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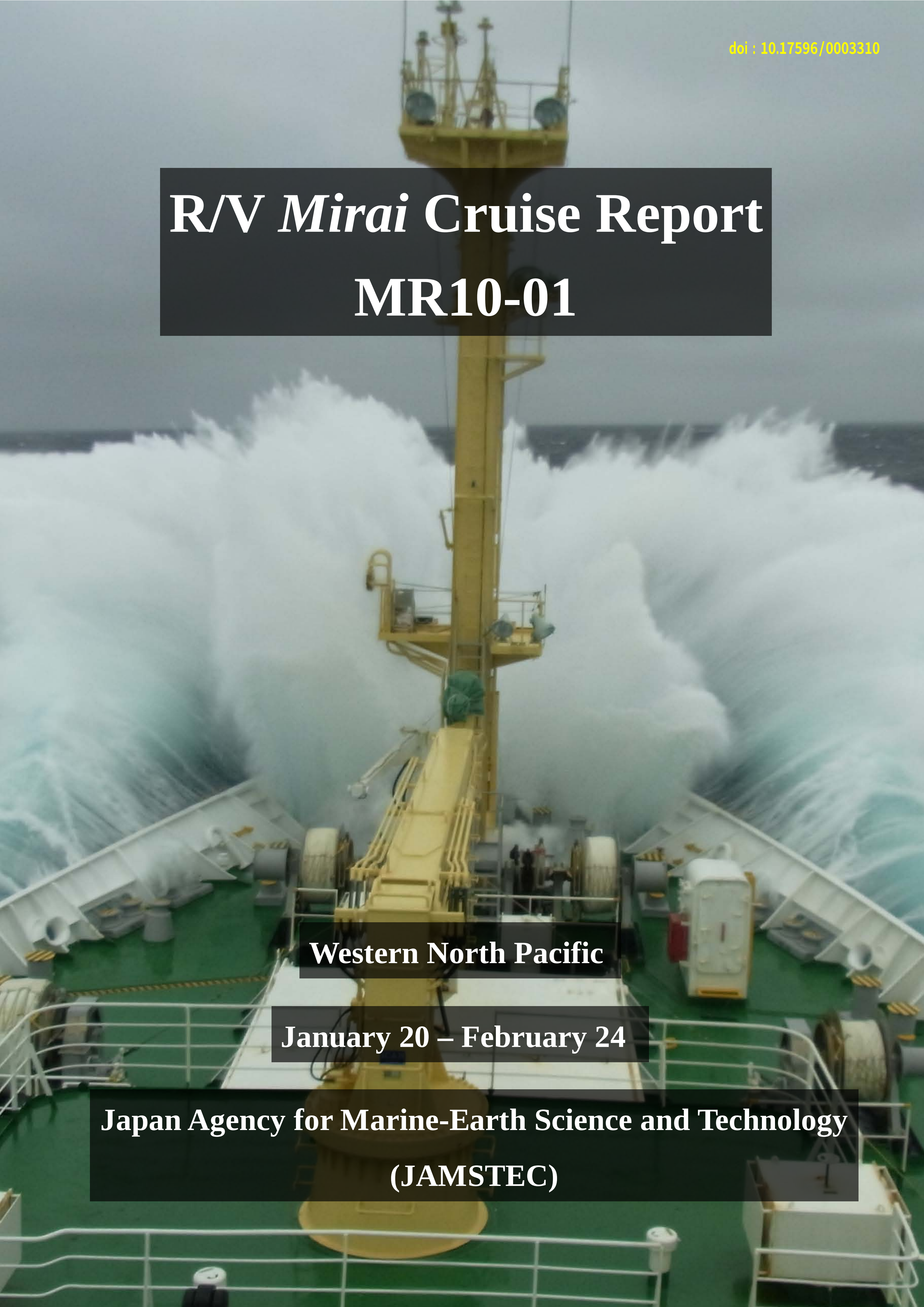

R/V *Mirai* Cruise Report MR10-01

Western North Pacific

January 20 – February 24

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Cruise Report ERRATA of the Photosynthetic Pigments part

page	Error	Correction
110	Ethyl-apo-8'-carotenoate	trans-β-Apo-8'-carotenal

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Notice on using

This cruise report is a preliminary documentation as of the end of the cruise. This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.

Users of data or results on this cruise report are requested to submit their results to the Data Integration and Analysis Group (DIAG) of JAMSTEC.

1. Outline of MR10-01

1.1. Introduction

Some disturbing effects are progressively coming to the fore in the ocean by climate change, such as rising water temperature, intensification of upper ocean stratification and oceanic acidification. It is supposed that these effects result in serious damage to the ocean ecosystems. Disturbed ocean ecosystems will change a material cycle through the change of biological pump efficiency, and it will be fed back into the climate. We are aimed at clarifying the mechanisms of changes in the oceanic structure in ocean ecosystems derived from the climate change.

We arranged the time-series observation stations in the subarctic gyre (K2: 47°N, 160°E) and the subtropical gyre (S1: 30°N, 145°E) in the western North Pacific. In general, biological pump is more efficient in the subarctic gyre than the subtropical gyre because large size phytoplankton is abundant in the subarctic gyre by its eutrophic oceanic condition. However, the responses against climate change will be different in each gyre. To elucidate the oceanic structure in ocean ecosystems at both gyres is important to understand the relationship between material cycle and climate change in global ocean.

There are significant seasonal variations in the ocean environments in both gyres. The seasonal variability of oceanic structures will be estimated by the mooring buoy and the seasonally repetitive ship observations scheduled for next several years.

In addition to the main research theme as described above, the 17 scientific themes which were proposed to this cruise were accepted for obtaining the data in the western North Pacific.

1.2. Cruise information

1.2.1. Cruise ID

MR10-01

Ship: R/V Mirai

Captain: Takao Nakayama

1.2.2. Title of the cruise

Change in material cycles and ecosystem by the climate change and its feed back

1.2.3. Representative of the science party / Title of the proposal

Sanae Chiba (RIGC/JAMSTEC):

"Change in material cycles and ecosystem by the climate change and its feed back"

Toshi Nagata (Ocean Research Institute/The University of Tokyo):

"Studies on the microbial-geochemical processes that regulate the operation of the biological pump in the subarctic and subtropical regions of the western North Pacific"

Toru Kobari (Kagoshima University):

"Effects of mesozooplankton on food web and vertical flux"

Naomi Harada (RIGC/JAMSTEC):

"Study on development of new paleo-proxies"

Hiroaki Yamagishi (National Institute for Environmental Studies):

"Analysis of spatiotemporal distribution of net community productivity base on continuous measurements of dissolved oxygen/argon ratio"

Mitsuhide Satoh (The University of Tokyo):

"Basic studies on effects of iron supply on seasonal variations of cryptophytes in the northwestern Pacific"

Osamu Tsukamoto (Okayama University):

"On-board continuous air-sea eddy flux measurement"

Tetsuichi Fujiki (MIO/JAMSTEC):

"Development of drifting buoy system with *in situ* sea surface pCO_2 sensor"

Atsushi Tsuda (Ocean Research Institute/The University of Tokyo):
"Identification of zooplankton species by fecal pellets"

Nobuo Sugimoto (National Institute for Environmental Studies):
"Lidar observations of optical characteristics and vertical distribution of aerosols and clouds"

Masahisa Kubota (Tokai University):
"Anatomy of the ocean-atmosphere interface in mid-latitudes"

Toshio Suga (RIGC/JAMSTEC):
"Variability of Salinity and Temperature in the North Western Pacific (Argo program)"

Kunio Yoneyama (RIGC/JAMSTEC):
"Archive of surface meteorological data"

Masao Nakanishi (Chiba University):
"Tectonic evolution of the Pacific Plate"

Takeshi Matsumoto (University of the Ryukyus):
"Standardising the marine geophysics data and its application to the ocean floor geodynamics studies"

Hiroshi Ichikawa (RIGC/JAMSTEC):
"Observational Research on the Kuroshio Transport and Sea Surface Flux"

Naoyuki Kurita (RIGC/JAMSTEC):
"Water sampling for making isotope distribution map over the Ocean"

Motoyoshi Oda (Tohoku University):
"Coccolithophore and Planktic foraminiferal ecology at NW Pacific"

1.2.4. Cruise period / Ports of call

Leg1: 20 Jan. 2010 – 6 Feb. 2010 (Sekinehama – Yokohama)

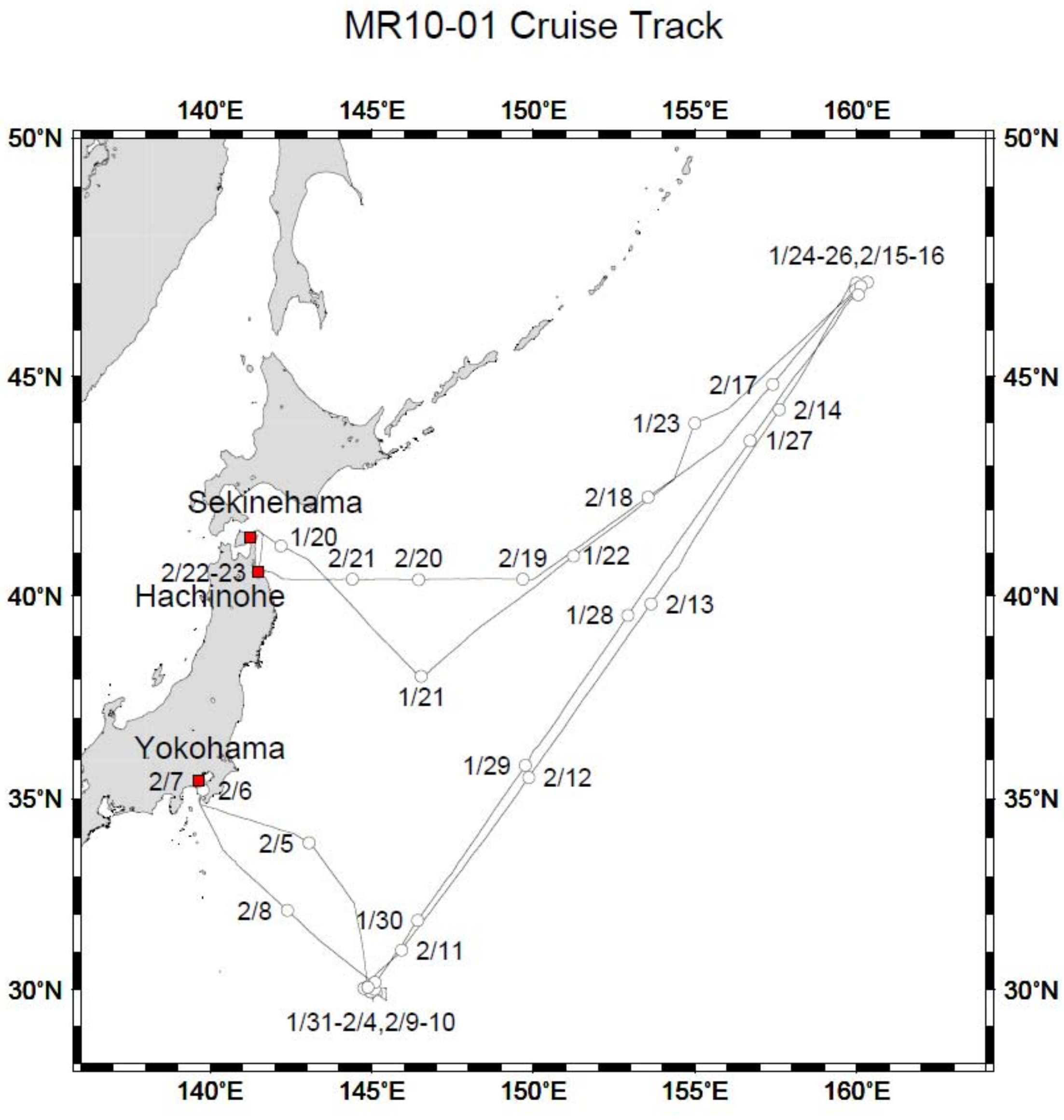
Leg2: 7 Feb. 2010 – 24 Feb. 2010 (Yokohama – Sekinehama)

1.3. Track and log

1.3.1. Research area

Western North Pacific

1.3.2. Cruise track



1.3.3. Cruise log

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
1/19	21:30	1/20	7:30			Deperture from Sekinehama
	23:00		9:00			Surface sea water sampling pump start
1/21	0:23	1/21	10:23	38-05N	146_25E	Arrival at Station JKEO
	1:33		11:33	38-02.65N	146-31.69E	CTD cast #01(5,402m)
	5:23		15:23			Departure from Station JKEO
1/22	21:35	1/23	7:35	44-00N	155-00E	Arrival at Station KNOT
	23:00		9:00	43-59.22N	154-59.79E	CTD cast #02(5,295m)
1/23	2:42		12:42			Departure from Station KNOT
	22:24	1/24	8:24			Arrival at Station K2
	23:32		9:32	46-59.95N	160-09.63E	Surface drifting float buoy deployment
	23:55		9:55	46-59.96N	160-06.85E	Free Fall optical mesurment #01
1/24	3:22		13:22	47-00.19N	159-58.44E	BGC mooring recovery
	6:43		16:43	46-59.9N	159-56.9E	BGC mooring recovery(on deck)
	8:00		18:00	46-59.9N	159-58.7E	CTD cast #03(300m)
	8:45		18:45	46-59.8N	159-59.8E	LISST #01(200m)
	10:00		20:00	46-39.5N	160-00.9E	Twin NORPAC net #01(200m)
	10:22		20:22	46-59.5N	160-01.6E	single NORPAC net #02(50m)
	11:19		21:19	46-59.07N	160-01.68E	IONESS #01(1000m)
	13:15		23:15			Flux mesurments #01
	19:00	1/25	5:00	47-00.18N	159-58.09E	CTD cast #04 (300m)
	22:20		8:20	46-50.77N	160-05.64E	POPPS mooring deployment
1/25	2:30		12:30	46-52.10N	159-58.32E	POPPS mooring Fixed position
	4:12		14:12	46-52.88N	160.00.58E	Free Fall optical mesuremens #02
	5:11		15:11	46-52.19N	160-02.06E	Twin NORPAC net #03(208m)
	5:27		15:27	46-52.14N	160-02.50E	Single NORPAC net #04-1(200m)
	5:45		15:45	46-52.08N	160-03.04E	Single NORPAC net #04-2(213m)
	6:02		16:02	46-51.95N	160-03.50E	Single NORPAC net #04-2(204m)
	6:22		16:22	46-51.63N	160-04.09E	LISST #02(200m)
	6:26		16:26	46-51.68N	160-04.02E	Bucket surface water sampling #01
	7:29		17:29	46-50.99N	160-05.21E	CTD cast #05 (2,000m)
	9:58		19:58	46-50.63N	160-06.61E	Twin NORPAC net #05-1(50m)
	10:10		20:10	46-50.56N	160-06.70E	Twin NORPAC net #05-2(100m)

	10:27		20:27	46-50.53N	160-06.76E	Twin NORPAC net #05-3(200m)
	10:43		20:43	46-50.52N	160-06.76E	Single NORPAC net #06-1(50m)
	10:50		20:50	46-50.50N	160-06.79E	Single NORPAC net #06-2(50m)
	11:15		21:15	46-50.36N	160-06.60E	Flux mesurements #02
	19:01	1/26	5:01	46-57.28N	160-13.14E	CTD cast #06 (300m)
	21:42		7:42	47-00.83N	160-14.89E	Surface drifting float buoy recovery (on deck)
	22:18		8:18	47-01.32N	160-17.82E	CTD cast#07(5204m)
1/26	2:00		12:00			Departure from Station K2
1/30	10:54	1/30	20:54	30-16.51N	145-11.15E	xctd for site survey
	11:00		21:00			Arrival at Station S1
	11:00		21:00			MBES,SBP site survey
	21:01	1/31	7:01	29-58.01N	145-06.97E	Surface drifting float buoy deployment
	22:29		8:29	29-56.24N	144-58.03E	CTD cast#08(200m)
	23:10		9:10	29-56.24N	144-58.03E	CTD cast#09(5892m)
1/31	4:09		14:09	29-56.18N	144-58.60E	FreeFall optical mesuremets #03
	6:00		16:00	30-03.83N	144-57.87E	CTD cast#10(5900m)
	10:24		20:24	30-03.51N	144-57.47E	IONESS #02
	13:50		23:50			Flux mesurements #03
	18:59	2/1	4:59	29-59.86N	144-59.99E	CTD cast#11(300m)
	22:28		8:28	29-59.91N	144-59.43E	POPPS mooring deployment
2/1	2:00		12:00	29-56.16N	144-58.14E	POPPS mooring Fixed position
	2:57		12:57	29-55.56N	144-57.82E	Free Fall optical mesurements #04
	3:46		13:46	29-54.61N	144-58.27E	twin NORPAC net #07(200m)
	4:02		14:02	29-54.48N	144-58.50E	single NORPAC net #08-1(204m)
	4:20		14:20	29-54.33N	144-58.77E	single NORPAC net #08-2(204m)
	5:17		15:17	29-55.49N	144-58.39E	POPPS mooring, Fixed Top buoy position
	5:46		15:46	29-55.71N	144-59-16E	CTD cast#12(300m)
	7:29		17:29	29-53.62N	145-00.83E	CTD cast#13(200m)
	8:07		18:07	29-53.10N	145-01.95E	LISST#03(200m)
	9:58		19:58	29-51.13N	145-03.38E	Twin NORPAC net #09(200m)
	10:19		20:19	29-51.02N	145-03.76E	single NORPAC net #10-1(50m)
	10:27		20:27	29-50.96N	145-03.90E	single NORPAC net #10-2(50m)
	10:34		20:34	29-50.50N	145-04.05E	single NORPAC net #10-3(50m)
	11:08		21:08	29-50.50N	145-04.46E	IONESS #03
	14:25	2/2	0:25			Flux mesurements #04
	18:30		4:30			Flux mesurements #05

2/2	2:59		12:59	30-02.00N	144-43.61E	Twin NORPAC net #11(200m)
	3:18		13:18	30-01.77N	144-43.75E	single NORPAC net #12(200m)
	5:57		15:57	30-03.44N	144-55.99E	CTD cast#14 (5,904m)
	9:59		19:59	30-03.42N	144-55.43E	Twin NORPAC net #13-1(50m)
	10:10		20:10	30-03.49N	144-55.28E	Twin NORPAC net #13-2(151m)
	10:28		20:28	30-03.06N[	144-56.07E	Twin NORPAC net #13-3(203m)
	10:47		20:47	30-03.76N	144-54.99E	Single NORPAC net #14-1(50m)
	10:54		20:54	30-03.83N	144-54.86E	Single NORPAC net #14-2(50m)
	11:01		21:01	30-03.89N	144-54.83E	Single NORPAC net #14-3(50m)
	11:45		21:45			Flux mesurements #06
	19:02	2/3	5:02	30-00.51N	145-26.03E	CTD cast #15(300m)
	19:56		5:56	30-00.42N	145-27.05E	FRRF #01
	21:37		7:37	30-02.18N	145-26.82E	Surface drifting float buoy recovery
2/3	0:30		10:30	29-59.90N	145-06.40E	FRRF #02
	2:45		12:45	30-01.19N	145-04.59E	BGC mooring deployment
	7:25		17:25	30-03.88N	144-57.96E	BGC mooring Fixed position
	8:25		18:25	30-03.50N	144-56.60E	LISST #04
	8:29		18:29			Bucket surface water sampling #02
	9:23		19:23	30-02.66N	144-55.71E	Calibration for magnetometer #01
	9:50		19:50			Flux mesurements #07
	21:55	2/4	7:55	29-59.82N	145-00.17E	ALGO float deployment #01
	22:15		8:15	30-00.05N	144-59.67E	IONESS #04
2/4	2:06		12:06			Departure from Station S1
	7:35		17:35	30-00.01N	144-44.73E	ARGO float deployment #02
	15:11	2/5	1:11	32-15.75N	144-28.17E	xctd at Station KEO
2/5	22:15	2/6	8:15			Surface sea water sampling pump stop
2/6	4:00		14:00			Arrival at Yokohama
2.8	18:36	2.9	04:36	30-00N	145-00E	Arrival at Station S1
	18:58		04:58	30-08.99N	145-06.12E	CTD cast #16 (300 m)
	19:52		05:52	30-09.25N	145-06.56E	FRRF #03 (200 m)
	20:36		06:36	30-09.29N	145-06.67E	Surface drifting float buoy deployment
	22:08		08:08	30-12.38N	145-06.33E	Multipul core #01
2.9	1:59		11:59	30-11.86N	145-06.04E	NORPAC net #15 (202 m)
	2:15		12:15	30-11.79N	145-06.09E	NORPAC net #15-2 (200 m)
	2:32		12:32	30-11.70N	145-06.22E	FRRF #04 (200 m)
	3:11		13:11	30-11.62N	145-06.23E	Free fall optical measruements #05

	4:08		14:08	30-11.29N	145-05.78E	VMPS #01-1 (50 m)
	4:29		14:29	30-11.26N	145-05.77E	VMPS #01-2 (300 m)
	5:19		15:19	30-11.27N	145-05.75E	VMPS #01-3 (150 m)
	5:51		15:51	30-11.31N	145-05.67E	VMPS #01-4 (200 m)
	6:28		16:28	30-10.91N	145-05.67E	CTD cast #17 (5,001 m)
	9:35		19:35	30-10.54N	145-06.43E	NORPAC net #16-1 (200 m)
	9:50		19:50	30-10.48N	145-06.54E	NORPAC net #16-2 (100 m)
	9:59		19:59	30-10.42N	145-06.63E	NORPAC net #16-3 (100 m)
	10:36		20:36	30-10.23N	145-06.32E	IONESS #05 (1,000 m)
	14:00	2.10	00:00	-	-	Flux mesurements start
	18:20		04:20			Flux mesurements finish
	18:57		04:57	30-09.69N	144-55.14E	CTD cast #18 (300 m)
	20:53		06:53	30-09.35N	144-56.15E	CTD cast #19 (497 m)
	22:06		08:06	30-09.00N	144-56.14E	IONESS #06 (1,000 m)
2.10	1:40		11:40	30-03.64N	144-52.85E	NORPAC net #17-1 (200 m)
	1:52		11:52	30-03.68N	144-53.01E	NORPAC net #17-2 (200 m)
	2:05		12:05	30-03.73N	144-53.24E	NORPAC net #17-3 (200 m)
	2:22		12:22	30-03.78N	144-53.48E	NORPAC net #17-4 (200 m)
	2:43		12:43	30-03.60N	144-53.62E	Free fall optical measruements #06
	3:19		13:19	30-03.17N	144-54.11E	CTD cast #20 (5,891 m)
	3:36		13:36	30-03.41N	144-54.77E	XBT observation #01
	7:41		17:41	30-02.43N	144-54.93E	VMPS #02-1 (1,000 m)
	8:58		18:58	30-02.51N	144-56.06E	Flux mesurements stop
	9:34		19:34	30-02.46N	144-55.15E	VMPS #02-3 (75 m)
	9:59		19:59	30-02.50N	144-55.19E	VMPS #02-4 (200 m)
	10:52		20:52	30-02.03N	144-55.21E	NORPAC net #18-1 (200 m)
	11:06		21:06	30-01.99N	144-55.35E	NORPAC net #18-2 (100 m)
	11:16		21:16	30-01.96N	144-55.49E	NORPAC net #18-3 (100 m)
	11:34		21:34	30-01.96N	144-55.72E	CTD cast #21 (200 m)
	12:20		22:20	-	-	Flux mesurements start
	16:15	2.11	02:15	-	-	Flux mesurements finish
	18:59		04:59	30-22.68N	145-06.95E	CTD cast #22 (300 m)
	21:02		07:02	30-22.09N	145-08.09E	Surface drifting float buoy recovory
	21:42		07:42	-	-	Departure from Station S1
2.11	1:36		11:36	30-59.95N	145-51.98E	XBT observation #02
	6:36		16:36	31-59.81N	146-44.91E	XCTD observation #03

	12:00		22:00	32-59.97N	148-37.97E	XBT observation #03
	14:50	2.12	00:50	33-29.80N	148-03.59E	XCTD observation #04
	17:41		03:41	33-59.92N	148-31.74E	XCTD observation #05
	17:42		03:42	34-00.03N	148-31.82E	ARGO float #01 deployment
	20:24		06:24	34-29.76N	148-57.57E	XCTD observation #06
	22:59		08:59	34-59.81N	149-24.00E	XCTD observation #07
	0:21		10:21	35-14.96N	149-36.35E	XCTD observation #08
2.12	1:44		11:44	35-29.78N	149-48.62E	XCTD observation #09
	3:13		13:13	35-44.84N	150-01.55E	XCTD observation #10
	4:56		14:56	35-59.84N	150-14.84E	XCTD observation #11
	6:33		16:33	36-15.02N	150-28.26E	XCTD observation #12
	8:01		18:01	36-29.78N	150-41.31E	XCTD observation #13
	10:57		20:57	36-59.77N	151-07.37E	XCTD observation #14
	13:42		23:42	37-29.78N	151-32.89E	XCTD observation #15
	16:27	2.13	2:27	37-59.79N	152-00.67E	XCTD observation #16
	21:41		07:41	38-59.93N	152-53.96E	XBT observation #04
2.13	3:02		13:02	39-59.84N	153-48.49E	XCTD observation #17
	4:10		14:10	40-12.01N	153-59.93E	ARGO float #02 deployment
	14:00	2.15	0448	47-00N	160-00E	Arrival at Station K2
	19:03		05:03	46-59.62N	160-08.71E	CTD cast #23 (300 m)
	21:13		07:13	46-58.26N	160-07.88E	CTD cast #24 (5,248 m)
	21:31		07:31	46-58.57N	160-08.15E	XBT observation #05
2.15	0:50		10:50	46-57.21N	160-07.01E	Free fall optical measruements #07
	2:43		12:43	46-57.38N	160-06.56E	BGC mooring deployment
	6:55		16:55	47-00.34N	159-58.24E	BGC mooring Fixed position
	7:28		17:28	47-01.22N	160-00.86E	FRRF #05
	8:24		18:24	47-01.24N	160-00.84E	VMPS #03-1 (1,000 m)
	9:38		19:38	47-01.31N	160-00.63E	VMPS #03-2 (200 m)
	10:09		20:09	47-01.38N	160-00.41E	VMPS #03-3 (75 m)
	10:49		20:49	47-01.56N	159-59.76E	IONESS #07 (1,000 m)
	14:22	2.16	00:22	-	-	Flux mesurements
	18:59		04:59	46-52.53N	160-01.36E	CTD cast #25 (300 m)
	19:52		05:52	46-52.38N	160-01.47E	NORPAC net #19-1 (200 m)
	20:07		06:07	46-52.33N	160-01.33E	NORPAC net #19-2 (200 m)
	20:22		06:22	46-52.28N	160-01.51E	NORPAC net #19-3 (200 m)
	20:40		06:40	46-52.23N	160-01.53E	NORPAC net #19-4 (200 m)

	21:16		07:16	46-52.15N	160-01.85E	CTD cast #26 (300 m)
	22:56		08:56			IONESS #08 (1,000 m)
2.16	3:02		13:02	46-44.87N	160-05.25E	NORPAC net #20-1 (200 m)
	3:19		13:19	46-44.91N	160-05.24E	NORPAC net #20-2 (200 m)
	3:25		13:25	46-44.93N	160-05.25E	NORPAC net #20-3 (200 m)
	3:40		13:40	46-45.05N	160-05.06E	CTD cast #27 (1,000 m)
	6:47		16:47			Multipul core #02
2.16	10:24		20:24	-	-	Departure from Station K2
2.19	12:00	2.19	22:00	-	-	Time adjustment -1 hours (SMT=UTC-10h)
2.20	20:00	2.21	06:00	40-23N	144-25E	Arrival at CTD cable free fall station
	22:50		08:50	40-26.65N	144-20.64E	Calibration for magnetometer #02
2.21	0:06		10:06	40-23.51N	144-24.01E	CTD cable free fall (7,000 m)
	5:00		15:00	-	-	Departure from CTD cable free fall station
	8:00		22:00	-	-	Time adjustment -1 hours (SMT=UTC-9h)
2.22	1:00	2.22	10:00	40-34N	141-29E	Arrival at Hachinohe
	6:00	2.23	15:00	-	-	Departure from Hachinohe
2.24	0:00	2.24	09:00	41-22N	141-14E	Arrival at Sekinehama

1.4. Researchers

1.4.1. Chief scientist

Kazuhiko Matsumoto

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Research Institute for Global Change (RIGC)

Mutsu Institute for Oceanography (MIO)

2-15 Natsushima-cho, Yokosuka 237-0061, Japan

1.4.2. List of participants

List of participants for leg 1

Name	**Affiliation**
Kazuhiko Matsumoto (Chief scientist)	RIGC / MIO / JAMSTEC
Minoru Kitamura	Biogeos / JAMSTEC
Hajime Kawakami	RIGC / MIO / JAMSTEC
Masahide Wakita	RIGC / MIO / JAMSTEC
Tetsuichi Fujiki	MIO / JAMSTEC
Makio Honda	MARITEC / JAMSTEC
Hideki Fukuda	ORI / The University of Tokyo
Mario Uchimiya	ORI / The University of Tokyo
Takuya Maesawa	ORI / The University of Tokyo
Jaeho Song	ORI / The University of Tokyo
Masato Minowa	Kagoshima University
Haruko Mori	Kagoshima University
Hiroyasu Akamatsu	Kagoshima University
Hiroaki Yamagishi	National Institute for Environmental Studies
Tetsuya Nakamura	Nichiyu Giken Kogyo Co., LTD.
Mitsuhide Sato	The University of Tokyo
Takuma Suzuki	The University of Tokyo
Fumiyoshi Kondo	ORI / The University of Tokyo
Yasuo Kamei	Okayama University
Kenichiro Sato (Chief technologist)	Marine Works Japan Ltd. (MWJ)
Kenichi Katayama	MWJ
Tatsuya Tanaka	MWJ

Yuichi Sonoyama	MWJ
Yoshiko Ishikawa	MWJ
Misato Kuwahara	MWJ
Ai Takano	MWJ
Hirokatsu Uno	MWJ
Ushiromura Hiroki	MWJ
Miyo Ikeda	MWJ
Shoko Tatamihashi	MWJ
Yasuhiro Arii	MWJ
Tomonori Watai	MWJ
Yusuke Sato	MWJ
Ei Hatakeyama	MWJ
Ai Yasuda	MWJ
Toru Idai	MWJ
Yuya Higashi	MWJ
Katsuhisa Maeno (Chief technologist)	Global Ocean Development Inc. (GODI)
Norio Nagahama	GODI

List of participants for leg 2

Name	**Affiliation**
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Minoru Kitamura	Biogeos / JAMSTEC
Hajime Kawakami	RIGC / MIO / JAMSTEC
Masahide Wakita	RIGC / MIO / JAMSTEC
Tetsuichi Fujiki	MIO / JAMSTEC
Susumu Yoshizawa	ORI / The University of Tokyo
Ryo Kaneko	ORI / The University of Tokyo
Akiko Tomaru	ORI / The University of Tokyo
Yumiko Obayashi	Yokohama National University
Toru Kobari	Kagoshima University
Masato Minowa	Kagoshima University
Haruko Mori	Kagoshima University
Hiroaki Yamagishi	National Institute for Environmental Studies

Katsunori Kimoto	RIGC / JAMSTEC
Yurika Ujiie	Shinshu University
Takuma Suzuki	The University of Tokyo
Yasuo Kamei	Okayama University
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Shinsuke Toyoda	MWJ
Akira Watanabe	MWJ
Masanori Enoki	MWJ
Kimiko Nishijima	MWJ
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Hironori Sato	MWJ
Hirokatsu Uno	MWJ
Ushiromura Hiroki	MWJ
Miyo Ikeda	MWJ
Shoko Tatamihashi	MWJ
Yasuhiro Arii	MWJ
Tomonori Watai	MWJ
Yusuke Sato	MWJ
Ei Hatakeyama	MWJ
Ai Yasuda	MWJ
Toru Idai	MWJ
Yuya Higashi	MWJ
Katsuhisa Maeno (Chief technologist)	Global Ocean Development Inc. (GODI)
Norio Nagahama	GODI

2. General observation

2.1. Meteorological observations

2.1.1. Surface Meteorological Observation

Kunio Yoneyama	**(JAMSTEC) Principal Investigator / Not on-board**
Katsuhisa Maeno	**(Global Ocean Development Inc., GODI)**
Norio Nagahama	**(GODI)**
Wataru Tokunaga	**(Mirai Crew)**

(1) Objectives

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

Surface meteorological parameters were observed throughout the MR10-01 cruise. During this cruise, we used three systems for the observation.

i. MIRAI Surface Meteorological observation (SMet) system
ii. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

i. MIRAI Surface Meteorological observation (SMet) system

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

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

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

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

SCS recorded PRP data every 6 seconds, while 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.

For the quality control as post processing, we checked the following sensors, before and after the cruise.

i. Young Rain gauge (SMet and SOAR)

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

ii. Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB220CASE, VAISALA.

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

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

(3) Preliminary results

Figure 2.1.1-1 shows the time series of the following parameters;
Wind (SMet)
Air temperature (SMet)
Relative humidity (SMet)
Precipitation (SOAR, Optical rain gauge)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(4) Data archives

These meteorological data will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC just after the cruise. Corrected data sets will be available from K. Yoneyama of JAMSTEC.

(5) Remarks

i. SST (Sea Surface Temperature) data were available in the following periods.
00:10UTC 20 Jan. - 23:14UTC 5 Feb. 2010
09:00UTC 7 Feb. - 03:30UTC 21 Feb. 2010

ii. SMet ORG cleaning
00:42UTC 27 Jan., 03:17UTC 31 Jan., 23:16UTC 6 Feb., 00:49UTC 15 Feb.

iii. SMet Young rain gauge includes invalid data at the following time due to MF/HF transmit.
04:04UTC, 04:45UTC 24 Jan.
23:00UTC 28 Jan.
22:25UTC, 22:30UTC 30 Jan.
01:15UTC, 01:20UTC 8 Feb.
09:15UTC, 21 Feb.

iv. SOAR optical rain gauge cleaning
02:00UTC 31 Jan., 01:43UTC 23 Feb.

v. SMet navigation data was invalid at the following time.
04:54UTC 7 Feb.

vi. PRP cleaning
01:20UTC 3 Feb., 01:44UTC 23 Feb.

vii. In the following period, PRP was stopped due to the communication trouble.
13:08UTC 28 Jan. - 01:39UTC 31 Jan. 2010
00:47UTC 3 Feb. - 01:50UTC 3 Feb. 2010

viii. In the following period, PIR(PRP11) data is invalid.
01:39UTC 31 Jan. - 00:47UTC 3 Feb. 2010

viiii. Inspection of Young Rain gauge (SMet and SOAR) was done at Hachinohe Port.
SMet: 05:30 - 06:35UTC 22 Feb. 2010
SOAR: 00:09 –01:30UTC 23 Feb. 2010

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-815DR	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-200	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table.2.1.1-2 Parameters of MIRAI Surface Meteorological observation system

Parameter		Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Ship's speed	knot	Mirai log, DS-30 Furuno
4	Ship's heading	degree	Mirai gyro, TG-6000, Tokimec
5	Relative wind speed	m/s	6sec./10min. averaged
6	Relative wind direction	degree	6sec./10min. averaged
7	True wind speed	m/s	6sec./10min. averaged
8	True wind direction	degree	6sec./10min. averaged
9	Barometric pressure	hPa	adjusted to sea surface level
			6sec. averaged
10	Air temperature (starboard side)	degC	6sec. averaged
11	Air temperature (port side)	degC	6sec. averaged
12	Dewpoint temperature (starboard side)	degC	6sec. averaged
13	Dewpoint temperature (port side)	degC	6sec. averaged
14	Relative humidity (starboard side)	%	6sec. averaged
15	Relative humidity (port side)	%	6sec. averaged
16	Sea surface temperature	degC	6sec. averaged
17	Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18	Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19	Down welling shortwave radiation	W/m2	6sec. averaged
20	Down welling infra-red radiation	W/m2	6sec. averaged
21	Significant wave height (bow)	m	hourly
22	Significant wave height (aft)	m	hourly
23	Significant wave period (bow)	second	hourly
24	Significant wave period (aft)	second	hourly

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

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Barometer	61202V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (23 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	Epply Labs, USA	foremast (25 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (25 m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25 m)

Table.2.1.1-4 Parameters of SOAR system

Parameter		Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	SOG	knot	
4	COG	degree	
5	Relative wind speed	m/s	
6	Relative wind direction	degree	
7	Barometric pressure	hPa	
8	Air temperature	degC	
9	Relative humidity	%	
10	Rain rate (optical rain gauge)	mm/hr	
11	Precipitation (capacitive rain gauge)	mm	reset at 50 mm
12	Down welling shortwave radiation	W/m2	
13	Down welling infra-red radiation	W/m2	
14	Defuse irradiance	W/m2	

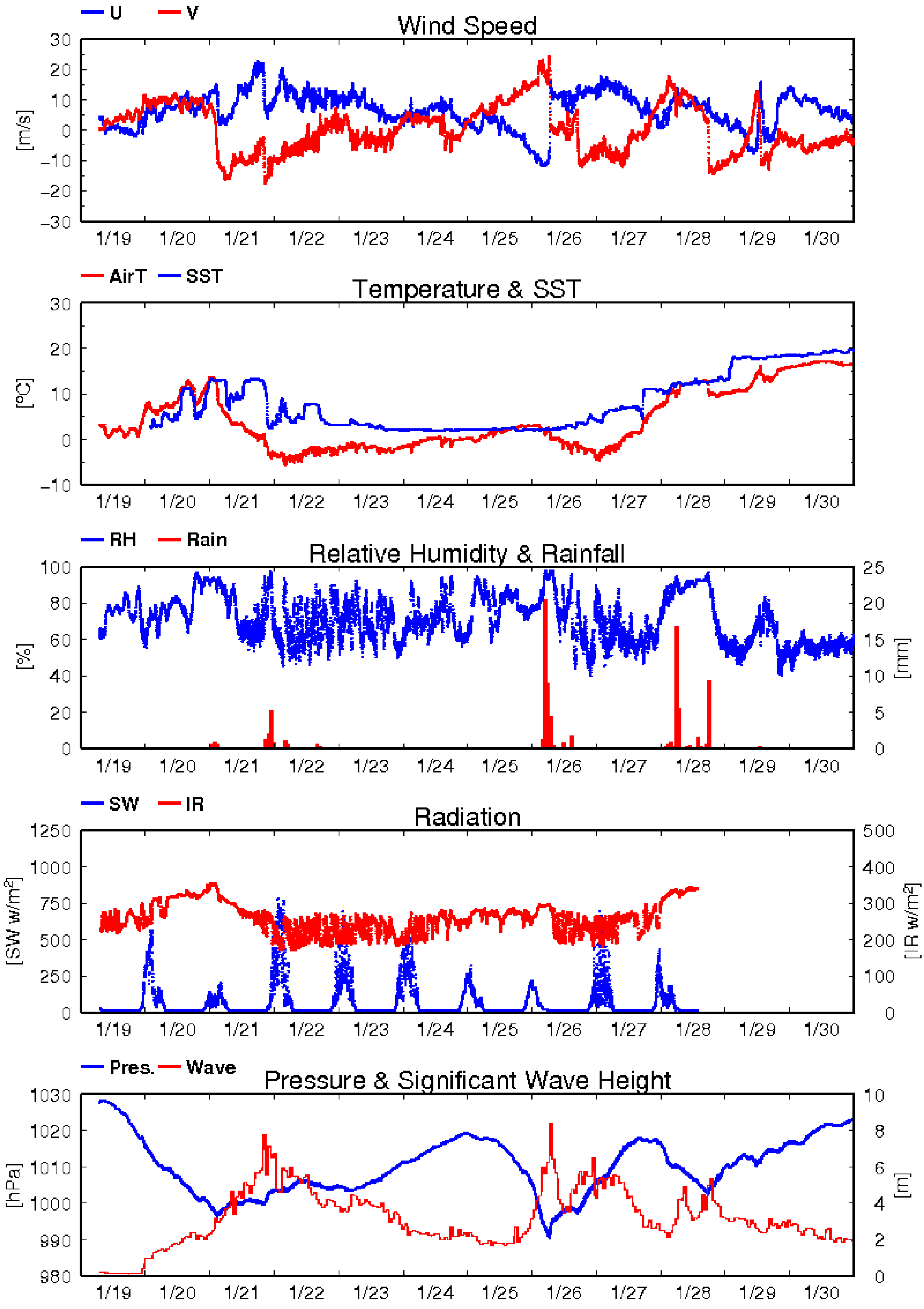

Fig.2.1.1-1 Time series of surface meteorological parameters during the MR10-01 cruise

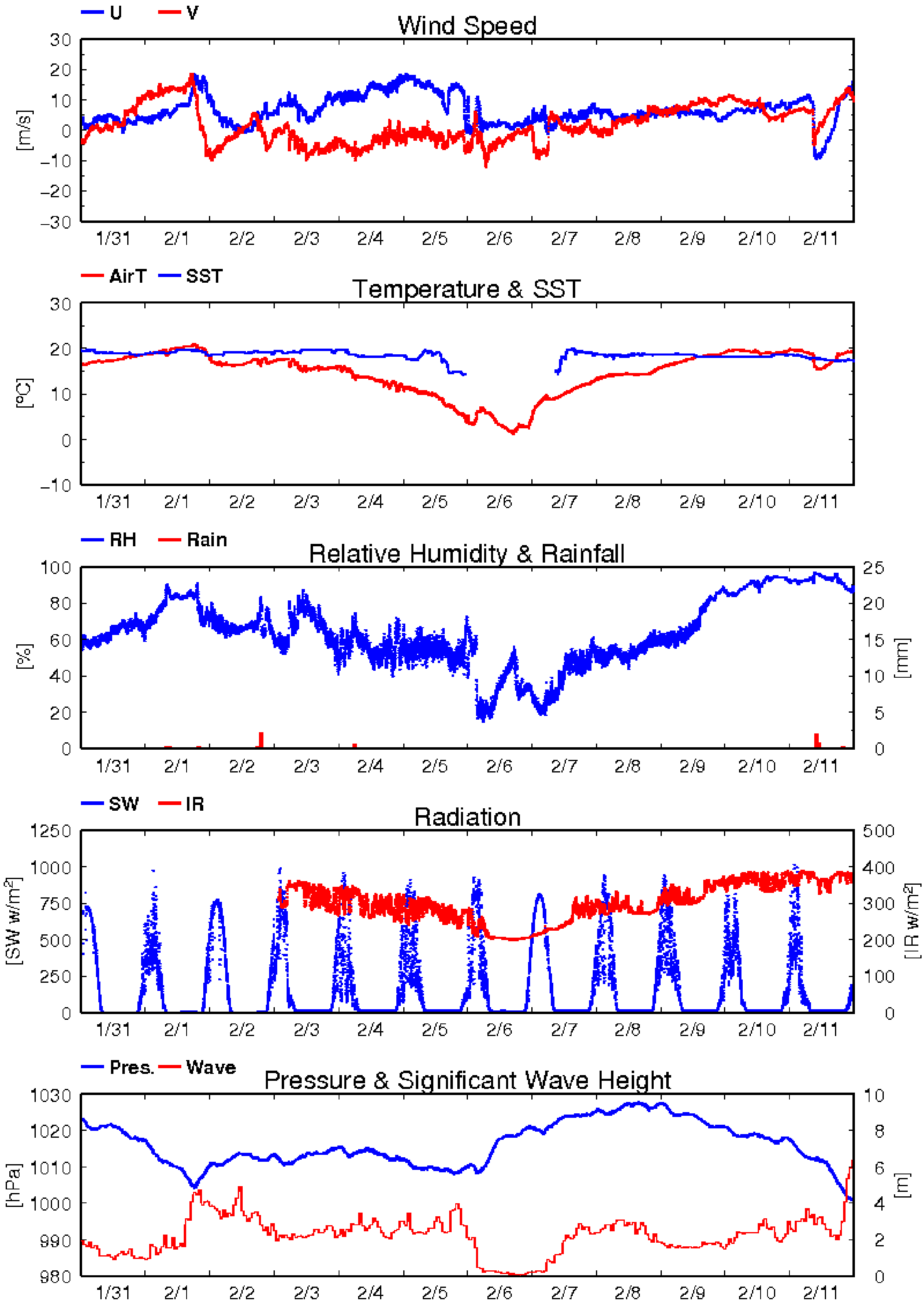

Fig.2.1.1-1 Continued

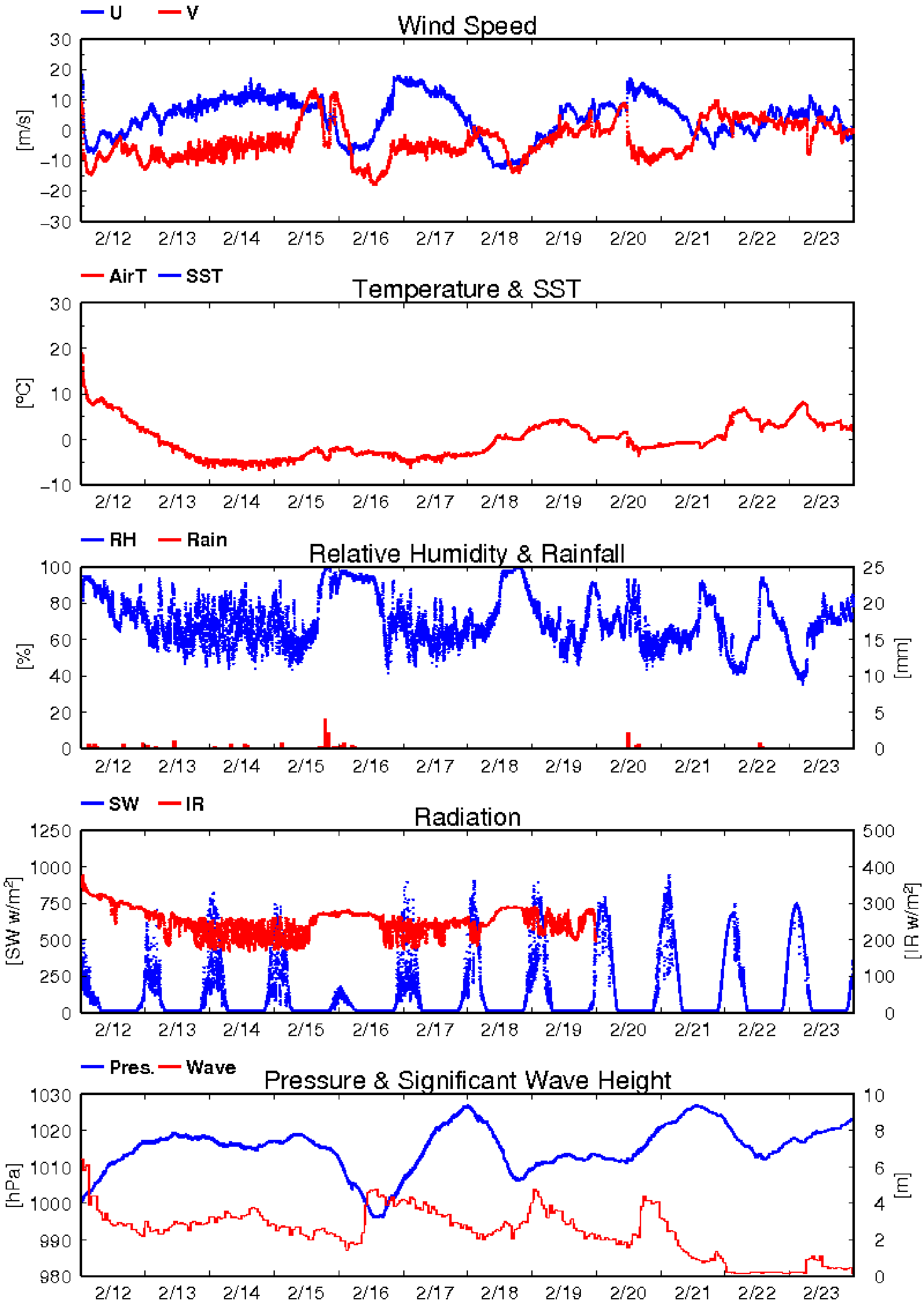

Fig.2.1.1-1 Continued

2.1.2. Ceilometer Observation

Kunio Yoneyama (JAMSTEC) Principal Investigator / Not on-board
Katsuhisa Maeno (Global Ocean Development Inc., GODI)
Norio Nagahama (GODI)
Wataru Tokunaga (Mirai Crew)

(1) Objectives

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

(2) Parameters

1. Cloud base height [m].
2. Backscatter profile, sensitivity and range normalized at 30 m resolution.
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR10-01 cruise from the departure of Sekinehama on 20 January 2010 to arrival of Sekinehama on 24 February 2010.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) 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).

(4) Preliminary results

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

(5) Data archives

The raw data obtained during this cruise will be submitted to the Data Integration and Analysis Group (DIAG) in JAMSTEC.

(6) Remarks

1. Window cleaning;
   00:41UTC 28 Jan., 03:16UTC 31 Jan., 23:15UTC 6 Feb., 00:49UTC 15 Feb.
2. Data acquisition was suspended due to the PC trouble.
   11:31 - 13:10UTC 20 Feb. 2010

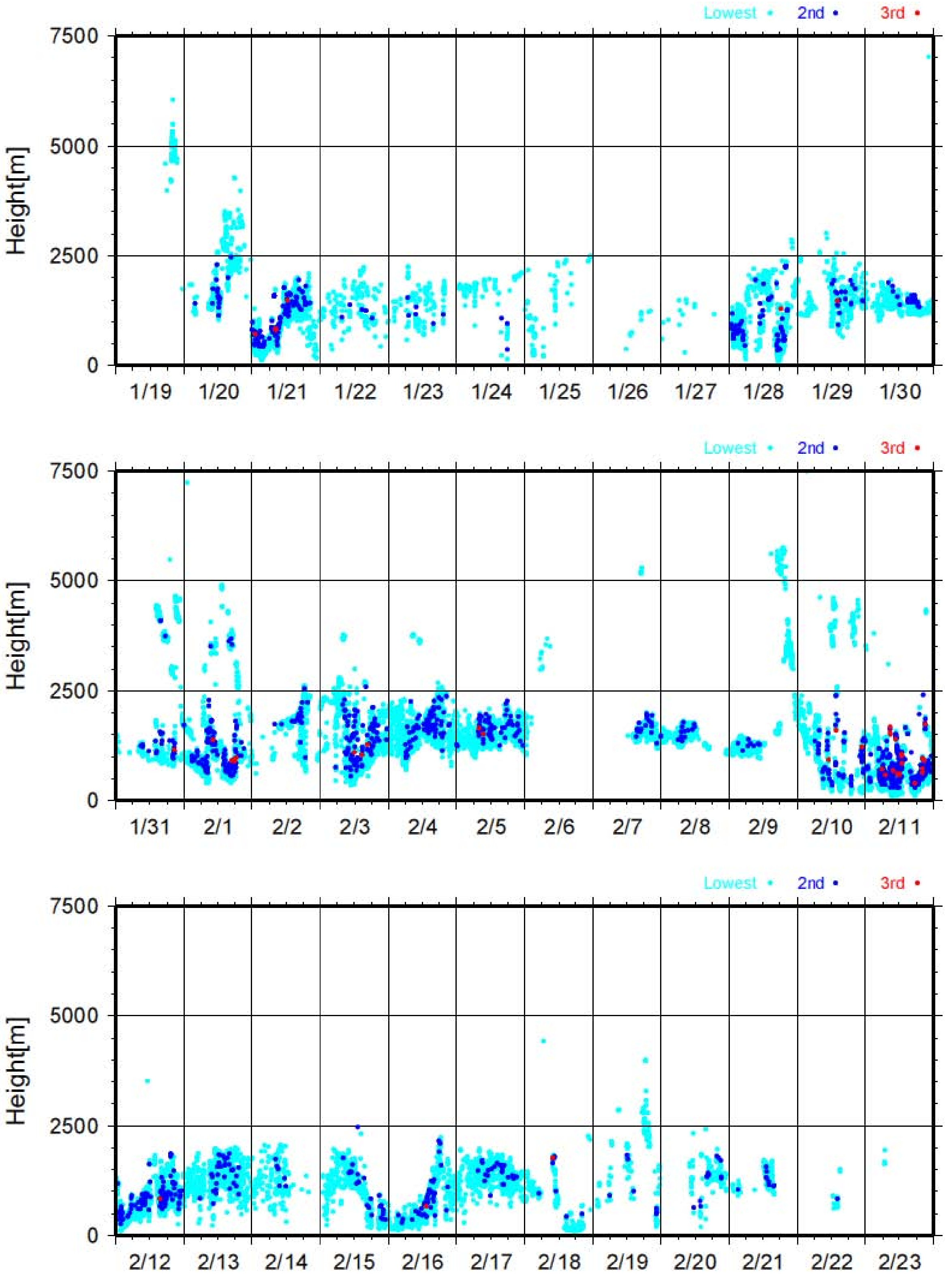

Fig.2.1.2-1 Lowest (blue), 2nd (green) and 3rd(red) cloud base height during the cruise.

2.1.3. Lidar observations of clouds and aerosols

(1) Personnel

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

(2) Objectives

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

(3) Measured parameters

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

(4) Method

Vertical profiles of aerosols and clouds were measured with a two-wavelength lidar. The lidar employs a Nd:YAG laser as a light source which generates the fundamental output at 1064 nm and the second harmonic at 532 nm. Transmitted laser energy is typically 100 mJ per pulse at 1064 nm and 50 mJ per pulse at 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.

