Cruise Report of NT04-05 (2004.5.19 – 2004.6.05)

JAMSTEC

Mutsu Institute for Oceanography (MIO) High Latitude Time Series observatory (HiLaTS)

Nov. 2004

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1. Outline of NT04-05

1.1 Cruise Summary

Hajime KAWAKAMI (JAMSTEC, Mutsu Institute for Oceanography)

This cruise was manly carried out in order to study the biogeochemistry in northwestern North Pacific by following institutes and universities.

Mutsu Institute for Oceanography (MIO) of Japan Marin Science Technology Center (JAMSTEC)

National Institute for Environmental Science (NIES)

National Institute of Advanced Industrial Science and technology (AIST)

Tokai University

R/V Natsushima left Yokosuka on 19 May. Because the typhoon came to Japan, we could not leave Tokyo Bay soon. We departed from Tokyo Bay to the sampling stations on 22 May. Then, we couldn't go to Station K1 so as to lose the ship time.

Station K1 (51N, 165E)

All sampling was canceled because of the lack of ship time.

Station KNOT (44N, 155E)

Hydrocast

We deploy water samplers (12L Niskin water sampler with CTD sensor) 2 times (Hydrocast). Water samples taken were or will be used for the following chemical analysis.

• the routine chemical analysis (Sal, DO, SiO₂, PO₄, NO₃, NO₂, TDIC, TALK)

In situ pumping

The in situ pumping was canceled because of bad condition.

Station K2 (47N, 160E)

Hydrocast

We deploy water samplers (rossette multiple sampler with CTD sensor) 5 times (Hydrocast). Water samples taken were or will be used for the following chemical analysis.

• the routine chemical analysis (Sal, DO, SiO₂, PO₄, NO₃, NO₂, TDIC, TALK)

- Th-234, POC, PON, Chl. a analysis
- simulated in situ measurement of Primary production used by C-13

In situ pumping

In order to collect suspended particles in the water column, large volume pumping system (LVP) were used. 4 casts of LVP were practiced and 4 LVP were deployed at once for respective casts. The particulate samples from LVP were will be used for Th-234, POC, PON and trace metal analysis.

Station K3 (39, 160E)

We could also do the observations smoothly similarly to St. K2.

However a percentage of success of the sampling was not much higher in this cruise, it is very significant that we could take the biogeochemical samples and data in spring, in northwestern North Pacific.

1.2 Cruise track and schedule



NT04-05 Cruise Track

UTC		Posi	tion	Events
Date	Time	Lat.	Long.	
5.19	00:00	35-19N	139-39E	Departure from Yokosuka
5.25	21:30	44-00N	155-00E	Arrive at St. KNOT
5.26	03:10	44-00N	155-00E	Departure from St. KNOT
5.27	03:00	39-40N	160-00E	Optical measurements
5.27	04:50	47-00N	160-00E	Arrive at St. K2
5.27	21:00	47-00N	160-00E	Departure from St. K2
5.29	17:30	39-00N	160-00E	Arrive at St. K3
5.30	09:50	39-00N	160-00E	Departure from St. K3
6.05	05:30	35-19N	139-39E	Arrival at Yokosuka

1.3 List of Participants

			Tel
Name	Affiliation	Address	Fax
			E-mail
Hajime	JAMSTEC		
KAWAKAMI	Mutsu Institute for		
	Oceanography (MIO)		
Hiroaki	JAMSTEC		
SAKO	MIO		
Kazuhiro	JAMSTEC		
HAYASHI	MIO		
Takayoshi	Marine Works		
SEIKE	Japan Ltd. (MWJ)		
Hirokatsu			
UNO	MWJ		
Kenichiro			
SATO	MWJ		
Taeko			
OHAMA	MWJ		

2. Observation

2.1 CTD Observations

(1) Personnel

Hirokatsu Uno (MWJ): Operation Leader

(2) Objective

Investigation of the oceanic structure and its time variation by measuring vertical profiles of temperature and salinity.

(3) Methods

We observed vertical profile of temperature and salinity CTD/Rosette (Conductivity, Temperature and Depth Profiler/Rosette Multi Water Sampler). The sensors attached on CTD were for temperature, conductivity and pressure. Salinity was calculated by measuring value of pressure, conductivity and temperature. The CTD/Rosette was deployed from stern on working deck. Descending rate and ascending rate were kept about 1.0 m/sec respectively. Sea surface temperature (SST) measurement was carried out in each time, too.

The CTD raw data was acquired in real time by using CTD2000 provided by S.E.A. Co., Ltd. and stored on the hard disk of personal computer. Water samplings were made during up-cast by sending a fire command from the computer. In total, 14 casting were carried out (see Table 2.1).

The CTD raw data was processed using CTD2000.

Specifications of sensors are listed below.

Under water unit:	ICTD (P/N 8001-ICTD, S/N 13	57)	Falmouth Scientific, Inc.
Deck unit: DT-200	0 Data Terminal (S/N 1357)	Falmouth	Scientific, Inc.
Water Sampler:	GO Model 1016 -12 (S/N 1541)	General Oceanics, Inc.
Under water booster	90165T (S/N 0010)		Sea Bird Electronics, Inc.

(4) Preliminary Results

Vertical profiles at each Station cast are shown in Fig. 2.1-1. ~3. Note that, in these figures, the correction of salinity and oxygen data by sampled water is not applied

~ .			Start			End			
Station	File Name	Date / Time	Lat. [N]	Long. [E]	Date / Time	Lat. [N]	Long. [E]	Water Sampling	Remarks
KNOT	KNOT CAST01.raw	04/5/24 22:47	-	-	04/5/24 23:11	43-99.90	154-60.00	Routine Shallow (~200m)	
KNOT	KNOT Cast02.raw	04/5/25 0:16	44-00.00	154-60.00	04/5/25 2:27	44-00.10	154-59.90	Routine Deep (~3,500m)	
К2	K2 Cast01.raw K2 Cast01b.raw	04/5/26 4:55	46-59.90	159-59.80	04/5/26 5:15	46-59.90	156-00.00	Routine Shallow (~200m)	Noisy System re-start
К2	K2 Cast02.raw	04/5/26 9:59	47-00.00	159-59.90	-	_	-	Th/POC Shallow (~60m)	Water sampling Failed.
K2	K2 Cast03.raw	-	-	-	04/5/26 10:11	46-59.90	160-00.00	Th/POC Shallow (~60m)	Re-deploy
K2	K2 Cast04.raw	04/5/26 10:31	46-59.90	159-59.90	04/5/26 10:50	47-00.00	159-59.90	Th/POC Deep (~200m)	
K2	K2 Cast05.raw	04/5/26 11:10	46-59.90	160-00.00	04/5/26 11:21	46-59.90	160-00.00	Primary Productivity	
К2	K2 Cast06.raw	04/5/26 9:27	46-59.92	159-59.97	04/5/26 9:40	46-59.98	159-59.95	Routine Deep (500~3,500m)	
K2	K2 Cast07.raw	04/5/26 9:27	46-59.92	159-59.97	04/5/26 9:40	46-59.98	159-59.95	Routine Deep (~500m)	
K3	K3 Cast01.raw	04/5/28 18:12	39-00.10	159-59.90	04/5/28 18:33	39-00.00	160-00.00	Routine Shallow (~200m)	
K3	K3 Cast02.raw	04/5/28 22:24	39-00.00	160-00.00	04/5/28 22:35	39-00.00	160-00.00	Th/POC Shallow (~60m)	
K3	K3 Cast03.raw	04/5/28 22:53	39-00.10	159-59.90	04/5/28 23:12	39-00.10	160-00.00	Th/POC Deep (~200m)	
К3	K3 Cast04.raw K3 Cast04b.raw	04/5/28 23:31	39-00.10	160-00.00	04/5/28 0:54	39-00.00	160-00.00	Routine Deep (~3,500m)	Noisy System re-start
K3	K3 Cast05.raw	04/5/29 9:28	38-59.90	160-00.00	04/5/29 9:40	39-00.00	160-00.00	Primary Productivity	

Table 2.1 CTD cast table



St.KNOT-Cast01



Fig.2.1-1. Vertical profiles at St.KNOT



St.K2-Cast01



Fig.2.1-2. Vertical profiles at St.K2



St.K3-Cast01



Fig.2.1-3. Vertical profiles at St.K3

2.2 Hydrocast 2.2.1 Salinity from Sampled Water

(1) Personnel

Hirokatsu UNO (MWJ): Operation Leader

(2) Objective

Bottle salinity was measured in order to compare with CTD salinity to identify leaking of the bottles and to calibrate CTD salinity.

