# MR04-06

# (14 Oct. 2004 - 9 Nov. 2004) Prelímínary Cruíse Report



Nov. 2004 JAMSTEC

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Cover: R/V Mirai approaching to the Crowley dock in Dutch Harbor to pick us up on 12 October, 2004. (Courtesy of F. Kobayashi (MWJ))

# 1. Outline of MR04-02 1.1 Cruise summary

# Makio HONDA (JAMSTEC MIO)

R/V Mirai left Dutch Harbor on 14 October 2004. Soon after leaving, we met rough sea and, as same as previous cruise in the northwestern North Pacific in autumn or winter, we could not help changing schedule very often all over the cruise. Especially several typhoons attacked Japan also affected our cruise. One participant was seasick in bed and could not leave his bed and eat anything for a few days (but he is still alive).

# (Station K-1)

On 18 October, we arrived at the first station, K-1 (51N / 165E). During the stay, we conducted measurement of under water light condition by "free fall", CTD / hydrocasting for routine and trace metal, and in situ pumping. In the early morning on 19 October, just before sunrise, we collected water sample for measurement of primary productivity and started simulated *in situ* incubation.

# (Station K-2: 47N / 160E)

At station K-2 (20 October), free fall, CTD / hydrocasting, *in situ* pumping and simulated *in situ* incubation were conducted. Although we intended to stay here for 24 hours for incubation, the sea condition did not permit us to do so.

# (Station 35N: 35N / 160E)

Because of bad weather and sea condition, we passed through stations K-2.5 and K-3, and arrived at station 35N (35N / 160E) on 23 October. Because of the high wave height, observation started from the next morning. Free fall, CTD / hydrocasting and simulated *in situ* incubation for primary productivity. However the *in situ* pumping was suspended because of worse sea condition.

# (Station K-3: 39N / 160E)

We were back to station K-3 on 26 October. Although sea condition was not good, we could conduct free fall, hydrocasting and simulated *in situ* incubation. On 27 October, after conducting *in situ* pumping for French colleague, we left this station for station K-2.5.

# (Station K-2.5: 43N / 160E)

Because of rough sea condition and as we were behind schedule, we passed through station K-2.5 on 28 October. However surface monitoring such as  $pCO_2$  and SST / salinity was conducted twice during this cruise.

# (Station KNOT: 44N / 155E)

On 29 October, we arrived station KNOT that is the former Japanese time-series station for biogeochemistry. We conducted all items planned (free fall, hydrocasting, simulated *in situ* incubation, *in situ* pumping).

(Station S7)

The last three stations were devoted to sea-floor sediment coring.

On 1 November, we arrived at station S1. This station was about two hours off Tomakomai, Hokkaido. Midnight "sea beam" and "sub bottom profiler" survey clarified topography and geography around station S1. Water depth was approximately 700 m. Multiple corer and 20 m piston corer were deployed. Piston corer successfully collected approximately 17 m long sea floor sediment.

### (Station S8)

After two days waiting, we conducted multiple and piston coring at station S2 near station K1. Although piston core was bent, 13 m long sea floor sediment was collected.

#### (Station S9)

This area was located in the area where live-fire training was conducted by self-defense forces and we could conduct sea floor sediment coring on only Sunday. However we got permission to do coring on Saturday morning thanks to negotiation by captain Akamine. On 6 November, we conducted multiple and piston coring at station S9. Water depth was approximately 1700 m. Although piston core was bent again, we successfully collected 12 m long sea floor sediment that is suspected to cover the last thirty thousands years including the last glacial maximum (LGM).

Beside the above observation, along the cruise track, underway  $pCO_2$  monitoring and SST / salinity / chlorophyll monitoring were conducted. In addition, suspended particles were also collected each 1 degree.

In addition, during this cruise, "MIRAI seminar" was held and three speakers (Honda, Ahagon and Ohkushi) gave a talk on their scientific interests and purpose of this cruise. In addition, BBQ party was held on deck two days before arrival of Hachinohe port and we enjoyed eating and cerebrating a couple of newly-weds (Mr. And Mrs. Moro from MWJ).

Team of marine technicians from Marine Works Japan (MWJ) and Global Ocean Development (GODI) were younger comparing with other cruise. However their preparation and operation of scientific gears such as water sampling system and sediment core were exact and enabled us to collect valuable materials for science. We acknowledge captain Akamine, chief officer Sakota, chief engineer Higashi and MIRAI ship crew for their enthusiastic work from early morning to midnight.

1.2 Track and log 1.2.1 Cruise Track





# 1.2.2 Piston and Multiple Coring Stations

U.	T.C.	S.M.T.		Pos	ition	Evente
Date	Time	Date	Time	Lat.	Lon.	Events
10/14	17:00	10/14	09:00	53-51.13N	166-34.37W	Departure of Dutch Harbor
10/15	08:00	10/15	00:00	-	-	Time adjustment (-2 hours)
10/16	08:00	10/15	22:00	-	-	Time adjustment (-2 hours)
10/17	10:00	10/16	22:00	-	-	Time adjustment (+23 hours)
10/18	00:24 00:38 01:12 05:08 08:33	10/18	11:24 11:38 12:12 16:08 19:33	51-00N 51-00.13N 50-59.78N 50-59.76N 51-01.38N	165-00E 164-59.73E 164-58.81E 164-57.79E 164-54.47E	Arrival at Station K1 Underwater optical measurement (Free fall) #01 CTD-01 cast (4,785m) In situ pumping (LVP) #01 (200m, 2 hours) CTD-02 cast (300m)
10/18	18:01 18:42	10/19	05:01 05:42	50-59.96N -	164-59.51E -	CTD-03 cast (58m) Departure of Station K1
10/19	21:30 21:49	10/20	08:30 08:49	47-00N 46-59.87N	160-00E 160-00.60E	Arrival at Station K2 CTD-04 cast
10/20	00:37 01:48 02:12 04:30 08:12	10/20	11:37 12:48 13:12 15:30 19:12	47-00.30N 46-59.57N 46-59.50N 46-59.10N	159-59.56E 160-00.04E 159-59.85E 159-59.54E	CTD-05 cast (1500m) Free fall #02 LVP #02 (200m, 1 hour) CTD-06 cast (5194m) Departure of Station K2
10/20	20:48 20:58 21:42	10/21	04:48 04:58 05:42	44-30N 44-29.91N -	160-00E 160-00.19E -	Arrival at Station K2.5 CTD-07 cast (51m) Departure of Station K2.5
10/23	00:30 00:49 02:18	10/23	11:30 11:49 13:18	35-00N 35-00.48N 35-01.22N	160-00E 159-59.95E 159-58.08E	Arrival at Station 35N Free fall #03 Calibration for magnetometer #1
10/23	18:00 18:55	10/24	05:00 05:55	35-00.03N 35-00.34N	159-59.51E 159-58.43E	CTD-08 cast (80m) CTD-09 cast (4526m)
10/24	03:12	10/24	14:12	-	-	Departure of Station 35N
10/25	00:30	10/25	11:30	38-00N	160-00E	Arrival at Station K3
10/25	21:00 21:53	10/26	08:00 08:53	38-59.89N 38-59.10N	160-00.47E 160-01.63E	CTD-10 cast (300m) LVP #03 (200m, 1 hour)
10/26	00:05 00:37 09:06	10/26	11:05 11:37 20:06	38-58.49N 38-58.10N 38-59.85N	160-00.92E 160-01.34E 160-00.48E	Free fall #04 CTD-11 cast (80m) CTD-12 cast (5500m)

U.	T.C.	S.I	M.T.	Γ. Position Ever		Events
Date	Time	Date	Time	Lat.	Lon.	EVOID
10/26	19:43	10/27	06:43	38-59.73N	160-00.40E	LVP #04 (200m, 5 hours)
10/27	00:30	10/27	11:30	-	-	Departure of Station K3
10/27	18:42	10/28	05:42	44-30N	160-00E	Pass through Station K2.5
10/28	01:27	10/28	12:27	43-16.86N	158-37.81E	Free fall #05
10/28	17:48 18:03 19:07	10/29	04:48 05:03 06:07	44-00N 44-00.17N 43-59.58N	155-00E 155-00.24E 155-00.05E	Arrival at Station KNOT CTD-13 cast (60m) CTD-14 cast (5283m)
10/29	00:33 02:25	10/29	11:33 13:25	44-00.42N 43-59.63N	155-00.55E 155.01.33E	CTD-15 cast (300m) LVP #05 (200m, 2 hours)
10/29	20:00	10/30	07:00	-	-	Departure of Station KNOT
10/30	11:00	10/30	22:00	-	-	Time adjustment (+1 hour)
10/31	12:00	10/31	22:00	-	-	Time adjustment (+1 hour)
10/31	16:00	11/1	01:00	42-08N	141-42E	Arrival on Survey area about Station 7 and 8
	23:29		08:29	- 42-08.64N	- 141-41.90E	Multiple Corer penatrate #1 (Station 7, 778m)
11/1	01:17 02:50	11/1	10:17 11:50	42-08.43N -	141-41.93E -	Piston Corer penatrate #1 (Station 7, 779m) Site Survey #2 (6 hours)
11/1	20:18	11/2	05:18	-	-	Departure of Station 7 and 8
11/2	22:00 23:35	11/3	07:00 08:35	41-00N -	143-00E -	Arrival on Survey area about Station 9 Site Survey #3 (15 hours)
11/3	14:00	11/3	23:00	-	-	Departure of Station 9
11/3	22:30 23:21	11/4	07:30 08:21	42-14.73N 42-11.84N	141-37.40E 141-36.99E	Arrival at Station 8 Multiple Corer penatrate #2 (604m)
11/4	01:08	11/4	10:08	42-14.72N	141-37.02E	Piston Corer penatrate #2 (606m)
11/5	02:07 02:36	11/5	11:07 11:36	42-05-89N -	142-01.40E -	Calibration for magnetometer #2 Departure of Station 8
11/5	10:00	11/5	19:00	41-03.29N	142-41.33E	Arrival at Station 9
11/5	23:02	11/6	08:02	41-03.15N	142-41.14E	Piston Corer penatrate #3 (1723m)
11/6	01:29 02:00	11/6	10:29 11:00	41-03.10N -	142-41.17E -	Multiple Corer penatrate #3 (1726m) Departure of Station 9
11/8	00:00 04:00	11/8	09:00 13:00	41-20N -	141-15E -	Arrival at Hachinohe Departure of Hachinohe
11/9	00:00	11/9	09:00	33-56N	130-56E	Arrival at Sekinehama

# 1.3 List of participants

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# 2. General observation

2.1 Meteorological observations (GODI) Makio HONDA (JAMSTEC) Principal Investigator Wataru TOKUNAGA (Global Ocean Development Inc.) Ryo KIMURA (GODI) Not on-board Kunio YONEYAMA (JAMSTEC) R. Michael REYNOLDS (Brookhaven National Laboratory, USA)

#### (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 MR04-06 cruise from the departure of Dutch Harbor on 14 October 2004 to arrival of Sekinehama on 9 November 2004.

At this cruise, we used two systems for the surface meteorological observation.

#### 1. MIRAI Surface Meteorological observation system (SMet)

Instruments of MIRAI Surface Meteorological system (SMet) are listed in Table 2.1-1 and measured parameters are listed in Table 2.1-2. Data was collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set has 6-second averaged and 10-minute averaged.

2. Shipboard Oceanographic and Atmospheric Radiation System (SOAR)

SOAR system designed by BNL consists of major 3 parts.

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

SCS recorded PRP data every 6 seconds, Zeno/met data every 10 seconds. Instruments and their locations are listed in Table 2.1-3 and measured parameters are listed in Table 2.1-4.

(3) Preliminary results

Figures 2.1-1 and 2 show the time series of the following parameters;

Wind (SOAR), air temperature (SOAR), sea surface temperature (EPCS and SMet), relative humidity (SMet), precipitation (SMet), short/long wave radiation (SOAR), pressure (SOAR) and hourly significant wave height (SMet).

(4) 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.

# (5) Remarks

- 1. Radiometers for the upwelling radiation measurement of SMet system were not installed during this cruise.
- 2. We used SST data as follows;

EPCS 15 October, 1902 UTC to 1 November, 0818 UTC

- SMet 1 November, 0819 UTC to 7 November, 0000 UTC
- 3. PRP data were not recorded between 0106 UTC and 0212 UTC, 8 November for sensors maintenance.
- 4. Position data was not collected as following periods (UTC);

10/21/2004 16:38:42 - 16:39:28, 16:40:08 - 16:40:44 10/26/2004 00:07:49 - 00:07:55, 12:12:37 - 12:12:43 10/28/2004 20:38:49 - 20:38:55, 21:09:02 - 21:09:08, 10:31:23 - 10:31:33 10/29/2004 18:10:34 - 18:10:40, 10/29/2004, 18:11:20 - 18:11:26 11/4/2004 01:01:15 - 01:01:31, 01:07:35 - 01:07:51, 10:07:00 - 10:07:06, 10:07:19 - 00:07:51, 14:35:39 - 14:36:37, 14:36:45 - 14:36:53 11/4/2004 18:33:59 - 18:34:05, 18:36:17 - 18:36:23, 18:36:59 - 18:37:05, 19:28:09 - 19:28:15, 19:33:59 - 19:34:05, 19:34:23 - 19:34:31, 19:58:48 - 19:58:56, 22:25:06 - 22:25:12, 22:55:21 - 22:55:27, 22:56:59 - 22:57:05, 22:57:21 - 22:57:27, 23:11:43 - 23:11:49, 23:23:44 - 23:23:50, 23:26:34 - 23:26:40, 23:27:06 - 23:27:12, 23:27:24 - 23:27:30 11/5/2004 00:21:06 - 00:21:12, 00:23:36 - 00:23:42, 00:29:49 - 00:29:55, 21:56:07 - 21:56:13 11/6/2004 10:27:17 - 10:27:23, 13:08:56 - 13:09:02 11/7/2004 23:51:33 - 23:51:39, 23:52:17 - 23:52:23, 23:52:49 - 23:52:55, 23:53:07 - 23:53:13, 23:53:23 - 23:53:31

Sensors		Туре	Manufacturer	Location (altitude from			
				surface)			
Anemometer		KE-500	Koshin Denki, Japan	foremast (24m)			
Thermometer	(water)	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m),			
				SST			
	(air & RH)	HMP45A	Vaisala, Finland	compass deck (21m)			
			with 43408 Gill aspirated shield (R.M. You				
Barometer		F-451	Yokogawa, Japan	weather observation room,			
				captain deck (13m)			
Rain gauge		50202	R.M. Young, USA	compass deck (19m)			
Optical Rain g	auge	ORG-115DR	Osi, USA	compass deck (19m)			
Radiometer	(short wave)	MS-801	Eiko Seiki, Japan	radar mast (28m)			
	(long wave)	MS-202	Eiko Seiki, Japan	radar mast (28m)			
Wave height m	neter (baw)	MW-2	Tsurumi-seiki, Japan	bow (10m)			
	(aft)	MW-2	Tsurumi-seiki, Japan	port quarter (8m)			

# Table 2.1-1 Instruments and installation locations of MIRAI SMet system

Table 2.1-2 Falameters of WIIKAI Swiet system
Table 2.1-2 Farameters of with AT Swiet system

No.	Parameter	Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Ship's speed	knot	MIRAI Log, DS-30 Furuno, Japan
4	Ship's heading	degree	MIRAI Gyro, TG-6000 tokimec, Japan
5	Relative wind speed	m/s	6 sec. / 10 min averaged
6	Relative wind direction	degree	6 sec. / 10 min averaged
7	True wind speed	m/s	6 sec. / 10 min averaged
8	True wind direction	degree	6 sec. / 10 min averaged
9	Barometer pressure	hPa	adjusted to the sea surface level
			6 sec. / 10 min averaged
10	Air temperature (starboard)	degC	6 sec. / 10 min averaged
11	Air temperature (portside)	degC	6 sec. / 10 min averaged
12	Dewpoint tempereature (starboard)	degC	6 sec. / 10 min averaged
13	Dewpoint tempereature (portside)	degC	6 sec. / 10 min averaged
14	Relative humidity (starboard)	%	6 sec. / 10 min averaged
15	Relative humidity (portside)	%	6 sec. / 10 min averaged
16	Sea surface temperature	degC	6 sec. / 10 min averaged
17	Rainrate (optical rain gauge)	mm/hr	hourly accumulation
18	Rainrate (capacitive rain gauge)	mm/hr	hourly accumulation
19	Downwelling shortwave radiation	W/m^2	6 sec. / 10 min averaged
20	Downwelling longwave radiation	W/m^2	6 sec. / 10 min 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

Sensors	Туре	Manufacturer	Location (altitude		from
			basenne)		
Zeno/Met					
Anemometer	5106	R.M. Young, USA	foremast (25 r	m)	
Air temperature / RH	HMP45A	Vaisala, USA	foremast (24 r	m)	
		with 43408	Gill aspirated s	hield (R.M.	Young)
Barometer	61201	R.M. Young, USA	foremast (24 r	m)	
		with 6	51002 Gill press	ure (R.M.	Young)
Rain gauge	50202	R.M. Young, USA	foremast (24 r	m)	
Optical rain gauge	ORG-815DA	Osi, USA	foremast (24 r	m)	
PRP					
Radiometer (shortwave)	PSP	Eppley labs, USA	foremast (25 r	m)	
Radiometer (longwave)	PIR	Eppley labs, USA			
Fast rotating shadowband ra	diometer	Yankee, USA			

# Table 2.1-3 Instrument installation locations of SOAR system

# Table 2.1-4 Parameters of SOAR system

No.	Parameter	Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Speed over ground	knot	
4	Course over ground	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	reset at 50 mm
11	Precipitation (capacitive rain	mm	
	gauge)		
12	Down welling shortwave	W/m^2	
	radiometer		
13	Down welling infra-red radiometer	W/m^2	
14	Defuse irradiation	W/m^2	





Fig.2.1-1 (continued)



Fig.2.1-1 (continued)



Fig.2.1-1 (continued)







# 2.2 Physical oceanographic observation2.2.1 CTD casts and water sampling

# Fujio KOBAYASHI (MWJ) Naoko TAKAHASHI (MWJ): Operation Leader Keisuke MATSUMOTO (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 3plus, S/N 032453 Part No.90953.1 (primary)

SBE, Inc., SBE 3-04/F, S/N 031525 (secondary)

Conductivity sensor:

SBE, Inc., SBE 4-04/0, S/N 041203 (primary)

SBE, Inc., SBE 4-02/0, S/N 041088 (secondary)

## Pump:

SBE, Inc., SBE 5T, S/N 053118 3K Part No.90160 (primary)

SBE, Inc., SBE 5T, S/N 050984 3K (secondary)

# 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 3221746-0278

#### Fluorometer:

Seapoint sensors, Inc., S/N 2579

Transmissometer:

Wetlabs, Inc., S/N 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

#### (2)-3 Pre-cruise calibrations

#### (2)-3-1 Pressure

The Paroscientific series 4000 Digiquartz high pressure transducer (Paroscientific, Inc., USA) uses a quartz crystal resonator whose frequency of oscillation varies with pressure induced stress with 0.01 per million of resolution over the absolute pressure range of 0 to 15,000 psia (0 to 10,332 dbar). Also, a quartz crystal temperature signal is used to compensate for a wide range of temperature changes at the time of an observation. The pressure sensor (MODEL 415K-187) has a nominal accuracy of 0.015 % FS (1.5 dbar), typical stability of

0.0015 % FS/month (0.15 dbar/month) and resolution of 0.001 % FS (0.1 dbar).

