoyuki Takamaori	Same as above	Same as above	
	○	Shinsuke Toyoda	Same as above	Same as above	

	○	Tomohide Nogucji	Same as above	Same as above	
	○	Hidekii Yamamoto	Same as above	Same as above	
	○	Ken-ichiro Sato	Same as above	Same as above	
	○	Masaki Moro	Same as above	Same as above	
	○	Ayumi Takeuchi	Same as above	Same as above	
○	○	Daiji Komura	Same as above	Assistant MT	
	○	Kosuke Okudaira	Same as above	Same as above	
○	○	Katsunori Maeno (Leg.1,Principal MT)	Global Ocean Development（GODI）	Marine Technician	045-849-6630
○		Ryo Ohyama	Same as above	Same as above	Same as above
	○	Norio Nagahama	Same as above	Same as above	Same as above

3. Overview of MR06-03

(1) Objective

To observe three dimensional distribution and seasonal variability of materials such as carbon dioxide in the western North Pacific for better understanding ocean's role in controlling the global environment

(2) Overview of MR06-03

Missions of MR06-03 were to observe three-dimensional distribution of materials such as carbon dioxide in the western North Pacific and to observe seasonal variability in the biological pump at time-series station K2.

For the first mission, hydrocastings at multiple sites in the Russian EEZ (near the Aleutian islands and Kamchatka peninsula) were planed before cruise. However observation in the Russian EEZ were not permitted by Russian government despite a lot of efforts in logistics has been made since eight months ago. However precise transect observation for distribution of materials such as nutrients, dissolved oxygen and carbon species could be done between station K1 (51°N/165°E) and station KNOT (44°N/155°E), between station KNOT and station 35N (35°N/155°E) along 155°E line, and between station K2 (47°N/160°E) and station 39N (39°N/160°E) along 160°E (Fig. 1). These data and current direction and velocity measured by LADCP will be used for the study of horizontal and vertical transportation of materials and of decadal change in biogeochemistry in the western North Pacific.

Owing to suspension of observation in the Russian EEZ, more ship time could be dedicated to time-series observation for the biological pump at time-series station K2. During this cruise, R/V MIRAI visited station K2 six times between the end of May to late July 2006. At each visit, we conducted hydrocastings, plankton netting, deployment of drifter for measurement of primary productivity and sediment trap experiments. Based on two months time-series observation, nutrients and total dissolved carbon decreased with time (Fig. 2). It is noted that its decrease was not monotonous and primary productivity did not increase with time because surface mixed layer depth was not stable. However maximum primary productivity of approximately 700 mg-C m^{-2} day^{-1}

observed was comparable to annual maximum observed previously and good relation between primary productivity and photosynthetically available radiation (PAR) could be observed (Fig. 3). During this cruise, the BGC mooring system and POPPS mooring system were deployed by JAMSTEC and Nagoya University, respectively. The former collected seawater and sinking particles and the latter observed optical condition upper 100 m for the study of primary productivity. These sample and data will be analyzed for the study of biological pump, i.e. relation between primary productivity and sinking particles, in the early summer in the western North Pacific. One noteworthy observation during MR06-03 was towing a giant plankton net, IONESS, to collect mesozooplankton living at multiple layers. The IONESS had not been conducted by R/V MIRAI before. Owing to big efforts for preparation, towing IONESS was conducted 11 times during daytime or midnight successfully. These data will clarify vertical distribution of mesozooplankton and its daily and monthly change qualitatively and quantitatively and contribute to the study of roles of zooplankton in the biological pump.

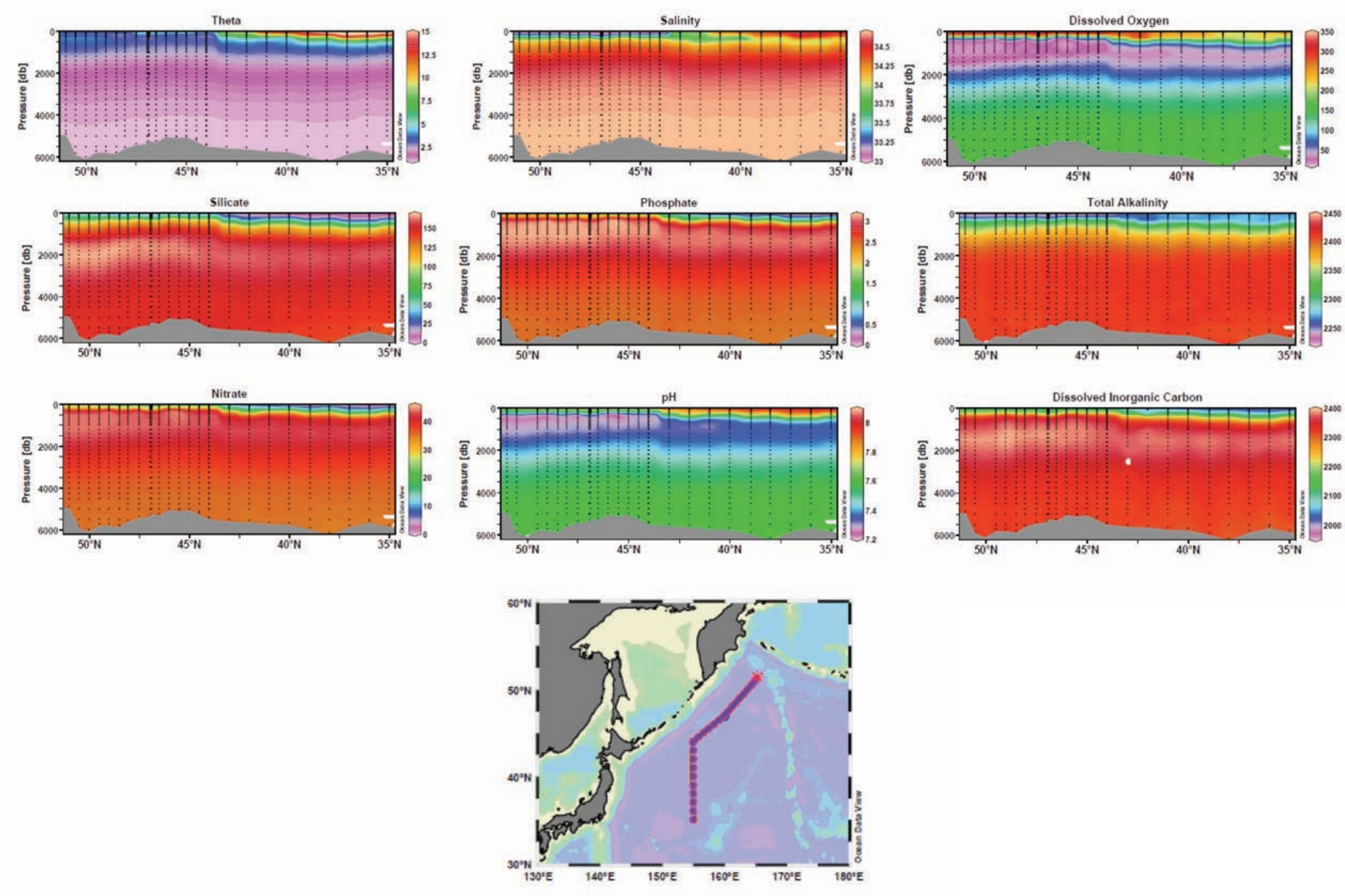


Fig.1 Vertical sections of principal components along line of K1-K2-KNOT-35°N

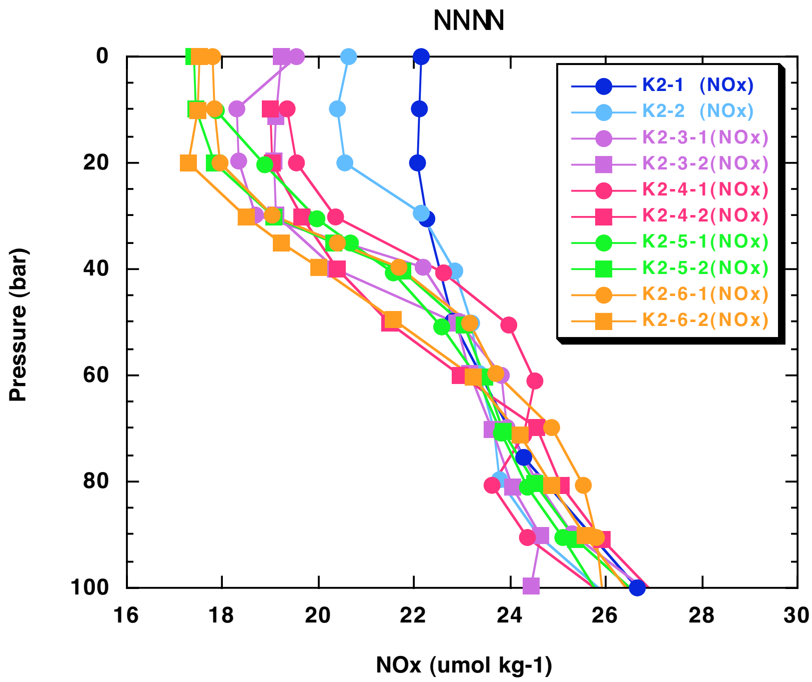


Fig.2 Vertical profiles of nitrate + nitrite (NOx) upper 100 m observed at each visit

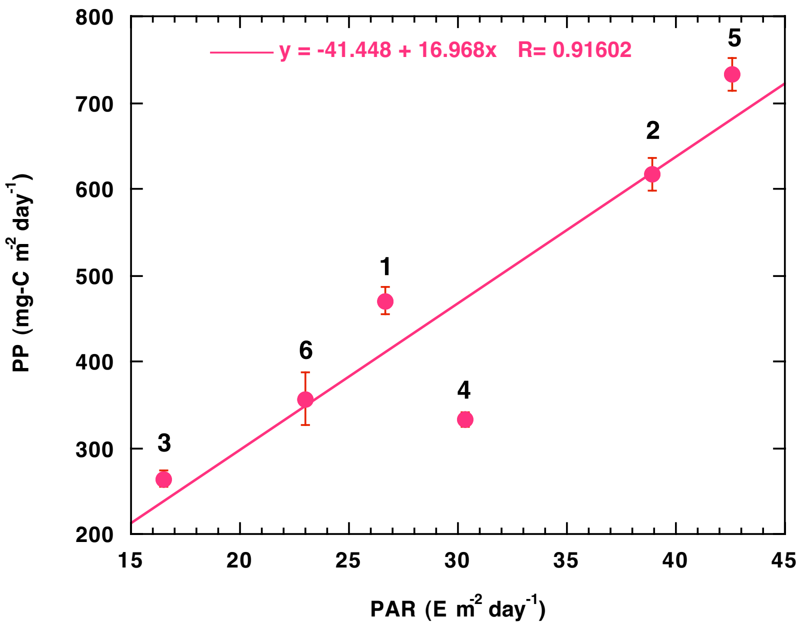


Fig.3 Relation between primary productivity (PP) and photosynthetically available radiation (PAR)

B. Text

1. Outline of MR06-03

Makio HONDA (JAMSTEC MIO)
Principal Investigator of MR06-03

1.1 Cruise summary

(1) Objective

To observe three dimensional distribution and seasonal variability of materials such as carbon dioxide in the western North Pacific for better understanding ocean's role in controlling the global environment

(2) Overview of MR06-03

Missions of MR06-03 were to observe three-dimensional distribution of materials such as carbon dioxide in the western North Pacific and to observe seasonal variability in the biological pump at time-series station K2.

For the first mission, hydrocastings at multiple sites in the Russian EEZ (near the Aleutian islands and Kamchatka peninsula) were planed before cruise. However observation in the Russian EEZ were not permitted by Russian government despite a lot of efforts in logistics has been made since eight months ago. However precise transect observation for distribution of materials such as nutrients, dissolved oxygen and carbon species could be done between station K1 (51°N/165°E) and station KNOT (44°N/155°E), between station KNOT and station 35N (35°N/155°E) along 155°E line, and between station K2 (47°N/160°E) and station 39N (39°N/160°E) along 160°E (Fig. 1). These data and current direction and velocity measured by LADCP will be used for the study of horizontal and vertical transportation of materials and of decadal change in biogeochemistry in the western North Pacific.

Owing to suspension of observation in the Russian EEZ, more ship time could be dedicated to time-series observation for the biological pump at time-series station K2. During this cruise, R/V MIRAI visited station K2 six times between the end of May to late July 2006. At each visit, we conducted hydrocastings, plankton netting, deployment of drifter for measurement of primary productivity and sediment trap experiments. Based on two months time-series observation, nutrients and total dissolved carbon decreased with time (Fig. 2). It is noted that its decrease was not monotonous and primary productivity did not increase with time because surface mixed layer depth was not stable. However maximum primary productivity of approximately 700 mg-C m^{-2} day^{-1} observed was comparable to annual maximum observed previously and good relation between primary productivity and photosynthetically available radiation (PAR) could be observed (Fig. 3).

During this cruise, the BGC mooring system and POPPS mooring system were deployed by JAMSTEC and Nagoya University, respectively. The former collected seawater and sinking particles and the latter observed optical condition upper 100 m for the study of primary productivity. These sample and data will be analyzed for the study of biological pump, i.e. relation between primary productivity and sinking particles, in the early summer in the western North Pacific. One noteworthy observation during MR06-03 was towing a giant plankton net, IONESS, to collect mesozooplankton living at multiple layers. The IONESS had not been conducted by R/V MIRAI before. Owing to big efforts for preparation, towing IONESS was conducted 11 times during daytime or midnight successfully. These data will clarify vertical distribution of mesozooplankton and its daily and monthly change qualitatively and quantitatively and contribute to the study of roles of zooplankton in the biological pump.

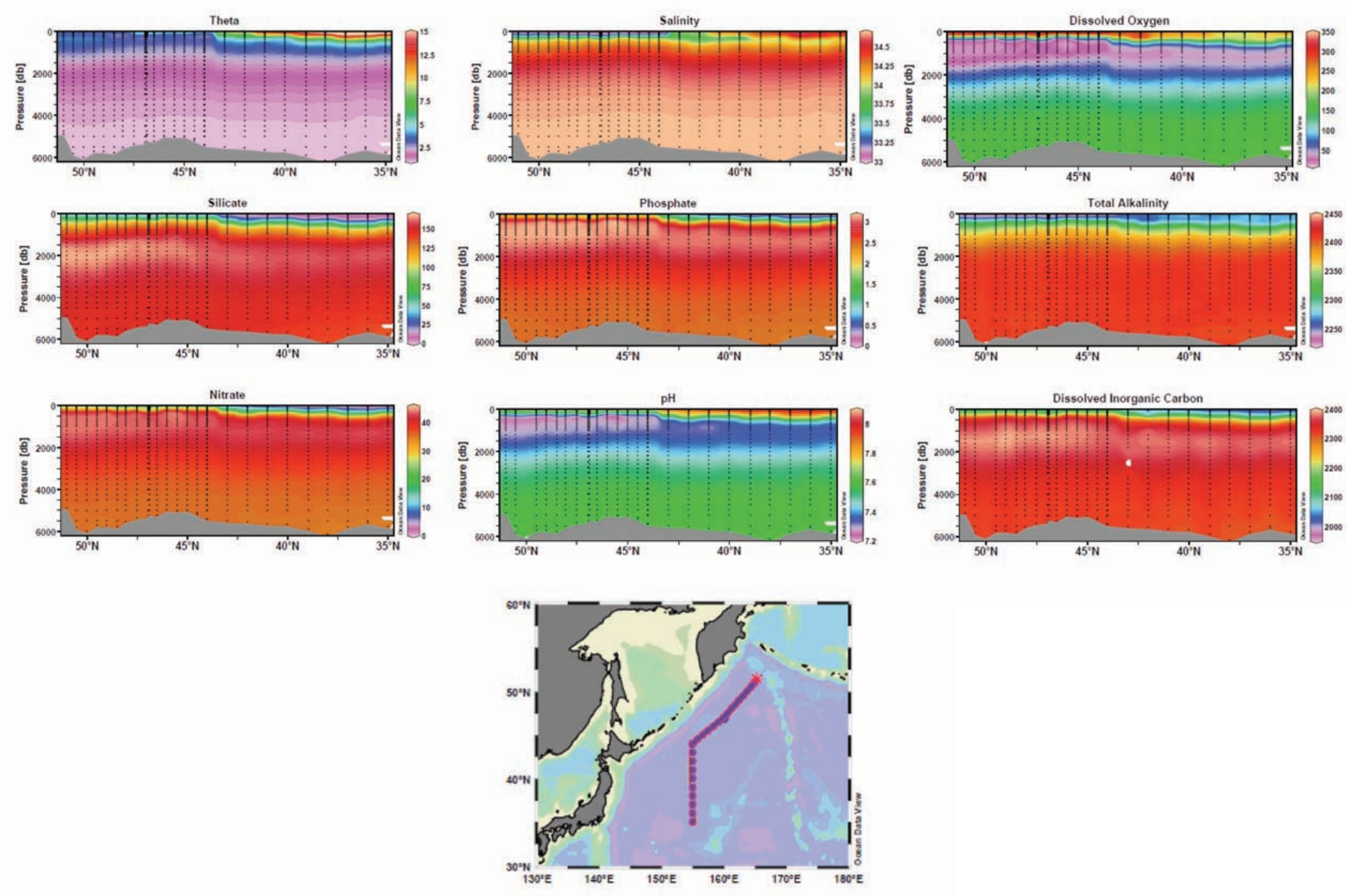


Fig.1 Vertical sections of principal components along line of K1-K2-KNOT-35°N

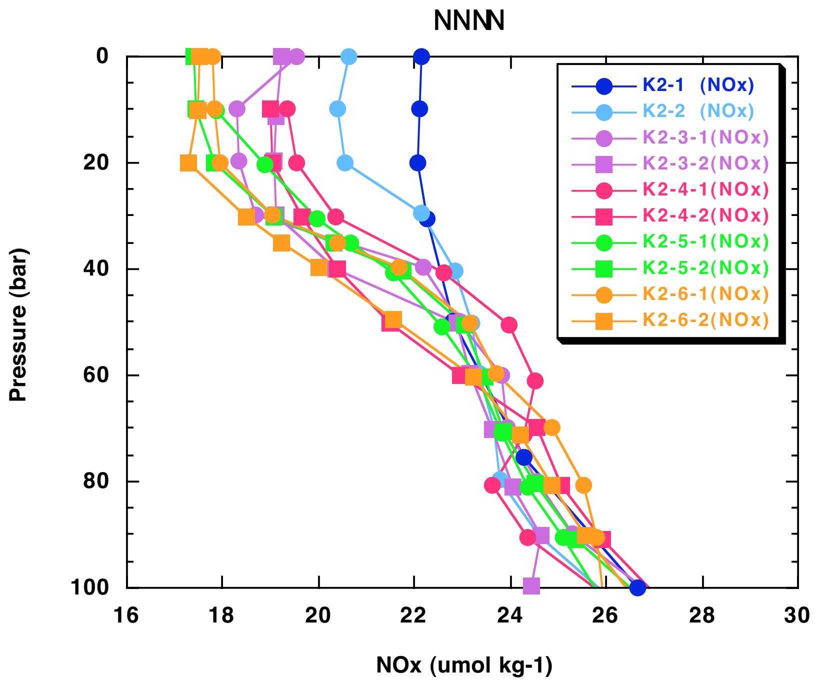


Fig.2 Vertical profiles of nitrate + nitrite (NOx) upper 100 m observed at each visit

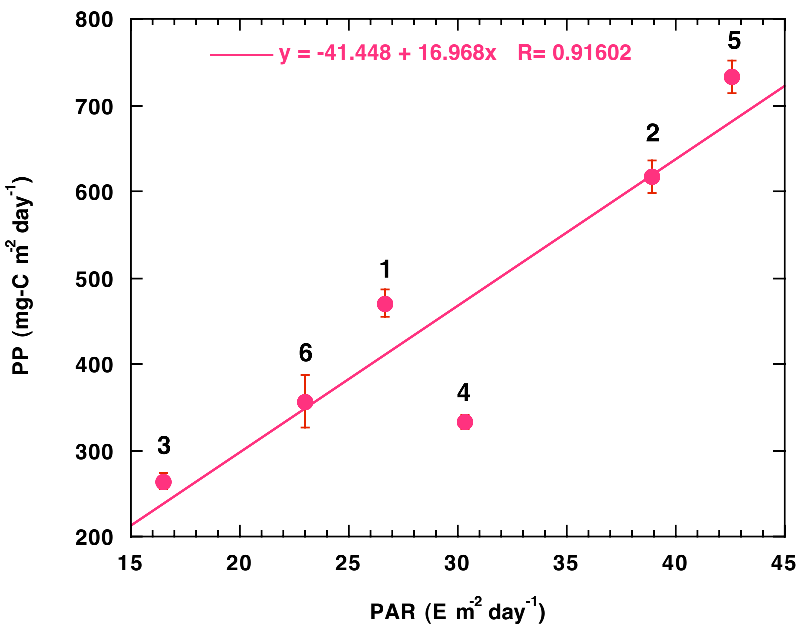


Fig.3 Relation between primary productivity (PP) and photosynthetically available radiation (PAR)

(3) Scientific gears

All hydrocasts were conducted using 36-position 12 liter Niskin bottles carousel system with SBE CTD-DO system, fluorescence, transmission sensors and LADCP. JAMSTEC MIO scientists and MWJ (Marine Work Japan Co. Ltd.) technician group were responsible for analyzing water sample for salinity, dissolved oxygen, nutrients, CFCs, total carbon contents, alkalinity and pH. Cruise participants from JAMSTEC IFREE and XBR, Hokkaido University and Nagoya University helped to divide seawater from Niskin bottles to sample bottles for analysis. Graduated students of Hokkaido University collected samples and analyzed Chlorophyll-a contents and bioactivity in seawater. Surface water was collected with bucket.

Optical measurement in air and underwater was conducted with PAR sensor (RAMSES-ACC) and SPMR/SMSR called “Free Fall”.

For collecting suspended particles at stationK2, Large Volume Pump (LVP) was deployed.

GODI technicians group undertook responsibility for underway current direction and velocity measurements using an Acoustic Current Profiler (ADCP), geological measurements (topography, geo-magnetic field and gravity), and collecting meteorological data.

For collection of zooplankton, NORPAC plankton net, and IONESS were deployed.

For conducting in situ incubation for measurement of primary productivity and collecting sinking particles at station K2, drifter was deployed 6 times at station K2.

In order to conducted time-series observation in physical, chemical and biological activity, two mooring systems, JAMSTEC BGC mooring and Nagoya University POPPS mooring, were deployed in the vicinity of station K2 during cruise period. The BGC consisted of an automatic water sampler (RAS) at around 35 m and 4 sediment traps at 150, 300, 1000 and 5000 m. The POPPS mooring consisted of underwater winch and FRRF (First Repeatation Refractory Fluorometer) .

1.2 Track and log

1.2.1 Cruise track

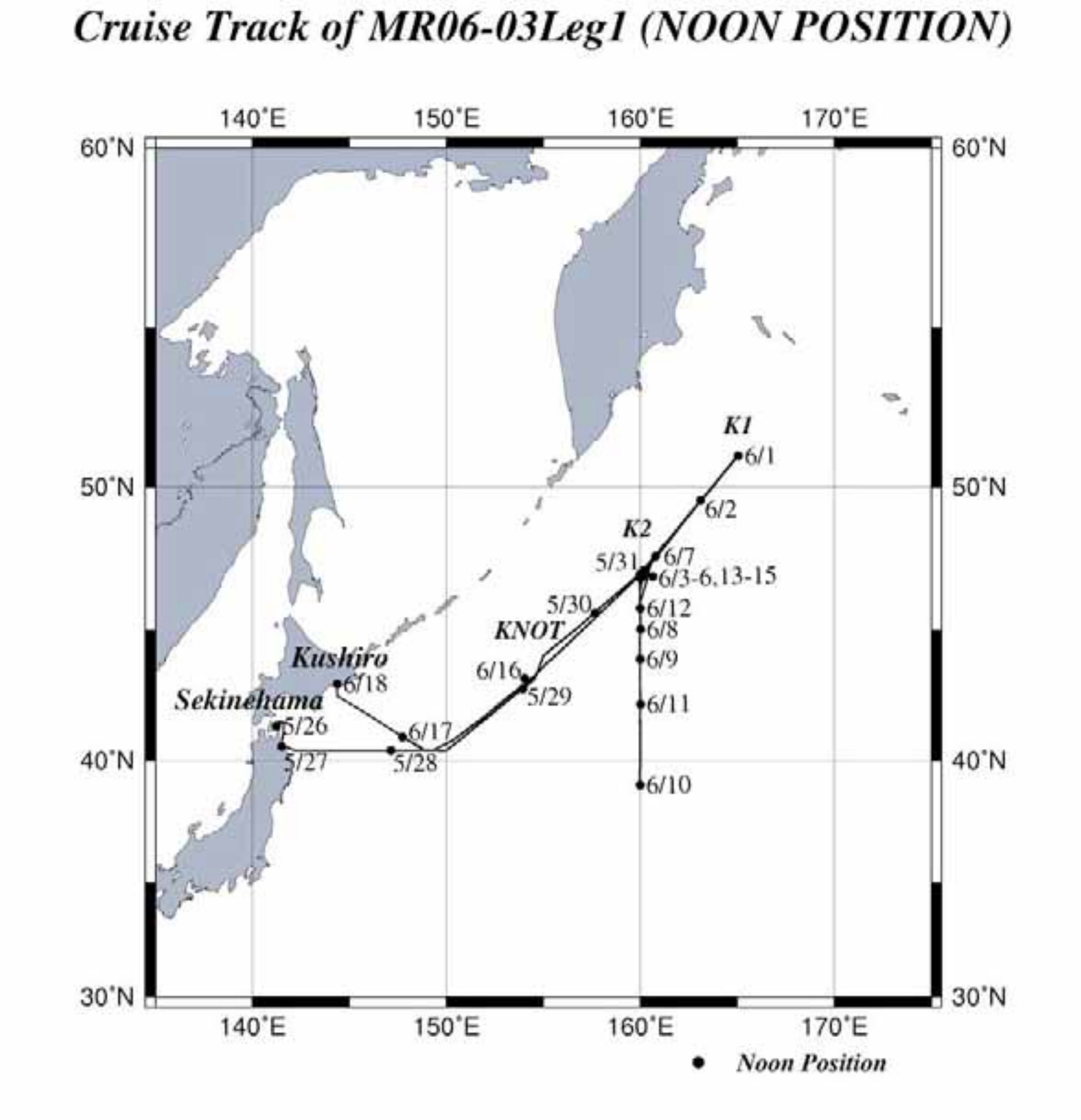


Figure 1.2.1 MR0603 Leg1 Noon Position

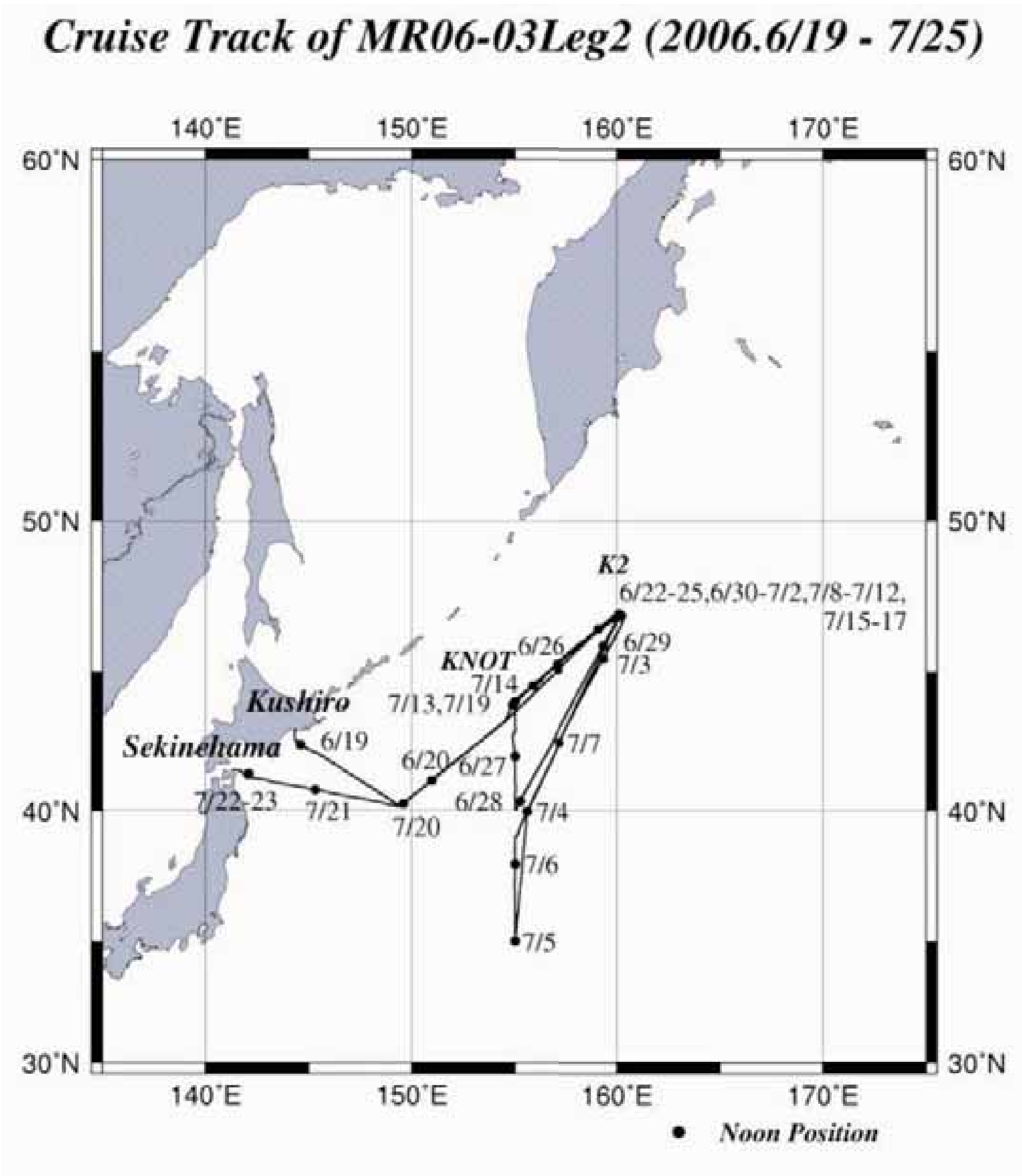


Figure 1.2.2 MR0603 Leg2 Noon Position

1.2.2 Cruise Log

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
5.26	21:00	5.27	06:00	41-21.97N	141-14.38E	Departure from Sekinehama
5.27	03:10	5.27	12:10	40-33.43N	141-29.94E	Arrival at hachinohe
	09:00		18:00	40-33.43N	141-29.94E	Departure from Hachinohe
5.28	13:00	5.28	22:00	-	-	Time adjustment +1 hours (SMT=UTC+10h)
5.29	07:30	5.29	17:30	44-00N	155-00E	Arrival at Station KNOT
	07:48		17:48	44-00.05N	155-00.05E	PlanktonNet #1
	09:06		19:06	44-00.89N	154-59.75E	CTD cast #1 (5312m)
	13:00		23:00	-	-	Departure from KNOT
5.30	03:55	5.30	13:55	45-50.12N	158-00.11E	Calibration for magnetometer
	12:00		22:00	-	-	Time adjustment +1 hours (SMT=UTC+11h)
	19:00	5.31	06:00	47-00N	160-00E	Arrival at Station K2
	21:01		08:01	47-00.61N	159-58.55E	BGC mooring recovery
5.31	00:06	5.31	11:06	-	-	Departure from Station K2
	20:48	6.1	07:48	51-00N	165-00E	Arrival at Station K1
	21:06		08:06	51-00.08N	165-00.22E	CTD cast #2 (4781)
6.1	00:54	6.1	11:54	51-00.99N	165-03.36E	Free Fall #1
	02:06		13:06	50-59.90N	165-00.19E	PlanktonNet #2
	03:18		14:18	-	-	Departure from Station K1
	06:06		17:06	50-30N	164-22.5E	Arrival at Station MR06012
	06:08		17:08	50-29.99N	164-22.54E	CTD cast #3 (5688m)
	10:18		21:18	-	-	Departure from MR06012
	13:12	6.2	00:12	50-00N	163-45E	Arrival at Station MR06013
	13:18		00:18	50-00.04N	163-44.96E	CTD cast #4 (1854m)
	17:36		04:36	-	-	Departure from MR06013
	20:42		07:42	49-30N	163-08E	Arrival at Station MR06014
	20:47		07:47	49-30.04N	163-07.40E	CTD cast #5 (5591m)
6.2	00:58	6.2	11:58	49-32.52N	163-06.92E	Free Fall #2
	01:18		12:18	-	-	Departure from MR06014
	04:18		15:18	49-00N	162-30E	Arrival at Station MR06015
	04:23		15:23	48-59.99N	162-30.03E	CTD cast #6 (5589m)
	08:24		19:24	-	-	Departure from MR06015
	19:48	6.3	06:48	47-00N	160-00E	Arrival at Station K2
	20:00		07:00	46-52.18N	159-59.07E	PO mooring recovery
6.3	00:44	6.3	11:44	46-51.51N	160-00.95E	Free Fall #3
	01:04		12:04	46-51.43N	160-01.12E	CTD cast #7 (4812m)
	04:16		15:16	46-51.49N	160-03.59E	CTD cast #8 (200m)
	07:00		18:00	46-51.91N	159-59.26E	PlanktonNet #3
	14:55	6.4	01:55	46-52.36N	159-59.09E	CTD cast #9 (200m)
	16:45		03:45	46-53.34N	159-59.02E	Drifting Sediment Trap #1 deployment
	20:59		07:59	46-52.61N	159-59.06E	PlanktonNet #4
	21:56		08:56	46-52.26N	159-59.19E	CTD cast #10 (5142m)
6.4	01:50	6.4	12:50	46-52.07N	159-58.06E	PlanktonNet #5
	03:20		14:20	46-51.90N	159-58.39E	Large Volume Pump (LVP) #5 cast
	06:55		17:55	46-53.52N	160-02.95E	PlanktonNet #6
	07:44		18:44	46-53.59N	160-02.87E	Calibration for magnetometer
	09:57		20:57	46-52.70N	160-02.77E	PlanktonNet #7
	15:27	6.5	02:27	46-52.08N	160-08.00E	PlanktonNet #8

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
	16:15		03:15	46-52.66N	160-08.01E	Drifting Sediment Trap #1 recovery
	21:05		08:05	46-46.37N	160-00.62E	POPPS mooring deployment
6.5	01:25	6.5	12:25	46-52.50N	159-59.05E	POPPS mooring calibrate position
	-		-	46-52.28N	159-59.15E	POPPS mooring Fixed position
	02:51		13:51	46-52.15N	159-58.93E	LVP cast #2
	21:10	6.6	08:10	46-53.91N	159-59.16E	BGC mooring deployment
6.6	03:20	6.6	14:20	46-59.90N	159-58.59E	BGC mooring calibrate position
	-		-	47-00.34N	159-58.41E	BGC mooring Fixed position
	04:12		15:12	-	-	Departure from Station K2
	12:12		23:12	48-30N	161-54E	Arrival at Station MR06016
	12:14		23:14	48-30.02N	161-52.51E	CTD cast #11 (5657m)
	16:12	6.7	03:12	-	-	Departure from MR06016
	18:36		05:36	48-06N	161-18E	Arrival at Station MR06017
	18:50		05:50	48-04.06N	161-17.65E	CTD cast #12 (5408m)
	22:48		09:48	-	-	Departure from MR06017
6.7	01:42	6.7	12:42	47-30N	160-36E	Arrival at Station MR06018
	02:00		13:00	47-29.94N	160-38.20E	Free Fall #4
	02:23		13:23	47-30.10N	160-38.40E	CTD cast #13 (5250m)
	06:18		17:18	-	-	Departure from MR06018
	12:54		23:54	46-00N	160-00E	Arrival at Station MR06003
	12:57		23:57	46-00.02N	160-00.04E	CTD cast #14 (5358m)
	16:48	6.8	03:48	-	-	Departure from MR06003
	22:18		09:18	45-00N	160-00E	Arrival at Station MR06004
	22:22		09:22	45-00.06N	160-00.13E	CTD cast #15 (5452m)
6.8	02:14	6.8	13:14	45-01.95N	160-00.71E	Free Fall #5
	02:30		13:30	-	-	Departure from MR06004
	10:12		21:12	47-00N	160-00E	Arrival at Station K2
	10:17		21:17	46-59.91N	160-00.12E	CTD cast #16 (200m)
	10:42		21:42	-	-	Departure from Station K2
6.9	20:48	6.10	07:48	39-00N	160-00E	Arrival at Station MR06010
	20:55		07:55	39-00.07N	160-00.00E	CTD cast #17 (5491m)
6.10	00:56	6.10	11:56	39-01.04N	159-59.10N	Free Fall #6
	01:30		12:30	39-01.47N	159-58.82E	PlanktonNet #9
	02:12		13:12	-	-	Departure from MR06010
	06:12		17:12	40-00N	160-00E	Arrival at Station MR06009
	06:14		17:14	40-00.09N	159-59.90E	CTD cast #18 (5517m)
	10:24		21:24	-	-	Departure from MR06009
	14:00	6.11	01:00	41-00N	160-00E	Arrival at Station MR06008
	14:04		01:04	40-59.99N	160-00.07E	CTD cast #19 (5572m)
	18:00		05:00	-	-	Departure from MR06008
	21:54		08:54	42-00N	160-00E	Arrival at Station MR06007
	21:59		08:59	41-59.94N	160-00.00E	CTD cast #20 (5628m)
6.11	02:50	6.11	13:50	42-11.28N	160-01.06E	Free Fall #7
	03:06		14:06	-	-	Departure from MR06007
	06:06		17:06	43-00N	160-00E	Arrival at Station MR06006
	06:07		17:07	42-59.90N	160-00.17E	CTD cast #21 (5459m)
	10:00		21:00	-	-	Departure from MR06006
	14:00	6.12	01:00	44-00N	160-00E	Arrival at Station MR06005
	14:04		01:04	44-00.02N	160-00.02E	CTD cast #22 (5282m)
	17:48		04:48	-	-	Departure from MR06005
6.12	02:00	6.12	13:00	46-00N	160-00E	Arrival at Station MR06004

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
6.12	02:02	6.12	13:02	46-00.98N	159-59.32E	Free Fall #8
	03:42		14:42	-	-	Departure from MR06004
	10:18		21:18	47-00N	160-00E	Arrival at Station K2
	15:28	6.13	02:28	46-51.96N	160-08.22E	CTD cast #23 (200m)
	16:46		03:46	46-52.05N	160-08.33E	Drifting Sediment Trap #2 deployment
	22:55		09:55	46-56.65N	160-05.08E	Free Fall #9
	23:16		10:16	46-56.74N	160-05.48E	CTD cast #24 (200m)
	23:45		10:45	46-56.71N	160-05.56E	IONESS caribration
6.13	04:26	6.13	15:26	46-54.41N	160-03.48E	LVP cast #3
	07:00		18:00	46-55.41N	160-03.59E	PlanktonNet #10
	12:11		23:11	46-56.35N	160-05.48E	IONESS #1
	16:22	6.14	03:22	46-50.00N	160-17.42E	PlanktonNet #11
	16:57		03:57	46-49.42N	160-16.20E	Drifting Sediment Trap #2 recovery
	17:41		04:41	46-49.00N	160-15.70E	FRRF #1
	18:59		05:59	46-54.20N	160-06.05E	FRRF #2
	20:54		07:54	46-55.42N	160-03.37E	FRRF #3
	21:30		08:30	46-55.23N	160-03.49E	CTD cast #25 (200m)
	22:55		09:55	46-55.75N	160-03.43E	FRRF #4
6.14	00:52	6.14	11:52	46-55.19N	160-03.43E	FRRF #5
	02:55		13:55	46-55.31N	160-03.77E	FRRF #6
	04:58		15:58	46-55.38N	160-03.76E	FRRF #7
	06:57		17:57	46-55.37N	160-03.56E	FRRF #8
	07:19		18:19	46-55.01N	160-03.76E	PlanktonNet #12
	09:25		20:25	46-55.34N	160-03.53E	FRRF #9
	10:11		21:11	46-55.01N	160-06.16E	IONESS #2
	18:15	6.15	05:15	46-55.31N	160-03.42E	LVP cast #4
6.15	00:44	6.15	11:44	46-55.51N	160-02.68E	IONESS #3
	03:12		14:12	46-57.25N	159-57.99E	Departure from Station K2
	11:00		22:00	-	-	Time adjustment -1 hours (SMT=UTC+10h)
6.16	12:00	6.16	22:00	-	-	Time adjustment -1 hours (SMT=UTC+9h)
	23:00	6:17	08:00	40-35.00N	148-31.23E	Calibration for magnetometer
6.18	00:00	6.18	09:00			Arrival at Kushiro

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
6.19	00:00	6.19	09:00	42-58.92N	144-22.22E	Departure from Kushiro
	13:00		22:00	-	-	Time adjustment +1 hours (SMT=UTC+10h)
	23:13	6.20	08:13	40-33.73N	150-03.52E	Calibration for magnetometer
6.20	12:00	6.20	22:00	-	-	Time adjustment +1 hours (SMT=UTC+11h)
6.21	02:42	6.21	13:42	45-22.23N	157-33.56E	Free Fall #1
	12:42		23:42			Arrival at Station K2
	15:30	6.22	02:30	46-52.31N	160-06.50E	CTD cast #1 (50m)
	16:45		03:45	46-52.23N	160-06.41E	Drifting Primary Productivity & Sediment Trap #1 deployment
	17:32		04:32	46-51.64N	160-06.83E	FRRF #1
	18:56		05:56	46-56.45N	160-07.29E	FRRF #2
	20:55		07:55	46-56.29N	160-07.22E	FRRF #3
	21:25		08:25	46-56.31N	160-07.66E	Large Volume Pump (LVP) cast #1
	23:26		10:26	46-55.48N	160-07.73E	FRRF #4
6.22	00:56	6.22	11:56	46-56.45N	160-07.48E	FRRF #5
	02:54		13:54	46-56.51N	160-07.30E	FRRF #6
	04:59		15:59	46-56.54N	160-07.43E	FRRF #7
	06:57		17:57	46-56.54N	165-07.42E	PlanktonNet #1
	07:24		18:24	46-56.71N	160-07.75E	FRRF #8
	08:58		19:58	46-56.41N	160-07.34E	FRRF #9
	10:55		21:55	46-56.39N	160-07.56E	FRRF #10
	15:55	6.23	02:30	46-53.53N	160-13.91E	PlanktonNet #2
	16:25		03:25	46-52.62N	160-12.62E	Drifting Primary Productivity & Sediment Trap #1 recovery
	18:57		05:57	46-57.33N	160-07.85E	CTD cast #2 (5186m)
	23:28		10:28	46-56.35N	160-07.49E	Free Fall #2
6.23	00:09	6.23	11:09	46-56.61N	160-07.10E	Large Volume Pump (LVP) cast #2
	07:00		18:00	46-56.44N	160-07.23E	PlanktonNet #3
	10:57		21:57	46-57.10N	160-09.95E	IONESS #1
	23:54	6.24	10:54	46-57.11N	160-03.99E	IONESS #2
6.24	03:26	6.24	14:26	46-56.62N	160-07.07E	CTD cast #3 (200m)
	06:59		17:59	46-56.81N	160-07.19E	PlanktonNet #4
	09:00		20:00	46-56.48N	160-07.78E	CTD cast #4 (50m)
	10:54		21:54	46-56.27N	160-07.24E	CTD cast #5 (50m)
	14:53	6.25	01:53	46-56.23N	160-07.07E	CTD cast #6 (50m)
	16:55		03:55	46-56.23N	160-06.96E	CTD cast #7 (50m)
	23:00		10:00	46-55.54N	160-10.66E	Free Fall #3
6.25	03:57	6.25	14:57	46-56.27N	160-07.18E	CTD cast #8 (200m)
	06:55		17:55	46-56.35N	160-07.18E	PlanktonNet #5
	10:58		21:58	46-55.30N	160-10.19E	IONESS #3
	14:00	6.26	01:00			Departure from Station K2
6.26	08:48	6.26	19:48			Arrival at Station KNOT
	09:03		20:03	44-01.00N	155-00.29E	CTD cast #9 (5296m)
	12:42		23:42			Departure from Station KNOT
	16:54	6.27	03:54			Arrival at Station M06022
	17:01		04:01	43-00.08N	155-00.73E	CTD cast #10 (5386m)
	20:48		07:48			Departure from Station M06022
6.27	00:54	6.27	11:54			Arrival at Station M06023
	01:00		12:00	42-00.43N	154-59.97E	Free Fall #4
	01:29		12:29	41-59.92N	155-00.30E	CTD cast #11 (5430m)
	05:21		16:21			Departure from Station M06023
	09:12		20:12			Arrival at Station M06024
	11:08		22:08	41-00.87N	155-00.37E	CTD cast #12 (5517m)

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
6.27	15:00	6.28	02:00	-	-	Departure from Station M06024
	19:18		06:18	-	-	Arrival at Station M06025
	19:19		06:19	40-00.50N	155-00.77E	CTD cast #13 (5549m)
6.28	23:10	6.28	10:10	40-01.32N	155-01.11E	Free Fall #5
	23:24		10:24	-	-	Departure from Station M06025
6.29	02:42	6.29	13:42	46-15.15N	159-37.32E	Free Fall #6
	05:54		16:54	-	-	Arrival at Station K2
	06:28		17:28	46-52.53N	160-07.09E	PlanktonNet #6
	15:29	6.30	02:29	46-52.26N	160-06.44E	CTD cast #14 (200m)
	16:51		03:51	46-52.28N	160-06.51E	Drifting Primary Productivity #2 deployment
	17:22		04:22	46-52.19N	160-07.15E	FRRF #11
	18:56		05:56	46-56.24N	160-07.10E	FRRF #12
	20:56		07:56	46-56.24N	160-07.10E	FRRF #13
	22:56		09:56	46-56.24N	160-07.10E	FRRF #14
	23:27		10:27	46-56.48N	160-08.03E	CTD cast #15 (200m)
6.30	00:27	6.30	11:27	46-56.43N	160-09.03E	Free Fall #7
	00:50		11:50	46-56.32N	160-09.66E	FRRF #15
	02:56		13:56	46-56.42N	160-07.38E	FRRF #16
	03:22		14:22	46-56.33N	160-07.49E	LVP cast #3
	05:27		16:27	46-55.82N	160-07.42E	FRRF #17
	06:56		17:56	46-56.00N	160-07.38E	PlanktonNet #7
	07:21		18:21	46-56.69N	160-07.48E	FRRF #18
	08:55		19:55	46-56.67N	160-07.20E	FRRF #19
	10:50		21:50	46-56.68N	160-07.16E	FRRF #20
	15:33	7.1	02:33	46-57.72N	160-12.15E	PlanktonNet #8
	17:00		04:00	46-55.14N	160-13.52E	Drifting Primary Productivity #2 recovery
	17:50		04:50	46-55.36N	160-13.98E	Drifting Sediment Trap #2 deployment
	19:58		06:57	46-56.33N	160-07.51E	PlanktonNet #9
	21:30		08:30	46-56.31N	160-06.93E	CTD cast #16 (200m)
7.1	01:53	7.1	12:53	46-56.53N	160-07.04E	PlanktonNet #10
	06:57		17:57	46-56.61N	160-07.45E	PlanktonNet #11
	08:55		19:55	46-56.51N	160-07.25E	PlanktonNet #12
	09:25		20:25	46-56.49N	160-07.82E	CTD cast #17 (50m)
	10:53		21:53	46-56.40N	160-07.46E	CTD cast #18 (50m)
	12:55		23:55	46-56.40N	160-07.29E	PlanktonNet #13
	13:25	7.2	00:25	46-56.67N	160-07.54E	CTD cast #19 (50m)
	14:54		01:54	46-56.41N	160-07.46E	CTD cast #20 (50m)
	16:52		03:52	46-56.44N	160-07.28E	CTD cast #21 (50m)
	21:53		08:53	46-56.42N	160-07.24E	CTD cast #22 (50m)
	23:42		10:42	46-56.36N	160-07.32E	Free Fall #8
7.2	00:28	7.2	11:28	46-56.12N	160-07.54E	LVP cast #4
	06:55		17:55	46-56.41N	160-07.32E	PlanktonNet #13
	17:58	7.3	04:58	46-56.96N	160-25.71E	Drifting Sediment Trap #2 recovery
	18:24		05:24	-	-	Departure from Station K2
7.4	20:24	7.5	07:24	-	-	Arrival at Station M06031
	20:58		07:58	34-59.83N	155-00.24E	CTD cast #23 (5648m)
7.5	00:52	7.5	11:52	34-59.77N	155-00.30E	Free Fall #9
	01:06		12:06	-	-	Departure from Station M06031
	05:12		16:12	-	-	Arrival at Station M06030
	05:14		16:14	35-58.89N	155-00.63E	CTD cast #24 (5463m)
	09:06		20:06	-	-	Departure from Station M06030
7.5	13:24	7.6	00:24	-	-	Arrival at Station M06029

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
7.5	13:30	7.6	00:30	37-00.54N	154-59.68E	CTD cast #25 (5661m)
	17:24		04:24	-	-	Departure from Station M06029
	21:24		08:24	-	-	Arrival at Station M06028
	21:30		08:30	38-00.30N	154-59.96E	CTD cast #26 (6003m)
7.6	01:35	7.6	12:35	38-00.66N	155-00.12E	Free Fall #10
	01:54		12:54	-	-	Departure from Station M06028
	02:55		13:55	38-14.7N	155-00.40E	Calibration for magnetometer
						Arrival at Station M06027
	06:07		17:07	39-00.61N	155-00.04E	CTD cast #27 (5785m)
	10:06		21:06	-	-	Departure from Station M06027
7.7	20:57	7.8	07:00	-	-	Arrival at Station K2
	22:57		09:57	46-53.71N	160-06.44E	CTD cast #28 (200m)
	23:59		10:59	46-54.20N	160-06.15E	Free Fall #11
7.8	01:52	7.8	12:52	46-56.56N	160-07.21E	LVP cast #5
	06:55		17:55	46-56.26N	160-06.98E	PlanktonNet #15
	08:58		19:58	46-56.49N	160-07.09E	CTD cast #29 (50m)
	10:56		21:56	46-56.49N	160-07.13E	CTD cast #30 (50m)
	12:55		23:55	46-56.42N	160-07.05E	CTD cast #31 (50m)
	14:57	7.9	01:57	46-56.54N	160-07.15E	CTD cast #32 (50m)
	15:31		02:31	46-56.41N	160-06.76E	CTD cast #33 (200m)
	16:47		03:47	46-52.20N	160-06.29E	Drifting Primary Productivity deployment #3
	17:26		04:26	46-52.90N	160-06.33E	CTD cast #34 (50m)
	18:55		05:55	46-56.38N	160-07.06E	FRRF #21
	20:55		07:55	46-56.41N	160-07.26E	FRRF #22
	22:54		09:54	46-56.38N	160-07.31E	FRRF #23
7.9	00:55	7.9	11:55	46-56.47N	160-07.17E	FRRF #24
	02:53		13:53	46-56.35N	160-06.96E	FRRF #25
	04:55		15:55	46-65.37N	160-06.99E	FRRF #26
	06:55		17:55	46-56.46N	160-07.18E	PlanktonNet #16
	07:19		18:19	46-56.29N	160-06.94E	FRRF #27
	08:54		19:54	46-56.34N	160-07.06E	FRRF #28
	10:52		21:52	46-56.36N	160-07.11E	FRRF #29
	16:00	7.10	03:00	46-48.05N	160-07.35E	PlanktonNet #17
	17:04		04:04	46-49.01N	160-08.00E	Drifting Primary Productivity recovery #3
	17:32		04:32	46-49.00N	160-08.00E	Drifting Sediment Trap deployment #3
	21:00		08:00	46-56.27N	160-07.92E	CTD cast #35 (200m)
	22:56		09:56	46-55.12N	160-07.10E	Free Fall #12
7.10	00:05	7.10	11:05	46-54.32N	160-06.27E	IONESS #4
	06:54		17:54	46-56.44N	160-07.20E	PlanktonNet #18
	10:53		21:53	46-52.89N	160-09.10E	IONESS #5
	21:00	7.11	08:00	46-56.27N	160-06.76E	CTD cast #36 (200m)
	23:55		10:55	46-56.31N	160-07.64E	Free Fall #13
7.11	00:25	7.11	11:25	46-56.28N	160-07.57E	LVP cast #6
	06:55		17:55	46-54.40N	160-08.00E	PlanktonNet #19
	10:54		21:54	46-57.39N	160-11.11E	IONESS #6
	20:57	7.12	07:57	46-45.51N	160-17.24E	Drifting Sediment Trap recovery #3
	21:54		08:54	46-45.08N	160-17.86E	PlanktonNet #20
7.12	00:03	7.12	11:03	46-57.72N	160-10.44E	IONESS #7
	02:48		13:48	-	-	Departure from Station K2
	23:30	7.13	10:30	-	-	Arrival at Station KNOT
7.13	05:18	7.13	16:18	-	-	Departure from Station K2

U.T.C.		S.M.T.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
7.13	11:48		20:48	-	-	Arrival at Station M06037
	21:00	7.14	08:00	44-29.97N	155-50.53E	CTD cast #37 (5090m)
7.14	00:38	7.14	11:38	44-30.43N	155-50.90E	Free Fall #14
	00:54		11:54	-	-	Departure from Station M06037
	04:00		15:00	-	-	Arrival at Station M06036
	04:05		15:05	44-59.93N	156-40.47E	CTD cast #38 (4854m)
	07:36		18:36	-	-	Departure from Station M06036
	10:42		21:42	-	-	Arrival at Station M06035
	10:43		21:43	45-30.19N	157-30.32E	CTD cast #39 (4937m)
	14:12	7.15	01:12	-	-	Departure from Station M06035
	23:18		10:18	-	-	Arrival at Station K2
	23:28		10:28	46-56.62N	160-07.26E	Free Fall #15
	23:52		10:52	46-56.43N	160-07.49E	CTD cast #40 (5200m)
7.15	03:47	7.15	14:47	46-56.26N	160-07.19E	LVP cast #7
	06:56		17:56	46-56.46N	160-07.29E	PlanktonNet #21
	20:55	7.16	07:55	46-51.71N	159-59.68E	POPPS mooring recovery
	23:58		10:58	46-52.43N	160-02.06E	Free Fall #16
7.16	00:19	7.16	11:19	46-52.43N	160-02.19E	CTD cast #41 (200m)
	08:03		19:03	46-56.00N	160-10.56E	PlanktonNet #22
	15:26	7.17	02:26	46-52.07N	160-06.41E	CTD cast #42 (200m)
	16:46		03:46	46-52.26N	160-06.26E	Drifting Primary Productivity & Sediment Trap deployment #4
	17:31		04:31	46-52.08N	160-05.56E	FRRF #30
	18:57		05:57	47-00.53N	159-59.74E	FRRF #31
	20:58		07:58	47-00.70N	159-59.17E	BGC mooring recovery
7.17	00:08	7.17	11:08	47-00.14N	160-04.34E	FRRF #32
	01:59		12:59	46-56.30N	160-07.08E	Free Fall #17
	02:25		13:25	46-55.96N	160-07.05E	CTD cast #43 (200m)
	03:18		14:18	46-55.43N	160-07.42E	FRRF #33
	04:56		15:56	46-56.20N	160-07.28E	FRRF #34
	06:57		17:57	46-56.32N	160-07.10E	PlanktonNet #23
	07:21		18:21	46-56.19N	160-06.97E	FRRF #35
	08:53		19:53	46-56.54N	160-07.05E	FRRF #36
	09:21		20:21	46-55.96N	160-07.04E	CTD cast #44 (50m)
	10:51		21:51	46-56.25N	160-07.35E	FRRF #37
	11:17		22:17	46-56.35N	160-07.22E	CTD cast #45 (50m)
	12:56		23:56	46-56.45N	160-07.19E	CTD cast #46 (50m)
	14:56	7.18	01:56	46-56.42N	160-07.47E	CTD cast #47 (50m)
	17:01		04:01	-	-	Drifting Primary Productivity & Sediment Trap recovery #4
	17:36		04:36	-	-	Departure at Station K2
	21:00		08:00	-	-	Arrival at Station M06033
	21:00		08:00	46-29.66N	159-10.06E	CTD cast #48 (5122m)
7.18	00:28	7.18	11:28	46-29.01N	159-09.38E	Free Fall #18
	00:48		11:48	-	-	Departure at Station M06033
	03:42		14:42	-	-	Arrival at Station M06034
	03:48		14:48	46-0.85N	158-19.70E	CTD cast #49 (4882m)
	07:30		18:30	-	-	Departure at Station M06034
	20:12	7.19	07:12	-	-	Arrival at Station KNOT
	20:13		07:13	44-00.01N	154-59.42E	CTD cast #50 (5290m)
	23:52		10:52	44-00.18N	154-59.16E	Free Fall #19
7.19	00:06	7.19	11.06	-	-	Departure at Station KNOT
7.20	02:02	7.20	13:02	40-09.61N	149-24.74E	Calibration for magnetometer
7.25	00:00	7.25	09:00			Arrival at Sekinehama

1.3 List of participant

Leg.		Name	Affiliation	Appointment	Tel
1	2				
○	○	Makio Honda (PI)	JAMSTEC MIO	Sub Leader	
○		Kazuhiko Matsumoto （Leg.1　Deputy PI）	Same as above	Researcher	
○		Hajime Kawakami	Same as above	Same as above	
○	○	Masahide Wakita （Leg.2 Deputy PI）	Same as above	Same as above	
	○	Yoshiyuki Nakano	Same as above	Same as above	
	○	Tetsuichi Fujiki	Same as above	Same as above	
○	○	Minoru Kitamura	JAMSTEC XBR	Same as above	
○		Masashi Tsuchiya	JAMSTEC IFREE	Same as above	
○		Atsushi Kurasawa	JAMSTEC IFREE	Graduated student	
○	○	Suguru Okamoto	Hokkaido Univ.	Graduated student	
○		Kazuhiko Ohishi	Same as above	Same as above	
	○	Takushi Hosaka	Nagoya Univ.	Technician	
	○	Vedula V. S. S. Sarma	Same as above	Researcher	
○		Tetsuya Nakamura	Nichiyu Giken Kogyo	Technician	
○		Satoshi Ozawa (Leg.1 Principal Marine Technician)	Marine Works Japan （MWJ）	Marine Technician	
○		Hirokatsu Uno	Same as above	Same as above	
○	○	Akinori Murata	Same as above	Same as above	
○		Tatsuya Tanaka	Same as above	Same as above	
○		Taiki Ushiromura	Same as above	Same as above	
○	○	Toru Idai	Same as above	Same as above	
○	○	Fuyuki Shibata	Same as above	Same as above	
○	○	Katsunori Sagishima	Same as above	Same as above	
○	○	Ai Yasuda	Same as above	Same as above	
○	○	Minoru Kamata (Leg.2 Principal Marine Technician)	Same as above	Same as above	
○		Takayoshi Seike	Same as above	Same as above	
○	○	Junko Hamanaka	Same as above	Same as above	
○	○	Yuishi Sonoyama	Same as above	Same as above	
○		Masanori Enoki	Same as above	Same as above	
○		Yoshiko Ishikawa	Same as above	Same as above	
○	○	Kimiko Nishijima	Same as above	Same as above	
○		Junji Matsushita	Same as above	Same as above	
○	○	Miyo Ikeda	Same as above	Same as above	
○	○	Ayaka Hatsuyama	Same as above	Same as above	
	○	Naoko Takahashi	Same as above	Same as above	
	○	Tomoyuki Takamaori	Same as above	Same as above	
	○	Shinsuke Toyoda	Same as above	Same as above	

	○	Tomohide Nogucji	Same as above	Same as above	
	○	Hidekii Yamamoto	Same as above	Same as above	
	○	Ken-ichiro Sato	Same as above	Same as above	
	○	Masaki Moro	Same as above	Same as above	
	○	Ayumi Takeuchi	Same as above	Same as above	
○	○	Daiji Komura	Same as above	Assistant MT	
	○	Kosuke Okudaira	Same as above	Same as above	
○	○	Katsunori Maeno (Leg.1,Principal MT)	Global Ocean Development（GODI）	Marine Technician	045-849-6630
○		Ryo Ohyama	Same as above	Same as above	Same as above
	○	Norio Nagahama	Same as above	Same as above	Same as above

2. General observation

2.1 Meteorological observation

2.1.1 Surface Meteorological Observation

Katsuhisa MAENO (Global Ocean Development Inc.) -Leg1 ,2-
Ryo OHYAMA (Global Ocean Development Inc.) -Leg1-
Norio NAGAHAMA (Global Ocean Development Inc.) -Leg2-
Kunio YONEYAMA (JAMSTEC) Not on-board

(1) Objectives

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

(2) Methods

The surface meteorological parameters were observed throughout the MR06-03 cruise from Sekinehama on 26 May 2006 to Sekinehama on 25 Jul 2006. During this cruise, we used two systems for the observation.

1) MIRAI Surface Meteorological observation (SMET) system
2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

1) MIRAI Surface Meteorological observation (SMET) system

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

2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

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

i) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
ii) Zeno Meteorological (Zeno/Met) system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.
iii) Scientific Computer System (SCS) designed by NOAA (National Oceanic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets.

SCS recorded PRP data every 6 seconds, Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table 2.1.1-3 and measured parameters are listed in Table 2.1.1-4.

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

a) Young Rain gauge (SMET and SOAR)

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

b) Barometer (SMET and SOAR)

Comparing with the portable barometer value, PTB220 VAISALA.

c) Thermometer (air temperature and relative humidity) (SMET and SOAR)

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

(3) Preliminary results

Figures 2.1.1-1 show the time series of the following parameters; Wind (SOAR), air temperature (SOAR), relative humidity (SOAR), precipitation (SOAR), short/long wave radiation (SOAR), pressure (SOAR), sea surface temperature (SMET) and significant wave height (SMET).

(4) Data archives

The raw data obtained during this cruise will be submitted to JAMSTEC. Corrected data sets will also be available from K. Yoneyama of JAMSTEC.

(5) Remarks

1) Sensor trouble for SOAR air temperature measurement had occurred on 2 July and temperature data may not be available after that. Information on this trouble will be updated and noted later by K. Yoneyama.
2) Sea surface temperature is not acquired from 10:00UTC 27 May to 00:30UTC 16 June, from 09:00UTC 19 Jun to 04:50UTC 19 July because we stopped pumping up surface water.

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

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side and port side
Thermometer: SST	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m) weather observation room
Rain gauge	50202	R. M. Young, USA	compass deck (19 m)
Optical rain gauge	ORG-815 DR	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table 2.1.1-2 Parameters of MIRAI Surface Meteorological observation system

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

Table 2.1.1-3 Instrument and installation locations of SOAR system

Sensors (*Zeno/Met*)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (24 m)
Barometer	61202V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (24 m)
Rain gauge	50202	R. M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-815DA	Osi, USA	foremast (24 m)

Sensors (*PRP*)	Type	Manufacturer	Location (altitude from surface)
Radiometer (short wave)	PSP	Eppley Labs, USA	foremast (25 m)
Radiometer (long wave)	PIR	Eppley Labs, USA	foremast (25 m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25 m)

