

# **MR02-K01 Cuise Report**



**March 2002**

**Japan Marine Science and Technology Center**

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## 1. Introduction

The equatorial Pacific has distinguished characteristics, those are it occupies a large region of the world's ocean and the warmest water of the planet exists there. The western equatorial Pacific contains so-called warm water pool. Nitrate is depleted there and primary production is small. In the central and eastern equatorial Pacific, vertical flux of nutrients is enhanced due to Quasi-stationary upwelling caused by equatorial divergence and consequently chlorophyll a concentration and primary production rate increased along the equator. However, primary production and biomass are not as high as would be expected from the flux of nutrients could support. This is called high nutrient low chlorophyll situation. Since this east to west asymmetry is affected by ENSO event, there is a significant variability in physical characters on seasonal-interannual scale with impact to biogeochemistry, as well potentially with the similar scale of variability.

In order to investigate the mechanism of this biogeochemical variability, Japan Marine Science and Technology Center (JAMSTEC) conducted biogeochemical observation cruise in the equatorial Pacific. Participants are from ;

- Central Research Institution of Electric Power Industries
- Dalhousie University
- Geological Survey of Japan
- Global Ocean Development (Technicians)
- Hokkaido University
- Kansai Environmental Engineering Center
- Kyushu University
- Marine Works Japan (Technicians)
- Meteorological Research Institute
- Nagoya University
- National Institute of Radiological Sciences
- Seikai National Fisheries Research Institute
- Tohoku University
- Tokyo University
- University of Sizuoka

We made a comprehensive observation to investigate carbon cycle especially in a biological aspect. Our observation includes ;

- Hydrocast for physical, chemical and biological parameters such as salinity, nutrients, dissolved inorganic carbon, plant pigments and so on..
- Atmospheric and oceanic CO<sub>2</sub> measurements.

- In situ and simulated in situ incubation for primary productivity and new productivity.
- Sediment trap moorings to observe export production.
- Distribution of phytoplankton and zooplankton.
- Etc.

We will conduct periodical and repeating observation to resolve a biogeochemical variation in a seasonal and inter-annual scale.

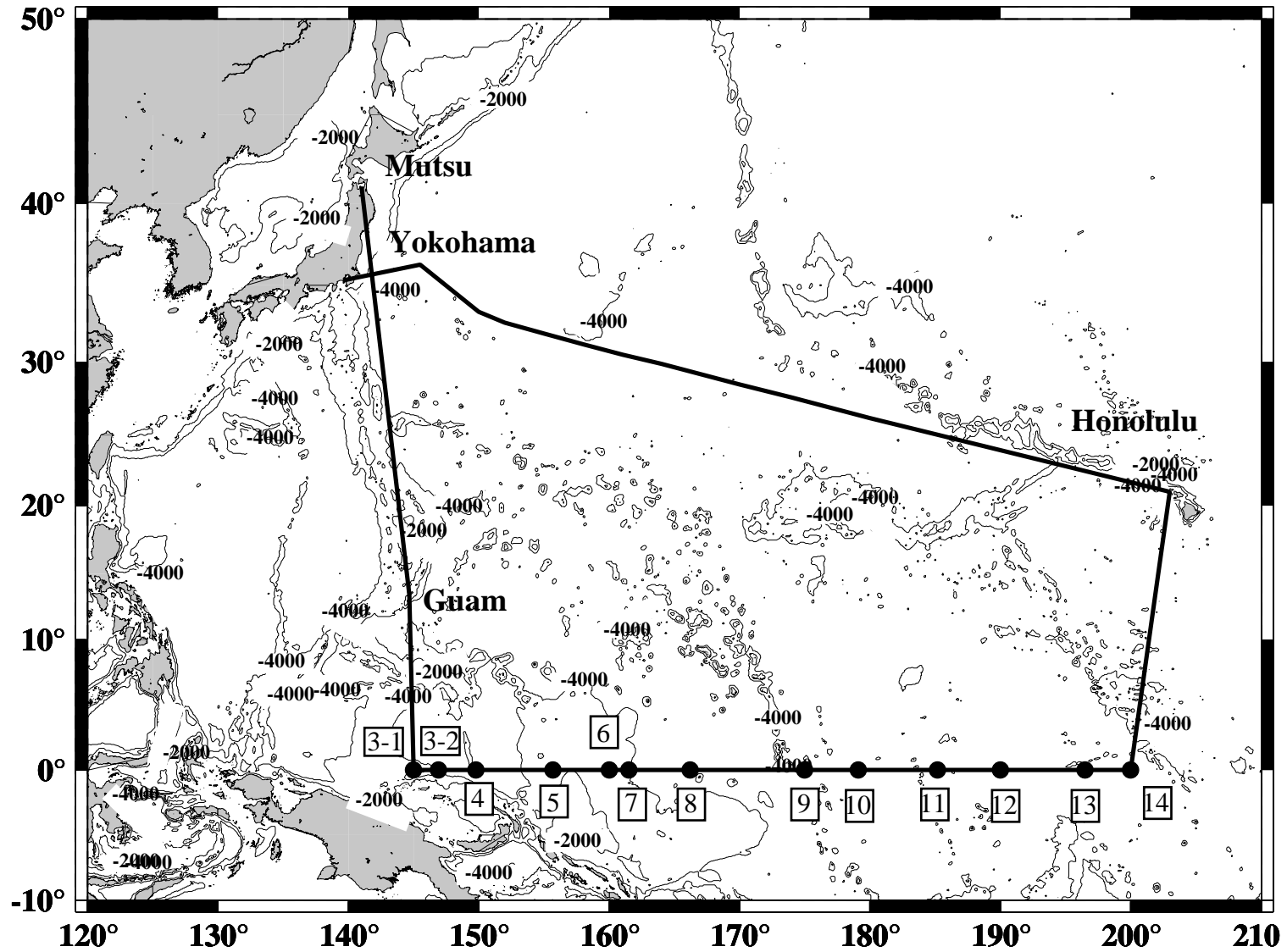
## **2. Outline of the cruise**

### **2.1 Cruise summary**

Ship : MIRAI  
Chief Scientist : Takeshi KAWANO, Ocean Research Department, JAMSTEC  
Cruise Code : MR02-K01  
Project title : Biogeochemical and optical research  
Period : Jan. 6, 2002 - Feb. 16, 2002  
Ports of call : 1) Yokohama, Japan  
2) Honolulu, U.S.A.  
3) Guam, Japan  
4) Hachinohe, Japan  
5) Sekinehama, Japan

### **2.2 Cruise Log and cruise Track**

See tables and figure attached.



MR02-K01 Cruise Track

Table. Cruise Log

Date	Time	Latitude degree	Longitude degree	Pressure hPa	Temp. deg.C	D.P.T. deg.C	R.H. %	W.D. deg.	W.S. m/s	S.S.T. deg.C	Rain mm	Wv.H. m	Wv.Pd. sec
2002-01-06	21:00	35.268	139.392	1025.1	2.2	-5.9	55	325	1.5	9.8	0	0.16	5.97
2002-01-07	0:00	35.268	139.392	1026.3	2.6	-6.4	51	342	2.3	9.6	0	0.27	4.15
2002-01-07	3:00	35.067	139.437	1023.1	6.1	-0.7	62	10	6.3	9.6	1	0.40	6.76
2002-01-07	6:00	34.529	140.143	1020.5	11.3	4.5	63	312	3.3	10.4	0	1.70	9.11
2002-01-07	9:00	35.026	141.078	1019.1	12.5	8.1	74	169	9.4	17.4	0	2.17	8.79
2002-01-07	12:00	35.190	142.022	1017.1	12.4	9.5	83	174	14.1	19.6	0	2.00	8.06
2002-01-07	15:00	35.349	142.566	1015.0	13.5	9.4	76	186	13.8	19.6	0	2.50	9.27
2002-01-07	18:00	35.516	143.518	1012.1	15.1	9.8	71	175	18.6	19.8	0	3.28	10.41
2002-01-07	21:00	36.082	144.479	1011.3	15.9	7.9	59	172	18.8	18	0	4.80	11.83
2002-01-08	0:00	36.256	145.315	1010.5	15.4	11.3	76	182	20.4	19.3	0	5.02	13.34
2002-01-08	3:00	36.141	146.201	1006.2	15.7	10.5	72	183	17.7	14.1	3	3.72	9.45
2002-01-08	6:00	35.488	146.595	1007.7	13.6	11.0	84	223	17.7	18.4	23	5.25	11.16
2002-01-08	9:00	35.238	147.371	1006.7	14.0	12.1	88	213	11.9	18.4	4	5.13	10.68
2002-01-08	12:00	34.577	148.103	1005.6	16.6	11.1	70	204	15.3	18.4	1	4.68	10.72
2002-01-08	15:00	34.301	148.422	1003.4	17.5	13.3	77	212	18	18.6	1	5.22	9.79
2002-01-08	18:00	34.014	149.137	1003.3	18.9	10.0	56	242	19.2	19.4	0	5.00	11.13
2002-01-08	21:00	33.305	149.477	1005.6	17.5	12.2	71	264	16.1	19.2	0	4.96	12.82
2002-01-09	0:00	33.192	150.281	1007.7	16.3	12.8	80	263	12.9	19.5	12	5.11	16.49
2002-01-09	3:00	33.165	151.226	1005.6	16.5	14.4	88	280	11.8	18.7	9	4.22	15.50
2002-01-09	6:00	33.142	152.120	1006.4	15.9	12.8	82	289	11	18.7	1	6.53	18.58
2002-01-09	9:00	33.111	153.051	1008.2	14.0	10.3	78	282	14.3	18.8	7	4.70	15.74
2002-01-09	12:00	33.084	153.594	1008.0	16.0	10.5	70	271	11	18.2	2	5.98	17.63
2002-01-09	15:00	33.074	154.543	1007.7	14.9	10.1	73	278	10.3	16.4	4	4.89	17.83
2002-01-09	18:00	33.051	155.477	1007.9	14.4	9.9	74	292	10	18.1	2	4.30	16.34
2002-01-09	21:00	33.023	156.448	1009.1	14.9	10.0	73	294	13	18.8	1	4.54	18.35
2002-01-10	0:00	32.598	157.409	1010.1	16.7	8.9	60	278	10.4	19.3	0	4.72	19.48
2002-01-10	3:00	32.571	158.328	1008.3	16.7	8.0	57	289	12.3	19.1	1	5.29	20.07
2002-01-10	6:00	32.520	159.269	1009.7	15.8	7.9	59	295	13.2	16.9	0	4.79	18.82
2002-01-10	9:00	32.491	160.187	1011.7	15.7	8.6	63	294	11.5	16.9	0	4.46	17.44
2002-01-10	12:00	32.451	161.066	1012.0	16.1	9.6	65	306	11.8	18.6	0	4.91	15.79
2002-01-10	15:00	32.382	162.014	1011.4	16.1	7.7	58	269	9.6	18.7	0	4.11	18.36
2002-01-10	18:00	32.314	162.561	1011.3	16.7	9.4	62	268	13.3	19.1	0	4.65	19.12
2002-01-10	21:00	32.245	163.465	1013.2	16.3	9.4	64	282	11.3	19.3	1	5.24	19.98
2002-01-11	0:00	32.190	164.310	1013.4	16.8	10.6	67	274	9.8	19.2	0	5.77	20.00
2002-01-11	3:00	32.129	165.243	1011.3	18.4	9.2	55	265	9.4	19.8	76	5.07	19.03
2002-01-11	6:00	32.062	166.178	1012.0	17.8	9.7	59	250	9.9	18.4	0	4.51	17.80
2002-01-11	9:00	32.003	167.049	1012.5	17.9	10.5	62	231	11.9	18.8	1	4.11	13.99
2002-01-11	12:00	31.534	167.597	1011.6	17.9	11.5	66	228	12	18.2	3	4.58	19.79
2002-01-11	15:00	31.465	168.545	1010.4	18.1	11.9	67	235	11.1	18.6	1	5.00	19.96
2002-01-11	18:00	31.407	169.407	1009.5	18.5	12.9	70	243	12.9	19.2	0	4.89	15.98
2002-01-11	21:00	31.378	170.008	1009.1	18.7	11.8	64	227	12.5	19.3	0	3.35	10.47
2002-01-12	0:00	31.356	170.133	1006.5	19.0	13.3	70	224	14.9	19.3	0	5.22	19.13
2002-01-12	3:00	31.277	171.059	1003.1	19.7	13.3	66	228	16.8	19.7	73	5.09	17.97
2002-01-12	6:00	31.196	171.589	1002.6	19.8	14.1	70	227	16.9	19.5	2	5.40	19.92
2002-01-12	9:00	31.108	172.524	1002.2	19.7	14.8	73	223	17.6	19.4	0	4.93	17.78
2002-01-12	12:00	31.018	173.470	1001.5	17.9	15.4	85	248	16.2	19.3	115	3.63	15.15
2002-01-12	15:00	30.535	174.395	1002.4	18.5	15.7	84	261	14.5	18.7	1	4.66	18.11
2002-01-12	18:00	30.448	175.341	1003.2	18.2	14.8	80	259	11.1	18	0	5.07	19.64
2002-01-12	21:00	30.362	176.276	1005.1	19.6	9.9	54	266	16.1	20.4	0	5.49	19.50
2002-01-13	0:00	30.284	177.171	1005.2	19.8	12.0	61	266	14.4	19.7	0	5.81	19.85
2002-01-13	3:00	30.192	178.089	1005.5	19.3	12.1	63	273	15.8	20	0	5.36	19.50
2002-01-13	6:00	30.103	179.004	1007.6	18.4	12.3	68	295	13.7	20.3	1	6.25	20.00
2002-01-13	9:00	30.018	179.503	1009.2	18.3	10.7	61	306	10.5	19.8	1	5.96	19.28
2002-01-13	12:00	29.503	-179.275	1009.1	18.3	9.5	57	270	4.6	20.1	0	4.27	17.69

Date	Time	Latitude degree	Longitude degree	Pressure hPa	Temp. deg.C	D.P.T. deg.C	R.H. %	W.D. deg.	W.S. m/s	S.S.T. deg.C	Rain mm	Wv.H. m	Wv.Pd. sec
2002-01-13	15:00	29.378	-178.443	1008.3	18.4	11.9	66	217	8.3	19.1	0	6.33	19.11
2002-01-13	18:00	29.252	-178.008	1008.3	18.7	14.4	76	212	10.7	19.7	0	4.89	18.37
2002-01-13	21:00	29.120	-177.173	1009.9	19.7	14.8	73	223	11.5	20.2	0	5.21	19.37
2002-01-14	0:00	28.592	-176.332	1008.6	20.4	14.9	71	230	11.8	21	1	6.54	19.56
2002-01-14	3:00	28.469	-175.514	1007.7	21.0	14.3	66	233	11.2	20.8	0	6.99	19.35
2002-01-14	6:00	28.344	-175.084	1008.2	21.2	15.7	71	237	9.1	21.7	0	5.33	18.84
2002-01-14	9:00	28.212	-174.259	1008.8	21.7	16.2	71	226	8.2	21.6	2	5.58	17.22
2002-01-14	12:00	28.084	-173.433	1007.8	21.6	17.9	80	201	7.7	21.7	1	5.49	17.56
2002-01-14	15:00	27.559	-173.009	1007.6	20.6	17.4	82	206	8.5	21.3	1	4.83	17.88
2002-01-14	18:00	27.440	-172.200	1007.4	21.1	18.5	85	216	9.7	22.2	1	4.19	16.92
2002-01-14	21:00	27.318	-171.394	1008.9	20.5	17.3	82	214	7.6	21.5	0	4.99	18.15
2002-01-15	0:00	27.194	-170.590	1007.6	19.3	18.1	93	239	5.1	21.4	0	3.95	17.42
2002-01-15	3:00	27.071	-170.187	1007.5	20.6	19.4	93	237	11.5	22.2	7	3.47	18.78
2002-01-15	6:00	26.532	-169.399	1008.0	21.4	19.7	90	217	7.8	21.4	0	3.11	16.86
2002-01-15	9:00	26.369	-169.021	1009.4	22.5	21.1	92	204	9.6	22.2	0	3.86	17.19
2002-01-15	12:00	26.215	-168.257	1009.3	22.7	21.2	91	197	11.5	23.3	0	3.74	16.44
2002-01-15	15:00	26.057	-167.494	1010.0	22.9	21.0	89	194	10.9	23.7	0	2.78	14.61
2002-01-15	18:00	25.502	-167.122	1011.4	22.0	20.4	91	197	14.7	23.5	2	3.55	15.84
2002-01-15	21:00	25.340	-166.338	1013.3	23.5	20.7	84	185	13.4	23.2	0	3.12	13.43
2002-01-16	0:00	25.173	-165.563	1012.6	23.6	20.7	84	183	12.1	23.4	1	2.89	12.38
2002-01-16	3:00	25.010	-165.188	1014.6	23.6	20.7	84	187	10.7	23.4	1	2.62	13.07
2002-01-16	6:00	24.445	-164.407	1017.6	23.2	20.5	85	180	7.6	23.7	0	2.24	11.64
2002-01-16	9:00	24.283	-164.024	1018.9	22.9	20.4	86	169	6.1	23.6	1	1.92	13.66
2002-01-16	12:00	23.552	-163.435	1019.0	23.0	19.3	80	134	7.5	23.6	1	2.31	13.68
2002-01-16	15:00	23.208	-163.256	1019.2	23.3	19.9	81	128	6.7	23.8	0	2.07	13.87
2002-01-16	18:00	22.450	-163.076	1020.6	23.4	19.2	77	114	5.6	24.3	0	1.64	10.41
2002-01-16	21:00	22.204	-162.419	1021.5	23.7	19.0	75	95	5.9	24.6	0	1.70	10.52
2002-01-17	0:00	22.033	-162.098	1019.2	23.8	18.9	74	74	8.1	25.2	0	1.75	11.19
2002-01-17	3:00	21.457	-161.376	1019.4	24.0	17.2	66	83	8.5	25.1	0	1.86	9.83
2002-01-17	6:00	21.290	-161.054	1020.7	23.7	17.5	68	90	11.1	24.7	1	1.86	7.93
2002-01-17	9:00	21.113	-160.309	1020.6	23.5	15.8	62	72	13.6	25	1	2.01	6.60
2002-01-17	12:00	21.111	-159.549	1020.1	23.4	16.2	64	73	12	25.1	0	2.02	7.43
2002-01-17	15:00	21.111	-159.167	1020.2	23.4	16.5	65	61	11.1	25.3	0	1.97	6.43
2002-01-17	18:00	21.112	-158.406	1021.7	23.2	15.9	63	45	10.5	25.1	0	1.65	7.09
2002-01-17	21:00	21.105	-158.120	1022.5	23.7	15.7	61	69	11.8	25.4	0	1.43	7.73
2002-01-18	0:00	21.184	-157.520	1020.6	25.0	14.1	51	48	4.9	25.4	71	0.14	6.04
2002-01-18	3:00	21.184	-157.520	1020.9	23.8	14.0	54	37	2.8	25.7	0	0.18	4.57
2002-01-18	6:00	21.184	-157.520	1021.9	22.7	15.3	63	38	2.7	25.8	1	0.15	5.68
2002-01-18	9:00	21.184	-157.520	1022.4	21.1	16.4	75	26	3.3	25.7	10	0.19	7.47
2002-01-18	12:00	21.184	-157.520	1020.9	20.5	16.6	79	46	1.7	25.6	48	0.21	5.29
2002-01-18	15:00	21.184	-157.520	1020.2	21.9	15.1	66	53	3.1	25.3	0	0.16	4.85
2002-01-18	18:00	21.184	-157.520	1020.8	21.9	14.4	63	40	2.9	24.9	7	0.14	6.93
2002-01-18	21:00	21.184	-157.520	1021.8	21.8	16.6	73	90	3.1	24.6	13	0.17	5.68
2002-01-19	0:00	21.184	-157.520	1018.8	23.4	17.7	70	65	2.7	24.5	19	0.13	5.19
2002-01-19	3:00	21.184	-157.520	1018.7	23.4	16.1	64	56	2.7	24.6	0	0.17	5.36
2002-01-19	6:00	21.184	-157.520	1019.8	21.6	16.2	71	69	2.2	24.6	4	0.14	5.01
2002-01-19	9:00	21.184	-157.520	1020.4	21.8	13.4	59	59	4.1	24.7	2	0.20	5.54
2002-01-19	12:00	21.184	-157.520	1019.3	20.4	15.6	74	103	2.2	24.5	15	0.23	6.83
2002-01-19	15:00	21.184	-157.520	1018.8	21.9	13.3	58	64	2.5	24.3	3	0.18	5.01
2002-01-19	18:00	21.184	-157.520	1020.3	22.2	13.3	57	87	3.3	24	0	0.15	6.85
2002-01-19	21:00	21.081	-157.538	1019.9	23.0	16.2	66	61	15.9	24	2	2.65	10.83
2002-01-20	0:00	20.222	-157.590	1015.7	23.7	16.8	66	53	16.9	24.2	0	4.18	15.81
2002-01-20	3:00	19.564	-158.018	1015.4	23.5	16.3	64	56	10.4	25	2	3.45	10.91
2002-01-20	6:00	19.113	-158.068	1016.3	23.2	17.0	68	54	13	25.1	2	4.05	16.71
2002-01-20	9:00	18.266	-158.111	1015.7	23.6	16.9	66	104	10.3	25.2	1	4.12	16.06



Date	Time	Latitude degree	Longitude degree	Pressure hPa	Temp. deg.C	D.P.T. deg.C	R.H. %	W.D. deg.	W.S. m/s	S.S.T. deg.C	Rain mm	Wv.H. m	Wv.Pd. sec
2002-01-20	12:00	17.413	-158.156	1014.0	23.6	17.7	70	80	9.6	25.2	0	3.51	13.76
2002-01-20	15:00	16.543	-158.203	1012.6	24.0	17.9	69	65	10	25.2	0	3.65	15.74
2002-01-20	18:00	16.074	-158.250	1013.1	24.3	18.9	72	60	10	25.2	2	4.38	17.32
2002-01-20	21:00	15.213	-158.302	1013.5	24.8	19.6	73	59	9.7	25.2	2	3.88	16.68
2002-01-21	0:00	14.346	-158.345	1010.9	23.0	20.3	84	63	11.2	25.5	3	3.52	17.35
2002-01-21	3:00	13.484	-158.392	1010.0	25.0	21.5	81	53	9	25.9	0	4.12	18.24
2002-01-21	6:00	13.025	-158.436	1011.2	25.2	21.4	79	63	8.6	26.2	1	3.71	18.21
2002-01-21	9:00	12.165	-158.484	1011.8	24.0	21.7	87	91	10	26.6	1	3.30	17.84
2002-01-21	12:00	11.310	-158.529	1010.6	25.7	21.9	80	106	9.1	26.8	0	3.20	16.26
2002-01-21	15:00	10.466	-158.570	1010.0	24.5	20.8	80	173	9.3	27.2	2	3.12	12.75
2002-01-21	18:00	10.037	-159.014	1010.9	25.8	20.4	72	163	8.1	27.4	0	3.50	14.38
2002-01-21	21:00	9.195	-159.057	1011.3	26.2	21.2	74	132	6.3	27.5	0	3.20	15.35
2002-01-22	0:00	8.343	-159.101	1008.9	26.9	21.3	71	115	6.2	27.4	0	3.37	16.81
2002-01-22	3:00	7.486	-159.144	1008.6	26.4	22.4	79	106	5.9	27.7	0	2.80	15.68
2002-01-22	6:00	7.038	-159.185	1010.3	27.3	22.3	74	133	5.9	28	2	2.58	15.16
2002-01-22	9:00	6.194	-159.233	1010.1	27.6	22.4	73	132	10.3	28.5	2	3.03	16.67
2002-01-22	12:00	5.349	-159.277	1008.4	26.9	22.2	76	142	10.4	28.3	1	3.09	17.87
2002-01-22	15:00	4.509	-159.322	1007.2	26.2	22.3	79	141	12.1	27.4	2	3.13	17.15
2002-01-22	18:00	4.091	-159.361	1008.8	26.8	21.7	74	132	10.1	27.5	1	2.39	14.84
2002-01-22	21:00	3.262	-159.401	1008.3	27.2	21.3	71	128	10.4	27.8	0	1.88	10.54
2002-01-23	0:00	2.438	-159.440	1006.6	27.2	21.5	71	116	10.4	28	0	2.34	13.43
2002-01-23	3:00	2.000	-159.486	1005.3	27.6	21.4	69	117	11.5	28.1	1	2.46	14.04
2002-01-23	6:00	1.156	-159.525	1006.8	27.3	21.5	71	117	11.9	28	0	2.95	16.20
2002-01-23	9:00	0.304	-159.575	1007.8	27.3	21.6	71	115	12.5	28.1	0	2.70	13.76
2002-01-23	12:00	0.001	-160.001	1007.1	27.2	21.1	69	103	9.9	28.1	1	2.17	9.08
2002-01-23	15:00	0.000	-160.001	1006.5	26.8	21.0	71	90	8.9	28	3	2.11	8.18
2002-01-23	18:00	0.000	-160.003	1008.4	27.3	21.9	73	87	10.3	28	2	2.23	9.21
2002-01-23	21:00	-0.004	-160.018	1008.3	28.4	22.1	69	95	8.7	28	0	1.75	9.24
2002-01-24	0:00	-0.016	-160.000	1005.6	27.5	22.1	73	90	9.4	28.1	1	2.26	8.62
2002-01-24	3:00	0.000	-159.600	1004.8	27.4	22.4	74	99	9.3	28.1	0	2.09	7.56
2002-01-24	6:00	-0.002	-159.598	1006.4	27.4	22.4	74	98	9	28	0	2.31	8.65
2002-01-24	9:00	0.009	-159.598	1006.9	27.2	22.4	75	89	9.6	28	0	2.20	8.57
2002-01-24	12:00	-0.001	-160.320	1005.7	27.1	23.0	78	97	9.2	28	0	2.95	18.55
2002-01-24	15:00	0.000	-161.200	1005.5	26.4	23.9	86	104	8.4	28	0	2.93	18.16
2002-01-24	18:00	0.000	-162.088	1007.3	27.3	23.4	79	100	8.7	28	0	2.51	18.69
2002-01-24	21:00	0.001	-162.590	1007.1	28.5	24.0	77	100	7.9	28.1	1	2.68	19.08
2002-01-25	0:00	-0.004	-163.299	1005.0	27.8	23.4	77	105	7.2	28.2	2	2.03	8.17
2002-01-25	3:00	0.000	-164.033	1003.9	28.5	24.1	77	114	7.7	28.2	2	3.09	17.48
2002-01-25	6:00	0.000	-164.549	1004.9	27.6	23.8	80	106	8.6	28.1	0	2.54	18.52
2002-01-25	9:00	0.001	-165.452	1006.6	27.4	23.8	81	112	9.5	28	0	2.59	19.69
2002-01-25	12:00	0.002	-166.350	1005.9	27.3	24.1	83	119	9.4	28.1	0	2.60	19.47
2002-01-25	15:00	0.000	-167.248	1004.8	25.8	23.4	87	94	9.2	28.2	18	2.84	19.77
2002-01-25	18:00	0.001	-168.143	1005.7	27.2	25.1	88	107	8.3	28.3	0	2.79	18.50
2002-01-25	21:00	0.000	-169.032	1006.7	28.6	24.5	79	114	9.6	28.4	0	2.92	17.40
2002-01-26	0:00	0.000	-169.530	1004.4	28.4	24.4	79	110	7	28.7	0	2.77	19.71
2002-01-26	3:00	-0.001	-169.600	1003.3	28.2	23.2	74	109	8.3	28.7	0	1.83	8.73
2002-01-26	6:00	-0.007	-170.007	1005.7	28.2	23.7	77	117	7.6	28.6	0	2.04	8.39
2002-01-26	9:00	0.000	-170.062	1007.6	28.1	23.6	77	112	8	28.6	0	1.95	8.68
2002-01-26	12:00	0.002	-170.005	1006.9	28.0	22.8	73	119	8.9	28.6	0	2.08	8.27
2002-01-26	15:00	0.000	-170.000	1005.4	27.8	22.7	74	112	9.5	28.6	0	2.17	8.22
2002-01-26	18:00	-0.002	-170.118	1007.1	27.8	22.8	75	117	8.4	28.6	2	2.35	11.26
2002-01-26	21:00	-0.011	-170.103	1008.4	28.2	23.7	77	125	7.2	28.6	2	2.15	9.20
2002-01-27	0:00	-0.012	-170.025	1006.6	28.1	23.8	78	124	7.6	28.7	0	2.27	8.62
2002-01-27	3:00	-0.009	-170.042	1004.8	28.1	23.1	74	114	7.4	28.8	0	2.15	9.55
2002-01-27	6:00	-0.011	-170.204	1005.8	28.0	23.4	76	118	10.3	28.7	2	3.32	18.69

Date	Time	Latitude degree	Longitude degree	Pressure hPa	Temp. deg.C	D.P.T. deg.C	R.H. %	W.D. deg.	W.S. m/s	S.S.T. deg.C	Rain mm	Wv.H. m	Wv.Pd. sec
2002-01-27	9:00	0.000	-171.104	1007.8	27.9	23.5	77	113	8.1	28.7	1	2.79	17.29
2002-01-27	12:00	-0.002	-172.011	1006.8	27.8	23.3	77	114	8.7	28.7	0	2.90	17.35
2002-01-27	15:00	-0.001	-172.520	1005.8	27.8	23.1	75	116	7	28.7	2	2.57	18.56
2002-01-27	18:00	0.003	-173.425	1007.1	27.9	23.2	76	114	7.2	28.7	0	2.90	18.31
2002-01-27	21:00	-0.001	-174.327	1009.2	28.4	24.2	78	121	5.9	28.9	1	2.80	17.56
2002-01-28	0:00	-0.002	-174.470	1007.3	28.4	23.2	74	123	6.4	29	0	2.02	9.24
2002-01-28	3:00	0.001	-175.253	1005.6	28.8	23.6	74	124	6	29.3	0	2.49	19.87
2002-01-28	6:00	0.000	-176.155	1007.0	28.4	23.8	76	105	6.5	29.1	2	1.93	16.94
2002-01-28	9:00	0.000	-177.048	1008.5	28.4	24.0	77	119	6.5	29.3	2	2.15	16.69
2002-01-28	12:00	0.000	-177.548	1008.4	28.4	23.7	76	128	5.9	29.4	3	2.08	17.43
2002-01-28	15:00	0.002	-178.442	1007.2	28.3	23.7	76	129	4.7	29.6	1	2.37	18.38
2002-01-28	18:00	0.001	-179.334	1007.7	28.4	23.6	75	125	6.3	29.6	0	2.46	19.56
2002-01-28	21:00	0.001	179.373	1009.1	28.9	24.0	75	109	6.2	29.6	0	2.09	17.22
2002-01-29	0:00	0.008	179.075	1008.5	29.0	23.7	73	76	5.4	29.8	0	1.80	9.83
2002-01-29	3:00	0.000	178.364	1006.5	29.4	23.7	72	71	5.1	30.1	0	2.16	17.54
2002-01-29	6:00	-0.002	177.460	1007.3	26.7	21.6	74	107	4.4	29.9	7	1.68	13.31
2002-01-29	9:00	0.001	176.557	1008.4	27.1	24.3	85	58	5.8	29.8	2	1.92	14.28
2002-01-29	12:00	0.000	176.047	1008.4	28.1	24.7	82	48	6	29.8	0	1.96	15.61
2002-01-29	15:00	-0.002	175.149	1006.5	28.0	24.1	79	68	4	29.7	0	2.14	18.51
2002-01-29	18:00	0.005	174.589	1006.6	28.2	24.1	78	81	5.4	29.8	0	1.75	9.04
2002-01-29	21:00	0.026	174.545	1008.5	28.6	24.4	78	72	6.1	29.7	2	1.67	9.62
2002-01-30	0:00	0.003	174.577	1007.4	29.0	24.2	75	64	4.7	30	0	1.62	8.84
2002-01-30	3:00	0.020	174.563	1005.0	29.3	24.3	74	46	5.1	30.2	2	1.82	9.93
2002-01-30	6:00	-0.009	174.533	1005.7	28.4	23.9	77	34	5	29.9	1	1.79	11.54
2002-01-30	9:00	0.003	174.568	1007.4	29.1	23.7	73	54	6.1	29.9	0	1.51	8.38
2002-01-30	12:00	0.007	174.587	1007.9	26.8	24.3	87	60	7.1	29.8	0	1.69	9.29
2002-01-30	15:00	-0.045	174.203	1005.9	27.9	24.4	81	87	6.1	29.8	0	1.85	17.96
2002-01-30	18:00	-0.092	173.288	1006.7	27.3	24.7	86	97	5.7	29.8	1	1.58	19.00
2002-01-30	21:00	-0.039	172.392	1009.3	24.4	23.2	93	150	4.3	29.7	263	1.51	14.85
2002-01-31	0:00	0.001	171.505	1008.5	25.8	23.7	89	238	10.7	29.6	13	1.32	14.96
2002-01-31	3:00	0.000	171.024	1007.5	24.1	22.4	91	284	11.1	29.6	88	1.16	7.66
2002-01-31	6:00	0.000	170.174	1007.5	26.2	24.2	89	313	5.6	29.6	2	1.39	6.35
2002-01-31	9:00	-0.003	169.356	1008.9	26.9	22.6	77	337	3.2	29.7	0	1.42	9.58
2002-01-31	12:00	0.001	168.535	1008.5	28.3	23.8	76	335	4.4	29.7	0	1.30	7.84
2002-01-31	15:00	0.000	168.117	1006.6	28.7	22.9	71	325	6	29.7	2	1.19	8.40
2002-01-31	18:00	-0.001	167.306	1006.9	28.7	23.4	73	338	5.2	29.8	1	1.30	10.51
2002-01-31	21:00	0.002	166.495	1009.5	28.6	23.7	75	289	5.1	29.9	2	1.40	10.18
2002-02-01	0:00	0.003	166.112	1008.4	27.3	23.3	79	320	3.9	29.8	0	1.48	9.17
2002-02-01	3:00	-0.009	166.080	1006.1	28.4	21.8	67	315	3.2	29.8	1	1.31	8.95
2002-02-01	6:00	0.001	165.282	1005.9	28.2	22.7	72	0	3.7	29.9	2	1.58	10.77
2002-02-01	9:00	-0.002	164.476	1008.6	28.1	23.5	76	8	3.3	29.6	1	1.33	10.83
2002-02-01	12:00	0.003	164.061	1008.8	28.2	23.7	77	21	3.6	29.7	1	1.53	11.67
2002-02-01	15:00	0.001	163.262	1007.9	24.7	23.0	90	333	4.3	29.5	16	1.58	12.17
2002-02-01	18:00	-0.001	162.465	1007.3	27.5	24.7	85	289	5.4	29.6	1	1.51	12.21
2002-02-01	21:00	0.001	162.064	1008.8	28.0	24.3	81	281	4.5	29.6	1	1.57	10.46
2002-02-02	0:00	0.002	161.288	1009.1	28.5	24.6	79	309	4.9	29.7	0	1.60	9.93
2002-02-02	3:00	-0.009	161.220	1007.0	28.8	23.6	73	323	4.9	30	26	1.50	9.29
2002-02-02	6:00	-0.001	160.408	1006.4	28.4	24.0	77	325	4.2	30.2	0	1.54	12.50
2002-02-02	9:00	0.002	159.591	1008.7	28.2	24.1	79	331	2.5	29.9	1	1.33	9.03
2002-02-02	12:00	-0.009	159.600	1009.9	28.3	23.6	75	337	1.4	29.8	0	1.35	9.27
2002-02-02	15:00	-0.003	159.598	1008.3	28.0	23.8	78	35	2.4	29.8	1	1.39	8.79
2002-02-02	18:00	-0.002	159.598	1007.8	28.0	24.1	80	43	2.3	29.8	1	1.47	8.21
2002-02-02	21:00	0.032	159.567	1009.3	28.2	23.7	77	91	2.4	29.7	2	1.32	8.59
2002-02-03	0:00	0.008	159.580	1009.2	27.5	23.9	80	41	2.6	29.7	2	1.40	8.78
2002-02-03	3:00	0.028	159.570	1007.7	28.6	23.2	73	22	1.9	29.8	61	1.50	9.15

Date	Time	Latitude degree	Longitude degree	Pressure hPa	Temp. deg.C	D.P.T. deg.C	R.H. %	W.D. deg.	W.S. m/s	S.S.T. deg.C	Rain mm	Wv.H. m	Wv.Pd. sec
2002-02-03	6:00	-0.009	159.599	1007.2	28.5	23.9	76	21	2.7	30	1	1.55	8.46
2002-02-03	9:00	0.002	159.349	1009.0	28.7	23.4	73	7	3.6	29.9	0	1.58	10.52
2002-02-03	12:00	0.002	158.486	1009.7	29.0	23.0	70	16	2.7	30	0	1.60	11.26
2002-02-03	15:00	0.008	158.008	1008.5	28.9	23.2	72	359	3.6	30.2	0	1.60	11.79
2002-02-03	18:00	0.006	157.144	1007.5	28.5	23.3	74	356	1.8	30	0	1.23	9.17
2002-02-03	21:00	0.012	156.267	1008.1	28.6	23.9	76	352	3.9	29.9	0	1.60	11.26
2002-02-04	0:00	-0.004	155.512	1009.1	29.1	24.0	74	11	1.8	29.9	2	1.65	10.92
2002-02-04	3:00	0.000	155.439	1007.2	29.1	23.7	72	21	1.9	30.2	0	1.40	11.54
2002-02-04	6:00	-0.001	154.557	1006.8	29.5	23.1	69	35	1.8	30.5	0	1.49	11.85
2002-02-04	9:00	0.002	154.063	1008.2	29.3	23.3	70	338	1.8	30.6	0	1.17	10.73
2002-02-04	12:00	0.000	153.174	1009.0	28.9	23.7	74	5	2.2	30.2	0	1.56	12.74
2002-02-04	15:00	0.001	152.283	1007.7	28.5	23.4	74	319	1.9	30	0	1.23	11.61
2002-02-04	18:00	-0.001	151.391	1007.0	28.2	22.9	73	296	0.5	29.9	0	1.14	10.21
2002-02-04	21:00	0.000	150.493	1008.6	28.1	23.0	74	21	0.8	29.9	0	1.31	10.57
2002-02-05	0:00	0.000	149.594	1010.2	28.3	22.9	73	315	1.3	29.8	1	1.31	11.55
2002-02-05	3:00	-0.005	149.449	1007.9	28.6	22.8	71	9	1.2	30	2	1.39	9.43
2002-02-05	6:00	0.000	149.040	1006.6	28.8	22.3	68	28	0.6	30	0	1.18	10.58
2002-02-05	9:00	0.001	148.157	1007.8	28.4	22.3	70	19	1.4	30.1	1	1.38	10.73
2002-02-05	12:00	0.000	147.274	1009.3	28.3	22.2	70	15	1.4	29.8	3	1.32	10.64
2002-02-05	15:00	0.007	146.570	1008.8	27.9	21.9	70	87	0.2	29.6	0	1.44	9.41
2002-02-05	18:00	0.007	146.391	1007.1	27.7	21.1	67	306	0.7	29.6	3	1.27	9.60
2002-02-05	21:00	0.000	145.505	1008.3	27.7	22.2	72	349	0.6	29.4	2	1.28	8.96
2002-02-06	0:00	-0.002	145.008	1010.5	25.2	24.1	93	298	1.9	29.4	3	1.34	11.34
2002-02-06	3:00	0.004	144.598	1008.6	25.9	24.0	89	292	7.5	29.4	28	1.53	9.40
2002-02-06	6:00	0.322	144.589	1006.9	27.9	25.9	89	271	6	29.8	1	1.40	7.57
2002-02-06	9:00	1.108	144.586	1009.0	28.0	22.8	74	4	4.5	29.7	0	1.34	8.25
2002-02-06	12:00	1.497	144.575	1010.5	27.9	22.5	72	45	2.9	29.8	1	1.29	7.85
2002-02-06	15:00	2.293	144.565	1009.8	28.0	21.5	68	14	1.5	29.6	1	1.30	7.57
2002-02-06	18:00	3.077	144.557	1008.2	27.9	21.5	68	58	1.8	29.6	1	1.25	7.39
2002-02-06	21:00	3.463	144.551	1009.4	27.8	22.0	71	79	0.5	29.4	0	1.27	7.54
2002-02-07	0:00	4.254	144.542	1011.1	27.9	22.5	72	0	0.5	29.4	0	1.25	7.14
2002-02-07	3:00	5.040	144.535	1009.1	27.8	23.1	76	37	1.4	29.4	0	1.19	7.40
2002-02-07	6:00	5.418	144.525	1007.7	28.1	23.1	74	21	1.2	29.6	0	1.21	7.40
2002-02-07	9:00	6.097	144.475	1009.1	26.1	23.7	87	61	9	29.2	1	1.21	7.40
2002-02-07	12:00	6.466	144.481	1010.6	26.9	23.8	83	61	4.8	28.6	0	1.21	7.40
2002-02-07	15:00	7.248	144.485	1009.8	27.7	23.6	78	80	6.3	28.4	0	1.21	7.40
2002-02-07	18:00	8.031	144.491	1009.0	26.9	23.5	82	63	5.7	28.4	0	1.21	7.40
2002-02-07	21:00	8.400	144.478	1010.5	27.5	23.4	78	43	6.5	28.4	0	1.21	7.40
2002-02-08	0:00	9.145	144.457	1011.7	27.8	23.3	77	45	7.8	28.3	0	1.49	8.38
2002-02-08	3:00	9.489	144.438	1010.3	27.5	23.3	78	48	7.4	28.5	0	1.32	7.67
2002-02-08	6:00	10.240	144.415	1008.4	27.3	23.0	77	38	8.7	29	0	1.45	7.98
2002-02-08	9:00	10.577	144.387	1009.9	27.5	22.9	76	45	8	29.1	0	1.37	7.77
2002-02-08	12:00	11.325	144.371	1010.9	27.2	22.4	75	46	8.7	29.1	0	1.35	7.40
2002-02-08	15:00	12.076	144.348	1010.6	27.2	22.3	75	54	8.1	28.9	0	1.40	7.44
2002-02-08	18:00	12.427	144.326	1009.6	26.9	22.2	76	63	7.6	28.8	1	1.38	7.23
2002-02-08	21:00	13.160	144.302	1010.7	26.9	22.2	76	84	5.9	28.6	1	1.19	5.81
2002-02-09	0:00	13.276	144.402	1011.9	28.4	22.6	71	55	5.9	28.7	0	0.24	9.01
2002-02-09	3:00	13.276	144.402	1010.0	28.0	22.4	72	36	5.6	29.2	0	0.30	4.10
2002-02-09	6:00	13.276	144.402	1008.5	29.1	22.1	66	78	3.2	29.5	0	0.21	4.47
2002-02-09	9:00	13.276	144.402	1010.1	26.8	22.0	75	64	1.6	29.6	0	0.13	6.79
2002-02-09	12:00	13.276	144.402	1011.5	26.0	22.5	81	77	1.9	29.7	0	0.13	8.41
2002-02-09	15:00	13.276	144.402	1010.5	25.4	22.5	84	90	0.2	29.6	0	0.05	7.29
2002-02-09	18:00	13.276	144.402	1008.8	25.1	22.1	83	64	2.1	29.5	0	0.11	7.30
2002-02-09	21:00	13.276	144.402	1009.9	25.1	22.5	86	69	0.4	29.3	0	0.06	6.03
2002-02-10	0:00	13.276	144.399	1011.2	27.7	22.9	75	51	3	29.1	2	0.16	5.93

Date	Time	Latitude degree	Longitude degree	Pressure hPa	Temp. deg.C	D.P.T. deg.C	R.H. %	W.D. deg.	W.S. m/s	S.S.T. deg.C	Rain mm	Wv.H. m	Wv.Pd. sec
2002-02-10	3:00	14.088	144.325	1009.8	26.5	22.7	80	63	4.4	28.4	1	1.35	7.12
2002-02-10	6:00	14.564	144.282	1008.8	26.5	21.3	73	54	7	28	0	1.28	5.84
2002-02-10	9:00	15.435	144.251	1011.0	26.4	20.1	68	32	7.1	28	0	1.29	6.65
2002-02-10	12:00	16.307	144.220	1012.5	25.7	19.4	68	34	5.8	27.8	0	1.33	7.28
2002-02-10	15:00	17.187	144.186	1012.1	24.7	17.7	65	56	4.3	26.9	1	1.36	7.65
2002-02-10	18:00	18.076	144.145	1011.4	23.7	16.8	65	327	2.9	27.2	0	1.33	8.16
2002-02-10	21:00	18.562	144.114	1012.8	23.9	16.5	64	320	6.8	26.3	0	1.34	8.88
2002-02-11	0:00	19.441	144.075	1014.4	24.7	17.3	64	299	6.2	25.9	1	1.06	9.27
2002-02-11	3:00	20.297	144.043	1012.3	23.7	18.8	74	357	7.9	26.2	0	1.06	8.47
2002-02-11	6:00	21.139	144.001	1011.9	23.0	15.9	64	342	9.5	25.3	0	1.26	6.31
2002-02-11	9:00	21.569	143.576	1013.4	22.4	14.3	60	328	9.1	25.5	0	1.66	6.97
2002-02-11	12:00	22.401	143.542	1016.3	21.4	12.8	58	319	11.1	23.9	0	1.95	6.34
2002-02-11	15:00	23.224	143.505	1016.9	20.3	10.2	52	326	8.4	23.9	0	2.89	7.91
2002-02-11	18:00	24.051	143.485	1016.7	20.1	9.4	50	308	12.9	23.7	0	2.34	7.31
2002-02-11	21:00	24.461	143.447	1017.1	20.1	9.6	51	314	10.8	24.2	0	2.72	8.09
2002-02-12	0:00	25.254	143.415	1018.7	18.5	8.1	51	318	11.6	20.8	0	2.58	7.60
2002-02-12	3:00	26.035	143.384	1017.2	17.2	8.5	57	318	9.7	19.7	2	3.19	8.27
2002-02-12	6:00	26.425	143.345	1016.7	16.2	7.3	55	331	9.5	19.9	0	3.48	8.90
2002-02-12	9:00	27.236	143.320	1019.9	15.6	6.0	53	312	6.1	20.2	1	3.20	8.24
2002-02-12	12:00	28.066	143.286	1019.7	15.2	7.0	58	271	4.8	18.8	0	3.03	8.55
2002-02-12	15:00	28.497	143.251	1019.1	15.1	7.0	58	259	5.5	18.8	0	2.95	8.48
2002-02-12	18:00	29.329	143.220	1016.9	14.9	7.6	62	224	7	19	0	2.82	8.49
2002-02-12	21:00	30.163	143.181	1017.4	14.1	8.7	70	273	6	19.3	0	2.31	9.01
2002-02-13	0:00	30.595	143.145	1016.7	13.8	9.2	74	235	8.7	19.2	0	2.74	10.86
2002-02-13	3:00	31.430	143.108	1014.3	13.3	4.4	55	292	10.2	18.7	0	2.53	10.31
2002-02-13	6:00	32.276	143.067	1013.2	12.9	5.1	59	306	17.6	18.5	0	3.12	9.56
2002-02-13	9:00	33.072	143.034	1016.5	8.0	5.3	83	354	8.1	18.9	8	3.16	8.30
2002-02-13	12:00	33.486	143.005	1018.3	8.2	4.7	79	19	10	19.1	4	2.73	7.97
2002-02-13	15:00	34.305	142.566	1018.2	8.7	-1.5	49	39	8.9	19.3	0	2.33	8.38
2002-02-13	18:00	35.114	142.535	1017.9	8.1	-2.6	47	9	11.4	19.1	0	2.21	8.07
2002-02-13	21:00	35.540	142.500	1020.3	5.9	-5.5	44	352	10.3	18.1	2	2.16	7.61
2002-02-14	0:00	36.397	142.457	1021.3	5.0	-7.1	41	348	10.1	15.3	0	2.05	7.84
2002-02-14	3:00	37.244	142.415	1019.9	2.7	-6.1	52	327	10	10.4	0	2.12	9.08
2002-02-14	6:00	37.591	142.391	1019.9	2.3	-7.5	48	311	6.8	17.1	0	1.62	10.10
2002-02-14	9:00	38.331	142.359	1019.4	2.8	-7.9	45	293	15.1	14.9	1	1.60	7.95
2002-02-14	12:00	39.064	142.324	1019.7	1.7	-9.1	45	312	8.7	12.9	0	1.79	10.14
2002-02-14	15:00	39.382	142.261	1019.2	0.1	-10.9	44	316	10.1	11.3	1	1.85	9.41
2002-02-14	18:00	40.072	142.078	1018.6	-1.0	-8.2	58	289	16.1	9.8	1	1.56	7.65
2002-02-14	21:00	40.315	141.478	1018.8	-2.0	-6.2	73	268	14.2	8.7	0	1.79	10.81
2002-02-15	0:00	40.350	141.320	1021.3	-1.8	-6.3	71	239	4.8	8.7	0	1.83	14.87
2002-02-15	3:00	40.338	141.294	1020.8	-1.3	-6.6	67	280	6.2	9	1	0.25	8.12
2002-02-15	6:00	40.523	141.512	1018.6	0.8	-4.6	67	276	12.3	9.2	1	1.70	10.81
2002-02-15	9:00	41.139	142.362	1018.3	0.2	-6.1	63	313	14.1	8.7	0	2.31	11.10
2002-02-15	12:00	41.166	142.307	1019.5	0.8	-7.2	55	317	14.6	8.9	0	1.79	6.29
2002-02-15	15:00	41.193	142.190	1020.3	-0.8	-7.5	60	304	12.1	8	0	1.99	6.59
2002-02-15	18:00	41.170	142.183	1020.7	0.8	-8.8	49	306	12.3	7.1	0	1.61	4.99
2002-02-15	21:00	41.338	141.248	1021.1	-0.1	-8.8	52	307	9.6	6.2	0	0.93	8.88

D.P.T. : Dew Point Temperature

R.H. : Relative Humidity

W.D. : Wind Direction

W.S. : Wind Speed

S.S.T. : Sea Surface Temperature

Wv.H. : Significant Wave Height

Wv.Pd. : Significant Wave Period

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JAMSTEC: Japan Marine Science and Technology Center

FORS GC :Frontier Observational Research System for Global Change

NIRS: National Institute of Radiological Sciences

GSJ/ AIST: Geological Survey of Japan/The National Institute of Advanced Industrial Science and Technology

MRI: Meteorological Research Institute

CRIEPI: Central Research Institute of Electric Power Industry

NHE: Nippon Hakuyo Electronics, LTD.

