Preliminary Report
of
The Hakuho Maru Cruises
KH-83-3 and KH-85-2

August 11 - September 13, 1983

April 14 - May 15, 1985

The western North Pacific

Ocean Research Institute

University of Tokyo

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By

The Scientic Members of the Expeditions

Edited by

Akihiko HATTORI and Toshisuke NAKAI

1986

Preface

This volume contains the oceanographic data obtained during the cruises KH-83-3 (11 August - 13 September 1983) and KH-85-2 (12 April - 15 May 1985) of the R.V. Hakuho Maru. Brief summaries of the research conducted by the scientists aboard are also included.

On behalf of the scientists, we wish to express our sincere gratitude to Captain Ichiro Tadama, the other officers and the crew members of the Hakuho Maru for their cooperation and skillful assistance throughout the cruises. We acknowledge the help of Ms. Masae Otsu in compiling and editing this volume.

20 November 1986

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Part II. Hakuho Maru KH-85-2 Cruise

Part I.

Hakuho Maru KH-83-3 Cruise

Outline of Hakuho Maru KH-83-3 cruise

The cruise consisted of two legs (Fig. 1). The locations of the oceanographic stations are given in Table 1.

The main objectives of this cruise were to collect information for understanding chemical, biochemical and biological processes in sub-arctic and subtropical waters of the western North Pacific with special reference to the cycling of biophilic elements. The oceanographic observations were intensively undertaken in two sea areas centered at 45°00'N and 160°00'E (Station C), and at 28°00'N and 153°00'E (Station E). Additional data were collected at several stations within the area enclosed with 28° and 45°N parallels and 145° and 160°E meridians. In addition, a seismological investigation was conducted in the Japan Trench region off Sanriku.

The names and institutions of the scientists participated in this cruise are listed in Table 2, and observation items at each station in Table 3.

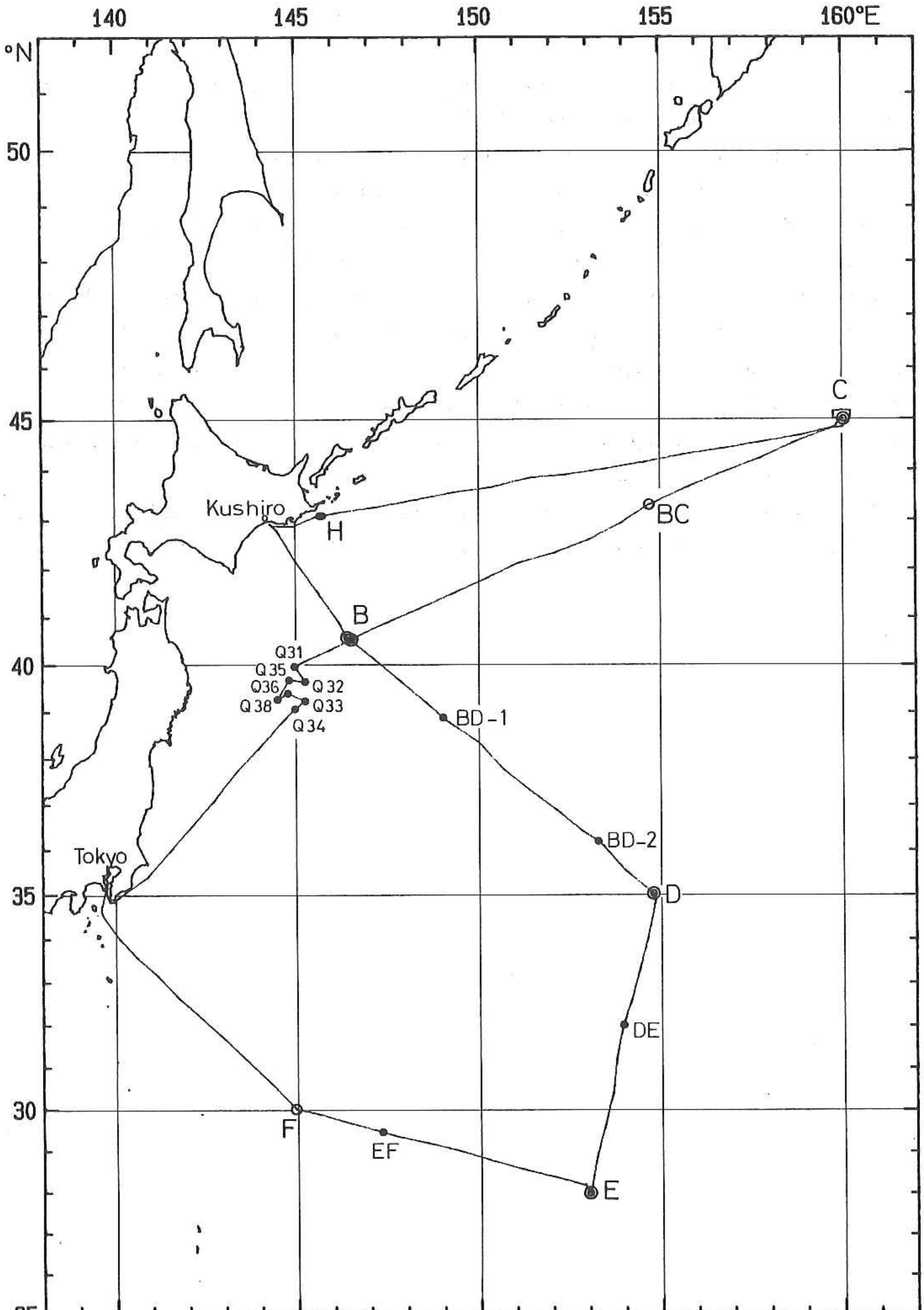


Fig. 1 Track chart of the KH-83-3 cruise of the Hakuho Maru.

Table 1. Location of oceanographic stations and dates

Station	Latitude		Longitude		Date
Leave Tokyo					8/11/83
Q34	39°03.5'N--	39°03.8 N	144°57.0 E--	144°57.8'E	8/11/83
Q33	39 13.9 N	39 13.7 N	145 14.6 E	145 15.2 E	8/13/83
Q36	39 22.6 N	39 22.4 N	144 47.9 E	144 48.5 E	8/13/83
Q38	39 15.5 N	39 15.3 N	144 27.7 E	144 28.5 E	8/13/83
Q35	39 41.2 N	39 40.7 N	144 46.4 E	144 47.9 E	8/13/83
Q32	39 38.8 N	39 38.6 N	145 14.2 E	144 15.1 E	8/14/83
Q31	39 58.1 N	39 58.0 N	144 56.2 E	144 57.5 E	8/14/83
B	40 31.3 N	40 31.7 N	146 28.2 E	146 30.7 E	8/14/83
BC	43 17.3 N	43 18.2 N	154 41.6 E	154 42.7 E	8/16/83
G1	44 50.0 N	44 50.1 N	159 45.7 E	159 45.6 E	8/17/83
G2	44 50.1 N	44 49.9 N	159 59.7 E	160 00.4 E	8/17/83
G3	44 49.8 N	44 50.1 N	160 13.9 E	160 13.5 E	8/17/83
G4	45 00.0 N	45 00.3 N	160 13.1 E	160 13.2 E	8/17/83
G5	45 09.9 N	45 10.1 N	160 13.8 E	160 14.1 E	8/17/83
G6	45 10.1 N	45 10.4 N	160 00.0 E	160 00.3 E	8/18/83
G7	45 09.3 N	45 09.4 N	159 44.7 E	159 45.1 E	8/18/83
G8	44 59.8 N	45 00.0 N	159 45.9 E	159 46.0 E	8/18/83
G9	45 00.0 N	45 00.0 N	160 01.3 E	160 01.4 E	8/18/83
C	44 57.4 N	45 15.4 N	159 57.1 E	160 32.8 E	8/18/83-8/24/83
G10	44 59.8 N	44 59.9 N	159 59.9 E	160 00.1 E	8/24/83
G11	44 57.3 N	44 57.5 N	159 56.4 E	159 56.5 E	8/24/83
G12	44 55.2 N	44 55.3 N	159 52.2 E	159 52.5 E	8/24/83
G13	44 52.5 N	44 52.5 N	159 49.5 E	159 49.9 E	8/24/83
G14	44 48.9 N	44 50.0 N	159 44.8 E	159 45.8 E	8/24/83
H1	43 04.8 N	43 07.1 N	145 42.0 E	145 55.0 E	8/26/83
H2	43 04.5 N	43 05.6 N	145 35.4 E	145 42.5 E	8/26/83
Arrive Kushiro					8/27/83
Leave Kushiro					9/ 1/83
B'	40 31.3 N	40 33.3 N	146 24.4 E	146 29.6 E	9/ 2/83
B-D-1	38 53.1 N	38 53.2 N	148 59.4 E	148 59.5 E	9/ 3/83
B-D-2	36 11.8 N	36 12.9 N	153 16.3 E	153 16.7 E	9/ 4/83
D	34 50.9 N	35 02.1 N	154 46.2 E	154 52.0 E	9/ 4/83-9/ 5/83
DE	32 09.5 N	32 09.6 N	153 59.2 E	154 00.0 E	9/ 6/83
E	28 00.3 N	28 12.0 N	152 50.7 E	153 00.1 E	9/ 7/83-9/ 9/83
EF-1	29 27.6 N	29 27.7 N	147 17.6 E	147 17.8 E	9/10/83
EF-2	29 27.8 N	29 27.8 N	147 17.5 E	147 17.5 E	9/10/83
EF-3	29 27.9 N	29 28.1 N	147 17.5 E	147 17.5 E	9/10/83
F	30 00.8 N	30 02.2 N	144 56.0 E	144 56.8 E	9/11/83
Arrive Tokyo					9/13/83

Table 2. Scientists aboard

Akihiko HATTORI	Ocean Research Institute, University of Tokyo
Toshisuke NAKAI	Ocean Research Institute, University of Tokyo
Toshiro SAINO	Ocean Research Institute, University of Tokyo
Takashi ISHIMARU	Ocean Research Institute, University of Tokyo
Hirotaka OTOBE	Ocean Research Institute, University of Tokyo
Jota KANDA	Ocean Research Institute, University of Tokyo
Shinichiro NORIKI	Faculty of Fisheries, Hokkaido University
Koh HARADA	Faculty of Fisheries, Hokkaido University
Shyuichi WATANABE	Faculty of Fisheries, Hokkaido University
Yasunori WATANABE	Faculty of Fisheries, Hokkaido University
Masatoshi YAMADA	Faculty of Fisheries, Hokkaido University
Norihito ISHIMORI	Faculty of Fisheries, Hokkaido University
Jun MATSUMOTO	Faculty of Fisheries, Hokkaido University
Tatsuo TANJI	Muroran Institute of Technology
Michio OKINO	Muroran Institute of Technology
Satoshi NISHIZAWA	Faculty of Agriculture, Tohoku University
Hiroshi HATTORI	Faculty of Agriculture, Tohoku University
Shinobu TAKAHASHI	Faculty of Agriculture, Tohoku University
Mihoko OKAZAKI	Faculty of Agriculture, Tohoku University
Shozaburo NAGUMO	Earthquake Research Institute, University of Tokyo
Sadayuki KORESAWA	Earthquake Research Institute, University of Tokyo
Junzo KASAHARA	Earthquake Research Institute, University of Tokyo
Naohiro YOSHIDA	Mitsubishi-Kasei Institute of Life Sciences
Jyusuke HORITA	Faculty of Science, Tokyo Institute of Technolgy
Takeshi OOBA	Faculty of Science, Tokyo Institute of Technolgy
Nobuhiko HANDA	Water Research Institute, Nagoya University
Hiroshi SAKUGAWA	Water Research Institute, Nagoya University

Table 3. Items of observation at each station

	Tokyo ↓					Kushiro ↓					Tokyo ↓
Station	A	B	BC	C	H	B'	BD	D	DE	E	F
CTDO observation		x	x	x				x		x	
OCTOPUS observation			x	x	x	x	x		x	x	x
Water sampling											
Niskin				x		x		x		x	
Goflo				x		x		x			
Van Dorn				x							
LVFS				x						x	
Pump				x						x	
Plankton sampling											
Norpac net			x	x	x						
MTD net				x						x	
ORI net				x						x	
Sled and MTD net					x						
MTD net (small)					x						
LHPR				x							
Box Corer			x	x				x			
In situ experiment				x						x	
Sediment trap		x				x		x			x
OBS	x										

Routine observations of oceanographic variables

Four hydrographic stations were occupied on leg 1, and two stations on leg 2 (Fig. 1). At each station, casts of CTD with twenty four 5-liter rosette samplers and casts of 23-liter or 30-liter Niskin samplers were made to collect information on water temperature, salinity, dissolved oxygen, phosphate, silicate, nitrate, nitrite, ammonium, and chlorophylls. On leg 2, pH and alkalinity were also determined. The names of the persons who conducted the measurements are given after each item.

Depth profiles of temperature, salinity and dissolved oxygen were obtained with a Neil Brown Mark III CTD profiler fitted with a Beckman oxygen electrode. Calibrations were made based on temperature values obtained at selected depths using pairs of protected reversing thermometers (Nakai, Otobe, Tanji and Okino), salinity values determined from discrete water samples using an AutoLab 601 MK III inductive salinometer (Nakai, Otobe, Tanji and Okino), and oxygen values determined by the Winkler titration method (Yamada, Noriki and Okazaki). Nitrate, nitrite and ammonium were determined using a Technicon type II autoanalyzer (Saino, A. Hattori and Ooba). The methods described in the manual of Strickland and Parsons (1972) were used with some modifications for autoanalyzer measurement. Reactive phosphate and silicate were determined manually using the method of Murphy and Riley (1962) and the molybdenum yellow method described in the Manual of Oceanographic Observation (1970), respectively (Ishimori, S. Watanabe and H. Hattori). Chlorophyll *a* and phaeophytin were determined by the fluorometric method as described by Strickland and Parsons (1972) (Sakugawa, Handa and Ishimaru). Proton concentration was measured with a pH meter, and alkalinity was estimated from the pH shift after addition of a definite amount of HCl to the seawater samples (Harada, Y. Watanabe and Takahashi). The data obtained are tabulated in Tables 4-10.

References

Murphy, J. and J. P. Riley (1962). A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta, 27, 31-36.

Oceanographical Society of Japan (1970). Manual of Oceanographic Observations, Tokyo.

Strickland, J. D. H. and T. R. Parsons (1972). A Practical Handbook of Seawater Analysis. Fisheries Research Board of Canada, Ottawa.

Table 4. Summary of hydrographic data at Station B

Date: 14 Aug 83, 20:25-23:29
Depth: 5210m
Latitude: 40°31.3'- 40°31.7'N
Longitude: 146°30.7'-146°28.3'E
Air Temp.: 22.6°C
Wind: SE - 5.5 m/s
Weather: Fog
Swell: 1
Sea: 2

Depth	Temp.	Sal.	D.O.	PO_4^{3-}	SiO_2	NO_2^-	NO_3^-	NH_4^+	pH	Alk.
m	°C	‰	ml/l	µg at/l						meq/l
0	19.61	32.823	5.53	0.21	0.6	-	-	-	8.199	
10	16.70	32.939	6.50	0.23	0.3	0.00	0.2	0.12	8.206	
30	4.90	33.009	7.22	1.28	24.4	0.08	10.6	2.01	8.004	
50	2.40	33.067	6.65	1.73	33.7	0.07	18.9	1.26	7.850	
75	1.76	33.159	6.07	2.01	45.3	0.00	23.7	0.10	7.786	
100	2.23	33.276	6.16	1.85	45.8	0.00	24.0	0.10	7.789	
125	2.86	33.377	6.06	1.84	43.7	0.00	22.9	0.10	7.819	
150	2.58	33.398	5.68	1.99	50.1	0.00	25.1	0.11	7.769	
175	2.32	33.409	5.12	2.18	57.1	0.00	27.4	0.10	7.724	
200	2.41	33.467	4.92	2.18	58.9	0.00	28.1	0.13	7.715	
300	3.01	33.729	2.63	2.67	83.9	0.00	35.9	0.10	7.572	
400	2.84	33.870	1.72	2.93	98.7	0.00	38.9	0.08	7.521	
500	3.27	34.062	0.97	3.02	112	0.00	40.9	0.09	7.504	
750	3.07	34.277	0.81	2.93	128	0.00	40.9	0.07	7.520	
1000	2.67	34.389	0.85	3.00	142	0.00	41.1	0.07	7.544	
1250	2.35	34.458	0.98	2.89	151	0.00	40.9	0.08	7.556	
1500	2.17	34.516	1.22	2.81	154	0.00	40.6	0.06	7.572	
1750	2.01	34.561	1.50	2.96	153	0.00	40.1	0.06	7.600	
2000	1.85	34.593	1.92	2.28	157	0.00	39.1	0.06	7.640	
2250	1.72	34.617	2.24	2.71	151	0.00	38.3	0.07	7.664	
2500	1.62	34.634	2.56	2.65	153	0.00	37.4	0.04	7.676	
2750	1.56	34.644	2.79	2.67	153	0.00	37.0	0.06	7.702	
3000	1.51	34.654	3.03	2.59	150	0.00	36.3	0.01	7.708	
3250	1.48	34.660	3.12	2.55	163	0.00	35.9	0.03	7.717	
3459	1.46	34.665	3.37	2.45	149	0.00	35.2	0.00	7.735	

Depth	Temp.	Sal.	δ st	Δ D
m	°C	‰	cl/ton	
0	19.61	32.823	466.0	0.0000
10	15.23	32.886	362.3	0.0414
30	5.66	33.048	194.7	0.0958
50	1.81	32.899	170.8	0.1320
75	1.96	33.130	154.3	0.1721
100	3.75	33.432	146.1	0.2089
125	2.77	33.374	142.0	0.2451
150	2.48	33.371	139.9	0.2804
175	2.25	33.382	137.3	0.3151
200	2.25	33.430	133.7	0.3491
300	2.89	33.716	117.1	0.4758
400	2.84	33.873	104.9	0.5887
500	3.29	34.073	93.6	0.6908
750	3.07	34.278	76.2	0.9119
1000	2.72	34.391	64.7	1.1012
1250	2.35	34.460	56.5	1.2667
1500	2.17	34.519	50.7	1.4164
1750	2.00	34.562	46.1	1.5551
2000	1.85	34.594	42.5	1.6847
2250	1.72	34.617	39.8	1.8073
2500	1.61	34.636	37.7	1.9244
2750	1.55	34.646	36.5	2.0383
3000	1.50	34.655	35.5	2.1505
3250	1.48	34.660	34.9	2.2619
3500	1.45	34.665	34.4	2.3731

Estimated from CTD record

Table 5. Summary of hydrographic data at Station BC

Date: 16 Aug 83, 15:45-19:00
Depth: 5380m
Latitude: 43°18.2'- 43°17.5'N
Longitude: 154°42.6'-154°42.7'E
Air Temp.: 14.2°C
Weather: Fog
Wind: E - 5.5 m/s
Swell: 3
Sea: 2

Depth	Temp.	Sal.	D.O.	PO_4^{3-}	SiO_2	NO_2^-	NO_3^-	NH_4^+	pH	Alk.
m	°C	‰	ml/l			µg at/l				meq/l
0	15.62	32.762	6.35	0.14	1.4	0.00	0.0	0.32	8.184	
10	14.02	33.012	6.48	0.20	3.8	0.00	0.0	0.18	8.202	
30	8.23	33.153	7.22	0.88	15.6	0.11	9.0	0.61	8.053	
50	6.94	33.293	6.61	1.14	16.8	0.26	10.1	2.45	8.001	
75	1.76	33.153	6.90	2.01	41.0	0.13	24.4	0.50	7.799	
100	1.28	33.159	6.79	2.10	46.9	0.01	27.0	0.11	7.766	
125	1.32	33.207	6.51	2.19	49.9	0.00	27.8	0.10	7.754	
150	1.59	33.315	5.54	2.34	57.9	0.00	30.8	0.06	7.681	
175	2.29	33.497	3.80	2.71	70.6	0.01	35.6	0.08	7.586	
200	2.68	33.610	3.20	2.83	75.0	0.00	36.5	0.02	7.570	
300	3.39	33.871	2.02	2.97	90.2	0.00	39.2	0.03	7.555	
400	3.55	34.019	2.01	3.03	99.2	0.00	40.9	0.11	7.513	
500	3.36	34.114	0.97	3.15	110	0.00	42.4	0.08	7.500	
750	3.05	34.306	0.84	3.15	133	0.00	42.7	0.06	7.478	
1000	2.62	34.393	0.79	3.17	147	0.00	43.3	0.05	7.485	
1250	2.37	34.468	0.93	3.13	154	0.00	43.0	0.04	7.524	
1500	2.19	34.521	1.16	2.93	157	0.00	42.5	0.07	7.530	
1750	2.00	34.561	1.47	2.94	162	0.00	41.9	0.05	7.560	
2000	1.85	34.591	1.73	2.93	164	0.00	41.1	0.05	7.595	
2250	1.72	34.617	2.13	2.78	169	0.00	40.1	0.09	7.613	
2500	1.63	34.636	2.48	2.68	160	0.00	39.1	0.04	7.653	
2750	1.57	34.647	2.73	2.71	157	0.00	38.4	0.06	7.661	
3000	1.52	34.657	2.95	2.67	155	0.00	38.1	0.01	7.687	
3500	1.46	34.670	3.27	2.59	150	0.00	37.0	0.02	7.722	
4011	1.44	34.676	3.47	2.50	148	0.00	36.4	0.11	7.730	

Depth	Temp.	Sal.	δ st	Δ D
m	°C	‰	cl/ton	
0	15.62	32.762	379.4	0.0000
10	15.15	32.801	366.9	0.0373
30	8.79	33.105	231.3	0.0987
50	5.58	33.193	183.0	0.1394
75	2.00	33.081	158.3	0.1818
100	1.42	33.137	150.2	0.2201
125	1.32	33.189	145.6	0.2570
150	1.43	33.272	140.0	0.2926
175	2.18	33.468	130.2	0.3265
200	2.52	33.571	125.1	0.3585
300	3.48	33.866	110.9	0.4775
400	3.55	34.007	100.9	0.5859
500	3.40	34.109	91.8	0.6853
750	3.06	34.291	75.1	0.9029
1000	2.62	34.394	63.6	1.0889
1250	2.37	34.470	55.9	1.2524
1500	2.18	34.522	50.5	1.4013
1750	2.00	34.562	46.0	1.5398
2000	1.84	34.594	42.5	1.6691
2250	1.73	34.616	40.0	1.7919
2500	1.64	34.634	38.0	1.9101
2750	1.57	34.647	36.6	2.0248
3000	1.52	34.657	35.5	2.1374
3250	1.48	34.664	34.6	2.2486
3500	1.46	34.669	34.1	2.3592
3750	1.45	34.674	33.7	2.4700
4000	1.44	34.677	33.4	2.5815

Estimated from CTD record

Table 6. Summary of hydrographic data at Station C-1

Date: 18 Aug 83, 16:57-22:08
Depth: 5450m
Latitude: 44°59.4'- 44°59.9'N
Longitude: 160°00.9'-160°02.8'E
Air Temp.: 12.5°C
Weather: Cloudy
Wind: Wind NE - 9.0 m/s
Swell: 3
Sea: 3

Depth	Temp.	Sal.	D.O.	PO_4^{3-}	SiO_2	NO_2^-	NO_3^-	NH_4^+	pH	Alk.
m	°C	‰	ml/l			µg at/l				meq/l
0	13.90	33.147	6.66	0.26	3.3	0.02	0.4	0.27	8.205	2.245
10	13.76	33.153	6.60	0.21	3.4	0.03	0.1	0.29	8.222	2.266
30	7.11	33.149	6.66	1.36	17.2	0.28	13.0	2.71	7.998	2.262
50	3.65	33.168	6.97	1.71	27.9	0.13	21.3	1.78	7.876	2.258
75	2.66	33.252	6.68	2.01	34.1	0.03	24.7	0.28	7.832	2.261
100	2.06	33.287	6.71	2.00	38.9	0.02	25.7	0.25	7.807	2.267
125	2.57	33.374	6.39	2.01	39.8	0.03	25.4	0.30	7.799	2.271
150	2.48	33.434	5.13	2.22	49.4	0.01	29.8	0.22	7.723	2.280
175	2.62	33.536	4.00	2.41	59.5	0.02	33.8	0.16	7.656	7.296
200	2.84	33.646	3.14	2.73	69.2	0.02	36.7	0.22	7.607	2.314
300	3.19	33.874	1.73	3.07	92.4	0.01	41.3	0.37	7.503	2.333
400	3.32	34.063	0.87	3.10	110	0.01	43.9	0.29	7.472	2.352
500	3.19	34.160	0.72	3.25	110	0.01	43.9	0.22	7.477	2.369
750	2.88	34.326	0.74	3.28	129	0.01	43.8	0.18	7.519	2.398
1000	2.57	34.424	0.68	3.31	143	0.00	44.2	0.14	7.491	2.411
1250	2.31	34.486	0.90	3.28	147	0.00	43.5	0.15	7.525	2.424
1500	2.09	34.541	1.20	3.24	157	0.00	42.9	0.16	7.546	2.437
1750	1.94	34.586	1.50	3.18	155	0.01	42.0	0.25	7.582	2.449
2000	1.80	34.607	1.86	3.04	149	0.01	41.2	0.19	7.607	2.471
2250	1.69	34.633	2.24	3.02	148	0.00	40.1	0.13	7.635	2.467
2500	1.61	34.644	2.54	2.95	148	0.00	39.4	0.16	7.681	2.476
2750	1.55	34.656	2.79	2.54	141	0.00	38.7	0.11	7.693	2.484
3000	1.51	34.666	3.06	2.52	138	0.00	38.1	0.12	7.699	-
3250	1.47	34.671	3.20	2.50	135	0.00	37.6	0.13	7.709	-
3500	1.45	34.677	3.34	2.51	132	0.00	37.2	0.11	7.723	2.481
3750	1.44	34.688	3.44	2.56	132	0.01	36.9	0.23	7.732	2.470
4000	1.44	34.683	3.51	2.59	132	0.00	36.6	0.09	7.733	2.466
4250	1.45	34.684	3.56	2.50	137	0.00	36.4	0.06	7.738	2.464
4500	1.46	34.686	3.62	2.62	136	0.01	36.2	0.09	7.744	2.468
4750	1.47	34.686	3.66	2.74	140	0.00	36.1	0.00	7.750	2.460
5000	1.50	34.689	3.67	2.69	144	0.01	35.8	0.09	7.758	2.466

Depth	Temp.	Sal.	δ st	Δ D
m	°C	‰	cl/ton	
0	13.66	33.135	312.4	0.0000
10	13.69	33.134	313.1	0.0313
30	7.74	33.012	223.5	0.0852
50	5.66	33.213	182.4	0.1255
75	2.65	33.170	156.5	0.1671
100	2.25	33.275	145.5	0.2043
125	2.53	33.381	139.6	0.2400
150	2.44	33.433	134.9	0.2744
175	2.62	33.537	128.5	0.3074
200	2.78	33.625	123.1	0.3390
300	3.25	33.888	107.2	0.4552
400	3.29	34.041	96.1	0.5593
500	3.21	34.147	87.3	0.6535
750	2.95	34.312	72.6	0.8621
1000	2.60	34.410	62.2	1.0429
1250	2.31	34.481	54.6	1.2029
1500	2.09	34.535	48.8	1.3474
1750	1.94	34.574	44.7	1.4815
2000	1.80	34.602	41.6	1.6076
2250	1.69	34.624	39.1	1.7277
2500	1.61	34.640	37.4	1.8435
2750	1.55	34.651	36.1	1.9566
3000	1.50	34.661	35.1	2.0678
3250	1.47	34.667	34.4	2.1780
3500	1.45	34.673	33.8	2.2878
3750	1.44	34.677	33.4	2.3978
4000	1.44	34.679	33.2	2.5086
4250	1.45	34.682	33.1	2.6206
4500	1.46	34.683	33.0	2.7341
4750	1.47	34.684	33.0	2.8495
5000	1.50	34.685	33.1	2.9671

Estimated from CTD record

Table 7. Summary of hydrographic data at Station C-2

Date: 23 Aug 83, 21:08 - 24 Aug 83, 01:14
Depth: 5480m
Latitude: 44°58.7'- 44°58.0'N
Longitude: 160°10.7'-160°13.5'E
Air Temp.: 11.5°C
Weather: Cloudy
Wind: NW - 2.5 m/s
Swell: 3
Sea: 1

Depth	Temp.	Sal.	D.O.	PO_4^{3-}	SiO_2	NO_2^-	NO_3^-	NH_4^+	pH	Alk.
m	°C	‰	ml/l			µg at/l				meq/l
0	13.40	33.247	6.24	0.27	2.3	0.04	1.2	0.36	-	-
10	13.31	33.230	6.21	0.28	2.4	0.03	1.3	0.19	8.163	2.285
30	8.04	33.179	6.71	1.18	13.1	0.17	9.1	1.41	8.030	2.284
50	3.46	33.095	7.09	1.80	31.1	0.84	21.2	1.00	7.855	2.274
75	1.50	33.124	7.13	2.09	39.5	0.01	27.5	0.14	7.785	2.278
100	2.46	33.164	6.29	2.12	42.8	0.01	28.2	0.10	7.763	2.279
125	1.46	33.250	4.59	2.21	46.7	0.01	29.5	0.13	7.743	2.283
150	1.90	33.351	4.35	2.33	54.4	0.01	32.8	0.12	7.681	2.290
175	2.41	33.517	3.23	2.60	63.0	0.01	36.4	0.21	7.624	2.307
200	2.61	33.608	-	2.75	68.3	0.01	38.5	0.10	7.566	2.312
300	3.15	33.875	1.45	2.91	90.4	0.00	43.2	0.07	7.486	2.336
400	3.35	34.026	1.12	3.06	97.8	0.00	43.7	0.13	7.487	2.356
500	3.24	34.136	0.51	3.23	113	0.00	45.8	0.12	7.452	2.377
750	2.95	34.307	0.78	3.20	135	0.00	44.2	0.12	7.501	2.412
1000	2.62	34.396	0.52	3.18	141	0.00	45.4	0.14	7.500	2.421
1250	2.33	34.472	0.87	3.02	147	0.00	44.4	0.10	7.520	2.432
1500	2.12	34.532	1.14	2.99	152	0.00	43.7	0.17	7.542	2.440
1750	1.95	34.575	1.46	2.96	155	0.00	43.0	0.07	7.569	2.446
2000	1.83	34.602	1.70	2.87	155	0.00	42.1	0.11	7.610	2.454
2250	1.71	34.625	2.24	2.74	147	0.00	41.1	0.05	7.655	2.462
2500	1.62	34.641	2.56	2.71	146	0.00	40.1	0.08	7.660	2.459
2750	1.55	34.654	2.80	2.69	143	0.01	39.1	0.06	7.701	2.458
3000	1.51	34.674	3.29	2.59	-	0.00	39.6	0.07	7.630	-
3250	1.47	34.664	3.20	2.52	135	0.00	38.4	0.05	7.702	2.455
3500	1.45	34.675	3.31	2.45	133	0.00	37.9	0.05	7.714	2.456
3750	1.44	34.677	3.42	2.52	132	0.00	37.6	0.02	7.720	2.454
4000	1.44	-	-	2.66	-	0.00	38.1	0.06	7.601	-
4250	1.45	34.684	3.58	2.41	130	0.00	37.2	0.02	7.731	2.455
4500	1.46	34.685	3.66	2.45	134	0.01	36.9	0.03	7.733	2.453
4750	1.48	34.686	3.70	2.42	132	0.00	36.9	0.00	7.737	2.451
5011	1.50	34.688	3.70	2.44	133	0.00	36.6	0.01	7.739	2.454

Depth	Temp.*	Sal.	δ st	Δ D
m	°C	‰	cl/ton	
0	13.12	33.240	294.4	0.0000
10	13.12	33.241	294.3	0.0294
30	12.64	33.115	294.6	0.0884
50	5.31	32.995	194.8	0.1348
75	1.99	33.092	157.4	0.1784
100	2.00	33.217	148.0	0.2164
125	1.56	33.220	144.8	0.2530
150	1.85	33.346	137.1	0.2882
175	2.50	33.541	127.2	0.3214
200	2.63	33.625	121.9	0.3526
300	3.36	33.913	106.2	0.4675
400	3.27	34.040	95.9	0.5708
500	3.20	34.158	86.4	0.6648
750	2.94	34.325	71.5	0.8699
1000	2.58	34.413	61.9	1.0483
1250	2.33	34.478	54.9	1.2080
1500	2.12	34.527	49.6	1.3544
1750	1.96	34.567	45.5	1.4906
2000	1.84	34.596	42.3	1.6189
2250	1.71	34.621	39.5	1.7407
2500	1.62	34.638	37.6	1.8576
2750	1.56	34.650	36.2	1.9712
3000	1.51	34.660	35.1	2.0827
3250	1.48	34.666	34.4	2.1931
3500	1.46	34.671	33.9	2.3033
3750	1.45	34.675	33.6	2.4137
4000	1.44	34.679	33.3	2.5249
4250	1.45	34.681	33.1	2.6370
4500	1.46	34.683	33.1	2.7506
4750	1.48	34.683	33.1	2.8662
5000	1.50	34.685	33.2	2.9839

*Estimated from CTD record

Table 8. Summary of hydrographic data at Station D

Date: 4 Sep 83, 20:19-23:19
Depth: 5600m
Latitude: 35°01.9'- 34°58.2'N
Longitude: 154°46.2'-154°46.7'E
Air Temp.: 21.6°C
Weather: Fine
Wind: E - 8.0m/s
Swell: 1
Sea: 3

