Preliminary Report of the R/V Hakuho Maru Cruise KH-94-4

Southern Ocean Expedition

(November 22, 1994 - February 14, 1995)

Ocean Research Institute
University of Tokyo

1996

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by
The Scientific Members of the Expedition

edited by
Kouichi KAWAGUCHI

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Contents

Introduction

The KH-94-4 cruise of R/V Hakuho Maru was conducted under the title "Biological Production and bio-geochemical cycling processes in the Southern Ocean" in the Australian sector of the Southern Ocean from November 22, 1994 to February 14, 1995. A total of 57 scientists and supporting staff from 25 organizations in Japan and the United Kingdom participated in this cruise.

Shiptime on this cruise was 65 days for the field of marine biology and biological oceanography, 15 days for physical oceanography and 5 days for geological fields.
In light of the restricted shiptime, special attention was given to the ice edge area and comparative studies were carried out on community structures, biological production and bio-geochemical cycling processes between the northern and southern sides of the Antarctic divergence.

Most of the community structure and process-oriented studies were conducted at 3 fixed stations located on both sides of the Antarctic divergence along the 140° E line.

The main topics of the studies at the 3 stations were as follows;

Biological and chemical:
1) Optical characteristics of aquatic environment and photosynthetic efficiency of various phytoplankton communities
2) Dynamics of phytoplankton communities and primary production patterns including iron deficiency problem
3) Role of microbial loop
4) Distribution and quantitative study of the colloidal particles
5) Rate process study on feeding and growth of main net zooplankton in the ice edge area
6) Distribution and food web structure of macrozooplankton and micronekton in the ice edge area (acoustic study included)
7) Study on the biological productivity in the epipelagic zone based on sediment trap analysis

Physical and geological:
1) Formation of upwelling and mesoscale eddies in the Antarctic Divergence Zone
2) Paleohydrographic structure and deepwater circulation history in the ice edge region based on piston core samples

Zoogeographical studies and global observation of aerosol particle concentrations and atmospheric and oceanic pCO_2 were also carried out along the long cruise track of this cruise.
On behalf of the all of the scientists aboard the ship, I express my special gratitude to the captain Yoichi Jinno and the officers and crew of R/V Hakuho Maru for their generous patient

help in the physically severe field of the Southern Ocean. Ms. Kimie Ishimaru, ORI greatly helped us in editing this report.

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Chief Scientist

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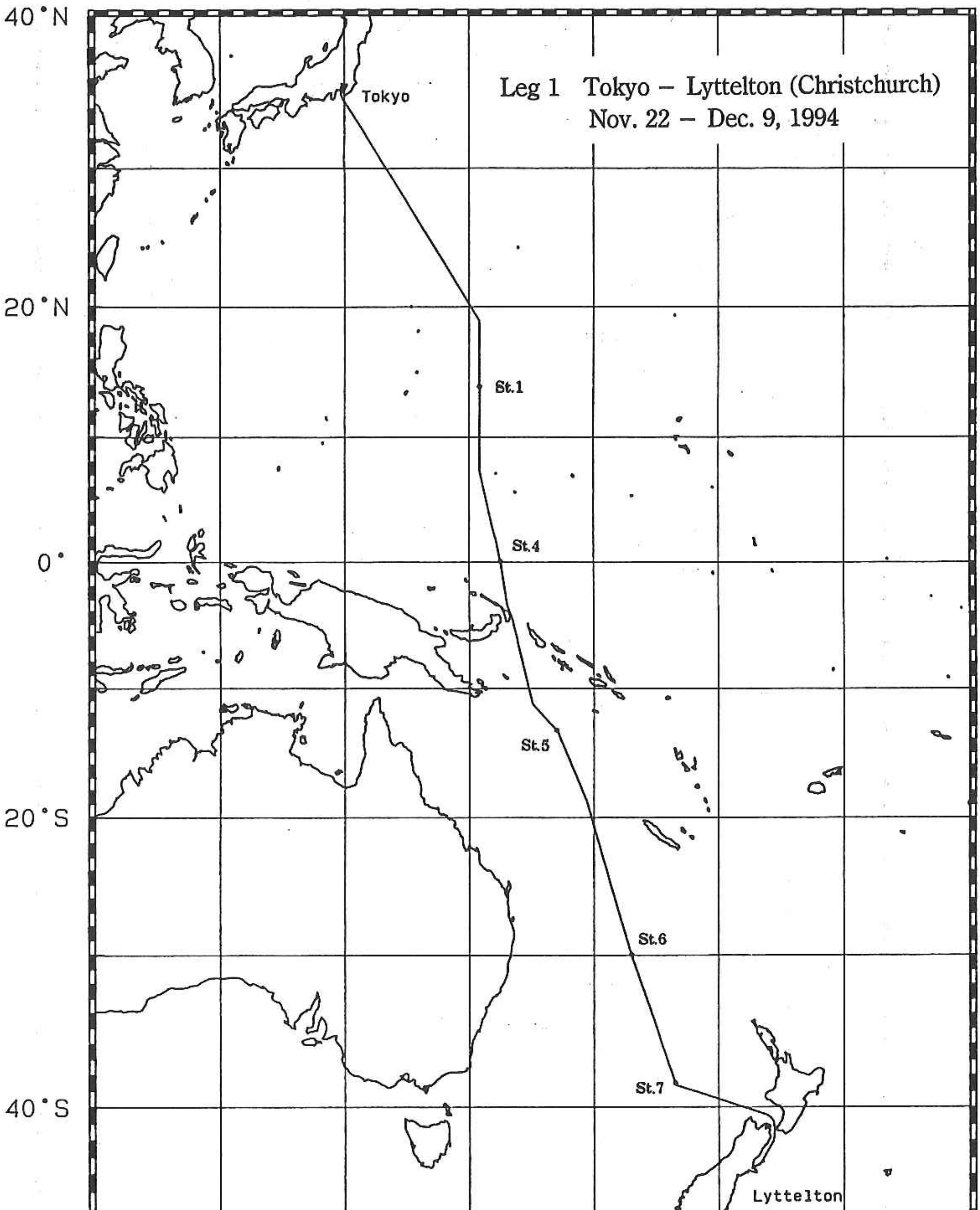
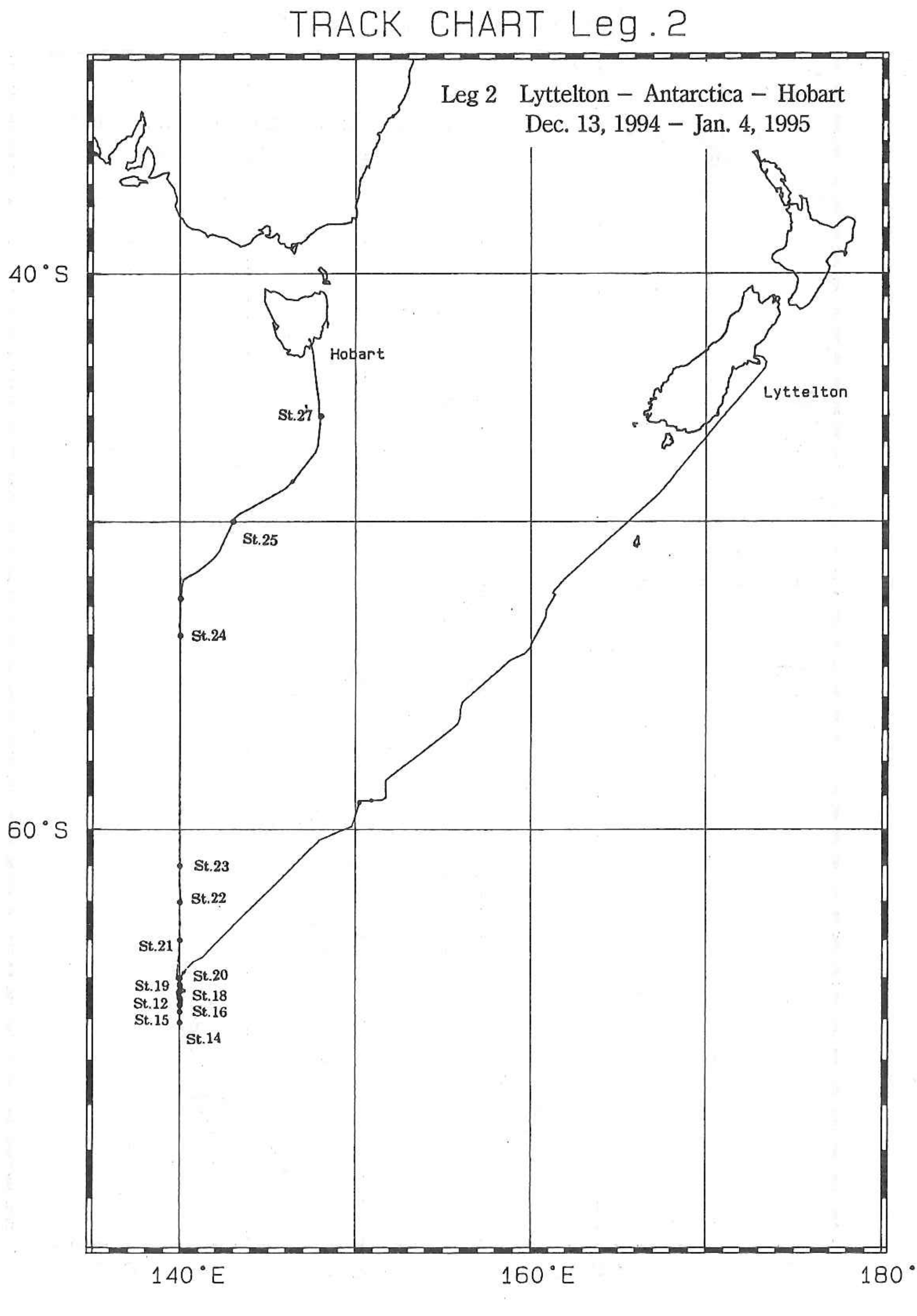
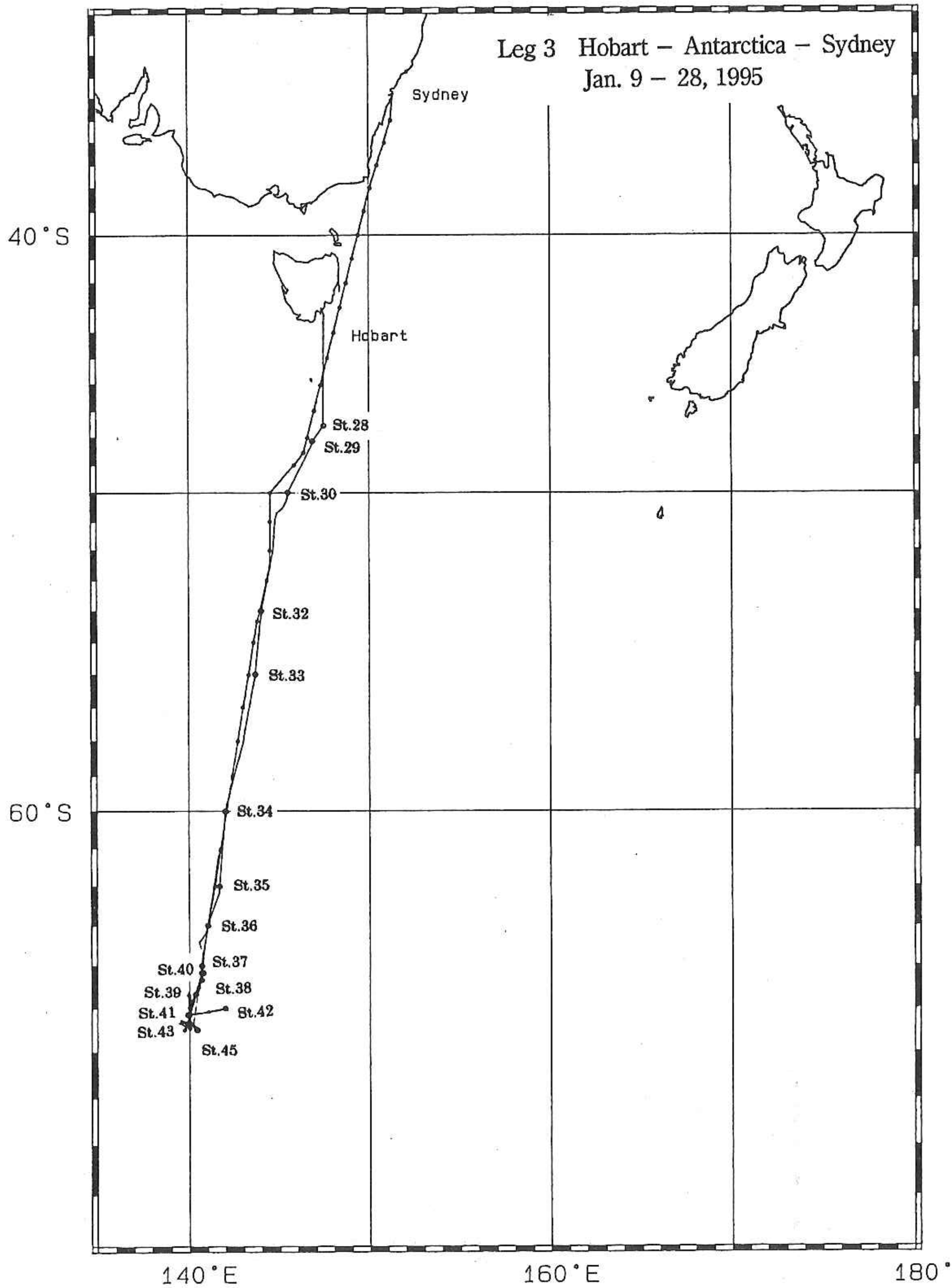
TRACK CHART Leg. 1

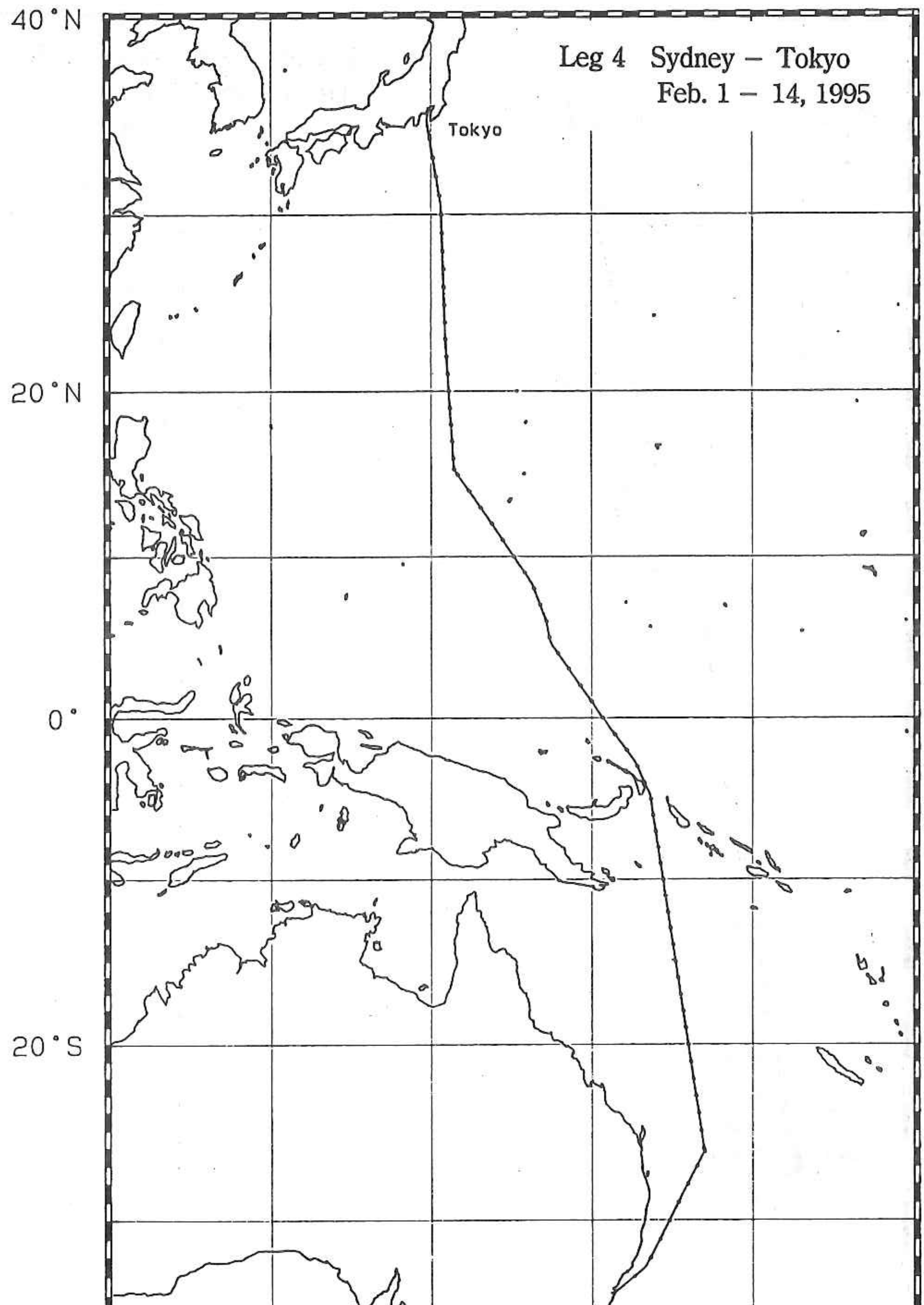



TRACK CHART Leg.2
Leg 2 Lyttelton – Antarctica – Hobart
Dec. 13, 1994 – Jan. 4, 1995
40°S
60°S
140°E
160°E
180°
Hobart
Lyttelton
St.27
St.25
St.24
St.23
St.22
St.21
St.20
St.19
St.18
St.12
St.16
St.15
St.14

TRACK CHART Leg.3



TRACK CHART Leg.4



Cruise log

Leg.1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Nov. 24. 94'																			Seminar1 Kawaguchi		JST-1			
Nov. 25. 94'																			Seminar-2 Ootuki					
Nov. 26. 94'														St.1 CTD, RMT Test, Flow meter cal. ORI 13.56S,150.51E										
Nov. 27. 94'																								
Nov. 28. 94'													RMT test			Rmt test			Seminar-3 Tuge					
Nov. 29. 94'				St.4 CTD,Norpac,ORI,OCT,IKMT 00.00 152.30E															Seminar-4 Miya					
Nov. 30. 94'																			Seminar-5 Yosikawa					
Dec. 01. 94'													St.5 CTD,Norpac,ORI,OCT,IKMT 13.20S,156.59 E								RMT test			
Dec. 02. 94'	JST-2																			Seminar-6 Hukami		IKMT,2 times		
Dec. 03. 94'																				Seminar-7 Han				
Dec. 04. 94'																							St.6 CTD 29.59S	
Dec. 05. 94'	ORI 162.59 E																							
Dec. 06. 94'					JST-3								St.7 CTD,Norpac,ORI,IKMT											
Dec. 07. 94'																				Seminar-8, Inagaki JST-4				
Dec. 08. 94'										Arrived at P.S			RMT test							P.S Anchor				
Dec. 09. 94'										Lyttelton a port														
Leg.3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Dec. 14. 94'													Proton cast 47.05S								JST-3			
Dec. 15. 94'																								
Dec. 16. 94'	JST-2																							
Dec. 17. 94'												Seabeam start												
Dec. 18. 94'				Seabeam end																				

Leg.2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Dec. 19. 94'										St. PIS-1 Piston core 65.51S,140.13E			Multi core M-1			St.8 CTD 64.00 S	St.9 CTD 64.10 S		St.10 CTD 64.20 S		Tr.			St.11 64.40
Dec. 20. 94'	St.11 CTD 64.40 S			ICTD		CTD60		In sit Buoy cast		Surf. Sediment buoy cast			VMPS, ORI, OCT			Tr.	VMPS,ORI			VMPS,ORI,OCT			VMPS,ORI	
Dec. 21. 94'		VMPS ORI			VMPS,ORI,OCT			Insit Buoy recovery		BCTD-1		RMT net test			IKMT			St.12 CTD 64.30 S		IKMT				
Dec. 22. 94'			Rest time			St.13 IKMT day series 64.20 S				ORI			St.11 Piston core 64.40 S		PIS-2			St.13 Surf. Buoy 64.20 S cost			IKMT nigth series			
Dec. 23. 94'		Camer	VMPS, ORI,OCT			VMPS, ORI			VMPS, ORI, OCT			VMPS, ORI, Sampl			VMPS, ORI, OCT			VMPS, ORI,			VMPS, ORI, OCT			BCTD -2
Dec. 24. 94'	VMPS, ORI		ICTD-2		CTD60-2			Sur.Buoy cast		In sit Buoy cast		BCTD -3	ORI, IKMT		VMPS,ORI, OCT			VMPS, ORI, OCT			experiment IKMT			
Dec. 25. 94'		ORI							In sit Buoy recovery		BCTD -4			St.11 64.40 S	Trap recoverry			Sur.Buoy collect		SCTD -1		IKMT nigth series		
Dec. 26. 94'		experiment IKMT				Multi core M-2		IKMT day series				CTD40				Sea beam correct			St.14 65.05 S	CTD,Norpac ORI			St.15 CTD, 64.50 S	
Dec. 27. 94'	Nor. ORI	St.16 CTD, Nor, OR 64.40 S			St.17 CTD,Nor.,ORI 64.30 S				St.18 CTD,Nor.,ORI 64.20 S			St.19 CTD,Nor.,ORI 64.10 S					ST.20 CTD,Nor.,ORI 64.00 S							
Dec. 28. 94'			St.21 CTD,Nor.,ORI 63.00 S							St.22 CTD40,Nor. 62.00 S			CTD, ORI bottom							St.23 CTD, Nor.,ORI 61.00 S				
Dec. 29. 94'		Stopped of observation for Stormy																						
Dec. 30. 94'							St.24 CTD40, ORI, IKMT 54S																	
Dec. 31. 94'	Proton Sea beam start			52.40 S 140.00 E			Sea beam end		Proton cast						Proton recovary		St.25 50.00 S	ORI, IKMT,Nor., CTD				Proton cast		
Jan. 01. 95'		Stopped of observation for Stormy									Proton recovary		St.26 Piston core 48.30S 147.30 E			(PIS-3)		Multi. IKMT					ORI	
Jan. 02. 95'												St.27 ORI, IKMT 46S 148 E												
Jan. 03. 95'																								
Jan. 04. 95'										Hoobart Oil Warfe			Sifte		Port									
Leg.3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan. 10. 95'								St.28 (PIS-4) Piston Multi core 47.35 S 147.28 E						St.29 (PIS-5) Piston Multi core 48.09 S 146.51 E					CTD Norpac					
Jan. 11. 95'					St.30 CTD40, CTD, Norpac 50 S, 145.35 E																			
Jan. 12. 95'	St.31 CTD, Norpac 54 S, 144 E												St.32 Multi core, CTD(B),Norpac 54.S 144.40 E											
Jan. 13. 95'		St.33 CTD40, CTD(S) 58.S 143.E															St.34 CTD, Multi core 60S,142 E							

Leg.3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan. 14. 95'								St.35 Multi core, CTD(S), Release test 62 S, 141.40 E										St.36 CTD(S) 63 S, 141 .00 S						
Jan. 15. 95'		St.37 Multi core Nor 64 S, 140.40 E			St.38 ORI 64 S, 140.20		XBT(64-65 S) (10' interval)				St.39 Mooring buoy cast 64.10S,140.20 E			Surf.Sediment bouy	OCT.,		St.40 OCT.,CTD10(CTD(B),Multi, CTD(S),Camera 64.10S,140.40E							X2
Jan. 16. 95'	ORI-1000 -2000		ICTD,CTD60 X3	X4		X6	Insit Buoy cast	X8	Release test			BCTD RMT net test					approaching ice adge				X9	X10	Camera X11	
Jan. 17. 95'			return St.43					Insit Bouy, OCT recover				St.41 Mooring bouy cast 65.10 S,140 E				XBC	St.42 Mooring bouy cast 65S, 142E	XBB					St.41 CTD(B 65.10 S, 140	
Jan. 18. 95'				St.39 CTD40, CTD (B) 64.40S, 140 E				Surf. recovery				St.43 OCT, ORI-1000,2000,2000 65.21S, 140 I X0P					Multi core							
Jan. 19. 95'	Camere		OCT,ICTD,CTD60		VMPS,ORI I			Insit Buoy cast		VMPS,ORI			Stoped of obervation for stormy window 21m/s											
Jan. 20. 95'			ICTD,CTD6(		VMPS,ORI			Insit Buoy recover		VMPS,ORI,IKMT				ORI				VMPS,IKM" CTG(B)				VMPSORI IKMT		
Jan. 21. 95'	Camer CTD(S)		VMPS.IKMT	CTD100		VMPS,IKMT		ICTD Piston,Multi core										Trap release ,recover 64.42 S,139.58.44 E						
Jan. 22. 95'	St.45 OCT,CTD(B),Multi core 65.30.49 S,140.24.87 E											Iceberg observation Proton cast 63.24.88 S,140.31.71 E				X13 63 S				X14 62 S				X16 61 S
Jan. 23. 95'				X17 60 S				X18 59 S				X19 58 S				X20 57 S				X21 56 S				X22 55 S
Jan. 24. 95'	Seabeam sta						Seabe: Seabe: X23 54 S				X24 53 S				X25 52 S				X26 51S				X27 50 S	
Jan. 25. 95'					X28 49 S		St.44	PIS-7 Piston core 48.33S,146.23E					PIS-7' Piston core 48.33S,146.22E				X29 48 S	8 cross				X30 47 S		
Jan. 26. 95'		X31 46S				X32 45 S				X33 44 S				X34 43 S				X35 42 S				X36 41 X		
Jan. 27. 95'		X37 36 S				X38 37 S				X39 38 S				X40 37 S				X41 36 S				X42 35 S		
Jan. 28. 95'										Sydney port(White bay No.2) arrived at port														
Leg.4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Feb. 01. 95'														Sydney departure						X43 33 S				
Feb. 02. 95'	X35 32 S				X45 31 S					X46 30 S				X47 29 S				X48 28 S				X49 27 S		
Feb. 03. 95'		St.46 Multi core 26.10S,157.00E				X50 26 S				X51 25 S				X52 24 S				X53 23 S				X54 22 S		
Feb. 04. 95'	X55 21 S			X56 20 S	JST-1		X57 19 S				X58 18 S				X59 17 S				X60 16 S	Semina Nisino		X61 15 S		
Feb. 05. 95'		X62 14 S			X63 13 S				X64 12 S				X65 11 S			X66 10 S				X67 09 S				X68 08 S
Feb. 06. 95'				X69 07 S			X70 06 S				X71 05 S				X72 04 S				X73 03 S	Semina Watanabe			X74 02 S	

Leg.4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Feb. 07. 95'				X73 01 S				X74 00.0					X75 01 N	Equator-crossing ceremony		Somen festiv:		X78 02 N					X79 03 N	
Feb. 08. 95'				X80 04 N				X81 05 N				X82 06 N			X83 07 N				X84 08 N	Semin. JST-0 Matuoka			X85 09 N	
Feb. 09. 95'			X86 10 N					X87 11 N					X88 12 N					X89 13 N				X90 14 N		
Feb. 10. 95'			X91 15 N		St.47 Multi core 15 N					X92 16 N				X93 17 N				X94 18 N		Semina Suzuki		X94 19 N		
Feb. 11. 95'	X96 20 N				X97 21 N					X98 22 N				X99 23 N				X100 24 N				X101 25 N		
Feb. 12. 95'		X102 26 N			X103 27 N				X104 28 N				X105 29 N			X106 30 N				X107 31 N				X108 32 N
Feb. 13. 95'			X109 33 N				X110 34 N								Haneda P.S									
Feb. 14. 95'										Harumi Port														
	CTD+Carrousel ICTD				Routine observation Insit CTD Mie,Tokyo, Univ.								The distance covered of Leg.1 The distance covered of Leg.2						5492.3 miles 4175.3 miles					
	BCTD SCTD				Bacteria CTD Micro zoo group Sennsyu Univ., N.I.P.,								The distance covered of Leg.3 The distance covered of Leg.4						4283.1 miles 3321.4 miles (02/10) noon					
	CTD40 CTD60		40 l 60 l		Nagoya Uive. Nagoya Uive.																			
	CTD100 OCT.		100 l		Biochemistry OCTOPUS Mie,Tokyo, Univ.																			
	Nor				Norpac net																			
	ORI IKMT				ORI net IKMT net																			
	VMPS RMT				VMPS net RMT net																			
	PIS				Piston core			Tokyo, Hokaido, Tritu, Univ.																
	Multi Tr				Multiple core Transmissiso-meter			Tokyo, Hokaido, Tritu, Univ.																

Community structure of phytoplankton and primary productivity in seasonal ice zone of the Antarctic Ocean

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The Antarctic marine ecosystem is characterized by zonal circumpolar distribution of hydrographic and biogeochemical sub-divisions which are defined by the major frontal zones and extent of sea ice. The sub-systems are presumed to be globally important in the control of excess of atmospheric carbon dioxide. However, contributions of each sub-system to carbon fluxes are poorly understood, largely owing to insufficiency of available information in both space and time. Phytoplankton play a major role in primary formation of particles and cycling of carbon, because its photosynthetic activity is the key process for transfer of carbon between inorganic and organic carbon pool in the sea. The present study aims to clarify community structures of phytoplankton and photosynthetic activity as a function of irradiance, and to evaluate primary productivity and community respiration in Seasonal Ice Zone of the Antarctic Ocean in austral summer.

Community structure of phytoplankton

Distribution of photosynthetic pigments and phytoplankton cells were used to deduce spatial and temporal variations in phytoplankton biomass and composition. Water samples were collected from six to eight layers ranging from the surface to the depth of 0.5 % irradiance of that just below the surface by lever-action Niskin bottles mounted on a CTD-rosette. The sample was filtered through Whatman GF/F filter in the dark for analysis of chlorophyll a and other taxon-specific chlorophylls and carotenoids by HPLC using a modified Mantoura and Llewellyn (1983) solvent system. The filter was stored at -80℃ with nitrogen gas and brought back to land laboratory for analysis. An aliquot of the water sample was fixed with 1 % glutaraldehyde, and specimen for fluorescence microscopy was prepared after Tsuji and Yanagita (1981) for counting of pico- and nanophytoplankton cells. Subsamples were preserved for identification and enumeration of microplanktonic algae.

Additional sampling was made at Stations 29 to 36 for examination of north-south distribution of diatoms. Water samples were taken from various depths in the upper 200-m water column by the CTD-rosette sampler, and preserved with 2 % formalin.

Photosynthetic activity as a function of irradiance

Photosynthesis vs. irradiance curves were in the vicinity of the Antarctic Divergence (Table 1). At Stn. 43 observations were made before and after a passage of low pressure. Water samples were collected from six to eight depths from the surface down to the 1 % light level by lever-action Niskin bottles mounted on a CTD-rosette. Uptake of ^{14}C-bicarbonate was measured at *in situ* temperature under white and blue (peak wave length, 480 nm) light using the photosynthetoron (Lewis and Smith, 1983) with light intensity ranging from 0 to 1478 $\mu mol\ m^{-2}\ s^{-1}$ for white light and from 0 to 122 $\mu mol\ m^{-2}\ s^{-1}$ for blue light. After 30 to 35 min incubation, phytoplankton were collected on Whatman GF/F filters and activity was measured by liquid scintillation counter with the external standard channel ratio method.

Primary production and community respiration

Gross primary production, net community production and community respiration were determined by an *in vitro* change in dissolved oxygen. Aliquots of the water samples for the P-I curve experiment were introduced into six-replicates of 200-mL borosilicate glass bottle and attached on a buoy line. The buoy was drifted for 24 hours (Table 1). After recovery dissolved oxygen content as well as that at the initial time were measured by the high precision Winkler titration (Furuya and Harada, 1995).

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Table 1. List of stations and time for P-I curve experiment (P) and in situ measurement of primary production (O). At Stn. 43 the experiment was made before (43-1) and after passage of a low pressure (43-2).

Station	Date	Position		Surface temperature (℃)	Item	Duration of *in situ* incubation (local time)
11	Dec.20-21,'94	64°39.9'S	139°59.9'E	-1.06 ~ -0.89	P, O	09:28 ~ 09:14
13	Dec.24-25,'94	64°18.3'S	139°59.2'E	-0.46 ~ -0.45	P, O	09:34 ~ 09:23
40	Jan.16-17,'95	64°09.5'S	140°43.6'E	2.91 ~ 2.97	P, O	07:58 ~ 08:27
43-1	Jan.19-20,'95	65°20.9'S	140°00.3'E	-0.81 ~ -0.80	P, O	08:49 ~ 11:30
43-2	Jan.21,'95	64°24.5'S	140°46.5'E	-1.05 ~ -0.75	P	no measurement

Studies on the light environment and photosynthetic production of phytoplankton in the Southern Ocean

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Introduction

Primary production processes in the sea has been recognized as one of major pathways to drive the carbon cycle in the biosphere particularly in absorbing carbon dioxide in significant quantity. Phytoplankton are the primary producer in pelagic ecosystem which covers the area of more than 90% of the world ocean, but our understanding how the ocean environment affects primary production processes is still not enough. The present study was conducted with focussing on light environment in the water column and its effects on photosynthetic processes in the Southern ocean. Actual study was conducted in the following two aspects.

Light environment and efficiencies of harvesting and utilization of light by planktonic algae in the water column

Spectral light environment of photosynthetically active radiation (PAR) at various depths in the water column and photosynthetic efficiency of planktonic algae at different light intensities of different light qualities were designed to be evaluated. However no measurement of spectral solar radiant energy penetrating into the water column was made during the present cruise because of instrument failure due to flooding of the underwater spectroradiometer by rough weather. Water samples were successfully collected at 4 different depths in the water column above 100 m by lever action water bottles which were handled with special care of keeping cleanliness at Stn.11 (60° 40′ S, 140° E; 20 December), Stn. 13 (64° 20′ S, 140° E; 24 December), and Stn. 22 (62° 00′ S, 140° E; 28 December). Sampling depths were 10m, 40m, 50m (55m at Stn. 13) and 70m at each station. Spectral light absorption and photosynthetic rate of planktonic algae sampled were then determined.

For the determination of light absorption measurements of planktonic algae, 1.5-2.5 liters of each water sample was filtered through a 25mm Whatman glass fiber filter, and the spectral light absorption of suspended particles retained on the filter was determined by the opal glass method before and after methanol extraction of pigments (Kishino et al., 1985). The difference of light absorption before and after methanol extraction was assumed to be due to planktonic algae, and was normalized by chlorophyll *a* determined by the fluorometry. For the determination of photosynthetic rate of planktonic algae, water sample kept at 4° C in dark in polycarbonate bottle for a few hours or less until measurements after sampling was assayed the photosynthesis at different light intensities of 4 different light qualities supplied by a 1 kw halogen lamp; white light (12 intensities from 5 to 533 $uE.m^{-2}.s^{-1}$), red light (650nm at the central wavelength, 10 intensities from 15 to 119 $uE.m^{-2}.s^{-1}$) , green light (530nm at the central wavelength, 10 intensities from 4 to 61 $uE.m^{-2}.s^{-1}$) and blue light (470nm at the central wavelength, 10 intensities from 5 to 21 $uE.m^{-2}.s^{-1}$) . Photosynthetic rate was determined by the ^{14}C method using 4ml sample for each photosynthesis assay for 1 hour incubation.

The following basic results are expected to be obtained from the present experiments; 1) light absorption characteristics of suspended particles in seawater between 350nm and 750nm at 4 depths at each station, 2) light absorption characteristics of planktonic algae in seawater between 350nm and 750nm at 4 depths at each station, 3) light absorption characteristics of other particles than algae in seawater between 350nm and 750nm at 4 depths at each station, 4) light absorption characteristics of dissolved matter in seawater between 350nm and 750nm at 4 depths at each station, 5) photosynthesis-light relation of planktonic algae at 4 depths at each station under white, green, blue and red lights, 6) initial slope characteristics of planktonic algae at 4 depths at each station under white, green, blue and red lights, and 7) light utilization efficiency and photosynthetic quota of planktonic algae at 4 depths at each station.

Areal distribution of large diatoms

Although large diatoms are not major group in total planktonic algal biomass in most of pelagic marine ecosystem except for high latitudes particularly at blooming season, their consistent occurrence is commonly recognized in the world pelagic ocean. Because of their large size, the large diatoms are probable to be more important than their actual biomass percentages in the community due to possible direct utilization of diatom cells by large zooplankton .

Large diatoms in the present study were defined those retained on 100 μm plankton netting. Water samples of 5-20m^3 pumped up from the ship bottom at a flow rate of 5 $liter.m^{-1}$ at the intake of the concentrating device were filtered through plankton netting during cruising using a specially designed filtration device. A NORPAC type net attached 100 μm mesh netting was towed vertically from 200m to the surface at a speed of 1$m.s^{-1}$ at each occupied station. All plankton samples were fixed with neutralized formalin. Continuous near surface sampling was conducted during leg. 1 and leg. 2 . NORPAC net samplings were done at 10 different stations of Stns. 11, 14, 15, 16, 17, 20, 21, 22, 23 and 25.

The following basic results are expected to be obtained; 1) surface distribution of large diatoms along cruise tracks of legs. 1 and 2, 2) water column distribution of large diatoms at 10 occupied stations, and 3) species dominancy of large diatoms observed in the total algal community in the study area.

Remarks

Most samples and data are still at a stage of analysis. Results and findings will be reported in the future whenever the analyses are completed.

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Algal pigment distribution and primary productivity in the Southern Ocean during austral summer 1995

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Introduction

In offshore regions of the Southern Ocean, phytoplankton (chlorophyll *a*) standing stocks and primary production are generally lower than might be expected from the high concentrations of macronutrients in surface waters. Therefore, much attention has recently focused on the regions and their potential role in global biogeochemical cycles. In this study, in order to investigate the abundance, composition and primary productivity of phytoplankton assemblage in the surface waters of the Southern Ocean during the austral summer of 1995, samples for pigment analysis using high-performance liquid chromatography (HPLC) and for productivity measurement using ^{13}C technique were collected during the KH-94-4 cruise (Leg 3) of R/V Hakuho-Maru.

Materials and Methods

Figure 1 shows the sampling sites of this study. Sea waters for surface samples were collected in lever-action type Niskin bottles attached with CTD-RMS and a clean plastic bucket.

The sea water samples (5 L) for pigment analysis were filtered through 47 mm Whatman GF/F filters. After the filtration, the GF/F filters were immediately transferred to amber vials and stored under nitrogen at -85°C until analysis. The samples were sonicated in cold 90% acetone/water (v/v) under subdued light, and sealed with Parafilm to minimize solvent evaporation. Pigments were extracted for ~4 hours in the dark at -20° C. The procedures of pigment analysis by HPLC are described in Suzuki *et al.* (submitted).

Simulated *in situ* incubations for productivity measurement using ^{13}C isotope were conducted during 24 hours on the deck of the research vessel. The incubated sea waters (0.6 L) in polycarbonate bottles were filtered through 25 mm GF/F filters. The filters were stored like those of the pigment analysis. After the GF/F filters were fumed over conc. HCl to remove inorganic carbons, the organic carbon contents and ^{13}C atomic % of particulate matters were measured by a mass spectrometer with an elemental analyzer. Production rates were determined by the equation of Hama *et al.* (1983).

Results

Chlorophyll *a* concentrations and primary production rates were < 0.6 μg L^{-1} and < 16 μgC

L^{-1} d^{-1} , respectively, at all sampling stations (Figs. 2 and 3). Multiple regression analysis of chlorophyll *a* and selected accessory pigment concentrations was conducted in an attempt to estimate the contribution of selected algal classes to the total phytoplankton crop in the surface waters of the Southern Ocean. The statistic analysis of pigments gave the following equation:

[Chl *a*] = 0.837 [Fuco] + 0.758 [19'-HF] + 4.26 [Peri] + 2.21 [19'-BF] + 0.0236.

The [Chl *a*], [Fuco], [19'-HF], [Peri] and [19'-BF] in the equation indicate that concentrations of chlorophyll *a*, fucoxanthin, 19'-hexanoyloxyfucoxanthin, peridinin and 19'-butanoyloxyfucoxanthin, respectively. The coefficient of determination (r^2) of this regression was 0.973. The result of an F-test showed that the F-value of 83.1 was larger than the critical F-value of 14.659 (significance level = 0.01). Therefore, the multiple regression equation obtained was considered to be statistically significant. Figure 4 illustrates that prymnesiophytes (19'-hexanoyloxyfucoxanthin; 11-49%) and diatoms (fucoxanthin; 9-49%) dominated the chlorophyll *a* biomass out of the Antarctic Divergence, with diatoms dominating within the Antarctic Divergence (58-65%). Chrysophytes (19'-butanoyloxyfucoxanthin; 4-23%) and dinoflagellates (peridinin; 6-15%) were consistently secondary constituents of the microalgal community in the surface waters of the Southern Ocean.

The other studies

We have obtained the other samples in this cruise:

1) samples for determining pigment turn-over rates using ^{13}C tracer method
2) mooring sediment trap samples
3) floating sediment trap samples
4) samples for investigating the impact of UV-B radiation on the photosynthetic products of phytoplankton using ^{13}C tracer technique
5) samples for evaluating the vertical distributions of pigments and primary production.

These data will be appeared soon.

Acknowledgements

Our nutrient samples were analysed by Dr. S. Watanabe. We thank Prof. M. Takahashi and Mr. D. H. Han for permitting us the use of their phytoplankton concentrating system on board. We are also indebted to Drs. K. Furuya and T. Odate for their technical support on *in situ* incubations for the measurements of primary production.

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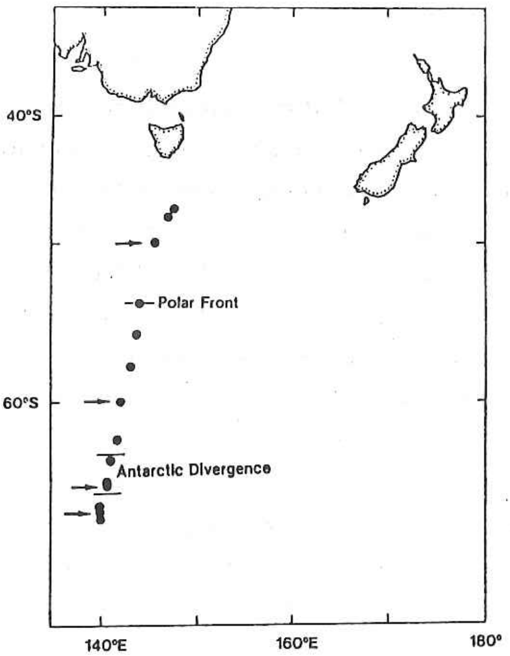

Fig. 1. Location of sampling sites. Arrows indicate the stations where simulated *in situ* incubations were conducted.

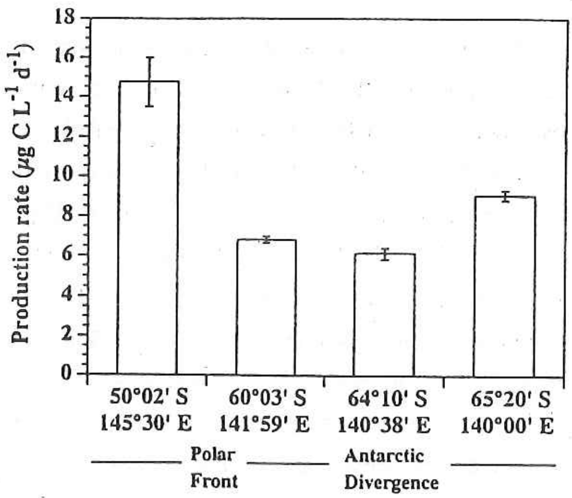

Fig. 3. Comparison of primary productivity in surface waters between the selected stations.

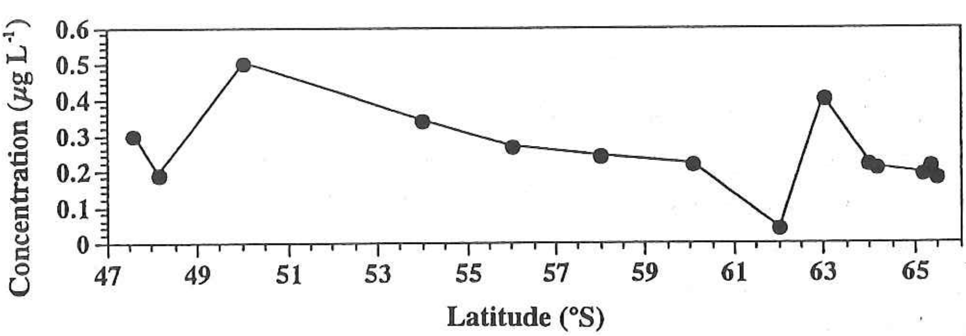

Fig. 2. Latitudinal variation of chlorophyll *a* (μg L^{-1}) in surface waters.

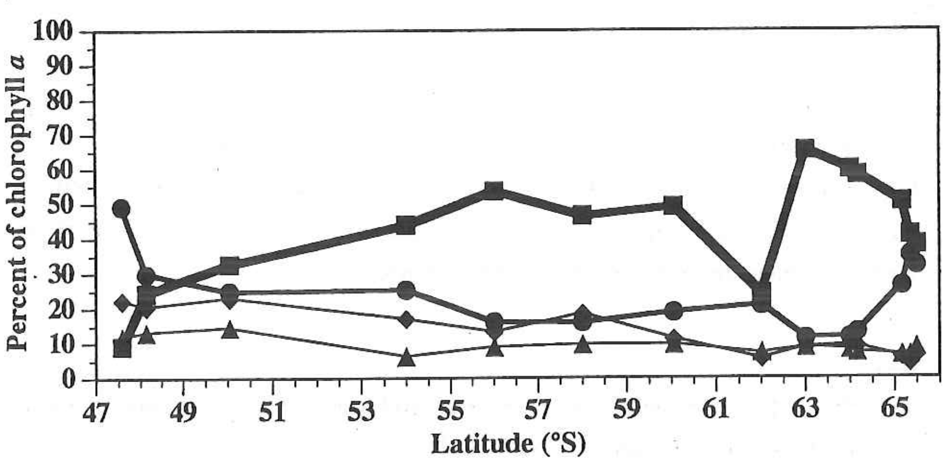

Fig. 4. Contribution of fucoxanthin-containing diatoms (■), 19'-hexanoyloxyfucoxanthin-containing prymnesiophytes (●), peridinin-containing dinoflagellates (▲) and 19'-butanoyloxyfucoxanthin-containing chrysophytes (◆) to total chlorophyll *a* biomass in surface waters as revealed by the multiple regression analysis.

The interaction between trace metals and phytoplankton community in the Southern Ocean

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Objective

Identifying the root causes for the comparatively small populations of phytoplankton in high-nitrate, low-chlorophyll (HNLC) regions of the Southern Ocean is important for understanding the regulation of the biological pump and hence ocean-atmosphere CO_2 exchange. The Fe/biota studies in neritic HNLC waters of the Southern Ocean have shown that iron addition stimulated phytoplankton growth. However, rapid accumulation of Chl *a* in untreated controls containing high ambient iron suggested that the in situ growth may be limited by other factors (light and grazing). To test the iron limitation hypothesis in oceanic low iron waters of the Southern Ocean, iron enrichment experiments were carried out with differing light and microzooplankton grazing in the Australian sector of the southern Antarctic circumpolar current.

Sampling and Methods

Iron enrichment experiments were conducted with indigenous plankton communities under ultra-clean conditions at station 40 (64° 10′ S). Water samples were collected from 11 m depth at 1500 hours local time using an acid-cleaned polypropylene bellows pump (Bellopon GY16, Nikkiso Eiko Co. Ltd.) with Teflon tubing (I.D. =12 mm). Six acid-cleaned 12 l polyethylene incubation bottles were filled with the sample water under low light. Six treatments were compared. Ambient seawater with no additions served as the control. Measured concentrations of dissolved Fe in the control bottles were 0.18 nM. The Fe treatment received an addition of 1 nM $FeCl_3$ solutions. In this experiment, two control and two Fe-enriched bottles were prepared. One of each was attenuated with neutral-density screening (27 % light level) to mimic the in situ light field at the depth of sample collection. Another was incubated under 2.6 % light level (Low light and Fe plus low light treatment) by shading with neutral-density screens and blue-light filter in order to test the effect of irradiance limitation, that may arise from deep mixing regime. To assess the role of grazers in the incubation bottles, perturbation-type experiments were performed by reducing the feeding of the grazers on phytoplankton by adding large quantities of inert plastic beads (Price et al., 1994). If the grazers could not discriminate between beads and their food, their consumption of phytoplankton would be reduced and grazing pressure relaxed. Acid-washed styrene/divinylbenzene microspheres (Dow Chemical) of 6.4 ± 1.9 μm diameter were added to two incubation bottles to achieve final density of 2×10^4 ml^{-1} (Beads treatment). One of these bottles was also enriched with 1 nM Fe (Fe plus beads treatment). These bottles were also attenuated at 27 % light level. The water samples were not prescreened with netting to exclude grazing organisms from incubation samples. The bottles were sealed in three plastic bags and incubated on deck in running surface seawater baths to maintain surface seawater temperatures for 7 days. During the course of the incubations, subsamples were poured into acid-cleaned 1 l polycarbonate bottles for the measurements of nutrients, Chl *a*, dissolved Fe, and POC. All treatment and repetitive subsampling procedures were carried out in a Class-100 clean-air laminar flow hood in a cold room (No. 10 laboratory). Plastic gloves were worn during these operations.

Nutrients were measured on shipboard with a Technicon Auto Analyzer II using standard techniques. Chl *a* was determined by fluorometric technique with a Turner Designs fluorometer (model 10). Dissolved Fe in seawater samples was determined shipboard according to the chemiluminescence method using a fully automatic Fe(III) analyzer (Kimoto Electric Ltd.). Samples for POC were collected on precombusted GF/F filters and analyzed using a CN analyzer (Sumitomo Chemical NC800).

Results and Discussion

Iron addition to surface (11 m) water samples in 12 l carboys immediately stimulated the phytoplankton community which was initially dominated by large diatoms (Fig. -1). Controls exhibited little growth under low ambient iron concentration (0.18 nM). The enhancement in Chl *a* in the iron-enriched samples compared to the controls was also observed under low light conditions, corresponding to 10 % of the light level at the sampling depth. However, nitrate consumption in the light-restricted samples was decreased to one-half of that found under sufficient light level. When the feeding of the microzooplankton grazers on the phytoplankton was reduced by adding large quantities of inert plastic beads, there was no significant effect on the small phytoplankton biomass which remained low throughout the incubation. These results suggest that the iron supply and irradiance-mixing regime may limit the growth of large diatoms in oceanic Antarctic ecosystems during summer.

Future studies

Plankton samples for species enumeration were preserved with 1% glutaraldehyde solution and 2% neutralized formaldehyde solution, and stored in darkness at 1° C for subsequent microscopic observation. The identification and counting of the specimens are now in progress. Samples for cytochrome *f* were collected on precombusted GF/F filters and then stored at -20° C. The amount of cytochrome *f* will be determined by measuring the oxidized/reduced absorption with the addition of ferricyanide and ascorbate. After the determination of these parameters, physiological iron status of phytoplankton communities will be investigated in detail.

Reference

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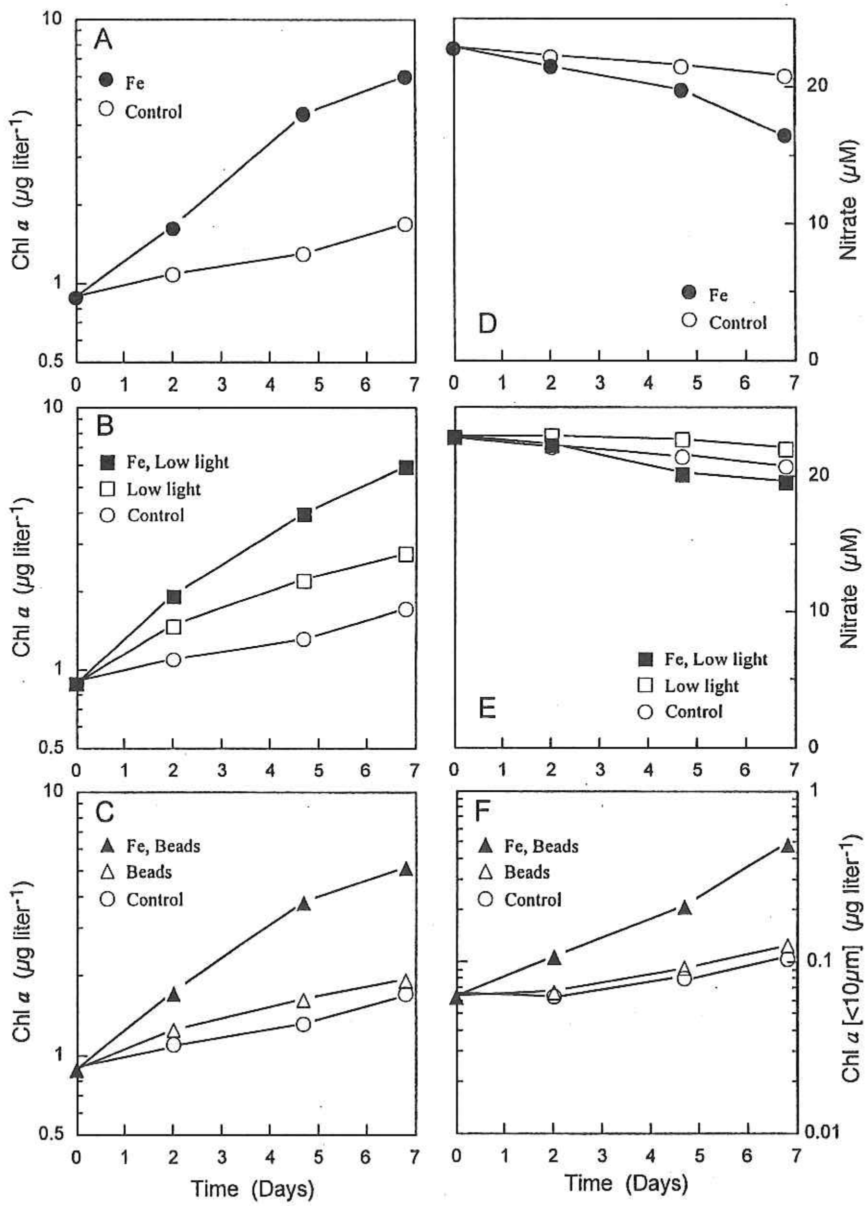

Fig. -1 Total Chl *a* and nitrate concentrations in (A, D) control bottles (O) and bottles enriched with 1 nM Fe (●); (B,D) low-light bottles with 1 nM (■), without (□) Fe, and controls (O); and Chl *a* concentrations; total (C) and <10 μm size fraction (F) in bottles enriched with 2×10^4 beads ml^{-1} with 1nM (▲), without (△) Fe, and controls (O) during on-deck incubation at station 40. Control data are included in each figure for ease of comparison.

