Preliminary Report
of
The Hakuho Maru Cruise KH-88-1

Jan. 22-Mar. 25, 1988

South Pacific Ocean

Ocean Research Institute
University of Tokyo
1990

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of
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by
The Scientific Members of the Expedition
Edited by
Usio SIMIDU

Preface

The KH-88-1 Cruise of the R. V. Hokuho Maru of the University of Tokyo was conducted in the Western Pacific Ocean during a period of 64 days from 22 January to 25 March, 1988 with port calls at Brisbane, Noumea, Majuro and Pohnpei (Ponape).

This report contains biological, biochemical and hydrographical data obtained during this crise and summaries of research carried out by each scientist and scientist group during the cruise.

On behalf of the scientists, I wish to express our hearty thanks to the scientists and officers of CSIRO and the University of Qeensland, Australia, and Pohnpei, Federated States of Micronesia, for their hospitality and for giving us a great help in doing our research works. Thanks are also to due to the officers of Papua New Guinea, Republic of Nauru and Republic of the Marshal Islands who gave us the permisson of research survey during the cruise. We also thank Captain Tadama and crew members of the Hakuho Maru for their sincere cooperation and capable assistance throughout this cruise.

Usio Simidu
Chief Scientist

Contents

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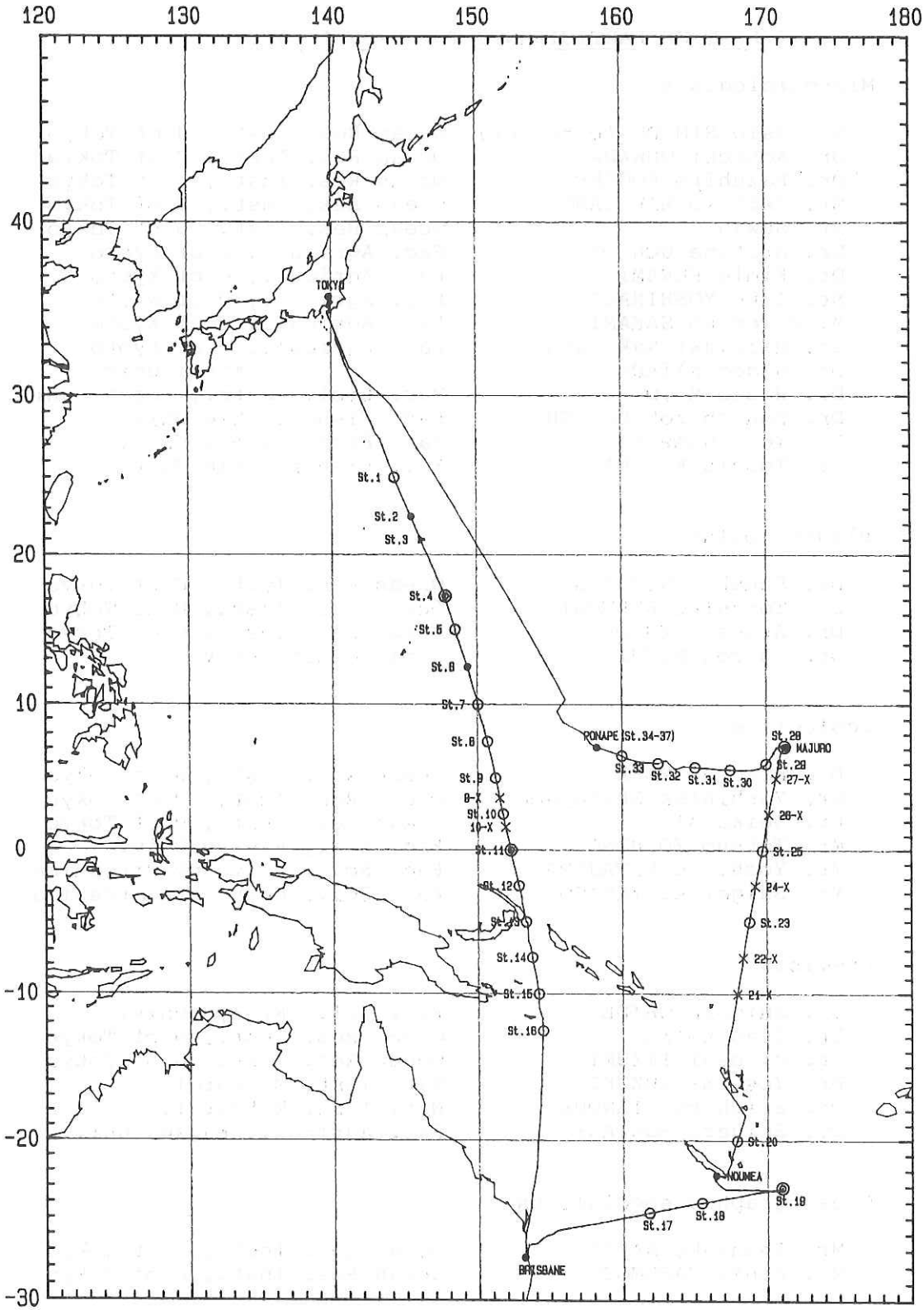
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NOUMEA
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BRISBANE

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	1-RMS	Date	JAN., 25, 1988	Lat.	24 - 59.6 N	Air T.	20.5 C	Weather	Fine	Sea	3
Depth	3970 m	TIME	05 : 24 - 08 : 07	Long.	144 - 18.0 E	Barro.	1018.4 mb	Wind	NNE -4.5m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	22.85	34.855	22.850	23.87	4.93	100.4	-0.02	0.00	0.0	0.02		8.212		0.17
Tr22	10	22.77	35.006	22.768	24.01	4.86	98.9	0.05	0.00	0.0	0.00		8.223		0.16
21	20	22.78	35.006	22.776	24.00	5.06	103.0	-0.15	0.00	0.0	0.00		8.237		0.15
20	30	22.78	35.006	22.774	24.00	4.88	99.4	0.03	0.00	0.0	0.00		8.236		0.17
19	50	22.77	35.005	22.759	24.01	4.87	99.1	0.04	0.00	0.0	0.00		8.235		0.17
18	75	22.43	34.995	22.414	24.09	4.92	99.5	0.02	0.00	0.0	0.00		8.225		0.25
17	100	22.16	34.991	22.139	24.17	4.98	100.3	-0.01	0.00	0.0	0.02		8.227		0.22
16	150	18.81	34.896	18.782	24.99	4.66	88.2	0.62	0.17	1.39	0.03		8.155		0.03
15	200	17.40	34.813	17.365	25.28	4.81	88.6	0.62	0.29	2.77	0.00		8.137		0.01
14	300	16.19	34.739	16.140	25.50	4.45	80.0	1.11	0.40	5.29	0.00		8.101		
13	400	14.34	34.590	14.279	25.80	4.45	77.0	1.33	0.67	8.87	0.00		8.041		
12	500	11.26	34.353	11.195	26.22	4.26	69.0	1.91	1.07	15.0	0.00		7.944		
11	600	8.64	34.180	8.573	26.53	3.80	58.1	2.75	1.55	22.8	0.00		7.830		
10	700	6.45	34.081	6.384	26.77	3.09	44.9	3.80	2.00	30.5	0.00		7.715		
9	800	4.91	34.130	4.843	27.00	1.90	26.6	5.24	2.55	40.2	0.00		7.587		
8	900	4.26	34.225	4.189	27.14	1.38	19.0	5.87	2.72	43.5	0.00		7.561		
7	1000	3.90	34.294	3.823	27.23	1.21	16.5	6.10	2.75	44.3	0.00		7.529		
6	1500	2.53	34.531	2.424	27.55	1.46	19.3	6.10	2.84	44.9	0.00		7.563		
5	2000	1.89	34.619	1.751	27.68	2.46	32.0	5.22	2.66	42.4	0.00		7.631		
4	2500	1.70	34.652	1.520	27.72	2.86	37.1	4.85	2.57	40.2	0.00		7.668		
3	3000	1.57	34.671	1.345	27.74	3.09	39.9	4.65	2.45	39.1	0.00		7.689		
2	3500	1.50	34.681	1.225	27.75	3.35	43.2	4.40	2.42	38.2	0.00		7.700		
1	3900	1.46	34.690	1.142	27.76	3.52	45.4	4.24	2.35	37.4	0.00		7.719		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	22.857	34.906	23.90	399.1	0.0000
10	22.870	35.016	23.98	391.5	0.0397
20	22.872	35.018	23.99	391.4	0.0788
30	22.794	35.009	24.00	389.9	0.1189
50	22.512	35.030	24.10	380.8	0.1968
75	22.302	35.016	24.15	376.1	0.2914
100	22.145	34.987	24.17	373.9	0.3863
150	19.434	34.911	24.84	309.7	0.5601
200	17.701	34.837	25.22	273.7	0.7073
300	16.401	34.760	25.47	249.9	0.9770
400	14.397	34.599	25.79	219.2	1.2227
500	11.638	34.369	26.17	183.8	1.4348
600	8.996	34.192	26.49	153.5	1.6153
700	6.468	34.073	26.76	127.5	1.7665
800	4.796	34.149	27.02	102.5	1.8897
900	4.246	34.240	27.16	90.0	1.9941
1000	3.843	34.308	27.25	80.9	2.0883
1250	3.059	34.476	27.46	61.1	2.2865
1500	2.462	34.549	27.57	50.5	2.4465
1750	2.099	34.601	27.64	43.8	2.5843
2000	1.893	34.631	27.68	39.9	2.7092
2500	1.704	34.663	27.72	36.2	2.9428
3000	1.571	34.681	27.75	33.8	3.1651
3500	1.495	34.693	27.76	32.4	3.3824

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	4-RMS	Date	JAN., 27, 1988	Lat.	17 - 14.0 N	Air T.	26.6 C	Weather	Clear	Sea	3
Depth	8180 m	TIME	18 : 51 - 22 : 24	Long.	147 - 49.2 E	Barro.	1013.5 mb	Wind	ENE 10.5m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	27.14	34.820	27.140	22.54	4.55	99.7	0.01	0.02	0.00	0.00	0.50	8.257		0.15
Tr22	10	27.13	34.856	27.128	22.57	4.47	98.0	0.09	0.00	0.00	0.02	0.10	8.262		0.06
21	20	27.14	34.857	27.135	22.57	4.74	103.9	-0.18	0.00	0.00	0.00	0.00	8.263		0.06
20	30	27.14	34.856	27.133	22.57	4.64	101.7	-0.08	0.00	0.00	0.00	0.00	8.263		0.06
19	50	27.14	34.857	27.128	22.57	4.55	99.7	0.01	0.02	0.00	0.00	0.10	8.262		0.06
18	75	27.14	34.874	27.121	22.58	4.67	102.4	-0.11	0.00	0.00	0.00	0.10	8.258		0.09
17	100	27.12	34.925	27.095	22.62	4.53	99.3	0.03	0.02	0.46	0.00	0.30	8.263		0.11
16	150	23.56	35.195	23.527	23.92	3.06	63.2	1.78	0.08	0.67	0.09	0.30	8.199		0.12
15	200	19.64	34.999	19.602	24.86	4.24	81.6	0.96	0.20	1.83	0.00	0.20	8.121		
14	300	15.89	34.685	15.841	25.53	4.46	79.7	1.14	0.43	7.60	0.00	0.00	8.064		
13	400	11.92	34.402	11.866	26.14	4.24	69.7	1.84	0.98	13.1	0.00	0.10	7.943		
12	500	9.23	34.236	9.173	26.48	3.10	48.0	3.36	1.69	28.0	0.00	0.00	7.780		
11	600	7.44	34.305	7.379	26.81	1.66	24.7	5.06	2.49	33.4	0.00	0.10	7.626		
10	700	5.96	34.308	5.896	27.01	1.53	22.0	5.43	2.59	38.8	0.00	0.00	7.592		
9	800	5.50	34.409	5.429	27.15	1.56	22.2	5.47	2.64	40.4	0.00	0.00	7.587		
8	900	4.96	34.462	4.883	27.25	1.77	24.9	5.35	2.64	42.0	0.00	0.00	7.605		
7	1000	4.48	34.486	4.398	27.33	1.76	24.4	5.44	2.59	41.3	0.00	0.00	7.616		
6	1500	2.99	34.578	2.879	27.55	2.16	28.9	5.31	2.66	41.0	0.00	0.00	7.621		
5	2000	2.18	34.618	2.037	27.65	2.46	32.3	5.16	2.65	40.9	0.00	0.00	7.638		
4	2500	1.80	34.654	1.618	27.71	2.83	36.8	4.86	2.52	40.6	0.00	0.00	7.684		
3	3000	1.61	34.671	1.384	27.74	3.15	40.8	4.58	2.47	39.8	0.00	0.00	7.688		
2	4000	1.46	34.691	1.131	27.77	3.62	46.7	4.14	2.33	38.3	0.00	0.00	7.719		
1	5000	1.47	34.700	1.019	27.77	4.03	52.0	3.73	2.18	37.3	0.00	0.00	7.735		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	27.147	34.810	22.53	530.5	0.0000
10	27.150	34.848	22.56	527.8	0.0532
20	27.151	34.860	22.57	527.0	0.1070
30	27.154	34.865	22.57	526.7	0.1616
50	27.139	34.871	22.58	525.8	0.2645
75	27.139	34.873	22.58	525.7	0.3969
100	27.151	34.885	22.59	525.2	0.5287
150	25.237	35.128	23.37	450.4	0.7754
200	21.990	35.170	24.35	356.6	0.9821
300	15.919	34.691	25.53	244.4	1.2894
400	12.370	34.398	26.05	194.8	1.5183
500	9.418	34.245	26.46	156.0	1.7033
600	7.557	34.302	26.79	124.6	1.8536
700	5.985	34.306	27.01	104.1	1.9774
800	5.544	34.426	27.16	90.0	2.0840
900	4.972	34.475	27.26	79.9	2.1784
1000	4.505	34.502	27.34	72.9	2.2650
1250	3.694	34.562	27.47	60.3	2.4572
1500	2.910	34.581	27.56	51.8	2.6223
1750	2.520	34.608	27.61	46.5	2.7693
2000	2.197	34.629	27.66	42.4	2.9048
2500	1.806	34.663	27.72	36.9	3.1513
3000	1.619	34.680	27.74	34.2	3.3786
3500	1.518	34.693	27.76	32.5	3.5987
4000	1.469	34.700	27.77	31.6	3.8164
4500	1.450	34.707	27.78	31.0	4.0356
5000	1.468	34.711	27.78	30.9	4.2590

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	7-RMS	Date	JAN., 31, 1988	Lat.	10 - 00.6 N	Air T.	26.8 C	Weather	Fine	Sea	4
Depth	5630 m	TIME	00 : 00 - 03 : 02	Long.	150 - 02.0 E	Barro.	1009.6 mb	Wind	ENE 12.0m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	27.54	34.190	27.540	21.94	4.60	101.1	-0.05	0.00	0.02	0.00	0.00	8.267		0.04
Tr22	10	27.53	34.219	27.527	21.96	4.52	99.4	0.03	0.00	0.02	0.00	0.00	8.262		0.04
21	30	27.54	34.221	27.532	21.96	4.70	103.3	-0.15	0.00	0.02	0.00	0.06	8.260		0.04
20	50	27.53	34.243	27.517	21.98	4.48	98.5	0.07	0.00	0.02	0.00	0.07	8.260		0.05
19	75	25.71	34.965	25.692	23.10	4.71	100.9	-0.04	0.00	0.02	0.00	0.08	8.230		0.09
18	100	21.89	35.165	21.869	24.38	4.12	82.6	0.87	0.12	0.46	0.06	0.12	8.139		0.27
17	150	17.13	34.786	17.104	25.32	3.69	67.6	1.77	0.61	7.90	0.03	0.10	8.017		0.12
16	200	12.06	34.469	12.033	26.17	2.90	47.8	3.16	1.57	22.1	0.01	0.20	7.806		0.02
15	300	9.49	34.618	9.455	26.74	2.40	37.5	4.00	1.15	16.1	0.01	0.07	7.867		0.05
14	400	8.71	34.615	8.666	26.86	1.23	18.9	5.29	2.39	36.5	0.00	0.15	7.628		
13	500	7.96	34.582	7.907	26.95	1.36	20.5	5.27	2.49	37.3	0.00	0.12	7.633		
12	650	6.76	34.546	6.697	27.09	1.46	21.4	5.36	2.61	39.2	0.00	0.09	7.615		
11	800	5.78	34.545	5.707	27.22	1.52	21.8	5.46	2.78	41.2	0.00	0.06	7.603		
10	1000	4.84	34.551	4.755	27.34	1.87	26.2	5.27	2.75	40.8	0.00	0.04	7.620		
9	1500	2.94	34.607	2.829	27.58	2.20	29.4	5.28	2.60	41.4	0.00	0.05	7.636		
8	2000	2.15	34.644	2.007	27.67	2.58	33.8	5.04	2.66	40.7	0.00	0.02	7.648		
6	3000	1.64	34.633	1.413	27.71	3.28	42.5	4.44	2.54	39.1	0.00	0.04	7.690		
4	4000	1.47	34.698	1.141	27.77	3.63	46.8	4.13	2.36	37.5	0.00	0.31	7.715		
2	5000	1.45	34.709	01.000	27.78	3.96	51.0	3.80	2.26	36.0	0.00	0.13	7.736		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	27.539	34.207	21.95	585.9	0.0000
10	27.541	34.219	21.96	585.1	0.0596
20	27.538	34.222	21.96	584.8	0.1198
30	27.539	34.224	21.96	584.7	0.1772
50	27.533	34.241	21.98	583.3	0.2934
75	25.444	35.013	23.22	464.7	0.4259
100	22.104	35.158	24.31	360.5	0.5297
150	17.252	34.794	25.30	266.5	0.6883
200	12.996	34.464	25.98	201.7	0.8089
300	9.630	34.614	26.71	132.0	0.9808
400	8.722	34.621	26.87	117.5	1.1127
500	7.865	34.587	26.97	107.7	1.2333
600	7.101	34.557	27.06	99.5	1.3456
700	6.355	34.548	27.15	90.6	1.4498
800	5.669	34.546	27.24	82.5	1.5465
900	5.219	34.553	27.30	76.8	1.6363
1000	4.720	34.556	27.35	71.1	1.7208
1250	3.613	34.590	27.50	57.5	1.9072
1500	2.923	34.615	27.59	49.3	2.0660
1750	2.481	34.636	27.64	44.1	2.2069
2000	2.149	34.655	27.68	40.0	2.3361
2500	1.850	34.674	27.72	36.4	2.5755
3000	1.645	34.689	27.75	33.7	2.8018
3500	1.530	34.698	27.77	32.2	3.0204
4000	1.462	34.707	27.78	31.1	3.2364
4500	1.433	34.714	27.79	30.4	3.4522
5000	1.451	34.717	27.79	30.2	3.6719

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	9-RMS	Date	FEB., 1, 1988	Lat.	4 - 59.9 N	Air T.	26.7 C	Weather	Overcast	Sea	2
Depth	4640 m	TIME	15 : 29 - 18 : 16	Long.	151 - 15.3 E	Barro.	1006.0 mb	Wind	NNW 5.0m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	28.59	33.992	28.590	21.45	4.44	99.2	0.04	0.00	0.02	0.01	0.30	8.258		0.16
Tr22	10	28.59	34.484	28.587	21.82	4.46	99.9	0.00	0.00	0.02	0.00	0.10	8.259		0.14
21	20	28.60	34.490	28.595	21.82	4.68	104.8	-0.22	0.00	0.02	0.00	0.00	8.261		0.16
20	30	28.60	34.497	28.592	21.82	4.39	98.4	0.07	0.00	0.02	0.00	0.10	8.260		0.16
19	50	28.56	34.512	28.547	21.85	4.48	100.3	-0.01	0.00	0.02	0.00	0.20	8.258		0.17
18	75	26.20	34.540	26.182	22.63	4.54	97.8	0.10	0.05	0.08	0.03	0.30	8.211		0.34
17	100	26.05	34.726	26.026	22.81	4.33	93.1	0.32	0.10	0.48	0.15	0.40	8.204		0.24
16	150	18.46	34.776	18.433	24.99	3.37	63.3	1.95	0.64	9.80	0.03	0.10	8.020		0.04
15	200	13.24	34.580	13.211	26.02	2.51	42.5	3.40	1.52	21.4	0.01	0.00	7.851		0.02
14	300	9.21	34.634	9.176	26.80	1.16	18.0	5.28	2.43	36.6	0.00	0.10	7.640		
13	400	8.19	34.609	8.147	26.94	1.41	21.4	5.18	2.52	37.6	0.00	0.00	7.636		
12	500	7.16	34.568	7.110	27.06	1.63	24.1	5.12	2.47	39.1	0.00	0.00	7.635		
11	600	6.32	34.552	6.264	27.16	1.63	23.7	5.26	2.65	39.9	0.00	0.00	7.623		
10	700	5.68	34.546	5.617	27.23	1.82	26.0	5.17	2.67	40.5	0.00	0.00	7.625		
9	800	5.28	34.549	5.210	27.29	1.92	27.2	5.14	2.68	40.9	0.00	0.00	7.625		
8	900	4.88	34.554	4.804	27.34	1.94	27.2	5.19	2.80	41.1	0.00	0.00	7.628		
7	1000	4.47	34.560	4.388	27.39	2.17	30.1	5.03	2.75	41.2	0.00	0.10	7.633		
6	1500	3.15	34.601	3.037	27.55	2.31	31.1	5.13	3.15	41.7	0.01	0.30	7.634		
5	2000	2.25	34.642	2.105	27.66	2.93	38.5	4.67	2.76	41.2	0.00	0.10	7.653		
4	2500	1.83	34.664	1.647	27.72	2.93	38.1	4.76	2.74	40.2	0.00	0.20	7.677		
3	3000	1.65	34.677	1.423	27.74	3.10	40.2	4.62	2.64	41.4	0.00	0.10	7.690		
2	4000	1.53	34.694	1.199	27.76	3.53	45.6	4.21	2.53	38.2	0.00	0.20	7.717		
1	4500	1.50	34.696	1.111	27.77	3.71	47.9	4.04	2.32	39.6	0.00	0.20	7.723		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.586	34.325	21.70	610.2	0.0000
10	28.594	34.400	21.75	605.0	0.0620
20	28.592	34.439	21.78	602.1	0.1221
30	28.586	34.461	21.80	600.4	0.1823
50	28.597	34.495	21.82	598.3	0.3040
75	27.211	34.558	22.32	550.6	0.4470
100	26.067	34.570	22.69	515.1	0.5815
150	21.965	34.827	24.10	380.7	0.8090
200	12.518	34.574	26.16	184.6	0.9517
300	9.157	34.634	26.81	123.1	1.1121
400	8.144	34.614	26.95	109.6	1.2347
500	7.233	34.574	27.05	99.9	1.3465
600	6.246	34.555	27.17	88.7	1.4489
700	5.654	34.553	27.24	81.7	1.5432
800	5.280	34.556	27.29	77.3	1.6318
900	4.882	34.562	27.34	72.4	1.7160
1000	4.481	34.569	27.39	67.6	1.7958
1250	3.818	34.588	27.48	59.5	1.9807
1500	3.130	34.611	27.56	51.5	2.1462
1750	2.687	34.630	27.62	46.3	2.2942
2000	2.274	34.649	27.67	41.4	2.4294
2500	1.843	34.674	27.72	36.3	2.6737
3000	1.655	34.685	27.75	34.1	2.9005
3500	1.579	34.695	27.76	32.8	3.1228
4000	1.532	34.701	27.77	32.0	3.3448
4500	1.505	34.706	27.77	31.4	3.5686

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	11-RMS	Date	FEB., 3, 1988	Lat.	0 - 00.4 N	Air T.	28.4 C	Weather	Fine	Sea	2
Depth	4530 m	TIME	00 : 56 - 03 : 49	Long.	152 - 18.0 E	Barro.	1006.6 mb	Wind	WNW 3.5m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	29.73	34.154	29.730	21.19	4.40	100.2	-0.01	0.00	0.04	0.00	0.10	8.285		0.07
Tr22	10	29.58	34.223	29.577	21.29	4.42	100.4	-0.02	0.00	0.04	0.00	0.00	8.284		0.07
21	20	29.16	34.337	29.155	21.52	4.68	105.7	-0.25	0.03	0.04	0.00	0.00	8.278		0.11
20	30	29.08	34.372	29.072	21.57	4.50	101.5	-0.07	0.05	0.04	0.00	0.00	8.275		0.16
19	50	27.87	34.607	27.857	22.14	4.35	96.4	0.16	0.06	0.04	0.00	0.00	8.258		0.34
18	75	26.09	34.767	26.072	22.83	4.32	93.0	0.33	0.12	0.17	0.05	0.00	8.218		0.37
17	100	21.95	34.959	21.929	24.20	3.35	67.2	1.64	0.58	7.32	0.10	0.00	8.105		0.23
16	125	19.84	35.218	19.816	24.97	3.22	62.2	1.95	0.77	10.1	0.02	0.00	8.050		0.05
15	150	19.12	35.158	19.092	25.11	3.24	61.8	2.01	0.84	10.7	0.01	0.10	8.042		0.03
14	200	15.20	35.086	15.168	25.99	3.26	57.6	2.40	1.04	15.1	0.00	0.04	7.965		0.02
13	300	11.83	34.856	11.790	26.51	2.68	44.1	3.40	1.54	24.0	0.00	0.00	7.835		0.00
12	400	9.72	34.712	9.673	26.77	1.99	31.3	4.38	1.91	31.7	0.00	0.00	7.724		
11	500	8.92	34.663	8.863	26.87	2.12	32.7	4.36	1.97	32.7	0.00	0.00	7.710		
10	700	6.36	34.554	6.294	27.15	2.16	31.4	4.72	2.34	38.3	0.00	0.00	7.658		
9	800	5.67	34.548	5.598	27.24	2.25	32.2	4.75	2.51	39.1	0.00	0.00	7.649		
8	900	4.90	34.549	4.824	27.33	2.26	31.7	4.87	2.57	39.7	0.00	0.00	7.650		
7	1000	4.48	34.558	4.398	27.38	2.23	31.0	4.97	2.58	40.5	0.00	0.00	7.638		
6	1500	3.08	34.604	2.967	27.56	2.42	32.5	5.03	2.58	41.3	0.00	0.00	7.645		
5	2000	2.19	34.645	2.046	27.67	2.83	37.2	4.79	2.46	39.9	0.00	0.00	7.667		
4	2500	1.76	34.665	1.598	27.72	3.05	39.6	4.65	2.46	39.7	0.00	0.00	7.682		
3	3000	1.59	34.682	1.364	27.75	3.25	42.0	4.48	2.43	38.6	0.00	0.04	7.701		
2	4000	1.51	34.692	1.179	27.76	3.56	45.9	4.19	2.41	37.8	0.00	0.00	7.719		
1	4400	1.53	34.696	1.152	27.76	3.61	46.6	4.13	2.31	37.8	0.00	0.07	7.722		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.733	34.169	21.20	658.1	0.0000
10	29.751	34.200	21.21	656.5	0.0669
20	29.539	34.215	21.30	648.5	0.1323
30	29.273	34.327	21.47	631.9	0.1968
50	28.921	34.431	21.67	613.2	0.3214
75	27.409	34.628	22.31	551.6	0.4673
100	23.957	34.945	23.61	426.9	0.5917
150	19.061	35.153	25.12	283.0	0.7714
200	15.475	35.115	25.96	203.9	0.8950
300	11.804	34.855	26.51	150.8	1.0796
400	9.706	34.714	26.78	125.7	1.2253
500	8.729	34.648	26.89	115.6	1.3548
600	7.379	34.586	27.04	101.1	1.4726
700	6.341	34.563	27.16	89.3	1.5774
800	5.656	34.552	27.24	81.8	1.6731
900	5.016	34.551	27.32	74.7	1.7611
1000	4.497	34.568	27.39	67.8	1.8425
1250	3.794	34.585	27.48	59.5	2.0275
1500	3.083	34.613	27.57	50.9	2.1920
1750	2.591	34.633	27.63	45.2	2.3374
2000	2.187	34.656	27.68	40.3	2.4689
2500	1.771	34.677	27.73	35.5	2.7062
3000	1.587	34.691	27.76	33.2	2.9270
3500	1.550	34.697	27.76	32.4	3.1444
4000	1.511	34.704	27.77	31.7	3.3635
4400	1.529	34.705	27.77	31.7	3.5422

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	13-RMS	Date	FEB., 4, 1988	Lat.	4 - 58.7 S	Air T.	29.2 C	Weather	Cloudy	Sea	2
Depth	4720 m	TIME	08 : 06 - 11 : 24	Long.	153 - 22.3 E	Barro.	1008.1 mb	Wind	W 5.5m/s	Swell	1