Table 2.1.1-4 Parameters of SOAR system

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

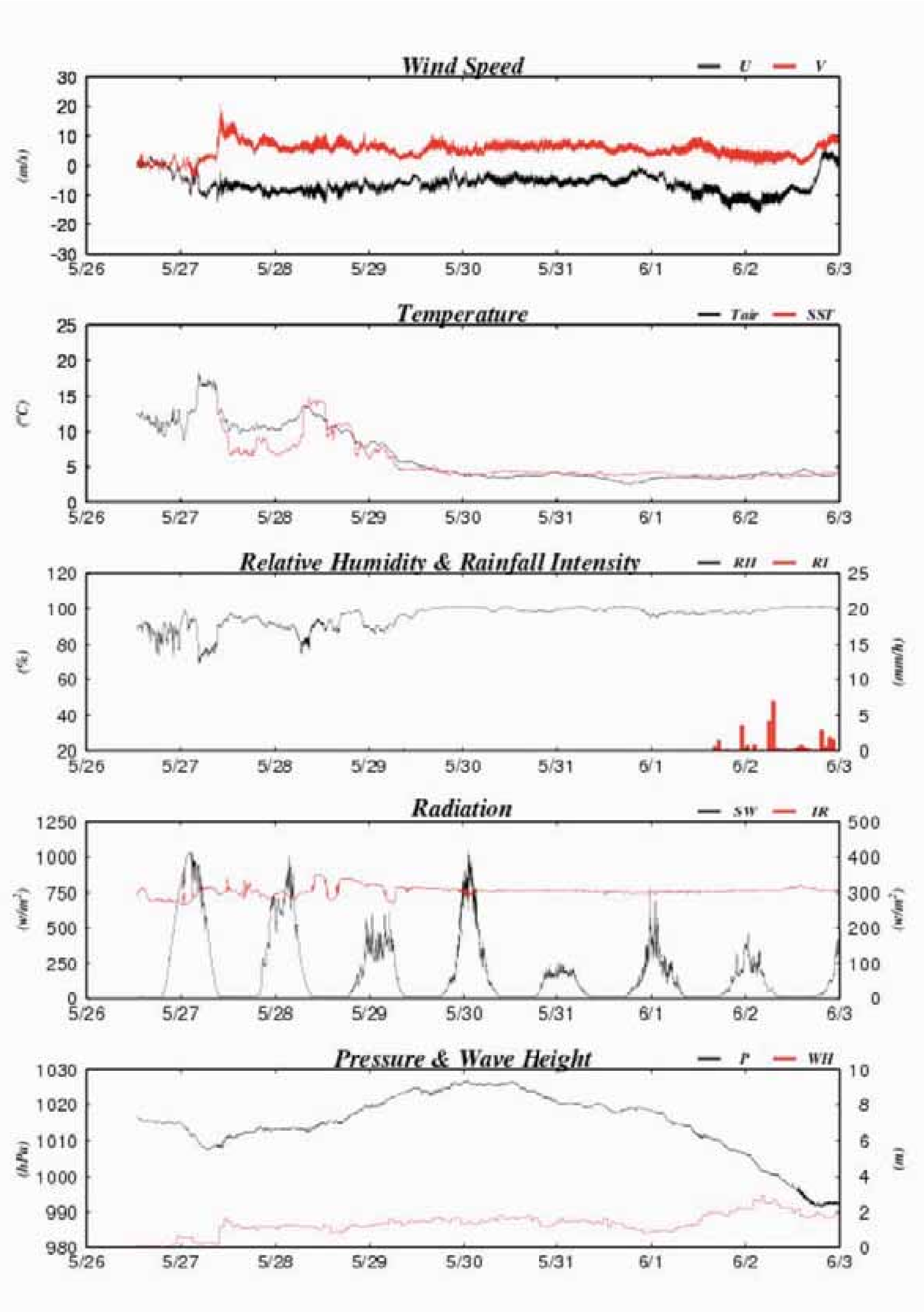


Fig.2.1.1-1 Time series of surface meteorological parameters during the cruise

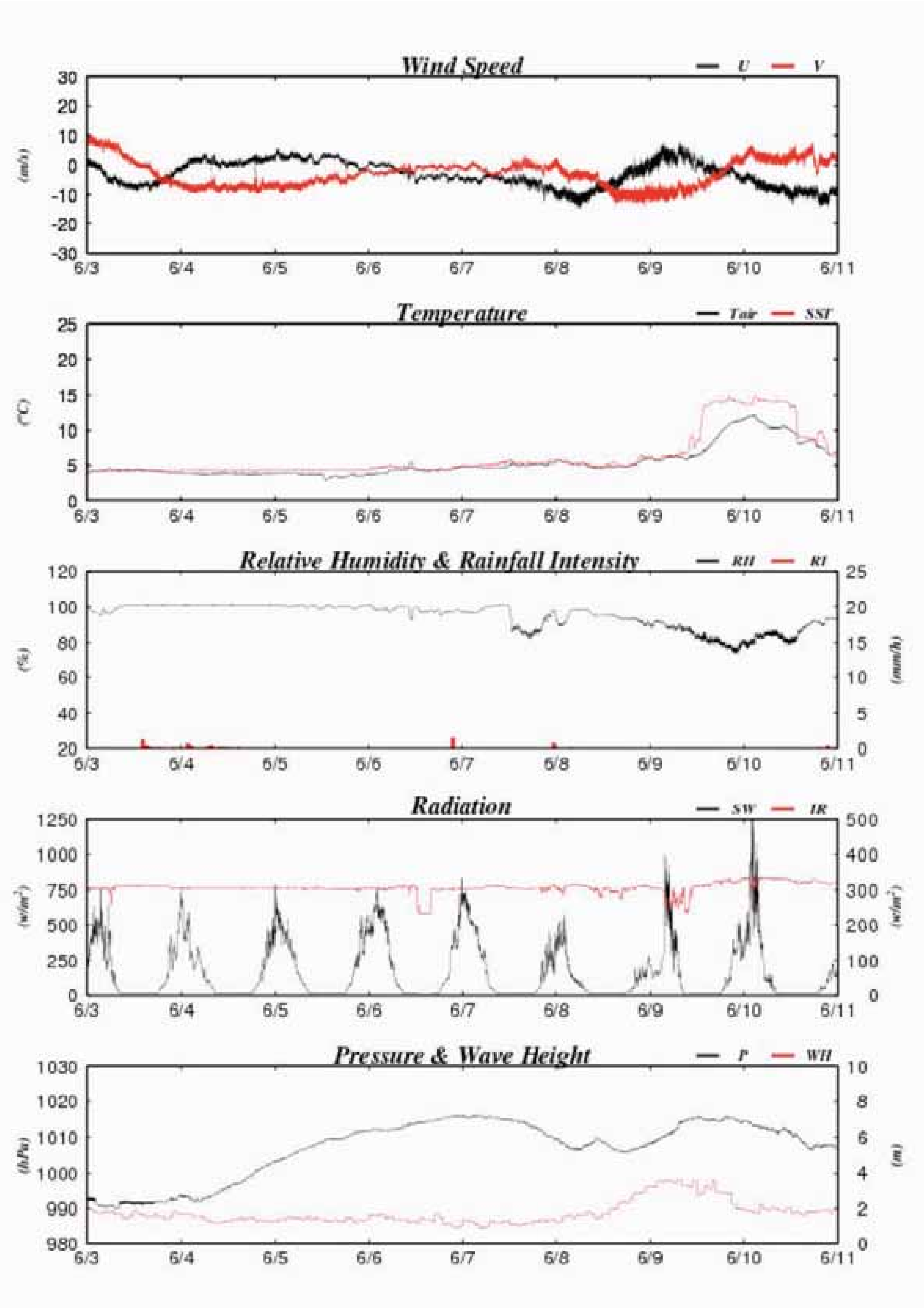


Fig.2.1.1-1 continued

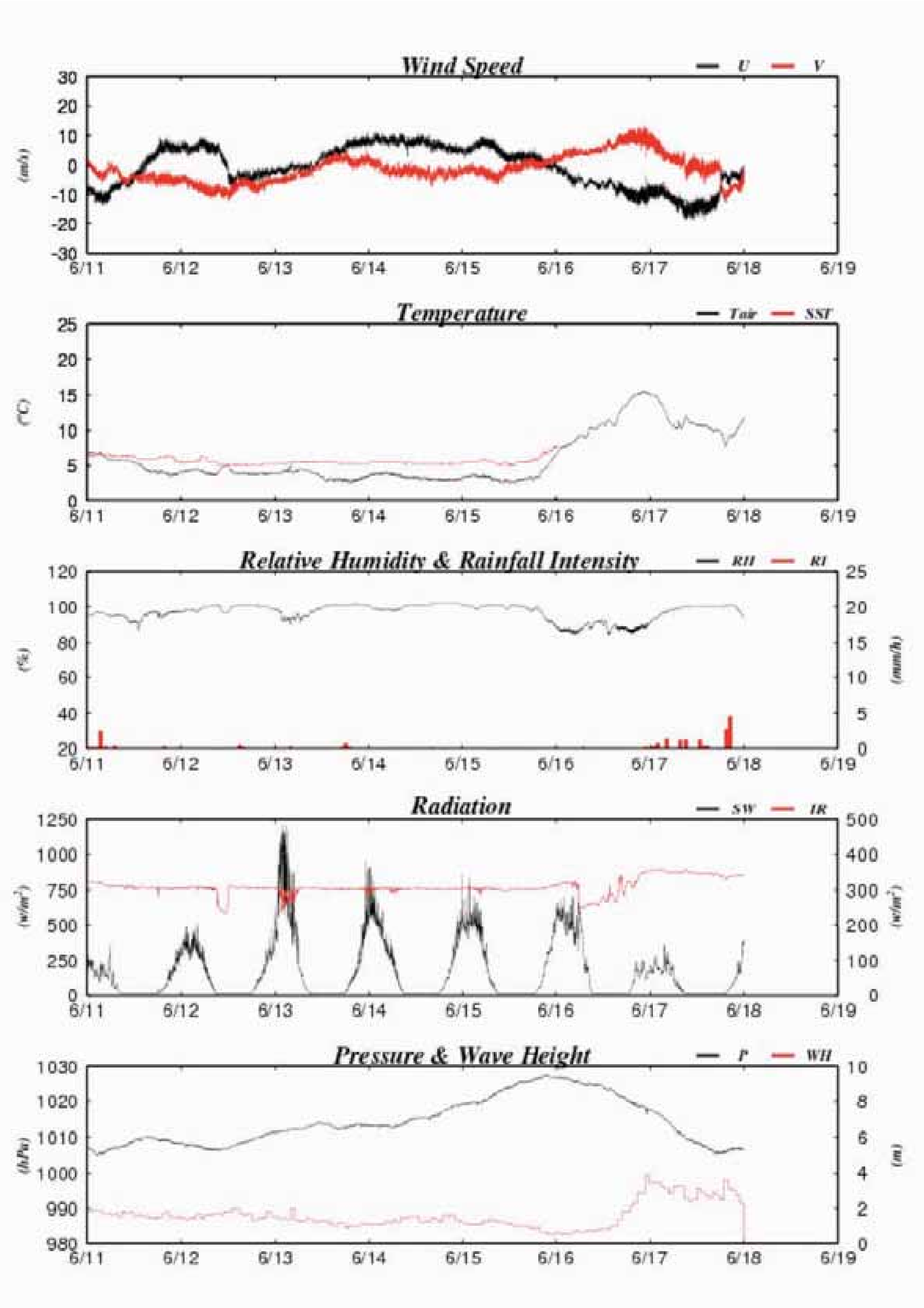


Fig.2.1.1-1 continued

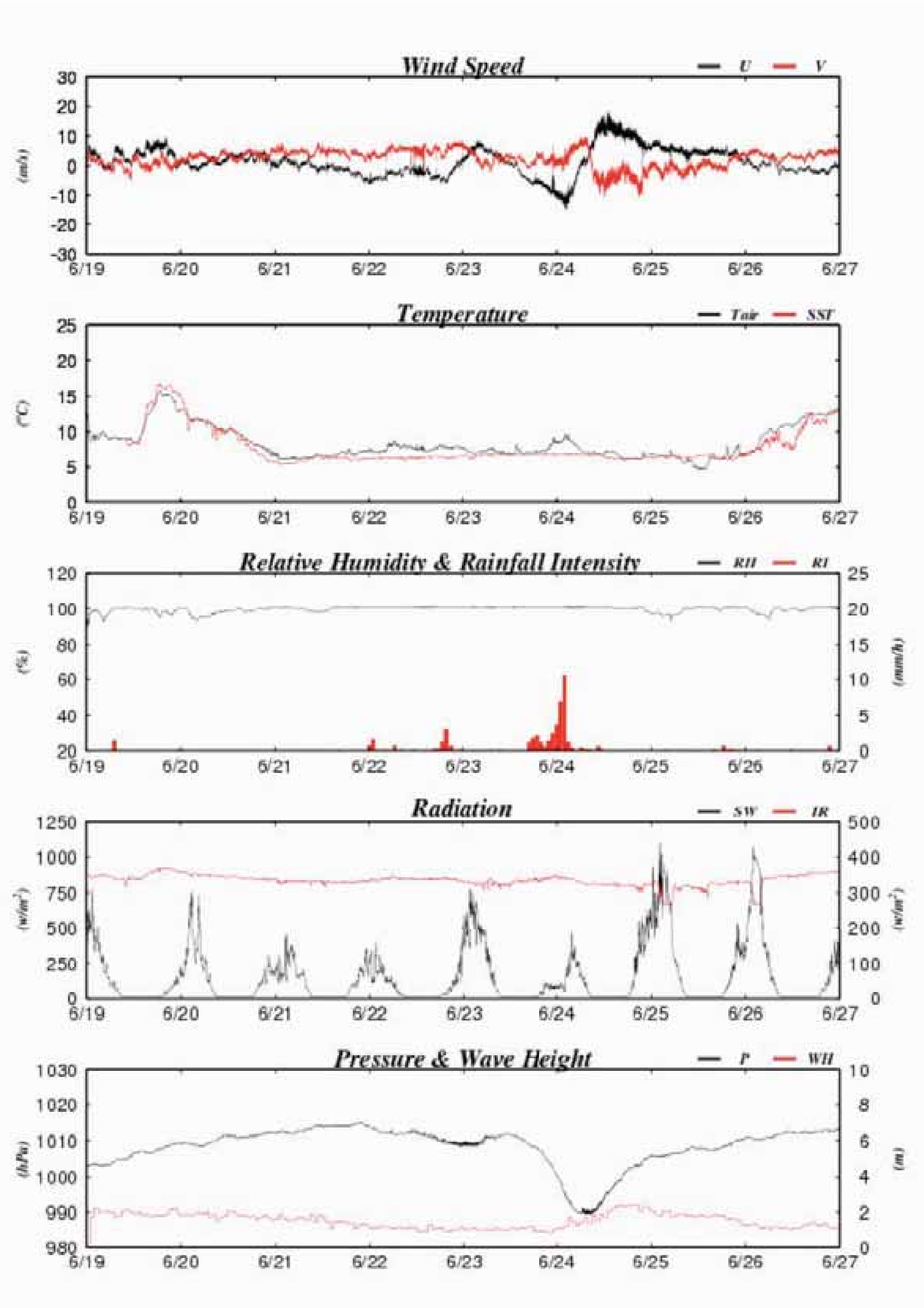


Fig.2.1.1-1 continued

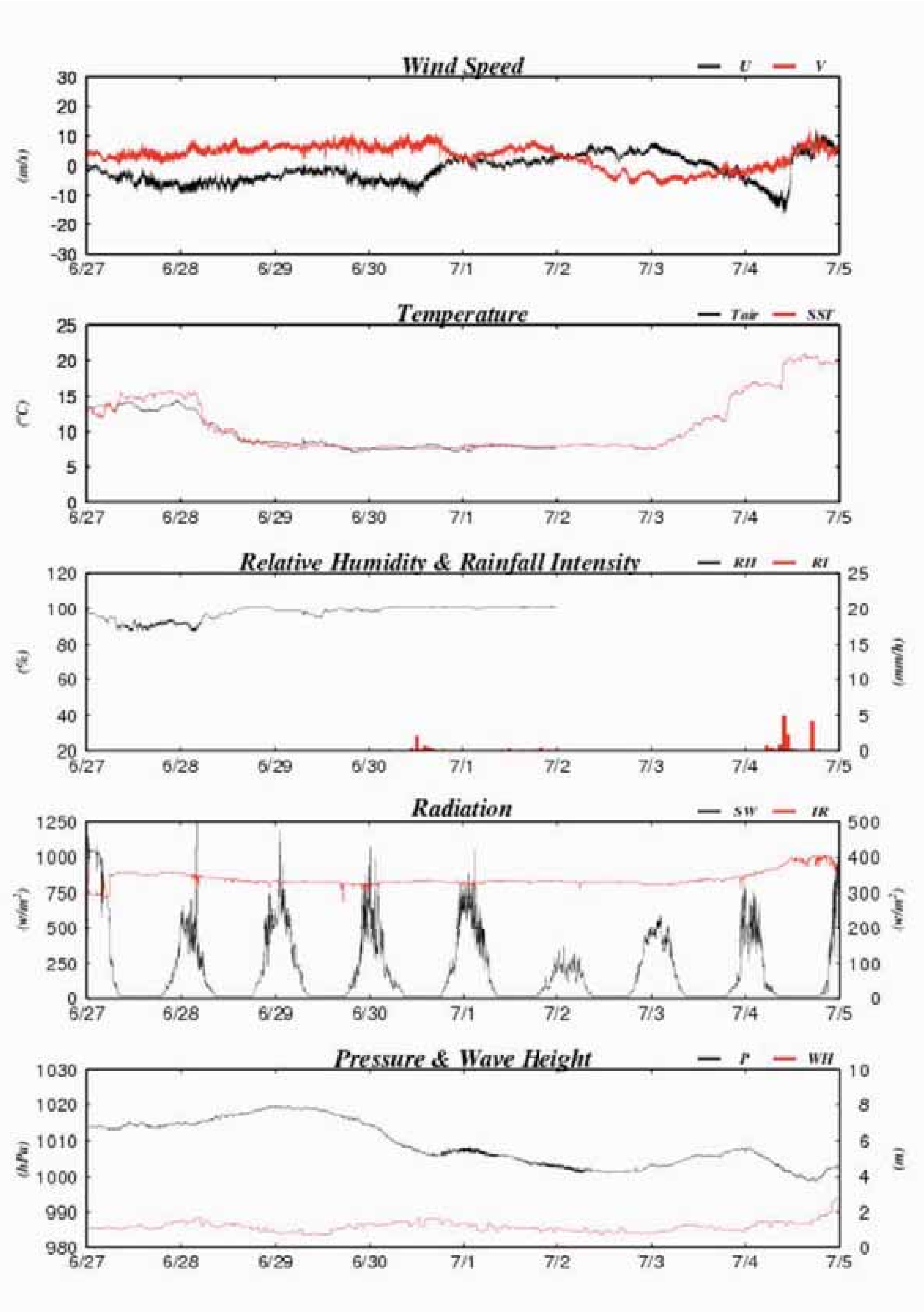


Fig.2.1.1-1 continued

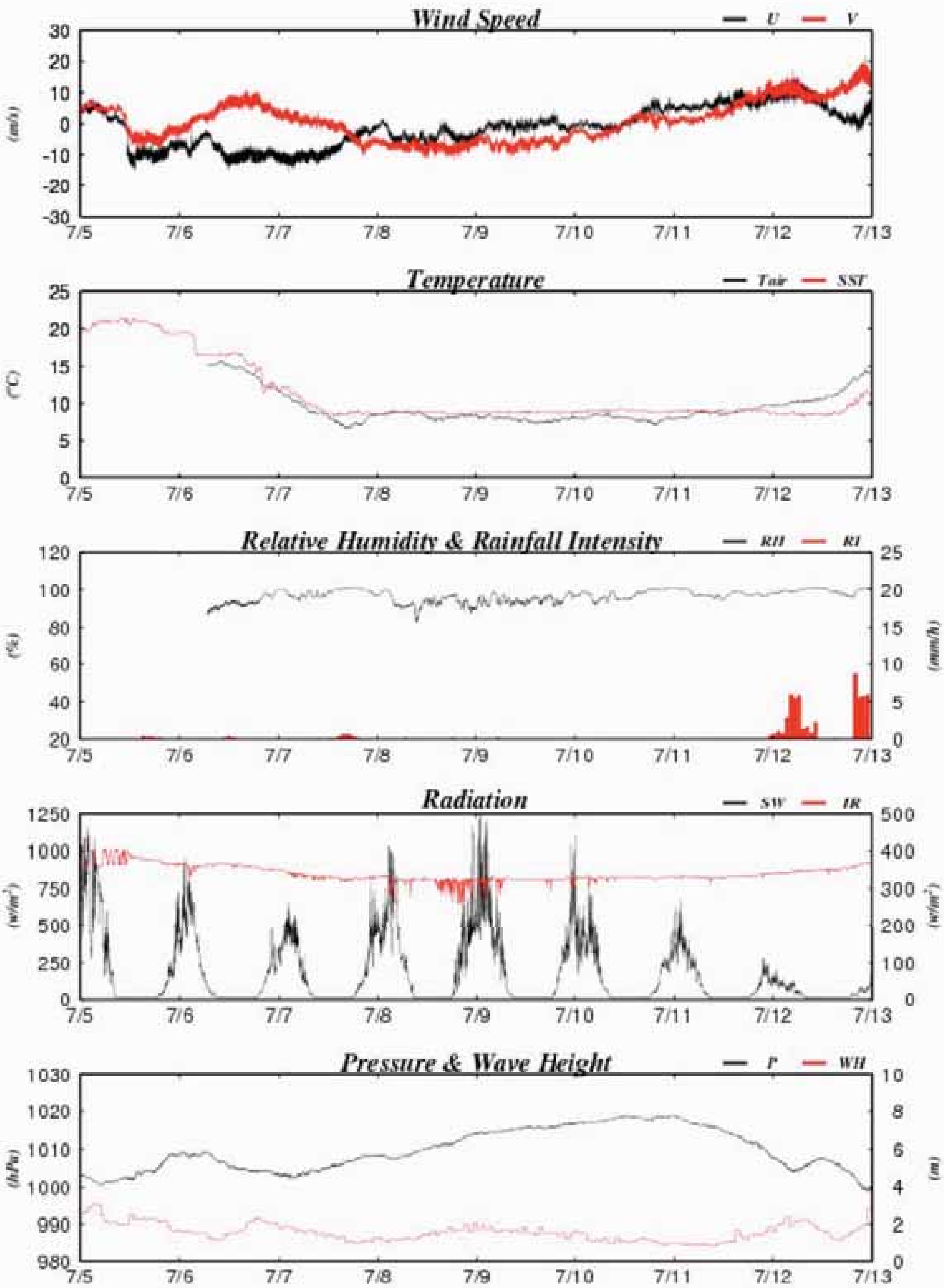


Fig.2.1.1-1 continued

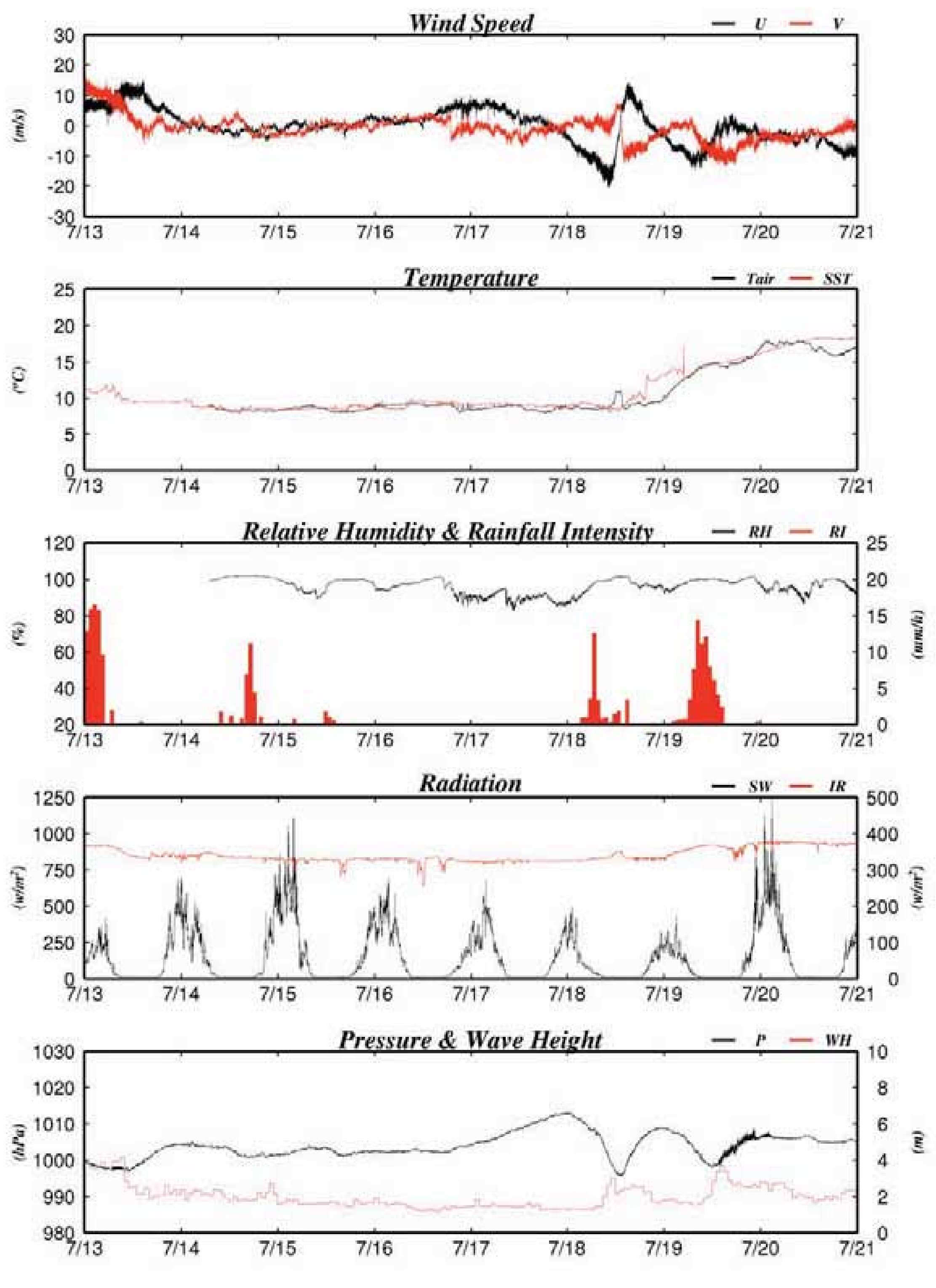


Fig.2.1.1-1 continued

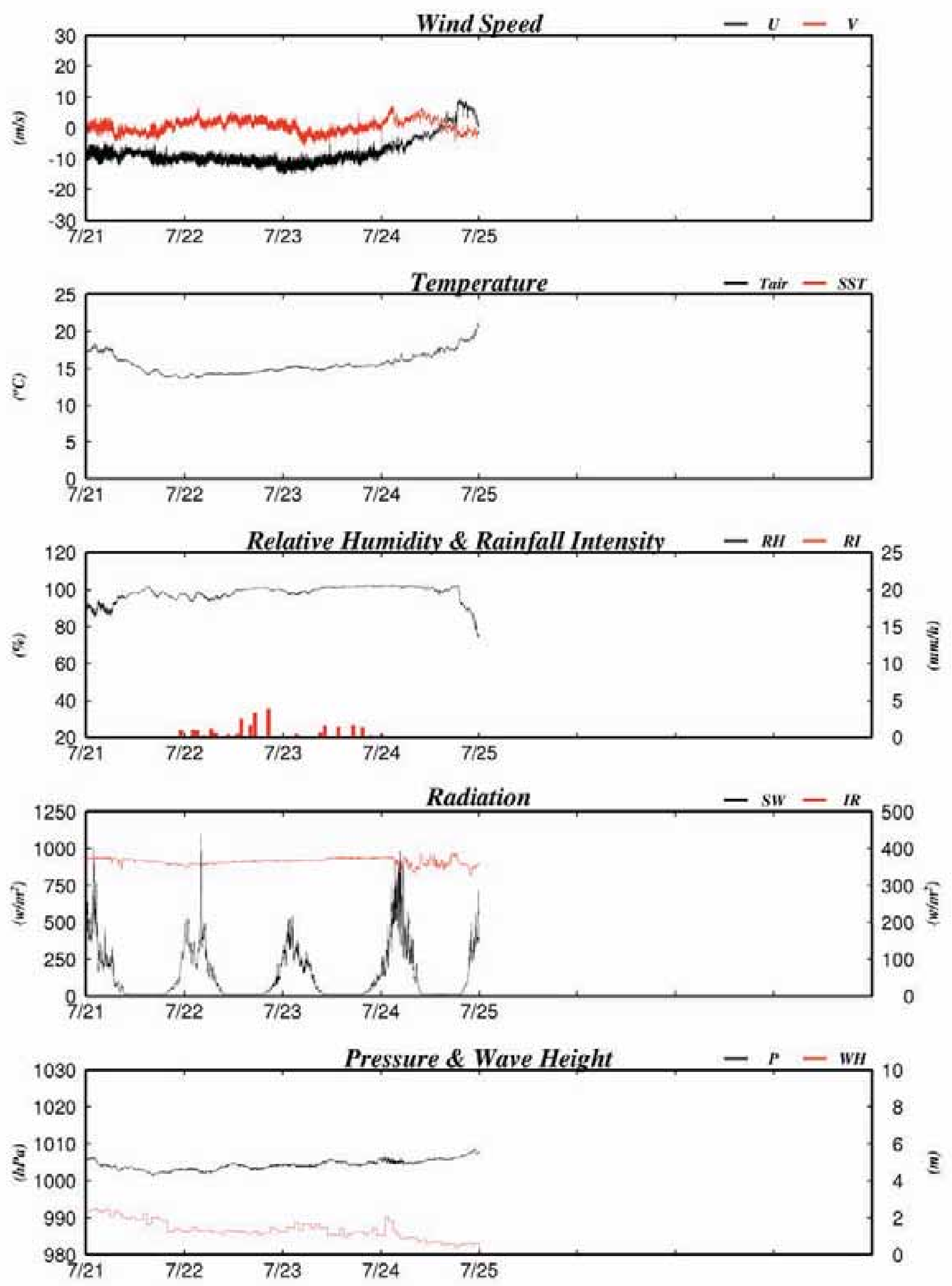


Fig.2.1.1-1 continued

2.1.2 Ceilometer Observation

Katsuhisa MAENO (Global Ocean Development Inc.) -Leg1,2-
Ryo OHYAMA (Global Ocean Development Inc.) -Leg1-
Norio NAGAHAMA (Global Ocean Development Inc.) -Leg2-

(1) Objectives

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

(2) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR06-03 cruise from Sekinehama on 26 May 2006 to Sekinehama on 25 July 2006. Major parameters to be measured are 1) cloud base height in meters, 2) backscatter profiles, and 3) estimated cloud amount in octas.

Specifications of the system are as follows.

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

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

(3) Preliminary results

Figure 2.1.2-1 shows the time series of the first and second lowest cloud base height.

(4) Data archives

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

(5) Remarks

Window cleaning : 2 Jun. 2006 23:20 UTC / 11 Jun. 2006 00:44 UTC / 18 Jun. 2006 02:55UTC / 8 Jul. 2006 20:20UTC / 13 Jul. 2006 20:20UTC

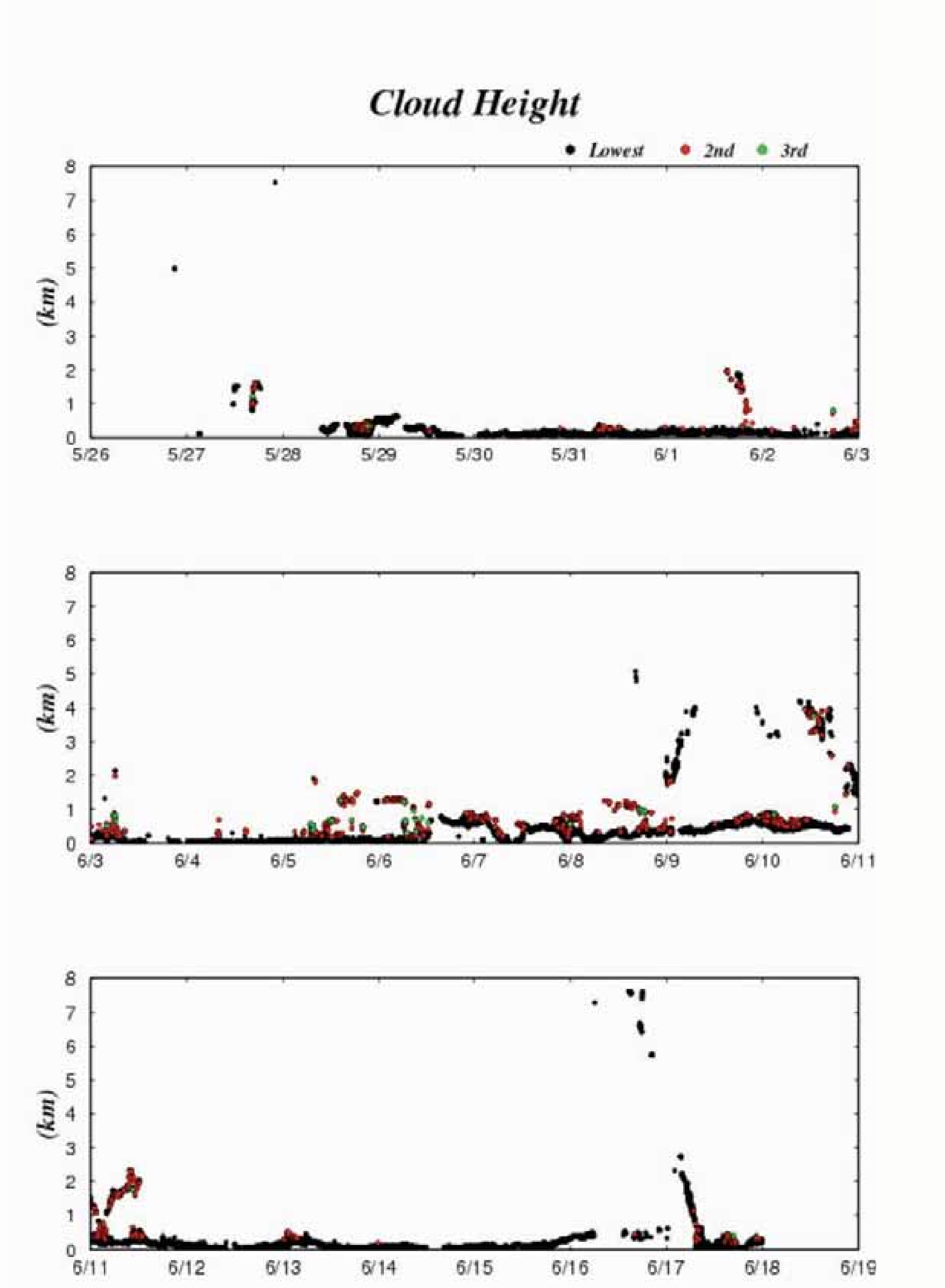


Fig.2.1.2-1 1st, 2nd and 3rd lowest cloud base height during MR06-03 cruise.

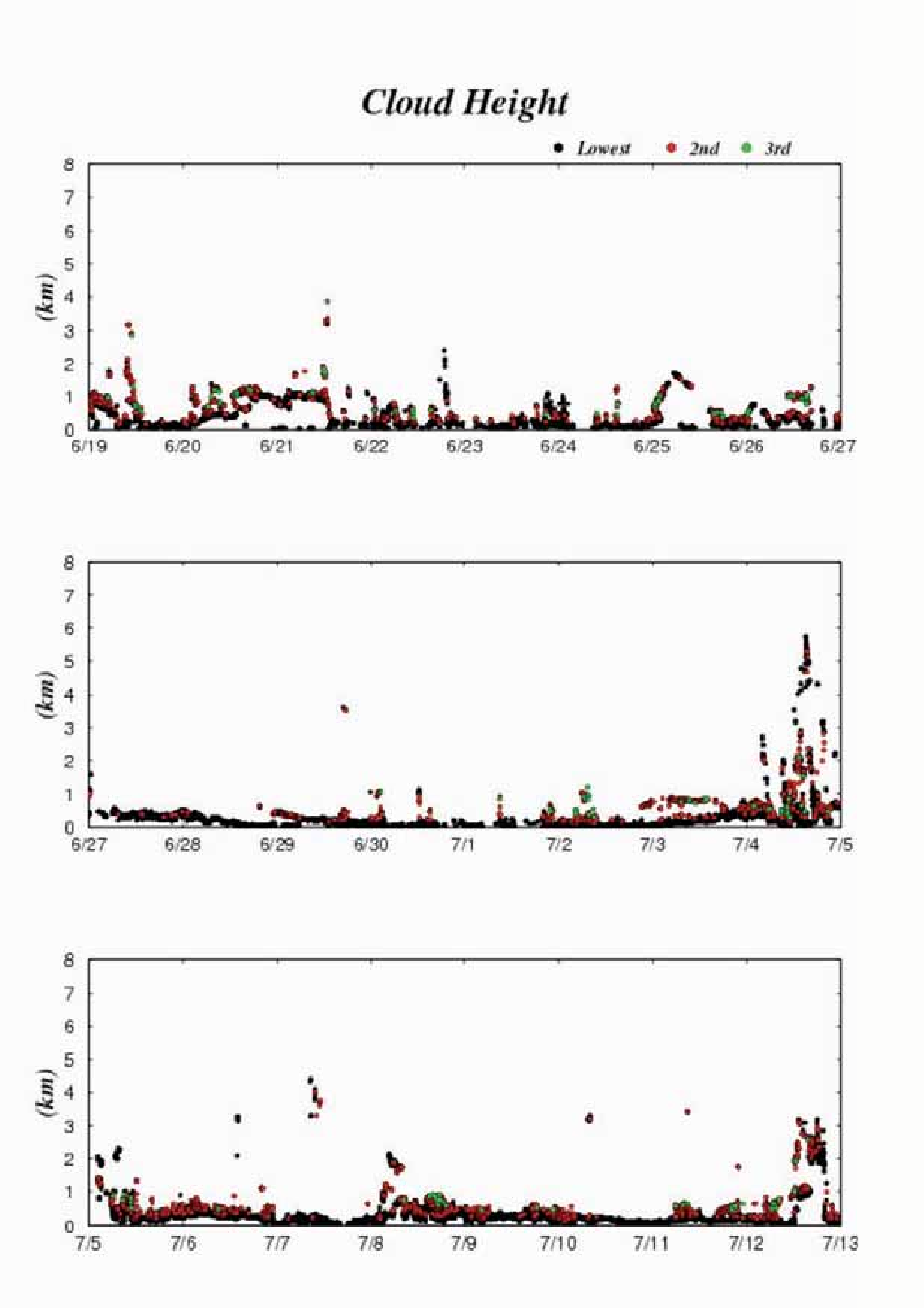


Fig.2.1.2-1 continued

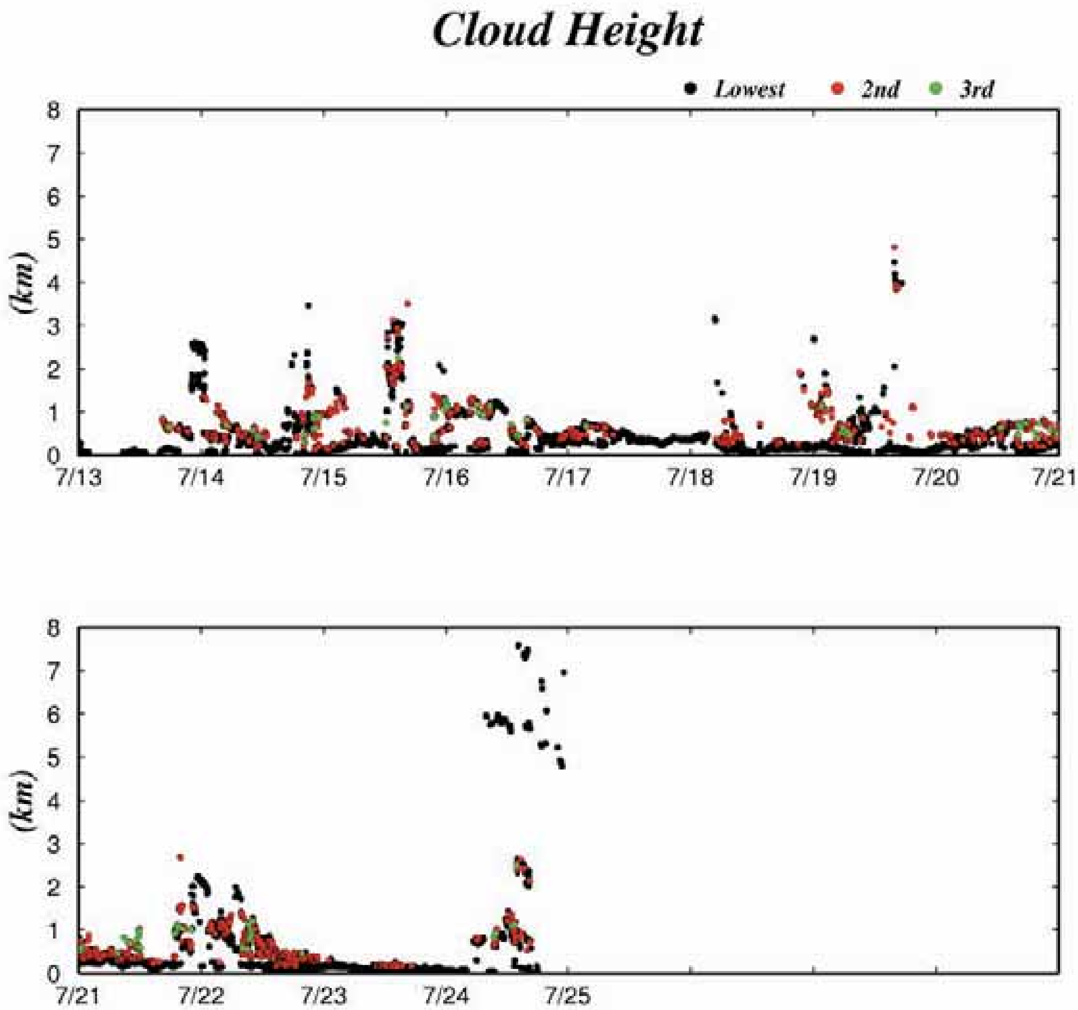


Fig.2.1.2-1 continued

2.1.3 Aerosol optical characteristics measured by Sky radiometer

Kazuma AOKI (University of Toyama) Associate Professor / not on board
Tatsuo ENDOH (Tottori University of Environmental Studies) Professor / not onboard
Tamio TAKAMURA (CEReS, Chiba University) Professor / not onboard
Teruyuki NAKAJIMA (CCSR, The University of Tokyo) Professor / not onboard
Nobuo SUGIMOTO (NIES) Chief Research Scientist / not onboard
Operation was supported by Global Ocean Development Inc. (GODI).

(1) Objective

Objective of the observations in this aerosol is to study distribution and optical characteristics of marine aerosols by using a sky radiometer (POM-01 MKII). Furthermore, collections of the data for calibration and validation to the remote sensing data were performed simultaneously

(2) Measured parameters

- Aerosol optical thickness at 5 wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at 5 wavelengths
- Size distribution of volume (0.01 μm – 20 μm)

GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of sun. Horizon sensor provides rolling and pitching angles.

(3) Methods

Sky radiometer is measuring the direct solar irradiance and the solar aureole radiance distribution, has seven interference filters. Analysis of these data is performed by SKYRAD.pack version 4.2 developed by Nakajima *et al*. 1996.

(4) Results

Data obtained in this cruise will be analyzed at University of Toyama.

(5) Data Archives

Measurements of aerosol optical data are not archived so soon and developed, examined, arranged and finally provided as available data after a certain duration. All data will archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) and Chiba University (T.Takamura, SKYNET) after the quality check and submitted to JAMSTEC within 3-year.

2.1.4 Lidar observations of clouds and aerosols

Nobuo SUGIMOTO (National Institute for Environmental Studies, not on board),
Ichiro MATSUI (NIES, not on board)
Atsushi SHIMIZU (NIES, not on board)
Operation was supported by GODI.

(1) Objectives

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

(2) Measured parameters

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

(3) Method

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

(4) Results

Although data obtained in this cruise has not been analyzed, lower clouds and fog were very frequently appeared and laser light could not penetrate into middle and upper troposphere. Quick-look figures of backscattering intensity at 532 nm , depolarization ratio at 532 nm and ratio of backscattering intensities between 1064 nm and 532 nm are shown in Fig. 1-3. Whity area in time-height indications mean that laser light did not reach the region and lidar did not detect any meaningful signals. Lower cloud structure were observed on several days including June 8 – June 12. Surface marine aerosol layer was clearly seen on June 16, and July 5.

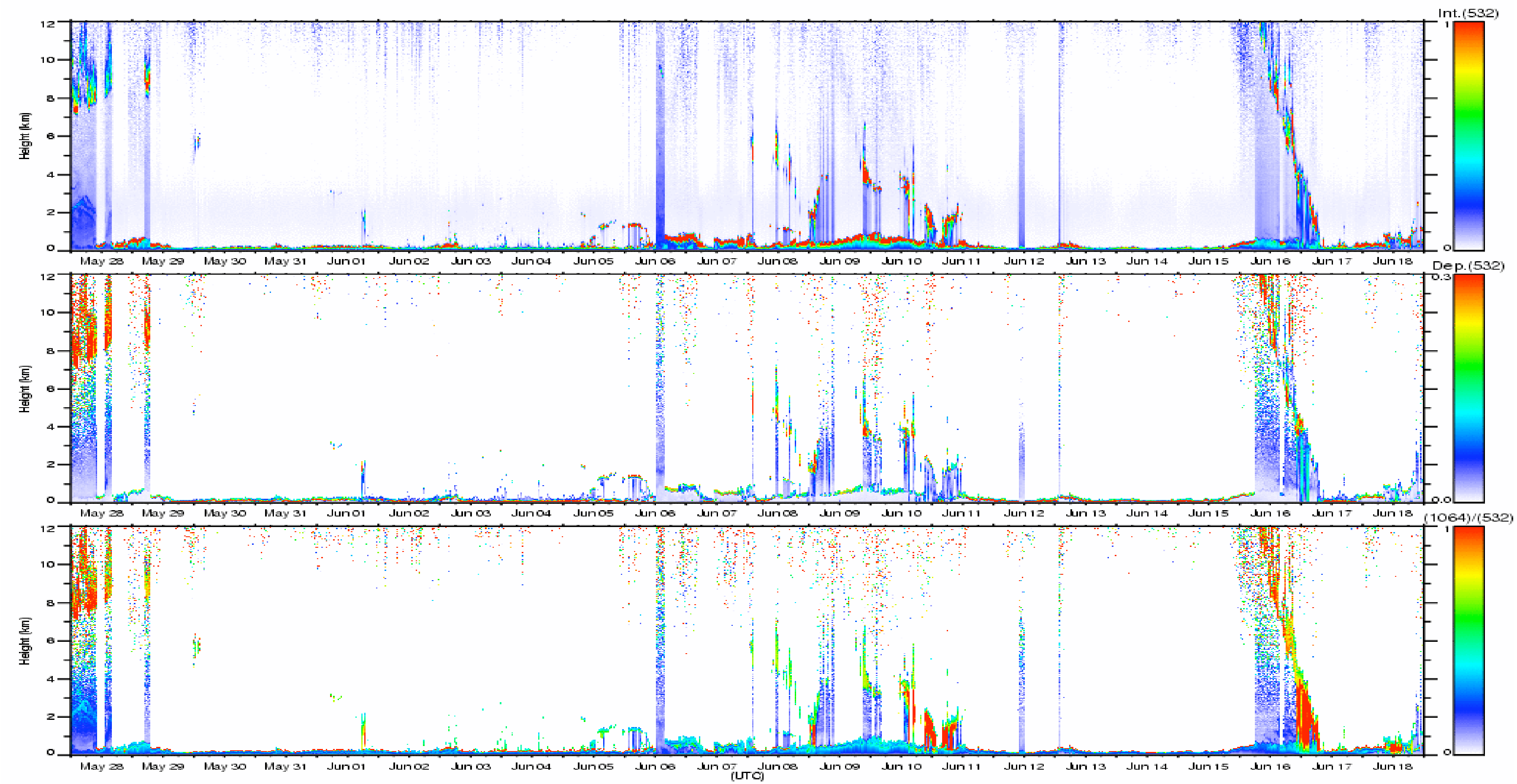


Figure 1 Time-height indications of backscattering intensity at 532 nm (top), depolarization ratio at 532 nm (middle), and ratio of backscattering intensities between 1064 nm and 532 nm (bottom), during MR06-03 leg 1. Depolarization ratio is a measure of non-sphericity of particles, and ratio of two wavelengths is a measure of particle size.

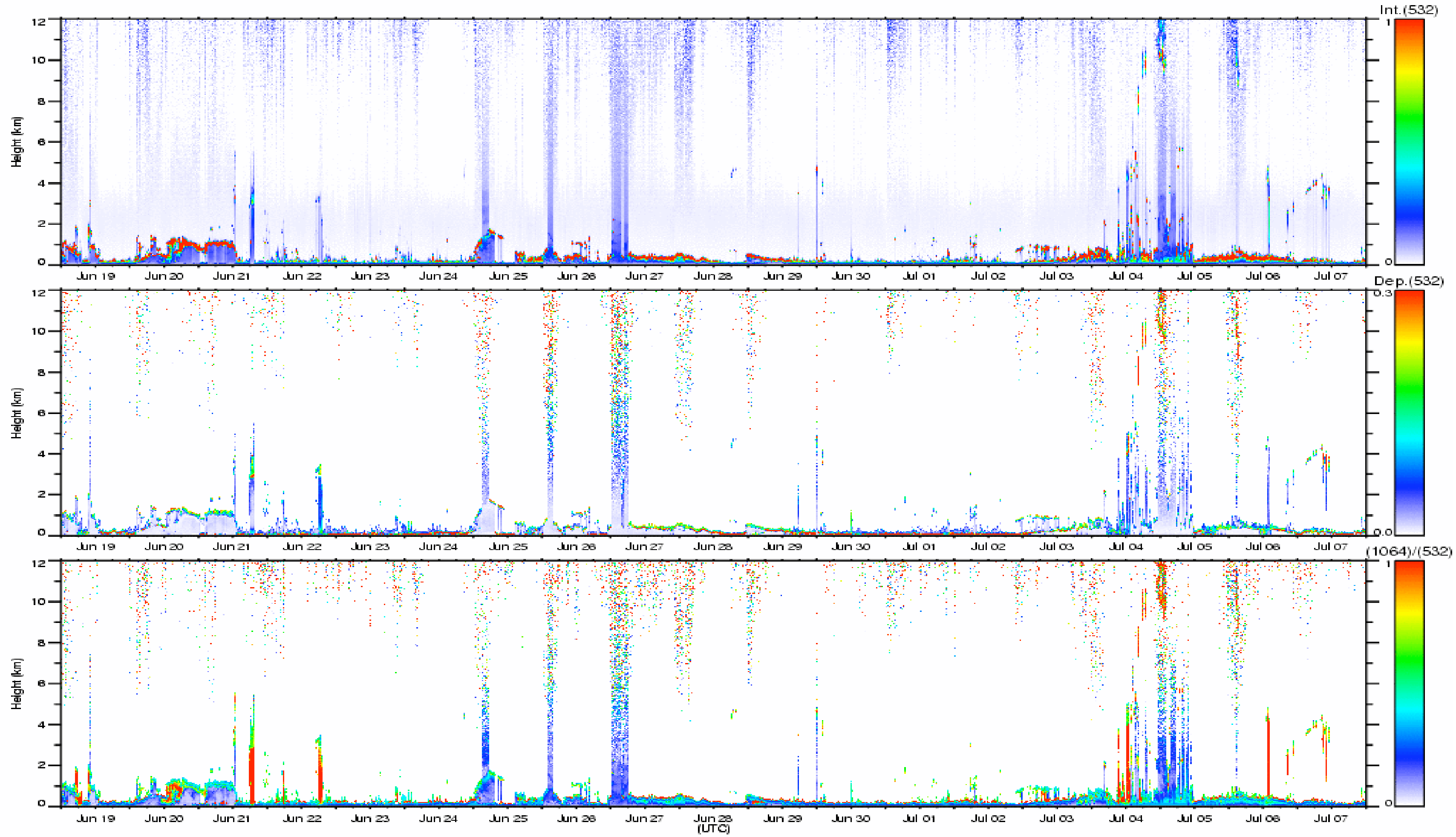


Figure 2 Same as Figure 1 but for first half of MR06-03 leg2.

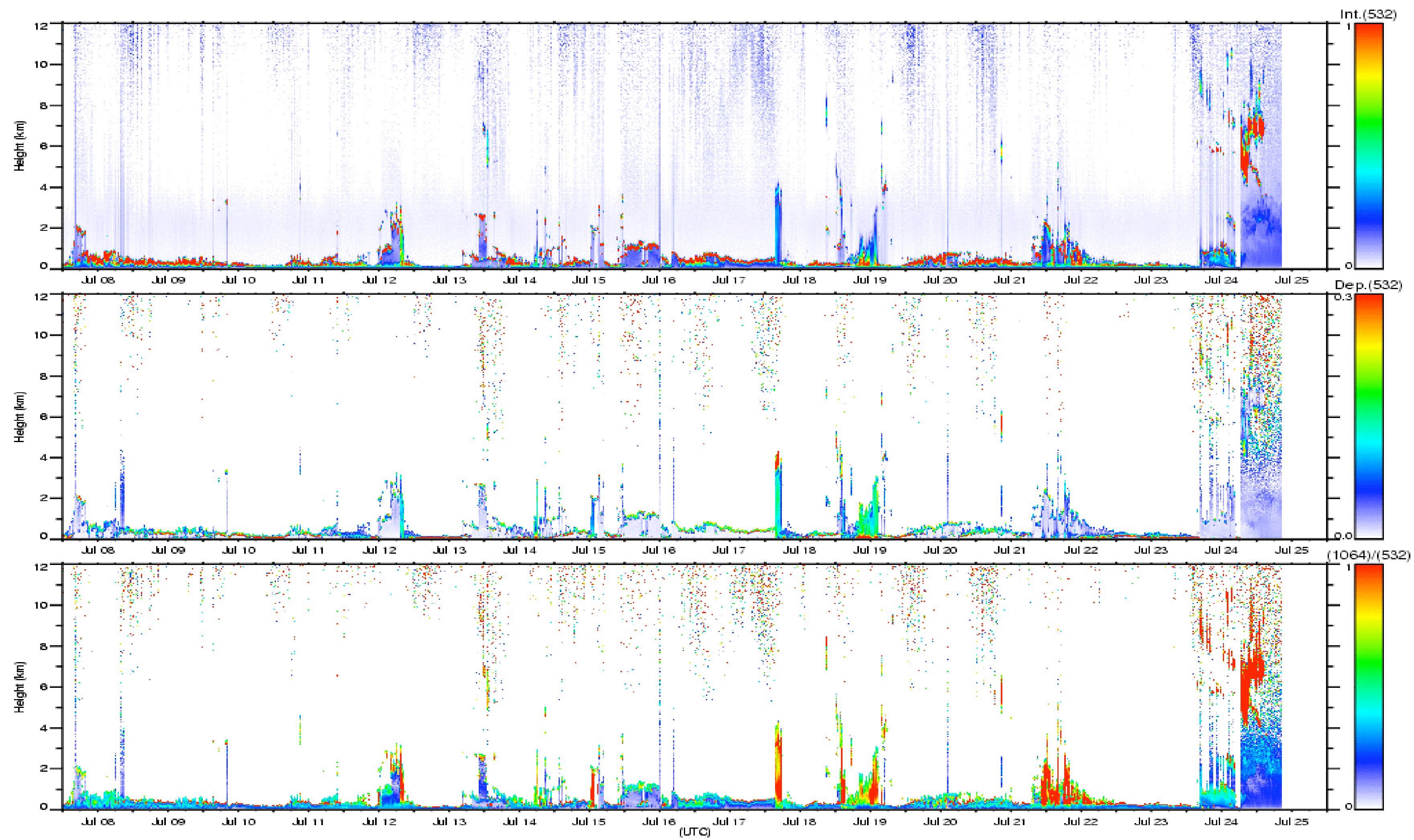


Figure 3 Same as Figure 1 but for second half of MR06-03 leg2.

(5) Data archive

- raw data
  - lidar signal at 532 nm
  - lidar signal at 1064 nm
  - depolarization ratio at 532 nm
  - temporal resolution 15 min/ vertical resolution 6 m
  - data period : May 28, 2006 – July 25, 2006
- processed data
  - cloud base height, apparent cloud top height
  - phase of clouds (ice/water)
  - cloud fraction
  - boundary layer height (aerosol layer upper boundary height)
  - backscatter coefficient of aerosols
  - particle depolarization ratio of aerosols

2.1.5 Rain Sampling for Stable Isotopes

Kimpei ICHIYANAGI (JAMSTEC) (Not on board)

(1) Objective

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

(2) Method

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

(3) Preliminary results

During this cruise, we collected 32 samples in total. Table 1 lists the date and location of rainfall samples. Analysis will be done after the cruise.

(4) Data archive

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

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

Sample No.	Date (UTC)		Location (lat/lon)		Rain (mm)
001	2006/6/2	20:19	46-52.5N	159-59.1E	0.62*
002	2006/6/3	20:58	46-52.6N	159-59.1E	0.6*
003	2006/6/3	23:43	46-51.7N	159-59.3E	0.3*
004	2006/6/11	00:26	42-00.95N	160-00.81E	1.0*
005	2006/6/11	05:50	42-57.41N	159-59.66E	1.2*
006	2006/6/14	20:50	46-55.26N	160-03.01E	0.0*
007	2006/6/17	03:30	40-58.72N	147-38.51E	2.4*
008	2006/6/17	07:20	41-20.68N	146-48.77E	0.7*
009	2006/6/17	22:50	42-57.26N	144-19.52E	10.0*
010	2006/6/18	21:25	42-58.92N	144-22.22E	9.0*
011	2006/6/19	07:14	41-55.55N	145-50.85E	0.1*
012	2006/6/19	20:32	40-17.88N	149-38.18E	2.0*
013	2006/6/21	20:56	46-56.30N	160-07.33E	0.1*
014	2006/6/22	01:58	46-56.87N	160-08.04E	1.8*
015	2006/6/22	06:52	46-56.52N	160-07.36E	0.8*
016	2006/6/22	21:09	46-57.70N	160-08.45E	3.0*
017	2006/6/23	20:58	46-56.99N	160-07.94E	2.8*
018	2006/6/24	02:48	46-55.91N	160-09.98E	3.5*
019	2006/6/24	18:49	46-55.58N	160-08.63E	0.5*

020	2006/6/30	18:46	46-56.09N	160-08.43E	2.6
021	2006/7/2	02:52	46-55.75N	160-08.83E	0.6*
022	2006/7/4	20:01	35-04.55N	155-00.51E	4.2
023	2006/7/6	18:53	41-04.27N	156-17.09E	0.4
024	2006/7/13	02:52	43-54.77N	154-59.01E	4.4
025	2006/7/14	20:08	46-26.47N	159-12.35E	6.4
026	2006/7/15	16:37	46-55.98N	160-08.47E	3.6
027	2006/7/18	19:00	44-11.04N	155-18.33E	7.2
028	2006/7/19	07:24	42-40.83N	153-32.48E	8.2
029	2006/7/19	18:24	41-00.56N	150-47.45E	77
030	2006/7/22	00:05	41-19.82N	142-00.31E	1.0
031	2006/7/22	08:32	41-21.93N	142-04.03E	0.7
032	2006/7/22	19:31	41-21.91N	142-02.54E	1.1

* maximum rainfall intensity (mm/hr)

2.2 Physical oceanographic observation

2.2.1 CTD casts and water sampling

Satoshi OZAWA * (MWJ): Operation Leader (Leg1)
Hirokatsu UNO * (MWJ)
Toru IDAI *** (MWJ)
Tomoyuki TAKAMORI ** (MWJ): Operation Leader (Leg2)
Tomohide NOGUCHI ** (MWJ)
Hiroki USHIROMURA * (MWJ)
Shinsuke TOYODA ** (MWJ)
*** Leg1 ** Leg2 *** Leg1, Leg2**

(1) Objective

Investigation of oceanic structure and water sampling of each layer

(2) Method

(2)-1 Overview of the equipment

The CTD system, SBE 911plus system (Sea-Bird Electronics, Inc., USA), is a real time data system with the CTD data transmitted from a SBE 9plus underwater unit via a conducting cable to the SBE 11plus deck unit. The SBE 11plus deck unit is a rack-mountable interface which supplies DC power to the underwater unit, decodes the serial data stream, formats the data under microprocessor control, and passes the data to a companion computer. The serial data from the underwater unit is sent to the deck unit in RS-232 NRZ format using a 34560 Hz carrier-modulated differential-phase-shift-keying (DPSK) telemetry link. The deck unit decodes the serial data and sends them to a personal computer (Hewlett Packard Vectra VL, Intel(r) Celeron(tm), Microsoft Windows98 2nd edition) to display, at the same time, to storage in a disk file using SBE SEASOFT software.

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

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

(2)-2 Details of sensors

The system used in this cruise is summarized as follows:

Under water unit:
SBE, Inc., SBE 9plus, S/N 0677, S/N 0575

Temperature sensor:
SBE, Inc., SBE 3-04F, S/N 031525, S/N 032453, S/N 031464

Conductivity sensor:
SBE, Inc., SBE 4C, S/N 041203, S/N 042854, S/N 043063, S/N 041088, S/N 042435

Dissolved Oxygen sensor:
SBE, Inc., SBE 43, S/N 430394

Pump:
SBE, Inc., SBE 5T, S/N 050984,S/N 052627

Altimeter:
Datasonics Inc., PSA-916T, S/N 1100

Deck unit:
SBE, Inc., SBE 11plus, S/N 11P9833-0344

Carousel Water Sampler:
SBE, Inc., SBE 32, S/N 0278

Deep Ocean Standards Thermometer:
SBE, Inc., SBE 35, S/N 0045

Optode *:
Arec Electronics Inc., S/N 001

Fluorometer **:
Seapoint sensors, Inc., S/N 2579

Transmissometer **:
Wetlabs, Inc., CST-207RD

* Continuation line observations (Observation Type R)
** Fixed-point observation (Observation Type K)

(3) Data collection and processing

(3)-1 Data collection

CTD measurements were made using a SBE 9plus CTD equipped with temperature-conductivity sensors. The SBE 9plus CTD (sampling rate of 24 Hz) was mounted horizontally in a 36-position carousel frame. Auxiliary sensors included altimeter, dissolved oxygen sensors, and optode or fluorometer, transmissometer.

The package was lowered into the water from the starboard side and held 10 m beneath the surface for about one minute in order to activate the pump. After the pump was activated the package was lifted to the surface, and the package was lowered again at a rate of about 1.0 m/s to 50m, 200m, 500m or Bottom-10m. For the up cast, the package was lifted at a rate of 1.0 m/s except for bottle firing stops. At each bottle firing stops, the bottle was fired.

The SBE 11plus deck unit received the data signal from the CTD. Digitized data were forwarded to a personal computer running the SEASAVE module of the SEASOFT acquisition and processing software, version 5.27b. Profiles, which were temperature, conductivity, salinity, descent rate, fluorescence, transmission, were displayed in real-time with the package depth and altimeter reading.

(3)-2 Data processing

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

The following are the SEASOFT-Win32 (Ver. 5.27b) processing module sequence and specifications used in the reduction of CTD data in this cruise

DATCNV converted the raw data to scan number, pressure, depth, temperature, conductivity, oxygen voltage, fluorescence, transmission, user poly 0, user poly 1, descent rate, modulo error count, and pump status. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds, and the offset was set to 0.0 seconds.

ROSSUM created a summary of the bottle data. The bottle position, date, time were output as the first two columns. Scan number, pressure, depth , temperature, conductivity, fluorescence, transmission, user poly 0, user poly 1 were averaged over 3 seconds.

ALIGNCTD converted the time-sequence of oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Oxygen data are also systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing oxygen sensor output (oxygen voltage) relative to the pressure.

ALIGNOPT (original module) compensated delay of optode sensor output (phase) due to the long time constant. The delay was compensated advancing optode sensor output relative to the CTD temperature by a following function of temperature.

align (sec) = 25 * exp(–0.13 * t) (for $0 \le t \le 16.3$ °C)
align (sec) = 25 (for $t < 0$ °C)
align (sec) = 3 (for $t > 16.3$ °C)

where t is CTD temperature (°C).

WILDEDIT marked extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 1000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to pressure, temperature, conductivity, oxygen voltage, fluorescence, transmission, user poly 0, user poly1, and descent rate outputs.

CELLTM used a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

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

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

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

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

DERIVE was used to compute Oxygen.

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

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

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

(4) Preliminary results

Total 75 casts of CTD measurements have been carried out (table 2-2-1).

Table 2-2-1: MR06-03 CTD Cast table

STNNBR	CAST NO	Observation Type	Date (UTC)	Time (UTC)		Start Position		CTD data file name
			yyyy/mm/dd	Start	End	Lat	Long	
M06001	1	K	2006/05/29	08:52	13:01	44-00.96N	154-59.72E	001M01
M06011	1	R	2006/05/31-06/01	21:00	00:45	51-00.12N	165-00.29E	011M01
M06012	1	R	2006/06/01	05:55	10:17	50-30.00N	164-22.65E	012M01
M06013	1	K	2006/06/01	13:04	17:35	50-00.06N	163-45.02E	013M01
M06014	1	K	2006/06/01-02	20:40	00:51	49-30.09N	163-07.37E	014M01
M06015	1	K	2006/06/02	04:14	08:23	49-00.03N	162-29.98E	015M01
M06002	1	K	2006/06/03	00:55	03:51	46-51.41N	160-01.21E	002M01
M06002	2	K	2006/06/03	04:15	04:56	46-51.38N	160-03.71E	002M02
M06002	3	K	2006/06/03	14:54	15:43	46-52.42N	159-59.09E	002M03
M06002	4	K	2006/06/03-04	21:51	01:35	46-52.26N	159-59.19E	002M04
M06016	1	K	2006/06/06	12:06	16:14	48-30.07N	161-52.54E	016M01
M06017	1	K	2006/06/06	18:47	22:44	48-04.06N	161-17.57E	017M01
M06018	1	K	2006/06/07	02:20	06:11	47-30.13N	160-38.34E	018M01
M06003	1	K	2006/06/07	12:48	16:49	46-00.06N	159-59.97E	003M01
M06004	1	K	2006/06/07-08	22:18	02:11	45-00.07N	160-00.16E	004M01
M06019	1	K	2006/06/08	10:05	10:38	46-59.93N	160-00.12E	019M01
M06010	1	K	2006/06/09-10	20:49	00:42	39-00.10N	160-00.05E	010M01
M06009	1	K	2006/06/10	06:05	10:23	40-00.13N	159-59.88E	009M01
M06008	1	K	2006/06/10	13:53	17:58	41-00.04N	160-00.11E	008M01
M06007	1	K	2006/06/10-11	21:56	01:47	42-00.00N	160-00.00E	007M01
M06006	1	K	2006/06/11	05:58	10:00	42-59.95N	160-00.15E	006M01
M06005	1	K	2006/06/11	13:54	17:47	44-00.04N	159-59.98E	005M01

M06019	2	K	2006/06/12	15:25	16:08	46-51.98N	160-08.22E	019M02
M06019	3	K	2006/06/12	23:14	23:41	46-56.74N	160-05.51E	019M03
M06019	4	K	2006/06/13	21:27	22:07	46-55.20N	160-03.50E	019M04
M06020	1	K	2006/06/21	15:29	16:11	46-52.28N	160-06.48E	020M01
M06020	2	K	2006/06/22	18:52	22:40	46-56.60N	160-07.37E	020M02
M06020	3	K	2006/06/24	03:24	04:05	46-56.64N	160-07.08E	020M03
M06020	4	K	2006/06/24	08:50	09:17	46-56.48N	160-07.71E	020M04
M06020	5	K	2006/06/24	10:49	11:16	46-56.28N	160-07.24E	020M05
M06020	6	K	2006/06/24	14:52	15:15	46-56.35N	160-07.08E	020M06
M06020	7	K	2006/06/24	16:50	17:16	46-56.30N	160-07.03E	020M07
M06020	8	K	2006/06/25	03:52	04:38	46-56.31N	160-07.41E	020M08
M06021	1	R	2006/06/26	08:49	12:44	43-59.91N	154-59.94E	021M01
M06022	1	R	2006/06/26	16:58	20:50	42-59.93N	155-00.18E	022M01
M06023	1	R	2006/06/27	01:25	05:12	42-00.09N	155-00.10E	023M01
M06024	2	R	2006/06/27	11:05	14:55	41-00.13N	154-59.96E	024M02
M06025	1	R	2006/06/27	19:14	23:07	39-59.97N	155-00.18E	025M01
M06026	1	K	2006/06/29	15:25	16:14	46-52.26N	160-06.44E	026M01
M06026	2	K	2006/06/29	23:24	23:55	46-56.47N	160-07.94E	026M02
M06026	3	K	2006/06/30	21:24	22:02	46-56.31N	160-06.09E	026M03
M06026	4	K	2006/07/01	09:20	09:47	46-56.49N	160-07.66E	026M04
M06026	5	K	2006/07/01	10:50	11:14	46.56.42N	160-07.30E	026M05
M06026	6	K	2006/07/01	13:20	13:44	46-56.67N	160-07.53E	026M06
M06026	7	K	2006/07/01	14:52	15:13	46-56.40N	160-07.31E	026M07
M06026	8	K	2006/07/01	16:50	17:11	46-56.43N	160-07.25E	026M08
M06026	9	K	2006/07/01	21:50	22:28	46-56.47N	160-07.46E	026M09
M06031	1	R	2006/07/04-05	20:55	00:49	34-59.99N	155-00.19E	031M01
M06030	1	R	2006/07/05	05:11	09:08	35-59.74N	154-59.99E	030M01
M06029	1	R	2006/07/05	13:20	17:21	37-00.05N	154-59.84E	029M01
M06028	1	R	2006/07/05-06	21:28	01:33	37.59.99N	155-00.00E	028M01
M06027	1	R	2006/07/06	05:50	10:08	38-59.99N	155-00.02E	027M01
M06032	1	K	2006/07/07	22:54	23:32	46-53.71N	160-06.49E	032M01
M06032	2	K	2006/07/08	08:50	09:19	46-56.49N	160-07.11E	032M02
M06032	3	K	2006/07/08	10:55	11:18	46-56.42N	160-07.16E	032M03
M06032	4	K	2006/07/08	12:50	13:14	46-56.41N	160-07.08E	032M04
M06032	5	K	2006/07/08	14:52	15:18	46-56.52N	160-07.18E	032M05
M06032	6	K	2006/07/08	15:29	16:14	46-56.36N	160-06.79E	032M06
M06032	7	K	2006/07/08	17:20	17:46	46-52.89N	160-06.36E	032M07

M06032	8	K	2006/07/09	20:55	21:35	46-56.31N	160-07.02E	032M08
M06032	9	K	2006/07/10	20:56	21:36	46-56.22N	160-07.48E	032M09
M06037	1	R	2006/07/13-14	20:58	00:34	44-29.99N	155-50.08E	037M01
M06036	1	R	2006/07/14	04:03	07:35	44-59.93N	156-40.03E	036M01
M06035	1	R	2006/07/14	10:39	14:10	45-29.97N	157-30.12E	035M01
M06039	1	K	2006/07/14-15	23:49	03:27	46-56.72N	160-07.51E	039M01
M06039	2	K	2006/07/16	00:10	01:05	46-52.44N	160-02.20E	039M02
M06039	3	K	2006/07/16	15:22	16:02	46-52.07N	160-06.40E	039M03
M06039	4	K	2006/07/17	02:18	03:12	46-56.01N	160-06.98E	039M04
M06039	5	K	2006/07/17	09:19	09:46	46-56.46N	160-07.04E	039M05
M06039	6	K	2006/07/17	11:14	11:42	46-56.41N	160-07.12E	039M06
M06039	7	K	2006/07/17	12:50	13:21	46-56.46N	160-07.17E	039M07
M06039	8	K	2006/07/17	14:54	15:17	46-56.42N	160-07.30E	039M08
M06033	1	R	2006/07/17-18	20:55	00:25	46-30.00N	159-10.08E	033M01
M06034	1-2	R	2006/07/18	03:37	07:31	46-00.10N	158-19.93E	034M01 034M02
M06038	1	R	2006/07/18	20:04	23:49	44-00.11N	155-00.18E	038M01

Leg1: M06001~M06019 (Cast4)

Leg2: M06020 (Cast1) ~M06038

(5) Data archive

All raw and processed CTD data files will be submitted to JAMSTEC Data Management Office (DMO).

2.2.2 Salinity measurement

Akinori MURATA (MWJ) : Operation reader
Tatsuya TANAKA(MWJ)
Naoko TAKAHASHI (MWJ)

1. Objectives

To measure bottle salinity obtained by CTD casts, bucket sampling and EPCS.

2. Instrument and Method

2.1 Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and the EPCS. The salinity sample bottle of the 250ml brown grass bottle with screw cap was used to collect the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. Its cap was also thoroughly rinsed. The bottle was stored more than 12 hours in the laboratory before the salinity measurement.

The kind and number of samples are shown as follows ;

Table 2.2.2.1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD and Bucket	1,674
Samples for EPCS	96
Total	1,770

2.2 Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR06-03 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62556,62827) with additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). We also used two pairs of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.). One thermometer monitored an ambient temperature and the other monitored a bath temperature.

The specifications of AUTOSAL salinometer and thermometer are shown as follows ;

Salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.)

Measurement Range	:	0.005 to 42 (PSU)
Accuracy	:	Better than ±0.002 (PSU) over 24 hours without restandardization
Maximum Resolution	:	Better than ±0.0002 (PSU) at 35 (PSU)

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

Measurement Range	:	-180 to +240 deg C
Resolution	:	0.001
Limits of error ±deg C	:	0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability	:	±2 least significant digits

The measurement system was almost same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. An ambient temperature varied from approximately 19 deg C to 24 deg C, while a bath temperature is very stable and varied within +/- 0.002 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio that is defined as median of 31 times reading of the salinometer. Data collection was started in 5 seconds after filling sample to the cell and it took about 10 seconds when S/N62556 was used, and 20 second after filling sample to the cell and it took about 15 second when S/N62827 was used to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In case the difference between the double conductivity ratio of these two fillings is smaller than 0.00002, the average value of these double conductivity ratio was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.0003, we measured eighth filling of the cell. In case the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured ninth and tenth filling of the cell and the median of the double conductivity ratios of five fillings are used to calculate the bottle salinity.

The measurement was conducted about 12hours per day (typically from 8:00 to 20:00 (Leg1), from 15:00 to 03:00 (Leg2)) and the cell was cleaned with soap or thin-ethanol or both after the measurement of the day. We measured 1,674 samples in total.

2.3 Preliminary Result

2.3.1 Standard Seawater

Standardization control of the salinometer with serial number of 62556 was set to 480 and all the measurements were done by this setting STANDBY of 62556 was 5502 +/- 0001 and ZERO was 0.0+0001. We used IAPSO Standard Seawater batch P146 which conductivity ratio was 0.99979 (double conductivity ratio is 1.99958) as the standard for salinity. We measured 73 bottles of P146.

Standardization control of the salinometer with serial number of 62827 was set to 400 and all the measurements were done by this setting STANDBY of 62827 was 5530+/-0001 and ZERO was 0.0+0000. We used IAPSO Standard Seawater batch P146 as the standard for salinity. We measured 31 bottles of P146.

Fig.2.2.2.1 shows the history of double conductivity ratio of the Standard Seawater batch P146. The average of double conductivity ratio serial 62556 and 62827 were 1.99957 and 1.99952 the standard deviation were 0.00002 and 0.00003, which is equivalent to 0.0004 and 0.0006 in salinity.

We added a value to data among two value of standard seawater that were measured about every 40 sample to correct nearly equal the determinate value of standard seawater.

Fig.2.2.2.2 shows the history of double conductivity ratio of the Standard Seawater batch P146 after correct.

The specifications of SSW used in this cruise are shown as follows ;

Standard seawater (SSW)

batch	:	P146
conductivity ratio	:	0.99979
salinity	:	34.992
preparation date	:	12-May.-2005

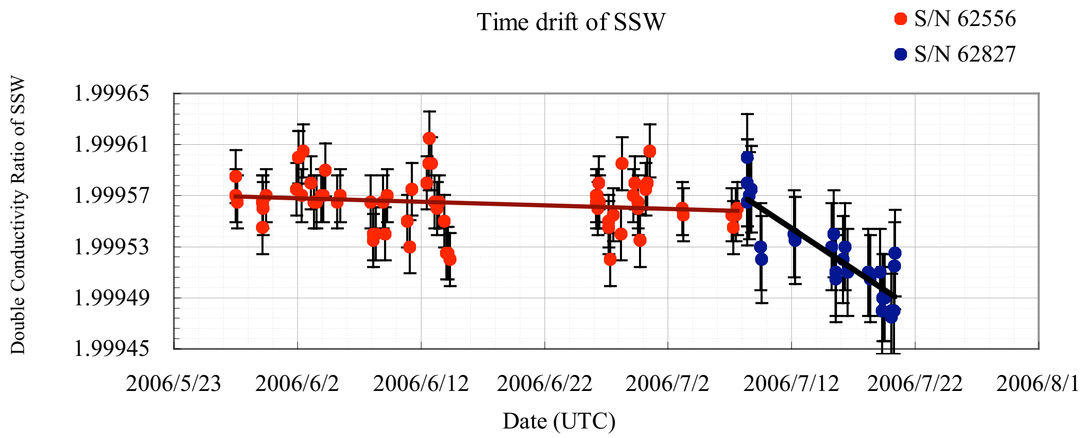


Fig. 2.2.2.1 the history of double conductivity ratio of the Standard Seawater batch P146 of serial number 62556 and 62827

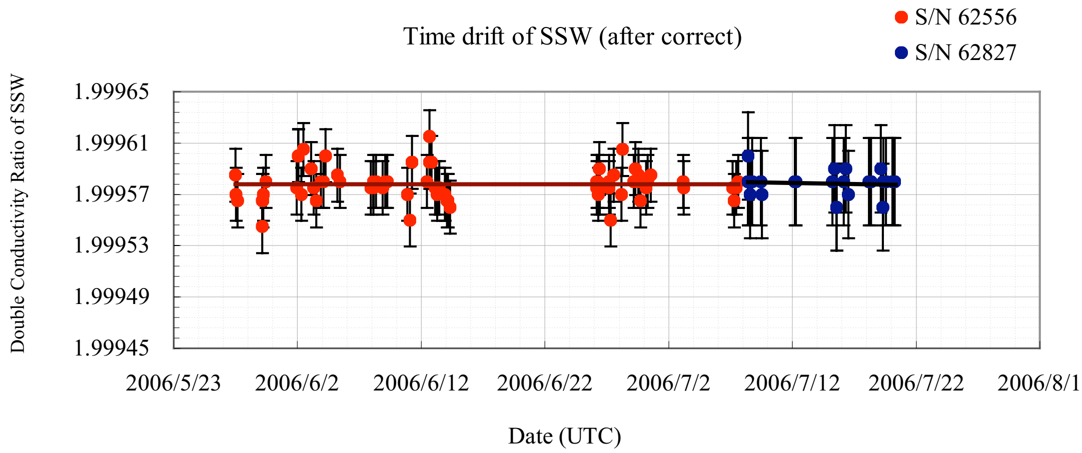


Fig. 2.2.2.2 the history of double conductivity ratio of the Standard Seawater batch P146 of serial number 62556 and 62827 (after correct)

2.3.2 Sub-Standard Seawater

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

2.3.3 Replicate Samples

We took 219 pairs of replicate samples. Fig.2.2.2.3 shows the histogram of the absolute difference between replicate samples, respectively. There were 9 questionable measurement of replicate samples. The standard deviation of the absolute deference of replicate samples was 0.0002 in salinity.

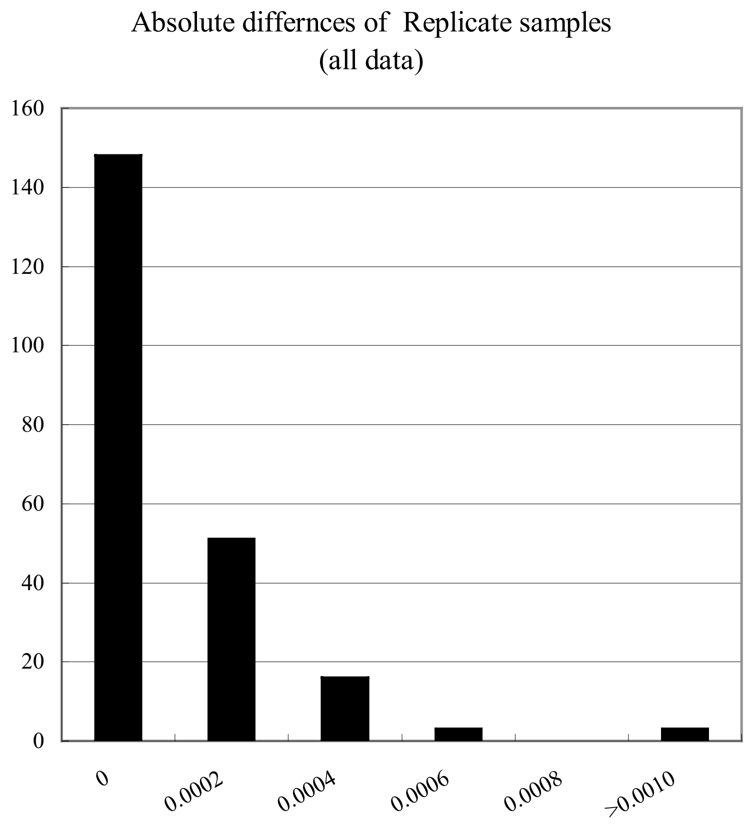


Fig. 2.2.2.3 the histogram of the difference between replicate samples (Include bad sample)

2.4 Further data quality check

2.5 Data archive

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

Reference

Aoyama, M., T. Joyce, T. Kawano and Y. Takatsuki : Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 49, 1103～1114, 2002

UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. UNESCO Tech. Papers in Mar. Sci., 36, 25 pp., 198

2.2.3 Shipboard ADCP observation

Katsuhisa MAENO (Global Ocean Development Inc.) -Leg1,2-
Ryo OHYAMA (GODI) -Leg1-
Noiro NAGAHAMA (GODI) -Leg2-

(1) Parameters

Current velocity of each depth cell [cm/s]

Echo intensity of each depth cell [dB]

(2) Methods

Continuous upper ocean current measurement along ship's track were made using hull-mounted Acoustic Doppler Current Profiler, RD Instruments VM-75 system installed on the centerline and approximately 28 m aft from the bow. The firmware version was 5.59 and the data acquisition software was VmDas Ver.1.4. For most of its operation, the instrument was configured for water-tracking mode recording each ping as the raw data in 8 m (bin size) x 100 bins (bin number) from 16.33 m to 816.33 m. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made in shallower water region to get the calibration data for evaluating transducer misalignment angle. Raw data was recorded in beam coordinate, and then converted to earth coordinate using ship's heading data from ship's main gyrocompass, Tokimec TG-6000. The position fix data from ship's navigation system was also recorded in NMEA0183 format and merged with ensemble data in the VmDas. Also, 60 seconds and 300 seconds average data were recorded as short-term average (STA) and long-term average (LTA) data.

The system consists of following components;

1. a 75 kHz Broadband (coded-pulse) profiler with 4-beam Doppler sonar operating at 75 KHz (RD Instruments, USA), mounted with beams pointing 30 degrees from the vertical and 45 degrees azimuth from the keel;
2. the Ship's main gyro compass (Tokimec, Japan), continuously providing ship's heading measurements to the ADCP;
3. a GPS navigation receiver (Leica MX9400) providing position fixes;
4. a personal computer running data acquisition software. The clock of the logging PC is adjusted to GPS time every 5 minutes.

The periods of bottom track mode and water mode track are as follows;

Bottom Track : 20:43UTC 26 May - 12:32UTC 27 May
00:00UTC 17 June - Arrival at Kushiro
Departure at Kushiro - 01:22UTC 19 Jun
00:14UTC 24 July - Arrival at Sekinehama
Water Track : 12:33UTC 27 May - 00:00UTC 17 June
01:25UTC 19 Jun - 00:14UTC 24 July

(3) Preliminary results

Fig. 2.2.3-1 and Fig. 2.2.2.3-2 show 60-minutes averaged water current vector along the ship track during leg1 and leg2 (only vector on the first pass is plotted). The data were processed LTA data using CODAS (Common Oceanographic Data Access System) software, developed at the University of Hawaii.

(4) Data archive

These data obtained in this cruise will be submitted to the JAMSTEC and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

Table 2.2.3 Major parameters

Bottom-Track Commands	
BP = 000	Bottom Tracking OFF
BP = 001	Bottom Tracking ON/Pings per Ensemble
Environmental Sensor Commands	
EA = +00000	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +0001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1020001	Sensor Source (C;D;H;P;R;S;T)
	C(1): Sound velocity calculate using ED, ES, ET(temp.)
	D(0): Manual ED
	H(2): External synchro
	P(0), R(0): Manual EP, ER (0 degree)
	S(0): Manual ES
	T(1): Internal transducer sensor
Timing Commands	
TE = 00:00:00.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:00.00	Time per Ping (min:sec.sec/100)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 counts)
WB = 1	Mode 1 Bandwidth Control (0=Wid,1=Med,2=Nar)
WC = 064	Low Correlation Threshold (0-255)
WD = 111 000 000	Data Out (V;C;A PG;St;Vsum Vsum^2;#G;P0)
WE = 5000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1	Rcvr Gain Select (0=Low,1=High)
WM = 1	Profiling Mode (1-8)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 0800	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 999	Mode 1 Ambiguity Velocity (cm/s radial)

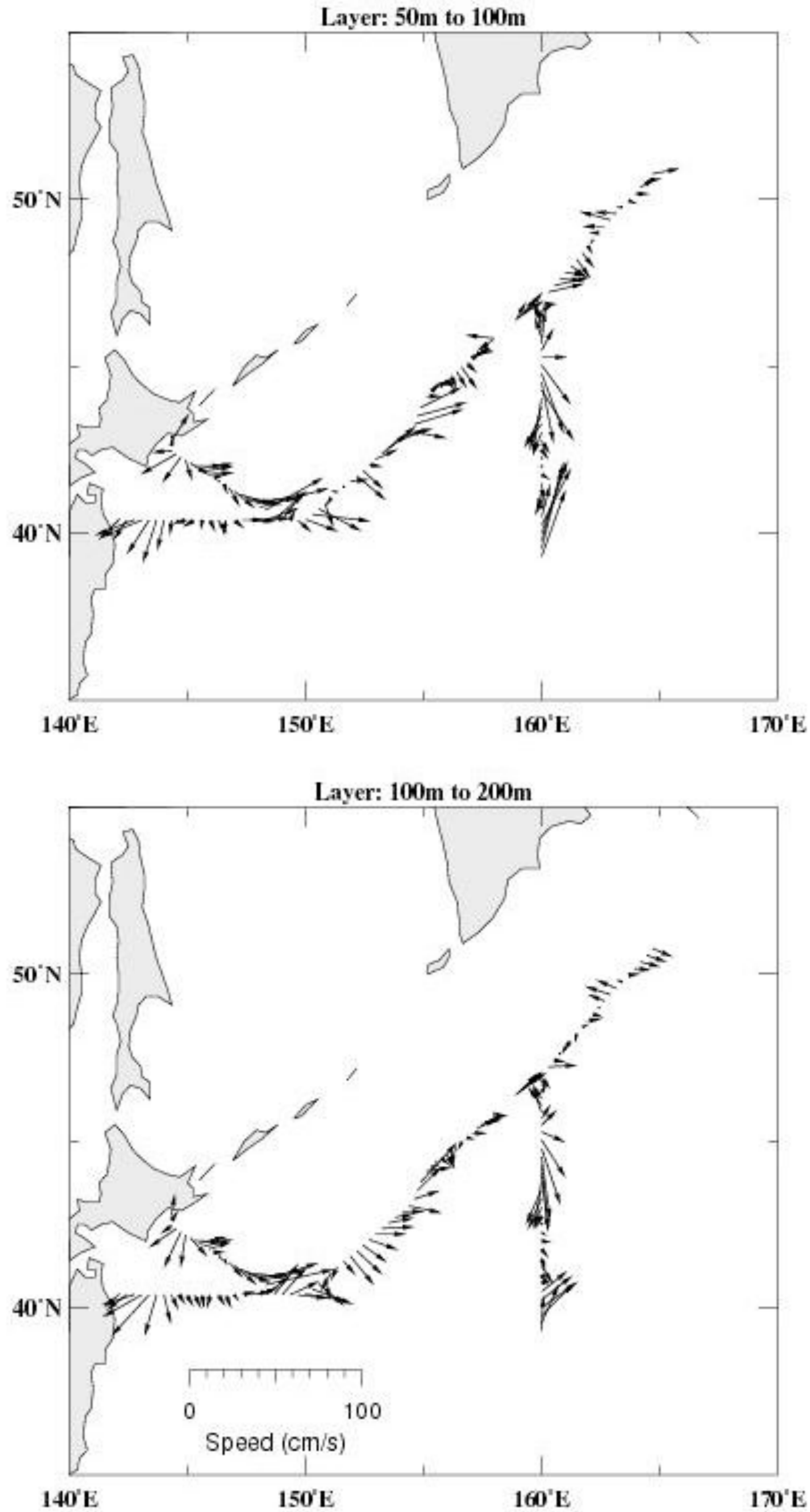


Fig. 2.2.3-1 Water current vector during leg1.