Depth	Temp.	Sal.	D.O.	PO_4^{3-}	SiO_2	NO_2^-	NO_3^-	NH_4^+	pH	Alk.
m	°C	‰	ml/l			µg at/l				meq/l
0	25.35	34.289	4.68	0.02	1.5	0.02	0.0	0.12	8.236	2.287
10	25.40	34.243	4.68	0.01	1.5	0.02	0.0	0.13	8.250	2.284
30	25.41	34.220	4.66	0.03	2.0	0.02	0.0	0.07	8.257	2.288
50	25.40	34.245	4.63	0.03	1.7	0.03	0.0	0.09	8.248	2.287
75	20.66	34.710	4.25	0.31	4.7	0.12	4.5	0.07	8.147	2.316
100	19.70	34.755	4.03	0.41	6.0	0.05	5.7	0.08	8.143	2.321
125	18.42	34.764	4.09	0.48	6.7	0.03	6.7	0.08	8.117	2.317
150	17.25	34.748	4.37	0.43	7.0	0.03	4.4	0.12	8.116	2.316
175	15.93	34.683	4.05	0.64	10.7	0.03	9.8	0.10	8.068	2.316
200	15.00	34.637	4.24	0.69	10.9	0.04	10.4	0.11	8.062	2.312
300	10.56	34.284	4.93	1.00	17.9	0.04	14.8	0.08	7.978	2.314
400	7.29	33.974	5.18	1.45	24.6	0.01	19.7	0.07	7.888	2.305
500	6.07	34.004	3.44	2.09	48.5	0.01	30.0	0.05	7.740	2.321
750	4.32	34.186	1.57	2.75	86.2	0.01	41.1	0.04	7.587	2.364
1000	3.39	34.334	1.03	3.00	114	0.01	44.3	0.05	7.538	2.397
1250	2.79	34.436	0.95	3.04	129	0.01	45.2	0.07	7.534	2.414
1500	2.41	34.506	1.04	3.11	139	0.00	45.3	0.05	7.536	2.433
1750	2.15	34.554	1.34	3.06	144	0.00	44.5	0.04	7.562	4.443
2000	1.95	34.593	1.65	3.01	146	0.00	43.8	0.05	7.574	2.450
2250	1.80	34.619	2.02	2.89	149	0.00	42.7	0.04	7.628	2.452
2500	1.68	34.642	2.42	2.80	144	0.00	41.4	0.02	7.658	2.452
2750	1.59	34.654	2.71	2.61	142	0.00	40.6	0.02	7.677	2.455
3000	1.54	34.663	2.95	2.57	138	0.00	40.0	0.06	7.688	2.456
3500	1.47	34.676	3.24	2.51	136	0.00	38.8	0.00	7.705	2.456
4000	1.44	34.682	3.49	2.48	132	0.01	38.0	0.03	7.718	2.452

Depth	Temp.	Sal.	δ st	Δ D
m	°C	‰	cl/ton	
0	25.35	34.071	530.3	0.0000
10	25.37	34.128	526.8	0.0529
30	25.38	34.180	523.3	0.1580
50	25.38	34.194	522.2	0.2629
75	20.87	34.664	364.2	0.3682
100	19.71	34.733	329.9	0.4552
125	18.37	34.722	298.2	0.5347
150	17.06	34.710	268.8	0.6067
175	15.40	34.552	243.9	0.6720
200	13.92	34.452	220.9	0.7315
300	10.83	34.323	173.5	0.9312
400	7.54	33.978	148.8	1.0980
500	6.11	33.980	130.2	1.2443
750	4.37	34.182	95.7	1.5389
1000	3.40	34.324	75.7	1.7688
1250	2.80	34.425	62.8	1.9592
1500	2.42	34.494	54.5	2.1237
1750	2.14	34.545	48.4	2.2719
2000	1.94	34.580	44.3	2.4078
2250	1.78	34.608	41.0	2.5350
2500	1.68	34.628	38.7	2.6558
2750	1.59	34.643	37.0	2.7723
3000	1.54	34.652	36.0	2.8863
3250	1.50	34.660	35.1	2.9992
3500	1.47	34.666	34.4	3.1111
3750	1.46	34.670	34.1	3.2230
4000	1.44	34.675	33.6	3.3351

Estimated from CTD record

Table 9. Summary of hydrographic data at Station E

Date: 7 Sep 83, 10:16-14:26
Depth: 5750m
Latitude: 28°00.3'- 28°00.8'N
Longitude: 152°58.1'-152°58.1'E
Air Temp.: 25.8°C
Weather: Cloudy
Wind: ENE -10.0 m/s
Swell: 3
Sea: 3

Depth	Temp.	Sal.	D.O.	PO_4^{3-}	SiO_2	NO_2^-	NO_3^-	NH_4^+	pH	Alk.
m	°C	‰	ml/l	μg at/l						meq/l
0	26.60	34.605	4.62	0.00	2.2	0.01	0.0	0.18	8.237	2.305
10	26.68	34.601	4.60	0.00	2.2	0.01	0.0	0.06	8.237	2.307
30	23.22	34.596	5.25	0.01	2.0	0.01	0.0	0.00	8.242	2.306
50	21.92	34.617	5.20	0.02	2.3	0.01	0.0	0.01	8.232	2.305
75	20.46	34.735	4.98	0.06	3.5	0.01	0.0	0.02	8.202	2.313
100	19.41	34.806	5.18	0.10	2.9	0.06	0.4	0.03	8.191	2.312
125	18.45	34.790	5.06	0.30	3.3	0.11	1.0	0.03	8.176	2.316
150	17.79	34.791	4.88	0.20	3.0	0.02	2.8	0.06	8.157	2.318
175	17.50	34.787	4.92	0.22	3.5	0.01	3.2	0.07	8.155	2.316
200	17.22	34.783	4.94	0.24	4.0	0.01	3.4	0.06	8.146	2.317
300	16.67	34.776	4.97	0.30	4.7	0.00	4.2	0.12	8.135	2.315
400	15.13	34.664	4.51	0.56	9.4	0.00	8.7	0.03	8.065	2.311
500	12.58	34.467	4.19	0.91	18.5	0.00	14.1	0.08	7.889	2.308
750	5.82	34.025	3.06	2.16	59.1	0.00	30.9	0.08	7.690	2.325
1000	3.98	34.255	1.09	2.90	105	0.00	41.6	0.14	7.527	2.378
1250	3.10	34.418	0.95	2.95	128	0.00	43.3	0.03	7.522	2.417
1500	2.56	34.506	1.14	3.01	142	0.00	43.1	0.08	7.542	2.430
1750	2.19	34.563	1.54	2.97	149	0.00	42.4	0.07	7.580	2.444
2000	1.95	34.601	1.97	2.86	150	0.00	41.1	0.08	7.617	2.449
2250	1.78	34.627	2.41	2.76	149	0.00	39.6	0.00	7.636	2.451
2500	1.69	34.643	2.66	2.68	147	0.00	39.2	0.06	7.664	2.452
2750	1.62	34.655	2.84	2.59	143	0.00	38.6	0.05	7.672	2.454
3000	1.56	34.664	3.08	2.58	143	0.00	38.1	0.05	7.688	2.456
3250	1.51	34.672	3.16	2.56	142	0.00	37.6	0.04	7.698	2.456
3500	1.48	34.674	3.35	2.52	142	0.00	37.2	0.06	7.707	2.459
3750	1.47	34.678	3.41	2.50	140	0.00	37.0	0.03	7.713	2.457
4000	1.46	34.683	3.52	2.36	139	0.00	36.7	0.10	7.720	2.455
4250	1.45	34.686	3.61	2.35	137	0.00	36.4	0.07	7.726	2.451
4500	1.46	34.689	3.64	2.36	137	0.00	35.8	0.09	7.727	2.454
4750	1.47	34.690	3.70	2.40	134	0.00	36.2	0.15	7.732	2.451
5000	1.48	-	3.88	2.35	133	0.00	35.9	0.20	7.732	2.449

Depth	Temp.*	Sal.	δ st	Δ D
m	°C	‰	cl/ton	
0	26.63	34.599	530.2	0.0000
10	26.63	34.599	530.2	0.0531
30	23.14	34.568	431.7	0.1541
50	22.03	34.599	399.4	0.2372
75	20.42	34.727	348.2	0.3309
100	19.20	34.787	313.6	0.4140
125	18.27	34.778	291.9	0.4907
150	17.76	34.784	279.4	0.5633
175	17.44	34.781	272.3	0.6336
200	17.19	34.780	266.6	0.7025
300	16.64	34.768	255.2	0.9710
400	14.96	34.636	228.6	1.2258
500	12.46	34.432	194.4	1.4501
750	5.74	34.020	122.8	1.8602
1000	3.94	34.262	85.5	2.1348
1250	3.10	34.414	66.2	2.3450
1500	2.58	34.501	55.3	2.5170
1750	2.21	34.554	48.3	2.6670
2000	1.97	34.593	43.5	2.8023
2250	1.78	34.623	39.9	2.9273
2500	1.69	34.638	38.1	3.0461
2750	1.63	34.648	36.8	3.1621
3000	1.57	34.658	35.7	3.2761
3250	1.52	34.665	34.8	3.3887
3500	1.49	34.671	34.2	3.5004
3750	1.47	34.675	33.7	3.6120
4000	1.46	34.679	33.3	3.7238
4250	1.45	34.682	33.1	3.8362
4500	1.46	34.684	33.0	3.9497
4750	1.47	34.686	32.9	4.0647
5000	1.48	34.687	32.9	4.1815

* Estimated from CTD record

Table 10. Concentrations of chlorophyll *a* and phaephytin

Station B

Depth	Chl.a	Phaeo	acid fac
m	µg/l		
0	0.33	0.04	1.98
10	0.46	0.01	2.07
30	1.53	0.42	1.86
50	0.16	0.19	1.49
75	0.03	0.14	1.19
100	0.01	0.14	1.10
125	0.01	0.11	1.08
150	0.01	0.13	1.08
175	0.01	0.13	1.06
200	0.01	0.13	1.10

Station BC

Depth	Chl.a	Phaeo	acid fac
m	µg/l		
0	0.80	0.33	1.78
10	0.95	0.31	1.83
30	2.17	0.79	1.81
50	0.95	0.42	1.76
75	0.09	0.11	1.49
100	0.05	0.12	1.33
125	0.03	0.12	1.19
150	0.01	0.14	1.08
175	0.01	0.16	1.06
200	0.00	0.15	1.03

Station C1

Depth	Chl.a	Phaeo	acid fac
m	µg/l		
0	1.69	0.55	1.83
10	1.64	0.54	1.83
30	0.60	0.36	1.69
50	0.17	0.18	1.54
75	0.09	0.14	1.42
100	0.03	0.15	1.20
125	0.03	0.16	1.16
150	0.01	0.13	1.09
175	0.01	0.14	1.09
200	0.01	0.14	1.07

Station C2

Depth	Chl.a	Phaeo	acid fac
m	µg/l		
0	0.93	0.37	1.79
10	1.03	0.29	1.86
30	1.03	0.41	1.79
50	0.27	0.19	1.64
75	0.05	0.13	1.33
100	0.03	0.12	1.23
125	0.01	0.12	1.09
150	0.01	0.13	1.07
175	-	-	-
200	0.01	0.14	1.06

Station D

Depth	Chl.a	Phaeo	acid fac
m	µg/l		
0	0.19	0.12	1.67
10	0.14	0.07	1.74
30	0.16	0.05	1.83
50	0.16	0.05	1.85
75	0.60	0.45	1.63
100	0.30	0.26	1.59
125	0.06	0.08	1.49
150	0.03	0.05	1.39
175	0.01	0.04	1.23
200	0.03	0.05	1.43

Station E

Depth	Chl.a	Phaeo	acid fac
m	µg/l		
0	0.08	0.02	1.91
10	0.09	0.02	1.92
30	0.12	0.02	1.92
50	0.13	0.03	1.91
75	0.25	0.13	1.71
100	0.55	0.43	1.62
125	0.22	0.18	1.61
150	0.05	0.05	1.54
175	0.04	0.05	1.50
200	0.01	0.02	1.40

Hydrographic characteristics

T. Nakai, H. Otobe and A. Hattori

1. Subarctic region (Stations B, BC and C)

Stations B, BC and C (Fig. 1) are located in the subpolar gyre of the western North Pacific where the Oyashio Current flows southwestward. Although the observations were made late in August, the water stratification was commonly maintained as shown by the vertical profiles of temperature, salinity and sigma t (Figs. 2-4). The strong seasonal thermocline was at about 20m and the dichothermal water was found in the subsurface layer (50-150m). The salinity was low at the surface and increased with depth. The dissolved oxygen content at the surface was relatively high and the maximum content was observed just below the thermocline. The vertical profile of oxygen saturation shows a similar pattern (Figs. 3 and 4). An oxygen minimum with less than 1 ml O_2/l was found at a depth between 700 and 900m (Figs. 2-4).

The salinity profile near the surface (shallower than 50m) at Station B (Fig. 2) shows a complex fine structure compared with those at the other stations (Figs. 3 and 4). The presence of some oceanic current at the vicinity of Station B was suggested. This current may be an offshore branch of the Oyashio Current. Judging from the T-S diagrams (Fig. 7), the watermass of these stations can be characterized as the Pacific Subarctic Water.

2. Subtropical region (Stations D and E)

At Station E, the seasonal thermocline and the main thermocline were located at about 30 and 550m, respectively (Fig. 6). The North Pacific Subtropical Mode Water with temperature of around 17°C and salinity of about 34.75‰ was observed between the two thermoclines. The salinity minimum centered at a depth of 725m can be attributed to the North Pacific Intermediate Water.

At Station D, the thickness of the Subtropical Mode Water was much thinner and the depth of the salinity minimum (~500m) was shallower than at Station E (Fig. 5). However, the core of the salinity minimum water was located on an isanosteric surface of 130 cl/ton as observed at Station E (Fig. 7). The vertical profiles of temperature, salinity and dissolved oxygen at Station D show rugged traces, suggesting the occurrence of water mixing induced by the strong current. Station D was probably located in the area of the Kuroshio extension, and Station E near the center of the subtropical gyre (cf. Fig. 8).

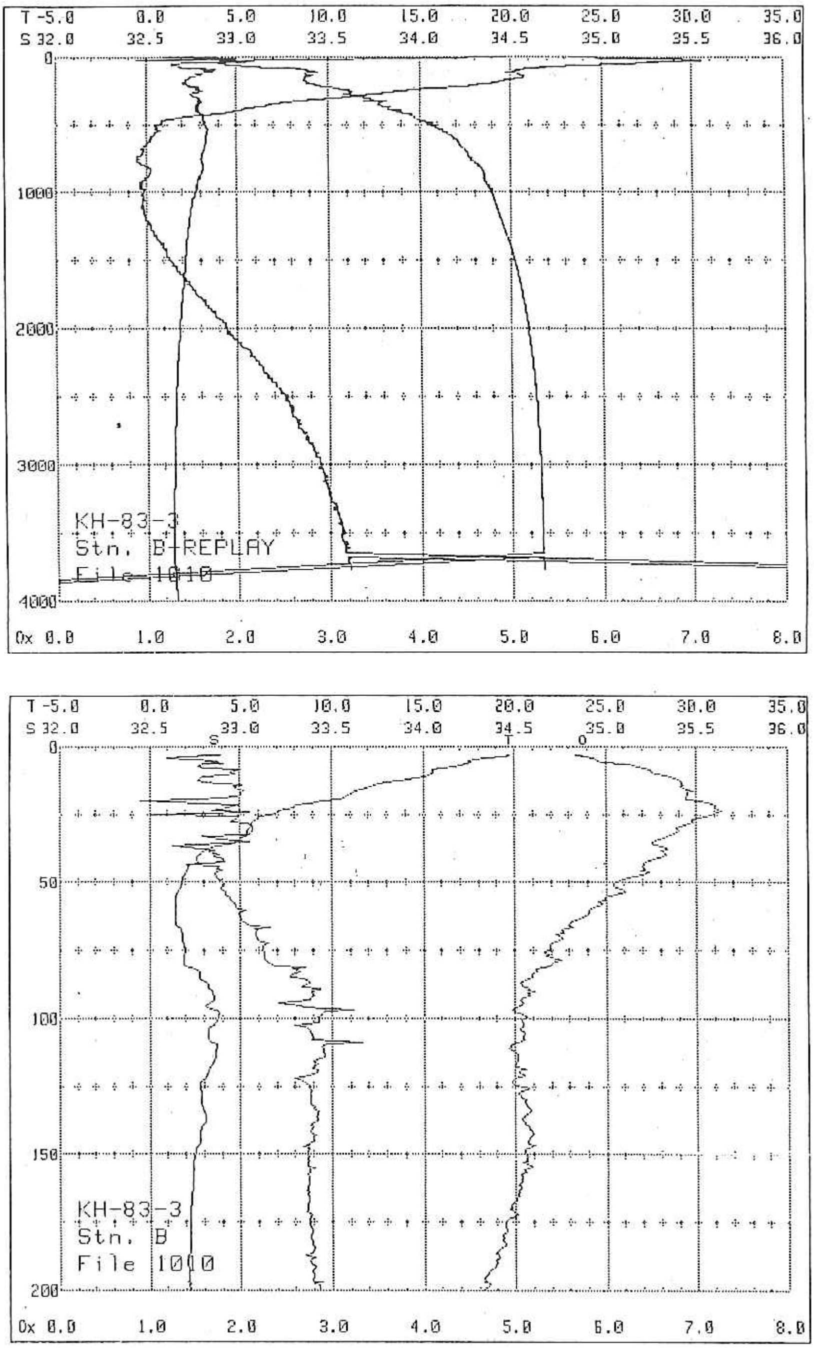
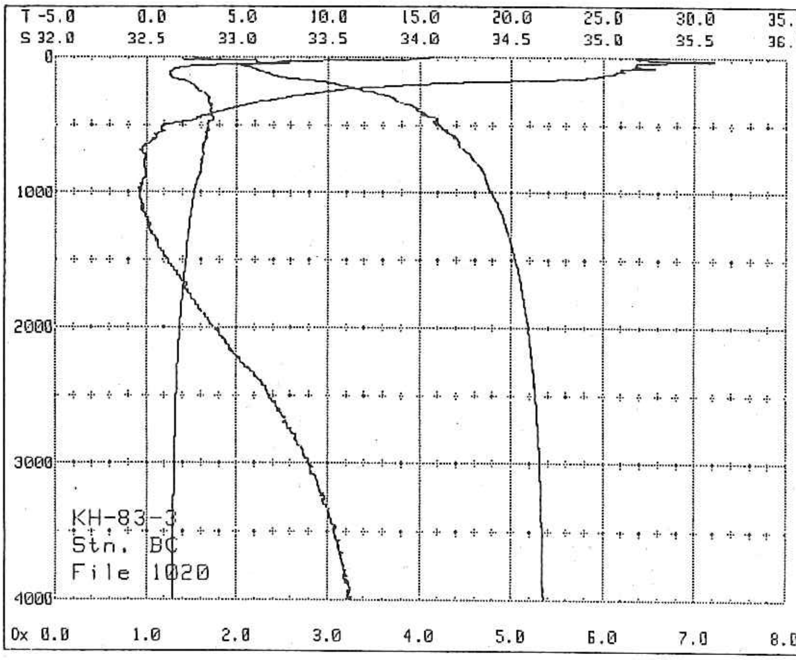


Fig. 2 Vertical profiles of temperature, salinity and dissolved oxygen at Station B. Downward CTDO record; A, regular scale; B, expanded scale.



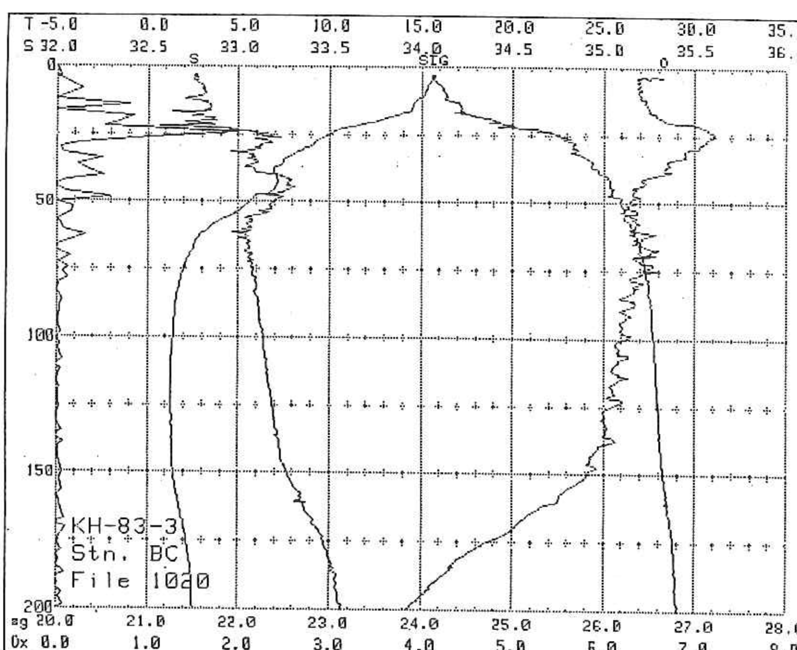
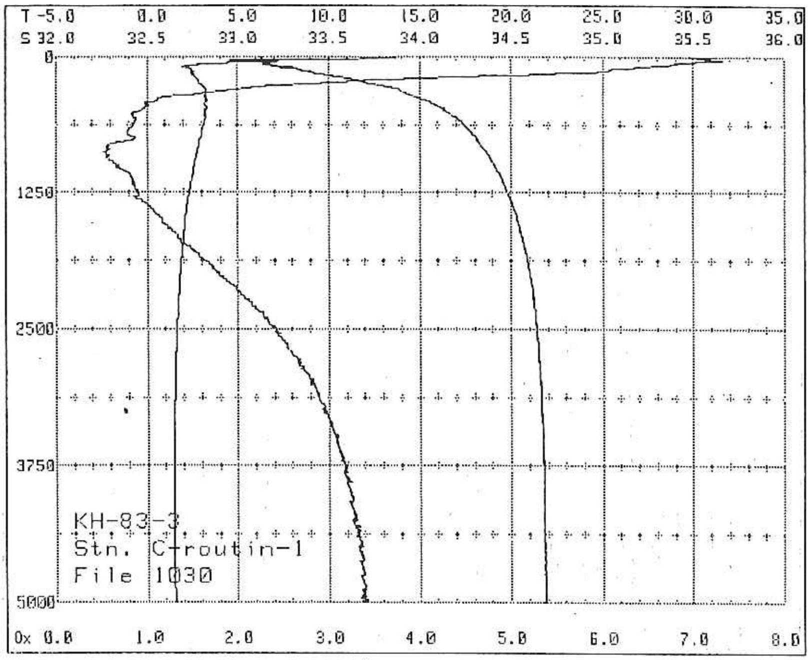


Fig. 3 Vertical profiles of temperature, salinity and dissolved oxygen at Station BC. Downward CTDO record; A, regular scale; B, expanded scale. In B, sigma t and oxygen saturation computer-calculated on the basis of temperature and salinity values are also shown.



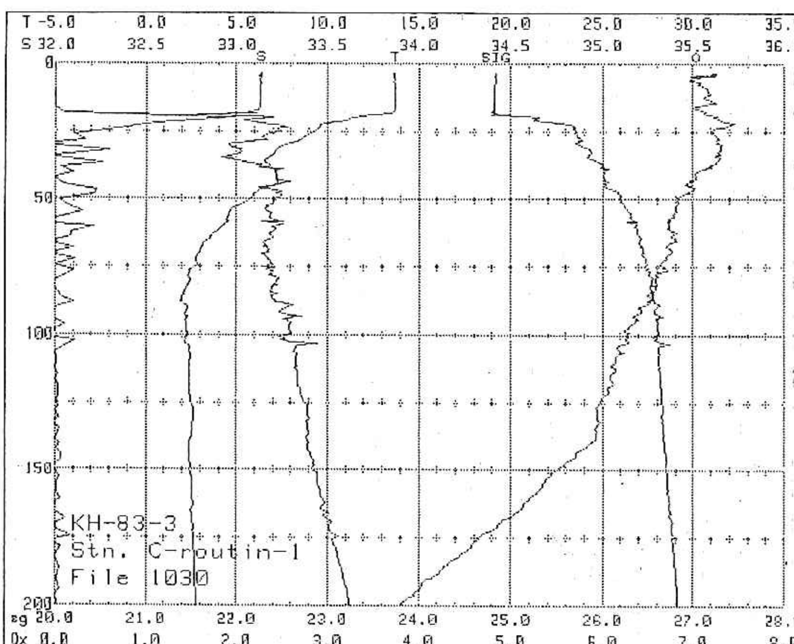


Fig. 4 Vertical profiles of temperature, salinity and dissolved oxygen at Station C. Downward CTDO record; A, regular scale; B, expanded scale. In B, sigma t and oxygen saturation computer-calculated on the basis of temperature and salinity values are also shown.

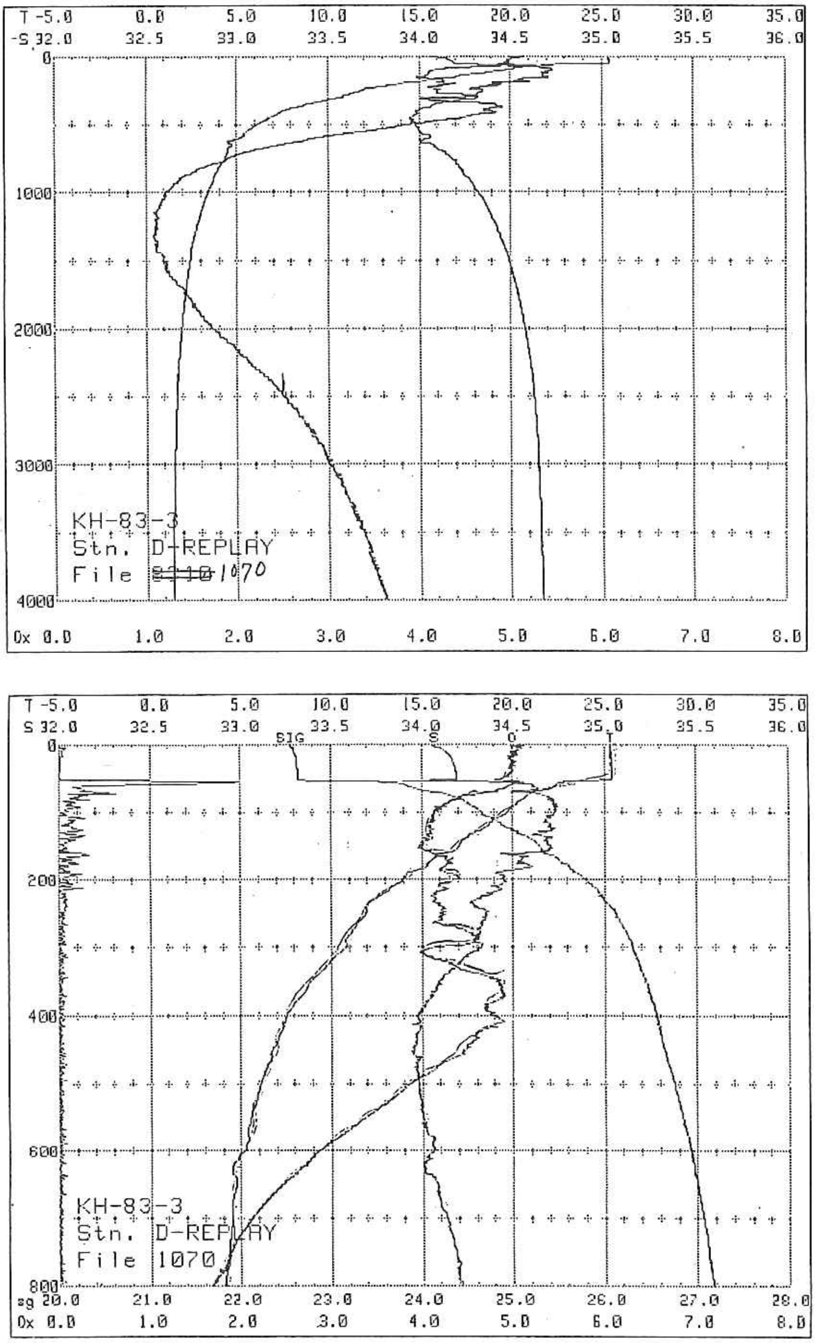


Fig. 5 Vertical profiles of temperature, salinity and dissolved oxygen at Station D. Downward CTDO record; A, regular scale record; B, expanded scale. In B, sigma t and oxygen saturation computer-calculated on the basis of temperature and salinity values are also shown.

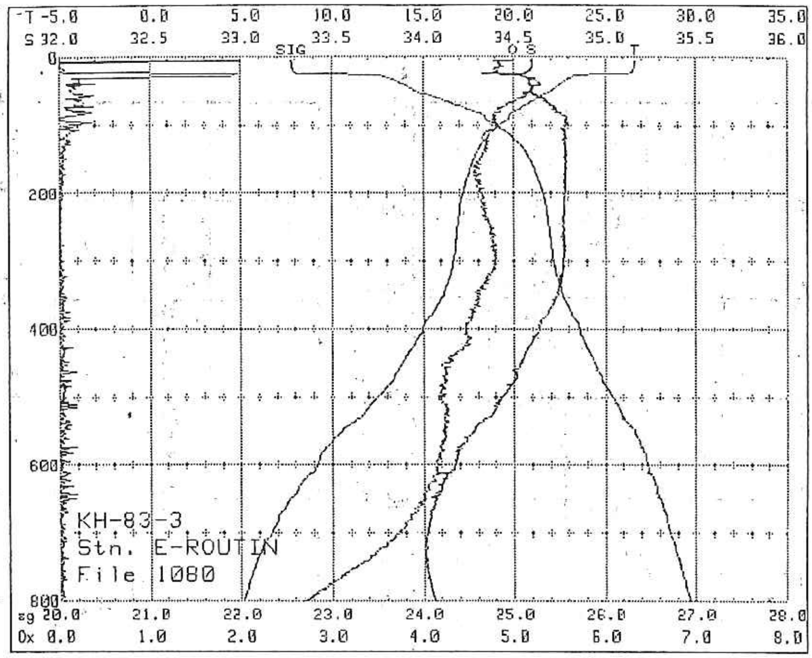


Fig. 6 Vertical profiles of temperature, salinity, sigma t, dissolved oxygen and percentage oxygen saturation at Station E. Downward CTDO record.

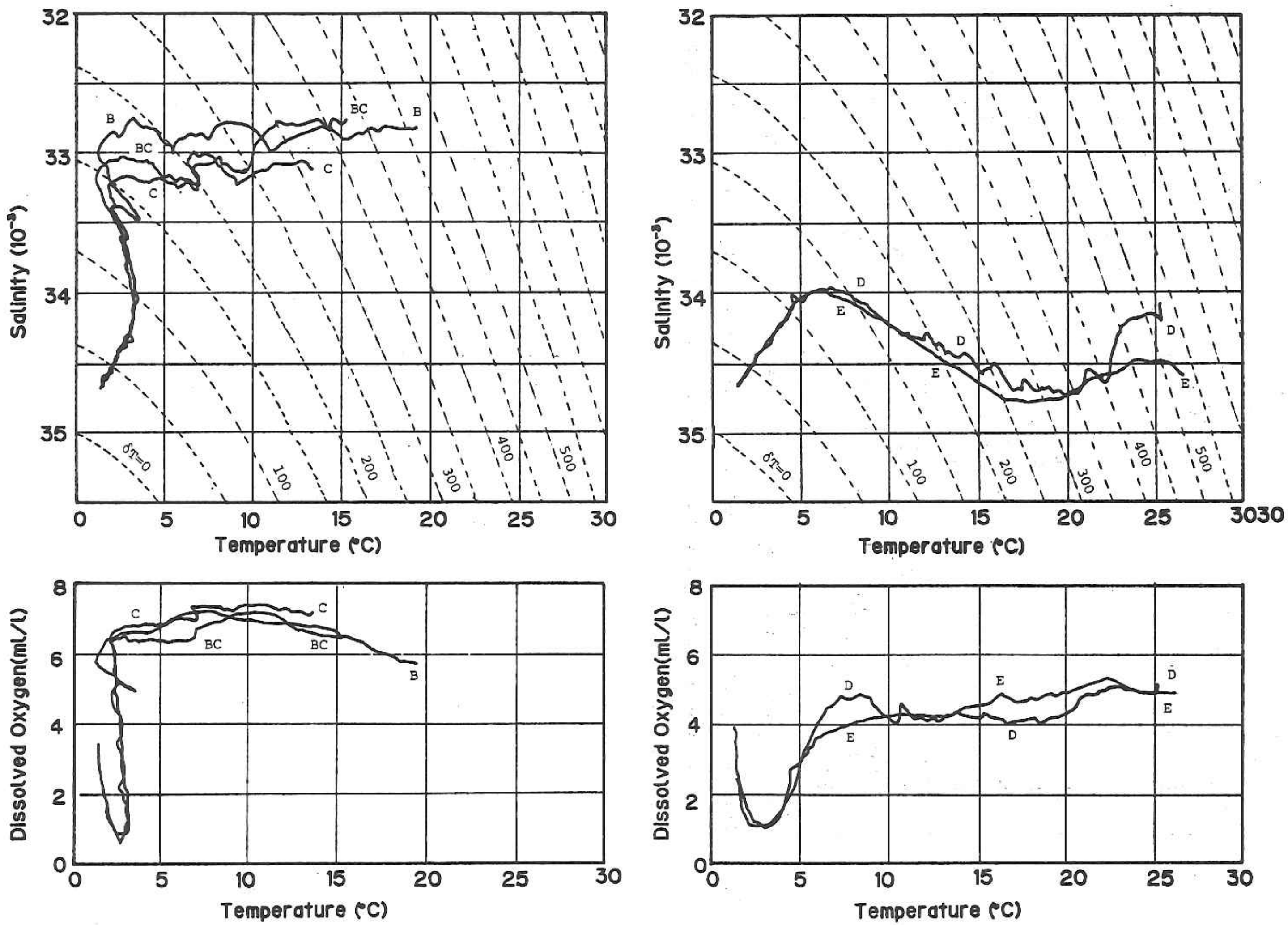


Fig. 7 T-S and T-O_2 diagrams at Stations B, BC and C (left) and at Stations D and E (right).