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	29.06	34.169	29.060	21.42	4.51	101.6	-0.07	0.00	0.00	0.00	0.00	8.282		0.60
Tr21	20	28.82	34.620	28.815	21.84	4.66	104.8	-0.22	0.03	0.00	0.00	0.00	8.276		0.15
20	30	28.71	34.611	28.702	21.87	4.48	100.6	-0.03	0.06	0.00	0.00	0.04	8.270		0.37
19	50	27.06	34.965	27.048	22.67	3.80	83.2	0.77	0.06	0.00	0.01	0.00	8.250		0.63
18	75	26.14	35.127	26.122	23.09	3.78	81.6	0.85	0.11	0.88	0.04	0.00	8.223		0.17
17	100	25.10	35.325	25.077	23.56	3.76	79.8	0.95	0.31	3.04	0.31	0.15	8.176		0.09
16	125	23.58	35.627	23.552	24.24	3.32	68.8	1.51	0.47	6.09	0.08	0.07	8.128		0.03
15	150	21.79	35.688	21.759	24.80	3.14	63.1	1.84	0.61	7.98	0.04	0.00	8.082		0.01
14	200	15.89	35.239	15.857	25.96	3.00	53.8	2.58	0.96	14.4	0.01	0.00	7.970		0.01
13	300	10.59	34.802	10.553	26.70	3.72	59.6	2.52	1.27	20.6	0.00	0.00	7.889		
12	400	8.43	34.627	8.386	26.92	3.63	55.4	2.93	1.56	26.2	0.00	0.04	7.825		
11	500	7.19	34.549	7.140	27.04	3.47	51.4	3.28	1.77	30.0	0.00	0.07	7.780		
10	700	5.49	34.516	5.428	27.23	3.11	44.3	3.92	2.10	35.3	0.00	0.11	7.727		
9	800	5.20	34.527	5.131	27.28	2.81	39.7	4.27	2.20	36.9	0.00	0.00	7.704		
8	900	4.82	34.516	4.744	27.31	3.18	44.5	3.96	2.16	35.9	0.00	0.00	7.718		
7	1000	4.60	34.548	4.517	27.36	2.47	34.4	4.71	2.39	39.5	0.00	0.00	7.656		
6	1500	3.04	34.598	2.928	27.56	2.76	37.0	4.70	2.39	39.3	0.00	0.07	7.671		
5	2000	2.26	34.641	2.115	27.66	3.00	39.5	4.60	2.36	39.3	0.00	0.22	7.681		
4	2500	1.92	34.661	1.736	27.71	3.01	39.3	4.66	2.33	39.0	0.00	0.22	7.689		
3	3000	1.87	34.682	1.637	27.73	3.45	44.9	4.23	2.21	37.4	0.00	0.22	7.713		
2	4000	2.00	34.703	1.654	27.73	3.82	49.9	3.83	2.12	35.9	0.00	0.11	7.738		
1	4500	2.06	34.704	1.651	27.73	3.87	50.7	3.77	2.06	35.6	0.00	0.00	7.742		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.056	34.267	21.50	629.3	0.0000
10	29.049	34.298	21.52	626.8	0.0636
20	29.088	34.450	21.62	617.1	0.1287
30	28.974	34.524	21.72	608.2	0.1884
50	27.108	34.952	22.65	519.0	0.3016
75	26.211	35.174	23.10	475.9	0.4249
100	24.445	35.401	23.81	407.8	0.5366
150	21.738	35.671	24.80	313.5	0.7198
200	16.653	35.301	25.83	216.0	0.8550
300	11.355	34.855	26.60	142.9	1.0416
400	8.886	34.664	26.87	116.8	1.1783
500	7.704	34.570	26.98	106.6	1.2983
600	6.743	34.541	27.09	96.0	1.4082
700	5.950	34.537	27.19	86.5	1.5084
800	5.360	34.531	27.26	80.0	1.6010
900	4.849	34.526	27.32	74.7	1.6880
1000	4.430	34.554	27.39	68.2	1.7691
1250	3.886	34.575	27.46	61.2	1.9572
1500	3.066	34.608	27.57	51.1	2.1240
1750	2.553	34.632	27.63	44.9	2.2691
2000	2.213	34.654	27.68	40.6	2.4006
2500	1.867	34.674	27.72	36.4	2.6429
3000	1.869	34.696	27.74	34.8	2.8761
3500	1.940	34.711	27.74	34.2	3.1148
4000	1.996	34.714	27.74	34.4	3.3641
4500	2.055	34.714	27.74	34.8	3.6265

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	15-AMS	Date	FEB., 5, 1988	Lat.	9 - 59.9 S	Air T.	28.9 C	Weather	Cloudy	Sea	2
Depth	4470 m	TIME	20 : 38 - 23 : 38	Long.	154 - 13.7 E	Barro.	1008.0 mb	Wind	SW 2.0m/s	Swell	1

AMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	29.74	34.564	29.740	21.49	4.43	101.1	-0.05	0.04	0.22	0.00	0.00	8.268		0.07
Tr22	20	29.50	34.738	29.495	21.70	4.58	104.2	-0.19	0.04	0.22	0.00	0.20	8.255		0.07
21	30	28.60	34.801	28.592	22.05	4.77	107.0	-0.31	0.08	0.24	0.03	0.00	8.236		0.10
20	50	25.86	35.296	25.848	23.30	4.28	92.1	0.37	0.13	0.64	0.08	0.00	8.198		0.21
19	75	24.53	35.540	24.513	23.89	3.70	77.9	1.05	0.34	4.03	0.19	0.16	8.153		0.23
18	100	23.54	35.684	23.518	24.30	3.32	68.8	1.51	0.46	6.54	0.05	0.00	8.109		0.09
17	125	21.73	35.669	21.704	24.80	3.16	63.4	1.82	0.61	8.65	0.02	0.00	8.068		0.02
16	150	20.18	35.672	20.151	25.23	3.46	67.5	1.67	0.51	7.64	0.19	0.00	8.072		0.01
15	175	18.43	35.530	18.398	25.57	3.76	70.9	1.54	0.50	7.64	0.01	0.06	8.060		0.00
14	200	16.90	35.403	16.866	25.85	3.76	68.8	1.70	0.62	9.71	0.01	0.00	8.027		0.00
13	300	13.93	35.127	13.885	26.30	3.78	65.1	2.03	0.93	14.5	0.00	0.00	7.962		0.00
12	400	11.20	34.827	11.148	26.60	3.80	61.7	2.36	1.28	20.3	0.00	0.00	7.890		
10	600	6.30	34.473	6.244	27.10	4.28	62.1	2.62	1.79	29.3	0.00	0.00	7.804		
9	700	5.68	34.481	5.617	27.18	3.95	56.5	3.05	2.08	32.3	0.00	0.00	7.770		
8	800	5.11	34.474	5.041	27.25	3.88	54.7	3.21	2.17	33.9	0.00	0.00	7.754		
7	1000	4.42	34.510	4.338	27.35	3.52	48.8	3.69	2.37	36.5	0.00	0.00	7.723		
6	1500	3.05	34.594	2.938	27.56	3.16	42.4	4.30	2.55	39.5	0.00	0.00	7.694		
5	2000	2.23	34.653	2.086	27.68	3.24	42.6	4.37	2.51	39.5	0.00	0.06	7.697		
4	2500	2.02	34.681	1.833	27.71	3.58	46.8	4.07	2.39	38.1	0.00	0.00	7.717		
3	3000	1.88	34.705	1.647	27.74	3.84	50.0	3.83	2.35	36.8	0.00	0.00	7.733		
1	4000	1.97	34.711	1.625	27.74	3.94	51.5	3.72	2.19	36.4	0.00	0.00	7.738		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.734	34.569	21.50	629.4	0.0000
10	29.665	34.588	21.53	625.8	0.0644
20	29.496	34.747	21.71	608.9	0.1272
30	28.597	34.810	22.06	575.6	0.1861
50	26.668	35.153	22.94	491.2	0.2936
75	24.671	35.509	23.83	406.5	0.4051
100	23.858	35.701	24.22	369.4	0.5047
150	20.133	35.648	25.22	273.7	0.6673
200	16.711	35.380	25.88	211.5	0.7914
300	13.993	35.134	26.29	171.9	0.9901
400	11.201	34.837	26.61	141.6	1.1555
500	8.369	34.622	26.92	112.2	1.2917
600	6.304	34.482	27.10	94.9	1.4042
700	5.677	34.491	27.19	86.7	1.5033
800	4.961	34.494	27.28	78.4	1.5948
900	4.667	34.509	27.32	74.1	1.6800
1000	4.248	34.523	27.38	68.7	1.7605
1250	3.571	34.568	27.49	58.8	1.9444
1500	3.110	34.601	27.56	52.1	2.1082
1750	2.625	34.634	27.63	45.4	2.2558
2000	2.259	34.662	27.68	40.3	2.3881
2500	2.027	34.693	27.72	36.2	2.6323
3000	1.885	34.717	27.75	33.4	2.8644
3500	1.914	34.721	27.76	33.2	3.0971
4000	1.966	34.722	27.75	33.6	3.3408

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	17-RMS	Date	FEB., 17, 1988	Lat.	24 - 38.6 S	Air T.	25.8 C	Weather	Fine	Sea	3
Depth	1130 m	TIME	16 : 58 - 17 : 53	Long.	161 - 47.7 E	Barro.	1004.7 mb	Wind	SSE 7.5m/s	Swell	4

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	26.38	35.607	26.380	23.37	4.49	97.6	0.11	0.00	0.00	0.00	0.02	8.243		0.09
18	10	26.39	35.606	26.388	23.37	4.59	99.8	0.01	0.00	0.00	0.00	0.00	8.243		0.08
17	20	25.99	35.694	25.985	23.56	4.62	99.8	0.01	0.00	0.00	0.00	0.00	8.237		0.06
16	30	25.83	35.742	25.823	23.65	4.66	100.4	-0.02	0.00	0.20	0.00	0.04	8.235		0.08
15	50	23.53	35.720	23.519	24.33	5.02	104.0	-0.19	0.02	0.60	0.00	0.00	8.225		0.12
14	75	21.18	35.724	21.165	25.00	5.09	101.1	-0.06	0.06	1.31	0.00	0.00	8.201		0.22
13	100	20.33	35.705	20.310	25.21	4.64	90.8	0.47	0.15	1.61	0.02	0.01	8.166		0.21
12	125	19.83	35.706	19.806	25.35	4.28	83.0	0.88	0.24	3.40	0.06	0.03	8.146		0.07
11	150	19.43	35.694	19.402	25.44	4.38	84.3	0.82	0.29	4.24	0.03	0.02	8.135		0.05
10	175	19.00	35.688	18.967	25.55	4.34	82.8	0.90	0.33	4.76	0.02	0.00	8.124		0.02
9	200	18.76	35.668	18.723	25.59	4.36	82.8	0.90	0.37	5.56	0.01	0.00	8.118		
8	300	16.13	35.448	16.080	26.06	4.28	77.2	1.27	0.66	9.92	0.00	0.00	8.055		
7	400	12.34	35.025	12.285	26.54	4.27	71.1	1.74	1.12	17.4	0.00	0.03	7.958		
6	500	9.28	34.693	9.222	26.83	4.41	68.6	2.02	1.62	24.5	0.00	0.00	7.881		
5	600	7.75	34.546	7.687	26.95	4.45	66.8	2.21	1.78	28.1	0.00	0.00	7.847		
4	700	6.54	34.463	6.473	27.06	4.48	65.3	2.38	2.00	31.8	0.00	0.00	7.812		
3	800	5.76	34.440	5.687	27.14	4.37	62.6	2.62	2.19	34.1	0.00	0.00	7.786		
2	900	5.03	34.451	4.953	27.24	4.11	57.8	3.00	2.35	35.9	0.00	0.02	7.763		
1	1000	4.45	34.484	4.368	27.33	4.02	55.8	3.19	2.33	36.2	0.00	0.00	7.745		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	26.381	35.619	23.38	449.0	0.0000
10	26.378	35.618	23.38	448.9	0.0452
20	26.132	35.611	23.45	442.1	0.0901
30	25.955	35.686	23.57	431.3	0.1345
50	24.417	35.690	24.04	386.1	0.2162
75	21.769	35.687	24.81	313.2	0.3055
100	20.461	35.719	25.19	276.8	0.3798
125	19.813	35.710	25.35	261.1	0.4482
150	19.360	35.700	25.46	250.6	0.5125
175	18.971	35.684	25.55	242.2	0.5760
200	18.708	35.664	25.60	237.3	0.6371
300	16.081	35.445	26.07	192.8	0.8598
400	12.640	35.061	26.51	151.0	1.0423
500	9.326	34.701	26.83	120.8	1.1876
600	7.507	34.534	26.98	106.6	1.3117
700	6.487	34.470	27.07	98.1	1.4238
800	5.721	34.449	27.15	90.4	1.5278
900	5.005	34.458	27.24	81.6	1.6240
1000	4.445	34.494	27.34	72.9	1.7107

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	18-RMS	Date	FEB., 18, 1988	Lat.	24 - 00.8 S	Air T.	23.8 C	Weather	Shower	Sea	4
Depth	3630 m	TIME	14 : 56 - 17 : 15	Long.	165 - 26.3 E	Barro.	1006.4 mb	Wind	S 11.0m/s	Swell	4

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	25.53	35.713	25.530	23.72	4.71	101.0	-0.05	0.00	0.00	0.00	0.00	8.216		0.07
Tr22	10	25.55	35.744	25.548	23.74	4.70	100.8	-0.04	0.00	0.00	0.00	0.00	8.218		0.07
21	20	25.53	35.746	25.525	23.74	4.90	105.1	-0.24	0.00	0.00	0.00	0.00	8.219		0.07
20	30	25.05	35.761	25.043	23.90	4.88	103.8	-0.18	0.00	0.00	0.00	0.00	----		0.09
19	50	22.66	35.810	22.649	24.65	5.14	104.9	-0.24	0.00	0.00	0.00	0.00	8.202		0.12
18	75	21.02	35.765	21.005	25.07	5.13	101.7	-0.08	0.00	0.00	0.00	0.00	8.199		0.12
17	100	19.74	35.723	19.721	25.38	5.21	100.8	-0.04	0.05	0.00	0.00	0.00	8.172		0.25
16	125	18.88	35.725	18.857	25.61	4.80	91.4	0.45	0.21	2.41	0.15	0.00	8.143		0.12
15	150	18.34	35.661	18.313	25.69	4.51	85.0	0.80	0.29	4.62	0.03	0.00	8.115		0.03
14	175	18.18	35.696	18.148	25.76	4.56	85.7	0.76	0.27	4.74	0.01	0.00	8.120		0.02
13	200	17.62	35.655	17.585	25.87	4.46	82.9	0.92	0.35	5.93	0.00	0.00	8.101		0.01
12	300	16.03	35.519	15.980	26.14	4.59	82.6	0.96	0.45	7.46	0.00	0.00	8.066		0.00
11	400	13.15	35.191	13.092	26.51	4.32	73.2	1.58	0.90	14.6	0.00	0.00	7.979		
10	500	10.76	34.868	10.696	26.72	4.32	69.5	1.90	1.19	19.4	0.00	0.00	7.916		
9	600	8.71	34.630	8.643	26.87	4.46	68.4	2.06	1.49	23.5	0.00	0.00	7.869		
8	700	7.02	34.495	6.950	27.02	4.53	66.8	2.25	1.74	28.2	0.00	0.00	7.830		
7	800	6.05	34.449	5.976	27.11	4.44	64.0	2.50	1.93	30.3	0.00	0.00	7.797		
6	900	5.12	34.449	5.042	27.22	4.22	59.5	2.87	2.15	32.4	0.00	0.00	7.768		
5	1000	4.49	34.470	4.408	27.31	3.94	54.7	3.26	2.27	33.6	0.00	0.00	7.750		
4	1500	2.87	34.606	2.760	27.58	3.55	47.4	3.94	2.52	36.8	0.00	0.00	7.710		
3	2000	2.27	34.659	2.125	27.68	3.55	46.7	4.05	2.53	37.3	0.00	0.00	7.709		
2	3000	1.94	34.696	1.706	27.73	3.68	48.0	3.98	2.49	37.3	0.00	0.00	7.717		
1	3508	1.89	34.704	1.603	27.74	3.67	47.8	4.00	2.42	37.3	0.00	0.00	7.723		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	25.532	35.727	23.73	415.9	0.0000
10	25.509	35.722	23.73	415.6	0.0426
20	25.405	35.734	23.77	411.6	0.0839
30	25.354	35.742	23.80	409.6	0.1242
50	22.808	35.798	24.60	333.2	0.1988
75	21.159	35.750	25.02	292.6	0.2780
100	19.544	35.724	25.44	253.4	0.3478
125	18.856	35.729	25.62	236.1	0.4105
150	18.301	35.672	25.71	226.9	0.4687
175	18.110	35.695	25.78	220.7	0.5268
200	17.549	35.638	25.87	211.8	0.5819
300	15.975	35.492	26.13	187.0	0.7888
400	13.062	35.153	26.50	152.3	0.9685
500	10.640	34.853	26.73	130.8	1.1209
600	8.806	34.651	26.88	116.5	1.2558
700	7.403	34.519	26.98	106.4	1.3780
800	6.390	34.460	27.08	97.6	1.4917
900	5.319	34.451	27.20	85.6	1.5944
1000	4.560	34.475	27.31	75.5	1.6847
1250	3.409	34.573	27.51	56.9	1.8747
1500	2.858	34.618	27.59	48.5	2.0304
1750	2.571	34.645	27.64	44.2	2.1707
2000	2.293	34.670	27.68	40.0	2.3011
2500	2.017	34.698	27.73	35.8	2.5437
3000	1.936	34.708	27.74	34.4	2.7781
3500	1.888	34.714	27.75	33.6	3.0142

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	19-RMS	Date	FEB., 19-20, 1988	Lat.	23 - 02.7 S	Air T.	26.2 C	Weather	Fine	Sea	4
Depth	6760 m	TIME	22 : 37 - 01 : 53	Long.	171 - 00.7 E	Barro.	1010.0 mb	Wind	SSE 9.0m/s	Swell	4

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	27.12	35.445	27.120	23.02	4.52	99.4	0.03	0.00	0.00	0.00	0.13	8.240		0.10
Tr22	20	27.01	35.513	27.005	23.10	4.63	101.6	-0.07	0.00	0.00	0.00	0.00	8.237		0.08
21	50	23.97	35.739	23.959	24.21	4.88	101.9	-0.09	0.00	0.00	0.00	0.00	8.227		0.10
20	75	21.73	35.726	21.715	24.85	5.03	100.9	-0.05	0.03	0.00	0.00	0.00	8.199		0.14
19	90	20.91	35.731	20.892	25.08	4.93	97.5	0.13	0.06	0.12	0.02	0.03	8.182		0.35
18	100	20.41	35.715	20.390	25.20	4.54	88.9	0.56	0.14	1.76	0.14	0.07	8.159		0.30
17	125	19.95	35.710	19.926	25.32	4.62	89.7	0.53	0.17	2.06	0.16	0.00	8.154		0.16
16	150	18.83	35.692	18.802	25.59	4.50	85.6	0.76	0.25	3.83	0.02	0.00	8.126		0.05
15	200	18.25	35.690	18.214	25.74	4.55	85.6	0.76	0.30	4.01	0.02	0.00	8.118		0.02
14	300	15.94	35.460	15.891	26.12	4.36	78.3	1.21	0.55	8.44	0.01	0.00	8.052		0.02
13	400	13.55	35.206	13.491	26.44	4.30	73.5	1.55	0.81	12.7	0.00	0.00	7.994		
12	500	10.91	34.885	10.846	26.70	4.32	69.7	1.88	1.16	18.2	0.00	0.00	7.924		
11	600	8.37	34.578	8.304	26.89	4.50	68.5	2.07	1.53	23.6	0.00	0.00	7.863		
10	700	6.76	34.458	6.691	27.02	4.57	67.0	2.25	1.76	27.4	0.00	0.00	7.824		
9	800	6.05	34.422	5.976	27.09	4.42	63.7	2.52	1.89	29.6	0.00	0.00	7.797		
8	900	5.17	34.406	5.092	27.18	4.27	60.3	2.82	2.30	31.7	0.00	0.00	7.774		
7	1000	4.65	34.441	4.567	27.27	----	----	----	----	----	----	----	----		
6	1500	2.79	34.597	2.681	27.58	3.51	46.8	3.99	2.51	36.9	0.00	0.00	7.709		
5	2000	2.23	34.648	2.086	27.67	3.42	45.0	4.19	2.53	37.5	0.00	0.00	7.704		
4	2500	2.00	34.672	1.814	27.71	3.55	46.4	4.10	2.49	37.4	0.00	0.00	7.714		
3	3000	1.84	34.691	1.608	27.74	3.52	45.8	4.16	2.55	37.1	0.00	0.00	7.712		
2	4000	1.84	34.699	1.499	27.74	3.55	46.2	4.13	2.52	37.2	0.00	0.00	7.718		
1	5000	1.94	34.698	1.471	27.73	3.76	49.1	3.90	2.48	37.2	0.00	0.00	7.708		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	27.125	35.451	23.02	483.7	0.0000
10	27.126	35.450	23.02	483.8	0.0507
20	27.128	35.463	23.03	482.8	0.0981
30	26.693	35.512	23.20	466.1	0.1447
50	24.746	35.627	23.89	400.1	0.2326
75	21.038	35.726	25.04	291.2	0.3199
100	20.155	35.724	25.27	268.7	0.3909
150	18.762	35.696	25.61	236.3	0.5183
200	18.165	35.690	25.76	222.4	0.6366
300	15.517	35.405	26.17	183.6	0.8478
400	12.988	35.134	26.50	152.3	1.0252
500	10.831	34.874	26.71	132.4	1.1780
600	8.011	34.554	26.92	112.2	1.3119
700	6.631	34.451	27.04	101.3	1.4285
800	5.966	34.429	27.11	94.7	1.5368
900	4.989	34.428	27.22	83.6	1.6356
1000	4.480	34.459	27.30	75.9	1.7257
1250	3.498	34.546	27.48	59.7	1.9197
1500	2.806	34.606	27.59	49.0	2.0794
1750	2.458	34.639	27.64	43.7	2.2193
2000	2.253	34.658	27.68	40.6	2.3487
2500	2.002	34.684	27.72	36.7	2.5941
3000	1.852	34.700	27.74	34.4	2.8290
3500	1.813	34.706	27.75	33.7	3.0623
4000	1.839	34.707	27.75	33.8	3.3026
4500	1.885	34.708	27.75	34.1	3.5539
5000	1.942	34.708	27.74	34.5	3.8176

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	28-1 RMS	Date	MER., 03, 1988	Lat.	7 - 03.1 N	Air T.	27.2 C	Weather	Rain	Sea	4
Depth	2010 m	TIME	11 : 28 - 12 : 36	Long.	171 - 03.9 E	Barro.	1012.2 mb	Wind	ENE 13.0m/s	Swell	4

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	28.07	34.648	28.070	22.11	4.47	99.4	0.03	0.00	0.00	0.00	0.50	8.270		0.05
Tr22	5	28.08	34.040	28.079	21.65	4.45	98.6	0.06	0.00	0.00	0.00	0.00	8.265		0.05
21	10	28.09	34.041	28.087	21.65	4.45	98.6	0.06	0.00	0.00	0.00	0.00	8.267		0.05
19	20	28.07	34.042	28.065	21.65	4.44	98.4	0.07	0.00	0.00	0.00	0.00	8.263		0.05
18	30	28.06	34.045	28.052	21.66	4.50	99.7	0.01	0.00	0.00	0.00	0.00	8.261		0.06
16	50	27.90	34.188	27.887	21.82	4.46	98.6	0.06	0.00	0.00	0.00	0.00	8.260		0.08
15	75	27.80	34.159	27.781	21.83	4.51	99.5	0.02	0.00	0.00	0.00	0.00	8.257		0.13
13	100	21.52	34.787	21.500	24.19	4.20	83.5	0.83	0.10	1.90	0.04	0.00	8.119		0.26
12	125	17.16	34.730	17.139	25.27	3.61	66.1	1.85	0.28	8.70	0.08	0.00	7.998		0.16
11	150	13.49	34.507	13.468	25.91	2.55	43.3	3.33	0.64	18.6	0.07	0.00	7.845		0.09
10	175	11.60	34.590	11.577	26.35	1.22	19.9	4.90	1.18	31.1	0.00	0.00	----		0.03
8	200	10.82	34.662	10.795	26.55	0.65	10.5	5.57	1.36	35.6	0.00	0.00	7.610		0.01
6	300	9.57	34.668	9.535	26.77	0.69	10.8	5.70	1.46	38.6	0.00	0.00	7.588		0.00
5	400	8.66	34.632	8.616	26.88	0.78	12.0	5.74	1.47	39.9	0.00	0.00	7.574		
3	500	7.57	34.584	7.519	27.01	0.90	13.5	5.79	1.57	41.8	0.00	0.00	7.558		
2	750	5.91	34.550	5.841	27.21	1.25	18.0	5.71	1.67	43.5	0.00	0.18	7.567		
1	1000	4.68	34.561	4.596	27.36	1.69	23.6	5.47	2.12	49.8	0.00	0.27	7.589		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.067	33.929	21.57	622.4	0.0000
10	28.062	33.983	21.61	618.3	0.0631
20	28.059	34.017	21.64	615.8	0.1248
30	28.053	34.032	21.65	614.5	0.1868
50	28.001	34.109	21.73	607.4	0.3107
75	27.861	34.208	21.85	595.8	0.4606
100	23.558	34.647	23.51	437.2	0.5916
125	17.481	34.730	25.19	276.4	0.6805
150	13.903	34.511	25.83	215.8	0.7436
175	11.574	34.588	26.35	166.4	0.7930
200	10.969	34.649	26.51	151.4	0.8337
300	9.713	34.678	26.75	128.6	0.9784
400	8.750	34.642	26.88	116.4	1.1080
500	7.561	34.592	27.02	103.1	1.2255
600	6.871	34.574	27.10	95.2	1.3332
700	6.141	34.556	27.18	87.4	1.4340
800	5.552	34.562	27.26	79.9	1.5273
900	4.966	34.567	27.34	72.9	1.6134
1000	4.515	34.575	27.39	67.5	1.6936

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	28-2 RMS	Date	MER., 03, 1988	Lat.	7 - 13.1 N	Air T.	28.0 C	Weather	Fine	Sea	4
Depth	1530 m	TIME	14 : 38 - 15 : 35	Long.	171 - 08.1 E	Barro.	1009.0 mb	Wind	ENE 10.0m/s	Swell	3

RMS or HYDROCAST CTDO data

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.	D	T	S	Sig-t	Dst	Del-D
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l	m	C			cl/t	
surf	0	28.03	34.093	28.030	21.71	4.50	99.7	0.02	0.00	0.00	0.00	0.00	8.257		0.10	0	28.034	34.103	21.71	608.8	0.0000
Tr22	5	28.05	34.100	28.049	21.70	4.52	100.1	-0.01	0.00	0.00	0.00	0.00	-----		0.08	10	28.032	34.104	21.71	608.7	0.0610
21	10	28.05	34.100	28.047	21.70	4.62	102.4	-0.11	0.00	0.00	0.00	0.00	8.260		0.09	20	28.007	34.107	21.72	607.7	0.1226
19	20	28.02	34.102	28.015	21.72	4.52	100.1	-0.00	0.00	0.00	0.00	0.00	-----		0.09	30	28.005	34.108	21.72	607.6	0.1842
18	30	27.99	34.104	27.982	21.73	4.51	99.8	0.01	0.00	0.00	0.00	0.00	-----		0.17	50	27.969	34.114	21.74	606.0	0.3054
16	50	27.94	34.124	27.927	21.76	4.46	98.6	0.06	0.00	0.00	0.00	0.00	8.256		0.26	75	27.924	34.162	21.79	601.2	0.4575
15	75	27.82	34.177	27.801	21.84	4.46	98.5	0.07	0.00	0.00	0.00	0.00	-----		0.13	100	26.278	34.380	22.48	535.2	0.6016
13	100	26.28	34.371	26.256	22.47	4.54	97.8	0.10	0.00	0.20	0.00	0.00	8.224		0.27	125	22.509	34.735	23.87	402.0	0.7197
12	125	22.38	34.700	22.354	23.88	4.38	88.4	0.58	0.08	1.20	0.00	0.00	-----		0.28	150	16.001	34.662	25.49	248.3	0.8017
11	150	15.96	34.657	15.936	25.49	2.06	36.8	3.53	0.38	13.0	0.02	0.00	7.951		0.15	175	13.397	34.553	25.97	202.8	0.8591
10	175	13.50	34.554	13.475	25.95	2.68	45.6	3.20	0.71	21.5	0.20	0.00	-----		0.07	200	12.230	34.572	26.21	179.4	0.9091
8	200	11.66	34.602	11.634	26.34	1.26	20.6	4.85	1.06	31.4	0.05	0.00	7.687		0.04	300	10.071	34.679	26.69	134.2	1.0708
6	300	9.82	34.684	9.784	26.74	0.58	9.1	5.77	1.36	39.4	0.00	0.00	7.584		0.02	400	9.023	34.656	26.85	119.4	1.2045
5	400	8.91	34.642	8.865	26.85	0.84	12.9	5.65	1.57	41.9	0.00	0.23	7.585			500	8.255	34.607	26.93	111.7	1.3287
3	500	8.10	34.609	8.047	26.95	0.74	11.2	5.87	1.54	42.1	0.00	0.00	7.564			600	7.172	34.583	27.07	98.5	1.4423
2	750	5.88	34.547	5.811	27.21	1.11	15.9	5.85	1.72	45.4	0.00	0.00	7.563			700	6.343	34.563	27.16	89.3	1.5463
1	1000	4.69	34.563	4.606	27.36	1.67	23.3	5.49	1.63	45.2	0.00	0.27	7.590			800	5.649	34.561	27.25	81.1	1.6411
																900	5.084	34.565	27.32	74.4	1.7290
																1000	4.700	34.572	27.37	69.7	1.8115

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	28-3R RMS	Date	MER., 03, 1988	Lat.	7 - 11.1 N	Air T.	28.3 C	Weather	Fine	Sea	4
Depth	1860 m	TIME	18 : 32 - 19 : 26	Long.	171 - 15.9 E	Barro.	1009.5 mb	Wind	ENE 12.0m/s	Swell	4