KANSO: Kansai Environmental Engineering Center CO., LTD

MWJ: Marine Works Japan

GODI: Global Ocean Development. Inc

### 3. Observation

#### 3.1 Meteorological Observation

##### 3.1.1 Surface Meteorological Parameters

(1) Personnel

Satoshi Okumura (GODI)

Shinya Iwamida (GODI)

(2) Objective

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

(3) Methods

The surface meteorological parameters were observed throughout MR02-K01 cruise from the departure of Yokohama on 7 January 2002 to the arrival of Sekinehama on 16 February 2002.

This cruise, we used 2 systems for the surface meteorological observation.

1. Mirai meteorological observation system
2. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

(3-1) Mirai meteorological observation system

Instruments of Mirai met system are listed in Table 3.1-1 and measured parameters are listed in Table 3.1-2. Data was collected and processed by KOAC-7800 weather data processor made by Koshin Denki, Japan. The data set has 6-second averaged every 6-second record and 10-minute averaged every 10-minute record.

Table 3.1-1: Instruments and their installation locations of Mirai met system

Sensors	Type	Manufacturer	location (altitude from baseline)
Anemometer	KE-500	Koshin Denki, Japan	foremast (30m)
Thermometer	FT	Koshin Denki, Japan	compass deck (27m)
dewpoint meter	DW-1	Koshin Denki, Japan	compass deck (27m)
Barometer	F451	Yokogawa, Japan	weather observation room captain deck (20m)
rain gauge	50202	R. M. Young, USA	compass deck (25m)
optical rain gauge	ORG-115DR	SCTI, USA	compass deck (25m)
radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (33m)
radiometer (long wave)	MS-200	Eiko Seiki, Japan	radar mast (33m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	Bow (16m)



Table 3.1-2: Parameters of Mirai meteorological observation system

	Parameters	units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Ship's speed	knot	Mirai log
4	Ship's heading	degree	Mirai gyro
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	barometric pressure	hPa	adjusted to the sea surface level 6 sec. / 10 min. averaged
10	air temperature (starboard side)	degC	6 sec. / 10 min. averaged
11	air temperature (port side)	degC	6 sec. / 10 min. averaged
12	dewpoint temperature (stbd side)	degC	6 sec. / 10 min. averaged
13	dewpoint temperature (port side)	degC	6 sec. / 10 min. averaged
14	relative humidity (starboard side)	%	6 sec. / 10 min. averaged
15	relative humidity (port side)	%	6 sec. / 10 min. averaged
16	Rain rate (optical rain gauge)	mm/hr	6 sec. / 10 min. averaged
17	Rain rate (capacitive rain gauge)	mm/hr	6 sec. / 10 min. averaged
18	down welling shortwave radiometer	W/m <sup>2</sup>	6 sec. / 10 min. averaged
19	down welling infra-red radiometer	W/m <sup>2</sup>	6 sec. / 10 min. averaged
20	sea surface temperature	degC	-5m
21	significant wave height (fore)	m	3 hourly
22	significant wave height (aft)	m	3 hourly
23	significant wave period (fore)	second	3 hourly
24	significant wave period (aft)	second	3 hourly

(3-2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

SOAR system, designed by BNL (Brookhaven National Laboratory, USA), is consisted of 3 parts.

1. Portable Radiation Package (PRP) designed by BNL – short and long wave down welling radiation
2. Zeno meteorological system designed by BNL – wind, Tair/RH, pressure and rainfall measurement
3. Scientific Computer System (SCS) designed by NOAA (National Oceanographic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets

SCS recorded PRP data every 6.5 seconds, Zeno/met data every 10 seconds.

Instruments and their locations are listed in Table 3.1-3 and measured parameters are listed in Table 3.1-4

Table 3.1-3: Instrument installation locations of SOAR system

Sensors	type	manufacturer	location (altitude from the baseline)
Zeno/Met			
Anemometer	05106	R. M. Young, USA	foremast (31m)
T/RH	HMP45A	Vaisala, USA	foremast (30m)
	with 43408 Gill aspirated radiation shield (R. M. Young)		
Barometer	61201	R. M. Young, USA	foremast (30m)
	with 61002 Gill pressure port (R. M. Young)		
rain gauge	50202	R. M. Young, USA	foremast (30m)
Optical rain gauge	ORG-115DA	ScTi, USA	foremast (30m)
PRP			
radiometer (short wave)	PSP	Eppley labs, USA	foremast (31m)
radiometer (long wave)	PIR	Eppley labs, USA	foremast (31m)
fast rotating shadowband radiometer		Yankee, USA	foremast (31m)

Table 3.1-4: Parameters of SOAR System

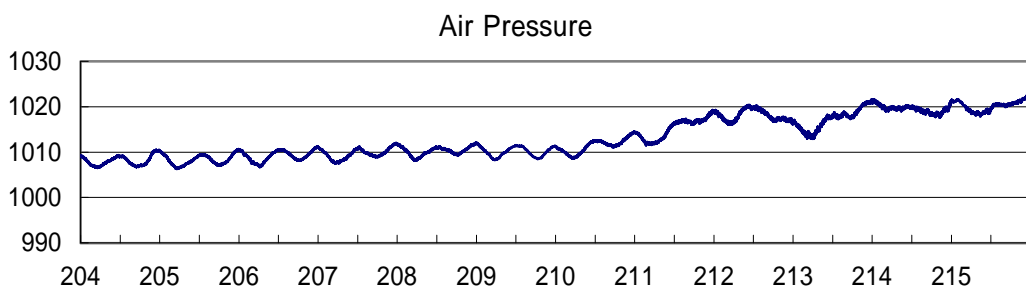
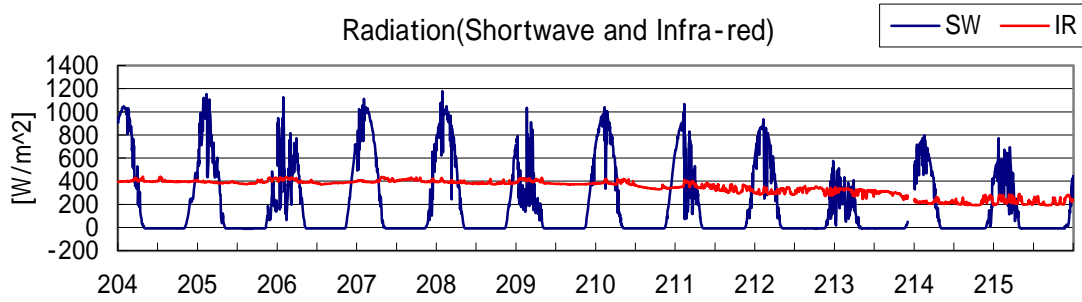
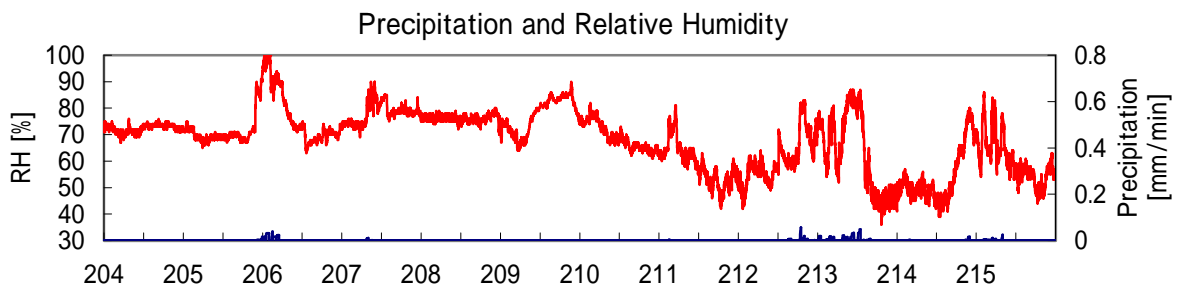
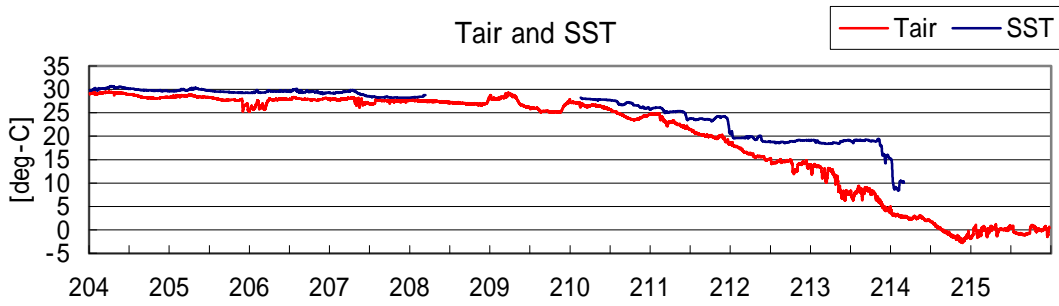
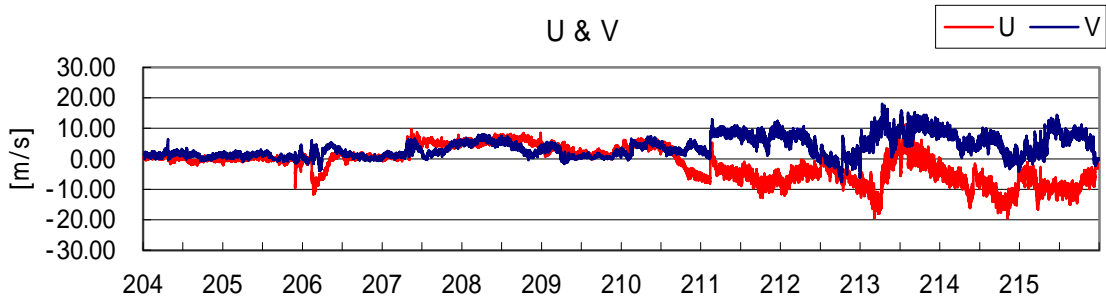
	parameters	units	remarks
1	Latitude	degree	
2	Longitude	degree	
3	Sog	knot	
4	Cog	degree	
5	relative wind speed	m/s	
6	relative wind direction	degree	
7	barometric pressure	hPa	
8	air temperature	degC	
9	relative humidity	%	
10	Rain rate (optical rain gauge)	mm/hr	
11	precipitation (capacitive rain gauge)	mm	reset at 50mm
12	down welling shortwave radiation	W/m <sup>2</sup>	
13	down welling infra-red radiation	W/m <sup>2</sup>	
14	defuse irradiation	W/m <sup>2</sup>	

(4) Preliminary results

Wind (converted to U, V component, from Mirai/met), Tair (from Mirai/met) / SST (from EPCS), RH (from Mirai/met) / precipitation (from Mirai/met), solar radiation (from SOAR) and pressure (from Mirai/met) observed during the cruise are shown in Figures.

(5) Data archives

These raw data will be submitted to the Data Management Office (DMO) in JAMSTEC just after the cruise.



### 3.1.2 Ceilometer

#### (1) Personnel

Satoshi Okumura (GODI)

Shinya Iwamida (GODI)

#### (2) Parameters

(1.1) Cloud base height [m]

(1.2) Backscatter profile, sensitivity and range normalized at 30 m resolution

#### (3) Methods

We measured cloud base height and backscatter profiles using CT-25K (VAISALA, Finland) ceilometer throughout MR02-K01cruise from the departure of Yokohama on 7 January 2002 to the arrival of Sekinehama on 16 February 2002.

Major parameters for the measurement configuration are as follows;

Laser source: Indium Gallium Arsenide (InGaAs) Diode

Transmitting wave length:  $905 \pm 5$  nm at 25 deg-C

Transmitting average power: 8.9 mW

Repetition rate: 5.57 kHz

Detector: Silicon avalanche photodiode (APD)

Responsibility at 905 nm: 65 A/W

Measurement range: 0 ~ 7.5 km

Resolution: 50 ft in full range

Sampling rate: 60 sec.

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

#### (4) Preliminary results

The results will be public after the analysis.

#### (5) Remarks

Due to the logging PC freeze, the records are missing from 10:13:37 on Feb.13th to 14:07:37 on Feb.14th.

#### (6) Data archives

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

## 3.2 Physical Parameters

### 3.2.1 CTD/CWS Observation with D.O. sensor, Fluorometer, and Transmissometer

Fujio KOBAYASHI (Marine Works Japan Ltd.): Operation Leader

Miki YOSHIKE (Marine Works Japan Ltd.)

Naoko TAKAHASHI (Marine Works Japan Ltd.)

#### (1). Introduction

Temperature and salinity were measured with CTD (SBE 911*plus*; Sea-Bird Electronics, Inc.) and the seawater samplings for chemical analysis were conducted with Carousel Water Sampler (CWS: SBE 32; Sea-Bird Electronics, Inc.). In addition, the dissolved oxygen sensor (D.O. sensor: SBE 43; Sea-Bird Electronics, Inc.), the fluorometer (Seapoint Chlorophyll Fluorometer: Seapoint Sensors, Inc.), the transmissometer (C-Star: WET Labs, Inc.), and the altimeter (2110-2; Benthos, Inc. and PSA-900D; Datasonics, Inc.) were attached with CTD system to measure dissolved oxygen concentration, Chl-*a* concentration, light transmission, and altitude from sea floor. In this section, we describe the CTD/CWS system in MR02-K01 cruise on R/V MIRAI from 7 January to 16 February 2002.

#### (2). Methods

##### (a). CTD/CWS systems

We used all three types of the CTD/CWS systems loaded on R/V Mirai. The first system has the 12 liters 12 positions CWS, the second has the 30 liters 24 positions CWS, and the third has the 12 liters 36 positions CWS. The first system was used for the reference data of the ARGO float by only 1 cast (A07S01) during Leg 1. The second system was used from 014L01 to 012L01 and the third system was used from 012S01 to 003S02. Each system configuration is listed in Table\*\*.

Conductivity, temperature, depth, dissolved oxygen concentration, Chl-*a* concentration, light transmission, and altitude from sea floor were measured from sea surface to 1,979m (the first System), 306m (the second System), or 5,102m (the third system) in maximum. Seawater was sampled with CTD/ CWS systems at 12 stations. The 31 water-sampling casts in total were for the chemical analysis of nutrients, dissolved gas, pH, alkalinity, pigment, and so on.

(b). Operation

The first and third systems were deployed and recovered with the frame (Dynacon, Inc.) on the starboard side. The other second system was done with the A-frame in the stern. The CTD raw data was acquired on real time by using the SEASAVE utility in the SEASOFT ver. 4.232 and 4.249 provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer set in the After Wheel-house. Water sampling was made during up cast by sending a fire command from the computer. The detail information such as station name, file name, date, time, location at the start/bottom/end of observation, water sampling layers, and events were recorded in CTD cast log sheets.

(c). CTD data processing

The CTD raw data were processed by the SEASOFT ver.4.232 and the SBE DataProcessing-Win32 ver.5.24 (Sea-Bird Electronics, Inc.) on another computer. The procedure of the data processing and used utilities in the SEASOFT and the SBE DataProcessing-Win32 were as following:

**DATCNV:** Convert raw data (binary format) to engineering units (ASCII format). Output items are scan number, pressure, depth, temperature, conductivity, oxygen sensor output voltage, descent rate, Chl-*a* concentration, light transmission, and altitude from sea floor. This utility makes a file which includes the data when the bottles were closed.

**SECTION:** Exclude the data in air. Write out selected rows of converted data to a new file.

**ALIGNCTD:** Align oxygen measurements in time relative to pressure. This ensures that calculation of dissolved oxygen concentration is made using measurements from the same parcel of water.

**WILDEDIT:** Mark wild points by setting their values to the bad value specified in the input file header.

**CELLTM:** Use a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity.

**FILTER:** Low pass filter pressure with a time constant to increase pressure resolution for LOOPEDIT.

**LOOPEDIT:** Mark scans "bad" by setting the flag value associated with the scan to bad flag in input files that have pressure reversals.

DERIVE: Compute dissolved oxygen concentration.  
BINAvg: Average data into depth bins.  
DERIVE: Compute salinity, density, and potential temperature.  
SPLIT: Split the data into up cast and down cast files. The filename of down cast is d\*.CNV and that of up cast is u\*.CNV.  
ROSSUM: Write out a summary of the bottle data to a file with a .BTL extension.

### (3). Preliminary results

The information for each CTD cast was summarized in the CTD Cast Table in \*\*. The profiles excluded noises are also shown in Fig. \*\*.

As the CTD Cast Table in Appendix, we could not help stopping the CTD observation three times through this cruise because of the sensor trouble and the failure in closing Niskin bottle (014L04, 012L01, 008S02). The restart of 008S02 caused the data file 008S03.DAT.

#### Note: Management of the CTD data

A file name of each cast consists of station name, CTD system type and cast number, e.g., 014L01. After SPLIT utility was used, up/down identification was added. As a result of data processing, 9 files were made every cast, such as .BL, .CON, .DAT, .HDR, .ROS, .BTL, d\*.CNV, u\*.CNV, and \*.CNV files.

The Raw and the processed CTD data files were copied into 3.5 inches magnetic optical disk (MO disk). All data are under the control of Data Management Office in JAMSTEC (DMO).

Table CTD System Configuration

CTD System	Sensor	Manufacturer	Model No.	Serial No.
	Underwater Unit (Pressure)	Sea-Bird Electronics, Inc.	SBE <i>9plus</i>	0280 (51190)
	Deck Unit	Sea-Bird Electronics, Inc.	SBE 11	11P7030-0272
12 liters	Temperature	Sea-Bird Electronics, Inc.	SBE <i>3plus</i>	032453
12 positions	Conductivity	Sea-Bird Electronics, Inc.	SBE 4C	041202
	Carousel	Sea-Bird Electronics, Inc.	SBE 32	3222295-0171
30 liters	Temperature	Sea-Bird Electronics, Inc.	SBE <i>3plus</i>	032453
24 positions	Conductivity	Sea-Bird Electronics, Inc.	SBE 4C	041202
	D.O.	Sea-Bird Electronics, Inc.	SBE 43	430069
	Fluorometer	Seapoint Sensors, Inc.	Seapoint Chlorophyll Fluorometer	2148
	Transmissometer	WET Labs, Inc.	C-Star	CST-207RD
	Altimeter	Benthos, Inc.	2110-2	228
	Carousel	Sea-Bird Electronics, Inc.	SBE 32	3221875-0240
	Temperature	Sea-Bird Electronics, Inc.	SBE <i>3plus</i>	031359
	Conductivity	Sea-Bird Electronics, Inc.	SBE 4C	041203
	D.O.	Sea-Bird Electronics, Inc.	SBE 43	430069
	Fluorometer	Seapoint Sensors, Inc.	Seapoint Chlorophyll Fluorometer	2148
	Transmissometer	WET Labs, Inc.	C-Star	CST-207RD
	Altimeter	Datasonics, Inc.	PSA-900D	396
	Carousel	Sea-Bird Electronics, Inc.	SBE 32	3221875-0240
12 liters	Temperature	Sea-Bird Electronics, Inc.	SBE <i>3plus</i>	031359
36 positions	Conductivity	Sea-Bird Electronics, Inc.	SBE 4C	041203
	D.O.	Sea-Bird Electronics, Inc.	SBE 43	430069
	Fluorometer	Seapoint Sensors, Inc.	Seapoint Chlorophyll Fluorometer	2148
	Transmissometer	WET Labs, Inc.	C-Star	CST-207RD
	Carousel	Sea-Bird Electronics, Inc.	SBE 32	3221746-0278



Table CTD Cast Table

Line	Cast No.	File Name	Lat.	Long.	Date [UTC]	Start Time	End Time	Max. Press. [db]	Max. Wire Out [m]	Depth [m]	Water Sampling	Remarks
Leg1	001	A07S01	31-37.87N	170-00.54E	11.Jan.2002	19:49	23:05	2002	1992.8	5601		This position was at the bottom.
Leg2	002	014L01	00-00.01S	160-00.12W	23.Jan.2002	15:09	15:33	202.673	196.3	5164		
	003	014L02	00-00.00S	160-00.02W	23.Jan.2002	22:04	22:24	202.947	-	5164		
	004	014L03	00-02.37S	160-00.81W	24.Jan.2002	04:07	04:28	204.041	194.8	5132		
	005	014L04	00-01.17N	159-59.84W	24.Jan.2002	06:35	09:34	5192.137	5089.7	5157		Altimeter Trouble
	006	013L01	00-00.44S	163-30.03W	25.Jan.2002	00:11	00:39	305.546	303.8	4940		
	007	012L01	00-00.05N	169-59.48W	26.Jan.2002	00:34	02:58	4519.998	4442.8	5386	-	Water Sampling Canceled
	008	012S01	00-00.02N	170-00.06W	26.Jan.2002	15:13	15:51	202.231	201.5	5528		
	009	012S02	00-00.97S	170-05.37W	26.Jan.2002	22:03	22:31	201.338	200.1	5608		
	010	012S03	00-00.94S	170-04.22W	27.Jan.2002	02:58	03:28	202.119	200.1	5524		
	011	011S01	00-00.03S	174-46.29W	27.Jan.2002	22:00	22:31	202.028	200.6	5361		
	012	011S02	00-00.24S	174-46.95W	27.Jan.2002	23:59	00:29	202.038	202.3	5359		
	013	010S01	00-00.16S	179-07.66E	28.Jan.2002	22:57	23:28	202.601	206.9	5388		
	014	010S02	00-01.02N	179-07.39E	29.Jan.2002	00:26	00:53	202.394	208.5	5401		
	015	009S01	00-00.16S	174-59.59E	29.Jan.2002	16:29	16:59	201.917	210.0	4826		
	016	009S02	00-00.00S	174-58.26E	29.Jan.2002	22:58	23:27	202.241	211.1	4819		
	017	009S03	00-01.58N	174-56.59E	30.Jan.2002	03:58	04:33	308.488	311.4	4820		
	018	008S01	00-00.25N	166-11.24E	31.Jan.2002	23:58	00:33	202.960	211.5	4363		
	019	008S02	00-00.48S	166-10.37E	01.Feb.2002	01:56	02:25	202.205	204.3	4367		Failure of closing Niskin #1
	020	008S03	-	-	01.Feb.2002	-	-	-	-	-		To 10m (Niskin #1 sampling only)
	021	007S01	00-00.17N	161-28.84E	01.Feb.2002	23:58	00:28	203.219	218.3	3788		
	022	007S02	00-00.52S	161-27.80E	02.Feb.2002	01:58	02:26	202.201	214.8	3763		
	023	006S01	00-00.05N	159-59.89E	02.Feb.2002	17:28	17:59	201.895	211.6	2824		
	024	006S02	00-00.74N	159-58.05E	02.Feb.2002	23:58	00:28	202.038	211.6	2821		
	025	006S03	00-00.96S	159-59.65E	03.Feb.2002	05:14	05:49	305.572	310.1	2810		
	026	005S01	00-00.41S	155-51.16E	03.Feb.2002	23:58	00:27	201.939	212.6	1935		
	027	005S02	00-00.32N	155-50.15E	04.Feb.2002	02:02	02:29	201.376	217.0	1940		
	028	004S01	00-00.04N	149-47.31E	05.Feb.2002	00:58	01:25	203.724	214.8	4538		
	029	004S02	00-00.51S	149-44.97E	05.Feb.2002	02:54	03:21	203.218	205.8	4591		
	030	003S01	00-00.11N	144-59.97E	06.Feb.2002	00:58	01:30	204.104	214.8	3708		
	031	003S02	00-00.38N	144-59.85E	06.Feb.2002	03:00	03:28	212.290	220.5	3632		

### 3.2.2 XCTD

#### (1) Personnel

Satoshi Okumura (GODI)

Shinya Iwamida (GODI)

#### (2) Parameters

(1.1) Conductivity [mS/cm]

(1.2) Water temperature [deg-C]

(1.3) Depth [m]

#### (3) Methods

The summary of expendable conductivity, temperature and depth profiling system

Probe: XCTD (TSK, Japan)

Converter: MK-100 (TSK, Japan)

Sampling rate: 40 msec

Range and Accuracy:	Range	Accuracy
Conductivity	0 – 70 mS/cm	+/-0.03 mS/cm
Temperature	-2 – 35 deg-C	+/-0.02 deg-C
Depth	0 – 1000 m	5 m or 2%

Following formula used for depth calibration:

$$Z = A * T + B * T^2$$

Where Z = depth (m)

T = elapsed time (sec)

A = 3.425432

B = -4.7026039

#### (4) Preliminary results

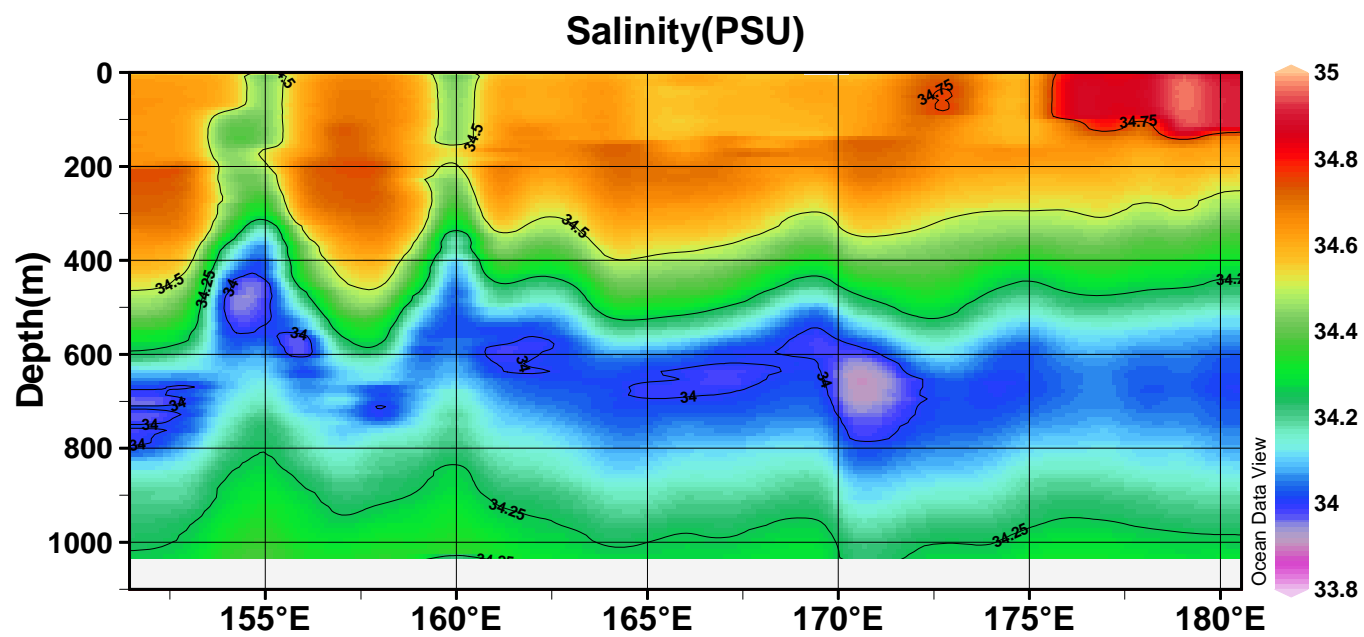
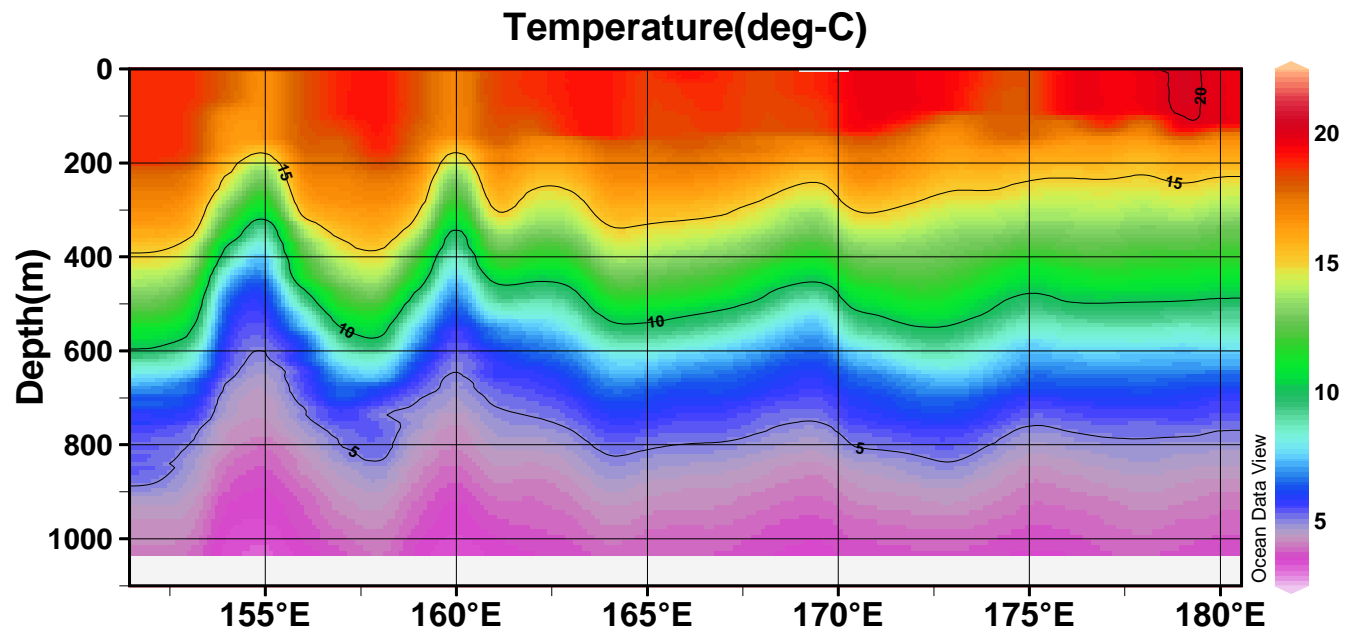
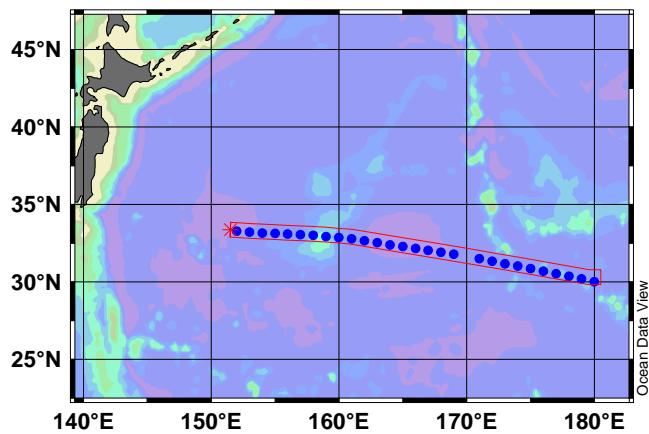
Following table shows the summary of xctd observation station, figure shows cross section of temperature and salinity. The results will be public after the analysis.

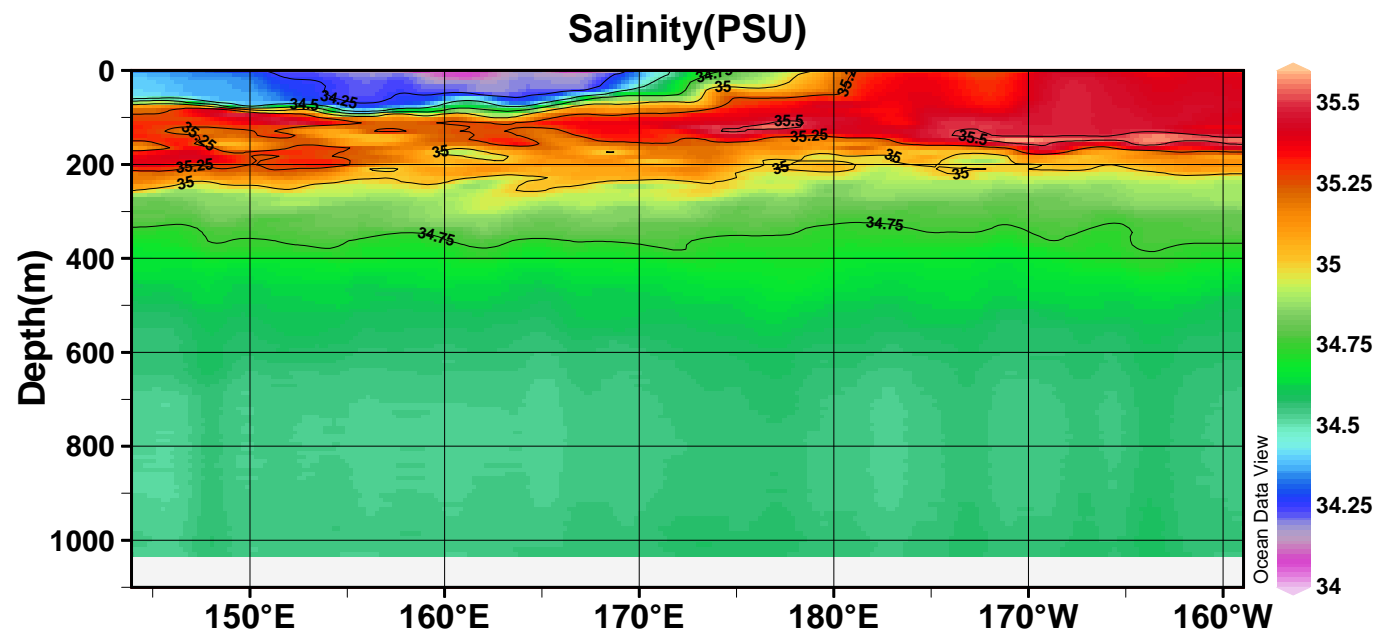
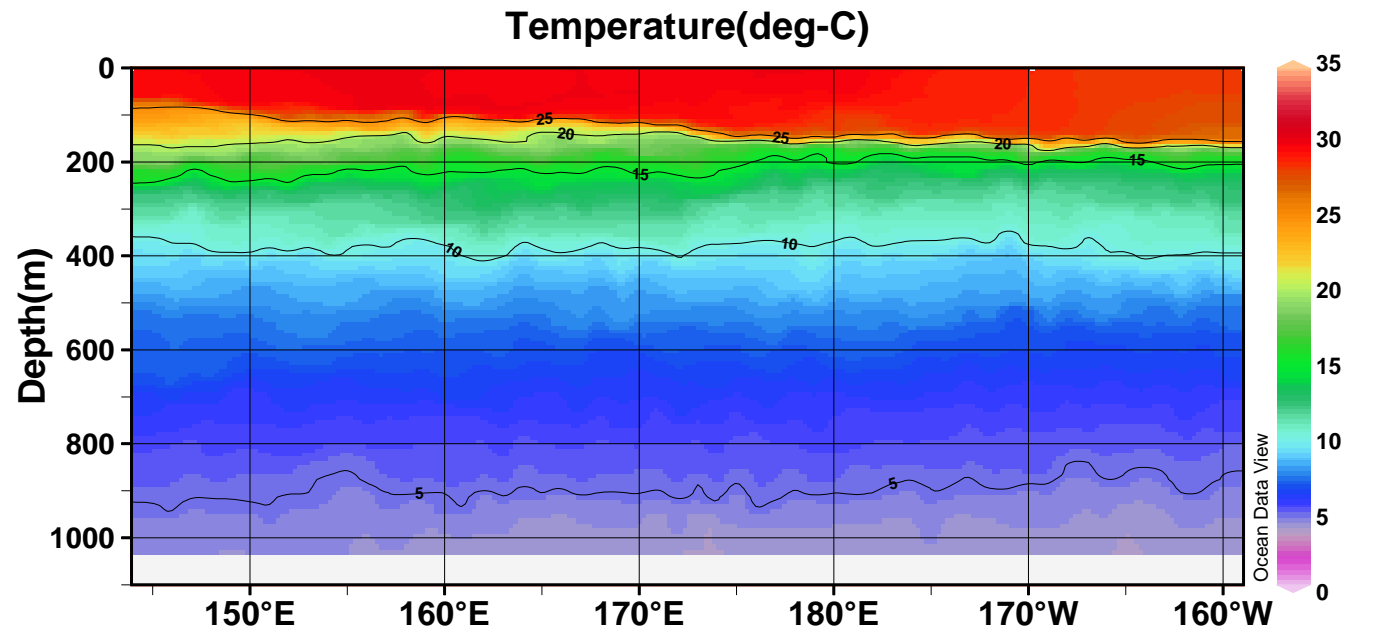
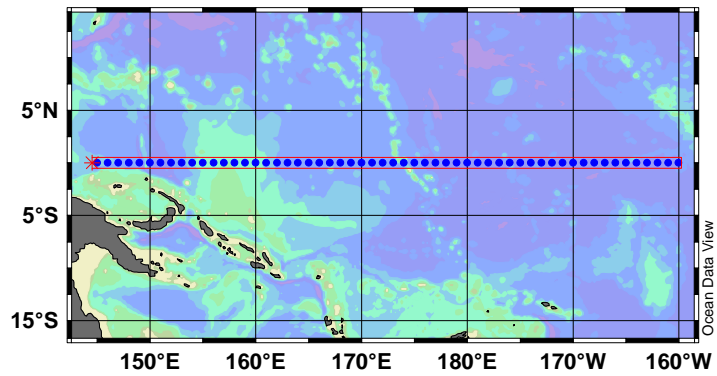
#### (5) Data archives

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

Station	Date	Time(UTC)	Latitude	Longitude	Probe S/N
X 01	9Jan, 2002	5:09	33 - 15.00 N	152 - 0.03 E	01055398
X 02	9Jan	8:42	33 - 11.37 N	153 - 0.13 E	01055401
X 03	9Jan	12:02	33 - 8.34 N	154 - 0.12 E	01055387
X 04	9Jan	15:26	33 - 7.00 N	155 - 0.19 E	01055388
X 05	9Jan	18:39	33 - 4.40 N	156 - 0.06 E	01055402
X 06	9Jan	21:49	33 - 1.68 N	157 - 0.06 E	01055389
X 07	10Jan	2:04	32 - 58.98 N	158 - 0.03 E	01055396
X 08	10Jan	4:29	32 - 54.76 N	159 - 0.01 E	01055400
X 09	10Jan	7:53	32 - 50.38 N	160 - 0.00 E	01055386
X 10	10Jan	11:28	32 - 45.98 N	161 - 0.00 E	01075811
X 11	10Jan	14:54	32 - 38.32 N	162 - 0.02 E	01075810
X 12	10Jan	18:14	32 - 30.86 N	163 - 0.22 E	01055397
X 12-2	10Jan	18:25	32 - 30.61 N	163 - 2.58 E	01055404
X 13	10Jan	22:05	32 - 22.72 N	164 - 0.01 E	01055399
X 14	11Jan	1:37	32 - 15.72 N	165 - 0.01 E	01075816
X 15	11Jan	4:59	32 - 8.18 N	166 - 0.00 E	01075814
X 16	11Jan	8:27	32 - 0.97 N	166 - 59.98 E	01075819
X 17	11Jan	12:01	31 - 53.33 N	168 - 0.00 E	01075818
X 18	11Jan	15:20	31 - 45.68 N	169 - 0.01 E	01075809
X 19	12Jan	2:38	31 - 28.48 N	171 - 0.02 E	01075812
X 20	12Jan	6:04	31 - 19.42 N	172 - 0.00 E	01075815
X 21	12Jan	9:25	31 - 9.52 N	172 - 59.99 E	01075813
X 22	12Jan	12:43	31 - 0.00 N	174 - 0.02 E	01075892
X 23	12Jan	16:06	30 - 50.32 N	175 - 0.00 E	01075817
X 24	12Jan	19:28	30 - 40.53 N	176 - 0.69 E	01075820
X 25	12Jan	22:52	30 - 30.96 N	176 - 59.98 E	01075888
X 26	13Jan	2:28	30 - 20.66 N	177 - 59.99 E	01075887
X 27	13Jan	5:58	30 - 10.34 N	179 - 0.05 E	01075890
X 28	13Jan	9:39	29 - 29.59 N	179 - 59.99 E	01075891
X 29	24Jan	10:08	0 - 0.07 N	160 - 2.27 W	01075889
X 30	24Jan	13:48	0 - 0.03 S	161 - 1.04 W	01075882
X 31	24Jan	17:26	0 - 0.08 N	162 - 0.04 W	01075886
X 32	24Jan	21:04	0 - 0.06 N	163 - 0.01 W	01075883
X 33	25Jan	2:46	0 - 0.02 N	164 - 0.04 W	01075885
X 34	25Jan	6:19	0 - 0.07 N	165 - 0.01 W	01075822
X 35	25Jan	9:53	0 - 0.14 N	166 - 0.04 W	01075884
X 36	25Jan	13:30	0 - 0.16 N	166 - 59.99 W	01075823
X 37	25Jan	17:06	0 - 0.20 N	168 - 0.02 W	01075881
X 38	25Jan	20:47	0 - 0.01 S	169 - 0.03 W	01075821
X 39	27Jan	5:06	0 - 2.18 S	170 - 6.02 W	01075825
X 40	27Jan	8:21	0 - 0.02 S	170 - 59.99 W	01075829
X 41	27Jan	11:55	0 - 0.25 S	172 - 0.01 W	01075824
X 42	27Jan	15:29	0 - 0.11 S	173 - 0.00 W	01075830
X 43	27Jan	19:02	0 - 0.00 N	173 - 59.99 W	01075831
X 44	28Jan	1:28	0 - 0.12 S	175 - 0.00 W	01075832
X 45	28Jan	5:03	0 - 0.07 N	175 - 59.99 W	01075827
X 46	28Jan	8:41	0 - 0.05 S	177 - 0.01 W	01075828
X 47	28Jan	12:20	0 - 0.02 S	177 - 59.99 W	01075864
X 48	28Jan	15:58	0 - 0.08 N	179 - 0.04 W	01075861
X 49	28Jan	19:36	0 - 0.00 S	179 - 59.99 E	01075826
X 50	29Jan	1:34	0 - 0.31 N	179 - 0.00 E	00103175
X 51	29Jan	5:09	0 - 0.05 S	178 - 0.01 E	00103174
X 52	29Jan	8:43	0 - 0.10 N	176 - 59.98 E	00103179
X 53	29Jan	12:18	0 - 0.03 S	176 - 0.01 E	00103176
X 54	29Jan	16:01	0 - 0.11 S	174 - 59.77 E	00103178
X 55	30Jan	16:12	0 - 7.11 S	173 - 59.94 E	00103192
X 56	30Jan	19:42	0 - 6.25 S	173 - 0.01 E	00103193
X 57	30Jan	23:23	0 - 0.01 N	172 - 0.04 E	00103196
X 58	31Jan	3:10	0 - 0.01 S	171 - 0.02 E	00103197
X 59	31Jan	7:14	0 - 0.17 N	170 - 0.00 E	00103198
X 60	31Jan	11:32	0 - 0.07 N	168 - 59.98 E	00103187
X 61	31Jan	15:50	0 - 0.07 N	168 - 0.01 E	00103191
X 62	31Jan	20:14	0 - 0.03 N	167 - 0.01 E	00103188
X 63	1Feb	3:37	0 - 0.31 S	166 - 0.01 E	00103189
X 64	1Feb	8:06	0 - 0.18 S	165 - 0.01 E	01116920
X 65	1Feb	12:28	0 - 0.12 N	163 - 59.74 E	00103195
X 66	1Feb	16:59	0 - 0.08 S	163 - 0.01 E	00103199
X 67	1Feb	21:29	0 - 0.03 N	162 - 0.00 E	00103200
X 68	2Feb	4:36	0 - 0.33 S	161 - 0.02 E	01116916
X 69	2Feb	8:50	0 - 0.03 S	160 - 0.00 E	01116917
X 70	3Feb	11:15	0 - 0.13 N	159 - 0.00 E	01116922
X 71	3Feb	15:04	0 - 0.80 N	157 - 59.99 E	01116915
X 72	3Feb	18:55	0 - 0.96 N	157 - 0.00 E	01116918
X 73	3Feb	22:39	0 - 0.23 S	156 - 0.68 E	01116924
X 74	4Feb	5:43	0 - 0.03 N	155 - 0.01 E	01116929
X 75	4Feb	9:24	0 - 0.19 N	154 - 0.00 E	01075863
X 76	4Feb	13:04	0 - 0.04 N	153 - 0.01 E	01116931
X 77	4Feb	16:43	0 - 0.07 N	151 - 59.97 E	01116926
X 78	4Feb	20:22	0 - 0.18 N	150 - 59.63 E	01075866
X 79	4Feb	23:58	0 - 0.04 S	149 - 59.99 E	01116921
X 80	5Feb	6:16	0 - 0.00 N	149 - 0.00 E	01116928
X 81	5Feb	9:59	0 - 0.02 N	147 - 59.99 E	10175862
X 82	5Feb	13:40	0 - 0.25 N	147 - 0.01 E	01075865
X 83	5Feb	20:24	0 - 0.08 N	146 - 0.00 E	01075859
X 84	6Feb	0:04	0 - 0.13 S	145 - 0.00 E	01075858

Table





### 3.2.3 Shipboard ADCP

(1) Personnel

Satoshi Okumura and Shinya Iwamida (GODI)

(2) Parameters

(2-1) N-S and E-W velocity components of each depth cell [cm/s]

(2-2) Echo intensity of each depth cell [dB]

(3) Methods

Upper ocean current measurements were made throughout MR02-K01 cruise (Departure from Yokohama on 7 January 2002 to the arrival at Sekinehama on 16 February) 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 (Tokimec, Japan), continuously providing ship's heading measurements to the ADCP;
- 3) a GPS navigation receiver (Leica MX9400) providing position fixes;
- 4) an IBM-compatible personal computer running data acquisition software (Win TRANSECT version 2.03d; SEA corporation, Japan). The clock of the logging PC are adjusted to GPS time every 5 minutes.