Distribution of bacteria, heterotrophic nanoflagellates, and pico-sized cyanobacteria in the Antarctic Ocean

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Introduction

The Antarctic Ocean is considered to be of high productivity supported by rich inorganic nutrients. Organic carbon of phytoplankton produced by primary production is consumed by hervivorous zooplankton and sequent carnivorous organisms, and the energy goes into the so-called grazing food chain. Bacterial activities in the Antarctic are also high, which was shown as high production rates (Kogure et al., 1986). Recently the roles of bacterivorous protozooplankters such as heterotrophic nanoflagellates (HNF) in various aquatic environments have been pointed out by many scientists (Fukami et al., 1991), and the importance of the energy flow in microbial loop was indicated. However, studies on the carbon cycling in the Antarctic Ocean so far are mainly on the grazing food chain and only few informations are available on the microbial loop. Results of recent studies showed that the biomass of bacteria and HNF in the marine environments is as much as that of phytoplankton (Hagstrom et al., 1988), and we must take account of the contribution of the biomass carbon of these heterotrophic microbes for estimating the absorption of atomospheric CO_2 to the ocean.

This study aimed to elucidate the geographical and seasonal distribution of pico-sized cyanobacteria, bacteria, and HNF in the Antarctic Ocean.

Materials and Methods

Water samples for determining abundances of cyanobacteria, bacteria and HNF were obtained by CTD-RMS at most stations where CTD observation was done. Sampling depths were 0, 10, 20, 30, 50, 75, 100, 125, 150, 175, 200, and 500 m. Seawater samples were fixed with glutaraldehyde (final conc. 1.0%) immediately after sample collection. Abundances of cyanobacteria, bacteria, and HNF in the samples were measured under an epifluorescence microscopy. Cyanobacteria were identified by their orange autofluorescence without any staining, while bacterial numbers were counted after stained with DAPI (Fukami et al., 1991), and HNF densities were determined after double staining with DAPI and FITC.

Results and Discussion

In Table 1 is shown the distribution of pico-sized cyanobacteria (PC) in KH-94-4 cruise. Densities of PC were abundant in tropical to temperate region, maximal densities of more than 2 $x10^4$ cells ml^{-1} were observed in upper 30 m at Stn. 7. In spite of this, PC was never observed in the Antarctic Ocean. These results suggest that PC did not contribute to the primary production in the Polar region.

Geographical and vertical distributions of bacteria are shown in Table 2. Although all data of bacterial densities in water samples collected have never been determined yet, bacterial abundances in the Antarctic were mostly less than 10^5 cells ml^{-1}. The maximal densities of bacteria in the water column were usually observed in subsurface layers of 20 to 40 m depth. These geographical and vertical distributions were nearly similar to those obtained in the KH-83-4 cruise of R/V Hakuho-Maru (Simidu et al., 1986). However, the difference of bacterial densities between leg 2 (December, spring) and 3 (January, early summer) was only little, while in the KH-83-4 bacteria increased nearly 1 order of magnitude from December to January (Simidu et al., 1986). We don 't know, so far, the reason of the difference between the two cruises. Satoh et al. (1989) also reported the rapid increase in bacterial abundance from October to December in the Antarctica. We must consider differences of the ocean condition by referring the concentration of chlorophyll *a* and/or other factor(s) in the future.

Abundances of HNF are indicated in Table 3. Densities of HNF in upper 100 m layers were 1 to 7 $x10^2$ cells ml^{-1} in tropical (Stns. 4 and 5) and subtropical (Stn. 1) areas, and 3 to 22 $x10^2$ cells ml^{-1} in temperate waters (Stns. 6, 7, 25, 29, 30). At Stn. 14, where the ocean condition was just after the ice thawing, HNF density was as low as in oligotrophic tropical stations. However, HNF abundances seemed to increased up to 15 $x10^2$ cells ml^{-1} at Stns. 11 and 13. As the density of HNF was influenced, to large extent, by prey (bacteria) amount or production rates, time sequence involved in seasonal changes must be taken into account.

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Table 1. Geographical and vertical distributions of pico-sized cyanobacteria in the KH-94-4 cruise of R/V Hakuho-Maru. Abundances are expressed in terms of x 10^1 cells ml^{-1}

Depth(m)	Stn. 1	Stn. 4	Stn. 5	Stn. 6	Stn. 7	Stn. 11	Stn. 11-2	Stn. 13-N1	Stn. 13-D1	Stn. 13-D2	Stn. 14	Stn. 18	Stn. 20	Stn. 22	Stn. 25
0	22.0	4.19	1.05	366	2260	0	1.57	0	0	0	0	0	0	0	948
10	13.1	4.19	9.92	230	2380	0	0	0	0	0	0	0	0	0	1480
20	33.5	5.24	7.33	265	2230	0.714	0	0	0	0	0	0	0	0	742
30	17.8	56.5	11.5	265	2080	0	0.785	0	0	0	0	0	0	0	344
50	10.1	4.71	27.2	848	861	0.698	0.785	0	0	0	0	0	0	0	
75	16.8	95.3	0	757	33.5	0	0	0	0	0	0	0	0	0	1560
100	11.5	4.19	66.9	114	10.1	0	0	0	0	0	0	0	0	0	445
125	11.5	3.14	6.08	73.6	10.5	0	0	0	0	0	0	0	0	0	14.1
150		8.38	1.05	24.1	7.33	0	0	0	0	0	0	0	0	0	39.3
175		6.28	1.05	11.5	9.42	0	0	0	0	0	0	0	0	0	7.85
200	9.42	0	1.05	6.83	7.85	0	0	0	0	0	0	0	0	0	0
500	3.14	0	0	2.09	300m 1.05	0	0	0	0	0	0	0	0	0	0

Depth(m)	Stn. 29	Stn. 30	Stn. 32	Stn. 33	Stn. 34	Stn. 35	Stn. 36	Stn. 40R	Stn. 40B	Stn. 41	Stn. 43	Stn. 45
0	495	785	0	0	0	0	0	0	0	0	0	0
10	330	718	0	0	0	0	0	0	0	0	0	0
20	515	681	0	0	0	0	0	0	0	0	0	0
30	937	947	0	0	0	0	0	0	0	0	0	0
40	832	1020	0	0	0	0	0	0	0	0	0	0
50	851	1110	0	0	0	0	0	0	0	0	0	0
75	185	553	0	0	0	0	0	0	0	0	0	0
100	9.42	83.5	0	0	0	0	0	0	0	0	0	0
125	0	153	0	0	0	0	0	0	0	0	0	0
150	0	92.5	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Geographical and vertical distributions of bacteria in the KH-94-4 cruise of R/V Hakuho-Maru. Abundances are expressed in terms of x10^4 cells ml^{-1}

Depth(m)	Stn. 1	Stn. 4	Stn. 5	Stn. 6	Stn. 7	Stn. 11	Stn. 11-2	Stn. 13-N1	Stn. 13-D1	Stn. 13-D2	Stn. 14	Stn. 18	Stn. 20	Stn. 22	Stn. 25
0				27.5		8.8	6.53		6.17			7.05	6.35	2.12	27.7
10				25.7		13.6	10.7		8.8			7.97	3.77	1.89	23.6
20				23.3		18.2	13.3		11.7			7.6	5.19	3.47	35.2
30				22.5		13.5	14.0		15.4			14.2	4.75	3.34	25.3
50				29.3		14.1	9.3		14.2			18.7	9.70	6.34	24.0
75				26.9		6.91	5.12		10.6			10.4	3.25	8.35	19.5
100				8.85		5.70	3.08		3.73			5.62	4.10	4.08	6.22
125				9.33		2.54	2.58		3.64			5.15	4.00	3.92	8.81
150				8.54		1.97	2.18		3.28			4.85	4.44	3.87	9.06
175				6.96		1.99	2.14		3.51			4.34	3.32	5.44	6.79
200				6.04		1.46	2.29		3.10			3.84	3.19	4.98	5.01
500				4.41		1.30	1.39		2.17			1.72	2.24	2.44	1.53

Depth(m)	Stn. 29	Stn. 30	Stn. 32	Stn. 33	Stn. 34	Stn. 35	Stn. 36	Stn. 40R	Stn. 40B	Stn. 41	Stn. 43	Stn. 45
0	32.6	33.0	8.02	11.1	8.26	3.99		4.36	2.7	3.95	9.74	17.6
10		41.6	5.48	9.6	10.2	5.44		4.92	6.1	4.51	9.04	17.9
20	32.5	33.3	9.18	15.1	10.9	4.54		11.6	8.82	11.6	9.80	16.8
30	34.8	34.4	8.68	16.1	9.61	4.57		11.9	12.7	9.92	8.08	17.0
40	32.9	45.3	8.32	13.4	12.7			11.5	15.2	9.13	10.6	18.0
50	34.5	34.2	9.24	13.3	29.0	7.28		11.1	8.88	9.50	7.93	11.4
75	16.8	29.0	16.8	11.9	17.7	10.0		6.16	9.92	6.76	5.84	14.1
100	9.56	29.5	6.81	9.10	11.1	9.95		5.35	7.58	2.44	3.06	3.80
125	7.82	15.5	6.13	5.40	5.48	5.92		4.79	5.05	2.69	2.77	3.02
150	6.54	8.51	4.21	4.47	4.46	6.55		6.01	5.06	2.09	2.82	1.76
200	5.62	7.17	3.01	3.44	3.61	3.58		4.22	3.69	1.92	2.37	3.23
500	7.36	3.08	2.01	2.58	2.34	3.06		2.41	1.80	1.91	1.49	1.36

Table 3. Geographical and vertical distributions of bacterivorous flagellates (HNF) in the KH-94-4 cruise of R/V Hakuho-Maru. Abundances are expressed in terms of x10^2 cells ml^{-1}

Depth(m)	Stn. 1	Stn. 4	Stn. 5	Stn. 6	Stn. 7	Stn. 11	Stn. 11-2	Stn. 13-N1	Stn. 13-D1	Stn. 13-D2	Stn. 14	Stn. 18	Stn. 20	Stn. 22	Stn. 25
0	2.58	7.87	7.10	13.9	22.0	16.0	6.80	12.8	13.7	10.8	5.94	4.95	3.99	2.89	3.58
10	3.15	4.60	6.54	13.3	19.8	9.37	6.45	14.8	14.9	12.2	6.85	1.38	2.35	4.21	4.49
20	1.94	2.58	5.37	8.92	14.4	9.14	8.98	8.54	8.68	11.9	4.09	4.59	2.71	5.11	3.22
30	1.95	2.23	4.16	14.7	7.88	11.6	7.23	16.9	16.8	15.1	3.42	7.04	2.86	3.67	4.90
50	3.51	2.17	4.24	12.3	3.51	10.1	6.85	16.7	15.1	14.3	4.55	6.13	3.27	3.76	
75	2.50	3.05	4.67	6.56	5.96	4.40	3.06	4.35	6.79	6.69	1.89	3.84	4.08	1.07	3.93
100	2.17	0.81	4.25	5.29	4.10	4.49	6.18	2.81	4.04	5.37	2.55	2.65	4.19	2.61	2.71
125	1.69	0.97	2.29	2.41	3.06	2.35	1.99	2.24	2.70	3.68		2.40	3.17	3.83	1.64
150	2.29	1.39	2.16	1.91	4.70	1.59	2.56	1.68	2.10	4.35		3.12	1.58	2.05	1.68
175	2.64	1.00	2.64	1.06	1.79	2.76	1.22	1.08	1.28	1.58	2.04	3.68	1.69	1.99	1.56
200	2.50	1.10	1.76	0.946	1.99	2.51	1.99	0.609	3.63	1.78	1.69	1.63	1.53	2.81	2.35
500	0.973	1.16	0.408	0.880	300m2.04	2.55	2.40	1.78	3.12	3.42	1.23	2.25	2.04	1.84	1.53

Depth(m)	Stn. 29	Stn. 30	Stn. 32	Stn. 33	Stn. 34	Stn. 35	Stn. 36	Stn. 40R	Stn. 40B	Stn. 41	Stn. 43	Stn. 45
0	2.43	4.04	11.4	1.48	2.20	2.09	2.89	10.6	9.71	5.29	5.93	13.0
10	1.06	4.19	10.8	2.05	1.53	1.28		9.40	10.5	5.94	5.44	17.4
20	2.79	2.40	5.01	3.35	1.79	1.33		13.9	11.3	5.98	8.51	21.5
30	2.09	4.57	8.23	1.58	1.33	0.820		6.16	10.9	3.12	5.25	13.9
40	2.51	4.14	3.93	3.01	2.10			4.00	5.16	1.84	3.63	5.14
50	1.28	2.45	4.24	2.66	2.05	1.33		5.83	3.68	3.17	4.04	5.26
75	3.17	4.90	4.39	4.70	1.49	1.13		2.30	5.42	1.69	5.31	4.80
100	1.80	3.58	1.02	2.14	1.07	1.53		2.76	4.04	2.55	2.40	3.07
125	1.64	2.46		2.10	0.917	1.48		3.38	3.52	2.46	3.22	1.53
150	1.84	1.84	1.22	1.79	1.23	1.38	2.30	0.659	3.22	1.74	1.43	2.19
200	1.94	1.79	2.05	1.69	1.38	1.48	1.58	1.87	3.17	1.38	1.28	1.33
500	0.715	0.817	1.94	0.766	0.562	1.28	2.09	0.358	2.50	1.23	1.07	1.23

Bacterial production and its consumption by heterotrophic nanoflagellates in the Antarctic ice edge waters

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Introduction

Our data obtained in a previous research cruise in the Antarctic Ocean (R/V Hakuho-Maru, KH-83-4 cruise) demonstrated that bacterial production rates were higher than those in the tropical regions although bacterial abundances in the Antarctic were relatively small, less than 3-4 x10^5 cells ml^{-1} (Kogure et al., 1986). These facts resulted in short turnover times of bacterial assemblages of few days. A question, therefore, remained why bacterial abundances in the Antarctic Ocean were small in spite of relatively high production rates. The results suggest the possible factors of high consumption rates on bacteria. In the present study, we measured the bacterial abundance and production rate, and the density and grazing rate of bacterivorous flagellate (HNF) in the Antarctic. The purpose of this study is to clarify the biomass pool and the energy flux in microbial loop, and try to give some information on the potential ability to fix carbon by heterotrophic microorganisms in the Antarctic.

Materials and Methods

Seawater samples were collected from Stns. 14, 11, 13 (leg 2), and 40 (leg 3) in the Antarctic Ocean by CTD-RMS. As the ice edge in the Antarctic Ocean retreats southward along with the season from spring to summer, the distance of stations from the ice edge possibly represents " time sequence " . Therefore, the processes at Stns. 14, 11, and 13 were considered to represent one time series of changes. Station 14 was located at the edge of pack ice zone and water condition of the station reflected a time just after the ice thawing, while Stns. 11 and 13 were regarded as points where short and enough time had passed since the ice thawing, respectively. Observation at Stn. 40 of leg. 3 was considered to be that of austral summer and was independent of leg. 2 observation, since about one month had passes since the observation at Stns. 11, 13, 14 of leg. 2.

A part of seawater samples were used for determining the densities of bacteria and HNF by using epifluorescence microscopy (Fukami et al., 1991). Another subsample was used for measuring bacterial production by using radio labeled thymidine (TdR) (Fuhrnan and Azam, 1982), and HNF consumption rates on bacteria were determined by fluorescently labeled bacteria (FLB) method (Sherr et al., 1987).

Results and Discussion

Vertical profiles of all parameters, chlorophyll *a* concentration, bacterial abundance and production rate, and HNF density and grazing rate, fluctuated, to some extent, in upper 100m depth. All parameters, however, decreased drastically and kept in low level in the layer deeper than 100 m. Therefore, results were indicated as integrated values from 0 to 100 m depths (Fig. 1).

Discussion was done on two station groups of Stns. 14, 11, 13 of leg. 2, and Stn. 40 of leg. 3. Abundances and activities of both bacteria and HNF at Stn. 14 were unexpectedly low. At Stn. 11 bacterial abundance increased significantly while other parameters increased just to small extent. HNF densities increased significantly from Stn. 14 to Stn. 13, but bacterial abundance decreased slightly. Although bacterial production rates gradually increased from Stns. 14 through 13, and consumption rate of HNF on bacteria was highest at Stn. 11, bacterial production rates and consumption rates by HNF were in the same order of 10^{10} cells m^{-2} h^{-1}. These results indicate that the energy flow in microbial loop advanced along with proceeding of the season.

At Stn. 40, which was in summer, bacterial abundance and activity (production rate) were highest while those of HNF were not. These results made us to expect that bacterial densities would probably increase afterward.

Estimation of the energy flow of microbial loop in the Antarctic ecosystem will be done by analyzing other chemical and biological data in the future.

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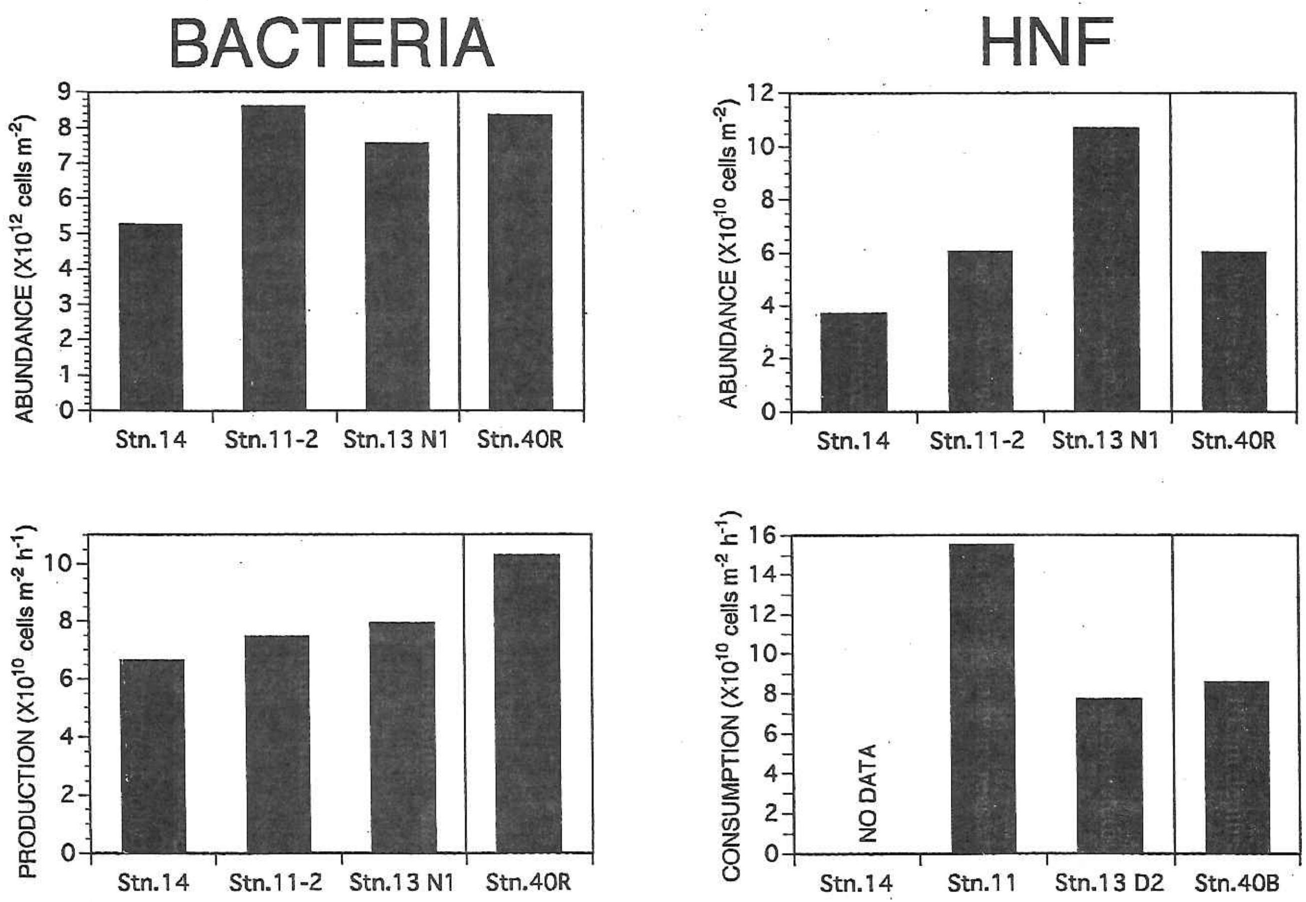

Fig. 1. Bacterial abundances and production rates, and HNF abundances and consumption rates on bacteria in four stations in the Antactic. Data are given as integrated values from 0 to 100 m depths.

Energy flow through microbial communities in the Southern Ocean -Samplings and incubation experiments on leg 3 -

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High primary production has been demonstrated in the seasonally retreating sea ice zone during the Antarctic summer period. Primary productivity and activities of microbial communities are to be estimated in the ice edge zone as well as off shore water.

Spatial distribution of microbial communities

Samples of sea water were collected at eight stations (Stns 30, 32, 33, 35, 37, 40, 40BCTD and 45) along the 140° E longitude between 50° 00'S and 65° 30'S . At each station, water samples were taken from nine different layers (surface, 10, 20, 30, 40, 50, 75, 100 and 200 m depths). However, eight layers shallower than 100 m were taken at Stn 32 due to sampling failure for deeper layers.

Microzooplankton for a size range of 20-200 μm and dissolved primary amine (DPA) will be analyzed for the above samples. Furthermore, five layers shallower than 100 m are used for POC analysis.

Primary productivity measurement and incubation of microbial communities

In order to estimate the growth rate of bacterial communities and predation rate of protozoans, two series of incubation experiments were carried out at Stns 39 and 43 where the drifting moored buoy experiments were made. The first series of experiment was done for water sample with bacterial communities after removing larger predatory protozoans by filtration. The second experiment was designed for water sample which contained algae and protozoans.

At Stn. 45, which located close to the ice edge, water samples from the subsurface chlorophyll maximum layer of 47 m depth, were used for primary productivity measurement under the simulated in-situ method on deck.

All incubation experiments were carried out on deck under two kinds of radiation condition; a reduced light intensity by covering a blue filter and a dark condition by covering an aluminum foil. All samples and incubation data are under processing at the National Institute of Polar Research, Tokyo.

Distribution of plankton and micronekton and pelagic food-web structure in the Southern Ocean

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The distribution of zooplankton in the Southern Ocean has well been studied, and knowledge have been accumulated on the distribution of major species and community structures corresponding to hydrographic conditions. However, information on macrozooplankton and micronekton is still very limited. In addition, still little is known on the mechanisms of formation and maintenance of these communities. The present cruise mainly aims to elucidate these mechanisms in the Southern Ocean, particularly in the circumpolar and the ice-edge areas centering around the divergence area at about 64° S, by performing time-series observations on a wide size-range of organisms from bacteria to fishes. In the present study we concentrated on the distribution of plankton and micronekton and their trophic relationships as described below. The details of sample collections are compiled in "Plankton Record: Hakuho Maru KH-94-4 Cruise" (stored in the Plankton Division, Ocean Research Institute).

Geographical distribution of plankton

For examining the geographical distribution and species composition of phytoplankton, zooplankton and micronekton in different sea areas ranging from the Subtropical to the Antarctic waters, samples were collected with a Norpac net (twin-type, mesh aperture: 0.1/0.33 mm), an ORI net (mesh aperture: 0.69 mm) and a 10-foot Isaacs-Kidd Midwater Trawl (IKMT, mesh aperture: 2 mm). The examination of these samples is now in progress.

Distribution of zooplankton in and around the Antarctic -Divergence area

Zooplankton distributions were investigated at three stations: Stn. 13 was located to the north of the Antarctic Divergence area (AD), while Stn. 11 was in the AD; Stn. 43 was also in the AD but investigated one month later than at Stn. 11. Samples were collected by stratified, oblique-horizontal tows of an IKMT at five layers between 0-ca. 500m in the daytime and at night. The towing depths of IKMT were monitored with a real-time depth-sensing system (SCANMAR System, SCANMAR Inc.). The samples were fixed and preserved in 10% formalin/seawater solution buffered with sodium tetraborate, sorted into15 higher taxa, the numbers of individuals enumerated and wet weights measured. The constituents of the major taxa were identified to the species.

In the present samples, the abundance and wet weight of zooplankton ranged from 64 to 2709 inds. $10^3 m^{-3}$ and from 2 to 263 mg m^{-3}, respectively, both with significantly higher values in the station north to (Stn. 13) than those within the AD (Stns. 11 and 43) (Fig. 1, 1-way ANOVA, Turkey-Kramer's post-hoc test, $p<0.05$). At all the stations there was no significant difference both in the abundance and wet weight for the water column investigated between the daytime and nighttime samples.

The macroplankton collected in the present study represented eight phyla (Table 1). Out of the lower taxa where the members have been identified to the species level, the copepods contained the largest number of species, being 15.

The numerically dominant taxa differed between the stations (Fig. 2). At Stn.13 north to the AD salps were much more abundant than other taxa, followed by copepods, while at Stn. 11 within the AD no salps occurred and copepods, chaetognaths and pteropods predominated. At Stn. 43 in the AD the taxonomic composition of the community was basically similar to that before one month, but euphausiids were more abundant than pteropods.

Pelagic food-web structure

Pelagic ecosystems involve diverse organisms with diverse food habits. Examination of the food-web structure based on such prey-predator relationships is essential in understanding the mechanisms of biological production and of maintenance of biodiversity. Previous studies on the pelagic food-web have generally been based on morphological examination of gut contents of predators. Recent observations suggest the importance of gelatinous plankters such as ctenophores, cnidarians and salps in the pelagic food-web. However, the detection of these organisms is difficult solely by conventional methods, which are also ineffective in examining other potentially important feeding strategies, such as detritivory and parasitism. Under these circumstances, an attempt was made in the present cruise to examine the pelagic food-web in the Southern Ocean by using stable-isotopic and immunochemical methods.

Various species of plankton and micronekton were sorted from the samples taken by IKMT- and ORI-net tows in the AD and adjacent areas, rinsed in distilled water and 0.1 N HCl, and frozen at -70° C. These organisms include: copepods, salps, euphausiids, siphonophores, cnidarians, decapods, amphipods, polychaets, chaetognaths, and fishes. Organic particles from water samples from chlorophyll-maximal layers and sediment-trap samples were collected on silica filters. Measurements of carbon and nitrogen stable-isotope ratios on these samples, by using combustion method and mass spectrometry, is now in progress.

Immunochemical analysis is being made focusing on gelatinous plankters as potential food organisms. Before the Cruise single species of salps and three species of jellyfishes were collected and their extracts were used to immunize rabbits, thus obtaining four sets of antibodies. Various species of zooplankton and micronekton were sorted from the IKMT- and ORI-net samples collected as above, rinsed with filtered seawater (Whatman GF/F), and frozen at -70° C. An examination of specificity of the antibodies, and identification of gelatinous plankters in the gut contents of pelagic animals are now in progress.

Vertical distribution and grazing of micro- and macro-zooplankton in and around the Antarctic Divergence area

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Time series stations (Stn 11, 13, 43)

Plankton, mainly copepods, euphausiids and salps were collected by vertical tows of a VMPS (vertical multi plankton sampler: 50x50 cm, 330 μm mesh opening) and obliquely with an ORI net (1.6m diameter, 0.69mm mesh opening) at a time interval of 3 to 4 h. Both samplings covered the 0-500m water column. Stn 11 was located at the center of the Antarctic Divergence (AD), Stn 13 to the north of AD, and Stn 43 at the south of AD. The objects of this sampling were to clarify: 1) the species composition and biomass, 2) the vertical distribution and migration, 3) feeding rhythm and rates by gut pigment, and 4) growth rate of salps (if possible)

Thirty-six species of copepods (except *Oncaea*) were identified from the VMPS samples at Stn 13 and 43 (Table). The number of copepod species was a little higher at Stn 13 but 25 species were common to the both stations. Numerically abundant species were *Rhincalanus gigas*, *Ctenocalanus citer*, *Microcalanus pygmaeus*, *Metridia* spp., *Oithona similis* and *O. frigida* at the both stations. The following differences of species composition were noted between the two stations. Relatively abundant occurrence of *Scolecithricella minor*, *Racovitzanus antarcticus*, *Metridia lucens*, *Pleuromamma robusta* and *Haloptilus oxcephalus* at Stn 13 and *Calanus propinquus*, *Gaidius* spp. and *M. gerlachei* at Stn 43. Dominance of *Salpa thompsoni* and Appendicularia at Stn 13 were the most striking difference in other zooplankters. Vertically, the surface layer (0-30m) was characterized by a very low copepod abundance. In the thermocline layer (30-120m), *C. citer* and *O. similis* dominated throughout the day and while diel vertical migrants appeared at the night. In the deeper layer (120-500m), scolecithricid copepods and *M. pygmaeus* were dominant throughout the day. The estimation of biomass, grazing rates, and growth rates of copepods and salps are in progress.

Grazing experiments of salps

Salps were gently collected with a 20-l bucket from the deck at night at Stn 40. The salps were incubated in the same bucket on the deck for 2 to 8 h. Size-fractionated chlorophyll-*a* concentrations (0.2-2, 2-20, >20μm), bacterial and flagellate densities were measured of each bucket at the beginning and the end of the experiments. Grazing rates were calculated from the difference of the chlorophyll concentrations. Five repricates were obtained using aggregate chains of 3 to 65 individuals. The body size of salps ranged between 20 and 40mm. Grazing rates roughly ranged between 40 and 300 ml h^{-1} $ind.^{-1}$. Size selectivity was not observed. Feacal pellet analysis is in progress.

Estimation of microzooplankton abundance and grazing rate

The surface water was sampled at Stn 11, 13 and 43 for microscopic analysis and the estimation of grazing rates by dilution method. The grazing rates were estimated of 3 size fractions (0.2-2, 2-20, >20μm). The incubation were done in the deck tank under natural light and in-situ temperature.

At Stn 13 microplankton (>20μm) dominated the cholorophyll standing stock, while nano- and picoplankton (<20μm) dominated at Stn 43. At Stn 13, copepod nauplii and large sized tintinnids were dominant components in the microzooplankton. In contrast, at Stn 43, oligotrichs of medium size were major components and microzooplankton biomass was much lower than Stn 13. Not only grazing rate of microzooplankton, but the growth rates of phytoplankton were not detectable at Stn 11 and 13. In contrast, balanced phytoplankton growth and microzooplankton grazing were detected for all size fractions.

Surface monitoring with the AMEMBO system

Continuous monitoring of temperature, salinity, in-vivo fluorescence and particles of surface water were done throughout the cruise except 2 days after the departure from Sydny. Meso-scale chlorophyll patches with highest concentration of about 3mg/m^3 were irregularly observed between Antarctic Convergence and Antarctic Divergence. These patches did not have apparent relations to environmental parameters such as temperature and salinity.

The AMEMBO data is available for all scientists aboard.

Table Species list of copepods collected at Stns 13 and 43

	Stn13	Stn43
Calanus propinquus	0	0
C. similimus	0	0
Calanoides acutus	0	0
Eucalanus longiceps	0	X
Rhincalanus gigas	0	0
Clausocalanus laticeps	0	X
Ctenocalanus citer	0	0
Microcalanus pygmaeus	0	0
Gaidius tenuispinus	0	0
G. intermedius	X	0
Aetideus armatus	0	0
Scolecithricella minor	0	0
S. cenotelis	0	0
S. vervoorti	0	X
Rocovitzanus antarcticus	0	0
Scaphocalanus vervoorti	0	0
S. farrani	0	0
S. brevirostris	0	0
Undinella brevipes	0	0
Stephos longipes	0	0
Euchirella rostromagna	0	0
Heterorhabdus austrinus	0	0
H. compactus	0	X
Candacia maxima	X	0
Metridia gerlachei	0	0
M. lucens	0	0
Pleuromamma robusta	0	0
Haloptilus oxycephalus	0	0
H. ocellatus	0	0
Paraeuchaeta biloba	0	X
P. antarctica	X	0
Onchocalanus magnus	0	X
Oithona similis	0	0
O. atlantica	0	X
O. frigida	0	0
Microsetella rosa	0	X
Oncaea spp.	0	0

The food habits of Antarctic krill *Euphausia superba* DANA

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In the Antarctic marine ecosystem Antarctic krill (*Euphausia superba* DANA) has been considered as the key species which links primary production to various predators during the austral summer when free-living large phytoplankton blooms. So feeding activities of *E.superba* have consequences of great importance for the understanding of the structure, function and management of the Antarctic marine ecosystem. The food habits of *E.superba* are considered to be essentially herbivorous in contrast to other euphausiid species, especially during the austral spring and summer when phytoplankton blooms. But in summer the succession of the phytoplankton species composition in the water column always occur, and once in a while there is the case that the biomass of microzooplankton and heterotrophic microflagellates are larger than phytoplankton and their importance has been suggested as the food resources for *E. superba*.

The study in this cruise aims at investigating the importance of microplankton, except diatom, for a food of *E.superba* and the existence of diel feeding rhythm of *E.superba* and getting the information of the swimming angle, direction and distance between individuals in the swarm by taking a underwater picture . In order to make clear the influence of the Global Warming it seems to be important to get the information of the food habits of *E.superba* which is typical primary consumer and key species in the Antarctic ecosystem.

The food habits of *E.superba*

Specimens were collected at intervals of about four hours through the one day at St.43 using ORI net and IKMT.

The foregut of *E.superba* (about 10 individuals) were taken out immediately after sampling and measured chl-*a* concentrations. The result of measurements of chl-*a* concentrations of specimen' s foregut were shown in Fig.1. Diel feeding rhythm was not recognized clearly, but the lower chl-*a* concentrations were found at noon and chl-*a* concentrations have a tendency to increase as the time go at night.

10 individuals of *E.superba* were frozen at the deep freezer (-80° C). That samples are intended to analyze the gut pigments by HPLC.

In order to know environmental food condition a 500ml seawater was collected at the depth of 0, 10, 20, 30, 40, 50, 75, 100, 125, 150, 200m and preserved in glutaraldehyde (2%). List of microplankton species found from the foregut contents of *E.superba* and seawater samples using inverted microscope is shown in Tables 1 and 2. The foregut contents of *E.superba* and seawater samples were predominated diatoms, especially the genus *Nitzschia* .

All specimens collected St.43 were preserved in formalin (about 10%) and distinguished their stages of sexual maturity and measured their body length. The stages of sexual maturity of *E.superba* are shown in Figs.2 & 3. The younger stages (♂: IIA, IIIA; ♀: IIIA) were dominant.

Underwater camera operation

Underwater camera was operated at Sts.13, 40, 43. But there is no picture which is taken *E.superba* so clear as we could analyze the swimming angle, direction and distance between individuals with computer.

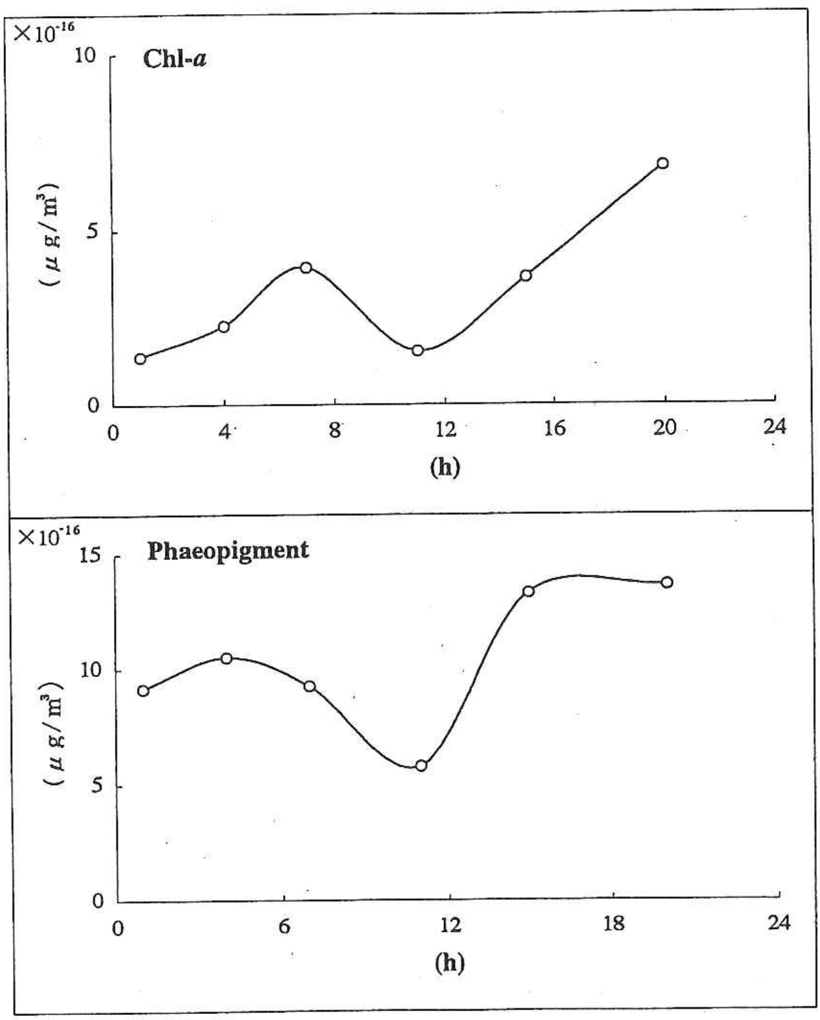

Fig. 1 The diel change of chl-*a* concentrations extracted from the foregut of *E. superba*

Table 1 Items of the foregut contnts of *E.superba* examined in this study

DIATOM	
Centrales	
Corethron criophilum	*Coscinodiscus* spp.
Rhizosolenia sp.	*Thalassiosira antarctica*
Thalassiosira gracilis	*Thalassiosira maculata*
Thalassiosira sp.	
Pennales	
Navicula directa	*Nitzschia angulata*
Nitzschia barbieri	*Nitzschia closterium*
Nitzschia curta	*Nitzschia cylindroformis*
Nitzschia cylindrus	*Nitzschia kerguelensis*
Nitzschia lineata	*Nitzschia peragallii*
Nitzschia pseudonana	*Nitzschia ritscheri*
Nitzschia separanda	*Nitzschia sublineata*
Nitzschia vanheurckii	*Nitzschia* sp.
Thalassiothrix longissima	
FORAMINIFERA	
Globigerina bulloides	
TINTINNIDS	
Codonellopsis sp.	*Cymatocilis brevicaudata*

Table 2 List of microplankotn found from the seawater at St.43.

DIATOM		
Centrales		
Asteromphalus hookeri	*Corethron criophilum*	*Coscinodiscus* spp.
Chaetoceros sp.	*Rhizosolenia alata*	*Rhizosolenia curvata*
Rhizosolenia setigera	*Rhizosolenia* sp.	*Thalassiosira antarctica*
Thalassiosira gracilis	*Thalassiosira* spp.	
Pennales		
Cocconeis sp.	*Grammatophora arucuata*	*Grammatophora marina*
Navicula jejunoides	*Navicula sp.*	*Nitzschia angulata*
Nitzschia curta	*Nitzschia cylindrus*	*Nitzschia kerguelensis*
Nitzschia lineata	*Nitzschia panduriformis*	*Nitzschia pseudonana*
Nitzschia ritscheri	*Nitzschia seriata*	*Nitzschia sublineata*
Nitzschia vanheurckii	*Nitzschia* sp.	*Thalassiothrix longissima*
Tropidoneis antarctica		
DINOFLAGELLATES		
Amphidinium sp.	*Gymnodinium* sp.	*Warnowia rubescens*
SILICOFLAGELLATES		
Distephanus speculum		
TINTINNIDS		
Codonellopsis sp.	*Cymatocilis brevicaudata*	*Cymatocilis kerguelensis*
Cymatocilis sp.		
Unidentified species		
NAKED CILIATE		
Strobilidium sp.		
Unidentified species		

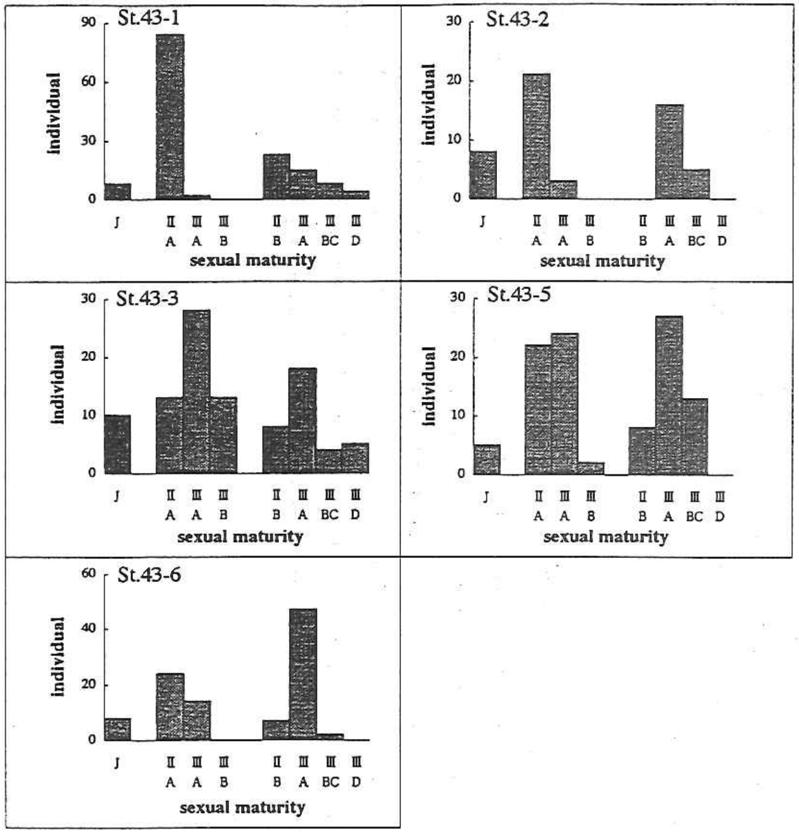

Fig.2 Frequency distribution of the stages of sexual maturity of *E.superba* collected at St.43

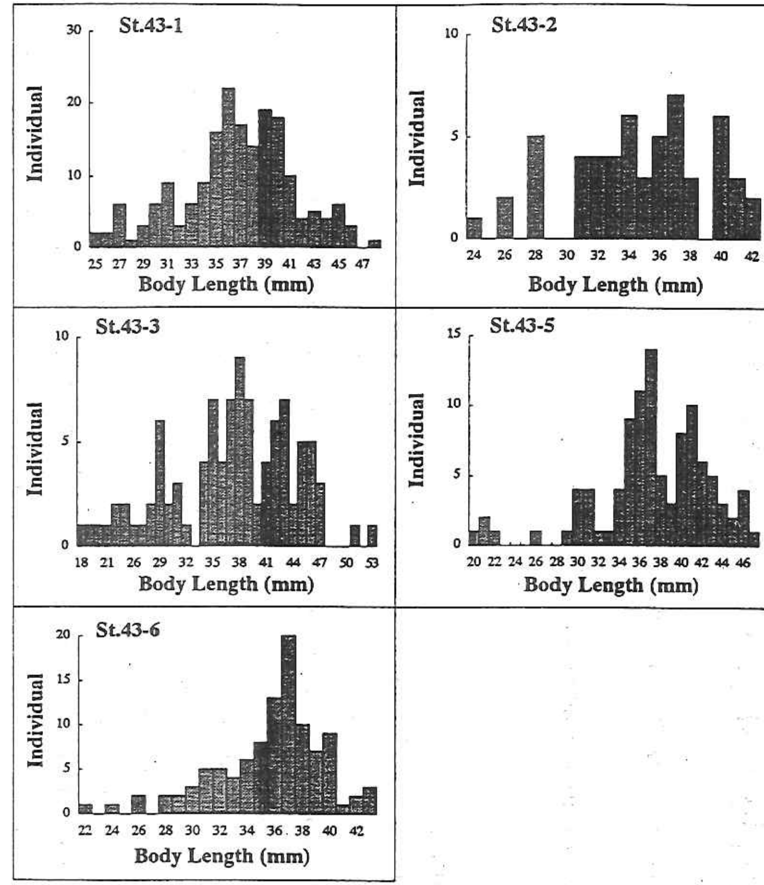

Fig.3 Frequency distribution of body length of *E.superba* collected at St.43

Zoogeography and genetic study on zooplankton

Harumi Kobayashi and Makoto Terazaki

Ocean Research Institute, University of Tokyo

Pelagic molluscs

Study on the taxonomic and morphological aspects of pelagic molluscs has a long history, mainly because of their ubiquity in the open oceans. However, their ecology is still poorly understood, owing mainly to the difficulties in rearing and sample collection, their rarity in plankton samples and to the chemical nature of their shells which are lysed after lengthy preservation in acidic media such as formaldehyde. Meanwhile, subspecies and varieties have been reported in many of the widely distributed species, but still little is known of their ecological and genetic differences.

In the present cruise different kinds of net-sampling and oceanographic observations were performed over a wide area covering the North Pacific Central Water, Equatorial Water, South Pacific and the Southern Ocean. The whole study area encompasses different current systems and water masses which are strongly related to the distribution of organisms and community structures. For the zoogeographical study pelagic molluscs were sorted, identified to the species level and their numbers in the zooplankton samples enumerated. So far 29 species of Thecosomata and 3 species of Gymnosomata were identified. Some species were frozen or fixed in alchohol on board for the genetic study.

Chaetognaths

Chaetognaths are typical carnivores and are distributed widely in the world's oceans. Of the 110 or so species, only *Eukrohnia hamata* is a bipolar species, being distributed throughout the Pacific and the Atlantic Oceans from the Arctic to the Antarctic. The specimens of *Eukrohnia hamata* collected in the Antarctic were fixed in formaldehyde or frozen. A comparison is now in progress on the morphology of the hooks, anterior teeth, posterior teeth, maturity stages, etc. between these specimens and those from the Arctic, the Bering Sea, the waters off Sanriku, Sagami Bay, the North Pacific Central Water and the Equatorial Water.

Molecular phylogeny of stomiiform fishes based on mitochondrial 16S rRNA sequences

Masaki Miya

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Two deep-sea oblique hauls were made using Isaacs-Kidd midwater trawl (mouth area, 7.3 m^2; mesh size, 5.0 mm) at two stations located in the western equatorial Pacific (St. 5) and off the east of New Zealand (St. 7) during KH-94-4 cruise of the R/V Hakuho-Maru, Ocean Research Institute, University of Tokyo. The stomiiform fishes were sorted on board, fixed in 99.5% ethanol for later molecular biological experiments.

Genomic DNAs were extracted from muscle tissues of the following five *Cyclothone* species to the present time: *C. parapallida* and *C. obscura* (equatorial bathypelagic species); *C. braueri*, *C. kobayashii*, and *C. microdon* (distributed south of 30° S in the Pacific). They were purified by phenol-chloroform extraction and approximately 570 bp of 16S rRNA gene of mitochondrial DNA from these five species were amplified using polymerase chain reaction (PCR). The PCR-amplified DNA fragments were directly sequenced using an autosequencer (ABI 373A) and the *Taq* Dye-Deoxy terminator cycle sequencing kit (ABI). Both strands were sequenced for all five species. The resulting sequences were aligned by eye with the aid of the computer software, Clustal V.