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	28.01	34.098	28.010	21.72	4.52	100.1	-0.00	0.00	0.00	0.00	0.00	8.270		0.06
Tr21	5	28.01	34.099	28.009	21.72	4.45	98.5	0.07	0.00	0.00	0.00	0.00	-----		0.06
20	10	28.01	34.100	28.007	21.72	4.45	98.5	0.07	0.00	0.00	0.00	0.00	8.271		0.06
19	20	27.99	34.112	27.985	21.73	4.63	102.5	-0.11	0.00	0.00	0.00	0.00	8.270		0.08
18	30	27.97	34.120	27.962	21.74	4.44	98.2	0.08	0.00	0.00	0.00	0.00	8.267		0.09
17	50	27.96	34.128	27.947	21.75	4.49	99.3	0.03	0.00	0.00	0.00	0.00	8.265		0.09
16	75	27.55	34.251	27.531	21.98	4.50	99.0	0.05	0.00	0.00	0.00	0.00	8.260		0.19
14	100	24.59	34.637	24.567	23.19	4.52	94.8	0.25	0.04	0.40	0.01	0.00	8.209		0.31
12	125	21.41	34.602	21.385	24.08	4.18	82.9	0.87	0.14	2.50	0.04	0.00	8.110		0.24
10	150	14.00	34.579	13.978	25.86	2.43	41.8	3.39	0.68	20.8	0.08	0.00	7.851		0.09
9	175	11.70	34.595	11.677	26.33	1.09	17.9	5.01	1.21	32.7	0.00	0.00	----		0.03
7	200	11.08	34.667	11.055	26.50	0.75	12.1	5.43	1.31	35.5	0.00	0.00	7.644		0.02
6	300	9.77	34.693	9.735	26.75	0.57	9.0	5.79	1.47	39.9	0.00	0.00	7.586		0.01
4	400	8.61	34.634	8.566	26.89	0.63	9.6	5.90	1.56	41.7	0.00	0.00	7.577		
3	500	7.69	34.589	7.638	27.00	0.69	10.3	5.98	1.64	43.5	0.00	0.00	7.556		
2	750	5.80	34.551	5.732	27.22	1.20	17.2	5.77	1.72	45.5	0.00	0.00	7.572		
1	1000	4.59	34.566	4.507	27.38	1.64	22.8	5.54	1.64	44.9	0.00	0.00	7.594		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.045	34.109	21.71	608.7	0.0000
10	28.046	34.109	21.71	608.7	0.0613
20	28.030	34.109	21.72	608.2	0.1251
30	28.011	34.108	21.72	607.7	0.1860
50	27.967	34.125	21.75	605.2	0.3049
75	27.881	34.161	21.80	599.9	0.4556
100	27.337	34.256	22.05	576.2	0.6052
125	21.525	34.733	24.15	375.9	0.7265
150	15.235	34.552	25.58	240.0	0.8039
175	12.775	34.531	26.07	192.6	0.8588
200	11.259	34.630	26.44	157.8	0.9034
300	9.867	34.685	26.73	130.5	1.0537
400	8.749	34.642	26.88	116.3	1.1839
500	7.763	34.598	26.99	105.4	1.3025
600	7.014	34.575	27.08	97.0	1.4128
700	6.366	34.562	27.16	89.6	1.5156
800	5.706	34.558	27.24	82.0	1.6113
900	5.101	34.563	27.32	74.7	1.6996
1000	4.718	34.570	27.37	70.1	1.7823

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	28-4 RMS	Date	MER., 03, 1988	Lat.	7 - 14.1 N	Air T.	27.8 C	Weather	Cloudy	Sea	4
Depth	2940 m	TIME	22 : 31 - 23 : 44	Long.	171 - 18.1 E	Barro.	1011.8 mb	Wind	ENE 12.0m/s	Swell	4

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	27.98	34.092	27.980	21.72	4.49	99.4	0.03	0.00	0.00	0.00	0.00	8.262		0.06
Tr22	5	27.98	34.093	27.979	21.72	4.54	100.5	-0.02	0.00	0.00	0.00	0.00	-----		0.06
21	10	27.98	34.094	27.977	21.72	4.48	99.1	0.04	0.00	0.00	0.00	0.00	-----		0.06
19	20	27.99	34.093	27.985	21.72	4.49	99.4	0.03	0.00	0.00	0.00	0.00	8.261		0.05
18	30	27.99	34.096	27.982	21.72	4.50	99.6	0.02	0.00	0.00	0.00	0.00	-----		0.06
16	50	28.00	34.096	27.987	21.72	4.52	100.1	-0.00	0.00	0.00	0.00	0.00	8.263		0.06
15	75	27.20	34.263	27.181	22.10	4.48	98.0	0.09	0.00	0.00	0.00	0.00	-----		0.19
13	100	24.85	34.561	24.827	23.06	4.46	93.9	0.29	0.04	0.20	0.00	0.00	8.199		0.24
12	125	19.54	34.880	19.516	24.79	4.11	78.8	1.10	0.15	3.50	0.06	0.09	-----		0.21
11	150	14.96	34.592	14.937	25.67	3.35	58.7	2.36	0.38	11.8	0.23	0.00	7.961		0.14
10	175	12.70	34.519	12.676	26.08	2.22	37.1	3.76	0.79	23.0	0.02	0.00	7.664		0.06
8	200	11.60	34.626	11.574	26.37	0.96	15.7	5.16	1.15	31.5	0.00	0.00	7.582		0.03
6	300	9.70	34.688	9.665	26.76	0.49	7.7	5.88	1.45	39.0	0.00	0.00	7.570		0.01
5	400	8.91	34.647	8.865	26.86	0.59	9.1	5.90	1.49	39.5	0.00	0.00	7.552		
3	500	7.95	34.603	7.897	26.97	0.70	10.6	5.93	1.60	41.3	0.00	0.00	7.561		
2	750	5.68	34.550	5.613	27.24	1.22	17.4	5.77	1.65	44.2	0.00	0.00	7.601		
1	1000	4.68	34.563	4.596	27.37	1.67	23.3	5.49	1.67	43.2	0.00	0.00			

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	27.982	34.101	21.73	607.3	0.0000
10	27.984	34.102	21.73	607.3	0.0631
20	27.989	34.101	21.72	607.5	0.1231
30	27.992	34.101	21.72	607.6	0.1829
50	27.998	34.105	21.72	607.5	0.3049
75	27.868	34.152	21.80	600.1	0.4567
100	26.308	34.335	22.44	539.3	0.6001
125	21.453	34.792	24.21	369.7	0.7166
150	16.412	34.670	25.40	256.7	0.7963
175	12.782	34.508	26.06	194.4	0.8531
200	11.667	34.608	26.35	166.6	0.8998
300	9.706	34.693	26.76	127.3	1.0516
400	8.914	34.657	26.86	117.7	1.1814
500	7.906	34.605	26.98	106.9	1.3015
600	6.928	34.577	27.10	95.7	1.4116
700	6.133	34.561	27.19	86.9	1.5126
800	5.428	34.563	27.28	78.4	1.6043
900	5.011	34.568	27.33	73.4	1.6903
1000	4.681	34.574	27.37	69.3	1.7719

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	31- RMS	Date	MER., 09, 1988	Lat.	5 - 46.3 N	Air T.	27.3 C	Weather	Fine	Sea	3
Depth	4940 m	TIME	03 : 49 - 05 : 27	Long.	165 - 01.2 E	Barro.	1011.3 mb	Wind	ENE 8.5 m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	28.94	34.078	28.940	21.39	4.37	98.2	0.08	1.10	0.00	0.00	0.00	8.276		0.06
Tri9	20	28.94	34.075	28.935	21.39	4.36	98.0	0.09	0.08	0.00	0.00	0.00	----		0.06
18	30	28.94	34.076	28.932	21.39	4.35	97.8	0.10	0.06	0.00	0.00	0.00	----		0.06
17	40	28.94	34.076	28.929	21.39	4.47	100.5	-0.02	0.08	0.00	0.00	0.07	----		0.05
16	50	28.95	34.081	28.937	21.39	4.44	99.8	0.01	0.08	0.00	0.00	0.14	8.278		0.06
15	75	28.96	34.103	28.940	21.41	4.47	100.5	-0.02	0.08	0.00	0.00	0.03	----		0.06
14	100	28.82	34.182	28.794	21.51	4.47	100.3	-0.01	0.06	0.00	0.00	0.00	8.273		0.13
13	125	23.92	34.722	23.892	23.46	3.89	80.7	0.93	0.29	20.6	0.00	0.14	----		0.26
12	150	19.79	34.735	19.761	24.62	3.28	63.2	1.91	0.69	88.2	0.00	0.12	----		0.14
11	175	17.57	34.733	17.539	25.17	3.14	58.0	2.28	0.92	12.1	0.00	0.28	----		0.07
10	200	15.25	34.698	15.218	25.68	3.08	54.3	2.59	1.19	15.6	0.00	0.10	7.945		0.04
9	300	10.24	34.648	10.203	26.64	----	----	----	2.58	33.2	0.00	0.14	----		0.02
8	400	9.12	34.640	9.074	26.82	1.09	16.9	5.37	2.60	34.7	0.00	0.10	7.627		
7	500	8.11	34.615	8.056	26.96	1.38	20.9	5.23	2.68	35.6	0.00	0.17	----		
6	600	7.28	34.583	7.219	27.05	1.13	16.8	5.60	2.90	38.2	0.00	0.21	7.580		
5	750	6.25	34.560	6.179	27.17	1.65	23.9	5.25	3.00	39.7	0.00	0.14	7.577		
4	900	5.36	34.555	5.280	27.28	1.78	25.3	5.27	2.95	39.1	0.25	0.14	----		
3	1000	4.76	34.559	4.675	27.35	2.28	31.9	4.87	2.94	39.1	0.03	0.17	7.610		
2	1500	3.21	34.604	3.096	27.55	----	----	----	2.94	39.1	0.02	0.14	7.619		
1	2000	2.29	34.644	2.145	27.66				2.85	38.5	0.01	0.24	7.639		

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.871	34.040	21.39	639.7	0.0000
10	28.881	34.048	21.39	639.4	0.0649
20	28.880	34.051	21.39	639.2	0.1291
30	28.880	34.052	21.39	639.2	0.1955
50	28.897	34.060	21.39	639.1	0.3209
75	28.953	34.111	21.41	637.2	0.4827
100	28.902	34.136	21.45	633.8	0.6417
125	23.767	34.682	23.47	440.5	0.7793
150	19.882	34.749	24.60	332.6	0.8769
175	16.938	34.733	25.32	263.9	0.9533
200	14.648	34.646	25.78	220.9	1.0144
300	10.209	34.656	26.65	138.2	1.1999
400	9.106	34.657	26.83	120.6	1.3361
500	8.096	34.620	26.96	108.5	1.4590
600	7.217	34.591	27.07	98.5	1.5713
700	6.418	34.570	27.16	89.7	1.6751
800	5.884	34.563	27.22	83.7	1.7722
900	5.278	34.561	27.29	76.9	1.8630
1000	4.729	34.569	27.36	70.2	1.9469
1250	3.975	34.588	27.46	61.1	2.1384
1500	3.168	34.615	27.56	51.5	2.3064
1750	2.662	34.635	27.62	45.6	2.4542
2000	2.272	34.655	27.67	41.0	2.5878

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	34-RMS	Date	Mar., 16, 1988	Lat.	6 - 54.0 N	Air T.	29.0 C	Weather	Fine	Sea	3
Depth	730 m	TIME	11 : 52 - 12 : 33	Long.	158 - 05.0 E	Barro.	1009.0 mb	Wind	ENE 9.5 m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	Phaeo	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		ug/l	ug/l
surf	0	28.90	33.871	28.900	21.25	4.71	105.7	-0.25	0.06	0.00	0.00	0.49		.020	0.07
Tr21	10	28.75	34.131	28.747	21.50	4.52	101.3	-0.06	0.03	0.00	0.00	0.61		.020	0.06
20	30	28.66	34.131	28.652	21.53	4.66	104.3	-0.19	----	0.00	0.00	0.44		.030	0.06
19	50	28.59	34.204	28.577	21.60	4.66	104.2	-0.19	0.03	0.00	0.00	0.51		.030	0.08
17	75	28.42	34.338	28.401	21.76	4.73	105.6	-0.25	0.05	0.00	0.00	0.63		.050	0.10
16	100	28.36	34.364	28.334	21.80	4.39	97.9	0.09	0.05	0.00	0.00	0.21		.060	0.14
14	124	19.77	34.759	19.746	24.64	3.46	66.6	1.73	0.81	5.90	0.12	0.72		.320	0.15
11	149	16.67	34.702	16.645	25.36	3.14	57.0	2.37	1.22	1.00	0.02	0.51		.180	0.06
10	175	15.52	34.675	15.492	25.61	2.92	51.8	2.72	1.37	11.3	0.01	0.54		.130	0.04
7	199	13.81	34.620	13.781	25.93	2.81	48.1	3.03	2.74	26.2	0.00	0.36		.070	0.02
5	300	9.73	34.620	9.695	26.70	1.19	18.7	5.18	2.36	25.6	0.00	0.64		.020	0.00
4	400	8.76	34.628	8.715	26.87	1.17	18.0	5.34	2.47	26.7	0.00	0.93			
1	500	8.03	34.601	7.977	26.96	1.36	20.5	5.26	2.53	28.5	0.00	0.64			

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.773	33.940	21.35	643.8	0.0000
10	28.766	34.013	21.40	638.3	0.0648
20	28.722	34.073	21.46	632.6	0.1294
30	28.668	34.100	21.50	628.9	0.1940
50	28.641	34.153	21.55	624.3	0.3197
75	28.451	34.329	21.74	605.7	0.4741
100	28.153	34.428	21.92	589.1	0.6223
150	16.806	34.718	25.34	262.0	0.8389
200	13.272	34.593	26.02	197.4	0.9549
300	9.289	34.635	26.79	125.1	1.1219
400	8.784	34.638	26.87	117.1	1.2498
500	8.122	34.613	26.95	109.4	1.3710
600	7.385	34.585	27.04	101.2	1.4800

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	35- RMS	Date	MER., 16, 1988	Lat.	6 - 50.1 N	Air T.	29.3 C	Weather	Fine	Sea	3
Depth	820 m	TIME	14 : 12 - 14 : 56	Long.	158 - 01.1 E	Barro.	1007.0 mb	Wind	NE 8.8 m/s	Swell	1

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	Phaeo	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		ug/l	ug/l
surf	0	29.10	34.106	29.100	21.36	4.52	101.9	-0.08	0.00	0.00	0.00	0.00		.020	0.06
Tr22	10	28.75	34.105	28.747	21.48	4.59	102.9	-0.13	0.00	0.00	0.00	0.00		.020	0.04
20	20	28.70	34.110	28.695	21.50	----	-----	----	0.00	0.00	0.00	0.00		.020	0.06
19	31	28.69	34.117	28.682	21.51	4.56	102.1	-0.09	0.00	0.00	0.00	0.00		.020	0.07
16	50	28.66	34.142	28.647	21.54	4.55	101.8	-0.08	0.00	0.00	0.00	0.00		.030	0.09
14	75	27.89	34.476	27.871	22.04	4.47	99.0	0.05	0.00	0.00	0.00	0.00		.080	0.13
11	99	26.32	34.572	26.296	22.61	4.31	93.0	0.32	0.00	0.00	0.00	0.00		.340	0.31
9	125	23.63	34.710	23.603	23.53	4.25	87.7	0.60	0.16	4.40	0.00	0.00		.520	0.32
7	150	15.65	34.676	15.626	25.58	2.96	52.6	2.66	1.11	14.5	0.06	0.64		.130	0.05
6	174	13.83	34.619	13.804	25.93	2.70	46.3	3.14	1.33	12.4	0.17	0.50		.080	0.02
4	199	12.90	34.545	12.872	26.06	2.46	41.3	3.49	4.62	15.1	0.00	0.79		.050	0.01
3	300	9.68	34.615	9.645	26.71	1.48	23.2	4.90	2.34	16.3	0.00	1.21		.020	0.00
1	399	8.67	34.628	8.626	26.88	1.43	21.9	5.09	2.31	24.7	0.00	0.71			

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.815	34.115	21.46	632.5	0.0000
10	28.816	34.116	21.46	632.5	0.0639
20	28.730	34.111	21.49	630.2	0.1271
30	28.695	34.118	21.51	628.5	0.1915
50	28.666	34.142	21.53	625.8	0.3158
75	28.149	34.450	21.93	587.4	0.4690
100	26.443	34.572	22.57	526.2	0.6084
125	24.689	34.613	23.14	471.7	0.7348
150	16.220	34.657	25.43	253.5	0.8283
175	14.070	34.622	25.88	211.0	0.8871
200	13.226	34.607	26.04	195.6	0.9387
300	10.009	34.621	26.65	137.5	1.1110
400	8.708	34.635	26.88	116.3	1.2447
500	8.120	34.613	26.95	109.3	1.3659
600	7.326	34.585	27.05	100.4	1.4794
700	6.727	34.563	27.11	94.1	1.5870

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	36- RMS	Date	MER., 16, 1988	Lat.	6 - 44.9 N	Air T.	28.8 C	Weather	Fine	Sea	4
Depth	1140 m	TIME	17 : 30 - 18 : 22	Long.	157 - 53.9 E	Barro.	1007.2 mb	Wind	NE 10.0 m/s	Swell	1

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	Phaeo	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		ug/l	ug/l
surf	0	29.10	34.082	29.100	21.34	4.49	101.2	-0.05	0.00	0.00	0.00	0.00		.020	0.05
Tr20	10	28.77	34.081	28.767	21.45	4.56	102.2	-0.10	0.00	0.00	0.23	0.00		.020	0.05
19	20	28.74	34.080	28.735	21.46	----	----	----	0.00	0.00	0.00	0.00		----	----
18	30	28.69	34.082	28.682	21.48	4.51	101.0	-0.04	0.00	0.00	0.06	0.00		.020	0.05
16	51	28.28	34.105	28.267	21.63	4.45	99.0	0.05	0.00	0.00	0.00	0.00		.020	0.07
14	75	26.25	34.388	26.232	22.50	4.58	98.6	0.06	0.00	0.00	0.00	0.00		.070	0.12
12	100	22.00	34.619	21.979	23.93	4.33	86.8	0.66	0.14	0.00	0.00	0.00		.330	0.26
10	124	18.89	34.759	18.867	24.87	3.77	71.4	1.51	0.55	37.8	0.00	0.00		.410	0.20
8	150	16.39	34.742	16.365	25.46	3.19	57.6	2.35	0.89	77.0	0.00	0.00		.220	0.09
7	175	14.36	34.714	14.334	25.89	3.02	52.3	2.75	1.05	94.4	0.00	0.71		.160	0.05
5	199	9.26	34.636	9.237	26.79	2.87	44.6	3.57	1.26	11.6	0.00	0.79		.090	0.02
4	300	8.96	34.638	8.926	26.84	1.12	17.3	5.36	2.46	23.1	0.00	0.71		.020	0.00
3	400	8.06	34.626	8.018	26.97	1.34	20.3	5.27	2.46	22.7	0.00	0.71			
2	500	6.12	34.602	6.074	27.22	1.49	21.5	5.43	2.53	24.0	0.00	0.86			
1	750	10.00	34.553	9.907	26.60	1.45	22.9	4.89	2.73	29.5	0.00	0.43			

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.802	34.091	21.45	633.9	0.0000
10	28.794	34.090	21.45	633.7	0.0658
20	28.792	34.089	21.45	633.7	0.1276
30	28.761	34.087	21.46	632.8	0.1914
50	28.703	34.098	21.49	630.2	0.3199
75	28.571	34.273	21.66	613.4	0.4743
100	26.390	34.561	22.58	525.5	0.6179
125	20.119	34.768	24.55	337.2	0.7262
150	18.306	34.728	24.99	295.8	0.8068
175	16.474	34.694	25.40	256.4	0.8779
200	14.286	34.632	25.84	214.6	0.9370
300	9.434	34.644	26.77	126.7	1.1139
400	8.957	34.636	26.84	119.9	1.2442
500	7.855	34.600	26.98	106.5	1.3654
600	7.375	34.584	27.04	101.1	1.4781
700	6.727	34.563	27.11	94.1	1.5859
800	5.800	34.558	27.23	83.1	1.6844
900	5.019	34.564	27.33	73.7	1.7734
1000	4.435	34.575	27.40	66.7	1.8533

KH-88-1 SUMMARY OF HYDROGRAPHIC DATA

Station	37- RMS	Date	MER., 16, 1988	Lat.	7 - 00.2 N	Air T.	28.6 C	Weather	Fine	Sea	4
Depth	2050 m	TIME	21 : 22 - 22 : 35	Long.	157 - 55.2 E	Barro.	1009.1 mb	Wind	ENE 10.0 m/s	Swell	3

RMS or HYDROCAST

Sample	D	T	S	Pot-T	Sig-t	D.O.	%-DO	AOU	PO4	NO3	NO2	Nh4	pH	AT	Chl.
No.	m	C		C		ml/l	%	ml/l	uM	uM	uM	uM		meq/l	ug/l
surf	0	28.90	34.166	28.900	21.47	4.72	106.1	-0.27	0.04	0.00	0.09				0.06
Tr20	10	28.64	34.171	28.637	21.56	4.48	100.3	-0.01	0.04	0.00	0.00				0.05
19	20	28.65	34.170	28.645	21.56	----	----	----	0.04	0.00	0.00				0.05
18	30	28.64	34.172	28.632	21.56	4.48	100.3	-0.01	0.04	0.00	0.00				0.05
16	50	28.33	34.356	28.317	21.80	4.45	99.2	0.04	0.04	0.00	0.00				0.11
15	75	27.83	34.479	27.811	22.06	4.54	100.4	-0.02	0.06	0.00	0.00				0.19
13	100	26.24	34.598	26.216	22.66	4.39	94.6	0.25	0.14	0.00	0.00				0.34
12	125	19.60	34.787	19.576	24.71	3.41	65.5	1.80	0.78	62.5	0.00				0.13
11	151	15.50	34.683	15.476	25.62	2.96	52.5	2.68	1.11	11.2	0.00				0.04
10	174	14.06	34.624	14.034	25.88	2.71	46.6	3.10	1.46	13.1	0.00				0.03
8	200	12.87	34.578	12.842	26.09	2.49	41.8	3.47	1.75	16.6	0.00				0.03
7	300	9.48	34.635	9.445	26.75	1.09	17.0	5.31	2.68	24.0	0.00				0.00
6	400	8.67	34.625	8.626	26.88	1.20	18.4	5.32	2.70	25.3	0.00				
4	500	7.74	34.591	7.688	26.99	1.42	21.3	5.24	2.80	26.0	0.00				
3	750	5.52	34.548	5.454	27.26	1.41	20.1	5.61	3.21	28.2	0.00				
2	1000	4.61	34.567	4.527	27.38	1.93	26.9	5.25	2.95	28.2	0.00				
1	1505	3.00	34.612	2.888	27.58	2.15	28.8	5.31	2.95	28.8	0.00				

CTDO data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.871	34.040	21.39	639.7	0.0000
10	28.881	34.048	21.39	639.4	0.0649
20	28.880	34.051	21.39	639.2	0.1291
30	28.880	34.052	21.39	639.2	0.1955
50	28.897	34.060	21.39	639.1	0.3209
75	28.953	34.111	21.41	637.2	0.4827
100	28.902	34.136	21.45	633.8	0.6417
125	23.767	34.682	23.47	440.5	0.7793
150	19.882	34.749	24.60	332.6	0.8769
175	16.938	34.733	25.32	263.9	0.9533
200	14.648	34.646	25.78	220.9	1.0144
300	10.209	34.656	26.65	138.2	1.1999
400	9.106	34.657	26.83	120.6	1.3361
500	8.096	34.620	26.96	108.5	1.4590
600	7.217	34.591	27.07	98.5	1.5713
700	6.418	34.570	27.16	89.7	1.6751
800	5.884	34.563	27.22	83.7	1.7722
900	5.278	34.561	27.29	76.9	1.8630
1000	4.729	34.569	27.36	70.2	1.9469
1250	3.975	34.588	27.46	61.1	2.1384
1500	3.168	34.615	27.56	51.5	2.3064

Station	12		Depth	1940m	
Date	Feb. 3 1988		Lat.	2-29.9S	
Time	18: 18-19: 22		Long.	152-50.6E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.703	34.305	21.308	647.4	0.0000
10	29.702	34.321	21.321	646.2	0.0652
20	29.675	34.327	21.334	644.9	0.1301
30	29.616	34.324	21.352	643.2	0.1945
50	29.548	34.329	21.379	640.6	0.3237
75	28.041	34.663	22.130	568.7	0.4751
100	24.564	35.375	23.759	413.1	0.5984
125	22.110	35.556	24.611	331.8	0.6930
150	20.720	35.605	25.032	291.7	0.7733
175	18.606	35.443	25.461	250.9	0.8411
200	16.760	35.315	25.814	217.4	0.9018
250	14.754	35.088	26.095	190.7	1.0078
350	10.545	34.788	26.692	134.0	1.1773
400	9.591	34.724	26.806	123.2	1.2454
450	9.001	34.684	26.871	117.0	1.3094
500	8.280	34.633	26.943	110.1	1.3708
550	7.552	34.582	27.012	103.7	1.4286
600	7.098	34.559	27.058	99.3	1.4840
650	6.507	34.533	27.118	93.6	1.5370
700	5.946	34.511	27.173	88.4	1.5871
750	5.466	34.537	27.253	80.8	1.6339
800	5.137	34.538	27.293	77.0	1.6779
850	5.032	34.542	27.308	75.5	1.7208
900	4.833	34.547	27.335	73.0	1.7629
950	4.487	34.550	27.376	69.1	1.8031
1000	4.377	34.557	27.394	67.5	1.8421
1500	3.034	34.613	27.573	50.5	2.1869

Station	14		Depth	4840m	
Date	Feb. 5 1988		Lat.	4-29.3S	
Time	05: 53-07: 01		Long.	153-45.5E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.378	34.146	21.299	648.3	0.0000
10	29.378	34.146	21.299	648.3	0.0920
20	29.097	34.387	21.574	621.9	0.1302
30	28.661	34.661	21.925	588.4	0.1922
50	27.551	34.895	22.464	536.8	0.3053
75	25.230	35.287	23.490	438.7	0.4259
100	23.712	35.541	24.138	376.9	0.5287
125	21.619	35.501	24.706	322.8	0.6182
150	18.727	35.398	25.396	257.1	0.6925
175	17.050	35.323	25.752	223.3	0.7534
200	15.178	35.166	26.062	193.8	0.8065
250	12.158	34.923	26.500	152.2	0.8961
350	8.910	34.663	26.869	117.2	1.0372
400	7.997	34.587	26.950	109.5	1.0978
450	7.408	34.558	27.013	103.5	1.1545
500	7.000	34.532	27.051	100.0	1.2087
550	6.486	34.513	27.105	94.8	1.2612
600	6.237	34.505	27.131	92.4	1.3123
650	5.887	34.498	27.171	88.6	1.3617
700	5.741	34.517	27.204	85.5	1.4099
750	5.635	34.519	27.219	84.1	1.4568
800	5.352	34.506	27.242	81.8	1.5029
850	5.051	34.501	27.274	78.8	1.5477
900	4.970	34.518	27.297	76.7	1.5912
950	4.709	34.514	27.323	74.2	1.6342
1000	4.558	34.531	27.354	71.3	1.6752
1500	3.026	34.609	27.571	50.7	2.0310
2000	2.291	34.657	27.673	41.0	2.3109

Station	16		Depth	3430m	
Date	Feb. 6 1988		Lat.	12-32.3S	
Time	20: 21-21: 40		Long.	154-29.4E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	30.235	34.444	21.232	654.8	0.0000
10	30.177	34.454	21.259	652.1	0.0677
20	29.800	34.522	21.438	635.0	0.1315
30	29.184	34.701	21.780	602.2	0.1922
50	28.051	34.997	22.378	545.0	0.3096
75	25.887	35.341	23.328	454.2	0.4334
100	24.598	35.460	23.813	407.9	0.5428
125	23.987	35.573	24.081	382.3	0.6415
150	22.937	35.697	24.482	344.1	0.7344
175	21.066	35.675	24.991	295.6	0.8164
200	19.674	35.591	25.299	266.3	0.8884
250	16.833	35.319	25.799	218.7	1.0128
350	12.125	34.929	26.511	151.2	1.2067
400	10.218	34.752	26.721	131.2	1.2812
450	8.831	34.639	26.863	117.8	1.3474
500	7.838	34.560	26.953	109.2	1.4089
550	6.950	34.510	27.040	101.0	1.4657
600	6.468	34.490	27.089	96.4	1.5189
650	5.844	34.465	27.150	90.6	1.5701
700	5.378	34.460	27.203	85.6	1.6185
750	5.110	34.468	27.241	82.0	1.6644
800	4.893	34.474	27.270	79.2	1.7087
850	4.666	34.484	27.304	76.0	1.7521
900	4.452	34.493	27.335	73.0	1.7935
950	4.294	34.503	27.360	70.7	1.8340
1000	4.050	34.517	27.397	67.2	1.8729
1500	2.891	34.609	27.583	49.5	2.2116
2000	2.320	34.656	27.670	41.3	2.4883

Station	20		Depth	4890m	
Date	Feb.26 1988		Lat.	20-00.3S	
Time	05: 46-07: 05		Long.	167-54.1E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.735	35.015	22.166	565.3	0.0000
10	28.739	35.019	22.168	565.1	0.0568
20	28.745	35.023	22.169	565.0	0.1144
30	28.742	35.131	22.251	557.2	0.1693
50	26.196	35.453	23.316	455.4	0.2710
75	24.220	35.578	24.015	388.6	0.3790
100	23.196	35.633	24.359	355.9	0.4715
125	22.360	35.664	24.622	330.7	0.5586
150	21.690	35.692	24.832	310.8	0.6402
175	21.082	35.706	25.010	293.8	0.7167
200	20.389	35.689	25.185	277.2	0.7899
250	19.022	35.603	25.478	249.3	0.9266
350	15.956	35.404	26.069	193.1	1.1573
400	14.178	35.193	26.299	171.3	1.2537
450	12.765	35.033	26.466	155.5	1.3408
500	10.931	34.831	26.657	137.3	1.4198
550	9.207	34.644	26.806	123.2	1.4909
600	8.070	34.547	26.908	113.5	1.5546
650	7.470	34.501	26.960	108.6	1.6162
700	6.782	34.452	27.017	103.1	1.6736
750	6.159	34.422	27.076	97.6	1.7290
800	5.775	34.413	27.117	93.7	1.7819
850	5.407	34.411	27.161	89.5	1.8330
900	4.959	34.425	27.224	83.5	1.8813
950	4.645	34.438	27.270	79.2	1.9266
1000	4.286	34.460	27.327	73.8	1.9697
1500	2.833	34.608	27.587	49.1	2.3244

