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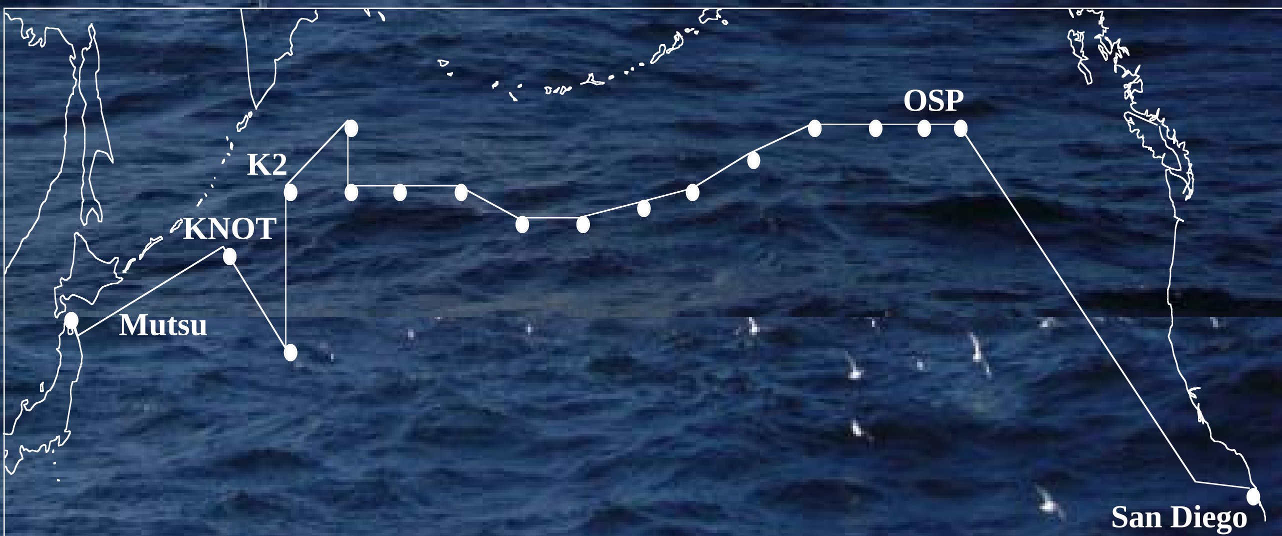
MR05-04

(13 Sep. - 27 Oct. 2005)

Preliminary Cruise Report



Dec. 2005

JAMSTEC

Contents of MR05-04 Preliminary Cruise Report

1. Outline of MR05-04
1.1 Cruise summary

Makio HONDA (JAMSTEC MIO)
Principal Investigator of MR05-04

This cruise was a long (45 days') cruise between 13 September and 27 October 2005, and started at Sekinehama, Mutsu and ended at San Diego in U.S.A. Principal missions were to recover and deploy time-series mooring systems and to compare oceanography between the western and eastern North Pacific. Although we were so exhausted, we felt satisfied to collect a plenty of oceanographic samples.

We successfully recovered a time-series mooring system for biogeochemistry (BGC mooring) at station K2. This mooring system was deployed in the last March during MR05-01 cruise. This was the first deployment after we lost a BGC mooring system in 2003. Although we certified renewed mooring system was too strong to be partitioned by two weeks deployment in the sea, all concerned have felt unease. However this mooring system was kept for approximately six months. Most of automatic sampling gears such as water sampler and sediment traps worked on schedule. Owing to that, time-series sample such as seawater and sinking particles from late winter to autumn, when biological activity changes drastically, were successfully collected. Especially sediment trap samples from 150 m and 500 m is useful for the study of materials' vertical flux in the mesopelagic layer or "twilight" zone. These samples will reveal precise mechanism of seasonal change in the biological pump.

Another mission was also accomplished. We conducted a transect observation from the northwestern North Pacific to eastern North Pacific. Along transect line in approximately 45 – 50 degree North, underway observation such as pCO_2 and total dissolved inorganic carbon and air sampling was conducted continuously. At 12 stations along transect, several hydrocastings were conducted and chemical and biological components such as nutrients, carbonate system, rare earth elements and pigments were measured. At 8 stations, we also deployed a drifter for 24 hours in order to conduct *in situ* incubation for measurement of primary productivity and to collect sinking particles, and deployed *in situ* pumping system (Large Volume Pump: LVP) to collect suspended particles for measurement of radionuclide (^{230}Th). Comprehensive observations at time-series stations in the western North Pacific (stations KNOT and K2) and in the eastern North Pacific (station OSP) are valuable for comparison of oceanography, especially biological pump between western and eastern gyres. In addition, we collected successfully sea-floor sediment by using piston corer at the Emperor seamount in the Western Subarctic Gyre and at the Cambella seamount in the Alaskan Gyre. Approximately 15 m and 13 m sea-floor sediment was obtained at the former and the later, respectively. These will reveal geological time-scale change in biological pump and difference between both areas. I would like to appreciate all efforts by ship's crews and marine technicians.

1.2 Track and log

1.2.1 Cruise track

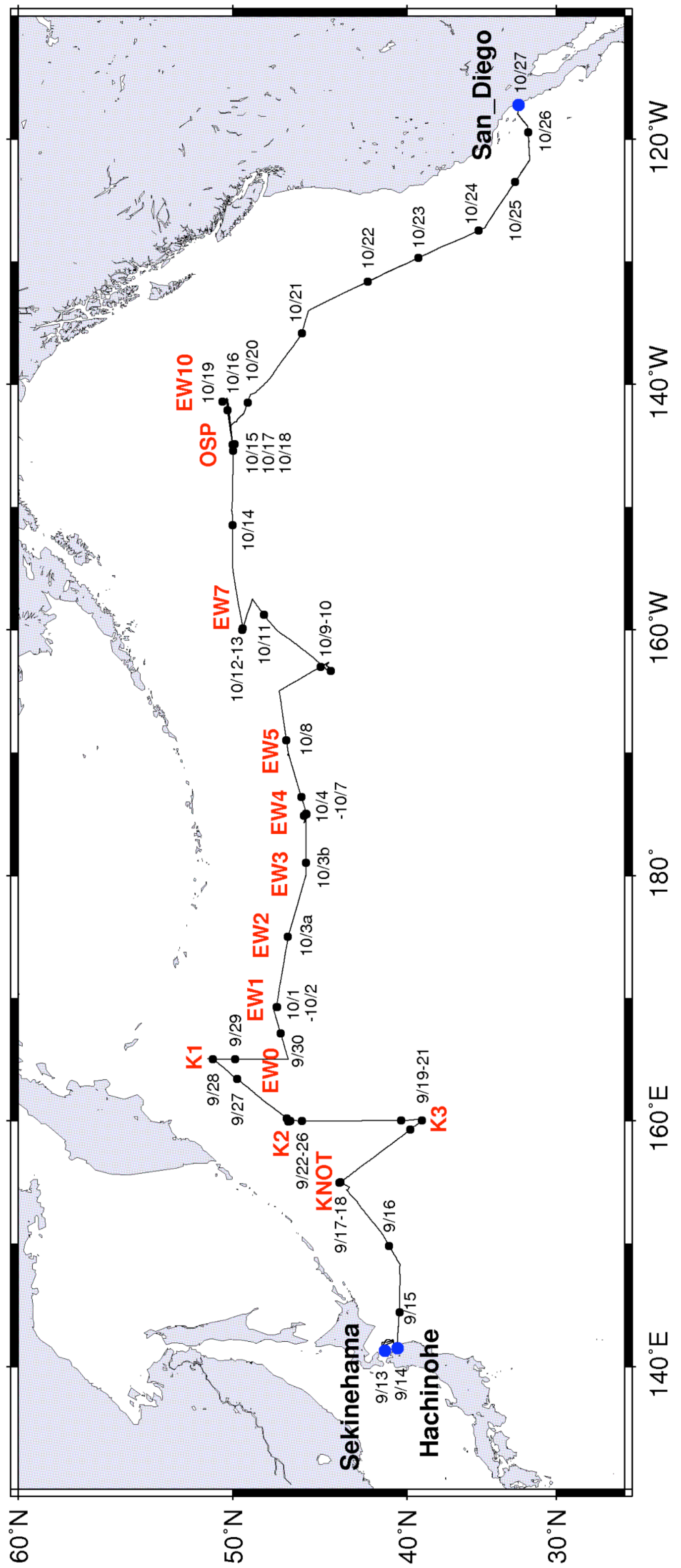


Figure 1.2.1-1. Noon Position

1.2.2 Cruise Log

S.M.T.		U.T.C.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
9/13	16:00	9/13	7:00	41-21.97N	141-14.38E	Departure of Sekinehama
9/14	8:40	9/13	23:40	40-33.28N	141-30.01E	Arrival at Hachinohe
9/14	16:00	9/14	7:00	40-33.28N	141-30.01E	Departure of Hachinohe
9/15	7:58	9/14	22:58	40-26.12N	144-24.50E	CTD cable Free Fall #1 (7,350m)
9/15	13:55	9/15	4:55	40-26.43N	144-24.38E	CTD cable Free Fall #2 (7,350m)
9/15	18:10	9/15	9:10	40-26.51N	144-25.11E	XBT launch
9/15	22:00	9/15	13:00	-	-	Time adjustment (+1hr)
9/16	12:40	9/16	2:40	40-56.35N	149-29.68E	Optical Profiler #1
9/16	22:00	9/15	12:00	-	-	Time adjustment (+1hr)
9/17	10:54	9/16	23:54	44-00N	155-00E	Arrived at Station KNOT
	10:57		23:57	43-59.95N	155-00.04E	CTD cast #1 (70m)
9/17	12:10	9/17	01:10	43-59.88N	154-59.95E	CTD cast #2 (300m)
	13:28		02:28	43-59.99N	154-59.95E	Drifting Sediment Trap #1 deployment (Buoy let it go)
	14:02		03:02	44-00.11N	154-92.92E	CTD cast #3 (5,300m)
9/18		9/17		44-03N	154-57E	Releaser Test (5,000m)
9/18	12:43	9/18	1:43	44-05.28N	154-55.63E	Optical Profiler #2
	13:56		2:56	44-04.66N	154-55.76E	Drifting Sediment Trap #1 recovery (Weight on deck)
	14:00		3:00			Departure of Station KNOT
9/19	12:50	9/19	1:50	39-36.75N	159-25.44E	Optical Profiler #3
9/19	18:00	9/19	7:00	39-00N	160-00E	Arrived at Station K3
9/20	4:28	9/19	17:28	39-00.10N	160-00.13E	CTD cast #4 (200m)
	6:34		19:34	39-00.98N	159-59.90E	Drifting Sediment Trap #2 deployment
	6:57		19:57	39-02.29N	159-59.88E	CTD cast #5 (5,492m)
9/20	12:40	9/20	1:40	39-02.47N	160-02.38E	Optical Profiler #4
	13:02		2:02	39-02.69N	160-02.89E	CTD cast #6
9/21	6:32	9/20	19:32	39-00.82N	160-07.41E	Drifting Sediment Trap #2 recovery

	6:36		19:36			Departure of Station K3
9/22	15:24	9/22	4:24	47-00N	160-00E	Arrived at Station K2
	15:28		4:28	46-57.85N	159-57.39E	CTD cast #7 (2,000m)
9/23	11:32	9/23	0:32	47-00.02N	159-55.84E	BGC mooring recovery (Releaser on deck)
	12:59		1:59	46-59.45N	159-56.71E	Optical Profiler #5
	14:40		3:40	47-00.56N	160-00.52E	In-situ Pumping #1 (2 hr)
9/24	13:13	9/24	2:13	46-52.01N	159-58.88E	PO mooring deployment (Sinker let it go)
	16:30		7:30	46-52.52N	160-01.69E	In-situ Pumping #2 (2 hr)

S.M.T.		U.T.C.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
9/25	4:28	9/24	17:28	47-00.46N	159-58.54E	CTD cast #8 (200m)
	6:24		19:24	47-06.76N	160-07.38E	Drifting Sediment Trap #3 deployment
9/25	7:58	9/24	20:58	47-05.84N	160-11.28E	CTD cast #9 (5,167m)
9/25	14:21	9/25	3:21	47-04.71N	160-09.14E	Additional GPS buoy deployment
	15:48		4:48	47-03.47N	160-12.71E	GPS buoy recovery
9/26	6:30	9/25	19:30	47-03.86N	160-10.93E	Drifting Sediment Trap #3 recovery
9/26	13:30	9/26	2:30	47-00.59N	159-58.65E	BGC mooring deployment (Sinker let it go)
	16:09		5:09	47-04.72N	160-11.99E	CTD cast #10 (300m)
	17:58		6:58	47-04.67N	160-12.06E	CTD cast #11 (50m)
	18:18		7:18			Departure of Station K2
9/27	12:45	9/27	1:45	49-52.09N	163-30.49E	Optical Profiler #6
9/28	21:00	9/27	10:00	51-00N	165-00E	Arrived at Station K1
	3:54		16:54	51-00.32N	164-59.69E	CTD cast #12 (200m)
	5:55		18:55	51-00.00N	165-00.44E	Drifting Sediment Trap #4 deployment
	6:07		19:07	51-00.04N	164-59.51E	CTD cast #13 (4,769m)
	10:15		23:15	51-02.13N	164-59.38E	In-situ Pumping #3 (1 hr)
9/28	12:43	9/28	1:43	51-00.13N	164-59.87E	Optical Profiler #7
	13:05		2:05	51-00.70N	164-59.57E	CTD cast #14 (300m)
9/29	6:05	9/28	19:05	51-17.60N	165-02.96E	Drifting Sediment Trap #4 recovery
	6:06		19:06			Departure of Station K1
9/29	19:00	9/29	8:00	-	-	Time adjustment (+1hr)
9/30	0:30	9/29	12:30	47-00N	165-00E	Arrived at Station EW0
	0:37		12:37	47-00.00N	164-59.96E	CTD cast #15 (300m)
	2:03		14:03	46-59.78N	164-59.78E	CTD cast #16 (5,850m)
	6:00		18:00			Departure of Station EW0
9/30	12:41	9/30	0:41	47-27.77N	167-20.65E	Optical Profiler #8

S.M.T. Date	S.M.T. Time	U.T.C. Date	U.T.C. Time	Position Lat.	Position Lon.	Events
9/30	17:30	9/30	5:30	47-00N	169-00E	Arrived at Station EW1
	17:30		5:30			Site Survey mapping (8hr)
10/1	4:28	9/30	16:28	47-38.91N	169-16.78E	CTD cast #17 (200m)
	6:19		18:19	47-38.65N	169-16.87E	Drifting Sediment Trap #5 deployment
	7:59		19:58	47-40.00N	169-15.83E	Multiple Corer penetrate #1 (2,240m)
	8:53		20:53	47-39.54N	169-15.62E	CTD cast #18 (2,190m)
10/1	12:46	10/1	0:46	47-38.72N	169-15.65E	Optical Profiler #9
	13:11		1:11	47-38.81N	169-15.66E	CTD cast #19 (200m)
	14:35		2:35	47-38.40N	169-15.52E	Piston Corer penetrate #1 (2,174m)
	17:30		5:30	47-38.46N	169-16.22E	In-situ Pumping #4 (1hr)
10/2	7:07	10/1	19:07	47-36.30N	169-19.31E	Drifting Sediment Trap #5 recovery
10/2	14:26	10/2	2:26	47-38.41N	169-165.49E	Piston Corer penetrate #2 (2,175m)
	15:30		3:30			Departure of Station EW1
10/3A	7:48	10/2	19:48	47-00N	175-00E	Arrived at Station EW2
	7:54		19:54	46-79.72N	174-59.93E	CTD cast #20 (300m)
	9:29		21:29	47-01.08N	174-58.61E	CTD cast #21 (5,621m)
10/3A	13:19	10/3	1:19	47-00.44N	174-59.70E	ARGO float deployment #1
	13:30		1:30			Departure of Station EW2
	20:39		8:39	46-30.07N	177-29.72E	ARGO float deployment #2
10/3B	4:30	10/3	16:30			Crossed Date line
10/3B	4:30	10/3	16:30	46-00N	180-00W	Arrived at Station EW3
	4:36		16:36	45-59.90N	179-59.57W	CTD cast #22 (300m)
	6:24		18:24	46-00.26N	179-58.51E	CTD cast #23 (3,000m)
	8:26		20:26	45-59.92N	179-59.36E	ARGO float deployment #3
	8:30		20:30			Departure of EW3
10/3B	12:49	10/4	0:49	45-59.66N	178-45.00W	ARGO float deployment #4
	17:18		5:18	45-59.95N	177-30.12W	ARGO float deployment #5
	21:45		9:45	45-59.73N	176-15.01W	ARGO float deployment #6
10/4	2:00	10/4	14:00	46-00N	175-00W	Arrived at Station EW4
	2:00		14:00			Site Survey mapping (4hr 40mn)

10/4	22:00	10/5	10:00	-	-	Time adjustment (+1hr)
10/5	8:26	10/5	19:26	45-58.85N	175-01.06W	CTD cast #24 (5,738m)
	12:43		23:43	45-58.70N	175-01.42W	Optical Profiler #10
10/5	13:57	10/6	0:57	46-00.19N	174-59.85W	CTD cast #25 (300m)
10/6	4:56	10/6	15:56	45-59.78N	175-00.01W	CTD cast #26 (200m)
	6:46		17:46	45-58.92N	175-02.45W	Drifting Sediment Trap #6 deployment
	9:54		20:54	46-00.00N	175-00.05W	Multiple Corer penetrate #2 (5,757m)
	12:43		23:43	46-00.31N	175-01.22W	Optical Profiler #11
10/6	13:40	10/7	0:40	46-00.72N	175-00.32W	In-situ Pumping #5 (1hr)
10/7	7:51	10/7	18:51	45-59.06N	174-57.03W	Drifting Sediment Trap #6 recovery
	7:55		18:55	45-59.15N	174-57.02W	ARGO float deployment #7
	8:00		19:00			Departure of Station EW4
10/7	15:28	10/8	2:28	46-29.97N	172-30.08W	ARGO float deployment #8
	22:48		9:48	47-00N	170-00W	Arrived at Station EW5
	22:55		9:55	46-59.86N	170-00.21W	CTD cast #27 (300m)
10/8	8:48	10/8	19:55	47-00.03N	169-59.90W	ARGO float deployment #9
	9:00		20:00			Departure of Station EW5

S.M.T.		U.T.C.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
10/8	16:27	10/9	3:27	47-15.03N	167-30.32W	ARGO float deployment #10
	23:48		10:48	47-29.93N	165-00.12W	ARGO float deployment #11
10/9	12:55	10/9	23:55	45-00.08N	162-54.27W	ARGO float deployment #12
	12:57		23:57	44-59.91N	162-54.15W	ARGO float deployment #13
10/10	19:10	10/11	6:10	45-24.32N	162-30.01W	ARGO float deployment #14
10/11	16:36	10/12	3:36	48-57.41N	157-30.00W	ARGO float deployment #15
10/12	8:00	10/12	19:00	49-30N	160-00W	Arrived at Station EW7
	9:25		20:25	49-29.80N	160-00.25W	CTD cast #28 (300m)
	10:40		21:40	49-29.92N	160-00.50W	Optical Profiler #12
	11:07		22:07	49-30.10N	160-00.78W	CTD cast #29 (200m)
10/12	13:21	10/13	0:21	49-30.78N	160-00.88W	Drifting Sediment Trap #7 deployment
	13:32		0:32	49-30.26N	160-01.11W	CTD cast #30 (4,974m)
	17:59		4:59	49-29.11N	159-58.09W	8noji kousou

10/13	9:30	10/13	20:30	49-29.73N	159-58.86W	In-situ Pumping #6 (1hr)
10/13	13:41	10/14	0:41	49-28.15N	159-53.42W	Drifting Sediment Trap #7 recovery
	13:45		0:45	49-28.03N	159-53.28W	ARGO float deployment #16
	14:00		1:00			Departure of Station EW7
10/13	22:00	10/14	9:00	-	-	Time adjustment (+1hr)
10/16	2:00	10/16	12:00	50-15N	140-00W	Arrived at Station EW10
	2:00		12:00			Site Survey mapping (4hr 50mn)
	7:00		17:00			Departure of Station EW10
10/17	3:00	10/17	13:00	50-00N	145-00W	Arrived at Station OSP
	9:00		19:00	49-57.37N	144-55.44W	In-situ Pumping #7 (1hr)
	10:24		20:24	49-56.70N	144-56.60W	Optical Profiler #13
	10:54		20:54	49-54.95N	144-56.90W	CTD cast #31 (200m)
	13:15		23:15	49-54.64N	144-53.22W	Drifting Sediment Trap #8 deployment
	13:28		23:28	49-54.08N	144-53.80W	CTD cast #32 (300m)
10/17	14:58	10/18	0:58	49-53.52N	144-54.08W	CTD cast #33 (300m)
10/18	6:00	10/18	16:00	49-55.99N	144-51.27W	In-situ Pumping #8 (5hr)
	11:28		21:28	50-00.13N	144-55.11W	Optical Profiler #14
	13:53		23:53	49-59.90N	144-55.11W	Drifting Sediment Trap #8 recovery
10/18	14:00	10/19	0:00			Departure of Station OSP

S.M.T.		U.T.C.		Position		Events
Date	Time	Date	Time	Lat.	Lon.	
10/18	22:30	10/19	8:30	50-15N	140-00W	Arrived at Station EW10
	22:30		8:30			Site Survey mapping (8hr 10mn)
10/19	9:46	10/19	19:46	50-31.88N	141-23.56W	Piston Corer penetrate #3 (3,413m)
	12:40		22:40			Site Survey mapping (0hr 20mn)
	13:00		23:00			Departure of Station EW10
10/20	22:00	10/21	8:00	-	-	Time adjustment (+1hr)
10/22	22:00	10/23	7:00	-	-	Time adjustment (+1hr)
10/24	22:00	10/25	6:00	-	-	Time adjustment (+1hr)
10/27	8:40	10/27	15:40	32-42.97N	117-10.54W	Arrived at San Diego

1.3 List of Cruise Participants

Name	Affiliation	Address	Tel Fax E-mail address
Makio HONDA (Principal Investigator)	Japan agency for Marine-Earth Science and Technology (JAMSTEC) Mutsu Institute for Oceanography (MIO)	2-15 Natsushima, Yokosuka, 237-0061, Japan	
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Ai YASUDA	MWJ	Same as above	
Takuhei SHIOZAKI	MWJ	Same as above	
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Junko	MWJ	Same as above	

HAMANAKA			
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Masanori ENOKI	MWJ	Same as above	
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Junji MATSUSHITA	MWJ	Same as above	
Yushuke SATO	MWJ	Same as above	
Kazuhiro YOSHIDA	MWJ	Same as above	
Yohei TAKETOMO	MWJ	Same as above	
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Kazuho YOSHIDA	GODI	Same as above	

2. General observation
2.1 Meteorological observations
2.1.1 Surface Meteorological Observation

Satoshi OKUMURA (Global Ocean Development Inc., GODI)
Kazuho YOSHIDA (GODI)
Kunio YONEYAMA (JAMSTEC) : Principal Investigator (Not on-board)

(1) Objectives

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

(2) Methods

The surface meteorological parameters were observed throughout the MR05-04 cruise from the departure of Sekinehama on 13 September 2005 to arrival of San Diego on 27 Octorber 2005. At this cruise, we used two systems for the surface meteorological observation.

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

1) MIRAI Surface Meteorological observation (SMet) system

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

2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

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

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

SCS recorded PRP data every 6 seconds, Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table2.1.1-3 and measured parameters are listed in Table 2.1.1-4.

We have carried out inspecting and comparing about following three kinds of sensors, before and after the cruise.

a) Young Rain gauge (SMet and SOAR)

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

b) Barometer (SMet and SOAR)

Comparing with the portable barometer value, PTB220CASE, VAISALA.

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

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

(4) Preliminary results

Figures 2.1.1-1 show the time series of the following parameters;
Wind (SOAR)
Air temperature (SOAR)
Relative humidity (SOAR)
Precipitation (SOAR)
Short/long wave radiation (SOAR)
Pressure (SOAR)
Sea surface temperature (EPCS)
Significant wave height (SMet)

(5) Data archives

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

(6) Remarks

1. SST (Sea Surface Temperature) data was valid from 7:45 14 September to 22:30 24 October.

2. 1) Following period, PRP (PSP, PIR, and FRSR) data was invalid or lacked due to sensor trouble (Time in UTC).

From 23:56:07, 14 Sep. to 01:13:09, 15 Sep.
From 10:14:00, 16 Sep. to 10:21:31, 16 Sep.
From 10:30:56, 16 Sep. to 10:50:27, 16 Sep.
From 10:51:46, 16 Sep. to 11:30:13, 16 Sep.
From 11:31:21, 16 Sep. to 12:32:48, 16 Sep.
From 09:25:55, 17 Sep. to 10:30:37, 17 Sep.
From 10:30:43, 17 Sep. to 05:42:38, 21 Sep.

2) PRP sensor was installed temporarily on the roof of the anti-rolling system on 21 September to 27 October.

3. Almost all period of this cruise Zeno ORG data includes some noise or error data due to sensor trouble.

4.SMet rain rate (capacitive rain gauge; 1hour accumulation) logged in doubled value due to wrong ROM settings. Note that a correction is needed when you use this data, divide by two.

Table 2.1.1-1 Instruments and installations of MIRAI Surface Meteorological 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	AP-370	Koshin Denki, Japan	captain deck (13 m) weather observation room
Capacitive 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-202	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table 2.1.1-2 Parameters of MIRAI Surface Meteorological observation system

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

Table 2.1.1-3 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 (24 m)
Barometer	61201	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (24 m)
Capacitive rain gauge	50202	R. M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-115DA	Osi, USA	foremast (24 m)

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

Table 2.1.1-4 Parameters of SOAR system

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

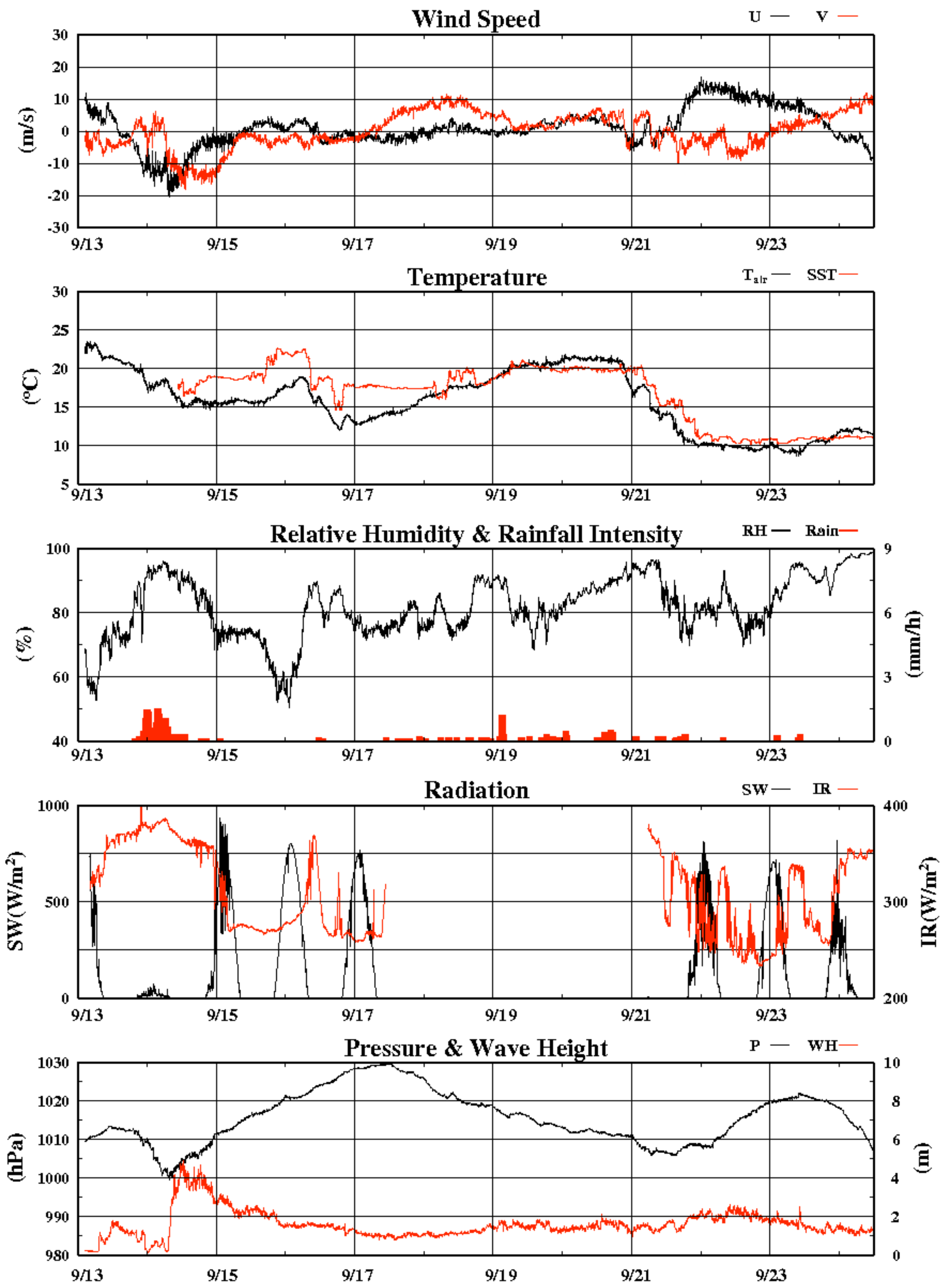
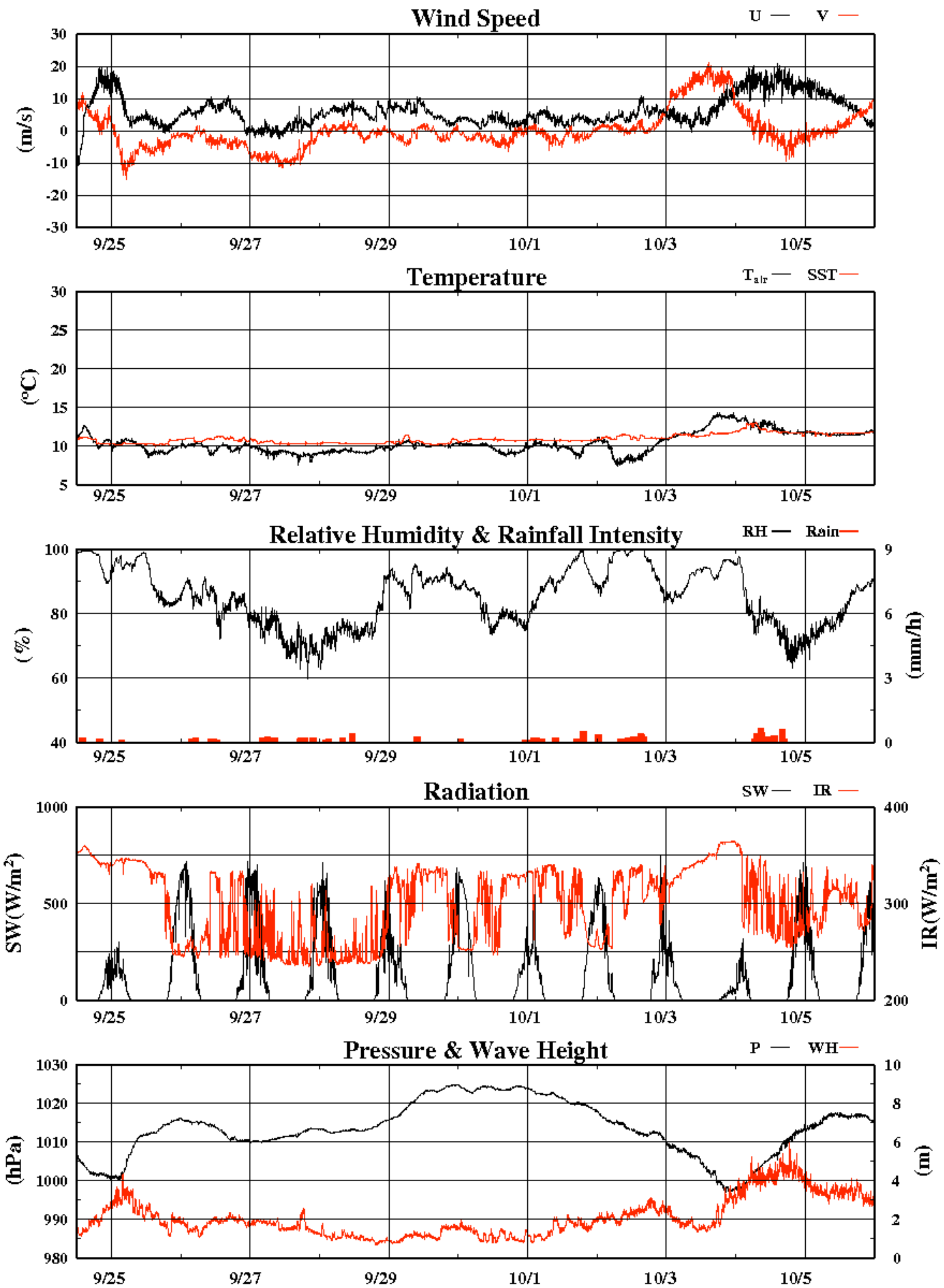


Fig.2.1.1-1 Time series of surface meteorological parameters during the cruise



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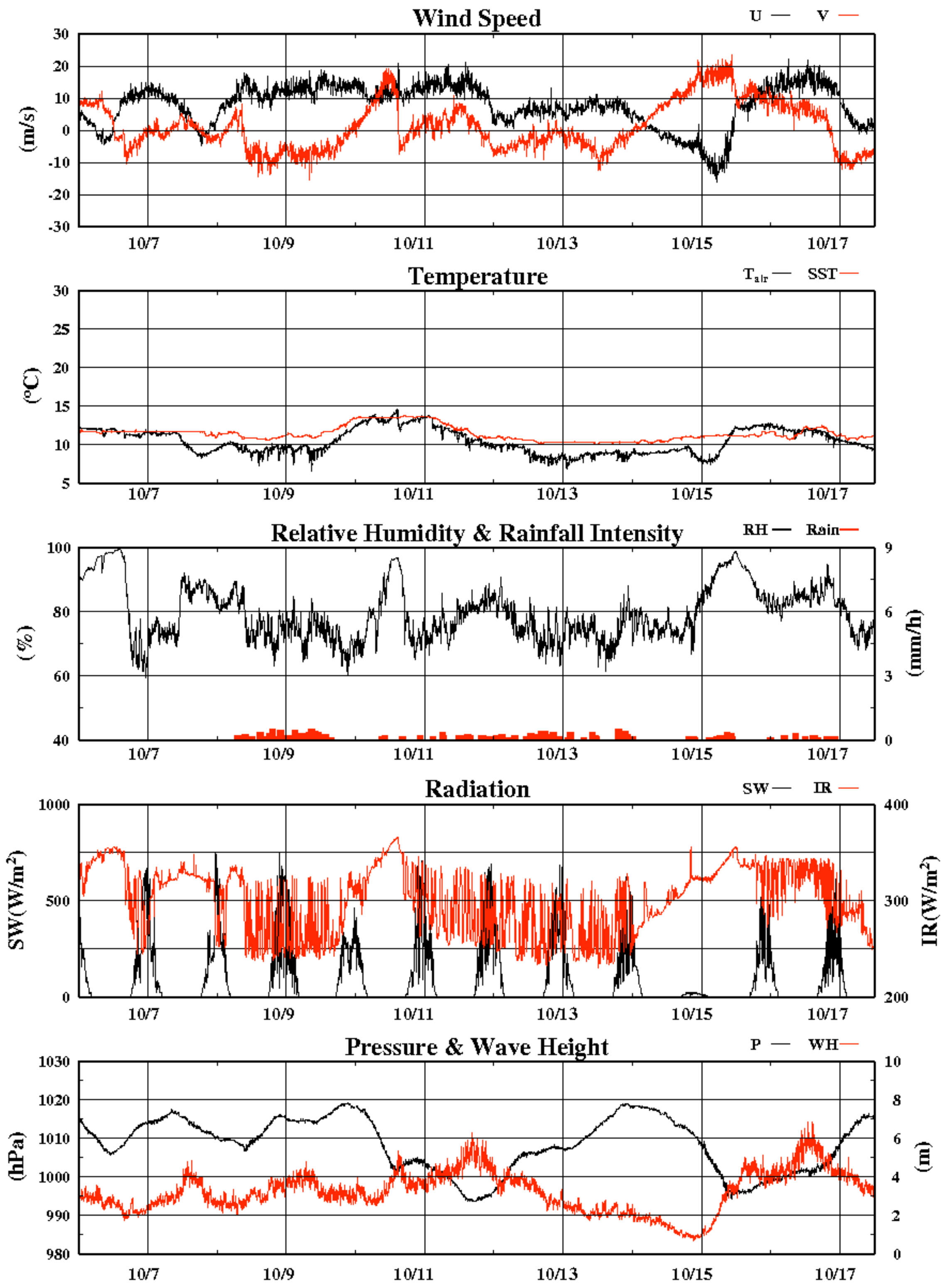

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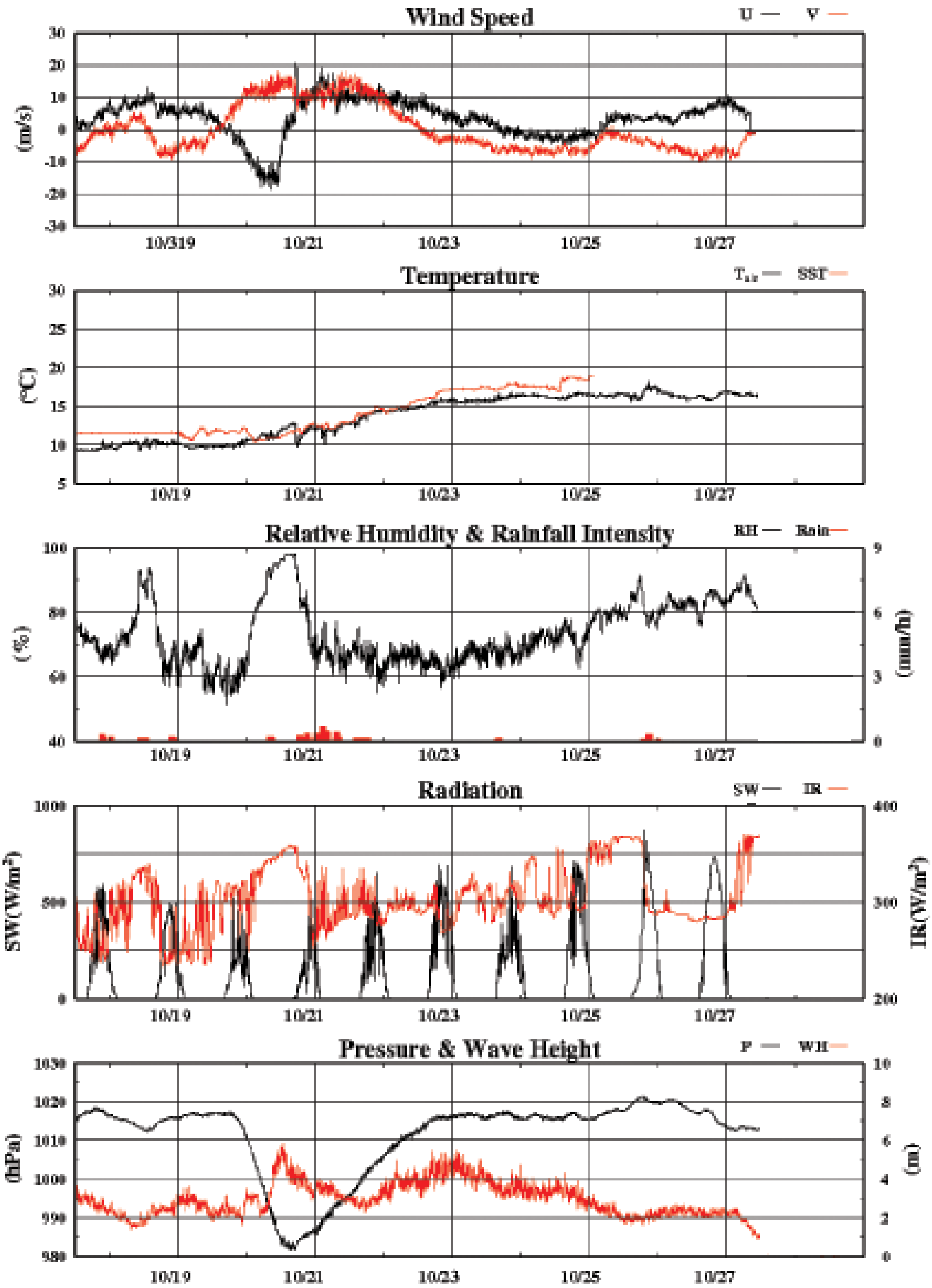


Fig.2.1.1-1 Continue

2.1.2 Ceilometer Observation

Satoshi OKUMURA (Global Ocean Development Inc., GODI)
Kazuho YOSHIDA (GODI)
Kunio YONEYAMA (JAMSTEC) : Principal Investigator (Not on-board)

(1) Objectives

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

(2) Parameters

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

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR05-04 cruise from 13 September 2005, the departure of Sekinehama, to 24 October 2005, before entering the US EEZ area.

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

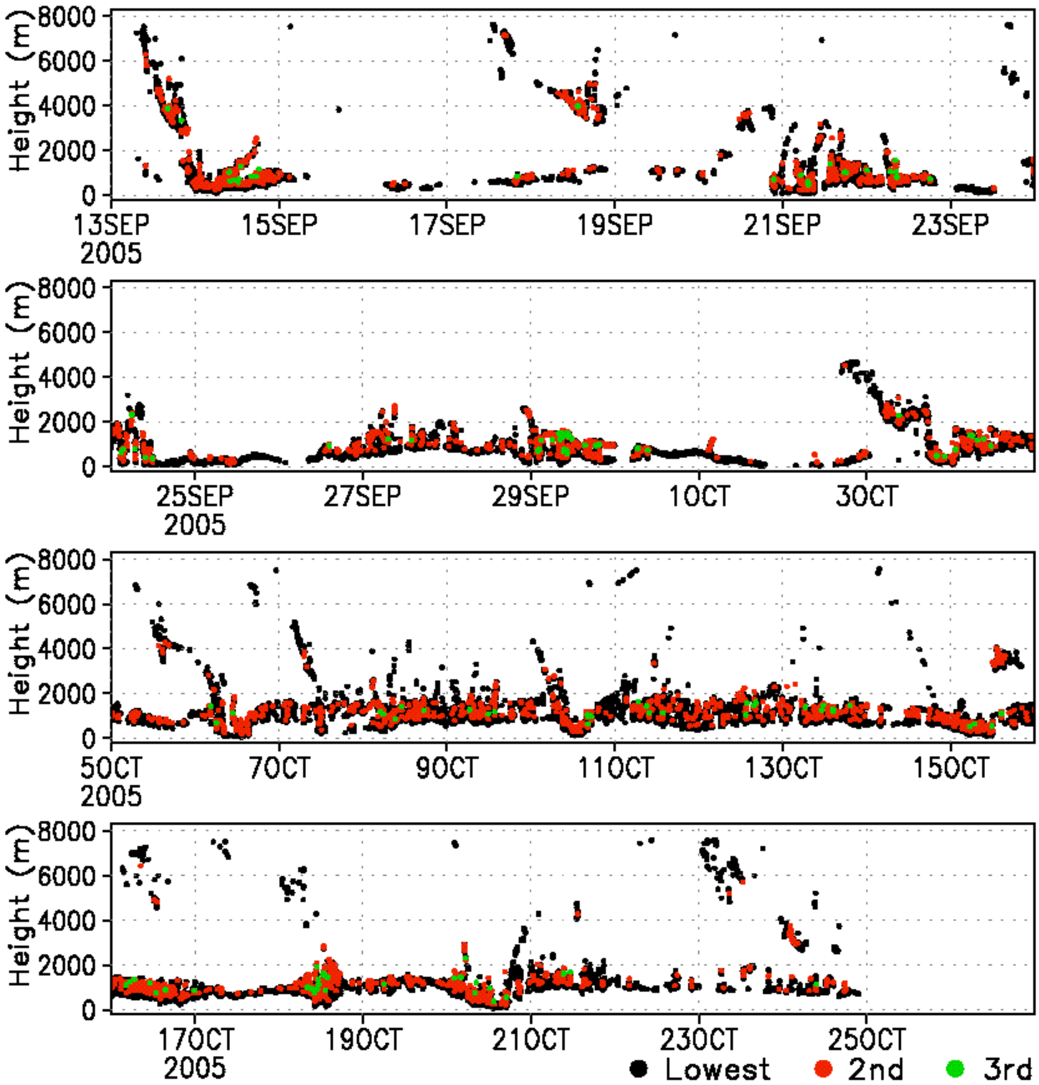
The figure 2.1.2-1 shows the time series of the first, second and third lowest cloud base height.

(5) Data archives

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

(7)Remarks

Data logging was stopped due to the PC trouble on 18 September. The data does not exist from 2:38 to 3:06 (UTC).



2.2 Physical oceanographic observation

2.2.1 CTD casts and water sampling (MWJ)

Hiroshi MATSUNAGA (MWJ) : Operation Leader
Naoko TAKAHASHI (MWJ)
Shinsuke TOYODA (MWJ)

(1) Objective

Investigation of oceanic structure and water sampling of each layer.

(2) Method

(2)-1 Overview of the equipment

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

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

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

(2)-2 Details of sensors

The system used in this cruise is summarized as follows:

Under water unit:
SBE, Inc., SBE 9plus, S/N 79492

Temperature sensor:
SBE, Inc., SBE 3-04F, S/N 031359

Conductivity sensor:

SBE, Inc., SBE 4C, S/N 042240

Dissolved Oxygen sensor:

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

Pump:

SBE, Inc., SBE 5T, S/N 053293 3K

Altimeter:

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

Deck unit:

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

Carousel Water Sampler:

SBE, Inc., SBE 32, S/N 3227443-0391

Fluorometer:

Seapoint sensors, Inc., S/N 2579

Transmissometer:

Wetlabs,Inc., CST-207RD

Water sample bottle:

General Oceanics, Inc., 12-litre Niskin-X (Normal) : #1-#24 bottles

General Oceanics, Inc., 12-litre Niskin-X (Teflon-coating) : #25-#36 bottles

(3) Data collection and processing

(3)-1 Data collection

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

The package was lowered into the water from the starboard side and held 10 m beneath the surface for about one minute in order to activate the pump. After the pump was activated the package was lifted to the surface, and the package was lowered again at a rate of about 1.0 m/s to Bottom-30m. For the up cast, the package was lifted at a rate of 1.0 m/s except for bottle firing stops. At each bottle firing stops, the bottle was fired.

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

(3)-2 Data collection problems

- Stn.KNOT(cast3): Down Data of Conductivity and Dissolved Oxygen showed unusual value from 60m to 130m. So we recommend use of Up Data on this cast.
- Stn.EW3(cast2): Because of rough condition, CTD started without lifting it to the surface after the pump was turned on. When the bottle is fired, Wire Speed was slow down, and the

bottle firing was carried out without stopping.

(3)-3 Data processing

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

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

DATCNV converted the raw data to scan number, pressure, depth, temperature, conductivity, altitude, fluorescence, transmission. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 3 seconds, and the offset was set to 0.0 seconds.

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

ALIGNCTD converted the time-sequence of oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. For a SBE 9plus CTD with the ducted temperature and conductivity sensors and a 3000 rpm pump, the typical net advance of the conductivity relative to the temperature is 0.073 seconds. So, the SBE 11plus deck unit S/N 11P9833-0344 as set to advance the conductivity for 1.73 scans (1.75/24 = 0.073 seconds). Oxygen data are also systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing oxygen sensor output (oxygen voltage) relative to the pressure.

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

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

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

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

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

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

DERIVE was used to compute Oxygen.

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

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

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

(4) Preliminary results

Total 33 casts of CTD measurements have been carried out (table 2-2-1(a)).

Vertical profiles of Temperature, Salinity, Oxygen, sigma- θ , Fluorescence and Transmission for routine cast are shown in Figure.2.2.1.1～Figure.2.2.1.11, from Figure 2.2.1.12 to 2.2.1.20 are shown for vertical profiles of Primary Production cast, from Figure 2.2.1.21 to 2.2.1.32 are shown for vertical profile of Trace Metal cast and Figure 2.2.1.33 is shown for vertical profile of Extra cast.

We also compared CTD-salinity and Bottle-salinity. The results are shown in Figure.2.2.1.34 and table 2.2.1 (b).

Table 2-2-1 (a): MR05-04 CTD Cast table

STN NBR	CAST NO	Date (UTC) yyyy/mm/dd	Time (UTC) Start	Time (UTC) End	Start Position Lat (N)	Start Position Long	Depth (MNB)	WIRE OUT	HT ABOVE BOTTOM	Max Depth	Max Pressure	CTD data File name	Sample	Remarks
KNOT	1	2005/9/17	0:02	0:17	43-59.98	155-00.03E	5302.0	68.1	-	70.0	71.0	KNTM01	Primary Productivity + Chl-a	
	2	2005/9/17	1:14	1:44	44-00.01	154-59.89E	5301.0	299.0	-	300.9	303.7	KNTM02	Trace metal	
	3	2005/9/17	3:07	6:35	44-00.38	155-00.46E	5316.0	5292.0	28.8	5277.0	5386.4	KNTM03	Routine and Trace metal	not normal data: Cond, DO (down cast 60m～130m)
K03	1	2005/9/19	17:32	17:59	39-00.04	160-00.08E	5501.0	199.8	-	200.9	203.1	K03M01	Primary Productivity + Chl-a	
	2	2005/9/19	20:02	23:40	39-01.60N	160-00.14E	5526.0	5574.9	30	5490.3	5604.8	K03M02	Routine and Trace metal	
	3	2005/9/20	2:07	2:34	39-02.62N	160-02.88E	5514.0	299.9	-	301.02	303.5	K03M03	Trace metal	
K02	1	2005/9/22	4:33	5:52	46-58.29N	159-57.50E	5188.0	2069.4	-	2034.2	2061.5	K02M01	extra	Spike: Sal (down cast 441m)
	2	2005/9/24	17:33	18:03	47-00.44N	159-58.37E	5218.0	201.3	-	203.0	204.8	K02M02	Primary Productivity + Chl-a	Spike: Sal (down cast 50m)
	3	2005/9/24-25	21:02	0:37	47-06.95N	160-10.70E	5190.0	5416.0	48.2	5166.7	5274.0	K02M03	Routine and Trace metal	
	4	2005/9/26	5:13	5:51	47-04.70N	160-12.03E	5251.0	299.0	-	300.5	303.4	K02M04	Trace metal	
	5	2005/9/26	7:02	7:15	47-04.67N	160-11.99E	5254.0	47.2	-	50.2	50.9	K02M05	Primary Productivity + Chl-a	
K01	1	2005/9/27	16:58	17:24	51-00.26N	164-59.81E	4794.0	198.6	-	201.5	203.0	K01M01	Primary Productivity + Chl-a	
	2	2005/9/27	19:12	22:21	50-59.71N	165-00.22E	4807.0	4797.5	29.5	4769.4	4866.3	K01M02	Routine and Trace metal	
	3	2005/9/28	2:10	2:45	51-00.10N	164-59.59E	4806.0	303.5	-	301.6	304.0	K01M03	Trace metal	
EW0	1	2005/9/29	12:42	13:15	47-00.01N	164-59.90E	5899.0	300.0	-	301.1	304.1	EW0M01	Trace metal	
	2	2005/9/29	14:08	17:58	47-00.00N	164-59.46E	5899.0	5879.9	32.8	5850.5	5980.6	EW0M02	Routine and Trace metal	

EW1	1	2005/9/30	16:31	16:58	47-38.95N	169-16.73E	2223.0	198.9	-	201.3	203.5	EW1M01	Primary Productivity + Chl-a	
	2	2005/9/30	20:57	22:37	47-39.98N	169-15.47E	2245.0	2234.3	25.9	2190.3	2220.5	EW1M02	Routine and Trace metal	
	3	2005/10/1	1:16	1:51	47-38.87N	169-15.64E	2191.0	297.9	-	299.5	302.0	EW1M03	Trace metal	
EW2	1	2005/10/2	19:58	20:34	46-59.80N	174-59.89E	5628.0	300.1	-	301.2	303.7	EW2M01	Trace metal	
	2	2005/10/2-3	21:34	1:10	47-01.28N	174-58.27E	5667.0	5644.7	29.8	5621.0	5744.0	EW2M02	Routine and Trace metal	
EW3	1	2005/10/3	16:38	17:10	45-59.91N	179-59.74W	5645.0	303.5	-	302.1	305.3	EW3M01	Trace metal	
	2	2005/10/3	18:29	20:20	46-00.48N	179-57.65E	5633.0	3084.8	-	3001.1	3049.0	EW3M02	Routine and Trace metal	Stop it by 3000m Because of stormy weather.
EW4	1	2005/10/5	19:30	23:25	46-00.00N	175-00.99W	5762.0	5916.6	30.5	5737.9	5863.4	EW4M01	Routine and Trace metal	Spike: Sal (down cast 460m)
	2	2005/10/6	1:02	1:33	46-00.08N	174-59.88W	5775.0	298.8	-	301.2	302.9	EW4M02	Trace metal	Spike: Cond, Sal (down cast 150m, 160m)
	3	2005/10/6	16:00	16:24	45-59.84N	174-59.99W	5738.0	201.9	-	201.1	203.5	EW4M03	Primary Productivity + Chl-a	
EW5	1	2005/10/8	10:00	10:31	46-59.98N	170-00.19W	5504.0	305.0	-	304.8	308.2	EW5M01	Trace metal	
EW7	1	2005/10/12	20:30	21:03	49-29.84N	160-00.28W	5012.0	299.3	-	300.2	304.2	EW7M01	Trace metal	
	2	2005/10/12	22:11	22:33	49-30.16N	160-00.75W	5010.0	198.9	-	200.2	202.8	EW7M02	Primary Productivity	
	3	2005/10/13	0:36	4:04	49-30.83N	160-01.27W	5006.0	5039.9	27.7	4973.9	5076.7	EW7M03	Routine and Trace metal	Spike: Sal (down cast 445m)
OSP	1	2005/10/17	20:59	21:20	49-56.69N	144-56.90W	4240.0	211.6	-	201.1	202.9	OSPM01	Primary Productivity + Chl-a	
	2	2005/10/17-18	23:32	0:06	49-54.23N	144-53.72W	4240.0	322.4	-	305.3	308.2	OSPM02	Trace metal	
	3	2005/10/18	1:02	3:53	49-54.03N	144-53.62W	4239.0	4246.0	28.0	4204.5	4283.6	OSPM03	Routine and Trace metal	