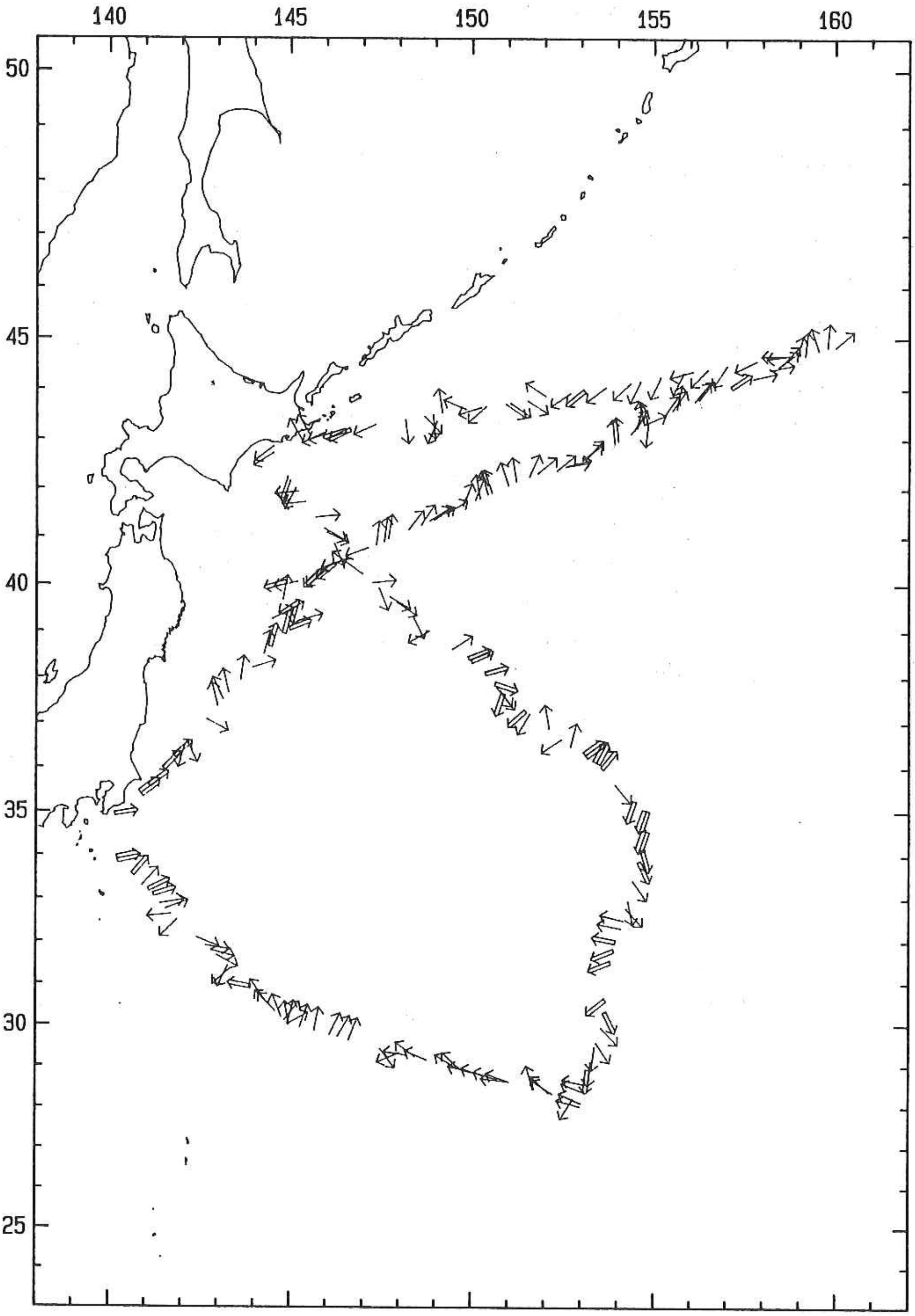


Fig. 8 Surface currents estimated from the ship's drift obtained by a Navy Navigation Satellite System.

Radiation measurement and heat flux across the sea surface

H. Otobe

Downward fluxes of short- and long-wave radiations were measured directly on board in order to estimate the heat budget in the surface water of the subpolar and subtropical gyres in the western North Pacific. A short-wave sensor (pyranometer Model S-185, Ishikawa Sangyo Co., Tokyo) and a long-wave sensor (Ishikawa Radiometer Model RL-5) mounted on gimbals were installed on the handrail of the upper bridge of the vessel.

Heat flux across the sea surface (Q) is given by

$$Q = Rn - (\ell E - H) \tag{1}$$

and

$$Rn = (1-r)S\downarrow - \varepsilon(\sigma T^4 - L\downarrow), \tag{2}$$

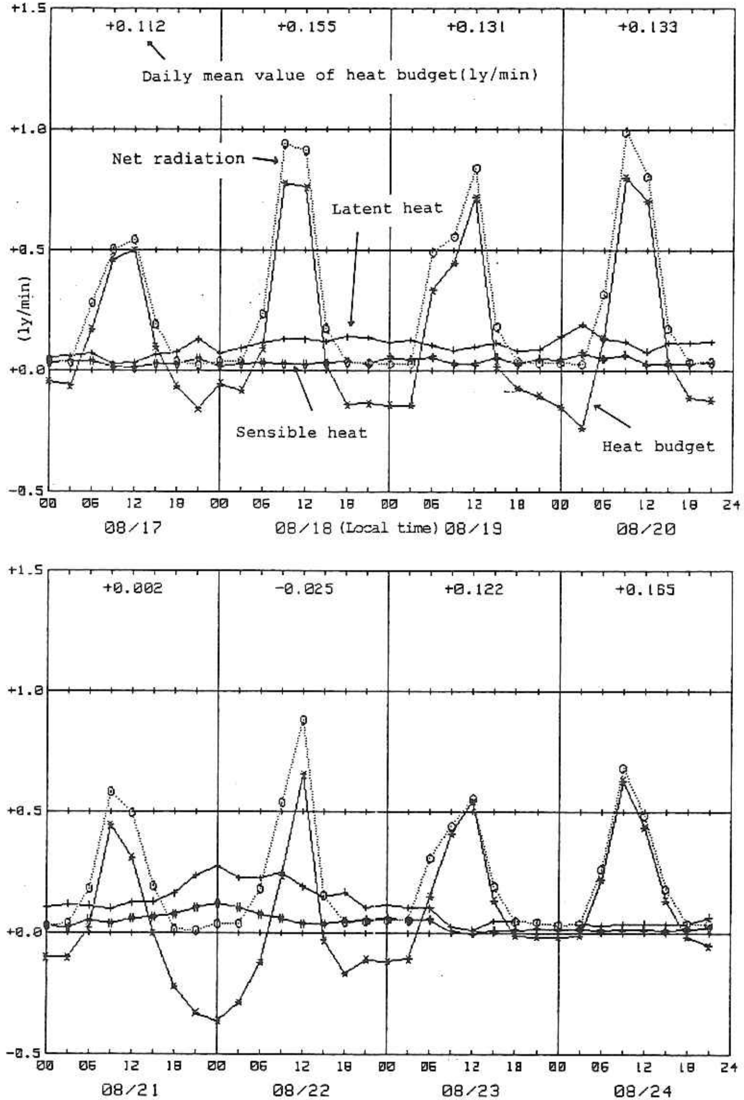
where Rn is the net radiation flux, ℓE latent heat flux, H sensible heat flux, r albedo, T sea surface temperature, ε emissivity of sea water, and σ Stefan-Boltzman constant. ℓE and H were estimated by the aerodynamic bulk method (Kondo, 1975) using the routine meteorological data obtained at three-hour intervals. The r values given by Payne (1972) was used.

The obtained results are shown in Fig. 9.

References

Kondo J. (1975) Air-sea bulk transfer coefficients in diabatic condition. Boundary-Layer Meteorol., 9, 91-112.

Payne R.E. (1972) Albedo of the sea surface. J. Atmos. Sci., 29, 959-970.



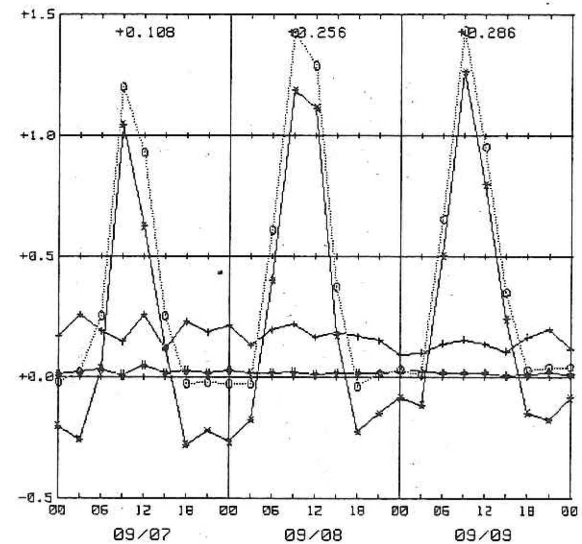


Fig. 9 Temporal variations of the heat flux and it's components plotted at 3-hour intervals for the periods of 17-24 August 1983 at Station C in the subpolar gyre region and 7-9 September 1983 at Station E in the subtropical gyre region.

Calibration of a Beckman dissolved oxygen sensor

T. Nakai and H. Otobe

A cast of CTDO with RMS (rosette multi sampler) was made at Station C in order to collect data for calibrating a Beckman dissolved oxygen sensor which forms an optional component of a Neil Brown Mark III CTD system. The calibration was made against oxygen values obtained by the Winkler method using discrete depth water samples collected during the same cast (cf. page 8)

Since the power supply to the oxygen sensor from the deck unit must be cut off during the period of triggering the RMS, we investigated the time required for restoration to regular operational conditions after the resupply of the power. The minimum time was found to be 2 minutes.

Areal and temporal variations of nutrients distribution in the shallow waters of the western North Pacific in summer

T. Saino, H. Otobe, T. Nakai, T. Ooba , T Ishimaru,
J. Kanda and A. Hattori

Vertical distributions of ammonium, nitrite, nitrate and phosphate were monitored together with other environmental parameters (e.g. temperature, salinity, dissolved oxygen, underwater irradiance, beam attenuation coefficient, in vivo fluorescence of chlorophyll *a*) at each station. Emphasis was placed on the areal and temporal variation in the vertical distribution of nutrients and environmental parameters at two representative stations located in subarctic (Sta. C) and subtropical (Sta. E) areas of the western North Pacific.

Water samples were collected from 11 depths (<200 m) by using a newly developed multiparameter profiler/sampler (OCTOPUS; Ishimaru et al., 1984). Nutrients were determined immediately after the water samplings by using a Technicon Autoanalyser II. Portions of seawater samples were shared for phytoplankton enumeration (T. Ishimaru). At some stations, salinity, dissolved oxygen and chlorophyll *a* were also determined using the same water samples for calibration of the OCTOPUS sensors.

A grid survey composed of 9 stations (Stas. G1-G9) was conducted at intervals of 10 nautical miles around the Station C while approaching the station. During stay at Station C for 6 days, 9 profiles (Stas. C1-C9) were obtained. On leaving the Station C, 5 stations (Stas. G10-G14) were occupied along a line at 2.5 nautical miles intervals. Ten profiles were obtained for 3 days at Station E.

Ship positions where OCTOPUS profiles were obtained are summarized in Table 11.

Reference

Ishimaru, T., H. Otobe, T. Saino, H. Hasumoto and T. Nakai (1984). OCTOPUS, an octo parameter underwater sensor, for use in biological oceanography studies. J. Oceanogr. Soc. Japan, 40, 207-212.

Table 11. Ship position of the OCTOPUS casts

No.	Name	Latitude	Longitude	Date	Time
1	OCT-BC	43°18.0'N	154°42.0'E	16 Aug	12:07-12:42
2	OCT-G1	44 50.0	159 45.7	17 Aug	16:42-17:15
3	OCT-G2	44 50.1	160 00.4	17 Aug	18:22-18:51
4	OCT-G3	44 49.8	160 13.9	17 Aug	19:56-20:28
5	OCT-G4	45 00.0	160 13.2	17 Aug	21:30-22:00
6	OCT-G5	45 10.1	160 14.1	17 Aug	23:00-23:30
7	OCT-G6	45 10.1	160 00.3	18 Aug	00:37-01:06
8	OCT-G7	45 09.4	159 45.1	18 Aug	02:15-02:55
9	OCT-G8	45 00.0	159 45.9	18 Aug	03:51-04:22
10	OCT-G9	45 00.0	160 01.3	18 Aug	06:22-06:48
11	OCT-C1	45 00.2	159 59.7	19 Aug	06:40-07:12
12	OCT-C2	45 00.6	160 03.4	19 Aug	12:09-12:29
13	OCT-C3	45 02.2	160 03.2	20 Aug	01:55-02:27
14	OCT-C4	45 02.3	160 02.9	20 Aug	11:02-11:30
15	OCT-C5	45 01.0	159 59.1	20 Aug	18:20-18:47
16	OCT-C6	45 02.2	160 05.2	21 Aug	04:00-04:33
17	OCT-C7	45 10.1	160 16.5	21 Aug	17:42-18:18
18	OCT-C8	45 07.4	160 14.8	22 Aug	00:16-00:48
19	OCT-C9	45 00.1	160 08.5	23 Aug	17:40-18:20
20	OCT-G10	44 59.9	159 59.9	24 Aug	04:14-04:45
21	OCT-G11	44 57.5	159 56.4	24 Aug	05:13-05:44
22	OCT-G12	44 55.2	159 52.2	24 Aug	06:11-06:40
23	OCT-G13	44 52.5	159 49.5	24 Aug	07:10-07:40
24	OCT-G14	44 50.0	159 45.8	24 Aug	08:12-08:40
25	OCT-H1	43 04.8	145 44.4	26 Aug	15:18-15:41
26	OCT-H2	43 05.0	145 35.4	26 Aug	19:36-20:00
27	OCT-B'	40 31.5	146 28.2	02 Sep	07:35-08:06
28	OCT-BD1	38 53.2	148 59.5	03 Sep	10:31-11:00
29	OCT-BD2	36 11.8	153 16.3	04 Sep	10:32-11:00
30	OCT-D	34 59.4	154 51.0	05 Sep	16:16-16:50
31	OCT-DE	32 09.6	154 00.0	06 Sep	10:32-11:02
32	OCT-E1	28 00.4	152 59.3	07 Sep	09:38-10:08
33	OCT-E2	28 00.8	152 58.1	07 Sep	14:35-15:07
34	OCT-E3	28 00.3	152 59.7	07 Sep	18:23-19:02
35	OCT-E4	28 03.8	152 57.5	08 Sep	01:02-01:33
36	OCT-E5	28 05.9	152 56.2	08 Sep	05:21-05:51
37	OCT-E6	28 06.1	152 55.9	08 Sep	07:42-08:16
38	OCT-E7	28 09.4	152 53.9	08 Sep	14:00-14:26
39	OCT-E8	28 10.9	152 53.2	08 Sep	17:49-18:18
40	OCT-E9	28 11.5	152 50.7	09 Sep	00:11-00:39
41	OCT-E10	28 10.7	152 53.4	09 Sep	05:05-05:39
42	OCT-EF1	29 27.6	147 17.8	10 Sep	14:02-14:30
43	OCT-EF2	29 27.8	147 17.5	10 Sep	14:36-15:01
44	OCT-EF3	29 27.9	147 17.5	10 Sep	15:06-15:39
45	OCT-F1	30 01.3	144 56.0	11 Sep	03:24-03:50
46	OCT-F2	30 01.9	144 56.3	11 Sep	04:00-04:29

Chemical studies of the western North Pacific

S. Noriki, K. Harada, S. Watanabe, M. Yamada, Y. Watanabe,
N. Ishimori and J. Matsumoto

1. Sediment trap experiments

The NH-type sediment traps were deployed on 14 August 1983 at Station B and retrieved on 2 September 1983. The settling matter was collected at three depths. Total particulate fluxes are listed in Table 12. The D-type sediment`trap which had been deployed on 4 June 1983 at Station D in the Hokusei Maru cruise was retrieved on 5 September. The settling matter was collected at two depths. Major inorganic components, trace metals, and radionuclides were determined.

2. Suspended particulate matter in seawater

Seawater samples collected from various depths at Stations C, B', D and E were filtered through a Nuclepore filter, a Millipore filter or a glass fiber filter. The dry weight of particulate matter was determined (Table 13), together with the content of Na, Ca, Si, Al and Mn.

3. Ca and alkalinity in seawater

Calcium and alkalinity were determined using the same water samples as used in 2.

4. Chemical studies of sediments and interstitial waters

The sediment samples were collected with a box corer. Their water content, radionuclides and some metals were determined.

Interstitial water samples were obtained by squeezing the sediments and the content of P, Si and some metals were determined. The data will be used to estimate sedimentation rates, and diffusive losses of chemical elements from the sediments.

5. Radionuclides in seawater

Seawater samples were obtained from various depths at Station C with Niskin bottles and a suction pump. Radionuclides were coprecipitated with ferric hydroxide and further fractionated by passing through anion and cation exchange columns. ^{232}Th, ^{230}Th, ^{234}Th, ^{228}Ra, ^{226}Ra, ^{210}Pb and ^{210}Po were determined.

6. ^{14}C in seawater.

Data on natural radioactive carbon in the ocean are useful to investigate the general water circulation and the residence time of the oceanic water. Since ^{14}C content in the area of the Oyashio stream might be influenced intricately by mixing of the deep ocean water with the local surface water, detailed ^{14}C data would provide important information for understanding the origin of inorganic carbon and the flow pattern of the Oyashio stream.

Thirteen water samples were collected from the surface, 40, 60, 100, 250, 500, 700, 1000, 1500, 20000, 4000 and 5000 m at Station C. Inorganic carbon was extracted from 100 l each of the sea water samples and absorbed in a 3N NaOH solution. Analysis of ^{14}C is underway.

This work was conducted in collaboration with S. Tsunogai, T. Suzuki, K. Taguchi and T. Kurosaki, Laboratory of Analytical Chemistry, Faculty of Fisheries, Hokkaido University.

Table 12. Total particulate flux determined by sediment trap experiments at Station B

Depth	Trap	Flux ($mg/m^2 \cdot day$)
3610m above sea floor	A	377.5
	B	275.2
	C	416.2
	D	436.5
	av	376.4±62.1
3310 above sea floor	A	440.1
	B	419.9
	C	394.1
	D	343.1
	av	424.3±19.6
1810 above sea floor	A	282.1
	B	103.9
	C	324.4
	D	295.2
	av	300.9±17.7

Table 13. Dry weight of suspended particle at Stations C, B', D and E

Station	Depth (m)	NP* (μg/kg)	GF* (μg/kg)	MP* (μg/kg)
C	10	30.1	118	80.0
	20	40.0	361	427
	50	13.4	72.2	161
	100	10.0	76.7	29.3
	500	8.89	30.4	25.8
	1000	14.6	23.2	18.6
	1500	17.2	15.0	13.3
	2000	27.3	7.33	43.0
	2500	9.52	10.8	38.8
	3000	21.7	22.4	53.3
	3500	12.4	8.28	23.9
	4000	4.0	20.0	97.6
B'	10	44.0	132	
			163	
	100	62.2	47.2	
	500	10.5	33.3	
		26.2	24.7	
	1500	15.7	25.9	
		34.8	25.4	
	2000	44.0	29.5	
		41.2	30.0	
	2500	34.2	13.2	
		21.2	8.57	
	3500	14.1	12.5	
		7.0	12.8	
	4500	11.3		
D	10	8.0	40.0	414
		25.0	93.3	303
				410
	4000 T_1	17.1	21.3	41.5
		18.9	10.6	67.1
			13.7	
	5000 T_2	17.9	5.95	12.0
		21.7	10.3	87.7
		3.53	15.6	
E	10	56.0	35.5	
		49.3		
	100	44.4	38.7	
		35.8		
	500	34.0	33.5	
		12.6	40.6	
	1000	23.5	17.7	
		13.0	22.6	
	1400	47.1	11.5	
		21.7	15.3	
	2000	22.3	11.3	
		22.6	17.4	
	2400	62.2	15.3	
		31.3	28.3	
	3000	42.9	13.3	
		31.6	11.9	
	3200	24.6		

* NP: Nuclepore filter, GF: Glass fiber filter,
MP: Millipore filter

Studies on aerosols in the atmosphere over the ocean

T. Tanji, M. Okino and S. Mochizuki

In order to obtain insight into the distribution of aerosols and radon daughters in the atmosphere and the processes of their dispersion from land to the ocean, the following measurements were carried out during sailing throughout the cruise.

(1) Atmospheric conductivity: a Gerdian-type conductivity apparatus was adopted. We measured alternately positive and negative conductivities at 5-min intervals.

(2) Numbers of Mie particle and its size distribution: a light scattering type particle counter was adopted. The measurment was conducted at 20-min intervals.

(3) Concentration of radon daughters: A filter pack method using a semiconductor detector and a pulse height analyzer was adopted. The measurement was conducted at 3-hour intervals.

(4) Aerosol sampling: Aerosol samples were collected using an eight stage Andersen air sampler once a day, and composition of aerosols was analyzed.

1. Observations on leg 1

Sea was always foggy along a traverse between 145°E, 39°N and 154°E, 43°N. The atmospheric conductivity was extremely low (of an order of 10^{-15} mho/m), and concentrations of Mie particles and radioactive aerosols (radon daughters) were also low. The concentration of radon daughters was 3.7×10^{-2} Bq/m^3, which was only 1/50 of that obtained around 160°E, and 45°N on a fine day. The observed trend was quite different from that obtained in Muroran where the land area is often covered with thick sea-fog.

2. Observations on leg 2

During the period of our observations, the Ogasawara high atmospheric pressure was predominant over the wide area of the western North Pacific. Therefore, the data collected concern the aged maritime air mass. In oceanic areas, the atmospheric conductivity was relatively high (of a level of 2×10^{-14} mho/m), but the concentration of Mie particles was extremely low. The concentrations of radon daughters decreased landwards: 1.85×10^{-1} Bq/m^3 around 153°E, and 28°N, and 3.7×10^{-2} Bq/m^3 between Ohshima Island and Miyake Islands. An opposite pattern has been observed during winter in the same area.

Geochemical studies of organic matter in the western North Pacific

N. Handa and H. Sakugawa

1. Determination of vertical flux of organic matter and chemistry of sinking particles

An array of sediment traps was moored at Station C. Particles deposited into the sediment traps were collected in PVC bottles (volume: 300 ml), and kept frozen at - 20 C until analysis.

After thawing, the sinking particles were collected by centrifugation, and dry weight of gross materials and organic carbon and nitrogen content were determined. Sinking particles were also analyzed for lipid materials, amino acids, proteins and carbohydrates. Cycloalkenes and polyunsaturated fatty acids were also determined by combined use of gas chromatography and mass spectrometry to obtain information on source terms of the sinking particles.

Scanning electron microscopy was applied to identify microorganisms occurring in the fecal pellet of zooplankton. A preliminary investigation indicated that diatoms are dominant, but that some foraminifera and coccoliths are also contained.

2. Chemistry of suspended particles

Two systems were applied for the collection of suspended particles. Niskin bottles were used for the collection of seawater samples (100 l) from the surface to 5,000 m depth at Stations C and E. Suspended particles were collected by filtration of the seawater samples through Whatman glass fiber filter (GF/C). Carbohydrates were analyzed by combined gas chromatography and mass spectrometry, and fatty acid methyl ester, glycerides and free fatty acids by gas chromatography.

In situ filtration system was applied for the collection of large amounts of suspended particles from depths of 700 and 1,500 m at Stations C and E. More than 40 mgC of organic matter was obtained at each depth, and hydrocarbons, waxesters, glycerides, polyaromatic hydrocarbons and sterols were determined.

3. Chemistry of dissolved carbohydrate

After separation of suspended particles from seawater samples (100 l) by filtration, a portion of the filtrate was applied to a column packed with charcoal. The fraction passed through the column was collected and frozen at - 20 C until analysis of oligosaccharides. The rest of the filtrate was used for analysis of mono- and polysaccharides.

4. Organic chemistry of sediment

Sediment samples were collected at Stations C and D by a box corer. Stainless steal barrel was directly inserted into the bottom sediment collected by the corer. The subcore samples obtained were sectioned to 1 or 2 cm segments and frozen at -20 C until analysis.

Experimental study on the nutrients dynamics in the shallow waters of the subarctic and subtropical western North Pacific

T. Saino, J. Kanda and A. Hattori

Nutrients dynamics in the shallow waters was investigated by in situ experiments at Stations C and E. Two sets of experiments were carried out at each station using a free drifting buoy and line to a depth of 150 m: (A) in situ ^{15}N (ammonium and nitrate) and ^{13}C (bicarbonate) dual tracer uptake experiments and (B) in situ incubation to determine concentration changes in nutrients and dissolved oxygen in seawater samples contained in bottles. Protocols of the experiments are given in Table 14.

Table 14. In situ nutrients dynamics experiments

A: In situ uptake of CO_2, NH_4^+ and NO_3^-

Station	Exp.No.	Duration	Depth(m)
C	IS-1	17:00, 19 Aug - 06:00, 20 Aug	10, 20, 30, 50
C	IS-2	07:00, 21 Aug - 17:10, 21 Aug	10, 20, 30, 50
C	IS-3	03:10, 22 Aug - 16:05, 22 Aug	10, 20, 30, 50
E	IS-1A	18:10, 07 Sep - 03:50, 08 Sep	8, 88
E	IS-2A	03:55, 08 Sep - 15:40, 08 Sep	8, 88

B: In situ changes in dissolved oxygen and nutrients

Station	Exp.No.	Depth (m)	Diss Oxy Init (ml/l)	Diss Oxy Fin (ml/l)	Ammnoium Init	Ammnoium Fin	Nitrite Init	Nitrite Fin	Nitrate Init	Nitrate Fin
					(µg atom N/l)					
C	IS-1	(All samples were not recovered)								
E	IS-1B*	10	4.65	4.59	0.00	0.01	0.00	0.00	0.00	0.00
		90	4.95	4.88	0.01	0.02	0.07	0.07	0.14	0.14
		125	4.92	4.83	0.03	0.02	0.04	0.04	1.75	1.77
	IS-2B**	10	4.68	4.63	0.04	0.02	0.01	0.00	0.00	0.00
		90	4.96	4.96	0.05	0.05	0.09	0.10	0.35	0.38
		125	4.88	4.87	0.01	0.10	0.02	0.02	2.05	2.12

* The same as IS-1A at Station E.
** The same as IS-2A at Station E.

Natural abundance of ^{15}N in suspended particulate organic matter

T. Saino and A. Hattori

Variation of the natural abundance of ^{15}N in the suspended particulate organic matter (POM) provides useful information for understanding the processes of POM production and decomposition.

Water samples were collected with 23-liter Niskin bottles at Stations C and E at depths ranging from the surface to 4000 m. At Station C, water samples were collected with closely spaced depth intervals from 20 to 80 m.

The water samples (60-90 liters for >200 m, ca. 20 liters for <150 m) were filtered through glass fiber filters (Whatman GF/F, 47 mm diameter, precombusted at 450°C for 4 hr), and POM collected on the filters was kept frozen.

Results can be found in Saino and Hattori (1985 and in press).

References

Saino, T. and A. Hattori (1985). Variation of ^{15}N natural abundance of suspended organic matter in shallow oceanic waters. In: Marine and Estuarine Geochemistry, A.C. Sigleo and A. Hattori (eds.), Lewis Publishers, Inc., Chelsea, MI, pp. 1-13.

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Natural abundance of ^{15}N and ^{13}C of net samples from deep water

T. Saino and A. Hattori

Particulate materials were collected with a closing NORPAC net from various depth ranges to a depth of 4000 m at Stations C and E (Table 15). It is expected that the difference in isotopic ratios between the larger (collected with net) and smaller (suspended) particles provides some information for understanding the particle dynamics in deep water. A portion of the sample was fixed with formalin for later microscopic inspection. The rest of the samples was filtered through precombusted glass fiber filters, and the collected materials were stored frozen for later mass spectrometric analyses.

Table 15. Net samples collected for ^{15}N and ^{13}C abundance ratio determinations

Station	Sample No.	Depth range	Mesh
C	1	1500-2500 m	>333 μm
	2	2500-4000	>333
E	3	0-200	>100
	4	0-200	>333
	5	0-1000	>333
	6	200-500	>333
	7	1000-1500	>333
	8	1500-2000	>333
	9	2500-4000	>333
	10	3000-4000	>333

Studies on the nitrogen isotope ratio of N_2O in the atmosphere and in the sea water

N. Yoshida, J. Horita, T. Ooba, T. Saino and A. Hattori

Data on the nitrogen isotope ratio of N_2O in the atmosphere and in the sea water provide novel information for understanding the geochemical cycle of N_2O (Yoshida and Matsuo, 1983; Yoshida et al. 1984). In this study, we attempted to collect detailed information on the vertical distribution of N_2O and the variation of natural ^{15}N abundance in N_2O in the western North Pacific. In order to identify the source and sink terms of N_2O, we also conducted tracer experiments on board the ship using ^{15}N tagged ammonium.

Maritime air samples were collected during sailing, 1 sample between stations A and B, and 6 samples between Stations B and C on leg 1, and 7 samples between Stations D and E on leg 2, using a pumping system described elsewhere (Yoshida et al., 1984).

Seawater samples were collected from five layers (10, 50, 400, 880 and 1500 m) at Station C and from six layers (10, 100, 500, 750, 1300 and 1800 m) at Station E.

The concentration and $^{15}N/^{14}N$ ratio of N_2O were later determined by mass spectrometry using the method of Yoshida and Matsuo (1983). The concentration of dissolved N_2O was also determined by the gas chromatographic method of Cohen(1977), using the seawater samples collected by routine hydrocasts.

References

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Yoshida , N., Hattori,A., Saino, T., Matsuo, S. and Wada, E. (1984). $^{15}N/^{14}N$ ratio of dissolved N_2O in the eastern tropical Pacific Ocean. Nature, 307, 442-444.

Studies on isotope abundances of hydrogen, carbon, nitrogen and oxygen in marine organisms

N. Yoshida, T. Ooba and J. Horita

Isotope fractionation of light elements such as hydrogen, carbon, nitrogen and oxygen occurs in association with metabolism of organic and inorganic compounds. Therefore, information on isotopic composition of these elements in marine organisms and their components can be used to trace food chain in marine ecosystem, and can provide a new approach to the analysis of metabolic pathways.

Plankton samples were collected by vertical tows of a NORPAC net (0 - 100m) at Station C, and by a horizontal tow of a MTD net at the surface at Station E. Sardine and Mackerel pike samples were collected by an ORI net at Stations C and E and cuttlefish samples by fishing at Stations B, D, E and F. Organs and tissues were separately collected. They will be further fractionated into several main biochemical components and the isotopic composition of the individual components will be determined. Approximately 1000 liter of seawater sample collected by a pump from 85 m depth at Station E was filtered through a glass fiber filter, and chlorophyll *a* was extracted from the collected particulate materials. Its nitrogen and carbon isotope ratios will be determined.

Community structure of phytoplankton in the western North Pacific

T. Ishimaru and T. Saino

Community structure of phytoplankton in the western North Pacific were studied at Stations C, D, E, and F.

Water samples were collected by a Rosette Multi Sampler attached to the OCTOPUS system. The water samples were fixed with neutralized formalin (1%, v/v) and filtered through HA Millipore filters. The filters were air-dried and preserved for later study. A portion of each filter sample was treated with Nikon immersion oil to make it transparent to examine composition and population densities of phytoplankton under a phase contrast microscope. Detailed study on thecated nanoplankton were also conducted using a scanning electron microscope.

Carbon and nitrogen uptake by a ^{13}C, ^{15}N dual tracer technique

J. Kanda, T. Saino and A. Hattori

Uptake of nitrogenous nutrients (ammonium and nitrate) was measured by bottle incubation experiments using ^{13}C and ^{15}N as tracers. A simultaneous determination technique of ^{13}C and ^{15}N in marine particulate organic matter with a quadrupole mass spectrometer was applied.

Vertical profiles of carbon and nitrogen uptake were obtained by in situ incubation experiments (cf. page 38). The in situ experiments were run both during day (starting at dawn) and during night (starting at sunset), and uptake in day and night were compared at each station.

In situ primary productivity measurements

S. Nishizawa

Seawater samples were collected from 5 layers (5, 10, 20, 30, and 40 m in depth) at Station C using Van Dorn samplers. Large zooplankton were removed by filtering the water through a 300 μm mesh gauze. A set of four 250 ml glass bottles were filled with the above sample water and another set of four 250 ml bottles with "nanoplankton" water which had been prepared by filtering through a Nytex gauze of 10 μm mesh size. All the eight bottles were inoculated with 500 μl $NaH^{13}CO_3$ solution (955 mg/100 ml). Two of the first set and two of the second set were covered with dark bags and were put in a specially designed incubator made of clear acrylic plastic together with the remaining four clear bottles. The four incubators were suspended at depths which the sample waters came from. The time of incubation was 24 hrs.

After retrieval, each sample water was filtered through a 25 mm GF/F filter and immediately frozen on board and brought to the shore laboratory for later mass-spectrometric analysis.

Diel vertical migration of copepods in the northwestern North Pacific Ocean

H. Hattori and S. Nishizawa

Seven LHPR (Longhurst-Hardy Plankton Recorder) hauls were carried out at about four-hour intervals at Station C on August 21 to 23 (Table 16). The sampler was towed obliquely at a ship speed of 3.0 knots during descent stages and of 1.5-2.0 knots during ascent stages. The filtering gauze (# 60) in the cod-end sampler was advanced at intervals of 60 seconds to obtain a series of discrete samples at depth intervals of 5 to 40 m. A conical net was regularly attached to the cod-end sampler to catch an integrated sample of the water column. Diel changes in vertical distribution of copepods is under examination.

Table 16. Records of plankton sampling by LHPR

Date and time	Depth range (m)	Sample numbers	
		Ascent	Descent
Aug. 21 1945-2100	0-1000	36	21
Aug. 22 0345-0510	0-1000	-	-
Aug. 22 0753-0916	0- 580	38	38
Aug. 22 1240-1400	0- 750	40	38
Aug. 22 1634-1807	0-1000	50	27
Aug. 22 2201-2323	0- 800	64	37
Aug. 23 0300-0415	0-1000	42	14

Observation of vertical distribution of zooplankton with a sled and MTD net system

S. Takahashi and S. Nishizawa

Any vertical or horizontal tow of a plankton net quite often tends to fail in complete sampling the plankton in the water column particularly in the epibenthic layer in which literature frequently has so far revealed high concentrations of various organisms.

A new opening/closing epibenthic sled sampler was designed and tested (Fig. 10). It consists of a frame with a bottom sled and a mouth chamber to which is attached a plankton net. The mouth chamber is fitted with a door which opens only when the sled is sliding on the bottom surface. The mouth has an area of 1200 cm^2 (20 x 60 cm) and is equipped with a flowmeter at the center. The side nets are double bags; the outer net has a mesh size of 334 μm and a side length of 100 cm, and the inner bag 1 mm in mesh size and 40 cm deep.

Around Station H located off Hanasaki Peninsula, Hokkaido with a depth range of 59-96 m, the sled was towed 3 times including two successful epibenthic sampling. However, judging from the flowmeter reading obtained, the sled seemed to have jumped frequently on the bottom and only during 10-20 % of the towing distance was the sled in close contact with the bottom. A series of MTD nets were also towed at the same station to collect samples in the water column.

Analysis is under processing.

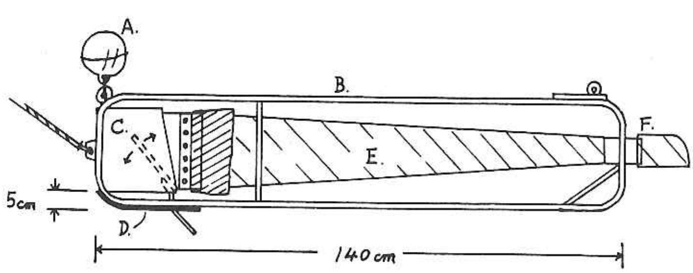


Fig. 10. Schematic lateral view of the opening/closing epibenthic sampler used. A, buoy; B, frame; C, mouth chamber with door; D, sled; E, plankton net; F, cod end.