Station	23		Depth	3160m	
Date	Feb.29 1988		Lat.	5-00.1S	
Time	15: 32-16: 43		Long.	168-48.8E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.618	34.016	21.120	665.5	0.0000
10	29.617	34.020	21.123	665.1	0.0671
20	29.495	34.018	21.163	661.3	0.1331
30	29.455	34.025	21.182	659.5	0.2012
50	29.600	34.198	21.264	651.7	0.3327
75	29.663	34.537	21.496	629.4	0.4961
100	29.530	34.990	21.880	592.6	0.6476
125	28.982	35.323	22.315	551.0	0.7916
150	27.125	35.530	23.079	477.9	0.9197
175	24.921	35.824	23.990	391.0	1.0305
200	22.012	35.769	24.800	313.8	1.1218
250	15.518	35.181	25.997	200.0	1.2532
350	10.811	34.820	26.670	136.1	1.4288
400	9.971	34.759	26.769	126.7	1.4988
450	9.361	34.710	26.833	120.6	1.5651
500	8.980	34.684	26.874	116.7	1.6293
550	8.515	34.657	26.926	111.8	1.6912
600	8.078	34.633	26.974	107.2	1.7508
650	7.618	34.613	27.027	102.3	1.8087
700	7.156	34.591	27.075	97.7	1.8637
750	6.639	34.566	27.126	92.8	1.9171
800	6.216	34.552	27.171	88.6	1.9677
850	5.836	34.551	27.219	84.1	2.0163
900	5.506	34.547	27.256	80.5	2.0631
950	5.182	34.548	27.295	76.8	2.1078
1000	4.758	34.549	27.346	72.0	2.1505
1500	3.030	34.614	27.574	50.4	2.5083

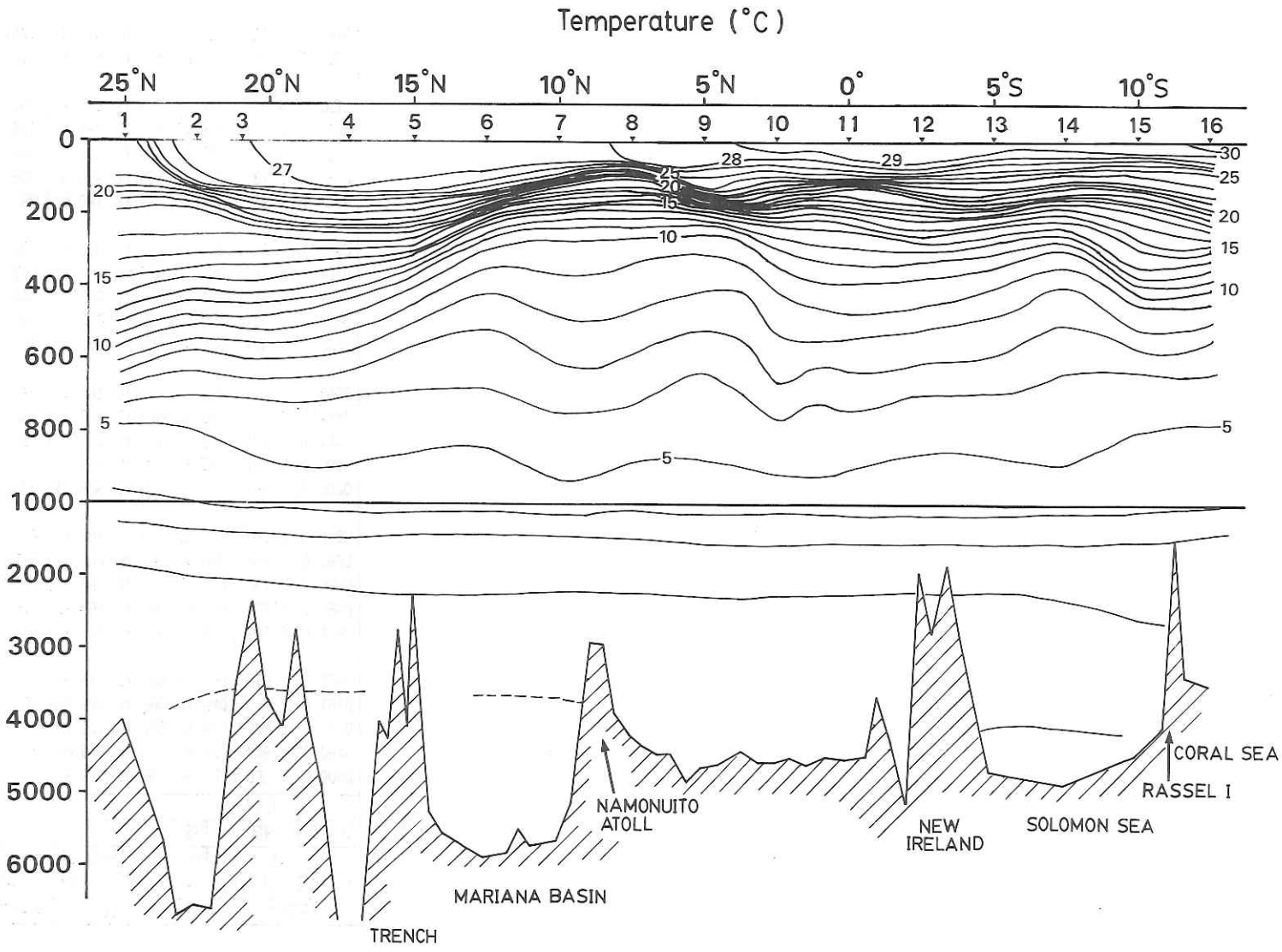
Station	25		Depth	4380m	
Date	Mar. 1 1988		Lat.	0-00.2S	
Time	20: 10-21: 20		Long.	169-43.2E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	29.281	34.709	21.754	604.7	0.0000
10	29.282	34.832	21.846	595.9	0.0602
20	29.144	35.031	22.041	577.2	0.1205
30	29.279	35.129	22.070	574.5	0.1770
50	29.219	35.170	22.121	569.6	0.2912
75	29.038	35.199	22.203	561.7	0.4348
100	24.553	35.206	23.634	425.0	0.5585
125	23.208	35.157	23.994	390.6	0.6634
150	21.065	35.113	24.563	336.3	0.7547
175	18.947	35.090	25.105	284.8	0.8325
200	18.062	35.227	25.431	253.7	0.9018
250	15.719	35.077	25.872	211.9	1.0223
350	12.038	34.848	26.464	155.6	1.2136
400	10.770	34.787	26.651	137.9	1.2915
450	9.513	34.705	26.804	123.4	1.3616
500	8.899	34.671	26.877	116.4	1.4262
550	8.619	34.654	26.907	113.6	1.4887
600	7.686	34.609	27.014	103.5	1.5476
650	6.714	34.577	27.125	93.0	1.6018
700	6.155	34.558	27.184	87.3	1.6513
750	5.618	34.557	27.250	81.0	1.6983
800	5.291	34.553	27.287	77.6	1.7426
850	5.000	34.563	27.329	73.6	1.7855
900	4.966	34.563	27.333	73.2	1.8267
950	4.670	34.566	27.369	69.8	1.8676
1000	4.446	34.573	27.399	66.9	1.9066
1500	2.887	34.627	27.598	48.1	2.2436

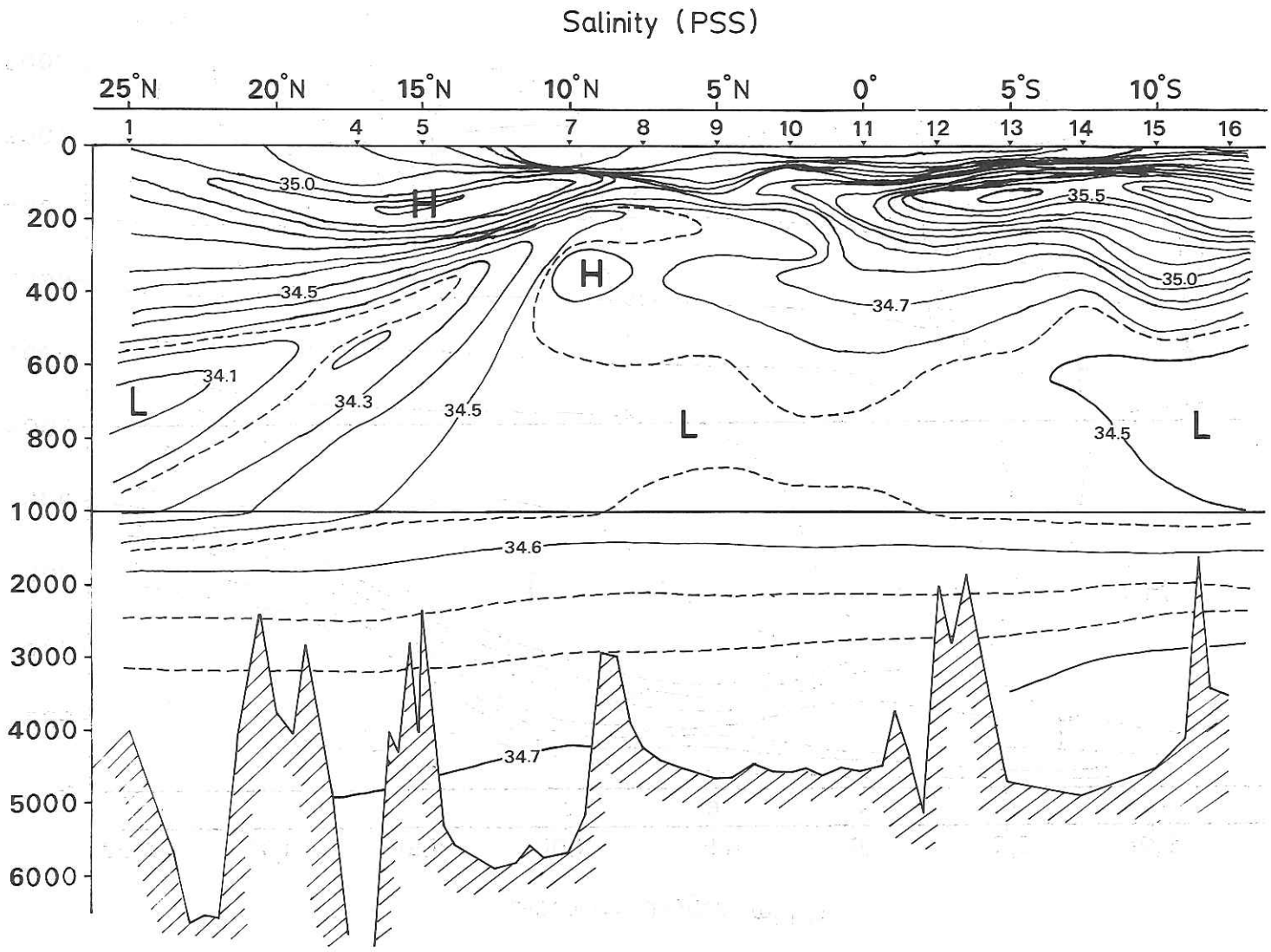
Station	29		Depth	4340m	
Date	Mar. 8 1988		Lat.	6-00.9N	
Time	00: 22-01: 23		Long.	169-59.2E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.641	34.027	21.455	633.3	0.0000
10	28.667	34.036	21.453	633.5	0.0644
20	28.649	34.056	21.474	631.5	0.1278
30	28.646	34.063	21.480	630.9	0.1903
50	28.619	34.058	21.486	630.4	0.3197
75	28.550	34.042	21.497	629.4	0.4774
100	28.292	34.093	21.620	617.6	0.6329
125	22.731	34.744	23.818	407.4	0.7633
150	17.857	34.740	25.109	284.4	0.8512
175	14.747	34.614	25.730	225.3	0.9149
200	12.752	34.561	26.102	190.0	0.9683
250	10.752	34.615	26.520	150.3	1.0561
350	9.216	34.657	26.815	122.3	1.1991
400	8.825	34.647	26.870	117.1	1.2626
450	8.413	34.628	26.919	112.4	1.3233
500	8.003	34.619	26.974	107.2	1.3826
550	7.668	34.606	27.014	103.5	1.4400
600	7.109	34.587	27.079	97.3	1.4949
650	6.526	34.567	27.142	91.3	1.5462
700	6.316	34.568	27.171	88.6	1.5963
750	5.878	34.565	27.224	83.5	1.6443
800	5.566	34.564	27.262	79.9	1.6896
850	5.205	34.566	27.307	75.7	1.7336
900	5.019	34.568	27.331	73.4	1.7761
950	4.828	34.571	27.355	71.1	1.8170
1000	4.640	34.573	27.378	69.0	1.8572
1500	3.085	34.622	27.575	50.3	2.2071

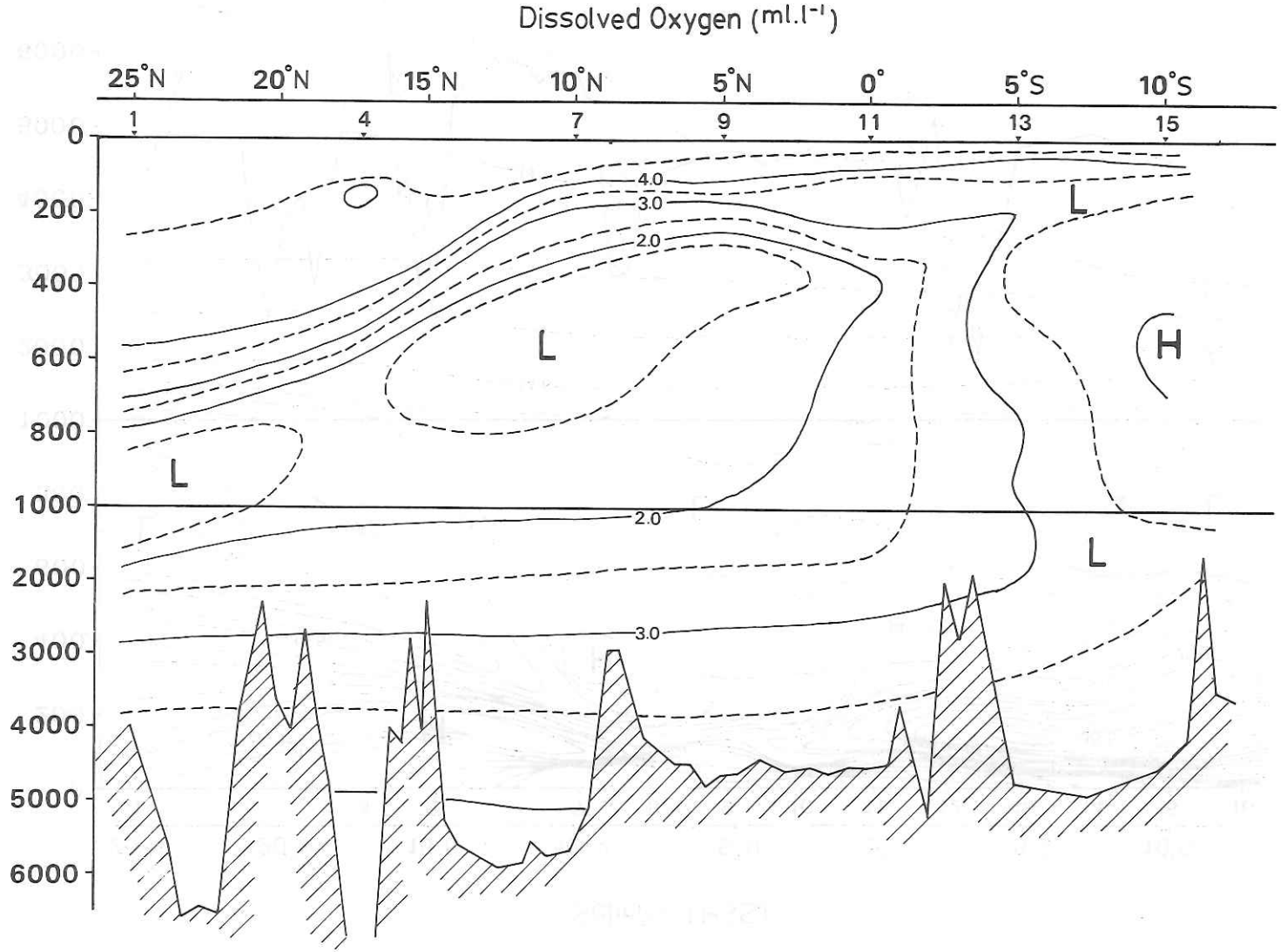
Station	30		Depth	4930m	
Date	Mar. 8 1988		Lat.	5-36.5N	
Time	15: 09-16: 01		Long.	167-29.7E	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.863	34.130	21.459	633.0	0.0000
10	28.870	34.215	21.520	627.1	0.0637
20	28.762	34.236	21.572	622.1	0.1266
30	28.714	34.257	21.603	619.1	0.1898
50	28.784	34.430	21.711	608.9	0.3111
75	28.777	34.508	21.771	603.1	0.4630
100	28.792	34.606	21.840	596.5	0.6164
125	28.802	34.664	21.880	592.6	0.7644
150	20.996	34.776	24.326	359.0	0.8859
175	16.729	34.684	25.337	262.7	0.9649
200	13.782	34.583	25.911	208.1	1.0246
250	10.980	34.552	26.431	158.8	1.1200
350	9.557	34.635	26.742	129.2	1.2695
400	9.013	34.646	26.839	120.1	1.3357
450	8.621	34.631	26.890	115.2	1.3984
500	8.179	34.624	26.952	109.4	1.4592
550	7.830	34.609	26.992	105.5	1.5170
600	7.472	34.597	27.035	101.5	1.5735
650	7.030	34.584	27.087	96.6	1.6283
700	6.571	34.572	27.140	91.5	1.6803
750	6.172	34.562	27.185	87.2	1.7300
800	5.733	34.560	27.239	82.1	1.7777
850	5.529	34.562	27.265	79.6	1.8233
900	5.239	34.562	27.300	76.3	1.8674
950	4.995	34.566	27.332	73.3	1.9097
1000	4.786	34.569	27.358	70.8	1.9514
1500	3.095	34.618	27.572	50.6	2.3076

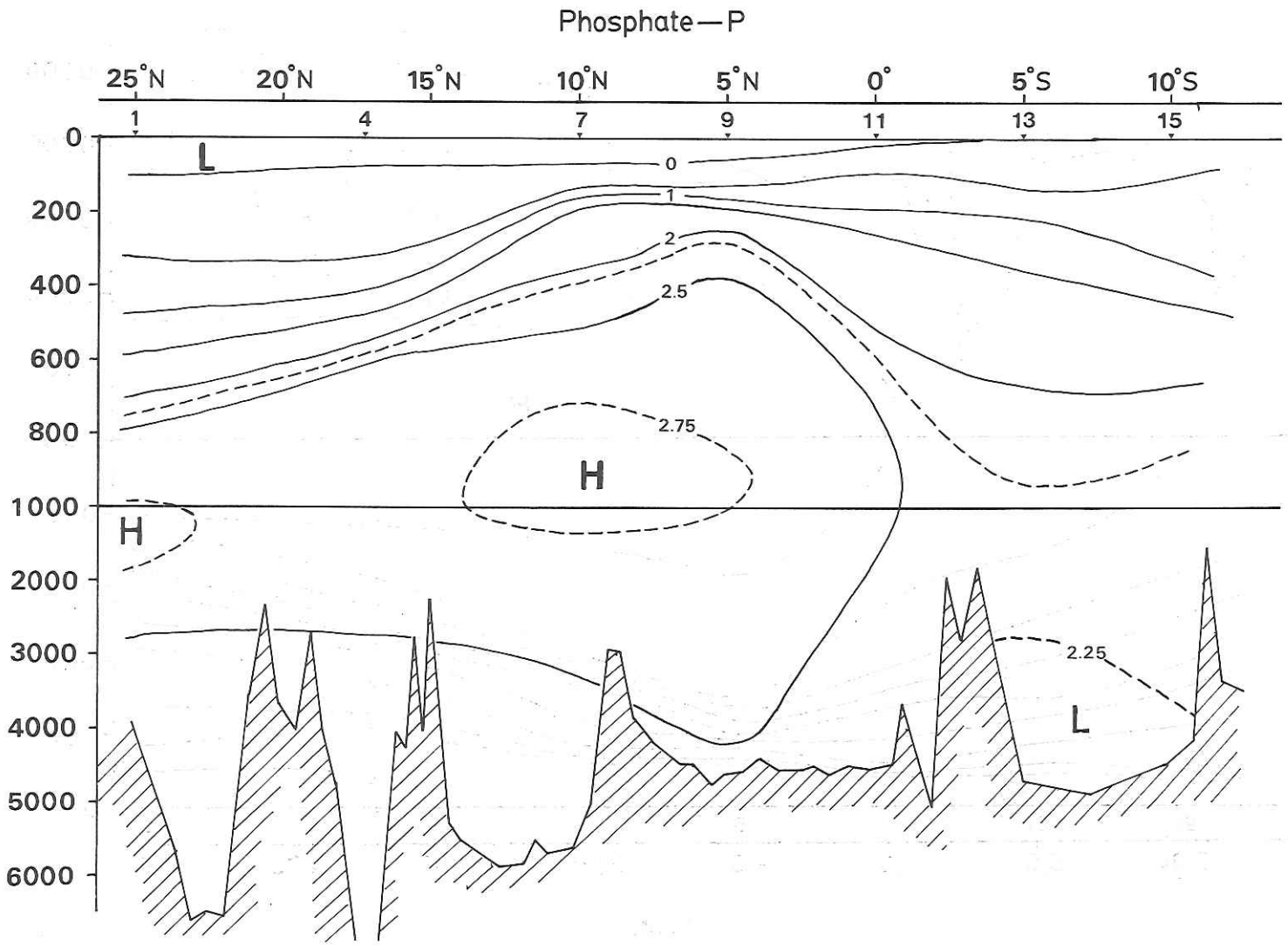
Station	32		Depth	4720m	
Date	Mar		Lat.	22: 34-23: 25	
Time	9 1988		Long.	6-01.7N	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.709	33.950	21.375	641.1	0.0000
10	28.716	33.955	21.376	640.9	0.0655
20	28.721	33.956	21.376	641.0	0.1298
30	28.717	33.957	21.377	640.8	0.1950
50	28.724	33.958	21.376	640.9	0.3210
75	28.701	33.965	21.389	639.7	0.4845
100	28.242	34.432	21.891	591.6	0.6392
125	23.624	34.642	23.483	439.4	0.7702
150	18.657	34.736	24.907	303.6	0.8635
175	15.551	34.671	25.597	238.0	0.9329
200	12.722	34.544	26.096	190.6	0.9870
250	10.403	34.621	26.587	144.0	1.0739
350	9.132	34.654	26.826	121.3	1.2119
400	8.665	34.642	26.891	115.1	1.2746
450	8.326	34.627	26.932	111.2	1.3354
500	7.863	34.606	26.985	106.2	1.3940
550	7.443	34.593	27.036	101.4	1.4503
600	7.059	34.582	27.081	97.1	1.5041
650	6.690	34.576	27.128	92.7	1.5563
700	6.410	34.568	27.158	89.8	1.6067
750	5.938	34.558	27.212	84.7	1.6556
800	5.623	34.562	27.254	80.7	1.7016
850	5.295	34.560	27.292	77.1	1.7464
900	5.062	34.563	27.322	74.3	1.7894
950	4.789	34.568	27.357	70.9	1.8304
1000	4.558	34.573	27.387	68.1	1.8702
1500	3.018	34.621	27.581	49.8	2.2160

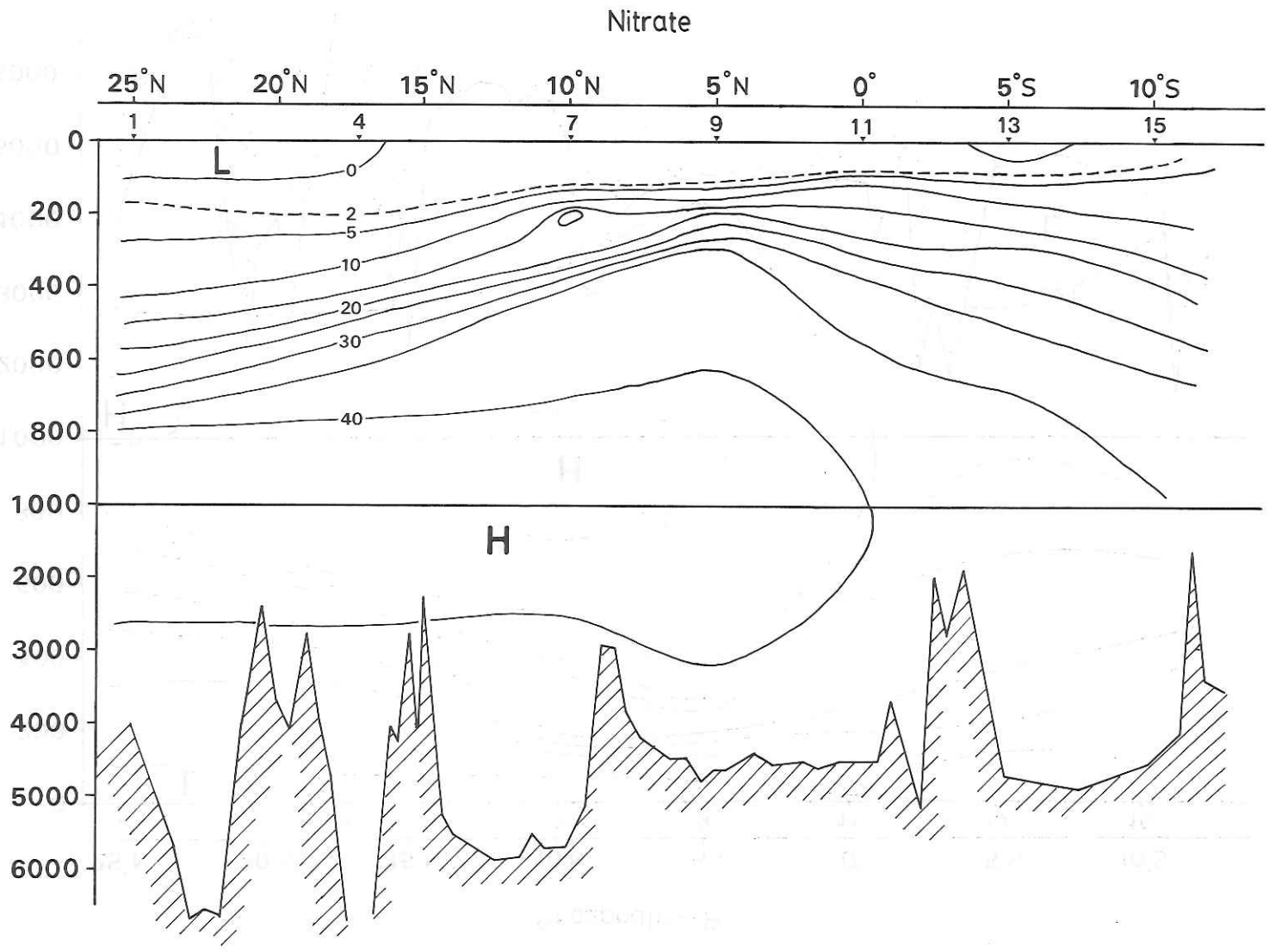
Station	33		Depth	4400m	
Date	Mar		Lat.	13: 12-14: 14	
Time	10 1988		Long.	6-33.1N	
D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	28.620	33.987	21.432	635.6	0.0000
10	28.613	34.077	21.502	628.9	0.0649
20	28.571	34.088	21.524	626.7	0.1270
30	28.539	34.095	21.540	625.3	0.1918
50	28.437	34.169	21.629	616.7	0.3157
75	28.220	34.530	21.971	583.9	0.4652
100	24.259	34.696	23.336	453.4	0.5958
125	21.252	34.797	24.272	364.1	0.6985
150	18.084	34.756	25.066	288.5	0.7823
175	14.984	34.607	25.673	230.7	0.8483
200	12.525	34.526	26.120	188.3	0.9020
250	10.516	34.594	26.546	147.9	0.9882
350	9.170	34.635	26.805	123.3	1.1301
400	8.835	34.639	26.862	117.8	1.1942
450	8.237	34.620	26.940	110.5	1.2552
500	7.790	34.605	26.995	105.2	1.3132
550	7.559	34.601	27.025	102.4	1.3696
600	7.285	34.587	27.054	99.7	1.4245
650	6.891	34.575	27.099	95.4	1.4778
700	6.470	34.569	27.152	90.4	1.5292
750	6.081	34.557	27.192	86.5	1.5786
800	5.635	34.559	27.250	81.1	1.6254
850	5.309	34.562	27.292	77.1	1.6704
900	4.984	34.564	27.332	73.3	1.7128
950	4.763	34.570	27.362	70.5	1.7537
1000	4.521	34.574	27.392	67.7	1.7936
1500	3.050	34.620	27.577	50.1	2.1386


Temperature (°C)
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
0
200
400
600
800
1000
2000
3000
4000
5000
6000
27
28
29
30
25
20
15
10
5
NAMONUITO ATOLL
NEW IRELAND
SOLOMON SEA
CORAL SEA
RASSEL I
MARIANA BASIN
TRENCH


Salinity (PSS)
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
1
4
5
7
8
9
10
11
12
13
14
15
16
0
200
400
600
800
1000
2000
3000
4000
5000
6000
35.0
35.5
34.5
34.7
34.1
34.3
34.6
H
L


Dissolved Oxygen (ml.l⁻¹)
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
1
4
7
9
11
13
15
0
200
400
600
800
1000
2000
3000
4000
5000
6000
4.0
3.0
2.0
2.0
3.0
L
L
L
L
H


Phosphate—P
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
1
4
7
9
11
13
15
0
200
400
600
800
1000
2000
3000
4000
5000
6000
L
0
1
2
2.5
2.75
H
H
2.25
L


Nitrate
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
1
4
7
9
11
13
15
0
200
400
600
800
1000
2000
3000
4000
5000
6000
L
H
0
2
5
10
20
30
40

Lytic Enzyme-producing Bacteria and Nitrogen-scavenging Bacteria in Tropical Pacific Ocean

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The abilities of marine microorganisms to lyse microbial cells and to assimilate a trace of nitrogenous compounds seem to be very unique characteristics.