(5) Results

Data obtained in this cruise has not been analyzed.

(6) 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 (utc) : 21:45 Nov. 3, 2009 – 00:00 Dec. 12, 2009,

- 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

2.1.4. Water isotopes in atmospheric vapor, precipitation, and sea surface water

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator（not on-board）

Operator

Katsuhisa Maeno (Global Ocean Development Inc.: GODI)

Norio Nagahama (GODI)

Wataru Tokunaga (MIRAI Crew)

(2) Objective

It is well known that the variability of stable water isotopes (HDO and $H_2^{18}O$) is closely related with the moisture origin and hydrological processes during the transportation from the source region to deposition site. Thus, water isotope tracer is recognized as the powerful tool to study of the hydrological cycles in the atmosphere. However, oceanic region is one of sparse region of the isotope data, it is necessary to fill the data to identify the moisture sources by using the isotope tracer. In this study, to fill this sparse observation area, intense water isotopes observation was conducted along the cruise track of MR10-01.

(3) Method

Following observation was carried out throughout this cruise.

- Atmospheric moisture sampling:

  Water vapor was sampled from the height about 20m above the sea level. The air was drawn at rate of 1.6-4.5L/min through a plastic tube attached to top of the compass deck. The flow rate is regulated according to the water vapor content to collect the sample amount 10-30ml. The water vapor was trapped in a glass trap submerged into an ethanol cooled to 100 degree C by radiator, and then they are collected every 12 hour during the cruise. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Rainwater sampling

  Rainwater samples gathered in rain collector were collected just after precipitation events have ended. The collected sample was then transferred into glass bottle (6ml) immediately after the measurement of precipitation amount.

- Surface seawater sampling

  Seawater sample taken by the pump from 4m depth were collected in glass bottle (6ml) around the noon at the local time.

(4) Results

Sampling of water vapor for isotope analysis is summarized in Table 2.1.4-1 (57 samples). The detail of rainfall sampling (8 samples) is summarized in Table 2.1.4-2. Described rainfall amount is calculated from the collected amount of precipitation. Sampling of surface seawater taken by pump from 4m depths is summarized in Table 2.1.4-3 (31 samples).

(5) Data archive

Isotopes (HDO, $H_2^{18}O$) analysis will be done at RIGC/JAMSTEC, and then analyzed isotopes data will be submitted to JAMSTEC Data Integration and Analysis Group (DIAG).

Table 2.1.4-1 Summary of water vapor sampling for isotope analysis

Sample No.	Date	Time (UT)	Date	Time (UT)	Lon	Lat	Total (m3)	MASS (ml)
V-02	1/19	22:03	1/20	10:00	143-40.03E	40-20.75N	2.16	7.0
V-03	1/20	10:04	1/20	21:03	145-46.96E	38-36.85N	1.98	13.0
V-04	1/20	21:07	1/21	09:00	147-18.43E	38-32.36N	2.13	15.0
V-05	1/21	09:03	1/21	21:05	150-07.88E	40-15.46N	2.18	6.5
V-06	1/21	21:15	1/22	09:00	152-55.93E	41-52.01N	2.13	3.9
V-07	1/22	09:04	1/22	21:01	154-55.98E	43-52.57N	2.33	5.0
V-08	1/22	21:05	1/23	09:00	156-45.43E	44-46.40N	2.86	6.1
V-09	1/23	09:03	1/23	21:00	159-50.12E	46-47.06N	3.61	8.0
V-10	1/23	21:02	1/24	21:00	160-05.92E	46-52.02N	7.23	19.5
V-11	1/24	21:03	1/25	21:00	160-14.95E	47-00.91N	7.22	26.0
V-12	1/25	21:05	1/26	09:00	159-21.55E	46-11.89N	?	13.5
V-13	1/26	09:04	1/27	21:00	157-27.19E	44-21.44N	3.44	8.0
V-14	1/26	21:00	1/27	09:00	155-38.17E	42-29.54N	3.44	6.8
V-15	1/27	09:04	1/27	21:07	153-44.97E	40-26.48N	3.47	9.0
V-16	1/27	21:10	1/28	09:00	151-58.41E	38-26.44N	3.40	22.0
V-17	1/28	09:03	1/28	21:08	150-24.95E	36-37.34N	3.15	24.0
V-18	1/28	21:10	1/29	09:00	148-50.75E	34-46.59N	2.74	12.5
V-19	1/29	09:03	1/29	21:06	147-07.45E	32-41.32N	2.53	18.0
V-20	1/29	21:08	1/30	09:00	145-27.09E	30-36.30N	2.47	17.8
V-21	1/30	09:03	1/31	09:22	144-57.84E	30-03.50N	2.91	23.0
V-22	1/31	09:26	2/1	09:00	145-02.50E	29-52.51N	2.85	28.0
V-23	2/1	09:02	2/2	09:00	144-55.83E	30-03.34N	2.56	25.0
V-24	2/2	09:04	2/3	09:00	144-56.57E	30-03.37N	2.48	22.0
V-25	2/3	09:03	2/4	09:00	144-42.52E	31-13.52N	2.48	18.2
V-26	2/4	09:03	2/4	21:00	143-41.01E	33-11.78N	1.24	5.5
V-27	2/4	21:04	2/5	09:00	141-49.17E	34-18.35N	2.37	10.0
V-28	2/5	09:03	2/5	22:00	140-01.64E	34-46.44N	1.96	10.5
V-29	2/5	22:03	2/6	05:17	139-38.95E	35-27.15N	1.65	3.9
V-30	2/6	05:20	2/7	04:46	139-38.95E	35-27.15N	2.09	3.2
V-31	2/7	04:49	2/7	21:02	141-29.60E	32-48.66N	3.74	12.0

V−32	2/7	21:04	2/8	09:27	143−36.64E	31−09.90N	4.40	18.0
V−33	2/8	09:30	2/8	21:00	145−06.56E	30−09.12N	2.97	18.0
V−34	2/8	21:03	2/9	21:00	144−56.13E	30−09.37N	2.52	23.0
V−35	2/9	21:03	2/10	21:00	145−05.68E	39−22.30N	2.52	34.0
V−36	2/10	21:02	2/11	09:00	147−09.73E	32−28.26N	1.80	26.0
V−37	2/11	09:02	2/11	21:00	149−03.65E	34−36.88N	2.11	28.0
V−38	2/11	21:03	2/12	09:00	150−50.62E	36−39.75N	1.65	14.0
V−39	2/12	09:01	2/12	21:00	152−47.53E	38−52.63N	1.65	7.0
V−40	2/12	21:03	2/13	09:00	154−48.80E	41−07.54N	2.84	7.0
V−41	2/13	09:03	2/13	20:00	156−42.37E	43−18.27N	2.63	5.0
V−42	2/13	20:03	2/14	08:00	158−46.72E	45−38.25N	2.89	5.0
V−43	2/14	08:03	2/14	20:00	160−08.27E	46−58.82N	3.82	6.2
V−44	2/14	20:02	2/15	20:00	160−01.61E	46−52.22N	6.85	14.0
V−45	2/15	20:00	2/16	20:00	158−05.03E	45−25.73N	6.84	20.0
V−46	2/16	20:04	2/17	08:00	156−23.68E	43−59.89N	3.37	6.0
V−47	2/17	08:04	2/17	20:00	154−29.74E	42−47.59N	3.80	6.2
V−48	2/17	20:02	2/18	08:00	152−26.67E	41−42.79N	3.87	7.0
V−49	2/18	08:03	2/18	21:00	150−22.49E	40−35.47N	4.03	15.0
V−50	2/18	21:00	2/19	09:00	148−38.72E	40−23.85N	−	14.0
V−51	2/19	09:04	2/19	21:00	147−03.53E	40−23.35N	3.57	10.0
V−52	2/19	21:04	2/20	09:00	145−33.07E	40−23.13N	3.56	10.0
V−53	2/20	09:03	2/20	21:00	144−24.42E	40−24.00N	3.57	8.0
V−54	2/20	21:02	2/21	09:00	143−40.06E	40−22.90N	3.57	6.5
V−55	2/21	09:03	2/22	00:40	141−29.73E	40−33.47N	4.68	12.0
V−56	2/22	00:42	2/23	05:53	141−29.73E	40−33.47N	−	10.1
V−57	2/23	05:56	2/24	00:00	141−14.38E	41−21.97N	5.46	20.0

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Table 2.1.4-2 Summary of precipitation sampling for isotope analysis.

Sample No.	Date	Time (UT)	Lon	Lat	Date	Time (UT)	Lon	Lat	Sample (ml)	Rain(mm)
R-01	1/28	00:45	153-07.55E	39-45.57N	1/29	00:20	149-56.93E	36-07.90N	202.5	18.9
R-02	1/29	02:55	149-38.67E	35-42.10N	2/01	09:21	145-02.73E	29-52.27N	6.5	0.3
R-03	2/01	09:38	145-02.89E	29-51.68N	2/02	21:17	145-26.76E	30-02.32N	20.0	1.6
R-04	2/08	00:00	142-02.76E	32-22.90N	2/11	21:07	149-04.89E	34-38.28N	17.5	2.3
R-05	2/11	21:10	149-05.44E	34-38.87N	2/12	07:45	150-39.11E	36-27.34N	8.4	0?
R-06	2/12	07:49	150-39.72E	36-28.02N	2/12	21:10	152-49.29E	38-54.52N	7.0	0.4
R-07	2/12	21:12	152-49.65E	38-54.90N	2/19	20:57	147-03.88E	40-23.36N	107.0	183.9
R-08	2/19	21:06	147-02.80E	40-23.32N	2/23	04:31	141-29.73E	40-33.47N	9.5	6.9

Table 2.1.4-3 Summary of water vapor sampling for isotope analysis

Sample No.	Sampling			
	Date	Time (UTC)	Lon	Lat
O-1	2010/01/20	03:03	142-12.74E	41-09.84N
O-2	2010/01/21	02:06	146-31.76E	38-03.12N
O-3	2010/01/22	02:04	151-15.92E	40-56.68N
O-4	2010/01/23	02:01	154-59.89E	43-58.62N
O-5	2010/01/24	04:45	159-56.66E	46-59.73N
O-6	2010/01/25	02:00	159-58.50E	46-52.20N
O-7	2010/01/26	02:00	160-19.61E	47-01.79N
O-8	2010/01/27	02:00	156-41.49E	43-34.20N
O-9	2010/01/28	02:00	152-55.02E	39-31.16N
O-10	2010/01/29	02:00	149-49.91E	35-50.21N
O-11	2010/01/30	02:00	146-25.44E	31-50.90N
O-12	2010/01/31	02:08	144-58.03E	29-56.29N
O-13	2010/02/01	04:19	144-58.66E	29-54.40N
O-14	2010/02/02	02:00	144-45.41E	30-02.47N
O-15	2010/02/03	02:01	145-05.37E	30-00.37N
O-16	2010/02/04	02:02	144-52.79E	30-04.98N
O-17	2010/02/05	02:02	143-02.94E	33-5235N
O-18	2010/02/08	02:03	142-24.02E	32-05.94N
O-19	2010/02/09	02:03	145-06.03E	30-11.87N
O-20	2010/02/10	02:15	144-53.29E	30-03.74N
O-21	2010/02/11	02:03	145-55.79E	31-04.54N
O-22	2010/02/12	02:02	149-51.69E	35-33.15N
O-23	2010/02/13	02:04	153-38.89E	39-49.18N
O-24	2010/02/14	01:01	157-37.13E	44-17.45N
O-25	2010/02/15	01:00	160-07.20E	46-57.09N
O-26	2010/02/16	02:05	160-05.24E	46-44.86N
O-27	2010/02/17	01:01	157-23.38E	44-49.80N
O-28	2010/02/18	01:03	153-31.55E	42-17.22N
O-29	2010/02/19	02:00	149-40.53E	40-23.14N
O-30	2010/02/20	02:00	146-26.76E	40-22.56N
O-31	2010/02/21	02:00	144-23.97E	40-23.51N

2.1.5. Air-Sea Turbulent CO_2 Flux by Eddy Covariance Technique

Fumiyoshi KONDO (The University of Tokyo)
Yasuo KAMEI (Okayama University)
Osamu TSUKAMOTO (Okayama University) * not on board (PI)
Hiroshi ISHIDA (Kobe University) * not on board

(1) Objective

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

(2) Method

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

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

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

(3) Results

Data will be processed after the cruise at Okayama University.

(4) Data Archive

All the data obtained during this cruise are archived at Okayama University, and will be open to public after quality checks and corrections. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department.

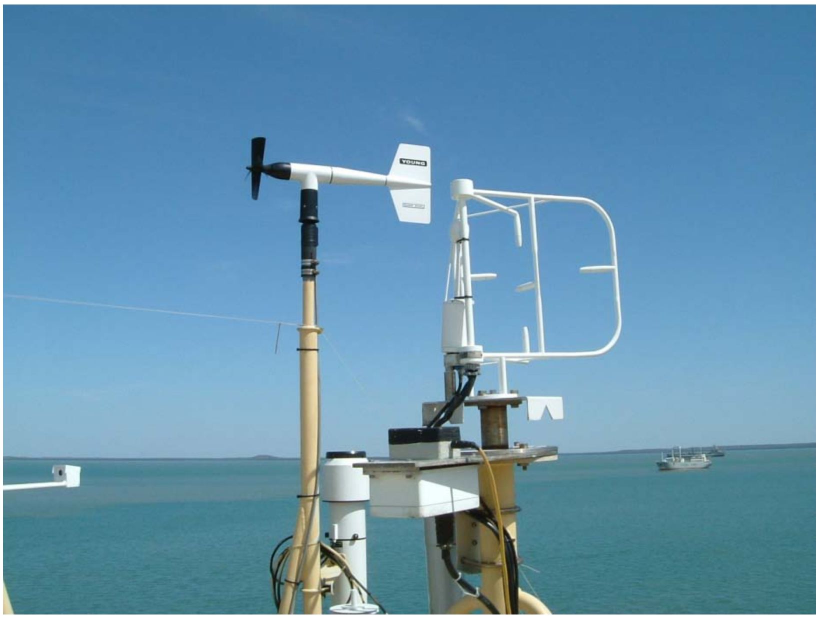

Fig.1. Installation of the turbulent flux and ship motion correction systems on the top of the foremast.

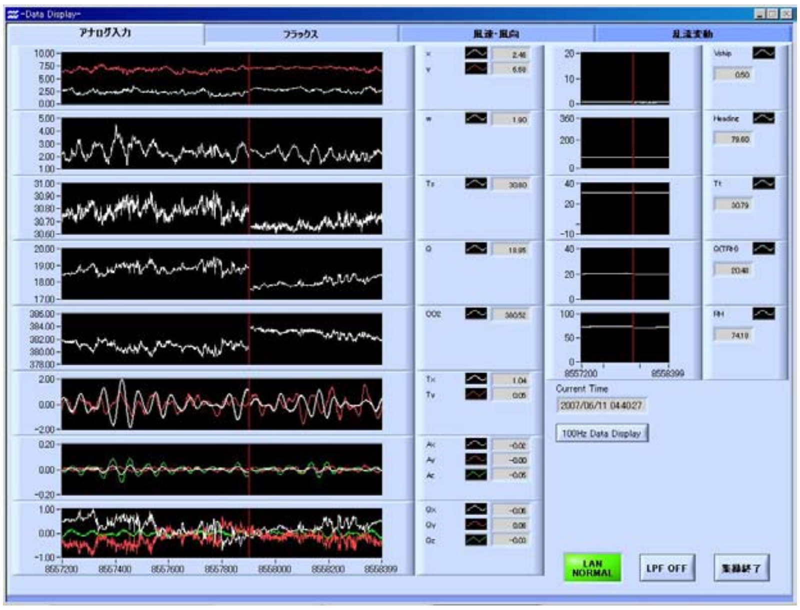

Fig.2. PC-based real time logging and monitoring system using LabVIEW8 software.

2.2. Physical oceanographic observation

2.2.1. CTD cast and water sampling

(1) Personnel

Masahide Wakita	(JAMSTEC): Principal investigator
Kenichi Katayama*	(MWJ): Operation leader
Shinsuke Toyoda**	(MWJ): Operation leader
Hirokatsu Uno	(MWJ)
Hiroki Ushiromura	(MWJ)

(*Leg1 only)
(**Leg2 only)

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary and Secondary)
Fluorescence
Photosynthetically Active Radiation

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles, which were washed by alkaline detergent and 1 N HCl, were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, dissolved oxygen (Primary and Secondary), RINKOⅢ(dissolved oxygen sensor), deep ocean standards thermometer, altimeter, fluorescence and PAR sensor. Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.19) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer.

27 casts of CTD measurements were conducted (table 2.2.1-1).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.18d) and SEASOFT were as follows:

DATCNV: Convert the binary raw data to engineering unit data. DATCNV also extracts 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.

TCORP (original module): Corrected the pressure sensitivity of the temperature (SBE3) sensor.

S/N 031464: 8.94556e-08 (degC/dbar)
S/N 031524: -2.5868e-07 (degC/dbar)
S/N 03P2453: -3.1274e-07 (degC/dbar)

RINKOCOR(original module): Corrected the of hysteresis of RINKOⅢ voltage.

RINKOCORROS(original module): Corrected the of hysteresis of RINKOⅢ voltage bottle data.

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 4.4 seconds.

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

WILDEDIT: Mark 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, depth, temperature, conductivity and dissolved oxygen voltage.

CELLTM: 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: Perform a low pass filter on pressure with a time constant of 0.15 second. In order to produce zero phase lag (no time shift) the filter runs forward first then backward

WFILTER: Perform a median filter to remove spikes in the fluorescence data. A median value was determined by 49 scans of the window.

SECTIONU (original module of SECTION): Select 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 of was set to be the end time when the package came up from the surface.

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

DESPIKE (original module): Remove spikes of the data. A median and mean absolute deviation was calculated in 1-dbar pressure bins for both down and up cast, excluding the flagged values. Values greater than 4 mean absolute deviations from the median were marked bad for each bin. This process was performed 2 times for temperature, conductivity and dissolved oxygen voltage (SBE43).

DERIVE: Compute dissolved oxygen (SBE43).

BINAVG: Average the data into 1-dbar pressure bins.

DERIVE: Compute salinity, potential temperature, and sigma-theta.

SPLIT: Separate the data from an input .cnv file into down cast and up cast files.

Configuration file

JKOM01: R1001A.con
KNTM01 - S01M08: MR1001B.con
S01M09 – K02M10: MR1001C.con

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system
Under water unit:
SBE9plus (S/N 09P79492-0575, Sea-Bird Electronics, Inc.)
Pressure sensor: Digiquartz pressure sensor (S/N 79492)
Calibrated Date: 23 Jul. 2009
Temperature sensors:
Primary: SBE03-04/F (S/N 031464, Sea-Bird Electronics, Inc.)
Calibrated Date: 15 Dec. 2009
→JKOM01 only
Primary: SBE03plus (S/N 03P2453, Sea-Bird Electronics, Inc.)
Calibrated Date: 11 Dec. 2009
→KNTM01 - K02M10
Secondary: SBE03-04/F (S/N 031524, Sea-Bird Electronics, Inc.)
Calibrated Date: 11 Dec. 2009
Conductivity sensors:
Primary: SBE04-04/0 (S/N 041172, Sea-Bird Electronics, Inc.)
Calibrated Date: 08 Jul. 2009
Secondary: SBE04-04/0 (S/N 042854, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 Dec. 2009
Dissolved Oxygen sensors:
Primary: SBE43 (S/N 430330, Sea-Bird Electronics, Inc.)
Calibrated Date: 03 Dec. 2009
Secondary: SBE43 (S/N 430205, Sea-Bird Electronics, Inc.)
Calibrated Date: 13 Jun. 2009
Dissolved Oxygen sensors:
RINKOⅢ(S/N 006, Alec Electronics Co. Ltd.)
Deep Ocean Standards Thermometer:

SBE35 (S/N 0045, Sea-Bird Electronics, Inc.)

Calibrated Date: 19 Aug. 2009

Altimeter:

JKOM01 - S01M08: Benthos PSA-916T (S/N 1157, Teledyne Benthos, Inc.)

S01M09 - K02M10: Benthos PSA-916T (S/N 1100, Teledyne Benthos, Inc.)

Fluorescence: Chlorophyll Fluorometer (S/N 3054, Seapoint Sensors, Inc.)

Photosynthetically Active Radiation: PAR sensor (S/N 0049, Satlantic Inc.)

Carousel water sampler:

SBE32 (S/N 3227443-0391, Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P7030-0272, Sea-Bird Electronics, Inc.)

(5) Preliminary Results

During this cruise, 27 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 2.2.1-1.

(6) Data archive

All raw and processed data files were copied onto HD provided by Data Integration and Analyses Group (DIAG), JAMSTEC will be opened to public via “R/V MIRAI Data Web Page” in the JAMSTEC home page.

Table 2.2.1-1 CTD Casttable

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	HT Above	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Bottom	Depth	Pressure	Filename	
JKO	1	012110	01:39	05:19	38-02.64N	146-31.68E	5420.0	5578.6	8.2	5402.6	5513.4	JKOM01	
KNT	1	012210	23:05	02:37	43-59.22N	154-59.78E	5336.0	5399.7	10.2	5296.6	5407.4	KNTM01	changed T1 sensor(1464→2453)
K02	1	012410	08:04	08:29	46-59.88N	159-58.86E	5215.0	301.2	-	300.4	302.8	K02M01	
K02	2	012410	19:05	19:41	47-00.18N	159-58.07E	5213.0	301.0	-	300.7	303.5	K02M02	
K02	3	012510	07:34	08:58	46-50.99N	160-05.20E	5254.0	2048.9	-	2000.7	2028.1	K02M03	
K02	4	012510	19:06	19:43	46-57.27N	160-13.15E	5236.0	304.1	-	302.0	304.5	K02M04	
K02	5	012510	22:24	01:57	47-01.32N	160-17.81E	5238.0	5432.2	8.9	5204.7	5313.6	K02M05	
S01	1	013010	22:35	22:46	29-56.23N	144-58.02E	5917.0	198.2	-	200.5	201.7	S01M01	
S01	2	013010	23:14	03:55	29-56.18N	144-58.05E	5918.0	5937.7	9.8	5892.1	6013.4	S01M02	DO1 sensor noise
S01	3	013110	06:04	09:36	30-03.82N	144-57.87E	5929.0	5944.8	9.7	5900.4	6024.5	S01M03	DO1 sensor noise
S01	4	013110	19:03	19:42	29-59.86N	144-59.98E	5962.0	301.0	-	300.6	302.9	S01M04	
S01	5	020110	05:51	06:16	29-55.70N	144-59.16E	5899.0	298.4	-	300.0	302.3	S01M05	
S01	6	020110	07:33	07:55	29-53.61N	145-00.83E	5906.0	198.7	-	200.9	202.4	S01M06	
S01	7	020210	06:01	09:41	30-03.44N	144-55.98E	5927.0	5962.8	7.8	5904.7	6028.2	S01M07	
S01	8	020210	19:06	19:45	30-00.50N	145-26.03E	6001.0	301.3	-	300.7	302.8	S01M08	Leg1 end
S01	9	020810	19:03	19:42	30-08.99N	145-06.11E	5949.0	299.1	-	300.9	302.9	S01M09	Leg2 start changed Alti sensaor(1157→1100)
S01	10	020910	06:32	09:24	30-10.90N	145-05.91E	5929.0	5057.5	-	5000.1	5094.1	S01M10	
S01	11	020910	19:02	19:42	30-09.68N	144-55.15E	5912.0	298.6	-	300.1	302.6	S01M11	RINKO III value was not good
S01	12	020910	20:54	21:31	30-09.34N	144-56.15E	5868.0	497.2	-	496.6	500.1	S01M12	
S01	13	021010	03:23	07:11	30-03.17N	144-54.11E	5918.0	5954.0	9.7	5891.4	6015.1	S01M13	DO1 sensor noise
S01	14	021010	11:39	12:05	30-01.96N	144-55.72E	5913.0	198.0	-	200.7	201.9	S01M14	
S01	15	021010	19:03	19:40	30-22.67N	145-06.06E	5823.0	304.6	-	300.5	303.2	S01M15	
K02	6	021410	18:08	18:46	46-59.62N	160-08.70E	5253.0	300.4	-	300.7	304.2	K02M06	
K02	7	021410	20:18	23:38	46-58.27N	160-07.88E	5266.0	5312.9	10.0	5248.3	5358.8	K02M07	DO1 sensor noise
K02	8	021510	18:04	18:39	46-52.53N	160-01.35E	5167.0	303.5	-	300.9	304.9	K02M08	
K02	9	021510	20:21	20:50	46-52.15N	160-01.85E	5168.0	300.4	-	300.9	304.0	K02M09	
K02	10	021610	02:44	03:38	46-45.05N	160-05.05E	5217.0	1016.8	-	1001.2	1012.3	K02M10	

2.2.2. Salinity measurement

Masahide Wakita (JAMSTEC) : Principal Investigator
Tatsuya Tanaka (MWJ) : Operation Leader
Hiroki Ushiromura (MWJ)
Akira Watanabe (MWJ)

(1) Objectives

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

(2) Method

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and EPCS. The salinity sample bottle of the 250ml brown grass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. The salinity sample bottles for EPCS were sealed with a plastic insert thimble and a screw cap because we took into consideration the possibility of storage for about a month. The thimble was rinsed 3 times with the sample water before use. The bottle was stored for more than 14 hours in the laboratory before the salinity measurement.

The kind and number of samples taken 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	440
Samples for EPCS	33
Total	473

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR10-01 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62827) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the 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 re-standardization
Maximum Resolution	:	Better than ±0.0002 (PSU) at 35 (PSU)

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

Measurement Range	:	-40 to +180 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 the 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. The ambient temperature varied from approximately 21 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.001 deg C on rare occasion.

The measurement for each sample was done with the double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing 5 times. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the 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 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured a ninth filling of the cell and calculated the bottle salinity above. The measurement was conducted in about 4 - 12 hours per day and the cell was cleaned with soap after the measurement of the day.

(3)Result

a. Standard Seawater

Standardization control of the salinometer was set to 455 and all measurements were done at this setting. The value of STANDBY was 24+5390 +/- 0001 and that of ZERO was 0.0+0001 +/- 0001. The conductivity ratio of IAPSO Standard Seawater batch P151 was 0.99997 (the double conductivity ratio was 1.99994) and was used as the standard for salinity. We measured 33 bottles of P151.

Fig.2.2.2-1 shows the history of the double conductivity ratio of the Standard Seawater batch P151 before correction. The average of the double conductivity ratio was 1.99994 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

Fig.2.2.2-2 shows the history of the double conductivity ratio of the Standard Seawater batch P151 after correction. The average of the double conductivity ratio after correction was 1.99994 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

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

batch	:	P151
conductivity ratio	:	0.99997
salinity	:	34.999
Use by	:	20th-May-2012
preparation date	:	20th-May-2009

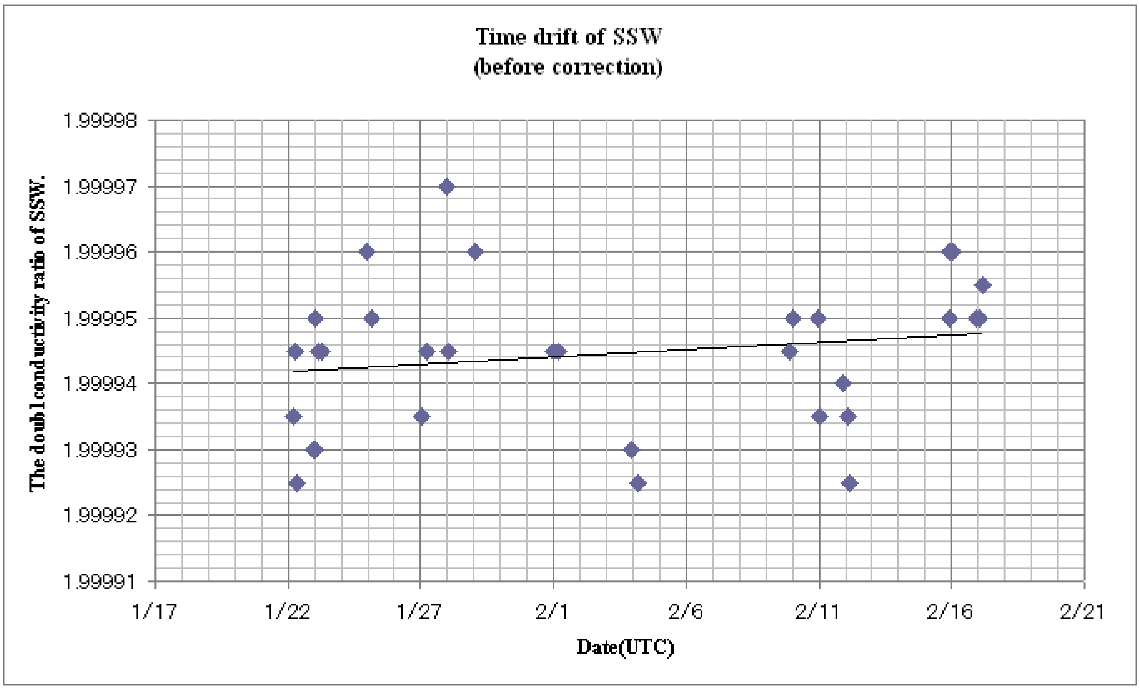

Fig. 2.2.2-1 The history of the double conductivity ratio for the Standard Seawater batch P151 (before correction)

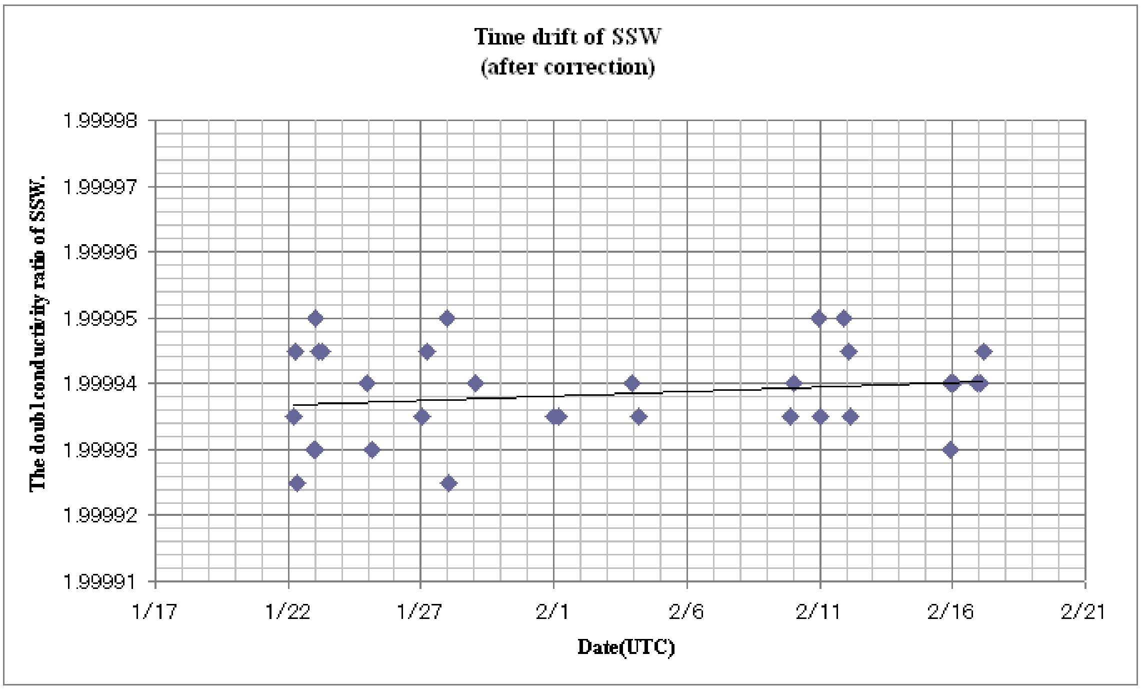

Fig. 2.2.2-2 The history of the double conductivity ratio for the Standard Seawater batch P151 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from deep-sea water filtered by a 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 about every 6 samples in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 38 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute deference among 38 pairs of replicate samples were 0.0002 and 0.0001 in salinity, respectively.

(4) Data archive

These raw datasets will be submitted to JAMSTEC Data Integration and Analyses Group (DIAG).

(5) Reference

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

2.2.3. XBT/XCTD

(1) Personnel

Hiroshi Ichikawa	(JAMSTEC): Principal Investigator（Not on-board）
Katsuhisa Maeno	(Global Ocean Development Inc.: GODI)
Norio Nagahama	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(2) Objectives

Investigation of oceanic structure.

(3) Parameters

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD (eXpendable Conductivity, Temperature & Depth profiler) and XBT(eXpendable Bathy Thermograph)（T-5) are as follows;

・XCTD

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]
Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

・XBT(T-5)

Parameter	Range	Accuracy
Temperature	-2 ~ 35 [deg-C]	+/- 0.2 [deg-C]
Depth	0 ~ 2 [m]	5 [m] or 2 [%] (either of them is major)

(4) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD-1 manufactured by Tsurumi-Seiki Co.. The signal was converted by MK-130, Tsurumi-Seiki Co. and was recorded by MK-130 software (Ver.3.07) provided by Tsurumi-Seiki Co.. We launched 5 XBT probes and 16 XCTD probes by using automatic launcher. The summary of XBT/XCTD observations and launching log were shown in Table 2.2.3.

(5) Preliminary results

(6) Data archive

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

Table 2.2.3 Summary of X-BT/C-CTD observation and launching log

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude	Longitude	Depth [m]	Probe S/N
X01	KEO	2010/02/04	15:10	32-15.75N	144-28.17E	5791	06090151
X02	S1	2010/02/10	03:35	30-03.41N	144-53.77E	5911	T-5
X03	E01	2010/02/11	01:36	30-59.95N	145-51.98E	6153	T-5
X04	E02	2010/02/11	06:35	31-59.81N	146-44.91E	5966	07126974
X05	E03	2010/02/11	12:00	33-00.00N	147-38.00E	6229	T-5
X06	E04	2010/02/11	14:50	33-29.80N	148-03.59E	6171	07126976
X07	E05	2010/02/11	17:40	33-59.92N	148-31.74E	6204	07126973
X08	E06	2010/02/11	20:23	34-29.76N	148-57.57E	6167	07126975
X09	E07	2010/02/11	22:59	34-59.81N	149-24.00E	6090	07116484
X10	E08	2010/02/12	00:21	35-14.96N	149-36.35E	6045	07116483
X11	E09	2010/02/12	01:43	35-29.78N	149-48.62E	6003	07116479
X12	E10	2010/02/12	03:12	35-44.84N	150-01.55E	6042	07116476
X13	E11	2010/02/12	04:55	35-59.84N	150-14.84E	5951	07116477
X14	E12	2010/02/12	06:33	36-15.02N	150-28.26E	5927	07116485
X15	E13	2010/02/12	08:00	36-29.78N	150-41.32E	5830	07116481
X16	E14	2010/02/12	10:57	37-00.06N	151-07.60E	5924	07116482
X17	E15	2010/02/12	13:43	37-30.16N	151-33.21E	5783	07116475
X18	E16	2010/02/12	16:27	37-59.79N	152-00.67E	5872	07116480
X19	E17	2010/02/12	21:41	39-00.01N	152-54.01E	5694	T-5
X20	E18	2010/02/13	03:01	39-59.84N	153-48.77E	5579	07116478
X21	K2	2010/02/14	20:31	46-58.56N	160-08.13E	5265	T-5

2.2.4. Shipboard ADCP

Katsuhisa Maeno (Global Ocean Development Inc., GODI)
Norio Nagahama (GODI)
Wataru Tokunaga (Mirai Crew)

(1) Objective

To obtain continuous measurement of the current profile along the ship's track.

(2) Methods

Upper ocean current measurements were made throughout MR10-01 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system that is permanently installed on the R/V MIRAI. For most of its operation, the instrument was configured for water-tracking mode recording. 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. The system consists of following components;

i) R/V MIRAI has installed the Ocean Surveyor for vessel-mount (acoustic frequency 75 kHz; Teledyne RD Instruments). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
ii) For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (INS) which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
iii) DGPS system (Trimble SPS751 & StarFixXP) providing position fixes.
iv) We used VmDas version 1.4.2 (TRD Instruments) for data acquisition.
v) To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute
vi) We have placed ethylene glycol into the fresh water to prevent freezing in the sea chest.
vii) The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

Data was configured at 8-m intervals starting 23-m below the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively. Major parameters for the measurement (Direct Command) are shown Table 2.2.4-1 Major parameters.

(3) Preliminary results

Fig.2.2.4-1 and Fig.2.2.4-2 show an hour averaged surface (100 – 150m) current vector along the ship track. In this cruise, the data quality was not in good condition When you use ADCP data, it is highly recommended to check the status data (correlation, echo amplitude and error velocity).

(4) Data archive

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC, and will be opened to the public via "R/V MIRAI Data Web Page" in JAMSTEC home page.

(5) Remarks

1) We did not collect data in the following period.
   22:42UTC 8 Feb. – 01:27UTC 9 Feb., 04:01 – 04:44UTC 9 Feb.,
   04:26UTC 10 Feb. – 07:22UTC 10 Feb., 04:21 – 06:46UTC 15 Feb.

Table 2.2.4-1 Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1000m depth) 22:08 UTC, 19 Jan. – 02:43 UTC, 20 Jan. 23:02 UTC, 5 Feb. – 05:15 UTC, 6 Feb. 16:35 UTC, 21 Feb. – xx:xx UTC, xx Feb.
BP = 000	Disable bottom-track ping (almost over 1000m depth) 02:46 UTC, 20 Jan. – 23:01 UTC, 5 Feb. 10:57 UTC, 7 Feb. – 16:35 UTC, 21 Feb.
Environmental Sensor Commands	
EA = +04500	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	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 = 10200010	Sensor Source (C; D; H; P; R; S; T; U) C (1): Sound velocity calculates using ED, ES, ET (temp.) D (0): Manual ED H (2): External synchro P (0), R (0): Manual EP, ER (0 degree) S (0): Manual ES T (1): Internal transducer sensor U (0): Manual EU
Timing Commands	
TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 110 000	Data Out (V; C; A; PG; St; Vsum; Vsum^2;#G;P0)
WE = 1000	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 = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

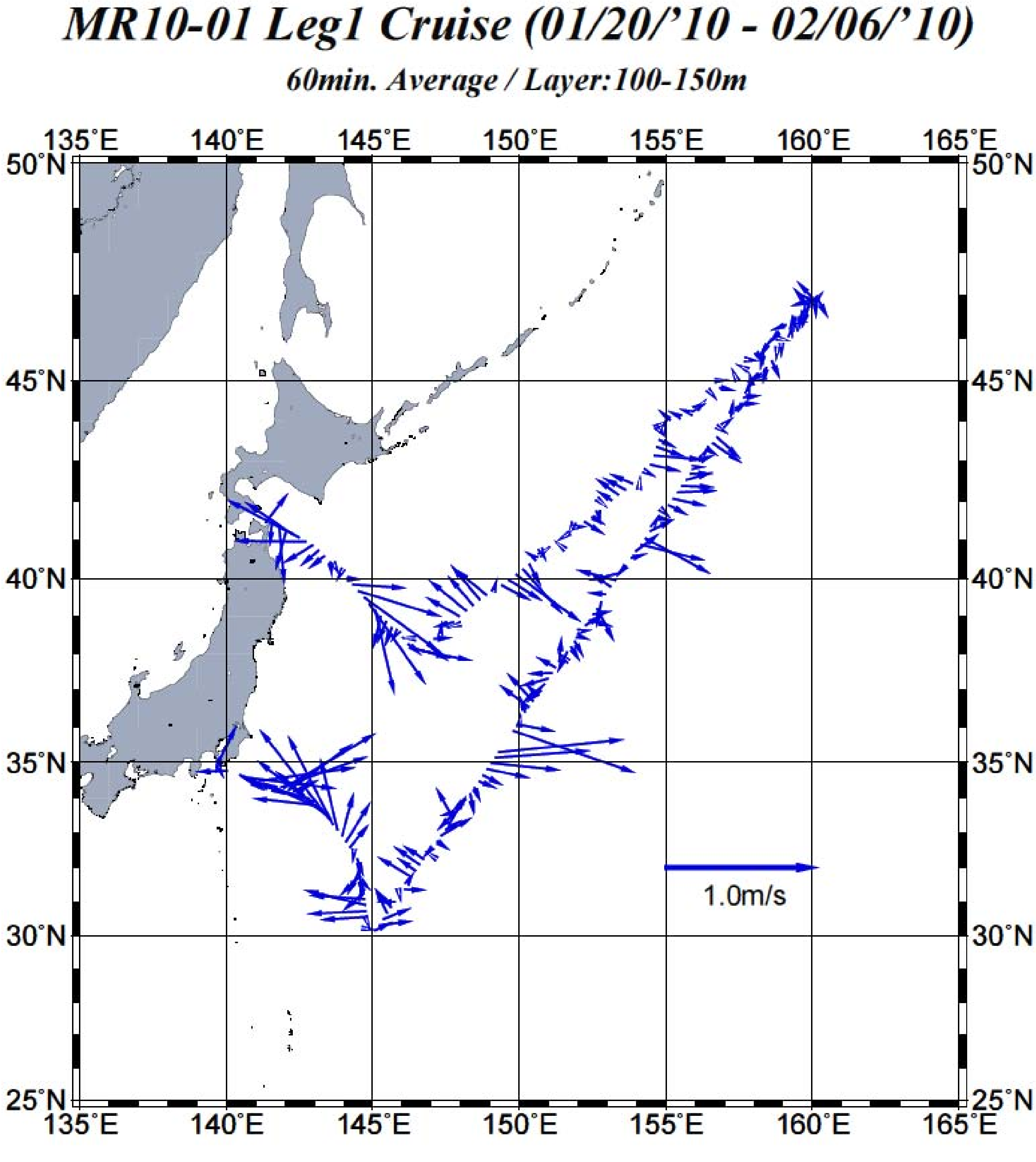

Fig. 2.2.4-1 An hour averaged surface (100 - 150 m) current vector along the ship track (leg1)

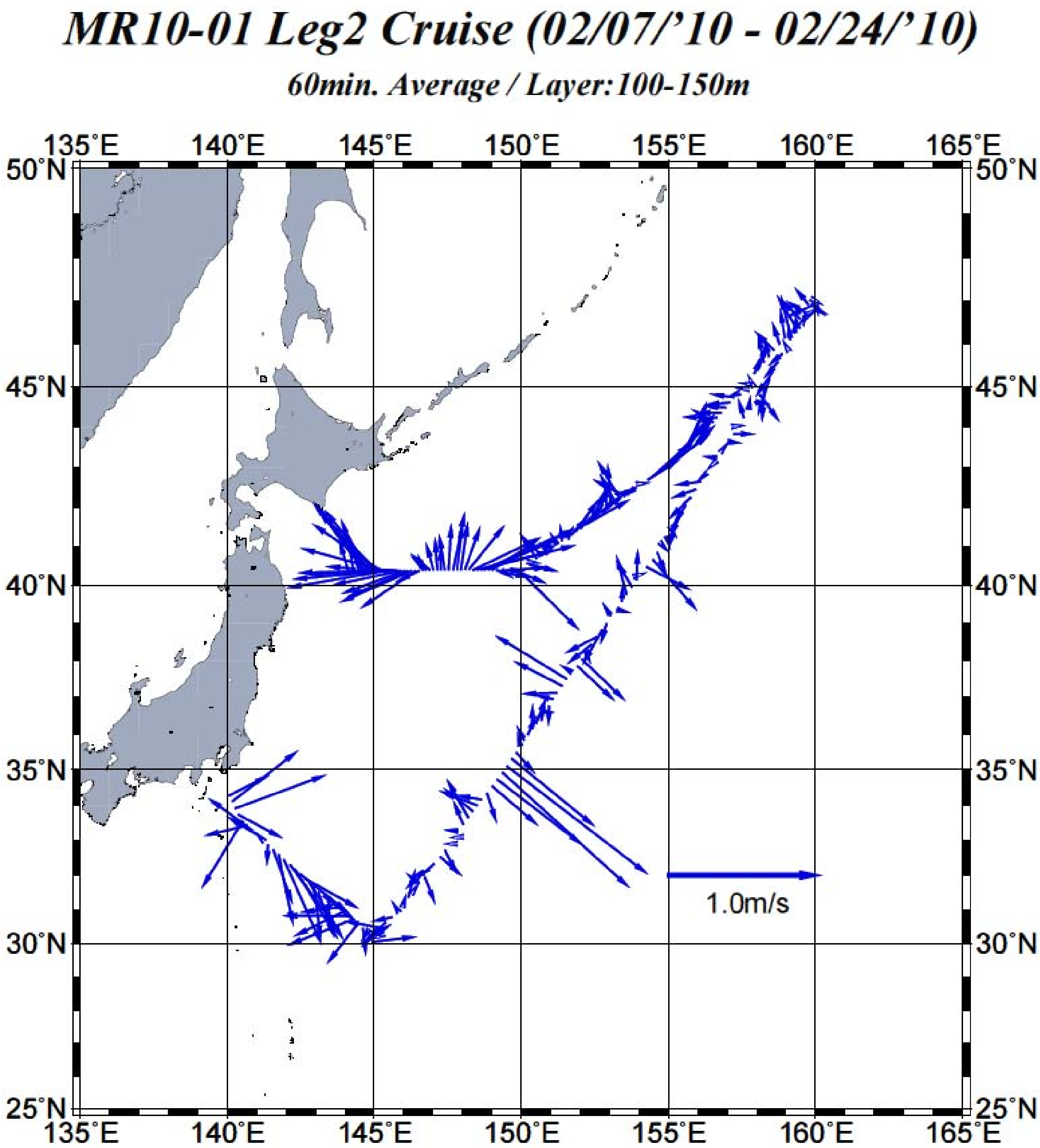

Fig. 2.2.4-2 An hour averaged surface (100 - 150 m) current vector along the ship track (leg2)

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2.3. Sea surface water monitoring

(1) Personnel

Masahide WAKITA (JAMSTEC): Principal Investigator
Misato KUWAHARA (Marine Works Japan Co. Ltd.): Operation Leader
Hironori SATO (Marine Works Japan Co. Ltd.)

(2) Objective

Measurements of temperature, salinity and dissolved oxygen of the sea surface water in the Arctic Sea.

(3) Instruments and methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) that equips five sensors of 1) salinity, 2) temperatures (two sensors) and 3) dissolved oxygen can continuously measure their values in near-sea surface water. Salinity is calculated by conductivity on the basis of PSS78. Specifications of these sensors are listed below.

This system is settled in the "*sea surface monitoring laboratory*" on R/V MIRAI, and near-surface water was continuously pumped up to the system through a vinyl-chloride pipe. The flow rate for the system is manually controlled by several valves with its value of 12 L min^{-1}. Flow rate is monitored with respective flow meter. The system is connected to shipboard LAN-system, and measured data is stored in a hard disk of PC every 1-minute together with time (UTC) and position of the ship.

a) Temperature and Conductivity sensor

Model: SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number: 2126391-3126
Measurement range: Temperature -5 to +35℃, Conductivity 0 to 7 S m^{-1}
Resolution: Temperatures 0.001℃, Conductivity 0.0001 S m^{-1}
Stability: Temperature 0.01℃ 6 $months^{-1}$, Conductivity 0.001 S m^{-1} $month^{-1}$

b) Bottom of ship thermometer

Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number: 032607
Measurement range: -5 to +35℃
Resolution: ±0.001℃
Stability: 0.002℃ $year^{-1}$

c) Dissolved oxygen sensor

Model: 2127A, Hach Ultara Analytics Japan, INC.
Serial number: 61230
Measurement range: 0 to 14 ppm
Accuracy: ±1% in ±5℃ of correction temperature
Stability: 5% $month^{-1}$

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 period (UTC) during this cruise are listed below.

Leg1 Start: 2010/1/21 02:29 Stop: 2010/2/5 23:11

Leg2 Start: 2010/2/7 09:30 Stop: 2010/2/21 03:29

(4) Preliminary Result

Preliminary data of temperature, salinity and dissolved oxygen at sea surface are shown in Fig.2.3-1(leg1) and Fig.2.3-2(leg2). We took the surface water samples once a day to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in Fig.2.3-3, 2.3-4. All the salinity samples were analyzed by the Guideline 8400B “AUTOSAL”, and dissolve oxygen samples were analyzed by Winkler method.

(5) Date archive

The data were stored on a CD-R, which will be submitted to JAMSTEC, and will be opened to public via “R/V MIRAI Data Web Page” in JAMSTEC homepage.

(6) Remarks

None

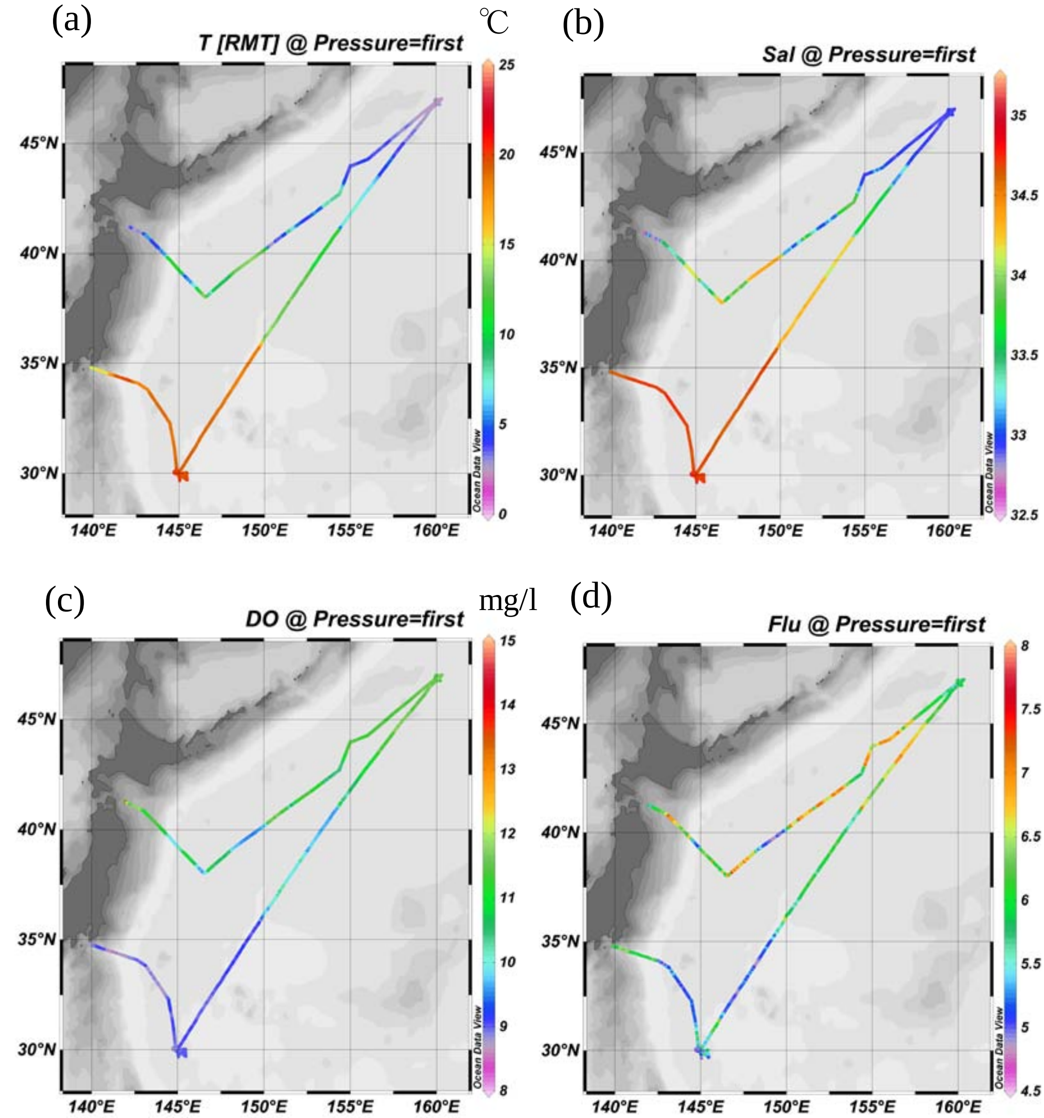

Fig.2.3-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen and (d) fluorescence in MR10-01 leg1 cruise. Fluorescence is relative value.