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in the SEASOFT:

S/N 79492 25-May-04

c1 = -6.570680+004 c2 = -1.758329e-001 c3 = 2.042500e-002 d1 = 2.714600e-002 d2 = 0 t1 = 2.992375e+001 t2 = -2.638690e-004 t3 = 3.921320e-006 t4 = 1.359470e-009t5 = 4.497040e-012

Pressure coefficients are first formulated into

 $c = c1 + c2 * U + c3 * U^{2}$ d = d1 + d2 \* U $t0 = t1 + t2 * U + t3 * U^{2} + t4 * U^{3} + t5 * U^{4}$ 

where U is temperature in degrees Celsius. The pressure temperature, U, is determined according to

U (degC) = M \* (12 bit pressure temperature compensation word) – B

The following coefficients were used in SEASOFT:

M = 1.28490e-002

B = -8.38803e + 000

(in the underwater unit system configuration sheet dated on May 24, 1994)

Finally, pressure is computed as

 $P(psi) = c * [1 - (t0^2 / t^2)] * \{1 - d * [1 - (t0^2 / t^2)]\}$ 

Where t is pressure period (microsec). Since the pressure sensor measures the absolute value, it inherently includes atmospheric pressure (about 14.7 psi). SEASOFT subtracts 14.7 psi from computed pressure above automatically.

Pressure sensor calibrations against a dead-weight piston gauge are performed at Marine Works Japan Ltd. in Yokosuka, Kanagawa, JAPAN, usually once in a year in order to monitor sensor time drift and linearity. The pressure sensor drift is known to be primarily an offset drift at all

pressures rather than a change of span slope. (Show Figure 2-3-1-1, 2) The pressure sensor hysterisis is typically 0.2 dbar. The following coefficients for the sensor drift correction were also used in SEASOFT through the software module SEACON:

S/N 79492 30-July-04 slope = 0.9999004 offset = 0.9452709

The drift-corrected pressure is computed as

Drift-corrected pressure (dbar) = slope \* (computed pressure in dbar) + offset

Figure 2-3-1-1 (upper): The residual pressures between the Dead Weight Tester and the CTD.

Figure 2-3-1-2 (lower): Drift (offset) of the pressure sensor measured by the Dead Weight Tester.

#### (2)-3-2 Temperature

The sensing element of temperature is a glass-coated thermistor bead in a thinstainless steel tube, providing a pressure-free measurement at depths up to 10,500 m (S/N 032453). The sensor output frequency ranges from approximately 3 to 6 kHz corresponding to temperature from -5 to 35 degC. The output frequency is inversely proportional to the square root of the thermistor resistance, which controls the output of a patented Wine Bridge circuit. The thermistor resistance is exponentially related to temperature. Main specifications of "SBE3 plus" are, the initial accuracy is  $\pm 0.001$  degC, the typical stability is 0.0002 degC/year, and the resolution is 0.0003 degC at 24 samples per second.

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA (Figure2-3-2-1).

The following coefficients were used in SEASOFT:

S/N 032453 23 April, 2004

g = 4.38138743e-03

h = 6.53348972e-04

i = 2.46291106e-05

j = 2.17414618e-06

f0 = 1000.000

Temperature (ITS-90) is computed according to

Temperature (ITS-90) =

 $1 \ / \ \{g + h \ * \ [\ln(f0 \ / \ f)] + i \ * \ [\ln^2(f0 \ / \ f)] + j \ * \ [\ln^3(f0 \ / \ f)] \} - 273.15 \ (\ \ c \ )$ 

Where f is the instrument frequency (kHz).



Figure 2.2.1.1: Residual temperature between bath and instrument temperatures.

#### (2)-3-3 Conductivity (SBE 4)

The sensing element of conductivity is a cylindrical flow-through borosilicate glass cell with three platinum electrodes to provide in-situ measurements at depths up to 10,500 meters. The impedance between the center and the en A d electrodes is determined by the cell geometry and the specific conductance of the fluid within the cell. The conductivity cell composes a Wien Bridge circuit with other electric elements of which frequency output is approximately 3 to 12 kHz corresponding to conductivity of the fluid of 0 to 7 Simens/meter. Specifications of "SBE 4" are, serial accuracy 0.0003 S/m, typical stability is 0.0003 S/m/month, and resolution is 0.00004 S/m at 24 samples per second.

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in SEASOFT:

S/N 041203 30April, 2004 g = -4.05242086 h = 4.93532786e-01 i = 7.26654890e-05 j = 2.32093798e-05CPcor = -9.57e-08 (nominal) CTcor = 3.25e-06 (nominal) Conductivity of a fluid in the cell is expressed as:

 $C (S/m) = (g + h * f^{2} + i * f^{3} + j * f^{4}) / [10 (1 + CTcor * t + CPcor * p)]$ 

Where f is the instrument frequency (kHz), t is the water temperature (degC) and p is the water pressure (dbar). The value of conductivity at salinity of 35, temperature of 15 degC (IPTS-68) and pressure of 0 dbar is 4.2914 S/m.

#### (2)-3-4 Oxygen (SBE 43)

The sensing element of SBE 43 is a Clark polarographic membrane to provide in-situ measurements at depths up to 7,000 meters. Calibration stability is improved by an order of magnitude and pressure hysterisis is largely eliminated in the upper ocean (1000 m). Continuous polarization eliminates the wait-time for stabilization after power-up. Signal resolution is increased by on-board temperature compensation. This Sensor is also included in the path of pumped seawater. The oxygen sensor determines the dissolved oxygen concentration by counting the number of oxygen molecules per second (flux) that diffuse through a membrane, where the permeability of the membrane to oxygen is a function of temperature and ambient pressure. Computation of dissolved oxygen in engineering units is done in SEASOFT software through almost the same way as for the case of the SBE 13. The range for dissolved oxygen is 120 % of surface saturation in all natural waters; nominal accuracy is 2 % of saturation; typical stability is 2 % per 1000 hours.

The following coefficients were used in SEASOFT:

S/N 430330 18-Jun-04

Soc = 0.3314 Boc = 0.0000 TCor = 0.0006 PCor = 1.350e-04 Offset = -0.5934 tau = 0

Oxygen (ml/l) is computed as

 $Oxygen (ml/l) = [Soc * {(v + offset) + (tau * doc/dt)} + Boc * exp(-0.03 * t)]$ \* exp(TCor \* t + PCor \* p) \* Oxsat(t, s) Oxsat(t, s) = exp[A1 + A2 \* (100 / t) + A3 \* ln(t / 100) + A4 \* (t / 100)+ s \* (B1 + B2 \* (t / 100) + B3 \* (t / 100) \* (t / 100))]

Where p is pressure in dbar, t is absolute temperature and s is salinity in psu. Oxsat is oxygen

saturation value minus the volume of oxygen gas (STP) absorbed from humidity-saturated air. Its coefficients are as follows.

A1 = -173.4292 A2 = 249.6339 A3 = 143.3483 A4 = -21.8482 B1 = -0.033096 B2 = -0.00170

## (2)-3-5 Altimeter

The Benthos PSA-916 Programmable Sonar Altimeter (Benthos, Inc., USA) determines the distance of the target. PSA-916 uses the nominal speed of sound of 1500 m/s. In a PSA-916 operating at a 250-microsecond pulse at 200 kHz, the jitter of the detectors can be as small as 5 microseconds or approximately 0.4 centimeters total distance. The unit (PSA-916) is rated to a depth of 10,000 meters. Full-scale range is 100 meters and 1.0 meter guaranteed minimum.

The following scale factors were used in SEASOFT:

S/N 0011 Altimeter height = [300\*voltage / scale factor] + offset Where Scale factor = full scale voltage\*300/full scale range =15 Offset = 0.0

#### (2)-3-6: Fluorometer

The Seapoint Chlorophyll Fluorometer (Seapoint sensors, Inc., USA) is a highperformance, low power instrument to provide in-situ measurements of chlorophyll-a at depths up to 6,000 meters. The instrument uses modulated blue LED lamps and a blue excitation filter to excite chlorophyll-a. The fluorescent light emitted by the chlorophyll-a passes through a red emission filter and is detected by a silicon photodiode. The low level signal is then processed using synchronous demodulation circuitry that generates an output voltage proportional to chlorophyll-a concentration.

Minimum Detectable Level :  $0.02 \ \mu \ g/l$ Sensitivity/range : <u>gain = 30x</u>, <u>sensitivity/  $\mu \ g/l = 1.0$ </u>, <u>Range,  $\mu \ g/l = 5$ </u>

The following coefficients were used in SEASOFT through the software module SEACON as

user defined polynomial:

S/N 2579

Concentration = (V\*30/gain) + offset Where Gain setting :30X 0-5 ug/l Offset :0.0

# (2)-3-7 Transmissometer

The C-Star Transmissometer (WET Labs, Inc., USA) measures light transmittance at a single wavelength over a known path. In general, losses of light propagating through water can be attributed to two primary causes: scattering and absorption. By projecting a collimated beam of light through the water and placing a focused receiver at a known distance away, one can quantify these losses. The ratio of light gathered by the receiver to the amount originating at the source is known as the beam transmittance. Suspended particles, phytoplankton, bacteria and dissolved organic matter contribute to the losses sensed by the instrument. Thus, the instrument provides information both for an indication of the total concentrations of matter in the water as well as for a value of the water clarity.

The following coefficients were used in SEASOFT through the software module SEACON:

S/N CST-207RD March 19, 1998

M = 19.6415B = -1.3945 Path length (m) = 0.25

The beam transmittance (Tr) is computed as

Tr (%) = M \* voltage + B The following scale factors were used in SEASOFT: S/N 0396 FSVolt \* 300 / FSRange = 5 Offset = 0.0

# (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.

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 the package was lowered again at a rate of about 1.0 m/s to Bottom-20m. 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

Four Niskin bottles #25, #26, #29, and #36 dropped from the frame pin (the bottles were hung for only the guide rope). These bottles were checked status by our eyes, and took the sample for Salinity. In result, Niskin bottles and samples did not have any problems.

# (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. Some modules are originally

developed for additional processing and post-cruise calibration.

DATCNV converted the raw data to scan number, pressure, depth, temperatures, conductivities. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds, and the offset was set to 0.0 seconds.

ROSSUM created a summary of the bottle data. The bottle position, date, time were output as the first two columns. Scan number, pressure, depth, temperatures, conductivities and altitude were averaged over 4.4 seconds.

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, temperatures, conductivities and altimeter 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. 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 seasurface 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 and sigma-T.

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

#### (4) Preliminary results

Total 15 casts of CTD measurements have been carried out (table 2-2-1(a)).

Vertical profiles of Temperature and salinity, sigma- $\theta$ , Fluorescence for routine cast are shown in Figure 2.2.1.2 Figure 2.2.1.4, from Figure 2.2.1.5 to 2.2.1.7 are shown for vertical profiles of Primary Production cast, and from Figure 2.2.1.8 and 2.2.1.9 are shown for vertical profile of Trace Metal cast.

We also compared CTD-salinity and Bottle-salinity. The results are shown in Figure 2.2.1.10 and table 2.2.1 (b).

STNNRD	STNNRR CASTNO		Time (UTC)		Start Position		Depth	WIRE	HT ABOVE	Max	Max	CTD data		
SIMDA	CASINO	yyyy/mm/dd	Start	End	Latitude	Longitude		OUT	воттом	Depth	Pressure	file name	Remarks	
	01	2004/10/18	1:10	4:39	51-00.45N	164-59.32E	4801.0	4878.3	25.3	4785.3	4882.8	K01m01	for Routine	
K01	02	2004/10/18	8:30	9:12	51-01.38N	164-54.45E	5222.0	305.0	_	303.5	306.1	K01m02	for trace metal *1	
	03	2004/10/18	17:57	18:25	50-59.97N	164-59.75E	4816.0	56.6	_	59.1	59.6	K01m03	for primary production	
	01	2004/10/19	21:44	23:11	46-59.86N	160-00.33E	5201.0	1526.9	_	1503.3	1521.1	K02m01	for trace metal &RM(Nut.)	
K02	02	2004/10/20	0:33	1:45	47-00.24N	159-59.58E	5188.0	1535.9	_	1504.4	1522.7	K02m02	for RM(Nut.)	
<b>K</b> 02	03	2004/10/20	4:29	8:10	46-59.01N	159-58.92E	5222.0	5245.7	15.7	5194.0	5301.0	K02m03	for Routine	
	04	2004/10/20	17:56	18:19	44-29.91N	160-00.14E	5934.0	51.6	_	54.4	54.8	K02m04	for primary production	
35N	01	2004/10/23	17:56	18:20	35-00.02N	159-59.46E	4549.0	75.3	_	81.2	81.7	K35m01	for primary production	
551	02	2004/10/23	18:50	22:05	35-00.33N	159-59.32E	4558.0	4578.2	23.2	4526.1	4608.0	K35m02	for Routine	
	01	2004/10/25	20:55	21:39	38-59.87N	160-00.52E	5503.0	313.4	_	307.0	310.0	K03m01	for trace metal	
K03	02	2004/10/26	0:31	0:59	38-58.16N	160-01.36E	5511.0	83.5	_	84.0	84.0	K03m02	for primary production	
	03	2004/10/26	9:01	12:47	38-59.84N	160-00.14E	5509.0	5491.0	19.5	5476.5	5589.1	K03m03	for Routine *2	
	01	2004/10/28	17:53	18:26	44-00.18N	155-00.24E	5323.0	55.8	_	60.6	61.3	KNTm01	for primary production	
Knot	02	2004/10/28	19:00	22:54	44-00.06N	154-59.85E	5336.0	5319.3	19.2	5283.0	5394.9	KNTm02	for Routine	
	03	2004/10/29	0:28	1:12	44-00.44N	155-01.54E	5336.0	304.3	_	302.2	306.4	KNTm03	for trace metal	

## Table 2-2-1 (a): MR04-06 CTD Cast table

\*1 We input the wrong data for header information (Lat.). We corrected the data (excluding .dat file).

\*2 When the CTD system came back on the deck, sea condition was bad. So, Niskin bottles # 25, #26, #29, #36 dropped from the flame fooks. (The guide rope was hanging these bottles.) We checked the status those bottles by our eyes, and took samples for Salinity measurement. These Results were shown "No Problem".



Figure 2.2.1.2: Vertical profiles for Routine cast



Figure 2.2.1.3: Vertical profiles for Routine Cast



Figure 2.2.1.4: Vertical profiles for the routine cast



Figure 2.2.1.5: Vertical profiles for the cast of Primary Production


Figure 2.2.1.6: Vertical profiles for the cast of Primary Production



Figure 2.2.1.7: Vertical profiles for the cast of Primary Production



Figure 2.2.1.8: Vertical profiles for the cast of Trace metal



Figure 2.2.1.9: Vertical profiles for the cast of Trace met



Figure 2.2.1.10: Difference of CTD-salinity and Bottle salinity. Table 2.2.1 (b) Comparison CTD-salinity and Bottle-salinity

		2	2
	Sample	Average of the	Standard
		absolute	deviation of
		deference	deference
All data	142	0.004	0.008
Data shallower than 1000m	73	0.006	0.012
Data deeper than 1000m	69	0.003	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

# Fujio KOBAYASHI (MWJ)

# (1) Objective

- 1. To measure salinity of the samples obtained by CTD casts, bucket sampling, and EPCS.
- 2. To identify salinity of CTD through comparing that of CTD with that of samples.

#### (2) Instrument and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR04-06 using the salinometer (Model 8400B "AUTOSAL"; Guildline Instruments Ltd.: S/N 62827) with additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). I also used two precision digital thermometers (Model 9540; Guildline Instruments Ltd.: S/N 62521 and 66723). 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 $\pm 0.002$ (PSU) over 24 hours	
	without restandardization	n
Maximum Resolution	: Better than $\pm 0.0002$ (PSU) at 35 (PSU)	

Thermometer (Model 9540; Guildline Instruments Ltd.)

Measurement R	ange : -180 to +240 deg C
Resolution	: 0.001
Limits of error	$\pm \deg C: 0.01 (24 \text{ hours } @ 23 \deg C \pm 1 \deg C)$
Repeatability	: $\pm 2$ 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. An ambient temperature varied from 20.7 deg C to 22.4 deg C, while a bath temperature is very stable and varied within +/- 0.002 deg C on rare occasion.

The measurement values were determined as median of 31 times reading of the salinometer. Data collection was started in 15 seconds after filling sample to the cell and it took about 10 seconds to collect 31 readings by a personal computer. In case the difference between the measurement values of this two fillings is smaller than 0.00002, the average value of them was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981).

#### (3-1) Standardization

AUTOSAL model 8400B was standardized at the beginning of the sequence of

measurements using IAPSO standard seawater (SSW). SSW salinity changes equivalent to less than 0.001 after 3 years storage on catalogue.

This standardization was done by adjusting the value on the display of AUTOSAL to the double conductivity ratio that is a double-fold value of conductivity ratio indicated the label of SSW bottles. In this cruise, standardization of the AUTOSAL was performed twice. I measured 13 bottles of SSW in total and exclude the data of 1 bad bottle in the process of correcting for measurement data.

