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R/V Mirai Cruise Report

MR02-K05 Leg 1

August 25 – October 10, 2002

(Sekinehama ~ Dutch Harbor ~ Barrow ~ Tuktoyaktuk ~ Dutch Harbor)

JWACS

(Joint Western Arctic Climate Studies)

Contents

Preface

Historically, the Arctic Ocean was assumed to exhibit little spatial and temporal variability and to have little impact on climate and the global heat balance. This highly inaccurate view has been corrected during the past decade. For example, the climatological summer ice edge was located on the shelf breaks along the perimeter of the Canada Basin in the Western Arctic Ocean. However the edge has now moved into the Canada Basin greater than 74N north of the Bering Strait after 1997 except 2001. The geographical distribution of recent ice reduction suggests the influence of Pacific inflow on the Western Arctic climate system. The global climate system is established by a balance between heating in the low latitude and cooling in the polar regions. The Arctic change could cause a change in the balance of the current climate state. Under these backgrounds, JAMSTEC and Fishery and Oceans of Canada (DFO) agreed to initiate joint observation oriented project called JWACS (Joint Western Arctic Climate Studies). The overarching goal is to prepare for global change and to reduce uncertainties in forecasting, a substantial improvement in our fundamental understanding of processes controlling variability in Arctic climate systems; specifically: of shelf/basin interactions; and inter-basin forcing of ice and water properties of land/ocean exchanges.

JWACS 2002 filed experiment is coordinated by multi ship operation using R/V Mirai, CCGS Louis S. St-Laurent and CCGS Sir Wilfrid Laurier to cover the entire southern Canadian Basin, to establish the climate mooring stations in the Canada Basin. R/V Mirai (MR02K05 leg1) was in charge of multi-disciplinary studies mainly focusing on the shelf-basin interaction. Figure 1 shows the JWACS 2002 hydrographic stations occupied by the three vessels.

The research missions of R/V Mirai are summarized as:

(1) Basin scale ocean circulation

- Conduct a CTD/XCTD, water sampling survey in the full span of the Southern Canada Basin from off Mackenzie shelf into the Chukchi Abyssal Plain west of the Chukchi Borderland.
- Hydrographic revisit of SHEBA 97 section from North Slope to near the initial SHEBA site.
- Hydrographic revisit of SHEBA 97-98 drift section

(2) Shelf basin interaction processes

- Conduct a CTD sections across/along the shelf breaks and submarine canyons
- Conduct an underway ADCP and surface water sampling.
- Plankton sampling

(3) Carbonate chemistry

- Observation of partial pressure of CO_2 (pCO_2), total alkalinity, total dissolved inorganic carbon (TDIC), dissolved oxygen and nutrients in order to assess the spatial and temporal variations of budget and flux of CO_2.

(4) Atmospheric science

- Radiosonde, Tethered balloon, Doppler radar, and Aerosol observations are conducted.

(5) Paleo Oceanography and geology

- Piston samplings at three locations in the Mackenzie Canyon were conducted.
- Surface sediment core samplings were conducted over the Kopanor Mud-volcano in the Mackenzie shelf.
- Underway surveys using Seabeam and Sub-bottom profiler surveys were conducted.
- High resolution survey of sea floor topography was conducted in the vicinity of the mud volcano.

This cruise report describes the content of the MR02K01-Leg1 briefly, that simply notes instruments, methods, and preliminary results.

1. Outline of MR02-K05 leg1

1.1. Cruise Summary

1.1.1 Ship

R/V Mirai

L x B x D	128.58m x 19.0m x 13.2m
Gross Tonnage	8,672 tons
Call Sign	JNSR

1.1.2 Cruise Code

MR02-K05 (Leg1)

1.1.3 Project Name

Arctic Ocean Observation Study

1.1.4 Undertaking Institute

Japan Marine Science and Technology Center (JAMSTEC)
2-15 Natsushima-cho, Yokosuka 237-0061, Japan

1.1.5 Chief Scientist

Akihiko Murata (JAMSTEC) : Sekinehama [Aug. 25] - Barrow [Sep. 6]
Koji Shimada (JAMSTEC) : Barrow [Sep. 7] – Dutch Harbor [Oct. 10]

1.1.6 Periods and Ports of Call

Leg-1a: August 25 (Sekinehama, Japan) to September 1 (Dutch Harbor, USA)
(call at Dutch Harbor for September 1-2)
Leg-1b September 2 (Dutch Harbor, USA) to September 6 (Barrow, USA)
Leg-1c September 7 (Dutch Harbor, USA) to September 20 (Tuktoyaktuk, Canada)
Leg-1d September 20 (Tuktoyaktuk, Canada) to October 10 (Dutch Harbor, USA)

1.1.7 Observation Summary

CTD (+ water sampling)	113 stations (Leg 1)
CTD (only)	33 stations (Leg 1)
XCTD	24 stations (Leg 1)
ADCP Observation	Continuously

Oceanic Environment Monitoring	Continuously
Surface Meteorology	Continuously
Towing Plankton Net Sampling	38 stations
Sediment Core Sampling	2 locations
Piston Core Sampling	3 locations
Sea Floor Topography (Seabeam)	Continuously
Sea Floor Topography (Sub-bottom profiler)	Mackenzie Canyon and Kopanor Mud Volcano area only
Tethered balloon Launching	5 times
Radiosonde Launching	120 times
Doppler Radar Observation	Continuously
Aerosol measurement	Continuously
Dual polarization lidar	Continuously
Cloud radar and microwave radiometer	Continuously
Eddy flux measurement	Continuously
Geophysical Parameters	Continuously

1.1.8 Data Policy

All data obtained during this cruise will be under the control of the Data Management Office (DMO) of JAMSTEC.

1.1.9. Overview

(1) Leg-1a: August 25 (Sekinehama) – September 1 (Dutch Harbor, USA)

We set sail for Dutch Harbor on 25 August, 2002 at Sekinehama, Japan. On the passage, we conducted sonde observations at the time when a satellite (ADEOSⅡ) is just above the ship, in addition to continuous weather and underway observations.

(2) Leg-1b: September 2 (Dutch Harbor, USA) – September 7 (Off Barrow, USA)

We had a CTD test cast off Dutch harbor (54-58.30ºN, 169-29.73ºW) on 2 September. On 4 September, we arrived at the Bering Strait and carried out 2 hydrographic observations. After passing through the Bering Strait, 10 hydrographic observations were conducted in the Chukchi Sea, especially focused on the Barrow Canyon, during 5 to 6 September. After that, we left for Pt. Barrow to rendezvous with CCGS Louis S. St-Laurent.

(3) Leg-1c: September 7 (Off Barrow, USA) – September 20 (Off Tuktoyaktuk, Canada)

On September 7 three vessels, R/V Mirai, CCGS Louis S. St-Laurent and CCGS Sir Wilfrid Laurier, rendezvoused off Point Barrow for the transfer of personnel and scientific instruments. The ocean color was green suggesting the strong buoyancy driven current of Eastern Chukchi Summer Water. After the rendezvous, we sail toward the mouth of the Barrow Canyon where three mooring are deployed to measure the volume, heat and salt flux through the Barrow Canyon. We have conducted CTD/ADCP section across the Barrow Canyon. Detail structure of the coastal current of ECSW with the advective speed greater than 2 knots was observed.

During September 8-12, we conducted the hydrographic survey focusing on the shelf basin interaction on the northern end of the Chukchi Sea and southern Chukchi Borderland. We have occupied two complete full water sampling sections across the shelf slope. On the Chukchi Borderland, the sea ice retreated about 75N. We have conducted spatially high resolution hydrographic survey using CTD/ADCP in this area. We will describe later in detail, significant differences has observed across the Northwind Ridge. Due to the ice condition, we could not enter the area north of 75N in first half of September.