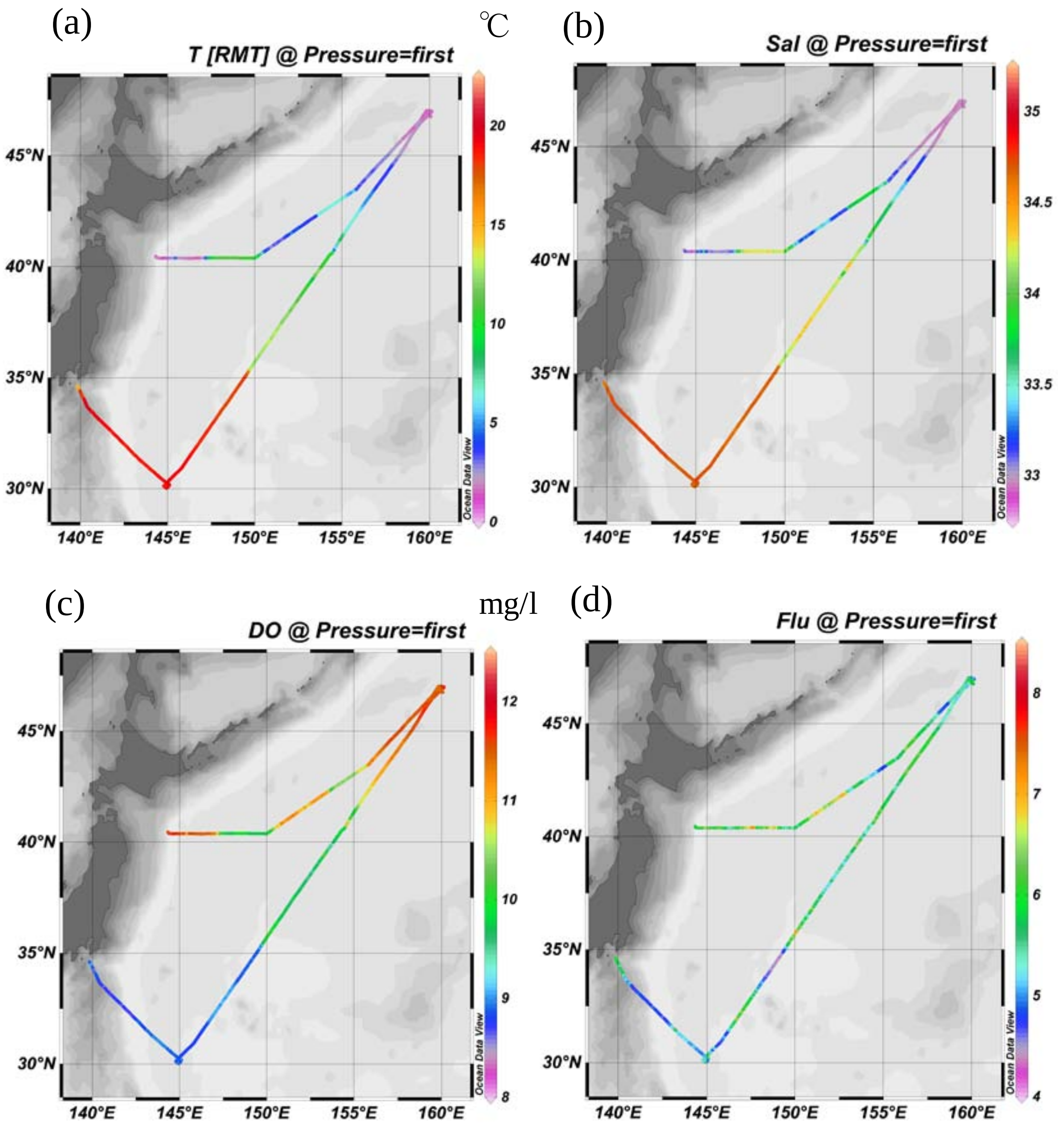

Fig.2.3-2 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen and (d) fluorescence in MR10-01 leg2 cruise. Fluorescence is relative value.

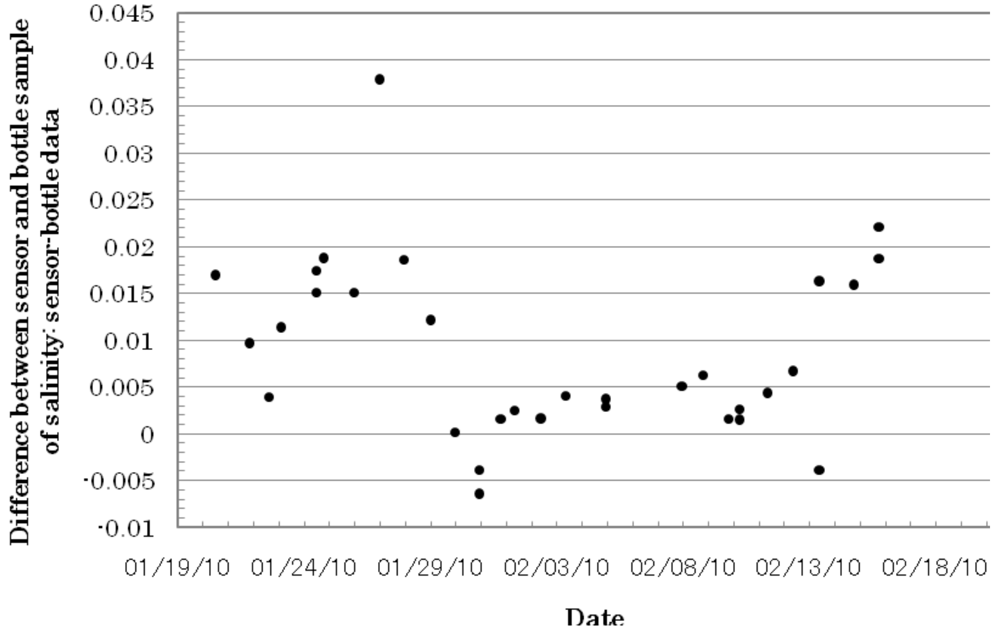

Fig.2.3-3 Difference of salinity between sensor data and bottle data.

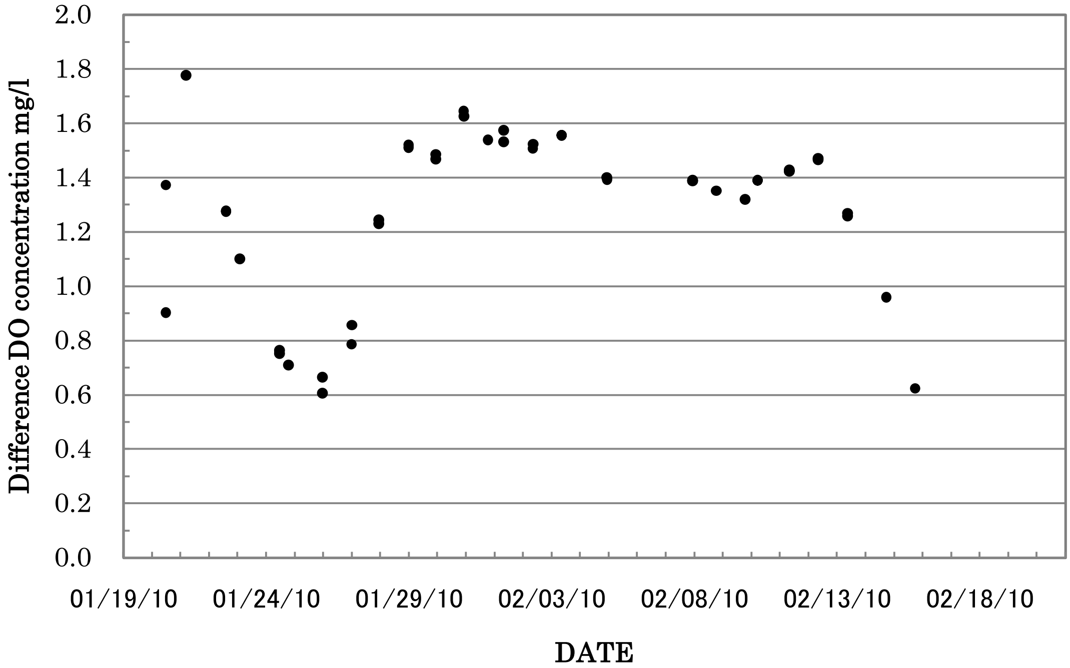

Fig.2.3-4 Difference of dissolved oxygen between sensor data and bottle data.

2.4. Dissolved Oxygen

(1) Personnel

Masahide WAKITA(JAMSTEC): Principal Investigator
Misato KUWAHARA(Marine Works Japan Co. Ltd.): Operation Leader
Hironori SATO(Marine Works Japan Co. Ltd.)

(2) Objective

Dissolved oxygen is important parameter to identify water masses of intermediate and deep water in the Arctic Ocean. We measured dissolved oxygen in seawater by Winkler titration.

(3) Parameters

Dissolved oxygen

(4) Instruments and Methods

a. Reagents

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

b. Instruments:

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

c. 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 and 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.

d. 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 2 sets of the titration apparatus. 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.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant (ca. 0.025 mol/dm^3) was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130^{o}C. 1.7835g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 mol/dm^3). 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. Firstly, 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. Secondary, 2 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. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate.

Table2.4-1 shows results of the standardization and the blank determination during this cruise.

Table2.4-1 Results of the standardization and the blank determinations during this cruise.

Date	KIO_3	$Na_2S_2O_3$	DOT-01(No.1)		DOT-01(No.2)	
			E.P.	Blank	E.P.	Blank
2010/1/21	20091214-01-01	20091207-01-1	3.960	-0.001	3.962	-0.001
2010/1/21	CSK	20091207-01-1	3.962	-0.001	3.963	-0.001
2010/1/23	20091214-01-02	20091207-01-1			3.963	0.002
2010/1/25	20091214-01-03	20091207-01-1	3.963	-0.002	3.965	0.000
2010/1/25	20091214-01-04	20091207-01-1			3.965	0.000
2010/1/29	20091214-01-05	20091207-01-1	3.960	-0.001		
2010/1/29	20091214-01-06	20091207-01-1	3.960	-0.001	3.963	0.001
2010/1/30	20091214-01-06	20091207-01-2	3.964	0.000	3.966	0.002
2010/1/31	20081204-20-02	20091207-01-2	3.964	-0.002	3.965	0.001
2010/1/31	20091214-01-07	20091207-01-2	3.963	-0.001	3.963	0.001
2010/2/1	20091214-01-08	20091207-01-2	3.961	-0.002	3.963	0.001
2010/2/5	20091214-01-09	20091207-01-2	3.956	-0.001	3.959	0.002
2010/2/5	20091214-02-01	20091207-01-2	3.960	-0.001	3.962	0.001
2010/2/8	20091214-02-02	20091207-01-2	3.959	-0.001	3.958	0.002
2010/2/8	20091214-02-02	20091207-02-1	3.958	-0.002	3.957	0.000
2010/2/13	20091214-02-03	20091207-02-1	3.956	-0.002	3.958	0.000
2010/2/17	20091214-02-03	20091207-02-1	3.956	-0.002	3.959	0.001
2010/2/17	CSK	20091207-02-1	3.958	-0.002	3.959	0.001

f. Repeatability of sample measurement

During this cruise we measured oxygen concentration in 445 seawater samples at 4 stations. Replicate samples were taken at every CTD casts. Results of replicate samples were shown in Table2.4-2 and this diagram shown in Fig2.4-1. The standard deviation was calculated by a procedure in Guide to best practices for ocean CO2 measurements Chapter4 SOP23 Ver.3.0 (2007).

Table2.4-2 Results of the replicate sample measurements

Layer	Number of replicate sample pairs	Oxygen concentration (μmol/kg) Standard Deviation.
1000m>=	35	0.21
>1000m	9	0.11
All	44	0.19

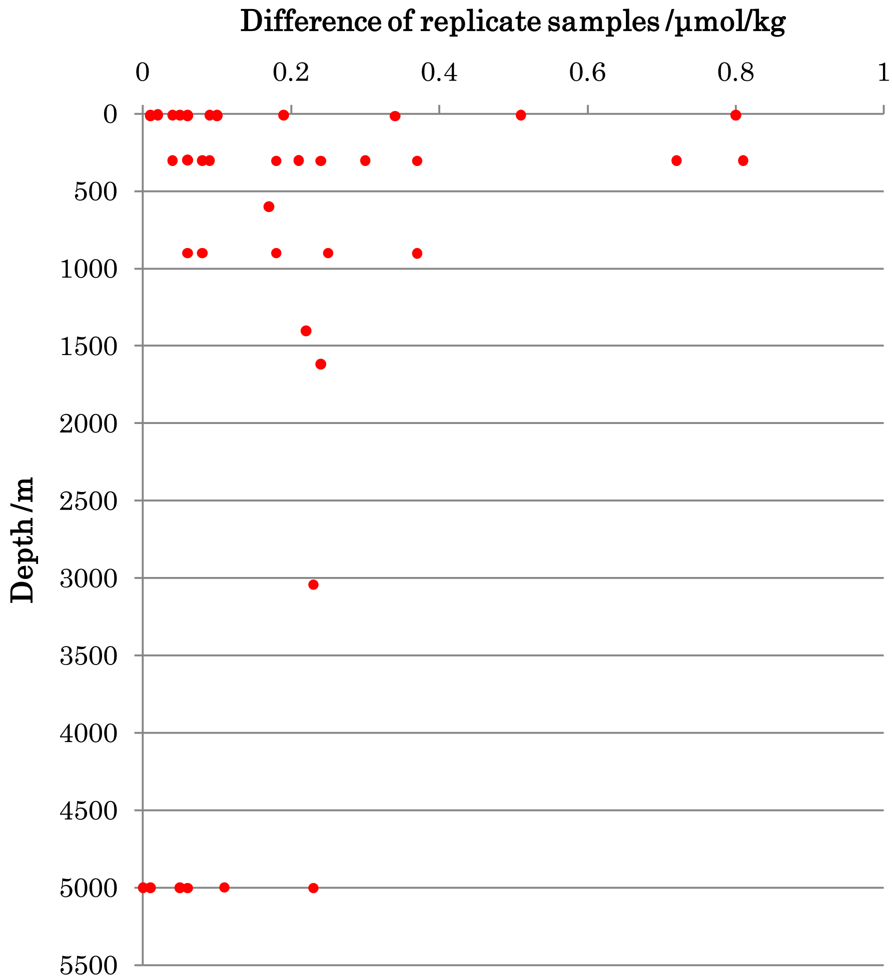

Fig.2.4-1 Differences of replicate samples against sampling depth.

(5) Data policy and citation

All data will be submitted to Chief Scientist.

(6) Reference

Dickson, A.G., Determination of dissolved oxygen in sea water by Winkler titration. (1996)

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), Guide to best practices for ocean CO2 measurements. (2007)

Culberson, C.H., WHP Operations and Methods July-1991 "Dissolved Oxygen", (1991)

Japan Meteorological Agency, Oceanographic research guidelines (Part 1). (1999)

KIMOTO electric CO. LTD., Automatic photometric titrator DOT-01 Instruaction manual

2.5. Nutrients

Masahide WAKITA (JAMSTEC MIO): Principal Investigator
Kenichiro SATO (Marine Works Japan Ltd.)
Kimiko NISHIJIMA (Marine Works Japan Ltd.)
Ai TAKANO (Marine Works Japan Ltd.)

(1) Objective

The vertical and horizontal distributions of the nutrients are one of the most important factors on the primary production. On the other hand, nutrients data are used to study of climate changes as chemical tracers of seawater mass movement. During this cruise nutrient measurements will give us the important information on the mechanism of the primary production and/or seawater circulation.

(2) Measured Parameters

Nitrate, Nitrite, Silicate (although silicic acid is correct, we use silicate because a term of silicate is widely used in oceanographic community), Phosphate and Ammonia. See below for further details.

(3) Instruments and Methods

Nutrients analysis was performed on the SEAL QuAAtro system. The laboratory temperature was maintained between 21-27 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 1 cm length cell for Nitrate and 3 cm length cell for nitrite.

The silicate method is analogous to that described for phosphate. The method used is essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid is first formed from the silicic acid in the sample and added molybdic acid; then the silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using L-ascorbic acid as the reductant. Absorbance of 630 nm by silicomolybdous acid in analysis is measured using a 1 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 L-ascorbic acid as the reductant. Absorbance of 880 nm by phosphomolybdous acid in analysis is measured using a 3 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 0.1 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 1 cm length cell.

b. 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 40 ml solution were diluted to 500 ml together with an aliquot of 20 ml of 1 M HCl. Primary standard for nitrate (KNO_3) and phosphate (KH_2PO_4) were obtained from Merck, Ltd., nitrite ($NaNO_2$) and ammonia ($(NH_4)_2SO_4$) were obtained from Wako Pure Chemical Industries, Ltd.

c. Sampling Procedures

Samples were drawn into virgin 10 ml polyacrylate vials that were rinsed 3 times before sampling without sample drawing tubes. Sets of five different concentrations for nitrate, nitrite, silicate, phosphate and sets of four difference concentrations 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 12 to 14 samples and were used to evaluate precision of nutrients analysis during the cruise. We also used reference material for nutrients in seawater, RMNS (KANSO Co., Ltd., lots AT, AU, AY, BA and BD), for every runs to secure comparability on nutrients analysis throughout this cruise.

d. Low Nutrients Sea Water (LNSW)

Surface water having low nutrients 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 July 2008.

(4) Results

Analytical precisions were 0.13% (55.0 μM) for nitrate, 0.22% (1.18 μM) for nitrite, 0.11% (170 μM) for silicate, 0.21% (3.64 μM) for phosphate, 0.25% (6.0 μM) for ammonia in terms of median of precision, respectively.

Results of RMNS analysis are shown in Table 2.5-1.

(5) Archive

All data will be submitted to JAMSTEC Data Integration and Analyses Group (DIAG) and is currently under its control.

(6) 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 RMNS concentrations in this cruise.

μmol/kg

		NO3	NO2	SiO2	PO4	NH4
RM-AT	avg	7.50	0.02	17.84	0.586	0.77
	stdev	0.05	0.01	0.13	0.014	0.03
	n=	17	17	17	17	10
RM-AU	avg	29.96	0.01	66.39	2.180	0.55
	stdev	0.13	0.01	0.24	0.009	0.04
	n=	17	17	17	17	10
RM-AY	avg	5.68	0.62	29.43	0.520	0.80
	stdev	0.05	0.01	0.10	0.011	0.03
	n=	17	17	17	17	10
RM-BA	avg	0.08	0.02	1.56	0.062	0.98
	stdev	0.04	0.01	0.12	0.011	0.03
	n=	17	17	17	17	10
RM-BD	avg	29.81	0.03	64.39	2.188	2.63
	stdev	0.14	0.01	0.27	0.013	0.17
	n=	17	17	17	17	10

2.6. pH measurement

Masahide WAKITA (JAMSTEC) : Principal Investigator
Yasuhiro ARII (MWJ)
Tomonori WATAI (MWJ)

(1) Introduction

Since the global warming is becoming an issue world-widely, studies on the greenhouse gases such as CO_2 are drawing high attention. The ocean plays an important role in buffering the increase of atmospheric CO_2, and studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. Oceanic biosphere, especially primary production, has an important role concerned to oceanic CO_2 cycle through its photosynthesis and respiration. However, the diverseness and variability of the biological system make difficult to reveal their mechanism and quantitative understanding of CO_2 cycle. Dissolved CO_2 in water alters its appearance into several species, but the concentrations of the individual species of CO_2 system in solution cannot be measured directly. However, two of the four measurable parameters (alkalinity, total dissolved inorganic carbon, pH and pCO_2) can estimate each concentration of CO_2 system (Dickson et al., 2007). Seawater acidification associated with CO_2 uptake into the ocean possibly changes oceanic ecosystem and garners attention recently. We here report on board measurements of pH during MR10-01 cruise.

(2) Apparatus and performance

(2)-1 Seawater sampling

Seawater samples were collected with CTD system mounted 12 L Niskin bottles and a bucket at 15 stations. Seawater was sampled in a 100 ml 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 silicone rubber tube with PFA tip was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (about 10 seconds) with care not to leave any bubbles in the bottle. The water in the bottle was sealed by a glass made cap gravimetrically fitted to the bottle mouth without additional force. After collecting the samples on the deck, the bottles were carried into the lab and put in the water bath kept about 25 ℃ before the measurement.

(2)-2 Seawater analyses

pH (-log[H+]) of the seawater was measured potentiometrically in the glass bottles. The pH / Ion meter (Radiometer PHM240) is used to measure the electromotive force (e.m.f.) between the glass electrode cell (Radiometer pHG201) and the reference electrode cell (Radiometer REF201) in the sample with its temperature controlled to 25 ± 0.05 ℃.

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

To calibrate the electrodes, the TRIS buffer (Lot=091209-1, 091209-2: pH=8.0909 pH units at 25℃, Delvalls and Dickson, 1998) and AMP buffer (Lot=091209-1, b091209-2: pH=6.7843 pH units at 25℃, DOE, 1994) in the synthetic seawater (Total hydrogen ion concentration scale) were applied. pH_T of seawater sample (pH_{spl}) is calculated from the expression:

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

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:

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

(3) Preliminary results

A replicate analysis of seawater sample was made at 75, 250, 1200, and 3500 m depth (deep cast) or 5, 60, and 250 m depth (shallow cast). 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 0.0006 pH units (n = 38 pairs) with its standard deviation of 0.0007 pH units. These values were lower than the value recommended by Guide (2007).

(4) Data Archive

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

(5) 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.

Dickson, A. G., C. L. Sabine and J. R. Christian, Eds. (2007): Guide to best practices for ocean CO_2 measurements, PICES Special Publication 3, 199pp.

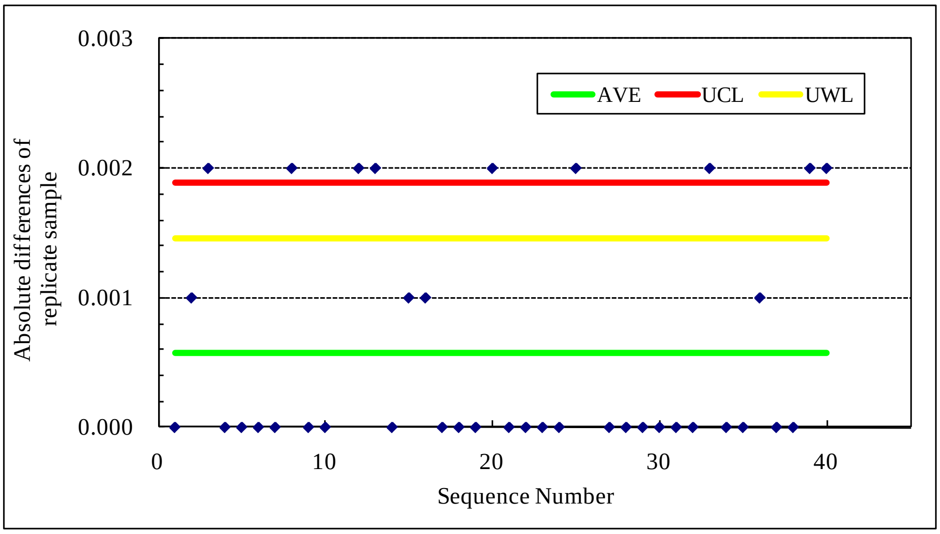

Figure 2.6-1 Range control chart of the absolute differences of duplicate measurements of pH carried out during the cruise. AVE represents the average value, UCL upper control limit (UCL = AVE * 3.267), and UWL upper warning limit (UWL = AVE * 2.512) (Dickson et al., 2007).

2.7. Dissolved inorganic carbon-DIC

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Tomonori WATAI (MWJ)

(1) Objective

Concentrations of CO_2 in the atmosphere are now increasing at a rate of 1.5 ppmv y^{-1} owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO_2, and to clarify the mechanism of the CO_2 absorption. The ocean plays an important role in buffering the increase of atmospheric CO_2 and oceanic biosphere, especially primary production, has an important role concerned to oceanic CO_2 cycle through its photosynthesis and respiration. However, the diverseness and variability of the biological system make difficult to reveal their mechanism and quantitative understanding of CO_2 cycle. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; total 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 can be estimated (Dickson et al., 2007). We here report on-board measurements of DIC performed during the MR10-01 cruise.

(2) Methods, Apparatus and Performance

(2)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 15 stations. Surface seawater samples were also collected by a bucket. Seawater was sampled in a 300ml glass bottle (SCHOTT DURAN) 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. They were sealed using the 29mm polyethylene inner lids with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were carried to the lab to be measured. Within one hour after the sampling, 3ml of the sample (1% of the bottle volume) was removed from the glass bottle and poisoned with 100µl of over saturated solution of mercury chloride. Then the samples were sealed with the 31.9mm polyethylene inner lids and stored in a refrigerator at approximately 5degC until analyzed.

(2)-2 Seawater analysis

Measurements of DIC were made with total CO_2 measuring system (Nippon ANS, Inc.). The system comprise of seawater dispensing system, a CO_2 extraction system and a coulometer (Model 5012, UIC, Inc.)

The seawater dispensing system has an auto-sampler (6 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 21ml volume. The pipette was kept at 20 ± 0.05 degC by a water jacket, in which water circulated from a thermostatic water bath (LP-3110, ADVANTEC) set at 20 degC.

The CO_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 extraction system by adding phosphoric acid (10% v/v). The stripping chamber is made approx. 25 cm long and has a fine frit at the bottom. The certain amount of acid is taken to the constant volume tube and added to the stripping chamber from its bottom by pressurizing an acid bottle 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 an acid. The seawater and phosphoric acid are stirred by the nitrogen bubbles 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 two electric dehumidifiers (kept at 4 degC) and a chemical desiccant ($Mg(ClO_4)_2$).

The measurement sequence such as 1.5% CO_2 gas in a nitrogen base, system blank (phosphoric acid blank), and seawater samples (6 samples) was programmed to repeat. The measurement of 1.5% CO_2 gas was made to monitor response of coulometer solutions (from UIC, Inc.)..

(3) Preliminary results

During the cruise, 425 samples were analyzed for DIC. A replicate analysis was performed at the interval decided beforehand and the difference between each pair of analyses was plotted on a range control chart (Figure 2.7-1). The average of the differences was 0.8μmol/kg (n=42). The standard deviation was 0.7μmol/kg, which indicates that the analysis was accurate enough according to the Guide (2007).

(4) Data Archive

All data will be submitted to JAMSTEC Data Integration and Analyses Group (DIAG) and is currently under its control.

(5) Reference

Dickson, A. G., Sabine, C. L. & Christian, J. R. eds. (2007), Guide to best practices for ocean CO_2 measurements; PICES Special Publication 3, 199pp.

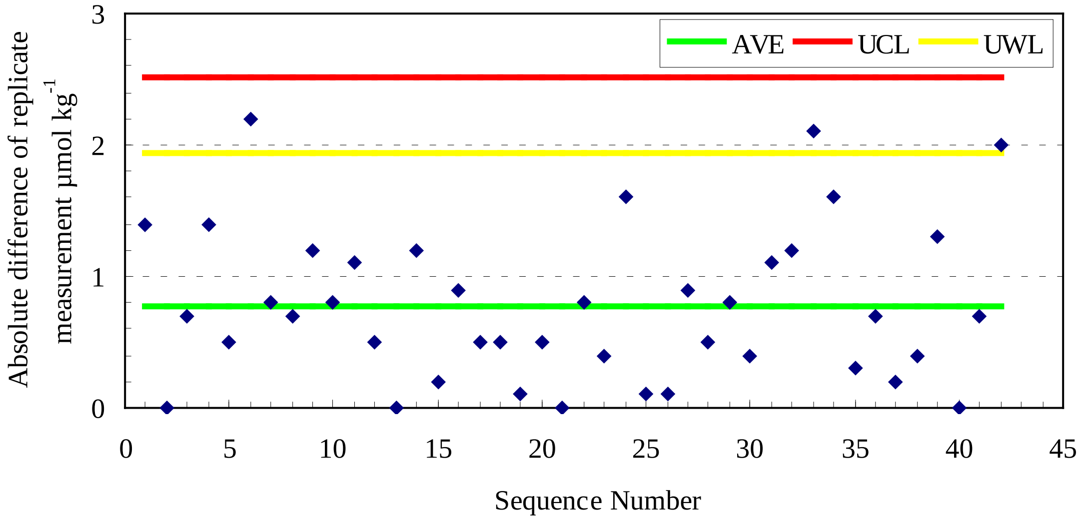

Figure 2.7-1 Range control chart of the absolute differences of replicate measurements of DIC carried out during this cruise. UCL and UWL represents the upper control limit (UCL=AVE*3.267) and upper warning limit (UWL=AVE*2.512), respectively.

2.8. Total Alkalinity

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Ayaka HATSUYAMA (MWJ)
Yasuhiro ARII (MWJ)
Tomonori WATAI (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on green house gases such as CO_2 are drawing high attention. Because the ocean plays an important role in buffering the increase of atmospheric CO_2, surveys on the exchange of CO_2 between the atmosphere and the sea becomes highly important. Oceanic biosphere, especially primary production, has an important role concerned to oceanic CO_2 cycle through its photosynthesis and respiration. However, the diverseness and variability of the biological system make difficult to reveal their mechanism and quantitative understanding of CO_2 cycle. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; total alkalinity, total dissolved inorganic carbon, pH and pCO_2. When two of the four parameters are measured, the concentration of CO_2 system in the water could be estimated (Dickson et al., 2007). We here report on-board measurements of total alkalinity performed during the MR10-01 cruise.

(2) Measured Parameters

Total Alkalinity, TA

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12 L Niskin bottles mounted on the CTD-rosette system and by a bucket at 15 stations. Surface seawater samples ware also collected by a bucket. A sampling silicone rubber with PFA tip was connected to the Niskin bottle when the sampling was carried out. The 125 ml borosilicate glass bottles (SHOTT DURAN) were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (10 seconds) with care not to leave any bubbles in the bottle. These bottles were pre-washed by soaking in 5 % non-phosphoric acid detergent (pH = 13) for more than 3 hours and then rinsed 5 times with tap water and 3 times with Milli-Q deionized water. After collecting the samples on the deck, the bottles were carried into the lab to be measured. The samples were stored in a refrigerator at approximately 5°C until being analyzed. Before the analysis, the samples were put in the water bath kept about 25°C for one hour.

(3)-2 Seawater analysis

Measurement of alkalinity was made using a spectrophotometric system (Nippon ANS, Inc.) using a scheme of Yao and Byrne (1998). The sample seawater of approx. 40ml is transferred from a sample bottle into the titration cell kept at 25° C in a thermostated compartment. Then, the sample seawater circulated through the line between the titration cell and the pH cell in the spectrophotometer (Carry 50 Scan, Varian) via dispensing unit by a peristaltic pump. The length and volume of the pH cell are 8 cm and 13 ml, respectively, and its temperature is kept at 25° C in a thermostated compartment. The TA is calculated by measuring two sets of absorbance at three wavelengths (750, 616 and 444 nm). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green) and another is the one after the injection. For mixing the acid with indicator solution and the seawater sufficiently, they are circulated through the line by a peristaltic pump 5 and half minutes before the measurement.

The TA is calculated based on the following equation:

$$\begin{aligned} pH_T = {} & 4.2699 + 0.002578 * (35 - S) \\ & + \log ((R(25) - 0.00131) / (2.3148 - 0.1299 * R(25))) \\ & - \log (1 - 0.001005 * S), \end{aligned} \qquad (1)$$

$$\begin{aligned} A_T = {} & (N_A * V_A - 10 \wedge pH_T * \mathrm{DensSW}(T, S) * (V_S + V_A)) \\ & * (\mathrm{DensSW}(T, S) * VS)^{-1}, \end{aligned} \qquad (2)$$

where R(25) represents the difference of absorbance at 616 and 444 nm between before and after the injection. The absorbance of wavelength at 750 nm is used to subtract the variation of absorbance caused by the system. DensSW (T, S) is the density of seawater at temperature (T) and salinity (S), N_A the concentration of the added acid, V_A and V_S the volume of added acid and seawater, respectively.

To keep the high analysis precision, some treatments were carried out during the cruise. The acid with indicator solution stored in 1 L DURAN bottle is kept in a bath with its temperature of 25° C, and about 10 ml of it is discarded at first before the batch of measurement. For mixing the seawater and the acid with indicator solution sufficiently, TYGON tube used on the peristaltic pump was periodically renewed. Absorbance measurements were done 10 times during each analysis, and the stable last five and three values are averaged for before and after the injection, respectively, and used for above listed calculation.

(4) Preliminary results

A few replicate samples were taken at all stations 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 0.5μmol/kg (n=38). The standard deviation was 0.4μmol/kg, which indicates that the analysis was accurate enough according to Guide (2007).

(5) Data Archive

All data will be submitted to JAMSTEC Data Integration and Analyses Group (DIAG) and is currently under its control.

(6) References

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

Guide to best practices for ocean CO2 measurements (2007); PICES Special Publication 3, 199pp. A. G. Dickson, C. L. Sabine & J. R. Christian, Eds.

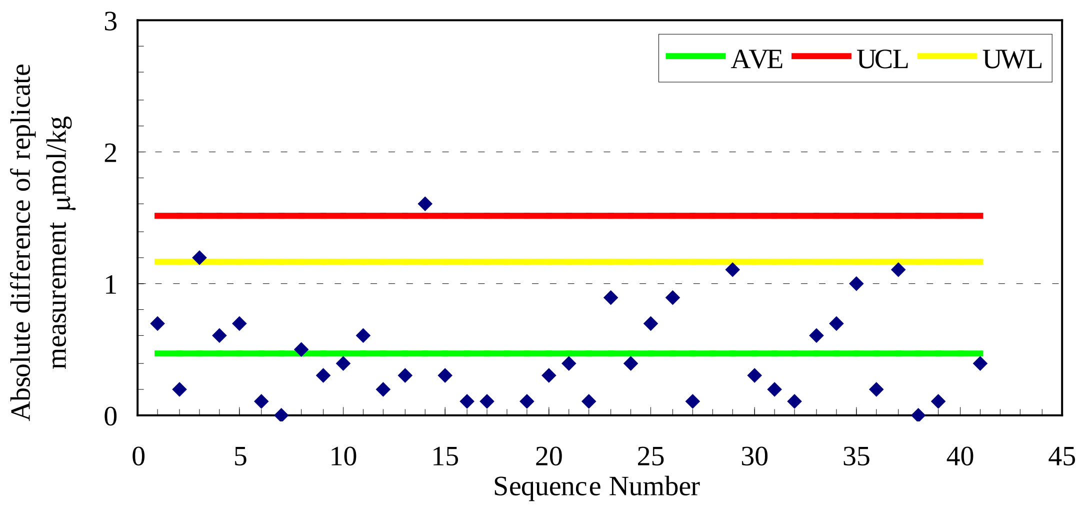

Figure 2.8-1 Range control chart of the absolute differences of replicate measurements of TA carried out during this cruise. UCL and UWL represents the upper control limit (UCL=AVE*3.267) and upper warning limit (UWL=AVE*2.512), respectively.

2.9. Underway pCO_2

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Tomonori Watai (MWJ)

(1) Objectives

Concentrations of CO_2 in the atmosphere are now increasing at a rate of 1.5 ppmv y^{-1} owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO_2, and to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

Since the global warming is becoming an issue world-widely, studies on green house gases such as CO_2 are drawing high attention. Because the ocean plays an important role in buffering the increase of atmospheric CO_2, surveys 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, concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; total 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 can be estimated (Dickson et al., 2007). We here report on board measurements of pCO_2 performed during MR10-01cruise.

(2) Methods, 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 gas analyzer (NDIR; MLT 3T-IR).

The automated system was operated by on one and a half hour cycle. In one cycle, standard gasses, marine air and equilibrated air with surface seawater within the equilibrator were analyzed subsequently. The concentrations of the standard gas were 300.03, 350.14, 400.09 and 450.10 ppm.

To measure marine air concentrations (mol fraction) of CO_2 in dry air (xCO_2-air), marine air sampled from the bow of the ship (approx.30m above the sea level) was introduced into the NDIR by passing through a mass flow controller which controls the air flow rate at about 0.5 L/min, a cooling unit, a perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

To measure surface seawater concentrations of CO_2 in dry air (xCO_2-sea), marine air equilibrated with a stream of seawater within 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 and a desiccant holder containing $Mg(ClO_4)_2$. The seawater taken by a pump from the intake placed at the approx. 4.5m below the sea surface flowed at a rate of 5-6L/min in the equilibrator. After that, the equilibrated air was introduced into the NDIR.

(3) Preliminary results

Concentrations of CO_2 (xCO_2) of marine air and surface seawater are shown in Fig. 2.9-1.

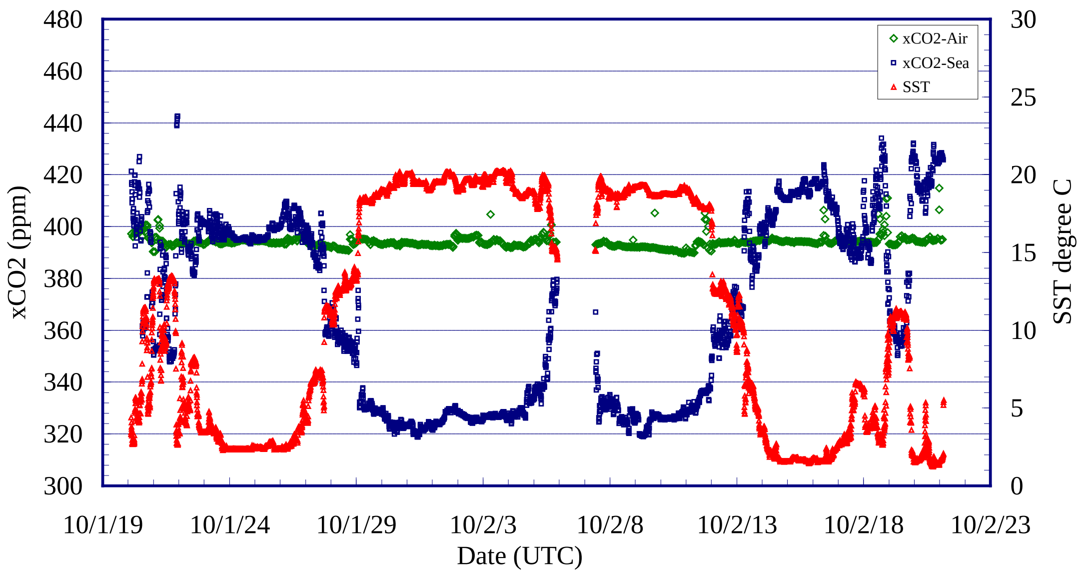

Figure 2.9-1 Temporal changes of concentrations of CO_2 (xCO_2) in atmosphere (green) and surface seawater (blue), and SST (red).

(4) Data Archive

All data will be submitted to the Data Integration and Analyses Group (DIAG), JAMSTEC and will be opened to public via "R/V MIRAI Data Web Page" in JAMSTEC home page.

(5) Reference

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO_2 measurements; PICES Special Publication 3, 199pp.

3. Special observation
3.1. BGC Mooring

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Hiroshi Uchida (JAMSTEC RIGC)
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Daiki Ushiromura (MWJ)
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Ei Hatakeyama (MWJ)

3.1.1. Recovery and Deployment

The one BGC mooring system was designed for biogeochemistry at Station K-2 and S-1 in the Western Subarctic Gyre. We recovered BGC mooring at Station K-2 which was deployed at MR08-05 and deployed one BGC mooring at Station K-2. 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 150m depth, 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. The position of the mooring is finally determined as follow:

Table 3.1.1-1 Mooring positions for respective mooring systems.

	Recovery	Deployment	Deployment
Station & type Mooring Number	K-2 BGC K2B081028	S-1 BGC S1BGC100203	K-2 BGC K2BGC100215
Date of deployment	Oct. 28th 2008	Feb. 3rd 2010	Feb. 5th 2010
Latitude	47° 00.36 N	30° 03.88 N	47° 00.34 N
Longitude	159° 58.16 E	144° 57.96 E	159° 58.24 E
Depth	5,206.2 m	5,926 m	5,206.2 m

The BGC mooring consists of a 64” syntactic top float with 3,000 lbs (1,360 kg) buoyancy, instruments, wire, vectran, and nylon ropes, glass floats (Benthos 17” glass ball), dual releasers (Edgetech) and 4,660 lbs (2,116 kg) sinker with mace plate. Two ARGOS compact mooring locators and one submersible recovery strobe are mounted on the top float. The recovered mooring system 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 RAS shows 10 m deeper than our expected by mooring tilt.

On the recovered BGC mooring, two RAS (Remote Access Sampler) were installed on the 30 m and 190 m with Depth sensors (RIGO) and CT sensors (ALEC). BLOOMS (Ocean Optical Sensor) was only installed on the RAS at 200 m. 5 Sediment Traps were installed on the 150 m, 300 m, 540 m, 1,000 m and 5,000 m.

On the deployment BGC mooring, 3 Sediment Traps are installed on the 200 m, 500 m and 5,000 m. Extra CTD (SBE-37) and DO Sensor (ALEC) are mounted on the dual acoustic releasers. Also extra RIGO Depth Sensor is mounted on the Nichiyu Sediment Trap at K-2.

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		Deployment		
Station and type Mooring Number	K-2 BGC K2B081028	Station and type Mooring Number	S-1 BGC S1BGC100203	K-2 BGC K2BGC100215
ARGOS	18841 / 52111	ARGOS	18840 / 52112	18842/52111
ARGOS ID	18570 / 5373	ARGOS ID	18558 / 5374	18577 / 5373
Strobe	N02-043	Strobe	N02-044	233
RAS (40m) BLOOMS SBE-37 ALEC DO sensor RAS (200m) SBE-37 ALEC DO sensor	ML11241-07 OCR-504-TCSW-57 2755 002 ML11241-08 2756 003			
Sediment Trap×4 Mark7-21 (150m) Mark7-13 (540m) Mark7-13(1000m) Mark7-21(5000m)	 ML11241-22 ML11241-25 ML11241-24 989	Sediment Trap×3 Nichiyu (200m) Rigo Depth Sensor Mark7-21 (500m) Mark7-21(5000m)	 ST98080 - 10292 878	 ST98025 DP1142 0256 989
Releaser Releaser SBE-37 ALEC DO sensor	27864 27867 2757 005	Releaser Releaser SBE-37 AREC DO sensor	27809 28386 2730 003	27805 28509 2731 005

Table 3.1.1-3 Recovery BGC Mooring Record BGC Mooring.

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	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27864		27867		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**344421**		**344573**		
Enable C.	357724		360536		
Disable C.	357762		360570		
Battery	2 years		2 years		
Release Test	OK		OK		
RECOVERY					
Recorder	Toru Idai		Work Distance	1.2	Nmile
Ship	MIRAI		Send Enable C.	11:20	
Cruise No.	MR10-01		Slant Renge	5301	m
Date	2010/1/24		Send Release C.	11:30	
Weather	bc		Discovery Buoy	12:33	
Wave Hight	2.8	m	Pos. of Top Buoy	47°00.55	N
Depth	5214	m		160°00.25	E
Ship Heading	<280>		Pos. of Start	47°00.19	N
Ship Ave.Speed	1.7	knot		159°58.44	E
Wind	<216> 6.2	m/s	Pos. of Finish	46°59.90	N
Current	<188> 0.4	knot		159°56.90	E

Note: Although release command were sent from bridge and mooring deck with transducer many times, release Command did not work as usuall. Return signal from S/N 27867 was recognized by deck unit at mooring deck only once.

Table 3.1.1-4 detail of Recovery BGC Mooring system.Recovery.

	Description	S/N	Joint	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	5185.72	30.48
2	Hardware		I	0.28	3.63	2.55	−1357.15	5183.45	32.75
3	**5** Meters 16mm T-Chain			5.00	27.80	7.55	−1329.35	5183.17	33.03
4	Hardware		G	0.25	2.40	7.80	−1326.95	5178.17	38.03
5	Instrument - "RAS"	ML11241-07	Z	2.30	51.00	10.10	−1275.95	5177.92	38.28
6	Hardware		E	0.24	2.00	10.34	−1273.95	5175.62	40.58
7	3-TON Miller Swivel			0.16	3.17	10.50	−1270.78	5175.38	40.82
8	Hardware		E	0.24	2.00	10.73	−1268.78	5175.22	40.98
9	**106** Meters 5/16″ Wire	T08-C		106.20	22.64	116.93	−1246.14	5174.99	41.21
10	Hardware		E	0.24	1.93	117.17	−1244.21	5068.79	147.41
11	**3** Meters 5/16″ Wire Coated	TRAP03		3.00	0.64	120.17	−1243.57	5068.55	147.65
12	Hardware		L	0.24	2.19	120.41	−1241.38	5065.55	150.65
13	Sediment Trap	ML11241-22	X	3.57	55.68	123.98	−1185.69	5065.31	150.89
14	Hardware		D	0.06	2.00	124.04	−1183.69	5061.74	154.46
15	**2.2** Meters 13mm Strong-Chain			2.20	5.65	126.24	−1178.04	5061.68	154.52
16	Hardware		E	0.24	2.00	126.47	−1176.04	5059.48	156.72
17	**40** Meters 5/16″ Wire	T08-E1		40.08	8.54	166.55	−1167.49	5059.25	156.95
18	Hardware		E	0.24	1.93	166.78	−1165.56	5019.17	197.03
19	**3** Meters 5/16″ Wire Coated	RAS01		3.00	0.64	169.78	−1164.93	5018.94	197.26
20	Hardware		E	0.24	2.00	170.02	−1162.93	5015.94	200.26
21	Instrument - "RAS"	ML11241-08	Z	2.30	51.00	172.32	−1111.93	5015.70	200.50
22	Hardware		E	0.24	2.00	172.55	−1109.93	5013.40	202.80
23	3-TON Miller Swivel			0.16	3.17	172.72	−1106.76	5013.17	203.03
24	Hardware		E	0.24	2.00	172.95	−1104.76	5013.01	203.20
25	**94** Meters 5/16″ Wire	G-2		94.15	20.07	267.10	−1084.69	5012.77	203.43
26	Hardware		E	0.24	1.93	267.33	−1082.76	4918.62	297.58
27	**3** Meters 5/16″ Wire Coated	TRAP05		3.00	0.64	270.33	−1082.12	4918.39	297.81
28	Hardware		E	0.24	2.19	270.57	−1079.93	4915.39	300.81
31	**5** Meters 13mm Strong-Chain			5.00	12.85	275.57	−1067.08	4915.15	301.05
32	Hardware		E	0.24	2.00	275.80	−1065.08	4910.15	306.05
33	**230** Meters 5/16″ Wire	T08-B		230.27	49.09	506.07	−1015.99	4909.92	306.28
34	Hardware		E	0.24	2.00	506.30	−1013.99	4679.65	536.55
35	**3** Meters 5/16″ Wire Coated	TRAP04		3.00	0.64	509.30	−1013.35	4679.42	536.78
36	Hardware		L	0.24	2.19	509.54	−1011.16	4676.42	539.78
37	Sediment Trap	ML11241-25	X	3.69	55.70	513.23	−955.45	4676.18	540.02
38	Hardware		D	0.06	2.00	513.29	−953.45	4672.49	543.71
39	**1.6** Meters 13mm Strong-Chain			1.60	4.11	514.89	−949.34	4672.43	543.77
40	Hardware		E	0.24	2.00	515.13	−947.34	4670.83	545.37
41	**450** Meters 5/16″ Wire	T08-A		450.95	96.14	966.08	−851.21	4670.59	545.61
42	Hardware		E	0.24	1.93	966.31	−849.28	4219.64	996.56
43	**3** Meters 5/16″ Wire Coated	TRAP02		3.00	0.64	969.31	−848.64	4219.41	996.79
44	Hardware		L	0.24	2.19	969.55	−846.45	4216.41	999.79
45	Sediment Trap	ML11241-24	Y	3.95	55.70	973.50	−790.75	4216.17	1000.03
46	Hardware		D	0.06	2.00	973.56	−788.75	4212.22	1003.98
47	**4** Meters 13mm Strong-Chain			4.00	10.28	977.56	−778.47	4212.16	1004.04
48	Hardware		E	0.24	2.00	977.80	−776.47	4208.16	1008.04
49	3-TON Miller Swivel			0.16	3.17	977.96	−773.30	4207.92	1008.28
50	Hardware		B	0.23	1.65	978.19	−771.65	4207.76	1008.44
51	**500** Meters 1/4″ Wire	T08-F1		501.72	70.55	1479.90	−701.10	4207.53	1008.67
52	Hardware		A	0.21	1.33	1480.11	−699.77	3705.82	1510.38
53	**500** Meters 1/4″ Wire	T08-F2		501.75	70.55	1981.87	−629.22	3705.61	1510.59
54	Hardware		B	0.23	1.65	1982.10	−627.57	3203.86	2012.35
55	4-17″ Glassballs			4.00	−91.32	1986.10	−718.89	3203.63	2012.58
56	Hardware		F	0.24	2.00	1986.33	−716.89	3199.63	2016.58
57	4-17″ Glassballsn			4.00	−91.32	1990.33	−808.21	3199.39	2016.81
58	Hardware		C	0.24	1.65	1990.57	−806.56	3195.39	2020.81

59	**500** Meters 1/4″ Wire	T08-F3		501.76	70.55	2492.33	-736.00	3195.15	2021.05
60	Hardware		A	0.21	1.33	2492.54	-734.67	2693.39	2522.81
61	**500** Meters 1/4″ Wire	T08-F4		501.74	70.55	2994.28	-664.12	2693.18	2523.02
62	Hardware		B	0.23	1.65	2994.51	-662.47	2191.44	3024.76
63	4-17″ Glassballs			4.00	-91.32	2998.51	-753.79	2191.21	3024.99
64	Hardware		F	0.24	2.00	2998.74	-751.79	2187.21	3028.99
65	4-17″ Glassballs			4.00	-91.32	3002.74	-843.11	2186.98	3029.22
66	Hardware		C	0.24	1.65	3002.98	-841.46	2182.98	3033.22
67	**500** Meters 1/4″ Wire	T08-F5		501.51	70.52	3504.49	-770.94	2182.74	3033.46
68	Hardware		A	0.21	1.33	3504.70	-769.61	1681.23	3534.97
69	**500** Meters 1/4″ Wire	T08-F6		501.67	70.54	4006.37	-699.07	1681.02	3535.18
70	Hardware		B	0.23	1.65	4006.60	-697.42	1179.35	4036.85
71	4-17″ Glassballs			4.00	-91.32	4010.60	-788.74	1179.12	4037.08
72	Hardware		F	0.24	2.00	4010.84	-786.74	1175.12	4041.08
73	4-17″ Glassballs			4.00	-91.32	4014.84	-878.06	1174.88	4041.32
74	Hardware		F	0.24	2.00	4015.07	-876.06	1170.88	4045.32
75	4-17″ Glassballs			4.00	-91.32	4019.07	-967.38	1170.65	4045.55
76	Hardware		C	0.24	1.65	4019.31	-965.73	1166.65	4049.55
77	**500** Meters 1/4″ Wire	T08-F7		501.75	70.55	4521.06	-895.18	1166.41	4049.79
78	Hardware		A	0.21	1.33	4521.27	-893.85	664.66	4551.54
79	**200** Meters 1/4″ Wire	T08-H1		200.32	28.17	4721.59	-865.68	664.45	4551.75
80	Hardware		A	0.21	1.33	4721.80	-864.35	464.13	4752.07
81	**50** Meters 1/4″ Wire			50.00	7.03	4771.80	-857.32	463.92	4752.28
82	Hardware		A	0.21	1.33	4772.01	-855.99	413.92	4802.28
83	**5** Meters 1/4″ Wire			5.00	0.70	4777.01	-855.29	413.71	4802.49
84	Hardware		B	0.20	1.33	4777.21	-853.96	408.71	4807.49
85	**3** Meters 5/16″ Wire Coated	TRAP01		3.00	0.64	4780.21	-853.32	408.51	4807.69
86	Hardware		L	0.20	1.33	4780.41	-851.99	405.51	4810.69
87	Sediment Trap	989	Y	3.82	55.70	4784.23	-796.29	405.31	4810.89
88	Hardware		D	0.06	2.00	4784.29	-794.29	401.49	4814.71
89	**7** Meters 13mm Strong-Chain			7.00	17.99	4791.29	-776.30	401.43	4814.77
90	Hardware		B	0.23	1.65	4791.52	-774.65	394.43	4821.77
91	**300** Meters 1/4″ Wire	T08-G		300.63	42.27	5092.16	-732.37	394.20	4822.00
92	Hardware		C	0.24	1.65	5092.40	-730.72	93.56	5122.64
93	5 Meters 16mm T-Chain			5.00	27.80	5097.40	-702.92	93.32	5122.88
94	Hardware		F	0.24	2.00	5097.63	-700.92	88.32	5127.88
95	4-17″ Glassballs			4.00	-79.36	5101.63	-780.28	88.09	5128.11
96	Hardware		F	0.24	2.00	5101.87	-778.28	84.09	5132.11
97	4-17″ Glassballs			4.00	-79.36	5105.87	-857.64	83.85	5132.35
98	Hardware		F	0.24	2.00	5106.10	-855.64	79.85	5136.35
99	4-17″ Glassballs			4.00	-79.36	5110.10	-935.00	79.62	5136.58
100	Hardware		F	0.24	2.00	5110.34	-933.00	75.62	5140.58
101	4-17″ Glassballs			4.00	-79.36	5114.34	-1012.36	75.38	5140.82
102	Hardware		F	0.24	2.00	5114.57	-1010.36	71.38	5144.82
103	4-17″ Glassballs			4.00	-79.36	5118.57	-1089.72	71.15	5145.05
104	Hardware		F	0.24	2.00	5118.81	-1087.72	67.15	5149.05
105	4-17″ Glassballs			4.00	-79.36	5122.81	-1167.08	66.91	5149.29
106	Hardware		F	0.24	2.00	5123.04	-1165.08	62.91	5153.29
107	4-17″ Glassballs			4.00	-79.36	5127.04	-1244.44	62.68	5153.52
108	Hardware		F	0.24	2.00	5127.28	-1242.44	58.68	5157.52
109	4-17″ Glassballs			4.00	-79.36	5131.28	-1321.80	58.44	5157.76
110	Hardware		F	0.24	2.00	5131.51	-1319.80	54.44	5161.76
111	4-17″ Glassballs			4.00	-79.36	5135.51	-1399.16	54.21	5161.99
112	Hardware		F	0.24	2.00	5135.75	-1397.16	50.21	5165.99
113	4-17″ Glassballs			4.00	-79.36	5139.75	-1476.52	49.97	5166.23
114	Hardware		F	0.24	2.00	5139.98	-1474.52	45.97	5170.23
115	4-17″ Glassballs			4.00	-79.36	5143.98	-1553.88	45.74	5170.46
116	Hardware		F	0.24	2.00	5144.22	-1551.88	41.74	5174.46
117	5 Meters 16mm T-Chain			5.00	27.80	5149.22	-1524.08	41.50	5174.70
118	Hardware		F	0.24	2.00	5149.45	-1522.08	36.50	5179.70
119	3-TON Miller Swivel			0.16	3.20	5149.61	-1518.88	36.27	5179.93
120	Hardware		G	0.25	2.40	5149.86	-1516.48	36.11	5180.09
121	Dual EGG Acoustic Releases		J	1.95	66.04	5151.81	-1450.44	35.86	5180.34

122	Hardware	G	0.25	2.40	5152.06	−1448.04	33.91	5182.29
123	5 Meters 16mm T−Chain		5.00	27.80	5157.06	−1420.24	33.66	5182.54
124	Hardware	H	0.26	2.85	5157.32	−1417.39	28.66	5187.54
125	**20** Meters 1″ Nylon		21.92	6.54	5179.24	−1410.85	28.40	5187.80
126	Hardware	H	0.26	2.85	5179.50	−1408.00	6.48	5209.72
127	5 Meters 16mm T−Chain		5.00	27.80	5184.50	−1380.20	6.22	5209.98
128	Hardware	H	0.26	2.40	5184.76	−1377.80	1.22	5214.98
129	4666 Lb Ww Anchor		0.96	2116.46	5185.72	738.66	0.96	5215.24
	OVERALL MOORING LENGTH		**5185.72**					5216.20

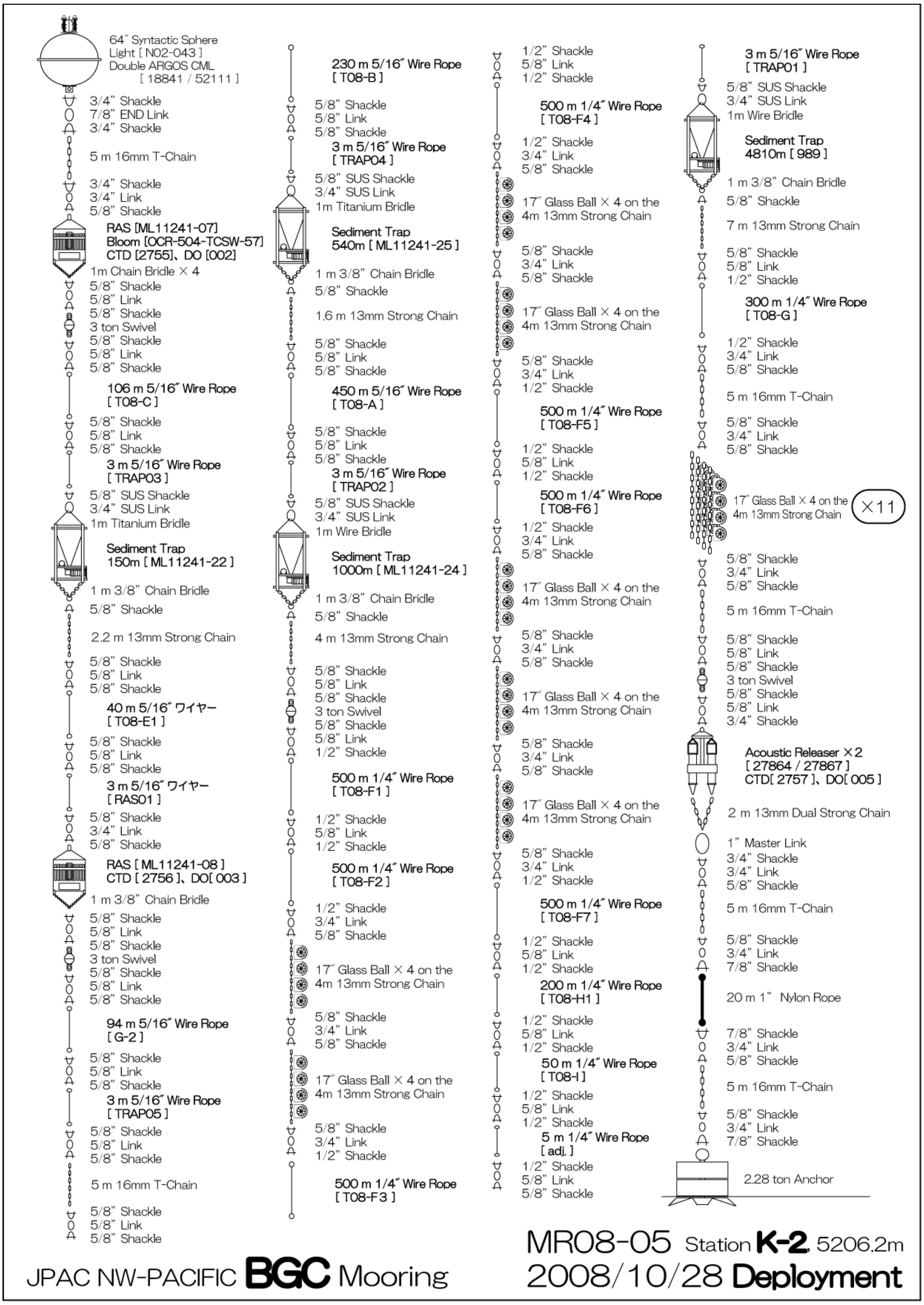


Fig. 3.1.1-1 Recovery BGC Mooring Figure.