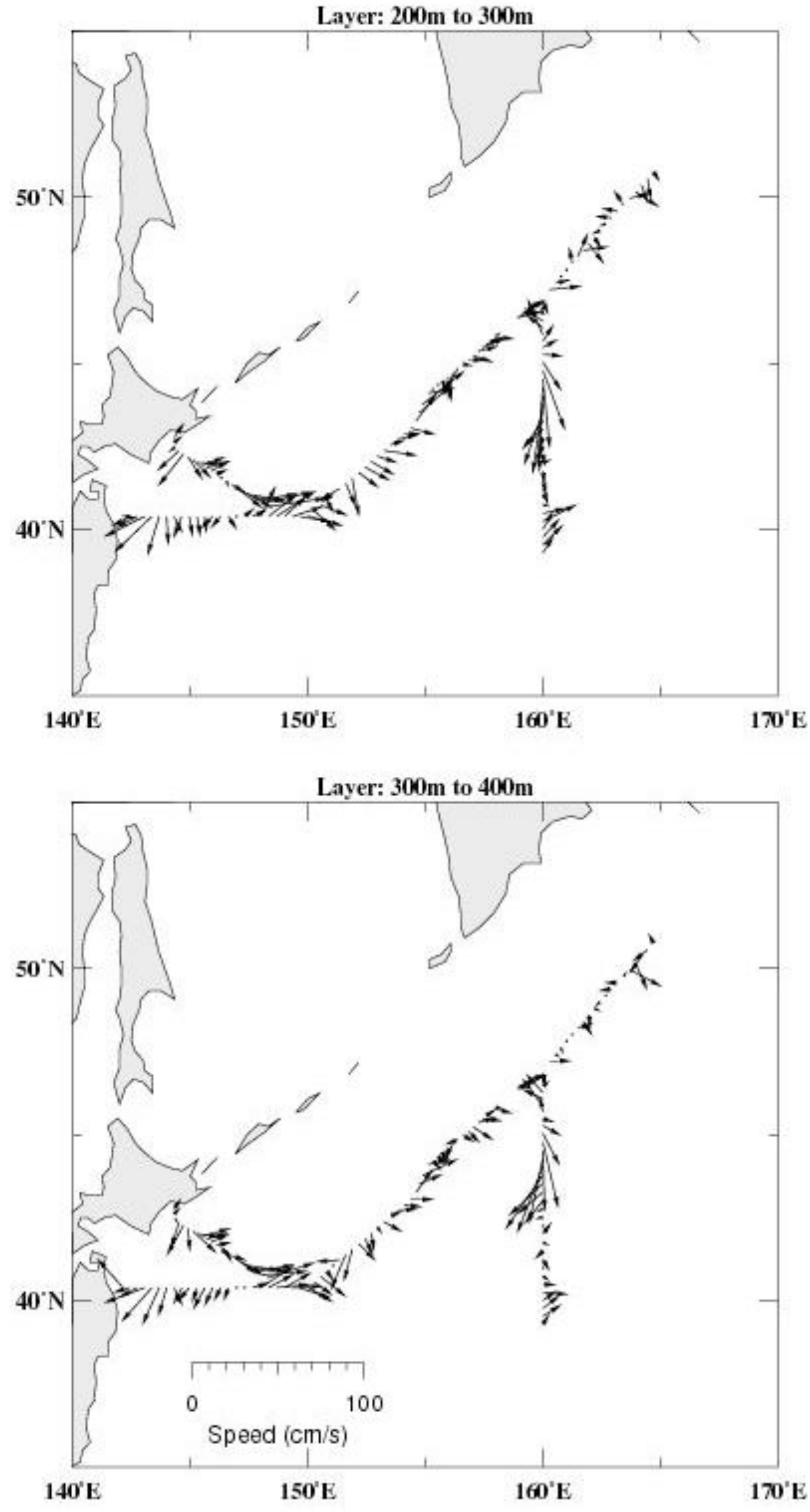


Fig. 2.2.3-1 Continued.

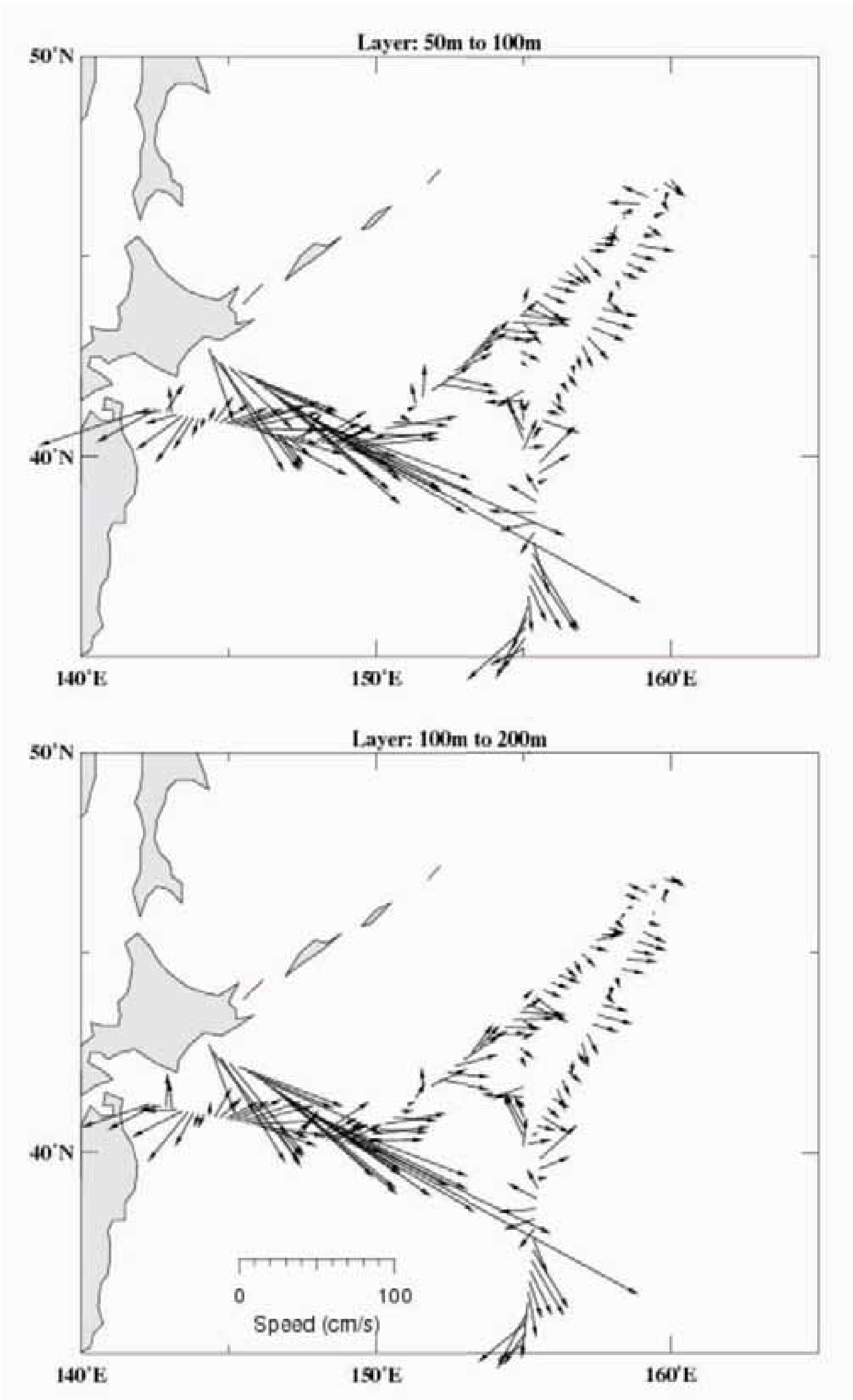


Fig. 2.2.3-2 Water current vector during leg2.

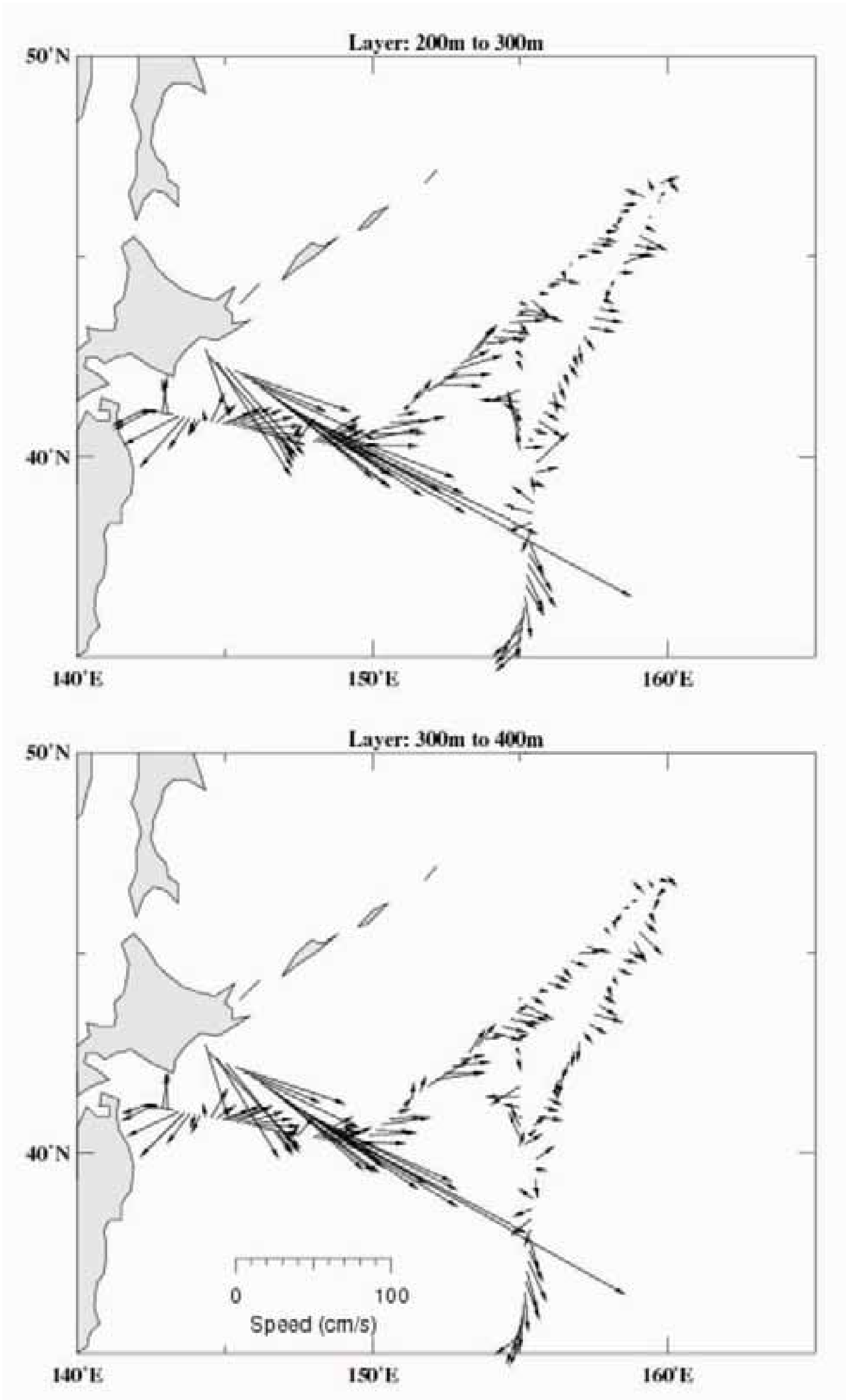


Fig. 2.2.3-2 Continued.

2.2.4 Lowered Acoustic Doppler Current Profiler

Shuichi WATANABE (JAMSTEC)
Ichiro YASUDA (ORI, Tokyo University)

(1) Purpose

Observation with LADCP is one of useful method for understanding the water transport. During this cruise, MR06-03, one of our purposes is the estimate of material transport around the time-series station, K2. Information about water current obtained from LADCP needs to consider lateral transport of chemicals with the transport of water. In this cruise we obtained the current profiles with LADCP at stations along the Kuril Islands.

(2) Instrument and method

Direct flow measurement from sea surface to the bottom was carried out using a lowered acoustic Doppler current profiler (LADCP). The instrument used was the RDI Workhorse Monitor 307.2 kHz unit (RD Instruments, USA). The instrument was attached on the CTD/RMS frame, orientating downward. The CPU firmware version was 16.20.

One ping raw data were recorded, where the bin number was 32 and the bin length was 8 m, except 4m at elected CTD casts during the cruise. The accuracies of each ping were 2.0 cm/s for 8 m bin and 3.0 cm/s for 4 m bin, respectively. Sampling interval was 1.29 seconds originally. The bottom-tracking mode was used, which made the LADCP capture the sea floor 200 m above. Salinity value in the sound speed calculation was set as a constant value 34 PSU.

A total of 36 operations were made with the CTD observations in the leg 1 and 2 along the Kuril Islands, and two lines (155 and 160 degree E) included time-series stations K1, K2, K3 and KNOT. Stations name, positions and operated date of LADCP were listed at Table 2.2.4.1 LADCP observations at the K2 were operated three times when the CTD observation at the K2 was started and we left from the K2 station. Those at KNOT, which is Japanese time series station during 1998 to 2001, were also twice when we visited at the KNOT at the beginning and end of this cruise. .

Table 2.2.4.1.　LADCP Observations during MR06-03 cruise

Leg	Sta.	Date (UTC)	Latitude	Longitude	Memo
1	M06001	2006/5/29	44-00.96	154-59.72	
1	M06011	2006/5/31	51-00.12	165-00.29	
1	M06012	2006/6/01	50-30.00	164-22.65	
1	M06013	2006/6/01	50-00.06	163-45.02	
1	M06014	2006/6/01	49-30.09	163-07.37	
1	M06015	2006/6/02	49-00.03	162-29.98	
1	M06002	2006/6/03	46-52.26	159-59.19	CTD Cast.4
1	M06016	2006/6/06	48-30.07	161-52.54	
1	M06017	2006/6/06	48-04.06	161-17.57	
1	M06018	2006/6/07	47-30.13	160-38.34	
1	M06003	2006/6/07	46-00.06	159-59.97	
1	M06004	2006/6/07	45-00.07	160-00.16	
1	M06010	2006/6/09	39-00.10	160-00.05	
1	M06009	2006/6/10	40-00.13	159-59.88	
1	M06008	2006/6/10	41-00.55	159-59.85	
1	M06007	2006/6/10	42-00.00	160-00.00	
1	M06006	2006/6/11	42-59.95	160-00.15	
1	M06005	2006/6/11	44-00.04	159-59.98	
2	M06020	2006/6/22	46-56.60	160-07.37	CTD Cast.2
2	M06021	2006/6/26	43-59.91	154-59.94	
2	M06022	2006/6/26	42-59.93	155-00.18	
2	M06023	2006/6/27	42-00.09	155-00.10	
2	M06024	2006/6/27	41-00.35	154-59.97	
2	M06025	2006/6/27	39-59.97	155-00.18	
2	M06031	2006/7/04	34-59.99	155-00.19	
2	M06030	2006/7/05	35-59.74	154-59.99	
2	M06029	2006/7/05	37-00.05	154-59.84	
2	M06028	2006/7/05	37-59.99	155-00.00	
2	M06027	2006/7/06	38-59.99	155-00.02	
2	M06037	2006/7/13	44-29.99	155-50.08	
2	M06036	2006/7/14	44-59.93	156-40.03	
2	M06035	2006/7/14	45-29.97	157-30.12	
2	M06039	2006/7/14	46-56.72	160-07.51	CTD Cast.1
2	M06033	2006/7/17	46-30.00	159-10.08	
2	M06034	2006/7/18	46-00.10	158-19.93	CTD system down
2	M06038	2006/7/18	44-00.11	155-00.18	

2.3. Sea surface monitoring

Kimiko NISHIJIMA (MWJ)
Miyo IKEDA (MWJ)

2.3.1 Objective

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

2.3.2 Methods

The *Continuous Surface Sea Water Monitoring System* (Nippon Kaiyo Co. Ltd.) has five kind of sensors and can automatically measure salinity, temperature, dissolved oxygen and fluorescence in near-surface sea water continuously, every 1-minute. Salinity is calculated by conductivity on the basis of PSS78. This system is located in the "*sea surface monitoring laboratory*" on R/V MIRAI. This system is connected to shipboard LAN-system. Measured data is stored in a hard disk of PC every 1-minute together with time and position of ship, and displayed in the data management PC machine.

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

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

a) Temperature and Conductivity sensor
SEACAT THERMOSALINOGRAPH
Model: SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number: 2126391-2641
Measurement range: Temperature -5 to +35℃, Conductivity 0 to 6.5 S m-1
Accuracy: Temperature 0.01 ℃ 6month-1,Conductivity 0.001 S m-1 month-1
Resolution: Temperatures 0.001℃, Conductivity 0.0001 S m-1

b) Bottom of ship thermometer
Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number: 032175
Measurement range: -5 to +35℃
Resolution: ±0.001℃
Stability: 0.002 ℃ year-1

c) Dissolved oxygen sensor
Model: 2127A, HACH ULTRA ANALYTICS JAPAN, INC.
Serial number: 44733

Measurement range: 0 to 14 ppm
Accuracy: ±1% at 5 ℃ of correction range
Stability: 1% month-1

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

e) Flow meter
Model: EMARG2W, Aichi Watch Electronics LTD.
Serial number: 8672
Measurement range: 0 to 30 l min-1
Accuracy: ±1%
Stability: ±1% day-1

The monitoring Periods (UTC) during this cruise are listed below.
27-May-'06 11:46 to 19-Jul.-'06 04:47

2.3.3 Preliminary Result

Preliminary data of temperature (Bottom of ship thermometer), salinity, dissolved oxygen, fluorescence at sea surface between this cruise are shown in Figs. 1-4 (Red lines are measurements at K2 station).

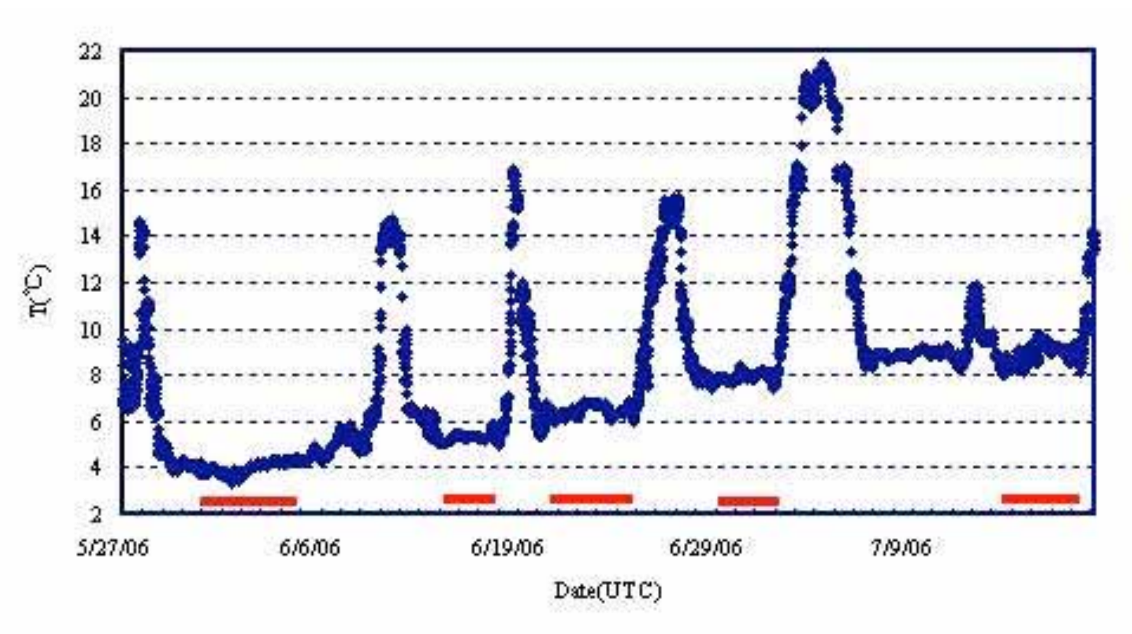


Fig.1 Contour line of Temperature.

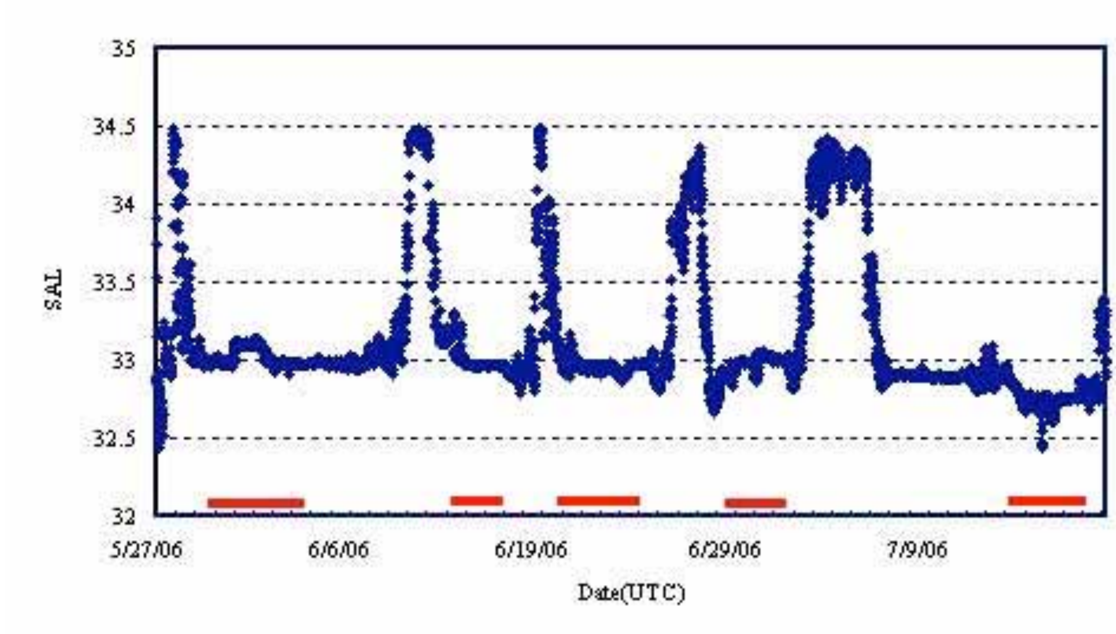


Fig.2 Contour line of salinity

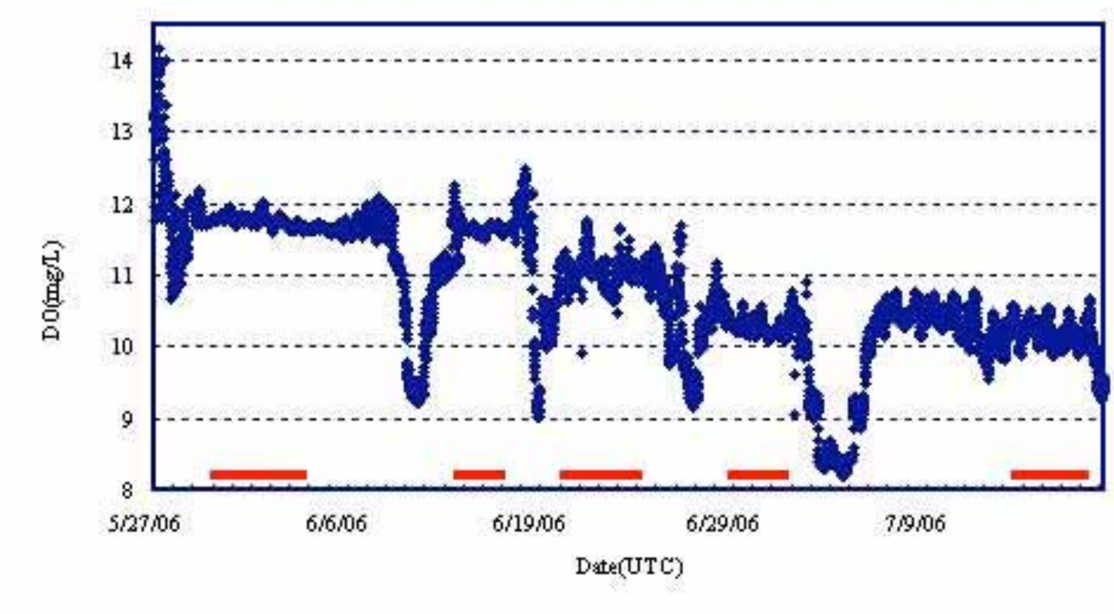


Fig.3 Contour line of dissolved oxygen

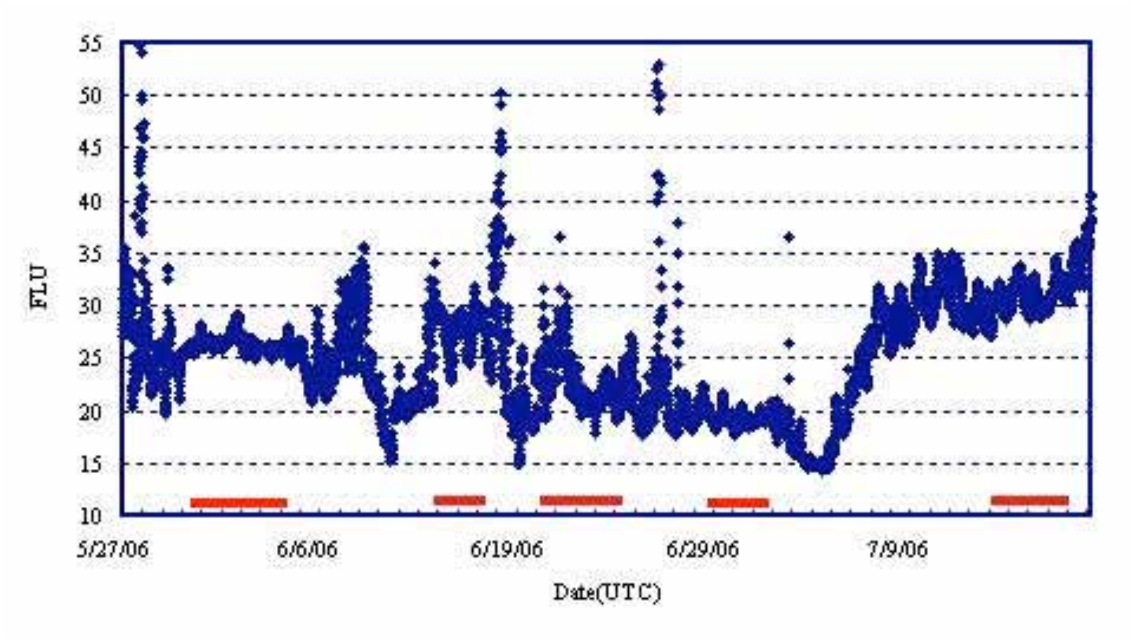


Fig.4 Contour line of fluorescence

Date archive

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

2.4 Dissolved oxygen

Kimiko NISHIJIMA (MWJ)
Miyo IKEDA (MWJ)

1. Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

2. Methods

2.1 Reagents:

Pickling Reagent I: Manganous chloride solution (3M)
Pickling Reagent II: Sodium hydroxide (8M) / sodium iodide solution (4M)
Sulfuric acid solution (5M)
Sodium thiosulfate (0.025M)
Potassium iodate (0.001667M)

2.2 Instruments:

Burette for sodium thiosulfate;
APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel
Burette for potassium iodate;
APB-410 manufactured by Kyoto Electronic Co. Ltd. / 20 cm^3 of titration vessel
Detector and Software; Automatic photometric titrator manufactured by Kimoto Electronic Co. Ltd.

2.3 Sampling

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

Seawater samples were collected with Niskin bottle attached to the CTD-system. Seawater for oxygen measurement was transferred from Niskin sampler bottle to a volume calibrated flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I, II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

2.4 Sample measurement

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

2.5 Standardization and determination of the blank

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

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

Table 1 shows results of the standardization and the blank determination during this cruise.

Table 1 Results of the standardization and the blank determinations during this cruise.

Date	KIO_3		DOT-1 (cm^3)			DOT-3 (cm^3)			Samples
(UTC)	#	bottle	$Na_2S_2O_3$	E.P.	blank	$Na_2S_2O_3$	E.P.	blank	(Stations)
2006/05/29		20060419-02-02	20060514-3	3.960	-0.012	20060514-4	3.957	-0.011	M06001
2006/06/01		20060419-02-03	20060514-3	3.958	-0.011	20060514-4	3.955	-0.011	M06011,012,013,014,015
2006/06/03		20060419-02-04	20060514-3	3.953	-0.011	20060514-4	3.953	-0.012	M06002cast3,cast4
2006/06/06	1	20060419-02-05	20060528-1	3.955	-0.012	20060528-2	3.956	-0.014	M0616,017,018
2006/06/07		20060419-02-06	20060528-1	3.958	-0.014	20060528-2	3.957	-0.012	M06003,004
2006/06/09		20060419-02-07	20060528-1	3.955	-0.012	20060528-2	3.958	-0.009	M06010,009,008
2006/06/11		20060419-02-08	20060528-3	3.958	-0.013	20060528-4	3.959	-0.014	.M06007,006
2006/06/12	2	20060419-03-01	20060528-3	3.959	-0.012	20060528-4	3.957	-0.013	M06019
2006/06/22		20060419-03-04	20060614-1	3.966	-0.011	20060614-2	3.966	-0.012	M06020
2006/06/26		20060419-03-05	20060614-1	3.966	-0.012	20060614-2	3.966	-0.009	M06021,022,023,024,025
2006/06/29	2	20060419-03-06	20060614-3	3.967	-	20060614-4	3.968	-	M06026 cast1,cast9
2006/07/04		20060419-03-07	20060614-3	3.966	-0.011	20060614-4	3.964	-0.009	M06031,030,029,028,027
2006/07/08		20060419-03-08	20060630-1	3.960	-0.011	20060630-2	3.960	-0.011	M06032 cast6, cast9
2006/07/13		20060419-04-01	20060630-1	3.961	-0.011	20060630-2	3.961	-0.010	M06037,036,035
2006/07/14	3	20060419-04-02	20060630-1	3.960	-0.011	20060630-2	3.960	-0.010	M06039 cast1, cast3
2006/07/17		20060419-04-03	20060630-3	3.958	-0.014	20060630-4	3.960	-0.013	M06033,034,038

Batch number of the KIO_3 standard solution.

2.6 Reproducibility of sample measurement

Replicate samples were taken at every CTD cast; usually these were 5 - 10 % of seawater samples of each cast during this cruise. Results of the replicate samples were shown in Table 2 and this histogram shown in Fig.1. The standard deviation was calculated by a procedure (SOP23) in DOE (1994).

Table 2 Results of the replicate sample measurements

Number of replicate sample pairs	Oxygen concentration (mol/kg)
	Standard Deviation.
156	0.087

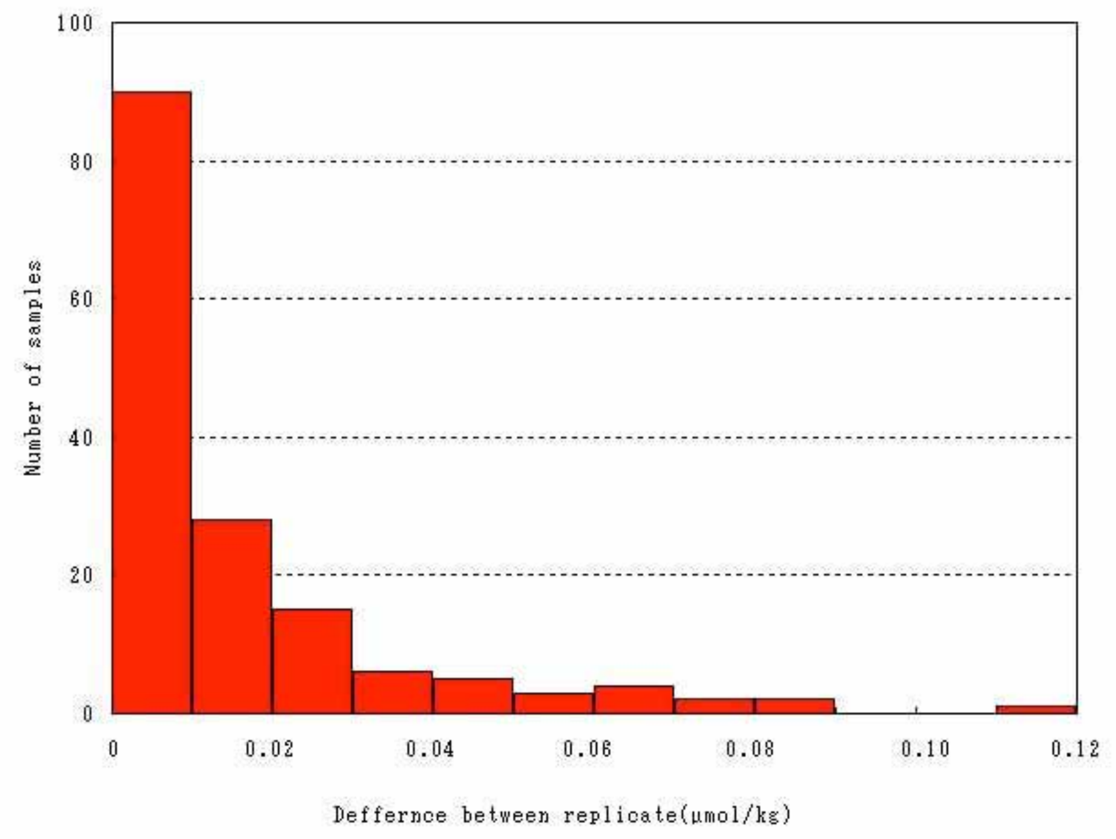


Fig.1 Results of the replicate sample measurements

3. Preliminary results

During this cruise we measured oxygen concentration in 1575 seawater samples at 33 stations.

References:

Dickson, A. (1996) Dissolved Oxygen, in WHP Operations and Methods, Woods Hole, pp1-13.

DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2. A.G. Dickson and C. Goyet (eds), ORNL/CDIAC-74.

Emerson, S, S. Mecking and J.Abell (2001) The biological pump in the subtropical North Pacific Ocean: nutrient sources, redfield ratios, and recent changes. *Global Biogeochem. Cycles*, 15, 535-554.

Watanabe, Y. W., T. Ono, A. Shimamoto, T. Sugimoto, M. Wakita and S. Watanabe (2001) Probability of a reduction in the formation rate of subsurface water in the North Pacific during the 1980s and 1990s. *Geophys. Res. Letts*., 28, 3298-3292.

2.5 Nutrients

Junko HAMANAKA (MWJ) ***
Takayoshi SEIKE (MWJ) *
Junji MATSUSHITA (MWJ) *
Ayumi TAKEUCHI (MWJ) **
Kenicihro SATO (MWJ) **
* Leg.1, ** Leg.2, *** Leg.1 and Leg.2

(1) Objectives

The vertical and horizontal distributions of the nutrients are one of the most important factors on the primary production. During this cruise nutrient measurements will give us the important information on the mechanism of the primary production or seawater circulation.

(2) Methods

Nutrient analysis was performed on the BRAN+LUEBBE TRAACS 800 system. The laboratory temperature was maintained between 25-27 deg C.

a. Measured Parameters

Nitrate + nitrite and nitrite are analyzed according to the modification method of Grasshoff (1970). The sample nitrate is reduced to nitrite in a cadmium tube inside of which is coated with metallic copper. The sample stream with its equivalent nitrite is treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid, which reacts with the sulfanilamide to produce a diazonium ion. N1-Naphthylethylene-diamine added to the sample stream then couples with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite react and are measured; without reduction, only nitrite reacts. Thus, for the nitrite analysis, no reduction is performed and the alkaline buffer is not necessary. Nitrate is computed by difference.

Absorbance of 550 nm by azo dye in analysis is measured using a 3 cm length cell for Nitrate and 5 cm length cell for Nitrite.

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

Absorbance of 630 nm by silicomolybdous acid in analysis is measured using a 3 cm length cell.

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

Absorbance of 880 nm by phosphomolybdous acid in analysis is measured using a 5 cm length cell.

Ammonia in seawater is mixed with an alkaline solution containing EDTA, ammonia as gas state is formed from seawater. The ammonia (gas) is absorbed in sulfuric acid solution by way of 0.5 µm pore size membrane filter (ADVANTEC PTFE) at the dialyzer attached to analytical system. The ammonia absorbed in acid solution is determined by coupling with phenol and hypochlorite solution to from an indophenol blue compound.

Absorbance of 630 nm by indophenol blue compound in analysis is measured using a 3 cm length cell.

b. Nutrients Standard

Silicate standard solution, the silicate primary standard, was obtained from Merck, Ltd. This standard solution, traceable to SRM from NIST was 1000 mg per litter. Since this solution is alkaline solution of 0.5 M NaOH, an aliquot of 40ml solution were diluted to 500 ml together with an aliquot of 20 ml of 1M HCl. Primary standard for nitrate (KNO_3) and phosphate (KH_2PO_4) were obtained from Merck, Ltd. and nitrite ($NaNO_2$) and ammonia ($(NH_4)_2SO_4$) were obtained from Wako Pure Chemical Industries, Ltd. Detail information about standard reagents in the previous cruises is shown in Table 2.5.1. The relative ratio between different types of standard reagent was evaluated based on the 6-9 measurements at the same concentration during a run. Summary of the ratios are shown in Table 2.5.2.

c. Sampling Procedures

Samples were drawn into virgin 10 ml polyacrylates vials that were rinsed three times before sampling without sample drawing tubes. Sets of 5 different concentrations for nitrate, nitrite, silicate, phosphate and 4 different concentrations for ammonia of the shipboard standards were analyzed at beginning and end of each group of analysis. The standard solutions of highest concentration were measured every 7–13 samples and were used to evaluate precision of nutrients analysis during the cruise. We also used three concentrations of reference material for nutrients in seawater, RMNS (KANSO Co., Ltd., lots AS, AT and AU), for all runs to secure comparability on nutrient analysis throughout the cruise.

d. Low Nutrients Sea Water (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.45 µm pore size membrane filter. This water is stored in 20-liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in April 2006.

(3) Preliminary Results

Analytical precisions were 0.07% (55 μM) for nitrate, 0.07% (1.2 μM) for nitrite, 0.07% (171 μM) for silicate, 0.09% (3.6 μM) for phosphate and 0.25% (4.0 μM) for ammonia in terms of median of precision, respectively.

Results of RMNS analysis are shown in Tables 2.5.3-2.5.5 for the station's comparability, and in Table 2.5.6 for the cruise's comparability.

(4) Data Archive

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

Reference

Grasshoff, K. (1970), Technicon paper, 691-57.

Grasshoff, K., Ehrhardt, M., Kremling K. et al. (1983), Methods of seawater analysis. 2nd rev. Weinheim: Verlag Chemie, Germany, West.

Murphy, J., and Riley, J.P. (1962), Analytica chim. Acta 27, 31-36.

Table 2.5.1 Summary of standard reagents.

Cruise	NO_3 Maker	NO_3 Batch	NO_2 Maker	NO_2 Batch	SiO_2 Maker	SiO_2 Batch	PO_4 Maker	PO_4 Batch	NH_4 Maker	NH_4 Batch
M06-03	Merck	B267665016	Wako	KSF7907 KSE7907*	Merck	OC551722	Merck	B781508550	Wako	CKR2895
M05-04	Wako	KSL4956	Wako	KSF7907	Kanto Chemical	609F9157	Wako	KSK5677	Wako	CKR2895
MR04-04 MR05-01	Wako	KSL4956	Wako	KSF7907	Kanto Chemical	507F9205	Wako	KSK5677	---	---

* Stn.M06039_3, M06033, M06034, M06038 used

NO_3: Merck, Potassium Nitrate 99,995 Suprapur
Wako, Potassium Nitrate, Analytical Grade
NO_2: Wako, Sodium Nitrite, Analytical Grade
SiO_2: Merck, Silicon standard solution traceable to SRM from NIST, SiO2 in NaOH 0.5 mol/l 1000mg/l Si CertiPUR
Kanto Chemical, Silicon standard solution for ICP analysis, SiO2 in KOH 0.5 mol/l
PO_4: Merck, Potassoim Dihydrogen Phosphate Anhydrous 99,995 Suprapur
Wako, Potassoim Dihydrogen Phosphate Anhydrous, Analytical Grade
NH_4: Wako, Ammonium Sulfate , Analytical Grade

Table 2.5.2 The relative ratio between different types of standard reagent.

NO_3	Batch or Serial	factor	count
Merck	B267665016	1.003±0.001	9
Wako	KSL4956	1.002±0.001	9

	SiO_2	Batch or Serial	factor	count
M06-03	Merck	OC551722	1.001±0.001	9
M05-04	Kanto Chemical	609F9157	0.975±0.001	9

	SiO_2	Batch or Serial	factor	count
M05-04	Kanto Chemical	609F9157	0.999±0.001	9
M04-04, MR05-01	Kanto Chemical	507F9205	1.002±0.001	9

PO_4	Batch or Serial	factor	count
Merck	B781508550	1.002±0.001	6
Wako	KSK5677	1.002±0.001	9

Table 2.5.3 Results of RMNS Lot.AS analysis in this cruise.

μmol/kg

	serial	Stn.	NO_3	NO_2	SiO_2	PO_4	NH_4
RM-AS	461	M06001	0.09	0.01	1.69	0.065	---
RM-AS	322	M06011	0.08	0.02	1.69	0.060	---
RM-AS	322	M06012	0.09	0.02	1.68	0.055	---
RM-AS	468	M06013	0.08	0.01	1.71	0.059	---
RM-AS	468	M06014	0.09	0.01	1.68	0.074	---
RM-AS	468	M06015	---	0.02	1.56	0.065	---
RM-AS	777	M06015	0.07	0.01	---	---	---
RM-AS	777	M06002_3	0.10	0.01	1.68	0.071	0.89
RM-AS	777	M06002_4	0.09	0.01	1.70	0.073	---
RM-AS	378	M06016	0.13	0.01	1.78	0.071	---
RM-AS	378	M06017	0.12	0.01	1.68	0.076	---
RM-AS	270	M06018	0.09	0.01	1.68	0.080	---
RM-AS	270	M06003	0.08	0.01	1.69	0.081	---
RM-AS	270	M06004	0.09	0.02	1.67	0.079	---
RM-AS	779	M06010	0.11	0.02	1.78	0.079	---
RM-AS	779	M06009	0.07	0.02	1.56	0.059	---
RM-AS	383	M06008	0.10	0.02	1.67	0.064	---
RM-AS	505	M06007	0.10	0.02	1.71	0.057	---
RM-AS	505	M06006	0.11	0.02	1.56	0.064	---
RM-AS	866	M06005	0.11	0.01	1.64	0.056	0.80
RM-AS	22	M06019	0.09	0.01	1.62	0.065	---
RM-AS	125	M06020_2	0.07	0.02	1.57	0.063	0.84
RM-AS	747	M06020_8	0.09	0.01	1.65	0.071	0.87
RM-AS	747	RAS1	0.09	0.02	1.61	0.064	---
RM-AS	500	M06021	0.10	0.01	1.61	0.070	---
RM-AS	203	M06022	0.09	0.02	1.63	0.071	---
RM-AS	203	M06023	0.10	0.02	1.54	0.060	---
RM-AS	587	M06024	0.11	0.01	1.68	0.061	---
RM-AS	587	M06025	0.10	0.01	1.62	0.064	---
RM-AS	939	M06026_1	0.09	0.01	1.64	0.067	0.86
RM-AS	661	M06026_9	0.10	0.02	1.67	0.072	0.89
RM-AS	466	M06031	0.07	0.02	1.69	0.066	---
RM-AS	466	M06030	0.10	0.01	1.61	0.070	---
RM-AS	10	M06029	0.09	0.01	1.55	0.057	---
RM-AS	10	M06028	0.09	0.02	1.64	0.069	---
RM-AS	10	M06027	0.11	0.02	1.77	0.069	---
RM-AS	966	M06032_6	0.11	0.01	1.70	0.077	0.84
RM-AS	603	M06032_9	0.13	0.01	1.71	0.063	0.85
RM-AS	792	M06037	0.09	0.01	1.62	0.056	---
RM-AS	792	M06036	0.10	0.01	1.62	0.052	---
RM-AS	792	M06035	0.11	0.02	1.66	0.056	---
RM-AS	868	M06039_1	0.11	0.01	1.83	0.060	0.82
RM-AS	791	M06039_3	0.08	0.02	1.52	0.058	0.83
RM-AS	103	M06033	0.11	0.02	1.69	0.080	---
RM-AS	103	M06034	0.09	0.02	1.58	0.071	---
RM-AS	996	RAS2	0.10	0.02	1.67	0.068	---
RM-AS	996	M06038	0.10	0.01	1.57	0.069	---

Table 2.5.4 Results of RMNS Lot.AT analysis in this cruise.

μmol/kg

	serial	Stn.	NO_3	NO_2	SiO_2	PO_4	NH_4
RM-AT	125	M06001	7.47	0.02	17.93	0.573	---
RM-AT	981	M06011	7.51	0.02	17.95	0.571	---
RM-AT	981	M06012	7.47	0.02	17.97	0.563	---
RM-AT	406	M06013	7.53	0.02	17.94	0.568	---
RM-AT	406	M06014	7.47	0.02	17.99	0.584	---
RM-AT	406	M06015	---	0.02	17.88	0.576	---
RM-AT	523	M06015	7.39	0.02	---	---	---
RM-AT	523	M06002_3	7.46	0.02	17.98	0.582	0.72
RM-AT	523	M06002_4	7.45	0.02	18.04	0.577	---
RM-AT	298	M06016	7.52	0.02	18.08	0.581	---
RM-AT	298	M06017	7.50	0.02	18.00	0.589	---
RM-AT	287	M06018	7.45	0.02	17.92	0.584	---
RM-AT	287	M06003	7.56	0.02	18.01	0.595	---
RM-AT	287	M06004	7.52	0.02	17.93	0.589	---
RM-AT	884	M06010	7.50	0.02	17.98	0.581	---
RM-AT	884	M06009	7.44	0.02	17.92	0.571	---
RM-AT	209	M06008	7.47	0.02	17.91	0.579	---
RM-AT	209	M06007	7.47	0.02	17.89	0.574	---
RM-AT	209	M06006	7.48	0.02	17.82	0.568	---
RM-AT	600	M06005	7.43	0.02	17.95	0.559	---
RM-AT	600	M06019	7.48	0.02	17.98	0.566	0.72
RM-AT	66	M06020_2	7.49	0.02	17.94	0.577	0.77
RM-AT	873	M06020_8	7.45	0.02	18.03	0.578	0.73
RM-AT	873	RAS1	7.47	0.02	17.98	0.573	---
RM-AT	724	M06021	7.48	0.01	17.97	0.587	---
RM-AT	766	M06022	7.46	0.02	17.93	0.586	---
RM-AT	766	M06023	7.45	0.02	17.84	0.571	---
RM-AT	598	M06024	7.51	0.02	17.92	0.570	---
RM-AT	598	M06025	7.47	0.02	18.01	0.572	---
RM-AT	779	M06026_1	7.46	0.01	17.99	0.576	0.73
RM-AT	813	M06026_9	7.45	0.02	18.01	0.582	0.76
RM-AT	937	M06031	7.44	0.02	18.04	0.578	---
RM-AT	937	M06030	7.52	0.02	17.93	0.580	---
RM-AT	417	M06029	7.48	0.01	17.87	0.568	---
RM-AT	417	M06028	7.49	0.02	17.88	0.572	---
RM-AT	417	M06027	7.51	0.02	18.09	0.572	---
RM-AT	973	M06032_6	7.50	0.02	18.02	0.583	0.76
RM-AT	801	M06032_9	7.55	0.02	18.04	0.570	0.77
RM-AT	845	M06037	7.45	0.02	17.97	0.570	---
RM-AT	845	M06036	7.46	0.02	17.91	0.563	---
RM-AT	845	M06035	7.49	0.02	17.89	0.565	---
RM-AT	59	M06039_1	7.42	0.02	17.98	0.576	0.76
RM-AT	651	M06039_3	7.47	0.02	17.94	0.569	0.76
RM-AT	888	M06033	7.47	0.03	17.99	0.581	---
RM-AT	888	M06034	7.50	0.02	17.96	0.580	---
RM-AT	207	RAS2	7.49	0.02	17.99	0.577	---
RM-AT	207	M06038	7.48	0.02	17.87	0.579	---

Table 2.5.5 Results of RMNS Lot.AU analysis in this cruise.

μmol/kg

	serial	Stn.	NO_3	NO_2	SiO_2	PO_4	NH_4
RM-AU	6	M06001	29.86	0.01	66.39	2.179	---
RM-AU	450	M06011	30.07	0.02	66.59	2.162	---
RM-AU	6	M06011	30.02	0.02	66.51	2.163	---
RM-AU	450	M06012	29.93	0.02	66.39	2.162	---
RM-AU	6	M06012	29.90	0.02	66.44	2.169	---
RM-AU	458	M06013	30.01	0.02	66.55	2.173	---
RM-AU	450	M06013	30.03	0.01	66.48	2.175	---
RM-AU	458	M06014	29.85	0.01	66.48	2.173	---
RM-AU	450	M06014	29.81	0.01	66.54	2.177	---
RM-AU	458	M06015	---	0.01	66.41	2.173	---
RM-AU	450	M06015	---	0.01	66.52	2.180	---
RM-AU	604	M06015	29.82	0.01	---	---	---
RM-AU	458	M06015	29.81	0.01	---	---	---
RM-AU	604	M06002_3	29.82	0.01	66.52	2.169	0.58
RM-AU	458	M06002_3	29.84	0.01	66.46	2.179	---
RM-AU	604	M06002_4	29.86	0.01	66.57	2.170	---
RM-AU	458	M06002_4	29.86	0.01	66.50	2.179	---
RM-AU	988	M06016	29.91	0.01	66.67	2.171	---
RM-AU	604	M06016	29.95	0.01	66.67	2.178	---
RM-AU	988	M06017	29.97	0.01	66.62	2.181	---
RM-AU	604	M06017	30.03	0.01	66.65	2.184	---
RM-AU	495	M06018	29.95	0.01	66.36	2.179	---
RM-AU	988	M06018	29.90	0.02	66.36	2.183	---
RM-AU	495	M06003	30.05	0.01	66.70	2.187	---
RM-AU	988	M06003	30.07	0.01	66.77	2.186	---
RM-AU	495	M06004	29.89	0.01	66.44	2.185	---
RM-AU	988	M06004	30.03	0.02	66.44	2.185	---
RM-AU	288	M06010	29.84	0.01	66.49	2.165	---
RM-AU	495	M06010	29.86	0.02	66.51	2.170	---
RM-AU	288	M06009	29.85	0.02	66.53	2.163	---
RM-AU	495	M06009	29.83	0.02	66.58	2.169	---
RM-AU	505	M06008	29.86	0.02	66.41	2.167	---
RM-AU	288	M06008	29.90	0.02	66.41	2.170	---
RM-AU	505	M06007	29.90	0.02	66.37	2.171	---
RM-AU	288	M06007	29.86	0.02	66.28	2.173	---
RM-AU	505	M06006	30.00	0.02	66.26	2.160	---
RM-AU	288	M06006	30.00	0.02	66.33	2.160	---
RM-AU	866	M06005	29.99	0.02	66.50	2.160	---
RM-AU	505	M06005	29.97	0.01	66.55	2.163	---
RM-AU	866	M06019	29.91	0.02	66.66	2.158	0.55
RM-AU	505	M06019	29.83	0.02	66.68	2.164	0.55
RM-AU	119	M06020_2	29.93	0.02	66.60	2.179	0.55
RM-AU	50	M06020_2	29.97	0.02	66.54	2.185	---
RM-AU	514	M06020_8	29.85	0.01	66.74	2.175	0.57
RM-AU	119	M06020_8	29.88	0.02	66.77	2.185	---
RM-AU	514	RAS1	29.93	0.02	66.63	2.181	---
RM-AU	119	RAS1	29.93	0.02	66.80	2.182	---

RM-AU	998	M06021	29.86	0.00	66.49	2.186	---
RM-AU	514	M06021	29.94	0.01	66.54	2.193	---
RM-AU	35	M06022	29.91	0.01	66.44	2.181	---
RM-AU	998	M06022	29.84	0.01	66.40	2.185	---
RM-AU	35	M06023	29.91	0.02	66.38	2.172	---
RM-AU	998	M06023	29.81	0.02	66.54	2.177	---
RM-AU	672	M06024	30.00	0.01	66.49	2.169	---
RM-AU	35	M06024	30.03	0.01	66.53	2.170	---
RM-AU	672	M06025	29.85	0.01	66.56	2.174	---
RM-AU	35	M06025	29.91	0.01	66.64	2.176	---
RM-AU	43	M06026_1	29.85	0.02	66.58	2.19	0.55
RM-AU	672	M06026_1	29.87	0.01	66.70	2.192	---
RM-AU	650	M06026_9	29.83	0.02	66.53	2.177	0.55
RM-AU	43	M06026_9	29.86	0.02	66.62	2.181	---
RM-AU	525	M06031	29.91	0.01	66.61	2.172	---
RM-AU	650	M06031	29.93	0.01	66.69	2.177	---
RM-AU	525	M06030	29.95	0.01	66.48	2.180	---
RM-AU	650	M06030	30.04	0.01	66.51	2.181	---
RM-AU	110	M06029	29.87	0.01	66.47	2.181	---
RM-AU	525	M06029	29.86	0.01	66.54	2.174	---
RM-AU	110	M06028	29.83	0.02	66.36	2.176	---
RM-AU	525	M06028	29.89	0.02	66.48	2.179	---
RM-AU	110	M06027	29.88	0.02	66.69	2.175	---
RM-AU	525	M06027	29.87	0.02	66.63	2.171	---
RM-AU	986	M06032_6	29.97	0.01	66.57	2.176	0.56
RM-AU	272	M06032_6	29.99	0.01	66.65	2.187	---
RM-AU	23	M06032_9	29.86	0.01	66.61	2.167	0.56
RM-AU	986	M06032_9	29.88	0.01	66.70	2.165	---
RM-AU	430	M06037	29.85	0.01	66.61	2.171	---
RM-AU	23	M06037	29.86	0.02	66.62	2.175	---
RM-AU	430	M06036	29.90	0.01	66.48	2.165	---
RM-AU	23	M06036	29.88	0.01	66.44	2.167	---
RM-AU	430	M06035	29.94	0.02	66.55	2.169	---
RM-AU	23	M06035	29.91	0.02	66.54	2.168	---
RM-AU	626	M06039_1	29.79	0.01	66.55	2.180	0.56
RM-AU	430	M06039_1	29.81	0.01	66.57	2.187	---
RM-AU	682	M06039_3	29.84	0.01	66.66	2.160	0.58
RM-AU	626	M06039_3	29.91	0.01	66.90	2.165	---
RM-AU	277	M06033	29.92	0.02	66.56	2.167	---
RM-AU	682	M06033	29.95	0.02	66.49	2.169	---
RM-AU	277	M06034	29.93	0.02	66.45	2.165	---
RM-AU	682	M06034	29.91	0.02	66.46	2.169	---
RM-AU	863	RAS2	29.92	0.02	66.46	2.176	---
RM-AU	277	RAS2	29.94	0.02	66.53	2.179	---
RM-AU	863	M06038	29.89	0.01	66.53	2.170	---
RM-AU	277	M06038	29.90	0.01	66.52	2.167	---

Table 2.5.6 Summary of RMNS Lot.AS, AT, AU analysis in MR04-04, MR05-05, MR05-04, and MR06-03 cruise.

μmol/kg

RM-AS		NO_3	NO_2	SiO_2	PO_4	NH_4
MR06-03	median	0.10	0.01	1.67	0.065	0.84
	stdev	0.01	0.00	0.07	0.008	0.03
	n=	49	50	49	49	12
MR05-04	median	0.14	0.01	1.68	0.078	0.82
	stdev	0.02	0.00	0.04	0.011	0.02
	n=	15	15	16	15	14
MR05-01	median	0.09	0.01	1.65	0.077	ND
	stdev	0.03	0.00	0.06	0.005	ND
	n=	16	16	16	16	ND
MR04-04	median	0.11	0.01	1.63	0.072	ND
	stdev	0.02	0.00	0.10	0.014	ND
	n=	41	41	42	41	ND

μmol/kg

RM-AT		NO_3	NO_2	SiO_2	PO_4	NH_4
MR06-03	median	7.47	0.02	17.97	0.576	0.76
	stdev	0.03	0.00	0.06	0.008	0.02
	n=	49	50	49	49	12
MR05-04	median	7.49	0.02	18.40	0.591	0.71
	stdev	0.03	0.00	0.05	0.011	0.02
	n=	15	15	16	15	14
MR05-01	median	7.49	0.02	18.31	0.587	ND
	stdev	0.06	0.00	0.07	0.005	ND
	n=	16	16	16	16	ND
MR04-04	median	7.47	0.01	18.32	0.582	ND
	stdev	0.04	0.00	0.10	0.012	ND
	n=	41	41	42	41	ND

μmol/kg

RM-AU		NO_3	NO_2	SiO_2	PO_4	NH_4
MR06-03	median	29.90	0.01	66.53	2.174	0.56
	stdev	0.07	0.00	0.12	0.008	0.01
	n=	94	96	94	94	12
MR05-04	median	29.99	0.01	68.25	2.186	0.52
	stdev	0.06	0.00	0.15	0.011	0.02
	n=	28	28	30	28	13
MR05-01	median	29.97	0.01	67.92	2.191	ND
	stdev	0.09	0.00	0.21	0.007	ND
	n=	28	28	28	28	ND
MR04-04	median	29.94	0.01	68.00	2.176	ND
	stdev	0.08	0.00	0.17	0.012	ND
	n=	102	102	104	102	ND

2.6 pH measurement

Minoru KAMATA (MWJ)
Ayaka HATSUYAMA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the greenhouse gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters (alkalinity, total dissolved inorganic carbon, pH and pCO_2) that could be measured. When more than two of the four parameters are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of pH during MR06-03cruise.

(2) Measured Parameters

pH (Total hydrogen ion concentration scale)

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 39 stations. Seawater was sampled in a 125ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution at least 3 hours and was cleaned by fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 10 seconds with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the lab to be measured. The glass bottles were put in the water bath kept about 25℃ before the measurement.

(3)-2 Seawater analysis

pH ($-\log[H^+]$) of the seawater was measured potentiometrically in the closed glass bottle at the temperature 25℃ (pH_{25}). Value of pH determined experimentally from sequential measurements of the electromotive force (the e.m.f.) of electrode cell in a standard buffer of known (defined) pH and in the seawater sample.

Ag, AgCl | solution of KCl || test solution | H+ -glass –electrode.

The e.m.f. of the glass / reference electrode cell was measured with a pH / Ion meter (Radiometer PHM240). Separate glass (Radiometer pHG201) and reference (Radiometer REF201) electrodes were used. In order not to have seawater sample exchange CO_2 with the atmosphere during pH measurement, closed glass bottle was used. The temperature during pH measurement was monitored with temperature sensor (Radiometer T201) and controlled to 25℃ within ±0.1℃.

To calibrate the electrodes the TRIS (Lot=060502-1, 060502-2: pH=8.0906 pH units at 25℃, Delvalls and Dickson, 1998) and AMP (Lot=060502: pH=6.7839 pH units at 25℃, DOE, 1994) in the synthetic seawater (Total hydrogen scale) were applied.

pH_T of seawater sample (pH_{samp}) is calculated from the expression:

$$pH_{samp} = pH_{TRIS} + (E_{TRIS} - E_{samp}) / ER$$

where electrode response "ER" is calculated as follows:

$$ER = (E_{AMP} - E_{TRIS}) / (pH_{TRIS} - pH_{AMP})$$

ER value should be equal to the ideal Nernst value as follows:

$$ER = RT\ LN(10) / F = 59.16 \text{ mV / pH units at } 25℃$$

(4) Preliminary results

A replicate analysis was made on every 8th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.6-1). The average of the difference was 0.001 pH units (n=140 pairs). The standard deviation was 0.001 pH units, which indicates that the analysis was accurate enough according to DOE (1994).

(5) Data Archive

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

Reference

DOE (1994), Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74

DelValls, T. A. and Dickson, A. G., 1998. The pH of buffers based on 2-amino-2-hydroxymethyl-1,3-propanediol ('tris') in synthetic sea water. Deep-Sea Research Ⅰ 45, 1541-1554.

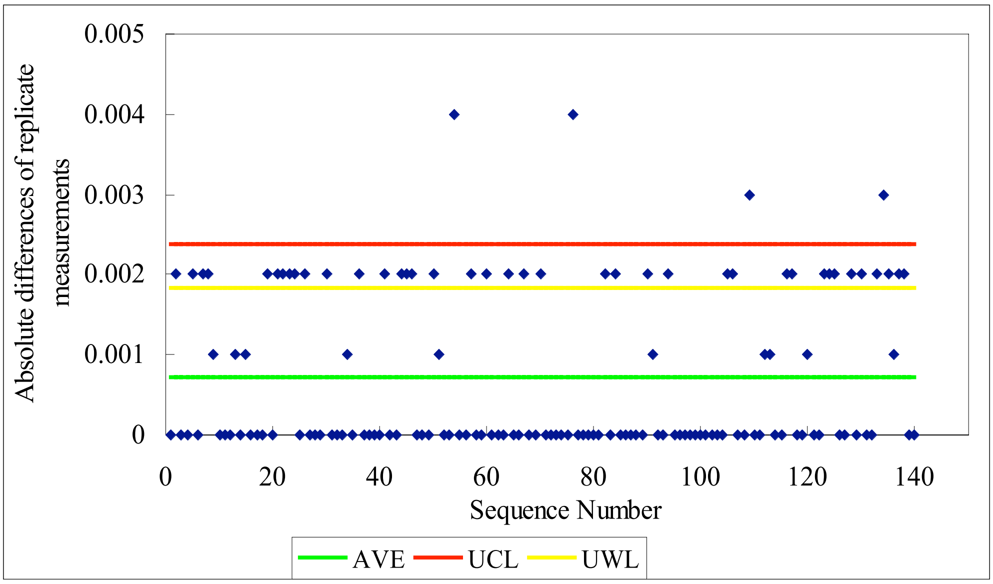


Figure 2.6-1 Range control chart of the absolute differences of replicate measurements carried out in the analysis of pH during the MR06-03 cruise.

2.7 Dissolved inorganic carbon

Fuyuki SHIBATA (MWJ)
Masaki MORO (MWJ)
Yoshiko ISHIKAWA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the greenhouse gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters (alkalinity, total dissolved inorganic carbon, pH and pCO_2) that could be measured. When more than two of the four parameters are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of DIC during MR06-03 cruise.

(2) Measured Parameters

Dissolved inorganic carbon

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 38 stations. Seawater was sampled in a 300ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution at least 3 hours and was cleaned by fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the lab to be measured. Prior to the analysis, 3ml of the sample (1% of the bottle volume) was removed from the glass bottle in order to make a headspace. The samples were then poisoned with 100μl of over saturated solution of mercury chloride within one hour from the sampling point. After poisoning, the samples were sealed using grease (Apiezon M grease) and a stopper-clip. The samples were stored in a refrigerator at approximately 5degC until analyzed.

(3)-2 Seawater analysis

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

The seawater dispensing system has an auto-sampler (6 ports), which takes seawater into a glass bottle and dispenses the seawater to a pipette of nominal 20 ml (system A and C) and 16ml (system B) volume by PC control. The pipette was kept at 20 degC by a water jacket, in which water from a water bath set at 20 degC is circulated.

CO_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 extraction system by adding phosphoric acid (10% v/v). The stripping chamber is made approx. 25 cm long and has a fine frit at the bottom. To degas CO_2 as quickly as possible, a heating wire kept at 40 degC (system A and B) is rolled from the bottom to a 1/3 height of the stripping chamber. The acid is added to the stripping chamber from the bottom of the chamber by pressurizing an acid bottle for a given time to push out the right amount of acid. The pressurizing is made with nitrogen gas (99.9999 %). After the acid is transferred to the stripping chamber, a seawater sample kept in a pipette is introduced to the stripping chamber by the same method as that for adding an acid. The seawater reacted with phosphoric acid is stripped of CO_2 by bubbling the nitrogen gas through a fine frit at the bottom of the stripping chamber. The CO_2 stripped in the chamber is carried by the nitrogen gas (flow rates of 140ml min^{-1}) to the coulometer through a dehydrating module. For system A, the module consists of two electric dehumidifiers (kept at 1 - 2 degC) and a chemical desiccant ($Mg(ClO_4)_2$). For system B, it consists of three electric dehumidifiers with a chemical desiccant. For system C, the module consists of two electric dehumidifiers (kept at 1 - 2 degC).

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

(4) Preliminary results

During the cruise, 1529 samples were analyzed for DIC. A replicate analysis was made on every forth seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.7.-1.). The average of the differences was 1.3μmol/kg (n=140). The standard deviation was 1.2 μmol/kg which indicates that the analysis was accurate enough according to DOE (1994).

(5) Data Archive

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

Reference

DOE (1994), Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74

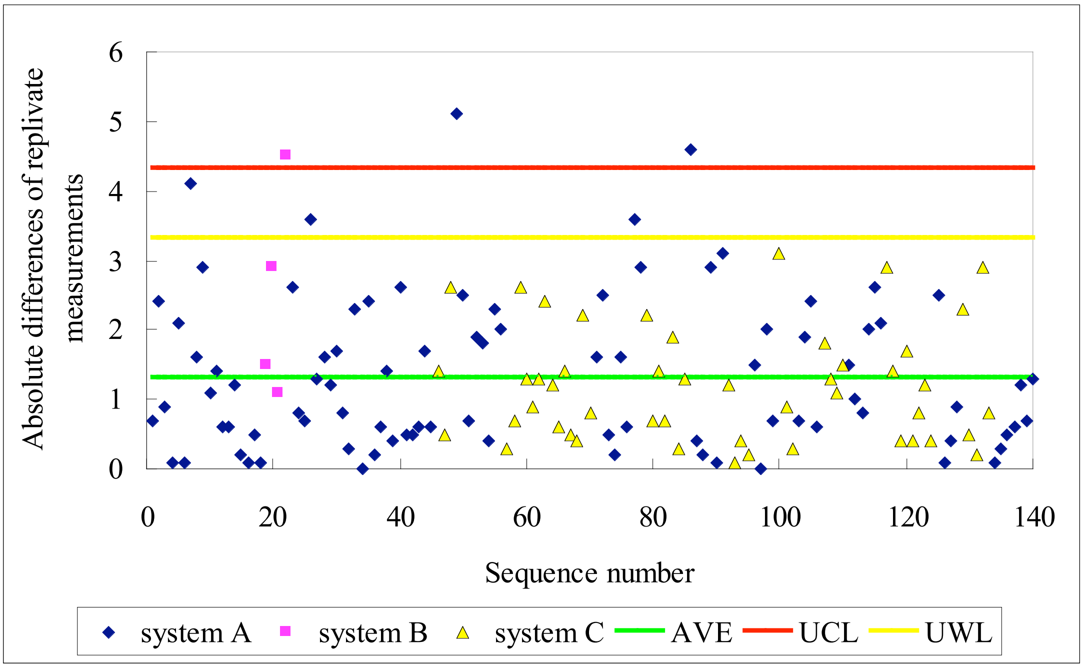


Figure 2.7.-1 Range control chart of the absolute differences of replicate measurements carried out in the analysis of DIC during the MR06-03 cruise.

2.8 Total Alkalinity

Minoru KAMATA (MWJ)
Ayaka HATSUYAMA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. When more than two of the four parameters are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of total alkalinity (TA) in MR06-03 cruise.

(2) Measured Parameters

Total Alkalinity, TA

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 39 stations. Seawater was sampled in a 125ml glass bottle (SCHOTT DURAN) that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 2 hours and was cleaned by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 10 seconds with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. The bottles were put in the water bath kept about 25℃ before the measurement.

(3)-2 Seawater analysis

Measurement of Alkalinity was made using a titration systems (Nippon ANS, Inc.). The systems comprise of water dispensing unit, an auto-burette (Metrohm) and a pH meter (Thermo Orion), which are automatically controlled by a PC.

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

Calibration of the acid titrant was made by measuring TA of 6 solutions of Na_2CO_3 in 0.7 M NaCl solutions. The computed TAs were approx. 0, 500, 1000, 1500, 2000 and 2500 $\mu mol\ kg^{-1}$. The measured values of TA (calculated by assuming 0.05 M) should be a linear function of the TA contributed by the Na_2CO_3. The line was fitted by the method of least squares. Theoretically, the slope should be unity. If the measured slope is not equal to one, the acid normality should be adjusted by dividing initial normality by the slope, and the whole set of calculations is repeated until the slope = 1

Calculation of TA was made based on a modified Gran approach.

(4) Preliminary results

A few replicate samples were taken on every station and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.8-1). The average of the difference was 1.3 μmol/kg (n= 133). The standard deviation was 1.1 μmol/kg, which indicates that the analysis was accurate enough according to DOE (1994).

(5) Data Archive

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

(6) Reference

DOE (1994), Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74

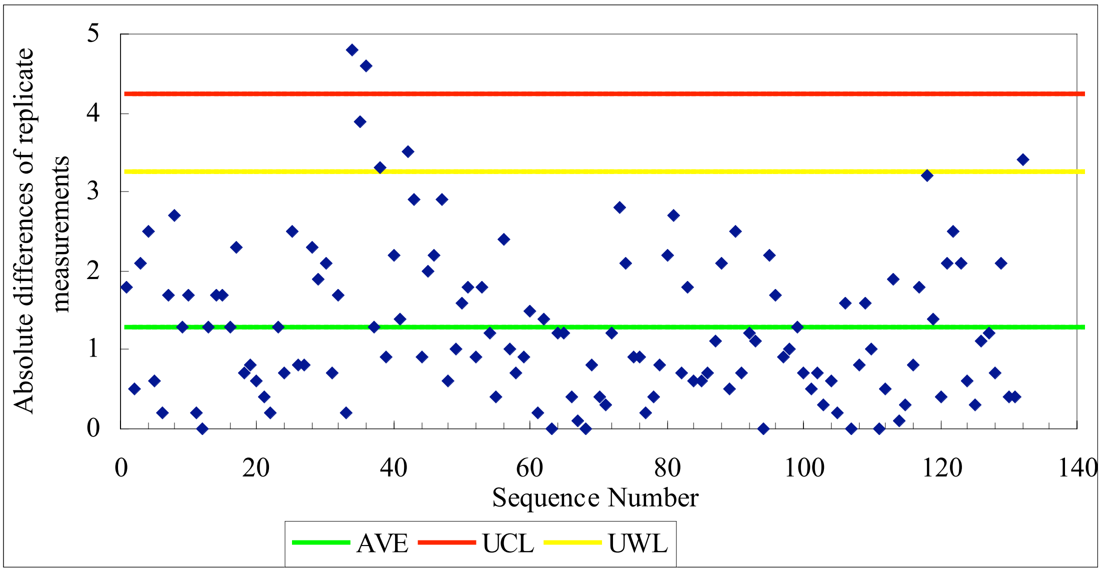


Figure 2.8-1 Range control chart of the absolute differences of replicate measurements carried out in the analysis of TA during the MR06-03 cruise.

2.9 Underway pCO_2 measurements

2.9.1 Partial Pressure of CO_2 (pCO_2) Measurement

Fuyuki SHIBATA (MWJ)
Masaki MORO (MWJ)

(1) Objective

Since global warming is becoming an environmental issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. As the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important in order to predict the phenomenon that is likely to happen in the future. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. Instead, the concentration of CO_2 system in the water could be estimated by measuring 2 parameters out of 4, which is alkalinity, total dissolved inorganic carbon (TDIC), pH and pCO_2 (DOE, 1994). We here report on board measurements of pCO_2 in the North Pacific that was analyzed during MR06-03 cruise.

(2) Measured Parameters

Partial pressure of CO_2 in the atmosphere and surface seawater

(3) Apparatus and performance

Concentrations of CO_2 in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (BINOS^{TM}). One cycle for the automated system ran for one and a half hour. In one cycle, standard gasses, marine air and air in a headspace of an equilibrator were analyzed subsequently. The concentrations of the standard gases used for the analysis were 150.02, 259.93, 310.04, 359.99 and 410.15 ppm.

The marine air taken from the bow was introduced into the NDIR by passing through a mass flow controller (controlling the air flow rate at about 0.5 L/min), a cooling unit, a Perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

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

(4) Preliminary results

Figure 2.9.1 is showing the results of measuring the CO_2 concentration (xCO_2) of ambient air samples and the seawater samples.

(5) Notification

The followings are the periods and the reasons for the lack of data from the analysis during the cruise (The periods appear in UTC).

6/4 3:40 - 6/6 3:45 K2 station site
6/6 13:02 - 6/6 16:41 Malfunction of the system due to the water trap going off.
6/13 2:29 - 6/15 4:21 K2 station site
6/15 23:25 - 6/19 10:00 Kushiro embarkment
6/19 15:28 - 6/19 17:05 Malfunction of the system due to water spillage in the lab.
6/28 11:18 - 6/28 11:25 Stopped the system in order to clean the filter and the shower.
6/30 9:29 - 6/30 14:55 Malfunction of the system due to the water trap going off.
7/12 17:08 - 7/12 17:11 Stopped the system in order to clean the filter and the shower.
7/13 6:50 - 7/13 9:03 Malfunction of the system due to an error of the data-path in the PC.

During the following periods, the data of salinity is incorrect due to the EPCS system being turned off.

(From) 06/05/27 11:15:00 (To) 06/05/27 11:45:00
(From) 06/06/19 10:36:00 (To) 06/06/19 11:06:00
(From) 06/06/19 15:15:00 (To) 06/06/19 15:26:00
(From) 06/06/19 23:51:00 (To) 06/06/20 01:55:59
(From) 06/06/22 02:24:57 (To) 06/06/22 03:24:57
(From) 06/06/22 04:04:57 (To) 06/06/22 04:29:56
(From) 06/06/23 21:43:55 (To) 06/06/23 23:17:54
(From) 06/06/30 9:25:00 (To) 06/06/30 9:28:00
(From) 06/07/03 03:59:56 (To) 06/07/03 04:54:56

(6) Data Archive

All data was submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), *Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water*; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74.

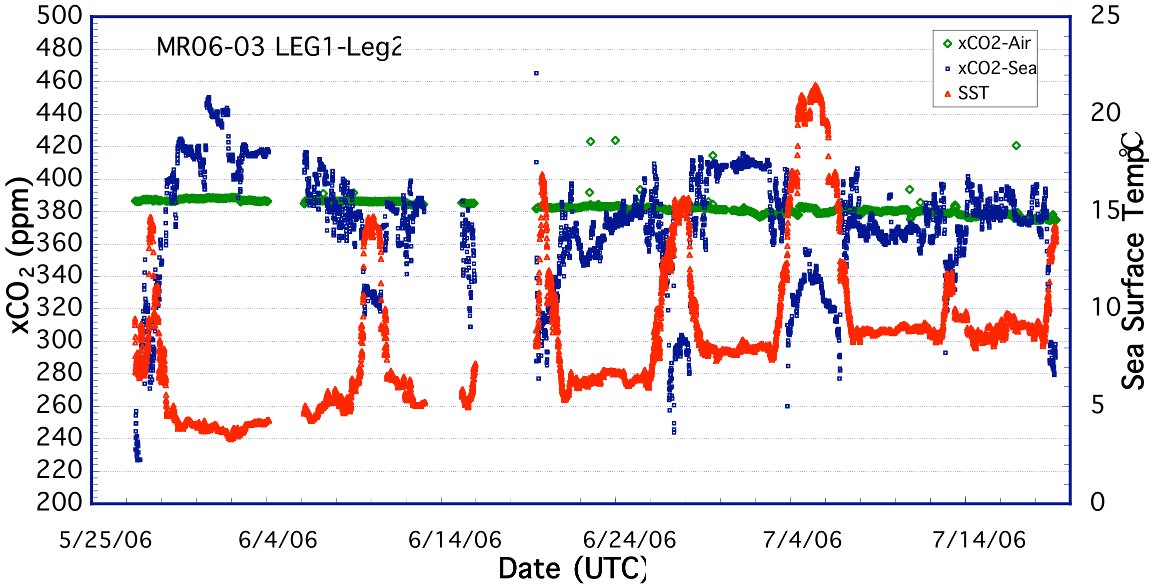


Figure 2.9.1 Mole fraction of CO_2 (xCO_2) in atmosphere (green) and surface seawater (blue), and SST (red) that was analyzed in the North Pacific during MR06-03 cruise.

2.9.2 Underway pCO_2

Yoshiyuki NAKANO (JAMSTEC MIO)

(1) Objective

I newly developed two CO_2 sensors to obtain surface distributions of partial of CO_2 (pCO_2), based on the spectrophotometric method. In this cruise, I aim at testing the new CO_2 sensors on first trial and comparing between CO_2 sensors data and automated underway pCO_2 analyzing system data.