The ADCP was configured for 16-m pulse length, 16-m processing bin, and a 8-m blanking interval. The sound speed is calculated from temperature (thermistor near the transducer faces), salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975). The transducer depth was 6.5 m; 40 velocity measurements were made at 16-m intervals starting 31m below the surface. 32 pings were sent in each ensemble. For each ping, velocities relative to the transducer were rotated to a geographical coordinate system using the gyro compass heading, but assuming pitch and roll to be zero.

Major parameters for the measurement (Direct Command) are listed in the appendix.

(4) Preliminary result

The ADCP data obtained during this cruise were post-processed using the University of Hawaii CODAS software. The upper ocean velocity field during the cruise (Leg2; Hawaii to Guam) is summarized in a map of shipboard ADCP velocity vectors averaged from 32 to 75 m and from 175 to 225 m (following figure).

The quality of the shipboard ADCP data in the equatorial region is almost good. But, western part (around 150E to 160E), as the abundance of acoustic target decreased, error velocity became slightly larger.

(5) Data archive

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

## Appendix: Configuration of ADCP measurement (Direct Command)

From 7 Jan 2002 to 18 Feb (Yokohama to Honolulu)

No Bottom Track pings  
EA = +04500 ----- 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)  
SD = 1111 1111 1111 1111 – Speed Log Data Select  
TP = 00:02.00 ----- Time per Ping (min:sec.sec/100)  
WA = 255 ----- False Target Threshold (Max) (0-255 counts)  
WB = 0 ----- Mode 1 Bandwidth Control (0=Wid,1=Med,2=Nar)  
WC = 064 ----- Low Correlation Threshold (0-255)  
WD = 111 111 111 ----- Data Out (V;C;A PG;St;Vsum Vsum^2;#G;P0)  
WE = 5000 ----- Error Velocity Threshold (0-5000 mm/s)  
WF = 0800 ----- Blank After Transmit (cm)  
WG = 001 ----- Percent Good Minimum (0-100%)  
WH = 111 100 000 ----- Bm 5 Data Out (V;C;A PG;St;Vsum Vsum^2;#G;P0)  
WI = 0 ----- Clip Data Past Bottom (0=OFF,1=ON)  
WJ = 1 ----- Rcvr Gain Select (0=Low,1=High)  
WL = 000,005 ----- Water Reference Layer: Begin Cell (0=OFF), End Cell  
WM = 1 ----- Profiling Mode (1-8)  
WN = 040 ----- Number of depth cells (1-128)  
WP = 00032 ----- Pings per Ensemble (0-16384)  
WQ = 0 ----- Sample Ambient Sound (0=OFF,1=ON)  
WS = 1600 ----- Depth Cell Size (cm)  
WT = 0000 ----- Transmit Length (cm) [0 = Bin Length]  
WV = 999 ----- Mode 1 Ambiguity Velocity (cm/s radial)  
WW = 004 ----- Mode 1 Pings before Mode 4 Re-acquire  
WX = 999 ----- Mode 4 Ambiguity Velocity (cm/s radial)  
WZ = 010 ----- Modes 5 and 8 Ambiguity Velocity (cm/s radial)

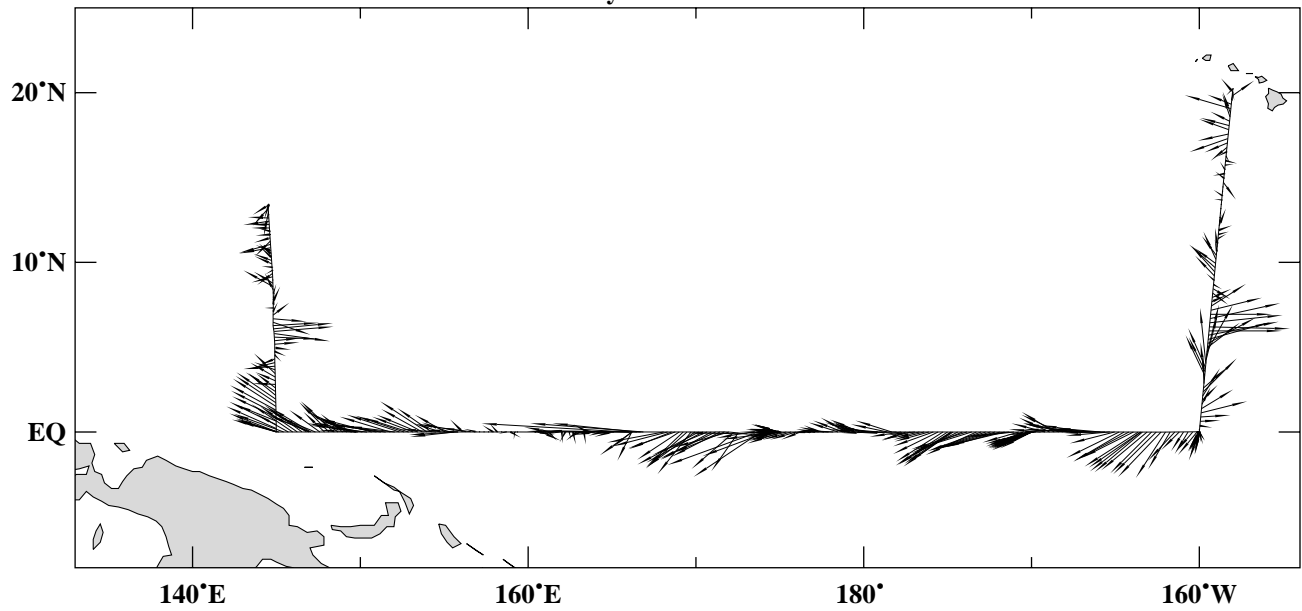
From 20 Jan to 15 Feb (Honolulu to Sekinehama)

BA = 030 ----- Evaluation Amplitude Min (1-255)  
BC = 220 ----- Correlation Magnitude Min (0-255)  
BE = 1000 ----- Max Error Velocity (mm/s)  
BF = 00000 ----- Depth Guess (0=Auto, 1-65535 = dm)  
BG = 80,30,00030 ----- N/A Shal Xmt (%), Deep Xmt (%), Deep (dm)  
BH = 190,010,004,040 ----- N/A Thresh(cnt), S Amb(cm/s), L Amb(cm/s), MinAmb  
BK = 0 ----- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)  
BL = 640,1280,1920 ----- Layer: Min Size (dm), Near (dm), Far (dm)  
BM = 5 ----- Mode (4 = Default - Coherent, 5 = Default)  
BP = 010 ----- Pings per Ensemble  
BR = 0 ----- Range Resolution (0 = 4%, 1 = 2%, 2 = 1%)  
BX = 9999 ----- Maximum Depth (80-9999 dm)  
BZ = 005 ----- Coherent Ambiguity Velocity (cm/s radial)  
\*Others are the same during 'Yokohama to Hawaii'

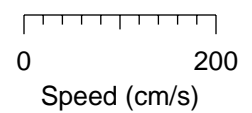
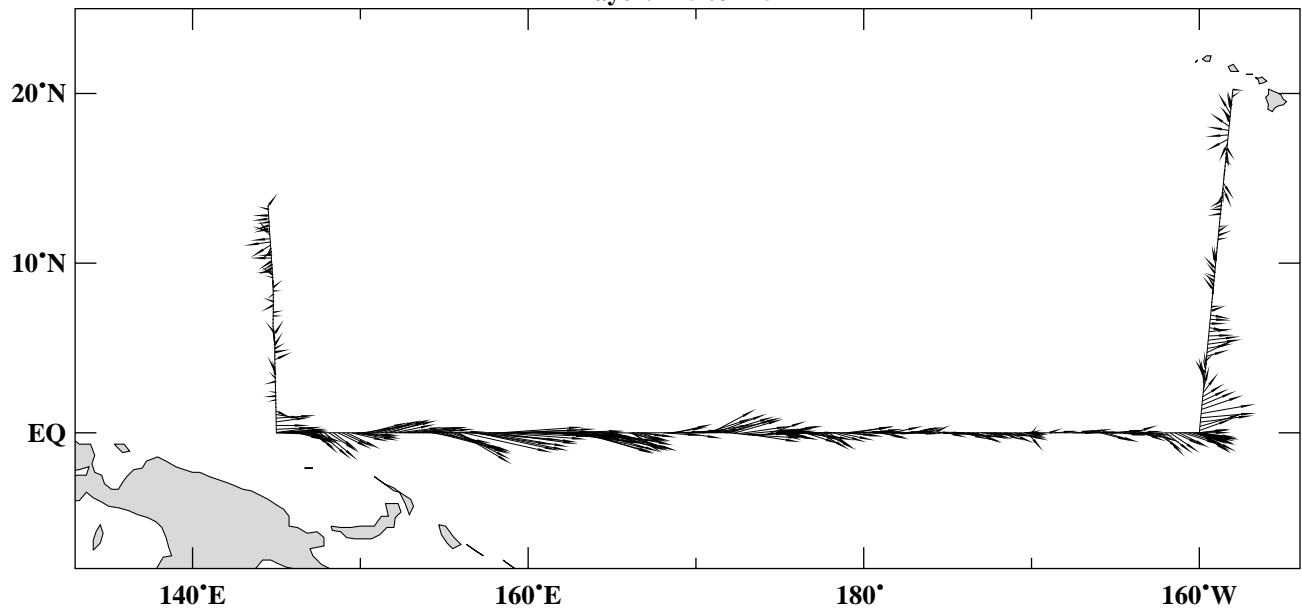
# MR02-K01

Jan 20 to Feb 8, 2002

Layer: 32m to 75m



Layer: 175 to 225m





### 3.3 Chemical Parameters

#### 3.3.1 Dissolved Oxygen Measurement

Tomoko Miyashita :Operation Leader  
Fuyuki Shibata  
(Marine Works Japan Ltd.)

##### (1) Objective

Vertical concentration of dissolved oxygen is one of the fundamental parameter to study of the ocean. During this cruise, concentration of dissolved oxygen obtained using the Winkler titration with potentiometric detection.

##### (2) Instruments and Methods

###### (a) Instruments and Apparatus

Sample bottle: Volumetrically calibrated glass bottle for dissolved oxygen measurements consist of the ordinary BOD flask (ca.180ml) and glass stopper with long nipple, modified from the nipple presented in Green and Carritt (1966).

Dispenser: Eppendorf Comforpette 4800 / 1000 $\mu$ l  
OPTIFIX / 2ml

Metrohm Model 725 Multi Dosimat / 20ml of titration vessel

Titration vessel: Metrohm Model 716 DMS Titrino / 10ml of titration vessel

Metrohm Pt electrode / 6.0403.100 (NC)

Software: Brinkmann Titrino Workcell / Data acquisition and Endpoint evaluation

###### (b) Methods:

Seawater samples were drawn from 30L Niskin TM bottles (stn14,13) and 12L Niskin TM bottles (stn12,11,10,9,8,7,6,5,4,3) and a bucket for the surface water into sample bottles with sampling tubes. Bottles were overflowed with seawater twice bottle volume while taking care not to entrain any bubbles and measuring the water temperature in order to correction of the volume of sample bottle. After the sampling, 1ml each of the MnCl<sub>2</sub> and NaOH/NaI reagents was immediately added into the seawater and the sample bottle was capped and shaken hard. After all sampling, sample bottles were shaken again to ensure complete oxidation of the precipitant. The bottles were kept at a wood box in the laboratory until titration.

The analytical method and the preparation of reagents were fundamentally done according to the WHP Operations and Methods (Dickson, 1996). We used 0.05N

thiosulfate of titrant at this cruise. Titration and the end point determination were made by 2 sets of titrators (Metrohm Model 716 DMS Titorino) and Pt electrode using whole bottle titration in the laboratory under controlled temperature. The water temperature in the laboratory was ca. 23 during this cruise. The end point was determined by the potentiometric method.

### (3) Preliminary results

#### (a) Comparison of each standard to CSK standard solution.

In this cruise, we compared with 0.0100N  $\text{KIO}_3$  standard solution for standardization (Lot 011212) and CSK standard solution (Lot ELQ9442), which was prepared by Wako pure chemical industries, Ltd. The results are shown in Table 1.

Table 1. Comparison of each  $\text{KIO}_3$  standard

$\text{KIO}_3$ Lot No.	Normality	Average titer (ml)	S.D.	n	Ratio to
ELQ9442	0.0100	1.969 <sup>0</sup>	0.001	9	
011212	0.01001	1.969 <sup>1</sup>	0.001	9	1.0000

#### (b) Thiosulfate Standardization and pure water blank

Standardization of thiosulfate solution and pure water blank were measured while this cruise. The averaged volume of thiosulfate for the standardization was 1.969ml (titrator A, n=8) and 1.971ml (titrator B, n=5), respectively and standard deviation was 0.001ml (A) and 0.001ml (B), respectively.

The blank results from the presence of redox species apart from oxygen in the reagents that can behave equivalently to oxygen in the analysis. The pure water blank (titration blank) were determined using deionized water (Milli-Q SP, Millipore) after standardization. The average of pure water blank was -0.005ml (A) and -0.006ml (B), respectively and standard deviation was 0.001ml (A) and 0.002ml (B), respectively.

#### (c) Reproducibility

In this cruise, duplicate samples were taken from same Niskin bottles at each station to estimate for precision for our analysis. We analyzed 30 pairs of duplicate samples throughout this cruise. The precision was  $0.20(2\sigma / \text{max concentration in this cruise} \times 100)$ .

#### (e) Vertical profiles

The vertical profiles of dissolved oxygen were shown in Fig.1.1-4.

#### (4) References

- Dickson,A. (1996) Determination of Dissolved Oxygen in Sea Water by Winkler Titration, In WOCE Operations Manual, Volume 3: The Observational Programme, Section 3.1: WOCE Hydrographic Programme, Part 3.1.3: WHP Operations and Methods, WHP Office Report WHPO 91-1 / WOCE Report No.68/91
- Culberson,C.H. (1991) Dissolved Oxygen, In WOCE Operations Manual, Volume 3: The Observational Programme, Section 3.1: WOCE Hydrographic Programme, Part 3.1.3: WHP Operations and Methods, WHP Office Report WHPO 91-1 / WOCE Report No.68/91
- Culberson,C.H., G.Knapp, M.C.Stalcup, R.T.Williams and F.Zemlyak (1991) A comparison methods for the determination of dissolved Oxygen in seawater, WHP Office Report WHPO 91-2
- Green,E.J. and D.E.Carritt (1966) An improved iodine determination for whole-bottle titrations, Analyst, 91, 207-208
- Murray, J.N., J.P.Riley and T.R.S.Wilson (1968) The solubility of oxygen in Winkler reagents used for determination of dissolved oxygen, Deep-Sea Res., 15, 237-238

### 3.3.2 Salinity Measurements of Sampled Water

(1) Personnel

Fujio Kobayashi (Marine Works Japan Ltd.) : Operation Leader  
Miki Yoshiike (Marine Works Japan Ltd.)  
Naoko Takahashi (Marine Works Japan Ltd.)

(2) Objectives

To calibrate the salinity obtained by CTD.

(3) Measured Parameters

Salinity of sampled water

(4) Method

Seawater samples were collected with 30 and 12 liters Niskin bottle. The salinity sample bottle of the 250 ml brown glass 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 shoulder of the bottle. Its cap was also thoroughly rinsed. The bottle was stored more than 24 hours in Autosol Room before the salinity measurement.

The salinity was measured by the Guildline Autosol Salinometer (Model 8400B), attached with an Ocean Science International peristaltic-type sample intake pump. A double conductivity ratio was defined as median of 31 times reading of the salinometer. Data collection started 5 seconds and it took about 10 seconds to collect 31 times reading by a personal computer. The instrument was operated in the Autosol Room with a bath temperature 24° C.

The salinometer was standardized before and after sequence of measurement by the IAPSO Standard Seawater batch P139 (conductivity ratio was 0.99993, salinity was 34.997).

We also used sub-standard seawater that was deep-sea water filtered by Millipore filter (pore size of 0.45 μm) and stored in a 20 liters container made from polyethylene. It was measured every 8 or 10 samples in order to check the drift of the salinometer.

(5) Preliminary Results

The average of difference between CTD data and AUTOSAL data with each was - 0.0023. The standard deviation was 0.0169.

(6) Data archive

The data of sample measured were copied into 3.5 inches magnetic optical disk (MO disk). All data are under the control of Data Management Office in JAMSTEC (DMO).

### 3.3.3 Nutrients

#### 3.3.3.1 Nitrite, Nitrate, Silicate and Phosphate

Kenichiro SATO (MWJ): Operation Leader  
Kazuhiko MATSUMOTO (JAMSTEC)

##### (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

There is TRAACS 800 system, which is BRAN+LUEBBE continuous flow analytical 4-channel system model, in the R/V MIRAI to analyze the nutrients in seawater. We usually used one system for nitrate + nitrite (1ch.), nitrite (2ch.), silicate (3ch.) and phosphate (4ch.). The laboratory temperature was maintained between 20-25 deg C.

##### a. Measured Parameters

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

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

**Silicate:** The standard AAII molybdate-ascorbic acid method was used. Temperature 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 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. Temperature of the samples was adjusted to be 45-50 deg C using a water bath. The phospho-molybdate produced is measured absorbance of 880 nm using a 5 cm length cell.

##### b. Sampling Procedures

Samples were drawn into polypropylene 100 ml small mouth bottles. These were rinsed three times before filling. The samples were analyzed as soon as possible. Five ml sample cups were used for analysis.

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

Ten containers (20L) of low nutrients seawater were collected in February, 2001 at

equatorial Pacific and filtered with 0.45mm pore size membrane filter (Millipore HA). They are used as preparing the working standard solution.

### (3) Results

#### Precision of the analysis

We have made the repeat analysis of about 200 m layer samples at each station. At this repeat analysis range of CV (concentration average to standard deviation) was 0.02 to 0.83 % except for nitrite

#### Distribution of nutrients

The vertical section of nitrate, nitrite, silicate and phosphate along the CTD line is shown in Figure 1.

### (4) Data Archive

These data are stored in MO disk in Ocean Research Department in JAMSTEC.

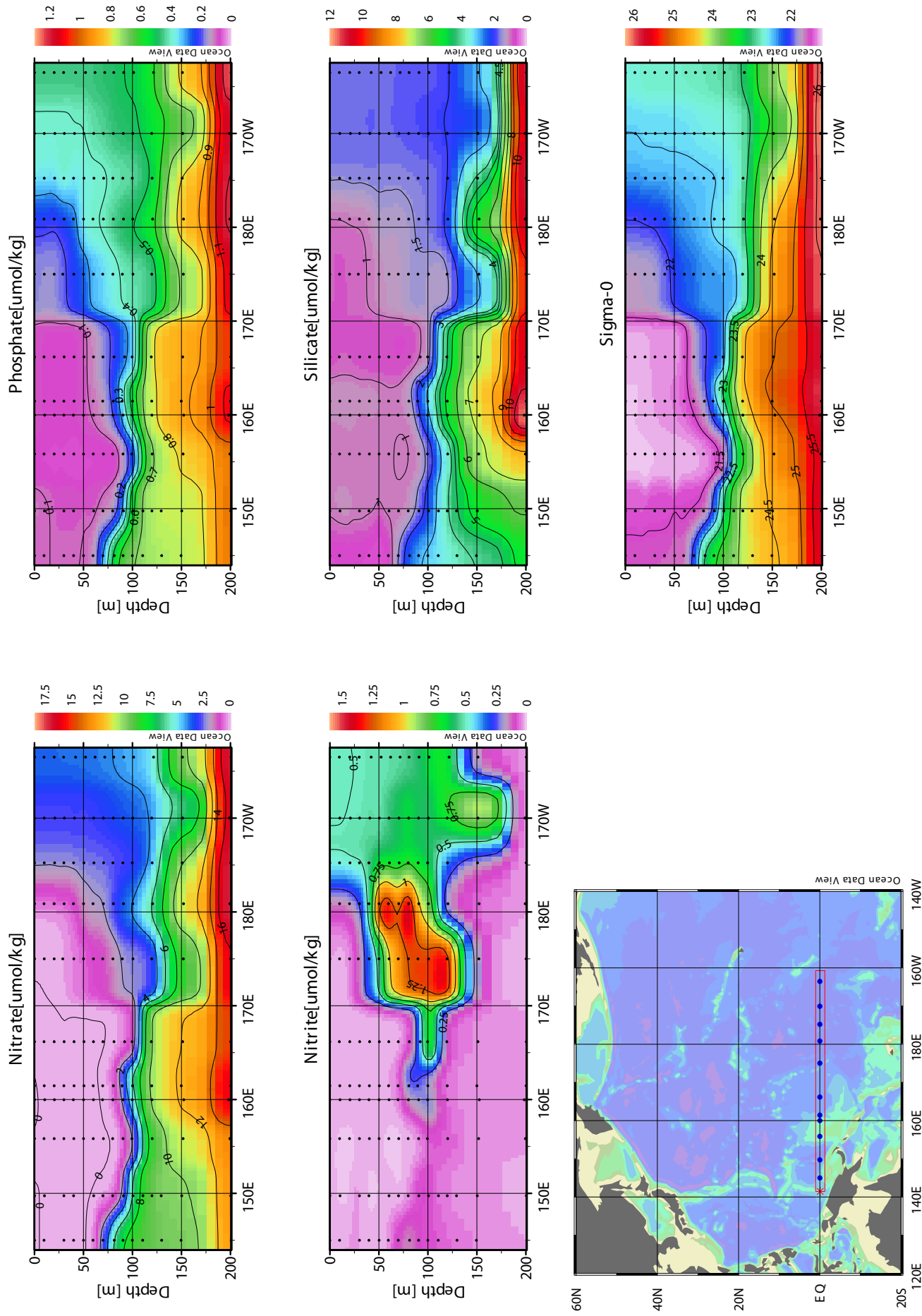


Figure 1 The vertical section of Nitrate, Nitrite, Silicate, Phosphate and Sigma-0 along the CTD line.

### 3.3.3.2 Low level Ammonia

#### (1) Personal

Shinya ENDO\* and Kazuhiko MATSUMOTO\*\*

\*Kansai environmental engineering center co ltd. (KANSO)

\*\*Japan marine science and technology center. (JAMSTEC)

#### (2) Abstract

Knowing of ammonia's role in the marine environment with respect to a biological activity, eutrophication and continental input assessment are wide interest.

However, accurate determination of ammonia in seawater seems to be difficult.

A direct automated method for routine determination of nutrients in seawater has been developed using segmented flow analysis.

The method based on the reaction of ammonia with sodium salicylate and hypochlorite, is sensitivity and highly reproducible method.

Until now, ammonia reacts in moderately alkaline solution with hypochlorite to monochloramine, which in the presence of phenol, catalytic amounts of nitroprusside ions excess hypochlorite gives indophenol blue.

However, IPB (indophenol blue) techniques are unsuitable for most unpolluted and open seawater where  $\text{NH}_3$  occurs lower concentration levels.

In the present cruise, we carried on new method that caused by Teflon membrane filter (PTFE) remove interference substances (e.g. magnesium) from seawater samples.

This method is application from Ion chromatography.

In ion chromatography cation exchange columns strong acidic eluents (e.g. HCl) are used to resolved ammonium and detected conductimetrically.

#### (3) Instruments and methods

Sample seawater was mixed with an alkaline solution containing citrate as masking agent, ammonia as gas state was formed from sample. The ammonia(gas) was absorbed in sulfuric acid solution by pathing a porous teflon membrane (pore-size  $0.5\mu\text{m}$ ) at the dialyzer attached to analytical system. The ammonia absorbed in acidic solution was determined by coupling with salicylate and hypochlorite to form a colored compound and by being measured the absorbance of 660 nm using 5 cm length flow cell in the system.

In the system, ammonia in sample was done to react with the reagent after separating from magnesium coexisted in sample. Thus we named this method "a gas diffusion method (GDM)".

#### (3)-1. Regents



1. 50%-Triton X100 solution.

Dissolved 50ml of Triton X100(aq) in ethanol, and dilute to 0.1 liter.

Store in a well-stopped polyethylene bottle.

2. Sodium salicylate solution.

Dissolved 40g of sodium salicylate, 20g of sodium hydroxide, 20g of boric acid and 4g of tri-sodium citrate dihydrate in Milli-Q water, and dilute to 0.2 liter.

Store in a well-stopped polyethylene bottle.

3. Tri-sodium citrate solution.

Dissolved 50g of tri-sodium citrate dihydrate, 0.2g of sodium hydroxide in Milli-Q water, and dilute to 0.5 liter. And add 5ml of 50%-Triton X100 solution.

Store in a well-stopped polyethylene bottle.

4. Tri-sodium citrate / NaOH solution.

Dissolved 5g of sodium hydroxide, 15g of tri-sodium citrate dihydrate and 7.5g of boric acid in Milli-Q water, and dilute 0.2 liter.

5. Nitroprusside reagent stock solution.

Dissolved 1.5g of disodium nitroprusside dihydrate, 0.1ml of hydrochloric acid in Milli-Q water, and dilute 0.1 liter.

Store in a well-stopped polyethylene bottle.

6. Sodium dichloroisocyanurate solution(SDI).

Dissolved 0.65g of sodium dichloroisocyanurate in Milli-Q water, and dilute 0.1 liter.

Store in a well-stopped polyethylene bottle.

7. Nitroprusside / H<sub>2</sub>SO<sub>4</sub> solution.

Dissolved 5ml of the Nitroprusside reagent stock solution and 0.75ml of Sulfuric acid in Milli-Q water, and dilute to 0.5 liter. And add 5ml of 50%-Triton X100 solution.

Store in a well-stopped polyethylene bottle.

### **(3)-2. Samplings**

Samples were drawn into polypropylene 100ml small mouth bottles from Niskin bottles mouth and bucket by directly. These were rinsed three times before filling. The samples were analyzed as soon as possible.

As analyzing by the TRAACS 800, glassy 7ml sample cups were used. Before this cruise, all the glass sample cups had been washed with a detergent solution (Contaminon L solution, Wako Pure Chem. Indus, Ltd.), had been rinsed by fresh water, had been rinsed by deionized water, had kept in some packing container with deionized water. These were rinsed twice with sample before being made to analyze.

### **(3)-3. Gas diffusion block**

All measurement was performed on a TRAACS 800 with axe module and pump-4, equipped with spectrum detector.

Axe module has consists a pair of mirror image blocks into which a shallow rectangular cross-section channel or track was cut. The two blocks 'sand-wiched' the gas diffusion membrane and were secured with stainless steels screws or bolts, which were reproducibly and uniformly, tightened using a calibrated torque-limiting screwdriver.

PTFE (Teflon) was used as the gas-permeable membrane. (W.Gibb et.al 1995)

Supplied in sheet form, these materials were cut whilst sandwiched between sheets of paper.

### (3)-4. Principle

Sample is pumped and treated to  $\text{pH} > 12$  by addition of alkali (NaOH). Under such conditions  $\text{NH}_4$  cations are efficiently deprotonated ( $>98\%$ ) to their volatile gaseous forms. (Fig 1.), which may then undergo transemembrane diffusion and accumulate in a recirculating acidic 'trapping solution' (nitroprusside solution). This flow injection step promotes continuous and selective gas diffusion of  $\text{NH}_3$  from seawater and is, by virtue of its containment, relatively free from atmospheric contamination.

React on this solution sodium salicylate and hypochlorite gave blue colors, which determine at 50mm cell with wavelength 660nm.

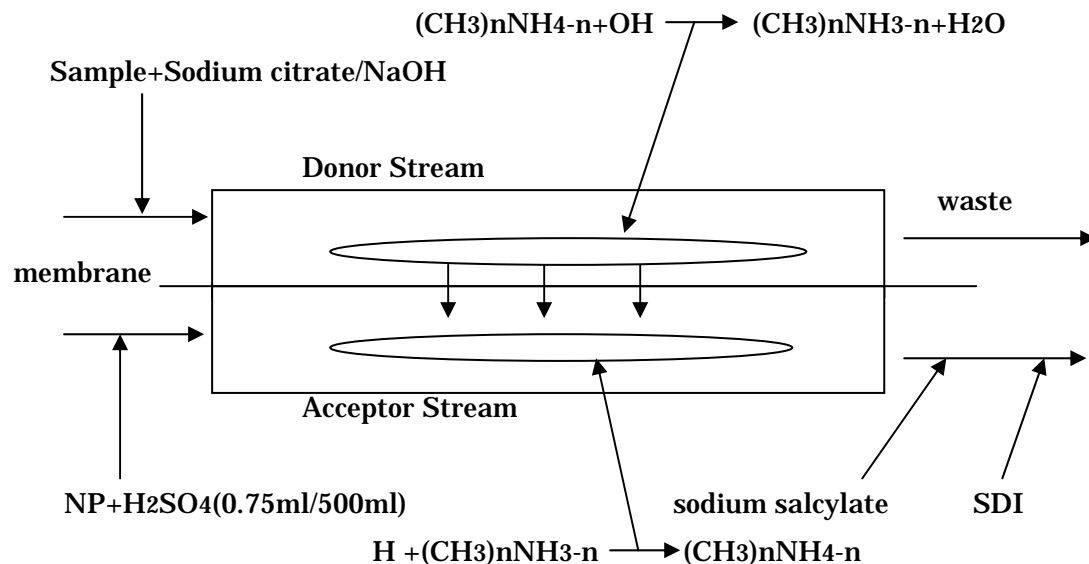


Fig 1. Schematic diagram of the speciation and diffusion of  $\text{NH}_3$  across the PTFE.

### (3)-5. Environment

The equipment of No.2 chemistry / Biology Laboratory was used.

Set up easily ventilation system around TRAACS 800. It is being made at aluminum frame and vinyl sheet, and an air cleaning unit was establishment. It was possible to reduce the contamination of the ammonia from the human body.

**(4) Calibration of volumetric utensil**

The calibration of all volumetric flasks and micropipettes used for the cruise had been checked before this cruise.

**(5) Nutrient standards**

Ammonia primary standard (stock solution) was prepared from ammonium sulfate ((NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>), that dried on oven at 110 degree C at 3 hours and cooled over silica gel in desiccater before weighting. Concentration of ammonia in the stock solution was 4,000 μmole/l for ammonium. These working standards were named N-6, 5,4,3,2,1 and 0 (N-6=0.8, N-5=0.64, N-4=0.4, N-3=0.16, N-2=0.08, N-1=0.032 and N-0=fresh Milli-Q water).

**(6) Precision check on each analysis**

On each analysis, precision check was done with the working standard N-6. The results of the repeat analysis are summarized in the percent of the concentration level in 0.5 – 2%(CV%). (Table 1.)

**(7) Preliminary results**

Vertical profiles of ammonia each casts are shown in Figure 2.

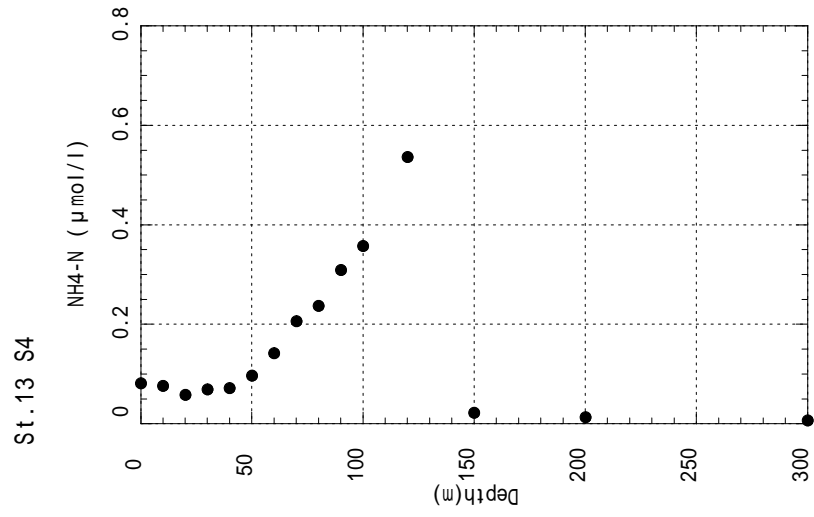
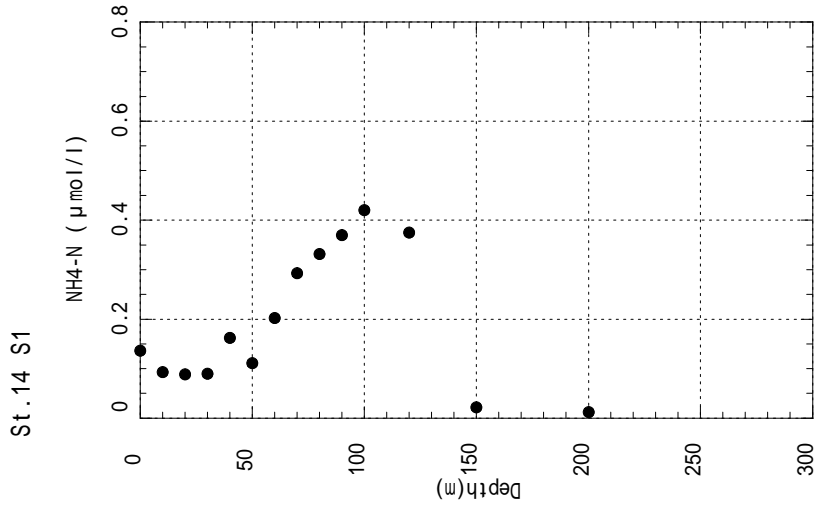
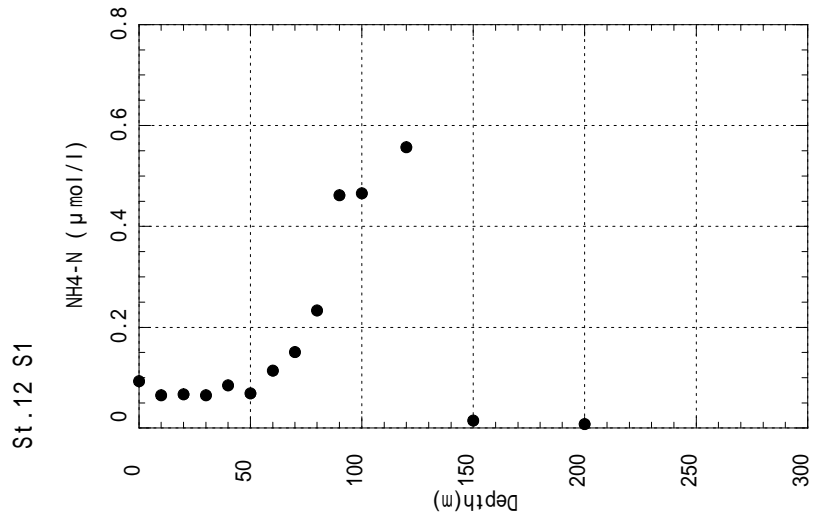
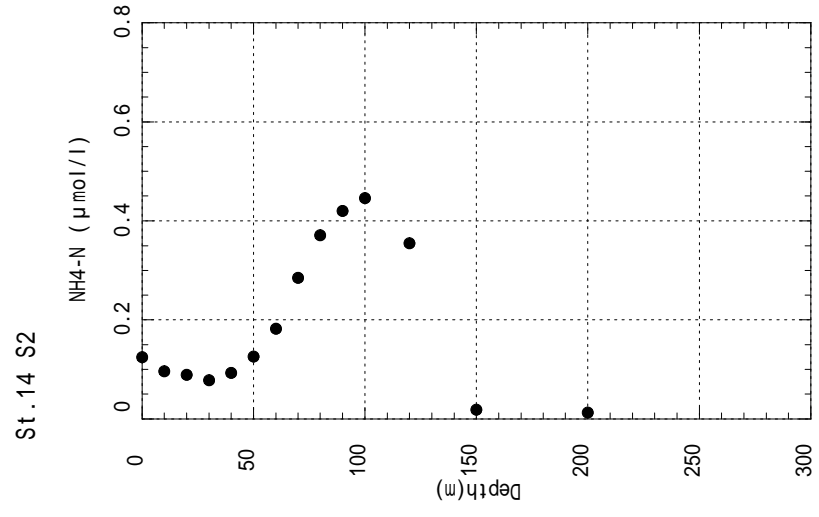


Fig 2-1. Vertical profiles of Ammonia in MR02-K01 cruise.

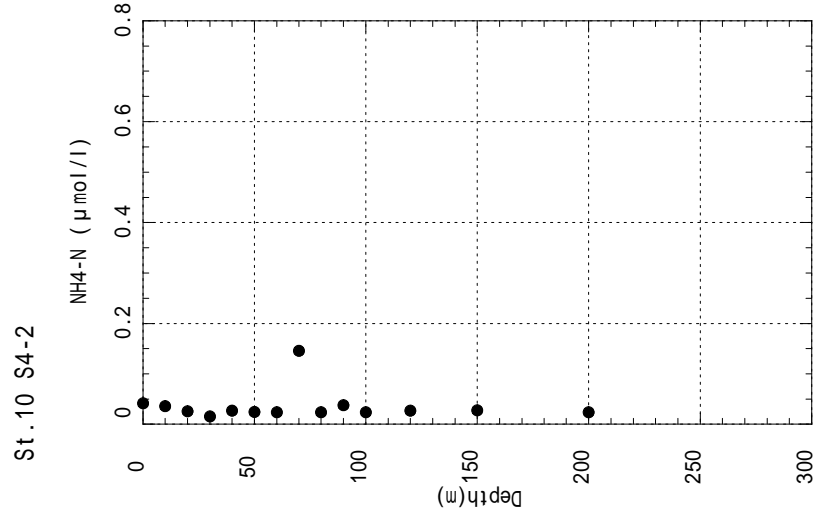
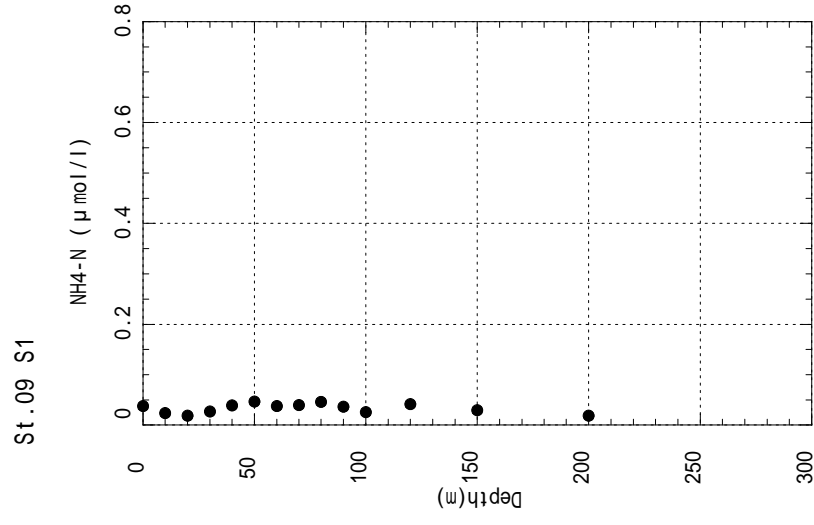
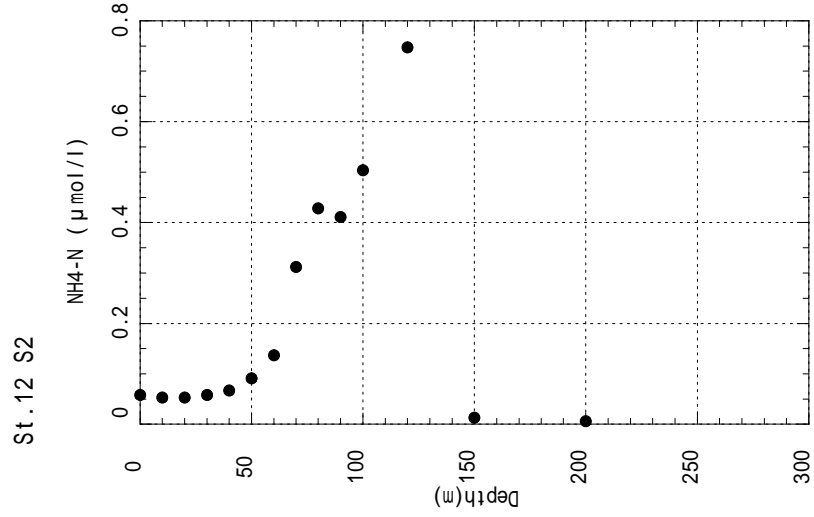
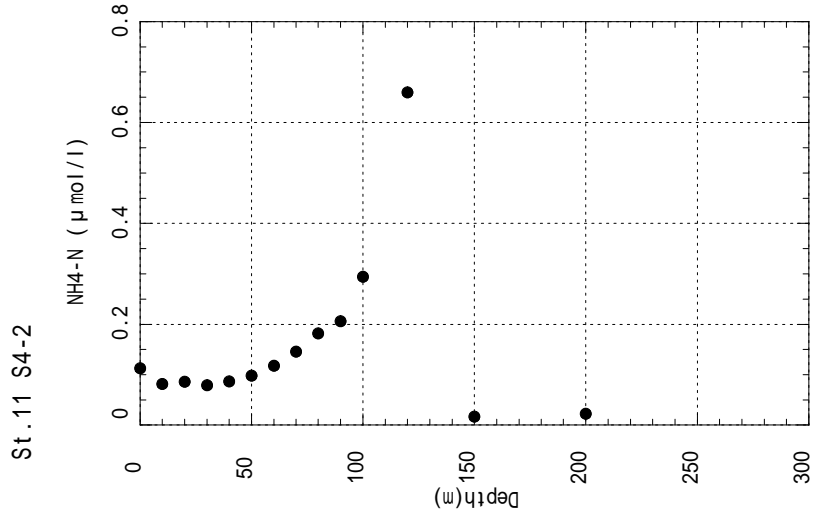


Fig 2-2. Vertical profiles of Ammonia in MR02-K01 cruise.