Table 3.1.1-5 Deployment S-1 BGC Mooring Record.

Project	Time-Series		Depth	5,910.0	m
Area	North Pacific		Planned Depth	5,900.0	m
Station	S-1 BGC		Length	5,752.3	m
Target Position	**30°03.8656**	**N**	Depth of Buoy	150	m
	144°58.0275	**E**	Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27809		28386		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**344535**		**354501**		
Enable C.	360320		376513		
Disable C.	360366		376530		
Battery	2 years		2 years		
Release Test	OK		OK		
DEPLOYMENT					
Recorder	Toru Idai		Start	6.5	Nmile
Ship	R/V MIRAI		Overshoot	600	m
Cruise No.	MR10-01		Let go Top Buoy	3:02	
Date	2010/2/3		Let go Anchor	3:06	
Weather	bc		Sink Top Buoy	7:07	
Wave Hight	2.5	m	Pos. of Start	30°01.49	N
Depth	5976	m		145°04.59	E
Ship Heading	<295>		Pos. of Drop. Anc.	30°04.03	N
Ship Ave.Speed	2	knot		144°57.63	E
Wind	<274> 10.0	m/s	Pos. of Mooring	30°03.88	N
Current	<122> 0.3	cm/sec		144°57.96	E

Table 3.1.1-6 detail of deployment S-1 BGC Mooring system.

	Description	S/N	Joint	Item Length (m)	Item Weight (kg)	Mooring Length (m)	Mooring Weight (kg)	Above Bottom (m)	Mooring Depth (m)
1	64″ Syntatic Sphere	015162-03		2.27	-1360.78		-1360.78	5752.30	157.70
2	Hardware		I	0.28	3.63	2.55	-1357.15	5750.03	159.97
3	5 Meters 16mm T-Chain			5.00	27.80	7.55	-1329.35	5749.75	160.25
4	Hardware		F	0.25	2.40	7.80	-1326.95	5744.75	165.25
5	3-TON Miller Swivel			0.16	3.17	7.96	-1323.78	5744.50	165.50
6	Hardware		A	0.24	1.90	8.20	-1321.88	5744.34	165.66
7	40 Meters 5/16″ Wire	E-②		40.08	8.54	48.27	-1313.33	5744.10	165.90
8	Hardware		A	0.24	1.90	48.51	-1311.43	5704.02	205.98
9	3 Meters 5/16″ Wire Coated			3.00	0.64	51.51	-1310.79	5703.78	206.22
10	Hardware		L	0.24	2.19	51.75	-1308.60	5700.78	209.22
11	Sediment Trap Nichiyu	ST98080	Y	3.79	55.68	55.54	-1252.92	5700.54	209.46
12	Hardware		E	0.06	0.70	55.60	-1252.22	5696.75	213.25
13	4.0 Meters 13mm Chain			4.00	10.28	59.60	-1241.94	5696.69	213.31
14	Hardware		A	0.24	1.90	59.84	-1240.04	5692.69	217.31
15	3-TON Miller Swivel			0.16	3.17	60.00	-1236.87	5692.45	217.55
16	Hardware		A	0.24	1.90	60.24	-1234.97	5692.29	217.71
17	200 Meters 5/16″ Wire	T09-A1		200.33	42.71	260.58	-1192.26	5692.05	217.95
18	Hardware		A	0.24	1.90	260.82	-1190.36	5491.72	418.28
19	88 Meters 5/16″ Wire Coated	T09-B2		88.16	18.79	348.98	-1171.57	5491.48	418.52
20	Hardware		A	0.24	1.90	349.22	-1169.67	5403.32	506.68
21	3 Meters 5/16″ Wire Coated			3.00	0.64	352.22	-1169.03	5403.08	506.92
22	Hardware		L	0.24	2.19	352.46	-1166.84	5400.08	509.92
23	Sediment Trap ML	10292	Y	3.80	55.70	356.26	-1111.14	5399.84	510.16
24	Hardware		E	0.06	0.70	356.32	-1110.44	5396.04	513.96
25	1.0 Meters 13mm Chain			1.00	2.57	357.32	-1107.87	5395.98	514.02
26	Hardware		A	0.24	1.90	357.56	-1105.97	5394.98	515.02
27	3-TON Miller Swivel			0.16	3.17	357.72	-1102.80	5394.74	515.26
28	Hardware		A	0.24	1.90	357.96	-1100.90	5394.58	515.42
29	1000 Meters 12mm Vectran Rope	SK1000-4		1000.00	31.00	1357.96	-1069.90	5394.34	515.66
30	Hardware		A	0.24	1.90	1358.20	-1068.00	4394.34	1515.66
31	1000 Meters 12mm Vectran Rope	SK1000-5		1000.00	31.00	2358.20	-1037.00	4394.10	1515.90
32	Hardware		A	0.24	1.90	2358.44	-1035.10	3394.10	2515.90
33	4-17″ Glassballs on 13mm Chain			4.00	-91.32	2362.44	-1126.42	3393.86	2516.14
34	Hardware		A	0.24	1.90	2362.68	-1124.52	3389.86	2520.14
35	4-17″ Glassballs on 13mm Chain			4.00	-91.32	2366.68	-1215.84	3389.62	2520.38
36	Hardware		A	0.24	1.90	2366.92	-1213.94	3385.62	2524.38
37	1000 Meters 12mm Vectran Rope	SK1000-6		1000.00	31.00	3366.92	-1182.94	3385.38	2524.62
38	Hardware		A	0.24	1.90	3367.16	-1181.04	2385.38	3524.62
39	500 Meters 12mm Vectran Rope	SK500-2		500.00	15.50	3867.16	-1165.54	2385.14	3524.86
40	Hardware		A	0.24	1.90	3867.40	-1163.64	1885.14	4024.86
41	300 Meters 12mm Vectran Rope	SK300-2		300.00	9.30	4167.40	-1154.34	1884.90	4025.10
42	Hardware		D	0.23	1.65	4167.63	-1152.69	1584.90	4325.10
43	200 Meters 1/4″ Wire	T09-E3		200.56	28.20	4368.19	-1124.49	1584.67	4325.33
44	Hardware		D	0.23	1.65	4368.42	-1122.84	1384.11	4525.89
45	4-17″ Glassballs on 13mm Chain			4.00	-91.32	4372.42	-1214.16	1383.88	4526.12
46	Hardware		D	0.23	1.65	4372.65	-1212.51	1379.88	4530.12
47	200 Meters 1/4″ Wire	T09-E2		200.56	28.20	4573.21	-1184.30	1379.65	4530.35
48	Hardware		C	0.21	1.33	4573.42	-1182.97	1179.09	4730.91
49	50 Meters 1/4″ Wire			50.00	7.03	4623.42	-1175.94	1178.88	4731.12
50	Hardware		C	0.21	1.33	4623.63	-1174.61	1128.88	4781.12
51	35 Meters 1/4″ Wire			35.00	4.92	4658.63	-1169.69	1128.67	4781.33
52	Hardware		D	0.23	1.65	4658.86	-1168.04	1093.67	4816.33
53	3 Meters 5/16″ Wire Coated			3.00	0.64	4661.86	-1167.40	1093.44	4816.56
54	Hardware		L	0.20	1.33	4662.06	-1166.07	1090.44	4819.56
55	Sediment Trap ML10236-01	878	Y	3.84	55.70	4665.90	-1110.37	1090.24	4819.76
56	Hardware		E	0.06	0.70	4665.96	-1109.67	1086.40	4823.60
57	1.0 Meters 13mm Strong-Chain			1.00	2.57	4666.96	-1107.10	1086.34	4823.66
58	Hardware		A	0.24	1.90	4667.20	-1105.20	1085.34	4824.66

59	3-TON Miller Swivel			0.16	3.17	4667.36	−1102.03	1085.10	4824.90
60	Hardware		D	0.23	1.65	4667.59	−1100.38	1084.94	4825.06
61	**500** Meters 1/4″ Wire	T08-F8		501.75	70.55	5169.33	−1029.83	1084.71	4825.29
62	Hardware		C	0.21	1.33	5169.54	−1028.50	582.97	5327.03
63	**300** Meters 1/4″ Wire	T09-D1		300.85	42.30	5470.39	−986.20	582.76	5327.24
64	Hardware		C	0.21	1.33	5470.60	−984.87	281.91	5628.09
65	**200** Meters 1/4″ Wire	T09-E1		200.55	28.20	5671.15	−956.67	281.70	5628.30
66	Hardware		H	0.22	1.65	5671.38	−955.02	81.14	5828.86
67	5 Meters 16mm T-Chain			5.00	27.80	5676.38	−927.22	80.92	5829.08
68	Hardware		B	0.24	2.00	5676.61	−925.22	75.92	5834.08
69	2-17″ Glassballs on 16mm Chain			2.00	−39.68	5678.61	−964.90	75.69	5834.31
70	Hardware		B	0.24	2.00	5678.85	−962.90	73.69	5836.31
71	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5682.85	−1042.26	73.45	5836.55
72	Hardware		B	0.24	2.00	5683.08	−1040.26	69.45	5840.55
73	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5687.08	−1119.62	69.22	5840.78
74	Hardware		B	0.24	2.00	5687.32	−1117.62	65.22	5844.78
75	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5691.32	−1196.98	64.98	5845.02
76	Hardware		B	0.24	2.00	5691.55	−1194.98	60.98	5849.02
77	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5695.55	−1274.34	60.75	5849.25
78	Hardware		B	0.24	2.00	5695.79	−1272.34	56.75	5853.25
79	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5699.79	−1351.70	56.51	5853.49
80	Hardware		B	0.24	2.00	5700.02	−1349.70	52.51	5857.49
81	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5704.02	−1429.06	52.28	5857.72
82	Hardware		B	0.24	2.00	5704.26	−1427.06	48.28	5861.72
83	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5708.26	−1506.42	48.04	5861.96
84	Hardware		B	0.24	2.00	5708.49	−1504.42	44.04	5865.96
85	4-17″ Glassballs on 16mm Chain			4.00	−79.36	5712.49	−1583.78	43.81	5866.19
86	Hardware		B	0.24	2.00	5712.73	−1581.78	39.81	5870.19
87	5 Meters 16mm Chain			5.00	27.80	5717.73	−1553.98	39.57	5870.43
88	Hardware		B	0.24	2.00	5717.96	−1551.98	34.57	5875.43
89	3-TON Miller Swivel			0.16	3.20	5718.12	−1548.78	34.34	5875.66
90	Hardware		F	0.25	2.40	5718.37	−1546.38	34.17	5875.83
91	Dual EGG Acoustic Releases		J	1.95	66.04	5720.31	−1480.33	33.93	5876.07
92	Hardware		F	0.25	2.40	5720.56	−1477.93	31.98	5878.02
93	5 Meters 16mm Chain			5.00	27.80	5725.56	−1450.13	31.74	5878.26
94	Hardware		G	0.26	2.85	5725.82	−1447.28	26.74	5883.26
95	**20** Meters 1″ Nylon	09-24-20-25		20.00	5.96	5745.82	−1441.32	26.48	5883.52
96	Hardware		G	0.26	2.85	5746.08	−1438.47	6.48	5903.52
97	5 Meters 16mm Chain			5.00	27.80	5751.08	−1410.67	6.22	5903.78
98	Hardware		G	0.26	2.85	5751.34	−1407.82	1.22	5908.78
99	2.116 Ton Anchor			0.96	2116.46	5752.30	708.64	0.96	5909.04
	OVERALL MOORING LENGTH			**5752.30**					5910.00

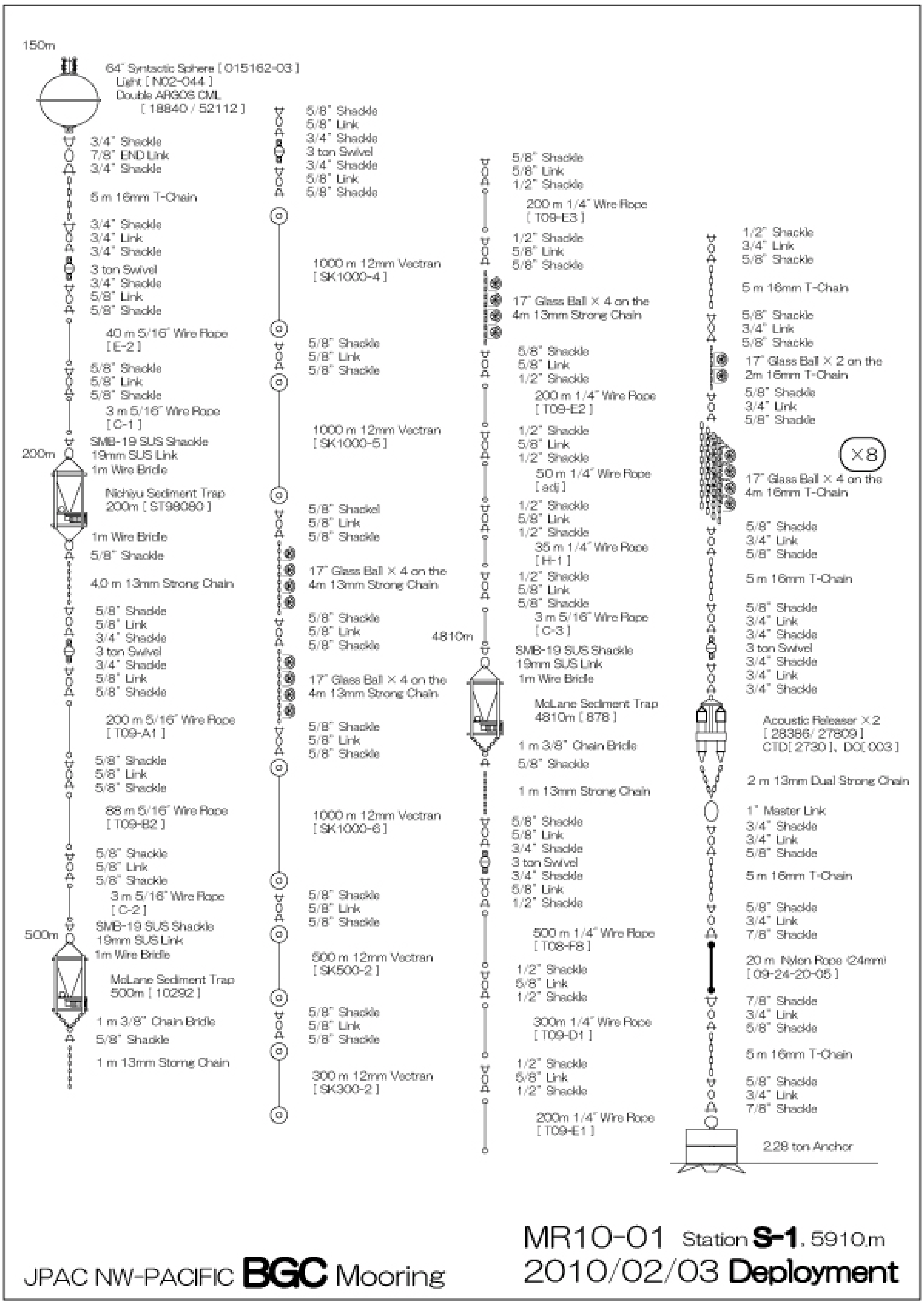


Fig 3.1.1-2 Deployment S-1 BGC Mooring Figure.

Table 3.1.1-7 Deployment K-2 BGC Mooring Record.

Project	Time-Series		Depth	5,206.2	m
Area	North Pacific		Planned Depth	5,216.2	m
Station	K-2 BGC		Length	5,068.2	m
Target Position	**47°00.350**	**N**	Depth of Buoy	150	m
	159°58.326	**E**	Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27805		28509		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**344611**		**335704**		
Enable C.	360631		377142		
Disable C.	360677		377161		
Battery	2 years		2 years		
Release Test	OK		OK		
DEPLOYMENT					
Recorder	Toru Idai		Start	6.5	Nmile
Ship	R/V MIRAI		Overshoot	530	m
Cruise No.	MR10-01		Let go Top Buoy	1:42	
Date	2010/2/15		Let go Anchor	5:05	
Weather	bc		Sink Top Buoy	-	
Wave Hight	2.8	m	Pos. of Start	46°57.38	N
Depth	5,253	m		160°06.56	E
Ship Heading	<300>		Pos. of Drop. Anc.	47°00.47	N
Ship Ave.Speed	2.0	knot		159°57.84	E
Wind	<285> 10.0	m/s	Pos. of Mooring	47°00.34	N
Current	<202> 0.3	knot		159°58.24	E

Table 3.1.1-8 detail of deployment K-2 BGC Mooring system.

	Description	S/N	Joint	Item Length (m)	Item Weight (kg)	Mooring Length (m)	Mooring Weight (kg)	Above Bottom (m)	Mooring Depth (m)
1	64″ Syntatic Sphere	025162-01		2.27	-1360.78		-1360.78	5068.12	148.08
2	Hardware		I	0.28	3.63	2.55	-1357.15	5065.85	150.35
3	**5** Meters 16mm T-Chain			5.00	27.80	7.55	-1329.35	5065.57	150.63
4	Hardware		F	0.25	2.40	7.80	-1326.95	5060.57	155.63
5	3-TON Miller Swivel			0.16	3.17	7.96	-1323.78	5060.33	155.87
6	Hardware		A	0.24	1.90	8.20	-1321.88	5060.17	156.03
7	**40** Meters 5/16″ Wire	C-1		40.08	8.54	48.27	-1313.33	5059.93	156.27
8	Hardware		A	0.24	1.90	48.51	-1311.43	5019.85	196.35
9	**3** Meters 5/16″ Wire Coated	C-4		3.00	0.64	51.51	-1310.79	5019.61	196.59
10	Hardware		L	0.24	2.19	51.75	-1308.60	5016.61	199.59
11	Sediment Trap	ST98025	Y	3.79	55.68	55.54	-1252.92	5016.37	199.83
12	Hardware		E	0.06	0.70	55.60	-1252.22	5012.58	203.62
13	**3.0** Meters 13mm Strong-Chain			3.00	7.71	58.60	-1244.51	5012.52	203.68
14	Hardware		A	0.24	1.90	58.84	-1242.61	5009.52	206.68
15	3-TON Miller Swivel			0.16	3.17	59.00	-1239.44	5009.28	206.92
16	Hardware		A	0.24	1.90	59.24	-1237.54	5009.12	207.08
17	**200** Meters 5/16″ Wire	T-05		200.63	42.77	259.87	-1194.77	5008.88	207.32
18	Hardware		A	0.24	1.90	260.11	-1192.87	4808.25	407.95
19	**88** Meters 5/16″ Wire Coated	T09-B1		88.17	18.80	348.28	-1174.07	4808.01	408.19
20	Hardware		A	0.24	1.90	348.52	-1172.17	4719.84	496.36
21	**3** Meters 5/16″ Wire Coated	C-5		3.00	0.64	351.52	-1171.53	4719.60	496.60
22	Hardware		L	0.24	2.19	351.76	-1169.34	4716.60	499.60
23	Sediment Trap	0256	Y	3.83	55.70	355.59	-1113.64	4716.36	499.84
24	Hardware		E	0.06	0.70	355.65	-1112.94	4712.53	503.67
25	**2.0** Meters 13mm Strong-Chain			2.00	5.14	357.65	-1107.80	4712.47	503.73
26	Hardware		A	0.24	1.90	357.89	-1105.90	4710.47	505.73
27	3-TON Miller Swivel			0.16	3.17	358.05	-1102.73	4710.23	505.97
28	Hardware		A	0.24	1.90	358.29	-1100.83	4710.07	506.13
29	**1000** Meters 12mm Vectran Rope	SK1000-1		1000.00	31.00	1358.29	-1069.83	4709.83	506.37
30	Hardware		A	0.24	1.90	1358.53	-1067.93	3709.83	1506.37
31	**1000** Meters 12mm Vectran Rope	SK1000-2		1000.00	31.00	2358.53	-1036.93	3709.59	1506.61
32	Hardware		A	0.24	1.90	2358.77	-1035.03	2709.59	2506.61
33	4-17″ Glassballs on 13mm Chain			4.00	-91.32	2362.77	-1126.35	2709.35	2506.85
34	Hardware		A	0.24	1.90	2363.01	-1124.45	2705.35	2510.85
35	4-17″ Glassballs on 13mm Chain			4.00	-91.32	2367.01	-1215.77	2705.11	2511.09
36	Hardware		A	0.24	1.90	2367.25	-1213.87	2701.11	2515.09
37	**1000** Meters 12mm Vectran Rope	SK1000-3		1000.00	31.00	3367.25	-1182.87	2700.87	2515.33
38	Hardware		A	0.24	1.90	3367.49	-1180.97	1700.87	3515.33
39	**500** Meters 12mm Vectran Rope	SK500-1		500.00	15.50	3867.49	-1165.47	1700.63	3515.57
40	Hardware		A	0.24	1.90	3867.73	-1163.57	1200.63	4015.57
41	**300** Meters 12mm Vectran Rope	SK300-1		300.00	9.30	4167.73	-1154.27	1200.39	4015.81
42	Hardware		D	0.23	1.65	4167.96	-1152.62	900.39	4315.81
43	**200** Meters 1/4″ Wire	T09-E5		200.56	28.20	4368.52	-1124.42	900.16	4316.04
44	Hardware		D	0.23	1.65	4368.75	-1122.77	699.60	4516.60
45	4-17″ Glassballs on 13mm Chain			4.00	-91.32	4372.75	-1214.09	699.37	4516.83
46	Hardware		D	0.23	1.65	4372.98	-1212.44	695.37	4520.83
47	**200** Meters 1/4″ Wire	T08-H2		200.36	28.17	4573.34	-1184.27	695.14	4521.06
48	Hardware		C	0.21	1.33	4573.55	-1182.94	494.78	4721.42
49	**50** Meters 1/4″ Wire			50.00	7.03	4623.55	-1175.91	494.57	4721.63
50	Hardware		C	0.21	1.33	4623.76	-1174.58	444.57	4771.63
51	**35** Meters 1/4″ Wire			35.00	4.92	4658.76	-1169.66	444.36	4771.84
52	Hardware		D	0.23	1.65	4658.99	-1168.01	409.36	4806.84
53	**3** Meters 5/16″ Wire Coated	C-6		3.00	0.64	4661.99	-1167.37	409.13	4807.07
54	Hardware		L	0.20	1.33	4662.19	-1166.04	406.13	4810.07
55	Sediment Trap	989	Y	3.80	55.70	4665.99	-1110.33	405.93	4810.27
56	Hardware		E	0.06	0.70	4666.05	-1109.63	402.13	4814.07
57	**4.0** Meters 13mm Strong-Chain			4.00	10.28	4670.05	-1099.35	402.07	4814.13

58	Hardware		A	0.24	1.90	4670.29	−1097.45	398.07	4818.13
59	3-TON Miller Swivel			0.16	3.17	4670.46	−1094.29	397.83	4818.37
60	Hardware		D	0.23	1.65	4670.69	−1092.64	397.67	4818.53
61	**300** Meters 1/4″ Wire	T07-F		300.63	42.27	4971.32	−1050.36	397.44	4818.76
62	Hardware		C	0.21	1.33	4971.53	−1049.03	96.80	5119.40
63	**20** Meters 1/4″ Wire			20.00	2.81	4991.53	−1046.22	96.59	5119.61
64	Hardware		H	0.22	1.65	4991.75	−1044.57	76.59	5139.61
65	5 Meters 16mm T-Chain			5.00	27.80	4996.75	−1016.77	76.37	5139.83
66	Hardware		B	0.24	2.00	4996.99	−1014.77	71.37	5144.83
67	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5000.99	−1094.13	71.14	5145.06
68	Hardware		B	0.24	2.00	5001.22	−1092.13	67.14	5149.06
69	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5005.22	−1171.49	66.90	5149.30
70	Hardware		B	0.24	2.00	5005.46	−1169.49	62.90	5153.30
71	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5009.46	−1248.85	62.67	5153.53
72	Hardware		B	0.24	2.00	5009.69	−1246.85	58.67	5157.53
73	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5013.69	−1326.21	58.43	5157.77
74	Hardware		B	0.24	2.00	5013.93	−1324.21	54.43	5161.77
75	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5017.93	−1403.57	54.20	5162.00
76	Hardware		B	0.24	2.00	5018.16	−1401.57	50.20	5166.00
77	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5022.16	−1480.93	49.96	5166.24
78	Hardware		B	0.24	2.00	5022.40	−1478.93	45.96	5170.24
79	4-17″ Glassballs on 16mm T-Chain			4.00	−79.36	5026.40	−1558.29	45.73	5170.47
80	Hardware		B	0.24	2.00	5026.63	−1556.29	41.73	5174.47
81	5 Meters 16mm T-Chain			5.00	27.80	5031.63	−1528.49	41.49	5174.71
82	Hardware		B	0.24	2.00	5031.87	−1526.49	36.49	5179.71
83	3-TON Miller Swivel			0.16	3.20	5032.03	−1523.29	36.26	5179.94
84	Hardware		F	0.25	2.40	5032.27	−1520.89	36.09	5180.11
85	Dual EGG Acoustic Releases		J	1.95	66.04	5034.22	−1454.85	35.85	5180.35
86	Hardware		F	0.25	2.40	5034.46	−1452.45	33.90	5182.30
87	5 Meters 16mm T-Chain			5.00	27.80	5039.46	−1424.65	33.66	5182.54
88	Hardware		G	0.26	2.85	5039.72	−1421.80	28.66	5187.54
89	**20** Meters 1″ Nylon			21.92	6.54	5061.64	−1415.26	28.40	5187.80
90	Hardware		G	0.26	2.85	5061.90	−1412.41	6.48	5209.72
91	5 Meters 16mm T-Chain			5.00	27.80	5066.90	−1384.61	6.22	5209.98
92	Hardware		G	0.26	2.85	5067.16	−1381.76	1.22	5214.98
93	2.116 Ton Anchor			0.96	2116.46	5068.12	734.70	0.96	5215.24
	OVERALL MOORING LENGTH			**5068.12**					5216.20

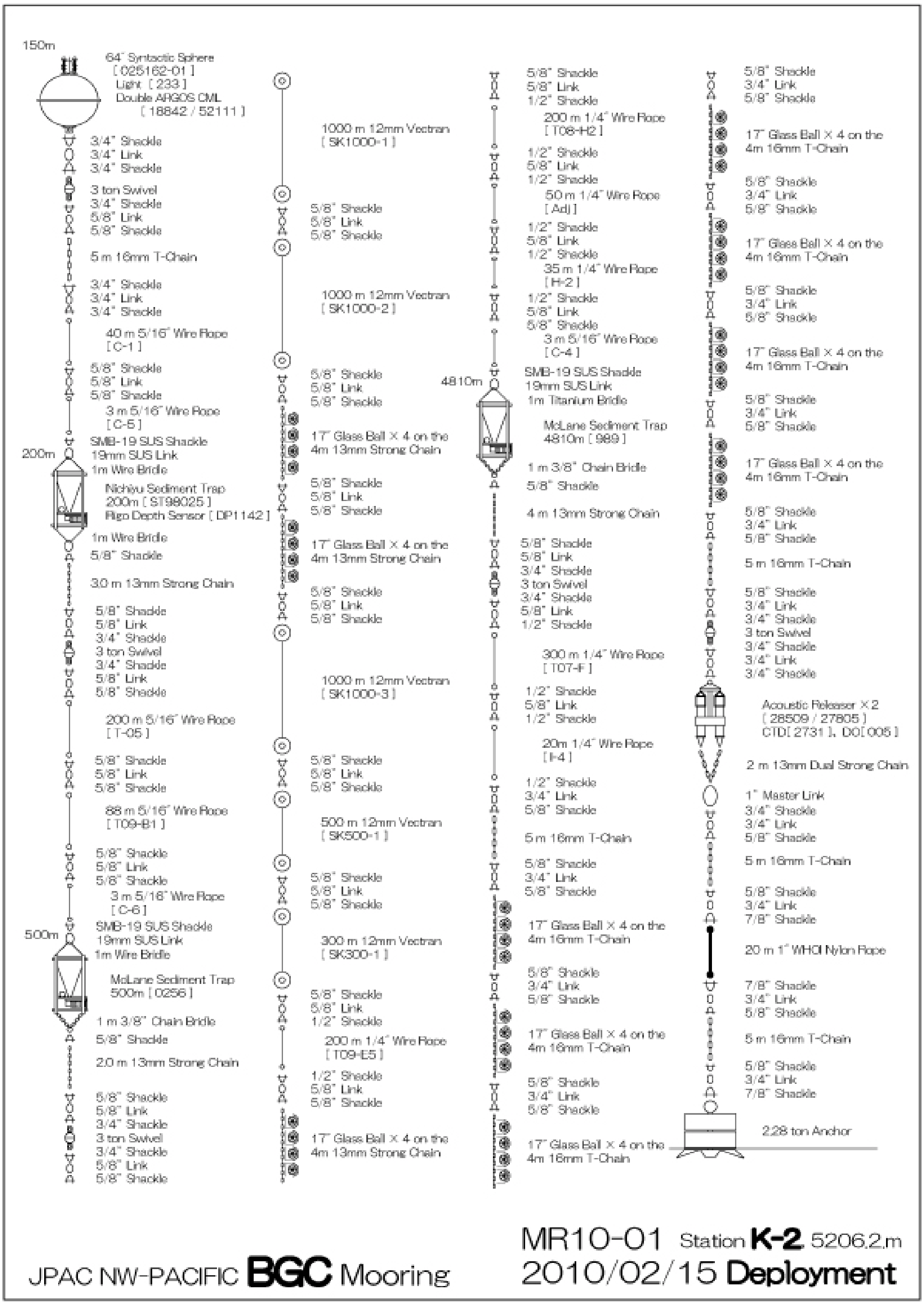


Fig 3.1.1-3 Deployment K-2 BGC Mooring Figure.

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 NOVATECH Xenon Flasher is 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)

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.
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.
Max. Depth:	7,300m

Daylight-off:	User selected, standard
Pressure Switch:	On at surface, auto off when submerged below 10m.
Weight in Air:	4 pounds
Weight in Water:	2 poundsOutside
Diameter:	1.7 inches nominal
Length:	21-1/2 inches nominal

(3) 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

(4) CTD SBE-37

The SBE 37-SM MicroCAT is a high-accuracy conductivity and temperature (pressure optional) recorder with internal battery and memory. Designed for moorings or other long duration, fixed-site deployments, the MicroCAT includes a standard serial interface and nonvolatile FLASH memory. Constructed of titanium and other non-corroding materials to ensure long life with minimum maintenance, the MicroCAT's depth capability is 7000 meters; it is also available with an optional 250-meter plastic *ShallowCAT* housing.

(Specification)

Measurement Range

Conductivity: 0 - 7 S/m (0 - 70 mS/cm)

Temperature: -5 to 35 °C

Optional Pressure: 7000 (meters of deployment depth capability)

Initial Accuracy

Conductivity: 0.0003 S/m (0.003 mS/cm)

Temperature: 0.002 °C

Optional Pressure: 0.1% of full scale range

Typical Stability (per month)

Conductivity: 0.0003 S/m (0.003 mS/cm)
Temperature: 0.0002 °C
Optional Pressure: 0.004% of full scale range
Resolution
Conductivity: 0.00001 S/m (0.0001 mS/cm)
Temperature: 0.0001 °C
Optional Pressure: 0.002% of full scale range
Time Resolution 1 second
Clock Accuracy 13 seconds/month
Quiescent Current * 10 microamps
Optional External Input Power 0.5 Amps at 9-24 VDC
Housing, Depth Rating, and Weight (without pressure sensor)
Standard Titanium, 7000 m (23,000 ft)
Weight in air: 3.8 kg (8.3 lbs)
Weight in water: 2.3 kg (5.1 lbs)

(sampling parameter)

Sampling start time:	Oct. 28th 2008 01:00:00
Sampling interval:	1800 seconds

(5) ALEC DO Sensor

ALEC DO (Compact Optode) 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 1 second or 1, 2 and 10 minutes. The data is converted to personal computer using exclusive cable (serial port).

(Specification)

Model:	COMPACT-Optode
Sensor Type:	Fluorescence quenching
Operating Range:	0 ~ 120%
Precision:	0.4%
Accuracy:	within 5%
Memory:	2Mbyte flash memory
Battery:	lithium battery 7Ah
Battery Life:	172800 data
Sample interval:	1,2,5,10,15,20 and 30 seconds
Diameter:	54mm
Length:	272mm
Main Material:	titanium
Weight in water:	0.6kg
Broken Pressure:	60MPa

(6) Sediment trap

Time-series sediment traps with 21 cups (McLane) were installed at 500, 4810 m at stations K2 and S1. Two traps with 26 cups (Nichiyu) were installed at 200 m at stations K2 and S1. Before deployment, collecting cups were filled up with deep seawater (~ 2000 m) based 10 % buffered formalin. NaCl of 50 g was add to this solution of 10L to increase salinity by 5 per-mil.

3.1.3. Sampling schedule

Sediment trap will collect samples under the following schedule.

	Openig day		Openig day
	21cup		26 cup
	(500, 4810)		(200)
Int	12	Int	6 or 12
1	2010.2.22	1	2010.2.22
2	2010.3.6	2	2010.3.6
3	2010.3.18	3	2010.3.18
4	2010.3.30	4	2010.3.30
5	2010.4.11	5	2010.4.11
6	2010.4.23	6	2010.4.23
7	2010.5.5	7	2010.5.5
8	2010.5.17	8	2010.5.17
9	2010.5.29	9	2010.5.29
		10	2010.6.4
10	2010.6.10	11	2010.6.10
		12	2010.6.16
11	2010.6.22	13	2010.6.22
		14	2010.6.28
12	2010.7.4	15	2010.7.4
		16	2010.7.10
13	2010.7.16	17	2010.7.16
		18	2010.7.22
14	2010.7.28	19	2010.7.28
15	2010.8.9	20	2010.8.9
16	2010.8.21	21	2010.8.21
17	2010.9.2	22	2010.9.2
18	2010.9.14	23	2010.9.14
19	2010.9.26	24	2010.9.26
20	2010.10.8	25	2010.10.8
21	2010.10.20	26	2010.10.20
Close	2010.11.1	Close	2010.11.1

3.1.4. Preliminary results

(1) Sediment trap

Time-series sediment traps were deployed at 150, 550, 1000 and 4810 m. The sediment traps at 150, 550, and 1000 m had 13 cups, and the sediment trap at 4810 m had 21 cups.

After recovery, collected samples were observed. In order to estimate amount of sample qualitatively, heights of collected sample was measured with a scale (Fig. 3.1.4-1). It was observed that material fluxes at respective depths increased toward summer and decreased toward winter 2009. With time lag, seasonal variability at respective depths synchronized well. As same as previous results, material fluxes at deepest depth (4810 m) seemed higher than fluxes at shallower depths.

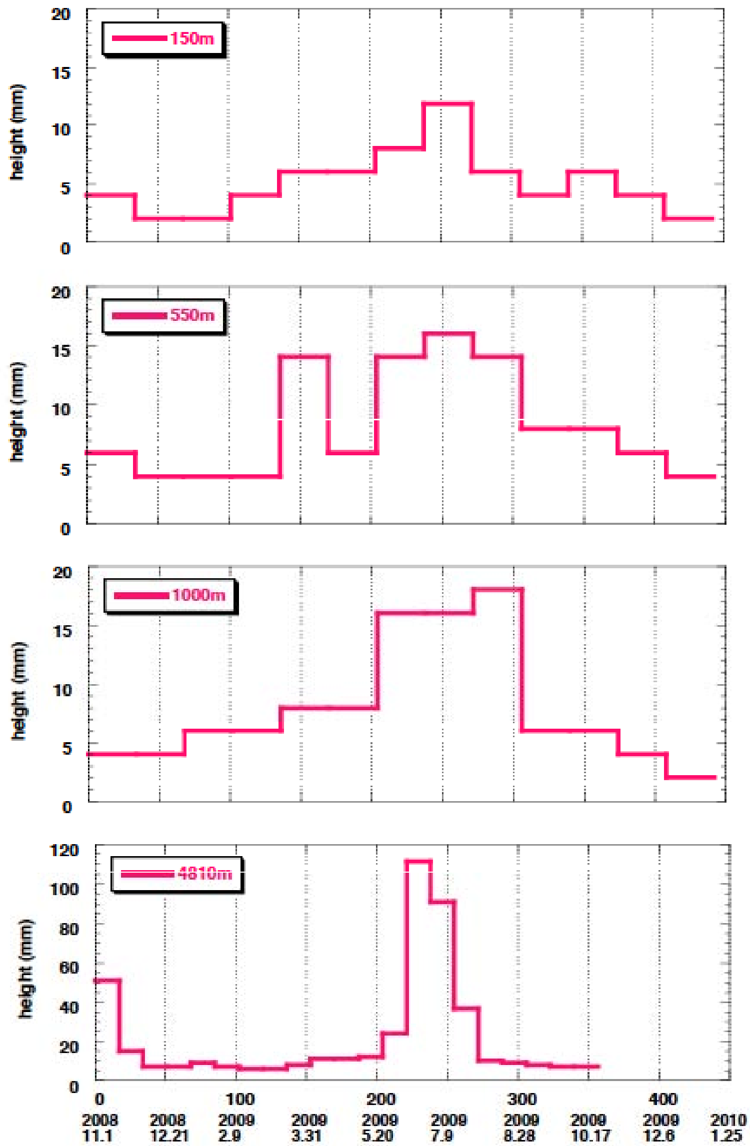


Fig. 3.1.4-1. Seasonal variability in material fluxes at 150, 550, 1000 and 4810 m.

(2) RAS

1. RAS depth

Two automatic water samplers (RAS) were designed to be located at approximately 30 m and 190 m (Fig. 3.1.4-2a). These RAS depths during deployment were observed every a half hour by depth sensors (Sea-birds SBE-37 SM) attached on RAS frame.

Although both RAS at 30 m and 190 m were sometimes deepened by approximately 20 m, both RAS depth were generally stable and were kept at designed depth before August 2009. However, RAS at 30 m from June 2009 to September 2009 was deeper than maximum mixed layer depth from 2003 to 2010 (Fig. 3.1.4-2a). It was noteworthy that both RAS were deepened by 200 m at maximum in August 2009. It is suspected that strong current took place and mooring system at least upper 400 m might be largely forced to be tilted.

2. Temperature and salinity at RAS depth

Conductivity and Temperature sensor (Sea-birds SBE-37 SM), and Temperature (ALEC, Optode) were installed on both RAS frame, and temperature and salinity were observed every a half hour during deployment (Figs.3.1.4-2b and 3.1.4- 2d)

Temperature at deeper RAS depth (~190 m, $Temp_{(190)}$ hereinafter) was approximately 3.5°C in October 2008. $Temp_{(190)}$ was generally constant all year around although temperature was sometimes lower than 3°C. On the other hand, temperature at shallower RAS depth (~30 m, $Temp_{(30)}$ hereinafter) showed seasonal variability. $Temp_{(30)}$ in October 2008 was approximately 8 °C and decreased toward winter. Between middle December 2008 and middle June 2009, $Temp_{(30)}$ was lower than $Temp_{(190)}$ with minimum temperature of approximately 1°C in March 2009. After March 2009, $Temp_{(30)}$ increased toward autumn 2009. However its increase since June 2009 was not smooth but had large deviation. Since RAS at 30m during this period was deeper than the maximum mixed layer depth from 2003 to 2010 (Fig. 3.1.4-2a), this deviation might be caused by diurnal tide. In August and September 2008, $Temp_{(30)}$ became lower largely. It is attributed to that RAS was deepened largely during this period.

Salinity at deeper RAS depth ($Sal_{(190)}$ hereinafter) also was generally stable. Average $Sal_{(190)}$ was approximately 33.8 during deployment. Salinity at shallower RAS depth ($Sal_{(30)}$ hereinafter) was ~32.8 in October 2008 and increased toward April 2009. It was attributed to winter mixing and supply of subsurface water with higher salinity to surface water. After April 2009, $Sal_{(30)}$ decreased toward July 2009. Increase of $Sal_{(30)}$ observed in August and September 2009 was likely caused by increase of RAS depth by 150 m. $Sal_{(30)}$ from June 2009 to September had large deviation, which might be due to diurnal tide, as well as $Temp_{(30)}$.

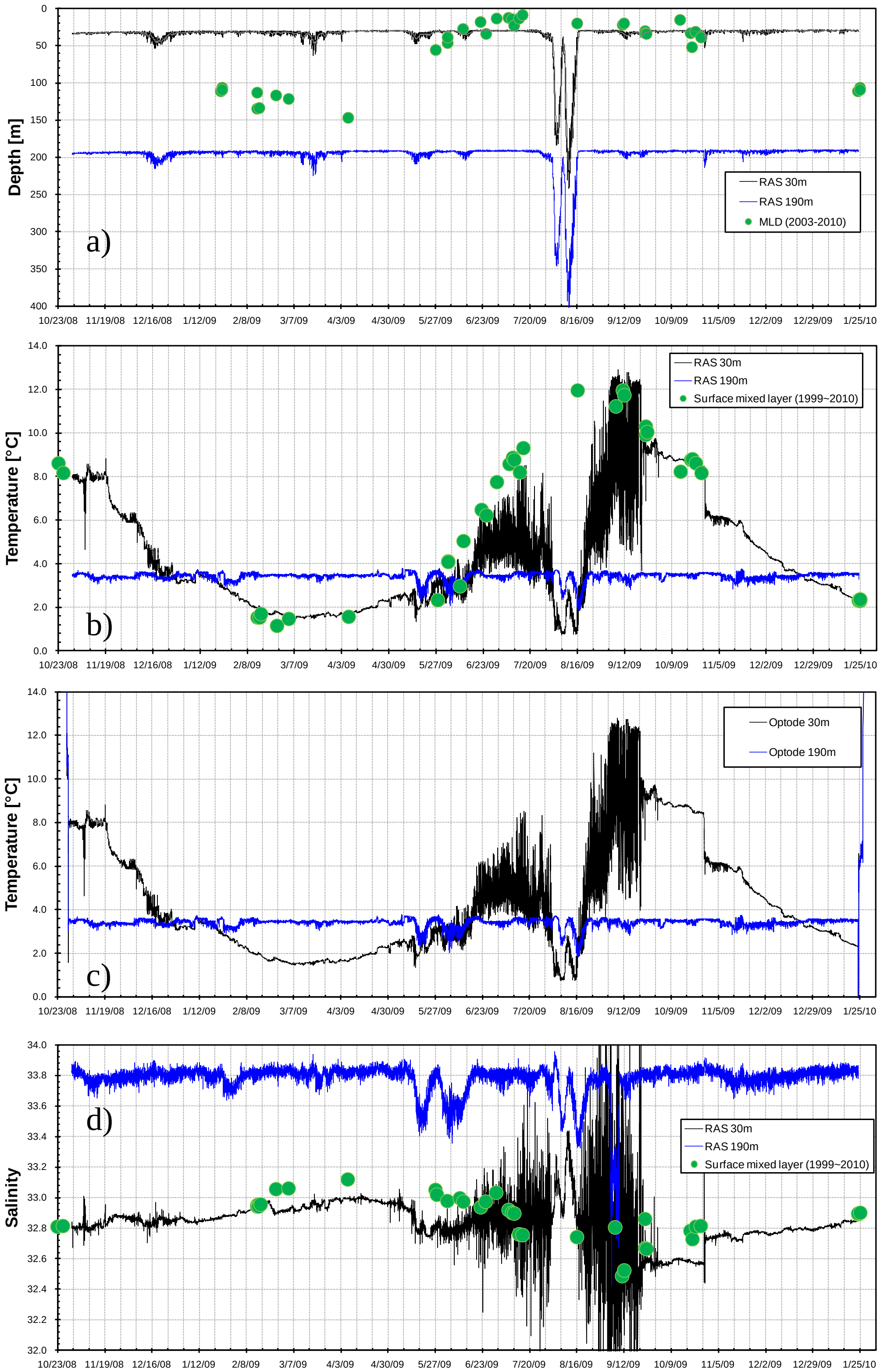


Fig. 3.1.4-2 Depth (a), temperature (SBE-37) (b), temperature (Optode) (c) and Salinity (SBE-37) (d) at two automatic water samplers (RAS (30m and 190m)) during deployment.

3. Chemical analysis of RAS sample

1) Status of RAS sampling (Table 3.1.4-1 and 3.1.4-2)

Because of clogging due to sinking particles in a single valve intake port on the top head, RAS at 30 m collected from late October 2008 to late May 2009 (Fig. 3.1.4-3a). Several sample bags (#3; 19 November 2008, #10; 21 January 2009) leaked with holes. We could not measure dissolved inorganic carbon (DIC), total alkalinity (TA), nutrients (Phosphate, Nitrate + Nitrite, Silicate) and salinity in this time.

RAS at 190 m worked following schedule. However, sample volume after collecting (#23 (middle May 2009), #31(late July 2009), and #33 (middle August 2009)) were quite small. Judging from the onboard test after recovery, sampling bags leaked, which chemical properties couldn't be measured.

Salinity of RAS seawater samples was measured by salinometer (AutoLab YEO-KAL). Salinity of RAS samples should be lower than ambient seawater, because RAS samples were diluted with $HgCl_2$ solution. Salinity measured by salinometer was slightly lower than that observed by CTD sensor (SBE-37) by 0.2 ± 0.1%. These differences showed that RAS samples (~500ml) were diluted with <~1 ml of $HgCl_2$ for preservative. For RAS samples with hole on sample bags (#3 and #10 at 30m; #23, #31, and #33 at 190 m), high salinity should be attributed to contamination of high saline seawater in the sample bag containers (not shown). For chemical properties, the dilutions of RAS samples by $HgCl_2$ were corrected by a ratio of salinity by CTD sensor (SBE-37) to that by salinometer. Preliminary results of chemical analysis of RAS sample are shown in Figs. 3.1.4-3b to 3f.

2) Preliminary results of chemical analysis of RAS sample

(a) Nutrients (phosphate, nitrate, nitrite, silicate)

Concentrations of nutrients (phosphate, nitrate+nitrite, silicate) for the first sample (collected on 1 November 2008) were comparable to previous value observed before deployments (MR08-05) and after recovery (MR10-01), and at same season (Honda and Watanabe, JO 63, 349 - 362, 2007). The values at 30 m increased towards spring. The nutrients in 190 m decreased in late January, middle June, early August 2009 (Figs. 3.1.4-3b to 3.1.4-3d), when temperature, salinity and density at 190 m also decreased (Figs. 3.1.4-2b, 3.1.4-2d and 3.1.4-3a). Thus, except these periods, the nutrients in 190 m remain constant in all year and have no seasonal variations.

(b) Dissolved inorganic carbon (DIC)

Both DIC concentrations at 30 m and 190 m were scattered, and smaller than those observed before deployments (MR08-05) and after recovery (MR10-01), and those observed from 2003 to 2010 by 50 – 100 μmol kg^{-1} (Fig. 3.1.4-3e). These differences at 190 m were larger than those at 30 m. We did not use HCl for anti-biofouling, because HCl affected DIC analysis (Honda and Watanabe, 2007). However, DIC collected at RAS became lower than DIC observed by hydrocasting, even if seawater was collected without HCl. CO_2 degassing might take place during deployment or analysis, regardless of usage of HCl. Most of metalized sample bags that lined polyethylene peeled after deployment, which CO_2 might degas from this peeled part of sample bag during deployment. Unfortunately RAS samples might not be available for measurements of DIC.

(c) Total alkalinity (TA)

Both TA concentrations at 30 m and 190 m tended to remain constant, and were comparable to previous values observed before deployments (MR08-05) and after recovery (MR10-01), and those observed from 2003 to 2010 (Fig. 3.1.4-3f). TA contents at 30m from early April to late May 2009 were eliminated, because quality control of TA analysis was questionable. TA in 190 m decreased in late January, middle June, early August 2009 (Fig. 3.1.4-3f), when temperature, salinity and density at 190m also decreased (Figs. 3.1.4-2b, 2d and 3.1.4-3a). Thus except these period, TA in 190m remain constant in all year and have no seasonal variations.

Table 3.1.4-1 RAS sample list at 30m.