We streamed to east after September 13. Taking the hydrographic station done by CCGS Louis S. St-Laurent into consideration, we occupied hydrographic sections in the southern Canada Basin. We reached the SHEBA97 hydrographic section at 72-50N 142W on September 16, and occupied the sections at the same stations of SHEBA97 until September 17.

We have transited to Canadian Beaufort Sea on September 18 and reached the shelf slope off the Kugmallit Canyon on September 19. We have conducted hydrographic section onto the Mackenzie shelf along the Kugmallit Canyon. In the afternoon on September 19, we have rendezvoused with a sailing boat Sedna IV. Canadian broadcast team interviewed the scientific activity of R/V Mirai. On September 20 three Canadians (Eddy Carmack, Conie Lovjoy and Loius Harwood) disembarked off Tuktoyakutuk.

(4) Leg-1d: September 20 (Off Tuktoyaktuk, Canada) – October 10 (Dutch Harbor, USA)

After the personnel transfer off Tuktoyakutuk, our scientific targets moved to shelf basin interactions and paleo oceanography on the Mackenzie Shelf in the first half of Leg-1d. The submarine canyons (Mackenzie and Kugmallit) and steep shelf slope close to coast are the area where strong water mass exchanges between shelf and basin and vertical mixing. The area is also corresponds to the area of Cape Bathurst Polynia and Lake Mackenzie. At first we streamed to the Cape Bathurst area for the surveys of the physics-biological connection. After that, we backed to the Mackenzie Canyon and sampled piston core sampling at three locations along the center of the canyon. Fortunately strong easterly begun to blow after the geological survey, we occupied along and across sections in the vicinity Mackenzie Canyon. Halocline water greater than 32 psu was upwelled onto the shelf region near the Herschel Island where the historically famous whaling area. Final mission in the Mackanzie shelf is to detect the oceanographic-geological interaction around the

Kopanor Mud Volcano at 70-23N, 135-25W. Due to the rough condition, planned three piston core samplings were cancelled. However, the excellent survey of sea floor topography was done by the excellent operation of the ship, detail 3-D features of the mud volcano and an evidence of gas emissions were clarified. These new results will be important preliminary understandings for future developments of Arctic environmental sciences.

The scheduled personnel transfer on September 29 was canceled due to rough condition. We streamed back to Western Canada Basin. We have complete a section along 152-30W from the shelf region into the central Canada Basin at 74N. We turned direction heading west across the Northwind Ridge. In late September, the sea ice was completely retreated southern half of the Chukchi Borderland at 76-77N. This ice condition was historical record of ice retreat in the western Canada Basin. We tried to occupy the zonal section across the Northwind Ridge and Chukchi Plateau into the Chukchi Abyssal Plain. The sea began to freeze in early October under the cold weather. We have reached 76-23N on October 3 in the Northwind Abyssal Plain. This location was a farthest north record of ice strengthen vessel in the western Arctic Ocean. Under the maximum ice retreat area, subsurface warm water originated from the Chukchi Sea was observed. We tackle to enter the Chukchi Abyssal Plain where the influences of the Pacific Water via the Herald Canyon. On October 4, we entered the deep Chukchi Abyssal Plain and had the last full depth water sampling there. After the final full water sampling stations, we continued to have XCTD section from the southern end of the Chukchi Plateau to the 50m isobath in the Northern Chukchi Sea.

We occupied hydrographic section across the eastern half of the Bering Strait on October 7 and then ended the cruise of MR02K01-Leg1 at Dutch Harbor in the early mooring on October 10.

1.1.10 Acknowledgement

MR02K01 Leg1 as a part of JWACS 2002 program has been a great success and this is because of the excellent science team, support and help of the crews of R/V Mirai and technical staffs of GODI and MWJ. We have established to address these important climate related questions together in the Arctic. I would like to express my heartfelt appreciation to all of them.

(MR02-K05 Leg1 Chief Scientist Koji Shimada)

1.2 Cruise track and log

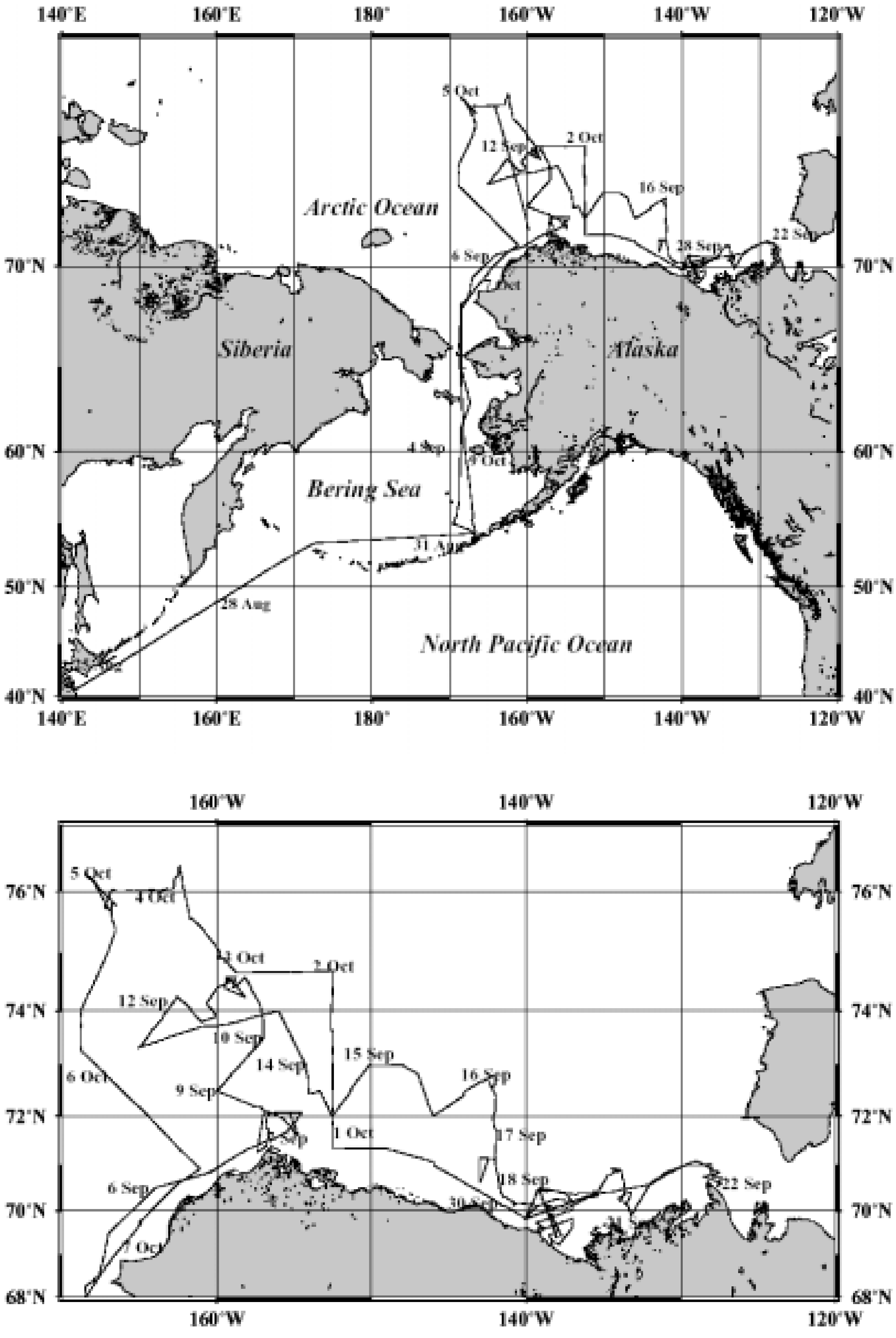


Figure 1.2-1 Cruise track of MR02-K05 leg1 (25 August – 10 October 2002)