(3) Instrument and Method

The salinity analysis was carried out at laboratory after the cruise of NT04-05 using the Guildline AUTOSAL salinometer model 8400B (S/N 60132), with additional peristaltic-type intake pump, manufactured by Ocean Scientific International. We also used two Guildline platinum hermometers model 9450. One thermometer monitored an ambient temperature and the other monitored a bath temperature. The resolution of the thermometers was 0.001 deg C. The measurement system was almost same as Aoyama et al (2003). The salinometer was operated in the air-conditioned laboratory at a bath temperature of 24 deg C. An ambient temperature varied from approximately 23 deg C to 25 deg C, while a bath temperature is very stable and varied within +/- 0.002 deg C on rare occasion.

A double conductivity ratio was defined as median of 31 times reading of the salinometer. Data collection was started after 5 seconds and it took about 10 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In case the difference between the double conductivity ratio of this two fillings is smaller than 0.00002, the average value of the two double conductivity ratio 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 (batch P144, conductivity ratio; 0.99987, salinity; 34.995 23-Sep-2003). Because of the good stability of the AUTOSAL, calibration of the AUTOSAL was performed only once: The value of the Standardize Dial was adjusted at the time. Instead of the calibration in the middle and after the measurement, standard seawater was measured after the measurement of approximately 30 samples for the drift check. 7 bottles of standard seawater were measured in total, and their standard deviation to the catalogue value was 0.0001(PSU). The value is used for the calibration of the measured salinity.

We also used sub-standard seawater which was obtained from 2,000 m depth and filtered by Millipore filter (pore size of $0.45 \,\mu$ m), which was stored in a 20 liter polyethylene container. It was measured every 12 samples in order to check the drift of the AUTOSAL.

(3-2) Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin (Non Teflon coating) bottle. 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 kind and number of samples are shown in Table 2.2.1-1.

Kind of Samples	#
Samples for CTD	81
Samples for EPCS	2
Total	83

Table 2.2.1-1 Kind and number of sample

(4) Preliminary Results

The preliminary results are shown in Table 2.2.1-2.

The average of difference between measurement data and CTD data were 0.0148 and the standard deviation was 0.0208.

As shown above, we took 3 pairs of replicate samples. The average of the absolute difference of replicate samples was 0.0197 (The values except bottle No.0501 and No.0502 are 0.0005.).

(5) Reference

- Aoyama, M., T. Joyce, T. Kawano and Y. Takatsuki: Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 49, 1103–1114, 2002
- UNESCO: Tenth report of the Joint Panel on Oceanographic Tables and Standards. UNESCO Tech. Papers in Mar. Sci., 36, 25 pp., 19

Station	No. of	Pressure	Depth	CTD	No. of	AUTOSAL	Difference
Station	Niskin	(db)	(m)	Salinity	Bottle	Salinity	CTD-AUTOSAL
KNOT	Bucket	0.0	0.0	33.1542	0493	33.1636	-0.0094
KNOT	1	200.4	198.7	33.6841	0494	33.6768	0.0073
KNOT	2	152.6	151.3	33.4064	0495	33.4099	-0.0035
KNOT	3	123.6	122.6	33.2934	0496	33.2985	-0.0051
KNOT	4	100.7	99.9	33.2232	0497	33.2163	0.0069
KNOT	5	80.1	79.4	33.3826	0498	33.3051	0.0775
KNOT	6	70.0	69.4	33.1787	0499	33.1999	-0.0212
KNOT	7	60.8	60.3	33.1734	0500	33.1766	-0.0032
KNOT	8	49.0	48.6	33.2551	0501	33.2725	-0.0174
KNOT	8	49.0	48.6	33.2551	0502	33.1754	0.0797
KNOT	9	39.3	39.0	33.1550	0503	33.2709	-0.1159
KNOT	10	29.1	28.9	33.1613	0504	33.1617	-0.0004
KNOT	11	18.4	18.3	33.1617	0505	33.1655	-0.0038
KNOT	12	9.0	8.9	33.1591	0506	33.1646	-0.0055
-	EPCS	0.0	0.0	-	0507	33.1727	-
KNOT	1	3559.0	3501.0	34.6766	0508	34.6799	-0.0033
KNOT	1	3559.0	3501.0	34.6766	0509	34.6796	-0.0030
KNOT	2	3046.2	3000.1	34.6674	0510	34.6682	-0.0008
KNOT	3	2535.7	2500.3	34.6448	0511	34.6476	-0.0028
KNOT	4	2026.2	2000.3	34.6055	0512	34.6090	-0.0035
KNOT	5	1516.2	1498.6	34.5354	0513	34.5386	-0.0032
KNOT	6	1009.3	1009.3	34.4171	0514	34.4199	-0.0028
KNOT	7	809.7	801.6	34.3384	0515	34.3403	-0.0019
KNOT	8	604.7	599.0	34.2703	0516	34.2766	-0.0063
KNOT	9	504.1	499.4	34.1085	0517	34.1142	-0.0057
KNOT	10	403.7	400.1	34.0220	0518	34.0279	-0.0059
KNOT	11	301.5	298.9	33.8839	0519	33.8907	-0.0068
KNOT	12	251.9	249.7	33.7811	0520	33.7876	-0.0065
K2	Bucket	0.0	0.0	33.0305	0521	33.0371	-0.0066
K2	1	201.2	199.5	33.8116	0522	33.8090	0.0026
K2	2	151.2	149.9	33.5688	0523	33.5723	-0.0035
K2	3	126.9	125.8	33.2657	0524	33.2876	-0.0219

Table 2.2.1-2 Difference between measured salinity and CTD salinity

Station	No. of	Pressure	Depth	CTD	No. of	AUTOSAL	Difference
Station	Niskin	(db)	(m)	Salinity	Bottle	Salinity	CTD-AUTOSAL
K2	4	100.9	100.0	33.0946	0525	33.1070	-0.0124
K2	5	81.3	80.6	33.0749	0548	33.0805	-0.0056
K2	6	70.1	69.5	33.0704	0527	33.0802	-0.0098
K2	7	60.8	60.3	33.0711	0528	33.0754	-0.0043
K2	8	49.9	49.9	33.0621	0529	33.0697	-0.0076
K2	8	49.9	49.9	33.0621	0530	33.0693	-0.0072
K2	9	39.5	39.2	33.0518	0531	33.0588	-0.0070
K2	10	31.8	31.5	33.0487	0532	33.0531	-0.0044
K2	11	19.6	19.4	33.0299	0533	33.0419	-0.0120
K2	12	9.7	9.6	33.0281	0534	33.0327	-0.0046
K2	1	3555.9	3506.9	34.6794	0535	34.6814	-0.0020
K2	1	3555.9	3506.9	34.6794	0536	34.6812	-0.0018
K2	2	3045.1	3006.6	34.6680	0537	34.6714	-0.0034
K2	3	2532.1	2503.1	34.6499	0538	34.6533	-0.0034
K2	4	2023.4	2002.6	34.6103	0539	34.6187	-0.0084
K2	5	1514.3	1500.5	34.5489	0540	34.5539	-0.0050
K2	6	1010.5	999.7	34.4398	0541	34.4449	-0.0051
K2	7	805.8	797.6	34.3749	0542	34.3767	-0.0018
K2	8	606.6	600.7	34.2769	0543	34.2811	-0.0042
K2	9	506.9	502.1	34.2041	0544	34.2197	-0.0156
K2	10	404.5	400.8	34.1311	0545	34.1327	-0.0016
K2	11	302.5	299.8	33.9832	0546	33.9930	-0.0098
K2	12	253.1	250.8	33.9237	0547	33.9252	-0.0015
-	EPCS	0.0	0.0	-	0549	33.0374	-
K2	Bucket	0.0	0.0	34.3453	0550	34.3553	-0.0100
K3	1	202.4	200.8	34.2023	0551	34.1788	0.0235
K3	2	151.9	150.7	34.2683	0552	34.2323	0.0360
K3	3	125.9	124.9	34.2958	0553	34.2595	0.0363
K3	4	101.0	100.2	34.3231	0554	34.2833	0.0398
К3	5	81.1	80.5	34.3400	0555	34.3015	0.0385
K3	6	70.7	70.2	34.3408	0556	34.3025	0.0383
K3	7	60.8	60.3	34.3455	0557	34.3037	0.0418
K3	8	50.6	50.2	34.3676	0558	34.3345	0.0331
K3	8	50.6	50.2	34.3676	0559	34.3356	0.0320