RAS No.	Date	CTD(SBE37)				Volume	Sample				Memo
		Pressure [db]	θ [°C]	Salinity	σ_θ		DIC	TA	Nuts	Sal	
#	dd/mm/yyyy										
1	1 Nov 2008	33.8	8.003	32.800	25.55	L	○	○	○	○	
2	10 Nov 2008	33.7	7.997	32.795	25.54	L	○	○	○	○	
3	19 Nov 2008	32.7	7.783	32.825	25.60	S	×	×	×	×	Leak in sample bag (upper)
4	28 Nov 2008	32.5	6.142	32.876	25.86	L	○	○	○	○	
5	7 Dec 2008	32.3	5.726	32.858	25.89	L	○	○	○	○	
6	16 Dec 2008	44.6	3.998	32.834	26.06	L	○	○	○	○	
7	25 Dec 2008	35.3	3.622	32.846	26.11	L	○	○	○	○	
8	3 Jan 2009	32.8	3.250	32.849	26.15	L	○	○	○	○	
9	12 Jan 2009	32.3	3.454	32.846	26.13	L	○	○	○	○	
10	21 Jan 2009	32.7	3.170	32.862	26.16	S	×	×	×	×	quite small sample
11	30 Jan 2009	31.3	2.647	32.884	26.23	L	○	○	○	○	
12	8 Feb 2009	31.4	2.177	32.911	26.29	L	○	○	○	○	
13	17 Feb 2009	33.7	1.812	32.947	26.34	L	○	○	○	○	
14	26 Feb 2009	34.2	1.706	32.906	26.32	L	○	○	○	○	
15	7 Mar 2009	34.5	1.531	32.917	26.34	L	○	○	○	○	
16	16 Mar 2009	42.8	1.548	32.958	26.37	L	○	○	○	○	Zooplankton contained sample bag
17	25 Mar 2009	32.8	1.742	32.932	26.33	L	○	○	○	○	
18	3 Apr 2009	32.5	1.677	32.982	26.38	L	○	○	○	○	
19	12 Apr 2009	30.5	1.778	32.996	26.38	L	○	○	○	○	
20	21 Apr 2009	30.4	1.988	32.980	26.35	L	○	○	○	○	
21	30 Apr 2009	30.4	2.196	32.963	26.32	L	○	○	○	○	
22	9 May 2009	31.1	2.532	32.933	26.27	L	○	○	○	○	
23	18 May 2009	35.0	2.365	32.799	26.18	L	○	○	○	○	
24	27 May 2009	30.8	2.893	32.807	26.14	L	○	○	○	○	
25	5 Jun 2009	30.6	2.974	32.780	26.12	S	×	×	×	×	quite small sample
26	14 Jun 2009	33.4	3.294	32.823	26.12	S	×	×	×	×	quite small sample
27	23 Jun 2009	30.3	4.755	32.879	26.02	S	×	×	×	×	quite small sample
28	2 Jul 2009	30.2	4.966	32.862	25.98	S	×	×	×	×	quite small sample
29	11 Jul 2009	30.4	4.693	32.831	25.98	S	×	×	×	×	quite small sample
30	20 Jul 2009	30.7	4.222	32.848	26.05	S	×	×	×	×	quite small sample
31	29 Jul 2009	37.1	3.776	32.870	26.11	S	×	×	×	×	quite small sample
32	7 Aug 2009	47.6	0.834	32.901	26.37	S	×	×	×	×	quite small sample
33	16 Aug 2009	32.5	2.084	32.808	26.21	S	×	×	×	×	quite small sample
34	25 Aug 2009	30.5	6.379	32.873	25.81	S	×	×	×	×	quite small sample
35	3 Sep 2009	31.1	8.584	32.744	25.40	S	×	×	×	×	quite small sample
36	12 Sep 2009	36.6	8.625	32.775	25.41	S	×	×	×	×	quite small sample
37	21 Sep 2009	35.8	8.918	32.651	25.28	S	×	×	×	×	quite small sample
38	30 Sep 2009	31.4	9.135	32.585	25.21	S	×	×	×	×	quite small sample
39	9 Oct 2009	30.7	8.758	32.585	25.27	S	×	×	×	×	quite small sample
40	18 Oct 2009	30.5	8.756	32.589	25.27	S	×	×	×	×	quite small sample
41	27 Oct 2009	41.3	7.385	32.652	25.51	S	×	×	×	×	quite small sample

Table 3.1.4-2 RAS sample list at 190m.

RAS No.	Date	CTD(SBE37)				Volume	Sample				Memo
		Pressure [db]	θ [°C]	Salinity	σ_θ						
#	dd/mm/yyyy						DIC	TA	Nuts	Sal	
1	1 Nov 2008	196.4	3.453	33.824	26.90	L	○	○	○	○	
2	10 Nov 2008	196.3	3.402	33.763	26.86	L	○	○	○	○	
3	19 Nov 2008	195.3	3.319	33.766	26.87	L	○	○	○	○	
4	28 Nov 2008	195.1	3.377	33.794	26.89	L	○	○	○	○	
5	7 Dec 2008	195.0	3.487	33.797	26.88	L	○	○	○	○	
6	16 Dec 2008	207.4	3.446	33.833	26.91	L	○	○	○	○	
7	25 Dec 2008	198.1	3.313	33.783	26.89	L	○	○	○	○	
8	3 Jan 2009	195.5	3.475	33.820	26.90	L	○	○	○	○	
9	12 Jan 2009	195.0	3.517	33.826	26.90	L	○	○	○	○	Zooplankton contained sample bag
10	21 Jan 2009	195.6	3.262	33.792	26.90	L	○	○	○	○	
11	30 Jan 2009	194.1	3.114	33.704	26.84	L	○	○	○	○	
12	8 Feb 2009	194.3	3.494	33.808	26.89	L	○	○	○	○	
13	17 Feb 2009	196.6	3.442	33.828	26.91	L	○	○	○	○	
14	26 Feb 2009	197.0	3.456	33.826	26.91	L	○	○	○	○	
15	7 Mar 2009	197.4	3.423	33.810	26.90	L	○	○	○	○	
16	16 Mar 2009	205.7	3.428	33.820	26.90	L	○	○	○	○	
17	25 Mar 2009	195.6	3.366	33.782	26.88	L	○	○	○	○	Zooplankton contained sample bag
18	3 Apr 2009	195.2	3.447	33.819	26.90	L	○	○	○	○	
19	12 Apr 2009	193.3	3.435	33.820	26.90	L	○	○	○	○	
20	21 Apr 2009	193.3	3.463	33.832	26.91	L	○	○	○	○	
21	30 Apr 2009	193.2	3.319	33.809	26.90	L	○	○	○	○	Zooplankton contained sample bag
22	9 May 2009	193.9	3.694	33.855	26.91	L	○	○	○	○	
23	18 May 2009	197.9	2.743	33.534	26.74	S	×	×	×	×	Leak in sample bag (upper)
24	27 May 2009	193.6	3.583	33.813	26.88	L	○	○	○	○	
25	5 Jun 2009	193.4	3.055	33.587	26.75	L	○	○	○	○	
26	14 Jun 2009	196.2	3.468	33.735	26.83	L	○	○	○	○	
27	23 Jun 2009	193.0	3.432	33.813	26.90	L	○	○	○	○	
28	2 Jul 2009	193.0	3.392	33.794	26.89	L	○	○	○	○	
29	11 Jul 2009	193.2	3.565	33.812	26.88	L	○	○	○	○	
30	20 Jul 2009	193.5	3.550	33.777	26.86	L	○	○	○	○	
31	29 Jul 2009	200.0	3.426	33.773	26.87	S	×	×	×	×	Leak in sample bag (upper)
32	7 Aug 2009	210.5	2.568	33.484	26.71	L	○	○	○	○	
33	16 Aug 2009	195.3	2.131	33.390	26.67	S	×	○	×	×	Leak in sample bag (upper)
34	25 Aug 2009	193.3	3.416	33.783	26.88	L	○	○	○	○	
35	3 Sep 2009	193.7	3.407	33.633	26.75	L	○	○	○	○	
36	12 Sep 2009	199.2	3.255	33.743	26.86	L	○	○	○	○	
37	21 Sep 2009	198.2	3.533	33.814	26.89	L	○	○	○	○	
38	30 Sep 2009	194.0	3.519	33.823	26.90	M	○	○	○	○	
39	9 Oct 2009	193.2	3.484	33.807	26.89	L	○	○	○	○	
40	18 Oct 2009	193.1	3.404	33.815	26.90	L	○	○	○	○	
41	27 Oct 2009	203.8	3.570	33.860	26.92	L	○	○	○	○	

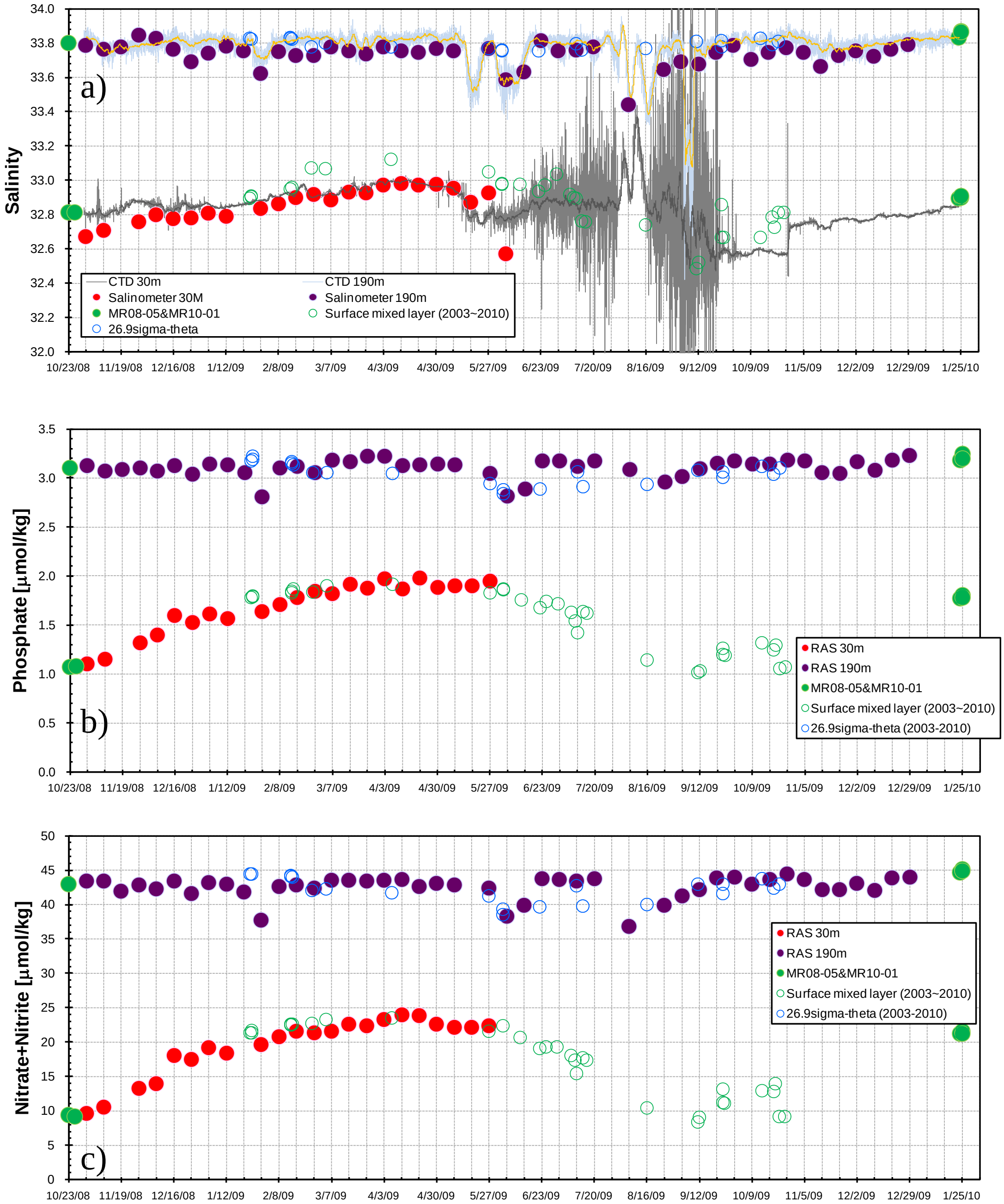


Figure 3.1.4-3 Salinity (a), phosphate (b), nitrate + nitrite (c), slinicate (d), dissolve inorganic car bon (DIC) (e) and total alkalinity (TA) (f) measured at two automatic water samplers (RAS (30m and 190m)) during deployment. Thin lines were the salinity value by CTD sensor (SBE-37) deployed at 30 m (gray) and 190 m (light blue). Solid green circles (●) show the measurements by hydrocasting before and after mooring deployment/recovery. Opened circles indicate the measurements at K2 from 2003 to 2010 in the surface mixed layer (○) and on the $26.9\sigma_\theta$ surface (○) to compare the typical features of seasonal variations at K2. The $26.9\sigma_\theta$ surface was similar to the σ_θ value calculated by potential temperature and salinity at 190 m.

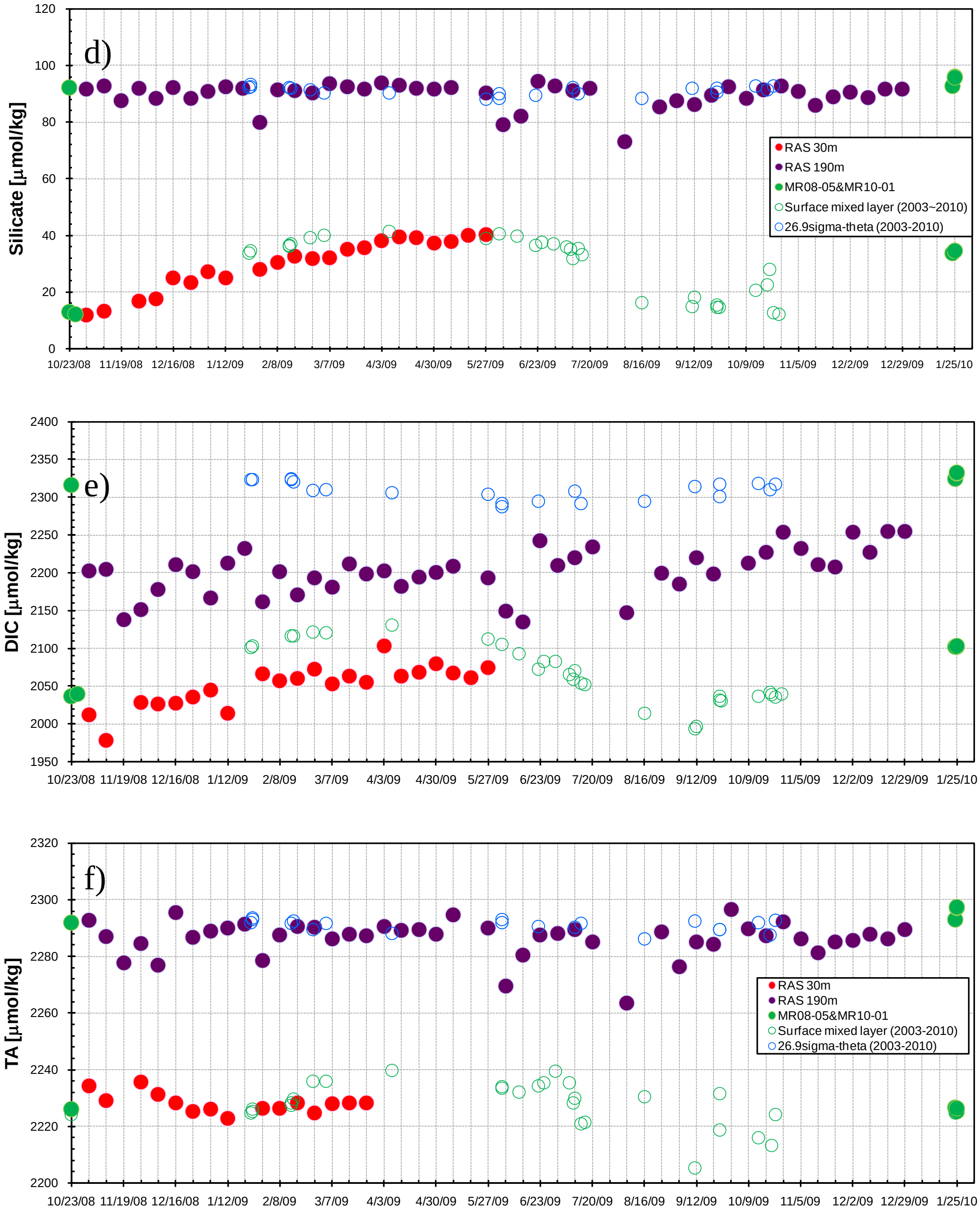


Fig. 3.1.4-3 (continued).

3.2. Underwater profiling buoy system

Tetsuichi FUJIKI (JAMSTEC)
Tetsuya NAKAMURA (Nichiyu Giken Kogyo)

(1) Objective

An understanding of the variability in phytoplankton productivity provides a basic knowledge of how aquatic ecosystems are structured and functioning. The primary productivity of the world oceans has been measured mostly by the radiocarbon tracer method or the oxygen evolution method. As these traditional methods use the uptake of radiocarbon into particulate matter or changes in oxygen concentration in the bulk fluid, measurements require bottle incubations for periods ranging from hours to a day. This methodological limitation has hindered our understanding of the variability of oceanic primary productivity. To overcome these problems, algorithms for estimating primary productivity by using satellite ocean color imagery have been developed and improved. However, one of the major obstacles to the development and improvement of these algorithms is a lack of *in situ* primary productivity data to verify the satellite estimates.

During the past decade, the utilization of active fluorescence techniques in biological oceanography has brought marked progress in our understanding of phytoplankton photosynthesis in the oceans. Above all, fast repetition rate (FRR) fluorometry reduces the primary electron acceptor (Q_a) in photosystem (PS) II by a series of subsaturating flashlets and can measure a single turnover fluorescence induction curve in PSII. The PSII parameters derived from the fluorescence induction curve provide information on the physiological state related to photosynthesis and can be used to estimate gross primary productivity. FRR fluorometry has several advantages over the above-mentioned traditional methods. Most importantly, because measurements made by FRR fluorometry can be carried out without the need for time-consuming bottle incubations, this method enables real-time high-frequency measurements of primary productivity. In addition, the FRR fluorometer can be used in platform systems such as moorings, drifters, and floats.

The current study aimed to assess the vertical and temporal variations in PSII parameters and primary productivity in the western Pacific, by using an underwater profiling buoy system that uses the FRR fluorometer (system abbreviation: PPOPS).

(2) Methods

a) Underwater profiling buoy system

The underwater profiling buoy system (original design by Nichiyu Giken Kogyo) consisted mainly of an observation buoy equipped with a submersible FRR fluorometer (Diving Flash, Kimoto Electric), a scalar irradiance sensor (QSP-2200, Biospherical Instruments), a CTD sensor (MCTD, Falmouth Scientific) and a dissolved oxygen sensor (Compact Optode, Alec Electronics), an underwater winch, an acoustic Doppler current profiler (Workhorse Long Ranger, Teledyne RD Instruments) and an acoustic releaser (Fig. 1). The observation buoy moved between the winch depth and the surface at a rate of 0.2 m s^{-1} and measured the vertical profiles of phytoplankton fluorescence, irradiance, temperature, salinity and dissolved oxygen. The profiling rate of the observation buoy was set to 0.2 m s^{-1} to detect small-scale variations (approx. 0.5 m) in the vertical profile. To minimize biofouling of instruments, the underwater winch was placed below the euphotic layer so that the observation buoy was exposed to light only during the measurement period. In addition, the vertical migration of observation buoy reduced biofouling of instruments.

b) Measurement principle of FRR fluorometer

The FRR fluorometer consists of closed dark and open light chambers that measure the fluorescence induction curves of phytoplankton samples in darkness and under actinic illumination. To allow relaxation of photochemical quenching of fluorescence, the FRR fluorometer allows samples in the dark chamber to dark adapt for about 1 s before measurements. To achieve cumulative saturation of PSII within 150 μs — i.e., a single photochemical turnover — the instrument generates a series of subsaturating blue flashes at a light intensity of 25 mmol quanta m^{-2} s^{-1} and a repetition rate of about 250 kHz s^{-1}. The PSII parameters are derived from the single-turnover-type fluorescence induction curve by using the numerical fitting procedure described by Kolber et al. (1998). Analysis of fluorescence induction curves measured in the dark and light chambers provides PSII parameters such as fluorescence yields, photochemical efficiency and effective absorption cross section of PSII, which are indicators of the physiological state related to photosynthesis. Using the PSII parameters, the rate of photosynthetic electron transport and the gross primary productivity can be estimated.

c) Site description and observations

The profiling buoy systems were deployed at time-series station K2 (47°N, 160°E; water depth approximately 5200 m) and station S1 (30°N, 145°E; water depth approximately 5900 m). At station K2, measurements with the profiling buoy system were made twice a day (0:00 and 12:00 h) from 27 January to 15 February 2010. At station S1, the measurements began on 2 February 2010 (once a day, 12:00 h) and will continue until 18 May 2010.

To gain a better understanding of observational data from the profiling buoy systems, separately from the profiling buoy systems, we moved up and down a submersible FRR fluorometer between surface and 200 m at both the stations K2 and S1 using a ship winch, and measured the vertical and spatial variation in PSII parameters. In addition, the photosynthesis-irradiance response curves of phytoplankton assemblage were measured using a desktop FRR fluorometer with the external light attachment.

(3) Preliminary results

Data analysis will be made after recovery of the profiling buoy systems. The profiling buoy systems deployed at stations S1 and K2 will be recovered in May and October 2010, respectively.

(4) Data archives

All data will be submitted to JAMSTEC Data Management Office.

(5) References

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.

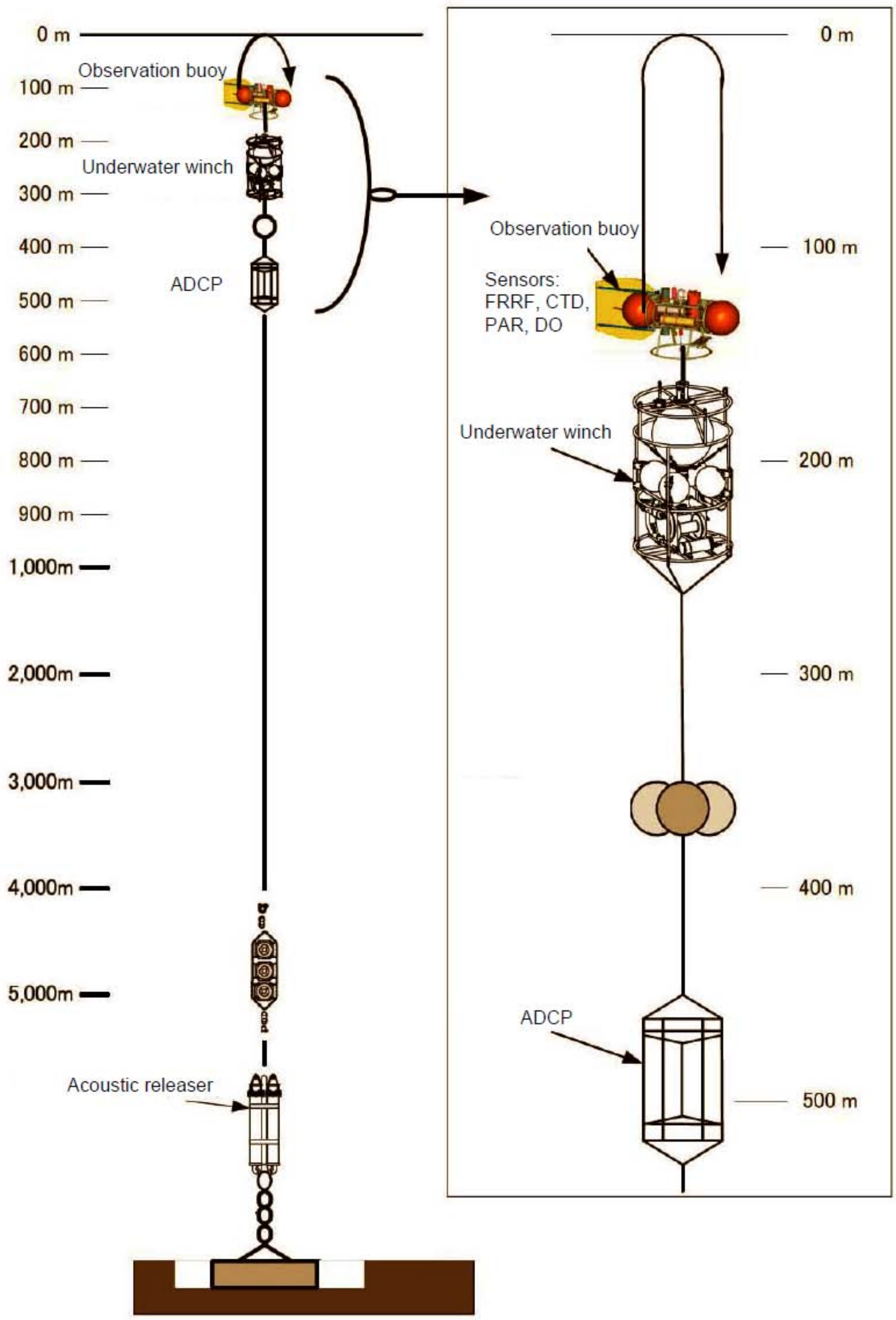


Figure 1a. Schematic diagram of the underwater profiling buoy system.

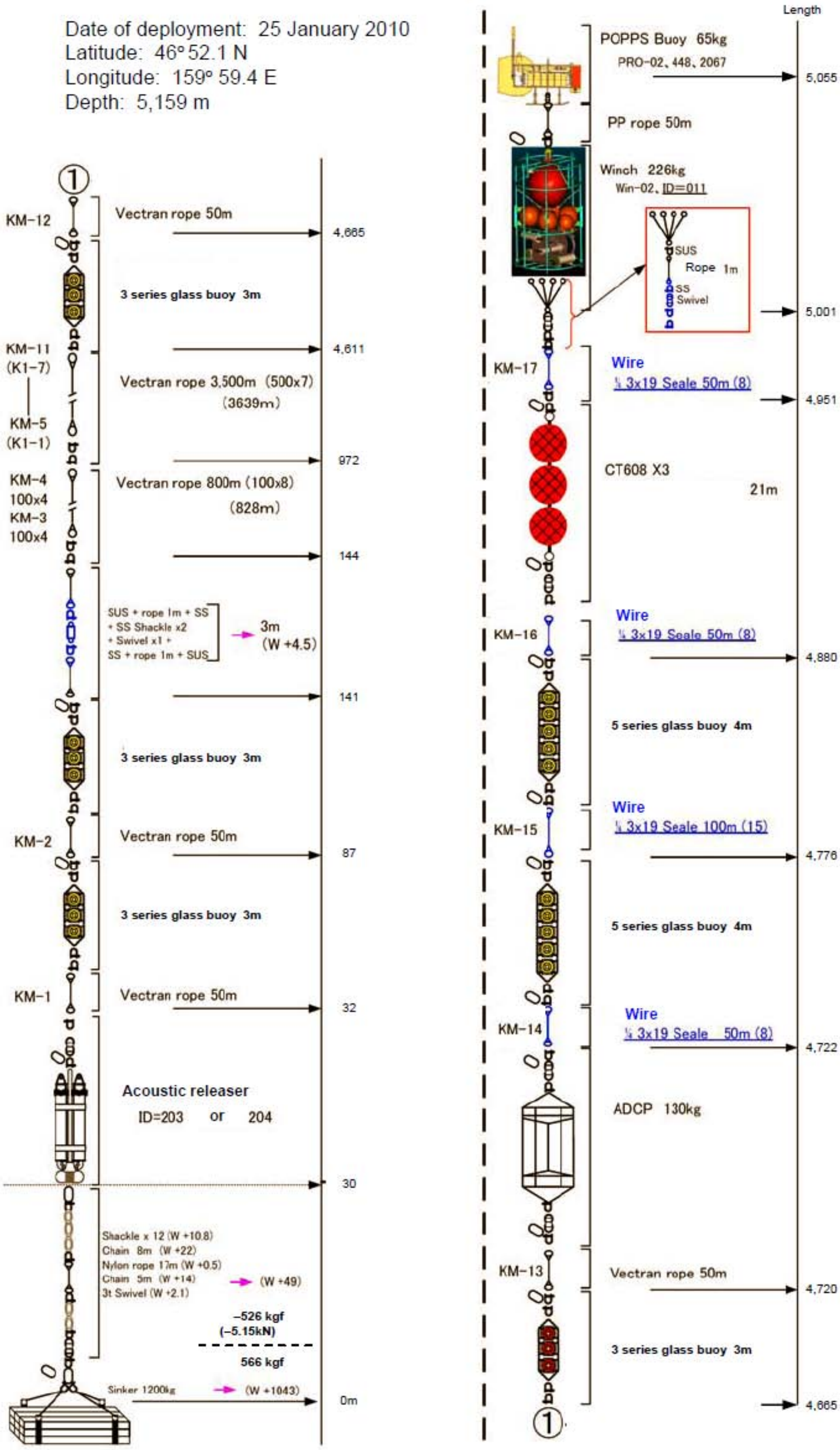


Figure 1b. Detailed design of the underwater profiling buoy system deployed at station K2.

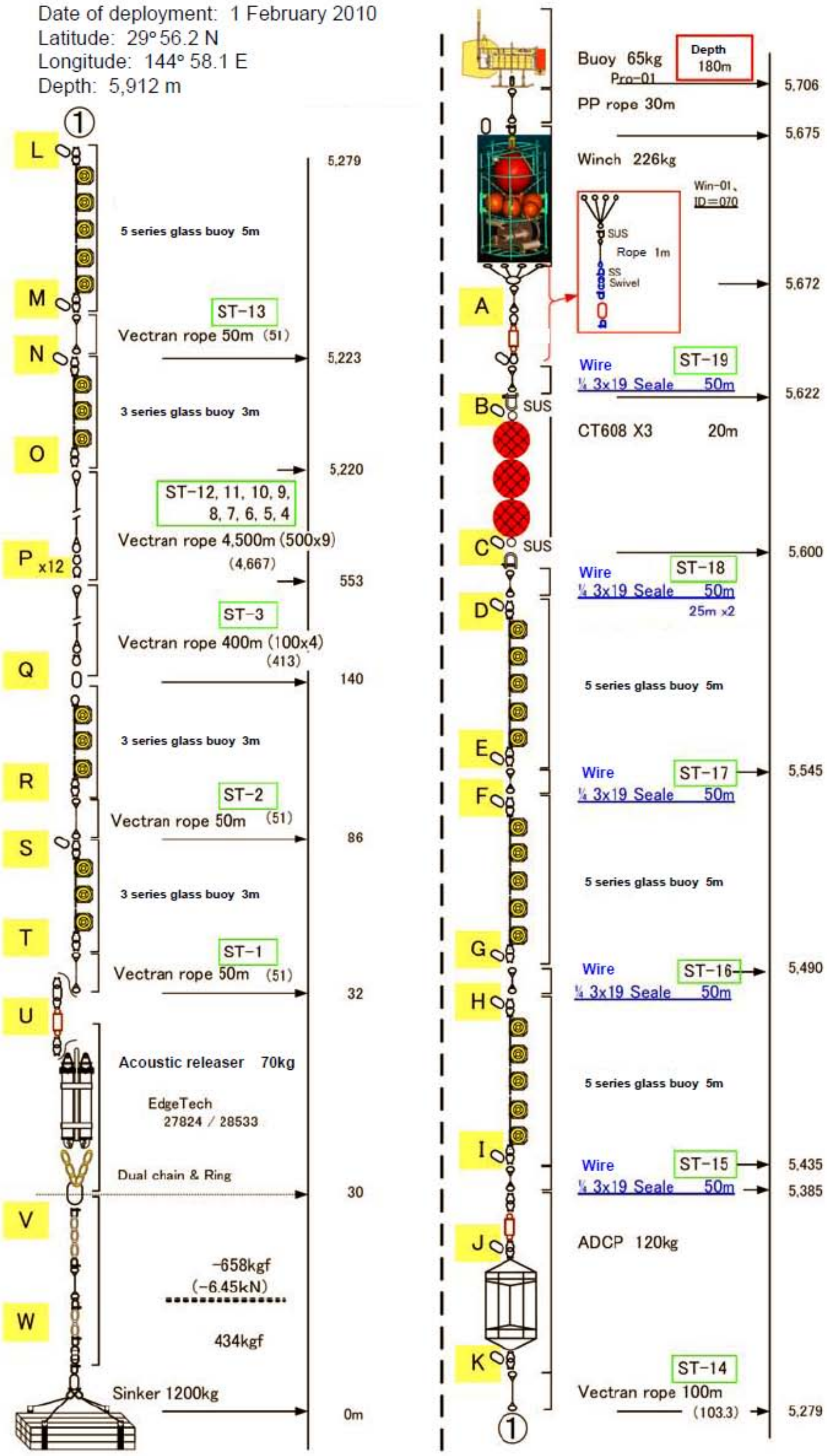


Figure 1c. Detailed design of the underwater profiling buoy system deployed at station S1.

3.3. Phytoplankton

3.3.1. Chlorophyll *a* measurements by fluorometric determination

1. Personnel

Kazuhiko MATSUMOTO	(JAMSTEC); Principal Investigator
Masanori ENOKI	(MWJ); Operation Leader
Yuichi SONOYAMA	(MWJ); Operator

2. Objective

Phytoplankton exist various species in the ocean, but the species are roughly characterized by their cell size. The objective of this study is to investigate the vertical distribution of phytoplankton as chlorophyll *a* (chl-*a*) by using the fluorometric determination with the size fractionations.

3. Sampling

We collected samples for total chl-*a* from 8 depths between the surface and 200 m during the deep-cast. We collected samples for total chl-*a* and size-fractionated chl-*a* from 16 depths respectively within the euphotic layer and upper 200m during the shallow-cast. The euphotic layer was determined by the downward irradiance sensor for the experiments of primary productivity at the shallow-casts, and the sampling depths were determined with the light intensity (%) of surface incident irradiance as 100, 50, 25, 10, 5, 2.5, 1 and 0.5%.

4. Instruments and Methods

Water samples for total chl-*a* were vacuum-filtrated (<0.02MPa) through 25mm-diameter Whatman GF/F filter. Water samples for size-fractionated chl-*a* were sequentially vacuum-filtrated (<0.02MPa) 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. Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylformamide. The tubes were stored at –20°C under the dark condition to extract chl-*a* for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma chemical Co.). We applied two kind of fluorometric determination for the samples of total chl-*a*: “Non-acidification method” (Welschmeyer, 1994) and “Acidification method” (Holm-Hansen *et al*., 1965). Analytical conditions of each method were listed in table 1. Size-fractionated samples were applied only

"Non-acidification method".

5. Preliminary Results

The result of total chl-*a* at Stn.K02 and S01 was shown as the vertical distribution (Figure 1 & 2). The result of size fractionated chlorophyll *a* measurments were shown by the irradiance distribution (Figure3).

6. Data archives

The processed data file of pigments will be submitted to the JAMSTEC Data Integration and Analysis Group (DIAG) within a restricted period. Please ask PI for the latest information.

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" and "Acidification method" for chlorophyll *a* with Turner Designs fluorometer (10-AU-005).

	Non-acidification method	Acidification method
Excitation filter (nm)	436	340-500
Emission filter (nm)	680	>665
Lamp	Blue Mercury Vapor	Daylight White

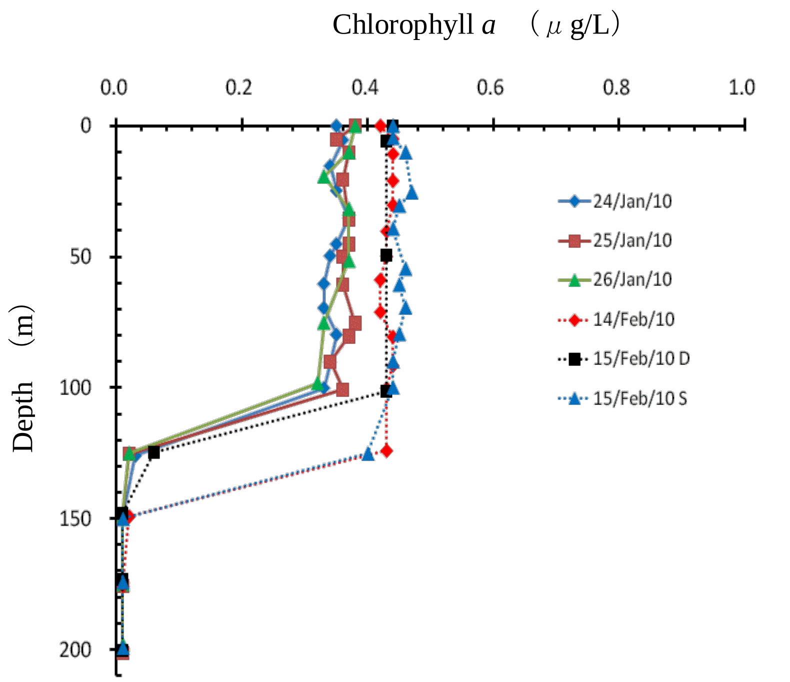


Figure1. Vertical distribution of chlorophyll *a* concentration (μg/L) at Stn.K02 in this cruise.

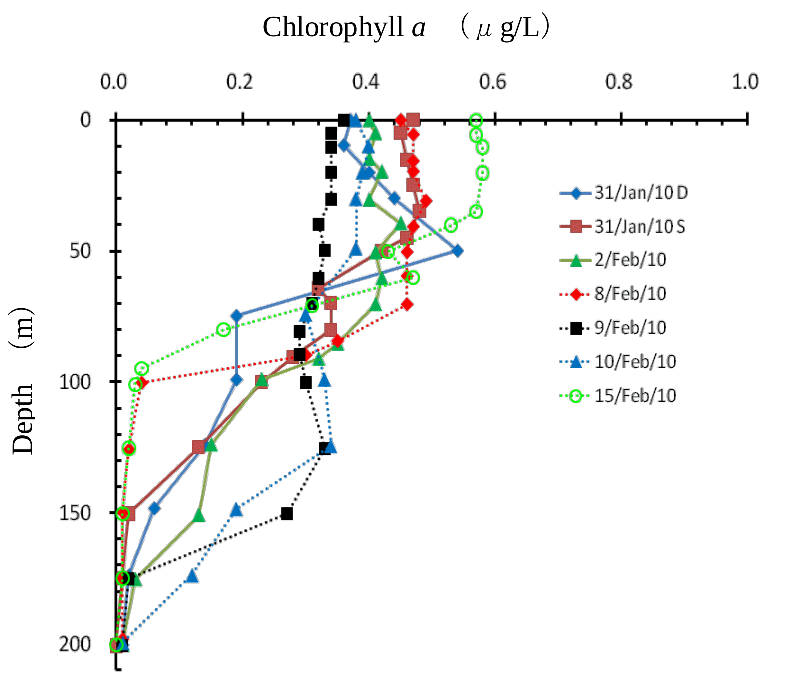


Figure2. Vertical distribution of chlorophyll *a* concentration (μg/L) at Stn.S01 in this cruise.

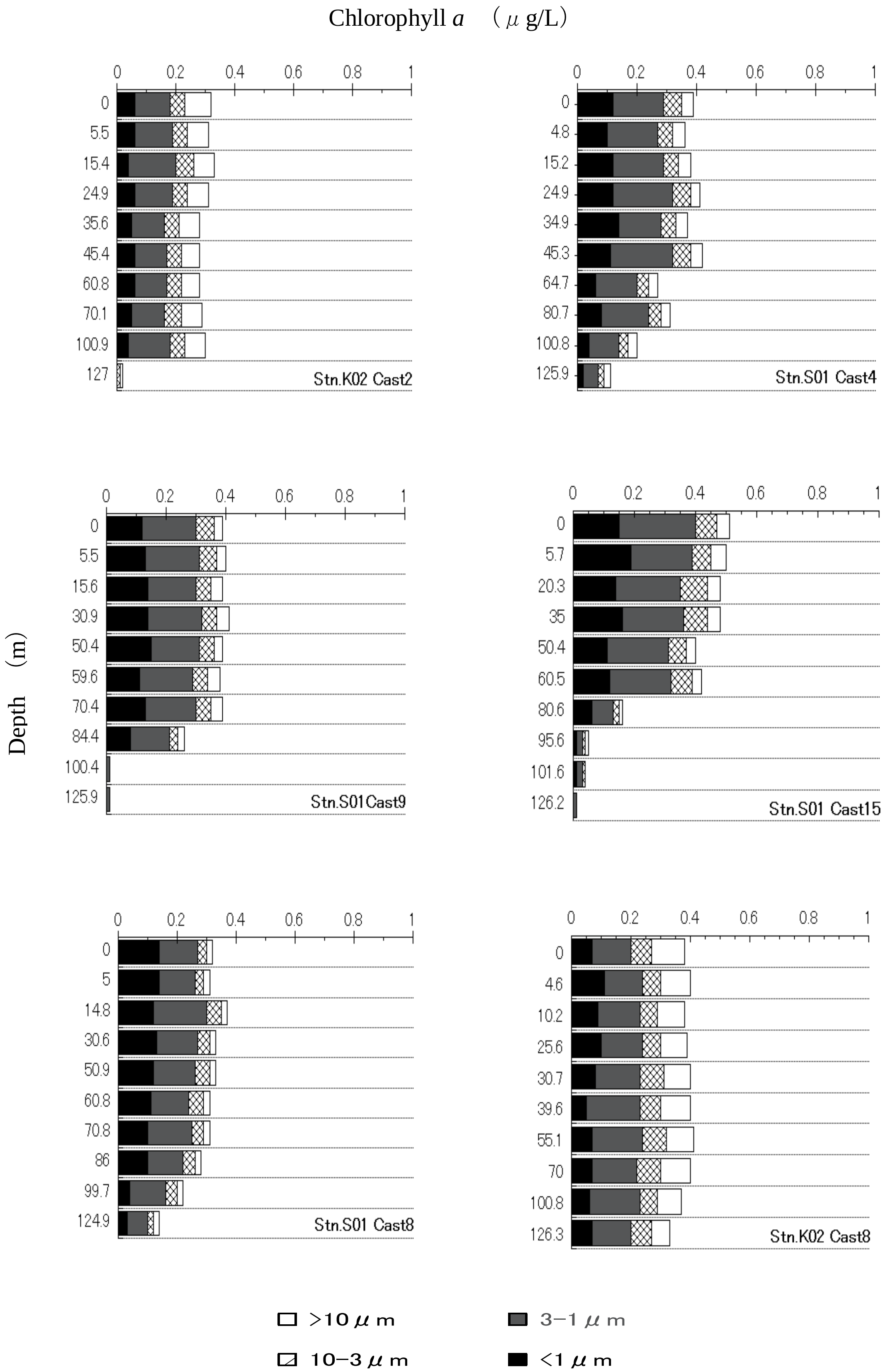


Figure3. Vertical distribution of size-fractionated chlorophyll *a* during shallow-cast.

3.3.2. HPLC measurements of marine phytoplankton pigments

Kazuhiko MATSUMOTO (JAMSTEC MIO)
Shoko TATAMISASHI (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 is 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 in the northwestern Pacific Ocean.

(2) Methods, Apparatus and Performance

Seawater samples were collected at 8 depths, which were determined by the light intensity as 100, 50, 25, 10, 5, 2.5, 1 and 0.5 % of surface incident irradiance during shallow-cast using Niskin bottles, except for the surface water (100%), which was taken by a bucket. The water samples (5L) were filtrated at a vacuum-pressure below 0.02MPa through the 47 mm-diameter Whatman GF/F filter. To remove retaining seawater in the sample filters, GF/F filters were vacuum-dried in a freezer (0 °C) within 5 hours. 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 °C), and analyzed by HPLC 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) with the extracted pigments (420µl). Phytoplankton pigments were quantified based on C8 column method containing pyridine in the mobile phase (Zapata *et al.*, 2000). The eluant linear gradients of this method were modified slightly to be fit for our system.

(i) 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).

(ii) Stationary phase

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

(iii) Mobile phases

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

(iv) Calibrations

HPLC was calibrated using the standard pigments (Table 1). We selected Chlorophyll *a*, Chlorophyll *b* (Sigma co.), β-Carotene (Wako co.) and other 22 pigments (DHI co.). Some pigments ([3,8-Divinyl]-Protochlorophyllide (Mg DVP), Antheraxanthin, Diatoxanthin and Crocoxanthin) were calibrated by using MR08-05 values. The solvents of pigment standards were displaced to N,N-dimethylformamide and the concentrations were determined with spectrophotometer by using its extinction coefficient of ethanol or acetone.

(v) Internal standard

Ethyl-apo-8'-carotenoate was added into the samples prior to the injection as the internal standard. Keep the area values of internal standard at a stable condition (Figure 1). The average of area values was 154670±3171 (n=67), the coefficient of variation was 2.1%.

(vi) Pigment detection and identification

Chlorophylls and carotenoids were detected by photodiode array spectroscopy (350~720nm). Pigment concentrations were calculated from the chromatogram area at different five channels (Table 1).

First channel was allocated at 661.4 nm of wavelength, the absorption maximum for Divinyl Chlorophyll *a* and Chlorophyll *a*.

Second channel was allocated at 664.0 nm, the absorption maximum for Chlorophyllide *a*, Pheophorbide *a* and Pheophytin *a*.

Third channel was allocated at 457.2nm, the absorption maximum for Chlorophyll *b*.

Fourth channel was allocated at 440.0 nm, the absorption maximum for [3,8-Divinyl]-Protochlorophyllide.

Fifth channel was allocated at 460.0 nm for other pigments. However, we could not acquire satisfactory separation between Zeaxanthin and Lutein, and Neoxanthin and Violaxanthin also could not be separated from other pigments.

(3) Preliminary results

Vertical profiles of major pigments at the station of Stn.S1 and Stn.K2. Shown in Figure 2~7. Chlorophyll *a* , Chlorophyll *b* , Fucoxanthin , 19'-Hexanoyloxyfucoxanthin are roughly represented as the abundance of total phytoplankton, green algae, diatoms, and haptophytes, respectively .

Zeaxanthin, Divinyl Chlorophyll *a* are roughly represented the Prochlorophyta, respectively.

(4) Data archives

The processed data file of pigments will be submitted to the JAMSTEC Data Integration and Analyses Group (DIAG) within a restricted period. Please ask PI for the latest information.

(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 identification for pigment standards.

No.	Pigment	Retention Time (minute)	Wavelength of identification (nm)
1	Chlorophyll *c3*	10.610	460
2	Chlorophyllide *a*	13.077	664.0
3	[3,8-Divinyl]-Protochlorophyllide	13.917	440
4	Chlorophyll *c2*	14.603	460
5	Peridinin	17.833	460
6	Pheophorbide *a*	20.267	664.0
7	19'-butanoyloxyfucoxanthin	21.005	460
8	Fucoxanthin	22.087	460
9	Neoxanthin	22.427	460
10	Prasinoxanthin	23.600	460
11	19'-hexanoyloxyfucoxanthin	24.267	460
12	Violaxanthin	24.372	460
13	Diadinoxanthin	26.220	460
14	Antheraxanthin	26.682	460
15	Alloxanthin	27.277	460
16	Diatoxanthin	27.488	460
17	Zeaxanthin	28.003	460
18	Lutein	28.083	460
19	Ethyl-apo-8'-carotenoate	29.400	460
20	Crocoxanthin	30.705	460
21	Chlorophyll *b*	31.258	457.2
22	Divinyl Chlorophyll *a*	32.325	661.4
23	Chlorophyll *a*	32.683	661.4
24	Pheophytin a	35.687	664.0
25	Alpha-carotene	35.970	460
26	Beta-carotene	36.277	460

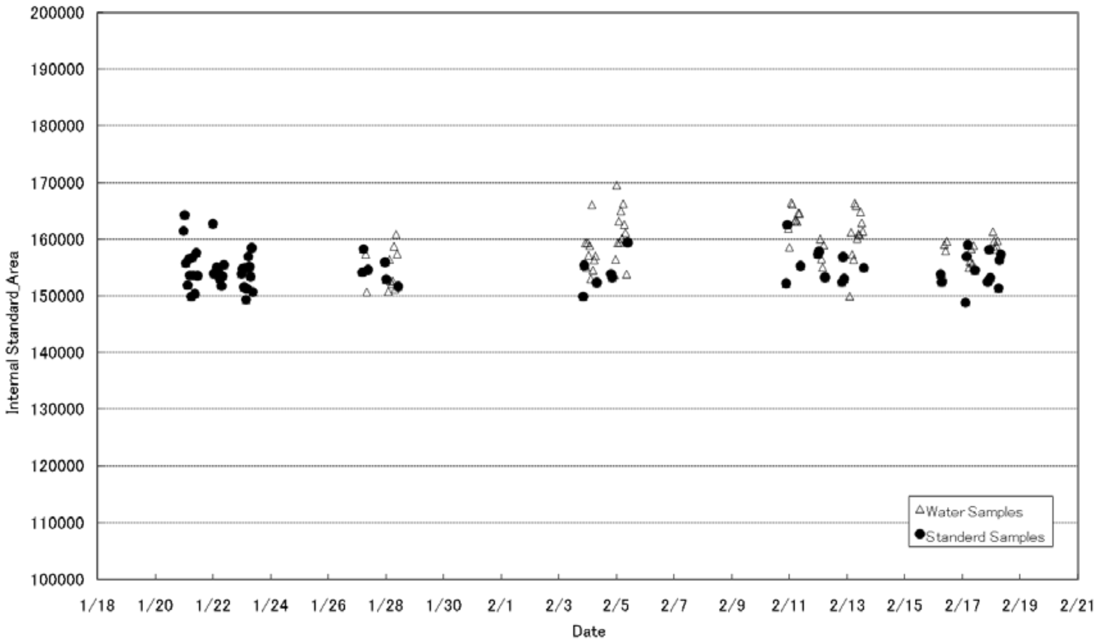
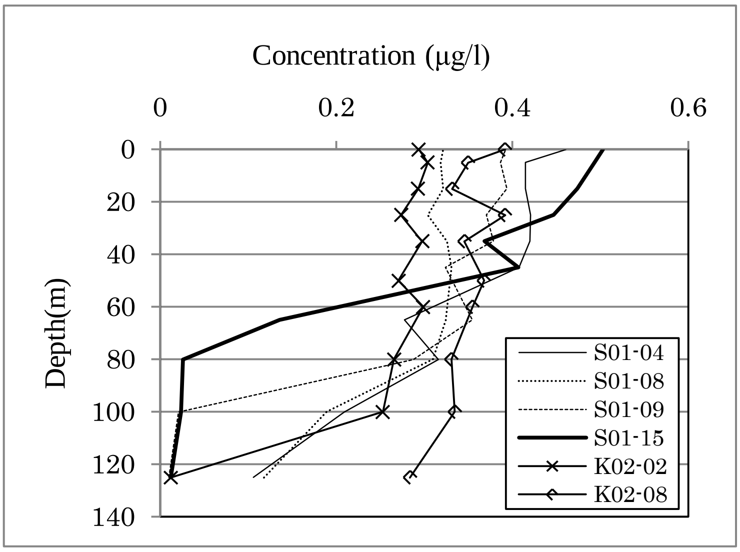
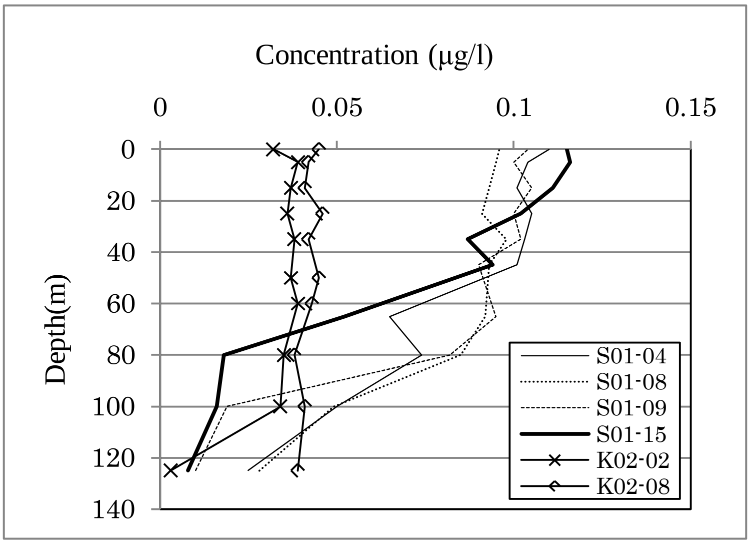


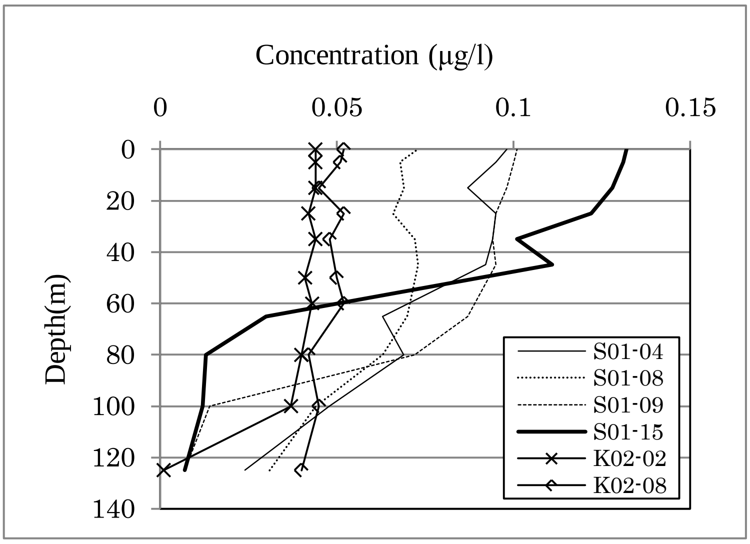
Figure 1. Variabilities of the chromatogram areas for the internal standard.