Shipboard rearing experiments of *Calanus cristatus* for measurement of respiration and grazing activity.

M. Okazaki and S. Nishizawa

Two series of shipboard rearing experiments on a zooplankter, *Calanus cristatus*, were carried out to study the energy expenditure under feeding conditions with various concentrations of food organisms. Living zooplankton specimens were collected at night by vertical net tows (50 cm in mouth diameter, 150 cm in side length, 500 μm in mesh size with a 1.0 liter cod end) from a depth of 100 m around Station C on 18 August (44° 59.1'N, 160° 02.4'E; Series 1) and on 23 August (45° 09.8'N, 160° 28.3'E; Series 2).

C. cristatus specimens (stage V) were picked up and kept in filtered seawater, and then left in the dark for about 24 hrs. The temperature was kept at about 9 C. The seawater used was taken from a depth of 40 m using a 25 liter Van Dorn bottle.

A cultured *Thalassiosira decipiens* cell suspension was serially diluted with filtered seawater and 6 sets of 8 food concentrations (approximate concentrations: 0, 30, 70, 120, 420, 840, 1280 and 2550 cells/ml) were prepared in 100 ml oxygen bottles. In two sets of serially diluted food suspensions were placed *Calanus* specimens, 2 individuals in each bottle. The other 2 sets without zooplankton served as controls. All the 4 sets were used for measuring respiration rate and grazing rate, respectively. The remaining 2 sets of serially diluted food suspensions were fixed at the start of experiments for obtaining initial food concentrations and dissolved oxygen concentrations. All experiments were run in duplicate.

Respiration rate was calculated from the difference in oxygen content of experimental bottles and initially fixed bottles with an appropriate correction obtainable from the control bottles. Grazing rate was calculated using the equation of Frost (1972).

Preliminary results show that the respiration rate of *Calanus* varied closely with food concentration supplied. The rate increased with increasing food concentration and attained a maximum rate at a food level of about 120 cells/ml. This maximum rate was about 4 to 5 times higher than the basal rate of metabolism obtained at the zero food concentration. With further increase in food concentration, respiration rate decreased more or less rapidly and leveled off at higher food concentrations above 1000 cells/ml. Functional response of *C. cristatus* obtained simultaneously showed a typical unimodal variation which is in good parallelism to the respiration rate described above.

Reference

Frost, B. W. (1972). Effects of size and concentration of food particles on the feeding behavior of the marine planktonic copepod *Calanus pacificus*. Limnol. Oceanogr., 17, 805-815.

Ocean-bottom seismometer array observation for studying micro-earthquake hypocenter distribution in the Japan Trench region

S. Nagumo, J. Kasahara and S. Koresawa

In order to determine the hypocenter distribution of microearthquakes occurring in the Japan Trench region, off Sanriku, Northeast Japan, an ocean-bottom seismometer array was deployed at seven stations, Q-31, 32, 33, 34, 35, 36 and 38, in the outer slope region of the trench (Fig. 11, Table 17). Locations of four stations (Q-31, 32, 33 and 34) were almost the same as those of the stations occupied in 1981 (Hakuho-Maru cruises KH-81-3 and 4). The other three stations (Q-35, 36 and 38) were selected since the previous observation (Kasahara et al., 1982; Nagumo et al., 1984) showed a trend of linear distribution of the hypocenter in the outer slope region. The present observation is to increase the accuracy of focal depth estimation.

The deployment of an ocean-bottom seismometer array started from early in the morning of August 13, and ended in the morning of August 14; total operation ship time was 29 hours.

The ocean-bottom seismometers used this time are acoustic release, pop-up type with a hydrophone (ERI-AR 81 type). This time, a guard-ring was newly attached to the bottom of the anchor-frame so as to improve the landing and coupling characteristics. The total weight of the instrument in air was about 100 kg and the sinking speed measured by acoustic ranging was about 100 m/min.

The 3.5 KH acoustic profiling was performed during the operation so as to examine bottom conditions.

All of the ocean-bottom seismometers were successfully recovered in 4 and 5 November 1983, about three months after the deployment, by R/V Shinyo-Maru of the Tokyo University of Fisheries.

References

Kasahara, J., S. Nagumo and S. Koresawa (1982). A linear trend of hypocenter distribution in the outer slope region of the Japan trench revealed by OBS array, a preliminary report. Bull. Earthq. Res. Inst., Univ. Tokyo, 57, 83-104.

Nagumo, S., J. Kasahara and S. Koresawa (1984). Hypocenter distribution in the Japan Trench region, off Sanriku, Northeast Japan, determined by an ocean-bottom seismometer array observation, Bull. Earthq. Res. Inst., Univ. Tokyo, 59, 441-465.

Table 17. Station data: Ocean-bottom seismometer array observation in the Japan Trench region off Sanriku in August-November 1983

Station	Position		Water depth	Deployment time		Recovery time		Total mooring
Q-34	39°03.55'N	144°57.02'E	5520m	0438	13 Aug	0308	5 Sep	85 days
Q-33	39 13.9	145 14.6	5380	0806	13 Aug	2311	4 Sep	84
Q-36	39 22.6	144 47.9	5790	1217	13 Aug	0831	5 Sep	85
Q-38	39 15.54	144 27.68	6430	1603	13 Aug	1307	5 Sep	85
Q-35	39 41.0	144 46.9	5850	2109	13 Aug	1359	4 Sep	84
Q-32	39 38.8	145 14.2	5405	0115	14 Aug	1822	4 Sep	83
Q-31	39 58.1	144 56.2	5690	0534	14 Aug	0917	4 Sep	83

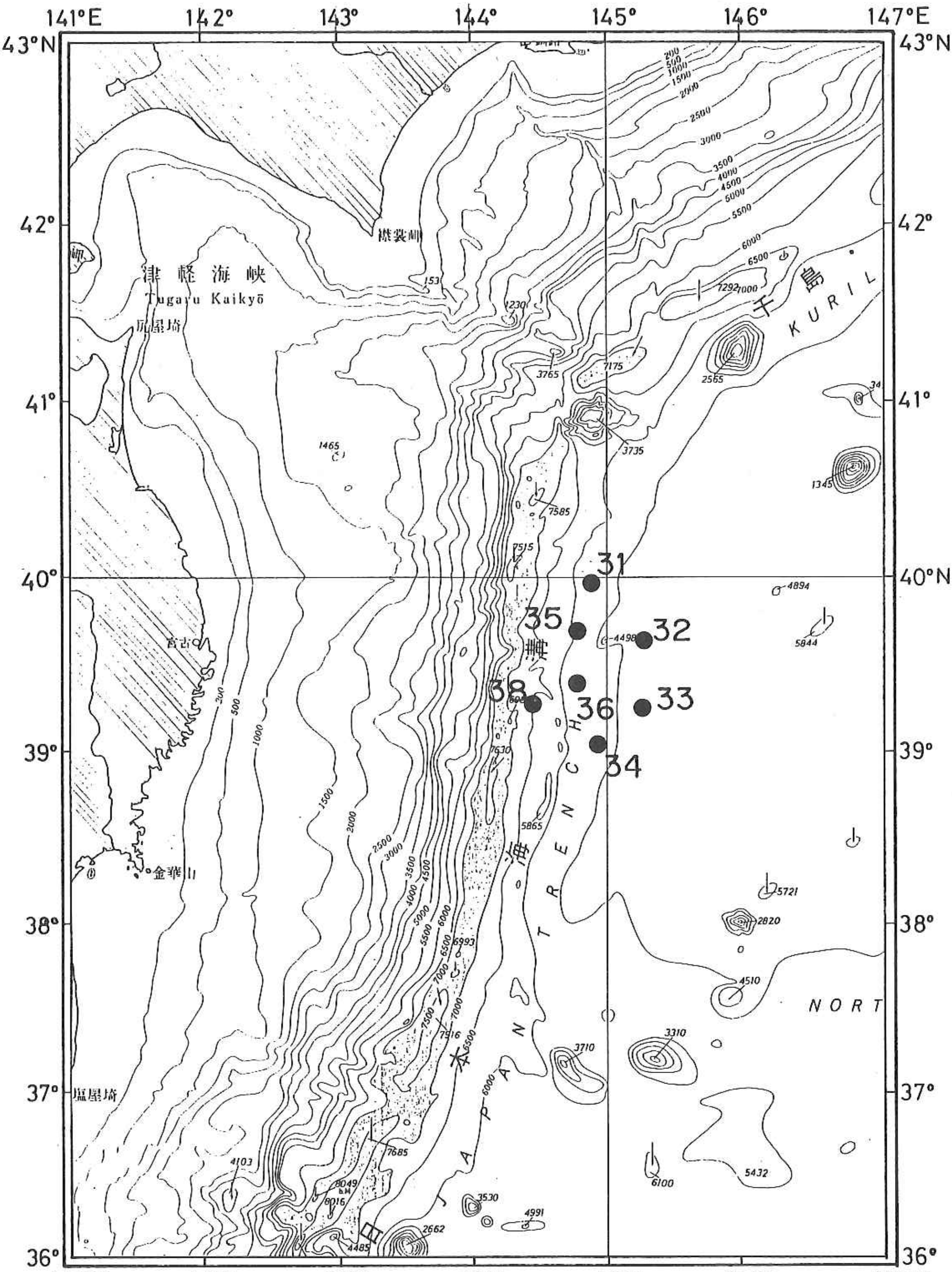


Fig.11 Location of seismometer stations.

Part II.

Hakuho Maru KH-85-2 Cruise

Outline of Hakuho Maru KH-85-2 cruise

The cruise consisted of two legs (Fig. 12). The locations of the oceanographic stations are given in Table 18.

This cruise was conducted along the same line as that of the previous one (KH-83-3), and was devoted to collecting information in spring time (cf. Part I). Two sea areas centered at 43°00'N and 150°10'E and at 24°40'N and 145°10'E were selected as active study sites. Additional data were collected at 13 stations on leg 1 and at 3 stations on leg 2.

T. Nakai served as the chief scientist on leg 1. The names and institutions of the scientists who participated in this cruise are listed in Table 19, and observation items at each station in Table 20.

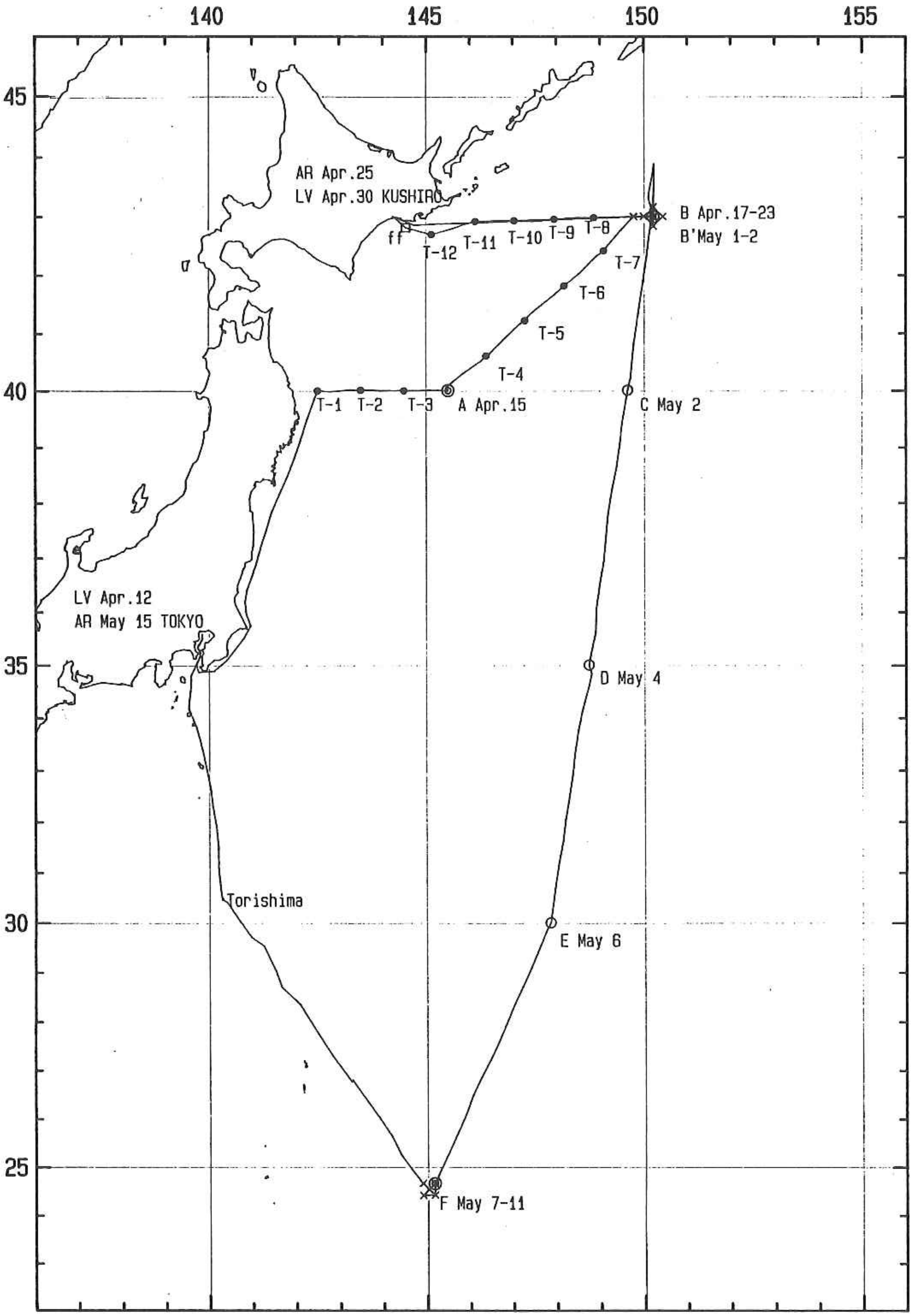


Fig. 12 Track chart of the KH-85-2 cruise of the Hakuho Maru.

Table 18. Location of oceanographic stations and dates

Station	Latitude		Longitude		Date
Leave Tokyo					4/12/85
T-1	39°59.2'N-	39°59.7'N	142°30.2'E-	142°30.4'E	4/14/85
T-2	40 00.2 N	40 00.4 N	143 28.4 E	143 29.3 E	4/14/85
T-3	39 59.9 N	40 00.3 N	144 28.8 E	144 29.3 E	4/14/85
A	39 59.1 N	40 01.0 N	145 20.9 E	145 29.0 E	4/15/85
T-4	40 35.2 N	40 36.1 N	146 23.0 E	146 23.7 E	4/16/85
T-5	41 12.5 N	41 12.7 N	147 16.1 E	147 17.0 E	4/16/85
T-6	41 47.9 N	41 48.6 N	148 10.9 E	148 11.3 E	4/16/85
T-7	42 24.7 N	42 24.9 N	149 04.7 E	149 05.1 E	4/16/85
O-1	43 00.1 N	43 00.2 N	149 45.9 E	149 46.1 E	4/17/85
O-2	43 00.2 N	43 00.3 N	149 59.9 E	150 00.1 E	4/17/85
O-3	43 00.2 N	43 00.2 N	150 13.4 E	150 13.6 E	4/17/85
O-4	43 09.9 N	43 10.0 N	150 13.3 E	150 13.5 E	4/17/85
B	42 55.1 N	43 04.0 N	150 04.8 E	150 14.2 E	4/17/85-4/22/85
OCT-26	43 09.8 N	43 10.1 N	150 12.7 E	150 13.4 E	4/23/85
OCT-27	42 59.9 N	43 00.1 N	150 26.4 E	150 26.6 E	4/23/85
OCT-28	42 50.1 N	42 50.3 N	150 13.0 E	150 13.2 E	4/23/85
OCT-29	43 00.0 N	43 00.7 N	150 12.1 E	150 13.3 E	4/23/85
OCT-30	43 00.1 N	43 00.1 N	149 59.8 E	150 00.1 E	4/23/85
OCT-31	42 59.8 N	43 00.4 N	149 46.3 E	149 46.5 E	4/23/85
T- 8	42 58.6 N	42 58.9 N	148 51.1 E	148 52.0 E	4/23/85
T- 9	42 56.9 N	42 57.0 N	147 57.0 E	147 57.4 E	4/24/85
T-10	42 55.6 N	42 55.8 N	147 02.1 E	147 02.7 E	4/24/85
T-11	42 54.6 N	42 54.7 N	146 07.9 E	146 08.4 E	4/24/85
T-12	42 41.4 N	42 41.5 N	145 07.0 E	145 07.2 E	4/24/85
Arrive Kushiro					4/25/85
Leave Kushiro					4/30/85
B'	42 59.4 N	43 01.4 N	150 10.8 E	150 13.9 E	5/ 1/85-5/ 2/85
C	40 00.3 N	40 03.4 N	149 37.4 E	149 42.0 E	5/ 2/85
D	34 56.2 N	34 59.9 N	148 42.9 E	148 54.3 E	5/ 4/85
E	29 59.9 N	30 00.2 N	147 49.6 E	147 51.5 E	5/ 5/85-5/ 6/85
F	24 23.1 N	24 42.1 N	145 54.8 E	145 10.7 E	5/ 7/85-5/11/85
O-51	24 39.5 N	24 39.9 N	145 09.2 E	145 09.9 E	5/11/85
O-52	24 25.0 N	24 25.4 N	145 09.3 E	145 10.0 E	5/11/85
O-53	24 24.9 N	24 25.0 N	144 53.2 E	144 53.9 E	5/11/85
O-54	24 32.4 N	24 32.5 N	145 01.2 E	145 01.7 E	5/11/85
O-55	24 40.1 N	24 40.1 N	144 53.0 E	144 53.5 E	5/11/85
Arrive Tokyo					5/15/85

Table 19. Scientists aboard

Akihiko HATTORI	Ocean Research Institute, University of Tokyo
Toshisuke NAKAI	Ocean Research Institute, University of Tokyo
Toshiro SAINO	Ocean Research Institute, University of Tokyo
Hirotaka OTOBE	Ocean Research Institute, University of Tokyo
Tadashi INAGAKI	Ocean Research Institute, University of Tokyo
Kenji SUGAI	Ocean Research Institute, University of Tokyo
Jota KANDA	Ocean Research Institute, University of Tokyo
Kitao FUJIWARA	Faculty of Science, University of Tokyo
Eiichiro TANOUE	Environmental Science, the Graduate School of Science and Technology, Kobe University
Shigemitsu HARA	Environmental Science, the Graduate School of Science and Technology, Kobe University
Yoshiaki MAITA	Faculty of Fisheries, Hokkaido University
Shinichiro NORIKI	Faculty of Fisheries, Hokkaido University
Shyuichi WATANABE	Faculty of Fisheries, Hokkaido University
Akihiro SHIOMOTO	Faculty of Fisheries, Hokkaido University
Tsuneo ODATE	Faculty of Fisheries, Hokkaido University
Kazunori TAGUCHI	Faculty of Fisheries, Hokkaido University
Taro KUROSAKI	Faculty of Fisheries, Hokkaido University
Makio HONDA	Faculty of Fisheries, Hokkaido University
Masayuki TAKAHASHI	Faculty of Science, Tokyo University
Hideshige TODA	Institute of Biological Science, University of Tsukuba
Sakae KUDO	Institute of Biological Science, University of Tsukuba
Akira TANIGUCHI	Faculty of Agriculture, Tohoku University
Hiroshi SASAKI	Faculty of Agriculture, Tohoku University
Hideyuki AKAHIRA	Faculty of Agriculture, Tohoku University
Yoshifumi OYAMA	Faculty of Agriculture, Tohoku University
David CHECKLEY	University of Texas at Austin
Carolyn MILLER	University of Texas at Austin
Kwang Woo LEE	Korea Ocean Research and Development Institute

Table 20. Items of observation at each station

	Tokyo ↓				Kushiro ↓					Tokyo ↓
Station	T1-3	A	T4-7	B	T8-12	B'	C	D	E	F
CTDO observation	x	x	x	x	x	x	x	x	x	x
OCTOPUS observation		x		x		x	x	x	x	x
Water sampling										
Niskin				x		x	x	x	x	x
Goflo		x		x						x
Van Dorn				x		x	x	x	x	x
LV and pump				x		x	x	x	x	x
Plankton sampling		x		x		x	x	x	x	x
Sediment sampling										
Box corer		x		x						x
Okean							x	x	x	
Sediment trap										
Hokkaido Univ.		x		x		x		x		
ORI				x						x
Tohoku Univ.				x						x

Routine observations of oceanographic variables

Two hydrographic stations were occupied on leg 1, and five stations on leg 2 (Fig. 12). At each station, casts of CTD fitted with twenty four 5-liter rosetted samplers were made to collect information on water temperature, salinity, dissolved oxygen, phosphate, silicate, nitrate, nitrite, ammonium, pH, alkalinity and chlorophylls. The methods used were essentially the same as those described in Part I (cf. page 8). The measurements were conducted by: (1) temperature: Otobe, Inagaki, Akahira and Koyama, (2) salinity: Otobe, Sugai, Toda and Shiomoto, (3) dissolved oxygen: Noriki, Taniguchi, Fujiwara and Taguchi, (4) nitrate, nitrite, ammonium and phosphate: Saino, Kanda, Kudo, (5) silicate: Noriki, Watanabe and Kurosaki, (6) pH and alkalinity: Watanabe, Honda and Odate, and (7) chlorophylls: Tanoue, Sasaki and Hara. The data obtained are summarized in Tables 21-27, and Figs. 13-16.

Table 21. Summary of hydrographic data at Station A

Station	A	Date	1985-4-15	Lat.	40 - 00.2 N	Air T.	2.4 C	Weather	Fine	Sea	3
Depth	5300 m	TIME	15:28 - 19:26	Long.	145 - 25.6 E	Barro.	1023.8 mb	Wind	E - 6.0m/s	Swell	3

Observed or RMS																CTD data					
D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst	D	T	S	Sig-t	Dst	Del-D
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t	m	C			cl/t	
0	2.60	33.088	2.600	26.39	9.00	118.2	-1.38	3.5	0.48	2.2	0.08	0.40	8.165	----	162.4	0	2.600	32.987	26.31	170.0	0.0000
11	2.76	33.084	2.760	26.38	9.07	119.6	-1.48	3.5	0.47	2.3	0.08	0.58	8.168	----	163.9	10	2.474	32.985	26.32	169.2	0.0171
29	2.70	33.050	2.695	26.35	8.70	114.5	-1.10	4.9	0.56	3.3	0.09	0.79	8.134	----	166.0	30	1.835	32.935	26.33	168.4	0.0508
50	3.95	33.435	3.948	26.55	7.29	99.2	0.06	27.5	1.35	14.6	0.21	1.30	7.964	----	147.8	50	3.582	33.422	26.57	145.4	0.0823
75	3.81	33.508	3.808	26.62	7.19	97.6	0.18	34.6	1.49	17.5	0.29	0.15	7.941	----	141.0	75	3.761	33.484	26.60	142.3	0.1184
100	4.60	33.639	4.593	26.64	6.88	95.3	0.34	33.2	1.45	17.2	0.20	0.15	7.936	----	138.9	100	4.640	33.651	26.65	138.4	0.1537
125	4.64	33.655	4.628	26.65	6.82	94.5	0.39	34.3	1.44	17.3	0.14	0.11	7.928	----	138.0	125	5.033	33.717	26.65	137.6	0.1885
150	4.42	33.630	4.409	26.65	6.74	92.9	0.51	32.6	1.44	17.1	0.05	0.06	7.941	----	137.7	150	4.946	33.693	26.65	138.4	0.2234
175	4.45	33.643	4.436	26.66	6.50	89.7	0.75	34.3	1.49	17.8	0.03	0.19	7.922	----	137.0	200	4.241	33.614	26.66	137.1	0.2932
200	4.25	33.651	4.239	26.69	6.55	89.9	0.73	36.9	1.56	19.1	0.02	0.15	7.908	----	134.4	300	3.084	33.526	26.70	133.1	0.4301
299	3.61	33.609	3.587	26.72	5.59	75.5	1.81	47.3	1.87	23.3	0.00	0.06	7.844	----	131.5	400	3.708	33.754	26.82	121.4	0.5599
400	3.48	33.693	3.454	26.80	3.92	52.8	3.50	71.6	2.47	32.1	0.00	0.06	7.702	----	124.0	500	3.704	33.888	26.93	111.3	0.6799
500	3.65	33.877	3.617	26.93	2.57	34.8	4.81	88.3	2.78	38.2	0.00	0.06	7.628	----	111.6	600	3.717	34.019	27.03	101.5	0.7908
752	3.56	34.179	3.502	27.18	1.16	15.7	6.22	120.0	3.11	44.0	0.00	0.11	7.573	----	87.9	700	3.668	34.135	27.13	92.3	0.8930
1000	2.97	34.301	2.901	27.33	0.94	12.6	6.54	140.0	3.20	44.7	0.00	0.09	7.568	----	73.5	800	3.163	34.172	27.21	85.0	0.9871
1252	2.63	34.412	2.548	27.45	0.89	11.8	6.65	154.0	3.17	49.8	0.00	0.06	7.580	----	62.3	1000	2.980	34.312	27.34	72.8	1.1567
1502	2.35	34.483	2.247	27.53	1.02	13.4	6.57	162.0	3.17	50.2	0.00	0.06	7.586	----	54.6	1250	2.631	34.411	27.45	62.4	1.3430
1749	2.20	34.540	2.079	27.59	1.25	16.4	6.37	164.0	3.12	50.2	0.00	0.05	7.576	----	49.1	1500	2.387	34.484	27.53	54.9	1.5086
1999	2.02	34.580	1.880	27.63	1.65	21.6	6.00	165.0	3.06	49.6	0.00	0.11	7.636	----	44.7	2000	2.025	34.580	27.63	44.8	1.8002
2499	1.75	34.633	1.569	27.70	2.31	30.0	5.39	165.0	2.90	47.3	0.00	0.17	7.682	----	38.7	2500	1.736	34.633	27.70	38.6	2.0551
3000	1.59	34.659	1.368	27.73	2.92	37.8	4.81	162.0	2.80	45.4	0.00	0.17	7.713	----	35.6	3000	1.584	34.660	27.73	35.5	2.2901
3499	1.50	34.675	1.234	27.75	3.25	41.9	4.50	159.0	2.69	44.4	0.00	0.04	7.729	----	33.8	3500	1.507	34.676	27.75	33.8	2.5161
3999	1.47	34.685	1.147	27.76	3.47	44.7	4.29	154.0	2.63	43.3	0.00	0.11	7.754	----	32.8	4000	1.469	34.685	27.76	32.8	2.7405
4498	1.47	34.693	1.089	27.77	3.66	47.2	4.10	154.0	2.62	42.8	0.00	0.00	7.767	----	32.2	4500	1.468	34.691	27.76	32.4	2.9681
5006	1.50	34.696	1.057	27.77	3.74	48.3	4.01	151.0	2.59	42.3	0.00	0.06	7.750	----	32.2	5000	1.497	34.694	27.76	32.4	3.2009

Table 22. Summary of hydrographic data at Station B

Station	B	Date	1985-4-17	Lat.	42 - 59.5 N	Air T.	2.6 C	Weather	Fine	Sea	2
Depth	5010 m	TIME	14:29 - 18:09	Long.	150 - 13.6 E	Barro.	1006.7 mb	Wind	NNE-4.0m/s	Swell	1

Observed or RMS															CTD data					
D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst	D	T	S	Sig-t	Dst	Del-D
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t	m	C			cl/t	
0	2.15	33.127	2.150	26.46	7.89	102.4	-0.19	45.1	1.86	22.1	0.27	0.27	7.857	----	156.0	0	2.152	33.135	26.47	155.5	0.0000
10	2.21	33.127	2.207	26.46	7.91	102.8	-0.22	44.5	1.86	21.9	0.27	0.28	7.867	----	156.4	10	2.065	33.121	26.46	155.9	0.0157
30	1.69	33.127	1.689	26.49	8.01	102.8	-0.22	45.1	1.86	22.5	0.26	0.54	7.868	----	152.8	30	1.636	33.135	26.50	151.8	0.0465
50	1.60	33.141	1.597	26.51	7.97	102.0	-0.16	45.1	1.88	22.3	0.26	0.45	7.867	----	151.1	50	1.547	33.132	26.51	151.4	0.0768
75	1.26	33.127	1.256	26.52	7.86	99.7	0.02	46.5	1.91	22.8	0.31	0.29	7.843	----	150.0	75	1.261	33.126	26.52	150.1	0.1146
99	1.13	33.132	1.122	26.54	7.81	98.8	0.10	45.9	1.94	23.3	0.34	0.36	7.841	----	148.8	100	0.962	33.150	26.56	146.5	0.1517
125	1.09	33.199	1.080	26.59	7.19	90.9	0.72	51.8	2.07	25.5	0.13	0.29	7.802	----	143.5	125	1.454	33.328	26.67	135.9	0.1870
149	1.78	33.443	1.771	26.74	4.83	62.2	2.93	72.5	2.53	32.7	0.02	0.33	7.670	----	129.4	150	1.938	33.484	26.76	127.4	0.2200
175	2.17	33.543	2.165	26.79	3.89	50.7	3.79	80.4	2.66	35.3	0.01	0.27	7.629	----	124.6	200	2.360	33.640	26.85	118.7	0.2819
200	2.45	33.621	2.437	26.83	3.18	41.7	4.44	86.3	----	37.0	0.00	0.04	7.600	----	120.8	300	2.814	33.861	26.99	105.5	0.3955
300	2.73	33.823	2.715	26.97	2.03	26.9	5.52	105.0	3.01	40.4	0.00	0.27	7.554	----	107.7	400	2.943	34.018	27.11	94.7	0.4980
400	2.94	33.992	2.918	27.09	1.25	16.7	6.26	118.0	3.12	42.3	0.00	0.36	7.523	----	96.7	500	3.022	34.138	27.19	86.3	0.5917
500	3.02	34.121	2.983	27.18	0.89	11.9	6.60	128.0	3.15	43.3	0.00	0.42	7.526	----	87.5	600	2.943	34.226	27.27	78.9	0.6780
749	2.69	34.284	2.637	27.34	0.90	11.9	6.64	148.0	3.15	42.9	0.00	0.47	7.541	----	72.4	700	2.871	34.297	27.34	73.0	0.7583
1000	2.54	34.412	2.478	27.46	0.90	11.9	6.66	156.0	3.12	42.5	0.00	0.02	7.565	----	61.6	800	2.786	34.352	27.39	68.1	0.8337
1250	2.28	34.470	2.198	27.52	1.08	14.2	6.53	165.0	3.09	42.1	0.00	0.00	7.570	----	55.1	1000	2.479	34.427	27.47	59.9	0.9722
1499	2.10	34.524	2.004	27.58	1.29	16.9	6.35	169.0	3.07	41.6	0.00	0.04	7.582	----	49.6	1250	2.234	34.489	27.54	53.2	1.1283
1749	1.99	34.573	1.871	27.63	1.63	21.3	6.03	165.0	----	41.0	0.00	0.11	7.624	----	45.0	1500	2.140	34.550	27.60	47.9	1.2715
2000	1.84	34.601	1.708	27.66	1.96	25.5	5.73	165.0	2.90	40.0	0.00	0.04	7.653	----	41.8	2000	1.846	34.573	27.64	44.0	1.5388
2500	1.63	34.637	1.454	27.71	2.58	33.4	5.15	165.0	2.77	38.5	0.00	0.04	7.670	----	37.6	2500	1.621	34.618	27.69	39.0	1.7883
3000	1.52	34.659	1.295	27.74	3.07	39.6	4.68	163.0	2.66	36.8	0.00	0.00	7.708	----	35.1	3000	1.511	34.638	27.72	36.7	2.0231
3499	1.45	34.672	1.186	27.75	3.37	43.4	4.39	158.0	2.58	35.9	0.00	0.07	7.725	----	33.7	3500	1.454	34.648	27.73	35.6	2.2537
4000	1.44	34.677	1.114	27.76	3.62	46.6	4.14	154.0	2.55	36.8	0.00	0.11	7.732	----	33.2	4000	1.435	34.652	27.74	35.1	2.4862
4500	1.45	34.682	1.072	27.76	3.70	47.7	4.06	154.0	2.53	35.7	0.00	0.22	7.749	----	32.9	4500	1.449	34.657	27.74	34.8	2.7226
4899	1.48	34.684	1.057	27.76	3.73	48.1	4.02	154.0	2.51	35.3	0.00	0.25	7.740	----	33.0	4900	1.488	34.693	27.77	32.3	2.9122

Table 23. Summary of hydrographic data at Station B'

Station	B'	Date	1985-5-1	Lat.	42 - 59.4 N	Air T.	2.3 C	Weather	Fog	Sea	3
Depth	5025 m	TIME	15:50 - 19:50	Long.	150 - 13.4 E	Barro.	1023.0 mb	Wind	S - 7.0m/s	Swell	3