Bacteriolytic enzymes may contribute to the initial decomposition of organic matter in marine environments(Nair et al. 1985). Lytic enzyme(s) produced by Bacillus sp. V 37 exhibited a remarkable lytic activity on the bacterial cells capable of putrefying kamaboko(Sugahara et al. 1982). Before applying lytic enzymes to protoplast formation, food preservation and other field of bioscience, the ecological and physiological characteristics of lytic enzyme-producing bacteria in marine environments must be determined.

On the other hand, it has been reported that some of microorganisms which can grow remarkably well on nitrogen-free medium cannot reduce acetylene to ethylene. These microorganisms had an ability to scavenge low levels of nitrogenous compounds from the atmosphere(Hill and Postgate, 1969: Jones and Rhodes-Roberts, 1980). Nitrogen-scavenging bacteria were tentatively identified as those bacteria that can grow on nitrogen-free(or nitrogen-limiting) media but cannot fix N_2. Nitrogen-scavenging bacteria seem to be very unique for their ability to scavenge or assimilate effectively very small amounts of nitrogenous compounds from the viewpoint of nitrogen recovery into biological systems in marine environments. Their scavenging ability may be applied to complete removal of nitrogen in waste treatment facilities.

The present study was designed to obtain preliminary information on lytic enzyme-producing bacteria and nitrogen-scavenging bacteria in tropical Pacific Ocean.

Methods

1. Enumeration of bacterial number

The opaque agar plate medium which contains Micrococcus luteus or Vibrio parahaemolyticus cells was used for counting the marine bacteria capable of lysing bacterial cells. Seawater or bottom sediment samples were diluted to 10 - 10^5 times with sterilized aged seawater, and aliquot of 0.1 ml from each dilution was spread on the surfaces of opaque agar plates. All plates inoculated were incubated at 5 °C or 25 °C for 1 - 2 weeks. The bacteria capable of lysing bacterial cells formed the transparent zone around the colonies on the opaque agar medium containing heat-killed cells of Micrococcus luteus or Vibrio parahaemolyticus.

Viable counts of nitrogen-scavenging bacteria were obtained using nitrogen-limiting agar plate medium. Cultivation was done at 25 °C for 1 - 2 weeks.

2. Isolation of nitrogen-fixing bacteria and assay of acetylene-reducing activity

Seawater, bottom sediment and plankton samples were added into the test tubes with side arm and serum stopper(NF test tubes) containing 10 ml of A medium. The NF test tubes were filled with N_2 gas, and incubated at 25 °C for 1 - 2 months. And then, the NF test tubes were evacuated, back-filled with acetylene(1.05%)-argon(balance) gas, and incubated at 25 °C for 7 days. The ethylene produced by incubations was measured by a gas chromatographic procedure. Nutrient agar plates inoculated with a loopful of samples from the NF test tubes with positive C_2H_4 formation were incubated at 25 °C. Colonies formed on the nutrient agar plates were isolated randomly, and tested for acetylene-reducing ability.

3. Media used in this study

Opaque agar plate medium(Sugahara et al. 1988): polypepton(Daigo) 5 g, yeast extract(Nakarai) 5 g, Micrococcus luteus cells, Vibrio parahaemolyticus cells, or Aspergillus niger cells 1 g(dry), agar 15 g, tap water 100 ml, seawater 900 ml, pH 7.0

Nitrogen-limiting agar plate medium(Sugahara et al. 1987, 1989a): glucose 0.2 g, glycerin 0.2 g, mannitol 0.2 g, sodium acetate 0.2 g, trisodium citrate 0.2 g, yeast extract(total nitrogen; about 1.1 mg) 0.01 g, NaCl 30.0 g, KCl 0.7 g, $MgCl_2 \cdot 6H_2O$ 10.8 g, $MgSO_4 \cdot 7H_2O$ 5.4 g, $CaCl_2 \cdot 2H_2O$ 1.0 g, purified agar 15 g, distilled and deionized water 1,000 ml, pH 7.2 - 7.5

Non-nitrogenous agar plate medium(Sugahara et al. 1989a): glucose 2.5 g, Tris (hydroxymethyl) aminomethane 12.1 g, KH_2PO_4 0.1 g, NaCl 30 g, KCl 0.7 g, $MgCl_2 \cdot 6H_2O$ 10.8 g, $MgSO_4 \cdot 7H_2O$ 5.4 g, $CaCl_2 \cdot 2H_2O$ 1.0 g, purified agar(Difco or Nakarai) 15 g, distilled and deionized water 1,000 ml, pH 7.5

NS medium(Sugahara et al. 1989a): glucose 2.5 g, NH_4Cl or KNO_3 0 - 0.5 g, Tris (hydroxymethyl) aminomethane 12.1 g, KH_2PO_4 0.1 g, NaCl 30 g, KCl 0.7 g, $MgCl_2 \cdot 6H_2O$ 10.8 g, $MgSO_4 \cdot 7H_2O$ 5.4 g, $CaCl_2 \cdot 2H_2O$ 1.0 g, distilled and deionized water 1,000 ml, pH 7.5

A medium(Sugahara et al. 1989b): mannitol 2.5 g, K_2HPO_4 0.2 g, $FeSO_4 \cdot 7H_2O$ 0.001 g, $MnSO_4 \cdot 7H_2O$ 0.001 g, $Na_2MoO_4 \cdot 2H_2O$ 0.001 g, NaCl 30 g, KCl 0.7 g, $MgCl_2 \cdot 6H_2O$ 10.8 g, $MgSO_4 \cdot 7H_2O$ 5.4 g, $CaCl_2 \cdot 2H_2O$ 1.0 g, distilled and deionized water 1,000 ml, pH 7.1 - 7.5

Chitin agar plate medium: polypepton(Daigo) 5 g, yeast extract(Nakarai) 5 g, precipitate chitin 10 g(wet), agar 15 g, tap water 100 ml, seawater 900 ml, pH 7.0 - 7.2

Chitosan agar plate medium: polypepton(Daigo) 5 g, yeast extract(Nakarai) 5 g, chitosan 5 g(dry), agar 15 g, tap water 100 ml, seawater 900 ml, pH 7.0 - 7.2

4. Sampling stations

Figs. 1 - 4 show the location of sampling stations set up in tropical Pacific Ocean, Majuro Atoll, Ponape Islands and New Caledonia Islands. Beach-sand samples were collected from Isle des Pins(New Caledonia) and Majuro Atoll. Plankton samples were collected by using plankton net(XX13 and GG54) from station 28-3.

Results and Discussion

1. Distribution of lytic enzyme-producing bacteria and nitrogen-scavenging bacteria

Nair et al.(1985) reported that the percent of bacteriolytic strains in the seawater isolates was 24 - 52 % at Tokyo, Sagami and Suruga Bays of Japan. The opaque agar plates containing Vibrio parahaemolyticus cells were inoculated with water samples collected from tropical Pacific Ocean, and incubated at 25 °C for 2 - 5 days. As shown in Table 1, heterotrophic bacteria usually occurred at the level of 10^2 - 10^3 cfu/ml. The percentage of the number of lytic enzyme-producing bacteria to that of heterotrophic bacteria ranged from 3 to 67 %(average 29 %). The number of bacteria capable of growing on nitrogen-limiting medium ranged from 10^2 to 10^3 cfu per 1 ml of water in tropical Pacific Ocean. These values were comparable to or sometimes more than those of aerobic heterotrophic bacteria.

Microorganisms capable of lysing bacterial cells at 20 - 25 °C were distributed widely in coastal and oceanic bottom sediments of Japan(Sugahara et al. 1988). However, sediment bacteria capable of lysing bacterial cells at 5 °C were very infrequent in the coastal and pelagic areas of Japan(Sugahara et al. 1988, 1990). As shown in Table 2, the colony-forming microorganisms on opaque agar plates containing Micrococcus luteus cells at ambient pressure(1 atm) at 25 °C and 5 °C were in the range of 10^5 - 10^6 cfu/g in the bottom sediments of tropical Pacific Ocean. In this study, of a total of 14 bottom sediment samples examined, bacteriolytic strains were detected at 25 °C in every samples. However, no bacteriolytic strains were detected at 5 °C in any bottom sediment samples examined.

As shown in Table 3, nitrogen-scavenging bacteria occurred at the level of 10^4 - 10^6 cfu per 1 g(wet) of beach-sand in New Caledonia Islands and Majuro Atoll.

2. Lytic ability of isolated heterotrophic bacteria

As shown in Table 4, 795 colonies were isolated randomly from opaque agar plates inoculated with water and bottom sediment samples in tropical Pacific Ocean. Among 795 strains isolated, 408 strains(51.3 %) were capable of lysing

Micrococcus luteus cells at 25 °C, but no strains capable of lysing Aspergillus niger cells were detected. Although no chitosan-decomposing bacteria were detected, 187 strains(23.5 %) of chitinolytic bacteria were obtained.

3. Nitrogen-scavenging bacteria isolated

Among 69 strains capable of forming colonies on the nitrogen-limiting agar plates inoculated with seawater of enclosed bays and coastal regions of Japan, only 4 strains(5.8 %) were nitrogen-fixing bacteria(Sugahara et al. 1989a).

Colonies formed on the nitrogen-limiting agar plates were isolated randomly. Sixty-one strains were isolated from seawater samples, 5 strains from beach-sand samples, and 15 strains from plankton samples(Table 5). About 20 %(17 strains) were able to reduce acetylene to ethylene. Acetylene-reducing bacteria seemed to be detected frequently in tropical Pacific Ocean. Sixty-eight strains of nitrogen-scavenging bacteria isolated from tropical Pacific Ocean were identified according to the characteristics of gram reaction, glucose fermentation, pigmentation, flagellation, spore-formation, catalase and oxidase. Pseudomonas (about 80 %) was the most dominant bacterial genus, although Alcaligenes and Flavobacterium were minor component of nitrogen scavengers isolated from tropical Pacific Ocean.

4. Nitrogen-fixing bacteria in seawater, bottom sediment and plankton samples

As shown in Table 6, among 117 of seawater, bottom sediment and plankton samples collected from tropical Pacific Ocean, 49 samples(41.9%) were positive in acetylene-reducing activity. Nutrient agar plates were inoculated with a loopful of samples showing positive C_2H_2 reduction, and incubated for 1 - 2 weeks. Colonies formed on nutrient agar plates were isolated, and tested for ability to reduce acetylene to ethylene. Nitrogen-fixing bacteria were usually detected in seawater and plankton of tropical Pacific Ocean. As shown in Table 7, acetylene-reducing activity of nitrogen-fixing bacteria was very low, i.e. 0.1 - 13 nmol C_2H_4/ml/72 h.

5. Growth of nitrogen-scavenging bacteria at limiting concentrations of NH_4Cl

Nitrogen-scavenging bacteria were grown on NS liquid medium containing 1 mg/l of NH_4Cl. As shown in Table 8, the extent of growth of nitrogen scavengers varied greatly between bacterial strains. Out of 18 strains tested, two strains were able to reduce acetylene to ethylene, and 4 strains were capable of denitrifying NO_3^-.

In order to demonstrate some physiological properties of nitrogen-scavenging isolates, three strains were selected as the representatives: strain S 542(grow well on 1 mg/l of NH_4Cl), strain S 548b(grow on 1 mg/l of NH_4Cl: denitrification positive) and strain S 599(grow well on 1 mg/l of NH_4Cl: denitrification and acetylene reduction positive). Tanle 9 shows growth of nitrogen-scavenging strains(S 542, S 548b and S 599) at different concentrations of NH_4Cl(1, 2, 10, 100 and 1,000 mg/l) in NS medium. Cultivation was carried out at 30 °C for 72 h. Three strains were able to grow at limiting concentrations of NH_4Cl. However, the growth of nitrogen scavengers increased with increasing the concentration of NH_4Cl from 1 to 10-100 mg/l. No increase in the growth of strain S 548b and S 599 was observed at more than 100 mg/l of NH_4Cl.

Table 10 shows specific growth rate of nitrogen-scavenging bacteria(strains S 542, S 548b and S599) grown at different concentrations of NH_4Cl. The values of specific growth rate had a tendency to increase with increasing the NH_4Cl concentration in NS medium. High specific growth rate of strain S 548b obtained at 100 mg/l of NH_4Cl. This value was almost comparable to the value at 1,000 mg/l of NH_4Cl. High specific growth rate of strain S 599(nitrogen-fixing bacteria) was observed at 10 - 100 mg/l of NH_4Cl. High concentration(1,000 mg/l) of NH_4Cl rather inhibited specific growth rate of strain S 599.

6. Utilization of nitrogenous compounds as sole source of nitrogen

In order to examine the effect of nitrogenous compounds on the growth of nitrogen-scavenging bacteria, glucose was used as carbon and energy sources. Various nitrogenous compounds at the concentration of 26 mg N/l were tested. Cultivation was carried out at 30 °C for 24, 48 and 72 h. As shown in

Tables 11 and 12, nitrogen-scavenging bacteria tested were able to utilize NH_4Cl, KNO_3, yeast extract, casamino acids and polypepton as source of nitrogen. They were able to grow well on glutamic acid and aspartic acid among amino acids, but could not utilize amines.

Summary

1. Microorganisms capable of lysing bacterial cells at 25 °C were distributed widely in seawater and bottom sediments of tropical Pacific Ocean. However, bacteria capable of lysing bacterial cells at 5 °C could not be found.
2. Among heterotrophic bacterial strains isolated from seawater and bottom sediments, about 51 % were able to lyse bacterial cells, and about 24 % were able to decompose chitin at 25 °C.
3. Colony-forming bacteria on non-nitrogenous agar plate medium were distributed widely in seawater and plankton of tropical Pacific Ocean. Among 85 strains of isolates, about 20 % were able to reduce acetylene to ethylene,i.e. nitrogen-fixing bacteria. Sixty-eight strains were unable to reduce acetylene, and were considered as nitrogen-scavenging bacteria. Most(80 %) of nitrogen-scavenging bacteria isolated were belonged to the genus Pseudomonas.
4. Nitrogen-fixing bacteria were detected widely in seawater and plankton samples, but their acetylene-reducing activity was very low.
5. The growth of representative strains of nitrogen-scavenging bacteria at different concentrations of NH_4Cl was examined. Growth and specific growth rate of nitrogen-scavenging bacteria tested increased with increasing the NH_4Cl concentration from 1 to 10 or 100 mg/l.

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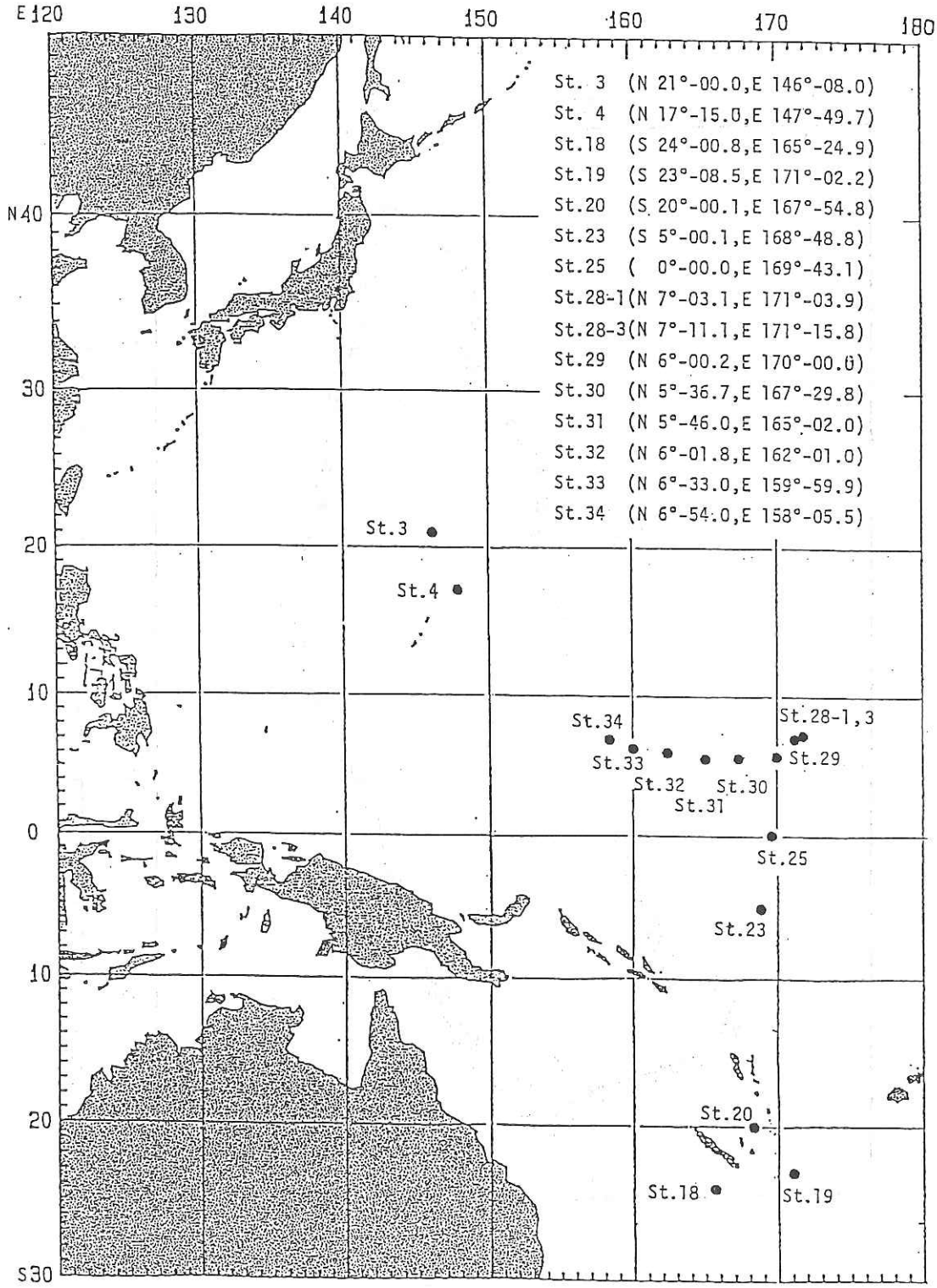

Fig. 1. Location of sampling stations set up in tropical Pacific Ocean.

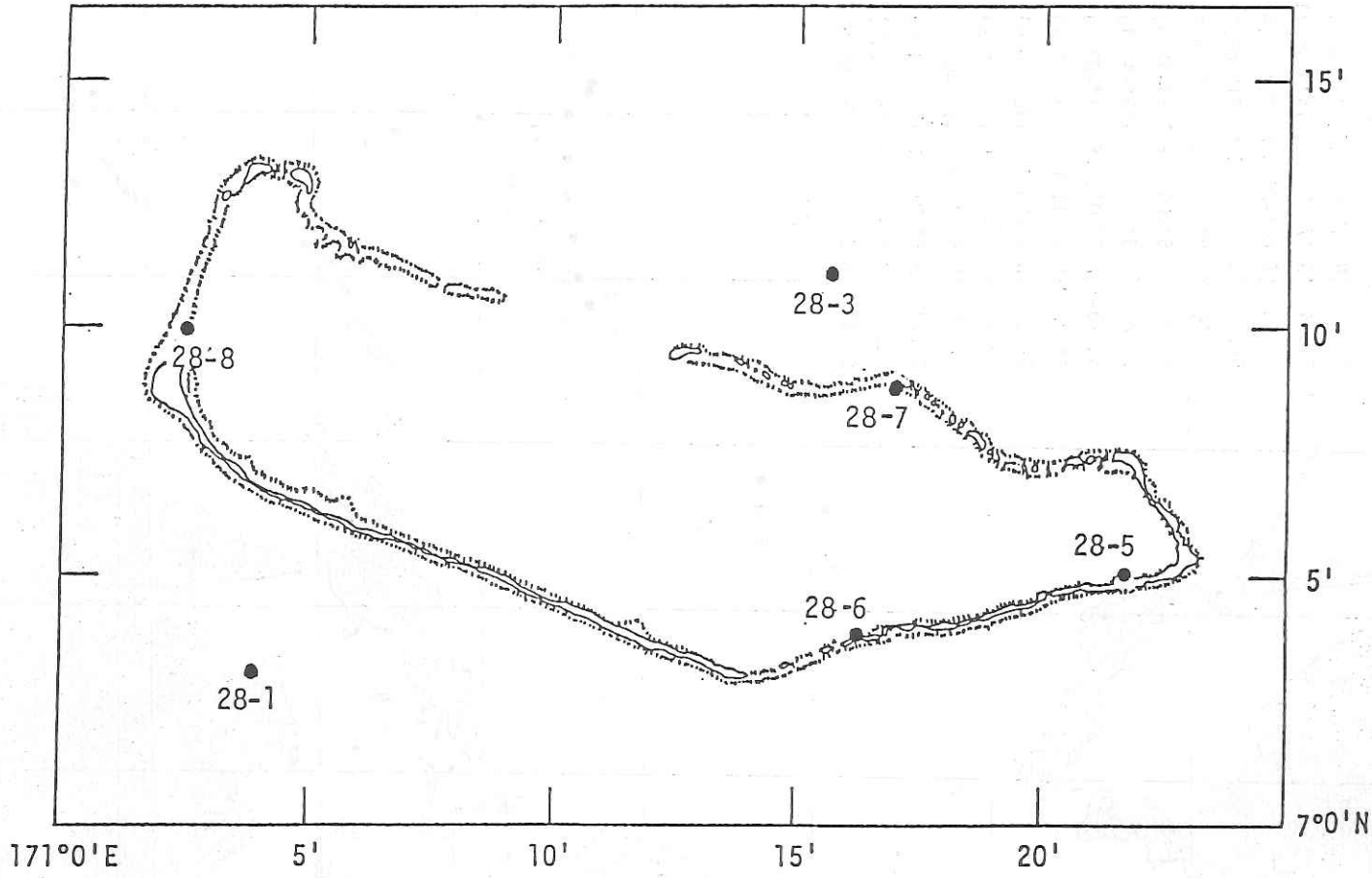

Fig. 2. Location of sampling stations in the Majuro Atoll.

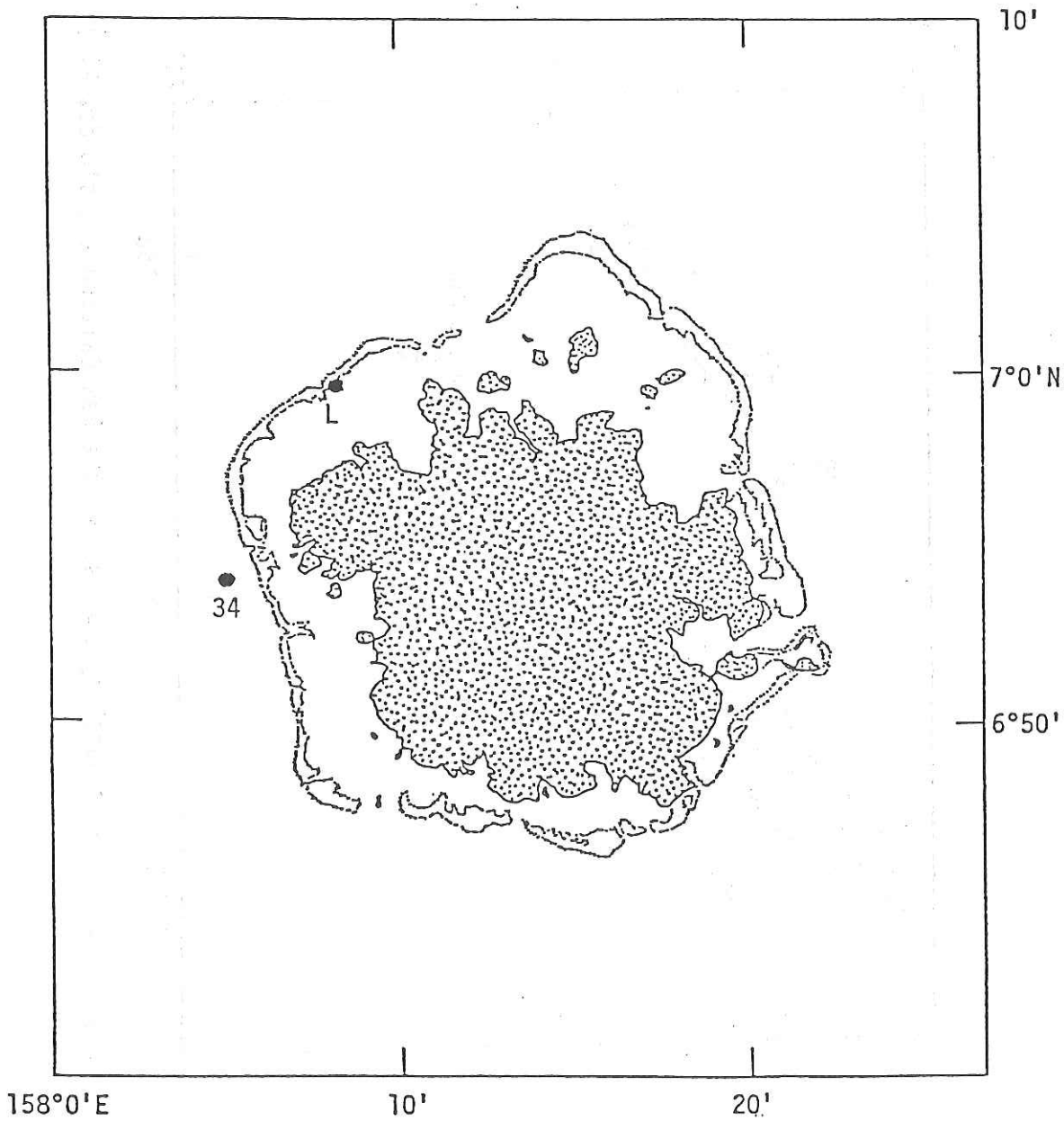

Fig. 3. Location of sampling stations set up in the Ponape Islands.

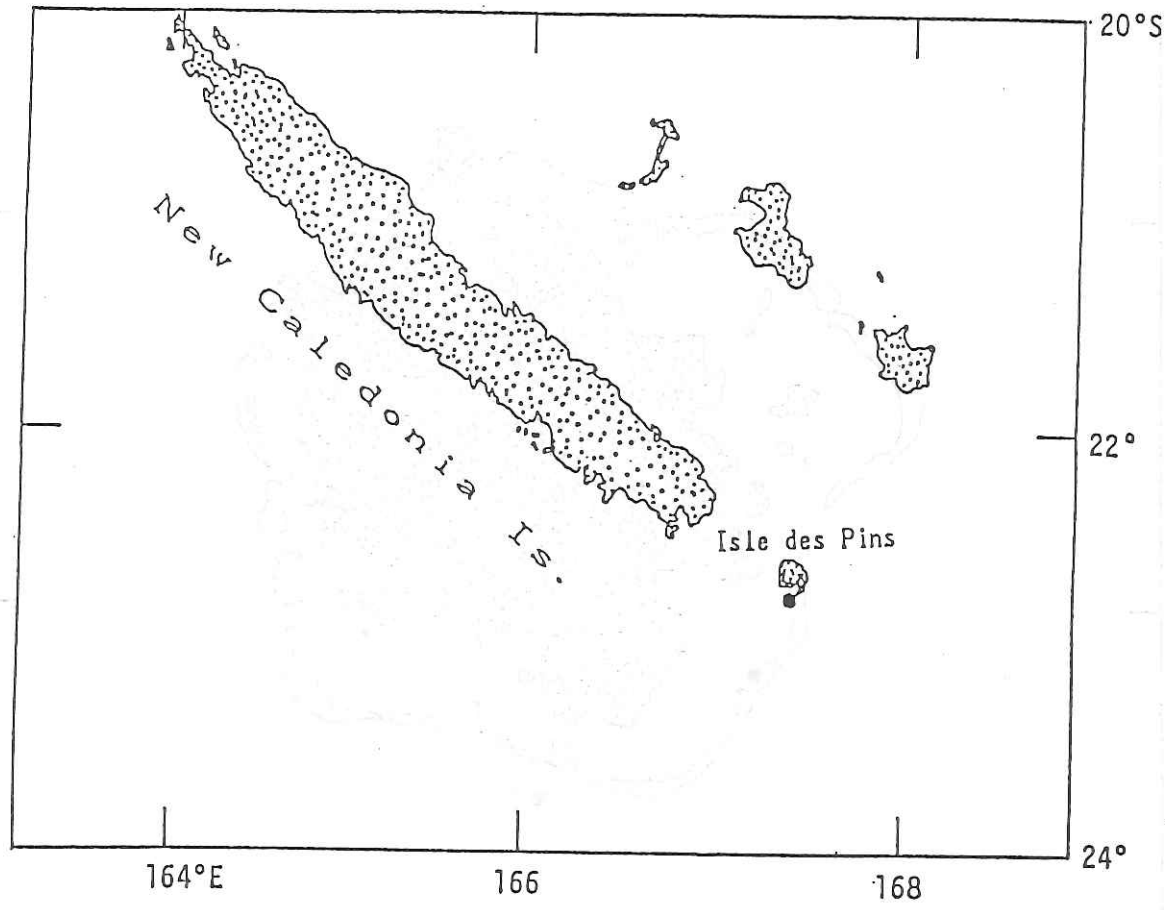

Fig. 4. Location of sampling station in the New Caledonia (Isle des Pins).