There were many phylogenetically informative sites in the aligned sequences (see Figure). The data matrix will be expanded to other gonostomatid species as well as other stomiiform genera. They will be subjected to various phylogenetic analyses, including maximum parsimony, neighbor-joining, and maximum-likelihood methods.

```
                  10          20          30          40          50
BRA    1 CTGCCCTGTG  ACTTTTCTAA  GTTTAACGGC  CGCGGTATCC  TGACCGTGCA    50
KOB    1 CTGCCCTGTG  ACTTTACTAG  GTTTAACGGC  CGCGGTATCC  TGACCGTGCA    50
MIC    1 CTGCCCTGTG  ACTTTACTAA  GTTTAACGGC  CGCGGCATCC  TGACCGTGCA    50
OBS    1 CTGCCCTGTG  ACTTAACTAG  GTTTAACGGC  CGCGGTATCC  TGACCGTGCA    50
PAR    1 CTGCCCTGTG  ACTTAACTAG  GTTTAACGGC  CGCGGTATCT  TGACCGTGCA    50

                  60          70          80          90         100
BRA   51 AAGGTAGCGC  AATCACTAGC  CTTTTAATTG  AAGGCCCGTA  TGAATGGCTA   100
KOB   51 AAGGTAGCGC  AATCACTAGC  CTCTTAATTG  GGGGCCCGTA  TGAATGGCTA   100
MIC   51 AAGGTAGCGC  AATCACTAGC  CTCTTAATTG  GGGGCCCGTA  TGAATGGCTA   100
OBS   51 AAGGTAGCGC  AATCACTTGC  CTTTTAATTG  GAGGCCCGTA  TGAATGGCTA   100
PAR   51 AAGGTAGCGC  AATCACTTGC  CTTTTAATTG  GAGGCCCGTA  TGAATGGCTA   100

                 110         120         130         140         150
BRA  101 GACGAGGGCT  CAGCTGTCTC  CTTACCCCAG  TCAATGAAAC  TGATCTCCCC   150
KOB  101 AACGAGGGCT  CGACTGTCTC  CTCACCCCAG  TCAATGAAAC  TGATCTCCCC   150
MIC  101 AACGAGGGCT  CGACTGTCTC  CTTACCCCAG  TCAATGAAAC  TGATCTCCCC   150
OBS  101 AACGAGGGCC  CGTCTGTCTC  CTCTCCCAAG  TCAATGAAAC  TAATCTCCCC   150
PAR  101 AACGAGGGCC  CGTCTGTCTC  CTCCCCCCAG  TCAGTGAAAC  TAATCTCCCC   150

                 160         170         180         190         200
BRA  151 GTGCAGAAAC  GGGGA-TACC  CACACAAGAC  GAGAAGACCC  TATGAAGCTT   200
KOB  151 GTGCAGAAGC  GGGGAATACC  CTCACAAGAC  GAGAAGACCC  CATGAAGCTT   200
MIC  151 GTGCAGAAGC  GGGGAATGCC  CCGACAAGAC  GAGAAGACCC  CATGAAGCTT   200
OBS  151 GTGCAGAAGC  GGGGA-TACC  ACTACAAGAC  GAGAAGACCC  CATGAAGCTT   200
PAR  151 GTGCAGAAGC  GGGGA-TTCC  TCGACAAGAC  GAGAAGACCC  CATGAAGCTT   200

                 210         220         230         240         250
BRA  201 TAGACACCCT  AAACCCGAGC  TATT-GCCCT  TTTCCCACAC  AAAAACGCAC   250
KOB  201 TAGACACCCT  GAAC-CCAAG  GTTAG-GTCT  C-TTATTT-C  ACAAGCGC-T   250
MIC  201 TAGACACCCT  GAAC-CTGGG  ACTGTTGCCT  CTCTACCCAC  ATGAGCAC-C   250
OBS  201 TAGACACCCT  AAACACGAGC  CATAAGTCCT  TCGCCCCCAC  AGAGACAACA   250
PAR  201 TAGACACCCT  AAACGCGAAC  CGTAAGACCC  TT--CCCCAC  AAAG-CAACA   250

                 260         270         280         290         300
BRA  251 C-GCTTG-CC  ACTTTCAAA-  GTGTCTTTGG  TTGGGGCGAC  CTAGGAGGAA   300
KOB  251 CCGCCTA-CC  CCTTTTGAAC  ATGTCTTCGG  TTGGGGCGAC  CTAGGAGGAG   300
MIC  251 TCACCCA-CC  CCTTTTGAAC  GTGTCTTCGG  TTGGGGCGAC  CTAGGAGGAA   300
OBS  251 CCGCCCGCCC  CCTTTTGAA-  GTGTCTTCGG  TTGGGGCGAC  CTAGGAGGAA   300
PAR  251 TCGCTCGTCC  CATTTTGAA-  GTGTCTTCGG  TTGGGGCGAC  CTAGGAGGAA   300

                 310         320         330         340         350
BRA  301 AGCATAGCCT  CCTTGTG-AC  AAGGGGCAAA  ACCCCTACCC  CTTAGAGCTA   350
KOB  301 AACTAAGCCT  CCTTGTG-AT  AAGGGGCAAA  ACCCCTACCC  CTCAGAACTA   350
MIC  301 AATCAAGCCT  CCTTGTG-AC  AAGGGGCAAA  ACCCCTACCG  TCCAGAGTCG   350
OBS  301 AACAGATCCT  CCTTGTG-AT  AAGGGGCAAA  ACCCCTACCC  CTAAGGGCTA   350
PAR  301 AACCAAGCCT  CCTTGTG-AT  AAGTGGCATA  ACCCCTACCG  CCTAGAACTA   350

                 360         370         380         390         400
BRA  351 CCCCTCCAAG  CAGCGGAACC  C---TGACCT  TATAGACCCG  GCACTGCCGA   400
KOB  351 CCCCTCTAAG  CAGCATAACC  C---TGACCT  CACAGACCCG  GCAGTGCCGA   400
MIC  351 CCCCTCTAAG  CAGCACAACC  T---TGACCT  CATAGACCCG  GTAATGCCGA   400
OBS  351 CCACCCTAAG  CAGCAGAATC  CCTCTGACCC  TATAGACCCG  GCACCGCCGA   400
PAR  351 CCCTTCTAAG  CAGCGGGACC  CC--CGACCT  TATAGACCCG  GCACTGCCGA   400

                 410         420         430         440         450
BRA  401 TCAACGAAAC  GAGTTACTCT  AGGGATAACA  GCGCAATCCC  CTCTTAGAGT   450
KOB  401 TCAACGGAAC  GAGTTACTCT  GGGGATAACA  GCGCAATCCT  CTCTCAGAGC   450
MIC  401 TCAACGGAAC  GAGTTACTCT  GGGGATAACA  GCGCAATCCC  CTCTCAGAGC   450
OBS  401 TCAACGAAAC  GAGTTACTCT  GGGGATAACA  GCGCAATCCC  CTCTTAGAGC   450
PAR  401 TCAACGAAAC  GAGTTACTCT  GGGGATAACA  GCGCAATCCC  CTCTTAGAGC   450

                 460         470         480         490         500
BRA  451 TCTTATTGAG  GAGGGGGTTT  ACGACCTCGA  TGTTGGATCA  GGACATCCTA   500
KOB  451 CCGTATCGAG  GAGGGGGTTT  ACGACCTCGA  TGTTGGATCA  GGACATCCTA   500
MIC  451 CCGTATCGAG  GAGGGGGTTT  ACGACCTCGA  TGTTGGATCA  GGACATCCTA   500
OBS  451 CCATATCGAG  GAGGGGGTTT  ACGACCTCGA  TGTTGAATCA  GGACATCCTA   500
PAR  451 CCATATCGAA  GAGGGGGTTT  ACGACCTCGA  TGTTGGATCA  GGACATCCTA   500
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Figure. The aligned sequences of a portion of mitochondrial 16S rRNA gene from five *Cyclothone* species (BRA: *C. braueri*; KOB: *C. kobayashii*; MIC: *C. microdon* ; OBS: *C. obscura* ; PAR: *C. parapallida*). Gaps are indicated by dashes.

Study on biological activities in surface layer analysed by downward sinking processes of particles produced in surface layer

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A spike or pulse like large primary production during a short limited summer is considered to be a main source of material and energy into the Antarctic marine ecosystem. To evaluate this characteristic primary production process, the temporal variabilities of downward sinking particles, which seem to reflect the production process through surface layer, were analysed. Two kinds of time-series sediment trap experiments were carried out on legs 2 and 3.

Surface drifting experiment

Surface drifting experiment was designed to observed the export production and primary production along the ice edge areas. A drifting arrays is consisted of the data logger of in-situ fluorescence intensity (a time series data on chlorophyll *a* concentration), which is suspended in the subsurface chlorophyll maximum layer, and the time series sediment trap(s), which are suspended below the data logger. The data logger is "Aquapack" of Chelsea Instruments Ltd., UK and has CTD and chlorophyll - a fluorescence fitted. These data are stored internally. Measurement range and accuracy for chlorophyll *a* are 0.01-100 $\mu g/l$ and 0.01 $\mu g/l$, respectively. The sediment trap is a model SMD12S-2000 of Nichiyu Giken Kogyo Ltd.. Sinking particles can be trapped into 12 discrete sample bottles and sampling intervals for each bottle can be controlled.

(1) Drifting experiment on leg 2

The surface drifting array was deployed at 64°40.00'S, 140°00.00'E at 10:45 local time on December 20, 1994, and was recovered at 21:00 local time on December 25, 1994.

The data logger was suspended at 35 m depth and recorded water temperature, salinity, depth and fluorescence intensity at 10 minutes interval from 12:00 local time on December 24,

1995. The data record continued until its recovery.

Two sediment traps were suspended at 55 m and 120 m depths each, but the deep trap was revealed to be abnormal condition when it was recovered. Therefore, only 12 samples from the shallow trap were obtained and each sample covered 8 hours as follows;

Sample No.	Starting time of sampling
1	Dec. 20, 12:00
2	" 20:00
3	Dec. 21, 04:00
4	" 12:00
5	" 20:00
6	Dec. 22, 04:00
7	" 12:00
8	" 20:00
9	Dec. 23, 04:00
10	" 12:00
11	" 20:00
12	Dec. 24, 04:00

Water sample was collected from 20 m depth two times at deployment and recovery of the drift array. These samples were offered to measure primary production using ^{13}C incubation on deck.

(2) Drifting experiment at Stn. 39 on leg 3

The drifting array of the data logger and one trap was deployed at Stn 39 (64°40.56'S, 140° 21.11'E, 3275 m depth) at 11:27 local time on January 15, 1995, and recovered at 64° 34.94'S, 139°55.38'E (3039 m depth) at 08:04 on January 18.

The data logger was suspended at 20 m depth and recorded the same data of the previous experiment at 10 minutes interval from 18:00 local time on January 15. The sediment trap was suspended at 50 m depth and collected 12 samples. Each sample represented five hours sampling period. Followings are sample details;

Sample No.	Starting time of sampling
DST-1-1	Jan. 15, 18:00
DST-1-2	" 23:00
DST-1-3	Jan. 16, 04:00
DST-1-4	" 09:00
DST-1-5	" 14:00
DST-1-6	" 19:00
DST-1-7	Jan. 17, 00:00

DST-1-8	〃 05:00
DST-1-9	〃 10:00
DST-1-10	〃 15:00
DST-1-11	〃 20:00
DST-1-12	Jan. 18, 01:00

Water samples from 20 m depth were offered to measure primary production as same as the first experiment.

(3) Drifting experiment at Stn. 43 on leg. 3.

The third drifting experiment was started at Stn. 43 (65°20.88'S, 140°01.41'E, 2280 m depth) at 08:40 local time on Jan. 19 and ended at 65°25.16'S, 139°45.08'E (2338 m depth) at 13:07 local time on Jan. 20.

The data logger at 40 m depth recorded the same data at 10 minutes interval from 01:00 local time on Jan. 19. The trap was suspended at 70 m depth and collected the following seven samples.

Sample No.	Starting time of sample	Sampling period
DST-2-1	Jan. 19, 11:00	1 hour
DST-2-2	〃 12:00	4 hours
DST-2-3	〃 16:00	4 hours
DST-2-4	〃 20:00	4 hours
DST-2-5	Jan. 20, 00:00	4 hours
DST-2-6	〃 04:00	4 hours
DST-2-7	〃 08:00	4 hours
DST-2-8	〃 12:00	1 hour

Measurement of primary production was carried out for water samples collected from 40 m depth as same as the previous two measurements.

Bottom mooring experiment

A bottom mooring array was designed to evaluate the downward flux through mid-deep layer and its vertical variability in order to extrapolate these flux into the surface production processes.

The array was deployed at 64°42.00'S, 139°58.44'E (2930 m depth) at 16:00 local time on December 25, 1994, and the array was set on the sea floor. Five time series sediment traps were at each of five depths of 537 m, 796 m, 1259 m, 1722 m and 2727 m depths. At 17:05 local time on January 21, 1995, the acoustic command to release the bottom weight was emitted and the five traps were recovered at 18:00 local time.

A total of 45 trap samples were successfully obtained with the following sampling period.

Sample No.*	Starting time	Sampling period
1-1, 2-1, 3-1, 4-1, 5-1	Dec. 26, 00:00	3 days
1-2, 2-2, 3-2, 4-2, 5-2	29, 00:00	3 days
1-3, 2-3, 3-3, 4-3, 5-3	Jan. 01, 00:00	3 days
1-4, 2-4, 3-4, 4-4, 5-4	04, 00:00	3 days
1-5, 2-5, 3-5, 4-5, 5-5	07, 00:00	3 days
1-6, 2-6, 3-6, 4-6, 5-6	10, 00:00	3 days
1-7, 2-7, 3-7, 4-7, 5-7	13, 00:00	3 days
1-8, 2-8, 3-8, 4-8, 5-8	16, 00:00	3 days
1-9, 2-9, 3-9, 4-9, 5-9	19, 00:00	2 days

* First numerals before hyphen indicate the layer of trap; namely 1 means the shallowest trap and 5 is the deepest one.

In addition to the trap sampling, zooplankton, micronekton and bottom sediment were collected in order to compare the bio-chemical composition of trap samples to these samples. ORI net, IKMT net and multi-core-sampler were used to collect these samples.

All samples and data are stored at either National Institute of Polar Research or Ishinomaki Senshu University and are now under processing.

Interdisciplinary studies using Multiple-corer samples

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Introduction

Multiple corer is devised by Burnet et al. in 1983. The virtue of this sediment sampler is that the velocity of the core penetrating into the sediment is regulated slow using hydrostatic dumper mechanism, and that upper and lower ends of the core are closed tightly *in situ*. Due to these features, multiple corer can collect entire sediment inclusive of so-called fluffy layer present in the very surface of the sediment without disturbance, and believed to be the best bottom sampler for the study of benthic ecosystem in the deep sea. The multiple corer used in the present study is modified from the original design by one of the present authors (Y.S.) and manufactured by Rigosha Ltd. considering for the use on board R/V Hakuho Maru. This gear can collect eight cores of 7.4 cm in inner diameter and 30 cm in length simultaneously.

Sample collection

In the present cruise, sediment samples were collected from 12 stations (Table 1). Eight subcores collected from a single station were shared by scientists on board ship and will be studied as described in Table 1.

Brief description of each research

1. Ecology of meiobenthos

(Y. Shirayama and M. Shimanaga)

Purpose of study

Two main purposes were set in the present study. They are:

1) Measurement of respiration-, ingestion-, and absorption-rates of nematodes, the most dominant meiobenthos to study the energy budget of meiobenthos in the Antarctic Ocean. In addition, abundance and biomass of meiobenthos will be analyzed. Based on these data, ecological characteristics of deep-sea meiobenthos in the Antarctic Ocean will be discussed.

2) Taxonomic studies of deep-sea nematodes in the Antarctic Ocean. This is further to investigate global scale biogeography and diversity pattern of the taxonomic group.

Methods

1) For the study of energy budget of nematodes, following three experiments were carried out using he sediment collected at St.43.

a) Measuring the ingestion rates of nematodes on POC

The surface sediment was washed with 63 μm mesh sieve, and labeled with gold by adding 5 ml of 10 nm colloidal gold solution to 200 ml filtrate. The filtrate was filtered using nucleopore filter of 10 μm opening, and the material trapped by the filter was dissolved with 10 ml of filtered seawater. This solution was used as labeled POC.

Nematodes were sorted out from the material caught by the 63 μm mesh under binocular dissecting microscope, and kept in the filtered seawater for two hours. Then they were cultured in the labeled POC solution for one hour, and fixed and preserved using 2% glutaraldehyde solution.

The ingestion rates of nematodes will be decided by measuring gold of POC and nematodes quantitatively by means of radio-activation analyses.

b) Absorption rate of DOC

The nematodes obtained as described in Table 1 were cultured for one hour in the seawater containing ^{14}C labeled amino acid mixture, and fixed and preserved using 5% formalin in seawater. The absorption rates of nematodes on DOC will be decided by measuring radioactivity of the animals using liquid scintillation counter after dissolving them using soluene 100 (Packard).

c) Respiration rate

The nematodes obtained as described in Table 1 were cultured for twelve hours in the microchamber. The dissolved oxygen concentration (DO) of the seawater in the chamber was monitored and the respiration rate of nematodes will be determined as the rate of decrease of DO in the chamber.

2) To measure the abundance and biomass of meiobenthos as well as to study taxonomy and biogeography of deep-sea nematodes, sediments of two cores were sliced horizontally in 2 mm interval for the topmost 1 cm layer and 1 cm interval for 1 to 10 cm layers. Each sliced sediment was fixed and preserved using 10% formalin.

Results of observation

In this cruise, three experiments (40 individuals) of a, two (24 individuals) of b, and one (10 individuals) of c were carried out. The data of these experiment will provide basic information regarding energy budget of benthos in the Antarctic deep sea. As is well known, flux of organic matter in the Antarctic Ocean fluctuates largely. The metabolic activity of benthos is the key to understand the fate of organic matter produced in the euphotic zone of the area. If the benthic community does not adapt to such habitat characteristics, the activity of the community is low, and the area will be considered as a sink of green house gas, i.e., CO_2. On the other hand, if the organisms are well adapted to such unstable environment, the metabolic activity of benthos is expected to be high, and the Antarctic cannot be a sink of CO_2.

In the present study, nematodes of 47° S to 65° S were sampled. The taxonomic studies of deep-sea nematodes in these zones are rare, and the material is precious for the study of biogeography of that taxon. Recently, Rex et al. reported latitudinal gradient of biodiversity in deep-sea macrobenthos of the Atlantic Ocean. The materials obtained in the present cruise will be a major material to evaluate their finding using different taxon and different place (Pacific).

2. *Reconstruction of paleoceanographic circulation and productivity in the Antarctic Ocean*

(N. Ahagon and M. Ikehara) ,

The recently proposed deep-sea circulation model (belt conveyer model) suggests that in the last glacial period a pattern of circulation was distinct from the present. However, discrepancies can be found among the reconstructed deep-sea circulations because the previous studies focused whether the mechanism to produce north Atlantic deep water is present. To solve the discrepancies, it is necessary to reveal contribution of the Antarctic Ocean as another place to produce deep-sea waters. In the present cruise, using multiple-corer samples, we will study stable isotope ratios of oxygen and carbon and trace metals concentration in the nanofossils to monitor spatial and temporal fluctuation of deep-sea waters in the Antarctic Ocean.

All the multiple-corer samples were stored in the refrigerator. For the description of each core, the same procedures as described in the section of piston corer sampling were taken. Two corers were sliced in every 1 cm layer, and kept frozen. One of them will be used for the inorganic analyses, and the other for the analyses of lipids and Uk37 ancient water temperature.

3. *Distribution of calcareous nanoplankton in the Antarctic Ocean*

(H. Matsuoka)

Calcareous nanoplanktons are mostly micro phytoplankton possessing calcareous shell such as haptic algae. They are commonly used for determining the age of ocean sediment as well as analyses of paleoceanographic environment. In the present cruise, I will attempt to analyze the community of calcareous nanoplankton in the surface sediment of the Antarctic Ocean. For this purpose, sediment samples collected using multiple corer will be observed using electron microscopes. The preliminary observation revealed that calcareous nanofossils are abundant up to 56° S.

4. *Studies of paleoceanographic deep-sea circulation in the Antarctic Ocean by means of analyses of ^{14}C in the foraminiferal tests.*

(M. Murayama)

The calcareous foraminifers produce calcium carbonate test using calcium and carbonate in the sea water. In this process, ^{14}C is incorporated in the test and this isotope is useful to determine the age of the material up to several tens thousand years BP. The difference of the age among planktonic and benthic foraminifers provides information regarding the circulation velocity and the source of deep-sea waters in the paleocean. For this purpose, sediment samples collected using multiple corer were sliced in 1 cm layer. The sliced sediments were fixed and preserved by 5% Rose Bengal formalin seawater adjusted pH to 8.5 and kept in the refrigerator. Planktonic and benthic foraminifers will be sorted out from these sediments, and ^{14}C in the test of these foraminifers will be analyzed.

5. Movement of Uranium and Manganese

(S. Watanabe, A. Ohtsuki and N. Narita)

Uranium is dissolved in sea water as a complex ion with carbonate. In the reduced environment, however, it attaches to sedimentary particle as uranium oxide. This chemical reaction is the major removal process of uranium from sea water, balancing its supply by means of weathering. On the other hand, manganese is in oxide state and difficult to be dissolved in the sea water. In the reduced environment in the sediment, however, it is reduced and moves within the sediment. The aim of the present study is to measure the total concentration of these metals and reveal their movement based on their distribution within the sediment. For this purpose, sediments were sliced horizontally every 1 cm. In the laboratory, uranium and manganese in these sediments will be analyzed.

Table 1. Sampling stations of multiple corer in the R/V Hakuho Maru cruise KH-94-4.

St.	Latitude	Longitude	Depth(m)	Date	Sample*
PIS-4	47° 34.30'S	147° 29.39'E	1301	1/10/1995	a
PIS-5	48° 07.60'S	146° 53.99'E	2283	1/10/1995	a
St.32	56° 00.07'S	143° 40.90'E	3429	1/12/1995	a
St.34	60° 02.71'S	142° 00.11'E	4354	1/13/1995	a
St.35	62° 00.77'S	141° 40.53'E	4265	1/14/1995	a
St.37	64° 00.25'S	140° 42.10'E	3700	1/15/1995	a
St.40	64° 09.52'S	140° 37.98'E	3630	1/15/1995	b
St.43	65° 21.03'S	139° 59.48'E	2286	1/18/1995	b
St.44	65° 23.90'S	139° 59.94'E	2471	1/21/1995	a
St.45	65° 28.11'S	140° 29.92'E	1567	1/22/1995	a
St.46	26° 10.72'S	156° 59.39'E	4548	2/03/1995	a
St.47	15° 19.96'N	141° 24.21'E	4613	2/10/1995	a

*Samples were shared as follows:

a: Division of Ecology, ORIUT	2
Division of Sedimentology, ORIUT	2
Tokyo Metropolitan University	1
Hokkaido University (Murayama)	1
Hokkaido University (Watanabe) & Kochi University	1
Reserve	1
b: Division of Ecology, ORIUT	8

Distributional and biochemical characteristics of dissolved and colloidal organic matter in the Antarctic Ocean

Hiroshi Ogawa, Rumi Fukuda and Isao Koike

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Dissolved organic matter (DOM) in seawater is known to be a major carbon pool in the ocean. The distribution and source/sink mechanism of DOM are important information to elucidate the relationship between the oceanic carbon cycle and the increasing atmospheric carbon dioxide, which results in heating the earth through "green house effect".

The recent measurements of dissolved organic carbon (DOC) in seawater using high temperature catalytic oxidation method (HTCO), which has been recently developed, have been giving details of the vertical, horizontal and seasonal distributions of bulk DOM, mainly in the Pacific, Atlantic Oceans, and some coastal areas (Ogawa & Ogura, 1992; Carlson et al., 1994; Peltzer & Hayward, 1995). However, little is known about those in the Antarctic Ocean. The bulk chemical characteristics and biological reactivities of DOM is further unknown. Particularly, some recent studies have indicated that the colloidal size fraction, which is previously categorized into DOM, could play a more active role in the oceanic carbon cycle through some biological processes (Koike et al., 1990; Amon & Benner, 1994).

This study will present some vertical distributions (measured as DOC) and biochemical characteristics of DOM, including colloidal fraction, in the Antarctic Ocean.

Vertical distribution of DOC (Leg.3)

Seawater samples for measuring DOC were collected with Niskin-type bottles at twenty five layers from the bottom to the surface at Stns.32 (56° S, 143° E), 34(60° S, 142° E), 40(64° S, 140° E) and 43(65° S, 139° E). A sample was filtered through a Whatman GF/F filter precombusted at 450° C for three hours under slightly reduced pressure (> ca. 600mmHg). Aliquots of about 5ml of filtered seawater were introduced into 10 ml glass ampules precombusted at 550° C for five hours, and then the ampules was sealed. The packed samples were immediately frozen and stored at ca.-20° C until the analyses.

All measurements of DOC will be done by the HTCO method (Shimadzu TOC-5000) in Ocean Research Institute. Preliminary results for the samples at Stn. 40 indicated significantly low concentrations of DOC in the upper layers (i.e. 45-55 μ MC in the upper water column above a 50 m depth) compared to those obtained from subtropical and tropical areas in the Pacific Ocean during KH-94-3 cruise (i.e. 60-85 μ MC: Ogawa & Koike, unpublished data). On the other hand, a quite constant profile (~40 μ MC) was obtained from the down layers below a 200 m depth. This value is well consistent with that from the deep sea water (below a 2000m depth) in the Pacific. It is possible that the low concentration of DOC in the productive upper layers may be mainly caused by the dilution with upwelling of deep water in which DOC concentrations is much lower.

Molecular weight fractionation of DOM (Leg.3)

To characterize chemical forms of DOM, the molecular weight fractionation was performed using the ultrafiltration method. Samples were collected with Niskin-type bottles from the surface (40 or 50m) and middle (1000m) layers at Stns. 40 and 43. Pre-filtered seawater with a Whatman GF/F filter was then filtered through a Millipore Omnipore filter (pore size 0.1 μm) to remove bacteria and other colloidal size materials. One liter of this filtrate was subjected to the ultrafiltration process using a stirred cell with a membrane filter of 10k molecular weight cut-off (YM10: Amicon Co.). Finally, high molecular weight DOM (>10k) was recovered in a retentate, which was concentrated by 20 times, while low molecular weight DOM (<10k) was recovered in a filtrate without the concentration. The fractionated samples were stored in the same manner as measuring DOC.

Consequently, following information will be obtained from the measurements of the concentration of organic carbon and some major organic components (amino acids and sugars) in these samples.

(1) Molecular weight compositions (>10k and < 10k) of bulk DOM and their changes with water depth.

(2) Quantitative contributions of major biomolecules (amino acids and sugars) to high and low molecular weight DOM and their changes with water depth.

Chemical characteristics and biodegradability of colloidal organic matter (Leg.3 & 4)

Seawater samples were collected with Niskin-type bottles from two layers (40 and 1000 m) at Stn.40 and from a 50 m depth at Stn.43. At five points between 48° S and 30° N during cruising of Leg.3 & 4, surface waters were sampled with the seawater supply system for the experimental use.

A sample was prefiltered through a glass fiber filter (GF/75: Advantec Co.), subsequently through a cartridge-type membrane filter (Micropore 0.8 μm: Organo Co.) to remove zooplankton, phytoplankton, flagellata and other micro-size materials. This filtrate was then subjected to Pericon tanjential flow ultrafiltration system (Millipore Co.) with a Durapore filter (pore size 0.1 μm, Millipore Co.). Most of bacterial cells in original seawater were passed through the 0.8 μm membrane but not through the 0.1 μm one. Therefore, bacterioplankton in seawater could be concentrated in the retentate during this process.

The colloidal solution (size range: 0.1 -0.8 μm) including bacterial cells was recovered as a concentrate from 90-630 l of pre-filtered seawater. The solution was further concentrated until the sample volume was finally reduced to 50-100 ml through a stirred ultrafiltration system (Amicon Co.) with a Omnipore filter (pore size: 0.1 μm). Bacterioplankton (2.5 x 10^5 - 1.1 x 10^6 cells/ml in original seawater) were finally concentrated to be 9.4 x 10^6 - 4.1 x 10^8 cells/ml.

Aliquots of the final concentrate were sealed in glass ampules and stored at -20° C until chemical analyses and degradation experiments. Organic carbon/nitrogen, carbohydrates, protein and total amino acids will be measured for the obtained colloidal samples. Assuming most of recovered materials consists of bacterial cells, these compositions could be available as the chemical information for bacterial cells in natural seawater.

A part of the stored sample will be subjected to a biodegradation experiment to identify biologically refractory components and labile ones in the natural colloidal size materials, particularly, bacterial cells. The experimental design consists of three steps: (1) physical destruction of collected materials with a ultrasonication, (2) inoculum of natural bacterial community, (3) observation of changes in the chemical composition of the materials with the degradation time.

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Study of the distribution and speciation of trace elements in the Southern Ocean

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The knowledge of the distribution of trace elements in the ocean has greatly advanced in the last two decades, because of the improvement of clean sampling and analytical methods[1,2]. Martin et al. reported the distribution of iron and affirmed that iron deficiency is limiting phytoplankton growth in high-nutrients and low-chlorophyll (HNLC) areas such as the north-east Pacific subarctic and the Antarctic[3-6]. Moreover, they suggested that oceanic iron fertilization aimed at the enhancement of phytoplankton production may turn out to be the most feasible method of stimulating the active removal of atmospheric CO_2[6,7]. Concerning this hypothesis, many studies and controversies have still been holding[8-11]. Any trace elements should have unknown significance in biogeochemistry according to their chemical characteristics. The data on the trace elements are very limited spatially and temporally. In the present study, simultaneous and speciation determination has been carried out in order to elucidate the behavior of the trace elements in the Southern Ocean.

Methods

Seawater samples were collected using a CTD rosette suspended on titanium armored cable. Two kinds of samplers were mounted on the rosette. One was conventional Niskin samplers of which inner springs were replaced by silicon tubes, and the other was lever action samplers. The interior of the samplers was coated with Teflon and cleaned with detergent and hydrochloric acid. Surface water samples were collected using Tygon tubing and a bellows pump. The flow line of the pump sampler was free from metallic parts and cleaned in the same manner for the Niskin samplers.

Shipboard determination of Fe(III)

The concentration of Fe(III) was determined using an automated shipboard analytical system developed by Obata et al[12]. Seawater sample acidified to pH 3.2 with formic acid-ammonium formate buffer was passed through a chelating resin column. The chelating resin was 8-quinolinol immobilized fluoride containing metal alkoxide glass (MAF-8HQ). Collected Fe(III) was eluted with 0.3 M hydrochloric acid, and the eluent was mixed with luminol, ammonium and hydrogen peroxide solutions. The Fe(III) concentration was obtained from the increase in chemiluminescence.

Simultaneous determination of trace elements

Immediately after the sampling, 250 ml of seawater was filtered through a 0.2 μm Nuclepore filter, adjusted to pH 5.0 with ammonium acetate buffer, and passed through a MAF-8HQ column. Collected trace elements were eluted with 25 ml of 0.5 M nitric acid. The results of preliminary experiments showed that more than 30 elements of transition and posttransition metals were recovered quantitatively with this procedure. The eluents were brought to our laboratory and analyzed with a high resolution ICP-mass spectrometer (HR-ICP-MS) JEOL JMS-PLASMAX1. The present technique allowed the determination of 22 elements with sufficiently low blank values.

Determination of the speciation of arsenic

In the temperate zone, significant amounts of arsenite [As(III)], dimethylarsinic acid [DMAA(V)] and monomethylarsonic acid [MMAA(V)] are observed in seawater, while the thermodynamically stable form of arsenic is arsenate [As(V)] under oxic conditions[13,14]. The change in the speciation is caused by the arsenic metabolism of aquatic organisms[15]. The metabolism is thought to be evolved to detoxify arsenic and common to organisms living in seas and lakes. The objective of this study is to investigate whether similar arsenic metabolism takes place in the Southern Ocean. The detail of the analytical method was reported previously[16] Sample water (600 ml) for the determination of trivalent arsenicals was collected by careful attention to avoiding the dissolution of atmospheric oxygen. The trivalent arsenicals were extracted into carbon tetrachloride as diethyldithiocarbamate complexes. Sample water (100 ml) for the determination of arsenic(III+V) species was acidified to pH 2 with hydrochloric acid. These samples were carried to our laboratory. As(V), As(III), MMAA(V), MMAA(III), DMAA(V) and DMAA(III) were determined by hydride generation atomic absorption spectrometry.

Results and Future Works

Some vertical profiles of Fe(III) are shown in Fig. 1. The standard deviation for replicate measurements was 0.03 nM. The concentrations for samples collected with different kinds of samplers at the same depth did not show significant difference. While it has been reported that the vertical profile of iron is similar to that of nitrate in some areas, such as the Gulf of Alaska[5], the obtained profiles of Fe(III) in this cruise were not similar to those of nitrate. Differences were observed between the profiles depending on the sampling area. At the ice-edge (Stn. 45), the concentrations were 0.2-0.3 nM in surface water and increased with the depth. The surface concentration decreased in the Antarctic Zone (Stn. 11). Other two characteristics in this area were uniformity in the 500-2500 m depth range and increase in bottom water. In the vicinity of Antarctic Polar Frontal Zone (Stn. 32), the surface concentration was slightly high (0.1-0.2 nM) and a maximum occurred at 2600 m. The surface Fe(III) was depleted in the Sub-Antarctic Zone, and the concentration increased with the depth accompanied with some maxima (Stn.