I used sub-standard seawater (SUB) that was sampled and filtered by Millipore filter (pore size: 0.45mm), which was stored in a 20 liters polyethylene container. It was measured every about 10 samples in order to check the drift of the AUTOSAL.

The specifications of SSW and SUB used in this cruise are shown as follows,

Standard seawater (SSW) batch : P144 conductivity ratio : 0.99987 salinity : 34.995 preparation date : 23-Sep.-2003

Sub standard seawater (SUB)

sampling cruise ID: MR03-K04 Leg1 sampling depth : 3,250dbar filtration date : 21-Aug.-2003

# (3-2) Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X (Teflon coating and non-coating) bottle, 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 24 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 sample

Kind of Samples	Number of Samples
Samples for CTD	180
Samples for EPCS	13
Total	193

# (4) Preliminary Results

# (4-1) Replicate and Duplicate Samples

33 pairs of replicate samples were collected from the same bottle to identify accuracy of measurement for raw seawater. 22 pairs of duplicate samples were collected from the different bottles in the same depth to check leak of water bottle, misfire, and miss-trip of CTD with water sampling system. The average and standard deviation of the absolute difference between each pair of replicate or duplicate samples were obtained. The results of replicate and duplicate samples are shown as Table 2.2.2-2. The frequency distribution for replicate samples is shown as Fig. 2.2.2-1.

Table 2.2.2-2 Results of replicate and duplicate samples

Kind of Samples	Number of Samples	Average	Standard deviation
Replicate	33	0.0002	0.0003
Duplicate	22	0.0006	0.0004



Fig. 2.2.2-1 Frequency distribution for replicate samples

According to these results, measurement and water sampling were done correctly.

# (4-2) Comparison between CTD data and Salinity measurement data

The average and standard deviation of difference between measurement data and

CTD data is shown as Table 2.2.2-3.

Kind of samples	Number of	Average	Standard
	samples		deviation
Primary sensor (all data)	175	-0.0040	0.0078
Secondary sensor (all data)	175	-0.0038	0.0081
Primary sensor (more than 1,000m)	97	-0.0023	0.0008
Secondary sensor (more than 1,000m)	97	-0.0017	0.0008

Table 2.2.2-3 Results of replicate and duplicate samples

According to these results, CTD data were considered reasonable and proper.

# (5) Data Archive

The data of salinity sample will be submitted to the DMO at JAMSTEC.

# (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 Tech. Papers in Mar. Sci., 36, 25 pp., 19

# 2.2.3 Shipboard ADCP Observation

Makio HONDA Wataru TOKUNAGA Ryo KIMURA (JAMSTEC): Principal Investigator (Global Ocean Development Inc.) (GODI)

#### (1) Objective

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

#### (2) Methods

Upper ocean current measurements were made throughout MR04-06 cruise (Departure from Dutch Harbor on 14 October 2004 to the arrival at Sekinehama on 9 November) except in EEZ of the U.S.A. and Russia, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system that is permanently installed on the R/V MIRAI. The system consists of following components;

1)A 75 kHz Broadband (coded-pulse) profiler with 4-beam Doppler sonar operating at 75 KHz (RD Instruments, USA), mounted with beams pointing 30 degrees from the vertical and 45 degrees azimuth from the keel;

2) The Ship's main gyro compass (TG-6000, Tokimec, Japan), continuously providing ship's heading measurements to the ADCP;

3) A GPS navigation receiver (Leica MX9400n ) providing position fixes;

4)An IBM-compatible personal computer running data acquisition software (VmDas version 1.3; RD Instruments, USA). The clock of the logging PC are adjusted to GPS time every 10 minutes.

The water sound velocity was calculated from water temperature (thermistor near the transducer head) and salinity (constant value; 35.0 PSU) using formula of Medwin (1975). Each pings were recorded as raw ensemble data (.ENR). And also, 60 seconds and 300 seconds average data were recorded as short term average (.STA) and long term average (.LTA) data., respectively. Major parameters for the measurement (Direct Command) are as follows:

#### **Bottom-Track Commands**

BP - 001

DI = 0.01	i mgs per Ensemble
Environmental S	ensor Commands
EA = +00000	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +0001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 11000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1020001	Sensor Source (C;D;H;P;R;S;T)
	C(1): Sound velocity calculate using ED, ES, ET(temp.)
	D(0): Manual ED

Pings per Ensemble

]	H(2): External synchro
]	P(0), R(0): Manual EP, ER (0 degree)
	S(0): Manual ES
r	Γ(1): Internal transducer sensor
Timing Command	ls s
TE = 00:00:02.0	00 Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)
Water-Track Com	mands
WA = 255	False Target Threshold (Max) (0-255 counts)
WB = 1	Mode 1 Bandwidth Control (0=Wid,1=Med,2=Nar)
WC = 064	Low Correlation Threshold (0-255)
WD = 111 111	Data Out (V;C;A PG;St;Vsum Vsum <sup>2</sup> ;#G;P0)
WE = 5000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1	Rcvr Gain Select (0=Low,1=High)
WM = 1	Profiling Mode (1-8)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 0800	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) $[0 = Bin Length]$
WV = 999	Mode 1 Ambiguity Velocity (cm/s radial)

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

Water Track :	22:00 17 October - 17:35 31 October
	10:04 5 November - 00:24 7 November
Bottom Track :	17:39 31 October - 10:00 5 November
	00:28 7 November - 00:00 9 November

# (3) Preliminary results

Fig. 2.2.3-1, 2.2.3-2 and 2.2.3-3 shows water current vector from 17 October to 1 November. The data was processed LTA data using CODAS (Common Oceanographic Data Access System) software, developed at the University of Hawaii.

# (4) Data archive

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Division.



Fig. 2.2.3-1 Water current vector. (Water depth layer: 50 m - 150 m)



Fig. 2.2.3-2 Water current vector. (Water depth layer: 150 m to 250 m)



Fig. 2.2.3-3 Water current vector at 35N to 40N.

# 2.3 Sea surface monitoring: EPCS

# Kimiko NISHIJIMA (Marine Works Japan Co. Ltd.) Fuyuki SHIBATA (Marine Works Japan Co. Ltd.) Masanori ENOKI(Marine Works Japan Co. Ltd.)

## Objective

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

# 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 THERMOS	ALINOGRAPH	
Model:	SBE-21, SEA-BIRD ELECTRON	ICS, INC.
Serial number:	2118859-3126	
Measurement range:	Temperature -5 to $+35^{\circ}$ ,	Salinity0 to 6.5 S m-1
Accuracy:	Temperature 0.01 °C 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:	$\pm 0.001$ °C
Stability:	0.002 °C year-1

c) Dissolved oxygen sensor

Model:	2127A, HACH ULTRA ANALYTICS JAPAN, INC.
Serial number:	44733
Measurement range:	0 to 14 ppm
Accuracy:	$\pm 1\%$ at 5 °C of correction range
Stability:	1% month-1

#### d) Fluorometer

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

# e) Particle Size sensor

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

The monitoring Periods (UTC) during this cruise are listed below. 15-Oct.-'04 19:31 to 6-Nov.-'04 06:48

# **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).

## Date archive

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



# 2.4 Dissolved oxygen

# Kimiko NISHIJIMA (Marine Works Japan Co. Ltd.) Fuyuki SHIBATA (Marine Works Japan Co. Ltd.)

## Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

# Methods

#### 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)

#### Instruments:

Burette for sodium thiosulfate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm<sup>3</sup> of titration vessel Burette for potassium iodate;

APB-410 manufactured by Kyoto Electronic Co. Ltd. / 20 cm<sup>3</sup> of titration vessel

Detector and Software; Automatic photometric titrator manufactured by Kimoto Electronic Co. Ltd.

#### 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<sup>3</sup>). 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<sup>3</sup> 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.

#### 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 (mmol  $kg^{-1}$ ) was calculated by sample temperature during seawater sampling, salinity of the sample, and titrated volume of sodium thiosulfate solution without the blank.

#### Standardization and determination of the blank

Concentration of sodium thiosulfate titrant (ca. 0.025M) was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130°C. 1.7835 g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm<sup>3</sup> in a calibrated volumetric flask (0.001667M). 10 cm<sup>3</sup> of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 90 cm<sup>3</sup> of deionized water, 1 cm<sup>3</sup> of sulfuric acid solution, and 0.5 cm<sup>3</sup> 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.  $1 \text{ cm}^3$  of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 100 cm<sup>3</sup> of deionized water,  $1 \text{ cm}^3$  of sulfuric acid solution, and 0.5 cm<sup>3</sup> of pickling reagent solution II and I were added into the flask in order. Just after titration of the first potassium iodate, a further  $1 \text{ cm}^3$  of standard potassium iodate was added and titrated. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate. The oxygen in the pickling reagents I (0.5 cm<sup>3</sup>) and II (0.5 cm<sup>3</sup>) were assumed to be  $3.8 \times 10^{-8}$  mol (Dickson, 1996).

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

Date	KIO <sub>3</sub>		DOT-1 $(cm^3)$			DOT-2 $(cm^3)$		
(UTC)	#	Bottle	$Na_2S_2O_3$	E.P.	blank	$Na_2S_2O_3$	E.P.	Blank
2004/10/18		040723-077	041017-2	3.962	-0.008	040723-077	3.968	-0.007
2004/10/20		040723-078	041017-2	3.969	-0.008	040723-078	3.975	-0.007
2004/10/23	#1	CSK	041017-2	3.954	-0.006	CSK	3.958	-0.007
2004/10/25		040723-079	041017-2	3.956	-0.004	040723-079	3.964	-0.004
2004/10/29		040723-080	041017-3	3.962	-0.007	040723-080	3.967	-0.004

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

# **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	Oxygen concentration (mmol/kg)
replicate sample pairs	Standard Deviation.
250	0.08

Defference between replicate [µmol/kg]

Fig.1 Results of the replicate sample measurements

# **Preliminary results**

During this cruise we measured oxygen concentration in 250 seawater samples at 5 stations.

References:

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

- DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2. A.G. Dickson and C. Goyet (eds), ORNL/CDIAC-74.
- Emerson, S, S. Mecking and J.Abell (2001) The biological pump in the subtropical North Pacific Ocean: nutrient sources, redfield ratios, and recent changes. *Global Biogeochem. Cycles*, 15, 535-554.
- Watanabe, Y. W., T. Ono, A. Shimamoto, T. Sugimoto, M. Wakita and S. Watanabe (2001) Probability of a reduction in the formation rate of subsurface water in the North Pacific during the 1980s and 1990s. *Geophys. Res. Letts.*, 28, 3298-3292.

#### **2.5 Nutrients**

## Asako KUBO (Marine Works Japan Ltd.: 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) Instruments and Methods

Nutrient analysis was performed on BRAN+LUEBBE TRAACS 800 systems that have 4channel analyzing systems for nitrate, nitrite, silicate and phosphate. The systems of analysis were improved which proposed for nutrients of seawater by BRAN+LUEBBE. The new systems are shown from Fig. 2. 5-1 to Fig. 2. 5-4

The laboratory temperature was maintained between 23 - 26 deg C.

#### a. Measured Parameters

Nitrite: Nitrite was determined by diazotizing with sulfanilamide and coupling with N-1naphthyl-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: 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.

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, is obtained from Kanto Chemical CO., Inc. This standard solution is 1000 mg per litter with 0.5 M KOH and prepared for ICP analysis. Primary standard for nitrate (KNO<sub>3</sub>), nitrite (NaNO<sub>2</sub>) and phosphate

(KH<sub>2</sub>PO<sub>4</sub>) obtained from Wako Pure Chemical Industries, Ltd.

#### c. Sampling Procedures

Samples were drawn into 10 ml acrylic screw-capped tubes that were rinsed three times before filling. Each sample was analyzed two times as soon as possible. Sets of 5 different concentrations of shipboard standards were analyzed at beginning, halfway and end of each group of analysis.

### d. Low Nutrients Sea Water (LNSW)

Twenty containers (20L) of low nutrients seawater were collected in January 2002 at equatorial Pacific and filtered with 0.45mm pore size membrane filter (Millipore HA). They are used as preparing the working standard solution.

#### e. Extra Sample

Seawater to be used for Reference Material (RM) production was collected from the depth of 1500 at K2 station. This seawater was transferred into 20 litters plastic containers, which were rinsed three times in advance. These samples were kept in a freezer at the temperature of  $-20^{\circ}$ .

## (3) Results

Nutrient analysis of the 5 stations (424 samples) from the carousel was performed including surface seawaters collected by bucket. Duplicate samples were collected from all bottles of each casting. Coefficient of variation (CV) of nitrate, nitrite, silicic acid, and phosphate analysis at each station were less than 0.16% (55 mM), 0.13% (1.2 mM), 0.16% (172 mM) and 0.22% (3.6mM), respectively.



Fig. 2. 5-1 1ch. (NO<sub>3</sub>+NO<sub>2</sub>) Flow diagram.



Fig. 2.5-2 2ch. (NO<sub>2</sub>) Flow diagram.







# 2.6 pCO2

# Masaki MORO (MWJ) Yoshiko ISHIKAWA (MWJ) Fuyuki SHIBATA (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 (TDIC), pH and pCO<sub>2</sub>. 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 pCO<sub>2</sub> during MR04-06 cruise.

#### (2) Measured Parameters

Partial pressure of CO<sub>2</sub> 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<sup>TM</sup>). The automated system was operated by on one and a half hour cycle. In one cycle, standard gasses, marine air and an air in a headspace of an equilibrator were analyzed subsequently. The concentrations of the standard gas were 268.84, 330.16, 369.37 and 414.39 ppm. The standard gases will be recalibrated after the 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 the marine air taken from the bow was equilibrated with a stream of seawater that flowed at a rate of 5-6L/min in the equilibrator. The air in the equilibrator was circulated with a pump at 0.7-0.8L/min in a closed loop passing through two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing  $Mg(ClO_4)_2$ .

#### (4) Preliminary results

Figure 2.6-1 is showing the results of measuring the  $CO_2$  concentration (xCO<sub>2</sub>) of ambient air samples and the seawater samples.



# 2.7 pH

# Fuyuki SHIBATA (MWJ) Masaki MORO (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 p $CO_2$ . 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 pH during MR04-06 cruise.

(2) Measured Parameters pH

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 5 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  $25^{\circ}$  before the measurement.

(3)-2 Seawater analysis

pH(-log[H<sup>+</sup>]) of the seawater was measured potentiometrically in the closed cell at the temperature 25  $^{\circ}$ C (pH<sub>25</sub>). The cell with liquid junction or 'salt bridge' (saturated solution of KCl) was applied.

Ag, AgCll 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 container with water jacket was used. The temperature during pH measurement was monitored with temperature sensor (Radiometer T901) and controlled to  $25^{\circ}$ C within  $\pm 0.1^{\circ}$ C.

To calibrate the electrodes the TRIS (pH=8.0936 pH unit at  $25^{\circ}$ C, Delvalls and Dickson, 1998) and AMP (pH=6.786 pH unit at  $25^{\circ}$ C, Dickson and Goyet, 1996) in the synthetic seawater (S=35 PSU) (Total hydrogen scale) were applied.

 $pH_{sws}$  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:

 $ER = RT LN(10) / F = 59.16 mV / pH unit at 25^{\circ}C$ 

(4) Preliminary results

A duplicate analysis was made on every 8th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.7-1). The average of the difference was 0.002 pH unit (n=16 pairs). The standard deviation was 0.003 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.

#### (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 2.7-1 Range control chart of the absolute differences of duplicate measurements carried out in the analysis of pH during the MR04-06 cruise.

# 2.8 Total dissolved Inorganic carbon-TDIC-2.8.1. Water column TDIC

# Fuyuki SHIBATA (MWJ) Yoshiko ISHIKAWA (MWJ) Masaki MORO (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<sub>2</sub>. If two of these four are measured, the concentration of  $CO_2$  system in the water could be estimated (DOE, 1994). Therefore, the measurement of total dissolved inorganic carbon (TDIC) was carried out during MR04-06 cruise.

#### (2) Measured Parameters

Total dissolved inorganic carbon

#### (3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 5 stations. Seawater was sampled in a 250ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 3 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 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 100\_l 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.

#### (3)-2 Seawater analysis

The system was connected to a Model 5012 coulometer (Carbon Dioxide Coulometer, UIC Inc.), an automated sampling and CO2 extraction system controlled by a computer (JANS, Inc.). The concentration of TDIC was measured as follows.

The sampling cycle was composed of 3 measuring factors; 70ml of standard CO<sub>2</sub> gas

 $(2\% \text{ CO}_2 - \text{N}_2 \text{ gas})$ , 2ml of 10%-phosphoric acid solution and 6 seawater samples. The standard  $\text{CO}_2$  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 14 minutes at the flow rate of 130-140ml/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 65: Scripps Institution of Oceanography) at the beginning of every run series, the slope was calibrated with the counts of this outcome. A reference material (QRM batch Q10) measurement during every run was carried out as well as CRM measurements. QRM was prepared in JAMSTEC by a similar procedure of CRM preparation. A fresh set of cell solution was limited to measure samples from only 2 stations (approximately 60 samples).

# (4) Preliminary results

During the cruise, 138 samples were analyzed for TDIC. A duplicate analysis was made on every nineth seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.8.1.-1.). The average of the differences was 1.1  $\mu$ mol/kg (n=15). The standard deviation was 1.0  $\mu$ mol/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.

#### (7) 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.-1. Range control chart of the absolute differences of duplicate measurements carried out in the analysis of TDIC during the MR04-06 cruise.

# 2.8.2. Sea surface TDIC

# Fuyuki SHIBATA (MWJ) Yoshiko ISHIKAWA (MWJ) Masaki MORO (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 (TDIC), pH and p $CO_2$ . If two of these four are measured, the concentration of  $CO_2$ system in the water could be estimated (DOE, 1994). Therefore, the measurement of TDIC of surface seawater was carried out in MR04-06 cruise.

#### (2) Measured Parameters

Total dissolved inorganic carbon

#### (3) Apparatus and performance

Surface seawater was continuously collected from 17<sup>th</sup> October 2004 to 29<sup>th</sup> October 2004 during this cruise. Surface seawater was continuously collected by a pump placed at the bottom of the vessel (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 basic coulometric measurement principles were the same as described in 2.6.1., except that the flow rate of nitrogen gas was set to 140ml/min. For the measuring cycle, standard gas and acid blank were both measured prior to every 5 sample measurements. However, due to standard gas shortage the use of the gas was reduced after 24<sup>th</sup> of October by altering the measuring cycle to measure standard gas and acid blank prior to every 9 sample measurements.