(2) Method

The CO_2 sensor for the measurement of pCO_2 is based on the optical absorbance of the pH indicator solution. The CO_2 in the surrounding seawater equilibrates with the pH indicator solution across gas permeable membranes, and the resulting change in optical absorbance, representing the change of pH, is detected by the photo multiplier detector. We calculated the pH in the pH indicator solution from the absorbance ratios. In this cruise I decided to use AF Teflon tube (amorphous fluoropolymer, AF Teflon, AF-2400, Biogeneral Inc.) as an equilibrium membrane because this material is well suited to pCO_2 measurements due to its high gas permeability. The AF Teflon tube (1200 mm) is fixed in a 10L bucket and surface seawater flow into the bucket at a rate of 15 L/min.

a. Indicator solutions

I used two pH indicator (bromocresol purple (BCP) and thymol blue (TB)) solutions for the CO_2 sensors respectively. The absorbance characteristics and dissociation behavior of BCP have been measured in freshwater at low ionic strength (Yao and Byrne, 2001). As the equilibrium constant of BCP (pK_1) is near 6.5, it is suitable for measurements around pH 6.0. The BCP solution was 6 μM, made by dissolving BCP sodium salt in Millipore Super Q water (18 MΩ) and containing 5 μM sodium hydroxide for pH adjustment. The absorbance characteristics and dissociation behavior of TB have been measured in surface seawater (Zhang and Byrne, 1996). The TB solution was 10μM, made by dissolving TB sodium salt in filtrated low nutrient surface seawater.

b. Instruments

The CO_2 sensor is composed of the following parts: an aluminum pressure housing for the electronic modules with a flow cell (1 mm diameter, 100 mm length); an acrylic silicon-oil filled, pressure-compensated vessel containing a tri-valve pump and solenoid valves. The aluminum pressure housing (245 mm diameter, 415 mm length) has an ability to resist water pressure to 3000 m depth. The housing holds a CPU board for system control, an optical component, power board and a 64 Mb flash memory for data logging. The optical fiber penetrates the pressure housing wall and connects the flow cell with the light source and a photomultiplier detector. The optical component is composed of two photomultiplier detectors with amplifiers, three LED lamps, a slit, lens, a beam splitter, and three optical filters. The three filters have wavelengths of 720 nm, 589 nm and 430 nm for BCP, and 720 nm, 600 nm and 438.5 nm for TB, with a band pass width of 10 nm. The three LED lamps flash every 300 msec respectively. The tri-valve pump supply intermittent flows of pH indicator solutions (0.5 ml/min).

(3) Preliminary results

Analytical precision was 0.001 pH, which equates to 1 μatm for pCO_2. Figures 2.9.2-2 and 2.9.2-3 show the calibration curves of BCP solution and TB solution respectively.

(4) Future plan and data Archive

The CO_2 sensors are prototypes, and their performance could be improved by miniaturization using new technology (e.g. micro pump and downsized PC). Our improved systems are available for continuous observations from buoys to obtain continuous spatiotemporal carbonate data in the future. The detailed spatiotemporal variation of these data sets could also give information on climate change and/or the oceanic uptake of CO_2.
All data will be submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74

Nakano, Y., H. Kimoto, S. Watanabe, K. Harada and Y. W. Watanabe (2006): Simultaneous Vertical Measurements of In situ pH and CO_2 in the Sea Using Spectrophotometric Profilers. J. Oceanogra., 62, 71-81.

Yao, W. and R. H. Byrne (2001): Spectrophotometric determination of freshwater pH using bromocresol purple and phenol red, Environ. Sci. Technol., 35, 1197-1201.

Zhang, H., and R. H. Byrne (1996): Spectrophotometric pH measurements of surface seawater at in-situ conditions: absorbance and protonation behavior of thymol blue, Mar. Chem., 52, 17-25.

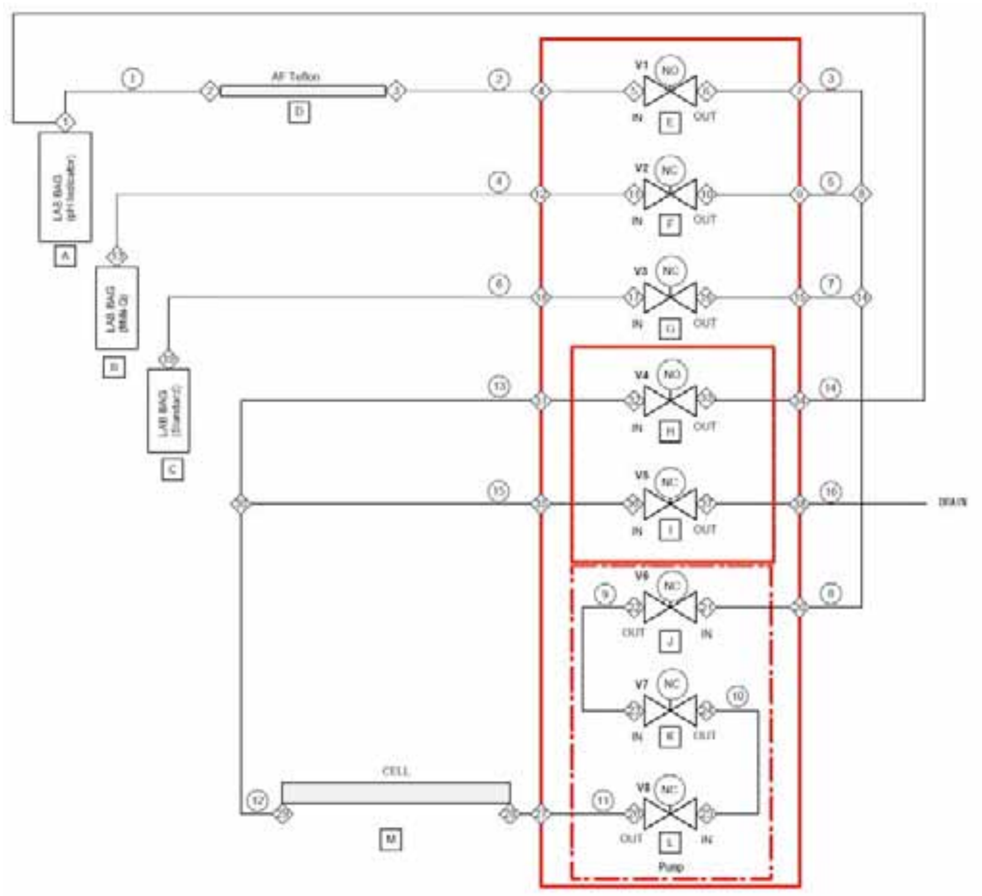


Fig. 2.9.2-1 Flow diagram of the CO_2 sensor.

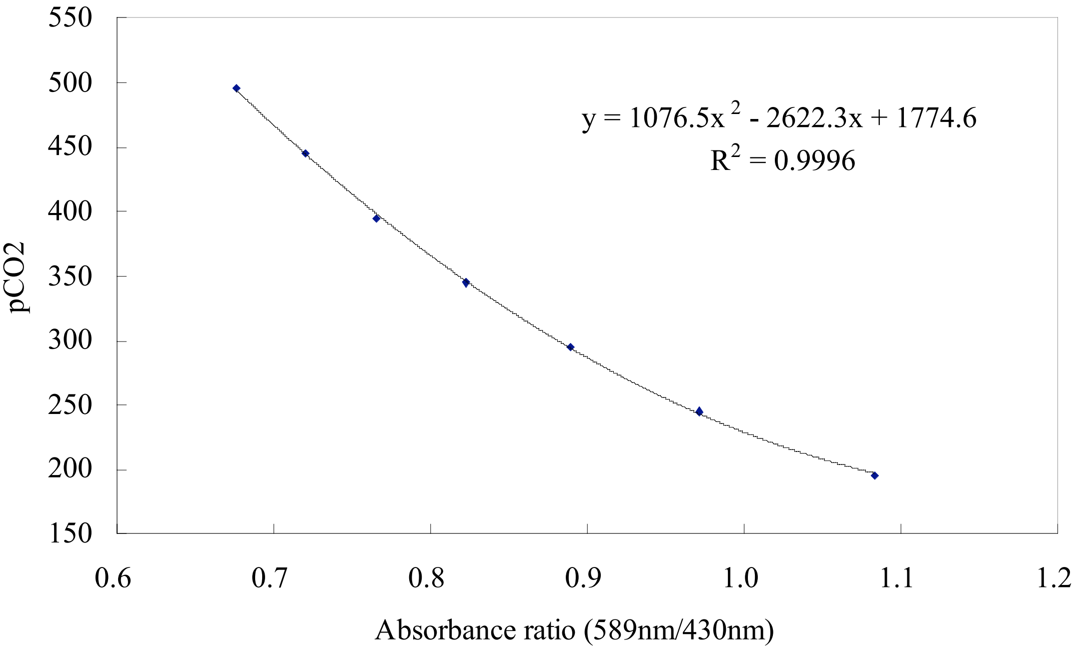


Fig. 2.9.2-2 Calibration curve of BCP solution.

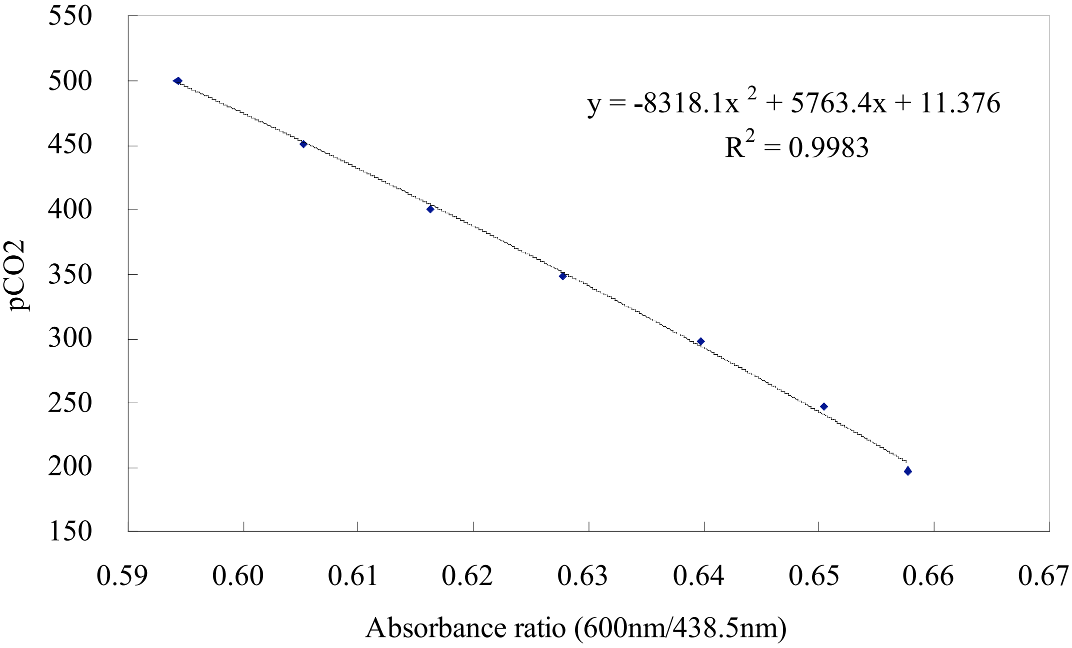


Fig. 2.9.2-3　Calibration curve of TB solution.

3. Special observation

3.1 North Pacific Time-series observatory (HiLATS)

Makio HONDA (JAMSTEC MIO)
Toru IDAI (MWJ)

During this cruise, two types mooring systems which was deployed in September 2005 were recovered and one mooring system was deployed and recovered for approximately 2 months.

3.1.1 Deployment and Recovery

Two types of mooring systems were designed and deployed: one for physical oceanography (PO mooring) and another for biogeochemistry (BGC mooring). We recovered each one PO and BGC mooring then we redeployed and recovered one BGC Mooring at Station K-2. These were deployed at MR05-04 in the Western Subarctic Gyre. It is 47N / 160E, where is close to station KNOT and, however, structure of water mass is more stable than station KNOT. Before deployment, sea floor topography was surveyed with Sea Beam. In order to place the top of mooring systems in the surface euphotic layer, precise water depths for mooring positions was measured by an altimeter (Datasonics PSA900D) mounted on CTD / CWS. Mooring works took approximately 5 hours for each mooring system. After sinker was dropped, we positioned the mooring systems by measuring the slant ranges between research vessel and the acoustic releaser. Each position of the moorings is finally determined as follows:

Table 3.1.1-1 Mooring positions for respective mooring systems

	K-2 BGC K2B060605
Date of deployment	Jun. 5th 2006
Latitude	47° 00.34 N
Longitude	159° 58.41 E
Depth	5,206.2 m

The PO mooring consists of a 64” syntactic top float with 3,000 lbs (1,360 kg) buoyancy, instrument, wire and nylon ropes, glass floats (Benthos 17” glass ball), dual releasers (Edgetech) and 4,660 lbs (2,116 kg). sinker with mace plate. Two autonomous CTD profilers, MMP (McLane Moored Profiler), are installed on the 500 m and 3,500 m wires for observation. Shallow MMP descends and ascends between 50 m and 500 m and deep MMP descends and ascends between 500 m and 4,550 m with taking vertical profiles of CTD and 3D current direction and velocity. Two ARGOS compact mooring locators and one submersible recovery strobe are mounted on all of top floats. Depth sensor (RIGO) is installed on the top of 500 m wire. Before cruise, all wires and nylon ropes are pre-stretched by approximately 1.3 ton, which load corresponds to mooring tension and measured exact length using a laser equipment, which error is ± 1 mm.

The BGC mooring consists of a top float, instruments, mooring wire and rope, glass floats, dual releasers and sinker. The BGC mooring was planned 5,216.2 m depth to keep the following time-series observational instruments are mounted approximately 40 ~ 50 m below sea surface. It is 10 m longer than 5,206.2 m real depth because recovered depth sensor which was installed on the WTS shows 10 m deeper than our expected at MR05-01 by mooring tilt.

- RAS - Remote Access Sampler with Ocean Optical Sensor (BLOOMS)
- WTS - Water Access Sampler with Depth Sensor
- ZPS - Zoo Plankton Sampler
- Sediment Trap – 150 m, 300 m, 540 m, 1,000 m and 5,000 m

Details for each instrument are described later (section 3.1.2). Serial numbers for instruments are as follows:

Table 3.1.1-2 Serial numbers of instruments

	Recovery	Recovery	Deployment and Recovery
Station and type of system Mooring system S / N	K-2 PO K2P050923	K-2 BGC K2B050925	K-2 BGC K2B060605
ARGOS	18840 / 18841	18842 / 52111	18842 / 52111
ARGOS ID	18558 / 18570	18577 / 5373	18577 / 5373
Strobe	233	234	N02-043
MMP (Shallow) (Deep)	ML11241-01 ML11241-04	- -	- -
RAS	-	ML11241-09	ML11241-11
OOS	-	DFLS-072	DFLS-072
WTS	-	ML11241-13	-
Depth Sensor	DP1158	DP1142	DP1142
ZPS	-	ML11241-21	-
Sediment Trap (150m) (300m) (540m) (1000m) (5000m)	- - - - -	0256 878 ML11241-22 ML11241-24 ML11241-25	10357-2 ML11241-22 Dummy ML11241-24 ML11241-25
Compass Sensor	-	-	-
Load-Cell	-	-	-
Releaser	027809 027867	027824 027864	027864 027867

Table 3.1.1-3 Deployment and Recovery Record

Recovered PO Mooring

Mooring Number K2P050923

Project	Time-Series		Depth	5,152.0	m
Area	North Pacific		Planned Depth	5,152.0	m
Station	K-2 PO		Length	5,121.5	m
Target Position	46°52.240	**N**	Depth of Buoy	30	m
	159°59.060	**E**	Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27867		27809		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	12.0	kHz	12.0	kHz	
RELEASE C.	**344573**		**344535**		
Enable C.	360536		360320		
Disable C.	360570		360366		
Battery	1 year		1 year		
Release Test	FINE		FINE		
DEPLOYMENT					
Recorder	Hiroshi Matsunaga		Start	7.1	Nmile
Ship	MIRAI		Overshoot	390	m
Cruise No.	MR05-04		Let go Top Buoy	21:10	
Date	2005/9/23		Let go Anchor	2:13	
Wather	bc		Sink Top Buoy	2:45	
Wave Hight	1.6	m	Pos. of Start	46°58.31	N
Depth		m		160°00.85	E
Ship Heading	<190>		Pos. of Drop. Anc.	46°52.01	N
Ship Ave.Speed	1.4	knot		159°58.88	E
Wind	<188> 5.5	m/s	Pos. of Mooring	46°52.18	N
Current	<082> 0.3	cm/sec		159°59.04	E
RECOVERY					
Recorder	A. Murata		Work Distance	1.4	Nmile
Ship	MIRAI		Send Enable C.	20:08	
Cruise No.	MR06-03		Slant Renge	3411	msec
Date	2006/6/2		Send Release C.	20:16	
Wather	d/f		Discovery Buoy	20:18	
Wave Hight	2.1	m	Pos. of Top Buoy	46°52.40	N
Depth	5165	m		159°54.05	E
Ship Heading	<195>		Pos. of Start	46°52.46	N
Ship Ave.Speed	0.7	knot		159°59.54	E
Wind	<185> ____	m/s	Pos. of Finish	46°51.34	N
Current	<359> 0.5	cm/sec		160°00.56	E

Recovered BGC Mooring

Mooring Number K2B050925

Project	Time-Series	Depth	5,206.2 m
Area	North Pacific	Planned Depth	5,206.2 m
Station	K-2 BGC	Length	5,176.2 m
Target Position	**47°00.350 N**	Depth of Buoy	30 m
	159°58.326 E	Period	1 year

ACOUCTIC RELEASERS

Type	Edgetech	Edgetech
Serial Number	27864	27824
Receive F.	11.0 kHz	11.0 kHz
Transmit F.	12.0 kHz	12.0 kHz
RELEASE C.	**344421**	**344674**
Enable C.	357724	361121
Disable C.	357762	361167
Battery	2 year	2 year
Release Test	FINE	FINE

DEPLOYMENT

Recorder	Hiroshi Matsunaga	Start	7.3 Nmile
Ship	MIRAI	Overshoot	520 m
Cruise No.	MR05-04	Let go Top Buoy	21:42
Date	2005/9/25	Let go Anchor	2:30
Wather	bc	Sink Top Buoy	3:08
Wave Hight	1.7 m	Pos. of Start	46°55.43 N
Depth	m		159°51.22 E
Ship Heading	<045>	Pos. of Drop. Anc.	46°00.59 N
Ship Ave.Speed	1.4 knot		159°58.65 E
Wind	<320> 3.0 m/s	Pos. of Mooring	47°00.33 N
Current	<010> 0.1 m/sec		159°58.31 E

RECOVERY

Recorder	Akinori Murata	Work Distance	1.0 Nmile
Ship	MIRAI	Send Enable C.	20:12
Cruise No.	MR06-03	Slant Renge	3449 msec
Date	2006/5/30	Send Release C.	20:13
Wather	o	Discovery Buoy	20:14
Wave Hight	1.5 m	Pos. of Top Buoy	47°00.55 N
Depth	5209 m		159°58.37 E
Ship Heading	<146>	Pos. of Start	47°00.61 N
Ship Ave.Speed	0.3 knot		159°58.54 E
Wind	<153> 9.1 m/s	Pos. of Finish	46°59.82 N
Current	<054> 0.3 cm/sec		160°00.57 E

Although S/N 27824 waked up by Enable Command 20:01, it did not release by Release Command. S/N 27864 worked fine.

Redeployed and Recovered BGC Mooring

Mooring Number K2B060605

Project	Time-Series		Depth	5,206.2	m
Area	North Pacific		Planned Depth	5,216.2	m
Station	K-2 BGC		Length	5,186.0	m
Target Position	**47°00.350**	**N**	Depth of Buoy	30	m
	159°58.326	**E**	Period	2	month
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27864		27867		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	12.0	kHz	12.0	kHz	
RELEASE C.	**344421**		**344573**		
Enable C.	357724		360536		
Disable C.	357762		360570		
Battery	1 year		6 months		
Release Test	FINE		FINE		
DEPLOYMENT					
Recorder	Akinori Murata		Start	6.8	Nmile
Ship	MIRAI		Overshoot	604	m
Cruise No.	MR06-03		Let go Top Buoy	5:21	
Date	2006/6/5		Let go Anchor	6:01	
Wather	o		Sink Top Buoy	6:01	
Wave Hight	1.7	m	Pos. of Start	46°53.91	N
Depth	5159	m		159°59.17	E
Ship Heading	<355>		Pos. of Drop. Anc.	47°00.67	N
Ship Ave.Speed	2.0	knot		159°58.20	E
Wind	<005> 4.3	m/s	Pos. of Mooring	47°00.34	N
Current	<081> 0.8	m/sec		159°58.41	E
RECOVERY					
Recorder	Naoko Takahashi		Work Distance	3.4	Nmile
Ship	MIRAI		Send Enable C.	19:53	
Cruise No.	MR06-03		Slant Renge	3451	msec
Date	2006/7/17		Send Release C.	19:54	
Wather	o		Discovery Buoy	19:56	
Wave Hight	1.7	m	Pos. of Top Buoy	47°00.30	N
Depth	5170	m		159°58.72	E
Ship Heading	<084>		Pos. of Start	47°00.70	N
Ship Ave.Speed	1.1	knot		159°59.17	E
Wind	<270> 6.1	m/s	Pos. of Finish	47°00.42	N
Current	<060> 0.4	cm/sec		160°03.57	E

Table 3.1.1-4 Deployment and Recovery Working Time Record

Recovery PO Mooring

MOORING NO. K2P050923 DATE 2006/6/2 Name : A. Murata

I T E M	S/N	Switch off	TIME
Top Buoy 025162-01 *ARGOS* and *Flasher*	A:18840/18841 ☑ F:233 ☑	3:20 ☑ ☑	22:32
5m 3/4" PC Chain			
3-TON Swivel			
500m 1/4" Wire *Depth Sensor*	F-05 ☑ DP1158 ☑	1:30 ☑	
Bumper			
MMP	ML11241-01 ☑	6/9 ☑	22:48
Bumper			
3,500m 1/4" Wire	α-05 ☑		
Bumper			
MMP	ML11241-04 ☑	6/9 ☑	23:40
Bumper			
3-TON Swivel			
(8) 17" Glass Balls			
500m 1/4" Wire	G-05 ☑		
(8) 17" Glass Balls			23:56
471m 1/4" Wire	H-05 ☑		
20m 1/4" Wire	#2/20 ☑		
5m 16mm T-Chain			
(32) 17" Glass Balls			0:12
5m 16mm T-Chain			
3-TON Swivel			
Dual Releases	27867 ☑ 27809 ☑	2:15 ☑ ☑	0:10

Joint	DAMAGE	PIN	Note
L ☑	☑	☑	
X ☑	☑	☑	
W ☑	☑	☑	
☑	☑	☑	
☑	☑	☑	
☑	☑	☑	
A ☑	☑	☑	
☑	☑	☑	Tangled α -05&MMP
☑	☑	☑	
☑	☑	☑	
W ☑	☑	☑	
Z ☑	☑	☑	
ZW ☑	☑	☑	
W ☑	☑	☑	Tangled&Cutted G-05&H-05
ZW ☑	☑	☑	
A ☑	☑	☑	
W ☑	☑	☑	
Z ☑	☑	☑	
Z ☑	☑	☑	
Z ☑	☑	☑	
X ☑	☑	☑	

Recovery BGC Mooring

MOORING NO. K2B050925 DATE 2006/5/30 Name :Akinori Murata

ITEM	S/N		Switch off		TIME
Top Buoy 015162-04	A:18842/52111	☑	4:26	☑	21:45
ARGOS and *Flasher*	F:234	☑		☑	
5m 3/4" PC Chain					
RAS	ML11241-09	☑			21:56
WTS	ML11241-13	☑			21:55
Depth Sensor	DP1142	☑			
ZPS	ML11241-20	☑			21:53
3-TON Swivel					
53m 5/16" Wire	X-05	☑			
50m 5/16" Wire Coated	AA-05	☑			
Sediment Trap 150m	10357-2	☑			22:05
2m 16mm T-Chain					
94m 5/16" Wire	V-05	☑			
50m 5/16" Wire Coated	Z-05	☑			
Sediment Trap 300m	-	☑			22:14
2m 16mm T-Chain					
183m 5/16" Wire	R-05	☑			
50m 5/16" Wire Coated	Y-05	☑			
Sediment Trap 540m	ML11241-22	☑			22:28
2m 16mm T-Chain					
403m 5/16" Wire	M-05	☑			
50m 5/16" Wire Coated	DL	☑			
Sediment Trap 1000m	ML11241-24	☑			22:41
2m 16mm T-Chain					
3-TON Swivel					
500m 1/4" Wire	A-05	☑			
(12) 17" Glass Balls					22:55
500m 1/4" Wire	B-05	☑			
500m 1/4" Wire	C-05	☑			
500m 1/4" Wire	D-05	☑			
(8) 17" Glass Balls					23:18
500m 1/4" Wire	E-05	☑			
500m 1/4" Wire	I-05	☑			
440m 1/4" Wire	#N	☑			
(8) 17" Glass Balls					23:41
200m 1/4" Wire	CC-05	☑			
50m 1/4" Wire	CO	☑			
20m 1/4" Wire		☑			
50m 1/4" Wire Coated	#Z	☑			
Sediment Trap 4810m	ML11241-25	☑			23:53
2m 16mm T-Chain					
286m 1/4" Wire	O-05	☑			
15m 1/4" Wire		☑			
5m 16mm T-Chain					
(48) 17" Glass Balls		☑			
5m 16mm T-Chain					
3-TON Swivel					
Dual Releases	27864	☑	1:30	☑	0:06
	27824	☑		☑	

Joint		DAMAGE	PIN	Note
L	☑	☑	☑	
X	☑	☑	☑	RAS one tube was broken
Z	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	ZPS other line tangle
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
W	☑	☑	☑	
W	☑	☑	☑	
ZZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	Tangle
ZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
ZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
K	☑	☑	☑	
Z	☑	☑	☑	
W	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	Tangle
Z	☑	☑	☑	
X	☑	☑	☑	

Redeployment BGC Mooring

MOORING NO. K2B060605 DATE 2006/6/5 Name : Akinori Murata

ITEM	S/N		Switch		TIME
Top Buoy 015162-04 *ARGOS and Flasher*	A:18842/5211 1	☑ ☑	21:00	☑ ☑	21:13
5m 3/4" PC Chain					
RAS *Depth Sensor*	ML11241-11 DP1142	☑ ☑			21:13
3-TON Swivel					
3 m 5/16" Wire	adj	☑			
53m 5/16" Wire	W-05	☑			
53m 5/16" Wire Coated	H	☑			21:23
Sediment Trap 150m	10357-2	☑			
1m 16mm T-Chain					
94m 5/16" Wire	U-05	☑			
50m 5/16" Wire Coated	I-1	☑			
Sediment Trap 300m	ML11241-22	☑			21:34
1m 16mm T-Chain					
183m 5/16" Wire	Q-05	☑			
50m 5/16" Wire Coated	I-2	☑			
Sediment Trap 540m	Dummy	☑			
1m 16mm T-Chain					
403m 5/16" Wire	N-05	☑			
50m 5/16" Wire Coated	I-3	☑			
Sediment Trap 1000m	ML11241-24	☑			22:00
2.8m 16mm T-Chain					
3-TON Swivel					
500m 1/4" Wire	J-05	☑			22:24
(10) 17" Glass Balls		☑			22:24
500m 1/4" Wire	K-05	☑			22:24
500m 1/4" Wire	B-1	☑			
500m 1/4" Wire	B-2	☑			22:55
(8) 17" Glass Balls		☑			23:10
500m 1/4" Wire	B-3	☑			23:10
500m 1/4" Wire	B-4	☑			23:25
440m 1/4" Wire	D	☑			0:07
(8) 17" Glass Balls		☑			0:07
200m 1/4" Wire	CM	☑			
50m 1/4" Wire	CR	☑			0:23
20m 1/4" Wire		☑			0:28
50m 1/4" Wire Coated	#AA	☑			0:31
Sediment Trap 4810m	ML11241-25	☑			0:36
2m 16mm T-Chain					0:36
286m 1/4" Wire	E	☑			0:36
15m 1/4" Wire	adj	☑			0:46
5m 16mm T-Chain					0:50
(48) 17" Glass Balls		☑			0:50
5m 16mm T-Chain					1:12
3-TON Swivel					1:12
Dual Releases	27864 27867	☑ ☑	1:05	☑ ☑	1:12
5m 16mm T-Chain					1:12
20m 1" Nylon	#12	☑			2:17
5m 16mm T-Chain					2:17
4,667lb Mace Anchor					2:17

Joint		DAMAGE	PIN	Note
L	☑	☑	☑	
X	☑	☑	☑	
NZ	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
W	☑	☑	☑	
W	☑	☑	☑	
ZZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
ZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
ZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
K	☑	☑	☑	
Z	☑	☑	☑	
W	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
X	☑	☑	☑	
MX	☑	☑	☑	
Y	☑	☑	☑	
Y	☑	☑	☑	
X	☑	☑	☑	

Recovery BGC Mooring

MOORING NO. K2B060605 DATE 2006/7/16 Name : Naoko Takahashi

I T E M	S/N		Switch		TIME
Top Buoy 015162-04	A:18842/52111	☑	22:49	☑	21:35
ARGOS and Flasher	F:043	☑	22:49	☑	
5m 3/4" PC Chain					21:38
RAS	ML11241-10	☑		☐	21:41
Depth Sensor	DP1142	☑		☐	
3-TON Swivel					〃
3 m 5/16" Wire	adj	☑			〃
53m 5/16" Wire	W-05	☑		☐	21:46
53m 5/16" Wire Coated	H	☑		☐	21:51
Sediment Trap 150m	0256	☑			〃
1m 16mm T-Chain					〃
94m 5/16" Wire	U-05	☑			21:55
50m 5/16" Wire Coated	I-1	☑			21:59
Sediment Trap 300m	ML11241-22	☑		☐	〃
1m 16mm T-Chain					〃
183m 5/16" Wire	Q-05	☑			22:04
50m 5/16" Wire Coated	I-2	☑			22:08
Sediment Trap 540m	Dummy	☑			〃
1m 16mm T-Chain					〃
403m 5/16" Wire	N-05	☑			22:17
50m 5/16" Wire Coated	I-3	☑			22:21
Sediment Trap 1000m	ML11241-24	☑		☐	〃
2.8m 16mm T-Chain					〃
3-TON Swivel					〃
500m 1/4" Wire	J-05	☑			22:31
(10) 17" Glass Balls		☑			〃
500m 1/4" Wire	K-05	☑			22:40
500m 1/4" Wire	B-1	☑			22:48
500m 1/4" Wire	B-2	☑			22:58
(8) 17" Glass Balls		☑			〃
500m 1/4" Wire	B-3	☑			23:08
500m 1/4" Wire	B-4	☑			23:17
440m 1/4" Wire	D	☑			23:24
(8) 17" Glass Balls		☑			〃
200m 1/4" Wire	CM	☑			23:32
50m 1/4" Wire	CR	☑			23:33
20m 1/4" Wire		☑			〃
50m 1/4" Wire Coated	#AA	☑			23:37
Sediment Trap 4810m	ML11241-25	☑		☐	〃
2m 16mm T-Chain					〃
286m 1/4" Wire	E	☑			23:44
15m 1/4" Wire	adj	☑			23:45
5m 16mm T-Chain					23:47
(48) 17" Glass Balls		☑			23:50
5m 16mm T-Chain					〃
3-TON Swivel					〃
Dual Releases	27864 27867	☑ ☑		☑ ☑	〃

Joint		DAMAGE	PIN	Note
L	☑	☑	☑	
X	☑	☑	☑	
NZ	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
H	☑	☑	☑	
I	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
W	☑	☑	☑	
W	☑	☑	☑	
ZZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
ZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	Tangle
ZW	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
A	☑	☑	☑	
K	☑	☑	☑	
Z	☑	☑	☑	
W	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	Tnagle
Z	☑	☑	☑	
X	☑	☑	☑	

Table 3.1.1-5　Detail of our mooring system.

Recovery PO Mooring

	Mooring ID	Joint	Water Depth						
	Description		Item Length (m)	Total (kg)	Mooring Length (m)	Mooring Weight (kg)	Above Bottom (m)	Below Surface (m)	
1	64" Syntatic Sphere		2.27	-1360.78	2.3	-1360.8	5123.1	29.2	30
	Hardware	L	0.28	3.60	2.6	-1357.2	5120.9	31.4	
2	3/4" Proof Coil Chain		5.00	40.01	7.6	-1317.2	5120.6	31.7	
	Hardware	X	0.25	2.40	7.8	-1314.8	5115.6	36.7	
3	3-TON Miller Swivel		0.16	3.20	8.0	-1311.6	5115.3	37.0	
	Hardware	W	0.22	1.65	8.2	-1309.9	5115.2	37.1	
4	500 Meters 1/4" Wire [F-05]		502.14	70.61	510.3	-1239.3	5115.0	37.4	40
	Hardware	A	0.21	1.30	510.5	-1238.0	4612.8	539.5	500
5	3500 Meters 1/4" Wire		3520.31	495.00	4030.8	-743.0	4612.6	539.7	540
	Hardware	W	0.22	1.65	4031.1	-741.4	1092.3	4060.0	4000
6	3-TON Miller Swivel		0.16	3.20	4031.2	-738.2	1092.1	4060.2	
	Hardware	Z	0.24	2.00	4031.5	-736.2	1091.9	4060.4	
8	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4035.5	-815.5	1091.7	4060.6	
	Hardware	Z	0.24	2.00	4035.7	-813.5	1087.7	4064.6	
10	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4039.7	-892.9	1087.4	4064.9	
	Hardware	W	0.22	1.65	4039.9	-891.2	1083.4	4068.9	
11	500 Meters 1/4" Wire [G-05]		502.09	70.60	4542.0	-820.6	1083.2	4069.1	
	Hardware	W	0.22	1.65	4542.2	-819.0	581.1	4571.2	
12	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4546.2	-898.3	580.9	4571.4	
	Hardware	Z	0.24	2.00	4546.5	-896.3	576.9	4575.4	
13	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4550.5	-975.7	576.7	4575.6	
	Hardware	W	0.22	1.65	4550.7	-974.0	572.7	4579.6	
14	471 Meters 1/4" Wire [H-05]		471.52	66.30	5022.2	-907.7	572.4	4579.9	
	Hardware	A	0.21	1.30	5022.4	-906.4	100.9	5051.4	
15	20 Meters 1/4" Wire		20.00	2.81	5042.4	-903.6	100.7	5051.6	
	Hardware	W	0.22	1.65	5042.6	-902.0	80.7	5071.6	
16	5 Meters 16mm T-Chain		5.00	27.80	5047.6	-874.2	80.5	5071.8	
	Hardware	Z	0.24	2.00	5047.9	-872.2	75.5	5076.8	
17	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5051.9	-951.5	75.3	5077.0	
	Hardware	Z	0.24	2.00	5052.1	-949.5	71.3	5081.0	
18	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5056.1	-1028.9	71.0	5081.3	
	Hardware	Z	0.24	2.00	5056.3	-1026.9	67.0	5085.3	
19	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5060.3	-1106.3	66.8	5085.5	
	Hardware	Z	0.24	2.00	5060.6	-1104.3	62.8	5089.5	
20	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5064.6	-1183.6	62.6	5089.7	
	Hardware	Z	0.24	2.00	5064.8	-1181.6	58.6	5093.7	
21	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5068.8	-1261.0	58.3	5094.0	
	Hardware	Z	0.24	2.00	5069.0	-1259.0	54.3	5098.0	
22	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5073.0	-1338.3	54.1	5098.2	
	Hardware	Z	0.24	2.00	5073.3	-1336.3	50.1	5102.2	
23	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5077.3	-1415.7	49.9	5102.4	
	Hardware	Z	0.24	2.00	5077.5	-1413.7	45.9	5106.4	
24	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5081.5	-1493.1	45.6	5106.7	
	Hardware	Z	0.24	2.00	5081.8	-1491.1	41.6	5110.7	
25	5 Meters 16mm T-Chain		5.00	27.80	5086.8	-1463.3	41.4	5110.9	
	Hardware	Z	0.24	2.00	5087.0	-1461.3	36.4	5115.9	
27	3-TON Miller Swivel		0.16	3.20	5087.1	-1458.1	36.1	5116.2	
	Hardware	X	0.25	2.40	5087.4	-1455.7	36.0	5116.3	
28	Dual EGG Acoustic Releases	M	1.95	66.04	5089.3	-1389.6	35.7	5116.6	
	Hardware	X	0.25	2.40	5089.6	-1387.2	33.8	5118.5	
29	5 Meters 16mm T-Chain		5.00	27.80	5094.6	-1359.4	33.5	5118.8	
	Hardware	Y	0.26	2.85	5094.9	-1356.6	28.5	5123.8	
30	20 Meters 1" Nylon (#11)		22.11	0.30	5117.0	-1356.3	28.3	5124.0	
	Hardware	Y	0.26	2.85	5117.2	-1353.4	6.2	5146.1	
31	5 Meters 16mm T-Chain		5.00	27.80	5122.2	-1325.6	5.9	5146.4	
	Hardware	X	0.25	2.40	5122.5	-1323.2	0.9	5151.4	Design
32	4000 Lb Ww Anchor		0.66	2267.96	5123.1	944.7	0.7	5151.6	Depth
	OVERALL MOORING LENGTH		**5123.13**				0.0	5152.3	**5152.3**

Recovery BGC Mooring

	Mooring ID Description	Joint	Water Depth Item Length (m)	Item Weight (kg)	Mooring Length (m)	Mooring Weight (kg)	Above Bottom (m)	Mooring Depth (m)	
1	64" Syntatic Sphere		2.27	-1360.78		-1360.78	5185.93	30.27	30
	Hardware	L	0.28	3.63	2.55	-1357.15	5183.66	32.54	
2	5 Meters 3/4" Proof Coil Chain		5.00	40.01	7.55	-1317.14	5183.38	32.82	
	Hardware	X	0.25	2.40	7.80	-1314.74	5178.38	37.82	
3	Instrument - "RAS"	N	2.25	51.00	10.05	-1263.74	5178.13	38.07	
	Hardware	Z	0.24	2.00	10.29	-1261.74	5175.88	40.32	
4	Instrument - "WTS"	N	2.83	37.00	13.12	-1224.74	5175.64	40.56	
	Hardware	Z	0.24	2.00	13.35	-1222.74	5172.81	43.39	
5	Instrument - "ZPS"	N	2.42	41.33	15.77	-1181.41	5172.58	43.62	
	Hardware	Z	0.24	2.00	16.01	-1179.41	5170.16	46.04	
6	3-TON Miller Swivel		0.16	3.17	16.17	-1176.24	5169.92	46.28	
	Hardware	Z	0.24	2.00	16.40	-1174.24	5169.76	46.44	
7	53 Meters 5/16" Wire [X-05]		53.34	11.37	69.74	-1162.87	5169.53	46.67	
	Hardware	H	0.24	1.93	69.98	-1160.94	5116.18	100.02	
8	50 Meters 5/16" Wire [AA-05]	P	50.08	10.68	120.05	-1150.26	5115.95	100.25	
	Hardware	I	0.06	2.19	120.12	-1148.07	5065.87	150.33	
9	Sediment Trap	O	3.92	55.68	124.04	-1092.39	5065.81	150.39	150
	Hardware	Z	0.24	2.00	124.27	-1090.39	5061.89	154.31	
10	2 Meters 16mm T-Chain		2.00	11.12	126.27	-1079.27	5061.66	154.54	
	Hardware	Z	0.24	2.00	126.51	-1077.27	5059.66	156.54	
11	94 Meters 5/16" Wire [V-05]		94.38	20.12	220.89	-1057.15	5059.42	156.78	
	Hardware	H	0.24	1.93	221.12	-1055.22	4965.04	251.16	
12	50 Meters 5/16" Wire [Z-05]	P	50.21	10.70	271.34	-1044.51	4964.80	251.40	
	Hardware	I	0.06	2.19	271.40	-1042.32	4914.59	301.61	
13	Sediment Trap	O	3.89	55.70	275.29	-986.62	4914.53	301.67	300
	Hardware	Z	0.24	2.00	275.52	-984.62	4910.64	305.56	
14	2 Meters 16mm T-Chain		2.00	11.12	277.52	-973.50	4910.41	305.80	
	Hardware	Z	0.24	2.00	277.76	-971.50	4908.41	307.80	
15	183 Meters 5/16" Wire [R-05]		183.74	39.17	461.50	-932.33	4908.17	308.03	
	Hardware	H	0.24	1.93	461.73	-930.40	4724.43	491.77	
16	50 Meters 5/16" Wire [Y-05]	P	50.26	10.72	511.99	-919.69	4724.20	492.00	
	Hardware	I	0.06	2.19	512.06	-917.50	4673.93	542.27	
17	Sediment Trap	O	3.74	55.70	515.80	-861.79	4673.87	542.33	540
	Hardware	Z	0.24	2.00	516.03	-859.79	4670.13	546.07	
18	2 Meters 16mm T-Chain		2.00	11.12	518.03	-848.67	4669.90	546.30	
	Hardware	Z	0.24	2.00	518.27	-846.67	4667.90	548.30	
19	403 Meters 5/16" Wire [M-05]		404.59	86.25	922.86	-760.42	4667.66	548.54	
	Hardware	H	0.24	1.93	923.10	-758.49	4263.07	953.13	
20	50 Meters 5/16" Wire [DL]	P	50.12	10.68	973.22	-747.81	4262.83	953.37	
	Hardware	I	0.06	2.19	973.28	-745.61	4212.71	1003.49	
21	Sediment Trap	O	3.73	55.70	977.01	-689.91	4212.65	1003.55	1000
	Hardware	Z	0.24	2.00	977.24	-687.91	4208.92	1007.28	
22	4 Meters 16mm T-Chain		4.00	22.24	981.24	-665.67	4208.69	1007.52	
	Hardware	Z	0.24	2.00	981.48	-663.67	4204.69	1011.52	
23	3-TON Miller Swivel		0.16	3.17	981.64	-660.51	4204.45	1011.75	
	Hardware	W	0.22	1.65	981.86	-658.86	4204.29	1011.91	
24	500 Meters 1/4" Wire [A-05]		503.09	70.74	1484.94	-588.11	4204.07	1012.13	
	Hardware	W	0.22	1.65	1485.16	-586.46	3700.98	1515.22	
25	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1489.16	-665.82	3700.76	1515.44	
	Hardware	Z	0.24	2.00	1489.40	-663.82	3696.76	1519.44	
26	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1493.40	-743.18	3696.53	1519.67	
	Hardware	Z	0.24	2.00	1493.63	-741.18	3692.53	1523.67	
27	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1497.63	-820.54	3692.29	1523.91	
	Hardware	W	0.22	1.65	1497.85	-818.89	3688.29	1527.91	
28	500 Meters 1/4" Wire [B-05]		502.11	70.60	1999.97	-748.29	3688.07	1528.13	
	Hardware	A	0.21	1.33	2000.18	-746.96	3185.96	2030.24	
29	500 Meters 1/4" Wire [C-05]		501.01	70.45	2501.19	-676.51	3185.75	2030.45	
	Hardware	A	0.21	1.33	2501.40	-675.18	2684.74	2531.46	
30	500 Meters 1/4" Wire [D-05]		501.89	70.57	3003.28	-604.61	2684.53	2531.67	
	Hardware	W	0.22	1.65	3003.50	-602.96	2182.65	3033.55	
31	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	3007.50	-682.32	2182.43	3033.77	
	Hardware	Z	0.24	2.00	3007.74	-680.32	2178.43	3037.77	

32	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	3011.74	-759.68	2178.19	3038.01	
	Hardware	W	0.22	1.65	3011.96	-758.03	2174.19	3042.01	
33	500 Meters 1/4" Wire [E-05]		502.10	70.60	3514.06	-687.43	2173.97	3042.23	
	Hardware	A	0.21	1.33	3514.27	-686.10	1671.87	3544.33	
34	500 Meters 1/4" Wire [I-05]		495.11	69.62	4009.38	-616.48	1671.66	3544.54	
	Hardware	A	0.21	1.33	4009.59	-615.15	1176.55	4039.65	
35	440 Meters 1/4" Wire [#N]		440.75	61.98	4450.34	-553.17	1176.34	4039.86	
	Hardware	W	0.22	1.65	4450.56	-551.52	735.59	4480.62	
36	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4454.56	-630.88	735.37	4480.84	
	Hardware	Z	0.24	2.00	4454.80	-628.88	731.37	4484.84	
37	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4458.80	-708.24	731.13	4485.07	
	Hardware	W	0.22	1.65	4459.02	-706.59	727.13	4489.07	
38	200 Meters 1/4" Wire [CC-05]		199.31	28.03	4658.33	-678.57	726.91	4489.29	
	Hardware	A	0.21	1.33	4658.54	-677.24	527.60	4688.60	
39	50 Meters 1/4" Wire [CO]		49.89	7.02	4708.43	-670.22	527.39	4688.81	
	Hardware	A	0.21	1.33	4708.64	-668.89	477.50	4738.70	
40	20 Meters 1/4" Wire		20.00	2.81	4728.64	-666.08	477.29	4738.91	
	Hardware	A	0.21	1.33	4728.85	-664.75	457.29	4758.91	
41	50 Meters 1/4" Wire [#Z]	Q	50.15	7.05	4779.00	-657.70	457.08	4759.12	
	Hardware	K	0.20	1.33	4779.20	-656.37	406.93	4809.28	
42	Sediment Trap [ML11241-25]	O	3.73	55.70	4782.93	-600.67	406.73	4809.48	4810.8
	Hardware	Z	0.24	2.00	4783.17	-598.67	403.00	4813.21	
43	2 Meters 16mm T-Chain		2.00	11.12	4785.17	-587.55	402.76	4813.44	
	Hardware	W	0.22	1.65	4785.39	-585.90	400.76	4815.44	
44	286 Meters 1/4" Wire [O-05]		287.56	40.43	5072.94	-545.46	400.54	4815.66	
	Hardware	A	0.21	1.33	5073.15	-544.13	112.98	5103.22	
45	15 Meters 1/4" Wire		15.00	2.11	5088.15	-542.02	112.77	5103.43	
	Hardware	W	0.22	1.65	5088.37	-540.37	97.77	5118.43	
46	5 Meters 16mm T-Chain		5.00	27.80	5093.37	-512.57	97.55	5118.65	
	Hardware	Z	0.24	2.00	5093.61	-510.57	92.55	5123.65	
47	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5097.61	-589.93	92.32	5123.88	
	Hardware	Z	0.24	2.00	5097.84	-587.93	88.32	5127.88	
48	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5101.84	-667.29	88.08	5128.12	
	Hardware	Z	0.24	2.00	5102.08	-665.29	84.08	5132.12	
49	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5106.08	-744.65	83.85	5132.35	
	Hardware	Z	0.24	2.00	5106.31	-742.65	79.85	5136.35	
50	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5110.31	-822.01	79.61	5136.59	
	Hardware	Z	0.24	2.00	5110.55	-820.01	75.61	5140.59	
51	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5114.55	-899.37	75.38	5140.82	
	Hardware	Z	0.24	2.00	5114.78	-897.37	71.38	5144.82	
52	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5118.78	-976.73	71.14	5145.06	
	Hardware	Z	0.24	2.00	5119.02	-974.73	67.14	5149.06	
53	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5123.02	-1054.09	66.91	5149.29	
	Hardware	Z	0.24	2.00	5123.25	-1052.09	62.91	5153.29	
54	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5127.25	-1131.45	62.67	5153.53	
	Hardware	Z	0.24	2.00	5127.49	-1129.45	58.67	5157.53	
55	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5131.49	-1208.81	58.44	5157.76	
	Hardware	Z	0.24	2.00	5131.72	-1206.81	54.44	5161.76	
56	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5135.72	-1286.17	54.20	5162.00	
	Hardware	Z	0.24	2.00	5135.96	-1284.17	50.20	5166.00	
57	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5139.96	-1363.53	49.97	5166.23	
	Hardware	Z	0.24	2.00	5140.19	-1361.53	45.97	5170.23	
58	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5144.19	-1440.89	45.73	5170.47	
	Hardware	Z	0.24	2.00	5144.43	-1438.89	41.73	5174.47	
59	5 Meters 16mm T-Chain		5.00	27.80	5149.43	-1411.09	41.50	5174.70	
	Hardware	Z	0.24	2.00	5149.66	-1409.09	36.50	5179.70	
60	3-TON Miller Swivel		0.16	3.20	5149.82	-1405.89	36.26	5179.94	
	Hardware	X	0.25	2.40	5150.07	-1403.49	36.10	5180.10	
61	Dual EGG Acoustic Releases	M	1.95	66.04	5152.02	-1337.45	35.85	5180.35	
	Hardware	X	0.25	2.40	5152.27	-1335.05	33.91	5182.29	
62	5 Meters 16mm T-Chain		5.00	27.80	5157.27	-1307.25	33.66	5182.54	
	Hardware	Y	0.26	2.85	5157.53	-1304.40	28.66	5187.54	
63	20 Meters 1" Nylon [#10]		21.93	6.54	5179.46	-1297.86	28.40	5187.80	
	Hardware	Y	0.26	2.85	5179.72	-1295.01	6.47	5209.73	
64	5 Meters 16mm T-Chain		5.00	27.80	5184.72	-1267.21	6.21	5209.99	
	Hardware	X	0.25	2.40	5184.97	-1264.81	1.21	5214.99	Design
65	4666 Lb Ww Anchor		0.96	2116.46	5185.93	851.65	0.96	5215.24	Depth
	OVERALL MOORING LENGTH		5185.93					5216.20	5216.2

Recovery BGC Mooring

Description		Length (m)	Weight (kg)	Length (m)	Weight (kg)	Bottom (m)	Depth (m)	
64″ Syntatic Sphere		2.27	−1360.78		−1360.78	5186.23	29.97	30
Hardware	L	0.28	3.63	2.55	−1357.15	5183.96	32.24	
5 Meters 3/4″ Proof Coil Chain		5.00	40.01	7.55	−1317.14	5183.68	32.52	
Hardware	X	0.25	2.40	7.80	−1314.74	5178.68	37.52	
Instrument − "RAS"	N	2.25	51.00	10.05	−1263.74	5178.43	37.77	
Hardware	Z	0.24	2.00	10.29	−1261.74	5176.18	40.02	
3−TON Miller Swivel		0.16	3.17	10.45	−1258.57	5175.94	40.26	
Hardware	Z	0.24	2.00	10.68	−1256.57	5175.78	40.42	
3 Meters 5/16″ Wire [adj]		3.00	0.64	13.68	−1255.93	5175.55	40.66	
Hardware	H	0.24	1.93	13.92	−1254.00	5172.55	43.66	
53 Meters 5/16″ Wire [W−05]		53.33	11.37	67.25	−1242.63	5172.31	43.89	
Hardware	H	0.24	1.93	67.48	−1240.70	5118.98	97.22	
53 Meters 5/16″ Wire [H]	P	53.09	11.32	120.57	−1229.39	5118.74	97.46	
Hardware	I	0.06	2.19	120.63	−1227.20	5065.66	150.55	
Sediment Trap	O	3.92	55.68	124.55	−1171.51	5065.59	150.61	150
Hardware	Z	0.24	2.00	124.79	−1169.51	5061.67	154.53	
1 Meters 16mm T−Chain		1.00	5.56	125.79	−1163.95	5061.44	154.76	
Hardware	Z	0.24	2.00	126.02	−1161.95	5060.44	155.76	
94 Meters 5/16″ Wire [U−05]		94.26	20.10	220.29	−1141.86	5060.20	156.00	
Hardware	H	0.24	1.93	220.52	−1139.93	4965.94	250.26	
50 Meters 5/16″ Wire [I−1]	P	50.07	10.68	270.60	−1129.25	4965.71	250.50	
Hardware	I	0.06	2.19	270.66	−1127.06	4915.63	300.57	
Sediment Trap [Dummy]	O	3.89	55.70	274.55	−1071.36	4915.57	300.63	300
Hardware	Z	0.24	2.00	274.78	−1069.36	4911.68	304.52	
1 Meters 16mm T−Chain		1.00	5.56	275.78	−1063.80	4911.44	304.76	
Hardware	Z	0.24	2.00	276.02	−1061.80	4910.44	305.76	
183 Meters 5/16″ Wire [Q−05]		183.71	39.17	459.73	−1022.63	4910.21	305.99	
Hardware	H	0.24	1.93	459.96	−1020.70	4726.50	489.70	
50 Meters 5/16″ Wire [I−2]	P	50.07	10.68	510.04	−1010.03	4726.26	489.94	
Hardware	I	0.06	2.19	510.10	−1007.84	4676.19	540.01	
Sediment Trap	O	3.74	55.70	513.84	−952.14	4676.13	540.07	540
Hardware	Z	0.24	2.00	514.07	−950.14	4672.39	543.81	
1 Meters 16mm T−Chain		1.00	5.56	515.07	−944.58	4672.15	544.05	
Hardware	Z	0.24	2.00	515.31	−942.58	4671.15	545.05	
403 Meters 5/16″ Wire [N−05]		404.63	86.26	919.94	−856.32	4670.92	545.28	
Hardware	H	0.24	1.93	920.18	−854.39	4266.29	949.91	
50 Meters 5/16″ Wire [I−3]	P	50.07	10.68	970.25	−843.71	4266.05	950.15	
Hardware	I	0.06	2.19	970.31	−841.52	4215.98	1000.22	
Sediment Trap	O	3.73	55.70	974.04	−785.82	4215.92	1000.29	1000
Hardware	Z	0.24	2.00	974.28	−783.82	4212.19	1004.02	
2.8 Meters 16mm T−Chain		2.80	15.57	977.08	−768.25	4211.95	1004.25	
Hardware	Z	0.24	2.00	977.31	−766.25	4209.15	1007.05	
3−TON Miller Swivel		0.16	3.17	977.47	−763.08	4208.92	1007.29	
Hardware	W	0.22	1.65	977.69	−761.43	4208.75	1007.45	
500 Meters 1/4″ Wire [J−05]		503.18	70.75	1480.87	−690.68	4208.53	1007.67	
Hardware	W	0.22	1.65	1481.09	−689.03	3705.35	1510.85	
2−17″ Glassballs on 16mm T−Chain		2.00	−39.68	1483.09	−728.71	3705.13	1511.07	
Hardware	Z	0.24	2.00	1483.33	−726.71	3703.13	1513.07	
4−17″ Glassballs on 16mm T−Chain		4.00	−79.36	1487.33	−806.07	3702.90	1513.30	
Hardware	Z	0.24	2.00	1487.56	−804.07	3698.90	1517.30	
4−17″ Glassballs on 16mm T−Chain		4.00	−79.36	1491.56	−883.43	3698.66	1517.54	
Hardware	W	0.22	1.65	1491.78	−881.78	3694.66	1521.54	
500 Meters 1/4″ Wire [K−05]		502.67	70.68	1994.45	−811.10	3694.44	1521.76	
Hardware	A	0.21	1.33	1994.66	−809.77	3191.78	2024.42	
500 Meters 1/4″ Wire [B−1]		501.35	70.50	2496.01	−739.27	3191.57	2024.63	
Hardware	A	0.21	1.33	2496.22	−737.94	2690.22	2525.98	
500 Meters 1/4″ Wire [B−2]		501.33	70.49	2997.54	−667.45	2690.01	2526.19	
Hardware	W	0.22	1.65	2997.76	−665.80	2188.68	3027.52	
4−17″ Glassballs on 16mm T−Chain		4.00	−79.36	3001.76	−745.16	2188.46	3027.74	
Hardware	Z	0.24	2.00	3002.00	−743.16	2184.46	3031.74	
4−17″ Glassballs on 16mm T−Chain		4.00	−79.36	3006.00	−822.52	2184.23	3031.97	
Hardware	W	0.22	1.65	3006.22	−820.87	2180.23	3035.97	
500 Meters 1/4″ Wire [B−3]		502.30	70.63	3508.52	−750.24	2180.01	3036.19	
Hardware	A	0.21	1.33	3508.73	−748.91	1677.71	3538.49	

500 Meters 1/4" Wire [B-4]		501.32	70.49	4010.05	-678.41	1677.50	3538.70	
Hardware	A	0.21	1.33	4010.26	-677.08	1176.18	4040.02	
440 Meters 1/4" Wire [D]		441.15	62.03	4451.41	-615.05	1175.97	4040.23	
Hardware	W	0.22	1.65	4451.63	-613.40	734.81	4481.39	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4455.63	-692.76	734.59	4481.61	
Hardware	Z	0.24	2.00	4455.87	-690.76	730.59	4485.61	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4459.87	-770.12	730.36	4485.84	
Hardware	W	0.22	1.65	4460.09	-768.47	726.36	4489.84	
200 Meters 1/4" Wire [CM]		199.29	28.02	4659.38	-740.45	726.14	4490.06	
Hardware	A	0.21	1.33	4659.59	-739.12	526.85	4689.35	
50 Meters 1/4" Wire [CR]		49.94	7.02	4709.53	-732.10	526.64	4689.56	
Hardware	A	0.21	1.33	4709.74	-730.77	476.70	4739.50	
20 Meters 1/4" Wire		20.00	2.81	4729.74	-727.96	476.49	4739.71	
Hardware	A	0.21	1.33	4729.95	-726.63	456.49	4759.71	
50 Meters 1/4" Wire [#AA]	Q	50.11	7.05	4780.06	-719.58	456.28	4759.92	
Hardware	K	0.20	1.33	4780.26	-718.25	406.17	4810.04	
Sediment Trap [ML11241-25]	O	3.73	55.70	4783.99	-662.55	405.97	4810.24	**4810.8**
Hardware	Z	0.24	2.00	4784.23	-660.55	402.24	4813.97	
2 Meters 16mm T-Chain		2.00	11.12	4786.23	-649.43	402.00	4814.20	
Hardware	W	0.22	1.65	4786.45	-647.78	400.00	4816.20	
286 Meters 1/4" Wire [E]		286.75	40.32	5073.19	-607.46	399.78	4816.42	
Hardware	A	0.21	1.33	5073.40	-606.13	113.03	5103.17	
15 Meters 1/4" Wire		15.00	2.11	5088.40	-604.02	112.82	5103.38	
Hardware	W	0.22	1.65	5088.62	-602.37	97.82	5118.38	
5 Meters 16mm T-Chain		5.00	27.80	5093.62	-574.57	97.60	5118.60	
Hardware	Z	0.24	2.00	5093.86	-572.57	92.60	5123.60	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5097.86	-651.93	92.37	5123.83	
Hardware	Z	0.24	2.00	5098.09	-649.93	88.37	5127.83	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5102.09	-729.29	88.13	5128.07	
Hardware	Z	0.24	2.00	5102.33	-727.29	84.13	5132.07	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5106.33	-806.65	83.90	5132.30	
Hardware	Z	0.24	2.00	5106.56	-804.65	79.90	5136.30	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5110.56	-884.01	79.66	5136.54	
Hardware	Z	0.24	2.00	5110.80	-882.01	75.66	5140.54	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5114.80	-961.37	75.43	5140.77	
Hardware	Z	0.24	2.00	5115.03	-959.37	71.43	5144.77	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5119.03	-1038.73	71.19	5145.01	
Hardware	Z	0.24	2.00	5119.27	-1036.73	67.19	5149.01	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5123.27	-1116.09	66.96	5149.24	
Hardware	Z	0.24	2.00	5123.50	-1114.09	62.96	5153.24	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5127.50	-1193.45	62.72	5153.48	
Hardware	Z	0.24	2.00	5127.74	-1191.45	58.72	5157.48	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5131.74	-1270.81	58.49	5157.71	
Hardware	Z	0.24	2.00	5131.97	-1268.81	54.49	5161.71	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5135.97	-1348.17	54.25	5161.95	
Hardware	Z	0.24	2.00	5136.21	-1346.17	50.25	5165.95	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5140.21	-1425.53	50.02	5166.18	
Hardware	Z	0.24	2.00	5140.44	-1423.53	46.02	5170.18	
4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5144.44	-1502.89	45.78	5170.42	
Hardware	Z	0.24	2.00	5144.68	-1500.89	41.78	5174.42	
5 Meters 16mm T-Chain		5.00	27.80	5149.68	-1473.09	41.55	5174.65	
Hardware	Z	0.24	2.00	5149.91	-1471.09	36.55	5179.65	
3-TON Miller Swivel		0.16	3.20	5150.07	-1467.89	36.31	5179.89	
Hardware	X	0.25	2.40	5150.32	-1465.49	36.15	5180.05	
Dual EGG Acoustic Releases	M	1.95	66.04	5152.27	-1399.45	35.90	5180.30	
Hardware	X	0.25	2.40	5152.52	-1397.05	33.96	5182.24	
5 Meters 16mm T-Chain		5.00	27.80	5157.52	-1369.25	33.71	5182.49	
Hardware	Y	0.26	2.85	5157.78	-1366.40	28.71	5187.49	
20 Meters 1" Nylon [#12]		21.98	6.55	5179.76	-1359.84	28.45	5187.75	
Hardware	Y	0.26	2.85	5180.02	-1356.99	6.47	5209.73	
5 Meters 16mm T-Chain		5.00	27.80	5185.02	-1329.19	6.21	5209.99	
Hardware	X	0.25	2.40	5185.27	-1326.79	1.21	5214.99	**Design**
4666 Lb Ww Anchor		0.96	2116.46	5186.23	789.67	0.96	5215.24	**Depth**
OVERALL MOORING LENGTH		**5186.23**					5216.20	**5216.2**

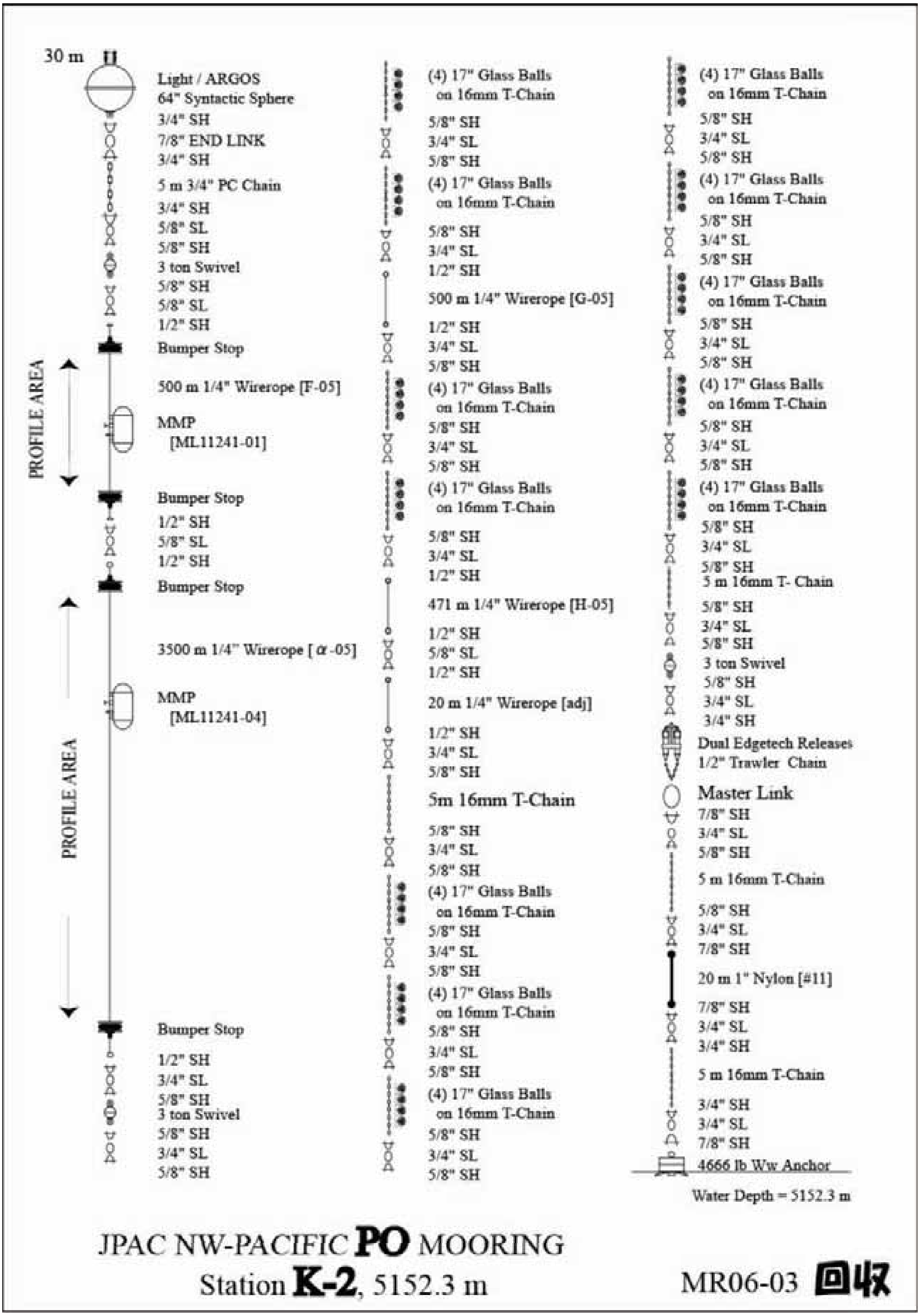


Fig. 3.1.1-1 Recovery PO Mooring Figure

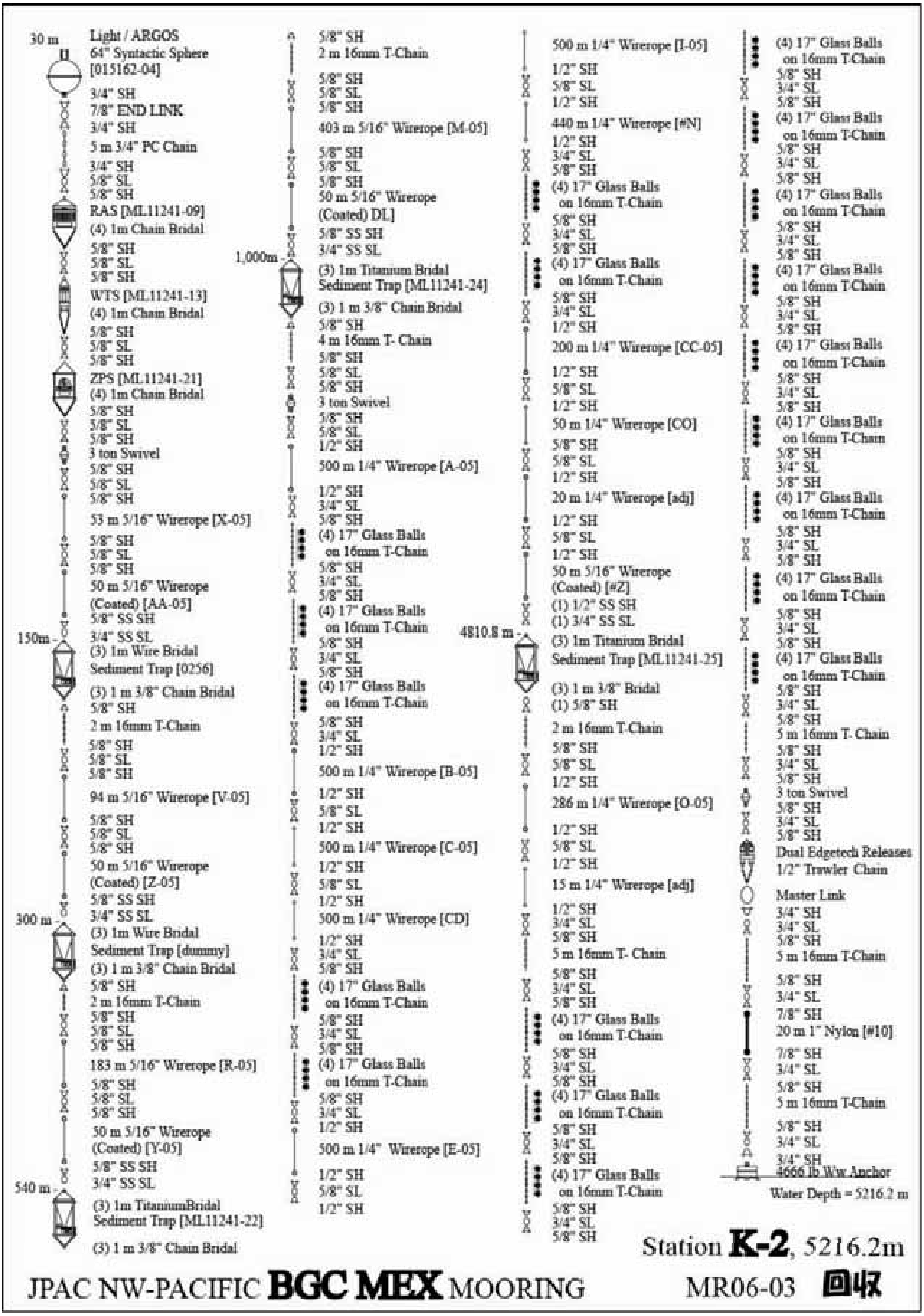


Fig. 3.1.1-2 Recovery BGC Mooring Figure

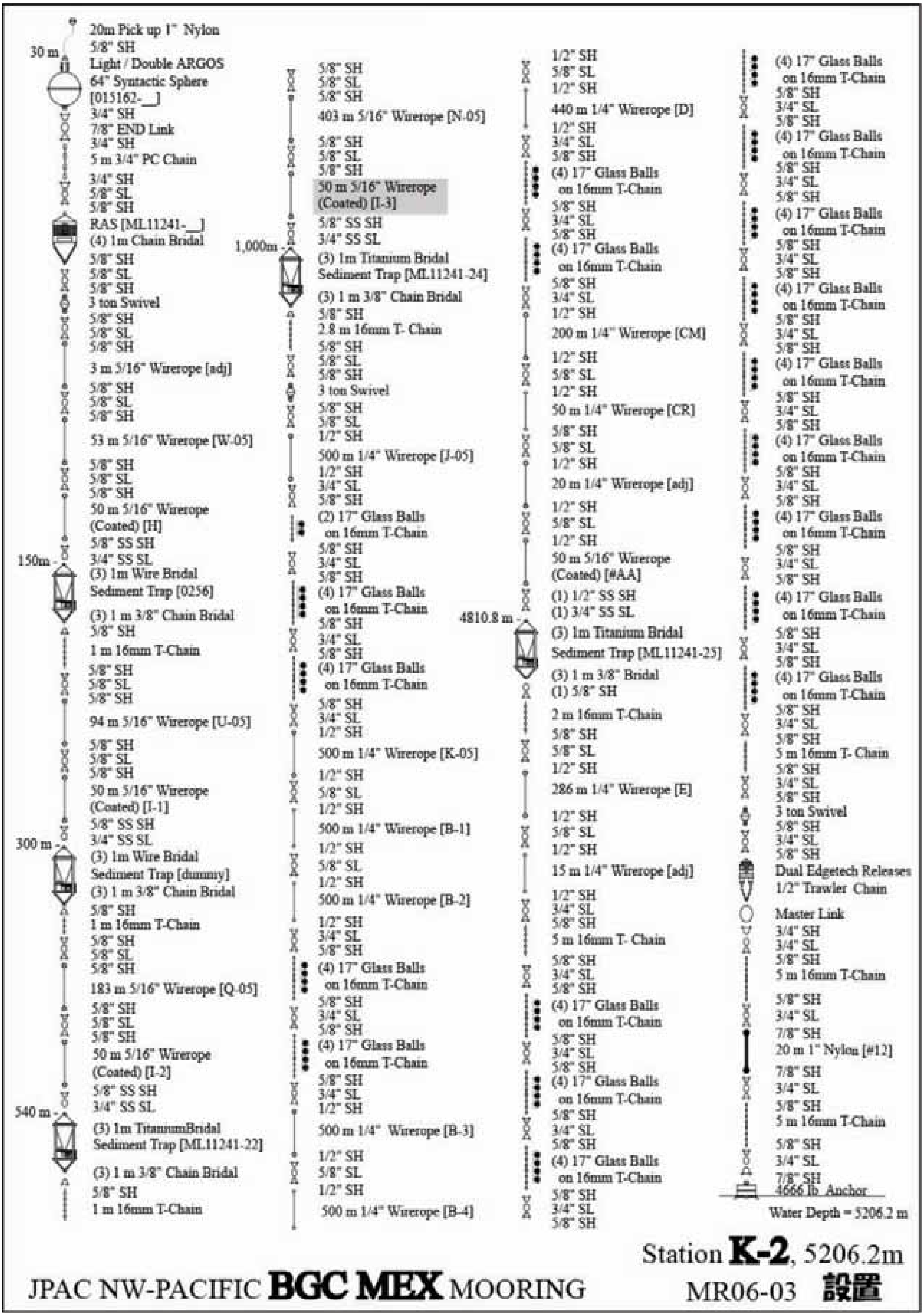


Fig. 3.1.1-3 Deployment BGC Mooring Figure

3.1.2 Instruments

On mooring systems, the following instruments are installed.

(1) ARGOS CML (Compact Mooring Locator)

The Compact Mooring Locator is a subsurface mooring locator based on SEIMAC's Smart Cat ARGOS PTT (Platform Terminal Transmitter) technology. Using CML, we can know when our mooring has come to the surface and its position. The CML employs a pressure sensor at the bottom. When the CML is turned ON, the transmission is started immediately every 90 seconds and then when the pressure sensor works ON by approximately 10 dbar, the transmission is stopped. When the top buoy with the CML comes to the surface, the pressure sensor will work OFF and the transmission will be started. Smart Cat transmissions will be initiated at this time, allowing us to locate our mooring. Depending on how long the CML has been moored, it will transmit for up to 120 days on a 90 second repetition period. Battery life, however, is affected by how long the CML has been moored prior to activation. A longer pre-activation mooring will mean less activation life.

Principle specification is as follows:

(Specification)

Transmitter:	Smart Cat PTT
Operating Temp.:	+35 [deg] to –5 [deg]
Standby Current:	80 microamps
Smart Cat Freq.:	401.650 MHz
Battery Supply:	7-Cell alkaline D-Cells
Ratings:	+10.5VDC nom., 10 Amp Hr
Hull:	6061-T6 Aluminum
Max Depth:	1,000 m
Length:	22 inches
Diameter:	3.4 inches
Upper flange:	5.60 inches
Dome:	Acrylic
Buoyancy:	-2.5 (negative) approx.
Weight	12 pounds approx.

(2) Submersible Recovery Strobe

The Benthos 204 – RS is fully self-contained 0.1 watt – second strobe intended to aid in the marking or recovery of oceanographic instruments, manned vehicles, remotely operated vehicles, buoys or structures. Due to the occulting (firing closely spaced bursts of light) nature of this design, it is much more visible than conventional marker strobes, particularly in poor sea conditions.

(Specification)

Power Level:	0.1 watt-second
Repetition Rate:	Adjustable from 2 bursts per second to 1 burst every 3 seconds.
Burst Length:	Adjustable from 1 to 5 flashes per burst. 100 ms between flashes nominal.
Battery Type:	C-cell alkaline batteries, (Eveready E-93 or equivalent).
Life:	Dependent on repetition rate and burst length. 150 hours with a one flash burst every 2 seconds.
Construction:	Awl-grip painted, Hard coat anodized 6061 T-6 aluminum housing.
Pressure Rating:	10,000 psi
Daylight-off:	User selected, standard
Pressure Switch:	Turns unit off below approximately 30 feet. Rotary, clockwise – ON, counter clockwise – OFF.
Weight in Air:	4 pounds
Weight in Water:	2 pounds
Outside Diameter:	1.7 inches nominal
Length:	21-1/2 inches nominal

(3) MMP

The McLane Moored Profiler is an autonomous, profiling, instrument platform. The purpose is to make moored profiler technology available to, operable by, and useful to a broad cross-section of the oceanographic community. The platform and software are designed for ease of access, operation, and maintenance. The instrument includes both a CTD and an acoustic current meter. Side and top views of the MMP are shown in Fig. 2. The major components of the system are labeled in the figures. There include the controller, the buoyancy elements, the drive motor and guide wheels, the instruments suite, the internal frame, and the hydrodynamically faired external shell. The platform is designed to profile between pressure limits (or physical stops), powered along a conventional, plastic jacketed mooring cable by a traction drive.