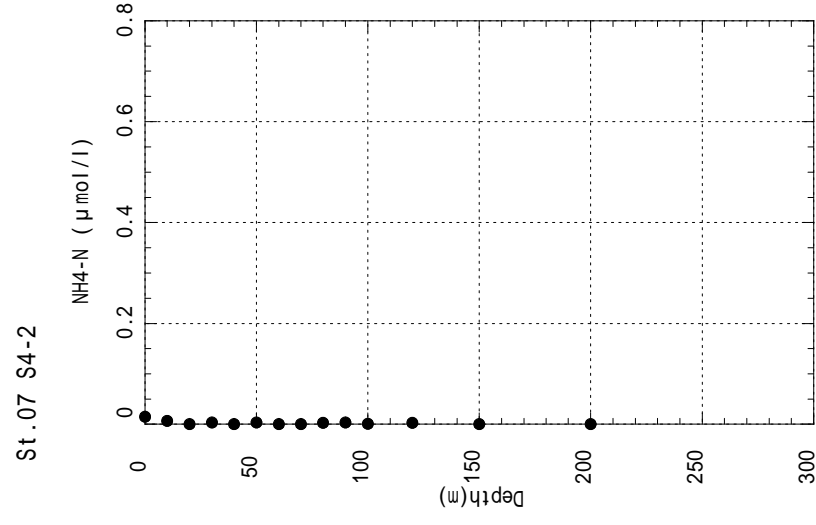
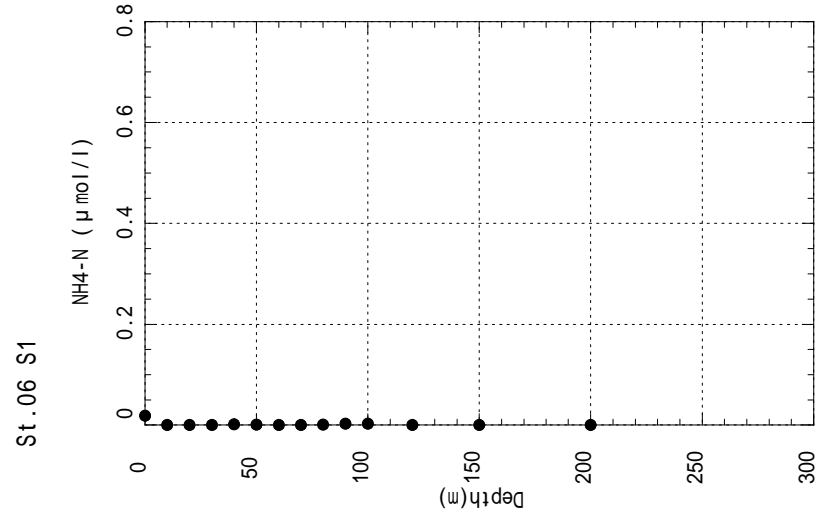
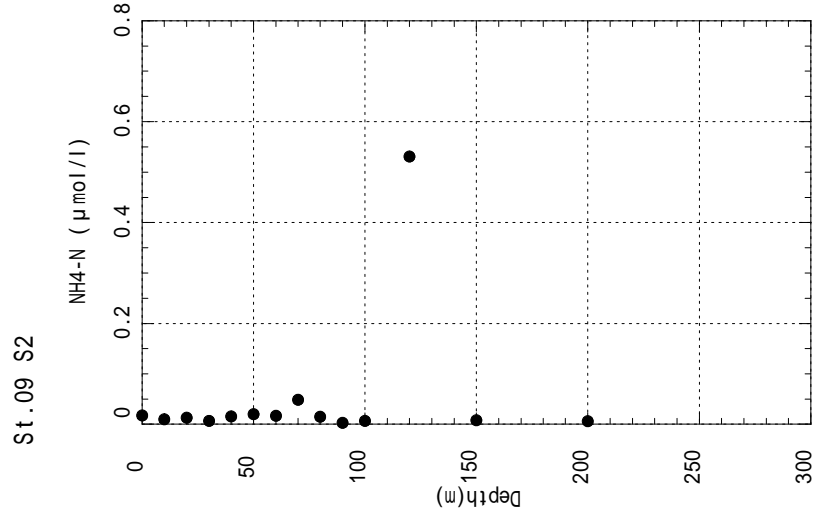
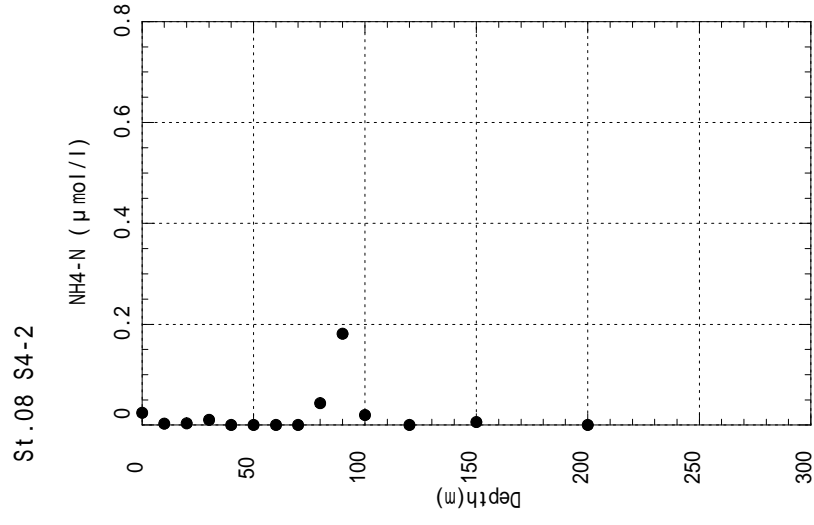


Fig 2-3. Vertical profiles of Ammonia in MR02-K01 cruise.

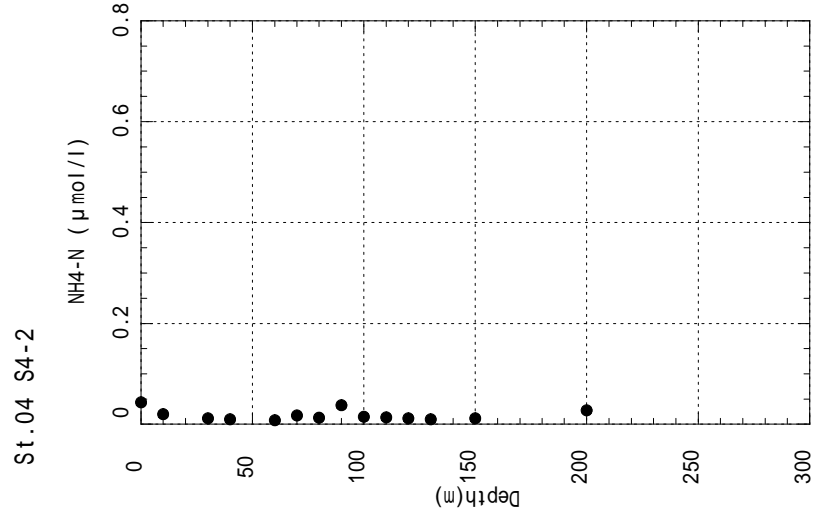
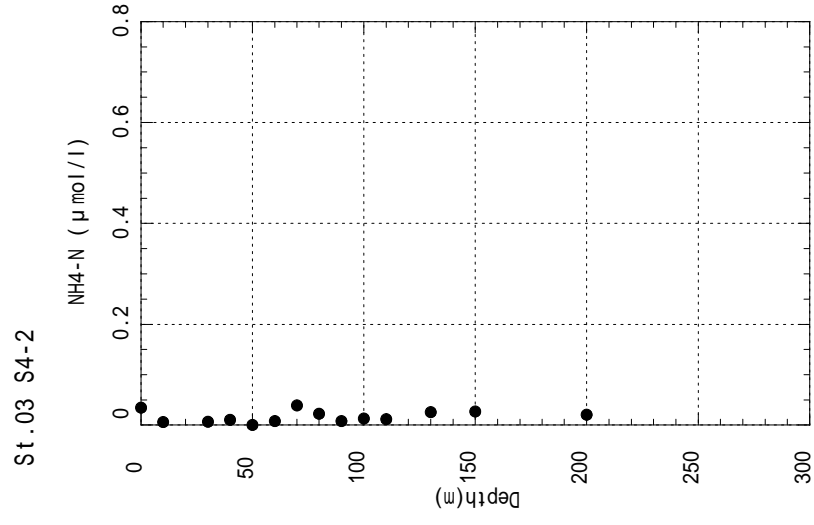
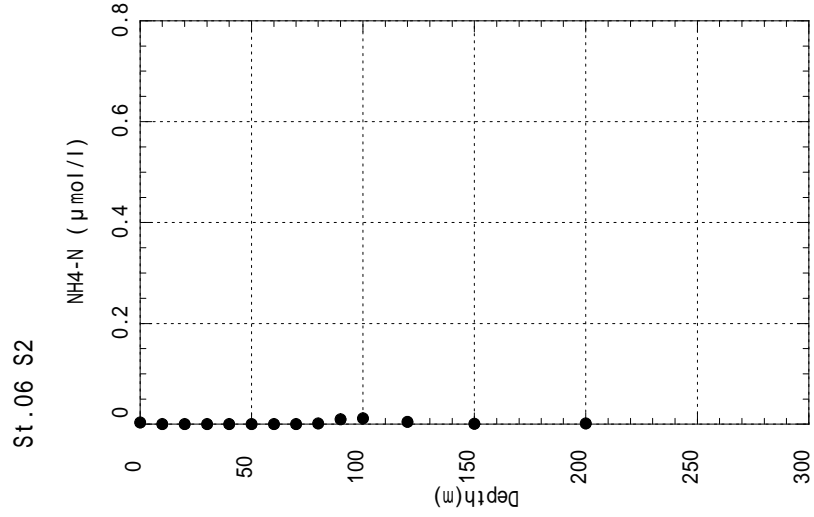
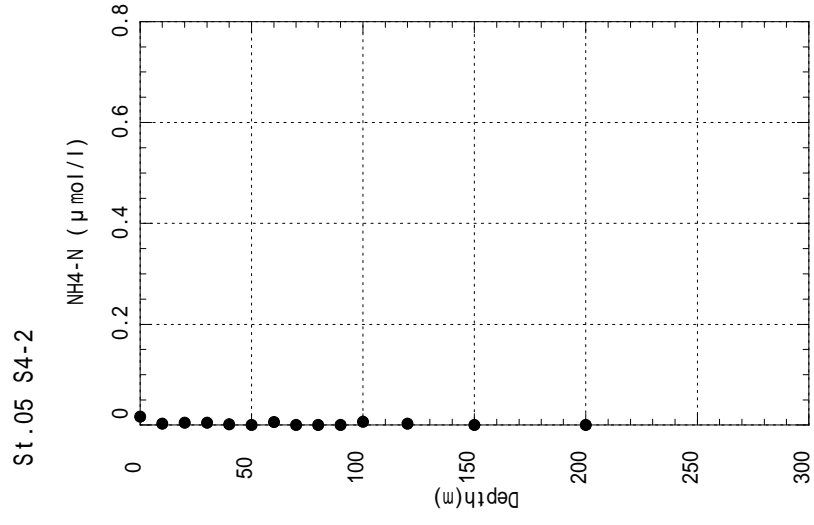


Fig 2-4. Vertical profiles of Ammonia in MR02-K01 cruise.

### 3.4 Pigment Analysis

#### 3.4.1 Chlorophyll *a* measurements of phytoplankton pigment by fluorometric analysis

Kazuhiko MATSUMOTO <sup>1)</sup>, Keisuke WATAKI <sup>2)</sup>, Yuichi SONOYAMA <sup>2)</sup>, Mio MURAKAMI <sup>2)</sup>, Kohei NAKAJIMA <sup>2)</sup>

1) JAMSTEC (Japan Marine Science and Technology Center)

2) MWJ (Marine Works Japan Ltd.)

#### Objectives

The purpose of this study is to estimate the distributions of chlorophyll-*a* in the equatorial Pacific Ocean by fluorometric analysis. Chlorophyll-*a* measurements are carried out with two different type fluorometers (broadband filter type and narrowband filter type). Broadband filter type fluorometer is used in common, but it is recognized the errors related to the acidification technique when chlorophyll-*b* is present. The new non-acidification method was developed by Welschmeyer (1994) with narrowband filter type fluorometer to eliminate the effect of acidification error. Narrowband filter type fluorometer is the same equipment as broadband filter type fluorometer, just changed excitation-emission filters and lamp. A new non-acidification method is not need to consider the acidification error, but the new method yields some overestimate of the true chlorophyll-*a* concentration, especially when chlorophyll-*b* is present.

#### Materials and Method

Seawater samples were collected at twelve sampling sites between longitude 145E and 160W in the equatorial Pacific Ocean. The samples were collected 0.5 liter at 14 depths from surface to 200m with Niskin bottles, except for the surface water, which was taken by the bucket. The samples were gently filtrated by low vaccum pressure (< 20cmHg) through Nuclepore filters(pore size: 0.4 $\mu$ m; diameter: 47mm) in the dark room. Phytoplankton pigments were immediately extracted in 7ml of N,N-dimethylformamide after filtration and then, the samples were stored in the freezer (-20 ) until the analysis of fluorometric determination. The measurements were performed at room temperature after the samples were taken out of the freezer.

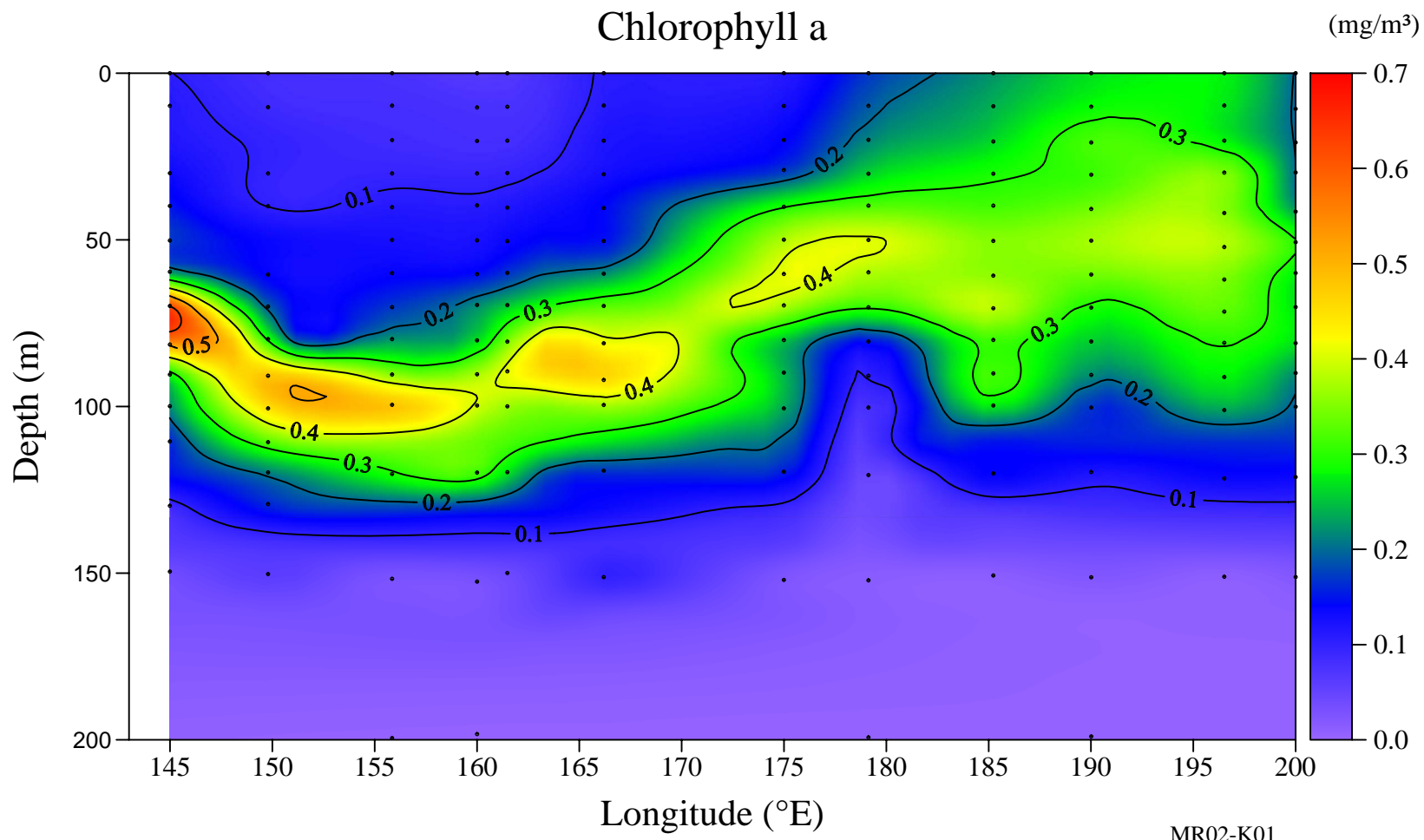
Traditional acidification and Welschmeyer non-acidification methods were



examined for the determinations of chlorophyll-*a* with Turner design model 10-AU-005 fluorometer. Analytical conditions of two methods are indicated in Table 1.

Table 1 Analytical conditions of traditional acidification and Welschmeyer non-acidification methods for chlorophyll-*a* with Turner fluorometer.

	Traditional method	Welschmeyer method
Excitation filter /nm	5-60 (340-500nm)	436nm
Emission filter /nm	2-64 (> 665nm)	680nm
Optical kit	10-037R	10-040R
Lamp	Daylight White F4R5D	Blue F4T5, B2/BP (F4T4, 5B2 equiv.)
Acidification	Yes (1M HCL, 1min.)	No



MR02-K01  
Jan. - Feb., 2002

### 3.4.2 The measurement of marine phytoplankton pigment by HPLC.

Keisuke WATAKI (M.W.J.)

Kazu MATSUMOTO (JAMSTEC)

M.W.J.: Marine Works Japan Ltd.

JAMSTEC: Japan Marine Science and Technology Center

#### *Objectives*

High performance liquid chromatography (HPLC) analysis has been shown to be a conclusive method for separating and quantifying pigments in natural seawater. In this cruise, the marine phytoplankton pigments were analyzed, in order to compare the marine phytoplankton community structure.

#### *Materials and Method*

Seawater samples were filtered through a 47 mm diameter Whatman GF/F filters (nominal size 0.7  $\mu\text{m}$ ). Sample filters were frozen by liquid nitrogen. It was the remaining seawater in filters to remove by vacuum dry in freezer. Samples were extracted with N,N-dimethylformamid over 24 hours in freezer (-20 deg C). Extracts were then filtered through 25 mm diameter polypropylene syringe filters (0.2  $\mu\text{m}$  pore size) to remove cell and filter debris. They are measured by the two way of HPLC method. As a role of ion-pair reagent, ultra pure water [Type-A] and [Type-B]. [Type-A] was, Canthaxanthin, as the internal standard was added to all samples, it was quickly to inject. [Type-A] is showed as the following solvents and column system, which is modified the method of Wright *et al* (1991). [Type-B] is showed as the following solvents and column system, which is modified the method of Zapata *et al* (2000).

#### [Type-A]

Solvent Amethanol : 0.5M ammonium acetate = 80 : 20

Solvent B            acetonitrile : water = 90 : 10

Solvent C            ethyl acetate

Column              C-18 (J'sphere ODS-H80 YMC,Inc.) 4.6 x 150 mm I.D.

#### [Type-B]

Solvent Amethanol : acetonitrile : 0.25M pyridine solution = 50 : 25 : 25

Solvent B            acetonitrile : acetone = 80:20

Column C-8 (Pro C8; YMC,Inc.) 4.6 x 150 mm I.D.

HPLC system is consisted as follows.

Detector Waters 996 Photodiode Array

Pump Waters 616

Auto Sampler Waters 717plus

Column temperature [Type-A] 40degC [Type-B] 25degC

The HPLC system is calibrated with the following commercially pigment standards.

Chlorophyll a,b,c <sub>2</sub> ,c <sub>3</sub>	Diadinoxanthin	Lutein	Fucoxanthin
Alpha-carotene	Beta-carotene	Neoxanthin	Peridinin
Prasinoxanthin	Alloxanthin	Violaxanthin	19'hexanoyloxyfucoxanthin
19'butanoyloxyfucoxanthin	Canthaxanthin	Zeaxanthin	Diatoxanthin
Divinyl-chlorophyll a			

(Chlorophyll-a and Chlorophyll-b are made by Sigma Chem.Co.. Others are made by VKI. )

Concentrations of pigment standards are determined using a spectrophotometer. Chlorophyll-a and Chlorophyll-b are quantitatively evaluated by drawing the calibration curve using the amount of the standards and their respective chromatogram peak areas. Other pigments are quantitatively evaluated using the formula of JGOFS Protocols (1994). Chlorophyll-a and Chlorophyll-b, Divinyl-chlorophyll-a peak areas are measured by Photodiode Array Detector at each blue maximum wavelength. Others are measured at 440nm.

Samples will be analyzed at JAMSTEC, Yokosuka.

### 3.4.3 Size fraction of phytoplankton by fluorometric analysis

Kazuhiko MATSUMOTO <sup>1)</sup>, Keisuke WATAKI <sup>2)</sup>, Yuichi SONOYAMA <sup>2)</sup>, Naoko SUKUMA <sup>2)</sup>, Yasuhiro KAWANISHI <sup>2)</sup>

- 1) JAMSTEC (Japan Marine Science and Technology Center)
- 2) MWJ (Marine Works Japan Ltd.)

#### Objectives

Phytoplankton are existed various species and size in the ocean. Phytoplankton species are roughly characterized by the cell size. The purpose of this study is to investigate the vertical distribution of phytoplankton by the size fractionation procedure in the equatorial Pacific Ocean.

#### Materials and Method

Seawater samples were collected at twelve sampling sites between longitude 145E and 160W in the equatorial Pacific Ocean. The samples were collected 1 liter at 14 depths from surface to 200m with Niskin bottles, except for the surface water, which was taken by the bucket. The samples were gently vacuum-filtrated (< 20cmHg) through the 47mm-diameter 10.0 $\mu$ m mesh filter and Nuclepore filters (pore size of 2.0 $\mu$ m, 1.0 $\mu$ m and 0.4 $\mu$ m) after sampling. Phytoplankton pigments on the filters were immediately extracted in 7ml of N,N-dimethylformamide after filtration. Then, the extracted samples were stored in the freezer (-20 ) for more than 24 hours before analysis. Chlorophyll-*a* was measured by the fluorometric acidification method using the spectrofluorophotometer (SHIMADZU RF-5300PC). Then, we attempted to measure the chlorophyll-*b* by the fluorometric determination. Analytical conditions of chlorophyll-*a* and chlorophyll-*b* are indicated in Table 1.

Table 1 Analytical conditions of chlorophyll-*a* and chlorophyll-*b* with SHIMADZU RF-5300PC.

	chlorophyll- <i>a</i>	chlorophyll- <i>b</i>
Excitation wavelength	433nm	461nm
Slit width	3.0nm	3.0nm
Emission wavelength	668nm	652nm
Slit width	5.0nm	5.0nm

### 3.4.4 Characterization of light absorption coefficients of phytoplankton in the Equatorial Pacific Ocean

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JAMSTEC: Japan Marine Science and Technology Center

MWJ: Marine Works Japan Ltd.

#### Objectives

The spectral characteristics of phytoplankton absorption coefficients ( $a_{ph}^*(\lambda)$ ) are essential parameters for bio-optical models to predict the carbon fixation rates, the heating rate of the upper ocean and the light propagation within the ocean and ocean color. The purpose of this study is to characterize the spectral absorption of phytoplankton in the equatorial Pacific ocean.

#### Materials and Method

Seawater samples were collected approximately 2-4 liters at 14 depths from surface to 200m. Seawater samples were gently filtrated through 25 mm Whatman GF/F filters under low vacuum pressure (<20cmHg). Sample filters were frozen in the bottle of liquid nitrogen, and stored in the deep freezer before the absorption measurements. Optical densities of the particulates retained on the filter ( $OD_f(\lambda)$ ) were measured using the quantitative filter technique (QFT) based on the glass fiber filter technique, and Shimadzu MPS-2400 multi-purpose spectrophotometer, equipped with an end-on photomultiplier, was used. To determine the optical density of unpigmented detrital particles, the pigments of filters were extracted by methanol for 1 hour and washed by distilled water. Then, hot water (80 °C) was added for 30 minutes to eliminate phycobiliprotein is the water-soluble pigment and washed by filtrated seawater. The measurements  $OD_f(\lambda)$  were converted to the equivalent optical densities of suspension ( $OD_s(\lambda)$ ) using the formula to correct the path length amplification effect. In this study, we applied the correlation formula of Allali *et al.*(1997).

$$OD_s(\lambda) = 0.264 OD_f(\lambda) + 0.322 OD_f(\lambda)^2$$

The absorption coefficient of particles ( $a_p(\lambda)$ , ( $m^{-1}$ )) and decolorized particulate matters ( $a_d(\lambda)$ , ( $m^{-1}$ )) are computed from the corrected optical densities  $OD_s(\lambda)$ , according to

$$a_{p/d}(\lambda) = 2.3 \times OD_{sp/sd}(\lambda) / L; (L = V / S)$$

Where, S is the clearance area of the filter ( $m^2$ ) and V is the volume of seawater

sample ( $m^3$ ). The subtraction of  $a_d$  from  $a_p$  shows the spectral absorption coefficient of the living phytoplankton ( $a_{ph}(\lambda)$ ).

$$a_{ph}(\lambda) = a_p(\lambda) - a_d(\lambda)$$

Finally, the absorption coefficients of living phytoplankton ( $a_{ph}(\lambda)$ ) were converted into chl-*a* specific absorption coefficients ( $a^*_{ph}(\lambda)$ ) by normalizing to the sum of chlorophyll *a* and dibinyl chlorophyll *a* concentrations.

### 3.4.5 Distribution and abundance of picophytoplankton in the equator of Pacific Ocean: Results of flow cytometry analysis during MR02-K01 cruise.

Atsushi Yamaguchi<sup>1</sup> and Kazuhiko Matsumoto<sup>2</sup>

<sup>1</sup>: KANSO (Kansai environmental engineering center)

<sup>2</sup>: JAMSTEC (Japan marine science technology center)

#### Abstract

Distribution and abundance of picophytoplankton populations along the equator of Pacific Ocean were investigated using Flowcytometry during the MR02-K01 cruise. Large regional difference was observed in distribution of picophytoplankton. Vertical distribution of picophytoplankton was deeper (peak was at 80-100 m) in the western stations (western warm water pool: Stns. 3-8), and was shallower in the eastern stations (eastern upwelling region: Stns. 9-14). Standing stock of picophytoplankton was greater in the eastern upwelling region ( $6.40 \pm 2.06$  cells  $m^{-2}$ ) than in the western warm water region ( $4.04 \pm 0.77$  cells  $m^{-2}$ ). *Prochlorococcus* was the most dominant taxon in picophytoplankton community throughout the layer or region.

#### Introduction

The structure of the pelagic ecosystem has been reconsidered after the discovery of the widespread occurrence of picophytoplankton (Waterbury et al. 1979), which are smaller than 2 $\mu$ m. Primary production in subtropical and tropical open waters is largely attributed by picophytoplankton. Picophytoplankton community is composed of prokaryotic cyanobacteria (*Synechococcus* spp.) and eukaryotic microalgae (Takahashi et al. 1985, Blanchot et al. 1992, Campbell and Vaulot 1993). Li and Wood (1988) also found very small red-fluorescing bodies by flowcytometry in the North Atlantic Ocean. They considered that the very small red-fluorescing bodies corresponded to prochlorophyte described by Chisholm et al. (1988). More recently, the prokaryotic alga was isolated and named *Prochlorococcus marinus* (Chisholm et al. 1992).

Picophytoplankton communities are well suited for analysis by using flowcytometry. Flowcytometry can count small particle rapidly, and measure type of fluorescence and size of particle. Three taxon of picophytoplankton can divide based on their fluorescence (Table 1). Flowcytometry can detect these three picophytoplankton. The present study aims to reveal features of distribution and community structure of picophytoplankton along the equator Pacific Ocean.

#### Material and methods

##### Equipment

The flow cytometer system used in this research was BRYTE HS system Bio-Rad Laboratories Inc. System specification were follows:

Light source: 75W Xenon arc or 75W Xenon/Mercury arc

Excitation wavelength: 350-650 nm

Selectable by changing filter block



Scatter sensitivity: approximately 0.2  $\mu\text{m}$ , resolution: 0.02  $\mu\text{m}$

Fluorescence detection: 3-colour (1 option) wavelength selectable by changing filter block

Detector: high-performance PMT

Analyzed volume: max 75  $\mu\text{l}$

Flow rate: 0.5-50  $\mu\text{l min}^{-1}$

As sheath fluid, high quality DW (milli-Q) was used. To detect fluorescence of chlorophyll and phycoerythrin, we selected B2 as excitation filter block and OR1 as fluorescence separator block. B2 and OR1 have ability as follows:

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

Because of the size of picophytoplankton (smaller than 2  $\mu\text{m}$ ), we changed voltage of PMT (photomultiplier tube) and gain as follow:

Parameter	PMT	Gain	Threshold
LS1	300	Log	19
LS2	350	Log	
FL1	500	Log	
FL2	500	Log	

Flow rate of sample was 0.7Bar 15  $\mu\text{l min}^{-1}$ .

### Sampling

Water samples were collected using Niskin sampler mounted on CTD. The surface water (0 m) was collected by bucket. After the recovery, water samples was immediately filtered with 10  $\mu\text{m}$  filter which mounted with filter holder, and placed in 50 ml poly-carbonate bottle, and stored in freezer (ca. 4 ) for one hour until measurement.

### Measurement

Before 10 min of measurement, the power of flow cytometer was turned on (for warm up). Internal beads were added before measurement. Water sample (75  $\mu\text{l}$ ) was run on the flow cytometer (e.g. it takes 5 min to measure 1 sample each [75/15=5]). Triplicate measurement was carried out for each water sample. Result was shown as mean of triplicate (for detail data of triplicate, refer the Appendix after). After the measurement, the sample was fixed with glutaraldehyde (1% final concentration) for 10 min, then frozen in deep freezer (-20 ).

### Data analysis

Analyzing a typical sample was as follows. In a scatter-plot of FL1 (orange fluorescence: phycoerythrin) vs. FL2 (red fluorescence: chlorophyll), there could be discriminated classify the cells into three groups: *Synechococcus*, *Prochlorococcus* and picoeukaryotes (Fig. 1). Left under corner of scatter-plot was low fluorescence group where could not identify from noise, and this fraction was abandoned as noise. In the software of BRYTE-HS, cell density (count per  $\mu\text{l}$ ) and mean of fluorescence (FL1 or FL2) and size (LS1 or LS2) were calculated for each gated group. Count per  $\mu\text{l}$  data were calibrated from the data of internal beads (Fig. 2).

## Size of cell

Size of cell was estimated from LS1 or LS2 (LS means light-scattering). Relationship between LS1 and diameter of beads was shown in Fig. 3. Relationship between beads diameter ( $Y$ ,  $\mu\text{m}$ ) and LS1 ( $X$ ) was fitted by equation:  $Y = a \cdot 10^{bX}$ , where  $a$  and  $b$  were constant.

$$Y = 0.132 \cdot 10^{0.006X}$$

Assuming shape of cell as a sphere, using this equation, data of LS1 for cell was converted to diameter.

## Results

### Distribution and abundance

Picophytoplankton cell density at the maximum layer was varied from  $10^4$  to  $10^5$  cells  $\text{ml}^{-1}$  (Fig. 4). Vertical distribution was different with station. At western stations (Stns. 3 to 8), cell density between 0 and 50 m was very small ( $< 10 \times 10^3$  cells  $\text{ml}^{-1}$ ), and increased rapidly below 50 m (the maximum depth was ca. 90 m). The maximum layer was shallow during St. 9 to 14 (ranged between 30 and 50 m).

Regional difference in abundance was also significantly ( $p < 0.05$ , U-test) varied with location (Table 2). All the taxa showed higher abundance in the eastern upwelling region. In terms of standing stock (or integrated cell density, cells  $\text{m}^{-2}$ : 0-200 m), there ranged from 4 to  $9 \times 10^{12}$  cells  $\text{m}^{-2}$  (Fig. 5).

Throughout the layer and station, *Prochlorococcus* was the most dominant taxon (ranged 77-94% of the picophytoplankton, see Table 2). *Synechococcus* was the second (2-17%) and Picoeukaryotes was the least (3-9%). The taxonomic composition was different with depth. Contribution of *Synechococcus* was larger in the surface layer (especially 0 to 30 m), and *Prochlorococcus* was larger in the deeper layer (below of 100 m).

## Discussion

### Distribution and abundance

Vertical distribution pattern is different between western warm water pool (Stns. 3-8) and eastern upwelling region (Stns. 5-12) (Fig. 6). In the western warm water pool, cell density in the upper 50 m is extremely small, while below of 50 m, cell number rapidly increase and show prominent peak near 90 m. In the eastern upwelling region, certain density is occurred at surface layer and have flat peak ca. 40 m.

Integrated cell density (cells  $\text{m}^{-2}$ : =standing stock) at all the station are in the same order ( $\times 10^{12}$  cells  $\text{m}^{-2}$ ) (Fig. 5, Table 2). Taxonomic composition is also the same (prochlorophytes: cyanobacteria: picoeukaryotes=85:10:5) throughout the equator (Table 2). The cell density of prochlorophytes in the present study ( $10^3$ - $10^5$  cells  $\text{ml}^{-1}$ ) is similar to previously reported in the open waters of the Pacific Ocean (Campbell and Vault 1993, Shimada et al. 1993). The order of density of cyanobacteria in the present study ( $10^2$ - $10^4$  cells  $\text{ml}^{-1}$ ) is also consistent with reported in the tropical waters of the Pacific Ocean (Blanchot et al. 1992).

Regional difference observed for vertical distribution and abundance of

picophytoplankton may be related with vertical distribution of nutrient and pycnocline. Nutrient especially NO<sub>2</sub> and PO<sub>4</sub> is limited (nearly zero) in the upper 100 m in the western stations, while it is increased to 0.3-0.4 μM in the eastern stations (refer report on nutrient in this cruise). In the western equator Pacific Ocean, Blanchot et al. (1992) found large differences between non-El Niño and El Niño conditions because upwelling brings nutrients to the surface layer during non-El Niño year whereas surface nitrate is depleted when El Niño weakens or stops the upwelling.

#### Acknowledgement

We would like to express our sincere thanks to captain, officers and crew of the R/V Mirai, for their cooperation throughout the present cruise. We are also grateful to Dr. T. Kawano, the chief scientist of the cruise, for his supervising during the MR02-K01 cruise.

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Table 1. Three taxa of picophytoplankton and their fluorescence.

Taxa	Fluorescence
<i>Synechococcus</i> (Cyanobacteria)	Orange (phycoerythrin) and Red (chlorophyll a)
<i>Prochlorococcus</i> (Prochlorophytes)	Red (chlorophyll, but mostly divinyl-chlorophyll a)
Picoeukaryotes	Red (chlorophyll, mostly chlorophyll a)

Table 2. Regional comparison of standing stocks ( $\times 10^{12}$  cells  $m^2$ ) of picophytoplankton in the equatorial Pacific. Western warm water pool and eastern upwelling region include the data of Stns. 3-8 and 9-14, respectively. Values are mean  $\pm$  1sd. Statistical U-test was carried out. \*:  $p < 0.05$ , \*\*\*:  $p < 0.001$ .

Taxa	Western warm water pool (Stns. 3-8)	Eastern upwelling region (Stns. 9-14)
<i>Synechococcus</i>	0.29 $\pm$ 0.07	1.03 $\pm$ 0.52***
<i>Prochlorococcus</i>	3.55 $\pm$ 0.76	4.95 $\pm$ 1.57*
Picoeukaryotes	0.20 $\pm$ 0.03	0.42 $\pm$ 0.12***
Total	4.04 $\pm$ 0.77	6.40 $\pm$ 2.06*

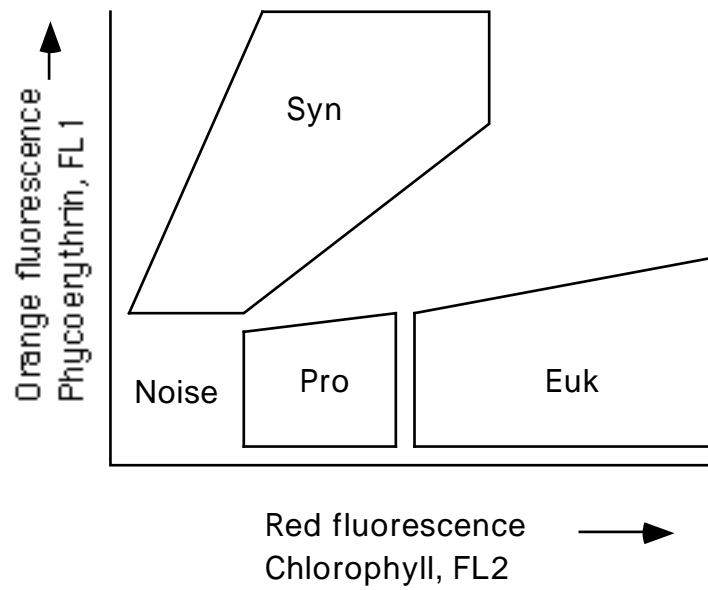


Fig. 1. Schematic diagram of scatter-plot of orange fluorescence (=phycoerythrin, FL1 in vertical axis) vs. red fluorescence (=chlorophyll, FL2 in horizontal axis). Positions of three picophytoplankton (Syn: *Synechococcus*, Pro: *Prochlorococcus* and Euk: Picoeukaryotes) appeared in the scatter plot are shown. Note the left under corner is noise (cannot detectable).

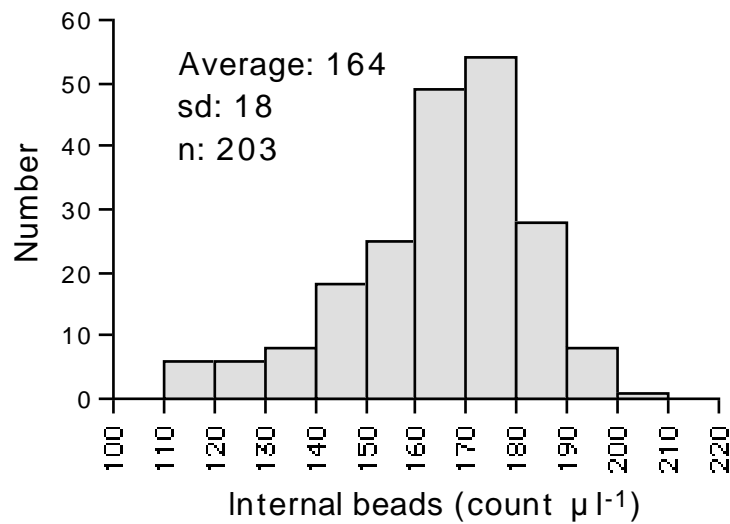


Fig. 2. Histogram of internal beads count (count  $\mu\text{l}^{-1}$ ). Average, standard deviation (sd) and number of total measurement (n) are shown in the panel.

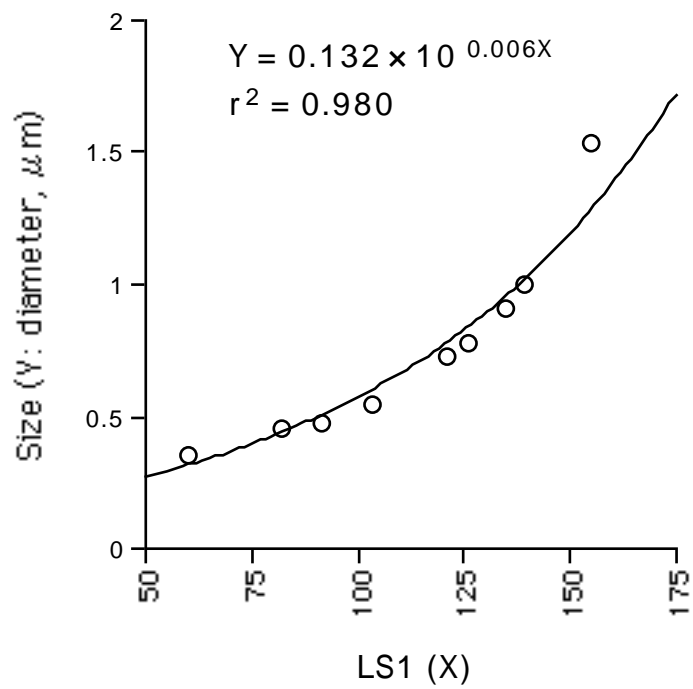


Fig. 3. Relationship between light scattering 1 (LS1) and beads diameter which previously known ( $\mu\text{m}$ ). Resulted regression line:  $Y=0.132 \times 10^{0.006X}$ , where  $Y$  is diameter of particle and  $X$  is LS1,  $r^2=0.980$ ,  $p<0.0001$  is shown in the panel.

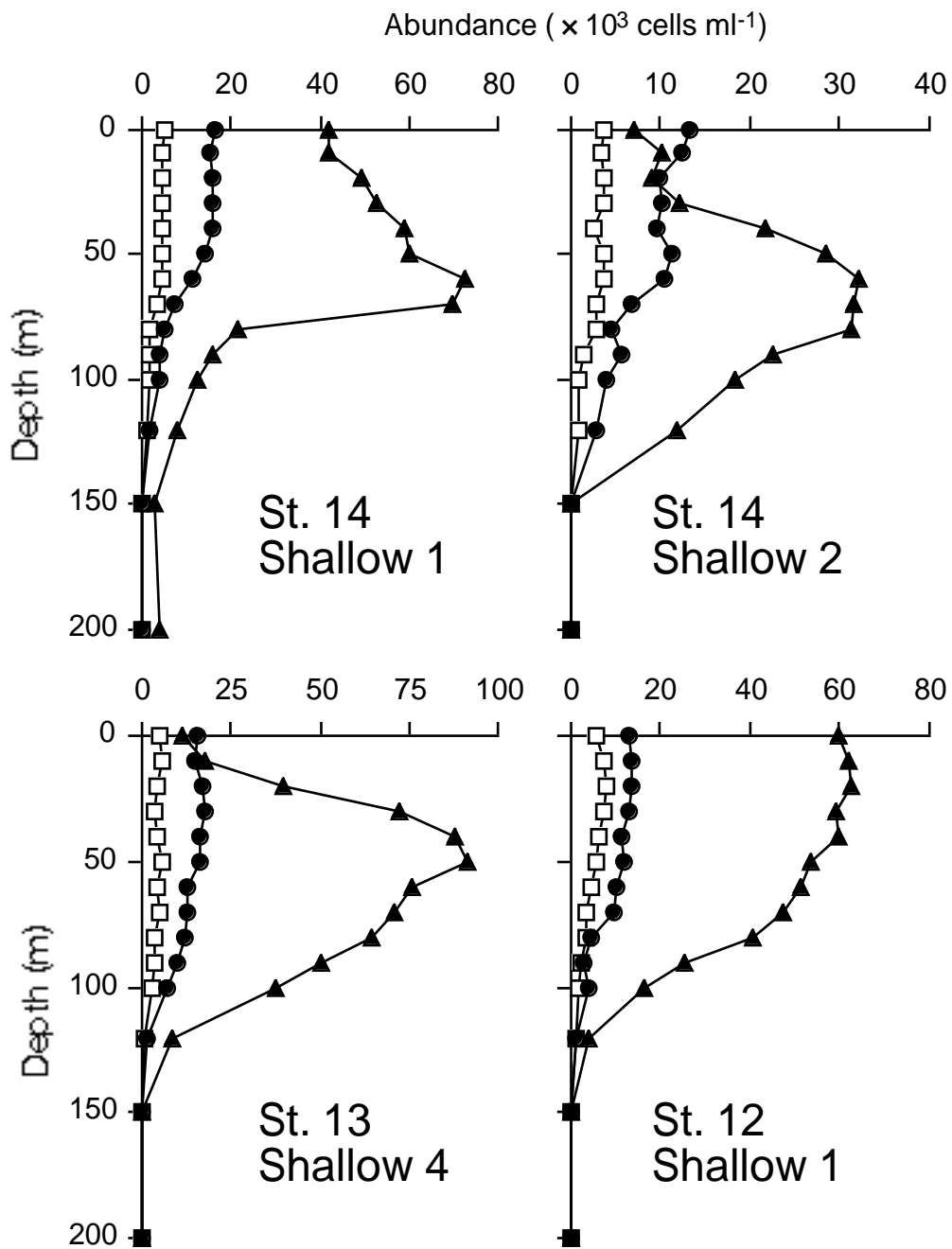


Fig. 4. Vertical distribution of picophytoplankton cell density ( $\times 10^3$  cells  $\text{ml}^{-1}$ ) at each station/cast. Picophytoplankton is divided into three taxa: *Synechococcus* ( ), *Prochlorococcus* ( ) and Picoeukaryotes ( ). Note that the cell density axes are different with panels.

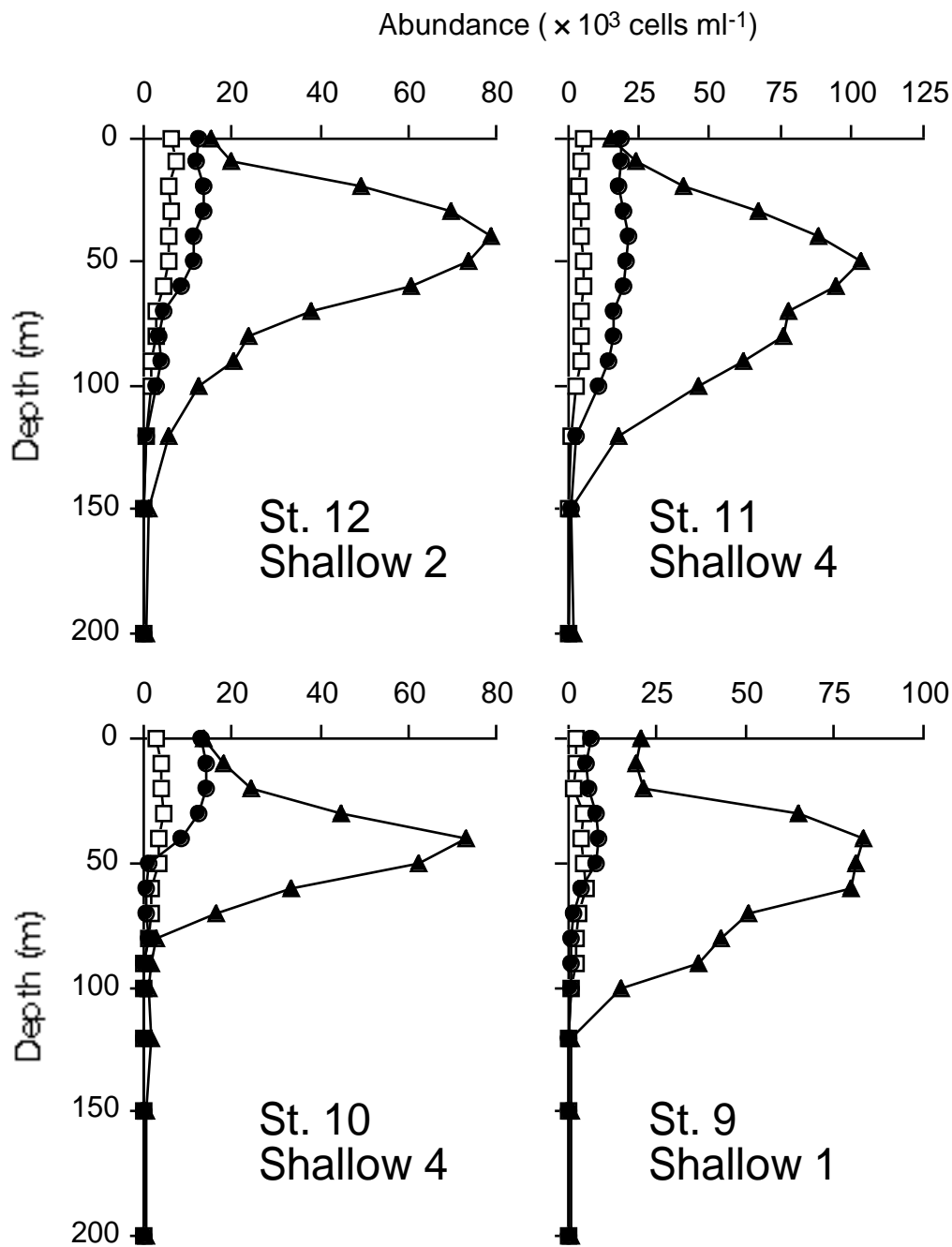


Fig. 4 (continued). Vertical distribution of picophytoplankton cell density ( $\times 10^3$  cells  $\text{ml}^{-1}$ ) at each station/cast. Picophytoplankton is divided into three taxa: *Synechococcus* ( ), *Prochlorococcus* ( ) and Picoeukaryotes ( ). Note that the cell density axes are different with panels.