Table 1. Distribution of bacteriolytic bacteria and nitrogen-scavenging bacteria in the water of tropical Pacific Ocean

Sampling station (date)	Sampling depth(m)	Total heterotrophs (cfu/ml)	V.p.-lytic bacteria (cfu/ml)	Ratio l.b/T.h (%)	N-scavenging bacteria (cfu/ml)
St. 20 (Feb.26,1988)	0	2.2×10^2	4.5×10^1	20	4.2×10^2
St. 23 (Feb.29,1988)	0	1.8×10^3	6.0×10^2	33	2.7×10^3
St. 25 (Mar. 1,1988)	0	2.6×10^3	1.3×10^3	50	2.5×10^3
	20	3.9×10^2	3.0×10^1	7.7	4.2×10^2
	50	4.1×10^2	6.0×10^1	15	6.5×10^2
	100	1.1×10^3	9.5×10^1	8.6	1.3×10^3
St. 28-1 (Mar. 3,1988)	0	1.1×10^3	6.6×10^2	60	1.2×10^3
St. 28-3 (Mar. 3,1988)	0	1.1×10^3	6.5×10^2	59	1.6×10^3
	20	8.1×10^2	2.3×10^2	28	7.4×10^2
	50	1.5×10^3	1.0×10^3	67	1.5×10^3
	100	1.4×10^3	9.4×10^2	67	1.7×10^3
St. 29 (Mar. 8,1988)	0	1.4×10^3	4.5×10^1	3.2	1.0×10^3
St. 30 (Mar. 8,1988)	0	1.1×10^3	8.0×10^1	7.3	1.8×10^3
St. 31 (Mar, 9,1988)	0	3.5×10^2	8.0×10^1	23	5.4×10^2
St. 32 (Mar. 9,1988)	0	1.2×10^3	2.9×10^2	24	2.0×10^3
St. 33 (Mar.10,1988)	0	2.3×10^3	1.1×10^3	48	2.5×10^3
St. 34 (Mar.16,1988)	0	1.9×10^3	3.0×10^2	16	4.9×10^3
	20	1.4×10^3	2.6×10^2	19	---
	50	1.5×10^3	2.4×10^2	16	2.1×10^3
	100	1.7×10^3	3.6×10^2	21	2.2×10^3
St. L(Ponape) (Mar.15,1988)	0	2.5×10^2	5.0×10^1	20	2.3×10^2
Isle des Pins	0	3.6×10^2	----	---	---

Incubation temperature; 25 °C

Table 2. Distribution of lytic enzyme-producing bacteria in the bottom sediments of tropical Pacific Ocean

Station	Station depth(m)	Sampling date	25 °C-incubation		5 °C-incubation	
			Total heterotrophs (cfu/g)	Lytic bacteria (cfu/g)	Total heterotrophs (cfu/g)	Lytic bacteria (cfu/g)
St. 3	3,500	Jan.26, 1988	1.6×10^6	D	1.3×10^6	ND
St. 4	8,200	Jan.27, 1988	1.7×10^6	D	1.8×10^6	ND
St. 18	3,650	Feb.18, 1988	7.8×10^5	D	4.3×10^5	ND
St. 19	6,800	Feb.20, 1988	2.4×10^6	D	1.5×10^6	ND

D; detected. ND; not detected.

Table 4. Lytic and chitin-, chitosan-decomposing activities of bacterial strains isolated from the water and bottom sediments of tropical Pacific Ocean

	Strains tested	M.l.-lytic activity positive	A.n.-lytic activity positive	Chitin decomposition positive	Chitosan decomposition positive
Water	218	163	0	3	0
Bottom sediments	577	245	0	184	0
Total	795 (100%)	408 (51.3%)	0	187 (23.5%)	0

Table 3. Distribution of nitrogen-scavenging bacteria in the sand of sand-beach of New Caledonia and Majuro coral reef

Sampling station	Sampling date	Aerobic heterotrophs (cfu/g)	Nitrogen-scavenging bacteria (cfu/g)
Isle des Pins	Feb. 26, 1988	3.4×10^4	3.5×10^4
Majuro St.28-5	Mar. 4, 1988	3.6×10^5	2.7×10^5
Majuro St.28-6	Mar. 5, 1988	5.0×10^4	8.6×10^4
Majuro St.28-7	Mar. 5, 1988	1.6×10^6	2.2×10^6
Majuro St.28-8	Mar. 5, 1988	8.5×10^4	1.3×10^5

Table 5. Generic composition of nitrogen-scavenging bacteria isolated from tropical Pcific Ocean

	water	sand	plankton	total
Number of strains tested	61	5	15	85(100 %)
C_2H_2-reducing activity positive	13	0	4	17(20 %)
negative	48	5	15	68(80 %)
Pseudomonas	39	5	11	55
Alcaligenes	2	0	0	2
Flavobacterium	3	0	2	5
Unknown	4	0	2	6

Table 6. C_2H_2-reducing activity of bottomsediments, muds, seawater and plankton samples

Samples	Number of samples tested	C_2H_2-reducing activity	
		positive	negative
Bottom sediments			
St. 3(station depth 3,500m)	20	8	12
St. 4(station depth 8,200m)	35	3	32
St.17(station depth 1,149m)	8	7	1
St.19(station depth 6,800m)	12	1	11
Muds			
Brisbane	5	2	3
others	3	3	0
Seawater			
St.19	31	22	9
others	2	2	0
Plankton			
St.17	1	1	0
Total	117	49	68

Table 7. C_2H_2-reducing activity of nitrogen-fixing bacteria isolated from tropical Pacific Ocean

Strains	C_2H_2-reducing activity (C_2H_4 nmol/72h/ml)
21- 8	13.2
21- 2	9.80
99-10	2.62
97- 3	2.24
13- 7	1.90
21- 9	1.66
13- 1	1.09
13- 4	0.787
90- 4	0.711
97- 6	0.427
13- 9	0.104
103- 1	0.104

Table 8. Growth of nitrogen-scavenging bacteria at a limiting concentration of NH_4Cl(1 mg/l)

Strains	Growth on non-nitrogenous agar medium	C_2H_2-reducing activity	Denitrification	Growth on 1mg/l NH_4Cl*	Sources	
Sc 473	+	-	-	0.009	St.25	100m
511	+	-	-	0.011	St.28-3	20m
536	+	-	-	0.0004	St.28-1	0m
540	+	-	-	0.013	St.32	0m
542	+	-	-	0.087	St.23	0m
548a	+	-	-	0.035	St.25	0m
548b	+	-	+	0.060	St.25	0m
552	+	-	-	0.064	St.25	0m
554	+	-	+	0.007	St.25	0m
561	+	-	-	0.017	St.28-3	XX13
564	+	-	+	0.066	St.28-3	XX13
565	+	-	-	0.045	St.28-3	XX13
566	+	-	-	0.066	St.28-3	XX13
568	+	-	-	0.060	St.28-3	XX13
571	+	-	-	0.078	St.28-3	GG54
582	+	+	-	0.028	St.34	50m
599	+	+	+	0.086	St.28-3	0m
601	+	-	-	0.058	St.28-3	GG54

*OD_{580}

Table 9. Growth of nitrogen-scavenging bacteria at different concentrations of NH_4Cl

NH_4Cl concentration (mg/l)	Growth (OD_{580})		
	Sc 542	Sc 548b	Sc 599
1	0.079	0.041	0.066
2	0.114	0.075	0.081
10	0.227	0.259	0.244
100	0.654	1.041	0.547
1,000	0.827	1.051	0.597

Table 10. Growth rate of nitrogen-scavenging bacteria at different concentrations of NH_4Cl

NH_4Cl concentration (mg/l)	Sc 542		Sc 548b		Sc 599	
	$\mu(h^{-1})$	$t_d(h)$	$\mu(h^{-1})$	$t_d(h)$	$\mu(h^{-1})$	$t_d(h)$
1	0.0429	16.2	0.0495	14.0	0.104	6.66
2	0.0606	11.4	0.0732	9.47	0.122	5.68
10	0.0700	9.90	0.198	3.50	0.536	1.29
100	0.485	1.43	0.221	3.14	0.521	1.33
1,000	0.606	1.14	0.228	3.04	0.393	1.76
$\mu_{max}(h^{-1})$	0.592		0.234		0.541	
K_s(mg/l)	17.5		3.84		4.16	

Table 11. Utilization of various compounds as sole source of nitrogen during growth of nitrogen-scavenging bacteria isolated from tropical Pacific Ocean

Nitrogen sources (26.2mgN/l)	Relative growth (%)					
	S 542		S 548b		S 599	
	24 h	48 h	48 h	72 h	24 h	48 h
NH_4Cl	100	100	100	100	100	100
KNO_3	175	139	107	84.3	136	115
Urea	0	3.32	328	199	0	4.00
Yeast extract	174	240	193	97.1	138	235
Malt extract	148	222	356	161	237	156
Polypepton	165	116	143	78.4	145	142
Casamino acids	174	252	170	90.3	134	236
L-Glycine	133	139	192	80.2	67.5	152
D-Alanine	—	4.16	—	90.3	—	1.76
β-Alanine	—	3.00	—	0	—	1.40
L-Valine	36.4	176	11.2	21.7	8.50	177
n-Leucine	0.731	29.1	80.2	92.0	9.97	30.2
D L-Serine	22.9	140	0	0	35.3	121
L-Tyrosine	7.86	33.2	15.9	26.0	11.9	63.6
D L-Tryptophan	13.5	57.1	7.57	4.47	25.2	49.8
L-Cystine	28.7	156	15.9	7.80	107	151
L-Methionine	0.731	14.3	54.0	51.7	2.45	11.8
L-Aspartic acid	72.6	249	330	187	152	265
L-Glutamic acid	40.4	343	173	120	148	270
Sodium glutamate	67.0	277	40.7	114	35.6	231
L-Histidine	53.9	155	2.61	0.573	44.4	117
L-Arginine	105	101	213	78.9	99.6	86.7
L-Lysine	—	19.2	—	73.6	—	14.3
L-Ornithine	21.4	113	137	129	46.9	131
Guanidine	50.1	84.2	211	130	52.8	58.8

Table 12. Utilization of various compounds as sole source of nitrogen during growth of nitrogen-scavenging bacteria isolated from tropical Pacific Ocean

Nitrogen sources (26.2mgN/l)	Relative growth (%)					
	S 542		S 548b		S 599	
	24 h	48 h	48 h	72 h	24 h	48 h
NH_4Cl	100	100	100	100	100	100
Dimethylamine	—	0	—	0	—	0.234
Trimethylamine(TMA)	—	1.15	—	0.557	—	2.10
Trimethylamineoxide	54.1	96.2	4.96	1.72	0.817	4.40
Ethanolamine	—	0.462	—	0	—	0
Histamine	—	2.08	—	0.650	—	0.935
Putrescine	—	2.31	—	0.929	—	3.27
n-Propylamine	—	0	—	0	—	0.935
n-Butylamine	—	0	—	0	—	2.10
iso-Butylamine	—	2.08	—	0.743	—	2.10
sec-Butylamine	—	0	—	0	—	3.04
tert-Butylamine	—	2.96	—	2.82	—	0.935
n-Amylamine	—	0	—	0	—	2.10
iso-Amylamine	—	2.54	—	0.557	—	3.27
n-Hexylamine	—	0	—	1.41	—	2.57
n-Heptylamine	—	1.48	—	0.587	—	4.44
n-Octylamine	—	0	—	0	—	1.87
Benzylamine	—	0	—	0	—	2.10

Vertical distributions of total and attached oligotrophic bacteria in tropical western Pacific Ocean

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Vertical distributions of oligotrophic bacteria and those associated with particulate materials were investigated at Stns. 7 and 11. The numbers of oligotrophic bacteria in situ seawater (total oligotrophs) and attached oligotrophs (on particles larger than 1.0 μm) were determined by a modified MPN method using a diluted peptone medium (5.0mg trypticase peptone, 0.5 mg yeast extract, ferric citrate 0.1mg in 1 l of seawater). For attached oligotrophs, 500 or 1000ml of seawater samples were filtered through 1.0 μm Nuclepore filters and the filters were homogenized with an ultra high speed homogenizer (Physcotron). The cell suspensions were then inoculated into the same type media. All samples were incubated at near in situ temperature for 3 weeks, then the number of bacterial growth-positive test tubes in 5 replicate samples in each dilution steps were checked by direct observation with epifluorescence microscopy. The detailed procedure was described in a previous paper (Fukami et al., 1988). Besides the number of total and attached oligotrophs, attached Vibrionaceae were counted by MPN method using 1/10-diluted liquid Vibrio-selective media (Simidu and Tsukamoto, 1980). After anaerobic incubation for 3 weeks, positive test tubes were judged by greenish yellow color.

The MPN of total oligotrophs were 0.33 to 1.7 (average 1.1) x 10^3 cells/ml and those attached were 0.082 to 22 (average 5.3) x 10^1 cells/ml. These MPNs of total oligotrophs were in the similar range as those in areas along with 130°E longitude line (Ishida et al.,

1986). However, vertical distribution patterns were quite different. In the previous paper (Ishida et al., 1986), MPNs of oligotrophs were maximal in surface layer and decreased with depth. At Stns. 7 (10°N, 150°E) and 11 (0°, 152°E) in the present cruise, however, maximum MPNs of both total and attached oligotrophs were observed at 300 m depth. Percentages of attached oligotrophs in total numbers were 0.06 to 16.9 (average 5.2) %, and maximum values were also obtained at 300 m in both stations. At stns. 7 and 11, the depth of 300 m was just above the oxygen minimum and thermostatic anomaly cline layers (Preliminary data report of KH-88-1). These results suggest that particulate materials accumulated around 300 m depth layers and the activity of microbes attached to particles were relatively higher.

Distribution of attached Vibrio didnot show any distinct patterns.

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Enumeration of coral-associated bacteria and their utilization of coral mucus

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It has been reported that mucus materials released by corals amounted nearly 20 % of primary production of coral symbiotic algae and these mucus materials were important nutrient source for bacteria living in the coral reef (Herndl and Velimirov, 1986). Besides this, bacterial population in the mucus layers was well adapted to this environment (Ducklow and Mitchell, 1979). In the cruise of KH-88-1, we studied on the number of attatched bacteria on corals and their utilization of mucus materials.

1). Enumerations of coral-associated bacteria

Enumerations of coral-associated bacteria were performed on two items; one was for "mucus bacteria" which were defined as those living on/in the mucus layer and easily removed from the coral surface. For counting the number of "mucus bacteria", a piece of coral was washed in sterilc seawater vigorously with a vortex mixer and cell suspensions obtained as above were inoculated onto agar plate media containing 500 mg pepton and 50 mg yeast extract in 1 ℓ seawater. Another was "tightly-attatched bacteria" which were attatched coral body tightly or living inside of coral. For the enumeration of this, coral pieces already removed the "mucus bacteria" were homoginized by a ultra high speed homogenizer (Physcotron) and the cell suspension was spread onto the same type of agar media.

At Majuro Atoll, numbers of "mucus bacteria" were 2.9 to 10.0 (average 6.4) x 10^1 CFU/mg-coral and those of "tightly-attatched bacteria" were 4.7 to 51 (average 21) x10^{-1}CFU/mg-coral, which were 0.7% to 17% of the former. These result show that most bacteria

associated with coral were in the mucus material and easily detached to the seawater.

2). Utilization of mucus material by coral associated bacteria

The growth of bacterial assemblages isolated from coral surface, besides from ambient seawater, was determined by using media in which mucus materials of coral were added as a sole carbon source, and was compared with their growth in pepton media. The amount of carbon in both mucus and pepton media were adjusted to some 22mg-C/ℓ .

There were no significant defferences in growth rates and final cell yields between coral associated and planktonic bacterial assemblages in both mucus and pepton media. However, interestingly, some strains isolated from seawater (not from coral surface) showed higher grouth rates in mucus media than in pepton. Those result indicate that mucus materials released from coral were as good substrates as pepton for bacterial assemblages in ccoral reef.

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Ecological Studies of Microorganisms in the Deep-Sea Area

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To obtain basic informations about bacterial population in the deep-sea area, following works have been carried out in this cruise.

(1) Operations of Pressure Retaining Sampler for microbiological study

For retrieval, subsequent subsampling and culture of deep-sea microorganisms without decompression, shipboard operations and test operations of Pressure Retaining Sampler, which has been under construction, were carried out. This sampler is equipped with timer operated trigger and stopper for in situ water pump, Millipore filtration systems to concentrate microorganisms in seawater and closing valves for holding in situ pressure.

Test operations at St. 3 and St. 13 at a depth of 500 m and operation at St. 4 at a depth of 6,000 m were not successful due to problems of opening the sample intake part. After improvement of opening part, test operation at St. 15 at a depth of 500 m and operation at St. 19 at a depth of 6,000 m were successful.

(2) Bacterial flora in the Mariana Trench, the New Hebrides Trench and their adjascent areas

Sediment samples taken with box corers were serially diluted and inoculated onto 2216E agar plates. Colonies appeared on the plates after incubation for longer than 2

weeks at 20 C at normal pressure were isolated and purified. Genus levels of bacterial flora were identified, as follows;

Taxonomic groups	St. 3	St. 4	St. 18	St. 19	St. 31
Vibrio		1			4
Pseudomonas	2				3
Alteromonsa	2	4	1		4
Alcaligenes			1	3	3
Flavobacterium	6		3	1	2
Acinetobacter	5		1		
Moraxella	4	1	7	6	1
Bacillus	3		9	12	
Coryneforms	1			1	
total	23	6	22	23	17

GROWTH OF NATURAL BACTERIAL POPULATION

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Many questions remain to be elucidated as to growth of natural bacterial population. This is mainly due to the limitation of techniques which can be applied to natural bacterial cells. At present, we can estimate the bacterial number by epifluorescent microscopy (Hobbie et al. 1977) and production rate by [^{3}H] thymidine incorporation method (Fuhrman and Azam 1982). However, there are still few numbers of research on the direct observation of behaviors of natural bacterial populations (e.g., Ammerman et al. 1984). This makes it difficult to further investigate on their physiological state in the sea. The purpose of this research is to clarify the bacterial growth pattern under the presence of different concentrations of organic matter. This investigation is for the subsequent steps of the research on their physiology under low-nutrient conditions.

Sample seawaters were taken at St. 14 (7° 29.3'S, 153° 45.7'E) on Feb. 5 and St. 19 (23° 08.5'S, 171° 02.0'E) on Feb. 20, 1988. Surface seawater was collected using sterilized glass bottles, and was immediately filtrated through 1.0 μm Nuclepore filters to remove most of bacterial

grazers and particulate matter. Care was taken not to exceed the pressure of 0.2 atm. Filter was replaced after filtrating at most 750 ml. After adding different levels of glutamic acid (50, 100, 200, 500μg/l), the sample seawater was incubated in a glass bottle under dark at an ambient temperature (29° C and 27° C at Sts. 14 and 19, respectively). The incubation was started within two hours of seawater sampling. Bacterial numbers were counted by acridine orange direct count (AODC) method (Hobbie et al. 1977) on board.

Bacterial growth in glass bottles are shown in Fig 1 and 2. The obtained growth patterns at each station were quite different. At St. 14 (Fig. 1), the numbers started to increase after 12 hours, whereas at St. 19 (Fig. 2), there was no apparent time lag before the onset of bacterial divisions. The first 6-10 hours may be regarded as a close reflection of their actual growth in natural seawater. Further incubation may lead to the artifact and subsequently deviate from the real growth. If we take the initial slope in the bottle without added glutamic acid as growth rate in nature, the doubling time at St. 19 was about 25 hours. This falls in a range of reported bacterial growth in the sea (Kogure 1985), although this is rather fast as the growth in open ocean.

At St. 14, no apparent growth was obtained during the first 12 hours. The microscopic observation, however, indicated that bacterial cellular size was increasing during

this period of time. There two possible interpretations for this time lag. First, bacterial cellular numbers were actually increasing slowly. As the incubation method is usually not sensitive enough for open ocean populations, we might miss their growth. Doubling times in open ocean are reported to easily exceed one hundred hours. The use of other sensitive method, such as [^{3}H] thymidine incorporation technique (Fuhrman and Azam 1982) may give us certain growth rate of the population at St. 14.

The second explanation is, the bacterial population had ceased the growth or cellular division, and it took time to regain the reproducibility. Cells in the sea might have been just maintaining themselves by taking up available organic matter, but this didn't result in the increase in biomass or cellular division. It might cost too much to keep the cellular machinery for reproduction under this kind of condition. The lag time before the onset of active growth might be required for the synthesis and construction of enzyme systems for the cellular division. The increase in cellular volume before starting active growth may support this idea. From the present investigation, however, it is impossible to state which is the real case. For the clarification, further physiological investigations are definitely required. It will be also necessary to keep in mind that natural bacterial population is consisted of

heterogeneous groups and do not behave in accordance. The final yields of bacterial population depended on the quantity of glutamic acid added. Fig. 3 shows the relationships between the increased bacterial number and the quantity of added glutamic acid. The increased fraction was obtained by subtracting the initial number from the number after 30 hours, which might be long enough for utilizing most of glutamic acid present. Up to 100 μg, the increased numbers were linearly correlated with the glutamic acid. The saturation was observed beyond c.a. 100μg, probably due to the limitation by other factors, e.g., phosphorus, iron or other micro elements.

Unfortunately, Elzone Particle Counter didn't work well on board and we are unable to get size distribution of bacterial cells (Kogure and Koike 1987). If we postulate that the average cell size of bacteria after incubation were 0.8μm in diameter, and the carbon/volume ratio is 0.2 (Kogure and Koike 1987), the increased bacterial fraction in a bottle with 100μg/l glutamic acid corresponded to 21.3 μgC/l and 13.3 μgC/l at Sts. 14 and 19 respectively. If we postulate that this growth was sustained only by the added glutamic acid, the assimilation efficiency was 52% and 32%, respectively.

The present investigation revealed that natural bacterial population can respond to the added organic matter at the level of less than 50μgC/l. The saturation was found around

100μgC/l. Above this level, the higher concentrations didn't always induce better growth in terms of yield and growth rate. The present investigation also raised the question on the physiological state of bacterial population in the sea, i.e., how are they maintaining their viability? In order to investigate on their physiological state, it will be necessary to take into account of observations obtained in this investigation.

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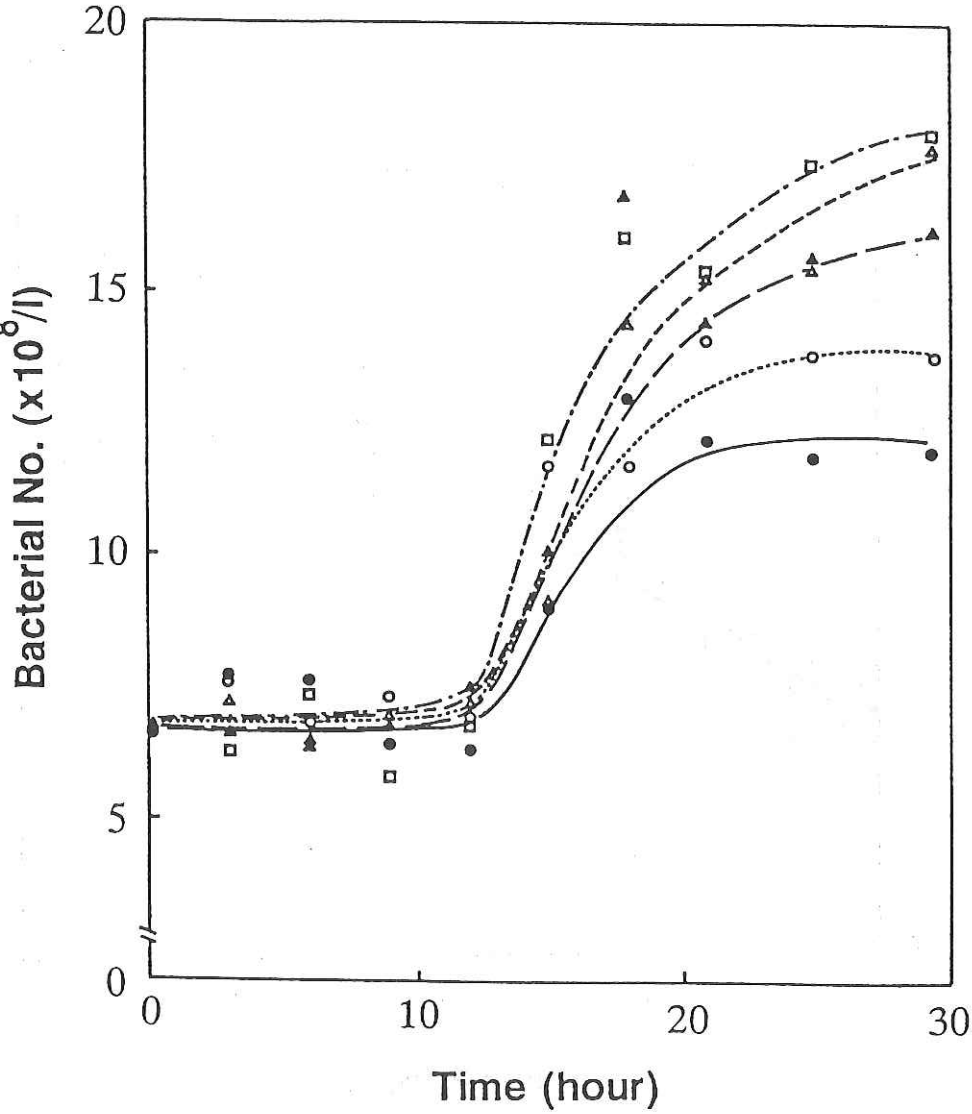

Fig. 1. Bacterial growth in seawater at St. 14 with different concentrations of glutamic acid.
Closed circles:0 µg/l; open circles:50 µg/l; closed triangles:100 µg/l; open triangles:200 µg/l; open squares:500 µg/l.

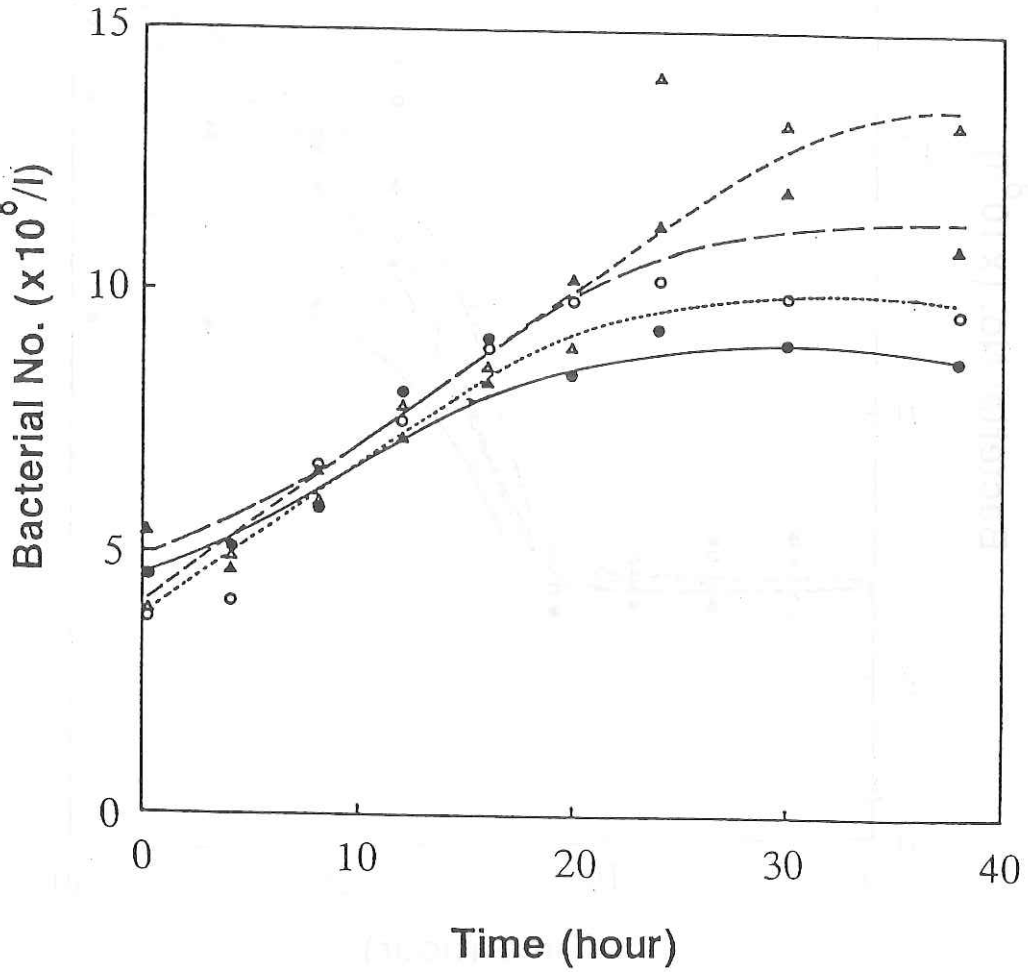

Fig. 2. Bacterial growth in seawater at St. 19 with different concentrations of glutamic acid.
Symbols are same as in Fig. 1.