Que tiene	No. of	Pressure	Depth	CTD	No. of	AUTOSAL	Difference
Station	Niskin	(db)	(m)	Salinity	Bottle	Salinity	CTD-AUTOSAL
K3	9	40.5	40.2	34.3856	0560	34.3448	0.0408
K3	10	30.2	30.0	34.4246	0561	34.3578	0.0668
K3	11	20.0	19.8	34.4189	0562	34.3707	0.0482
K3	12	10.5	10.4	34.3874	0563	34.3454	0.0420
K3	1	3557.4	3501.0	34.6748	0565	34.6788	-0.0040
K3	1	3557.4	3501.0	34.6748	0566	34.6784	-0.0036
K3	2	3045.1	3000.4	34.6609	0567	34.6655	-0.0046
K3	3	2535.2	2500.9	34.6381	0568	34.6406	-0.0025
K3	4	2025.5	2000.5	34.5853	0569	34.5896	-0.0043
K3	5	1517.8	1500.8	34.5023	0570	34.5087	-0.0064
K3	6	1010.9	1000.8	34.3586	0571	34.3611	-0.0025
K3	7	807.4	799.7	34.2562	0572	34.2569	-0.0007
K3	8	606.0	600.5	34.0960	0573	34.0936	0.0024
K3	9	504.3	499.9	33.9564	0574	33.9564	0.0000
K3	10	403.1	399.7	33.8925	0575	33.8992	-0.0067
K3	11	303.2	26.5	33.9795	0576	33.9566	0.0229
K3	12	252.1	250.0	34.0622	0577	34.0330	0.0292

2.2.2 Dissolved Oxygen

(1) Personnel

Takayoshi SEIKE (Marine Works Japan Ltd.)

(2) Objective

Precise determination of dissolved oxygen (below D.O.) using the Winkler titration with potentiometric detection.

(3) Instruments and Apparatus

Titrator:

Metrohm Model 716 DMS Titrino, capable of titrating Na₂S₂O₃ solution for 0.001cm³.

Detector:

Metrohm Pt Electrode 6.0401.100.

Software:

Data acquisition/ Metrohm, Tinet 2.4.

Sample flasks:

BOD flasks of 180cm³ nominal capacity with glass stoppers.

OPTIFIX:

Capable of dispensing 1cm³ pickling reagents(Reagent I; Manganous chloride solution(3M), Reagent II; Sodium hydroxide(8M)/Sodium iodide solution(4M)).

Dispensers:

Metrohm Model 765 Multi Dosimat, capable of dispensing 10cm³ and 1cm³ standard KIO₃ solution.

(4) Methods

Sampling and analytical methods were based on the WHP Operations and Methods (Culberson, 1991, Dickson, 1994).

(a) 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. 180cm³). 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 1cm³ 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.

(b) Analytical methods

The samples were analyzed by 1 sets of Metrohm titrator with 10 ml piston burette and Pt electrode. Titration values were determined by the potentiometeric methods, and the endpoint for titration was evaluated by the software of Metrohm, Tinet 2.4. From the titration values, we calculated concentration of dissolved oxygen by WHP Operations and Methods (Culberson, 1991, Dickson, 1994).

(5) Result

(a) Reproducibility of sample measurement

Replicate samples were taken at every CTD cast; usually these were 10 % of seawater samples of each cast during this cruise. Results of the replicate samples were shown in Table 2.2.2. The standard deviation was calculated by a procedure (SOP23) in DOE (1994).

Table 2.2.2 Results of the replicate sample measurement

Number of replicate	Oxygen concentration (mmol/kg)
sample pairs	Standard Deviation.
12	0.20

(b) Vertical profiles

The vertical profiles of dissolved oxygen were shown in Fig. 2.2.2.

(6) References

- Culberson, C.H. (1991) Dissolved Oxygen, in WHP Operations and Methods, Woods Hole., pp1-15.
- Culberson, C.H., G.Knapp, R.T.Williams and F.Zemlyak (1991) A comparison of methods for the determination of dissolved oxygen in seawater. (WHPO 91-2)
- Dickson, A.G. (1994) Determination of dissolved oxygen in seawater by Winkler titration, in WHP Operations and Methods, Woods Hole., pp1-14.
- Murray, N., J.P.Riley and T.R.S. Wilson (1968) The solubility of oxygen in Winkler regents used for the determination of dissolved oxygen, Deep-Sea Res., 15, 237-238.



Fig. 2.2.2 Vertical profiles at each station.

2.2.3 Nutrients

Yukihiro NOJIRI (National Institute for Environmental Science) Kazuhiro HAYASHI (JAMSTEC MIO) Makio HONDA (JAMSTEC MIO)

(1) Sampling Procedures

Samples were drawn into polypropylene 100 ml small mouth bottles. These were rinsed twice before filling. The samples were quickly stored in a freezer under - 20 °C and kept by the day the nutrients analyses were conducted on land.

(2) Instruments and Methods

The nutrients analyses were performed on BRAN+LUEBBE continuous flow analytical system Model TRAACS 800 (4 channels). The laboratory temperature was maintained between 20-25 deg C.

Nitrite: The nitrite is determined by diazitizing with sulfanilamide and coupling with N-1-naphthylethylenediamine (NED) to form a colored azo dye which is measured at 550 nm using 5 cm length cell.

Nitrate: Nitrate in seawater is reduced to nitrite, which is determined by the method described above. Nitrite initially present in the sample is corrected.

Silicate: The standard AAII molybdate-ascorbic acid method was used. Tempreture of the sample was maintained at 45-50 deg C using a water bath to reduce the reproducibility problems encountered when the samples were analyzing at different temperatures. The silicomolybdate produced is measured spectrophotometrically at 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. Tempreture of the samples were adjusted to be 45-50 deg C using a water bath. The phospho-molybdate produced is measured at 880 nm using a 5 cm length cell.

(3) Preliminary results

The results are shown in Appendix.

2.2.4 TCO2 and Alkalinity

Nubuo TSURUSHIMA (National Institute of Advanced Industrial Science and technology) Kazuhiro HAYASHI (JAMSTEC MIO) Makio HONDA (JAMSTEC MIO)

(1) Sampling

We collected samples for on board measurements of total carbon dioxide (TC) and total alkalinity (TA). Water samples were collected with CTD rosette systems attached with Niskin bottles of 12 1 capacity. Sample waters for TC/TA were drawn from Niskin samplers into 250 (200 ?) ml glass bottles with plastic screw cap (Schott Duran). Sequentially, mercuric chloride solution (3 mg-HgCl₂ / 100 g-H₂O) of 0.05 cm³ was added as preservative. Samples collected on board were kept in refrigerator by the day the analysis was conducted

(2) Analysis

TC and TA in seawater were determined by the methods similar to DOE (1994) with new automatic measurement system (KIMOTO ELECTRIC Co., LTD.). This system contain two devices, device for extraction of carbon dioxide and a device for determination of TA by titration, each in a 50x60x40cm console. This system is coupled to a CO₂ coulometric detector (model 5012, supplied by UIC Coulometrics Inc.), an Autoburette (ABU901, supplied by RADIOMETER Co., LTD.), two cooling units to maintain the sample water at constant temperature, and a personal computer. All procedures except exchange of the samples and rinsing of TA titration cell are operated automatically. Sample water for TC analyses were controlled at constant temperature (10°C). A known volume (about 30 ml) of seawater sample is dispensed into the stripping chamber and acidified with 8.5% reagent grade phosphoric acid, converting all carbonate species to free CO₂. The evolved CO₂ is then extracted from seawater using ultra high purity nitrogen gas (99.9995%) for 10 minutes at a rate of 200 ml/min. The CO₂ gas is absorbed by a coulometer cell solution, containing ethanolamine, dimethylsulfoxide and thymolphthalein indicator, and quantified by coulometric titration. Seawater based reference materials were prepared by Hokkaido University used for calibration. The precision was 0.1%, which was obtaned from 10 replicate determinations on board the ship once a day. TA was determined by potentiometric titration. Sample water for determination of TA was controlled at constant temperature (20°C). A known volume (about 100 ml) of seawater sample is dispensed into closed titration cell containing two glass electrodes, a thermometer and a capillary tube that supplies acid from a burette. Sample seawater was titrated with 0.2 N hydrochloric acid past the carbonic acid endpoint. TA was calculated from titration data by the non-linear least-squares approach (DOE, 1994). The precision was 0.1%, which was obtained from 10 replicate determinations on board the ship once a day.