Cruise Log

Date		Time(SMT) start	end	from UTC	Remarks	Stn.
Aug	25	06:00		+9	Depart Sekinehama	
	25	06:00		+9	Start ADCP observation	
	25	12:10		+9	Arrive Hachinohe	
	25	16:30		+9	Depart Hachinohe	
Aug	26	18:10		+9	Start Dopplar Radar Observation	
	26	22:00		+10	Time Adjustment(UTC+10)	
Aug	27	22:00		+11	Time Adjustment(UTC+11)	
Aug	28	13:10		+11	Radio Sonde	RS-001
	28	22:00		+12	Time Adjustment(UTC+12)	
Aug	29	01:59		+12	Radio Sonde	RS-002
	29	14:00		+12	Radio Sonde	RS-003
	29	22:00		+13	Time Adjustment(UTC+13)	
Aug	30 (A)	02:00		+13	Radio Sonde	RS-004
	30 (A)	13:59		+13	Radio Sonde	RS-005
	30 (A)	22:00		+14	Time Adjustment(UTC+14)	
Aug	30 (B)	03:09		-10	Radio Sonde	RS-006
	30 (B)	14:59		-10	Radio Sonde	RS-007
	30 (B)	22:00		-9	Time Adjustment(UTC-9)	
Aug	31	02:59		-9	Radio Sonde	RS-008
	31	14:59		-9	Radio Sonde	RS-009
	31	22:00		-8	Time Adjustment(UTC-8)	
Sep	1	09:20		-8	Arrive Dutch Harbor	
Sep	2	08:00		-8	Depart Dutch Harbor	
	2	17:33	19:50	-8	CTD	A02001-1/BRG01
	3	15:40		-8	Radio Sonde	RS-010
Sep	4	03:30		-8	Radio Sonde	RS-011
	4	14:24	14:43	-8	CTD	A02002-1/BRG02
	4	15:29		-8	Radio Sonde	RS-012
	4	17:49	18:09	-8	CTD	A02003-1/BRG03
Sep	5	01:58	02:20	-8	CTD	A02004-1/CHU01
	5	03:29		-8	Radio Sonde	RS-013
	5	04:13	04:36	-8	CTD	A02005-1/CHU02
	5	08:52	09:12	-8	CTD	A02006-1/CHU03
	5	14:47	15:04	-8	CTD	A02007-1/CHU04
	5	15:11	15:31	-8	Multiple core sampling	
	5	15:30		-8	Radio Sonde	RS-014
	5	15:49	16:00	-8	Plankton net	
Sep	6	03:29		-8	Radio Sonde	RS-015
	6	06:54	07:16	-8	CTD	A02008-1/BRW01
	6	10:51	11:24	-8	CTD	A02009-1/BRW02
	6	13:01	13:33	-8	CTD	A02010-1/BRW03
	6	15:21	16:03	-8	CTD	A02011-1/BRW04
	6	15:31		-8	Radio Sonde	RS-016
	6	17:39	18:18	-8	CTD	A02012-1/BRW05
	6	19:54	21:08	-8	CTD	A02013-1/BRW06
	6	21:29		-8	Radio Sonde	RS-017
Sep	7	03:29		-8	Radio Sonde	RS-018
	7			-8	Rendez-vous	
	7	09:29		-8	Radio Sonde	RS-019
	7	15:39		-8	Radio Sonde	RS-020
	7	21:30		-8	Radio Sonde	RS-021
	7	21:59	22:02	-8	CTD	A02014-1/BC01
	7	22:43	22:57	-8	CTD	A02015-1/BC02
	7	23:29	23:47	-8	CTD	A02016-1/BC03
Sep	8	00:17	00:34	-8	CTD	A02017-1/BC04
	8	01:00	01:39	-8	CTD	A02018-1/BC05
	8	02:39	03:01	-8	CTD	A02019-1/BC06
	8	03:30		-8	Radio Sonde	RS-022
	8	03:35	03:56	-8	CTD	A02020-1/BC07
	8	04:40	04:58	-8	CTD	A02021-1/BC08
	8	05:39	05:56	-8	CTD	A02022-1/BC09

	8	06:56	07:11	-8	CTD	A02023-1/HS01
	8	08:33	08:48	-8	CTD	A02024-1/HS02
	8	09:30		-8	Radio Sonde	RS-023
	8	10:18	10:33	-8	CTD	A02025-1/HS03
	8	12:06	12:18	-8	CTD	A02026-1/HS04
	8	13:45	13:58	-8	CTD	A02027-1/HS05
	8	15:30		-8	Radio Sonde	RS-024
	8	15:33	15:57	-8	CTD	A02028-1/CS01
	8	16:05	16:13	-8	Plankton net	CS01
	8	17:27	17:47	-8	CTD	A02029-1/CS02
	8	18:47	19:10	-8	CTD	A02030-1/CS03
	8	19:17	19:28	-8	Plankton net	
	8	20:15	20:48	-8	CTD	A02031-1/CS04
	8	21:30		-8	Radio Sonde	RS-025
	8	22:58	23:45	-8	CTD	A02032-1/CS05
	8	23:53	00:04	-8	Plankton net	CS05
Sep	9	00:59	02:23	-8	CTD	A02033-1/CS06
	9	03:30		-8	Radio Sonde	RS-026
	9	04:03	05:57	-8	CTD	A02034-1/CS07
	9	06:05	06:16	-8	Plankton net	CS07
	9	09:05	11:14	-8	CTD	A02035-1/CS08
	9	09:30		-8	Radio Sonde	RS-027
	9	12:53	15:24	-8	CTD	A02036-1/CS09
	9	15:31		-8	Tethered ballon observation	
	9	15:53	16:05	-8	Plankton net	CS09
	9	16:15		-8	Radio Sonde	RS-028
	9	17:29	18:04	-8	CTD	A02036-2/CS09
	9	19:57	20:59	-8	CTD	A02037-1/NWR02
	9	21:29		-8	Radio Sonde	RS-029
	9	22:28	23:28	-8	CTD	A02038-1/NWR04
Sep	10	00:39	01:41	-8	CTD	A02039-1/NWR06
	10	02:19	04:42	-8	CTD	A02040-1/NWR07
	10	04:10		-8	Radio Sonde	RS-030
	10	05:20	06:34	-8	CTD	A02041-1/NWR08
	10	07:44	08:00	-8	Plankton net	NWR08
	10	09:00	10:00	-8	CTD	A02042-1/NWR09
	10	09:30		-8	Radio Sonde	RS-031
	10	11:01	11:58	-8	CTD	A02043-1/NWR10
	10	12:05	12:18	-8	Plankton net	NWR10
	10	13:00	13:44	-8	CTD	A02044-1/NWR11
	10	14:27	15:17	-8	CTD	A02045-1/NWR12
	10	15:30		-8	Radio Sonde	RS-032
	10	15:54	16:34	-8	CTD	A02046-1/NWR13
	10	21:30		-8	Radio Sonde	RS-033
Sep	11	02:03		-8	XCTD	XC-001
	11	02:39		-8	XCTD	XC-002
	11	03:30		-8	Radio Sonde	RS-034
	11	03:39		-8	XCTD	XC-003
	11	04:28		-8	XCTD	XC-004
	11	05:20		-8	XCTD	XC-005
	11	09:30		-8	Radio Sonde	RS-035
	11	10:58	12:06	-8	CTD	A02047-1/NCS02
	11	12:13	12:23	-8	Plankton net	NCS02
	11	13:31	14:03	-8	CTD	A02047-2/NCS02
	11	15:00	15:42	-8	CTD	A02048-1/NCS03
	11	15:31		-8	Radio Sonde	RS-036
	11	16:41	17:16	-8	CTD	A02049-1/NCS04
	11	17:22		-8	Plankton net	NCS04
	11	18:55	19:22	-8	CTD	A02050-1/NCS05
	11	20:37	21:03	-8	CTD	A02051-1/NCS06
	11	21:08		-8	Plankton net	NCS06
	11	21:30		-8	Radio Sonde	RS-037
	11	22:22	22:41	-8	CTD	A02052-1/NCS07
	11	23:44	00:03	-8	CTD	A02053-1/HC01

