KH-13-Furuya (KH-13-7) Cruise Report

Apr 7 2014

R/V Hakuho-maru

Directed by Hiroshi Ogawa (Atmosphere and Ocean Research Institute, The University of Tokyo)

Dec 22 2013 – Dec 25 2013 (Leg 1)
Cruise Area: South Pacific Ocean

Including:

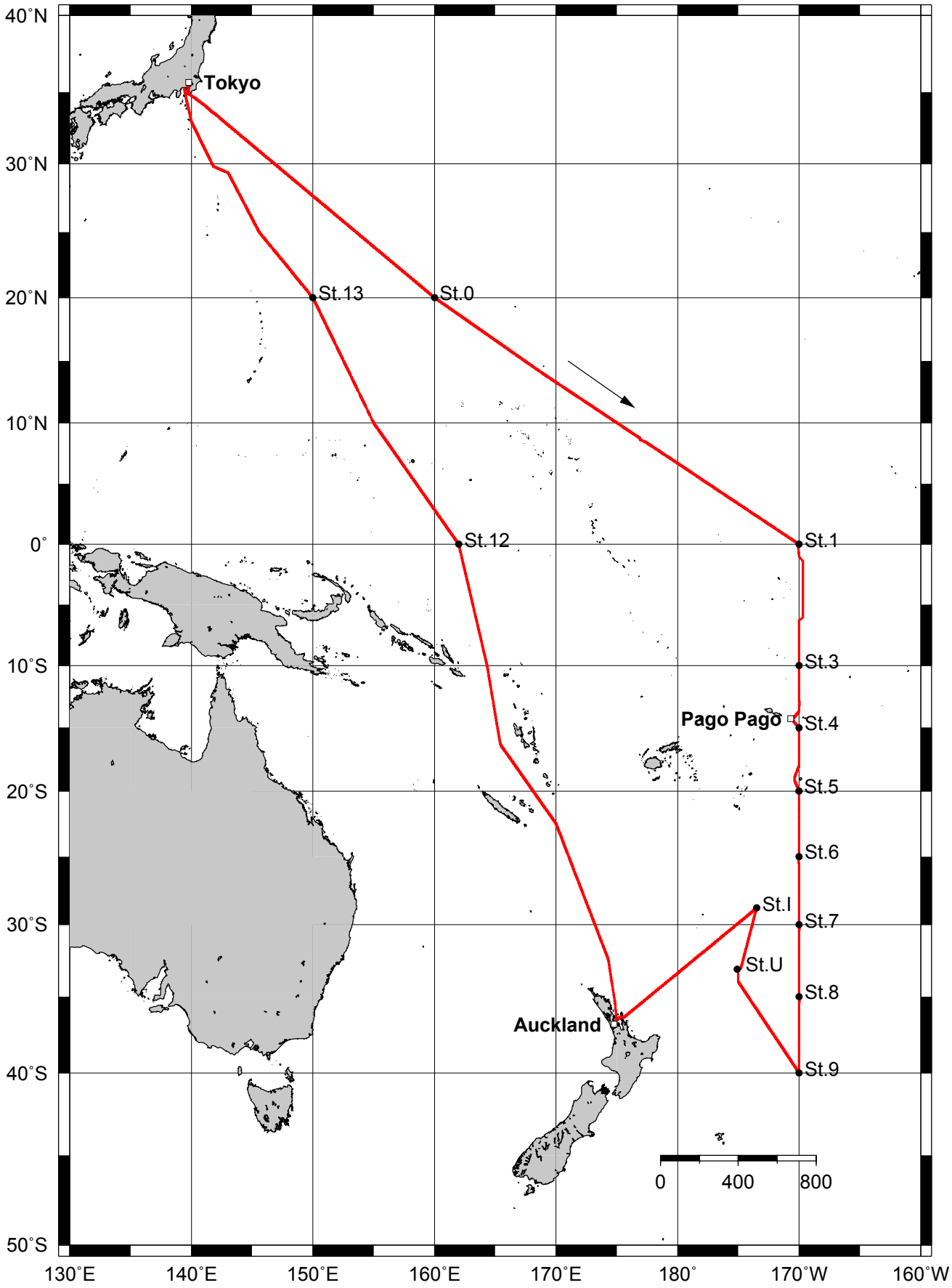
Cruise Track

Working Log

Preliminary results

Scientist List

KH−13−7


40˚N
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Tokyo
St.13
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St.I
St.7
St.U
St.8
Auckland
St.9
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400
800

Date	Time	Latitude	Longitude	Station	
131222	1727	00 20.482N	170 30.508W		ENTERED KIRIBATI EEZ
131222	1742	00 18.556N	170 27.746W		UNDERWAY-CTD STARTED (U-205)
131222	1743	00 18.463N	170 27.614W		UNDERWAY-CTD DEEPEST
131222	1756	00 16.814N	170 25.161W		UNDERWAY-CTD FINISHED
131222	1804	00 15.810N	170 23.662W		UNDERWAY-CTD STARTED (U-206)
131222	1805	00 15.720N	170 23.524W		UNDERWAY-CTD DEEPEST
131222	1816	00 14.286N	170 21.376W		UNDERWAY-CTD FINISHED
131222	1825	00 13.215N	170 19.755W		UNDERWAY-CTD STARTED (U-207)
131222	1826	00 13.124N	170 19.617W		UNDERWAY-CTD DEEPEST
131222	1837	00 11.780N	170 17.566W		UNDERWAY-CTD FINISHED
131222	1846	00 10.617N	170 15.874W		UNDERWAY-CTD STARTED (U-208)
131222	1847	00 10.517N	170 15.730W		UNDERWAY-CTD DEEPEST
131222	1859	00 08.963N	170 13.502W		UNDERWAY-CTD FINISHED
131222	1911	00 07.443N	170 11.179W		UNDERWAY-CTD STARTED (U-209)
131222	1912	00 07.365N	170 11.058W		UNDERWAY-CTD DEEPEST
131222	1925	00 05.827N	170 08.667W		UNDERWAY-CTD FINISHED
131222	1933	00 04.734N	170 07.014W		UNDERWAY-CTD STARTED (U-210)
131222	1934	00 04.640N	170 06.874W		UNDERWAY-CTD DEEPEST
131222	1948	00 02.955N	170 04.362W		UNDERWAY-CTD FINISHED
131222	1955	00 01.992N	170 02.955W		UNDERWAY-CTD STARTED (U-211)
131222	1956	00 01.917N	170 02.843W		UNDERWAY-CTD DEEPEST
131222	2005	00 00.741N	170 01.098W		S/B ENG
131222	2008	00 00.443N	170 00.657W		UNDERWAY-CTD FINISHED
131222	2014	00 00.010S	169 59.978W		PASSED EQUATOR
131222	2015	00 00.027S	169 59.956W		STOPPED ENG
131222	2018	00 00.054S	169 59.924W		CHANGED ENG TO E/M
131222	2103	00 00.419N	170 00.453W	ST1	HYPER PRO STARTED
131222	2115	00 00.544N	170 00.494W	ST1	HYPER PRO FINISHED
131222	2140	00 00.620S	170 00.626W	ST1	SETTING OF SEDIMENT TRAP STARTED
131222	2222	00 00.321S	170 00.340W	ST1	SETTING OF SEDIMENT TRAP FINISHED
131222	2222	00 00.321S	170 00.340W	ST1	SEDIMENT TRAP RELEASED
131222	2240	00 00.158N	169 59.923W	ST1	CTD-CMS STARTED
131222	2302	00 00.392N	169 59.894W	ST1	NORPAC NET STARTED
131222	2312	00 00.464N	169 59.875W	ST1	NORPAC NET FINISHED
131222	2317	00 00.489N	169 59.835W	ST1	NORPAC NET STARTED
131222	2330	00 00.542N	169 59.791W	ST1	NORPAC NET FINISHED
131222	2348	00 00.592N	169 59.695W	ST1	NORPAC NET STARTED
131223	1	00 00.638N	169 59.685W	ST1	NORPAC NET FINISHED
131223	5	00 00.646N	169 59.677W	ST1	NORPAC NET STARTED
131223	18	00 00.670N	169 59.662W	ST1	NORPAC NET FINISHED
131223	19	00 00.671N	169 59.662W	ST1	STARTED BREEDING NET

131223	25	00 00.681N	169 59.670W	ST1	CTD-CMS DEEPEST
131223	42	00 00.765N	169 59.674W	ST1	FINISHED BREEDING NET
131223	216	00 01.110N	169 59.663W	ST1	CTD-CMS FINISHED
131223	247	00 01.209N	170 00.009W	ST1	VMPS NET STARTED
131223	336	00 01.514N	170 00.179W	ST1	VMPS NET DEEPEST
131223	425	00 01.814N	170 00.208W	ST1	VMPS NET FINISHED
131223	451	00 01.885N	170 00.297W	ST1	TURBO-VMP STARTED
131223	500	00 01.956N	170 00.565W	ST1	TURBO-VMP DEEPEST
131223	509	00 02.027N	170 00.849W	ST1	TURBO-VMP FINISHED
131223	509	00 02.029N	170 00.855W	ST1	TURBO-VMP STARTED
131223	516	00 02.077N	170 01.067W	ST1	TURBO-VMP DEEPEST
131223	522	00 02.124N	170 01.249W	ST1	SUNSET & PUT ON REGULATION LIGHTS
131223	526	00 02.167N	170 01.363W	ST1	TURBO-VMP FINISHED
131223	622	00 00.010N	170 00.045W	ST1	CTD-CMS STARTED
131223	635	00 00.137N	170 00.236W	ST1	CTD-CMS DEEPEST
131223	658	00 00.326N	170 00.430W	ST1	CTD-CMS FINISHED
131223	707	00 00.381N	170 00.651W	ST1	ORI NET STARTED
131223	743	00 01.278N	170 00.150W	ST1	ORI NET DEEPEST
131223	841	00 02.347N	169 59.181W	ST1	ORI NET FINISHED
131223	849	00 02.377N	169 59.278W	ST1	IKMT NET STARTED
131223	938	00 03.147N	169 56.870W	ST1	IKMT NET DEEPEST
131223	1115	00 04.491N	169 52.873W	ST1	IKMT NET FINISHED
131223	1225	00 00.003S	170 00.060W	ST1	CTD-CMS STARTED
131223	1252	00 00.197N	170 00.098W	ST1	CTD-CMS DEEPEST
131223	1328	00 00.454N	170 00.022W	ST1	CTD-CMS FINISHED
131223	1348	00 00.595N	170 00.401W	ST1	VMPS NET STARTED
131223	1403	00 00.743N	170 00.437W	ST1	VMPS NET DEEPEST
131223	1420	00 00.879N	170 00.459W	ST1	VMPS NET FINISHED
131223	1433	00 00.967N	170 00.639W	ST1	VMPS NET STARTED
131223	1513	00 01.207N	170 00.604W	ST1	VMPS NET DEEPEST
131223	1602	00 01.586N	170 00.615W	ST1	VMPS NET FINISHED
131223	1659	00 00.506S	170 00.090W	ST1	CTD-CMS STARTED
131223	1715	00 00.402S	170 00.328W	ST1	SUNRISE & PUT OFF REGULATION LIGHTS
131223	1717	00 00.382S	170 00.310W	ST1	CTD-CMS DEEPEST
131223	1743	00 00.239S	170 00.483W	ST1	CTD-CMS FINISHED
131223	1753	00 00.238S	170 00.785W	ST1	VMP2000 STARTED
131223	1817	00 00.340S	170 01.720W	ST1	VMP2000 DEEPEST
131223	1901	00 00.458S	170 03.267W	ST1	VMP2000 FINISHED
131223	1951	00 00.020N	170 00.002W	ST1	CTD-CMS STARTED
131223	2010	00 00.125N	170 00.004W	ST1	CTD-CMS DEEPEST
131223	2037	00 00.275N	170 00.062W	ST1	CTD-CMS FINISHED
131223	2101	00 00.031S	170 00.007W	ST1	CTD-CMS STARTED

131223	2111	00 00.016N	170 00.124W	ST1	CTD-CMS DEEPEST
131223	2130	00 00.188N	170 00.206W	ST1	CTD-CMS FINISHED
131223	2142	00 00.232N	170 00.515W	ST1	LISST STARTED
131223	2152	00 00.265N	170 00.713W	ST1	LISST DEEPEST
131223	2254	00 00.959N	170 00.990W	ST1	LISST FINISHED
131223	2347	00 03.243N	170 05.625W	ST1	RETRIEVING OF SEDIMENT TRAP STARTED
131223	2356	00 03.323N	170 05.616W	ST1	RETRIEVING OF SEDIMENT TRAP FINISHED
131224	8	00 03.341N	170 05.785W		CHANGED ENG TO T/M
131224	11	00 03.184N	170 05.823W		S/CO ON 180°
131224	12	00 03.135N	170 05.819W		UNDERWAY-CTD STARTED (U-212)
131224	12	00 03.062N	170 05.811W		UNDERWAY-CTD DEEPEST
131224	20	00 01.889N	170 05.686W		UNDERWAY-CTD FINISHED
131224	30	00 00.401S	170 05.404W		R/UP ENG
131224	30	00 00.413S	170 05.403W		UNDERWAY-CTD STARTED (U-213)
131224	30	00 00.513S	170 05.389W		UNDERWAY-CTD DEEPEST
131224	50	00 05.210S	170 04.838W		UNDERWAY-CTD FINISHED
131224	50	00 05.230S	170 04.837W		UNDERWAY-CTD STARTED (U-214)
131224	51	00 05.332S	170 04.828W		UNDERWAY-CTD DEEPEST
131224	101	00 07.790S	170 04.616W		UNDERWAY-CTD FINISHED
131224	110	00 09.967S	170 04.458W		UNDERWAY-CTD STARTED (U-215, data not acquired)
131224	110	00 10.170S	170 04.443W		UNDERWAY-CTD DEEPEST
131224	121	00 12.705S	170 04.269W		UNDERWAY-CTD FINISHED
131224	131	00 15.152S	170 04.106W		UNDERWAY-CTD STARTED (U-216)
131224	134	00 15.944S	170 04.042W		UNDERWAY-CTD DEEPEST
131224	143	00 18.056S	170 03.831W		UNDERWAY-CTD FINISHED
131224	155	00 20.974S	170 03.557W		UNDERWAY-CTD STARTED (U-217)
131224	156	00 21.327S	170 03.526W		UNDERWAY-CTD DEEPEST
131224	207	00 23.889S	170 03.287W		UNDERWAY-CTD FINISHED
131224	215	00 25.852S	170 03.103W		UNDERWAY-CTD STARTED (U-218)
131224	216	00 26.059S	170 03.081W		UNDERWAY-CTD DEEPEST
131224	225	00 28.386S	170 02.866W		UNDERWAY-CTD FINISHED
131224	244	00 33.107S	170 02.453W		UNDERWAY-CTD STARTED (U-219)
131224	245	00 33.291S	170 02.437W		UNDERWAY-CTD DEEPEST
131224	254	00 35.526S	170 02.239W		UNDERWAY-CTD FINISHED
131224	305	00 38.031S	170 02.026W		UNDERWAY-CTD STARTED (U-220)
131224	306	00 38.225S	170 02.011W		UNDERWAY-CTD DEEPEST
131224	315	00 40.585S	170 01.810W		UNDERWAY-CTD FINISHED
131224	325	00 42.892S	170 01.616W		UNDERWAY-CTD STARTED (U-221)
131224	326	00 43.075S	170 01.599W		UNDERWAY-CTD DEEPEST
131224	335	00 45.375S	170 01.394W		UNDERWAY-CTD FINISHED
131224	350	00 48.966S	170 01.081W		UNDERWAY-CTD STARTED (U-222)
131224	350	00 49.151S	170 01.065W		UNDERWAY-CTD DEEPEST

131224	400	00 51.455S	170 00.889W	UNDERWAY-CTD FINISHED
131225	2127	06 46.022S	170 00.011W	CLEARED OUT KIRIBATI EEZ & ENTERED N.Z. EEZ

KH-13-7	St. 01-1(Deep)	Depth	5395m
Date:	2013/12/22	Lat.	0 00.21N
Time:	22:45	Long.	169 59.91W

CTD data (LAY)	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
	Sur.	27.7	***	***	***
	10	27.320	35.478	3.8459	0.4140
	20	27.256	35.477	3.9264	0.7270
	30	27.241	35.476	3.9527	0.8740
	40	27.228	35.475	3.9486	1.1200
	50	27.216	35.473	3.9354	1.1300
	75	27.045	35.449	3.7555	0.9340
	100	26.667	35.414	3.5071	0.5260
	125	24.144	35.098	2.9620	0.1980
	150	20.359	35.156	2.8327	0.1130
	175	17.630	35.157	2.8620	0.0848
	200	16.197	35.171	2.9979	0.0714
	250	13.136	34.925	2.7520	0.0693
	300	11.669	34.830	2.0472	0.0727
	400	10.015	34.729	1.8889	0.0747
	500	8.052	34.620	0.8963	0.0855
	600	7.061	34.577	1.2418	0.0855
	700	6.273	34.554	1.4971	0.0846
	800	5.424	34.543	1.7706	0.0825
	900	5.120	34.544	1.8131	0.0815
	1000	4.730	34.550	1.7966	0.0833
	1200	3.883	34.572	1.8332	0.0851
	1500	3.173	34.597	1.9930	0.0858
	2000	2.292	34.637	2.3686	0.0827
	2500	1.902	34.660	2.6088	0.0811
	3000	1.705	34.671	2.8369	0.0788
	3500	1.517	34.683	3.1858	0.0757
	4000	1.411	34.693	3.4598	0.0753
	4500	1.264	34.702	3.8717	0.0736
	5000	1.264	34.705	3.9803	0.0728

CTD data (BTL)

BTL No.	Depth m	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
1	5367	5465.8	1.315	34.704	3.7026	0.0716
2	4912	4996.5	1.262	34.704	3.7197	0.0713
3	3941	4000.1	1.408	34.692	3.2227	0.0738
4	2963	3000.2	1.700	34.667	2.6285	0.0787
5	2470	2498.1	1.899	34.658	2.3975	0.0808
6	1979	1999.4	2.302	34.635	2.1808	0.0824
7	1486	1499.3	3.205	34.595	1.8152	0.0862
8	992	1000.1	4.682	34.542	1.6497	0.0848
9	5368	5466.0	1.315	34.704	3.7063	0.0712
10	5367	5465.6	1.315	34.704	3.7178	0.0721
11	5367	5465.9	1.315	34.704	3.6973	0.0709
12	5367	5465.4	1.315	34.704	3.7062	0.0712
13	5367	5465.8	1.315	34.704	3.7076	0.0712
14	5368	5466.5	1.315	34.704	3.6890	0.0701
15	4911	4995.5	1.262	34.704	3.7059	0.0712
16	2963	3000.1	1.701	34.671	2.6322	0.0792
17	2962	2999.3	1.698	34.671	2.6260	0.0789
18	2962	2999.3	1.699	34.670	2.6236	0.0786
19	1979	1999.1	2.303	34.636	2.1703	0.0830
20	1979	1999.0	2.303	34.636	2.1805	0.0834
21	1979	1999.7	2.304	34.636	2.1829	0.0824
22	993	1000.5	4.695	34.546	1.6361	0.0854
23	992	999.9	4.692	34.547	1.6620	0.0854
24	992	999.8	4.694	34.549	1.6440	0.0854

KH-13-7	St. 01-2(Light Evening)	Depth	5430m
Date:	2013/12/23	Lat.	0 00.04N
Time:	06:26	Long.	170 00.13W

CTD data (LAY)	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
	Sur.	27.6	***	***	***
	10	27.347	35.486	3.8965	1.2600
	20	27.305	35.484	3.9726	1.4600
	30	27.232	35.483	3.9536	1.5600
	40	27.213	35.483	3.9143	1.5400
	50	27.186	35.481	3.8505	1.3800
	75	27.028	35.467	3.7174	0.8730
	100	26.595	35.432	3.4056	0.4260
	125	25.398	35.195	3.1325	0.2550
	150	21.608	35.395	2.7741	0.1170
	175	18.976	35.120	2.8461	0.0947
	200	16.293	35.187	2.9524	0.0689

CTD data (BTL)