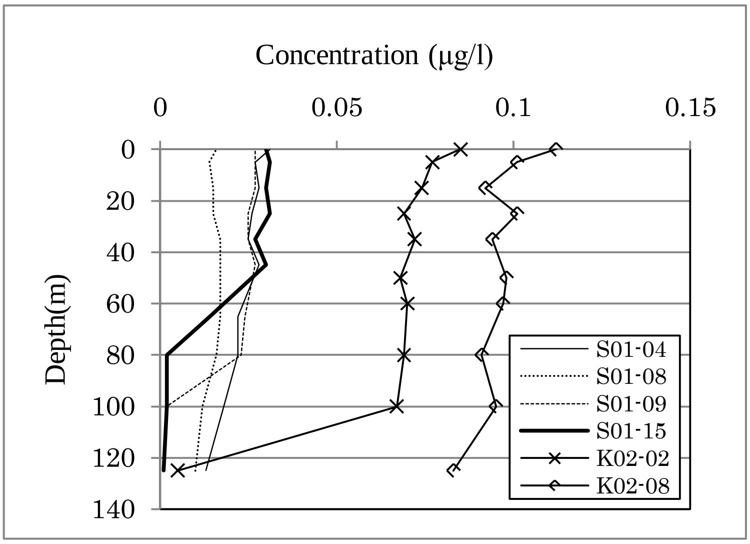
Figuare 2. Vertical distributions of phytoplankton pigments (μg/l) at the Chlorophyll *a*



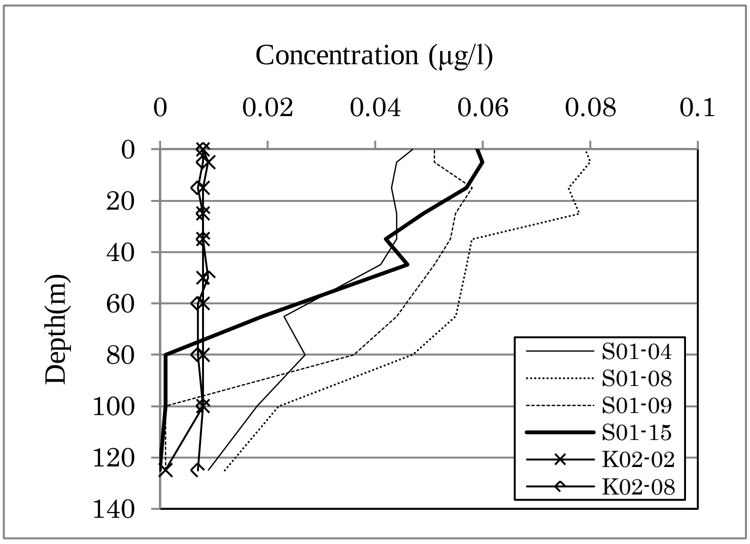
Figuare 3. Vertical distributions of phytoplankton pigments (μg/l) at the Chlorophyll *b*



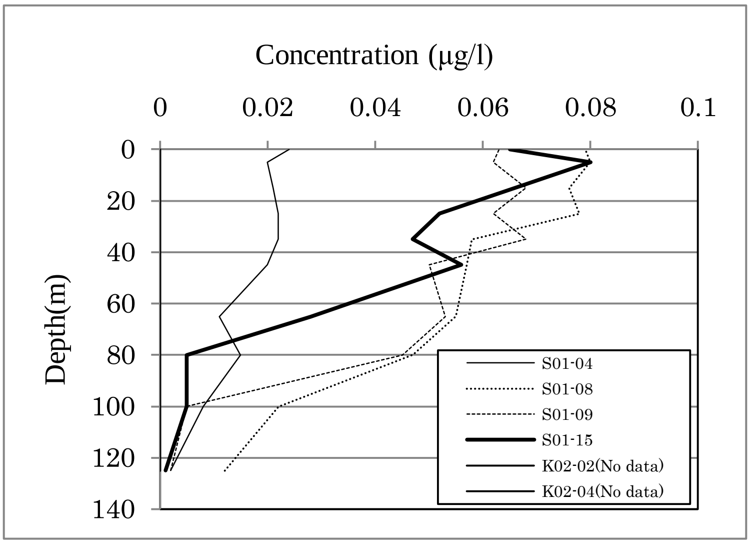
Figuare 4. Vertical distributions of phytoplankton pigments (μg/l) at the 19’-Hexanoyloxyfucoxanthin



Figuare 5. Vertical distributions of phytoplankton pigments (µg/l) at the Fucoxanthin.



Figuare 6. Vertical distributions of phytoplankton pigments (µg/l) at the Zeaxanthin.



Figuare 7. Vertical distributions of phytoplankton pigments (μg/l) at the Divinyl Chlorophyll *a*.

3.3.3. Phytoplankton abundance

(1) Personnel

Kazuhiko MATSUMOTO (JAMSTEC)

(2) Objectives

The main objective of this study is to estimate phytoplankton abundances and their taxonomy in the subarctic gyre (Stn. K2) and the subtropical gyre (Stn. S1) in the western North Pacific. Phytoplankton abundances will be measured by microscopy for large size phytoplankton.

(3) Sampling

Samplings were conducted within the euphotic zone using Niskin bottles, except for the surface water, which was taken by a bucket. Sampling depths were determined to correspond to eight light levels (100%, 50%, 25%, 10%, 5%, 2.5%, 1% and 0.5% of surface incident irradiance). Samplings were conducted two times in each gyre (K2-cast_4, K2-cast_6, S1-cast_8 and S1-cast_11).

(4) Methods

Water samples were placed in 500 ml plastic bottle and fixed with neutral buffered formalin solution (1% final concentration). The microscopic measurements are scheduled after the cruise.

(5) Data archives

The processed data file will be submitted to the JAMSTEC Data Integration and Analyses Group (DIAG) within a restricted period.

3.3.4. Primary production and new production

Personnel

Kazuhiko MATSUMOTO (JAMSTEC)
Ai YASUDA (MWJ)
Miyo IKEDA (MWJ)
Yuya AZUMA(MWJ)

Overview

Primary production (PP) was measured as incorporation of inorganic C^{13} at K2 and S1 stations. Incubation for PP measurement was conducted by simulated *in situ* incubation method using the light-controlled water bath on deck. New production is generally defined as "primary production associated with not old or regenerated nitrogen such as NH_3-N, but newly available nitrogen such as NO_3-N". In order to observe the new production, measurement of NO_3 uptake rate was conducted with ^{15}N stable isotope tracer when primary production was measured.

Bottles and filters

Bottles for incubation are *ca.* 1 liter Nalgen polycarbonate bottles with screw caps. Glass fiber filters (Wattman GF/F 25mm) pre-combusted with temperature of 450°C for at least 4 hours were used for a filtration of phytoplankton after incubation.

Water samples of three transparent bottles 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, PAR, as determined from the optical profiles obtained by SPMR sensor.

Incubation

All samples of three bottles in each depth were spiked with 0.2 mmol L^{-1} of $NaH^{13}CO_3$ solution for primary production just before incubation. When simulated *in situ* incubation for measurement of primary production was conducted, ^{15}N-enriched NO_3, $K^{15}NO_3$ solution, was injected to two incubation bottles, resulting that the final concentration of additional ^{15}N is 0.5 µmol L^{-1} or 0.01 µmol L^{-1} (Table 3.3.4). After spike, bottles were incubated in the water baths on deck, and then natural light was adjusted to the light level for each depth with blue film (Fig. 3.3.4). After 24 hours incubation, samples were filtrated through glass fiber filters (Wattman GF/F 25mm). GF/F filters were kept in a freezer (-20°C) on board until analysis. After that, filters were dried in the oven (45°C) for at least 20 hours.

Measurement

Before analysis, inorganic carbon of samples was removed by an acid treatment in a HCl vapor bath for 4 - 5 h. ^{13}C of samples were measured by using a mass spectrometer ANCA-SL system on board.

Instruments: preprocessing equipment ROBOPLEP-SL (Sercon Co., Ltd.)
stable isotope ratio mass spectrometer EUROPA20-20 (Sercon Co., Ltd.)

Methods: Dumas method, Mass spectrometry

Precision: All specifications are for n=5 samples.

It is a natural amount and five time standard deviation of the analysis as for amount 100 µg of the sample. ^{13}C (0.07 ‰) , ^{15}N (0.18 ‰)

Reference Material: The third-order reference materials L-asparatic acid (SHOKO Co., Ltd.)

Calculation

(a) Primary production

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

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

This equation is converted to the following equation;

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

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 (1.082 and 1.085 for K2 and S1, respectively 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;

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

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

$$PP = 1.025 \text{ x } \Delta POC$$

(b) New production

NO_3 uptake rate or new production (NP) was estimated with following equation:

$$NP\ (\mu g\ L^{-1}\ day^{-1}) = (15N_{excess} \text{ x } PON) / ({}^{15}N_{enrich}) / day$$

where $^{15}N_{excess}$, PON and $^{15}N_{enrich}$ are excess ^{15}N (measured ^{15}N minus ^{15}N natural abundance, 0.366 atom%) in the post-incubation particulate sample (%), particulate nitrogen content of the sample after incubation (mg L^{-1}) and ^{15}N enrichment in the dissolved fraction (%), respectively.

Data archives

All data will be submitted to Data Integration and Analyses Group (DIAG), JAMSTEC

Table 3.3.4 Sampling cast table and spike density.

Incubation	Leg.	Station	CTD cast No.	$NaH^{13}CO_3$ (mmol/L)	$K^{15}NO_3$ (μmol/L)
SIS/PE	1	K2	2	0.2	0.5
SIZE PE	1	K2	4	0.2	0.5
SIS	1	S1	1	0.2	0.5
SIS/PE	1	S1	4	0.2	0.5
SIS/SIZE PE	1	S1	8	0.2	0.5
SIS/PE	2	S1	9	0.2	0.01
SIZE PE	2	S1	11	0.2	0.01
SIS/SIZE PE	2	S1	15	0.2	0.01
SIZE PE	2	K2	6	0.2	0.5
SIS/PE	2	K2	8	0.2	0.5

SIS : *Simulated in-situ* incubation
PE : P-E curve
SIZE PE : Size fractionation P-E curve

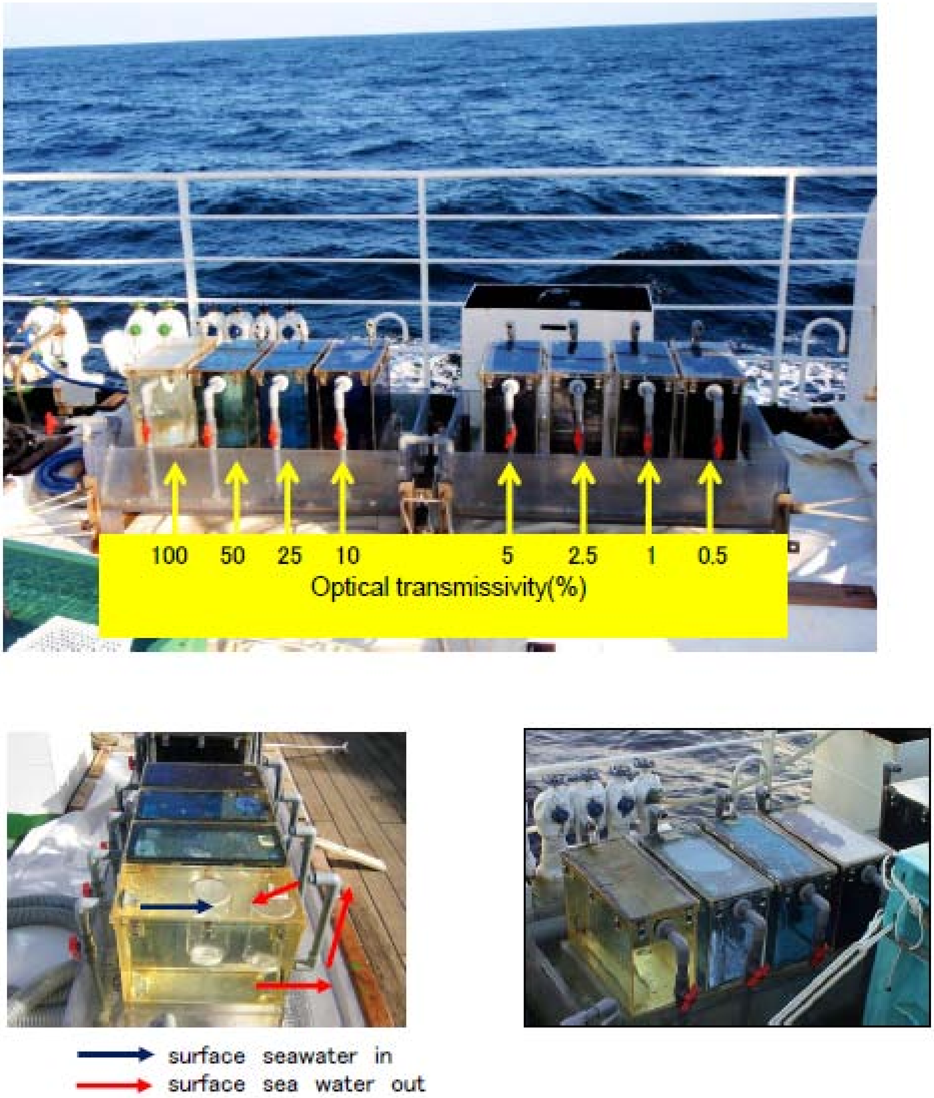


Fig. 3.3. 4 Incubator of simulated *in-situ* incubation

3.3.5. P vs. E curve

Personnel

Kazuhiko MATSUMOTO (MIO)
Ai YASUDA (MWJ)
Miyo IKEDA (MWJ)
Yuya AZUMA(MWJ)

Photosynthesis and irradiation curve was measured at station K2 and S1.

Objectives

The objective of this study is to estimate the relationship between phytoplankton photosynthetic rate (P) and scalar irradiance (E) in the western North Pacific.

Sampling

Samplings were carried out at two observational stations of K2 and S1 (Table 3.3.5). Sample water was collected at the surface and another two depths of different irradiance level, using Niskin bottles.

Methods

1) Incubation

Three incubators filled in water were used, illuminated at one end by a 500W halogen lamp. Water temperature was controlled by circulating water-cooler (Fig. 3.3.5). Water samples were poured in nine flasks (approx. 1 liter) and arranged in the incubator linearly against the lamp after adding the isotope solutions. The isotope solutions of 0.2 mmoles/mL of $NaHP^{13}CO_3$ solution and 0.5μmoles/ mL or 0.01μmoles/ mL of $K^{15}NO_3$ solution were spiked. All flasks were controlled light intensity by shielding with a neutral density film on lamp side. The light intensities inside the flasks were shown in table 3.3.5. We prepared the high light intensity incubator (Bath A) for the surface sample. The incubations were conducted for three hours round about noon in local time. Glass fiber filters (Wattman GF/F 25mm) were used for a filtration, which were pre-combusted under 450 degree C of temperature condition for at least 4 hours.

2) Size fractionation experiment

At the station of K2 and S1, the P vs. E curve experiments were conducted for the size fractionated samples. The collected sample water by a Niskin bottle was filtrated through 3μm and 10μm Nuclepore filter individually before the incubation at the station of K2. The size fractionation was conducted for 1μm and 3μm at the station of S1. The P vs. E curve of three size fractions were acquired from the incubations of filtrated water and non-filtrated water.

3) Measurement

Samples were filtered immediately after the incubation and the filters were kept to freeze -20 degree C till analysis during this cruise. After that, filters were dried on the oven of 45 degree C for at least 20 hours. After the incubation, samples were treated as same as the primary productivity experiment. The analytical function and parameter values used to describe the relationship between the photosynthetic rate (P) and scalar irradiance (E) are best determined using a least-squares procedure from the following equation.

$$P=P_{max}\tanh(\alpha E/P_{max})$$: (Jassby and Platt 1976)

$$P=P_{max}(1-e^{-\alpha E/Pmax})e^{-b\alpha E/Pmax}$$: (Platt et al., 1980)

where, P_{max} is the light-saturated photosynthetic rate, α is the initial slope of the P vs. E curve, b is a dimensionless photoinhibition parameter.

During the cruise, all samples will be measured by a mass spectrometer ANCA-SL system at MIRAI.

Instruments: preprocessing equipment ROBOPLEP-SL (Sercon Co., Ltd.)
stable isotope ratio mass spectrometer EUROPA20-20 (Sercon Co., Ltd.)
Methods: Dumas method, Mass spectrometry
Precision: All specifications are for n=5 samples.
It is a natural amount and five time standard deviation of the analysis as for amount 100 μg of the sample.^{13}C (0.07 ‰) ,^{15}N (0.18 ‰)
Reference Material: The third-order reference materials of L-asparatic acid (SHOKO Co., Ltd.)

Data archives

All data will be submitted to Data Integration and Analyses Group (DIAG), JAMSTEC.

References

Jassby, A.D., Platt, T. 1976. Mathematical formulation of relationship between photosynthesis and light for phytoplankton. Limnology and Oceanography, 21, 540-547.

Platt, T., Gallegos, C.L., Harrison, W.G. 1980. Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. Journal of Marine Research, 38, 687-701.

Table.3.3.5 Light Intensity of P-E measurements

	Bath A	Bath B	Bath C	Bath C'
Bottle No.	Light intensity ($\mu E/m^2/sec$)			
1	2100	2050	1150	2000
2	1125	1100	540	1050
3	550	520	245	470
4	235	255	120	225
5	100	96.0	46	88
6	50	51.0	24	44
7	25	25.0	13.5	22.5
8	12.2	11.5	7.2	10.5
9	0.0	0.0	0.0	0.0

*Bath C' was using in size fraction experiment.

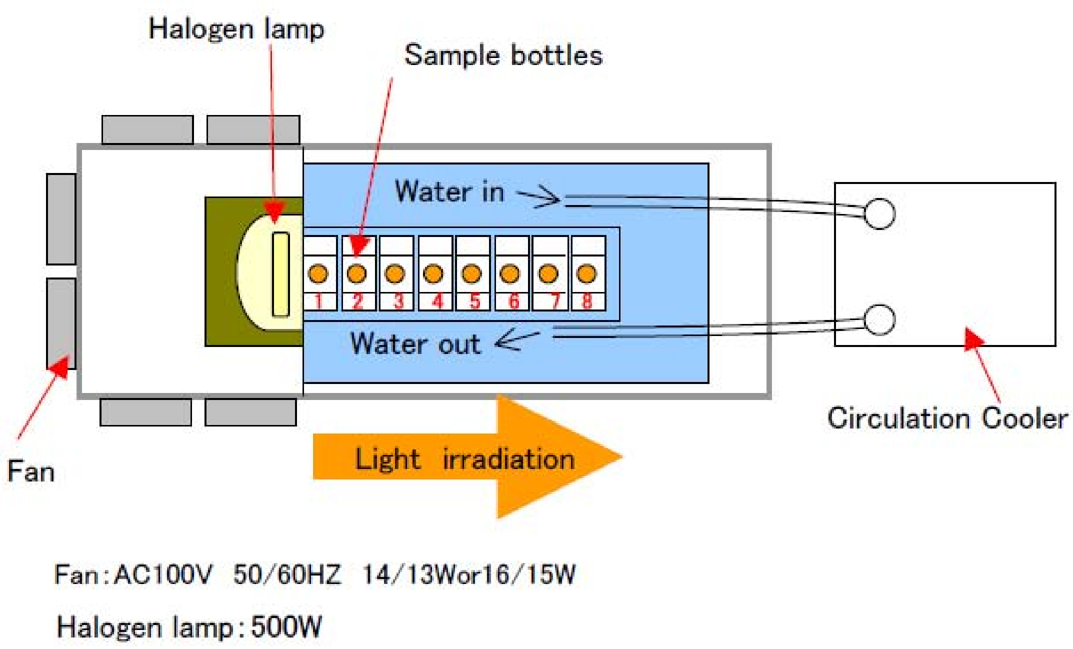


Fig.3.3.5. Look down view of Incubator for Photosynthesis and irradiation curve

3.4. Optical measurements

1. Personnel

Kazuhiko MATSUMOTO (MIO / JAMSTEC)
Hajime KAWAKAMI (MIO / JAMSTEC)
Makio HONDA (MARITEC / JAMSTEC)

2. 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 winter.

3. Description of instruments deployed

3.1 SPMR/SMSR (Free Fall optical measurements)

The first instrument system deployed was the SeaWiFS Profiling Multichannel Radiometer (SPMR) and SeaWiFS Multichannel Surface Reference (SMSR), (Satlantic Inc.). The SPMR is deployed in a freefall mode through the water column while measuring the following physical and optical parameters. The profiler carries a 13-channel irradiance sensor (Ed) and a 13-channel radiance sensor (Lu), as well as instrument tilt and fluorometry probe. The SMSR or reference sensor has a 13-channel irradiance sensor (Es). Those channels represent in Table 1.

Optical measurements by SPMR were conducted at our time-series stations K2 and S1. Measurements should be ideally conducted around noon at local time. However observations were conducted irregularly because of limited ship-time and other observation’s convenience. The profiler was deployed thrice at respective stations to a depth of 200 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 1. Center wavelengths 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

3.2 Spectroradiometer

The second instrument system was the PUV-510B (Biospherical Instruments Inc.). This instrument package measures downwelling irradiance (Es) including UV and photosynthetically available radiation (PAR) in the air. The PUV-510B was set up on the anti-rolling system's deck and started collecting data immediately upon departure from Sekinehama. This instrument package ran 24 hours a day and the data was collected using LOGGER software.

3.3 Calibration

SPMR/SMSR were calibrated on January 2007.

PUV-510B was calibrated on November 2008.

4. Data archives

Optical data were filed on two types of file.

BIN file: digital data of upwelling radiance and downwelling irradiance each 1 m from near surface to approximately 200 m for respective wave-lengths with surface PAR data during "Free Fall" deployment

PAR file: in situ PAR each 1 m from near surface to approximately 200 m with extinction coefficient with surface PAR data during "Free Fall" deployment

These data files will be submitted to JAMSTEC Data Integration and Analyses Group (DIAG).

3.5. Drifting sediment trap

3.5.1. Drifting mooring system

Hajime KAWAKAMI (JAMSTEC MIO)
Makio C. HONDA (JAMSTEC MARITEC)

In order to conduct drifting sediment trap experiment at stations K2 and S1, drifting mooring system (drifter) was deployed. This drifter consists of radar reflector, GPS radio buoy (Taiyo TGB-100), flush light, surface buoy, ropes and sinker. On this system, “Knauer” type sediment trap at 4 layers were installed together. Thanks to the effort by MWJ technicians, drifting mooring system was upgraded on board. The configuration is shown in Fig. 3.5.1-1.

The drifter was deployed at 23:25 on 23 January (UTC) at station K2, at 21:30 on 30 January (UTC) at station S1 (S1-1), and at 20:54 on 8 February (UTC) at station S1 (S1-2). The drifter was recovered after 2 or 3 days. The drifter’s position was monitored by using GPS radio buoy (Taiyo TGB-100). Fig. 3.5.1-2 shows tracks of the drifter. In general, the drifter tended to drift eastward at station K2 and S1-1 with rotation. The drifter tended to drift northward at station S1-2

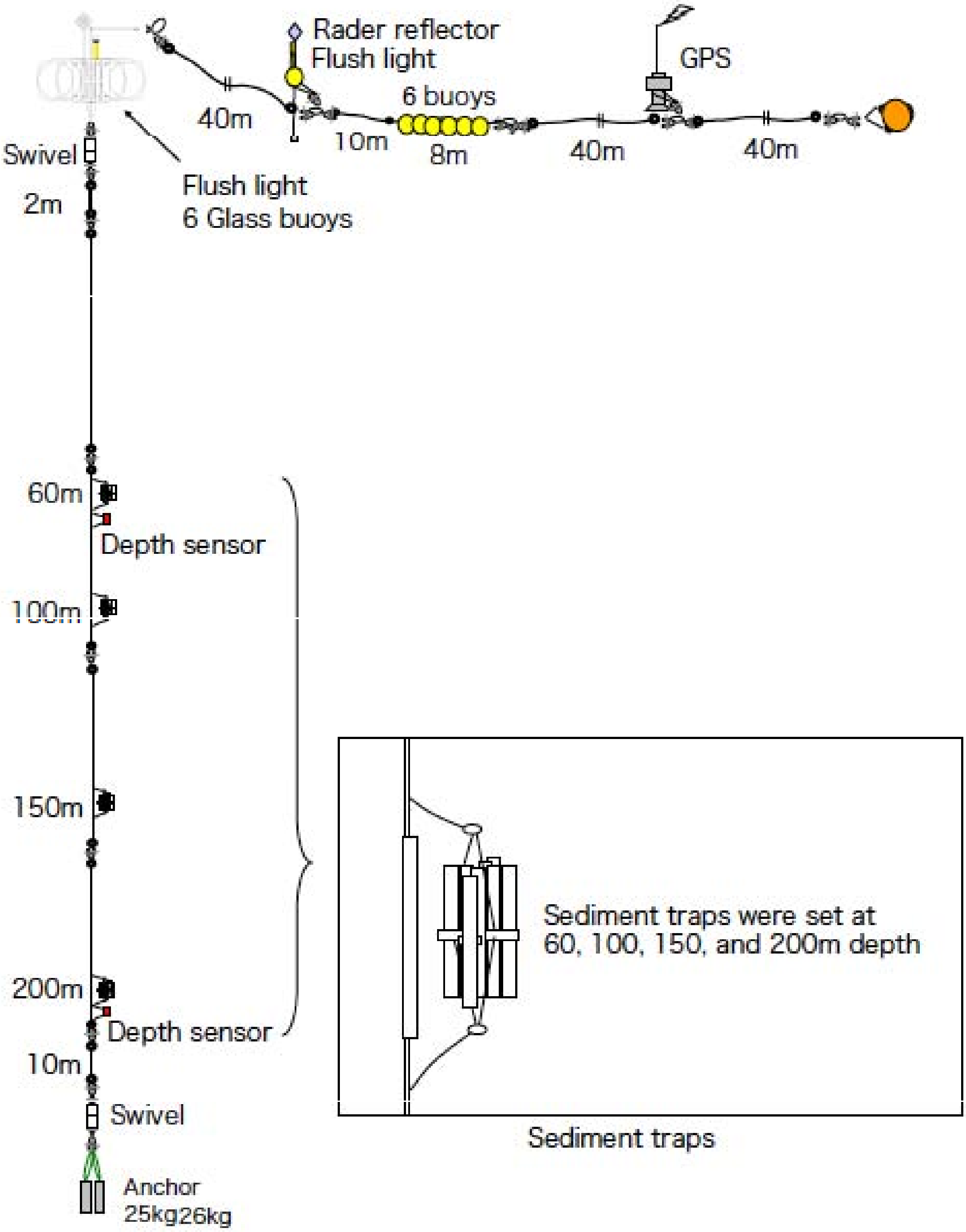
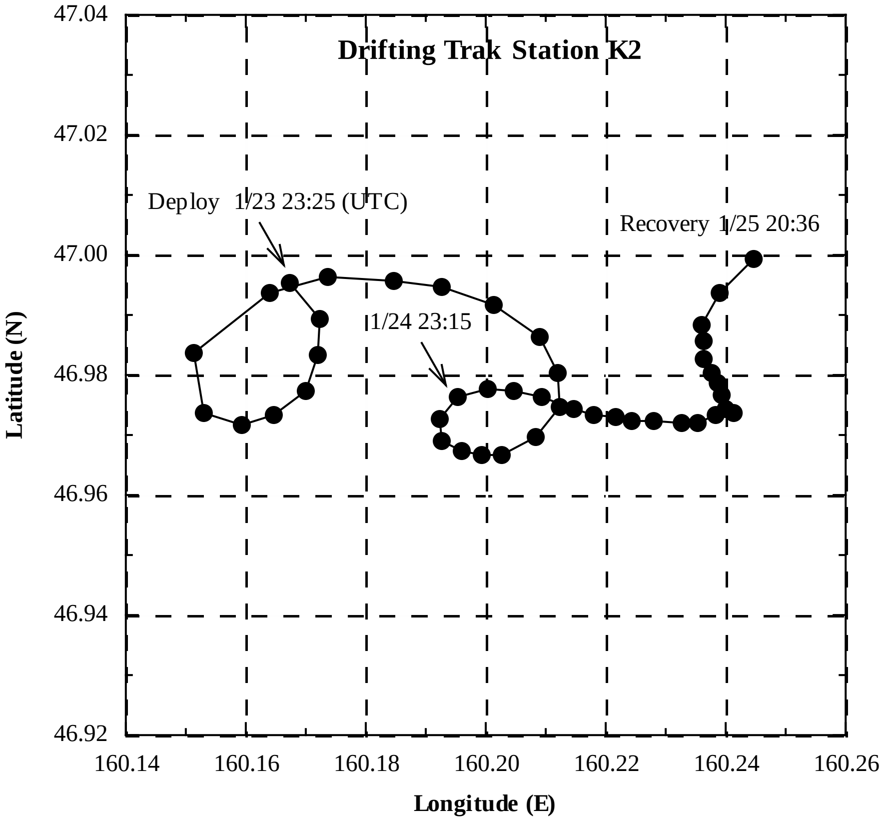


Fig. 3.5.1-1 Drifting mooring system at stations K2 and S1.



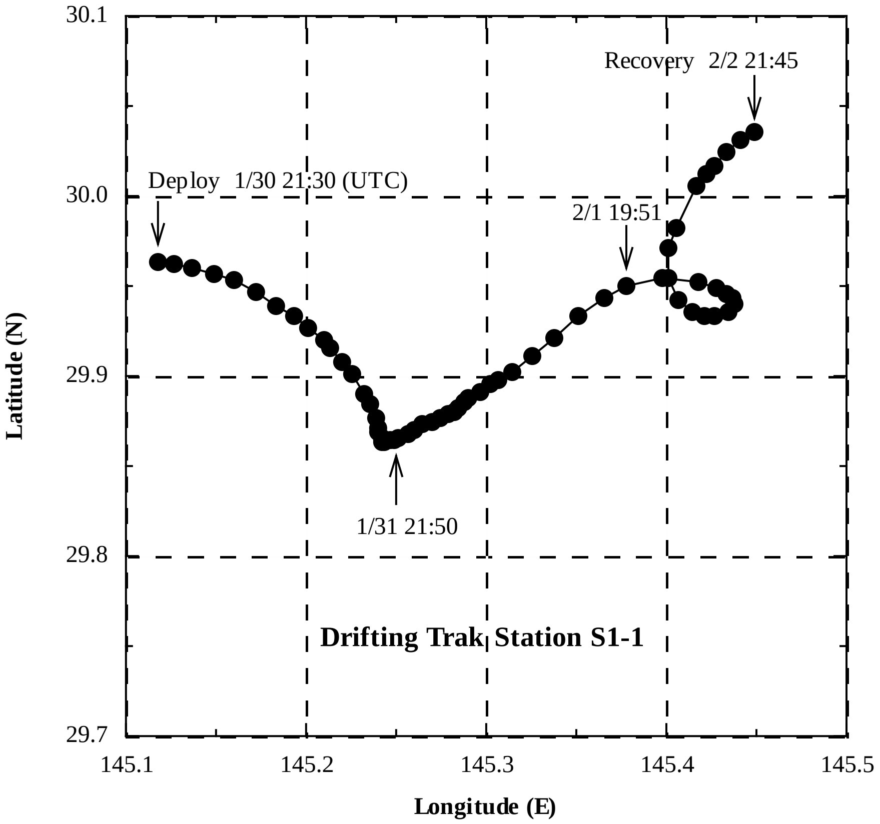


Fig. 3.5.1-2 Track of drifter (GPS buoy) at stations K2 and S1.

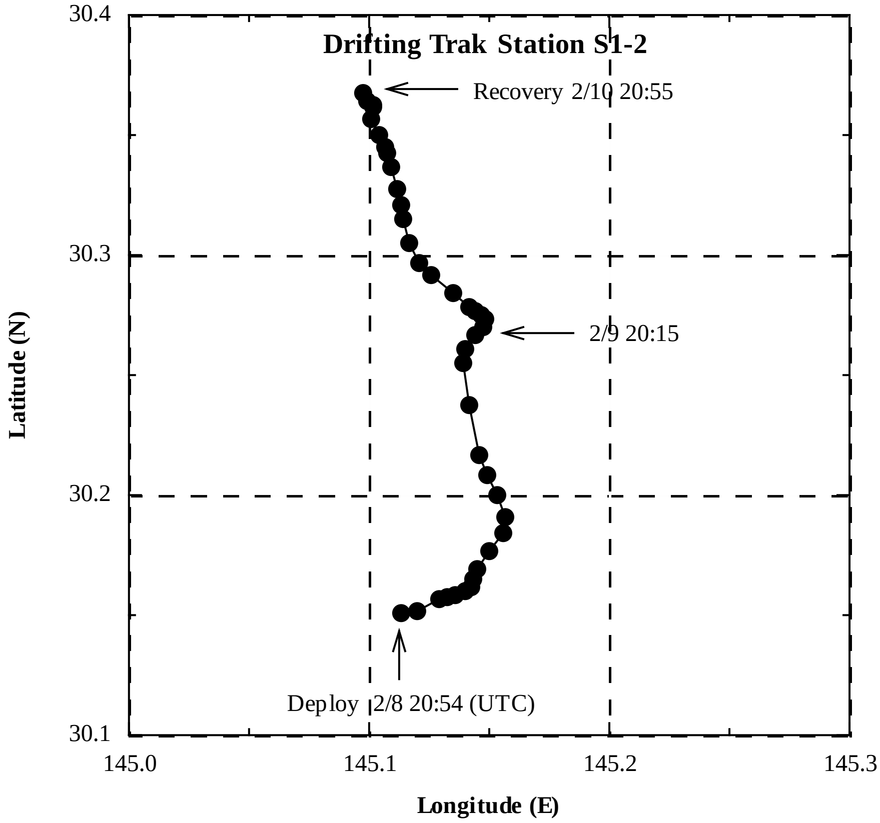


Fig. 3.5.1-2 Continued.

3.5.2. Drifting sediment trap of JAMSTEC

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

In order to collect sinking particles and measure carbon flux, and zooplankton, “Knauer type” cylindrical sediment trap (Photo 3.5.2-1) was deployed at stations K2 and S1 where measurement of primary productivity was 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. These were kept in freezer by the day when these were analyzed.

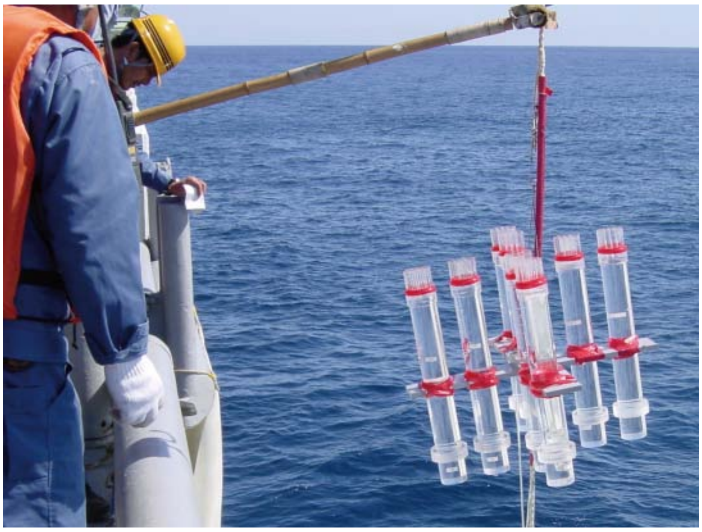


Photo 3.5.2-1 Drifting Sediment Trap.

3.5.3. Vertical changes of fecal pellets

Toru KOBARI (Kagoshima Univ.)
Hiroyasu AKAMATSU (Kagoshima Univ.)

(1) Objective

Sinking particles includes phytoplankton aggregates, fecal pellets, feeding mucus and carcass of zooplankton and crustacean molts. Especially, zooplankton fecal pellets can significantly contribute to vertical flux of particulate organic carbon (POC) and are a key component of the biological pump. Fecal pellets are changed by zooplankton ingestion (coprophagy), fragmentation via sloppy feeding or swimming activity (coprorhexy) and loosening of membrane (coprochaly) during sinking. These processes largely affect attenuation of POC flux. It is considered that fecal pellets are declined by bacterial decomposition and/or coprophagy/coprorhexy of small copepods or heterotrophic microbes. Thus, we should re-consider how fecal pellets are declined or changed during sinking from surface to mesopelagic depths.

In the present study, we investigated vertical differences of number, shape and volume of fecal pellets from drifting sediment trap experiments to evaluate how fecal pellets were changed and declined.

(2) Methods

Knauer-type sediment traps were deployed at 60, 100, 150 and 200 m at K2 and S1 in the Northwestern Pacific Ocean for 48 hours during the Mirai cruise from January to February 2010. The sediment traps were constructed from 8 cylinders with a baffle to reduce turbulence, mounted on a polyvinylchloride frame. A sample cup was attached to the bottom of each cylinder via screw threads. The sample cup was filled with a brine solution.

Once traps were recovered, samples for particle organic carbon (POC) flux were preserved at $4^{o}C$ until filtration. To measure passive POC flux, swimmers were picked out under a stereo dissecting microscope. These samples were filtered through a pre-combusted and pre-weighed Whatman GF/F filter under vacuum pressure less than 10kPa and rinsed with Milli-Q water. Samples for fecal pellet flux were fixed with 5% buffered formaldehyde solution.

(3) Preliminary results

During the cruise, we collected 12 filter samples for POC flux and 12 fixed samples for microscopic analyses of fecal pellets. In the land laboratory, carbon and nitrogen contents will be measured for filter samples. For fixed samples, number, shape and volume will be measured under a stereo dissecting microscope following Wilson et al. (2008). From these results, we will evaluate contribution of mesozooplankton feces to POC flux and vertical change/decline of fecal pellets.

Table 1. Sampling data for drifting sediment trap experiments.

Start		End		Station	Depth	Sample		Gear
Date	Time	Date	Time			POC	Feces	
20100124	9:30	20100126	7:30	K2	60	Yes	Yes	Knauer Trap
20100124	9:30	20100126	7:30	K2	100	Yes	Yes	Knauer Trap
20100124	9:30	20100126	7:30	K2	150	Yes	Yes	Knauer Trap
20100124	9:30	20100126	7:30	K2	200	Yes	Yes	Knauer Trap
20100131	7:30	20100203	8:30	S1	60	Yes	Yes	Knauer Trap
20100131	7:30	20100203	8:30	S1	100	Yes	Yes	Knauer Trap
20100131	7:30	20100203	8:30	S1	150	Yes	Yes	Knauer Trap
20100131	7:30	20100203	8:30	S1	200	Yes	Yes	Knauer Trap
20100209	6:30	20100211	6:30	S1	60	Yes	Yes	Knauer Trap
20100209	6:30	20100211	6:30	S1	100	Yes	Yes	Knauer Trap
20100209	6:30	20100211	6:30	S1	150	Yes	Yes	Knauer Trap
20100209	6:30	20100211	6:30	S1	200	Yes	Yes	Knauer Trap

(4) Reference

Wilson, S. E., Steinberg, D. K., Buesseler, K. O. (2008). Changes in fecal pellet characteristics with depth as indicators of zooplankton repackaging of particles in the mesopelagic zone of the subtropical and subarctic North Pacific Ocean. Deep-Sea Research II, 55, 1636-1647.

3.6. Zooplankton
3.6.1. Community structure and ecological roles

Minoru KITAMURA (JAMSTEC, BioGeos)
Toru KOBARI, M. MINOWA, H. MORI and H. AKAMATSU (Kagoshima Univ.)
Sanae CHIBA (JAMSTEC, FRCGC)

(1) Objective
Subarctic western North Pacific is known to be a region with high biological draw down of atmospheric CO_2 due to extensive diatom bloom in spring. Time-series biogeochemical observations conducted at the Station K2 have revealed high annual material transportation efficiency to the deep compared to the other time-series sites set in the subtropical regions.

Zooplankton dominated in this regions are large copepods, which mainly feed on diatoms, and supposed to help enhancing Biological Carbon Pump (BCP) function, by repackaging diatoms through the fecal pellet production. However, the reported zooplankton fecal pellet flux to the deep were smaller than expected from the production in the surface layer, suggesting consumption and biological breakdown occurred in surface and mesopelagic layers. In particular, biological processes in the mesopelagic layer are largely unknown.

Besides the fecal pellet production, “active transport” of carbon by ontogenetic migrating copepods, e.g. *Neocalanus* spp. recently was reported large, even equivalent to amount of carbon flux estimated based on the sediment trap experiments. Other copepods, *Metridia* spp. perform extensive diel vertical migration, and could transport large amount of surface carbon to the several hundred meters deep through respiration. Detailed information of timing and biomass of vertical migration of these copepods should be investigated.

With these background, goal of these research is to investigate roles of zooplankton in vertical material transport in the western subarctic North Pacific. We deployed two types of plankton nets to investigate species and size composition of zooplankton from the surface to the greater deep. We also conducted same samplings at a new time-series station, S1, for comparison to K2 ecosystem.

(2) Materials and methods
Mesozooplankton and micronekton samplings (IONESS Sampling)
For collection of stratified sample sets, multiple opening/closing plankton net system, IONESS, was used. This is a rectangular frame trawl with nine nets. Area of the net mouth is 1.5 m^2 when the net frame is towed at 45° 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. The net system is towed obliquely. 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.

Total seven tows (two at K2, five at S1) of IONESS were done. The stratified sampling layers at stations K2 and S1 were as follows; 0-50, 50-100, 100-150, 150-200, 200-300, 300-500, 500-750, 750-1000m. To understand diel vertical migration of mesozooplankton and micronekton, the stratified samplings were conducted during both day and night. Towing data such as date, time, position, filtering volume are summarized in Table 3.6.1-1 and ship tracks of IONESS tows are shown in the Figs. 3.6.1-1 and 3.6.1-2.

Collected zooplankton samples were divided using a sample splitter on board. Purpose of the sample dividing, fixation of each subsample are also summarized (Table 3.6.1-2).

NORPAC net sampling

A twin-type NORPAC net with fine mesh (100 μm) and a flow meter was used. The net was vertically towed 0-50 m and 0-150 m at the Station K2, and S1 (Table 3.6.1-3). Zooplankton collected were preserved in the 5% buffered formalin seawater for the later analysis.

Vertical distribution of surface nano- and microzooplankton

Four series of seawater samples were collected at Stations K2 and S1. Each series comprises eight waters which collected using bucket and Niskin bottles at different depths. These depths corresponded to nominal specific optical depths approximately 100, 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’’.

Seawater samples were immediately treated with the final concentration of 1% glutaraldehyde and were kept at 4°C until filtering. Each seawater sample were filtered through 1μm pore size Nuclepore fitter, pre-stained by irgalan black, at the low vacuum of 15 cmHg, and 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 0.45 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°C) until the observation.

Above mentioned water samples are for analysis of nanozooplankton. Because filtering volume is little (up to 400 ml), these samples are not appropriate for microzooplankton analysis such as tintiniids whose abundance is low. So, additional seawater samples for this taxon were collected in the same depths, same time. Collected water samples were immediately fixed in 1% acid Lugol’s solution.

Sampling data such as depths or filtering volume are summarized in Table 3.6.1-3.

Table 3.6.1-1. Summary of IONESS samplings.

MR10-01 IONESS Samplings

including filtering efficiency, 96%, in calculations of filtering volume

Stn.	Tow ID	Local Time		Position		Sampling layer (upper, m) and filtering vol. (lower, m^3)									Remarks
			in out	in out		Net No. 0	1	2	3	4	5	6	7	8	
K2-1	I100124A	2010.1.24	21:00	46 59.070	160 01.680	0~1020~0	-	-	-	-	-	-	-	-	trouble in release mechinery and data transport
			23:09	46 56.320	159 59.210	-									
S1-1	I100131A	2010.1.31	20:00	30 03.510	144 57.470	0~1027~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	no digital data (missed data loging)
			23:35	30 07.310	144 51.370	-	7480.2	3447.1	2497.5	1530.2	737.3	1199.4	1002.9	1104.5	
S1-1	I100201A	2010.2.1	20:45	29 50.479	145 04.470	0~1028~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	
		2010.2.2	0:11	29 44.989	145 01.920	-	2485.7	2417.3	1896.7	1336.1	1055.2	1149.7	1224.1	548.1	
S1-1	I100204A	2010.2.4	8:18	30 00.048	144 59.630	0~1042~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	Winch trable in No. 5, 8 net tows
			11:55	30 04.972	144 52.820	-	3097.3	3817.7	2901.1	1716.9	2810.6	882.9	1340.0	593.6	
S1-2	I100209A	2010.2.9	20:40	30 10.230	145 06.310	0~1035~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	
			23:52	30 05.324	145 02.400	-	3113.6	3758.9	2358.9	2006.0	1840.6	1322.0	1167.7	1029.7	
S1-2	I100210A	2010.2.10	8:10	30 08.957	144 56.11	0~1040~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	
			11:20	30 03.537	144 52.66	-	3123.6	3205.5	2118.7	2169.1	1186.0	1396.3	1270.7	1002.5	
K2-2	I100215A	2010.2.15	20:52	47 01.567	159 59.75	0~1043~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	PC time recorded in digital data was UTC+10h
		2010.2.16	0:05	46 58.304	159 41.58	-	3123.5	2670.1	1997.1	1432.7	547.3	952.3	991.0	951.9	
K2-2	I100216A	2010.2.16	9:02	46 51.880	160 02.60	0~1044~1000	1000~750	750~500	500~300	300~200	200~150	150~100	100~50	50~0	
			11:49	46 46.444	160 03.12	-	1334.0	3003.0	2540.3	808.9	465.5	983.9	928.1	615.7	

Table 3.6.1-2. Division of each IONESS sample

Division of sample	Fixation	Storage	Pourpose
1/2	5% folmalin	JAMSTEC	community structure analysis (except copepods)
1/4	5% formalin	Kagoshima Univ.	community structure analysis (copepods)
1/8	5% formalin	JAMSTEC	biomass composition in higher taxa level (ex. copepods, euphausiids, etc.)
1/16 (or 1/8)	-30 degree C frozen	JAMSTEC	dry mass measurement
1/16	-30 degree C frozen	JAMSTEC	archive

Table 3.6.1-3. Summary of NORPAC samplings

MR10-01

NORPAC net hauls for collections of archive samples

Samples were fixed in 5% folmarin sea water

flow-meter No.: new net; 1997, old net; 522

Rewind speed: 1.0 m / sec

Stn.	Date	Local Time	Position		Sampling Layer	Wire out	Wire angle	Flow-meter revolution	
			Lat.	Long.	(m)	(m)	(°)	new net	old net
K2-1	2010.1.25	20:01	46 50.58	160 06.71	50-0	50	0	531	555
		20:13	46 50.58	160 06.71	150-0	151	5	1480	1556
S1-1	2010.2.2	20:00	30 03.41	144 55.47	50-0	50	4	940	1060
		20:12	30 03.41	144 55.47	150-0	151	5	2480	2590

Table 3.6.1-4. Summary of water samplings for analysis of nano- and microzooplankton abundance and biomass.

MR10-01

Water samplings for analysis of nano- and microzoopankton abundance

* local ship time # Kitamura, ## Kagshima Univ.

Stn.	Date*	CTD		Depth	Irradiance	Nanozooplankton samplings #			Microzoo ##	Remarks
		Time*	Cast ID	(m)	(%)	Sample No.	Filtering vol. (ml)	Funnel No.	Sample vol. (ml)	
K2-1	2010.1.26	5:04-5:43	K2 cast 4	90	0.5	K2-1, 1	500	2	1000	
				75	1	K2-1, 2	500	3	1000	
				60	2.5	K2-1, 3	500	4	1000	
				45	5	K2-1, 4	500	5	1000	
				35	10	K2-1, 5	500	1	1000	
				20	25	K2-1, 6	500	2	1000	
				10	50	K2-1, 7	500	3	1000	
				0	100	K2-1, S	500	1	1000	Bucket
S1-1	2010.2.2	19:00-19:47	S1 cast 7	85	0.5	S1-1, 1	350	1	1000	
				70	1	S1-1, 2	415	2	1000	
				60	2.5	S1-1, 3	395	3	1000	
				50	5	S1-1, 4	420	4	1000	
				30	10	S1-1, 5	410	5	1000	
				15	25	S1-1, 6	370	1	1000	
				5	50	S1-1, 7	350	2	1000	
				0	100	S1-1, S	320	3	1000	Bucket
S1-2	2010.2.10	5:00-5:47	S1 cast 11	85	0.5	S1-2, 1	500	1	1000	
				70	1	S1-2, 2	500	2	1000	
				55	2.5	S1-2, 3	500	3	1000	
				40	5	S1-2, 4	500	4	1000	
				30	10	S1-2, 5	500	5	1000	
				15	25	S1-2, 6	500	1	1000	
				5	50	S1-2, 7	500	2	1000	
				0	100	S1-2, S	500	3	1000	Bucket
K2-2	2010.2.16	5:00-5:45	K2 cast 8	70	0.5	K2-2, 1	410	1	1000	
				55	1	K2-2, 2	425	2	1000	
				40	2.5	K2-2, 3	340	3	1000	
				30	5	K2-2, 4	430	4	1000	
				25	10	K2-2, 5	348	5	1000	
				10	25	K2-2, 6	500	1	1000	
				5	50	K2-2, 7	500	2	1000	
				0	100	K2-2, S	500	4	1000	Bucket

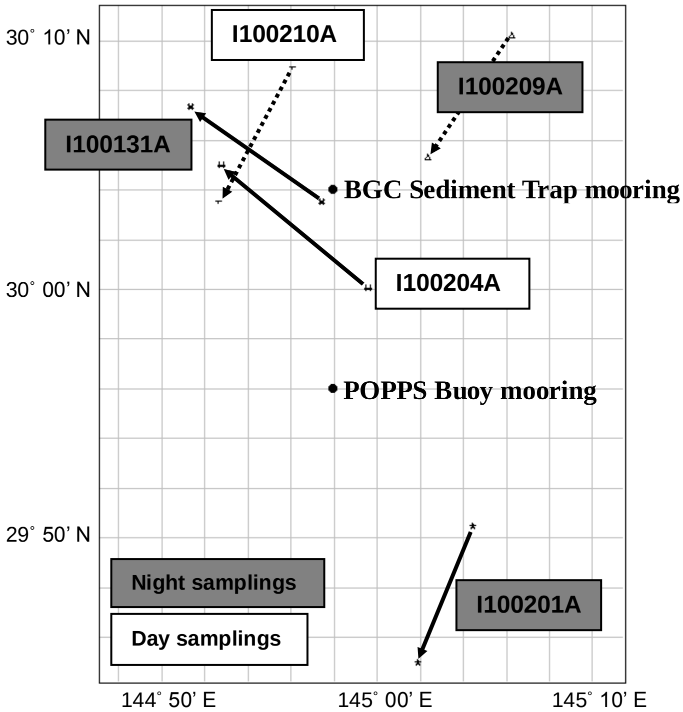


Figure 3.6.1-1. Tracks of IONESS samplings in the Stn. S1.

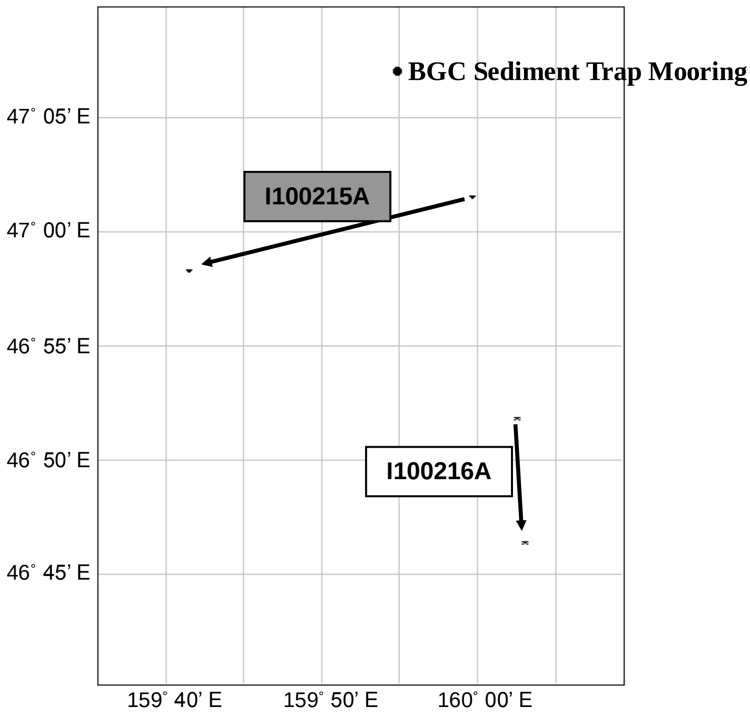


Figure 3.6.1-2. Tracks of IONESS samplings in the Stn. K2.

(3) Preliminary results

Vertical distributions of mesozooplankton biomass (dry weight) in the station S1 is shown in Fig. 3.6.1-1.