25). Iron may have been a limiting nutrient for plankton growth in the Antarctic and Sub-Antarctic Zones. The high concentration of Fe(III) in the bottom water is probably attributed to reduction of ferric oxide in the sediment over the continental shelf and circulation of the Antarctic Bottom Water. Fe(III) may be used as a new tracer of water masses, since such unique profiles were not observed for the other chemical species determined previously.

Figures 2 and 3 show profiles for trace elements determined with HR-ICP-MS, and Fig. 4 shows the distribution of arsenic species at two stations. We are now carrying out the analysis of the rest of the samples and investigating the data. Our data will be more comprehensive than that ever reported on the trace elements in the Southern Ocean.

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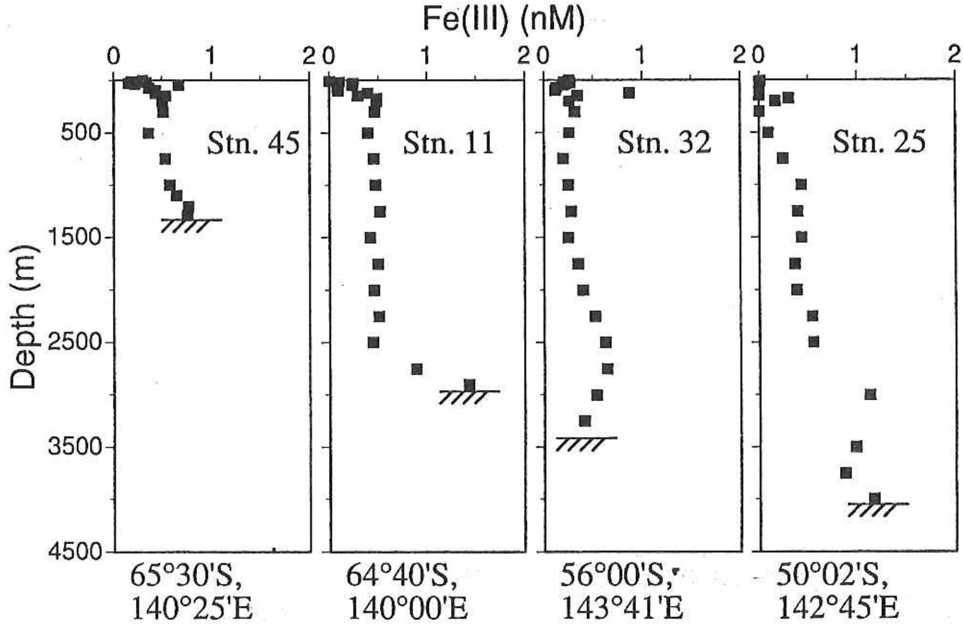

Fig. 1 Vertical profiles of Fe(III) in the Southern Ocean.

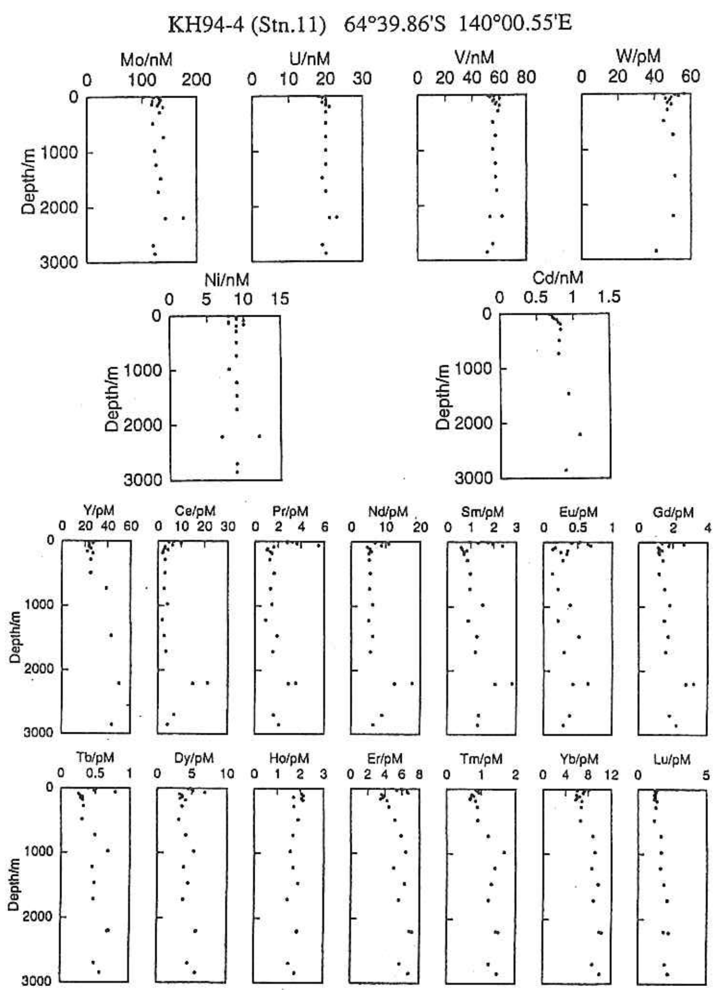

Fig. 2 Vertical profiles of transition metals at Stn. 11.

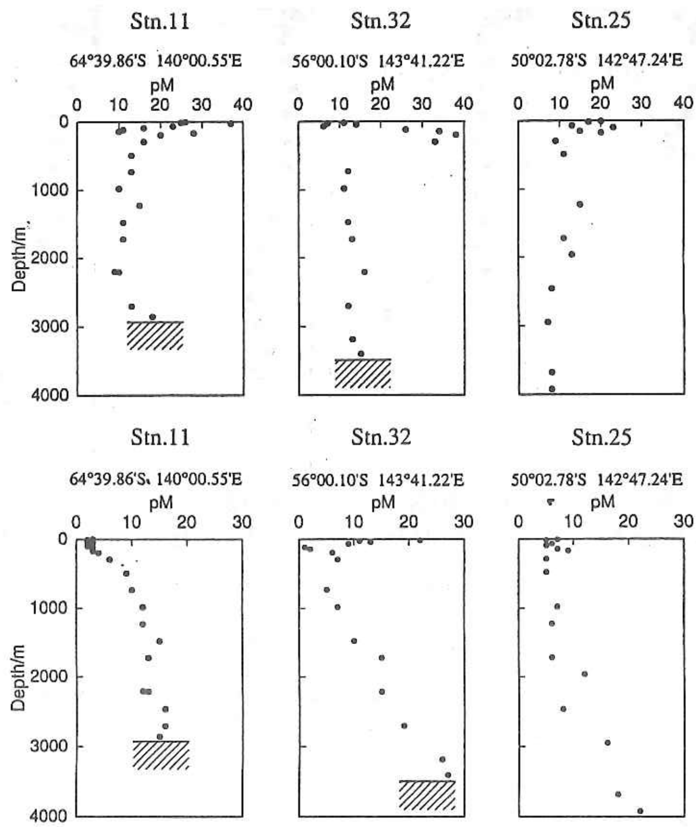

Fig. 3 Vertical profiles of Co (upper) and Ga (lower) at Stns. 11, 32 and 25.

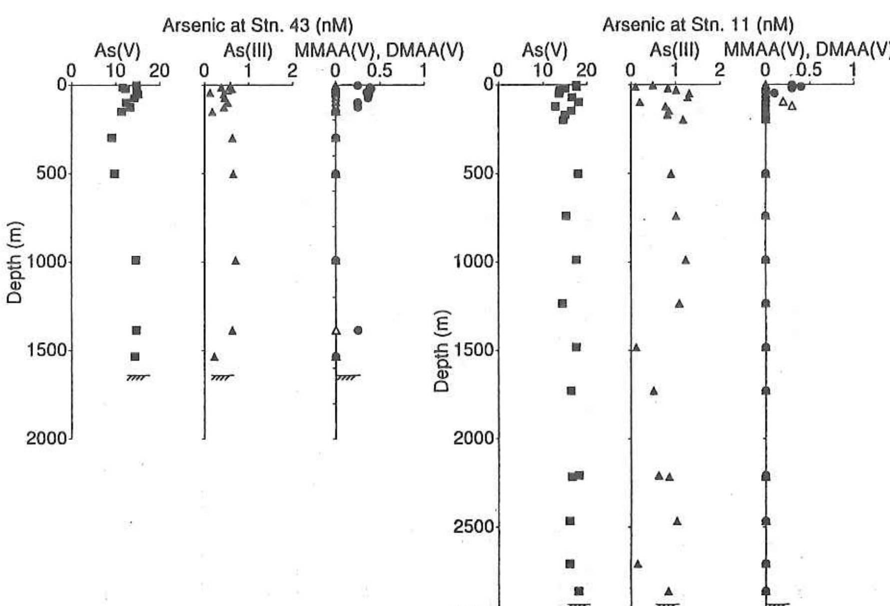

Fig. 4 Vertical profiles of arsenic species at Stns. 43 and 11. ■, As(V); ▲, As(III); △, MMAA(V); ●, DMAA(V).

XBT Section in the Western Pacific Ocean

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During the cruise, a research group of physical oceanography carried out CTD casts, mooring of current meters, and XBT sounding. The CTD data are to be used to study the deep circulation from the Southern Ocean to the North Pacific Ocean. The current measurement is described elsewhere.

XBT sounding is made to examine thermal structure in the upper ocean, and a similar attempt was made on board the Aro used to examine propagation of sound signals in the long distance.

The XBT casts were made every degree of latitude from 65°S to 33°N along the ship track as shown elsewhere in this report. Fig. 1 shows a contour map of temperature in the upper 800 m. A seasonal thermocline is formed in the upper 10 m south to 45°S. A mixed layer exists with thickness of about 50 m from 20°S to 10°N, and more than 100 m in the northern area. Temperature change is small in the south of 50°S, where Antarctic Convergence is located. The Subtropical Convergence seems to be located around 33°S, which is indicated by a large horizontal contrast of temperature from 100 m to 800 m. A down-welling may be indicated by the contour in the region between two fronts.

A Sofar channel is estimated to be located in the upper 200 m in the summer season. However, it is suggested that Sofar channel may not exit in the winter season with surface temperature below freezing point.

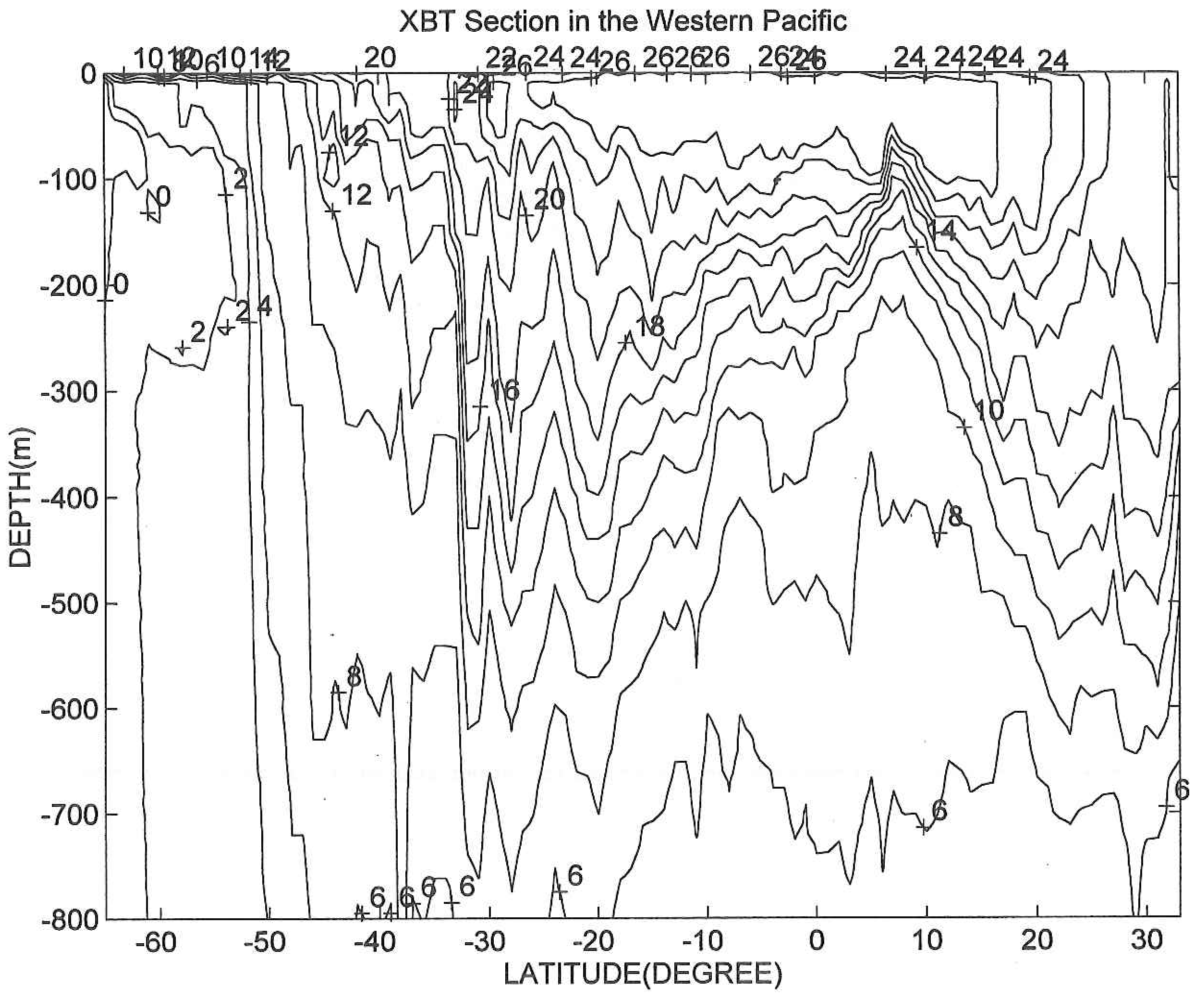

Fig. 1 A contour map of temperature in the upper 800 m measured with T-7 XBT sensors in the Western Pacific Ocean from 65°S to 33°N

Moorings in a region around 65°S latitude and 140°E longitude of the Antarctic Divergence

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[4] National Institute of Polar Research

Introduction

It is well known that the Antarctic Divergence (AD) which surrounds Antarctica and has the form of a narrow belt (Sverdrup et al., 1942) is a region of upwelling of deep water. Deep water in the Antarctic Ocean, named the Circumpolar Deep Water (CDW), generally has warm, salty properties. Since upwelling of the CDW brings about upward heat fluxes of heat and salt, this upwelling may lead to the formation of polynyas within the ice cover. Wakatsuchi et al. (1994) have showed with observational data that the AD in the Indian Ocean sector is composed of a street of cyclonic eddies which measure about 500 km in the zonal direction and 200 km in the meridional. They have also showed that a polynya was observed to persistently occur, corresponding with one of the eddies in location, size and form. Enomoto and Ohmura (1990) show a good geographical correspondence between the Weddell Polynya and the Atmospheric Circumpolar Trough which coincides with the AD. Therefore the Antarctic climate is significantly affected by the air-sea-ice interaction in the AD. In spite of the climatic importance of the AD in the Antarctic Ocean, our understanding of it is extremely poor because of the lack of regional oceanographic observations.

Deployment of current moorings

In order to examine water structure and its seasonal variations in a region of the AD where the cyclonic eddies and/or polynyas may occur, we performed the deployments of current moorings at three stations on the continental shelf slope in 14 and 17 January 1995. According to Rodman and Gordon (1982), this region also may be one of the major regions of the Antarctic Bottom Water formation.

The locations and sea depths of the moorings at each station are summarized in Table 1. Figure 1 shows the forms of current moorings at each station. A current meter at St.A has successfully been recovered aboard the icebreaker Shirase of the 36th Japanese Antarctic Research Expedition(JARE). Figure 2 shows records of current directions, speeds and water temperature for about 40 days which were obtained from the current meter at St. A. The other six current meters will be recovered aboard the Shirase of the 37th JARE in March 1996. We are planning to make hydrographical observations around the location of our current moorings, aboard the R/V Umitaka-Maru of the Tokyo University of Fisheries in February 1996. We would like to discuss about the water circulation and its seasonal variations in a typical region of the AD after we obtained all the observational data.

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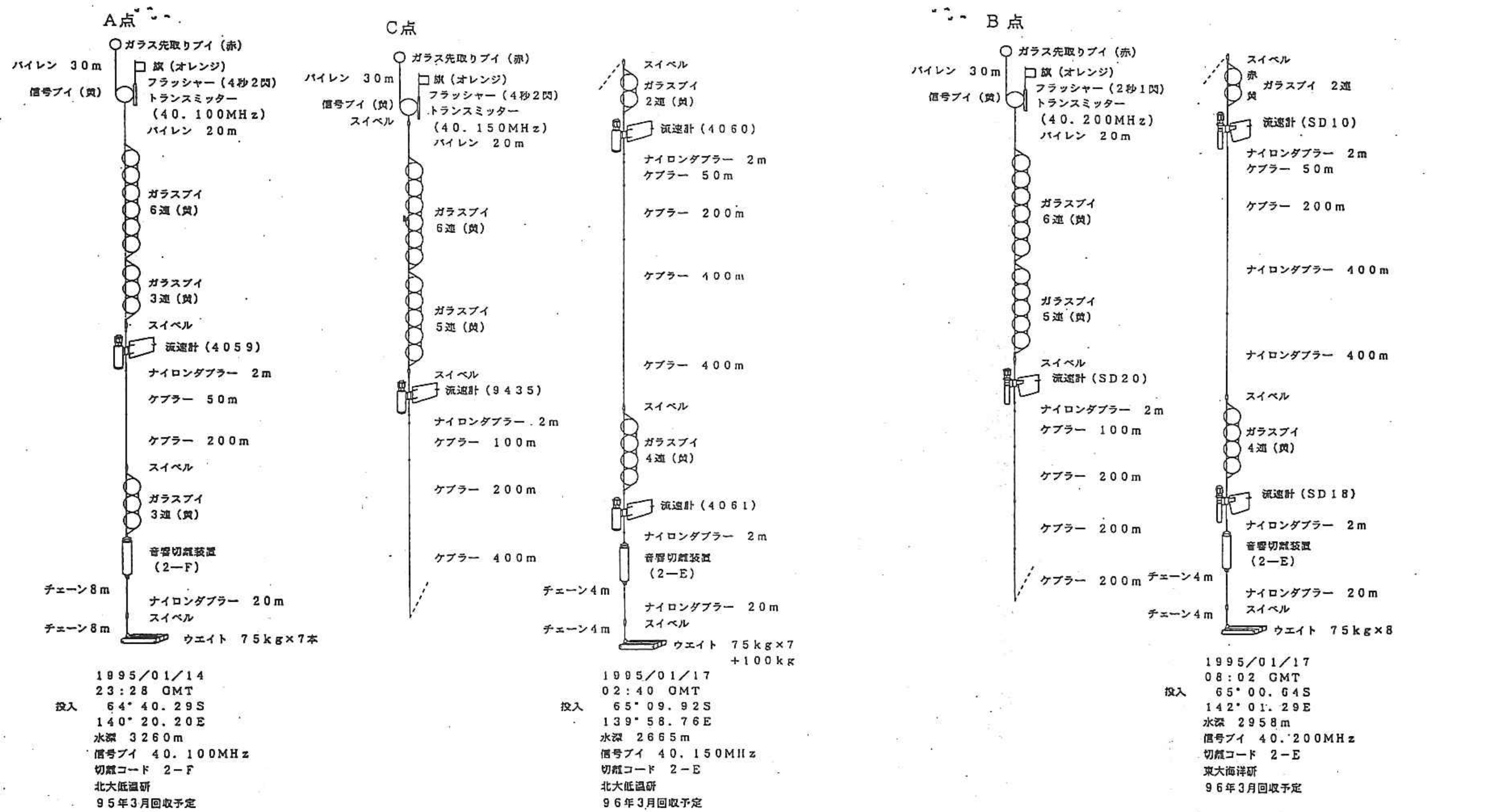

Fig.1 Forms of current moorings at each station

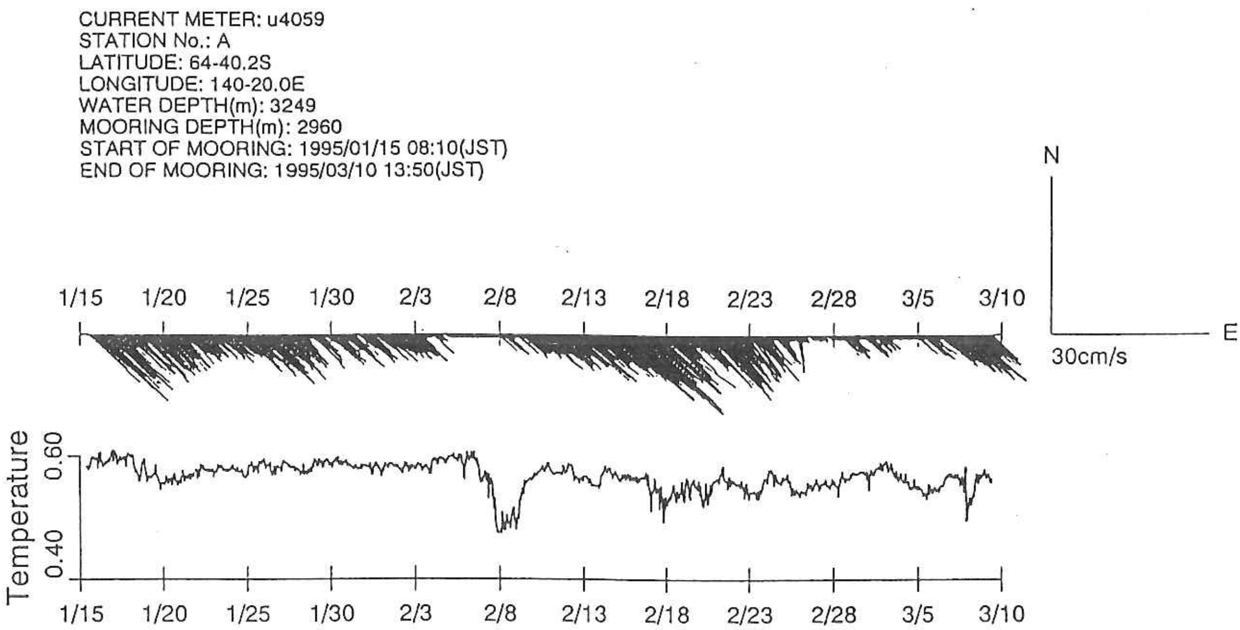

Fig.2 Records of current direction, speed and water temperature obtained from current meter at St.A

Table 1. Dates, locations and sea depths at each station

St.A	14 Jan. 1995	64°40.29S,	140°20.20E	3260m
St.B	17 Jan. 1995	65°00.64S,	142°01.29E	2958m
St.C	17 Jan. 1995	65°09.92S,	139°58.76E	2665m

Description of piston core samples in the Southern Ocean

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[4]Tokyo Metropolitan University

The Southern Ocean plays a key role in the global climate system through the permanent and/or sea-ice cover, air-sea gas exchange, primary productivity of surface water, and global deep-water ventilation through late Quaternary times. The Southern Ocean was strongly influenced by late Quaternary glacial- interglacial processes. Therefore, Tasman Plateau and Antarctic continental margin are an ideal region to study late Quaternary glacial-interglacial cycles because detailed records of the oceanic response to various climatic conditions are usually well documented in marine sediments.

Location of sites

We used basically a 10m-long aluminum pipe sampler with 900 kg weight, however, pipe length was changed depending on sediment type of bottom sea floor. Seven piston cores were collected in the Southern Ocean during KH-94-4 cruise. One piston coring (station PIS-3) which was performed by the 15m-long pipe piston corer, unfortunately failed because of bottom roughness at the Tasman Plateau. The sites are listed in Table 1. Locations of sites are divided into two ocean areas, which are Tasman Plateau region (TSP) and Antarctic Margin region (AMR). Four piston cores, TSP-1PC, -2PC, -3PC and -4PC, were obtained from the Tasman Plateau with deferent water depths. They are composed of nannofossil and foraminiferal ooze with clay. Three core samples, AMR-1PC, -2PC, and -3PC, were recovered from the slope of the Antarctic continental margin with deferent water depths. These sediment are composed of siliceous ooze with terrigenous materials.

Sample process

Sample process of all cores proceeds as follows:

1) Each whole cores were cut into 1m-length, and stored in refrigerator at until shipboard and shorebase measurements.
2) Magnetic susceptibility of each cored samples was measured as a whole core sample by 5 cm intervals using Bartington pass through type magnetic susceptibility system.

3) They were cut into two half-core samples; archive half and working half.
4) For both of them, white and blue pins were marked at 10 and 50 cm intervals, respectively.
5) The archive cores were processed immediately to take a photo, performed visual core description and sliced from a surface of core sediment for soft-X ray radiograph.
6) They were stored in freezer at about -15℃ for prevent of organic material decomposition.
7) Color analysis of the working cores were performed by 5 cm intervals using MINOLTA CR-300 chroma meter.
8) The quantitative samples using cube samplers (2.3x2.3x2.3 cm) were continuously collected in a double line from five working cores (TSP-1PC, TSP-2PC, TSP-4PC, AMR-2PC, and AMR-3PC).
9) The rest sample was cut into segments of 2.3 cm thickness.

These cube and segment samples are intended to analyze for magnetic susceptibility, radioisotopic dating, oxygen and carbon isotope, grain size, micropaleontological assemblage, organic geochemical composition, and so on.

Magnetic susceptibility

Magnetic susceptibility was measured each cube samples of five piston cores using KAPPABRIDGE KLY-2 magnetic susceptibility meter (Fig. 1). The result was represented in SI units, $10^{-6}/10cm^3$. These values fluctuated from 100 to 1900 for AMR-2PC and from 70 to 5000 for AMR-3PC, respectively. These fluctuation of magnetic susceptibility probably reflect the input variation of ice-rafting terrigenous supply from the Antarctica. Magnetic susceptibility of TSP-1PC, -2PC and -4PC ranged from -7 to 5.5, from -8.8 to 29.5, and from -6.7 to 45.7, respectively. It seems that these values indicate carbonate content variation.

Table 1. List of piston core samples.

Station	Core Name	Latitude	Longitude	Water depth (m)	Core Length (cm)	Remarks
PIS-1	AMR-1PC	63° 51.71'S	140° 12.98'E	3714	354.0	Yellowish gray silty clay with sand
PIS-2	AMR-2PC	64° 39.88'S	139° 58.78'E	2965	919.0	Grayish olive siliceous ooze with clay
PIS-3		48° 32.51'S	146° 22.00'E	2948	0.0	
PIS-4	TSP-1PC	47° 34.59'S	147° 28.65'E	1219	768.5	Light gray calcareous ooze
PIS-5	TSP-2PC	48° 08.18'S	146° 52.45'E	2321	713.0	Light gray to white calcareous ooze
PIS-6	AMR-3PC	65° 23.77'S	139° 58.16'E	2474	373.5	Gray silty clay
PIS-7	TSP-3PC	48° 32.93'S	146° 22.46'E	2942	597.5	Light gray to white calcareous ooze
PIS-7'	TSP-4PC	48° 33.03'S	146° 22.47'E	2946	857.5	Light gray to white calcareous ooze

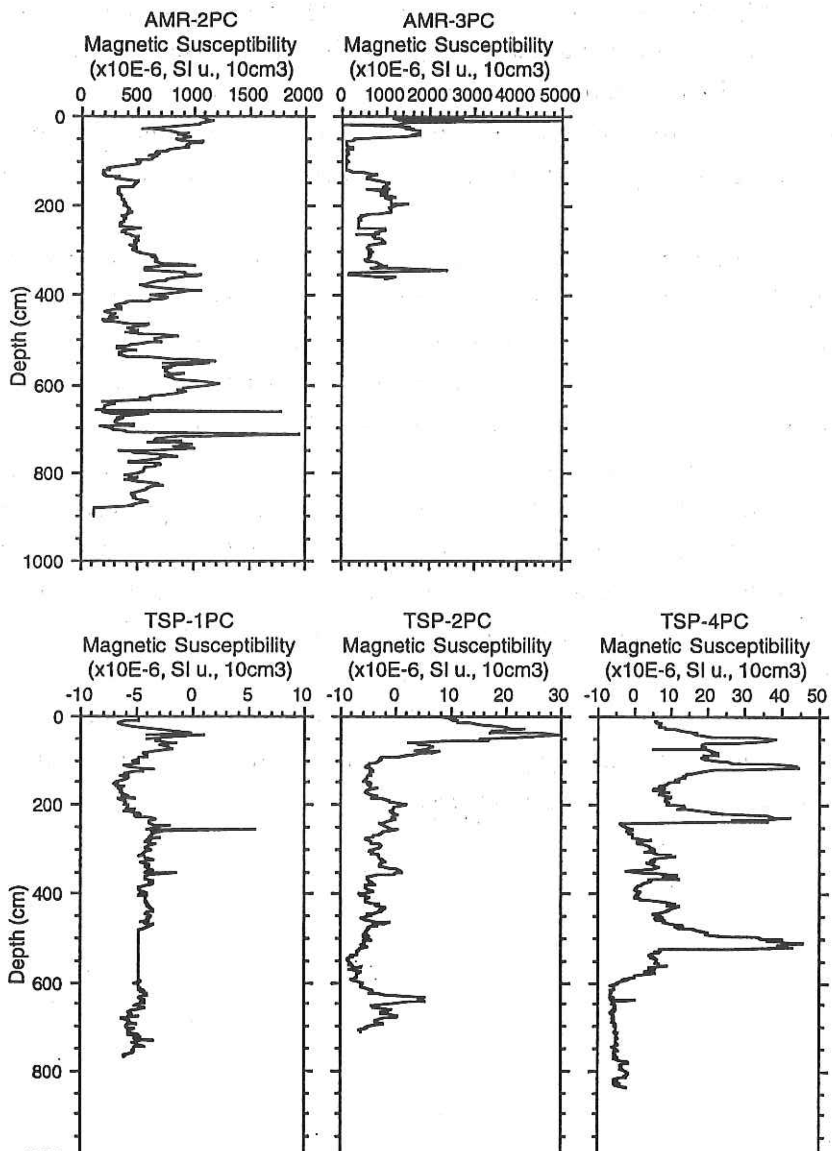

Figure 1. Magnetic susceptibility of piston cores AMR-2PC, AMR-3PC, TSP-1PC, TSP-2PC and TSP-4PC.

Geophysical survey during KH-94-4 research cruise

Kensaku Tamaki, Chiori Tamura and Chiaki Igarashi

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We conducted geophysical survey at parts of eastern margin of the Australia-Antarctica Ridge during Legs 2 and 3 of the research cruise KH-94-4 by R/V Hakuho-maru (Fig. 1). The geophysical survey includes Sea Beam swath mapping, geomagnetic survey, and ship-board gravity measurements. As the principal objective of KH-94-4 cruise was biological research in the Antarctic Sea, limited amount of time (about 24 hours) was allocated for geophysical mapping while transits between Antarctic Sea and Tasmania. Regardless limited survey time, we have succeeded to collect valuable data to show a distinct contrast of the ridge axis topography.

The eastern margin of Australia-Antarctic Ridge dislocates to the south with large scale fracture zones and connects to Pacific-Antarctic Ridge. There are a few very short ridge segments are observed between fracture zones. Fig. 2 shows a 3D topographic view of one of such segment along the Tasmania Fracture Zone. The total length of the ridge segment (SB1) is only 30 km. In contrast Fig. 3 shows topography of ridge axis (SB4) which segment length is about 200 km. The two ridge segments show a contrasting topography regardless their neighboring setting and same spreading rates of 7 cm/yr. Segment SB1 has a clear MAR-type median valley while segment SB4 shows axial rise similar to EPR. As the Australia-Antarctic ridge regionally shows EPR-type axis topography in this area, the topography of Segment SB1 is rather anomalous. The anomalous ridge axis topography is considered to be caused by insufficient magma supply that is further caused by immature development of mantle plume beneath the ridge. The extreme short length of the segments appear to reduce the size of mantle plume. Further study of this area will provide us the opportunity to understand the interaction of mid-ocean ridge and mantle dynamics beneath it.

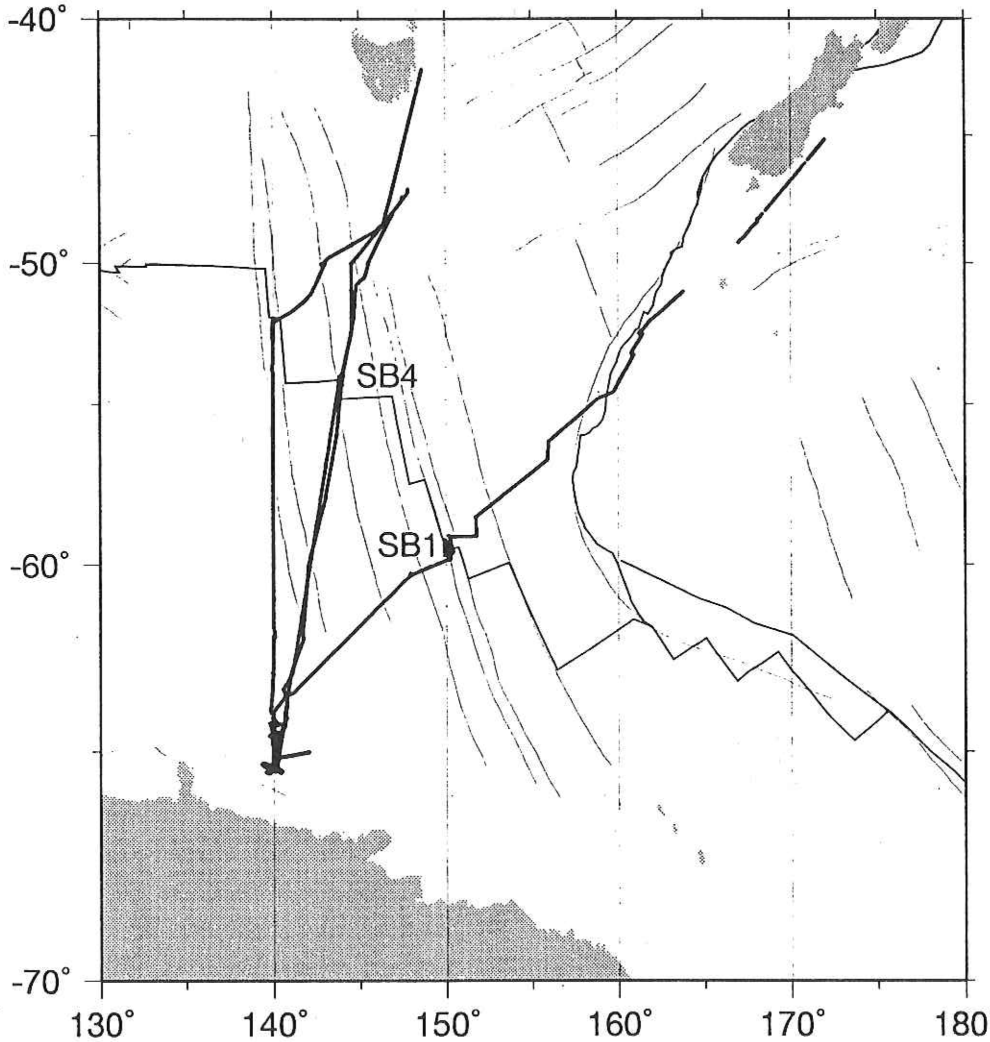

Fig. 1 Geophysical ship's tracks of KH-94-4 cruise

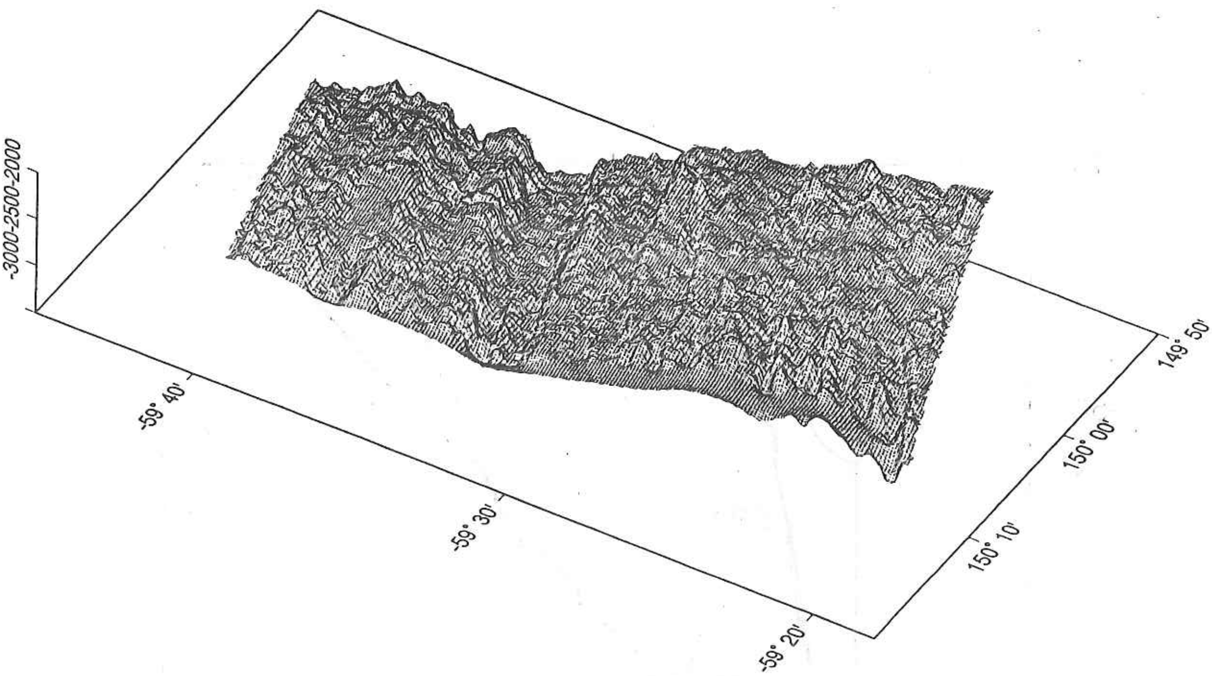

Fig. 2 3D view of ridge axis topography at SB1

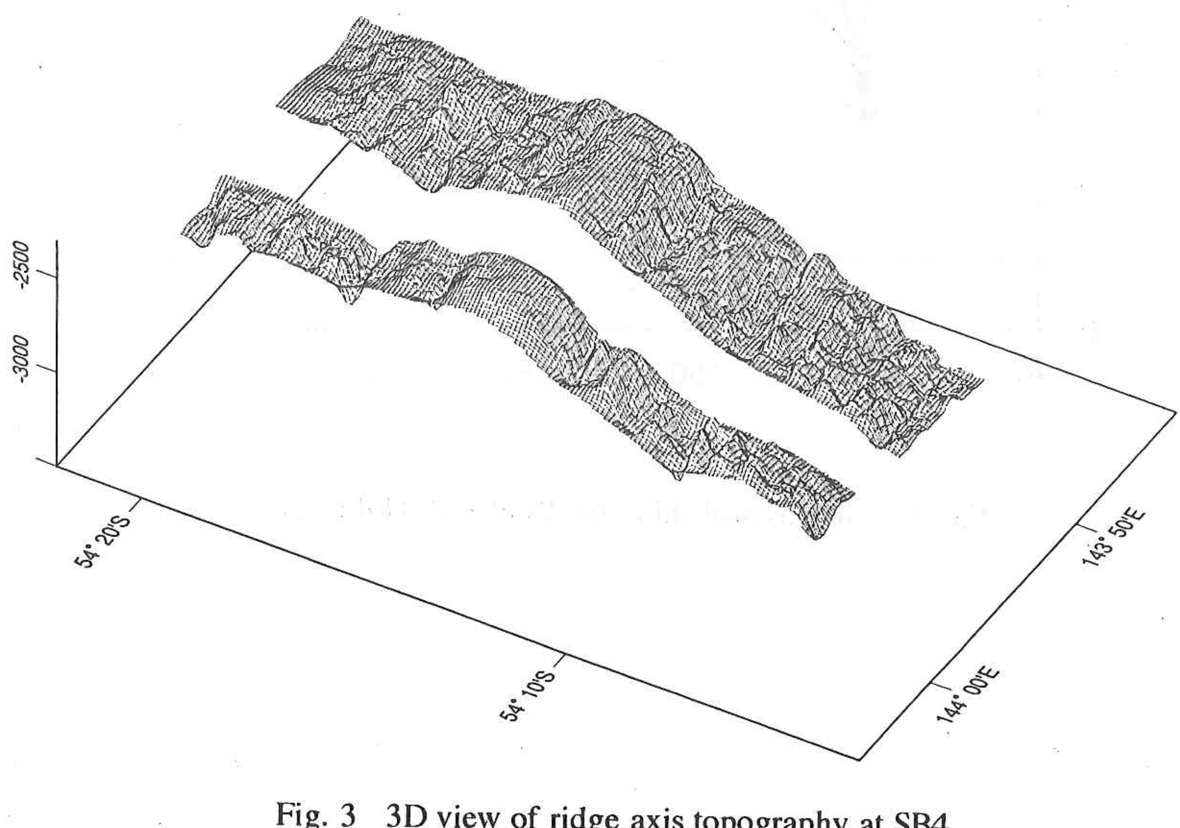

Fig. 3 3D view of ridge axis topography at SB4

Calcareous nannofossils observed in the three piston cores recovered from the Tasman Plateau by KH-94-4 Cruise- A preliminary report

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Calcareous nannoflora was studied for selected samples taken from the three piston cores recovered along a depth transect from the Tasman Plateau. Although this investigation is still in preliminary stage, studied only preservation state and approximate age for the bottom of each section, it is apparent that these are useful cores for the paleoceanographic analysis in the Southern Ocean for the late Quaternary.

The deep-photic calcareous nannoplankton species *Florisphaera profunda* is well known to be the most useful indicator of the Quaternary Paleoceanography (Molfino and McIntyre, 1990; Castradori, 1993; Ahagon et al., 1993; Okada and Matsuoka, in press). Unfortunately, this taxon is totally absent in the studied materials, indicating that the water temperature in the lower-photic zone did not exceed the critical 10℃ level through the late Quaternary (Okada and Wells, in press). Potential for the paleoceanographic reconstruction based upon the analysis of calcareous nannoflora, therefore, will be somewhat limited for the Tasman Plateau area. On the other hand, small to large forms of genus *Gephyrocapsa* occur abundantly in many studied samples. The small form of the genus was recently confirmed to be a good indicator of upwelling (Okada and Matsuoka, in press), and the various morphotypes of the medium to large forms are reported to have restricted geographical distribution controlled by water masses (Bollmann, in press). *Coccolithus pelagicus*, a typical cold water indicator for the late Quaternary sequence, is also abundant in some samples. Therefore, a quantitative investigation of various forms and morphotypes of genus *Gephyrocapsa* and of *C. pelagicus* will enable us to study the paleoceanographic history of the Tasman Plateau area for the late Quaternary. The followings are summaries of this preliminary investigation.

Core TSP-1PC

This is the core recovered from the shallowest site (water depth: 1,219 m), and the preservation of nannofossils is the best among the three cores studied. No obvious effects of dissolution nor recrystallization can be observed, and reworking is minimal. Although the diversity of flora is generally low, warm water taxa such as *Umbellosphaera irregularis* is observed in some samples. These warm elements are likely resided in either the Leeuwin Current or in the East Australian Current. *Emiliania huxleyi* occurs commonly even in the bottom of core (Table 1), and the entire core is correlatable to CN15 nannofossil zone (younger than 0.27 Ma). The change of dominance from medium *Gephyrocapsa* to *E. huxleyi* (0.073 Ma) is likely to occur within the Section 3. Since the recovered core measures 7.7 m in total length, this core is suitable for a high-resolution analysis of the latest Quaternary paleoceanography.

Core TSP-2PC

Calcareous nannofossils are abundant and exhibit a slight dissolution in the most of samples examined for this core which was retrieved from the water depth of 2,310m. In addition, a weak recrystallization is also evident in the samples taken from the lower sections (Table 2). Reworked specimens are generally scarce. Base of CN15 zone, corresponding to the first occurrence of *E. huxleyi* (0.27 Ma), and base of CN14b zone, defined by the last occurrence of *Pseudoemiliania lacunosa* (0.46 Ma), are likely to present within Sections 5 and 8, respectively. Because *Reticulofenestra asanoi* do not occur, the bottom level of this core belongs to the uppermost portion of CN14a zone. Thus it is likely that this core records the history of last 0.5 My. The crude estimation of sedimentation rates are 2.8 cm/kyr and 1.4 cm/kyr for Cores TSP-1PC and TSP-2PC. The slower sedimentation rate for this core may be attributable to a dissolution of carbonate materials or to the presence of hiatuses.

Core TSP-4PC

This core was recovered from the deepest water (2,946 m) among the three studied cores. Ten samples investigated so far yielded abundant calcareous nannofossils, and a slightly advanced dissolution affects the floral composition. Delicately constructed taxa such as *Umbellosphaera* spp. or *Syracosphaera* spp. that are less resistant to dissolution are generally scarce (Table 3). As is the case for the Core TSP-2PC, nannofossils are slightly overgrown in the lower sections. Although moderate level of reworking is evident in some samples, indigenous specimens are easily identifiable from the reworked Miocene and Pliocene taxa. The FA of *E. huxleyi* (0.27 Ma) and the LA of *Pseudoemiliania lacunosa* (0.46 Ma) are likely to locate in Sections 3 and 7, respectively. Bottom of the core is correlatable to CN14a zone, and the absence of larger *Reticulofenestra asanoi* (> 6.5mm) possibly indicates younger than 0.81 Ma. Thus this core is suitable to study a longer paleoceanographic record of the region if no hiatus is detected in the later investigation.

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Table 1. Occurrence of Calcareous Nannofossils in "TSP-1PC" Core

SAMPLE DEPTH (cm) ABUNDANCE - PRESERVATION ETCHING / OVERGROWTH	120.0 A G 0/0	216.5 A G 0/0	306.5 A G 0/0	398.5 A G 0/0	487.5 A G 0/0	586.0 A G 0/0	677.0 A G 0/0	768.5 A G 0/0
Calcidiscus leptoporus	C	C	F	C	F	C	F	F
Calciosolenia murrayi	-	-	-	-	-	-	-	-
Coccolithus pelagicus	C	A	C	C	C	C	C	C
Cruciplacolithus neohelis	-	-	-	-	-	-	R	-
Emiliania huxleyi	A	A	C	C	C	C	C	C
Gephyrocapsa caribbeanica (M)	R	C	-	-	-	-	-	-
Gephyrocapsa oceanica (cold type)	C	C	C	C	C	A	F	-
G. oceanica (transitional type)	A	D	D	D	D	D	D	D
G. oceanica (equatorial type)	-	-	-	F	F	F	-	F
G. oceanica (large type)	R	-	-	-	-	R	-	R
Gephyrocapsa spp. (small)	C	A	A	C	C	C	C	A
Helicosphaera carteri	F	F	F	F	F	F	F	C
Oolithotus fragilis	R	-	R	R	-	-	R	-
Pontosphaera sp.	-	-	-	-	-	-	-	-
Pseudoemiliania lacunosa (elliptical)	-	-	-	-	-	-	-	-
Pseudoemiliania lacunosa (round type)	-	-	-	-	-	-	-	-
Reticulofenestra asanoi (5-6.5um)	-	r	-	-	-	-	-	-
Reticulofenestra minuta	C	F	F	F	-	F	C	C
Reticulofenestra minutula	-	-	C	C	F	F	F	F
Reticulofenestra productus	R	R	-	R	R	-	-	R
Rhabdosphaera clavigera	R	-	-	-	-	-	-	-
Syracosphaera spp. (endothecal)	F	-	R	-	R	-	-	R
Umbellosphaera irregularis	-	-	R	-	-	-	-	-
Umbellosphaera tenuis	-	-	-	-	-	-	-	-
Umbilicosphaera sibogae v. *foliosa*	-	-	-	-	-	-	-	-
Umbilicosphaera sibogae v. *sibogae*	-	-	R	-	R	-	-	-
(Reworked taxa)								
Cyclicargolithus floridanus	-	-	-	-	-	-	-	-
Reticulofenestra gelida	-	-	-	-	-	-	-	-
Reticulofenestra pseudoumbilica	-	-	-	-	-	-	-	-
Sphenolithus abies	-	-	r	-	-	-	-	-
Nannozone (CN-)	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**

Table 2. Occurrence of Calcareous Nannofossils in "TSP-2PC" Core

SAMPLE DEPTH (cm)	23.0	118.5	215.0	313.5	408.5	503.0	600.5	675.5
ABUNDANCE - PRESERVATION	A M	A M	A M	A M	A M	A M	A M	A M
ETCHING / OVERGROWTH	1/0	1/0	1/0	1/0	1/1	1/0	1/1	0/1
Calcidiscus leptoporus	C	F	C	C	C	F	F	F
Calciosolenia murrayi	F	-	-	-	R	-	-	-
Coccolithus pelagicus	R	C	F	F	C	C	F	C
Cruciplacolithus neohelis	-	-	F	-	-	-	-	-
Emiliania huxleyi	D	A	F	F	-	-	-	-
Gephyrocapsa caribbeanica (M)	-	-	F	A	A	A	D	D
Gephyrocapsa oceanica (cold type)	C	A	A	-	-	-	-	C
Gephyrocapsa oceanica (transitional type)	C	A	D	C	A	A	A	A
Gephyrocapsa oceanica (equatorial type)	F	C	F	C	C	C	-	A
Gephyrocapsa oceanica (large type)	R	-	-	F	-	-	-	-
Gephyrocapsa spp. (small)	F	F	F	D	A	D	C	C
Helicosphaera carteri	F	F	F	C	C	F	R	C
Oolithotus fragilis	R	-	R	F	F	-	-	R
Pontosphaera sp.	-	-	-	R	-	-	-	-
Pseudoemiliania lacunosa (elliptical)	-	-	-	-	-	-	R	F
Pseudoemiliania lacunosa (round type)	-	-	-	-	-	-	-	R
Reticulofenestra asanoi (5-6.5um)	-	-	-	-	-	-	-	-
Reticulofenestra minuta	-	F	-	C	A	A	F	C
Reticulofenestra minutula	-	F	C	-	-	C	F	F
Reticulofenestra productus	R	R	-	A	A	A	A	A
Rhabdosphaera clavigera	-	-	-	F	-	-	R	R
Syracosphaera spp. (endothecal)	F	F	F	F	F	R	F	R
Umbellosphaera irregularis	-	-	-	-	-	-	-	-
Umbellosphaera tenuis	-	-	-	-	R	-	-	-
Umbilicosphaera sibogae v. *foliosa*	-	R	-	R	-	-	-	-
Umbilicosphaera sibogae v. *sibogae*	-	-	R	R	-	-	-	-
(Reworked taxa)								
Cyclicargolithus floridanus	-	-	r	-	-	-	-	-
Reticulofenestra gelida	r	-	r	-	-	r	-	r
Reticulofenestra pseudoumbilica	-	-	-	-	-	-	-	-
Sphenolithus abies	-	-	-	-	-	-	-	-
Nannozone (CN-)	**15**	**15**	**15**	**15**	**14b**	**14b**	**14b**	**14a**

Table 3. Occurrence of Calcareous Nannofossils in "TSP-4PC" Core

SAMPLE DEPTH (cm)	75.0	173.0	233.0	269.0	366.0	465.0	562.0	653.0	741.5	838.5
ABUNDANCE - PRESERVATION	A M	A M	A M	A M	A M	A M	A M	A M	A M	A M
ETCHING / OVERGROWTH	1/0	1/0	1/0	1/1	1/1	1/1	0/1	0/1	0/1	0/1
Calcidiscus leptoporus	C	C	F	C	C	A	F	F	F	F
Calciosolenia murrayi	-	-	-	-	-	-	-	-	-	-
Coccolithus pelagicus	C	F	C	C	A	C	C	C	F	F
Cruciplacolithus neohelis	-	-	-	-	-	-	-	-	R	-
Emiliania huxleyi	A	D	C	-	-	-	-	-	-	-
Gephyrocapsa caribbeanica (M)	-	-	C	A	A	A	A	A	A	A
Gephyrocapsa oceanica (cold type)	C	A	-	-	-	-	-	-	-	-
G. oceanica (transitional type)	D	A	D	D	A	A	A	A	A	A
G. oceanica (equatorial type)	-	-	F	C	C	C	C	F	C	C
G. oceanica (large type)	R	R	-	R	C	F	-	-	-	-
Gephyrocapsa spp. (small)	C	C	C	A	D	D	A	A	A	D
Helicosphaera carteri	F	F	-	R	F	F	F	F	F	F
Oolithotus fragilis	-	-	-	-	-	F	F	F	F	R
Pontosphaera sp.	-	-	-	-	-	-	-	-	-	-
Pseudoemiliania lacunosa (elliptical)	-	-	-	-	-	-	F	C	C	A
Pseudoemiliania lacunosa (round type)	r	-	-	-	-	r	r	C	F	F
Reticulofenestra asanoi (5-6.5um)	-	-	-	-	-	-	-	R	R	-
Reticulofenestra minuta	-	-	-	-	-	-	-	-	-	-
Reticulofenestra minutula	-	F	-	-	-	-	C	C	C	F
Reticulofenestra productus	-	-	-	C	C	A	A	A	C	A
Rhabdosphaera clavigera	-	-	-	-	-	-	-	-	-	-
Syracosphaera spp. (endothecal)	-	-	-	-	-	F	-	-	-	R
Umbellosphaera irregularis	-	-	-	-	-	-	-	-	-	-
Umbellosphaera tenuis	-	-	-	-	-	-	-	-	-	-
Umbilicosphaera sibogae v. *foliosa*	-	-	-	-	-	-	-	-	-	-
Umbilicosphaera sibogae v. *sibogae*	-	R	-	-	F	-	-	-	-	-
(Reworked taxa)										
Reticulofenestra gelida	-	-	-	r	-	r	r	f	f	-
Reticulofenestra pseudoumbilica	-	-	-	-	-	-	r	f	-	-
Sphenolithus abies	r	-	-	-	-	-	-	-	-	-
Nannozone (CN-)	**15**	**15**	**15**	**14b**	**14b**	**14b**	**14a**	**14a**	**14a**	**14a**

Distribution and variation of atmospheric CO_2, oceanic CO_2 and total dissolved inorganic carbon in the Southern Ocean

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Introduction

Net CO_2 flux from the sea to the atmosphere is usually estimated on the basis of the bulk method with the equation given as follows :

$$F = E \cdot \Delta pCO_2 = k \cdot S \cdot \Delta pCO_2 = k \cdot S \cdot (pCO_2^{sea} - pCO_2^{air})$$

where F is the net air-sea CO_2 flux, E is the gas transfer coefficient, k is gas transfer piston velocity of CO_2, S is the solubility of CO_2 in seawater, pCO_2^{sea} and pCO_2^{air} are the partial pressure of CO_2 in the air equilibrated with seawater and the atmosphere, respectively. The range of distribution and variation of pCO_2^{sea} in the global ocean ($\approx$ 200 μatm) is much larger than that of pCO_2^{air} ($\approx$ 20 μatm). Therefore, the variability of pCO_2^{sea} is usually responsible for the variability of ΔpCO_2.

Factors which alter the chemical equilibria of carbonate system in seawater, hence pCO_2^{sea}, are :

(1) temperature and salinity,
(2) air-sea CO_2 exchange,
(3) biological activities : photosynthesis, respiration, decomposition of organic matters to CO_2 etc., formation of calcium carbonate shell by calcareous algae and its dissolution,
(4) dilution and concentration of seawater due to precipitation and evaporation, ice-melt and formation of sea-ice in the polar oceans,
(5) mixing of seawaters with different carbonate systems.

In order to clarify the role of the Southern Ocean in the global budget of the air-sea CO_2 flux, we made semi-continuous measurements of the mole fraction of CO_2 (xCO_2) in air equilibrated with surface seawater as well as that in the ocean boundary air during the whole cruise, and calculated pCO_2^{sea} and pCO_2^{sea}. Furthermore, we made semi-continuous measurement of total dissolved inorganic carbon (total DIC) in surface seawater as well as measurements of vertical profiles of total DIC at several hydrographic stations near marginal ice zone in order to describe the complete carbonate system in surface seawater and investigate the factors controlling the distribution and the temporal variation of pCO_2^{sea}.

Observations

CO_2 in marine boundary air and in surface seawater

We made semi-continuous measurements of xCO_2^{air} in marine boundary air and xCO_2^{sea} in surface seawater using an automated CO_2 analyzer. For xCO_2^{air} measurements, a sample of air pumped continuously from the bow of the ship was dried with an electric cooling unit and magnesium perchlorate column, and it was introduced into non-dispersive infrared (NDIR) gas analyzer (BINOS 4. 1, Rosemount Co.). For xCO_2^{sea} measurements, seawater pumped up continuously from the bottom of the ship was introduced into a shower-type eqeuilibrator and its water jacket, where it was equilibrated with air in closed circuit. The seawater-equilibrated air was dried in the same manner as the sample of the atmosphere and introduced into the NDIR gas analyzer. All NDIR output voltages were recorded under the ambient pressure while stopping the air stream temporarily, and they were calibrated twice in 1.5 hour using four CO_2-in-air workng standard gases (290ppm, 340ppm, 372ppm, 422ppm) prepared by Nippon Sanso Co. Values of pCO_2^{air} and pCO_2^{sea} were calculated from xCO_2^{air} and xCO_2^{sea}, respectively, with saturated water vapor pressure taken into account.

SST

The temperature of seawater was monitored at the equilibrator while equilibrating an air with the seawater. The temperature of seawater in the equilibrator is usually a little higher than that in situ due to warming in the inner piping of the ship. In order to correct for the effect of this temperature rise on pCO_2^{sea}, we compared the temperature of seawater at the equilibrator with that at sea surface basically once a day by taking surface seawater with bucket. The temperature differences between the equilibrator and in situ were generally about 0.4°C.

Total DIC in surface seawaters

We made measurements of total DIC in surface seawaters twice every 1.5 hours at the same time with xCO_2^{sea} measurement. Seawater pumped up continuously from the bottom of the ship was introduced into a automated coulometric DIC analysis system which consists of a automated CO_2 extraction unit, CO_2 gas calibration unit, a coulometer (Model 5012, UIC Co.) and a control unit. Suites of sodium carbonate solutions prepared under nitrogen stream with primary standard grade Sodium Carbonate Anhydrous (99.97%, Asahi glass Co.) dried at 600°C for 1 hour and pure water provided by MILLI-Q SP TOC were used to calibrate the system. Cathode and Anode solutions of the coulometer were renewed once every day and the reference seawater prepared in MRI which is traceable to the Certified Reference Material provided by Dr. A. G . Dickson in Scripps Institution of Oceanography was also analyzed during the each run. CO_2-in-air (1%) was introduced into the system once every 4.5 hours in order to monitor the change in the efficiency of the coulometer.

Vertical profiles of total DIC near marginal ice zone

Significant seasonal or more short-term variability of the carbonate system due to sea-ice melt, stratification or vertical mixing, and biological activities is expected in the upper layer of the ocean near marginal ice zone in summner. Vertical profiles of total DIC basically above 500m were obtained at hydrographic stations listed below.

Leg II : stations 11, 13, 14, 20, 22, 25

Leg III : stations 35, 36, 40. 41, 43, 45

Subsamples were drawn from Niskin bottles on rosette sampler into 300 cm^3 borosilicate glass reagent bottles carefully (i.e. , no bubbles, low turbulence) after the bottles has been rinsed twice with approximately one fourth of their volume and overflowed with at least half their volume. Total DIC was analyzed using the automated coulometric system mentioned above.

Preliminary results

Data analyses are in progress at present. An example of the meridional distributions of pCO_2^{sea} and SST during Leg I and Leg II are shown in Figure 1 . In the equatorial region and a part of the Southern Ocean, pCO_2^{sea} showed maxima over 380 μatm, and it showed minimum below 300 μatm at around 40° S . Between the equatorial region and 40° S, pCO_2^{sea} decreased with the poleward decrease of SST. In the south of 40° S, on the other hand, pCO_2^{sea} increased poleward, although spatial variability is very large especially in the region near marginal ice zone (the range is more than 60 μatm) .

Vertical profiles of total DIC at station 22 (62 °02'S, 140°02'E) and station 35 (62°02'S, 141 °42'S) are shown in Figure 2. In and above the dicothermal Antarctic Surface Water (above 200m; temperature minimum is less than -1°C at 75 - 100m), both salinity and total DIC were lower than those below ASW. Normalized total DIC (total DIC normalized at salinity = 34.5psu in order to correct for the dilution of seawater due to ice-melt) were also lower in and above the ASW, which suggests the importance of the biological consumption of DIC in summer. However, normalized total DIC above temperature minimum layer at station 35 observed on 14 January 1995 was 19.9 μmol/kg (in average) higher than that at station 22 observed on 28 December 1994.

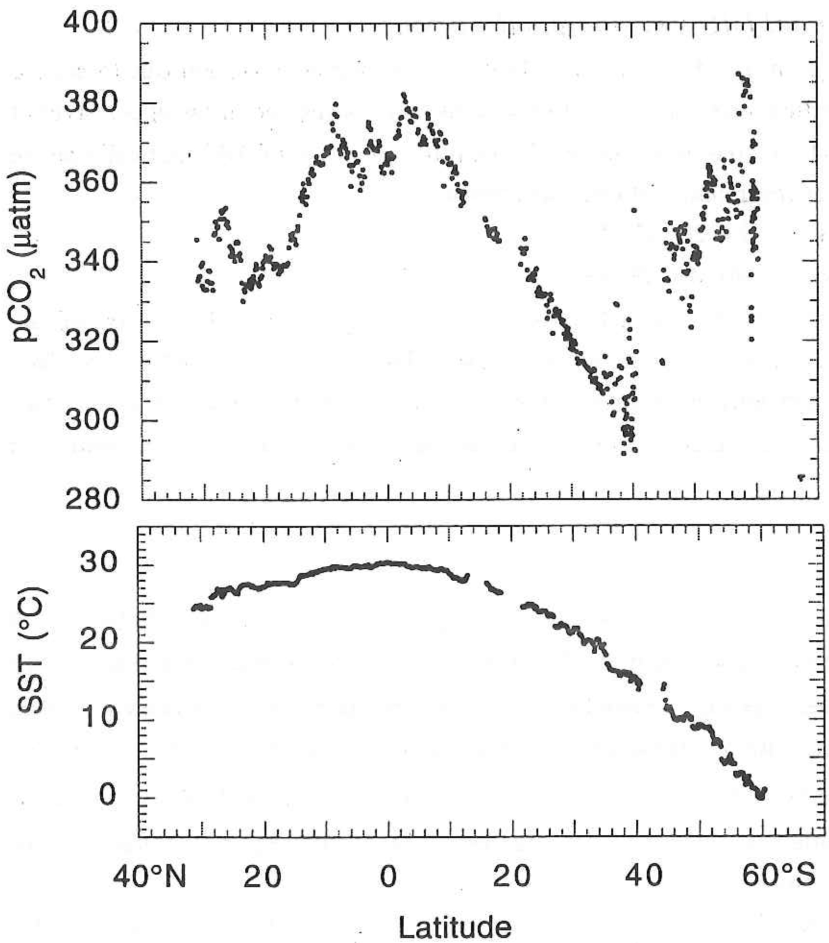

Figure 1. Meridional distributions of pCO_2^{sea} and SST during Leg I and Leg II.

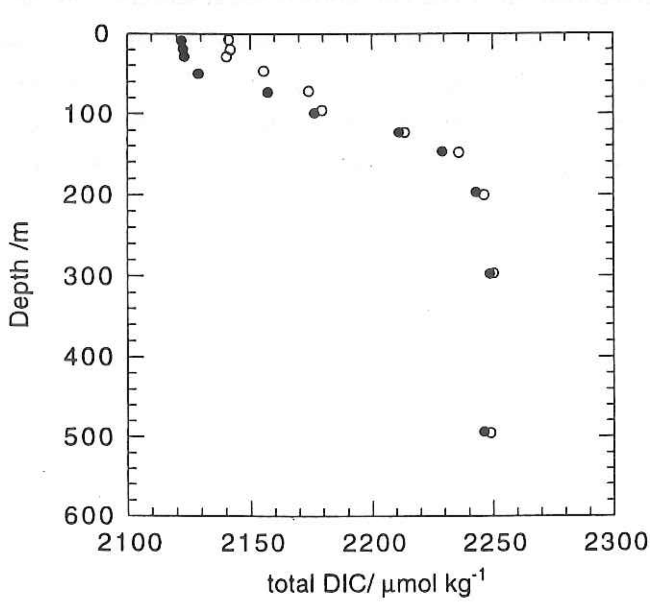

Figure 2. Vertical profiles of total DIC (not normalized) at station 22 (closed circle : 62°02'S, 140°02'E, observed on 28 December 1994) and station 35 (open circle : 62°02'S, 141°42'E, observed on 14 January 1994).

Methane release from Antarctic krills

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Introduction

Methane is well known as green house effect gas. Several reports showed that methane has its maximum at sub-surface layer in the Ocean and biogenic methane production has been suggested to occur in that zone(Ward, 1992; Scranton and Frarrington, 1977). Although methane is produced only by the methanogenic bacteria biologically, they can't live under any traces of oxygen (Whitman and Boone, 1991). Therefore, these bacteria is thought to probably live in the anaerobic micro environment supplied by organic particles or guts of zooplankton (Oremland, 1979; Cyner and Yayanos, 1992). Recently, it is reported that some amount of methane is released by zooplankton - phytoplankton coculture in the laboratory (Angelis and Lee, 1994). Moreover, our data suggested that methane is released by some special species of zooplankton (Sunamura, master thesis). But, there was no data that prove environmental sub-surface methane production. So, in this cruise, we investigated methane profile in the water column and estimated zooplankton methane release through incubation.

Materials and Methods

Methane concentration analysis