BTL No.	Depth m	Pres. db	Temp. ℃	Sal (psu)	DO $ml \cdot l^{-1}$	Flu. ug/l
1	104	104.8	26.396	35.393	3.3837	0.3510
2	69	69.0	27.096	35.472	3.7951	0.9980
3	69	69.6	27.100	35.472	3.8051	0.9850
4	36	36.5	27.217	35.483	3.9637	1.4700
5	35	35.2	27.222	35.483	3.9671	1.5500
6	22	21.8	27.261	35.483	4.0315	1.5200
7	21	21.1	27.269	35.484	4.0291	1.5300
8	35	35.6	27.223	35.483	3.9548	1.5700
9	36	35.8	27.222	35.483	3.9597	1.6100
10	36	36.0	27.222	35.483	3.9666	1.3800
11	36	36.4	27.221	35.483	3.9575	1.4100
12	36	36.6	27.219	35.483	3.9580	1.6700
13	35	35.6	27.220	35.483	3.9736	1.4500
14	204	205.2	15.830	35.128	2.9802	0.0671
15	205	206.6	15.613	35.116	2.9687	0.0700
16	99	99.8	26.603	35.432	3.4145	0.3860
17	99	99.9	26.610	35.433	3.4324	0.4020
18	21	21.3	27.254	35.483	4.0186	1.4900
19	21	20.8	27.267	35.484	4.0290	1.5400
20	9	9.3	27.344	35.486	3.9510	1.2500
21	4	4.4	27.350	35.487	3.8748	1.3700
22	4	4.0	27.349	35.487	3.8715	1.2800
23	4	4.4	27.349	35.487	3.8671	1.3700
24	5	5.0	27.349	35.487	3.8693	1.3900

KH-13-7	St. 01-3(Middle)	Depth	5436m
Date:	2013/12/23	Lat.	0 00.03N
Time:	12:30	Long.	170 00.14W

CTD data (LAY)	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
	Sur.	27.3	***	***	***
	5	27.255	35.489	3.8195	1.0800
	10	27.258	35.489	3.8547	1.0800
	20	27.256	35.489	3.9336	1.1200
	30	27.236	35.489	3.9106	1.0600
	40	27.211	35.490	3.8911	1.0900
	50	27.159	35.490	3.7992	1.0200
	75	26.915	35.474	3.5793	0.5880
	100	26.163	35.398	3.2536	0.3330
	125	23.539	35.072	2.8429	0.1900
	150	20.627	35.377	2.8089	0.1010
	175	18.466	35.028	2.8584	0.0977
	200	15.773	35.120	2.9548	0.0681
	250	13.114	34.932	2.7472	0.0666
	300	11.606	34.826	1.9893	0.0703
	400	10.114	34.735	1.7041	0.0761
	500	8.137	34.623	0.8787	0.0844
	600	7.298	34.586	1.1677	0.0827
	700	6.205	34.552	1.5058	0.0827
	800	5.305	34.539	1.9813	0.0804
	900	5.012	34.546	1.7591	0.0820
	1000	4.572	34.553	1.7967	0.0827

CTD data (BTL)

BTL No.	Depth m	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
1	746	751.0	5.545	34.542	1.7524	0.0840
2	498	501.0	8.134	34.623	0.8963	0.0884
3	498	501.4	8.134	34.623	0.8951	0.0891
4	498	501.2	8.134	34.623	0.8956	0.0880
5	447	449.9	8.942	34.662	0.7955	0.0872
6	447	450.3	8.950	34.663	0.7984	0.0875
7	447	450.2	8.952	34.663	0.7986	0.0883
8	447	450.3	8.951	34.663	0.7996	0.0884
9	447	449.9	8.956	34.664	0.7979	0.0884
10	447	449.7	8.958	34.664	0.7983	0.0884
11	397	399.5	10.113	34.735	1.6918	0.0789
12	397	399.8	10.122	34.735	1.6956	0.0791
13	745	750.8	5.545	34.542	1.7514	0.0837
14	746	751.1	5.545	34.542	1.7480	0.0831
15	998	1006.3	4.488	34.554	1.8157	0.0832
16	999	1006.8	4.485	34.555	1.8153	0.0835
17	999	1006.7	4.484	34.555	1.8234	0.0840
18	998	1006.3	4.488	34.554	1.8147	0.0840
19	745	750.9	5.545	34.542	1.7506	0.0833
20	746	751.3	5.545	34.542	1.7520	0.0823
21	596	600.1	7.268	34.583	1.1724	0.0867
22	498	501.5	8.134	34.623	0.8961	0.0884
23	498	501.6	8.133	34.623	0.9000	0.0885
24	499	502.1	8.133	34.623	0.8998	0.0888

KH-13-7	St. 01-4(Shallow)	Depth	5462m
Date:	2013/12/23	Lat.	0 00.48S
Time:	17:04	Long.	170 00.19W

CTD data (LAY)	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
	Sur.	27.1	***	***	***
	10	27.221	35.487	3.8632	0.8210
	20	27.223	35.487	3.9371	0.7850
	30	27.219	35.489	3.9648	0.8260
	40	27.211	35.490	3.9386	0.8340
	50	27.204	35.492	3.9048	0.7300
	75	27.145	35.501	3.8076	0.7530
	100	26.897	35.535	3.5060	0.4840
	125	25.351	35.320	3.0691	0.2590
	150	22.009	35.338	2.7733	0.1210
	175	19.664	35.160	2.8364	0.0979
	200	16.435	35.187	2.9892	0.0704
	250	13.346	34.949	2.7993	0.0661
	300	11.578	34.823	1.9783	0.0714
	400	10.001	34.729	1.7872	0.0771

CTD data (BTL)

BTL No.	Depth m	Pres. db	Temp. ℃	Sal (psu)	DO $ml \cdot l^{-1}$	Flu. ug/l
1	398	400.5	9.997	34.728	1.7204	0.0762
2	294	295.8	11.605	34.822	1.9841	0.0734
3	197	198.4	16.950	35.232	2.9556	0.0739
4	152	153.0	21.442	35.272	2.7987	0.1240
5	123	123.3	24.979	35.236	3.0417	0.2030
6	99	99.3	26.820	35.532	3.4913	0.4970
7	74	74.0	27.093	35.508	3.7517	0.6540
8	397	399.8	10.005	34.729	1.8017	0.0757
9	293	295.0	11.615	34.823	1.9984	0.0729
10	246	247.2	13.481	34.955	2.8197	0.0686
11	195	196.2	17.278	35.266	2.9203	0.0748
12	193	193.8	17.740	35.308	2.8416	0.0820
13	193	194.4	17.873	35.309	2.8381	0.0766
14	193	194.1	17.962	35.285	2.8296	0.0758
15	193	193.8	17.970	35.284	2.8375	0.0760
16	149	149.5	22.464	35.390	2.7663	0.1290
17	149	150.4	22.345	35.378	2.7579	0.1130
18	149	150.4	22.200	35.357	2.7689	0.1350
19	100	100.2	26.822	35.534	3.4847	0.3900
20	99	99.7	26.826	35.534	3.4876	0.4830
21	99	99.6	26.825	35.534	3.4981	0.4820
22	99	99.4	26.828	35.534	3.4989	0.4950
23	100	100.7	26.811	35.535	3.4879	0.4370
24	75	74.9	27.129	35.503	3.7993	0.6970

KH-13-7	St. 01-5(Light Morning)	Depth	5436m
Date:	2013/12/23	Lat.	0 00.04N
Time:	19:55	Long.	170 00.04W

CTD data (LAY)	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
	Sur.	27.6	***	***	***
	5	27.214	35.488	3.7925	0.3880
	10	27.214	35.488	3.8697	0.4230
	20	27.207	35.488	3.9513	0.6070
	30	27.198	35.490	3.9215	0.6800
	40	27.190	35.492	3.9257	0.7090
	50	27.135	35.501	3.8276	0.6590
	75	27.099	35.508	3.7610	0.5970
	100	26.919	35.528	3.5496	0.4350
	125	25.288	35.307	3.0317	0.2160
	150	22.956	35.448	2.7692	0.1200
	175	19.237	35.110	2.8467	0.0907
	200	16.595	35.195	2.9583	0.0699
	250	13.574	34.963	2.8565	0.0640
	300	11.624	34.824	2.0149	0.0695
	400	10.026	34.730	1.8505	0.0742
	500	8.195	34.623	1.0134	0.0848

CTD data (BTL)

BTL No.	Depth m	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
1	104	104.9	26.614	35.535	3.3839	0.4220
2	105	105.4	26.572	35.534	3.3787	0.4010
3	104	104.8	26.608	35.535	3.3838	0.3970
4	69	69.8	27.106	35.504	3.8158	0.7750
5	70	70.2	27.106	35.505	3.8040	0.6630
6	70	70.9	27.101	35.505	3.7891	0.6590
7	70	70.6	27.100	35.506	3.7964	0.7400
8	38	38.2	27.194	35.491	3.9803	0.7390
9	39	39.1	27.190	35.492	3.9624	0.7220
10	39	39.0	27.180	35.493	3.9456	0.7470
11	39	39.4	27.182	35.492	3.9486	0.7410
12	23	23.0	27.204	35.488	3.9920	0.5830
13	23	23.1	27.204	35.490	3.9959	0.6690
14	23	23.4	27.202	35.490	3.9868	0.6020
15	23	23.2	27.201	35.490	3.9751	0.6030
16	498	501.5	8.150	34.621	1.0315	0.0828
17	251	252.5	13.417	34.951	2.8269	0.0685
18	171	171.5	19.275	35.108	2.8499	0.1050
19	69	69.7	27.097	35.506	3.7900	0.6980
20	42	42.6	27.176	35.493	3.9344	0.7490
21	42	41.9	27.179	35.493	3.9323	0.7650
22	42	41.8	27.180	35.493	3.9369	0.7540
23	4	4.5	27.224	35.490	3.8413	0.4060
24	5	4.7	27.225	35.490	3.8332	0.4100

KH-13-7	St. 01-6(Surface)	Depth	5459m
Date:	2013/12/23	Lat.	0 00.02N
Time:	21:04	Long.	170 00.05W

CTD data (LAY)	Pres. db	Temp. ℃	Sal (psu)	DO ml/l	Flu. ug/l
	Sur.	27.8	***	***	***
	5	27.265	35.488	3.8594	0.3490
	10	27.225	35.488	3.8971	0.3880
	20	27.220	35.489	3.9251	0.5340
	30	27.200	35.490	3.9549	0.6790
	40	27.186	35.492	3.9387	0.7820
	50	27.173	35.495	3.8923	0.7590
	75	27.093	35.508	3.7697	0.7260
	100	26.868	35.534	3.5224	0.5020
	125	25.023	35.244	3.0435	0.2420
	150	21.131	35.309	2.7982	0.1140

CTD data (BTL)

BTL No.	Depth m	Pres. db	Temp. ℃	Sal (psu)	DO $ml \cdot l^{-1}$	Flu. ug/l
1	46	45.8	27.174	35.494	3.9316	0.8550
2	50	50.2	27.146	35.499	3.8726	0.8280
3	29	29.1	27.190	35.491	3.9752	0.8110
4	20	20.1	27.220	35.489	4.0211	0.5460
5	9	9.0	27.221	35.489	3.9689	0.4800
6	5	5.0	27.295	35.489	3.8971	0.3140
7	45	44.8	27.171	35.494	3.9139	0.8570
8	45	44.8	27.170	35.494	3.9095	0.8490
9	45	44.9	27.169	35.495	3.9175	1.2200
10	44	44.5	27.169	35.495	3.9282	0.8400
11	44	44.6	27.168	35.495	3.9208	0.8390
12	99	99.9	26.667	35.542	3.4138	0.4100
13	50	50.1	27.149	35.498	3.8773	0.8140
14	50	50.6	27.148	35.498	3.8723	0.8160
15	50	50.7	27.148	35.498	3.8772	0.8130
16	29	29.5	27.192	35.491	3.9597	0.7500
17	29	29.6	27.189	35.491	3.9580	0.7590
18	19	19.3	27.221	35.489	4.0256	0.5810
19	11	10.7	27.224	35.488	3.9615	0.4320
20	10	10.4	27.254	35.488	3.9536	0.3780
21	10	10.0	27.269	35.490	3.9698	0.3520
22	10	10.0	27.266	35.489	3.9652	0.3520
23	10	9.6	27.256	35.489	3.9649	0.3990
24	11	10.9	27.235	35.488	3.9604	0.4070

1. Meteorological data

On the transects from 00 20.482 N, 170 30.508 W (17:27 Dec 22 2013) to 00 59.960 S, 170 00.420 W (4:34 Dec 24 2013) and from 06 30.019 S, 169 59.833 W (20:23 Dec 25 2013) to 06 46.022 S, 170 00.011 W (21:27 Dec 25 2013), excluding the territorial waters.

Data are attached in the form of excel file.

2. Vertical profiles of turbulence

Digital data, under quality control

	Location		Date
St. 1	0 N	170 W	2013/12/22

3. DO

Data are provided in this report

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

4. Nutrients (nitrate, nitrite, ammonium, phosphate and silicic acid)

Frozen, under investigation

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

5. Chlorophyll, phytoplankton community composition

Data are provided in this report

	Location		Depth	Date
St. 1	0 N	170 W	0 m – 300 m	2013/12/22

6. Salinity

Preserved, under investigation

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

7. Microbial community composition (DNA samples)

Frozen, under investigation

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

8. Dissolved trace metal samples (iron, iodide, and rare metals)

Stored in bottles, under investigation

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

9. Nutrients (at nanomolar level), dissolved organic phosphorus and arsenate

Frozen, under investigation

	Location		Depth	Date

St. 1	0 N	170 W	0 m – B-50	2013/12/22

10. Dissolved and particulate organic carbon samples

Frozen in the form of water or filter samples, under investigation

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

11. Dissolved gases (methane and nitrous oxide)

Preserved, under investigation

	Location		Depth	Date
St. 1	0 N	170 W	0 m – B-50	2013/12/22

12. Surface monitoring of temperature and salinity

On the transects from 00 20.482 N, 170 30.508 W (17:27 Dec 22 2013) to 00 59.960 S, 170 00.420 W (4:34 Dec 24 2013) and from 06 30.019 S, 169 59.833 W (20:23 Dec 25 2013) to 06 46.022 S, 170 00.011 W (21:27 Dec 25 2013), excluding the territorial waters.

Digital date, under investigation

13. Aerosols

On the transects from 00 20.482 N, 170 30.508 W (17:27 Dec 22 2013) to 00 59.960 S, 170 00.420 W (4:34 Dec 24 2013) and from 06 30.019 S, 169 59.833 W (20:23 Dec 25 2013) to 06 46.022 S, 170 00.011 W (21:27 Dec 25 2013), excluding the territorial waters.

Filter samples, under investigation

14. Zooplankton collected by nets

Collected for microscopic observation and genomic analyses

Preserved in fixatives, under investigation in charge of Prof. Atsushi Tsuda at Atmospheric and Ocean Research Institute, the University of Tokyo.

VMPS 6000D nets

	Location		Depths	Date
1	00 01 74 N	170 00 11 W	2000-1000	2013/12/22
			1000-500	
			500-200	
			200-0	
			1000-500	2013/12/23
			500-200	
			200-0	

ORI net

	Location		Depths	Date
1	00 03 30 N	169 56 45 W	0-542	2013/12/22

Norpac twin nets

	Location		Depths	Date
1	00 00 11 N	169 59 91 W	0-200	2013/12/22

IKMT net

	Location		Depths	Date
1	00 02 51 N	169 58 81 W	1735 (W.O.)	2013/12/22

15. Vertical light profiles

Digital data, under quality control

	Location		Date
St. 1	0 N	170 W	2013/12/22

16. Sediment trap samples

Collected on filters, under investigation

	Location		Date
St. 1	0 N	170 W	2013/12/23

17. Particle distribution data by LISST

Digital date, under investigation

	Location		Date
St. 1	0 N	170 W	2013/12/22

Other samples and data collected by each scientific group and their preliminary results are described in detail in the following reports.

Chlorophyll *a* concentration (μg L^{-1})

Stn. 1	
Depth	Chl-a
0	0.3403
5	0.2452
10	0.3817
20	0.3702
30	0.3747
45	0.3862
50	0.3803
75	0.3224
100	0.2078
125	0.1044
150	0.0397
200	0.0118
250	0.0054
300	0.0061

Dissolved oxygen

Station	Depth (m)	DO (ml L^{-1})
Station 1	5367	4.4951
	4912	4.4469
	3941	3.8648
	2963	3.1465
	2470	2.8953
	1979	2.6156
	1486	2.1901
	992	1.9638
	746	1.9491
	498	1.0530
	398	1.9617
	294	2.1867
	246	3.0012
	197	3.1911
	152	3.0152
	123	3.2712
	99	3.7201
	74	3.9937
	50	4.1431
	29	4.2154
	20	4.2607
	9	4.2749

Measurements of turbulent intensity distribution with Vertical Microstructure Profiler VMP2000

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PURPOSE

Vertical turbulent mixing is considered to influence on water-mass transformation and circulation as well as biological production, because turbulence plays essential roles to supply nutrients to euphotic layer through strongly stratified seasonal thermocline We aim to quantitatively estimate vertical diffusivity by the tethered microstructure profiler.

MEASUREMENTS

VMP2000 (Rockland Scientific) equipped with two shear probes, two micro temperature sensors, one conductivity sensor, and a sea bird CTD, measured vertical microstructure with the sampling rate of 470Hz down to 2000m, yielding turbulent energy dissipation rates. VMP2000 falls freely with a cable and can get real time data.

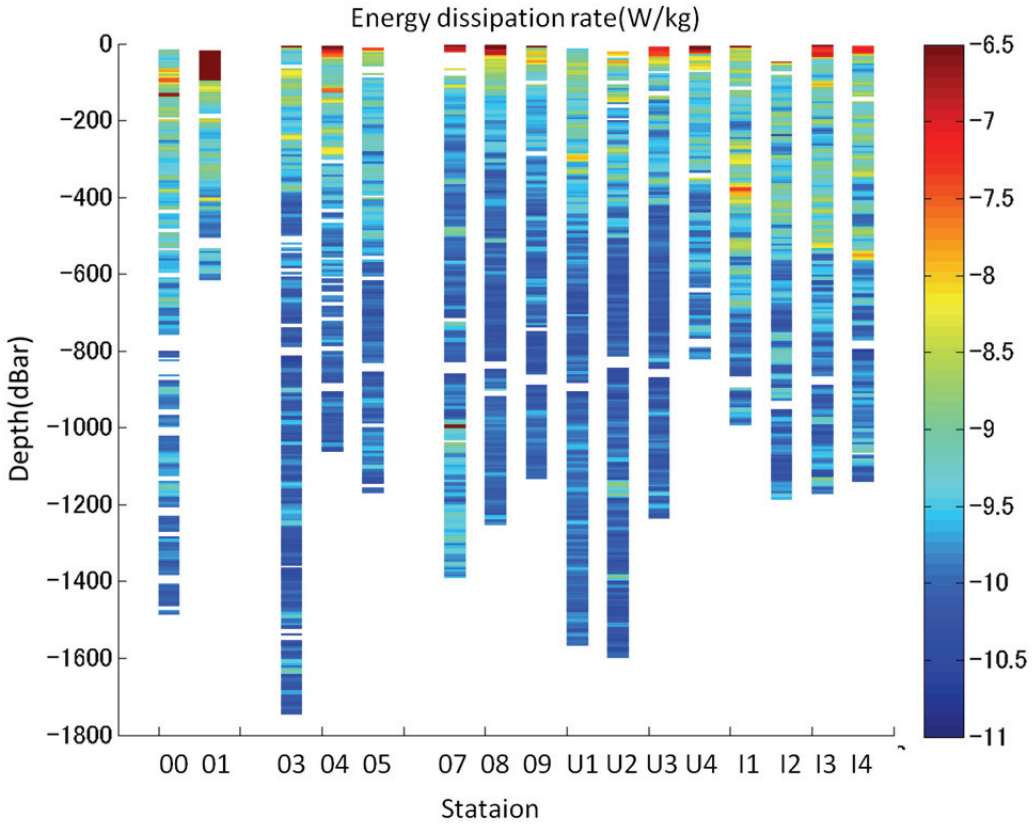
All VMP2000 stations in this cruise are shown in the following table. We found abnormal value in the T1 sensor after Sta.03, and then changed this sensor at Sta. 4.