By measuring a reference material (RM), which was prepared in JAMSTEC, every time the cell was filled with fresh anode and cathode solutions, the slope was calibrated with the counts of this outcome. The set of cell solutions was changed once every three days.

#### (4) Preliminary results

Figure 2.8.2.-1. is showing the results of measuring the TDIC concentration of surface seawater samples. During the cruise, 4 bottles of RM (batch Q10) was analyzed in order to calibrate the slope of the calibration factor. The standard deviation of the absolute differences of duplicate measurements was  $0.9 \text{_mol/kg} (n=5)$ .

# (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 2.8.2.-1. Result of the analysis of the surface seawater carried out during MR04-06 cruise. Blue dots indicate the concentration of the total dissolved inorganic carbon (TDIC) in surface seawater and red dots indicate the sea surface temperature (SST).

### 2.9 Total alkalinity

# Fuyuki SHIBATA (MWJ) Masaki MORO (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 p $CO_2$ . 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) during MR04-06 cruise.

- (2) Measured Parameters Total alkalinity
- (3) Apparatus and performance
- (3)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 5 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 15 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  $25^{\circ}$  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 autoburette (Radiometer, ABU901), a pH glass electrode (pHG201-7), a reference electrode (Radiometer, REF201), a thermometer (Radiometer, T201) and two computers, the one was installed burette operation software (Lab Soft, Tim Talk 9) and the another one was for calculated total alkalinity.

#### (4) Preliminary results

A duplicate analysis was made on every 8th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.9-1). The average of the difference was 1.38 \_mol/kg (n=14 pairs). The standard deviation was 1.28 \_mol/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 2.9-1. Range control chart of the absolute differences of duplicate measurements carried out in the analysis of TA during the MR04-06 cruise.
#### 2.10 Chlorophyll a

# Masanori ENOKI (MWJ) : Operation Leader Makio HONDA (JAMSTEC MIO) : Principal Investigator

#### 1. Objective

Chlorophyll *a* is one of the most convenient indicators of phytoplankton stock, and has been used extensively for the estimation of phytoplankton abundance in various aquatic environments. The object of this study is to investigate the vertical distribution of phytoplankton in various light intensity depth.

2. Sampling elements Chlorophyll *a* 

#### 4. Materials and Method

Seawater samples were collected 1.0 liter at 8 depths from surface to100m with Niskin bottles, except for the Surface water, which was taken by the bucket. The samples were gently filtrated by low vaccum pressuer (<15cmHg) through Whatman GF/F filter(diameter 25mm) in the dark room. Phytoplankton pigments were immediately extracted in 7ml of N,N-dimethylformamide (DMF) after filtration and then, the samples were stored in the freezer( $20^{\circ}$ C) until the analysis of fluorometric determination (over 24 hours).The extracts of the samples are measured the fluorescence by Turner fluorometer (10-AU-005,TURNER DESIGNS) with a 340-500nm bound excitation filter and a >665nm bound emission filter, before and after acidification. We had the measurements twice. At first, we measured the fluoroscence of samples, after that we dropped 1N HCL to the sample and measured.

#### 5. Results

(1) Vertical distribution of Chlorophyll a for respective stations

The results of Chlorophyll *a* measurements ware showed in Figure 2.10.1.

(2) Relation between integrated chlorophyll-a and the ratio of irradiance at 555 nm to that at 443 nm

It has been verified that irradiance (Ed) at approximately 440 nm (blue) is preferentially absorbed by pigments (chlorophyll) of principal phytoplankton such as diatoms and coccolithophorids as opposed to Ed at wavelengths of approximately 550 nm (green) (e.g. Kirk, 1994; Vaillancourt et al., 2003). Duntley et al. (1974) and Gordon and Morel (1983) reported a good correlation between chlorophyll-a (Chl-a) and Ed<sub>(441)</sub> while not at Ed <sub>(520)</sub>. Smith et al. (1991) and Abbott et al. (1995) documented a good relationship between concentration of chlorophyll-a (Chl-a) and the ratio  $Ed_{(441)}/Ed_{(520)}$ . Loisel and Morel (1998) and Kinkade *et al.* (2001) reported a good correlation of depth-integrated chlorophyll-*a* upper 65 m (Chl-a<sub>(int)</sub>) with  $Ed_{(443)}/Ed_{(550)}$  from noon measurements made at 65 m depth. Moreover Abbott et al. (2000)

showed good relation between Chl-a(int) and Ed(443)/Ed (555) instead of Ed(520) or Ed(550).

Figure 2.10.2 shows Chl- $a_{(int)}$  in the upper 60 m of the water column plotted against Ed<sub>(443)</sub> / Ed<sub>(555)</sub> observed during this cruise (pink circles) and during previous cruises (black circles) in the northwestern North Pacific. The Chl- $a_{(int)}$  data were obtained using a Turner Designs fluorometer aboard ship and Ed<sub>(555)</sub> / Ed<sub>(443)</sub>, the reciprocal of Ed<sub>(443)</sub> / Ed<sub>(555)</sub>, was observed by an underwater optical sensor (SPMR). Ed<sub>(555)</sub> /Ed<sub>(443)</sub> also correlated well with Chl- $a_{(int)}$  (r = 0.8) and its relation can be expressed as a logarithmic function instead of a power function as suggested previously (e.g. Smith et al., 1991; Abbott et al., 1995; Kinkade et al., 2001):

$$\text{Chl-a}_{(\text{int})} (\text{mg m}^{-2}) = 42.359 + 30.227 * \log (\text{Ed}_{(555)}/\text{Ed}_{(443)})$$

#### 6. Data archives

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



Figure 2.10.1 The vertical distributions of chlorophyll a at MR04-06



Fig. 2.10.2 Relation between Ed  $_{\scriptscriptstyle (555)}$  /Ed  $_{\scriptscriptstyle (443)}$  and integrated chl-a upper 60 m

# **3. Special observation3.1 Vertical distribution of suspended particles**

# Kazuhiro HAYASHI (JAMSTEC MIO) Xuedong XU (JAMSTEC MIO)

#### **Objectives**

Understanding the mechanism of export flux is important for research of biological pump. Especially, SPM in the sea surface is the origin of sinking particles, and the behavior of it is important to understand export flux. Sediment trap catch the sinking particles at the time series and records of sinking particles have a distribution of the SPM at the ocean surface. By clarifying the relation, the amount of reproduction from the euphotic layer to the pelagic layer can be estimated.

The objectives of this investigation are to understand the seasonal variation relationship between chemical tracers and primary production at the northwestern Pacific, and also obtain more knowledge of behavior of the particulate matter in the euphotic layer.

#### Sampling

Vertical suspended particulate matters (SPM) were collected on 142mm Millipore HA filter by Large volume pump systems. Samples were collected from St. K-2, St. K-3, St. KNOT, and St.35N. Filtered volume was counted by flowmeter. After filtrated, each filter was rinsed over 3 times by milli-Q water. Millipore HA filters were moved to acid clean zip lock bag, which were stored in the refrigerator.

#### Analytical method

Table 1. is shown on LVP results. Millipore HA filters are cut in half size by plastic cutter in the clean food, one is digested by using microwave digestion system (Ethoth: Milestone) with HNO<sub>3</sub> and HF. Dissolved samples are transferred to 50ml centrifuge tube. For ICP-AES samples, uptake of 5ml, add Sc as an internal standard, which take for major elements. These samples will be measured by ICP-AES (Optima 3300DV: Perkin-Elmer). After divided for ICP-AES, almost 45ml sample is added spikes, transferred to Teflon beaker, and evaporated to small drop. Teflon beaker wall is rinsed by conc. HNO<sub>3</sub> 3 or 4 times. Sample will be measured by ICP-MS with dessolvator (modified Cullen *et al.*, 2001).

#### Reference

Cullen *et al.*, (2001) Determination of elements in filtered suspended marine particulate material by sector field HR-ICP-MS, J. Anal. At. Spectrom. , 2001, 16, 1307-1312

	St. K-1	St. K-2	St. K-3	St.KNOT		St. K-3
Cast ID	SPM	SPM	SPM	SPM		Ra
						Filteration
depth/m		Filteration	volume/L		depth/m	volume/L
10	Not work	210.4	146.5	129.4	10	221.4
20	Not work	121.5	170.7	Not work	40	197.2
40	Not work	119.2	136.3	Not work	110	302.8
60	Not work	233.2	159.7	276.7	250	448.5
80	Not work	167.7	172.2	286.5	400	408.8
100	Not work	159.0	166.2	356.9	800	440.6
150	338.0	175.6	188.5	Not work	1500	446.3
200	Not work	185.1	176.0	321.0		

Table.1 Sampling log

#### **3.2 Optical measurement**

#### Makio HONDA (JAMSTEC MIO)

#### (1) Objective

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

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

#### (2) Description of instruments deployed

The instrument consisted of the SeaWiFS Profiling Multichannel Radiometer (SPMR; and SeaWiFS Multichannel Surface Reference (SMSR). The SPMR was deployed in a free fall mode through the water column. The 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 1). These instruments observed the vertical profiles of visible and ultra violet light and chlorophyll concentration.

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

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

Measurements were conducted 5 stations. Measurements should be ideally conducted at median time and, however, were conducted irregularly because of limited ship-time and other observation's convenience (Table 2). The profiler was deployed twice at respective stations to a depth of 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 photosynthetically available radiation (PAR) were computed.

			,		
For	K1	K2	KNOT	K3	35N
Free Fall Position					
Observation Date	Oct.18	Oct.20	Oct.28	Oct. 26	Oct. 23
	2004	2004	2004	2004	2004
Observation Time	11:45	12:30	12:30	11:00	11:45
Sun rise (ca.)	06:28	06:46	07:07	06:43	07:10
Median time (ca.)	11:45	12:04	12:24	12:03	12:03
Sun set (ca.)	17:01	17:22	17:40	17:24	16:56
Irradiance	$1124 \pm 61$	$844\pm67$	$397 \pm 17$	$282\pm7$	$652 \pm 82$
in air (PAR in air)					
$(mE/sec/m^2)$					
1% depth (m)	44	43	76	76	71

Table 2 locations of optical observation and principle characteristics

(Date and Time in LST: UTC+11hr.)

(3) Preliminary results

1) PAR in air.

Table 2 shows PAR in air. Maximum PAR in air was observed at station K1 and minimum was observed at station K3. Intensity of PAR depends on the weather condition during observation.

2) Comparison of PAR observed by SPMR with solar radiation observed by meteorological instrument

During observation of light intensity in the water column, PAR in the air is simultaneously observed by SPMR. On the other hand, a radiometer (MS-80, Eiko Seiki, Japan) installed on a radar mast (28m) of R/V Mirai observes short wave solar radiation every one minute. During this cruise, both data was compared. Fig. 1 shows PAR against solar radiation. As a result, PAR correlates well with solar radiation observed by radiometer. Although solar radiation data is supplied with unit of "W m<sup>-2</sup>", it is possible to convert this unit to "mE m<sup>-2</sup> sec<sup>-1</sup>" using this empirical equation.

3) Vertical profile of relative intensity in the water column

Fig. 2 shows relative intensity of PAR to surface PAR at respective stations. Pink line was observed during this cruise. Relative intensity decreases with depth exponentially. Although absolute surface PAR were different among stations, depth with 1 % intensity, which depth is known as the depth of bottom of euphotic zone, were approximately 43 m for northern stations (K1, K2). Depth of 1 % intensity at other stations was approximately 75 m and deeper than those at northern stations. This is supported by the fact that surface chlorophyll-a is higher at stations K1 and K2 than at other stations.

4)Seasonal change in light extinction

Optical observation was also conducted at stations K1, K2, K3, 35N and KNOT during the former cruise (R/V Mirai, Natsushima and Kairei). Fig. 1 also shows comparison of light extinction (decrease of relative light intensity with depth) between that during this cruise and that during former cruise. The intensity of light extinction varies seasonally. These are attributed to the difference in amount of living or non-living suspended particles.



Fig.1 Solar radiation against PAR



Fig.2 Vertical change in relative light intensity

#### **3.3 Primary productivity**

Ai YASUDA (Marine Works Japan LTD) Fuyuki SHIBATA (Marine Works Japan LTD) Junichi WATANABE (Marine Works Japan LTD) Makio HONDA (JAMSTEC MIO)

#### (1) Simulated 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 degree C for at least 2 hours, were used for a filtration.

#### 2) Simulated in-situ incubation

We took three transparent bottles samples from 8 layers took from the surface and seven predefined depth by a bucket and Niskin bottles at St. K1, K2, 35N, K3 and KNOT. These depths corresponded to nominal specific optical depths i.e. 50%, 25%, 10%, 5%, 2.5%, 1% and 0.5% light intensity relative to the surface irradiance, PAR, as determined from the optical profiles.

All samples were spiked with 0.2  $\mu$ moles/mL of NaH<sup>13</sup>CO<sub>3</sub> solution. After spike, bottles were placed into incubators by neutral density filters corresponding to nominal light levels at the depth at which samples were taken. Two samples of each layer were incubated in a bath on the deck for 24 hours. One sample of each layer was incubated in a bath on the deck for 12 hours.

At the end of the incubation period, samples were filtered through Grass fiber filters (Wattman GF/F 25mm). GF/F filters were kept to freeze till analyse of MR04-07 or MR05-01 cruise.

We took 6 transparent bottles samples for incubation and two dissolved oxygen samples from the surface at St.K2 and KNOT. All samples were not spiked. Four samples were incubated in a bath for 24 hours. After incubation two samples were filtered through Grass fiber filters (Wattman GF/F 25mm ). GF/F filters were kept to freeze till analysis of MR04-07 or MR05-01 cruise. Two samples were sampled dissolved oxygen. Another two samples were

incubated in a bath for 12 hours and were sampled dissolved oxygen.

Table 1 shows log sheets for respective incubation.

#### (3) Measurement

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

#### (4) Irradiance and water temperature during incubation

Fig.1 shows daily change of light irradiance observed by solar radiation measurement system during incubation. Station 35N and station K-3 had the strongest and weakest total solar radiation. Numbers in figures were intensity of PAR (photosynthesic Available Radiation) converted with the relation between PAR and total solar radiation obtained by "free fall observation".

Fig.2 shows change in water temperature of SST (incubator) during incubation. Although we collected water sample for measurement of primary productivity and started incubation at respective station, we could not stay there for 24 hours except station KNOT. Therefore incubation was carried out between stations and water temperature, especially between station K2 and 35N, changed largely. Primary productivity that will be estimated, therefore, represents that at not respective stations, but area between stations.

#### (5) DO measurement

In order to estimate net / gross primary productivity and respiration, we also measured dissolved oxygen (DO) for some incubation bottles.

Experiment 1 was conducted at station K-2. Surface water was collected and distributed to some incubation bottles. After measuring DO for two bottles as the initial value, other bottles were incubated for daytime (12 hrs.) or for whole day (24 hrs) in the incubation water bath. After incubation, DO was measured. DO decreased not only after 24 hrs. but also after 12 hrs. unlike we expected. During incubation, we moved from station K-2 to station 35N and water temperature increased from 12°C to 20°C (Table 2). Saturated DO concentration should decrease and it is possible that DO might escape from seawater. Therefore difference in saturated DO was taken into account and measured DO was corrected. As a result, DO increased during daytime by 1.44 µmol kg<sup>-1</sup>. It corresponds to net primary productivity (NPP) of 13.3 mg-C kg<sup>-1</sup>. On the other hand, DO decreased during night by 2.33 mmol kg<sup>-1</sup>. If this is caused by respiration, it means that organic carbon of 21.5  $\mu$ g-C kg<sup>-1</sup> was decomposed during nighttime and total NPP per day was minus 8 µg-C kg<sup>-1</sup>. This result that decomposition of organic carbon was higher than production was indeed strange. On the other hand, daytime gross primary production (GPP) was estimated to be 34.8 µg-C kg<sup>-1</sup> if daytime respiration was equal to nighttime respiration (21.5 µg-C kg<sup>-1</sup>). If this is the case, the ratio of NPP to GPP during daytime was estimated to be 38 %.

In order to avoid effect of change in water temperature for incubation, the experiment 2 was conducted at station KNOT. During incubation, we stayed here. In addition, plankton net was attached on the water tank outlet to eliminate zooplankton. As shown in Table 2, water temperature was almost stable and effect of water temperature on dissolved oxygen was negligible. However DO concentration decreased during even daytime again. GPP was estimated to be 47.4 mg-C kg<sup>-1</sup> and slightly higher than that at station K-2 although NPP was not detected.

At last, we could not clarify NPP and GPP by measurement of DO. Some factors such as air-sea exchange of oxygen and the exist of zooplankton should be considered in the future experiment.