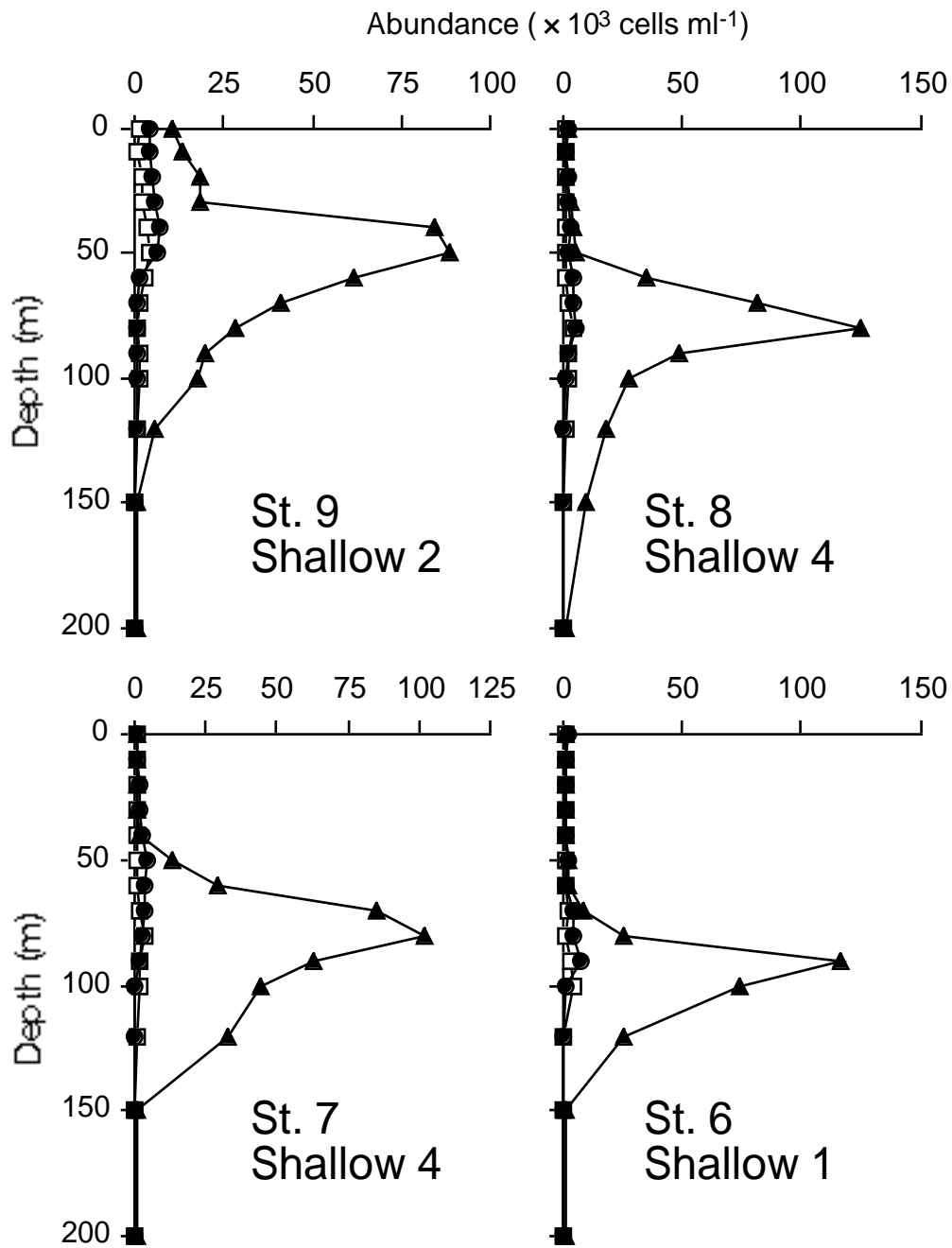


Fig. 4 (continued). Vertical distribution of picophytoplankton cell density ( $\times 10^3$  cells  $\text{ml}^{-1}$ ) at each station/cast. Picophytoplankton is divided into three taxa: *Synechococcus* ( ), *Prochlorococcus* ( ) and Picoeukaryotes ( ). Note that the cell density axes are different with panels.

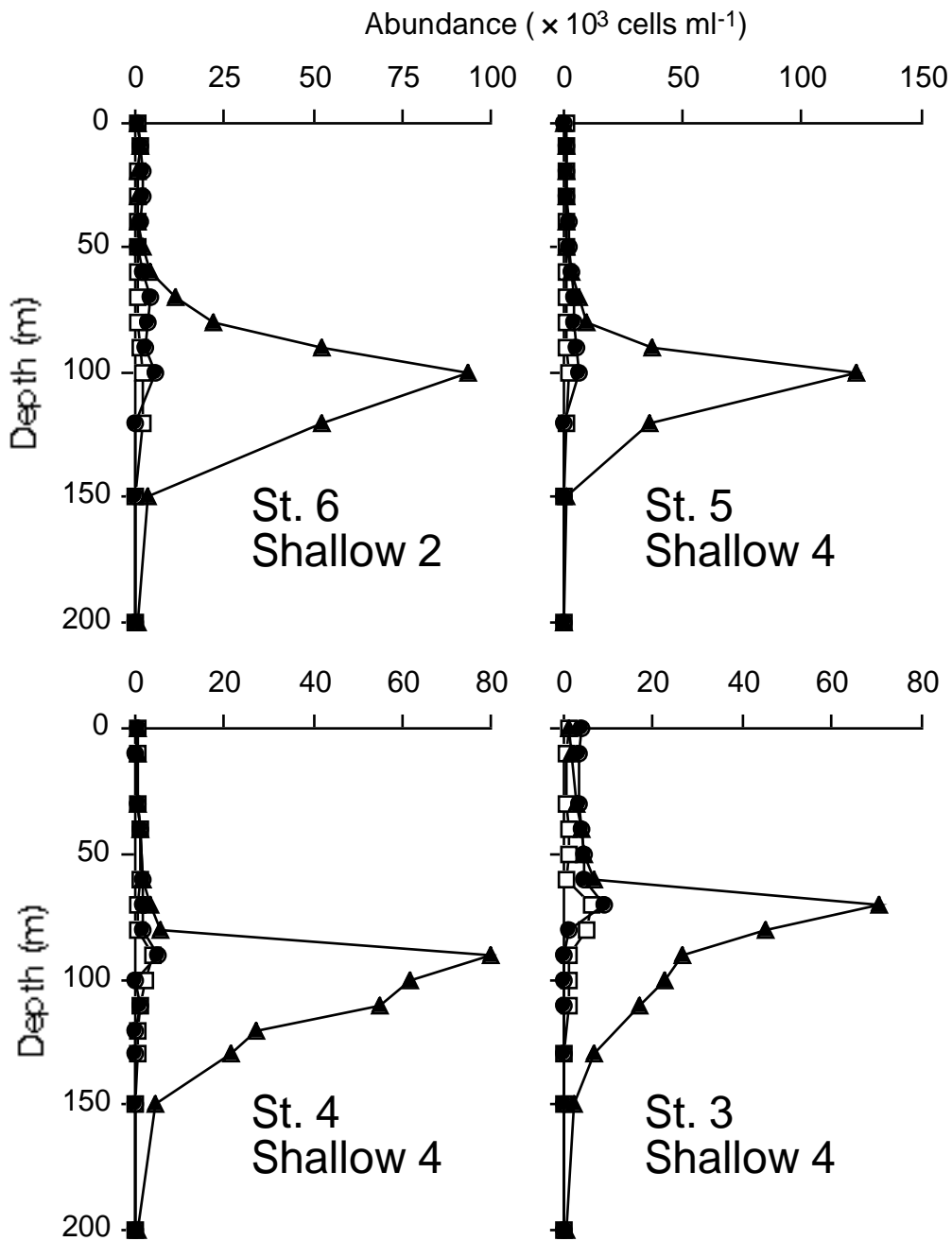


Fig. 4 (continued). Vertical distribution of picophytoplankton cell density ( $\times 10^3$  cells  $\text{ml}^{-1}$ ) at each station/cast. Picophytoplankton is divided into three taxa: *Synechococcus* ( ), *Prochlorococcus* ( ) and Picoeukaryotes ( ). Note that the cell density axes are different with panels.

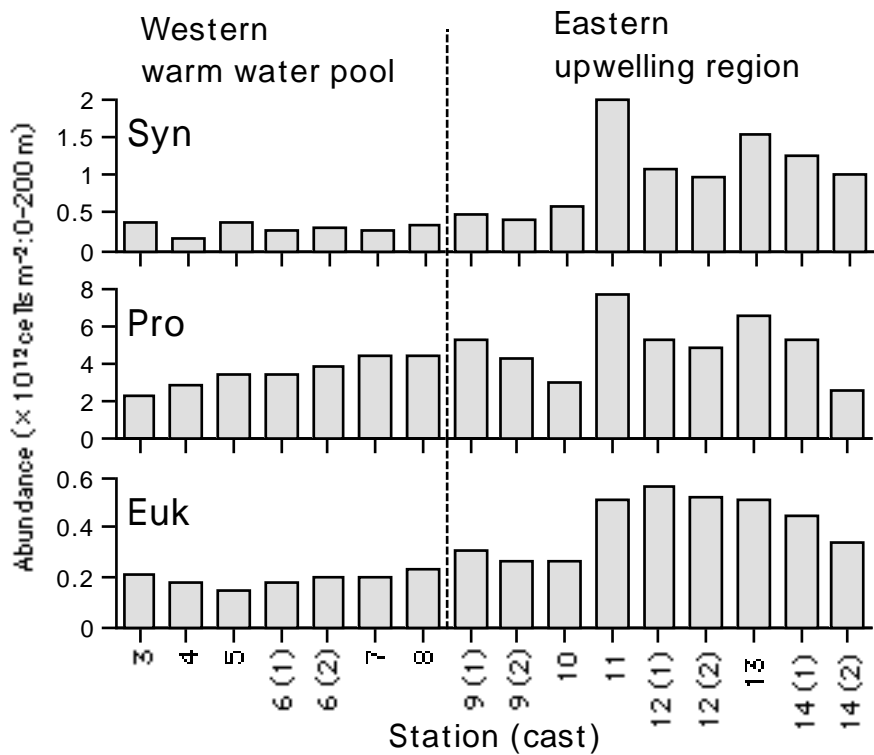


Fig. 5. Spatial changes in abundance of picophytoplankton along the equatorial Pacific. Position of boundary between western warm water pool and eastern upwelling region (ca.  $165^{\circ}$ E) was shown as dotted line. Syn: *Synechococcus*, Pro: *Prochlorococcus*, Euk: Picoeukaryotes.

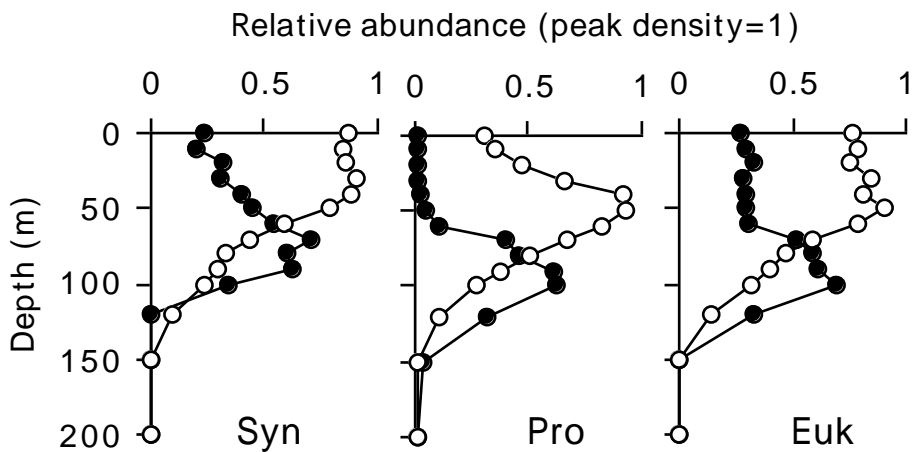


Fig. 6. Vertical distribution of relative abundance (peak density=1) of picophytoplankton in the western warm water region (○) and eastern upwelling region (●). Values are means of each region and depth. Syn: *Synechococcus*, Pro: *Prochlorococcus*, Euk: Picoeukaryotes.

### 3.4.6 Phycoerythrin determination and light adaptation of picophytoplankton

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#### Objective

Cyanobacteria that possess phycoerythrin as the major light-harvesting phycobiliproteins, are the dominant component of phytoplankton in the oligotrophic ocean. Small coccoid cyanobacteria, *Synechococcus* spp., contain high concentration of phycobiliproteins and seem to use them as nitrogen reserves as well as light-harvesting pigments. Phycoerythrin contains two kinds of pigment, phycoerythrobilin(PEB) and phycourobilin(PUB). The ratio of these pigments varies spatially, and it may also vary according to the light.

During this cruise, the object is to evaluate biomass of coccoid cyanobacteria and their spatial distribution through determination of phycoerythrin, as well as conduct experiments to study the light adaptation of *Synechococcus*.

#### Method

##### 1. Phycoerythrin determination

Seawater samples were collected from the surface and 13 depths in the upper 200m water column. The collected samples (1L) were vacuum-filtered (< 180mmHg) through 0.4 $\mu$ m Nuclepore filters (47mm). Cells on the filters were resuspended in 4ml 50% glycerol for 10-30 minutes and in vivo fluorescence of phycoerythrin was determined using a Turner Design TD700. Both excitation and emission spectra were also determined on the glycerol sample with Hitachi F-4500 spectrofluorometer.

After in vivo determination, the samples were fixed in 2% glutaraldehyde, and preserved at 4 for a day. A part of the fixed samples (0.6-1.0ml) was then filtered through 0.2 $\mu$ m cellulose acetate filters under a vacuum of 180mmHg. The filters were mounted onto a cover glass with a drop of glycerol, and stored at -30 until cell counting under a fluorescent microscope.

##### 2. On-board incubation experiment

Seawater samples collected from the two depths, 5m and chlorophyll max layer, were incubated in duplicate 4L Nalgene bottles in an on-deck incubation pool for 3 days. One bottle was covered with a black mesh (about 1/64 light quantum), the other was without cover. Initial and final samples were obtained for estimation of phycoerythrin concentration and phytoplankton composition (HPLC and flow cytometry). The method described above was followed for phycoerythrin estimation. HPLC and flow cytometry samples will be analyzed later in the laboratory.

### **3.5 Primary and new productivity**

Ai YASUDA 1), Taeko OHAMA 1), Fuma Matsunaga 1), Takeshi KAWANO 2)

- 1) Marine Works Japan LTD
- 2) Japan Marine Science and Technology Center

#### **Objectives**

The objective of this study is to know the mechanism of primary production at the open sea on the equator.

#### **(1) In-situ Incubation**

##### ***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 under 420 degree C of temperature for at least 4 hours, were used for a filtration.

##### ***Incubation***

In-situ incubation for 12 hours were executed at station before incubated 6,9,12 and 14. We took two transparent bottles samples from 13 layers took from 150m depth ( every 10m from surface to 100m, 120m and 150m depth and morred these samples at each depth for 12 houres, after morring all samples incubated in bath on deck 12 hours). All the samples were spiked with 0.2 mmoles/ mL of  $\text{NaH}^{13}\text{CO}_3$  solution just before mooring. Samples were filtered immediately after the incubation and the filters were kept frozen till analyze of this cruise. After that, filters were dried on the oven of 45 degree C.

##### ***Measurement***

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

#### **(2) Photosynthesis and irradiation curve measurement**

##### ***Bottles for incubation and filters***

Bottles for incubation ( ca.1 litter ) was done to cut off the light on bottle's side, upper and bottom, which did not pass the light from a 500W halogen lamp ( light source ). These bottles were numbered from No.1 to 8, on the lamp. All bottles were shield with a film on lamp side. Grass fiber filters ( Wattman GF/F 25mm ) pre-combusted under 420 degree C of temperature condition for at least 4 hours, were used for a filtration.

### ***Incubation***

Photosynthesis and irradiation curve measurement were carried out at Hchinohe to Equatorial Pacific Ocean and all stations. Sampling was made at surface and chlorophyll maximum layer. The bottles were spiked with 0.2 mmoles/mL of  $\text{NaH}^{13}\text{CO}_3$  solution, and incubated for 3 hours at temperature- controlled bath in a laboratory. The light intensity was shown in table 1. Samples were filtered immediately after the incubation and the filters were kept to freeze till analyse of this cruise. After that, filters were dried on the oven of 45 degree C.

Table. 1 Light Intensity of P-I measurements

Bottle No.	Light Intensity ( $\mu\text{E}/\text{cm}^2/\text{sec}$ )
1	1100
2	500
3	250
4	145
5	70
6	28
7	22
8	12

### ***Measurement***

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

### **(3) Simulated in-situ incubation**

#### ***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 420 degree C for at least 4 hours, were used for a filtration.

#### ***Simulated in-situ incubation***

We took four samples form the surface and chlorophyll maximum layer by a bucket and Niskin bottles at each stations. All samples were spiked with 0.2 mmoles/mL of  $\text{NaH}^{13}\text{CO}_3$  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. Samples were incubated in a bath on the deck for 24 hours. After incubation, samples were mixed and then divided into four fractions. The first fraction was filtrated with

grass fiber filter ( Wattman GF/F 25mm ). The second fraction was pre-filtrated with the 47mm-diameter 10.0 $\mu$ m mesh filter and then filtrated with the grass fiber filter. The third fraction was pre-filtrated onto Nuclepore filter with pore size of 3.0 $\mu$ m and then filtrated with the grass fiber filter. The fourth fraction was pre-filtrated onto Nuclepore filter with pore size of 1.0 $\mu$ m and then filtrated with the grass fiber filter. GF/F filters were kept frozen a day before analyses. After that, filters were dried in the oven with temperature of about 45 degree C.

### ***Measurement***

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

### 3.6 Continuous measurements of surface seawater

#### 3.6.1 Integrated monitoring system of surface seawater

(1) Name & Affiliation

Tomoko MIYASHITA (Marine Works Japan LTD.)

Fuyuki SHIBATA (Marine Works Japan LTD.)

(2) Objective

In order to measure salinity, temperature, dissolved oxygen, and fluorescence of near-sea surface water.

(3) Methods

*EPCS* (Nippon Kaiyo co.,Ltd.) has five kind of sensors and fluorescence photometer and can automatically measure salinity, temperature, dissolved oxygen, fluorescence and particle size of plankton in near-sea surface water continuously on real time 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 machine 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 *EPCS* 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 and each values were checked everyday.

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

a) Temperature and Salinity sensor

SEACAT THERMOSALINOGRAPH

Model: SBE-21, SEA-BIRD ELECTRONICS, INC.

Serial number: 2118859-2641

Measurement range: Temperature -5 to +35 , Salinity 0 to 6.5 S m-1

Accuracy: Temperature 0.01 6month-1, Salinity 0.001 S m-1 month-1

Resolution: Temperatures 0.001 , Salinity 0.0001 S m-1

b) Bottom of ship thermometer

Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.

Serial number: 032607

Measurement range: -5 to +35

Resolution: ± 0.001

Stability: 0.002 year-1

c) Dissolved oxygen sensor



Model: 2127A, Oubisufair Laboratories Japan INC.  
Serial number: 44733  
Measurement range: 0 to 14 ppm  
Accuracy:  $\pm 1\%$  at 5 of correction range  
Stability: 1% month-1

d) Fluorometer

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

e) Particle Size sensor

Model: P-05, Nippon Kaiyo LTD.  
Serial number: P5024  
Measurement range: 0.02681 mmt 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.

Leg.1 08-Jan.-'02 08:15 to 17-Jan.-'02 19:50  
Leg.2 20-Jan.-'02 04:22 to 08-Feb.-'02 04:02  
Leg.3 10-Feb.-'02 03:26 to 14-Feb.-'02 03:59

(4) Preliminary Result

The profiles of comparison of salinity [sensor] and salinity analysis result were shown in Fig.1.  
The profiles of comparison of D.O.[sensor] and D.O. analysis result were shown in Fig.2.

(5) Date archive

The data were stored on a magnetic optical disk, which will be kept in Ocean Research Department, JAMSTEC.

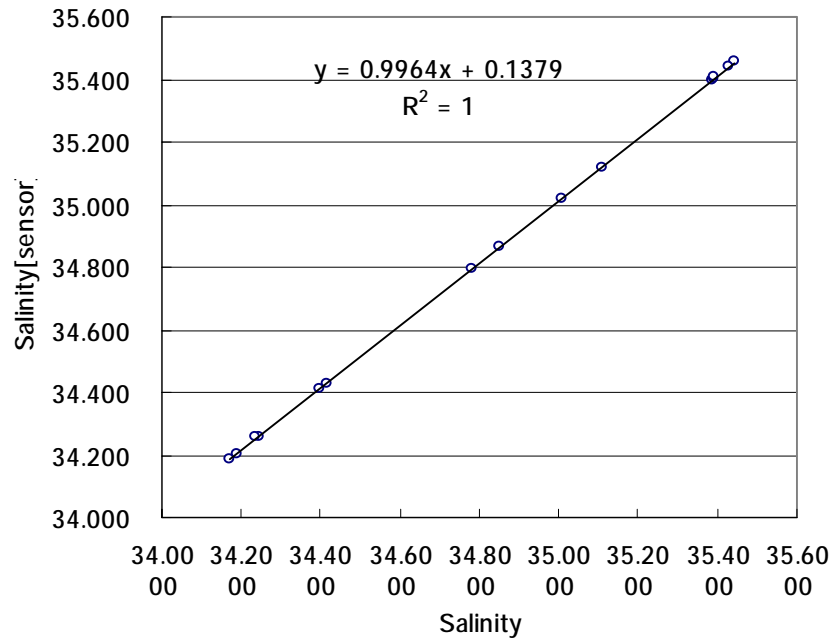


Fig.1: The profiles of comparison of salinity [sensor] and salinity analysis result

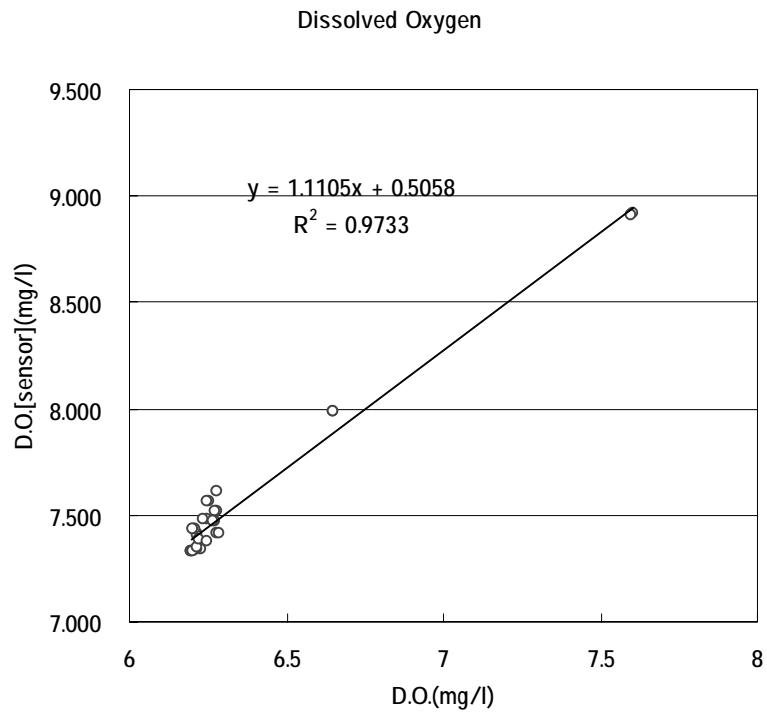


Fig.2: The profiles of comparison of D.O.[sensor] and D.O. analysis result

### 3.6.2 Nutrients monitoring in seawater

Kenichiro SATO (MWJ): Operation leader  
Kazuhiko MATSUMOTO (JAMSTEC)

#### (1) Objectives

The distribution of nutrients of sea surface water is important to investigate the primary production.

#### (2) Instruments and Methods

The nutrients monitoring system was performed on BRAN+LUEBBE continuous monitoring system Model TRAACS 800 (4 channels). It was located at the surface seawater laboratory for monitoring in R/V Mirai. The seawater of 4.5 m depth under sea surface was continuously pumped up to the laboratory inner R/V Mirai. The seawater was poured in 5 L of Polyethylene beaker through a faucet of the laboratory. The seawater was introduced direct to monitoring system with narrow tube continuously. The methods are as follows:

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

**Silicate:** Silicate was determined by complexing with molybdate, by reducing with ascorbic acid to form a colored complex, and by being measured the absorbance of 800 nm using 3 cm length flow cell in the system.

**Nitrite:** Nitrite was determined by diazotizing with sulfanilamide by coupling with N-1-naphthyl-ethylendiamine (NED) to form a colored azo compound, and by being measured the absorbance of 550 nm using 3 cm length flow cell in the system.

**Phosphate:** Phosphate was determined by complexing with molybdate, by reducing with ascorbic acid to form a colored complex, and by being measured the absorbance of 800 nm using 5 cm length flow cell in the system.

We collected the 12 samples from a faucet of the laboratory and analyzed by TRAACS 800 (4 channels) method. Revisionary expression was sought from monitoring data and TRAACS 800 data.

#### (3) Preliminary results

The nutrients monitoring was operated during the period of Yokohama to Sekinehama. Monitoring data was obtained every 1 minute. Preliminary data of every 10 minutes on the equator was shown in Figure 1.

(4) Data archive

All data will be archive at JAMSTEC Data Management Office.

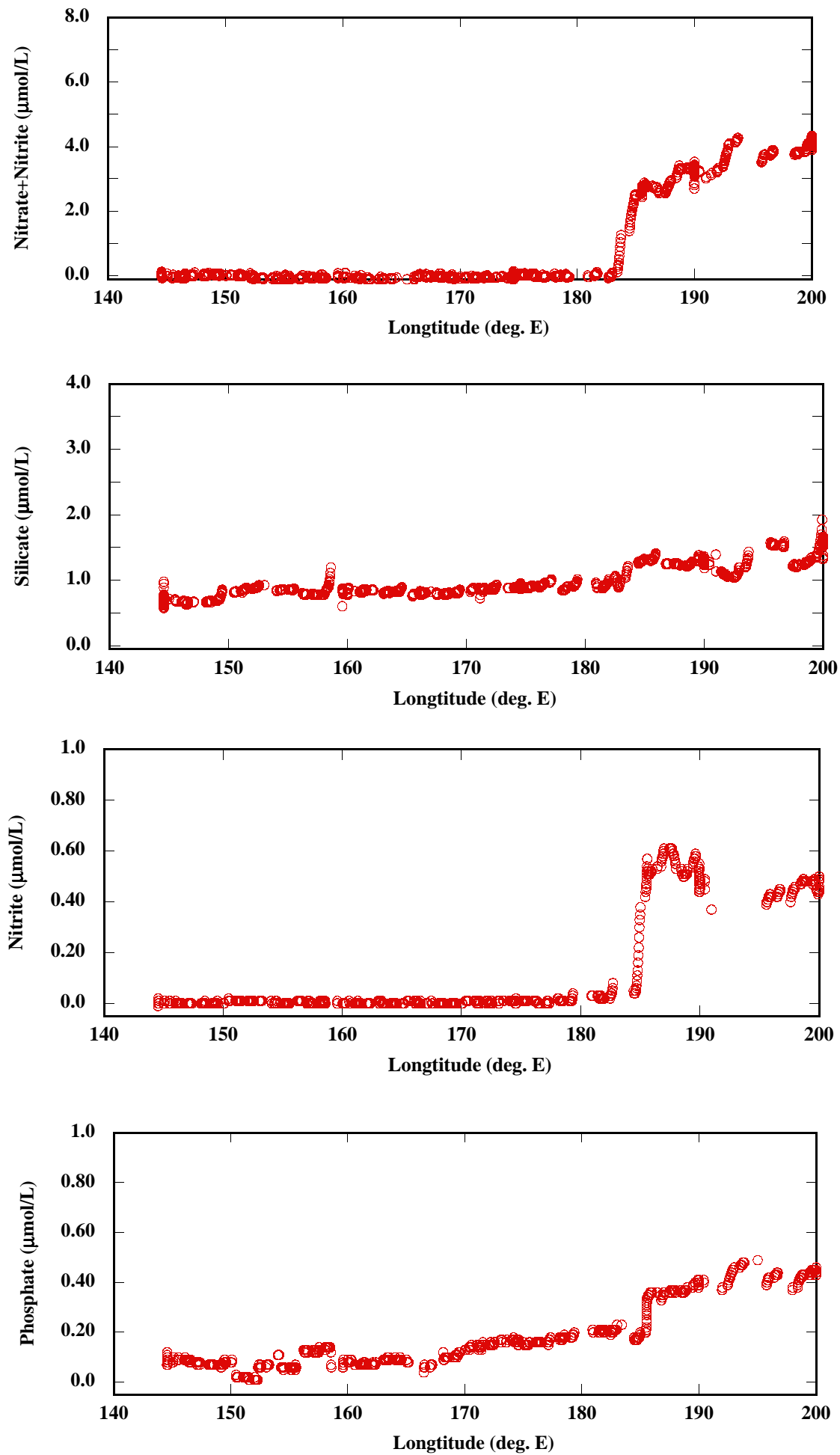


Figure 1 Seasurface nutrients concentration on the equator.

### **3.7 Horizontal distribution of diatoms in an equatorial transect in the central and western Pacific**

Itsuro Ono and Naomi Nagai (Kyushu University)

Diatoms are one of the major primary producers, and are well known as environmental indicators for temperature and nutrients. In the central and western equatorial Pacific, the oceanographic conditions change every few years depending on the situation such as El Niño and La Niña. Little is known about distribution pattern of diatoms in the area. The purpose of this study is to investigate diatoms distribution in the surface waters in the central and western equatorial Pacific. This study will be helpful to us when we understand sedimentation and particle flux, which are indispensable for analyzing past and present climate signals

Two liters of surface water samples were collected using a shipboard pump. Then the samples were filtered using Gelman<sup>®</sup> membrane filters (diameter: 25 mm, pore size: 0.45 μm). Their sampling locations are located every 1° between 145°E and 160°W along the Equator and Station 3, 6, 9, 12 and 14 are collected two samples, one in the morning and the other in the evening. The filtered samples are will be analyzed at the Kyushu University.

### **3.8 Relationship between Cd and phosphate in the western equatorial Pacific**

Kazuo Abe

Ishigaki Tropical Station, Seikai National Fisheries Research Institute

#### **Objective**

The distribution of Cd in the ocean is strongly correlated with the behavior of phosphate, which indicates that the behavior of Cd in seawater is regulated by marine biogeochemical processes, namely uptake by phytoplankton in surface waters, consequential decomposition of the produced organic matter and remineralization in deep waters. Generally, the plot of dissolved Cd against phosphate shows a good linearity and the slope varies from basin to basin. These variations of the relationship in the Cd-phosphate plots in the world oceans are considered to be caused by multiple factors that affect the distributional patterns in each oceans, namely biogeochemical processes, biomass composition, preformed concentrations, atmospheric deposition, benthic input or hydrographical conditions. The main purpose of this study in this cruise is to investigate the distributional features of Cd and to examine the relationship between Cd and phosphate in the equatorial Pacific Ocean.

#### **Methods**

Water samples were vertically collected at 4 stations using rosetto-mounted 30 l and 10 l Niskin bottles. The water samples for dissolved Cd were transferred to acid-cleaned polyethylene bottles and kept in a freezer until analysis. Cd in samples filtered through 0.4  $\mu$ m Nuclepore filter will be concentrated by the modified APDC co-precipitation of Boyle and Edmond (1977) in a clean ventilation system. The determination of Cd will be carried out by flameless-AAS (Atomic Absorption Spectrophotometer).

### **3.9 $^{234}\text{Th}/^{238}\text{U}$ and $^{210}\text{Po}/^{210}\text{Pb}$ Disequilibria as indicators of removal rates and particulate organic carbon fluxes in the western and central equatorial Pacific**

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These nuclides, thorium-234( $t_{1/2} = 24.1$  day), lead-210( $t_{1/2} = 22.3$  yr) and polonium-210( $t_{1/2} = 138$  days) in seawater, are especially useful for studies on material transport scavenging processes within relatively short times and on the mechanism of material transport from the surface ocean, because they are highly reactive to particulate matter and its rapid removal from the water column. The aim of this study is to investigate the removal rates of these radionuclides from the water column in the equatorial Pacific through understanding of the distributions of radionuclides in seawater and particle matter. And, the goal of this study is to clarify the material transport and the implications for POC export in the equatorial Pacific.

The study of the disequilibria of lead-210 and polonium-210 in seawater can be used to observe relatively short term oceanic particle flux processes. The seawater samples were collected at Stns. 6, 9, 12 and 14 with the CTD/RMS. The collected samples will be analyzed for activities of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  by an alpha spectrometry in the laboratory.

Thorium-234 produced by decay of uranium-238 in seawater, has been used to studies on removal rates and transport processes of marine particles. The seawater samples were collected at Stns. 6, 9, 12 and 14 using the CTD/RMS. The collected samples have been analyzed for  $^{234}\text{Th}$  activity at sea and for POC in the laboratory.

The settling particles were collected using a combined drifting trap. The trap array was deployed at the depth of 210m at Stns. 6, 9, 12 and 14. Upon recovery of the sediment traps, the sample bottles were stored under refrigeration. The collected samples have been analyzed for radioactivity of  $^{234}\text{Th}$  and POC in the laboratory.



### **3.10 Spatial variations in the concentrations of transparent exopolymer particles (TEP) in equatorial Pacific and implications in the vertical organic matter flux**

Neelam RAMAIAH and Ken FURUYA

Faculty of Agricultural and Life Sciences, The University of Tokyo.

#### **Objective:**

Transparent exopolymer particles formed largely from the phytoplankton exudates, have substantial implications for the understanding of the vertical carbon flux in marine ecosystems, as TEP may be a direct sink for the carbon acquired by phytoplankton during photosynthesis. Information on the ambient concentrations of TEP in relation to the phytoplankton biomass is thus a necessity in understanding the spatial/seasonal dynamics of TEP. Objective of the present study was to repeat the sampling in the equatorial Pacific to compare the variations if any in TEP concentrations obtained during our previous study (MR98-K02) and infer the factors responsible for the variations. On-board incubation experiments that would provide an insight into the production/utilization of TEP by bacteria also formed a part of this investigation.

#### **Materials & Methods:**

Ambient concentrations of TEP: Sampling was conducted from 12 stations (Stns. 14 to 3) located along the equator between 160°W and 147°E during the MR02-K01 cruise onboard R/V Mirai. Samples for TEP concentrations and bacterial counts (total and TEP attached), were obtained from the CTD casts collected from 13 depths in the upper 200 m water column at all stations, and from several depths upto 5000 m depth at Stn. 14. TEP concentrations were estimated by the colorimetric alcian blue method of Passow & Alldredge (1995) and expressed as Xanthan equivalents. Most of the TEP samples were analyzed on-board. Glutaraldehyde preserved, refrigerated samples for bacterial counts were carried back to the laboratory. Total and TEP attached bacterial numbers will be estimated by observing the double stained filters (with DAPI and alcian blue) under epifluorescence and light microscope.

Experimental approach: On-board incubation experiments were conducted at two stations. Samples obtained by CTD casts from the aphotic zone (300 m) and collected in 4 L Nalgene

bottles (in duplicate), were incubated in the dark at ambient temperature for 3 days. Control bottle was incubated as such, while antibiotics (a combination of Nalidixic acid, Chloramphenicol and Ampicillin) were added to the experimental bottle to arrest the bacterial activity and growth. Subsamples were obtained at regular intervals (6 hrs during the first 48 hours and 12 hrs of the remaining time) for estimation of TEP concentrations and bacterial numbers. Respective initial values were also obtained.

**Expected results:**

Data on the spatial and vertical profiles of TEP in relation to the phytoplankton biomass obtained during this cruise will help us to compare the data with that of our previous results during the MR98-K02 cruise and infer the factors responsible if any, for the variations. Results of the experiment will help elucidate the role of bacteria in the production and utilization of TEP and understand whether TEP in the deeper layers of the ocean are that which sink out of the euphotic zone or, the ones produced by bacteria in the aphotic zone.

### 3.11 Atmospheric and oceanic CO<sub>2</sub> measurements

#### (1) Personnel

Shu Saito\*, Takayuki Tokieda\*, Masao Ishii, and Hisayuki Y. Inoue  
Geochemical Research Department, Meteorological Research Institute,  
Nagamine 1-1, Tsukuba, Ibaraki 305-0052, Japan

\* on board personnel

#### (2) Objectives

Carbon dioxide (CO<sub>2</sub>), known as a major greenhouse gas, has been increasing in the atmosphere due to the anthropogenic emission. Its current concentration is approximately 30% higher than that in the preindustrial era (280 ppm). In order to predict the future atmospheric CO<sub>2</sub> increase and the potential alteration of the carbon cycle as a result of the climate change, it is fundamental to understand the processes that are controlling the fluxes and their temporal variability among the global carbon reservoirs; the atmosphere, the terrestrial biosphere and the ocean.

The eastern and the central equatorial Pacific is known to act as a significant source of the CO<sub>2</sub> to the atmosphere due primarily to the equatorial upwelling that brings subsurface CO<sub>2</sub>-rich water into the mixed layer. Biological activities in the euphotic zone are also considered to be important processes that determine the content of CO<sub>2</sub> in the mixed layer. The western equatorial Pacific, where warm and less saline water prevails in the surface layer, also occasionally exhibits a large CO<sub>2</sub> emission from the sea to the atmosphere. Flux of CO<sub>2</sub> from the equatorial Pacific has been reported to show a significant interannual variability that is associated with the ENSO event. However, the temporal and spatial variation in the whole CO<sub>2</sub> system in seawater has not been well documented and the controlling processes that determine the variation have not been quantitatively clarified.

In this cruise, we made concurrent underway measurements of CO<sub>2</sub> concentration in the atmosphere and in an air equilibrated with surface seawater, total inorganic carbon (TCO<sub>2</sub>) and total hydrogen ion concentration index (pH<sub>T</sub>) in surface seawater. We also measured TCO<sub>2</sub>, pH<sub>T</sub> and inorganic <sup>13</sup>C in water columns at each hydrographic station. The purpose of these observations and collection of samples is to describe the air-sea CO<sub>2</sub> flux and the oceanic CO<sub>2</sub> system in the central and western equatorial Pacific.

#### (3) Parameters

(a) CO<sub>2</sub> concentration (xCO<sub>2</sub>) in marine boundary air and in the air equilibrated with

surface seawater.

- (b) Total inorganic carbon (TCO<sub>2</sub>) in surface seawater
- (c) pH<sub>T</sub> (total hydrogen ion scale) in surface seawater
- (d) Total inorganic carbon (TCO<sub>2</sub>) in the water columns
- (e) pH<sub>T</sub> (total hydrogen ion scale) in the water columns
- (f) Isotopic ratio of <sup>13</sup>C/<sup>12</sup>C in dissolved inorganic carbon in the water columns

#### (4) Methods

(a) Underway measurements of CO<sub>2</sub> concentration in marine boundary air and in the air equilibrated with surface seawater:

We made measurements of the CO<sub>2</sub> concentration (mole fraction of CO<sub>2</sub> in air; xCO<sub>2</sub>) in marine boundary air twice every 1.5 hour and that in the air equilibrated with the large excess of surface seawater four times every 1.5 hour during the whole cruise using the automated CO<sub>2</sub> measuring system (Nippon ANS Co.). Marine boundary air was taken continuously from the foremast. Seawater was taken continuously from the seachest located ca.5 m below the sea level and introduced into the MRI-shower-type equilibrator. Non-dispersive infrared (NDIR) gas analyzer (BINOS 4) was used as a detector. It was calibrated with four CO<sub>2</sub> reference gases (299ppm, 351ppm, 398ppm, 450ppm in air, Nippon Sanso Co.) once every 1.5 hour. Concentration of CO<sub>2</sub> will be published on the basis of the WMO X85 mole fraction scale after the cruise. Corrections for the temperature-rise from the seachest to the equilibrator and the drift of CO<sub>2</sub> concentration in reference gases are also to be made. Partial pressure of CO<sub>2</sub> will be calculated from xCO<sub>2</sub> by taking the water vapor pressure and the atmospheric pressure into account.

(b) Underway measurement of total inorganic carbon (TCO<sub>2</sub>) in surface seawater:

We made underway measurement of TCO<sub>2</sub> in surface seawater using the automated TCO<sub>2</sub> analyzer (Nippon ANS Co.) equipped with carbon coulometer 5012 (UIC Co.). Seawater was taken continuously from the seachest and a portion of the seawater (ca. 22 cm<sup>3</sup>) was introduced into the water-jacketed pipette of the analyzer twice every 1.5 hour for the analysis. TCO<sub>2</sub> in the reference seawater prepared in MRI that is traceable to the CRM provided by Dr. A. Dickson in Scripps Institution of Oceanography was also analyzed at least once every run of the coulometric cathode-and anode-solution.

(c) Underway measurement of pH<sub>T</sub> (total hydrogen ion scale) in surface seawater

We made underway measurement of pH<sub>T</sub> in surface seawater using the automated pH<sub>T</sub> analyzer (Nippon ANS Co.) equipped with UV/VIS spectrophotometer

Cary 50 (Varian Instruments Co.). The method is spectrophotometry of m-cresol purple indicator dye in the sample. Seawater was taken continuously from the seachest and a portion of the seawater (ca. 13 cm<sup>3</sup>) was introduced into the sample loop of the analyzer twice every 1.5 hour for the analysis. The sample loop includes water-jacketed quartz flow cell whose light path length is 8 cm. Small portion of m-cresol purple indicator dye solution (0.042 cm<sup>3</sup>) was measured in a dye loop and then mixed with seawater by circulating about 11 times in the sample loop. After regulating sample temperature to 25.0 deg-C, absorbance of indicator dye in the sample seawater was measured at 4 wavelengths 730, 578, 488 and 434 nm. The dye concentration in the sample was 6.5 µmol/kg. pH<sub>T</sub> perturbation induced by dye addition is to be corrected.

(d)(e)(f) Measurement of TCO<sub>2</sub>, pH<sub>T</sub> (total hydrogen ion scale) and inorganic <sup>13</sup>C in the water column:

Discrete samples for TCO<sub>2</sub>, pH<sub>T</sub> and inorganic <sup>13</sup>C were taken from Niskin bottles on CTD/carousel sampler at the total of 12 hydrographic stations:

Stn.14 (shallow cast 2 and deep cast),

Stn.13 (shallow cast 4),

Stn.12 (shallow cast 2)

Stn.11 (shallow cast 4-2),

Stn.10 (shallow cast 4-2),

Stn. 9 (shallow cast 2),

Stn. 8 (shallow cast 4-2),

Stn. 7 (shallow cast 4-2),

Stn. 6 (shallow cast 2),

Stn. 5 (shallow cast 4-2),

Stn. 4 (shallow cast 4-2),

Stn. 3 (shallow cast 4-2)

Samples were collected in 250cm<sup>3</sup> borosilicate glass bottles (Sibata or Iwaki) with ground-glass stopcock lubricated with Apiezon L grease, and were poisoned with 0.2 cm<sup>3</sup> of saturated HgCl<sub>2</sub> solution. Duplicate samples were routinely taken from surface water.

Samples for TCO<sub>2</sub> and dissolved inorganic <sup>13</sup>C will be analyzed at the laboratory in our institute.

We made measurement of pH<sub>T</sub> in discrete samples by automated pH<sub>T</sub> analyzer that is described in section (c). When we measure bottle samples during steaming, we inserted measurements of on-line sample (surface seawater) once every 45 minutes. The reference seawaters for TCO<sub>2</sub> measurement were measured at the beginning and the end

of a series of measurements at a station, expecting that the  $\text{pH}_T$  of the reference seawater is sufficiently stable for months. Samples from “shallow cast” and those from “deep cast” were analyzed within 7 h and 10 h after the CTD/carousel arrived on deck, respectively. Corrections for the addition of  $\text{HgCl}_2$  solution and m-cresol purple solution are to be made.