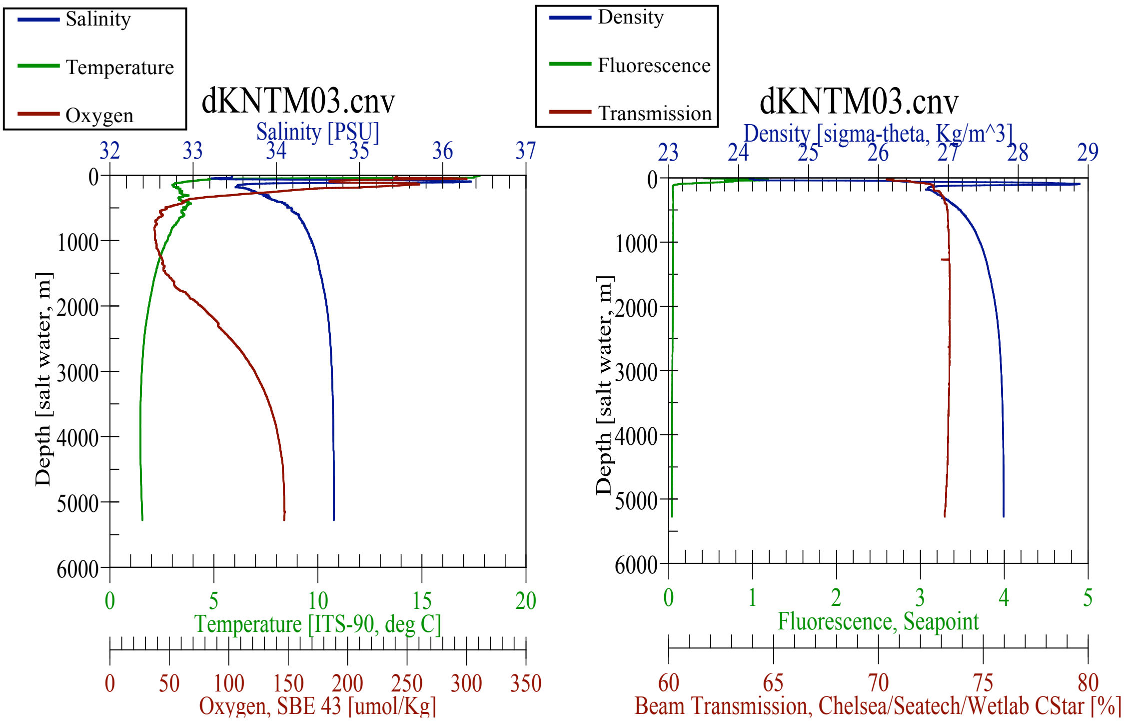


Figure2.2.1.1: Vertical profiles for Routine cast of Stn.KNOT

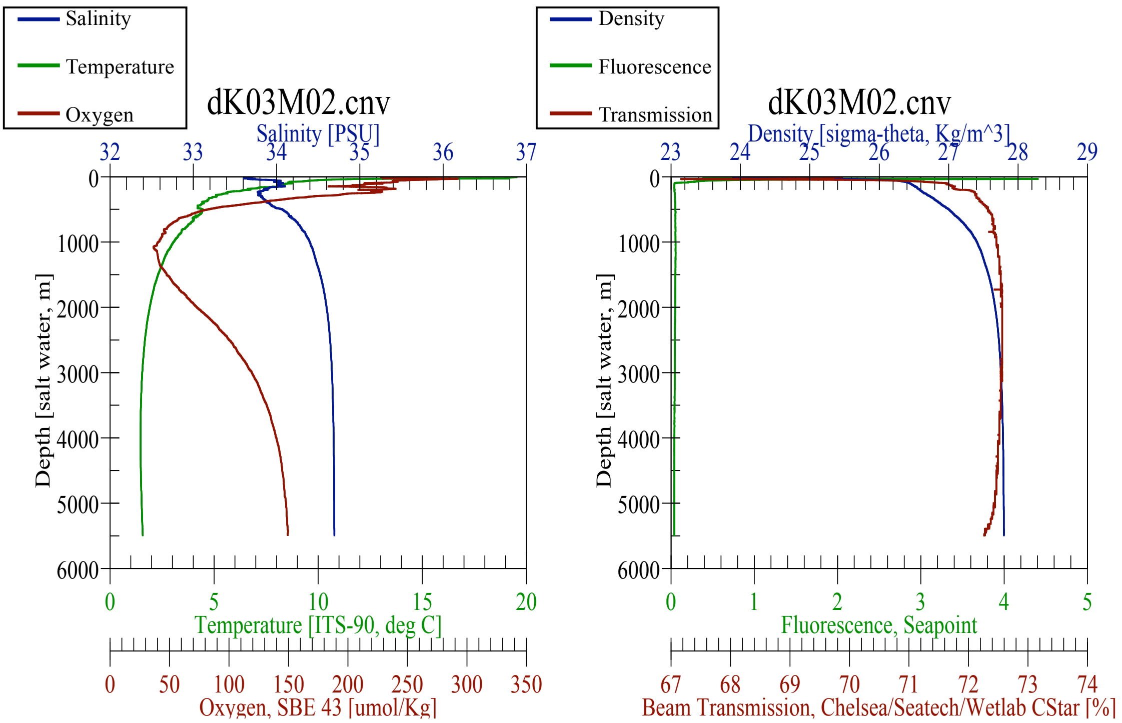


Figure 2.2.1.2: Vertical profiles for Routine Cast of Stn.K03

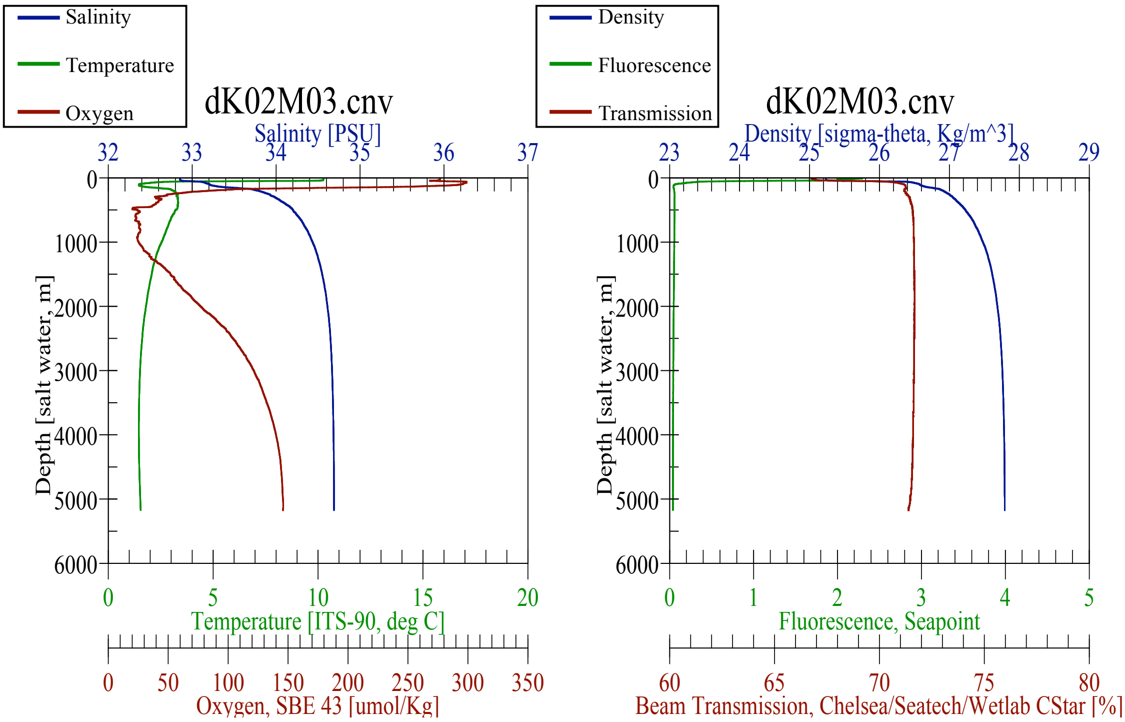


Figure 2.2.1.3: Vertical profiles for Routine Cast of Stn.K02

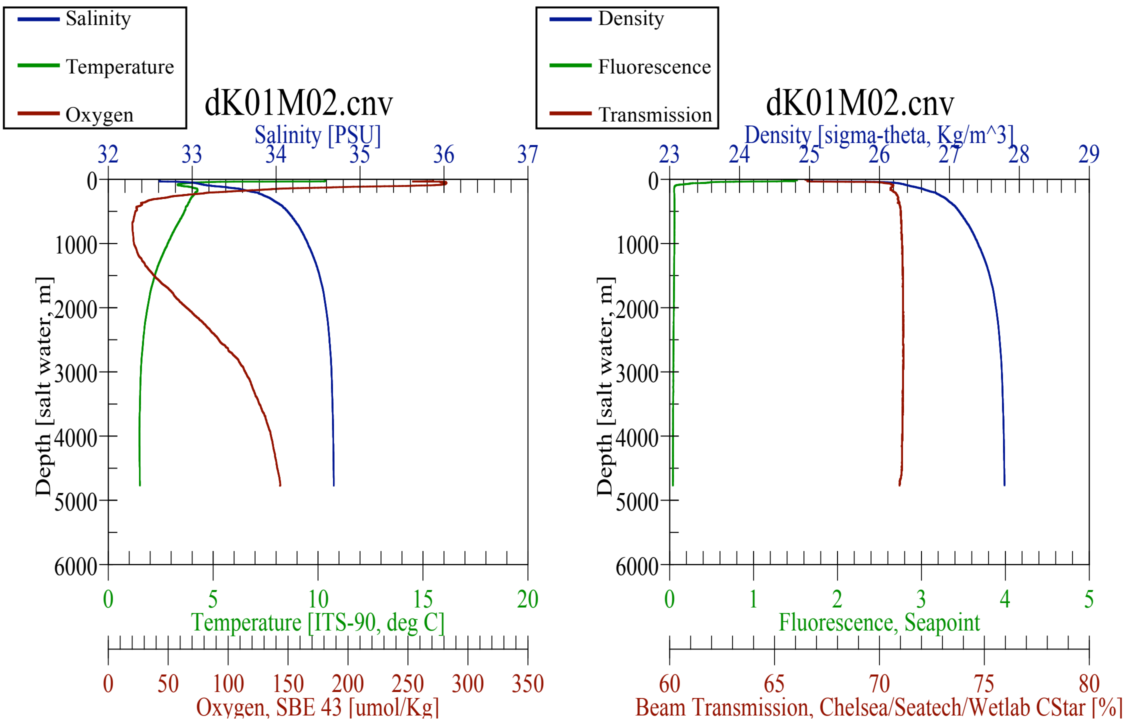


Figure 2.2.1.4: Vertical profiles for Routine Cast of Stn.K02

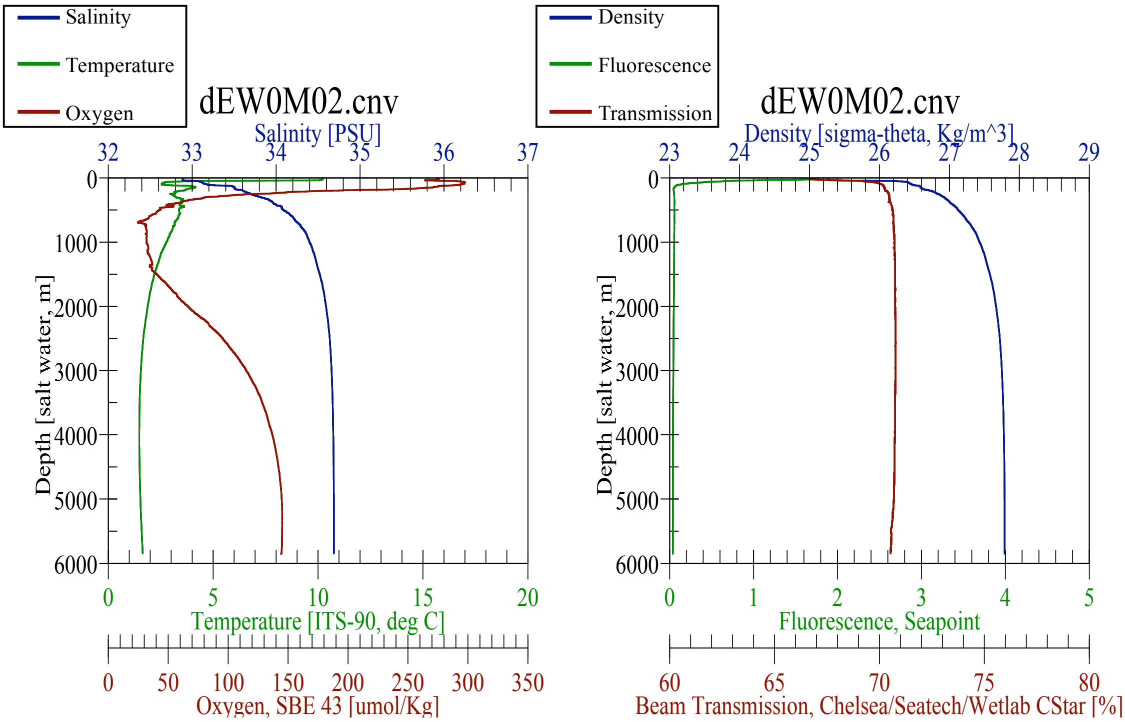


Figure 2.2.1.5: Vertical profiles for Routine Cast of Stn.EW0

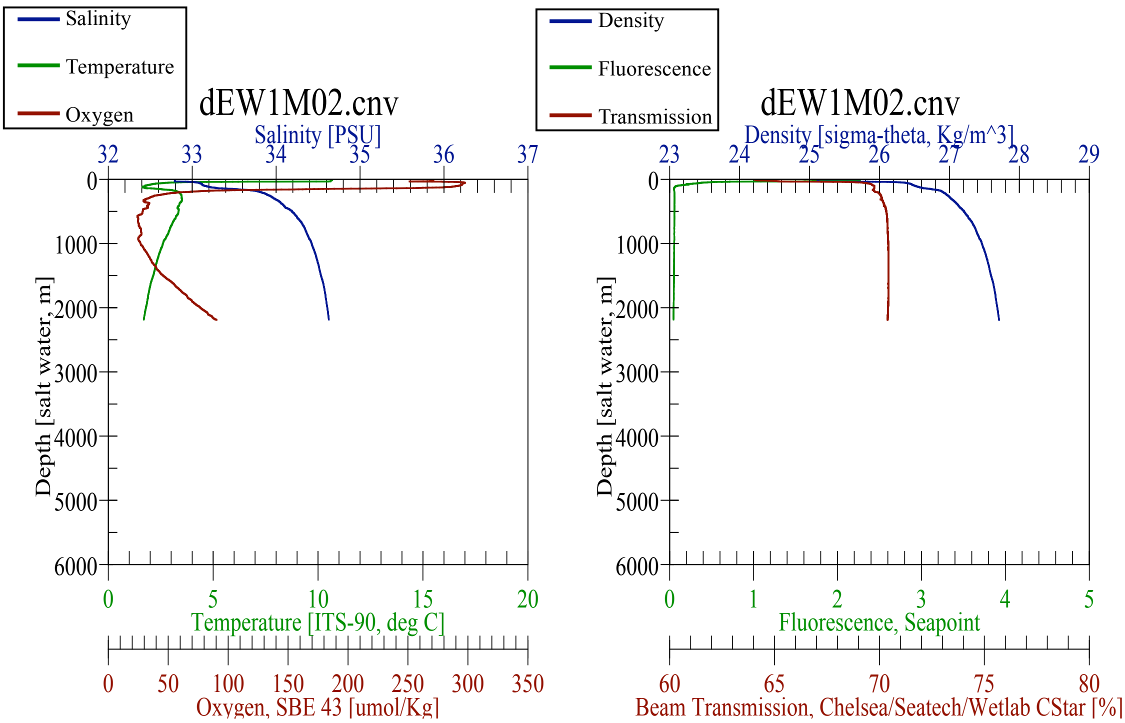


Figure 2.2.1.6: Vertical profiles for Routine Cast of Stn.EW1

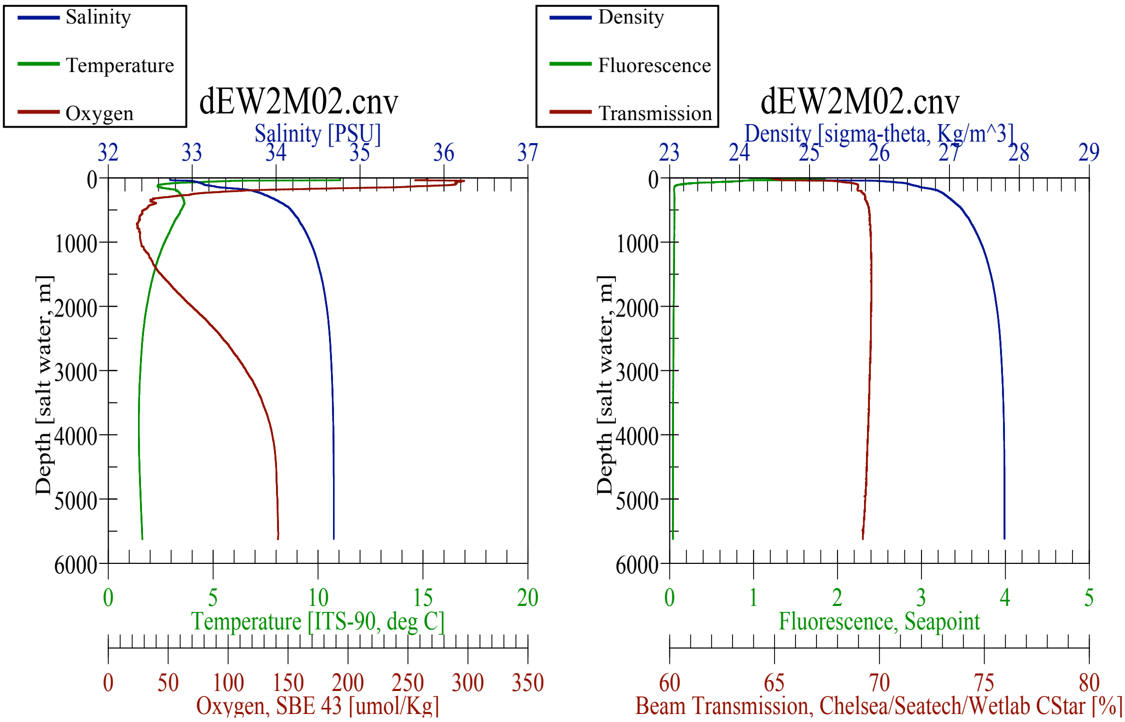


Figure 2.2.1.7: Vertical profiles for Routine Cast of Stn.EW2

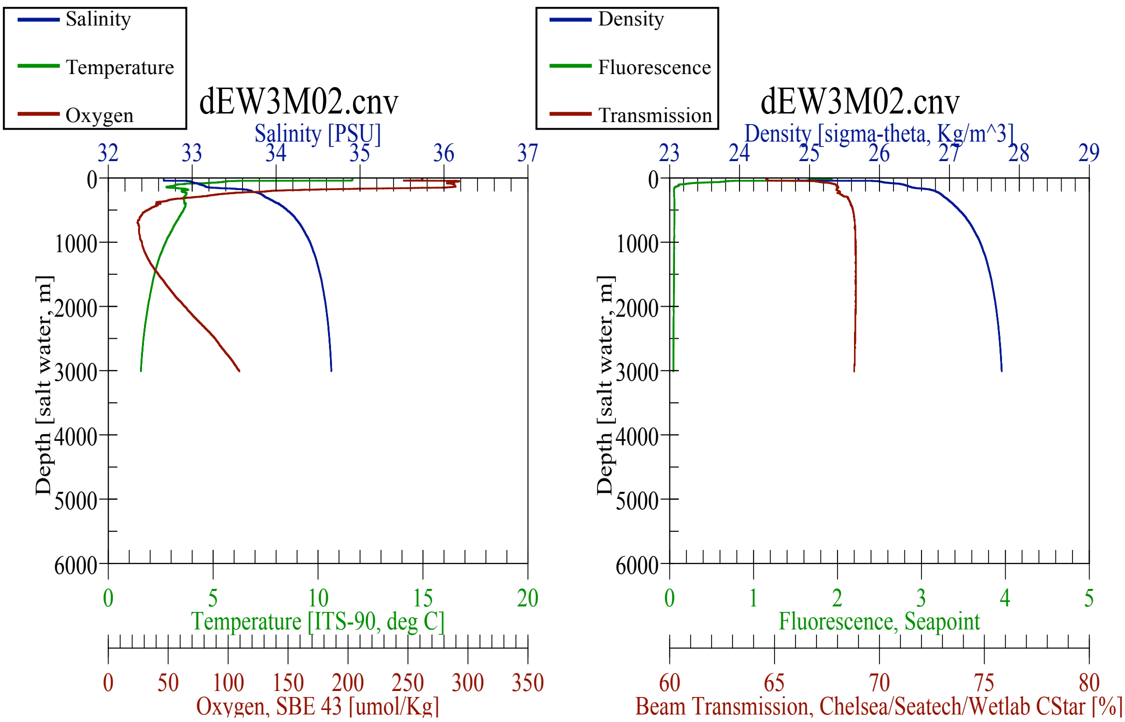


Figure 2.2.1.8: Vertical profiles for Routine Cast of Stn.EW3

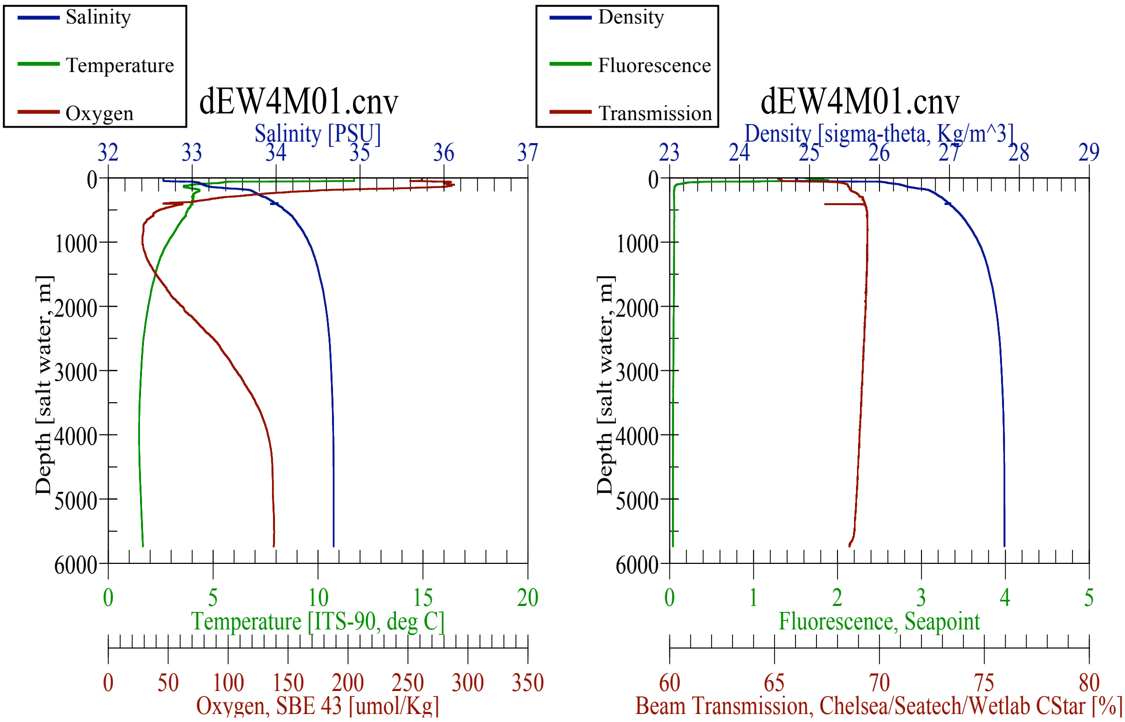


Figure 2.2.1.9: Vertical profiles for Routine Cast of Stn.EW4

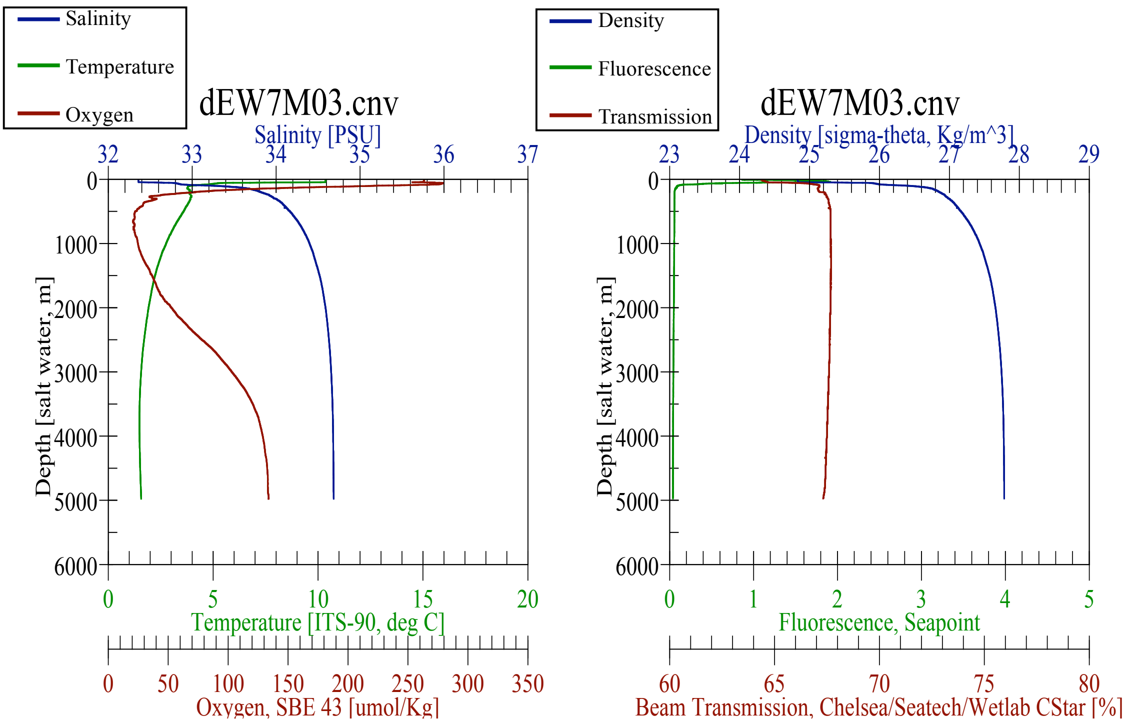


Figure 2.2.1.10: Vertical profiles for Routine Cast of Stn.EW7

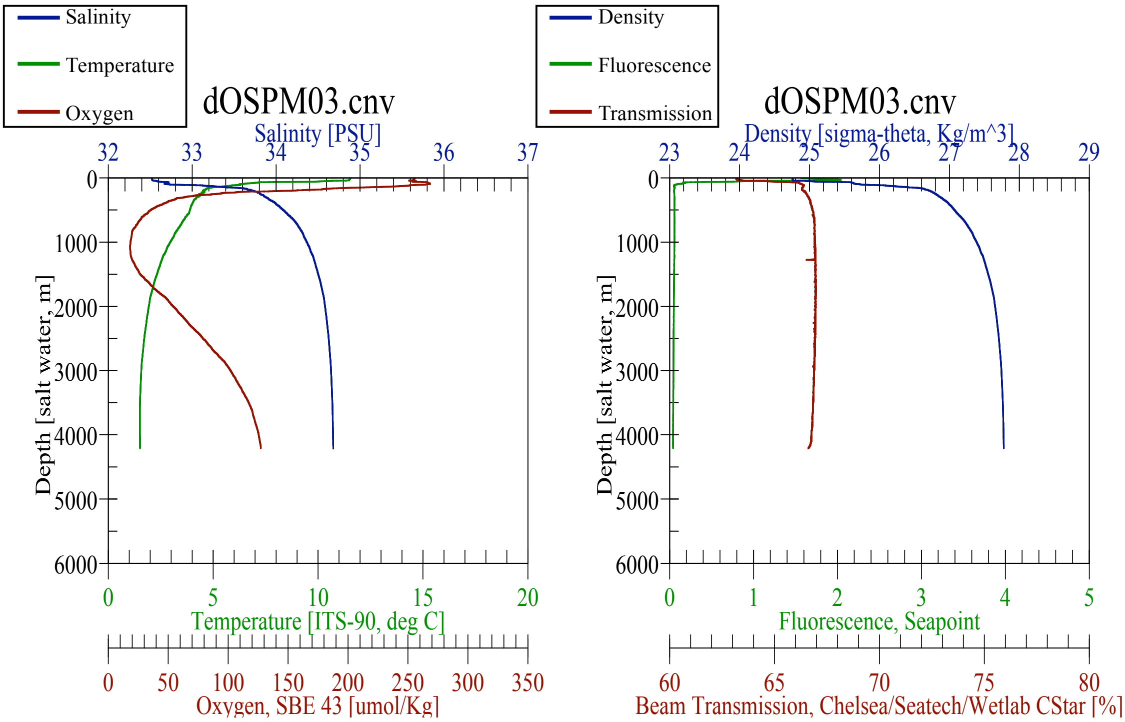


Figure 2.2.1.11: Vertical profiles for Routine Cast of Stn.OSP

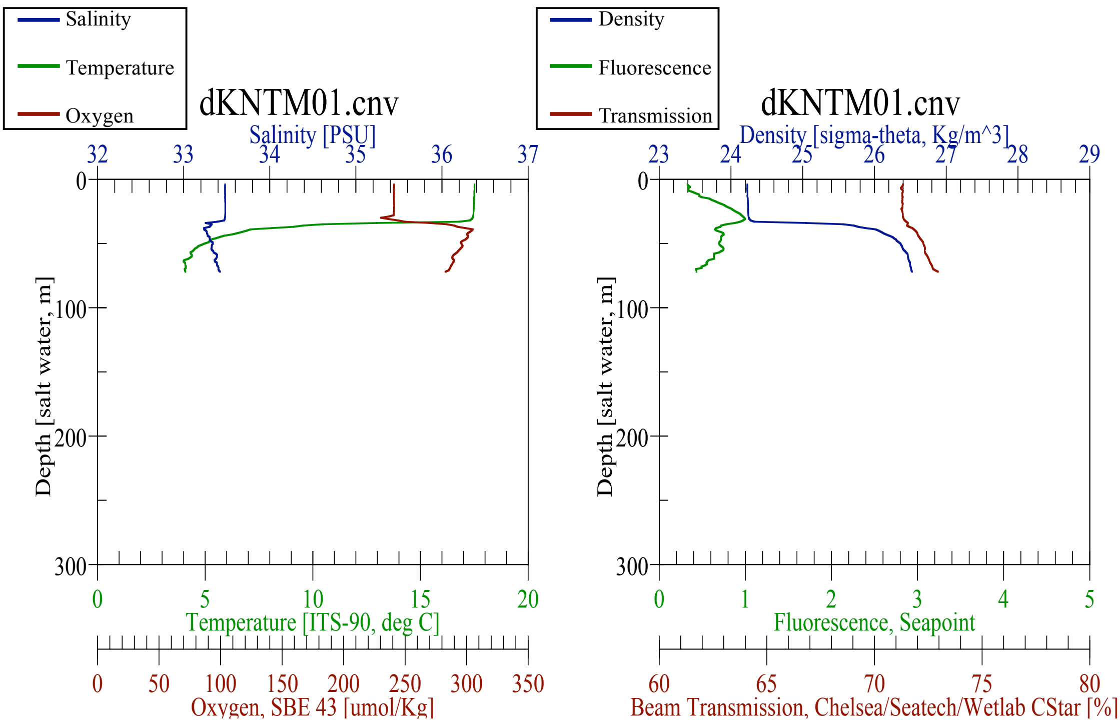


Figure 2.2.1.12: Vertical profiles for the cast of Primary Production of Stn.KNOT

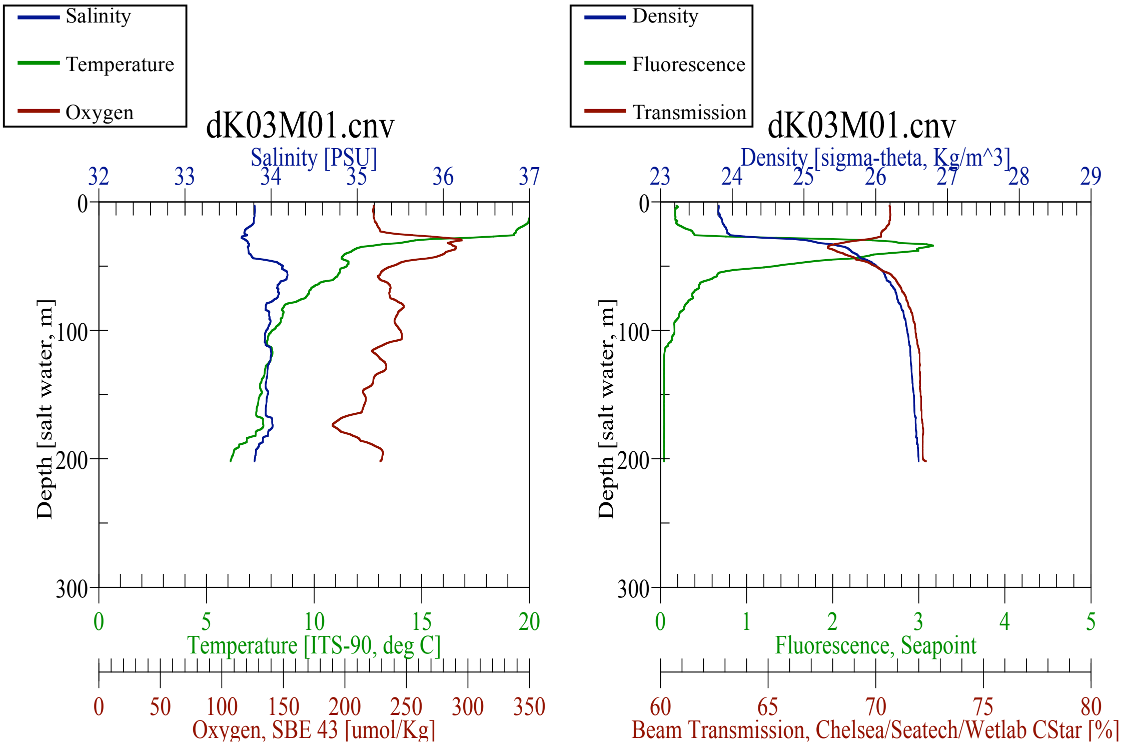


Figure 2.2.1.13: Vertical profiles for the cast of Primary Production of Stn.K03

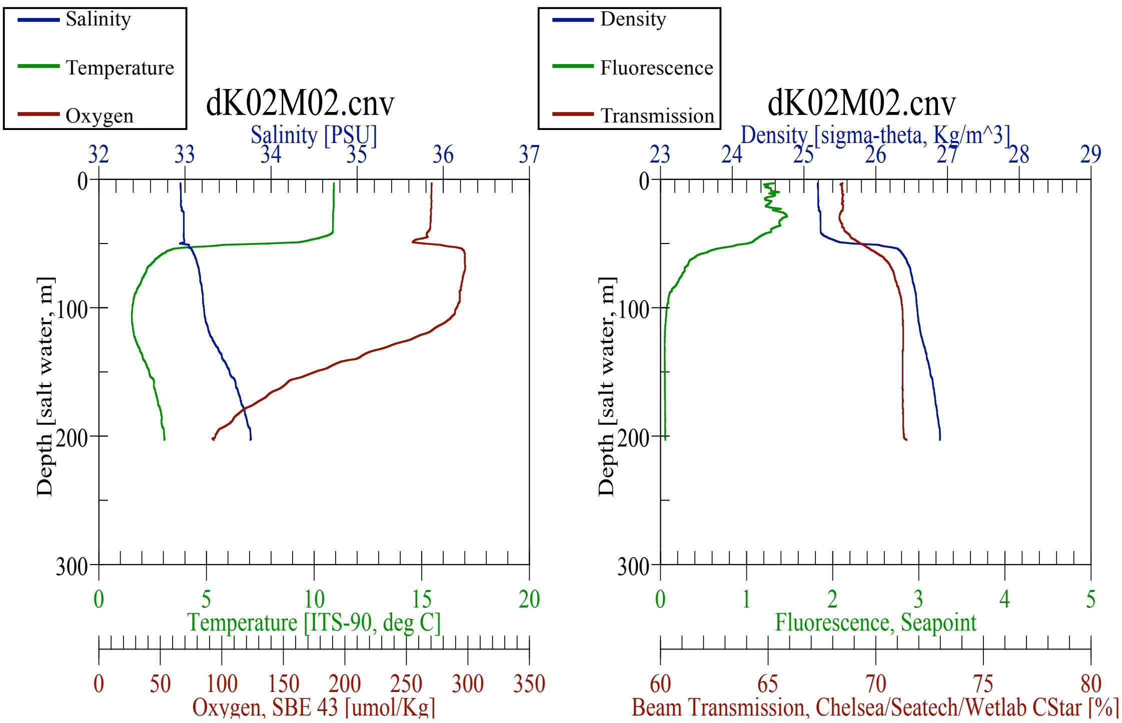


Figure 2.2.1.14: Vertical profiles for the cast of Primary Production of Stn.K02

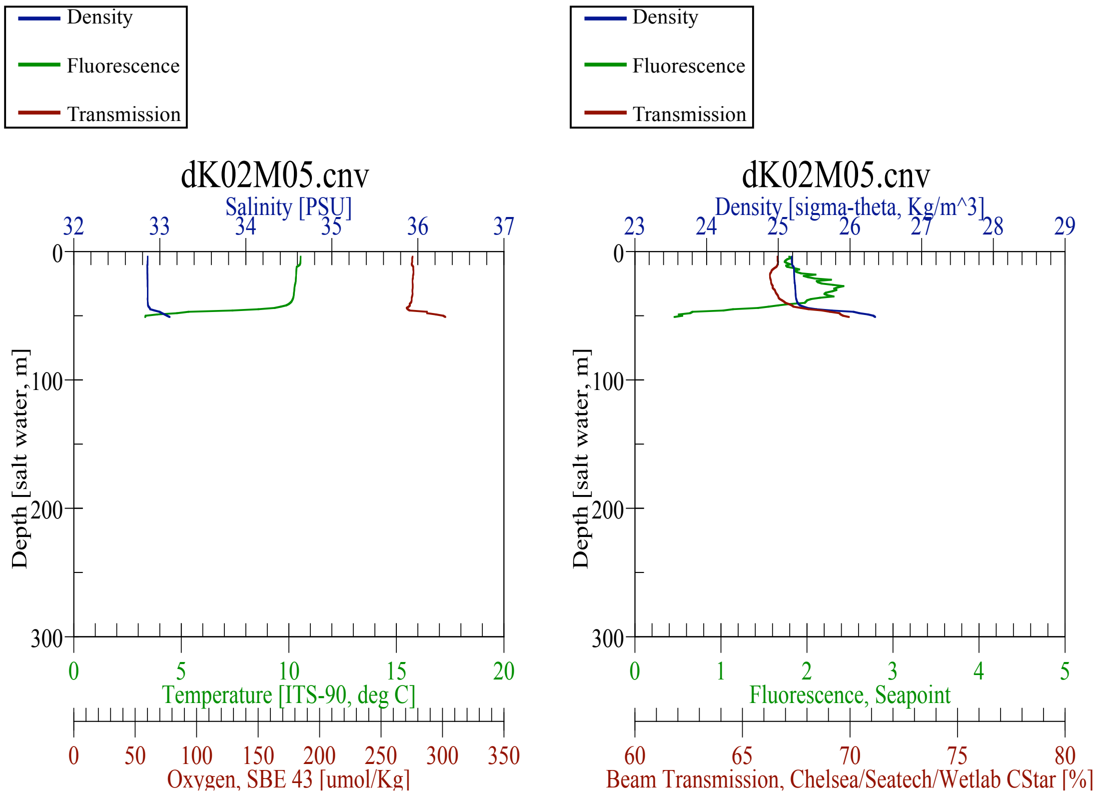


Figure 2.2.1.15: Vertical profiles for the cast of Primary Production of Stn.K02

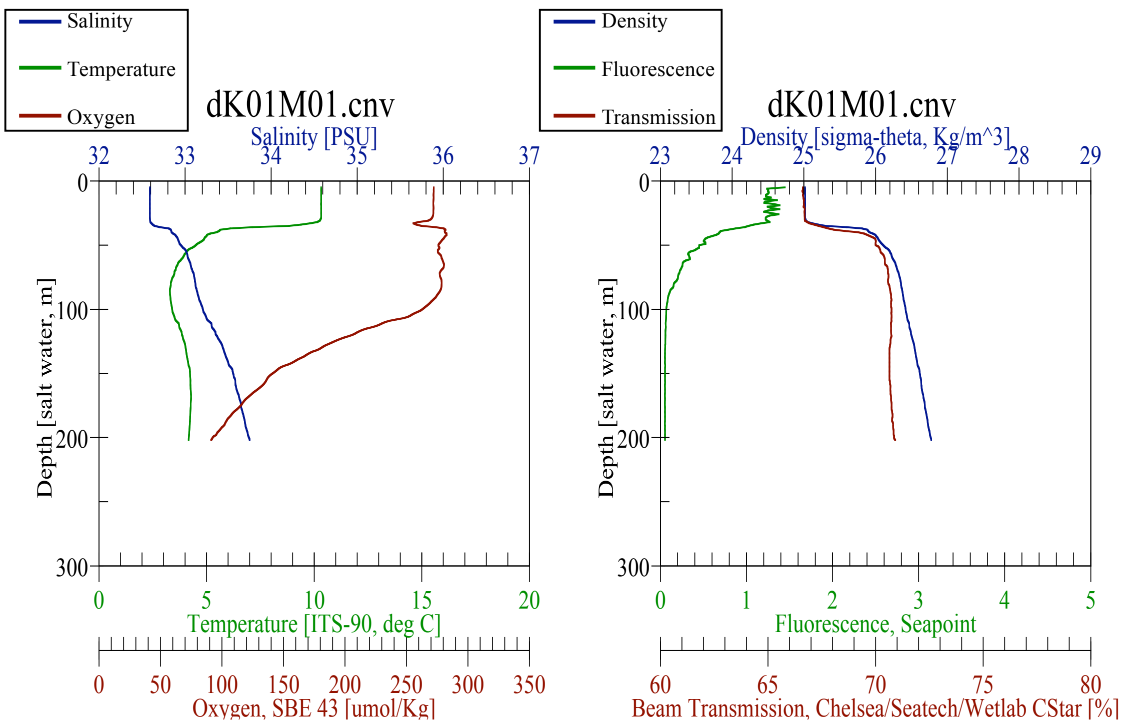


Figure 2.2.1.16: Vertical profiles for the cast of Primary Production of Stn.K01

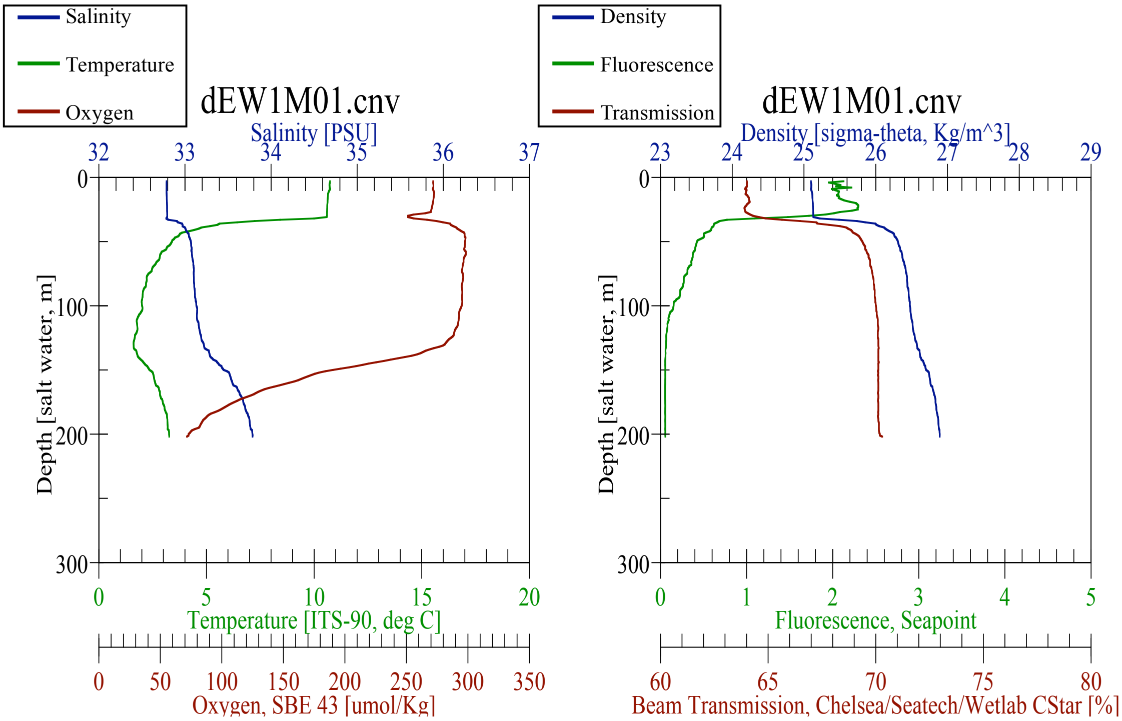


Figure 2.2.1.17: Vertical profiles for the cast of Primary Production of Stn.EW1

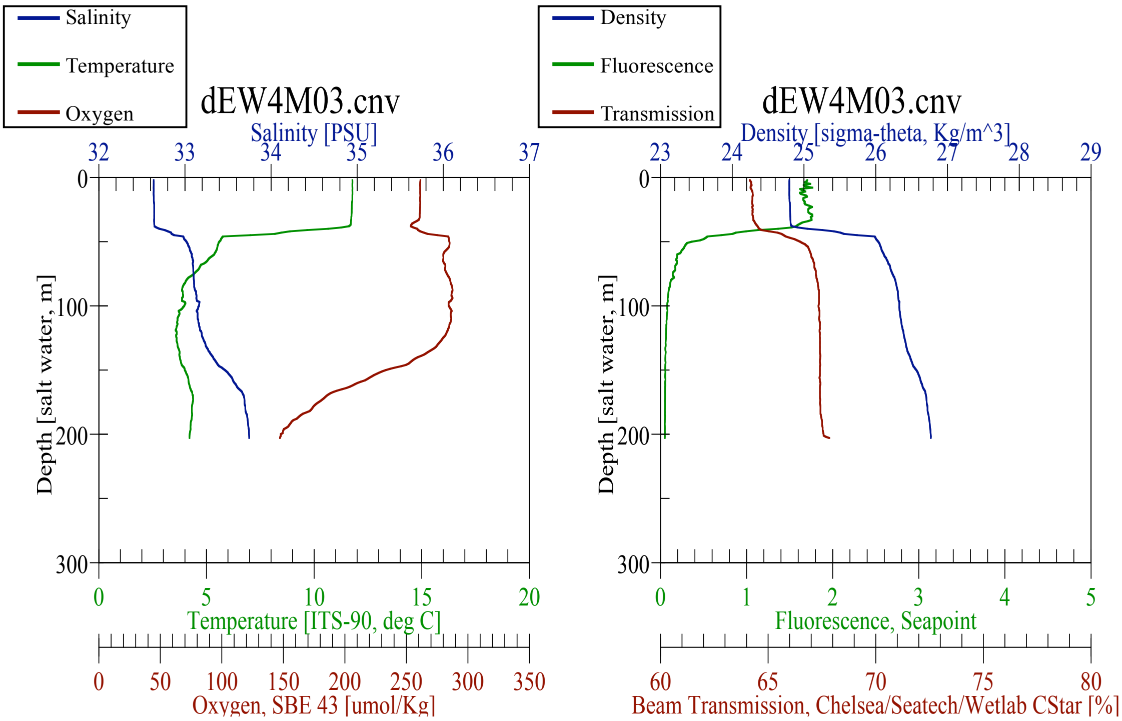


Figure 2.2.1.18: Vertical profiles for the cast of Primary Production of Stn.EW4

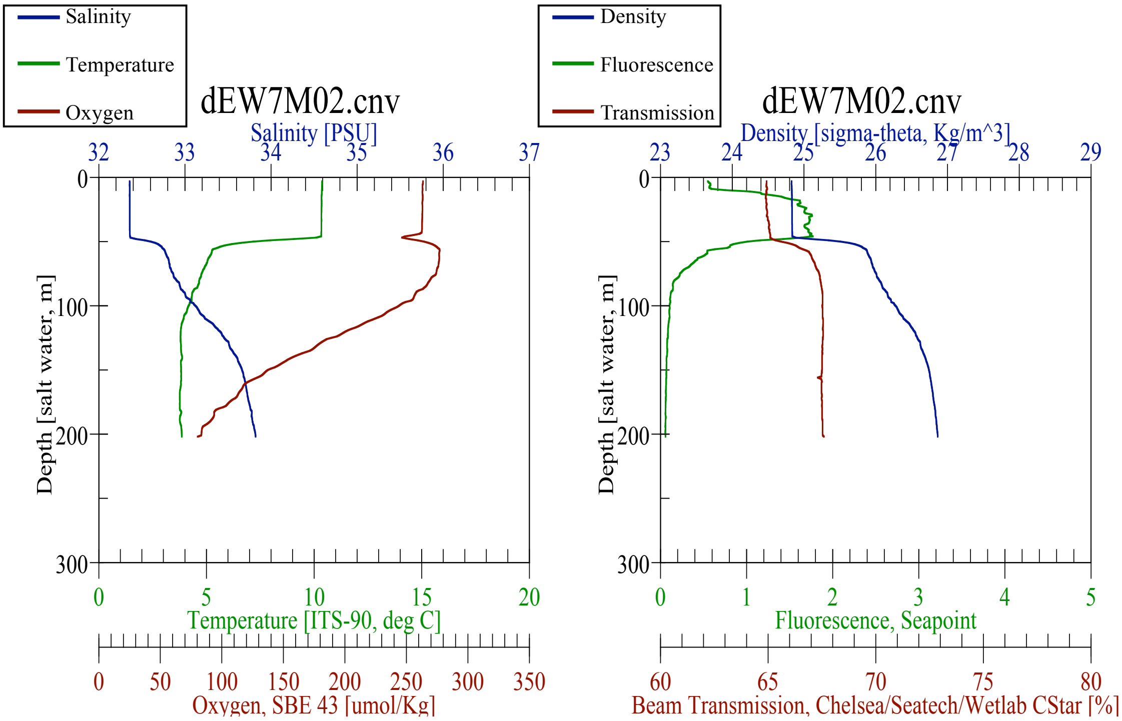


Figure 2.2.1.19: Vertical profiles for the cast of Primary Production of Stn.EW7

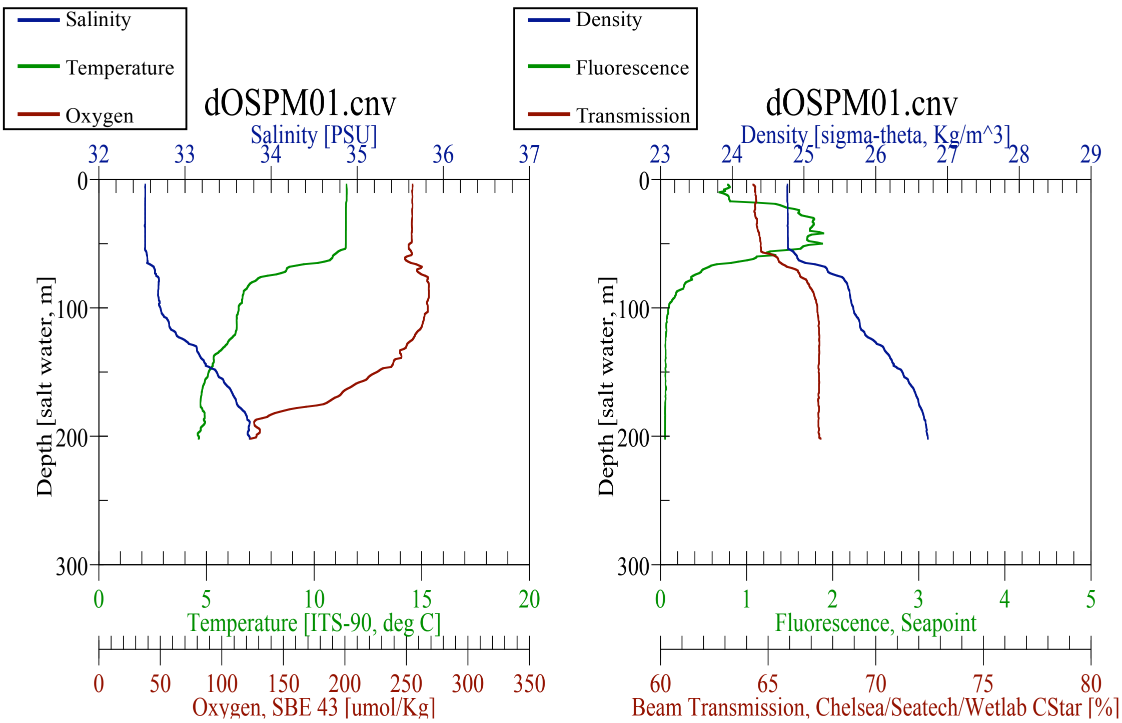


Figure 2.2.1.20: Vertical profiles for the cast of Primary Production of Stn.OSP

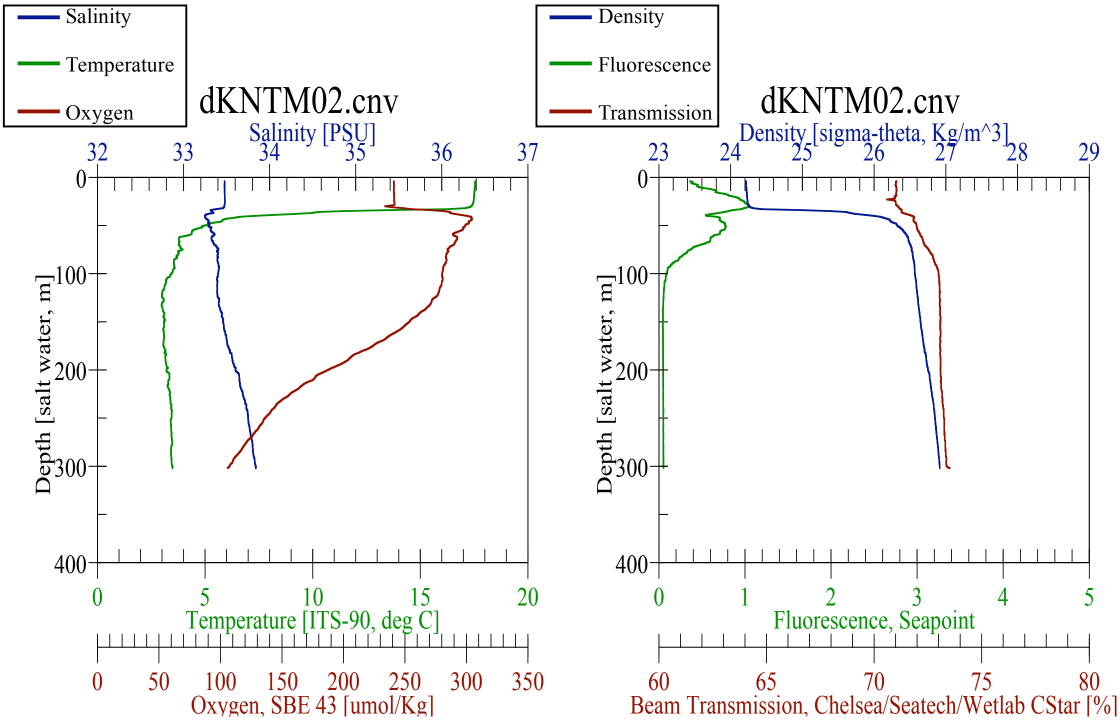


Figure 2.2.1.21: Vertical profiles for the cast of Trace metal of Stn.KNOT

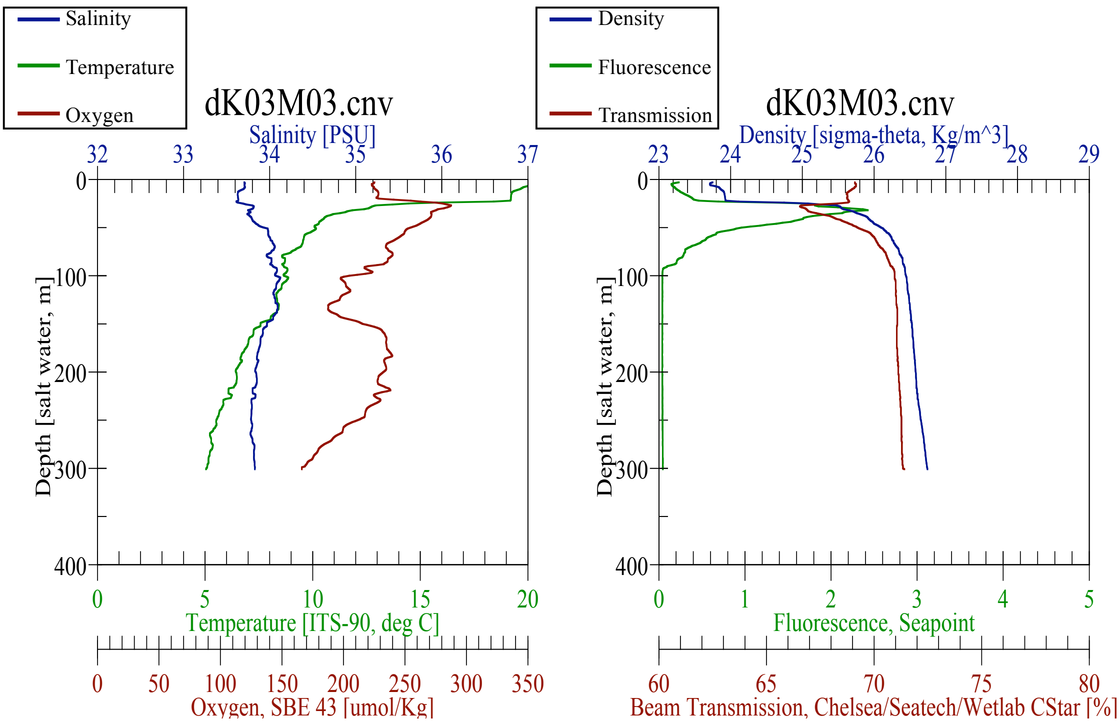


Figure 2.2.1.22: Vertical profiles for the cast of Trace metal of Stn.K03

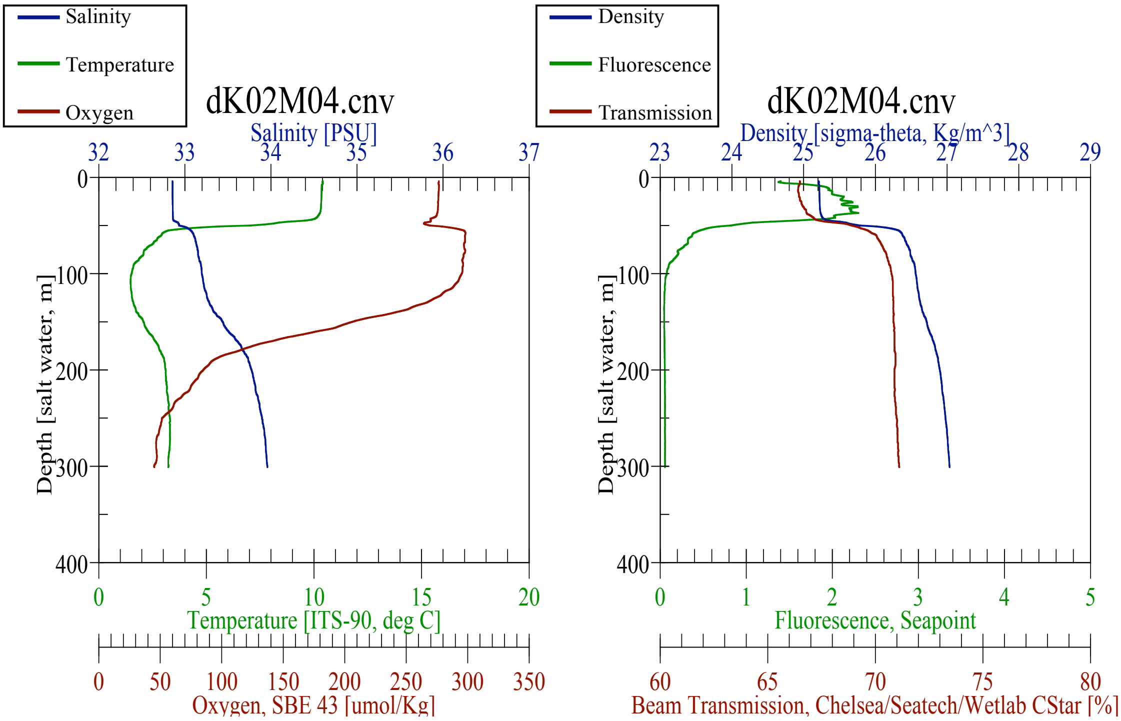


Figure 2.2.1.23: Vertical profiles for the cast of Trace metal of Stn.K02

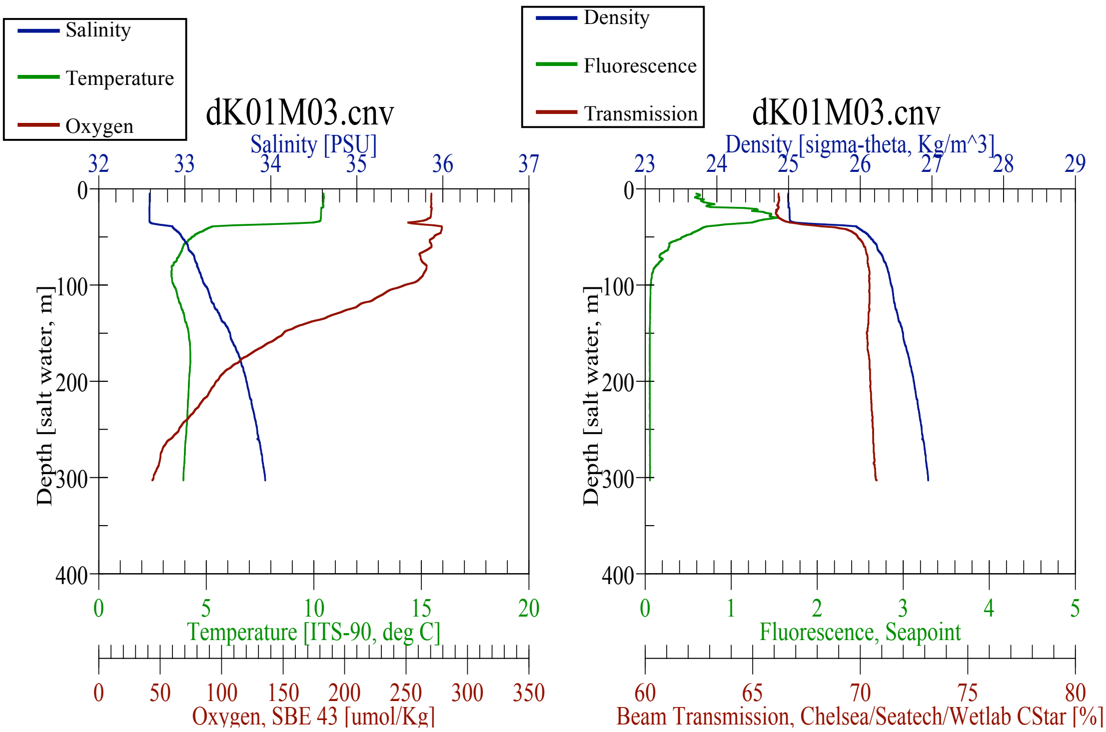


Figure 2.2.1.24: Vertical profiles for the cast of Trace metal of Stn.K01

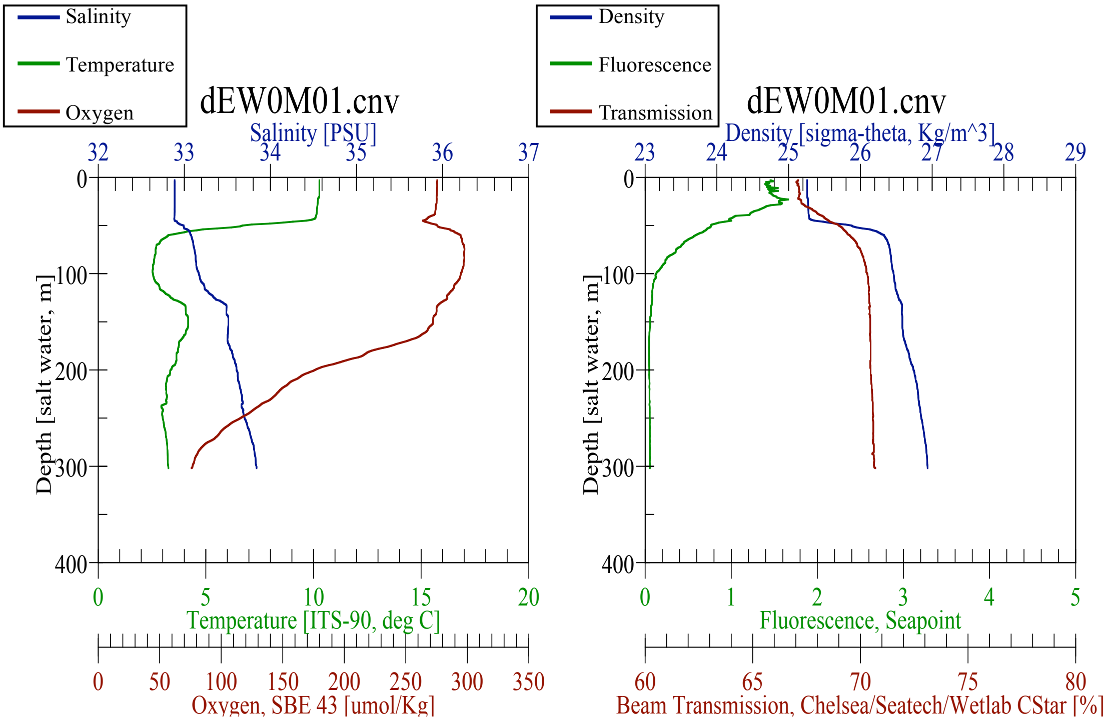


Figure 2.2.1.25: Vertical profiles for the cast of Trace metal of Stn.EW0

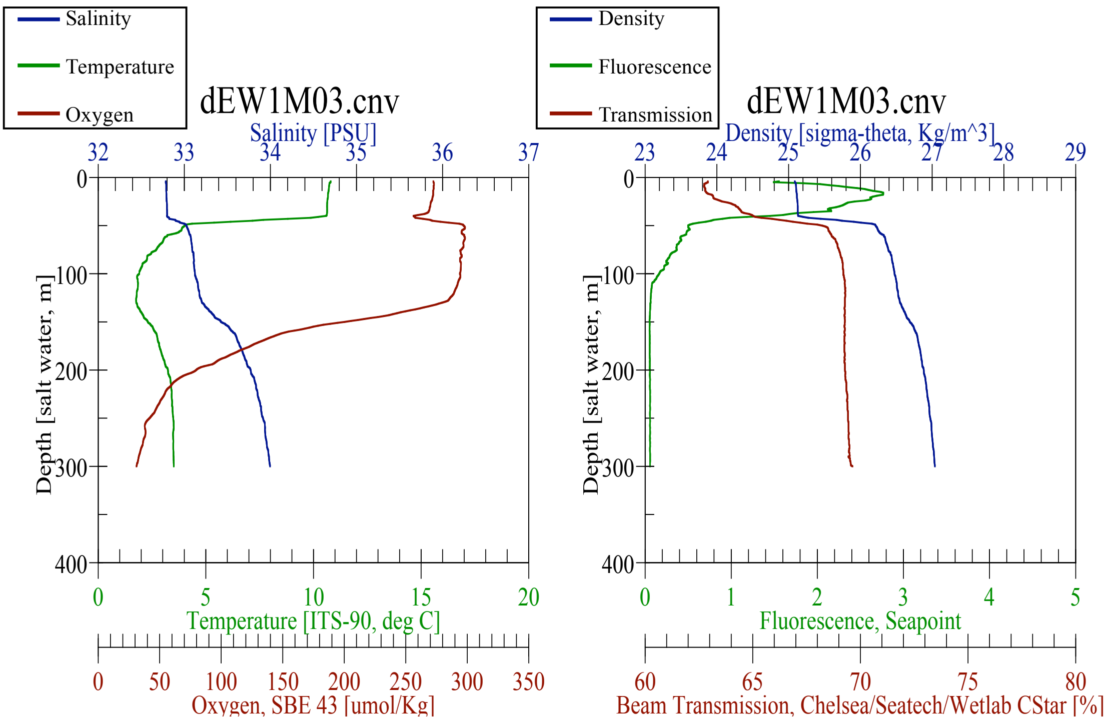


Figure 2.2.1.26: Vertical profiles for the cast of Trace metal of Stn.EW1

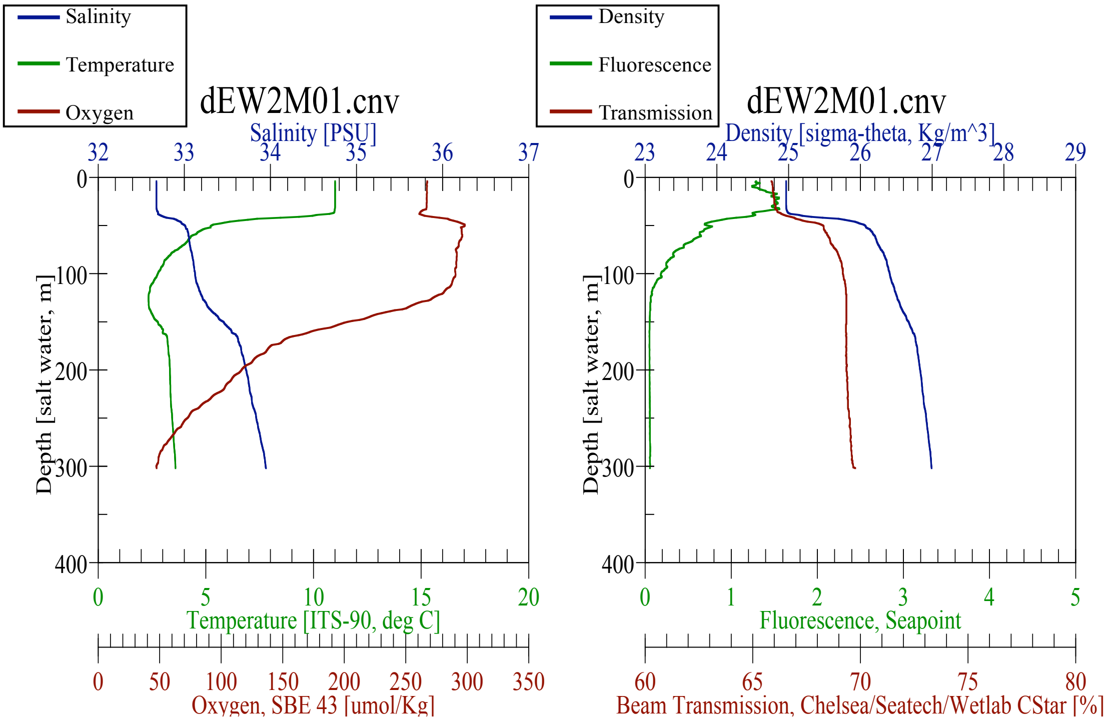


Figure 2.2.1.27: Vertical profiles for the cast of Trace metal of Stn.EW2

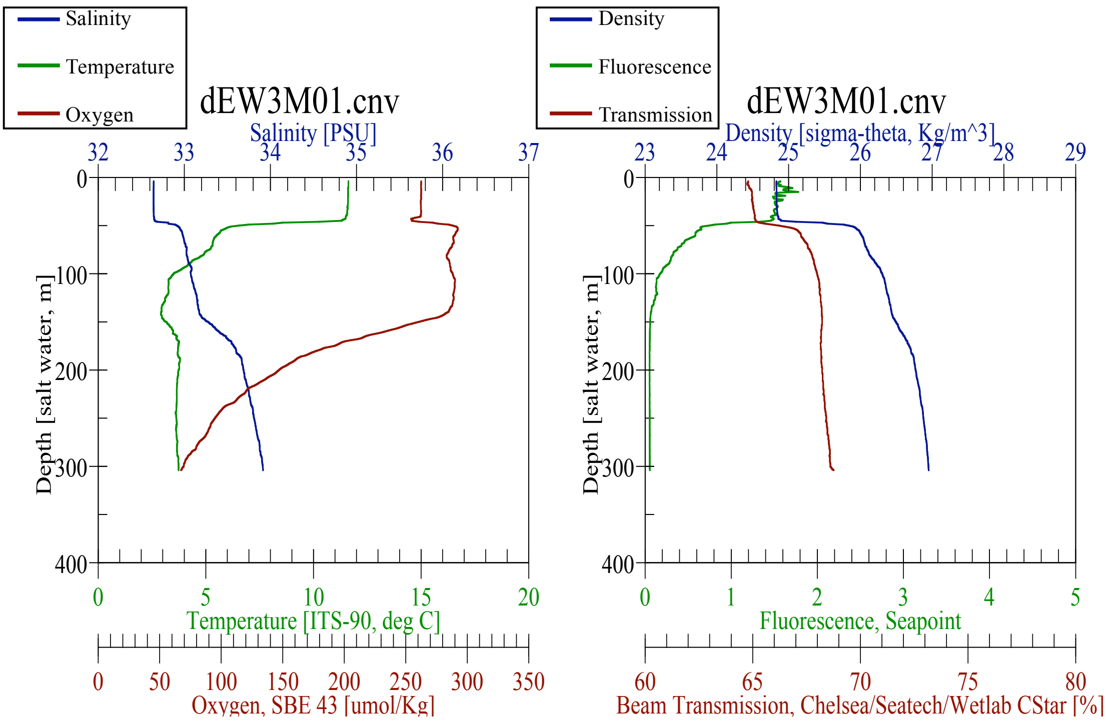


Figure 2.2.1.28: Vertical profiles for the cast of Trace metal of Stn.EW3

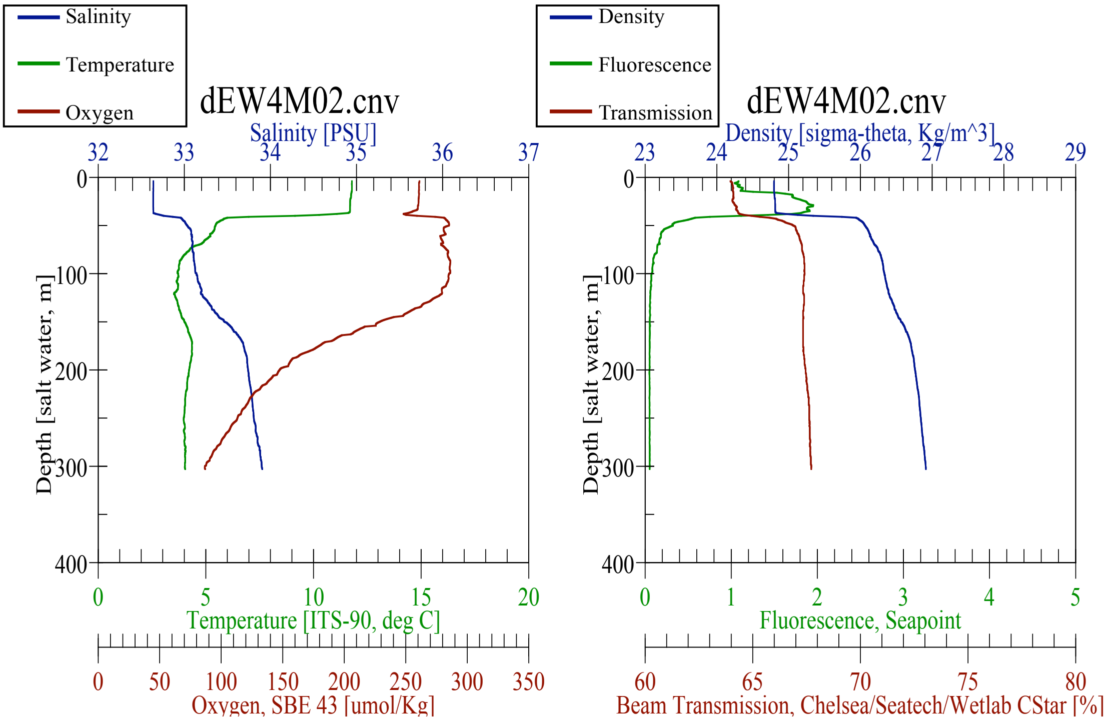


Figure 2.2.1.29: Vertical profiles for the cast of Trace metal of Stn.EW4

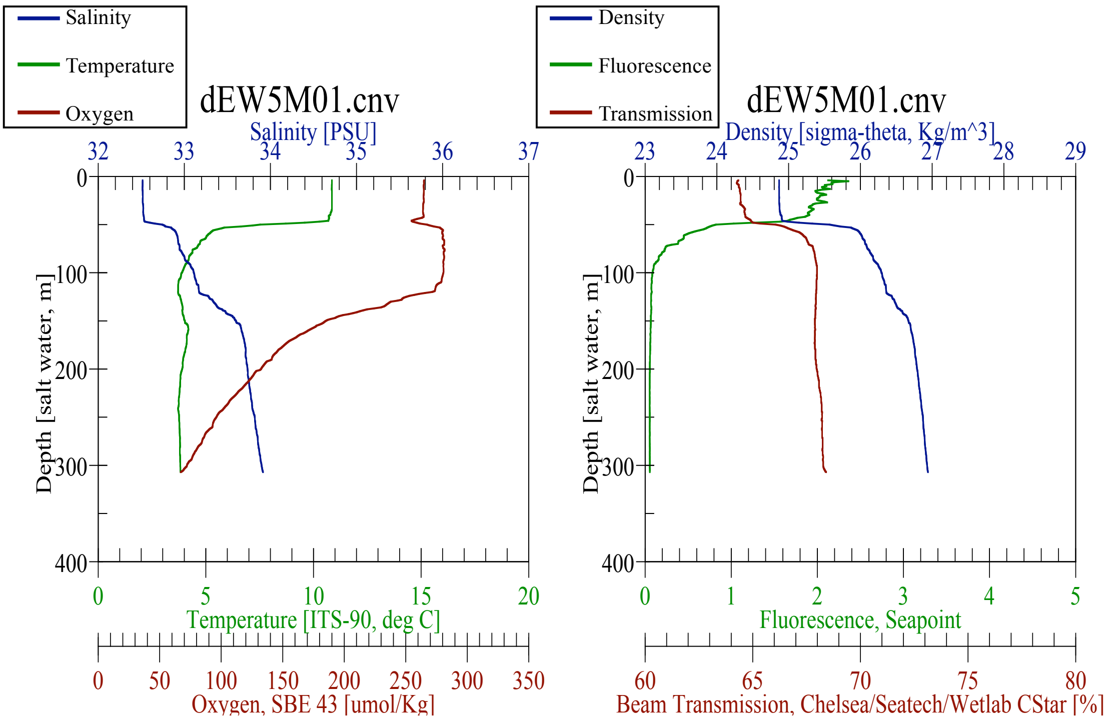


Figure 2.2.1.30: Vertical profiles for the cast of Trace metal of Stn.EW5

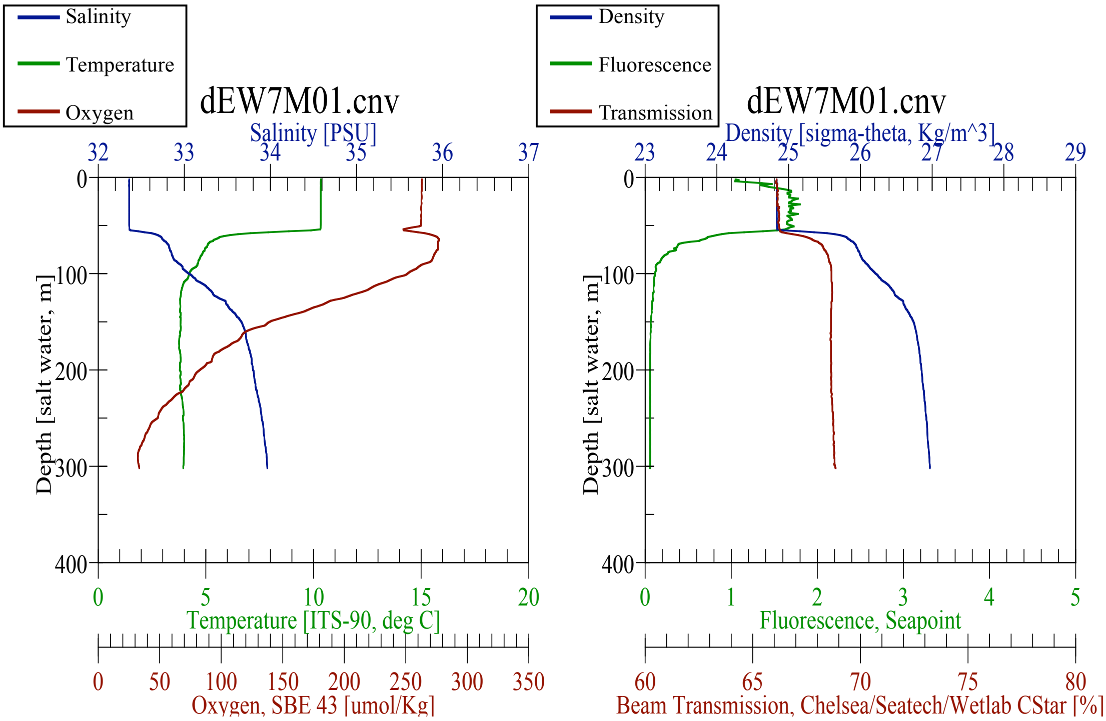


Figure 2.2.1.31: Vertical profiles for the cast of Trace metal of Stn.EW7

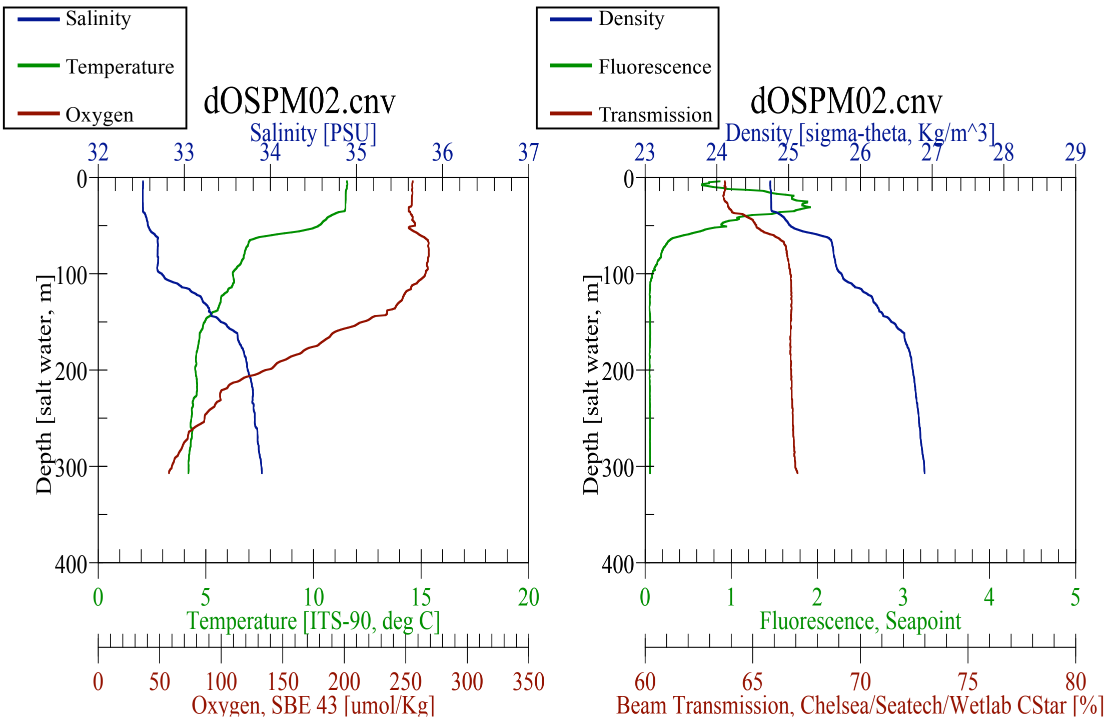


Figure 2.2.1.32: Vertical profiles for the cast of Trace metal of Stn.OSP

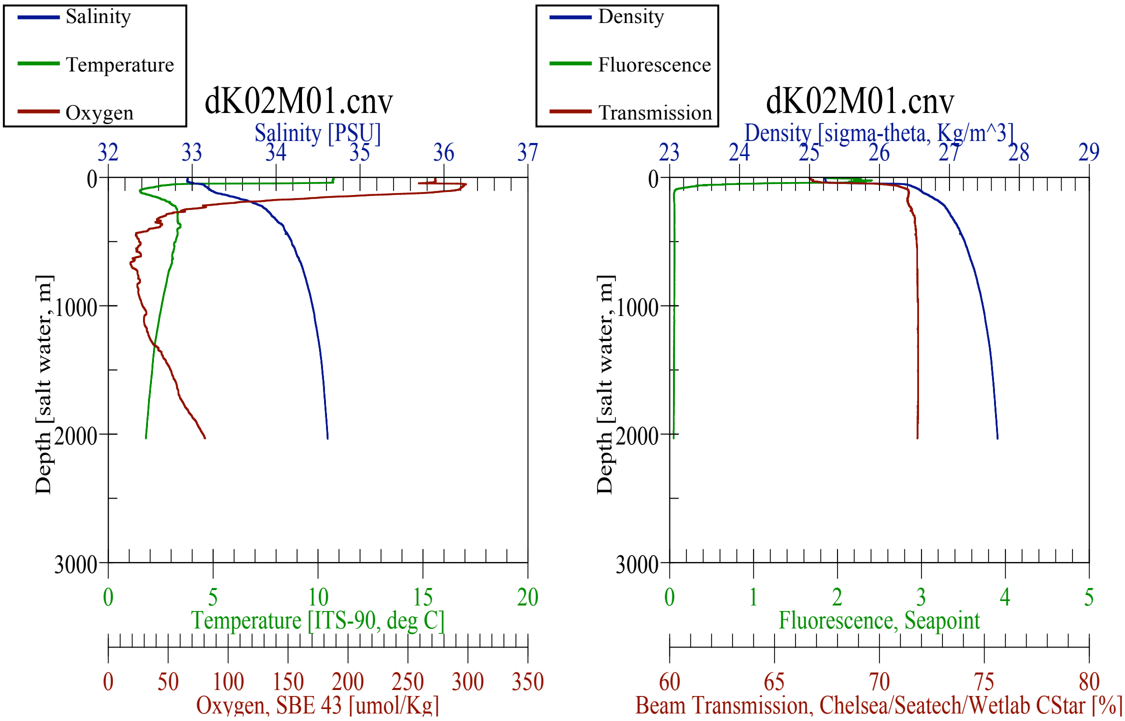


Figure 2.2.1.33: Vertical profiles for the cast of Extra of Stn.K02

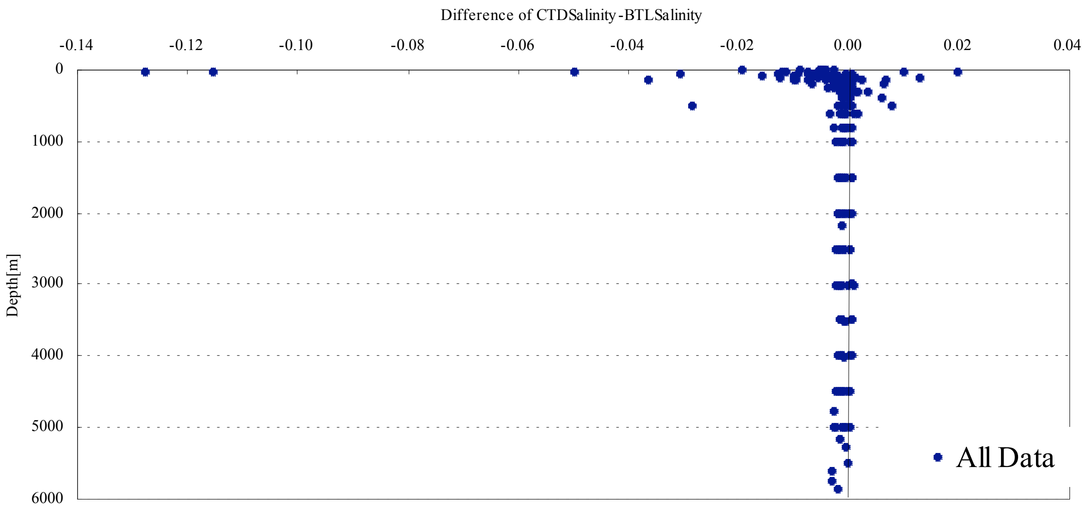


Figure 2.2.1.34: Difference of CTD-salinity and Bottle salinity.