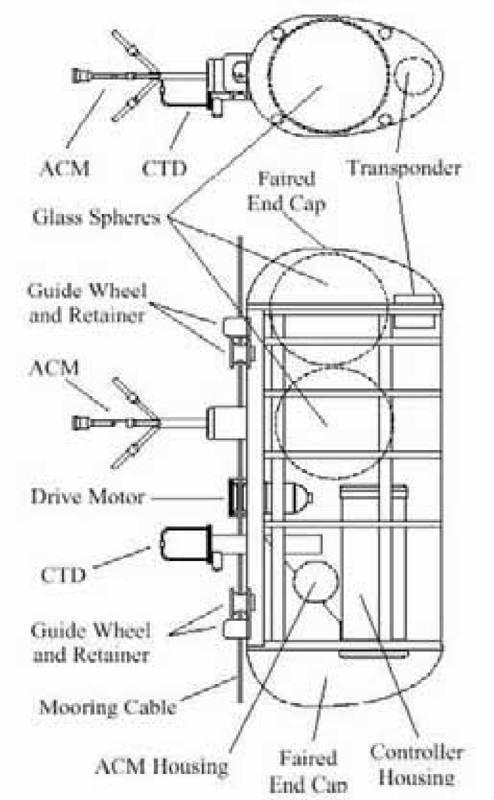


Fig.3.1.2-1 Cut away side and top views of the MMP showing the major components of the system. The overall dimensions of the faired external shell are 124 cm * 51 cm* 34 cm

While profiling it samples the water column with a suite of instruments and stores the measurements for later retrieval. The shape accommodates a cylindrical housing that has sufficient length for batteries and electronics and a 6,000 m depth rating. Two glass spheres are used for buoyancy only. The mooring cable threads through faired retainers at the top and bottom of the vehicle. The retainers can be opened for launch and recovery and are strong enough to support the full weight, including trapped water, of the MMP on a horizontal cable, a normal situation during recovery. Sampling will be conducted once a day.

(Specification)

Dimensions	Height:	130.5 cm
	Width:	33.3 cm
	Length:	50.5 cm
	ACM Sting:	45.2 cm
Weight	With Sensors (air):	70.5 kg
	Without Sensors (air):	64.3 kg
Depth Rating	Max Depth:	6000 m
	Endurance:	1000 km
Other	Frame:	ultra high molecular weight polyethylene
	Skin:	medium density polyethylene
	Mounting Posts:	316 stainless steel
	Housing:	Titanium
	Spheres:	borosilicate glass
	Cable jackets:	neoprene, polyvinyl chloride
	Drive wheel:	urethane, PBT, titanium

Table 3.1.2-1 MMP Setting Parameter

Station MMP S / N	K-2 PO Shallow ML11241-01	K-2 PO Deep ML11241-04
*1 Initialize Down	01:00:00 Sep.30th 2005	01:00:00 Sep.30th 2005
*2 Sampling Start	01:00:00 Oct.1st 2005	01:00:00 Oct.1st 2005
*3 Profile Interval	6 hours	4 days
*4 Burst Interval	1 day	20 days
Burst (up and down)	twice	twice
Shallow Depth [db]	40	550
Deep Depth [db]	520	4000
Shallow Error [db]	20	50
Deep Error [db]	20	50
Profile Time Limit	3 hours	6 hours
Stop Check Interval	30 sec	30 sec

(4) Depth Sensor

RMD Depth sensor is digital memory type and designed for mounting on the plankton net and instrument for mooring and so on. It is small and right weight for easy handling. Sampling interval is chosen between 2 and 127 seconds or 1 and 127 minutes and sampled Time and Depth data. The data is converted to personal computer using exclusive cable (printer interface).

(Specification)

Model:	RMD-500
Operating Depth:	0 ~ 500m
Precision:	0.5% (F.S.)
Accuracy:	1/1300
Memory:	65,534 data (128kbyte)
Battery:	lithium battery (CR2032) DC6V
Battery Life:	65,000 data or less than 1 year
Sample interval:	2 ~ 127 seconds or 1 ~ 127 minutes
Broken Pressure:	20Mpa
Diameter:	50mm
Length:	150mm
Main Material:	vinyl chloride resin
Cap material:	polyacetal resin
Weight:	280g

(sampling parameter)

Sampling interval: 2 hours

(5) RAS (Remotely Access Sampler)

There are four major components mounted within the RAS: (1) the controller housing, (2) the pump assembly, (3) the multi-port valve, and (4) the sample containers. The principle of water sampling is that the pump draws out water in the sample container in which the collapsed sample bag is mounted. This creates a pressure gradient that pushes ambient seawater through the intake and into the inflating sample bag.

Length, width and Height is 73 cm, 73 cm, and 114 cm, respectively, and weight with empty sample containers is 110 kg in air and 57 kg in water. The RAS instruments were loaded with acid-cleaned, 500 ml–capacity bags made of the following 3 laminated layers; a thin exterior Mylar® film for protection, a vacuum coated aluminum foil layer for blocking solar radiation and minimizing gas diffusion and an interior, Teflon® film for reinforcement and insulation of sample water from the Al layer. Each bag was pre-loaded with a preservative solution (2 ml $HgCl_2$ solution: 35 g $HgCl_2$ in 100 ml distilled water), connected to a distribution valve and placed within a sturdy 600 ml sample container (acrylic sheathe) within the instrument. The remaining spaces within sheathes were filled with seawater before deployment.

There are 49 identical bag assemblages on a RAS. Of these, 48 were used to sample seawater on a scheduled sequence. The remaining bag was filled with 6M HCl that was used to flush the intake path before each water sampling procedure in order to avoid biofouling.

Normally, the RAS multi-port valve resides in a home position that block all intake paths. Five minutes before sampling, the multi-port valve aligns with the intake path and the cleansing acid bag and a 5 ml jet of 6M HCl flushes the intake manifolds. After a one-minute pause, the same path was rinsed with 100 ml of *in situ* seawater. Then the multi-port valve aligns the intake valve to a designated sampling bag assemblage. As the seawater is removed from the acrylic sheathe by operating the pump in reverse to the previous flush stage, the resultant low pressure induces the *in situ* water to move into the sampling bag. To minimize cross contamination of water samples, the graphite-gear pump is not exposed to the sample water but only to the evacuated distilled water in the sheathes. Execution records documenting sample timing, estimated sample volume, flushing periods, and electricity consumption were logged by the RAS instruments and retrieved from the memory on recovery.

(6) BLOOMS

The Bio-optical Long-term Optical Ocean Measuring System package (BLOOMS) consisted of a WETLabs fluorometer and a Satlantic Inc. spectral radiometer (OCR-504-ICWS; Halifax, Canada) along with data acquisition / storage systems and a pressure housing. The BLOOMS was mounted on the frame of the RAS for measurements of chlorophyll *a* (chl-*a*) concentrations as a proxy for phytoplankton biomass (fluorometer) and downwelling spectral irradiance at four wavelengths (412, 443, 490, and 555 nm). The optical system was kept free of biofouling by use of copper shutters. Unfortunately the fluorometer malfunctioned.

(7) WTS

The water transfer system – phytoplankton sampler (WTS-PPS) collects *in situ* suspended particulate matter especially phytoplankton in an aquatic environment by filtrating 10 L seawater. A dual multi-port valve directs the water through 24 x 47-millimeter GF/F filters for a time-series operation. The positive displacement pump is placed downstream from the filters to prevent sample contamination. Samples are preserved in an array of filter-preservation units that each contains a chemical fixative (seawater based buffered 5 % formalin). Before taking sample, seawater is flushed through the valve and tube. This becomes clear out any particle and living things in the sampling way. The flow rate is controlled in order to prevent the sample from being crushed onto the filter. The computer records the instantaneous flow rate and total volume at a constant interval of time for each filter.

(8) ZPS

Zooplankton Sampler (ZPS) collects zooplankton samples in time-series. A sample is collected using a positive displacement pump that generates negative pressure. Zooplanktons are unaware of being drawn towards the sampler until they are well inside and can not escape. Prefilter covers the mouth of the sample intake path to avoid invasion of large creatures. They are transported onto a 3.5 x 6 cm frame of a special roll of Nitex mesh (100 m mesh). The zooplankton community retained on a frame is sandwiched by another piece of Nitex mesh for protection and immediately moved to the fixative bath for storage until recovery of the sampler. A new frame of mesh is positioned automatically to be ready for the next sampling cycle. This procedure can be repeated up to 50 times for each roll of Nitex mesh as instructed by the micro-controller. Before taking sample and every 4 days, seawater is flushed opposite direction. This becomes clear out any particle and living things in the sampling way.

(9) Sediment trap

A time-series sediment trap with 21 cups were installed at 150 m and three traps were installed at 500 m, 1000 m and 5000 m. Before deployment, collecting cups were filled up with seawater based 5 % buffered formalin.

3.1.3 Sampling schedule

a) Long term sampling

Time-series instruments on BGC mooring system deployed during MR05-04 were scheduled to collect sample. Following Table shows these schedule. Because mooring system was recovered on 29 May 2006, some late samples were not collected.

		A: ST (13 cups)		B: ST (21 cups)		WTS-PPS		ZPS		RAS
Samp.		13		21		24		50		48
Int.		14		14		14		14		4
	1	2005.10.1 1:00	1	2005.10.1 1:00	1	2005.10.1 1:00	1	2005.10.1 13:00	1	2005.10.1 1:00
	2	2005.10.15 1:00	2	2005.10.15 1:00	2	2005.10.15 1:00	2	2005.10.15 13:00	2	2005.10.5 1:00
	3	2005.10.29 1:00	3	2005.10.29 1:00	3	2005.10.29 1:00	3	2005.10.29 13:00	3	2005.10.9 1:00
	4	2005.11.19 1:00	4	2005.11.12 1:00	4	2005.11.12 1:00	4	2005.11.12 13:00	4	2005.10.13 1:00
	5	2005.12.10 1:00	5	2005.11.26 1:00	5	2005.11.26 1:00	5	2005.11.26 13:00	5	2005.10.17 1:00
	6	2005.12.31 1:00	6	2005.12.10 1:00	6	2005.12.10 1:00	6	2005.12.10 13:00	6	2005.10.21 1:00
	7	2006.1.21 1:00	7	2005.12.24 1:00	7	2005.12.24 1:00	7	2005.12.24 13:00	7	2005.10.25 1:00
	8	2006.2.11 1:00	8	2006.1.7 1:00	8	2006.1.7 1:00	8	2006.1.7 13:00	8	2005.10.29 1:00
	9	2006.3.4 1:00	9	2006.1.21 1:00	9	2006.1.21 1:00	9	2006.1.21 13:00	9	2005.11.2 1:00
	10	2006.3.25 1:00	10	2006.2.4 1:00	10	2006.2.4 1:00	10	2006.2.4 13:00	10	2005.11.6 1:00
	11	2006.4.15 1:00	11	2006.2.18 1:00	11	2006.2.18 1:00	11	2006.2.18 13:00	11	2005.11.10 1:00
	12	2006.5.6 1:00	12	2006.3.4 1:00	12	2006.3.4 1:00	12	2006.3.4 13:00	12	2005.11.14 1:00
	13	2006.5.20 1:00	13	2006.3.18 1:00	13	2006.3.18 1:00	13	2006.3.18 13:00	13	2005.11.18 1:00
		2006.6.3 1:00	14	2006.4.1 1:00	14	2006.3.25 1:00	14	2006.4.1 13:00	14	2005.11.22 1:00
			15	2006.4.15 1:00	15	2006.4.1 1:00	15	2006.4.15 13:00	15	2005.11.26 1:00
			16	2006.4.22 1:00	16	2006.4.8 1:00	16	2006.4.29 13:00	16	2005.11.30 1:00
			17	2006.4.29 1:00	17	2006.4.15 1:00	17	2006.5.13 13:00	17	2005.12.4 1:00
			18	2006.5.6 1:00	18	2006.4.22 1:00	18	2006.5.27 13:00	18	2005.12.8 1:00
			19	2006.5.13 1:00	19	2006.4.29 1:00	19	2006.6.10 13:00	19	2005.12.12 1:00
			20	2006.5.20 1:00	20	2006.5.6 1:00	20	2006.6.24 13:00	20	2005.12.16 1:00
			21	2006.5.27 1:00	21	2006.5.13 1:00			21	2005.12.20 1:00
				2006.6.3 1:00	22	2006.5.20 1:00			22	2005.12.28 1:00
					23	2006.5.27 1:00			23	2006.1.5 1:00
					24	2006.6.3 1:00			24	2006.1.13 1:00
									25	2006.1.21 1:00
		21 days interval		7 days interval		7 days interval		400L	26	2006.1.29 1:00
									27	2006.2.6 1:00
		540m		150m		GF/F			28	2006.2.14 1:00
		1000m		300m					29	2006.2.22 1:00
		4810m							30	2006.3.2 1:00
									31	2006.3.10 1:00
									32	2006.3.18 1:00
				As 21cups traps have "2000 year problem", this year is defined as 1985 instead of 2005. 300m trap was dead because of circuit board problem.					33	2006.3.26 1:00
									34	2006.4.3 1:00
									35	2006.4.11 1:00
									36	2006.4.15 1:00
									37	2006.4.19 1:00
									38	2006.4.23 1:00
									39	2006.4.27 1:00
									40	2006.5.1 1:00
									41	2006.5.5 1:00
									42	2006.5.9 1:00
									43	2006.5.13 1:00
									44	2006.5.17 1:00
									45	2006.5.21 1:00
									46	2006.5.25 1:00
									47	2006.5.29 1:00
NEXT CRUISE: 1 Jun. 2006 Lv. Sekinehama、5 June. Ar. station K2 (tentative)									48	2006.6.2 1:00
		Solar noon time:	ca. 1:00 (UTC)							
		Mid night:	ca. 13:00 (UTC)							8 days interval

BLOOM swicth on: 2005.9.25 6:00 (LST) LST+UTC+11hr.

b) Short term sampling

Time-series instruments (RAS and sediment trap) on BGC mooring system deployed during this cruise were scheduled to collect sample. Following Table shows these schedule. Because mooring system was recovered on 19 July 2006, some late samples were not collected.

	ST	ST	RAS
	150m (21cups)	300/1000/4810m (13 cups)	
Interval (days)	2	4	2
1	2006.6.7 0:00	2006.6.7 0:00	2006.6.7 0:00
2	2006.6.9 0:00	2006.6.11 0:00	2006.6.7 2:00
3	2006.6.11 0:00	2006.6.15 0:00	2006.6.9 0:00
4	2006.6.13 0:00	2006.6.19 0:00	2006.6.9 2:00
5	2006.6.15 0:00	2006.6.23 0:00	2006.6.11 0:00
6	2006.6.17 0:00	2006.6.27 0:00	2006.6.11 2:00
7	2006.6.19 0:00	2006.7.1 0:00	2006.6.13 0:00
8	2006.6.21 0:00	2006.7.5 0:00	2006.6.13 2:00
9	2006.6.23 0:00	2006.7.9 0:00	2006.6.15 0:00
10	2006.6.25 0:00	2006.7.11 0:00	2006.6.15 2:00
11	2006.6.27 0:00	2006.7.13 0:00	2006.6.17 0:00
12	2006.6.29 0:00	2006.7.15 0:00	2006.6.17 2:00
13	2006.7.1 0:00	2006.7.17 0:00	2006.6.19 0:00
14	2006.7.3 0:00	2006.7.19 0:00	2006.6.19 2:00
15	2006.7.5 0:00		2006.6.21 0:00
16	2006.7.7 0:00	Interval 2 days	2006.6.21 2:00
17	2006.7.9 0:00		2006.6.23 0:00
18	2006.7.11 0:00		2006.6.23 2:00
19	2006.7.13 0:00		2006.6.25 0:00
20	2006.7.15 0:00		2006.6.25 2:00
21	2006.7.17 0:00		2006.6.27 0:00
22	2006.7.19 0:00		2006.6.27 2:00
23			2006.6.29 0:00
24			2006.6.29 2:00
25			2006.7.1 0:00
26			2006.7.1 2:00
27			2006.7.3 0:00
28			2006.7.3 2:00
29			2006.7.5 0:00
30			2006.7.5 2:00
31			2006.7.7 0:00
32			2006.7.7 2:00
33			2006.7.9 0:00
34			2006.7.9 2:00
35			2006.7.11 0:00
36			2006.7.11 2:00
37			2006.7.13 0:00
38			2006.7.13 2:00
39			2006.7.15 0:00
40			2006.7.15 2:00
41			2006.7.17 0:00
42			2006.7.17 2:00
43			2006.7.19 0:00
44			2006.7.19 2:00
45			2006.7.21 0:00
46			2006.7.21 2:00
47			2006.7.23 0:00
48			2006.7.23 2:00

Date and Time are Local Ship Time (UTC+11 hours)

3.1.4 Preliminary Result

3.1.4.1 MMP and Depth

(1) MMP

Table 3.1.4-1 MMP Engineering Result

Station MMP S / N	K-2 PO Shallow ML11241-01	K-2 PO Deep ML11241-04
Sampling Start	01:00:00 Oct.1st 2005	01:00:00 Oct.1st 2005
Profile Interval	6 hours	4 days
Burst Interval	1 day	20 days
Profile count	490	26
Min Pressure [db]	36	518
Max Pressure [db]	543	3938
Total Distance [m]	59115	10711

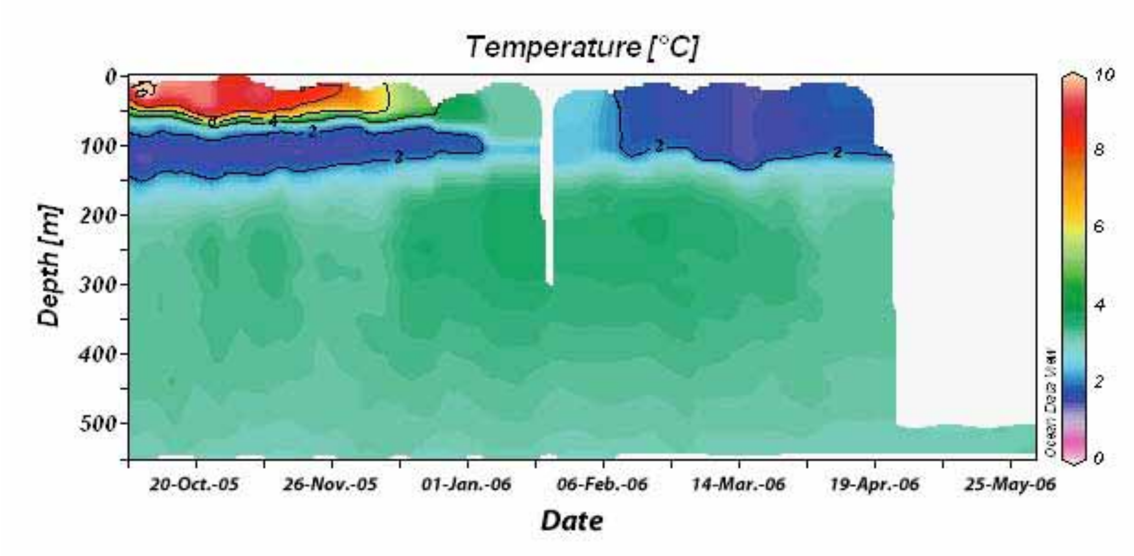


Fig 3.1.4-1 Shallow MMP Shallow Temperature

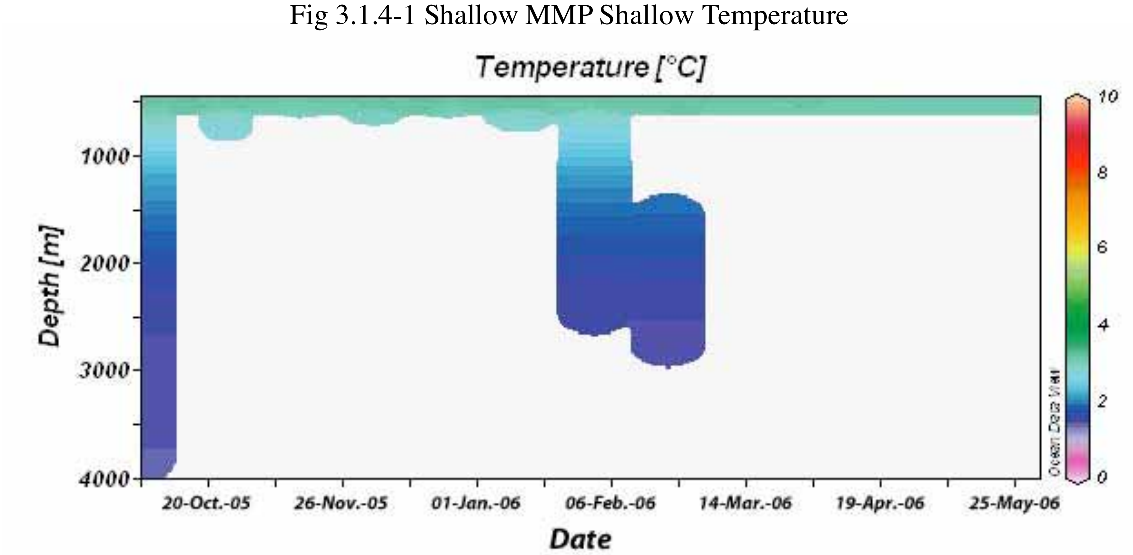


Fig 3.1.4-2 Deep MMP Temperature

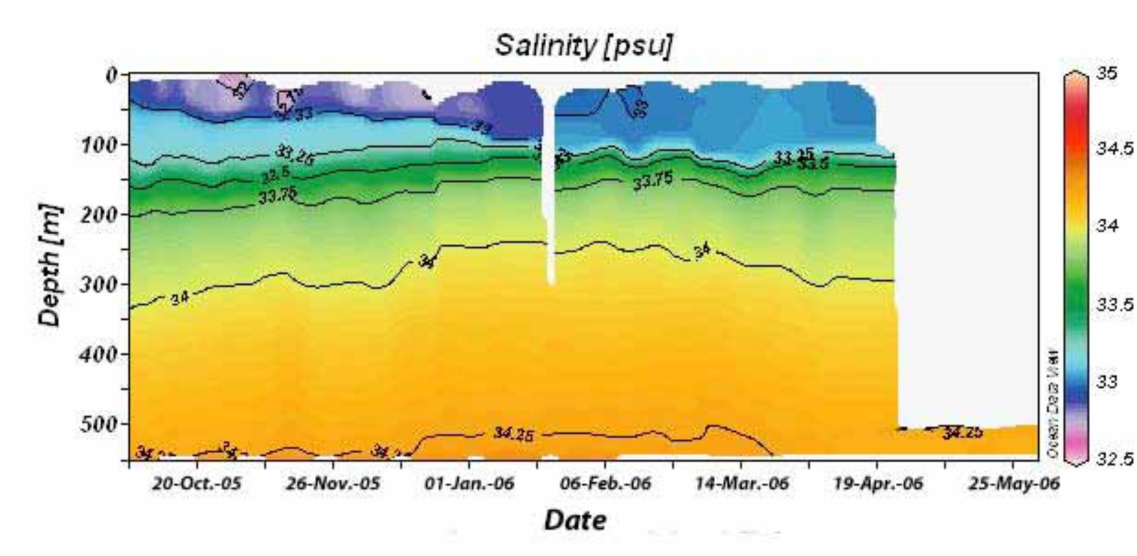


Fig 3.1.4-3 Shallow MMP Salinity

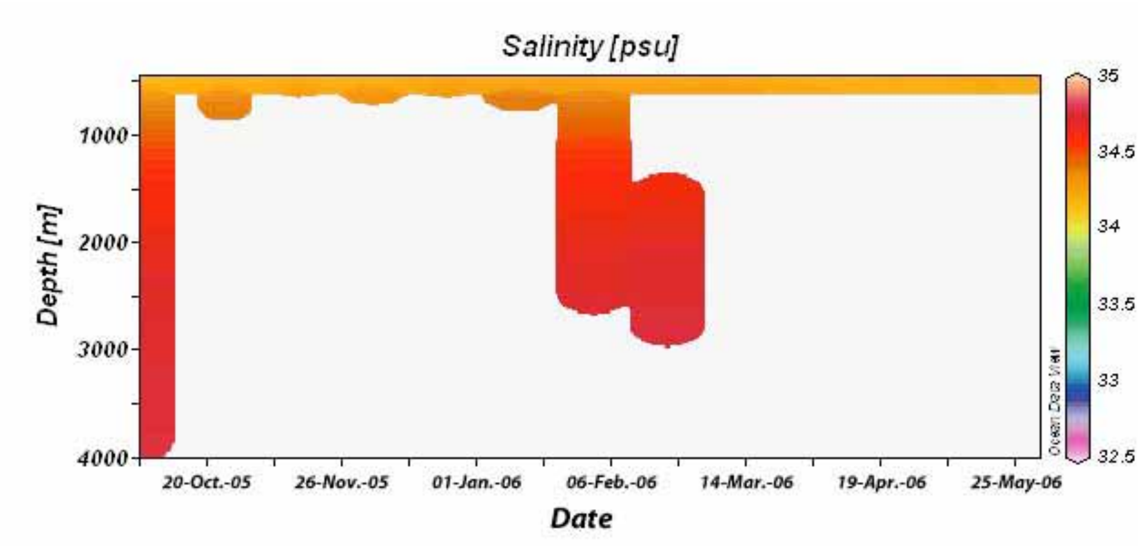


Fig 3.1.4-4 Deep MMP Salinity

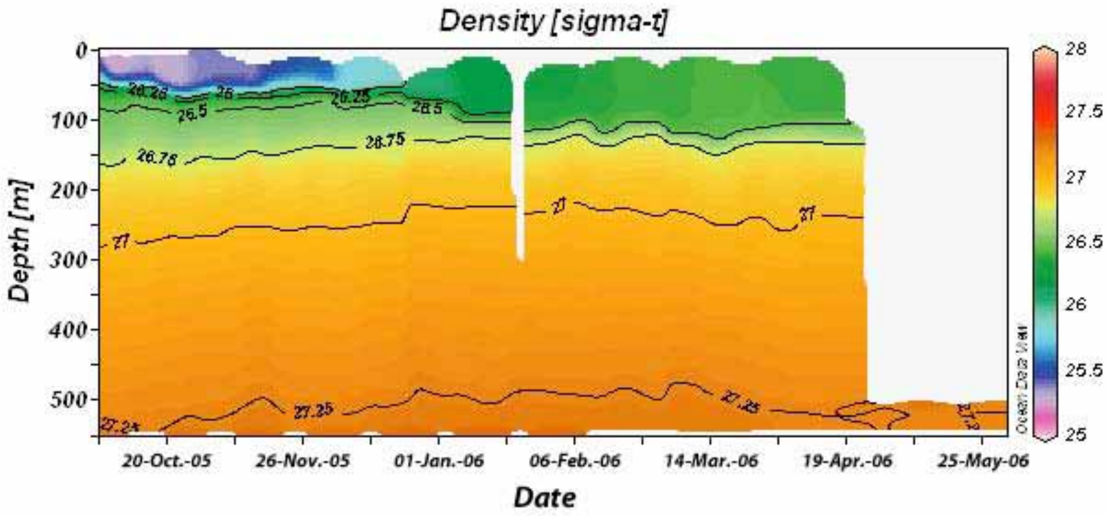


Fig 3.1.4-5 Shallow MMP Density

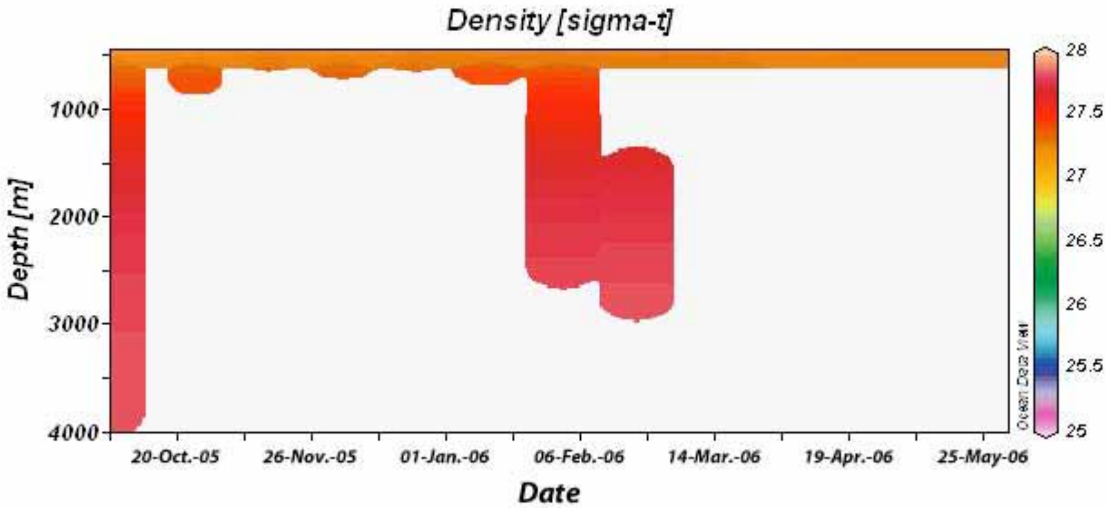


Fig 3.1.4-6 Deep MMP Density

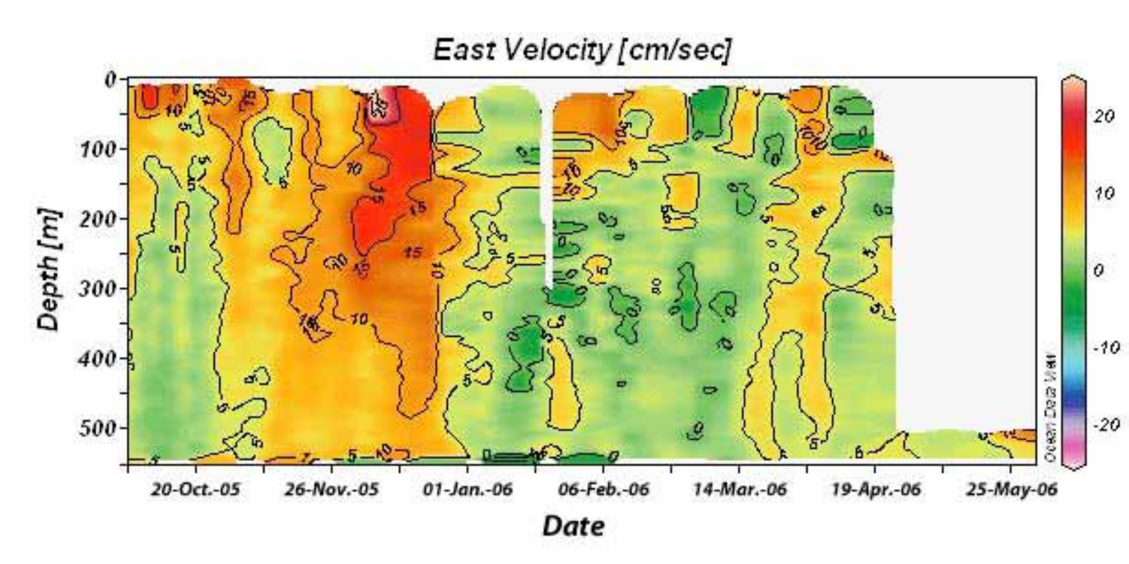


Fig 3.1.4-7 Shallow MMP East Velocity

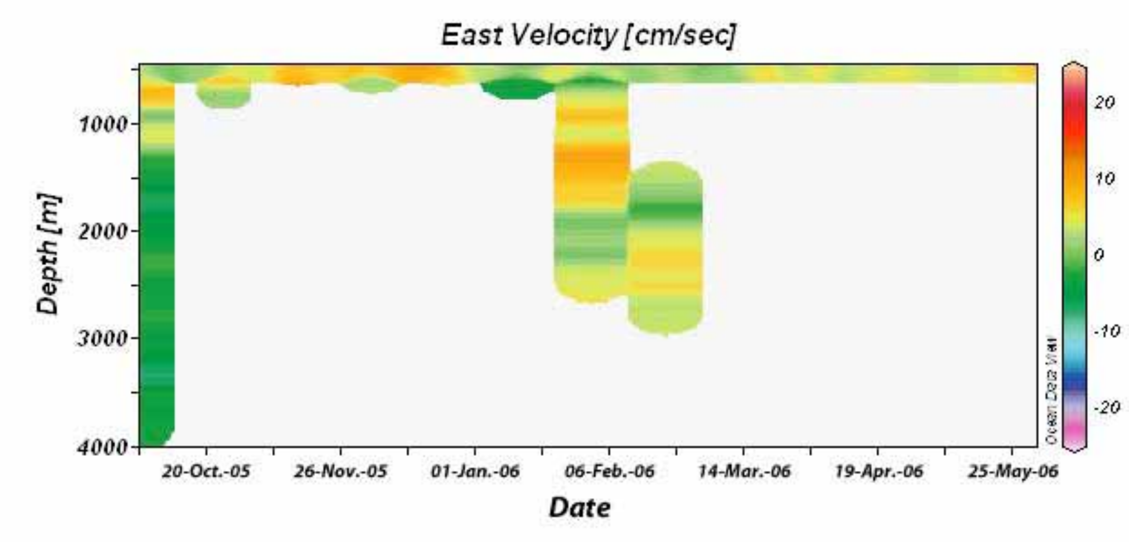


Fig 3.1.4-8 Deep MMP East Velocity

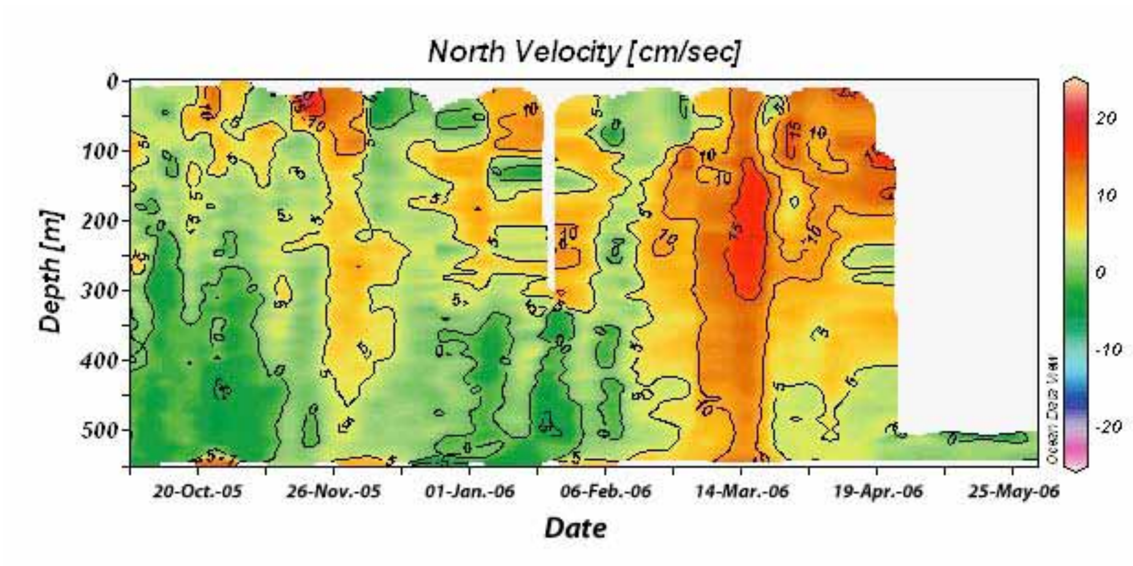


Fig 3.1.4-9 Shallow MMP North Velocity

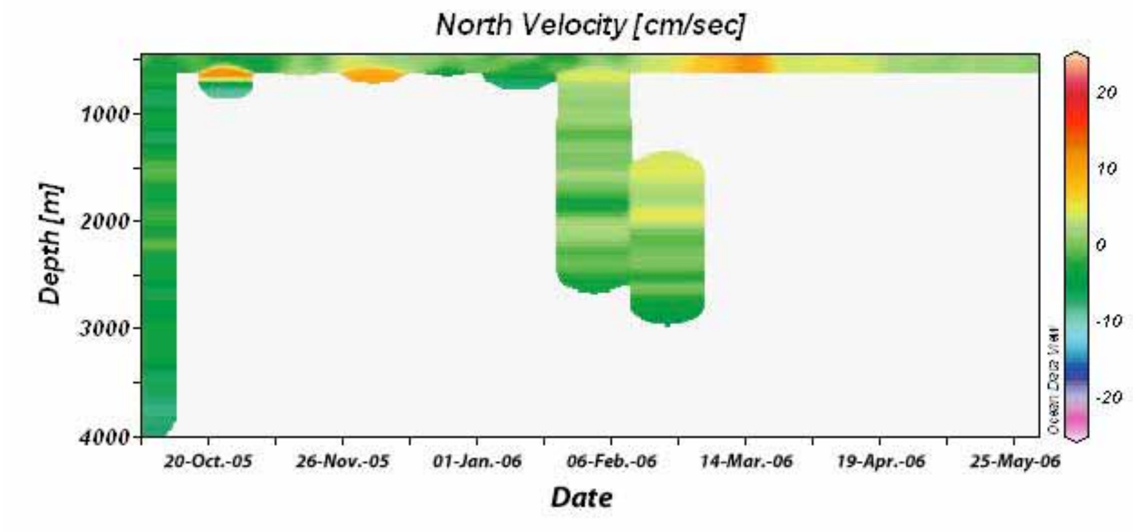


Fig 3.1.4-10 Deep MMP North Velocity

(2) Depth

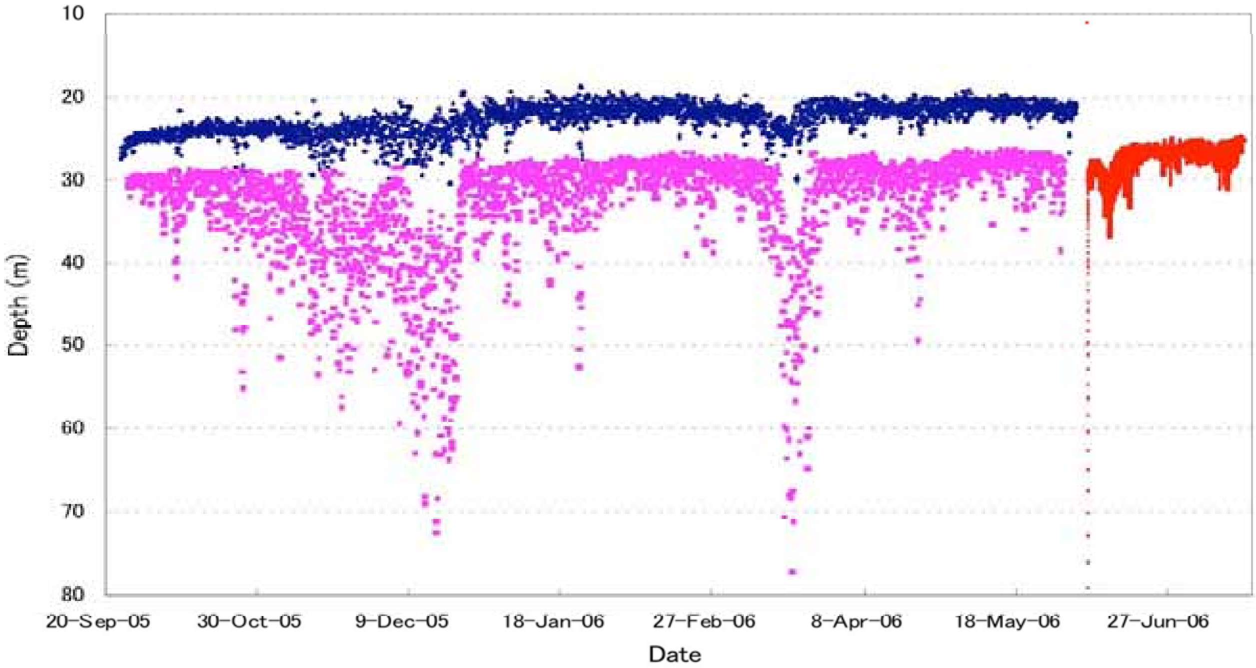


Fig 3.1.4-11 Top Buoy depth by Depth sensor

Top Buoy Depth Ave.	
PO	22.5m
BGC	32.8m
Re-BGC	27.4m

3.1.4.2 RAS

(1) Preservative

We used mercury chloride ($HgCl_2$) solution as preservative. Before deployment, 2 ml $HgCl_2$ solution of which concentration is 36,000 ppm (3.6 g $HgCl_2$ in 100 ml distilled water) was pre-loaded in the sample bag. In the seawater sample of approximately 500 ml, final concentration of $HgCl_2$ was approximately 140 ppm. This $HgCl_2$ concentration is comparable to that for long-term preservation of seawater sample for measurements of nutrients (105 ppm: Kattner, 1999) and approximately 15 times higher than that for measurement of carbonate species (approximately 10 ppm: DOE, 1994).

During R/V *MIRAI* MR05-01 cruise in March 2005, we collected seawater samples by RAS and conducted preservation test. With addition of the above preservative against 500 ml seawater sample, we measured concentrations of nutrients and DIC when seawater samples were collected (March 2005), and after 6 months (September 2005) and 15 months (June 2006) storage in refrigerator of 4°C. As a result, a good accordance was found between the quick measurements and those after 6 months and 15 months storage within 2% for nutrients and 0.2% for DIC (Table 3.1.4.2.1). Thus it can be judged that concentration of preservative was appropriate for this observation.

Table 3.1.4.2.1 Preservation test

Nomalized to salinity of 33PSU

		Hydrocast	RAS sampling		
Sampling Date		4.Mar.05	7.Mar.05	7.Mar.05	7.Mar.05
Analysis Date		4.Mar.05	18.Mar.05	4.Oct.05	23.Jun.06
Sample number		2	6	2	2
N-DIC	(μmol L^{-1})	2170.3 ± 5.0	2179.1 ± 5.0	2169.5 ± 5.0	2173.0 ± 7.3
N-NO_3	(μmol L^{-1})	23.57 ± 0.12	24.38 ± 0.12	24.27 ± 0.12	23.80 ± 0.10
N-NOx	(μmol L^{-1})	23.70 ± 0.12	24.53 ± 0.12	24.45 ± 0.12	24.04 ± 0.10
$Si(OH)_4$	(μmol L^{-1})	41.81 ± 0.21	42.03 ± 0.21	42.71 ± 0.21	42.09 ± 0.50
PO_4	(μmol L^{-1})	1.93 ± 0.01	1.95 ± 0.01	1.96 ± 0.01	1.95 ± 0.01

(2) Methods

1) Water depth, temperature and salinity

Depths of RAS were measured with a depth sensor (RIGO RMD-500) every 120 minutes during the mooring deployment. Water temperature at the RAS depth was suspected by a thermister inside of RAS electronics pressure housing. Essentially, this thermister records inside temperature when RAS seawater sampling starts and stops for respective round. Its accuracy is ± 0.5°C and this thermister can not detect low temperature < 2°C. Though end data after a sampling process increased usually up to 2 - 3°C, the initial data should represent environmental temperature because at least 4 days passed since the final sampling was done and, therefore, this enabled us to know rough *in situ* temperature. In order to certify dilution rate of RAS sample by preservative (2 ml $HgCl_2$), salinity of RAS samples were measured onboard by an inductively coupled salinometer (AutoLab®: YEO-KAL) after recovery. Measurement error was 0.02 psu on average.

2) Nutrients and DIC

After recovery, the RAS water samples were sub-divided into four aliquots to analyze DIC, nutrients, salinity and other biogeochemical constituents (not included in this article) onboard.

Nutrient concentrations (NOx = NO_2 + NO_3, $Si(OH)_4$ and PO_4) were measured with an onboard continuous flow analytical system (BRAN+LUEBEB TRAACS® 800). Because of usage of $HgCl_2$ as a preservative, copperised cadmium reductor (Cu-Cd column) necessary to reduce nitrate to nitrite for the determination for NO_3 lost its efficiency faster than with pure seawater samples (from 92 % to 82 %). However this error could be excluded by regularly checking the efficiency of Cu-Cd column.

Concentration of PO_4 was not able to be determined for approximately 20% of samples (18/89) because of undetermined peak, *i.e.* color-dulling phosphomolybdous acid produced in molybdenum blue method by Murphy and Riley (1961).

For DIC analysis, sample water was introduced directly from the sampling bag assemblage into a DIC extraction module with a CO_2 coulometer (Ishii et al., 1998) by applying a gentle N_2-gas pressure to the sheathe cavity.

Measurement errors based on analysis of the 6-hour-spaced samples from a RAS instruments (n=6) were 0.40, 0.33, 0.002 and 2.9 μmol kg^{-1} for NOx, $Si(OH)_4$,PO_4 and DIC, respectively, while analytical error based on the repeatability of reference materials were less than 0.09, 0.19, 0.004 and 1.1 μmol kg^{-1} for NOx, $Si(OH)_4$, PO_4 (n=10), and DIC (n=27), respectively.

(3) Results

In Figs. 3.1.4.2.1 and 3.1.4.2.2, results obtained during this cruise and the last cruise (MR05-04) are essentially shown as closed circles (for long-term mooring) and pink circles (for short-term mooring). In order to validate RAS data, two types of data are also shown. Double circles are respective data at water depth of 35 m observed by shipboard hydrocasting at station K2 during cruises that mooring system with RAS was deployed and recovered (hereinafter hydrocasting data). Open circles show respective data at 35 m obtained by shipboard hydrocasting at station K2 for corresponding period during other cruises that conducted different years from 2001 to 2006 (hereinafter climatological data; http://www.jamstec.go.jp/mirai/). In addition, the VERTIGO cruise by R/V Roger Revelle was conducted between 30 July and 15 August 2005 around K2 (between 46.1°N and 47.9°N / 158.67°E and 161.32°N) during mooring deployment. Figs. 3.1.4.2.1 and 3.1.4.2.2 also show VERTIGO unpublished data obtained at 35 m (courtesy of K. Buesseler and P. Henderson facility of Woods Hole Oceanographic Institution) for comparison.

1) Water depth, temperature and salinity

a) Water depth

Water depths of RAS (RAS depth) when respective samplings were conducted were shown in Fig. 3.1.4.2.1(a). RAS depth tended to increase slightly from March to September 2005. It might be attributed to decrease of current velocity resulting less tilt of mooring system or extension of mooring wire ropes. However maximum and minimum RAS depth were no more than 37.1 m on 13 April 2005 and 34.2 m on 12 September 2005 and water depth was very stable with average of 35.4 ± 0.6 (1s) m. Compared to the phase I, RAS depths during the phase II varied relatively larger and ranged from 35.3 m and 53.5 m with average of 40.5 ± 5.0 (1s) m. Fig. 3.1.4.2.1(a) also shows surface mixed layer depths (MLD) defined with 0.125 criteria based on hydrocasting and climatological data. Annual maximum and minimum MLD were found in March (~ 140 m) and July (~ 20 m), respectively. Based on seasonal change in MLD, it is suspected that RAS was located in MLD year round except the period between middle June 2005 to late September 2005. RAS depth during this cruise (short-term mooring; pink circles) was 35.0 ± 1.0 m and coincided with those for corresponding season in 2005. Judging from CTD data, RAS was located below MLD during this cruise.

b) Water temperature

Water temperature at RAS depth (hereinafter *in situ* water temperature) were approximately 2°C by early May 2005 (Julian days, JD, 128; Fig. 3.1.4.2.1 b). Thereafter *in situ* water temperature increased with fluctuation and the annual maximum of approximately 11°C was observed in September and October 2005. Then *in situ* temperature decreased toward February 2006 and increased again after middle May 2006. Seasonal variability of *in situ* temperature observed in this study coincided well with hydrocasting and climatological temperature data. Compared to surface seawater temperature (SST) around station K2 observed by the Advanced Very High Resolution Radiometer (AVHRR) sensor aboard satellite NOAA, *in situ* temperature was lower than SST significantly between early June 2005 and late September 2005 while *in situ* temperature coincided generally with SST in other periods. This evidence supports that RAS was located in the surface MLD year round except period between early June and late September 2005 as described above. Water temperature during this cruise was also identical to these for corresponding season in 2005.

c) Salinity

Fig. 3.1.4.2.1 (c) shows seasonal variability in observed salinity (gray circles). Although fluctuation of salinity was large, salinity generally tended to be higher during winter and lower in autumn and its trend was similar to hydrocasting and climatological salinity data. It is noted that the RAS salinity was approximately 0.2 psu lower than hydrocasting and climatological data. This is caused by the fact that RAS seawater sample was diluted by preservative (2 ml $HgCl_2$) and its dilution rate depended on seawater sample volume. Assuming that RAS seawater sample volumes were 500 ml exactly, RAS samples were diluted by 0.4%. Taking this dilution into account, observed RAS salinity data were corrected (closed circles in Fig. 3.1.4.2.1 c). Corrected salinity coincided generally with hydrocasting, climatological and VERTIGO salinity data ranging from approximately 33.1 to 32.6 psu. As VERTIGO salinity shows, salinity should be variable or changeable at 35 m around station K2 in summer.

2) Nutrients and DIC

In order to correct dilution rate controlled by relative volume of $HgCl_2$ to RAS seawater sample volume, and eliminate the effect of natural evaporation and precipitation, following nutrients and DIC data were normalized to constant salinity of 33 psu. For comparison, hydrocasting, climatological and VERTIGO data were also normalized to salinity of 33 psu.

a) N-NOx

The maximum NO_x (NO_3 and NO_2) normalized to salinity of 33 psu (N-NOx) was observed in the middle April 2005 (JD 108; Fig. 3.1.4.2.2 a). After that, N-NOx decreased. Especially decrease after the end of June (JD 180) was large being accompanied by large fluctuation. This large fluctuation might be attributed to that RAS was located just below the MLD and vertical gradient in N-NOx concentration around RAS depth was large resulting RAS nutrients data changeable easily. Annual minimum was observed in late October 2005 (JD 295). Based on climatological N-NOx data and previous report (Wong et al., 2002), this minimum value of approximately 11 μmol kg^{-1} was comparable to annual minimum value observed in surface water although annual minimum in surface water generally appears in summer. Thus RAS could observe surface nutrient minimum although RAS depth was a little below the MLD during July and September. N-NOx increased again toward middle April 2006 (JD 478). Seasonal variability in N-NOx was also comparable to that of hydrocasting and climatological data. In addition, our data in July and August 2005 were comparable with that observed by VERTIGO research group in July and August 2005. VERTIGO data also show large fluctuation of concentration of N-NOx at 35 m around station K2.

b) N-$Si(OH)_4$

Concentration of N-$Si(OH)_4$ also increased by middle April 2005 and then decreased (Fig. 3.1.4.2.2 b). However, unlike N-NOx, N-$Si(OH)_4$ did not decrease significantly by the end of June (JD 180) and annual maximum concentration was observed during this period. After then, N-$Si(OH)_4$ decreased largely by middle October 2005 (~ JD 280) with fluctuation similar to N-NOx. After middle October 2005, $Si(OH)_4$ increased again toward April 2006 (JD 478). Seasonal variability in N-$Si(OH)_4$ also coincided with that of hydrocasting and climatological data. In addition, N-$Si(OH)_4$ of RAS sample coincided well with VERTIGO N-$Si(OH)_4$ data.

c) N-PO_4

Although concentrations of PO_4 was not able to be determined for approximately 20% of total samples as described before (and see discussion), "valid" N-PO_4 also showed same seasonal pattern of N-NOx and N-$Si(OH)_4$: decrease from April 2005 to October 2005 with fluctuation and increased again to April of 2006 (Fig. 3.1.4.2.2 c) and its seasonal variability coincided with hydrocasting, climatological and VERTIGO data. The change ratio of N-NOx to N-PO_4 ($\Delta N/\Delta P$) was estimated to be approximately 16 and this ratio was consistent with phytoplankton N/P uptake ratio reported previously (Redfield, 1963; Anderson and Sarmient, 1994).

Based on the relation between normalized nutrients and salinity that can be regarded as conservative component, relatively better correlation was observed during the period between October 2005 and May 2006 ($r = 0.90$ for NOx, 0.88 for $Si(OH)_4$ and 0.84 for PO_4) than between March and September 2005 ($r = 0.55$ for NOx, 0.55 for $Si(OH)_4$ and 0.37 for PO_4). Thus seasonal variability in above nutrients can be explained as follows; nutrients decrease from late spring to late summer by biological activity in the MLD and nutrients increases from late autumn to late winter by physical process that is growth of MLD resulting supply of nutrients from subsurface water (> 100 m).

d) N-DIC

N-DIC also shows seasonal decrease from April to September 2005 and increase from October 2005 to April 2006 similar to those for nutrients (Fig. 3.1.4.2.2 d). N-DIC of RAS sample collected in the early period of the phases I (between March and September 2005) and II (between October 2005 and May 2006) coincided with hydrocasting N-DIC data. However the fluctuation of N-DIC was quite large during the phase I and quite low N-DIC < 2030 μmol kg^{-1} were often observed. Based on climatological data, annual minimum of N-DIC at station K2 is at least 2030 μmol kg^{-1} that usually observed at surface in autumn. In addition, concentrations of N-DIC during the phase II were systematically lower than climatological data although the early N-DIC values were close to hydrocasting N-DIC data.

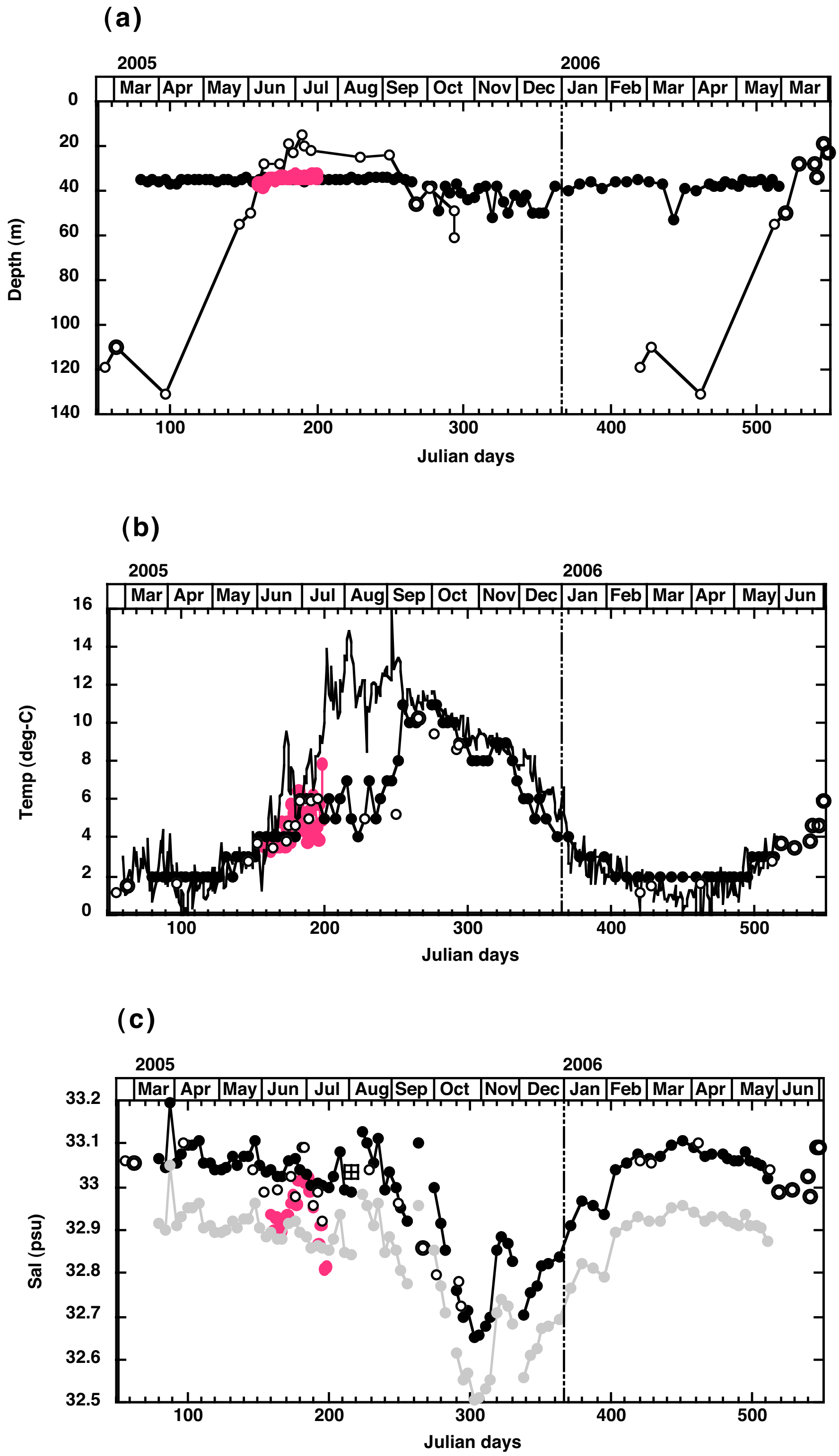


Fig.3.1.4.2.1 RAS depth and Mixed Layer Depth (MLD) (a), in situ water temperature and SST (b), and RAS salinity (c) with climatological and hydrocasting data.

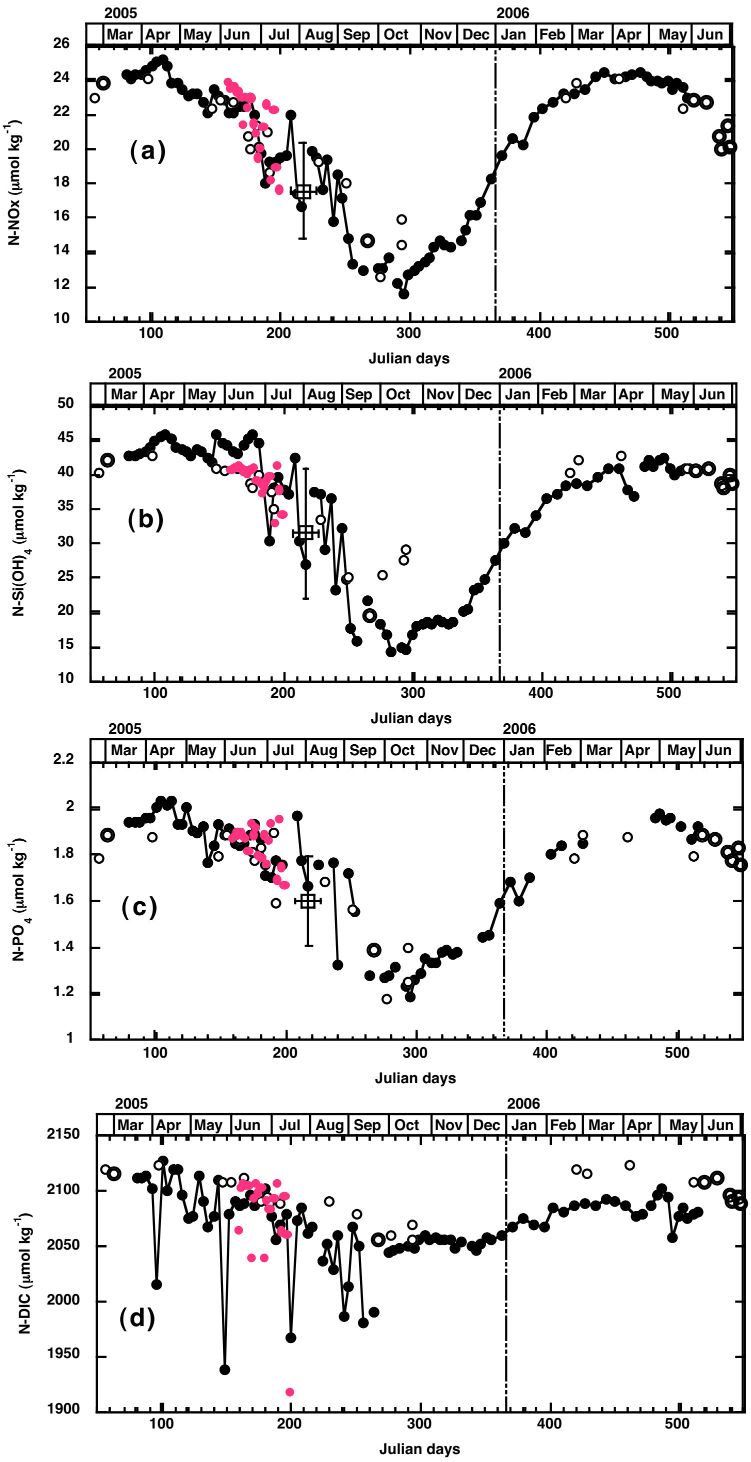


Fig. 3.1.4.2.2 N-NOx (a), N-Si$(OH)_4$ (b), N-PO_4 (c) and N-DIC (d).

3.1.4.3 Sediment trap

During the last cruise in September-October 2005 (MR05-04), sediment traps were installed at approximately 150 m (21 cups), 300 m (21 cups), 500 m (13 cups), 1000 m (13 cups) and 5000 m (13 cups) on the BGC mooring system. Before deployment, collecting cups were filled up with 5 % seawater based buffered formalin solution. Unfortunately 300 m sediment trap did not work because of malfunction (circuit board was burn). In addition, 150 m sediment trap stopped after 2nd collection. After recovery, it was found that battery voltage was almost zero. However seasonal data of materials' flux were successfully collected at 500 m, 1000 m and 5000 m. On board, heights of sample in collecting cups were measured using a "ruler" in order to estimate general pattern of flux (Fig. 3.1.4.3.1). Qualitatively, total mass flux decreased from October 2005 to April 2006 and increased to May 2006. As same as previous results, total mass flux at 500 m was smaller and that at 5000 m was larger than others.

In addition, we deployed sediment trap mooring system during this cruise. 150 m sediment trap did not work again after 1 month because of battery exhaustion. Based on failure of long-term mooring, 150 m sediment trap could not work after 1 month because of short circuit or unexpected consumption of battery. However 150 m sediment trap collected a lot of mesozooplanktons such as copepod, euphausiid and arrowworm rather than sinking particles < 1 mm. However 300 m, instead of 500 m, 1000 m and 5000 m sediment trap collected sinking particle by 2 – 4 days interval. In near future, chemical analysis for biogenic / lithogenic materials and natural radionuclide (^{230}Th) and biological analysis on sediment trap samples will be conducted and how biogenic substances such as organic carbon are transported vertically will be discussed.

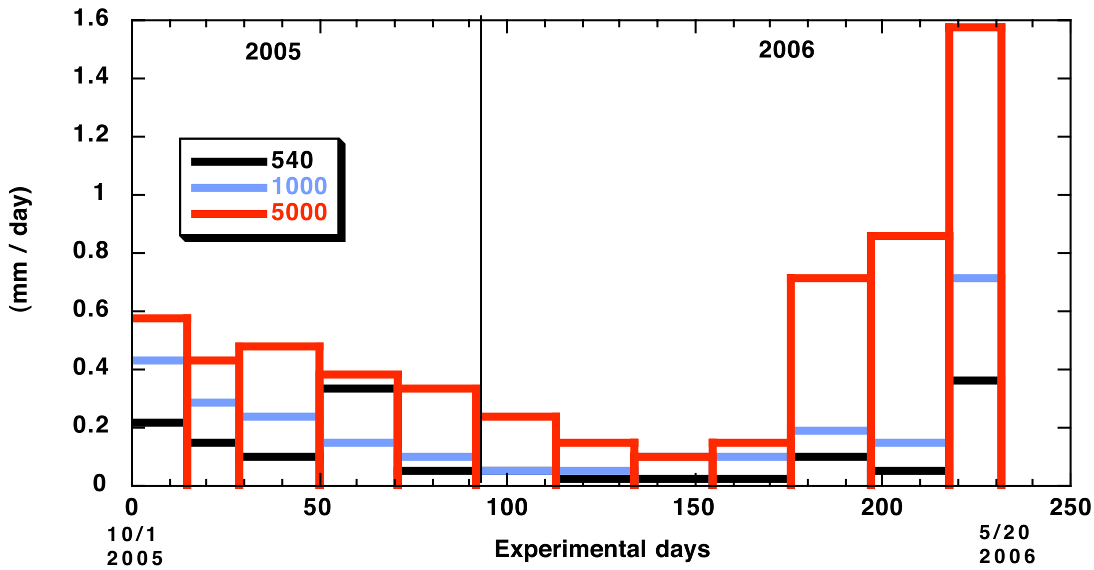


Fig. 3.1.4.3.1 Total mass flux at 540 m, 1000 m and 5000 m between October 2005 and May 2006

3.1.4.4 ZPS (Zooplankton sampler)

In the early years of HiLATS project, we started to use ZPS and filtrated volume of seawater was set to be 100 l. However enough zooplankton samples could not be obtained. Therefore ZPS was initialized to filtrate seawater of 500 l through roll-type filter (Nitex 100μm mesh) when deployment in MR05-04 cruise. After recover during this cruise, ZPS record said that ZPS worked on schedule. However enough zooplankton samples could not be obtained. In addition, filter number could not be recognized.

3.1.4.5 WTS (Phytoplankton sampler)

During the last cruise (MR05-04), it was noticed that WTS possibly could not filtrate seawater through GF/F filter because of pump capacity. Thus WTS pump was exchanged to SID pump with higher ability. After recovery, it was certified that WTS filtrated seawater through GF/F filter ranging from 35 ml to 5000 ml by 25 March 2006 and time-series samples of 14 pieces (colored filters) could be collected. Though filtration volume could not be exact because of different pump, qualitative data will be obtained after laboratory analysis.

3.1.4.6 BLOOMS (Bio-optical Long-term Optical Ocean Measuring System)

BLOOMS measures downwelling spectral irradiance at four wave lengths (412, 443, 490, and 555 nm) on the hour between 6:00 and 18:00 LST, namely 13 times a day and recorded in one file a day. BLOOMS started its sampling on 25 September and final file was made on 17 July 2006 and 294 files were obtained. These files will be sent to Professor Tommy Dickey of University of California, Santa Barbara and analyzed.

3.2. Phytoplankton

3.2.1. Chlorophyll *a* measurements by fluorometric determination

Kazuhiko MATSUMOTO (JAMSTEC) : Principal Investigator
Masanori ENOKI (MWJ) : Operation Leader (Leg.1)
Yuichi SONOYAMA (MWJ) : Operation Leader (Leg.2)

1. Objective

Phytoplankton distributes as various species and sizes in the ocean. Phytoplankton species are roughly characterized by their cell size. The object of this study is to investigate the variation of the vertical distribution of phytoplankton within a period of the time-series observation by using the size-fractionated filtration method at station K2 in the western North Pacific subarctic gyre.

2. Sampling elements

・Total-chlorophyll *a* (Stn.K2, Shallow-cast)
・Size-fractionated chlorophyll *a* (Stn.K2, Shallow-cast)

3. Instruments and Methods

Seawater samples were collected at 8 depths in the euphotic zone at shallow-cast of Stn.K2 using Niskin bottles, except for the surface water, which was taken by a bucket. Sampling depths were determined by the optical free-fall sensor before the experiments of primary productivity at shallow-casts. Water samples were filtered at a vacuum-pressure below 0.02MPa. The samples for size-fractionation were filtered sequentially through the three types of 47mm-diameter nuclepore filters (pore size of 10.0μm, 3.0μm and 1.0μm) and the 25mm-diameter Whatman GF/F filter, and the samples for total were filtered through 25mm-diameter Whatman GF/F filter. Phytoplankton pigments retained on the filters were immediately extracted in polypropylene tube with 7 mL of N,N-dimethylformamide. The tubes were stored at –20℃ in a freezer to extract chlorophyll *a* for 24 hours or more. Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was previously calibrated against a pure chlorophyll *a* standard (Sigma chemical Co.).
We applied both fluorometric “Non-acidification method” (Welschmeyer, 1994) and “Acidification method” (Holm-Hansen *et al.*, 1965) to estimate chlorophyll *a*, but size-fractionated samples were used only “Non-acidification method”

4. Preliminary Results

The temporal variability of chlorophyll *a* was shown in Figure 1.

6. Data archives

The processed data file of Chlorophyll *a* was copied onto CD-ROM and submitted to chief scientist.

7. Reference

Holm-Hansen, O., Lorenzen, C. J., Holmes, R.W., J. D. H. Strickland 1965.Fluorometric determination of chlorophyll. *J. Cons. Cons. Int. Explor. Mer* :30,3-15.

Welschmeyer, N. A. 1994. Fluorometric analysis of chlrophyll *a* in the presence of chlorophyll *b* and pheopigments. *Limnol.Oceanogr* :39,1985-1992.

Table 1. Analytical conditions of "Non-acidification method" & "Acidification method" for chlorophyll *a* with Turner Designs fluorometer (10-AU-005).

	Non-acidification method	Acidification method
Excitation filter (nm)	436	340-500nm
Emission filter (nm)	680	>665nm
Lamp	Blue F4T5,B2/BP	Daylight white F4T5D

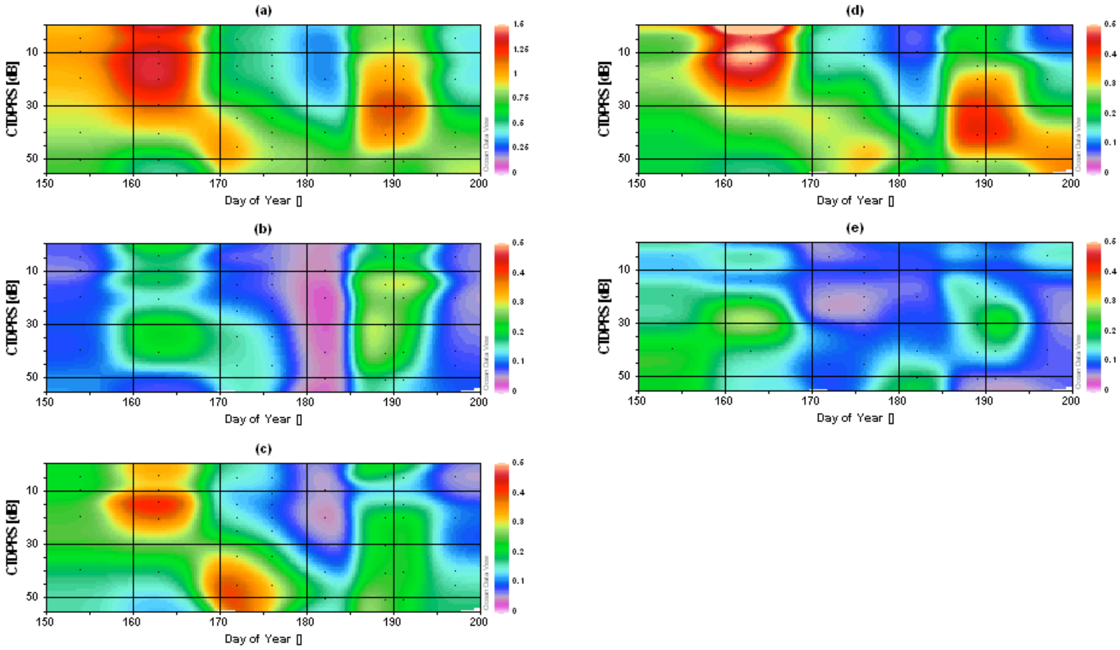


Figure 1. Temporal variability of chlorophyll *a* concentrations (μg/L) at station K2. (a)Total-chlorophyll *a*, (b)>10μm, (c)3-10μm, (d)1-3μm, and (e)<1μm.

3.2.2. HPLC measurements of marine phytoplankton pigments

Kazuhiko MATSUMOTO (JAMSTEC)
Yuichi SONOYAMA (MWJ)

1. Objective

The chemotaxonomic assessment of phytoplankton populations present in natural seawater requires taxon-specific algal pigments as good biochemical markers. A high-performance liquid chromatography (HPLC) measurement seems to be an optimum method for separating and quantifying phytoplankton pigments in natural seawater.

In this cruise, we measured the marine phytoplankton pigments by HPLC to investigate the marine phytoplankton community structure at station K2 in the western North Pacific subarctic gyre.

2. Methods or Apparatus & Performance

Seawater samples were collected at 8 depths in the euphotic zone at shallow-cast of Stn.K2 using Niskin bottles, except for the surface water, which was taken by a bucket. The water samples (3~5L) were filtered at a vacuum-pressure below 0.02MPa through the 47 mm-diameter Whatman GF/F filter. To remove remaining seawater of the sample filters, GF/F filters were vacuum-dried in a freezer (-20 deg C) for 1 hour. Subsequently, phytoplankton pigments retained on a filter were extracted in a glass tube with 4 ml of N,N-dimethylformamide (HPLC-grade) for at least 24 hours in a freezer (-20 deg C), and analyzed within a few days.

Residua cells and filter debris were removed through polypropylene syringe filter (pore size: 0.2 μm) before the analysis. The samples (500μl) were injected from the auto-sampler immediately after the addition of pure water (180μl) and internal standard (10μl) into the samples (420μl), and measured with photodiode array detector. Analytical conditions of HPLC system were modified the method of Zapata *et al*. (2000).

2.1 HPLC System

HPLC System was composed by a Waters modular system (high dwell volume) including 600S controller, 616 pump (low-pressure mixing system), 717 Plus auto-sampler and 996 photodiode array detector (2.4 nm optical resolution).

2.2 Stationary phase

Analytical separations were performed using a YMC C_8 column (150×4.6 mm). The column was thermostatted at 25 deg C in the column heater box.

2.3 Mobile phases

Eluant A was a mixture of methanol : acetonitrile : aqueous pyridine solution (0.25M pyridine) (50 : 25 : 25 v : v : v). Eluant B was acetonitrile : acetone (80 : 20 v : v). Organic solvents for mobile phases were used reagents of HPLC-grade.

2.4 Standard pigments

The HPLC system is calibrated with the following pigment standards (Table 1). We selected Chlorophyll *a*, Chlorophyll *b* (Sigma co.) and other 22 pigments (DHI co.). The concentrations of pigment standards were determined using its extinction coefficient by spectrophotometer, then the solvents of pigment standards were displaced to N,N-dimethylformamide.

2.5 Internal standard

To calibrate the area values of chromatograms, we selected Ethyl-apo-8'-carotenoate for internal standard.

2.6 Pigment detection and identification

Chlorophylls and carotenoids were detected by photodiode array spectroscopy (350~720nm). Pigment concentrations were calculated from the chromatograms at different three channels.

First channel was allocated at 661.4 nm of wavelength for measurement of Chlorophyllide *a*, Pheophorbide *a*, Divinyl Chlorophyll *a*, Chlorophyll *a* and Pheophytin *a*.

Second channel was allocated at 454.8 nm for Chlorophyll *b*.

Third channel was allocated at 460.0 nm for other pigments.

3. Preliminary results

Preliminary results were shown in Figure 1.

4. Data archives

The processed data file of pigments was copied onto CD-ROM and submitted to the Chief Scientist.

5. Reference

Zapata M, Rodriguez F, Garrido JL (2000) Separation of chlorophylls and carotenoids from marine phytoplankton : a new HPLC method using a reversed phase C8 column and pyridine-containing mobile phases. Mar. Ecol. Prog. Ser. 195 : 29-45

Table 1. Retention time and wavelength of pigment standards.