Shear Sensor	S1 M778	S2 M1058	micro-T	T1 T416	T2 T841	
Station	date	time	latitude	longitude	water depth	comment
St.00	2013/12/16	1:50	19° 59.82N	160° 00.55E	4386	
St.01	2013/12/23	17:57	00° 00.25S	170° 00.95W	5490	
St.02						no observation
St.03	2013/12/26	20:54	10° 00.09S	170° 00.32W	4993	
St.04	2014/1/3	4:08	15° 00.75S	170° 01.04W	4843	T2 sensor exchanged (T841→T843)
St.05	2013/1/4	19:57	20° 00.33S	170° 00.10W	5339	
St.06	2014/1/7	20:16	24° 59.87S	170° 00.24W	5604	
St.07	2014/1/9	14:39	30° 03.52S	169° 58.4W	5387	
St.08	2014/1/11	19:27	35° 00.05S	170° 00.21W	5193	
St.09	2014/1/14	3:11	40° 04.71S	169° 58.62W	4620	
St.U-1	2014/1/16	6:03	33° 07.12S	175° 05.31W	5828	
St.U-2	2014/1/16	12:14	33° 05.85S	175° 04.33W	5821	
St.U-3	2014/1/16	19:27	33° 05.74S	174° 58.64W	5434	
St.U-4	2014/1/17	1:59	33° 03.44S	174° 49.85W	5907	
St.I-1	2014/1/17	23:46	28° 47.89S	173° 29.80W	4616	
St.I-2	2014/1/18	4:54	28° 46.78S	173° 27.00W	4453	
St.I-3	2014/1/18	11:19	28° 52.59S	173° 30.18W	5010	
St.I-4	2014/1/18	15:57	28° 51.87S	173° 30.84W	4917	

RESULTS

The vertical distribution of the turbulent energy dissipation rate computed by using S1 sensor is shown in the following picture (S2 gives almost the same results, and not shown). Abnormal values measured in a large or small fall rate are rejected in this picture. At around 800-900m depth, data were not properly obtained because of the damaged cable and data transmission failure. At St. I (28.8°S), at which parametric subharmonic instability (PSI) is expected to enhance turbulence from M2 internal tides, turbulent energy dissipation rates with > 10^{-9} W/kg extended down to 600m.

Note that these data are preliminary and need qualification. We particularly thank Drs. Sachihiko Itoh, Shinya Kouketsu and Hitoshi Kaneko for VMP2000 operations.



Measurements of turbulent intensity distribution with Micro Rider 6000 attached to the CTD frame

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PURPOSE

There has been very few turbulence observation down to bottom in deep sea. Efficient and easy methods to measure turbulence in the deep ocean are expected. We attached microstructure profiler MicroRider MR-6000 to the CTD frame.

Disturbing the frame makes fluctuations of velocity of a moving fluid. So data measured with a shear probe are probably unavailable. But data measured with micro temperature sensors have a potential to yield better data.

In this observation, we attempted to estimate turbulent energy dissipation rates with micro temperature sensors equipped to MR-6000.

MEASUREMENTS

MR6000 equipped one shear probe (sampling rate of 1024Hz), two micro temperature sensors (T1-1024Hz, T2-512Hz), two conductivity sensors (C1-512Hz, C2-512Hz), were operated at CTD deep casts. Our research mainly focuses on micro temperature sensors.

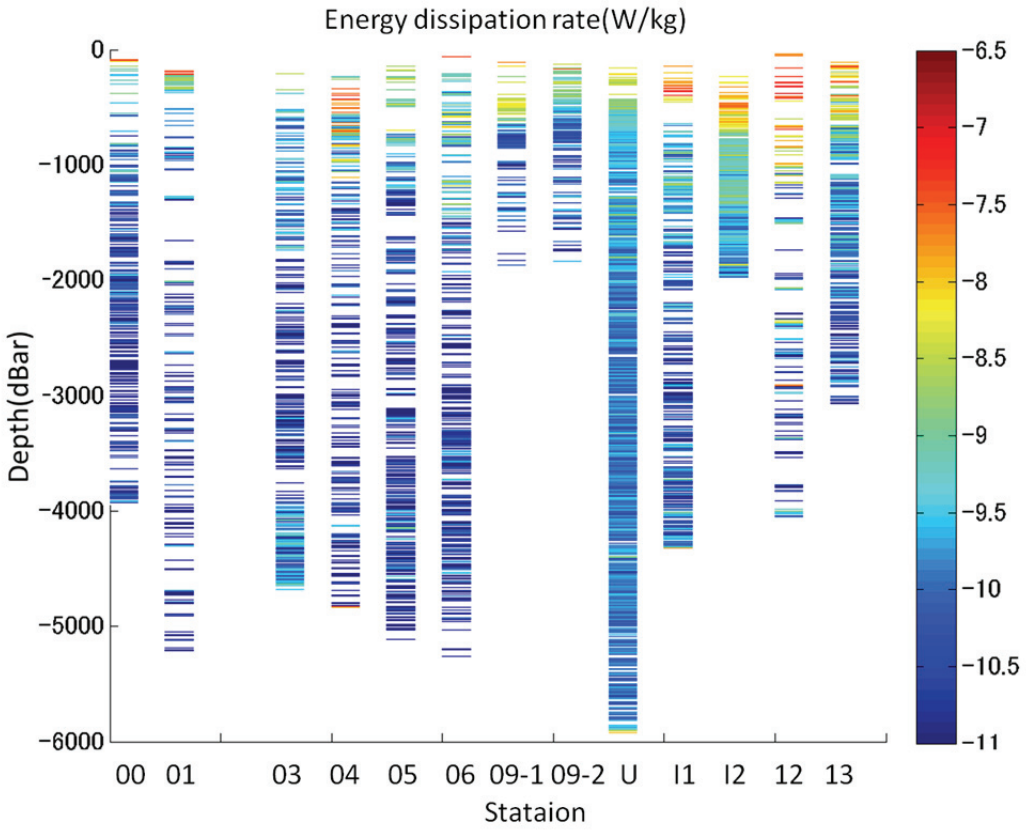
All MR6000 stations in this cruise are listed in Table 1. St.03-1 is a cast for the CTD test, and the frame didn't fall smoothly. From St.05, CTD data were taken from VMP500-CTD attached to MR6000, before St. 5 CTD data were from 9plus CTD. After St.08, all MR6000 sensors were water-invaded (T2, flooded heavily, especially), and exchanged these sensors. At St.08 and St.09-3 bottom cast, data could not be obtained.

Shear Sensor	S1 M778	S2 M1058	micro-T	T1 T416	T2 T841		
Station	date	time	latitude	longitude	water depth	comment	
St.00	2013/12/15	22:36	19° 59.9877N	160° 00.0142E	4411		
St.01	2013/12/22	22:42	00° 00.1679S	169° 59.9226W	5416		
St.02						no observation	
St.03	2013/12/26	10:37	10° 00.0526S	170° 00.0056W	4981		
St.03-1	2013/12/28	14:13	10° 01.0314S	169° 56.8630W		CTD test(didn't fall smoothly)	
St.04	2013/1/2	6:03	15° 00.1749S	169° 59.9981W	4809		T2 abnormal
St.05	2014/1/4	15:31	20° 00.0679S	170° 00.0595W	5335	CTD exchanged	T2 abnormal
St.06	2014/1/7	16:24	25° 00.0964S	170° 00.0987W	5666		T2 abnormal
St.07	2014/1/10	0:27	30° 01.0783S	170° 00.2971W	5395		T2 abnormal
St.08	2014/1/11	20:38	35° 01.1173S	170° 00.4051W		Sensors exchanged	data doesn't exist
St.9-1	2014/1/13	10:30	40° 00.1382S	169° 59.8504W	4625		
St.9-2	2014/1/13	13:30	40° 00.4320S	169° 59.5282W	4627		
St.9-3	2014/1/13	19:54	40° 00.4795S	169° 59.4743W	4628		data doesn't exist
St.U	2014/1/16	1:00	33° 07.0273S	175° 04.8266W	5829		
St.I-1	2014/1/18	0:48	28° 46.7399S	173° 28.3930W	4354		
St.I-2	2014/1/18	17:54	28° 50.5308S	173° 31.5100W			

RESULTS

The vertical distribution of turbulent energy dissipation rates from the T1 sensor is shown in Fig.1. T2 had abnormal data at St.04~St.08 because of water invasion (not shown). At the PSI-critical latitude, turbulence intensity are larger than at other stations, suggesting that the enhancement actually occurred.

Similarly to the VMP2000 data, MR6000 data are also preliminary and needs qualification.



High spatial/temporal resolution observations of physical structure across the Pacific

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1. Introduction

Biogeochemical and ecological processes in the ocean vary region by region, with tight linkages with physical processes. Recent advances in satellite remote sensing and numerical modeling techniques have revealed that relatively smaller scale physical processes (typically < 10 km) play important roles in horizontal and vertical transports of heat, materials, and biota; however, few *in situ* observations have conducted with suitable spatial resolution and coverage comparable to be comparable to the results from the satellite and models. In the present study, we made observations of velocity, temperature, salinity and turbulent structure across the Pacific Ocean, with higher spatial or temporal resolution than conventional methods, using shipboard ADCP, underway CTD (UCTD), vertical microstructure profilers, and XCTD.

2. Observations

High resolution temperature/salinity profiles of the upper layer were obtained with the UCTD system (Oceanscience). The UCTD probes were deployed basically down to 150 dbar with a horizontal interval of 5 nautical miles during the ship steaming at 15 knot, while deeper profiles were conducted by XCTD with latitudinal intervals of 2.5–3°N (Fig. 1). In addition, intensive observations of UCTD and microstructure profilers (TurboVMP, Rockland Scientific International) were carried out along zones of P-I, P-II, and P-III (Fig. 1). TurboVMP (TVMP) observations were also conducted at CTD stations along the 170°W transect. In total, we completed 484 UCTD casts, 117 TVMP casts, and 58 XCTD casts during the cruise. Horizontal velocity data were taken by shipboard ADCP throughout the cruise.

2. Preliminary results and future perspective

Temperature and salinity profiles by XCTD confirm classical views of the physical structure of the North Pacific (Fig. 2a and 2b). The high resolution observation by UCTD reveals, however, that the XCTD observation alone would miss the vigorous variability in temperature and salinity within the upper layer (Fig. 2b). The variations detected by the UCTD observations do not only capture 100–300 km scale structure

corresponding to satellite-derived sea surface height, but also detect 30–50 km fluctuations of the pycnocline. Anomalous salinity fluctuations exceeding 0.1PSU were frequently observed within and just below the surface mixed layer. The temperature and salinity profiles will further be analyzed together with turbulence data taken by TVMP to clarify processes relevant to nutrient transport.

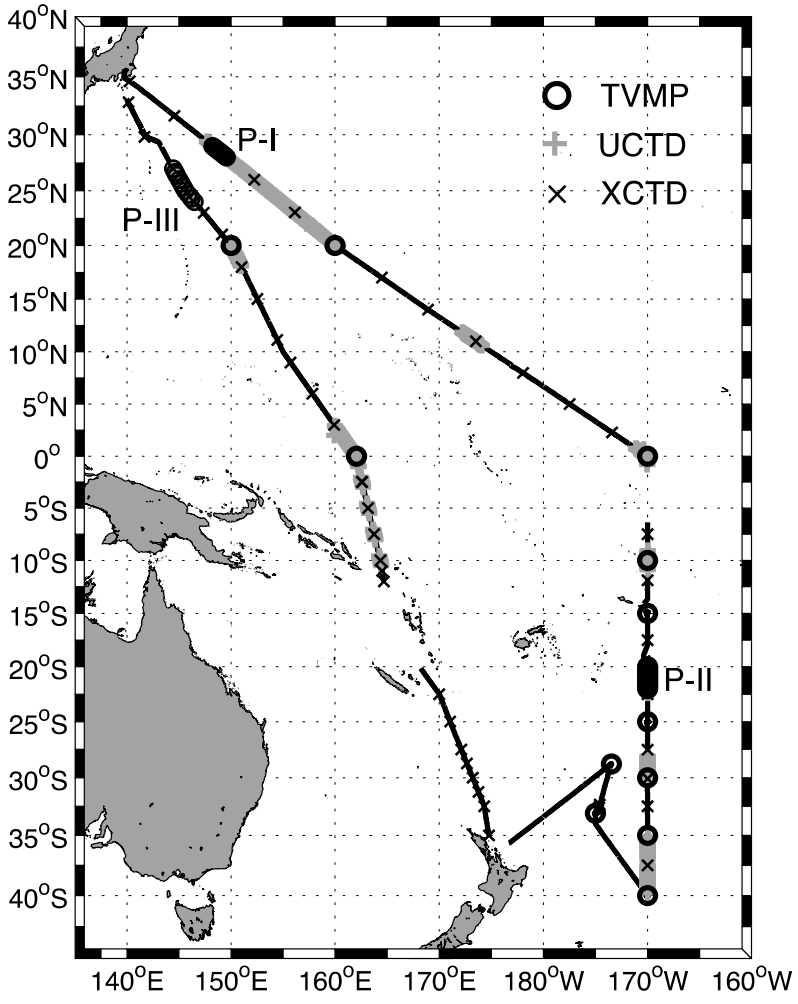

Figure 1. Cruise track and major observation points

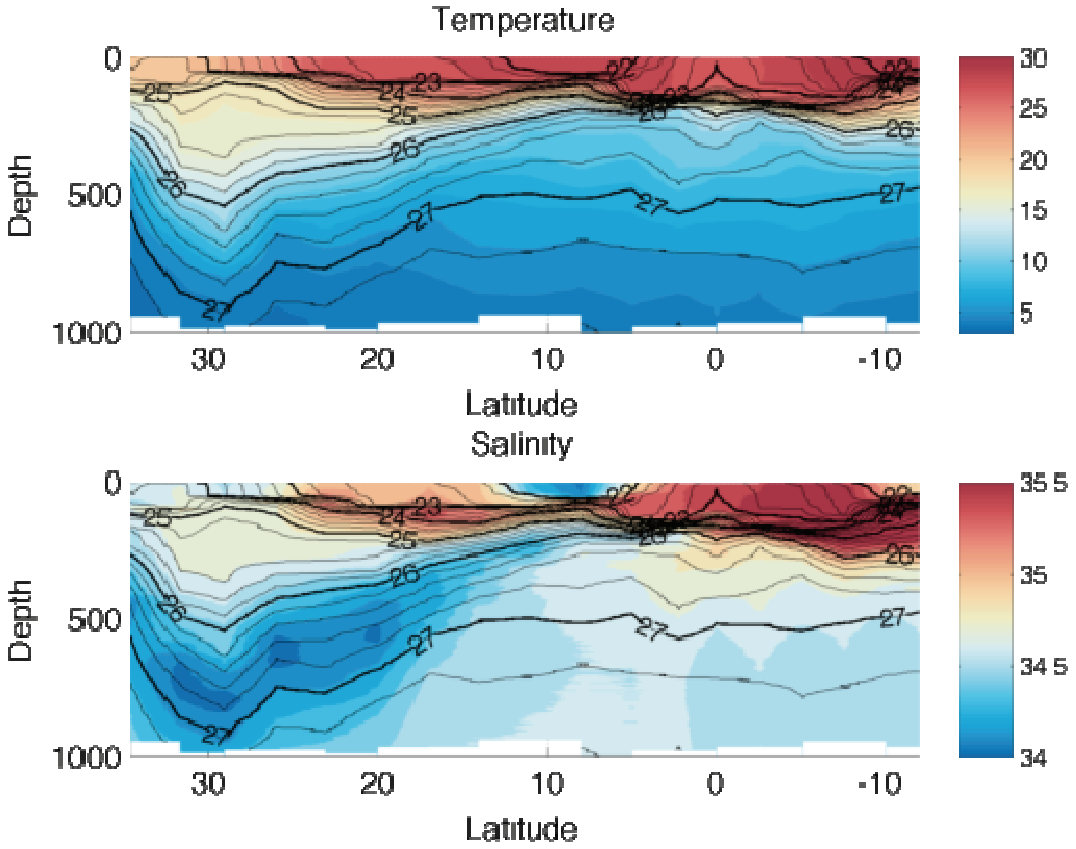

Figure 2. Cross sections of temperature and salinity (color shades) and potential density (σ_θ; contour lines) during leg 1 as measured by XCTD.

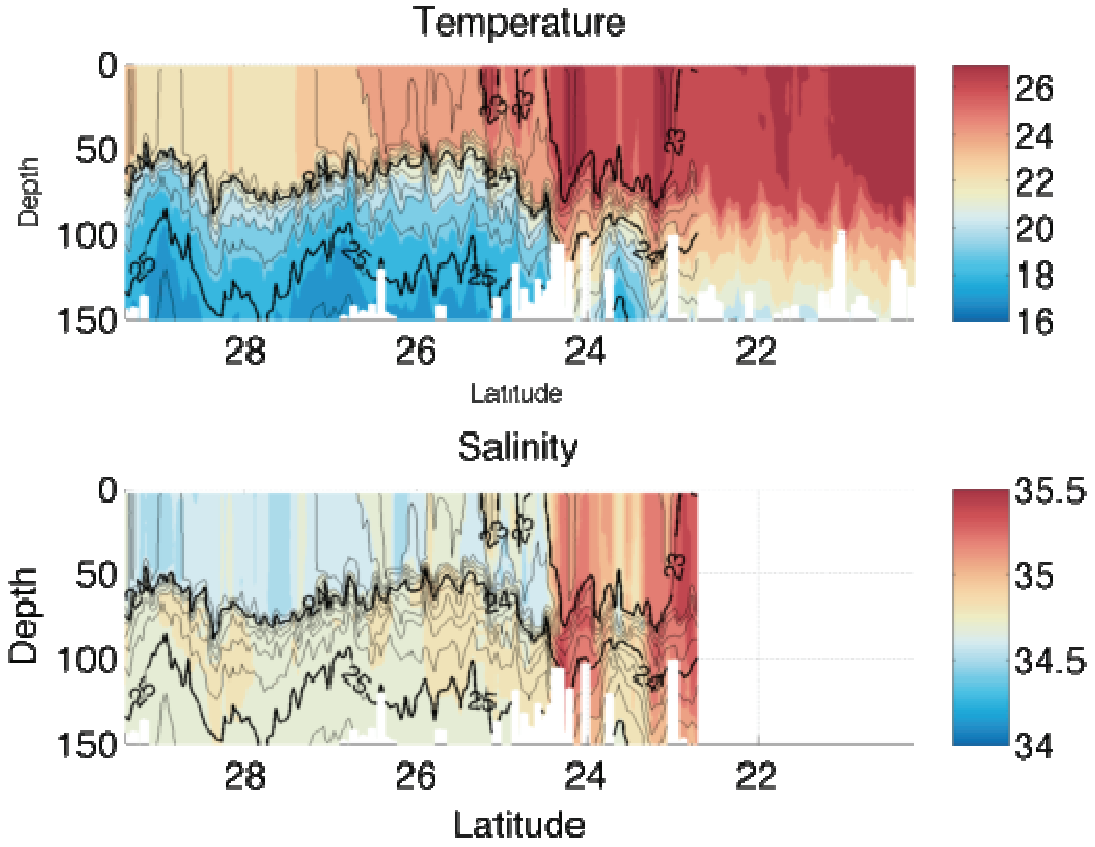

Figure 3. Cross sections of temperature and salinity (color shades) and potential density (σ_θ; contour lines) within the subtropical gyre of the North Pacific as measured by UCTD.

New production in the tropical and subtropical South Pacific Ocean

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It has long been thought that nitrate in deepwater is the major source of new production. However, recent studies have shown that biological nitrogen fixation has a critical role in supporting new production in the oligotrophic tropical and subtropical waters. Furthermore, nitrate assimilation which is the standard method for estimating nitrate-based new production is recently recognized to overestimate due to influence on nitrification. To elucidate spatial variation of new production in the tropical and subtropical South Pacific Ocean, we conducted following experiments during this cruise.

Methods

Sampling depths

Water samples for incubation experiments, nutrients, chlorophyll *a*, microscopic observation, and DNA analysis were collected in an acid-cleaned bucket and Niskin-X bottles from those layers having surface light intensities of 100, 25, 10, 1, and 0.1%. The depth profiles of light intensity were obtained using Hyper Profiler (Biospherical Instruments) before the sampling.

Incubation experiments

Nitrogen fixation, nitrate assimilation, and nitrification rates were evaluated using ^{15}N tracer. Nitrogen fixation rate was determined by both the gas addition method (Montoya et al., 1996, AEM) and the gas dissolution method (Mohr et al., 2010, PLoS one). Primary production was determined using ^{13}C tracer. After addition of the tracers, the incubation bottles were placed into on-deck incubators cooled by flowing surface seawater. Light levels were adjusted using neutral-density screens. Samples of 4.5 L collected for estimating the initial ^{15}N and ^{13}C enrichment of particulate organic matter were filtered immediately at the beginning of the incubation. The incubations for nitrogen fixation, and nitrate assimilation were terminated by gentle vacuum filtration of the seawater samples through a precombusted GF/F filter. Those for nitrification

were terminated by filtration using 0.2 μm pore-size filters, and filtrate was collected. The filters and filtrate were kept frozen (-20 °C) for on-shore analysis.