Table 2.2.1 (b) Comparison CTD-salinity and Bottle-salinity

	Sample	Average of the absolute deference	Standard deviation of deference
All data	249	0.005	0.012
Data shallower than 1000m sampling layer	154	0.007	0.015
Data deeper than 1000m sampling layer	95	0.001	0.001

(5) Data archive

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

2.2.2 Salinity measurement

Naoko TAKAHASHI (MWJ) : Operation reader
Hiroshi MATSUNAGA (MWJ)

2.2.2.1 Objectives

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

2.2.2.2 Instrument and Method

2.2.2.2.1 Salinity Sample Collection

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

The kind and number of samples are shown as follows ;

Table 2.2.2.1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	310
Samples for EPCS	36
Total	346

2.2.2.2.2 Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR05-04 using the salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.: S/N 62827) with additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). We also used two pairs of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.). One thermometer monitored an ambient temperature and the other monitored a bath temperature.

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

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

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

Thermometer (Model 9540, Guildline Instruments Ltd.)

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

The measurement system was almost same as Aoyama et al. (2003). The salinometer was operated in the air-conditioned ship's laboratory ‘AUTOSAL ROOM’ at a bath temperature of 24 deg C, very stable and varied within 24 deg C +/- 0.002 deg C on rare occasion.

The measurement for each sample was done with a double conductivity ratio that is defined as median of 31 times reading of the salinometer. Data collection was started in 5 seconds after filling sample to the cell and it took about 10 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In case the difference between the double conductivity ratio of these two fillings is smaller than 0.00002, the average value of these double conductivity ratio was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.0003, we measured eighth filling of the cell. In case the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured ninth and tenth filling of the cell and the median of the double conductivity ratios of five fillings are used to calculate the bottle salinity.

The measurement was conducted about 14hours per day (typically from 8:00 to 22:00) and the cell was cleaned with ethanol or soap or both after the measurement of the day.

2.2.2.3 Preliminary Result

2.2.2.3.1 Standard Seawater

Standardization control of the salinometer with serial number of 62556 was set to 491. During the measurement, the STANDBY of 62556 was 5408 +/- 0001 and ZERO was 0.0-0001. We used IAPSO Standard Seawater batch P145 which conductivity ratio was 0.99981 (double conductivity ratio is 1.99962) as the standard for salinity. We measured 22 bottles of P145.

Fig.2.2.4.1 shows the history of double conductivity ratio of the Standard Seawater batch P145 The average of double conductivity ratio was 1.99962 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

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

Standard seawater (SSW)

batch	:	P145
conductivity ratio	:	0.99981
salinity	:	34.993
preparation date	:	15-Jul.-2004

Time drift of SSW

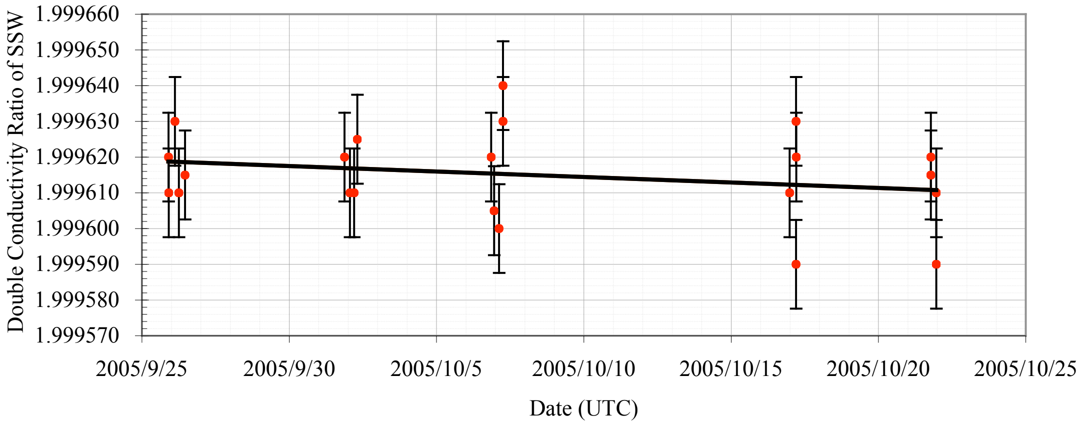


Fig. 2.2.2.3.1 the history of double conductivity ratio of the Standard Seawater batch P145

2.2.2.3.2 Sub-Standard Seawater

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

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

Sub standard seawater (SUB)

sampling cruise ID	:	MR04-05
sampling depth	:	2,000dbar
filtration date	:	10-Sep.-2004
re-filtration date	:	15-Sep.-2005

2.2.2.3.3 Replicate Samples

We took 50 pairs of replicate samples. Fig.2.2.4.3 shows the histogram of the absolute difference between replicate samples, respectively. There was 1 questionable measurement of replicate samples. The standard deviation of the absolute deference of replicate samples was 0.0003 in salinity.

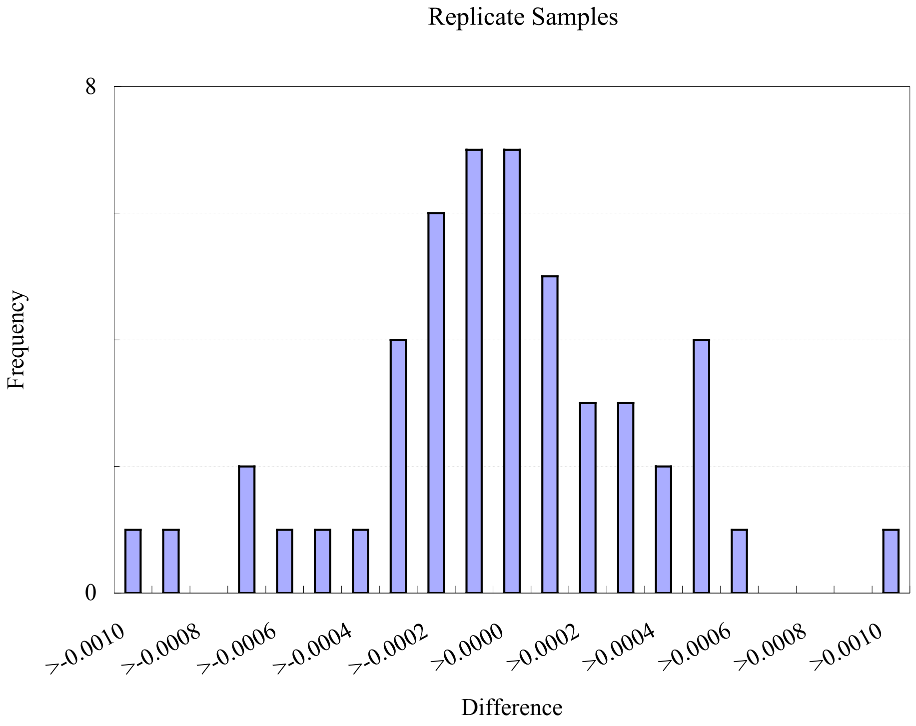


Fig. 2.2.2.3.3 the histogram of the difference between replicate samples

2.2.2.4 Further data quality check

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

2.2.2.5.5 Data correction

Measurement value (double conductivity ratio) of samples of EPCS (Bottle Number from 5031 to 5036) were added 0.00001 as offset.

2.2.2.6 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 Technical Papers in Marine Science, 36, 25 pp., 1981

2.2.3 Shipboard ADCP

Satoshi OKUMURA (Global Ocean Development Inc.)
Kazuho YOAHIDA (GODI)

(1) Parameters

Current velocity of each depth cell [mm/s]
Echo intensity of each depth cell [dB]

(2) Methods

Continuous upper ocean current measurement along ship's track were made using hull-mounted Acoustic Doppler Current Profiler, RD Instruments VM-75 system installed on the centerline and approximately 28 m aft from the bow. The firmware version was 5.59 and the data acquisition software was VmDas Ver.1.3. For most of its operation, the instrument was configured for water-tracking mode recording each ping as the raw data in 8 m x 100 bins from 22.97 m to 822.97 m. Raw data was recorded in beam coordinate, and then converted to earth coordinate using ship's heading data from ship's main gyrocompass (TG-6000; Tokimec, Japan). The position fix data from ship's navigation system was also recorded in NMEA0183 format and merged with ensemble data in the VmDas. Also, 60 seconds and 300 seconds average data were recorded as short-term average (STA) and long-term average (LTA) data.

The system consists of following components;

1. a 75 kHz Broadband (coded-pulse) profiler with 4-beam Doppler sonar operating at 75 kHz (RD Instruments, USA), mounted with beams pointing 30 degrees from the vertical and 45 degrees azimuth from the keel;
2. Ship's main gyro compass (Tokimec, Japan), continuously providing ship's heading measurements to the ADCP;
3. GPS navigation receiver (Leica MX9400) providing position fixes;
4. Data acquisition PC, which clock is adjusted to GPS time every 5 minutes.
5. Additional heading sensor, Inertial Navigation Unit (DRUH; Honeywell, USA) also available for post-processing.

(3) Preliminary results

The system performed almost well under calm weather, but sometimes decreased precision due to rough sea condition. The profiling range was over 600m under calm sea. Fig. 2.2.3.1 shows a summary of surface current vector around north western Pacific. The data was processed using CODAS software; transducer misalignment and scale factor was taken into account but still containing bad profile.

Extremely fast current, not common from EW0 to EW10 in north Pacific, was observed occasionally in the surface layer while steaming, e.g. around Station EW7 shown in Fig. 2.2.3.2. This phenomenon measured by ADCP often appears in the area where the thermocline develops, therefore it might be also concerned in this case (Fig. 2.2.3.3).

(4) Data archives

These data obtained in this cruise will be submitted to the JAMSTEC DMD (Data Management Division), and will be opened to the public via "R/V Mirai Data Web" in JAMSTEC website.

(5) Remarks

Data logging was stopped due to PC trouble from 5:20 to 5:36 (UTC) on 14 October.

Table 2.2.3 Major parameters

Bottom-Track Commands

BP000	-------------------- Bottom Tracking OFF
BP001	-------------------- Bottom Tracking ON/ Ping per ansemble

Environmental Sensor Commands

EA = +00000	-------------------- Heading Alignment (1/100 deg)
EB = +00000	-------------------- Heading Bias (1/100 deg)
ED = 00065	-------------------- Transducer Depth (0-65535dm)
EF = +0001	-------------------- Pitch/Roll Division/Multiplier (pos/neg) [1/99-99]
EH = 00000	-------------------- Heading (1/100 deg)
ES = 35	-------------------- Salinity (0-40 pp thousand)
EX = 11000	-------------------- Coord Transform (Xform; Type; Tilts; 3Bm; Map)
EZ = 1020001	-------------------- Sensor Source(C; D; H; P; R; S; T)

Timing Commands

TE = 00000200	-------------------- Time per Ensemble (hrs; min; sec; sec/100)
TP =	-------------------- Time per Ping (min: sec; sec/100)

Water Track Commands

WA = 255	-------------------- False Target Threshold (Max) (0-255 counts)
WB = 1	-------------------- Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 064	-------------------- Low Correlation Threshold (0-255)
WD = 111111111	------------------ Data Out (V; C; A; PG; St; Vsum; Vsum^2; #G; P0)
WE = 5000	-------------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0800	-------------------- Blank After Transmit (cm)
WG = 001	-------------------- Percent Good Minimum (0-100%)
WM = 1	-------------------- Profiling Mode (1-8)
WN = 100	-------------------- Number of Depth Cells (1-128)
WP = 00001	-------------------- Pings per Ensemble (0-100%)
WS = 0800	-------------------- Depth Cell Size (cm)
WV =	-------------------- Mode 1 Ambiguity Velocity (cm/s radial)

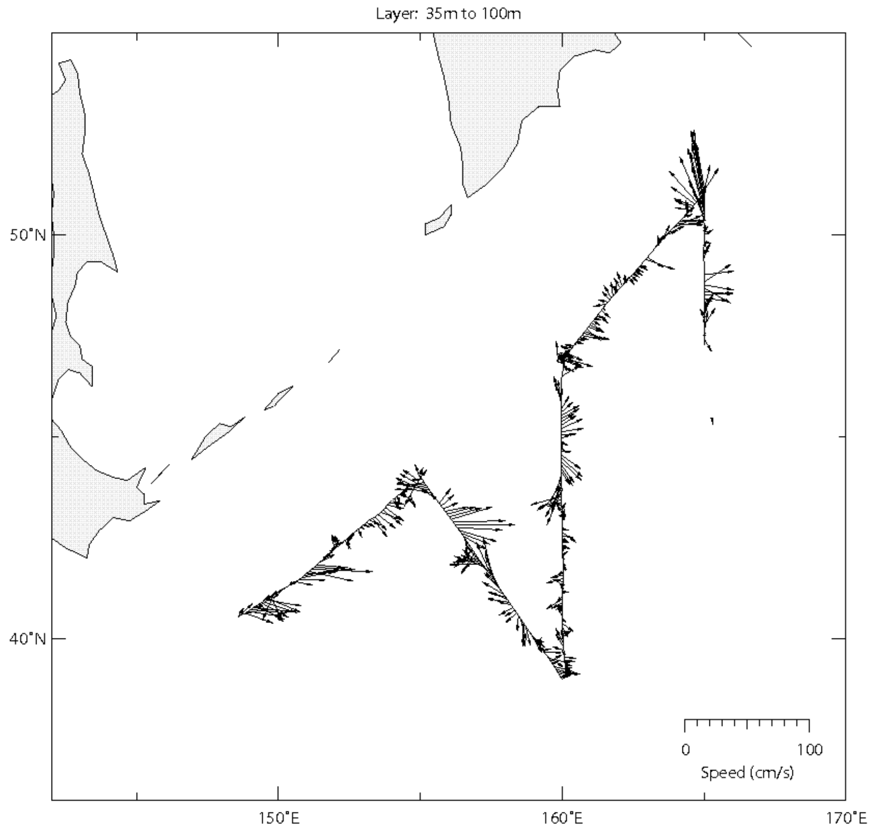


Fig 2.2.3.1 Horizontal velocity vector along ship's track

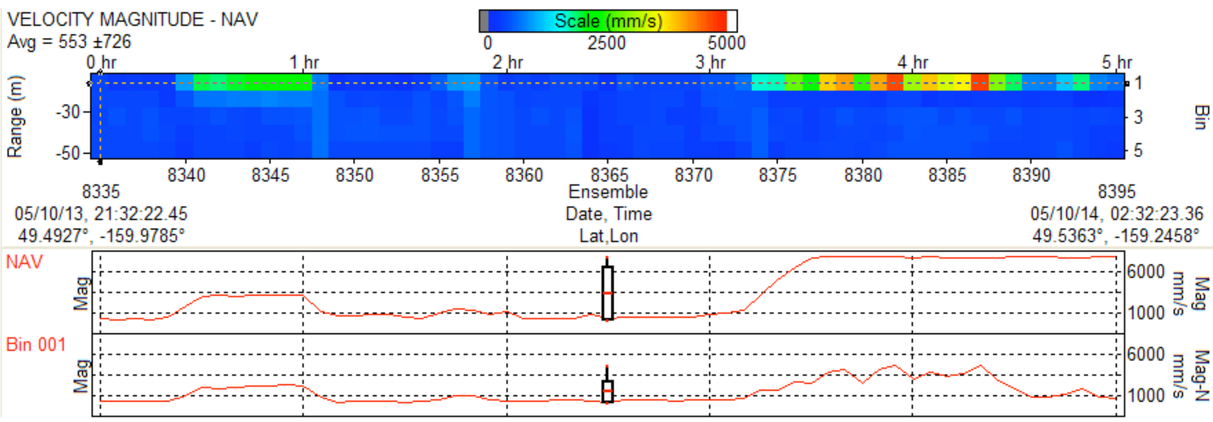


Fig 2.2.3.2　Velocity magnitude profile (color gradation), ship's speed and current velocity of the first layer (line) at station EW7

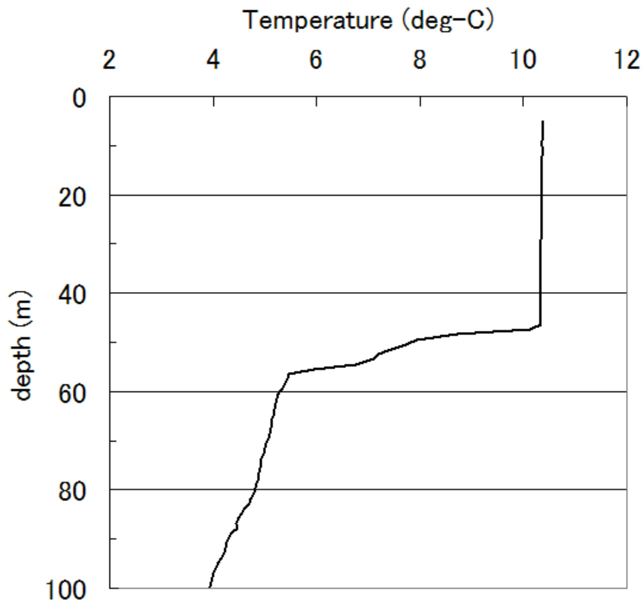


Fig 2.2.3.3 Temperature profile from CTD at station EW7

2.3 Sea surface monitoring: EPCS

Takuhei SHIOZAKI (Marine Works Japan Co. Ltd.)

(1) Objective

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

(2) Methods

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

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

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

a) Temperature and Salinity sensor

SEACAT THERMOSALINOGRAPH

Model:	SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number:	2118859-3126
Measurement range:	Temperature -5 to +35℃, Salinity0 to 6.5 S m-1
Accuracy:	Temperature 0.01 ℃ 6month-1, Salinity0.001 S m-1 month-1
Resolution:	Temperatures 0.001℃, Salinity0.0001 S m-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 ULTRA ANALYTICS JAPAN, INC.
Serial number:	47477
Measurement range:	0 to 14 ppm
Accuracy:	±1% at 5 ℃ of correction range

Stability: 1% month-1

d) Fluorometer

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

e) Particle Size sensor

Model:	P-05, Nippon Kaiyo LTD.
Serial number:	P5024
Measurement range:	0.2681 mm to 6.666 mm
Accuracy:	±10% of range
Reproducibility:	±5%
Stability:	5% week-1

f) Flow meter

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

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

14-Sep.-‘05 11:01 to 24-Oct.-’05 22:10

(3) Preliminary Result

Preliminary data of temperature (Bottom of ship thermometer), salinity, dissolved oxygen, fluorescence at sea surface between this cruise are shown in Figs. 1-4. These figures were drawn using Ocean Data View (R. Schlitzer, http://www.awi-bremerhaven.de/GEO/ODV, 2002).

(4) Date archive

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

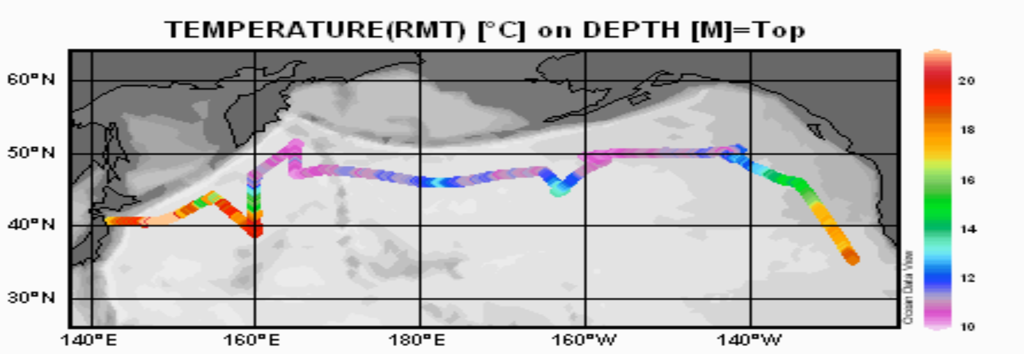


Fig.1 Contoour line of temperature

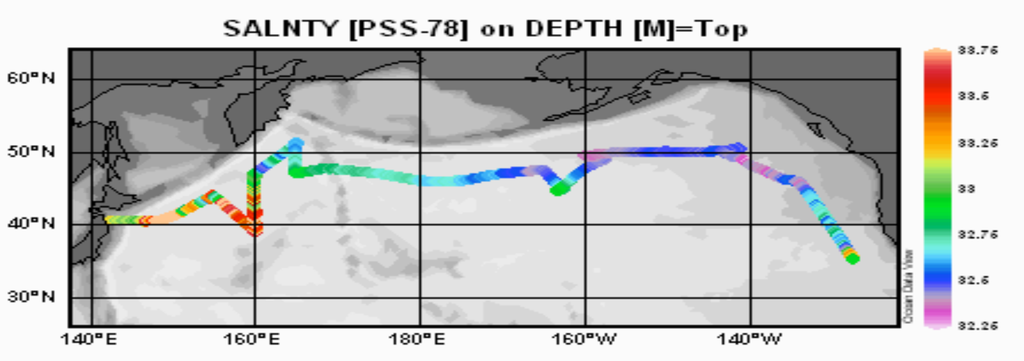


Fig.2 Contoour line of salinity

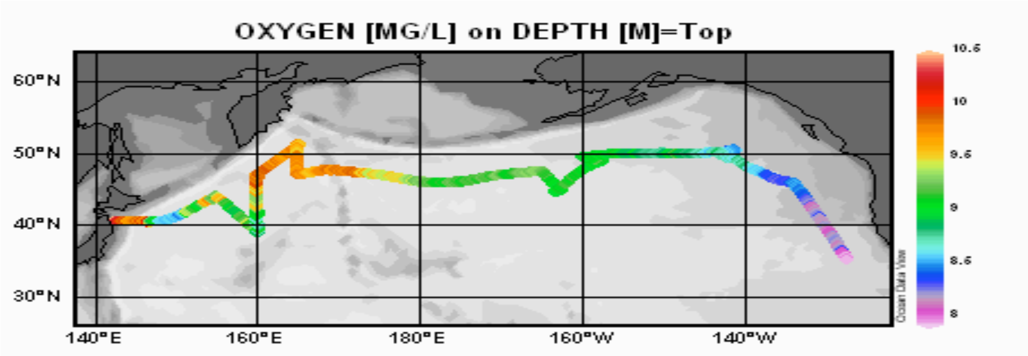


Fig.3 Contoour line of oxygen

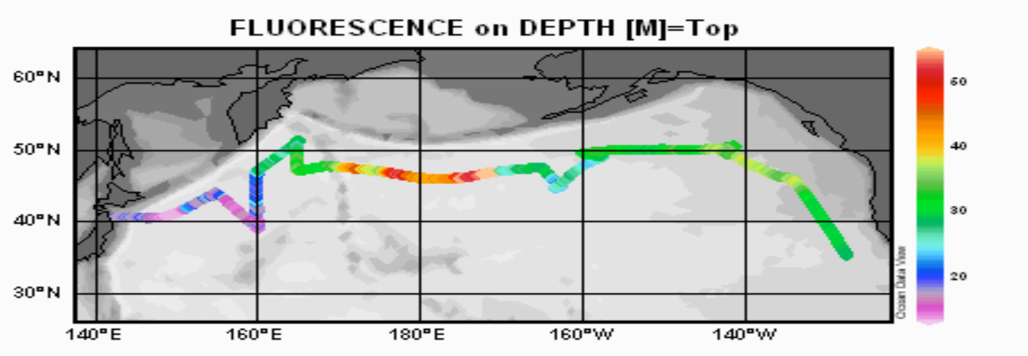


Fig.4 Contoour line of fluorescence*

* Because of the flow-cell cleaning, fluorescence has descended since 2005/10/8 11:37

2.4 Dissolved oxygen

Takuhei SHIOZAKI (Marine Works Japan Co. Ltd.)

(1) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(2) Methods

1) Reagents:

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

2) Instruments:

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

3) Sampling

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

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

4) Sample measurement

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

5) Standardization and determination of the blank

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

The blank from the presence of redox species apart from oxygen in the reagents was determined as follows. 1 and 2 cm^3 of the standard potassium iodate solution were added to two flasks respectively. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the two flask in order. The blank was determined by difference between the two times of the first (1 cm^3 of KIO_3) titrated volume of the sodium thiosulfate and the second (2 cm^3 of KIO_3) one. The averaged blank of DOT-1 and DOT-2 were –0.011 and –0.006 cm^3 , respectively. Most of them are negative, implying that there are deoxidizers in the reagents.

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

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

Date	KIO_3		DOT-1 (cm^3)			DOT-2 (cm^3)		
(UTC)	#	Bottle	$Na_2S_2O_3$	E.P.	blank	$Na_2S_2O_3$	E.P.	Blank
2005/9/17	1	20050829-01	20050916-1	3.959	-0.013	20050916-1	3.962	-0.006
2005/9/19		20050829-02	20050916-1	3.957	-0.012	20050916-1	3.960	-0.002
2005/9/24		20050829-03	20050916-1	3.957	-0.012	20050916-1	3.961	-0.007
2005/9/27		20050829-04	20050916-1	3.956	-0.009	20050916-1	3.958	-0.008
2005/9/29		20050829-05	20050916-1	3.956	-0.009	20050916-1	3.959	-0.006
2005/10/2		20050829-06	20050916-1	3.959	-0.012	20050916-1	3.958	-0.012
2005/10/6		20050829-07	20050916-3	3.960	-0.010	20050916-3	3.961	-0.007
2005/10/13		20050829-08	20050916-3	3.964	-0.007	20050916-3	3.963	-0.001
2005/10/18		20050829-09	20050916-3	3.963	-0.009	20050916-3	3.961	-0.004

6) Reproducibility of sample measurement

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

Table 2 Results of the replicate sample measurements

Number of replicate sample pairs	Oxygen concentration (μmol/kg)
	Standard Deviation.
41	0.135

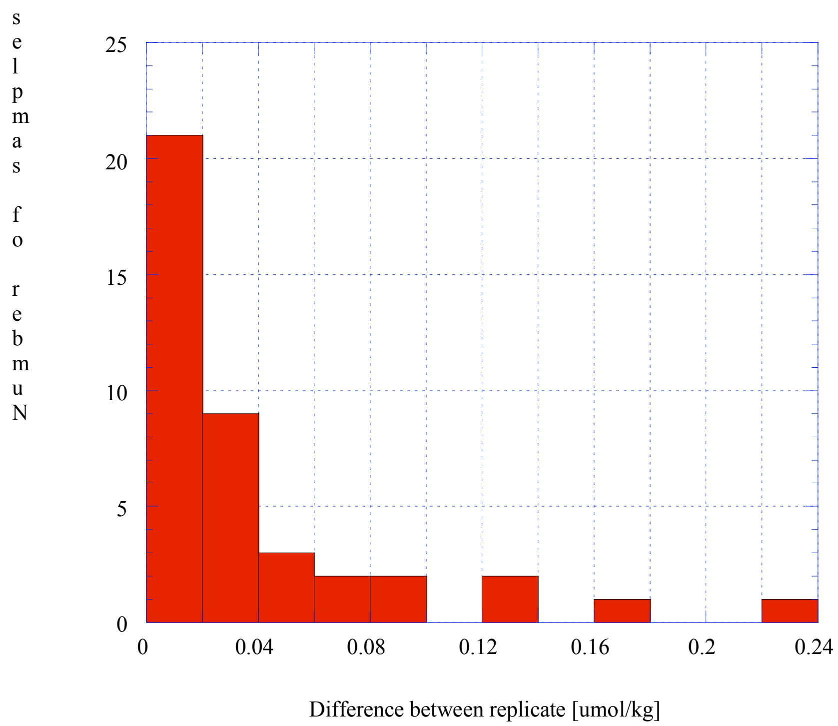
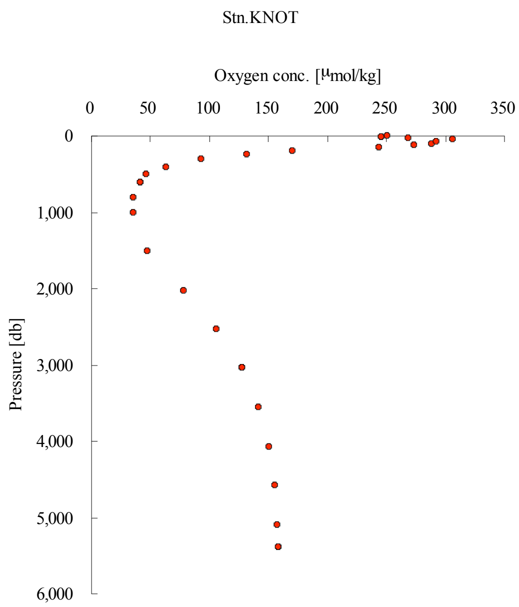
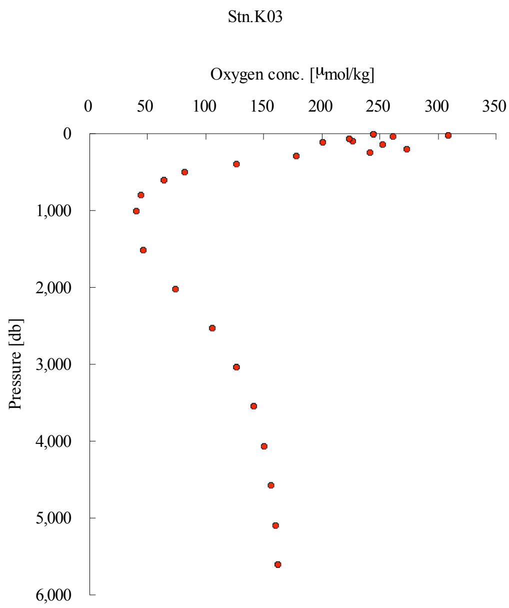


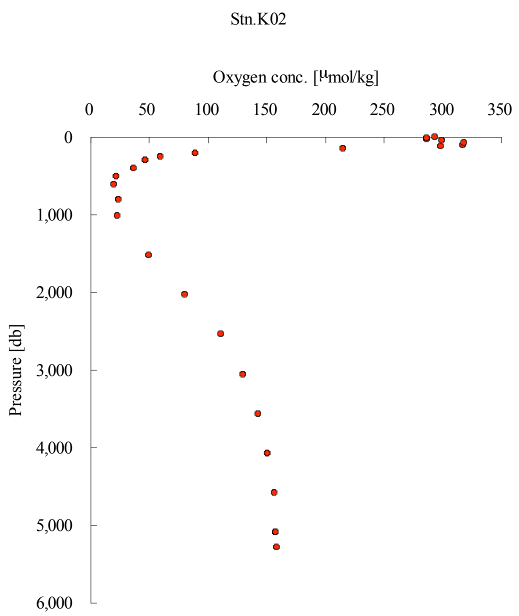
Fig.1 Results of the replicate sample measurements

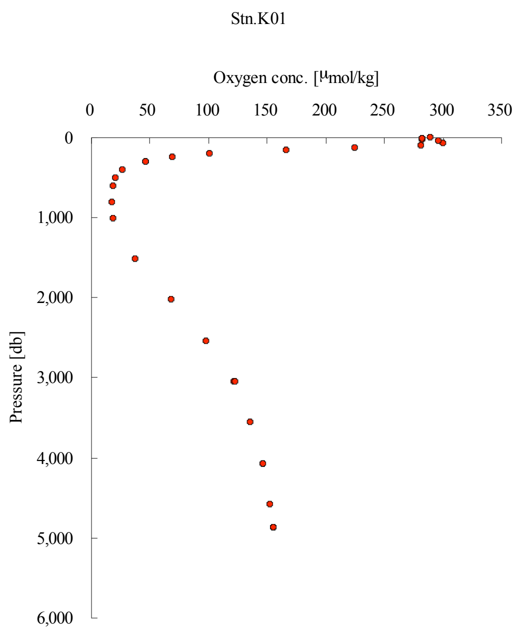
(3) Preliminary results

During this cruise we measured oxygen concentration in 299 seawater samples at 11 stations. Vertical profiles show Figs 2 at each cast.

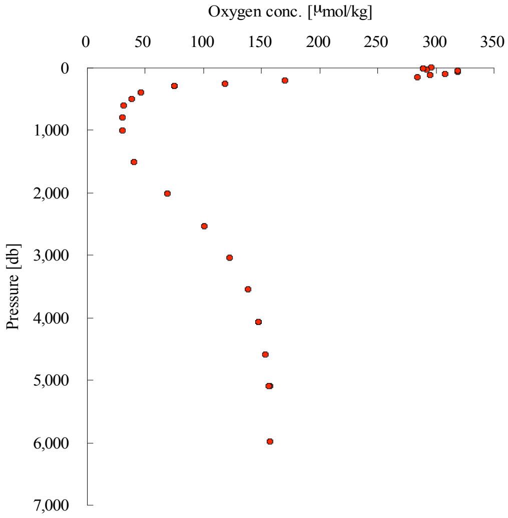




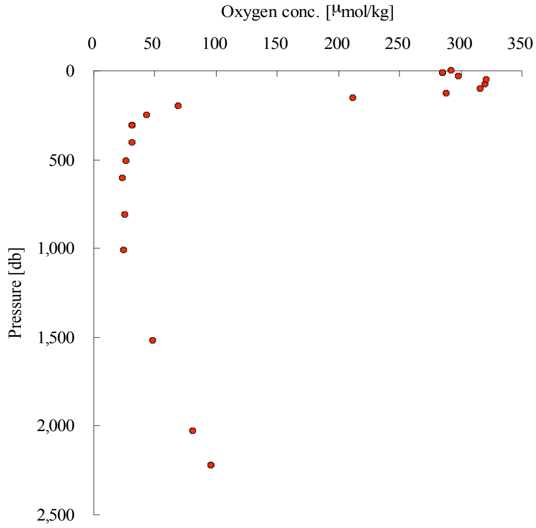




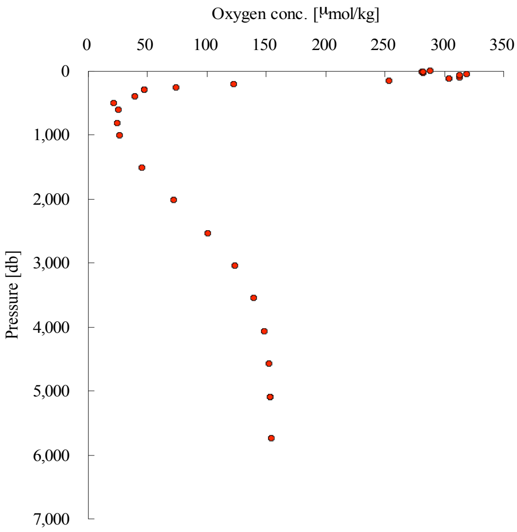
EW0



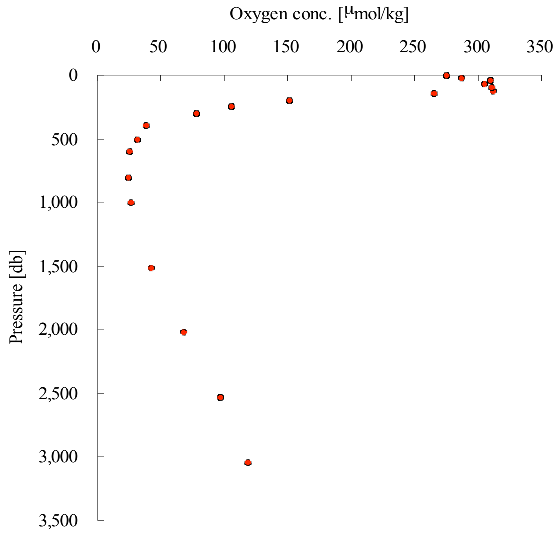
EW1



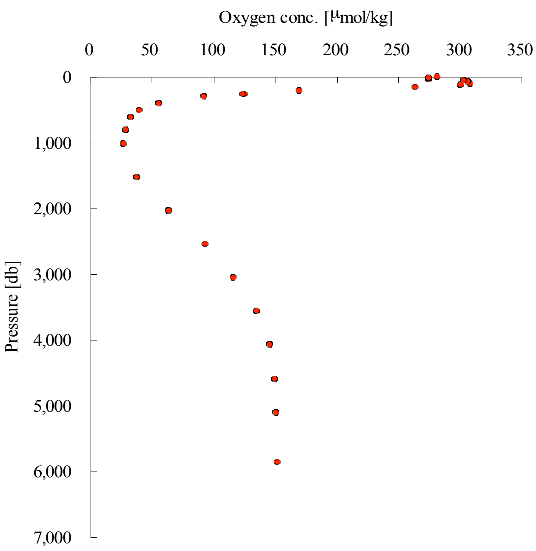
EW2



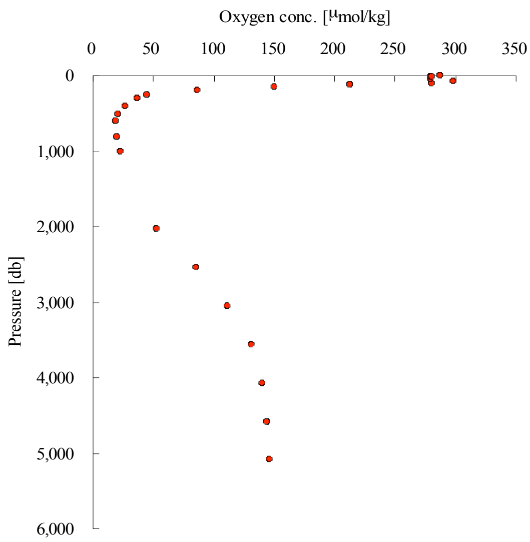
EW3

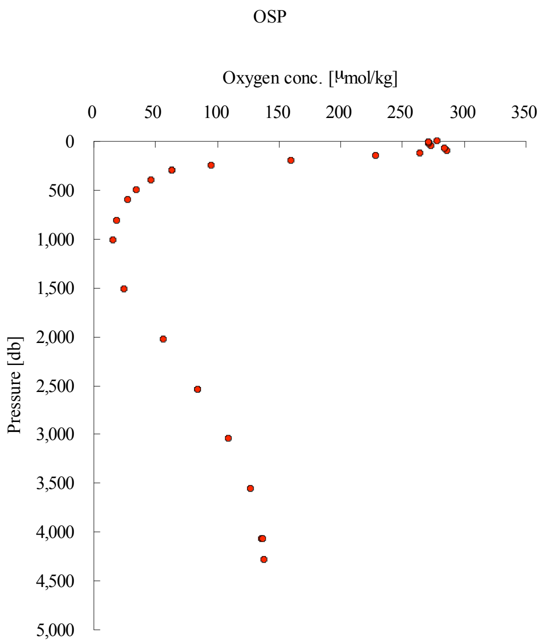


EW4



EW7





Figs.2 Vertical profiles at each station

References:

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

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

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

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

2.5 Nutrients

Junko HAMANAKA (MWJ)
Junji MATSUSHITA (MWJ)

1. Objectives

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

2. Methods or Apparatus & Performance

Nutrient analysis was performed on the BRAN+LUEBBE TRAACS 800 systems. The system of analysis was improved which proposed for nutrients of seawater by BRAN+LUEBBE.

The laboratory temperature was maintained between 22-25 deg C.

a. Measured Parameters

Nitrite: Nitrite was determined by diazotizing with sulfanilamide and coupling with N-1-naphthyl-ethylenediamine (NED) to form a colored azo dye that was measured absorbance of 550 nm using 5 cm length cell.

Nitrate: Nitrate in seawater is reduced to nitrite by reduction tube (Cd - Cu tube), and the nitrite determined by the method described above, but the flow cell used in nitrate analysis was 3 cm length cell. Nitrite initially present in the sample is corrected.

Silicate (Although silicic acid is correct, we use silicate because a term of silicate is widely used in oceanographic community.): The standard AAII molybdate-ascorbic acid method was used. The silicomolybdate produced is measured absorbance of 630 nm using a 3 cm length cell.

Phosphate: The method by Murphy and Riley (1962) was used with separate additions of ascorbic acid and mixed molybdate-sulfuric acid-tartrate. The phospho-molybdate produced is measured absorbance of 880 nm using a 5 cm length cell.

Ammonia: Ammonia in seawater was mixed with an alkaline solution containing EDTA, ammonia as gas state was formed from seawater. The ammonia (gas) was absorbed in sulfuric acid solution by way of 0.5 μm pore size membrane filter (ADVANTEC PTFE) at the dialyzer attached to analytical system. The ammonia absorbed in acid solution was determined by coupling with phenol and hypochlorite solution to from an indophenol blue compound. That compound produced is measured absorbance of 630 nm using a 3 cm length cell.

Nutrients reported in micromoles per kilogram were converted from micromoles per liter by dividing by density calculated at sample temperature.

b. Nutrients Standard

Silicate standard solution, the silicate primary standard, was obtained from Kanto Chemical CO., Inc. This standard solution was 1000 mg per litter with 0.5 M KOH and prepared for ICP analysis. Primary standard for nitrate (KNO_3), nitrite ($NaNO_2$), phosphate (KH_2PO_4) and ammonia ($(NH_4)_2SO_4$) were obtained from Wako Pure Chemical Industries, Ltd.

c. Sampling Procedures

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

d. Low Nutrients Sea Water (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.45 µm pore size membrane filter. This water is stored in 20-liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in March 2005.

3. Preliminary Results

Analytical precisions were 0.12% (55 µM) for nitrate, 0.09% (1.2 µM) for nitrite, 0.08% (172 µM) for silicate, 0.12% (3.6 µM) for phosphate and 0.29% (4.0 µM) for ammonia in terms of median of precision, respectively.

Results of RMNS analysis are shown in Table 2.5.

Table 2.5. Summary of RMNS concentrations

µmol/kg

		NO3	NO2	SiO2	PO4	NH4
RM-AS	median	0.14	0.01	1.68	0.078	0.82
	stdev	0.02	0.00	0.04	0.011	0.02
	n=	15	15	16	15	14
RM-AT	median	7.49	0.02	18.40	0.591	0.71
	stdev	0.03	0.00	0.05	0.011	0.02
	n=	15	15	16	15	14
RM-AU	median	29.99	0.01	68.25	2.186	0.52
	stdev	0.06	0.00	0.15	0.011	0.02
	n=	28	28	30	28	13

2.6 pH measurement

Fuyuki SHIBATA (MWJ)
Minoru KAMATA (MWJ)
Yoshiko ISHIKAWA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. When more than two of the four parameters are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of total alkalinity (TA) and pH during MR05-04cruise.

(2) Measured Parameters

pH (Total hydrogen ion concentration scale)

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 11 stations. Seawater was sampled in a 125ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 2 hours and was cleaned by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 10 seconds with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. The bottles were put in the water bath kept about 25℃ before the measurement.

(3)-2 Seawater analysis

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

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

The e.m.f. of the glass / reference electrode cell was measured with a pH / Ion meter (Radiometer PHM95). Separate glass (Radiometer PHG201) and reference (Radiometer REF201) electrodes were used. In order not to have seawater sample exchange CO_2 with the atmosphere during pH measurement, closed glass bottle was used. The temperature during pH measurement was monitored with temperature sensor (Radiometer T901) and controlled to 25℃

within ±0.1℃.

To calibrate the electrodes the TRIS (pH=8.0865 pH unit at 25℃, Delvalls and Dickson, 1998) and AMP (pH=6.7838 pH unit at 25℃, Dickson and Goyet, 1996) in the synthetic seawater (S=35 PSU) (Total hydrogen scale) were applied.

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

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

where electrode response "ER" is calculated as follows:

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

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

$$ER = RT\ LN(10) / F = 59.16\ mV / pH\ unit\ at\ 25℃$$

(4) Preliminary results

A replicate analysis was made on every 4th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.6-1). The average of the difference was 0.001 pH unit (n=43 pairs). The standard deviation was 0.001 pH unit, which indicates that the analysis was accurate enough according to DOE (1994).

(5) Data Archive

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

Reference

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

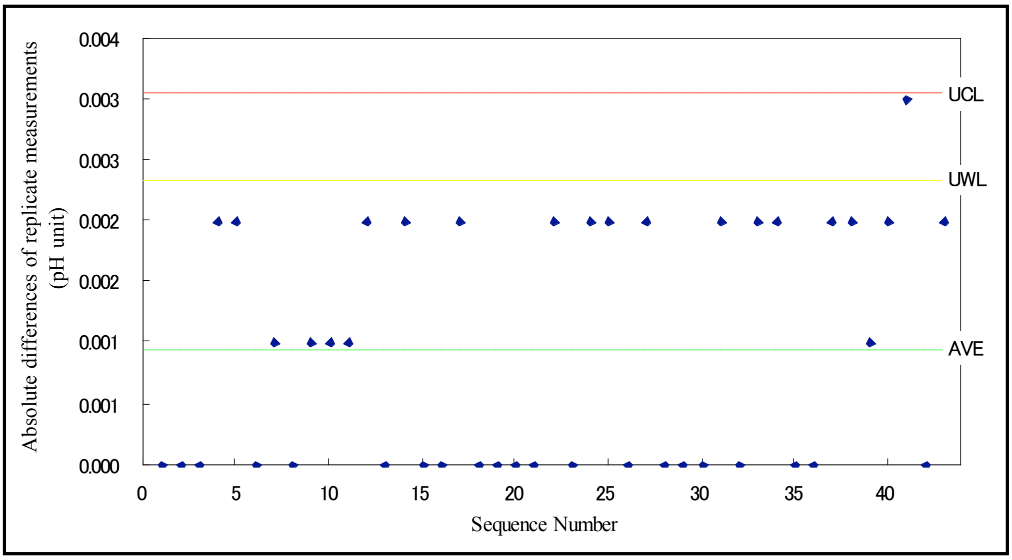


Figure 2.6-1 Range control chart of the absolute differences of replicate measurements carried out in the analysis of pH during the MR05-04 cruise.

2.7. Total Dissolved Inorganic Carbon –TDIC-

2.7.1. Water column TDIC

Fuyuki SHIBATA (MWJ)
Minoru KAMATA (MWJ)
Yoshiko ISHIKAWA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. In stead, there are four parameters (alkalinity, total dissolved inorganic carbon, pH and pCO_2) that could be measured and if two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). The following measurements were carried out in order to acquire data of total dissolved inorganic carbon (TDIC) during MR05-04 cruise.

(2) Measured Parameters

Total dissolved inorganic carbon

(4) Apparatus and performance

(4)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 11 stations. Seawater was sampled in a 250ml glass bottle. The glass bottle was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 3 hours and was cleansed by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out in order to let the sample calmly be introduced to the bottle. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. Prior to the analysis, 3ml of the sample (1% of the bottle volume) was removed from the glass bottle in order to make a headspace. The samples were then poisoned with 100μl of over saturated solution of mercury chloride within one hour from the sampling point. After poisoning, the samples were sealed using grease (Apiezon M grease) and a stopper-clip. The samples were stored in a refrigerator at approximately 5℃ until analyzed.

(4)-2 Seawater analysis

The system was connected to a Model 5012 coulometer (Carbon Dioxide Coulometer, UIC Inc.), an automated sampling and CO_2 extraction system controlled by a computer (JANS, Inc.). The concentration of TDIC was measured as followings.

The sampling cycle was composed of 3 measuring factors; 70ml of standard CO_2 gas

(2% CO_2 - N_2 gas), 2ml of 10%-phosphoric acid solution and 6 seawater samples. The standard CO_2 gas was measured to confirm the constancy of the calibration factor during a run and phosphoric acid was measured for acid blank correction.

From the glass bottle, approximately 20ml of seawater was measured in a receptacle and was mixed with 2ml of 10%-phosphoric acid. The carbon dioxide gas evolving from the chemical reaction was purged by nitrogen gas (carbon dioxide free) for 12 minutes at the flow rate of 140ml/min. and was absorbed into an electrolyte solution. In the electrolyte solution, acids forming from the reaction between the solution and the absorbed carbon dioxide were titrated with hydrogen ions in the coulometer and the counts of the titration were stored in the computer.

Before any of the samples were measured, the calibration factor (slope) was calculated by measuring series of sodium carbonate solutions (0~2.5mM) and this calibration factor was applied to all of the data acquired throughout the cruise. By measuring Certified Reference Material (CRM batch 69: Scripps Institution of Oceanography) at the beginning of every run series, the slope was calibrated with the counts of this outcome. A measurement value of CRM was 1907. 5 $\pm$ 0.8μmol/kg(n=6). This value almost coincided with a certificated value(1097.63μmol/kg). A reference material (RM batch Q11) was also measured for every run in the beginning and in the middle and in the end to calibrate the inclination of the outcome that occurs during the run due to the drift in the reaction of the solution. RM was prepared in JAMSTEC by a similar procedure of CRM preparation. A measurement value of RM(batch Q11) was 2044.4$\pm$0.4μmol/kg(n=6). This value was almost coincided with a measurement value of RM(Q11) in MR05-02(2044.8$\pm$0.7μmol/kg(n=7). A fresh set of cell solution was limited to measure samples from only 2 stations (approximately 72 samples).

(5) Preliminary results

During the cruise, 460 samples including RM and CRM were analyzed for TDIC. A replicate analysis was made on every forth seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.7.1.-1.). The average of the differences was 1.0 µmol/kg (n=41). The standard deviation was 0.9 µmol/kg which indicates that the analysis was accurate enough according to DOE (1994).

(6) Data Archive

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

Reference

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

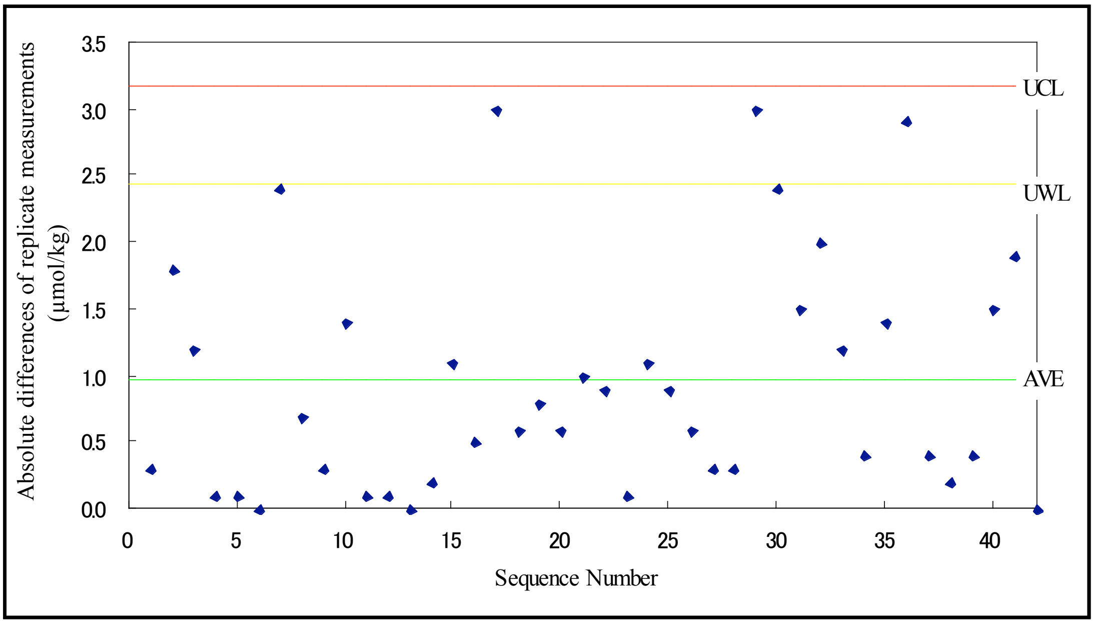


Figure 2.7.1-1 Range control chart of the absolute differences of replicate measurements carried out in the analysis of TDIC during the MR05-04 cruise.

2.7.2 Underway Total Dissolved Inorganic Carbon Measurement

Minoru KAMATA (MWJ)
Yoshiko ISHIKAWA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. If two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of total dissolved inorganic carbon during MR04-04 cruise.

(2) Measured Parameters

Total dissolved inorganic carbon

(3) Materials and Methods

Surface seawater was continuously collected from 16th Sep 2005 to 19th Oct 2005 during this cruise. Surface seawater was collected continuously by a pump from bottom of this ship (depth of 4.5m). The TDIC of the introduced surface seawater was constantly measured by a coulometer that was set to analyze surface seawater specifically. The coulometric measurement is same as described in 2.7.1.

Before the samples were measured, the calibration factor (slope) was calculated by measuring series of sodium carbonate solutions (0~2.5mM) and this calibration factor was applied to all of the data acquired throughout the cruise. By measuring of RM (batch Q12: 2048.3±0.6 μmol/kg (n=2); JAMSTEC) every time the cell was filled with fresh anode and cathode solutions, the slope was calibrated with the counts of this outcome. This RM of a concentration of TDIC was calculated with measuring the Certified Reference Material (CRM batch 69: 1907.63±0.18 μmol/kg; SIO) .The set of cell solutions was changed in every three days.

(4) Preliminary results

Figure 2.7.1 is showing the results of measuring the TDIC concentration of surface seawater samples. During the cruise, 18 bottles of RM (batch Q12) was analyzed in order to calibrate the slope of the calibration factor. The standard deviation of the absolute differences of duplicate measurements was 1.0 μmol/kg (n=18).

(5) Data Archive

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

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

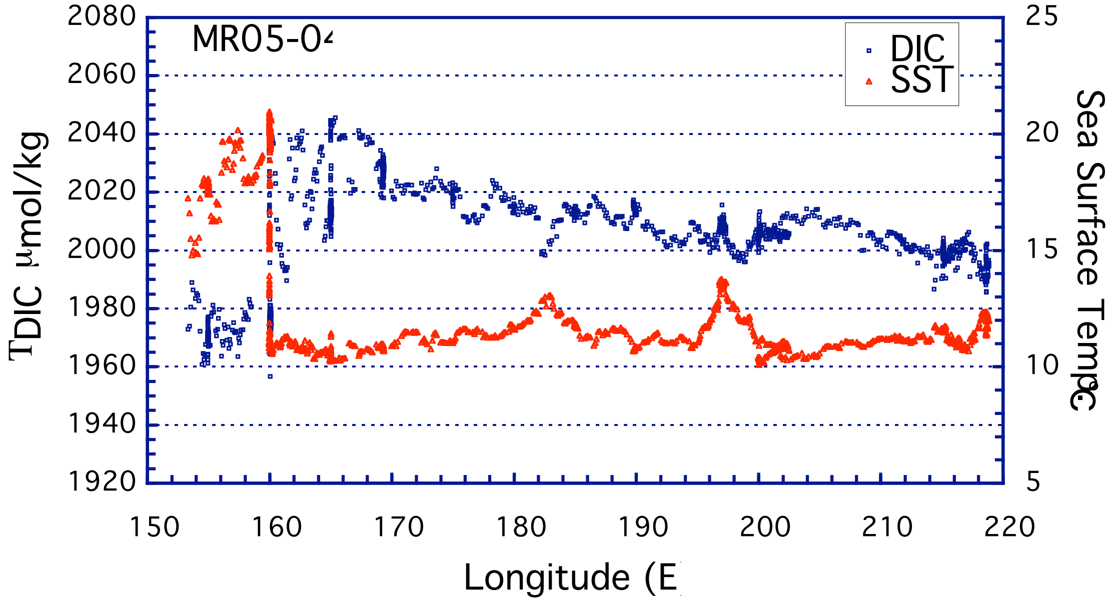


Figure 2.7.2 TDIC concentration (blue) in surface seawater and SST (red) in this cruise

2.8 Total alkalinity measurement

Fuyuki SHIBATA (MWJ)
Minoru KAMATA (MWJ)
Yoshiko ISHIKAWA (MWJ)

(1) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. In stead, there are four parameters (alkalinity, total dissolved inorganic carbon, pH and pCO_2) that could be measured and if two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). The following measurements were carried out in order to acquire data of total alkalinity (TA) during MR05-04 cruise.

(2) Measured Parameters

Total alkalinity

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 11 stations. Seawater was sampled in a 125ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent solution (pH13) for at least 2 hours and was cleaned by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 12 seconds. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. The bottles were put in the water bath kept about 25℃ before the titration.

(3)-2 Seawater analysis

The method of total alkalinity measurement was that approx. 50ml of seawater was placed in a 100ml tall beaker with a Knudsen pipette, and titrated with a solution of 0.05M hydrochloric acid. The acid was made up in a solution of sodium chloride background (0.7M) to approx. the ionic strength of seawater. The titration carried out adding the acid to seawater past carbonic acid point with a set of electrodes used to measure electromotive force at 25 degree C. After titration, the data of titrated acid volume and electromotive force and seawater temperature pipetted were calculated to total alkalinity.

The titration system consisted of a titration manager (Radiometer, TIM900), an auto-burette (Radiometer, ABU901), a pH glass electrode (pHG201-7), a reference electrode (Radiometer, REF201), a thermometer (Radiometer, T201) and a computer installed burette operation software (Lab Soft, Tim Talk 9) and calculated total alkalinity.

. Before any of the samples were measured, the calibration factor (acid concentration) was calculated by measuring series of sodium carbonate solutions (0.5~2.5mM) and this calibration factor was applied to all of the data acquired throughout the cruise. By measuring Certified Reference Material (CRM batch 69: Scripps Institution of Oceanography) before all samples were measured, the factor was calibrated. Filtered seawater measurement during every run was carried out before and after samples were measured.

(4) Preliminary results

A duplicate analysis was made on every 6th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.8-1). The average of the difference was 1.3 μmol/kg (n= 13 pairs). The standard deviation was 1.05 μmol/kg which indicates that the analysis was accurate enough according to DOE (1994).

(5) Data Archive

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

(6) Reference

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

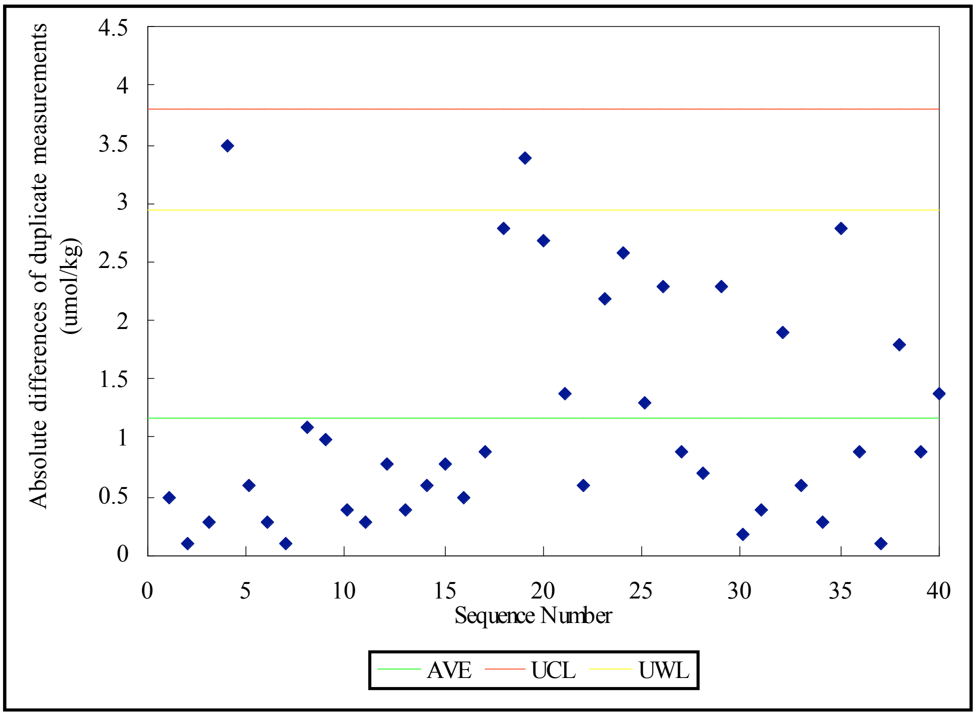


Figure 2.8-1. Range control chart of the absolute differences of duplicate measurements carried out in the analysis of TA during the MR05-04 cruise.