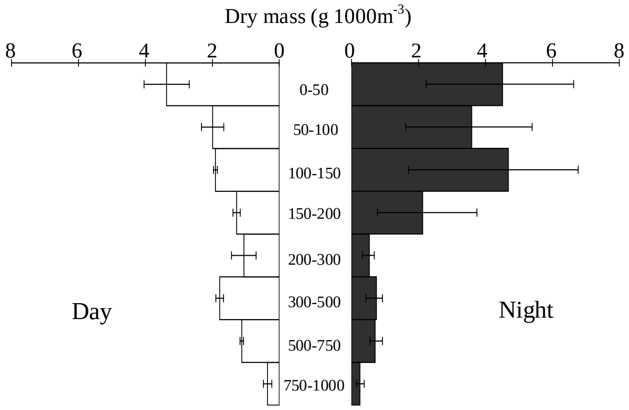


Fig.3.6.1-1. Vertical distribution of mesozooplankton dry mass in the station S1.

(4) Future plans and sample archives

Community structure and ecological role of mesozooplankton

Subsamples are stored at JAMSTEC or Kagoshima Univ. We will analyze as follows; (1) vertical distribution of zooplankton carbon mass, (2) vertical distribution of biomass in higher taxa revel (copepods, euphausiids, etc.) and taxa composition based on the carbon weight, (3) vertical distribution, composition, biomass, and diel vertical migration for each species of dominant taxa such as copepods, euphausiids and chaetognaths, (4) estimation of carbon transport through diel or ontogenetic migration.

Environmental (T, S) and net status (net number, towing distance, R/V position, etc.) data were recorded during each IONESS tow. All data is under Kitamura, Kobari and submitted to DMO, JAMSTEC.

Vertical distribution of surface microzooplankton

Sample analysis is consigned to Marine Biological Research Institute of Japan Co. LTD., Shinagawa, Tokyo.

3.6.2. Grazing pressure of microzooplankton

Minoru KITAMURA (JAMSTEC, BioGeos)
Toru KOBARI, M. MINOWA, H. MORI and H. AKAMATSU (Kagoshima Univ.)

(1) Objective

To understand material export from surface to deep ocean, not only estimations of primary productivity or vertical flux but also evaluation of grazing impacts at surface is needed. Grazing by larger organisms might bring about efficient vertical carbon transport through repacking phytoplankton into fecal pellets or active carbon transport by diel and ontogenetic migrator. On the other hand, grazing by smaller organisms might have small or negative impact to vertical export. Identification of influential grazers and quantitative estimation of their grazing rates are essential to discuss the carbon cycle in the ocean. Recently, large grazing pressure of not only the crustacean plankton but also microzooplankton has been recognized in the several area. The grazing pressure by the micro organisms maybe important in the northwestern north Pacific in winter because large calanoid copepods migrate to midwater. Based on this background, we estimated grazing rate of them.

(2) Materials and methods

Six dilution incubation experiments were done through the cruise (Table 3.6.2-1). For each experiment 40 l of water were collected from Niskin bottle. 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. Filtered water was obtained by direct gravity flow through a compact cartridge filter (ADVANTEC, MCS-020-D10SR). Incubation of the dilute water was done in transparent polycarbonate bottle. Duplicate or triplicate bottle were prepared. 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. Nutrient was added in the incubation bottles. To measure initial and final chl.*a* concentration, experiment water were filtered onto GF/F filter and extracted 6 ml DMF at –20°C until measurement. Chl.*a* were measured fluorometrically (Welshmeyer method) with a Turner Design fluorometer.

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

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

where t is incubation time (day), 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 (k; d^{-1}) and grazing coefficient of microzooplankton (g: d^{-1}), respectively. According to Verity et al. (1993) and Zhang et al. (2006), microzooplankton grazing pressure on primary production (P_p; %) is calculated as the following equation:

$$P_p = (e^{kt} - e^{(k-g)t}) / (e^{kt}-1)*100$$

Through the three incubation experiments, we tried to estimate true growth rate of phytoplankton, grazing rate of microzooplankton and grazing pressure of microzooplankton on primary production. Incubation states are summarized in Table 3.6.2-1.

References

Verity, P.G., D.K. Stoecker, M.E. Sieracki & J.R. Nelson. 1996. Grazing, growth and mortality of microzooplankton during the 1989 North Atlantic spring bloom at 47°N, 18°W. Deep-Sea Res., 40: 1793-1814.

Zhang, W., H. Li, T. Xiao, J. Zhang, C. Li & S. Sun. 2006. Impact of microzooplankton and copepods on the growth of phytoplankton in the Yellow Sea and East China Sea. Hydrobiologia, 553: 357-366.

Table 3.6.2-1. Dilution experiments, sampling and incubation conditions.

Station	Date	Exp. ID.	Water sampling					Incubation					
			Depth m	Irradiance %	Temp. degree C	Chl.*a* ug/l	CTD cast No.	Start (LST)	End (LST)	Temp. degree C	Irradiance %	PAR-daily $E/m^2/d$	Added nutrients
K2-1	25-26 Jan. 2010	K2-1_a	5	50	2.3	0.30	K2 cast 2	7:20	7:40	2.3-2.8	50	5.3	A
S1-1	1-2 Feb. 2010	S1-1_a	5	50	19.1	0.45	S1 cast 4	7:13	7:10	19.0-20.2	50	19.4	B
S1-1	3-4 Feb. 2010	S1-1_b	60	2.5	19.5	0.44	S1 cast 8	7:15	7:00	19.2-20.3	2.5	19.8	B
S1-2	9-10 Feb. 2010	S1-2_a	5	50	19.0	0.46	S1 cast 9	7:00	7:00	18.6-19.3	50	25.2	B
S1-2	11-12 Feb. 2010	S1-2_b	60	2.5	19.1	0.43	S1 cast 15	7:03	7:00	17.8-19.1	2.5	17.0	B
K2-2	15-16 Feb. 2010	K2-2_a	10	2.5	1.5	0.38	K2 cast 6	7:05	7:00	1.4-1.8	100	10.2	A

Added nutrients
Pattern A in the stn.K2: $NaNo_3$; 0.5uM, Na_2HPO_4; 0.03uM
Pattern B in the stn.S1: $NaNo_3$; 10nM, Na_2HPO_4; 20nM

(3) Preliminary results

All measurements of Chl.*a* and estimation of grazing pressures were finished on board. Negative correlation between apparent phytoplankton growth rates and dilution factors is recognized four of six incubations. All six results are shown in the Figure 3.6.2-1.

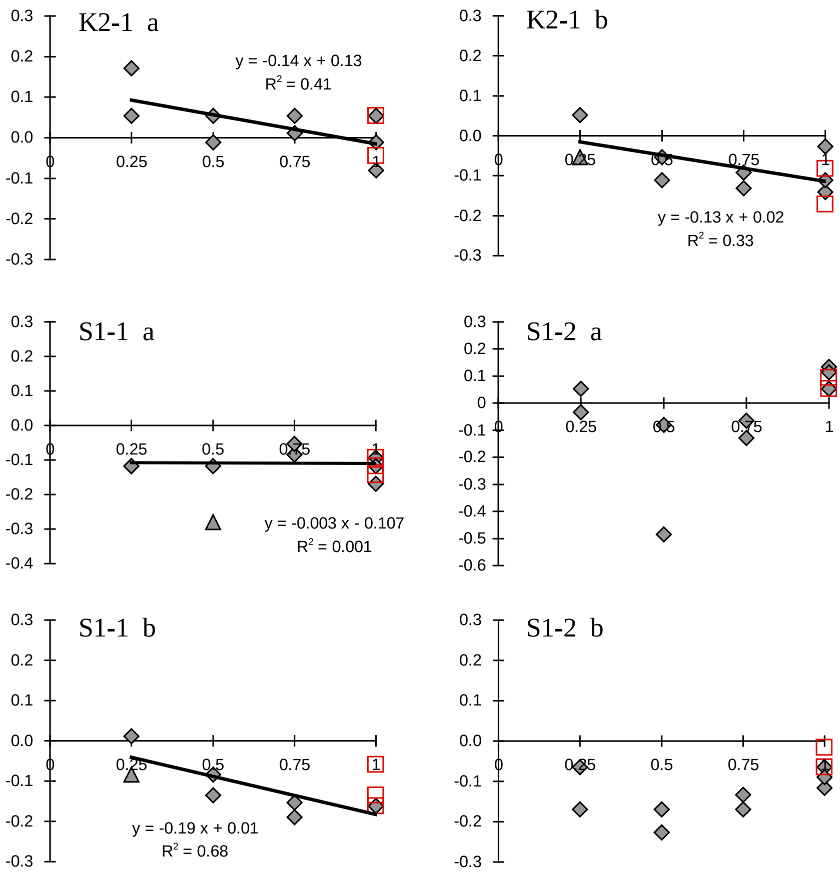


Fig.3.6.2-1. Correlation between apparent growth rates of phytoplankton and dilution factors in the six dilution incubation experiments during MR10-01, January and February 2010.

3.7. Effects of zooplankton on sinking carbon flux
3.7.1. Active carbon flux

Toru KOBARI (Kagoshima Univ.)
Masato MINOWA (Kagoshima Univ.)

(1) Objective

It has been long accepted that sinking particles are major pathway of vertical carbon flux into the ocean interior and support mesopelagic carbon demand. In the past decade, a number of studies have shown that diel vertical migrants contribute to carbon flux by consuming particulate organic carbon (POC) in surface waters and respiring and excreting the metabolized POC at depth. This “active carbon flux” is equivalent to 3–127%, of the sinking POC flux in tropical to subarctic waters. Moreover, there is increasing information that seasonally migrants significantly contribute carbon flux because their respiration and mortality at depth are more than 97% of sinking POC flux. Thus, we should evaluate how active carbon flux by mesozooplankton community contributes to passive carbon flux.

In the present study, we investigated mesozooplankton abundance and community structure at K2 and S1 in Northwestern Pacific Ocean to estimate active carbon flux.

(2) Methods

Samplings were carried out during the R/V Mirai cruise (MR10-01) from January to February 2010 at K2 and S1 in the Northwestern Pacific Ocean.

To estimate diel active carbon flux, mesozooplankton were collected from 200 m to sea surface using Twin-type North Pacific Standard net (diameter 45 cm, mesh size 0.1 mm) during both day and night. To estimate seasonally active carbon flux, mesozooplankton were collected with a IONESS (1-m^2 mouth square, 330-μm mesh size) during both day and night at each cruise. The following 8 discrete depth intervals were sampled on the upcast: 0–50, 50–100, 100–150, 150-200, 200-300, 300-500, 500-750 and 750-1000 m.

Net tow samples were split using a Folsom-type or MTD-type plankton splitter and subsamples were processed using protocols similar to Steinberg et al. (2008). Both subsamples were fractionated into five size categories (0.1-0.2, 0.2-0.5, 0.5-1.0, 1.0-2.0, >2.0-mm) using nested sieves. The first halves of subsamples at each size category were preserved in borax-buffered 5% formaldehyde for microscopic analysis. The other halves of subsamples were transferred onto pre-weighed 0.1-mm nylon mesh filters and preserved lower than -20˚C after rinsed with Milli-Q water until weight measurement.

(3) Preliminary results

During the cruise, we collected 13 samples of NORPAC and 40 samples of IONESS (Table 1). For first subsamples, major taxonomic groups or species will be identified under a stereo dissecting microscope from fixed samples. For the other subsamples, dry weights of each size fraction will be measured on a micro balance. Active carbon flux will be estimated by the methods of Al-Mutairi and Landry (2001) and Kobari et al. (2003).

Table 2. Sampling data for mesozooplankton.

Date	Time	Station	Max. depth (m)	Layer
NORPAC				
20100124	20:01	K2	200	1
20100125	15:12	K2	200	1
20100125	20:29	K2	200	1
20100201	13:47	S1	200	1
20100201	20:00	S1	200	1
20100202	13:01	S1	200	1
20100202	20:30	S1	200	1
20100209	12:00	S1	200	1
20100209	19:37	S1	200	1
20100210	11:42	S1	200	1
20100210	20:53	S1	200	1
20100216	6:42	K2	200	1
20100216	13:11	K2	200	1
IONESS				
20100131	21:00	S1	1000	8
20100203	9:30	S1	1000	8
20100204	8:30	S1	1000	8
20100209	21:00	K2	1000	8
20100210	8:30	K2	1000	8

(4) Reference

Al-Mutairi, H., Landry, M.R. (2001). Active export of carbon and nitrogen at StationALOHA by diel migrant zooplankton. Deep-Sea Research II, 48, 2083–2103.

Kobari, T., Shinada, A., Tsuda, A. (2003). Functional roles of interzonal migrating mesozooplankton in the western subarctic Pacific. Progress in Oceanography 57, 279-298.

Steinberg, D.K., Cope, J.S., Wilson, S.E., Kobari, T. (2008). A comparison of mesopelagic mesozooplankton community structure in the subtropical and subarctic North Pacific Ocean. Deep-Sea Research II, 55, 1615– 1635.

3.7.2. Nutritional conditions of copepods

Toru KOBARI (Kagoshima Univ.)
Haruko MORI (Kagoshima Univ.)

(1) Objective

Copepod populations have known to change growth or nutritional conditions dependent on food availability and ambient temperature. To date, there is little information on growth and nutritional conditions for epipelagic copepods due to no practical methods. Wagner et al. (1998, 2001) proposed that nucleic acids and protein contents were indicators as nutritional conditions for predominant copepod in the Atlantic Ocean, whereas this protocol is not applied to the other species.

In this study, we analyze DNA, RNA and protein contents of copepods at K2 and S1 in Northwestern Pacific Ocean to compare nutritional conditions of copepods to food availability between subarctic and subtropical waters.

(2) Methods

Samplings were carried out during the R/V Mirai cruise from January to February 2010 at K2 and S1 in the Northwestern Pacific Ocean. Live copepods were collected in surface layers (0-50, 0-100 and 0-200 m) using single-type North Pacific Standard net with large cod-end bottle (diameter 45 cm, mesh size 0.33 or 0.1 mm) at a speed of 0.5 m sec^{-1}. Healthy specimens were indentified species and development stage under a dissecting microscope. Each specimen was rinsed with Milli-Q water, put into 2 mL tube, and then preserved under -80^{o}C after quickly frozen in liquid nitrogen. These procedures were done within 4 hours.

(3) Preliminary results

During the cruise, 295 samples were collected. These samples will be brought back to the land laboratory for nucleic acids and protein analyses following the method of Wagner et al. (1998, 2001). We will compare RNA/DNA or RNA/Protein ratios of copepods to food availability and ambient temperature.

(4) Reference

Wagner, M.M., Campbell, R.G., Boudreau, C.A., Durbin, E.G. (2001). Nucleic acids and growth of Calanus finmarchicus in the laboratory under different food and temperature conditions. Marine Ecology Progress Series, 221, 185-197.

Wagner, M.M., Durbin, E., Buckley, L. (1998). RNA:DNA ratios as indicators of nutritional condition in the copepod Calanus finmarchicus. Marine Ecology Progress Series, 162, 173-181.

3.7.3. Production and consumption of fecal pellets

Toru KOBARI (Kagoshima Univ.)
Atsushi TSUDA (University of Tokyo ORI)
Hiroyashu AKAMATSU (Kagoshima Univ.)

(1) Objective

Fecal pellets are produced by zooplankton in surface waters and also changed by zooplankton ingestion (coprophagy), fragmentation via sloppy feeding or swimming activity (coprorhexy) and loosening of membrane (coprochaly) during sinking. These processes largely affect production and transfer efficiency of particulate organic carbon (POC) flux. It has been believed that fecal pellets are declined by bacterial decomposition and/or coprophagy/coprorhexy of small copepods for last two decades. In recent years, however, these copepods showed minor contributions to coprophagy/coprorhexy from the field observations and laboratory experiments, and heterotrophic microbes consume fecal pellets. Thus, we should re-consider how fecal pellets are declined or changed during sinking from surface to mesopelagic depths.

In the present study, we carried out on-board experiments to evaluate relationship between fecal pellet volume and body size of mesozooplankton and consumption of fecal pellets by heterotrophic at K2 and S1 in Northwestern Pacific Ocean.

(2) Methods

Samplings were carried out during the R/V Mirai cruise from January to February 2010 at K2 and S1 in the Northwestern Pacific Ocean. Live mesozooplankton were collected from surface layers (0-50, 0-100 or 0-200 m) using single-type North Pacific Standard net with large cod-end bottle (diameter 45 cm, mesh size 0.33 or 0.1 mm) at a speed of 0.5 m sec^{-1}. We carried out on-board experiments to evaluate consumption of fecal pellets by heterotrophic microbes (Exp.A) and production of fecal pellets by copepods (Exp.B) at both stations.

For Exp.A, live zooplankton were transferred into chambers (20-cm diameter, 1-m long) and placed at ambient temperature under dark condition during 3 to 6 hours. Fecal pellets were gently collected using 20-μm sieve. Following the protocol of Poulsen and Iversen (2008), bottle incubations were done.

For Exp.B, Individual copepods were observed under a dissecting microscope to determine class. Each specimen was transferred into 250 or 9 mL bottle. These bottles were kept under dark conditions at ambient temperature during 1 to 2 hours or in a deck container cooled with running surface seawater during 5 hours. After incubation, copepods and fecal pellets were preserved in borax-buffered 5% formaldehyde for microscopic analysis.

(3) Preliminary results

During the cruise, Exp.A and Exp.B were carried out 4 times and 2 times, respectively. We collected 60 samples for Exp.A (Table 3) and 82 samples for Exp.B (Table

4). We will observed number, shape and volume for fecal pellets and also species and body size of copepods.

(4) Reference

Poulsen, M. R., Iversen, M. H. (2008). Degradation of copepod fecal pellets: key role of protozooplankton. Marine Ecology Progress Series, 367, 1-13.

Table 3. Summary for experiments of microbial consumption of fecal pellets (Exp.A). SW: Seawater. FSW: Filtered sea water. SF: Size fraction.

Start		End		Station	Incubation medium					Replicate
Date	Time	Date	Time		Depth (m)	SW (%)	FSW (%)	Food (%)	SF (μm)	
20100125	20:30	20100127	14:30	K2	75	100	0	0	200	3
20100125	20:30	20100127	14:30	K2	75	100	0	0	100	3
20100125	20:30	20100127	14:30	K2	75	100	0	0	20	3
20100125	20:30	20100127	14:30	K2	75	100	0	0	5	3
20100125	20:30	20100127	14:30	K2	75	100	0	0	0.2	3
20100201	19:30	20100202	19:30	S1	65	100	0	0	200	3
20100201	19:30	20100202	19:30	S1	65	100	0	0	100	3
20100201	19:30	20100202	19:30	S1	65	100	0	0	20	3
20100201	19:30	20100202	19:30	S1	65	100	0	0	5	3
20100201	19:30	20100202	19:30	S1	80	100	0	0	0.2	3
20100210	23:45	20100211	23:50	S1	80	100	0	0	200	3
20100210	23:45	20100211	23:50	S1	80	100	0	0	100	3
20100210	23:45	20100211	23:50	S1	80	100	0	0	20	3
20100210	23:45	20100211	23:50	S1	80	100	0	0	5	3
20100210	23:45	20100211	23:50	S1	80	100	0	0	0.2	3
20100216	16:00	20100217	16:30	K2	55	100	0	0	200	3
20100216	16:00	20100217	16:30	K2	55	100	0	0	100	3
20100216	16:00	20100217	16:30	K2	55	100	0	0	20	3
20100216	16:00	20100217	16:30	K2	55	100	0	0	5	3
20100216	16:00	20100217	16:30	K2	55	100	0	0	0.2	3

Table 4. Summary for experiments of production of fecal pellets (Exp.B). SW: Seawater. FSW: Filtered sea water. ORI: Ocean Research Institute. KU: Kagoshima University.

Start		End		Station	Incubation medium				Added copepods		Analysis
Date	Time	Date	Time		Depth (m)	SW (%)	FSW (%)	Food (%)	Sampling layer (m)	Number	
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	100	0	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	25	75	0	0-200	1	ORI
20100209	13:30	20100209	18:30	S1	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	100	0	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100216	8:00	20100216	13:00	K2	5	25	75	0	0-200	1	ORI
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	5	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	5	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	2	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	3	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100209	14:50	20100209	15:50	S1	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU
20100216	8:30	20100216	10:30	K2	5	99	0	1	0-200	1	KU

3.8. Biological study of phytoplankton and zooplankton
3.8.1. Plankton tow sampling by the VMPS

(1) Personnel

Katsunori Kimoto (RIGC, JAMSTEC) Leg.2

Yurika Ujiié (Shinshu Univ.) Leg.2

Toru Kobari (Kagoshima Univ.) Leg.2

(2) Objectives

Oceanic microplankton is one of the groups of marine Protista, and they are fundamental components of oceanic material cycles and food-web. Especially, the unicellular organisms, such as foraminifera, radiolarians and diatoms are very common in the water column and they build a hard-skeletons made from calcareous and/or silicates. After they died, their hard skeletal shells sink down and are preserved in the deep-sea sediments. Therefore their secreted shells are good indicator for estimating paleo-sea surface environmental conditions.

It is known that such skeleton-bearing microplankton make habitats in wide range of environments in the surface water, however, their distribution, abundances, and genetic diversity in the water column are poorly documented. Especially in high latitude area, basic data of ecology of skeleton-bearing plankton is lacking prominently. In this study, we collected planktic foraminifer and radiolarian samples used the multi-depth plankton net (VMPS, Tsurumi Seiki co.,Ltd) from the water column at station S1 and K2, the North Pacific Ocean, and try to make general view of their habitat and ecology between both oceanographic areas. This study will be contributed to make blueprint for reconstructing the paleo-sea surface environmental conditions in the high and mid-latitude oceans in the northern hemisphere. In addition, this cruise was the first experiment of operation of the VMPS by the R/V Mirai.

(3) Equipments and Sampling strategy

The VMPS net was used for multiple-depth plankton sampling in this study. This net is a kind of vertical-towing plankton sampler and it can close the mouth at the any depth by the electric signals from the ship. Totally 4 plankton nets can be equipped on the VMPS at the same time. Fundamental specification of this net is shown in Figure 3.8.1.1. Details of sampling stations and data for collection were listed in Table 3.8.1.1.

Fundamental strategy for sampling by VMPS net is as follows:

1) The VMPS was lowered from boat tail of R/V Mirai using the No. 11 winch (armored electric cable). The lowering speed of wire was approximately 0.7 m /sec.

2) When the VMPS reached at target (deepest) water depth, close the no. 1 net. At this moment, No. 1 plankton net had been closed and No. 2 net is open. And then, the VMPS is pulled up from bottom to next water depth where we targeted. Pulling up speed of wire is at 0.5 m /sec.

3) After closing all plankton net, VMPS is pulled up to the deck at 1.0 m wire speed.

4) Samples were gently collected using 0.2 µm filtered seawater on deck.

(4) Shipboard treatments

VMPS experiments were performed at all observation stations in Leg 2. All samples were divided using sample separation apparatus for microfossil assemblages and DNA analysis. For microfossils, they were fixed by Ethanol immediately in the laboratory, and they were kept in the refrigerator (4°C). For DNA analysis, For DNA analysis, samples were sorted under a stereo-microscope immediately after collection. Isolated specimens were cleaned with filtered seawater using fine brush in order to remove microorganisms from the test surface. Cleaned specimens were transferred on the faunal slides and dried at room temperature. The dried specimens were stored in deepfreezer at -80°C. The extraction of DNA and further molecular biological analysis were carried out after the cruise.

(5) Analytical items

All plankton samples were shared for following analysis.

1) Phylogenic diversity of living planktic foraminifers and radiolarians.

2) Faunal analysis of planktic foraminifers, radioralians.

3) Trace metals and stable isotopic analysis incorporating planktic foraminiferal shells.

Table 3.8.1.1. List of the casts of plankton tows in MR10-01 (Leg.2) cruise.

MR10-01 Leg 2. date	Station S1	date	Station K2
	Cast 1		**Cast 1**
2010.2.9	0-20m	2010.2.15	0-30m
	20-30m		30-50m
	30-50m		50-75m
	50-75m		75-100m
	75-100m		100-150m
	100-150m		150-200m
	150-200m		200-400m
	200-300m		400-600m
	300-400m		600-1000m
	Cast 2		**Cast 2**
	0-30m		0-30m
	30-50m		30-50m
	50-75m		50-75m
	75-100m		75-100m
	10-150m		100-150m
	150-200m		150-200m
	200-400m		200-400m
	400-600m		400-600m
	600-1000m		600-1000m
	Cast 3		
	0-50m		
	50-100m		
	100-200m		
	200-1000m		


Figure 3.8.1.1. Overview of the VMPS system.

3.8.2. Shell-bearing phytoplankton studies in the western North Pacific

(1) personnel

Katsunori Kimoto (RIGC, JAMSTEC)

Shun Chiyonobu (Tohoku University)

Motoyoshi Oda (Tohoku University)

Jonaotaro Onodera (RIGC, JAMSTEC)

Itsuki Suto (Nagoya University)

(1) objectives

Shell-bearing phytoplanktons (Diatoms, Silicoflagellates, and Coccolithophorids) are main primary producer of the ocean, therefore it is important to know their seasonal distribution, interactions, and transgressions of assemblages. Furthermore, hard skeletons of phytoplankton remains in the deep sea sediments and it provide useful information for paleoceanographic changes of sea surface water conditions. In this study, we collected water samples from St. S1 and K2 to investigate vertical distributions and ecological features of each phytoplankton.

(2) Methods

Seawater samples were obtained from upper 300 m water depths at all hydrocast stations by CTD/Niskin systems of 12L bottle capacity. Surface (0 m) water samples were collected by bucket from the ship deck.

For coccolithophorid separations, 5 litter seawaters were filtered using 0.45 um membrane filter (ADVANTEC MFS, Inc.) immediately after collection. For diatoms and silicoflagellates separations, maximally 5 litter seawaters were also filtered using 0.45 um membrane filter and made ~100 ml condensed seawater. After that, condensed seawater samples were stocked into the 125 ml low density polyethylene (LDPE) bottles and were added 2 ml 0.3M HCl to each samples to acidify.

(3) Future works

Collected samples were analyzed assemblages, diversities and spacial distributions for each taxon at onshore laboratory. These data will be compared with the sediment trap datasets that are moored at St. S1 and K2, same locations with water sampling points in this time. That should be provide the precious information of seasonal and spacial behavior of phytoplankton related with oceanographic changes in the western north Pacific.

3.8.3. Study of Archaea DNA and TEX_{86}

(1) personnel

Katsunori Kimoto (RIGC, JAMSTEC)

Koji Suzuki (Hokkaido University)

Masanobu Yamamoto (Hokkaido University)

(2) Objectives

The purpose of this study is to investigate the abundance of Archaea DNA and distributions of TEX_{86} (TetraEther indeX of tetraethers consisting of 86 carbon atoms) in the seawater. TEX_{86} is the paleo-SST proxy that is based on the number of cyclopentyl moieties in the isoprenoid glycerol dialkyl tetraether (GDGT) lipids. Isoprenoid GDGTs containing cyclopentyl moieties arebiosynthesized by crenarceaeota, a kind of ubiquitous marine archaea. In this study, we will synthesize basic data of the vertical and spacial distribution of TEX_{86} in the water in order to enhance the precision of this new SST-proxy in the western North Pacific.

(3) Methods

Water samples collected by CTD/Niskin water sampler system were filtered using GF/F filter for TEX86 (19 litter of water) and 0.2 µm pore membrane filter for Archaea DNA (1 litter of water) immediately after collection. And then, filter samples were kept in cryovials and stored in deepfreezer (-80°C).

3.8.4. Deep sea core sampling

(1) personnel

Kana Nagashima (RIGC, JAMSTEC)

Katsunori Kimoto (RIGC, JAMSTEC)

Yusuke Okazaki (RIGC, JAMSTEC)

(2) objectives

In order to understand the latitudal migrations and intensity of the wind system in the geologic ages, research of the aeorian dust component deposited on the deepsea floor are important. We collected surface sediment materials from observational stations S1 and K2 and investigate the grain size distribution and flux to clarify the special and temporal variations of the Asian monsoon and the Westerly Jet with the orbital-scale that are related with atmospheric circulation systems in the northern hemisphere.

(3) Method

Deepsea sediment samples were taken from S1 and K2 stations in Leg 2. A multiple core sampler (Rigo, co.Ltd., 620 kg weight with 8 sub-core samplers) was used for correcting surface sediments. The bathymetric figures of each locations were shown in Fig 3.8.4.1 and 3.8.4.2.

To understand the basic core physical properties, gamma-ray attenuation (GRA) , P-wave amplitude and travel time, magnetic susceptibility (MS), core diameter and temperature data were acquired by Multi-Sensor Core Logger (MSCL) operated by the Marine Works Japan Co. Ltd. (MWJ). Collected samples were cutted 1 cm core depth intervals and stored in the core stocker (refrigerator at 4°C). One sub-core in each stations had kept as a whole core in the refrigerator.

(4) Future studies

Sediment samples will be used for following investigations:

1) Aeorian dust analysis for reconstruction of the Westerly Jet and Asian Monsoon history in the Quaternary.

2) Study of silica(SiO_2) -bonding oxygen isotope analysis.

3) Diversity of agglutinated benthic foraminiferal faunas living at deepsea plane.

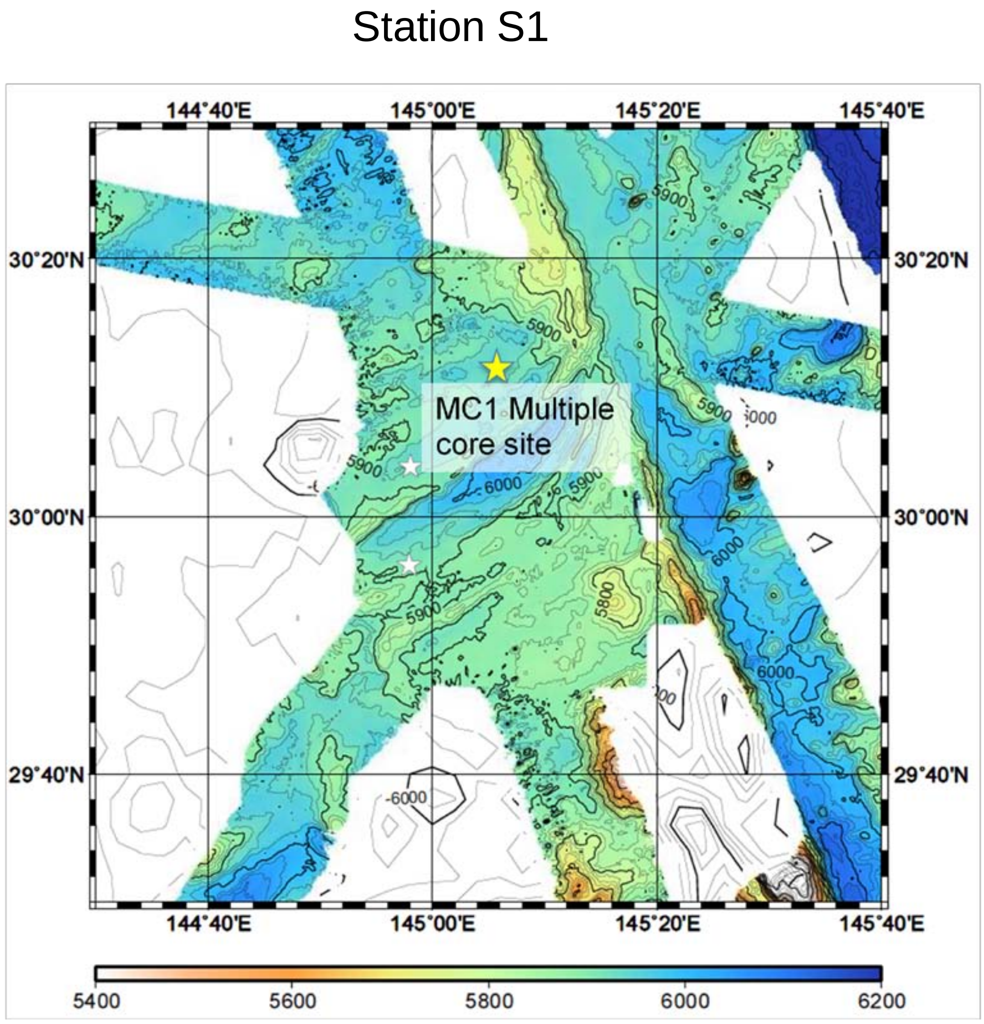


Figure 3.8.4.1 Multiple core location MC1 of Station S1.

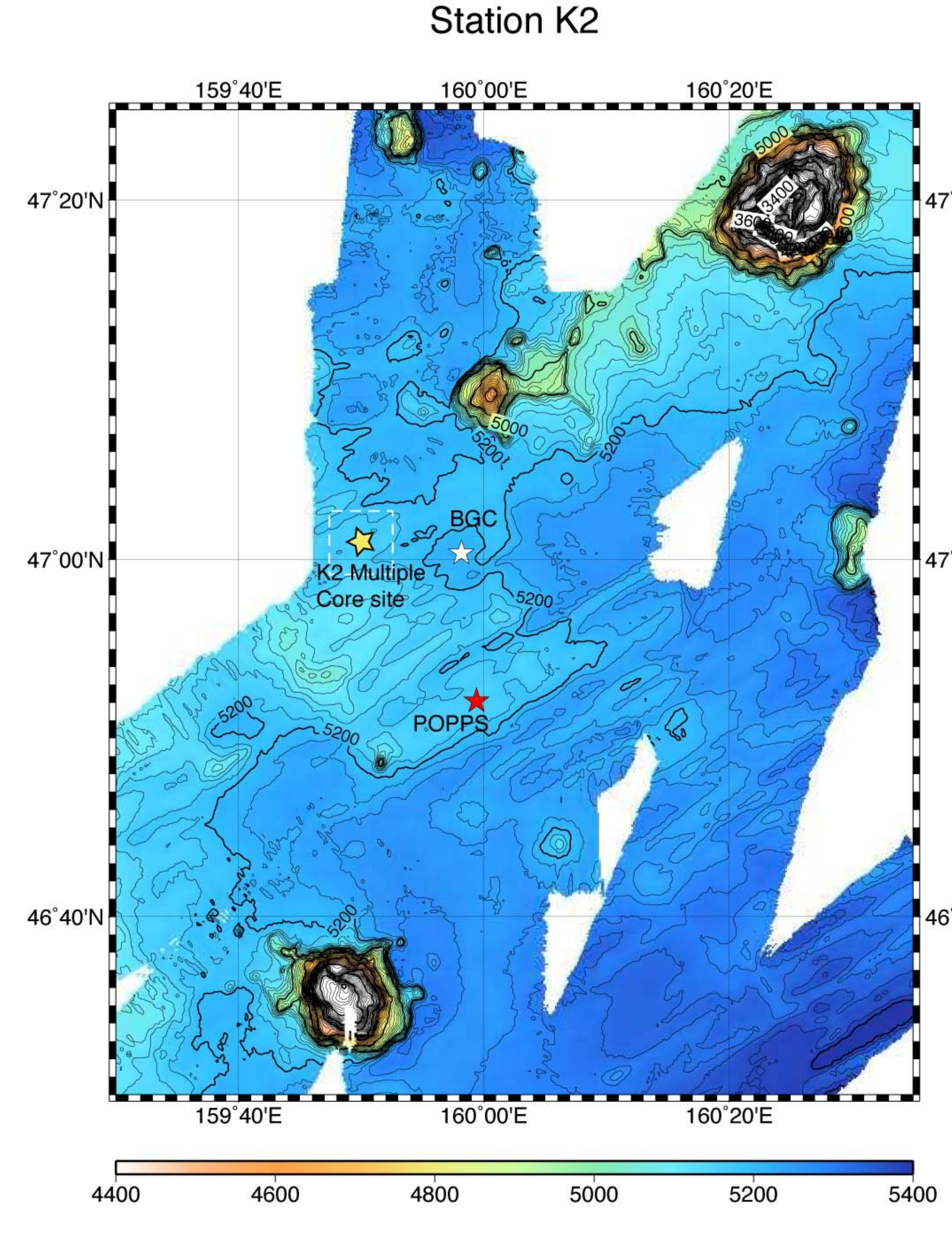


Figure 3.8.4.2 Multiple core MC2 location of Station K2.

3.8.5. Multiple Corer (MC)

(1) Personnel

Yusuke Sato (Marine Works Japan Co. Ltd): Operation Leader
Ei Hatakeyama (Marine Works Japan Co. Ltd)

(2) Objectives

Collection of surface sediment

(3) Instruments and Method

Multiple Corer (MC) used in this cruise consists of main body (620kg weight) and eight pipes, which are 7 acryl pipes and 1 polycarbonate pipe. Core barrel is 60cm length and 74mm inside diameter.

Winch Operation

When we starts lowering the MC, a speed of wire out is set to be 0.5m/s., and then gradually increased to be 1.0m/s. The MC is stopped at a depth about 50m above the sea floor for 3minutes to reduce any pendulum motion of the sampler. After the sampler is stabilized, the wire is stored out at a speed of 0.3m/s., and we carefully watch a tension meter. When the MC touches the bottom, wire tension leniently decreases by the loss of the sampler weight. After confirmation that the MC touch seafloor, the wire out is stopped then another 5m rewinding. The wire is started at dead slow speed, until the tension gauge indicates that the corer is lifted off the bottom. After leaving the bottom, which wire is wound in at the maximum speed. The MC came back ship deck, the core barrel was detached main body.

(4) Results

Details of coring position and core length are shown in the Appendix 1 (Coring summary).

3.8.5.1 Soft-X ray photographs

(1) Personnel

Ei Hatakeyama (Marine Works Japan Co. Ltd)
Yusuke Sato (Marine Works Japan Co. Ltd)

(2) Objective

To obtain information of invisible sedimentary microstructure of the cores, we took soft-X ray photographs.

(3) Instruments and methods

Sediment was sub-sampled by using an original plastic case (200mm x 7mm x 3mm) from sediment halves. The voyage code, core number, section number, case number, and the position range (cm) printed on the TEPRA label was put on each case, and sub-sampled plastic cases were tightly sealed to avoid exudation of pore water by using thin film seal “PARAFILM”.
Soft-X ray photographs were taken by a device of SOFTEX PRO-TEST 150 on board. Soft-X ray photographs of sediment samples through the cases were in the situation of two type power (①45 kVp, 2 mA in 200 seconds,②40 kVp, 2 mA in 200 seconds). All negative films of soft-X ray photograph were developed by a device FIP-1400 on board. These negative films were scanned by EPSON Offirio ES-10000G and were preserved as electric files.

(4) Preliminary results

In this cruise, the total 2 sediment samples were sub-sampled in plastic cases from Multiple cores, and the total 4 negative films of soft-X ray photograph were taken and developed. Scan data of the all cores are displayed as Fig. 3.8.5.1-1~2.

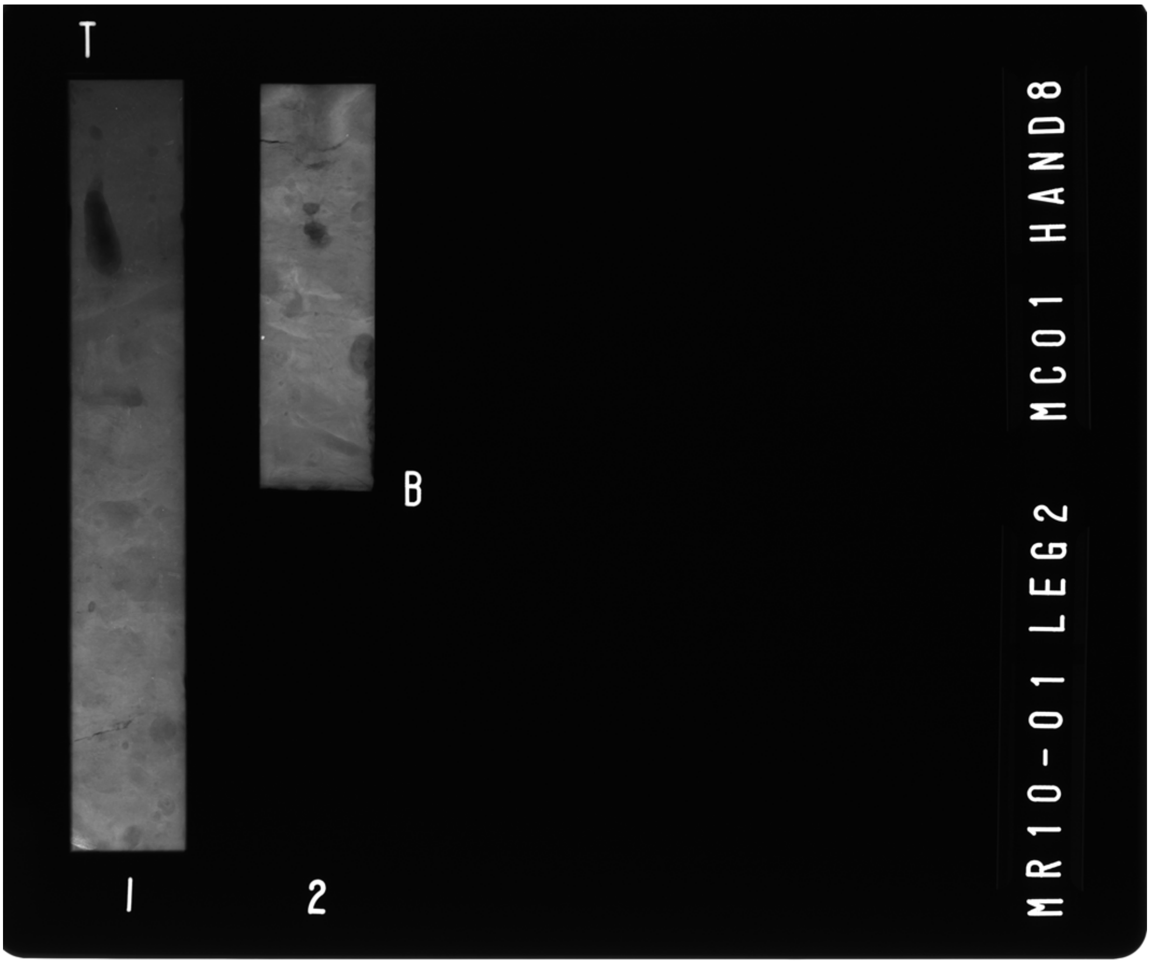


Figure 3.8.5.1-1. Soft X-ray images of Multiple core (MC1) hand 8.

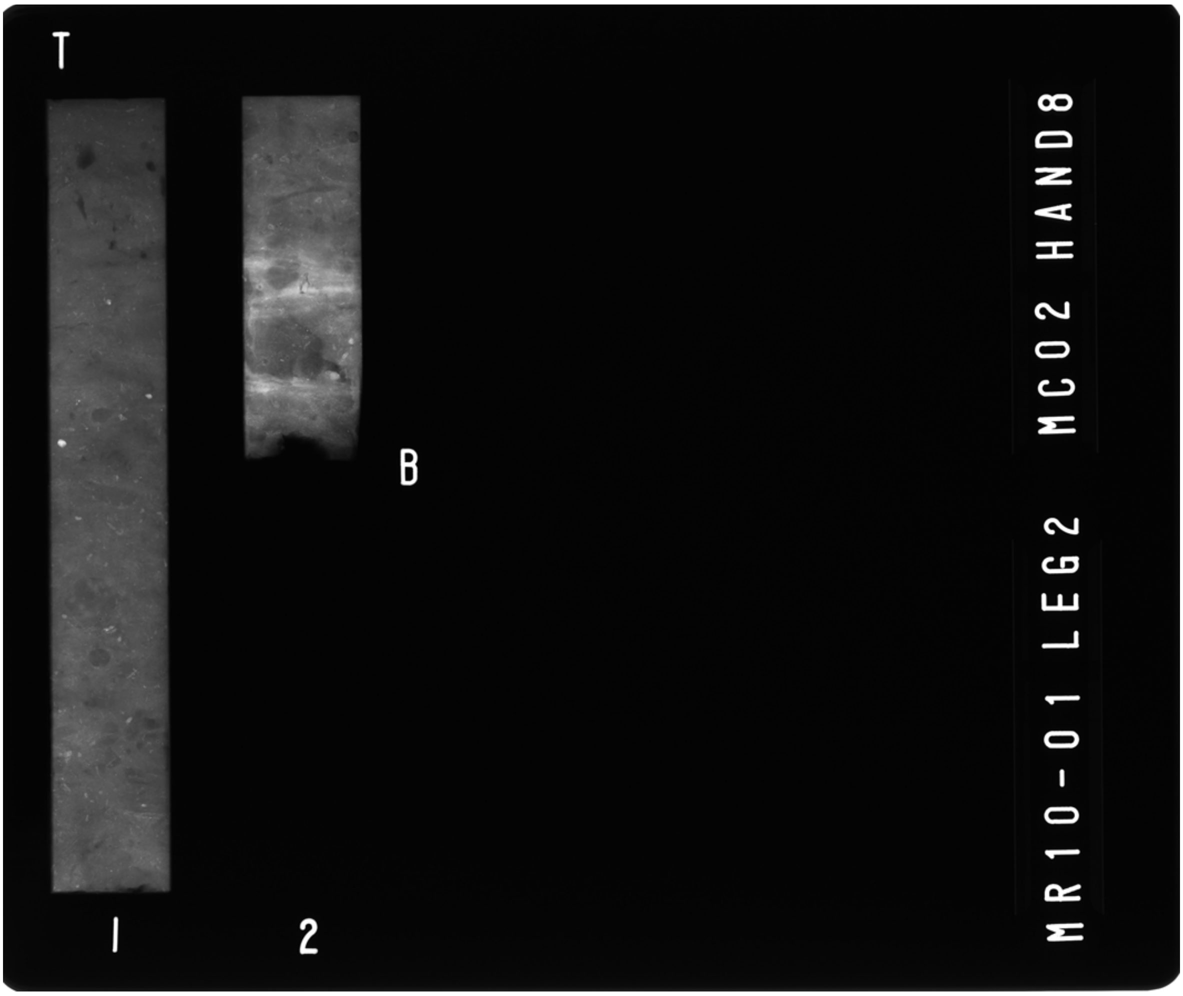


Figure 3.8.5.1-2. Soft X-ray images of Multiple core (MC2) hand 8.

3.8.5.2 Core photograph

(1) Personnel

Ei Hatakeyama (Marine Works Japan Co. Ltd)

(2) Objectives

Photographs were taken to observe sedimentary structures of the cores.

(3) Instruments and Method

After splitting, sectional photographs of archive were taken using a digital camera (Camera body: Nikon D1x / Lens: Nikon AF Zoom-Nikkor 24-50mm). When using the digital camera, shutter speed was 1/25 ~ 1/15 sec, F-number was 5.6～7.1. Sensitivity was ISO 125. File format of raw data is TIFF-RGB.

(4) Results

Photographs of the all cores are displayed as Photo 3.8.5.2-1~2.

Photo.3.8.5.2-1 MR10-01 Leg2 MC01 photo

Photo.3.8.5.2-2 MR10-01 Leg2 MC02 photo

Appendix 1 (Coring summary)

Date (mmddyy)	Core ID	Location	Lat.	Lon.	Depth(m)	HAND No.	Core length(cm)	Tension max.(t)	Remarks
02/09/10	MC01	The North western North Pacific	30°11.9720' N	145°05.9478' E	5,940	HAND1	34.8	6.2	acryl pipe
						HAND2	34.5		acryl pipe
						HAND3	34.8		acryl pipe
						HAND4	34.7		acryl pipe
						HAND5	35.7		acryl pipe
						HAND6	34.0		acryl pipe
						HAND7	34.0		acryl pipe
						HAND8	30.8		polycarbonate pipe
02/16/10	MC02	The North western North Pacific	47°00.6654' N	159°49.3029' E	5,161	HAND1	29.5	5.4	acryl pipe
						HAND2	28.8		acryl pipe
						HAND3	30.0		acryl pipe
						HAND4	30.5		acryl pipe
						HAND5	29.5		acryl pipe
						HAND6	30.8		acryl pipe
						HAND7	29.0		acryl pipe
						HAND8	28.0		polycarbonate pipe

*Latitude and Longitude was used the ship's position.

3.8.6. Physical properties measurements (Multi-Sensor Core Logger)

(1) Personnel

Ei Hatakeyama (Marine Works Japan Co. Ltd)

(2) Objectives

Whole cores were measured physical properties because of observed characteristics of the sediments and correlate different cores.

(3) Measured parameters

A GEOTEK multi-sensor core logger (MSCL) has three sensors, which is gamma-ray attenuation (GRA), P-wave velocity (PWV), and magnetic susceptibility (MS). There were measured on whole-core section before splitting using the onboard MSCL. These data measurement was carried on every 0.5cm.

(4) Instruments and Method

GRA was measured a gamma ray source and detector. These mounted across the core on a sensor stand that aligns them with the center of the core. A narrow beam of gamma ray is emitted by Caesium-137 (^{137}Cs) with energies principally at 0.662MeV. Also, the photon of gamma ray is collimated through 5mm diameter in rotating shutter at the front of the housing of ^{137}Ce. The photon passes through the core and is detected on the other side. The detector comprises a scintillator (a 2” diameter and 2” thick NaI crystal).

GRA calibration assumes a two-phase system model for sediments, where the two phases are the minerals and the interstitial water. Aluminum has an attenuation cofficient similar to common minerals and is used as the mineral phase standard. Pure water is used as the interstitial-water phase standard. The actual standard consists of a telescoping aluminum rob (five elements of varying thickness) mounted in a piece of core liner and filled with distilled water. GRA was measured with 10 seconds counting.

MS was measured using Bartington loop sensor that has an internal diameter of 100mm installed in MSCL. An oscillator circuit in the sensor produces a low intensity (approx. 80 A/m RMS) non-saturating, alternating magnetic field (0.565kHz). MS was measured with 1 second.

PWV was measured two oil filled Acoustic Rolling Contact (ARC) transducers, which are mounted on the center sensor stand with gamma system. These transducers measure the velocity of P-Wave through the core and the P-Wave pulse frequency.

Core image was taken by GEOSCAN Digital Imaging.

(5) Results

The MSCL measurement data are displayed Fig.3.8.6.1.

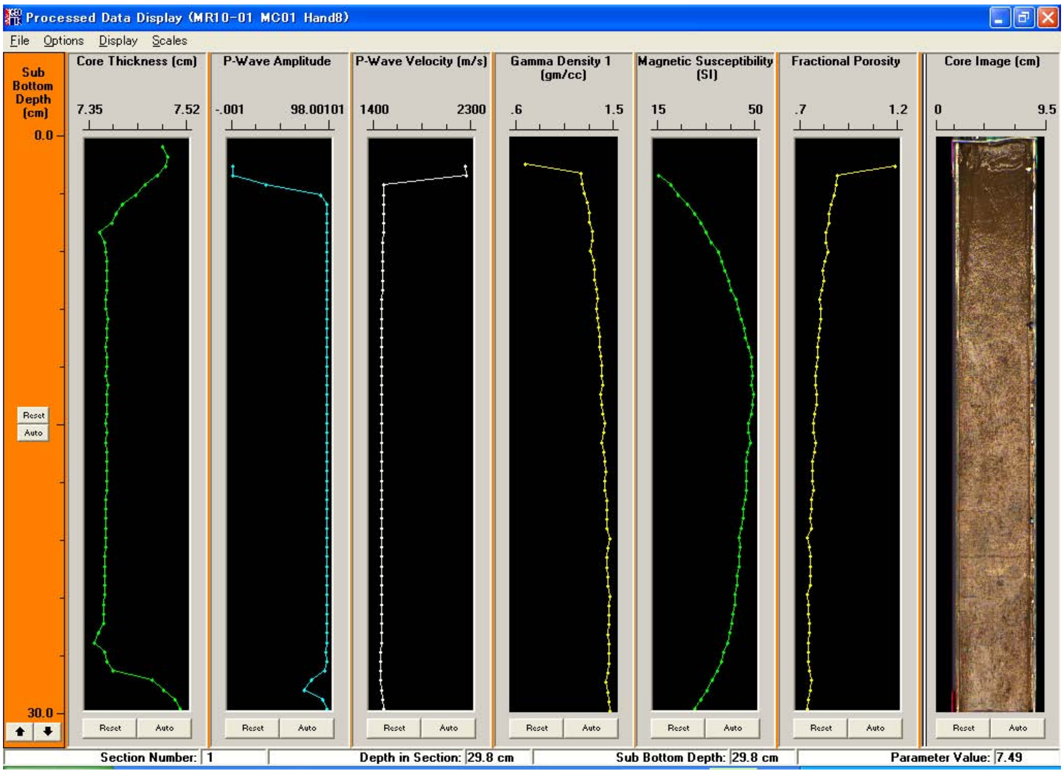


Fig.3.8.6.1 MR10-01 Leg2 MC01 MSCL data

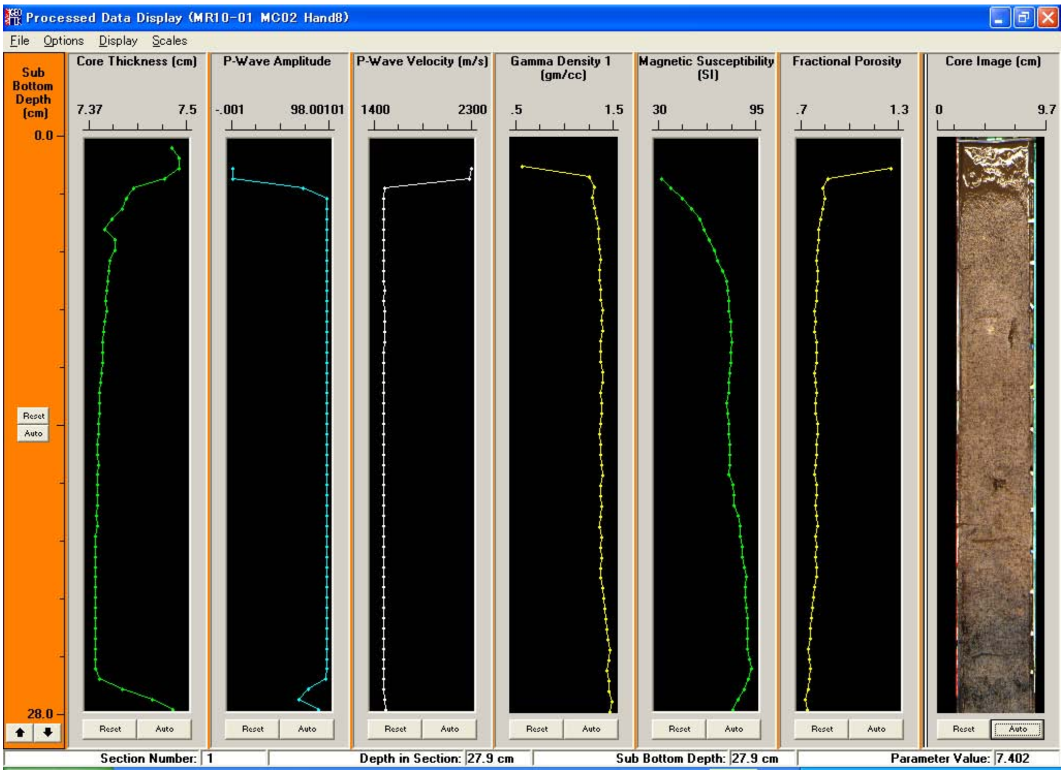


Fig.3.8.6.2 MR10-01 Leg2 MC02 MSCL data

3.8.7. Sediment color

(1) Personnel

Yusuke Sato (Marine Works Japan Co. Ltd)

(2) Objectives

Split cores were measured color reflectance because of observe characteristics of the sediments such as lithology, oxidation rate, concentrations of carbonates, organic matter and certain inorganic compounds. It is also frequently used to different cores.