Sep	12	00:07		-8	Plankton net	HC01
	12	00:22		-8	Plankton net	HC01
	12	03:30		-8	Radio Sonde	RS-038
	12	09:04	09:55	-8	CTD	A02054-1/HC02
	12	09:30		-8	Radio Sonde	RS-039
	12	11:38	13:11	-8	CTD	A02055-1/HC03
	12	14:29	16:16	-8	CTD	A02056-1/HC04
	12	15:30		-8	Radio Sonde	RS-040
	12	17:37	19:40	-8	CTD	A02057-1/HC05
	12	21:30		-8	Radio Sonde	ES-041
	12	22:13	00:18	-8	CTD	A02058-1/CB01
Sep	13	03:30		-8	Radio Sonde	RS-042
	13	07:58	08:35	-8	CTD	A02059-1/CB02
	13	09:30		-8	Radio Sonde	RS-043
	13	09:41	12:18	-8	CTD	A02059-2/CB02
	13	15:27	17:38	-8	CTD	A02060-1/CB03
	13	15:29		-8	Radio Sonde	RS-044
	13	18:11	20:01	-8	Tethered ballon observation	
	13	21:27	23:13	-8	CTD	A02061-1/CB04
	13	21:30		-8	Radio Sonde	RS-045
Sep	14	02:57	04:06	-8	CTD	A02062-1/CB05
	14	03:30		-8	Radio Sonde	RS-046
	14	07:58	10:40	-8	CTD	A02063-1/CB06
	14	09:30		-8	Radio Sonde	RS-047
	14	14:00	16:24	-8	CTD	A02064-1/CB07
	14	14:29		-8	Radio Sonde	RS-048
	14	20:08	22:18	-8	CTD	A02065-1/CB08
	14	21:30		-8	Radio Sonde	RS-049
Sep	15	02:15	03:18	-8	CTD	A02066-1/CB09
	15	03:30		-8	Radio Sonde	RS-050
	15	04:00		-8	Radio Sonde	RS-051
	15	07:31	10:05	-8	CTD	A02067-1/CB10
	15	09:30		-8	Radio Sonde	RS-052
	15	12:07		-8	XCTD	XC-006
	15	14:32		-8	XCTD	XC-007
	15	15:30		-8	Radio Sonde	RS-053
	15	17:56	20:21	-8	CTD	A02068-1/SHEBA09
	15	21:16		-8	XCTD	XC-008
	15	21:30		-8	Radio Sonde	RS-054
Sep	16	03:30		-8	Radio Sonde	RS-055
	16	07:01	09:18	-8	CTD	A02069-1/SHEBA08
	16	09:30		-8	Radio Sonde	RS-056
	16	10:21		-8	XCTD	XC-009
	16	11:04		-8	XCTD	XC-010
	16	11:44		-8	XCTD	XC-011
	16	12:36	14:44	-8	CTD	A02070-1/SHEBA07
	16	12:48	13:40	-8	Tethered ballon observation	
	16	15:29		-8	Radio Sonde	RS-057
	16	15:46		-8	XCTD	XC-012
	16	16:25		-8	XCTD	XC-013
	16	17:28		-8	XCTD	XC-014
	16	18:14	20:23	-8	CTD	A02071-1/SHEBA06
	16	21:10		-8	XCTD	XC-015
	16	21:29		-8	Radio Sonde	RS-058
Sep	17	03:30		-8	Radio Sonde	RS-059
	17	07:00	07:53	-8	CTD	A02072-1/SHEBA05
	17	09:30		-8	Radio Sonde	RS-060
	17	10:28	11:26	-8	CTD	A02072-2/SHEBA05
	17	12:07	13:50	-8	CTD	A02073-1/SHEBA04
	17	15:19	16:31	-8	CTD	A02074-1/SHEBA03
	17	15:30		-8	Radio Sonde	RS-061
	17	17:55	18:39	-8	CTD	A02075-1/SHEBA02
	17	18:44	18:54	-8	Plankton net	SHEBA02
	17	19:50	20:13	-8	CTD	A02076-1/SHEBA01

	17	20:18	20:26	-8	Plankton net	SHEBA01
	17	21:19	21:37	-8	CTD	A02077-1/SHEBA00
	17	21:30		-8	Radio Sonde	RS-062
	17	21:42	21:50	-8	Plankton net	SHEBA00
Sep	18	03:30		-8	Radio Sonde	RS-063
	18	09:30		-8	Radio Sonde	RS-064
	18	15:30		-8	Radio Sonde	RS-065
	18	21:30		-8	Radio Sonde	RS-066
Sep	19	03:30		-8	Radio Sonde	RS-067
	19	08:30	08:56	-8	CTD	A02078-1/KC04
	19	09:02	09:11	-8	Plankton net	KC04
	19	09:29		-8	Radio Sonde	RS-068
	19	10:00	10:16	-8	CTD	A02079-1/KC05
	19	11:34	11:52	-8	CTD	A02080-1/KC06
	19	13:10	13:29	-8	CTD	A02081-1/KC07
	19	13:39	14:58	-8	Tethered ballon observation	
	19	15:32	15:52	-8	CTD	A02082-1/KC058W
	19	16:03	16:12	-8	Plankton net	KC058W
	19	17:02	17:22	-8	CTD	A02083-1/KC08
	19	17:29	17:37	-8	Plankton net	KC08
	19	19:19	19:35	-8	CTD	A02084-1/KC08E
	19	19:42	19:48	-8	Plankton net	KC08E
	19	21:16	21:32	-8	CTD	A02085-1/KC09
	19	21:29		-8	Radio Sonde	RS-070
Sep	20	03:30		-8	Radio Sonde	RS-071
	20	09:29		-8	Radio Sonde	RS-072
	20	13:03	14:37	-8	Tethered ballon observation	
	20	15:30		-8	Radio Sonde	RS-073
	20	20:16	20:25	-8	Plankton net	MSE01
	20	21:30		-8	Radio Sonde	RS-074
	20	22:18	22:42	-8	Plankton net	MSE02
Sep	21	03:30		-8	Radio Sonde	RS-075
	21	07:58	08:17	-8	CTD	A02086-1/CBAT01
	21	08:23	08:30	-8	Plankton net	CBAT01
	21	08:54	09:17	-8	CTD	A02087-1/CBAT02
	21	09:30		-8	Radio Sonde	RS-076
	21	10:02	10:22	-8	CTD	A02088-1/CBAT03
	21	11:01	11:30	-8	CTD	A02089-1/CBAT04
	21	11:34	11:50	-8	Plankton net	CBAT04
	21	11:56	12:02	-8	Plankton net	CBAT04
	21	13:18	13:32	-8	CTD	A02090-1/CBAT11
	21	13:36	13:46	-8	Plankton net	CBAT11
	21	14:00	14:16	-8	CTD	A02091-1/CBAT10
	21	14:41	15:00	-8	CTD	A02092-1/CBAT09
	21	15:04	15:21	-8	Plankton net	CBAT09
	21	15:23	15:34	-8	Plankton net	CBAT09
	21	15:29		-8	Radio Sonde	RS-077
	21	16:00	16:21	-8	CTD	A02093-1/CBAT08
	21	18:10	18:25	-8	CTD	A02094-1/CBAT12
	21	18:32	18:38	-8	Plankton net	CBAT12
	21	20:57	21:14	-8	CTD	A02095-1/CBAT13
	21	21:30		-8	Radio Sonde	RS-078
	21	21:57	22:13	-8	CTD	A02096-1/CBAT14
	21	22:18	22:25	-8	Plankton net	CBAT14
	21	23:36	23:51	-8	CTD	A02097-1 /CBAT15
	21	23:56	00:06	-8	Plankton net	CBAT15
Sep	22	03:30		-8	Radio Sonde	RS-079
	22	09:30		-8	Radio Sonde	RS-080
	22	13:11	13:23	-8	Plankton net	PINGO
	22	15:31		-8	Radio Sonde	RS-081
	22	21:30		-8	Radio Sonde	RS-082
Sep	23	03:30		-8	Radio Sonde	RS-083
	23	09:30		-8	Radio Sonde	RS-084
	23	09:52	11:44	-8	Piston Core sampling	