2.9. Underway pCO_2 measurement

Minoru KAMATA (MWJ)
Yoshiko ISHIKAWA (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, because the magnitude of the anticipated global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise, we are aimed at quantifying how much anthropogenic CO_2 absorbed in the surface ocean in the Southern Hemisphere, where data for CO_2 are sparse. For the purpose, we measured pCO_2 (partial pressure of CO_2) in the atmosphere and surface seawater.

(2) Measured Parameters

Partial pressure of CO_2 in the atmosphere and surface seawater

(3) Apparatus and performance

Concentrations of CO_2 in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (BINOS^{TM}). The automated system was operated by on one and a half hour cycle until 4th Oct., then on 3 hours cycle for controlling a use of standard gases. In one cycle, standard gasses, marine air and an equilibrated air with surface water were analyzed subsequently. The concentrations of the standard gas were 262.95, 320.44, 381.03 and 420.75 ppm. The standard gases will be recalibrated after MR05-05 cruise.

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

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

(4) Preliminary results

Figure 2.9 is showing the results of measuring the CO_2 concentration (pCO_2) of ambient air samples and the seawater samples.

(5) Data Archive

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

Reference

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

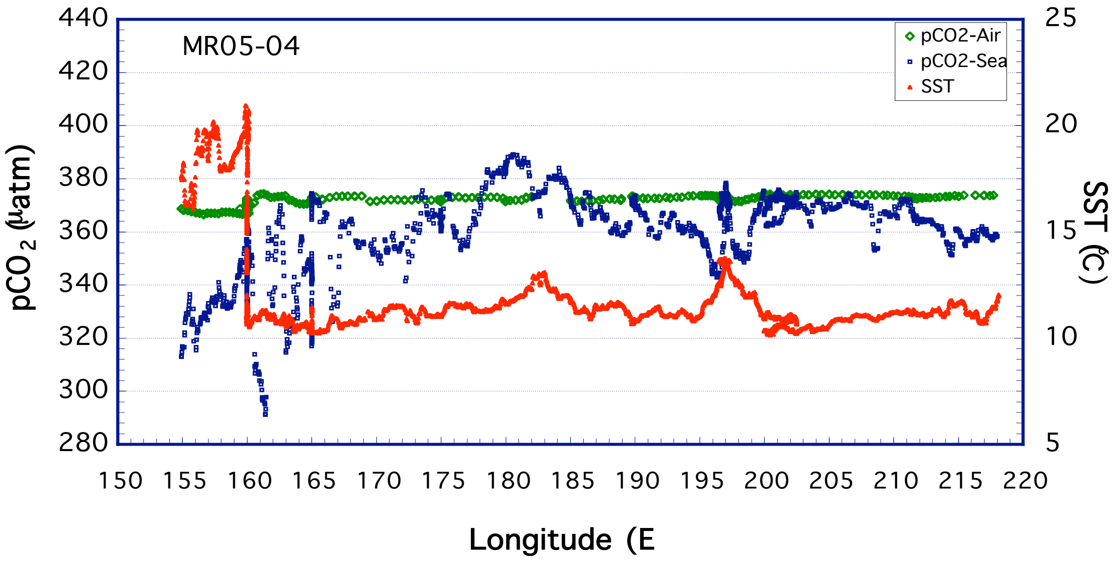


Figure 2.9 Partial pressure of CO_2 (pCO_2) in atmosphere (green) and surface seawater (blue), and SST (red) in this cruise.

3. Special observation
3.1 North Pacific Time-series observatory (HiLaTS)

Makio HONDA (JAMSTEC MIO)
Toru IDAI (MWJ)

3.1.1 Recovery, deployment and instruments

(1) Deployment and Recovery

Two types of mooring systems were designed and deployed: one for physical oceanography (PO mooring) and another for biogeochemistry (BGC mooring). We recovered one BGC mooring at Station K-2 which was deployed at MR05-01 and deployed each one PO and BGC mooring at Station K-2 in the Western Subarctic Gyre. It is 47N / 160E, where is close to station KNOT and, however, structure of water mass is more stable than station KNOT. Before deployment, sea floor topography was surveyed with Sea Beam. In order to place the top of mooring systems in the surface euphotic layer, precise water depths for mooring positions was measured by an altimeter (Datasonics PSA900D) mounted on CTD / CWS. Mooring works took approximately 5 hours for PO mooring system and 6 hours for BGC mooring system. After sinker was dropped, we positioned the mooring systems by measuring the slant ranges between research vessel and the acoustic releaser. Each position of the moorings is finally determined as follows:

Table 3.1.1-1 Mooring positions for respective mooring systems

	K-2 PO K2P050923	K-2 BGC K2B050925
Date of deployment	Sep. 23 rd 2005	Sep. 25th 2005
Latitude	46° 52.18 N	47° 00.33 N
Longitude	159° 59.04 E	159° 58.31 E
Depth	5,152.0 m	5,206.2 m

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

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

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

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

Table 3.1.1-2 Serial numbers of instruments

	Recovery	Deployment	Deployment
Station and type of system Mooring system S / N	K-2 BGC K2B050304	K-2 PO K2P050923	K-2 BGC K2B050925
ARGOS	52111 / 52112	18840 / 18841	18842 / 52111
ARGOS ID	5373 / 5374	18558 / 18570	18577 / 5373
Strobe	232 / 234	233	234
MMP (Shallow) (Deep)	- -	ML11241-01 ML11241-04	- -
RAS	ML11241-10	-	ML11241-09
OOS (BLOOMS)	DFLS-072	-	DFLS-072
WTS	ML11241-13	-	ML11241-13
Depth Sensor	DP1142	DP1158	DP1142
ZPS	ML11241-21	-	ML11241-21
Sediment Trap (150m) (300m) (540m) (1000m) (5000m)	878 ML11241-22 0256 ML11241-24 ML11241-25	- - - - -	0256 878 ML11241-22 ML11241-24 ML11241-25
Compass Sensor	01	-	-
Load-Cell	496450001	-	-
Releaser	027809 027867	027809 027867	027824 027864

Table 3.1.1-3 Deployment and Recovery Record

K-2 BGC Long Term Mooring

Mooring Number K2B050317

Project	Time-Series	Depth	5,206.2 m
Area	North Pacific	Planned Depth	5,216.2 m
Station	K-2 BGC	Length	5,185.5 m
Target Position	**47°00.350 N**	Depth of Buoy	30 m
	159°58.326 E	Period	6 month
ACOUCTIC RELEASERS			
Type	Edgetech	Edgetech	
Serial Number	27867	27809	
Receive F.	11.0 kHz	11.0 kHz	
Transmit F.	12.0 kHz	12.0 kHz	
RELEASE C.	**344573**	**344535**	
Enable C.	360536	360320	
Disable C.	360553	360366	
Battery	2 year	2 year	
Release Test	FINE	FINE	
DEPLOYMENT			
Recorder	Tomohide Noguchi	Start	7.0 Nmile
Ship	MIRAI	Overshoot	343.9 m
Cruise No.	MR05-01	Let go Top Buoy	21:06
Date	2005/3/17	Let go Anchor	2:01
Wather	o	Sink Top Buoy	2:51
Wave Hight	1.4 m	Pos. of Start	47°04.90 N
Depth	5,212 m		159°51.73 E
Ship Heading	<135>	Pos. of Drop. Anc.	47°00.22 N
Ship Ave.Speed	1.4 knot		159°58.51 E
Wind	<115> 9.5 m/s	Pos. of Mooring	47°00.47 N
Current	<010> 0.2 knot		159°58.06 E
RECOVERY			
Recorder	Hirosih Matsunaga	Work Distance	2.1 Nmile
Ship	MIRAI	Send Enable C.	20:07
Cruise No.	MR05-04	Slant Renge	3424 msec
Date	2005/9/22	Send Release C.	20:13
Wather	bc	Discovery Buoy	20:14
Wave Hight	2.8 m	Pos. of Top Buoy	46°59.99 N
Depth	5,218 m		159°58.62 E
Ship Heading	<295>	Pos. of Start	46°59.86 N
Ship Ave.Speed	0.6 knot		159°57.90 E
Wind	<290> 11.5 m/s	Pos. of Finish	47°00.02 N
Current	<171> 0.8 cm/sec		159°55.84 E

K-2 PO Mooring

Mooring Number K2P050923

Project	Time-Series	Depth	5,152.0 m
Area	North Pacific	Planned Depth	5,152.0 m
Station	K-2 PO	Length	5,121.5 m
Target Position	**46°52.240 N**	Depth of Buoy	30 m
	159°59.060 E	Period	1 year

ACOUCTIC RELEASERS

Type	Edgetech	Edgetech
Serial Number	27867	27809
Receive F.	11.0 kHz	11.0 kHz
Transmit F.	12.0 kHz	12.0 kHz
RELEASE C.	**344573**	**344535**
Enable C.	360536	360320
Disable C.	360570	360366
Battery	1 year	1 year
Release Test	FINE	FINE

DEPLOYMENT

Recorder	Hiroshi Matsunaga	Start	7.1 Nmile
Ship	MIRAI	Overshoot	390 m
Cruise No.	MR05-04	Let go Top Buoy	21:10
Date	2005/9/23	Let go Anchor	2:13
Wather	bc	Sink Top Buoy	2:45
Wave Hight	1.6 m	Pos. of Start	46°58.31 N
Depth	m		160°00.85 E
Ship Heading	<190>	Pos. of Drop. Anc.	46°52.01 N
Ship Ave.Speed	1.4 knot		159°58.88 E
Wind	<188> 5.5 m/s	Pos. of Mooring	46°52.18 N
Current	<082> 0.3 cm/sec		159°59.04 E

K-2 BGC Mooring

Mooring Number K2B050925

Project	Time-Series	Depth	5,206.2 m
Area	North Pacific	Planned Depth	5,216.2 m
Station	K-2 BGC	Length	5,176.2 m
Target Position	**47°00.350 N**	Depth of Buoy	30 m
	159°58.326 E	Period	1 year

ACOUCTIC RELEASERS

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

DEPLOYMENT

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

Table 3.1.1-4 Deployment and Recovery Working Time Record

Recovery K-2 BGC Long Term Mooring

MOORING NO. K2B050317 DATE 2005/09/22 Name : Hiroshi Matsunaga

ITEM	S/N	On Deck	Joint	DAMAGE	PIN	Note
Syntactic Sphere *ARGOS* and *Flasher*	A:52112/52111 ✓ F:234 ✓	22:04				
			L ✓	✓	✓	2:56 ARGOS STOP
5m 3/4" PC Chain		:				
			F ✓	✓	✓	
RAS	ML11241-10 ✓	:				
			H ✓	■	✓	Dropped one Bottle of RAS
WTS *Depth Sensor*	ML11241-15 ✓ DP1142 ✓	:				
			H ✓	✓	✓	
ZPS	ML11241-21 ✓	22:13				
			HSH ✓	✓	✓	
50m 5/16" Wire	DN ✓	22:13				
			H ✓	✓	✓	
50m 5/16" Wire Coated	#DE ✓	22:20				
			I ✓	✓	✓	
Sediment Trap_150m	0256 ✓	22:25				
			H ✓	✓	✓	
2m 16mm T-Chain		22:25				
			H ✓	✓	✓	
50m 5/16" Wire	#V ✓	22:27				
			H ✓	✓	✓	
43m 5/16" Wire	#DI ✓	22:30				
			H ✓	✓	✓	
50m 5/16" Wire Coated	#U ✓	22:31				
			I ✓	✓	✓	
Sediment Trap_300m	878 ✓	22:36				
			H ✓	✓	✓	
2m 16mm T-Chain		22:36				
			H ✓	✓	✓	
143m 5/16" Wire	BC ✓	22:37				
			H ✓	✓	✓	
43m 5/16" Wire	CE ✓	22:41				
			H ✓	✓	✓	
50m 5/16" Wire Coated	#DG ✓	22:43				
			I ✓	✓	✓	
Sediment Trap_540m	ML11241-22 ✓	22:46				
			H ✓	✓	✓	
2m 16mm T-Chain		22:46				
			H ✓	✓	✓	
403m 5/16" Wire	#S ✓	22:48				
			H ✓	✓	✓	
50m 5/16" Wire Coated	#DH ✓	22:54				
			I ✓	✓	✓	
Sediment Trap_1000m	ML11241-24 ✓	22:57				
			H ✓	✓	✓	
2m 16mm T-Chain		22:57				
			HSB ✓	✓	✓	
500m 1/4" Wire	CG ✓	22:59				
			B ✓	✓	✓	
(12) 17" Glass Balls		23:08				
			HHB ✓	✓	✓	
500m 1/4" Wire	CF ✓	23:12				
			A ✓	✓	✓	
500m 1/4" Wire	CE ✓	23:19				
			A ✓	✓	✓	
500m 1/4" Wire	CD ✓	23:25				
			B ✓	✓	✓	
(10) 17" Glass Balls		23:41				
			HHB ✓	✓	✓	Tangle with Wire [CJ]
500m 1/4" Wire	BL ✓	23:47				
			A ✓	✓	✓	
500m 1/4" Wire	BJ ✓	23:52				
			A ✓	✓	✓	
387m 1/4" Wire	CJ ✓	23:57				
			B ✓	■	✓	Damaged
(8) 17" Glass Balls		0:05				
			HB ✓	✓	✓	Tangle with Wire [CN]
200m 1/4" Wire	CN ✓	0:05				
			A ✓	■	✓	Damaged
100m 1/4" Wire	TT ✓	0:12				
			A ✓	✓	✓	
29m 1/4" Wire	#1/29 ✓	0:13				
			A ✓	✓	✓	
50m 1/4" Wire Coated	#Y ✓	0:15				
			K ✓	✓	✓	
Sediment Trap_4810m	ML11241-25 ✓	0:18				
			B ✓	✓	✓	
2m 16mm T-Chain		0:18				
			B ✓	✓	✓	
200m 1/4" Wire	CL ✓	0:18				
			A ✓	✓	✓	
50m 1/4" Wire	AF ✓	0:22				
			A ✓	✓	✓	
25m 1/4" Wire	#4/25 ✓	0:24				
			A ✓	✓	✓	
20m 1/4" Wire	#3/20 ✓	0:25				
			B ✓	✓	✓	
5m 16mm T-Chain		0:29				
			H ✓	✓	✓	
(52) 17" Glass Balls		0:29				
			H ✓	✓	✓	
5m 16mm T-Chain		0:32				
			H ✓	✓	✓	
Tension Meter	1 ✓	0:32				
			HSH ✓	✓	✓	
Dual Releases	27809 ✓ 27867 ✓	0:32				

Deployment K-2 PO Mooring

MOORING NO. K2P050923 DATE 2005/9/23 Name : Hiroshi Matsunaga

ITEM	S/N		Switch		TIME
Top Buoy 025162-01 *ARGOS* and *Flasher*	A:18840/18841 F:233	☑ ☑	21:04	☑ ☑	21:10
5m 3/4" PC Chain					21:10
3-TON Swivel					21:10
500m 1/4" Wire *Depth Sensor*	F-05 DP1158	☑ ☑	21:00	☑ ☑	21:10
Bumper		☑			21:10
MMP	ML11241-01	☑		☑	21:22
Bumper					21:34
3,500m 1/4" Wire	α-05	☑			21:34
Bumper					21:34
MMP	ML11241-04	☑		☑	21:43
Bumper		☑			23:58
3-TON Swivel		☑			23:58
(8) 17" Glass Balls		☑			23:58
500m 1/4" Wire	G-05	☑			23:58
(8) 17" Glass Balls		☑			0:12
471m 1/4" Wire	H-05	☑			0:12
20m 1/4" Wire	#2/20	☑			0:28
5m 16mm T-Chain					0:30
(32) 17" Glass Balls		☑			0:30
5m 16mm T-Chain					0:38
3-TON Swivel		☑			1:51
Dual Releases	27867 27809	☑ ☑		☑ ☑	1:51
5m 16mm T-Chain					1:51
20m 1" Nylon	#11	☑			1:51
5m 16mm T-Chain					2:13
4,666lb Mace Anchor					2:13

Joint		DAMAGE	PIN	Note
L	☑	☑	☑	
X	☑	☑	☑	
W	☑	☑	☑	
	☑	☑	☑	
	☑	☑	☑	
	☑	☑	☑	
A	☑	☑	☑	
	☑	☑	☑	
	☑	☑	☑	
	☑	☑	☑	
W	☑	☑	☑	
Z	☑	☑	☑	
ZW	☑	☑	☑	
W	☑	☑	☑	
ZW	☑	☑	☑	
A	☑	☑	☑	
W	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	
Z	☑	☑	☑	Tension Test 0:40~1:43
X	☑	☑	☑	
MX	☑	☑	☑	
Y	☑	☑	☑	
Y	☑	☑	☑	
X	☑	☑	☑	

Deployment K-2 BGC Mooring

MOORING NO. K2B050925 DATE 2005/9/25 Name : Hiroshi Matsunaga

ITEM	S/N		Switch	TIME	Joint	DAMAGE	PIN	Note
Top Buoy 015162-04 *ARGOS* and *Flasher*	A:18842/52111 F:234	☑ ☑	21:20 ☑ ☑	21:42	L ☑	☑	☑	
5m 3/4" PC Chain				21:42	X ☑	☑	☑	
RAS	ML11241-09	☑	☑	21:42	Z ☑	☑	☑	
WTS *Depth Sensor*	ML11241-13 DP1142	☑ ☑	☑ ☑	21:42	Z ☑	☑	☑	
ZPS	ML11241-21	☑	☑	21:42	Z ☑	☑	☑	
3-TON Swivel		☑		21:42	Z ☑	☑	☑	
53m 5/16" Wire	X-05	☑		21:42	H ☑	☑	☑	
50m 5/16" Wire Coated	AA-05	☑		21:46	I ☑	☑	☑	
Sediment Trap 150m	0256	☑	☑	21:52	Z ☑	☑	☑	
2m 16mm T-Chain				21:52	Z ☑	☑	☑	
94m 5/16" Wire	V-05	☑		21:52	H ☑	☑	☑	
50m 5/16" Wire Coated	Z-05	☑		21:59	I ☑	☑	☑	
Sediment Trap 300m	-	☑		22:02	Z ☑	☑	☑	
2m 16mm T-Chain				22:02	Z ☑	☑	☑	
183m 5/16" Wire	R-05	☑		22:02	H ☑	☑	☑	
50m 5/16" Wire Coated	Y-05	☑		22:12	I ☑	☑	☑	
Sediment Trap 540m	ML11241-22	☑	☑	22:17	Z ☑	☑	☑	
2m 16mm T-Chain				22:17	Z ☑	☑	☑	
403m 5/16" Wire	M-05	☑		22:17	H ☑	☑	☑	
50m 5/16" Wire Coated	DL	☑		22:35	I ☑	☑	☑	
Sediment Trap 1000m	ML11241-24	☑	☑	22:39	Z ☑	☑	☑	
2m 16mm T-Chain				22:39	Z ☑	☑	☑	
3-TON Swivel				22:39	W ☑	☑	☑	
500m 1/4" Wire	A-05	☑		22:39	W ☑	☑	☑	
(12) 17" Glass Balls				23:05	ZZW ☑	☑	☑	
500m 1/4" Wire	B-05	☑		23:05	A ☑	☑	☑	
500m 1/4" Wire	C-05	☑		23:19	A ☑	☑	☑	
500m 1/4" Wire	D-05	☑		23:37	W ☑	☑	☑	
(8) 17" Glass Balls				23:57	ZW ☑	☑	☑	
500m 1/4" Wire	E-05	☑		23:57	A ☑	☑	☑	
500m 1/4" Wire	I-05	☑		0:16	A ☑	☑	☑	
440m 1/4" Wire	#N	☑		0:32	W ☑	☑	☑	
(8) 17" Glass Balls				0:46	ZW ☑	☑	☑	
200m 1/4" Wire	CC-05	☑		0:46	A ☑	☑	☑	
50m 1/4" Wire	CO	☑		0:50	A ☑	☑	☑	
20m 1/4" Wire		☑		0:53	A ☑	☑	☑	
50m 1/4" Wire Coated	#Z	☑		0:53	K ☑	☑	☑	
Sediment Trap 4810m	ML11241-25	☑	☑	0:59	Z ☑	☑	☑	
2m 16mm T-Chain				0:59	W ☑	☑	☑	
286m 1/4" Wire	O-05	☑		0:59	A ☑	☑	☑	
15m 1/4" Wire		☑		1:05	W ☑	☑	☑	
5m 16mm T-Chain				1:10	Z ☑	☑	☑	
(48) 17" Glass Balls		☑		1:13	Z ☑	☑	☑	
5m 16mm T-Chain				2:17	Z ☑	☑	☑	Tension Test 1:20～2:10
3-TON Swivel				2:17	X ☑	☑	☑	
Dual Releases	27864 27824	☑ ☑	☑ ☑	2:17	X ☑	☑	☑	
5m 16mm T-Chain				2:30	Y ☑	☑	☑	
20m 1" Nylon	#10	☑		2:30	Y ☑	☑	☑	
5m 16mm T-Chain				2:30	X ☑	☑	☑	
4,666lb Mace Anchor				2:30				

Table 3.1.1-5 Detail of our mooring system.

Recovery K-2 BGC Long Term Mooring

	Mooring ID Description	Joint	Water Depth Item Length (m)	Item Weight (kg)	Mooring Length (m)	Mooring Weight (kg)	Above Bottom (m)	Mooring Depth (m)	
1	64" Syntatic Sphere		2.27	-1360.78		-1360.78	5184.27	31.93	**30**
	Hardware	L	0.28	3.63	2.55	-1357.15	5182.00	34.20	
2	**5** Meters 3/4" Proof Coil Chain		5.00	40.01	7.55	-1317.14	5181.72	34.48	
	Hardware	F	0.26	2.42	7.81	-1314.72	5176.72	39.48	
3	Instrument - "RAS"	N	2.25	72.03	10.06	-1242.69	5176.46	39.74	
	Hardware	H	0.24	1.93	10.29	-1240.76	5174.21	41.99	
4	Instrument - "WTS"	N	2.83	50.33	13.12	-1190.43	5173.98	42.22	
	Hardware	H	0.24	1.93	13.36	-1188.50	5171.15	45.05	
5	Instrument - "ZPS"	N	2.42	41.33	15.78	-1147.17	5170.91	45.29	
	Hardware	H	0.24	1.93	16.01	-1145.24	5168.49	47.71	
6	3-TON Miller Swivel		0.16	3.17	16.17	-1142.07	5168.26	47.94	
	Hardware	H	0.24	1.93	16.41	-1140.14	5168.10	48.10	
7	**50 M 5/16" Wire [DN]**		50.13	10.69	66.54	-1129.45	5167.86	48.34	
	Hardware	H	0.24	1.93	66.77	-1127.52	5117.73	98.47	
8	**50 Meters 5/16" Wire [DE]**	P	50.36	10.74	117.13	-1116.79	5117.49	98.71	
	Hardware	I	0.06	2.19	117.19	-1114.60	5067.14	149.06	
9	Sediment Trap [0256]	O	3.92	55.68	121.11	-1058.91	5067.08	149.12	**150**
	Hardware	H	0.24	1.93	121.35	-1056.98	5063.16	153.04	
10	**2** Meters 3/4" Proof Coil Chain		2.00	16.00	123.35	-1040.98	5062.92	153.28	
	Hardware	H	0.24	1.93	123.58	-1039.05	5060.92	155.28	
11	**50 Meters 5/16" Wire [#V]**		50.17	10.70	173.75	-1028.36	5060.69	155.51	
	Hardware	H	0.24	1.93	173.98	-1026.43	5010.52	205.68	
12	**43 Meters 5/16" Wire [#DI]**		43.56	9.29	217.54	-1017.14	5010.28	205.92	
	Hardware	H	0.24	1.93	217.78	-1015.21	4966.72	249.48	
13	**50 Meters 5/16" Wire [#U]**	P	50.10	10.68	267.88	-1004.53	4966.49	249.71	
	Hardware	I	0.06	2.19	267.94	-1002.34	4916.39	299.81	
14	Sediment Trap [878]	O	3.89	55.70	271.83	-946.64	4916.33	299.87	**300**
	Hardware	H	0.24	1.93	272.07	-944.71	4912.44	303.76	
15	**2** Meters 3/4" Proof Coil Chain		2.00	16.00	274.07	-928.71	4912.20	304.00	
	Hardware	H	0.24	1.93	274.30	-926.78	4910.20	306.00	
16	**143 Meters 5/16" Wire [BC]**		143.85	30.67	418.15	-896.11	4909.97	306.23	
	Hardware	H	0.24	1.93	418.38	-894.18	4766.12	450.08	
17	**43 Meters 5/16" Wire [CE]**		43.47	9.27	461.86	-884.91	4765.88	450.32	
	Hardware	H	0.24	1.93	462.09	-882.98	4722.41	493.79	
18	**50 Meters 5/16" Wire [#DG]**	P	51.04	10.88	513.13	-872.10	4722.18	494.03	
	Hardware	I	0.06	2.19	513.19	-869.91	4671.14	545.06	
19	Sediment Trap [ML11241-22]	O	3.74	55.70	516.93	-814.21	4671.08	545.12	**540**
	Hardware	H	0.24	1.93	517.16	-812.28	4667.34	548.86	
20	**2** Meters 3/4" Proof Coil Chain		2.00	16.00	519.16	-796.28	4667.10	549.10	
	Hardware	H	0.24	1.93	519.40	-794.35	4665.10	551.10	
21	**403 Meters 5/16" Wire [#S]**		403.79	86.08	923.19	-708.27	4664.87	551.33	
	Hardware	H	0.24	1.93	923.42	-706.34	4261.08	955.12	
22	**50 Meters 5/16" Wire [#DH]**	P	50.54	10.78	973.96	-695.56	4260.85	955.35	
	Hardware	I	0.06	2.19	974.03	-693.37	4210.30	1005.90	
23	Sediment Trap ML11241-24]	O	3.73	55.70	977.76	-637.67	4210.24	1005.96	**1000**
	Hardware	H	0.24	1.93	977.99	-635.74	4206.51	1009.69	
24	**2** Meters 3/4" Proof Coil Chain		2.00	16.00	979.99	-619.74	4206.28	1009.92	
	Hardware	H	0.24	1.93	980.23	-617.81	4204.28	1011.92	
25	3-TON Miller Swivel		0.16	3.17	980.39	-614.64	4204.04	1012.16	
	Hardware	B	0.23	1.63	980.61	-613.01	4203.88	1012.32	
26	**500** Meters 1/4" Wire [CG]		498.48	70.09	1479.10	-542.92	4203.65	1012.55	
	Hardware	B	0.23	1.63	1479.32	-541.29	3705.17	1511.03	
27	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1483.32	-620.65	3704.95	1511.25	
	Hardware	H	0.24	1.93	1483.56	-618.72	3700.95	1515.25	
28	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1487.56	-698.08	3700.71	1515.49	
	Hardware	H	0.24	1.93	1487.79	-696.15	3696.71	1519.49	
29	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1491.79	-775.51	3696.48	1519.72	
	Hardware	B	0.23	1.63	1492.02	-773.88	3692.48	1523.72	
30	**500** Meters 1/4" Wire [CF]		498.45	70.09	1990.46	-703.79	3692.25	1523.95	
	Hardware	A	0.21	1.33	1990.67	-702.46	3193.80	2022.40	
31	**500** Meters 1/4" Wire [CE]		498.46	70.09	2489.13	-632.37	3193.59	2022.61	
	Hardware	A	0.21	1.33	2489.34	-631.04	2695.14	2521.06	
32	**500** Meters 1/4" Wire [CD]		498.09	70.04	2987.42	-561.01	2694.93	2521.27	
	Hardware	B	0.23	1.63	2987.65	-559.38	2196.84	3019.36	
33	2-17" Glassballs on 16mm T-Chain		2.00	-39.68	2989.65	-599.06	2196.62	3019.58	
	Hardware	H	0.24	1.93	2989.89	-597.13	2194.62	3021.58	
34	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	2993.89	-676.49	2194.38	3021.82	
	Hardware	H	0.24	1.93	2994.12	-674.56	2190.38	3025.82	
35	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	2998.12	-753.92	2190.15	3026.05	

	Hardware	B	0.23	1.63	2998.35	-752.29	2186.15	3030.05	
36	**500** Meters 1/4" Wire [BL]		500.63	70.40	3498.98	-681.89	2185.92	3030.28	
	Hardware	A	0.21	1.33	3499.19	-680.56	1685.29	3530.91	
37	**500** Meters 1/4" Wire [BJ]		500.68	70.40	3999.87	-610.16	1685.08	3531.12	
	Hardware	A	0.21	1.33	4000.08	-608.83	1184.40	4031.80	
38	**387 Meters 1/4" Wire [CJ]**		392.32	55.17	4392.40	-553.66	1184.19	4032.01	
	Hardware	B	0.23	1.63	4392.63	-552.03	791.87	4424.33	
39	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4396.63	-631.39	791.64	4424.56	
	Hardware	H	0.24	1.93	4396.86	-629.46	787.64	4428.56	
40	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	4400.86	-708.82	787.40	4428.80	
	Hardware	B	0.23	1.63	4401.09	-707.19	783.40	4432.80	
41	**200 Meters 1/4" Wire [CN]**		199.39	28.04	4600.48	-679.16	783.18	4433.02	
	Hardware	A	0.21	1.33	4600.69	-677.83	583.79	4632.41	
42	**100 Meters 1/4" Wire [TT]**		99.95	14.05	4700.64	-663.77	583.58	4632.62	
	Hardware	A	0.21	1.33	4700.85	-662.44	483.63	4732.57	
43	**29 Meters 1/4" Wire [#1/29]**		29.09	4.09	4729.94	-658.35	483.42	4732.78	
	Hardware	A	0.21	1.33	4730.15	-657.02	454.33	4761.87	
44	**50 Meters 1/4" Wire [#Y]**	Q	50.17	7.06	4780.32	-649.97	454.12	4762.08	
	Hardware	K	0.20	1.33	4780.52	-648.64	403.94	4812.26	
45	Sediment Trap [ML11241-25]	O	3.73	55.70	4784.25	-592.94	403.74	4812.46	**4810.8**
	Hardware	H	0.24	1.93	4784.49	-591.01	400.01	4816.19	
46	**2** Meters 3/4" Proof Coil Chain		2.00	16.00	4786.49	-575.00	399.78	4816.42	
	Hardware	B	0.23	1.63	4786.71	-573.38	397.78	4818.42	
47	**200 Meters 1/4" Wire [CL]**		199.34	28.03	4986.06	-545.35	397.55	4818.65	
	Hardware	A	0.21	1.33	4986.27	-544.02	198.21	5017.99	
48	**50 Meters 1/4" Wire [AF]**		50.04	7.04	5036.31	-536.98	198.00	5018.20	
	Hardware	A	0.21	1.33	5036.52	-535.65	147.96	5068.24	
49	**25 Meters 1/4" Wire [adj]**		25.00	3.52	5061.52	-532.13	147.75	5068.45	
	Hardware	A	0.21	1.33	5061.73	-530.80	122.75	5093.45	
50	**20 Meters 1/4" Wire [adj]**		20.00	2.81	5081.73	-527.99	122.54	5093.66	
	Hardware	B	0.23	1.63	5081.95	-526.36	102.54	5113.66	
51	5 Meters 16mm T-Chain		5.00	27.80	5086.95	-498.56	102.31	5113.89	
	Hardware	H	0.24	1.93	5087.19	-496.63	97.31	5118.89	
52	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5091.19	-575.99	97.08	5119.12	
	Hardware	H	0.24	1.93	5091.42	-574.06	93.08	5123.12	
53	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5095.42	-653.42	92.84	5123.36	
	Hardware	H	0.24	1.93	5095.66	-651.49	88.84	5127.36	
54	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5099.66	-730.85	88.61	5127.59	
	Hardware	H	0.24	1.93	5099.89	-728.92	84.61	5131.59	
55	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5103.89	-808.28	84.37	5131.83	
	Hardware	H	0.24	1.93	5104.13	-806.35	80.37	5135.83	
56	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5108.13	-885.71	80.14	5136.06	
	Hardware	H	0.24	1.93	5108.36	-883.78	76.14	5140.06	
57	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5112.36	-963.14	75.90	5140.30	
	Hardware	H	0.24	1.93	5112.60	-961.21	71.90	5144.30	
58	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5116.60	-1040.57	71.67	5144.53	
	Hardware	H	0.24	1.93	5116.83	-1038.64	67.67	5148.53	
59	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5120.83	-1118.00	67.43	5148.77	
	Hardware	H	0.24	1.93	5121.07	-1116.07	63.43	5152.77	
60	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5125.07	-1195.43	63.20	5153.00	
	Hardware	H	0.24	1.93	5125.30	-1193.51	59.20	5157.00	
61	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5129.30	-1272.87	58.96	5157.24	
	Hardware	H	0.24	1.93	5129.54	-1270.94	54.96	5161.24	
62	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5133.54	-1350.30	54.73	5161.47	
	Hardware	H	0.24	1.93	5133.77	-1348.37	50.73	5165.47	
63	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5137.77	-1427.73	50.49	5165.71	
	Hardware	H	0.24	1.93	5138.01	-1425.80	46.49	5169.71	
64	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	5142.01	-1505.16	46.26	5169.94	
	Hardware	H	0.24	1.93	5142.24	-1503.23	42.26	5173.94	
65	5 Meters 16mm T-Chain		5.00	27.80	5147.24	-1475.43	42.02	5174.18	
	Hardware	H	0.24	1.93	5147.48	-1473.50	37.02	5179.18	
66	Tension Meter		0.45	39.00	5147.93	-1434.50	36.79	5179.41	
	Hardware	H	0.24	1.93	5148.16	-1432.57	36.34	5179.86	18.63
67	3-TON Miller Swivel		0.16	3.20	5148.32	-1429.37	36.10	5180.10	
	Hardware	F	0.26	2.42	5148.58	-1426.95	35.94	5180.26	
68	Dual EGG Acoustic Releases	M	1.95	66.04	5150.52	-1360.90	35.69	5180.51	
	Hardware	F	0.26	2.42	5150.78	-1358.48	33.74	5182.46	
69	5 Meters 16mm T-Chain		5.00	27.80	5155.78	-1330.68	33.49	5182.71	
	Hardware	G	0.25	2.70	5156.02	-1327.99	28.49	5187.71	
70	**20** Meters 1" Nylon [#09]		21.78	6.49	5177.81	-1321.49	28.24	5187.96	
	Hardware	G	0.25	2.70	5178.05	-1318.79	6.46	5209.74	
71	5 Meters 16mm T-Chain		5.00	27.80	5183.05	-1290.99	6.21	5209.99	
	Hardware	F	0.26	2.42	5183.31	-1288.57	1.21	5214.99	**Design**
72	4666 Lb Ww Anchor		0.96	2116.46	5184.27	827.89	0.96	5215.24	**Depth**
	OVERALL MOORING LENGTH		**5184.27**					5216.20	**5216.2**

Deployment K-2 PO Mooring

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

Deployment K-2 BGC Mooring

	Mooring ID Description	Joint	Water Depth Item Length (m)	Item Weight (kg)	Mooring Length (m)	Mooring Weight (kg)	Above Bottom (m)	Mooring Depth (m)	
1	64" Syntatic Sphere		2.27	-1360.78		-1360.78	5185.93	30.27	**30**
	Hardware	L	0.28	3.63	2.55	-1357.15	5183.66	32.54	
2	**5** Meters 3/4" Proof Coil Chain		5.00	40.01	7.55	-1317.14	5183.38	32.82	
	Hardware	X	0.25	2.40	7.80	-1314.74	5178.38	37.82	
3	Instrument - "RAS"	N	2.25	51.00	10.05	-1263.74	5178.13	38.07	
	Hardware	Z	0.24	2.00	10.29	-1261.74	5175.88	40.32	
4	Instrument - "WTS"	N	2.83	37.00	13.12	-1224.74	5175.64	40.56	
	Hardware	Z	0.24	2.00	13.35	-1222.74	5172.81	43.39	
5	Instrument - "ZPS"	N	2.42	41.33	15.77	-1181.41	5172.58	43.62	
	Hardware	Z	0.24	2.00	16.01	-1179.41	5170.16	46.04	
6	3-TON Miller Swivel		0.16	3.17	16.17	-1176.24	5169.92	46.28	
	Hardware	Z	0.24	2.00	16.40	-1174.24	5169.76	46.44	
7	**53** Meters 5/16" Wire [X-05]		53.34	11.37	69.74	-1162.87	5169.53	46.67	
	Hardware	H	0.24	1.93	69.98	-1160.94	5116.18	100.02	
8	**50** Meters 5/16" Wire [AA-05]	P	50.08	10.68	120.05	-1150.26	5115.95	100.25	
	Hardware	I	0.06	2.19	120.12	-1148.07	5065.87	150.33	
9	Sediment Trap	O	3.92	55.68	124.04	-1092.39	5065.81	150.39	**150**
	Hardware	Z	0.24	2.00	124.27	-1090.39	5061.89	154.31	
10	**2** Meters 16mm T-Chain		2.00	11.12	126.27	-1079.27	5061.66	154.54	
	Hardware	Z	0.24	2.00	126.51	-1077.27	5059.66	156.54	
11	**94** Meters 5/16" Wire [V-05]		94.38	20.12	220.89	-1057.15	5059.42	156.78	
	Hardware	H	0.24	1.93	221.12	-1055.22	4965.04	251.16	
12	**50** Meters 5/16" Wire [Z-05]	P	50.21	10.70	271.34	-1044.51	4964.80	251.40	
	Hardware	I	0.06	2.19	271.40	-1042.32	4914.59	301.61	
13	Sediment Trap	O	3.89	55.70	275.29	-986.62	4914.53	301.67	**300**
	Hardware	Z	0.24	2.00	275.52	-984.62	4910.64	305.56	
14	**2** Meters 16mm T-Chain		2.00	11.12	277.52	-973.50	4910.41	305.80	
	Hardware	Z	0.24	2.00	277.76	-971.50	4908.41	307.80	
15	**183** Meters 5/16" Wire [R-05]		183.74	39.17	461.50	-932.33	4908.17	308.03	
	Hardware	H	0.24	1.93	461.73	-930.40	4724.43	491.77	
16	**50** Meters 5/16" Wire [Y-05]	P	50.26	10.72	511.99	-919.69	4724.20	492.00	
	Hardware	I	0.06	2.19	512.06	-917.50	4673.93	542.27	
17	Sediment Trap	O	3.74	55.70	515.80	-861.79	4673.87	542.33	**540**
	Hardware	Z	0.24	2.00	516.03	-859.79	4670.13	546.07	
18	**2** Meters 16mm T-Chain		2.00	11.12	518.03	-848.67	4669.90	546.30	
	Hardware	Z	0.24	2.00	518.27	-846.67	4667.90	548.30	
19	**403** Meters 5/16" Wire [M-05]		404.59	86.25	922.86	-760.42	4667.66	548.54	
	Hardware	H	0.24	1.93	923.10	-758.49	4263.07	953.13	
20	**50** Meters 5/16" Wire [DL]	P	50.12	10.68	973.22	-747.81	4262.83	953.37	
	Hardware	I	0.06	2.19	973.28	-745.61	4212.71	1003.49	
21	Sediment Trap	O	3.73	55.70	977.01	-689.91	4212.65	1003.55	**1000**
	Hardware	Z	0.24	2.00	977.24	-687.91	4208.92	1007.28	
22	**4** Meters 16mm T-Chain		4.00	22.24	981.24	-665.67	4208.69	1007.52	
	Hardware	Z	0.24	2.00	981.48	-663.67	4204.69	1011.52	
23	3-TON Miller Swivel		0.16	3.17	981.64	-660.51	4204.45	1011.75	
	Hardware	W	0.22	1.65	981.86	-658.86	4204.29	1011.91	
24	**500** Meters 1/4" Wire [A-05]		503.09	70.74	1484.94	-588.11	4204.07	1012.13	
	Hardware	W	0.22	1.65	1485.16	-586.46	3700.98	1515.22	
25	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1489.16	-665.82	3700.76	1515.44	
	Hardware	Z	0.24	2.00	1489.40	-663.82	3696.76	1519.44	
26	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1493.40	-743.18	3696.53	1519.67	
	Hardware	Z	0.24	2.00	1493.63	-741.18	3692.53	1523.67	
27	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	1497.63	-820.54	3692.29	1523.91	
	Hardware	W	0.22	1.65	1497.85	-818.89	3688.29	1527.91	
28	**500** Meters 1/4" Wire [B-05]		502.11	70.60	1999.97	-748.29	3688.07	1528.13	
	Hardware	A	0.21	1.33	2000.18	-746.96	3185.96	2030.24	
29	**500** Meters 1/4" Wire [C-05]		501.01	70.45	2501.19	-676.51	3185.75	2030.45	
	Hardware	A	0.21	1.33	2501.40	-675.18	2684.74	2531.46	
30	**500** Meters 1/4" Wire [D-05]		501.89	70.57	3003.28	-604.61	2684.53	2531.67	
	Hardware	W	0.22	1.65	3003.50	-602.96	2182.65	3033.55	
31	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	3007.50	-682.32	2182.43	3033.77	
	Hardware	Z	0.24	2.00	3007.74	-680.32	2178.43	3037.77	
32	4-17" Glassballs on 16mm T-Chain		4.00	-79.36	3011.74	-759.68	2178.19	3038.01	
	Hardware	W	0.22	1.65	3011.96	-758.03	2174.19	3042.01	
33	**500** Meters 1/4" Wire [E-05]		502.10	70.60	3514.06	-687.43	2173.97	3042.23	
	Hardware	A	0.21	1.33	3514.27	-686.10	1671.87	3544.33	
34	**500** Meters 1/4" Wire [I-05]		495.11	69.62	4009.38	-616.48	1671.66	3544.54	
	Hardware	A	0.21	1.33	4009.59	-615.15	1176.55	4039.65	
35	**440** Meters 1/4" Wire [#N]		440.75	61.98	4450.34	-553.17	1176.34	4039.86	
	Hardware	W	0.22	1.65	4450.56	-551.52	735.59	4480.62	

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

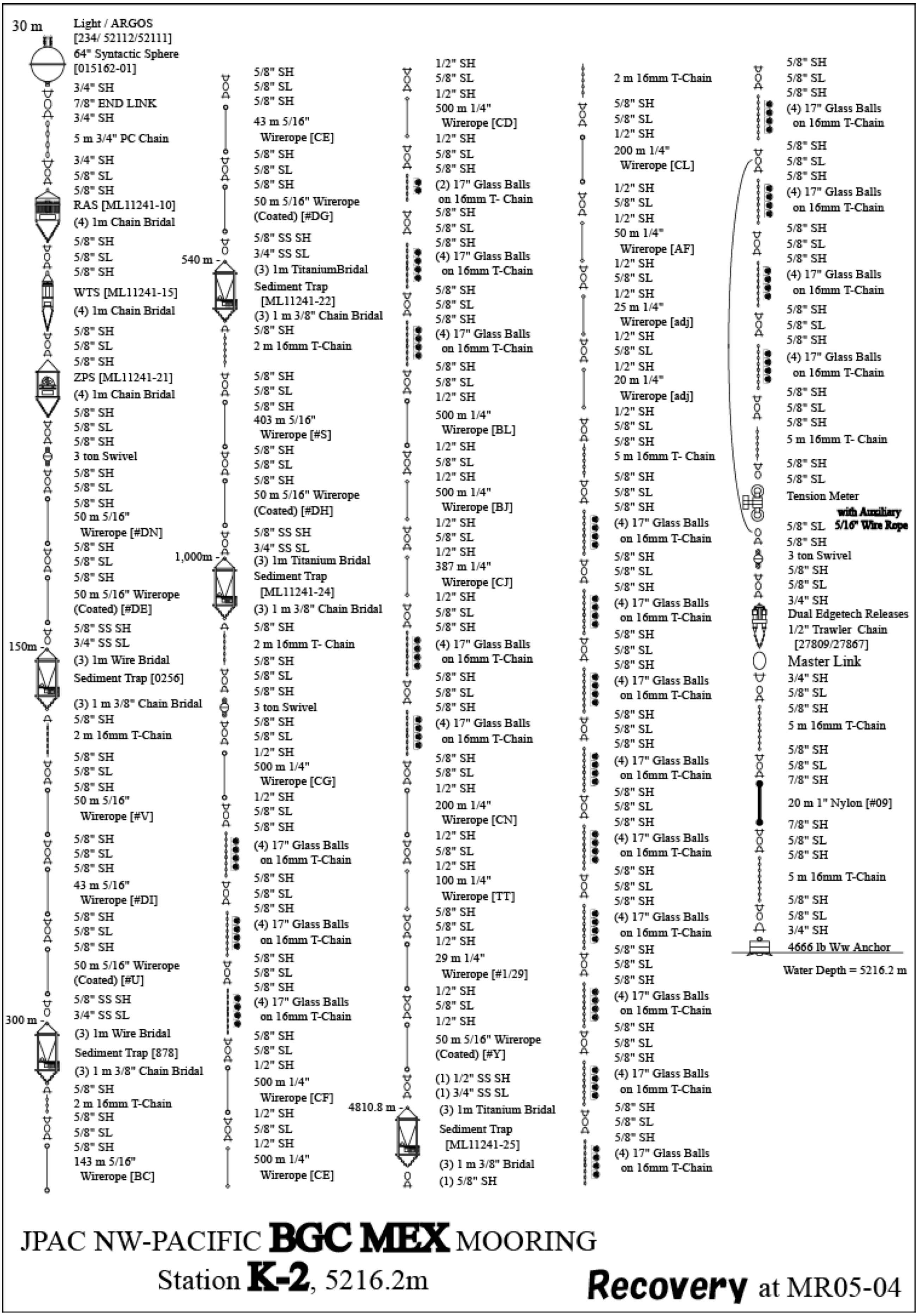


Fig. 3.1.1-1 Recovery K-2 BGC Long Term Mooring Figure

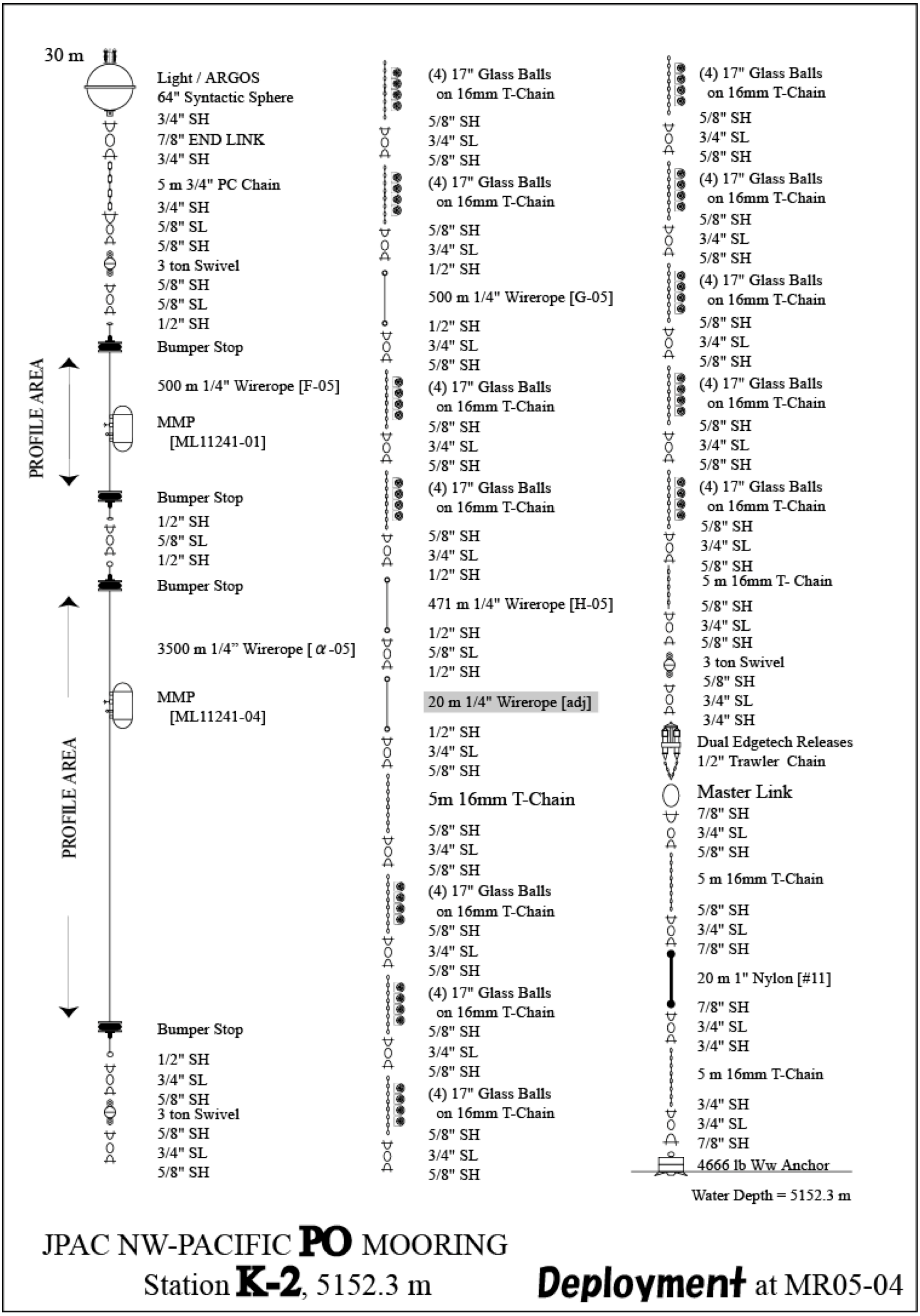


Fig. 3.1.1-2 Deployment K-2 PO Mooring Figure

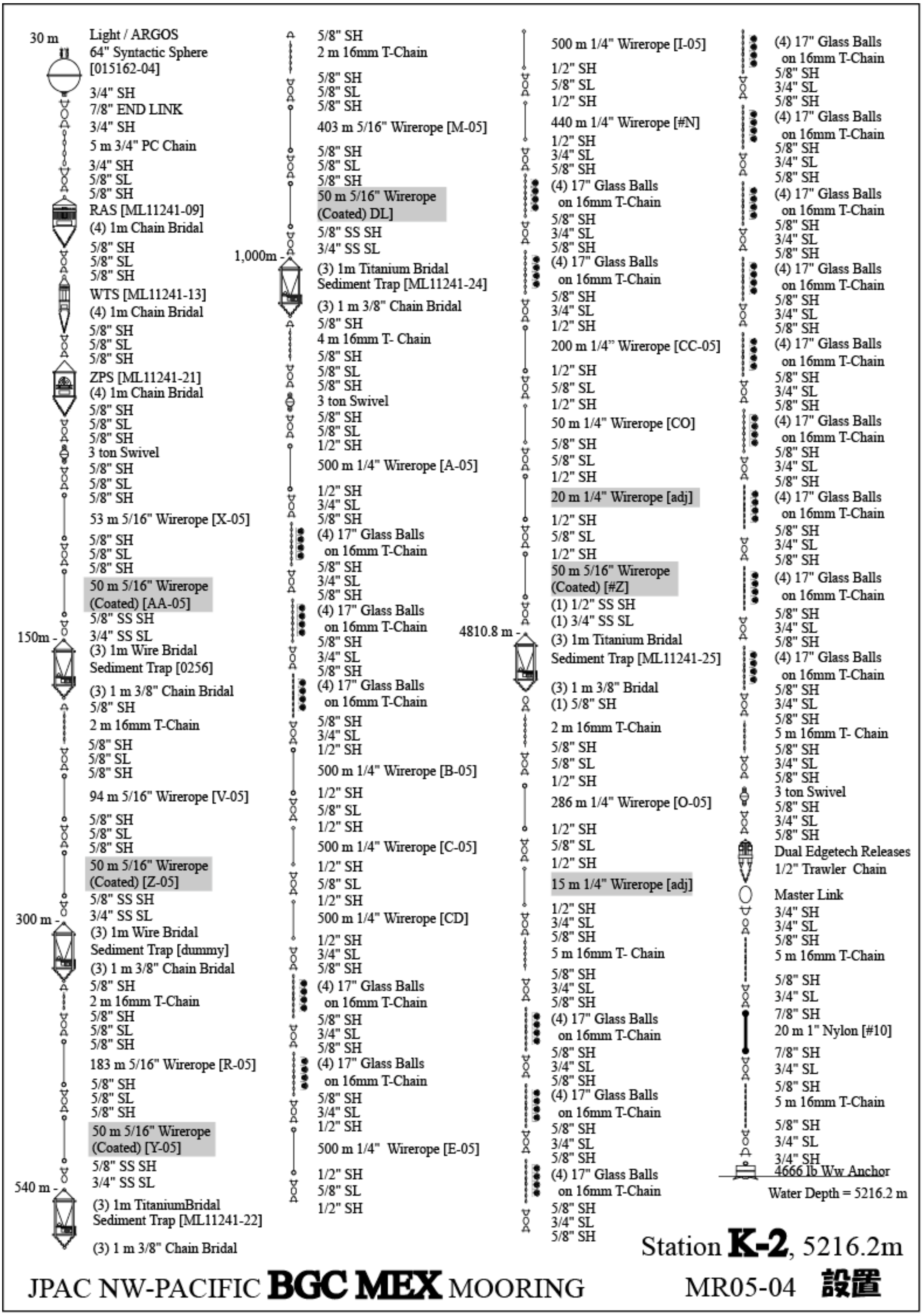


Fig. 3.1.1-3 Deployment K-2 BGC Mooring Figure

(2) Instrument

On mooring systems, the following instruments are installed.

1) ARGOS CML (Compact Mooring Locator)

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

Principle specification is as follows:

(Specification)

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

2) Submersible Recovery Strobe

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

(Specification)

Power Level:	0.1 watt-second
Repetition Rate:	Adjustable from 2 bursts per second to 1 burst every 3 seconds.
Burst Length:	Adjustable from 1 to 5 flashes per burst. 100 ms between flashes

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

3) MMP

The McLane Moored Profiler is an autonomous, profiling, instrument platform. The purpose is to make moored profiler technology available to, operable by, and useful to a broad cross-section of the oceanographic community. The platform and software are designed for ease of access, operation, and maintenance. The instrument includes both a CTD and an acoustic current meter. Side and top views of the MMP are shown in Fig. 2. The major components of the system are labeled in the figures. There include the controller, the buoyancy elements, the drive motor and guide wheels, the instruments suite, the internal frame, and the hydrodynamically faired external shell. The platform is designed to profile between pressure limits (or physical stops), powered along a conventional, plastic jacketed mooring cable by a traction drive. While profiling it samples the water column with a suite of instruments and stores the measurements for later retrieval. The shape accommodates a cylindrical housing that has sufficient length for batteries and electronics and a 6,000 m depth rating. Two glass spheres are used for buoyancy only. The mooring cable threads through faired retainers at the top and bottom of the vehicle. The retainers can be opened for launch and recovery and are strong enough to support the full weight, including trapped water, of the MMP on a horizontal cable, a normal situation during recovery. Sampling will be conducted once a day.

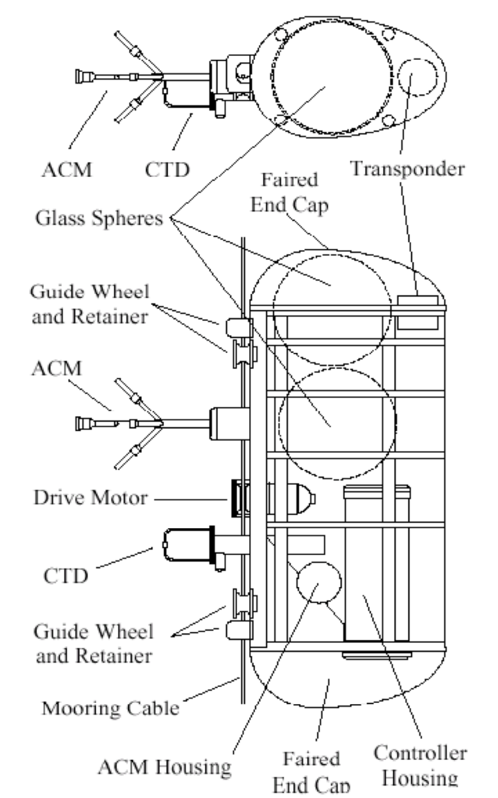


Fig.3.1.2-1 Cut away side and top views of the MMP showing the major components of the system. The overall dimensions of the faired external shell are 124 cm * 51 cm* 34 cm

(Specification)

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

Table 3.1.2-1 MMP Setting Parameter

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

4) Depth Sensor

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

(Specification)

Model:	RMD-500
Operating Depth:	0 ~ 500m
Precision:	0.5% (F.S.)
Accuracy:	1/1300

Memory:	65,534 data (128kbyte)
Battery:	lithium battery (CR2032) DC6V
Battery Life:	65,000 data or less than 1 year
Sample interval:	2 ~ 127 seconds or 1 ~ 127 minutes
Broken Pressure:	20MPa
Diameter:	50mm
Length:	150mm
Main Material:	vinyl chloride resin
Cap material:	polyacetal resin
Weight:	280g

(sampling parameter)

Sampling interval:	2 hours

5) Load-Cell

Load-Cell was designed to measured the mooring tension during deployment, moored and recovery even short term and long term at about 5,000 m depth. This system consists of waterproof load-cell, digital strain recorder, housing and connecting cable.

(Specification)

Waterproof Load-Cell

Model:	LTF-A-50KNS49106
Max. Tension:	50 kN
Rated Output:	0.5 mV/V (1000*10^{-6} strain)
Nonlinearity:	±1 %RO
Operating Temp.:	+50 [deg] to –10 [deg]
Diameter:	135 mm
Length:	567 mm
Weight:	30 kg

Digital strain recorder

Model:	RMH-201A-0 M10
Sample:	30,720 data
Sample Interval:	1 minutes ~ 99 hours 59 minutes
Operating Temp.:	+50 [deg] to –20 [deg], 10-95 %RH
Battery:	DC6-15V Battery Pack
Size:	180 mm * 70 mm * 55 mm
Weight:	800 g

(sampling parameter)

Sampling interval:	30 minutes

This system was installed approximately one meter above a releaser system during MR05-01 mooring and not installed MR05-04 mooring.

6) RAS (Remotely Access Sampler)

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

Length, width and Height is 73 cm, 73 cm, and 114 cm, respectively, and weight with empty sample containers is 110 kg in air and 57 kg in water. The RAS instruments were loaded with acid-cleaned, 500 ml–capacity bags made of the following 3 laminated layers; a thin exterior Mylar® film for protection, a vacuum coated aluminum foil layer for blocking solar radiation and minimizing gas diffusion and an interior, Teflon® film for reinforcement and insulation of sample water from the Al layer. Each bag was pre-loaded with a preservative solution (2 ml $HgCl_2$ solution: 35.g $HgCl_2$ in 100 ml distilled water), connected to a distribution valve and placed within a sturdy 600 ml sample container (acrylic sheathe) within the instrument. The remaining spaces within sheathes were filled with seawater before deployment. There are 49 identical bag assemblages on a RAS. Of these, 48 were used to sample seawater on a scheduled sequence. The remaining bag was filled with 6M HCl that was used to flush the intake path before each water sampling procedure in order to avoid biofouling.

Normally, the RAS multi-port valve resides in a home position that blocks all intake paths. Five minutes before sampling, the multi-port valve aligns with the intake path and the cleansing acid bag and a 5 ml jet of 6M HCl flushes the intake manifolds. After a one-minute pause, the same path was rinsed with 100 ml of *in situ* seawater. Then the multi-port valve aligns the intake valve to a designated sampling bag assemblage. As the seawater is removed from the acrylic sheathe by operating the pump in reverse to the previous flush stage, the resultant low pressure induces the *in situ* water to move into the sampling bag. To minimize cross contamination of water samples, the graphite-gear pump is not exposed to the sample water but only to the evacuated distilled water in the sheathes. At stations K-1 and K-2, 450 to 480 ml samples were collected at programmed event times. Execution records documenting sample timing, estimated sample volume, flushing periods, and electricity consumption were logged by the RAS instruments and retrieved from the memory on recovery.
The RAS instruments collected 48 *in situ* seawater samples, up to 500 ml each, at 4 or 8 day interval starting at 1:00 from October 1, 2005 to June 2, 2006.

7) BLOOMS

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

8) WTS

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

9) ZPS

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

10) Sediment trap

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

11) Sampling schedule

Time-series instruments on BGC mooring system were scheduled to collect sample. Table 3.1.1 shows these schedule.

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

As 21cups traps have "2000 year problem", this year is defined as 1985 instead of 2005. 300m trap was dead because of circuit board problem.

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

3.1.2 Preliminary results

(1) Tension

By using a tension meter installed approximately 1m above a releaser system, tension was monitored each 30 minutes.

During towing, tension was approximately 1 ton (Fig. 3.1.2.(1).1). When sinker was descending to the ocean floor, tension was approximately 2 ton that corresponds to sinker weight (2 ton). After sinker touched down the seafloor, tension became approximately 1.7 ton (it is noted that tension in the deep sea under high pressure increased by 0.13 ton because of change in characteristics of strain gauge). These tensions were same as those we observed during MR05-01 BGC and PO deployment.

During the early mooring period, tension was approximately 1.72 ton (actually 1.59 ton) (Fig. 3.1.2.(1).2). This tension is slightly higher than designed tension (1.4 ton). However tension jumped up to approximately 1.9 ton on 14 May and became stable around 1.9 ton thereafter. It is likely that strain gauge of tension meter "drifted". Even if this shift was real, this tension was significantly too small to damage chains and wires used for mooring system.

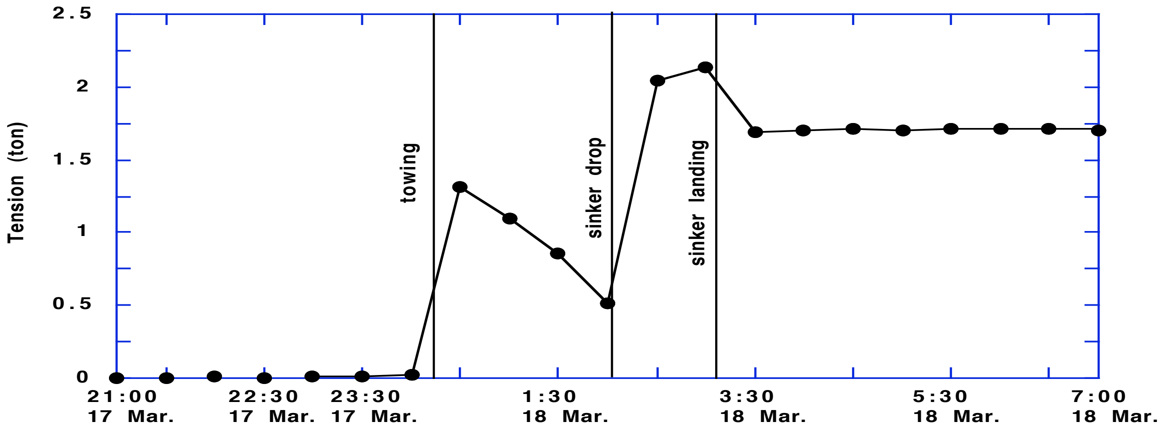


Fig. 3.1.2.(1).1 Variability of tension during deployment work

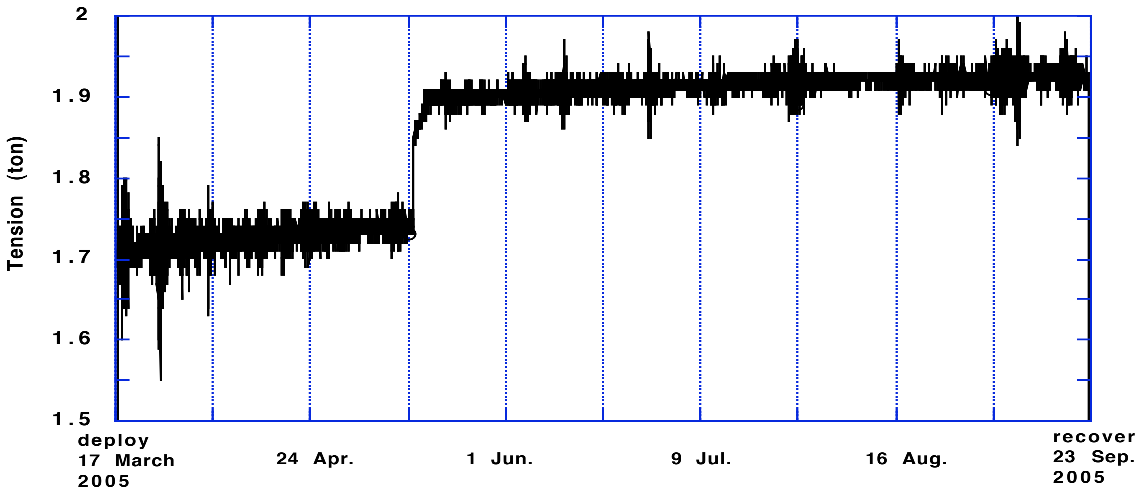


Fig. 3.1.2.(1).2 Variability of tension during mooring work

(2) Depth

During the mooring period, depth sensor was installed on the frame of WTS and variability in WTS depth was monitored each 2 hours (Fig. 3.1.2(2)1). Average of WTS depth was 37.6 m with standard deviation of 1.0 m. Design depth of WTS was approximately 39 m and actual depth was close to that. Depth sometimes increased by more than 40 m. It is likely that tilt of mooring system became larger because of, primarily, increase of current velocity and, secondarily, wave height. In contrast, depth tended to decrease gradually. It is suspected that current velocity gradually decreased from winter toward summer and early autumn. Fortunately depth was relatively stable and shallower than 40 m when water sampling was conducted by RAS (Remote Access Sampler: automatic water sampling system) in order to collect water in the sunlit layer or surface mixed layer.

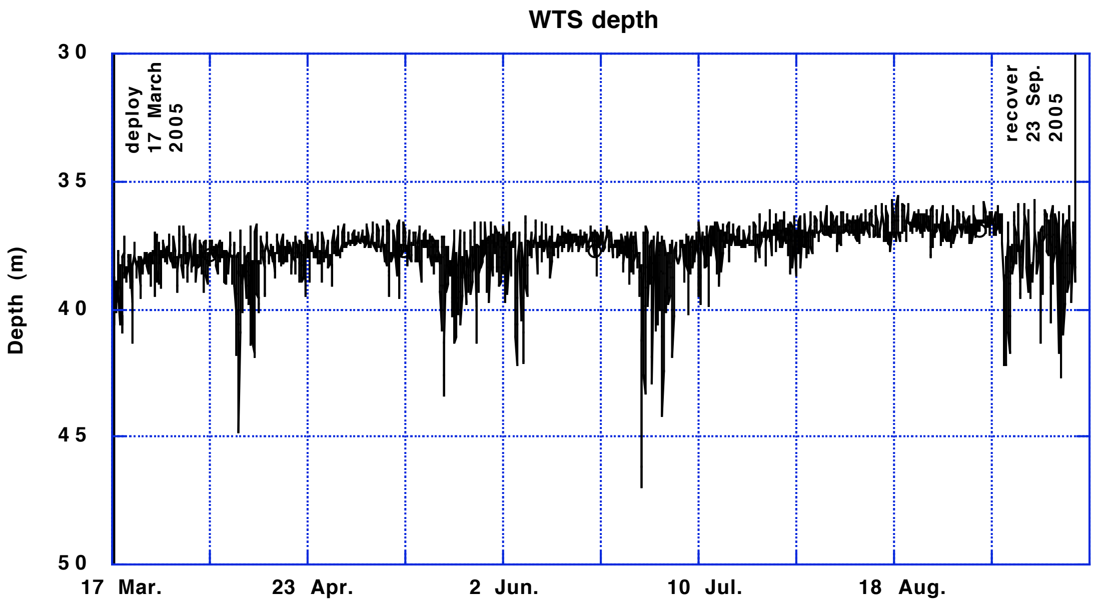


Fig. 3.1.2(2)1 Variability in WTS depth

(3) RAS

RAS (Remotely Access sampler water sampling system) was programmed to collect seawater each 4 days. Before deployment, $HgCl_2$ solution of 2 ml (3.5 g $HgCl_2$ in 100 ml distilled water) was added into sample bag for preservation. Water sampling of approximately 450 ml started on 20 March and ended on 20 September. Samples # 36 and # 46 were not obtained because of lost of sample bag (drop into the sea when recovery) and disconnection of tube, respectively. In addition, surface layer (Mylar®film) of some sample bags were corroded. However water samples of 45 collected seasonally were successfully obtained (Table 3.1.2 (3) 1). Depth of RAS was monitored by a depth sensor installed on WTS (approximately 2 m below RAS) and temperature of seawater collected by RAS was suspected with a thermometer inside of a pressure vessel of RAS (precision: 0.5°C). After recovery, salinity, total dissolved inorganic carbon (TDIC) and nutrients were measured on board.