Fig. 1 diurnal change in solar irradiance during respective incubations



Fig. 2 diurnal change in SST during respective incubations

# Table 1 log sheet of incubation (Station K-1)

#### Primary production ( Experiment Log Sheet )

			•				No.1						
Cruise :	MR04-06	Time of water samp	oling: 2004/10/18 17:57	7~18:25	Location 50-59.97N	, 164-59.75E							
Station No :	St.K01	Incubation time A	(LST) : 2004/10/19	9 6:35~2004/10/20 6:35	•								
Cast No. :	03	Incuvbation time B	acuvbation time B (LST) : 2004/10/19 6:35~2004/10/19 17:05										
Aquarium Light	Bottle	Sampling depth	Incubation time	Bottle	13C tracer	(*1	N						
Extinction Rate	No.	(m)	(LST)	No.	(mL)	filtration condition	Note						
				100%-A	1.0								
100%	Bucket	0m	А	100%-B	1.0								
			В	100%12h	1.0								
				50%-A	1.0								
50%	7	7m	А	50%-В	1.0								
			В	50%12h	1.0								
				25%-A	1.0								
25% 8		13m	А	25%-В	1.0								
			В	25%12h	1.0								
			٨	10%-A	1.0								
10%	9	21m	л	10%-B	1.0								
			В	10%12h	1.0	2 hours							
			٨	5%-A	1.0	2 10013							
5%	10	29m	л	5%-В	1.0								
			В	5%12h	1.0								
			Δ	2.5%-A	1.0								
2.5%	11	36m	А	2.5%-В	1.0								
			В	2.5%12h	1.0								
			Δ	1%-A	1.0								
1%	12	47m	1	1%-B	1.0								
			В	1%12h	1.0								
			Δ	0.5%-A	1.0								
0.5%	13	58m	A	0.5%-B	1.0								
			В	0.5%12h	1.0								

MEMO

person for sampling Honda, Shibata, Watanabe, Enoki, Yasuda filter on sampling tube 200 m person for 13C injection Yasuda

#### Table 1 log sheet of incubation (Station K-2)

#### Primary production ( Experiment Log Sheet )

		No.2
Cruise :	MR04-06	Time of water sampling (UTC) : 2004/10/20 17:56~18:19 Location 44-29.91N, 160-00.14E
Station No :	St.K02	Incubation time A (LST) : 2004/10/21 6:40~2004/10/22 6:40
Cast No. :	01	Incubation time B (LST) : 2004/10/21 6:40~2004/10/21 17:30

Aquarium Light	Bottle	Sampling depth	Incubation time	Bottle	13 C tracer	filtration condition	Note
Extinction Rate	N 0.	(m)	(LST)	No.	(mL)		
			4	100%-A	1.0		
100%	bucket	0m		100%-B	1.0		
			В	100%12h	1.0		
				50%-A	1.0		
50%	7	4m	~	50%-B	1.0		
			В	50%12h	1.0		
				25%-A	1.0		
25%	6	9m	A	25%-В	1.0		
			В	25%12h	1.0		
				10%-A	1.0		
10%	5	19m	A	10%-B	1.0		
			В	10%12h	1.0		
				5%-A	1.0	1	
5%	4	27m	A	5%-B	1.0	1	
			В	5%12h	1.0	2 hours	
				2.5%-A	1.0	1	
2.5%	3	34m	A	2.5%-B	1.0		
			В	2.5%12h	1.0		
				1%-A	1.0		
1%	2	45m	A	1%-B	1.0		
			В	1%12h	1.0		
				0.5%-A	1.0		
0.5%	1	53m	A	0.5%-B	1.0		
			В	0.5%12h	1.0		
				100%-A	1.0		
			A	100%-B	1.0		
				100%12h-A	1.0		
			В	100%12h-B	1.0		
100%				Blank-A	None		
(bucket for DO	bucket	0m	A	Blank-B	None		
measurement)			А	DO12b-B	None		DO bottle #:A059
			В	DO12h-B	None		DO bottle #:A060
		-	A	DO24h-A	None		DO bottle #:A037
			В	DO24h-A	None		DO bottle #:A038
1	1	1				1	1

MEMO

\*\* After CTD cast, duplicate water samples for DO measurement were collected from bucket (DO bottle # : A053, A054)

person for sampling Honda, Shibata, Watanabe, Enoki, Yasuda

filter on sampling tube 200  $\mu$ 

person for 13C injectio Yasuda

#### Table 1 log sheet of incubation (Station 35N)

#### Primary production ( Experiment Log Sheet )

		No.3
Cruise :	MR04-06	Time of water sampling (UTC) : 2004/10/23 17:56~18:20 Location 35-00.02N, 159-59.46E
Station No :	St.35N	Incubation time A (LST) : 2004/10/24 6:30~2004/10/25 6:30
Cast No. :	01	Incubation time B (LST) : $2004/10/19 6:30 \sim 2004/10/19 17:30$

Aquarium Light	Bottle	Sampling depth	Incubation time	Bottle	13C tracer	filtration condition	Note
Extinction Rate	No.	(m)	(LST)	No.	(mL)	initiation condition	INORE
			4	100%-A	1.0		
100%	Bucket	0m	А	100%-B	1.0		
			В	100%12h	1.0		
			4	50%-A	1.0		
50%	7	8m	A	50%-B	1.0		
			В	50%12h	1.0		
				25%-A	1.0		
25%	6	18m	А	25%-В	1.0		
			В	25%12h	1.0		
				10%-A	1.0		
10%	5	35m	А	10%-B	1.0	]	
			В	10%12h	1.0	1	
				5%-A	1.0	1.5 hours	
5%	4	48m	A	5%-В	1.0		
			В	5%12h	1.0		
				2.5%-A	1.0		
2.5%	3	60m	А	2.5%-В	1.0		
			В	2.5%12h	1.0		
				1%-A	1.0		
1%	2	71m	А	1%-B	1.0		
			В	1%12h	1.0		
				0.5%-A	1.0		
0.5%	1	81m	А	0.5%-B	1.0		
			В	0.5%12h	1.0		

#### MEMO

person for sampling Honda, Shibata, Watanabe, Enoki, Yasuda filter on sampling ti 200  $\mu$  person for 13C inje; Yasuda

#### Table 1 log sheet of incubation (Station K-3)

#### Primary production ( Experiment Log Sheet )

#### No.4 MR04-06 Cruise : Time of water sampling (UTC) : 2004/10/26 0:31~0:59 Location 38-58.16N, 160-01.36E St.K03 Station No : Incubation time A (LST) : $2004/10/26 \ 12:40 \sim 2004/10/27 \ 12:40$ 02 Cast No. : Incubation time B (LST) : 2004/10/26 12:40~2004/10/26 17:30 Aquarium Light Bottle Sampling depth Incubation time Bottle 13C tracer filtration condition Note (LST) Extinction Rate Νo. (m) No. (mL) 100%-A 1.0 А 100% bucket $0 \mathrm{m}$ 100%-B 1.0 В 100%12h 1.0 50%-A 1.0 А 50% 7 7m 50%-B 1.0 В 50%12h 1.0 25%-A 1.0 А 6 25% 17m 1.0 25%-B В 25%12h 1.0 10%-A 1.0 А 10% 5 34m 1.0 10%-B В 10%12h 1.0 2 hours 5%-A 1.0 А 5% 4 46m 1.0 5%-B В 1.0 5%12h 2.5%-A 1.0 А 3 2.5% 58m 1.0 2.5%-B В 2.5%12h 1.0 1%-A 1.0 А 1% 2 74m 1%-B 1.0 В 1%12h 1.0 0.5%-A 1.0 А 0.5% 1 85m 0.5%-B 1.0 в 0.5%12h 1.0

#### MEMO

person for sampling Honda, Shibata, Watanabe, Enoki, Yasuda filter on sampling tube 200 µ person for 13C injection Yasuda

# Table 1 log sheet of incubation (Station KNOT)

#### Primary production ( Experiment Log Sheet )

		1			r		No.5
Cruise :	MR04-06	Time of water sam	pling (UTC) : 2004/1	10/28 17:53~18:26	Location 44-00.18N	, 155-00.24E	
Station No :	St.KNOT	Incubation time A	(LST) : 2004/10/2	9 6:50~2004/10/30 7:00			
Cast No. :	01	Incubation time B	(LST) : 2004/10/29	9 6:50~2004/10/21 19:00			
Aquarium Light	Bottle	Sampling depth	Incubation time	Bottle	13C tracer	filmaine no disine	Nete
Extinction Rate	No.	(m)	(LST)	No.	(mL)	Intration condition	INOLE
				100%-A	1.0		
100%	bucket	0m	А	100%-B	1.0	1	
			В	100%12h	1.0		
				50%-A	1.0	1	•
50%	7	4m	A	50%-B	1.0	1	-
			В	50%12h	1.0	1	
				25%-A	1.0		
25%	6	11m	А	25% R	1.0		
			В	25%12h	1.0		
				10% A	1.0		-
10%	5	22m	А	10%-A	1.0		
	10/0 5		В	10%-B	1.0	-	
			5	10%12h	1.0	_	
5%	4	31m	А	5%-A	1.0		
570		5111	D	5%-B	1.0	1.5 hours	
			в	5%12h	1.0	-	
2.50	2	20	А	2.5%-A	1.0	-	
2.3%	5	5911	p	2.5%-B	1.0	-	
			Б	2.5%12h	1.0		
			А	1%-A	1.0		
1%	2	50m		1%-B	1.0		
			В	1%12h	1.0		
			А	0.5%-A	1.0	-	
0.5%	1	60m		0.5%-B	1.0		
			В	0.5%12h	1.0	-	
			А	100%-A	1.0		
				100%-B	1.0		
			в	100%12h-A	1.0		
1000			2	100%12h-B	1.0		
100% (bucket for DO	bucket	0m	Δ	Blank-A	None		
measurement)	Ducket		n	Blank-B	None		
			А	DO12h-A	None		DO bottle #:A085, A086
			В	DO12h-B	None		DO bottle #:A087, A088
		А	DO24h-A	None		DO bottle #:A091, A092	
			В	DO24h-B	None		DO bottle #:A093, A095

MEMO

%After CTD cast, duplicate water samples for DO measurement were collected from bucket (DO bottle # : A082, A083) person for sampling Honda, Shibata, Watanabe, Enoki, Yasuda filter on sampling tut 200 m person for 13C inject Yasuda

# Table 2 Change in DO during incubation and estimated productivity

Experin	nent 1	Station K-	2 / 35N												
	measured DO			ΔDO			saturated DO	∆saturated DO	corrected DO	ΔDO		NPP (mg	g-C kg <sup>-1</sup> )	GPP(mg-C kg <sup>-1</sup> )	NPP/GPP
	(µmol kg <sup>-1</sup> )	ave	stdev	0-12	12-24	SST(°C)	(µmol kg <sup>-1</sup> )		(µmol kg <sup>-1</sup> )	0-12	12-24	0-12	12-24	0-12	(%)
0	269.58	269.83	0.36			12.67	263.18		269.83						
0	270.09														
12	262.83	262.80	0.04	-7.03		14.25	254.70	-8.48	271.28	1.44		13.32		34.77	38.29
12	262.77					(ave. 0-12)									
24	250.92	250.84	0.11		-11.96	16.16	245.07	-18.11	268.95		-2.33		-21.46		
24	250.76					(ave. 0-24)									

Experin	ment 2	Station KI	NOT												
	measured DO			ΔDO			saturated DO	∆saturated DC	) corrected DO	ΔDO		NPP (mg	$g-C kg^{-1}$	GPP(mg-C kg <sup>-1</sup> )	NPP/GPP
	(µmol kg <sup>-1</sup> )	ave	stdev	0-12	12-24	SST(°C)	(µmol kg <sup>-1</sup> )		(µmol kg <sup>-1</sup> )	0-12	12-24	0-12	12-24	0-12	(%)
0	281.70	281.66	0.05			9.91	279.88		281.66						
0	281.62														
12	275.06	275.14	0.13	-6.52		9.87	280.13	0.25	274.89	-6.77		-62.41		47.41	-
12	275.01					(ave. 0-12)									
12	275.29														
12	275.19														
24	262.80	263.16	0.37		-11.98	9.88	280.07	0.19	262.98		-11.92		-109.83		
24	262.89					(ave. 0-24)									
24	263.49														
24	263.48														

#### 3.4 Horizontal distribution of suspended particles

## Kazuhiro HAYASHI (JAMSTEC MIO) Xuedong Xu (JAMSTEC MIO) Hisashi NARITA (Tokai University)

#### **Objectives**

Understanding the seasonal variation of the trace metals in the particle matter at the ocean surface is important for study of export fluxes by them. The contents of trace elements in particulate matter differ by dominant phytoplankton communities. The objectives of this investigation are to understand the seasonal variation relationship between chemical tracers and primary production at the northwestern Pacific, and obtain more knowledge of characteristics of the particulate matter and phytoplankton communities in this area.

#### Sampling

Underway samples were collected at 50m from sea surface by continuous seawater pump on R/V MIRAI. Underway seawater is introduced to stainless steel filter holder (SUS 316) for 142mm filters. Particulate matter was collected by Millipore-HA (0.45mm) and Supor (0.45mm). Filtered volume was counted by flowmeter. After filtrated, each filter was rinsed over 3 times by milli-Q water. Millipore HA filters were moved to acid clean zip lock bag, which were stored in the refrigerator. In order to obtain horizontal nutrients distribution, seawater samples were collected for nutrients when each filtration started. Seawater samples were stored in refrigerator, and analyzed by autoanalyzer (TRAACS 800; BRAN+LUEBE) within 10 days after sampling. Table 1. is shown on sampling details and the results of on board data about nutrients and chl-a.

#### Analytical method

Millipore HA filters are cut in half size by plastic cutter in the clean food, one is digested by using microwave digestion system (Ethoth: Milestone) with HNO<sub>3</sub> and HF. Dissolved samples are transferred to 50ml centrifuge tube. For ICP-AES samples, uptake of 5ml, add Sc as an internal standard, which take for major elements. These samples will be measured by ICP-AES (Optima 3300DV: Perkin-Elmer). After divided for ICP-AES, almost 45ml sample is added spikes, transferred to Teflon beaker, and evaporated to small drop. Teflon beaker wall is rinsed by conc. HNO<sub>3</sub> 3 or 4 times. Sample will be measured by ICP-MS with dessolvator (modified Cullen *et al.*, 2001).

#### Reference

Cullen *et al.*, (2001) Determination of elements in filtered suspended marine particulate material by sector field HR-ICP-MS, J. Anal. At. Spectrom. , 2001, 16, 1307-1312



#### 3.5 Horizontal distribution of planktonic foraminifera

# Kazuhiro HAYASHI (JAMSTEC MIO) Katsunori KIMOTO (JAMSTEC MIO)

#### Objective

Planktonic foraminifera in the sediments are well known as useful one of paleoproxy, species, oxygen isotope and radiocarbon. Especially, the elements / calcium ratio of foraminiferal shells has been used by reconstruction paleoenvironments in past oceans. However, these studies mainly have been foraminiferal fossil in sediment cores still now, and the relation with marine environment to living them is not know well. The results of that recently studies have suggested question that the relation equations about elements / calcium ratio and marine environmental parameter depended on habitat and the other factor.

This study aims at relation equations about them and the ecology of foraminifera in the western North Pacific by investigating the relationship between marine environments and living it.

#### Sampling

Planktonic foraminifera were collected by using underway-sampling pump equipped in the stem of R/V Mirai. The entry port of seawater is located at ca. 5m under sea surface. Nonfiltered seawater in the sea surface water-monitoring laboratory was screened over 100\_m mesh at all stations. The collected materials were soaked in the mixture of 1:1 volumetric ratio of seawater and ethanol in plastic vials. After addition of small amount of sodium tetra-borate as a pH buffer, the vials were sealed and then stored in the refrigerator.

#### Analytical method

Foraminifera are picked up under microscope from sample bottle, and some of them will be used for DNA analysis to investigate the relationship between genetic and morophlogic species.

The rest will be cleaned up by oxidation-reduction reaction to remove organic matter and salt by ultra-pure reagent in the clean laboratory. Ca, Sr and Mg concentrations in foraminiferal shell are analyzed by ICP-MS, Cd contents are analyzed ICP-MS with dissolvator by Isotope dilution method.

## **3.6 Trace elements**

# Taishi SATO (Institute for Chemical Research, Kyoto Univ.)

#### (1) Objective

The distribution and speciation of trace elements in seawater are controlled by various physical, chemical and biological processes and therefore can provide useful information about the ocean. Our objective is to reveal the behavior of trace elements in seawater and elucidate the processes occurring in the ocean. On the present cruise, we are studying the distribution and speciation of trace bioelements (Fe, Co, Ni, Cu, Zn, Cd, Pb) in seawater.

- (2) Measurement Parameters
- 1. Dissolved trace bioelements (passed through a 0.2 µm pore size Nuclepore filter)
- 2. Acid dissolvable trace bioelements (without filtration)
- 3. Particulate trace bioelements (retained on a 0.2 µm pore size Nuclepore filter)

#### (3) Instruments and Methods

The seawater samples were collected by Niskin-X sampler mounted on a CTD carousel system. The Niskin-X samplers were thoroughly cleaned with detergent and hydrochloric acid before the cruise.

Seawater samples for dissolved, acid dissolvable and particulate trace bioelements were transferred from the sampler to a precleaned low-density polyethylene bottle. We used a silicon tube and plastic bell, wearing plastic gloves, to avoid contamination by airborne particles.

In order to decrease the contamination from the ship, the sampling was usually conducted as soon as possible after arrival at a station using the gallows crane.

Immediately after sampling, seawater samples were filtered through an acid-cleaned Nuclepore filter (0.2  $\mu$ m pore size) using a closed filtration system in a clean room. The filtered and unfiltered seawater samples were acidified with hydrochloric acid to about pH 2 and stored. The waters and filter samples were brought back to our laboratory for further analysis.

#### (4) Results

About 300 samples were collected during this cruise. The sampling station were Station1 (K1), 2 (K2), 3 (K3), 4 (KNOT).

#### (5) Data archive

Raw data of trace elements will be submitted to DMO (Data Management Office), JAMSTEC and will be under its control.

#### 4. Geological Survey

Naokazu AHAGON (MIO/JAMSTEC) Ken'ichi OHKUSHI (Faculty of Education, Ibaraki Univ.) Akihiko SHIBAHARA (Graduate Student, Tsukuba Univ.), Sawako ARAKI, Tamami UENO, Kazuhiro YOSHIDA, and Hiroyuki HAYASHI (MWJ, Co. Ltd.) Wataru TOKUNAGA and Ryo KIMURA (GODI, INC.)

#### 4.1. Objectives

Recent paleoceanographic studies have been revealed the abrupt environmental shifts had occurred at the millennial scales in the northwest Pacific during the last glacial period. The main objective in this survey is to investigate the past environmental changes around the western North Pacific since the last glacial period, especially for evaluating the past instability of the gas hydrates in the Oyashio region, and for reconstructing the past changes in the strength of North Pacific Intermediate Water (NPIW) formation. Although the catastrophic failure of gas hydrates is a potential mechanism for abrupt climatic changes (e.g., Kennet, 2000), this should be proven using more paleoceanographic records from various ocean regions. High-resolution (i.e., high sedimentation rate & enough time controls) sediment cores should be required for this purpose. We focused on the area around the Tsugaru Strait between Hokkaido and Honsyu for this purpose, because the past change in NPIW formation can be traced by using foraminiferal radiocarbon measurements and productivity/lamination signals in this region (e.g., Ahagon *et al.*, 2003; Ohkushi *et al.*, 2004). The evidence of methane release also can be tested using lipids-biomarker analysis (e.g., Uchida *et al.*, 2004).