No.	Pigment	Retention Time (minute)	Wavelength (max : nm)	Extinction Coefficient (l/g/cm)	Solvent
1	Chlorophyll *c3*	10.463	457.2	346	90% Acetone
2	Chlorophyllide *a*	12.728	661.4	127	90% Acetone
3	Chlorophyll *c2*	14.188	452.4	374	90% Acetone

4	Peridinin	17.413	474.1	132.5	100% Ethanol
5	Pheophorbide *a*	19.727	409.0	74.2	90% Acetone
6	19'-butanoyloxyfucoxanthin	20.318	445.1	160	100% Ethanol
7	Fucoxanthin	21.430	449.9	160	100% Ethanol
8	Neoxanthin	21.843	437.9	224.3	100% Ethanol
9	Prasinoxanthin	22.955	454.8	160	100% Ethanol
10	19'-hexanoyloxyfucoxanthin	23.630	445.1	160	100% Ethanol
11	Violaxanthin	23.668	440.3	255	100% Ethanol
12	Diadinoxanthin	25.572	447.5	262	100% Ethanol
13	Antheraxanthin	26.210	447.5	235	100% Ethanol
14	Alloxanthin	26.597	452.4	262	100% Ethanol
15	Diatoxanthin	27.038	452.4	262	100% Ethanol
16	Zeaxanthin	27.418	452.4	254	100% Ethanol
17	Lutein	27.505	447.5	255	100% Ethanol
18	Ethyl-apo-8'-carotenoate	28.797	459.6	—	100% DMF
19	Crocoxanthin	30.280	447.5	250	100% Ethanol
20	Chlorophyll *b*	30.677	454.8	51.23	100% DMF
21	Divinyl Chlorophyll *a*	31.857	437.9	87.67	90% Acetone
22	Chlorophyll *a*	32.013	428.2	88.74	100% DMF
23	Pheophytin a	34.973	406.6	51.2	90% Acetone
24	Alpha-carotene	35.188	447.5	270	100% Acetone
25	Beta-carotene	35.480	454.8	250	100% Acetone

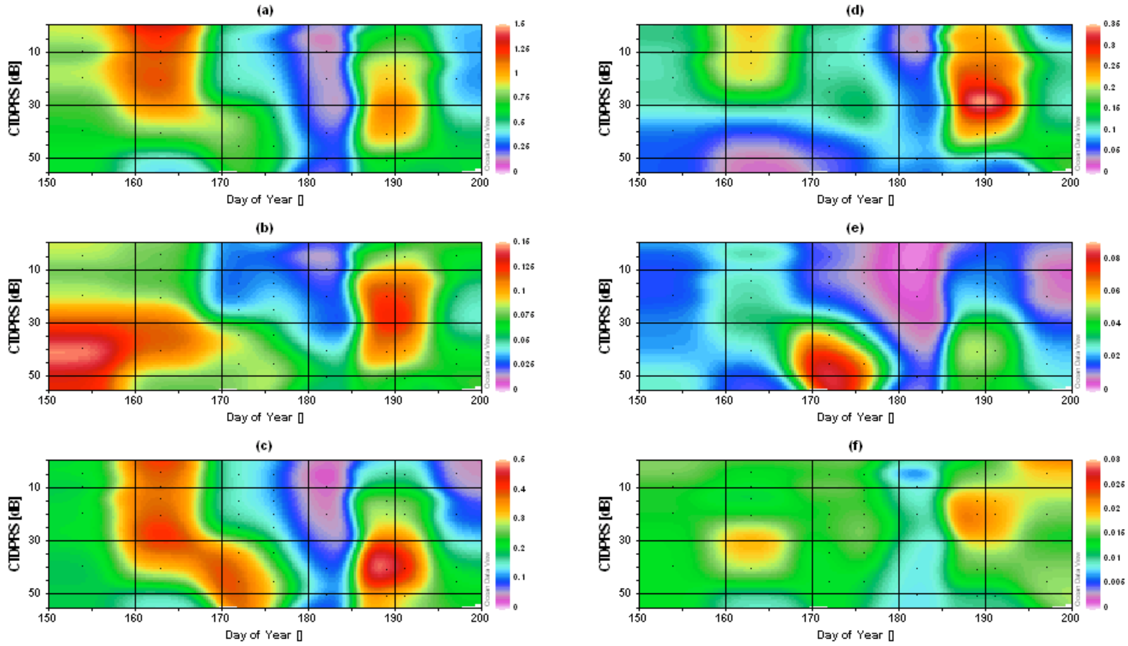


Figure 1. Temporal variability of phytoplankton pigments concentrations (μg/L) at station K2. Chlorophyll *a* (a), Chlorophyll *b* (b), Fucoxanthin (c), 19'-Hexanoyloxyfucoxanthin (d), Peridinin (e) and Zeaxanthin (f) are roughly represented as the abundance of total phytoplankton, green algae, diatoms, haptophytes, dinoflagellates and cyanobacteria, respectively.

3.2.3. Phytoplankton abundances

Kazuhiko MATSUMOTO (JAMSTEC MIO)
Tetsuichi FUJIKI (JAMSTEC MIO)

(1) Objectives

The main objective of this study is to estimate phytoplankton abundances and their taxonomy at the station K2 in the western North Pacific subarctic gyre. Phytoplankton abundances were measured with two kinds of methods: microscopy for large size phytoplankton and flowcytometry for pico- and nanophytoplankton.

(2) Sampling

Samplings were conducted at 8 depths within the euphotic zone at shallow-cast of Stn.K2 using Niskin bottles, except for the surface water, which was taken by a bucket. Sampling depths were coincided to the depth for primary productivity experiment. Samplings were carried out six times during the cruise through leg-1 and leg-2.

(3) Methods

1) Microscopy

Water samples were placed in 500 ml plastic bottle and fixed with neutral buffered formalin solution (3% final concentration). The measurements are scheduled after the cruise.

2) Flowcytometry

2)-1 Equipment

The flowcytometry system used in this research was BRYTE HS system (Bio-Rad Laboratories Inc). System specifications are follows:

Light source: 75W Xenon arc lamp
Excitation wavelength: 350-650 nm
Detector: high-performance PMT
Analyzed volume: 75 μl
Flow rate: 10 μl min^{-1}
Sheath fluid: Milli-Q water
Filter block: B2 as excitation filter block, 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

2)-2 Measurements

The pre-filtered sample by Nuclepore filter (pore size: 10μm) was fixed immediately with glutaraldehyde (1% final concentration) and stored in the dark at 4°C. The analysis by the flow cytometer was acquired on board within 24 hours after the sample fixation for the samples taken at leg-1. The other samples taken at leg-2 were preserved in the deep-freezer at -80°C, and those analyses will be scheduled after the cruise. Calibration was achieved with standard beads (Polysciences) from 0.356 to 9.146μm, and 2.764μm beads were added into each sample prior to injection as internal standard. Phytoplankton cell populations and cell sizes were estimated from the forward light scatter signal. Acquired data were stored in list mode file and analyzed with WinBryte software. Phytoplankton are classified with prokaryotic cyanobacteria (*Prochlorococcus* and *Synechococcus*) and other eukaryotes on the basis of scatter and fluorescence signals. *Synechococcus* is discriminated by phycoerythrin as the orange fluorescence, while other phytoplankton are recognized by chlorophylls as the red fluorescence without the orange fluorescence. *Prochlorococcus*, picoeukaryotes and nanoeukaryotes were distinguished with their cell size.

(4) Data Archive

All data will be submitted to JAMSTEC Data Management Office (DMO).

3.2.4. Transparent Exopolymer Particles (TEP)

Kazuhiko MATSUMOTO (JAMSTEC)
Tetsuichi FUJIKI (JAMSTEC)

(1) Objectives

The sinking of biogenic particles plays an important role in carbon cycling in the ocean. Phytoplankton generates large amounts of extracellular polysaccharides. Polysaccharides transform to the particle by itself, and the formation of polysaccharide particle is a pathway to convert dissolved into particulate organic carbon. Furthermore, the extracellular polysaccharide particles, described as transparent exopolymer particles (TEP) support the formation of large particle aggregates. Their contribution to the carbon fluxes may be significant because TEP promotes the sedimentation of particles. The objective in this study is to estimate the abundance and the variability of TEP by the phytoplankton bloom in the northern North Pacific.

(2) Materials and Methods

(a) Sampling

Samplings were conducted at 8 depths within the euphotic zone at shallow-cast of Stn.K2 using Niskin bottles, except for the surface water, which was taken by a bucket. Sampling depths were coincided to the depth for primary productivity experiment. In addition, samples were taken from the floating sediment traps and their installation depths -50m, 100m, 150m and 200m. Samplings were carried out six times during the cruise through leg-1 and leg-2.

(b) Sample treatment

30 – 100 ml of seawater samples were filtered with 0.4µm Nuclepore filter. The samples of sediment traps were measured to 500 ml with filtered seawater (<0.2µm) and 30 – 50 ml of their samples were filtered with 0.4µm Nuclepore filter. TEP was stained on the filter with 500 µl of a 0.02% aqueous solution of alcian blue (8GX) in 0.06% acetic acid (pH 2.5). Sample filters are stored at -80°C until the subsequent analysis. TEP will be quantified by the method on the basis of Passow and Alldredge (1995). The analysis is scheduled after the cruise.

(4) Data Archive

All data will be submitted to JAMSTEC Data Management Office (DMO).

References

Passow, U. and A. L. Alldredge (1995). "A dye-binding assay for the spectrophotometric measurement of transparent exopolymer particles (TEP) in the ocean." Limnology and Oceanography 40(7): 1326-1335.

3.3 Th-234 and export flux

Hajime KAWAKAMI (JAMSTEC MIO)
Makio HONDA (JAMSTEC MIO)

(1) Purpose of the study

The fluxes of POC were estimated from Particle-reactive radionuclide (^{234}Th) and their relationship with POC in the northwestern North Pacific Ocean.

(2) Sampling

Seawater and suspended particulate sampling for ^{234}Th and POC: 6 stations (stations K2-1, K2-2, K2-3, K2-4, K2-5 and K2-6) and 8 depths (10m, 20m, 30m, 50m, 75m, 100m, 150m and 200m) at each station. Settling particulate sampling for ^{234}Th: 6 stations (similar to above) and 4 depths (55m, 100m, 150m, 200m).

Seawater samples (20–30 L) were taken from Hydrocast at each depth. The seawater samples were filtered with 47mm GF/F filter on board immediately after water sampling.

In situ filtering (suspended particulate) samples were taken from large volume pump sampler (LVP). About 200L seawater was filtered with GF/F filter, and about 1 m^3 seawater was filtered with Nitex mesh filter (53μm), at each stations. Drifting sediment trap's (settling particulate) samples were filtered with GF/F filter. The filter samples were divided for ^{234}Th and POC.

(3) Chemical analyses

Dissolved, particulate and drifting sediment trap's ^{234}Th was separated using anion exchange method. Separated samples of ^{234}Th were absorbed on 25mm stainless steel disks electrically, and were measured by β-ray counter.

The determinations of POC were used CHN analyzer in land-based laboratory.

(4) Preliminary result

The distributions of ^{234}Th and POC will be determined as soon as possible after this cruise. This work will help further understanding of particle dynamics at the euphotic layer.

3.4 Optical measurement

Makio HONDA (JAMSTEC MIO)
Kazuhiko MATSUMOTO (JAMSTEC MIO)
Suguru OKAMOTO (Hokkaido University)

(1) Objective

The objective of this measurement is to investigate the air and underwater light conditions at respective stations and to determine depths for simulated *in situ* measurement of primary production by using carbon stable isotope (C-13) during late spring or early summer. In addition, optical data can be used for the validation of satellite data.

In addition, our group (JAMSTEC-MIO) have been conducting time-series observation with using mooring systems in the northwestern North Pacific (NWNP). On these mooring systems, optical sensor package called BLOOMS are installed. The BLOOM measures spectral downwelling irradiance and upwelling radiance for four wavelengths (412 nm, 443 nm, 490 nm and 555 nm) and chlorophyll. Another objective of optical observation during this cruise was to know the optical characteristics and to contribute to the evaluation of observed values by BLOOM.

(2) Description of instruments deployed

The instrument consisted of the SeaWiFS Profiling Multichannel Radiometer (SPMR; and SeaWiFS Multichannel Surface Reference (SMSR). The SPMR was deployed in a free fall mode through the water column. The SPMR profiler called "Free Fall" has a 13 channel irradiance sensors (Ed), a 13 channel radiance sensors (Lu), tilt sensor, and fluorometer. The SMSR has a 13 channel irradiance sensors (Es) and tilt meter (Table 1). These instruments observed the vertical profiles of visible and ultra violet light and chlorophyll concentration.

Table 1. Center wavelength (nm) of the SPMR/SMSR

Es	379.5	399.6	412.2	442.8	456.1	490.9	519.0	554.3	564.5	619.5	665.6	683.0	705.9
Ed	380.0	399.7	412.4	442.9	455.2	489.4	519.8	554.9	565.1	619.3	665.5	682.8	705.2
Lu	380.3	399.8	412.4	442.8	455.8	489.6	519.3	554.5	564.6	619.2	665.6	682.6	704.5

Optical measurements by Free Fall were conducted at our time-series station K2 and other stations at where we stayed during 10:00 – 14:00 (LST). Measurements should be ideally conducted at median time. However observations were conducted irregularly because of limited ship-time and other observation's convenience (Table 2). The profiler was deployed twice at respective stations to a depth of 150 m. The SMSR was mounted on the anti-rolling system's deck and was never shadowed by any ship structure. The profiler descended at an average rate of 1.0 m/s with tilts of less than 3 degrees except near surface.

Observed data was analyzed by using software "Satlantic PPROSOFT 6" and extinction rate and photosynthetically available radiation (PAR) were computed.

Table 2 Locations of optical observation and principle characteristics
(Date and Time in LST: UTC+11hr.)

S/N	Date and Time (LST = UTC+11hr.)	Station	Lat/Long	SurfacePAR (quanta/cm2/sec)	Euphotic layer(1% Depth) (m)
1	2006.6.1 11:45	M06011(K1)	51N/165E	6.27E+16	57
2	2006.6.2 11:45	M06014	49-30N/163-08E	3.22E+16	48
3	2006.6.3 11:40	M06002(K2-1)	47N/160E	3.73E+16	49
4	2006.6.7 12:45	M06018	47-30N/160-38E	6.36E+16	49
5	2006.6.8 13:00	M06004	45N/160E	4.52E+16	38
6	2006.6.10 12:00	M06010(K3)	39N/160E	4.94E+16	62
7	2006.6.11 13:00	M06007	42N/160E	1.82E+16	55
8	2006.6.12 13:00	M06000(Before K2)		3.82E+16	36
9	2006.6.13 10:00	M06019(K2-2)	47N/160E	3.31E+16	38
10	2006.6.21 13:45	M06020(K2-3-1)	47N/160E	1.96E+16	37
11	2006.6.23 10:30	M06020(K2-3-2)	47N/160E	3.63E+16	33
12	2006.6.25 10:00	M06020(K2-3-3)	47N/160E	7.19E+16	50
13	2006.6.27 12:00	M06023	42N/155E	1.18E+17	27
14	2006.6.28 10:10	M06025	40N/155E	3.46E+16	44
15	2006.6.29 13:45	M06026 (before K2)	46N/155E	6.33E+16	35
16	2006.6.30 11:30	M06026(K2-4-1)	47N/160E	4.98E+16	55
17	2006.7.2 10:45	M06026(K2-4-2)	47N/160E	2.41E+16	59
18	2006.7.5 11:50	M06031	35N/155E	1.15E+17	64
19	2006.7.6 12:45	M06028	38N/155E	6.27E+16	67
20	2006.7.8 11:00	M06032(K2-5-1)	47N/160E	5.71E+16	40
21	2006.7.10 10:00	M06032(K2-5-2)	47N/160E	6.39E+16	36
22	2006.7.11 11:00	M06032(K2-5-3)	47N/160E	3.52E+16	38
23	2006.7.14 11:40	M06037	44-30N/155-60E	3.73E+16	48
24	2006.7.15 10:30	M06039(K2-6-1)	47N/160E	7.03E+16	44
25	2006.7.16 11:00	M06039(K2-6-2)	47N/160E	5.39E+16	46
26	2006.7.17 13:00	M06039(K2-6-3)	47N/160E	2.47E+16	46
27	2006.7.18 11:30	M06033	46-30N/159-10E	4.06E+16	53
28	2006.7.19 12:00	M06038(KNOT)	44N/155E	2.45E+16	37

(3) Preliminary result

We deployed "Free Fall sensor" 28 times. In general, weather was cloudy and foggy during this cruise. Surface PAR ranged from 1.8×10^{16} to 1.2×10^{17} quanta cm^{-2} sec^{-1}. The euphotic layer that is defined as water depth with 1 % of surface PAR ranged from 67 to 27 m. There was tendency that euphotic layer at stations in south 40°N were deep. It is likely that particulate materials, i.e. phytoplankton, in the water column were smaller than those at northern stations. At time series station K2, we repeated optical measurement (14 times). Euphotic layer became shallower than 40 m at the second, third and fifth visit to K2 (K2-2, K2-3, K2-5). This shallower euphotic layer coincided with the fact that chlorophyll concentration and primary productivity at these visit were higher.

3.5 Primary productivity and drifting sediment trap

Makio HONDA (JAMSTEC MIO)
Kazuhiko MATSUMOTO (JAMSTEC MIO)
Hajime KAWAKAMI (JAMSTEC MIO)
Ai YASUDA (MWJ)
Fuyuki SHIBATA (MWJ)

3.5.1 Drifting mooring system

In order to conduct in situ incubation for measurement of primary productivity and drifting sediment trap experiment, drifting mooring system (drifter) was deployed 6 times at stations K2 in order to conduct *in situ* incubation and sediment trap experiment. This drifter consists of radar reflector, GPS radio buoy (Taiyo TGB-100), flush light, surface buoy, ropes and sinker. On this system, incubation bottles at 7 layers and “Knauer” type sediment trap at 4 layers were installed together or separately. Thanks to the effort by MWJ technicians, drifting mooring system was upgraded on board. Final configuration is shown in Fig. 3.5.1.1.

The drifter was deployed just before sunrise and recovered after 24 hours (or 48 hours for sediment trap). The drifter’s position was monitored by using GPS radio buoy (Taiyo TGB-100). Fig. 3.5.1.2 shows tracks of the drifter for 6 deployments. In general, the drifter tended to drift eastward at station K2.

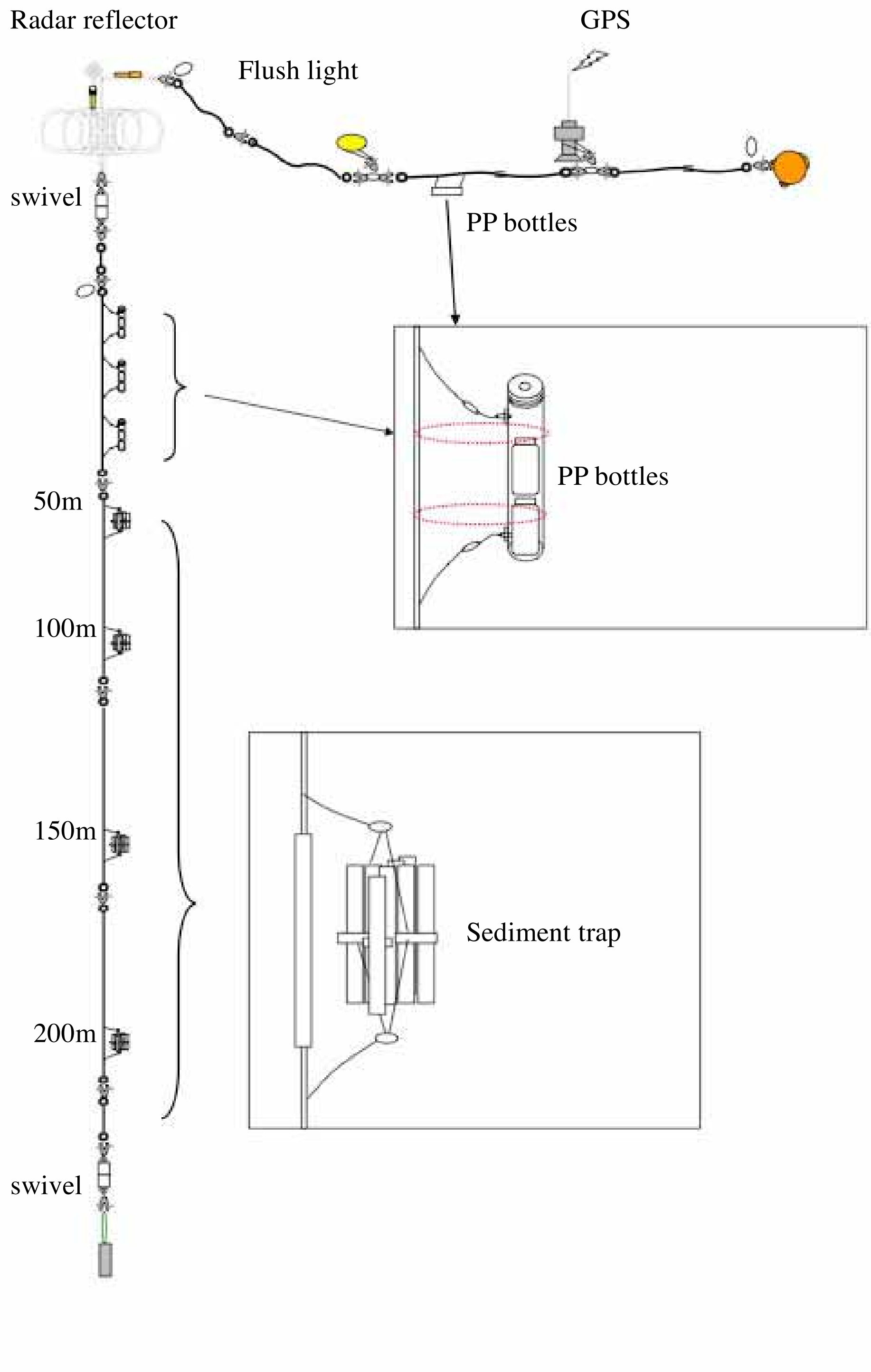


Fig. 3.5.1.1 Drifting mooring system

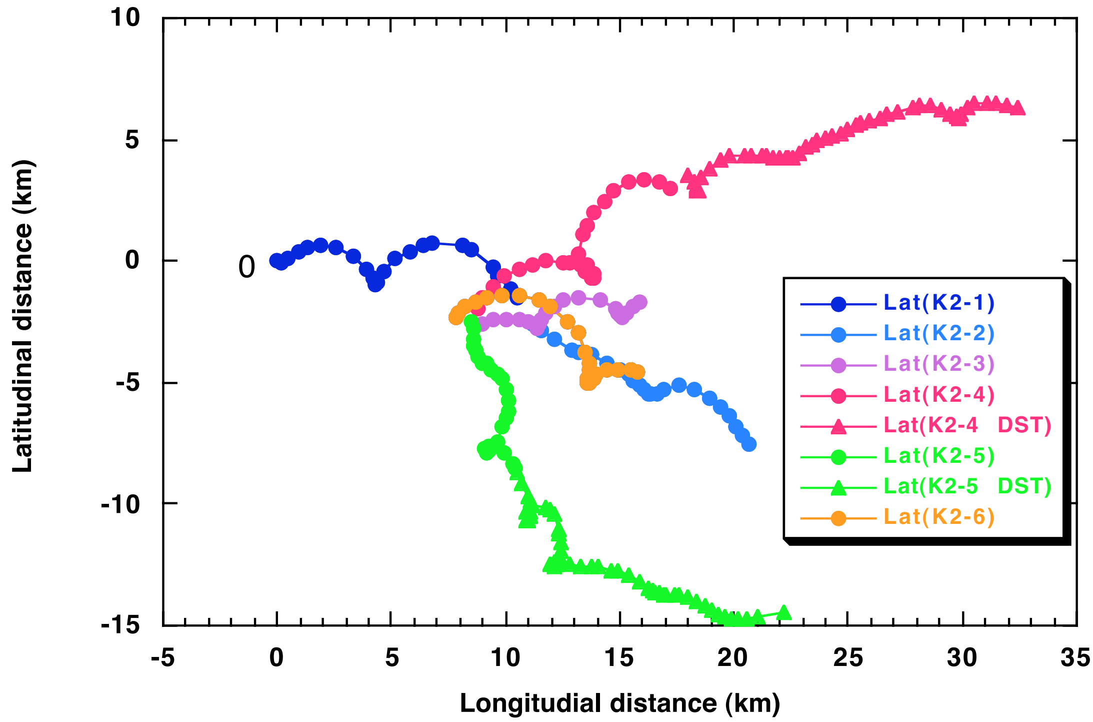


Fig. 3.5.1.2 Track of drifter (GPS buoy) for 6 deployments. Position 0 is the point that the drifting mooring system was deployed at the first time.

3.5.2 Primary productivity

Primary productivity was measured 6 times at station K2.

(1) in-situ incubation

1) 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 with temperature of 450° C for at least 2 hours were used for a filtration of phytoplankton after incubation.

2) in-situ incubation

Water samples were collected at 8 layers between the surface and seven pre-determined depths by a bucket or Niskin bottle. These depths corresponded to nominal specific optical depths *i.e.* approximately 50%, 25%, 10%, 5%, 2.5%, 1% and 0.5% light intensity relative to the surface irradiance as determined from the optical profiles obtained by "Free Fall sensor". All samples were spiked with 0.2 μmoles/mL of $NaH^{13}CO_3$ solution. After spike, bottles were installed at respective depths on the drifter (Fig.3.5.1.1). After 24 hours incubation, samples were filtrated through grass fiber filters (Wattman GF/F 25mm). GF/F filters were kept in a freezer on board until analysis.

(2) Irradiance and surface water temperature during incubation

Fig.3.5.2.1 and 3.5.2.2 shows diurnal change of photosynthetically available radiation (PAR) observed by PAR sensor (TriOS Optical Sensors RAMSES-ACC) and SST observed by EPSM system during in situ incubation at station K2, respectively. Dairy PAR ranged from approximately 42.6 E m^{-2} day^{-1} to 16.5 E m^{-2} day^{-1}. During two months cruise, SST at station K2 increased with time and SST during the final incubation conducted at middle July was approximately 9°C and 5°C higher than SST during the first incubation conducted at the early Junes.

(3) Measurement

^{13}C of samples were measured by using a mass spectrometer ANCA-SL system on board.

Before analysis, inorganic carbon of samples was removed by an acid treatment in a HCl vapor bath for 4 - 5 h.

Based on the balance of ^{13}C, assimilated organic carbon (ΔPOC) is expressed as follows (Hama *et al.*, 1983):

$$^{13}C_{(POC)} * POC = {}^{13}C_{(sw)} \times \Delta POC + (POC - \Delta POC) * {}^{13}C_{(0)}$$

This equation is converted to the following equation;

$$\Delta POC = POC * (^{13}C_{(POC)} - {}^{13}C_{(0)}) / (^{13}C_{(sw)} - {}^{13}C_{(0)})$$

where $^{13}C_{(POC)}$ is concentration of ^{13}C of particulate organic carbon after incubation, *i.e.*, measured value (%). $^{13}C_{(0)}$ is that of particulate organic carbon before incubation, *i.e.*, that for sample as a blank (1.083 in this cruise).
$^{13}C_{(sw)}$ is concentration of ^{13}C of ambient seawater with a tracer. This value for this study was determined based on the following calculation;

$$^{13}C_{(sw)} (\%) = [(TDIC * 0.011) + 0.0002] / (TDIC + 0.0002) * 100$$

where TDIC is concentration of total dissolved inorganic carbon at respective bottle depths (mol l^{-1}) and 0.011 is concentration of ^{13}C of natural seawater (1.1 %). 0.0002 is added ^{13}C (mol) as a tracer.

	For 0m PP	
S/N	TDIC (mol/l)	$^{13}C_{(sw)}$ (%)
K2-1	0.002160	9.481
K2-2	0.002147	9.528
K2-3	0.002073	9.602
K2-4	0.002084	9.563
K2-5	0.002066	9.631
K2-6	0.002054	9.672

Taking into account for the discrimination factor between ^{13}C and ^{12}C (1.025), primary productivity (PP) was, finally, estimated by

$$PP = 1.025 \times \Delta POC$$

The precision (repeatability: standard deviation / average) ranged from 0.05 % to 22 % with average of 4.0 ± 4.3 %.

(5) Preliminary results

In general, primary productivity decreased with depth (Fig. 3.5.2.3). For the fourth observation, primary productivity was measured by only 45 m though primary productivity was still detectable in deeper depth. It was caused by the fact that euphotic layer was determined by optical measurement at not K2, but point where euphotic layer was shallower because of higher productivity. Based on integrated PP (Table 3.5.2.1), PP at the second and fifth observation were higher than 600 mg-C m^{-2} day^{-1}. In contrast, PP at the third observation was lower than 300 mg m^{-2} day^{-1}. Between PP and surface PAR, there was good correlation (Fig. 3.5.2.4).

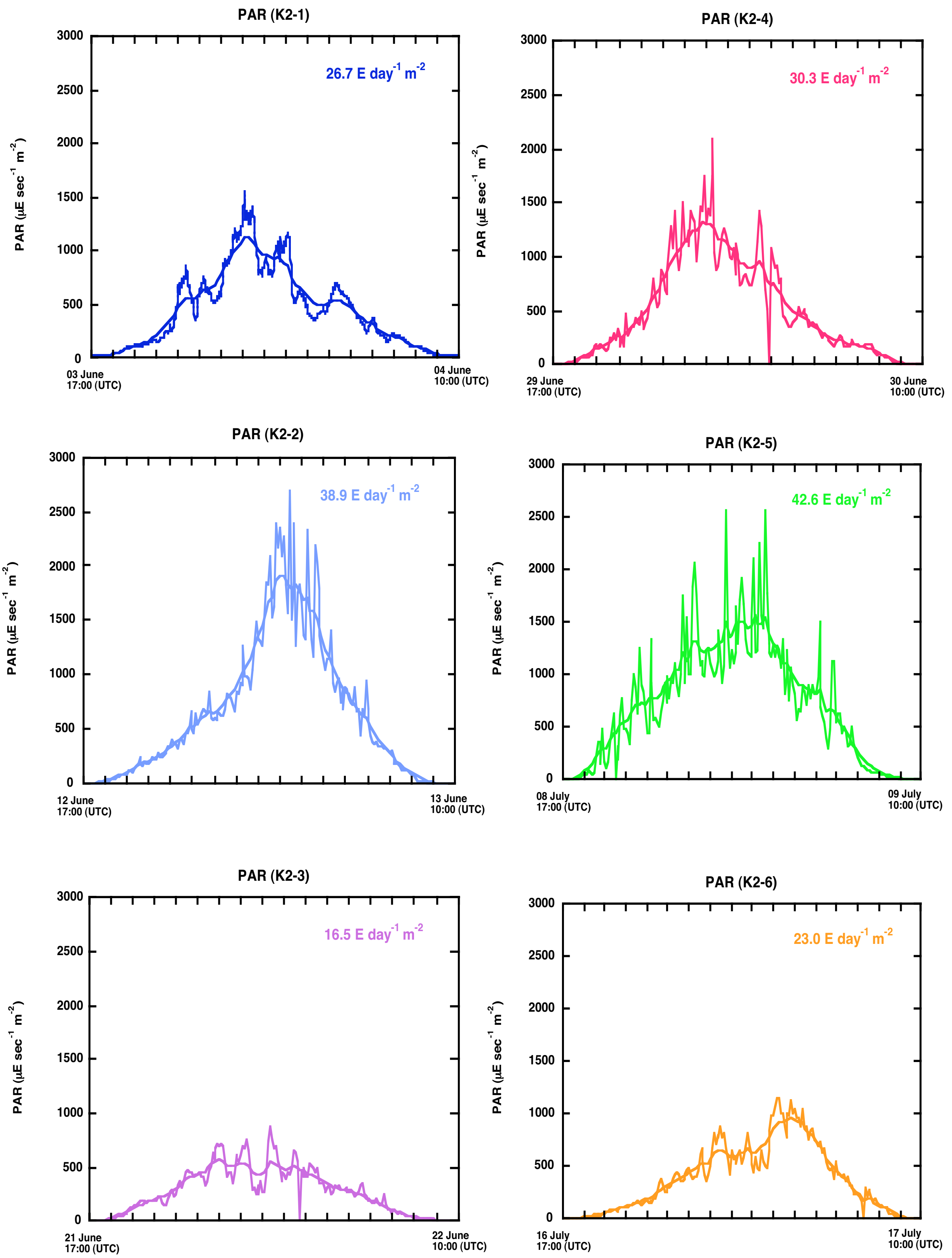


Fig. 3.5.2.1 Photosynthesis Available Radiation (PAR) during *in situ* incubation

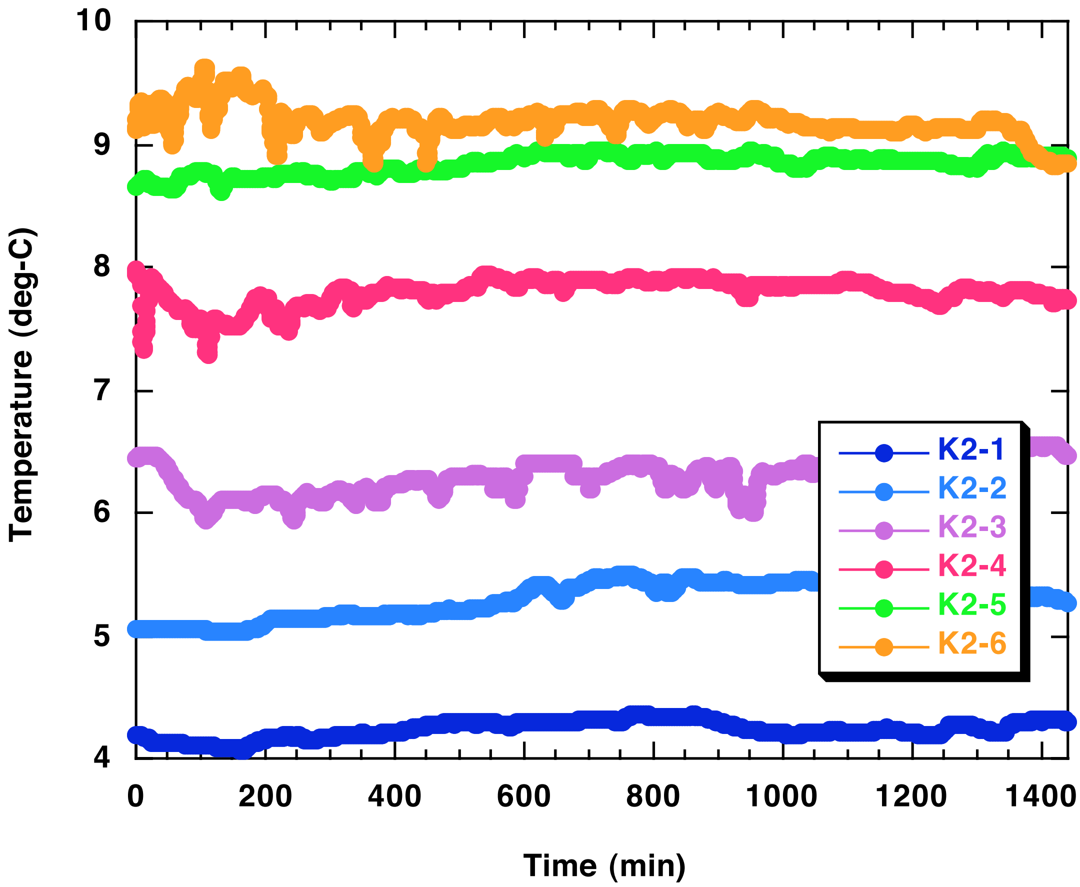


Fig. 3.5.2.2 SST during in situ incubation

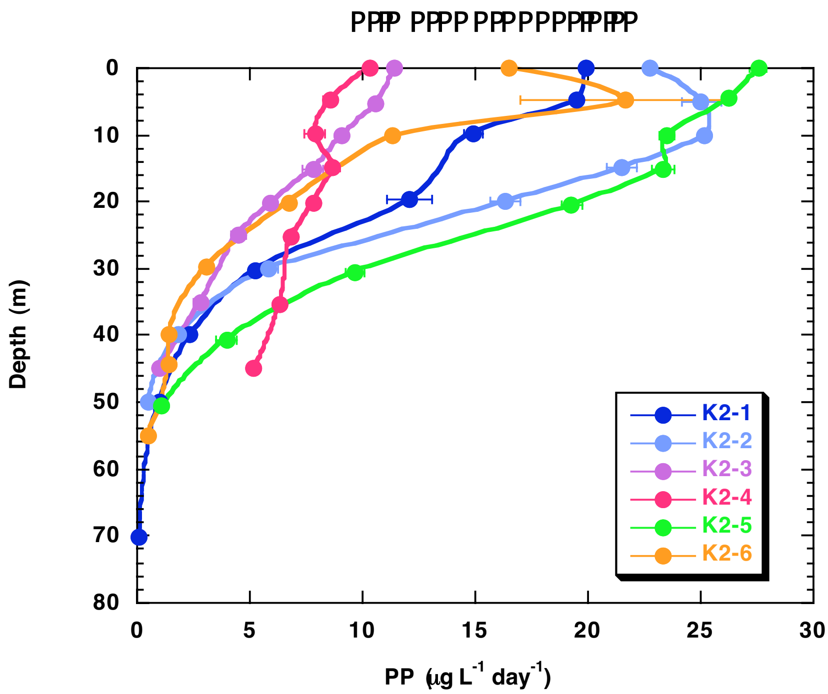


Fig. 3.5.2.3 Primary Productivity

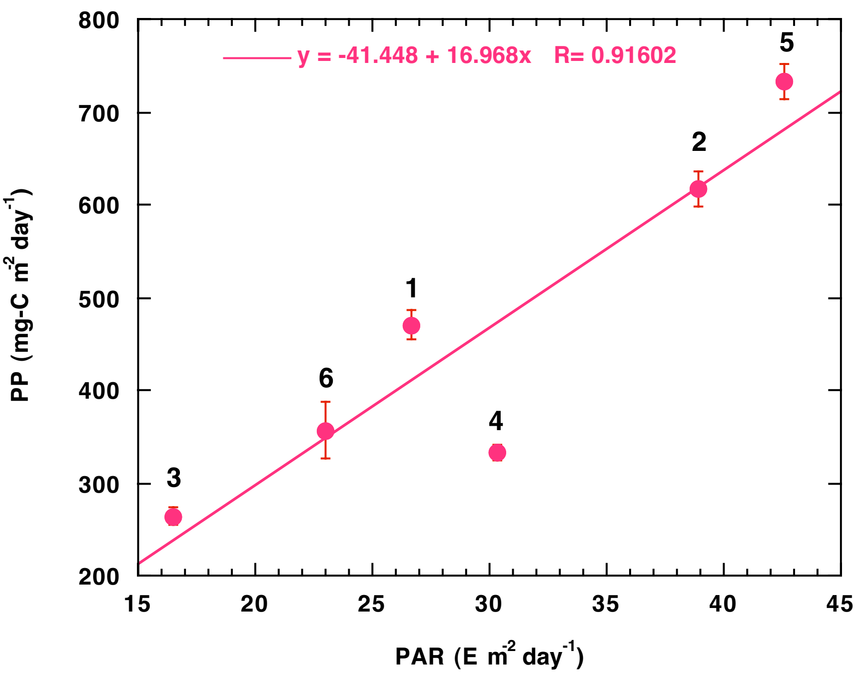


Fig. 3.5.2.4 Relation between PP and PAR

Table. 3.5.2.1 Integrated Primary Productivity. Date and time is UTC.

S/N	S/Nr/DN/e S NNg e	S/egrN/ee PP Sg g-P/g A/eNgh	S/egrN/ee PhI-N Sg g-Ph/g Ah	Sg g-P/g g-PhlN/eNgh	DNNg PAR S/g A/eNgh	ψ	SSN Seeg-Ph
SA-r	A//rggArrPA/	S//gg S rggA	grgr	SgAr	Arg/	/gAr	SgAS
SA-A	A//rggArrPA/	rrrgS S rSgA	g/g/	r/gg	ASgg	/gA/	ggA/
SA-A	A//rggAr rrPA/	ArAgS S ggr	AAgg	Sgr/	rrgg	/gSg	rgAg
SA-S	A//rggAg rrPA/	AAAgA S Sgg	A/gS	rrgAS	A/gA	/ggS	/g/g
SA-g	A//rg/gS rrPA/	/AAgA S rSgg	g/gg	rSgS/	SAgr	/gAS	SgSS
SA-r	A//rg/gr rrPA/	AgrgS S A/gA	Agg/	rAg/r	AA	/ggA	ggrg

3.5.3 Drifting sediment trap

In order to collect sinking particles and measure carbon flux, radionuclide, zooplankton and biogenic substances such as TEP , “Knouer type” cylindrical sediment trap (Photo 3.5.3.1) was deployed 6 times at station K2 where measurement of primary productivity and in situ pumping (LVP) were conducted. This trap consists of 8 individual transparent policarbonate cylinders with baffle (collection area: ca. 0.0038 m^2, aspect ratio: 620 mm length / 75 mm width = 8.27), which were modified from Knauer (1979). Before deployment, each trap was filled with filtrated surface seawater, which salinity is adjusted to ~ 39 PSU by addition of NaCl (addition of 100 mg NaCl to 20 L seawater) were placed in tubes. These were located at approximately 60 m, 100 m, 150 m and 200 m. After recovery, sediment traps were left for half hour to make collected particles settle down to the bottle. After seawater in acrylic tube was dumped using siphonic tube, collecting cups were took off. In laboratory on board, seawater with sinking particles were filtrated on various filters for respective purpose (Table 3.5.3.1). These were kept in freezer by the day when these were analyzed.

Photo 3.5.3.1 Drifting Sediment Trap

Table 3.5.3.1 Measured components and filters

#	For measurement of	Filter	Parson in charge
1	Total Mass Flux+Trace elements	25mm NP	Honda
2	Total Particulate Carbon	21mm GF/F	Honda
3	Thorium	47mm NP	Kawakami
4	Opal	47mm NP	Kawakami
5	Total Mass Flux+Trace elements	25mm NP	Honda
6	Total Particulate Carbon	21mm GF/F	Honda
7	TEP	see TEP	Matsumoto
8	Zoo plankton	25mm GF/F	Kitamura

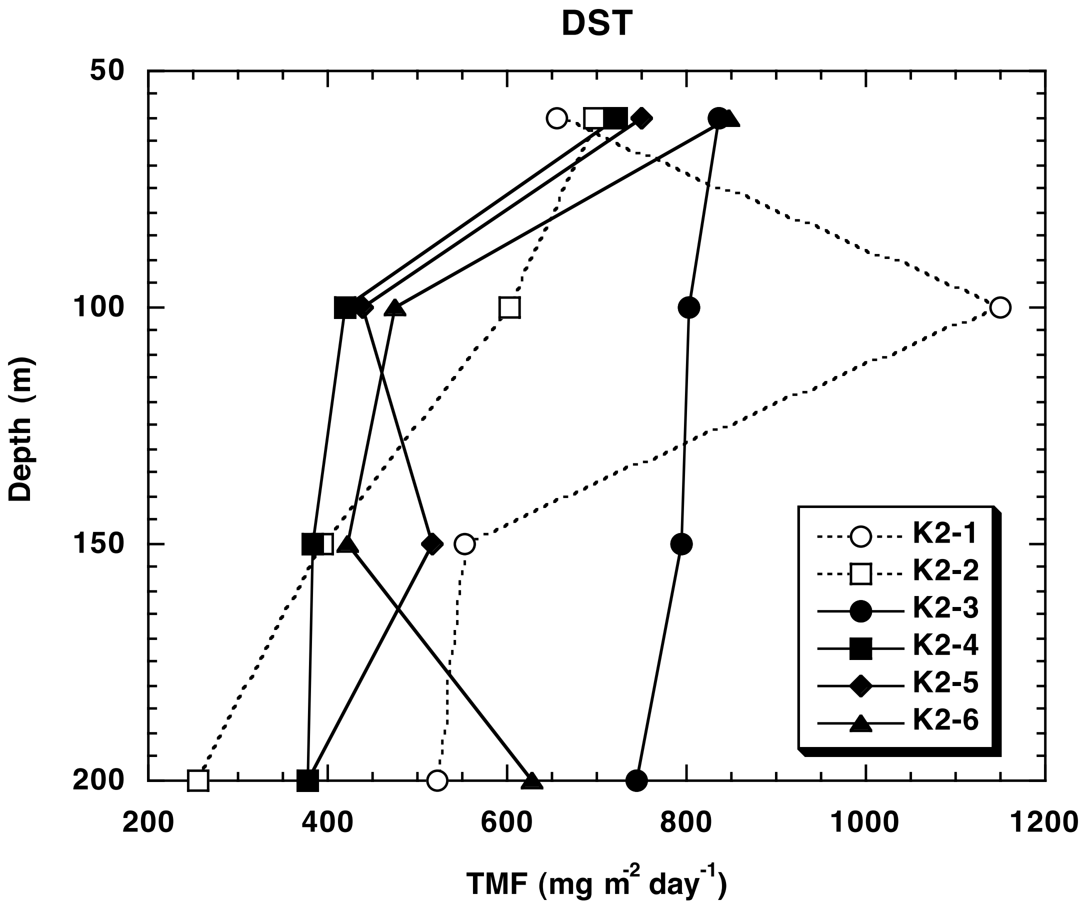


Fig. 3.5.3.1 Total Mass Flux

3.6 FRRF observation

Takuji HOSAKA (Nagoya University)
V. V. S. S. SARMA (Nagoya University)
Tetsuya NAKAMURA (Nichiyu Giken Kogyo Co., Ltd.)
Tetsuichi FIJIKI (JAMSTEC)

(1) Objective

During the past decade, the utilization of active fluorescence techniques in biological oceanography brought significant progress in our knowledge of primary productivity in the oceans (Falkowski and Kolber 1995). Above all, the fast repetition rate (FRR) fluorometry reduces the primary electron acceptor (Q_a) in photosystem II (PSII) by a series of subsaturating flashlets and can measure a single turnover (ST) fluorescence induction curve in PSII (Kolber et al. 1998). The PSII parameters, such as the photochemical energy conversion efficiency and the functional absorption cross-section of PSII, derived from the ST fluorescence induction curve can be used to estimate gross primary productivity. In the present study, we set the FRR fluorometer in the underwater profiling buoy system (denomination: POPPS Mooring) and have attempted to observe the vertical and temporal variations in PSII parameters and primary productivity in K2 through ca. 40 days. This study represents one of the first attempts with FRR fluorometer installed in the profiling buoy system in order to observe changes in primary productivity in the oceans.

(2) Methods

The POPPS Mooring mainly consists of an observation buoy, equipped with the FRR fluorometer and CTD sensor, an underwater winch, an Acoustic Doppler Current Profiler (ADCP) and acoustic releasers (Fig. 1). The observation buoy moves between winch depth and surface at the rate of 0.2 m s^{-1} and measures vertical profile of phytoplankton fluorescence. The profiling rate of the observation buoy was set to minimal in order to detect small scale variations (~0.5 m) in phytoplankton fluorescence. Once the observation buoy reaches to the surface, it transmits measured data to the shore based laboratory using Iridium network (satellite phone) and returns to the winch depth. In order to minimize the effect of biofouling on the surface of the sensors, the underwater winch was placed below the euphotic zone so that observation buoy is exposed to the photic layer only during measurement period. Using the POPPS Mooring, the vertical and temporal variations in primary productivity were examined at the station K2 during the period from June 7 to July 15, 2006. The observation buoy was moved up and down between the winch depth and surface at 10:00 a.m. (JST) every day during the period of investigation. Additionally, in order to compare the primary productivity derived by FRR fluorometry with widely used ^{13}C-tracer method, FRRF measurements were made at 2 hour intervals on June 14, 22, 30 and July 9, 17 when *in situ* ^{13}C incubations were carried out.

(3) Preliminary results

The profiles of temperature, salinity, photosynthetically active radiation (PAR), chlorophyll *a* concentration (estimated from fluorescence), photosynthetic activity (F_v/F_m) and primary productivity measured using the POPPS Mooring were shown in figure 2.

(4) Data archives

All data will be submitted to JAMSTEC Data Management Office and is currently under its control.

References

Falkowski, P. G. and Z. Kolber. 1995. Variations in chlorophyll fluorescence yields in phytoplankton in the worlds oceans. *Aust J Plant Physiol*. 22: 341-355.

Kolber, Z. S., O. Prášil and P. G. Falkowski. 1998. Measurements of variable chlorophyll fluorescence using fast repetition rate techniques: defining methodology and experimental protocols. *Biochim. Biophys. Acta*. 1367: 88-106.

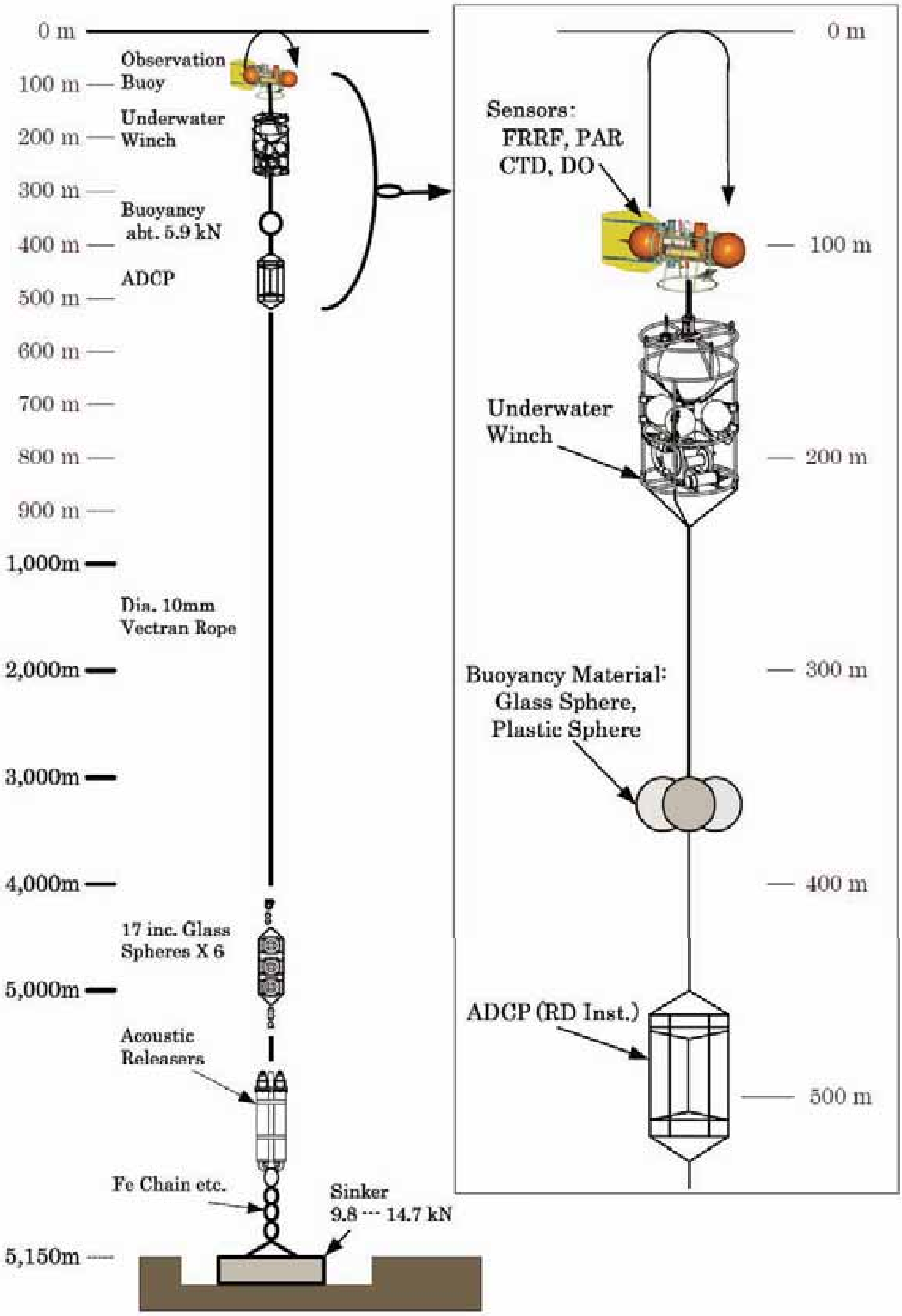


Fig. 1a. Schematic diagram of the POPPS Mooring.

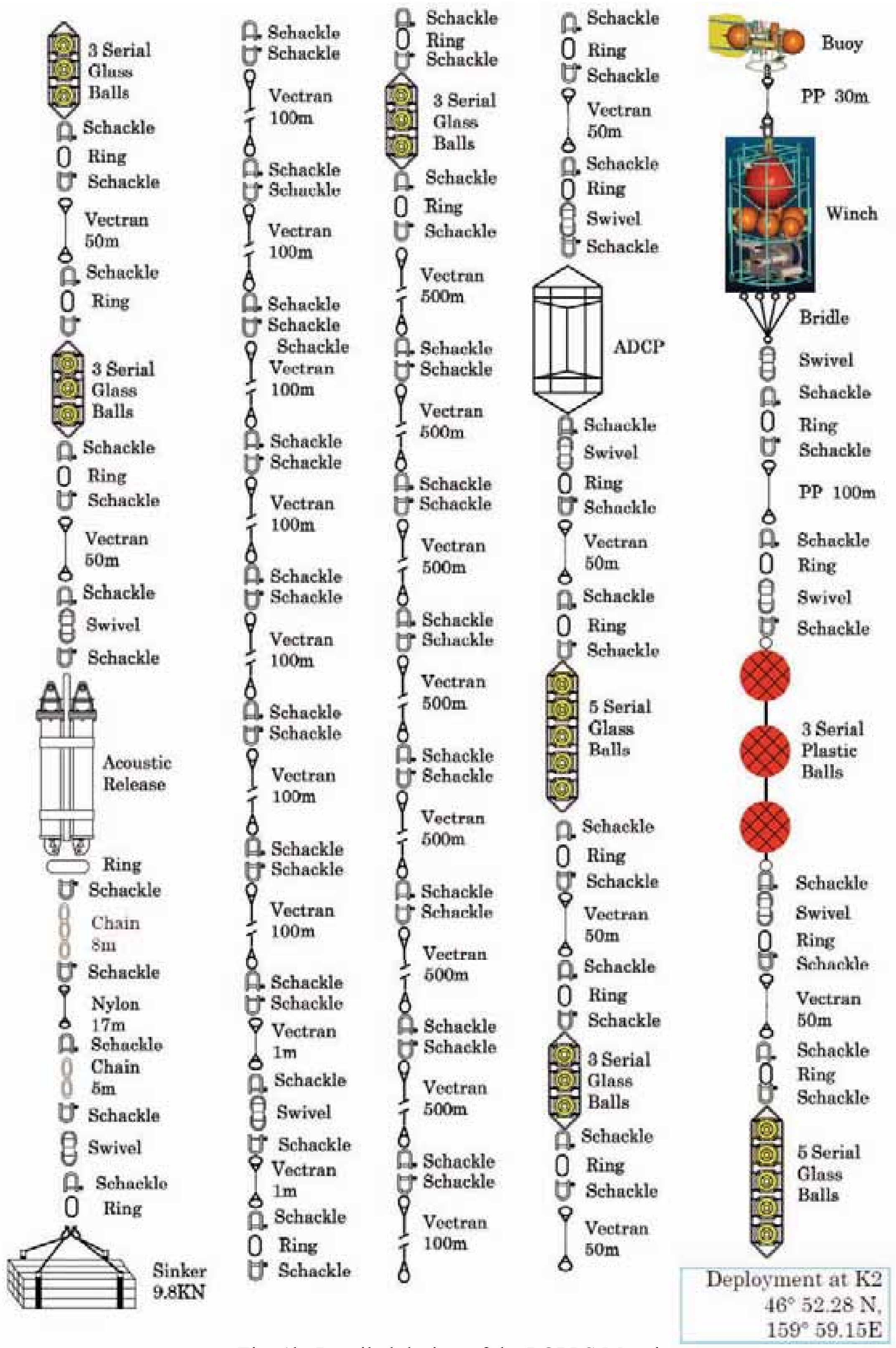


Fig. 1b. Detailed design of the POPPS Mooring.

Fig. 1c. The observation buoy equipped with the FRR fluorometer.

Fig. 1d. Underwater winch.

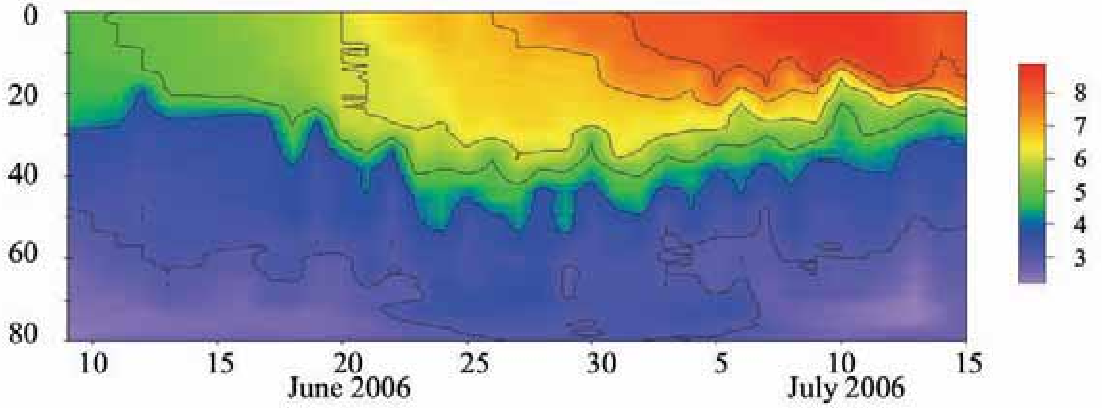


Fig. 2a. Temperature [°C].

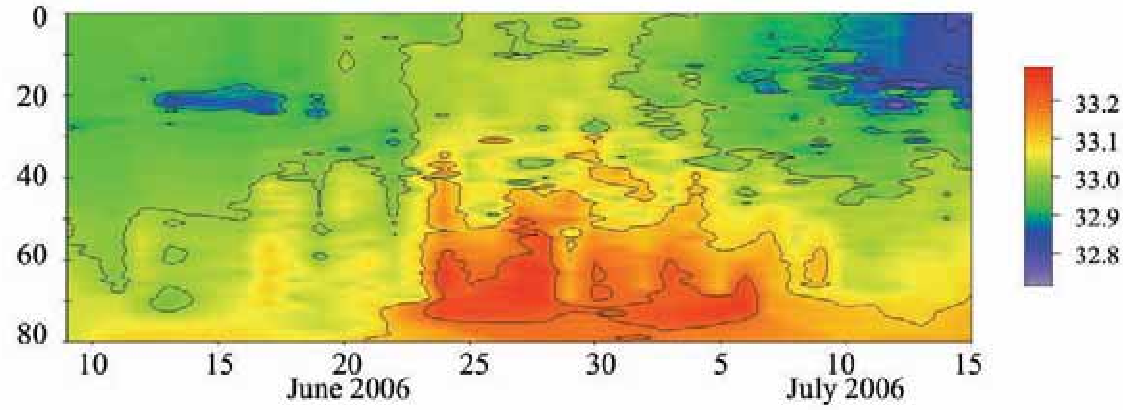


Fig. 2b. Salinity [PSU].

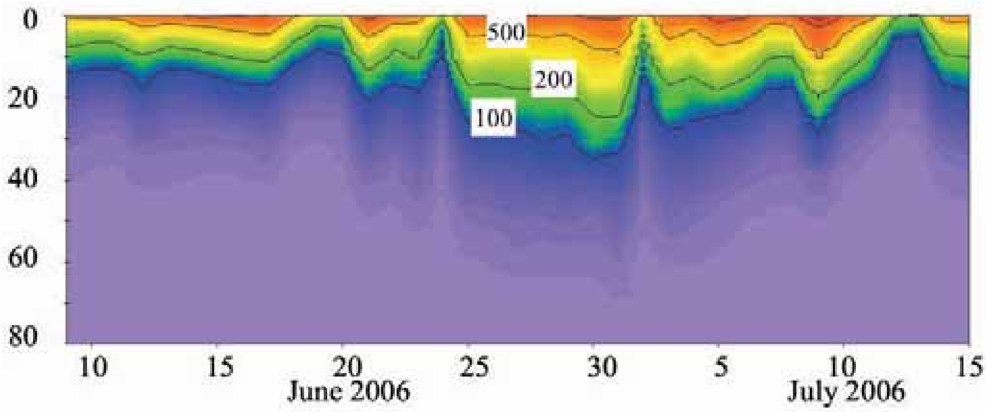


Fig. 2c. PAR [μmol quanta m^{-2} s^{-1}].

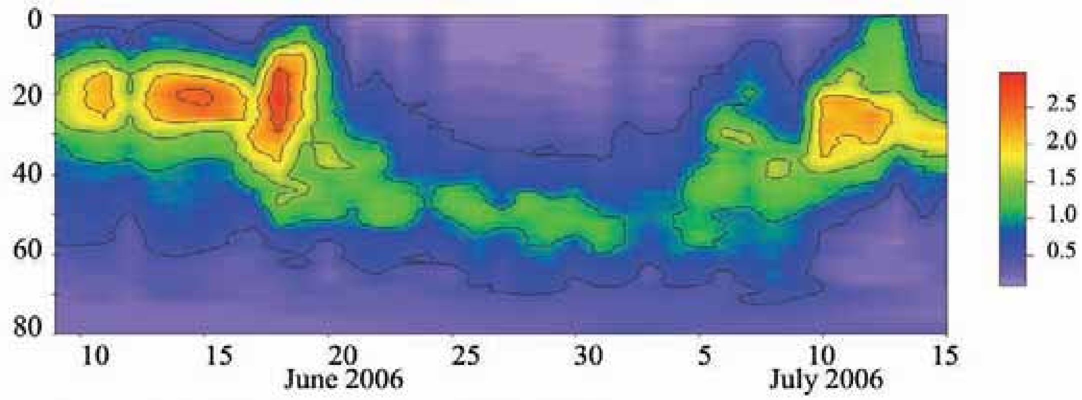


Fig. 2d. Chlorophyll *a* concentration [mg m^{-3}].

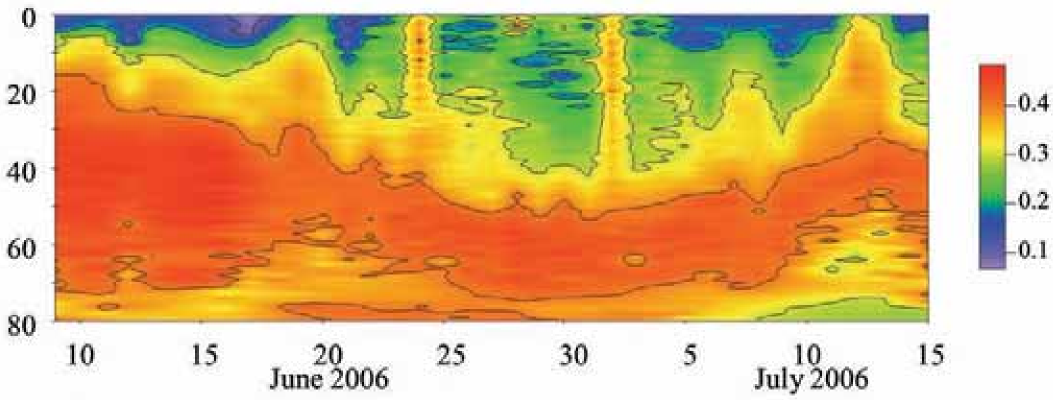


Fig. 2e. F_v/F_m.

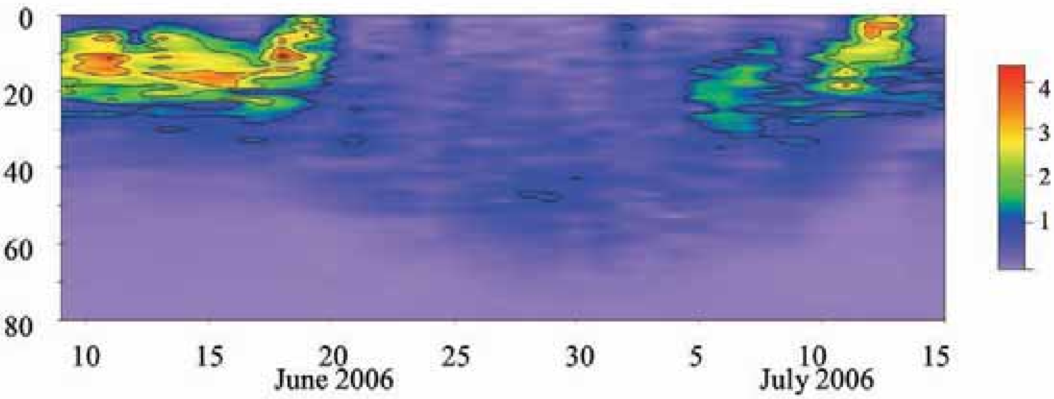


Fig. 2f. Primary productivity [mgC m^{-3} h^{-1}].

3.7 Oxygen Isotope

V. V. S. S. SARMA (Nagoya University)

3.7.1 Air-sea gas exchange rate from oxygen-17 anomaly of dissolved oxygen

(1) Objective

The exchange of gases between ocean and atmosphere, which still has a major uncertainty, is an important part of the biogeochemical cycles of climatically important elements. The exchange between these two bodies is determined by the transfer velocity and concentration gradient across the interface. The *k* has been parameterized to obtain averages of weekly to several years using either artificial tracer, such as $SF_6/^3He$ (Wanninkhof et al., 1985; Watson et al., 1991; Nightingale et al., 2000), bomb radiocarbon (Wanninkhof et al., 1992) or using numerical models (eg: Erickson, 1993; Woolf, 2005) with several assumptions. Recently, McGillis et al. (2005) and Calleja et al. (2005) suggested that presence of surfactants, and organic carbon, for instance, could reduce *k* by 50% based on their laboratory experiments compared to that of Wanninkhof (1992) method. This suggests that global average parameterization of *k* would yield large errors on regional scale; therefore, frequent measurements of *k* in different regions are essential for precise estimation of net exchange of gases across air-water interface. We would like to use triple isotopic composition of dissolved oxygen in the mixed layer as a proxy to estimate transfer velocity of gas across air-water interface.

(2) Principle

Our technique involves precise measurements of triple oxygen isotopes (^{16}O, ^{17}O and ^{18}O) in dissolved oxygen (O_2) in the surface mixed layer of the ocean, which is controlled by photosynthetic O_2 production, respiration, and exchange with atmosphere. The isotopic composition of O_2 produced during photosynthesis and fractionation during respiration is the primary controls on the ratios of stable oxygen isotopes in atmospheric O_2. These processes fractionate oxygen isotopes in a mass-dependent way such that $\delta^{17}O$ enrichment is about half of $\delta^{18}O$ relative to ^{16}O. On the contrary, mass-independent fractionation occurs in the stratosphere during photochemical reactions involving O_3, O_2 and CO_2 and both $\delta^{17}O$ and $\delta^{18}O$ are equally lowered (Thiemens, 2001). Therefore, $\delta^{18}O$ of O_2, which is produced and consumed by biological processes, there is always an excess of ^{17}O in comparison to that of atmospheric O_2, which is influenced by stratospheric O_2 (Luz et al., 1999). This excess or the ^{17}O anomaly ($^{17}\Delta$) in the dissolved O_2 in the surface mixed layer is determined by the relative contributions of photosynthetically produced “normal” O_2 and “anomalous” O_2 from the atmosphere. If the rate of decrease in $^{17}\Delta$ with time is known in the absence of gross oxygen production, the rate of transfer of O2 from atmosphere, and thus *k*, can be derived using oxygen solubility at *in situ* temperature and salinity.

(3) Method

Triple oxygen isotopes of dissolved oxygen are measured using Delta Plus Mass spectrometer following gas separation technique of Sarma et al. (2003). About 150 ml of water sample was collected in the flask while leaving 150 ml headspace. Extreme care was taken to avoid trapping of gas bubbles during sampling. The stopcock is closed and port is refilled with distilled water and then sealed with rubber cap to avoid air contamination. The water and headspace in the sampling flasks were equilibrated for 24 hours at room temperature. After equilibration, the water was sucked out of the flasks by leaving only headspace gases. The flasks were then connected to the preparation system for separation and purification of O_2. The separation system consists of vacuum line connected to the gas chromatographic column of 5A molecular sieve at –90 C. The molecular sieve at –90C retains nitrogen and elutes O2 and Ar and the eluted gases are trapped using 15x molecular sieve at liquid nitrogen temperature. These samples are admitted to the mass spectrometer for isotopic ratios of the 16,17 and 18O against atmospheric air as a standard.

(4) Preliminary Results:
The samples analysis is underway.

(5) Data Archive
All the data will be submitted to JAMSTEC Data Management Office (DMO)

3.7.2 Assessment of plankton metabolic processes (gross, net production and respiration) using triple oxygen isotopes of dissolved oxygen and O_2/Ar ratios

(1) Objective

Assessment of plankton metabolic processes, such as community gross, net production, and respiration, is very important in order to understand how biological processes influence carbon flux from the sunlit zone. In general, these metabolic rates are measured using incubation techniques involving either geochemical or artificial tracers such as 14C and give rates of a given water mass sampled over time incubated. These methods involve several uncertainties due to bottle effect, tracer recycling, changes of nutrients concentrations in the bottle, continuous exposure to the constant light etc, resulting in ambiguous estimation of metabolic rates. Nevertheless, bottle incubation techniques will not able to capture short-term bloom events. On the other hand, the estimation of metabolic rates based on triple oxygen isotopic composition of dissolved oxygen would alleviate problems involved in the incubation techniques and would give time-integrated rates over residence time of oxygen in the mixed layer. Our aim is to examine spatial variations in the plankton metabolic processes in the subarctic western North Pacific to understand how biological pump in this region influences carbon flux to the twilight zone.

(2) Principle and approach

The principle of this method is given in the section 3.7. As mentioned in section 3.7, the 17O anomaly in the mixed layer is mainly controlled by gross oxygen production and influx of oxygen from the atmosphere. Based on the transfer velocity derived using triple oxygen isotopes, as described in section 3.7, flux of oxygen to the mixed layer can be computed. Using measured average mixed layer 17O anomaly and influx of oxygen, the gross oxygen production in the mixed layer is estimated. Since both oxygen and argon have similar solubility, therefore, it is possible to estimate the influence of biological processes on oxygen concentrations using measurements of O2/Ar ratios. By assuming the steady state, the net to gross production ratios can be derived using Hendricks et al. (2004). Using gross oxygen production, net to gross production ratios, net community production and respiration rates can be derived.

(3) Method

Triple oxygen isotopes of dissolved oxygen are measured using Delta Plus Mass spectrometer following gas separation technique of Sarma et al. (2003). About 150 ml of water sample was collected in the flask while leaving 150 ml headspace. Extreme care was taken to avoid trapping of gas bubbles during sampling. The stopcock is closed and port is refilled with distilled water and then sealed with rubber cap to avoid air contamination. The water and headspace in the sampling flasks were equilibrated for 24 hours at room temperature. After equilibration, the water was sucked out of the flasks by leaving only headspace gases. The flasks were then connected to the preparation system for separation and purification of O_2. The separation system consists of vacuum line connected to the gas chromatographic column of 5A molecular sieve at –90 C. The molecular sieve at –90C retains nitrogen and elutes O2 and Ar and the eluted gases are trapped using 15x molecular sieve at liquid nitrogen temperature. These samples are admitted to the mass spectrometer for isotopic ratios of the 16,17 and 18O and O2/Ar ratios against atmospheric air as a standard.

(4) Preliminary Results
The samples analysis is underway.

(5) Data Archive
All the data will be submitted to JAMSTEC Data Management Office (DMO)

References

Calleja, M.L.L. *et al.,* Evidence for an important role of surface water layer processes on air-water gas transfer in the subtropical Atlantic Ocean, 37th International Liege Colloquium on ocean dynamics, *Gas transfer at water surfaces*, 2-6th May 2005.

Erickson III, D.J., A stability-dependent theory for air-sea gas exchange, *J. Geophys.Res., 98,* 8471-8488, 1993.

Luz, B, E. Barkan, M.L. Bender, M.H. Thiemens, K.A. Boering, Triple-isotope composition of atmospheric oxygen as a tracer of biosphere productivity, *Nature, 400*, 547-550, 1999.

McGillis, W.R. *et al.,* Measurements of the air-water CO2 flux using atmospheric profiles, 37th International Liege Colloquium on ocean dynamics, *Gas transfer at water surfaces*, 2-6th May 2005.

Nightingale, P.D., *et al.,* In situ evaluation of air-sea gas exchange parameterizations using novel conservative and volatile tracers, *Global Biogeochem. Cycles, 14*, 373-387, 2000.

Sarma, V.V.S.S., O. Abe, and T. Saino, Chromatographic separation system of nitrogen, argon and oxygen in dissolved air for determination of triple oxygen isotopes by Dual-inlet mass spectrometry, *Anal. Chem., 75*, 4913-4917, 2003.

Thiemens, M.H., Atmospheric science – The mass-independent ozone isotope effect, *Science, 293*, 226-226, 2001.

Wanninkhof , R., J.R. Ledwell, W.S. Broecker, Gas-exchange wind-speed relation measured with sulfur-hexafluoride on a lake, *Science 227*, 1224-1226, 1985.

Wanninkhof, R., Relationship between gas exchange and wind speed over the ocean, *J. Geophys. Res. 97*, 7373-7381, 1992.

Watson, A.J., R.C. Upstill-Goddard, and P.S. Liss, Air-sea exchange in rough and stormy seas, measured by a dual tracer technique, *Nature 349*, 145-147, 1991.

Woolf, D. Parametrization of gas transfer velocities and sea-state-dependent wave breaking, *Tellus, 57B,* 87-94, 2005.

3.8 Chlorophyll-*a* concentration, size fraction and light absorbance

Suguru OKAMOTO (Hokkaido University)
Kazushige OOISHI (Hokkaido University)

(1) Objective

In Northwestern Pacific, phytoplankton biomass and primary production is high and many species of pelagic fishes live. It is also a major sink for atmospheric CO_2. It is important to understand the variability of primary production in the whole of the Northwestern Pacific in order to understand the environment of prey for nekton and carbon cycle. The objective of our study is to clarify the spatial and vertical distribution of chlorophyll-*a* (chl-*a*), the temporal variability of chl-*a*, and the spatial and temporal difference of size composition of chl-*a* in Northwestern Pacific. In addition, light absorbance was measured in order to validate and develop bio-optical algorithm in subarctic North Pacific.

(2) Methods

Seawater samples for chl-*a* concentration measurement were collected 44 times at 32 sampling stations. The 0.2 liter of samples was collected at 9 or 14 depths from surface to 200m with Niskin-X bottles, except for the surface water, which was taken by the bucket. The samples were gently filtrated by low vacuum pressure (<100mmHg) through Whatman GF/F filters (pore size: 0.7μm; diameter: 25mm) in the dark room. And seawater samples for size fraction were collected 33 times at 21 sampling stations. The 0.5 liter of samples was collected at 6 depths from surface to 75m. Surface water was taken by the plastic bucket. The samples were filtered by low vacuum pressure (<100mmHg) through three different pore size filters; 10μm Milipore, 2μm Milipore and Whatman GF/F filters diameter: 47mm) in the dark room. Phytoplankton pigments were immediately extracted in 6ml of N,N-dimethylformamide after filtration and then, the samples were stored in the freezer (-20 degree celsius) until the analysis of fluorometer determination. The measurements were performed at room temperature after the samples were taken out of the freezer. Welschmeyer non-acidification methods were examined for the determinations of chlorophyll-*a* with Turner design model 10-AU-005 fluorometer.

The samples for absorbance of particle and detritus were collected in 1 gallon brown bottles, and the 0.2 liter of samples for absorbance of colored dissolved organic material (CDOM) was collected. For particle absorbance samples, the seawater filtered the Whatman GF/F (filter diameter: 25m). The filtering volume was decided by the color of filter after filtration. The absorbance measurements were examined using Shimadzu UV-2400PC spectrophotometer. After that, chl-*a* pigment on filter was extracted using methanol between 24 and 48 hours, and the absorbance of detritus was measured. For measurement of absorbance of CDOM, seawater was filtered the 0.2μm Millipore filter, and analyzed using spectrophotometer. The measurement stations were same as bio-optical measurement stations.

(3) Preliminary results

1) 51ºN to 39ºN line (Leg1)

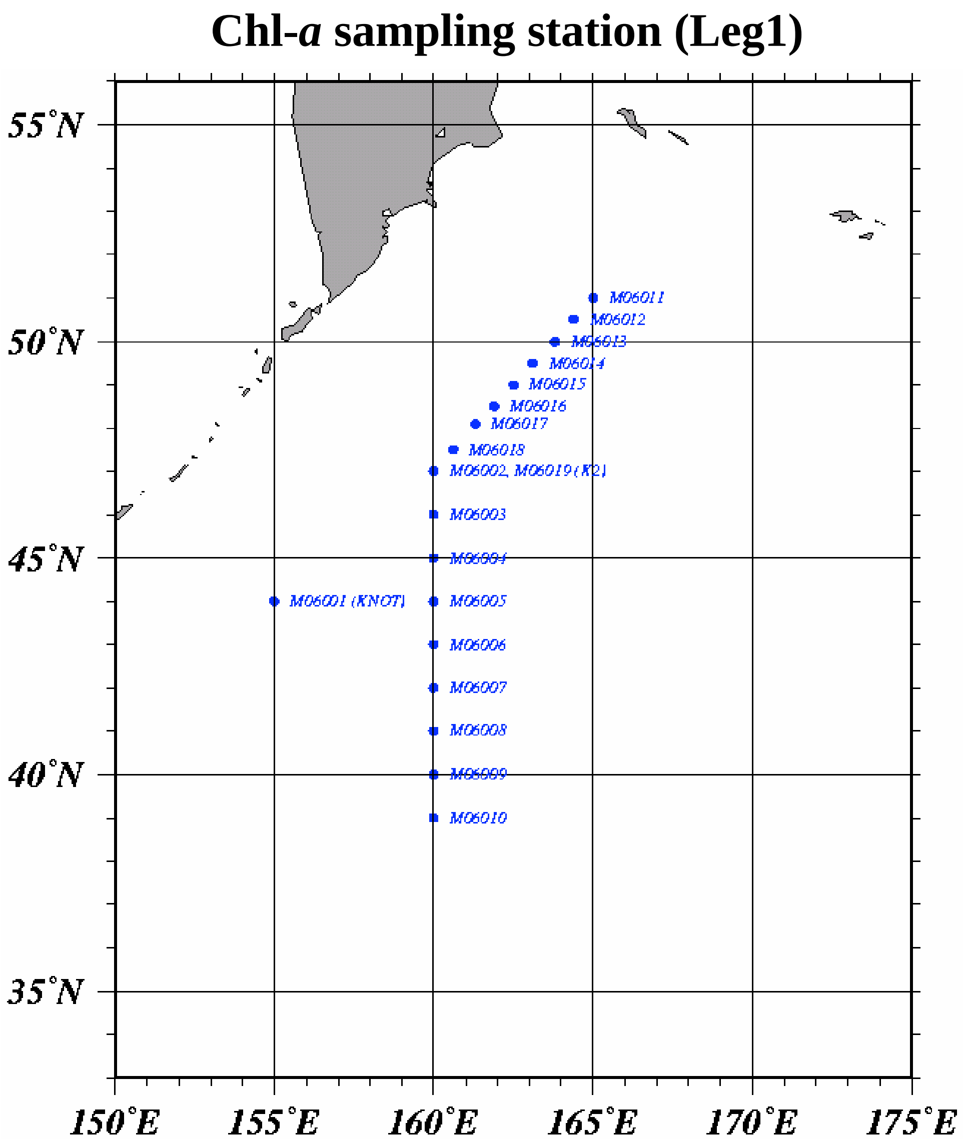


Fig.1 Map of chl-*a* concentration sampling station.