Observed or RMS																CTD data					
D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst	D	T	S	Sig-t	Dst	Del-D
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t	m	C			cl/t	
0	3.61	33.064	3.613	26.28	7.88	106.1	-0.45	30.3	1.41	18.5	0.21	0.12	7.931	2.297	172.7	0	3.613	33.007	26.24	177.0	0.0000
10	3.54	33.067	3.541	26.29	7.94	106.7	-0.50	29.4	1.38	18.5	0.21	0.00	7.944	2.299	171.8	10	3.619	33.005	26.24	177.2	0.0178
29	2.79	33.086	2.783	26.38	7.78	102.6	-0.20	34.2	1.54	20.5	0.21	0.00	7.909	2.305	164.0	30	2.834	33.070	26.36	165.6	0.0521
49	1.65	33.130	1.652	26.50	7.62	97.7	0.18	45.8	1.74	23.5	0.27	0.00	7.850	2.307	152.3	50	1.816	33.112	26.47	154.8	0.0842
75	1.16	33.134	1.160	26.53	7.49	94.8	0.41	47.9	1.82	24.9	0.36	0.00	7.814	2.308	140.9	75	1.078	33.133	26.54	148.4	0.1221
99	1.04	33.135	1.040	26.54	6.92	87.3	1.00	52.4	1.95	27.2	0.03	0.00	7.798	2.297	148.1	100	0.853	33.179	26.59	143.7	0.1587
125	1.51	33.296	1.507	26.64	6.08	77.7	1.74	61.5	2.10	29.9	0.02	0.00	7.753	2.313	138.8	125	1.440	33.351	26.69	134.1	0.1935
151	2.01	33.470	1.998	26.75	4.33	56.1	3.38	77.6	2.42	35.0	0.02	0.00	7.654	2.322	128.9	150	2.225	33.520	26.77	126.8	0.2262
175	2.20	33.566	2.191	26.81	3.60	46.9	4.07	85.2	2.52	37.2	0.01	0.00	7.601	2.336	123.0	200	2.377	33.627	26.84	119.8	0.2883
201	2.38	33.626	2.370	26.84	3.13	41.0	4.50	90.6	2.63	38.3	0.00	0.00	7.585	2.344	119.9	300	2.669	33.842	26.99	105.8	0.4023
301	2.87	33.853	2.846	26.98	1.70	22.6	5.83	107.0	2.86	42.2	0.00	0.00	7.503	2.361	106.5	400	3.026	34.035	27.11	94.2	0.5043
398	3.03	34.031	3.004	27.11	1.20	16.0	6.29	124.0	2.97	44.0	0.00	0.12	7.483	2.374	94.4	500	3.068	34.156	27.21	85.3	0.5970
500	3.05	34.153	3.013	27.20	0.79	10.6	6.69	136.0	2.99	44.4	0.00	0.20	7.488	2.386	85.4	600	2.893	34.223	27.27	78.8	0.6827
750	2.79	34.334	2.736	27.37	0.78	10.4	6.74	154.0	2.97	44.2	0.00	0.16	7.527	2.417	69.5	700	2.819	34.297	27.34	72.6	0.7626
1001	2.55	34.427	2.486	27.47	0.87	11.5	6.69	164.0	2.94	44.0	0.00	0.24	7.535	2.433	60.5	800	2.719	34.356	27.40	67.2	0.8371
1249	2.26	34.483	2.177	27.54	1.07	14.1	6.54	173.0	2.94	43.8	0.00	0.12	7.553	2.452	53.9	1000	2.527	34.429	27.47	60.1	0.9749
1500	2.10	34.534	1.998	27.59	1.26	16.5	6.38	174.0	2.89	43.7	0.00	0.16	7.585	2.458	48.8	1250	2.276	34.484	27.54	54.0	1.1321
1749	1.98	34.575	1.861	27.63	1.53	20.0	6.13	176.0	2.84	42.9	0.00	0.08	7.626	2.462	44.8	1500	2.124	34.531	27.59	49.2	1.2775
1998	1.84	34.603	1.707	27.67	1.85	24.1	5.84	176.0	2.79	42.0	0.00	0.12	7.648	2.463	41.7	2000	1.851	34.605	27.67	41.6	1.5427
2499	1.62	34.643	1.449	27.71	2.50	32.4	5.23	171.0	2.63	40.2	0.00	0.04	7.678	2.471	37.1	2500	1.633	34.644	27.72	37.0	1.7813
2999	1.51	34.664	1.293	27.74	2.92	37.7	4.83	169.0	2.55	39.2	0.00	0.12	7.724	2.477	34.7	3000	1.513	34.667	27.74	34.5	2.0058
3500	1.46	34.677	1.188	27.75	3.29	42.4	4.47	165.0	2.47	38.3	0.00	0.08	7.741	2.478	33.3	3500	1.453	34.680	27.76	33.1	2.2259
4000	1.43	34.684	1.111	27.76	3.36	43.3	4.40	161.0	2.42	37.6	0.00	0.12	7.744	2.477	32.6	4000	1.434	34.687	27.76	32.4	2.4455
4500	1.45	34.689	1.069	27.76	3.49	45.0	4.27	161.0	2.39	37.2	0.00	0.12	7.754	2.475	32.4	4500	1.447	34.692	27.77	32.1	2.6688
4903	1.49	34.689	1.057	27.76	3.51	45.3	4.24	162.0	2.37	37.0	0.00	0.12	7.756	2.480	32.6	4900	1.485	34.693	27.76	32.3	2.8529

Table 24. Summary of hydrographic data at Station C

Station	C	Date	1985-5-2	Lat.	40 - 00.3 N	Air T.	13.5 C	Weather	Clear	Sea	3
Depth	5440 m	TIME	17:42 - 18:46	Long.	149 - 37.7 E	Barro.	1018.8 mb	Wind	SSW-10.0m/s	Swell	3

Observed or AMS															CTD data					
D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst	D	T	S	Sig-t	Dst	Del-D
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t	m	C			cl/t	
0	13.10	34.400	13.097	25.91	----	----	----	----	0.56	6.9	0.11	0.21	----	----	208.3	0	13.096	34.399	25.91	208.4	0.0000
11	12.98	34.379	12.976	25.92	5.80	97.5	0.15	----	0.56	6.9	0.11	0.17	----	----	207.6	10	13.099	34.399	25.91	208.4	0.0210
29	12.64	34.433	12.632	26.03	5.31	88.6	0.68	----	0.62	8.4	0.13	0.21	----	----	197.2	30	12.948	34.436	25.97	202.9	0.0622
51	11.96	34.434	11.949	26.16	5.11	84.1	0.97	----	0.91	12.9	0.21	0.21	----	----	184.6	50	12.239	34.441	26.11	189.2	0.1016
75	10.59	34.347	10.578	26.34	4.60	73.5	1.66	----	0.97	13.3	0.30	0.29	----	----	167.3	75	11.174	34.354	26.24	176.8	0.1478
100	9.50	34.246	9.488	26.45	4.44	69.2	1.98	----	1.19	16.8	0.09	0.04	----	----	157.2	100	9.685	34.249	26.42	159.9	0.1904
148	8.25	34.101	8.238	26.53	4.30	65.1	2.31	----	1.28	17.8	0.06	0.13	----	----	149.3	125	9.117	34.210	26.48	154.0	0.2302
198	7.07	33.991	7.054	26.61	4.53	66.7	2.26	----	1.66	22.9	0.02	0.08	----	----	141.4	150	8.251	34.090	26.52	150.2	0.2689
299	5.84	33.911	5.816	26.71	3.16	45.2	3.84	----	1.54	20.8	0.09	0.08	----	----	132.1	200	7.244	33.996	26.59	143.3	0.3437
499	4.84	34.122	4.801	27.00	1.47	20.5	5.69	----	2.86	42.1	0.00	0.13	----	----	105.0	300	5.870	33.906	26.70	132.8	0.4852
999	3.04	34.394	2.973	27.40	0.62	8.3	6.85	----	3.53	49.1	0.00	0.13	----	----	67.1	400	4.478	33.900	26.86	117.9	0.6145
1505	2.31	34.520	2.211	27.56	0.70	9.2	6.90	----	3.49	50.2	0.00	0.00	----	----	51.5	500	4.867	34.126	27.00	105.0	0.7306
																600	4.267	34.194	27.12	93.6	0.8353
																700	3.706	34.232	27.20	85.4	0.9304
																800	3.420	34.285	27.28	78.7	1.0183
																1000	3.040	34.395	27.40	67.0	1.1768
																1250	2.593	34.463	27.49	58.1	1.3507
																1500	2.315	34.519	27.56	51.6	1.5063

Table 25. Summary of hydrographic data at Station D

Station	D	Date	1985-5-4	Lat.	35 - 00.1 N	Air T.	16.8 C	Weather	Fine	Sea	2
Depth	6020 m	TIME	03:03 - 04:12	Long.	148 - 44.1 E	Barro.	1014.4 mb	Wind	S -4.0 m/s	Swell	1

Observed or RMS																CTD data					
D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst	D	T	S	Sig-t	Dst	Del-D
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t	m	C			cl/t	
0	18.85	34.820	18.845	24.92	5.10	96.5	0.18	----	0.03	0.0	0.00	0.04	----	----	302.0	0	18.745	33.447	23.90	399.6	0.0000
10	18.60	34.809	18.594	24.98	5.06	95.3	0.25	----	0.02	0.0	0.00	0.17	----	----	296.8	10	18.810	34.802	24.92	302.4	0.0352
30	18.08	34.786	18.079	25.09	4.82	89.9	0.54	----	0.02	0.0	0.02	0.34	----	----	286.3	30	18.175	34.784	25.06	288.6	0.0945
50	17.87	34.817	17.863	25.16	4.59	85.3	0.79	----	0.14	1.9	0.13	0.13	----	----	279.1	50	17.923	34.809	25.15	280.9	0.1517
73	17.46	34.804	17.443	25.26	4.70	86.6	0.73	----	0.14	2.0	0.15	0.17	----	----	270.4	75	17.484	34.798	25.24	271.5	0.2213
99	17.27	34.819	17.249	25.31	4.65	85.4	0.79	----	0.16	2.3	0.08	0.13	----	----	265.0	100	17.235	34.821	25.32	264.2	0.2890
125	17.17	34.827	17.145	25.34	4.72	86.5	0.73	----	0.17	2.6	0.04	0.13	----	----	262.1	125	17.169	34.823	25.34	262.5	0.3557
149	17.09	34.823	17.066	25.36	4.71	86.2	0.75	----	0.19	2.8	0.03	0.08	----	----	260.7	150	17.059	34.814	25.36	260.7	0.4222
200	16.65	34.800	16.616	25.44	4.72	85.6	0.79	----	0.17	2.8	0.04	0.13	----	----	252.5	200	16.715	34.795	25.43	254.3	0.5539
301	16.45	34.790	16.398	25.48	4.99	90.2	0.54	----	0.22	3.3	0.02	0.05	----	----	248.8	300	16.472	34.791	25.48	249.2	0.8136
500	12.04	34.441	11.977	26.15	3.72	61.3	2.35	----	1.06	15.2	0.02	0.10	----	----	185.7	400	15.093	34.672	25.70	228.3	1.0626
1002	4.21	34.297	4.131	27.21	1.41	19.4	5.85	----	2.83	38.4	0.01	0.00	----	----	85.3	500	12.167	34.442	26.12	187.9	1.2826
1500	2.66	34.477	2.554	27.50	1.05	13.9	6.48	----	3.09	41.5	0.00	0.27	----	----	57.6	600	9.200	34.214	26.47	155.0	1.4660
																700	6.285	34.045	26.76	127.4	1.6178
																800	5.137	34.085	26.93	111.0	1.7461
																1000	4.251	34.313	27.21	84.5	1.9599
																1250	3.191	34.391	27.38	68.7	2.1744
																1500	2.662	34.476	27.50	57.7	2.3546

Table 26. Summary of hydrographic data at Station E

Station	E	Date	1985-5-5	Lat.	30 - 00.2 N	Air T.	19.0 C	Weather	Cloudy	Sea	3
Depth	6100 m	TIME	21:57 - 23:13	Long.	147 - 51.1 E	Barro.	-	Wind	ESE-6.0m/s	Swell	3

Observed or RMS

D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t
0	21.54	34.960	21.535	24.32	5.35	106.5	-0.33	----	0.00	0.0	0.00	0.17	----	----	359.7
5	21.50	34.962	21.498	24.33	5.39	107.2	-0.36	----	0.00	0.0	0.00	0.25	----	----	358.6
10	21.51	34.962	21.507	24.33	5.17	102.9	-0.14	----	0.00	0.0	0.00	0.07	----	----	358.9
20	21.50	34.963	21.498	24.33	5.18	103.1	-0.15	----	0.00	0.0	0.00	0.09	----	----	358.6
29	21.40	34.964	21.397	24.36	4.98	98.9	0.05	----	0.00	0.0	0.00	0.14	----	----	355.9
50	18.28	34.847	18.274	25.09	5.05	94.6	0.29	----	0.04	0.0	0.00	0.19	----	----	286.6
77	17.57	34.789	17.555	25.22	4.81	88.8	0.60	----	0.13	1.4	0.15	0.17	----	----	274.1
101	17.43	34.807	17.409	25.27	4.75	87.5	0.68	----	0.19	2.2	0.19	0.19	----	----	269.5
150	17.02	34.788	16.998	25.35	4.48	81.9	0.99	----	0.27	3.5	0.17	0.21	----	----	261.8
201	16.68	34.784	16.650	25.42	4.94	89.7	0.57	----	0.30	4.2	0.18	0.22	----	----	254.4
301	15.77	34.734	15.722	25.60	4.32	77.0	1.29	----	0.47	6.7	0.22	0.28	----	----	238.1
500	11.29	34.390	11.225	26.25	3.74	60.7	2.43	----	1.17	16.3	0.26	0.26	----	----	176.1
1000	3.76	34.285	3.684	27.24	1.10	15.0	6.24	----	2.98	41.1	0.24	0.26	----	----	81.8
1503	2.49	34.515	2.384	27.54	1.15	15.2	6.42	----	3.10	43.0	0.12	0.68	----	----	53.3

CTD data

D	T	S	Sig-t	Dst	Del-D
m	C			cl/t	
0	21.533	34.956	24.32	359.9	0.0000
10	21.542	34.958	24.32	360.0	0.0361
30	21.546	34.958	24.31	360.1	0.1083
50	18.899	34.774	24.87	306.7	0.1753
75	17.632	34.798	25.21	275.0	0.2485
100	17.421	34.804	25.26	269.6	0.3173
125	17.249	34.801	25.30	265.9	0.3852
150	16.946	34.790	25.37	259.9	0.4521
200	16.675	34.783	25.43	254.3	0.5833
300	15.778	34.727	25.59	238.8	0.8375
400	13.745	34.548	25.89	210.0	1.0718
500	11.230	34.361	26.24	177.2	1.2766
600	8.533	34.150	26.53	149.8	1.4513
700	6.077	34.068	26.81	123.2	1.5977
800	5.005	34.139	26.99	105.5	1.7210
1000	3.769	34.283	27.24	82.1	1.9258
1250	2.973	34.423	27.43	64.3	2.1297
1500	2.500	34.513	27.54	53.6	2.2978

Table 27. Summary of hydrographic data at Station F

Station	F	Date	1985-5-7	Lat.	24 - 39.3 N	Air T.	24.3 C	Weather	Clear	Sea	2
Depth	5160 m	TIME	15:25 - 18:45	Long.	145 - 09.8 E	Barro.	1017.6 mb	Wind	E - 4.0m/s	Swell	2

Observed or RMS																CTD data					
D	T	S	Pot-T	Sig-t	O2	Sat-O	AOU	SiO2	PO4	NO3	NO2	NH4	pH	Alk	Dst	D	T	S	Sig-t	Dst	Del-D
m	C		C		ml/l	%	ml/l	uM	uM	uM	uM	uM		meq/l	cl/t	m	C			cl/t	
0	24.47	34.920	24.467	23.44	4.92	103.1	-0.15	1.4	0.00	0.0	0.00	0.24	8.291	2.360	443.2	0	24.467	34.895	23.42	445.0	0.0000
10	24.03	34.824	24.032	23.50	4.96	103.1	-0.15	2.0	0.00	0.0	0.00	0.06	8.268	2.351	437.8	10	24.281	34.866	23.46	441.8	0.0445
30	22.93	34.887	22.927	23.87	5.03	102.6	-0.13	2.8	0.00	0.0	0.00	0.11	8.268	2.354	402.6	30	23.753	34.916	23.65	423.2	0.1311
50	22.19	34.862	22.180	24.06	5.09	102.5	-0.12	2.0	0.00	0.0	0.00	0.11	8.257	2.346	384.2	50	22.474	34.866	23.98	391.6	0.2129
75	20.72	34.902	20.709	24.50	5.17	101.4	-0.07	2.0	0.00	0.0	0.00	0.22	8.246	2.524	342.8	75	21.677	34.894	24.23	368.2	0.3085
100	19.88	34.889	19.864	24.71	5.33	102.9	-0.15	2.3	0.02	0.0	0.00	0.08	8.238	2.357	322.5	100	20.376	34.901	24.59	334.0	0.3970
125	19.07	34.854	19.042	24.89	5.22	99.2	0.04	3.7	0.03	0.2	0.06	0.15	8.229	2.372	304.8	125	19.526	34.886	24.80	313.8	0.4790
150	18.17	34.818	18.139	25.09	5.11	95.5	0.24	4.0	0.10	1.4	0.05	0.13	8.208	2.354	285.9	150	18.513	34.847	25.03	292.1	0.5559
175	17.48	34.796	17.453	25.24	5.12	94.4	0.30	3.4	0.16	2.2	0.07	0.08	8.181	2.343	271.7	200	17.431	34.810	25.27	269.4	0.6992
200	17.23	34.796	17.200	25.30	5.18	95.1	0.27	3.4	0.17	2.5	0.07	0.11	8.181	2.350	266.0	300	16.290	34.763	25.50	247.3	0.9653
300	15.87	34.719	15.818	25.56	4.76	85.0	0.84	8.3	0.39	6.4	0.08	0.12	8.113	2.353	241.2	400	14.617	34.622	25.76	222.1	1.2102
400	14.30	34.580	14.236	25.80	4.54	78.5	1.24	12.3	0.59	9.3	0.11	0.19	8.050	2.350	218.6	500	11.590	34.359	26.17	183.6	1.4246
500	11.55	34.330	11.485	26.15	4.26	69.4	1.87	22.2	0.99	16.4	0.15	0.36	7.963	2.344	185.1	600	8.566	34.166	26.53	149.0	1.6023
750	6.07	34.093	5.996	26.83	2.62	37.7	4.33	68.4	2.30	31.6	0.16	0.18	7.711	2.373	121.1	700	6.490	34.097	26.78	126.0	1.7500
1000	3.87	34.325	3.791	27.26	1.11	15.2	6.21	119.0	2.78	40.5	0.19	0.15	7.585	2.427	79.9	800	5.107	34.153	26.99	105.6	1.8752
1250	3.15	34.435	3.057	27.42	1.17	15.7	6.28	138.0	2.81	40.9	0.21	0.18	7.584	2.459	64.9	1000	3.861	34.333	27.27	79.2	2.0776
1500	2.52	34.517	2.413	27.54	1.52	20.1	6.04	149.0	2.77	40.5	0.22	0.11	7.627	2.469	53.4	1250	3.169	34.450	27.43	64.0	2.2783
1750	2.15	34.561	2.030	27.61	1.88	24.6	5.75	157.0	2.70	39.7	0.24	0.35	7.640	2.480	47.2	1500	2.616	34.526	27.54	53.5	2.4474
2002	1.94	34.597	1.799	27.65	2.31	30.1	5.36	157.0	2.63	38.5	0.26	0.12	7.695	2.491	42.8	2000	1.979	34.610	27.66	42.1	2.7309
2500	1.70	34.633	1.522	27.70	2.88	37.3	4.83	155.0	2.53	36.9	0.27	0.08	7.712	2.491	38.4	2500	1.710	34.651	27.71	37.1	2.9743
3000	1.58	34.651	1.363	27.72	3.15	40.7	4.59	155.0	2.47	36.4	0.26	0.20	7.720	2.489	36.2	3000	1.589	34.670	27.74	34.8	3.2025
3500	1.51	34.662	1.241	27.74	3.35	43.2	4.40	154.0	2.43	35.5	0.27	0.16	7.752	2.492	34.8	3500	1.512	34.683	27.75	33.3	3.4256
4000	1.47	34.672	1.152	27.75	3.60	46.4	4.16	152.0	2.38	35.0	0.27	0.16	7.732	2.492	33.8	4000	1.472	34.691	27.76	32.3	3.6473
4499	1.46	34.675	1.079	27.75	3.80	49.0	3.96	147.0	2.34	34.2	0.27	0.12	7.764	2.487	33.5	4500	1.458	34.698	27.77	31.7	3.8708
5000	1.47	34.678	1.032	27.75	3.95	50.9	3.81	143.0	2.27	33.8	0.26	0.16	7.760	2.490	33.4	5000	1.471	34.703	27.77	31.5	4.0988

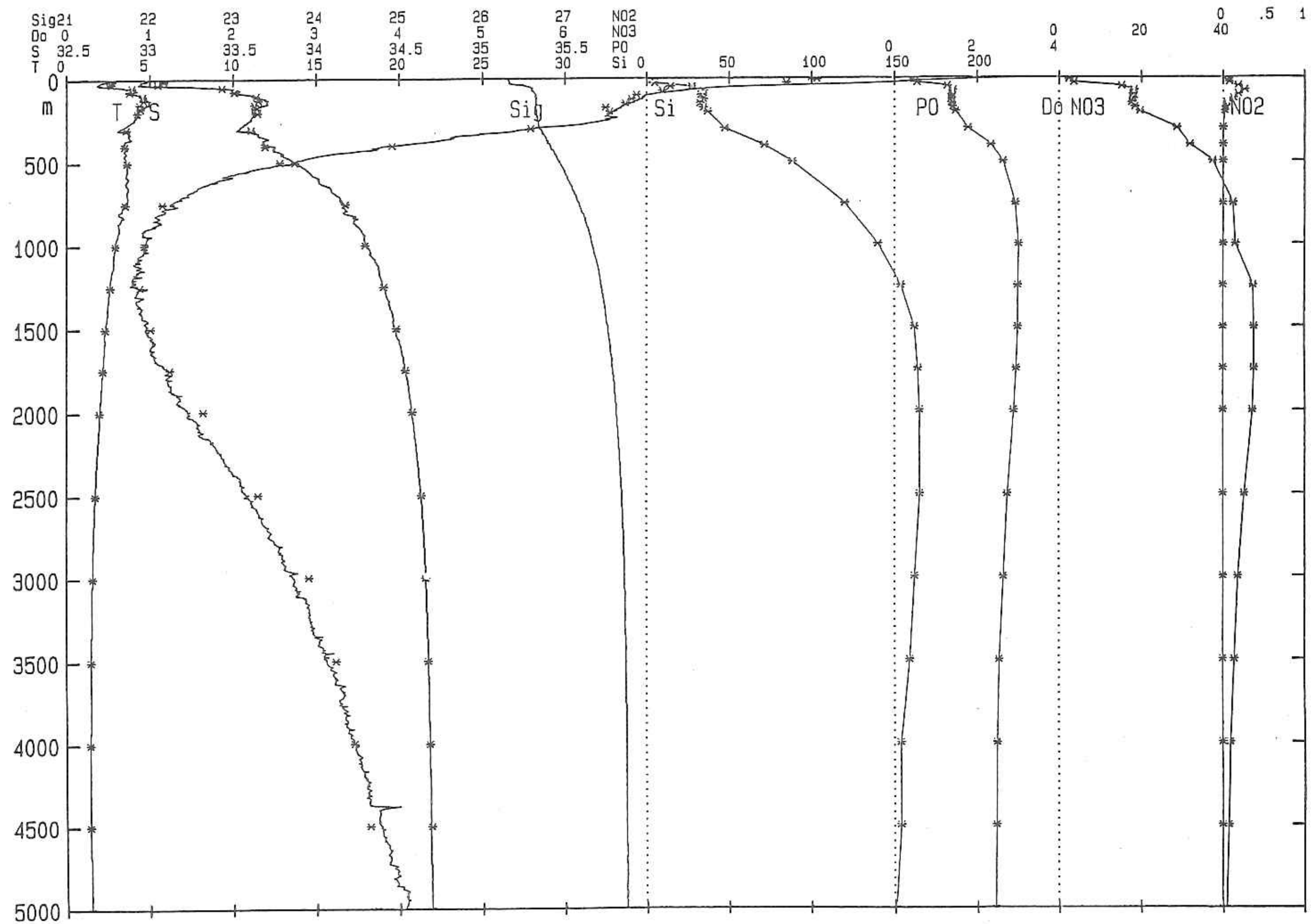


Fig. 13 Vertical profiles of temperature, salinity, sigma-t, dissolved oxygen, silicic acid, phosphate, nitrate and nitite at Station A.

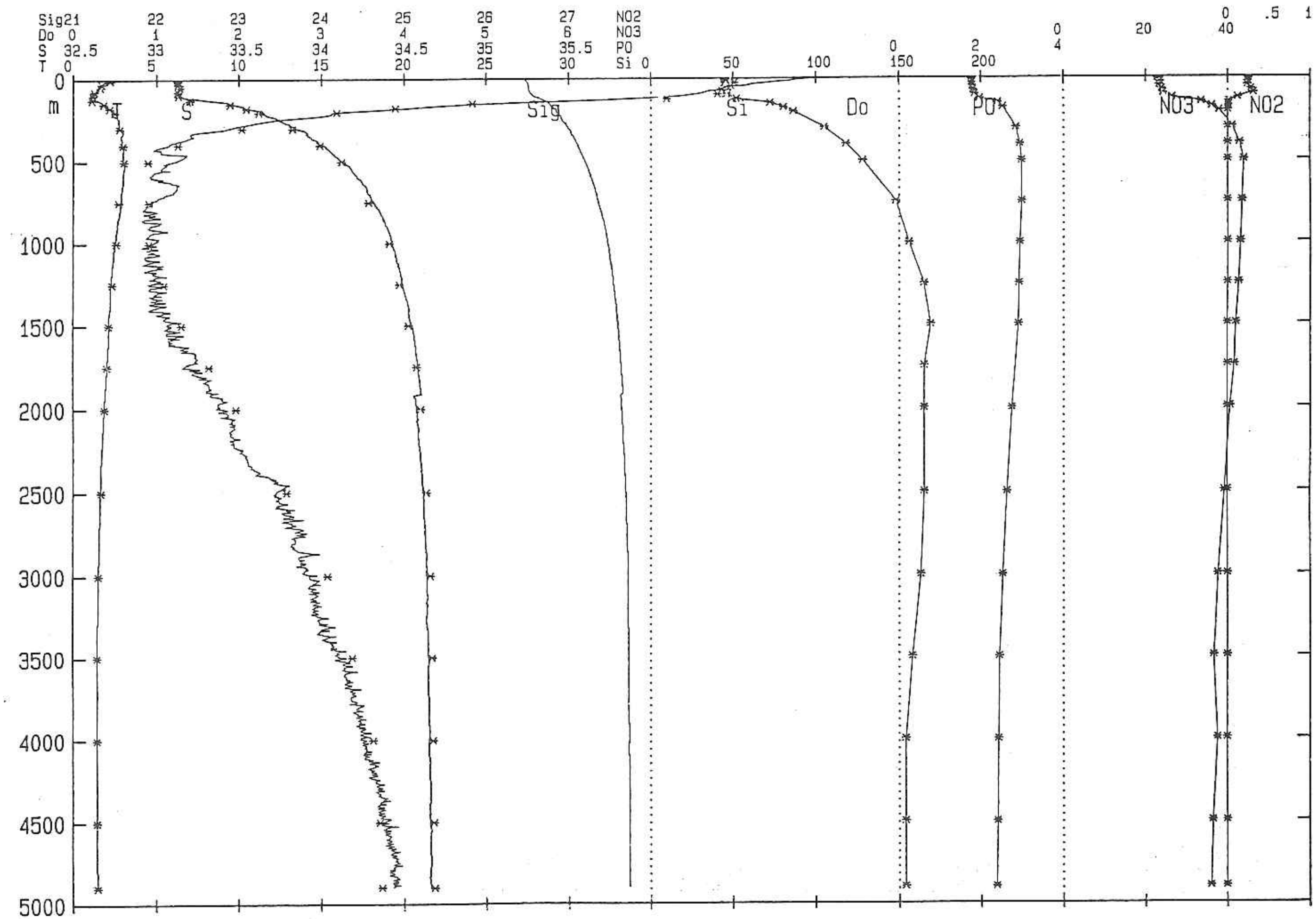


Fig. 14 Vertical profiles of temperature, salinity, sigma-t, dissolved oxygen, silicic acid, phosphate, nitrate and nitite at Station B.

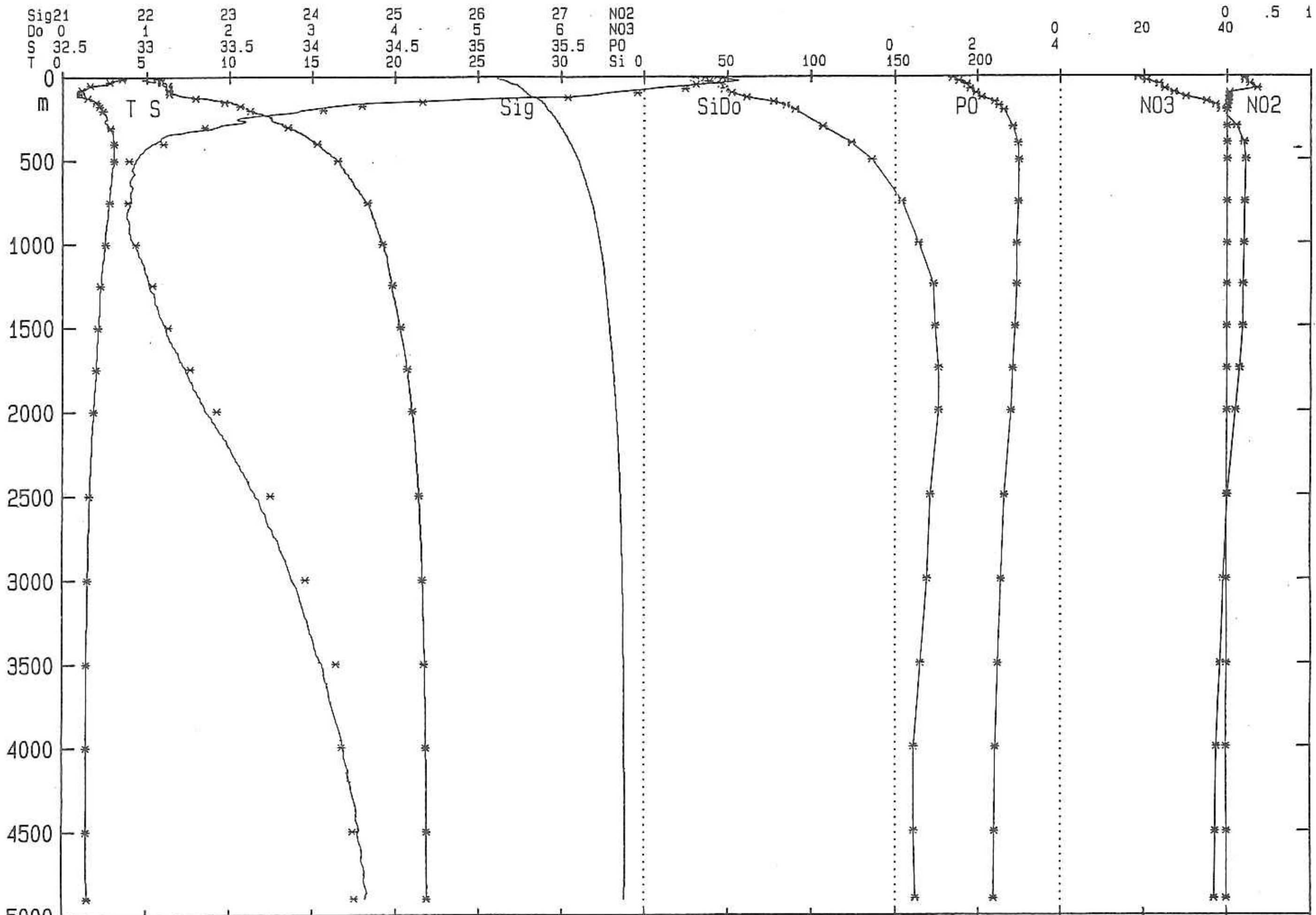


Fig. 15 Vertical profiles of temperature, salinity, sigma-t, dissolved oxygen, silicic acid, phosphate, nitrate and nitite at Station B'.

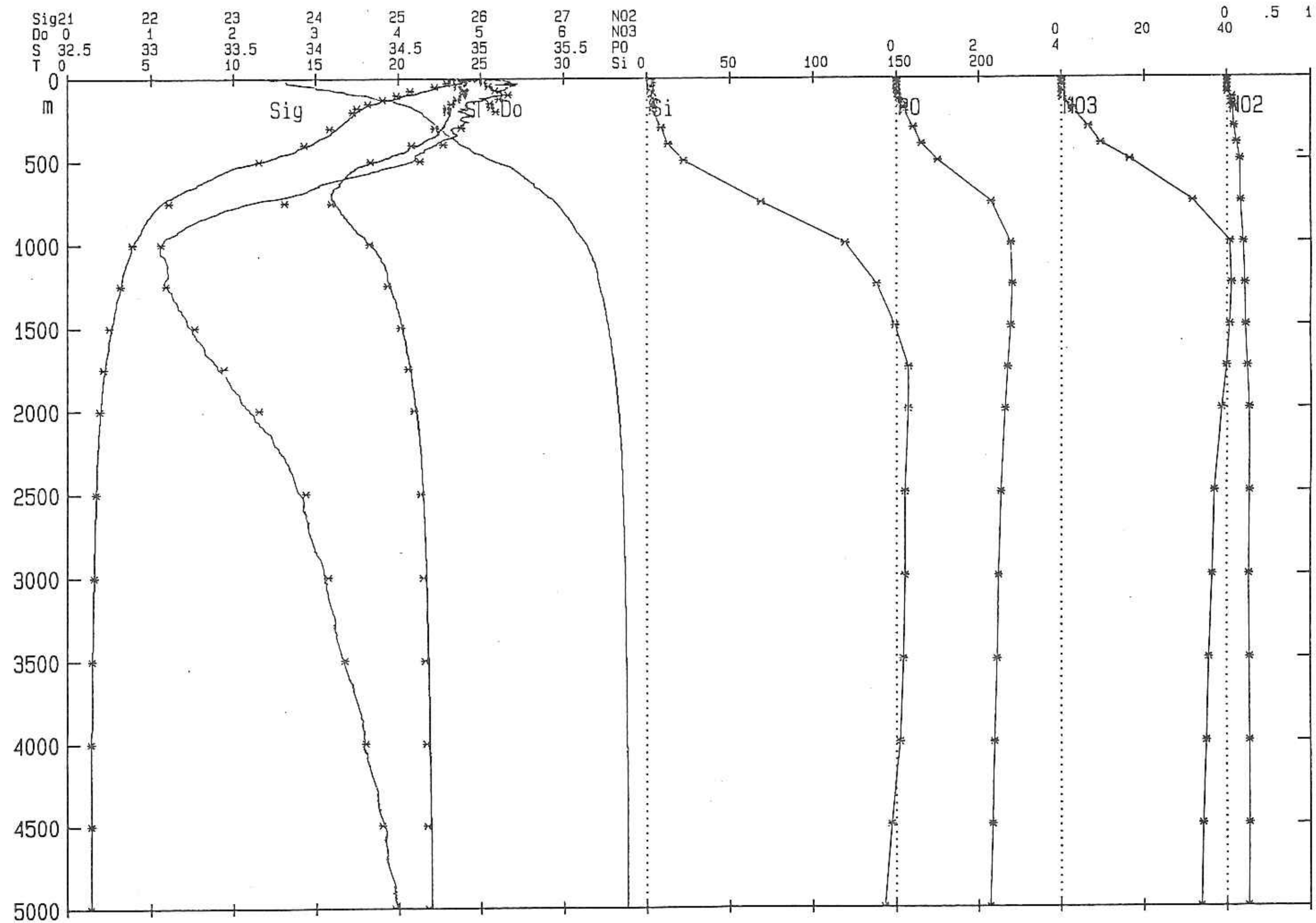


Fig. 16 Vertical profiles of temperature, salinity, sigma-t, dissolved oxygen, silicic acid, phosphate, nitrate and nitite at Station F.