Samples were taken by CTD-RMS. Each Niskin sample was introduced into the bial bottle (125ml) using overflow methods and sealed with butyl rubber and aluminum cap. These samples were analyzed within 6hours on board. Dissolved methane was purged with He gas and concentrated in the active carbon column cooled with dry ice - acetone. Concentrated methane was released at 100° C and injected into gas chromatography (GC12A, Shimazu co.). Injector and detector temperature was 120° C, column temperature was 90° C and nitrogen carrier gas flow rate was 40ml / min. using FID detector. The column was used packed column(2m*3mm) filled with active carbon (60/80mesh, GL Science co.).

Methanogenic activity in the zooplankton

For zooplankton culture, 50ml of seawater ,which was autoclaved and removed methane, was added into the 125ml bial bottle. The gas phase and medium was replaced by N2/O2 (v/v) purging. A live collected zooplankton samples were put into bial, and sealed with butyl rubber and aluminum cap. Methane of all samples were analyzed after incubation.

Results and Discussion

Methane profile is shown in Fig.1. In subtropical area at St.5, methane maximum was observed around subsurface chlorophyll maximum (Fig.1-a), but in the Antarctic, there observed no methane maximum through water column. Furthermore, we can observe the difference between the profiles of Leg.2 and Leg.3, i.e. in Leg.2 methane profile are clear but in Leg.3 they fluctuate especially above 100m depth (Fig.1-b,c). This may be affected by zooplankton activities; in Leg.2 sulps were dominant groups, however in Leg.3 krills were dominant. Based on my rearing experiment, anaerobically fermented sulps didn't release methane after one month incubation (data not shown).

Fig.2 shows the release of methane through krills incubation. Fig.2-a is a result at St.5 and Fig2-b is a result at the Antarctic. Although these data dispersed, methane was increased through aerobic incubation. So, krills release methane even in the oxygenic marine environments.

From these data, I try to estimate methane production rate by krills very roughly. The methane production rate of subtropical area at St.5 and Antarctic area is $0.1 nmol*krill^{-1}*day^{-1}$ and $0.05 nmol*krill^{-1}*day^{-1}$, respectively. Angelis and Lee (1994) estimated 4~20$nmol*copepod^{-1}*day^{-1}$ in laboratory copepods and phytoplankton coculture. As their experiments were performed under sufficient feed, cultured copepods and high temperature, their estimation was thought higher than the rate measured in this work. To estimate the environmental methane release by zooplankton, we must make clear about the microbiological system of methane production in the microenvironment such as the guts of zooplankton or feacal pellets.

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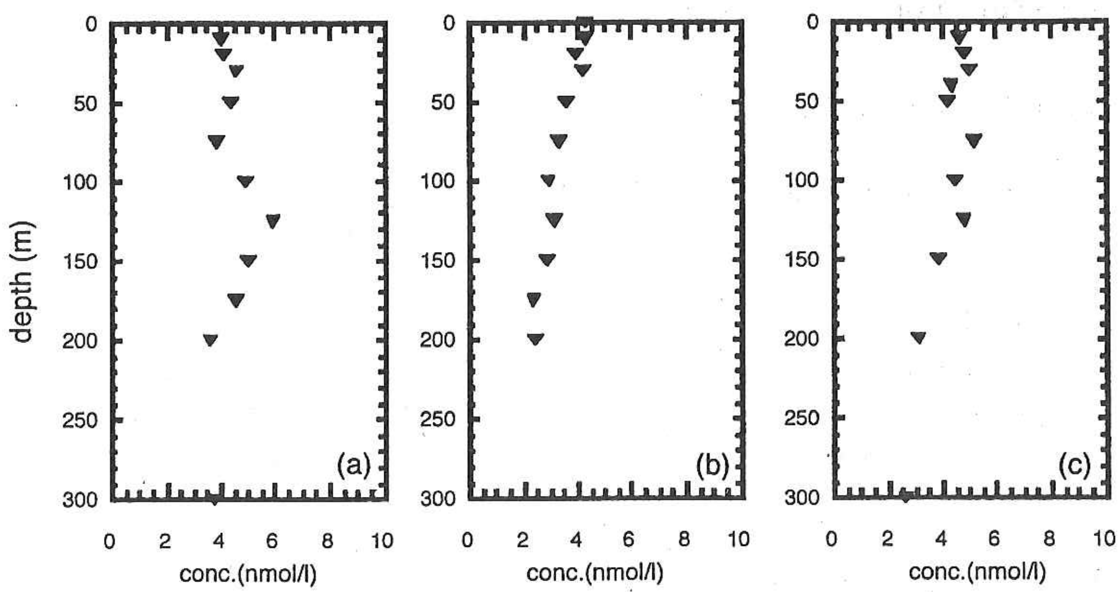

Fig.1 Methane profiles through KH-94-4 cruise. (a) : St.5(Leg 1), (b) : St.12(Leg 2), (c) : St.32 Leg 3). ▼ shows methane concentration in the water column.

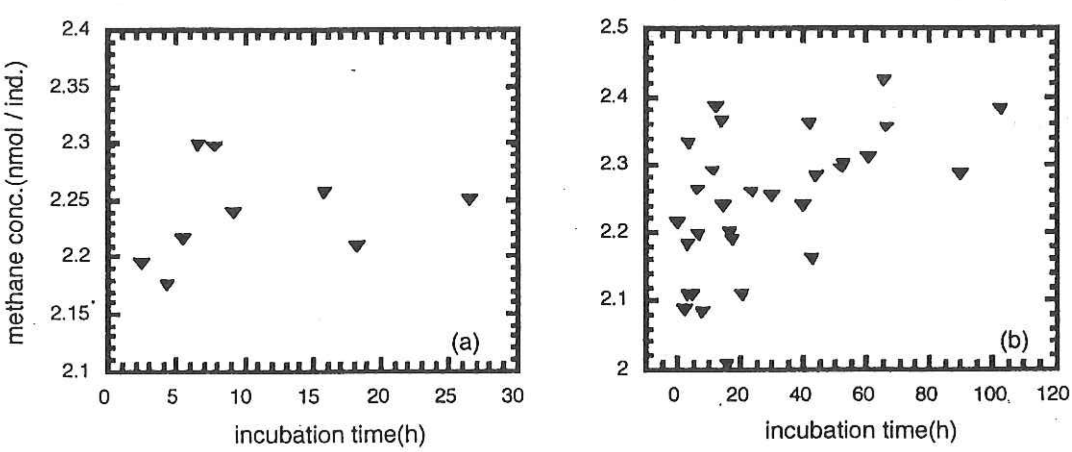

Fig.2 The change of methane concentration through zooplankton incubation. (a) : Subtropical region (St.5), (b) : Antarctic. ▼ shows methane concentration.

Aerosol particle concentration over the West Pacific Ocean and the Antarctic Ocean

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Introduction

Atmospheric aerosol particles give rise to both direct and indirect effects on the climate. The direct effects of atmospheric aerosols on the climate are that aerosols absorb and scatter both solar and infrared radiation. The indirect effects are the influence on the process of cloud formation.

We have measured background aerosol particle concentration aboard the R/V Hakuho-Maru in our seven expeditions (KH-89-T3, KH-89-2, KH-91-5, KH-92-5, KH-93-3, KH-94-1, KH-94-3). We reported the global map of Aitken particles drawn by our three expeditions' data in addition to other workers' data (Miura et al., 1993). In this expedition, we first measured particle concentration over the Antarctic Ocean. We also collected aerosols on filters and on a carbon-covered nitrocellulose film supported on an electron microscopic grid. Moreover, we observed solar radiation and measured atmospheric electrical conductivity and several gases. In this report, we describe the concentration of aerosol particles over the western Pacific Ocean and the Antarctic Ocean.

Methods

Counting of aerosol particles was carried out with two counters on an upper deck, being about 15m above the sea surface and in the direction of 30 degrees left from the front of a funnel. Aitken particle concentrations ($r < 0.1\ \mu m$) were measured with a Pollak condensation nuclei counter. Larger particle concentrations ($r > 0.15, 0.25, 0.5, 1, 2.5\ \mu m$) were measured with an optical particle counter (KC01, Rion Co. Ltd.). We used concentrations larger than 0.15 and 1 μm in radius as those of large and giant particles, respectively.

High concentration of aerosol particles was sometimes caused by the exhaust of ship. To avoid exhaust gases of ship, we omitted the data measured during a calm (relative wind speed was less than 1 m/s) period or a period of blowing from the funnel.

Latitudinal distributions of particle concentrations

Latitudinal distributions of Aitken particle, large particle, and giant particle concentrations measured in legs 1 and 2 and legs 3 and 4 were shown in Figs 1 and 2, respectively. Figure 1 shows that the concentration of Aitken particles decreased as leaving from Tokyo and recorded a minimum value around 10°N (5°-15°N) in latitude. The concentration measured at 0-10°S was somewhat high because the ship passed near islands. High concentrations at 43°S were measured in Lyttelton or Hobart. The concentration over the Antarctic Ocean (south of 64°S) was lower than that in the storm zone (around 50°S) but somewhat higher than that around 10° N.

Figure 2 shows that the concentration in the storm zone in leg 3 was lower than that measured in the same area in leg 2 because the weather in the zone was not as stormy in leg 3 as in leg 2. High concentrations at 33°S were measured in Sydney. The concentrations measured in leg 3 over north of 10°S were similar to those in leg 2.

Concentrations of large and giant particles had similar variations to that of Aitken particles. They were also affected by wind force as mentioned later.

Particle concentrations over the Antarctic Ocean

We measured aerosols over the Antarctic Ocean (south of 64°S) from 19 to 27 December 1994 in leg 2 and from 14 to 21 January 1995 in leg 3. The weather is usually stable in this area. The average, standard deviation and the number of data are listed in Table 1. The average concentrations of Aitken particles, which were 280 and 196 particles/cm^3 in legs 2 and 3, respectively, were lower than the value, 320 particles/cm^3, measured over the western equatorial Pacific Ocean in the KH-92-5 expedition (Miura et al., 1995) but were somewhat higher than that around 10°N. Source of Aitken particles over a land is almost anthropogenic one. But it is difficult to think that the air over this area was transported from the Australian Continent. In the marine boundary layer over remote oceans, the principal constituent of Aitken particles is sulfur-dominant one. Therefore, it is considered that these sulfur-dominant particles are produced by gas-to-particle conversion of organosulfur gases.

Figure 3 shows size distributions of large and giant particles measured over this area in leg 3. They increased as wind force became strong. This relation has been previously reported (e.g., Kojima and Sekikawa, 1974; Miura et al., 1995) but it is first confirmed over the Antarctic Ocean. It suggests that the large and giant particles over the Antarctic Ocean are mainly seasalt particles.

More detailed analysis will be done by comparing with the other elements.

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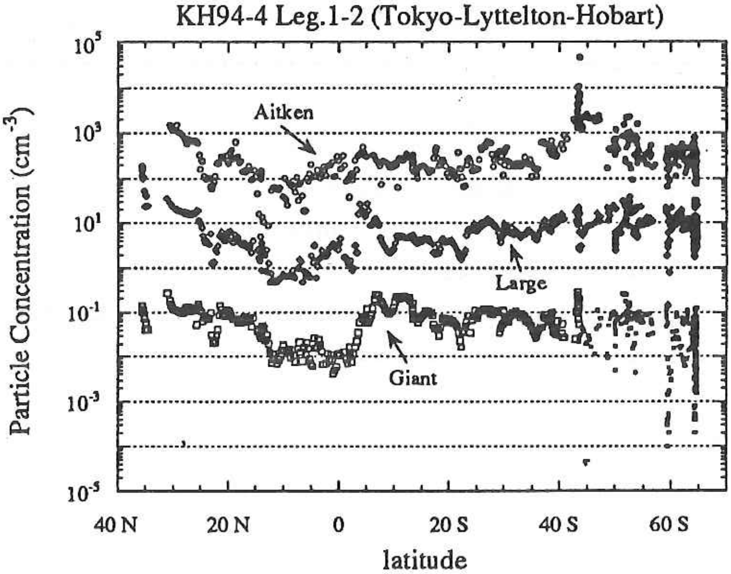

Fig. 1 The variations of concentrations of Aitken particles, large particles, and giant particles measured in Legs 1 and 2 from Tokyo to Hobart via Lyttelton and the Antarctic Ocean

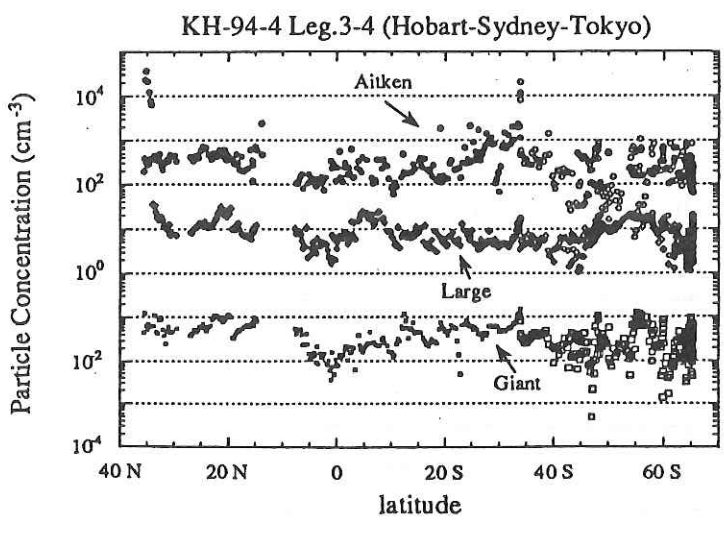

Fig. 2 The same as Fig. 1, but for Legs 3 and 4 from Hobart to Tokyo via the Antarctic Ocean and Sydney

Table 1 Aerosol concentration (cm^{-3}) over the Antarcitc Ocean (> 64S)

	Aitken		large		giant	
	Leg 2	Leg 3	Leg 2	Leg 3	Leg 2	Leg 3
average value	280	196	7.535	6.119	0.021	0.035
standard deviation	133	79	5.199	4.444	0.023	0.020
number of data	97	78	103	84	103	84

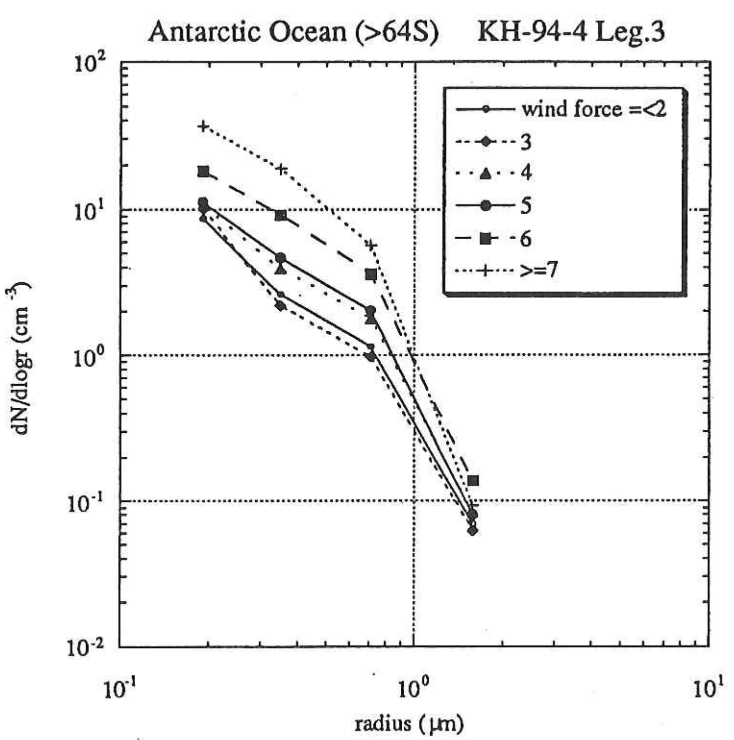

Fig. 3 The relation between size distribution of large and giant particles and wind force

A preliminary result of organic geochemical study on the marine aerosols collected from western North Pacific to Southern Oceans

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Introduction

Remote marine aerosols from the North Pacific have been studied for lipid class compounds using a gas chromatography and mass spectrometry (Peltzer and Gagosian, 1989). The molecular distributions of lipids in the marine aerosols collected at Enewetak Atoll, Marshall Islands (11° 20'N, 162° 20'E) have shown a strong signature of continentally derived organic materials, which generally contain longer carbon chain length (≥C20). They are long range transported over the Pacific Ocean. Their atmospheric concentrations also increased in spring as a result of atmospheric transport of Asian soil dusts and decreased toward summer. Continentally derived lipids have been abundantly detected in the deep sea sediments of the North Pacific (Kawamura, 1995), suggesting that they are significantly deposited in the deep sea ocean floors. In contrast, marine derived organic matter which are emitted to the atmosphere through sea/air exchange are generally characterized by shorter carbon chain length (< C20), also contribute to the remote marine aerosols. Thus, chain length distributions of lipid class compounds have been used as useful tracers to evaluate the contributions of continental and marine sources to the aerosol particles in the remote marine atmosphere (Peltzer and Gagosian, 1989; Kawamura, 1995).

Recently, detailed analyses of water soluble fraction of organic aerosols have been conducted in the marine aerosol samples from North Pacific (Kawamura and Usukura, 1993). The results showed that oxalic (C2), malonic (C3) and succinic (C4) acids are major constituents of the organic aerosols. These small diacids have been considered as photochemical oxidation products of anthropogenic and natural organic compounds. The low molecular weight dicarboxylic acids (C2-C10) were found to contribute up to 2% of total aerosol masses and account for up to 16% of total aerosol carbon in the marine atmosphere. These studies indicated that both natural and anthropogenic organic materials are subjected to a significant photochemical transformation and oxalic acid and other water soluble organic molecules are consequently produced in the remote marine atmosphere. Photochemical transformation of marine aerosols should enhance water solubility of the organic aerosols and may play an important role in the formation of cloud condensation nuclei, which participates in the cloud formation and controls radiation balance of the Earth surfaces (Novakov and Penner, 1993).

The enhanced cloud activity may compensate the potential global warming caused by the increased concentrations of greenhouse gases such as carbon dioxide.

Southern Oceans are surrounded by less continents, being different from the Northern Hemisphere. Thus, the atmospheric aerosol compositions of the Southern Hemisphere may be less influenced from continental sources, but, may be relatively more affected from marine biological sources. However, there is very few studies on organic chemical composition of the remote marine aerosols from the Southern Oceans. In order to conduct organic geochemical studies of remote marine aerosols from Antarctic Ocean, we collected numbers of marine aerosol samples over the western North Pacific to Southern Oceans during the R/V Hakuho-Maru cruise (KH-94-4). In this report, we present a preliminary result on spatial distributions of total carbon, nitrogen and sulfur contents in the marine aerosol samples as well as n-alkanes, n-alcohols, and fatty acids. Although we have not completed the chemical analyses of the samples, we describe here the types of atmospheric, seawater and sediment samples which were collected during the KH-94-4 Antarctic Expedition.

Samples and Methods

Samples collection

Marine aerosol samples (n=28) were collected during R/V Hakuho-Maru cruise (KH-94-4; 22 November, 1994 to 14 February, 1995) using a pre-combusted (450° C, 3 hours) quartz fiber filter (Pallflex, 25 x 20 cm) and high volume air sampler (Shibata HVC-1000) with a flow rate of 1 m^3/min. The air sampler was operated on the upper deck of the ship under a control of the wind sector ($\pm 60°$) and wind speed ($\geq$ 5 m/sec) system to avoid potential contamination from the ship exhausts. The cruise trucks are shown in Fig. 1a-1d. Filter samples were stored in a pre-cleaned glass jar (150 ml) with a Teflon-lined screw cap at -20° C prior to analysis.

High volume impactor sampler (Kimoto 131S) was also operated on the ship to collect fine (smaller than 2μm) and coarse (larger than 2μm) particles using quartz fiber filters. For the collection of volatile organic acids such as formic and acetic acids in the atmosphere, a low volume air sampler was operated with a KOH impregnated quartz filter (Kawamura and Kaplan, 1985). The filter samples (n=25) were stored in a pre-cleaned glass vial (50 ml) at -20 °C.

Rainwater samples (n=6) were collected using a stainless steel rain collector. The rain samples (400-800 ml) were stored at 4° C in a gallon bottle, to which small amount of $HgCl_2$ (ca. 10 mg) was added as bactericide.

Seawater samples were also collected at several sites and were extracted in the laboratory of the ship using organic solvent mixture of methylene chloride and ethyl acetate (2:1). The solvent extracts were stored in a brown glass bottle (500 ml) with a Teflon-lined screw cap at -20° C.

Multiple corer was employed for the collection of surface core sediments, which were cut every 1 cm in the ship laboratory. Each section was stored in a 50 ml glass vial at -20° C.

Analytical procedures

Small portion of filter samples (ca. 15 cm^2) were subjected to a CHNS elemental analyzer (Carlo Erba EA 1108) to measure total carbon, nitrogen and sulfur contents.

Aliquots of aerosol filter samples were extracted with KOH/methanol under a reflux. The extracts were divided into neutral and acidic fractions and further isolated to individual compound classes (Kawamura et al., 1995). Normal alkanes, alcohols and fatty acids were determined using a capillary gas chromatograph (GC) and GC/mass spectrometer, after appropriate derivatization if required.

Results and Discussion

Aerosol mass concentration

Table 1 describes the quartz filter samples collected and presents the aerosol mass concentrations. The aerosol mass concentrations ranged from 16 to 192 μgm^{-3}. These values are comparable to or less than those reported in the continental aerosols collected from Tokyo (54-220 μgm^{-3}, av. 107 μ gm^{-3}; Kawamura et al., 1995). Higher concentrations were observed for the marine aerosol samples collected under meteorological conditions with strong winds around 50°S, suggesting that sea salt spray significantly contribute to the marine aerosol concentrations.

Carbon, Nitrogen and Sulfur

Total aerosol carbon, nitrogen and sulfur concentrations are summarized in Table 2, together with their relative abundances in the aerosol masses, and C/N and S/C weight ratios. Total aerosol carbon contents ranged from 0.03 to 4.7 μgm^{-3} with an average of 0.44 μgm^{-3}. Except for QFF 663 and 672 samples which showed relatively high values (2-4 μgm^{-3}), total carbon contents are less than 0.7 μgm^{-3}. These values are extremely low compared to those of continental aerosols from urban Tokyo (12-44 μgm^{-3}, av. 22 μgm^{-3}) and mountain area (4-5 μgm^{-3}) of Japan (Kawamura et al., 1995). However, when air samples were collected near the New Zealand Islands (QFF 663) and Tasmania Island (QFF 672), the carbon contents were recorded as high as continental aerosols, suggesting that continentally derived materials are important source of the coastal marine aerosols. Although the aerosol carbon concentrations seem to be lower in Antarctic Ocean and South Pacific than North Pacific (see Table 2 and Fig. 1), the remote marine aerosols from the Southern Oceans may be significantly influenced from the continental aerosols, as suggested from the lipid analyses.

Total aerosol nitrogen showed a concentration range of 0.03 - 0.57 μgm^{-3} with an average of 0.1 $\mu g/m^3$. These values are much lower than those of continental data from Tokyo (1-21 μgm^{-3}, av. 5 μgm^{-3}, Kawamura et al., 1995). They are generally lower in the Southern Oceans than other ocean sites. Although most of the samples showed that nitrogen contents are less than those of carbon, some aerosol samples showed that nitrogen contents are at the similar level with the carbon contents or even higher than the carbon (e.g., QFF 683, 688). It is of interest to note that the samples collected near the islands showed higher C/N ratios such as 8 and 21 (see QFF 663, 672, Table 2). Such high values are similar to those of land derived organic matter which generally shows C/N ratios of ca. 20 whereas marine derived organic materials give lower C/N ratios of 6-7. These results again support that the marine aerosols are influenced from continental organic materials.

There are no reported data of aerosol total sulfur together with aerosol carbon contents. This study reports, for the first time, such data sets in the marine atmosphere. Interestingly, sulfur contents are generally more abundant than the carbon contents. This suggests that non-sea salt sulfate significantly contribute the total sulfur, although sulfate is not measured yet. The sulfate is most likely produced by the photochemical oxidation of dimethyl sulfide (DMS), which is of phytoplankton origin and abundantly emitted from seawater to the atmosphere (Saltzman et al., 1986; Koga et al., 1991). The highest sulfur content was recorded in the aerosol sample collected in 65°S, suggesting that sea-to-air emission of DMS is enhanced in the Antarctic Ocean probably due to high biological productivity. In contrast, sulfur contents are not high in the aerosol samples collected near the islands (QFF 663, QFF 672), which were significantly influenced from the continental organic materials.

n-Alkanes

A homologous series of normal alkanes (C15-C35) were detected in the remote marine aerosol samples collected from North Pacific to Southern Oceans. Figure 2 gives a typical capillary gas chromatograph of n-alkane fraction isolated from the marine aerosols (QFF 677). Their molecular distribution generally shows an odd carbon number predominance with a maximum at n-C31 or n-C29. These features are characteristic of terrestrial higher plant waxes and suggest that continentally derived organic materials are long range atmospheric transported over the North Pacific and South Pacific Oceans and even to the Antarctic Ocean. Table 3 gives individual n-alkane concentrations in the marine aerosol samples studied and their carbon preference index (CPI: ratios of even carbon numbered n-alkanes over odd carbon numbered n-alkanes). Generally, n-alkane concentrations are higher near the continents and lower in the remote site (Fig. 3), being consistent with the idea that n-alkanes are of higher plant origin. Highest n-alkane concentration was observed in the QFF 663 sample, which was collected near the New. Zealand Islands (see Fig. 1a) whereas lowest concentration was observed in the QFF681 sample collected in the Antarctic Ocean of 52° -63° S (see Table 3, Fig. 1c and Fig. 3).

However, even carbon numbered n-alkanes were sometimes abundantly detected in the aerosol samples in a range of C20-C26 (see Fig. 2). These alkanes with no even/odd predominance are of anthropogenic origin and are mainly derived from petroleum residues and their combustion processes (Kawamura and Kaplan, 1991). It is interesting to note that in the Antarctic Ocean molecular distributions of n-alkanes (C20-C35) are characterized by higher CPI ratios (2.2-4.3) than those (1.3-2.0) in the North Pacific regions (Table 3). These results indicate that the marine aerosols from the Antarctic Oceans are influenced from continental natural organic materials rather than continental polluted air. Long range atmospheric transport of terrestrial higher plant waxes seems to be important in the Southern Oceans.

Fatty alcohols

Normal alcohols and sterols were detected in the marine aerosols as shown in Fig. 4 (QFF 688). Molecular distributions of n-alcohols show a strong even carbon number predominance with a maximum at C18, C16 or C26. Concentrations of n-alcohols and sterols are presented in Table 4. The marine aerosols collected near continents (QFF 663 and QFF 672) showed very high concentrations of C20-C30 n-alcohols whereas those of the Antarctic Oceans showed lower concentrations (Fig. 5). These results are consistent with a general knowledge that lower carbon numbered alcohols (C12-C19) are present in both marine and terrestrial organisms whereas n-alcohols with C20-C30 carbon chain length are characteristic of terrestrial higher plant waxes (Simoneit et al., 1977). Although the C20-C30 n-alcohols are less abundant in the deep south of South Pacific, this study clearly showed that continental organic materials of higher plant origin are long range transported to the Antarctic Ocean through the atmosphere.

Cholesterol (C27) is present in marine algae whereas stigmasterol and ß-sitosterol with C29 are more characteristic of higher plants (Tissot and Welte, 1984). The C29 sterols were abundantly detected in the aerosols collected near the continents (QFF 663, QFF 672, see Table 4), being consistent with the results of n-alcohols. ß-Sitosterol is also found in the remote marine aerosols of the Antarctic Ocean (Table 4), suggesting a long range atmospheric transport of terrestrial organic matter to the deep south.

Fatty acids

A homologous series of n-fatty acids were detected in the remote marine aerosols, as shown in Fig. 6 (QFF 688). Their molecular distributions are characterized by a predominance of C14, C16 and C18 acids, with a maximum at C16. The even carbon numbered predominance was observed in a whole range (C8-C34) of fatty acids, except for the relatively abundant presence of C9 acid. The C9 acid has been detected in the marine aerosols from North Pacific as a relatively abundant species, which is produced as a result of photochemical oxidation of unsaturated fatty acid such as oleic acid (C18:1) containing a double bound at C-9 position (Kawamura and Gagosian, 1987). The lower molecular weight fatty acids (C12-C19) are general constituents of organisms including marine and terrestrial plants whereas higher molecular weight fatty acid (C20-C34) are characteristic of continental higher plant waxes and present in soil organic matter (Kawamura, 1995). As shown in Fig. 7, higher concentrations of C20-C34 fatty acids were found in the marine atmosphere near the Asian continents, New Zealand and Australia, indicating that the higher fatty acids are of continental origin and are long range transported to the remote marine atmosphere.

In the Antarctic Ocean, the terrestrial fatty acids (C20-C34) are less abundant (Fig. 7). However, they are present in all the aerosol samples collected near the Antarctica, suggesting that continent-derived organic materials are atmospheric transported over the Antarctic Ocean and the Antarctica. They may be scavenged by dry deposition and snow fall from the atmosphere. In the Antarctic Ocean areas, they should be transported to the deep sea through the water column and settled down in the sediments. Alternatively, they are preserved in the Antarctic ice sheet when the marine aerosols are transported over the Antarctica and scavenged from the atmosphere by dry and/or wet (snow) deposition processes.

Summary

Organic geochemical analyses of the remote marine aerosols collected from the North Pacific to Southern Oceans showed a homologous series of n-alkanes, n-alcohols and fatty acids. Their molecular distributions suggested that both marine and continental organic materials are transported to the remote marine atmosphere. Continentally derived organic materials were abundantly detected in the aerosols collected near continents. However, they are always present over the Antarctic Ocean, suggesting that land-derived organic materials are long range transported to the deep south of the South Pacific. The land-derived organic compounds are likely removed from the atmosphere by dry/wet processes in the Southern Ocean. Some lipids may be transported to the deep sea floor and incorporated in the deep sea sediments. Others may be scavenged over the Antarctic ice sheet and stored for a long time of period.

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Table 1. Description of quartz fiber aerosol samples (QFF) collected from western North Pacific to Southern Oceans (KH94-4).

QFF No.	Date/Time (JST) Start	Latitude Start	Longitude Start	Date/Time (JST) STOP	Latitude Stop	Longitude Stop	Air vol.(m3)	Leg	Comments	Aerosol mass (ug)	Aerosol conc.(ug/m3)
655	1994/11/22 22:24	34°05.42'N	140°17.44'E	1994/11/25 8:00	21°10.01'N	149°20.94E	2424	1		126200	52.1
656	1994/11/25 8:00	21°10.01'N	149°20.94'E					1	Blank		
657	1994/11/25 8:56	20°57.33'N	149°29.53'E	1994/11/27 9:16	10°12.28'N	150°50.01'E	2856	1		64600	22.6
658	1994/11/27 10:13	9°57.27'N	150°50.02'E	1994/11/29 9:50	1°03.02'S	152°42.11'E	2855	1		52800	18.5
659	1994/11/29 10:14	1°09.66'S	152°42.16'E	1994/12/1 9:10	12°45.10'S	156°26.50'E	3306	1		89000	26.9
660	1994/12/1 11:15	13°08.55'S	156°49.09'E	1994/12/3 10:54	22°09.50'S	160°27.92'E	3098	1		133800	43.2
661	1994/12/3 11:23	22°16.92'S	160°30.24'E	1994/12/5 11:00	32°42.82'S	164°04.82'E	3409	1		655500	192.3
662	1994/12/5 12:05	32°58.71'S	164°11.23'E	1994/12/7 10:30	40°06.21'S	172°23.10'E	3188	1		102700	32.2
663	1994/12/7 11:10	40°08.73'S	172°33.35'E	1994/12/9 4:00	43°34.55'S	172°50.19'E	1370	1		107200	78.3
664	1994/12/13 14:08	44°05.85'S	173°18.01'E	1994/12/16 7:50	55°08.41'S	158°10.00'E	4248	2	Break		
665	1994/12/13 10:30	43°36.33'S	172°46.69'E					2	Break		
666	1994/12/16 8:40	55°16.13'S	157°54.20'E	1994/12/17 12:00	59°31.66'S	150°21.86'E		2	Break		
667	1994/12/17 12:20	59°31.66'S	150°21.86'E	1994/12/19 12:00	63°51.01'S	140°14.68'E	1800	2	Break		
668	1994/12/19 12:30	63°51.00'S	140°14.69'E	1994/12/23 22:00	64°19.69'S	139°58.75'E	3457	2		272900	78.9
669	1994/12/23 22:10	64°19.71'S	139°59.06'E	1994/12/27 5:50	64°20.18'S	140°00.19'E	3350	2		113400	33.9
670	1994/12/27 6:00	64°19.90'S	140°00.45'E	1994/12/29 3:30	60°00.00'S	139°59.95'E	2284	2		156900	68.7
671	1994/12/29 4:00	59°44.88'S	139°59.97'E	1995/1/1 22:40	48°33.27'S	146°24.29'E	3088	2		304700	98.7
672	1995/1/1 23:05	48°33.52'S	146°23.58'E	1995/1/4 6:30	42°50.00'S	147°19.00'E	2615	2		107900	41.3
673	1995/1/9 12:00	42°52.95'S	147°20.16'E					3	Blank		
674	1995/1/9 13:35	43°11.18'S	147°30.07'E	1995/1/11 11:45	51°10.19'S	144°45.61'E	3030	3		198300	65.4
675	1995/1/11 11:45	51°10.19'S	144°45.61'E	1995/1/13 21:50	60°03.49'S	141°59.03'E	2927	3		322200	110.1
676	1995/1/13 21:55	60°03.50'S	141°59.00'E	1995/1/16 10:10	64°10.28'S	140°42.77'E	2826	3		63100	22.3
677	1995/1/16 10:50	64°10.10'S	140°43.08'E	1995/1/18 21:00	65°29.58'S	139°38.82'E	2748	3		217600	79.2
678	1995/1/18 22:00	65°30.62'S	139°42.07'E	1995/1/20 14:10	65°27.44'S	139°48.94'E	1726	3		60800	35.2
680	1995/1/20 14:17	65°27.45'S	139°48.92'E	1995/1/22 11:00	63°24.90'S	140°31.63'E	2003	3		260700	130.2
681	1995/1/22 11:30	63°24.69'S	140°32.73'E	1995/1/24 13:10	52°04.40'S	144°31.12'E	3277	3		548300	167.3
682	1995/1/24 13:40	51°58.14'S	144°30.73'E	1995/1/26 11:30	43°14.19'S	148°19.17'E	1783	3		119300	66.9
683	1995/1/26 11:40	43°10.35'S	148°20.51'E	1995/1/28 0:50	33°51.82'S	151°11.07'E	2643	3		59200	22.4
684	1995/1/31 15:30	33°51.82'S	151°11.07'E					4	Blank		
685	1995/2/1 16:24	33°17.59'S	152°11.83'E	1995/2/3 10:24	24°33.90'S	156°43.95'E	2692	4		75100	27.9
686	1995/2/3 10:34	24°31.53'S	156°43.63'E	1995/2/5 10:32	11°09.31'S	154°36.38'E	3512	4		81300	23.2
687	1995/2/5 12:01	11°01.09'S	154°35.18'E	1995/2/7 11:19	0°44.68'N	150°09.88'E	3296	4		55000	16.7
688	1995/2/7 12:37	0°48.77'N	150°07.04'E	1995/2/9 12:28	11°46.08'N	143°53.94'E	3348	4		101500	30.3
689	1995/2/9 12:49	11°50.43'N	143°50.90'E	1995/2/11 12:30	22°44.18'N	140°54.13'E	3433	4		182400	53.1
690	1995/2/11 13:12	22°49.95'N	140°53.71'E	1995/2/13 5:18	33°24.07'N	140°01.05'E	1618	4		97500	60.2

Break: Filter was broken due to strong winds.

Table 2. Concentrations of total carbon, nitrogen and sulfur in the marine aerosols collected from western North Pacific to Southern Oceans (KH94-4).

	Concentraions (μg/m3)				% of Aerosol Mass			Ratios	
Sample ID	C	N	S	Aero.(μg/m3)	C	N	S	C/N	S/C
QFF655	0.74	0.17	0.86	52.1	1.42	0.32	1.65	4.4	1.2
QFF657	0.15	0.03	0.15	22.6	0.67	0.13	0.66	5.4	1.0
QFF658	0.11	0.04	bdl	18.5	0.59	0.22	bdl	2.6	
QFF659	0.47	0.30	0.47	26.9	1.74	1.10	1.75	1.6	1.0
QFF660	0.09	0.10	0.37	43.2	0.22	0.24	0.87	0.9	4.0
QFF661	0.18	0.13	1.42	192.3	0.09	0.07	0.74	1.3	8.0
QFF662	0.20	0.08	0.84	32.2	0.62	0.24	2.60	2.5	4.2
QFF663	4.79	0.57	0.61	78.3	6.13	0.72	0.77	8.5	0.1
QFF668	0.22	0.03	0.45	78.9	0.28	0.04	0.57	6.8	2.0
QFF669	0.25	0.08	0.41	33.9	0.73	0.24	1.22	3.0	1.7
QFF670	0.10	0.03	0.29	68.7	0.14	0.04	0.42	3.8	3.0
QFF671	0.18	0.02	0.52	98.7	0.18	0.02	0.53	8.2	2.9
QFF672	2.66	0.13	0.47	41.3	6.44	0.31	1.14	21.0	0.2
QFF674	0.38	0.13	0.65	65.4	0.58	0.20	0.99	2.9	1.7
QFF675	0.07	0.04	0.60	110.1	0.07	0.04	0.54	1.8	8.3
QFF676	0.08	0.04	0.19	22.3	0.38	0.18	0.85	2.1	2.3
QFF677	0.09	0.05	2.09	79.2	0.11	0.06	2.64	1.9	23.3
QFF678	0.07	0.08	2.17	35.2	0.19	0.23	6.16	0.8	32.6
QFF680	0.06	0.06	0.42	130.2	0.04	0.04	0.32	1.0	7.5
QFF681	0.05	0.03	0.91	167.3	0.03	0.02	0.55	1.6	17.7
QFF682	0.07	0.06	0.45	66.9	0.10	0.10	0.68	1.1	6.7
QFF683	0.08	0.08	0.29	22.4	0.36	0.34	1.30	1.1	3.6
QFF685	0.18	0.12	0.35	27.9	0.64	0.44	1.27	1.4	2.0
QFF686	0.17	0.06	0.26	23.2	0.76	0.24	1.14	3.2	1.5
QFF687	0.18	0.09	0.41	16.7	1.09	0.55	2.45	2.0	2.2
QFF688	0.03	0.04	0.29	30.3	0.10	0.15	0.97	0.7	9.6
QFF689	0.36	0.03	0.67	53.1	0.67	0.06	1.27	11.7	1.9
average	0.44	0.10	0.64	60.7	0.90	0.23	1.31	3.8	5.8

bdl: below detection limit.

Table 3. Concentrations of n-alkanes in the remote marine aerosols collected from western North Pacific to Southern Oceans (KH94-4).

Sample No.	QFF655	QFF657	QFF658	QFF659	QFF660	QFF661	QFF662	QFF663	QFF668	QFF669	QFF670	QFF671	QFF672	QFF674	QFF675	QFF676	QFF677	QFF680	QFF681	QFF682	QFF683	QFF685	QFF686	QFF687
n-Alkanes,pg/m3																								
C15	15.9	4.4	0.0	8.0	3.2	3.6	3.8	23	3.2	3.9	2.4	3.2	0.0	3.7	3.5	3.8	1.7	3.9	1.0	2.2	0.0	5.6	4.0	8.5
C16	8.9	4.8	0.0	6.3	3.5	3.4	3.8	15	4.7	3.4	5.2	130.8	2.0	3.8	3.4	3.7	2.0	3.9	1.2	2.8	2.4	4.5	2.9	5.0
C17	6.9	3.7	0.0	3.5	2.8	3.0	2.9	12	6.1	2.2	3.0	2.8	1.9	3.0	2.8	2.7	1.9	4.3	1.3	2.2	2.2	3.6	2.2	2.3
C18	8.6	3.9	0.0	4.4	3.0	2.9	2.9	12	7.0	2.6	3.8	3.5	3.4	3.2	2.8	2.7	2.0	4.2	1.3	2.2	2.3	3.5	2.1	2.2
C19	8.6	4.0	0.0	3.0	2.7	2.8	2.8	12	5.1	1.9	3.3	3.3	4.5	3.2	2.8	2.5	1.7	4.1	1.2	1.4	2.1	2.8	1.5	1.4
C20	11.4	4.3	3.4	3.5	2.9	3.1	2.6	14	5.9	1.8	4.6	3.9	8.3	4.2	2.2	2.4	1.7	4.1	1.2	1.8	4.0	2.6	1.3	1.4
C21	21.3	4.7	5.6	5.8	3.3	5.0	3.4	91	9.9	4.6	26.1	7.1	24.6	13.3	2.3	4.6	4.4	15.3	1.1	2.0	9.7	4.5	1.8	3.5
C22	39.6	4.3	10.9	11.8	4.8	9.0	7.7	68	20.0	9.7	68.1	12.1	35.0	27.4	2.7	16.5	10.7	31.2	1.8	3.9	21.7	11.5	3.6	8.6
C23	70.4	5.9	14.0	13.8	5.7	13.0	18.7	804	34.7	17.4	70.5	21.7	151.8	53.3	4.4	31.4	13.1	23.8	3.4	4.5	25.7	17.3	4.2	10.9
C24	100.1	6.9	14.2	10.9	6.0	11.8	18.2	383	42.8	24.5	50.1	98.4	102.1	71.6	4.4	29.4	12.4	15.3	4.1	7.7	22.6	15.6	3.9	8.8
C25	161.2	8.4	13.5	8.9	7.3	16.0	60.0	6918	50.6	34.5	32.0	148.9	330.7	142.0	6.2	19.8	11.7	11.3	4.5	8.2	25.7	29.5	8.2	9.9
C26	283.6	12.5	15.6	8.3	8.3	13.0	22.4	437	41.1	25.9	14.6	103.5	113.8	117.3	5.8	10.7	8.9	7.6	4.1	6.8	15.0	22.0	5.9	7.1
C27	449.3	32.3	28.2	20.5	17.2	32.4	83.5	6174	79.8	37.0	23.7	61.3	543.5	150.9	16.6	20.1	20.9	16.2	8.3	14.6	28.5	70.5	17.8	19.0
C28	422.6	60.1	46.4	37.0	26.1	33.9	28.8	480	57.1	16.2	8.4	37.3	100.5	69.7	6.2	6.4	8.3	6.0	3.6	5.9	10.3	21.2	9.3	9.7