(3) Results

The results are shown in Appendix.

(4) Reference

DOE (1994): Handbook of methods for the analysis of the various parameters of the carbon dioxide system in seawater; version 2.0, A. G. Dickson and C. Goyet, editors, U. S. Department of Energy CO₂ Science Team

Report.

2.2.5 Primary productivity

Hiroaki SAKOH (JAMSTC MIO), Taeko OHAMA (Marine Works Japan Ltd.), Makio HONDA (JAMSTEC MIO)

(1) Objective

The objective of this experiments was measured the primary production by simulated *in situ* incubation from uptake rate of labeled inorganic ¹³C-carbon.

(2)Collected Samples

Samples were collected from the surface and other five depths at K1 and K3. Samples were collected using a bucket for surface and Niskin sampler for five pre-defined depth. Samples were sieved through a 200 µm mesh to remove large-size zooplankton. The five depths were determined from the light intensity which measured by optical profiler (see optical measurements). These depths had 100%, 45%, 27%, 12%, 5%, 1% PAR light intensity relative to the surface light irradiance. The sample collection depths at each station were shown in Table 2.2.5-1.

PAR light intensity (%)		45	27	12	5	1
Sampling	K2	7	13	23	34	55
depth (m)	K3	7	13	22	32	50

Table 2.2.5-1 Sample collection depths at K1 and K3

(3) Simulated in situ incubation

Each sample was divided to 1 liter into Nalgen polycarbonate bottles with screw caps. 1 ml NaH¹³CO₃ solution as a tracer was added the 2 bottles of samples at each station. Sequentially, bottles except the surface sample were put into light shield nets and all samples place into deck incubators with light shield filter adjusting to the light levels at respective depth. Water temperature for each incubator was also adjusted to those at respective depth. Samples were incubated for 24 hours started before sunrise (3:20 at K2 and 3:40 at station K3). After incubation, samples were filtered through the Whatman GF / F glass-fiber filter (diameter: 25 mm, pore size: 0.7μ m) pre-combusted with temperature of 450 °C for at least 6 hours. These filtered samples were frozen immediately until laboratory analysis.

(4) ¹³C analysis

On land, ¹³C of samples were measured by using a mass spectrometer ANCA-SL system.

Before analysis, inorganic carbon of samples was removed by an acid treatment in a HCl vapor bath for 4 - 5 h. Table 3 shows total particulate organic carbon (POC) and concentrations of ¹³C of POC for respective samples.

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

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

This equation is converted to the following equation;

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

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

 ${}^{13}C_{(sw)}$ is concentration of ${}^{13}C$ of ambient seawater with a tracer. This value for this study was determined to be 10.203 (10.636 for K-3) % based on the following calculation;

 ${}^{13}C_{(sw)}(\%) = [(0.002 * 0.011) + 0.000203] / (0.002 + 0.000203) * 100$

where 0.002 (0.0019 for K-3) is observed concentration of total dissolved inorganic carbon (TDIC: mol l^{-1}) and 0.011 is concentration of ${}^{13}C$ of natural seawater (1.1 %). 0.000203 is added ${}^{13}C$ (mol) as a tracer.

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

$$PP = 1.025 * \Delta POC$$

Table 2.2.5-2 also shows estimated primary productivity. The precision (repeatability: standard deviation / average) ranged from 2 % to 22 % with average of 9 %.

Trapezoidal integrated primary productivity in the euphotic layer (> 1 % light level) were also estimated (Table 2.2.5-1). Integrated primary productivity were estimated to be approximately 510 mg m⁻³ day⁻¹ for station K2 and 767 mg m⁻³ day⁻¹ for station K3. These were higher than integrated PP observed previously at station KNOT (Imai *et al.*, 2002).

It is noted that simulated *in-situ* incubation methods during this cruise had problem in the light and water temperature control. Especially there is much possibility that the light for surface sample was partly shielded. More precise experiment is requested in future.

Ag Temp	Light level	Water Denth	POC	13C	PP	average	stdev	PP(int)		
(deg-C)	(%)	(m)	$(\mu \alpha^{\prime})$	$(\Lambda tom \%)$	$(m\sigma/m3/dav)$	average	stuev	(mg m-2 day)		
Station K-2	(70)	(111)	$(\mu g/I)$	(Atom /)	(ing/ins/duf)			(ing in 2 day)		
Blank 13C · 1	087									
added 13C tracer: 0.000203 mol										
TDIC: 0.002	0 mol/1									
13C(sw): 10.	2033 %									
5	100	0	118.5	1.932	11.26	11.26		70.0		
5	100	0	143.0	1.082	-0.07					
5	45	7	101.4	1.853	8.73	9.31	0.81	65.2		
5	45	7	110.8	1.880	9.88					
5	27	13	129.8	1.978	13.01	13.49	0.68	152.6		
5	27	13	133.7	2.016	13.97					
5	12	23	126.9	2.314	17.50	15.85	2.33	138.7		
5	12	23	122.7	2.116	14.20					
5	5	34	85.1	1.893	7.72	8.60	1.24	84.5		
5	5	34	103.0	1.906	9.48					
5	1	55	90.6	1.119	0.32	0.28	0.06			
5	1	55	58.8	1.123	0.24			510.9		
Station K-3										
Blank 13C: 1	.087									
added 13C tra	acer: 0.00020	3 mol								
TDIC: 0.001	9 mol/l									
13C(sw): 10.	6362 %									
13	100	0	161.6	2.413	23.00	22.54	0.64	194.4		
13	100	0	144.0	2.516	22.09					
13	45	7	163.2	2.944	32.53	32.04	0.70	162.4		
13	45	7	161.1	2.911	31.54					
12	27	13	148.1	2.446	21.60	21.18	0.59	182.3		
12	27	13	144.8	2.422	20.76					
12	12	22	146.6	2.288	18.90	18.75	0.22	141.5		
12	12	22	149.2	2.248	18.59					
11	5	32	122.9	1.800	9.40	8.75	0.92	86.5		
11	5	32	121.9	1.706	8.10					
11	1	50	95.0	1.107	0.20	0.23	0.03			
11	1	50	93.1	1.112	0.25			767.0		

Table

Primary productivity

(5) PP observed by HiLaTS project

We have measured PP during recent cruises (NT03-07 in July 2003, KR03-11 in September / October 2003, MR04-02 in March / April 2004, and this cruise of NT04-05 in May / June 2004). These data were summarized as follows:

1) Seasonal change in vertical profiles

Fig. 2.2.5 shows seasonal variability in vertical profiles at various stations.



Fig. 2.2.5 Seasonal variability in vertical profiles of PP at various stations

2) NPP/GPP

Based on PP data obtained during MR04-02 cruise, net primary productivity (NPP) that is PP for 24 hrs. incubation were compared with gross primary productivity (GPP) that is PP for 12 hrs. incubation in day time.

Date	April 13 2004	April 8 2004	April 8 2004	April 8 2004
Location	34-02.53N	K2 (47N, 160E)	K2 (47N, 160E)	K2 (47N, 160E)
	150-47.27E			
Depth (m)	0	0	11.1	37.1
Relative irradiance	49	100	29	5.1
(%)				
Temperature (°C)	17	1.7	1.6	1.6
GPP (12hr) (µg/l)	13.88 ± 3.65	6.60	6.16	2.84
	(n=5)			
NPP (24hr) (µg/l)	13.72 ± 3.05	6.55	5.55	0.93
	(n=6)			
NPP / GPP	0.988	0.993	0.901	0.329

There is a tendency that the ratio of NPP to GPP (NPP/GPP) decreases with depth or light level.

3) Light utilization Index: Ψ

Light utilization index (Ψ) is defined as follows:

 Ψ = depth-integrated PP / Chl-a_(int) / PAR

where Chl-a(int) is integrated chl-a in the euphotic zone (mg-Chl-a m⁻²) PAR is dairy PAR (mol quanta m⁻² day⁻¹). Par was observed once a day at solar noontime by using "Free fall sensor". Therefore dairy PAR was estimated with a following empirical equation:

 $\int PAR_{(T)} = \int PAR_{(max)} * (\sin (\pi / I * T))^2$

where $PAR_{(max)}$ is PAR observed at noontime and I and T is time and day length, respectively.