Hydrographic characteristics

T. Nakai and H. Otobe

1. Vertical sections of the subarctic region (Figs. 17-20)

Figures 17 and 18 show the cross sections of temperature and salinity, along a 40°N parallel between Stations T-1 and A, along a northeastward transect between Stations A and B and along a 43°N parallel between Stations B and T-12. No indication was obtained for the initiation of the surface water stratification in these areas during the period of our observations (14-24 April 1985).

In the sea area south of Station T-6, the vertical distributions of temperature and salinity were complicated, indicating the mixing of the subarctic water with warm water flowing from the south. The cold and less saline water was seen in the surface layer of Station A. The offshore branch of the Oyashio Current penetrated into the vicinity of Station A. On the other hand the warm water was found on the coastal side of Station T-2. At Station 7, salinity minimum water extended vertically down to 200 m.

On the northern side of Station T-7, the dichothermal water was centered at 100 m and the intermediate warm water at 600 m. The halocline was found just below the dichothermal layer and the salinity increased with depth. The watermass in this region can be identified as the Northwestern Pacific Subarctic Water.

The vertical sections of the thermosteric anomaly and the geostrophic currents relative to 1500 db are shown in Figs. 19 and 20, respectively.

2. T-S diagram

Figure 21 shows T-S diagrams drawn on the basis of the CTD data obtained at Stations A, B, C, D, E, and F. The cores of the Oyashio Water and the Kuroshio Water were identified at Stations B and F, respectively. The rugged traces on the T-S diagrams suggested that the other stations (A, C, D and E) were located in the sea areas where the intense of different watermasses occurs.

3. Horizontal distribution of the surface temperature

Figure 22 illustrates the horizontal distribution of temperature on the basis of the drift data of NNSS (Fig. 23) and the satellite images of NOAA-6 and 7. The presence of a southward flow of the Oyashio Current along a 145°E meridian is apparent. The pattern of temperature distribution was consistent with that reported by the Hydrographic Department, Maritime Safety Agency, Japan.

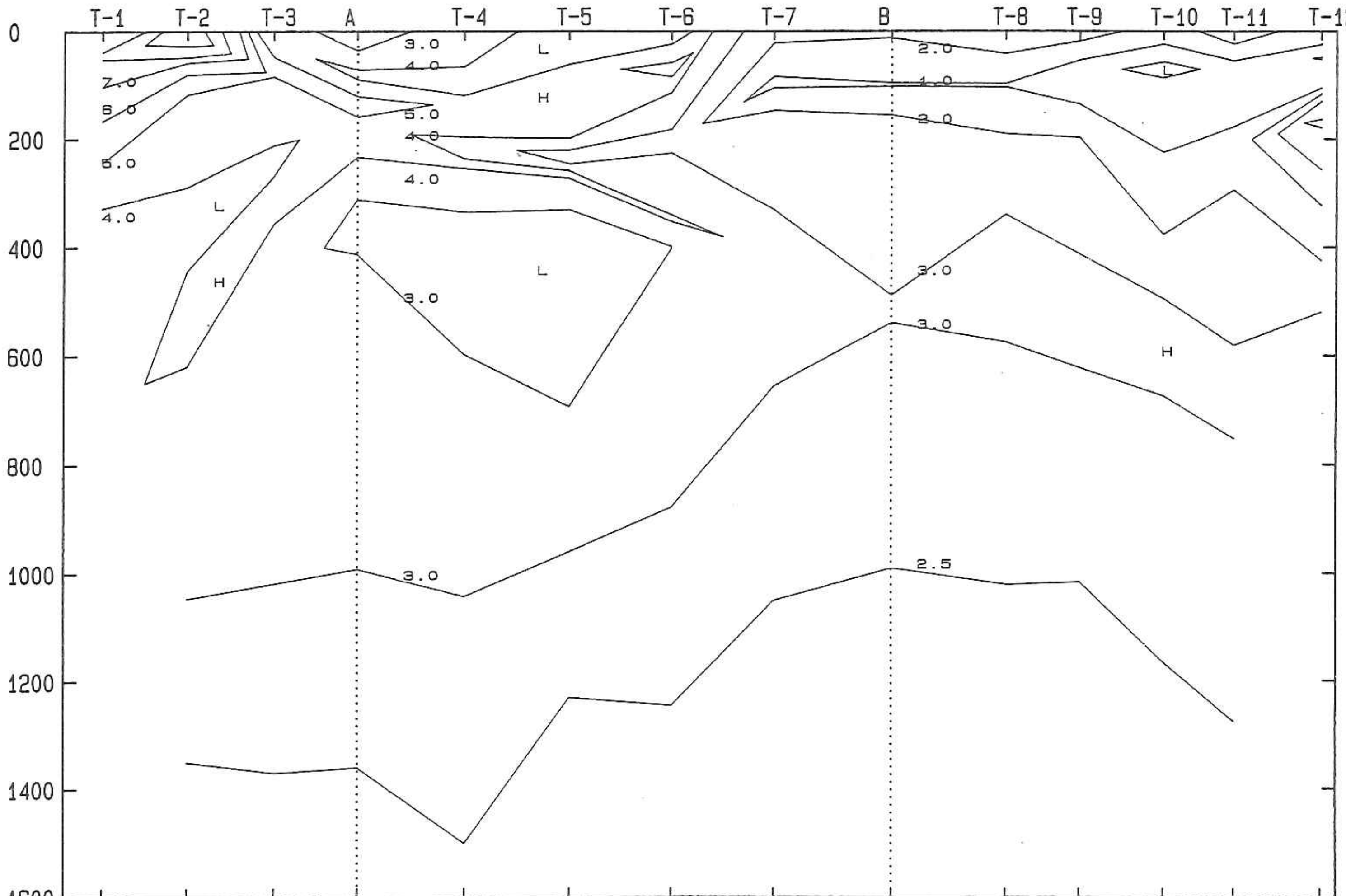


Fig. 17 Cross section of temperature. Data collected by CTD on leg 1 were used.

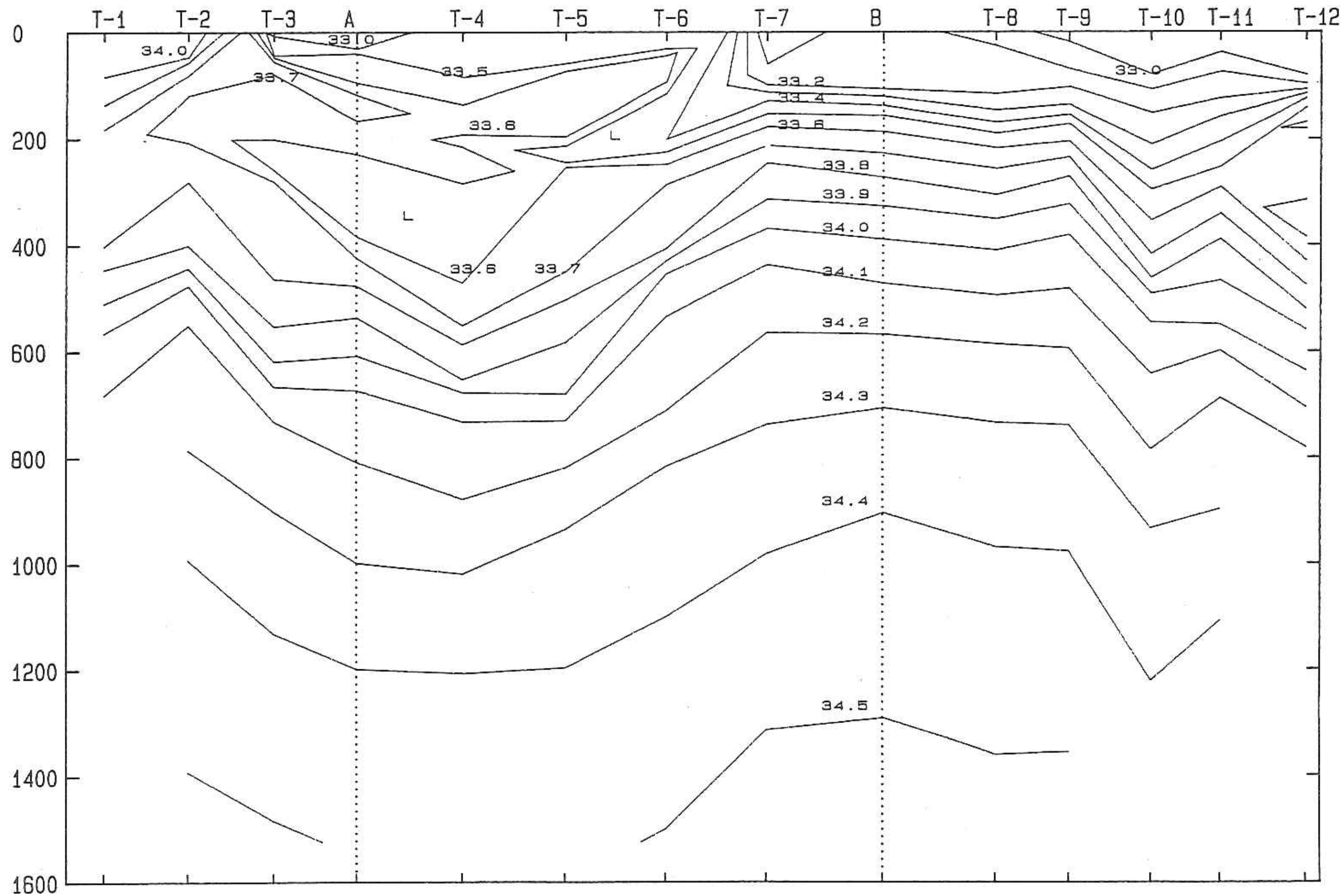


Fig. 18 Cross section of salinity. Data collected by CTD on leg 1 were used.

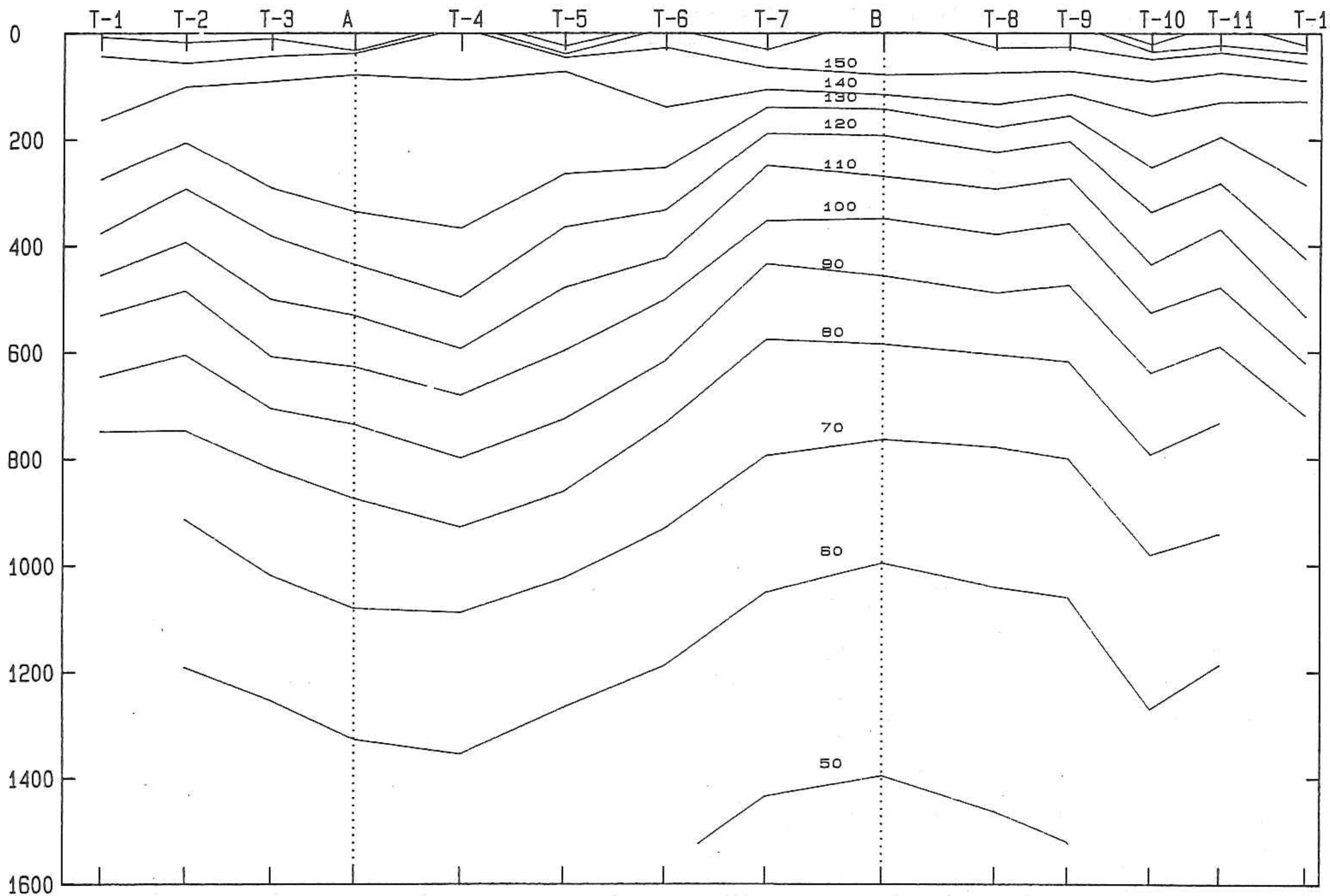


Fig. 19 Cross section of thermosteric anomaly calculated on the basis of data obtained by CTD on leg 1.

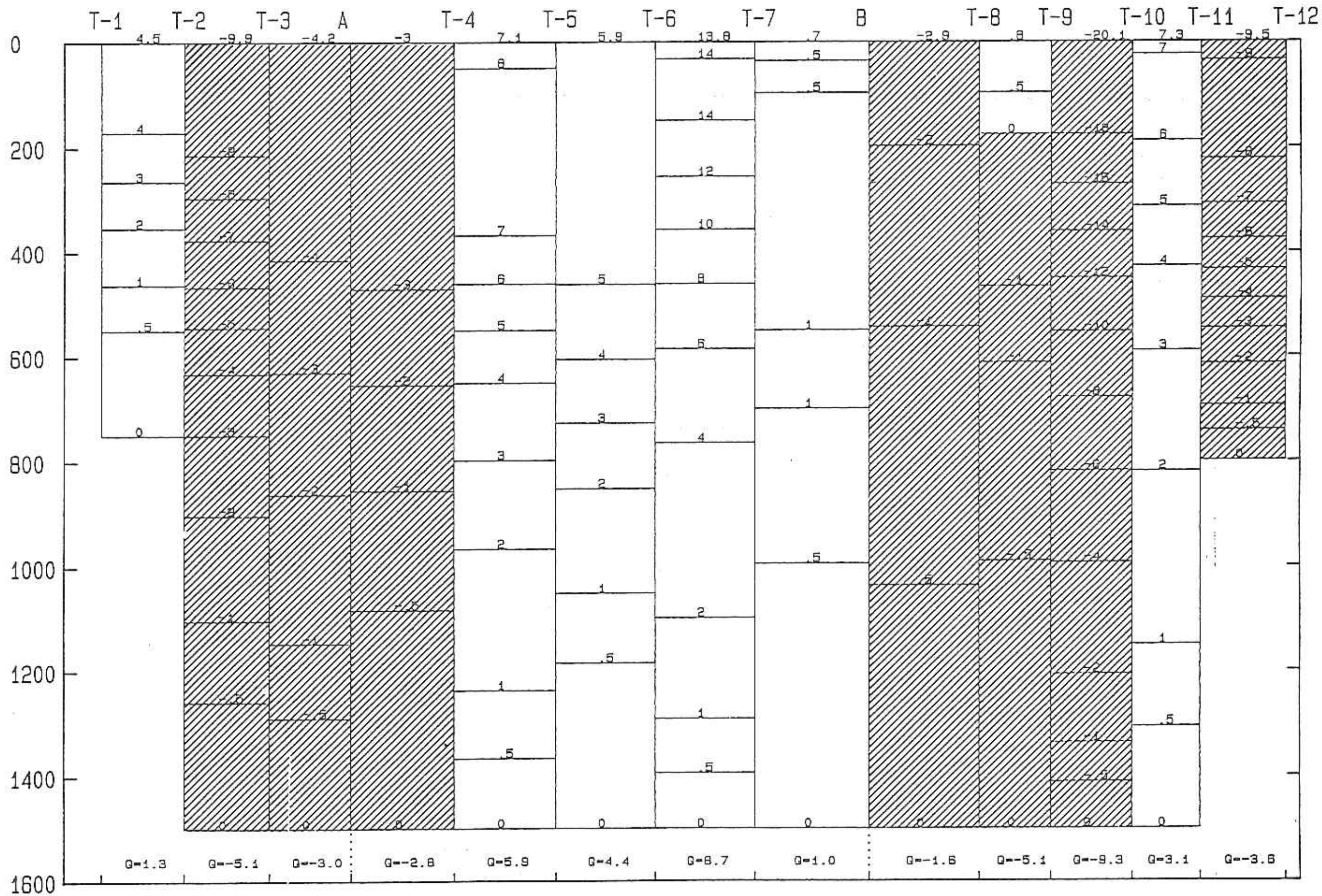


Fig. 20 Zonal geostrophic velocity along three transects (T1-A, A-B and B-T12). Numerical figures given in each bar refer to geostrophic velocity (cm/sec) of component perpendicular to the transects at indicated depths. Inward flow (northward flow across transect T1-A, westward flow across transect A-B, and southward flow across transect B-T12) are shown by shaded bars, and outward flows by open bars. Volume transport ($10^6 m^3/sec$) is given near the bottom of the figure (Q value).

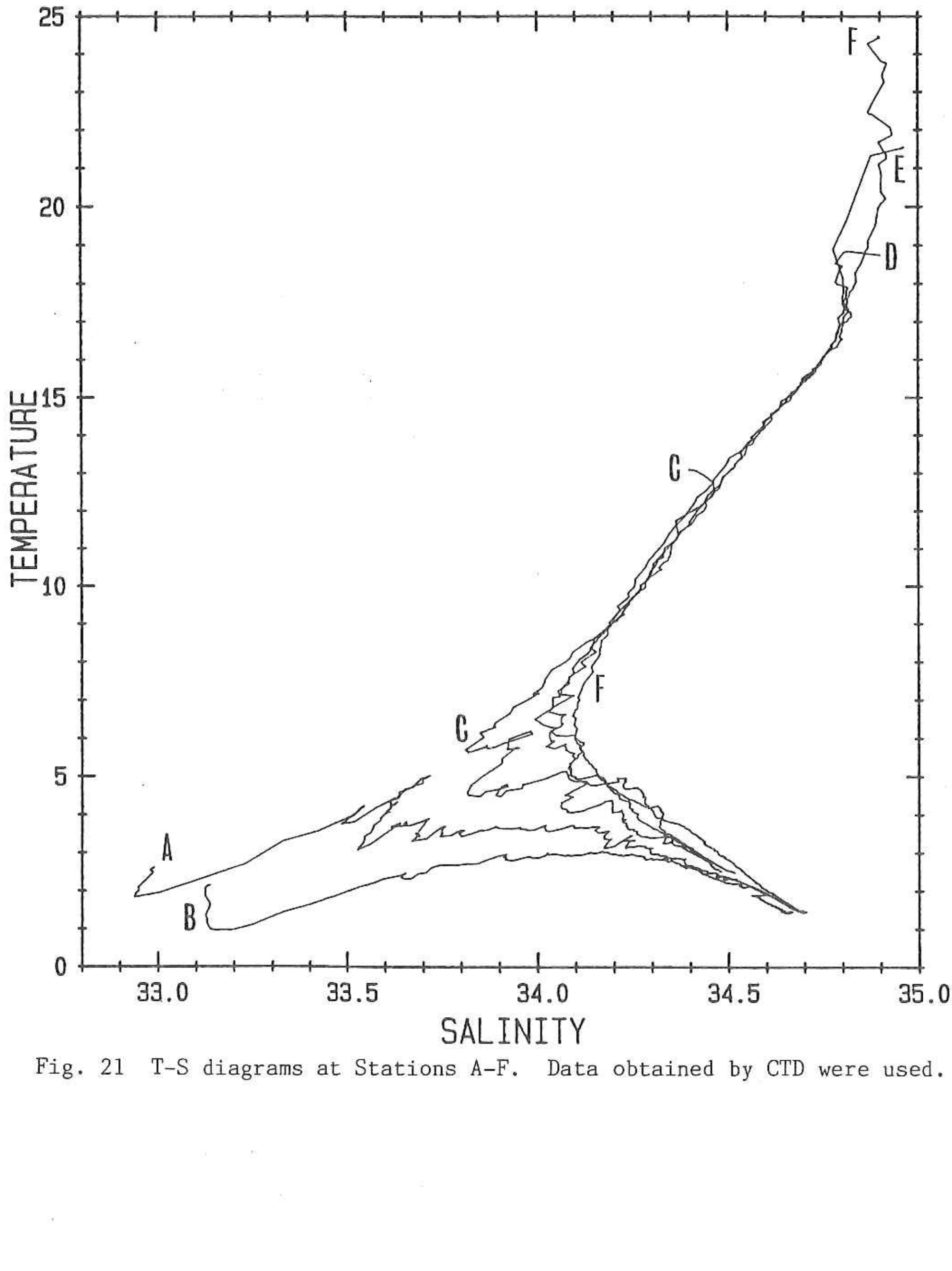


Fig. 21 T-S diagrams at Stations A-F. Data obtained by CTD were used.

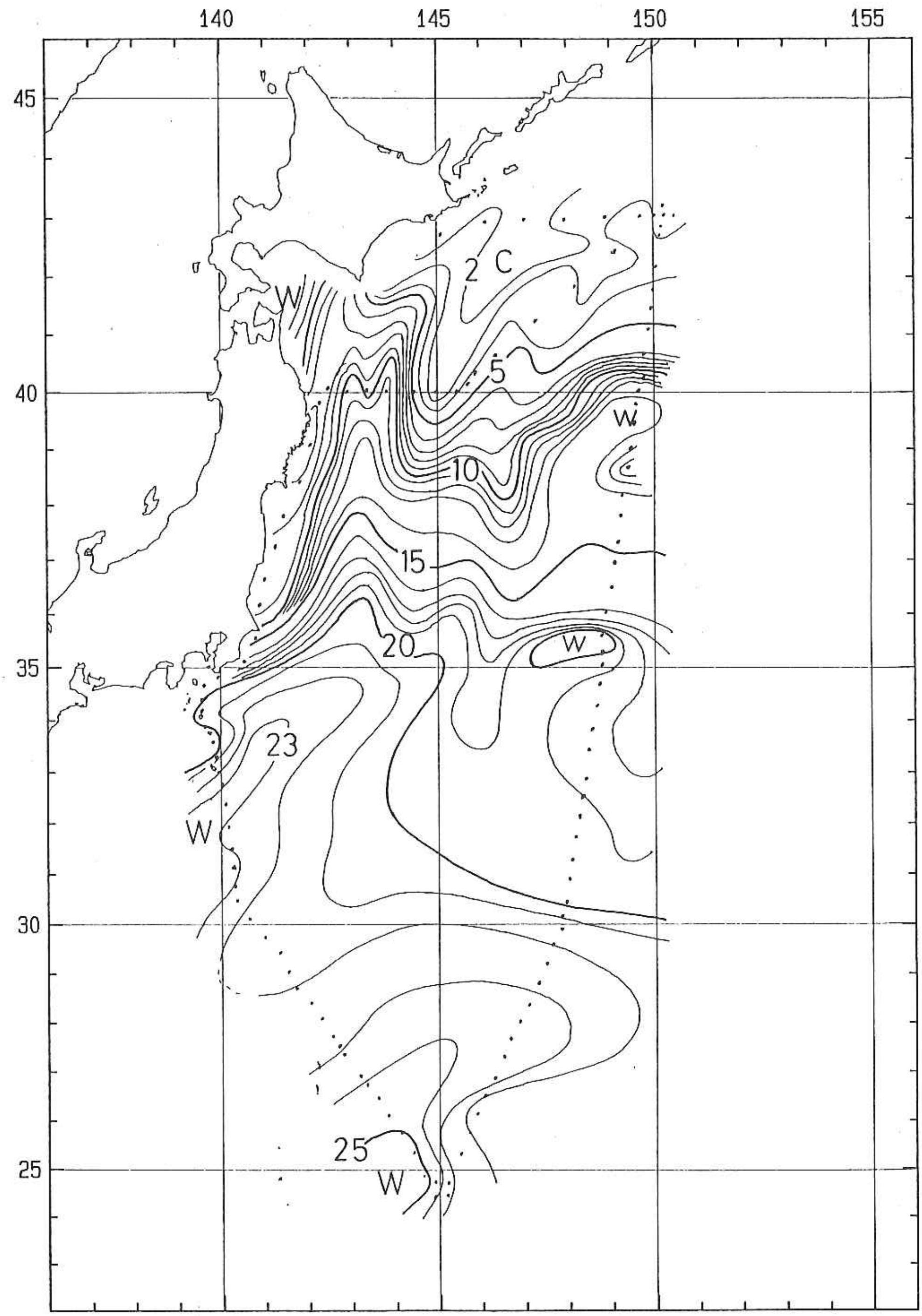


Fig. 22 Horizontal distribution of the surface temperature over studied areas of the western North Pacific as illustrated on the basis of NNSS, NOAA-6 and NOAA-7 data.

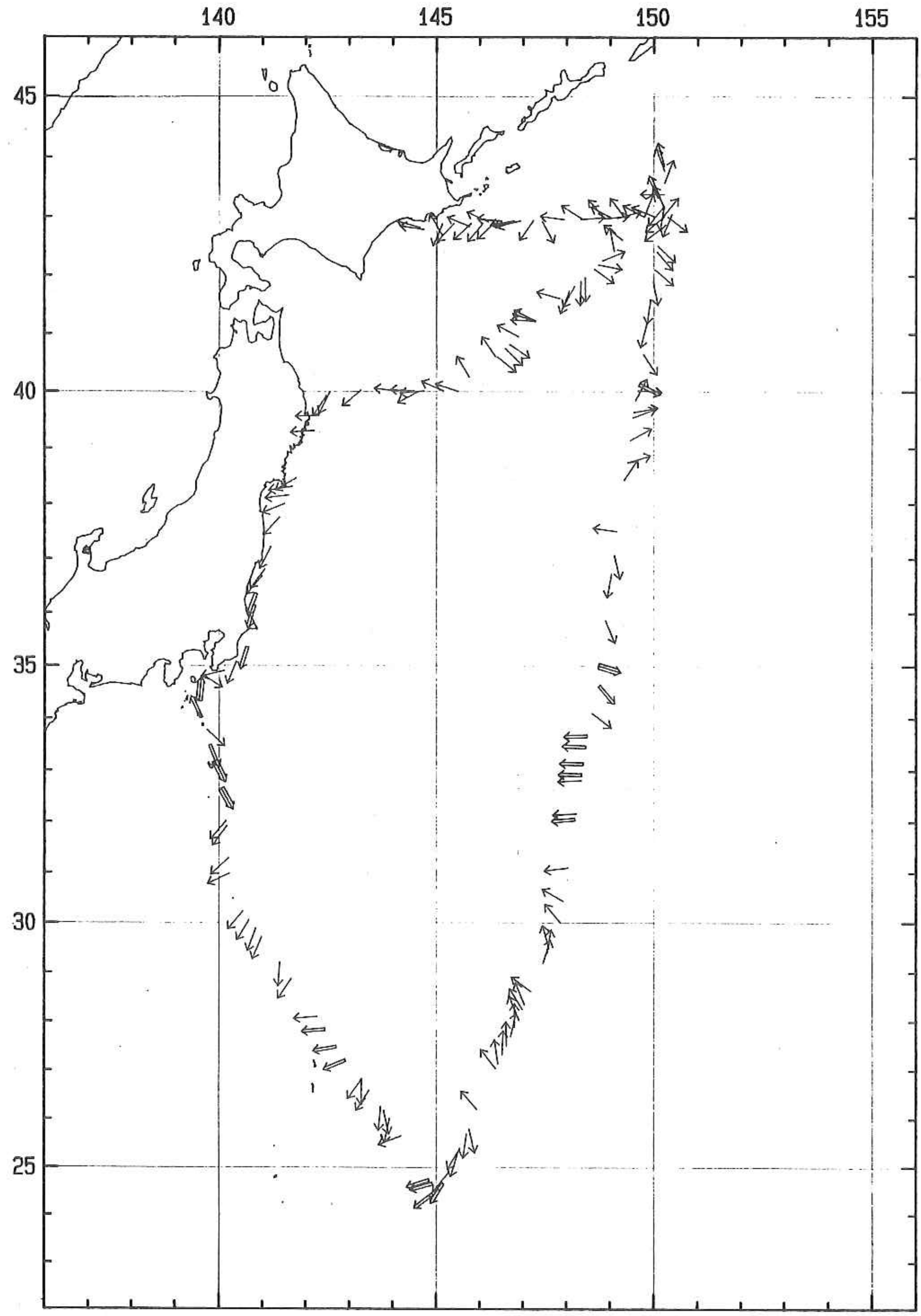


Fig. 23 Surface currents estimated from the NNSS ship's drift data.

Radiation measurement and heat flux across the sea surface

H. Otobe

Downward fluxes of short- and longwave radiation were measured directly on board in order to estimate the heat flux across the sea surface of the Kuroshio and the Oyashio regions. A short-wave sensor (Neo Pyranometer Model MS-41, Eiko Seiki Sangyo Co., Tokyo) and a long-wave sensor (Ishikawa Radiometer Model RL-5, Ishikawa Sangyo Co., Tokyo) mounted on gimbals were installed on the handrail of the upperbridge of the vessel.

Heat flux across the sea surface (Q) is given by

$$Q = Rn - (\ell E + H) \quad (1)$$

and

$$Rn = (1 - r)S\downarrow - \varepsilon(\sigma T^4 - L\downarrow), \quad (2)$$

where Rn is the net radiation flux, ℓE the latent heat flux, H the sensible heat flux, r the albedo, T the sea surface temperature, ε the emissivity of sea water, and σ the Stefan-Boltzman constant. ℓE and H were estimated by an aerodynamic bulk method (Kondo, 1975) using the routine meteorological data obtained at three-hour intervals. The r values given in Payne's table (Payne, 1972) were used. The results are shown in Figs. 24 and 25.

References

Kondo J. (1975). Air-Sea bulk transfer coefficients in diabatic condition. Boundary-Layer Meteorol., 9, 91-112.

Payne R. E. (1972). Albedo of the sea surface. J. Atms. Sci., 29, 959-970.

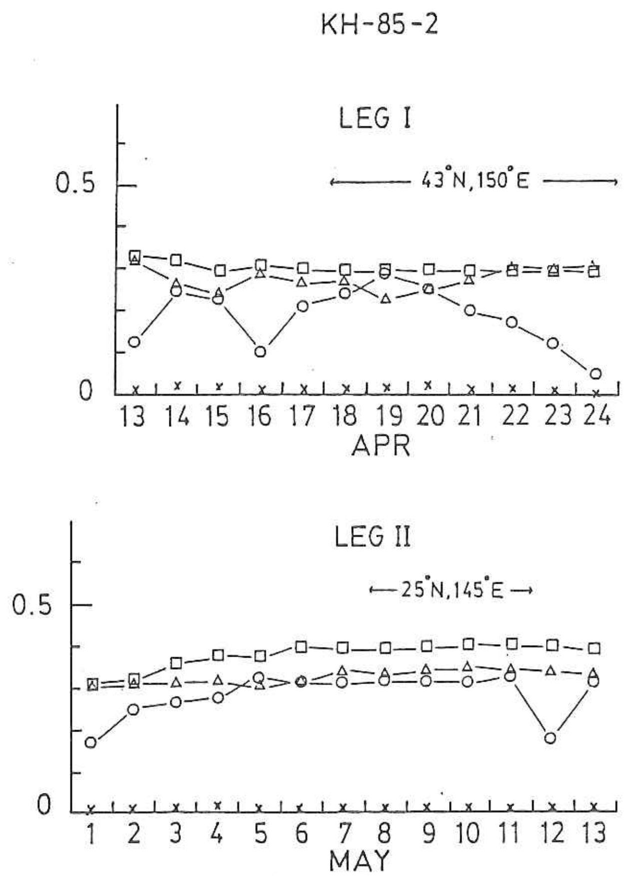


Fig. 24 Day to day variation of the radiation fluxes during Leg 1 (upper) and leg 2 (bottom). ○ : downward short-wave (S↓), x : upward short-wave (rS↓), △ : downward long-wave (εL↓), □ : upward longwave ($\varepsilon\sigma T^4$) (unit:kw m^{-2})

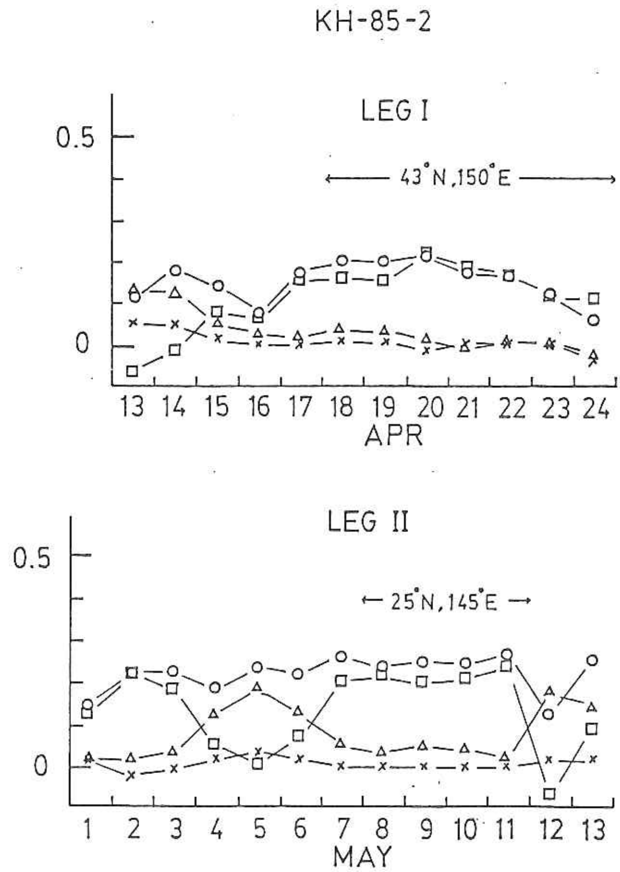


Fig. 25 Day to day variation of the suface heat flux and its components during Leg 1 (upper) and Leg 2 (bottom).
○ : net radiation (Qn), x : sensible heat (H),
△ : latent heat (ℓE), □ : heat balance (Q) (unit: kw m^{-2})

Time series observation of water temperature in the upper ocean

H. Otobe, T. Inagaki and T. Nakai

In order to study the heat budget in the upper ocean, water temperatures in the upper layers were measured at given intervals at two representative stations located in the Oyashio and the Kuroshio regions, using self-contained digital thermometers with an accuracy of $\pm$ 0.05°C and resolving power of 0.02°C (Model RMT water thermometer, Rigosha & Co., LTD, Tokyo). The thermometers were attached to 3 buoy systems of the sediment trap experiments of University of Tokyo, Hokkaido University and Tohoku University (Table 28). The surface heat fluxes were simultaneously determined (see the previous section).