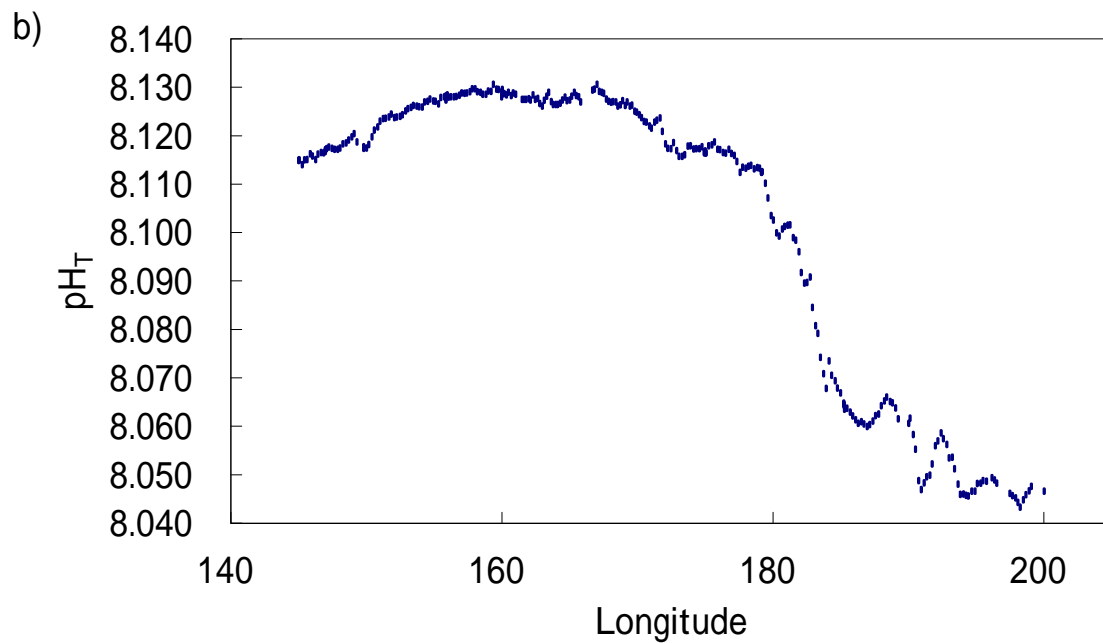
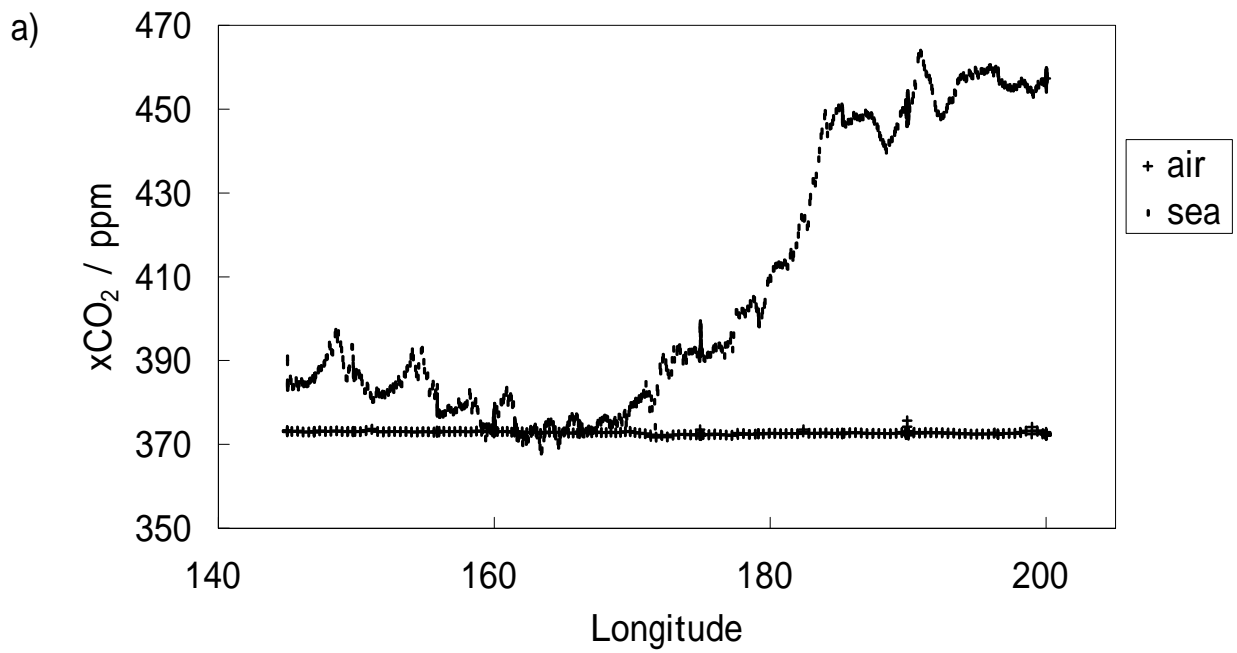
#### (5) Results

Figure shows the preliminary result of a)  $x\text{CO}_2$  and b)  $\text{pH}_T$  in surface seawater along the equator. The distributions of both  $x\text{CO}_2$  and  $\text{pH}_T$  in surface seawater showed clear boundary near  $180^\circ$  indicating the eastend of the western Pacific warm water. Detailed analysis will be made after some corrections.

Samples for  $\text{TCO}_2$  and dissolved inorganic  $^{13}\text{C}$  in the water column will be analyzed at the laboratory of our institute.

#### (6) Data archive

The original data will be archived at Geochemical Research Department, Meteorological Research Institute. Data will be also submitted to Data Management Office at JAMSTEC within 3 years.



Horizontal distributions of  $\text{CO}_2$  system parameters along the equator  
 a)  $x\text{CO}_2$  in marine boundary air and in the air equilibrated with surface seawater, b)  $\text{pH}_T$  in surface seawater

### 3.12 Chlorofluorocarbons in sea water at the equatorial area

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Meteorological Research Institute,  
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#### 1. Objectives

Anthropogenic Chlorofluorocarbons (CFCs) cross the air-sea interface and dissolve in surface seawater. At equilibrium, the concentration of dissolved CFCs in surface seawater is a function of the temperature and salinity of the water (Warner and Weiss 1985) and of the air mixing ratio in the overlying atmosphere. The equilibrium CFCs concentrations in surface mixed layer can be reconstructed as a function of time and position. As these dissolved compounds are carried from the surface into the interior of the ocean, the resulting distributions can be used to trace ocean mixing and circulation pathways. In this cruise, we made measurements of three CFCs (CFC-11, CFC-12 and CFC-113) in seawaters in the central and western equatorial Pacific.

#### 2. Methods

Water samples for CFCs measurements were taken from Niskin bottles on RMS and a bucket at each station by using the glass syringes to avoid the contact with air. Seawater samples for the CFCs measurement were collected at 12 stations.

The concentrations of CFCs were determined on board the vessel with a gas-chromatography equipped with an electron capture detector (SHIMADZU GC-8A). The purging and trapping system of CFCs was similar to that of Bullister and Weiss (1988). The CFCs concentrations were calibrated against the MRI calibration scale.

#### 3. Reference

- M. J. Warner and R. F. Weiss, Solubilities of chlorofluorocarbons 11 and 12 in water and seawater. *Deep-Sea Res.*, **32**, 1485-1497 (1985)
- J. L. Bullister and R. F. Weiss, Determination of  $\text{CClF}_3$  and  $\text{CCl}_2\text{F}_2$  in seawater and air. *Deep-Sea Res.*, **35**, 839-853 (1988)



### 3.13 Pb-210, Po-210 and Be-7 in the marine aerosol

Takayuki TOKIEDA

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Meteorological Research Institute,

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#### 1. Objectives

A pair of two radon daughters, Pb-210 (half-life 22.3 years) and Po-210 (138 days) have been used as a tracer for atmospheric aerosols. Because the ratio of Po-210 to Pb-210 increases with time, the ratio has been used to determine the mean atmospheric residence times of aerosols since 1960s. Tokieda et al. (1996) suggested that the ratio of Bi-210 to Pb-210 is better for estimation of the mean residence time rather than its of Po-210 and that the Po-210 ratio represents the degree of change for continental air mass. In this study, a cosmogenic nuclide, Be-7 will be measured to get some information of the mixing with aerosols derived from upper atmosphere and to characterize the marine aerosols.

#### 2. Sampling

Marine air samples were collected with a high-volume air sampler (SHIBATA HIGH VOLUME AIR SAMPLER MODEL HVC-1000N). The sampler was set on the compass deck of R/V MIRAI. The filter paper (Whatman 41) to collect aerosols was replaced once a day at usually 10 o'clock (JST) and 30 filter samples were gotten.

The analysis of Pb-210, Po-210 and Be-7 will be carried out on land laboratory.

#### 3. Reference

T. Tokieda, K. Yamanaka, K. Harada and S. Tsunogai, Seasonal variations of residence time and upper atmospheric contribution of aerosols studied with Pb-210, Bi-210, Po-210 and Be-7. *Tellus* **48**, 690-702 (1996)

### **3.14 Determination of carbonate (total dissolved inorganic carbon and alkalinity), sulfur hexafluoride (SF<sub>6</sub>) and nitrous oxide (N<sub>2</sub>O) in seawater at the equatorial area.**

Kiminori Shitashima, Masahiro Imamura and Michimasa Magi\*

Central Research Institute of Electric Power Industry

(\* indicates on board personnel)

#### **Objectives**

In the view of the problem of the global warming, it is important to know the concentration level of greenhouse effect gases in the ocean and the penetration rate of these gases through air-sea surface interface. Our purpose of this cruise is to collect the data of carbonate (total carbon dioxide and alkalinity), nitrous oxide (N<sub>2</sub>O) and sulfur hexafluoride (SF<sub>6</sub>) at the equatorial Pacific. We will make clear the penetration and return processes of anthropogenic carbon dioxide in this area using the SF<sub>6</sub> data as a tracer.

#### **Parameters**

Oceanic parameters for vertical profile; alkalinity, total carbon dioxide (TCO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O) and sulfur hexafluoride (SF<sub>6</sub>)

#### **Description of Methods**

##### **Total Alkalinity (At)**

Total Alkalinity samples were collected in 250 mL polyethylene bottles with inner caps from Niskin sampler and capped after an overflow of about 150 mL of seawater. Samples were transferred into a glass titration cell using a 50 mL transfer pipette and titrated at 20° C ± 0.1° C with 1M HCl containing 0.6M NaCl within 10 minutes. The electric potential and temperature of the sample were followed with an Ag/AgCl combined electrode (Radiometer Analytical A/S, GK2401C) and a temperature sensor (Radiometer Analytical A/S, T901) connected to the Titra Lab system (Radiometer Analytical A/S). The titration was controlled automatically and the titration curve was analyzed with the inflection point titration method by the system. The precision of the method was determined to be ± 0.61 μmol/l (n=8) from replicate analysis of the Certified Reference Solutions (CRMs (batch 44) supplied by Dr. Andrew Dickson of Scripps Institution of Oceanography (SIO)). Standardization of the titrant (0.1M HCl) was accomplished with Na<sub>2</sub>C<sub>3</sub> (99.99% pure; AsahiGrass) standards.

### Total dissolved inorganic carbon (TCO<sub>2</sub>)

The TCO<sub>2</sub> concentration in seawater samples was determined by using the coulometric titration system (UIC Inc., Carbon Coulometer model 5011). Samples for TCO<sub>2</sub> analysis were drawn from the Niskin sampler into 125 mL glass vial bottles after an overflow of about 100 mL of the seawater. The samples were immediately poisoned with 50 µl of 50% saturated HgCl<sub>2</sub> in order to restrict biological alteration prior to sealing the bottles. All samples were stored at room temperature after sampling and analyzed within a few hours. Seawater was introduced manually into the thermo stated (20° C ± 0.1° C) measuring pipette with a volume of ~30 mL by a pressurized headspace CO<sub>2</sub>-free air that had been passed through the KOH scrubber. The measured volume was then transferred to the extraction vessel. The seawater sample in the extraction vessel was acidified with 1.5 mL of 3.8% phosphoric acid and the CO<sub>2</sub> was extracted from the sample for 5 minutes by bubbling with the CO<sub>2</sub>-free air. After passing through the Ag<sub>2</sub>SO<sub>4</sub> scrubber, polywool and Mg(ClO<sub>4</sub>)<sub>2</sub> scrubber to remove sea salts and water vapor, the evolved CO<sub>2</sub> gas was continuously induced to the coulometric titration cell by the stream of the CO<sub>2</sub>-free air. All reagents were renewed every day. The TCO<sub>2</sub> concentration in seawater was calculated using a calibration curve constructed by measuring six different concentrations (0, 500, 1000, 1500, 2000 and 2500 µM) of dissolved Na<sub>2</sub>CO<sub>3</sub> (99.99% pure; Asahi Grass) used as a standard solutions. The precision of the TCO<sub>2</sub> measurements was tested by analysis of the CRMs (batch 44) at the beginning of the measurement of samples every day. Our shipboard measurements yielded a mean value of 2030.90 ± 0.97 µmol/kg (n=6), which compares with 2030.66 ± 0.60 µmol/kg (n=11) certified by SIO. We also prepared and analyzed sub-standards that were bottled into 125 mL glass vial bottles from a 20L bottle of filtered and poisoned offshore surface water in order to check the condition of the system and the stability of measurements every day. The resulting standard deviation from replicate analysis of 8 sub-standards was ± 1.00 µmol/l.

### Nitrous Oxide (N<sub>2</sub>O)

Samples for N<sub>2</sub>O analysis were drawn from the Niskin sampler into 125 mL glass vial bottles after an overflow of about 100 mL of the seawater. The samples were immediately poisoned with 50 µl of 50% saturated HgCl<sub>2</sub> in order to restrict biological alteration prior to sealing the bottles. All samples were stored in a refrigerator before measurement, and were analyzed within 12 hours of collection. The concentration of N<sub>2</sub>O in seawater was determined using the Shimadzu GC14B gas chromatograph (carrier gas; pure N<sub>2</sub> gas 40-50 mL/min., column: Molecular Sieve 5A 60/80 2m x 3ø)

with  $^{63}\text{Ni}$  electron capture detector on board. A purge-and-trap method and a headspace method were employed to concentrate  $\text{N}_2\text{O}$  from seawater.

#### § Purge-and-trap method

Seawater was introduced into a measuring pipette with a volume of 100 mL by a pressurized headspace pure  $\text{N}_2$  gas (99.9998%). The measured volume was then transferred to the extraction vessel and  $\text{N}_2\text{O}$  was extracted from the sample for 10 minutes by bubbling with the pure  $\text{N}_2$  gas (flow rate: 100 mL/min). After passing through the calcium chloride scrubber to remove water vapor, the evolved  $\text{N}_2\text{O}$  gas was continuously induced to the Porapak Q (80-100  $\mu\text{m}$ , 0.21 m) column and trapped onto the cooled ( $-80^\circ\text{C}$ ) column. After bubbling for 10 minutes, the column was heated at  $120^\circ\text{C}$  to desorb the  $\text{N}_2\text{O}$  by the stream of the carrier gas (pure  $\text{N}_2$ ) and the desorbed  $\text{N}_2\text{O}$  was introduced to the gas chromatograph.

#### § Headspace method

About 15 mL of headspace gas ( $\text{N}_2$ ) was introduced into a glass vial bottle by removing seawater with syringe. Subsequently, the bottle was stood in thermo stated water bath ( $40 \pm 0.5^\circ\text{C}$ ) for 3 hours in order to make an equilibration between gas phase and liquid phase. The  $\text{N}_2\text{O}$  was taken from the headspace gas into a gas tight syringe and injected to the gas chromatograph.

#### Sulfur hexafluoride ( $\text{SF}_6$ )

A sample for  $\text{SF}_6$  analysis was drawn from the Niskin sampler into 500 mL SCOTT DURAN glass bottle after an overflow of about 250 mL of the seawater. The bottle was sealed tightly and stored in a refrigerator before measurement. Samples were analyzed on board or land laboratory.  $\text{SF}_6$  in seawater was concentrated by using a purge-and-trap method and determined by the HP 5890 series II gas chromatograph (column: RESTEK Molecular Sieve 5A (80-100  $\mu\text{m}$ ) 30 m x 0.53 mm) with non-radioactive electron capture detector (VICI, Pulsed discharge Detector (ECD mode)). Seawater was introduced into a measuring pipette with a volume of 480 mL by a pressurized headspace  $\text{SF}_6$ -free  $\text{N}_2$  gas. The measured volume was then transferred to the extraction vessel and  $\text{SF}_6$  was extracted from the sample for 5 minutes by bubbling with the  $\text{SF}_6$ -free  $\text{N}_2$  gas (flow rate: 350 mL/min). After passing through the calcium chloride scrubber to remove water vapor, the evolved  $\text{SF}_6$  gas was continuously induced to the Porapak Q (80-100  $\mu\text{m}$ ) column and trapped onto the cooled ( $-80^\circ\text{C}$ ) column. After bubbling for 5 minutes, the column was heated at  $80^\circ\text{C}$  to desorb the  $\text{SF}_6$  by the stream of the carrier gas ( $\text{SF}_6$ -free pure  $\text{N}_2$ ) and the desorbed  $\text{SF}_6$  was introduced to the gas chromatograph.

### **3.15 Study on the biogeography of the coccolithophorid in the Western and Central Equatorial Pacific**

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#### **Introduction**

Coccolithophorids are one of the important primary producers in the tropical warm ocean. Due to the production of extra cellular calcium carbonate scales (coccoliths), coccolithophorids contribute to the export flux of calcium carbonate from the sea surface to the sea floor. The topography and surface water circulation control the standing crop and the floral composition of coccolithophorids. Surface currents of the Equatorial Pacific Ocean is characterized by the westward North and South Equatorial Currents and the eastward Equatorial Counter Current. Strength of the westward transportation and the oceanographic setting are controlled by Asian Monsoon and El Nino and the Southern Oscillations (ENSO). Strength of stratification is different between the Eastern and Western Equatorial Pacific Ocean. In the El Nino phase of ENSO, westward surface transportation is weakened, and the warm surface waters that piled up in the western Pacific during the Normal and La Nina phase flow back to the east. As a result, Central and Eastern Equatorial Pacific get stratified as well as Western Equatorial Pacific. Several researchers have studied Coccolithophorids in the Equatorial Pacific Ocean; however, effect of environmental changes caused by ENSO on the coccolithophorid flora has not been revealed, yet. In this study, we will try to clarify the environmental control on the primary production and floral composition of coccolithophorid assemblages.

#### **Material and Methods**

For the study of the standing crop and floral composition of the coccolithophorid assemblages, surface water samples were taken during the cruises from Japan to the site 14 and from the site3 to Japan by using a water pump(Table 1). Subsurface water samples were collected in the 12 stations by using Niskin bottles (Table 2). Immediately after sampling, 8 liter of water samples were filtered onto Millipore filter with a pore size of 0.45 $\mu$ m. Filters were then air- dried by the automatic desicator.

In the laboratory, the absolute abundance and floral composition of coccolithophorid assemblage will be studied under a cross-polarized light microscope and SEM, respectively.

Table 1. Locations of samples and sampling data on the surface waters

Sample No.	Date	Time (LST)	Time (UTC)	Latitude	Longitude	Salinity (%)	Temperature ( )	Water (l)
1	8 Jan. 2002	9:35	0:35	36-27.92560N	145-44.33490E			8
2	8 Jan. 2002	20:05	11:05	36-65.34680N	148-00.72790E			8
3	9 Jan. 2002	9:49	23:49	33-19.37700N	150-25.01800E	34.672	19.633	8
4	9 Jan. 2002	19:31	9:31	33-10.65490N	153-15.20180E	34.646	18.915	8
5	10 Jan. 2002	9:35	23:35	33-00.25270N	157-32.40240E		19.278	8
6	10 Jan. 2002	19:40	9:40	32-48.18530N	160-30.41680E	34.398	16.727	8
7	11 Jan. 2002	9:35	22:35	32-22.29230N	164-06.05800E	34.680	19.206	8
8	11 Jan. 2002	19:35	8:35	32-00.84870N	167-00.72070E	34.615	18.804	8
9	12 Jan. 2002	9:40	22:40	32-37.84440N	170-01.69430E	34.620	19.289	8
10	12 Jan. 2002	19:49	8:49	31-11.35420N	172-49.29070E	34.742	19.505	8
11	13 Jan. 2002 (A)	9:42	21:42	30-33.99530N	176-40.39260E	34.975	20.177	8
12	13 Jan. 2002 (A)	19:39	7:39	30-05.35990N	179-28.25490E	34.959	19.661	8
13	13 Jan. 2002 (B)	9:32	21:32	29-09.70490N	177-09.28730W	34.967	20.197	8
14	13 Jan. 2002 (B)	19:38	7:38	28-27.45880N	174-44.89760W	35.214	21.674	8
15	14 Jan. 2002	9:36	20:36	27-33.24500N	171-44.54730W	35.096	21.087	8
16	14 Jan. 2002	19:40	6:40	26-49.47070N	169-31.28110W	35.017	21.659	8
17	15 Jan. 2002	9:35	20:35	25-36.05240N	166-38.70150W	35.363	23.107	8
18	15 Jan. 2002	19:36	6:36	24-40.95230N	164-32.49280W	35.436	23.519	8
19	16 Jan. 2002	9:35	19:35	22-28.38440N	162-57.32770W	35.397	23.908	8
20	16 Jan. 2002	19:38	5:38	21-31.13970N	161-09.10690W	35.294	24.705	8
21	17 Jan. 2002	9:31	19:31	21-11.04200N	158-23.37430W	35.133	25.263	8
22	19 Jan. 2002	18:24	4:24	19-35.14770N	158-04.03620W	34.735	24.902	8
23	20 Jan. 2002	8:33	19:33	15-43.15650W	158-27.79280W	34.807	25.184	8
24	20 Jan. 2002	19:30	6:30	12-54.44530N	158-44.30700W	34.344	26.150	8
25	21 Jan. 2002	8:34	18:34	09-40.31130N	159-03.79100W	34.400	27.302	8
26	21 Jan. 2002	19:35	6:35	06-54.65760N	159-19.58100W	34.591	27.972	8
27	22 Jan. 2002	8:35	19:35	03-46.57180N	159-38.20470W	35.311	27.473	8
28	22 Jan. 2002	19:37	6:37	01-06.20660N	159-53.61970W	35.362	27.836	8
29	24 Jan. 2002	8:32	19:32	00-00.03600S	162-34.67560W	35.428	27.927	8
30	24 Jan. 2002	19:47	6:47	00-00.20680S	165-06.92160W	35.478	28.031	8
31	25 Jan. 2002	8:42	19:42	00-00.12610S	168-42.64900W	35.478	28.204	8
32	27 Jan. 2002	8:30	19:30	00-00.14480S	174-07.74820W	35.384	28.669	8
33	27 Jan. 2002	19:44	6:44	00-00.00330N	176-28.10720W	35.367	29.072	8
34	29 Jan. 2002	8:32	20:32	00-00.02930N	179-44.94540E	35.197	29.583	8
35	29 Jan. 2002	19:39	7:39	00-00.09980N	177-17.60430E	34.815	29.821	8
36	31 Jan. 2002	8:28	20:28	00-04.87100S	172-47.75490E	34.629	29.532	8
37	31 Jan. 2002	19:44	7:44	00-00.19240N	169-52.88300E	34.422	29.622	8
38	1 Feb. 2002	8:26	21:26	00-00.29430N	166-43.49270E	34.240	29.654	8
39	1 Feb. 2002	19:41	8:41	00-00.16880S	164-51.90150E	34.217	29.541	8
40	2 Feb. 2002	7:33	20:33	00-00.14560N	162-12.16580E	34.201	29.531	8
41	2 Feb. 2002	19:46	8:46	00-00.06960S	160-00.57660E	34.178	29.882	8
42	4 Feb. 2002	7:39	20:39	00-01.25480N	156-32.21920E	34.292	29.819	8
43	4 Feb. 2002	19:32	8:32	00-00.16540N	154-13.93310E	34.288	30.401	8
44	5 Feb. 2002	7:39	21:39	00-00.00400N	150-38.17210E	34.393	29.623	8
45	5 Feb. 2002	19:45	9:45	00-00.06570N	148-03.00260E	34.407	30.036	8
46	6 Feb. 2002	7:37	21:37	00-00.06090S	145-40.11330E	34.432	29.294	8
47	6 Feb. 2002	19:28	9:28	01-17.08600N	144-58.40750E	34.554	29.726	8
48	7 Feb. 2002	7:46	21:46	03-56.5110N	144-54.786E	34.351	29.344	8
49	7 Feb. 2002	20:59	10:59	06-34.02970N	144-48.05260E	34.287	28.588	8
50	8 Feb. 2002	7:40	21:40	08-48.02110N	144-47.34060E	34.095	28.232	8
51	10 Feb. 2002	19:43	9:43	15-54.98650N	144-24.43720E	34.619	27.799	8
52	11 Feb. 2002	7:43	22:43	19-24.39110N	144-09.02780E	34.994	26.005	8
53	11 Feb. 2002	19:31	10:31	22-18.72380N	143-55.98270E	35.038	24.781	8
54	12 Feb. 2002	7:35	22:35	25-07.47610N	143-43.03880E	35.021	24.059	8
55	12 Feb. 2002	19:32	10:32	27-45.61150N	143-30.36370E	34.755	18.807	8
56	13 Feb. 2002	8:44	23:44	30-55.73340N	143-14.78660E	34.836	19.072	8
57	13 Feb. 2002	19:33	10:33	33-28.85070N	143-02.20320E	34.777	19.063	8
58	14 Feb. 2002	8:38	23:38	36-24.27170N	142-46.11900E	34.680	15.298	8

Table 2. Location of samples and sampling data

Sample no.	Station no.	Date	Depth (m)	Water (l)
STN-3-0	3	6 Feb. 2002	0	8
STN-3-20	3	6 Feb. 2002	20	8
STN-3-40	3	6 Feb. 2002	40	8
STN-3-60	3	6 Feb. 2002	60	8
STN-3-80	3	6 Feb. 2002	80	8
STN-3-100	3	6 Feb. 2002	100	8
STN-3-120	3	6 Feb. 2002	120	8
STN-3-140	3	6 Feb. 2002	140	8
STN-3-160	3	6 Feb. 2002	160	8
STN-3-180	3	6 Feb. 2002	180	8
STN-3-200	3	6 Feb. 2002	200	8
STN-3-Chl. Max	3	6 Feb. 2002	72	8
STN-4-0	4	5 Feb. 2002	0	8
STN-4-20	4	5 Feb. 2002	20	8
STN-4-40	4	5 Feb. 2002	40	8
STN-4-60	4	5 Feb. 2002	60	8
STN-4-80	4	5 Feb. 2002	80	8
STN-4-100	4	5 Feb. 2002	100	8
STN-4-120	4	5 Feb. 2002	120	8
STN-4-140	4	5 Feb. 2002	140	8
STN-4-160	4	5 Feb. 2002	160	8
STN-4-180	4	5 Feb. 2002	180	8
STN-4-200	4	5 Feb. 2002	200	8
STN-4-Chl. Max	4	5 Feb. 2002	90	8
STN-5-0	5	4 Feb. 2002	0	8
STN-5-20	5	4 Feb. 2002	20	8
STN-5-40	5	4 Feb. 2002	40	8
STN-5-60	5	4 Feb. 2002	60	8
STN-5-80	5	4 Feb. 2002	80	8
STN-5-100	5	4 Feb. 2002	100	8
STN-5-120	5	4 Feb. 2002	120	8
STN-5-140	5	4 Feb. 2002	140	8
STN-5-160	5	4 Feb. 2002	160	8
STN-5-180	5	4 Feb. 2002	180	8
STN-5-200	5	4 Feb. 2002	200	8
STN-5-Chl. Max	5	4 Feb. 2002	110	8
STN-6-0	6	3 Feb. 2002	0	8
STN-6-20	6	3 Feb. 2002	20	8
STN-6-40	6	3 Feb. 2002	40	8
STN-6-60	6	3 Feb. 2002	60	8
STN-6-80	6	3 Feb. 2002	80	8
STN-6-100	6	3 Feb. 2002	100	8
STN-6-120	6	3 Feb. 2002	120	8
STN-6-140	6	3 Feb. 2002	140	8
STN-6-160	6	3 Feb. 2002	160	8
STN-6-180	6	3 Feb. 2002	180	8
STN-6-200	6	3 Feb. 2002	200	8
STN-6-Chl. Max	6	3 Feb. 2002	90	8
STN-7-0	7	2 Feb. 2002	0	8
STN-7-20	7	2 Feb. 2002	20	8
STN-7-40	7	2 Feb. 2002	40	8
STN-7-60	7	2 Feb. 2002	60	8
STN-7-80	7	2 Feb. 2002	80	8
STN-7-100	7	2 Feb. 2002	100	8
STN-7-120	7	2 Feb. 2002	120	8
STN-7-140	7	2 Feb. 2002	140	8
STN-7-160	7	2 Feb. 2002	160	8
STN-7-180	7	2 Feb. 2002	180	8
STN-7-200	7	2 Feb. 2002	200	8
STN-7-Chl. Max	7	2 Feb. 2002	90	8



Table 2. continued

Sample no.	Station no.	Date	Depth (m)	Water (l)
STN-8-0	8	1 Feb. 2002	0	8
STN-8-20	8	1 Feb. 2002	20	8
STN-8-40	8	1 Feb. 2002	40	8
STN-8-60	8	1 Feb. 2002	60	8
STN-8-80	8	1 Feb. 2002	80	8
STN-8-100	8	1 Feb. 2002	100	8
STN-8-120	8	1 Feb. 2002	120	8
STN-8-140	8	1 Feb. 2002	140	8
STN-8-160	8	1 Feb. 2002	160	8
STN-8-180	8	1 Feb. 2002	180	8
STN-8-200	8	1 Feb. 2002	200	8
STN-8-Chl. Max	8	1 Feb. 2002	90	8
STN-9-0	9	30 Jan. 2002	0	8
STN-9-20	9	30 Jan. 2002	20	8
STN-9-40	9	30 Jan. 2002	40	8
STN-9-60	9	30 Jan. 2002	60	8
STN-9-80	9	30 Jan. 2002	80	8
STN-9-100	9	30 Jan. 2002	100	8
STN-9-120	9	30 Jan. 2002	120	8
STN-9-140	9	30 Jan. 2002	140	8
STN-9-160	9	30 Jan. 2002	160	8
STN-9-180	9	30 Jan. 2002	180	8
STN-9-200	9	30 Jan. 2002	200	8
STN-9-Chl. Max	9	30 Jan. 2002	50	8
STN-10-0	10	29 Jan. 2002	0	8
STN-10-20	10	29 Jan. 2002	20	8
STN-10-40	10	29 Jan. 2002	40	8
STN-10-60	10	29 Jan. 2002	60	8
STN-10-80	10	29 Jan. 2002	80	8
STN-10-100	10	29 Jan. 2002	100	8
STN-10-120	10	29 Jan. 2002	120	8
STN-10-140	10	29 Jan. 2002	140	8
STN-10-160	10	29 Jan. 2002	160	8
STN-10-180	10	29 Jan. 2002	180	8
STN-10-200	10	29 Jan. 2002	200	8
STN-10-Chl. Max	10	29 Jan. 2002	50	8
STN-11-0	11	27 Jan. 2002	0	8
STN-11-20	11	27 Jan. 2002	20	8
STN-11-40	11	27 Jan. 2002	40	8
STN-11-60	11	27 Jan. 2002	60	8
STN-11-80	11	27 Jan. 2002	80	8
STN-11-100	11	27 Jan. 2002	100	8
STN-11-120	11	27 Jan. 2002	120	8
STN-11-140	11	27 Jan. 2002	140	8
STN-11-160	11	27 Jan. 2002	160	8
STN-11-180	11	27 Jan. 2002	180	8
STN-11-200	11	27 Jan. 2002	200	8
STN-11-Chl. Max	11	27 Jan. 2002	50	8
STN-12-0	12	26 Jan. 2002	0	8
STN-12-20	12	26 Jan. 2002	20	8
STN-12-40	12	26 Jan. 2002	40	8
STN-12-60	12	26 Jan. 2002	60	8
STN-12-80	12	26 Jan. 2002	80	8
STN-12-100	12	26 Jan. 2002	100	8
STN-12-120	12	26 Jan. 2002	120	8
STN-12-140	12	26 Jan. 2002	140	8
STN-12-160	12	26 Jan. 2002	160	8
STN-12-180	12	26 Jan. 2002	180	8
STN-12-200	12	26 Jan. 2002	200	8
STN-12-Chl. Max	12	26 Jan. 2002	50	8

Table 2. continued

Sample no.	Station no.	Date	Depth (m)	Water (l)
STN-13-0	13	24 Jan. 2002	0	8
STN-13-10	13	24 Jan. 2002	10	8
STN-13-20	13	24 Jan. 2002	20	8
STN-13-30	13	24 Jan. 2002	30	8
STN-13-40	13	24 Jan. 2002	40	8
STN-13-50	13	24 Jan. 2002	50	6
STN-13-60	13	24 Jan. 2002	60	8
STN-13-80	13	24 Jan. 2002	80	8
STN-13-100	13	24 Jan. 2002	100	8
STN-13-150	13	24 Jan. 2002	150	8
STN-13-200	13	24 Jan. 2002	200	8
STN-14-0	14	23 Jan. 2002	0	8
STN-14-20	14	23 Jan. 2002	20	8
STN-14-40	14	23 Jan. 2002	40	8
STN-14-60	14	23 Jan. 2002	60	8
STN-14-80	14	23 Jan. 2002	80	8
STN-14-100	14	23 Jan. 2002	100	8
STN-14-120	14	23 Jan. 2002	120	8
STN-14-140	14	23 Jan. 2002	140	8
STN-14-160	14	23 Jan. 2002	160	8
STN-14-180	14	23 Jan. 2002	180	8
STN-14-200	14	23 Jan. 2002	200	8
STN-14-Chl. Max	14	23 Jan. 2002	60	8

### 3.16 Volatile organic compounds

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Volatile organic compounds (VOCs) produced in the marine environment are thought to play a key role in atmospheric reactions, particularly those involved in the global radiation budget and the destruction of tropospheric and stratospheric ozone. Volatile organic compounds, including halogens and halocarbons that are produced by marine algae and phytoplankton, may cause ozone depletion in the troposphere and stratosphere. The assessment of numerous naturally produced VOCs in the atmosphere and in seawater is considered to be important for the estimation of the seawater/atmosphere exchange of these gases in the ocean.

The water sample was collected in 40 ml brown colored glass bottle (I-CHEM Certified 200, Nalge Company) for the measurement of halocarbons. After overflow of more than 100 ml of water, 0.1 ml of  $\text{HgCl}_2$  was added to inhibit microbial activity, and the sample bottle was immediately sealed with a two layer septa (silicone/PTFE) with care to exclude air bubbles, and stored in the box (in the dark) and kept at 5 °C in refrigerator. Samples containing air bubbles were discarded. The final concentration of  $\text{HgCl}_2$  in sample bottles was about 180 mg/l. Analysis of VOCs will be done through selected ion monitoring using purge and trap-GC-MS in the lab. Distribution of halocarbon concentrations of the equatorial zone in the Pacific Ocean will be examined to evaluate this oceanic area as a natural halocarbon source.

\*Water sample

depth	St. 14	St. 13	St. 12	St. 11	St. 10	St. 9	St. 8	St. 7	St. 6	St. 5	St. 4	St. 3
0	○	○	○	○	○	○	○	○	○	○	○	○
10	○	○	○	○	○	○	○	○	○	○	○	
20	○	○	○	○	○	○	○	○	○			
30	○	○	○	○	○	○	○	○		○	○	○
40	○	○	○	○	○	○	○	○	○			○
50	○	○	○	○	○	○	○	○	○	○		○
60	○	○	○	○	○	○	○	○	○	○	○	○
70	○	○							○	○	○	○
80	○	○	○	○	○	○	○	○	○	○	○	○
90	○								○	○	○	○
100	○	○	○	○	○	○	○	○	○	○	○	○
110											○	○
120	○	○	○	○	○	○	○	○	○	○	○	
130											○	○
150	○		○	○	○	○	○	○	○	○	○	○
200	○		○	○	○	○	○	○		○		
Chl. max 20L	▲					▲						▲
○	: for harocarbon measurement											
▲	: for incubaion											

\*Air sample

### **3.17 Distribution of planktic foraminifera and radiolarians in the equatorial Pacific Ocean.**

Makoto Yamasaki (Tohoku University), Naomi Nagai, Itsuro Ono, Naoki Fujitani (Kyushu University)

#### ***Objective:***

Plankton samples were collected by a plankton net at the site of St.3, St.6, St.9, St.12 and St.14 in the Equatorial Pacific. The purpose of this study is to clarify vertical and horizontal distribution patterns, depth habitats and standing stocks of planktic foraminifera and radiolarians in the equatorial Pacific Ocean.

#### ***Method:***

Samples were obtained by a closing type plankton net, 0.75 m in diameter, 3.5 m in length and 63  $\mu\text{m}$  in mesh size. This net can be closed by sending a messenger at a decided depth while the net was towing upward. Depth intervals of samplings were 0-20 m, 20-40 m, 40-80 m, 80-120 m, 120-160 m, 160-200 m and 200-500 m at the site of St.3, St.6, St.12 and St.14. At St.3, St.6 and St.12, sample of the interval of 500-1,000 m was also recovered. At St.9, there was not much filtering volume (measured with a flow meter) at the depth intervals, which suggests that the net mouth could not be opened. Therefore, we changed the depth intervals at this site to 0-40 m, 0-80 m, 0-120 m and 0-200 m.

Samples were preserved in seawater filtered through a screen with an opening of 63  $\mu\text{m}$  with 4 % formalin solution buffered to pH 7.6 by sodium tetraborate. And a protoplasm of plankton was dyed by Rose Bengal in order to examine which plankton was living or dead.

Samples had been kept at 4-5 °C.

Specimens of planktic foraminifera and radiolarian will be identified and counted in the laboratory.

### **3.18 Distribution of planktic foraminifera in the surface water in the Pacific Ocean.**

#### ***Objective:***

The purposes of this study are; (1) to reveal the distribution pattern of planktic foraminifera in the surface water in the Pacific Ocean, and (2) to investigate the intensity of upwelling or downwelling in the western Pacific Ocean by measuring the difference of oxygen isotope values of foraminiferal tests.

#### ***Method:***

Plankton samples were collected from the 8th of January to the 14th of February 2002, during the R. V. MIRAI cruise MR02-K01. A continuous set of samples was obtained with a surface water pump of the R. V. MIRAI. The samples were filtered 1-3 m<sup>3</sup> of seawater through a screen with an opening of 75 µm in the morning and/or the evening, and were preserved in approximately 50 % Ethanol .

The planktic foraminiferal specimens will be identified, and then, their tests will be measured oxygen isotope in the laboratory.

### 3.19 SEDIMENT TRAP EXPERIMENT

A. SHIMAMOTO<sup>1)</sup>, Y. Tanaka<sup>2)</sup>

- 1) Kansai Environmental Engineering Center Co. Ltd.  
Environmental chemistry department, Ocean environmental survey team
- 2) Geological Survey of Japan

#### OBJECTIVE

We are planning next items about how to use collected settling particles.

- A) Total mass flux and main component  
To analyze total mass flux and main component (Opal, Carbonate, Organic carbon, Organic nitrogen).
- B) Carbonate flux by calcareous nannoplankton.  
To analyze seasonal varieties of the coccolith species, and annual and vertical changes of the coccolith flux.
- C) Planktonic foraminifera flux.  
To analyze planktonic foraminifera flux, and the dissolution process of settling foraminiferal shell in the water column.
- D) Flux of silicoplankton (1.Diatom, 2.Radiolaria, 3.Silicofragellate, 4.Silicodinofragellate)  
To estimate vertical flux of the carbon and silica based on that analyzing each species flux of the time-series settling particles.
- E) Radio-nuclide (U-238, Th-230, Pa-231, Pu-239+240, Pb-210, Po-210, etc.)  
To consider that settling particle flux, and horizontal and vertical transport process.

#### DEPLOYMENT

We deployed four systems of the sediment trap mooring arrays for about one year. The detailed data is followed (Table-1).

All of the sediment traps, releasers and winches are SMD26S-6000, Model-L and ATDS (Nichiyu-Giken Co. Ltd.). The sampling layers of sediment traps are about 1 and 2 or 3 km depth. At station 14, we had deployed ATDS (Automatic Temperature Depth System: It's had a depth sensor and a temperature one, and measuring vertical profiles running automatically the built-in winch) with the top of mooring arrays.

We made preservative compounded seawater filtered with GF/F filter for neutralized formalin. Neutralized Formalin was filtered with 0.6µM Nucleporefilter after neutralized Formaldehyde solution to about pH=7.4-7.6 by Sodium tetraborate. The rate of mixture was 15L filtrated seawater for 1L neutralized formalin.

Each collecting interval is divided a month the first and latter half. All of sampling schedules is synchronized (Table-2).

Table-1 Deployed mooring array data

Station	6	9	12	14
Start time (LST)	2002/2/3 13:25 (JST +2h)	2002/1/30 13:25 (JST +3h)	2002/1/26 7:29 (JST -20h)	2002/1/23 14:19 (JST -20h)
Mooring start point	00-01.93N 159-56.80E	00-02.18N 174-54.10E	00-00.33S 170-11.65W	00-00.63S 160-02.33W
Deployed sinker time and point	14:27 00-03.33N 159-57.18E 2,808m	14:46 00-02.33N 174-55.77E 4,820m	9:06 00-00.87S 170-09.54W 5,625m	16:15 00-00.01N 159-59.77W 5,130m

Table-1 Deployed mooring array data (continuation)

Station	6	9	12	14
Collecting layer	960m 2,070m	990m 3,090m	860m 2,850m	970m 3,070m
ATDS deployed layer				190m
Sampling start time (JST)	2001/2/4 1:00	2002/2/1 1:00	2002/2/1 1:00	2002/1/25 1:00
Sampling stop time (JST)	2003/1/15 1:00	2003/1/16 1:00	2003/1/21 1:00	2003/1/24 1:00
Interval	c.a. 15days (see next time table)			
Preservative	Seawater and formalin neutralized with sodium tetraborate			
Recovery	MR03-K06			

Table-2 Sampling schedule (JST)

EVENT #	Station#06	Station#09	Station#12	Station#14
1	2002.2.1.1:00	2002.2.1.1:00	2002.2.1.1:00	2002.1.25.1:00
2	2002.2.16.1:00	2002.2.16.1:00	2002.2.16.1:00	2002.2.1.1:00
3	2002.3.1.1:00	2002.3.1.1:00	2002.3.1.1:00	2002.2.16.1:00
4	2002.3.16.1:00	2002.3.16.1:00	2002.3.16.1:00	2002.3.1.1:00
5	2002.4.1.1:00	2002.4.1.1:00	2002.4.1.1:00	2002.3.16.1:00
6	2002.4.16.1:00	2002.4.16.1:00	2002.4.16.1:00	2002.4.1.1:00
7	2002.5.1.1:00	2002.5.1.1:00	2002.5.1.1:00	2002.4.16.1:00
8	2002.5.16.1:00	2002.5.16.1:00	2002.5.16.1:00	2002.5.1.1:00
9	2002.6.1.1:00	2002.6.1.1:00	2002.6.1.1:00	2002.5.16.1:00
10	2002.6.16.1:00	2002.6.16.1:00	2002.6.16.1:00	2002.6.1.1:00
11	2002.7.1.1:00	2002.7.1.1:00	2002.7.1.1:00	2002.6.16.1:00
12	2002.7.16.1:00	2002.7.16.1:00	2002.7.16.1:00	2002.7.1.1:00
13	2002.8.1.1:00	2002.8.1.1:00	2002.8.1.1:00	2002.7.16.1:00
14	2002.8.16.1:00	2002.8.16.1:00	2002.8.16.1:00	2002.8.1.1:00
15	2002.9.1.1:00	2002.9.1.1:00	2002.9.1.1:00	2002.8.16.1:00
16	2002.9.16.1:00	2002.9.16.1:00	2002.9.16.1:00	2002.9.1.1:00
17	2002.10.1.1:00	2002.10.1.1:00	2002.10.1.1:00	2002.9.16.1:00
18	2002.10.16.1:00	2002.10.16.1:00	2002.10.16.1:00	2002.10.1.1:00
19	2002.11.1.1:00	2002.11.1.1:00	2002.11.1.1:00	2002.10.16.1:00
20	2002.11.16.1:00	2002.11.16.1:00	2002.11.16.1:00	2002.11.1.1:00
21	2002.12.1.1:00	2002.12.1.1:00	2002.12.1.1:00	2002.11.16.1:00
22	2002.12.16.1:00	2002.12.16.1:00	2002.12.16.1:00	2002.12.1.1:00
23	2003.11.1:00	2003.1.1.1:00	2003.1.1.1:00	2002.12.16.1:00
24	2003.1.15.1:00	2003.1.16.1:00	2003.1.16.1:00	2003.1.1.1:00
25	-	-	2003.1.21.1:00	2003.1.16.1:00
26	-	-	-	2003.1.24.1:00
Bottle Name	C02M06Sxx C02M06Dxx	C02M09Sxx C02M09Dxx	C02M12Sxx C02M12Dxx	C02M14Sxx C02M14Dxx



## RECOVERY

We've recovered three sediment trap mooring arrays. All of them were deployed in January 2000 (MR00-K02). It seemed that all of sediment traps carried out completely.

However ATDS systems were not carried out. The top buoy of ATDS was broken at station 14 (Fig.-1). It seemed that this was crushed by high water pressure, because the capacity for resisting pressure of the buoy is c.a. 800m, and the data of depth sensor recorded more than 900m in May 2001. And furthermore, at station 6 the top buoy of ATDS was disappeared because the rope rolled onto the winch of ATDS was cut (Fig.-2).



Fig.-1 ATDS in St. 14.



Fig.-2 ATDS in St.6.

We named sampling bottles as follows.

[Example] "C00M06S01"

C = Mission Name (Carbon Mapping)

00 = deployed year

M = Cruise Name (MIRAI)

06 = Station Number

S = Sampling Layer (Shallow "S" or Deep "D")

01 = Collecting Number

The working record on deck is followed as next table (Table-3).

The event schedule of collected samples is followed as next table (Table-4).

Table-3 Recovered mooring array data

Station number	6	9	14
Released time (LST) and point	2002/2/3 6:55 00-02.90N 159-57.23E	2002/1/30 7:03 00-02.18N 174-54.95E	2002/1/23 7:02 00-00.03S 160-00.32W
Recovery start time	7:39	8:15	8:10
Recovery end time	8:50	9:50	10:10
Collecting layer (*1)	960m 2,130m	810m 3,230m	690m 2,160m
Total depth	2,811m	4,816m	5,176m
Event start time (JST)	2001.1.26.0:57	2001.1.22.0:57	2001.1.16.1:00
Event stop time (JST)	2002.2.1 1:00	2002.1.27.1:00	2002.1.16.1:00
Interval	c.a. 15days (see next time table)		
Preservative	Seawater and formalin neutralized with sodium tetraborate		

\*1: the mean depth during sampling period calculated by the data of built-in depth sensors.