	NT03-07	KR03-11	MR04-02	NT04-05
	Jul. 2003	Oct / Nov. 2003	Apr. 2004	May/Jun. 2004
K1				
PP		343.39	221.16	
Chl-a		34.79	25.81	
PAR		14.76	31.26	
ϕ		0.6689	0.274	
K2				
PP	366.73		141.12	510.94
Chl-a	40.89		20.62	43.12
PAR	16.55		33.74	19.22
ϕ	0.542		0.2029	0.6165
K3				
PP	220.99	419.89		767.01
Chl-a	34.29	16.58		36.92

	PAR	10.961	9.08		36.15
	ψ	0.588	2.789		0.575
KNOT					
	PP	267.81			
	Chl-a	37.63			
	PAR	22.26			
	ψ	0.320			
35N					
	PP			568.26	
	Chl-a			19.16	
	PAR			39.20	
	ψ			0.757	

It is note that Ψ reported by Imai et al. (2002) is approximately 0.3 and constant while Ψ reported by Shiomoto (2000) was ranged from 0.75 – 0.96 in summer to 0.33 – 0.53 in winter. Shiomoto (2000) reported that ϕ increases with decrease of PAR.

References

- Allen *et al.* (1996): New production and photosynthetic rates within and outside a cyclonic mesoscale eddy in the North Pacific subtropical gyre. Deep-Sea Research I 43, 917-936.
- Hama *et al.* (1983): Measurement of photosynthetic production of a marine phytoplankton population using a stable ¹³C isotope. Marine Biology 73, 31-36.
- Imai *et al.* (2002): Time series of seasonal variation of primary productivity at station KNOT (44°N, 155°E) in the sub-arctic western North Pacific. Deep-Sea Research 49, 5395-5408.

Shiomoto, A. (2000) Efficiency of water-column light utilization in the subarctic northwestern Pacific. Limnology and Oceanography 45(4), 982-987.

2.2.6 Chlorophyll a

(1) PersonnelHajime KAWAKAMI (JAMSTEC)Kenichiro SATO (Marine Works Japan Ltd.)

(2) Objective

The purpose of this study is to estimate the distributions of chlorophyll a at the Northwest pacific by fluorometric analysis. Chlorophyll-a measurements are carried out with broadband filter type fluorometer. Broadband filter type fluorometer is used in common, but it is recognized the errors related to the acidification technique when chlorophyll b is present.

(3) Materials and Methods

Seawater samples were collected at two sampling sites at the Northwest pacific. The samples were collected 0.5 liter at 7 depths from surface to 200 m with Niskin bottles, except for the surface water, which was taken by the bucket. The samples were gently filtrated by low vacuum pressure (< 15 mmHg) through GF/F filters (diameter: 25 mm) in the dark room. Phytoplankton pigments were immediately extracted in 7 ml of N,N-dimethylformamide after filtration and then, the samples were stored in the freezer (-80 $^{\circ}$ C) until the analysis of fluorometric determination. The measurements were performed at room temperature after the samples were taken out of the freezer. The Traditional acidification method was examined for the determinations of chlorophyll *a* with Turner design model 10-AU-005 fluorometer.

Analytical conditions of this method are indicated in Table 2.2.6, and the vertical profiles of chlorophyll *a* concentrations at stn. K2 and K3 with traditional method were showed in Figure 2.2.6.

Table 2.2.6 Analytical conditions of traditional acidification method for chlorophyll-*a* with Turner fluorometer.

Method	Traditional
Excitation filter /nm	5 - 60 (340 - 500 nm)
Emission filter /nm	2 - 64 (> 665 nm)
Optical kit	10-037R
Lamp	Daylight White F4R5D
Acidification	Yes
	(1M HCL, 1min.)



Fig. 2.2.6 Vertical profiles of chlorophyll-*a* concentrations at stn. K2 and K3.

2.2.7 Th-234 and POC

Hajime KAWAKAMI (JAMSTEC, Mutsu Institute for Oceanography)

(1) Purpose of the study

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

(2) Sampling

Seawater sampling for ²³⁴Th and POC: 2 stations (St. K2 and St. K3) and 8 depths (10m, 20m, 40m, 60m, 80m, 100m, 150m and 200m) at each station.

Seawater samples (ca. 30 L) were taken from Hydrocast at each depth. The seawater samples were filtered with 47mm GF/F filter (for ²³⁴Th: ca. 25L) and 25mm GF/F filter (for POC and PON: 2.5–5L) on board immediately after water sampling.

In situ filtering samples were taken from large volume pump sampler (LVP) at same depths as Hydrocast. The filter samples (150mm GF/F filter) were divided for ²³⁴Th, POC and PON.

(3) Chemical analyses

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

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

(4) Preliminary result

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

2.3 Large Volume Pump (LVP)

Kazuhiro HAYASHI (JAMSTEC MIO)

Instruments over vies

The Large volume pump (LVP) is *in-situe* pump, battery powered, single sample devices that filter large volumes of water through 142mm filters. Flow rate can be adjusted for filter types by exchanging pump head. Filtering volume is recorded from the external flow meter. And also, during sampling system continuously monitors pump performance, flow rate, filtration volume and battery voltage. For each cast four LVP systems was attached on wire. Locations along the wire were selected to sample the depth of interest. Depth sensors (SBE39: Sea bird Electronics inc.) were attached to the maximum and median depth instruments.

	Deployment	K-2	K-2	Deployment	K-3	K-3
Cast ID	depth /m	(RI) /L	(SPM)/L	depth /m	(RI) /L	(SPM)/L
LVP#1	10	155.2	89.7	10	155.2	67.4
LVP#2	20	190.0	73.4	20	205.1	48.8
LVP#3	40	159.3	125.7	40	152.9	96.5
LVP#4	*60	196.4	173.0	*60	207.4	173.4
LVP#5	80	185.1	178.3	100	194.5	208.2
LVP#6	100	171.8	208.2	120	179.0	226.7
LVP#7	150	206.7	306.6	170	201.7	261.9
LVP#8	*200	197.6	294.5	*220	199.8	287.7
SBE_0389	LVP-4					
Depth	m	58.9	60.0		59.40	59.24
Dev.		0.6	1.1		0.26	0.30
SBE_0388	LVP-8					
Depth	m	203.87	204.50		224.32	223.32
Dev.		0.50	1.00		0.32	0.37
Each pumps		60min	120min		60min	120min
working time		JUIIII	12011111		JUIIII	12011111

Table 1 LVP filtration volume and deployment depth.

2.4 Surface underway observations

2.4.1 Horizontal and vertical distributions of suspended particles

Kazuhiro HAYASHI (JAMSTEC MIO) Xuedonz XU (JAMSTEC MIO)

(1) Objectives

Understanding the seasonal variation of the trace metals in the particle matter at the ocean surface and euphotic layer 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.

(2) Sampling

Underway samples were collected at 50m from sea surface by continuous seawater pump on R/V Natushima. Underway seawater is introduced to stainless steel filter holder (SUS 316) for 142mm filters. Particulate matter was collected by Millipore-HA (0.45μ m) (Table 2.4.1). 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 freezer, and will analyze by autoanalyzer (TRAACS 800; BRAN+LUEBE) in near future.

Vertical suspended particulate matters (SPM) were collected on 142mm Millipore HA filter by Large volume pump systems. Samples were collected from St. K-2 and St. K-3. 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.

(3) 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 HNO₃ 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. HNO₃ 3 or 4 times. Sample will be measured by ICP-MS with dessolvator (modified Cullen *et al.*, 2001).

(4) 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

2.5 Optical Measurements

Hiroaki SAKOH (JAMSTC 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 using labeled inorganic ¹³C-carbon.

(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 sensor (Ed), a 13 channel radiance sensor (Lu), tilt sensor, and fluorometer. The SMSR has a 13 channel irradiance sensor (Es), tilt meter. These instruments observed the vertical profiles of visible and ultra violet light and chlorophyll concentration.