Photo 3.1.2 (3) Recovered RAS

Table 3.1.2 (3) 1   RAS sample memo

Sample name	Sampling date	memo	RAS depth (m)	Water temp (deg-C)
R 1	2005.3.20	RAS time-series sample	35.8	2
R 2	2005.3.24	HgCl2 2 ml	36.0	2
R 3	2005.3.28		35.8	2
R 4	2005.4.1		35.9	2
R 5	2005.4.5	reak ?	35.3	2
R 6	2005.4.9		36.8	2
R 7	2005.4.13		37.1	2
R 8	2005.4.17		35.0	2
R 9	2005.4.21		35.7	2
R 10	2005.4.25	reak ?	35.4	2
R 11	2005.4.29	upper tube of #12	35.3	2
R 12	2005.5.3	upper tube of #11	35.1	2
R 13	2005.5.7		35.5	2
R 14	2005.5.11		36.7	3
R 15	2005.5.15		35.3	2
R 16	2005.5.19		35.1	3
R 17	2005.5.23	tube broken (reak)?	36.7	3
R 18	2005.5.27	sample bag corrosion	35.4	3
R 19	2005.5.31		34.6	3
R 20	2005.6.4		36.1	4
R 21	2005.6.8	sample bag corrosion	35.7	4
R 22	2005.6.12		34.8	4
R 23	2005.6.16		35.3	4
R 24	2005.6.20		35.3	4
R 25	2005.6.24		35.6	4
R 26	2005.6.28		35.7	4
R 27	2005.7.2		35.2	6
R 28	2005.7.6	sample bag corrosion	35.8	6
R 29	2005.7.10		36.1	6
R 30	2005.7.14		34.6	6
R 31	2005.7.18		35.4	5
R 32	2005.7.22		35.6	6
R 33	2005.7.26		35.1	5
R 34	2005.7.30	TCO2 re-measurement	34.9	6
R 35	2005.8.3		34.9	7
R 36	2005.8.7	sample lost	35.7	5
R 37	2005.8.11		34.6	4
R 38	2005.8.15		35.0	5
R 39	2005.8.19		35.0	7
R 40	2005.8.23		34.6	5
R 41	2005.8.27		34.8	6
R 42	2005.8.31		34.8	7
R 43	2005.9.4		34.6	7
R 44	2005.9.8		35.7	8
R 45	2005.9.12		34.2	11
R 46	2005.9.16	tube disconnect	34.9	10
R 47	2005.9.20		36.1	10
R 48	2005.9.24	no sample		

1) RAS depth and seawater temperature

Based on a depth sensor, RAS was sometimes deepened to below 40 m (Fig. 3.1.2(3)1). But RAS was located at around 35 m fortunately when sampling time came. Although RAS depth tended to increase, its depth was generally stable and 35.4 m on average during mooring period.

Seawater temperature was approximately 2°C (likely < 2°C) from late March to early May. Thereafter temperature increased and reached to 11°C in early September. Based on seawater temperature observed previously, monitored temperatures for respective seasons are reasonable. Relatively large fluctuation can be seen in summer (from middle July to the end of August). It is suspected that boundary between surface mixed layer and subsurface layer existed at around 35 m.

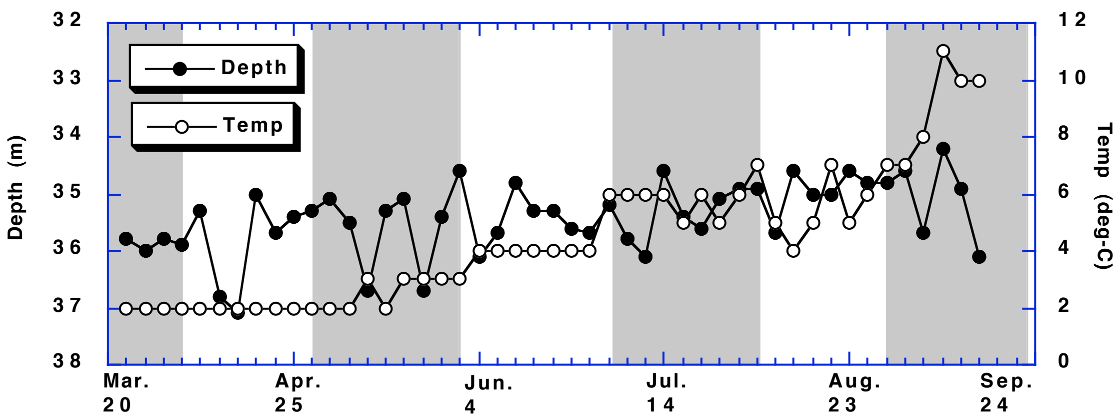


Fig. 3.1.2(3)1 Variability in RAS depth and temperature

2) Salinity

Salinity was measured by using inductively coupled salinometer (AutoLab®YEO-CAL). The salinometer was unstable and repeatability of salinity measurement (n=3) was no good ranging from 0.003 to 0.029 PSU with average of 0.012 psu (n=45). In addition, measured values were approximately 0.05 PSU higher than certificated value based on measurement of salinity of IAPSO standard seawater and substandard. Corrected salinity are shown in Fig. 3.1.1.(3)2. Salinity obtained by RAS ranged from 33.05 to 32.8 with average of 32.903 +/- 0.015 (1σ) PSU. Based on salinity data observed with hydrocasting or CTD, salinity around at 35 m at station K2 is expected to be 33 +/- 0.3 PSU. As RAS seawater sample was diluted by $HgCl_2$ solution up to 0.5% (2 ml in 400 ml seawater sample) – 0.4 % (2 ml in 500 ml seawater sample), salinity of ambient seawater collected by RAS was expected to be 32.8 +/- 0.3 PSU. These corresponded to that of RAS seawater sample.

Generally salinity tended to decrease from March to September. It is likely that depth of 35 m was gradually affected by surface water with lower salinity and higher temperature. Salinity increased in August and its increase was accompanied by decrease of water temperature. In this case, it is likely that subsurface water with lower temperature and higher salinity affected seawater collected by RAS.

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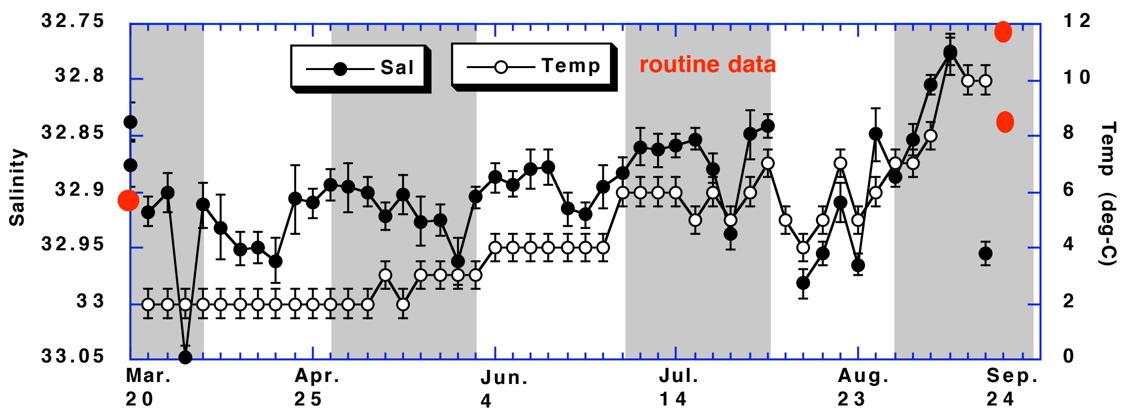


Fig. 3.1.2(3) 2 Variability in RAS salinity and temperature. Red circles are salinity obtained by CTD at the beginning and end of mooring.

3) Nutrients

Approximately 5 ml RAS sample was drawn into virgin 10 ml polyacrylates vial. Concentrations of nutrients (NO_3, NO_2, $Si(OH)_4$ and PO_4) were measured with a continuous flow analytical system on board (BRAN+LUEBEB TRAACS®800). Detail is described in section 2.5 Nutrient.

Concentration of NO_3 was approximately 23 μmol kg^{-1} on 20 March (Fig. 3.1.2(3) 3). This concentration coincided with that observed by hydrocasting at the beginning of March. Maximum of NO_3 was observed on 21 April. Thereafter NO_3 decreased toward summer and autumn with large fluctuation between July and September.

Generally seasonal variation of $Si(OH)_4$ and PO_4 synchronized well with that of NO_3 (Fig. 3.1.2(3) 4). These concentrations for the first and last RAS samples also coincided well with those observed by hydrocasting before and after mooring of RAS, respectively. When RAS was recovered, its surface was biofouled (Photo 3.1.2 (3) 1). However it did never affect concentrations of nutrients.

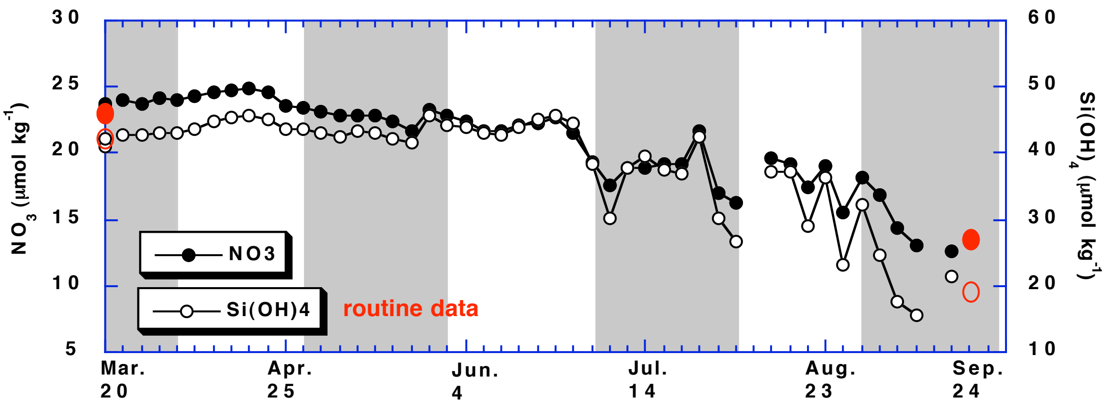


Fig. 3.1.2(3) 3 Variability in NO_3 and $Si(OH)_4$. Red circles are respective concentrations obtained by CTD at the beginning and end of mooring.

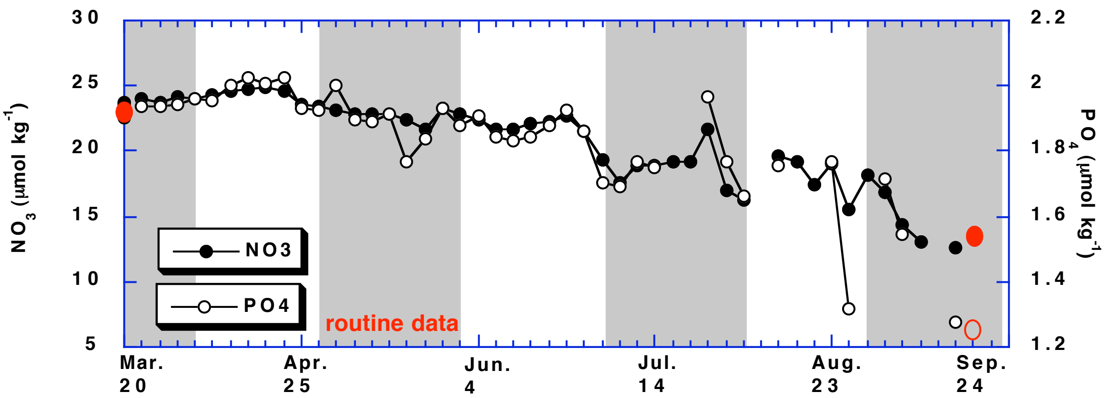


Fig. 3.1.2(3) 4 Variability in NO_3 and PO_4. Red circles are respective concentrations obtained by CTD at the beginning and end of mooring.

4) Total dissolved inorganic carbon (TDIC)

For TDIC analysis, RAS sample water was introduced directly from the sampling bag assemblage into a DIC extraction module with a CO_2 coulometer by applying a gentle N2 gas pressure to the acrylic sheathe cavity. Some acrylic sheathes had a crack when recovery. In this case, sample bags were placed in the new sheathe for TDIC measurement.

Although fluctuation of TDIC was larger than that of nutrients and concentrations of TDIC seemed too low (data in parenthesis in Fig. 3.1.2 (3) 5), TDIC coincided with TDIC observed by hydrocasting and seasonal variation pattern of TDIC was identical to that of nutrients: decrease after May toward summer and autumn.

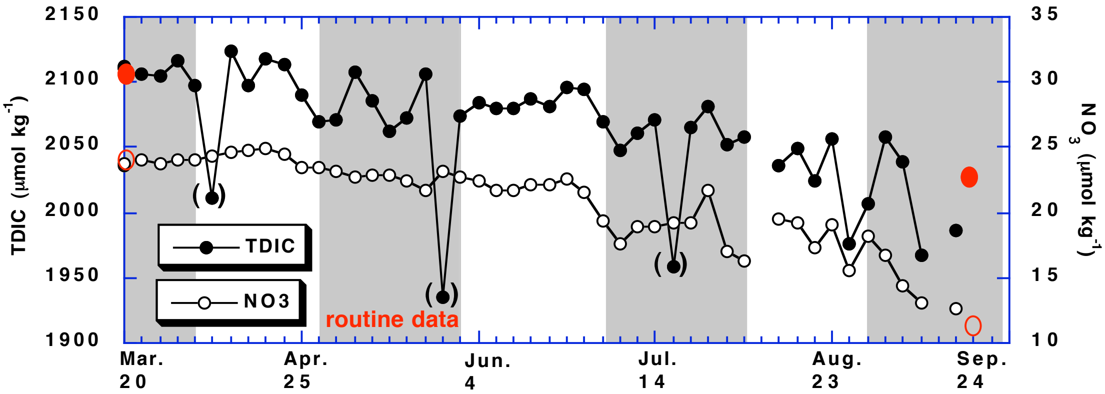


Fig. 3.1.2(3) 4 Variability in TDIC and NO_3. Red circles are respective concentrations obtained by hydrocasting at the beginning and end of mooring.

5) Preservation test

In order to certify appropriate volume of preservative ($HgCl_2$ solution: 3.5g $HgCl_2$ in 100 ml distilled water), nutrients, TDIC and salinity in RAS sample taken during MR05-01 in March 2005 (approximately 6 month ago) were measured. RAS samples without preservative, with 1 ml and 2 ml preservative have been kept in refrigerator since MR05-01.

Table 3.1.2 (3) 1 shows results. Measured values for respective components were corrected with its density and dilution rate of original seawater by preservative.

It was expected that concentrations of nutrients and TDIC of RAS sample without preservative became higher than those with preservative because of decomposition of particles in RAS sample. However there was not significant difference between samples.

Table 3.1.2 (3) 1 Results of preservation test sample analysis

Sample name	Sampling Date	Analysis Date		DIC (μmol kg^{-1})	NO_3 (μmol kg^{-1})	NO_2 (μmol kg^{-1})	NOx (μmol kg^{-1})	$Si(OH)_4$ (μmol kg^{-1})	PO_4 (μmol kg^{-1})	Sal (PSU)
PO-3	2005.3.7	2005.10.4	0	2121.0	23.03	0.186	23.22	41.24	1.857	33.042
PO-4	2005.3.7	2005.10.4	0	2116.4	22.98	0.189	23.17	41.99	1.864	32.947
			average	2118.7	23.01	0.187	23.19	41.61	1.860	32.995
			(μmol $^{-1}$)	2168.1	23.54	0.192	23.73	42.58	1.904	
			+/-	2.4	0.02	0.002	0.02	0.39	0.004	0.048
			dilution correct	2168.1	23.54	0.192	23.73	42.58	1.904	32.995
			(* 1 +/-0)	2.4	0.02	0.002	0.02	0.39	0.004	0.048
P1-3	2005.3.7	2005.10.4	1	2114.4	23.39	0.179	23.57	41.04	1.918	32.950
P1-4	2005.3.7	2005.10.4	1	2114.4	23.41	0.180	23.59	41.22	1.919	32.945
			average	2114.4	23.40	0.179	23.58	41.13	1.918	32.948
			(μmol $^{-1}$)	2163.6	23.95	0.184	24.13	42.09	1.963	
			+/-	0.0	0.01	0.001	0.01	0.09	0.001	0.002
			dilution correct	2168.5	24.00	0.184	24.18	42.18	1.968	33.022
			(* 1.00225+/-0.00025)	0.5	0.02	0.00	0.02	0.10	0.00	0.019
P2-3	2005.3.7	2005.10.4	2	2111.7	23.54	0.171	23.71	40.98	1.903	32.876
P2-4	2005.3.7	2005.10.4	2	2110.5	23.69	0.175	23.87	42.15	1.915	32.837
			average	2111.1	23.62	0.173	23.79	41.56	1.909	32.857
			(μmol $^{-1}$)	2160.3	24.17	0.177	24.35	42.53	1.953	
			+/-	0.6	0.08	0.002	0.08	0.60	0.006	0.019
			dilution correct	2166.8	24.24	0.178	24.42	42.66	1.959	32.955
			(* 1.003+/-0.001)	2.7	0.10	0.00	0.11	0.64	0.01	0.052

These data were compared with those during MR05-0 (Table 3.1.2 (3) 2). There was tendency that NO_2 was higher after 6 months. In the case of TDIC, its concentration tended to be lower. However every data was within measurement error and, at least, even RAS sample without preservative was preserved well for 6 months. In future, during next cruise held in June 2006, respective concentrations in remains of RAS sample will be measured.

Table 3.1.2 (3) 2 Comparison of respective concentrations between MR05-01 and MR05-04

		$HgCl_2$ (ml)	DIC (mmol l^{-1})	NO_3 (mmol l^{-1})	NO_2 (mmol l^{-1})	NOx (mmol l^{-1})	$Si(OH)_4$ (mmol l^{-1})	PO_4 (mmol l^{-1})	Sal (mmol l^{-1})
MR05-01	Routine	0	2174.0	23.61	0.131	23.74	41.88	1.935	33.056
sampling D	(4 Mar. 05)								
analysis D	(4 Mar. 05)								
MR05-01	RAS	0	2174.8	23.83	0.144	23.97	42.60	1.946	-
sampling D	(7 Mar.05)	1	2177.4	23.87	0.145	24.01	42.19	1.947	-
analysis D	(18 Mar.05)	2	2179.6	24.38	0.148	24.53	42.04	1.946	-
MR05-04	RAS	0	2168.1	23.54	0.192	23.73	42.58	1.904	32.995
sampling D	(7 Mar.05)	1	2168.5	24.00	0.184	24.18	42.18	1.968	33.022
analysis D	(4 Oct.05)	2	2166.8	24.24	0.178	24.42	42.66	1.959	32.955

(4) Sediment trap

During MR05-01, sediment traps were installed at approximately 150 m (21 cups), 300 m (21 cups), 500 m (13 cups), 1000 m (13 cups) and 5000 m (13 cups) on the BGC mooring system. Before deployment, collecting cups were filled up with 5 % seawater based buffered formalin solution. Unfortunately 300 m sediment trap did not work because of malfunction (circuit board was burn). One bottle was lost from 500 m sediment trap. However, seasonal data of materials' flux were successfully collected from 150 m to 5000 m. Especially sediment trap samples from 150 m and 500 m were valuable for the study of materials' transportation in the Mesopelagic layer (twilight zone). On board, heights of sample in collecting cups were measured using a "ruler" in order to estimate general pattern of flux (Table 3.1.2 (4) 1, Fig. 3.1.2 (4) 1).

Collecting cups of sediment trap at 150 m were filled up with mesozooplanktons such as copepod, euphausiid and arrowworm. There was tendency that increase of these zooplanktons succeeded increase of small sinking particles, that is mainly phytoplankton. It should be argued whether collected mesozooplankton can be defined as "swimmer" or "carbon flux". Trapping efficiency of sediment traps at 150 m, 500 m and 1000 m seemed low and, conversely high at 5000 m. High flux was observed during June and July at 150 m and in August at 5000 m. The peak of flux seemed delay with increasing depth. If these fluxes originated from the same biogenic events took place in the epipelagic layer, its sinking rate can be estimated to be approximately 150 – 200 m per day. In near future, chemical analysis for biogenic / lithogenic materials and natural radionuclide (^{230}Th) and biological analysis on sediment trap samples will be conducted and how biogenic substances such as organic carbon are transported vertically will be discussed.

Photo 3.1.2 (4) 1 Sediment trap recovered from 150 m. Cruise participants are interested in a lot of mesozooplankton in collecting cups.

Table 3.1.2 (4) 1 Sediment trap record

150m

S/N	Opening date	interval (days)	Sample heights (mm)		memo
			Total	<1mm	
1	2005.3.20	14	10	1	copepoda, sagitta
2	2005.4.3	14	12	1	copepoda, sagitta, pteropod
3	2005.4.17	14	20	5	copepoda
4	2005.5.1	14	25	10	copepoda, oikopleura
5	2005.5.15	7	130	10	copepoda, Sagitta
6	2005.5.22	7	130	0	Large copepoda
7	2005.5.29	7	120	10	
8	2005.6.5	7	15	1	
9	2005.6.12	7	15	15	large copepoda, preropod
10	2005.6.19	7	110	25	relatively large < 1mm
11	2005.6.26	7	25	25	relatively large < 1mm, sagitta, copepoda
12	2005.7.3	7	60	40	relatively large < 1mm, thysanoessa
13	2005.7.10	7	110	5	tomopteris, Clione
14	2005.7.17	7	120	10	relatively large < 1mm, sagitta
15	2005.7.24	7	70	5	Sagitta, thmisto
16	2005.7.31	7	20	7	sagitta, salpa
17	2005.8.7	7	20	20	relatively large < 1mm, sagitta, copepoda
18	2005.8.14	7	55	20	relatively large < 1mm
19	2005.8.21	7	80	10	sagitta
20	2005.8.28	7	30	10	sagitta
21	2005.9.4	7	7	5	
	2005.9.11				

540m

S/N	Opening date	interval (days)	Sample heights (mm)		memo
			13 cups	21 cups*	
1	2005.3.20	14	1	1.8	
2	2005.4.3	14	1	1.8	
3	2005.4.17	14	1	1.8	
4	2005.5.1	14	1	1.8	
5	2005.5.15	14	1	1.8	
6	2005.5.29	14	2	3.6	
7	2005.6.12	14	2	3.6	
8	2005.6.26	14			bottle lost
9	2005.7.10	14	10	18	
10	2005.7.24	14	5	9	
11	2005.8.7	14	3	5.4	
12	2005.8.21	14	2	3.6	
13	2005.9.4	14	1	1.8	
	2005.9.18				

* x 450/250

Table 3.1.2 (4) 1　Continued

1000m

S/N	Opening date	interval (days)	Sample heights (mm)		memo
			13 cups	21 cups	
1	2005.3.20	14	0.5	0.5	fisf scale
2	2005.4.3	14	0.5	0.5	fisf scale, foraminifera
3	2005.4.17	14	0.5	0.5	fisf scale
4	2005.5.1	14	1	3	fisf scale, foraminifera
5	2005.5.15	14	1	3	
6	2005.5.29	14	1	2	
7	2005.6.12	14	2	3	
8	2005.6.26	14	10	15	
9	2005.7.10	14	20	30	
10	2005.7.24	14	10	20	
11	2005.8.7	14	6	10	
12	2005.8.21	14	1	1	
13	2005.9.4	14	2	3	
	2005.9.18				

sample bottle changed to 21 cups foe shipping

4810m

S/N	Opening date	interval (days)	Sample heights (mm)		memo
			13 cups	21 cups*	
1	2005.3.20	14	1	1.8	
2	2005.4.3	14	2	3.6	
3	2005.4.17	14	5	9	
4	2005.5.1	14	8	14.4	
5	2005.5.15	14	8	14.4	
6	2005.5.29	14	5	9	
7	2005.6.12	14	5	9	
8	2005.6.26	14	2	3.6	
9	2005.7.10	14	40	72	
10	2005.7.24	14	85	153	gigantic flux
11	2005.8.7	14	90	162	gigantic flux
12	2005.8.21	14	45	81	
13	2005.9.4	14	15	27	
	2005.9.18				

* x 450/250

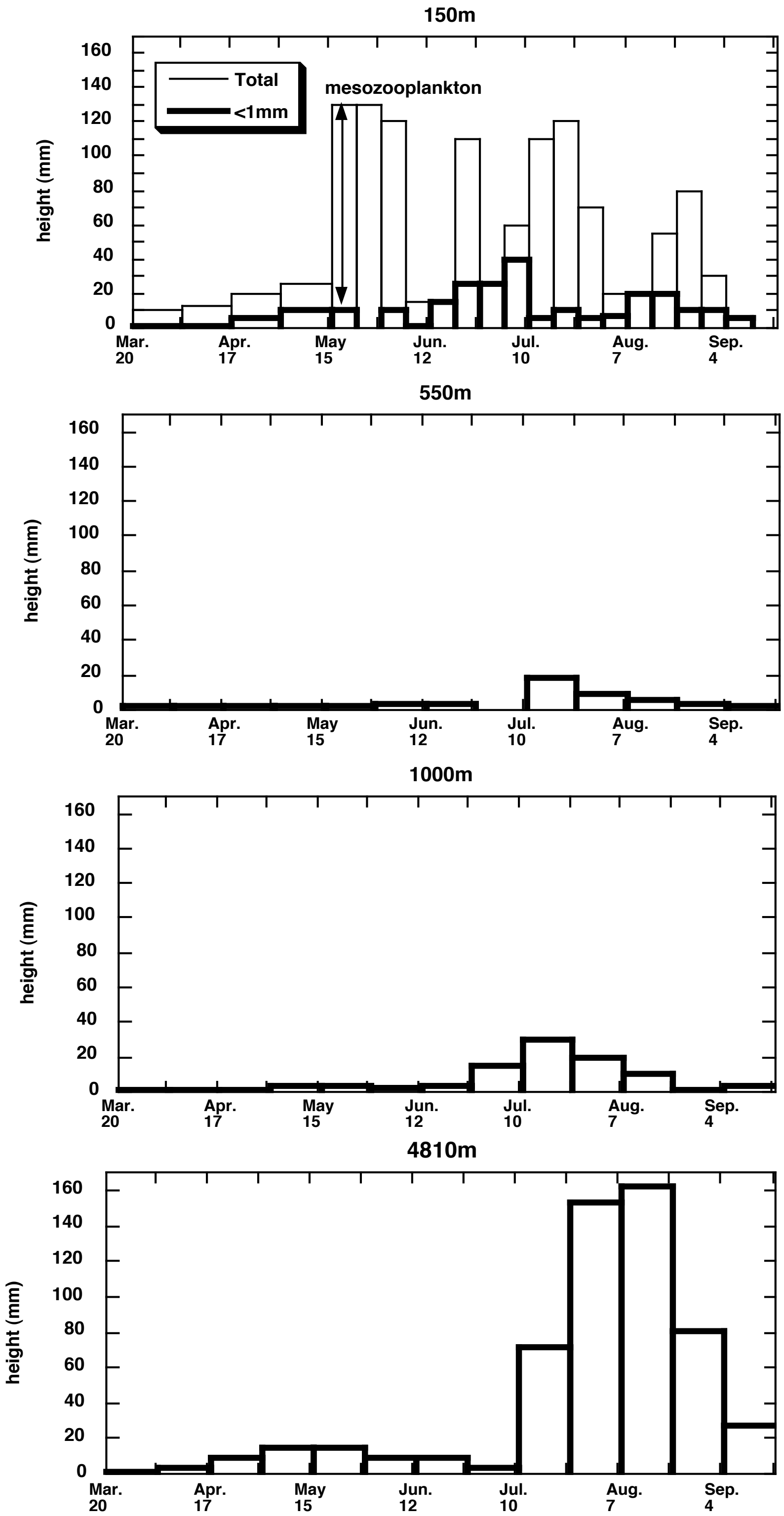


Fig. 3.1.2 (4) 1 Heights of sediment trap samples

(5) ZPS (Zoo plankton sampler)

In the early years we started to use ZPS, filtrated volume of seawater was set to be 100 l. However enough zooplankton samples could not be obtained. Therefore ZPS was initialized to filtrate seawater of 500 l through roll-type filter (Nitex 100μm mesh) when deployment in MR05-01 cruise. However a battery power were exhausted after 16 th pumping (19 May). When a battery power was too low, control function of filter exchange did not work and roll type filter was winded by the end. Therefore filter number could not be recognized and no sample could be obtained. In addition, even increase of filtrated seawater volume did not collect enough zooplankton.

(6) WTS (Phytoplankton sampler)

The WTS was initialized to collect phytoplankton sample by filtrating 10 l seawater through GF/F filter and Nucleopore filter once per 14 days. Time-record of WTS showed every filtration was conducted on schedule and normally. However particles collected on filters were very little. According to sediment trap experiment, more phytoplankton and zooplankton should be filtrated in spring and summer. After inspection, inside metal parts of pump such as gear and magnet were seriously oxidized or corroded. Based on the test on board and on land laboratory, time-record of WTS shows only normal situation even if seawater is not filtrate through GF/F and Nuclepore filter as long as electric current runs. This problem should be overcome in near future.

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

BLOOMS measures downwelling spectral irradiance at four wave lengths (412, 443, 490, and 555 nm) on the hour between 6:00 and 18:00 LST, namely 13 times a day and recorded in one file a day. BLOOMS started its sampling on 18 March and final file was made on 22 September and 189 files were obtained. These files will be sent to Professor Tommy Dickey of University of California, Santa Barbara and analyzed.

3.2 Phytoplankton

3.2.1 Chlorophyll *a* measurements by fluorometric determination

Kazuhiko MATSUMOTO (JAMSTEC)：Principal Investigator
Masanori ENOKI (MWJ)：Operation Leader

1. Objective

Phytoplankton exists various species and size in the ocean. Phytoplankton species are roughly characterized by the cell size. The object of this study is to investigate the vertical distribution of phytoplankton by using the size-fractionated filtration method in the North Pacific Ocean.

2. Sampling elements

・Total-chlorophyll *a* (Shallow & Deep-cast)
・Size-fractionated chlorophyll *a* (Shallow-cast)

3. Instruments and Methods

Samplings were conducted at shallow-cast and deep-cast using Niskin bottles, except for the surface water, which was taken by a bucket. Seawater samples were collected from 8 layers which was determined by the optical free-fall sensor for the experiments of primary productivity at shallow-casts, and collected at 9 depths from surface to 200m at deep-casts. Water samples (1L) for size-fractionated chlorophyll *a* were sequentially vacuum-filtrated (<15cmHg) 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. Water samples (0.5L) for total-chlorophyll *a* were vacuum-filtrated (<15cmHg) through 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℃ under the dark condition to extract chlorophyll *a* for 24 hours or more. Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was previously calibrated against a pure chlorophyll *a* (Sigma chemical Co.).

We applied the fluorometric "Non-acidification method"(Welschmeyer, 1994) and "Acidification method"(Holm-Hansen *et al.*, 1965), but size-fractionated samples were used by only "Non-acidification method".

4. Preliminary Results

The distributions of chlorophyll *a* show in Figure 1.

5. Data archives

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

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. *Limno.Oceanogr* :39,1985-1992.

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

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

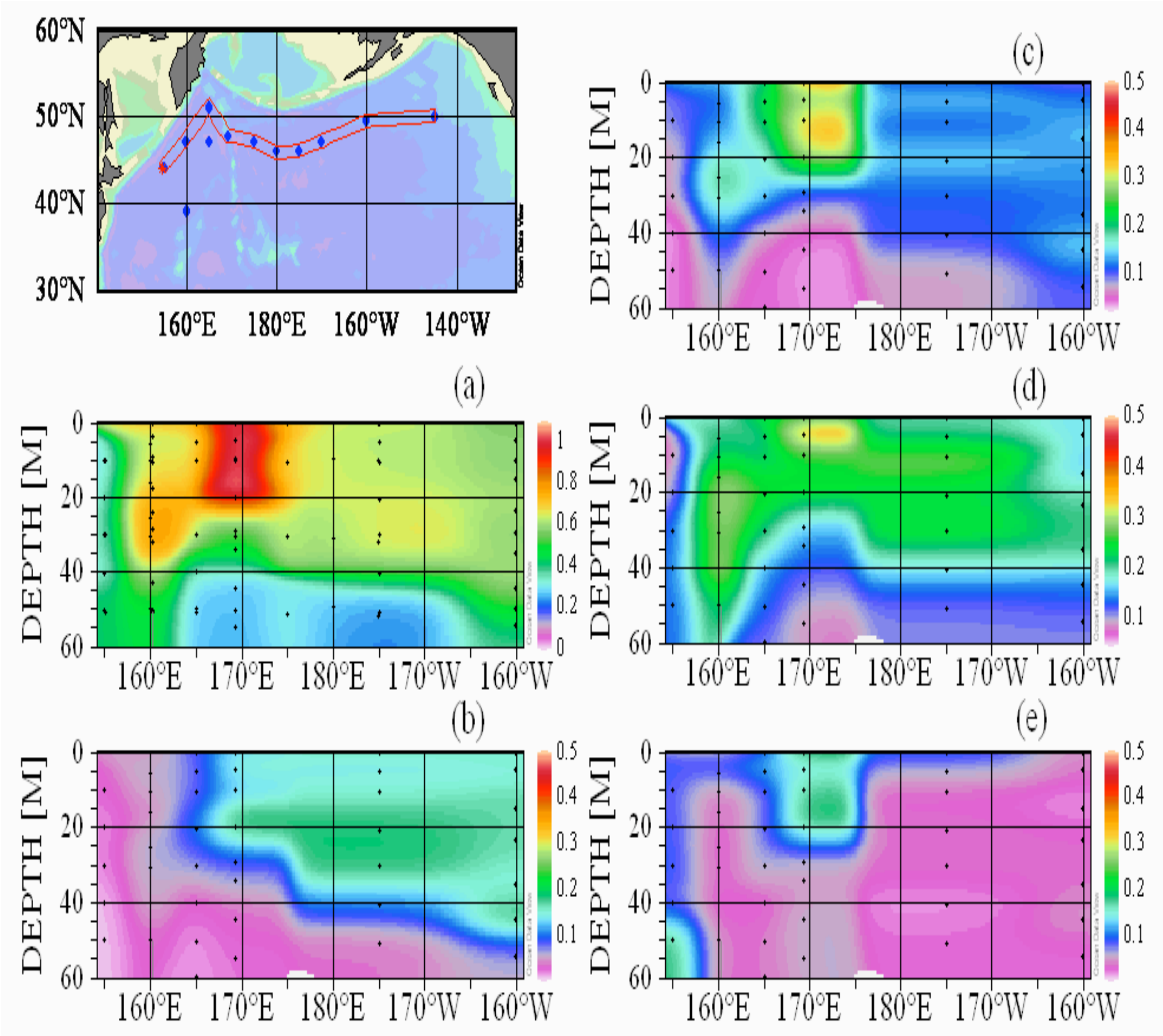


Fig.1 Vertical distributions of chlorophyll *a* concentrations, (a)Total-Chl.a, (b)>10 μ m, (c)3-10 μ m, (d)1-3 μ m, (e)<1 μ m .

3.2.2 HPLC measurements of marine phytoplankton pigments

Kazuhiko MATSUMOTO (JAMSTEC) : Principal Investigator
Yuichi SONOYAMA (Marine Works Japan Ltd.) : Operation Leader

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 chromatographic (HPLC) measurement seems to be a conclusive method for separating and quantifying phytoplankton pigments in natural seawater.

In this cruise, we measured the marine phytoplankton pigments by HPLC method to investigate the marine phytoplankton community structure between 150E and 140W in the North Pacific Ocean.

2. Methods or Apparatus & Performance

Seawater samples were collected at 8 depths in the euphotic zone at shallow-cast using Niskin bottles, except for the surface water, which was taken by a bucket. The water samples (3~5L) were vacuum-filtrated (< 0.020Mpa) through the 47 mm-diameter Whatman GF/F filter. To remove the remaining seawater of the sample filters, GF/F filters were vacuum-dried in freezer (-20 deg C) for 1 hour. Subsequently, phytoplankton pigments retained on a filter were extracted in a glass tube with 4 ml of N,N-dimethylformamide (HPLC-grade) for at least 24 hours in freezer (-20 deg C), and analyzed within a few days.

Cells and filter debris were removed through polypropylene syringe filter (pore size: 0.2 μm) before the analysis. The samples(500μl) were injected by the auto-sampler and measured with photodiode array detector, immediaetly after the addition of pure water(180μl) into the samples(420μl). Our HPLC system was modified the method of Zapata *et al* (2000).

2.1 HPLC System

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

2.2 Stationary phase

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

2.3 Mobile phases

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

2.4 Standard pigments

The HPLC system is calibrated with the following pigment standards (Table 1). We selected Chlorophyll *a*, Chlorophyll *b* (Sigma co.) and other 28 pigments (DHI co.). The concentrations of pigment standards were determined using its extinction coefficient by spectrophotometer, then the solvents of pigment standards were displaced to N,N-dimethylformamide.

2.5 Pigment detection and identification

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

First channel was detected at 664.0 nm of wavelength for measurement of Chlorophyllide *a*, Pheophorbide *a*, Divinyl Chlorophyll *a*, Chlorophyll *a* and Pheophytin *a*.

Second channel was detected at 457.2 nm of wavelength for Chlorophyll *b*.

Third channel was detected at 460.0 nm of wavelength for other pigments.

3. Preliminary results

Preliminary results were shown in Figure 1~4.

4. Data archives

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

Reference

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

Table 1. Retention time and wavelength of pigment standards.

No.	Pigment	Retention Time (minute)	Wavelength (max : nm)	Extinction Coefficient (l/g/cm)	Solvent
1	Chlorophyll *c3*	10.513	459.6	346	90% acetone
2	Chlorophyllide *a*	12.748	433.1	127	90% acetone
3	Chlorophyll *c2*	14.272	454.8	374	90% acetone
4	Peridinin	17.537	476.5	132.5	100% ethanol
5	Pheophorbide *a*	19.795	411.4	74.2	90% acetone
6	19'-butanoyloxyfucoxanthin	20.422	447.5	160	100% ethanol
7	Fucoxanthin	21.608	452.4	160	100% ethanol
8	Neoxanthin	21.897	440.3	224.3	100% ethanol
9	Prasinoxanthin	23.080	454.8	160	100% ethanol
10	19'-hexanoyloxyfucoxanthin	23.725	447.5	160	100% ethanol
11	Violaxanthin	23.738	442.7	160	100% ethanol
12	Diadinoxanthin	25.625	450.0	255	100% ethanol
13	Antheraxanthin	26.253	450.0	262	100% ethanol
14	Alloxanthin	26.642	454.8	235	100% ethanol
15	Myxoxanthophyll	26.680	478.9	216	100% acetone
16	Diatoxanthin	27.063	454.8	262	100% ethanol
17	Zeaxanthin	27.405	454.8	254	100% ethanol
18	Lutein	27.492	447.5	255	100% ethanol
19	Canthaxanthin	28.360	474.1	207.5	100% ethanol
20	Gyroxanthin-diester	28.857	445.1	262	100% ethanol
21	Crocoxanthin	30.203	450.0	250	100% ethanol
22	Chlorophyll *b*	30.647	457.2	51.23	100% DMF
23	Beta-cryptoxanthin	30.757	454.8	347	100% n-Hexane
24	Echinenone	31.080	462.0	215.2	100% ethanol
25	Divinyl Chlorophyll *a*	31.715	437.9	87.67	90% acetone
26	Lycopene	31.797	474.1	344.6	100% acetone
27	Chlorophyll *a*	31.960	430.7	88.74	100% DMF
28	Pheophytin a	34.895	411.4	51.2	90% acetone
29	Alpha-carotene	34.975	450.0	270	100% acetone
30	Beta-carotene	35.213	454.8	250	100% acetone

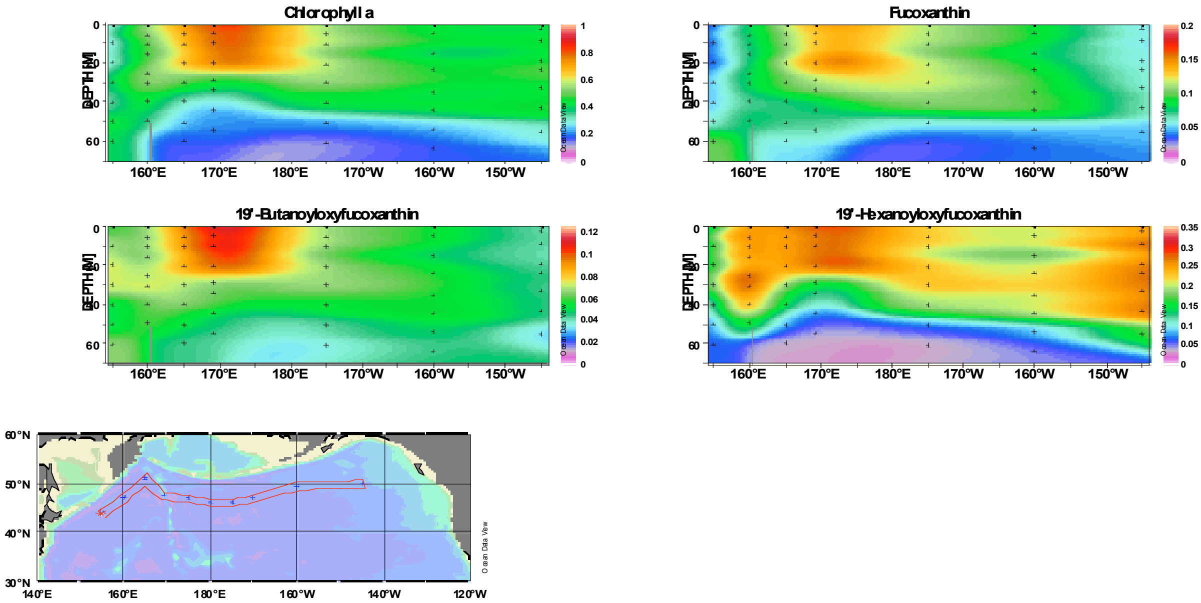


Figure 1. Vertical distribution of phytoplankton pigments concentrations (μg/L) of Chlorophyll *a*, Fucoxanthin, 19'-Butanoyloxyfucoxanthin and 19'-Hexanoyloxyfucoxanthin across the transect shown on the map (stations from KNOT to OSP).

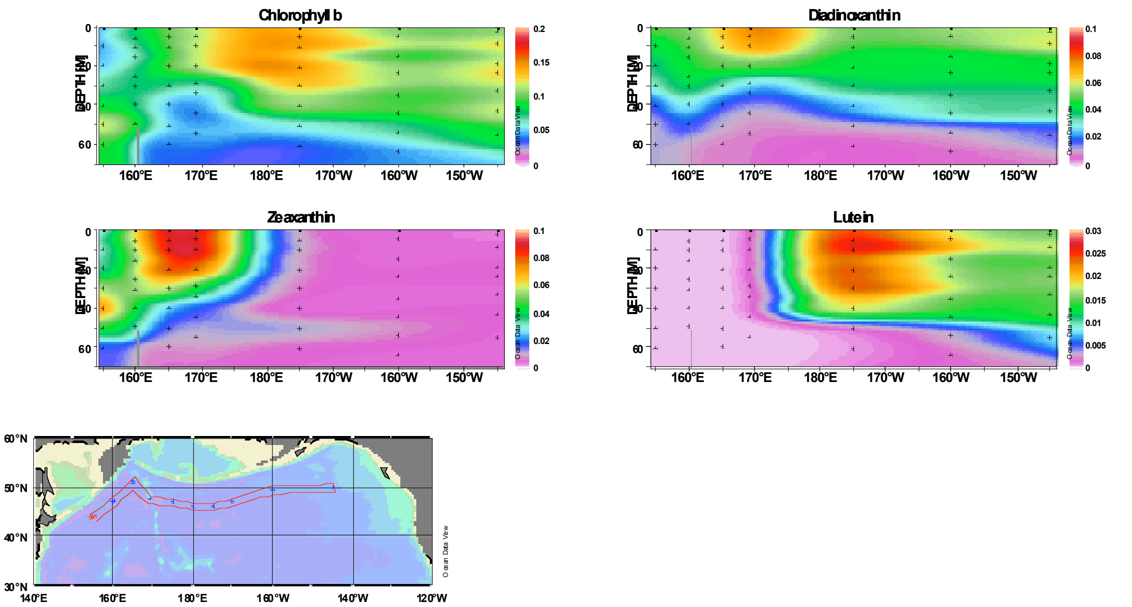


Figure 2. Vertical distribution of phytoplankton pigments concentrations (μg/L) of Chlorophyll *b*, Diadinoxanthin, Zeaxanthin and Lutein across the transect shown on the map (stations from KNOT to OSP).

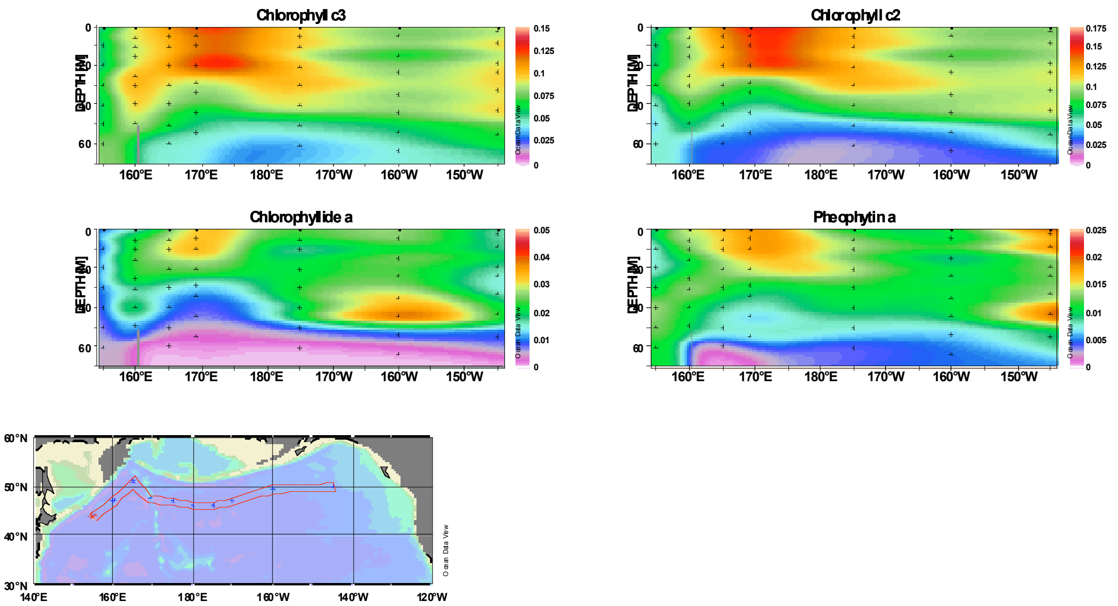


Figure 3. Vertical distribution of phytoplankton pigments concentrations (µg/L) of Chlorophyll *c3*, Chlorophyll *c2*, Chlorophyllide *a* and Pheophytin *a* across the transect shown on the map (stations from KNOT to OSP).

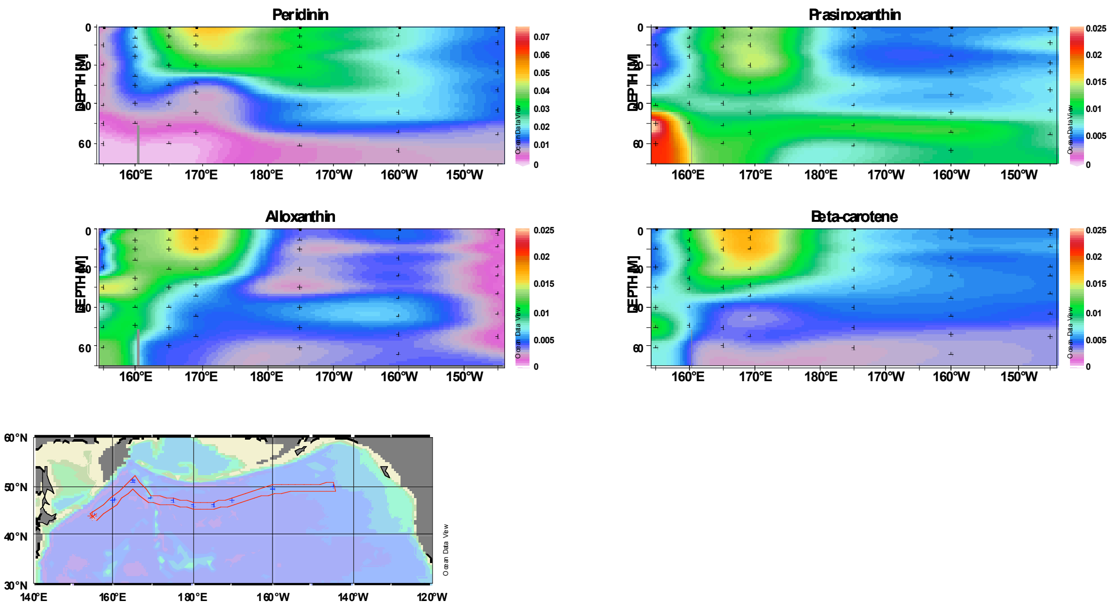


Figure 4. Vertical distribution of phytoplankton pigments concentrations (μg/L) of Peridinin, Prasinoxanthin, Alloxanthin and Beta-carotene across the transect shown on the map (stations from KNOT to OSP).

3.2.3 Phytoplankton abundances

Kazuhiko MATSUMOTO (JAMSTEC)

(1) Objectives

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

(2) Materials and Methods

1) Microscopy

Samplings were conducted at all stations from surface to the depth of 75m. Water samples were placed in 500 ml plastic bottle and fixed with neutral buffered formalin solution (3% final concentration). The measurements are scheduled after the cruise.

2) Flowcytometry

2)-1 Equipment

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

Light source: 75W Xenon arc lamp
Excitation wavelength: 350-650 nm
Detector: high-performance PMT
Analyzed volume: 75 µl
Flow rate: 10 µl min^{-1}
Sheath fluid: Milli-Q water
Filter block: B2 as excitation filter block, OR1 as fluorescence separator block
B2 and OR1 have ability as follows:

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

2)-2 Sampling

Samplings were conducted at the cast for primary productivity at the same depths. Water samples were drawn with filtering by Nuclepore filter (pore size: 10µm) which mounted to a filter holder, and placed into 50 ml bottle. The sample was fixed immediately with glutaraldehyde (1% final concentration) and stored in the dark at 4°C.

2)-3 Measurements

Flow cytometer was acquired on board within 24 hours after the sample fixation. Calibration was achieved with standard beads (Polysciences) from 0.356 to 9.146µm, and

2.764μm beads were added into each sample prior to injection as internal standard. Phytoplankton cell populations and cell sizes were estimated from the forward light scatter signal. Acquired data were stored in list mode file and analyzed with WinBryte software. Phytoplankton are classified with prokaryotic cyanobacteria (*Prochlorococcus* and *Synechococcus*) and other eukaryotes on the basis of scatter and fluorescence signals. *Synechococcus* is discriminated by phycoerythrin as the orange fluorescence, while other phytoplankton are recognized by chlorophylls as the red fluorescence without the orange fluorescence. *Prochlorococcus*, picoeukaryotes and nanoeukaryotes were distinguished with their cell size.

(3) Preliminary result

Although *Prochlorococcus* was not clearly identified in all sites, *Synechococcus* (SYN) and the groups of picoeukaryotes (Pico-S and Pico-L) were identified obviously. Small group of nanoeukaryotes (Nano-S) were relatively distinguished. Since middle or large sizes of nanoeukaryotes were not distinguished clearly by size, their countings were added up as Nano-M. Mean cell sizes of each phytoplankton group were calculated as follows:

Synechococcus (SYN): 0.9μm
Picoeukaryotes (Pico-S): 1.3μm
Picoeukaryotes (Pico-L): 2.0μm
Nanoeukaryotes (Nano-S): 3.4μm
Nanoeukaryotes (Nano-M): 6.7μm

Vertical distributions of phytoplankton abundances ($x10^3$cells ml^{-1}) show in Figure 1. Distinct spatial heterogeneity was found in distribution for each phytoplankton group.

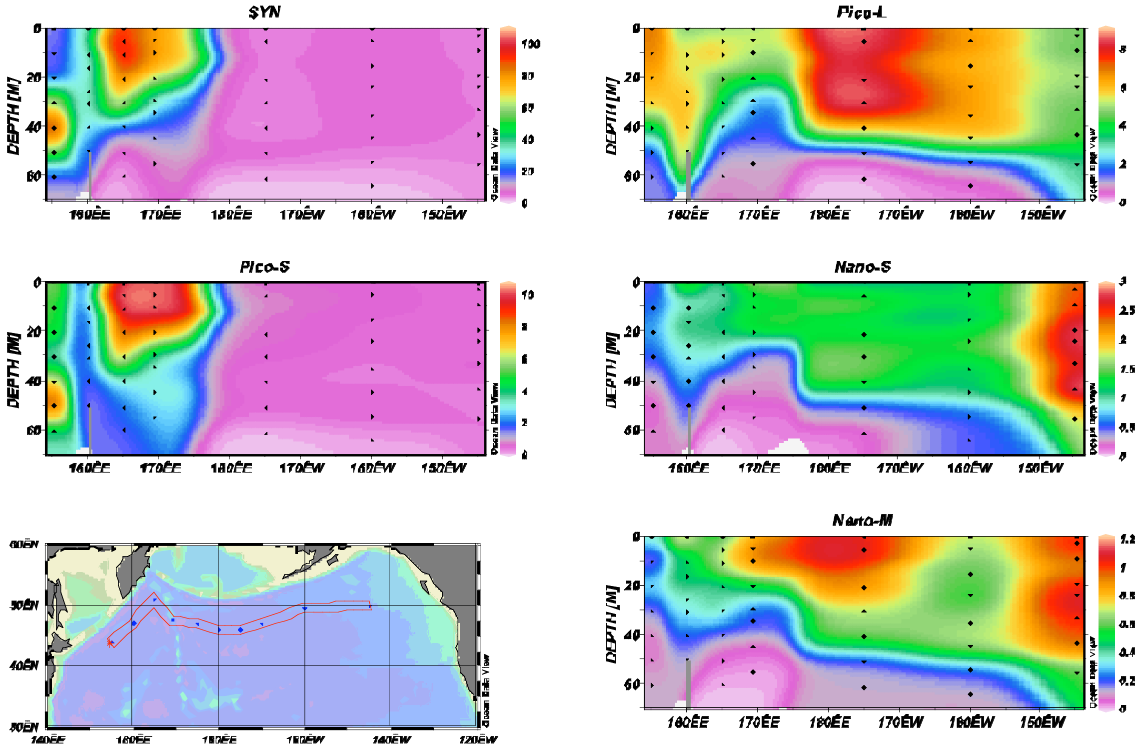


Figure 1. Vertical distributions of cell abundances (10^3 cells ml^{-1}) for each phytoplankton group along the transect which are shown in map.

3.2.4 Polysaccharides and TEP

Kazuhiko MATSUMOTO (JAMSTEC)

(1) Objectives

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

(2) Materials and Methods

(a) Polysaccharides

Samplings were conducted at the cast for primary productivity at the same depths. Water samples were drawn with filtering by precombusted GF/F filters which mounted to a filter holder, and placed into precombusted glass ampoules. Samples were stored at -30°C until the subsequent analysis. A spectrophotometric method is described for the determination of dissolved mono- and polysaccharides in seawater (Hung et al., 2001). It is based upon the well known alkaline ferricyanide reaction with the reagent 2,4,6-tripyridyl-s-triazine (TPTZ), followed by spectrophotometric analysis (Myklestad et al., 1997). The analysis is scheduled after the cruise.

(b) TEP

Samplings were conducted at the cast for primary productivity at the same depths and the deep cast at the station K2. In addition, samples were taken from the floating sediment traps and their installation depths. 100 ml of seawater samples were filtered with 0.4µm Nuclepore filter. The samples of sediment traps were measured to 500 ml with filtered seawater (<0.2µm) and 30 – 50 ml of their samples were filtered with 0.4µm Nuclepore filter. TEP was stained on the filter with 500 µl of a 0.02% aqueous solution of alcian blue (8GX) in 0.06% acetic acid (pH 2.5). Sample filters are stored at -80°C until the subsequent analysis. TEP will be quantified by the method on the basis of Passow and Alldredge (1995). The analysis is scheduled after the cruise.

References

Hung, C.-C., D. Tang, K. W. Warnken and P. H. Santschi (2001). "Distributions of carbohydrates, including uronic acids, in estuarine waters of Galveston Bay." Marine Chemistry 73(3-4): 305-318.

Myklestad, S. M., E. Skånøy and S. Hestmann (1997). "A sensitive and rapid method for analysis of dissolved mono- and polysaccharides in seawater." Marine Chemistry 56(3-4): 279-286.

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

3.3 Th-234 and export flux

Hajime KAWAKAMI (Mutsu Institute for Oceanography, JAMSTEC)

(1) Purpose of the study

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

(2) Sampling

Seawater and suspended particulate sampling for ^{234}Th and POC: 6 stations (stations K2, K1, EW1, EW4, EW7 and OSP) and 8 depths (10m, 30m, 50m, 75m, 100m, 125m, 150m and 200m) at each station.

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

In situ filtering (suspended particulate) samples were taken from large volume pump sampler (LVP). About 200L seawater was filtered with GF/F filter at each stations, and about 1 m^3 seawater was filtered with Nitex mesh filter (53μm) at stations K2 and OSP. The filter samples were divided for ^{234}Th and POC.

(3) Chemical analyses

Dissolved ^{234}Th was separated using anion exchange method on board; all Hydrocast samples. Particulate ^{234}Th from LVP samples were separated in land-based laboratory. Separated samples of ^{234}Th were absorbed on 25mm stainless steel disks electrically, and were measured by β-ray counter.

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

(4) Preliminary result

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

3.4 Optical measurement

Makio HONDA (JAMSTEC)
Kazuhiko MATSUMOTO (JAMSTEC)

(1) Objective

The objective of this measurement is to investigate the air and underwater light conditions at respective stations and to determine depths for *in situ* or simulated *in situ* measurement of primary production by using carbon stable isotope (C-13).

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

(2) Description of instruments deployed

The instrument consisted of the SeaWiFS Profiling Multichannel Radiometer (SPMR; and SeaWiFS Multichannel Surface Reference (SMSR). The SPMR was deployed in a free fall mode through the water column. The profiler has a 13 channel irradiance sensors (Ed), a 13 channel radiance sensors (Lu), tilt sensor, and fluorometer. The SMSR has a 13 channel irradiance sensors (Es) and tilt meter (Table 3.4.1). These instruments observed the vertical profiles of visible and ultra violet light and chlorophyll concentration.

Table 3.4.1. Center wavelength (nm) of the SPMR/SMSR

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

Measurements were conducted at 8 stations usually before and during incubation for measurement of primary productivity. Measurements should be ideally conducted at median time and at each station. However observations were conducted irregularly because of limited ship-time and other observation's convenience. The profiler was deployed twice at respective stations to a depth of 200 m. The reference (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 photosynthesically available radiation (PAR) were computed.

(3) Preliminary results

Fig. 3.4.1 shows vertical profiles of relative PAR for respective station (average with standard deviation for two measurement). Based on these observation, bottom of euphotic layer with relative PAR of 1 % were located between 40 m and 50 m. Station KNOT had deeper euphotic layer (~70 m). Surface PAR shown in figures are mean surface PAR with standard deviation during observation. Maximum surface PAR was observed at station K3 which was the most southern station in this cruise.

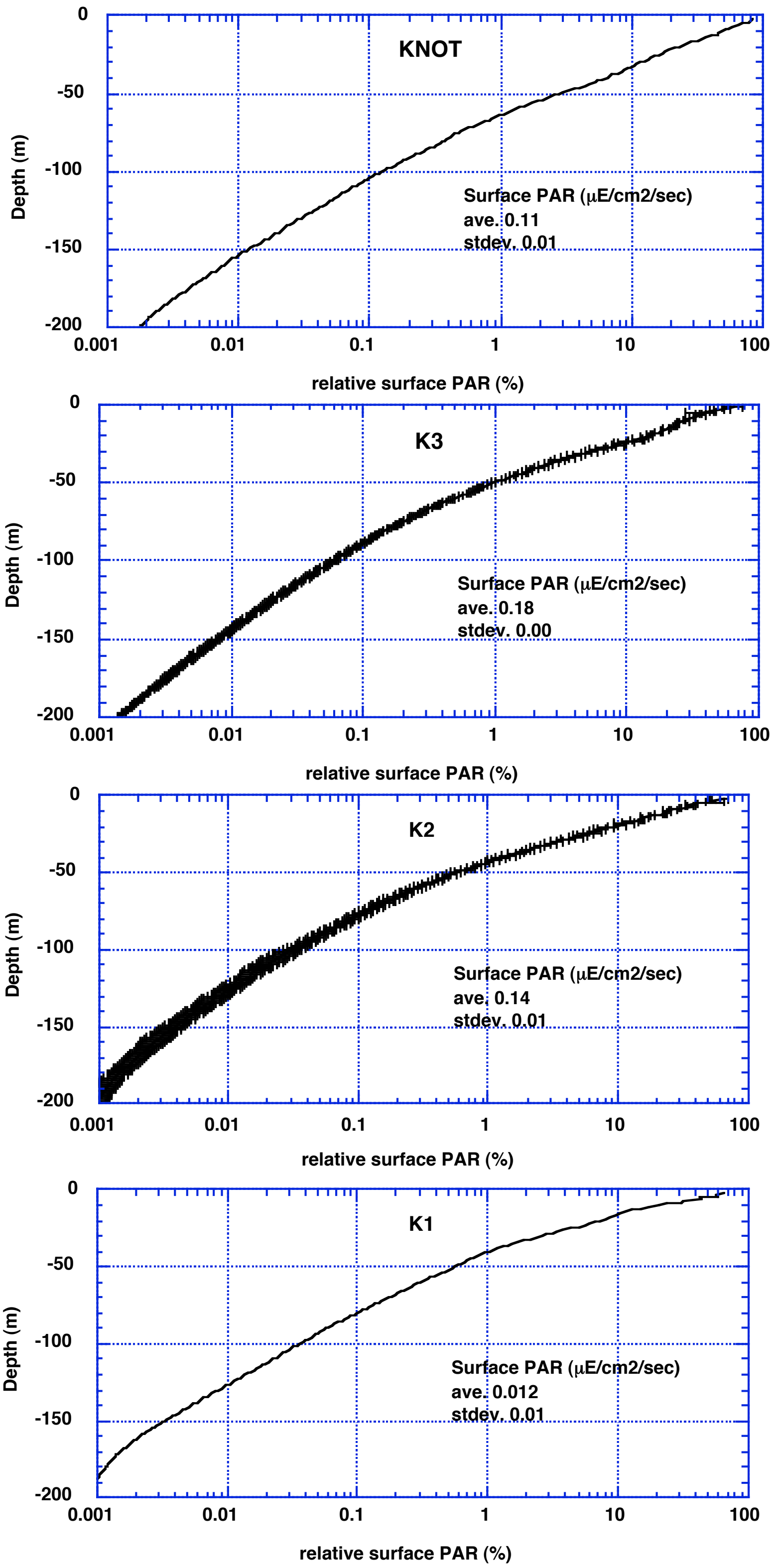


Fig. 3.4.1 Vertical profile of relative PAR for respective

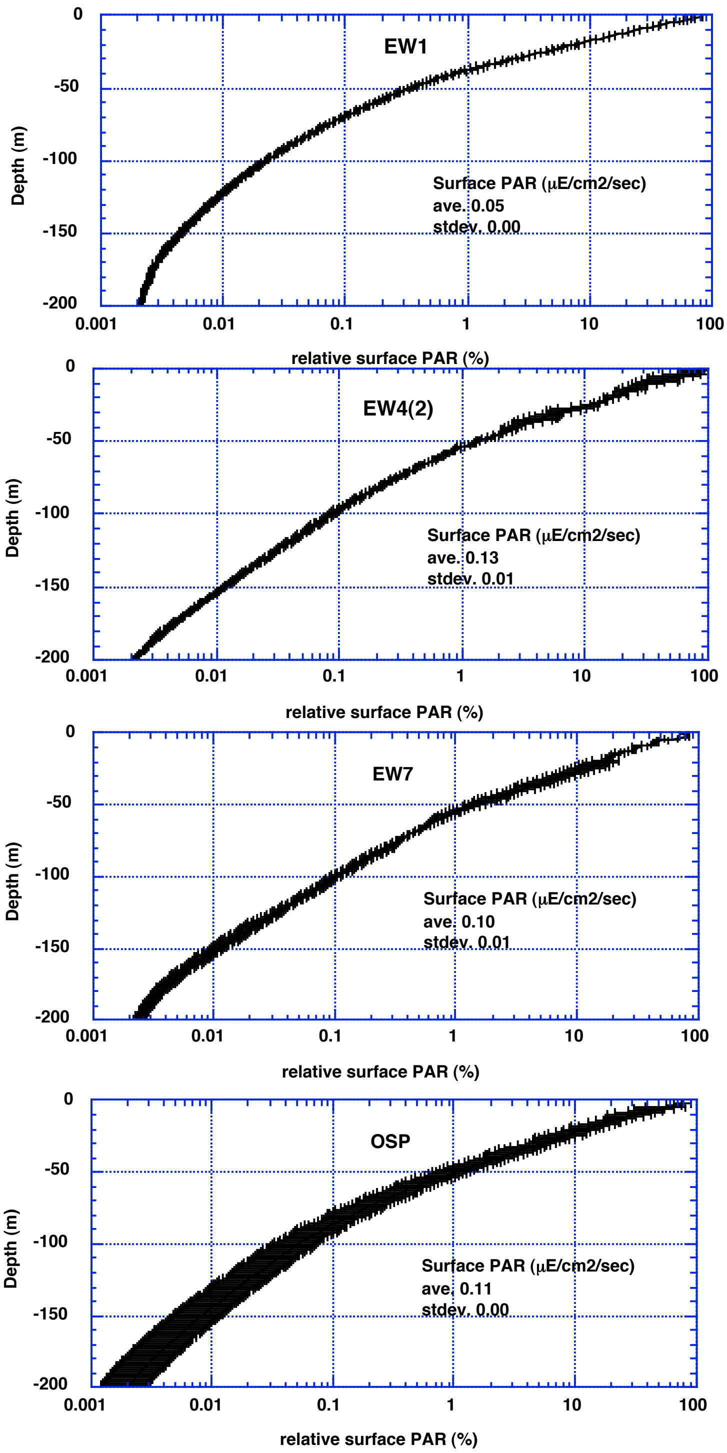


Fig. 3.4.1 Continued

3.5 Primary productivity and Drifting sediment trap

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

3.5.1 Drifting mooring system

In order to conduct in situ incubation for measurement of primary productivity and drifting sediment trap experiment, drifting mooring system (drifter) was deployed at stations KNOT, K3, K2 K1, EW1, EW4, EW7 and OSP. This drifter consists of radar reflector, GPS radio buoy (Taiyo TGB-100), flush light, surface buoy, ropes and sinker. On this system, incubation bottles at 7 layers and "Knauer" type sediment trap at 4 layers were installed. Thanks to the effort by MWJ stuff, drifting mooring system was upgraded on board. Final configuration is shown in Fig. 3.5.1.