Table-4 Sampling schedule (JST)

EVENT #	Station#06	Station#09	Station#14
1	2001.1.26.0:57	2001.1.22.0:57	2001.1.16.1:00
2	2001.1.26.1:00	2001.1.22.1:00	2001.2.1.1:00
3	2001.2.1.1:00	2001.2.1.1:00	2001.2.16.1:00
4	2001.2.16.1:00	2001.2.16.1:00	2001.3.1.1:00
5	2001.3.1.1:00	2001.3.1.1:00	2001.3.16.1:00
6	2001.3.16.1:00	2001.3.16.1:00	2001.4.1.1:00
7	2001.4.1.1:00	2001.4.1.1:00	2001.4.16.1:00
8	2001.4.16.1:00	2001.4.16.1:00	2001.5.1.1:00
9	2001.5.1.1:00	2001.5.1.1:00	2001.5.16.1:00
10	2001.5.16.1:00	2001.5.16.1:00	2001.6.1.1:00
11	2001.6.1.1:00	2001.6.1.1:00	2001.6.16.1:00
12	2001.6.16.1:00	2001.6.16.1:00	2001.7.1.1:00
13	2001.7.1.1:00	2001.7.1.1:00	2001.7.16.1:00
14	2001.7.16.1:00	2001.7.16.1:00	2001.8.1.1:00
15	2001.8.1.1:00	2001.8.1.1:00	2001.8.16.1:00
16	2001.8.16.1:00	2001.8.16.1:00	2001.9.1.1:00
17	2001.9.1.1:00	2001.9.1.1:00	2001.9.16.1:00
18	2001.9.16.1:00	2001.9.16.1:00	2001.10.1.1:00
19	2001.10.1.1:00	2001.10.1.1:00	2001.10.16.1:00
20	2001.10.16.1:00	2001.10.16.1:00	2001.11.1.1:00
21	2001.11.1.1:00	2001.11.1.1:00	2001.11.16.1:00
22	2001.11.16.1:00	2001.11.16.1:00	2001.12.1.1:00
23	2001.12.1.1:00	2001.12.1.1:00	2001.12.16.1:00
24	2001.12.16.1:00	2001.12.16.1:00	2002.1.1.1:00
25	2002.1.1 1:00	2002.1.1.1:00	2002.1.16.1:00
26	2002.1.16 1:00	2002.1.16.1:00	-
27	2002.2.1 1:00	2002.1.27.1:00	-
Bottle Name	C00M06Sxx C00M06Dxx	C00M09Sxx C00M09Dxx	C00M14Sxx C00M14Dxx

### 3.20 Argo float deployment

#### (1) Personnel

Eitarou Oka (FORSGC): Principal Investigator  
Fujio Kobayashi (MWJ)  
Miki Yoshiike (MWJ)  
Satoshi Okumura (GODI)  
Shinya Iwamida (GODI)

#### (2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of the North Pacific Subtropical Mode Water (Leg1) and variation of temperature and salinity associated with an extension of the warm water pool to the tropical central Pacific in association with ENSO events and the intraseasonal oscillation (Leg2).

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

#### (3) Parameters

- water temperature, salinity, and pressure

#### (4) Methods

##### 1) Profiling float deployment

We launched 15 PROVOR floats (ten in Leg1 and five in Leg2) manufactured by METOCEAN Data Systems Ltd. Each float equips a CTD sensor SBE41CP manufactured by Sea-Bird Electronics Inc.

The floats drift at a depth of 2000 dbar (called the parking depth) and rise up to the sea surface every ten days by increasing their volume and changing the buoyancy. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for twelve hours, transmitting their positions and the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The status of the floats and the launch are shown in Table ??? (Note that WMO IDs of the floats have not been given yet).

##### 2) CTD observation

A CTD cast to a depth of 2000 m was made just before the launch of the float MT029 in Leg1 for calibration of the float sensor (Sec. ???).

##### 3) XCTD observation

XCTD observations to a depth of about 1000 db were made at 28 stations between 152°E and 180°E with an interval of 1 longitude degree (except at 170°E) in Leg1 and at 56 stations between 160°W and 145°E with an interval of 1 longitude

degree in Leg2 in order to understand the distributions of salinity and temperature around the float-launch point (Sec. ???).

(6)Data archive

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

Table 3.20.1 Status of floats and the launch

Float

Float Type	PROVOR manufactured by METOCEAN Data Systems Ltd
CTD sensor	SBE41CP manufactured by Sea-Bird Electronics Inc.
Cycle	10 days (12 hours at the sea surface)
ARGOS transmit interval	30 sec
Target Parking Pressure	2000 dbar
Sampling layers	71 (2000, 1900, 1800, 1700, 1600, 1500, 1400, 1300, 1250, 1200, 1150, 1100, 1050, 1000, 975, 950, 925, 900, 875, 850, 825, 800, 780, 760, 740, 720, 700, 680, 660, 640, 620, 600, 580, 560, 540, 520, 500, 480, 460, 440, 420, 400, 380, 360, 340, 320, 300, 280, 260, 240, 220, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20, 10 [dbar])

Launch in Leg 1

Float S/N	ARGOS PTT ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch
MT-015	24550	04:42, Jan 9	05:16, Jan 9	33-14.94 N, 152-00.60 E
MT-018	24553	14:47, Jan 9	15:33, Jan 9	33-06.96 N, 155-00.62 E
MT-036	10911	00:26, Jan 10	01:12, Jan 10	32-58.91 N, 158-00.88 E
MT-033	10624	10:44, Jan 10	11:36, Jan 10	32-45.92 N, 161-00.67 E
MT-034	10625	21:25, Jan 10	22:13, Jan 10	32-22.74 N, 164-00.64 E
MT-050	17795	07:48, Jan 11	08:33, Jan 11	32-00.84 N, 167-00.81 E
MT-029	10601	22:52, Jan 11	23:17, Jan 11	31-37.71 N, 170-02.54 E
MT-025	10595	12:04, Jan 12	12:50, Jan 12	30-59.92 N, 174-00.80 E
MT-026	10596	22:05, Jan 12	23:01, Jan 12	30-30.82 N, 177-00.81 E
MT-030	10602	08:51, Jan 13	09:46, Jan 13	29-59.84 N, 179-59.42 W

Launch in Leg 2

Float S/N	ARGOS PTT ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch
MT-031	10609	08:36, Jan 24	09:55, Jan 24	00-00.57 N, 160-00.32 W
MT-037	10916	00:19, Jan 25	00:59, Jan 25	00-00.59 S, 163-31.03 W
MT-019	24573	04:37, Jan 27	04:59, Jan 27	00-02.26 S, 170-04.85 W
MT-035	10688	00:10, Jan 28	00:39, Jan 28	00-00.18 S, 174-47.53 W
MT-032	10610	00:17, Jan 29	01:03, Jan 29	00-01.43 N, 179-07.04 E

### **3.21 Optical Measurement**

#### **1. Scope**

This document summarizes scientific investigations carried out by JAMSTEC and Dalhousie University onboard the R/V Mirai in the equatorial Pacific between Jan. 19 and Feb 09, 2002. It represents work supported by JAMSTEC, Dalhousie University, and the Office of Naval Research, HyCODE project.

#### **2. Referenced Documents**

RD 1 Mueller, J.L., and R.W. Austin, 1995: Ocean Optics Protocols for SeaWiFS Validation, Revision 1. NASA Tech. Memo. 104566, Vol. 25, S.B. Hooker, E.R. Firestone, and J.G. Acker, Eds., NASA Goddard Space Flight Center, Greenbelt, Maryland, 67 pp.

RD 2 JAMSTEC, 2002: MR02-K01 Cruise Report

#### **3. Background and Rationale**

Satellite observations of the multi-spectral reflectance of the ocean's surface, as exemplified by the Coastal Zone Color Scanner (CZCS), the Ocean Color and Temperature Sensor (OCTS) and the Sea-Viewing, Wide Field of View Sensor (SeaWiFS), have transformed perceptions of optical variability in the sea.

The objectives of Dalhousie University during this cruise were several and included:

- i. Evaluate the net vertical transport of energy associated with penetrating irradiance, for comparison with the net surface heat flux along an equatorial transect.
- ii. Carry out a collaborative effort with JAMSTEC in the development and validation of bio-optical algorithms for use with the currently operating SeaWiFS satellite.
- iii. To investigate the uptake rates of labeled  $^{15}\text{N}$ -nitrate and labeled inorganic  $^{13}\text{C}$ -carbon in simulated *in-situ* incubations to determine rates of new and total primary production along equatorial transect 160W to 145E.

#### **4. Participants**

Takeshi Kawano / Chief Scientist, JAMSTEC

Geoff MacIntyre M.Sc. / Research Associate, Dalhousie University

Michael MacDonald / Research Associate, Dalhousie University

Fujio Kobayashi / Technician, Marine Works Japan Ltd.

Ai Yasuda / Technician, Marine Works Japan Ltd.

**Table 1. List of Symbols and Abbreviations**

<b>Symbol</b>	<b>Description</b>	<b>Units</b>
$E(\lambda)$	Instrument measured irradiance	$\mu\text{W cm}^{-2} \text{nm}^{-1}$
$E_d(\lambda)$	Downwelling spectral irradiance below the sea-surface	$\mu\text{W cm}^{-2} \text{nm}^{-1}$
$E_s(\lambda)$	Downwelling spectral irradiance just above the sea-surface	$\mu\text{W cm}^{-2} \text{nm}^{-1}$
$E_{\text{lamp}}(\lambda)$	Spectral irradiance of standard lamp at a specified distance	$\mu\text{W cm}^{-2} \text{nm}^{-1}$
$F1(\lambda)$	Reduction in Field of View due to differences in refractive index	dimensionless
$F2(\lambda)$	Immersion reflectance changes at window - water interface	dimensionless
$\text{Imm}(\lambda)$	Total spectral immersion effects	dimensionless
$L(\lambda)$	Instrument measured radiance	$\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$
$L_u(\lambda)$	Upwelling spectral radiance below the sea-surface	$\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$
$L_w(\lambda)$	Upwelling spectral radiance just above the sea-surface	$\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$
$L_T(\lambda)$	Target Radiance	$\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$
$\eta_g(\lambda)$	Relative spectral index of refraction of optical window	dimensionless
$\eta_w(\lambda)$	Relative spectral index of refraction of water	dimensionless
NASA	National Aeronautics and Space Administration (U.S. Space Agency)	
NIST	National Institute of Standards and Technology (U.S. Standards agency)	
ONR	Office of Naval Research	
$\rho(\lambda)$	Spectral reflectance of standard target	dimensionless
$R_{rs}$	Remote Sensing Reflectance	$\text{sr}^{-1}$

## 5. Mission Summary

Reflectance data were collected on a series of deployments from the R/V Mirai. The Mirai departed Hawaii on January 19, 2002 for a transect along the equator from 160W to 145E, and arrived at Guam on February 09, 2002. A large number of optical, biological, physical and chemical measurements were taken, including profiler and reference optical data.

### 5.1 Deployment Coordinates

The locations and dates of each station are summarized below.

**Table 2. Summary of station locations and dates**

Location	Date	Position
Honolulu	Jan 19, 2002	22°00N 158°00W
Stn14	Jan 23, 2002	0°00N 160°00W
Stn13	Jan 24, 2002	0°00N 163°29W
Stn12	Jan 26, 2002	0°00N 170°10W
Stn11	Jan 27, 2002	0°00N 174°46W
Stn10	Jan 29, 2002	0°00N 179°07E
Stn09	Jan 30, 2002	0°00N 174°58E
Stn08	Feb 01, 2002	0°00N 166°11E
Stn07	Feb 02, 2002	0°00N 161°29E
Stn06	Feb 03, 2002	0°00N 159°58E
Stn05	Feb 04, 2002	0°00N 155°51E
Stn04	Feb 05, 2002	0°00N 149°47E
Stn03	Feb 06, 2002	0°00N 145°00E

**Table 3. Inventory of casts<sup>1</sup> – Locations and times**

Station ID	Cast	Date [UTC]	JD [UTC]	Start Time [UTC]	Local Time	LAT Deg	LONG Deg	Cast name
SPMR03	A	06-Feb	37	01:40	11:40	0.00N	145.00E	MR02K01SPMRStn03A
SPMR03	B	06-Feb	37	01:46	11:46	0.00N	145.00E	MR02K01SPMRStn03B
NPR03	A	06-Feb	37	01:59	11:59	0.00N	145.00E	MR02K01NPRStn03A
NPR03	B	06-Feb	37	02:08	12:08	0.00N	145.00E	MR02K01NPRStn03B
SPMR04	A	05-Feb	36	01:34	11:34	0.00N	149.78E	MR02K01SPMRStn04A
SPMR04	B	05-Feb	36	01:42	11:42	0.00N	149.78E	MR02K01SPMRStn04B
NPR04	A	05-Feb	36	01:55	11:55	0.00N	149.78E	MR02K01NPRStn04A
NPR04	B	05-Feb	36	02:05	12:05	0.00N	149.78E	MR02K01NPRStn04B
SPMR05	A	04-Feb	35	00:38	11:38	0.00N	155.85E	MR02K01SPMRStn05A
SPMR05	B	04-Feb	35	00:45	11:45	0.00N	155.85E	MR02K01SPMRStn05B
NPR05	A	04-Feb	35	01:00	12:00	0.00N	155.85E	MR02K01NPRStn05A
NPR05	C	04-Feb	35	01:17	12:17	0.00N	155.85E	MR02K01NPRStn05C
SPMR06	A	03-Feb	34	00:37	11:37	0.01N	159.97E	MR02K01SPMRStn06A
SPMR06	C	03-Feb	34	00:45	11:45	0.01N	159.97E	MR02K01SPMRStn06C
NPR06	B	03-Feb	34	01:07	12:07	0.01N	159.97E	MR02K01NPRStn06B
NPR06	C	03-Feb	34	01:17	12:17	0.01N	159.97E	MR02K01NPRStn06C
SPMR07	A	02-Feb	33	00:37	11:37	0.00N	161.48E	MR02K01SPMRStn07A
SPMR07	B	02-Feb	33	00:45	11:45	0.00N	161.48E	MR02K01SPMRStn07B
NPR07	A	02-Feb	33	01:00	12:00	0.00N	161.48E	MR02K01NPRStn07A
NPR07	B	02-Feb	33	01:09	12:09	0.00N	161.48E	MR02K01NPRStn07B
SPMR08	A	01-Feb	32	00:43	11:43	0.00N	166.19E	MR02K01SPMRStn08A
SPMR08	B	01-Feb	32	00:50	11:50	0.00N	166.19E	MR02K01SPMRStn08B
NPR08	A	01-Feb	32	01:03	12:03	0.00N	166.19E	MR02K01NPRStn08A
NPR08	B	01-Feb	32	01:12	12:12	0.00N	166.19E	MR02K01NPRStn08B
SPMR09	A	29-Jan	29	23:37	11:37	0.00N	174.97E	MR02K01SPMRStn09A
SPMR09	B	29-Jan	29	23:43	11:43	0.00N	174.97E	MR02K01SPMRStn09B
NPR09	B	29-Jan	29	23:56	11:56	0.00N	174.97E	MR02K01NPRStn09B
NPR09	C	30-Jan	30	00:04	12:04	0.00N	174.97E	MR02K01NPRStn09C
SPMR10	A	28-Jan	28	23:39	11:39	0.00N	179.13E	MR02K01SPMRStn10A
SPMR10	B	28-Jan	28	23:45	11:45	0.00N	179.13E	MR02K01SPMRStn10B
NPR10	A	29-Jan	29	00:00	12:00	0.00N	179.13E	MR02K01NPRStn10A
NPR10	B	29-Jan	29	00:10	12:10	0.00N	179.13E	MR02K01NPRStn10B
SPMR11	A	27-Jan	27	22:46	11:46	0.00N	174.77W	MR02K01SPMRStn11A
SPMR11	B	27-Jan	27	22:51	11:51	0.00N	174.77W	MR02K01SPMRStn11B
NPR11	A	27-Jan	27	23:03	12:03	0.00N	174.77W	MR02K01NPRStn11A
NPR11	B	27-Jan	27	23:16	12:16	0.00N	174.77W	MR02K01NPRStn11B
SPMR12	A	26-Jan	26	22:44	11:44	0.02S	170.17W	MR02K01SPMRStn12A
SPMR12	B	26-Jan	26	22:50	11:50	0.02S	170.17W	MR02K01SPMRStn12B
NPR12	A	26-Jan	26	23:03	12:03	0.02S	170.17W	MR02K01NPRStn12A
NPR12	B	26-Jan	26	23:11	12:11	0.02S	170.17W	MR02K01NPRStn12B
SPMR13	A	24-Jan	24	23:03	12:03	0.00N	163.49W	MR02K01SPMRStn13A
SPMR13	B	24-Jan	24	23:10	12:10	0.00N	163.49W	MR02K01SPMRStn13B
NPR13	A	24-Jan	24	23:25	12:25	0.00N	163.49W	MR02K01NPRStn13A
NPR13	B	24-Jan	24	23:29	12:29	0.00N	163.49W	MR02K01NPRStn13B
SPMR14	A	23-Jan	23	22:51	11:51	0.00N	160.01W	MR02K01SPMRStn14A
SPMR14	B	23-Jan	23	22:57	11:57	0.00N	160.01W	MR02K01SPMRStn14B
NPR14	B	23-Jan	23	23:18	12:18	0.00N	160.01W	MR02K01NPRStn14B
NPR14	C	23-Jan	23	23:28	12:28	0.00N	160.01W	MR02K01NPRStn14C

<sup>1</sup> "NPR" Station ID's indicate HyperPro casts, while "SPMR" ID's refer to SPMR/SMSR casts



**Table 4. Inventory of casts – Environmental conditions and processing notes**

Station ID	Cast	Air temp (°C)	cloud cover	cloud Type	Sea cond. [m]	swell [m]	depth [m]	Dark correction	Cast and Processing comments
SPMR03	A	27.4	8/10ths	overcast	calm	0.5	205	calibrated	variable clouds; unstable Es
SPMR03	B	27.4	8/10ths	overcast	calm	0.5	204	calibrated	variable clouds; unstable Es
NPR03	A	27.4	8/10ths	overcast	calm	0.5	85	shutter	variable clouds
NPR03	B	27.4	8/10ths	overcast	calm	0.5	85	shutter	variable clouds
SPMR04	A	30.1	6/10ths	high haze	calm	0.5	203	calibrated	mostly clear, high haze
SPMR04	B	30.1	6/10ths	high haze	calm	0.5	210	calibrated	mostly clear, high haze
NPR04	A	30.1	6/10ths	high haze	calm	0.5	75	shutter	clear w/ small wispy clouds
NPR04	B	30.1	6/10ths	high haze	calm	0.5	83	shutter	clear w/ wispy cloud, possible cloud at end
SPMR05	A	30.0	1/10th	high haze	calm	0.5	199	calibrated	uniform haze
SPMR05	B	30.0	1/10th	high haze	calm	0.5	200	calibrated	uniform haze
NPR05	A	30.0	1/10th	high haze	calm	0.5	112	shutter	uniform haze
NPR05	C	30.0	1/10th	high haze	calm	0.5	116	shutter	uniform haze
SPMR06	A	28.1	10/10ths	overcast	calm	0.5	201	calibrated	uniformly overcast
SPMR06	C	28.1	10/10ths	overcast	calm	0.5	204	calibrated	uniformly overcast
NPR06	B	28.1	10/10ths	overcast	calm	0.5	101	shutter	uniformly overcast
NPR06	C	28.1	10/10ths	overcast	calm	0.5	86	shutter	uniformly overcast
SPMR07	A	29.1	3/10ths	high cirrus	no caps	0.5	200	calibrated	clear with wispy clouds, sun unobstructed
SPMR07	B	29.1	3/10ths	high cirrus	no caps	0.5	201	calibrated	clear with wispy clouds, sun unobstructed
NPR07	A	29.1	3/10ths	high cirrus	no caps	0.5	93	shutter	cloud from 10-40m, wispy cloud throughout
NPR07	B	29.1	3/10ths	high cirrus	no caps	0.5	85	shutter	slight wisps, cloud obstruction 50m to end
SPMR08	A	27.9	9/10ths	overcast	no caps	0.5	207	calibrated	uniformly overcast
SPMR08	B	27.9	9/10ths	overcast	no caps	0.5	215	calibrated	uniformly overcast
NPR08	A	27.9	9/10ths	overcast	no caps	0.5	101	shutter	uniformly overcast
NPR08	B	27.9	9/10ths	overcast	no caps	0.5	108	shutter	uniformly overcast
SPMR09	A	29.3	3/10ths	clear	no caps	0.5	217	calibrated	cloud at 125m
SPMR09	B	29.3	3/10ths	clear	no caps	0.5	214	calibrated	wispy cloud at 130m
NPR09	B	29.3	3/10ths	clear	no caps	0.5	99	shutter	clear
NPR09	C	29.3	3/10ths	clear	no caps	0.5	104	shutter	clear
SPMR10	A	29.3	2/10ths	high cirrus	small caps	1	200	calibrated	clear; tilts 3-4 for final 30m
SPMR10	B	29.3	2/10ths	high cirrus	small caps	1	201	calibrated	cloud at 180m
NPR10	A	29.3	3/10ths	high cirrus	small caps	1	109	shutter	cloud at 50m, then clear
NPR10	B	29.3	3/10ths	high cirrus	small caps	1	104	shutter	wispy cloud after 40m; unstable Es
SPMR11	A	28.8	2/10ths	high cirrus	small caps	1	210	calibrated	wispy cloud at 100m
SPMR11	B	28.8	2/10ths	high cirrus	small caps	1	206	calibrated	clear
NPR11	A	28.8	2/10ths	high cirrus	small caps	1	109	shutter	wispy cloud at end
NPR11	B	28.8	2/10ths	high cirrus	small caps	1	93	shutter	clouds – poor cast
SPMR12	A	28.5	2/10ths	clear	whitecaps	1	207	calibrated	clear
SPMR12	B	28.5	2/10ths	clear	whitecaps	1	209	calibrated	clear
NPR12	A	28.5	3/10ths	clear	whitecaps	1	89	shutter	cloud at 30m
NPR12	B	28.5	3/10ths	clear	whitecaps	1	114	shutter	clear
SPMR13	A	31.0	5/10ths	cumulus	whitecaps	1-1.5	204	calibrated	big cloud for entire cast
SPMR13	B	31.0	5/10ths	cumulus	whitecaps	1-1.5	202	calibrated	log started at 15m; clouds, not blocking sun
NPR13	B	31.0	5/10ths	cumulus	whitecaps	1-1.5	82	shutter	clear
SPMR14	A	28.0	8/10ths	high cirrus	whitecaps	1-1.5	206	calibrated	overcast
SPMR14	B	28.0	8/10ths	high cirrus	whitecaps	1-1.5	202	calibrated	overcast
NPR14	B	28.0	8/10ths	high cirrus	whitecaps	1-1.5	99	shutter	overcast
NPR14	C	28.0	8/10ths	high cirrus	whitecaps	1-1.5	99	shutter	overcast

## 6. Description of Instruments Deployed and Data Collected

### 6.1 SPMR/SMSR

The first instrument system deployed was the SeaWiFS Profiling Multichannel Radiometer (SPMR) and SeaWiFS Multichannel Surface Reference (SMSR). The SPMR is deployed in a freefall mode through the water column while measuring the following physical and optical parameters.

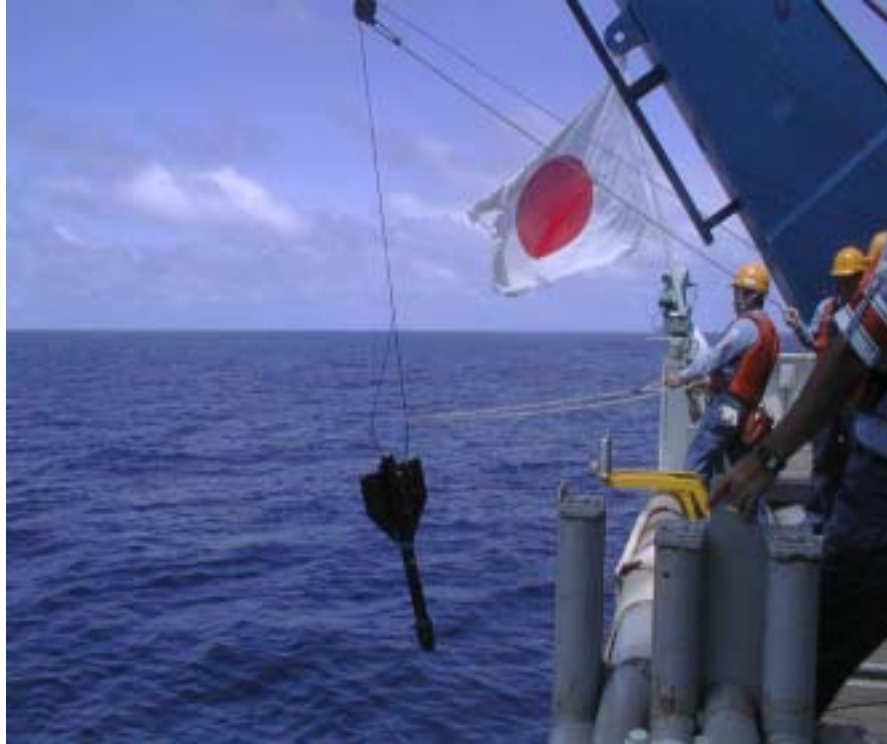
The profiler carries a 13-channel irradiance sensor (Ed) and a 13-channel radiance sensor (Lu), as well as instrument tilt, fluorometry, conductivity and an external temperature probe. The SMSR or reference sensor has a 13-channel irradiance sensor (Es), tilt meter and an internal temperature sensor. This instrument suite is used for the derivation of the penetration of visible and ultra-violet light in the ocean, and for the determination of the vertical distribution of apparent optical properties for comparison with in-situ pigment measurements. It is used to provide normalized water leaving radiance for SeaWiFS calibration and validation and the empirical development of radiative transfer algorithms for the exploration of ocean color satellite data.

The profiler was deployed twice per station to a depth of 200m. Care was taken to attempt to obtain a full cast without clouds fully or partially occluding the sun. The reference was mounted on the compass deck and was never shadowed by any ship structures. The profiler fell at an average rate of  $1\text{ms}^{-1}$  with tilts of less than 3 degrees.

These measurements provide data for the computation of key quantities required to characterize the underwater light field, such as profiles of reflectance, attenuation coefficients, photosynthetically available radiation (PAR), spectral water-leaving radiance, and remote sensing reflectance. These quantities are linked to the inherent optical properties of the ocean (IOP), and can be used to derive the concentration of sea-water constituents such as dissolved organic matter, suspended sediments, and the local chlorophyll concentration. The water-leaving radiance and remote sensing reflectance obtained from in-water profiles is the most accurate surface truth available for calibration/validation of ocean colour satellites.



**Figure 1. Profiler configuration**



**Figure 2. Profiler deployment**

**Table 5. Center wavelengths of the SPMR/SMSR**

<b>SMSR Es</b>	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
<b>SPMR Ed</b>	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
<b>SPMR Lu</b>	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 6. Specifications of the SPMR**

<b>Spatial Characteristics:</b>		
Field of view	Irradiance	Cosine response
	Radiance	10° in water
Collector area	Irradiance	86.0mm <sup>2</sup>
Entrance aperture	Radiance	9.5 mm diameter
Detector type	Irradiance	Custom 17mm <sup>2</sup> and 33mm <sup>2</sup> silicone photodiodes
	Radiance	Custom 13mm <sup>2</sup> and 33mm <sup>2</sup> silicone photodiodes
<b>Spectral Characteristics:</b>		
Number of channels	13	
Spectral bandwidth	10nm	
Bandwidth range	380-705nm	
Filter type	Custom low fluorescence interference	
<b>Electrical specifications:</b>		
Acquisition system	Two 14 channel 24bit DSP A/D system One 8 channel 16bit DSP A/D system	
System frame rate	10 Hz	
Data rate	57.6 kbps	
Data format	Binary	
Data interface	RS-422 / RS-232	
Power	56-80 VDC	
Telemetry	RS485 (RS485 to RS232 converter in deck unit)	
<b>Physical specifications:</b>		
Size	8.9 cm diameter x 122cm long	
Weight	15 kg	
Operating temp. range	-10°C to +60°C	
Depth rating	375m	

## 6.2 Hyperspectral Profiler

The second optical instrument package deployed was Satlantic's prototype hyperspectral profiler, the HyperPro (NPR). The HyperPro data is accompanied by in-air surface irradiance (Es) reference measurements obtained from an OCR3000 hyperspectral irradiance sensor. The HyperPro system therefore has 138 surface irradiance channels, 138 downwelling irradiance channels and 138 upwelling radiance channels ranging from 350 to 800nm. The HyperPro also uses optical shutters for dark readings during deployment. Like the SPMR, the HyperPro free-falls through the water column, providing a profile of spectral upwelling radiance and

downwelling irradiance. These measurements provide data for the computation of key quantities needed to characterize the underwater light field, such as profiles of reflectance, attenuation coefficients, photosynthetically available radiation (PAR), spectral water-leaving radiance, and remote sensing reflectance. These quantities are linked to the inherent optical properties of the ocean (IOP), and can be used to derive the concentration of sea-water constituents such as dissolved organic matter, suspended sediments, and the local chlorophyll concentration. The water-leaving radiance and remote sensing reflectance obtained from in-water profiles is the most accurate surface truth available for calibration/validation of ocean colour satellites.



**Figure 3. Satlantic's Hyperspectral Profiler**



**Figure 4. OCR3000 Hyperspectral surface reference**



**Figure 5. HyperPro deployment**

**Table 7. Specifications of the HyperPro**

<b>Optical Specifications:</b>		
Spectral range	350-800nm	
Entrance slit	70 x 2500 $\mu$ m	
Detector type	256 channel Silicon photodiode array	
Pixel size	25 x 2500 $\mu$ m	
Spectral sampling	3.3nm/pixel	
Spectral resolution	10nm (3 pixel slit image)	
Spectral accuracy	0.3nm	
Stray light	$< 1 \times 10^{-3}$	
Field of view	Irradiance	Cosine corrected single collector
	Radiance	8.5° half angle baffled Gershun tube
<b>Electrical specifications:</b>		
Acquisition module	16 bit ADC	
Digital resolution	16 bits	
Frame rate	0.5 Hz	
Data rate	57.6 kbps	
Data format	Binary	
Data interface	RS-422 / RS-232	
Power	18-72 VDC at 3 Watts	
Telemetry options	Real time	
<b>Physical specifications:</b>		
Size	6 cm diameter x 32cm long (sensor length)	
Weight	1.07 kg	
Operating temp. range	-10°C to +50°C	
Absolute maximum spectrometer storage temperature range	-40°C to +60°C	

### 6.3 METSAS

The third instrument deployed was the METSAS meteorological station. This instrument package measures a wide range of physical and optical properties. In its present form, this instrument can measure physical properties such as GPS location, relative ship speed and direction, temperature and relative humidity, wind speed and wind direction and barometric pressure. It also measures solar radiation, sea surface skin temperature, downwelling irradiance ( $E_s$ ) and upwelling above surface radiance ( $L_t$ ). The last set of optical properties were measured with two 7 channel Satlantic MVD instruments. These two instruments running in unison are also known as the SAS (SeaWiFS aircraft Simulator).

The METSAS was set up and started collecting data immediately upon departure from Hawaii. This instrument package ran 24 hours a day and the data was collected using SatView 2.2a data logging software. These data files can become very large so it was decided to collect data files at two-hour intervals. This makes data processing much easier.



**Figure 6. SAS radiance  $L_t$  sensor**





**Figure 7. Weather station**



**Figure 8. Solar radiation sensor**

#### 6.4 MicroTops II Sunphotometer

The fourth instrument deployed on MR02-K01 was the MicroTops II Sunphotometer. This instrument has the capability of measuring the direct solar radiation at 440, 500, 675, 870, and 936nm. This data can then be used to determine optical thickness. A Garmin GPS was used in unison with the MicroTopsII and downloaded NMEA sentences to the sunphotometer in real time. The collected GPS position and time is then used to determine the solar zenith angle. It is very important only to collect sunphotometer data while the sun is in direct view, ie. clouds and high cirrus do not obstruct the solar disc. The sunphotometer files were collected during the SPMR deployment on days when the solar disc was unobstructed. The Microtops data can be found on the MR02K01 Cruise Data CD as text files using the naming protocol: MT[serial#][year][month][day].txt. For example, the filename MT377020020205.txt is a file from instrument #3770, captured on February 05, 2002.



Figure 9. Microtops II hand-held sunphotometer

## 6.5 Total and New Production

### 6.5.1 Methodology for measurements

A rosette system equipped with 30L General Oceanics Niskin bottles was used to collect seawater at eight optical depths for simulated *in-situ* at each station. A surface water sample was collected just prior to retrieval of the rosette system with a HDPE bucket. The optical depths were determined using Satlantic SPMR Profiler to correspond to eight light levels (100, 51, 22, 16, 13, 2 and 1 % of surface irradiance for new and primary production measures) available in the incubators aboard the R/V Mirai.

A summary of station locations, sample times and depths is shown in table 8. The incubators consisted of 0.6m long acrylic tubes covered with a neutral density screen. Measurement of light transparencies for the incubators is shown in Table 9. For estimation of  $^{15}\text{N}$  and  $^{13}\text{C}$  uptake rates, triplicate - 1L polycarbonate bottles were rinsed with sample water from each optical depth and filled to 1L using a silicon tube connected to the Niskin bottle to deliver the sample gently into the bottles, allowing a small air space at the top of the bottle. All sample bottles were then inoculated with 200  $\mu\text{M}$   $^{13}\text{C}$ -sodium bicarbonate and 0.5  $\mu\text{M}$   $^{15}\text{N}$ -potassium nitrate in the surface mixed layer above the chlorophyll-a maximum, and 1.0  $\mu\text{M}$  of  $^{15}\text{N}$ -potassium nitrate at and below the chlorophyll maximum.

Immediately after inoculation with stable isotopes, sample bottles were placed into incubators corresponding to their nearest light level and then put into a large tank located on the deck with continuously flowing seawater pumped from 7 m below the surface to maintain stable temperatures in the sample bottles. All isotope additions were done in a dark room prior to placing sample bottles into incubators. All sample bottles were maintained just under the surface in the holding tanks during the 3-hour incubation under ambient irradiance and temperature conditions. At the end of the incubation, samples were filtered onto 21 mm pre-combusted (475 °C for 4 h) Whatman GF/F filters and placed into labelled Petri dishes and dried at 45 °C for 20 h. Samples were then placed into plastic bags with dessicant and vacuum sealed. Sample filters will be maintained under vacuum and dessicant until analysis with an CN Analyzer coupled to a Europa Tracemass Spectrometer located at the Bedford Institute of Oceanography located in Dartmouth, Nova Scotia, Canada.

## 6.5.2 Sampling

**Table 8. Summary of station locations, start times, and depths for simulated in-situ incubations.**

station #	local date mm/dd/yy	local time hh:mm	Chl Max.	Mixed Layer	latitude	longitude	Sampling depths (m)
14	01/23/02	13:25	70	150	0 N	160 W	0,10,20,30,40,60,80
13	01/24/02	14:35	50	150	0 N	163 W	0,10,20,30,40,60,80
12	01/26/02	12:40	58	140	0 N	170 W	0,10,20,30,40,60,80
11	01/27/02	14:27	50	140	0 N	175 W	0,10,20,30,40,60,80
10	01/29/02	13:50	50	140	0 N	179 E	0,10,20,30,40,60,80
09	01/30/02	12:43	50	120	0 N	175 E	0,10,20,30,40,60,80
08	02/01/02	14:37	90	105	0 N	166 E	0,20,30,40,50,80,90
07	02/02/02	14:23	85	90	0 N	162 E	0,20,30,40,50,80,90
06	02/03/02	12:36	100	105	0 N	160 E	0,10,30,40,60,80,90
05	02/04/02	14:21	100	100	0 N	156 E	0,10,30,40,60,80,100
04	02/05/02	14:23	90	100	0 N	150 E	0,10,30,40,60,80,100
03	02/06/02	14:52	75	70	0 N	145 E	0,10,30,40,60,80,100

**Table 9. Summary of percent light transparencies for simulated *in-situ* (SIS) and uptake kinetics (UK) incubators measured under ambient photosynthetic active radiation (PAR 400-700 nm) with Li-Cor 1400 light meter.**

Tube I.D.	Light transparency (% of ambient)
G	100
A	51
B	22
C	16
D	13
E	2
F	1

### 6.5.3 Data Processing

A total of 168 samples were collected for measurement of uptake rates of  $^{15}\text{N}$  and  $^{13}\text{C}$  for determination of new and total primary production. We anticipate completion of mass spectrometric analyses of all samples at the Bedford Institute of Oceanography by the end of April 2001. The uptake rate of nitrate into phytoplankton will be calculated using equation 1;

$$\rho_{\text{N}} = \frac{\Delta\text{APE PON} (^{14}\text{N} + ^{15}\text{N})}{100 ^{15}\text{N} \Delta t} \quad \text{mg N m}^{-3} \text{ h}^{-1} \quad (1)$$

where  $\Delta\text{APE}$  = atom percent enrichment of  $^{15}\text{N}$  in sample  
 $\text{PON}$  = particulate organic nitrogen ( $\text{mg N m}^{-3}$ )  
 $^{15}\text{N}$  =  $\mu\text{M}$  concentration of labeled nitrate added to the sample bottle  
 $^{14}\text{N}$  =  $\mu\text{M}$  concentration of ambient nitrate  
 $\Delta t$  = time of incubation in hours

The uptake rate of carbon into phytoplankton will be calculated using equation 2;

$$\rho_{\text{TC}} = \frac{\text{POC} (\text{AP}^{13}\text{C}_{\text{inc}} - \text{AP}^{13}\text{C}_{\text{n}})}{\Delta t (\text{AP}^{13}\text{C}_{\text{tic}} - \text{AP}^{13}\text{C}_{\text{n}}) f} \quad \text{mg C m}^{-3} \text{ h}^{-1} \quad (2)$$

where  $\text{POC}$  = particulate organic carbon ( $\text{mg C m}^{-3}$ )  
 $\text{AP}^{13}\text{C}_{\text{inc}}$  = atom percent enrichment of  $^{13}\text{C}$  in sample  
 $\text{AP}^{13}\text{C}_{\text{n}}$  = atom percent of  $^{13}\text{C}$  in natural sample ( $\text{AP}^{13}\text{C}_{\text{n}} = 1.1$ )  
 $\text{AP}^{13}\text{C}_{\text{tic}}$  = atom percent of total inorganic carbon  
 $\Delta t$  = incubation time in h  
 $f$  = discrimination factor of  $^{13}\text{C}$  ( $f = 1.025$ )

## 6.6 Characterization

The instruments are characterized according to the detailed community consensus measurements embodied in SeaWiFS Technical Memorandum, Vol. 25 (RD 3), augmented with advances made by Satlantic in conjunction with NASA and NIST.

### *Spectral Range*

The spectral range is determined by the nature of the spectrometer, the specifications of which are given by the manufacturer. The manufacturer's specifications are cross-checked by viewing a NIST standard source of spectral irradiance, and by viewing lamps with known spectral lines. The spectral range includes the wavebands from 350 to 800nm for the HyperPro and 400 to 800nm for the SPMR/SMSR.

### *Spectral Resolution*

The spectral resolution is determined by the nature of the spectrometer, the specifications of which are given by the manufacturer. The spectral resolution is 10nm.

### *Spectral Accuracy*

The spectral accuracy is determined to within +/- 0.3nm from the calibration sheet provided by the manufacturer.

### *Field of View*

Field of view of the radiance sensor is determined by placing the instrument in a stepper motor controlled rotation table, and performing a rotation about the entrance optics center of rotation in a collimated light beam. The accuracy and precision of the measurement is 0.1 degrees and 0.05 degrees respectively.

### *Linearity*

The linearity of the instrument is determined by placing the instrument on an optical bench, viewing a collimated beam from a 1kW arc source. A series of calibrated neutral density screens are placed in the beam allowing the intensity to be varied by a factor of 1000. The system is linear to less than 1% over the measured range.

### *Cosine Response*

The cosine response of the radiance sensor is determined by placing the instrument in a stepper motor controlled rotation table, and performing a rotation about the entrance optics center of rotation in a collimated light beam. The accuracy and precision of the measurement is 0.1 degrees and 0.05 degrees respectively. The acceptable range of response is within 3% from 0 to 60 degrees, and 10% from 60 to 85 degrees of the perfect cosine response to angle of incidence.

### *Thermal Response*

The thermal response of the dark current is compensated for by using a shutter that measures the dark current every 6 frames. The thermal effects to responsivity are compensated by correction factors if the change in response is greater than 1% from the calibration values. This correction factor is measured by viewing a calibration source while the instrument is thermally stabilized at 5, 10, 15, 25, 30°C (calibrations are done in a thermally controlled room at 20°C±1°C).

### *Immersion Effects (Radiance)*

Due to the difference in indices of refraction between air (where the instrument is characterized and calibrated) and water (where it is operated), a correction factor must be applied to obtain the effective in water radiances. This correction factor is referred to as the immersion factor. There

are two effects contributing. First, the reduction in solid angle viewed by the sensors effectively reduces the amount of flux into the sensor. This correction is given by F1:

$$F1(\lambda) = (\eta_w(\lambda))^2$$

where  $\eta_w$  is the index of refraction of water.

To correct for the calibration values in air, the in-water values are multiplied by the effective loss of viewing area in water (F1).

The second effect is due to the change in index of refraction at the glass/air (glass/water) interface. This correction is given by F2:

$$F2(\lambda) = (\eta_w(\lambda) + \eta_g(\lambda))^2 / ((\eta_w(\lambda) \cdot (1 + \eta_g(\lambda))^2)$$

where  $\eta_g$  is the index of refraction of the window.

Since the indices of refraction of water and glass are better matched, there are less reflection losses at the window. The immersion factor thus increases the in-water values to correct for this effect.

The total immersion effect is then:

$$\text{Imm}(\lambda) = F1(\lambda) \cdot F2(\lambda)$$

Thus the correction for actual in-water radiance values is:

$$L_{w1}(\lambda) = L(\lambda) \cdot \text{Imm}(\lambda)$$

## **6.7 Calibration**

Each instrument is calibrated according to the detailed community consensus procedures embodied in SeaWiFS Technical Memorandum, Vol. 25 (RD 3), augmented with advances made by Satlantic in conjunction with NASA and NIST.

*Absolute Radiometric Calibration, Radiance*

Absolute radiometric radiance calibration is performed with a calibrated 1000W FEL lamp on a 5m optical bar using the 'plaque method'. The lamp is powered by an Optronics 83A current source. The flux from the lamp is normally incident on a 50cm diffuse reflectance target standard at a distance of  $D$  cm. The instrument views the target at an angle of  $45.0^\circ$  such that the field of view of all the sensors is completely covered by the target. The calibration radiances are determined using:

$$L(\lambda) = (E_{lamp}(\lambda, 50\text{cm}) / \pi) * (50.0 \text{ cm} / D \text{ cm})^2 * \rho(\lambda)$$

where:

$L(\lambda)$  is the calibration radiance

$E_{lamp}(\lambda, 50\text{cm})$  is the lamp standard spectral irradiance at 50cm

$(50.0 \text{ cm} / D \text{ cm})^2$  is the  $1/r^2$  distance

$\rho(\lambda)$  is the target standard reflectance

Reflection Target: (Labsphere, calibration traceable to NIST)

Standard Lamp: (Optronics, calibration traceable to NIST)

The demonstrated uncertainty in this method is <3% absolute and <1% relative.

#### *Absolute Radiometric Calibration, Irradiance*

Absolute radiometric irradiance calibration is done using a calibrated 1000W FEL on a 5m optical bar using direct radiation from the lamp. The lamp is powered by an Optronics 83A current source. The flux from the lamp is normally incident on the irradiance sensor cosine collector at a distance of 50cm. The calibration irradiances are determined using equation 2:

$$E(\lambda) = E_{lamp}(\lambda, 50\text{cm}) \cdot (50.0 \text{ cm} / 50 \text{ cm})^2$$

where:

$E(\lambda)$  is the calibration irradiance

$E(\lambda, 50 \text{ cm})$  is the lamp calibration at 50 cm

$(50.0 \text{ cm} / 50 \text{ cm})^2$  is the lamp  $1/R^2$  distance

Standard Lamp: Optronics, traceable to NIST standard

The demonstrated uncertainty in this method is <3% absolute and <1% relative.



## 6.8 Overview of Data Types

### 6.8.1 Reflectances and Profiles

The objective of this activity is the collection and collation of a library of reflectance signatures of the ocean, the “Ocean Background”.

- i. Above water reference downwelling irradiance ( $E_s(\lambda)$ )
- ii. Underwater profiler downwelling irradiance ( $E_d(\lambda)$ ) of the water column
- iii. Underwater profiler upwelling radiance ( $L_u(\lambda)$ ) of the water column

A data collection event includes ancillary data taken coincidentally with the radiance and irradiance measurement (“Instrument Measurement Data”). The following observations were recorded:

- i. Instrument Measurement Data
- ii. Time and location of acquisition

Instrument Measurement Data was acquired and processed as follows:

- i. Level 1 data (time series sample data, in digital instrument counts) was acquired from the sensors onboard the platform.
- ii. Level 2 data (calibrated physical units, i.e.  $\text{W cm}^{-2} \text{nm}^{-1}$  for irradiance;  $\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$  for radiance) was generated using standard instrument software and calibration coefficients derived from a rigorous controlled laboratory absolute radiometric calibration.
- iii. Level 3 data (depth-binned) was generated using standard instrument software.
- iv. Level 4 data (computed reflectance spectrum and propagated surface properties) was generated using standard instrument software.

The ocean background reflectance (Level 4) is derived by analysis of the base measurement data. This analysis was performed using Satlantic software. The measurement of spectral upwelling radiance was propagated to, and through the sea-surface using radiative transfer calculations to provide the water-leaving radiances ( $L_w(\lambda)$ ). These values were then normalized by the downwelling spectral irradiance to compute the remote sensing reflectance,  $R_{rs} = L_w(\lambda) / E_s(\lambda)$ .

## 6.8.2 Chlorophyll-*a*

At each cruise station, water samples were collected for the measurement of various properties, including chlorophyll-*a*. An estimate of chlorophyll-*a* distributions in the equatorial Pacific was made using fluorometric analysis and HPLC. Results for the HPLC measurements are not available at this time. The remainder of this section paraphrases the fluorometric chlorophyll-*a* measurement methods outlined in the JAMSTEC MIRAI Cruise Report (RD2).

Chlorophyll-*a* measurements were carried out using broadband and narrowband filter fluorometers. Broadband filter fluorometers are commonly used for measuring chlorophyll concentrations, but it is recognized that the acidification technique results in errors when chlorophyll-*b* is present. The new non-acidification method developed by Welschmeyer (1994) for narrowband filter fluorometers eliminates the effect of acidification error. Narrowband and broadband filter fluorometers are identical, with the exception of their excitation and emission filters and lamp. Though the Welschmeyer method alleviates the need to consider acidification error, an overestimation of chlorophyll-*a* concentration is still introduced, especially when chlorophyll-*b* is present.

During the cruise, seawater samples were collected at the twelve stations (see Table 2). Samples were collected at 14 depths from 0m to 200m using Niskin bottles, except for the surface water, which was taken by bucket. The samples (0.5L volume) were gently filtered by low vacuum pressure (<20 cmHg) through Nucleopore filters (pore size: 0.4  $\mu$ m; diameter: 47 mm) in the dark room. The sample filters were immediately extracted in the N,N-dimethylformamide (7 ml) and stored at -30 °C until the analysis, which was performed at room temperature.

Traditional acidification and Welschmeyer non-acidification methods were carried out using a Turner design model 10-AU-005 fluorometer. Analytical conditions of the two methods are indicated in Table .