	23	15:30		-8	Radio Sonde	RS-085
	23	21:30		-8	Radio Sonde	RS-086
Sep	24	03:40		-8	Radio Sonde	RS-087
	24	08:56	10:15	-8	Piston Core sampling	
	24	09:30		-8	Radio Sonde	RS-088
	24	14:51	15:53	-8	Piston Core sampling	
	24	15:29		-8	Radio Sonde	RS-089
	24	21:30		-8	Radio Sonde	RS-090
Sep	25	03:30		-8	Radio Sonde	RS-091
	25	09:30		-8	Radio Sonde	RS-092
	25	15:29		-8	Radio Sonde	RS-093
	25	21:30		-8	Radio Sonde	RS-094
Sep	26	03:30		-8	Radio Sonde	RS-095
	26	08:00	08:20	-8	CTD	A02098-1/MCZ01
	26	09:30		-8	Radio Sonde	RS-096
	26	09:35	09:52	-8	CTD	A02099-1/MCZ02
	26	09:58	10:07	-8	Plankton net	MCZ02
	26	10:38	11:00	-8	CTD	A02100-1/MCZ03
	26	11:38	12:06	-8	CTD	A02101-1/MCZ04
	26	12:58	13:32	-8	CTD	A02102-1/MCZ05
	26	14:09	14:47	-8	CTD	A02103-1/MCZ-Z
	26	15:00	15:12	-8	Plankton net	MCZ-Z
	26	15:29		-8	Radio Sonde	RS-097
	26	16:38	17:14	-8	CTD	A02104-1/MCM05,06
	26	18:31	19:36	-8	CTD	A02105-1/MCM07
	26	21:30		-8	Radio Sonde	RS-098
Sep	27	03:30		-8	Radio Sonde	RS-099
	27	07:58	08:16	-8	CTD	A02106-1/MCM01
	27	08:21	08:27	-8	Plankton net	MCM01
	27	09:18	09:35	-8	CTD	A02107-1/MCM02
	27	09:30		-8	Radio Sonde	RS-100
	27	10:25	10:51	-8	CTD	A02108-1/MCM03
	27	11:44	12:04	-8	CTD	A02109-1/MCM04
	27	12:59	13:22	-8	CTD	A02110-1/MCJ-M
	27	14:22	14:52	-8	CTD	A02111-1/MCZ06
	27	15:30		-8	Radio Sonde	RS-101
	27	15:42	16:06	-8	CTD	A02112-1/MCZ07
	27	16:50	17:08	-8	CTD	A02113-1/MCZ08
	27	18:03	18:22	-8	CTD	A02114-1/MCZ09
	27	18:27	18:34	-8	Plankton net	MCZ09
	27	21:30		-8	Radio Sonde	RS-102
Sep	28	03:30		-8	Radio Sonde	RS-103
	28	08:34	08:47	-8	Multiple core sampling	PINGO
	28	09:30		-8	Radio Sonde	RS-104
	28	10:24	10:36	-8	Multiple core sampling	PINGO
	28	16:00		-8	Radio Sonde	RS-105
	28	21:30		-8	Radio Sonde	RS-106
Sep	29	03:30		-8	Radio Sonde	RS-107
	29	09:30		-8	Radio Sonde	RS-108
	29	15:29		-8	Radio Sonde	RS-109
	29	21:30		-8	Radio Sonde	RS-110
Sep	30	00:03	01:26	-8	CTD	A02115-1/NS01
	30	03:30		-8	Radio Sonde	RS-111
	30	06:12	07:29	-8	CTD	A02116-1/NS02
	30	09:30		-8	Radio Sonde	RS-112
	30	12:57	13:17	-8	CTD	A02117-1/BRWE01
	30	14:29	14:53	-8	CTD	A02118-1/BRWE02
	30	15:56	16:37	-8	CTD	A02119-1/BRWE03
	30	17:56	19:23	-8	CTD	A02120-1/BRWE04
	30	21:38	23:55	-8	CTD	A02121-1/BRWE05
Oct	1	06:14	08:44	-8	CTD	A02122-1/WCB01
	1	09:30		-8	Radio Sonde	RS-113
	1	14:49	18:39	-8	CTD	A02123-1/WCB02
	1	22:36	01:12	-8	CTD	A02124-1/WCB03

Oct	2	07:04	08:12	-8	CTD	A02125-1/NWA01
	2	09:02	10:00	-8	CTD	A02126-1/NWA02
	2	09:30		-8	Radio Sonde	RS-114
	2	10:34	11:48	-8	CTD	A02127-1/NWA03
	2	12:58	14:33	-8	CTD	A02128-1/NWA04
	2	14:37	14:50	-8	Plankton net	NWA04
	2	14:54	15:12	-8	Plankton net	NWA04
	2	15:19	16:36	-8	Tethered ballon observation	
	2	17:10		-8	Radio Sonde	RS-115
	2	17:20		-8	XCTD	XC-016
	2	19:32	20:59	-8	CTD	A02129-1/NWA06
	2	22:18	00:11	-8	CTD	A02130-1/NWA07
Oct	3	02:02	02:56	-8	CTD	A02131-1/NWA10
	3	08:08	08:21	-8	CTD	A02132-1/NWA12
	3	09:30		-8	Radio Sonde	RS-116
	3	11:15	11:42	-8	CTD	A02133-1/NWAN01
	3	13:21	14:03	-8	CTD	A02134-1/NWAW03
	3	14:34	15:33	-8	CTD	A02135-1/NWAW02
	3	15:30		-8	Radio Sonde	RS-117
	3	16:30	17:14	-8	CTD	A02136-1/NWAW04
	3	19:05	19:40	-8	CTD	A02137-1/CP03
	3	21:08	21:57	-8	CTD	A02138-1/CP04
Oct	4	01:02	01:41	-8	CTD	A02139-1/BL01
	4	09:40		-8	Radio Sonde	RS-118
	4	13:34	15:04	-8	CTD	A02140-1/CA04
	4	17:23	18:33	-8	CTD	A02141-2/CA02
	4	18:47		-8	XCTD	XC-017
	4	19:23		-8	XCTD	XC-018
	4	19:58		-8	XCTD	XC-019
	4	23:03		-8	XCTD	XC-020
Oct	5	01:06		-8	XCTD	XC-021
	5	03:16		-8	XCTD	XC-022
	5	05:29		-8	XCTD	XC-023
	5	08:58		-8	XCTD	XC-024
	5	09:30		-8	Radio Sonde	RS-119
	5	13:06		-8	XCTD	XC-025
Oct	6	13:20		-8	Radio Sonde	RS-120
Oct	7	13:01	13:17	-8	CTD	A02142-1/BRS05
	7	13:49	14:06	-8	CTD	A02143-1/BRS04
	7	15:08	15:23	-8	CTD	A02144-1/BRS03
	7	15:09		-8	Radio Sonde	RS-121
	7	15:58	16:12	-8	CTD	A02145-1/BRS02
	7	16:49	17:03	-8	CTD	A02146-1/BRS01
	9	22:10		-8	Finish Dopplar Radar Observation	
Oct	10	09:50		-8	Arrive Dutch Harbor	