The drifter was usually deployed just before sunrise (except stations KNOT, EW7 and OSP) and recovered after 24 hours. The drifter's position was monitored by using GPS radio buoy (Taiyo TGB-100). Fig. 3.5.2 shows tracks of the drifter for respective stations. A trajectory of current, that is accumulation of current observed using ADCP on MIRAI during drifting is also shown. The drifter tended to drift by surface or upper (0-50m) current rather than wind. However the track and trajectory of current did not always coincide when MIRAI was far from the drifter for other observation and current observed did not represent one at the drifter. I addition, surface current observed tended to be influenced by MIRAI's motion. At station K1, the drifter almost approached to the EEZ boundary. At the station OSP, the drifter almost approached to Canadian mooring system.

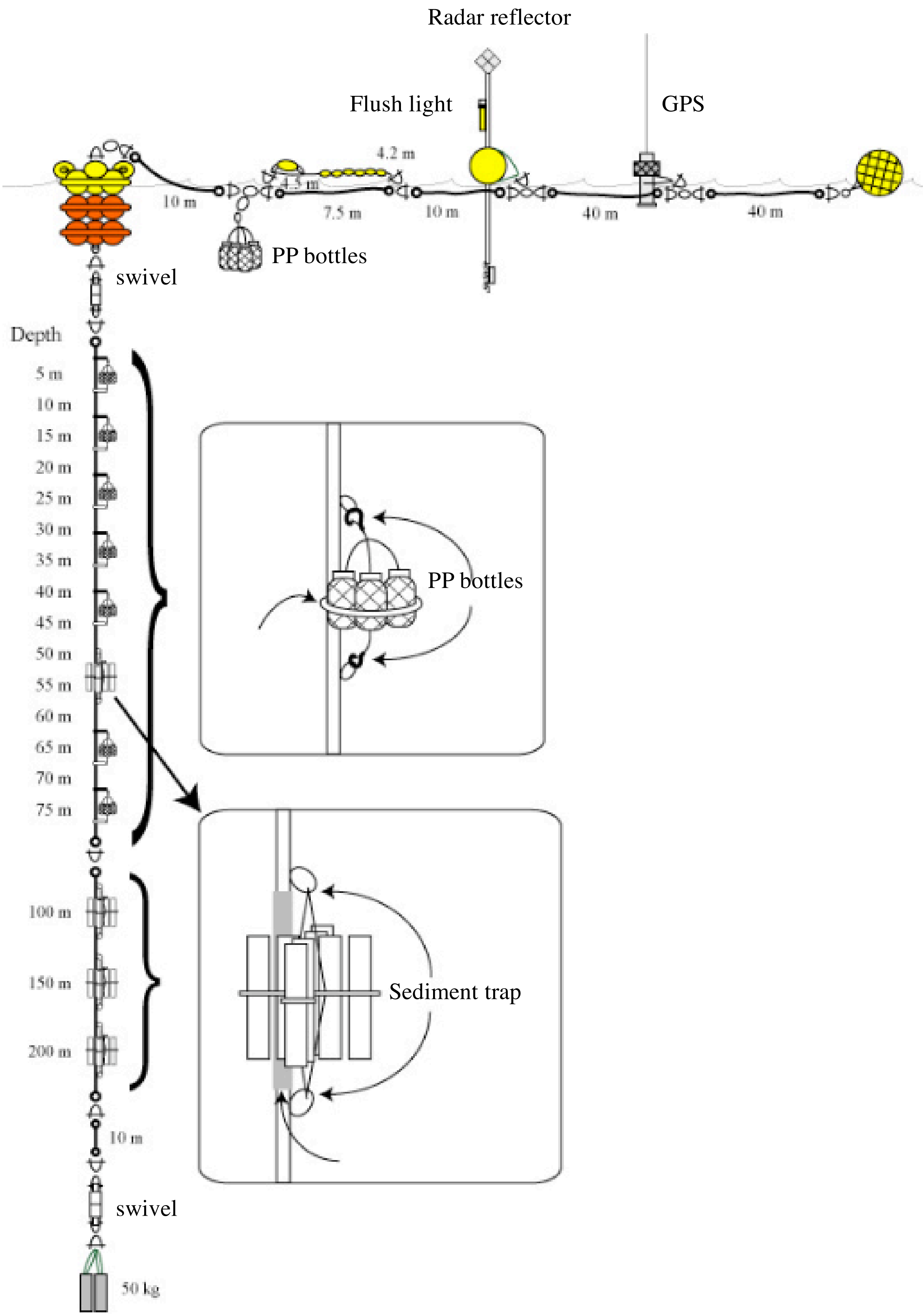


Fig. 3.5.1 Drifting mooring system

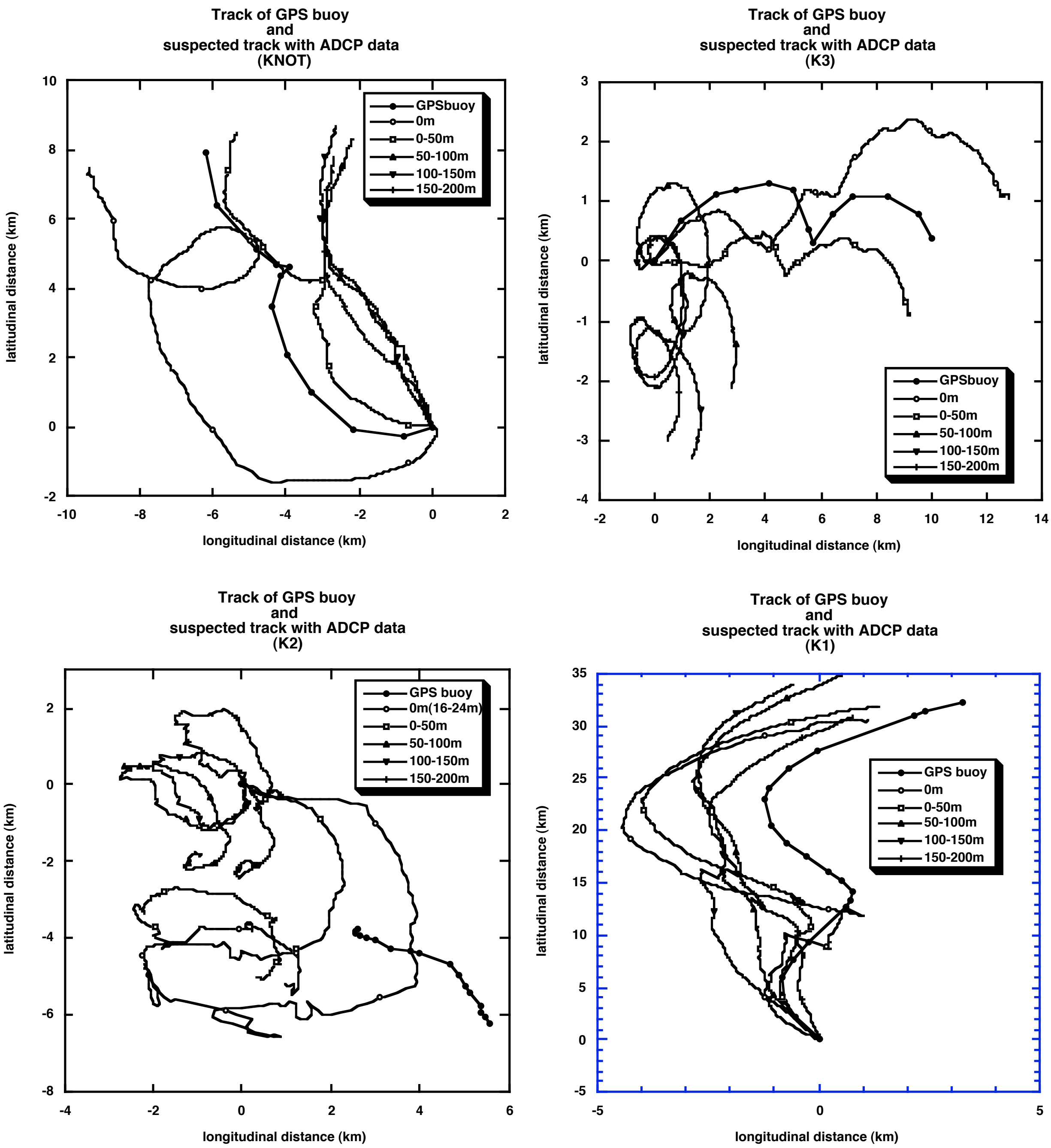


Fig. 3.5.2 Track of drifter (GPS buoy) and trajectory of current observed with ADCP on MIRAI. 0 m is trajectory of current at 16.4 m depth and 0-50 m is trajectory of mean current between 16.4 m – 56.4 m.

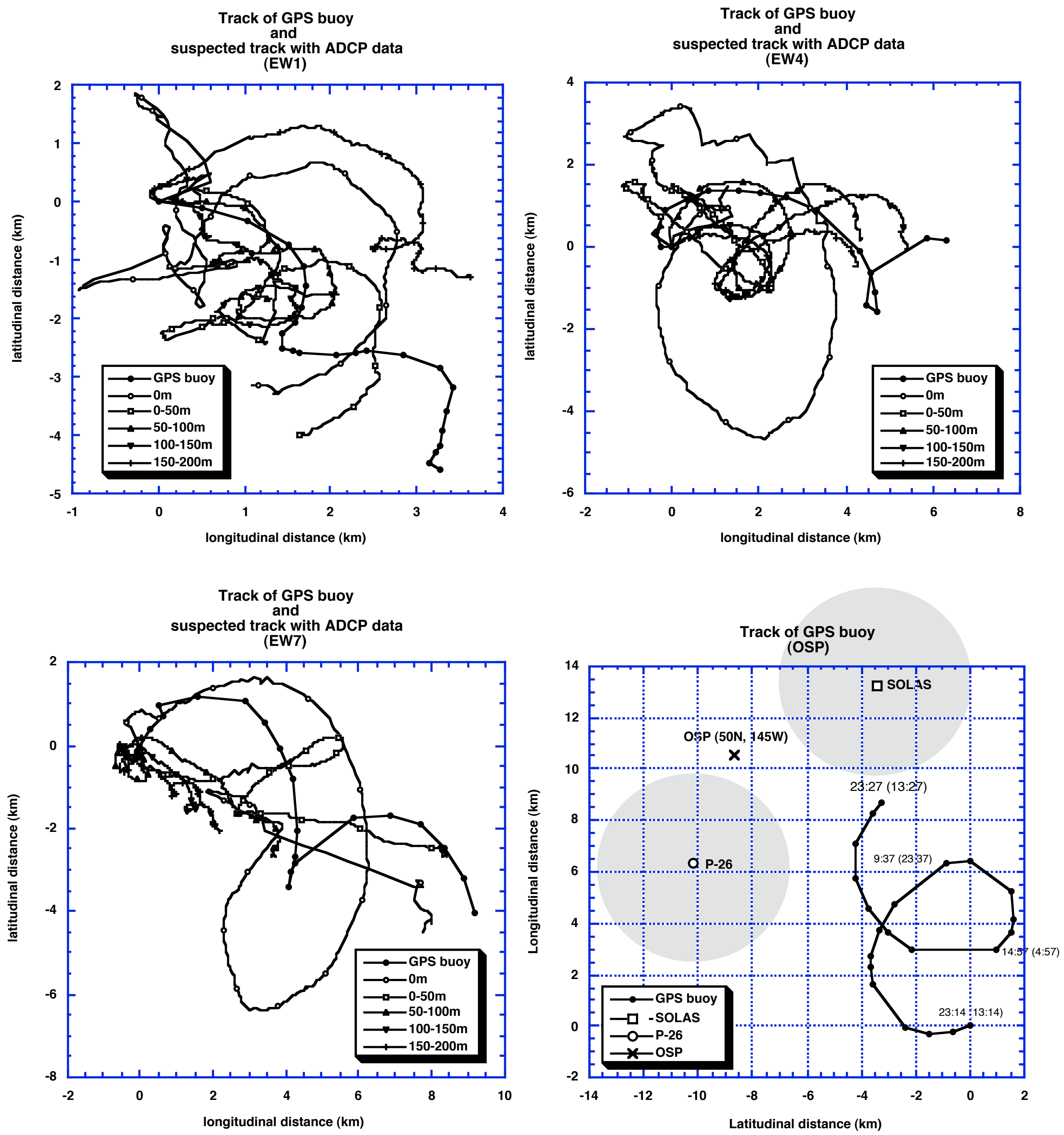


Fig. 3.5.2 continued

3.5.2 Primary productivity

During this cruise, not only usual primary productivity but also carbonate productivity and net community productivity were measured. The following table shows sample types.

Station: KNOT, K2, K3

Primary productivity				
through 200μm mesh				
13C in Organic Carbon			13C in Total Carbon	
	13C/15N	13C/15N	13C/15N (No Acid)	BLK
100%	●	●	●	●
50%	●	●		●
25%	●	●		●
10%	●	●		●
5%	●	●		●
2.5%	●	●		●
1%	●	●		●
0.5%	●	●		●

Station: K1, E1, E4, E7, OSP

Primary productivity					Net Comunty Productivity
through 200μm mesh					no mesh
13C in Organic Carbon			13C in Total Carbon		
	13C/15N	13C/15N	13C/15N (No Acid)	BLK	13C/15N
100%	●	●	●		●
50%	●	●			●
25%	●	●			●
10%	●	●			●
5%	●	●			●
2.5%	●	●			●
1%	●	●			●
0.5%	●	●			●

(1) in-situ incubation

1) Bottles for incubation and filters

Bottles for incubation are *ca*. 1 liter Nalgen polycarbonate bottles with screw caps. Grass fiber filters (Wattman GF/F 25mm) pre-combusted with temperature of 450° C for at least 2 hours were used for a filtration of phytoplankton after incubation.

2) in-situ incubation

Water samples were collected at 8 layers between the surface and seven pre-determined depths by a bucket or Niskin bottle at 8 stations (stations KNOT, K3, K2, K1, EW1, EW4, EW7 and OSP). 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 "free fall sensor".

All samples were spiked with 0.2 μmoles/mL of $NaH^{13}CO_3$ solution. After spike, bottles were installed at respective depths on the drifting mooring system (see 3.5.1). At station K2, bottles located between 5 m and 30 m were lost because of rough sea and, therefore, simulated in-situ incubation was also conducted in an onboard bath with light intensity adjusted to respective depths.

After 24 hours incubation, samples were filtrated through grass fiber filters (Wattman GF/F 25mm). GF/F filters were kept in a freezer till on board.

(2) Irradiance and surface water temperature during incubation

Fig.3.5.2.1 and 3.5.2.2 shows diurnal change of light irradiance observed by PAR sensor (Biospherical Instruments inc. PUV510) and SST observed by EPSM system during incubation, respectively. Dairy solar irradiances at respective incubations ranged from approximately 39 E m^{-2} day^{-1} at station K3 to 11 E m^{-2} day^{-1} at station K2. Water temperature during incubations at stations KNOT and K3 were higher than 17°C while that was 10 - 12°C at other stations.

(3) Measurement

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

Before analysis, inorganic carbon of samples was removed by an acid treatment in a HCl vapor bath for 4 - 5 h. However some samples were not decalcified with HCl in order to detect uptake of ^{13}C as $Ca^{13}CO_3$.

Table 3.5.2.1 shows total particulate organic carbon (POC) and concentrations of ^{13}C of POC for respective samples.

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

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

This equation is converted to the following equation;

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

where $^{13}C_{(POC)}$ is concentration of ^{13}C of particulate organic carbon after incubation, *i.e.*, measured value (%). $^{13}C_{(0)}$ is that of particulate organic carbon before incubation, *i.e.*, that for sample as a blank (1.084).

$^{13}C_{(sw)}$ is concentration of ^{13}C of ambient seawater with a tracer. This value for this study was determined based on the following calculation;

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

where TDIC is concentration of total dissolved inorganic carbon at respective bottle depths (mol l^{-1}) and 0.011 is concentration of ^{13}C of natural seawater (1.1 %). 0.0002 is added ^{13}C (mol) as a tracer (Table 3.5.2.1).

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

$$PP = 1.025 * \Delta POC$$

(5) Preliminary results

Table 3.5.2.1 shows estimated primary productivity. The precision (repeatability: standard deviation / average) ranged from 2 % to 22 % with average of 9 %.

1) Vertical profile and horizontal distribution of PP

Fig. 3.5.2.3 shows vertical profiles of PP at respective stations. Integrated PP (shown in respective graphs) ranged from 185 mg m^{-2} day^{-1} at station K3 to 447 mg m^{-2} day^{-1}. Fig. 3.5.2.4 shows horizontal distribution of PP. PP tended to decrease eastward.

2) Primary productivity and Net Community Productivity

Fig. 3.5.2.5 shows horizontal distribution of primary productivity and net community productivity which includes effect of zoo plankton activity. Main purpose of this measurement was to understand the grazing pressure at respective stations. However there is not significant difference between both production.

3) Organic carbon production and Carbonate production

Fig. 3.5.2.6 shows carbon uptake as organic carbon (sample was filtrated with 200 μm mesh net before incubation) and that as inorganic carbon named "carbonate productivity" (sample was not filtrated before incubation), in other words, $CaCO_3$. Unlike we expected, there was not significant difference between the western Pacific and Eastern Pacific.

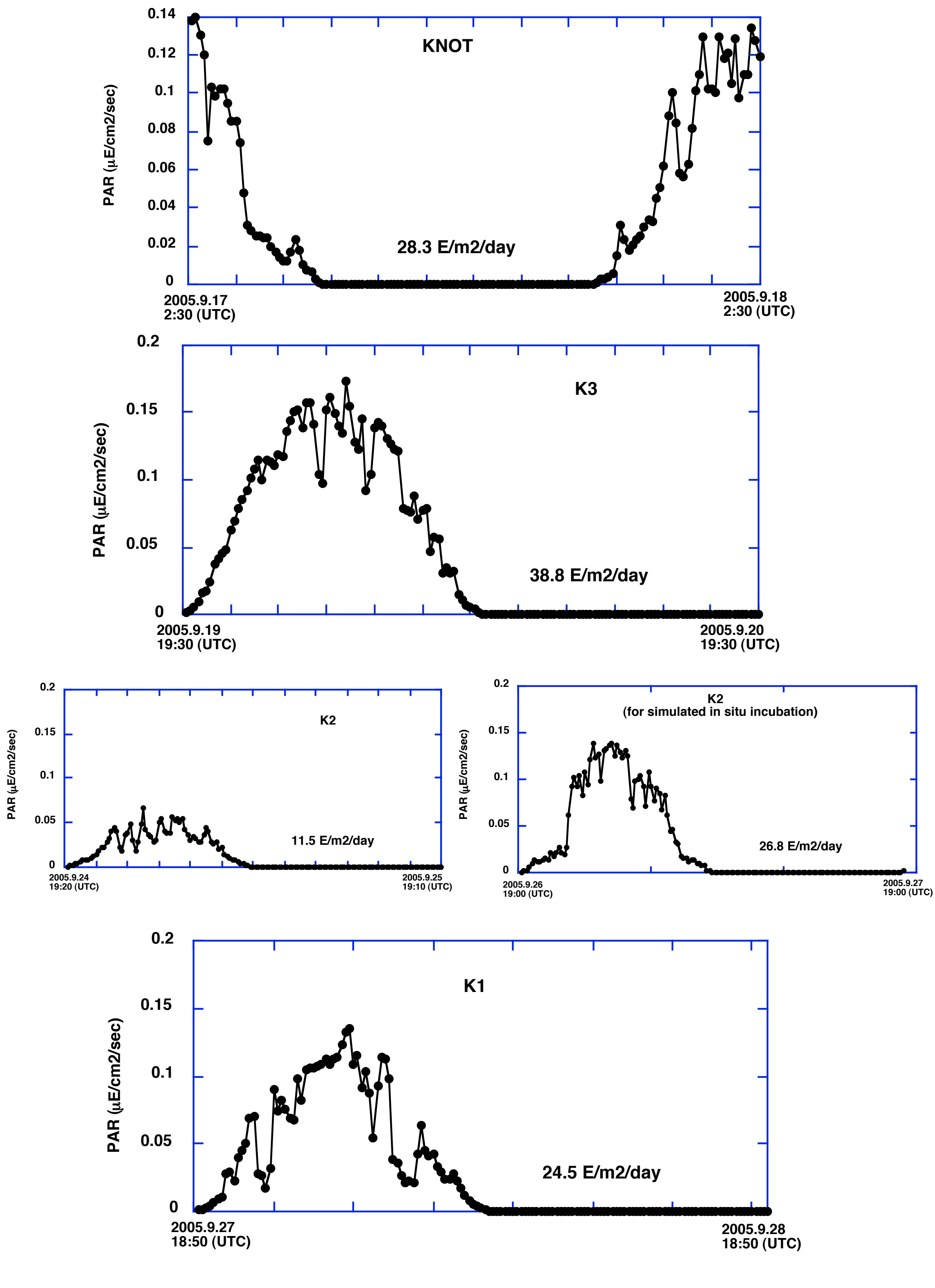


Fig. 3.5.2.1 Photosynthesis Available Radiation (PAR) during *in situ* incubation

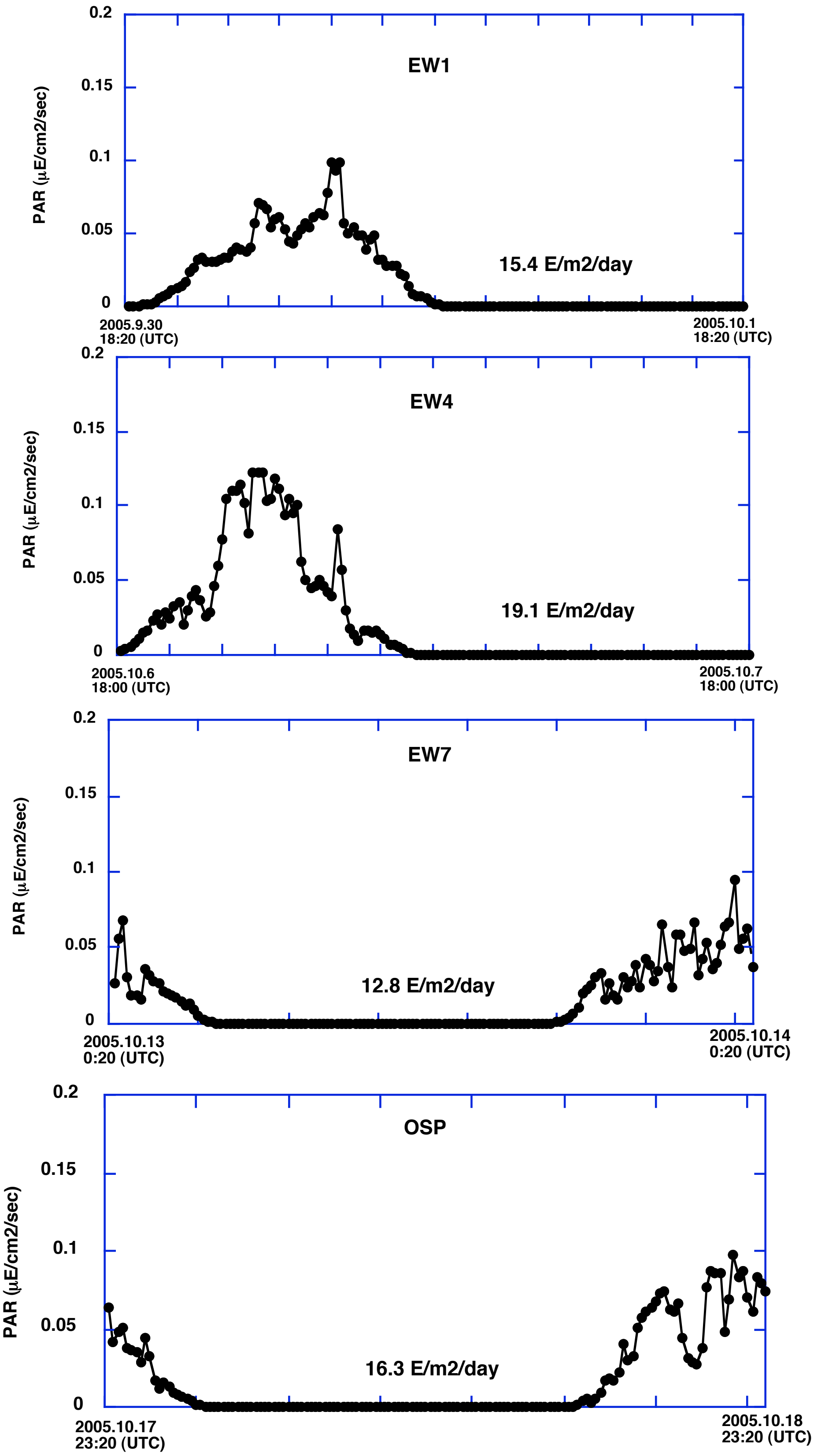


Fig. 3.5.2.1 Continued

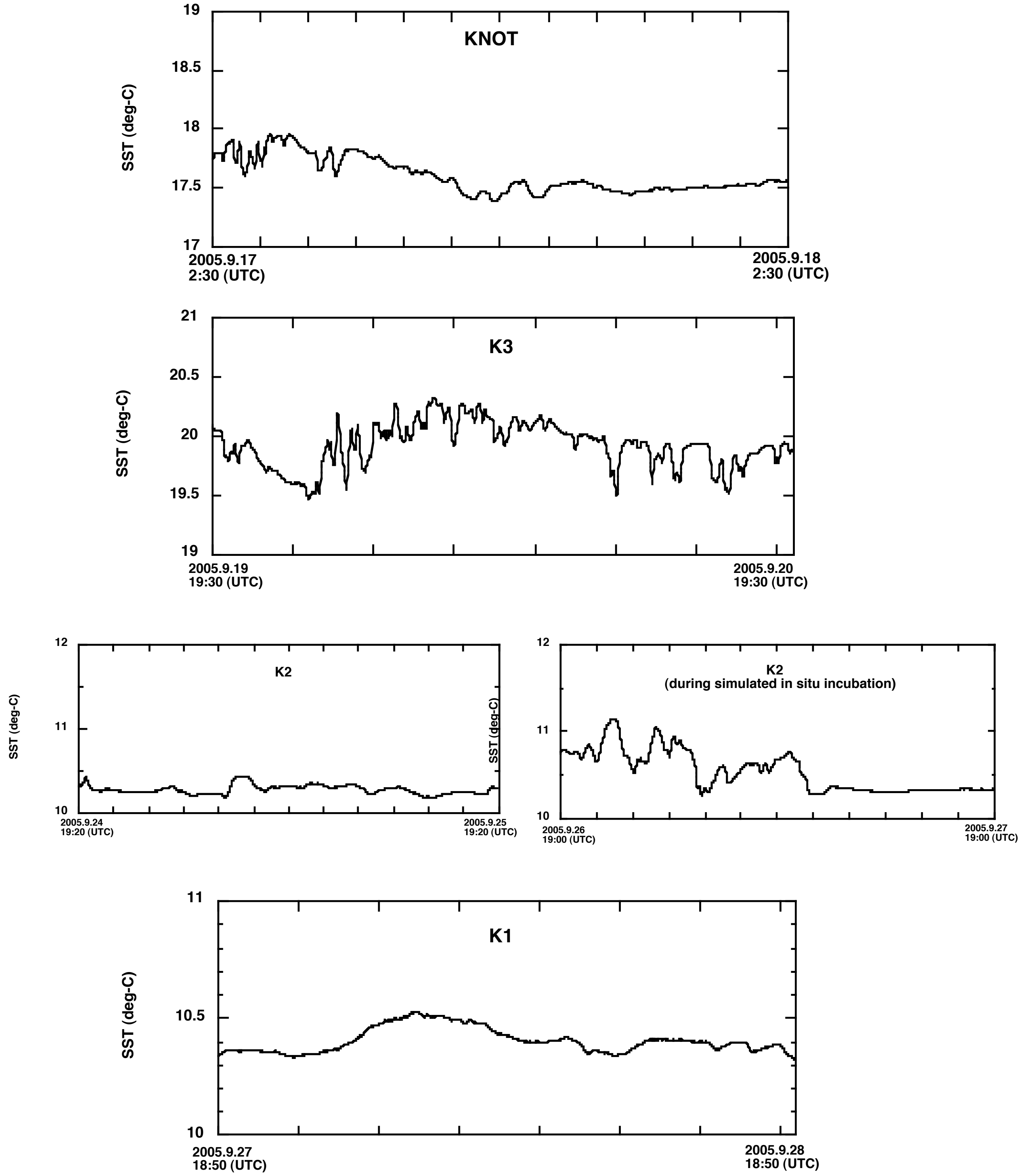


Fig. 3.5.2.2 SST during incubation

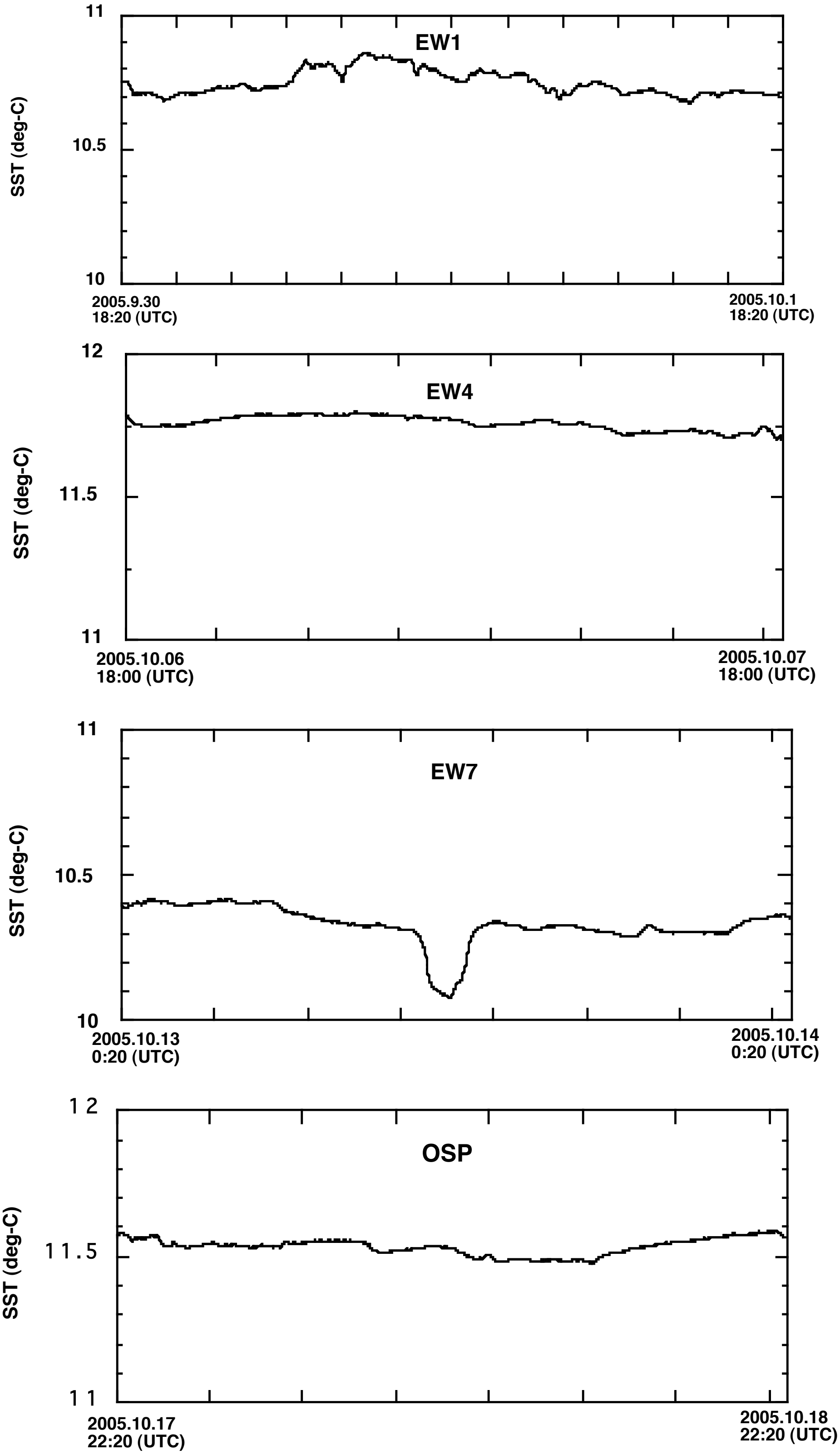


Fig. 3.5.2.2 Continued

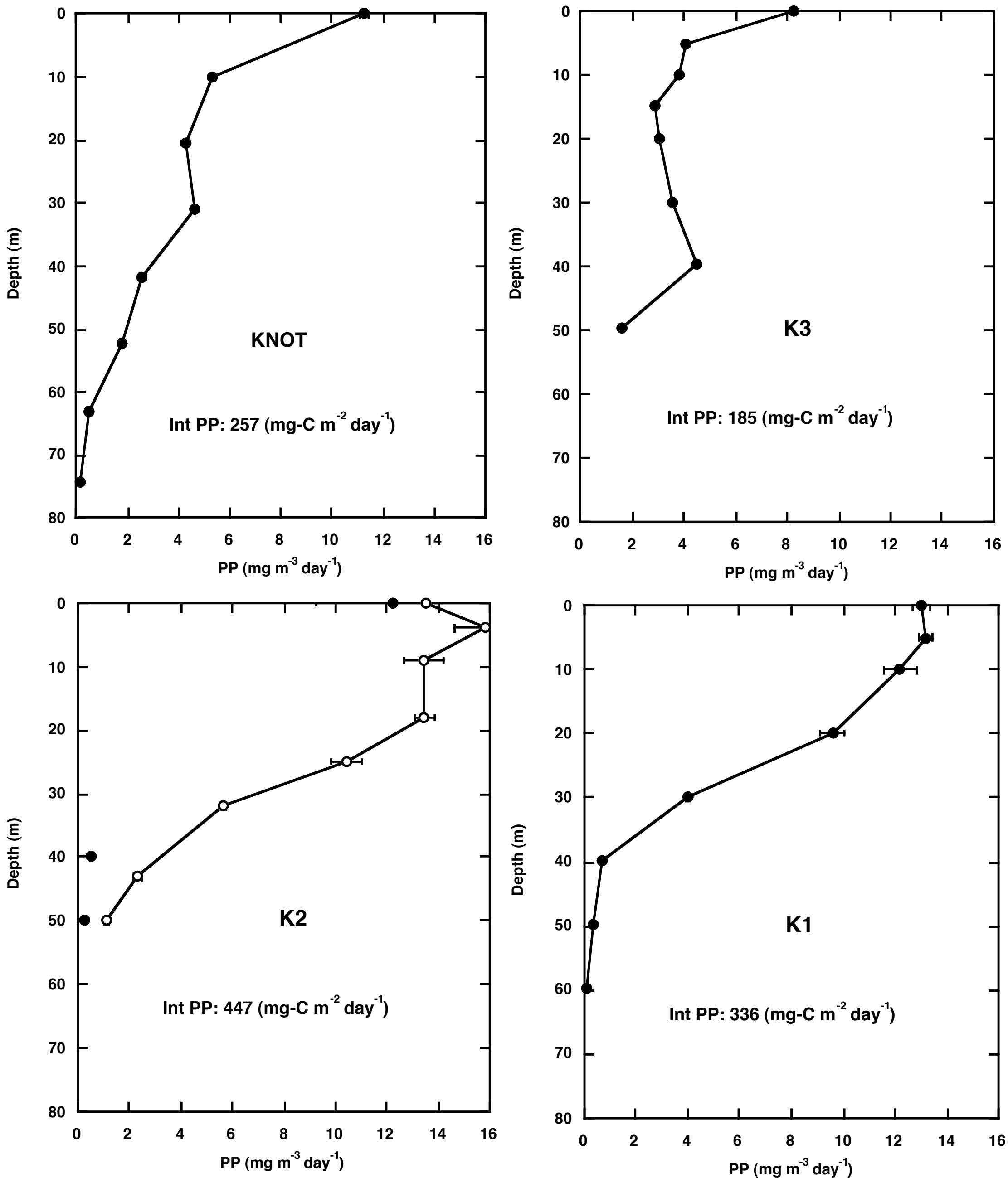


Fig. 3.5.2.3 Vertical profiles of primary productivity (PP). Integrated PP are shown in respective graphs. PP values at station K2 (open circles) were obtained from simulated in situ incubation onboard.

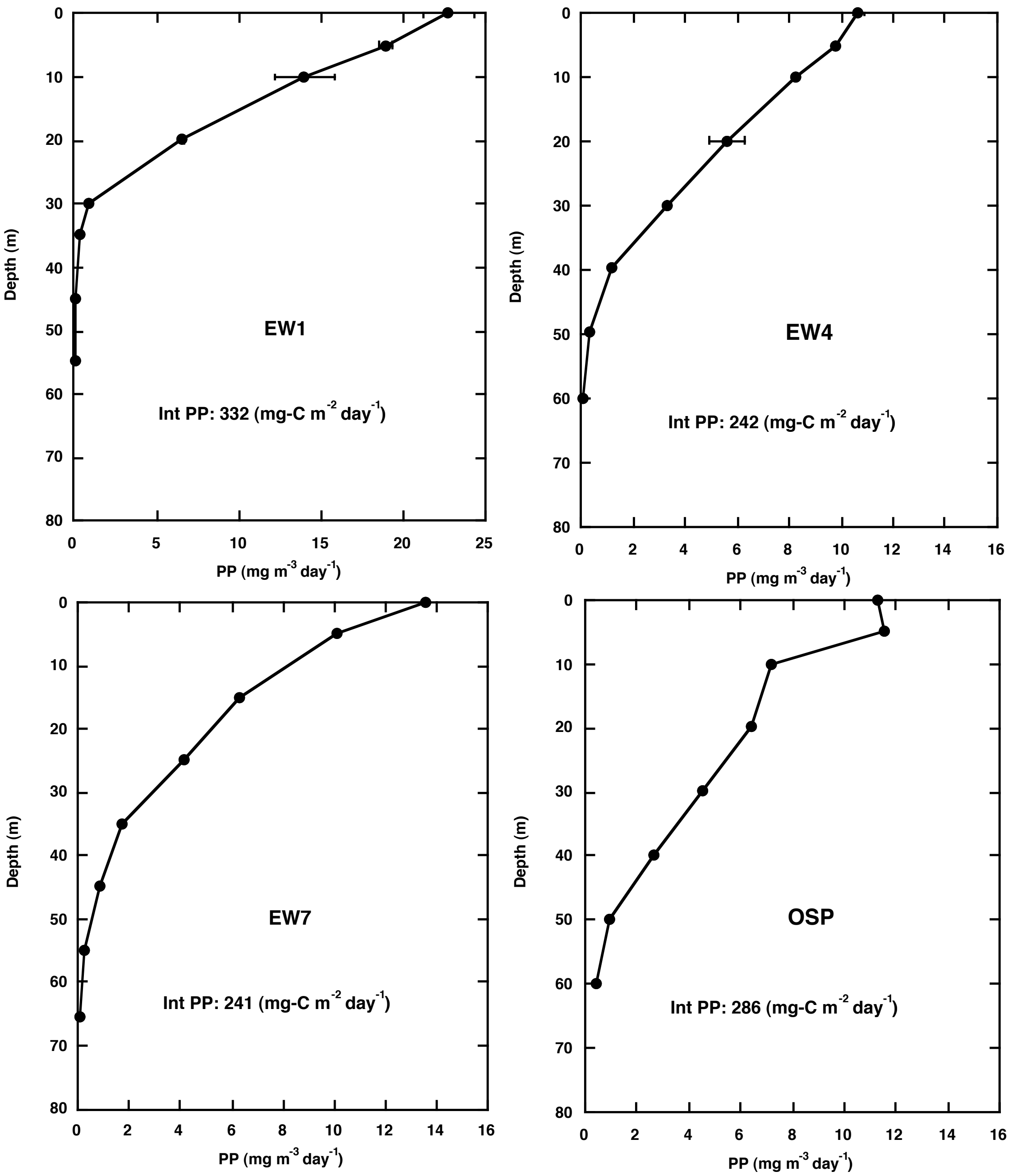


Fig. 3.5.2.3 continued

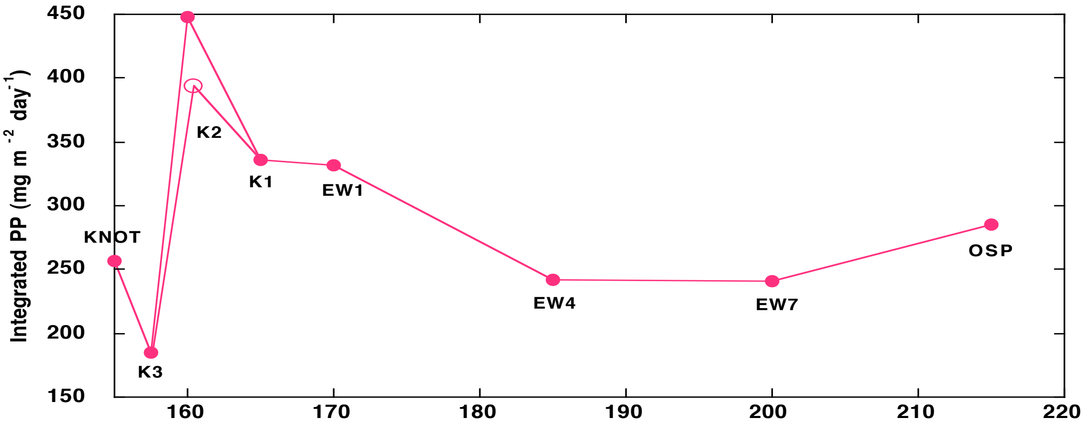


Fig. 3.5.2.4 Horizontal distribution of integrated PP.

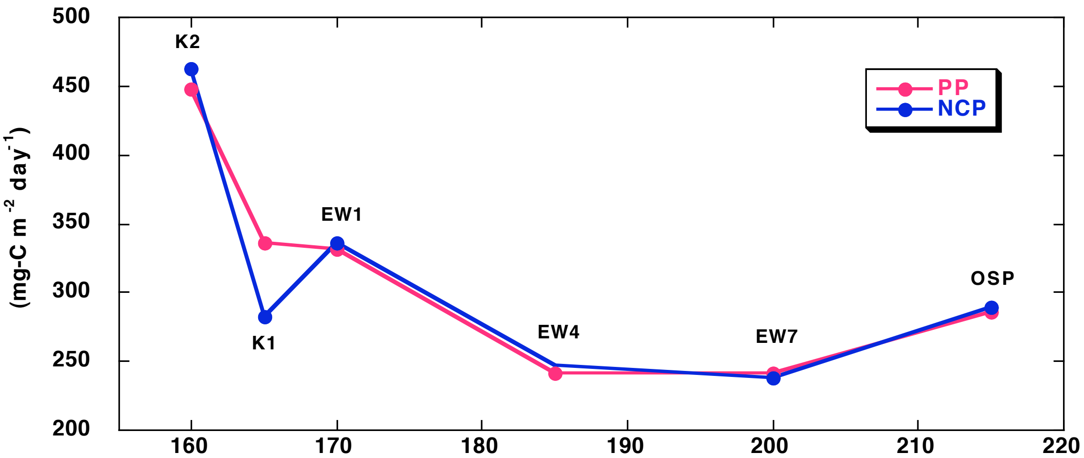


Fig. 3.5.2.5 Horizontal distribution of PP and Net Community Productivity (NCP)

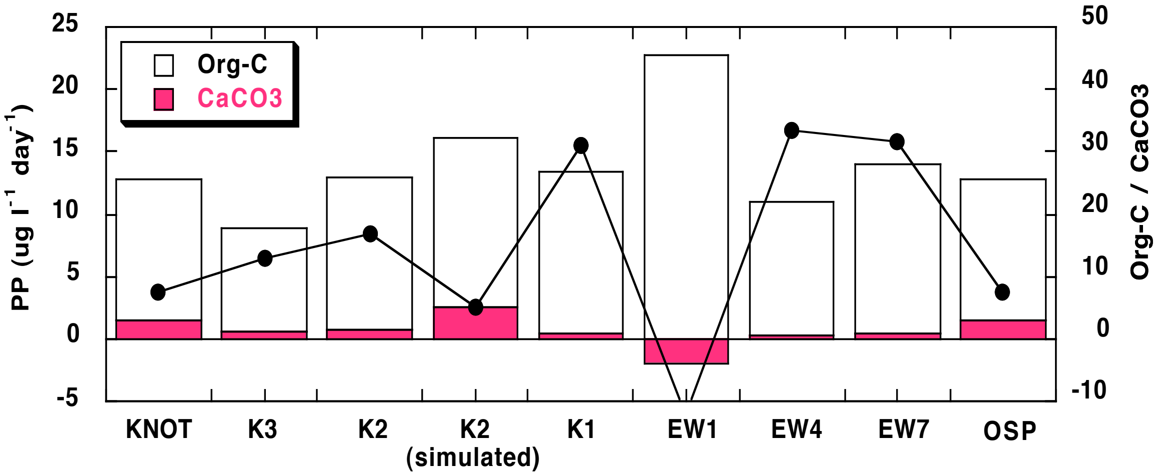


Fig. 3.5.2.6 Horizontal distribution of carbon uptakes as organic carbon and as inorganic carbon ($CaCO_3$)

MR05-04 St.KNOT IS Data

Bottle No.	Niskin No.	POC （μg）	13C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)
0m A		204.463	1.565	1973.4	10.201	11.040	11.251	0.211	0.000	
0m B		152.117	1.755	1973.4	10.201	11.461				
0m C		150.899	1.835	1973.4	10.201	12.724	12.724			
0m D		157.848	1.088	1973.4	10.201					
10m A	31	143.543	1.415	1970.2	10.214	5.324	5.335	0.010	10.000	82.9
10m B	31	122.611	1.473	1970.2	10.214	5.345				
10m C	31	113.136	1.086	1970.2	10.214					
20m A	30	135.078	1.356	1972.2	10.206	4.121	4.259	0.138	20.500	50.4
20m B	30	118.580	1.415	1972.2	10.206	4.396				
20m C	30	124.351	1.087	1972.2	10.206					
30m A	29	100.530	1.484	2013.5	10.036	4.592	4.624	0.032	31.100	47.1
30m B	29	110.396	1.453	2013.5	10.036	4.656				
30m C	29	151.384	1.085	2013.5	10.036					
40m A	28	125.265	1.249	2094.6	9.720	2.431	2.565	0.134	41.700	38.1
40m B	28	140.541	1.247	2094.6	9.720	2.700				
40m C	28	111.999	1.083	2094.6	9.720					
50m A	27	141.169	1.187	2122.8	9.616	1.729	1.764	0.034	52.200	22.7
50m B	27	130.551	1.200	2122.8	9.616	1.798				
50m C	27	243.022	1.084	2122.8	9.616					
60m A	26	121.494	1.122	2133.2	9.578	0.540	0.489	0.051	62.990	12.2
60m B	26	108.109	1.119	2133.2	9.578	0.438				
60m C	26	88.118	1.083	2133.2	9.578					
70m A	25	102.443	1.099	2137.3	9.563	0.177	0.168	0.009	74.080	3.6
70m B	25	92.765	1.099	2137.3	9.563	0.159				
70m C	25	82.803	1.084	2137.3	9.563					
		sum	8.6800						sum	257.0
	Blank	average	1.085000744						(mg/m2/day)	

Table 3.5.2.1 Results of PP measurements

MR05-04 St.K3 IS Data

Bottle No.	Niskin No.	POC （μg）	13C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)
0m A		121.292	1.672	1981.3	10.168	8.036	8.267	0.231	0.000	
0m B		124.670	1.689	1981.300	10.168	8.498				
0m C		141.760	1.642	1981.300	10.168	8.909	8.909			
0m D		106.318	1.087							
5m A	31	107.280	1.441	1970.3	10.214	4.291	4.083	0.207	5.000	30.9
5m B	31	101.395	1.425	1970.300	10.214	3.876				
5m C	31	81.545	1.087							
10m A	30	97.977	1.469	1974.6	10.196	4.237	3.816	0.422	10.000	19.7
10m B	30	115.763	1.346	1974.600	10.196	3.394				
10m C	30	70.586	1.085							
15m A	29	91.835	1.378	1968.9	10.220	3.018	2.866	0.152	14.900	16.4
15m B	29	67.799	1.442	1968.900	10.220	2.714				
15m C	29	89.953	1.087							
20m A	28	75.937	1.422	1970.8	10.212	2.875	3.052	0.176	19.900	14.8
20m B	28	81.437	1.438	1970.800	10.212	3.228				
20m C	28	79.994	1.084							
30m A	27	97.289	1.415	1977.4	10.184	3.617	3.557	0.060	29.900	33.0
30m B	27	107.789	1.373	1977.400	10.184	3.497				
30m C	27	86.893	1.085							
40m A	26	108.156	1.460	2039.1	9.934	4.701	4.481	0.221	39.800	39.8
40m B	26	109.675	1.420	2039.100	9.934	4.260				
40m C	26	108.322	1.083							
50m A	25	63.300	1.293	2082.3	9.767	1.552	1.583	0.032	49.800	30.3
50m B	25	78.321	1.260	2082.300	9.767	1.615				
50m C	25	75.691	1.086							
		sum	8.6839						sum	184.9
	Blank	average	1.085483036						(mg/m2/day)	

Table 3.5.2.1 Continued

MR05-04 St.K2 IS Data

Bottle No.	Niskin No.	POC （μg）	3C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)
0m A		138.806	1.847	2038.5	9.936	12.253	12.248	0.004	0.000	
0m B		130.048	1.898	2038.5	9.936	12.244				
0m C		135.477	1.912	2038.5	9.936	12.972	12.972			
0m D		136.270	1.827	2038.5	9.936	11.709	11.709			
40m A	26	110.284	1.125	2042.0	9.922	0.510	0.523	0.012	39.800	254.142
40m B	26	100.104	1.131	2042.0	9.922	0.535				
40m C	26	84.056	1.134	2042.0	9.922	0.480	0.480			
50m A	25	122.691	1.102	2076.2	9.790	0.240	0.216	0.023	49.800	3.7
50m B	25	134.620	1.097	2076.2	9.790	0.193				
50m C	25	87.894	1.105	2076.2	9.790	0.206	0.206			
									sum (mg/m2/day)	257.836

Table 3.5.2.1 Continued. Because of rough sea, intermediate incubation bottles were lost at station K2.

MR05-04 St.K2 SIS Data

Light Intensity	Bottle No.	Niskin No.	Depth(m)	POC (μg)	13C (%atom)	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)	Int PP(mg m2/day)
100%	100% A		0	138.652	1.660	2038.5	9.936	9.229	13.528	4.299	0		
100%	100% B		0	168.798	1.997	2038.500	9.936	17.826					
100%	100% C		0	143.309	2.057	2038.500	9.936	16.123	16.123				
100%	100% D		0	146.984	2.029	2038.500	9.936	16.075	16.075				
50%	50% A	31	4	138.497	1.997	2037.6	9.940	14.627	15.780	1.152	4	58.615	66.223
50%	50% B	31	4	138.458	2.141	2037.600	9.940	16.932					
50%	50% C	31	4	158.053	2.016	2037.600	9.940	17.037	17.037				
25%	25% A	30	9	121.139	1.986	2038.2	9.937	12.637	13.401	0.764	9	73.0	76.582
25%	25% B	30	9	125.645	2.059	2038.200	9.937	14.165					
25%	25% C	30	9	117.858	2.081	2038.200	9.937	13.596	13.596				
10%	10% A	29	18	128.526	2.014	2037.6	9.940	13.817	13.446	0.371	18	120.8	124.700
10%	10% B	29	18	125.372	1.986	2037.600	9.940	13.075					
10%	10% C	29	18	137.483	1.972	2037.600	9.940	14.115	14.115				
5%	5% A	28	25	126.017	1.757	2039.6	9.932	9.806	10.416	0.610	25	83.5	81.240
5%	5% B	28	25	127.325	1.832	2039.600	9.932	11.027					
5%	5% C	28	25	123.309	1.722	2039.600	9.932	9.097	9.097				
2.5%	2.5% A	27	32	119.659	1.501	2040.4	9.929	5.767	5.648	0.119	32	56.2	51.572
2.5%	2.5% B	27	32	108.806	1.523	2040.400	9.929	5.529					
2.5%	2.5% C	27	32	112.681	1.517	2040.400	9.929	5.638	5.638				
1%	1% A	26	43	77.728	1.320	2042.0	9.922	2.122	2.305	0.183	43	43.7	47.773
1%	1% B	26	43	74.076	1.375	2042.000	9.922	2.488					
1%	1% C	26	43	78.523	1.420	2042.000	9.922	3.048	3.048				
0.5%	0.5% A	25	50	59.047	1.228	2076.2	9.790	0.994	1.076	0.082	50	11.8	14.088
0.5%	0.5% B	25	50	54.996	1.264	2076.200	9.790	1.158					
0.5%	0.5% C	25	50	60.312	1.223	2076.200	9.790	0.977	0.977				
											sum (mg/m2/day)	447.691	462.179

Table 3.5.2.1 Continued. Result of PP measurement by simulated in situ incubation at station K2.

MR05-04 St.K1 IS Data

Bottle No.	Niskin No.	POC （μg）	3C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)	Int PP(mg m2/day)
0m A		168.267	1.744	2012.6	10.040	12.683	13.029	0.345	0.000		
0m B		156.572	1.831	2012.600	10.040	13.374					
0m C		166.231	1.792	2012.600	10.040	13.449	13.449				
0m D		157.697	1.846	2012.600	10.040	13.733	13.733				
5m A	25	135.639	1.950	2012.3	10.041	13.420	13.152	0.268	5.000	65.453	66.483
5m B	25	128.567	1.961	2012.300	10.041	12.885					
5m C	25	124.948	1.984	2012.300	10.041	12.860	12.860				
10m A	26	132.193	1.930	2013.8	10.035	12.796	12.166	0.631	10.000	63.3	58.675
10m B	26	126.972	1.878	2013.800	10.035	11.535					
10m C	26	115.130	1.890	2013.800	10.035	10.610	10.610				
20m A	27	123.619	1.796	2012.6	10.040	10.061	9.577	0.484	19.900	107.6	76.714
20m B	27	123.571	1.728	2012.600	10.040	9.093					
20m C	27	119.899	1.441	2012.600	10.040	4.887	4.887				
30m A	28	106.126	1.410	2025.8	9.987	3.966	4.046	0.079	29.900	68.1	46.576
30m B	28	95.478	1.460	2025.800	9.987	4.125					
30m C	28	116.575	1.415	2025.800	9.987	4.428	4.428				
40m A	29	58.143	1.188	2087.6	9.747	0.711	0.743	0.032	39.800	23.7	26.152
40m B	29	56.221	1.202	2087.600	9.747	0.775					
40m C	29	68.705	1.190	2087.600	9.747	0.856	0.856				
50m A	30	70.991	1.125	2112.1	9.655	0.337	0.334	0.003	49.800	5.4	5.748
50m B	30	49.913	1.141	2112.100	9.655	0.331					
50m C	30	55.205	1.130	2112.100	9.655	0.294	0.294				
60m A	31	38.261	1.116	2122.8	9.616	0.143	0.145	0.002	59.900	2.4	2.182
60m B	31	38.019	1.117	2122.800	9.616	0.147					
60m C	31	49.610	1.108	2122.800	9.616	0.138	0.138				
									sum (mg/m2/day)	335.993	282.530

Table 3.5.2.1 Continued.

MR05-04 St.EW1 IS Data

Bottle No.	Niskin No.	POC （μg）	13C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)	Int PP(mg m2/day)
0m A		194.565	2.032	2024.4	9.992	21.192	22.729	1.537	0.000		
0m B		210.331	2.088	2024.4	9.992	24.266					
0m C		200.447	1.986	2024.4	9.992	20.790	20.790				
0m D		213.284	1.999	2024.4	9.992	22.426	22.426				
5m A	31	171.529	2.027	2024.4	9.992	18.588	18.966	0.378	5.000	104.238	101.768
5m B	31	179.714	2.020	2024.4	9.992	19.345					
5m C	31	166.830	2.037	2024.4	9.992	18.282	18.282				
10m A	30	177.050	1.682	2025.4	9.988	12.165	13.969	1.804	10.000	82.3	85.447
10m B	30	147.836	2.012	2025.4	9.988	15.772					
10m C	30	150.491	2.003	2025.4	9.988	15.897	15.897				
20m A	29	129.699	1.526	2034.9	9.951	6.620	6.565	0.055	19.900	101.6	108.415
20m B	29	112.049	1.588	2034.9	9.951	6.510					
20m C	29	139.873	1.456	2034.9	9.951	6.005	6.005				
30m A	28	59.536	1.207	2092.9	9.727	0.864	0.847	0.017	29.900	37.1	33.999
30m B	28	61.744	1.198	2092.9	9.727	0.829					
30m C	28	72.920	1.177	2092.9	9.727	0.795	0.795				
35m A	27	70.797	1.131	2109.7	9.664	0.393	0.384	0.009	34.900	3.1	3.054
35m B	27	84.902	1.122	2109.7	9.664	0.374					
35m C	27	78.124	1.131	2109.7	9.664	0.427	0.427				
45m A	26	56.533	1.104	2121.1	9.622	0.129	0.121	0.008	44.800	2.5	2.702
45m B	26	51.328	1.103	2121.1	9.622	0.113					
45m C	26	53.229	1.104	2121.1	9.622	0.119	0.119				
55m A	25	50.796	1.096	2123.8	9.612	0.066	0.068	0.003	54.800	0.9	0.951
55m B	25	46.063	1.098	2123.8	9.612	0.071					
55m C	25	58.952	1.095	2123.8	9.612	0.071	0.071				
									sum (mg/m2/day)	331.803	336.337

Table 3.5.2.1 Continued.

MR05-04 St.EW4 IS Data

Bottle No.	Niskin No.	POC （μg）	3C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)	Int PP(mg m2/day)
0m A		162.522	1.647	2013.0	10.038	10.457	10.660	0.203	0.000		
0m B		161.622	1.672	2013.000	10.038	10.864					
0m C		159.368	1.687	2013.000	10.038	10.980	10.980				
0m D		144.625	1.721	2013.000	10.038	10.536	10.536				
5m A	31	173.087	1.578	2012.6	10.040	9.776	9.779	0.003	5.000	51.099	51.641
5m B	31	135.188	1.717	2012.600	10.040	9.782					
5m C	31	158.583	1.643	2012.600	10.040	10.121	10.121				
10m A	30	141.308	1.590	2012.2	10.041	8.164	8.251	0.087	10.000	45.1	45.567
10m B	30	159.088	1.543	2012.200	10.041	8.338					
10m C	30	150.976	1.554	2012.200	10.041	8.106	8.106				
20m A	29	122.241	1.438	2013.3	10.037	4.947	5.638	0.691	19.900	68.8	70.833
20m B	29	141.301	1.476	2013.300	10.037	6.329					
20m C	29	132.220	1.495	2013.300	10.037	6.204	6.204				
30m A	28	122.113	1.319	2013.9	10.034	3.272	3.277	0.006	29.900	44.6	47.183
30m B	28	108.735	1.349	2013.900	10.034	3.283					
30m C	28	106.121	1.351	2013.900	10.034	3.233	3.233				
40m A	27	94.939	1.195	2034.0	9.954	1.210	1.205	0.006	39.800	22.2	21.780
40m B	27	81.558	1.212	2034.000	9.954	1.199					
40m C	27	88.820	1.199	2034.000	9.954	1.167	1.167				
50m A	26	63.181	1.129	2087.6	9.747	0.330	0.341	0.010	49.800	7.7	7.561
50m B	26	78.464	1.123	2087.600	9.747	0.351					
50m C	26	61.095	1.133	2087.600	9.747	0.345	0.345				
60m A	25	64.517	1.097	2090.0	9.738	0.095	0.097	0.003	59.900	2.2	2.279
60m B	25	54.403	1.100	2090.000	9.738	0.100					
60m C	25	79.749	1.096	2090.000	9.738	0.106	0.106				
									sum (mg/m2/day)	241.626	246.844

Table 3.5.2.1 Continued.

MR05-04 St.EW7 IS Data

Bottle No.	Niskin No.	POC （μg）	3C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)	Int PP(mg m2/day)
0m A		186.094	1.703	2004.3	10.073	13.110	13.536	0.426	0.000		
0m B		178.648	1.770	2004.300	10.073	13.963	13.963				
0m D		215.769	1.609	2004.300	10.073	12.887	12.887				
5m A	31	126.776	1.788	2005.1	10.070	10.170	10.107	0.064	5.000	59.1	57.634
5m B	31	145.495	1.690	2005.100	10.070	10.043					
5m C	31	143.162	1.708	2005.100	10.070	10.167	10.167				
15m A	30	128.162	1.535	2005	10.071	6.573	6.268	0.305	14.900	81.1	84.257
15m B	30	143.759	1.449	2005.000	10.071	5.963					
15m C	30	118.477	1.592	2005.000	10.071	6.855	6.855				
25m A	29	120.778	1.374	2005	10.071	3.975	4.098	0.123	24.900	51.8	50.834
25m B	29	135.365	1.358	2005.000	10.071	4.220					
25m C	29	153.322	1.274	2005.000	10.071	3.312	3.312				
35m A	28	122.718	1.206	2004.8	10.071	1.690	1.712	0.022	34.900	29.0	25.322
35m B	28	91.741	1.251	2004.800	10.071	1.734					
35m C	28	106.056	1.230	2004.800	10.071	1.753	1.753				
45m A	27	104.808	1.162	2017.9	10.018	0.925	0.851	0.074	44.800	12.7	12.744
45m B	27	93.436	1.157	2017.900	10.018	0.777					
45m C	27	87.693	1.167	2017.900	10.018	0.822	0.822				
55m A	26	79.251	1.115	2074.2	9.798	0.278	0.279	0.001	54.800	5.7	5.352
55m B	26	64.019	1.122	2074.200	9.798	0.280					
55m C	26	57.974	1.121	2074.200	9.798	0.249	0.249				
65m A	25	63.897	1.097	2080.8	9.772	0.089	0.084	0.005	65.400	1.9	1.775
65m B	25	57.706	1.096	2080.800	9.772	0.078					
65m C	25	65.465	1.096	2080.800	9.772	0.086	0.086				
									sum (mg/m2/day)	241.295	237.919

Table 3.5.2.1 Continued.

MR05-04 St.OSP IS Data

Bottle No.	Niskin No.	POC （μg）	13C （%atom）	TDIC	13C(sw)	PP(ug/l/day)	PP(average)	deviation	Depth	Int PP(mg m2/day)	Int PP(mg m2/day)
0m A		127.835	1.844	1998.9	10.095	11.044	11.251	0.207	0.000		
0m B		130.905	1.854	1998.900	10.095	11.458					
0m C		134.460	1.918	1998.900	10.095	12.742	12.742				
0m D		125.862	1.855	1998.900	10.095	11.021	11.021				
5m A	31	114.488	1.975	1997.8	10.100	11.591	11.513	0.078	5.000	56.910	55.903
5m B	31	123.226	1.901	1997.800	10.100	11.435					
5m C	31	122.810	1.897	1997.800	10.100	11.340	11.340				
10m A	30	121.377	1.615	1998.1	10.099	7.321	7.159	0.163	10.000	46.7	45.817
10m B	30	120.213	1.597	1998.100	10.099	6.996					
10m C	30	115.822	1.615	1998.100	10.099	6.987	6.987				
20m A	29	124.385	1.478	1998.5	10.097	5.565	6.377	0.812	19.900	67.0	69.871
20m B	29	108.493	1.668	1998.500	10.097	7.189					
20m C	29	124.009	1.590	1998.500	10.097	7.128	7.128				
25m A	28	128.823	1.392	2000.2	10.090	4.506	4.573	0.066	29.900	54.7	59.131
25m B	28	115.913	1.437	2000.200	10.090	4.639					
25m C	28	128.462	1.406	2000.200	10.090	4.698	4.698				
35m A	27	110.370	1.291	2000.2	10.090	2.587	2.661	0.074	39.800	35.8	35.016
35m B	27	112.577	1.299	2000.200	10.090	2.736					
35m C	27	106.301	1.281	2000.200	10.090	2.376	2.376				
45m A	26	116.867	1.155	1997.3	10.102	0.933	0.913	0.020	49.800	17.9	16.238
45m B	26	121.290	1.150	1997.300	10.102	0.892					
45m C	26	125.159	1.146	1997.300	10.102	0.871	0.871				
55m A	25	149.852	1.110	2005.9	10.067	0.430	0.440	0.010	59.900	6.8	6.670
55m B	25	156.220	1.110	2005.900	10.067	0.450					
55m C	25	122.132	1.117	2005.900	10.067	0.450	0.450				
									sum (mg/m2/day)	285.847	288.645

Table 3.5.2.1 Continued.

3.5.3 Drifting sediment trap

Makio HONDA (JAMSTEC)
Kazuhiko MATSUMOTO (JAMSTEC)
Hajime KAWAKAMI (JAMSTEC)

In order to collect sinking particles and measure carbon flux, radionuclide and biogenic substances such as TEP , “Knouer type” cylindrical sediment trap (Photo 3.5.3.1) was deployed at 8 stations where measurement of primary productivity and in situ pumping (LVP) were conducted. This trap consists of 8 individual transparent policarbonate cylinders with baffle (collection area: ca. 0.0038 m^2, aspect ratio: 620 mm length / 75 mm width = 8.27), which were modified from Knauer (1979). Before deployment, each trap was filled with filtrated surface seawater, which salinity is adjusted to ~ 39 PSU by addition of NaCl (addition of 100 mg NaCl to 20 L seawater) were placed in tubes. These were located at approximately 60 m, 100 m, 150 m and 190 m. After recovery, sediment traps were left for several hours to make collected particles settle down to the bottle. After seawater in acrylic tube was dumped using siphonic tube and collecting cups were took off. In laboratory on board, seawater with sinking particles were filtrated on various filters for respective purpose (Table 3.5.3.1). These were kept in freezer by the day when these were analyzed.