**Table 10. Characteristics of Turner fluorometer for chlorophyll-*a* measurements.**

	Traditional method	Welschmeyer method
Excitation filter /nm	5-60 (340-500nm)	436nm
Emission filter /nm	2-64 (>665nm)	680nm
Optical kit	10-037R	10-040R
Lamp	Daylight White F4T5D	Blue F4T5, B2/BP (F4T4, 5B2 equiv.)
Acidification	Yes (1M HCl, 1min.)	No

## 6.9 Quality Assurance

Several layers of quality assurance were taken during the measurement program. The laboratory calibration provides a first order assurance in that the instrument response is referenced to an internationally traceable reference standard. This calibration took place immediately prior to the field program. Deviations greater than 3% in calibration coefficients are flagged for further investigation via controlled laboratory re-calibration checks. No deviations were noted.

During each field deployment, the operator views the spectrum of both upwelling radiance and downwelling irradiance. Visually identifiable departures from “normal” spectra are noted and are flagged for further investigation via controlled laboratory re-calibration checks.

## 7. Data Reduction/Analysis

The data collection is followed by a defined series of analysis steps, which reduce the collected data to geo-referenced, calibrated, and averaged data products for further statistical analysis. The steps include depth binning and derivation of products, and encompass transitions from Level 1 (raw data) to Level 4 (derived products). The analysis is carried out by the software package ProSoft (Ver. 6.3) developed by Satlantic (copies available on request).

Collected and processed data archiving and organization is based on the level of processing. Data processing was divided into four levels: Level 1, 2, 3 and 4.

- RAW – Level 1 binary data obtained as a result of data acquisition. **(submitted)**
- REF – Level 2 ASCII data obtained as a result of SMSR and OCR3000 reference data calibration and some filtration. **(submitted)**
- PRO – Level 2 ASCII data obtained as a result of SPMR and HyperPro profiler data calibration and some filtration. **(submitted)**
- BIN – Level 3 ASCII data obtained by depth-binning the data. **(submitted)**
- Level 4 files:
  - SPR – ASCII subsurface products for both SPMR/SMSR and HyperPro, containing all casts, one per line, obtained from BIN data propagation to subsurface level. **(submitted)**
- PNG – Data plots for all casts. (submitted PNG images within MR02K01-PLOTS.zip)

### 7.1 Level 1 to Level 2 Conversion

The first step in the analysis of the data is the conversion from Level 1 to Level 2 calibrated, dark corrected data. Calibration files are used, along with calibration darks for the SPMR/SMSR, and shutter darks for the HyperPro, to derive upwelling radiances ( $L_u(\lambda)$ ), and downwelling irradiances ( $E_s(\lambda)$ ), in calibrated physical units ( $\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$  and  $\text{W cm}^{-2} \text{nm}^{-1}$  respectively). The steps involved are:

1. Convert raw binary optical (light and dark) and ancillary data into an integer representation in counts.

- Convert data counts into engineering units in accordance with the calibration equations (see *Satlantic Instrument File Standard V6.0*). The calibration equation for optical data is:

$$L_{DarkDat} = L_{CountsDarkDat} \cdot a \cdot ic \frac{it_1}{it_2}$$

$$L_{LightDat} = L_{CountsLightDat} \cdot a \cdot ic \frac{it_1}{it_2} \quad (1)$$

where  $a$  is a slope,  $ic$  is an immersion coefficient,  $it_1$  is the first integration time and  $it_2$  is the second integration time.  $a$ ,  $ic$  and  $it_2$  are taken from a calibration file, and  $it_1$  is obtained from the same log file as optical data.

- Check the sequence of frame numbers. Blank the frames that are out of sequence.
- Deglint dark data using a first difference filter (optional step for hyperspectral shutter darks only).
- Smooth shutter darks using a running boxcar filter (hyperspectral instruments only).
- Interpolate shutter darks as a function of measurement time to match the number of dark and light data measurements (hyperspectral instruments only).
- Dark correct the light data:

$$L = L_{LightDat} - L_{DarkDat} \quad (2)$$

- Correct light data using a derived temperature correction:

$$L = \frac{L}{0.01(c_1 \cdot w^3 + c_2 \cdot w^2 + c_3 \cdot w + c_4)(T - 20) + 1} \quad (3)$$

where  $c_1$ ,  $c_2$ ,  $c_3$  and  $c_4$  are constants,  $w$  is wavelength and  $T$  is temperature of the radiance or irradiance sensor (here  $c_1 = 6.79131e-9$ ,  $c_2 = -1.09902e-5$ ,  $c_3 = 6.51646e-3$ ,  $c_4 = -1.31056$ ).

## 7.2 Level 2 to Level 3 Conversion

The calibrated Level 2 data includes measured radiances, irradiances and ancillary data types. For the HyperPro, the nature of the spectrometer is such that the specific center wavelengths do not match precisely. In the Level 3 conversion, there are two options. The radiance and irradiance spectra can be interpolated using a linear interpolator, and the interpolated spectra

subsampled at center wavelengths chosen by the operator. Alternatively, optical data can be used at the original wavelengths. For this dataset, the original wavelengths were retained for the hyperspectral instruments. All profiler data is depth-binned at a 1 meter binning interval. The steps of the binning process are:

1. Interpolation of optical data into 1nm wavelength intervals (not performed for this dataset).
2. Natural logarithm transformation of the Level 2 optical data.
3. Data binning. The optical data is divided into equal depth layers. (Note that the number of data points within each layer can vary, since profiler's falling speed is not constant).
4. Data averaging.
5. Application of exponent to mean log transformed data.

### **7.3 Level 3 to Level 4 Conversion**

The Level 3 data serve as the basis for the production of a number of derived information products: “Surface Products”, “Remote Sensing Reflectance”, and “Diffuse Attenuation Coefficient”. These represent a series of mathematical manipulations of the data in the Level 3 files. The “Surface Products” represent the propagation of both radiance and irradiance to a common depth horizon, which is specified as just below the sea surface. For upwelling radiance taken at some depth below the sea-surface the radiance just below the surface is estimated by first computing the spectral attenuation coefficient for spectral radiance based on statistical computations using a ratio of blue to green wavebands as input. This attenuation coefficient governs the propagation of radiance to the surface based on an exponential model, and this model is used to determine the upwelling radiance just below the sea-surface. For irradiance, the above-water measurement is used and propagated through the sea-surface using an estimated albedo.

Subsurface values are derived from the near-surface data recorded at the start of a cast. Each set of these spectra is then combined to produce the Level 4 data.

Remote sensing reflectances are produced by propagating the radiance at a level just below the sea-surface through the surface by use of Fresnel reflectances, giving water-leaving radiances ( $L_w(\lambda)$ ). These are then divided by the above-water irradiances on a band by band basis to produce remote sensing reflectances.

### **7.4 Processing Configurations**

#### **7.4.1 SPMR / SMSR**

- Pressure Tare performed with Ed sensor just below surface
- Ed – Lu distance (1.14m)
- Es distance to surface (0m)
- Dark correction: calibration file used

- Number of bins regressed for computing K (NUM\_K\_BINS) = 9
- Binning interval: 1m

#### 7.4.2 HyperPro

- Ed – Lu distance (0.35m)
- Es distance to surface (0m)
- Shutter darks used for dark correction
- Binning interval: 1m

### 8. Data SUBMISSION

This SeaBASS data submission includes the following:

**Table 11. Data Submitted**

<b>Data type</b>	<b>Comments</b>
SPMR/SMSR depth-binned data	Level 3 depth-binned data (BIN) files
HyperPro depth-binned data	Level 3 depth-binned data (BIN) files
SPMR/SMSR subsurface data	Level 4 subsurface spectra data (SPR) file
HyperPro subsurface data	Level 4 subsurface spectra data (SPR) file
Data plots (PNG image files)	Data plots for each station (MR02K01-PLOTS.ZIP)

## 9. Sample Plots

Sample plots from the westernmost (bluest water) and easternmost station casts are included below. The complete set of plots for all casts is included with the submission in the file MR02K01-PLOTS.zip.

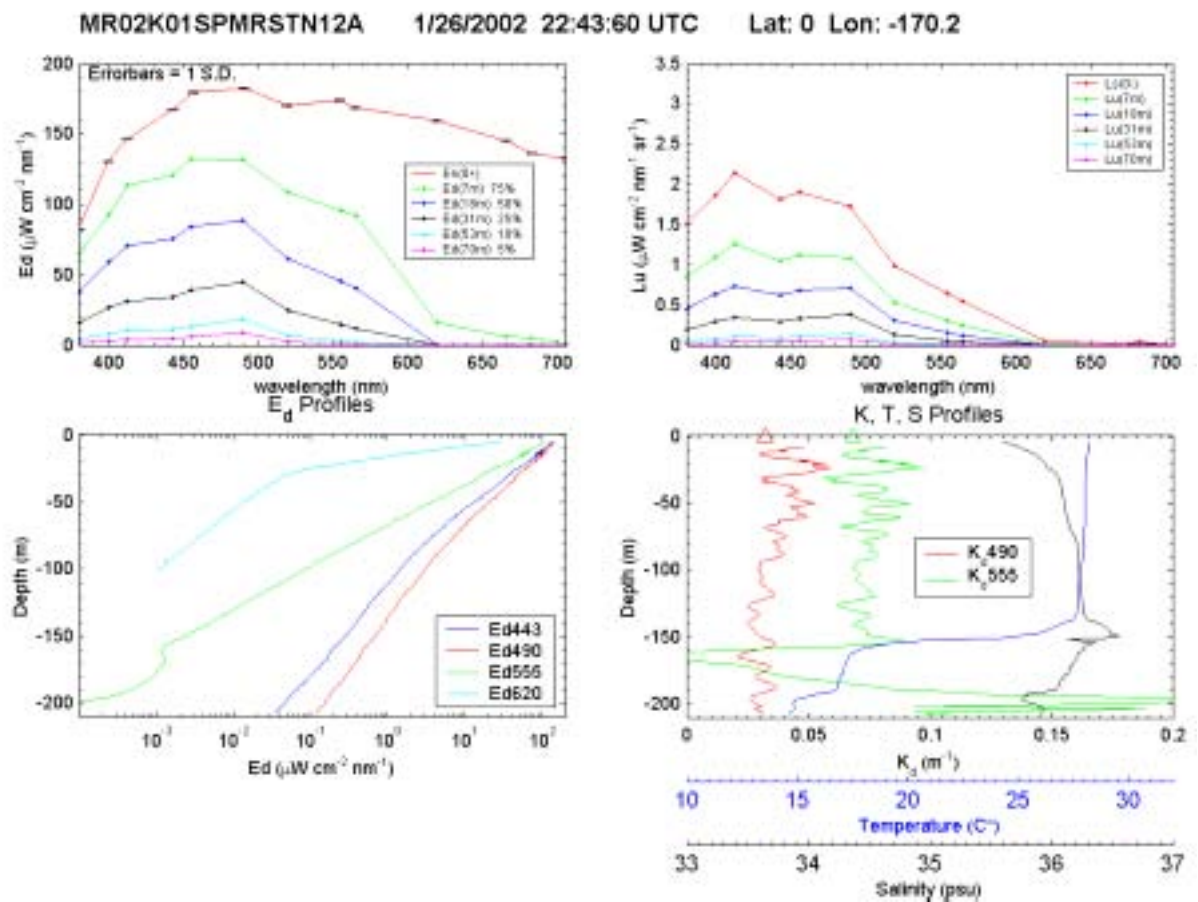


Figure 10. Sample plot 1 for Station MR02K01SPMRSTN12, Cast A.

MR02K01SPMRSTN12A 1/26/2002 22:43:60 UTC Lat: 0 Lon: -170.2

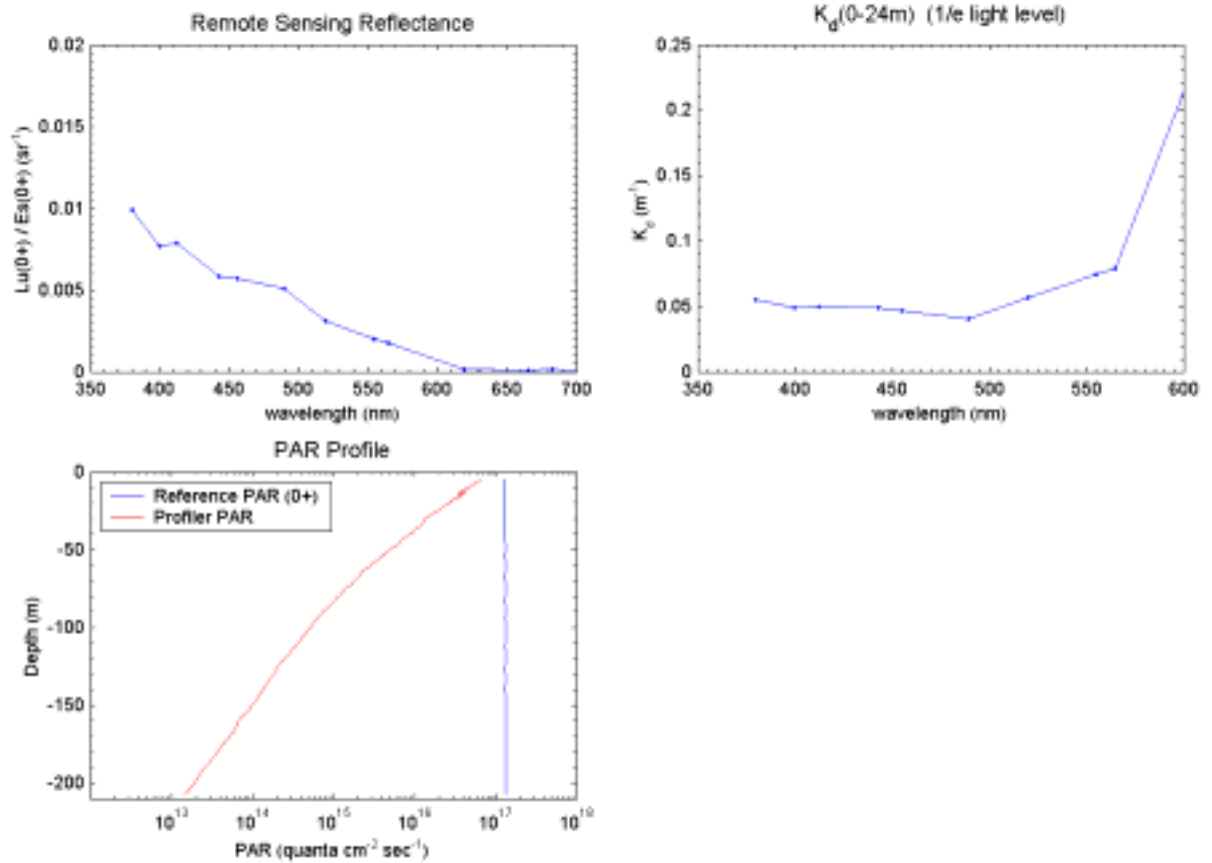


Figure 11. Sample plot 2 for Station MR02K01SPMRSTN12, Cast A.



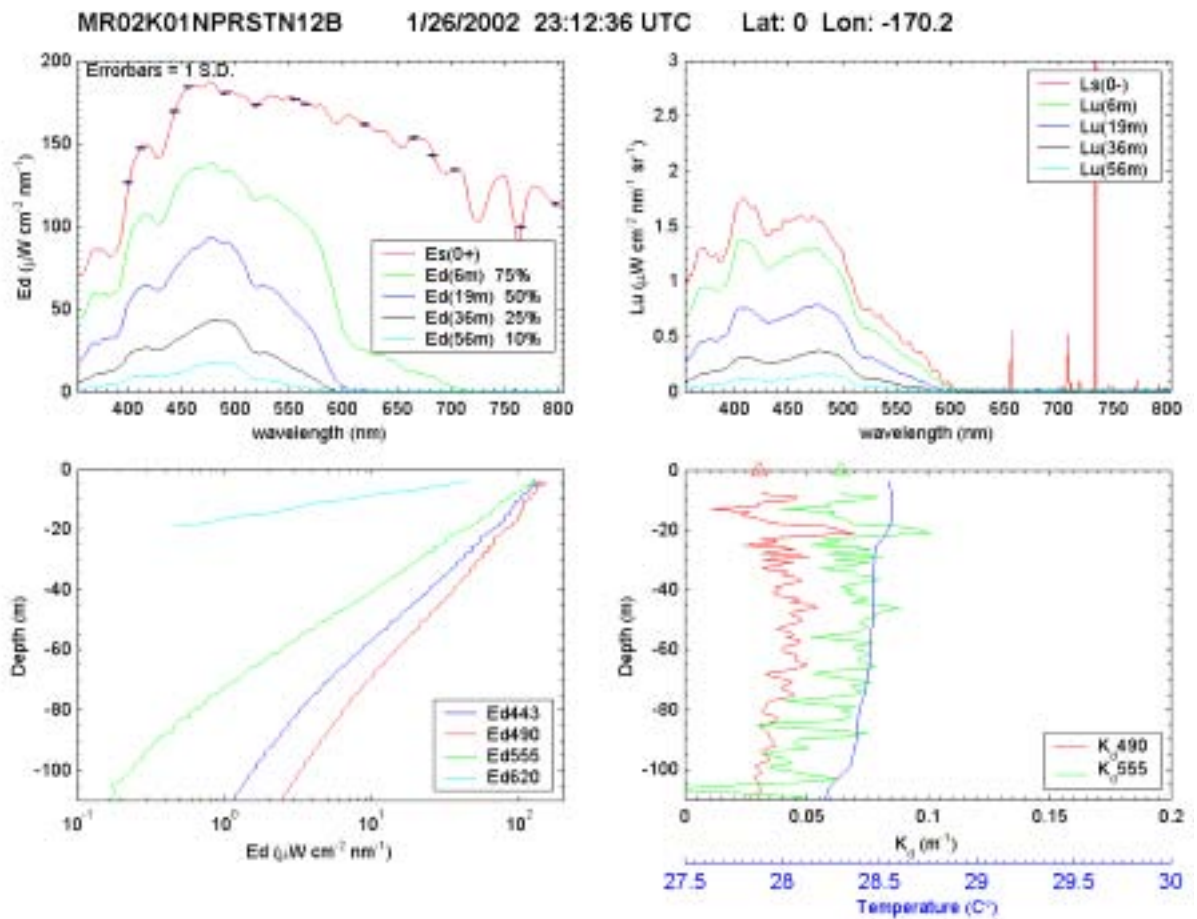


Figure 12. Sample plot 1 for Station MR02K01NPRSTN12, Cast B.

MR02K01NPRSTN12B

1/26/2002 23:12:36 UTC

Lat: 0 Lon: -170.2

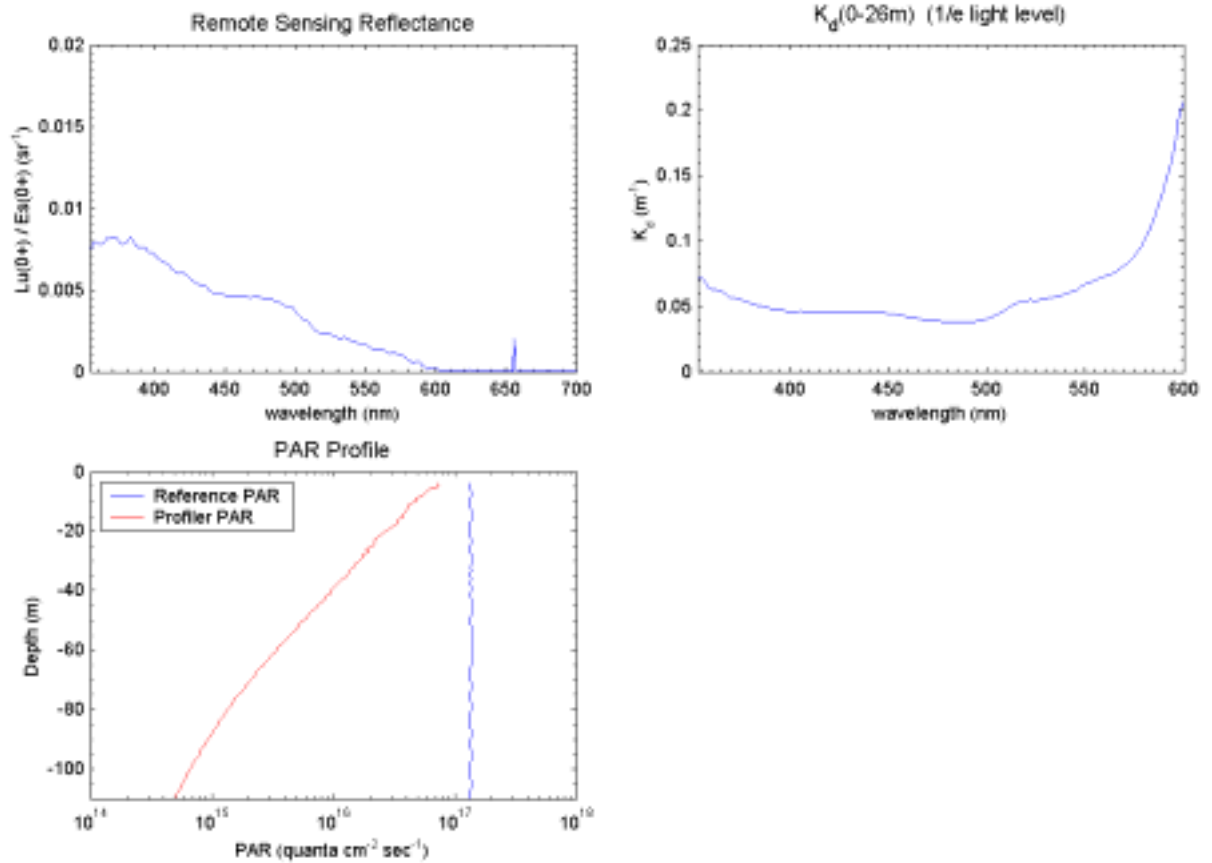


Figure 13. Sample plot 2 for Station MR02K01NPRSTN12, Cast B.

MR02K01SPMRSTN04B 2/5/2002 01:45:00 UTC Lat: 0 Lon: 149.8

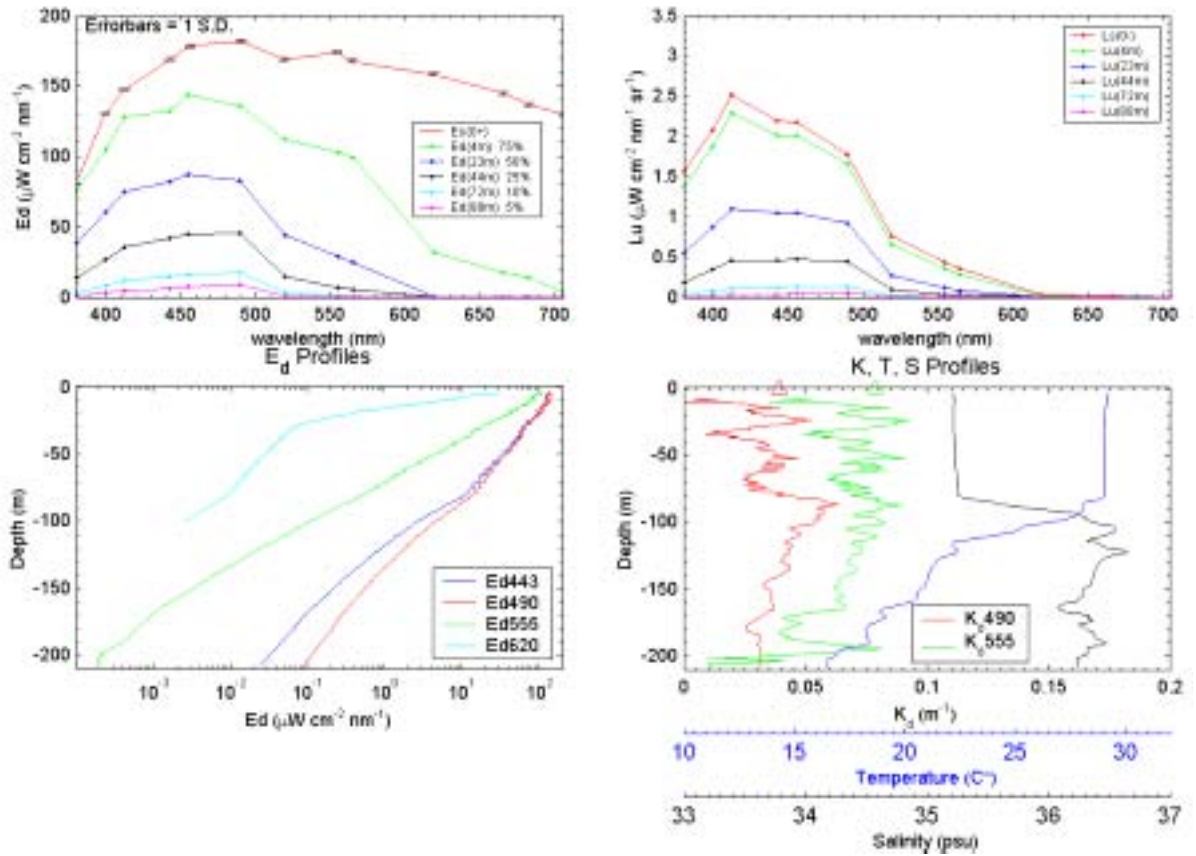


Figure 14. Sample plot 1 for Station MR02K01SPMRSTN04, Cast B.

MR02K01SPMRSTN04B 2/5/2002 01:45:00 UTC Lat: 0 Lon: 149.8

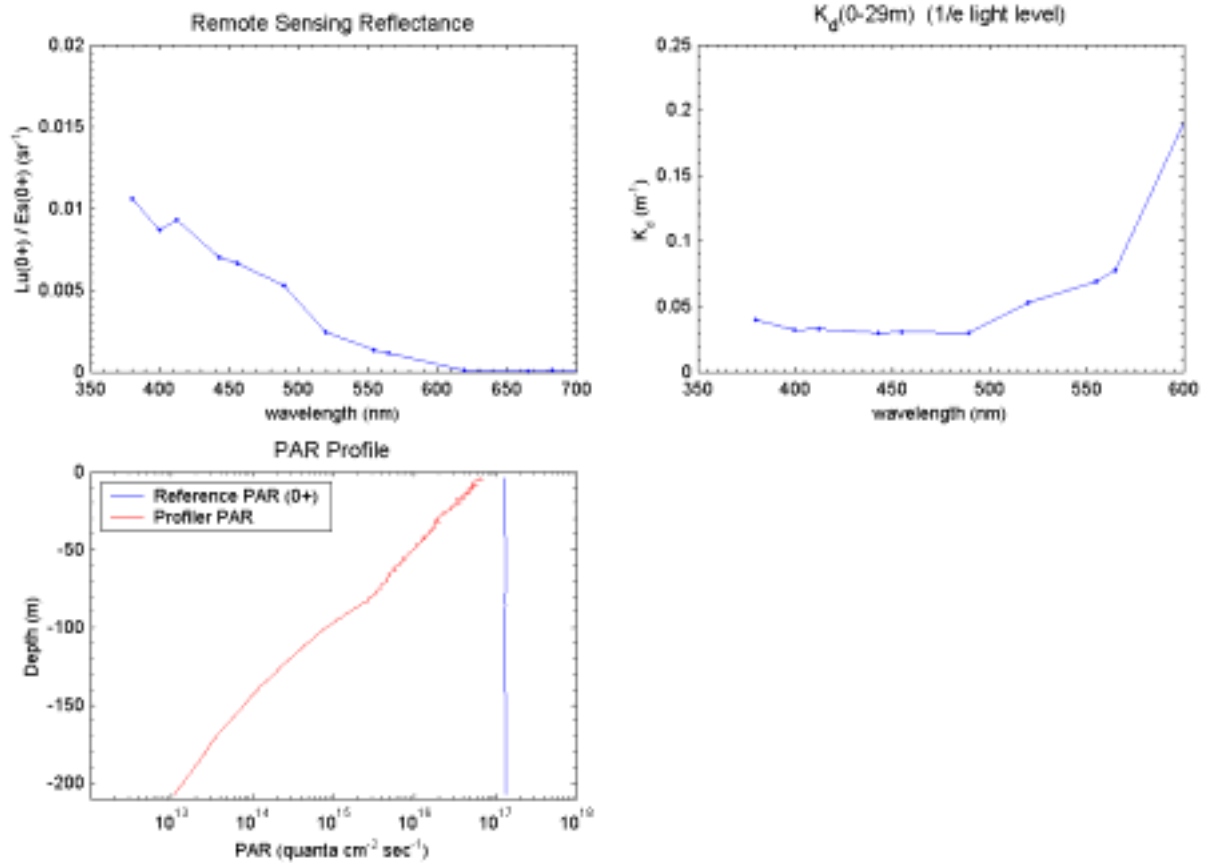


Figure 15. Sample plot 2 for Station MR02K01SPMRSTN04, Cast B.

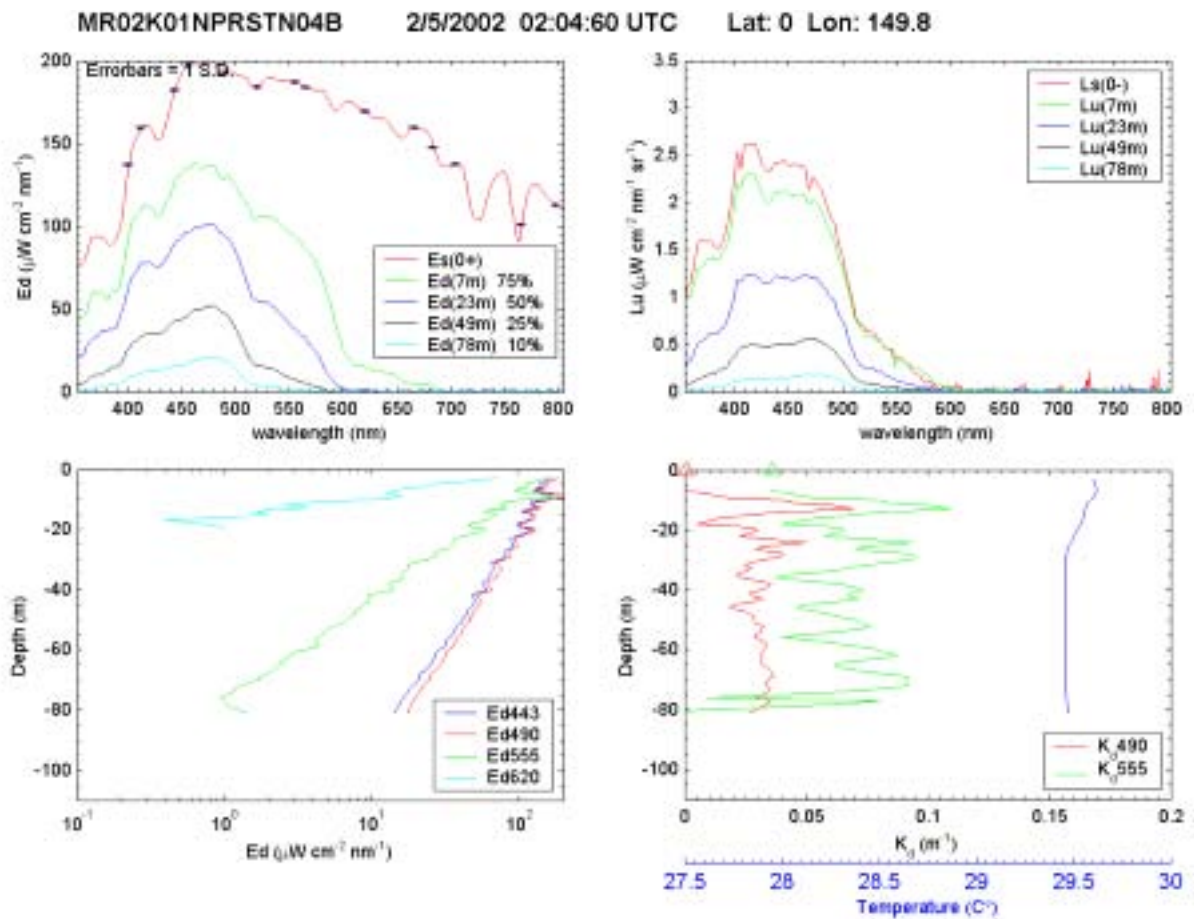


Figure 16. Sample plot 1 for Station MR02K01NPRSTN04, Cast B.

MR02K01NPRSTN04B 2/5/2002 02:04:60 UTC Lat: 0 Lon: 149.8

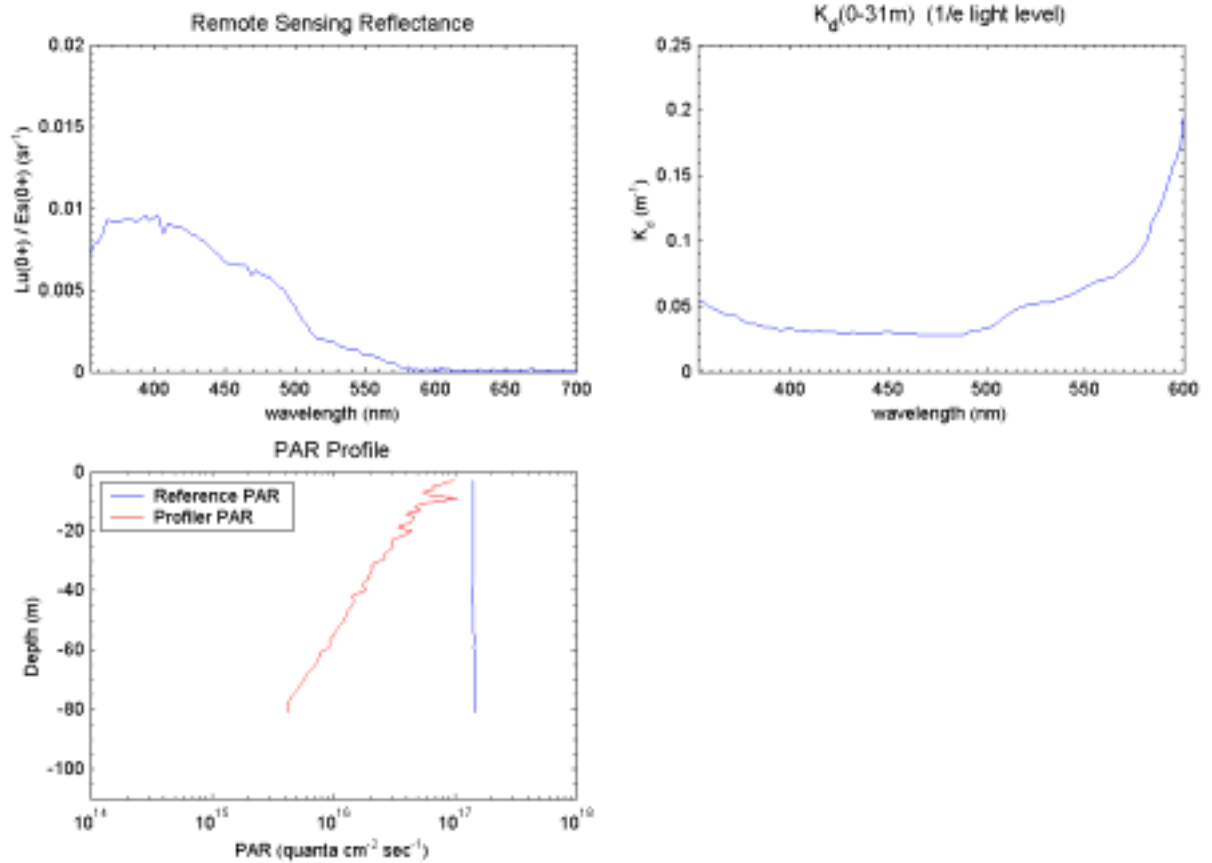


Figure 17. Sample plot 2 for Station MR02K01NPRSTN04, Cast B.

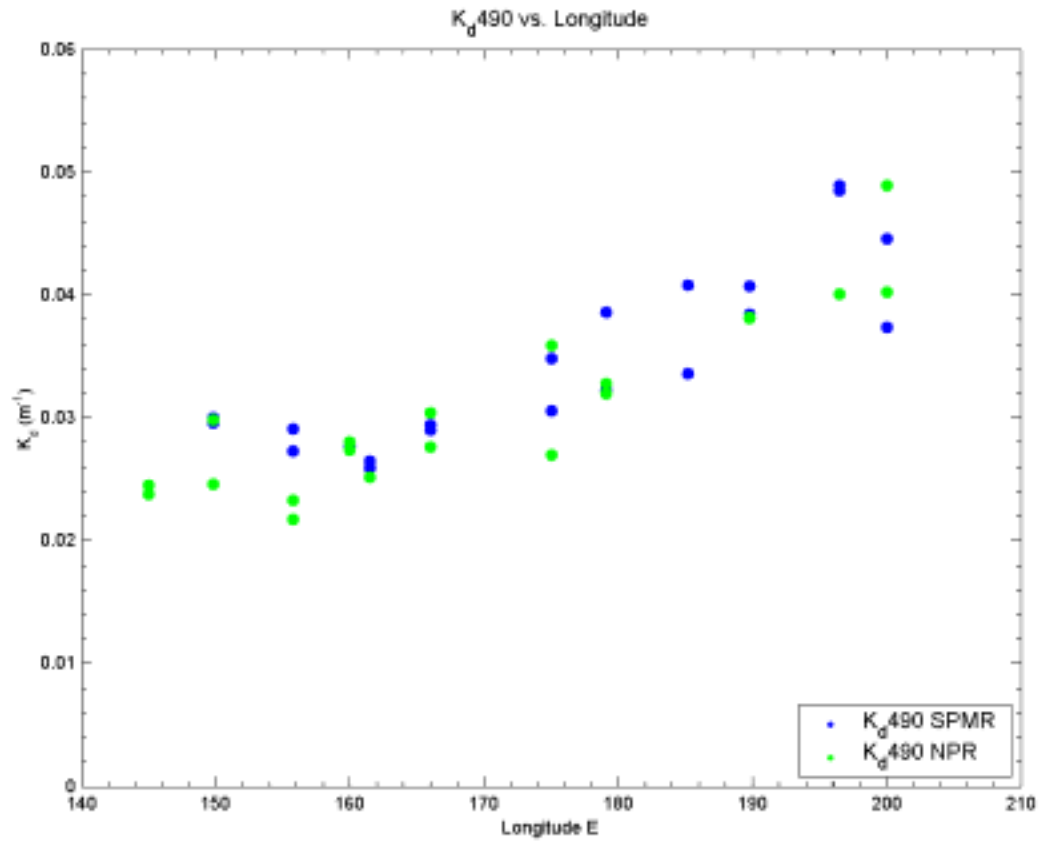
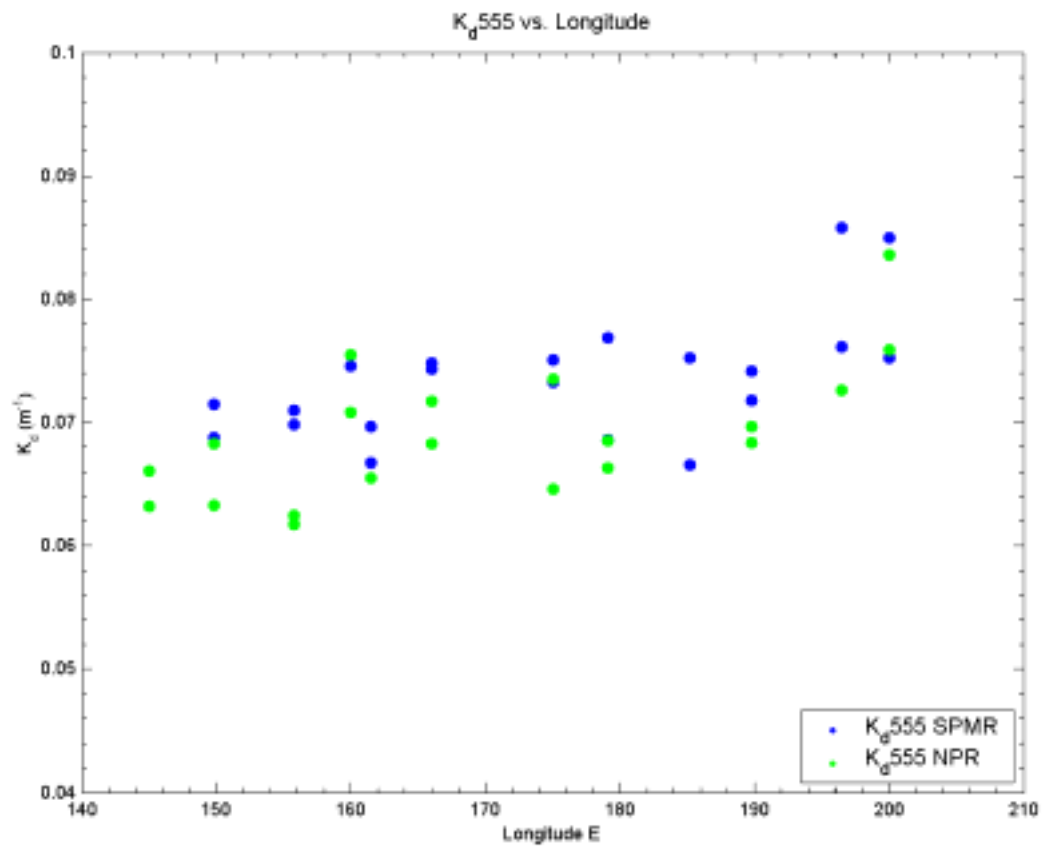


Figure 18. Comparison plot of K<sub>d</sub>490 vs. longitude obtained from the SPMR and NPR.



**Figure 19. Comparison plot of Kd555 vs. longitude obtained from the SPMR and NPR.**



### **3.22 Satellite observation**

Takeshi Kawano, JAMSTEC

Ichio Asanuma, EORC/NASDA

Takanori Akiyoshi, Nippon Hakuyo Electronics

#### ***Objectives***

It is our objectives to monitor the ocean color and the sea surface temperature, to build the data set of those parameters, and to build the practical algorithm to estimate the primary production.

#### ***Methods***

##### a) Ocean Color

We receive the down link HRPT signal from the OrbView-2 polar orbit satellite by the HRPT receiving station on the R/V Mirai. Our receiving station is the TeraScan receiving system, which has the 1.2 m antenna in the redome, the down converter, the bit synchronizer, the frame synchronizer, and the workstation to control antenna and to process received data.

We generated the level-0 data from the pass disk of the receiving system with the function 'swlevel-0', which is a products of SeaSpace. Then we generated the level-1a data by the function 'run11a', which is a software of NASA. Then we processed data into the geophysical values including chlorophyll-a by the function in the SeaDAS.

##### b). Sea Surface Temperature

We receive the down link HRPT signal from the NOAA polar orbit satellite by the same way as the signal of the OrbView-2. We processed the HRPT signal with the inflight calibration and computed the sea surface temperature by the multi-channel sea surface temperature method. We projected the data on the map, which covers 20S to 20N and 150E to 130W. In the daily steps, we overlaid data of 6 to 8 passes to generate a daily composite. Finally, we generated two images of the weekly composite for this cruise.

#### Data

Data will be analyzed after the cruise.

### 3.23 Geophysical Observation

#### 3.23.1 Multi arrow Beam Echo sounding System

(1) Personnel

Satoshi Okumura and Shinya Iwamida ( GODI )

(2) Objective

R/V Mirai has installed a multi narrow beam echo sounding system(MNBES), SeaBeam 2112.004 (SeaBeam Inc., USA). The main objective of MNBES observation is collecting continuous bathymetry data along ship's track to make a contribution to geological and geophysical investigations.

(3) Method

We had carried out bathymetric survey from the departure of Yokohama on 7 January 2002 to the arrival of Sekinehama on 15 February 2002. This observation was made exclude the area of foreign EEZ and territorial sea.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used temperature and salinity profiles from CTD data and calculated sound velocity by equation in Mackenzie (1981).

System configuration and performance

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

Depth accuracy: Within  $< 0.5\%$  of depth or  $\pm 1$  m,  
(whichever is greater, over the entire swath)

(4) Preliminary result

The results will be public after the analysis.

(5) Data archives

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

### 3.23.2 Surface three component magnetometer

**\*This observation was made in the international waters and EEZ of Japan.**

#### Personnel

Satoshi Okumura ( GODI )

Shinya Iwamida ( GODI )

#### (1) Objective

To obtain the geomagnetic field vectors on the sea surface continuously by three-component magnetometer system for contribution to geophysical investigation.

The magnetic force on the sea is affected by induction of magnetized body beneath the sub-bottom in addition to the earth dipole magnetic field. The magnetic measurement on the sea is, therefore, one of utilities for geophysical reconstruction of crustal structure and so on. The geomagnetic field can be divided into three components, i.e., two horizontal (x&y) and one vertical(z) moments. Three-component observation instead of total force includes much information of magnetic structure of magnetized bodies.

#### (2) Method

The sensor is a three axis fluxgate magnetometer (SFG-1214; Tierra technica, Japan) on the top of foremast at 8 Hz sampling rate. Every record includes; navigation information, three-component of magnetic forces and attitude data.

#### (3) Preliminary result

During MR02-K01 cruise, the magnetic force is measured within Japanese territorial sea, Japanese EEZ and the open sea. The results will be public after the analysis. The procedure of quality control is mainly to eliminate the effect of ship's magnetized vector condition.

#### (4) Data archives

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

### 3.23.3 Sea Surface Gravity

**\*This observation was made in the international waters and EEZ of Japan.**

#### (1) Personnel

Satoshi Okumura (GODI)

Shinya Iwamida (GODI)

#### (1) Method

We measured relative gravity value by LaCoste-Ronberg onboard gravity meter S-116 within Japanese territorial sea, Japanese EEZ and the open sea to obtain the continuous gravity measurement for contribution of geophysical investigations.

We also measured relative gravity value at comparative points at Sekinehama port, where the absolute gravity value have been known, using by portable gravity meter CG-3M Autogav (SCINTREX, Canada). To determine the drift ratio during this cruise, we need to measure the absolute gravity values at Yokohama port (No.1-Berth, Yamashita wharf; where Mirai departed). The mechanical drift of our sensor, in our experience, would be less than 0.1mgal during this cruise.

#### (2) Preliminary results

The results will be public after the analysis.

#### (3) Data archives

Sea surface gravity data obtained during this cruise will be submitted to JAMSTEC Data Management Division and will be under their control.

#### **4. Acknowledgement**

We thank Capt. Hashimoto, the commanding officer of MIRAI, and his crew for their skillful and diligent work. We also thank Mr. Kamatie Kautu for his useful advice during the cruise.