1.3. Participant List

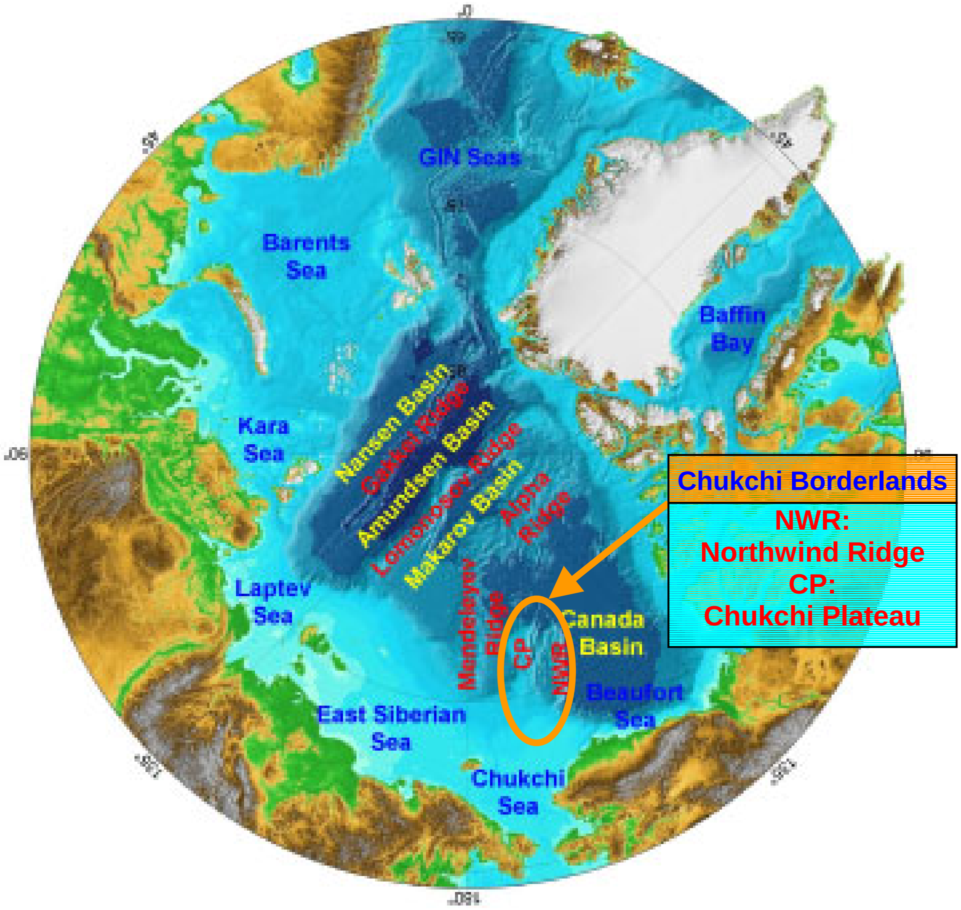
Name	Affiliation	E-mail	S→D leg1a	D→B leg1b	B→T leg1c	T→D leg1d
Scientists						
Koji Shimada	JAMSTEC				○	○
Shigeto Nishino	JAMSTEC		○	○	○	○
Motoyo Ito	JAMSTEC				○	○
Eddy Carmack	IOS/DFO			○	○	
John Harris	IOS/DFO				○	○
Stefan Blasco	GSC					○
Andre Rochon	GSC					○
Paola Travaglini	CHS/DFO					○
Richard Crawford	FWI/DFO			○	○	○
Cindy Frederickson	Univ. British Columbia			○	○	○
Lisa Pickell	Univ. Western Ontario			○	○	○
Connie Lovejoy	Laval Univ.				○	
Lois Harwood	FWI/DFO				○	
Ronald Allen	DFO					○
Akihiko Murata	JAMSTEC		○	○	○	○
Munehito Kimura	KANSO			○	○	○
Sanae Chiba	FRSGC			○	○	○
Tomoyuki Tanaka	FORSGC			○	○	○
Laodong Guo	FORSGC			○	○	○
Celine Gueguen	Univ. Alaska, Fairbanks			○	○	○
Hisashi Narita	Hokkaido Univ.			○	○	○
Yasushi Fujiyoshi	Hokkaido Univ.			○	○	○
Kazuho Yoshida	Hokkaido Univ.			○	○	○
Masayuki Sasaki	NASDA		○			
Masaki Katsumata	JAMSTEC		○			
Noriyuki Tanaka	FORSGC					
Tatsuo Endoh	Hokkaido Univ.					
Ichio Asanuma	NASDA					
Kunio Yoneyama	JAMSTEC					
Toshiya Fujiwara	JAMSTEC					
Marine Technicians						
Satoshi Okumura	GODI		○	○	○	○
Souichiro Sueyoshi	GODI		○	○	○	○
Norio Nagahama	GODI		○	○	○	○
Nobuharu Komai	MWJ		○	○	○	○
Fuyuki Shibata	MWJ		○	○	○	○
Ai Yasuda	MWJ		○	○	○	○
Keisuke Wataki	MWJ		○	○	○	○
Junko Hamanaka	MWJ		○	○	○	○
Masaki Moro	MWJ		○	○	○	○
Toru Fujiki	MWJ		○	○	○	○
Tomomi Kondo	MWJ		○	○	○	○
Masumi Ishimori	MWJ		○	○	○	○
Sawako Araki	MWJ		○	○	○	○
Satoshi Ozawa	MWJ			○	○	○
Miki Yoshiike	MWJ			○	○	○
Kenichi Katayama	MWJ			○	○	○
Naoko Takahashi	MWJ			○	○	○
Mikio Kitada	MWJ			○	○	○
Kenichiro Sato	MWJ			○	○	○
Takayoshi Seike	MWJ			○	○	○
Kaori Taguchi	MWJ			○	○	○
Toru Koizumi	MWJ			○	○	○
Ice Pilot						
David Snider	Martech Polar			○	○	○

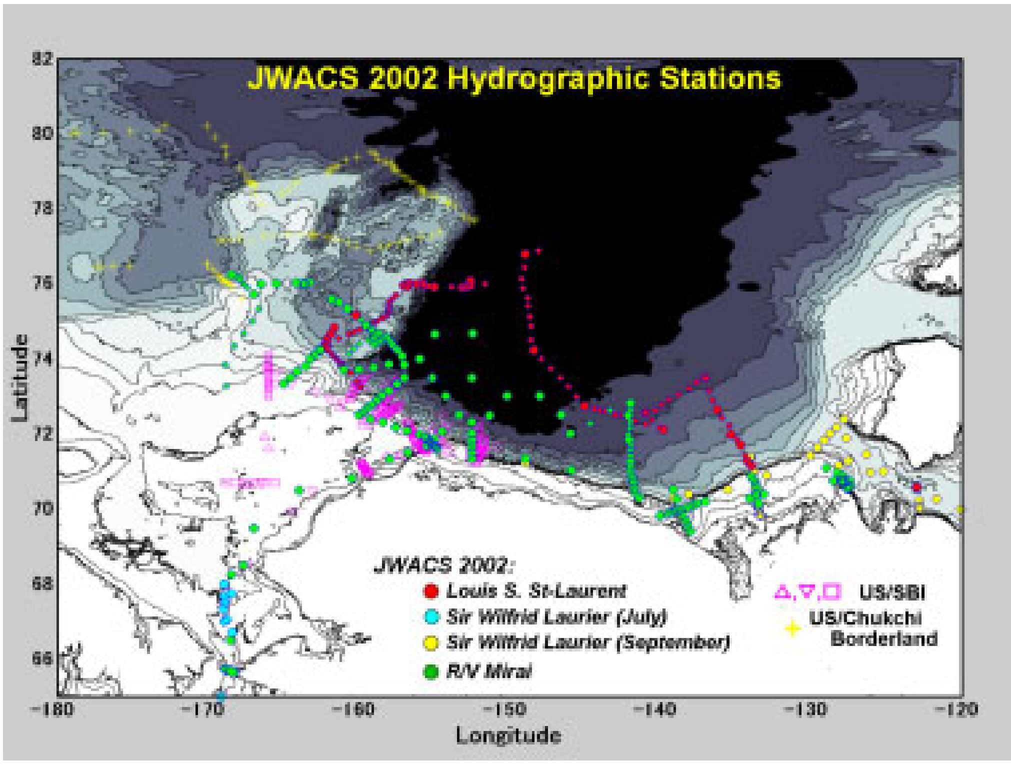
S: Sekinehama, D: Dutch Harbor, B: Barrow, T: Tuktoyaktuk
JAMSTEC: Japan Marine Science and Technology Center
DFO：Department of Fisheries and Oceans, IOS：Institute of Ocean Sciences, GSC：Geological Survey of Canada,
CHS：Canadian Hydrographic Service, FWI：Fresh Water Institute,
FRSGC: Frontier Research System for Global Change,
FORSGC:Frontier Observational Research System for Global Change
NASDA:National Space Development Agency of Japan, KANSO:Kansai Environmental Engineering Center Co., LTD.
GODI：Global Ocean Development Inc., MWJ：Marine Works Japan LTD.