Table 1.Center wavelength of the SPMR/SMSR

			<u> </u>										
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

The profiler was deployed twice at respective stations to a depth of 200 m. The reference (SMSR) was mounted on the compass deck and was never shadowed by any ship structure. The profiler descended at a rate from 0.7 to 1.1 m/s with tilts of almost less than 4 degrees.

(3) Calculation of photosynthetically available radiation (PAR)

These measurements provide data for the computation of quantities of photosynthetically available radiation (PAR) by software "Satlantic PROSOFT6". PAR is integrated quantum yield between 400 and 700 nm. Quantum yield between two wavelengths ($\lambda 1$ and $\lambda 2$) ($Q_{((\alpha/\alpha))}$) are estimated with Ed of respective wavelengths (Ed_(α) and Ed_($\alpha 2$)) and the following equation:

$$Q_{((1/2))}) (\text{quanta cm}^{-2} \text{sec}^{-1}) = (\text{Ed}_{(12)} + \text{Ed}_{(12)}) * ((\lambda 2) - (\lambda 1)) / 2 * 10^{-6} / \text{h} / \text{c} * ((\lambda 1) + (\lambda 2)) / 2 * 10^{-9} / (\lambda 1) + (\lambda 2)) / 2 * 10^{-9} / (\lambda 1) / (\lambda 2) / (\lambda 1) /$$

where Ed $_{(3)}$ and Ed $_{(2)}$ are irradiance of wave length of $\lambda 1$ and $\lambda 2$ nm, respectively. Therefore (Ed $_{(3)}$ + Ed $_{(2)}$) * (($\lambda 2$) - ($\lambda 1$)) / 2 * 10⁻⁶ is integrated Ed (W·cm⁻² or joule·cm⁻²) between wavelength of $\lambda 1$ and $\lambda 2$ nm. (($\lambda 1$) + ($\lambda 2$)) / 2 * 10⁻⁹ is average wavelength (m). The h and c are the Planck constant and light velocity, and 6.626 * 10⁻³⁴ joule·sec·m⁻¹ and 3.0 * 10⁸ m·sec⁻¹, respectively.

The preliminary results were shown in Figs. 2.5-1 and 2.5-2.



Fig.2.5-1. Vertical profiles of underwater light field at station K2.

- a: downwelling spectral irradiance
- b: upwelling spectral radiance
- c: calculated chlorophyll concentration and photosynthetically available radiation (PAR)



Fig.2.5-2. Vertical profiles of underwater light field at station K3.

- a: downwelling spectral irradiance
- b: upwelling spectral radiance
- c: calculated chlorophyll concentration and photosynthetically available radiation (PAR)

3. Appendix

List of Hydrocast

Station: KNOT

	Start	End
Date/Time:	2004/5/25 22:47	2004/5/25 23:11
Lat.:	No data	43-99.90N
Long .:	No data	154-60.00E
Depth (m):	-	-

Remarks: Cast for Routine SHALLOW (~200m) 開始位置は、後部操舵室ハイブリッド表示機の不調の為確認できなかった。□

		C	TD data			A	UTOSAL		Chemical a	nalysis (uncorrec	cted data)			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[°Ë]	[PSU]	[kg/m^3]	B/N	(PSU)	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg
1	198.7	200.4	2.7765	33.6760	26.853	494	33.6768	128.07		2272.0	0.12	37.50	2.80	80.35
2	151.3	152.6	2.2634	33.3937	26.675	495	33.4099	242.12		2195.5	0.13	29.07	2.29	55.62
								241.91						
3	122.6	123.6	2.4224	33.2810	26.572	496	33.2985	308.38		2144.5	0.14	23.90	1.93	42.87
4	99.9	100.7	2.0299	33.2081	26.546	497	33.2163	325.06		2141.1	0.31	23.63	1.95	41.53
5	79.4	80.1	3.3604	33.3758	26.562	498	33.3051	319.44		2128.8	0.46	21.35	1.78	37.90
6	69.4	70.0	2.5993	33.1666	26.465	499	33.1999	328.9		2135.0	0.50	22.43	1.86	39.25
7	60.3	60.8	2.7388	33.1619	26.450	500	33.1766	331.47		2131.0	0.49	22.37	1.86	38.60
8	48.6	49.0	3.8252	33.2501	26.416	501	33.2725	325.11		2117.4	0.43	20.20	1.71	36.73
						502	33.2709							
9	39.0	39.3	4.7398	33.1542	26.242	503	33.1754	330.34		2106.4	0.37	19.01	1.67	36.53
10	28.9	29.1	4.8030	33.1609	26.240	504	33.1617	330.76		2101.3	0.34	17.11	1.59	34.51
11	18.3	18.4	4.8218	33.1614	26.238	505	33.1655	330.87		2098.3	0.36	18.85	1.63	36.31
12	8.9	9.0	4.8265	33.1588	26.235	506	33.1646	330.58		2102.5	0.36	18.77	1.64	36.06
								330.57						
bucket	0	0	4.829	33.1561	26.110	493	33.1636	329.97		2098.5	0.37	19.16	1.65	37.08

	Start	End
Date/Time:	2004/5/26 0:16	2004/5/26 2:27
Lat.:	44-00.00N	44-00.10N
Long.:	154-60.00E	154-59.90E
Depth (m):	-	-

Remarks: Cast for Routine DEEP (~3500m)	
	Data File

Name: KNOT Cast02.raw

Data File Name: KNOT CAST01.raw

		С	TD data				AUTOSAL		Chemical	analysis (uncorre	cted data)			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[°Ċ]	[PSU]	[kg/m^3]	B/N	(PSU)	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg
1	3501.0	3559.0	1.1945	34.6735	27.772	508	34.6799	142.90		2328.1		36.32	2.53	150.88
						509	34.6796							
2	3000.1	3046.2	1.3002	34.6650	27.758	510	34.6682	129.61		2334.6		37.20	2.60	154.55
								129.64						
3	2500.3	2535.7	1.4583	34.6416	27.728	511	34.6476	107.98		2350.5		38.29	2.71	158.49
4	2000.3	2026.2	1.6999	34.6017	27.679	512	34.6090	80.41		2363.6		40.12	2.84	158.31
5	1498.6	1516.2	2.0612	34.5319	27.595	513	34.5386	54.16		2360.3		41.62	2.97	156.27
6	1009.3	1009.3	2.4981	34.4132	27.464	514	34.4199	33.35		2370.0		42.50	3.06	147.52
7	801.6	809.7	2.7812	34.3368	27.377	515	34.3403	25.80		2366.5		43.11	3.08	138.16
8	599.0	604.7	3.4277	34.2708	27.263	516	34.2766	41.84		2336.7		41.33	2.98	120.58
								41.75						
9	499.4	504.1	2.9683	34.1056	27.176	517	34.1142	41.81		2343.5		39.64	2.96	114.97
10	400.1	403.7	3.1436	34.0182	27.091	518	34.0279	49.05		2331.8		41.67	3.02	108.06
11	298.9	301.5	3.1499	33.8791	26.981	519	33.8907	77.97		2305.0		39.56	2.88	95.80
12	249.7	251.9	2.9864	33.7724	26.913	520	33.7876	94.94		2239.8		38.88	2.80	89.72

	Start	End
Date/Time:	04/5/27 4:55	04/5/27 5:15
Lat.:	46-59.90N	46-59.90N
Long.:	159-59.80E	156-00.00E
Depth (m):	-	-

Remarks: Cast for Routine SHALLOW (~200m) Down Cast中、140m付近でConductivityにノイズ。続いてPressureにもノイズが入り、ソフト中断。デッキユニットをリ セットして、ソフトを再立ち上げ。以降エラー無し。□