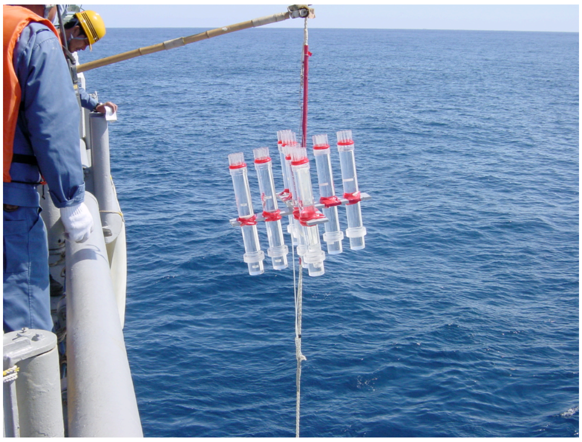
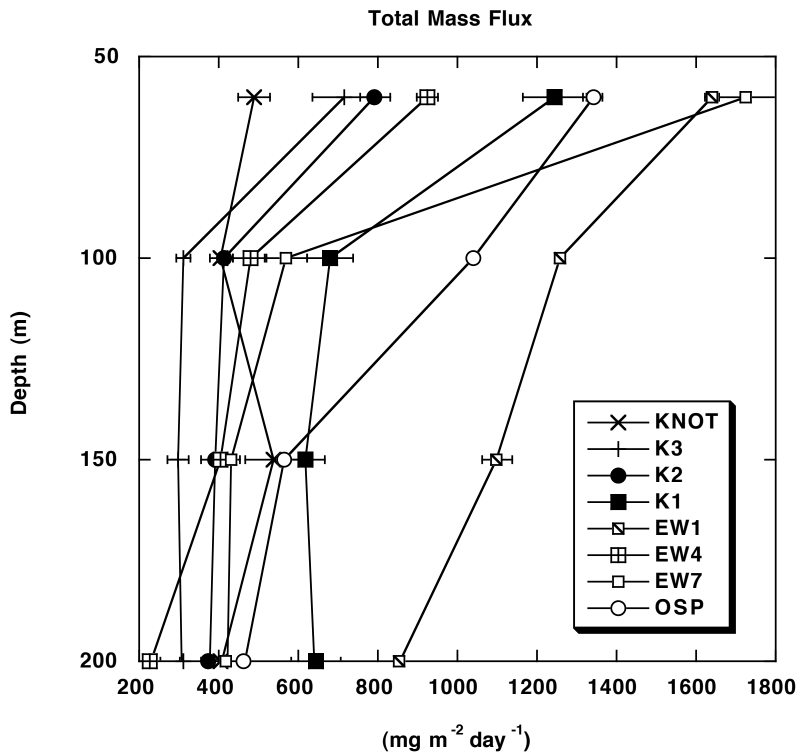


Photo 3.5.3.1 Drifting Sediment Trap

Table 3.5.3.1 Measured components and filters

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



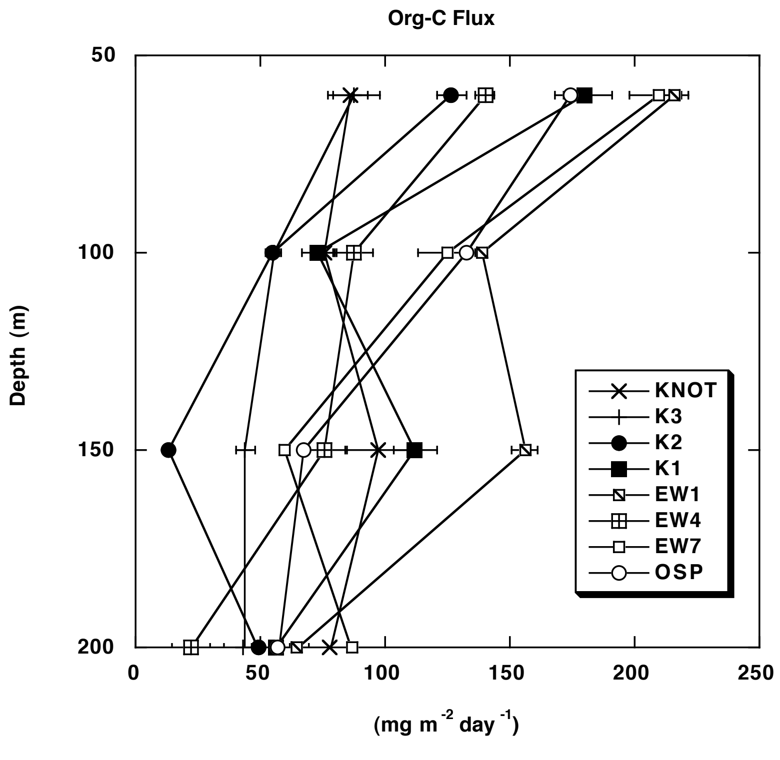


Fig. 3.5.3.1 Preliminary results of Total Mass Flux and Organic Carbon Flux

3.6 Rare Earth Elements

Eriko SHIMIZU (University of Toyama)
Ryoko OHIRA (University of Toyama)
Jing ZHANG (University of Toyama, not on board)

1. Introduction

The North Pacific is an upwelling area of oceanic general circulation, as well as an important area with a high level of primary productivity. However, it is known that part of North Pacific is characterized by high nutrients and low chlorophyll (HNLC).

Recently, coccolithophorids were observed in HNLC areas. To clarify the causes of coccolithophorids' appearance, it is important to understand the details regarding abyssal circulation.

2. Objectives

The objectives of this study are to clarify and investigate oceanic general circulation and biogeochemical activity in North Pacific, the Rare Earth Elements (REEs), nutrients, chlorophyll *a* and phytoplankton species.

3. Inventory Information for the Sampling

1) Rare Earth Elements (REEs)

A total of 261 seawater samples, about one liter for each sample, were collected from 12 stations (Table 1) for dissolved REE determination of seawater in North Pacific, using standard CTD/Niskin-Rosette and X-NISKIN bottles. All seawater samples (1 liter) were filtered immediately through 0.1-μm membrane filters after being collected. The residues and filters were stored in a refrigerator, and the filtrate was acidified to pH<1.6 for measurements on land performed with ICP mass spectrometers immediately afterwards.

2) Nutrients

Seawater samples of about 20 ml were collected at same station (Table 1) for nutrients.

3) Chlorophyll *a*

Seawater samples of about 100~1000ml (depth:0~200m) were collected same at station (Table 1). They were filtered through a GF/F filter and a nuclepore filter (pore size 2.0μm, 5μm and 10.0μm) to measure the concentration of chlorophyll *a*, and these concentrations were measured on board.

4) Phytoplankton Species

Seawater samples of about 100~200ml (depth:0~100m) were collected at the same station (see Table 1). Samples were filtered through a 25-mm Millipore HA (pore size:0.45 μm) filter, and the identification and counting of phytoplankton will be conducted on land with a scanning electron microscope.

4. Data Archive

All of the raw and processed data on the seawater and sediment will be submitted to the JAMSTEC Data Management Office (DMO) as soon as the analysis is completed, and will remain under its control.

Table 1. Sample locations and descriptions for REEs, Chlorophyll *a*, nutrient concentration and cell counting collected by NISKIN-X.

Station name	REEs	Cell counting
KNOT	24	7
K3	24	7
K2	24	7
K1	23	7
EW0	24	7
EW1	18	7
EW2	24	7
EW3	19	7
EW4	24	7
EW5	12	7
EW7	23	7
OSP	22	7

3.7 Particulate nutrients, Calcium carbonate, Chlorophyll *a* and Barium

Hisashi NARITA (Tokai Univ.)
Yoko KISHI (Tokai Univ.)

(1) Introduction

The subarctic Pacific is one of the most productive areas among the world's oceans. In contrast to occurring a distinct spring bloom in the Western Subarctic Gyre (WSG), the growth of large phytoplankton (especially centric diatom) in the Alaskan Gyre (AG), which is the northeastern subarctic Pacific, is thought to be Fe limited, and it is known to be one of the high-nutrient, low-chlorophyll (HNLC) regions. Therefore, previous works in the WSG have recorded high abundances of diatoms.

Recently, the WSG is also known the HNLC regions due to Fe limitation during summer season after finishing spring bloom. Actually, some works have reported that coccolithophorids (*Emiliania huxleyi*) were present in significant numbers in surface water during summer to fall in the WSG. Coccolithophorids are one of the main groups of calcifying organisms in the marine environment, and *E. huxleyi* is the most common coccoithophorid and is one of the species, which has a worldwide distribution. Thus, the present of *E. huxleyi* in the WSG can contribute to primary production or export production, which is the oceanic carbon cycle, with the present of a distinct spring bloom. Therefore, *E. huxleyi* may influence the global climate system, because CO_2 was released from the ocean surface during calcification by this organism and dimethylsulfonio-propionate (DMSP), which is the precursor of dimethyl-sufide (DMS), are more produced by this species. Here, we measure particulate nutriments, calcium carbonate and Chollopyll *a* to evaluate the contributions of diatom and coccolithophorids account for chlorophyll biomass during late summer in the subarctic Pacific and examine its contrast west to east.

(2) Method

(2)-1 Measurement of particulate nutrients, calcium carbonate and chlorophyll *a* concentrations

Vertical seawater samples for particulate nutrients, calcium carbonate and chlorophyll a were collected using Niskin-X bottles attached CTD/CWSS at all stations. In addition, surface seawater samples for particulate nutrients, calcium carbonate and chlorophyll *a* were collected in the Sea Surface Water Monitoring during this cruise. Particulate nutrients and calcium carbonate samples were collected into a 2 L of dark polyethen bottles. Particulate matter was filtered onto 0.5 μm hydrophilic PTFE (polytetrafluoroethylene) membrane fitter (ADVANTEC MFS, Inc.) and grass fiber filter (Whatman GF/F). The filter after filtration was stored under –85 °C in a freezer until analysis. Chlorophyll *a* samples were carried out size fraction with nuclepore filter (with the pore size in 2, 5 and 10 μm) and grass fiber filter (Whatman GF/F), appling to vacuum less than 15 cmHg. Samples were collected in 2 L of dark polyethen bottles and filtered though each filter. Filtering volume were ~200 ml for GF/F filter, ~150 ml for 2 μm, ~500 ml for 5 μm and ~1,000 ml for 10 μm of nuclepore filter. Filtered samples were extracted in 6 ml of N, N-dimethylformamide (DMF) and stored keeping in cold (-20 °C) and dark condition until analysis. Chlorophyll *a* was determined by the acidification method with a Turner Designs Fluorometer (10-AU-005) on borad, which was previously calibrated against a pure chlorophyll *a* (Sigma chemical Co.).

(2)-2 Measurement of barium concentrations

Vertical seawater samples for barium were collected using Niskin-X bottles attached CTD/CWSS at all stations and also surface water samples were collected in the Sea Surface Water Monitoring during this cruise. The samples for barium analysis were collected in 100 ml acid cleaned polycarbonate bottles, after filtration using 0.2 μm hydrophilic cellulose acetate syringe disc filter (ADVANTEC MFS, Inc.). The external joints between caps and bodies were wrapped in Parafilm to minimize evaporation. All samples were stored at room temperature till analysis in Tokai University.

(3) Expected results and future works

The results for chlorophyll *a* show the pico- and nano-size chlorophyll *a* are more numerous than the >10 μm fraction in the subarctic Pacific and the percentage of >2 μm fraction in the eastern subarctic Pacific is higher than that in the western regions. These findings are a difference of phytoplankton community due to differences of chemical and physical environment during late summer season in the subarctic Pacific.

In future, particulate nutrients and calcium carbonate will be analyzed as direct information for a difference of phytoplankton community in the subarctic Pacific. The west-east difference of biogeochemical processes in the subarctic Pacific will be discussed according to chlorophyll *a*, particulate nutrients and calcium carbonate data including nutrients, barium and CTD data.

3.8 Atmospheric Observation
3.8.1 Macro and micro nutrients

Eriko SHIMIZU (University of Toyama)
Ryoko OHIRA (University of Toyama)
Jing ZHANG (University of Toyama, not on board)

1. Introduction

The North Pacific is an important area with a high primary productivity resulting from high CO_2 absorption. The dust aerosol from the Asian continent is considered to transport and supply the major nutrients (nitrite, nitrate, phosphate, and silicate) and microelement nutrients (Fe) to the North Pacific, since nitrate and iron become available for uptake by the phytoplankton while the aerosol settles on the ocean surface.

3. Objectives

The objectives of this study are to determine the influence of continental dust, both aerosol and surface sea water samples have been collected from the North Pacific, and chemical composition will be measured.

4. Methods

1) Aerosol Collection:

The aerosol samples were collected on a Teflon filter by using a high-volume air sampler (SHIBATA Co.) on the compass deck, and a wind-sector controller was used to avoid contamination from the ship during this cruise (MR05-04, 9/15/2005 to 10/24/2005). The samples were collected along 14 sections of the cruise track. The detail is shown in Table 1.

2) Aerosol Analysis:

The filter was divided into four parts, one for nutrient analysis (extracted by the artificial seawater) on board (see Fig.1), one for water-soluble major ions, and the rest for trace metals. This will be conducted at the laboratory on land afterwards.

3) Surface Seawater:

The surface water samples were collected by bucket and under way pumping system (Table 2). All seawater samples (100~500ml) were filtered immediately after being collected through a GF/F filter and a nuclepore filter (pore size 2.0μm, 5μm and 10.0μm) to measure chlorophyll *a* concentration.

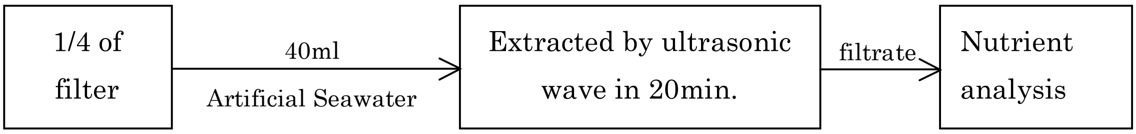


Fig.1. The experiment procedure of nutrients

Table 1. The details of aerosol collecting

Sample#	Start		Stop		Total time	Air Volume
	Lat. (-N)	Long. (-E)	Lat. (-N)	Long. (-E)	(h)	(m^3)
1	40.44	144.41	40.94	149.49	17.2	1043.3
2	41.01	149.64	44.00	155.00	20.5	1239.8
3	44.08	154.93	39.01	159.96	25.8	1560.7
4	39.08	160.13	46.97	159.97	30.9	1870.9
5	47.11	160.26	51.00	165.00	25.8	1564.5
6	51.21	165.05	47.01	165.00	17.0	1028.4
7	47.00	165.06	46.00	184.87	35.9	2177.8
8	45.99	185.07	45.65	196.58	9.2	556.0
9	45.45	196.73	49.50	200.00	27.9	1690.0
10	49.51	199.99	50.00	209.38	37.9	2297.4
11	50.06	209.66	50.04	216.65	33.1	2006.3
12	50.14	216.60	46.48	223.59	34.9	2116.6
13	46.34	223.89	42.84	228.05	17.3	1047.7
14	39.20	230.33	34.92	232.74	20.4	1232.9

Table 2. Locations for chlorophyll *a* collection by under-way water pumping system.

Sample #	Lat. (-N)	Long (-E)		Sample #	Lat. (-N)	Long (-E)
UW-001	40.56	142.21		UW-011	41.94	151.53
UW-002	40.49	143.75		UW-012	42.58	152.57
UW-003	40.44	144.43		UW-013	43.55	154.23
UW-004	40.43	144.99		UW-014	43.49	154.53
UW-005	40.42	146.00		UW-015	44.06	154.96
UW-006	40.41	147.61		UW-016	43.04	156.01
UW-007	40.46	148.41		UW-017	42.02	157.02
UW-008	40.85	149.27		UW-018	41.00	158.04
UW-009	41.16	149.99		UW-019	40.00	159.03
UW-010	41.42	150.63		UW-020	39.53	160.08

Sample #	Lat. (-N)	Long (-E)		Sample #	Lat. (-N)	Long (-E)
UW-021	40.00	160.03		UW-056	46.99	159.95
UW-022	40.55	160.01		UW-057	47.49	160.66
UW-023	41.01	160.01		UW-058	48.00	161.23
UW-024	41.41	160.03		UW-059	48.68	162.14
UW-025	42.00	160.02		UW-060	48.97	162.41
UW-026	42.49	160.01		UW-061	49.50	163.07
UW-027	42.93	159.99		UW-062	50.00	163.65
UW-028	44.50	159.98		UW-063	50.49	164.34
UW-029	45.01	159.97		UW-064	50.99	164.98
UW-030	45.48	159.98		UW-065	50.50	165.00
UW-031	45.73	159.98		UW-066	50.01	165.00
UW-032	46.00	159.96		UW-067	49.50	165.00
UW-033	46.49	159.99		UW-068	49.01	165.01
UW-034	46.97	159.96		UW-069	48.51	165.02
UW-035	47.01	159.99		UW-070	48.01	165.00
UW-036	46.90	159.97		UW-071	47.50	165.00
UW-037	46.85	160.85		UW-072	47.20	166.01
UW-038	46.99	159.93		UW-073	47.40	167.00
UW-039	46.95	160.02		UW-074	47.60	168.00
UW-040	46.89	159.93		UW-075	47.64	169.26
UW-041	46.88	159.98		UW-076	47.57	170.00
UW-042	46.86	160.03		UW-077	47.46	171.04
UW-043	47.04	159.97		UW-078	47.34	172.04
UW-044	47.07	159.96		UW-079	47.11	174.05
UW-045	47.11	160.12		UW-080	46.80	176.00
UW-046	47.10	160.19		UW-081	46.60	177.00
UW-047	47.07	160.16		UW-082	46.40	178.00
UW-048	47.06	160.19		UW-083	46.00	181.00
UW-050	47.07	160.15		UW-084	46.01	182.00
UW-051	47.06	160.16		UW-085	46.00	182.99
UW-052	47.06	160.17		UW-086	46.00	183.99
UW-053	47.06	160.18		UW-087	46.18	185.99
UW-054	46.93	159.86		UW-088	46.41	186.92
UW-055	46.98	159.94		UW-089	46.60	188.00

Sample #	Lat. (-N)	Long (-E)		Sample #	Lat. (-N)	Long (-E)
UW-090	46.804	188.993		UW-124	49.99	213.03
UW-091	47.099	191.000		UW-125	49.99	213.99
UW-092	47.202	191.997		UW-126	50.00	214.99
UW-093	47.301	192.994		UW-127	50.10	215.99
UW-094	47.394	193.995		UW-128	50.20	216.99
UW-095	47.498	194.989		UW-129	50.29	218.00
UW-096	46.993	195.457		UW-130	50.05	215.25
UW-097	46.501	195.861		UW-131	49.96	215.08
UW-098	46.009	196.278		UW-132	49.93	215.05
UW-099	45.006	197.091		UW-133	49.91	215.12
UW-100	44.718	197.276		UW-134	49.90	215.41
UW-101	44.578	196.560		UW-135	49.89	215.10
UW-102	45.001	197.009		UW-136	49.94	215.06
UW-103	46.001	198.194		UW-137	49.95	215.10
UW-104	47.002	199.295		UW-138	49.97	215.12
UW-105	47.711	200.092		UW-139	49.96	215.13
UW-106	48.169	200.892		UW-140	49.94	215.14
UW-107	48.966	202.485		UW-141	49.93	215.14
UW-108	49.059	201.999		UW-142	49.94	215.13
UW-109	49.182	201.498		UW-143	49.96	215.11
UW-110	49.291	200.999		UW-144	49.99	215.09
UW-111	49.504	199.999		UW-145	49.98	215.08
UW-112	49.567	200.999		UW-146	50.03	215.51
UW-113	49.694	201.985		UW-147	50.09	216.36
UW-114	49.798	202.996		UW-148	50.15	217.20
UW-115	49.909	203.997		UW-149	50.21	218.00
UW-116	50.000	204.995		UW-150	50.33	218.61
UW-117	50.006	205.990		UW-151	50.53	218.57
UW-118	50.006	206.996		UW-152	50.26	218.74
UW-119	50.006	208.029		UW-153	50.33	218.67
UW-120	50.002	208.976		UW-154	50.56	218.62
UW-121	50.043	209.990		UW-155	50.54	218.62
UW-122	50.008	210.993		UW-156	50.53	218.60
UW-123	50.002	211.990		UW-157	50.33	218.69

Sample #	Lat. (-N)	Long (-E)		Sample #	Lat. (-N)	Long (-E)
UW-158	50.25	217.90		UW-174	42.51	228.25
UW-159	50.17	217.09		UW-175	42.00	228.58
UW-160	50.00	216.78		UW-176	41.51	228.92
UW-161	49.56	217.42		UW-177	41.00	229.24
UW-162	49.01	219.18		UW-178	40.51	229.55
UW-163	48.47	219.78		UW-179	40.06	229.79
UW-164	48.00	220.48		UW-180	39.53	230.12
UW-165	47.00	222.56		UW-181	39.00	230.44
UW-166	46.20	224.32		UW-182	38.43	230.78
UW-167	46.02	225.26		UW-183	38.02	231.04
UW-168	46.57	226.21		UW-184	37.51	231.33
UW-169	44.99	226.62		UW-185	37.01	231.58
UW-170	44.51	226.95		UW-186	36.51	231.83
UW-171	44.02	227.28		UW-187	36.08	232.08
UW-172	43.53	227.61		UW-188	35.49	232.27
UW-173	42.90	228.01		UW-189	35.00	232.70

3.8.2 Development of Low-Power Millimeter-Wave FM-CW Radar and Observations of the Atmosphere

Jun YAMAGUCHI (Postgraduate Student of Chiba University) On-Board Researcher
Toshiaki TAKANO (Associate Professor of Chiba University) Supervisor
Youhei KAWAMURA (Technical Official of Chiba University) Advisor
Hideji ABE (Postgraduate Student of Chiba University) Researcher
Kenichi FUTABA (Undergraduate Student of Chiba University) Researcher
Shinichi YOKOTE (Undergraduate Student of Chiba University) Researcher

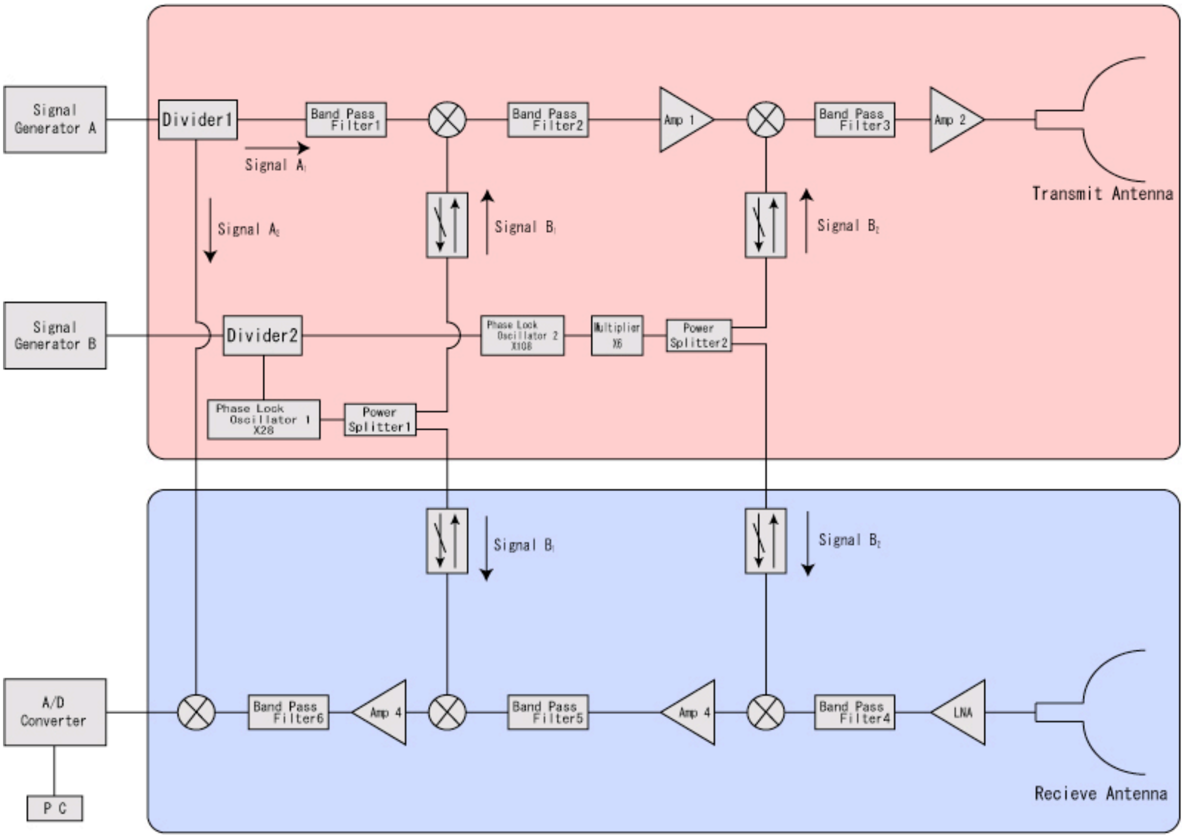
(1) Objectives

It is getting more important to know the global environment and the global changes of climate for the human beings. It is necessary to make clear the balance of the solar energy coming to the Earth and the cycle of water to understand the global environment, and clouds play one of the most significant role. The information like three-dimensional structure of clouds, sizes and distribution of clouds particles is needed to solve this problem. 5GHz conventional radars can detect precipitation particles, but are not able to detect particles in clouds because their sizes, less than a few tens of microns, are much shorter than the wavelength. The use of millimeter-wave (30- to 300GHz) is very effective to observe cloud process at these scales, and to study cloud's influence on precipitation development, cloud lifetimes and other meteorological phenomena. Our research program is to determine the usefulness of the millimeter radar at 95-GHz for observing cloud and rain precipitation, then to measure scattering from precipitation and clouds, and to reveal a model of cloud phenomena.

(2) Status

Figure 1 shows the block diagram of the millimeter-wave FM-CW radar. FMCW is used as the modulation type of this radar. This mode can provide high signal-to-noise ratio with low transmit power. All signals including the transmitted FM-CW signal at 95GHz and local frequencies are generated from two signal generators in 140MHz range, which are synchronized each other

Figure 1

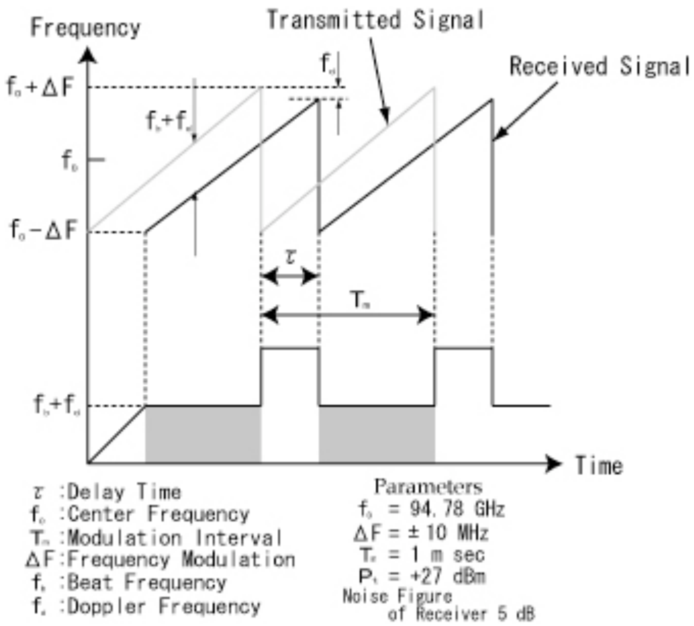


The signal frequency is modulated in the range of $f_0 \pm \Delta F$. Transmitted signal from the transmit antenna is reflected by cloud particles, returns, and is received by the receive antenna with a delay time of τ relative to the original transmitted signal. Mixing the transmitted and received frequencies, beat frequencies f_b are observed in the spectra, which are caused by ensemble of cloud particles:

$f_b = 4Frl(cT_m)$ (1)

where r is the height of the clouds, T_m is the modulation interval, and c is the light velocity. When the objects move in the line of the sight, the frequencies of reflected signals change by f_d:

$f_d = -2(f_0 / c)(dr / dt)$ (2)



Because one of the purpose of the facility is evaluation and verification of an FM-CW radar at 94GHz, we designed it to be a simple system so as to develop with commercially available components and to make maintenance and upgrade by ourselves.

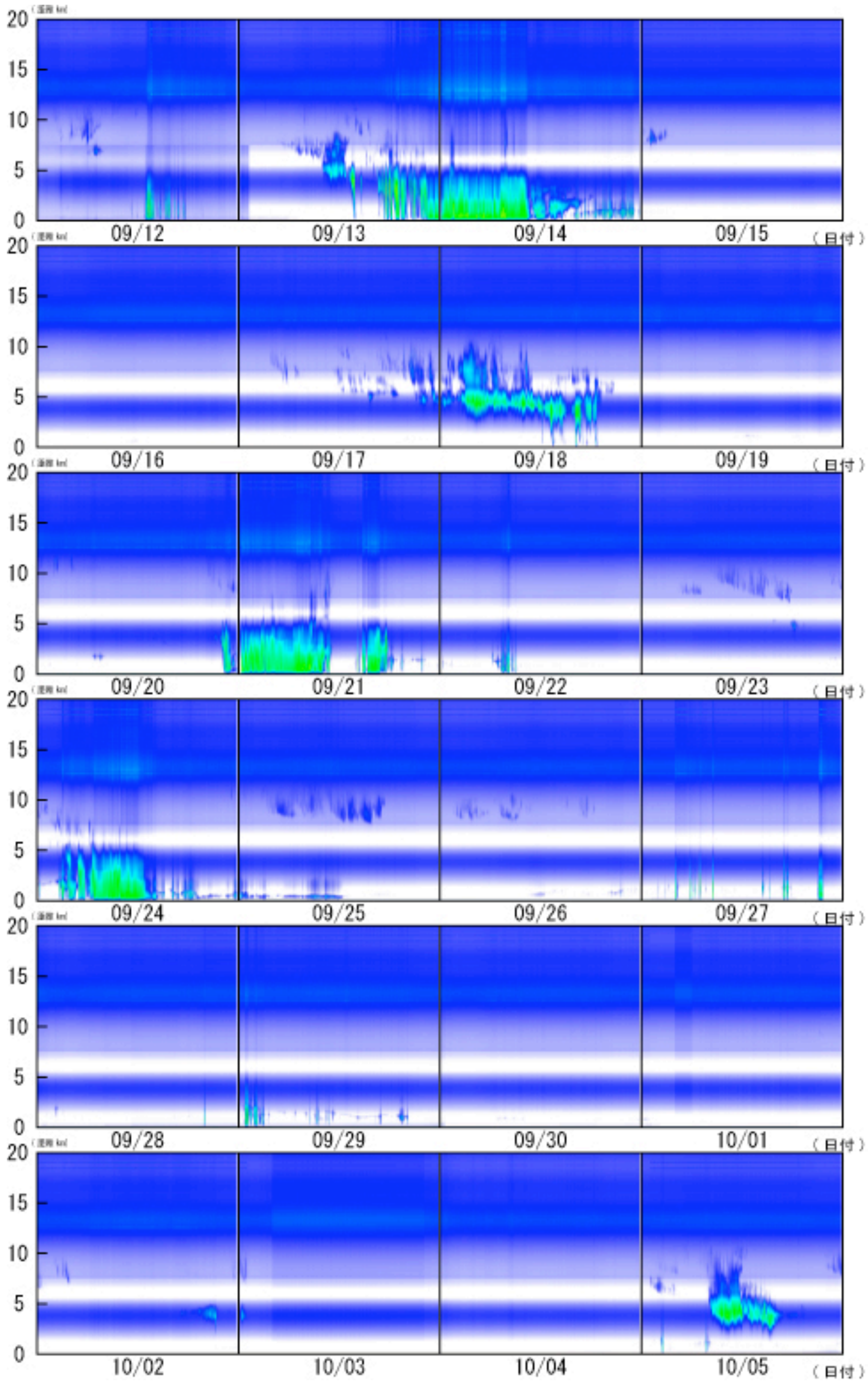
We designed the facility to observe clouds between 0.3 and 15km in height with a resolution of 15m. The velocities measured as Doppler shift should be less than 1m/sec. The facility should be mobile for measurement at variety of places.

According with the requirements described above, we designed the parameters of the antennas listed in Table.1.

Table1 Designed parameters of antennas

Antenna Diameters	1 m
f/D Ration of Antenna	0.35
Antenna Optics	Cassegrain
Gain of Antennas	57dBi
Beam Width	0.18 degree
Antenna Seperation	1.4 m
Direction of Antennas	Zenith
Polarization	1 Linear

The next two pages are quick-look images from the result of this research-trip from Sekinehama to San Diego. We will analyze all the data we got during this trip, and it will help us develop and improve the radar with comparing with the other weather radars.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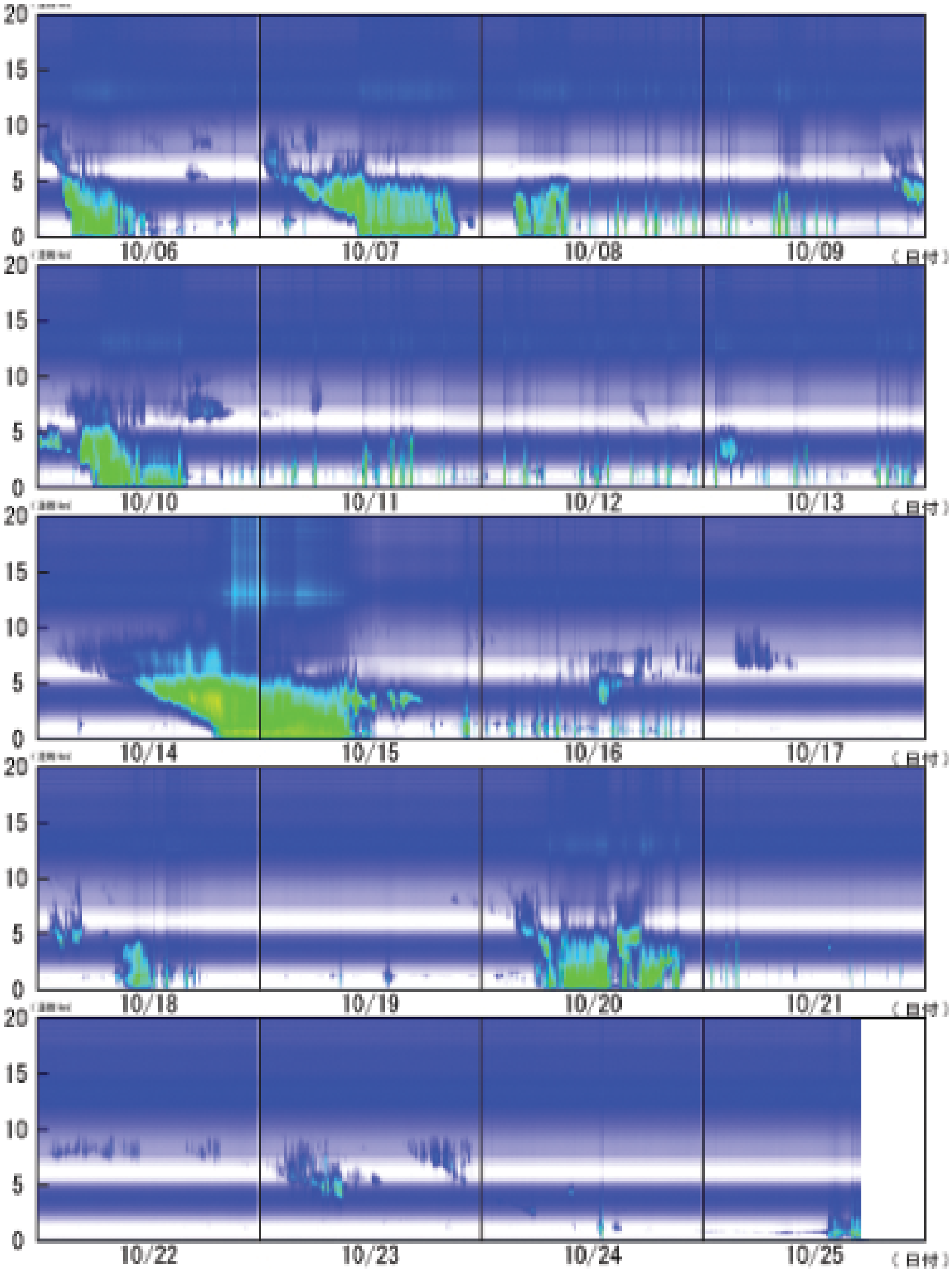

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3.9 ARGO float

Hiromichi UENO (JAMSTEC) not on board
Mizue HIRANO (JAMSTEC) not on board
Hiroshi MATSUNAGA (MWJ)
Shinsuke TOYODA (MWJ)

(1) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the North Pacific Ocean .

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

(2) Parameters

・water temperature, salinity, and pressure

(3) Methods

1) Profiling float deployment

We launched 16 APEX floats of JAMSTEC. 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), rising up to the sea surface every ten days by increasing their volume and thus changing the buoyancy. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately nine hours, transmitting their positions and the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The status of floats and their launches are shown in Table 3.9-1.

(4) Data archive

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

Table 3.9-1 Status of floats and their launches

APEX

Float Type	APEX floats manufactured by Webb Research Ltd.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	10 days (approximately 9 hours at the sea surface)
ARGOS transmit interval	30 sec
Target Parking Pressure	1000dbr

Launches

Owner	Type	S/N	ARGOS PTT ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch
JAMSTEC	APEX	2272	60072	23:49, Oct. 2	01:19, Oct. 3	47-00.44N 174-59.70E
JAMSTEC	APEX	2273	60073	07:19,Oct,3	08:39,Oct,3	46-30.07N 177-29.72E
JAMSTEC	APEX	2274	60074	19:25,Oct,3	20:26,Oct,3	45-59.92N 179-59.36E
JAMSTEC	APEX	2275	60075	23:45,Oct,3	00:49,Oct,4	45-59.66N 178-45.00E
JAMSTEC	APEX	2276	60076	03:08,Oct,4	05:18,Oct,4	45-59.95N 177-30.12W
JAMSTEC	APEX	2279	60079	08:32,Oct,4	09:45,Oct,4	45-59.73N 176-15.01W
JAMSTEC	APEX	2278	60078	16:52,Oct,7	18:55,Oct,7	45-59.15N 174-57.02W
JAMSTEC	APEX	2277	60077	01:20,Oct,8	02:28,Oct,8	46-29.97N 172-30.08W
JAMSTEC	APEX	2280	60080	18:58,Oct,8	19:48,Oct,8	47-00.03N 169-59.90W
JAMSTEC	APEX	2281	60081	02:25,Oct,9	03:27,Oct,9	47-15.03N 167-30.32W
JAMSTEC	APEX	2282	60082	09:45,Oct,9	10:48,Oct,9	47-29.93N 165-00.12W
JAMSTEC	APEX	2289	60087	22:52,Oct,9	23:55,Oct,9	45-00.08N 162-54.27W
JAMSTEC	APEX	2288	60086	22:51,Oct,9	23:57,Oct,9	44-59.91N 162-54.15W
JAMSTEC	APEX	2283	60083	05:02,Oct,11	06:10,Oct,11	45-24.32N 162-30.01W
JAMSTEC	APEX	2290	60088	02:28,Oct,12	03:36,Oct,12	48-57.41N 157-30.00W
JAMSTEC	APEX	2284	60084	23;32,Oct,13	00:45,Oct,14	49-28.03N 159-53.28W

4. Geophysical observation

Satoshi OKUMURA (Global Ocean Development Inc.)
Kazuho YOSHIDA (GODI)
Takeshi MATSUMOTO (University of Ryukyus): Principal Investigator: Not on-board)

4.1 Swath Bathymetry

(1) Introduction

R/V MIRAI equipped a Multi Narrow Beam Echo Sounding system (MNBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.). The main system of "SeaBeam 2100", 12 kHz system, provides swath bathymetry data.

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

In addition, topographyic survey was conducted around the target area to find a suitable setting for sediment coreing. Also sub-surface conditions were investigated to estimate thickness of sediments without disturbance on the gentle slope for paleoceanographic study using the data of sub-bottom profiler.

(2) Method of Data Acquisition

The "SEABEAM 2100" on R/V MIRAI was used for bathymetry mapping during MR05-04 cruise from 14 September 2005 to 24 October. For data quality management, applying applicable sound velocity profile is the most important. Sound velocity profile was calculated using formula of Mackenzie (1981), which parameter were water temperature and salinity from CTD. Variations of sound velocity at transducer face have a large influence on measurement depth, especially side beams. So that this system has Surface Sound Velocimeter (SSV), which measuring sound velocity in the surface intake (6.2 m) water continuously.

Obvious bad data was flagged automatically by real-time data screening function of the system. The data was post-processed using CARIS HIPS (CARIS, Canada).

System configuration and performance of SEABEAM 2112.004;

<12kHz System>

Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m

Depth accuracy:	Within < 0.5% of depth or +/-1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or +/-1m, whichever is greater)

<Sub-bottom Profiler; 4kHz System>

Frequency:	4kHz; operating from 2.5 to 6.5 kHz chirp signal
Transmit beam width:	5 degree
Sweep:	5 to 100 msec.
Depth Peneration:	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 of survey around Stn. EW1 and EW10 are shown in Sec. 7.

(5) Data Archives

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

4.2 Sea Surface Gravity

(1) Introduction

The distribution of local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR05-04 cruise from 13 September 2005, departure of Sekinehama, to 24 October, just before entering US EEZ.

(2) Parameters

Relative Gravity [mGal]

(3) Data Acquisition

We have measured relative gravity by on-board gravity meter (Air-Sea System II; Micro-G LaCoste, USA) during this cruise. Comparative measurement was conducted at the land gravity base near the port of call by the portable gravity meter (CG-3M; Scintrex, Canada) to estimate the sensor drift of the on-board meter.

(4) Preliminary Results

We carried out the land measurements for calculating absolute gravity at Sekinehama on 12 September. Absolute gravity of MR05-04 cruise will be calculated after the next land measurement in MR05-05 cruise.

(5) Data Archives

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

(6) Remarks

The data includes invalid data due to the logging PC trouble from 10:01:28 to 11:48:16, on 09 October (Time in UTC).

4.3 Sea surface three-component magnetic field

(1) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR05-K04 cruise from 13 September 2005, departure of Sekinehama, to 24 October, before entering US EEZ area.

(2) Parameters

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

(3) Method of Data Acquisition

A shipboard three-component magnetometer system (SFG1214, Tierra Tecnica, Japan) consists of three axes fluxgate sensors, setting on the top of foremast. Output signal from the sensor is digitized through 20-bit A/D converter and sent to the deckbox. Data sampling is controlled by 1-pps (pulse per second) signal from GPS standard clock. Navigation information, 8 Hz three-component of magnetic force, and ship's attitude data from Vertical Reference Unit data are merged and recorded every one-second.

For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation) from 3:00 to 3:27 on 13 October at 49-30N, 160-00W.

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

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

(6) Remarks

Data logging was stopped due to the PC trouble on 10 October. The data does not exist following periods (times in UTC),

From 00:00:00 to 00:00:01
From 09:13:59 to 12:31:08
From 12:33:52 to 12:35:50

5. Satellite observation (MCSST)

Satoshi OKUMURA (Global Ocean Development Inc., GODI)
Kazuho YOSHIDA (GODI)

(1) Objectives

It is our objective to obtain sea surface temperature (SST) distribution in the North Pacific Ocean. We collected the data of Advance Very High Resolution Radiometer (AVHRR) on the NOAA weather satellites for calculating SST.

(2) Method

We received and archived the High Resolution Picture Transmission (HRPT) data from AVHRR/NOAA, in which NOAA-12, NOAA-14 and NOAA-17 were currently available, by Terascan system installed in the R/V MIRAI. The AVHRR data was calibrated, mapped to Mercator projection, and converted to SST, using the multi-channel sea surface temperature (MCSST) algorithm.

MCSST images are composited to a daily image around the location of the R/V MIRAI at 00:00 (UTC) for each day.

We archived HRPT data throughout MR05-04 cruise from 13 September 2005, departure of Sekinehama, to 27 October, arrival of San Diego.

(3) Preliminary results

Fig.5-1 and Fig.5-2 show MCSST composite images, entire cruise and weekly composite from 13 September to 24 October.

(4) Data archives

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

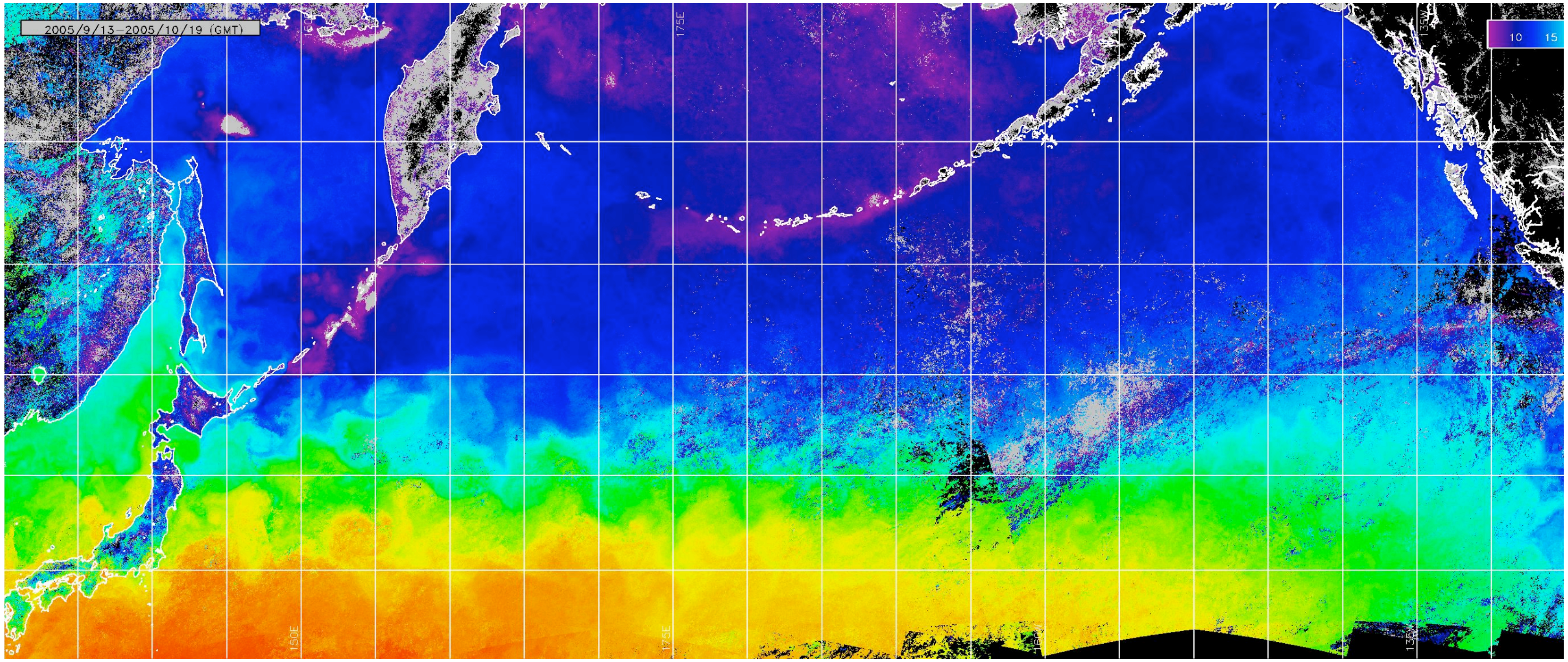


Fig.5-1　Composite map of MCSST data

The map shows sea surface temperature about the North Pacific Ocean from 13 September 2005 to 19 October 2005.

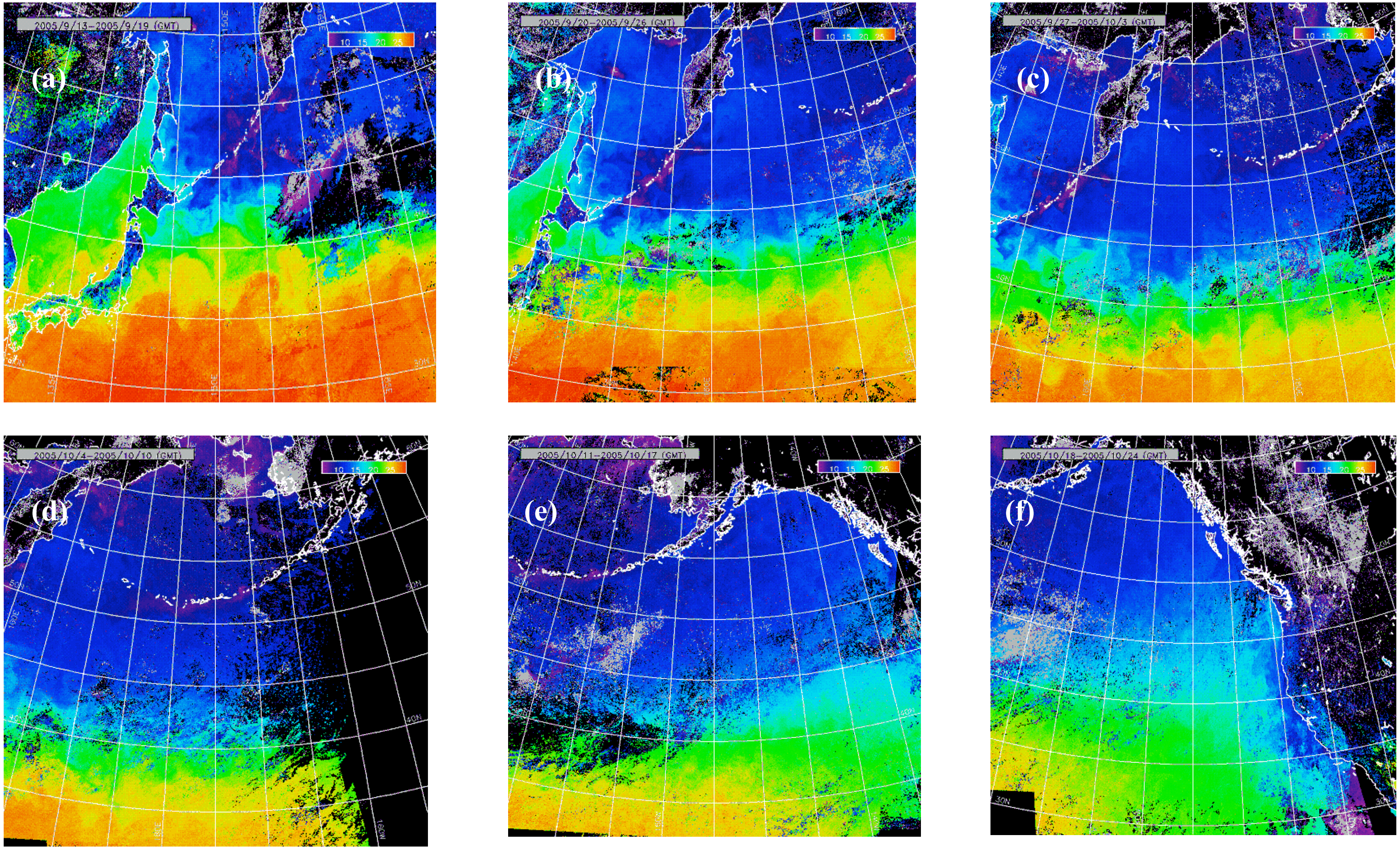


Fig.5-2 Weekly Composite maps of MCSST data during this cruise.(a)13 Sep. – 19 Sep., (b) 20 Sep. – 26 Sep., (c) 27 Sep. – 3 Oct., (d) 04 Oct. – 10 Oct., (e) 11 Oct. – 17 Oct., (f) 18 Oct. – 24 Oct.

6. Ship's handling

6.1 Ship's Handling for the Deployment of the ＭＭＰ/BGC moorings

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

(1) Objectives

・**To deploy it accurately and efficiently to the position where a mooring is required.**

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

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

(2) Observation parameters

・Ship's position, course, speed

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

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

・ Working hours

・ Tension of the towing

・ Position of the sinker

(3) Methods

(3.1) Measurement of the actual ship-movement

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

(3.2) Measurement of the wind and the current

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

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

(3.3) Ship's speed

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

(3.4) Ship's course

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

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

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

(3.5) Working hours for the deployment of the MMP/BGC moorings

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

"Total of Distance " means the navigating distance from the work beginning to the sinker dropping. This is a standard without a big flow influence in accordance with data in past. Each ship's speed is the numerical value of the above standard in (3.3).

MMP mooring

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

BGC mooring

Works	Time	Ship's speed	Distance
Stand by the top-buoy	0.5 hour	0 knot	0 mile
Attachment of the sediment traps	4.0	1.0	4.0
Paying out the mooring lines	0.5	1.5	0.8
Towing	1.0	1.7	1.7
Setting the sinker	0.5	1.0	0.5
Total	6.5 hours	1.4 knots	7.0 miles

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

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

The analysis of the tension is mainly remarkable to the BGC mooring as it has a big resistance of water by some sediment traps in comparison with MMP mooring.

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

(3.7) Designated mooring location (Target)

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

MMP mooring **: lat.46° 52'.24N, Long. 159° 59'.06E** Depth 5152.3 meters
BGC mooring **: lat.47° 00'.35N, Long. 159° 58'.32E** Depth 5206.2 meters

(3.8) Decision of the anchored position

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

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

The acoustic transducer: Edgetech Inc. USA
The radio navigation device: "Sains" assembled by Sena Co., Ltd. Japan.
The ship's radar: "JMA9000 X band" and "JMA 9000 S band " assembled by JRC Ltd. "MM950 X & S band" assembled by Consilium Selesmar, Italy.

(4) Results

(4.1) Ship's speed

The results are shown in Fig.6.1-1 and Table 6.1-1 to 6.1-3.
An approximate speed at through-the-water in each work is shown in the following.

	MMP	BGC
During setting the top buoy	1.8 (1.4) knots	0.7 (0.5) knots
During paying out mooring lines	1.4 (0.9)	1.3 (1.3) with sediment traps
During towing at the final stage	2.0 (1.5)	1.5 (2.2)
During setting the sinker	1.2 (0.7)	1.1 (1.4)
The average speed during the deployment	1.7 (1.3)	1.3 (1.4)

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

The mooring lines of the MMP were paid out slowly by using the traction winch as they had been wound around the drums loosely. The BGC mooring lines were paid out slowly from the drum with adding tension to lines without using the traction winch because these lines which have been wound around the drum are prevented from becoming loose, and from damage sediment traps etc. Accordingly the ship's speed was slow in comparison with the usual.

About the speed of the MMP deployment, there is a big difference between the through-the–water and the over-the-ground because the ship navigated against the current.

The increase and decrease of the speed is different according to the condition of the sea.

In case of the MMP mooring, an average significant wave height was 1.6 meters, the cycle of the wave was 6.8 seconds, and the swell came from the direction of 330 degrees. In case of the BGC mooring, an average significant wave height was 1.7 meters, the cycle of the wave was 6.2 seconds, and the swell came from the direction of 320 degrees. Other data show it in the Table 6.1-1. The condition of the sea was moderate this time, and there were a few influences in both MMP and BGC.

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

An external force influence to the ship is expected to change while deploying the mooring because both MMP mooring and BGC mooring need long time to deploy them.

Therefore, the direction of the current being a big external force influence was checked over a span of 24 hours as indicated in Fig 6.1-2. This data shows the current direction is changing frequently.

Fig.6.1-3 shows the relative wind that the ship received. The ship received the wind nearly end on in case of the MMP mooring. In case of the BGC mooring, the wind blew to the ship's portside though it was breeze.

The gyro course and the true course of the ship are shown in followings.

	CMG	Gyro Co.	True Co.	Sinker Co.	Unit: degrees
MMP	<192>	<215>	<204>	<208>	
BGC	<045>	<040>	<043>	<043>	

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

"Gyro Co." is the ship's heading in a final stage of the work of the deployment.

"True Co." is the bearing on the sinker point from the top buoy in the moment when the sinker was dropped.

"Sinker Co." means the course that the ship is passing a certain distance beyond the target point. It is shown in (4.5) Sinker's position. It is demanded that there is no difference between "True Co." and "Sinker Co." so that the sinker hits the target point when it doesn't have a great external force influence. Fig.6.1-4 and 6.1-5 show the current influence. Firstly the direction and the speed of the current are shown by absolute value. Next, the speed of the current is divided into the direction of Y (lateral force) and X (longitudinal force). Because Y moves the ship laterally, the amount of it influences the ship's control. It is mainly adjusted by using the side-thrusters. X influences the speed of the ship. This influence is mentioned in (4.1) Ship's speed and (4.3) Working hours.

MMP mooring

The course of the ship was set to receive the wind in the bow because the wind was the strongest in the external force influence. The course was decided to 190 degrees being the direction of the wind. Although it was expected to be the current in the North direction by referring to data in the Figure 6.1, it shifted to the northeast actually. In addition, the Northwesterly swell surged to her starboard. The hull shift to the left was forced with the current and the swell, but it reverted by using the powerful side thruster.

BGC mooring

While the set drift, wind was breeze, and the influence of the current was judged to be big, and the course was decided as 45 degrees against the current in the SW direction. When the deployment of the buoy was started, the current changed to the north. However the ship's course couldn't be changed suddenly without having any time to spare it. The westerly wind was freshening gradually. The current, the wind and the Northwesterly swell impelled the ship to front of the left after all. The side thruster was used efficiently to return the ship to the course line.

(4.3) Working hours

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

MMP mooring

The time spent in setting top buoy and instrument		1 minutes
The time spent in paying out mooring lines (including the time spent in setting MMP/glass balls)		3 hours 29 minutes
The time spent on towing		1 hour 13 minutes
The time spent in setting releasers and sinker		21 minutes
	Total	5 hours 04 minutes

As the mooring lines had been paid out slowly to prevent the line of the drum from loosening as described by (4.1) Ship's speed, working hours were extended compared with last time. The towing time became longer than the average due to an opposite current. Therefore, working hours are long for about thirty minutes in comparison with actual results.

BGC mooring

The time spent in setting top buoy and instrument		19 minutes
The time spent in paying out mooring lines with sediment traps (including the time spent in setting glass balls)		3 hours 30 minutes
The time spent on towing		1 hour 03 minutes
The time spent in setting releasers and sinker		14 minutes
	Total	5 hours 06 minutes

Although mooring lines were paid out slowly in order to prevent lines in the drum from becoming loose as described by (4.1) Ship's speed, it did not be extension of working hours very much. The towing time was short in comparison with past results because the ship ran with the following current.

(4.4) Tension of towing the MMP/BGC moorings

The results of the tension in the towing work being a final stage of the deployment are shown in Fig 6.1-6 and 6.1-7.

The next characteristics are seen from these tables.

- A difference in the line tension of the MMP and BGC is evident.
- The line tension of the BGC which have many sensors and sediments is bigger than that of the MMP.
- When the towing speed increases, the difference becomes remarkable.
- Even if the angle of the CPP was fixed, the ship's speed fluctuated by the external force influence such as the wind, the wave and the swell etc. However the amplitude of the speed correlated clearly that of the line tension.
- Relations between the towing speed(X) and the line tension(Y) are shown with Y=337.47X-80.757 in case of the MMP, Y=732.91X-429.79 in case of the BGC.

Following data are calculated by the correlation formula.

	Towing speed at through-the-water	Towing tension
MMP	1.0 knot	260 kgs
	1.5 knots	430 kgs
	2.0 knots (Average speed during tow)	600 kgs
BGC	1.0 knot	300 kgs
	1.5knots (Average speed during tow)	670 kgs
	2.0 knots	1040 kgs

- In this measurement, the line tension of both MMP and BGC never exceeded 1400 kilograms though the each towing speed exceeded 2 knots.

(4.5) Sinker’s position (Fig 6.1-8)

The difference between the position of **the sinker dropped (the sinker drop point)** and the position of **the sinker reached the seabed** (**the fixed point**) are shown in the following numerical data.

	Drop point to Target point direction/ distance	Drop point to Fixed point direction/ distance	Difference Sin/ Cos
MMP	028 degrees/ 483 meters	032 degrees/ 382 meters	27/101 meters
BGC	223 degrees/ 609 meters	222 degrees/ 645 meters	11/ -36 meters

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

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

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

The “Sin of Difference” and the “Cos of Difference” are the amount of difference in the X/Y directions to the fixed point from the target point.

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

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

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

Fig. 6.1-9 is shown the ship's track and each point after the sinker was dropped. Each point is located nearly on the truck of the ship. This can be said to MMP, BGC both.

As far as the above result is seen, it can guess that there were a few the external force influences after the sinker was dropped.

(4.6) Required depth

Depth of the SEA-BEAM was continuously measured to the point of the sinker dropped from about 500 meters on this side of the target point via the target point. This purpose is to confirm the depth in the vicinity of the mooring point and the situation of the seabed in that occasion. Fig 6.1-10 shows the map of three dimensions that indicates the bottom of the sea around the K2 station by using the SEA-BEAM data.

Both of the moorings were actually anchored within the same depth contour as shown in Fig 6.1-11 and the following depths were obtained.

Site No.	Actual	Demanded depth in 2001
K2-MMP	(5158 meters)	5152 meters (5169 meters)
K2-BGC	(5217 meters)	5206 meters (5214 meters)

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

In 2001, an original depth was the one sounded by the CTD and the altimeter in detail. The depths of water measured by the SEA-BEAM 2000 in 2001 show that the MMP mooring was 5169 meters, and the BGC mooring was 5214 meters. The difference between the original depth and the SEA-BEAM’s depth was 17 or 8 meters. It is able to guess that it is within error margin though there is a difference of 11 or 3 meters between 2001 and this time on the SEA-BEAM’s depth basis. Namely the difference from the original depth in the BGC widens by 3 meters, and that in the MMP narrows by 11meters. Because there are within the depth accuracy (0.5%) of the SEA-BEAM 2000, and a seasonal factor is contained in them.

(4.7) Distance for Deployment of MMP/BGC mooring (Table 6.1-2 and 6.1-3)

Results are shown in the following table. Unit: miles

	Actual	Tow	T/A
MMP	6.45 miles	1.78 miles	27.6 %
BGC	7.48	2.2	29.4 %

“Actual” is the distance from the starting point to the position of the dropped sinker.

"Tow" is the distance to the releaser installation point from the point where the tow begins. The distance of "Actual" includes that of "Tow".
"T/A" is the ratio of the distance for towing to the actual distance. As for this rate, 24% is found as a standard by data shown in (4.5) Working hours. This percent shows a tendency to vary with an influence of the current. In other words, this is small in case of against the current, and big in case of the following current.
The distance to the site in which the sinker was dropped from the stage that the releaser was set to the stern was as follows.

Mooring No.	Distance (Time)
MMP	0.25 miles (21 minutes)
BGC	0.32 miles (14 minutes)

During this navigation, the distance to the dropped point was one by one informed with the communication device from the bridge to a team of technician and deck personnel. And the bridge counted down from 10 meters before the point dropping the sinker.
After the sinker had been dropped, the ship made a U-turn and pursued it so as to make sure that the top buoy disappeared from surface. The ship went near the buoy as soon as possible to catch the top buoy clearly by radars, and the ship was abreast with the buoy near. During the running the speed and course of the buoy were grasped.
The information grasped here is diagrammed in the following page and Fig 6.1-9 to understand them easily.
The time to disappearing of the top buoy from dropping of the sinker was as follows.

		Previous deployment
MMP	32 minutes	30 minutes
BGC	38 minutes	47 minutes (Test), 50 minutes (Long term)

The horizontal distance from the point where the top buoy disappeared from the surface to the fixed point is that the MMP has 2225 meters in the direction of 205 degrees, and the BGC has 2256 meters in direction of 44 degrees.
And the top buoy of the MMP and the BGC ran on the surface at average speed 1.93 knots and 1.25 knots.
When a top buoy disappeared from the surface of the water, the position where the sinker arrives at the seabed can be predicted by these data.
According to past testing results, the sinker dropped arrived at the bottom of water 57 minutes later, and then after the top buoy disappeared from the surface, that was after 10 minutes. This is useful when time to decide a fixed position is calculated.

MMP (Date of Deployment: September 24, 2005)

Movement	Position	Time (SMT)	Direction and Distance
Top buoy was dropped	46-58.32N 160-00.88E	08:10	<degree>
Sinker was dropped	46-54.22N 160-00.35E	13:13	
Top buoy sank	46-53.27N 159-59.78E	13:45	<202>1902m
Target point	46-52.24N 159-59.06E		
Fixed point	46-52.18N 159-59.04E		<205>2225m
Sinker drop point	46-52.01N 159-58.88E		<192>11957m <204>4496m <208>483m

BGC (Date of Deployment: September 26, 2005)

Movement	Position	Time (SMT)	Direction and Distance
Top buoy was dropped	46-55.48N 159-51.27E	08:43	<degree>
Sinker was dropped	46-58.86N 159-56.30E	13:30	
Top buoy sank	46-59.46N 159-57.06E	14:08	<041>1496m
Target point	47-00.35N 159-58.32E		
Fixed point	47-00.33N 159-58.31E		<044>2256m
Sinker drop point	47-00.59N 159-58.65E		<045>13287m <043>4368m <043>609m

Remark:

The position of the top buoy and the sinker drop point were measured with radar in the position of 87 meters from the stern.

(7) Data archive

All data will be archived on board.

(8) Remarks

This time, there was a new finding which had to make a special mention for handling the ship as follows.

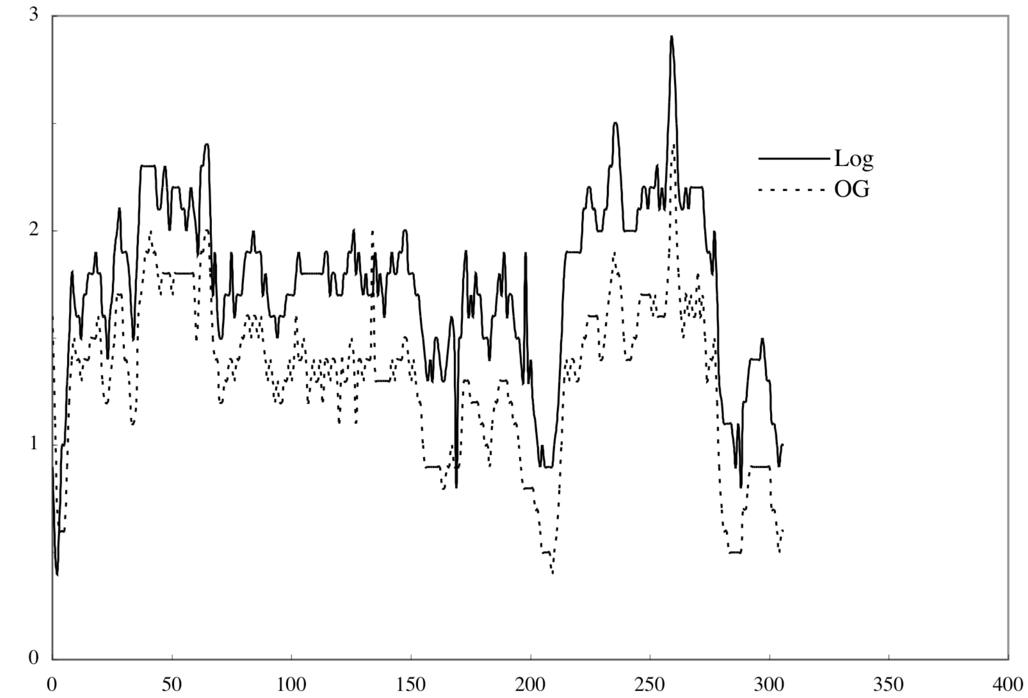
Sinkers of both MMP and BGC anchored near the target point. It is because the position to drop each sinker was accurate. It found that the software which reflected previous results. was useful for deciding the accurate position for dropping the sinker.

On the other hand, the external force influences the movement of the ship during deploying the mooring buoy. It was difficult to decide the course for deploying the mooring buoy in this time though the ship's maneuver was easy when the ship's course was selected so as to be parallel to the fixed external force. Because the external force such as the wind and the current changed irregularly to need a long time in deploying the mooring buoy.