CREW MEMBER LIST

NAME		POSITION	
MASAHARU	AKAMINE	CAPTAIN	
HIROKI	MARUYAMA	CHIEF	OFFICER
HARUHIKO	INOUE	FIRST	OFFICER
TAKESHI	ISOHI	SECOND	OFFICER
SHINGO	FUJITA	THIRD	OFFICER
KOICHI	HIGASHI	CHIEF	ENGINEER
AKITERU	ONO	FIRST	ENGINEER
KYOICHI	HASHIMOTO	SECOND	ENGINEER
TAKAHIRO	MACHINO	THIRD	ENGINEER
SHUJI	NAKABAYASHI	CHIEF	OPERATOR
NAOTO	MORIOKA	SECOND	OPERATOR
KENETSU	ISHIKAWA	BOATSWAIN	
HIROKAZU	KINOSHITA	ABLE	SEAMAN
YASUYUKI	YAMAMOTO	ABLE	SEAMAN
SEIICHIRO	KAWATA	ABLE	SEAMAN
HISAO	OGUNI	ABLE	SEAMAN
TSUYOSHI	MONZAWA	ABLE	SEAMAN
YOSUKE	KUWABARA	ABLE	SEAMAN
MASARU	SUZUKI	ABLE	SEAMAN
MASASHIGE	OKADA	ABLE	SEAMAN
SYUJI	KOMATA	ABLE	SEAMAN
TAKEHARU	AISAKA	ABLE	SEAMAN
YUKIHARU	SUZUKI	ABLE	SEAMAN
YUKITOSHI	HORIUCHI	NO.1	OILER
TOSHIO	MATSUO	OILER	
YOSHIHIRO	SUGIMOTO	OILER	
KAZUMI	YAMASHITA	OILER	
NOBUO	BOSHITA	OILER	
HIDEO	YANAI	OILER	
TAKAAKI	YAMAGUCHI	CHIEF	STEWARD
TAKAYUKI	AKITA	COOK	
TATSUYA	HAMABE	COOK	
HATSUJI	HIRAISHI	COOK	
KOZO	UEMURA	COOK	
KANJURO	MURAKAMI	COOK	

1.4. Preliminary results





Hydrographic status in the summer of JWACS2002 focusing on the upper ocean stratification

In September 2002, the ice on the Arctic Ocean reached record lows. Ice extended over only 5.27 million square kilometers of the Arctic Ocean. Seven to nine million square kilometers is the normal minimum. September's concentration was 17% below normal and 9% below the previous low record observed in 1998. Figure 1.4.1 shows ice concentration on October 3 for climatology and year 2002. Patterns of ice reduction was not uniform in the Arctic; substantial reduction was observed in the western Arctic Ocean north of Bering Strait. Another notable area where huge amount of ice reduction occurred was the Greenland Sea. This geographical implies the ongoing Arctic Change or variability would be strongly associated with the inflows from adjacent Pacific and Atlantic Oceans. The MR02-K05 cruise focused on the role of ocean circulation and the resultant stratification on the Arctic Climate system. We distributed the hydrographic stations of this cruise so as to cover the spreading pathways of Pacific and Atlantic Waters both in the shelf region and basins.

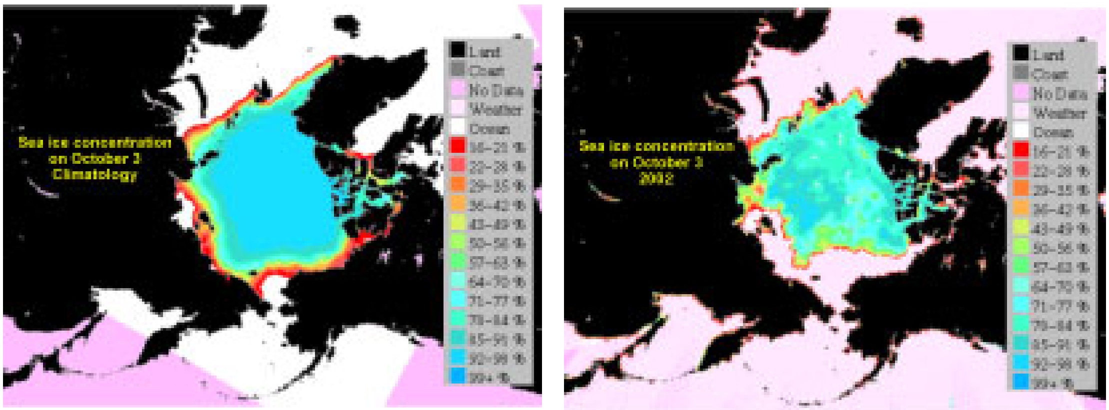


Figure 1.4.1 Spatial distribution of sea ice concentration on October 3 for climatology (left) and year 2000 (right).

Figure 1.4.2 shows the typical layering structure of water masses in the western Arctic Ocean. A remarkable feature is a salt-stratified ocean rather than temperature. So the addition and removal of halocline waters will have an impact on the ice cover through the changes in the depth of surface mixed layer and fluctuation of upward heat flux from the underlying warm waters. Here we briefly report the hydrographic status in the Western Arctic according to the major water masses consisting of the western Arctic stratification. In this section, we argue the hydrography using CTD data acquired by MR02-K05 and Louis S. St-Laurent 2002 cruises.