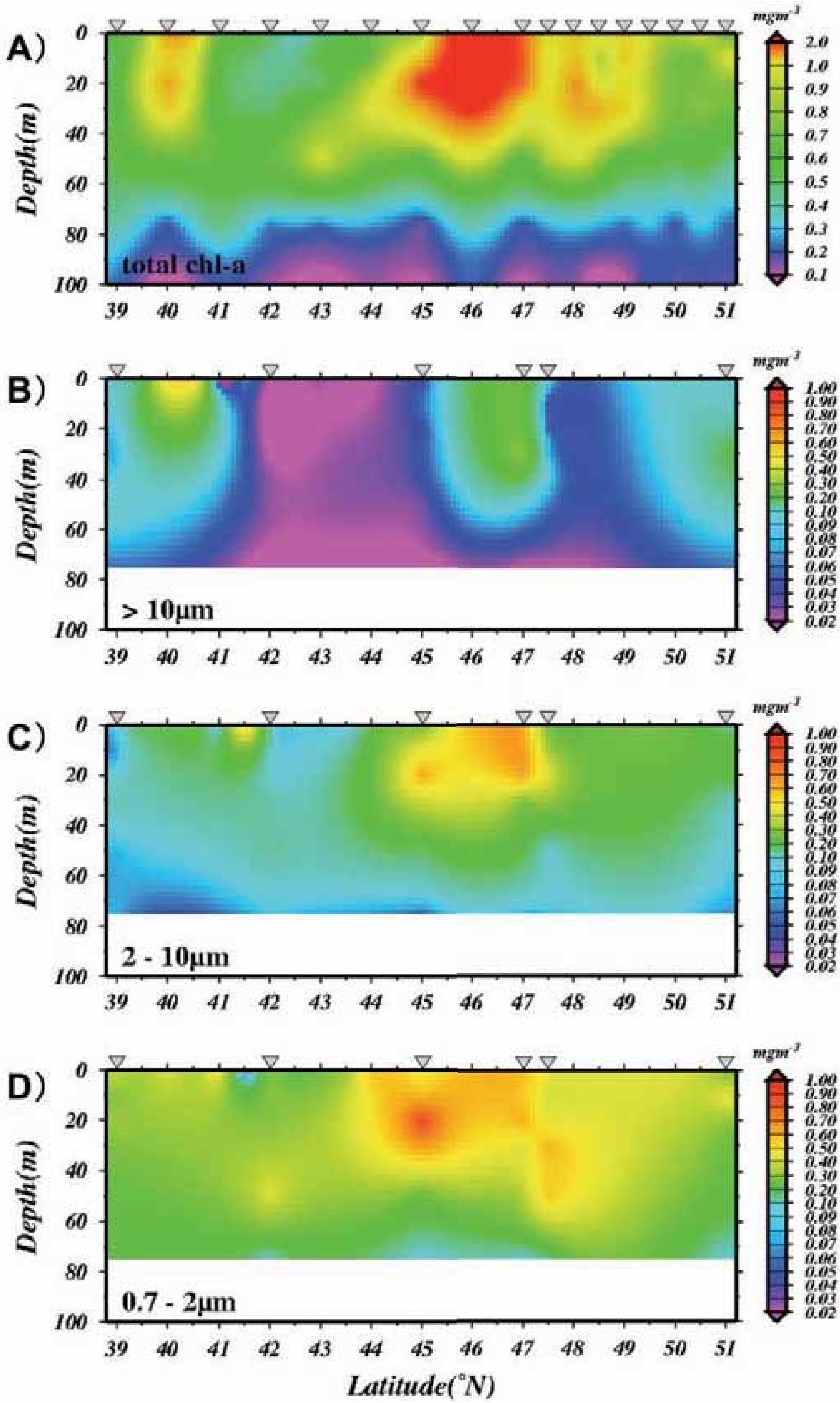


Fig.2 Section of A) total chl-*a*, B) >10μm chl-*a*, C) 2-10μm chl-*a*, D) 0.7-2μm chl-*a* on 51°N to 39°N line.

2) 44°N to 35°N line along 155°E (Leg2)

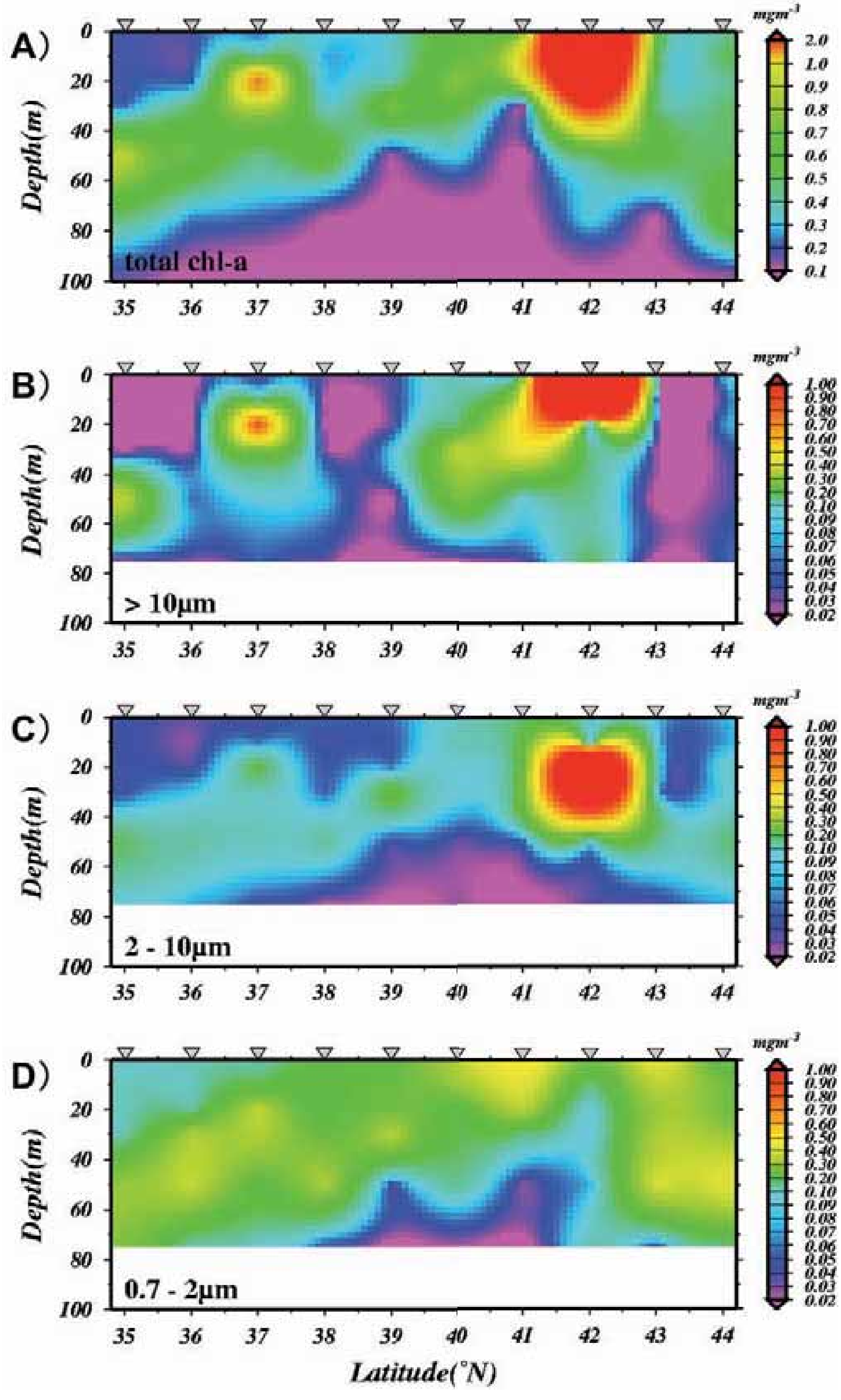


Fig.3 Section of A) total chl-*a*, B) >10μm chl-*a*, C) 2-10μm chl-*a*, D) 0.7-2μm chl-*a* on 44°N to 35°N line along 155°E.

3) K2 (47°N, 160°E)

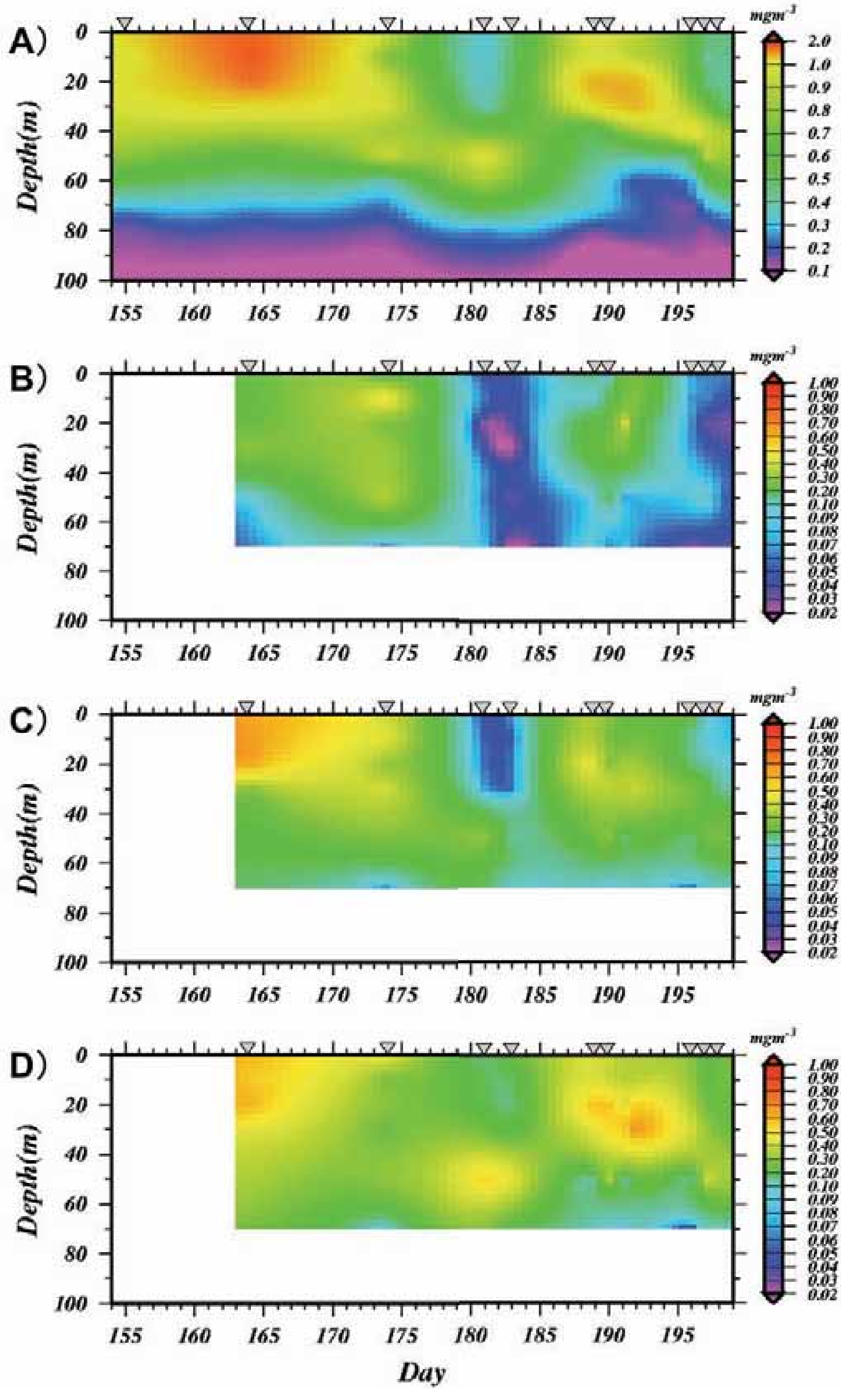


Fig.3 Temporal variability of A) total chl-*a*, B) >10μm chl-*a*, C) 2-10μm chl-*a*, D) 0.7-2μm chl-*a* at K2 (47°N, 160°E).

4) Satellite image

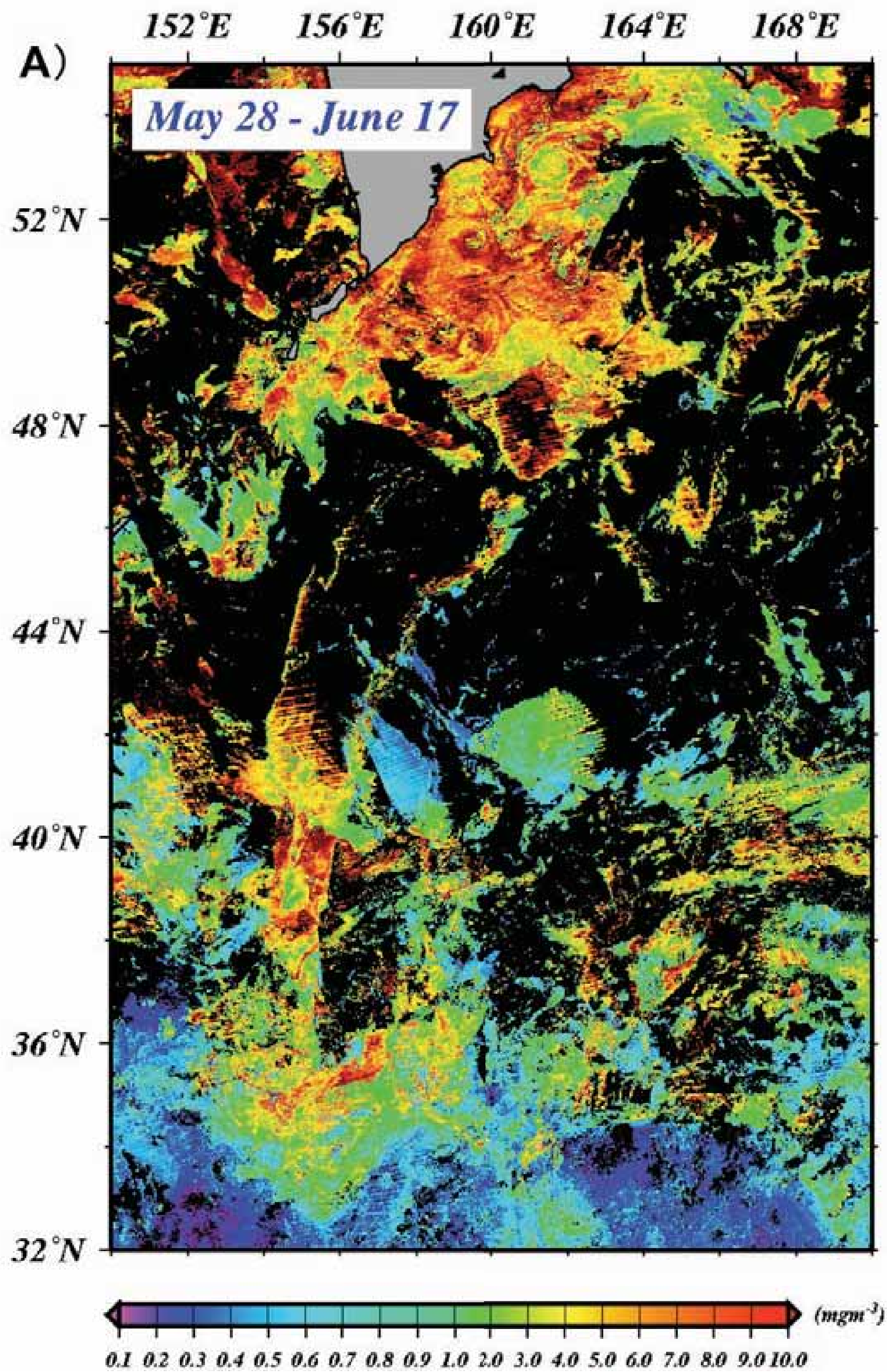


Fig.4 Chl-*a* concentration averaged between May 28th and June 17th (Leg1) from MODIS.

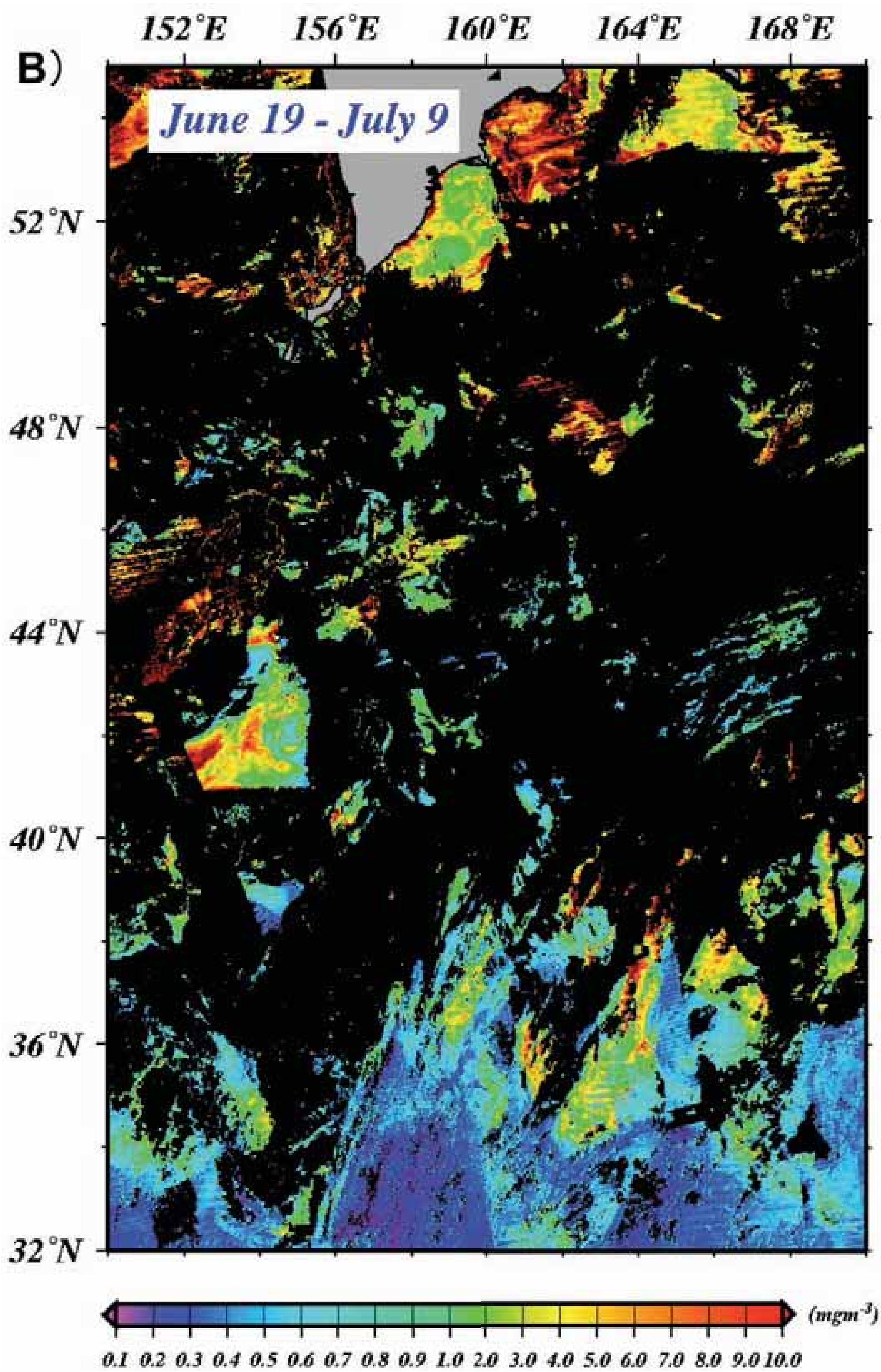


Fig.5 Chl-*a* concentration averaged between June 19th and July 9th (Leg2) from MODIS.

We will measure the absorption coefficients of phytoplankton (a_{ph}) and detritus (a_d), and then calculate a chlorophyll normalized specific absorption spectra, a^*_{ph} to divide by chl-*a* concentration. In future study, we will use these chl-*a* and absorbtion coefficients for the model parameter to estimate primary production from satellite ocean color data.

3.9 Biological observation

3.9.1 Community structure of zooplankton

Minoru KITAMURA (JAMSTEC)
Kazuhiko MATSUMOTO (JAMSTEC)

(1) Objective

Recently, importance of biological actions in ocean material cycle is recognized. Although roles of plankton are maybe important owing to their large biomass, quantitative estimation of their impacts on material cycles was not fully studied. Among them, zooplankton is focused as transporter of carbon from surface to deepsea. Carbon transport by zooplankton was done through their biological actions such as vertical migration and excretion of fecal pellets. It is needed ecological studies on zooplankton. And at the first, study on quantitative community structure of zooplankton is important for their ecology. In this study, following three were researched to understand the community structure of micro- (20-200 μ m) and mesozooplankton (over 200 μ m) in early summer.

a) Vertical distribution of mesozooplankton between 0 and 1000m.

b) Short-termed fluctuation of surface mesozooplankton community and growth rate of dominant copepod species.

c) Vertical distribution of surface microzooplankton.

All samples were collected at Stn. K2.

(2) Materials and method

a) Vertical distribution of mesozooplankton

For collection of stratified sample sets, multiple opening/closing plankton net system, IONESS, was used. This is a rectangular frame trawl with seven nets. Area of the net mouth is 1.5 m^2 when the net frame is towed at 45 degree in angle, and mesh pore size is 0.33-mm. Researcher can open and close nets at discretion depths and can real time monitor net status. Volume of filtering water of each net is estimated using area of net mouth, towing distance, and filtering efficiency. The area of net mouth is calibrated from frame angle during tow, the towing distance is calculated from revolutions of flow-meter, and the filtering efficiency is 96% which was directory measured.

Total twelve oblique tows of IONESS were done, six tows in daytime and others in nighttime although two tows were failed due to mechanical trouble and bad sea status. Ship speed during net tow was about 2 knot, speeds of wire out and reeling were 0.1-0.7 m/s and 0.1-0.3 m/s, respectively. Stratified sampling were designed as follows; 0-50, 50-100, 100-150, 150-200, 200-300, 300-400, 400-500, 500-750, 750-1000m. Zooplankton samples were fixed and preserved in 5% formalin-seawater buffered with borax.

b) Short-termed fluctuation of surface mesozooplankton community and growth rate of dominant copepod species

Mesozooplankton samples were collected with twin NORPAC nets (45-cm mouth diameter, 0.1 and 0.25-mm mesh openings). The NORPAC nets were hauled vertically from density cline to surface and 150 m to surface at speed 1 m/s. The purposes of the two hauls are sample collections for analysis of fluctuation of surface community and growth rate, respectively. Nine sample sets were collected for the former purpose, and 18 samples were collected for the latter. Flow-meter was attached in mouth of each net for estimation of filtering volume of water. After collection, zooplankton samples were fixed and preserved in 5% formalin-seawater buffered with borax.

c) Vertical distribution of surface microzooplankton

Six series of seawater samples were collected. Each series comprises eight waters which collected at different depths. Seawater samples were immediately treated with the final concentration of 1% glutaraldehyde and were kept at 4 degree C until filtering. Each seawater sample were filtered through 1 μm pore size Nuclepore fitter, pre-stained by irgalan black, at the low vacuum of 15 cmHg. Seawater samples were double-stained using DAPI (4'6-diamidino-2-phenylindole dihydrochloride) and proflavine (3-6-diamidino-acridine hemisulfate). Just before the finish of filtering, DAPI was added to sample in filtering funnel for the staining DNA. After the DAPI staining, proflavine was also added for the staining of flagella. Both the staining time is five minute. The working solution of DAPI (10 μg/ml) and proflavine (0.033%) were pre-filtered through 0.22 μm pore size of non-pyrogenic Durapore membrane filter (Millipore, Millex-GX). After the filtering, sample filters put on a slide-glass with one drop of immersion oil, and covered with micro cover glass. All preparations were stored in the deep freezer (-80 degree C) until the observation.

(3) Preliminary results

All analysis will be scheduled at the laboratory after the cruise.

(4) Future plans and sample archives

a) Vertical distribution of mesozooplankton

All IONESS samples are stored at JAMSTEC, Yokosuka. Kitamura will analyze following two: (1) Vertical distribution of biomass of each taxa (copepods, euphausiid, etc.), (2) Vertical distribution, species composition, biomass, and diel migration of copepods, euphausiids, and gelatinous animals (cnidaria and ctenophore). And Dr. Okutani will identify planktonic mollusca. He and Kitamura will analyze community structure of this group.

b-1) Short-termed fluctuation of surface mesozooplankton community.

Samples collected using both the 0.1-mm and 0.25-mm mesh NORPAC nets are stored at JAMSTEC, Yokosuka. The samples collected using the former mesh net will be analyzed the temporal change of mesozooplankton biomass in higher taxa levels (copepods, chaetognatha, cnidaria, etc.). Individual density of *Neocalanus* spp. will be counted using samples collected using the latter mesh net. Grazing pressure of *Neocalanus* copepods will be estimated using this individual density and grazing rate of a copepod (see next chapter, grazing pressure of zooplankton).

b-2) Growth rate of dominant copepods.

Samples collected using 0.1-mm meshed NORPAC net are stored at Kagoshima University. Dr. Kobari, Kagoshima University, will analyze the growth rate of dominant copepods such as *Neocalanus* spp., *Eucalanus* and etc. On the other hand, plankton samples collected using 0.25-mm mesh net are stored at JAMSTEC, Yokosuka.

c) Vertical distribution of surface microzooplankton.

Frozen filter samples are stored at Mutsu Institute of oceanography, JAMSTEC. And analysis will be scheduled at the laboratory (Marine Biological Research institute of Japan Co. LTD., Shinagawa, Tokyo).

3.9.2. Grazing pressure of zooplankton

Minoru KITAMURA (JAMSTEC)

(1) Objective

The northeastern Pacific Ocean is a region of high-nutrient and low-chlorophyll (HNLC) water. Traditionally, the low phytoplankton stock is explained that high grazing pressure of *Neocalanus* copepods control it. However, recent some reports suggested that the low levels of available Fe and high grazing pressure of microzooplankton play important roles in maintaining the low phytoplankton stocks. Both the bottom up and top down effects on primary productivity or phytoplankton stocks should be more researched. Primary productivity and phytoplankton stock are also important to understand carbon transport from sea surface to mid/deep water. Because grazing pressure maybe affected the latter, roles of zooplankton have to be more focused in the material cycle studies.

For understanding the vertical carbon transport, sinking flux, nutrients, primary productivity, chlorophyll abundance, and etc. have been researched in the northeastern Pacific time-series observation station, K2. In the next step of the study, zooplankton research should be added to discuss the transport process in detail.

Under the background, qualitative grazing pressure of micro- and mesozooplankton is estimated in several ways as follows:

a) Dilution experiment for estimation of microzooplankton grazing,
b) Grazing rate of copepods estimated by bottle incubation,
c) Grazing rate and diel grazing pattern of mesozooplankton estimated by gut pigment.

All the samplings and experiments were conducted in station K2.

(2) Method

a) Dilution experiment for estimation of microzooplankton grazing

Seven experiments were done at station K2 through the cruise. For each experiment 40 l of surface water were collected using bucket. Water was pre-screened through 200 μm mesh to exclude larger zooplankton. Dilution series were prepared with 25, 50, 75, and 100% of natural seawater. In some experiments, dilution series of 85, 60, or 40% were added. Filtered water was obtained by direct gravity flow through a GF/F filter. Incubation of the dilute water was done in transparent polycarbonate bottle. Duplicate or triplicate bottle were prepared. Water samplings were done before sunrise and incubations were started at about sunrise. Incubation lasted for 24 h in a tank with continuous flow of surface seawater under natural light conditions. All the water samplings, filtering, and incubate items were soaked in 10% HCl and rinsed Milli-Q water between each use on board. No nutrient was added in the incubation bottles. To measure initial and final chlorophyll a concentration, experiment water were filtered onto GF/F filter and extracted 6 ml DMF at –30 degree C until measurement. Chlorophyll a concentrations were measured fluorometrically (Welshmeyer method) with a Turner Design fluorometer.

Apparent phytoplankton growth rate (d^{-1}) were calculated using following equation:

Apparent growth rate = $(1/t)\ln(P_t/P_0)$

where t is incubation time (d), P_t and P_0 are final and initial chlorophyll a concentration, respectively. When the apparent phytoplankton growth rate is plotted as a function of dilution factor, the y-intercept and negative slope of the approximate line means true phytoplankton growth and grazing coefficient of microzooplankton, respectively.

b) Grazing rate of copepods estimated by bottle incubation

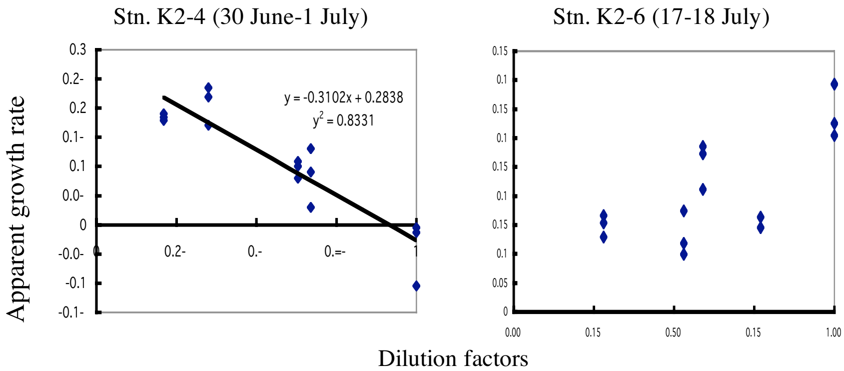
Five experiments were done through the cruise. Copepods for experiments were collected by vertical hauls from 50-0 m with a ring net (57-cm mouth diameter, 0.2-mm mesh opening) with a 500 ml cod end. Speed of the net hauls was 0.5 m/s to reduce damages for zooplankton. Samplings were done before sunrise, and incubation were started at about sunrise. *Neocalanus cristatus* and *Neocalanus* spp. were sorted immediately after net hauls. Three to eight copepods were introduced into a 1.2 l polycarbonate bottle with pre-screened surface seawater. Duplicate or triplicate bottles prepared for each species. Triplicate control bottle were also prepared without copepods. Incubation lasted for 24 h in a tank with a continuous flow of surface seawater under natural light conditions. Initial and final chlorophyll a concentrations were measured same as the dilution experiments.

c) Grazing rate and diel grazing pattern of mesozooplankton estimated by gut pigment

Mesozooplankton for the experiment were collected by vertical hauls from 50-0 m with a same net of bottle incubation experiments. Speed of the net hauls was 0.5 m/s to reduce damages for zooplankton. Five hauls (2:40, 8:00, 13:00, 18:30, and 21:00) between 3rd and 5th June and six hauls (2:40, 7:00, 13:00, 18:00, 20:00, and 24:00) in 1st July were done. After the net haul, zooplankton in cod end were filtered through some pieces of 0.2-mm mesh, the meshes were folded double, wrapped in aluminum foil, and were finally frozen at deep freezer (-80 degree C). These procedures after net haul to freeze were done within ten minutes.

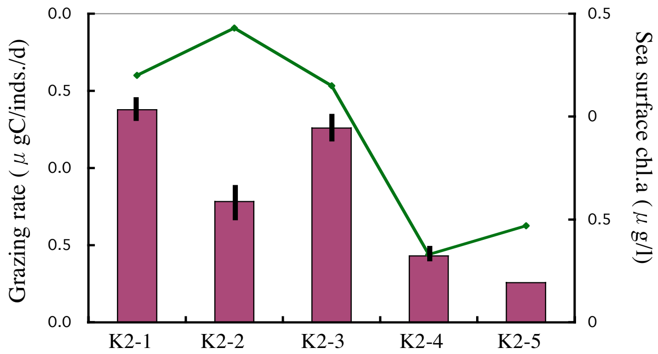
(3) Preliminary results

All chlorophyll a measurements of experiments a) and b) were finished on board. Results of preliminary calculation of some dilution incubations are shown in the following figures.



Theoretically, negative correlation between apparent phytoplankton growth rates and dilution factors is shown like a graph of Stn. K2-4 (30th June ~ 1st July). In this experiment, 'true' phytoplankton growth rate and grazing coefficient of microzooplankton were estimated at 0.28 d^{-1} and 0.31 d^{-1}, respectively. However, some experiments failed lake a result of Stn. K2-6, the negative correlation is not recognized.

A part of results of the bottle incubation for copepod grazing is shown as following graph. Bar graph shows grazing rate per individual *N. cristatus* (μgC/inds./d), and line graph shows temporal change of surface chlorophyll a concentrations (μg/l). Date of each experiment are 5-6 June (K2-1), 14-15 June (K2-2), 23-24 June (K2-3), 1-2 July (K2-4), and 10-11 July (K2-5).



When surface chlorophyll a concentrations were high, grazing rates of the individual *N. cristatus* were also high as shown the results of experiments in June (K2-1 ~ K2-3). On the other hand, both the chlorophyll a concentrations and grazing rates were low in July. Difference of the grazing rates between June (high chlorophyll period) and July (low chlorophyll period) was statistically supported (t test). These results maybe suggest that feeding activity of *N. cristatus* changed through the study period, and their activity was affected by chlorophyll a concentration in environment.

(4) Future plans and sample archives

a) Dilution incubation

Because all chlorophyll a measurements were finished on board, re-estimations of growth rate and grazing rate are needed. The estimated grazing rates of microzooplankton will be compared to standing crop of phytoplankton, primary productivity, and grazing rates of mesozooplankton. Causes of the failed experiments should be also considered.

b) Grazing rate of copepods estimated by bottle incubation

In the preliminary results, grazing rates of individual copepod were calculated. After back to laboratory, I will measure biomass of *Neocalanus* copepods using NORPAC samples. And grazing rates of *Neocalanus* community will be estimated from the values of individual grazing rate and biomass. Temporal change of the community grazing rates will be also considered.

c) Gut pigment analysis

Frozen mesozooplankton samples are stored in JAMSTEC, Yokosuka. These samples will be rinsed with filtered seawater and sorted by species immediately. Sorted animals are placed into DMF and extracted pigments will be measured fluorometrically (Holm-Hansen method) with a Turner Design fluorometer.

3.9.2 Planktonic foraminifera: Genetic diversity of planktonic foraminifera in northern Northwest Pacific and its relationship to Quaternary paleoenvironmental changes.

Atsushi KURASAWA[*1*2],
Masashi TSUCHIYA[*1],
Takashi TOYOFUKU[*1],
Kate DARLING[*3],
Michael KUCERA[*4],
Christopher WADE[*5],
Hidetaka NOMAKI[*1],
Kazuhiko FUJITA[*6],
Hiroshi NISHI[*2],
Hiroshi KITAZATO[*1]
[*1]: IFREE, JAMSTEC
[*2]: Graduate School of Science, Hokkaido University
[*3]: School of Geosciences, Science and Engineering at the University of Edinburgh
[*4]: Dept. Geology, Royal Holloway, Univ. of London
[*5]: Genetics at. The University of Nottingham
[*6]: Faculty of Science, Ryukyu University

(1) Objective

The aim of this study is to reveal genetic diversity of planktonic foraminifera to understand relations among genotypes, ecology, and morphology with oceanography and environmental changes. The observation area of this MR06-03 cruise is under influences of both Oyashio current and Kuroshio current, and in the southern part (station K3) the water mass is expected to be different from the northern part (station K1, K2, and KNOT). Therefore, we collect foraminiferal specimens from both water mass constructions to observe the relationships between genetic population distributions and oceanographic settings.

Planktonic foraminifera are one of the major marine carbonates producer have calcareous tests. Planktonic foraminifers exist in various oceanographic conditions, from polar to equatorial, and from surface to deep water in relation to water masses, surface and deep water current, that lives from past and Modern Ocean. Planktonic foraminifers are useful tool for reconstruct such oceanic environment, and thus, these have important rolls in global carbon and calcium circulation in the ocean. The other hand, the regional distribution of foraminiferal assemblage should be controlled by such oceanographic environments as temperature, salinity and primary productivity. In a word, foraminiferal assemblage and oceanographic environments have a close relationship with each other.

The problems are arisen from recent molecular phylogenetic studies that demonstrated high genetic variability existed within a species. These genotypes respectively distributed in each oceanic environment, and it is not always represent a relationship between assemblage and ocean environments in a species level.

For instance, high intra-species genetic diversity of planktonic foraminifera that was not expected from traditional morphological studies. All morphospecies studied so far include multiple genotypes, and these genotypes appeared to be differ in environmental preferences (Bauch *et al.* 2003). Then the intra-species genetic diversity and their difference of habitat is important problem for paleoceanographic studies. The paleo-environmental information derived from planktonic foraminifera may have been based on ecologically distinct populations and therefore contain significant noise (Darling *et al.* 2000). In order to deal with this problem, the genetic diversity of planktonic foraminifera and its relations to chemical and physical environments should be clarify. Molecular biological study may also gives us important information about evolution on planktonic foraminifera in the oceans, such as inter-oceanic gene flows, speciation at open sea, and the correlation among paleoceanographic changes, geographical distribution between land and seas, geologic events and genetic isolations.

We chose three morphospecies of planktonic foraminifera, *Globigerina bulloides, Turborotalita quinqueloba,* and *Neogloboquadrina pachyderma* as the main targets of this study. They are bipolar species and widely adapted in middle to high latitude oceans. These species, chemical composition, and isotopic ratio of these species are generally used as paleoceanographic proxies. The genetic studies of these species have just started in Atlantic Ocean, but wide area research has not yet been carried out in northwest Pacific Ocean. Therefore, this study will the first report about regional genetic variation of planktonic foraminiferal populations in north Pacific ocean.

(2) Method

Living planktonic foraminifera were collected by both plankton net method and pumping method for molecular biological study and morphological observation. Planktonic foraminifera are identified and sorted under stereomicroscopes. The number of total sorted individuals and target species, *Globigerina bulloides, Turborotalita quinqueloba, and Neogloboquadrina pachyderma*, are counted. Ethanol-fixed bulk samples were also taken for species composition, chemical and stable isotope analysis.

Morphology of the tests will be observed using a SEM after this cruise. DNA extractions, PCR, and sequencings of SSU rDNA will be carried out using the same individuals as SEM observation. DNA were extracted from a single individual specimen to clarify the genotype-morphotype relation.

(2)-1 Plankton net sampling

Planktonic foraminifera were collected using a NORPAC net system (XX13: 100μm mesh) with closing mechanism. The plankton net towing was carried out five times at four stations. (Fig. 1). Sampling depth was divided into 4 layers (0-25 m, 25-50 m, 50-100 m, 100-200 m) and the NORPAC net was towed 4 times at each station (Table 1). Collected samples were stored in plastic bottles and kept at 4 ℃ until sample sorting.

(2)-1-1 Sampling equipments

The plankton net used in this sampling (Fig. 2) consists of 45 cm NORPAC frame, 210 cm length plankton net (XX13: 100 μm mesh) and protected cod end with a releaser and weight (10 kg). A releaser is placed between the wire and the plankton net. When a messenger hit the device, it releases the net frame and closes the net. The holes on the protected cod ends are covered with rubber sheet and 100μm mesh to trap samples in the plastic cover (Fig. 3).

(2)-1-2 Towing operation

The net was deployed at 0.5 m/sec. or slower until the cable length reaches the bottom depth of the sampling layer, and the wire angle was measured to correct the depth of the net. The net was raised to the top of the sampling layer at 1.0 m/sec. At the top of the sampling layer, a messenger was deployed from the deck to detach the net ring and close the net. After we confirmed the messenger was reached the releaser, the net was raised to the deck. First towing was for the deepest layer (100-200 m), and then switched for the shallower layers.

(2)-1-3 Environmental data

The net samplings are carried out after CTD casts. The CTD data profiles are used as the basic information to determine the sampling layer depths.

A small environmental data logger （DST CTD, Star-Oddi Ltd.) was also attached to the net frame to measure the sampling depth, temperature and salinity. The hydrographic conditions were recorded at station K1, K2, K2-2, and K3 during sample collections. The data logging intervals are set to either 1 second or 2 seconds. Recorded data was retrieved from the data logger after the sampling.

(2)-2 Pumping methods

Planktonic foraminifera in surface water (0-4 m) were collected by filtering surface water from surface water supply in the laboratory. Pumping methodss were carried out at 15 stations. Six additional sampling areas were established and pumping methods was carried out during navigation (Fig. 2). A Filtering apparatus (100 μm mesh) was used to filter planktonic foraminifera (Fig. 4). The apparatus was connected to seawater supply and placed in a bucket. Seawater filtering was carried out for 1-2 hours for each station and the trapped planktons were stored in glass bottles until sorting. Water temperature was measured at the beginning and end of filtration. Sampling location, sampling time, water temperature, and number of sorted specimens were recorded (Table 2).

(2)-3 Sorting and sample storage

Planktonic foraminifera were sorted using stereomicroscopes. Sorted individual specimen were cleaned with a fine writing brush to remove associated microorganisms and transferred to paper slides and air-dried. Air dried specimens are kept under –80 ℃ for molecular biological analysis. The residues of the plankton net samples were preserved with 70% ethanol to the assemblage analyze and chemical and stable isotopic measurements.

(3) Preliminary results

(3)-1 Sea surface properties

Pressure, temperature and salinity data from the environmental data logger attached to the net are shown in Fig. 5. Sea water temperature and salinity changed from 2.9 ℃ to 8.6 ℃ and 26.2 to 30.3 respectively between sea surface and a depth of 250 m at station K1. Temperature profile indicate reverse-correlation with salinity from surface to a depth of 150 m, meanwhile temperature increased with salinity below a depth of 150 m. The temperature and salinity at station K2 range from 2.1 ℃ to 3.8 ℃ and from 29.7 to 30.8 respectively. Both temperature and salinity decreases as the depth is increased to 100 m, and temperature and salinity rise below a depth of 100 m. Sea water temperature and salinity range from 10.1 ℃ to 14.1 ℃ and from 30 to 31.6 at station K3. The temperature gradually decreases from surface to a depth of 100 m, and drop sharply below a depth of 100 m. Salinity shows a negative spike at a depth of 127 m. At station K2-2, water temperature and salinity range from 2.3 ℃ to 6.7 ℃ and from 26.2 to 29.4 respectively. Temperature profile seems to indicate correlation with salinity. The lowest temperature is at a depth of 120 m.

(3)-2 Planktonic foraminifera samples

The numbers of sorted specimens are shown in Table 1 (NORPAC net samples) and Table 2 (pumping method samples).

Globigerina bulloides and *Turborotalita quinqueloba* were abundant at station K1, K2, and KNOT. *Neogloboquadrina pachyderma* (dextral) was rare at all stations while large numbers of *Neogloboquadrina pachyderma* (sinistral) were found from 50-100 m at station K1.

The sample taken at station K3 contain less planktonic foraminifera than planktonic samples of other stations. The K3 population contains such subtropical species as *Neogloboquadrina dutertrei, Globorotalia truncatulinoides*. The water temperature profiles also indicate that water property of station K3 is different from the other northern stations (K1, K2, and KNOT) . Stations K1, K2, and KNOT are under influence of Oyashio current, while station K3 has much warmer water mass from Kuroshio current. We are expecting that the correlation between the distribution of genotypes and the water mass structure to be observed by comparing genetic information and the environmental data. In addition, the detailed test morphology may give us some idea to distinguish genotypes by the structure of the tests.

(4) DNA analysis

The foraminiferal DNA was extracted from twelve individuals of *Globigerina bulloides* and terminal end of SSU rDNA (approximately 1000bp) was sequenced so far. Preliminary phylogenic analysis shows that *Globigerina bulloides* collected at K3 are genetically close to both off Shimoda and Tosa Bay populations, while another genotype is distributed in northern three stations. This might be the evidence that the different genotypes have the different environmental preferences.

(5) Future plan and data archive

We are planning to continue the genetic analysis and to carry out morphological observations with scanning electron microscope (SEM) and chemical and isotopic measurement on foraminifera specimens. These studies will examine genotype-morphotype correlations and reveal possible genotype-specific vital effects, which affect chemical and isotopic compositions of the tests. The phylogenic tree will be obtained by molecular phylogenic analysis, and the genetic relationship should be compared with detailed morphological characters. The geochemical signals of calcareous hard tissue will be connected with both species-specific ecology and environmental factors. All data will be submitted to JAMSTEC Data Management Office (DMO).

References

Bauch et al. (2003), Palaeoceanographic implications of genetic variation in living North Atlantic Neogloboquadrina pachyderma, Nature 424, 299-302.

Darling *et al*. (2000), Molecular evidence for genetic mixing of Arctic and Antarctic subpolar populations of planktonic foraminifers. Nature 404, 43-47.

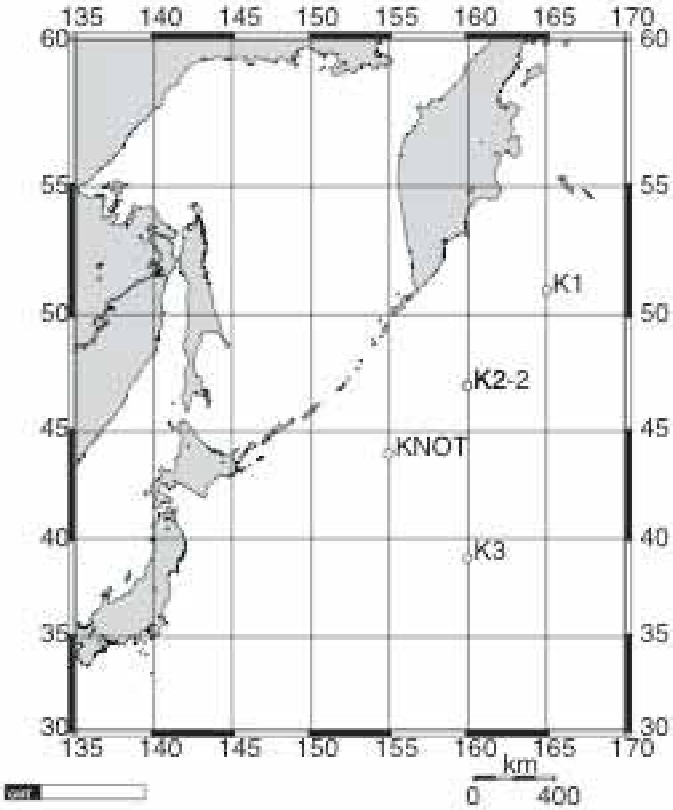


Fig. 1: Plankton net sampling stations

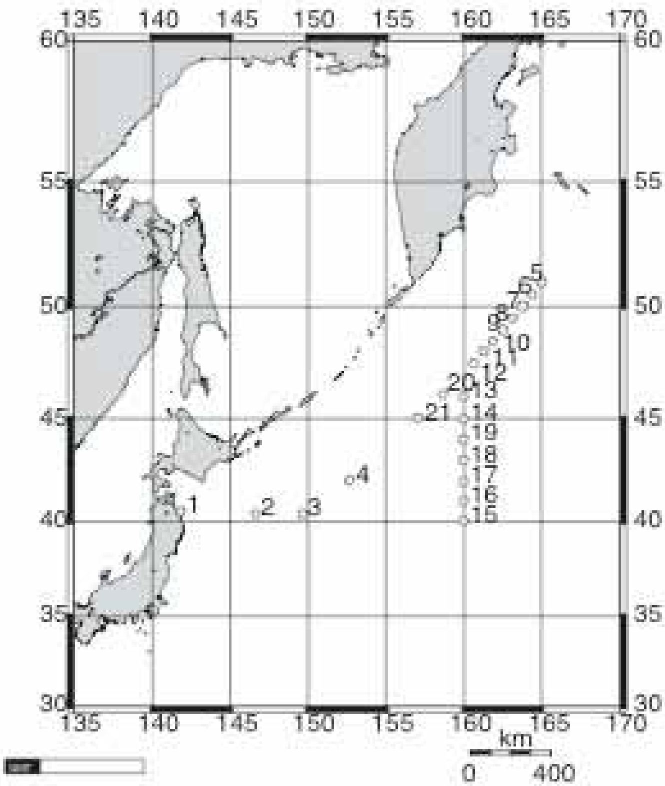


Fig.2: Pumping method sampling stations

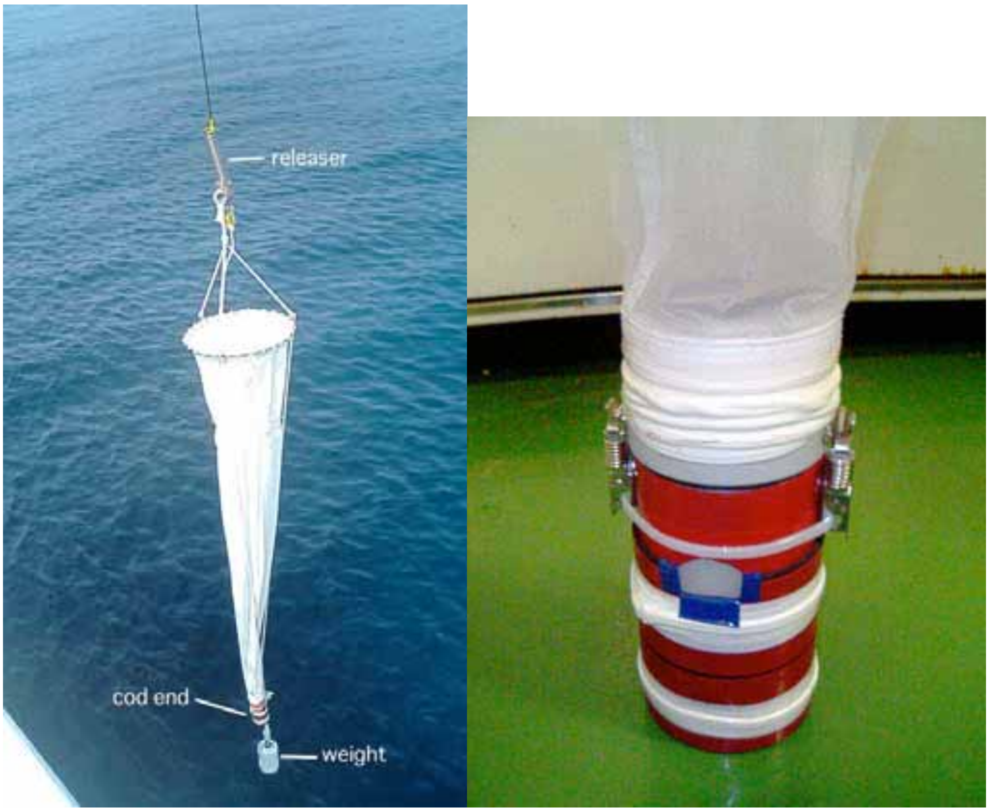


Fig. 3: NORPAC net used for sampling (left) and protected cod end (right)

Fig. 4: Surface water filtration (left) and the filtration apparatus(right)

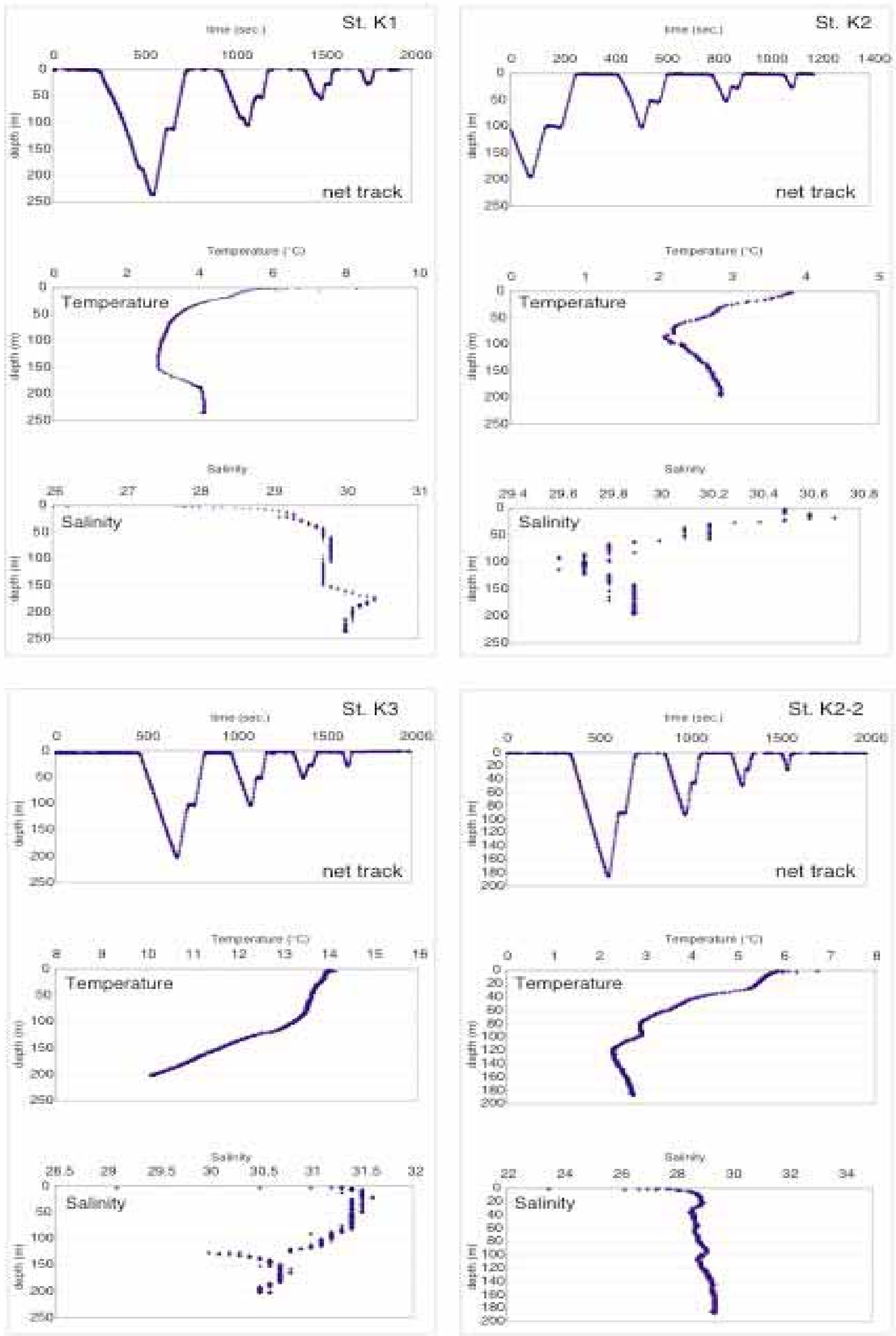


Fig. 5: Sampling depth, temperature and salinity

Table 1. MR06-03 Leg.1 Plankton net sample list.

Sample Number	Date	Sampling point		Time start	Latitude		Longitude		SST (deg C)	Depth intervals (m)	Remarks	Preservation (buk)	Preservation (sorted)	number of indiv.
060529-1	29.May.06	KNOT	M06001	17:50	44-00.57	N	154-59.73	E	4.5	0-25		EtOH	-80℃ (Air dried)	443
										25-50		EtOH	-80℃ (Air dried)	356
										50-100		EtOH	-80℃ (Air dried)	79
										100-200		EtOH	-80℃ (Air dried)	254
060601-2	1.Jun.06	K1	M06011	13:07	50-59.90	N	165-00.20	E	4.0	0-25		EtOH	-80℃ (Air dried)	97
										25-50		EtOH	-80℃ (Air dried)	87
										50-100		EtOH	-80℃ (Air dried)	546
										100-200		EtOH	-80℃ (Air dried)	117
060604-3	4.Jun.06	K2	M06002	17:55	46-53.52	N	160-02.93	E	4.1	0-25		EtOH	-80℃ (Air dried)	409
										25-50		EtOH	-80℃ (Air dried)	311
										50-100		EtOH	-80℃ (Air dried)	69
										100-200		EtOH	-80℃ (Air dried)	122
060610-4	10.Jun.06	K3	M06010	12:30	39-01.46	N	159-58.81	E	14.4	0-25		EtOH	-80℃ (Air dried)	67
										25-50		EtOH	-80℃ (Air dried)	38
										50-100		EtOH	-80℃ (Air dried)	43
										100-200		EtOH	-80℃ (Air dried)	89
060613-5	13.Jun.06	K2-2	M06019	18:00	46-55.40	N	160-03.59	E	5.3	0-25		EtOH	-80℃ (Air dried)	637
										25-50		EtOH	-80℃ (Air dried)	519
										50-100		EtOH	-80℃ (Air dried)	368
										100-200		EtOH	-80℃ (Air dried)	110

Table 2. Pumping method sampling sample list.

Sample Number	Date	Sampling point	Time start	Latitude		Longitude		Water temp.	Time end	Latitude		Longitude
01-060527	27.May.06		19:25	40-30.8007	N	141-50.0893	E	---	21:25	40-23.9650	N	142-24.2364
02-060528	28.May.06		7:30	40-24.0724	N	146-36.9690	E	8.5	8:30	40-24.1286	N	146-57.2013
03-060528	28.May.06		19:30	40-23.7570	N	149-40.2279	E	14.8	20:30	40-23.9854	N	150-00.2498
04-060529	29.May.06		7:30	42-02.8970	N	152-40.0962	E	8.5	8:30	42-12.7338	N	152-57.2031
05-060601	1.Jun.06	St.K1; M06011	8:15	51-00.1565	N	165-00.4242	E	5.0	9:15	51-00.3176	N	165-01.3514
06-060601	1.Jun.06	M06012	18:45	50-30-3315	N	164-23.0427	E	4.7	19:45	50-30.9978	N	164-23.6277
07-060602	2.Jun.06	M06013	0:30	50-00.1834	N	163-45.1558	E	4.5	1:30	50-00.7133	N	163-45.7733
08-060602	2.Jun.06	M06014	8:00	49-30.1017	N	163-07.3787	E	4.6	9:00	49-30.9812	N	163-07.1740
09-060602	2.Jun.06	M06015	15:42	49-00.1516	N	162-29.9440	E	4.5	16:44	49-00.5953	N	162-30.1136
10-060606	6.Jun.06	M06016	23:20	48-30.0584	N	161-52.5454	E	---	0:20	48-30.2216	N	161-52.4763
11-060607	7.Jun.06	M06017	6:00	48-04.0609	N	161-17.6803	E	5.8	7:00	48-04.1219	N	161-16.7037
12-060607	7.Jun.06	M06018	13:30	47-30.1115	N	160-38.3855	E	6.0	14:30	47-30.2201	N	160-37.9989
13-060608	8.Jun.06	M06003	0:05	46-00.0628	N	159-59.9216	E	6.1	1:20	46-01.1927	N	159-59l3854
14-060608	8.Jun.06	M06004	9:30	45-00.0655	N	160-00.1615	E	6.8	10:30	45-00.6294	N	160-00.0563
15-060610	10.Jun.06	M06009	17:37	40-00.3227	N	159-59.7652	E	15.0	19:20	40-01.5425	N	159-59.8129
16-060611	11.Jun.06	M06008	1:20	41-00.1235	N	160-00.1444	E	9.9	2:20	41-00.5238	N	159-59.8739
17-060611	11.Jun.06	M06007	9:10	41-59.9959	N	160-00.0095	E	7.2	10:10	42-00.6053	N	160-00.3360
18-060611	11.Jun.06	M06006	17:25	43-00	N	160-00	E	7.2	19:20	43-00	N	160-00
19-060612	12.Jun.06	M06005	1:25	43-59.9806	N	160-00.0239	E	6.9	2:30	44-00.0588	N	159-59.0433
20-060615	15.Jun.06		19:08	46-07.4645	N	158-42.4247	E	6.1	20:08	45-57.2425	N	158-26.7742
21-060621	16.Jun.06		0:20	45-01.8674	N	157-04.7749	E	6.0	1:20	44-51.6340	N	156-49.3906

3.10 Dissolved Organic Carbon

Masahide WAKITA (JAMSTEC MIO)

(1) Purpose of the study

Fluctuations in the concentration of dissolved organic carbon (DOC) in seawater have a potentially great impact on the carbon cycle in the marine system, because DOC is a major global carbon reservoir. A change by < 10% in the size of the oceanic DOC pool, estimated to be ~ 700 GtC, would be comparable to the annual primary productivity in the whole ocean. In fact, it was generally concluded that the bulk DOC in oceanic water, especially in the deep ocean, is quite inert based upon ^{14}C-age measurements. Nevertheless, it is widely observed that in the ocean DOC accumulates in surface waters at levels above the more constant concentration in deep water, suggesting the presence of DOC associated with biological production in the surface ocean. This study presents the first detailed account the distribution of DOC during spring bloom of MR06-03 cruise at Station K1, K2 and KNOT in the northwestern North Pacific Ocean.

(2) Sampling

Seawater samples were collected at Stations K1 (M06011), K2 (M06002, M060019, M06020, M06026, M06032 and M06039) and KNOT (M06001, M06021and M06038) and brought the total to ~ 350. ^{14}C/DOC and ^{14}C/DIC are also sampled to estimate the 14C-age of DOC at Station K2 (M06039). Seawater from each Niskin bottle was transferred into a 500 ml glass bottle rinsed with same water three times. About 200 ml this water was immediately filtered through a Whatman GF/F filter (47 mm) under gravity. The filtrate was distributed into 50 ml glass ampoules with a 5 ml pipette. Each ampoule was sealed with a torch, quick-frozen, and preserved at ~ -20 °C until the analysis in our land laboratory. Before use, all glassware was muffled at 550 °C for 5 hrs.

(3) Analysis

DOC analysis was basically made with a high-temperature catalytic oxidation (HTCO) system improved a commercial unit, the Shimadzu TOC-V (Shimadzu Co.). In this system, the non-dispersive infrared was used for carbon dioxide produced from DOC during the HTCO process (temperature: 680 °C, catalyst: 0.5% Pt-Al_2O_3).

(4) Preliminary result

The distributions of DOC will be determined as soon as possible after this cruise.

(5) Data Archive

All data will be submitted to JAMSTEC Data Management Office (DMO) within 2 years.

3.11 Chlorofluorocarbons

Masahide WAKITA (JAMSTEC MIO)
Katsunori SAGISHIMA (MWJ)
Hideki YAMAMOTO (MWJ)
Yuichi SONOYAMA (MWJ)

1 Objectives

Chlorofluorocarbons (hereafter CFCs) are chemically and biologically stable gases that have been artificially synthesized at 1930's or later. The atmospheric CFCs can slightly dissolve in sea surface water and then circulate in the ocean. Three chemical species of CFCs, namely CFC-11 (CCl_3F), CFC-12 (CCl_2F_2) and CFC-113 ($C_2Cl_3F_3$), can be used as transient tracers for decadal scale circulation of the ocean. We determined these CFCs concentrations in seawater on board.

2 Apparatus

Dissolved CFCs are detected by an electron capture detector – gas chromatograph attached with a purging & trapping system.

Table 1 Instruments

Gas Chromatograph:	GC-14B (Shimadzu Ltd.)
Detector:	ECD-14 (Shimadzu Ltd)
Analytical Column:	
Pre column:	Silica Plot capillary columns [i.d.: 0.53mm, length: 4m, tick: 0.25μm]
Main column:	Connected two capillary columns (Pola Bond-Q [i.d.: 0.53mm, length: 7m, tick: 6.0μm] followed by Silica Plot [i. d.: 0.53mm, length: 22m, tick: 0.25μm])

3 Methods

3.1 Sampling

Seawater sub-samples for CFCs measurement were collected from 12 litter Niskin bottles to 300ml glass bottle. The bottle was filled by nitrogen gas before sampling. Two times of the bottle volumes of seawater sample were overflowed. The bottles filled by seawater sample were kept in water bathes roughly controlled on sample temperature. The CFCs concentrations were determined as soon as possible after sampling (within 24 hr in maximum). These procedures were needed in order to minimize contamination from atmospheric CFCs.

Air samples for CFCs measurement were collected to 100ml glass cylinder attached magnesium perchlorate dryer tube at the navigation deck on R/V "MIRAI".

3.2 Analysis

The CFCs analytical system is modified from the original design of Bullister and Weiss (1988). Constant volume of sample water (50ml) is taken into the purging & trapping system. Dissolved CFCs are de-gassed by N_2 gas purge and concentrated in a trap column cooling to -45 degree centigrade. The CFCs are desorbed by heating the trap column to 140 degree centigrade within 1.5 minutes, and lead into an electron capture detector - gas chromatograph (ECD-GC). The analytical conditions are listed following table in detail.

Table 2 Analytical conditions of dissolved CFCs in seawater.

Temperature	
Analytical Column:	95 deg-C
Detector (ECD):	240 deg-C
Trap column:	-45 deg-C (at adsorbing) & 140 deg-C (at desorbing)
Mass flow rate of nitrogen gas (99.9999%)	
Carrier gas:	20 ml/min
Detector Make UP:	16 ml/min
Back flush gas:	20 ml/min
Sample purge gas:	150 ml/min
Standard gas (Japan Fine Products co. ltd.)	
Base gas:	Nitrogen
CFC-11:	300 ppt (v/v)
CFC-12:	160 ppt (v/v)
CFC-113:	30 ppt (v/v)

3.3 Preliminary results

The analytical precisions are estimated from replicate sample analyses. The precisions were calculated to be ± 0.006 pmol/kg (n = 73), ± 0.004 pmol/kg (n = 73) and ± 0.008 pmol/kg (n = 73) for CFC-11, -12 and -113, respectively. The standard gases used in this cruise will be calibrated to SIO scale standard gases after the cruise, and then the data will be corrected.

3.4 Data archive

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

Reference

Bullister, J.L and Weiss R.F. 1988. Determination of CCl_3F and CCl_2F_2 in seawater and air. Deep Sea Research, 35, 839-853.

4. Geophysical observation

Takeshi MATSUMOTO (University of the Ryukyus)
Principal Investigator (Not on-board)
Katsuhisa MAENO (Global Ocean Development Inc.) - Leg1 ,2-
Ryo OHYAMA (GODI) - Leg1 -
Norio NAGAHAMA (GODI) - Leg2 -

4.1 Swath Bathymetry

(1) Introduction

R/V MIRAI is equipped with a Multi Narrow Beam Echo Sounding system (MNBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.).

The major objective of MNBES is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

(2) Data Acquisition

The "SEABEAM 2100" on R/V MIRAI was used for bathymetry mapping during the this cruise from Sekinehama, Japan on 26 May 2006 to Sekinehama, Japan on 25 Jul. 2006

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data at the surface (6.2m) sound velocity, and the others depth sound velocity calculated temperature and salinity profiles from CTD data by the equation in Mackenzie (1981) during the cruise.

Table 4.1-1 listed system configuration and performance of SEABEAM 2112.004 system.

Table 4.1-1 System configuration and performance

SEABEAM 2112.004 (12kHz system)	
Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or +/-1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or +/-1m, whichever is greater)

(3) Preliminary Results

The results will be published after primary processing.

(4) Data Archives

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

4.2. Sea Surface Gravity

(1) Introduction

The distribution of local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR06-03 cruise from Sekinehama, Japan on 26 May 2006 to Sekinehama, Japan on 25 Jul. 2006.

(2) Parameters

Relative Gravity [CU: Counter Unit]

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

(3) Data Acquisition

We have measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (LaCoste and Romberg Gravity Meters, Inc.) during this cruise. To convert the relative gravity to absolute one, we measured gravity using portable gravity meter (Scintrex gravity meter CG-3M and CG-5), at Sekinehama Port and Kushiro Port as reference points.

(4) Preliminary Results

Absolute gravity shown in Table 4.2-1

Table4.2-1

No.	Date	U.T.C.	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *[1] [mGal]	L&R *[2] Gravity [mGal]
#01	May/26	01:48	Sekinehama	980371.93	315	604	980372.93	12645.62
#02	Jun/18	03:03	Kushiro	980600.62	195	635	980601.27	12871.68
#03	Jul/26	04:20	Sekinehama	980371.93	254	594	980372.71	12644.86

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

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

(5) Data Archives

Gravity data obtained during this cruise will be submitted to the JAMSTEC and archived there.

4.3 Sea Surface Three-Component Magnetic Field

(1) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR06-03 cruise from Sekinehama, Japan on 26 May 2006 to Sekinehama, Japan on 25 Aug. 2006.

(2) Parameters

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

(3) Method of Data Acquisition

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

For calibration of the ship's magnetic effect, we made a running like a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation). This calibration carried out as below.

Leg.1
30 May. 2006 03:55UTC - 04:20UTC (at 45-51N,158-00E)
4 Jun. 2006 07:44UTC - 08:48UTC (at 46-54N,160-03E)
16 Jun. 2006 23:00UTC - 23:24UTC (at 40-35N,148-31E)
Leg.2
19 Jun 2006 22:13UTC - 22:30UTC (at 40-34N,150-03E)
6 Jul 2006 02:55UTC - 03:10UTC (at 38-15N,155-00E)
20 Jul 2006 02:02UTC - 02:17UTC (at 40-10N,149-25E)

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

Magnetic force data obtained during this cruise will be submitted to the JAMSTEC and archived there.

5. Satellite image acquisition (NOAA/HRPT)

Katsuhisa MAENO (Global Ocean Development Inc.) - Leg1, 2 -
Ryo OHYAMA (GODI) - Leg1 -
Norio NAGAHAMA (GODI) - Leg2 -

(1) Objectives

It is our objectives to collect data of sea surface temperature in a high spatial resolution mode from the Advance Very High Resolution Radiometer (AVHRR) on the NOAA polar orbiting satellites.

(2) Method

We receive the down link High Resolution Picture Transmission (HRPT) signal from NOAA satellites. We processed the HRPT signal with the in-flight calibration and computed the sea surface temperature by the Multi-Channel Sea Surface Temperature (MCSST) method. A daily composite map of MCSST data is processed for each day on the R/V MIRAI for the area, where the R/V MIRAI located.

We received and processed NOAA data throughout MR06-03 cruise from Sekinehama, Japan on 26 May 2006 to Sekinehama Japan on 25 Jul. 2006.

(3) Preliminary results

Fig. 5-1, Fig. 5-2 and Fig.5-3 showed sea surface temperature about North-Western Pacific Ocean around of the K-2. There were composite maps of 20days MCSST data.

(4) Data archives

The raw data obtained during this cruise will be submitted to JAMSTEC and will be under their control.

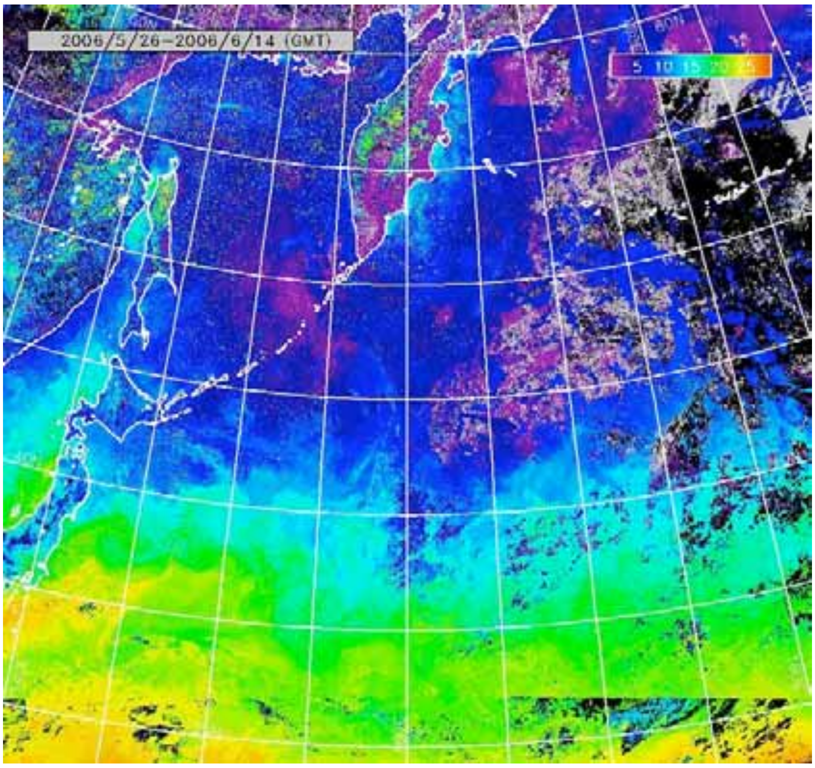


Fig. 5-1　MCSST composite image, from 26 May to 14 Jun. 2006.

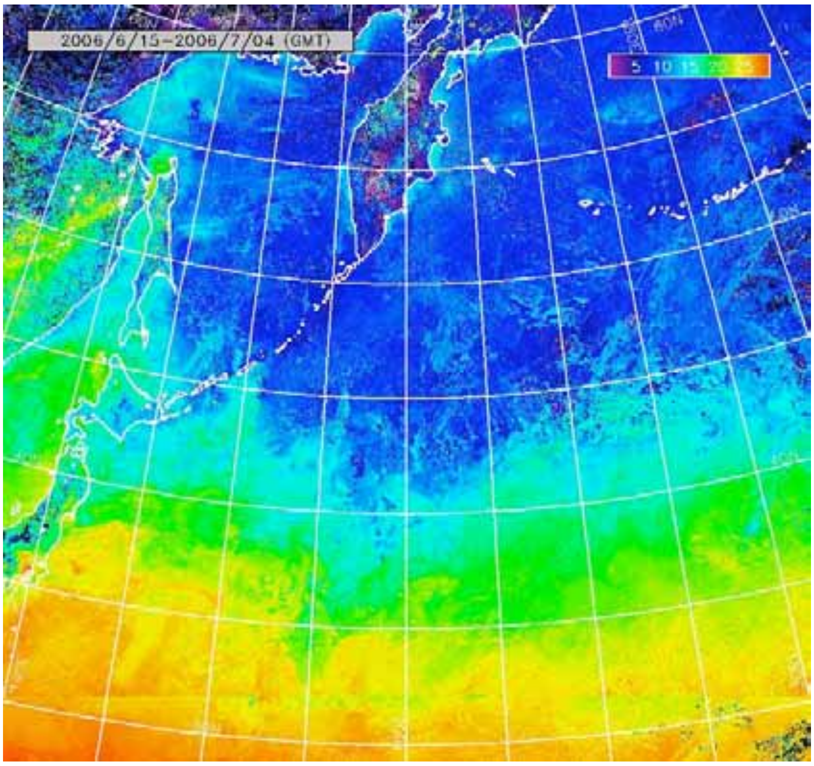


Fig. 5-2　MCSST composite image, from 15 Jun. to 4 Jul. 2006.

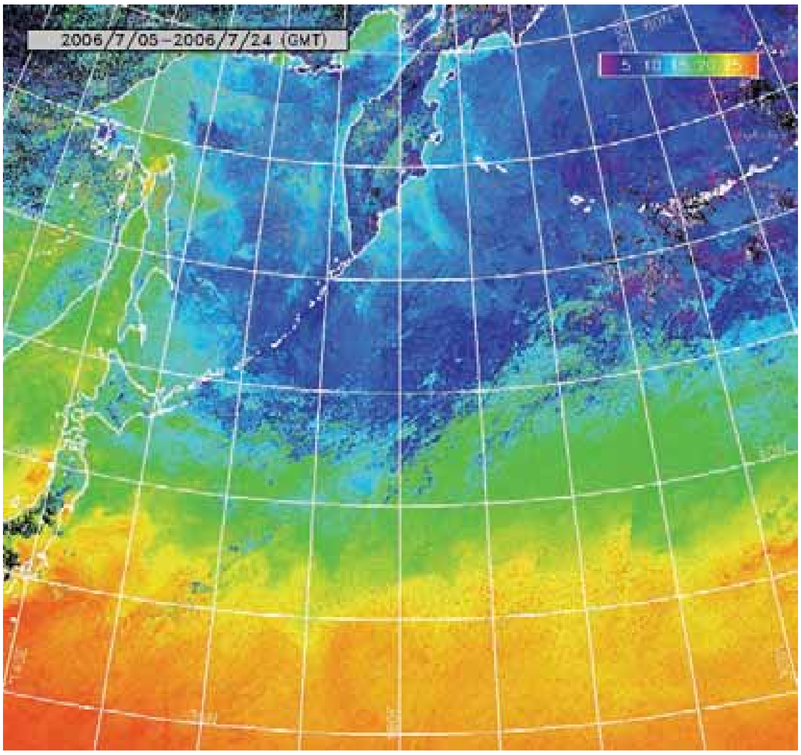


Fig. 5-3 MCSST composite image, from 5 Jul. to 24 Jul. 2006.