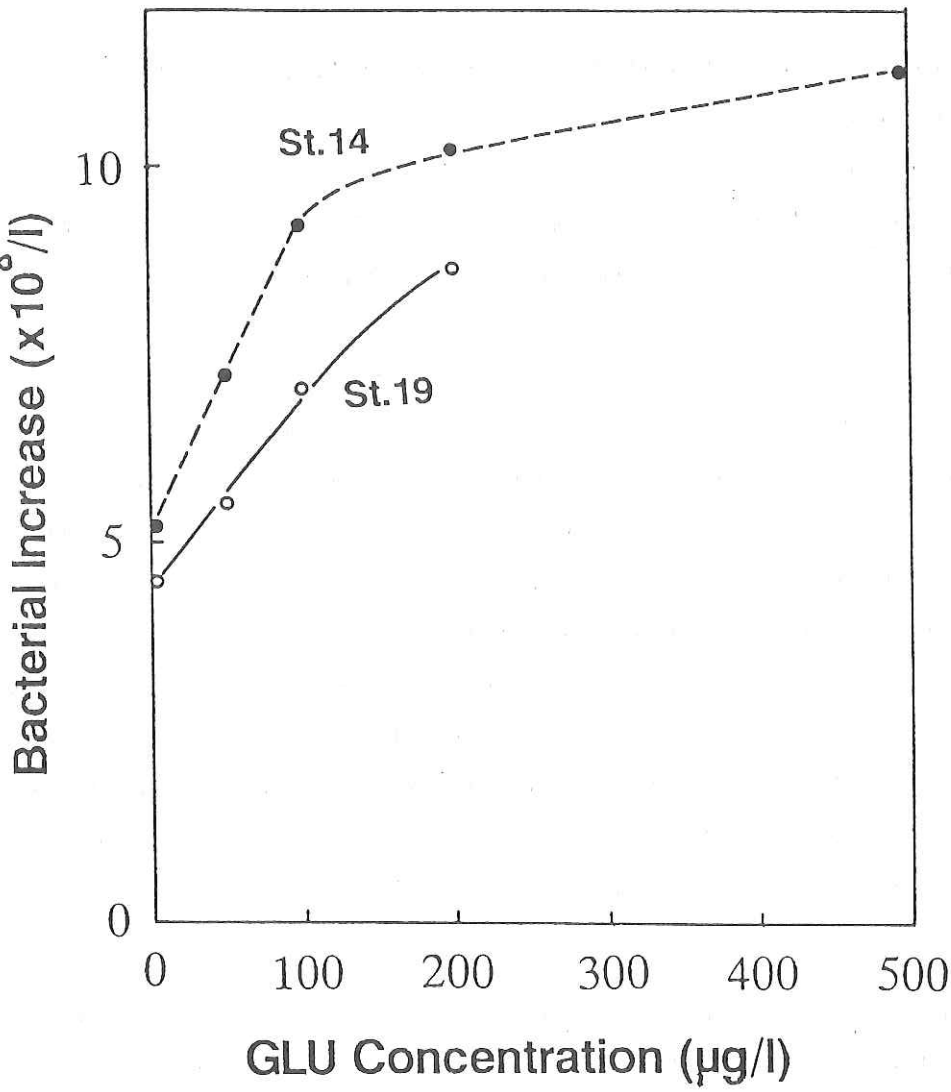

Fig. 3. Relationship between increased bacterial number and concentration of glutamic acid.

The Distribution of Dimethylsulphide in The Tropical and Subtropical Pacific Ocean

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Abstract: Dimethylsulphide(DMS) was determined in seawater and vertical hydrographic profiles in the tropical and subtropical Pacific Ocean during the cruise of the Hakuho-maru(The Hakuho-maru Cruise KH-88-1, Ocean Research Institute, University of Tokyo). The vertical distribution of DMS in the euphotic zone follows that of primary production, with a maximum at or near the ocean surface and a decrease with depth. Below the level of 1% light penetration, DMS levels decline gradually. The mean DMS concentration in surface water was 265 ng(DMS)l^{-1}. DMS is the major volatile sulphur compound in the ocean, and its transfer across the sea-air interface contributes significantly to the atmospheric sulphur budget.

1. Introduction

The production of dimethylsulphide(DMS) by marine macroalgae and microalgae via enzymatic and non-enzymatic cleavage of the algal product β-dimethyl-propiothetin(DMPT) has been demonstrated by Challenger(1951) and Ishida(1968). The widespread distriution of DMS, both in the atmosphere and in marine and freshwater systems, and its correlation with phytoplankton has been pointed out by a number of

researchers but not fully examined (Lovelock et al., 1972; Rasmussen, 1974; Nguyen et al., 1978; Barnard et al., 1982).

The role of DMS in the atmospheric sulphur budget has been documented (Lovelock et al., 1972;Maroulis and Bandy, 1977; Nguyen et al., 1978; Graedel, 1979; Sze and Ko, 1980; Barnard et al., 1982; Andreae and Raemdonck, 1983). These findings are based on flux models dependent on the concentration gradient that exists between the atmosphere and the ocean. Since atmospheric DMS concentrations are low relative to the values expected in equilibrium with seawater (Maroulis and Bandy, 1977), the concetration difference driving the DMS flux across the sea-air interface depends almost entirely on the concentration of DMS in surface seawater.

Biogenic trace substances, such as DMS and its oxidation product dimethylsulphoxide (DMSO) (Uchida, 1988), are important to understand the organic chemistry of seawater and of the biogeochemical cycling of the elements in the atmosphere especially from the view point of acidic precipitation. Data are presented here on the oceanic distribution of DMS and some of the biogeochemical factors controlling this distribution.

2. Method

2.1. Sampling

The cruise tacks for sampling in the Pacific Ocean aboard the R/V "Hakuho-maru"(Cruise KH-88-1) is shown in Fig. 1. Surface water samples were taken with hand-held bucket. In most cases, a sample was

drawn for chlorophyll a analysis at the same time as that for DMS. All water samples were collected in polyethylene bottles and immediately frozen at -20°C. Depth profile samples were collected using polycarbonate or polyvinylcarbonate samplers(Model CTD/RMS or Niskin). Once collected, sub-samples were drawn into polyethylene bottles and stored -20°C.

2.2. Aanlysis

Seawater samples were analyzed for DMS using Shimadzu Model GC-9A gas chromatograph equipped with a specially designed, sulphur specific, highly sensitive linearized flame photometric detector(FPD). Samples were drawn into the analytical system through a GF/C glass-fiber filter which removed plankton and biological debris. The sample volume(5 - 100 ml) is measured and injected into the gas-stripping chamber. A helium carrier gas stream is used to degas the sample for 20 min. The carrier-gas stream then passes through a drying tube filled with anhydrous K_2CO_3 and into a U-shaped tube filled with chromatographic packing(15% OV3 on chromosorb W-AW-DMCS). The tube is immersed in liquid nitrogen to collect the volatile sulphur compounds. After the 20 min stripping time is completed, the U-shaped tube is connected with gas chromatograph, romeved from liquid nitrogen and heated immediately at 100°C. The tube then acts as a simple, temperature-programmed gas chromatograph, separating the different sulphur compounds. In most cases, DMS was the only volatile sulphur compund detectable at the sample sizes used. Chlorophyll a was determined spectrophotometrically according to the method of

SCOR/UNESCO(1966).

3. Results and discussion

3.1. DMS distribution

Figure 2 details the surface seawater distribution of DMS versus. latitude along the R/V "Hakuo-maru" cruise track shown in Fig. 1. The surface water DMS levels maintained concentrations of 100 - 700 ng DMS l^{-1}, and mean DMS concentration was 265 ng DMS l^{-1}. Only in the region between 5°N and the equator the surface water DMS concentrations incrreased to the level of 600 ng DMS l^{-1}. Similar results were obtained by Andreae et al.(1983) in the waters sampled along a meridional section of 140°W, and by Cline and Bates (1983) in the waters sampled south of Hawaii between the equator and 6°N.

Elevated concentrations of DMS near the equator are consistent with the view of increrased primary production in the region of equatorial divergence. North(south) of 10°N(S) are the nutrient-impoverished waters of the North(South) Pacific subtropical gyre. Phytoplankton abundance and primary production are both minimal in these waters, supporting the low concentration of DMS observed.

Though chlorophyll a and DMS maxima were sometime displaced at several stations, the vertical distribution of DMS was similar at all stations along the cruise track, and showed subsurface maximum concentractions in the depth range of 0 to 100 m (Fig.3). Concentrations below the maximum decreased to undetectable levels at 200 m. The distribution of DMS in the upper 200 m suggests that the

production of DMS is related to the abundance of phytoplankton, or perhaps to primary production (Lovelock et al., 1972; Aneja et al., 1982; Barnard et al., 1982; Cline and Bates, 1983). However, the correlation between DMS and Chl. a for all samples was not so significant (r=0.56, n=83). This poor corrrelation may be the result of variations in the taxonomic composition of the phytoplankton, with only certain species or taxa producing DMS (Holligan et al., 1987).

3.2. Flux of reduced sulphur compounds

To accomplish the evaluation of the regional flux of DMS from the tropical and subtropical Pacific Ocean to the atmosphere, we adopted the stagnant film boundary layer model, which predicts that the flux of a gas is proportional to the piston velocity and to the partial pressure difference between the atmosphere and the surface mixed layer. The stagnant film boundary layer model is: $F=k(C - \beta p)$, where k is the piston velocity, C is the measured surface concentration, β is the Bunsen solubility coefficient of the gas, and p is its atmospheric partial prerssure(Broecker and Peng, 1974). The surface concentration was determined from measurements made between 0.1 - 1 m. No measurements of DMS in the surface microfilm were made. In the foregoing expression, the equilibrium concentration of DMS, βp, can be ignored because the atmosphere mixing ratio of DMS is small. Andreae(1983) found the atmospheric concentration of DMS in the equatorial Pacific to vary from 240 to 400 ng DMS/m^3. Adopting a mean value for the equatorial Pacific of 320 ng DMS/m^3 and a Bunsen coefficient of 10 ml

DMS/ml· H_2O atm(Cline and Bates, 1983) at 27°C and 35 ‰, the equilibrium concentration of DMS becomes 3.2 ng/l, a value negligiblie compared to the measured values in the surface layers of the tropical Pacific.

The piston velocity can be defined as the ratio of the molecular diffusivity(D) to the stagnant film thichness(h), the latter being dependent on wind velocity(Broecker and Peng, 1974). In the absence of measured diffusivities, we use the expression(Wilke and Chang, 1955)

$$D=7.4 \times 10^{-8}(2.6/18)^{0.5}T/\eta V^{0.6}$$

$$= 1.3 \times 10^{-5} \text{ cm}^2/\text{s}$$

to estimate the molecular diffusion coefficient of DMS in pure water. The viscosity (η) of water at 27 C is 0.91 centipoises and the molar volume (V) of DMS is 73.4 cc/g-mole. The absolute temperature, T, was 300°K. The diffusivity of DMS is estimated 1.3×10^{-5} cm^2/s. The film thickness was estimated to be 50 μm(Emerson, 1975), based on mean monthly wind speed of 5 m/s(Climatic Atlas of the World, 1977). Thus, the piston velocity for DMS in the tropical Pacific is about 2.3 m/d (Cline and Bates, 1983).

Adopting a mean surface concentration of 200 ngDMS/l in the subtropical Pacific, the mean flux of DMS is about 5 ng/m^2s. On the other hand, in the equatorial Pacific the mean flux of DMS is about 15 ng/m^2s.

The chemistry of DMS remains poorly understood in both the atmosphere and the oceans. Whereas DMS concentrations have been measured in both productive areas (some estuaries, continental shelves, and equatorial

waters) and non-productive areas(subtropical gyres of the Atlantic and Pacific Oceans), only a small fraction of the world oceans have been investigated and little progress has been made on the seasonal variations at high latitudes(Uchida, 1988). It is clear that different phytoplankton groups release different amounts of DMS per unit biomass. The most abundant producers are the coccolithophorids (Turner et al., 1988), haptophyte Phaeocystis poucheti (Barnard et al., 1984) and dinoflagellates (Ishida, 1968; Ishida et al., 1987 and Uchida, 1988). These plankton may be responsible for the abundance of DMS near the equator. It is necessary to investigate the relationship between biomass of these plankton and the concentration of DMS.

Oceanic fluxes have not been determined directly and are currently based on a large number of assumptions, chief among them is the model as it applies to a reactive species such as DMS. To significantly improve our estimate of the oceanic flux of reduced sulphur compounds, there needs to be an increased understanding of air-sea exchange processes. Seasonal information on the near-surface distributions of DMS and other volatile sulfur compounds is also needed.

4. Acknowledgements

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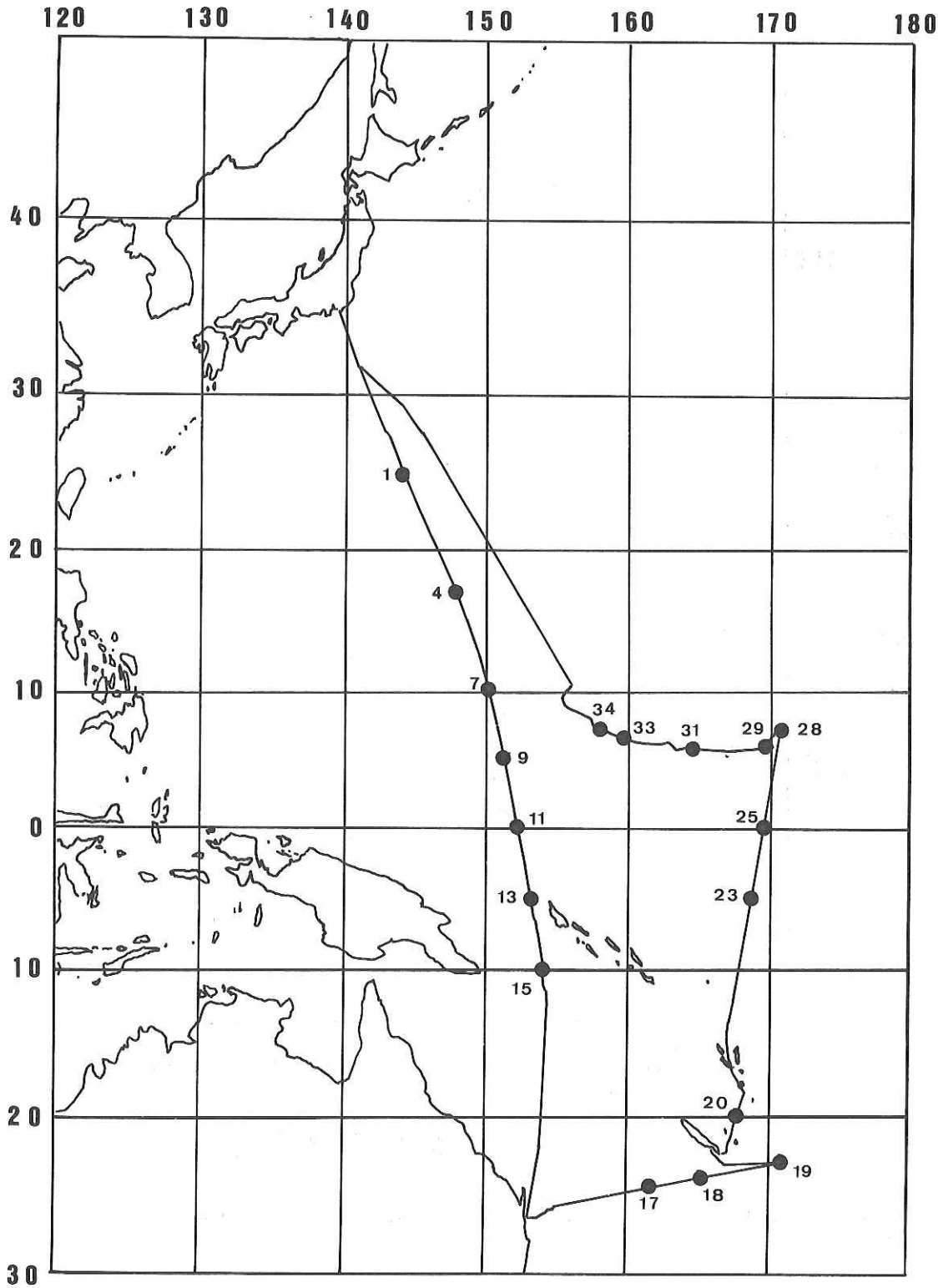

Fig. 1. Cruise track and location of stations in the tropical and subtropical Pacific Ocean.

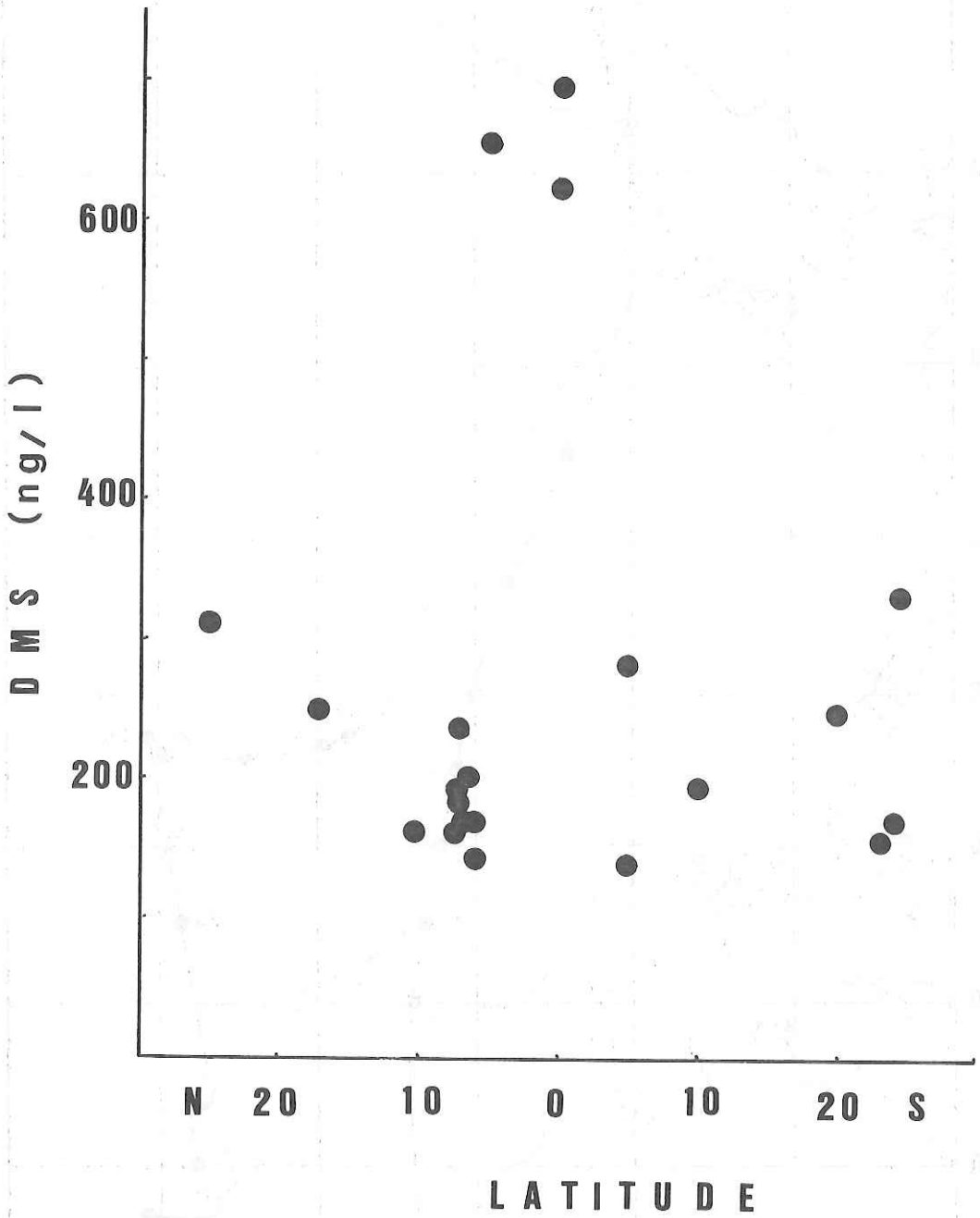

Fig. 2. Surface concentrations of DMS at stations along the cruise track.

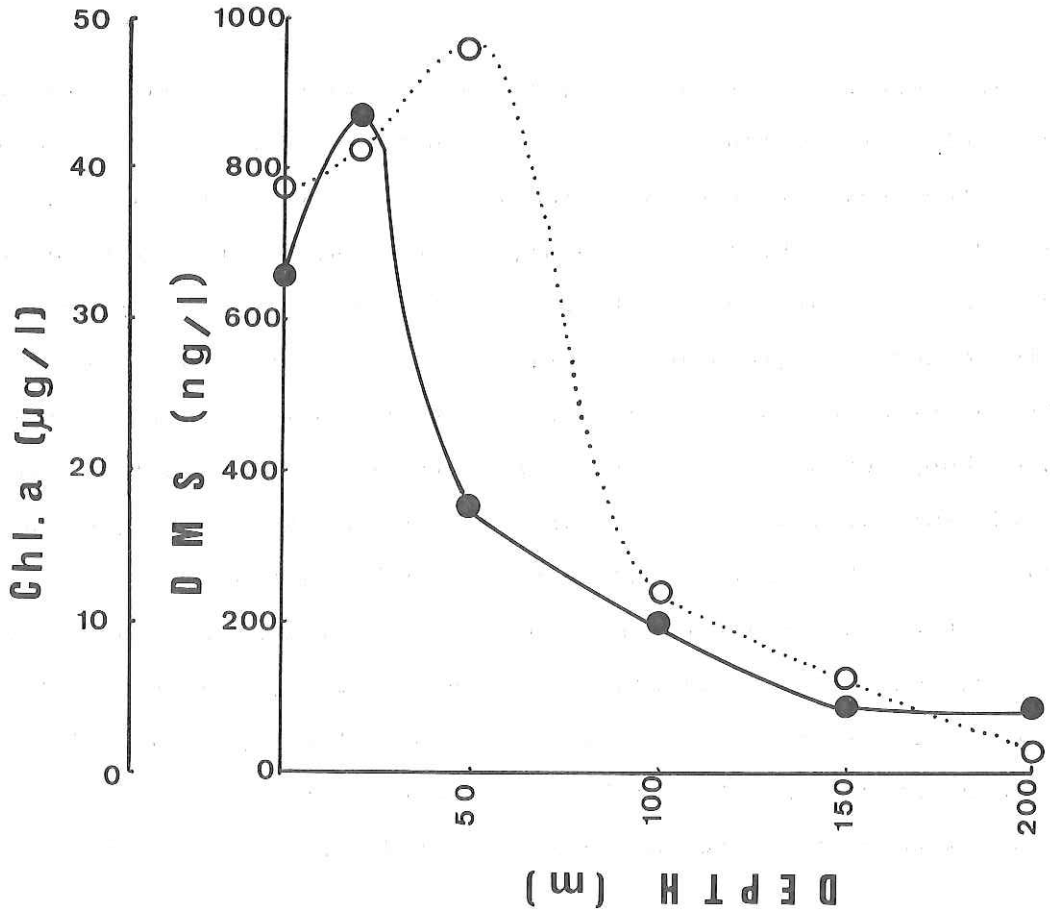

Fig. 3. Vertical distributions of DMS and chlorophyll a at station 9 (0°00.6'N, 152°17.7'E).

Decomposition of organic matter in the south Pacific Ocean

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The characteristics of microbial activities which seem to control nutrient flux were studied in the south Pacific Ocean.

Water samples were collected from sea surface at stations 4, 7, 9, 11, 13, 15, 17, 19 and 31, and several depths, from 20 to 200 m, at stations 4, 11, 19 and 31. Protease, α-amylase, lipase and -D-glucosidase activities were measured at 22-24° C by using model substrates labeled with paranitrophenol or azure dye (Hoppe et al. 1983). The concentrations of particulate amino acids and particulate carbohydrates were analyzed by the methods described by Strickland and Parsons (1968), while the concentration of ATP was determined by the procedures described by Parsons et al. (1984). Biological oxygen consumption (BOC) rate was measured at in situ water temperature by the Winkler oxygen titration. Viable bacteria were counted by the spread plate method employing partially modified marine 2216E agar.

Surface water collected was examined chemically and bacteriologically, and nine sets of data obtained were subjected to statistical analysis (Table 1). Log transformed number of bacteria had highly significant correlation with chlorophyll a ($P=0.01$). Significant correlations were also observed between chlorophyll a and ATP ($P=0.05$), and particulate amino acids and particulate carbohydrates ($P=0.05$). Therefore, the growth of

bacteria in the surface water seems to be supported by the pool of nutrients derived mainly from phytoplankton, which seems to comprise a significant portion of living organisms in the surface water.

All water samples collected were examined for BOC rate and hydrolytic activities of macromolecular organic matter. Under the experimental conditions employed, the hydrolytic potential generally decreased in the following order: protease; β-D-glucosidase; lipase; α-amylase, and the values for α-amylase were very low. The tendency is in good agreement with the result reported by Hoppe et al. (1983). Relatively low protease activity was observed in deeper layers of water.

Twenty three sets of data obtained were also subjected to statistical analysis (Table 2). Significant correlations were observed between protease, β-D-glucosidase and lipase activities. Therefore, the activities for these enzymes appeared to be involved synergistically in the process for the transformation of organic particles into dissolved organic matter. Reverse correlation between bacterial number and lipase activity ($P=0.05$) and low correlation between BOC rate and hydrolytic potentials could not be explained satisfactorily.

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Table 1. Correlation matrix showing the relationships between log transformed number of viable bacteria and some biomass -related variables.

Temperature					
0.35	Particulate amino acids				
-0.14	0.72*	Particulate carbohydrates			
0.06	0.42	0.46	ATP		
0.12	0.40	0.40	0.72*	Chlorophyll a+	
0.39	0.58	0.26	0.63	0.83**	Bacterial number(log)

* Significant at 5% level; ** significant at 1 % level.

+ The concentrations were shown by Tsuda in the preliminary data report of the cruise (Zerox copy).

Table 2. Correlation coefficients between log transformed number of viable bacteria , BOC rate, and hydrolytic potentials

Temperature						
0.28	Glucosidase					
0.36	-0.06	Amylase				
0.50*	0.72**	0.27	Protease			
0.08	0.70**	0.04	0.49*	Lipase		
0,25	-0.25	0.08	-0.20	-0.19	BOC	
0.40	-0.35	0.44	-0.03	-0.49*	0.41	Bacterial number(log)

* Significant at 5% level; ** significant at 1% level.

Nannoplankton assemblages in the Equatorial Pacific

Shiro NISHIDA

During the Hakuho-Maru KH88-1 cruise, two series of vartical nannoplankton samples were collected in Stations 11 and 25. Both stations were located just on the equator in the western and central Pacific.

St.11 Lat. 00-00.4'N, Long. 152-18.0'E, Date 88-02-03
St.25 Lat. 00-00.2'S, Long. 169-43.2'E, Date 88-03-01

Quantitative nannoplankton samples were prepaired by filtration using a 0.8μm pore-size filter on the board, dried in room temperature and stored in a plastic case. Present nannoplankton results are linked with the oceanographic data taken by a CTD apparatus and analytical data on nutrients. On the station 25 oceanographic data are lacked in nutrient con-t ents.

On a shore laboratory filtrated and dried samples were processed with ordinary SEM preparation procedure and observed with a SEM technique. Therefore present nannoplankton observation are restricted in calcareous and/or siliceous hard tissues of organisms. Nannoplankton specimens were identified and counted in a SEM. Based on SEM observation population of each species in an unit area of sample was counted and calculated to an unit volume of water, usually adopted for a liter of water sample.

Vertical nannoplankton comunity structures were shown in the figures. In the both stations, nannoplankton optimum layer are in surface to above 100 meter depth. Nannoplankton vertical habitat selection is conspicuous in station 11 and consisted of more than 14 nannoplankton species. On the other hand in station 25, nannoplankton comunities are rather monotonous and consisted of a small number of species. Oceanographic data in station 25 sujest similar interpretation, that is, in the water column both the thermocline and haloclineare under the euphotic layer.

In station 11 surface nannoplankton assemblage are composed of 22 taxa and tatal numbers of individuals attain to more than 24,000. Umbellosphaera irregularis and Gephyrocapsa oceanica occupies in superior status in the nannoplankton community. Umbellosphaera irregularis have a habitat niche in surface layer and Gephyrocapsa oceanica in mid-layer of euphotic zone.

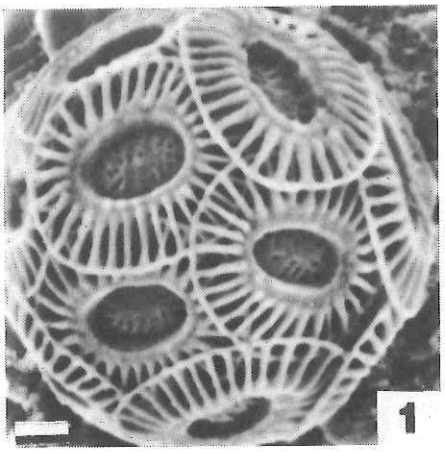
Also in station 11 Umbellosphaera irregularis, Umbellosphaera tenuis, Discosphaera tubifer and Caneosphaera molishii are surface dwellers. Syracosphaera pirus, Emiliania huxleyi and Anoplosolenia sp. are found in mid-layer of euphoticzone. Helladosphaera adoriaticus, Umbilicosphaera sibogae, Florisphaera profunda and Thorosphaera flabellata are restricted in lower layer of euphotic zone and their numbers of individuals are small.

Explanation of plate

Nannplanktons in the tropical Pacific

scale bar represents 1 micrometer.