After the measurements, 4096 data stored in a memory unit of each thermometer were read out on a personal computer through a RS-232C serial interface and transferred to mini floppy disks.

The temperature records obtained are reproduced in Figs. 26-28.

Table 28. Summary of time series observations of water temperature by RMT

Station	Observation period	Sampling interval (min)	Depth (m)	Buoy system
B	1400 Apr 17 - 1700 Apr 18 1000 Apr 19 - 0800 Apr 20 1500 Apr 21 - 1600 Apr 22	1	0,5,10,20, 30,50,80	ORI(floating)
B	0800 Apr 18 - 1300 May 1	10	100	Hokkaido Univ (anchored)
F	0000 Apr 23 - 0800 Apr 23	1	3	surface obs. on boad
F	0800 May 8 - 0900 May 9 1600 May 9 - 1700 May 10	5	0,10,20,30	ORI(floating)
F	1800 May 8 - 0600 May 9 0700 May 9 - 1800 May 9 1900 May 9 - 0700 May 10	5	0,10,20,30	Tohoku Univ. (floating)
F	1405 May 11 - 1520 May 11	1		Calibration by CTD

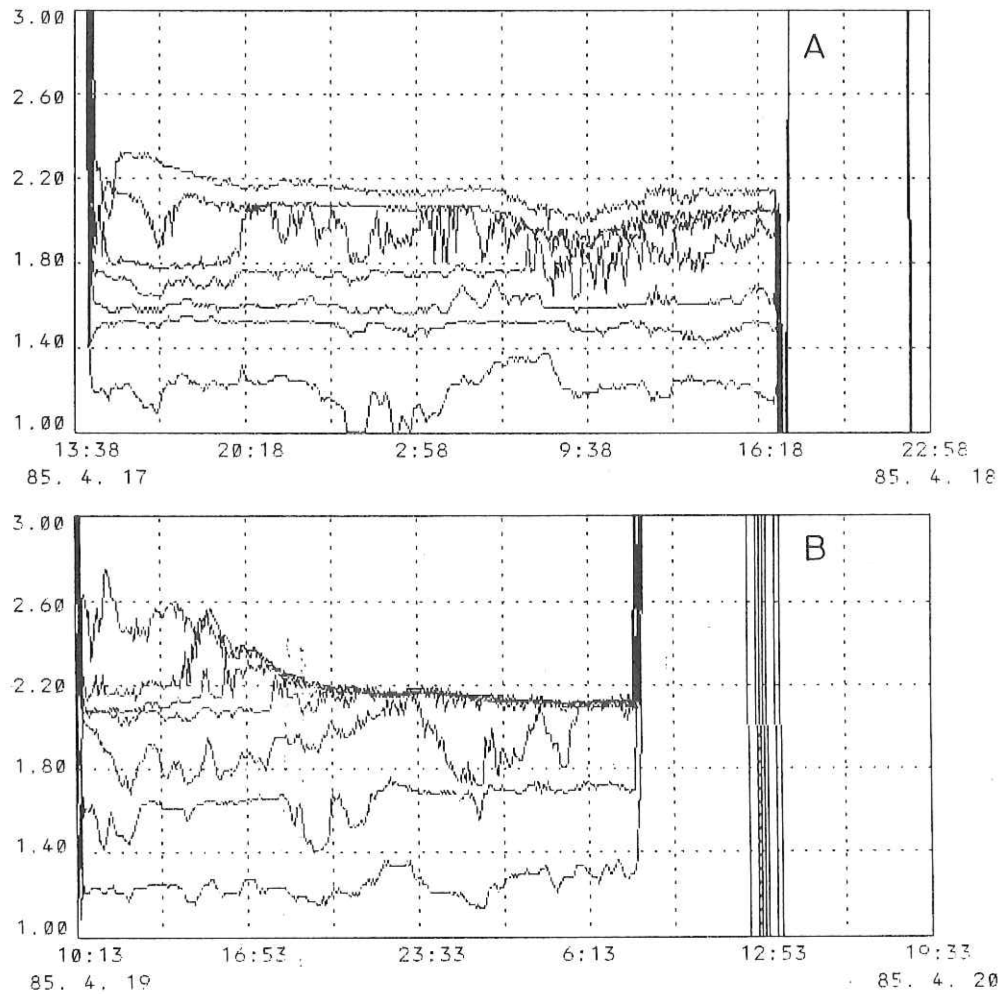
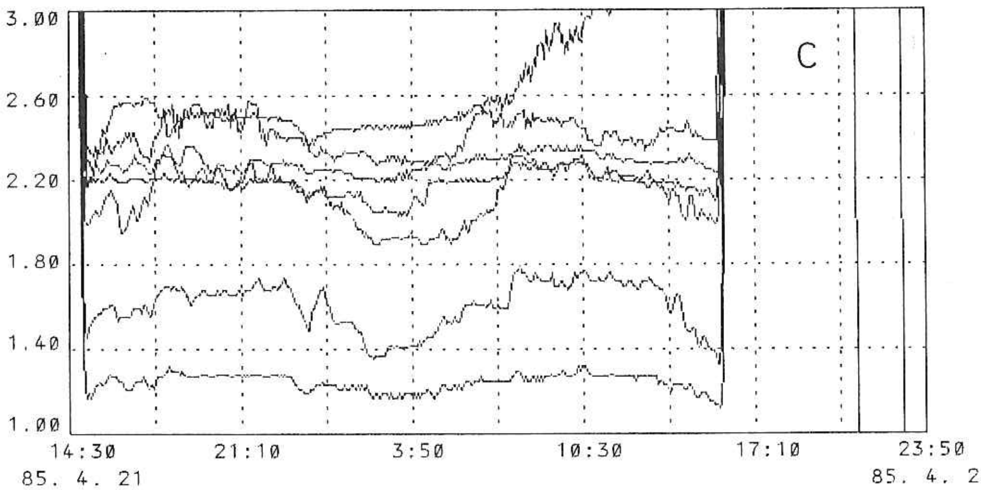
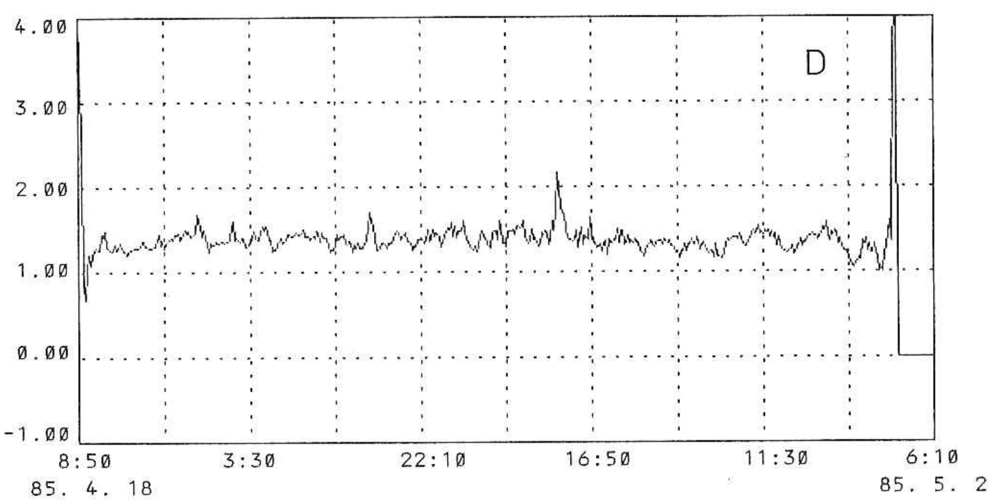


Fig. 26. Time series observations of water temperature at 0, 5, 10, 20, 30, 50 and 80 m (from top to bottom) at Station B during the periods: A, from 1400 LST 17 April to 1700 LST 18 April 1985, B, from 1000 LST 19 April to 0800 LST 20 April 1985, C, from 1500 LST 21 April to 1600 LST 22 April 1985, and D, from 0800 LST 18 April to 1300 LST 1 May 1985.


C
3.00
2.60
2.20
1.80
1.40
1.00
14:30
21:10
3:50
10:30
17:10
23:50
85. 4. 21
85. 4. 22


D
4.00
3.00
2.00
1.00
0.00
-1.00
8:50
3:30
22:10
16:50
11:30
6:10
85. 4. 18
85. 5. 2

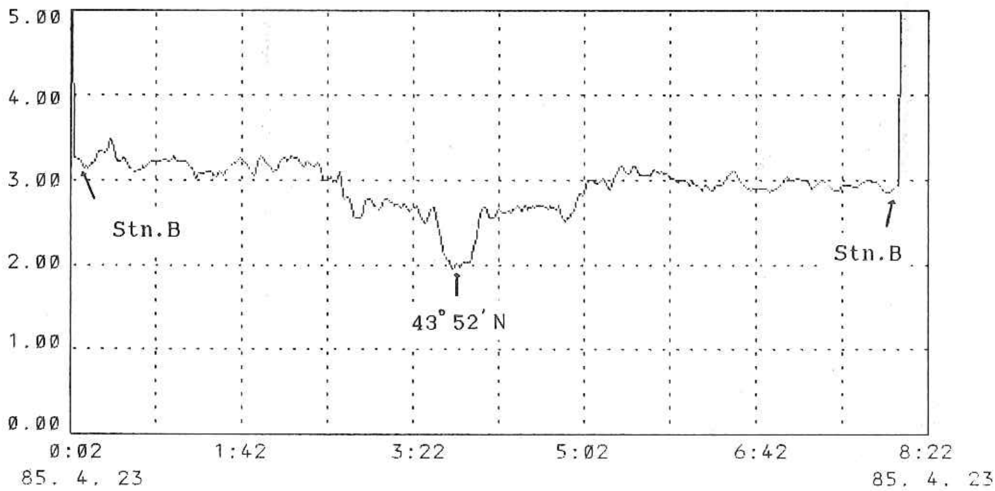


Fig. 27. Surface temperature measured on board by an intake method during a round trip from Station B to the northernmost point of 43°52'N, 150°14'E (cf. Fig. 12).

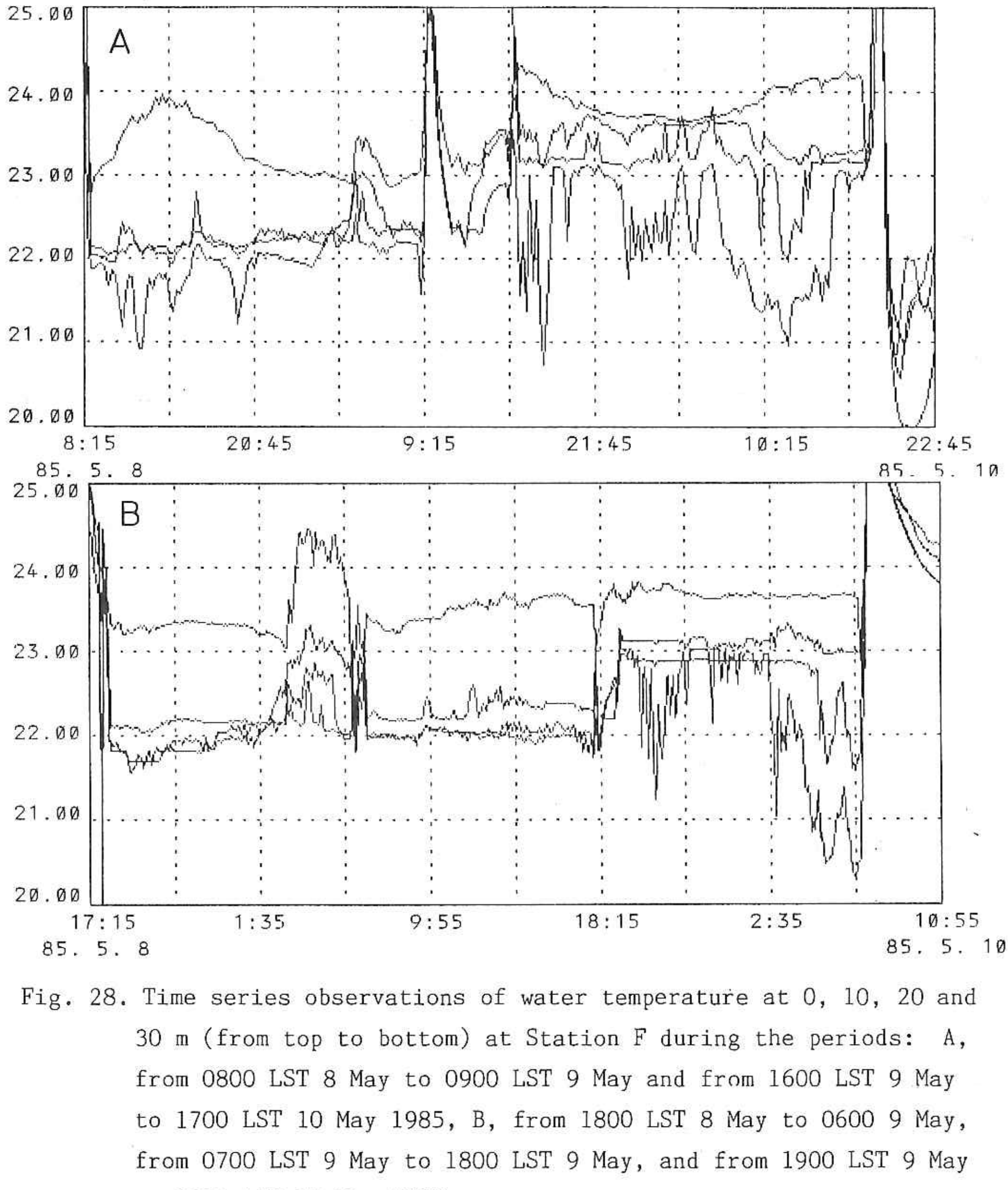


Fig. 28. Time series observations of water temperature at 0, 10, 20 and 30 m (from top to bottom) at Station F during the periods: A, from 0800 LST 8 May to 0900 LST 9 May and from 1600 LST 9 May to 1700 LST 10 May 1985, B, from 1800 LST 8 May to 0600 9 May, from 0700 LST 9 May to 1800 LST 9 May, and from 1900 LST 9 May to 0700 LST 10 May 1985.

Areal and temporal variations of nutrients distribution in the shallow waters of the western North Pacific in spring

T. Saino, H. Otobe, J. Kanda, S. Kudo,
T. Nakai and A. Hattori

Vertical distributions of ammonium, nitrite, nitrate and phosphate were monitored together with other environmental parameters (e.g., temperature, salinity, dissolved oxygen, underwater irradiance, beam attenuation coefficient, in vivo fluorescence of chlorophyll *a*) at each station. Emphasis was placed on the areal and temporal variation in the vertical distribution of nutrients and environmental parameters at two representative stations located in subarctic (Sta. B) and subtropical (Sta. F) areas of the western North Pacific.

Water samples were collected from 11 depths (<200 m) using a multiparameter profiler/sampler (OCTOPUS; Ishimaru et al., 1984). Nutrients were determined immediately after the water samplings using a Technicon Autoanalyser II. At some stations, salinity, dissolved oxygen and chlorophyll *a* were also determined using the same water samples for calibration of the OCTOPUS sensors.

Areal surveys were conducted around the Stations B and F. While staying at Station B for 6 days and at Station F for 5 days, 19 and 11 profiles were obtained respectively.

Ship's position where OCTOPUS profiles were obtained are summarized in Table 29.

Reference

Ishimaru, T., H. Otobe, T. Saino, H. Hasumoto and T. Nakai (1984). OCTOPUS, an octo parameter underwater sensor, for use in biological oceanography studies. J. Oceanogr. Soc. Japan, 40, 207-212.

Table 29. Ship's position during OCTOPUS casts

Cast	Latitude	Longitude	Date	Time
		Leg 1		
OCT-A	39°59.7'N	145°25.0'E	15 Apr	10:18-10:51
OCT-01	43 00.1	149 45.9	17 Apr	03:37-03:54
OCT-02	43 00.2	150 00.1	17 Apr	04:54-05:09
OCT-03	43 00.2	150 13.6	17 Apr	06:09-06:23
OCT-04	43 09.9	150 13.5	17 Apr	07:18-07-30
OCT-B1	42 59.9	150 14.2	17 Apr	13:40-13:55
OCT-B2	42 58.0	150 11.7	17 Apr	22:34-23:00
OCT-B3	42 58.4	150 11.8	18 Apr	12:45-13:09
OCT-B4	42 57.5	150 09.7	18 Apr	17:23-17:36
OCT-B5	42 56.7	150 12.6	18 Apr	23:25-23:50
OCT-B6	42 57.9	150 10.6	19 Apr	10:40-10:53
OCT-B7	42 58.3	150 10.8	19 Apr	11:07-11:30
OCT-B8	42 55.8	150 09.7	19 Apr	23:50-00:14
OCT-B9	42 58.2	150 12.1	20 Apr	08:30-08:44
OCT-B10	42 58.5	150 13.6	20 Apr	12:01-12:16
OCT-B11	42 57.9	150 12.3	20 Apr	17:18-17:30
OCT-B12	43 00.3	150 11.1	21 Apr	00:03-00:20
OCT-B13	42 59.9	150 10.5	21 Apr	05:59-06:10
OCT-B14	43 00.8	150 09.2	21 Apr	11:00-11:26
OCT-B15	43 01.2	150 09.3	21 Apr	12:03-12:26
OCT-B16	43 00.8	150 09.1	21 Apr	15:06-15:18
OCT-B17	43 01.4	150 08.5	21 Apr	18:01-18:17
OCT-B18	43 02.7	150 07.2	21 Apr	22:25-22:54
OCT-B19	43 01.8	150 05.4	22 Apr	12:45-13:10
OCT-B20	43 01.5	150 07.7	22 Apr	16:10-16:33
OCT-B21	43 03.6	150 04.9	22 Apr	23:15-23:43
OCT-026	43 09.9	150 12.8	23 Apr	09:00-09:26
OCT-027	43 00.1	150 26.6	23 Apr	10:50-11:14
OCT-028	42 50.1	150 13.4	23 Apr	12:29-12:52
OCT-029	43 00.0	150 13.3	23 Apr	14:11-14:31
OCT-030	43 00.1	150 00.1	23 Apr	16:03-16:26
OCT-031	42 59.8	149 46.3	23 Apr	17:29-17:55
		Leg 2		
OCT-B'1	42 59.6	150 13.9	01 May	12:17-12:46
OCT-B'2	43 00.5	150 11.8	01 May	21:18-21:39
OCT-C1	40 00.4	149 37.4	02 May	17:11-17:36
OCT-D1	34 59.8	148 45.2	04 May	04:25-04:51
OCT-E1	30 00.1	147 50.3	06 May	06:05-06:24
OCT-F1	24 39.9	145 09.8	07 May	10:58-11:14
OCT-F2	24 39.6	145 09.6	07 May	11:17-11:33
OCT-F3	24 36.9	145 08.5	07 May	20:35-21:06
OCT-F4	24 41.7	145 09.4	08 May	08:41-09:07
OCT-F5	24 39.5	145 07.6	08 May	15:07-15-37
OCT-F6	24 35.8	145 03.9	08 May	21:37-22:05
OCT-F7	24 26.6	145 00.7	09 May	10:52-11:15
OCT-F8	24 35.0	145 05.8	09 May	16:04-16:20
OCT-F9	24 33.9	145 03.4	09 May	21:52-22:07
OCT-F10	24 29.7	144 58.9	10 May	11:51-12:12
OCT-F11	24 27.9	144 55.3	10 May	16:48-17:14
OCT-F12	24 37.7	145 06.5	10 May	21:35-21:51
OCT-F13	24 38.4	145 09.9	11 May	09:27-09:40
OCT-051	24 39.9	145 09.9	11 May	15:59-16:26
OCT-052	24 25.4	145 10.0	11 May	17:36-18:11
OCT-053	24 25.0	144 53.9	11 May	19:22-19:46
OCT-054	24 32.5	145 01.7	11 May	20:53-21:15
OCT-055	24 40.1	144 53.5	11 May	22:13-22:34

Chemical studies of the western North Pacific

S. Noriki, S. Watanabe, K. Taguchi, M. Honda and T. Kurosaki

1. Sediment trap experiments

Two D-type sediment traps which had been deployed on 4 September 1984 at Station AN-5 in the KH-84-3 cruise were retrieved on 12 April 1985 at Station A. Four consecutive time-series samples, each 55 days long, were collected at 3800 and 4800 m. Seasonal variations of total particulate flux, major inorganic components, trace metals, and radionuclides in settling matter were determined. Total particulate fluxes are listed in Table 30.

NH-type sediment traps were deployed on 18 April 1985 at Station B and retrieved on 1 May 1985. The settling matter was collected at four depths, and the variation of chemical composition of settling matter during a phytoplankton bloom was determined. Total particulate fluxes are listed in Table 31.

The NH-type sediment traps were deployed at five depths on 4 May 1985 at Station D. They will be retrieved during the KH-85-4 cruise.

2. Suspended particulate matter in sea water

Seawater samples were collected from various depths at Stations B and F. These samples were filtered through a Nuclepore filter, and the dry weight of particulate matter was determined. The concentrations of Na, Ca, Si, Al and Mn will be determined later.

3. Aluminum and manganese in sea water

Seawater samples were obtained from various depth at Stations A, B and F with Go-Flo samplers. The samples were placed in precleaned CPE Nalgen bottles and acidified with conc. HCl to pH<2.

Aluminum will be determined by the fluorometric method and manganese by FLAAS after concentration by solvent extraction.

4. Natural radionuclides in sea water

Seawater samples were obtained from various depths at Stations B, B' and F with a 200-liter large volume sampler or a suction pump.

Radionuclides were coprecipitated with ferric hydroxide and carbonates, and further fractionated by passing through anion and cation exchange columns. ^{232}Th, ^{230}Th, ^{234}Th, ^{228}Th, ^{231}Pa, ^{228}Ra, ^{226}Ra, ^{210}Pb, ^{210}Po and ^{7}Be were determined.

MnO_2-acrylic fibers which had been attached to the sediment traps were recovered from 7 depths at Stations A and B. The MnO_2-acrylic fiber was treated with 500 ml of hot 6N HCl for one hour. Radionuclides which had been adsorbed on MnO_2-impregnated acrylic fiber were leached, and fractionated by passing through anion exchange columns. Thorium isotopes and ^{231}Pa were determined.

Ten MnO_2-fibers were attached to the sediment traps mooring system at Station D. They will be retrieved during the Hakuho-Maru KH-85-4 cruise.

5. Measurement of ^{14}C and tritium in sea water

Radio carbon activity measurement is one of the useful technique to determine the structure and age of water mass.

Thirty samples were collected at Stations B and F in order to get detailed ^{14}C profile in the Oyashio area.

The water samples for ^{14}C determination were collected using a 200 liter large volume sampler. The dissolved inorganic carbon was extracted and absorbed in 4N NaOH solution using an extraction apparatus illustrated in Fig 29. The extracted carbon was converted to benzene and its ^{14}C activity was measured by a liquid scintillation method.

The water samples for tritium measurement were also collected at Stations A, B and F to obtain information about how the surface water penetrates into intermediate depth.

6. Air sampling for studying the sulfur cycle in the atmosphere

To measure the sulfur stable isotope ratio, gaseous sulfur in the atmosphere was collected using an alkaline filter paper. Three samples were obtained on leg. 2. Stable isotope analysis is in progress.

This work was conducted in collaboration with S. Tsunogai, K. Harada, H. Masaki, S. Okawa and E. Takahashi, Laboratory of Analytical Chemistry, Faculty of Fisheries, Hokkaido University.

Table. 30 Total downward flux of particulate matter at Station A as determined by D-type traps*

Duration	Total flux($mg/m^2 \cdot day$) at depth of	
	3800m	4800m
4 Sep. '84 - 29 Oct. '84	77.9	124
29 Oct. '84 - 23 Dec. '84	170	141
23 Dec. '84 - 16 Feb. '85	102	105
16 Feb. '85 - 12 Apr. '85	109	117

* Sodium azide was added as a preservative.

Table 31. Total downward flux of particulate matter at Station B as determined by NH-type traps*

Depth(m)	Total flux ($mg/m^2 \cdot day$)
260	216 ± 17
490	216 ± 18
1630	215 ± 12
3320	138 ± 10

* Means of 5 determinations with standard deviations (1σ) are given.

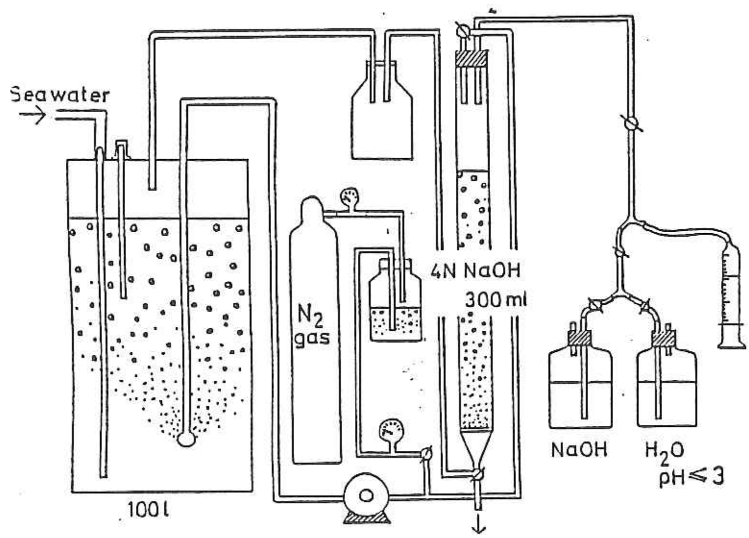


Fig. 29 A device used for extraction of CO_2 from seawater

Organo-chemical and morphological studies on particulate matter and plankton

E. Tanoue and S. Hara

Vertical distributions of various particulate organic materials, and quantitative and qualitative characteristics of a plankton community were examined.

Seawater samples (30 l each) were collected from fifteen layers from the surface to increasingly deepen layers at each station. Particulate matter was collected by filtering approximately 20 l of seawater through a Whatman GF/F filter and stored frozen at -20°C. Chlorophyll *a* and phaeopigment were determined on board by a fluorometric method (Table 32). Particulate organic carbon and nitrogen were determined on land using a CHN analyzer. Carbohydrates, amino acids and lipids were determined by colorimetric, fluorometric and wet oxidation methods, respectively. A part of the seawater sample was treated with glutaraldehyde (1% final concentration) and another part was filtered through a Gelman GA-8 filter. The filter was mounted on a glass slide with glycerin jelly and stored in a desiccator at -20 °C for later examination of picoplankton by fluorescent microscopy. The rest of the seawater sample was used for quantitative and qualitative examination of autotrophic and heterotrophic plankton by light and electron microscopies on land.

Seawater samples (200-400 l each) were collected from seven layers from the surface through deep waters at Stations B and F. Another 200 l of seawater was also collected from three layers, i.e., the subsurface chlorophyll maximum layer, and layers above and below the chlorophyll maximum layer at Stations D and E. Particulate matter was fractionated into four size fractions: >100 μm, 20-100, 10-20 and <10. Aliquots of fractionated samples were used for chlorophyll *a* and phaeopigment determination on board (Table 33). Another part of each fraction was treated with glutaraldehyde, and was stored for later microscopical examinations including fine structural observations on pico-, nano- and microplankters. Particulate matter of each fraction was collected on Whatman GF/F and stored frozen until chemical analyses on land. Particulate lipids were separated into simple lipids, glycolipids and phospholipids by silica gel chromatography, and quantified by gas liquid chromatography. Particulate protein was characterized by a polyacrylamide gel electrophoresis technique.

Table 32. Vertical distribution of chlorophyll *a* and phaeopigment*

Depth (m)	Station													
	A		B		B'		C		D		E		F	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
0	7.86	2.40	0.35	0.09	1.24	1.16	0.92	0.46	0.20	0.10	0.08	0.04	0.06	0.03
10	6.21	2.42	0.36	0.13	1.02	0.81	0.87	0.38	0.19	0.05	0.08	0.04	0.05	0.02
20							0.88	0.38			0.09	0.03		
30	8.36	4.28	0.24	0.32	1.15	1.18	1.30	0.53	0.17	0.08	0.09	0.04	0.08	0.04
45									0.34	0.18				
50	0.56	0.41	0.40	0.30	0.39	0.36	0.48	0.41			0.11	0.05	0.08	0.04
60									0.25	0.14				
75	0.22	0.26	0.22	0.30	0.16	0.18	0.20	0.26			0.37	0.23	0.12	0.06
80									0.13	0.08				
100	0.13	0.19	0.20	0.16	0.07	0.15	0.05	0.10	0.13	0.08	0.26	0.20	0.21	0.12
125	0.09	0.15	0.05	0.11	0.03	0.10	0.04	0.10	0.07	0.05	0.05	0.04	0.38	0.23
150	0.06	0.15	0.01	0.06	0.01	0.05	0.06	0.11	0.02	0.03	0.01	0.02	0.15	0.07
175	0.05	0.15	0.00	0.06	0.01	0.06							0.06	0.05
200	0.06	0.16	0.00	0.07	0.01	0.05	0.02	0.11	0.01	0.04	0.00	0.02	0.03	0.03

* (a) chlorophyll *a* (µg/l), (b) phaeopigment (µg/l)

Table 33. Percent abundances of chlorophyll *a* and phaeopigment in different size fractions*

Station	Depth (m)	Total (μg/1) (a)	(b)	Size fraction >100μm (a)	(b)	100-20μm (a)	(b)	20-10μm (a)	(b)	<10μm. (a)	(b)
B	20	0.29	0.14	2.3	7.3	2.6	6.2	95**	86**		
	60	0.41	0.31	0.6	1.2	1.3	1.5	98**	97**		
	100	0.13	0.17	0.7	1.2	5.9	3.6	93**	95**		
B'	10	1.27	1.44	36	75	5.1	3.6	1.5	1.2	57	20
	60	0.38	0.39	12	11	4.4	3.1	3.4	1.8	80	85
C	10	0.95	0.57	4.3	6.1	3.9	5.7	2.7	2.8	89	89
	30	1.23	0.67	2.1	4.1	3.1	5.2	1.8	2.8	93	88
	100	0.15	0.25	1.2	1.3	5.1	5.5	2.0	2.1	92	91
D	10	0.17	0.09	12	15	15	29	3.1	5.7	70	50
	45	0.63	0.40	17	33	27	27	2.4	3.3	54	37
	300	0.01	0.03	6.7	6.1	14	8.3	15	4.8	65	81
E	20	0.10	0.06	4.7	5.2	4.1	4.5	2.5	1.5	89	89
	75	0.43	0.27	7.6	15	5.5	14	2.7	4.6	84	66
	200	0.01	0.03	2.3	5.8	54	29	3.1	4.9	41	61
F	30	0.06	0.02	0.5	1.1	0.4	1.4	0.2	0.5	99	97
	95	0.25	0.19	0.6	0.6	1.3	1.8	0.4	0.6	98	97
	160	0.07	0.05	0.5	2.3	0.6	1.7	0.3	0.6	99	95

* (a) chlorophyll *a*, (b) phaeopigment

** Chlorophyll *a* and phaeopigment in the size fraction less than 20 μm.

Natural abundance of ^{15}N in suspended and settling particulate organic matter

T. Saino and A. Hattori

Data on the natural ^{15}N abundance of particulate organic matter (POM) have been used to investigate processes of POM production and decomposition. We can expect that the comparison of isotopic ratios in suspended and settling particulate materials provides information to obtain insight into particle dynamics in the oceanic waters. We focused on the upper 200 m layer.

Water samples were collected with 23-liter Niskin bottles at Stations B, B', and F at depths from 0-4000 m. Closely spaced water samplings were also carried out at stations B, B' and F in the shallow layer (<200 m). At stations B and F, additional samplings were made at 6-hour intervals, while the ship chased the drifting buoy of Tohoku University (Oyama and Sasaki). Sediment trap experiments (Table 34) were conducted at Stations B and F in collaboration with M. Takahashi, H. Toda and S Kudoh. Sediment traps were suspended at 10, 30, 50, 70, 90, 110, and 150 m at Station B and at 20, 40, 60, 80, 120, 160, and 200 m at Station F.

The water samples (60-90 liters for >300 m, ca. 20 liters for <200 m) and the sediment trap samples were filtered through glass fiber filters (Whatman GF/F, 47 mm diameter, precombusted at 450 C for 4 hr), and POM collected on the filters was kept frozen for later mass spectroscopic analysis.

Table 34. Summary of the sediment trap experiments

Exp. No.		Date	Location
1B	Initial:	1410, 17 Apr	42°59.9'N, 150°14.1'E
	Final:	1710, 18 Apr	42 57.5'N, 150 09.7'E
2B	Initial:	1010, 19 Apr	42 58.1'N, 150 10.7'E
	Final:	0810, 20 Apr	42 58.1'N, 150 12.1'E
3B	Initial:	1500, 21 Apr	43 00.8'N, 150 09.8'E
	Final:	1600, 22 Apr	43 01.5'N, 150 07.7'E
4F	Initial:	0820, 08 May	24 41.8'N, 145 09.7'E
	Final:	0920, 09 May	24 28.2'N, 145 01.0'E

Ammonium uptake by natural populations of phytoplankton

J. Kanda, T. Saino and A. Hattori

The mode of ammonium uptake by natural populations of phytoplankton was investigated by using an ^{15}N tracer technique. The experiment was designed to clarify the following points which are matters of debate.

1. Uptake response to the elevated concentration of ammonium

When chemostat grown phytoplankton are exposed to a high concentration of ammonium, uptake rate of ammonium is initially very high but declines later (Conway et al. 1976). Similar time course of uptake was observed with natural populations in coastal areas where ammonium is exhausted by phytoplankton blooming. McCarthy and Goldman (1979) have suggested that phytoplankton in the oligotrophic open ocean can efficiently utilize sporadically supplied ammonium with enhanced uptake capacity induced by nitrogen limitation, and that they maintain nearly maximum rate of growth in these areas. However, our data collected over the extended areas of the North Pacific (Kanda et al. 1985) does not support this view. We therefore attempted to examine the time course of uptake in response to the addition of high concentration of ammonium (10 μM). The methods used are the same as described in Kanda et al. (1985).