Nutrients, chlorophyll a*, microscopic observation, DNA*

Samples for nutrients analysis were collected in acid-cleaned 30 ml centrifuge tubes. Concentrations of nitrate, nitrite, soluble reactive phosphorus, and ammonium were immediately determined using a high sensitive colorimetric system. Samples for chlorophyll *a* of 280 ml were filtered onto 25-mm Whatman GF/F filters, and the chlorophyll *a* concentrations were measured fluorometrically using a Turner Design 10-AU fluorometer after extraction with N′, N′-dimethylformamide on board. Samples for microscopic observation were collected in 500-ml PP bottles and were preserved with acidified Lugol's solution. The samples were kept in darkness, and microplanktonic diazotrophs, *Trichodesmium* spp. and *Richelia intracellularis*, will be enumerated by using an inverted microscope on land. Samples for DNA analysis were collected in 2 L bottles, and were gently filtered onto 0.2 μm pore-size filters. The filters were subsequently stored in deep freezer for on-shore analysis.

Ecology of planktonic microbes in the central South Pacific – Abundance and production

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Background:

Planktonic microbes, including prokaryotes, eukaryotes and viruses, play an important role in food webs and biogeochemical cycles in pelagic marine environments (Kirchman 2008). Moreover the link between planktonic microbe activity and biogeochemistry in the meso- and bathypelagic layers is not firmly established despite recent studies that highlight the role of microbes in the cycling of organic matter. (Nagata et al. 2010; Herndl and Reinthaler 2013; Yokokawa et al. 2013).

Prokaryotes play a major role in marine biogeochemical fluxes. Microbially mediated biogeochemical transformation rates is a central research topic in microbial ecology. Previous study, which showed a result of both KH04-5 and KH05-2 cruises, have revealed that prokaryotic production and abundance distributions in the mesopelagic layer display consistent vertical patterns among distant locations and generally reflect the POC flux regime over a large scale, although complex prokaryotic production distributions were found in the bathypelagic zone (Yokokawa et al 2013). Despite the major insights gained from previous studies on prokaryotic activity in the pelagic oceans, knowledge on the microbial processing of organic matter in the meso- and bathypelagic layers is still in its infancy due to the lack of data.

Viral lysis is a major prokaryote mortality factor. Although variable depending on the oceanic regions, viral lysis causes comparable prokaryote mortality as those by nanoflagellates grazing. Moreover, viral lysis could influence prokaryotic diversity, especially the actively functioning groups. Strong viral shunt will increase the respiration of the microbial communities and thus reduce the production output to the higher trophic levels (Weinbauer 2004). However, our knowledge on the ecological roles of viruses in deep ocean is limited. Previous studies found that viral abundance closely correlated with prokaryotic abundance in the mesopelagic layer which

suggesting active lysis of mesopelagic prokaryotes, but the correlations were weak in the bathypelagic layer (De Corte et al. 2012; Yang et al. 2014). Evidences suggested that lateral transport by deep ocean water currents and vertical transport by sinking fluxes might play important roles in determining viral distribution patterns in deep ocean.

The objectives of our study, which conducted during the KH13-7 cruise, were 1) to determine the planktonic microbial abundances (prokaryotes, eukaryotes, and viruses) and prokaryotic production through the water columns of the central South Pacific 2) to compare the variations between this cruise (KH13-7) and the previous cruises (KH04-5 and KH05-2) for revealing decadal shift of the microbial variables in the central Pacific.

Methods:

Prokaryotic heterotrophic production using the microcentrifuge method 3H-leucine incorporation rate was determined as a proxy for prokaryotic production. Triplicate subsamples (1.5 mL) dispensed into screw-capped centrifuge tubes amended with 10 nmol L^{-1} (final concentration) of [^{3}H]-leucine (Cat#: NET1166, Perkin elmer) and incubated at in situ temperature (± 2ºC) in the dark. One trichloroacetic acid (TCA) killed blank was prepared for each sample. Incubation periods were 1 hour and 24 hours for the upper (0 – 250 m) and deeper (300 – bottom) water layers, respectively. After the incubation, proteins were TCA (final conc. 5%) extracted twice by centrifugation (20800 × g, 10 min, Eppendorf 5417R), followed by the extraction with ice-cold 80% ethanol. The samples were radioassayed with a liquid scintillation counter using Ultima-GOLD (Packard) as scintillation cocktail. Quenching was corrected by external standard channel ratio. The disintegrations per minute (DPM) of the TCA-killed blank was subtracted from the average DPM of the samples, and the resulting DPM was converted into leucine incorporation rates.

Samples for microbial abundances (prokaryotes, eukaryotes and viruses) were collected in every station and depth from the surface to the bottom layers. 1.5 ml of samples were fixed with 0.02 μm-filtered glutaraldehyde (final concentration 1%), frozen in liquid nitrogen and stored at -80°C. The abundance of prokaryotes and viruses will be measured by flow cytometry (Beckton Dickinson) after nucleic acid staining with SYBR-Green I. The abundance will be estimated using an internal standard of fluorescence beads and the sample injection flow rate.

Measurements:

Samples of microbes for flow cytometry were collected from all the routine depths and the depth of deep chlorophyll maximum at all the stations. Samples of prokaryotic production were collected at all the routine depths and the depth of deep chlorophyll maximum at Stas. 0, 1, 3, 5, 7, 8, 9 and Sta. I (28° 48’ S, 173° 30’ W).

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Estimation of emission rate of isoprene and dimethyl sulfide by culture experiment

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Objective

Ocean surface is known as one of the emission sources of biogenic trace gases such as isoprene and dimethyl sulfide (DMS). The trace gases contribute to formation of secondary organic aerosol (SOA) and following creation of cloud condensation nuclei (CCN), consequently, the Earth's radiation balance. Oceanic isoprene is produced as a by-product through photosynthesis of phytoplankton. Dimethylsulphoniopropionate (DMSP), a precursor of DMS, is also emitted from oceanic phytoplankton, and DMS is produced through enzymatic cleavage of DMSP by bacteria. It is known that emission rate of these trace gases have dependences on phytoplankton species through laboratory experiments. However, culture experiment at oceanic observation by using *in situ* seawater sample has not been carried out yet. Here, we estimate emission rate of isoprene and DMS from pico- (0.2–2 μm), nano- (2–10 μm), and micro- (>10 μm) size of phytoplankton by separating phytoplankton into each size fraction.

Methods

Size fraction and culture experiment

We performed size fraction of phytoplankton by using Nucleopore filter, and estimated isoprene and DMS emission rate from each phytoplankton size. The detailed procedure is as following;

1. 30-L of seawater sample was taken from Niskin bottles to 10-L square bottles. Subsamples were taken from the depth of 5-m and subsurface chlorophyll maximum (SCM), and stored in dark until size fraction.
2. One of the subsamples for each depth was filtered through 0.2-μm of filter cartridge to make filtered seawater for diluting and re-suspension of residue on the filter for each size fraction experiment.
3. 1-L of subsample was taken by measuring cylinder, and phytoplankton particles were condensed on 10-, 2-, and 0.2-μm of Nucleopore filter by the size fraction. The filterings by 0.2-μm filter were omitted for St. 1 samples because the filtering procedure took so long time at St. 0 samples, therefore, samples at St. 1 was not condensed.
4. Phytoplankton particles on the filter were re-suspended into 2-L of filtered seawater.
5. The procedure 3 and 4 were repeated for three times and twice for the samples at St. 0 and 1, respectively.
6. The re-suspended sample was introduced to 250-mL polycarbonate bottles. The filtered seawater and the original subsample were taken as blank and un-filtered samples. Triplicate samples were

prepared for each size fraction.

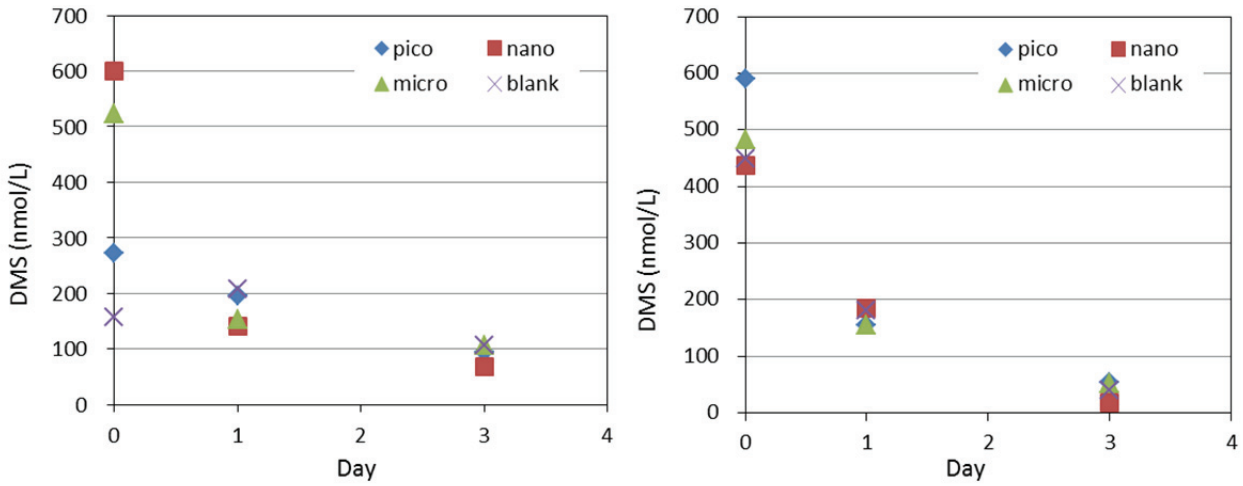
7. Remains of subsamples were introduced into 2-L polycarbonate bottles for culture experiment, and taken as DMSP, HPLC, FCM, and microscopy samples on Day 0.
8. Subsamples were cultured in water tank in which surface seawater was continuously flowed to keep the temperature of culture for that of surface. Subsamples for SCM was covered "shield net" to keep the light intensity about 1%.
9. Subsamples for isoprene and DMS measurement on Day 0 were immediately measured after the size fraction.
10. Culture experiment continued for 72 hours at maximum, and subsamples were taken up at 24 and 72 hour after the start of the experiment.

Measurement of isoprene and DMS concentration

All samples were measured by gas chromatography (GC) coupling with conventional purge and trap extraction system. Briefly, seawater sample was introduced into a purge bottle and extracted by pure N_2 carrier gas for 14 minutes. Extracted gas stream including DMS and isoprene passed through cold dehydration trap (dry ice/ethanol cooled hollow U-shaped glass tube) and concentrated on the cold trap (dry ice/ethanol temperature) with TENAX TA. Concentrated gas was eliminated by replacing the Dewar bottle of from dry ice/ethanol refrigerant to boiled water. Eliminated gas was introduced to GC (GC-2014, Shimadzu) with Flame Ionization Detector (FID).

Preliminary results

Figure shows variations of DMS concentrations during culture experiments at St. 1. All samples tend to decrease in DMS for both culture settings even for blank samples. We have to consider the reason by combining with other data of biochemical factors after the analyses in laboratory in Hokkaido University.



Data archives

All samples will be analyzed in the laboratory in Hokkaido University. All data will be opened within a year.

Table 1. Sample list of a culture experiment

	Day 0	Day 1	Day 3
unfiltered	○	○	○
pico (0.2–2 μm)	○	○	○
nano (2–10 μm)	○	○	○
micro (>10 μm)	○	○	○
blank (<0.2 μm)	○	○	○
HPLC	○	○	○
FCM	○	○	○
microscopy	○		

*Samples were taken at St. 0 and 1.

Table 2. Procedure of sample treatments except for trace gas samples

	sampling volume	sampling bottle	treatment	preservation
DMSPt	30mL	brown glass vial	8mL of subsampling by pipette -->add 1mL of H_2SO_4 (5N) by pipette	cold
DMSPd	30mL*2	brown glass vial	gravity filtering of 2 samples by GF/F for 4mL subsample -->add 0.5mL of H_2SO_4 (5N) by pipette	cold
HPLC	1000mL	black plastic bottle	measure 1000mL by cylinder -->filtered by GF/F (25mm) in darkroom	freeze
FCM	2mL*2 (included in HPLC sampling)	black plastic bottle	subsample 2mL -->add 0.4 mL of PFA by pipette	freeze
microscopy	500mL	black plastic bottle	measure 500mL by cylinder -->add 20mL of Lugol's solution by syringe	cold

Dynamics of nanomolar nutrients, labile dissolved organic phosphorus, and arsenate in the western subtropical Pacific Ocean

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Oligotrophic open oceans are characterized by low concentrations of surface nutrients due to strong stratification and small upward nutrient supply. This oligotrophic seascape had traditionally been thought of as a fairly homogeneous habitat. However, recent studies using highly sensitive analytical methods have revealed that surface nutrients shows dynamic geographic variations at nanomolar levels (Hashihama, 2013 *Oceanogr. Japan*). Among various nutrient fields in the oligotrophic habitat, there exist unique domains with drastic variation of phosphate. Surface phosphate is extremely depleted to <10 nM in the western subtropical North Pacific, compared to other subtropical Pacific domains (Hashihama et al., 2009 *GRL*). Both the western subtropical North Pacific and the other domains are characterized by an overall depletion of surface nitrate (<10 nM), providing a favorable condition for diazotrophs.

Concentration levels of phosphate are thought to regulate biological production through dinitrogen fixation and likely influence elemental stoichiometry of microorganisms. Furthermore, in phosphate-depleted domain, enzymatically labile fraction of dissolved organic phosphorus (DOP) may be important for biological utilization as a phosphate alternative (Sañudo-Wilhelmy, 2006 *Nature*). On the other hand, toxic arsenate may regulate biological production in the phosphate-depleted domain, because arsenate has a similar physicochemical property of phosphate and its concentration likely exceeds the phosphate concentration in the phosphate-depleted domain (Cutter & Cutter, 2006 *G3*).

In this cruise, we examined dynamics of nanomolar nutrients, labile DOP, and arsenate in the western subtropical Pacific Ocean for understanding of regional differences in nutrient regime and associated biogeochemical processes in the oligotrophic habitat. We conducted the following two different observations, which are mainly focused: 1) horizontal distributions of above-mentioned dissolved components and their relationships to elemental stoichiometry of microorganisms, and 2) changes in primary production and microbial community as induced by arsenate or phosphate enrichment.

Surface monitoring and water sampling

On the transects of Leg 1 and 2, underway surface monitoring was conducted using the surface water pumped up from the ship bottom. Seawater samples for nutrients (nitrate, nitrite, ammonium, phosphate, and silicic acid) were taken and measured using a highly sensitive colorimetric system, which was constructed from Auto Analyzer II (Technicon) and Liquid Waveguide Capillary Cell (LWCC, WPI). Along with the nutrient sampling, seawater samples for labile DOP, arsenate, total dissolved nitrogen (TDN) and phosphorus (TDP) were collected. These samples will be analyzed

on land after the cruise.

At observation stations, seawater samples for nanomolar nutrients, labile DOP, arsenate, TDN, and TDP were collected using Niskin bottles with a rosette system attached to CTD. The samples for nutrients, labile DOP, and arsenate were collected at 11 depths in the upper 150 m of the water column. The TDN and TDP samples were collected at 16 depths in the upper 500 m of the water column. The samples for nanomolar nutrients and arsenate were analyzed on board using a highly sensitive colorimetric system. The other samples will be analyzed on land after the cruise.

Along with our sampling, samples for particulate organic carbon, nitrogen, phosphorus, and biogenic silica were also collected by Drs. H. Saito, H. Ogawa, and H. Fukuda. These parameters will be useful to examine elemental stoichiometry of microorganisms.

Arsenate or phosphate enrichment incubation experiment

At stations 0, 5, and 6, seawater samples for on-board incubation experiment were collected at 10-m depth using Niskin bottles with a CTD rosette system. The collected samples were used to examine changes in primary production and microbial community as induced by arsenate or phosphate enrichment.

For the experiment of primary production, 10, 50, and 100-nM arsenate or phosphate were enriched to the collected water in 2.3-L polycarbonate bottle together with ^{13}C-labeled bicarbonate, then each triplicate bottles of As-, P-enrichments, and control were incubated on deck in the running surface seawater baths, which shaded the ambient light to a 30% level. After 24 h, the incubations were terminated by filtrations. The filter samples will be analyzed on land after the cruise.

For the experiment of microbial community, 100, 1000-nM arsenate or 100-nM phosphate were enriched to the collected water in 2.3-L polycarbonate bottle, then each triplicate bottles of As-, P-enrichments, and control were incubated in the running surface seawater baths as mentioned above. During 96-h incubations, samples for arsenate, phosphate, TDP, particulate P/As, chlorophyll *a*, flow cytometry, and microscopy were arbitrarily collected from each bottles. The samples for chlorophyll *a* and flow cytometry were analyzed on board. For the flow cytometry, cell densities of *Prochlorococcus*, *Synechococcus*, pico- and nano-sized eukaryotes, nano-sized cyanobacteria, and bacteria were enumerated using a flow cytometer (CyFlow Space, Partec) with the help of Dr. M. Sato. The other samples will be analyzed on land after the cruise.

Physiological status of phytoplankton in the South Pacific

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The traditional view on phytoplankton communities in the subtropical gyres is that they are considerably stably dominated by picophytoplankton, particularly *Prochlorococcus*, throughout the vast areas. However, recent studies have provided somewhat different views. First, the phytoplankton communities dynamically fluctuate both spatially and temporarily. Second, they inhabit diverse eukaryotic phytoplankton communities. These differences are suggested to be caused by many different environmental factors including nitrogen, phosphorus, silicon, iron, light condition, temperature and grazing by zooplankton. My study aim is to elucidate which factor(s) limit or allow flourish of different phytoplankton assemblages by diagnosing their physiological status by different approaches.

1. Analysis of phytoplankton communities
   Samples for flow cytometry were obtained at every station. Flow cytometric samples were obtained from 14 different depths between 0 and 300 m of routine casts and immediately analyzed for *Prochlorococcus*, *Synechococcus*, eukaryotes, and nano-sized cyanobacteria by using a flow cytometer CyFlow Space (partec).
2. Measurement of alkaline phosphatase activity
   Activity of alkaline phosphatase, which is an index of phosphorus limitation, was measured at the community level for the samples from 10 m at every station. Total community activity was measured fluorometrically using fluorescent substrate conjugates 4-methylumblliferyl phosphate and bis (4-methylumblliferyl) phosphate. Hydrolysis of the substrate was monitored at four different time points during 12 hours after the addition of the substrate at five different concentrations.
3. Grazing of heterotrophic and mixotrophic nanoplankton
   In the oligotrophic surface ocean, grazing by mixotrophic nanoplankton is important as a loss term of picoplankton, as well as heterotrophs. To quantify the importance of mixotorphy, FLB (fluorescently labelled bacteria) method was applied to the 10-m sample at every station. Approximatley 100 mL of seawater was amended with FLB concentrate and incubated in the dark for 2 h. The aliquots were added with glutaraldehyde and stored in a refrigerator. At long stations, picoplankton was labelled with $^{15}NH_4Cl$ and added to natural seawater to quantify mixotrophic transfer of biogenic materials to higher trophic levels. The seawater was also

amended with $NaH^{13}CO_3$ to label photoautotrophic organisms. The incubation was run for 12 h of light periods under 50% level of PAR. The samples were fixed with glutaraldehyde filtered onto polycarbonate membrane filters, and stored frozen for SIMS analysis on land.

Physicochemical characterization of atmospheric aerosols in the marine environment over the Pacific Ocean

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1. Introduction

Atmospheric aerosol particles play an important role in global material cycles and global climate by acting as an agent which transports materials over long distances and through affecting cloud formation and radiation budget by scattering and absorbing of solar radiation. Such aerosol impacts can significantly vary depending on physical and chemical characteristics of the aerosols, such as number concentration, chemical composition and mixing, and their size dependences. Over the open oceanic regions, where contribution of aerosols transported from lands is generally small, atmospheric marine aerosols can be dominated by natural oceanic aerosol sources and largely affected by ocean biota (marine primary productivity). The primary particle matter and/or precursor gases emitted by biological activity of phytoplankton may affect size, concentration and chemical composition of atmospheric marine aerosols, and even contribute new particle formation. In order to study the variation of physicochemical properties of atmospheric aerosols in maritime environment and their relation to the atmospheric chemistry of aerosols and atmospheric electricity, number-size distribution, size-resolved chemical composition, trace gas concentrations, and electrical elements of the atmosphere have been observed during the cruise.