Data File Name: K2 Cast01.raw, K2 Cast01b.raw

									<i>a</i> , , , ,	1				
		_	CID data			AU	TOSAL		Chemical a	nalysis (uncorrec	ted data)			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[·Ċ]	[PSU]	[kg/m^3]	B/N	(PSU)	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg
1	199.5	201.2	3.1013	33.8060	26.9262	522	33.8090	71.82		2314.9	0.10	41.53	2.94	91.12
2	149.9	151.2	2.5379	33.5587	26.7817	523	33.5723	150.64		2254.6	0.10	36.42	2.66	74.68
								149.82						
3	125.8	126.9	1.8484	33.2498	26.5936	524	33.2876	261.04		-	0.14	28.75	2.20	54.27
4	100.0	100.9	1.7421	33.0771	26.4641	525	33.1070	327.88		2134.8	0.49	23.82	1.91	41.62
5	80.6	81.3	2.0579	33.0591	26.4252	548	33.0805	333.26		2126.0	0.41	23.19	1.86	40.91
6	69.5	70.1	2.1689	33.0552	26.4131	527	33.0802	333.62		2125.5	0.40	23.08	1.85	40.46
7	60.3	60.8	2.2559	33.0564	26.4070	528	33.0754	334.39		2123.3	0.38	22.96	1.85	40.16
8	49.9	49.9	2.3899	33.0481	26.3890	529	33.0697	335.77		2118.7	0.37	22.88	1.83	40.84
						530	33.0693							
9	39.2	39.5	2.7730	33.0399	26.3496	531	33.0588	337.40		2113.9	0.35	22.74	1.84	41.26
10	31.5	31.8	2.9285	33.0376	26.3339	532	33.0531	339.07		2111.5	0.33	20.80	1.77	38.34
11	19.4	19.6	3.2981	33.0207	26.2861	533	33.0419	338.21		2108.5	0.35	22.27	1.81	40.59
12	9.6	9.7	3.4342	33.0196	26.2722	534	33.0327	336.49		2111.6	0.35	22.27	1.90	40.49
								336.82						
bucket	0	0	3.435	33.0305	26.594	521	33.0371	336.30		2111.1	0.30	16.35	1.62	32.69

	Start	End	Remarks: Cast for Routine DEEP (~3500m)
Date/Time:	2004/5/27 9:27	2004/5/27 9:40	
Lat.:	46-59.92N	46-59.98N	
Long .:	159-59.97E	159-59.95E	
Depth (m):	-	-	Data File Name: K2 Cast06.raw

			CTD data			AU	TOSAL		Chemical	analysis (uncorre	cted data)			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[°Ē]	[PSU]	[kg/m^3]	B/N	(PSU)	µmol/kg	µmol/kg	µmol/kg	µmol/kg	μmol/kg	µmol/kg	µmol/kg
1	3506.9	3555.9	1.1919	34.6794	27.7761	535	34.6814	143.53		2325.5		36.18	2.53	147.69
						536	34.6812							
2	3006.6	3045.1	1.2841	34.6680	27.7614	537	34.6714	131.91				36.79	2.58	152.67
								131.63						
3	2503.1	2532.1	1.4227	34.6499	27.7376	538	34.6533	113.69				38.65	2.83	158.34
4	2002.6	2023.4	1.6445	34.6103	27.6900	539	34.6187	84.32				39.72	2.83	161.40
5	1500.5	1514.3	1.9560	34.5489	27.6170	540	34.5539	50.13				41.49	2.99	163.85
6	999.7	1010.5	2.4434	34.4398	27.4896	541	34.4449	25.58				43.19	3.11	153.64
7	797.6	805.8	2.7099	34.3749	27.4144	542	34.3767	22.09				43.00	3.12	145.84
8	600.7	606.6	3.0298	34.2769	27.3070	543	34.2811	24.25				42.75	3.11	132.79
								24.14						

	Start	End	آ	Remarks: Cast for	r Routine DEEP	P (~3500m)					1	
Date/Time:	2004/5/27 9:27	2004/5/27 9:40										
Lat.:	46-59.92N	46-59.98N										
Long.:	159-59.97E	159-59.95E										
Depth (m):	-	-						Data File Name	: K2 Cast07.raw			
			_									
			CTD data	AUTOSAL Chemical analysis				analysis (uncorr	corrected data)			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx
	[m]	[db]	[·Ē]	[PSU]	[kg/m^3]	B/N	(PSU)	μmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg
1	502.1	506.9	3.1832	34.2041	27.2347	544	34.2197	22.97				43.01
2	400.8	404.5	3.3009	34.1311	27.1631	545	34.1327	23.58				43.04
3	299.8	302.5	3.2920	33.9832	27.0494	546	33.9930	39.28				42.28
4	250.8	253.1	3.3022	33.9237	27.0013	547	33.9252	40.88				42.98

	Start	End
Date/Time:	04/5/27 9:59	04/5/27 10:11
Lat.:	47-00.00N	46-59.90N
Long.:	159-59.90E	160-00.00E
Depth (m):	-	-

Remarks: Cast for Th/POC Shallow (~60m) このSic でのCast 目 (20 Cast02.ram) でDown Cast 52mでConductivityにスパイク状のノイズ。そのまま観測を続けたが、40mでの採水を行うためにボトル#4の採水信号を送ったが、コマンドエラー が表示され、そのままフアトが専調不能となった。システンA再ざむ上げを行い、ホームコマンドを送信せずに、採水を統行した。揚収したとろ、#10~12が採水されていなかト ^ 化技術局に離信が好くないとい、異Casteでった。

Data File Name: K2 Cast02.rawは破棄 K2 Cast03.rawを使うこと。□

PO4

µmol/kg

3.12

3.12

3.07

3.08

SiO4

µmol/kg

126.09

117.51

105.17

99.94

			CTD data		
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0
	[m]	[db]	[°Ē]	[PSU]	[kg/m^3]
1	59.0	59.5	2.2210	33.0561	26.4096
2	59.8	60.3	2.2144	33.0599	26.4131
3	60.0	60.5	2.2169	33.0585	26.4118
4	39.4	39.7	2.8399	33.0432	26.3462
5	38.6	38.9	2.8535	33.0408	26.3431
6	40.1	40.4	2.8359	33.0420	26.3457
7	19.5	19.7	3.3961	33.0223	26.2779
8	19.7	19.9	3.4051	33.0239	26.2783
9	19.8	20.0	3.4036	33.0230	26.2777
10	9.5	9.6	3.4132	33.0218	26.2759
11	10.0	10.1	3.4127	33.0220	26.2762
12	10.1	10.2	3.4102	33.0209	26.2754

	G	E 1		1 0 1	
	Start	End	K	cemarks: Cast for	r In/POC DEEI
Date/Time:	04/5/27 10:31	04/5/27 10:50			
Lat.:	46-59.90N	47-00.00N			
Long.:	159-59.90E	159-59.90E			
Depth (m):	-	-			
	-				
			CTD data		
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0
	[m]	[db]	[·Ē]	[PSU]	[kg/m^3]
1	201.3	203.1	3.1947	33.8251	26.9325
2	200.5	202.3	3.1947	33.8280	26.9359
3	199.6	201.3	3.1958	33.8263	26.9345
4	150.6	151.9	2.6380	33.6058	26.8111
5	149.5	150.8	2.6326	33.6011	26.8078
6	150.4	151.7	2.6345	33.6034	26.8095
7	99.5	100.3	1.6372	33.1043	26.4936
8	99.1	99.9	1.6592	33.0953	26,4849
9	99.9	100.8	1.6456	33.1039	26,4927
10	79.9	80.6	2.0914	33.0796	26.4388
11	79.8	80.5	2.1044	33.0824	26.4400
12	79.8	80.5	2.1064	33.0803	26.4382

	Start	End
Date/Time:	04/5/27 11:10	04/5/27 11:21
Lat.:	46-59.90N	46-59.90N
Long.:	160-00.00E	160-00.00E
Depth (m):	-	-

nd	Remarks: Cast for Primary Productivity
7 11:21	
9.90N	
0.00E	
	Data File Name: K2 Cast05.raw

			CTD data			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	
	[m]	[db]	[°Ē]	[PSU]	[kg/m^3]	
1	54.8	55.3	2.3022	33.0539	26.4012	
2	55.2	55.7	2.2887	33.0565	26.4043	
3	54.6	55.1	2.2872	33.0559	26.4040	
4	35.3	35.6	2.8592	33.0467	26.3473	
5	34.2	34.5	2.8752	33.0370	26.3382	
6	32.8	33.1	2.8768	33.0387	26.339	
7	21.9	22.1	3.0770	33.0474	26.328	
8	23.2	23.4	3.1204	33.0399	26.3180	
9	12.7	12.8	3.3175	33.0255	26.288	
10	12.8	12.9	3.3355	33.0265	26.287	
11	8.6	8.7	3.3398	33.0234	26.2842	
12	8.2	8.3	3.3408	33.0263	26.2864	
bucket	0	0	3.292	33.0347	26.30	

	Start	End	Rem
Date/Time:	04/5/29 18:12	04/5/29 18:33	
Lat.:	39-00.10N	39-00.00N	
Long.:	159-59.90E	160-00.00E	
Depth (m):	-	-	