C29	717.5	100.4	80.1	84.6	64.0	95.4	164.6	7538	106.4	43.8	24.7	50.7	780.9	154.7	18.4	20.1	23.3	16.9	10.1	17.3	36.7	152.6	34.7	45.9
C30	308.1	88.8	71.8	66.2	49.8	53.1	26.5	371	51.5	15.4	9.1	29.0	44.3	35.4	8.1	8.3	10.3	7.5	4.6	7.4	9.1	20.2	8.0	14.7
C31	501.3	115.8	110.1	133.4	113.6	134.7	205.2	6404	207.7	98.6	57.4	104.2	620.9	123.6	48.5	51.9	58.5	43.6	25.6	43.6	54.6	162.4	58.1	113.2
C32	139.3	51.4	47.3	50.3	31.5	31.8	5.8	162	51.1	19.9	11.3	24.3	24.0	25.8	9.2	9.9	12.0	9.0	5.0	7.7	8.3	20.3	6.2	19.2
C33	166.5	54.0	51.0	68.6	50.2	51.8	61.1	1036	92.7	44.4	23.3	28.3	128.5	51.5	20.9	22.1	25.2	19.0	10.5	15.9	20.4	65.7	34.5	55.7
C34	49.8	24.6	17.6	18.1	6.4	11.9	4.4	42	9.4	3.7	2.4	5.8	3.4	9.8	1.7	1.6	0.0	0.0	0.0	0.0	1.3	4.0	1.7	2.1
C35	68.7	8.8	16.7	14.4	4.9	4.6	3.9	97	11.3	2.9	1.7	13.1	4.9	11.9	0.0	0.0	0.0	0.0	0.0	0.0	1.5	6.8	3.3	3.6
total n-Alkanes	3559.6	604.0	546.2	581.4	417.2	536.2	732.7	31093	898.0	414.0	445.7	893.0	3029.0	1079.5	172.9	270.7	231.0	247.2	93.8	158.1	304.0	646.6	215.2	352.8
CPI(20-35)	1.6	1.3	1.4	1.7	2.0	2.1	5.2	15	2.1	2.4	1.5	1.4	6.0	1.9	2.9	2.0	2.4	1.8	2.6	2.6	2.2	4.3	4.1	3.7
CPI(25-34)	1.7	1.3	1.4	1.8	2.1	2.3	6.5	19	2.6	3.2	3.5	2.0	8.4	2.4	3.6	3.6	3.5	3.5	3.4	3.6	3.8	5.5	4.9	4.6

Table 4. Concentrations of n-alcohols and sterols in the remote marine aerosols collected from western North Pacific to Southern Oceans (KH94-4).

Sample No.	QFF655	QFF657	QFF658	QFF659	QFF660	QFF661	QFF662	QFF663	QFF668	QFF669	QFF670	QFF671	QFF672	QFF674	QFF675	QFF676	QFF677	QFF680	QFF681	QFF682	QFF683	QFF685	QFF686	QFF687
n-Alkanols,pg/m3																								
C12	15.8	4.3	28.8	6.6	3.9	9.4	2.9	66	19.0	11.4	7.5	3.5	42.7	12.4	2.7	6.1	5.7	15.9	3.8	29.3	4.2	5.3	3.1	4.0
C13	22.1	5.9	5.8	13.1	8.1	15.9	3.7	71	14.6	11.2	7.6	5.5	71.2	13.3	1.5	5.1	6.2	15.8	3.7	37.4	11.6	7.2	11.4	8.1
C14	92.8	32.5	36.1	40.2	23.0	19.4	8.9	260	65.3	34.2	40.5	30.1	128.2	28.6	1.7	24.2	25.4	53.2	10.4	33.8	22.7	24.0	28.1	24.9
C15	46.7	18.0	8.9	17.4	12.3	8.9	4.5	142	17.4	12.8	23.8	15.3	237.7	13.1	2.4	9.9	14.4	19.1	8.4	51.3	28.9	16.3	14.3	8.6
C16	179.8	70.2	55.0	61.4	34.3	12.6	44.9	473	87.1	31.2	47.3	53.5	224.4	48.1	20.1	17.8	20.8	38.7	9.4	73.2	101.4	91.8	25.4	45.5
C17	16.5	2.3	5.0	2.9	0.9	8.1	3.7	110	7.9	1.0	1.4	2.3	87.3	8.3	2.4	1.3	1.5	2.3	1.5	4.0	4.2	5.9	1.2	1.5
C18	313.5	131.5	49.2	78.2	57.6	9.0	23.4	417	76.0	17.2	25.8	27.5	284.5	33.6	25.9	8.4	15.3	20.4	6.1	36.9	38.0	72.0	18.0	25.4
C19	28.2	15.8	11.3	4.8	3.7	1.0	4.0	401	9.8	2.1	1.3	1.4	121.1	5.6	3.6	1.7	1.6	2.0	0.9	4.3	3.4	4.6	5.7	0.9
C20	127.4	44.8	41.0	32.9	15.5	3.7	17.7	636	43.2	9.8	7.9	5.8	700.1	23.7	12.9	6.8	9.9	14.0	3.2	16.7	7.8	12.1	8.2	8.9
C21	19.3	5.2	7.4	4.8	1.0	1.1	4.4	468	4.6	1.2	1.6	1.5	206.9	4.5	1.8	2.0	2.4	2.8	1.2	4.0	1.1	3.6	0.9	0.9
C22	112.9	26.3	25.7	37.1	17.6	1.7	33.4	2590	77.2	14.9	8.5	5.4	2105.3	35.4	8.5	7.4	15.3	10.6	5.0	13.7	8.5	24.4	10.1	11.2
C23	15.3	1.4	3.6	5.8	2.0	1.0	11.0	539	6.8	0.9	1.2	1.1	207.8	9.8	6.8	7.0	4.6	2.6	4.6	3.3	1.4	5.8	1.4	2.9
C24	43.0	10.3	10.1	27.6	6.6	1.6	54.8	3415	3.3	4.6	2.9	2.4	2488.8	42.3	3.9	2.0	9.9	6.6	2.9	4.6	8.5	31.7	10.4	3.7
C25	2.3	1.3	1.3	10.2	0.9	1.1	10.4	623	1.1	0.6	0.0	1.0	238.3	5.8	1.6	1.4	1.5	1.7	1.7	1.5	1.1	6.4	6.4	1.0
C26	17.1	2.4	3.2	30.3	8.0	1.3	330.1	10495	1.4	1.2	0.0	1.3	2861.9	105.6	2.7	1.8	1.6	2.4	2.2	2.8	27.8	81.7	27.7	20.0
C27	1.3	0.8	1.0	1.0	0.9	1.2	4.8	224	1.3	0.0	0.0	0.0	139.0	4.7	2.0	1.2	1.3	0.0	1.0	1.5	0.9	4.5	5.7	0.7
C28	17.9	12.2	2.6	12.0	3.1	0.9	73.4	2281	15.1	0.0	0.0	0.0	872.8	26.8	1.4	0.8	0.0	0.0	0.0	2.6	8.3	37.4	25.3	21.1
C29	1.7	0.0	0.0	1.0	1.2	0.0	5.7	83	0.0	0.0	0.0	0.0	95.3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.9	1.4	0.7
Cholesterol (27)	314.8	0.2	12.0	0.1	12.9	16.8	13.8	221	32.7	10.9	15.0	13.7	201.0	37.4	83.2	15.3	16.7	47.1	11.7	8.8	6.4	11.9	7.0	7.3
Cholestanol (27)	0.0	33.4	0.0	3.8	0.0	7.4	10.1	32	0.9	0.0	0.0	0.0	143.6	12.2	6.7	11.0	9.1	1.7	5.3	0.0	0.0	13.7	11.9	0.9
Ergosterol (28)	1.6	1.4	0.0	13.0	4.7	4.6	3.5	1891	0.0	0.0	0.0	0.0	17.3	9.2	7.0	7.9	7.5	1.5	5.4	0.0	1.8	5.5	5.4	9.0
Stigmasterol (29)	26.7	12.4	2.1	5.0	0.0	7.2	6.5	162	20.1	5.6	0.0	0.0	77.9	21.8	23.8	7.7	5.7	4.4	11.1	0.0	3.5	0.0	0.0	0.0
C30	7.9	4.6	2.2	12.8	4.5	0.0	33.5	1569	0.7	0.0	0.0	0.0	306.5	20.6	0.7	0.0	0.0	0.0	0.0	0.0	1.8	27.5	19.6	21.9
b-Sitosterol (C29)	9.9	0.0	0.0	7.4	1.4	1.8	1.1	10043	1.0	0.0	0.0	0.0	311.8	4.9	1.1	0.8	1.6	2.0	3.0	0.0	3.7	11.8	0.0	31.1
Total	1434.6	437.1	312.1	429.4	224.2	135.7	709.9	37210	506.5	171.0	192.4	171.4	12171.2	529.7	224.5	147.7	178.2	265.0	102.7	329.7	297.7	507.0	248.5	260.1
CPI(13-28)	6.0	6.5	5.0	5.3	5.6	1.3	12.6	8	5.8	3.8	3.6	4.5	7.4	5.3	3.5	2.3	2.9	3.1	1.7	1.7	4.2	6.9	3.3	6.5
Low(13-19)	699.6	276.1	171.3	218.1	139.9	75.1	93.0	1872	278.0	109.8	147.8	135.6	1154.3	150.8	57.7	68.5	85.2	151.6	40.5	241.0	210.1	221.8	104.0	114.9
High(20-28)	356.7	104.8	95.7	161.8	55.6	13.6	539.9	21270	154.1	33.3	22.1	18.5	9820.9	258.7	41.5	30.4	46.7	40.7	21.9	50.6	65.3	207.7	96.0	70.4

Table 5. Concentrations of fatty acids in the remote marine aerosols collected from western North Pacific to Southern Oceans (KH94-4).

Sample No.	QFF655	QFF657	QFF658	QFF659	QFF660	QFF661	QFF662	QFF663	QFF668	QFF669	QFF670	QFF671	QFF672	QFF674	QFF675	QFF676	QFF677	QFF680	QFF681	QFF682	QFF683	QFF685	QFF686	QFF687
n-Fatty acid,pg/m3																								
C8	91.8	14.8	7.8	33.9	12.0	13.7	13.9	265	5.3	7.9	4.1	9.3	151.2	26.4	17.4	21.9	21.1	19.2	5.7	9.9	3.5	19.5	17.7	22.1
C9	93.7	18.6	16.5	41.4	14.7	15.2	17.9	565	10.6	19.6	7.2	12.0	54.9	24.0	32.3	36.9	39.6	28.1	9.3	16.1	8.4	19.9	20.9	22.2
C10	122.3	26.4	22.2	65.0	17.3	21.5	19.2	510	17.1	27.9	9.6	15.6	232.2	75.5	40.0	39.0	40.8	40.1	13.7	16.6	21.8	48.3	25.1	62.6
C11	34.1	8.7	4.9	7.9	4.3	4.5	4.8	175	6.7	8.5	2.5	5.3	81.9	10.0	5.7	7.4	7.0	9.5	3.3	4.1	2.1	6.0	3.9	4.0
C12	223.4	61.1	54.6	127.1	18.9	33.8	32.4	4291	91.3	70.6	20.9	37.9	761.9	82.4	108.9	76.7	68.0	75.0	11.2	10.2	21.7	88.1	32.7	105.4
C13	59.0	15.2	12.4	16.1	5.2	9.2	7.4	262	26.2	17.9	2.7	8.5	214.1	15.9	14.6	14.3	13.0	17.9	7.4	7.4	2.2	13.6	4.8	9.5
C14	936.2	161.7	93.2	192.7	50.6	119.8	115.1	5069	287.4	169.9	41.3	86.0	3002.3	270.3	478.3	92.4	173.7	183.3	106.3	35.8	95.0	257.1	59.4	170.1
C15	450.1	85.8	78.4	133.6	23.1	46.7	59.1	1262	146.1	69.1	7.5	22.1	743.3	101.7	0.3	17.8	44.2	0.0	66.5	15.1	43.0	98.5	24.5	133.3
C16:n	357.1	0.8	236.8	110.6	0.0	65.1	54.8	2236	0.0	20.6	0.0	0.0	131.1	118.1	142.7	0.0	0.0	253.5	97.0	0.0	112.8	13.4	19.3	70.5
C16	4456.0	577.9	570.4	3881.3	223.4	441.2	870.4	173471	858.0	403.6	44.7	145.7	10098.8	1517.4	934.2	126.6	349.5	467.8	318.1	43.3	238.3	1230.6	307.1	5381.2
C17	244.7	42.9	52.1	81.1	19.6	24.1	27.2	1291	67.3	35.2	8.2	14.1	428.0	41.3	40.3	14.8	21.3	38.1	25.0	11.4	7.9	37.0	15.1	75.5
C18:n	1703.9	0.0	214.5	3382.1	0.0	219.1	1253.6	467170	12.8	16.1	4.5	0.0	6065.9	1972.0	419.4	19.2	0.0	160.9	80.7	0.0	124.1	563.9	135.5	1828.6
C18	1945.9	252.4	146.3	1463.5	115.9	149.5	327.9	21782	355.5	171.8	17.9	56.4	2389.0	399.2	151.2	58.8	104.1	85.6	76.0	83.7	39.4	346.1	140.5	1711.3
C19	73.8	11.4	9.5	13.2	5.6	6.6	8.5	421	19.1	8.3	1.2	4.7	375.8	10.2	5.5	3.7	5.4	6.7	4.3	1.6	1.7	9.7	3.4	6.2
C20	257.0	29.4	22.9	124.1	19.1	34.3	83.7	9839	43.3	22.7	5.8	9.4	2606.5	101.6	24.3	11.7	13.7	18.5	10.8	9.7	3.0	89.5	23.9	139.8
C21	76.9	9.6	5.0	16.2	6.7	6.8	11.6	575	10.4	6.7	1.0	4.3	850.9	14.2	4.3	2.7	4.4	4.5	4.0	2.3	1.9	10.5	3.4	11.0
C22	377.7	28.4	21.0	157.9	25.1	36.1	94.2	12147	33.4	16.8	4.1	8.3	7110.6	142.6	24.2	13.4	12.6	15.2	10.0	5.6	3.6	100.4	23.6	193.6
C23	165.0	14.9	11.5	40.0	11.5	13.3	21.9	931	17.0	9.0	1.6	5.2	1473.8	27.1	8.8	5.5	5.5	7.9	4.7	2.4	2.0	21.5	6.5	29.6
C24	560.0	43.1	43.0	267.4	36.7	50.7	113.4	7048	44.9	24.6	6.5	11.9	10489.4	186.7	42.4	17.9	21.6	35.0	21.1	17.8	9.5	125.1	44.5	344.5
C25	163.5	15.3	22.3	41.2	12.0	18.3	36.3	791	24.2	11.9	6.2	10.2	1057.2	35.8	44.9	8.9	7.4	15.4	7.0	19.3	3.1	27.5	12.2	31.0
C26	348.5	21.6	24.4	94.9	25.2	39.4	101.4	5249	19.4	10.9	4.1	5.1	6226.0	126.3	21.1	9.0	9.7	15.3	10.0	7.8	5.0	108.3	54.8	84.2
C27	88.3	5.7	3.1	14.4	5.9	6.7	13.3	478	4.6	3.5	1.0	1.5	436.0	14.8	4.1	2.7	4.4	3.5	2.7	0.0	1.5	12.8	5.6	7.8
C28	287.7	16.1	12.8	64.0	21.6	31.3	84.5	3564	15.5	8.4	2.6	4.0	2462.4	98.5	11.0	6.7	6.7	7.2	5.2	0.0	3.9	234.6	58.3	59.5
C29	70.1	4.7	1.8	13.3	5.1	5.1	10.9	547	4.1	2.2	0.0	1.5	258.9	11.6	2.1	1.9	2.9	2.2	2.1	0.0	1.3	12.9	4.6	7.3
C30	226.4	9.5	4.4	58.2	14.8	19.0	54.0	2570	7.8	4.0	0.0	1.5	1341.4	54.0	4.0	3.8	5.2	3.4	4.2	0.0	2.6	121.7	32.9	55.5
C31	40.3	3.1	0.0	7.9	2.9	2.6	5.0	167	3.0	1.4	0.0	0.0	94.9	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	3.3	5.4
C32	129.0	4.9	0.0	31.9	8.5	10.7	27.3	1168	6.1	3.2	-0.0	0.0	488.2	19.6	0.0	0.0	2.8	0.0	0.0	0.0	0.0	48.8	16.3	34.4
C33	13.6	0.0	0.0	3.9	0.0	0.0	2.2	49	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	2.7
C34	41.7	0.0	0.0	13.6	1.9	1.8	4.8	349	0.0	0.0	0.0	0.0	141.5	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9	3.9	12.6
C16:n+C18:n	2061.0	0.8	451.4	3492.7	0.0	284.1	1308.5	469406	12.8	36.7	4.5	0.0	6197.0	2090.1	562.1	19.2	0.0	414.4	177.7	0.0	236.9	577.3	503.4	1899.1
total	13762.5	1515.5	1701.8	10534.9	738.4	1468.9	3498.8	724687	2256.3	1351.3	212.1	488.6	59911.6	5668.6	2614.5	645.6	1028.6	1546.9	927.3	333.7	762.2	3743.5	1127.4	10652.9
low C13-C19	8165.8	1147.2	962.3	5781.5	443.4	797.1	1415.6	203560	1759.6	875.7	123.5	337.5	17251.1	2356.0	1624.4	328.4	711.1	799.4	603.6	198.3	427.6	1992.7	554.8	7487.2
high C20-C34	2845.5	206.4	172.2	948.9	197.0	276.2	664.5	45473	233.8	125.2	32.8	62.9	35043.4	838.7	191.1	84.2	97.1	128.0	81.8	64.9	37.4	933.8	293.8	1018.9
sat. C8-C34	11350.2	1473.6	1236.0	6947.5	692.9	1143.0	2114.4	252268	2116.6	1131.4	200.6	479.0	52235.2	3359.1	2015.8	590.8	979.6	1096.0	724.3	320.1	519.8	2986.6	916.0	8666.9

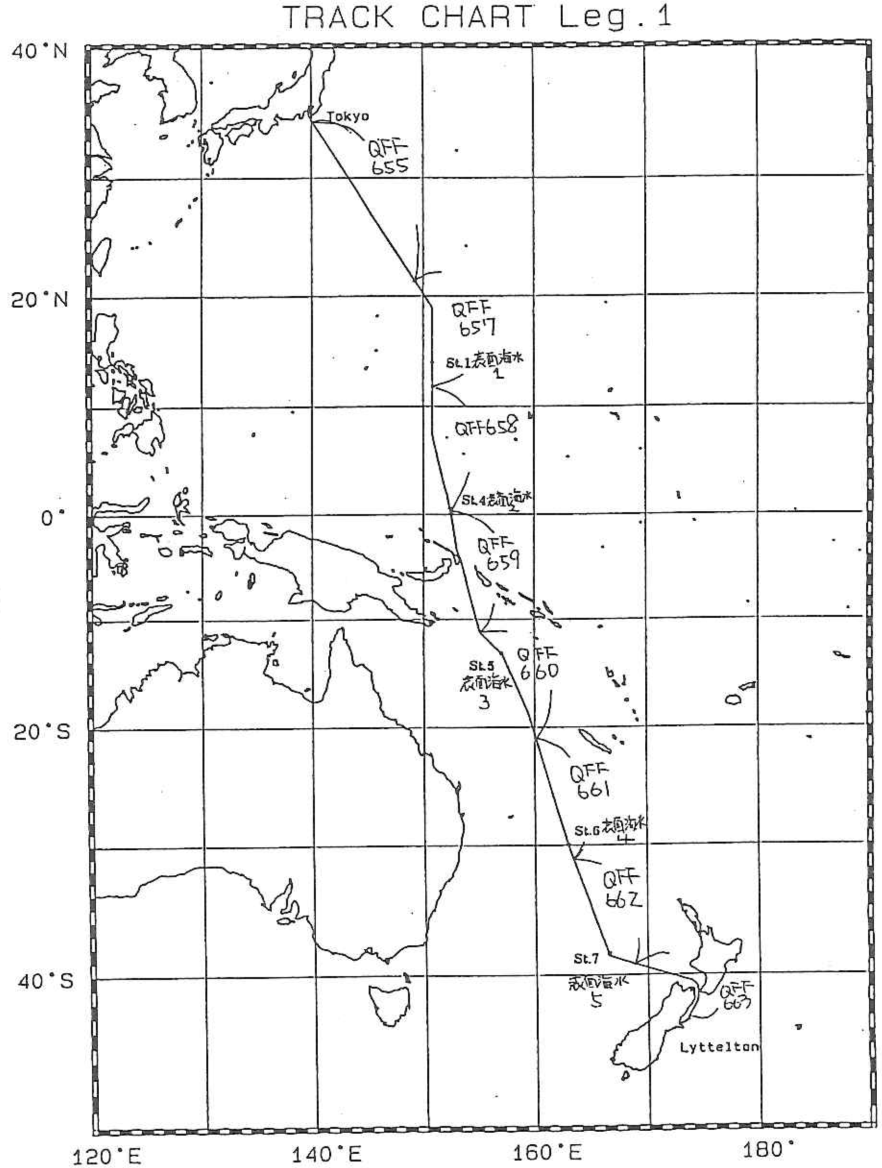


Fig. 1a. Cruise track of R/V Hakuho-Maru (KH-94-4) , Leg. 1.

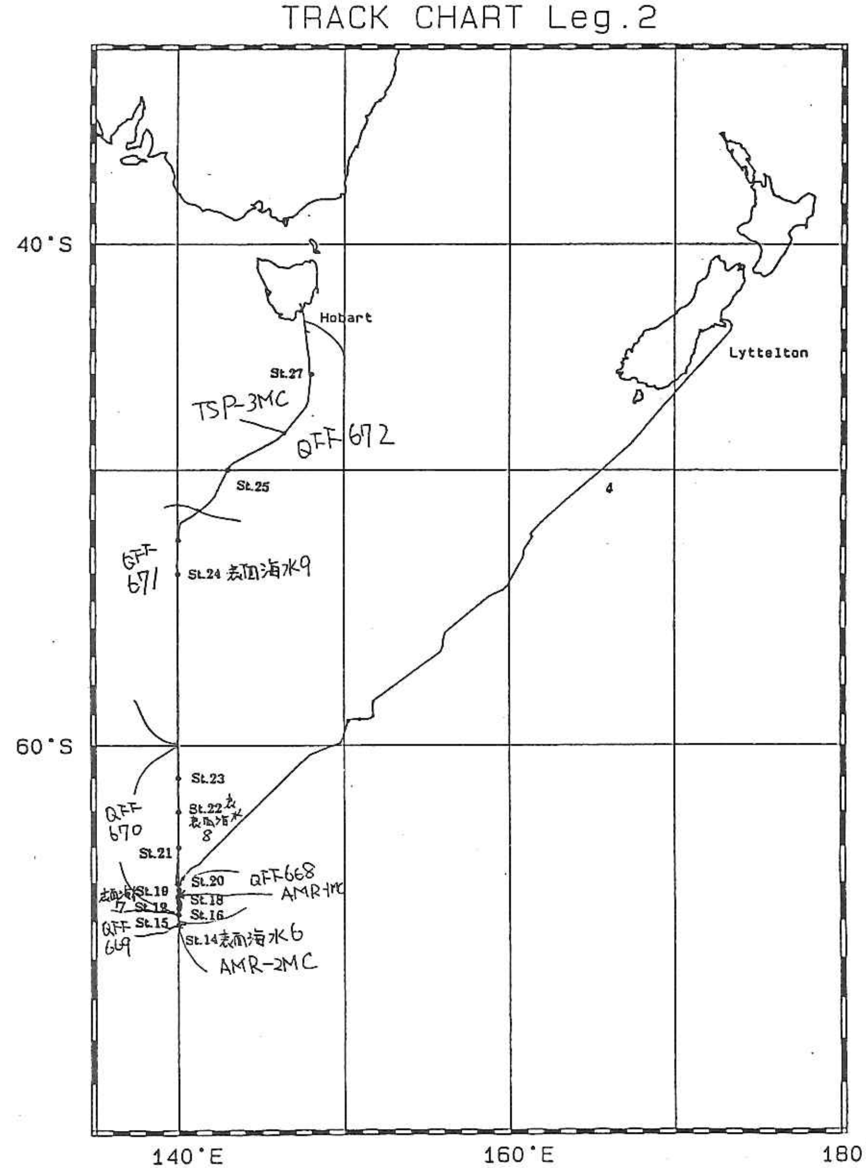


Fig. 1b. Cruise track of R/V Hakuho-Maru (KH-94-4) , Leg. 2.

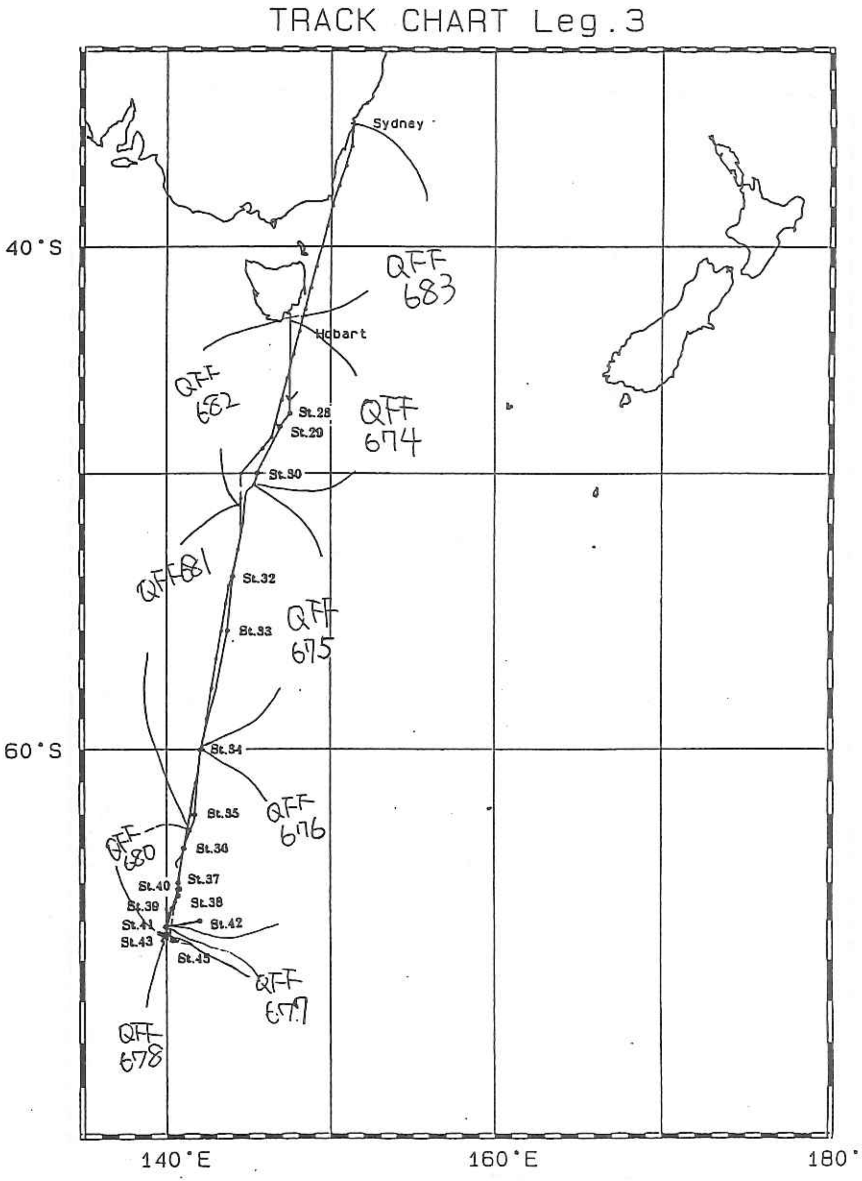


Fig. 1c. Cruise track of R/V Hakuho-Maru (KH-94-4) , Leg. 3.

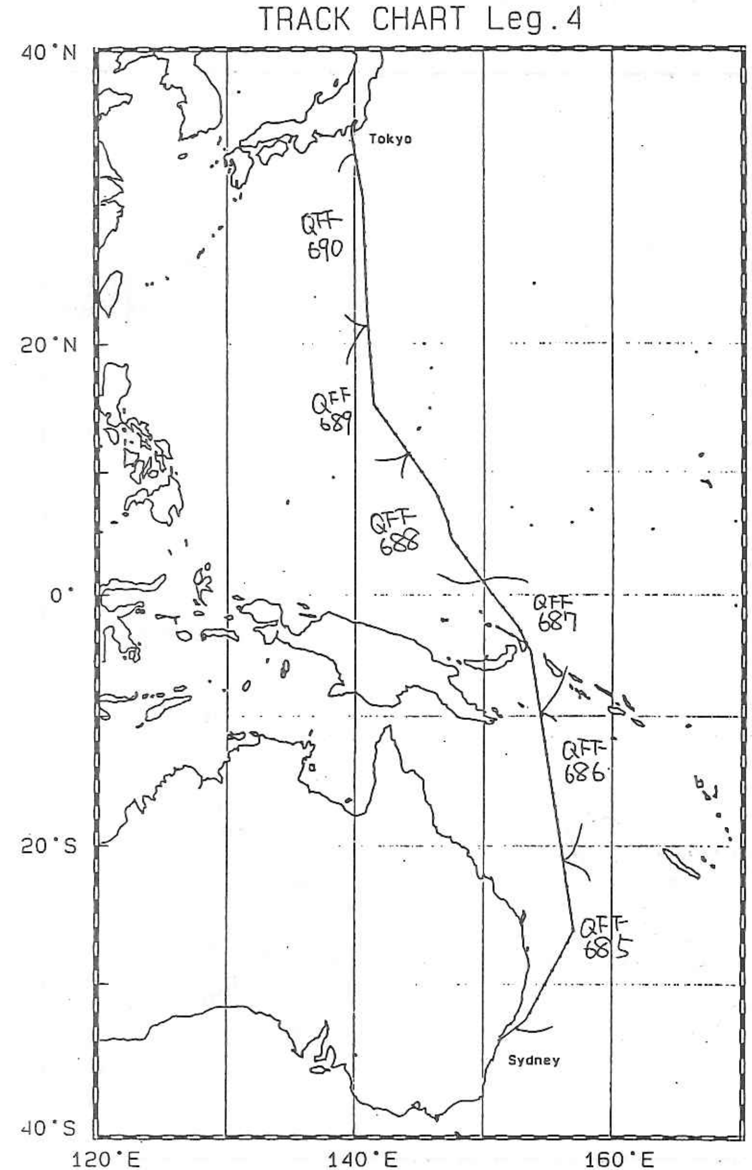


Fig. 1d. Cruise track of R/V Hakuho-Maru (KH-94-4) , Leg. 4.

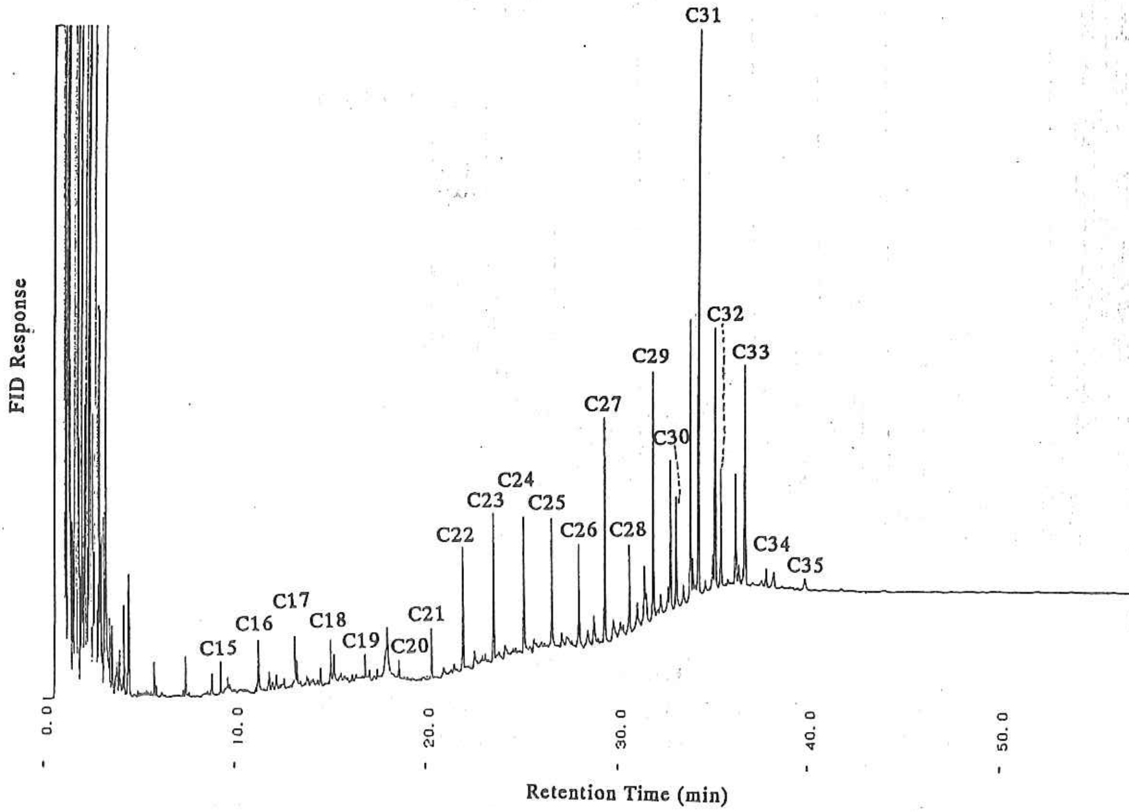


Fig. 2. A capillary gas chromatogram of aliphatic hydrocarbon fraction isolated from the remote marine aerosol sample (QFF 677, Antarctic Ocean).

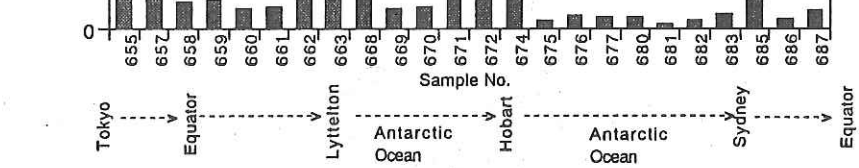


Fig. 3 Spatial distributions of n-alkanes detected in the western North Pacific to the Antarctic Ocean.

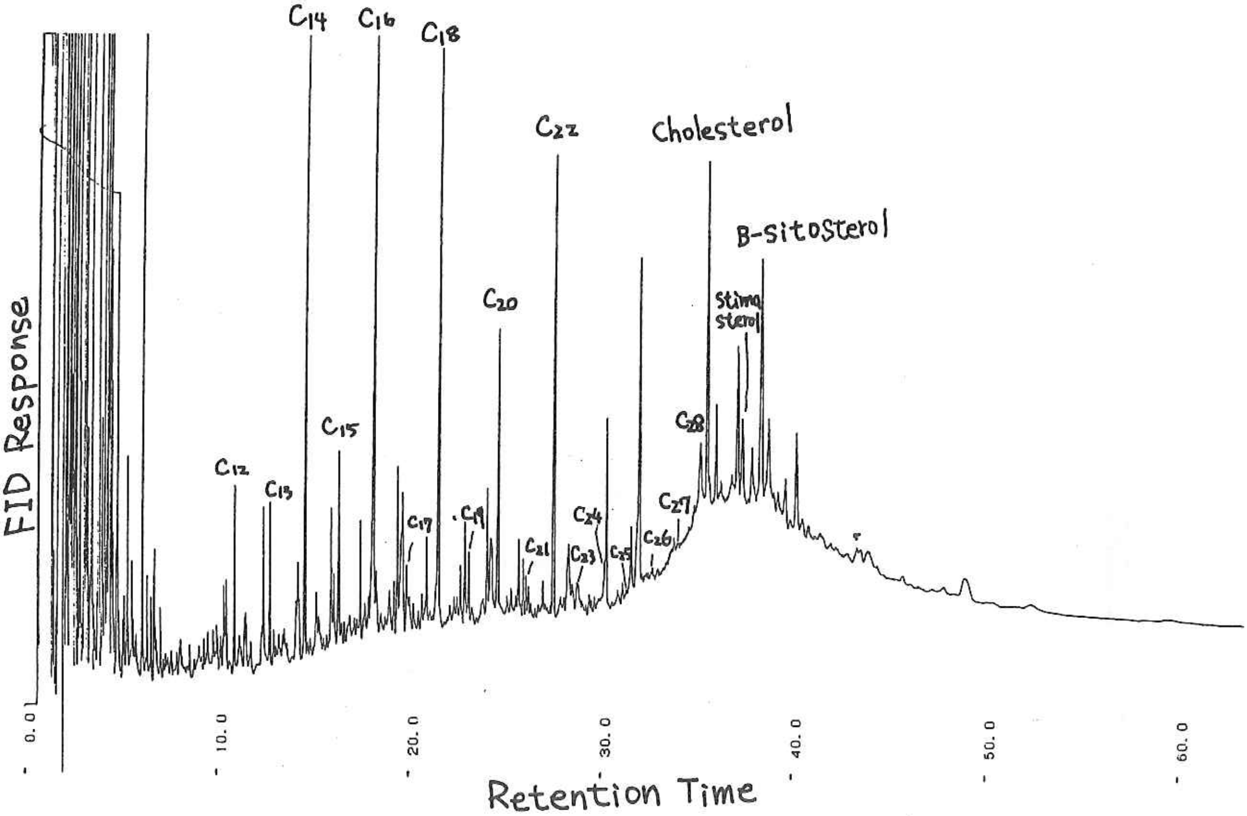


Fig. 4. A capillary gas chromatogram of alcohol fraction (TMS ethers) isolated from the remote marine aerosol sample (QFF 668 Antarctic Ocean).

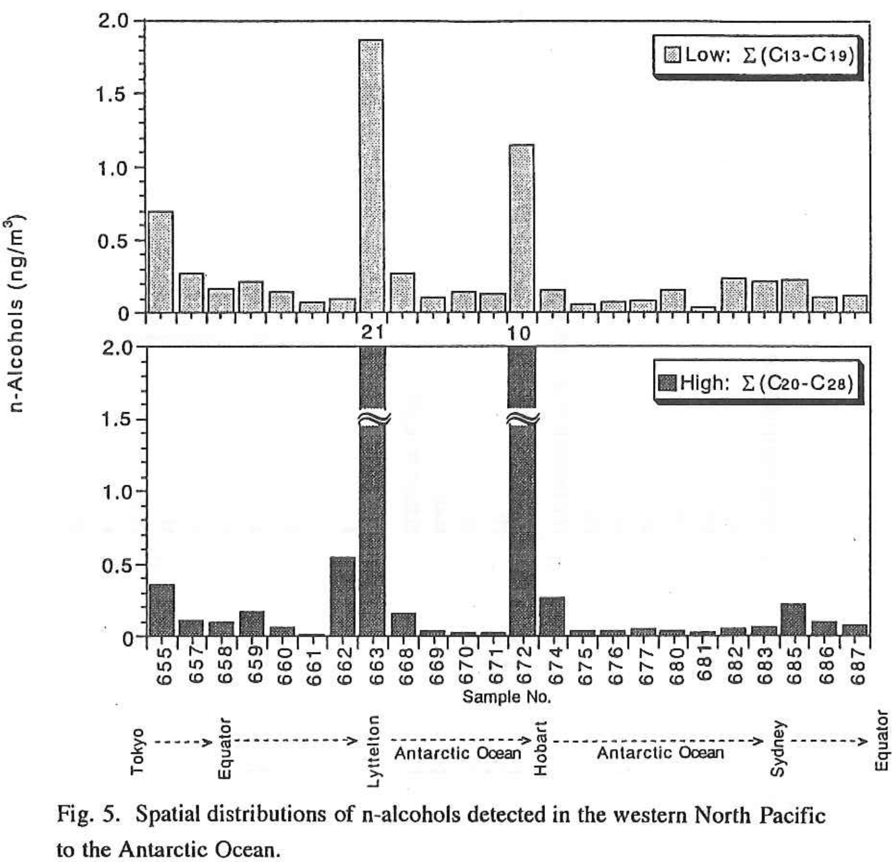


Fig. 5. Spatial distributions of n-alcohols detected in the western North Pacific to the Antarctic Ocean.

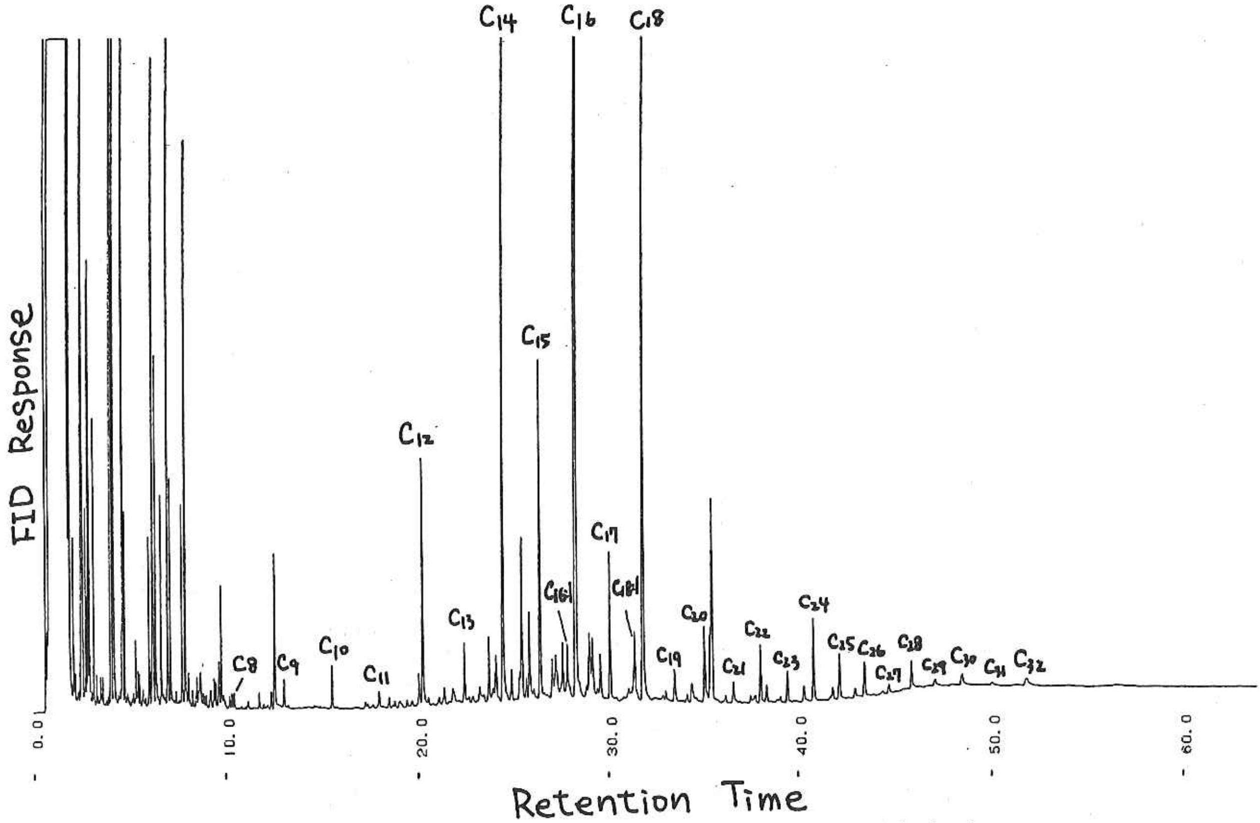


Fig. 6. A capillary gas chromatogram of fatty acids (methyl esters) isolated from the remote marine aerosol sample (QFF 668, Antarctic Ocean).

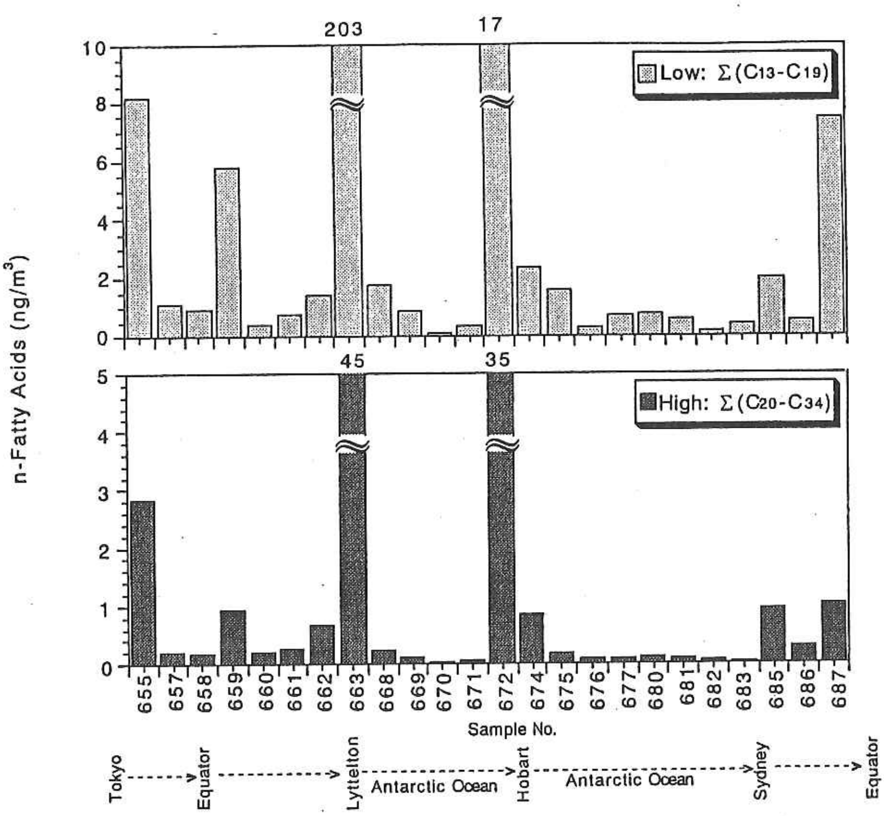


Fig. 7. Spatial distributions of n-fatty acids over the western North Pacific to the Antarctic Ocean.

Oceanographic Data

(H. Hasumoto, M. Watanabe, C. Igarashi and S. Watanabe)

St.	St.1		Date	Nov.26.1994		Lat.	13°56.29'N				Depth	6014	(m)				
CTD-1			Time(GMT	06:40-08:17		Long.	150°51.31'E								CTD	DOWN	CAST
Bottle	P	Depth	T(CTD)	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	28.5	34.128	4.55	0.0	0.05	0.0	0.00	8.232	2.307	0.05		2	28.408	34.113	21.594
24	11	11	28.365	34.219	4.54	0.0	0.07	0.0	0.00	8.279	2.308	0.04	34.167	10	28.383	34.145	21.627
23	19	19	28.317	34.243		0.0	0.07	0.0	0.00	8.282	2.313	0.04	34.231	20	28.329	34.229	21.708
22	29	29	28.326	34.260	4.53	0.0	0.00	0.0	0.00			0.04	34.251	30	28.329	34.254	21.726
21	50	50	28.315	34.265	4.53	0.0	0.07	0.0	0.00	8.288	2.309	0.05	34.256	50	28.314	34.264	21.739
20	75	75	27.121	34.666	4.75	0.0	0.13	0.0	0.00	8.263	2.340	0.09	34.622	75	27.049	34.644	22.434
19	99	98	25.976	34.850	4.78	0.0	0.08	0.0	0.00	8.263	2.361	0.13	34.844	100	25.836	34.888	23.000
18	125	124	24.262	34.945	4.56	0.0	0.12	0.0	0.00	8.217	2.366	0.15	34.935	125	23.158	34.978	23.871
17	151	150	22.664										35.046	150	21.405	35.104	24.462
16	173	172	21.108										35.077	175	19.168	34.985	24.966
15	198	197	18.536	34.927	4.29	2.2	0.27	3.5	0.01	8.125	2.359	0.01	34.924	200	17.818	34.878	25.224
14	500	497	7.227	34.428	1.35	54.2	2.35	35.0	0.00	7.623	2.373		34.426	500	7.223	34.430	26.939
13	749	743	5.526	34.502	1.35	78.1	2.54	39.0	0.00	7.603	2.406		34.501	750	5.514	34.503	27.220
12	998	990	4.426	34.538	1.45	97.3	2.58	40.6	0.00	7.639	2.432		34.537	1000	4.436	34.537	27.371
11	1248	1235	3.411	34.566	1.85	118.6	2.47	43.6	0.00	7.639	2.464		34.565	1250	3.415	34.566	27.499
10	1521	1500	2.816	34.591									34.590	1500	2.859	34.589	27.569
9	1521	1500	2.817	34.591	2.08	130.0	2.44	43.8	0.00	7.636	2.463		34.590				
8	1520	1506	2.816	34.591		130.0	2.47	44.1	0.01				34.590				
7	1520	1506	2.821	34.591		130.2	2.45	44.1	0.01				34.590				
6	1519	1505	2.819	34.591		130.6	2.47	44.3	0.01				34.590				
5	1519	1505	2.822	34.592		130.8	2.50	44.3	0.01				34.590				
4	1518	1504	2.821	34.590		129.8	2.45	44.4	0.00				34.590				
3	1517	1503	2.821	34.591		129.6	2.44	44.3	0.00				34.590				
2	1516	1501	2.822	34.590		130.0	2.45	44.5	0.01				34.590				
1	1515	1501	2.822	34.591		130.4	2.46	44.6	0.00				34.590				

* S, O2, SiO2, PO4. NO3, NO2, PH and PH values were obtatind by analysis in the laboratory

* P, T(CTD) and CTD(S) values were obtaind by SEA-BIRD CTD.

St.	St.4		Date	Nov. 28.1994.		Lat.	00°00.06'N				Depth	4455	(m)				
CTD-4			Time(GMT	17:37-18:59		Long.	152°30.22'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	30.1	33.962	4.36	0.0	0.00	0.0	0.00	8.255	2.289	0.08		2	30.028	33.985	20.956
24														10	29.957	33.992	20.985
23	9	9	30.114		4.47	0.0	0.00	0.0	0.00			0.05	33.974	20	29.993	34.021	20.995
22														30	29.926	34.032	21.026
21	9	9	30.121										33.973	50	28.300	34.489	21.912
20														75	27.231	35.010	22.651
19														100	26.072	35.209	23.168
18	9	9	30.139										33.967	125	24.226	35.104	23.653
17	9	9	30.045	33.956						8.297	2.289		33.981	150	20.828	35.159	24.662
16	20	20	30.017	34.021	4.47	0.0	0.00	0.0	0.00	8.302	2.292	0.06	34.015	175	19.215	35.389	25.264
15	29	29	29.957	34.025	4.47	0.0	0.00	0.0	0.00	8.305	2.292	0.08	34.015	200	16.780	35.264	25.769
14	50	50	29.587	34.072	4.52	0.0	0.01	0.0	0.00	8.292	2.298	0.09	34.048	300	11.924	34.860	26.495
13	75	75	27.101	34.930	3.95	0.0	0.34	0.4	0.00	8.203	2.352	0.48	34.990	500	7.789	34.588	26.982
12	100	99	25.313	35.196	3.35	1.5	0.66	6.6	0.00	8.140	2.369	0.52	35.181	750	5.708	34.543	27.228
11	124	123	22.990	35.039	3.03	3.8	0.77	9.1	0.24	8.088	2.359	0.06	35.028	1000	4.681	34.548	27.353
10	150	149	19.738	35.092	3.19	6.0	0.87	10.3	0.21	8.058	2.367	0.01	35.067	1250	3.736	34.573	27.473
9	173	172	18.354	35.389	3.27	4.5	1.00	12.2	0.03	8.035	2.387	0.00	35.376	1500	3.068	34.596	27.557
8	199	198	16.732	35.255	3.20	6.8	1.20	14.4	0.02	7.996	2.383	0.00	35.242				
7	299	297	11.915	34.856	2.95	17.4	1.74	22.6	0.02	7.876	2.367	0.00	34.852				
6	499	496	7.662	34.579	2.96	31.0	2.30	30.9	0.01	7.780	2.371		34.577				
5	750	744	5.647	34.571	2.14	57.1	2.89	38.4	0.00	7.687	2.393		34.540				
4	999	991	4.618	34.550	2.27	74.8	2.97	39.2	0.00	7.655	2.412		34.548				
3	1249	1238	3.712	34.576	2.25	93.7	3.00	39.6	0.00	7.652	2.437		34.574				
2	1509	1495	3.051	34.599	2.46	105.8	2.95	39.4	0.00	7.657	2.454		34.597				
1	1509	1495	3.050	34.599									34.597				

St.	St.5		Date	Dec. 01.1994		Lat.	13°19.93'S				Depth	2106	(m)				
CTD-5			Time(GMT	03:30-04:51		Long.	156°59.69'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	29.1	34.543	4.42	0.0	0.14	0.0	0.00	8.282	2.321	0.05	-	2	28.450	34.518	21.885
24	75	74	25.848									-	34.873	10	28.397	34.515	21.900
23	10	10	28.489									0.06	34.511	20	28.370	34.513	21.907
22														30	28.345	34.510	21.914
21	10	10	28.443										34.508	50	27.336	34.717	22.397
20														75	26.097	34.788	22.843
19														100	25.311	34.917	23.183
18	9	9	28.488	34.520									34.510	125	24.617	35.459	23.804
17	10	10	28.455	34.518	5.45	0.0	0.14	0.0	0.00	8.294	2.325		34.509	150	23.531	35.818	24.399
16	19	19	28.379	34.513	4.71	0.0	0.13	0.0	0.00	8.300	2.326	0.05	34.503	175	22.638	35.859	24.690
15	30	30	28.365	34.516	4.58	0.0	0.14	0.0	0.00	8.300	2.326	0.05	34.502	200	21.209	35.829	25.068
14	49	49	27.292	34.720	4.70	0.0	0.14	0.0	0.00	8.298	2.339	0.09	34.703	300	16.674	35.401	25.899
13	73	73	25.859	34.855	4.79	0.0	0.12	0.0	0.00	8.292	2.353	0.11	34.873	500	8.389	34.582	26.886
12	99	98	24.919	35.040	4.77	0.0	0.14	0.0	0.00	8.278	2.362	0.21	35.040	750	5.334	34.451	27.201
11	125	124	24.097	35.631	3.96	0.0	0.37	2.1	0.09	8.220	2.399	0.17	35.620	1000	4.146	34.510	27.381
10	150	149	23.212	35.848	3.82	0.0	0.47	3.3	0.03	8.191	2.418	0.06	35.830	1250	3.429	34.553	27.488
9	173	172	22.076	35.873	3.49	0.0	0.59	5.3	0.02	8.154	2.423	0.06	35.858	1500	2.885	34.591	27.569
8	199	198	21.074	35.818	3.66	0.0	0.57	5.4	0.00	8.136	2.390	0.02	35.800				
7	300	298	16.686	35.392	3.56	2.2	0.93	10.5	0.00	8.136	2.417	0.03	35.385				
6	500	497	8.418	34.583	4.05	12.7	1.80	24.1	0.00	7.864	2.356		34.575				
5	750	744	5.294	34.458	3.79	37.5	2.30	32.1	0.00	7.783	2.376		34.450				
4	1000	992	4.106	34.519	3.42	63.0	2.51	35.0	0.00	7.692	2.415		34.512				
3	1249	1238	3.403	34.560	3.26	79.1	2.59	36.1	0.00	7.724	2.426		34.555				
2	1509	1495	2.879	34.597	3.18	91.8	2.62	36.5	0.00	7.719	2.444		34.592				
1	1509	1495	2.880	34.598									34.592				

St.	St.6		Date	Dec.4.1994		Lat.	29°59.81'S				Depth	1216	(m)				
CTD-6			Time(GMT	11:56-13:07		Long.	162°59.55'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	21.5	35.839	5.17	0.0	0.06	0.0	0.00	8.231	2.405	0.11		2	21.519	35.829	24.982
24														10	21.544	35.811	24.962
23	9	9	21.515										35.812	20	21.546	35.811	24.961
22														30	21.547	35.811	24.961
21	9	9	21.510										35.812	50	21.537	35.81	24.963
20														75	20.001	35.752	25.335
19														100	19.645	35.764	25.438
18	9	9	21.520										35.812	125	19.269	35.738	25.516
17	8	8	21.519	35.813	5.21	0.0	0.06	0.0	0.00	8.238	2.416	0.11	35.812	150	18.929	35.703	25.577
16	19	19	21.525	35.815	5.18	0.0	0.06	0.0	0.00	8.237	2.407	0.11	35.812	175	18.778	35.699	25.612
15	29	29	21.520	35.812	5.14	0.0	0.06	0.0	0.00	8.239	2.404	0.11	35.810	200	18.476	35.665	25.662
14	49	49	21.046	35.775	5.21	0.0	0.07	0.0	0.00	8.235	2.407	0.16	35.773	300	16.494	35.544	26.051
13	75	75	19.986	35.752	5.03	0.0	0.15	0.0	0.03	8.213	2.404	0.65	35.749	500	11.829	35.015	26.633
12	99	99	19.612	35.759	4.82	0.0	0.22	1.8	0.12	8.189	2.404	0.21	35.754	750	8.046	34.594	26.948
11	124	123	19.242	35.753	4.87	0.0	0.22	1.9	0.03	8.185	2.403	0.09	35.748	1000	5.768	34.465	27.159
10	149	148	18.973	35.704	4.68	0.0	0.31	3.2	0.03	8.171	2.399	0.03	35.703				
9	174	173	18.761	35.696	4.81	0.0	0.32	3.2	0.03	8.171	2.403	0.01	35.696				
8	199	198	18.520	35.671	4.66	0.0	0.35	3.9	0.03	8.168	2.404	0.00	35.661				
7	300	298	16.546	35.542	4.75	0.0	0.48	5.6	0.02	8.13	2.397	0.00	35.538				
6	499	495	11.786	35.006	4.47	4.2	1.13	15.3	0.01	7.976	2.368		35.005				
5	749	743	7.891	34.580	4.47	13.4	1.72	24.3	0.00	7.868	2.361		34.574				
4	1007	998	5.742	34.469	4.30	29.8	2.08	29.1	0.00	7.813	2.370		34.464				
3																	
2																	
1	1008	999	5.735										34.464				

St.	St.7		Date	Dec.6.1994		Lat.	38°29.95'S				Depth	2262	(m)				
CTD-7			Time(GMT	01:51-03:16		Long.	166°30.11'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	15.6	35.270	6.08	0.0	0.19	0.0	0.0	8.180	2.384	0.80		2	15.469	35.261	26.068
24	10	10	15.428										35.265	10	15.372	35.261	26.09
23	10	10	15.419										35.265	20	15.259	35.268	26.121
22	76	76	13.754										35.264	30	15.234	35.262	26.122
21	11	11	15.377										35.264	50	14.126	35.249	26.353
20	101	99	13.350										34.224	75	13.609	35.243	26.457
19														100	13.243	35.227	26.52
18	10	10	15.402										35.317	125	13.06	35.222	26.553
17	10	10	15.373	35.285	6.21	0.0	0.17	0.0	0.00	8.182	2.383	0.80	35.263	150	12.97	35.217	26.567
16	20	20	15.169	35.281	6.45	0.0	0.15	0.0	0.00	8.180	2.385	0.79	35.317	175	12.873	35.211	26.582
15	29	29	15.196	35.283	6.32	0.0	0.17	0.0	0.00	8.182	2.388	0.93	35.259	200	12.661	35.181	26.601
14	50	50	14.160	35.259	6.27	0.0	0.26	0.1	0.48	8.149	2.385	1.30	35.235	300	11.455	35.009	26.699
13	75	75	13.786	35.251	5.83	0.8	0.42	2.4	0.33	8.113	2.378	0.32	35.227	500	9.404	34.736	26.845
12	99	98	13.353	35.248	5.71	0.8	0.50	4.7	0.23	8.096	2.376	0.09	35.224	750	7.402	34.56	27.016
11	124	123	13.121	35.223	5.65	0.8	0.55	5.5	0.03	8.083	2.376	0.05	35.224	1000	5.203	34.449	27.215
10	150	149	12.995	35.213	5.63	1.6	0.57	6.1	0.01	8.082	2.386	0.03	35.219				
9	174	173	12.872	35.229	5.58	1.6	0.61	6.6	0.01	8.077	2.374	0.02	35.205				
8	200	198	12.744	35.190	5.48	2.4	0.65	7.4	0.01	8.065	2.373	0.01	35.188				
7	303	300	11.703	35.041	4.89	4.0	1.02	13.0	0.01	8.008	2.368	0.01	35.041				
6	499	495	9.507	-	-	-	-	-	-	-	-	-	34.746				
5	750	743	7.046	34.893	4.49	14.3	1.64	22.8	0.00	7.908	2.364	-	34.893				
4	1009	999	5.162	34.444	4.17	37.2	2.27	31.7	0.0	7.810	2.373	-	34.449				
3																	
2																	
1																	

94-4 (St.08,09,10,12)

St.No. St. 8 CTD08
Date Dec.19.1994
Time(GMT) 05:30-06-31
Lat. 64°00.05'S
Long. 140°00.08'E
Depth 3704m

CTD DOWN CAST			
P	T	S	Sigma-T
db	°C	psu	
2	-0.174	33.679	27.048
10	-0.203	33.702	27.068
20	-0.483	33.811	27.169
30	-0.846	33.893	27.250
50	-1.615	34.050	27.403
75	-0.714	34.271	27.551
100	0.154	34.427	27.636
125	1.124	34.539	27.666
150	1.275	34.572	27.683
175	1.222	34.587	27.698
200	0.767	34.565	27.711
300	1.254	34.647	27.745
500	1.383	34.702	27.780

St.No. St. 9 CTD09D
Date Dec.19.1994
Time(GMT) 07:51-08:38
Lat. 64°10.43'S
Long. 140°00.36'E
Depth 3617m

CTD DOWN CAST			
P	T	S	Sigma-T
db	°C	psu	
2	0.005	33.763	27.107
10	0.022	33.766	27.109
20	-0.130	33.827	27.166
30	-0.383	33.865	27.208
50	-1.585	34.088	27.434
75	-0.901	34.249	27.541
100	-0.036	34.387	27.613
125	0.181	34.462	27.662
150	0.711	34.533	27.689
175	0.900	34.566	27.703
200	0.919	34.590	27.721
300	1.430	34.671	27.751
500	1.498	34.714	27.781

St.No. St. 10 CTD10D
Date Dec.19.1994
Time(GMT) 09:38-10:11
Lat. 64°20.34'S
Long. 139°59.98'E
Depth 3454m

CTD DOWN CAST			
P	T	S	Sigma-T
db	°C	psu	
2	-0.315	33.588	26.982
10	-0.316	33.589	26.982
20	-0.339	33.647	27.030
30	-0.863	33.732	27.120
50	-1.636	34.074	27.424
75	-1.186	34.204	27.515
100	0.264	34.421	27.624
125	1.043	34.531	27.666
150	0.998	34.565	27.696
175	1.239	34.608	27.714
200	1.404	34.641	27.729
300	1.669	34.699	27.756
500	1.630	34.731	27.785

St.No. St.12 CTD12D
Date Dec.21.1994
Time(GMT) 07:23-07:53
Lat. 64°29.85'S
Long. 140°00.81'E
Depth 3217m

CTD DOWN CAST			
P	T	S	Sigma-T
db	°C	psu	
2	-0.270	33.594	26.984
10	-0.452	33.598	26.995
20	-1.315	33.749	27.150
30	-1.577	33.941	27.314
50	-1.642	34.125	27.465
75	-1.569	34.218	27.539
100	-1.409	34.286	27.589
125	-0.766	34.385	27.646
150	-0.243	34.445	27.671
175	0.319	34.517	27.699
200	0.860	34.583	27.719
300	1.269	34.666	27.759
500	1.394	34.714	27.788

St.	St.11		Date	Dec.19.1994		Lat.	64°39.86'S				Depth	2943	(m)				
CTD-11			Time(GMT	13:00-15:00		Long.	140°00.55'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	μM	μM	μM	μM		meq/L	μg/L	PSU	db	°C	psu	
0	0	0	-0.9	33.598	8.06	49.0	2.31	34.9	0.34	7.851	2.336	0.13		2			
24	10	10	-0.992	33.709	7.97	51.5	2.33	35.4	0.29	7.840	2.342	0.15	33.592	10	-1.000	33.593	27.013
23	18	18	-1.476	33.847	6.80	52.5	2.40	35.7	0.23	7.832	2.353	0.19	33.818	20	-1.492	33.825	27.217
22	29	29	-1.580	33.933	6.21	54.3	2.47	36.5	0.22	7.830	2.359	0.23	33.915	25	-1.537	33.856	27.243
21	47	47	-1.667	34.145	5.26	60.0	2.60	38.0	0.16	7.801	2.373	0.70	34.129	30	-1.591	33.941	27.314
20	71	70	-1.505	34.218	4.72	65.0	2.61	39.1	0.13	7.785	2.377	0.60	34.210	50	-1.586	34.148	27.482
19	97	96	-1.218	34.290	4.76	70.0	2.65	39.6	0.10	7.776	2.382	0.20	34.279	75	-1.504	34.221	27.539
18	122	121	-1.750	34.330	4.79	71.7	2.62	38.7	0.02	7.796	2.389	0.07	34.324	100	-1.225	34.281	27.579
17	147	146	-1.154	34.395	4.82	78.7	2.67	39.4	0.02	7.778	2.395	0.03	34.392	125	-1.713	34.333	27.636
16	171	169	-1.454	34.410	4.93	80.8	2.62	37.9	0.01	7.794	2.393	0.01	34.408	150	-1.145	34.392	27.666
15	199	197	-0.582	34.487	5.03	88.5	2.69	39.9	0.01	7.767	2.399	0.01	34.486	175	-1.357	34.418	27.694
14	297	294	0.439	34.609	5.22	99.4	2.76	40.4	0.01	7.754	2.410	0.01	34.610	200	-0.561	34.489	27.721
13	497	498	1.131	34.709	5.34	110.6	2.71	40.6	0.00	7.762	2.422		34.706	300	0.532	34.616	27.766
12	747	738	0.965	34.708	4.40	120.3	2.75	41.0	0.00	7.755	2.424		34.708	500	1.125	34.707	27.801
11	997	985	0.806	34.706		127.2	2.74	41.3	0.00	7.761	2.425		34.704	750	0.964	34.708	27.813
10	1248	1232	0.607	34.697		132.0	2.80	41.7	0.00	7.748	2.426		34.696	1000	0.804	34.704	27.821
9	1499	1479	0.432	34.690		134.1	2.88	41.7	0.00	7.756	2.427		34.688	1250	0.602	34.696	27.826
8	1748	1724	0.197	34.674		133.3	2.83	41.7	0.00	7.743	2.426		34.677	1500	0.429	34.688	27.831
7	2238	2205	-0.076										34.673	2000	0.034	34.675	27.842
6	2248	2214	-0.078	34.674		130.4	2.79	41.2	0.00	7.755	2.424		34.673	2500	-0.164	34.674	27.851
5	2502	2463	-0.171	34.675		129.4	2.79	41.1	0.00	7.747	2.424		34.673	2907	-0.456	34.652	27.848
4	2751	2707	-0.308	34.669		129.3	2.74	41.0	0.00	7.755	2.425		34.668				
3	2908	2860	-0.456	34.653		118.3	2.73	40.9	0.00	7.751	2.421		34.652				
2																	
1	1997	1968	0.036	34.676		131.5	2.79	41.7	0.00	7.759	2.422		34.675				

St.	St.11		Date	Dec.19.1994		Lat.	64°39.97'S	
ICTD-1			Time(GMT	17:01-17:30		Long.	139°59.97'E	
Bottle	P	Depth	T	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	db	°C	psu	
0	0	0	-0.9		2	-1.022	33.585	27.007
24	10	10	-1.017	33.588	10	-1.021	33.586	27.008
23	10	10	-1.064	33.601	20	-1.376	33.692	27.106
22	11	11	-1.101	33.611	30	-1.545	33.809	27.206
21	10	10	-1.204	33.641	50	-1.645	34.066	27.417
20	25	25	-1.504	33.763	75	-1.688	34.215	27.540
19	26	26	-1.517	33.777	85	-1.389	34.260	27.568
18	40	40	-1.609	33.952				
17	41	41	-1.620	33.979				
16	40	40	-1.623	33.985				
15	50	50	-1.648	34.071				
14	51	50	-1.647	34.086				
13	51	50	-1.648	34.077				
12	51	50	-1.651	34.078				
11	51	50	-1.646	34.073				
10	51	50	-1.646	34.080				
9	49	49	-1.641	34.095				
8	55	54	-1.636	34.117				
7	55	54	-1.613	34.149				
6	69	68	-1.663	34.201				
5	69	68	-1.675	34.198				
4	70	69	-1.694	34.200				
3	69	68	-1.651	34.220				
2	87	86	-1.137	34.284				
1	86	85	-1.146	34.285				

St.	St.13		Date	Dec.23.1994		Lat.	64°18.04'S	
ICTD-2			Time(G	16:15-16:43		Long.	139°59.16'E	
Bottle	P	Depth	T	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	db	°C	psu	
0	0	0	0.0		2	-0.025	33.595	26.973
24	10	10	0.020	33.590	10	0.020	33.590	26.967
23	10	10	0.020	33.590	20	0.312	33.808	27.128
22	10	10	0.020	33.590	30	-0.337	33.814	27.165
21	10	10	0.020	33.590	50	-1.339	34.177	27.498
20	10	10	0.020	33.590	75	0.057	34.580	27.764
19	25	25	0.242	33.791	100	1.530	34.569	27.663
18	25	25	0.242	33.791				
17	40	40	-1.094	34.428				
16	25	25	0.242	33.791				
15	40	40	-1.094	34.428				
14	55	54	-1.258	34.180				
13	55	54	-1.258	34.180				
12	25	25	0.242	33.791				
11	70	69	-0.727	34.425				
10	50	50	-1.339	34.177				
9	70	69	-0.727	34.425				
8	40	40	-1.094	34.428				
7	55	54	-1.258	34.180				
6	55	54	-1.258	34.180				
5	70	69	-0.727	34.425				
4	85	84	1.270	34.476				
3	75	74	0.057	34.580				
2	85	84	1.270	34.476				
1	100	99	1.530	34.569				

St.	St.11		Date	Dec.19.1994		Lat.	64°39.66'S				Depth	2946	(m)				
CTD60-1			Time(GMT	18:04-18:30		Long.	139°59.58'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.9											2	-1.005	33.587	27.008
24	9	9	-1.019			49.0	2.27	33.7	0.32				33.591	10	-1.008	33.589	27.010
23	9	9	-1.032										33.594	20	-1.302	33.674	27.089
22	9	9	-1.039										33.597	30	-1.512	33.778	27.180
21	9	9	-1.037										33.595	50	-1.573	34.060	27.410
20	25	25	-1.515										33.777	75	-1.536	34.217	27.537
19	25	25	-1.519			50.3	2.30	34.4	0.25				33.790	85	-1.527	34.234	27.551
18	25	25	-1.521										33.797				
17	24	24	-1.527										33.819				
16	40	40	-1.571										33.898				
15	39	39	-1.574			50.2	2.37	34.9	0.24				33.910				
14	40	40	-1.578										33.917				
13	39	39	-1.582										33.926				
12	55	54	-1.557			52.3	2.44	35.5	0.18				34.066				
11	55	54	-1.564										34.072				
10	55	54	-1.603										34.100				
9	55	54	-1.568										34.076				
8	70	69	-1.586			61.6	2.59	37.4	0.12				34.197				
7	70	69	-1.584										34.199				
6	70	69	-1.589										34.196				
5	69	68	-1.564										34.213				
4	85	84	-1.524			62.5	2.58	37.5	0.10				34.235				
3	85	84	-1.531										34.233				
2	85	84	-1.513										34.237				
1	86	84	-1.515										34.236				

St.	St.11		Date	Dec.20.1994		Lat.	64°40.31'S				Depth	2982	(m)				
BCTD-1			Time(GMT	23:06-23:38		Long.	139°57.17'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	0.0		8.05	47.4	2.34	33.4	0.35	7.836	2.330	0.12		2	-0.731	33.574	26.987
24														10	-0.941	33.588	27.006
23	11	11	-1.083		8.03	47.6	2.29	33.5	0.31	7.833	2.330	0.15	33.610	20	-1.131	33.645	27.060
22														30	-1.477	33.752	27.158
21	19	19	-1.212		7.98	48.2	2.29	33.7	0.27	7.826	2.337	0.14	33.645	50	-1.680	34.019	27.380
20	29	29	-1.497		7.87	49.4	2.23	34.2	0.23	7.823	2.344	0.19	33.779	75	-1.680	34.172	27.505
19	50	50	-1.722		7.10	58.5	2.39	36.5	0.15	7.790	2.362	0.44	34.087	100	-1.303	34.273	27.575
18														125	-0.762	34.377	27.639
17	74	73	-1.675			61.7	2.38	37.6	0.11	7.772	2.368	0.34	34.178	150	-0.461	34.434	27.672
16														175	-0.069	34.505	27.710
15	99	98	-1.310		6.59	66.4	2.50	38.0	0.04	7.763	2.375	0.12	34.279	200	0.118	34.540	27.728
14	124	123	-0.716		6.16	72.9	2.55	38.4	0.01	7.755	2.386	0.06	34.392	300	0.995	34.662	27.774
13	149	147	-0.327		6.04	79.2	2.57	38.6	0.00	7.748	2.381	0.03	34.461	500	1.175	34.710	27.801
12																	
11	173	171	-0.045		5.65	87.2	2.59	38.7	0.00	7.745	2.393	0.01	34.510				
10																	
9	198	196	0.225		5.40	91.1	2.57	40.6	0.00	7.742	2.400	0.01	34.558				
8																	
7																	
6																	
5																	
4	504	498	1.153		4.77	108.7	2.57	38.6	0.00	7.745	2.413		34.709				
3																	
2																	
1																	

St.	St.11		Date	Dec.25.1994		Lat.	64°32.47'S				Depth	3389	(m)				
SCTD-1			Time(GMT	10:10-12:31		Long.	140°19.96'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.2											2	-0.373	33.616	27.006
24														10	-0.431	33.616	27.009
23														20	-0.482	33.619	27.014
22	3384	3324	-0.399										34.654	30	-1.275	33.768	27.165
21	2997	2947	-0.123										34.677	50	-1.593	33.999	27.361
20	1998	1969	0.255										34.685	75	-1.684	34.173	27.505
19	1499	1479	0.546										34.696	100	-1.553	34.254	27.568
18	999	987	0.878										34.707	125	-1.280	34.308	27.603
17	749	740	1.062										34.712	150	-1.122	34.373	27.650
16	499	494	1.163										34.703	175	-1.040	34.408	27.675
15	199	197	-0.035										34.511	200	-0.766	34.449	27.697
14	150	148	-1.324										34.369	300	1.015	34.653	27.765
13	98	97	-1.472										34.259	500	1.163	34.700	27.793
12	61	60	-1.663										34.130	750	1.064	34.712	27.810
11	60	59	-1.663										34.116	1000	0.898	34.709	27.818
10	60	59	-1.659										34.104	1250	0.649	34.696	27.823
9	61	60	-1.658										34.105	1500	0.522	34.691	27.827
8	59	58	-1.656										34.100	2000	0.267	34.685	27.838
7	60	59	-1.655										34.097	2500	0.065	34.681	27.845
6	60	59	-1.653										34.093	3000	-0.118	34.676	27.851
5	30	30	-1.375										33.787				
4	19	19	-0.678										33.643				
3	9	9	-0.394										33.615				
2																	
1																	

St.	St.11		Date	Dec.26.1994		Lat.	64°41.25'S				Depth	2988	(m)				
CTD40-1			Time(GMT	01:04-01:46		Long.	140°08.32'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0		0	0.000			40.5	2.01	28.7	0.23					2	-0.622	33.640	27.036
24	303	300	0.925			83.6	2.35	33.4	0.00				34.655	10	-0.620	33.640	27.036
23	304	301	0.940										34.657	20	-0.626	33.640	27.036
22	250	247	0.416			80.4	2.35	33.4	0.00				34.597	30	-1.571	33.898	27.279
21	250	247	0.416										34.595	50	-1.742	34.136	27.477
20	200	198	0.123			75.4	2.35	33.3	0.01				34.534	75	-1.727	34.202	27.530
19	200	198	0.130										34.534	100	-1.685	34.285	27.596
18	85	84	-1.731			53.9	2.27	32.4	0.09				34.221	125	-1.671	34.336	27.637
17	85	84	-1.733										34.219	150	-1.484	34.359	27.651
16	70	69	-1.718			53.1	2.29	32.4	0.11				34.191	175	-0.244	34.474	27.694
15	70	69	-1.745										34.185	200	0.213	34.537	27.721
14	55	54	-1.706			51.2	2.23	31.6	0.12				34.118	300	1.133	34.674	27.774
13	55	54	-1.705										34.116				
12	39	39	-1.627			45.5	2.08	29.9	0.12				33.996				
11	40	40	-1.628										34.001				
10	26	26	-1.441			41.9	1.97	29.2	0.16				33.769				
9	25	25	-0.810										33.660				
8	150	148	-1.727			62.0	2.22	32.0	0.01				34.352				
7	150	148	-1.730										34.350				
6	124	123	-1.613			59.3	2.24	32.2	0.02				34.320				
5	124	123	-1.604										34.320				
4	9	9	-0.627			40.5	1.93	28.5	0.22				33.641				
3	9	9	-0.624										33.641				