1. Emiliania huxleyi (Lohmann) Hay and Mohler
2. Gephyrocapsa oceanica Kamptner
3. Umbellosphaera tenuis Kamptner
4. Umbellosphaera irregularis Paasche
5. Oolithotus fragilis cavum Okada and McIntyre
6. Florisphaera frofunda Okada and Honjo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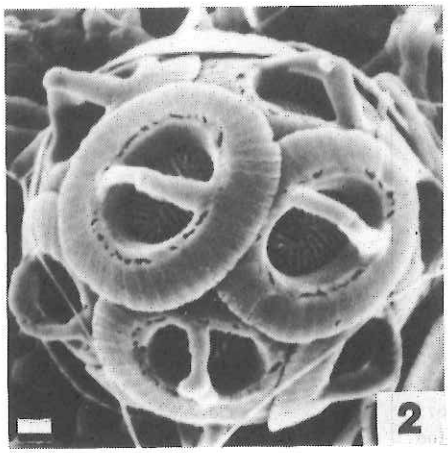
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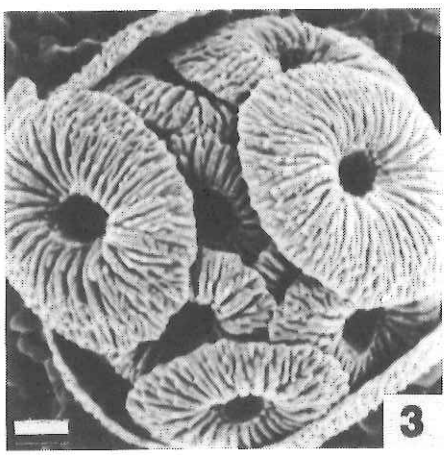
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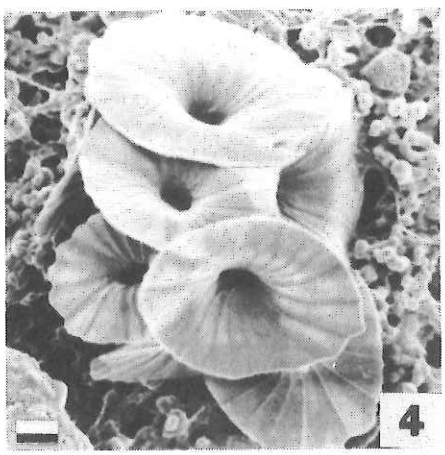
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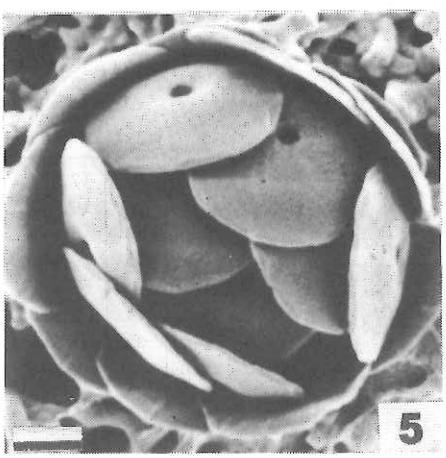
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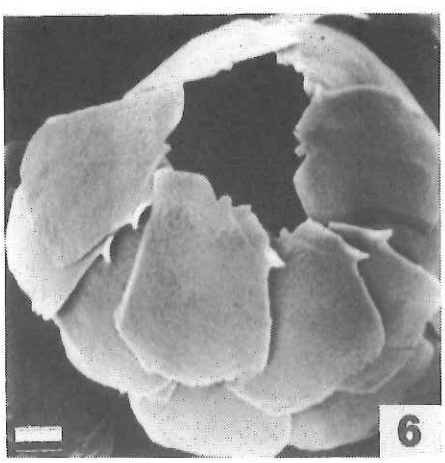

6

FLORAL COMPOSITION IN THE WATER COLUMN
OF KH88-1-ST.11

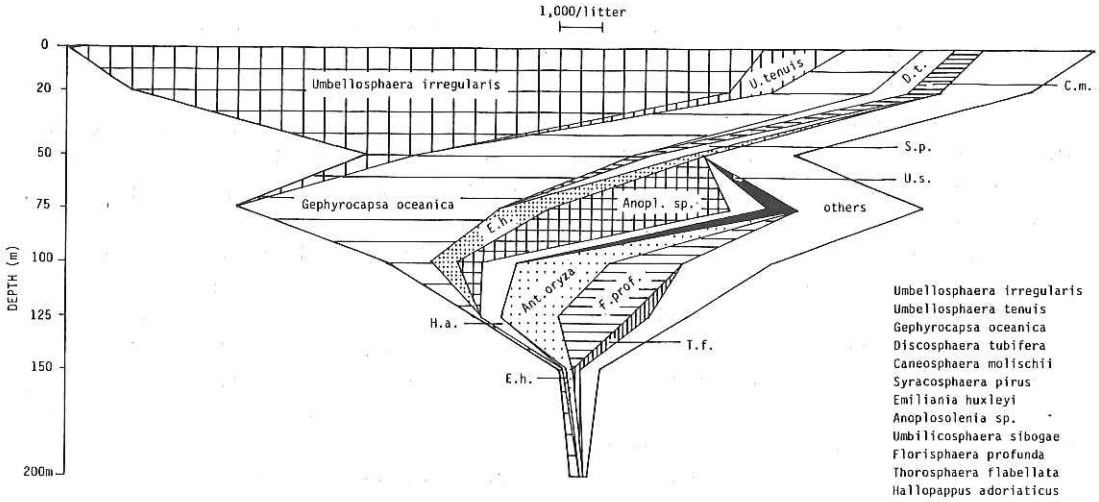
DEPTH (m)	*Umbellosphaera irregularis*	*Umbellosphaera tenuis*	*Gephyrocapsa oceanica*	*Discosphaera tubifera*	*Caneosphaera molischii*	*Syracosphaera pirus*	*Emiliania huxleyi*	*Anoplosolenia*	*Halopappus adoriaticus*	*Umbilicosphaera sibogae*	*Anthosphaera oryza*	*Florisphaera profunda*	*Thorosphaera flabellata*	*Syracosphaera lamina*	TAXA	cocco-spheres/l
000	68.7	8.1	7.5	3.4	2.5										22	24,192
020	67.0	5.2	11.5	4.2	3.1										21	21,484
050	12.7		51.4		3.8	7.5	4.0								23	9,964
075			38.0				7.0	26.9	5.2	4.5					24	16,156
100			10.8				6.5	6.5	8.6		23.8	18.6			25	9,302
125			4.4						7.7		27.5	34.1	7.7		25	5,241
150			33.3					12.1			15.2		24.2		17	950
200			50.0					14.3	7.1		21.4			7.1	11	403

Floral composition represented in percentage

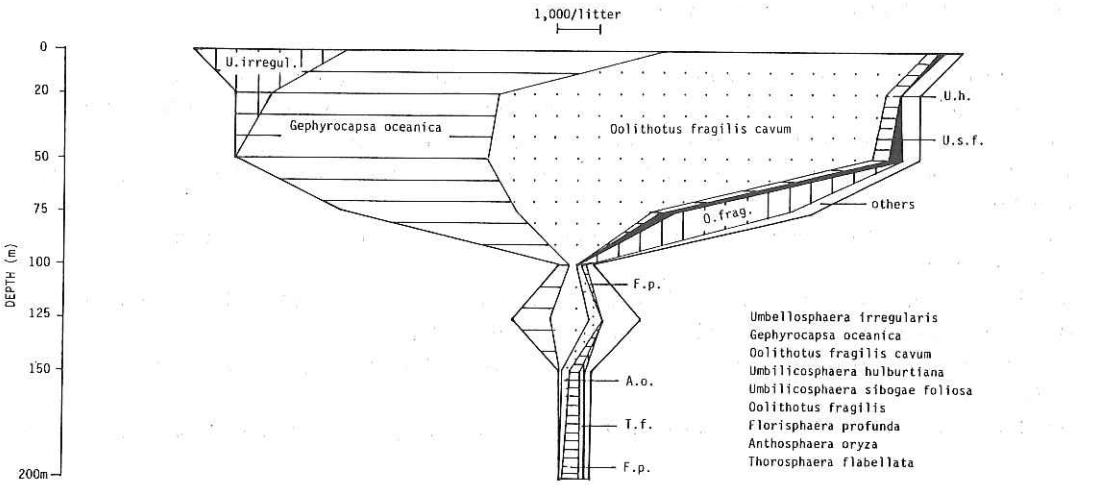
FLORAL COMPOSITION IN THE WATER COLUMN
OF KH88-1-ST. 25

DEPTH (m)	*Gephyrocapsa oceanica*	*Oolithotus fragilis cavum*	*Umbellosphaera irregularis*	*Umbilicosphaera hulburtiana*	*Umbilicosphaera sibogae foliosa*	*Cyrtocarpolithus leptopora*	*Oolithotus fragilis*	*Anthosphaera oryza*	*Florisphaera profunda*	*Thoroshaera flabellata*	TAXA	cocco spheres/l.
000	48.1	34.8	20.0	0.8	0.8						14	17,971
020	33.5	56.9	5.1	2.1		1.7					9	16,502
050	36.6	55.6		2.2	2.0	1.8					8	16,070
075	37.6	28.3		1.3	2.6		26.2				13	10,886
100	34.5	20.7			6.9			20.7	6.9		9	835
125	31.1	31.1				4.9	8.7	9.7			14	2,966
150					8.0	8.0		24.0	24.0	12.0	32	720
200								8.3	62.5	25.0	9	690
300	66.7				33.3						6	86

Floral composition represented in percentage



NANNOPLANKTON FLORA IN THE WATER COLUMN OF KH88-1-ST.11



NANNOPLANKTON FLORA IN THE WATER COLUMN OF KH88-1-ST.25

Studies of deep-sea sediments collected using USNEL type box corer

Yoshihisa SHIRAYAMA (Ocean Research Institute, University of Tokyo)

During the cruise of KH-88-1, sampling of deep-sea sediment using USNEL (US Naval Electric Laboratory) type large (50 x 50 cm) box corer was tried at five stations (Table 1). At four stations out of them, sampling was successful.

The main research project using the collected deep-sea sediment is ecological and taxonomic study of deep-sea meiobenthos. For this purpose, five subcores (Φ=3.6 cm i.e. 10 cm^2) were taken from the box core sample. These subcores were sliced at every 1 cm layer on board ship. The sliced samples of three subcores were then fixed with 10% seawater formalin for the quantitative study of meiofauna. The other two subcores were kept in frozen for the granulometric analyses of the sediment.

In addition to the subcores, ca. 300 g of the surface sediment were sieved with 63 μm mesh on board ship. The retained material was fixed and preserved with 10 % seawater formalin. This material will be used for the taxonomic studies of the deep-sea meiofauna in collaboration with specialists of various countries. Nematoda will be studied with W. Duane Hope of the Smithsonian Institution, Kinorhyncha with Robert P. Higgins of the Smithsonian Institution and Loricifera and Tardigrada with Reinhardt M. Kristensen of the University of Copenhagen.

The box core sample will be used also for several other purposes than meiofaunal studies. These are:

1) Chemical analyses of pore water by H. Iizumi, ORI (pore water was squeezed using a gas pressure type pore water squeezer, and nutrients, DOC, DON and amino acid concentration in the squeezed pore water are analyzed).
2) Geochemical studies of carbonate sediment by S. Ohde, University of the Ryukyus.
3) Trace elements and organic compounds in the deep-sea sediments by Y. Suzuki, MRI.
4) Isolation of bacteria and determination of bacterial activities in the deep-sea sediment by U. Simidu and K. Ohwada, ORI.
5) Organic geochemical studies of deep-sea sediments by S. Montani, Kagawa University.
6) Isolation of lytic-enzyme-producing bacteria by I. Sugihara, University of Mie.

Table 1. List of stations established for box corer sampling.

Station	Area	Date	Depth	Position
3	off Guam	26 Jan 88	3460 m	21° 00.0'N 146° 07.8'E
4	Mariana Trench	27 Jan 88	8120	17° 14.8'N 147° 48.9'E
17	West of *N.C.	17 Feb 88	1140	No sample
18	N.C. Basin	18 Feb 88	3630	24° 01.0'S 165° 25.6'E
19	**N.H. Trench	20 Feb 88	6840	23° 02.3'S 171° 00.5'E

* N.C.: New Caledonian
**N.H.: New Hebrides

The distribution of seaweed propagules in water in coral reefs of the central Pacific

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Abstract

The composition and abundance of macroalgal propagules contained in sea water at coral reefs was estimated by culture experiments at Majuro Atoll, Ponape Island and Ant Atoll in March, 1988. Between twenty and five hundred sporelings per litre of near bottom waters were counted. Marked variability in number of sporelings was observed between samples taken from sites only 10 m apart. Sporelings of Enteromorpha sp. were most abundant. However, except one site of tide pool at Majuro Atoll, where Enteromorpha sp. formed dense algal mat, the fronds of this species could not be found among algal samples collected from the experimental sites.

Introduction

Patterns of immigration was important as the primary process regulating structure in marine communities (Underwood and Denley, 1984; Menge and Sutherland, 1987). In the studies of algal colonization on cleared or introduced substrata, differences have been found in the diversity of the initial colonizing species. It has also been found that different species may arise on substrata exposed at the same time. These differences have generally been attributed to the availability of the propagules (Hurby and Norton, 1979; Reed et al, 1988). Anyway, species can colonize the substratum only when viable settling cells are available. However, most of the settled cells are died soon after settlement and a few of them developed into the plants which can be seen by naked eyes. So it is very difficult to calculate the acute number of attached cell. Hurby and Norton (1979) found that algal recruitment on frosted slides was positively correlated with spore abundance in seawater. To assess the role of immigration in structuring marine community, numbers of propagules in water must be determined.

There are several studies which clarified the composition and number of seaweed propagules in the water in the temporal regions, where dense algal bed were formed (Hruby and Norton, 1979; Amsler and Searles, 1980; Hoffmann and Ugarte, 1985; Zechman and Mathieson, 1985) However, no work have been conducted in the tropical regions.

Here we examined the number and diversity of algal propagules

in waters of tropical coral reefs. On tropical coral reefs, the abundance of algae is often maintained at low levels, but the primary production by algal communities is comparable to that of high biomass algal community (Hatcher and Larkum, 1985). This fact indicates a high turnover rate in this community. A major factor contributing to this rapid turnover is grazing by macro hervibories, (Hay et al, 1983; Carpenter, 1986; Sammarco et al, 1986). Substrates that are protected experimentally from grazing rapidly become colonized by macroalgae (Wanders, 1977; Sammarco, 1983; Hay and Taylor, 1985). So, the roles of algal propagules in tropical reef community is very important.

Methods

The studies were conducted at three tropical coral reefs in the central Pacific, Majuro Atoll (7° 10' N: 170° 15' S), Ponape Island (7° 00' N: 158° 15' E) and Ant Atoll (6° 55' N: 158° 00' E) in March 1988. Approximately three litre samples of near bottom water were collected with plastic bags by skin diving from four sites at Majuro Atoll, two in the lagoon (each site was 10 m apart and the benthic community was different), one in a tide pool of the reef flat and one in the reef front, two sites of north-west coast of Ponape Island, one on the barrier reef and the other in the fringing reef where Sargassum beds were developed, and two sites in the lagoon at Ant Atoll (each site was 1 km apart and the bottom condition was different). Macroalgae growing near the experiment sites were collected at the same time.

Within 10 minutes of collection of near bottom water, two to three litre samples were filtered through 45 mm grass-fiber filters (Whatman GF/C). The filters were examined under stereomicroscope removing micro invertebrates heribories and were then cultured in 50 ml of enriched sea-water media (PES, Provasoli, 1968; 1mg/l GeO_2 added). The plants growing on them were counted as soon as they could be identified, because some of the germlings became fertile in minute stage and liberated reproductive cells which developed into minute germlings on the filter. However, most juvenile stages could not be identified beyond the generic or family level.

Results

Sporelings of at least six different seaweeds grew on the filters from the near bottom water samples at Majuro Atoll (Table 1). Six different seaweeds at Ponape Island and four dufferent seaweeds at Ant Atoll were observed (Table 2). There was difference in the number of sporelings developed in the samples from the near bottom water among sampling sites. The numbers of sporelings from the tide pool water was high and that from the reef front water was low at Majuro Atoll. The difference of sporelings between two close sampling days from the water in the tide pool and from the water above living corals in the lagoon was small. The number of sporelings was about threefold greater in cultures from the water above living corals in the lagoon at 5th of March as compared with the water only 10 m apart. However, this difference was not occurred at 6th of March. In

the reef front, Enteromorpha sp. was dominant at 5th of March, but not at 6th of March, when Entocladia sp. germinated more abundant.

At the barrier reef of Ponape Island, Enteromorpha sp. was dominated and occupied over 90% of all germlings . On the other hand, Enteromorpha sp., Entocladia sp. and creeping brown filaments were observed simultaneously at the fringing reef, where Sargassum were growing luxuriantly. At the lagoon of Ant Atoll, the differences in number and dominant species of propagules between samples taken from sites 1 km apart were large. Enteromorpha sp. dominated in the water of sandy beach in the lagoon. However, it was the minor component of samples from the water of reef flat of the lagoon, where Entocladia sp. was abundant.

Mature Enteromorpha was collected only from the tide pool of Majuro Atoll. However, it was not collected from other sites where this observations were conducted. Bryopsis sp. was collected from the lagoon of Majuro Atoll, but other seaweeds germinated on the filters could not be found among the collected macroalgae.

Discussion

Abundant sporelings grew in all samples from the near bottom seawater in coral reefs of the central Pacific. Between twenty and five hundred sporelings per litre of the seawater were counted. These values were about the same with the coastal surface water in Scotland reported by Hurby and Norton (1979) and

were an order smaller compared with the surface water in central Chile reported by Hoffmann and Ugarte (1985).

Spatial and temporal variations took place in the diversity and abundance of propagules in the seawater (Hurby and Norton, 1979; Amsler and Searles, 1980; Hoffmann and Ugarte, 1985). The abundance of propagules would vary according to local algal composition, water movement and specific characteristics of the propagules (Hoffmann and Ugarte, 1985). In this observations at Majuro Atoll, the great differences in number of them were observed between two close days in waters above limestone in the lagoon and the numbers of Enteromorpha and Entocladia sporelings was highly variable in two sites separated only 10 m. Hurby and Norton (1979) found that the number of propagules was highly variable in sites separated only 100 m in Scotland coast. These variations were explained by aggregated dispersal of propagules.

The opportunistic algae produce large number of propagules over extended period and have large dispersal shadows. While late successional species release small number of propagules having more restricted dispersal shadows. The recent reports shows that propagules of opportunistic algae dominated in coastal and offshore seawater (Hurby and Norton, 1979; Amsler and searles, 1980; Hoffmann and Ugarte, 1985; Zechman and Mathieson, 1985). In this study, all propagules germinated on the filters, except one red algae from Ponape Island, belong to the species having opportunistic life style. Sporelings of Enteromorpha sp. was most abundant in the three islands.

Zechman and Mathieson (1985) found that some species which

were not recorded in the experimental sites germinated from the cultures of surface waters. They thought that these species may have been missed on the shore due to their small size. Except Enteromorpha sp. and Bryopsis sp., the species germinated on filters could not find in the collected macroalgae from the sampling sites. Entocladia sp. and all brown and red algae germinated on the filters were very minute species. So they were missed to collect at the experimental sites.

The fronds of Enteromorpha sp. were collected only from the tide pool of Majuro Atoll, but they were not collected from the other sampling sites. Enteromorpha sp. usually grew into few centimeters large in culture. However, they became fertile at five to ten cells stage of germlings and liberated swarmers when cultured at higher temperature. These minute germlings could be collected in the field when they grew together forming the algal mat. If they distributed sparsely, we have few chance to collect them. Most sporelings of Enteromorpha sp. might develop into minute fronds and become fertile within several days after settlement in the coral reefs. The abundance of propagules of opportunistic algae in seawater may account for the rapidness of maturity until they became fertile.

It was expected that if most of the settled cells were survived, the spaces would be occupied by the species whose propagules attached most abundantly and dense bed would be formed (Nakahara and Ueno, 1985). In some rocky intertidal, it was documented that settlement of invertebrates larvae can be the primary determinant of population size and structure (Caffey,

1985; Connell, 1985; Gaines and Roughgarden, 1985). However, even though the propagules of opportunistic algae were always dominated in waters, they became dominant species at some districted area. In this study site, opportunistic algal propagules were most abundant in the waters, but they formed conspicuous population only in a tide pool at Majuro Atoll.

In the tropical coral reefs, grazing by large hervibories (coral fishes and sea urchins) have a major influence on the species composition, abundance and standing crop of algae (Hatcher and Larkum, 1983; Hay, 1985). These large hervibories usually graze algal turfs. A significant increase in biomass of algae in algal turf following exclusion of grazing fishes and sea urchins (Montogomery, 1980; Sammarco, 1982; Ross, 1987). In any experimental exclusion, however, opportunistic algae were never dominated in those areas.

Many small, mobile invertebrates were living associated with such algal turfs and also living in the small crevice and cavity of coral reefs. Zeller (1988) have shown that caging resulted in an increase in density of small mobile invertebrates which increased grazing intensity to algae and shifted in species composition of algae. These small mobile invertebrates also eat settled propagules of opportunistic algae. The large harvibories were not found in the tide pools of Majuro Atoll. At the same time, the small mobile invertebrates was sparse in the tide pool where Enteromorpha mat were formed (Nakahara, unpublished). This micrograzing is thought to account for the species composition of algae and limited distribution of

opportunistic algae in tropical coral reefs.

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Tabler 2. Number of propagules developing into sporelings in cultures of one littler from near bottom water at Ponape Island and Ant Atoll: values represent the average number in two or three samples.

Locality	Ponape Island			Ant Atoll	
Sites	Barrier reef		Fringing reef	Lagoom	Lagoon
Bottom	Limestone		Limestone (Sargassum bed)	Sand	Living corals
Depth	1.5 m		0.8 m	1.0 m	1.0 m
Date	13 March	15 March	13 March	14 March	14 March
Local time	11:10	9:15	10:15	12:00	13:15
Chlorophyte					
Entocladia sp.	6.7	7.0	20.0	1.0	23.7
Enteromorpha sp.	162.0	259.0	33.0	123.0	0.3
Cladophora sp.				1.0	
Phaeophyceae					
Ectocarpoid		5.0			
Creeping brown filaments	4.3	37.5	13.0		
Rhodophyta					
Erythrotrichia sp.		0.5	0.5		
non-identified sp.			2.0		0.3
Total	173.0	309.0	68.5	125.0	24.3

Table 1. Number of propagules developing into sporelings in cultures of one litter from near bottom water at Majuro Atoll: values represent the average of sporelings in two or three samples.

Sites	Lagoon		Lagoon		Reef flat(Tide pool)		Reef front	
Bottom	Living corals		Limestone		Limestone(algal mat)		Crustoce corarine algae	
Depth	1.0 m		1.0 m		0.3 m		1.5 m	
Date	5 March	6 March	5 March	6 March	5 March	6 March	5 March	6 March
Local time	12:00	11:20	12:10	11:10	12:20	10:50	12:30	10:30
Chlorophyte								
Entocladia sp.	2.0	1.5	20.5	7.0		0.5	4.3	28.3
Enteromorpha sp.	225.5	189.0	60.5	240.0	481.0	342.0	17.7	1.0
Cladophora sp.		0.5	2.0	2.0				
Bryopsis sp.		3.0		3.0				
Phaeophyceae								
Creeping brown filaments	11.5	10.0		7.0			2.0	0.3
Rhodophyta								
Erythrotrichia sp.		0.5	1.0	3.5	1.0	1.3		
Total	239.0	204.5	84.0	261.5	482.0	343.8	24.0	29.7

Study on Tropical Seagrass Communities in tropical Pacific

Mukai, H. and K. Aioi

Many species of seagrasses distribute in the Southern Pacific, around Papua New Guinea and northern Australia (den Hartog, 1970). Seagrasses, in western Pacific, have expanded their distribution primarily by an aid of two ocean currents, the Anti-equatorial Cureent and Kuroshio Current. The number of seagrass species, thus decreases along these currents. Information of sea grass vegetation in islands along the Anti-equatorial Current is surely useful to know developmental processes of tropical seagrass communities. Both Pohnpei Islands and Marshall Islands locataed on 7°N which is a main course of the Anti-equatorial Current. Grass shrimps associated to seagrasses have also the distribution similar to seagrasses. Seagrasses and associated animals like grass shrimps consist to an entire community.

We have no information of photosynthesis or respiration of tropical sea grasses available.

Our thanks are due to Prof. Shimidu, and the officers and crews of the Hakuho-maru. We are indebted to Dr. H. Nakahara for his identification of e piphytes.

1) Distribution of seagrasses

The field survey on tropical seagrass community was conducted at Majuro Atoll, Marshall Islalnds(7°10'N, 171°15'E) and Pohnpei Islands (7°00'N, 158°05'E).

Although only one species has been reported in Marshall Islands, even a piece of seagrass leaves were not recognized in the lagoon of Majuro Atoll.

Otherwise, dense beds of seagrasses were observed at many cites around Pohnpei Island (Table 1). Off Nanmatol a very dense seagrass vegetation consisted of two species, Thalassia hemprichii and Enhalus acoroides. At Oumoar Inlet near Kolonia also T. hemprichii and E. acoroides occurred. At a headland of Pahnitipwe dense seagrass bed consisted of three species, T. hemprichii, E. acoroides and Cymodocea rotundata. Occurrence of C. rontundata is the first record here (Tsuda et al., 1974). Dense algae associated with in the lagoon of Pohnpei Island. The epiphytic community on an E. acoroides leaf consists of various microalgae and animals. More than 95% of epiphytes was occupied by Centroceras sp. and the rest consisted of Ceramium sp., Hypnea sp., Chondria sp., Cladophora sp. and young buds of Melobesioideae. Besides blue-green algae and diatoms were recognized as a minor quantity asso-

ciated with nematods, polychaets and copepods.

In a lagoon of Ant Atoll (6°48'N, 157°58'E) located in the south-west of Pohnpei Island, a very sparse vegetation of C. rotundata (small type) was found from ca.4 meter deep sandy bottom.

2) Photosynthesis of Enhalus acoroides and epiphytes.

Photosynthesis rate of Enhalus acoroides leaf piece was determined with a productmeter devised by Yokohama et al.(1986). For determination of photosynthetic O_2 evolution, 3 cm long pieces of full-grown leaves (ca.30cm) of E. acoroies was used. Epiphytes were gently scraped off from leaves and suspend ed in 5 ml filtered seawater in a productmeter flask. They were incubated at constant temperature (23°-24°C). A light intensity was kept at 3×10^4 lux, since the previous experiments showed that the photosynthesis of seagrasses was saturated at a light intensity between 2×10^4 lux and 3×10^4 lux.

Mean photosynthesis of leaf pieces was 21.5(+ 5.0) $\mu lO_2\ cm^{-2}\ hr^{-1}$. Mean photosynthetic activity of epiphytes was 0.42 (+ 0.19) $\mu lO_2\ cm^{-2}\ hr^{-1}$. The rate of epiphytes was estimated to be nearly 2 % of the leaf photosynthesis of E. acoroides. Both of the photosynthetic rates of E. acoroides leaf and epiphytes were low as compared with the results in Papua New Guinea (Hattori et al., 1985; Hattori, 1987). The photosynthesis of E. acoroides leaves in Papua New Guinea showed about 40 $\mu lO_2\ cm^{-2}\ hr^{-1}$ under the light intensity of 3×10^4 lux 28°C. Optimal water temperature for photosynthesis of E. acoroi-des is considered to be nearly 28°C rather than 23°-24°C.

3). Dispersion of seagrasses and associated grass shrimps along the Anti-equ atorial Current.

Species richness in a given island along an ocean current is determined by an equilibrium between colonizing rate and extinction rate. These two parameters have never been measured directly in almost marine organisms. The colonizing rate depends on frequency and abundance of dispersing propagules.

The propagule of seagrasses could be taken two types, i.e. seed and sh-oot with roots. In case of grass shrimps, pelagic larvae and adults bearing eggs are possible to be propagules. In order to know the type of dispersing propagules of seagrasses and their abundance in the Anti-equatorial Current, surface-net samplings were tried at 5 stations (Sts. 29-33) between Majuro Atoll and Pohnpei Island with an ORI-type net. Each towing was performed during 30 min. Samples are processing to be sort out and identified. At only one station, a piece of seagrass leaf was found.

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Station	C r	T h	E a	Algae
Nanmatol		**	**	**
Oumoar		*	*	**
Pahnitipwe	*	**	**	**
Ant Atoll	*			

Table 1. Distribution of seagrass and algae in the lagoon of Pohnpei Island.

* sparse ** dense

C r: Cymodocea rotundata, T h: Thalassia hemprichii,

E a: Enhalus acoroides.

GENETIC VARIATION IN DAMSELFISHES COLLECTED FROM NEW CALEDONIA, MAJURO, PONAPE, PHILIPPINES AND OKINAWA

T. YOSHINO

The following four damselfishes were collected from five localities in the western Pacific: *Amphiprion melanopus* (Majulo Atoll and Ponape Island); *A. frenatus* (Okinawa and Philippines); *Pomacentrus coelestis* (Okinawa, Philippines and Majulo Atoll); *Chrysiptera cyanea* (Okinawa, Philippines and New Caledonia). These specimens were subsequently stored at -20° C and transported to the laboratory. Electrophoretic analysis was utilized to estimate genetic variation in distant populations within a species and to study interrelationships of congeneric species.

Electrophoretic variation was examined at 23 enzyme loci in *P. coelestis* and *C. cyanea*, and 28 enzyme loci in two species of *Amphiprion* (*A. melanopus* and *A. frenatus*). The genetic distances (D) were calculated following procedure in Nei (1978).

The D values range from 0.002 (Okinawa vs. Philippines) to 0.126 (Okinawa vs. Majulo) in *P. coelestis* and from 0.047 (Okinawa vs. Philippines) to 0.171 (Okinawa vs. New Caledonia) in *C. cyanea*. In two species of *Amphiprion*, the D value is less than 0.007 within each species. These ranges consistent with the distances between sampling localities. However, the genetic distance between *A. melanopus* and *A. frenatus* is smaller than intraspecific distances as in *P. coelestis* and *C. cyanea*, and the D values range from 0.049 (Ponape vs. Philippines) to 0.100 (Majulo vs. Okinawa). This result supports that these two *Amphiprion* species fail to exhibit substantial morphological difference except pigmentation. Further biochemical and morphological analysis is needed to solve speciation and taxonomy of damselfishes.