Present KH-13-7 cruise have sailed four different oceanic regions with different biogeochemical and atmospheric chemical characteristics; (1) Middle latitudes in the North Pacific Ocean (low Chl-a and affected by anthropogenic substances), air mass from Asian continent, (2) The equator (high Chl-a), air mass from the equator, (3) Middle latitudes in the South Pacific Ocean (low Chl-a), air mass from the South Pacific Ocean, (4) High latitudes in the South Pacific Ocean(high Chl-a), air mass from the area high marine primary productivity such as the Antarctic Ocean. Further analysis and comparison of the observed aerosol physicochemical properties over the four regions should provide an insight into the interaction between atmosphere and ocean through atmospheric aerosols and their impact on global climate system.

2. Observation

Table 1 shows all of our atmospheric aerosol and gas measurements during the KH-13-7 cruise. We will analyze filter and gas samples in our laboratory. These results will be compared with data measured by continuous chemical/physical aerosol and gas observation instruments.

Table 1. Atmospheric aerosol and gas measurements conducted during KH-13-7 cruise.

Categoly	Instrument	Type	Time Resolution	Note
Aerosol	OPC(KC01-D)	Size distribution	3min	0.3-5 μm, 5 size bin
	OPC(AERO TRAK)			
	SMPS3034			10-487 nm, 54 size bin
	Filter sampling by AS-9(1day)	Chemical composition	1day	
	Filter sampling by AS-9(3day)		3day	
	Filter sampling by AS-900(4day)		4day	
	Sampling for TEM		once or twice a day	3 size bin
	Rn Counter	Number concentration	1hour	
Gas	O3 Monitor	Mass concentration	1min	
	CO Monitor			
	Canister Sampling		every 5° latitude	
Ion	Ion Counter	Number concentration	3min	

2.1 Number size distribution of aerosol particles

Number size distribution is most fundamental parameter of atmospheric aerosols. We measured number size distribution of aerosol particles with scanning mobility particle analyzer (SMPS) (Model 3034; TSI Inc.) and optical particle counter (OPC) (KC01-D; RION Co. and AERO TRAK; TSI Inc.) at the forward part of the upper deck (Table 1). The results of SMPS and KC01-D from Harumi to Auckland are shown in Figure 1. Number concentration in Middle latitudes in the North Pacific Ocean region was higher than that in another region.

2.2 Atmospheric aerosol sampling for transmission electron microscopy analysis

Mixing states of chemical substances in aerosol particles are often reflected formation, changing processes of the individual particles and the air mass history. To investigate for mixing state of individual aerosol particles, aerosol particles for morphological analysis using a transmission electron microscopy (TEM) were collected by cascade impactors (50% cut-off diameters of the three stages were 4 μm, 0.5 μm, 0.25 μm). Aerosol samples were collected once or twice a day for 10-15 min at a flow rate about 1.0 l・min-1, referencing real time measurements of aerosol number concentration. Carbon-coated nitrocellulose (collodion) films and Ti-plates were used for TEM sample collection. The TEM samples were stored under dry conditions at room temperature until TEM analysis were performed at laboratory of Tokyo University of Science.

2.3 Radon and ion concentration measurement

As tracer materials of land source air mass, radon concentration was measured with Radon monitor (ES-7420; JREC Co., Ltd.). Radon monitor was set in two wood boxes at the backward part of the upper deck and measured every 1 hour. Ion concentration was measured with Gerdien type ion counter (COM-3400; Com-system Co.), which was set in two wood boxes at the right side of the upper deck

2.4 Filter sampling

For the measurement of chemical composition of atmospheric aerosols, aerosol samples were collected on the filter every 1 day, 3 days or 4days with AS9 and AS900 at the forward part of the upper deck (Table 1). After sampling, ionic components in the filter sample will be analyzed and separated using a Dionex ion chromatography system connected to a fraction collector. The separated and collected NO_3^- and SO_4^{2-} then chemically converted to silver nitrate, silver sulfate, and silver sulfide for triple oxygen (^{16}O, ^{17}O, ^{18}O) and quadruple sulfur (^{32}S, ^{33}S, ^{34}S, ^{36}S) isotopic analyses, respectively. These measurement will be performed by laboratory of Tokyo Institute of Technology.

2.5 CO and O_3 mass concentration

CO and O3 mass concentration was measured with CO Analyzer (48C; TEI Inc.) and Ozone Monitor (Model 1150; DYLEC Inc.) at the upper deck. The results of CO and O3 concentration from Harumi to Auckland are shown in Figure 1. Net CO concentration is the difference between upper bound and lower bound.

2.6 Canister sampling

For the measurement of atmospheric Volatile Organic Compounds (VOC), ambient air was sampled into canisters. The canisters were filled using a Teflon diaphragm pump within 1 minute. Total 32 canisters were sampled. The sampled canisters will be analyzed after the cruise by GC-FID and anthropogenic and biogenic VOCs (including DMS) will be detected quantitatively.

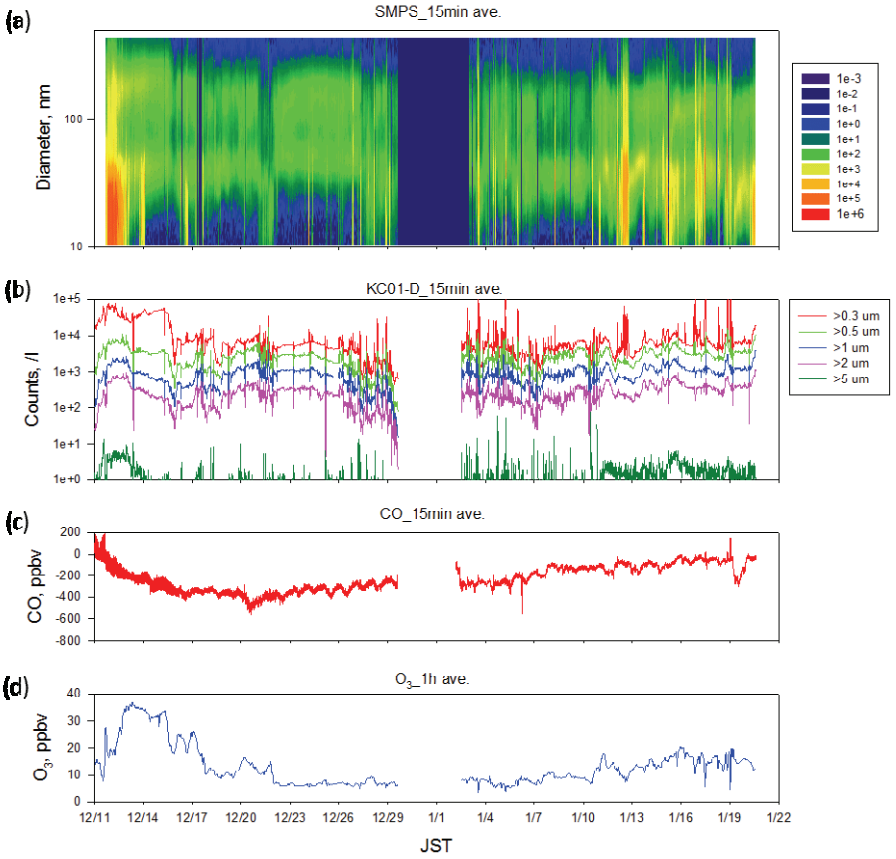

Figure 1. Temporal variation of (a) number size distribution (10-500 nm) with SMPS, (b) number concentration measured with KC01-D (>0.3, 0.5, 1, 2 and 5 μm), (c) CO mass concentration and (d) O3 mass concentration.

Heterotrophic bacterial production and extracellular enzyme activities in sinking particulate matter

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Heterotrophic activities on sinking particulate matter (SPM) have important role for flux of SPM. To demonstrate regional differences in heterotrophic activities on SPM, we measured heterotrophic bacterial production (HBP) and potential extracellular enzyme activity (EEA) in seawater and SPM on a transect along 170°W in the South Pacific.

Physical and biogeochemical processes in the ocean are major regulators of atmospheric carbon dioxide (CO_2), with the ocean particularly important as a sink for fossil fuel CO_2. Therefore, understanding the biogeochemistry of carbon in the oceans is key to predicting and assessing the future evolution of climate. It is essential to quantify the processes that control the transport of carbon and nutrients that support marine primary production (PP) from the surface to the deep ocean. Sinking particulate matter (SPM) plays an important role in transporting and redistributing carbon and nutrients in the ocean as part of the "biological pump" (Volk and Haffert, 1985; Boyd and Trull, 2007). It is estimated that 2–20% of PP is exported from the surface euphotic zone to mesopelagic depths (Boyd and Trull, 2007). In addition to gravitational sinking of particulate organic matter, the downward flux of dissolved organic matter (DOM) could play a more important role in carbon transport in the ocean's interior than previously thought (Toggweiler, 1988; Hansell et al., 2009). In both SPM and DOM cycling, heterotrophic bacteria have been recognized as the major consumers and transformers of PP in ocean ecosystems (Karl et al., 1988; Fuhrman, 1992; Steinberg et al., 2008). Heterotrophic bacterial production (HBP) comprises 30% of PP integrated over the entire water column (Cole et al., 1988). Nagata et al. (2000) summarized that HBP at meso- and bathy-pelagic depths accounts for 38–118% of sinking particulate organic carbon (POC).

Marine sinking particles provide potential "hot spots" for microbial decomposition of organic matter (Azam, 1998; Azam and Long, 2001). Because bacteria can only incorporate small molecules (<600 Da) via their cell-membrane permeases, macromolecules and particles must be broken down to monomers prior to their

incorporation (Weiss et al., 1991). HBP in the ocean interior is apparently fueled by the enzymatic hydrolysis of organic matter in SPM to dissolved organic carbon (DOC), which is then remineralized to CO_2 by the suspended, “free-living” bacteria in the ambient seawater as well as the pool of bacteria attached to the particles (Cho and Azam 1988). Marine bacteria hydrolyze polymers and organic particles using extracellular enzymes, both cell-surface-bound and those released into the ambient seawater (Azam and Malfatti, 2007; Nagata, 2008 and references cited therein). Extracellular enzyme activity (EEA) has previously been examined in various marine particles collected from mesopelagic environments, including suspended particulate matter (Hoppe et al., 1993), marine snow (Smith et al., 1992; Karner and Herndl, 1992), and sinking particles collected by sediment traps (Huston and Deming, 2002; Taylor et al., 2009). These studies measured the activities of hydrolytic enzymes such as proteases, lipases, chitinases, and glucosidases, which catalyze chemical bond cleavage in protein, lipid, and polysaccharide macromolecules, and phosphatases, which release phosphate.

We used a free-drifting sediment-trap system to investigate SPM flux, HBP and EEA (leucine aminopeptidase (LAPase), ß-glucosidase (BGase), lipase, and alkaline phosphatase (APase)) in seawater and SPM at three locations (10°S, 20°S and 30°S) along 170°W and optional location of 28°48’S 173°30’W with a geographic variation in the South Pacific. We deployed standard cylindrical multi-traps with eight acrylic traps mounted at each depth. The bottom part of the cylindrical trap was separable as a collection cup with an approximate volume of 500 mL. The traps were set vertically on the array line at two targeted depths. The upper deployment depths were chosen to be just under the bottom of the euphotic zone. The lower deployment depths were just under the 100m of the euphotic zone. The euphotic zone was defined as the depth at which photosynthetically active radiation was 1% of the value just below the surface.

Studies on full depth distributions of biogeochemical parameters and coupling of biological processes in the central South Pacific

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General Objectives:

Our group mainly focuses on biological degradation and physicochemical alteration of organic materials produced by planktonic community in the upper ocean along the meridian transect of 170W in the central Pacific. Advance of analytical techniques on board or on land and underwater in situ observation instruments can great help to deepen our understanding the complexity of cycling of biophilic elements in the ocean. Followings are more detailed description of each study.

Vertical and north-south horizontal distribution of bulk dissolved organic matter (DOM) in the central South Pacific (H .Ogawa & H. Fukuda)

Seawater samples for DOM analyses were collected at all the stations from all the depth layers used in the routine cast by CTD/CMS sampler. Dissolved organic carbon (DOC) and nitrogen (DON) measurements will be done by high temperature combustion (HTC) method. Amino acids in the combined (DCAA) and free form will be measured by ultra-high performance liquid chromatography (UHPLC) method. A part of these samples will be sent to US for the research collaboration, to Dr. R. Benner (South Carolina Univ., US) for measuring the neutral sugars and D/L ratio of amino acids.

Horizontal and vertical variation of concentration and isotopic composition of particulate organic carbon and nitrogen (POC and PON) (H. Fukuda & Y. Yamada)

The samples for POC and PON analyses were collected from about fixed 13 layers (0, 10, 30, 50, 100, 150, 200, 300, 500, 750 1000, 2000 and 3000 m) and from two unfixed layers (just above 50 m from the bottom and the subsurface chlorophyll maximum layer) at all sampling stations except for station 9 at which 5 layers (30, 150, 300, 750 and 1000 m) were omitted. Suspended particle was collected onto a Whatman GF/F filter from 8-20L of seawaters. Amount of organic carbon and nitrogen will be determined after going back to land facility. Moreover at selected 4 layers (10, 100, 200 m and the subsurface chlorophyll maximum layer) isotopic composition of organic carbon and nitrogen will also be determined.

Vertical profile and physicochemical properties of suspended particles (H. Fukuda, Y. Yamada & H. Ogawa)

Despite increasing recognition that sinking flux of POC is related closely with that of biominerals (opal and calcite), which act as ballast of settling particles (Armestrong et al. 2002, Klaas and Aecher 2002, Passow 2004, Sanders et al. 2010), variability of effective density (excess density) of suspended particles in the surface layer of oceanic environments and its controlling mechanism are still largely unknown.

In this cruise we examined spatial patterns of 1) the high resolution vertical profile of size spectrum of suspended particles (1.25-252 μm in diameter), which are potentially constituent of settling aggregates, by using a low-angle light scattering instrument (LISST-100X, Sequoia Scientific Inc., USA), 2) the structure and type of suspended particles (25-2500 μm in diameter) by using a submersible particle imaging system (LISST-HOLO, Sequoia Scientific Inc., USA), which can obtain 3D holography of suspended particles and planktonic organisms and 3) settling velocity of suspended particles (1.25-252 μm in diameter).

The observation using LISST-100X and LISST-HOLO was conducted at all stations from the surface to 200 m in depth. At station 4-9 and I, water samples were collected from 10 m in depth and the subsurface chlorophyll maximum layer by CTD-RMS to determine settling velocity of suspended particles. Then we estimated a fractal dimension of suspended particles and excess density of solid in suspended particles from relationship between particle size and settling velocity assuming that suspended particles had spherical shape.

Spatial and vertical characteristics of microbial uptake of glucose (H. Fukuda)

The log-log relationships between prokaryote carbon production (PP) and prokaryote abundance (PA) in various oceanic environments including meso- and bathy-pelagic layers convergences around a universal line suggesting that a simple universal mechanism connects prokaryote assemblage with their carbon consumption (Arístegui et al., 2009, De Corte et al., 2012 etc.). On the other hand, genomic analysis on oceanic microbes provided that uptake ability of specific growth substrate such as glucose, which is one of the major labile dissolved organic carbon released from phytoplankton, is not uniform in oceanic prokaryote. It is unclear why the log-log relationship between PP and PA is universal in diverse aquatic systems under complicated dynamics of available organic and inorganic substrate. To address this

question, spatial and vertical characteristics of microbial uptake of glucose were examined by using a concentration series bioassay technique of radioisotope dilution. This technique gives more accurate estimates of compound bioavailability compared with less reproducible analytical chemical methods (Berman and Bronk, 2003).

The experiments were conducted at 4 stations (5, 7, 8 and I) using samples collected from 10, 400 and 2000 m. Seawater amended with 14C labeled glucose was incubated at in situ temperature. Radio assay will be conducted after going back to land facility.

Viral production and dynamics in microbial food webs in the upper mesopelagic zone (Y. Yang, H. Fukuda, N. Yamada)

Introduction

Mesopelagic microbial activities play a central role in the mineralization and sequestration of organic carbon exported from the euphotic zone, which is crucial to the global carbon cycle (Burd et al. 2010; Passow & Carlson 2012). However, the efficiency of the microbial community in mineralization or sequestration of carbon not only depends on the bottom-up controls (e.g. temperature, quality and quantity of the resources) but also is affected by the top-down controls (protist grazing and virus lysis). Strong viral lysis will release the prokaryotic production into dissolved phase and reduce the export production to the higher trophic levels (known as viral shunt), which will finally increase the respiration of the microbial communities, an important parameter to estimate the C-budget in the mesopelagic zone. Previous studies found the viral to prokaryotic abundance ratios in the mesopelagic layer were slightly but significantly higher than those in the upper layer (Yang et al. 2010; 2014), while the grazer (heterotrophic nanoflagellates and ciliates) abundances decreased more rapidly than did prokaryotic abundance in the mesopelagic layer (Sohin et al. 2010). However, the apparent abundance relationships may not necessarily suggest the relative importance in mortality rates due to viral lysis, because viral abundance is also determined by their decay rates, which was estimated to be lower than those in the euphotic zone (Parada et al. 2007). But estimates on viral decay rate in comparison with viral production rate are limit in the mesopelagic layer. Besides the autochthonous production, viruses could also be transported from the euphotic zone by sinking particles (Proctor & Fuhrman 1991). However the contribution of sinking flux transported viruses to local viral communities, and its ecological implications require more solid investigations. The objectives of the present research in this cruise are to 1) estimate the viral lysis pressure and heterotrophic nanoflagellates grazing on the

prokaryotic production and growth efficiency in the upper mesopelagic zone, and how these variables vary in different oceanic regimes, and 2) to estimate a viral budget concerning the local production, decay, and transport by sinking particles in the mesopelagic. The results of this study will improve our understanding on the viral dynamics and the controls in the mesopelagic microbial food web, and the roles of viruses and microbial food web in mesopelagic C-cycle.

Study sites

Incubation experiments for estimating viral production, prokaryotic production and respiration were carried out at 50 m below the euphotic zone (generally 150 m to 180 m) at 4 stations (5, 7, 9 and I) during cruise KH13-7.

Methods

Viral production was estimated by the virus reduction method (Weinbauer et al. 2010). Briefly, ~1000 ml of sea water was concentrated using a 0.2 μm cutoff tangential flow filtration cartridge (Vivaflow 200) to ~100 ml. The concentrate was diluted by the virus-free sea water, which was produced by a 100 kDa Vivaflow 200 cartridge using the same water sample, to the initial volume to get the virus reduced microbial communities. The virus-reduced sea water was incubated in triplicates at in situ temperature in dark for 2–3 days. 2-ml subsamples were taken at a general 12 hours' interval, fixed with 0.02-μm filtrated 20% glutaraldehyde (final conc. 1%), shock frozen in liquid nitrogen, and stored in a -80 oC deep freezer for later analysis by flow cytometry.

Viral decay rate was estimated by the linear decrease of log viral abundance over time (Parada et al. 2007). The virus fraction of the sea water was obtained by the 0.2 μm cutoff tangential flow filtrate. 3 duplicates were incubated and subsampled together with those for viral production estimation.

Heterotrophic nanoflagellate (HNF) grazing pressure was estimated using the abundance and cellular biomass of HNF (Fukuda et al. 2007). Microscopy slides for estimating HNF abundance and cellular biomass were prepared by filtrating 20–50 ml of FITC and DAPI stained sea water onto 25 mm diameter, 0.8-μm pore size black polycarbonate membrane filter within 12 hours after the water sample was fixed with glutaraldehyde (1% final conc.). The dried membrane filter was mounted on a glass slide with emersion oil, covered by cover slide, and the slide was preserved in -20oC for later epifluorescence microscopy examination.

Prokaryotic respiration was estimated using the oxygen concentration reduction

method (Weinbauer et al. 2013). Original sea water was gravity filtrated through 0.8-μm pore size polycarbonate membrane filter (diameter 47 mm, Whatman) to remove large eukaryotes. The filtrate was distributed into calibrated 300 ml borosilicate glass bottles taking care to avoid air bubbles. 3 replicates were fixed at the beginning of the incubation to determine the oxygen concentration at T_0. 3 replicates were incubated at in situ temperature for 3–5 days and fixed to determine the oxygen concentration at T_end. Prokaryotic respiration was estimated using the decrease in oxygen concentration vs time. Dissolved oxygen concentration was estimated by potentiometric titration using an automatic titrator (Metrohm, 793 MPT Titrino, details see the method part of the cruise report).

Prokaryotic production was estimated by the 3H-leucine incorporation rate method, as described in Yokokawa et al. (this cruise report).

Viral sinking flux was estimated by the difference in viral concentrations of the sediment trap water collected from just below the euphotic zone (1% surface light intensity) and from 100 m deeper than the euphotic zone. Viral abundances in sediment trap water will be estimated using epifluorescence microscopy. Slides were prepared according to Taylor et al. 2009 and Luef et al. 2007 within 8 hours after the samples were fixed by glutaraldehyde (1% final conc.), and stored at -20oC until analysis.