Remarks: Cast for Routine SHALLOW (~200m)

Data File Name: K3 Cast01.raw

			CTD data			AU	JTOSAL		Chemical	analysis (uncorrec	ted data)			
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[°Ċ]	[PSU]	[kg/m^3]	B/N	(PSU)	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg	µmol/kg
1	200.8	202.4	9.4568	34.2023	26.3987	551	34.1788	253.58		2089.8	0.03	13.04	0.97	19.73
2	150.7	151.9	10.0940	34.2683	26.3410	552	34.2323	242.49		2098.7	0.05	12.92	0.96	18.01
								242.38						
3	124.9	125.9	10.4262	34.2958	26.3040	553	34.2595	252.88		2093.4	0.06	11.46	0.85	16.92
4	100.2	101.0	10.6859	34.3231	26.2789	554	34.2833	256.26		2088.3	0.07	10.70	0.80	15.93
5	80.5	81.1	10.9177	34.3400	26.2500	555	34.3015	258.82		2075.9	0.09	10.22	0.76	14.96
6	70.2	70.7	11.0344	34.3408	26.2293	556	34.3025	261.40		2072.8	0.26	9.82	0.74	14.38
7	60.3	60.8	11.1336	34.3455	26.2147	557	34.3037	261.93		2071.0	0.33	9.60	0.73	14.43
8	50.2	50.6	11.3637	34.3676	26.1891	558	34.3345	258.41		2073.2	0.29	9.45	0.71	13.76
						559	34.3356							
9	40.2	40.5	11.6379	34.3856	26.1515	560	34.3448	262.93		2062.8	0.59	8.43	0.64	12.72
10	30.0	30.2	12.4085	34.4246	26.0327	561	34.3578	270.21		2049.9	0.38	6.72	0.55	11.59
11	19.8	20.0	13.0123	34.4189	25.9076	562	34.3707	270.93		2042.7	0.24	5.39	0.45	10.09
12	10.4	10.5	13.1316	34.3874	25.8591	563	34.3454	272.13		2044.5	0.25	5.44	0.46	10.46
								272.20						
bucket	0	0	13.123	34.3453	17.211	550	34.3553	271.63		2039.8	0.27	5.57	0.47	10.52

	Start	End
Date/Time:	04/5/29 23:31	04/5/29 0:54
Lat.:	39-00.10N	39-00.00N
Long.:	160-00.00E	160-00.00E
Depth (m):	-	-

Remarks: Cast for Routine DEEP (~3500m) 上昇中の水深1,876mで全センサーが異常値。制御不能になったのでリセットして観測再開。□
Data File Name: K3 Cast04.raw, K3 Cast04b.raw

	CTD data					AU	AUTOSAL Chemical analysis (uncorrected data)							
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0	Sal	Salinity	DO	TA	TDIC	NO2	NOx	PO4	SiO4
	[m]	[db]	[·Ċ]	[PSU]	[kg/m^3]	B/N	(PSU)	µmol/kg	µmol/kg	µmol/kg	µmol/kg	μmol/kg	µmol/kg	µmol/kg
1	3501.0	3557.4	1.2181	34.6748	27.7705	565	34.6788	140.10		2325.7		36.34	2.55	146.79
						566	34.6784							
2	3000.4	3045.1	1.3350	34.6609	27.7518	567	34.6655	125.16		2337.6		32.75	2.51	144.40
								125.34						
3	2500.9	2535.2	1.5162	34.6381	27.7211	568	34.6406	102.14		2348.6		37.96	2.70	153.49
4	2000.5	2025.5	1.8330	34.5853	27.6550	569	34.5896	68.75		2365.5		40.92	2.91	157.94
5	1500.8	1517.8	2.2500	34.5023	27.5550	570	34.5087	42.52		2373.5		42.17	3.03	149.02
6	1000.8	1010.9	3.2299	34.3586	27.3515	571	34.3611	41.17		2348.0		41.28	3.01	124.29
7	799.7	807.4	3.7724	34.2562	27.2159	572	34.2569	46.98				40.46	2.96	110.26
8	600.5	606.0	4.5815	34.0960	27.0015	573	34.0936	82.81				36.43	2.71	84.93
								82.85						
9	499.9	504.3	4.9116	33.9564	26.8535	574	33.9564	127.67				32.08	2.39	66.72
10	399.7	403.1	5.9255	33.8925	26.6790	575	33.8992	190.12				24.77	1.91	45.95
11	26.5	303.2	7.5773	33.9795	26.5199	576	33.9566	249.62				16.38	1.27	26.15
12	250.0	252.1	8.4169	34.0622	26.4575	577	34.0330	267.66				12.31	1.06	18.80

10 11 12

	Start	End	R	emarks: Cast fo	r Th/POC Shall	ow (~60m)	
Date/Time:	04/5/29 22:24	04/5/29 22:35					
Lat.:	39-00.00N	39-00.00N					
Long .:	160-00.00E	160-00.00E					
Depth (m):	-	-					Data File Name: K3 Cast02.raw
			CTD data				
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0		
	[m]	[db]	[·Ē]	[PSU]	[kg/m^3]		
1	60.132	60.6	11.0231	34.3039	26.2028		
2	60.033	60.5	11.0086	34.3055	26.2066		
3	59.934	60.4	10.9947	34.3026	26.2070		
4	40.09	40.4	11.7034	34.3171	26.0861		
5	40.487	40.8	11.6903	34.3152	26.0870		
6	40.189	40.5	11.6894	34.3152	26.0873		
7	19.947	20.1	12.7153	34.3697	25.9295		
8	20.145	20.3	12.7203	34.3680	25.9271		
9	19.947	20.1	12.7213	34.3691	25.9278		

25.8621

25.8558 25.8572

	Start	End
Date/Time:	04/5/29 22:53	04/5/29 23:12
Lat.:	39-00.10N	39-00.10N
Long.:	159-59.90E	160-00.00E
Depth (m):	-	-

9.924

9.924 9.726

] [Remarks: Cast for Th/POC DEEP (~200m)
23:12		
lON		
00E		
		Data File Name: K3 Cast03.raw

			CTD data		
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0
	[m]	[db]	[°Ē]	[PSU]	[kg/m^3]
1	201.2	202.8	9.2460	34.1925	26.4261
2	202.0	203.6	9.1895	34.1721	26.4195
3	201.4	203.0	9.2031	34.1877	26.4294
4	150.2	151.4	9.8022	34.2337	26.3648
5	150.3	151.5	9.8112	34.2355	26.3646
6	150.6	151.8	9.8122	34.2313	26.3612
7	100.6	101.4	10.3047	34.2667	26.3029
8	99.9	100.7	10.3078	34.2662	26.3020
9	100.2	101.0	10.3037	34.2637	26.3008
10	80.3	80.9	10.5604	34.2796	26.2677
11	80.5	81.1	10.5599	34.2759	26.2650
12	80.8	81.4	10.5589	34.2798	26.2681

10.0

10.0 10.0 9.8

13.0551

13.0816 13.0802

34.3711

34.3700 34.3714

	Start	End
Date/Time:	04/5/30 9:28	04/5/30 9:40
Lat.:	38-59.90N	39-00.00N
Long.:	160-00.00E	160-00.00E
Depth (m):	-	-

Remarks: Cast for Primary Productivity	
	Data File Name: K3 Cast05.raw

			CTD data		
Bottle #	Depth	Pressure	Pot-Temp.	Salinity	Sigma-0
	[m]	[db]	[°Ē]	[PSU]	[kg/m^3]
1	50.707	51.1	12.0399	34.5696	26.0523
2	51.897	52.3	11.8848	34.5689	26.1140
3	51.302	51.7	11.9189	34.5676	26.1110
4	32.351	32.6	12.8436	34.5661	25.9143
5	32.251	32.5	12.8426	34.5023	25.9160
6	32.648	32.9	12.8276	34.3586	25.9176
7	22.725	22.9	13.2822	34.2562	25.8571
8	22.428	22.6	13.2914	34.0960	25.8498
9	13.695	13.8	13.6206	33.9564	25.7963
10	12.901	13.0	13.5942	33.8925	25.8074
11	7.344	7.4	13.6645	33.9795	25.7891
12	7.939	8.0	13.6649	34.0622	25.7885
bucket	0	0	13.675	34.4333	25.792