2. Nitrogen deficiency in natural populations

It is still controversial whether phytoplankton in the oligotrophic area are nitrogen deficient or not (Goldman et al. 1979; Sharp et al. 1980). Nitrogen deficient phytoplankton accumulate ^{15}N in an ethanol soluble fraction when ^{15}N-ammonium is added to the media (Kanda et al., in prep.). Taking this accumulation of ^{15}N as an index of N deficiency, the natural populations in surface water were examined.

Figure 30 shows the time course of ammonium uptake in response to the addition of 10 μM together with ^{15}N partitioning into ethanol soluble and insoluble fractions. At Stations J6 (30°00'N, 147°51'E) and J8 (24°37'N, 145°06'E), located in the oligotrophic subtropical North Pacific, nitrogenous nutrients were not detectable. However, initial rapid ammonium uptake was not observed at these stations although ^{15}N accumulation in ethanol soluble fraction was found at Station J8.

References

Conway, H. L., P. J. Harrison, and C. O. Davis (1976). Marine diatoms grown in chemostats under silicate or ammonium limitation. II. Transient response of *Skeletonema costatum* to a single addition of the limiting nutrient. Mar. Biol., 35, 187-199.

Goldman, J.C., J. J. McCarthy and D. G. Peavey (1979). Growth rate influence on the chemical composition of phytoplankton in oceanic waters. Nature, 279, 210-215.

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McCarthy, J. J. and J. C. Goldman (1979). Nitrogenous nutrition of marine phytoplankton in nutrient-depleted waters. Science, 203, 670-672.

Sharp, J. H., M. J. Perry, E. A. Renger and R. W. Eppley (1980). Phytoplankton rate processes in the oligotrophic waters of the central North Pacific Ocean. J. Plankton Res., 2, 335-353.

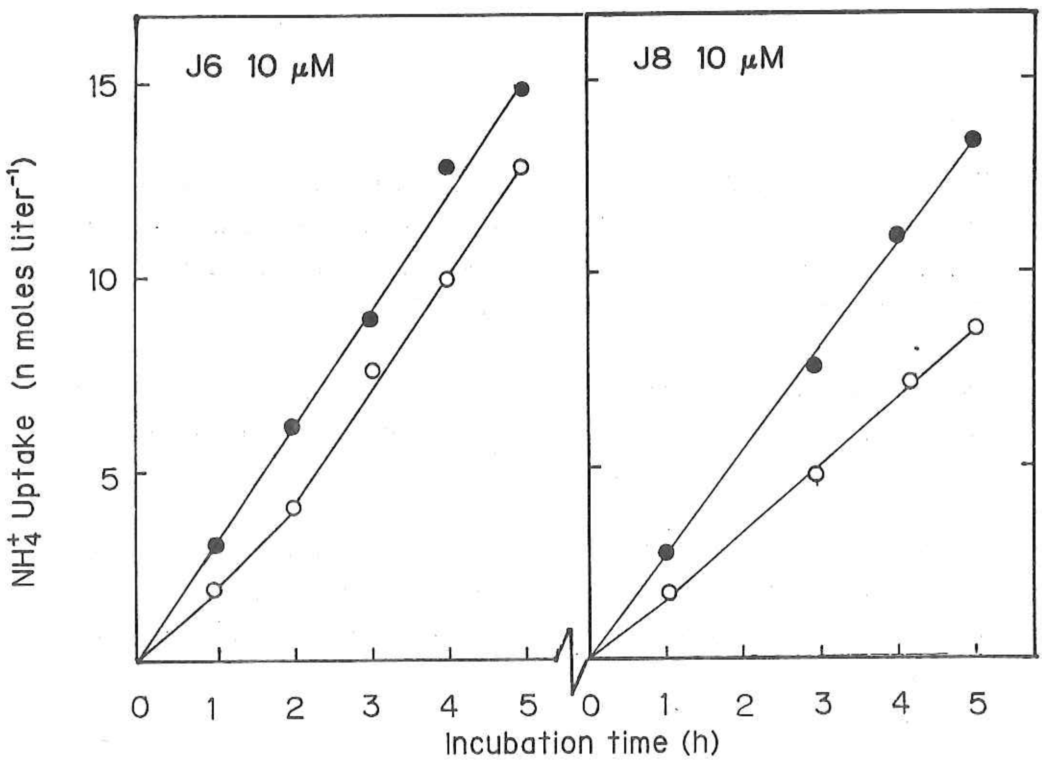


Figure 30. Time courses of ammonium uptake at Stations J6 and J8. Closed circles, total ^{15}N taken up; open circles, ^{15}N in ethanol insoluble fraction.

Studies on primary production in the northwestern Pacific Ocean

Y. Maita, A. Shiomoto and T. Odate

This study was conducted to clarify the size characteristics of the primary productivity in the subarctic and subtropical areas of the northwestern Pacific Ocean. The following subjects are focused: (1) regional changes in the distribution of zooplankton and phytoplankton, (2) vertical distribution of ATP in particulate matter with special reference to the particle size, (3) uptake of ^{15}N organic compounds by phytoplankton and heterotrophic micro-organisms, (4) vertical distribution of amino acids and carbohydrates in water column, and (5) organic constituents in sediment trap samples and bottom sediment samples. The experiments carried out on board the ship are briefly summarized below.

1. Regional changes in the distribution of zooplankton and phytoplankton

Samples were collected from the surface to 200 m by Norpac nets (XX-13 and GG-54) at Stations B, C, D, E and F. Zooplankton in 20 l of seawater samples from discrete depths between the surface and 200 m were concentrated by filtering through a small net of 40 μm mesh. Species and cell numbers of phytoplankton and microzooplankton will be later examined in the land laboratory. Portions of the seawater samples were filtered through Nuclepore filters of 10, 2 and 0.2 μm in pore size, and chlorophyll *a* and phaeophytin were determined.

Sixty eight seawater samples were collected at three-hour intervals from 4m during sailing.

Vertical distribution of chlorophyll *a* at the five stations are shown in Fig. 31. The percent distributions of chlorophyll *a* in the size fractionated samples are illustrated in Figs. 32 and 33.

2. Vertical distribution of ATP in particulate matter with special reference to particle size

Seawater samples (0.25 to 2.0 l) were filtered through the three types of filters described above. ATP in particulate samples were immediately extracted with Tris-buffer according to the method described in Parsons et al. (1984). The extracts were stored below -20 °C until analysis. The analysis of ATP was carried out either on board or in the land laboratory.

Vertical distributions of ATP at Stations B, D and F are shown in Fig. 34.

3. Uptake of ^{15}N-organic substances by phytoplankton and heterotrophic microorganisms

Uptake of ^{15}N-glycine and ^{15}N-urea were examined using surface seawater samples from Stations B and F. The seawater samples (5 l) were poured into light and dark bottles, and incubated in the presence of trace amounts of labelled compounds at controlled temperature under natural light conditions on an upper deck. Subsequently, the samples were filtered through Whatman GF/C and ^{15}N in the particulate matter was determined by emission spectrometry.

4. Vertical distribution of amino acids and carbohydrates in seawater samples

Seawater samples were collected from the surface to 5000 m at Stations B and F using Niskin bottles. The seawater samples were filtered through Whatman GF/C filters. To the filtrates 10^{-4}M of $HgCl_2$ was added as a preservative. Particulate samples were stored at -20 °C. Amino acids and carbohydrates will be determined in the laboratory by the methods described in Parsons et al.(1984).

5. Organic matter in sediment trap samples and bottom sediment samples

A sediment trap, comprised of 8 cylinders (12 cm in diameter and 55 cm in length) was deployed at 200 m depth of Stations B and F. Sediment samples, about 40 cm long, were cut at 2 to 3 cm intervals immediately after collection and stored below -20 °C. Organic constituents in both the samples will be later examined.

Reference

Parsons, T. R., Y. Maita and C.M. Lalli (1984). A Manual of Chemical and Biological Methods for Seawater Analysis, Pergamon Press, Oxford, pp. 80-84.

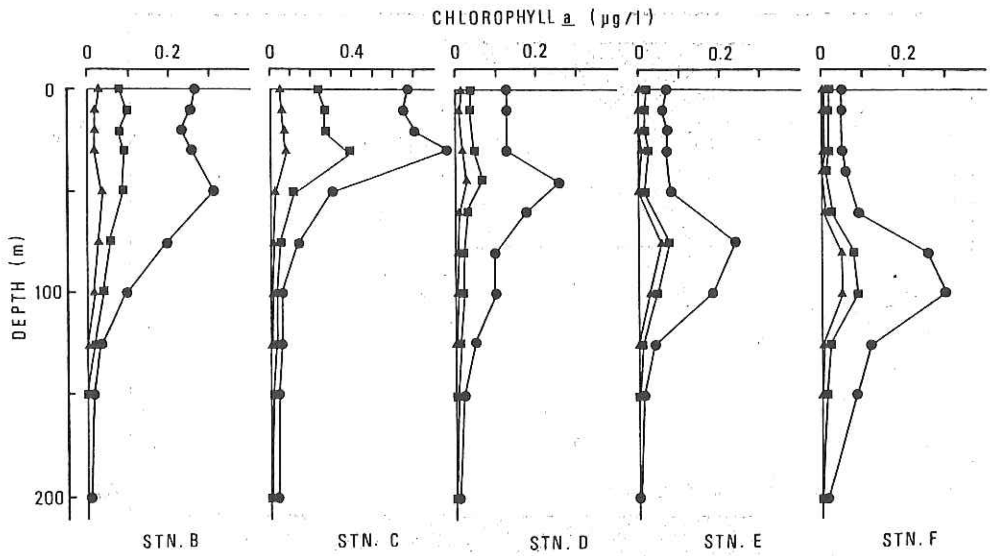


Fig. 31 Vertical distribution of chlorophyll *a* at five stations of the northwestern Pacific Ocean in April-May 1985. Circles, particulate matter collected on 0.2 µm filter; squares, on 2 µm filter and triangles, on 10 µm filter.

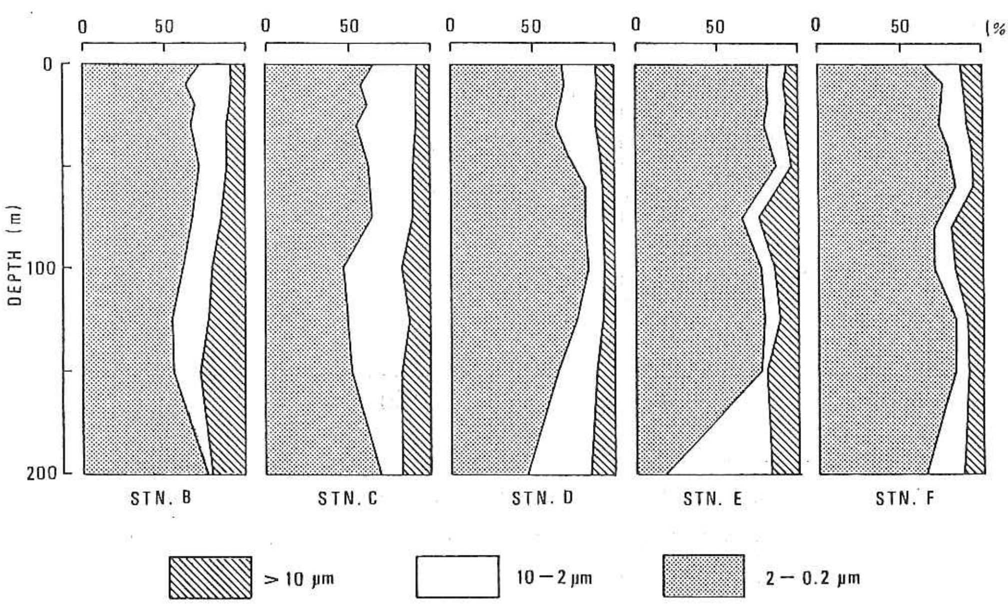


Fig. 32 Relative abundance of chlorophyll *a* in three size fractions (>10 µm, 10 -2, and 2 - 0.2) at five stations of the northwestern Pacific Ocean in April May 1985.

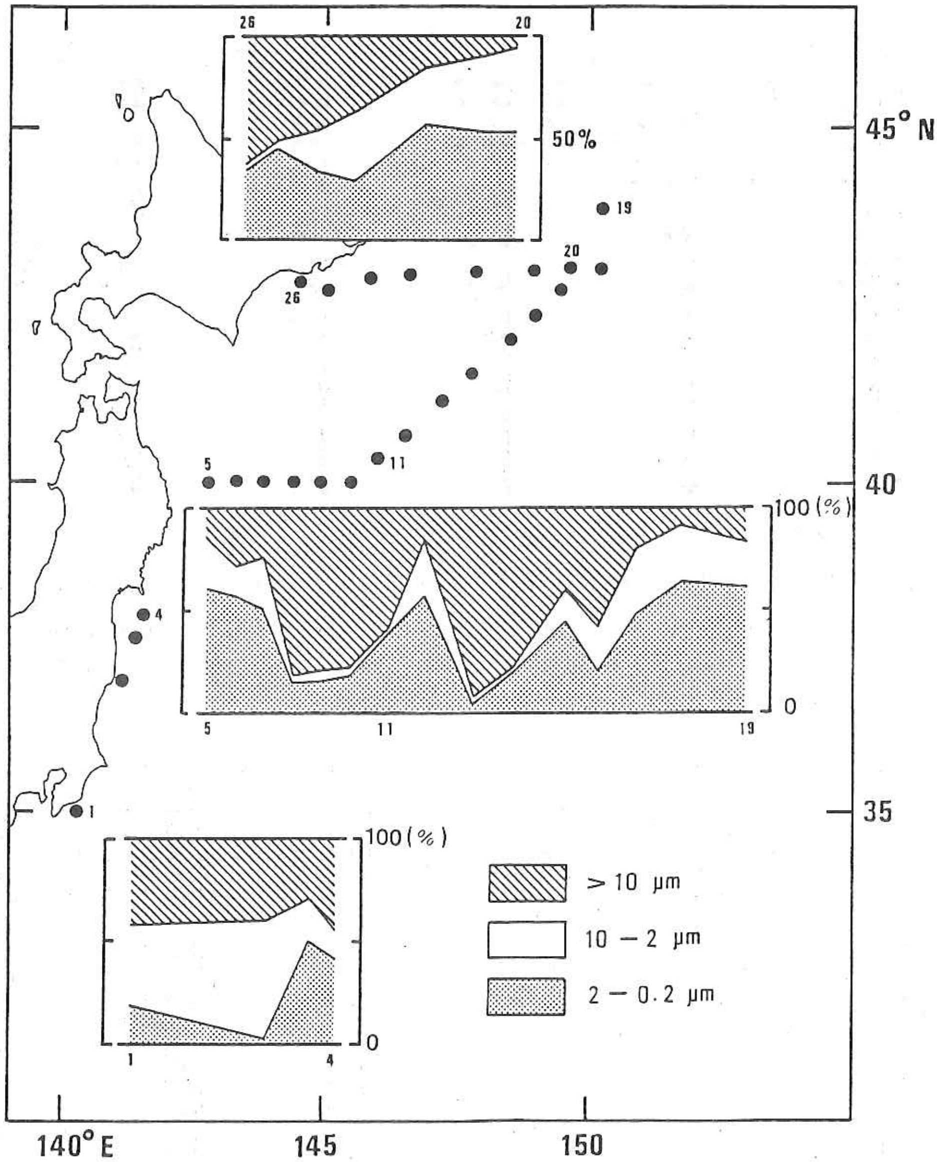
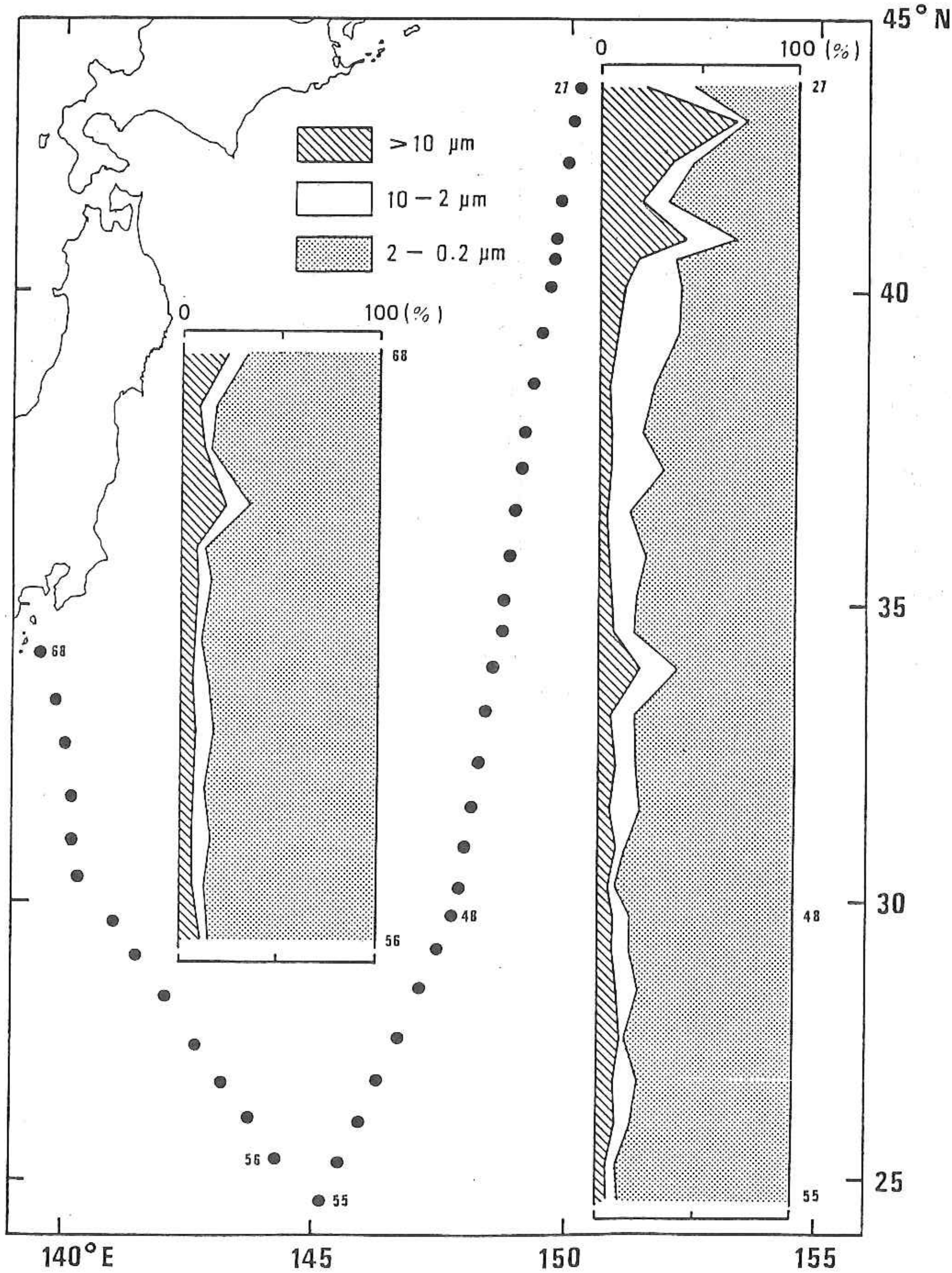


Fig. 33 Regional changes in relative abundances of chlorophyll *a* in three size fractions of particulate matter in the surface seawater collected at 68 stations of the northwestern Pacific Ocean in April-May 1985.
Left: 12-24 April, *right*: 30 April-14 May.



45° N
40
35
30
25
140° E
145
150
155
>10 μm
10 − 2 μm
2 − 0.2 μm
0
100 (%)
27
48
55
56
68

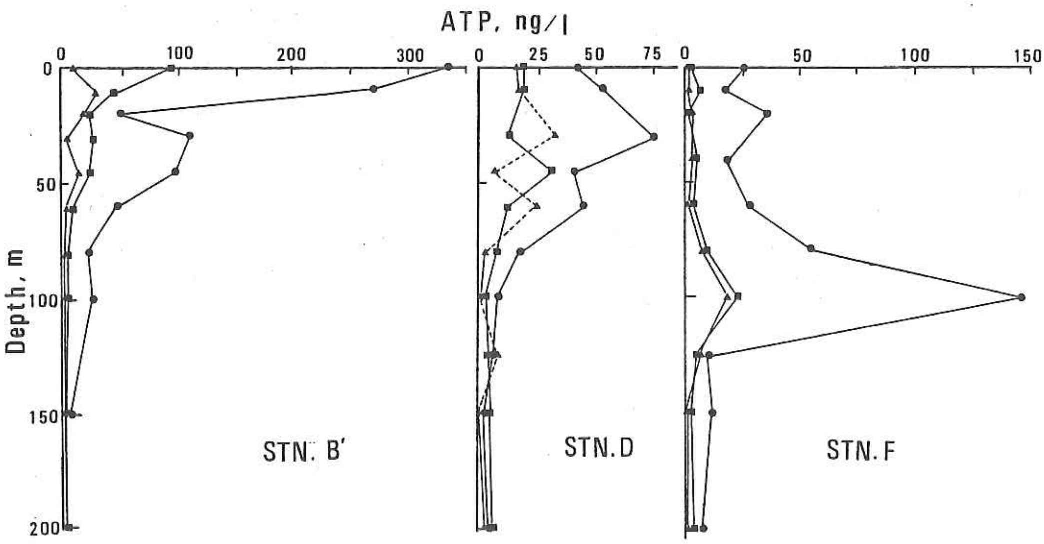


Fig. 34 Vertical distributions of ATP in particulate matter at Stations B', D, and F of the northwestern Pacific Ocean in May 1985. Circles, particulate matter collected on 0.2 μm filter; squares, on 2 μm filter; triangles, on 10 μm filter. No correction was made for the loss of ATP during processing.

Alkaline phosphatase activity in oceanic waters

K. Fujiwara

The activity of alkaline phosphatase in natural waters has been inferred to be closely related to phosphate requirement in the ecosystem. However, this view has been only supported by evidence obtained in lakes and coastal waters. Actually, the alkaline phosphate activity in oceanic waters is too low to determine with certainty the rate of orthophosphate liberation using the method which has been tradionally used. The low activity can be attributed to low biomass in oceanic waters.

We developed a highly sensitive technique in which very low activities of alkaline phosphatase can be determined fluorometrically using 4-methylumbelliferyl phosphate as a substrate. By applying this technique, we attempted to determine alkaline phosphatase activity in oligotrophic waters of the subtropical western North Pacific. Figure 35 shows the vertical profiles of the alkaline phosphatase activity at Station F. In order to reduce the error caused by bacterial growth before and during assay, 2% chloroform was added to the sample waters immediately after samplings. Temporal variation of the activity within a day was noted. The activity was one or two orders of magnitude lower than that obtained in Tokyo Bay waters. The activity appears to be inversely correlated with the ambient concentrations of orthophosphate.

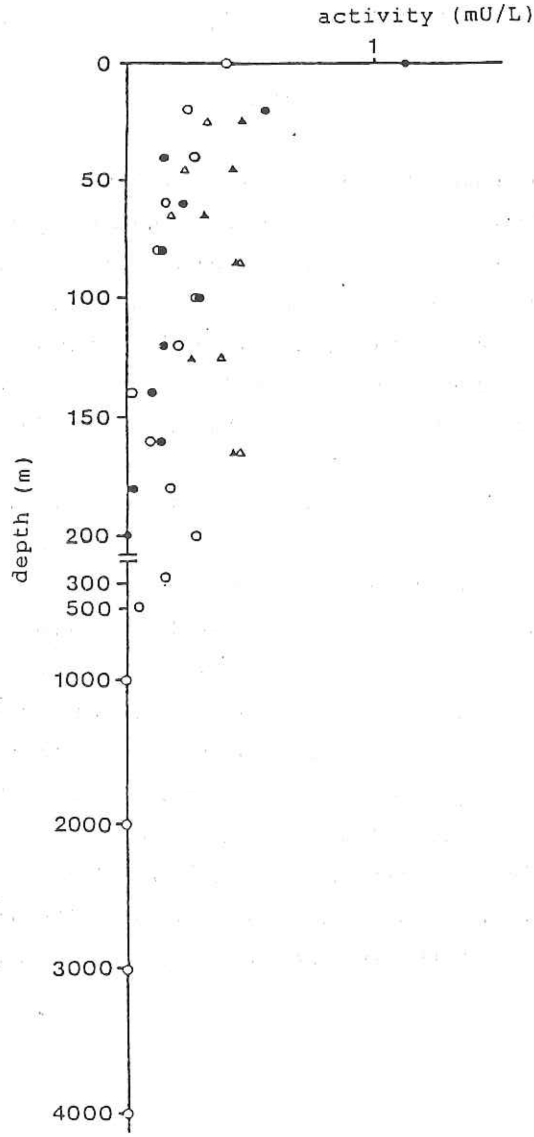


Fig. 35 Vertical profiles of alkaline phosphatase activity at Station F. Water samples were collected: open circles, at 1740 on 8 May 1985 (<200m) and at 1500 on 10 May (>300m), closed circles, at 1100 on 9 May, open triangles, at 0600 on 8 May, and closed trangles, at 1500 9 May.

Morphological and structural characteristics of phytoplankton

S. Kudo and M. Takahashi

In order to examine the difference in morphology and cell structure of phytoplankton in various environments, water samples were collected with Van Dorn bottles from several depths shallower than 200 m at Stations B, B', C, D, E, and F. Immediately after sampling, preservatives, glutaraldehyde-paraformaldehyde and glutaraldehyde, were added for optical microscopic observation and electron microscopic inspection, respectively.

Estimation of picophytoplankton biomass

S. Kudo and M. Takahashi

This study aims to accumulate information on picophytoplankton biomass in various sea environments. Water samples were collected as described in the previous section, fractionated by using Nuclepore filters of various pore sizes, and their chlorophyll contents measured by fluorometry using a Turner III fluorometer. Parts of the water samples were fixed with glutaraldehyde-paraformaldehyde. Picophyto plankton were collected on membrane filters, embedded in glycerine, and analyzed by epifluorescence microscopy.

Direct utilization of picophytoplankton by metazoan zooplankton

H. Toda and M. Takahashi

The purpose of this study is to determine whether picophytoplankton are directly utilized by metazoan zooplankton such as copepods and doliolids. The experimental samples were obtained at Station F. Picophytoplankton from the surface and subsurface layers were size-fractionated, using Nucleopore filters, into three groups: <1 μm, 1-3 μm and 3-10 μm. ^{14}C labeled picophytoplankton were prepared by incubating the concentrated picophytoplankton sample of each group for about 12h in the presence of added $NaH^{14}CO_3$. The copepods and doliolids were collected with a Puget Sound Closing Net (1/2 m diameter, 60 μm mesh) hauled vertically from 100 m to the surface. They were sorted, and placed into 100-300 ml glass bottles together with the labeled picophytoplankton. The radioactivity of zooplankton was measured at appropriate time intervals during feeding periods.

Adults and nauplii of mixed copepod species could almost equally ingest and assimilate picophytoplankton with size of 1-3 μm and those with size of 3-10 μm. A doliolid, *Dolioletta nationales*, showed a similar feeding behavior, but it ingested less efficiently picophytoplankton less than 1 μm.

Ingestion, excretion, and isotopic fractionation of nitrogen by marine zooplankton

D. M. Checkley, Jr., and C. A. Miller

The zooplankton play an important role in the marine nitrogen cycle: they consume and nourish the phytoplankton and contribute to the sinking flux of particles. Thus, a knowledge of ingestion, excretion, and defecation by zooplankton is requisite to understanding the nitrogen cycle of the sea. The rate of these processes are known to vary dielly for some species and stages of zooplankton, with potentially important consequences to the nutrition and mortality of the phytoplankton. In particular, some planktonic copepods feed most at night (Gauld, 1953) and excrete ammonium primarily by day (Checkley and Miller, in preparation). Copepods also fractionate nitrogen isotopes during ingestion, excretion, and defecation, with important consequences to the distribution of nitrogen isotopes in the sea (Checkley and Entzeroth, 1985). Our objectives here were to investigate nitrogen isotope fractionation by and diel variations in excretion and feeding of particle-grazing zooplankton under eutrophic and oligotrophic conditions. The cruise KH-85-2 afforded us an excellent opportunity to address these objectives in collaboration with other investigators of plankton ecology and isotope chemistry.

1. Isotopic fractionation of nitrogen

We hypothesized that the ratio of nitrogen isotopes, expressed as $\delta^{15}N$, varies for the particle-grazing zooplankton of a single station as follows: $\delta^{15}N_{feces}$, $\delta^{15}N_{bodies} > \delta^{15}N_{suspended\ particles} > \delta^{15}N_{excreta}$. Further, we hypothesized that these substances (bodies, excreta, feces) would be enriched in ^{15}N under eutrophic (Station B) relative to oligotrophic (Station F) conditions. To test these hypotheses, we sampled the bodies, excreta, and feces of dominant types of zooplankton for isotopic analysis and comparison with the $\delta^{15}N$ of the suspended particulate matter. Zooplankton were collected by net and incubated in filtered seawater to permit the accumulation of excreta and feces. Zooplankton bodies and feces were thereafter retained separately on filters and the filtrate saved for excreta analysis. All samples were stored frozen (ca -70°C).

Calanus cristatus copepodite V females (CVF) dominated the zooplankton at Station B; bodies, excreta, and feces were collected. *Calanus plumchrus* copepodites were abundant at Station C; bodies and excreta were collected. The zooplankton assemblage at Station F was diverse and comprised of doliolids and many species of small copepods; the bodies and excreta of doliolids and mixtures of copepod species and stages were collected. Nitrogen in particulate samples and in steam-distilled ammonium will be analyzed using a ratio mass spectrometer in the laboratory of Drs. A. Hattori and T. Saino of the Ocean Research Institute.

2. Diel periodicity

We hypothesized that for the particle-grazing zooplankton feeding and ammonium excretion exhibit a diel periodicity. Our test consisted of measuring gut pigment content, as an index of feeding (Mackas and Bohrer 1976), and the short-term rate of ammonium excretion of dominant zooplankton at Stations B and F. Excretion rate was estimated from the concentrations of ammonium in control (without added zooplankton) and treated (with added zooplankton) aliquots of filtered seawater after an incubation period of 1-18 hours, normally ~ 3 hours. Zooplankton was collected at 4-8 hour intervals for 1.5 to 2.0 days at Stations B and F; the types of zooplankton used are listed above. Preliminary analysis of our results indicates the following conclusions. Station B: (1) Values of gut pigment content and excretion rate for ocean-caught *C. cristatus* CVF far exceed values for individuals starved in the laboratory, indicating good nutrition in the sea. (2) Gut pigment content of *C. cristatus* CVF was greatest at mid-day, intermediate at mid-night, and least at dawn and dusk; individuals collected between the surface and 20 m contained more pigment than individuals collected between 20 and 60 m, the apparent center of abundance of the population. (3) Ammonium excretion by *C. cristatus* CVF was greater at night than by day, though the difference was not large. Station F: The gut pigment content of doliolids did not vary with time of day while for mixtures of copepods it was greater at night than by day. Excretion rate measurements for doliolids and copepods are not yet analyzed.

References

Checkley, D.M., Jr., and L.C. Entzeroth (1985). Elemental and isotopic fractionation of carbon and nitrogen by marine, planktonic copepods and implications to the marine nitrogen cycle. J. Plankton Res., 7, 553-568.

Gauld, D.T. (1953). Diurnal variation in the grazing of planktonic copepods. J. Mar. Biol. Assoc. U.K., 31, 461-474.

Mackas, D., and R. Bohrer (1976). Fluorescence analysis of zooplankton gut contents and an investigation of diel feeding patterns. J. Exp. Mar. Biol. Ecol., 25, 77-85.

Measurement of microzooplankton feeding pressure on natural phytoplankton assemblages

H. Akahira

A large volume of water sample(40 l) was collected from 4 m depth, and poured into a specially designed light-insulated microzooplankton concentrator. The concentrator was illuminated from the top for 1 h to lead the microzooplankters into the upper part of the concentrator. Then, the water samples were separately withdrawn from the top part and the bottom part of the concentrator.

The two water samples withdrawn (15 l each) were incubated under natural light conditions for 24 h. After the incubation, numbers of microzooplankton and chlorophyll *a* concentrations of nano- and micro-phytoplankton were measured. Based on the data obtained we are going to calculate the feeding pressure of microzooplankton on phytoplankton.

Seven experiments were done at five stations: Exps. 1-3 at Station B, Exp. 4 at Station B', Exp. 5 at Station D, Exp. 6 at Station E, and Exp. 7 at Station. F.

Observation of species succussion in plankton assemblages

A. Taniguchi

To monitor the species succession of a plankton assemblage containing both phytoplankton and microzooplankton under the cultured conditions, 20 l of water sample from 4 m depth at Station B was incubated in a Tedlar bag for 6 days. The bag was placed in a tank containing running surface seawater on deck and exposed to sun light.

Two 500 ml aliquots were taken out at 12-hour intervals and chlorophyll concentration and species composition of the plankton assemblage were determined.

Diel change in downward flux of particles

Y. Oyama and H. Sasaki

The diel change of downward particulate flux in the upper 200 m of the water column was observed at Station B using 10 sediment traps on 20-21 April 1985. A surface-floating array with sediment traps was deployed and retrieved after 6 hours. Experiments were repeated 5 times during a 30 h period. The largest flux in terms of phaeopigments and POC were obtained during 1500-2100 at 60 m depth about 20 m below the subsurface chlorophyll maximum layer (Fig. 36). The integrated chlorophyll *a* standing stock (0-100 m) fluctuated with a day and the maximum occurred at 1800. The time coincided with that of the maximum particulate flux. During 1500-2100, a large amount of copepod population, mainly consisting of *Calanus cristatus*, was caught by net tows down to 200 m, suggesting the importance of copepod feeding activities.

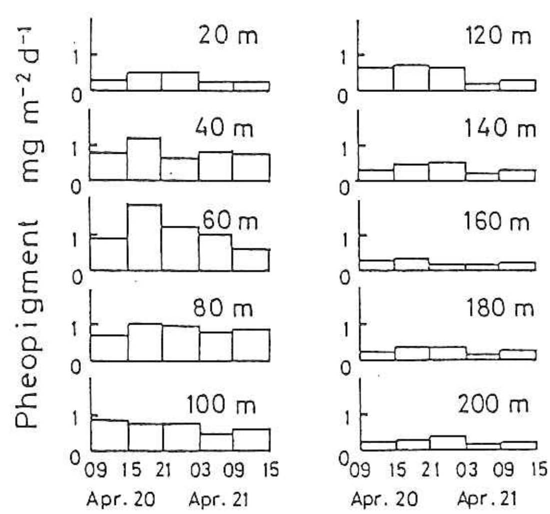


Fig. 36. Diel change of downward particulate flux in terms of pheopigments in the upper 200 m of the water column.