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Organic carbon and nitrogen, TEP and size distribution of suspended particles in the tropical South Pacific (Y. Yamada & H. Fukuda)

Objective:

To clarify the spatial variations and regulation of particulate substance in the South Pacific.

Parameters:

a) Particulate organic carbon and nitrogen (POC/N)
b) Transparent exopolymer particles (TEP)
c) Abundance, volume and size distribution of suspended particles

Methods and Instruments:

The following parameters were observed at all station of Leg. 1 (Stn. 0-3).

a) POC/N

Seawater sample was filtrated through a pre-combusted GF/F filter and the filter was stored in a freezer (-20°C). Total mass of POC/N collected on the filter will be determined by CHN elemental analyzer in a land laboratory.

b) TEP

Seawater and sediment trap sample were filtered through a polycarbonate filter (pore size, 0.4 μm). The filter was stained with cationic dye Alcian Blue and

stored in a freezer (-20°C). The concentration of TEP collected on the filter will be determined by colorimetry in a land laboratory.

c) Abundance, volume and size distribution of suspended particles

Vertical size distribution of suspended particles in the upper layer (<200 m) was determined by an *in situ* size-scattering instrument, LISST-100 (Sequoia Scientific Inc.).

Future plans:

After measuring POC/N and TEP concentration in a land laboratory, I will clarify the spatial variations of these parameters and compare other parameters (conductivity, chlorophyll a, bacterial phylogenetic diversity and production) to explain the variations.

Elucidation of biogeochemical cycles of amino acids in the central South Pacific

(A. Sakai, H. Fukuda, H. Ogawa)

Organic matter is important to elucidate biological activity or biogeochemical cycle in ocean. Most of the dissolve organic matter exists as biologically refractory organic matter. However dissolve amino acids exist as easily decomposable organic matter. And amino acids are composed of nitrogen and carbon. This suggests that dissolved amino acids will effect on organic nitrogen (DON) and dissolve organic carbon (DOC) dynamics. Consequently, studying about amino acids are important to understand biogeochemical cycle in ocean.

The purpose of this study is to investigate the distribution of amino acids in the central South Pacific and their microbial utilization. In this research I used surface waters at 10 m. And I measured microbial uptake rate and turnover time of leucine, glycine, glutamic acid by using a tracer technique of radio isotope (^{3}H). At the main station (Stn. 1, 3, 5, 7, 9) these amino acids were added at final concentrations ranging from 0.1 to 1.0 nM. At other station (Stn. 4, 6, 8) they were added at final concentrations range from 0.2 to 0.8 nM.

Study on the phytoplankton diversity in the Pacific

Koji Sugie (Faculty of Environmental Earth Sciences, Hokkaido University)

Introduction

Phytoplankton community composition has been studied traditionally using microscopy and/or photosynthetic pigments analysis. The former method can measure larger than ~10 μm phytoplankton and the latter can estimate only the differences of class levels. Therefore, the true picture of the diversity of the phytoplankton diversity in the ocean is poorly unraveled. Recent progress in molecular technique may be able to distinguish the difference of the phytoplankton species comprehensively compared to the previous methods. Further, our group tries to investigate phytoplankton groups or functional types using satellite images. To convert satellite images into the qualitative data on phytoplankton groups, optical property of seawater such as spectral absorption and standing stock of each phytoplankton groups should be investigated. The goal of our study is to link phytoplankton diversity from molecular level to synoptic, basin scale dynamics.

Objective

Here we investigate the diversity of phytoplankton community in the Pacific using molecular technique, microscopy, pigment analysis, and flow cytometry. Furthermore, we compare the phytoplankton community composition between surface and subsurface chlorophyll maximum layers to clarify the characteristics of each community.

Materials and Methods

Sampling items

DNA (> 10 μm, 0.2–10 μm), chlorophyll-*a* (>20 μm, 10–20 μm, 2–10 μm, 0.7–2 μm), phytoplankton pigments, pico- and nano-size plankton (fixed with paraformaldehyde), scanning electron (fixed with neutralized formalin) and light microscopic (fixed with neutralized formalin) analysis, chromophoric dissolved organic matter, and chl-*a*-specific absorption coefficient of phytoplankton were collected at the stations listed below. At some stations (station with asterisk below), I also collected RNA and plankton net (20 μm mesh) samples to investigate what the species are active for growth and meta-genomic analysis of micro- phytoplankton diversity, respectively.

Sampling time (Local time, dd/mm/yyyy), locations, and depth.

12/12/2013 32°09’N, 143°51’E (~5 m)

14/12/2013 26°39’N, 151°23’E (~5 m)

16/12/2013 20°00’N, 160°00’E (5 m, 114 m)

18/12/2013	14°36’N, 168°03’E (~5 m)
19/12/2013	8°17’N, 177°36’E (~5 m)
21/12/2013	2°38’N, 173°5’W (~5 m)
23/12/2013	0°00’, 170°00’W (5 m, 41 m)*
26/12/2013	10°00’S, 170°00’W (5 m, 110 m)*
2/1/2014	15°00’S, 170°04’W (10 m, 135 m)
4/1/2014	20°01’S, 170°02’W (5 m, 145 m)*
7/1/2014	25°00’S, 170°01’W (5 m, 113 m)
9/1/2014	30°00’S, 170°00’W (5 m, 108 m)*
11/1/2014	35°00’S, 170°00’W (5 m, 130 m)
13/1/2014	40°00’S, 170°00’W (5 m, 82 m)
13/1/2014	40°02’S, 169°59’W (~5 m)
15/1/2014	33°07’N, 175°04’W (~5 m)
18/1/2014	28°51’S, 173°32’W (~5 m, 90 m)
18/1/2014	29°11’S, 174°03’W (~5 m)
20/1/2014	33°03’S, 179°30’W (~5 m)
20/1/2014	34°59’S, 177°41’E (~5 m)
27/1/2014	31°50’S, 174°02’E (~5 m)
28/1/2014	26°38’S, 171°44’E (~5 m)
29/1/2014	21°18’S, 169°06’E (~5 m)
31/1/2014	10°37’S, 164°26’E (~5 m)
1/2/2014	4°43’S, 163°06’E (~5 m)
2/2/2014	0°01’S, 162°05’E (5, 104 m)
2/2/2014	1°46’N, 160°46’E (~5 m)
3/2/2014	4°18’N, 160°00’E (~5 m)
4/2/2014	9°22’N, 155°27’E (~5 m)
5/2/2014	14°42’N, 152°41’E (~5 m)
6/2/2014	20°00’N, 150°00’E (5, 114 m)
7/2/2014	23°37’N, 146°50’E (~5 m)
8/2/2014	26°36’N, 144°39’E (~5 m)
9/2/2014	~30°N, ~142°E (~5 m)
10/2/2014	~32°30’N, ~141°E (~5 m)
10/2/2014	~33°50’N, ~140°30’E (~5 m)
10/2/2014	~34°30’N, ~140°E (~5 m)

Result

Only the data on size fractionated chl-*a* can be shown to date here. Chl-*a* was higher in the subsurface chl-*a* maximum except at stn. 1, where equatorial upwelling may be affected. In general, small sized phytoplankton (< 2 μm) dominate at all stations. Large phytoplankton (>20 μm) increase the dominancy 15–20% at Stn. 6 surface, and Stn. 9 surface and SCM. Such variability in the composition of size fractionated chl-*a* may change community composition of phytoplankton examined using pigment analysis, microscopy and molecular assays.

Possible outcomes

Our study would be the first demonstration that shows the phytoplankton diversity including prokaryotes and eukaryotes over the wide range in the central South Pacific. Comparison with the surface sampling in the North Pacific and South Pacific may provide interesting feature of phytoplankton dynamics. Because marine biodiversity plays a key role on the productivity, our study will contribute to deep understanding on the productivity in the central South Pacific. In addition, we try to clarify what mechanisms drive the phytoplankton diversity in the oceanic environment.

1) Latitudinal and depth profiles of marine prokaryotic populations in the South Pacific

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Background

Marine microbes including bacteria and archaea are capable of thriving in all oceanic habitats from surface to deep-sea and involved in many kinds of biogeochemical reactions occurring in the oceans (Azam and Worden, 2004). During the last two decades, introduction of the molecular techniques such as DNA fingerprinting with 16S rRNA gene to marine microbial ecology has revealed the taxonomic diversity of prokaryotes in the ocean. In addition, development of genome analysis has revealed the functional diversity of marine prokaryotic phylotypes, which closely link to organic and inorganic material cycles in the ocean. For example, SAR11 group known as the most abundant phylotype in the surface ocean possesses the "proteorhodopsin" protein for harvesting light energy (Giovannoni et al., 2005). Marine crenarchaeotes (the "Group I 1A" phylotype) live as autotrophs, using ammonia derived from the decomposition of organic matter as the source of reducing power to fuel carbon (Könneke et al., 2005). Thus, to grasp the spatiotemporal distribution of each phylotype of marine prokaryotes would be important for better understanding biogeochemical cycles in the open ocean. However, the data regarding horizontal and vertical profiles of each phylogenetic group in the water columns of the South Pacific are still scarce. Our primary goal of this cruise is to investigate the latitudinal and depth profiles of each prokaryotic phylotype and to quantify phylotype-specific abundance along a north-south transect across the South Pacific.

Materials and Methods

In this cruise, the distributions of each prokaryotic phylotype were analyzed using catalyzed reporter deposition and fluorescence *in situ* hybridization (CARD-FISH). Seawater samples were collected from 9-20 sampling depths (i.e., 0, 5, 10, 20, 50, 100, [150], 200, [300], [400], 500, [750], 1000, 1500, 2000, 2500, 3000, 4000, Bottom-50 [or 40] m, and subsurface chlorophyll maximum (SCM)) at all stations (Table). Then, prokaryotic cells in the seawater were filtered onto 0.22-μm pore-size polycarbonate membrane filters. Then these cells were fixed with 2% paraformaldehyde (pH 7.2). These filters were stored at -80 °C until analysis on land. In addition, to measure total prokaryotic abundance using flow cytometry (FCM), seawater (2 mL each) collected from each depth was preserved with 1% paraformaldehyde (pH 7.2) and then stored at -80˚C.

2) Responses of heterotrophic bacteria to dissolved organic matter derived from phytoplankton cultures

Background

Primary production (~50 Gt C $year^{-1}$) and heterotrophic respiration (~37 Gt C $year^{-1}$) in the euphotic layer account for about half of global open ocean carbon processing (del Giorgio and Duarte, 2002). In this highly active layer, dissolved organic matter derived from phytoplankton exudation or cell lysis is a key component to stimulate heterotrophic bacterial proliferation (Hellebust, 1965; Mague et al., 1980). However, interaction patterns between specific phytoplankton and bacteria are still unknown. We hypothesized that the type of phytoplankton exudate plays a key role in determining the community structure of heterotrophic bacteria. To test this hypothesis, we investigated the bacterial community shifts in response to a known amount (in terms of carbon) of five different DOMPs (dissolved organic matters derived from phytoplankton) using *Synechococcus* sp., *Pelagomonas calceolate*, *Thalassiosira oceanica*, *Chrysochromulina camella*, *Pycnococcus provasolii*) and some molecular techniques (e.g., FCM cell-sorting, PCR-cloning, FISH and Ion Torrent amplicon sequencing methods). The incubation experiments were carried out using seawater at stations 1, 3, 5, 7, and 8. In addition, at stations 9 and I, we conducted extra experiments in order to estimate the effect of different DOMP levels on the bacterial diversity.

Materials and Methods

Before this cruise, we prepared five different DOMPs from the NCMA (National Center for Marine Algae and Microbiota, USA) algal cultures (CCMP1334, 1756, 1005, 289, and 3401) isolated from open oceans. Seawater samples for the incubation experiment were collected from SCM layer or 0 m depth (St. 8), and filtrated with GF/F glass-fiber filter to remove protozoa. Duplicate or triplicate of GF/F pre-filtered seawater samples (250 mL each) were incubated at dark controlled *in situ* temperature with addition of the different DOMPs (3.5 μg C each) for 12 to 20 h. At the stations 9 and I, duplicate samples of pre-filtered seawater were incubated for 14 to 20 h with addition of different DOMP concentrations (0, 0.6, 1.2, 3.0, 6.0 μg C; from *T. oceanica*).

After incubation, seawater samples (10 mL) were preserved with 1% paraformaldehyde, frozen and stored at -80˚C for cell-sorting, PCR-Cloning analysis. For the FISH analysis, bacterial fractions in the seawater were filtered onto 0.22-μm pore-size polycarbonate membrane filters. Then these cells were fixed with 2% paraformaldehyde (pH 7.2). These filters were stored at -80°C until analysis on land. To measure initial dissolved organic carbon (DOC) concentration, seawater samples were filtered with 0.22-μm pore-size PVDF filters (Millipore) and then stored in the pre-combusted (450°C) glass bottles at -30°C.

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Table. Sampling depth for FCM and CARD-FISH samples

Station	Depth (m)
0	0, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 3000, 4000, Bottom-50, and SCM
1	0, 5, 10, 20, 50, 100, 200, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
2	0, 5, 10, 20, 50, 100, 200, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
3	0, 5, 10, 20, 50, 100, 200, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
4	0, 5, 10, 20, 50, 100, 200, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
5	0, 5, 10, 20, 50, 100, 200, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
6	0, 5, 10, 20, 50, 100, 200, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
7	0, 5, 10, 20, 50, 100, 200, 400, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
8	0, 5, 10, 20, 50, 100, 200, 400, 500, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
9	0, 5, 10, 20, 50, 100, 150, 200, 300, 400, 500, 750, 1000,1500, 2000, 2500, 3000, 4000, Bottom-50, and SCM
I	0, 10, 50, 100, 200, 500, 1000, 2000, and SCM
12	0, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 3000, 4000, Bottom-50, and SCM
13	0, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 3000, Bottom-40, and SCM

Underway measurements of volatile organic compounds in the surface seawater and atmosphere

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1. Introduction

In the atmosphere, volatile organic compounds (VOCs) such as dimethyl sulfide (DMS) and acetone have substantial effects on the radiative budget of the atmosphere and the regulation of Earth's climate. Ocean is believed to play important roles in global budgets of VOCs. However, the contribution of VOCs from ocean to atmosphere remains largely unexplored, because there is a little information on distribution of VOCs concentrations in the surface seawater and its sea-air flux.

We recently developed online analytical method, an equilibrator inlet–proton transfer reaction–mass spectrometry (EI-PTR-MS) technique, for continuous measurement of VOCs concentrations dissolved in seawater (Kameyama et al., 2009, 2010; Omori et al., 2013). The underway measurement is expected to greatly increase the number of data points in the VOCs database, and hence, to improve our understanding of the distribution of VOCs, and its sea-air flux. In addition, our group developed a new method for *in situ* measurement of air-sea fluxes of multiple VOCs by combining PTR-MS and gradient flux (GF) technique (Tanimoto et al., 2013). In the GF technique, a fine buoy system is used for the measurement of VOCs concentration profile in the lower atmosphere.

The purpose of this study is to obtain the distributions of VOCs concentration in both of the surface seawater and the air, and to clarify its sea-air flux in the South Pacific. We also examined the biomass and composition of phytoplankton in the surface seawater which were key parameters controlling the distribution of some VOCs concentration.

2. Sampling and analysis

2.1. Underway measurements of VOCs concentrations in the surface seawater

The EI-PTR-MS system comprised a PTR-MS instrument (PTR-MS-hs, IONICON Analytik, Innsbruck, Austria) and a bubbling-type equilibrator for equilibration between the liquid and gas phases. The equilibrator consisted of brown (to prevent photolysis) vertical glass tubes (water volume: 10 L). For this observation, perfluoroalkoxy tubing and Tygon tubing® (Saint-Gobain, Courbevoie, France) were used for gas and water samples, respectively.

Surface seawater was pumped from a seawater intake on the bottom of the ship

(approximately 5-m depth), and supplied to the laboratory. The surface seawater was continuously supplied to the equilibrator at a flow rate of 1 L min^{-1}. Ultrapure nitrogen gas flowed as the carrier gas from bottom of the equilibrator at a flow rate of 120 sccm. Dissolved VOCs were extracted into the gas phase, and a portion of the gas was continuously directed to the PTR-MS instrument at ambient pressure.

PTR-MS measurements were conducted in multiple ion detection mode at 1 or 5-s integration for each mass per cycle to obtain mass signals at 1-min intervals. We mainly monitored the ion signal intensities of *m/z* = 33 (methanol), 43 (propene), 45 (acetaldehyde), 59 (acetone), 63(DMS), 69 (isoprene). The detection sensitivity was determined by dynamic dilution of a gravimetrically prepared gas standard (methanol, propene, acetaldehyde, acetone, DMS and isoprene) balanced with ultrapure N_2 (5.08 ppm, Japan Fine Products Co., Kawasaki, Japan).

2.2. Measurement of VOCs concentrations in the air

The air sample was pumped from inlet on upper deck (height of about 14 m) to the 7 Lab at flow rate of 4 SML. VOCs concentrations in the air were measured by PTR-MS at approximately 2° intervals throughout Leg.1 and 2. We mainly monitored the ion signal intensities of *m/z* = 33 (methanol), 43 (propene), 45 (acetaldehyde), 59 (acetone), 63(DMS), 69 (isoprene).

2.3. High-pressure liquid chromatographic analysis of phytoplankton pigments

For the determination of phytoplankton pigment concentrations, the surface seawater pumped from the bottom of the ship (5-m depth) was collected at every 2.5 degree. The seawater samples (2.3 L) were filtered through a Whatman GF/F filter (25 mm in diameter) under gentle vacuum (<100 mm Hg). The filters were stored in liquid nitrogen until analysis by means of high-performance liquid chromatography according to the procedure described by Suzuki et al. (2002).

Phosphate uptake by phytoplankton and bacteria in the subtropical west Pacific and along the south Pacific transect (0°–40°S, 170°W)

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Objective

Phosphate is one of the essential elements for marine organisms. Phosphate is transformed to particulate phosphorus by osmotrophs such as phytoplankton and bacteria in the marine food web. Although phosphate concentration has long been measured by the molybdenum blue reaction method, information of phosphate uptake rate (i.e. inverse of phosphate turnover time) by biological activity is still limited in the ocean. To better understand P dynamics in the ocean pelagic layer, I measured phosphate turnover time during KH-13-7 cruise. This study was performed through the collaboration with Drs. H. Ogawa and H. Fukuda (AORI).

Materials and methods

Water samples for the measurement of phosphate turnover time were collected using a multi-sampler carousel rosette system equipped with clean Niskin bottles and a CTD from 10–200 m depths at 11 stations: St. 0 (20°N, 160°E), St. 1 (0°S, 170°W), St. 3 (10°S, 170°W), St. 4 (15°S, 170°W), St. 5 (20°S, 170°W), St. 6 (25°S, 170°W), St. 7 (30°S, 170°W), St. 8 (35°S, 170°W), St. 9 (40°S, 170°W) and St. I (28°48'S, 173°30'W). In order to characterize a small surface area where phosphate concentration is small and chlorophyll concentration is high (F. Hashihama, personal communication), water samples for phosphate turnover time was collected from the inline seawater (ca. 5 m depth) every 15' of latitude between 20°15'S and 22°45' along 170°W. Because the measurement of leucine incorporation rate in samples from the inline seawater of R/V *Hakuho maru* has shown significant reduction of biological activity (H. Fukuda, personal communication), phosphate turnover times were compared between samples from a clean Niskin bottle (collected at 5 m depth) and from the inline seawater (ca. 5 m depth) collected at the same time at St. 7.