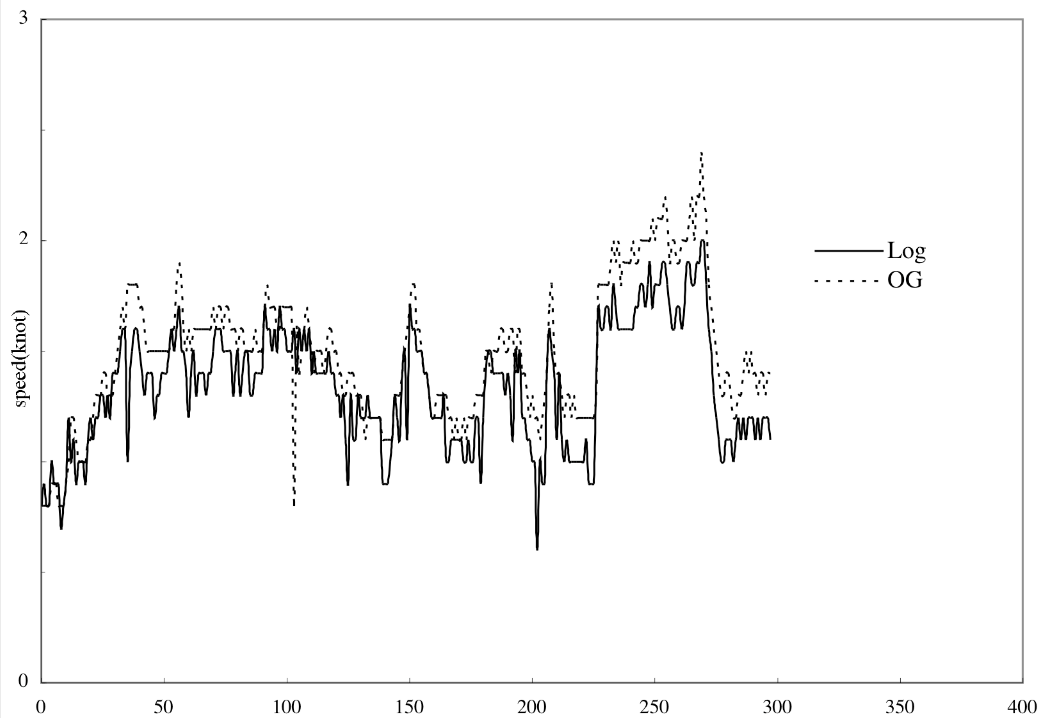
As a conclusion the MIRAI's excellent maneuvering function such as the thruster etc. got over that difficulty.

It seems to be certain to develop the science and technical skill to deploy the buoy safely and efficiently by the past experience.

MMP

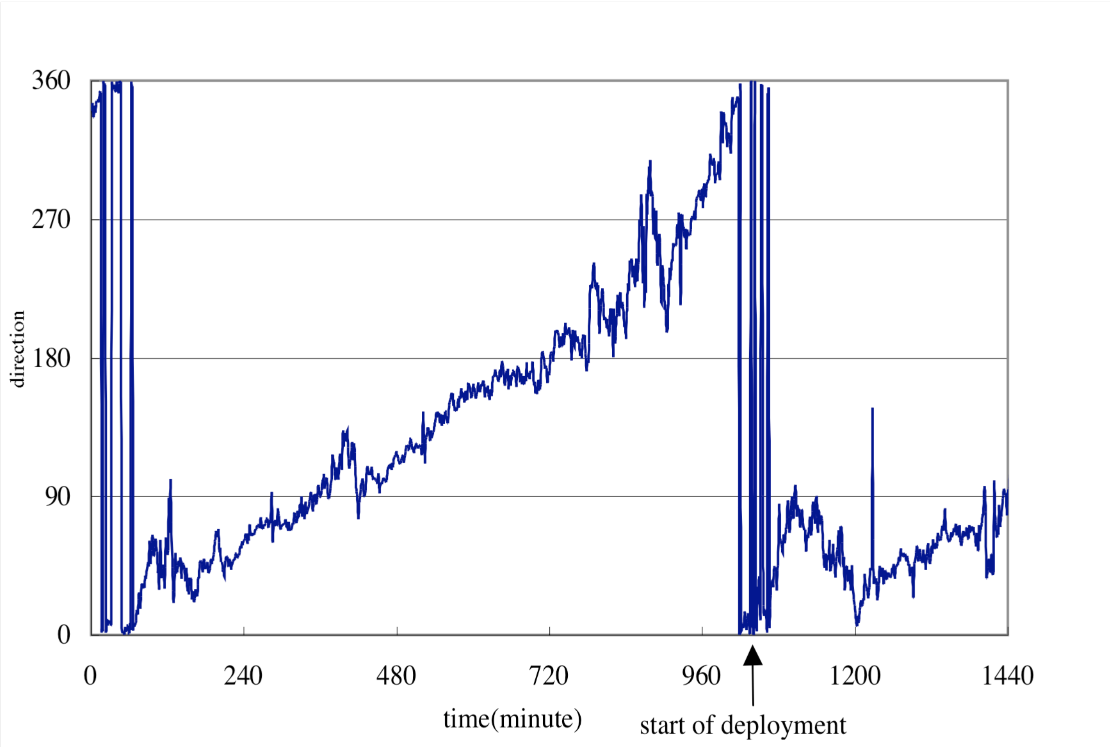


time(minute)



time(minute)

Fig6.1-1 Ship's speed in deployment at k2 station



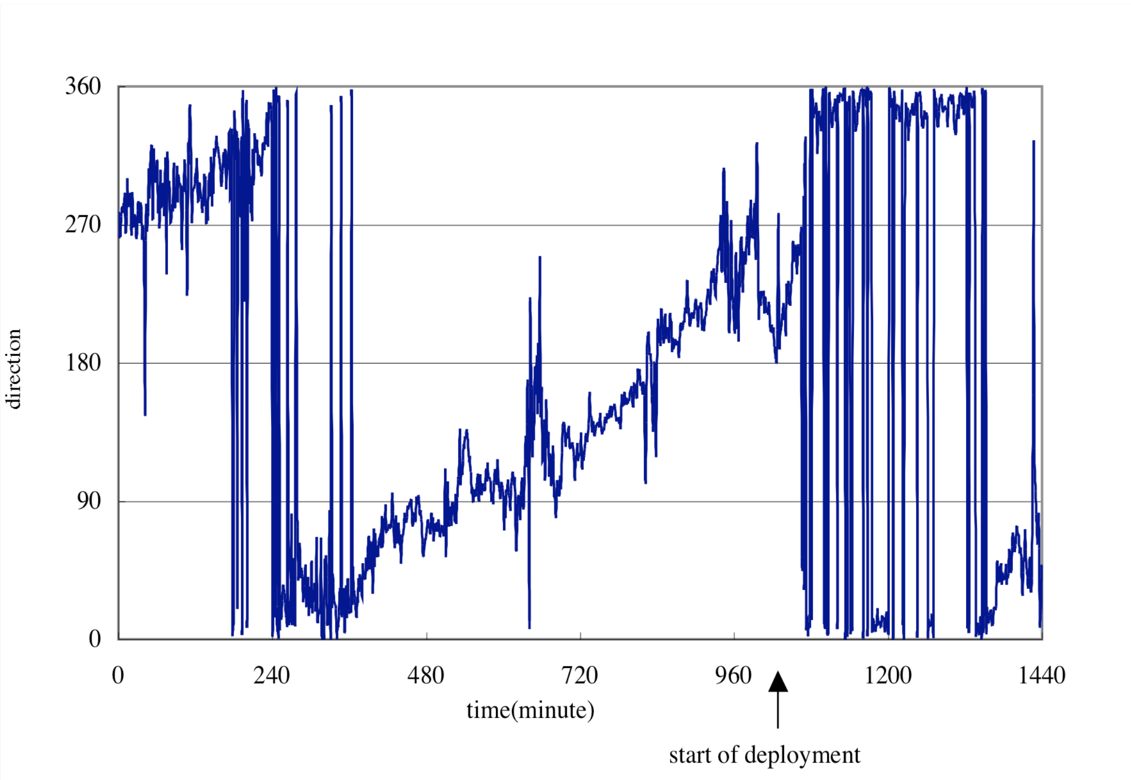


Fig6.1-2 Current direction for 24 hours at k2 station

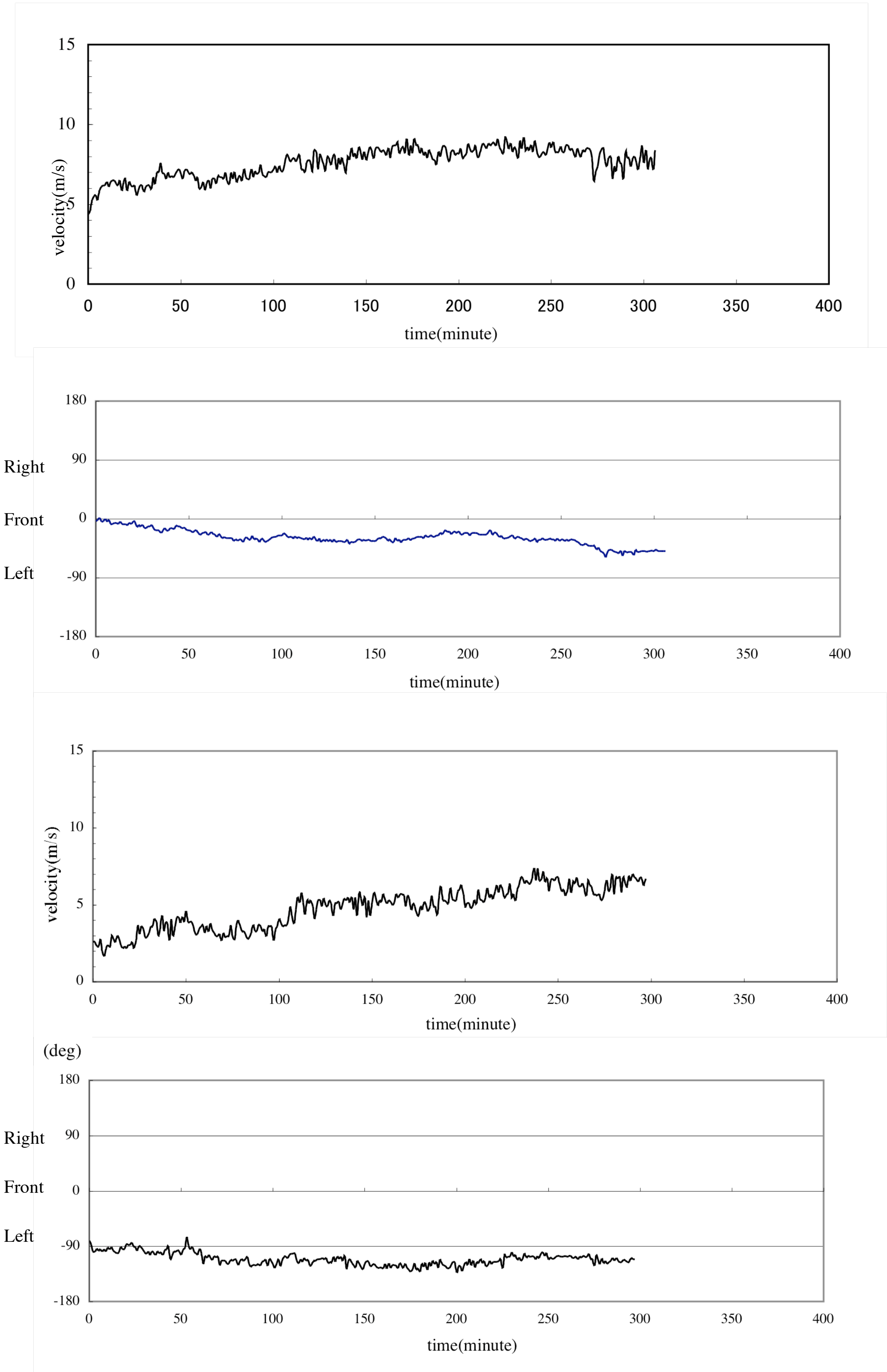
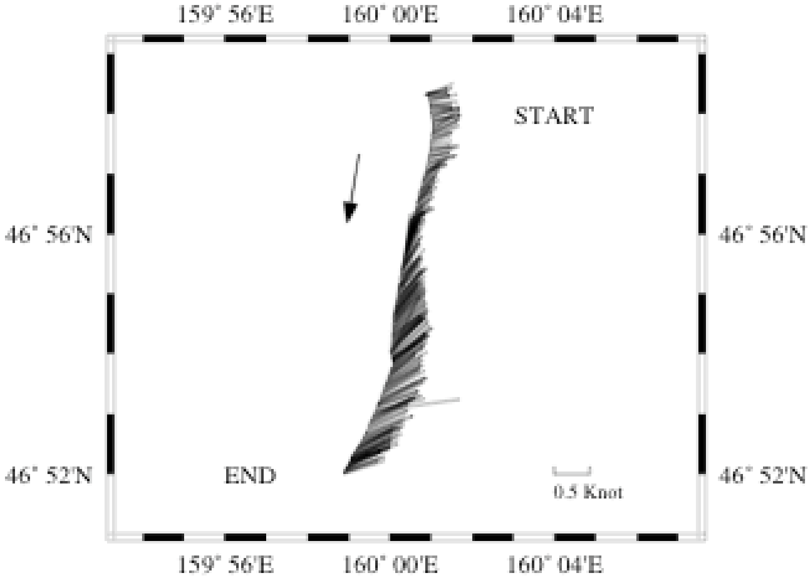


Fig-6.1-3 Relative wind in deployment at k2 station

MMP



BGC

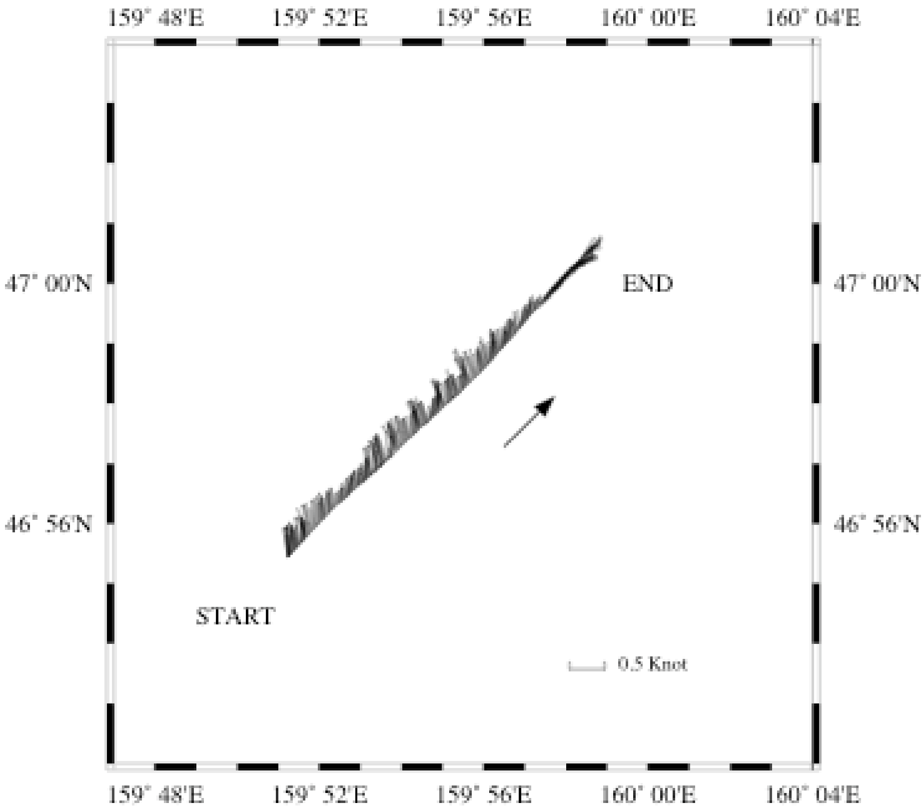
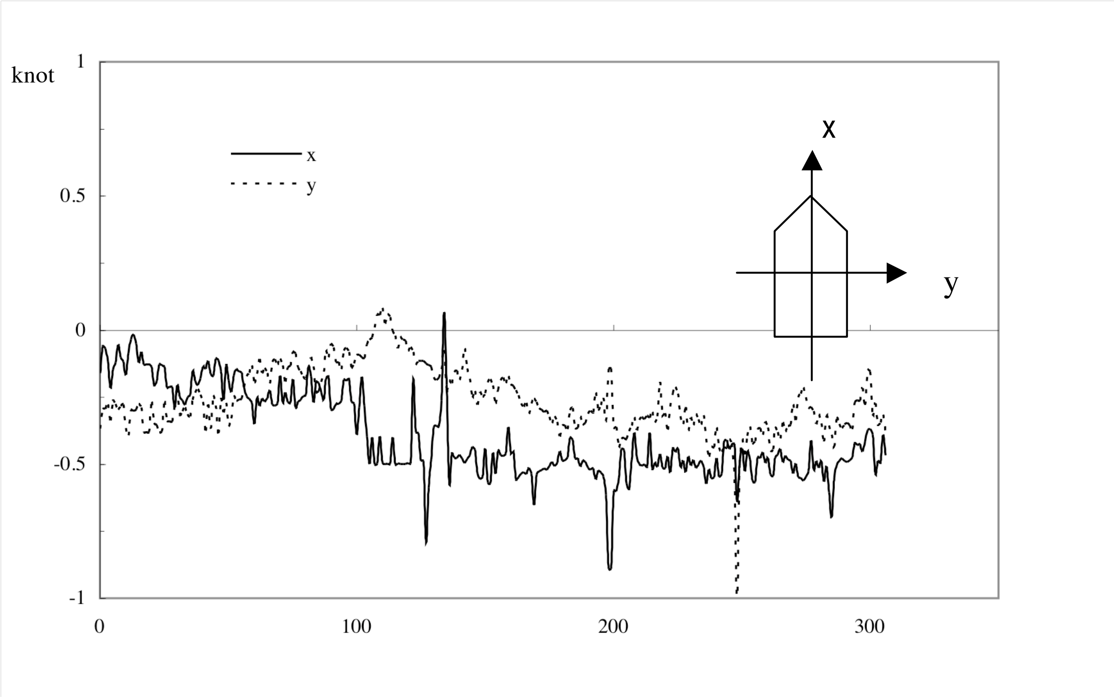


Fig 6.1-4 True current to ship's track in deployment at k2 station

Fig 6.1-4 True current to ship's track in deployment at k2 station



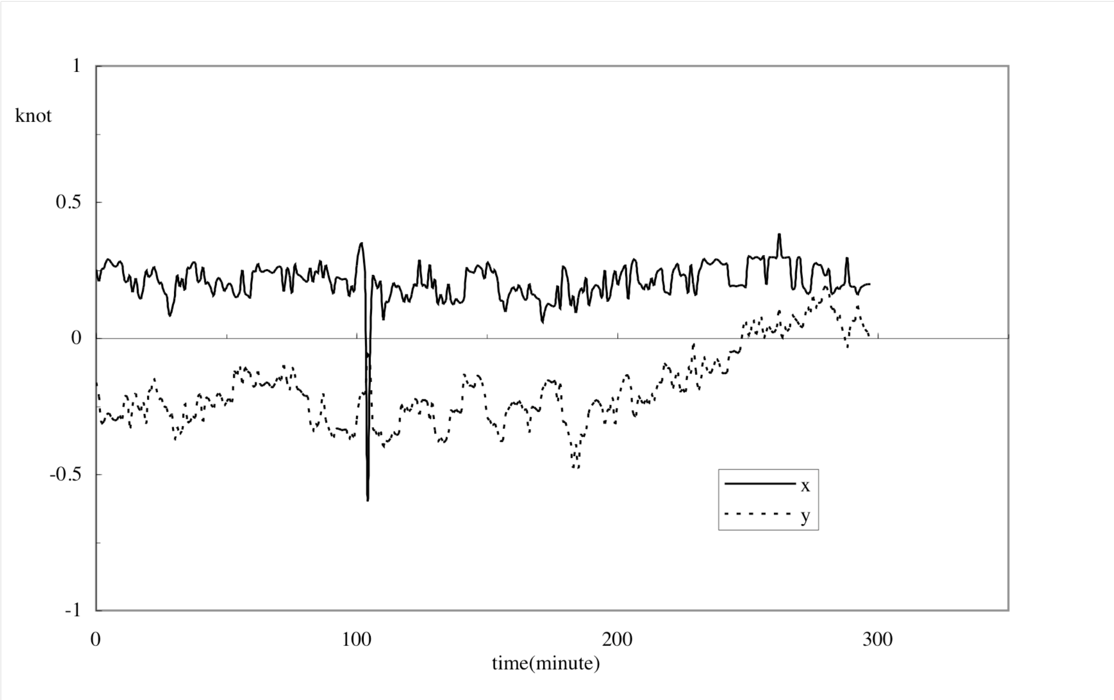
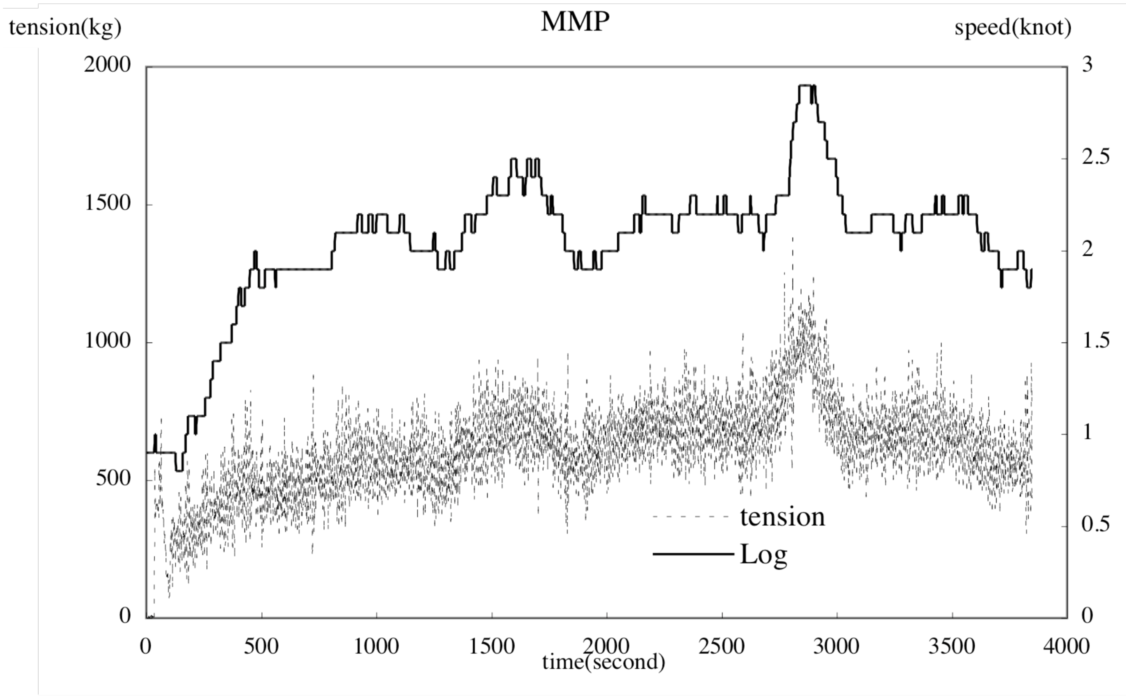


Fig-6.1-5 Current influence in deployment at k2 station



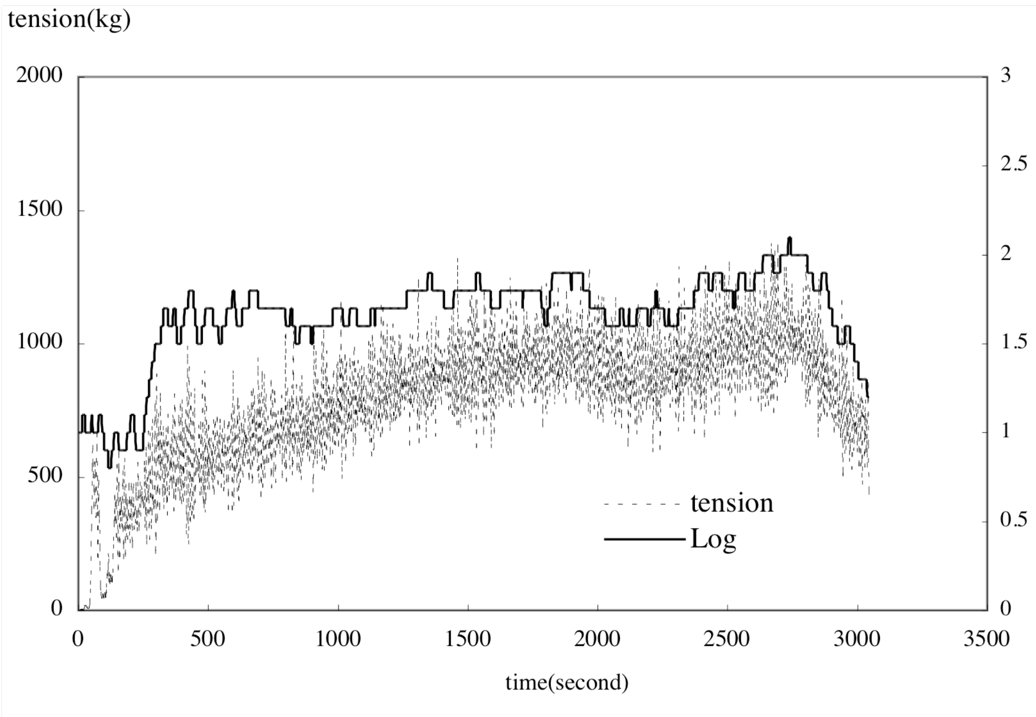
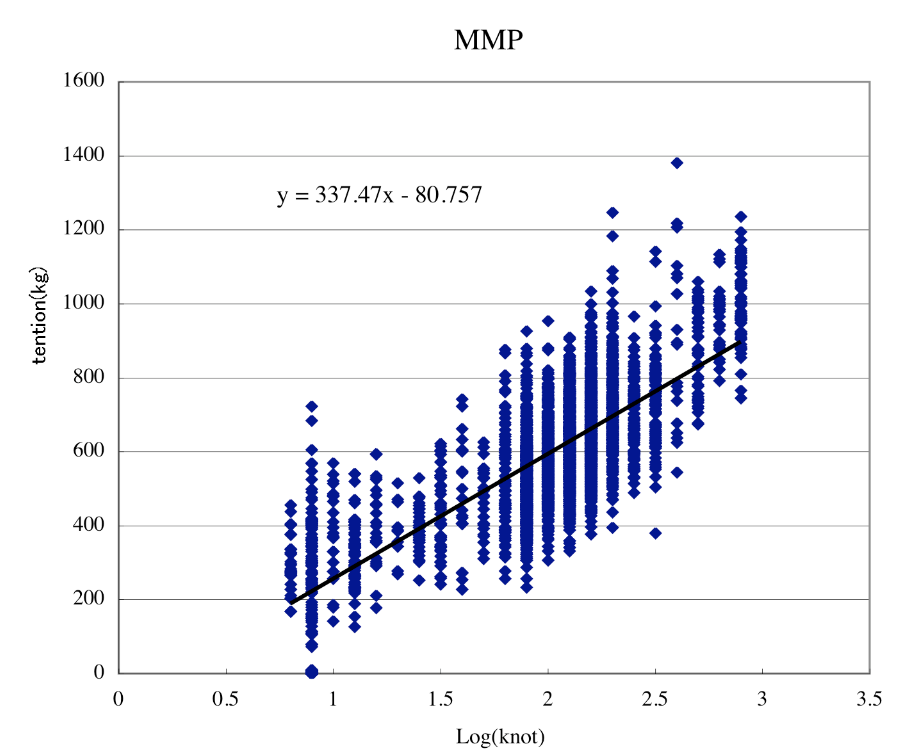


Fig6.1-6 Rope tension during tow in deployment at k2 station



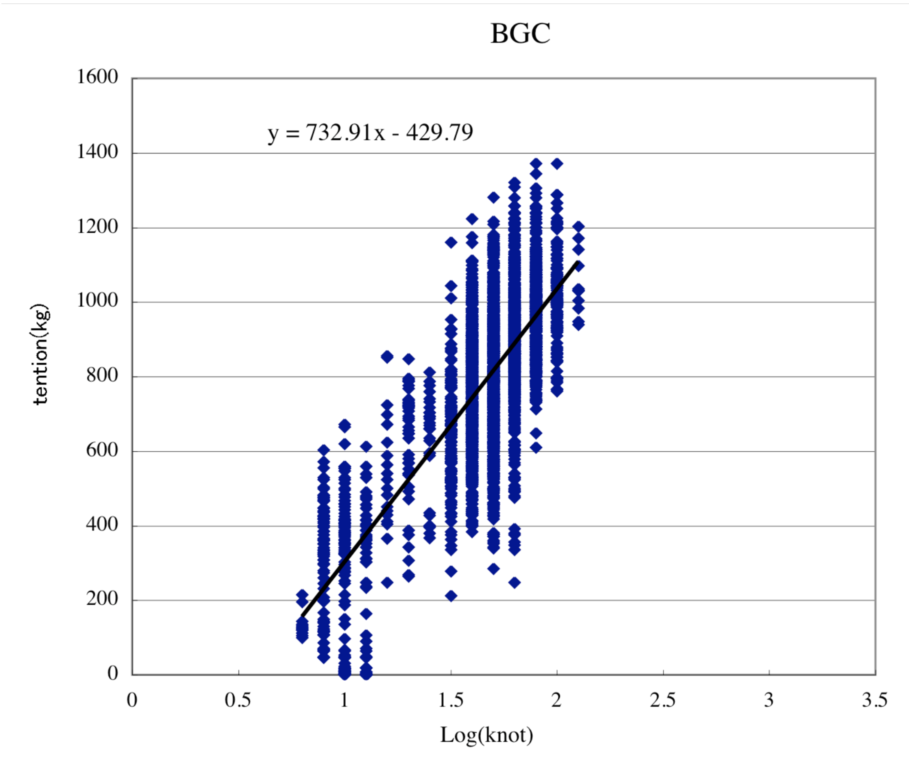
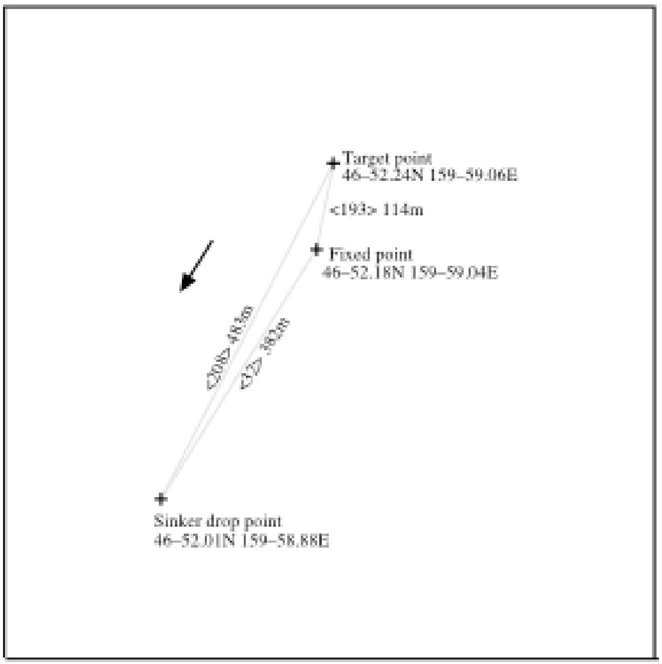


Fig6.1-7 Correlation coefficient of rope tension/ship's speed in deployment at k2 station

MMP



BGC

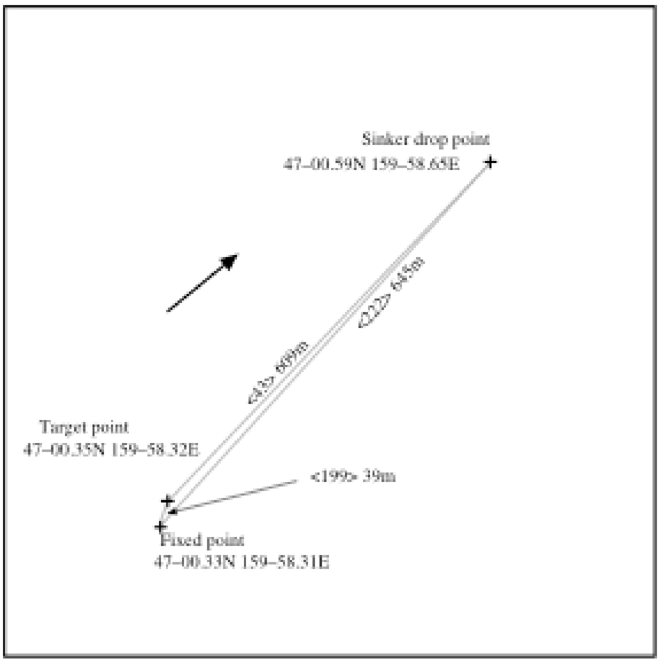
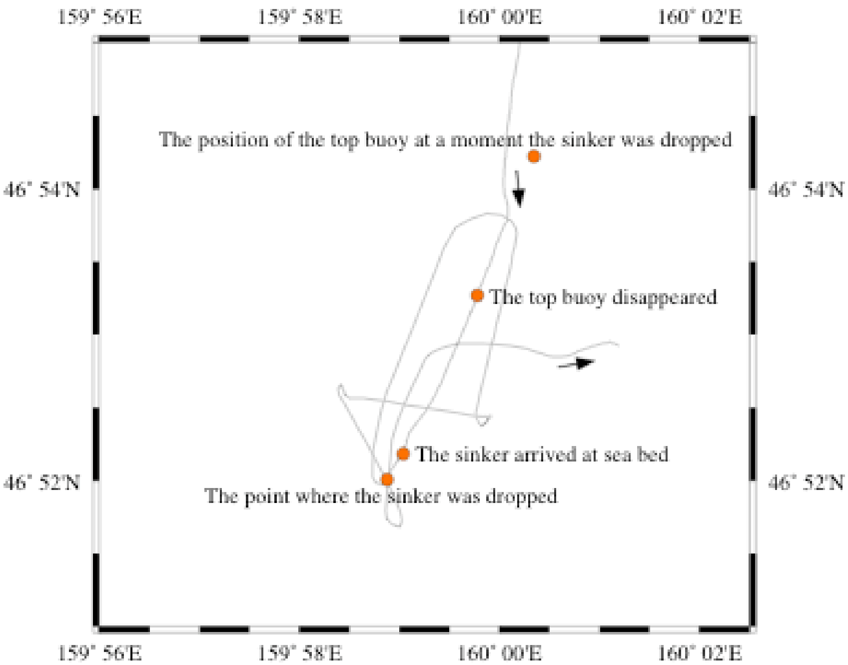


Fig 6.1–8 Mooring point at k2 station

MMP



BGC

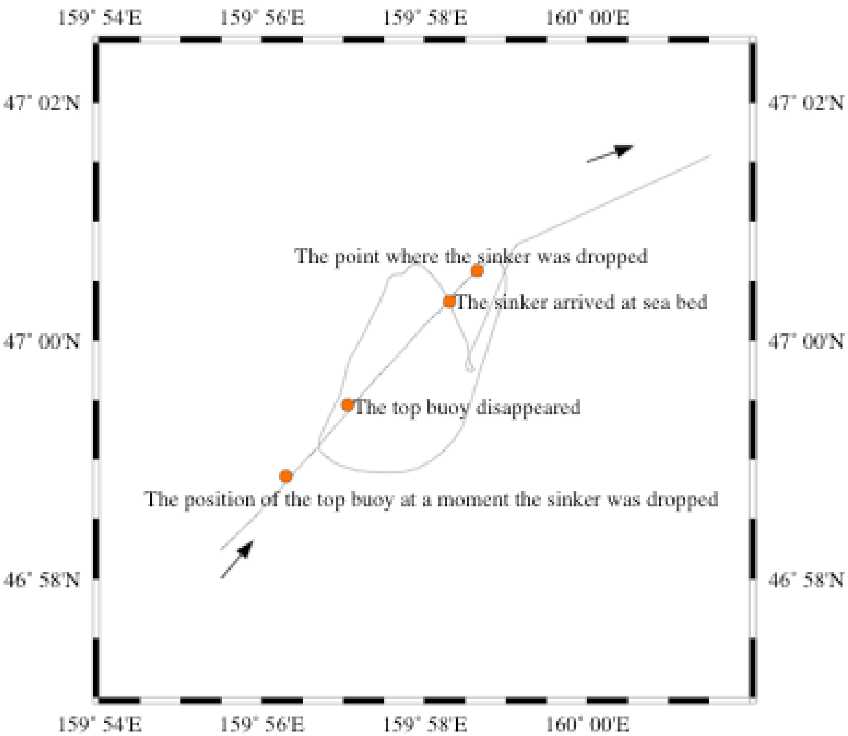


Fig 6.1-9 Ship's track in deployment at k2 station

Table 6.1-1 Navigational data in deployment at k2 station

The above data is the instantaneous value observed every 10 minutes

Table 6.1-2

BGC

time(UTC)	OG(knot)	Course (deg.)	Log(knot)	Heading (deg.)	True Wind direction (Deg.)	True Wind speed(m/s)	Current direction(deg.)	Current Speed(knot)
21:00	0.5	141.0	0.6	129.5	120.0	9.4	34.9	0.2
21:10	0.7	144.4	0.8	130.5	117.0	9.0	30.7	0.2
21:20	1.0	122.8	1.1	124.4	119.0	9.7	72.7	0.1
21:30	0.8	110.9	0.8	124.6	111.0	10.4	35.2	0.2
21:40	1.2	119.6	1.2	119.4	117.0	9.8	29.1	0.1
21:50	1.1	135.0	0.9	124.2	119.0	9.8	63.4	0.2
22:00	0.9	115.5	0.8	132.8	123.0	10.2	60.0	0.1
22:10	1.2	144.4	1.1	132.5	119.0	8.9	95.0	0.2
22:20	1.6	149.1	1.6	134.4	123.0	11.0	111.2	0.2
22:30	1.8	135.0	1.7	128.4	123.0	10.1	100.5	0.2
22:40	1.6	135.7	1.4	128.6	121.0	9.7	118.6	0.1
22:50	1.8	144.4	1.7	132.4	117.0	10.0	114.0	0.2
23:00	1.4	149.5	1.1	132.5	122.0	11.6	85.0	0.1
23:10	1.3	100.3	1.2	122.8	118.0	10.6	83.6	0.2
23:20	1.6	140.4	1.4	129.3	124.0	11.2	135.6	0.2
23:30	1.6	144.9	1.4	132.5	123.0	11.4	112.8	0.2
23:40	1.0	157.0	0.9	133.4	126.0	10.0	168.1	0.1
23:50	0.8	163.4	0.8	132.5	128.0	11.1	242.0	0.1
0:00	0.8	168.1	0.8	133.7	125.0	10.8	214.4	0.1
0:10	1.7	131.2	1.7	128.4	126.0	9.5	230.4	0.0
0:20	1.6	123.2	1.7	125.6	124.0	9.4	276.6	0.0
0:30	2.0	138.6	2.1	132.5	131.0	10.3	225.1	0.1
0:40	2.0	137.8	2.0	132.4	135.0	10.3	4.8	0.0
0:50	1.9	132.8	1.9	130.8	138.0	9.4	151.9	0.1
1:00	1.9	127.3	1.9	130.3	143.0	10.1	95.5	0.1
1:10	2.0	133.8	2.1	134.6	144.0	9.9	146.6	0.1
1:20	1.9	134.5	2.0	135.5	149.0	11.1	126.2	0.0
1:30	1.4	138.7	1.6	137.3	148.0	9.2	214.3	0.1
1:40	1.0	139.2	1.0	132.4	142.0	8.8	348.7	0.1
1:50	1.1	137.0	1.3	132.4	141.0	10.9	216.7	0.0
2:00	1.0	136.9	1.0	132.6	137.0	9.7	251.7	0.1
2:10	8.1	329.2	8.1	330.2	142.0	10.0	318.0	0.4

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

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

(1) Objectives

When a MMP mooring or a BGC mooring is recovered, after separating it from the seabed, it is important to know in what direction it will be adrift by the wind, the current, and the swell, etc. in order to catch it safely, and efficiently. Moreover, it is greatly helpful to grasp actual working hours when performing future work.
It aims at recording results of recovering the mooring systems such as the MMP/BGC from the standpoint of the ship's handling.
In this time, only the recovery of the BGC mooring was done.

(2) Observation parameters

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

(3) Methods

(3.1) Measurement of the actual ship-movement
Measurement of the ship-movement at coming close to the top buoy and the glass ball floats is carried out in a radio navigation device assembled by Sena Co., Ltd. Japan.
(3.2) Measurement of the wind and the current
The wind direction and speed are measured by KOAC-7800 weather data processor and sensors assembled by Koshin Denki.
The current direction and speed are continuously measured by a Doppler sonar installed at the bottom of the ship. The Doppler sonar is assembled by FURUNO Electric Co., Ltd.
(3.3) Measurement of the releaser-movement in the sea
The releaser is operated with an acoustic transducer which is made by Edgeteh Inc. USA.

(4) Maneuver

(4.1) Surfacing of the moorings
(a) The ship is located downwind or downstream on a distance of 200 - 400 meters from the
anchor position of the BGC mooring. The clutches of the CPP are disengaged and

the operation of the Stern thruster and the SEABEAM are suspended except the bow thruster for adjusting the ship's head.

The "Enable" signal is sent from the stern of the ship by the transducer and the signal reception is confirmed. It is demanded to be nearly over the mooed point when the signal reception is difficult. After the reception is confirmed, it is necessary to go away from the moored point by 400, 500 meters because the point where the top buoy surfaces might shift by about 200 meters.

(b) The BGC mooring is released from the seabed by using the acoustic transducer on 11 and 12 kHz at the mooring deck of the ship's stern.

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

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

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

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

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

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

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

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

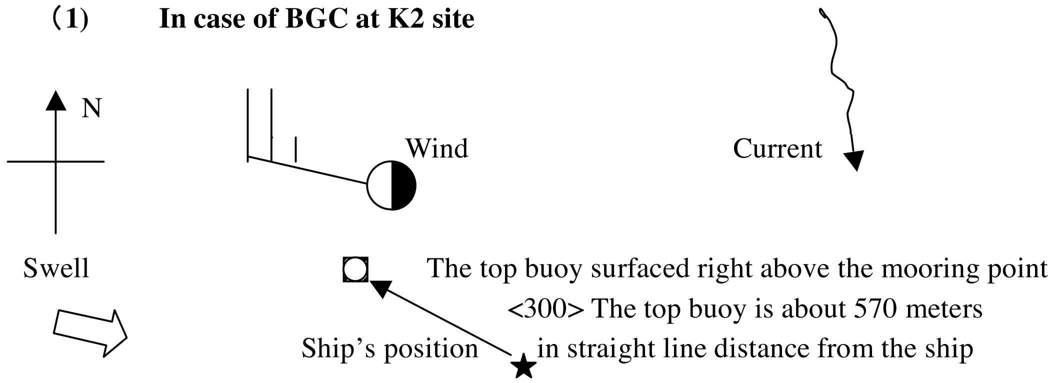
(f) Since the BGC mooring in which a lot of observation equipments and sediment traps are installed, it cannot be strongly towed. The ship's speed is kept about 1 knot or less. When these observation equipments are slung up the ship, Care is needed in handling them not to upset the observation equipment.

(5) Results

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

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

(1) In case of BGC at K2 site



(a) The ship stopped in about 300 meters leeward of the mooring point.

(b) The ship received the wind from the starboard bow, and the operation of devices (CPP, the stern thruster and the SEABEAM) which influence the measurement of the transducer was suspended. Afterwards, the acoustic transducer was lowered over the starboard stern. After the release signal on 11 and 12 kHz was sent, the mooring was separated immediately from the seabed.

(c) The top buoy surfaced in the direction of 300 degrees from the ship at the distance of about 570 meters. The point was right above the mooring point of the buoy without the influence of the current.

(d) After the top buoy had surfaced, the glass floats being connected near the bottom of the mooring surfaced 48 minutes later. The point was in the direction of 300 degrees from the top buoy at the distance of about 430 meters by the influence of the wind and the current.

(5.2) Working hours for recovering the BGC mooring

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

(a) The time consumed in recovery of the BGC mooring was 4 hours and 25 minutes. The working hours of the BGC mooring are long in comparison with the MMP mooring because the BGC mooring is with many instruments such as sediment traps.

(b) Receipt of the release' acoustic response of the BGC mooring was comparatively quick.

(c) Although the operation of the workboat was a severe situation on the weather, the top buoy of the BGC mooring was caught by the workboat from her starboard side because it gave priority to the recovery of various delicate equipments. The working hours from the time when the workboat was lowered to the time when the workboat was hoisted in were 23 minutes.

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

(e) The delay of the recovery time did not happen because it got free easily though the middle of the rope of the BGC mooring was entangled in the floats (2+4+4 glass balls).

(f) Since the bottom floats (52 glass balls) being connected near the end of the BGC mooring was bunching up together, it was recovered in 1 lump.

(6)Data archive

All data will be archived on board.

(7) Remarks

The handling of the BGC mooring with various delicate equipments requires great care when recovering it or when deploying it. In this time, the following suitable means were taken..

+ The top buoy was caught by using **the workboat** instead of the grapnel which is likely to damage equipments.
+ There is a greater risk of damages of equipments when the ship cruises with the tail wind or before the wave. Accordingly **to face the wind and the wave**, the ship was managed.
+ **The towing speed was reduced** as much as possible to prevent giving big resistance to equipments in the water.

Fig.6.2-1 FIGURE OF RECOVERY　B G C

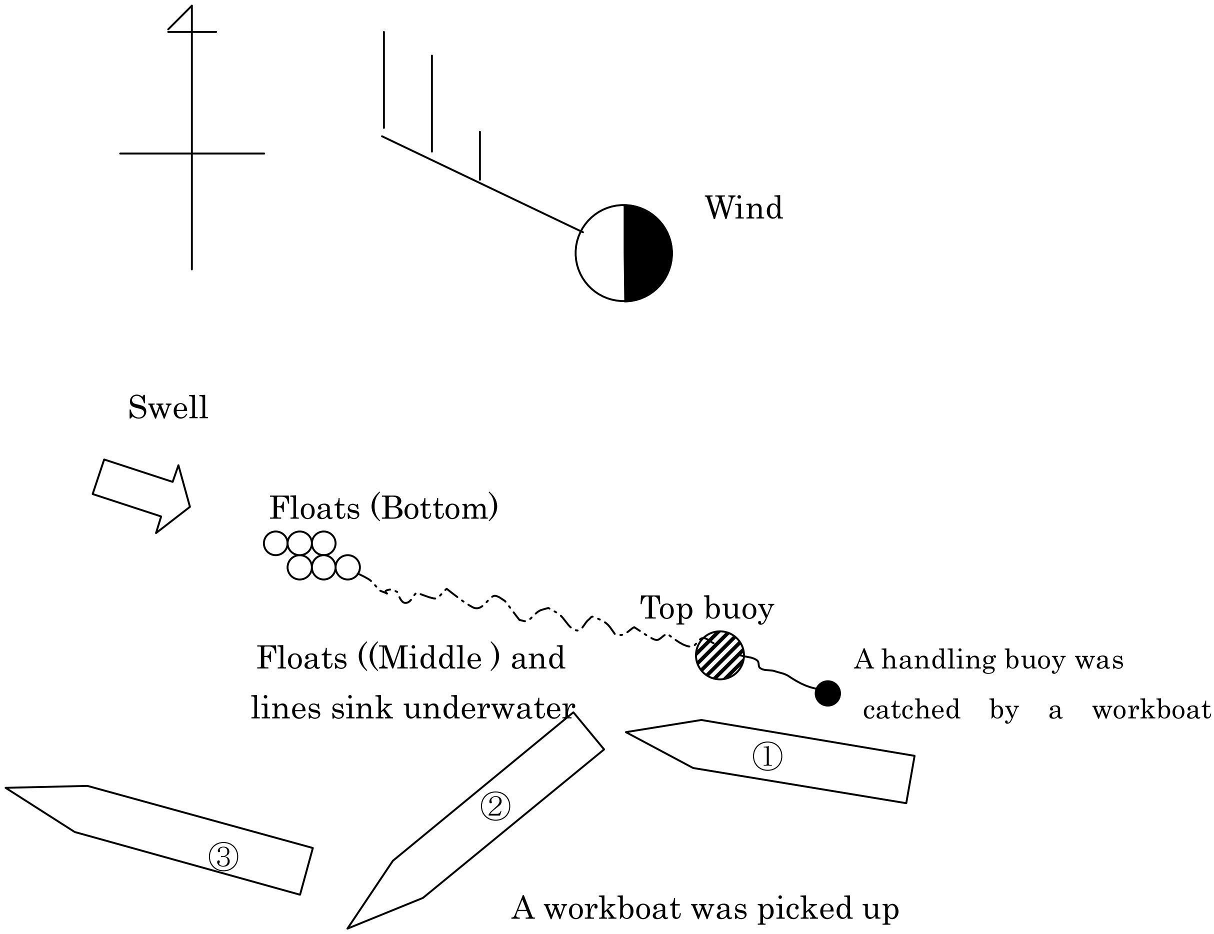
Location: 47-00.468 N, 159-58.057E

Date: 23rd September　2005

Wind: <290> 11.5 m/s, Current: <170> 0.8 knot

Swell: WNW, Wave height: 2.8 m, 6.4 sec

Weather: bc, Depth: 5206.2 m



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7. Sediment core sampling

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Yoko KISHI (Tokai Univ.)
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Yohei TAKETOMO(Marine Works Japan Ltd.)
Ei HATAKEYAMA (Marine Works Japan Ltd.)

7.1 Objective

Objective of sediment coring in this cruise is to investigate paleoceanographic changes in the subarctic Pacific during late Quaternary as follows:
(1) variations in paleo-flux of biogenic components, specially biogenic opal and calcium carbonate, (2) change from coccolithphorids to diatom during deglacation to Holocene, (3) variations in atmospheric input of lithogenic particles originating Asian desert regions and (4) changes in biogeochemical cycles and oceanic environments related to global climate.

7.2 Coring Equipment and General Operation

7.2.1 Piston Core Sampler

7.2.1.1 System

The system is a device that collects sediments from the seafloor. It is composed of the Head of the corer, barrels, piston, catcher, bit, trigger and pilot sampler. The aluminum pipes are used for the barrel, so that measurements of magnetic properties are available. A total of 15~20m-long aluminum pipe is composed of four 5m segments which are combined one another by stainless joint sleeves.

In the outer type piston corer (OUTPC), it uses only in the barrel, but in the inner type piston corer (INTPC), it inserts inner tubes in the barrel and it uses it. In the INPC, it pulls out inner tubes only from the aluminum pipes and the sediment can be collected. The inner tubes filled by sediments are cut with the handy cutter every 1m after taking out from the barrel. The sediment sections are longitudinally cut into working and archive halves by a splitting devise and a stainless wire. After splitting, both cores are putted white pins at interval of 2cm and blue pins at interval of 10cm. The INPC was implemented in the PC-01 and 02.

In the OUTPC, after cutting aluminum pipes to the 1 m length with the ribbon saw, the sediment is extruded into half round PVC lining using the hydraulic piston. It cuts the sediment section that put on another half round PVC lining longitudinal by a stainless wire, and it divides it into working and archive halves. After that, it marks with the white and blue pins in the 2 cm interval as same as the INPC. The OUTPC was implemented in the PC-03.

Moreover, it installed the azimuth inclinometer in the weight of the piston corer as the addition equipment in this cruise. The conduct of the piston corer system in the undersea can be clarified from the data of this equipment.

Specification of the piston corer system is shown below.

Head of the corer Main unit

Weight: 1,200 kg	Materials; Stainless, Lead
Barrel:	Material; Aluminum
Length; 5 m, Inner diameter; 80 mm, Outer diameter; 92 mm	
Inner tube:	Material; Polycarbonate
Length; 5 m, Inner diameter; 74 mm, Outer diameter; 78 mm	

Azimuth inclinometer:

Weight; 9.5 kg (in air), 4.5 kg (in water)
Material; Titanium alloy
Length; 604mm, Diameter; 100 mm
Available depth; 7,000 m
Sensor; Hall device compass, 2 axes inclination sensor and depth sensor
Sampling interval; 0.5 seconds

Pilot (Ashura corer)

Weight: 100 kg
Sampling barrel: Material; Acryl
Number; three pieces
Length; 60 cm, Inner diameter; 74 mm, Outer diameter; 80 mm

7.2.1.2 General Operation

7.2.1.2.1Preparation for the piston coring

After barrels are attached to the Head of the corer, in case of the INPC, it inserts inner tubes in the barrels and it connects the piston and the main wire which is in the barrel tip through the inside of the barrel. The core catcher and the bit are then attached. After moving the piston corer to the investing position, it is lifted with the crane. Poured into the piston corer of it for the case to prevent the rise of the piston by the water pressure. After that, the trigger is connected to the end of the main wire and the clip ring, and the pilot sampler is installed in the trigger.

7.2.1.2.2 Typical winch operation; wire-out and wire-in

Typical winch operation of piston coring in this cruise is to investigate as follows:

1. The trigger halts in the sea surface and a wire length is reset.
2. At first the system is descended at a slow winch speed by a 200 m depth, and the swell-compensator is supplied. Then, the speed is gradually increased to a maximum of 1m/sec.
3. The winch operation is stopped at a depth of 100 m above the bottom for several minutes (3-5 min.) to reduce pendulum motions of the system.
4. After making it stop for several minutes until the system is stabilized, the wire is released out at a speed of 0.2 to 0.3 m/sec. until the sampler reaches the bottom.
5. After confirmation of the reaching the bottom and passing for about 2 seconds, the winch is stopped and is changed into wire-in.
6. The rewinding is started at a slow speed (0.2 to 0.3 m/sec.). After the sampler leaves the bottom, winch speed is gradually increased up to about 1.2 m/sec. The swell-compensator will be stopped if the system reaches a 200 m depth.

7.2.2 Multiple Core Sampler

7.2.2.1 System

Multiple Core Sampler (MC) used in this cruise consists of main body (620 kg weight) and eight acryl pipes (core barrel). Core barrel is 60 cm and 74 mm inside diameter.

7.2.2.2 General Operation

When we start lowering the MC, a speed of wire out is set to be 0.2 m/s., and then gradually increased to be 1.0 m/s. The MC is stopped at a depth about 50 m above the sea floor for 3 minutes to reduce any pendulum motion of the sampler. After the sampler is stabilized, the wire is stored out at a speed of 0.3 m/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 5~10 m 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.

7.3 Sampling location and Site survey

Three piston cores and one multiple core were obtained during this cruise at three stations. The geographic positions were determined by using the global positioning system (GPS) of WGS84. In order to comprehend bathymetric and sub-bottom refection distributions, site survey for coring was carried out also using the 12 kHz SEA BEAM 2100 Multi Narrow Beam Bathymetric Survey System with 4 kHz Sub-bottom Profiler (SeaBeam Instruments, Inc.) in some station. Bathymetric survey map and seismic survey of piston coring stations are shown in Fig.1 and 2.

7.4 Onboard measurements

7.4.1 Multi-Sensor Core Logging (MSCL)

The Gamma-Ray attenuation (GRA), the velocity of P-waves and the amount of magnetically susceptible material present (MS) were measured on whole core section before splitting using the onboard GEOTEK multi-sensor core logger (MSCL). GRA measurement was carried out each 1 or 2 cm of whole core. Gamma-ray (at 662 keV) emitted from ^{137}Cs source was counted for 10 seconds using NaI scintillation counter to estimate bulk density of the sediment. The calibration was achieved by using the piece that mounted the telescoping aluminum rod, which consists of six kinds of thicknesses in the central part of the core liner that filled with distilled water. GRA data provide the wet bulk density and the fractional porosity for core thickness.

A short P-waves are produced at the transmitter. The length and repetition rate of this pulse can be adjusted to suit the type of the transducer elements supplied. This pulse propagates through the core and is detected by the receiver. Pulse timing circuitry is used to measure the travel time of the pulse with a resolution of 50 ns. The distance traveled is measured as the outside core diameter with an accuracy of 0.1 mm. After suitable calibration procedures have been followed the P-wave velocity can be calculated with a resolution of about 1.5 ms^{-1}. The accuracy of the measurements will largely depend on any variations in liner wall thickness. However, experience has shown that an absolute accuracy of ± 3 ms^{-1} is normally achievable with some care. The acoustic impedance is the product of the corrected P-wave velocity and the wet bulk density. The PC-03 (OUTPC) didn't measure the P-wave velocity because appropriate value wasn't gotten.

MS was measured using Bartington MS2C system within the MSCL. The main unit is the widely used, versatile MS2 susceptibility meter. The unit has a measuring range of 1×10^{-5} to 9999×10^{-5} (SI, volume specific). The loop sensor has an internal diameter of 100mm. It operates at a frequency of 0.565 kHz and an alternating field (AF) intensity of 80 A/m (= 0.1 mT). MS data measurement was also carried on every 1 or 2 cm whole core with 1 second.

7.4.2 Core Color

Core color reflectance was measured by using the Minolta CM-2002 reflectance photospectrometer using 400 to 700 nm in wavelengths. This is a compact and hand-held instrument, and can measure spectral reflectance of sediment surface with a scope of 8 mm diameter. To ensure accuracy, the CM-2002 was used with a double-beam feedback system, monitoring the illumination on the specimen at the time of measurement and automatically compensating for any changes in the intensity or spectral distribution of the light.

Calibration was carried out using the zero and white calibration piece (Minolta CM-2002 standard accessories) 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.

The core color reflectance data was indicated as second CIE (Commission International d'Eclairage) 1976 color space in terms of L*, a* and b* values. The color reflectance data are indicated by color parameters of L*, a*, b* (L*: black and white, a*: red and green, b*: yellow and blue). L* value indicates lightness and corresponds to black (L*=0) and white (L*=100). a* and b* are chromaticity. The plus values correspond to reddish, the minus one to greenish. For b* value, the plus values correspond to yellowish, the minus one to bluish. Spectral data can be used to estimate the abundance of certain components of sediments.

The core color reflectance was measured PC-1, PC-2, PC-3, PL-1 HAND1, PL-2 HAND2, PL-3 HAND1, PL-3 HAND3, MC-1 HAND2 and MC-2 HAND2.

7.4.3 Soft X-ray photographs analysis system

Soft X-ray photographs analysis system (Soft X), PRO-TEST 150 (SOFTEX), was used to observe the structures of sediment samples. This system consists of two units (control unit and cabinet unit). The control unit is operated to adjust the voltages and the currents and samples are put in the cabinet unit. Sediment samples were picked up from cores using original plastic cases (200 x 30 x 7 mm). X-ray photographs of the samples through the cases were in the situation of standard power (50 kVp, 3 mA, in 200 seconds).

In this cruise, total 217 samples were photographed in 90 negative-films. The developer is equipped on this ship and photographed films were developed on board. FIP-1400 was used as development device.

7.5 Future work

The working halves of the core were continuously sub-samples for analysis in Tokai University. After sampling, the samples are going to be stored in the cold storage (4 °C) and will be transferred and the following measurements will be performed in Tokai University:

1. Biogenic opal, calcium carbonate and organic carbon, nitrogen and its isotopes.
2. Trace elements in opal, carbonate and bulk sediment.
3. AMS ^{14}C and stable isotopes of foraminifera.

The archive materials were placed into polyethylene bags, then tightly sealed and transferred to cold storage (4 °C) aboard R/V Mirai. These materials are going to be stored in the cold storage (4 °C) in JAMSTEC after the cruise.

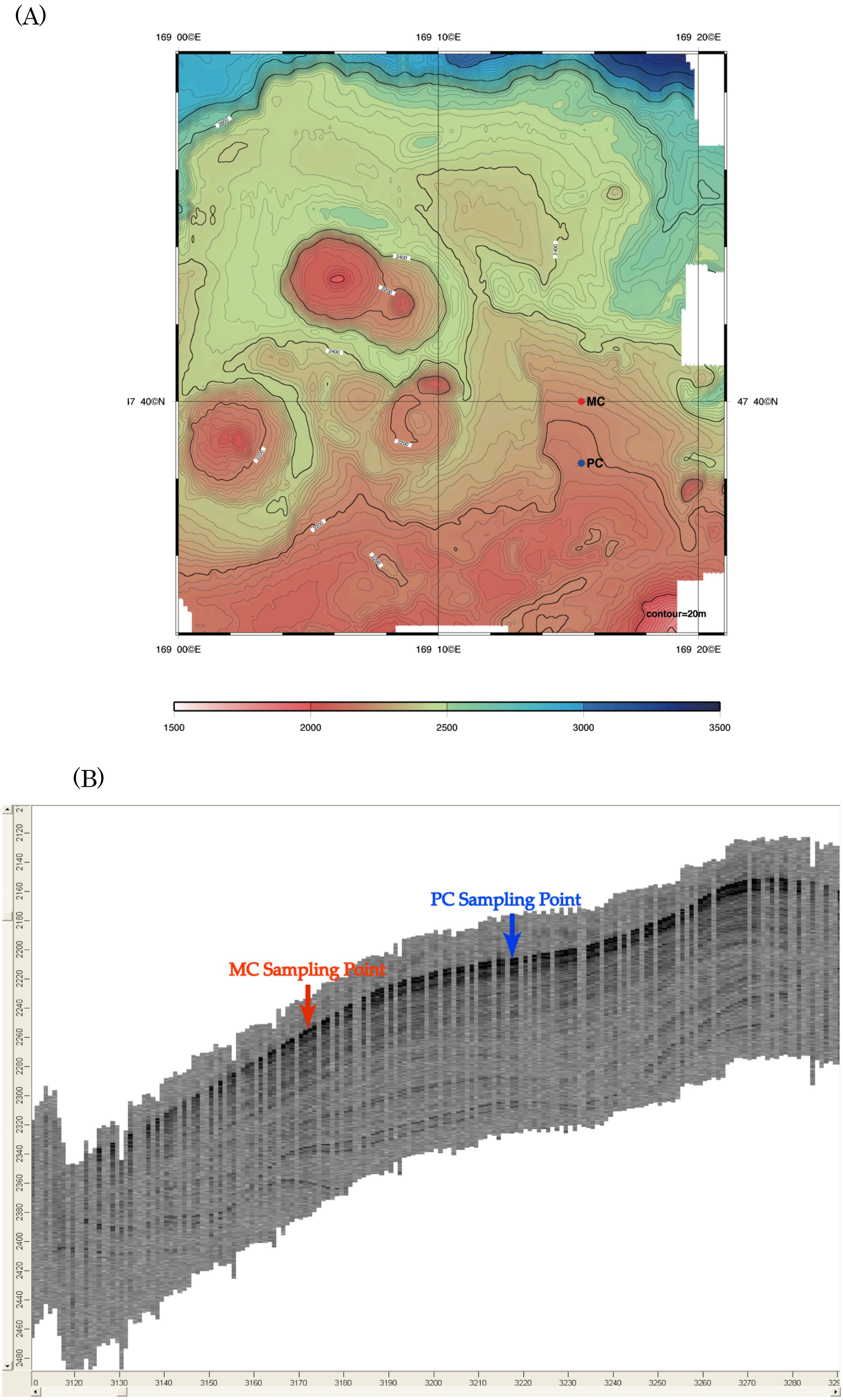
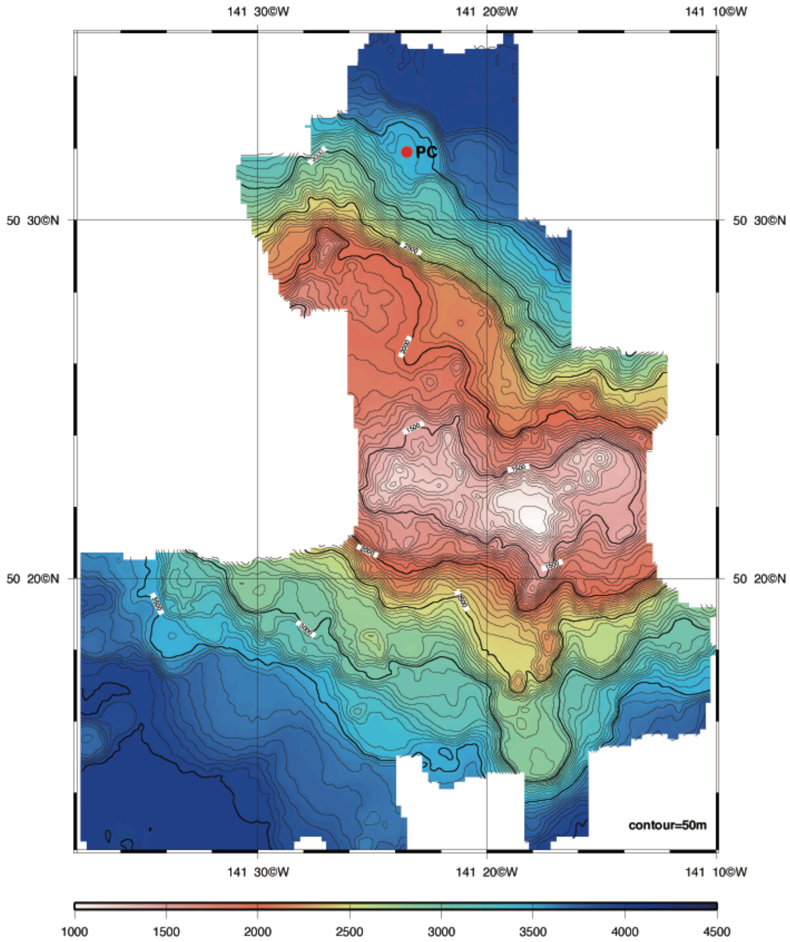


Fig. 1 SeaBeam Map (A) and sub-bottom profile (B) at EW1 (PC1, PC2 and MC1) at the New Emperor Seamounts, located in WSG of the NW Pacific..

(A)



(B)

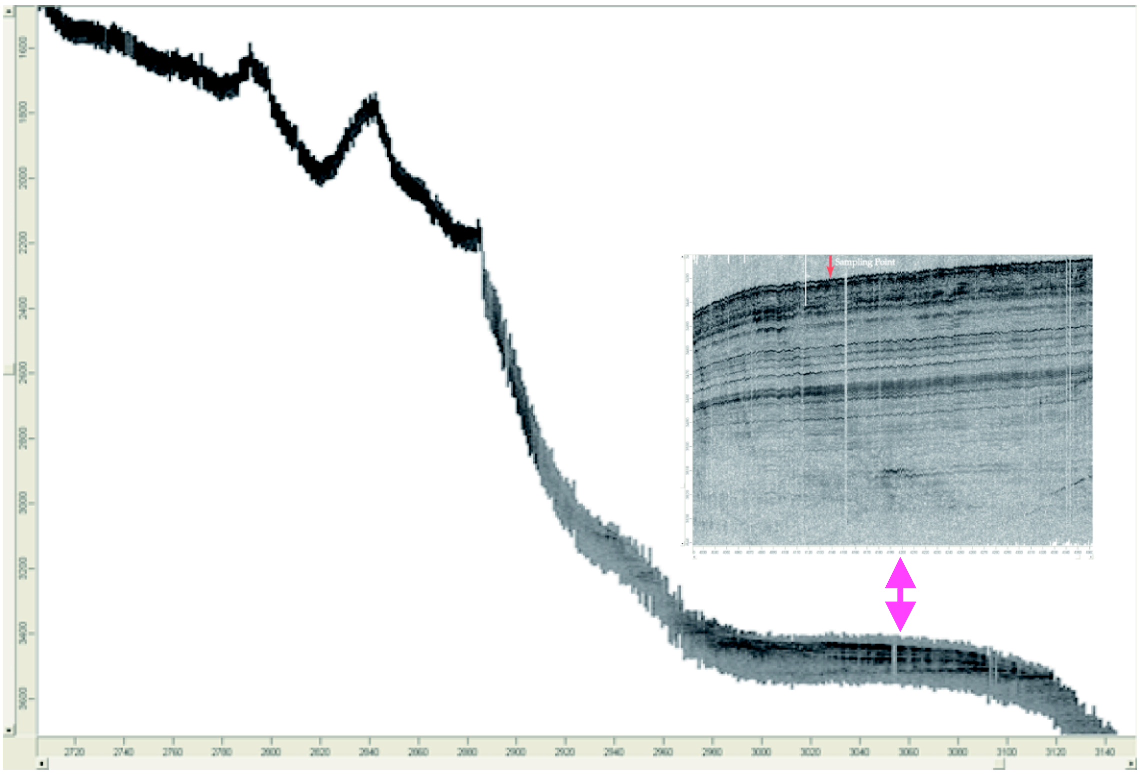


Fig. 2 SeaBeam Map (A) and sub-bottom profile (B) at EW10 (PC3) at the Scott Seamount, located in the Alaskan Gyre of the NE Pacific.