(3) Measured parameters

There are different systems to quantify the color reflectance for soil and sediment measurements, the most common is the L*a*b* system, also referred to as the CIE (Commision International d'Eclairage) LAB system. It can be visualized as a cylindrical coordinate system in which the axis of the cylinder is the lightness variable L*, ranging from 0% to 100%, and the radii are the chromaticity variables a* and b*. Variable a* is the green (negative) to red (positive) axis, and variable b* is the blue (negative) to yellow (positive) axis. Spectral data can be used to estimate the abundance of certain components of sediments.

(4) Instruments and methods

Core color reflectance was measured by using the Konica Minolta CM-700d reflectance photospectrometer using 400 to 700nm in wavelengths. This is a compact and hand-held instrument, and can measure spectral reflectance of sediment surface with a scope of 8mm diameter. The CM-700d has a switch that allows the specular component to be included (SCI) or excluded (SCE). Including the specular component (SCI) essentially includes glare and provides a better estimate of color as seen by the human eye. However, glare does not contribute to the spectrum reflected from the sediments. We recommend setting the switch to SCE. The SCE setting is the recommended mode of operation for sediments in which the light reflected at a certain angle (angle of specular reflection) is trapped and absorbed at the light trap position on the integration sphere.

Calibration was carried out using the zero and white calibration piece without crystal clear polyethylene wrap before the measurement of core samples. The color of the sediment surface of split working half core was measured on every 2-cm through crystal clear polyethylene wrap.

Measurement parameters are displayed Table 3.8.7.1-1.

Table 3.8.7.1-1. Measurement parameters.

Instrument	Konica Minolta Photospectrometer CM-700d
Illuminant	de:8 (SCE)
Light source	D_{65}
Viewing angle	10 degree
Color system	L*a*b* system

(5) Results

The core color data are compiled in the Fig.3.8.7.1-1~6.

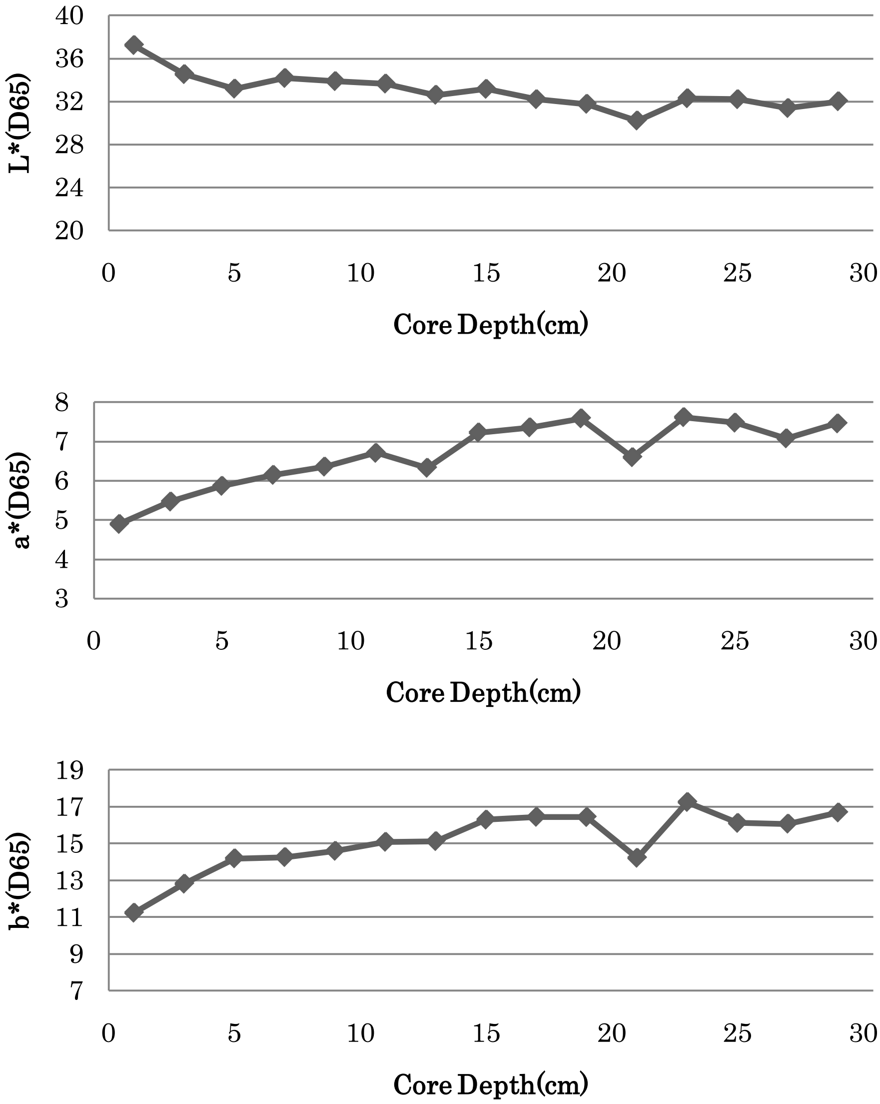


Figure 3.8.7.1-1~3 Color trend of MC01 Hand8

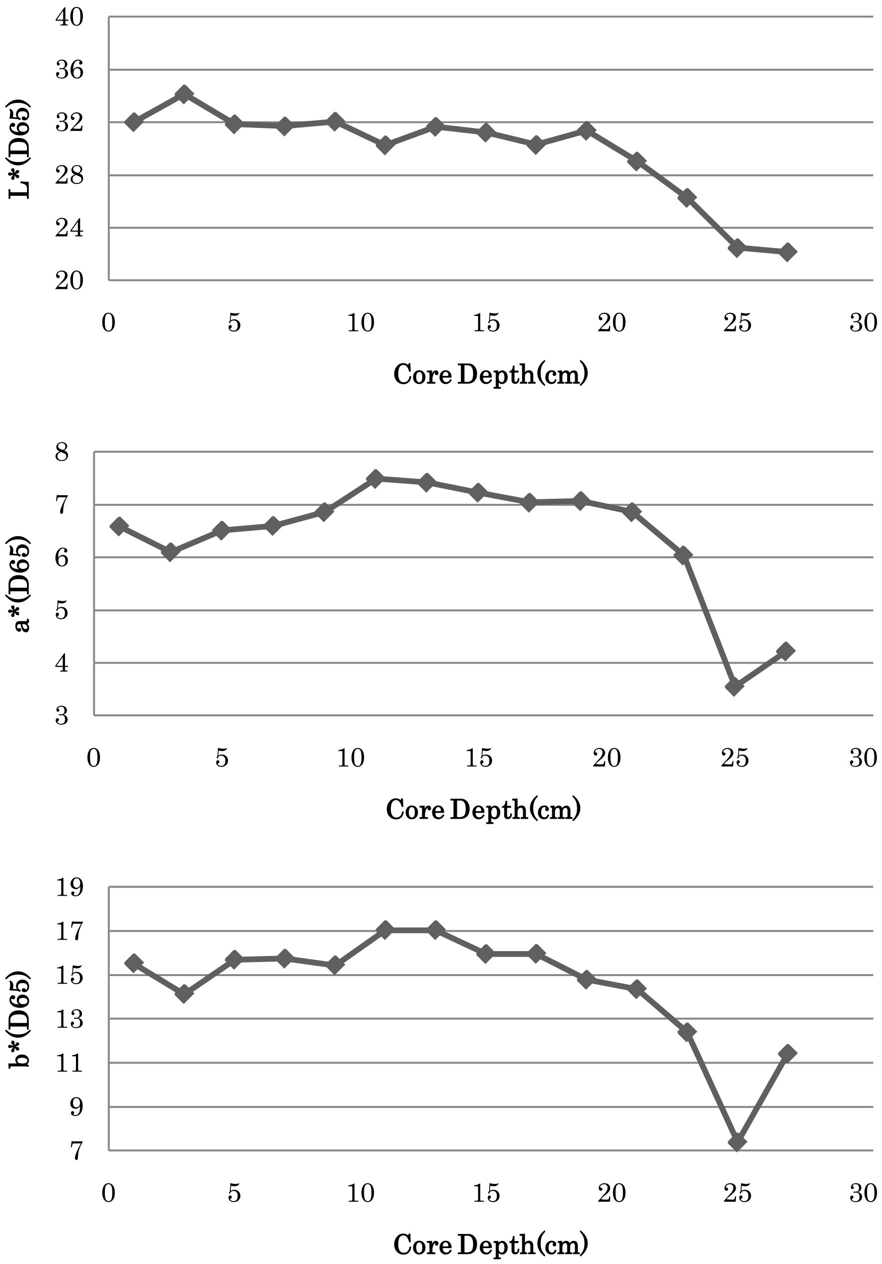


Figure 3.8.7.1-4~6 Color trend of MC02 Hand 8.

3.9. Community structures and metabolic activities of microbes

Toshi NAGATA[1], Kazuhiro KOGURE[1], Koji HAMASAKI[1], Hiroshi OGAWA[1], Hideki FUKUDA[1], Susumu YOSHIZAWA[1], Yumiko OBAYASHI[2], Akiko TOMARU[1], Ryo KANEKO[1], Jeho SONG[1], Mario UCHIMIYA[1], Takuya MAESAWA[1] (1. Ocean Research Institute, The University of Tokyo, 2. Graduate School of Engineering, Yokohama National University)

(1) Objective

A significant fraction of dissolved and particulate organic matter produced in the euphotic layer of oceanic environments is delivered to meso- and bathypelatic layers, where substantial transformation and decomposition of organic matter proceeds due to the actions of diverse microbes thriving in these layers. Statio-temporal variations in organic matter transformation and decomposition in the ocean's interior largely affect patterns in carbon cycling in the global ocean. Thus elucidating diversity, activities and distribution patterns of microbes in deep oceanic waters is fundamentally important in order to better understand major controls of oceanic material cycling in the ocean.

The objective of this study is to determine seasonal variability of microbial diversity and activities during the time-series observation of vertical fluxes at the two distinctive oceanic stations located in the subarctic and subtropical western North Pacific. We investigated i) full-depth profiles of prokaryotic activity and abundance and related biogeochemical parameters including dissolved organic carbon and nitrogen concentrations (potential resources of prokaryotes), and the abundances of nanoflagellates and viruses (potential predators of prokaryotes), ii) community structures of Bacteria and Archaea and iii) sinking velocity and physic-chemical properties of suspended particles in the mixing layer.

(2) Method

Seawater samples were collected from predetermined depths of two CTD casts, i.e. the Ocean Research Institute (ORI) cast and the Routine cast, conducted at Stations K2 and S1 (see the meta-data sheet for details). Sinking particles were collected by drifting traps to determine fluxes of sinking POC/PON and their weight (see the meta-data sheet for details).

i) Full-depth profiles of prokaryotic activity and abundance and related biogeochemical parameters

a) Prokaryotic abundance: Flow cytometry
b) Prokaryotic production: ^{3}H-leucine incorporation
c) Virus abundance: Flow cytometry
d) Nanoflagellate abundance: Direct counting under the epifluorescent microscopy
e) DOC/DON: Concentrations of dissolved organic carbon and total dissolved nitrogen were determined by the high temperature catalytic oxidation (HTCO) method. The concentration of dissolved organic nitrogen was calculated by subtracting the concentration of dissolved inorganic nitrogen (determined by Auto-analyzer) from that of total dissolved nitrogen.

ii) Relationship between community structures of Bacteria and Archaea and their metabolic activities

a) Bacterial community structures: PCR-DGGE method after extracting DNA from particles collected on 0.22 µm-pore-size filters (Sterivex).

b) Abundance of bacteria: Direct counting by the fluorescent microscopy after filtering fixed seawater with 0.2 and 3 µm pore-size polycarbonate filters, respectively.

c) Activities of bacteria: Bromodeoxyuridine-incorporating methods and exoenzymatic activity measurements.

d) Isolation of some key groups of bacteria: The high-through-put dilution culture method as well as conventional agar plating.

iii) Sinking velocity and physic-chemical properties of suspended particles

Sampling and observation were conducted only during Leg 1.

a) Concentrations of particulate organic carbon and nitrogen: Determined using an elemental analyzer for samples collected on GF/F filters.

b) Weight of suspended solid: Determined by weighing samples collected on pre-weighted GF/F filter.

c) Particle size distribution of suspended particles in upper layer (0-200 m): Determined by an *in situ* particle sizing instrument, LISST-100 (Sequoia Scientific Inc., USA).

d) Settling velocity of suspended particles: Determined from time course changes of particle abundance in a settling chamber attached to LISST-100X (Sequoia Scientific Inc., USA).

(3) All results will be submitted to Data Management Office, JAMSTEC after analysis and validation and be opened to public via the web site.

3.10. Preliminary studies to elucidate effects of iron supply on seasonal variations of cryptophytes in the northwestern Pacific

Mitsuhide SATO (University of Tokyo)
Takuma SUZUKI (University of Tokyo)
Shigenobu TAKEDA (Nagasaki University)
Ken FURUYA (University of Tokyo)

(1) Objective

Iron deficiency is considered to be a primary factor that limits primary productivity in the surface water of the subarctic Pacific and causes high concentrations of residual silicic acid and nitrate there. Three *in situ* mesoscale iron enrichment experiments have been conducted in the subarctic Pacific, all of which resulted in increase of primary production and surface chlorophyll *a* concentration, strongly demonstrating iron limitation in this area. In the three experiments, microorganisms that responded to the iron infusion most strikingly were diatoms. However, in SEEDS II, the last experiment conducted in the western subarctic Pacific in 2004, cryptophytes also increased their abundance in response to the iron infusion, and remained abundant after the surface iron concentration decreased down to a pre-infusion level. This observation suggests that cryptophytes are a key component when considering the community response to iron supply to this area. However, there is a very limited data on their distribution, annual fluctuation, taxonomy and physiology. Thus the present study aimed at collecting data to elucidate a contribution of cryptophytes to annual changes of primary production and algal biomass.

On the contrary to the subarctic Pacific, the southern area of Japan is considered to show less evident annual changes in primary production and algal biomass, which is probably dominated by pico-sized cyanobacteria. However, there is very limited data on phytoplankton composition, including that on cryptophytes. We consider this area a reference sampling point to the subarctic area.

(2) Methods

(2)-1 Seawater sampling

Seawater samples were collected from 11 or 15 discrete depths down to 200 m using 12-L Niskin bottles at all the stations surveyed. Surface seawater samples were also collected by a direct tow of a plastic bucket. For sample collection of nitrogen

(2)-2 Sample treatment

Flow cytometry (FCM): Samples were collected into 125-mL brown polyethylene bottles. Then 4 ml of aliquots were dispensed into cryogenic vials, fixed with 20% glutaraldehyde at a final concentration of 1%, and snap frozen in liquid nitrogen. All the samples were stored at −80 °C.

Algal pigment: Samples were collected into 2-L brown polyethylene bottles. Two litters of seawater from each bottle was filtered onto a GF/F filter. All the filters were snap frozen in liquid nitrogen and stored at −80 °C for analysis using HPLC on land.

Microscopy: From FCM sampling bottles of 10 and 100 m, 100-mL were dispensed into other black polyethylene bottles and fixed with 20% glutaraldehyde at a final concentration of 1%. They were store in a refrigerator for microscopy by a scanning electric microscope. From the same depths, 500 mL of seawater was also collected into 500-mL black polyethylene bottles. They were fixed with 5 mL of acid Lugol's solution for observation using a light microscope.

Nitrogen fixer biomass: Five hundred milliliters of seawater was collected from 6 depths on the basis of relative irradiance (100, 50, 25, 10 and 5% of surface). They were filtered onto 0.2-µm polycarbonate filters. They were stored at −80 °C. In the land laboratory, DNA encoding *nifH* proteins (key proteins in nitrogen fixation reactions) will be extracted from these samples, amplified by PCR, and quantified.

(2)-3 Sample analyses

All analyses will be performed on land.

3.11. Dissolved Organic Carbon

Masahide WAKITA (Mutsu Institute for Oceanography, JAMSTEC)

(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 distribution of DOC during autumn in the northwestern North Pacific Ocean.

(2) Sampling

Seawater samples were collected at stations K2 (Cast 5, 7 and 8) and S1 (Cast 2, 7 and 13) and brought the total to ~200. Δ^{14}C of DOC and DIC are also sampled to estimate the ^{14}C-age of DOC at stations K2 (Cast 5) and S1 (Cast 7). Seawater from each Niskin bottle was transferred into 60 ml High Density Polyethylene bottle (HDPE) (for DOC) or 1000 ml Duran glass bottle (forΔ^{14}C of DOC) rinsed with same water three times. Water taken from the surface to 250 m is filtered using precombusted (450°C) GF/F inline filters as they are being collected from the Niskin bottle. At depths > 250 m, the samples are collected without filtration. After collection, samples are frozen upright and preserved at ~ -20 °C cold until analysis in our land laboratory. Before use, all glassware was muffled at 550 °C for 5 hrs.

(3) Analysis

Prior to analysis, samples are returned to room temperature and acidified to pH < 2 with concentrated hydrochloric acid. 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.

3.12. Chloroflurocarbons

Masahide Wakita (JAMSTEC MIO)
Ken'ichi Sasaki (JAMSTEC MIO)

(1) Objective

Chlorofluorocarbons (CFCs) are chemically and biologically stable gases that have been synthesized at 1930's or later. The atmospheric CFCs can slightly dissolve in sea surface water by air-sea gas exchange and then are spread into the ocean interior. Three chemical species of CFCs, CFC-11 (CCl_3F), CFC-12 (CCl_2F_2), and CFC-113 ($C_2Cl_3F_3$), can be used as transient chemical tracers for the ocean circulation on timescale of several decades. We measured concentrations of these compounds in seawater.

(2) Apparatus

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

Table 3-14-1 Instruments

Gas Chromatograph:	GC-14B (Shimadzu Ltd.)
Detector:	ECD-14 (Shimadzu Ltd)
Analytical Column:	
Pre-column:	Silica Plot capillary column [i.d.: 0.53mm, length: 8 m, film thickness: 0.25µm]
Main column:	Connected two capillary columns (Pola Bond-Q [i.d.: 0.53mm, length: 9 m, film thickness: 6.0µm] followed by Silica Plot [i. d.: 0.53mm, length: 14 m, film thickness: 0.25µm])
Purging & trapping:	Developed in JAMSTEC. Cold trap columns are 1/16" SUS tubing packed with Porapak T.

(3) Procedures

3-1 Sampling

Seawater sub-samples for CFC measurements were collected from 12 litter Niskin bottles to 300 ml glass bottles at stations K2 (Cast 7) and S1 (Cast 13) and brought the total to ~75. The bottles were filled by nitrogen gas before sampling. Three times of the bottle volumes of seawater sample were overflowed. The bottles filled by seawater sample were kept in water bathes controlled at 5°C until analysis in our land-based laboratory. The CFCs concentrations were determined as soon as possible after this cruise.

In order to confirm CFC concentrations of standard gases and their stabilities, CFC mixing ratios in air were also analyzed. Air samples were collected into a 200ml glass cylinder at outside of our laboratory.

3-2 Analysis

The analytical system is modified from the original design of Bullister and Weiss (1988). Constant volume of sample water (50ml) is taken into a sample loop. The sample is send into stripping chamber and dissolved CFCs are de-gassed by N_2 gas purging for 8 minutes. The gas sample is dried by magnesium perchlorate desiccant and concentrated on a trap column cooled down to -50 °C. Stripping efficiencies of CFCs are confirmed by re-stripping of surface layer samples and more than 99.5 % of dissolved CFCs are extracted on the first purge. Following purging & trapping, the trap column is isolated and electrically heated to 140 °C. CFCs are desorbing by electrically heating the trap column, and lead into the pre-column. CFCs are roughly separated from other compounds in the pre-column and are sent to main analytical column. And then the pre-column is switched to another line and flushed by counter flow of pure nitrogen gas. CFCs sent into main column are separated further and detected by an electron capture detector (ECD). Nitrogen gases used in this system was filtered by gas purifier tube packed Molecular Sieve 13X (MS-13X).

Table 3-14-2 Analytical conditions of dissolved CFCs in seawater.

Temperature	
Analytical Column:	95 °C
Detector (ECD):	240°C
Trap column:	-50 °C (at adsorbing) & 140 °C (at desorbing)
Mass flow rate of nitrogen gas (99.99995%)	
Carrier gas:	15 ml/min
Detector make-up gas:	22 ml/min
Back flush gas:	20 ml/min
Sample purge gas:	130 ml/min
Standard gas (Japan Fine Products co. ltd.)	
Base gas:	Nitrogen

CFC-11:	300 ppt (v/v)
CFC-12:	160 ppt (v/v)
CFC-113:	30 ppt (v/v)

(4) Preliminary result

The distributions of CFCs will be determined as soon as possible after this cruise. The standard gases used in this analysis will be calibrated with respect to SIO scale standard gases and then the data will be corrected.

(5) Data archive

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

(6) 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.

3.13. pCO_2 sensor drifting buoy system

Shuichi Watanabe, Tetsuichi Fujiki (JAMSTEC)

(1) Objective

We have been developing *in situ* drifting system for pCO_2 measurement using spectrophotometric technique. We aim at testing the new CO_2 sensors on comparing between CO_2 sensor data and Mirai automated underway pCO_2 analyzing system data during MR10-01 cruise.

(2) Method

The pCO_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) as an equilibrium membrane because this material is well suited to pCO_2 measurements due to its high gas permeability. This measuring system was constructed from LED light source, optical fiber, CCD detector, micro pump, and downsized PC. The new simple system is attached in aluminum drifting buoy with satellite communication system, which size is about 340 mm diameter and 500 mm length and weight is about 15 kg (Fig. 3.13-1). In the laboratory experiment, we obtained high response time (less than 10 minutes) and precision within 3 µatm.

The buoy was fixed in a 10L bucket next to equilibrator of Mirai pCO_2 system and surface seawater (same faucet as Mirai pCO_2 system) flow into the bucket at a rate of 15 L/min (Fig. 3.13-2).

(3) Preliminary results

The pCO_2 in the sea surface were measured continuously (every 1min) during the cruise. We are checking the obtained pCO_2 data from the sensor.

(4) Data Archive

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

Reference

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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.

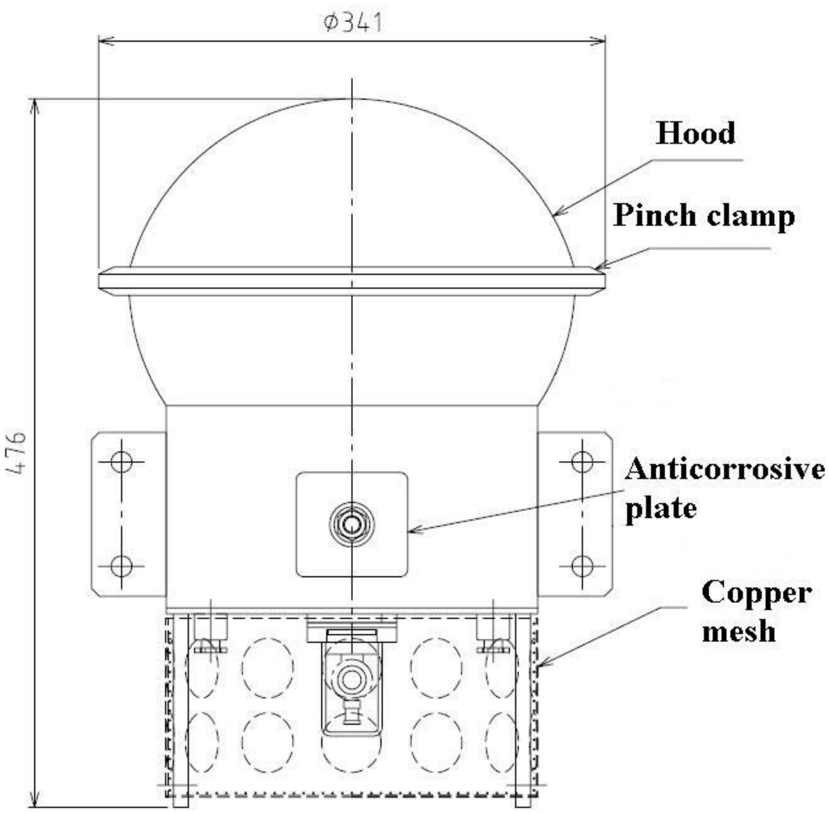

Fig. 3.13-1 Side view of pCO_2 sensor drifting buoy system.

Fig. 3.13-2 pCO_2 inter comparison at Mirai. The acrylic tower (left side) is equilibrator of Mirai pCO_2 system.

3.14. Continuous measurements of dissolved oxygen/argon and nitrogen/argon ratios

Hiroaki YAMAGISHI (NIES, Atmos. Env. Division)
Nicolas CASSAR (Duke Univ., Nicholas School)
Bruce A. BARNETT (Princeton Univ., Geosciences)
Rachel H. R. STANLEY (NOAA, WHOI)
Yasunori TOHJIMA (NIES, Atmos. Env. Division)
Hitoshi MUKAI (NIES, CGER)
Vinu K. VALSALA (NIES, CGER)
Yukio TERAO (NIES, CGER)

(1) Objectives

O_2/Ar ratio of the surface water has been analyzed to estimate net community productivity in the mixed layer [*Craig and Hayward*, 1987; *Hendricks et al.*, 2004; *Spitzer and Jenkins*, 1989]. Continuous measurements have been conducted after membrane inlet mass spectrometry (MIMS) has been developed by *Kaiser et al.* [2005] and *Tortell* [2005]. Recently, equilibrator inlet mass spectrometry (EIMS) has been developed by *Cassar et al.,* [2009]. EIMS is more simple and robust rather than MIMS.

N_2/Ar ratio can be applied to estimate contribution of small bubbles and large bubbles to gas exchange rate by analyzing it with concentration of a noble gas such as neon [*Hamme and Emerson*, 2006]. Small bubbles mean the bubbles that are dissolved completely after injected into the water, and large bubbles mean the bubbles that are partially dissolved and go back to the atmosphere. Contribution of small bubbles to the bubble-mediated gas exchange was estimated to be more than 95% at Bermuda Atlantic Time series Study site (BATS) (31°40’N 64°10’W) [*Stanley et al.*, 2009], but about 50-67% at Station ALOHA (22°45'N, 158°00'W) [*Hamme and Emerson*, 2006]. Contribution of these bubbles might be changed due to conditions of surface waters, such as property of surfactants and dissolved organic carbons, wave height, and white cap coverage, as well as wind speed. It is essential to parameterize bubble-mediated gas exchange to estimate oxygen flux especially in winter time [*Stanley et al.,* 2009].

Subarctic western North Pacific is one of the regions with high positive flux of oxygen (positive direction is from air to sea) and sea surface becomes rough due to strong wind. Station K2 (47°00’N, 160°00’E) has good properties to analyze contribution of bubbles to gas exchange. Parameters of bubble-mediated gas exchange estimated in this region will be useful to analyze interannual and synoptic scale variabilities of atmospheric O_2/N_2 ratio monitored at Cape Ochi-ishi (43°09’N, 145°30’E) [*Tohjima et al.,* 2008; *Yamagishi et al.,* 2008].

Although there are several reports about continuous measurements of O_2/Ar ratio, measuring N_2/Ar ratio has not been established yet by these studies. Here we have modified EIMS to measure N_2/Ar ratio and deployed it on R/V Mirai to measure dissolved O_2/Ar ratio and N_2/Ar ratio of the surface water continuously.

(2) Methods and Apparatus

Sea water at the depth of ~4 m is pumped at the front of the ship and delivered to the sea surface water monitoring laboratory, where EIMS was set, and also other laboratories. Sea water at the flow of 3.5L/min was supplied to the tab for EIMS. Sea water was flown out from a 2L - internal tab and 125mL/min of water was sampled from the bottom of the tab and then introduced into a porous membrane filter cartridge. The cartridge was put into a ~10L outer tab to keep its temperature at that of surface water. Gas phase in a cartridge was equilibrated with water sample at the temperature of water in an outer tab. Then small amount of gas sample is introduced into a quadrupole mass spectrometer. Ion currents of m/z 18, 28, 32, 40, and 44 and also pressure in the mass spectrometer were monitored. Air dried at the temperature of -70 °C was also introduced into the mass spectrometer every 2.5 hours. Once a day, mass scale calibration and offset determination were executed. Ion current ratio of N_2/Ar changes due to pressure change in the mass spectrometer. This effect was corrected by equations that were determined by pressure change experiments conducted once in every day. Low and high span gases for N_2/Ar ratio were measured after pressure experiments.

Oxygen concentration in the inner tab, where sample water was collected, was measured at some stations by using Winkler titration by technicians of Marine Works Japan Ltd. Consumption of O_2 between the intake and the tab will be evaluated by comparing O_2 concentration in the tab, and Niskin bottles or bucket sampling to correct O_2/Ar ratio.

(3) Preliminary results

Ratios of O_2/Ar and N_2/Ar were measured continuously both in Leg-1 and Leg-2. Figure 1 shows preliminary result from J-KEO (38°05'N, 146°25'E) to station S1 (30°00'N, 145°00'E) of Leg-1. Here $\Delta(O_2/Ar)$ and $\Delta(N_2/Ar)$ are percent deviations from the mixing ratios at equilibrium:

$$\Delta(O_2/Ar) = \{(O_2/Ar)_{sample} / (O_2/Ar)_{equilibrium} - 1\}\times 100 \quad (\%)$$

$$\Delta(N_2/Ar) = \{(N_2/Ar)_{sample} / (N_2/Ar)_{equilibrium} - 1\}\times 100 \quad (\%)$$

O_2/Ar ratio has not been corrected for O_2 consumption in a sampling line. N_2/Ar and O_2/Ar ratios of sea water were computed using tentative composition ratios of span gasses. Final results will be recalculated after N_2/Ar and O_2/Ar ratios of span gases are calibrated with gravimetric standard gases prepared following *Tohjima et al.* [2005].

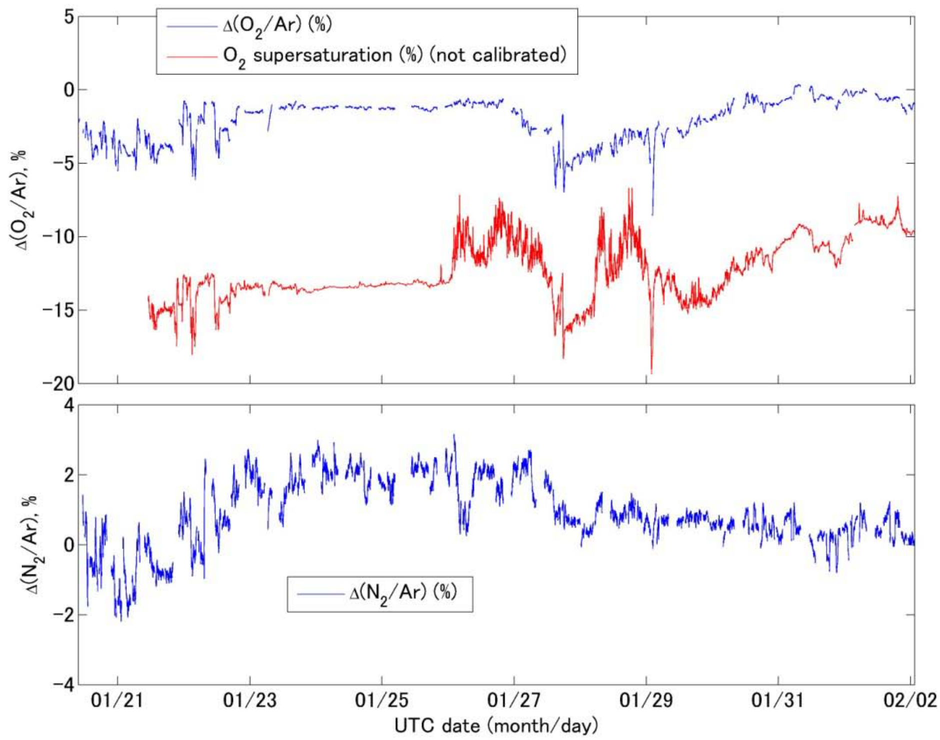

Fig.1 Preliminary results of O_2/Ar and N_2/Ar ratios measured by equilibrator inlet mass spectrometry and O_2 supersaturation measured by an oxygen sensor, Optode (not calibrated). The ship visited each station as following schedule: 1/21, J-KEO (38°5'N, 146°25'E); 1/22, KNOT (44°00'N 155°00'E); 1/24-26, K2 (47°00'N, 160°00'E); 1/31-2/2, S1 (30°00'N, 145°00'E).

(4) Data Archive

Method paper will be submitted to an appropriate journal. *Hiroaki Yamagishi* will take responsibility of the quality of the final data and will submit the data to the database of JAMSTEC/Data Integration and Analyses Group (DIAG) ~two years after the cruise.

(5) References

Cassar, N., B. A. Barnett, M. L. Bender, J. Kaiser, R. C. Hamme, and B. Tilbrook (2009), Continuous high-frequency dissolved O_2/Ar measurements by equilibrator inlet mass spectrometry, *Anal. Chem.*, *81*(5), 1855-1864, doi: 10.1021/Ac802300U.

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Hamme, R. C., and S. R. Emerson (2006), Constraining bubble dynamics and mixing with dissolved gases: Implications for productivity measurements by oxygen mass balance, *Journal of Marine Research*, *64*(1), 73-95.

Hendricks, M. B., M. L. Bender, and B. A. Barnett (2004), Net and gross O_2 production in the Southern Ocean from measurements of biological O_2 saturation and its triple isotope composition, *Deep-Sea Res. Part I-Oceanogr. Res. Pap.*, *51*(11), 1541-1561, doi: 10.1016/J.Dsr.2004.06.006.

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Spitzer, W. S., and W. J. Jenkins (1989), Rates of vertical mixing, gas-exchange and new production - Estimates from seasonal gas cycles in the upper ocean near Bermuda, *Journal of Marine Research*, *47*(1), 169-196.

Stanley, R. H. R., W. J. Jenkins, D. E. Lott, and S. C. Doney (2009), Noble gas constraints on air-sea gas exchange and bubble fluxes, *J. Geophys. Res.-Oceans*, *114*, C11020, doi: 10.1029/2009Jc005396.

Tohjima, Y., T. Machida, T. Watai, I. Akama, T. Amari, and Y. Moriwaki (2005), Preparation of gravimetric standards for measurements of atmospheric oxygen and reevaluation of atmospheric oxygen concentration, *J. Geophys. Res.-Atmos.*, *110*, D11302, doi: 10.1029/2004JD005595.

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Tortell, P. D. (2005), Dissolved gas measurements in oceanic waters made by membrane inlet mass spectrometry, *Limnology and Oceanography-Methods*, *3*, 24-37.

Yamagishi, H., Y. Tohjima, H. Mukai, and K. Sasaoka (2008), Detection of regional scale sea-to-air oxygen emission related to spring bloom near Japan by using in-situ measurements of the atmospheric oxygen/nitrogen ratio, *Atmos. Chem. Phys.*, *8*(12), 3325-3335.

3.15. Argo float

(1) Personnel

Toshio Suga	*(JAMSTEC/RIGC): Principal Investigator (not on board)*
Shigeki Hosoda	*(JAMSTEC/RIGC): not on board*
Kanako Sato	*(JAMSTEC/RIGC): not on board*
Mizue Hirano	*(JAMSTEC/RIGC): not on board*
Kenichi Katayama	*(MWJ): Technical Staff (Operation Leader Leg.1)*
Hiroki Ushiromura	*(MWJ): Technical Staff*
Shinsuke Toyoda	*(MWJ): Technical Staff (Operation Leader Leg.2)*
Akira Watanabe	*(MWJ): Technical Staff*

(2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the North Pacific such as North Pacific Central Mode Water.

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

Moreover, we launched another type of float in order to understand the formation mechanism of North Pacific Subtropical Mode Water. Two floats of this type are launched in the North Pacific subtropical region, and these measure vertical profiles of temperature and salinity automatically every five days.

(3) Parameters

・water temperature, salinity, and pressure

(4) Methods

i. Profiling float deployment

We launched an APEX float manufactured by Webb Research Ltd. These floats equip an SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc.

The floats usually drift at a depth of 1000 dbar (called the parking depth), diving to a depth of 2000 dbar and rising up to the sea surface by decreasing and increasing their volume and thus changing the buoyancy in ten-day cycles. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately nine hours, transmitting the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The status of floats and their launches are shown in Table 4.1.1.

Table 4.1.1 Status of floats and their launches
Float (2000dbar)

Float Type	**APEX floats manufactured by Webb Research Ltd.**
CTD sensor	**SBE41 manufactured by Sea-Bird Electronics Inc.**
Cycle	**10 or 5 days (approximately 10 hours at the sea surface)**
ARGOS transmit interval	**30 sec**
Target Parking Pressure	**1000 dbar**

Sampling layers	**115 (2000,1950,1900,1850,1800,1750,1700,1650,1600,1550,1500,1450,1400,1350,1300,1250,1200,1150,1100,1050,1000,980,960,940,920,900,880,860,840,820,800,780,760,740,720,700,680,660,640,620,600,580,560,540,520,500,490,480,470,460,450,440,430,420,410,400,390,380,370,360,350,340,330,320,310,300,290,280,270,260,250,240,230,220,210,200,195,190,185,180,175,170,165,160,155,150,145,140,135,130,125,120,115,110,105,100,95,90,85,80,75,70,65,60,55,50,45,40,35,30,25,20,15,10,4 or surf, dbar)**

Launches

Float S/N	ARGOS ID	Date and Time of Reset (UTC)	Date and Time of Launch(UTC)	Location of Launch	CTD St. No.	Observation Cycle
3874	80651	2010/02/03 21:23	2010/02/03 21：54	29° 59.82 [N] 145° 00.14[E]	S1	5days
4041	86509	2010/02/04 06:48	2010/02/04 07：35	31° 00.01 [N] 144° 44.73[E]		5days
3548	76303	2010/02/11 16:34	2010/02/11 17：42	34° 00.03 [N] 148° 31.82[E]		10days
3872	80649	2010/02/13 03:16	2010/02/13 04：10	40° 12.01 [N] 153° 59.93[E]		10days

(5) Results

The vertical profiles of temperature measured at 31.019N, 144.661E on February 5, 2010 and at 31.496N, 144.784E on March 2, 2010 are shown in Fig. 3-17-1. According to season progress, temperature near surface got cold and mixed layer got deep up to 240 dbar. The formation are of North Pacific Subtropical Mode Water is near the area measured by floats. If the floats keep measuring steadily, the measurement of the launched floats can capture the feature of mode water formation.

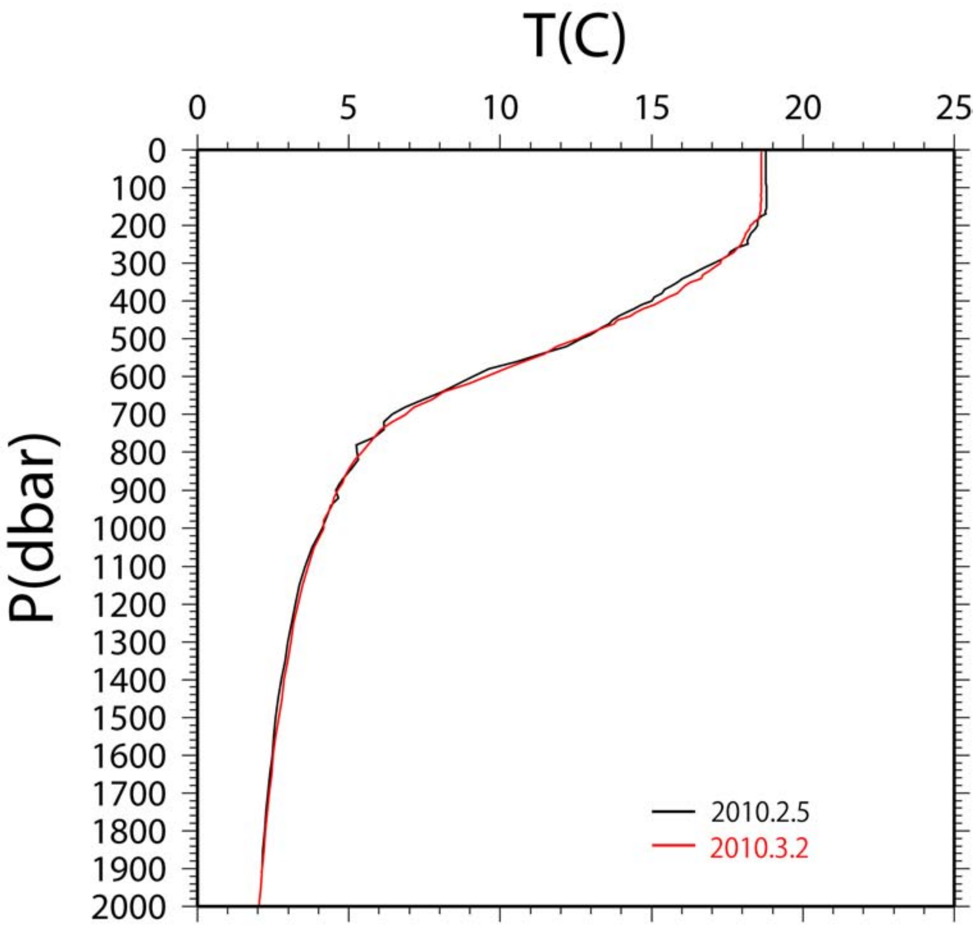

Fig. 3-17-1 Vertical profiles of temperature measured at 31.019N, 144.661E on February 5 (black), 2010 and at 31.496N, 144.784E on March 2, 2010 (red).

(6) Data archive

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

4. Geophysical observation
4.1. Swath Bathymetry

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus) : Principal Investigator（not on-board）
Masao Nakanishi (Chiba University) : Principal Investigator（not on-board）
Katsuhisa Maeno (Global Ocean Development Inc.: GODI)
Norio Nagahama (GODI)
Wataru Tokunaga (Mirai Crew)

(2) Introduction

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.), add system Sub-Bottom Profiler (SBP). The objective of MBES is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

In addition, we surveyed and collected data at the Station K2 and Station S1 with SBP (see; 3.10). And we need to estimate the depth at the location of deployment of BGC buoy in order to design these mooring systems.

(3) Data Acquisition

The "SEABEAM 2100" on R/V MIRAI was used for bathymetry mapping during the MR10-01 cruise from 20 January to 24 February 2010.

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

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

Table 4.1-1 System configuration and performance

SEABEAM 2112.004 (12 kHz 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)

Sub-Bottom Profiler (4kHz system)

Frequency:	4 kHz
Transmit beam width:	5 degree
Sweep:	5 to 100 msec
Depth Penetration:	As much as 75 m (varies with bottom composition)
Resolution of sediments:	Under most condition within < tens-of-centimeters range (dependent upon depth and sediment type)

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

Bathymetric data obtained during this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC, and will be archived there.

(6) Remark

4.2. Sea surface gravity

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus) : Principal Investigator(not on-board)
Masao Nakanishi (Chiba University) :Principal Investigator(not on-board)
Katsuhisa Maeno (Global Ocean Development Inc.: GODI)
Norio Nagahama (GODI)
Wataru Tokunaga (Mirai Crew)
:

(2) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface.

(3) Parameters

Relative Gravity [CU: Counter Unit]
[mGal] = (coef1: 0.9946) * [CU]

(4) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during the MR10-01 cruise from 20 January 2010 to 24 February 2010.

To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-3M), at Sekinehama as the reference points.

(5) Preliminary Results

Absolute gravity shown in Tabel 4.2-1

Table 4.2-1

No.	Date	U.T.C.	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *1 [mGal]	L&R *2 Gravity [mGal]
#1	18 Jan.	06:12	sekinehama	980371.94	229	635	980372.69	12637.65
#2	24 Jan.	--:--	sekinehama	------------	----	-----	-----------	-----------

*1: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431
*2: LaCoste and Romberg air-sea gravity meter S-116

(6) Data Archives

Surface gravity data obtained during this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC, and will be archived there.

(7) Remark

4.3. Sea Surface three-component magnetic field

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus) : Principal Investigator（not on-board）
Masao Nakanishi (Chiba University) : Principal Investigator（not on-board）
Katsuhisa Maeno (Global Ocean Development Inc.: GODI)
Norio Nagahama (GODI)
Wataru Tokunaga (Mirai Crew)

(2) Introduction

Measurements of magnetic force on the sea are 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 MR10-01 cruise from 20 January 2010 to 24 February 2010.

(3) Principle of ship-board geomagnetic vector measurement

The relation between a magnetic-field vector observed on-board, **H**ob, (in the ship's fixed coordinate system) and the geomagnetic field vector, **F**, (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}\mathrm{ob} = \mathbf{A}\,\mathbf{R}\,\mathbf{P}\,\mathbf{Y}\,\mathbf{F} + \mathbf{H}\mathrm{p} \qquad \text{(a)}$$

where **R**, **R** and **Y** are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\tilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and **H**p is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (a) makes

$$\mathbf{B}\,\mathbf{H}\mathrm{ob} + \mathbf{H}\mathrm{bp} = \mathbf{R}\,\mathbf{P}\,\mathbf{Y}\,\mathbf{F} \qquad \text{(b)}$$

where $\mathbf{B} = \mathbf{A}^{-1}$, and $\mathbf{H}\mathrm{bp} = -\mathbf{B}\,\mathbf{H}\mathrm{p}$. The magnetic field, **F**, can be obtained by measuring **R**, **P**, **Y** and **H**ob, if **B** and **H**bp are known. Twelve constants in **B** and **H**bp can be determined by measuring variation of **H**ob with **R**, **P** and **Y** at a place where the geomagnetic field, **F**, is known.

(4) Instruments on *R/V MIRAI*

A shipboard three-component magnetometer system (Tierra Technica SFG1214) is equipped on-board *R/V MIRAI*. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs of the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch, and roll are measured utilizing a ring-laser gyro installed for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

(5) Data Archives

Magnetic force data obtained during this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC, and will be archived there.

(6) Remarks

1. For calibration of the ship’s magnetic effect, we made a “Figure eight” turn (a pair of clockwise and anti-clockwise rotation). The periods were follows;
   i) 09:22 - 09:43 UTC, 2 Feb. about at 30-03N, 144-56E
   ii) 22:51 - 23:19 UTC, 20 Feb. about at 40-27N, 144-21E

5. Satellite Image Acquisition (MCSST from NOAA/HRPT)

(1) Personnel

Kazuhiko Matsumoto (JAMSTEC): Principal Investigator
Katsuhisa Maeno (Global Ocean Development Inc.: GODI)
Norio Nagahama (GODI)
Wataru Tokunaga (Mirai Crew)

(2) 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 and to build a time and depth resolved primary productivity model.

(3) 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 MR10-01 cruise from 20 January 2010 to 24 February 2010.

The sea surface temperature data will be applied for the time and depth resolved primary productivity model to determine a temperature field for the model.

(4) Preliminary results

Fig.5-1 showed MCSST composite image during this cruise from 20 January 2010 to 24 February 2010 at the Northern-west Pacific Ocean.

(5) Data archives

The raw data obtained during this this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC, and will be archived there.

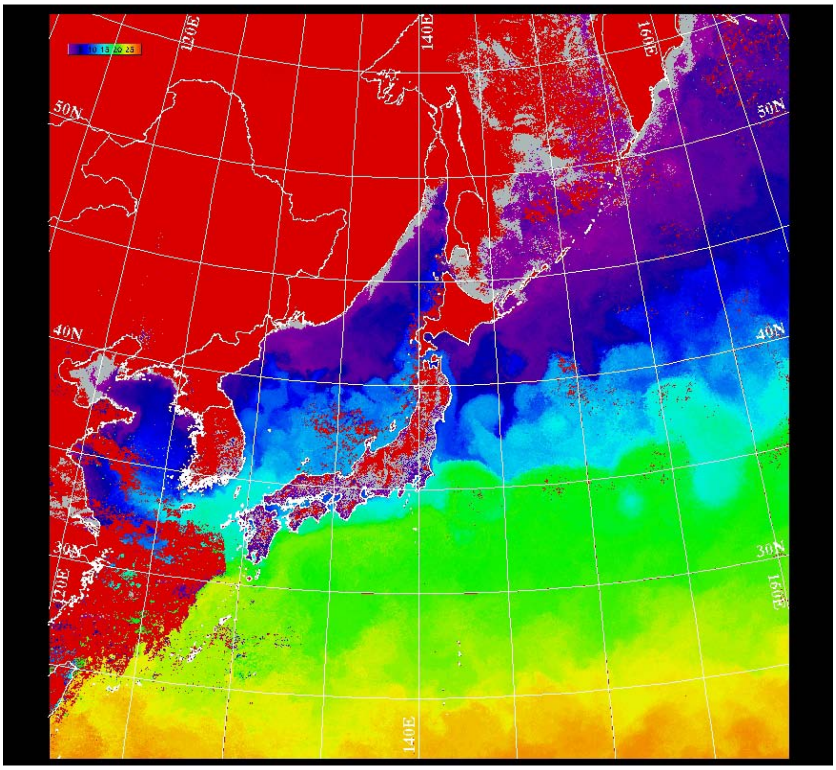

Fig.5-1　MCSST composite image at Northern-west Pacific Ocean.
from 20 January 2010 to 6 February 2010

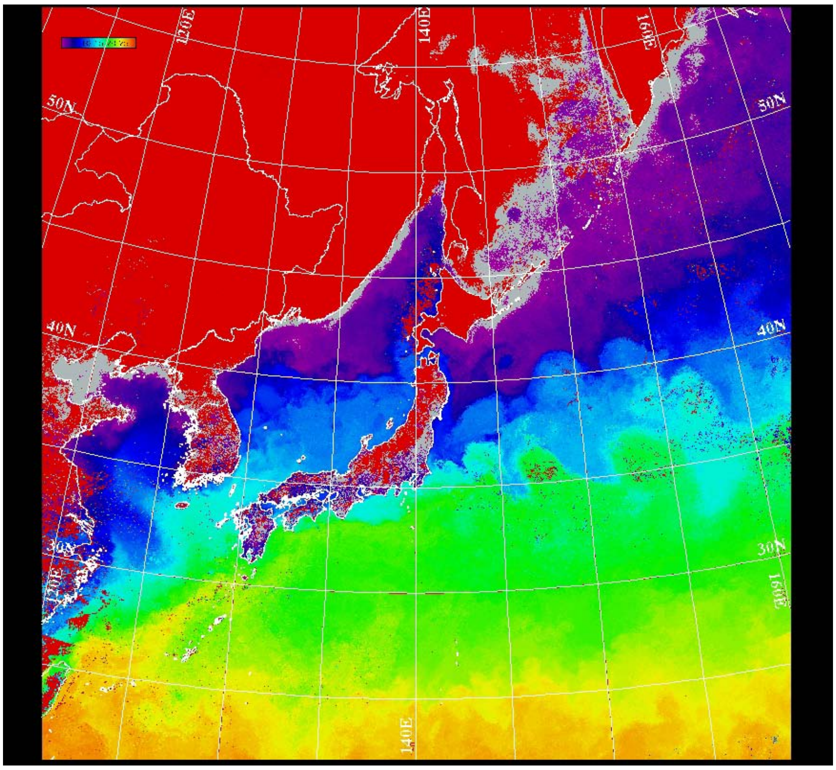

Fig.5-2　MCSST composite image at Northern-west Pacific Ocean.
from 7 February to 24 February 2010