2	100	99	-1.711			56.6	2.26	31.6	0.08				34.253				
1	100	99	-1.716										34.254				

St.No. St.13 CTD13D
Date Dec.21.1994
Time(GMT) 09:44-10:13
Lat. 64°19.98'S
Long. 139°59.65'E
Depth 3458m

CTD DOWN CAST

P db	T °C	S psu	Sigma-T
2	-0.049	33.582	26.964
10	-0.058	33.584	26.966
20	-0.924	33.725	27.117
30	-1.098	33.885	27.253
50	-1.523	34.083	27.428
75	-0.985	34.257	27.551
100	0.467	34.443	27.631
125	1.028	34.531	27.666
150	1.480	34.598	27.689
175	1.597	34.628	27.705
200	1.608	34.639	27.712
300	1.589	34.675	27.743
500	1.641	34.722	27.777

St.No. St.15 CTD5002
Date Dec.26.1994
Time(GMT) 12:01-12:30
Lat. 64°49.84'S
Long. 139°59.84'E
Depth 2710m

CTD DOWN CAST

P db	T °C	S psu	Sigma-T
2	-0.709	33.603	27.010
10	-0.704	33.604	27.011
20	-1.431	33.821	27.212
30	-1.550	33.879	27.263
50	-1.730	34.116	27.460
75	-1.608	34.222	27.543
100	-1.005	34.355	27.631
125	-0.559	34.435	27.677
150	-0.468	34.479	27.709
175	-0.059	34.530	27.730
200	0.182	34.561	27.742
300	0.949	34.667	27.781
500	1.101	34.709	27.805

St.No. St.16 CTD5003
Date Dec.26.1994
Time(GMT) 14:58-15:25
Lat. 64°39.89'S
Long. 140°00.28'E
Depth 2496m

CTD DOWN CAST

P db	T °C	S psu	Sigma-T
2	-0.530	33.628	27.023
10	-0.551	33.628	27.024
20	-1.438	33.814	27.206
30	-1.578	33.867	27.254
50	-1.625	33.993	27.358
75	-1.727	34.168	27.502
100	-1.768	34.277	27.592
125	-1.549	34.338	27.636
150	-1.635	34.365	27.660
175	-0.929	34.408	27.671
200	-0.806	34.462	27.709
300	0.629	34.623	27.766
500	1.067	34.698	27.798

St.No. St.17 CTD5004
Date Dec.26.1994
Time(GMT) 17:55-18:33
Lat. 64°29.93'S
Long. 140°00.78'E
Depth 3218m

CTD DOWN CAST

P db	T °C	S psu	Sigma-T
2	-0.176	33.576	26.965
10	-0.173	33.576	26.965
20	-1.042	33.756	27.147
30	-1.450	33.861	27.245
50	-1.648	34.049	27.404
75	-1.605	34.165	27.497
100	-1.460	34.281	27.587
125	-1.710	34.322	27.627
150	-1.787	34.352	27.654
175	-1.618	34.375	27.668
200	-0.841	34.430	27.686
300	0.187	34.563	27.744
500	1.256	34.705	27.791

St.	St.13		Date	Dec.23.1994		Lat.	64°19.74'S				Depth	3455	(m)				
BCTD-2			Time(GMT	13:05-14:03		Long.	139°59.05'E								CTD	DOWN	CAST
Bottle No.	P db	Depth m	T °C	S psu	O2 ml/L	SiO2 µM	PO4 µM	NO3 µM	NO2 µM	pH	Alk meq/L	Chl-a µg/L	CTD(S) PSU	P db	T °C	S psu	Sigma-T
0	0	0	-0.1		7.98	37.9	1.92	27.8	0.26	7.859	2.378	0.05		2	-0.183	33.558	26.951
24														10	-0.199	33.562	26.955
23	10	10	-0.199		8.03	38.5	1.98	28.6	0.24	7.858	2.341	0.06	33.562	20	-0.948	33.709	27.105
22														30	-1.215	33.887	27.259
21	20	20	-0.948		7.97	39.3	2.01	28.4	0.19	7.850	2.344	0.08	33.709	50	-0.612	34.207	27.495
20	30	30	-1.215		7.37	45.6	2.12	29.9	0.13	7.828	2.365	0.14	33.887	75	0.745	34.430	27.603
19	50	50	-0.612		6.61	53.5	2.28	31.8	0.10	7.796	2.384	0.44	34.207	100	1.590	34.573	27.661
18														125	1.720	34.598	27.672
17	75	74	0.745		4.48	70.7	2.48	35.2	0.06	7.711	2.402	0.47	34.430	150	1.790	34.622	27.685
16														175	1.830	34.636	27.693
15	100	99	1.590		4.26	74.2	2.57	35.3	0.05	7.715	2.405	0.09	34.573	200	1.920	34.655	27.702
14	125	124	1.720		4.16	76.0	2.55	35.4	0.04	7.723	2.408	0.04	34.598	300	1.870	34.684	27.729
13	150	148	1.790		4.44	77.0	2.52	35.1	0.03	7.721	2.406	0.03	34.622	500	1.730	34.709	27.759
12																	
11	175	173	1.830		4.28	78.2	2.49	34.9	0.03	7.721	2.409	0.01	34.636				
10																	
9	200	198	1.920		4.24	77.9	2.48	34.3	0.02	7.760	2.410	0.01	34.655				
8																	
7																	
6																	
5																	
4	500	495	1.730		4.46	83.7	2.34	32.6	0.01	7.763	2.419		34.709				
3																	
2																	
1																	

St.	St.13		Date	Dec.23.1994		Lat.	64°18.68'S				Depth	3474	(m)				
CTD60-2			Time(GMT	17:17-17:44		Long.	139°58.24'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	μM	μM	μM	μM		meq/L	μg/L	PSU	db	°C	psu	
0	0	0	0.1			37.1	1.93	28.0	0.27					2	0.013	33.582	1.980
24	9	9	-0.026			37.5	1.91	27.8	0.27				33.581	10	0.019	33.582	1.870
23	9	9	-0.030										33.581	20	-0.344	33.693	1.850
22	10	10	-0.030										33.581	30	-1.135	33.847	1.900
21	9	9	-0.040										33.577	50	-1.388	34.149	1.830
20	26	26	-0.899			36.7	1.94	27.9	0.18				33.747	75	0.253	34.413	1.580
19	25	25	-0.899										33.744				
18	25	25	-0.926										33.752				
17	25	25	-1.056										33.802				
16	40	40	-1.453			43.9	2.07	29.9	0.12				34.042				
15	39	39	-1.383										34.035				
14	39	39	-1.445										34.052				
13	39	39	-1.491										34.074				
12	54	53	-1.419			53.5	2.05	32.4	0.10				34.216				
11	54	53	-1.409										34.218				
10	54	53	-1.392										34.221				
9	54	53	-1.346										34.231				
8	71	70	-0.054			63.0	2.42	33.1	0.10				34.382				
7	69	68	-0.218										34.373				
6	69	68	-0.053										34.384				
5	70	69	-0.038										34.399				
4	85	84	0.984			70.3	2.56	35.2	0.11				34.500				
3	85	84	1.017										34.504				
2	85	84	1.057										34.507				
1	86	85	1.051										34.510				

St.	St.13		Date	Dec.24.1994		Lat.	64°20.80'S				Depth	3432	(m)				
BCTD-3			Time(GMT	00:02-01:05		Long.	139°57.88'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	μM	μM	μM	μM		meq/L	μg/L	PSU	db	°C	psu	
0	0	0	0.4		7.98	39.7	1.91	28.1	0.25	7.855	2.339	0.05		2			
24	9	9	-0.336		8.00	40.2	1.92	28.5	0.24	7.853	2.336	0.06	33.597	10	-0.432	33.591	26.989
23	10	10	-0.308										33.594	20	-0.838	33.667	27.067
22	10	10	-0.360										33.593	30	-1.175	33.976	27.330
21	20	20	-0.626		7.83	41.4	1.97	29.0	0.19	7.847	2.348	0.09	33.608	50	-0.036	34.387	27.613
20	30	30	-1.173		7.20	49.9	2.15	30.6	0.11	7.821	2.374	0.10	34.002	75	1.381	34.563	27.668
19	51	50	-0.088		5.85	63.3	2.34	33.2	0.08	7.771	2.389	0.23	34.353	100	1.706	34.612	27.683
18	50	50	-0.155										34.364	125	1.765	34.632	27.695
17	76	75	1.356		4.42	74.5	2.54	35.7	0.08	7.724	2.402	0.23	34.557	150	1.819	34.650	27.705
16	75	74	1.370										34.559	175	1.835	34.663	27.715
15	102	101	1.702		4.15	78.0	2.55	35.6	0.06	7.718	2.404	0.09	34.612	200	1.813	34.673	27.724
14	124	123	1.764		4.12	78.3	2.54	35.7	0.04	7.711	2.413	0.06	34.631	300	1.778	34.699	27.748
13	151	149	1.819		4.10	80.2	2.52	35.0	0.01	7.727	2.407	0.02	34.650	500	1.683	34.727	27.778
12	151	149	1.820										34.650	509	1.691	34.729	27.778
11	174	172	1.833		4.17	80.8	2.50	35.0	0.00	7.719	2.407	0.01	34.662				
10	175	173	1.833										34.662				
9	202	200	1.816		4.24	82.1	2.47	34.9	0.01	7.728	2.409	0.01	34.673				
8	202	200	1.815										34.673				
7	202	200	1.814										34.673				
6	201	199	1.823										34.673				
5	200	198	1.824										34.673				
4	509	503	1.690		4.45	87.4	2.33	33.0	0.00	7.751	2.417		34.729				
3	508	502	1.691										34.729				
2	508	502	1.691										34.729				
1	509	503	1.693										34.729				

St.	St.13		Date	Dec.24.1994		Lat.	64°22.08'S				Depth	3421	(m)				
CTD13(BCTD-4)			Time(GMT	23:03-01:32		Long.	140°00.09'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.1	33.612	7.97	38.2	1.98	28.1	0.26	7.853	2.336	0.06		2	-0.278	33.604	2.010
24	8	8	-0.234	33.613	7.94	38.0	1.94	28.2	0.24	7.844	2.337	0.05	33.609	10	-0.285	33.605	1.960
23	18	18	-0.529	33.868	7.90	39.4	2.00	28.6	0.14	7.841	2.353	0.10	33.656	20	-0.289	33.605	1.950
22	30	30	-1.374	33.999	7.84	40.1	2.03	29.0	0.10	7.840	2.363	0.12	33.973	30	-0.936	33.758	1.960
21	49	49	-1.580	34.120	7.35	46.1	2.18	30.3	0.11	7.809	2.370	0.19	34.104	50	-1.440	34.115	1.950
20	74	73	0.303	34.391	5.56	61.7	2.45	33.7	0.10	7.736	2.389	0.56	34.385	75	0.380	34.408	1.630
19	99	98	0.915	34.500	4.81	69.2	2.53	34.6	0.09	7.715	2.395	0.10	34.500	100	1.459	34.571	1.350
18	124	123	1.601	34.594	4.30	74.4	2.56	35.2	0.03	7.714	2.402	0.04	34.601	125	1.425	34.588	1.230
17	149	147	1.539	34.649	4.33	76.1	2.53	35.3	0.03	7.716	2.397	0.02	34.618	150	1.602	34.626	1.160
16	173	171	1.698	34.650	4.28	76.5	2.57	35.3	0.02	7.713	2.406	0.01	34.649	175	1.579	34.634	1.150
15	198	196	1.818	34.674	4.23	77.2	2.47	34.4	0.01	7.723	2.409	0.01	34.673	200	1.409	34.630	1.160
14	299	296	1.658	34.694	4.36	78.9	2.20	33.9	0.00	7.725	2.408	0.01	34.689	300	1.710	34.695	1.110
13	499	494	1.548	34.720	4.49	83.0	2.40	32.9	0.00	7.751	2.411		34.719	500	1.611	34.726	1.160
12	748	739	1.422	34.739	4.65	89.3	2.37	32.8	0.01	7.762	2.418		34.733	750	1.416	34.733	1.210
11	999	987	1.174	34.728	4.44	97.1	2.36	32.9	0.01	7.761	2.421		34.727	1000	1.184	34.727	1.260
10	1249	1233	1.011	34.718	4.74	102.6	2.37	33.2	0.00	7.763			34.721	1250	1.002	34.720	1.330
9	1500	1480	0.830										34.710	1500	0.849	34.711	1.380
8	1749	1725	0.626	34.693	4.99	110.5	2.41	34.3	0.01	7.743	2.426		34.700	2000	0.398	34.689	1.530
7	1999	1970	0.408	34.689	4.95	114.5	2.47	33.8	0.01	7.754	2.423		34.690	2500	0.132	34.682	1.680
6	2248	2214	0.256	34.682	5.07	115.3	2.45	34.2	0.00	7.745	2.421		34.685	3000	-0.102	34.676	1.860
5	2498	2459	0.130	34.681	5.13	116.2	2.45	34.4	0.00	7.746	2.423		34.682				
4	2749	2705	-0.011	34.673	5.40	109.1	2.41	33.9	0.00	7.749	2.418		34.677				
3	2999	2949	-0.108	34.674	5.39	112.2	2.43	34.2	0.00	7.750	2.420		34.676				
2	3248	3192	-0.208	34.671	5.34	107.4	2.42	34.0	0.00	7.763	2.420		34.672				
1	3413	3353	-0.285	34.660	5.64	98.6	2.36	33.7	0.00	7.758	2.418		34.665				

St.	St.14		Date	Dec.26.1994		Lat.	65°05.74'S				Depth	2947	(m)				
CTD5001			Time(GMT	06:55-07:38		Long.	139°59.79'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.9		7.84	44.4	1.94	29.1	0.18	7.842	2.344	0.39		2	-1.087	33.739	27.135
24														10	-1.222	33.742	27.141
23	9	9	-1.246		7.83	44.6	1.85	28.4	0.16	7.849	2.342	0.37	33.739	20	-1.305	33.745	27.147
22														30	-1.660	34.036	27.393
21	19	19	-1.665		7.36	48.8	1.92	29.5	0.07	7.832	2.368	0.51	34.042	50	-1.756	34.191	27.522
20	29	29	-1.766		7.23	51.4	2.13	30.4	0.11	7.815	2.379	0.48	34.235	75	-1.763	34.293	27.606
19	49	49	-1.787		7.23	54.0	2.10	30.5	0.14	7.812	2.376	0.77	34.274	100	-1.807	34.319	27.627
18														125	-1.781	34.349	27.651
17	74	73	-1.809		7.16	55.3	2.11	30.6	0.14	7.817	2.407	0.27	34.305	150	-1.651	34.375	27.669
16														175	-1.551	34.394	27.681
15	100	99	-1.801		7.19	56.9	2.09	32.1	0.14	7.812	2.389	0.10	34.328	200	-1.464	34.412	27.693
14	123	122	-1.765										34.350	300	-0.380	34.521	27.738
13	149	147	-1.638										34.373	500	0.894	34.693	27.806
12																	
11	174	172	-1.590		7.01	62.6	2.14	32.9	0.07	7.797		0.01	34.389				
10																	
9	199	197	-1.438		6.76	65.7	2.16	32.7	0.07	7.800	2.387	0.01	34.417				
8																	
7	249	246	-1.009							7.793	2.391		34.463				
6																	
5	300	297	-0.477		6.02	73.4	2.27	32.2	0.04	7.777	2.391	0.01	34.516				
4	504	498	0.923		4.84	92.0	2.32	32.6	0.00	7.763	2.413		34.696				
3																	
2																	
1																	

St.	St.18		Date	Dec.26.1994		Lat.	64°19.94'S				Depth	3465	(m)				
CTD5005			Time(GMT	21:01-21:47		Long.	140°00.64'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	0.4	33.709	7.95	32.2	1.79	27.8	0.26			0.21		2	0.284	33.742	27.076
24														10	0.555	33.845	27.144
23	9	9	0.200	33.726	8.04	30.4	1.66	27.2	0.25			0.22	33.716	20	0.545	33.871	27.165
22	11	11	0.389										33.771	30	-0.261	33.912	27.241
21	9	9	0.360										33.761	50	-1.368	34.111	27.446
20	20	20	0.547	33.863	7.96	22.7	1.59	26.0	0.21			0.77	33.855	75	-0.111	34.344	27.582
19	26	26	0.450			22.9	1.60	26.2	0.20				33.864	100	1.105	34.527	27.658
18														125	1.462	34.581	27.676
17	30	30	-0.456	33.913	8.29	26.3	1.79	27.1	0.17			1.43	33.904	150	1.675	34.627	27.698
16	40	40	-0.462			28.5	1.88	28.2	0.17				33.949	175	1.669	34.640	27.709
15	41	41	-0.432										33.939	200	1.685	34.651	27.717
14	51	50	-1.208	34.126	7.62	45.6	2.26	30.9	0.13			0.51	34.118	300	1.718	34.688	27.743
13	54	53	-1.171			46.2	2.25	30.9	0.12				34.137	500	1.598	34.717	27.776
12	53	52	-1.135										34.151				
11	71	70	-0.553			57.3	2.36	33.0	0.12				34.295				
10	77	76	-0.138	34.355	5.97	60.7	2.41	33.7	0.13			0.21	34.356				
9	86	85	0.236			66.7	2.49	35.3	0.16				34.430				
8																	
7																	
6	100	99	1.496	34.570	4.32	72.8	2.56	36.6	0.09			0.05	34.570				
5	124	123	1.630	34.613	4.20	74.3	2.54	36.0	0.06			0.03	34.608				
4	151	149	1.636	34.628	4.20	76.0	2.52	36.1	0.04			0.03	34.623				
3	175	173	1.687	34.635	4.18	76.0	2.51	36.1	0.03			0.02	34.636				
2	201	199	1.731	34.655	4.20	76.9	2.42	36.2	0.03			0.01	34.656				
1	500	495	1.712	34.730	4.40	82.5	2.29	33.9	0.03				34.730				

94-4 (St.19)

St.No. St.19 CTD5006
Date DEC.27.1994
Time(GMT) 03:36-03:49
Lat. 64°10.21'S
Long. 140°00.41'E
Depth 3618m

	CTD	DOWN	CAST
P	T	S	Sigma-T
db	°C	psu	
2	0.740	33.557	26.901
10	0.722	33.614	26.948
20	0.721	33.638	26.967
30	0.721	33.668	26.991
50	0.096	34.057	27.340
75	-0.569	34.038	27.356
100	-0.222	33.698	27.066
125	0.579	33.424	26.804
150	1.032	33.365	26.729
175	1.244	33.465	26.796
200	1.445	33.464	26.781
300	1.640	34.012	27.207
500	1.786	34.571	27.645

St.	St.20		Date	Dec.27.1994		Lat.	64°00.65'S				Depth	3690	(m)				
CTD-20			Time(GMT	06:45-10:29		Long.	139°56.95'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	1.1	33.961	8.06	25.0	1.67	25.3	0.24	7.890	2.352	0.18		2	0.962	33.689	26.993
24	8	8	0.783	33.850	8.16	23.1	1.60	25.1	0.22	7.890	2.360	0.45	33.847	5	0.968	33.687	26.992
23	18	18	0.336	33.925	8.19	21.4	1.65	25.4	0.21	7.885	2.366	0.69	33.899	10	0.964	33.685	26.990
22	28	28	-0.200	33.962	8.21	22.6	1.78	26.6	0.17	7.875	2.363	1.07	33.942	20	0.886	33.764	27.059
21	49	49	-0.259	34.231	6.17	51.2	2.41	32.7	0.13	7.773	2.377	0.49	34.216	30	0.130	33.930	27.236
20	74	73	1.434	34.503	4.28	66.1	2.65	36.0	0.04	7.706	2.397	0.05	34.469	50	-0.443	33.948	27.278
19	100	99	1.764	34.547	4.13	70.0	2.65	36.3	0.03	7.710	2.397	0.01	34.556	75	-0.371	34.243	27.513
18	123	122	1.877	34.609	4.03	71.9	2.61	35.7	0.02	7.696	2.402	0.01	34.608	100	1.369	34.504	27.622
17	148	147	1.939	34.628	4.07	73.4	2.57	35.3	0.02	7.699	2.420	0.01	34.635	150	1.705	34.594	27.669
16	176	174	1.950	34.649	4.06	73.8	2.53	35.2	0.02	7.694	2.409	0.01	34.648	200	1.909	34.646	27.695
15	197	195	1.923	34.663	4.10	74.7	2.51	34.9	0.01	7.721	2.411	0.01	34.663	300	1.826	34.674	27.724
14	298	295	1.901	34.702	4.21	77.2	2.42	33.4	0.01	7.728	2.420	0.00	34.701	400	1.713	34.682	27.739
13	498	493	1.775	34.723		80.1	2.36	32.3	0.00	7.743	2.415		34.724	500	1.662	34.695	27.754
12	747	738	1.562	34.740	4.57	86.0	2.31	32.0	0.00	7.757	2.421		34.740	600	1.614	34.704	27.765
11	997	985	1.337	34.735	4.65	92.7	2.32	32.0	0.00	7.761	2.424		34.735	800	1.479	34.714	27.782
10	1246	1230	1.083	34.724	4.70	100.7	2.36	33.1	0.00	7.754	2.429		34.724	1000	1.293	34.709	27.791
9	1497	1477	0.873	34.711	4.75	106.3	2.39	32.9	0.00	7.758	2.424		34.714	1500	0.869	34.691	27.806
8	1746	1722	0.684	34.704		111.6	2.42	33.3	0.00	7.753	2.430		34.704	2000	0.528	34.674	27.813
7	1999	1970	0.501	34.694	4.88	114.9	2.43	33.5	0.00	7.765	2.429		34.695	2500	0.221	34.661	27.820
6	2498	2459	0.194	34.676	5.12	116.8	2.43	33.8	0.00	7.765	2.425		34.682	3000	0.010	34.655	27.827
5	2747	2703	0.099	34.678	5.24	114.7	2.42	33.8	0.00	7.764	2.426		34.679	3500	-0.190	34.648	27.832
4	2998	2948	-0.010	34.674	5.31	116.8	2.42	33.5	0.00	7.760	2.422		34.677				
3	3247	3191	-0.121	34.676		111.6	2.40	33.5	0.00	7.753	2.424		34.673				
2	3499	3437	-0.211	34.666	5.51	108.6	2.39	33.1	0.00	7.769	2.422		34.669				
1	3668	3601	-0.398	34.650	5.77	96.7	2.34	32.7	0.00	7.759	2.419		34.652				

St.	St.21		Date	Dec.27.1994		Lat.	63°00.25'S				Depth	3787	(m)				
CTD-21			Time(GMT	16:17-17:51		Long.	140°00.30'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	1.0									0.53		2	0.903	33.725	27.027
24	8	8	1.044									0.57	33.750	10	0.900	33.725	27.026
23	20	20	1.005									0.62	33.745	20	0.704	33.744	27.054
22	29	29	-0.236									1.05	33.797	30	-0.081	33.804	27.145
21	50	50	-0.928									1.00	34.144	50	-1.435	34.089	27.430
20	76	75	1.310									0.30	34.462	75	1.428	34.448	27.572
19	98	97	1.780									0.06	34.542	100	1.735	34.528	27.614
18	124	123	1.703									0.04	34.566	125	1.932	34.581	27.641
17	148	147	1.814									0.04	34.598	150	1.973	34.607	27.659
16	174	172	1.845									0.03	34.621	175	1.839	34.617	27.678
15	198	196	1.887									0.01	34.633	200	1.791	34.627	27.689
14	300	297	1.821									0.01	34.672	300	1.888	34.681	27.725
13														500	1.773	34.715	27.761
12														750	1.659	34.737	27.787
11														1000	1.456	34.736	27.802
10														1250	1.243	34.730	27.812
9														1500	1.033	34.720	27.818
8																	
7																	
6																	
5																	
4																	
3																	
2																	
1																	
	fail in an analysis of nutrient																

St.	St.22		Date	Dec.28.1994		Lat.	62°00.37'S				Depth	4246	(m)				
CTD40-2			Time(GMT	00:48-01:30		Long.	140°00.56'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	1.5											2	1.349	33.762	27.027
24	304	301	2.114										34.573	10	1.259	33.767	27.037
23	250	247	2.116										34.540	20	1.252	33.778	27.046
22														30	0.970	33.822	27.100
21	201	199	2.066										34.503	50	0.800	33.831	27.118
20	148	147	1.711										34.407	75	-1.121	33.953	27.309
19	125	124	1.229										34.332	100	-0.821	34.044	27.372
18														125	1.317	34.330	27.485
17	98	97	-0.908										34.039	150	1.768	34.419	27.524
16	72	71	-1.143										33.938	175	1.936	34.459	27.543
15	70	69	-1.126										33.935	200	2.072	34.506	27.570
14	51	51	0.629										33.826	300	2.120	34.572	27.619
13	49	49	0.662										33.831				
12																	
11	39	39	0.850										33.832				
10	40	40	0.906										33.834				
9	31	31	0.932										33.828				
8	19	19	1.224										33.781				
7																	
6																	
5																	
4	10	10	1.227										33.765				
3	11	11	1.228										33.764				
2																	
1																	
	fail in an analysis of nutrient																

St.	St.22		Date	Dec.28.1994		Lat.	62°02.14'S				Depth	4217	(m)				
CTD-22			Time(GMT	3:06-05:54		Long.	140°01.75'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	1.6	33.760	7.92	22.7	1.70	25.4	0.18	7.899	2.347	0.10		2	1.501	33.735	26.995
24	9	9	1.222	33.755	7.39	22.2	1.71	25.6	0.17	7.915	2.348	0.16	33.755	5	1.530	33.736	26.994
23	19	19	1.207	33.763	8.02	21.9	1.71	25.6	0.16	7.903	2.347	0.18	33.756	10	1.241	33.738	27.015
22	29	29	0.854	33.772	8.30	21.9	1.73	26.3	0.14	7.905	2.348	0.42	33.768	20	1.225	33.741	27.018
21	50	50	-0.283	33.841	8.39	23.7	1.83	27.3	0.11	7.892	2.350	0.99	33.846	30	1.044	33.767	27.051
20	74	73	-1.157	33.944	8.02	31.2	2.11	29.7	0.15	7.846	2.356	0.60	33.948	50	0.809	33.810	27.100
19	100	99	-0.994	34.040	7.25	38.7	2.27	32.3	0.19	7.802	2.362	0.11	34.026	75	-1.186	33.929	27.292
18	124	123	0.239	34.242	5.61	52.6	2.51	35.4	0.08	7.739	2.377	0.05	34.204	100	-0.903	34.014	27.350
17	148	147	1.578	34.379	4.72	61.4	2.64	37.3	0.03	7.720	2.380	0.02	34.379	150	1.722	34.381	27.497
16	174	172	1.880	34.440	4.30	66.8	2.67	37.7	0.01	7.720	2.392	0.01	34.449	200	2.050	34.465	27.539
15	199	197	2.021	34.495	4.12	69.7	2.66	37.4	0.00	7.697	2.392	0.01	34.492	300	2.101	34.557	27.609
14	300	297	2.065	34.581	4.00	75.4	2.59	36.7	0.01	7.702	2.400		34.579	400	2.147	34.615	27.651
13	499	494	2.087	34.672	4.10	79.4	2.46	34.9	0.00	7.718	2.407		34.670	500	2.100	34.648	27.682
12	749	740	1.941	34.723	4.32	82.6	2.35	33.8	0.01	7.745	2.413		34.721	600	2.066	34.674	27.705
11	999	987	1.772	34.740	4.48	86.8	2.31	33.2	0.01				34.739	800	1.938	34.704	27.739
10	1248	1232	1.569	34.742	4.58	92.8	2.30	32.7	0.02				34.741	1000	1.795	34.717	27.761
9	1499	1430	1.359	34.734	4.65	98.7	2.32	33.0	0.01	7.761	2.421		34.735	1500	1.364	34.713	27.789
8	1749	1725	1.172	34.726	4.71	104.1	2.34	33.5	0.01	7.754	2.423		34.726	2000	0.984	34.695	27.802
7	1998	1969	0.985	34.717	4.82	114.2	2.36	33.7	0.01	7.776	2.423		34.718	2500	0.633	34.678	27.810
6	2498	2459	0.611	34.697	4.90	119.3	2.42	34.3	0.00	7.771	2.428		34.699	3000	0.318	34.664	27.817
5	2999	2949	0.292	34.683	5.05	124.0	2.43	34.6	0.01	7.760	2.426		34.685	3500	0.120	34.658	27.824
4	3498	3436	0.104	34.679	5.28	125.1	2.43	34.4	0.01	7.758	2.424		34.680	4000	-0.080	34.653	27.831
3	3748	3680	-0.029	34.675	5.33	120.5	2.41	34.2	0.01	7.744	2.425		34.677				
2	3996	3921	-0.086	34.672	5.44	116.0	2.41	34.4	0.01	7.743	2.420		34.675				
1	4235	4153	-0.129	34.671	5.48	114.4	2.40	34.2	0.01	7.746	2.426		34.671				

St.	St.23		Date	Dec.28.1994		Lat.	60°59.39'S				Depth	4397	(m)				
CTD-23			Time(GMT	11:14-12:41		Long.	139°59.78'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0		0	1.6			18.7	1.68	27.4	0.26			0.11		2	1.466	33.855	27.094
24														5	1.460	33.856	27.095
23	19	19	1.432			18.7	1.73	27.8	0.25			0.12	33.875	10	1.454	33.856	27.095
22	29	29	1.222			18.8	1.72	27.6	0.25			0.13	33.877	20	1.446	33.857	27.096
21	47	47	0.873			18.6	1.77	27.8	0.22			0.20	33.876	30	1.177	33.859	27.117
20	71	70	0.395			20.5	1.80	28.4	0.22			0.56	33.920	50	0.723	33.867	27.151
19	98	97	-0.555			27.2	2.03	29.6	0.20			0.19	33.944	75	0.272	33.891	27.196
18	124	123	-1.143			33.3	2.14	30.7	0.17			0.19	33.974	100	-0.476	33.919	27.256
17	150	149	0.293			49.5	2.46	35.4	0.13			0.06	34.184	150	-0.018	34.099	27.380
16	172	170	1.522			59.0	2.58	37.1	0.05			0.03	34.370	200	1.780	34.389	27.499
15	297	294	2.068										34.531	300	2.090	34.513	27.574
14	298	295	2.067			113.2	2.41	33.8	0.01			0.01	34.530	400	2.143	34.583	27.626
13	200	198	1.776			65.8	3.47	36.9	0.03			0.01	34.418	500	2.109	34.627	27.665
12														600	2.052	34.654	27.691
11														800	1.988	34.694	27.728
10														1000	1.867	34.712	27.751
9														1500	1.500	34.718	27.784
8																	
7																	
6																	
5																	
4																	
3																	
2																	
1	9	9	1.416			18.6	1.72	27.7	0.25			0.11	33.875				

St.	St.24		Date	Dec.29.1994		Lat.	53°59.48'S				Depth	3325	(m)				
CTD40-3			Time(GMT	20:20-22:19		Long.	140°00.51'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	4.2			0.0	1.59	24.0	0.29					2	3.990	33.865	26.884
24														10	3.999	33.865	26.884
23	251	249	2.674			25.8	2.25	31.6	0.03				34.118	20	4.001	33.865	26.884
22														30	4.005	33.865	26.883
21	201	199	1.764			15.7	2.06	28.4	0.24				33.928	50	3.991	33.865	26.884
20	151	150	2.167			11.8	2.00	27.1	0.26				33.907	75	3.789	33.868	26.907
19	128	127	2.426			11.1	1.97	27.3	0.28				33.914	100	2.917	33.916	27.027
18														125	2.452	33.913	27.065
17	102	101	2.888			8.3	1.92	26.1	0.36				33.918	150	2.169	33.906	27.082
16	77	76	3.781			0.0	1.69	24.7	0.28				33.869	175	2.018	33.918	27.104
15														200	1.772	33.930	27.132
14	48	48	3.994										33.865	300	2.521	34.161	27.257
13														306	2.536	34.164	27.258
12																	
11	3	3	3.988										33.865				
10	41	41	3.989			0.0	1.62	24.3	0.29				33.865				
9	31	31	4.003			0.0	1.63	23.7	0.27				33.866				
8	22	22	4.002			0.0	1.61	23.9	0.28				33.865				
7																	
6																	
5																	
4	6	6	3.997										33.865				
3	12	12	4.000			0.0	1.62	23.9	0.29				33.865				
2																	
1	299	296	2.505			31.3	2.30	32.2	0.01				34.158				

St.	St.25		Date	Dec.31.1994		Lat.	50°02.78'S				Depth	3991	(m)				
CTD-25			Time(GMT	12:40-15:58		Long.	142°47.24'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	9.1	34.368	6.48	3.2	1.18	15.8	0.20	7.978	2.344	0.13		2	8.977	34.440	26.683
24	10	10	8.992	34.449	6.53	3.1	1.18	15.8	0.20	7.988	2.349	0.12	34.445	10	8.993	34.445	26.685
23	20	20	8.978	34.450	6.51	3.2	1.18	15.7	0.20	7.982	2.352	0.13	34.445	20	8.975	34.445	26.687
22	29	29	8.934	34.446	6.49	3.1	1.19	16.1	0.19	7.957	2.354	0.12	34.441	30	8.914	34.441	26.694
21														50	8.864	34.439	26.700
20	73	72	8.848	34.467	6.53	3.1	1.19	16.2	0.19	7.979	2.356	0.13	34.437	75	8.850	34.437	26.701
19	100	99	8.823	34.512	6.37	2.8	1.19	15.9	0.17	7.972	2.353	0.14	34.516	100	8.817	34.507	26.761
18	124	123	8.846	34.627	6.16	2.8	1.19	16.0	0.06	7.975	2.358	0.04	34.618	125	8.852	34.618	26.842
17	150	149	8.609	34.587	6.25	3.2	1.23	16.9	0.06	7.964	2.356	0.03	34.584	150	8.601	34.583	26.855
16	175	173	8.381	34.551	6.20	3.8	1.29	17.9	0.06	7.951	2.353	0.02	34.551	175	8.357	34.548	26.865
15	201	199	7.716	34.442	6.42	3.9	1.37	18.5	0.22	7.945	2.347	0.01	34.439	200	7.714	34.439	26.875
14	298	295	7.040	34.357	6.44	4.5	1.45	20.1	0.05	7.932	2.347	0.01	34.351	300	7.038	34.350	26.902
13	493	488	5.892	34.236	6.19	7.5	1.67	24.1	0.04	7.899	2.345		34.234	500	5.867	34.234	26.964
12	745	737	4.820	34.324	5.01	22.5	2.15	31.1	0.02	7.794	2.357		34.319	750	4.804	34.319	27.157
11	996	985	3.722	34.392	4.44	43.2	2.42	34.4	0.01	7.746	2.376		34.384	1000	3.699	34.386	27.328
10	1244	1230	2.886	34.451	4.21	55.1	2.54	36.5	0.01	7.723	2.392		34.450	1250	2.865	34.452	27.460
9	1496	1478	2.628	34.557	4.02	64.7	2.54	36.2	0.01	7.727	2.398		34.556	1500	2.624	34.558	27.566
8	1745	1723	2.476	34.651	4.09	71.0	2.46	34.8	0.01	7.747	2.417		34.648	2000	2.347	34.703	27.705
7	1993	1967	2.352	34.704	4.17	74.1	2.38	34.2	0.00	7.760	2.411		34.702	2500	2.023	34.746	27.766
6	2249	2218	2.197	34.732	4.34	77.8	2.31	33.2	0.00	7.770	2.414		34.732	3000	1.475	34.733	27.797
5	2500	2464	2.025	34.747	4.46	81.0	2.28	32.7	0.00	7.777	2.418		34.746	3500	1.183	34.721	27.809
4	2998	2951	1.476	34.733	4.52	101.4	2.37	33.8	0.00	7.770	2.435		34.733	3999	1.026	34.712	27.812
3	3497	3439	1.184	34.722	4.64	110.2	2.39	34.0	0.00	7.764	2.438		34.721				
2	3749	3684	1.036	34.715	4.69	114.1	2.41	34.7	0.02	7.773	2.441		34.714				
1	3998	3927	1.026	34.716	4.69	113.8	2.42	34.4	0.00	7.764	2.440		34.712				

St.	St.29		Date	Jan.10.1995		Lat.	48°08.01'S				Depth	2281	(m)				
CTD-26			Time(GMT	07:57-10:01		Long.	146°54.49'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	10.0		6.60	2.9	1.25	15.8		8.002	2.355	0.33		3	9.830	34.408	26.518
24	10	10	9.772		6.64	3.1	1.19	15.4		8.003	2.355	0.32	34.428	5	9.830	34.408	26.518
23	21	21	9.451		6.65	3.0	1.17	15.3		8.006	2.355	0.38	34.432	10	9.798	34.408	26.524
22	30	30	9.329		6.41	3.1	1.13	15.1		8.007	2.358	0.39	34.434	20	9.552	34.414	26.570
21	40	40	9.284		6.65	3.2	1.17	15.2		8.009	2.358	0.42	34.442	30	9.391	34.414	26.596
20	51	51	9.206		6.60	3.0	1.13	15.0		8.009	2.358	0.74	34.460	50	9.240	34.435	26.637
19	76	75	9.169		6.28	2.5	1.12	14.7		7.997	2.360	0.22	34.616	75	9.121	34.568	26.760
18	100	99	9.030		6.23	2.7	1.15	15.2		7.987	2.356	0.04	34.634	100	9.062	34.614	26.806
17	125	124	8.999		6.16	3.1	1.18	15.4		7.983	2.358	0.01	34.635	150	9.028	34.620	26.816
16	150	149	8.996		6.28	3.1	1.20	15.3		7.988	2.358	0.01	34.637	200	8.958	34.610	26.819
15	200	198	8.954		6.19	2.9	1.26	15.9		7.987	2.361	0.03	34.633	300	8.841	34.597	26.828
14	299	296	8.836		6.21	3.3	1.23	16.2		7.983	2.359	0.03	34.622	400	8.566	34.561	26.843
13	500	495	7.684		6.10	5.4	1.53	20.5		7.947	2.352		34.459	500	7.712	34.439	26.876
12	751	743	5.949		5.13	15.8	2.18	29.4		7.846	2.355		34.358	600	7.112	34.378	26.914
11	999	988	4.182		4.74	31.6	2.59	34.8		7.775	2.369		34.354	800	5.293	34.306	27.090
10	1248	1234	3.250		4.40	46.5	2.84	37.6		7.743	2.383		34.404	1000	4.324	34.345	27.231
9														1500	2.684	34.501	27.515
8	1748	1726	2.533		4.03	65.2	2.79	37.4		7.747	2.405		34.614	2000	2.418	34.659	27.664
7	2004	1978	2.411		4.17	68.1	2.67	36.4					34.678				
6	2257	2226	2.154		4.27	76.6	2.64	35.4		7.769	2.420		34.728				
5																	
4																	
3																	
2																	
1																	
	This station`s samples were frozen																

St.	St.30		Date	Jan.10.1995		Lat.	50°00.63'S				Depth	4637	(m)				
CTD40-4			Time(GMT	18:40-19:31		Long.	145°30.06'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	9.4					16.0	0.20					3	9.163	34.324	26.562
24														5	9.162	34.324	26.562
23	6	6	9.111					16.0	0.22				34.312	10	9.159	34.322	26.562
22	300	297	7.590					19.9	0.05				34.415	20	9.157	34.322	26.562
21	6	6	9.107										34.311	30	9.118	34.319	26.566
20	6	6	9.108										34.311	50	8.894	34.320	26.603
19	6	6	9.114										34.311	75	8.936	34.379	26.642
18	251	249	7.911					18.8	0.05				34.457	100	8.833	34.400	26.675
17	6	6	9.109										34.311	150	8.116	34.445	26.820
16	200	198	8.064					17.7	0.09				34.470	200	8.047	34.466	26.847
15	6	6	9.112										34.312	300	7.505	34.397	26.873
14	152	151	8.054					17.0	0.61				34.455	400	6.631	34.284	26.905
13	6	6	9.110										34.312	500	6.326	34.290	26.950
12	125	124	8.773					16.1	0.30				34.432				
11	6	6	9.112										34.311				
10	100	99	8.851					16.1	0.23				34.408				
9	74	73	8.891					15.9	0.20				34.398				
8	50	50	8.874					16.5	0.21				34.322				
7	40	40	8.919					16.3	0.21				34.309				
6	31	31	9.054					16.2	0.21				34.313				
5	20	20	9.109					16.1	0.21				34.312				
4	10	10	9.114					16.1	0.20				34.312				
3																	
2	75	74	8.893										34.399				
1																	

St.	St.30		Date	Jan.10.1995		Lat.	50°02.45'S				Depth	4609	(m)				
CTD-27			Time(GMT	20:06-21:30		Long.	145°30.13'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	9.3			3.2	1.14	16.3		8.020	2.355	1.98		5	9.056	34.302	26.563
24	10	10	9.034			3.2	1.23	16.5		8.013	2.353	0.55	34.321	10	9.060	34.302	26.562
23	20	20	8.975			3.0	1.23	16.5		8.003	2.358	0.58	34.320	20	9.060	34.302	26.562
22	30	30	8.875			3.3	1.18	16.4		8.009	2.352	0.62	34.327	30	9.038	34.302	26.566
21	40	40	8.858			3.5	1.26	16.6		8.009	2.354	0.50	34.333	50	8.891	34.326	26.608
20	50	50	8.862			3.7	1.26	16.5		8.008	2.353	0.50	34.352	75	8.527	34.328	26.666
19	75	74	8.295			4.4	1.36	17.7		7.996	2.354	0.14	34.313	100	8.557	34.351	26.679
18	99	98	8.576			4.6	1.31	16.9		8.001	2.354	0.08	34.382	150	8.268	34.500	26.841
17	123	122	8.384			3.9	1.33	16.9		7.987	2.356	0.07	34.494	200	8.055	34.468	26.848
16	150	149	8.142			4.5	1.27	17.4		7.985	2.355	0.05	34.502	300	7.634	34.425	26.876
15	201	199	8.025			4.9	1.34	18.1		7.976	2.358	0.02	34.490	400	6.767	34.306	26.904
14	298	295	7.451			5.6	1.50	20.2		7.956	2.356	0.00	34.415	500	6.326	34.306	26.962
13	498	493	6.338			10.8	1.94	26.0		7.894	2.354		34.332	600	5.833	34.323	27.038
12														800	4.542	34.297	27.170
11														1000	3.479	34.319	27.296
10														1500	2.648	34.532	27.543
9	4	4	9.037										34.321				
8	30	30	8.914										34.322				
7	49	49	8.858										34.350				
6	100	99	8.575										34.383				
5	199	197	8.020										34.489				
4																	
3																	
2																	
1																	

St.	St.31		Date	Jan.11.1995		Lat.	54°00.24'S				Depth	2831	(m)				
CTD-28			Time(GMT	14:12-17:51		Long.	144°01.73'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	μM	μM	μM	μM		meq/L	μg/L	PSU	db	°C	psu	
0	0	0	4.5	33.850						7.943	2.346	0.57		2	4.308	33.846	26.836
24														10	4.307	33.846	26.836
23														20	4.307	33.844	26.835
22														30	4.308	33.845	26.836
21														50	4.297	33.845	26.836
20														75	4.231	33.844	26.843
19														100	1.858	33.883	27.088
18														125	1.563	33.884	27.110
17														150	1.396	33.908	27.141
16														175	1.179	33.933	27.176
15														200	1.866	34.064	27.232
14														300	2.311	34.235	27.334
13														500	2.384	34.445	27.496
12														750	2.373	34.594	27.616
11														1000	2.246	34.686	27.700
10														1250	2.076	34.724	27.744
9														1500	1.904	34.743	27.773
8														2000	1.469	34.739	27.803
7														2500	1.038	34.720	27.818
6																	
5																	
4																	
3																	
2																	
1																	

St.	St.32		Date	Jan.12.1995		Lat.	56°00.10'S				Depth	3435	(m)				
CTD-29			Time(GMT	04:58-07:31		Long.	143°41.22'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	μM	μM	μM	μM		meq/L	μg/L	PSU	db	°C	psu	
0	0	0	3.5	33.851	7.55	1.1	1.62	25.5		7.933	2.346	0.47		2	3.361	33.983	27.040
24	10	10	3.381	33.847	7.57	1.0	1.70	25.4		7.934	2.349	0.53	33.844	5	3.375	34.264	27.263
23	22	22	3.126	33.847	7.68	1.3	1.64	25.3		7.934	2.348	0.54	33.846	10	3.266	34.385	27.370
22	30	30	3.102	33.843	7.60	1.4	1.62	25.3		7.936	2.347	0.67	33.846	20	3.136	33.827	26.936
21	38	38	3.056	33.848	7.66	1.5	1.66	25.3		7.936	2.351		33.846	30	3.067	33.826	26.942
20	49	49	2.986	33.848	7.62	1.5	1.62	25.0		7.933	2.346	0.53	33.848	40	3.056	33.825	26.942
19	73	72	1.271	33.892	7.73	11.5	2.02	27.5		7.891	2.354	0.75	33.888	50	3.019	33.826	26.946
18	102	101	0.495	33.916	7.59	19.6	2.12	29.0		7.863	2.350	0.09	33.917	75	1.922	33.860	27.064
17	123	122	-0.120	33.926	7.79	21.4	2.17	29.5		7.857	2.355	0.07	33.924	100	0.639	33.893	27.177
16	149	148	0.865	34.046	6.71	29.7	2.30	32.4		7.816	2.367	0.03	34.057	150	-0.190	33.908	27.234
15	201	199	1.932	34.269	5.10	47.5	2.55	36.0		7.740	2.370	0.02	34.268	200	1.733	34.184	27.338
14	302	299	2.155	34.407	4.34	60.4	2.65	37.3		7.711	2.382	0.02	34.412	300	2.191	34.392	27.469
13	501	496	2.268	34.565	3.99	69.8	2.61	36.7		7.712	2.398		34.565	400	2.267	34.484	27.537
12	743	735	2.191	34.665	4.06	71.8	2.47	35.0		7.734	2.413		34.666	500	2.279	34.549	27.588
11	999	988	2.073	34.716	4.28	76.8	2.36	33.3		7.758	2.410		34.719	600	2.273	34.599	27.629
10	1249	1234	1.898	34.742	4.50	80.0	2.35	32.4		7.773	2.412		34.742	800	2.181	34.661	27.686
9	1497	1478	1.721	34.741	4.45	81.6	2.31	32.6		7.770	2.413		34.746	1000	2.086	34.698	27.723