Phosphate turnover time was measured using carrier-free $^{32}PO_4$ according to Thingstad et al. (1993). Isotope was added to water samples (10–50 ml: no replicate except for the comparison samples at St. 7: n=3) in sterile Falcon tubes to give radioactivity of 1.2×10^4 to 2.3×10^4 Bq ml^{-1}. Samples for the subtraction of the background and abiotic adsorption were fixed with 100% trichloroacetic acid (final concentration, 0.5%) before isotope addition. Samples were incubated (1–3 hours) at in situ temperature (±3°C) under

subdued (laboratory) illumination. Incubation time was short enough to assure a linear relationship between the fraction of isotope transformed to the particulate fraction vs. the incubation time but was long enough to detect the isotope uptake above the background level. However $^{32}PO_4$ uptake in samples below 100 m was generally so small that the detected isotope uptake was close to the background level. Subsamples (0.1 ml) were collected to count the added radioactivity. Incubation was stopped by a cold chase of 100 mM KH_2PO_4 (final concentration, 1 mM). Subsamples at St. 0 were filtered in parallel onto 25 mm polycarbonate filters with 2, 0.6 and 0.2 μm pore sizes, and subsamples at the other stations were filtered onto 25 mm polycarbonate filters with 0.2 μm pore size. All polycarbonate filters were placed on a Millipore 12 place manifold with Whatman (GF/C) glass fiber filters saturated with 100 mM KH_2PO_4 as support. After filtration, filters were placed in glass scintillation vials with MQ water, and radio-assayed on board. After the radioactivities of the filter were corrected for those of the blank filter obtained from fixed samples, phosphate turnover time (*Tt*: days) was calculated as $Tt = -t / \ln (1 - f)$ where f is the fraction (no dimension) of added isotope collected on the 0.2 μm filter after the incubation time (t: days).
Preliminary results

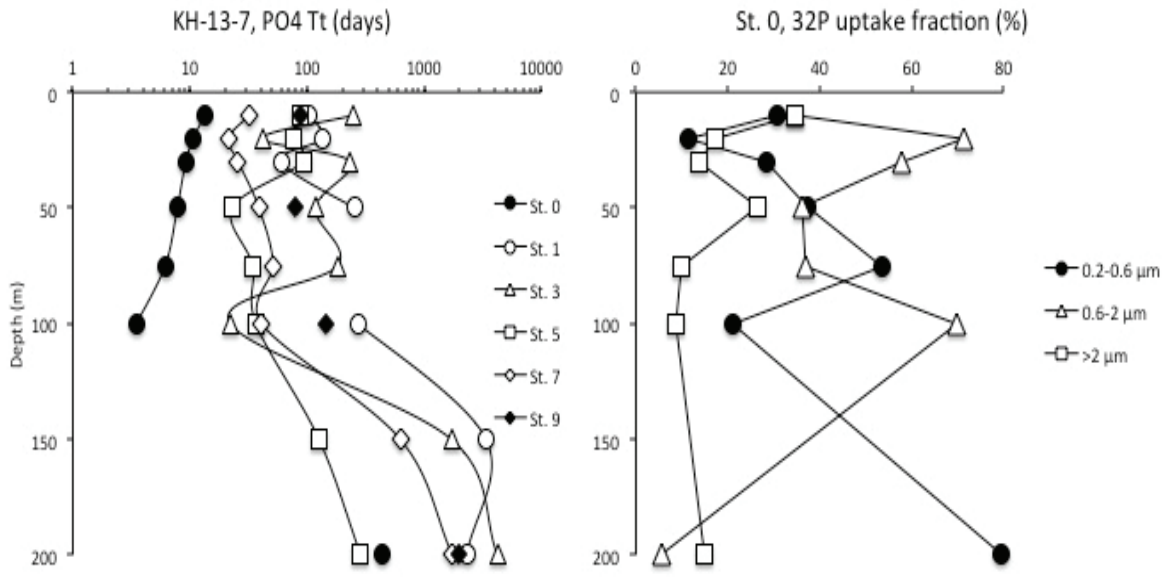

Fig. 1. Vertical profiles of phosphate turnover time (days) at St. 0, 1, 3, 5, 7 and 9 (left) and ^{32}P uptake fraction (%) by the 0.2–0.6, 0.6–2 and >2 μm fractions at St. 0 (right).

Vertical profiles of phosphate turnover time are shown for the certain stations for simplicity (Fig. 1). Phosphate turnover times were generally shorter in the upper 100 m and longer at 150 m and 200 m. This is likely because of the existence of phosphacline below 100 m. It should be noted that turnover times varied one order of magnitude (100 to >1000 d) at 150 m and 200 m between the stations. In the upper 100 m, turnover times were short (3–13 d) at St. 0, on the order of 10 d at St. 5 and 7, and long (ca. 100 d) at St. 1, 3 and 9. The shortest was found at 100 m at St. 0 (3 d), where ^{32}P uptake was dominated by the 0.6–2 µm fraction with two peaks (20 m and 100 m) (Fig. 1). ^{32}P uptake fraction by the >2 µm fraction decreased with depth, and that by the 0.2–0.6 µm fraction showed the opposite trend. Interestingly, relatively short turnover times were sporadically found at 30 m (60 d) at St. 1 and at 20 m (42 d) and 100 m (22 d) at St. 3, and at 50–100 m (23–37 d) at St. 5.

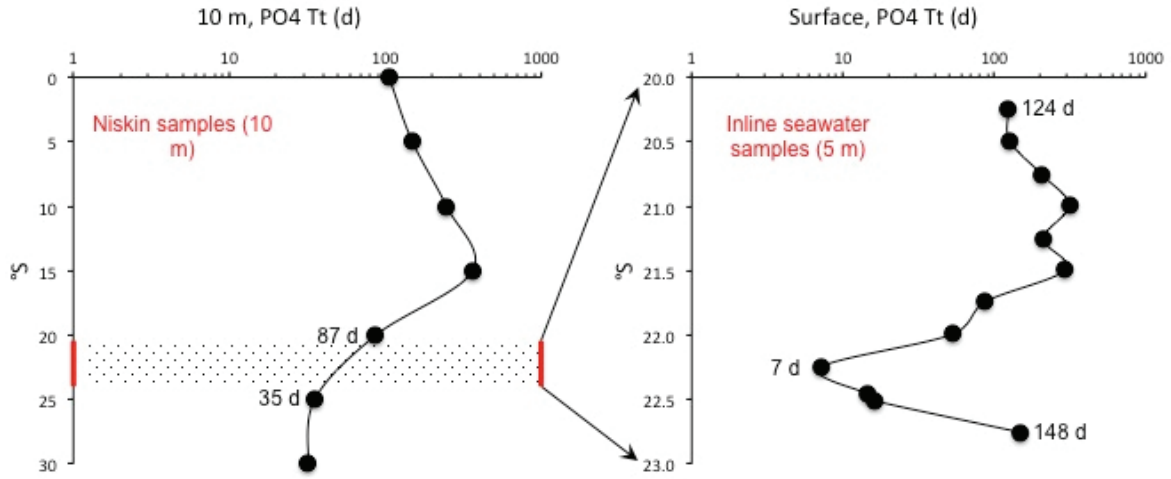

Fig. 2. Spatial changes of phosphate turnover time (days) at 10 m depth collected by clean Niskin bottles every 5° of latitude between 0° and 30°S along 170°W (left), and that of phosphate turnover time (days) collected from the inline seawater (ca. 5 m depth) every 15' of latitude between 20°15' and 22°45'S along 170°W (right).

Phosphate turnover times at 10 m depth were in a range of 100–300 d between 0° and 15°S and became relatively short (ca. 30 d) towards 25° and 30°S (Fig. 2). The area where surface water was frequently sampled corresponded to the transition of turnover time being shorter towards the south. The frequent measurement showed that turnover times were ca. 100 d between 20°15'S and 21°30'S, decreased greatly towards 22°15'S (7 d) and increased again towards 22°45'S (Fig. 2). The area of short turnover times (<10 d) corresponded to the chlorophyll peak (KH-13-7 SSM team, unpublished data). The shortest (7 d) found in the inline seawater sample was one order of magnitude shorter than the one found in the Niskin sample (35 d) (but see below). Such a change of turnover time in a limited area is what the regular sampling (e.g. every 5° of latitude) could not detect. The comparison of phosphate turnover time between Niskin samples (5 m) and the inline seawater samples (6th Lab) showed that the former (mean±SD: 35±2 d) was ca. 3 times shorter than the latter (mean±SD: 99±7 d) (Fig. 3). The result clearly indicates that the biological activity of phosphate uptake was significantly reduced in the inline seawater. Thus, the results of the frequent measurement of turnover time should be regarded with caution. However if one can assume that the biological activity of phosphate uptake was similarly influenced in all samples from the inline seawater, actual turnover times should have been much shorter. Overall, the large spatial change of turnover time in a limited area would reflect the in situ phenomenon in a relative sense.

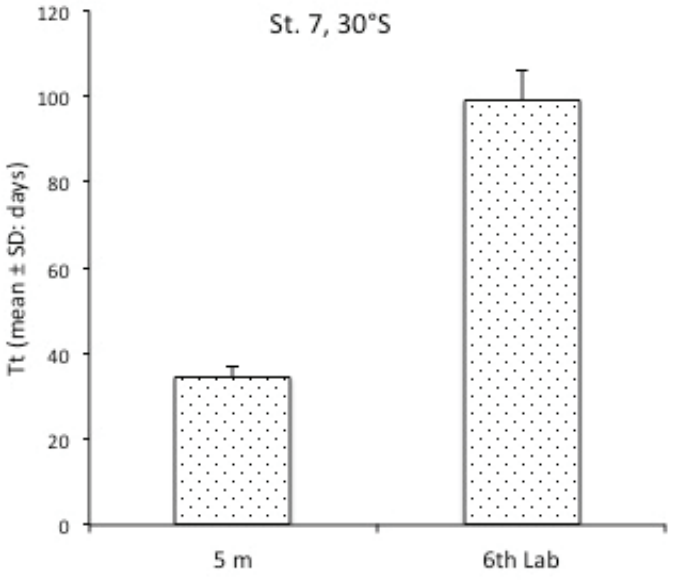

Fig. 3. Comparison of phosphate turnover time (days: mean±SD, n=3) between Niskin samples (5 m depth) and inline seawater samples (6th Lab, ca. 5 m depth) collected at the same time at St. 7.

PO_4 turnover time is the function of PO_4 concentration in the water (S) and the PO_4 uptake flux (V) to the particulate fraction (i.e. uptake by phytoplankton and bacteria in this study): $Tt = S / V$. However turnover time was determined without knowing S and V in this study. By combining Tt with the chemically determined PO_4 concentration (S) which was measured by Hashihama et al. during the same cruise, it is possible to estimate PO_4 uptake rate by phytoplankton and bacteria (V). The data on PO_4 uptake rate will give further insight to the understanding of P dynamics in the study area.

Acknowledgments

I thank the captain and crew of the R/V *Hakuho maru* for their excellent assistance and all scientists for their cooperation. Special thanks are given to the members in the RI laboratory who kindly shared limited bench space and fixed some technical problems during the cruise.

Reference

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Biogeochemical dynamics of trace metals in the South Pacific

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Purpose

Recent findings on the role of trace metals as a factor controlling primary productivity and biogeochemical processes in the oceanic waters emphasized the need for better understandings of interaction between macro- and micronutrients as well as chemical speciation of trace metals in seawater. In the subtropical Pacific Ocean, both trace metals and dissolved inorganic nitrogen is in extremely low concentrations in the surface waters and thus inputs of macro- and micronutrients from the subsurface layer or atmosphere could be one of the mechanisms regulating composition and productivity of phytoplankton assemblage. In addition, differences in availability of iron between the equatorial HNLC waters and the subtropical LNLC waters may also have influences on the distinct biological responses to the supply of limiting elements.

The present study was undertaken to examine the effects of macro- and micronutrients supplies from the subsurface layer or atmosphere on the growth of phytoplankton in the upper and lower euphotic zone. In parallel, distributions of trace-metals, chemical speciation of dissolved iron, and atmospheric deposition of macro-nutrients were determined to understand biogeochemical dynamics of trace metals in the South Pacific Ocean.

Methods

Responses of phytoplankton assemblage to the additions of macro- and micronutrients:

Potential effects of macro- and micronutrients supplies from the subsurface layer on phytoplankton growth were examined by onboard bottle incubation experiments using the surface water collected from 10 m depth and subsurface water collected from the subsurface chlorophyll maximum layer (SCM) by acid-cleaned Teflon-coated 12-liter Niskin-X bottles at stations 1, 3, 5, 7 and 9. The water sample was homogenized in an acid-cleaned 2.5-1iter polycarbonate carboy, and then the water (150 ml) was dispensed into acid-cleaned, replicate 300-ml polycarbonate bottles in a class-1000 clean room. Three bottles were used for each treatment. The treatments were additions of filtered seawater (150 ml; 50% dilution) collected from 150 or 200 m depth (SSW), and simultaneous additions of 150/200 m filtered seawater and 0.6 nmol/L Fe (SSW+Fe). Samples added with the filtered seawater (150 ml; 50% dilution) collected from 10 m depth or SCM were treated as controls. These filtered seawater was prepared using AcroPak 200 Capsule filter unit having 0.8/0.2 μm pore-size Supor Membrane (Pall). The bottles for 10 m depth samples were incubated on deck in a running surface seawater bath to maintain surface seawater temperatures.

The incubation bath was covered with a neutral density screen, which shaded the ambient light to a 50% level. The bottles for SCM samples were placed in an incubator maintained at the temperature of the SCM layer with an illumination of white LED light at 18 μmol/m^2/s (12L:12D or 14L:10D cycle). After 1, 2 and 3 days of incubation, the incubation bottles were recovered from the incubation bath and the incubator, and subsamples were collected for measurements of nutrients and pico- and nanophytoplankton abundance in the class-1000 clean room. Replicate samples were taken from the replicate bottles. At the beginning and the end of the experiments, samples were also collected for determinations of chlorophyll a concentration and microscopic observation of dominant phytoplankton species.

Effects of nutrients supply by atmospheric wet deposition were examined by onboard bottle incubation experiments using the surface water collected by bucket at stations 0 and 3. The surface water was homogenized in an acid-cleaned 20-1iter polycarbonate carboy, and then the water was dispensed into acid-cleaned polycarbonate incubation bottles, after passing through a 210 μm acid-cleaned Teflon mesh for removal of meso-zooplankton. Twenty-four and nine 500-ml bottles were used for each treatment at stations 0 and 3, respectively. As treatments, a rainwater sample, which collected during the KH-12-3 cruise in the subtropical western North Pacific, stored frozen, and filtered through pre-combusted (450˚C, 2h) Whatman GF/F glass-fiber filter, was used at station 0. At station 3, a fresh rainwater sample collected near the station 3 during the KH-13-7 cruise was used. Additions were 0.1, 1 and 2 v/v% at station 0, and 1 v/v% only at station 3. Incubation bottles without addition and added with 1 v/v% of Milli-Q water were treated as controls at stations 0 and 3, respectively. The bottles were incubated on deck in a running surface seawater bath to maintain surface seawater temperatures for 4 day at station 0 and 2 days at station 3. The incubation bath was covered with a neutral density screen, which shaded the ambient light to a 50% level. After every 24 hours of incubation, 500ml bottles were recovered from the incubation bath, and submitted to the measurements of macro-nutrients and phytoplankton abundance. Cell density and cellular pigment content of pico- and nano-phytoplankton were determined onboard by Flow cytometric analysis. At the end of the incubation, samples for Chl *a* measurement were also obtained.

The samples (250–300 ml) for Chl *a* measurement were filtered onto Whatman GF/F filter by gentle vacuum filtration (< 200 mm Hg), and Chl *a* was extracted from the filters for >24 hr in N,N-dimethylformamide at 4ºC. Extracted Chl *a* was determined onboard by the fluorometric technique with a Turner Designs 10-AU field fluorometer with the chlorophyll optical kit for the non-acidification method (Welschmeyer, 1994). Samples for nutrient analysis were collected in 10-ml acrylic tubes and stored at –20ºC. Abundance and cellular pigment content of pico- and nanophytoplankton were determined onboard by Flow cytometric analysis (CyFlow Space flow cytometer, Partec). Forward light scatter (FSC), side light scatter (SSC), orange fluorescence (FL2,

fluorescence mainly from phycoerythrin), and red fluorescence (FL3, fluorescence mainly from chlorophyll) were measured. FL3 was utilized as a trigger parameter to distinguish phytoplankton cells from heterotrophs and non-living particles. Based on FL2 vs.FL3 and FL3 vs. FSC cytograms, *Synechococcus*, *Prochlorococcus* and nano-size cyanobacteria could be distinguished from the other phytoplankton cells. After excluding *Synechococcus* and *Prochlorococcus* from cytograms, pico- and nano eukaryotes are identified. All the data were analyzed using a software FloMaxs (Partec, Germany). Samples for microscopic observation of dominant phytoplankton species were preserved with 1% neutral formalin and stored at 4ºC.

In addition to these onboard experiments, photosynthetic physiology of phytoplankton in the surface water was monitored during the cruise. Seawater was continuously pumped up from a depth of 5 m, and phytoplankton assemblage in the surface water was passed through a black plastic-tubing for dark adaptation, and then variable chlorophyll fluorescence (such as single turnover induction parameters; Fv/Fm and σPSII) was measured using an In Situ FIRe (Satlantic) with flow-cell.

Trace-metals and Iron speciation:

Water samples were collected using acid-cleaned Teflon-coated 12-liter Niskin-X bottles on a CTD-Carousel system attached at the end of the titanium armored cable (8 mm o.d.) from the No.2 winch. Seawater was obtained from 10 m depth to near bottom (6-19 layers) at stations 0, 1-9 and I. After the recovery, Niskin-X bottles were placed in a clean-air booth and the sample seawater was filtered through an AcroPak 200 Capsule filter unit having 0.8/0.2 μm pore-size Supor Membrane (Pall) attached directly to the spigot with silicon tubing under a pressure of <1 atm by compressed clean air. Filtered seawater collected in acid-cleaned 500-ml FLPE bottles were stored frozen under –20ºC for analysis of iron complexing ligands in the onshore laboratory. Samples for analyses of dissolved trace-metals (Mn, Fe, Co, Ni, Cu and Zn) were collected in acid-cleaned 125-ml LDPE bottles and acidified to pH <1.7 with 20% quartz-distilled HCl (TAMAPURE AA-100). Filtered seawater samples were also collected from some selected layers into 30-ml amber-glass vials and stored frozen under –20ºC for the 3-D fluorometrical analysis of C-DOM.

Water samples collected from 10 m depth and the subsurface chlorophyll maximum layer were also used for the determination of elemental composition of suspended particulate matters at stations 1, 3, 5 and 7. Two-liter water sample was passed through an acid-cleaned 0.45 μm pore-size Supor Membrane filter or a pre-combusted Whatman GF/F filter for analysis of trace-metals or particulate organic carbon/nitrogen, respectively. The filtration was conducted in a class-100 clean-room using an in-line filtration system. The filter samples were stored frozen under –20ºC. Zooplankton (copepod) samples were also collected by vertical net tows from 200 m depth for the analysis of trace-metal composition.

Atmospheric deposition of macro- and micro-nutrients:

Atmospheric deposition is an important process that transports biologically-active trace elements and macro-nutrients, mostly nitrogen, from the continents to the surface ocean. Atmospheric aerosols could also be a source of the organic ligands to the surface (Gerringa et al., 2006) and, therefore, the organic component of atmospheric aerosol may play a role in determining solubility and biological availability of highly insoluble micronutrient. Organic N exists in gas, particle and dissolved phases and represents a large (ca. 30%) fraction of total airborne nitrogen (Cape et al., 2011), but little information is available for distribution over the North Pacific and its spatiotemporal variability.

Atmospheric aerosol samples were continuously (ca. 3 days interval) collected using a high-volume virtual dichotomous air sampler (Model AS-9, Kimoto Electric, Co., Ltd.) that was mounted on the upper deck of the ship, 13 m above the sea surface. The virtual impactor separated coarse (diameter, d>2.5 μm) and fine (d<2.5 μm) particles, wherein both the fractions were collected on a single 90 mm diameter Teflon filter (ADVANTEC PF040). These filters were stored at 4˚C for onshore analysis of nutrients (inorganic/organic N) and major ions.

Wet deposition samples were collected using a collector with a 30 cm i.d. acid-cleaned plastic funnel into acid-cleaned 250 ml FLPE bottles. The collector was set up at the front of the upper deck and the funnel was opened only under the against wind condition during the cruise. Collected samples were frozen under –20ºC for onshore analysis of nutrients (inorganic/organic N) and major ions.

Preliminary results and future works

At the equatorial station 1, the surface phytoplankton assemblage increased their chlorophyll biomass significantly to the simultaneous additions of 150 m filtered seawater and 0.6 nmol/L Fe (SSW+Fe), while the addition of 150 m filtered seawater (SSW) resulted in a small increase relative to the control, suggesting a severe Fe-limitation in the upper water column. The phytoplankton collected from the subsurface chlorophyll maximum did not show growth response in the SSW and SSW+Fe treatments during the 3-days of incubation, probably due to the light limitation. At the subtropical stations 3-9, the surface phytoplankton responded to the addition of subsurface water (SSW), but there was no growth stimulation with the added Fe. In fact, chlorophyll *a* concentrations in the SSW+Fe bottles decreased compared with those in the SSW bottles at station 3. The SCM phytoplankton at stations 5 and 9 showed a small increase in chlorophyll *a* concentration relative to the controls, but growth stimulation by Fe addition was observed only at station 9. There was no difference in the final chlorophyll *a* concentrations of SCM samples between the SSW treatment and the control at stations 3 and 7. A small decrease in the chlorophyll *a* concentration was also

observed in the SSW+Fe treatment of the SCM phytoplankton at station 3. These results suggest that a vertical disturbance of water column in the subtropical South Pacific may supply both micro- and macro-nutrients to support phytoplankton production in the surface waters. FCM data obtained during the experiments will be analyzed to identify the major phytoplankton group that responded to the nutrient supply and nutrient consumption by phytoplankton assemblages will be compared between the treatments.