#### 4.2 Coring equipments

#### 4.2.1 Multiple corer

The multiple corer produced by Rigosha Co. was used for taking the surface sediments without any turbidity. This system has a frustum framework on which trigger, 620kg weight, and 8 acryl barrel (I.D.; 73 mm, O.D.; 80 mm, length; 60 cm) are attached. Bottom water sampling system (four 8L-Niskin bottles) with Temperature and pressure recorder (TD sensor. SBE39) is also attached, since some chemists are interested in the "bottom seawater. The vertical temperature variation of the station 7,8 and 9 area is shown in the figure 4.2-1 to figure 4.2-4.

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

- 1) At first the multiple corer was descended at a slow winch speed by a 100-200m depth, and the swell-compensator was supplied. Then, the speed was gradually increased to a maximum of 1m/sec.
- 2) The winch operation was stopped at a depth of 50m above the bottom for 3 minutes to reduce pendulum motions of the multiple corer.
- 3) After the multiple corer was stabilized, the wire was released out at a speed of 0.2 to

0.3m/sec. until the multiple corer reaches the bottom.

4) After confirmation of the reaching the bottom, the wire was released out more 5 meters. Then we wait for 15 seconds to the corer was operated.

5) The rewinding was started at a slow speed (0.2 to 0.3m/sec.). After the multiple corer leaves the bottom, winch speed was gradually increased up to about 1.2m/sec. The swell-compensator was stopped at the multiple corer reached a 200m depth.

#### 4.2.2 Piston corer system

This system collects sediments from seafloor. It is compose of weight, barrels, inner tubes, piston, catcher, and bit. The barrel is made of aluminum, so that measurements of magnetic properties are available. The 20m-long aluminum pipe is consist of four 5m segments and each segment is combined by stainless joint sleeve. The polycarbonate inner tube is inserted the aluminum pipes to avoid coring disturbance and keeping the high quality measurements for the Multi-Sensor Core Logger.

#### Specifications for the system

#### 1) Piston corer

Specification of the inner tube type piston corer system is shown below.

Weight: 1250kg Materials: Stainless, Lead Outer pipe: Material; Aluminum Length; 5m Inner diameter; 80mm Outer diameter; 92mm Inner tube: Material; Polycarbonate Length; 5m Inner diameter; 74mm Outer diameter; 78mm

2) Pilot; Ashura corer

We used a multiple-type core sampler so-call "Ashura", which has a 90kg-weight and three acryl pipes of 60cm long and 74mm in I.D. as same as Multiple core sampler.

Weight: 90kg Sampling barrel: Material; Acryl Length; 60cm Inner diameter; 74mm Outer diameter; 80mm

3) Compass and tilt sensor

In this cruise, the compass and tilt sensor was attached in the head of the piston corer weight as additional equipment. Specifications show below.

Weight: 9.5kg (in air), 4.5kg (in water) Sensor: Hall device compass, 2 axes tilt sensor and Depth sensor Material of Hardware: Titanium alloy Size: 100mm diameter and 604mm length Available depth: 7000m

This sensor measured for all piston core site. Sampling interval is 1 second for PC-01 and 0.5 seconds for PC-02 and PC-03. All results are plotted in Fig. 4.2-5 to Fig. 4.2-16.

1	Number of PC	Sensor	
Fig. 4.2-5. I	PC-01 (whole)	Direction and I	Depth
Fig. 4.2-6. I	PC-01 (100m above the bottor	n) Direction and I	Depth
Fig. 4.2-7. I	PC-01 (whole)	Inclination and	Depth
Fig. 4.2-8. I	PC-01 (100m above the bottor	n) Inclination and	Depth
Fig. 4.2-9. I	PC-02 (whole)	Direction and I	Depth
Fig. 4.2-10.	PC-02 (100m abov	e the bottom) Dire	ection and Depth
Fig. 4.2-11.	PC-02 (whole)	Incl	ination and Depth
Fig. 4.2-12.	PC-02 (100m abov	e the bottom) Incl	ination and Depth
Fig. 4.2-13.	PC-03 (whole)	Dire	ection and Depth
Fig. 4.2-14.	PC-03 (100m abov	e the bottom) Dire	ection and Depth
Fig. 4.2-15.	PC-03 (whole)	Incl	ination and Depth
Fig. 4.2-16.	PC-03 (100m abov	e the bottom) Incl	ination and Depth

Piston core operation as follow.

- (1): Started operation
- (2): Trigger on surface
- (3): Stopped wire out supplying the swell-compensator
- (4): Restarted wire out
- (5): Stopped wire out to reduce pendulum motions of the system
- (6): Restarted wire out slowly
- (7): Piston core hit the bottom
- (8): Piston core left the bottom
- (9): Stopped wire in stopping the swell-compensator
- (10): Restarted wire in
- (11): Trigger off surface
- (12): Piston core off surface
- (13): Piston core on deck

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

1)At first the sampler systems are descended at a slow winch speed by a 200-700m depth, and the swell-compensator is supplied. Then, the speed is gradually increased to a maximum of 1m/sec.

2) The winch operation is stopped at a depth of 100m above the bottom for several minutes (3-5min.) to reduce pendulum motions of the system.

3) 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.

4) After confirmation of the reaching the bottom and passing for about 2 seconds, the winch is stopped and is changed into wire-in.

5) The rewinding is started at a slow speed (0.2 to 0.3m/sec.). After the sampler leaves the bottom, winch speed is gradually increased up to about 1.2m/sec. The swell-compensator will be stopped if the system reaches a 200m depth.

#### 4.3 Site Survey

Site survey was conducted using SEABEAM 2100 system with a 4 kHz sub-bottom profiler (SBP) equipped on R/V *Mirai*. Seabeam maps for Stations 7-8 (Fig. 4.3-1) and Station 9 (Fig.4.3-2) were constructed for determination of coring points. Sub-bottom profiles at coring sites are shown in Fig.4.3-3 to Fig. 4.3-5.

#### 4.4 Coring point

Sediment coring was conducted at three stations using multiple corer and 20-m piston coring system. Geographic positions of cored locations are listed below.

			Longitude	Depth	Length
Station	Core ID	Latitude*	*	(m)	(cm)**
	MR04-06	42°08.64'	141°42.07		
7	MC-1	Ν	' E	775	30
	MR04-06	42°08.53'	141°42.03		
7	PC-1	Ν	' E	777	1760
	MR04-06	42°14.72'	141°37.42		
8	MC-2	Ν	' E	604	31
	MR04-06	42°14.72'	141°37.41		
8	PC-2	Ν	' E	606	1222
	MR04-06	42° 03.10'	142°41.17		
9	MC-3	Ν	' E	1726	31
	MR04-06	41°03.14'	142°41.16		
9	PC-3	Ν	' E	1725	1182

 Table. 4.4.1
 Summary of sediment samples obtained during MR04-06 cruise

\* WGS-84 was used for positioning; \*\* void space uncorrected

#### 4.5 Methods and Preliminary results

#### 4.5.1 Core Handling

After retrieving the corer on deck, piston core tube was sectioned into every 1m in length using the inner tubes filled sediments are cut into 1m long sections using a handy-cutter. After carrying the sections into wet-laboratory, routine analysis was performed as following order:

Whole-round sections were equilibrated at room temperature, and then run through Multi-sensor core logger (MSCL).

The sections are longitudinally cut into working and archives halves by a splitting devise with a stainless steel wire. After splitting, both cores are putted white pins at interval of 2cm and blue pins at interval of 10cm. After splitting, two halves of cores were first scraped across to expose a fresh surface for visual core description and color reflectance measurement, and then sediments were photographed with a digital camera.

Slab samples of 1cm thick were taken for soft X-ray photograph using a plastic case of 20cm-long and 3cm –wide from archive halves.

After this process, each half of the samples were placed into plastic bags, and then sealed. The archive halves were transferred to a cold storage aboard the R/V MIRAI. After the cruise, the archive halves are going to be stored at a storage of MIO-JAMSTEC under  $4^{\circ}$ . The working halves were processed for routine sampling as requested by researcher.

In the case of multiple and pilot core materials, at least one sub-core in each site was processed for on-board routine analysis. The remaining sub-cores were sliced in every 1 or 2cm, which depended on researcher.

#### 4.5.2 Multi-Sensor Core Logging

#### S. Araki and K. Yoshida

Gamma-ray attenuation (GRA), P-wave velocity (PWV) and magnetic susceptibility (MS) were measured on whole-core section before splitting using the onboard GEOTEK multi-sensor core logger (MSCL).

A short PWV is 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 0.1mm. After suitable calibration procedures have been followed the PWV velocity can be calculated with a resolution of about  $1.5 \text{ms}^{-1}$ . The accuracy of the measurements will largely depend on any variations in liner wall thickness. However, experience has shown that an absolute accuracy of  $\pm 3 \text{ms}^{-1}$  is normally achievable with some care.

The principle of GRA is based on the facts that medium-energy gamma rays (0.1-1Mev) interact with the formation material by Compton scattering, that the elements of most rock-forming minerals have similar Compton mass attenuation coefficients, and that the electron measured density can easily be related to the material bulk density. The <sup>137</sup>Cs source used transmits gamma rays at 660 KeV. A standard NaI scintillation detector is used in conjunction

with a universal counter. GRA calibration assumes a two-phase system model for sediments and rocks, where the two phases are the minerals and the interstitial water. Aluminum has an attenuation coefficient similar to common minerals and is used as the mineral phase standard. Pure water is used as the interstitial-water phase standard. The actual standard consists of a telescoping aluminum rob (five elements of varying thickness) mounted in a piece of core liner and filled with distilled water. GRA measurement was carried on every 1 or 2 cm whole core with 20 seconds counting. GRA data provide wet bulk density and fractional porosity for core thickness is constant (74 mm).

MS was measured using Bartington MS2C system installed in 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<sup>-5</sup> (SI, volume specific). The loop sensor has an internal diameter of 100mm. It operates at a frequency of 0.565kHz and an alternating field (AF) intensity of 80 A/m (=0.1mT). MS data measurement was also carried on every 1 or 2 cm whole core with 1 second. All results are processed to eliminate data gaps between sections and then plotted in Fig.4.5-1 to Fig.4.5-4.

#### 4.5.3 Color reflectance

#### H. Hayashi and T. Ueno

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 zero and white calibration pieces (Minolta CM-2002 standard accessories) before measurement of core samples. Color reflectance of working half cores was measured on every 2 cm through clear crystal polyethylene wrap.

The color reflectance data are shown by parameters of L\*, a\*, and 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 chromaticness. The plus and minus values of a\* correspond reddish and greenish, respectively. For b\* value, plus values correspond to yellow, and minus ones to blue. The Munsell colors (H: hue, V: value, C: chroma) and spectral data were also available as the result of the measurements. Spectral data can be used to estimate the abundance of certain components of sediments. The results of this curse are shown in Fig.4.5-1 to Fig.4.5-4.

#### 4.5.4 Core Photographs

#### K. Yoshida

After splitting each sections of piston, pilot and multiple cores into working and archive halves, sectional photographs of working halves were taken using a Nikon single-lens digital camera. Shutter speed was selected on 1/25 and sensitivity ISO 400 was used. The photos are shown by Fig. 4.5-5 to 4.5-19.

#### 4.5.5 Visual Core Description

N. Ahagon, K. Ohkushi and A. Shibahara

Working halves of cores were first scraped across to expose a smooth, fresh surface, and then described visually using a standard Visual Core Description form. In this cruise, 3 multiples and 3 piston cores were obtained at three stations (7, 8 and 9). The sediment at St.8 (the most closest site to the land), is generally composed of olive gray diatom-bearing silt, and characterized by abundant white pumice grains. The sediment at St.7 (approximately 10 km southeast from St.8) is mainly composed of diatom bearing silty clay. Thin volcanic ash layers and pumiceous layers are often intercalated. The sediment at St.9, continental slope off Hachinohe, is characterized by olive gray diatom-bearing clayey silt to silty clay. Lithological summaries of each cores are shown in Fig. 4.5.5-1 to 4.5.5-3.




























Fig.4.3.1 Stations 7 and 8



Fig.4.3.2 Station 9



Fig.4.3-3 Sub-bottom profile for Station 7.



Fig.4.3-4 Sub-bottom profile for Station 8.



Fig.4.3-5 Sub-bottom profile for Station 9.



Fig.4.5-1 MSCL and Color reflectance results of MR04-06 MC-01(HAND8), MC-02(HAND8) and MC-03(HAND8)



Fig.4.5-2 MSCL and Color reflectance results of MR04-06 PL-01(HAND1) & PC-01



Fig.4.5-3 MSCL and Color reflectance results of MR04-06 PL-02(HAND1) & PC-02



Fig.4.5-4 MSCL and Color reflectance results of MR04-06 MC-03(HAND8) & PC-03



Fig. 4.5-5. Core photograph of MC-01 HAND-8  $(F\!-\!4.5).$ 



Fig. 4.5-6. Core photograph of MC-02 HAND-8 (F=4.5).



Fig. 4.5-7. Core photograph of MC-03 IIAND-8 (F=5).



Fig. 4.5-8. Core photograph of PC-01 Sec. 1-5 (T=4.5).



Fig. 4.5-9. Core photograph of PC-01 Sec. 6-10 (F=4.5).



Fig. 4.5-10. Core photograph of PC-01 Sec. 11-15 (F=4.5).



Fig. 4.5-11. Core photograph of PC-01 Sec. 16-19 (C.C. (T-4.5).



Fig. 4.5-12. Core photograph of PC-02 Sec. 1-5 (F-4.5).



Fig. 4.5-13. Core photograph of PC-02 Sec. 6-10 (F–5).



Fig. 4.5-14. Core photograph of PC-02 Sec. 11-14 (F=5).



Fig. 4.5-15. Core photograph of PC-03 Sec. 1-5 (T-15).



Fig. 4.5-16. Core photograph of PC-03 Sec. 6-10 (P=5).



Fig. 4.5-17. Core photograph of PC-03 Sec. 11-12 ( C.C. (F-5).



Fig. 4.5-18. Care photograph of PL-01 HAND-1 (F=4.5).



Fig. 4.5-19. Core photograph of PL-02 IIAND-1 (F=5).

## 5. Geophysical observation 5.1 Swath Bathymetry

Makio HONDA(JAMSTEC) : Principal InvestigatorNaokazu AHAGON(JAMSTEC)Wataru TOKUNAGA(Global Ocean Development Inc.)Ryo KIMURA(GODI)Not on-board:Toshiya FUJIWARA(JAMSTEC)

#### (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. Sub Bottom Profiler (SBP) is an add-on option to the "SEABEAM 2100". SBP subsystem collects vertical sediments information.

The major objective of MNBES is site survey so that we have gathered necessary bathymetric and sub-sediment information around the core sampling point. And also, the other objective is collecting continuous bathymetry data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

### (2) Data Acquisition

The "SEABEAM 2100" on R/V MIRAI was used for bathymetry mapping during MR04-06 cruise from 20:04UTC 14 October 2004 to 02:03UTC 07 November 2004 except for EEZ of the USA and Russia. 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, XCTD and XBT. 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, which measuring sound velocity in the surface intake water continuously.

Obvious bad data was flagged automatically by real-time data screening function of the system.

Table 5.1 listed system configuration and performance of SEABEAM 2112.004 system and SBP subsystem.

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		

Table 5.1	System	configuration	and	performance
-----------	--------	---------------	-----	-------------

100 degree to 6,000 m
90 degree to 11,000 m
Within $< 0.5\%$ of depth or $+/-1m$ ,
whichever is greater, over the entire swath.
(Nadir beam has greater accuracy; typically within $< 0.2\%$ of
depth or +/-1m, whichever is greater)

## Sub-Bottom Profiler (4kHz system)

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

### (3) Preliminary Results

We carried out survey at the Station No.7 and Station No.8, and Station No.9 for core sampling sites. The results of survey are shown in 4.4. Site survey

### (4) Data Archives

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

# (5) Remarks

- The values of SSV were not updated as follows (UTC); 1500.00 m/s; 29/October/2004 04:41 - 31/October/2004 09:12 1514.24 m/s; 31/October/2004 09:18 - 20:24 31
- 2) Position data was not collected as following periods (UTC);

2) 1 05111011 data was not c	onected as following periods (01C),
21/October/2004	16:38:42 - 16:39:28, 16:40:08 - 16:40:44
26/October/2004	00:07:49 - 00:07:55, 12:12:37 - 12:12:43
28/October/2004	20:38:49 - 20:38:55, 21:09:02 - 21:09:08, 10:31:23 - 10:31:33
29/October/2004	18:10:34 - 18:10:40, 18:11:20 - 18:11:26
04/November/2004	01:01:15 - 01:01:31, 01:07:35 - 01:07:51, 10:07:00 - 10:07:06,
	10:07:19 - 00:07:51, 14:35:39 - 14:36:37, 14:36:45 - 14:36:53,
	18:33:59 - 18:34:05, 18:36:17 - 18:36:23, 18:36:59 - 18:37:05,
	19:28:09 - 19:28:15, 19:33:59 - 19:34:05, 19:34:23 - 19:34:31,
	19:58:48 - 19:58:56, 22:25:06 - 22:25:12, 22:55:21 - 22:55:27,
	22:56:59 - 22:57:05, 22:57:21 - 22:57:27, 23:11:43 - 23:11:49,
	23:23:44 - 23:23:50, 23:26:34 - 23:26:40, 23:27:06 - 23:27:12,
	23:27:24 - 23:27:30
05/November/2004	00:21:06 - 00:21:12, 00:23:36 - 00:23:42, 00:29:49 - 00:29:55,
	21:56:07 - 21:56:13
06/November/2004	10:27:17 - 10:27:23, 13:08:56 - 13:09:02
07/November/2004	23:51:33 - 23:51:39, 23:52:17 - 23:52:23, 23:52:49 - 23:52:55,
	23:53:07 - 23:53:13, 23:53:23 - 23:53:31





# 5.3 Sea Surface Three-component Magnetic Field

(1) Introduction

Measurements of magnetic force on the sea are required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure.

We measured geomagnetic field using a three-component magnetometer during the MR04-06 cruise from 14 October 2004 to 9 November 2004 except in EEZ of the U.S.A. and Russia.