6. Ship's handling

Captain Masaharu AKAMINE (Master of R/V "MIRAI")
and Ship's Crew

6.1 Ship's Handling for Deployment of POPPS/BGC moorings

(1) Objectives

・To deploy it accurately and efficiently to a spot where a mooring is required.

・To prevent damage of an observation equipment and a sensor.

Results are analyzed from the standpoint of ship's maneuvering to achieve two purposes that mentioned above, and it aims to make the results useful for observation work in the future.

(2) Observation parameters

・Ship's position, course, speed

・Directions of the wind and the current, velocities of the wind and the current

・ Vectors of the wind and the current, the resultant force

・ Working hours

・ Tension of the towing

・ Position of the sinker

(3) Methods

A work of a deployment of a POPPS mooring is the first time as MIRAI. The deployment of the POPPS mooring is carried out according to the past method of the MMP mooring because the POPPS mooring is a similar system to the MMP mooring.

(4.1) Measurement of the actual ship-movement

Measurement of the ship-movement at engine stopped is executed by a set-drift which is measured before deploying the POPPS/BGC moorings in order to make in advance a comparison between reality and expectation. A direction and a velocity of the ship-movement in the external force influence is measured by a radio navigation device " Sains" assembled by Sena Co., Ltd. Japan and a Doppler sonar "DS-30" assembled by FURUNO Electric Co., Ltd. Japan.

(4.2) Measurement of the wind and the current

The wind direction and speed is measured by KOAC-7800 weather data processor and sensors assembled by Koshin Denki Co., Ltd.

The current direction and speed are continuously measured by a Doppler sonar "DS-30" installed at the bottom of the ship.

(4.3) Ship's speed

According to the results measured in past, and the instruction from the marine technician of Woods Hole Oceanographic Institution, on the deploy of the MMP (POPPS)/BGC moorings, the ship's speed is set up so as to keep her speed on 1.0~ 2.0 knots at ship's through-the-water while the mooring lines are paid out, to keep her speed on about 1 knot at ship's through-the-water while the various instruments such as sensors, sediment traps, glass balls /releasers/sinker etc. are attached. In order to avoid their instrument accident and to maintain a safety of the work, an average speed in all the works being around 1.5 knots at through-the-water is made an aim in deploying. About the deployment of the BGC mooring, the ship's way is most stopped while some instruments are attached in the top buoy at the stage of the start.

(4.4) Ship's course

The standard of the ship's course is to make the ship proceed to upwind. The final decision is done in consideration of the external force influence such as the wind-drift, the wave, the current, and the swell, making reference to the data of the set-drift carried out before the deploying operation of the POPPS/BGC moorings.

It is important to lessen the angle between the ship's course and the wind direction in order to prevent the ship drifting to the lee. The ship shall be managed to make the mooring lines paid out from the stern, straight behind. It is necessary to grasp the current influence in the long span to set a sinker to the target point accurately.

It is also necessary to consider the direction of the swell that influences the shift of the ship.

(4.5) Working hours for the deployment of the POPPS/BGC moorings

The time that the ship needs in each work is investigated and recorded referring to past data. An example in principle is given as follows.

"Total of Distance " means the navigating distance from the work beginning to the sinker dropping. This is a standard without a big flow influence in accordance with data in past. Each ship's speed is the numerical value of the above standard in (4.3).

MMP (POPPS) mooring

Works	Time	Ship's speed	Distance
Stand by the top-buoy	0.1 hour	1.0 knot	0.1 mile
Paying out the mooring ropes	3.0	1.44	4.3
Attachment of the various instruments	0.5	1.0	0.5
Towing	1.0	1.7	1.7
Setting the sinker	0.4	1.0	0.4
Total	5.0 hours	1.4 knots	7.0 miles

BGC mooring

Works	Time	Ship's speed	Distance
Stand by the top-buoy	0.5 hour	0 knot	0 mile
Attachment of the sediment traps	4.0	1.0	4.0
Paying out the mooring ropes	0.5	1.5	0.8

Towing	1.0	1.7	1.7
Setting the sinker	0.5	1.0	0.5
Total	6.5 hours	1.4 knots	7.0 miles

(4.6) Tension of the wire cable and the nylon ropes

The tension of the cable and the ropes streamed astern can be measured with the tension meter temporarily equipped next to the upper end of releaser of the mooring system, when the mooring line is towed. The maker of the tension-meter "CL-5T" is NMB Co. Ltd.

The analysis of the tension is mainly remarkable to the POPPS mooring because there is no data as this is the first work for MIRAI.

The speed of the ship and revolutions of the winch are adjusted so as not to hang a big stress in the cable/ropes actually paid out from her stern, checking the above-mentioned data and the cable/ropes tension measurement by skilled hands of marine technicians and chief officer at ship's stern.

(4.7) Designated mooring location (Target point)

Targets at K2 station are fixed based on the sounding result of execution in 2001.

MMP mooring **: lat.46° 52'.24N, Long. 159° 59'.06E** Depth 5152.3 meters

BGC mooring **: lat.47° 00'.35N, Long. 159° 58'.32E** Depth 5206.2 meters

(4.8) Decision of the anchored position

As soon as the sinker dropped into the ocean, the ship returns to the position of the top-buoy, watches the top-buoy disappearing from the surface by the ship's radars and etc.

The position of the sinker arrived at the seabed is fixed by an acoustic transducer which is lowered over the stern, a radio navigation device.

The acoustic transducer: Nichiyu Giken Kogyo Co. Japan (POPPS mooring)
(19.692 kHz & 20.480 kHz)

The acoustic transducer: Edgetech Inc. USA (MMP/BGC moorings)
(11 kHz & 12 kHz)

The radio navigation device: "Sains" assembled by Sena Co., Ltd. Japan.

The ship's radar: "JMA9000 X band" and "JMA 9000 S band " assembled by JRC Ltd. "MM950 X & S band" assembled by Consilium Selesmar, Italy.

(4) Results

(5.1) Ship's speed

The results are shown in Fig.6.1-1 and Table 6.1-1 to 6.1-3.

An approximate speed at through-the-water in each work is shown in the following.

	POPPS	**BGC**
During setting the top buoy	0.8 (1.0) knots	0.3 (0.1) knots

During paying out mooring ropes	2.3 (2.7)	1.4 (1.2) with sediment traps
During towing at the final stage	1.8 (2.0)	2.0 (2.1)
During setting the sinker	1.7 (1.7)	0.6 (0.6)
The average speed during the deployment	1.8 (2.1)	1.4 (1.3)

( ) An average speed at over-the -ground.

Mooring ropes of the POPPS were able to be paid out smoothly because they had already been connected and they were being wound around the drum tidily. Therefore the ship's speed was allowed to increase.

Mooring ropes of the BGC were paid out slowly by adjusting the drum winch speed because the tug of ropes leads to severe rope damage by allowing it to slide down between them as ropes have not been spooled onto the drum under high tension. Accordingly the ship's speed was slow in comparison with the usual.

(5.2) Ship's course (Table 6.1-1)

The course-made-good and the heading of the ship are shown as follows.

	Course	CMG	Towing Co.	Sinker Co. Unit: degrees
POPPS	<350>	<349>	<346>	<343>
BGC	<350>	<354>	<353>	<346>

"Course" is the course set when the development of the mooring started.

"CMG" stands for "course-made-good ". It means the furrow that the ship actually navigated from the deployment start to the sinker drop.

"Towing Co." means the furrow in navigation from the towing start to the sinker drop.

"Sinker Co." means the course that the ship passed in a certain distance beyond the target point. It is shown in (5.6) Sinker position.

As for the POPPS mooring, the course of the ship was set to 350 degrees to receive the wind in the bow and moderate head swell.Fig.6.1-2 shows that there were few influences of the wind laterally. The NE'ly current influenced the movement of the ship as shown in Fig.6.1-3 & 6.1-4. The hull shift to the right was forced with the current, but it reverted by using the powerful side thruster. Although the ship's heading was changed variously, the ship navigated on the course nearly. It is clear because there is no difference between the setting course and the CMG. The ship's course was altered a little after the ship had passed the target point in order to take measures against the NE'ly current.

As for the BGC mooring, the ship's course was set to 350 degrees to receive the wind in the bow and to reduce the influence of the NE'ly and the NW'ly swell. The influence of the wind is a little as shown in Fig.6.1-2.The irregular current made the choice of her course difficult at the stage of start of the deployment. Consequentially, the direction of the current has changed from NE to SE as shown in Fig.6.1-3 & 6.1-4. It impelled the ship to the right after all. The side thruster was used efficiently to return the ship to the course. After the ship passed through the target point, her course was changed to the left in consideration of the current.

(5.3) Working hours

The results are shown in Table 6.1-2 to 6.1-3 and the following figure.

The POPPS mooring

The time spent in setting top buoy and instruments		44 minutes
The time spent in paying out mooring ropes		1 hour 21 minutes
The time spent on towing		1 hour 1 minutes
(The tension measurement time is contained)		
The time spent in setting releasers and sinker		4 minutes
	Total	3 hours 10 minutes

The time spent in paying out mooring ropes was short very much because they had already been connected and they were being wound around the drum tidily. If tension isn't added to the rope to a certain extent, the rope that was paid out is likely to be in a tangle. Accordingly the ship accelerated with checking the state of the ropes tension by skilled hands of marine technicians and chief officer at ship's stern. The working time was shortened to half its the MMP mooring after all.

The BGC mooring

The time spent in setting top buoy and instrument		16 minutes
The time spent in paying out mooring lines with sediment traps		4 hours 04 minutes
(including the time spent in setting glass balls)		
The time spent on towing		48 minutes
The time spent in setting releasers and sinker		12 minutes
	Total	5 hours 20 minutes

Because mooring ropes were paid out slowly in order to prevent ropes in the drum from making inroads into ropes as described by (5.1) Ship's speed, it became extension of working hours very much. The towing time was short in comparison with past results because the ship ran with a little following current.

(5.4) Tension of the POPPS mooring

Tension investigation was carried out only to the POPPS mooring because this work was the first time for MIRAI. The investigation time is 20 minutes from 07:59 UTC to 08:19 UTC.

The results of the tension in the towing work being a final stage of the deployment are shown in Fig 6.1-5 and 6.1-6.

The next characteristics are seen from this table.

・Relations between the towing speed(X knot) and the line tension(Y kg) are shown with

Y=206.59X-20.004

Following data are calculated by the above-mentioned correlation formula.

Towing speed at through-the-water	Towing tension
1.0 knot	190 kgs
1.5 knots	290 kgs
2.1 knots (Average speed during tow)	410 kgs

Y=337.47X-80.757 in case of the MMP (data in 2005)

・The rope tension of the POPPS mooring is less about 35 % in comparison with that of the MMP mooring.

・In this measurement, the rope tension of the POPPS mooring never exceeded 550 kilograms though the towing speed exceeded 2.25 knots at through-the-water .

・Even if the angle of the CPP was fixed, the ship's speed fluctuated by the external force influence such as the wind, the wave and the swell etc. However the amplitude of the speed correlated clearly that of the rope tension.

(5.5) Dropping sinker

As for both moorings, the preparation to drop a sinker started about 200 meters on this side of the spot where the sinker is dropped.

During this navigation, the distance to the dropped point was one by one informed with the communication device from the bridge to a team of technician and deck personnel. And the bridge counted down from 10 meters before the point dropping the sinker.

In case of the BGC mooring, after the sinker had been dropped, the ship made a U-turn and pursued it so as to make sure that the top buoy disappeared from surface. The ship went near the buoy as soon as possible to catch the top buoy clearly by radars, and the ship was abreast with the buoy near. During the running the speed and course of the buoy were grasped. The information grasped here is diagrammed in the following table and Fig 6.1-8.

BGC (Date of Deployment: September 26, 2005) UTC +11 h

Movement	Position	Time (SMT)	Direction and Distance
Top buoy was dropped	46-53.95N 159-59.19E	08:13	<degree>
Top buoy's position (Sinker was dropped)	46-58.43N 159-59.21E	13:17	① ②
Top buoy sank	46-59.28N 159-58.93E	13:58	<348>1611m
Target point	47-00.35N 159-58.32E		③
Fixed point	47-00.34N 159-58.41E		<342>2075m <099>115m
Sinker drop point	47-00.67N 159-58.20E		<354>12508m <343>4352m <346>612m

Remark: A distance from the fixed point to the sinker drop point is 666 meters.

The time from the drop of the sinker to the disappearance of the top buoy was as follows.

This deployment	Previous deployment
41 minutes	38 minutes (2005), 47 minutes (Test), 50 minutes

(Long term)

After the top buoy got free, it ran on the surface at speed 2 to 1 knot in the direction of 343 degrees. In the above-mentioned table, ① minus ② minus ③ equal the horizontal distance from the point where the top buoy disappeared from the surface to the fixed point. It is a distance of 2129 meters in direction of 343 degrees. There is no big difference between this answer and the result (the distance of 2075 meters in direction of 342 degrees).

When a top buoy disappeared from the surface of the water, the position where the sinker arrives at the seabed can be approximately predicted by these data.

According to past testing results, the sinker dropped arrived at the bottom of water 57 minutes later, and then after the top buoy disappeared from the surface, that was after 10 minutes. This is useful when time to decide a fixed position is calculated.

In case of the POPPS mooring, the ship stood by at the spot where the sinker had been dropped because the ship was unable to pursue it by the difficulty to catch sight of the small top buoy. And then the work to confirm the precise location of the sinker was started here about 1 hour after the sinker had been dropped.

(5.6) Sinker's position (Fig 6.1-7)

The difference between the position that the sinker was dropped (the drop point) and the position that the sinker reached the seabed (the fixed point) is shown in the following numerical data.

	Drop point to Target point direction/ distance	Drop point to Fixed point direction/ distance	Difference Sin/ Cos
POPPS	163 degrees/ 601 meters	150 degrees/ 579 meters	130/ 30 meters
BGC	166 degrees/ 612 meters	157 degrees/ 666 meters	106/ -45 meters

Above-mentioned numerical value shows that the straight-line distance between the sinker drop point and the target point or the fixed point.

"Drop point" means the distance from the position of the sinker dropped to the target point**.** The distance is obtained by the simulation program of Marine Works Japan Ltd.

"Fixed point" is obtained with the new software of MWJ after the measurement of the transducer to decide the fixed position.

The "Sin of Difference" and the "Cos of Difference" are the amount of difference in the X/Y directions to the fixed point from the target point. The plus sign of Sin shows that the fixed point exists in the right side of the target point toward the sinker drop point. The plus sign of Cos shows that the fixed point exists in the far side of the target point toward the sinker drop point. The minus sign shows the reverse in each.

These numerical values are included the about 79 meters of the distance between the bridge with which GPS is equipped and the ship's stern where the acoustic transducer is lowered to decide the fixed position.

This time, it is understood that the sinker of each mooring was set up near the target point according to the above-mentioned results, though the current seems to have influenced the top buoy/mooring ropes a little after the sinker had been dropped.

In order to calculate a certain distance proceeding beyond the target point, the software referring to the past results made in March 2005 by MWJ was used.

(5.7) Required depth

Depth of the SEA-BEAM was continuously measured to the point of the sinker dropped from about 500 meters on this side of the target point via the target point. This purpose is to confirm the depth in the vicinity of the mooring point and the situation of the seabed in that occasion.

Both of the moorings were actually anchored within the same depth contour as shown in Fig 6.1-9 and the following depths were obtained.

Site No.	Actual	Demanded depth in 2001
K2-POPPS	(5159 meters)	5152 meters (5169 meters)
K2-BGC	(5217 meters)	5206 meters (5214 meters)

( ) the depth of water was measured by a SEA-BEAM 2000.

In 2001, an original depth was the one sounded by the CTD and the altimeter in detail. The depths of water measured by the SEA-BEAM 2000 in 2001 show that the MMP mooring was 5169 meters, and the BGC mooring was 5214 meters. The difference between the original depth and the SEA-BEAM's depth was 17 or 8 meters. It is able to guess that it is within error margin though there is a difference of 10 or 3 meters between 2001 and this time on the SEA-BEAM's depth basis. Namely the difference from the original depth in the BGC widens by 3 meters, and that in the POPPS narrows by 10meters. Because there are within the depth accuracy (0.5%) of the SEA-BEAM 2000, and a seasonal factor is contained in them.

(5.8) Distance for Deployment of POPPS/BGC mooring (Table 6.1-2 & 6.1-3)

Results are shown in the following table.

Unit: miles

	Actual	Tow	T/A
POPPS	6.53 miles	2.05 miles	31.4 %
BGC	6.79	1.66	24.4 %

"Actual" is the distance from the starting point to the position of the dropped sinker. "Tow" is the distance between the point where the tow begins and the point where the sinker is slung. The distance of "Actual" includes that of "Tow".

“T/A” is the ratio of the distance for towing to the actual distance. As for this rate, 24% is found as a standard by data shown in (4.5) Working hours. This percent shows a tendency to vary with an influence of the current. In other words, this is small in case of against the current, and big in case of the following current.

(6) Data archive

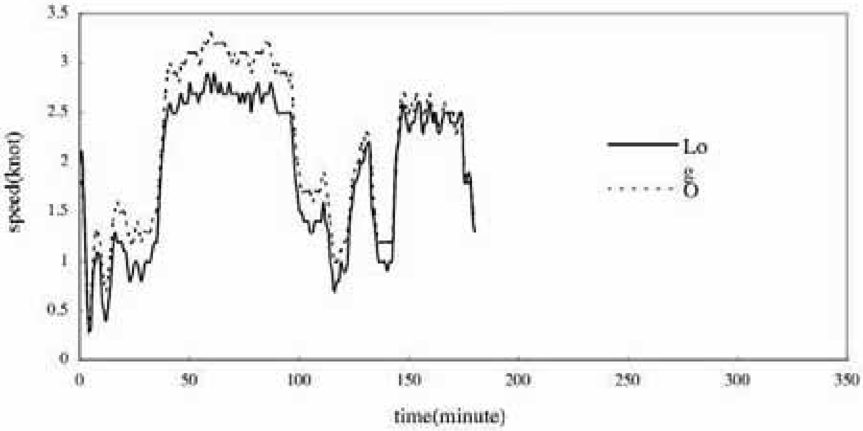
All data will be archived on board.

(7) Remarks

Sinkers of both POPPS and BGC were anchored near the target point each.
The key of success is to calculate precisely the distance that the resistance of the top buoy/mooring ropes pulls back it after the sinker is dropped into the sea. It seems that the modeling to calculate the distance was established as this result. It is necessary to consider measures against the flow in order to reduce more the difference between the position that the sinker was dropped and the position that the sinker reached the seabed. Although the work of the POPPS mooring was the first time for MIRAI, it finished safely smoothly by referring to the past work of the MMP mooring. It was found to be able to shorten working hours in comparison with the MMP mooring by adopting this method of deployment of the POPPS mooring. It was also found that the tension of the mooring during the towing was not so big as that quantitatively.
The current crossing the ship’s course during deploying the mooring influenced the ship’s maneuvering in each but the MIRAI' s excellent actuating devices such as the thruster etc. was very helpful for maneuvering the ship accurately.

Fig 6.1-1 Ship's speed in deployment at k2 station (MR06-03)

POPPS



BGC

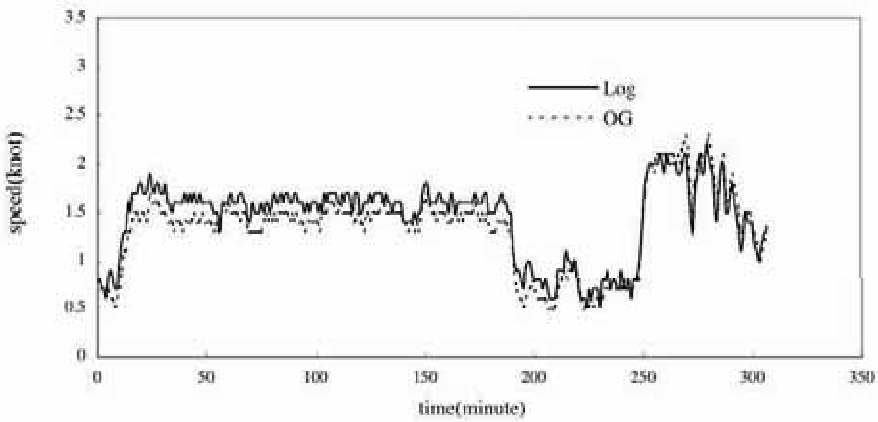
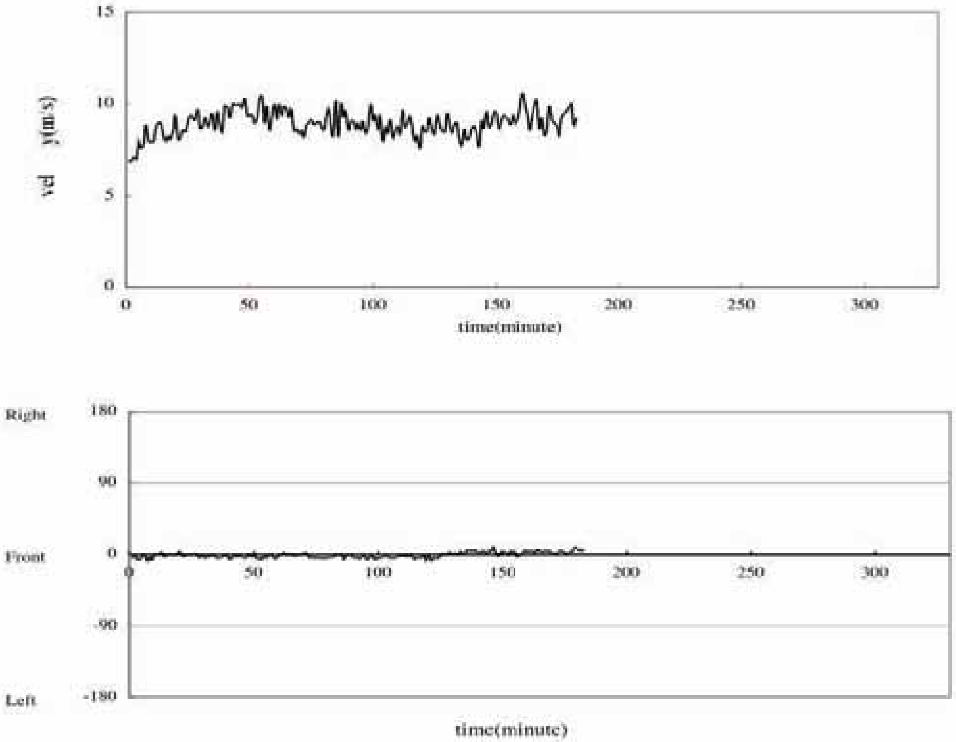


Fig-6.1-2 Relative wind in deployment at k2 station (MR06-03)

POPPS



BGC

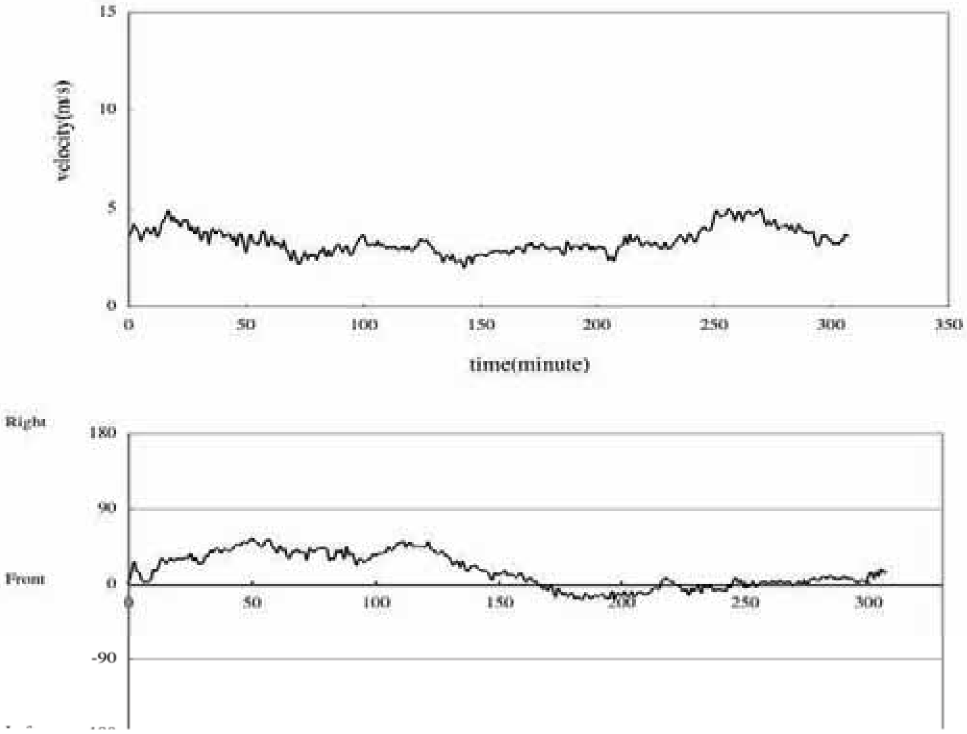
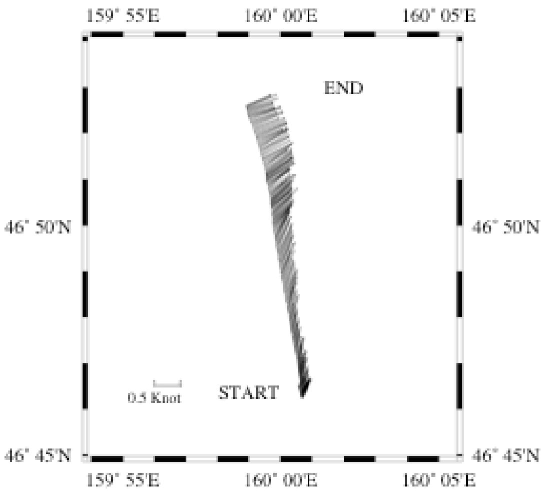
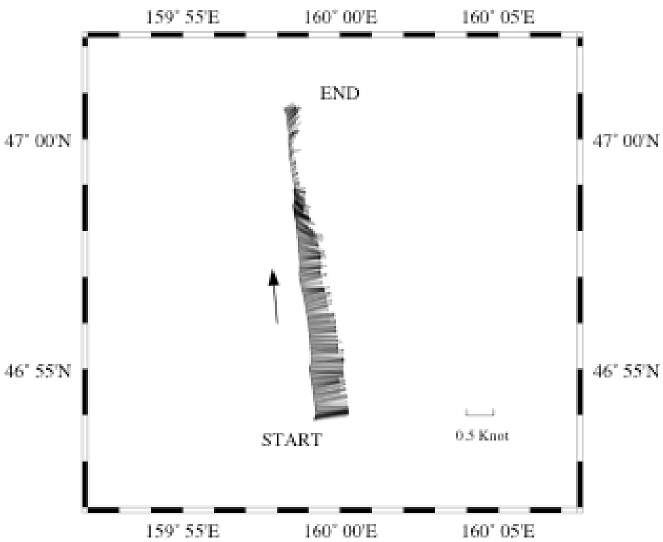


Fig 6.1-3 True current to ship's track in deployment at k2 station (MR06-03)

POPPS

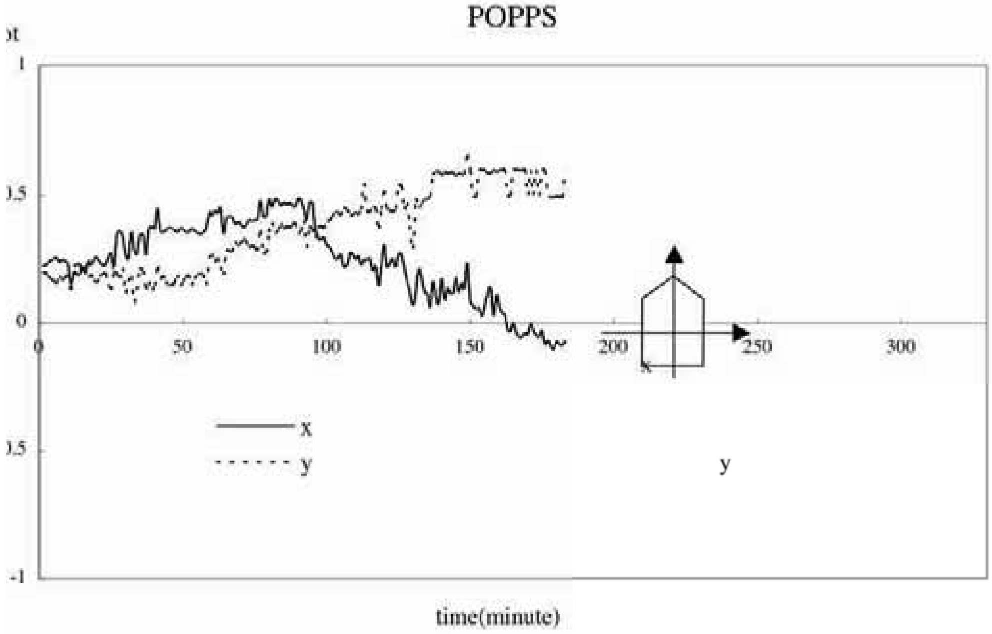


BGC



6.1-13

Fig-6.1-4 Current influence in deployment at k2 station (MR06-03)



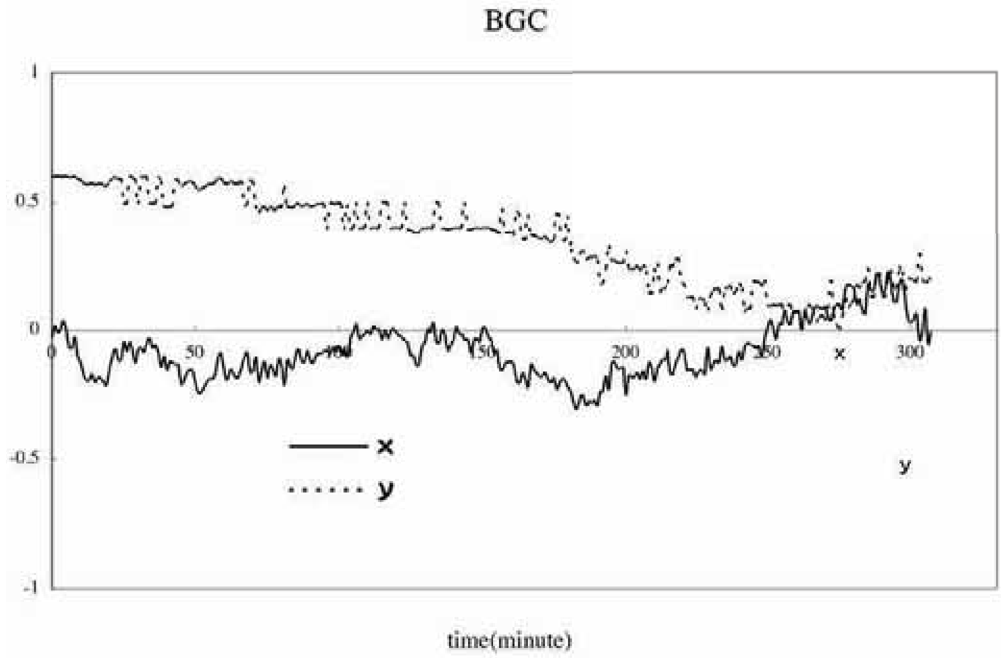


Fig6.1-5 Rope tension during tow in deployment at k2 station (MR06-03)

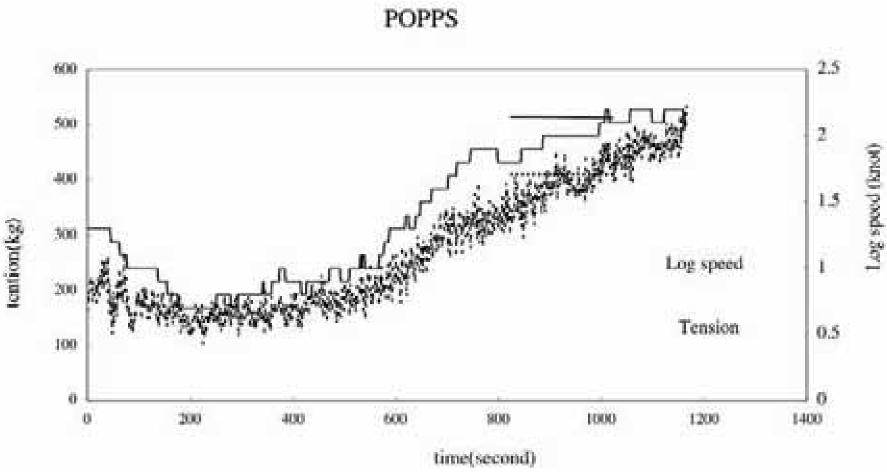


Fig6.1-6 Correlation coefficient of rope tension/ship's speed
in deployment at k2 station

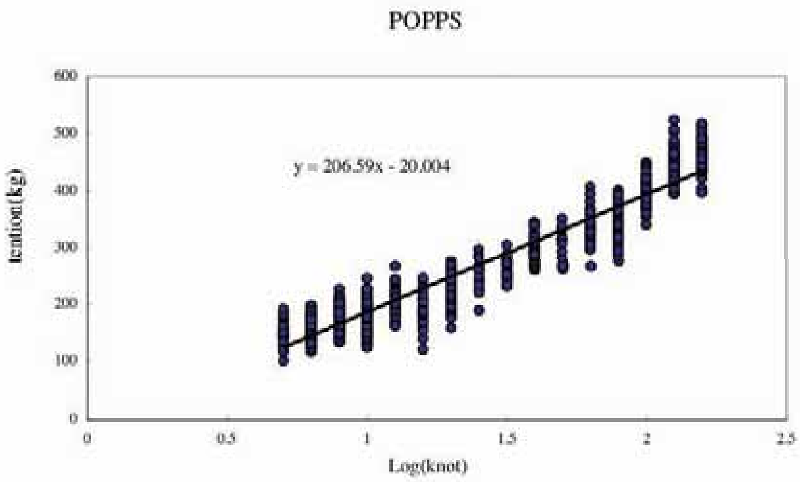
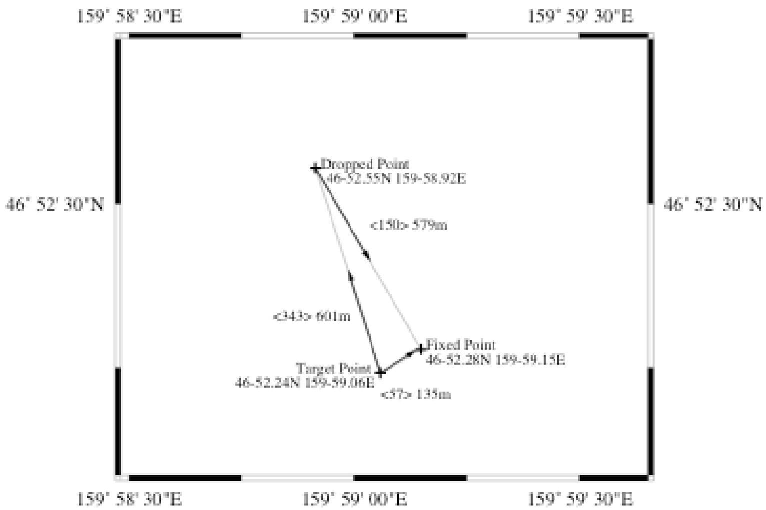
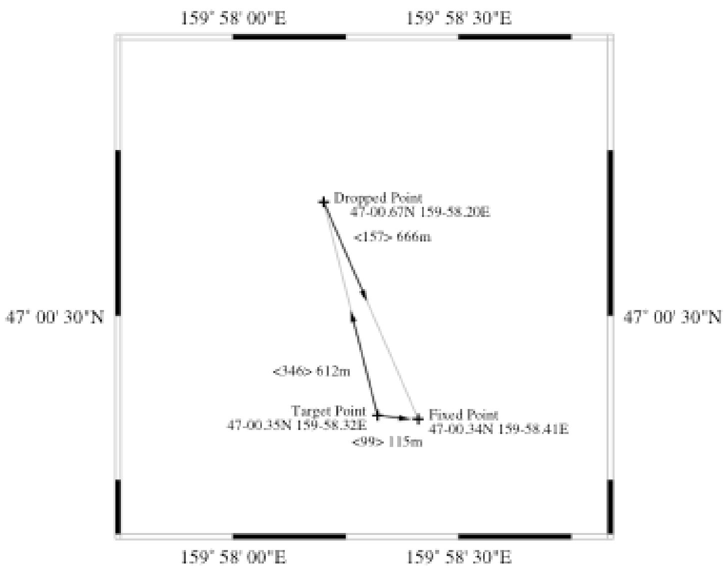


Fig 6.1-7 Mooring Point at k2 station (MR06-03)

POPPS



BGC



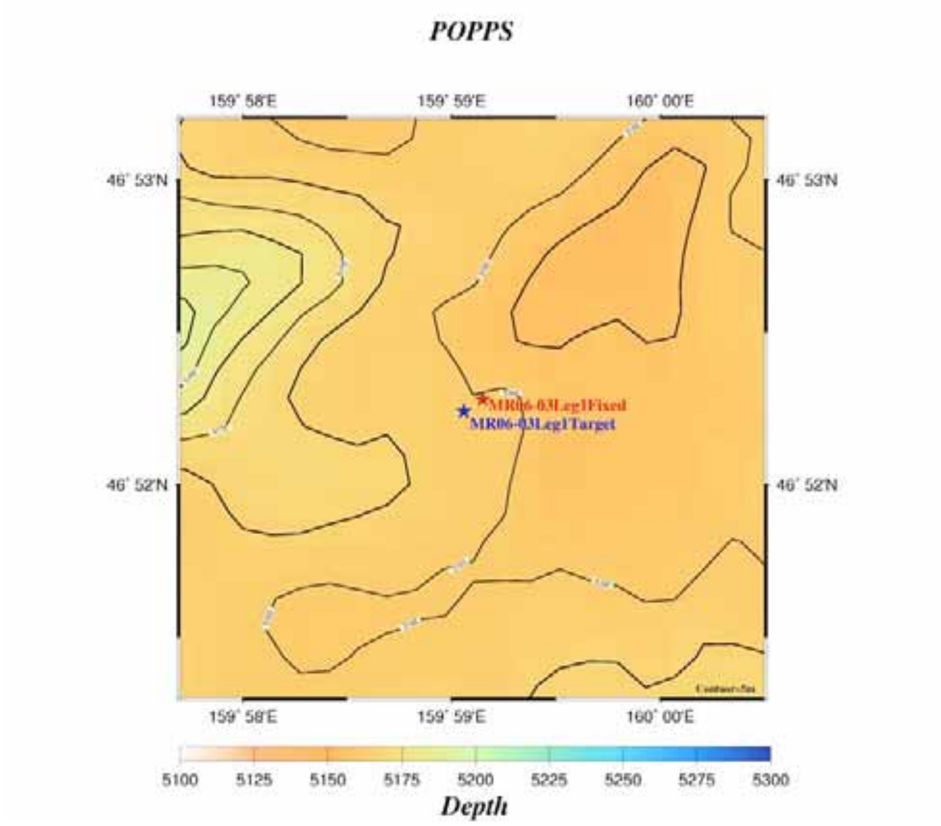
6.1-16

Fig 6.1-8 Ship's track in deployment at k2 station (MR06-03)

BGC

6.1-17

Fig6.1-9 Terrain of ocean floor at K2 station (MR06-03Leg1)



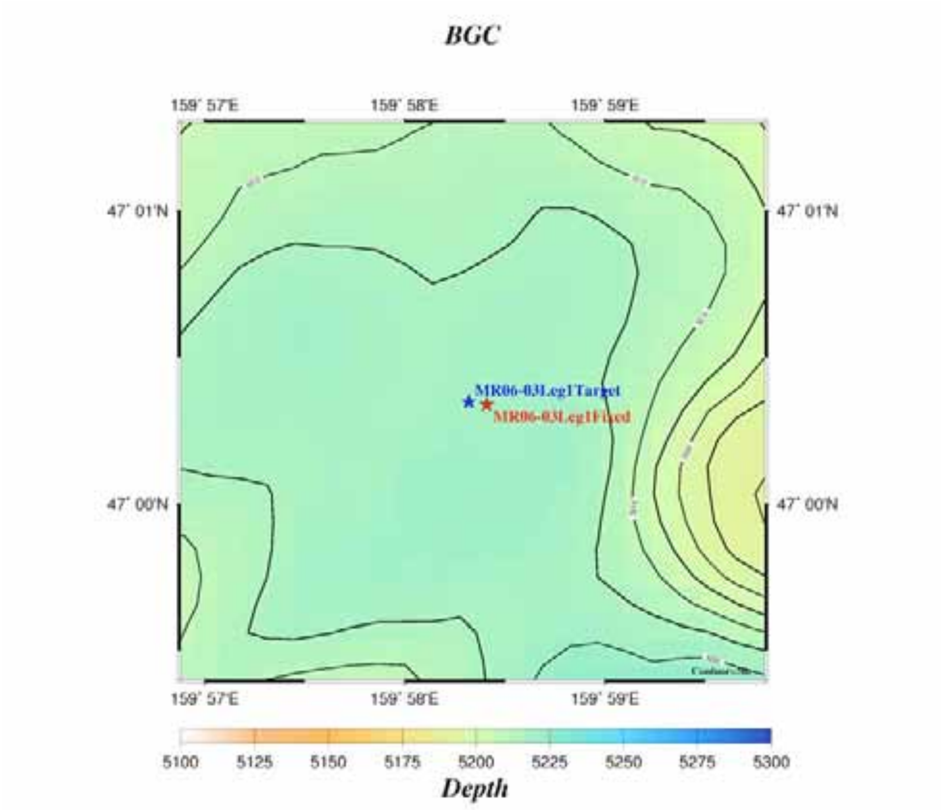


Table 6.1-1 Navigational data in deployment at k2 station (MR06-03)

POPPS

Jun 5 ,2006 UTC+11h

time(SMT)	OG(knot)	Course (deg.)	Log(knot)	Heading (deg.)	True Wind directic (Deg.)	True Wind speed(m/s)	Current direction(deg.)	Current Speed(knot)
8:00	0.7	156.3	0.9	350.4	342	8.2	26.3	0.2
8:10	0.7	155.9	0.8	349.8	350	7.2	21.1	0.3
8:20	0.9	1.1	0.6	345.1	346	7.7	34	0.3
8:30	1.2	351.3	0.8	344.2	345	8.9	25.9	0.3
8:40	1.4	351.7	1.1	344.7	341	8	15.2	0.4
8:50	2.9	349	2.5	345.5	343	8.7	7.2	0.4
9:00	3.1	349	2.7	344.5	345	7.6	13.4	0.4
9:10	3.2	349.3	2.7	345.2	343	8	19.1	0.5
9:20	3.1	350.6	2.6	345.3	340	7.5	19.8	0.5
9:30	3.1	351.1	2.6	345	338	7	24.2	0.6
9:40	2.9	350.5	2.5	344.7	341	7.8	26.3	0.5
9:50	1.7	356.1	1.4	344.2	341	7.7	47.8	0.5
10:00	1.6	351.9	1.3	343.7	340	8.1	49.1	0.5
10:10	1.5	354.2	1.4	341.7	342	8.7	44.8	0.6
10:20	1.9	347.2	1.6	338.4	344	7	61.3	0.5
10:30	1.5	350.8	1.4	337.4	348	8.9	55.2	0.6
10:40	2.7	345.8	2.5	338.5	334	7.6	57.2	0.6
10:50	2.4	343	2.3	335.6	339	8.8	69	0.6
11:00	2.5	337.3	2.5	334.8	335	6.9	72.1	0.6
11:10	0.9	350.9	0.9	335.4	335	7.8	69.3	0.5

BGC

Jun 6 ,2006 UTC+11h

time(SMT)	OG(knot)	Course (deg.)	Log(knot)	Heading (deg.)	True Wind directic (Deg.)	True Wind speed(m/s)	Current direction(deg.)	Current Speed(knot)
8:00	0.6	111.1	0.4	350.0	350	3.1	82.0	0.6
8:10	0.8	29.9	0.8	350.1	355	3.2	83.0	0.6
8:20	0.7	7.6	1.0	339.4	1	3.3	81.3	0.6
8:30	1.5	352.6	1.8	339.9	20	3.5	85.0	0.6
8:40	1.5	353.9	1.7	339.6	15	2.9	78.2	0.5
8:50	1.4	350.3	1.7	339.6	33	3.0	87.2	0.5
9:00	1.4	349.5	1.6	339.9	51	2.4	89.7	0.6
9:10	1.6	5.4	1.6	347.4	38	2.7	91.8	0.6
9:20	1.3	355.1	1.4	345.1	33	2.4	89.8	0.6
9:30	1.4	354.3	1.6	345.3	43	1.9	91.9	0.5
9:40	1.4	353.1	1.7	345.1	35	2.3	88.2	0.5
9:50	1.4	351.3	1.6	344.6	30	3.0	81.6	0.5
10:00	1.5	349.0	1.6	345.4	49	2.6	75.8	0.5
10:10	1.4	347.1	1.5	344.7	45	2.4	75.8	0.4
10:20	1.6	348.4	1.7	345.5	28	2.2	82.1	0.4
10:30	1.4	1.7	1.4	348.3	23	1.6	83.5	0.4
10:40	1.6	355.5	1.8	349.7	9	1.8	78.5	0.4
10:50	1.4	354.2	1.6	350.2	3	2.2	97.7	0.4
11:00	1.5	354.0	1.6	350.2	343	2.4	106.8	0.4
11:10	1.3	353.8	1.5	349.8	333	2.1	106.1	0.5
11:20	1.1	352.4	1.2	349.8	333	2.4	126.7	0.4
11:30	0.7	346.9	0.8	349.4	333	2.5	118.8	0.4
11:40	0.6	348.9	0.7	350.2	338	2.7	121.5	0.3
11:50	0.8	34.6	0.7	353.7	0	2.8	105.3	0.2
12:00	0.6	356.2	0.5	353.9	350	2.7	132.3	0.2
12:10	0.7	345.4	0.9	353.9	347	3.2	108.8	0.2
12:20	1.4	354.1	1.4	355.7	352	3.9	81.8	0.1
12:30	2.1	351.3	1.9	355.1	0	3.8	37.7	0.1
12:40	2.3	353.0	2.1	356.9	358	3.9	18.5	0.1
12:50	2.3	353.4	2.1	354.9	3	3.0	30.4	0.2
13:00	1.8	353.9	1.7	355.0	9	2.9	39.2	0.2
13:10	1.4	347.0	1.4	344.6	358	2.7	66.1	0.2
13:20	1.8	356.3	2.0	17.4	6	3.2	30.1	0.2

Table 6.1-2 SUMMARY OF WORKING TIME FOR DEPLOYMENT POPPS MOORING DURING MR06-03

U+11

Mooring No.	K2 (POPPS)
Fixed position lat.	46-52.28N
Long.	159-59.15E
Works Date	5.Jun.06
SEABEAM Depth (m)	5159.0
Com'ced	7:57
Buoy/Winch into sea	8:09
ADCP into sea	8:30
Set floats(Middle)	8:41
Set floats (Bottom)	10:02
Set Releaser	10:30
Stand by sinker	11:03
Let go sinker	11:07
H for top buoy	0:12
o for floats/winch etc.	0:32
u for wire rope	1:21
r for towing	1:01
s for S/B sinker	0:04
Total	3:10
Length of wirerope(m)	4300
Length of rope(m/h)	3,185
D for buoy/rope (mile)	0.74
I for wire rope (mile)	3.63
s for towing (mile)	2.05
t for sinker (mile)	0.11
Total (mile)	6.53
S for buoy/floats (knot)	1.0
p for wire rope (knot)	2.7
ee for towing (knot)	2.0
d for sinker (knot)	1.7
Average OG speed (knot)	2.1
Average Log speed (knot)	1.8

Mooring No.	K2 (MMP)	K2 (MMP)	K2 (MMP)	K2 (MMP)
Fixed position lat.	46-52.24N	46-52.38N	46-52.29N	46-52.30N
Long.	159-59.06E	159-59.96E	159-59.04E	159-59.03E
Works Date	24.Sep.05	3.Mar.05	24.Oct.02	9.Sep.01
SEABEAM Depth (m)	5158.0	5158.0	5158.0	5169.0
Com'ced	8:09	8:16	13:24	8:13
Buoy into sea	8:10	8:19	13:25	8:15
Set MMP (Upper)	8:20	9:30	13:54	8:44
Set Bumper stop (Lower)	10:47	10:27	16:15	11:04
Set floats (Middle)	11:10	10:49	16:21	11:07
Set floats (Bottom)	11:39	11:21	16:42	11:35
Set Releaser	12:52	12:25	17:23	12:31
Let go sinker	13:13	12:43	17:53	12:43
H for top buoy	0:01	0:03	0:01	0:02
o for wire rope	2:37	2:08	2:50	2:49
u for floats	0:52	0:54	0:27	0:31
r for towing	1:13	1:04	0:41	0:56
s for S/B sinker	0:21	0:18	0:30	0:12
Total	5:04	4:27	4:29	4:30
Length of wirerope(m)	4000	4000	4500	4500
Length of rope(m/h)	1,529	1,875	1,588	1,598
D for buoy/rope (mile)	3.6	2.54	4.31	4.09
I for floats (mile)	0.82	1.11	0.7	0.73
s for towing (mile)	1.78	1.89	0.79	1.69
t for sinker (mile)	0.25	0.26	0.66	0.25
Total (mile)	6.45	5.8	6.46	6.76
S for buoy/rope (knot)	1.4	1.2	1.5	1.4
p for glass balls (knot)	0.9	1.2	1.6	1.4
ee for towing (knot)	1.5	1.8	1.2	1.8
d for sinker (knot)	0.7	0.9	1.3	1.3
Average OG speed (knot)	1.3	1.3	1.4	1.5
Average Log speed (knot)	1.45	1.45	1.4	1.4

Table 6.1-3 SUMMARY OF WORKING TIME FOR DEPLOYMENT BGC MOORING DURING MR0603

U+11

	Mooring No.	K2	K2	K2(Long-term)	K2(Test)	K2	K2	
	Fixed position	47-00.34N	47-00.33N	47-00.47N	47-00.48N	47-00.23N	47-00.32N	
		159-58.41E	159-58.31E	159-58.06E	159-57.97E	159-58.42E	159-58.25E	
	Works Date	6.Jun.06	26.Sep.05	18.Mar.05	5.Mar.05	25.Oct.02	9.Sep.01	
	SEABEAM Depth (m)	5217	5217	5214	5216	5215	5214	
	Com'ced deployment	7:57	8:24	7:51	8:25	10:30	10:09	
	Top buoy into sea	8:13	8:43	8:09	8:38	10:54	10:32	
	Sediment(1) into sea	8:24	8:49	8:24	8:47	11:19	11:23	
	Sediment(2) into sea	8:35	8:59	8:36	8:59	13:09	12:09	
	Sediment(3) into sea	8:45	9:13	8:48	9:11	15:02	14:22	
	Sediment(4) into sea	9:02	9:35	9:00	9:44			
	Sediment(5) into sea	11:36	11:54	10:29	11:15			
	Set Glass balls/Releaser	12:17	12:13	10:54	11:47	15:31	14:48	
	Stand by sinker	13:05	13:16	12:36	14:02	15:59	16:20	
	Let go sinker	13:17	13:30	13:01	14:14	16:11	16:40	Average
H	for top buoy/sensors	0:16	0:19	0:18	0:13	0:24	0:23	0:19
o	for sediments	4:04	3:30	2:45	3:09	4:37	4:16	3:39
u	for towing	0:48	1:03	1:42	2:15	0:28	1:32	1:24
r	for S/B sinker	0:12	0:14	0:25	0:12	0:12	0:20	0:16
	Total	5:20	5:06	5:10	5:49	5:41	6:31	5:39
D	for top buoy (mile)	0.03	0.26	0.23	0.15	0.09	0	0.15
I	for sediments (mile)	4.99	4.6	2.9	5.37	6.69	5.29	4.97
s	for towing (mile)	1.66	2.3	3.25	4.38	0.71	2.56	2.64
t	for sinker (mile)	0.11	0.32	0.41	0.26	0.28	0.45	0.34
	Total (mile)	6.79	7.48	6.79	10.16	7.77	8.30	8.10
S	for top buoy (knot)	0.1	0.8	0.8	0.7	0.2	0.0	0.5
p	for sediments (knot)	1.2	1.3	1.1	1.7	1.4	1.2	1.4
ee	for towing(knot)	2.1	2.2	1.9	1.9	1.5	1.7	1.9
d	for sinker (knot)	0.6	1.4	1.0	1.3	1.4	1.3	1.2
	Average OG speed (knot)	1.3	1.5	1.3	1.7	1.4	1.3	1.4
	Average LOG speed (knot)	1.4	1.3	1.3	1.6	1.3	1.7	1.4

6.2 Ship's Handling for the recovery of the BGC/MMP moorings

(1) Objectives

When a BGC mooring or a MMP mooring is recovered, after separating it from the seabed, it is important to know in what direction it will be adrift by the wind, the current, and the swell, etc. in order to catch it safely, and efficiently. Moreover, it is greatly helpful to grasp actual working hours when performing future work.

It aims at recording results of recovering the mooring systems such as the BGC/MMP from the standpoint of the ship's handling.

(2) Observation parameters

- Movement of the BGC/MMP mooring released from the seabed
- Ship's position, course, speed
- Directions of the wind/the current/the swell, velocities of the wind/the current

(3) Methods

(3.1) Measurement of the actual ship-movement

Measurement of the ship-movement at coming close to the top buoy and the glass ball floats is carried out in a radio navigation device assembled by Sena Co., Ltd. Japan.

(3.2) Measurement of the wind and the current

The wind direction and speed are measured by KOAC-7800 weather data processor and sensors assembled by Koshin Denki Co., Ltd.

The current direction and speed are continuously measured by a Doppler sonar installed at the bottom of the ship. The Doppler sonar is assembled by FURUNO Electric Co., Ltd.

(3.3) Measurement of the releaser-movement in the sea

The releaser is operated with an acoustic transducer which is made by Edgeteh Inc. USA.

(4) Maneuver

(4.1) Surfacing of the moorings

(a) The ship is located downwind or downstream on a distance of 200 - 400 meters from the

sinker position of the mooring. The clutches of the CPP are disengaged and the operation of the stern thruster and the SEABEAM are suspended except the bow thruster for adjusting the ship's head if necessary.

The "Enable" signal is sent from the stern of the ship by the transducer and the signal reception is confirmed. It is demanded to be nearly over the mooed point when the signal reception is difficult. After the reception is confirmed, it is necessary to go away from the moored point by about 400 meters because the point where the top buoy surfaces might shift by about 200 meters.

(b) Both the BGC/MMP moorings are released from the seabed by using the acoustic transducer on 11 and 12 kHz at the mooring deck of the ship's stern.

(c) On the assumption that the mooring point is correct, a top buoy of the mooring is surfaced in the direction of the current. In case there is hardly a flow, the top buoy surfaces right above the mooring point. The top buoy receives the influence of the wind after it surfaces, and drifts.

(4.2) How to approach the top buoy/the glass ball floats

(a) When the ship approaches buoy etc, the angle between the ship's course and the wind direction is made as small as possible in order to lessen the external force influence of the wind. In addition the ship's course is decided to make her locate in the lee of buoys/glass ball floats.

(b) To prevent the ropes etc. from twining round the ship's propeller, the clutch of the propeller in the recovery-side is discharged until the handling rope is connected to buoy etc. from the time that the ship approaches buoys etc.

(c) In case of calm sea state, the work to catch the top buoy is carried out with the working boat after all of the system appear on the surface. When the working boat is lowered, and the working boat is drawn up, the ship makes the lee to have calm water, an ample berth for it.

(d) In case of rough sea state, the ship is handled to approach the top buoy most and the top buoy is caught from the upper deck of the ship by a grapnel or a hook and a long pole because the working boat is not able to use due to rough sea. Because delicate measuring instruments are installed under the top buoy, it is prohibited to push the buoy strongly, and to hit it the discharging current from CPP and propeller of the side-thruster.

Be careful when the hook/pole is used to catch the top buoy since the various instruments installed under the top buoy might be damaged. Therefore the hook installed the end of the long pole, a long rope connected with the hook is used as the second plan.

(e) While recovering mooring ropes/cables, the ship is steered by side thrusters in order to tow them straight behind. It is easy to carry out the work if the ship proceeds to upwind.

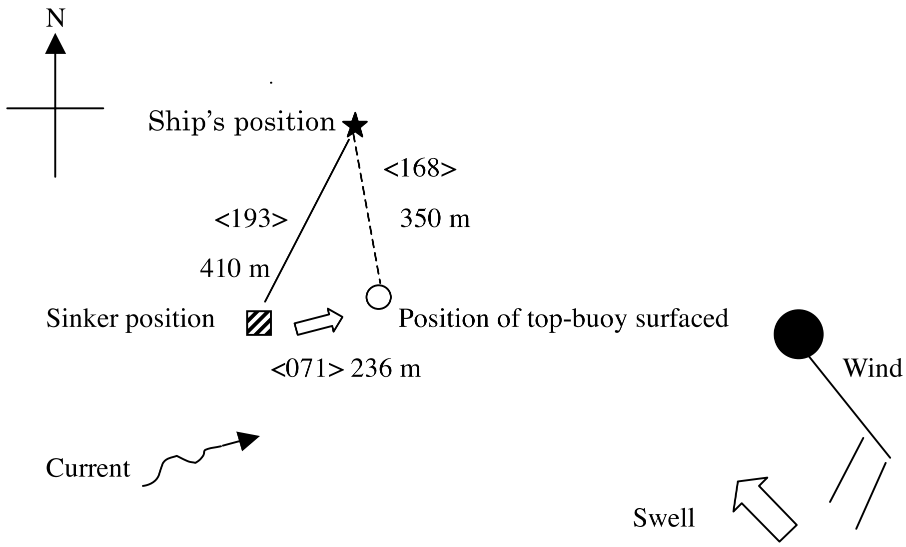
(f) Since the BGC mooring in which a lot of observation equipments and sediment traps are installed, it cannot be strongly towed. The ship's speed is kept about 1 knot or less. When these observation equipments are slung up the ship, Care is needed in handling them not to upset the observation equipment.

(5) Results

(5.1) Surfacing of the BGC mooring (Fig 6.2-1)

The results are shown in following figures and these are characterized as follows.

(1) In case of the BGC mooring at K2 site



(a) The ship was stopped near right on the sinker position.

(b) The ship's head was set windward, and the operation of devices (CPP, bow/stern thrusters and the SEABEAM) which influence the measurement of the transducer was suspended. Afterwards, the acoustic transducer was lowered over the starboard stern. After the release signal on 11 and 12 kHz was sent twice, the mooring was separated from the seabed by the second signal which was sent to another reserve releaser.

(c) The top buoy surfaced in the direction of 168 degrees from the ship at the distance of about 350 meters. The point was moved from the sinker position at a distance of about 236 meters by the influence of the current.

(d) After the top buoy had surfaced, the glass floats being connected near the bottom of the mooring surfaced 46 minutes later. The point was in the direction of about 235 degrees from the top buoy at the distance of about 460 meters by influence of the wind and the current.

(5.2) Working hours for recovering the BGC mooring

The result is shown in Table 6.2-1 and the following matters are pointed out.

(a) The time consumed in recovery of the BGC mooring was 3 hours and 56 minutes.

The working hours of the BGC mooring are long in comparison with the MMP mooring because the BGC mooring is with many instruments such as sediment traps.

(b) The top buoy of the BGC mooring was caught by the workboat because it was ensured to recover various delicate equipments safely. The working hours from the time when the workboat was lowered to the time when the workboat was hoisted in were 24 minutes.

(c) Because there was danger to lose sight of the buoy due to poor visibility, the ship kept her position a distance of about 350 meters away from the top buoy. Therefore, the time required for approaching a buoy was short in comparison with past result.

(d) Since the BGC mooring in which a lot of observation equipments and sediment traps are installed, it cannot be strongly towed. The BGC mooring was recovered over the ship going toward the windward to avoid the irregular tension given to the towing line by shocks of the strong wind and the wave abaft.

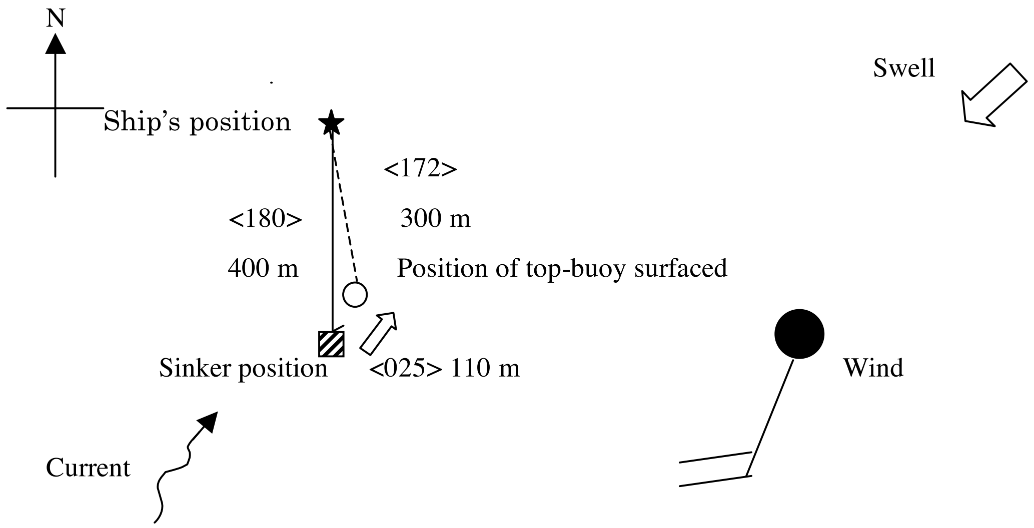
(e) The floats (8 glass balls) for a sediment trap in the deepest depth were entangling to the connecting rope. This did not take so much time.

(f) Since the bottom floats (48 glass balls) being connected near the end of the BGC mooring got entangled to each other, these were recovered as a bunch of the thing together with releasers. This did not take so much time too.

(5.3) Surfacing of the MMP mooring (Fig 6.2-2)

The results are shown in following figures and these are characterized as follows.

(1) In case of the MMP mooring at K2 site



(a) The ship was stopped in about 100 meters leeward of the sinker position.

(b) The operation of devices (CPP, bow/stern thrusters and the SEABEAM) which influence the measurement of the transducer was suspended. Afterwards, the acoustic transducer was lowered over the starboard stern. After the release signal on 11 and 12 kHz was sent, the mooring was separated from the seabed without using a reserve releaser.

(c) The top buoy appeared on the surface in the direction of 172 degrees from the ship at a distance of about 300 meters. The point was moved about 110 meters from the sinker position by the influence of the current flowing in the direction of 25 degrees.

(d) After the top buoy had surfaced, the glass floats being connected near the bottom of the mooring rose to the surface of the water 50 minutes later. A distance from the top buoy to the glass floats was about 235 meters in the direction of 260 degrees meters by influence of the current for NE and the wind from SSW. The top buoy drifted in the direction of 65 degrees at a distance of about 300 meters by the resistance to the wire cable under the water. The middle glass floats bobbed up and down between the waves and ropes connected with them were sinking.

(5.4) Working hours for recovering the MMP mooring

The result is shown in Table 6.2-1 and the following matters are pointed out.

(a) The time consumed in recovery of the MMP mooring was 4 hours and 6 minutes. This was almost the same as the last working hours.

(b) The top buoy of the MMP mooring was caught by the workboat from her starboard side. The working hours from the time when the workboat was lowered to the time when the workboat was hoisted in were 45 minutes. This includes hours that the workboat played for checking the middle glass floats bobbing up and down on the surface.

(c) The top floats (8 glass balls) got entangled to each other but this was not the limit to delay working hours.

(b) The middle floats (8 glass balls) were entangling to the connecting rope. An entangled rope was wound around the drum as it is. This didn't cause the big delay of the working hours.

(c) As the bottom floats (32 glass balls) were bunching up together, they were recovered in a lump.

(6) Data archive

All data will be archived on board.

(7) Remarks

After the top buoy of the BGC mooring appeared on the surface, the ship was not able to be away from the buoy because there was a worry to lose sight of the buoy due to too bad visibility. Meanwhile there is danger that glass balls rise to the surface of the water near the ship. We should note any dangers to navigation expected to be encountered during the watching of the top buoy in case of the restricted visibility.

Fig.6.2-1 RECOVERY OF BGC MOORING

Location: 47-00.33N, 159-58.31E

Date: 31st May 2006

Wind: <145> 9.1 m/s, Current: <070> 0.5 knot

Swell: SE, Wave height: 1.5 m, 7.2 sec

Weather: o & m, Depth: 5206.2 m

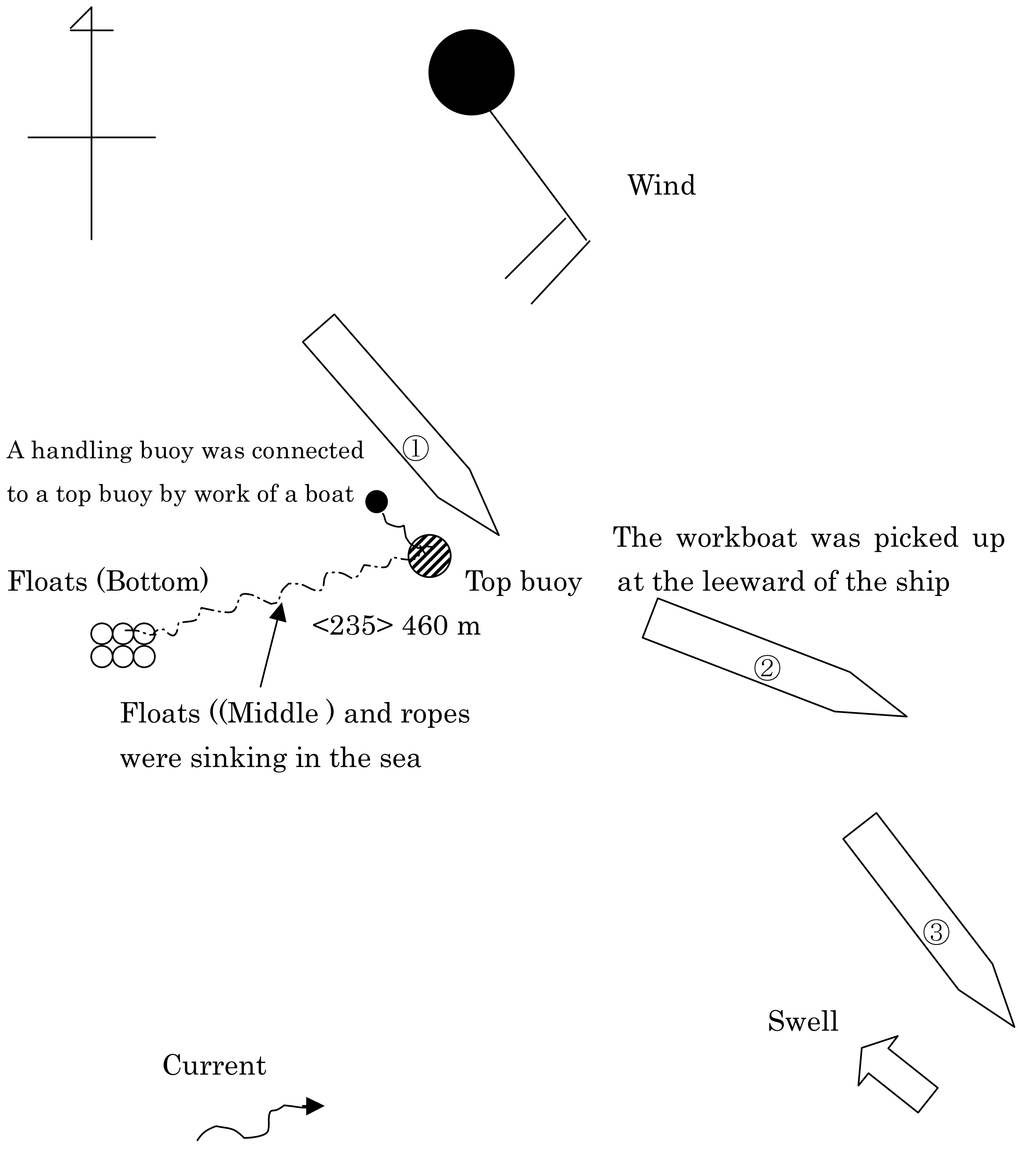


Fig.6.2-2 RECOVERY OF MMP MOORING

Location: 46-52.18N, 159-59.04E

Date: 3rd June 2006

Wind: <195> 9 m/s, Current: <025> 0.5 knot

Swell: NE, Wave height: 2.2 m, 6.5 sec

Weather: o & r, Depth:5152.3m

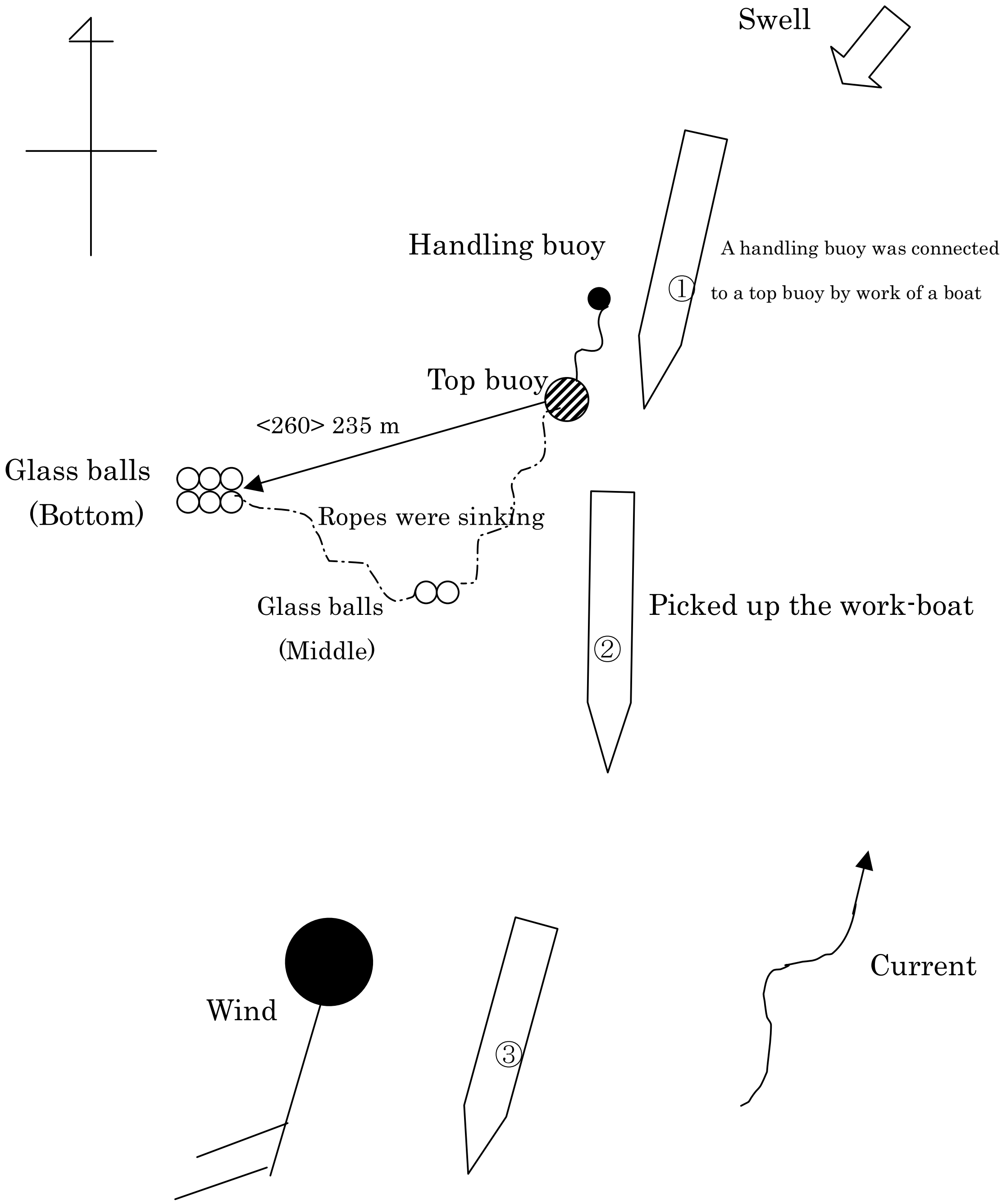


Table 6.2-1 RECOVERY OF BGC/MMP MOORING DURING MR06-03

Mooring No.		K2-BGC	K2-BGC	K2-BGC
Location	lat	47-00.33N	47-00.47N	47-00.48N
	Long	159-58.31E	159-58.06E	159-57.97E
Date		31.May.06	23.Sep.05	17.Mar.05
Water depth (m)		5206.2	5206.2	5206.2
Com'ced work (Set transducer)		7:10	7:07	7:03
Released from sinker		7:13	7:14	7:05
Top buoy surfaced		7:14	7:15	7:06
Floats (Bottom) surfaced		8:00	8:03	7:53
Catched handling buoy by workboat		8:06	8:28	8:34
Slinged top buoy stern		8:40	8:55	8:41
Winded up top buoy (on deck)		8:45	9:04	8:47
Recovery of equipments		8:53	9:15	8:57
Recovery of sediment (1)		9:10	9:25	9:08
Recovery of sediment (3)		9:31	9:47	9:41
Recovery of sediment (5)		10:57	11:19	11:52
Recovery of floats (Bottom)/releaser		11:05	11:31	12:16
Finished work (Releaser on deck)		11:06	11:32	12:18
Total working hours		3:56	4:25	5:15

Time consumed

in preparation for recovery	0:03	0:07	0:02
in rising of glass balls (Bottom)	0:47	0:49	0:48
in catching of top buoy	0:06	0:25	0:41
in recovery of top buoy	0:39	0:36	0:13
in recovery of sediments	2:12	2:15	3:05
in recovery of floats/releaser	0:09	0:13	0:26
Total working hours	3:56	4:25	5:15

Maneuvering data

MOORING NUMBER	K2(May.'06)	K2(Sep.'05)	K2(Mar.'06)
Course when approaching (deg)	145	290	260
Course when catching buoy (deg)	145	280	220
Wind direction (deg)	145	290	290
Wind velocity (m/s)	9.1	11.5	3.7
Current direction (deg)	70	170	Various
Current velocity (knot)	0.5	0.8	0.2
Swell direction	SE	WNW	WSW
Wave height (m)	1.5	2.8	2.4

Mooring No.		K2-MMP	K2-MMP
Location	lat	46-52.18N	46-52.38N
	Long	159-59.04E	159-58.96E
Date		3.Jun.06	16.Mar.05
Water depth (m)		5152.3	5152.3
Com'ced work (Set transducer)		7:06	8:38
Released from sinker		7:15	8:48
Top buoy surfaced		7:16	8:49
Floats (Bottom) surfaced		8:06	9:38
Catched handling buoy		8:47	10:28
Slinged top buoy stern		9:18	10:35
Winded up top buoy on deck		9:23	10:50
Recovery of MMP (Shallow)		9:52	11:08
Recovery of MMP (Deep)		10:44	11:57
Recovery of floats(Top)		10:45	12:10
Recovery of floats (Middle)		10:58	12:34
Recovery of floats (Bottom)/releaser		11:12	12:34
Finished work		11:12	12:42
Total working hours		4:06	4:04

Time consumed

in preparation for recovery	0:09	0:10
in rising of floats (Top)	0:51	0:50
in catching of buoy	0:41	0:50
in recovery of top buoy	0:36	0:22
in recovery of MMP (Deep)	1:21	1:07
in recovery of floats/releaser	0:28	0:45
Total working hours	4:06	4:04

Maneuvering data

MOORING NUMBER	K2(Jun.'06)	K2(Mar.'06)
Course when approaching (deg)	200	250
Course when catching b'y (deg)	195	250
Wind direction (deg)	195	240
Wind velocity (m/s)	9	13
Current direction (deg)	25	20
Current velocity (knot)	0.5	0.4
Swell direction	NE	WEST
Wave height (m)	2.2	3.6