8	1749	1726	1.508	34.737	4.59	88.2	2.29	32.7		7.776	2.423		34.741	1500	1.735	34.724	27.771
7	1996	1968	1.281	34.730	4.68	94.6	2.33	33.1		7.775	2.423		34.732	2000	1.308	34.712	27.793
6	2248	2216	1.068	34.720	4.73	94.7	2.36	33.4		7.772	2.427		34.722	2500	0.901	34.691	27.804
5	2499	2462	0.875	34.710	4.78	103.6	2.38	33.9		7.770	2.423		34.712	3000	0.559	34.675	27.812
4	2750	2707	0.702	34.702	4.83	112.6	2.40	33.8		7.774	2.423		34.704				
3	3000	2952	0.539	34.695	5.01	113.2	2.42	34.2		7.766	2.423		34.697				
2	3249	3195	0.445	34.691	4.98	118.3	2.44	34.3		7.766	2.424		34.693				
1	3470	3410	0.459	34.684	4.98	124.2	2.46	34.4		7.764	2.426		34.693				

St.	St.33		Date	Jan.12.1995		Lat.	58°00.86'S				Depth	3821	(m)				
CTD-30			Time(GMT	20:14-21:00		Long.	143°00.87'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.9			0.0	1.62	25.0		7.949	2.346			3	3.785	33.797	26.851
24	9	9	3.784			0.0	1.64	25.1		7.950	2.348		33.819	5	3.783	33.798	26.851
23	19	19	3.778			0.0	1.65	25.2		7.950	2.347	0.33	33.821	10	3.782	33.798	26.852
22	27	27	3.753			0.0	1.66	25.2		7.950	2.346		33.821	20	3.784	33.800	26.853
21	38	38	3.456			0.8	1.66	25.6		7.943	2.348	0.52	33.826	30	3.614	33.805	26.874
20	48	48	3.107			1.2	1.65	25.7		7.938	2.348		33.842	40	3.110	33.829	26.940
19	74	73	2.292			5.3	1.81	26.6		7.925	2.349	0.67	33.863	50	3.055	33.825	26.942
18	99	98	1.398			13.2	2.04	28.2		7.892	2.348		33.877	75	2.300	33.852	27.029
17	124	123	1.113			15.2	2.06	28.8		7.888	2.349	0.08	33.887	100	1.403	33.857	27.099
16	150	149	0.950			17.1	2.07	29.7		7.879	2.351	0.03	33.909	150	1.030	33.893	27.153
15	201	199	1.682			33.5	2.34	33.3		7.811	2.360	0.01	34.102	200	1.660	34.089	27.267
14	298	295	2.118			51.6	2.58	36.6		7.747	2.376		34.306	300	2.149	34.281	27.384
13	497	492	2.309			63.6	2.69	37.2		7.724	2.391		34.490	400	2.287	34.391	27.461
12														500	2.326	34.473	27.523
11														600	2.335	34.543	27.578
10														800	2.281	34.626	27.649
9	4	4	3.793										33.819	1000	2.172	34.675	27.698
8	28	28	3.745										33.822	1500	1.882	34.722	27.758
7	48	48	3.055										33.843				
6	99	98	1.406										33.876				
5	201	199	1.643										34.100				
4																	
3																	
2																	
1																	

St.	St.34		Date	Jan.13.1995		Lat.	60°01.01'S				Depth	4248	(m)				
CTD-31			Time(GMT	06:02-09:20		Long.	142°00.01'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.4	33.851	7.58	1.6	1.52	25.1		7.951	2.347	0.45		2	3.284	33.826	26.922
24	10	10	3.271	33.847	7.62	1.5	1.54	25.1		7.950	2.348	0.47	33.846	5	3.324	33.824	26.917
23	21	21	3.237	33.848	7.68	1.0	1.56	25.0		7.951	2.346	0.52	33.847	10	3.252	33.830	26.928
22	30	30	3.165	33.851	7.74	0.9	1.57	24.9		7.951	2.348	0.67	33.849	20	3.141	33.830	26.938
21	40	40	2.877	33.859	7.75	1.8	1.68	27.8		7.940	2.348	1.13	33.849	30	3.022	33.831	26.950
20	50	50	1.722	33.879	7.81	6.4	1.95	29.2		7.922	2.349	0.96	33.877	40	2.524	33.849	27.008
19	74	73	0.957	33.894	7.72	15.1	2.11	28.0		7.889	2.351	0.19	33.892	50	1.680	33.867	27.088
18	101	100	0.382	33.906	7.75	19.3	2.13	28.4		7.875	2.350	0.10	33.903	75	0.812	33.878	27.155
17	123	122	0.156	33.927	7.72	22.1	2.16	29.5		7.862	2.351	0.05	33.927	100	0.301	33.889	27.194
16	151	150	0.490	34.032	6.85	30.4	2.31	32.0		7.831	2.354	0.02	34.030	150	0.238	33.974	27.265
15	201	199	1.869	34.286	5.01	49.9	2.62	36.2		7.756	2.373	0.00	34.284	200	1.864	34.252	27.383
14	299	296	2.205	34.442	4.25	61.4	2.67	37.0		7.733	2.385	0.00	34.443	300	2.192	34.403	27.478
13	500	495	2.275	34.591	4.01	69.6	2.57	35.7		7.730	2.397		34.593	400	2.289	34.499	27.547
12	751	743	2.202	34.677	4.15	73.5	2.46	34.1		7.755	2.404		34.678	500	2.307	34.566	27.599
11	999	987	2.058	34.721	4.32	76.4	2.36	32.8		7.770	2.408		34.723	600	2.269	34.613	27.640
10	1250	1234	1.888	34.740	4.49	80.3	2.31	32.1		7.787	2.411		34.743	800	2.184	34.670	27.693
9	1499	1480	1.666	34.741	4.53	85.4	2.30	32.1		7.788	2.413		34.744	1000	2.064	34.702	27.728
8	1724	1701	1.455	34.735	4.62					7.789	2.417		34.739	1500	1.681	34.722	27.774
7	1999	1971	1.224	34.724	4.69					7.786	2.418		34.729	2000	1.255	34.709	27.794
6	2501	2463	0.855	34.708	4.77					7.787	2.419		34.711	2500	0.867	34.689	27.804
5	3001	2952	0.507	34.686	4.93					7.782	2.425		34.695	3000	0.526	34.673	27.813
4	3500	3439	0.282	34.682	5.09					7.780	2.418		34.686	3500	0.310	34.666	27.819
3	3750	3682	0.231	34.680	5.16					7.780	2.420		34.684	4000	0.191	34.660	27.821
2	4000	3925	0.183	34.678	5.19					7.780	2.418		34.681				
1	4235	4154	0.067	34.674	5.29					7.781	2.417		34.678				

St.	St.34		Date	J an.13.1995		Lat.	60°0.03'S				Depth	4391	(m)				
CTD40-5			Time(GMT	12:35-13:26		Long.	141°58.98'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.4			1.9	1.50	13.8						2	3.222	33.848	26.946
24														5	3.221	33.849	26.946
23														10	3.221	33.849	26.946
22	299	296	2.202			63.8	2.62	37.6					34.438	20	3.225	33.848	26.945
21	5	5	3.222			2.1	1.50	25.6					33.849	30	3.176	33.849	26.950
20	6	6	3.222										33.848	50	1.629	33.883	27.104
19	5	5	3.222										33.849	75	0.688	33.901	27.181
18	250	247	2.078			58.8	2.61	37.4					34.369	100	0.295	33.917	27.217
17	5	5	3.221										33.848	125	-0.007	33.934	27.246
16	201	199	1.939			52.9	2.57	36.9					34.295	150	0.652	34.037	27.293
15	5	5	3.222										33.848	175	1.433	34.175	27.353
14	150	149	0.813			35.4	2.33	33.4					34.079	200	1.860	34.277	27.403
13	4	4	3.222										33.848	300	2.199	34.436	27.504
12	123	122	0.748			27.2	2.21	31.7					33.992				
11	4	4	3.223										33.848				
10	100	99	0.254			21.8	2.09	29.4					33.918				
9	5	5	3.224										33.848				
8	74	73	0.846			17.9	2.08	29.3					33.898				
7	50	50	1.591			9.3	1.93	27.5					33.877				
6	40	40	2.567			2.3	1.64	26.1					33.856				
5	29	29	3.163			1.6	1.54	25.7					33.845				
4	20	20	3.185			1.8	1.52	25.6					33.849				
3	10	10	3.220			1.9	1.51	25.9					33.849				
2																	
1																	

St.	St.35		Date	Jan.14.1995		Lat.	62°01.65'S				Depth	4262	(m)				
CTD-32			Time(GMT	00:32-02:16		Long.	141°41.59'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	2.6			20.2	1.51	26.0		7.910	2.352	0.05		2	2.443	33.755	26.939
24	8	8	2.570			20.4	1.57	26.4		7.914	2.353	0.04	33.762	5	2.445	33.755	26.939
23	20	20	2.392			20.8	1.58	26.5		7.905	2.353	0.04	33.800	10	2.438	33.755	26.940
22	29	29	2.402			20.4	1.57	26.0		7.905	2.352	0.04	33.803	20	2.288	33.782	26.973
21	39	39	1.948										33.820	30	2.197	33.806	27.000
20	47	47	0.741			18.1	1.65	27.5		7.904	2.358	0.17	33.907	40	1.111	33.862	27.123
19	73	72	-0.997			31.1	2.03	30.0		7.864	2.359	0.16	33.960	50	0.745	33.892	27.170
18	97	96	-1.185			44.2	2.26	32.4		7.819	2.368	0.18	34.044	75	-1.048	33.952	27.306
17	124	123	0.390			57.4	2.53	36.0		7.765	2.382	0.10	34.269	100	-0.990	34.051	27.384
16	149	148	1.455			72.0	2.67	38.0		7.730	2.388	0.03	34.420	150	1.510	34.403	27.531
15	202	200	1.894			74.7	2.66	38.2		7.705	2.396	0.02	34.537	200	1.880	34.511	27.590
14	299	296	2.021			76.8	2.59	37.5		7.717	2.403	0.01	34.610	300	2.033	34.588	27.639
13	500	495	1.994			82.9	2.45	36.0		7.737	2.418		34.683	400	2.041	34.635	27.676
12														500	2.020	34.659	27.697
11														600	1.952	34.682	27.721
10														800	1.848	34.706	27.748
9	5	5	2.636										33.751	1000	1.732	34.718	27.767
8	28	28	2.340										33.807	1500	1.300	34.709	27.791
7	48	48	0.695										33.908				
6	97	96	-1.012										34.076				
5	201	199	1.888										34.534				
4																	
3																	
2																	
1																	

St.	St.36		Date	Jan.14.1995		Lat.	63°00.14'S				Depth	3853	(m)				
CTD-33			Time(GMT	07:27-09:14		Long.	140°59.57'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.2			17.4	1.37	25.1	0.35	7.923	2.365	1.21		7	2.916	33.767	26.908
24														10	2.678	33.785	26.943
23														20	2.284	33.807	26.993
22														30	-0.138	33.932	27.251
21														40	-0.508	33.982	27.309
20														50	-1.003	34.074	27.403
19														75	-0.205	34.312	27.561
18														100	1.105	34.499	27.636
17														150	1.497	34.577	27.671
16														200	1.496	34.606	27.694
15														300	1.757	34.661	27.719
14														400	1.712	34.681	27.738
13		500				85.0	2.82	39.2	0.15	7.758	2.419			500	1.666	34.695	27.753
12		300				87.8	2.79	38.8	0.12	7.730	2.414	0.010					
11		200				91.5	2.77	38.2	0.13	7.735	2.409	0.030					
10		150				95.2	2.66	37.2	0.12	7.720	2.404	0.030					
9																	
8																	
7																	
6																	
5																	
4																	
3																	
2																	
1																	

St.	St.39		Date	Jan.17.1995		Lat.	64°36.18'S				Depth	3010	(m)				
CTD40-6			Time(GMT	17:00-18:10		Long.	139°56.50'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	0.7											8	0.548	33.194	26.619
24														10	0.544	33.194	26.620
23														20	0.293	33.494	26.876
22	302	299	-0.388										34.524	30	-1.081	34.009	27.354
21														50	-1.647	34.154	27.489
20														75	-1.688	34.243	27.563
19														100	-1.607	34.329	27.630
18	249	246	-1.265										34.435	125	-1.797	34.341	27.645
17														150	-1.791	34.352	27.654
16	198	196	-1.696										34.376	175	-1.770	34.361	27.660
15	198	196	-1.698										34.376	200	-1.707	34.372	27.668
14	149	147	-1.800										34.355	300	-0.420	34.511	27.732
13																	
12	124	123	-1.802										34.346				
11																	
10	100	99	-1.737										34.327				
9	99	98	-1.717										34.329				
8	74	73	-1.693										34.244				
7	49	49	-1.616										34.126				
6	39	39	-1.472										34.059				
5	29	29	-1.149										33.992				
4																	
3																	
2	49	49	-1.617										34.121				
1																	

St.	St.40		Date	Jan.15.1995		Lat.	64°10.20'S		St.	St.43		Date	Jan.20.1995		Lat.	65°23.80'S	
CTD100-1			Time(GMT	03:48-04:57		Long.	140°40.08'E		CTD100-2			Time(G	17:50-18:51		Long.	139°57.06'E	
Bottle	P	Depth	T	CTD(S)	P	T	S	Sigma-T	Bottle	P	Depth	T	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	db	°C	psu		No.	db	m	°C	psu	db	°C	psu	
0	0	0	3.2		2	3.008	33.696	26.843	0	0	0	-0.4		2	-0.538	33.455	26.883
24	50	50	-1.259	34.098	5	3.041	33.696	26.840	24	38	38	-1.670	34.257	5	-0.538	33.454	26.883
23	51	50	-1.297	34.110	10	2.881	33.702	26.860	23	37	37	-1.672	34.257	10	-0.535	33.459	26.886
22	50	50	-1.268	34.101	20	2.292	33.737	26.937	22	37	37	-1.671	34.256	20	-1.288	33.940	27.304
21	51	50	-1.291	34.110	30	0.198	33.883	27.194	21	38	38	-1.673	34.256	30	-1.648	34.205	27.530
20	50	50	-1.268	34.097	40	-0.773	33.953	27.296	20	37	37	-1.669	34.256	40	-1.734	34.282	27.595
19	49	49	-1.236	34.090	50	-1.197	34.047	27.388	19	38	38	-1.676	34.259	50	-1.745	34.301	27.611
18	49	49	-1.251	34.092	75	-1.072	34.188	27.498	18	38	38	-1.685	34.261	75	-1.784	34.333	27.638
17	50	50	-1.260	34.099	100	-0.220	34.340	27.585	17	38	38	-1.691	34.262	100	-1.776	34.347	27.649
16	50	50	-1.262	34.099	150	0.904	34.528	27.673	16	38	38	-1.683	34.261	150	-1.833	34.356	27.658
15	50	50	-1.242	34.090	200	1.262	34.605	27.710	15	37	37	-1.689	34.263	200	-1.815	34.364	27.665
14	49	49	-1.235	34.085	300	1.510	34.667	27.742	14	38	38	-1.710	34.267	300	-0.797	34.491	27.732
13	50	50	-1.259	34.090	400	1.305	34.668	27.758	13	37	37	-1.722	34.274	400	-0.071	34.592	27.780
12	1005	993	1.070	34.720	500	1.498	34.703	27.772	12	1004	992	0.439	34.689	500	0.710	34.677	27.804
11	1005	993	1.071	34.720	600	1.424	34.706	27.780	11	1004	992	0.441	34.690	600	0.668	34.684	27.813
10	1005	993	1.070	34.720	800	1.270	34.706	27.791	10	1004	992	0.438	34.689	800	0.549	34.688	27.824
9	1005	993	1.071	34.720	1000	1.098	34.699	27.797	9	1005	993	0.437	34.689	1000	0.438	34.689	27.831
8	1004	992	1.076	34.720					8	1005	993	0.436	34.689	1003	0.438	34.690	27.831
7	1005	993	1.073	34.720					7	1004	992	0.437	34.689				
6	1005	993	1.073	34.720					6	1005	993	0.436	34.689				
5	1004	992	1.080	34.721					5	1002	990	0.436	34.689				
4	1004	992	1.080	34.721					4	1003	991	0.436	34.689				
3	1004	992	1.082	34.721					3	1004	992	0.436	34.689				
2	1003	991	1.083	34.721					2	1004	992	0.436	34.689				
1	1003	991	1.083	34.721					1	1004	992	0.436	34.689				

St.	St.40		Date	Jan.15.1995		Lat.	64°10.42'S				Depth	3651	(m)				
CTD-34D			Time(GMT	05:17-07:48		Long.	140°39.07'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.3											2	3.065	33.698	26.840
24	751	742	1.293	34.732	4.63	98.2	2.30	34.0	0.00	7.767	2.422		34.703	5	3.153	33.697	26.831
23														10	2.558	33.708	26.891
22														20	2.325	33.718	26.919
21	1001	989	1.084	34.728		105.9	2.35	34.5	0.00	7.777	2.426		34.697	30	0.238	33.891	27.199
20	1251	1235	0.798	34.701	4.86	111.3	2.38	34.9	0.00	7.766	2.424		34.677	40	-0.784	33.980	27.318
19	1500	1480	0.746	34.711	4.78	119.9	2.41	35.5	0.00	7.776	2.429		34.686	50	-1.245	34.070	27.408
18	1775	1750	0.518	34.698	4.90	124.2	2.42	35.9	0.00	7.760	2.428		34.673	75	-1.033	34.224	27.526
17	2001	1972	0.373	34.692	4.99	127.4	2.44	35.9	0.00	7.767	2.428		34.667	100	-0.123	34.370	27.604
16	2252	2218	0.236	34.688	5.08	128.3	2.44	35.9	0.00	7.769	2.428		34.662	150	1.022	34.550	27.682
15	2500	2461	0.146	34.684	5.21	128.1	2.43	35.5	0.00	7.764	2.426		34.661	200	1.277	34.608	27.711
14	2752	2707	0.058	34.680	5.20	131.7	2.44	35.2	0.00	7.771	2.428		34.659	300	1.420	34.659	27.742
13	3000	2950	-0.047	34.679	5.34	121.2	2.42	35.1	0.00	7.763	2.424		34.656	400	1.536	34.691	27.759
12	3249	3193	-0.153	34.677	5.48	116.7	2.41	34.7	0.00	7.767	2.424		34.652	500	1.521	34.703	27.770
11	3499	3436	-0.330	34.661	5.68	105.9	2.39	34.6	0.00	7.772	2.422		34.637	600	1.395	34.702	27.778
10	3550	3486	-0.378	34.657	5.78	105.5	2.38	34.6	0.00	7.773	2.420		34.633	800	1.242	34.702	27.790
9	3629	3563	-0.400	34.655	5.86	105.1	2.40	34.9	0.00	7.778	2.422		34.630	1000	1.111	34.701	27.797
8														1500	0.727	34.683	27.809
7	201	199	1.236										34.609	2000	0.380	34.667	27.817
6	101	100	0.136										34.418	2500	0.139	34.660	27.824
5	76	75	-0.918										34.249	3000	-0.046	34.655	27.830
4	6	6	3.112										33.698	3500	-0.325	34.638	27.831
3	50	50	-1.193										34.072				
2	31	31	-0.337										33.930				
1	11	11	2.876										33.693				

St.	St.40		Date	Jan.15.1995		Lat.	64°09.89'S				Depth	3623	(m)				
CTD-34S			Time(GMT	10:44-11:34		Long.	140°40.42'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.3	33.727	7.97	16.8	1.16	22.7	0.32	7.947	2.352	0.93		2	2.644	33.733	26.905
24	10	10	2.398	33.754	8.19	16.8	1.20	23.1	0.28	7.952	2.352	0.93	33.741	10	2.404	33.742	26.932
23	20	20	0.997	33.880	8.85	16.6	1.29	23.2	0.21	7.956	2.364	1.91	33.811	20	0.822	33.832	27.117
22	30	30	-0.457	33.982	8.27	33.9	1.85	27.7	0.14	7.899	2.366	1.38	33.934	30	-0.545	33.944	27.279
21	40	40	-0.980	34.041	7.84	43.0	2.06	29.4	0.13	7.860	2.371	1.01	34.023	50	-1.315	34.102	27.437
20	50	50	-1.320	34.134	7.26	52.2	2.24	31.4	0.12	7.823	2.374	0.45	34.104	75	-0.780	34.292	27.571
19	76	75	-0.775	34.309	6.42	63.8	2.36	33.5	0.10	7.787	2.386	0.12	34.294	100	0.175	34.449	27.652
18	100	99	0.163	34.464	5.39	75.0	2.46	35.2	0.07	7.756	2.396	0.05	34.447	125	0.803	34.542	27.690
17	124	123	0.760	34.542	4.94	80.4	2.49	35.8	0.03	7.738	2.403	0.02	34.535	150	1.134	34.591	27.708
16	150	148	1.103	34.590	4.66	84.6	2.50	35.9	0.03	7.737	2.406	0.01	34.587	175	1.141	34.610	27.723
15	202	200	1.218	34.630	4.61	86.6	2.46	35.3	0.00	7.740	2.408	0.01	34.629	200	1.218	34.629	27.732
14	300	297	1.407	34.682	4.56	89.2	2.41	35.1	0.00	7.751	2.414	0.01	34.679	300	1.376	34.676	27.759
13	500	495	1.495	34.729	4.58	94.8	2.35	34.4	0.00	7.766	2.419		34.725	500	1.496	34.725	27.790
12	11	11	2.400										33.739	500	1.496	34.725	27.790
11	20	20	0.616										33.838				
10	30	30	-0.702										33.961				
9	40	40	-1.052										34.039				
8	50	50	-1.320										34.105				
7	75	74	-0.755										34.297				
6	100	99	0.175										34.449				
5	125	124	0.772										34.536				
4	149	147	1.102										34.588				
3	201	199	1.218										34.629				
2	300	297	1.402										34.679				
1	500	495	1.496										34.725				

St.	St.40		Date	Jan.15.1995		Lat.	64°09.14'S				Depth	3629	(m)				
CTD60-3			Time(GMT	15:54-16:37		Long.	140°43.98'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	2.9			22.6	1.38	26.2						2	2.833	33.722	26.880
24														10	2.709	33.720	26.889
23														20	1.609	33.788	27.030
22	303	297	1.380			93.5	2.68	37.5					34.682	30	0.107	33.899	27.212
21	4	4	2.851			22.4	1.53	26.3					33.722	50	-1.454	34.082	27.425
20	4	4	2.853										33.723	75	-1.181	34.204	27.515
19	4	4	2.817										33.723	100	-0.069	34.376	27.606
18	250	247	0.994			90.9	2.71	37.8					34.625	125	0.331	34.478	27.667
17	4	4	2.853										33.723	150	0.443	34.518	27.692
16	200	198	0.838			88.0	2.72	38.0					34.588	175	0.669	34.558	27.711
15	4	4	2.839										33.723	200	0.807	34.586	27.725
14	150	148	0.533			83.9	2.74	38.2					34.531	300	1.434	34.686	27.763
13	4	4	2.824										33.722				
12	125	124	0.361			80.2	2.74	38.2					34.489				
11	4	4	2.841										33.723				
10	100	99	-0.035			72.6	2.75	38.2					34.385				
9	4	4	2.790										33.722				
8	73	72	-1.013			62.0	2.57	36.1					34.235				
7	50	50	-1.463			51.5	2.35	33.5					34.094				
6	39	39	-0.932			43.7	2.20	31.7					34.010				
5	30	30	0.196			25.4	1.70	27.4					33.862				
4	19	19	1.273			18.3	1.42	25.5					33.794				
3	10	10	2.593			22.0	1.40	26.1					33.723				
2																	
1																	

St.	St.40		Date	Jan.15.1995		Lat.	64°09.47'S	
ICTD-3			Time(GMT	15:00-15:30		Long.	140°43.62'E	
Bottle	P	Depth	T	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	db	°C	psu	
0	0	0	2.9		2	2.754	33.720	26.885
24	4	4	2.747	33.722	10	2.677	33.723	26.894
23	4	4	2.759	33.722	20	2.200	33.749	26.954
22					30	0.245	33.896	27.202
21	4	4	2.725	33.717	50	-1.446	34.072	27.416
20	19	19	1.114	33.811	75	-1.233	34.198	27.512
19	19	19	1.103	33.811				
18	19	19	0.981	33.817				
17	30	30	-0.174	33.894				
16	30	30	-0.106	33.884				
15	30	30	-0.154	33.876				
14	44	44	-1.245	34.054				
13	44	44	-1.399	34.060				
12								
11	44	44	-1.420	34.062				
10	59	58	-1.528	34.121				
9	59	58	-1.513	34.126				
8								
7								
6								
5	80	79	-1.126	34.222				
4	80	79	-1.100	34.222				
3								
2	80	79	-1.074	34.220				
1				34.285				

St.	St.43		Date	Jan.18.1995		Lat.	65°21.00'S	
ICTD-4			Time(G	16:10-16:42		Long.	140°00.44'E	
Bottle	P	Depth	T	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	db	°C	psu	
0	0	0	-0.3		2	-0.361	33.319	26.766
24	4	4	-0.075	33.325	5	-0.374	33.314	26.763
23	4	4	-0.073	33.325	10	-0.354	33.323	26.769
22	40	40	-1.661	34.246	20	-0.367	33.436	26.861
21	5	5	-0.077	33.324	40	-1.656	34.246	27.564
20	14	14	-0.104	33.327	45	-1.701	34.274	27.588
19	26	26	-0.797	33.694	50	-1.721	34.294	27.605
18	14	14	-0.134	33.325	75	-1.805	34.332	27.638
17	40	40	-1.662	34.248	100	-1.808	34.344	27.648
16	26	26	-0.813	33.709	125	-1.798	34.354	27.655
15	60	59	-1.763	34.311	150	-1.780	34.361	27.661
14	40	40	-1.669	34.254				
13	79	78	-1.813	34.334				
12	40	40	-1.670	34.256				
11	60	59	-1.761	34.310				
10	40	40	-1.658	34.243				
9	80	79	-1.814	34.335				
8	41	41	-1.667	34.253				
7	39	39	-1.655	34.240				
6	40	40	-1.658	34.244				
5	40	40	-1.657	34.242				
4	40	40	-1.651	34.237				
3	40	40	-1.650	34.236				
2	40	40	-1.652	34.236				
1	39	39	-1.652	34.236				

St.	St.40		Date	Jan.16.1995		Lat.	64°10.23'S				Depth	3620	(m)				
BCTD-5			Time(GMT	00:59-01:51		Long.	140°43.04'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	3.1			16.1	1.20	23.0	0.33	7.946	2.371	0.57		2	2.928	33.709	26.861
24	9	9	2.431			17.1	1.24	23.2	0.30	7.944	2.354	0.98	33.743	5	2.940	33.710	26.861
23	18	18	0.787			17.1	1.72	18.6	0.22	7.941	2.362	1.43	33.839	10	2.883	33.713	26.868
22	29	29	-0.025			29.0	1.93	24.2	0.17	7.902	2.365	1.38	33.898	20	0.502	33.858	27.157
21	40	40	-0.868			37.2	2.06	27.6	0.15	7.868	2.368	1.10	34.003	30	-0.360	33.917	27.249
20	49	49	-1.298			49.7	2.28	30.5	0.12	7.818	2.376	0.42	34.119	40	-0.836	33.983	27.323
19	72	71	-0.659			61.9	2.45	32.7	0.12	7.787	2.385	0.19	34.302	50	-1.253	34.061	27.402
18	99	98	0.277			72.0	2.56	34.1	0.11	7.748	2.390	0.04	34.460	75	-0.723	34.257	27.540
17	124	123	0.845			77.3	2.60	34.6	0.08	7.712	2.404	0.03	34.539	100	0.021	34.390	27.612
16	149	147	1.281			79.4	2.61	34.4	0.04	7.740	2.404	0.02	34.605	150	1.335	34.581	27.686
15	201	199	1.443			80.7	2.55	33.8	0.01	7.744	2.410	0.01	34.649	200	1.618	34.639	27.711
14	299	296	1.631			81.7	2.50	33.0	0.00	7.758	2.414	0.01	34.701	300	1.555	34.667	27.739
13	507	501	1.541			82.4	2.43	32.1	0.00	7.758	2.420		34.727	400	1.591	34.694	27.758
12														500	1.581	34.707	27.769
11																	
10																	
9																	
8																	
7																	
6																	
5																	
4																	
3																	
2																	
1	9		2.440										33.743				

St.	St.41		Date	Jan.17.1995		Lat.	65°09.29'S				Depth	2700	(m)				
CTD-35			Time(GMT	11:40-14:32		Long.	139°59.20'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	0.3	33.401	7.92	41.3	1.79	27.8	0.24	7.858	2.326	0.51		3	0.136	33.391	26.801
24	9	9	0.285	33.398	7.96	42.3	1.79	27.7	0.24	7.871	2.327	0.42	33.372	10	0.142	33.391	26.801
23	19	19	-1.411	34.060	7.52	49.6	2.11	30.4	0.06	7.832	2.370	0.34	33.980	20	-0.319	33.450	26.870
22	28	28	-1.609	34.159	7.17	52.9	2.19	31.6	0.09	7.811	2.376	0.27	34.134	30	-1.535	34.090	27.434
21	40	40	-1.630	34.212	7.02	54.6	2.23	32.2	0.08	7.808	2.379	0.34	34.178	50	-1.611	34.233	27.552
20	49	49	-1.605	34.236	7.05	55.2	2.25	32.4	0.08	7.799	2.379	0.34	34.224	75	-1.714	34.308	27.616
19	74	73	-1.666	34.331	7.18	60.6	2.23	32.5	0.10	7.803	2.387	0.32	34.319	100	-1.650	34.345	27.645
18	99	98	-1.584	34.373	7.01	64.1	2.24	32.8	0.01	7.795	2.389	0.06	34.362	125	-1.612	34.369	27.663
17	124	123	-1.365	34.400	6.84	66.6	2.25	33.0	0.00	7.793	2.397	0.03	34.395	150	-1.346	34.411	27.689
16	149	147	-1.145	34.431	6.60	70.3	2.29	33.4	0.01	7.785	2.398	0.01	34.424	175	-1.217	34.441	27.708
15	200	198	-0.554	34.506	6.10	76.3	2.32	33.8	0.01	7.773	2.400	0.01	34.501	200	-0.872	34.475	27.723
14	300	297	0.886	34.661	4.93	87.5	2.36	33.6	0.01	7.754	2.412	0.00	34.657	300	0.913	34.662	27.779
13	500	494	1.085	34.715	4.75	97.9	2.36	33.5	0.00	7.761	2.420		34.710	500	0.944	34.695	27.804
12	749	740	0.864	34.711	4.78	107.1	2.39	33.8	0.00	7.766	-		34.707	750	0.875	34.707	27.818
11	1000	988	0.650	34.702	4.86	113.3	2.41	34.2	0.00	7.764	2.422		34.698	1000	0.666	34.699	27.825
10	1249	1223	0.396	34.690	4.98	117.9	2.43	34.5	0.00	7.754	2.425		34.687	1250	0.419	34.688	27.831
9	1499	1479	0.214	34.683	5.05	118.3	2.43	34.5	0.00	7.754	2.423		34.680	1500	0.243	34.681	27.836
8	1748	1724	0.079	34.680	5.14	115.6	2.41	34.3	0.00	7.753	2.421		34.676	2000	-0.002	34.679	27.847
7	1998	1969	0.009	34.684	5.20	112.3	2.41	34.3	0.00	7.758	2.423		34.680	2500	-0.180	34.686	27.862
6	2248	2214	-0.096	34.683	5.32	115.9	2.41	34.4	0.00	7.758	2.423		34.680				
5	2525	2485	-0.162	34.688	5.46	107.0	2.40	34.3	0.00	7.752	2.419		34.686				
4	2721	2677	-0.206	34.688	5.46	105.4	2.40	34.3	0.00	7.752	2.421		34.685				
3																	
2																	
1	9	9	0.270										33.375				

St.	St.43		Date	Jan.20.1995		Lat.	65°30.85'S				Depth	1612	(m)				
CTD-36D			Time(GMT	09:17-11:10		Long.	139°48.68'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.7											3	-0.779	33.235	26.715
24	749	740	0.132										34.669	10	-0.776	33.417	26.862
23	749	740	0.132	34.675	5.13	115.8	2.41	34.3	0.02	7.758	2.432		34.669	20	-0.774	33.422	26.866
22														30	-0.811	33.439	26.881
21	998	986	0.101	34.683	5.09	118.0	2.45	34.6	0.02	7.759	2.435		34.679	50	-1.728	34.221	27.546
20	1247	1231	-0.256	34.660	5.54	109.6	2.43	34.1	0.03	7.754	2.429		34.654	75	-1.752	34.307	27.616
19	1400	1382	-0.523	34.640	5.91	102.0	2.40	33.7	0.05	7.749	2.430		34.636	100	-1.786	34.328	27.635
18														125	-1.791	34.342	27.646
17	1499	1479	-0.543	34.638	5.87	99.6	2.40	33.7	0.05	7.761	2.426		34.634	150	-1.772	34.353	27.654
16														175	-1.780	34.360	27.660
15	1499	1479	-0.550	34.639	5.90	99.6	2.40	33.7					34.634	200	-1.743	34.370	27.667
14														300	-1.120	34.453	27.715
13	1551	1530	-0.565	34.636	5.93	98.0	2.40	33.7	0.06	7.768	2.424		34.632	500	-0.246	34.603	27.798
12														750	0.140	34.669	27.832
11	199	197	-1.706										34.374	1000	0.116	34.679	27.841
10	200	198	-1.711										34.374	1250	-0.297	34.651	27.840
9	100	99	-1.802										34.337	1500	-0.575	34.631	27.837
8	101	100	-1.801										34.336				
7	75	74	-1.747										34.306				
6	50	50	-1.675										34.071				
5	49	49	-1.664										34.058				
4	4	4	-0.764										33.413				
3	30	30	-0.817										33.436				
2	31	31	-0.817										33.437				
1	10	10	-0.766										33.414				

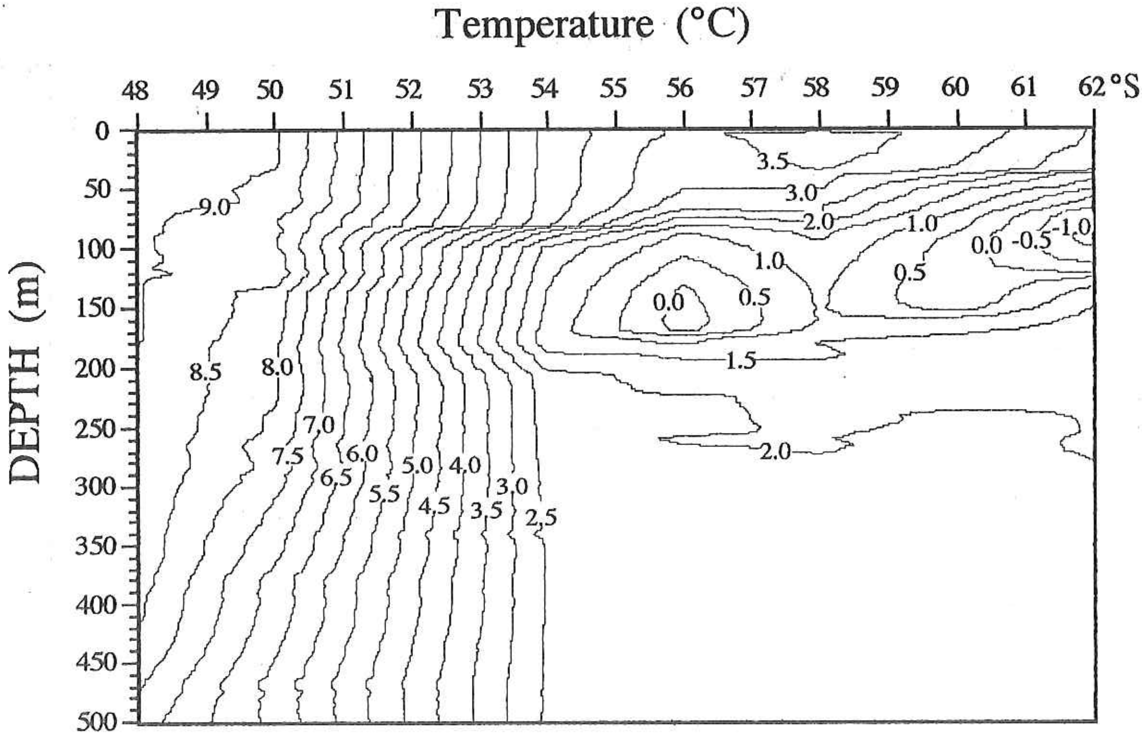
St.	St.43		Date	Jan.20.1995		Lat.	65°24.76'S				Depth	2109	(m)				
CTD-36S			Time(GMT	14:14-15:07		Long.	139°52.78'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.5	33.466	7.90	1.79	43.3	27.2	0.20	7.860	2.335	0.21		3	-0.587	33.458	26.888
24	10	10	-0.574	33.462	7.92	1.80	44.5	26.6	0.20	7.865	2.332	0.25	33.457	10	-0.592	33.458	26.888
23	19	19	-0.575	33.464	7.93	1.81	44.0	27.3	0.20	7.860	2.333	0.25	33.457	20	-0.587	33.458	26.888
22	29	29	-0.749	33.825	7.60	2.02	47.9	28.9	0.20	7.839	2.354	0.20	33.569	30	-0.586	33.459	26.889
21	40	40	-1.637	34.211	7.21	2.23	54.1	31.1	0.10	7.815	2.383	0.22	34.190	50	-1.657	34.229	27.551
20	50	50	-1.654	34.265	7.14	2.27	56.9	31.7	0.10	7.797	2.387	0.23	34.251	75	-1.682	34.303	27.611
19	73	72	-1.730	34.313	7.22	2.26	59.7	31.6	0.08	7.797	2.394	0.17	34.309	100	-1.823	34.334	27.640
18	99	98	-1.752	34.341	7.01	2.27	60.8	31.9	0.05	7.799	2.390	0.09	34.335	125	-1.802	34.347	27.650
17	125	124	-1.786	34.353	7.31	2.26	63.3	31.8	0.03	7.803	2.391	0.06	34.347	150	-1.789	34.359	27.659
16	152	150	-1.630	34.366	7.16	2.27	65.0	32.1	0.02	7.795	2.395	0.00	34.360	175	-1.738	34.372	27.669
15	198	196	-1.615	34.393	7.20	2.28	68.5	32.1	0.01	7.791	2.401	0.01	34.386	200	-1.543	34.394	27.681
14	300	297	-0.089	34.569	5.69	2.38	82.1	33.3	0.02	7.759	2.417	0.01	34.561	300	-0.215	34.555	27.758
13	504	499	0.504	34.668	5.14	2.39	96.7	33.5	0.01	7.759	2.424		34.662	500	0.521	34.663	27.805
12	10	10	-0.573										33.457				
11	19	19	-0.579										33.459				
10	29	29	-0.722										33.549				
9	40	40	-1.638										34.191				
8	50	50	-1.654										34.255				
7	73	73	-1.734										34.310				
6	99	99	-1.770										34.337				
5	126	125	-1.788										34.347				
4	150	148	-1.648										34.361				
3	199	197	-1.607										34.388				
2	299	296	-0.075										34.561				
1	504	498	0.504										34.662				

St.	St.43		Date	Jan.18.1995		Lat.	65°21.14'S				Depth	2381	(m)				
CTD60-4			Time(GMT	17:04-17:44		Long.	139°58.89'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	0.1			44.0	1.69	27.2	0.25					5	-0.027	33.297	26.733
24														10	-0.027	33.297	26.733
23														20	-0.157	33.316	26.755
22	304	301	-0.804			80.7	2.33	33.6	0.01				34.507	30	-1.365	33.927	27.296
21	4	4	-0.048			44.7	1.70	27.5	0.24				33.307	50	-1.726	34.299	27.609
20	5	5	-0.049										33.307	75	-1.810	34.333	27.639
19	5	5	-0.048										33.307	100	-1.819	34.343	27.647
18	249	246	-1.301			74.4	2.30	33.1	0.03				34.439	125	-1.807	34.353	27.655
17	4	4	-0.048										33.306	150	-1.791	34.361	27.661
16	200	198	-1.691			69.6	2.26	32.7	0.03				34.383	175	-1.764	34.369	27.667
15	5	5	-0.047										33.306	200	-1.674	34.384	27.676
14	150	148	-1.803			65.4	2.23	31.7	0.03				34.359	300	-0.764	34.509	27.746
13	4	4	-0.051										33.307				
12	125	124	-1.810			64.1	2.22	32.3	0.04				34.352				
11	4	4	-0.051										33.307				
10	99	98	-1.816			62.7	2.20	32.2	0.05				34.345				
9	5	5	-0.052										33.308				
8	74	73	-1.813			60.2	2.21	32.2	0.06				34.334				
7	49	49	-1.725			59.2	2.17	31.5	0.08				34.303				
6	40	40	-1.667			56.6	2.16	31.3	0.10				34.251				
5	29	29	-0.882			48.2	1.88	28.5	0.17				33.678				
4	19	19	-0.111			44.8	1.73	27.5	0.24				33.320				
3	10	10	-0.050			44.1	1.70	27.5	0.25				33.306				
2																	
1																	

St.	St.43		Date	Jan.20.1995		Lat.	65°24.51'S				Depth	2385	(m)				
ICTD-5			Time(GMT	21:30-22:00		Long.	139°46.47'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-0.4											4	-0.553	33.444	26.875
24	5	5	-0.547			46.4	1.88	27.1	0.21				33.449	5	-0.553	33.447	26.878
23	4	4	-0.546										33.449	10	-0.555	33.448	26.879
22	4	4	-0.546										33.449	20	-0.557	33.449	26.879
21	5	5	-0.545										33.450	30	-0.856	33.668	27.068
20	15	15	-0.553			47.5	1.80	27.3	0.21				33.450	40	-1.642	34.250	27.567
19	15	15	-0.556										33.450	50	-1.730	34.281	27.595
18	15	15	-0.556										33.450	75	-1.795	34.323	27.630
17	27	27	-0.615			48.6	1.89	27.4	0.20				33.493	100	-1.812	34.338	27.643
16	27	27	-0.590										33.474				
15	26	26	-0.613										33.489				
14	39	39	-1.675			55.9	2.22	31.2	0.09				34.260				
13	39	39	-1.677										34.261				
12	39	39	-1.678										34.261				
11	39	39	-1.681										34.262				
10	61	61	-1.767			59.4	2.23	31.6	0.07				34.307				
9	61	61	-1.766										34.306				
8	62	62	-1.767										34.307				
7	61	61	-1.770										34.308				
6	80	79	-1.800			61.9	2.24	32.2	0.06				34.328				
5	80	79	-1.800										34.328				
4	79	79	-1.800										34.328				
3	15	15	-0.557										33.450				
2	28	28	-0.640										33.507				
1	79	78	-1.803										34.329				

St.	St.45		Date	Jan.21.1995		Lat.	65°29.91'S				Depth	1317	(m)				
CTD-37			Time(GMT	13:37-15:04		Long.	140°25.74'E								CTD	DOWN	CAST
Bottle	P	Depth	T	S	O2	SiO2	PO4	NO3	NO2	pH	Alk	Chl-a	CTD(S)	P	T	S	Sigma-T
No.	db	m	°C	psu	ml/L	µM	µM	µM	µM		meq/L	µg/L	PSU	db	°C	psu	
0	0	0	-1.2	33.369	8.06	45.5	1.85	27.1	0.20	7.863	2.327	0.15		3	-1.216	33.323	26.801
24	9	9	-1.156	33.550	8.00	46.1	1.91	27.5	0.19	7.855	2.335	0.18	33.401	10	-1.188	33.329	26.805
23	20	20	-0.681	33.669	7.93	47.0	1.92	27.6	0.19	7.848	2.345	0.17	33.650	20	-1.026	33.547	26.976
22	30	30	-0.667	33.711	7.93	47.0	1.94	27.9	0.18	7.858	2.349	0.19	33.678	30	-0.793	33.660	27.059
21	40	40	-1.583	34.245	7.53	55.7	2.25	16.4	0.10	7.822	2.391	0.57	34.200	50	-1.671	34.281	27.593
20	49	49	-1.706	34.304	7.51	57.6	2.33	30.6	0.09	7.814	2.391	0.71	34.289	75	-1.763	34.323	27.630
19	75	74	-1.791	34.338	7.40	60.0	2.38	31.3	0.14	7.803	2.393	0.30	34.330	100	-1.817	34.342	27.646
18	99	98	-1.814	34.350	7.36	60.6	2.37	31.5	0.05	7.803	2.393	0.11	34.342	125	-1.813	34.351	27.654
17	123	122	-1.811	34.358	7.34	62.3	2.35	31.6	0.03	7.804	2.395	0.05	34.352	150	-1.805	34.359	27.660
16	149	147	-1.801	34.364	7.42	63.2	2.35	31.5	0.03	7.801	2.399	0.02	34.359	175	-1.749	34.373	27.670
15	200	198	-1.732	34.392	7.14	65.3	2.41	31.8	0.03	7.798	2.401	0.01	34.384	200	-1.672	34.386	27.678
14	300	297	-0.685	34.512	6.18	78.1	2.50	32.6	0.03	7.767	2.411	0.00	34.507	300	-0.757	34.492	27.732
13	500	495	0.551	34.667	5.07	95.5	2.55	33.1	0.03	7.762	2.427		34.665	500	0.514	34.662	27.804
12	750	741	0.398	34.682	4.97	106.1	2.59	33.9	0.03	7.765	2.432		34.677	750	0.413	34.677	27.822
11	1000	988	0.108	34.675	5.17	108.7	2.60	34.0	0.03	7.749	2.429		34.670	1000	0.121	34.671	27.834
10	1099	1085	-0.257	34.656	5.54	98.8	2.55	33.5	0.04	7.771	2.424		34.650	1250	-0.469	34.643	27.841
9	1199	1183	-0.331	34.659	5.58	97.7	2.54	33.6	0.04	7.767	2.424		34.656				
8	1249	1233	-0.460	34.649	5.73	95.3	2.51	33.5	0.05	7.760	2.422		34.644				
7	9	9	-1.135										33.413				
6	56	55	-1.750										34.313				
5	49	48	-1.700										34.286				
4	40	40	-1.588										34.206				
3	30	30	-0.673										33.679				
2	19	19	-0.685										33.647				
1	5	5	-1.208										33.368				

Leg II (CTD)


Temperature (°C)
48 49 50 51 52 53 54 55 56 57 58 59 60 61 62°S
0 50 100 150 200 250 300 350 400 450 500
DEPTH (m)
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8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
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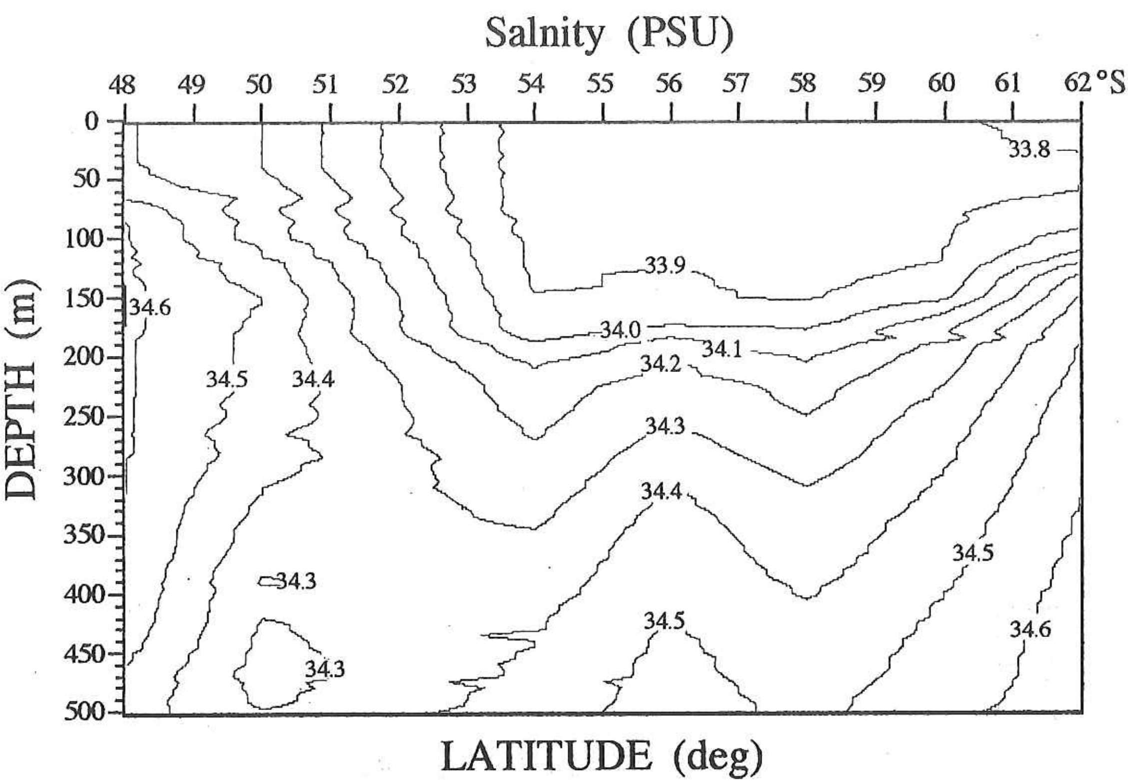
2.0


Salnity (PSU)
48 49 50 51 52 53 54 55 56 57 58 59 60 61 62°S
0 50 100 150 200 250 300 350 400 450 500
DEPTH (m)
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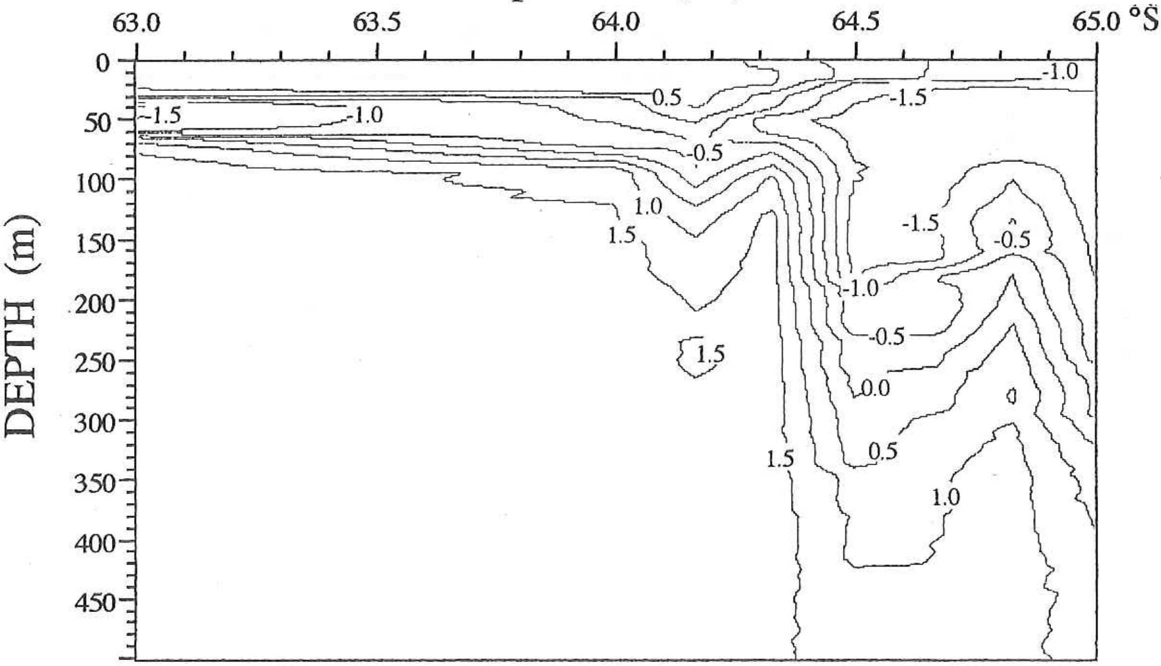
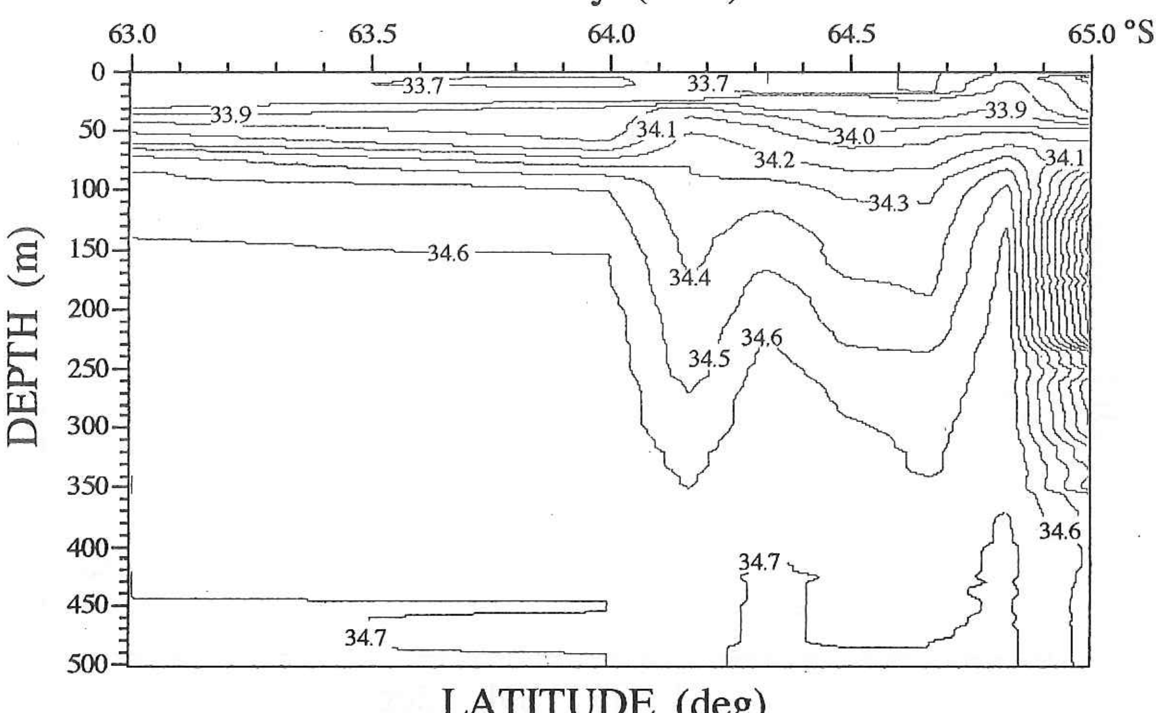
33.9
34.0
34.1
34.2
34.3
34.4
34.5
34.6
34.3
34.3
LATITUDE (deg)

Leg II (CTD)

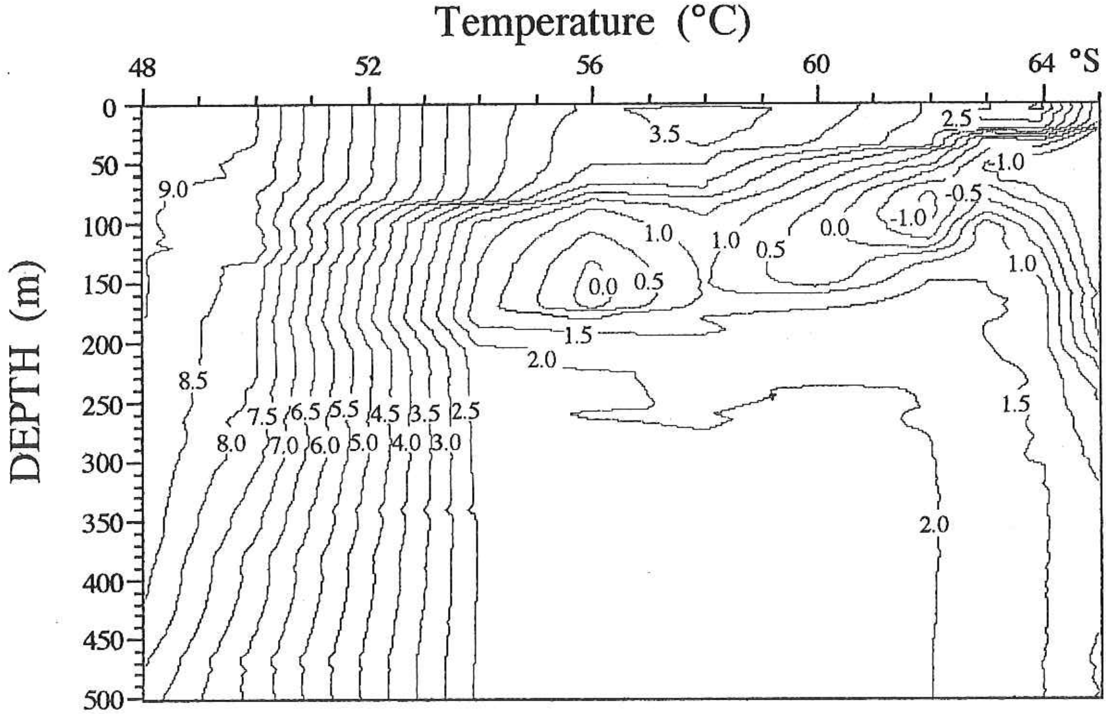
Temperature (°C)

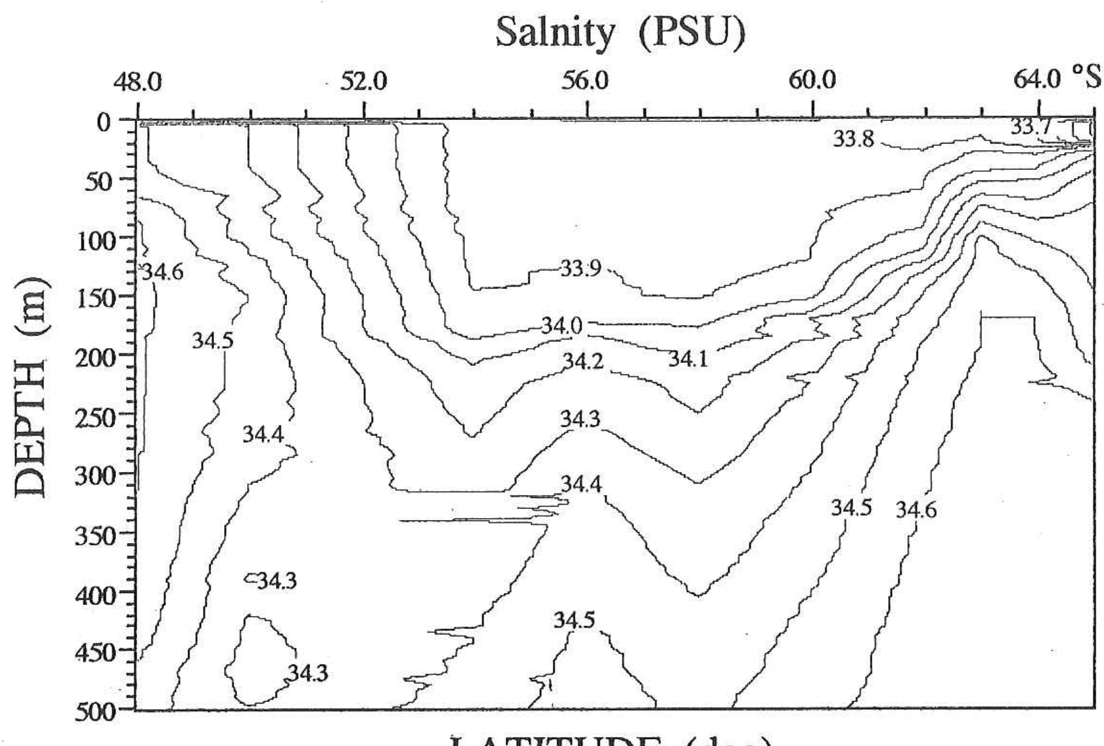


Salnity (PSU)



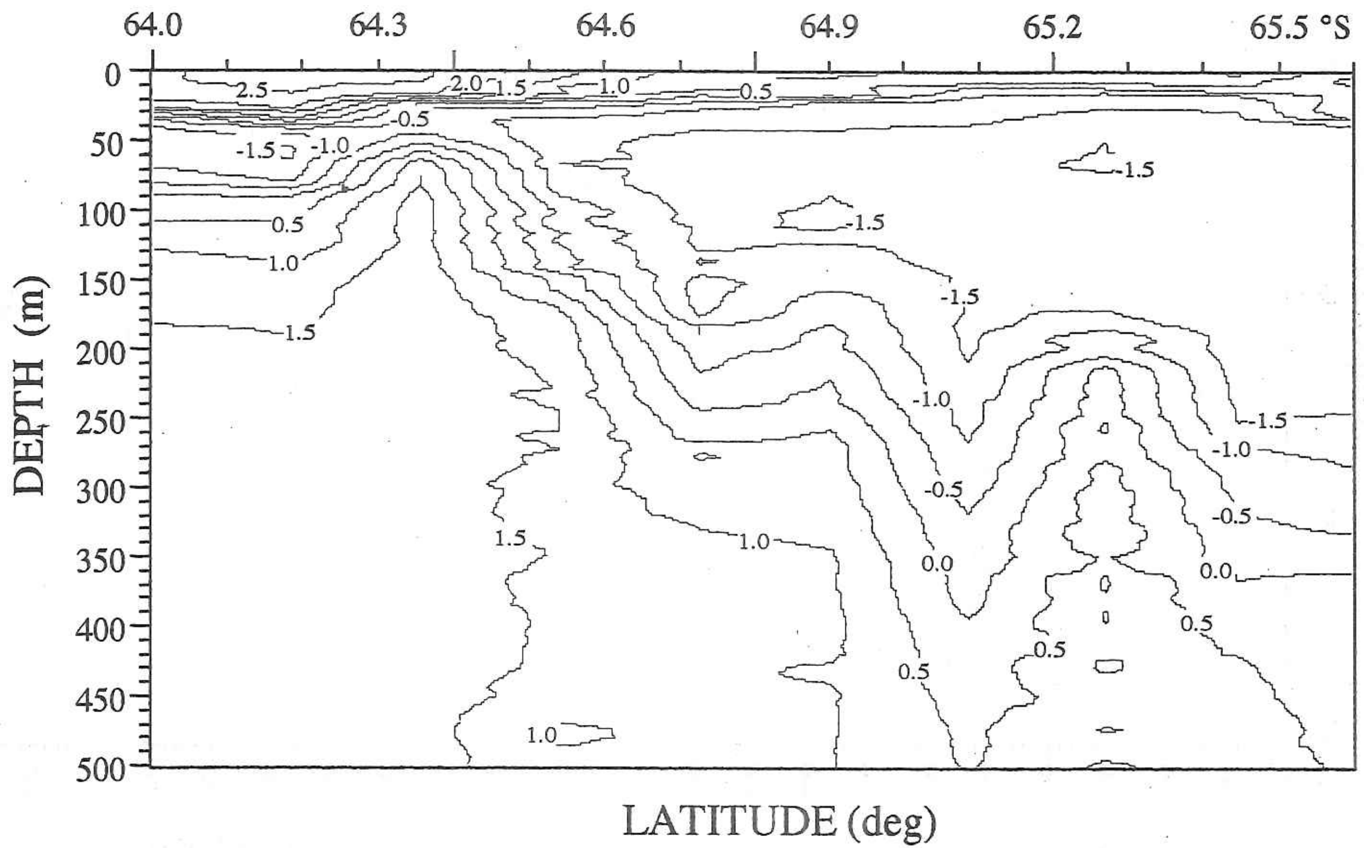
Leg lll (CTD)

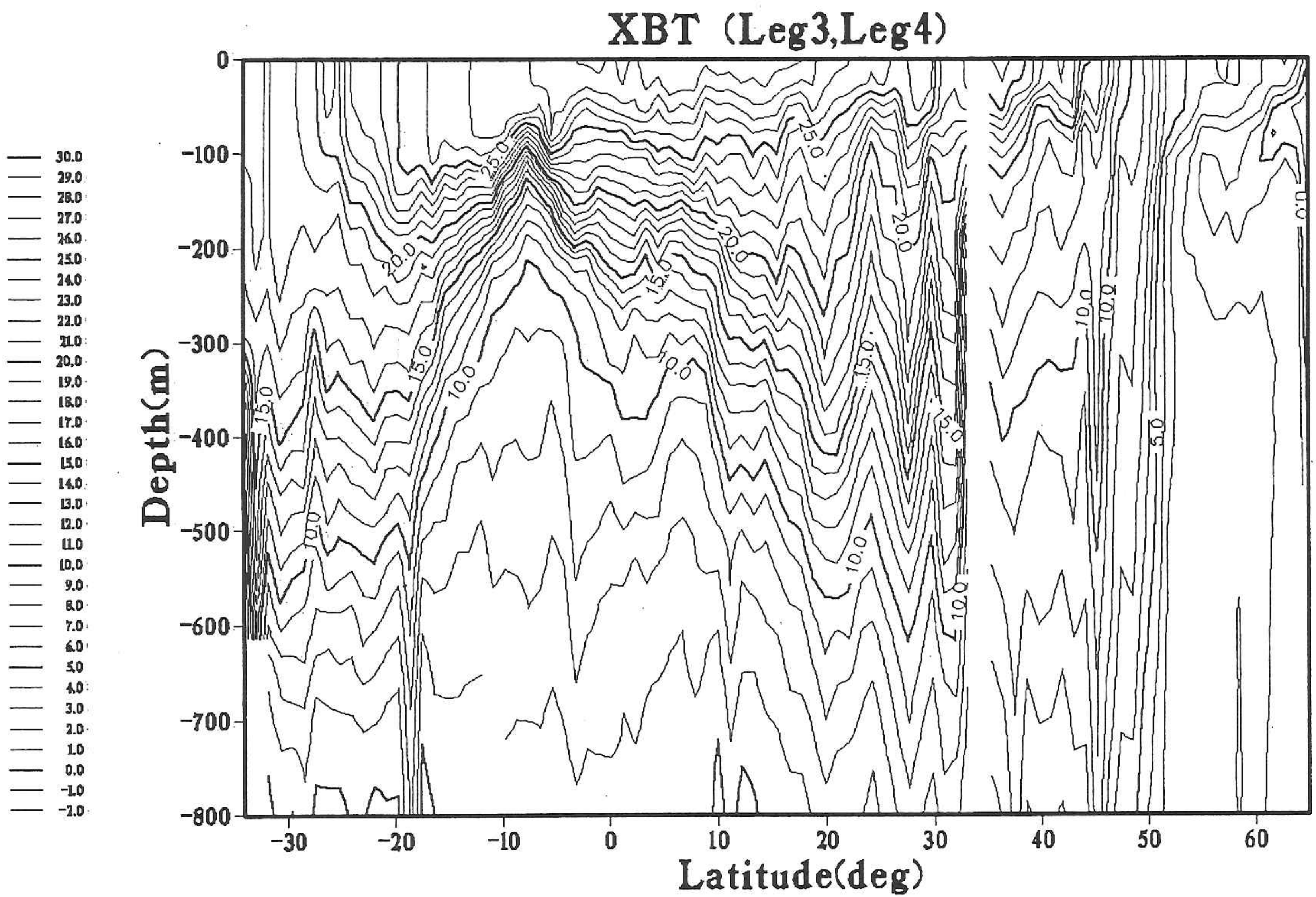

Temperature (°C)
48
52
56
60
64 °S
DEPTH (m)
0
50
100
150
200
250
300
350
400
450
500
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
3.5
2.5
-1.0
-0.5
-1.0
0.0
0.5
1.0
1.0
1.0
0.5
0.0
1.5
2.0
1.5
2.0


Salnity (PSU)
48.0
52.0
56.0
60.0
64.0 °S
DEPTH (m)
0
50
100
150
200
250
300
350
400
450
500
33.8
33.7
34.6
34.5
33.9
34.0
34.2
34.1
34.4
34.3
34.4
34.5
34.6
34.3
34.5
34.3
LATITUDE (deg)

Leg III (XBT)

Temperature (°C)





XBT (Leg3,Leg4)
Depth(m)
Latitude(deg)
0
-100
-200
-300
-400
-500
-600
-700
-800
-30
-20
-10
0
10
20
30
40
50
60
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0