The acidified water samples will be stored for more than three months, and then analysis of trace-metals (Mn, Fe, Co, Ni, Cu and Zn) concentration will be done by an automated, on-line extraction, flow-injection ICP-MS method (Lagerström *et al*. 2013). Concentrations of natural iron-complexing organic ligands will be measured by competitive ligand exchange-cathodic stripping voltammetry using the 2-(2-Thioazolylazo)-*p*-cresol (TAC) as the competitive ligand (Croot and Johansson, 2000). Speciation of Iron (III) will be estimated from measured concentrations of total dissolved iron and iron binding organic ligands, and these conditional conditional stability constants.

Nitrate+nitrite, nitrite, phosphate and silicic acid concentrations will be measured by the standard methods using a continuous flow analyzing system (AACS IV, BLTEC) or a highly sensitive colorimetry system consisted of an AutoAnalyzer II (Technicon, USA) and Liquid Waveguide Capillary Cells (World Precision Instruments, USA).

Water-soluble nutrients in aerosol and wet deposition samples will be determined using a continuous flow analyzing system (AACS IV, BLTEC). Water-soluble total nitrogen will be analyzed by a $NO/NO_2/NO_x$ analyzer (Yanaco ECL-880US) attached to a total organic carbon analyzer (Simadzu, TOC-V_{CSH}), and amounts of organic nitrogen will be estimated from the differences between total and inorganic nitrogen concentrations. Major anions and cations in the samples will be analyzed by an ion chromatography.

The biogeography of planktonic copepods in the Pacific Ocean

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Planktonic copepods are one of the most abundant and widely distributed taxa of metazoans in marine ecosystems, playing a significant role in marine food webs and in biogeochemistry. In the Pacific Ocean, studies of copepod communities are restricted to local areas, and large-scale biogeography of planktonic copepods is still unclear in the Pacific. In order to study diversity and distribution of planktonic copepods with high species diversity, sophisticated expertise of morphology is required for classifications of copepods. On the other hand, the molecular techniques enable us to classify copepods efficiently without morphological knowledge. A recently developed metagenetic approach using second-generation sequencer could reveal copepod community structure rapidly and comprehensively. During the KH-13-7 cruise aboard the R. V. '*Hakuho-Maru*', zooplankton samples were collected by following methods using three plankton nets (VMPS, Norpac and ORI net). The detailed information for all samplings is listed in separate papers.

- VMPS net

VMPS net with 100 μm mesh size were carried out by vertical tows at station 1–9. Samples were collected from 4 layers (0–200, 200–500, 500–1000, 1000–2000 m). All samples were preserved in ethanol.

- Norpac net

Norpac twin net with 100 μm mesh size was towed three times at the depth of 0–200 m at station 0–9. Samples were preserved in formalin, and ethanol and RNA later.

- ORI net

Samplings using ORI net with 335μm mesh size were carried out by oblique tows at the station 1, 3, 5 and 7. All samples were preserved in ethanol.

- VMPS net

Station	Data	Latitude	Longitude	Depth	Time (local time)	Flow
1 (day)	2013/12/22	00-01 74N	170 00 11W	2000-1000	16:38-17:00	26-320
				1000-500	17:00-17:10	320-476
				500-200	17:10-17:17	476-575
				200-0	17:17-17:21	575-645
1 (night)	2013/12/23	00-01 21N	170 00 60W	2000-1000	04:15-04:37	10-329
				1000-500	04:37-04:47	329-494
				500-200	04:47-04:54	494-600
				200-0	04:54-04:58	600-670
3 (day)	2013/12/27	09-59.84 S	169-59.13 W	2000-1000	14:04-14:27	18-372
				1000-500	14:27-14:37	372-573
				500-200	14:37-14:44	573-700
				200-0	14:44-14:49	700-784
3 (night)	2013/12/27	10-00.56 S	170-00.02 W	2000-1000	20:51-21:13	14-321
				1000-500	21:13-21:24	321-491
				500-200	21:24-21:31	491-595
				200-0	21:31-21:35	595-665
4	2014/1/2	14-59.74 S	170-00.26 W	2000-1000	04:54-04:16	18-341
				1000-500	04:16-04:27	341-522
				500-200	04:27-04:33	522-637
				200-0	04:33-04:38	637-710
5 (night)	2014/1/4-5	19-57.07 S	170-00.49 W	2000-1000	0:22-0:43	11-303
				1000-500	0:43-0:53	303-465
				500-200	0:53-0:59	465-568
				200-0	0:59-1:03	568-638
st5 (day)	2014/1/5	20-00.03 S	170-00.43 W	2000-1000	11:02-11:23	10-309
				1000-500	11:23-11:34	309-470
				500-200	11:34-11:40	470-573
				200-0	11:40-11:44	573-645
6	2014/1/7	24-59.71 S	169-59.90 W	2000-1000	0:28-0:49	10-314
				1000-500	0:49-1:00	314-480
				500-200	1:00-1:06	480-586
				200-0	1:06-1:10	586-652
7 (night)	2014/1/9	30-01.02 S	170-00.15 W	2000-1000	20:14-20:35	20-296
				1000-500	20:35-20:45	296-456
				500-200	20:45-20:50	456-558
				200-0	20:50-20:54	558-627
7 (day)	2014/1/10	30-00.03 S	169-59.39 W	2000-1000	7:38-7:59	30-341

				1000-500	7:59-8:09	341-500
				500-200	8:09-8:15	500-598
				200-0	8:15-8:19	598-665
8	2014/1/11-12	34-59.48 S	170-02.71 W	2000-1000	23:32-23:53	11-327
				1000-500	23:53-0:02	327-493
				500-200	0:02-0:08	493-603
				200-0	0:08-0:12	603-675
9	2014/1/13	40-00.42 S	169-59.39 W	2000-1000	6:03-6:24	14-334
				1000-500	6:24-6:33	334-505
				500-200	6:33-6:39	505-611
				200-0	6:39-6:43	611-680
U	2014/1/16	33-03.85 S	174-47.08 W	1000-500	16:33-16:43	6-158
				500-200	16:43-16:49	158-268
				200-0	16:49-16:53	268-327
I	2014/1/17	28-45.53 S	173-26.32 W	2000-1000	19:46-20:09	10-318
				1000-500	20:09-20:20	318-476
				500-200	20:20-20:26	476-575
				200-0	20:26-20:30	575-639

- NORPAC net

							Flow	
Station	Date	Latitude	Longitude	Cast	Depth	Time (local time)	#1234	#3503
0	2013/12/16	19-59 90N	160-00 14E	1	0-200	10:32-10:37	2011	2197
				2	0-200	10:51-10:56	1947	2162
				3	0-200	11:03-11:14	2016	2110
1	2013/12/22	00-00 11N	169-59 91W	1	0-200	12:25-12:31	2356	2446
				2	0-200	12:51-13:01	2420	2425
				3	0-200	13:12-13:17	2410	2460
3	2013/12/26	10-00.19 S	170-00.18 W	1	0-200	03:24-03:31	1685	1735
				2	0-200	03:41-03:46	1856	1855
				3	0-200	03:57-04:03	1748	1750
4	2014/1/2	14-59.74S	170-00.76 W	1	0-200	08:13-08:20	2596	2709
				2	0-200	08:34-08:42	2100	2104
				3	0-200	08:55-08:59	2580	2628
				4				
5	2014/1/3	19-59.91S	170-00.32 W	1	0-200	20:30-20:37	1918	1936
				2	0-200	20:49-20:54	2059	2170
				3	0-200	21:00-21:11	2080	2053
				4	0-200	21:18-21:27	2042	2104

6	2014/1/7	25-00.92S	170-04.02 W	1	0-200	18:04-18:09	1443	1450
				2	0-200	18:22-18:26	1482	1500
				3	0-200	18:41-18:46	1600	1718
				4				
7	2014/1/8	30-03.89 S	170-00.27 W	1	0-200	2:42-2:47	1932	1913
				2	0-200	2:59-3:05	1890	1894
				3	0-200	3:17-3:23	1793	1861
				4				
8	2014/1/11	34-59.70 S	170-04.74 W	1	0-200	18:52-18:58	2308	2354
				2	0-200	19:09-19:15	2052	2058
				3	0-200	19:26-19:32	1948	2032
9	2014/1/13	40-00.50 S	169-59.12 W	1	0-200	14:13-14:20	2208	2350
				2	0-200	14:29-14:38	2362	2596
U	2014/1/16	33-04.37 S	174-55.12 W	1	0-200	3:11-3:18	2078	2212
				2	0-200	3:28-3:42	2198	2124
I	2014/1/18	28-51.59 S	173-30.39 W	1	0-200	2:41-2:46	2100	2441
				2	0-200	2:59-3:06	2358	2430
				3	0-200	3:16-3:22	2138	2220

- ORI net

Station	Date	Latitude	Longitude	Depth (m)	Time (local time)	Flow
1	2013/12/22	00-03.30N	169-56.45W	0-542	20:10-21:37	44995
3	2013/12/26	10-00.40 S	170-00.69 W	0-580	19:08-20.27	41895
5	2014/1/4	19-59.73 S	170-00.39 W	0-529	20:20-21:38	46525
7	2014/1/8-9	30-03.89 S	170-00.27 W	0-703	23:40-0:57	36070

Particulate conversion of newly fixed nitrogen in the subtropical South Pacific during the austral summer

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N_2 fixation is important as a bioavailable nitrogen supply for planktonic communities in the oligotrophic subtropical oceans. However, it is poorly known how the fixed nitrogen is utilized within a grazing-food web. We aim at elucidating utilization of the fixed nitrogen within planktonic ecosystems by analyzing the relationships between natural ^{15}N abundance of particulate nitrogen, and composition of N_2-fixing cyanobacterium community as follows. N_2 fixation activity was determined by Dr. Shiozaki and Mr. Koda during this cruise.

1. Sampling of zooplankton

   Zooplankton were collected at every station using a Nansen net towed vertically from 0 to 200 m depth, and were immediately size-fractionated (>2, 2-1, 1-0.5, 0.5-0.2 mm). An aliquot of each size-fractionated sample was fixed in 5% borax-buffered formaldehyde-seawater solution for later microscopic observation. The remaining sample was collected onto a nylon mesh, GF/F filters or plastic petri dish for measurement of natural abundance of ^{15}N. When *Trichodesmium* colonies or filaments were observed with zooplankton, we eliminated them or separated them as different samples. These samples were then frozen at -80°C for later analysis on land.

2. Sampling of particles smaller than 0.2 mm

   Surface seawater was obtained using a bucket at every station. Seawater from 4 different depths between 20 and 200 m were obtained using Niskin-X bottles at Station 1, 3, 5, 7, 9, 12 and 13. Samples were pre-filtered by a 0.2-mm nylon mesh to remove larger particles, and particles in the filtrates were collected on pre-combusted GF/F filters by gentle vacuum filtration. They were then frozen at -80°C for later isotopic analysis of nitrogen on land.

3. Sampling for analysis of deep-water nitrate

   Seawater samples were obtained from 300 m depth using Niskin-X bottles at every station. Samples were filtered by 0.2 μm filters for sterilization and the filtrates were frozen at -20°C for later isotopic analysis of nitrate on land

4. Sampling for microscopic observation

   Seawater was obtained from 5 different depths between 0 and 200 m at every station using a bucket or Niskin-X bottle for microscopic observation of phytoplankton,

with emphasis on *Trichodesmium* and *Richelia* species. The samples were immediately fixed in 1% Lugol-seawater solution and kept at 5 °C for later observation on land.

5. Continuous water sampling

   During this cruise, particulate samples were continuously collected for isotopic analysis of C and N, using seawater pumped from the bottom of the ship. Zooplankton larger than 0.2 mm and particles smaller than 0.2 mm were collected once or twice a day and kept frozen as described above.

The diet assessment of micronecton in the Pacific Ocean

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The analysis of food webs and their dynamics facilitates understanding of the mechanistic processes behind community ecology and ecosystem functions. In the Pacific Ocean, the diet of micronecton has been studied using a variety of techniques, but current methods still suffer from problems that are difficult to solve. This study examined an alternative approach utilizing molecular techniques as a prey biomarker. A recently developed metagenetic approach using second-generation sequencer could reveal diet diversity of micronecton. During the KH-13-7 cruise aboard the R. V. '*Hakuho-Maru*', micronecton samples were collected by following methods using IKMT net.

- IKMT net

IKMT net with 5 mm mesh size were carried out by oblique tows at station 1-9 and I. Samples were collected at the depth of 0-500 m. All samples were preserved in ethanol.

IKMT net

Stn.	Latitude	Longitude	Date	Time (Local Time)	Wire out	Flow
1	00 02.51N	169 58.81W	22-Dec	21:52-00:15	1735	114522
3	09 58.3S	170 01.78W	26-Dec	20:38-23:30	1747	159708
4	15 00.14S	170 00.85W	1-Jan	22:20-00:47	1900	164400
5	19 56.93S	170 00.57W	4-Jan	22:43-01:05	1806	181400
5	19 51.64S	169 56.06W	5-Jan	01:12-03:03	1818	110520
6	24 59.51S	169 59.55W	7-Jan	2:22-4:30	1738	131058
7	30 00.92S	169 59.34W	9-Jan	22:05-00:05	1659	125000

7	30 08.64S	169 59.89W	10-Jan	00:12-02:35	1850	166520
8	34 59.87S	170 02.87W	12-Jan	00:30-02:40	1640	133172
9	40 05.87S	169 57.57W	13-Jan	17:20-19:15	1447	105918
I	28 46.33S	173 26.05W	17-Jan	21:45-00:03	1759	139612

Microbial diversity and ecological functioning in the Pacific Ocean

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Marine prokaryotes play important roles in the ocean's food web and biogeochemical cycles. Bacterial diversity and community structures determine their ecological functions, however underlying mechanisms of linking the diversity to the functions are not fully understood. Here, we report the investigation of microbial diversity and some functional genes distribution in relation to environmental variables in the Pacific Ocean. Recent studies emphasize the importance of anaerobic ammonia oxidation (ANAMMOX) for nitrogen cycling in a water column, especially Oxygen Minimum Zones (OMZ). Also, bacteria degrading one of the major phytoplankton metabolites, dimethylsulfoniopropionate (DMSP) play an important role in carbon and sulfur cycling. Thus, we especially focus on the following two relationships in this study: DMSP metabolism vs. DMS concentration, ANAMMOX metabolism vs. oxygen concentration and nutrients. Both culture-dependent and –independent approaches were used.

1. Diversity and distribution of bacteria and specific functional genes

Water samples (5/10 L) were collected at total 13 depths from 0 m to Bottom-50 m (0, 5, 10, 100, SCM, 200, 400, 1000, 2000, Oxygen Minimum Zones (OMZ), OMZ-50m, OMZ+50m and Bottom-50m) at all stations (from Stn. 0 to 13). Niskin-X bottles on a CTD-CMS were used for collecting the water samples except from 0 m surface water. Surface water samples (5 L) were collected by the use of a plastic bucket. Additionally, large amount of water samples (100 L) were collected by the use of a water pump from the surface. Collaborating with on-board DMS monitoring by PTR-MS (Tanimoto Group), water samples (5 L) were collected from surface water at high DMS area for collecting bacteria relating to DMSP transformation. After the sampling, water samples were serially filtered onto 3.0-μm and 0.2-μm filters, and the filters were subsequently stored at −80 °C until further processing in the lab.

2. Diversity and distribution of actively growing bacteria

Water sample (10/20 L) were collected at 4 depths from 0 m to the bottom-50 (0, 100, 1000 and Bottom-50 m) at 5 stations (Stn.1, 3, 5, 7 and 9). After the sampling,

bromodexyuridine (BrdU) was added to the water samples at a final concentration of 20 nM, and samples were incubated in a dark condition for 17 or 24h at *in situ* temperature±2 °C. After the incubation, water samples were filtered onto 3.0-μm and 0.2-μm filters, and the filters were subsequently stored at −80 °C until further processing in the lab.

3. Catalyzed reporter deposition-fluorescence *in situ* hybridization (CARD-FISH)

CARD-FISH samples (50/100 mL) were collected at total 4 depths (0 m, OMZ-50 m and OMZ+50 m) at 10 stations (from Stn.0 to 9). After the sampling, Paraformaldehyde was added to the samples at 2% final concentration, and samples were incubated in a dark condition for 2 h at 4 °C. After the incubation, samples were filtered onto 0.2-μm filters, and stored at −80 °C until further processing in the lab.

4. Enrichment of ANAMMOX bacteria

Enrichment culture samples (20 L) were collected at 4 depths (0 m, OMZ-50 m, OMZ m and OMZ+50 m) at 4 stations (Stn. 0, 1, 2 and 3). After the sampling, water samples were serially filtered onto 3.0 μm and sterivex filter (0.22 μm pore size), and the filters were transferred to 1.5 mL micro tubes half-filled with MAAOB medium. 0.7 mL of sample was used an inoculum in a glass vial with 60 ml MAAOB medium following 30 seconds voltex. The medium was flushed with argon gas for 2 minutes and degassed until the air bubble was disappeared completely before inoculation. The inoculated glass vials were incubated in a dark condition at 4 °C until processing in the lab.

Dynamics of particulate biogenic elements in the South Pacific Ocean

Hiroaki Saito (Fisheries Research Agency)

Nutrient concentration in the euphotic zone is highly variable with latitude in the Pacific Ocean. The high concentration (e.g., NO_3 > 1 □M liter^{-1}) is observed in the equatorial and the Southern Ocean. On the other hand, nutrients are depleted in the subtropical region. In the oligotrophic regions, DON and DOP play significant contribution of ecosystem dynamics as well as DIN and DIP and the role has been investigated. The relative contribution of the particles (i.e., organisms and detritus) in the inventory of biogenic elements is larger in the oligotrophic region than one in the eutrophic regions. The role of particles including zooplankton on biogeochemical cycles is, however, not fully studied. In order to understand the role of particulate forms of biogenic elements (N, P, Si, C) in the biogeochemical cycles in the South Pacific Ocean, following observations were carried out.

1. Vertical distribution of particulate forms of P and Si.

In order to understand the vertical distribution of total particulate phosphorus (TPP), particulate inorganic phosphorus (PIP) and biogenic silicon (BSi), water samples were collected in the upper 500 m (10, 30, 50, 75, 100, 150, 200, 500 m and SCM) water column. Water samples were filtered on precombusted and acid washed GF/F filter (TPP, PIP) or polycarbonate filter (Nuclepore) with pore size of 0.8 μm (BSi). The filters were kept in refrigerator during the cruise. Collaborating with Hashihama group, TUMST, TPP, PIP, and BSi sampling will be continued in the Leg2. The concentrations will be examined after the cruise. Using TPP and PIP concentrations, particulate organic phosphorus (POP) concentration will be calculated.

2. Discrete sampling of particulate forms of P, Si

In order to understand the horizontal variation of biogenic elements, surface sea water samples were collected every 1 degree in latitude through water sampling system of the RV Hakuho-Maru. The water samples were processed as mentioned above.

3. Zooplankton sampling

Zooplankton has been overlooked as a reserver of biogenic elements in marine ecosystems. In order to determine the contribution of zooplankton as a reserver of biogenic element and biogenic elemental cycling, zooplankton was collected from 3 layers by means of a VMPS net. The shallowest layer (L1) was euphotic zone (0 m to

1 % light depth), the 2nd layer (L2) was 100 m below the L1, and the 3rd layer was between the bottom of L2 and 500 m. The obtained samples were divided using a Folsom's splitter. The subsamples were prepared for enumeration and elemental analysis (C, N, P) and for enumeration. This sampling will be continued during Leg2 by scientists of AORI, the Univ. of Tokyo.

4. Vertical flux of biogenic elements

In order to determine the vertical flux of biogenic elements and the drivers of biological pump, drifting sediment traps were moored at Stations 1 and 3 for 24-48 hours. The sediment traps were set at the bottom of EZ (1% light depth), 100 m below the EZ. Obtained samples were prepared for elemental analysis (POC, PON, BSi, TPP) and for enumeration. The rope of the drifting system was cut by strong current in St. 1, and the samples were not obtained. The sediment trap mooring will be carried out at Sts 5, 7, 9, and 11 during Leg 2 by scientists on board.