(2) Parameters

Three-component magnetic force (nT) Ship's attitude (1/100deg)

## (3) Data Acquisition and Instruments

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

(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

- For calibration of the ship's magnetic effect, we made a running (a pair of clockwise and anti-clockwise rotation). The periods were as follows (UTC);
  - 23/October/2004 02:16 02:42
- 3/November/2004 02:07 02:34 2) Position data was not collected as following periods (UTC):

2)	Position data was not con	ected as following periods (01C),
	21/October/2004	16:38:42 - 16:39:28, 16:40:08 - 16:40:44
	26/October/2004	00:07:49 - 00:07:55, 12:12:37 - 12:12:43

28/October/2004	20:38:49 - 20:38:55, 21:09:02 - 21:09:08, 10:31:23 - 10:31:33
29/October/2004	18:10:34 - 18:10:40, 18:11:20 - 18:11:26
4/November/2004	01:01:15 - 01:01:31, 01:07:35 - 01:07:51, 10:07:00 - 10:07:06,
	10:07:19 - 00:07:51, 14:35:39 - 14:36:37, 14:36:45 - 14:36:53,
	18:33:59 - 18:34:05, 18:36:17 - 18:36:23, 18:36:59 - 18:37:05,
	19:28:09 - 19:28:15, 19:33:59 - 19:34:05, 19:34:23 - 19:34:31,
	19:58:48 - 19:58:56, 22:25:06 - 22:25:12, 22:55:21 - 22:55:27,
	22:56:59 - 22:57:05, 22:57:21 - 22:57:27, 23:11:43 - 23:11:49,
	23:23:44 - 23:23:50, 23:26:34 - 23:26:40, 23:27:06 - 23:27:12,
	23:27:24 - 23:27:30
5/November/2004	00:21:06 - 00:21:12, 00:23:36 - 00:23:42, 00:29:49 - 00:29:55,
	21:56:07 - 21:56:13,
6/November/2004	10:27:17 - 10:27:23, 13:08:56 - 13:09:02
7/November/2004	23:51:33 - 23:51:39, 23:52:17 - 23:52:23, 23:52:49 - 23:52:55,
	23:53:07 - 23:53:13, 23:53:23 - 23:53:31

## 6. Satellites Observation (NOAA HRPT: Sea surface temperature and IR)

Makio HONDA(JAMSTEC): Principal InvestigatorWataru TOKUNAGA(Global Ocean Development Inc.)Ryo KIMURA(GODI)

#### (1) Objectives

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

#### (2) Method

We receive the down link High Resolution Picture Transmission (HRPT) signal from NOAA satellites by the same way as the signal of OrbView-2. We processed the HRPT signal with the in-flight calibration and computed the sea surface temperature by the Multi-Channel Sea Surface Temperature (MCSST) method. A daily composite map of MCSST data is processed for each day on the R/V MIRAI for the area, where the R/V MIRAI located.

We received and processed NOAA data throughout MR04-06 cruise from the departure of Dutch Harbor on 17:00UTC 14 October 2004 to the arrival at Sekinehama on 00:00UTC 9 November 2004.

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

#### (3) Preliminary results

Fig.6-1 shows MCSST composite image during this cruise from 14 October 2004 to 8 November 2004 at the Northern-west Pacific Ocean.

#### (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.6-1 MCSST composite image at Northern-west Pacific Ocean.

# Appendix

# **CTD / CMS bottle list and routine data**
	Start	
Date/Time:	2004.10.18 1:10	(UTC)
Lat.:	51-00.45N	
Long.:	164-59.32E	
Depth (m):	4801.0	

Remarks:	Cast for Routine
file name:	K01m01

			CTD data			Autosal		Chemical ar	alysis (unco	orrected da	ta)		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[PSU]	[. C]	[kg/m^3]	(psu)	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg
0	0.0	0.0				32.819	296.32	2239.9	2047.4	0.27	13.40	1.33	22.63
24	9.3	9.4	32.813	7.549	25.621	32.816	296.29	2225.3	2047.1	0.25	13.41	1.32	22.65
26	9.5	9.6	32.813	7.550	25.620								
23	29.7	30.0	32.814	7.535	25.624	32.837	296.93	2226.3	2052.7	0.26	14.15	1.37	23.58
22	49.5	50.0	33.125	2.640	26.422	33.140	314.58	2237.3	2132.9	0.08	26.01	2.08	40.76
21	75.0	75.6	33.162	1.954	26.503	33.175	308.53	2238.3	2145.2	0.01	27.53	2.17	45.36
20	99.1	100.0	33.193	1.409	26.565	33.214	302.55	2241.3	2155.2	0.01	28.81	2.25	49.73
19	124.9	126.0	33.332	1.910	26.642	33.376	243.71	2279.5	2194.5	0.01	32.63	2.47	60.61
18	149.2	150.5	33.594	3.098	26.755	33.612	133.92	2272.1	2257.6	0.01	38.37	2.81	77.02
17	199.9	201.7	33.823	3.668	26.884	33.831	59.72	2290.8	2309.8	0.01	42.60	3.07	93.32
16	250.1	252.4	33.940	3.808	26.963	33.945	31.89	2300.8	2329.50	0.01	44.12	3.15	98.97
15	300.0	302.8	34.012	3.729	27.029	34.024	23.95	2311.7	2339.5	0.01	44.25	3.17	106.11
14	399.3	403.2	34.119	3.557	27.132	34.123	18.51	2326.9	2352.7	0.00	44.28	3.17	117.61
36	499.3	504.3	34.194	3.378	27.209								
13	499.7	504.6	34.193	3.379	27.208	34.195	16.05	2337.6	2362.7	0.00	44.22	3.16	126.08
2	599.9	606.0	34.262	3.295	27.272								
12	599.9	606.0	34.262	3.297	27.271	34.265	15.80	2344.7	2365.6	0.00	44.13	3.18	131.18
35	750.2	758.1	34.326	2.955	27.355								
11	800.3	808.9	34.345	2.890	27.376	34.347	15.29	2367.9	2380.9	0.00	44.22	3.18	147.17
10	1000.0	1011.2	34.420	2.612	27.461	34.420	19.79	2381.9	2388.8	0.00	44.03	3.17	155.98
34	1000.7	1012.0	34.419	2.619	27.459								
9	1498.8	1517.4	34.540	2.107	27.602	34.542	44.16	2400.2	2387.9	0.00	42.73	3.05	168.69
33	1499.0	1517.6	34.540	2.108	27.602								
32	1999.4	2026.7	34.605	1.812	27.680								
8	1999.6	2026.9	34.605	1.812	27.680	34.607	74.91	2410.6	2376.05	0.00	40.95	2.92	170.85
7	2500.2	2537.3	34.643	1.627	27.726	34.645	103.87	2414.7	2358.1	0.00	39.05	2.78	167.04
31	2500.5	2537.6	34.643	1.627	27.726								
6	3000.3	3048.4	34.664	1.529	27.753	34.665	126.80	2412.9	2345.1	0.00	37.69	2.66	159.34
30	3000.9	3049.0	34.664	1.529	27.753								
5	3501.5	3561.8	34.676	1.477	27.770	34.678	140.18	2418.5	2334.6	0.00	36.81	2.59	154.93
29	3502.7	3563.0	34.676	1.477	27.770								
4	4006.3	4080.1	34.682	1.472	27.779	34.684	148.50	2413.6	2328.0	0.00	36.32	2.54	153.05
28	4010.9	4084.9	34.682	1.472	27.779								
3	4500.9	4589.1	34.686	1.493	27.785	34.689	153.48	2414.6	2323.2	0.00	35.89	2.51	152.69
27	4501.2	4589.4	34.686	1.493	27.785	34.688							
25	4785.3	4882.3	34.688	1.514	27.787								
1	4785.6	4882.6	34.688	1.514	27.787	34.689	155.40	2415.4	2323.80	0.01	35.71	2.50	153.43

	Start
Date/Time:	2004.10.18 8:30 (UTC)
Lat.:	51-01.38N
Long.:	164-54.45E
Depth (m):	5222.0

Remarks: Cast for Trace metal file name: K01m02

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[.C]	[kg/m^3]
36	4.9	5	32.808	7.618	25.607
35	9.2	9.3	32.808	7.622	25.607
34	24.0	24.2	32.807	7.615	25.607
33	49.7	50.1	33.151	2.356	26.462
32	74.3	74.9	33.146	1.324	26.534
31	99.0	99.9	33.281	1.974	26.596
30	124.2	125.4	33.448	2.621	26.679
29	149.0	150.4	33.641	3.288	26.775
28	174.7	176.3	33.772	3.659	26.844
27	200.0	201.9	33.855	3.797	26.896
26	250.4	252.7	33.963	3.779	26.984
25	301.6	304.5	34.012	3.701	27.032

	Start	Remarks: Cast for Primary Productivity
Date/Time:	2004.10.18 17:57 (UTC)	
Lat.:	50-59.97N	
Long.:	164-59.75E	file name: K01m03
Depth (m):	4816.0	

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[.C]	[kg/m^3]
7	8.2	8.3	32.792	7.730	25.579
8	13.6	13.7	32.792	7.732	25.579
9	22.0	22.2	32.793	7.734	25.579
10	29.5	29.8	32.793	7.734	25.580
11	36.9	37.2	32.793	7.734	25.579
12	47.2	47.6	33.061	3.865	26.259
13	59.0	59.5	33.143	2.550	26.440

	Start
Date/Time:	2004.10.19 21:44 (UTC)
Lat.:	49-59.86N
Long.:	160-00.33E
Depth (m):	5201.0

Remarks: Cast for trace metal and RM (Nuts) file name: K02m01

			CTD data			Autosal
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q	Salinity
	[m]	[db]	[PSU]	[.C]	[kg/m^3]	(psu)
36	9.3	5.9	32.781	8.595	25.443	
35	9.5	9.9	32.781	8.582	25.445	
34	29.7	25.1	32.781	8.566	25.448	
33	49.5	50.0	32.795	8.101	25.530	
32	75.0	76.2	33.085	3.083	26.348	
31	99.1	99.9	33.167	1.673	26.527	
30	124.9	124.8	33.227	1.567	26.583	
29	149.2	151.1	33.454	2.313	26.709	
28	199.9	175.8	33.716	3.330	26.831	
27	250.1	201.6	33.776	3.204	26.890	
26	300.0	252.2	33.905	3.347	26.980	
25	399.3	303.8	33.989	3.366	27.046	
24	499.3	1522.9	34.548	2.062	27.612	34.551
23	499.7	1522.7	34.548	2.062	27.613	
22	599.9	1522.8	34.548	2.062	27.613	
21	599.9	1522.7	34.548	2.061	27.613	
20	750.2	1522.1	34.548	2.061	27.613	
19	800.3	1521.9	34.548	2.061	27.613	
18	1000.0	1522.3	34.548	2.061	27.613	
17	1000.7	1522.3	34.548	2.061	27.613	
16	1498.8	1522.5	34.549	2.061	27.613	34.551
15	1499.0	1521.9	34.549	2.061	27.613	
14	1999.4	1521.6	34.548	2.061	27.613	
13	1999.6	1522.2	34.549	2.061	27.613	
12	2500.2	1522.3	34.549	2.060	27.613	
11	2500.5	1521.9	34.549	2.060	27.613	
10	3000.3	1522.0	34.549	2.060	27.613	
9	3000.9	1521.8	34.549	2.060	27.613	
8	3501.5	1520.7	34.548	2.061	27.613	34.551
7	3502.7	1520.8	34.548	2.061	27.613	
6	4006.3	1520.2	34.548	2.062	27.613	
5	4010.9	1519.7	34.548	2.062	27.612	
4	4500.9	1520.2	34.548	2.062	27.612	
3	4501.2	1519.6	34.548	2.062	27.612	
2	4785.3	1519.7	34.548	2.062	27.612	
1	4785.6	1519.4	34.548	2.063	27.612	

	Start
Date/Time:	2004.10.20 0:33 (UTC)
Lat.:	47-00.24N
Long.:	159-59.58E
Depth (m):	5188.0

Remarks: Cast for RM (Nuts) file name: K02m02

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[.C]	[kg/m^3]
36	1511.5	1529.8	34.545	2.081	27.608
35	1510.9	1529.2	34.544	2.082	27.608
34	1510.9	1529.1	34.544	2.082	27.608
33	1510.9	1529.2	34.544	2.082	27.608
32	1510.8	1529.0	34.544	2.082	27.608
31	1510.8	1529.0	34.544	2.082	27.608
30	1510.1	1528.3	34.544	2.082	27.608
29	1509.8	1528.0	34.544	2.082	27.608
28	1509.5	1527.7	34.544	2.082	27.608
27	1509.3	1527.5	34.544	2.082	27.608
26	1509.0	1527.2	34.544	2.082	27.608
25	1509.8	1528.0	34.544	2.082	27.608
24	1508.8	1527.0	34.544	2.083	27.607
23	1508.6	1526.8	34.544	2.083	27.607
22	1508.4	1526.6	34.544	2.083	27.607
21	1507.9	1526.1	34.544	2.083	27.607
20	1508.5	1526.7	34.544	2.083	27.607
19	1507.8	1526.0	34.544	2.083	27.607
18	1507.0	1525.1	34.544	2.084	27.607
17	1507.6	1525.7	34.544	2.083	27.607
16	1506.9	1525.0	34.544	2.084	27.607
15	1506.9	1525.0	34.544	2.084	27.607
14	1506.1	1524.3	34.544	2.084	27.607
13	1506.7	1524.9	34.544	2.084	27.607
12	1505.3	1523.5	34.543	2.085	27.607
11	1506.0	1524.1	34.544	2.084	27.607
10	1505.6	1523.7	34.543	2.085	27.607
9	1504.8	1523.0	34.543	2.085	27.607
8	1504.8	1522.9	34.543	2.085	27.607
7	1504.4	1522.5	34.543	2.086	27.606
6	1504.0	1522.2	34.543	2.086	27.606
5	1503.8	1521.9	34.543	2.086	27.606
4	1503.6	1521.7	34.543	2.087	27.606
3	1503.2	1521.3	34.543	2.087	27.606
2	1502.9	1521.0	34.543	2.087	27.606
1	1502.0	1520.1	34.543	2.087	27.606

	Start	
Date/Time:	2004.10.20 4:29	(UTC)
Lat.:	46-59.01N	
Long.:	159-58.92E	
Depth (m):	5222.0	

Remarks: Cast for Routine and Trace metal	
file name: K02m03	
me name. Rozmos	

			CTD data			Autosal		Chemical ar	alysis (unco	orrected da	ta)		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[PSU]	[.C]	[kg/m^3]	(psu)	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg
0	0.0					32.787	291.404	2221.8	2041.3	0.330	12.875	1.250	23.175
24	9.8	9.9	32.776	8.781	25.411	32.780	291.824	2222.9	2040.3	0.310	12.700	1.240	23.055
23	29.7	29.9	32.777	8.710	25.423	32.784	291.245	2224.6	2043.4	0.320	12.845	1.245	23.225
22	49.6	50.0	32.982	4.992	26.078	33.025	307.969	2230.8	2110.5	0.275	22.010	1.810	36.040
21	74.2	74.9	33.134	2.173	26.463	33.146	316.827	2237.2	2140.9	0.010	25.670	2.025	44.085
20	99.5	100.4	33.199	1.566	26.561	33.197	306.919	2238.9	2153.8	0.010	27.330	2.135	48.920
19	124.3	125.4	33.373	2.004	26.669	33.411	218.742	2256.1	2212.8	0.005	33.120	2.485	64.815
18	149.9	151.2	33.648	2.998	26.807	33.662	115.499	2277.9	2277.1	0.010	39.470	2.865	83.210
17	199.2	201.0	33.845	3.341	26.932	33.853	47.738	2292.3	2326.1	0.005	43.870	3.125	98.680
16	249.0	251.2	33.938	3.400	27.001	33.943	31.012	2304.2	2339.6	0.010	44.550	3.175	106.230
15	299.4	302.1	33.995	3.363	27.051	34.003	27.572	2312.9	2344.6	0.010	44.385	3.175	111.660
14	400.4	404.1	34.121	3.317	27.156	34.125	20.939	2329.6	2355.8	0.000	44.280	3.165	122.780
13	499.3	504.1	34.204	3.216	27.233	34.207	17.481	2343.8	2363.7	0.005	44.315	3.145	131.220
36	499.4	504.2	34.204	3.216	27.233								
12	600.2	606.1	34.270	3.063	27.300	34.274	17.357	2353.5	2371.3	0.000	44.135	3.165	138.165
35	749.4	757.0	34.347	2.855	27.381								
11	801.4	809.7	34.367	2.789	27.403	34.369	17.651	2370.2	2383.4	0.000	44.175	3.165	150.145
34	1000.1	1010.9	34.439	2.512	27.485								
10	1000.9	1011.7	34.439	2.512	27.485	34.441	23.512	2384.3	2387.9	0.005	43.815	3.140	159.105
33	1499.7	1517.7	34.551	2.053	27.615								
9	1499.8	1517.9	34.551	2.053	27.615	34.553	50.735	2402.4	2385.6	0.000	42.245	3.020	169.525
32	1999.1	2025.6	34.611	1.789	27.686								
8	2000.1	2026.6	34.611	1.789	27.686	34.613	78.635	2410.1	2371.3	0.000	40.655	2.890	170.040
31	2500.3	2536.4	34.647	1.606	27.732								
7	2500.4	2536.6	34.648	1.606	27.732	34.650	109.852	2413.6	2354.1	0.000	38.785	2.740	162.920
30	3000.3	3047.3	34.666	1.515	27.756								
6	3000.4	3047.4	34.666	1.515	27.756	34.668	129.126	2413.2	2340.6	0.000	37.590	2.640	157.390
5	3499.2	3558.2	34.676	1.474	27.771	34.677	141.494	2411.0	2333.1	0.000	36.755	2.575	153.885
29	3499.5	3558.5	34.676	1.474	27.771								
4	4000.3	4072.5	34.684	1.455	27.782	34.686	150.997	2411.8	2325.7	0.000	36.100	2.520	150.805
28	4001.0	4073.1	34.684	1.455	27.782	34.686							
3	4500.1	4586.6	34.687	1.478	27.787	34.689	155.577	2413.0	2320.9	0.000	35.825	2.495	150.290
27	4501.0	4587.5	34.687	1.479	27.787								
2	5000.3	5102.3	34.689	1.525	27.789	34.691	157.917	2411.0	2320.3	0.000	35.650	2.485	149.880
26	5000.4	5102.4	34.689	1.525	27.789								
1	5193.1	5301.4	34.690	1.546	27.790	34.691	158.223	2410.4	2319.2	0.005	35.595	2.480	150.300
25	5193.6	5301.9	34.690	1.546	27.790								

	Start
Date/Time:	2004.10.20 17:56 (UTC)
Lat.:	44-29.91N
Long.:	160-00.14E
Depth (m):	5934.0

Remarks: Cast for primary productivity

file name: K02m04

		CTD data					
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q		
	[m]	[db]	[PSU]	[.C]	[kg/m^3]		
4.1	4.1	4.1	33.028	12.245	25.012		
9.4	9.3	9.4	33.028	12.246	25.012		
19.2	19.0	19.2	33.027	12.234	25.014		
19.4	19.2	19.4	33.028	12.244	25.012		
27.6	27.3	27.6	33.007	11.753	25.095		
35.0	34.7	35.0	33.128	6.877	25.961		
45.6	45.3	45.6	33.199	3.503	26.401		
53.9	53.5	53.9	33.260	3.127	26.485		

	Start
Date/Time:	2004.10.25 20:55 (UTC)
Lat.:	38-59.87N
Long.:	160-00.52E
Depth (m):	5503.0

Remarks: Cast for Trace metal file name: K03m01

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[.C]	[kg/m^3]
36	5.0	5.1	34.373	20.034	24.2750
35	10.2	10.3	34.374	20.023	24.2790
34	24.5	24.7	34.371	20.027	24.2768
33	50.0	50.4	34.180	18.854	24.4345
32	76.0	76.6	34.445	15.291	25.4832
1	100.5	101.3	34.419	13.332	25.8790
2	101.1	101.9	34.423	13.330	25.8822
31	102.4	103.2	34.429	13.336	25.8860
30	125.9	126.9	34.363	12.129	26.0733
29	148.6	149.8	34.307	11.317	26.1817
28	174.2	175.6	34.234	10.462	26.2782
27	199.5	201.1	34.143	9.581	26.3568
26	250.2	252.3	34.034	8.375	26.4631
25	304.3	306.8	33.860	6.721	26.5617

	Start	
Date/Time:	2004.10.26 0:31 (UTC)	
Lat.:	38-58.16N	
Long.:	160-01.36E	
Depth (m):	5511.0	

Remarks:	Cast for Primary Productivity
file name:	K03m02

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[.C]	[kg/m^3]
7	6.7	6.7	34.331	19.951	24.265
6	17.6	17.7	34.331	19.951	24.265
5	33.5	33.7	34.331	19.954	24.265
4	45.8	46.2	34.331	19.956	24.265
3	57.4	57.8	34.331	19.928	24.274
2	74.0	74.6	34.450	16.833	25.134
1	84.6	85.2	34.460	14.953	25.568

	Start	
Date/Time:	2004.10.26 9:01	(UTC)
Lat.:	38-59.84N	
Long.:	160-00.14E	
Depth (m):	5509.0	

Remarks: Cast for Routine and Trace metal	
file name: K03m03	
file name: K03m03	

			CTD data			Autosal		Chemical ar	nalysis (unco	orrected da	ta)		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[PSU]	[.C]	[kg/m^3]	(psu)	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg
0	0.0	0.0				34.351	227.840	2267.7	1984.0	0.015	0.075	0.075	2.170
24	9.5	9.5	34.293	19.799	24.277	34.307	228.970	2265.7	1981.2	0.000	-0.015	0.060	2.160
23	30.4	30.7	34.344	19.903	24.289	34.344	228.450	2268.7	1983.1	0.000	0.000	0.060	2.150
22	49.4	49.8	34.341	19.774	24.322	34.338	229.380	2265.2	1988.4	0.010	0.135	0.070	2.405
21	73.6	74.2	34.446	14.837	25.587	34.451	198.185	2274.9	2066.1	0.050	8.830	0.630	11.320
20	100.4	101.2	34.433	13.188	25.920	34.417	186.440	2274.0	2097.1	0.010	13.165	0.920	18.010
19	123.9	124.9	34.358	12.159	26.063	34.349	192.200	2272.4	2102.2	0.005	13.960	0.990	19.575
18	149.9	151.1	34.294	11.179	26.198	34.286	210.630	2271.7	2103.5	0.010	14.030	1.000	19.755
17	199.6	201.2	34.147	9.549	26.366	34.143	227.085	2268.8	2111.6	0.010	15.095	1.100	22.705
16	249.6	251.6	34.056	8.568	26.451	34.056	240.340	2265.6	2116.6	0.010	15.840	1.165	24.665
15	299.2	301.7	33.872	6.825	26.557	33.868	231.540	2263.2	2143.4	0.000	19.935	1.485	34.070
14	400.2	403.6	33.909	5.466	26.760	33.913	155.820	2282.1	2215.3	0.000	29.215	2.135	58.845
13	499.7	504.2	34.006	4.749	26.920	34.009	103.910	2301.5	2265.8	0.000	35.055	2.530	79.405
36	500.3	504.7	34.006	4.747	26.920	34.009							
12	599.6	605.0	34.133	4.462	27.053	34.135	70.420	2317.8	2303.6	-0.010	38.380	2.760	95.775
35	750.3	757.4	34.238	3.887	27.197								
11	800.0	807.7	34.267	3.735	27.236	34.269	44.310	2344.1	2342.0	-0.010	41.330	2.965	118.300
34	999.2	1009.3	34.359	3.174	27.364								
10	999.5	1009.6	34.359	3.174	27.364	34.362	37.400	2365.3	2364.5	-0.010	42.525	3.040	134.895
33	1500.3	1517.3	34.501	2.373	27.550								
9	1500.3	1517.2	34.501	2.374	27.550	34.504	42.350	2395.1	2384.3	-0.010	42.865	3.045	157.965
8	1999.5	2024.5	34.587	1.959	27.655	34.590	70.190	2410.9	2378.0	-0.010	41.455	2.915	164.520
32	2000.3	2025.3	34.587	1.959	27.655								
31	2499.6	2533.9	34.635	1.705	27.715								
7	2500.8	2535.1	34.635	1.704	27.715	34.637	102.060	2412.9	2358.9	-0.010	39.305	2.765	161.220
30	3000.3	3045.0	34.660	1.557	27.749	34.662							
6	3000.3	3045.1	34.660	1.557	27.749	34.662	124.505	2413.5	2347.4	-0.010	38.050	2.655	157.865
29	3499.9	3556.2	34.673	1.492	27.768	34.676							
5	3499.9	3556.2	34.673	1.492	27.768	34.675	139.740	2415.1	2336.9	-0.010	36.975	2.575	153.860
28	4000.4	4069.6	34.681	1.471	27.779								
4	4001.1	4070.3	34.681	1.471	27.779	34.683	149.630	2413.9	2328.4	-0.010	36.335	2.520	151.015
3	4499.9	4583.0	34.686	1.483	27.786	34.688	156.100	2411.6	2324.1	-0.010	35.950	2.485	148.385
27	4500.7	4583.8	34.686	1.483	27.786								
26	5000.6	5098.8	34.688	1.522	27.789	34.690							
2	5000.7	5098.9	34.688	1.522	27.789	34.691	158.830	2409.7	2322.1	-0.010	35.705	2.470	149.280
1	5475.9	5589.5	34.690	1.569	27.792	34.692	162.320	2409.3	2318.8	-0.010	35.485	2.445	145.840
25	5477.1	5590.7	34.690	1.569	27.792	34.693							

# Station: 35N

	Start
Date/Time:	2004.10.23 17:56 (UTC)
Lat.:	35-00.02N
Long.:	159-59.46E
Depth (m):	4549.0

Remarks: Cast for Primary Productivity

file name: K35m01

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[ <b>.</b> C]	[kg/m^3]
7	8.0	8.0	34.371	23.447	23.3287
6	18.5	18.6	34.372	23.449	23.3295
5	34.8	35.1	34.370	23.444	23.3305
4	47.7	48.1	34.423	20.262	24.2566
3	60.5	60.9	34.416	18.024	24.8263
2	70.6	71.2	34.406	16.333	25.2170
1	80.8	81.4	34.462	15.553	25.4361

## Station: 35N

	Start
Date/Time:	2004.10.23 18:50 (UTC)
Lat.:	35-00.33N
Long.:	159-59.32E
Depth (m):	4558.0

Remarks: Cast for Routine

file name: K35m02

			CTD data			Autosal	Autosal Chemical analysis (uncorrected data)						
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[PSU]	[.C]	[kg/m^3]	(psu)	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg
0	0.0					34.469	213.8	2266.3	1956.7	0.01	0.05	0.09	1.93
24	10.0	10.0	34.446	23.557	23.354	34.451	213.7	2265.0	1956.9	0.00	0.01	0.04	1.88
23	28.3	28.5	34.446	23.518	23.367	34.450	213.7	2262.8	1956.5	0.00	0.01	0.04	1.88
22	49.3	49.7	34.435	23.414	23.389	34.436	214.3	2268.9	1970.2	0.12	0.63	0.09	2.64
21	73.8	74.3	34.403	16.513	25.174	34.428	208.3	2275.7	2038.5	0.11	6.01	0.47	8.17
20	101.3	102.1	34.465	14.858	25.595	34.468	197.6	2274.6	2069.2	0.04	9.14	0.67	11.58
19	124.8	125.7	34.431	13.213	25.913	34.433	196.8	2274.0	2088.4	0.02	12.17	0.87	15.62
18	150.0	151.2	34.277	11.596	26.108	34.281	193.1	2270.3	2107.2	0.02	14.34	1.05	20.57
17	200.6	202.1	34.127	9.481	26.361	34.127	205.9	2270.7	2124.0	0.01	16.61	1.23	25.94
16	250.4	252.4	34.109	8.181	26.551	34.110	168.4	2281.4	2170.7	0.01	23.08	1.68	41.74
15	299.6	302.0	33.974	6.507	26.681	33.975	172.7	2281.8	2190.8	0.01	25.86	1.91	50.09
14	400.0	403.3	33.933	4.918	26.842	33.937	137.4	2292.8	2237.8	0.01	31.65	2.33	68.55
13	499.6	503.9	34.073	4.659	26.982	34.074	90.3	2309.4	2280.3	0.00	36.25	2.63	86.27
12	599.5	604.8	34.187	4.326	27.110	34.190	55.9	2331.4	2316.3	0.00	39.63	2.85	100.48
11	798.9	806.3	34.310	3.610	27.282	34.312	38.0	2356.1	2350.9	0.00	41.93	3.01	121.72
10	1002.6	1012.3	34.390	3.040	27.401	34.392	35.9	2371.5	2362.5	0.01	42.64	3.05	138.43
9	1500.2	1516.6	34.529	2.252	27.582	34.531	46.4	2399.9	2386.3	0.00	42.57	3.03	161.06
8	2000.4	2024.7	34.602	1.858	27.674	34.604	76.2	2406.9	2374.0	0.01	41.04	2.89	166.12
7	2499.9	2533.3	34.646	1.618	27.730	34.648	110.3	2413.6	2355.8	0.00	38.72	2.73	161.22
6	3002.7	3046.4	34.667	1.498	27.758	34.669	131.9	2415.6	2337.4	0.01	37.43	2.62	156.18
5	3501.7	3556.8	34.678	1.452	27.774	34.679	144.5	2416.6	2334.1	0.00	36.59	2.55	152.80
4	4001.1	4068.9	34.684	1.447	27.783	34.687	152.2	2414.4	2326.9	0.01	36.04	2.51	150.78
29	4495.1	4576.4	34.687	1.470	27.788	34.690							
3	4498.6	4580.0	34.687	1.470	27.788	34.690	157.2	2414.6	2322.1	0.01	35.71	2.47	148.83
2	4500.0	4581.5	34.687	1.470	27.788	34.689							
1	4525.2	4607.4	34.688	1.461	27.789	34.691	159.8	2411.3	2320.5	0.01	35.39	2.45	145.96

## Station: KNOT

	Start
Date/Time:	2004.10.28 17:53 (UTC)
Lat.:	44-00.18N
Long.:	155-00.24E
Depth (m):	5323.0

Remarks: Cast for Primary Productivity

file name: KNTm01

			CTD data		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q
	[m]	[db]	[PSU]	[ <b>.</b> C]	[kg/m^3]
	4.2	4.2	32.714	9.707	25.2154
	10.9	11.0	32.714	9.708	25.2155
	22.0	22.2	32.714	9.708	25.2160
	30.5	30.8	32.715	9.692	25.2201
	40.0	40.3	32.722	9.587	25.2425
	49.4	49.8	32.863	7.393	25.6805
	60.8	61.3	33.163	2.567	26.4557

### Station: KNOT

	Start
Date/Time:	2004.10.28 19:00 (UTC)
Lat.:	44-00.06N
Long.:	154-59.85E
Depth (m):	5336.0

Remarks:	Cast for Routine and Trace metal
file name:	KNTm02

			CTD data			Autosal		Chemical ar	alysis (unco	orrected da	ta)		
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[PSU]	[. C]	[kg/m^3]	(psu)	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg	umol/kg
0	0.0					32.715	280.71	2218.0	2029.1	0.24	10.48	1.13	16.64
24	9.5	9.6	32.702	10.068	25.147	32.706	279.12	2214.1	2026.2	0.23	10.09	1.10	16.29
23	29.9	30.1	32.702	10.035	25.153	32.714	279.89	2216.0	2028.9	0.23	10.46	1.13	16.88
22	49.8	50.2	33.050	4.562	26.182	33.110	297.94	2234.9	2128.4	0.08	22.95	1.87	38.06
21	74.1	74.7	33.254	2.487	26.535	33.259	302.74	2238.8	2147.8	0.02	25.29	1.97	43.84
20	97.4	98.2	33.284	2.322	26.573	33.288	297.23	2241.6	2146.9	0.01	25.73	2.00	46.12
19	125.8	126.9	33.382	2.260	26.656	33.386	250.50	2252.2	2188.1	0.01	29.36	2.24	56.82
18	150.8	152.0	33.472	2.341	26.722	33.478	205.26	2258.7	2216.1	0.01	32.60	2.46	66.26
17	200.5	202.2	33.673	2.752	26.849	33.678	125.80	2278.7	2272.2	0.01	37.71	2.78	84.50
16	249.6	251.8	33.824	3.181	26.931	33.825	85.77	2292.9	2298.0	0.01	40.11	2.91	93.57
15	301.3	304.0	33.903	3.194	26.994	33.906	51.44	2299.1	2326.4	0.01	42.85	3.08	103.33
14	400.2	403.9	34.067	3.308	27.114	34.071	36.49	2322.8	2343.5	0.01	43.09	3.10	116.15
13	499.8	504.5	34.160	3.178	27.201	34.162	27.65	2336.2	2356.7	0.01	43.32	3.11	125.93
36	500.2	504.8	34.160	3.178	27.202	34.162							
12	600.6	606.3	34.243	3.053	27.280	34.246	24.66	2349.2	2359.0	0.01	43.50	3.13	134.75
35	748.9	756.3	34.317	2.848	27.358	34.320							
11	801.1	809.2	34.336	2.789	27.379	34.339	26.48	2363.9	2374.9	0.00	43.36	3.13	146.22
10	1002.6	1013.2	34.424	2.558	27.470	34.425	31.51		2381.1	0.01	43.23	3.10	154.19
34	1004.0	1014.6	34.424	2.554	27.470	34.426							
33	1501.0	1518.7	34.546	2.118	27.607	34.549							
9	1501.4	1519.0	34.546	2.119	27.607	34.548	54.15	2400.3	2381.2	0.00	42.17	3.00	163.18
32	2000.3	2026.3	34.609	1.823	27.683	34.613							
8	2000.7	2026.7	34.609	1.823	27.683	34.612	82.66	2412.2	2367.5	0.00	40.45	2.87	163.93
31	2499.3	2534.7	34.645	1.625	27.729	34.647							
7	2499.5	2534.9	34.645	1.625	27.729	34.646	109.14	2410.5	2355.0	0.01	38.73	2.74	161.89
30	2998.6	3044.7	34.665	1.512	27.756	34.667							
6	2999.1	3045.2	34.665	1.512	27.756	34.668	129.88	2409.9	2340.8	0.00	37.46	2.64	156.21
29	3500.3	3558.3	34.676	1.464	27.772	34.680							
5	3500.9	3558.9	34.676	1.464	27.772	34.678	142.83	2409.8	2330.5	0.01	36.65	2.57	153.31
28	3999.8	4070.8	34.683	1.453	27.782	34.686							
4	4000.0	4071.0	34.683	1.453	27.782	34.685	151.18	2412.1	2325.5	0.00	36.14	2.53	150.99
3	4501.7	4587.0	34.687	1.475	27.787	34.689	156.21	2409.4	2322.0	0.00	35.78	2.50	150.15
27	4502.1	4587.4	34.687	1.475	27.787	34.690							
2	5000.6	5101.1	34.688	1.525	27.789	34.691	154.86	2412.2	2321.6	0.00	35.64	2.49	150.76
26	5000.7	5101.3	34.688	1.525	27.789	34.690							
25	5284.6	5394.4	34.688	1.561	27.789	34.691							
1	5285.9	5395.7	34.688	1.561	27.789	34.691	158.03	2411.4	2320.1	0.00	35.56	2.49	150.74

## Station: KNOT

	Start			
Date/Time:	2004.10.29 0:28	(UTC)		
Lat.:	44-00.44N			
Long.:	155-01.54E			
Depth (m):	5336.0			

Remarks: Cast for Trace metal file name: KNTm03

		CTD data					
Bottle #	Depth	Pressure	Salinity	Temp.	Sigma-q		
	[m]	[db]	[PSU]	[.C]	[kg/m^3]		
0	4.6	4.7	32.704	9.858	25.183		
36	9.9	10.0	32.704	9.855	25.184		
35	24.8	25.0	32.706	9.790	25.199		
34	49.9	50.3	33.149	2.707	26.432		
33	74.4	75.0	33.266	2.474	26.546		
32	100.5	101.4	33.337	2.403	26.609		
31	123.9	124.9	33.481	2.939	26.679		
30	149.7	150.9	33.556	2.940	26.739		
29	175.4	176.9	33.603	2.661	26.800		
28	200.1	201.9	33.677	2.797	26.848		
27	250.4	252.6	33.781	2.975	26.915		
26	303.6	306.3	33.909	3.227	26.995		