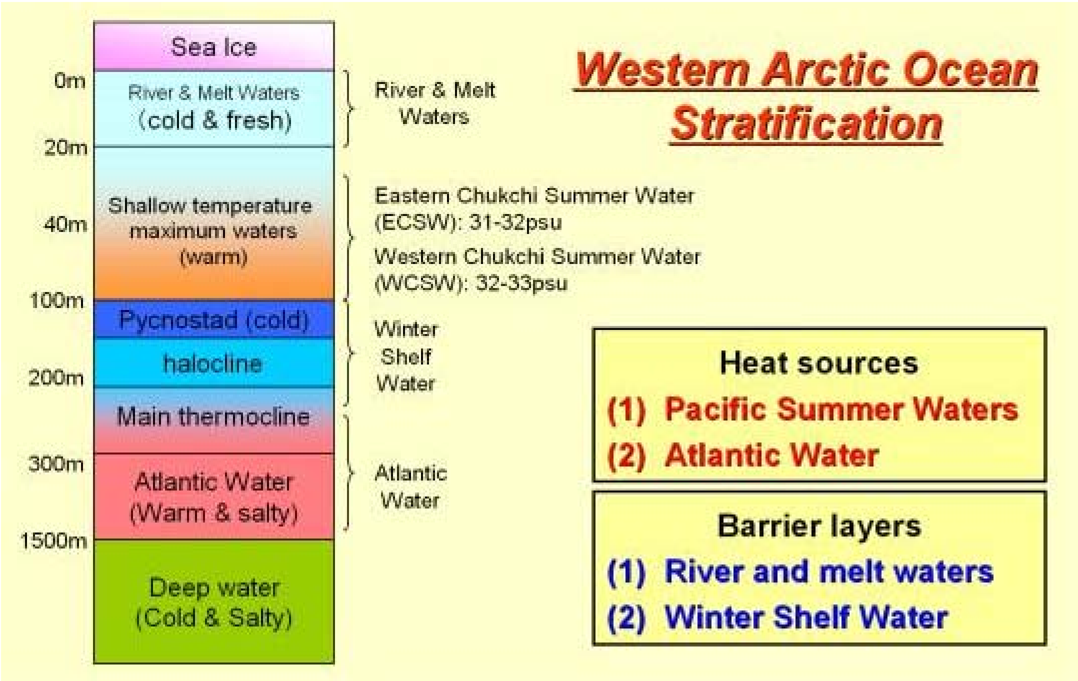


Figure 1.4.2. Schematic diagram of western Arctic Ocean stratification paying an attention to the heat source and barrier layers.

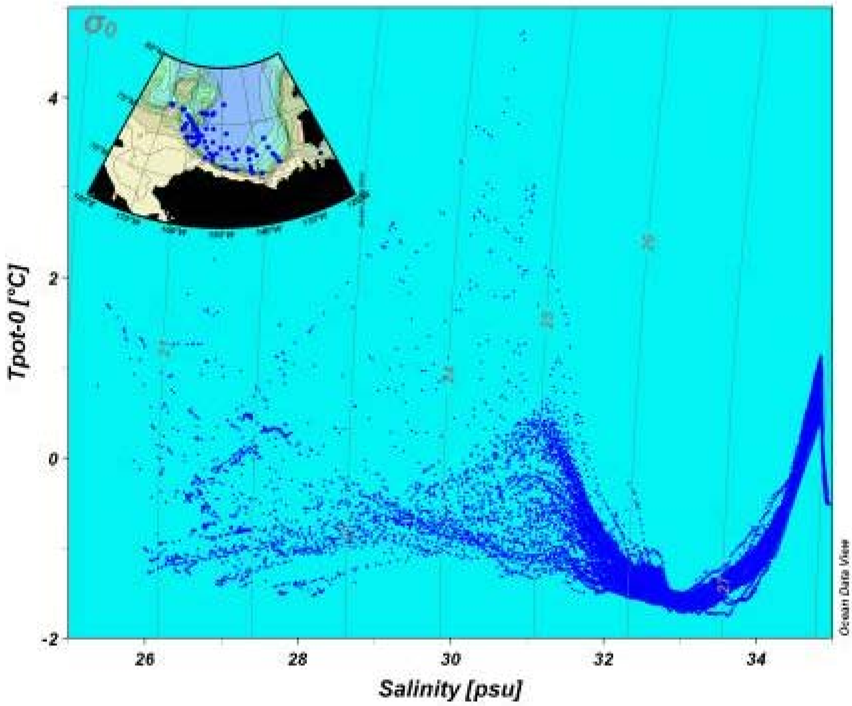


Figure 1.4.3 temperature and salinity scatter plots for all CTD stations of Mirai and Louis S. St-Laurent 2002 cruises.

1.4.1. Heat sources

1.4.1.1. Eastern Chukchi Summer Water (ECSW)

Warmest shallow temperature maximum water with salinity range of 31-32psu enters the Canada Basin via the Barrow Canyon (Figure 1.4.3). This water mass has been called as “Alaskan Coastal Water” in classical literatures (e.g., Coachman et al., 1975). Taking the seasonality of the shelf water and pathway in the Chukchi Sea into consideration, we call this water mass as “Eastern Chukchi Summer Water”,

The summer of 2002 was the recorded ice retreat year in the Western Arctic Ocean. The region where the maximum ice retreat appeared was the Northwind Ridge. Just before the JWACS 2002 field experiment, a symptom of the ice retreat was already expected from the NOAA/AVHRR satellite image on July 19 (Figure 1.4.4). The ice concentration over the Northwind Ridge was much lower than the surrounding. This implied a substantial ice melt was ongoing in this area. We occupied hydrographic stations in this area to investigate oceanic influences on the ice cover. Figure 1.4.5 shows the potential temperature on 31.3 psu within the salinity range of ECSW. Two warm water regions were found in the western Beaufort Sea. One of them appeared in the vicinity of the Barrow Canyon. The maximum temperature on S=31.3 was higher than the 5 degree with an interleaving structure suggesting a new ECSW. The other was observed over the Northwind Ridge. The later one was much colder than the former one and showed no interleaving structure. Therefore the ECSW on the Northwind Ridge would be an old ECSW that entered the Beaufort Sea in 2001. The eastward spreading of ECSW into the deep Canada Basin from the Northwind Ridge suggest the clockwise circulation of ECSW. The spatial distribution of the old ECSW well corresponded to the spatial pattern of the low sea ice concentration in the satellite image on July 19.

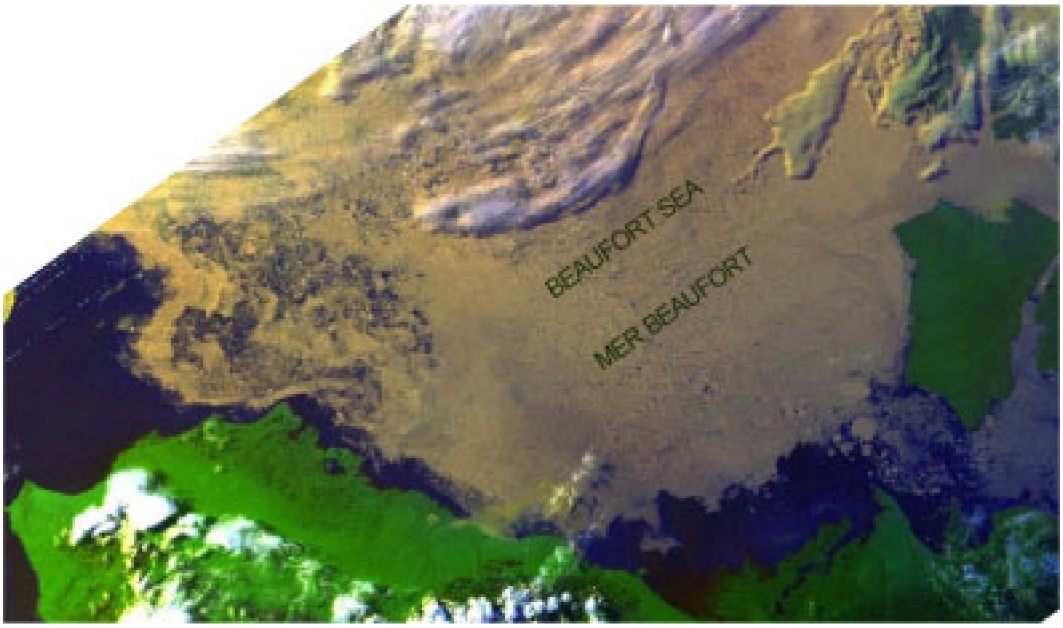


Figure 1.4.4. NOAA AVHRR image on July 19, 2002

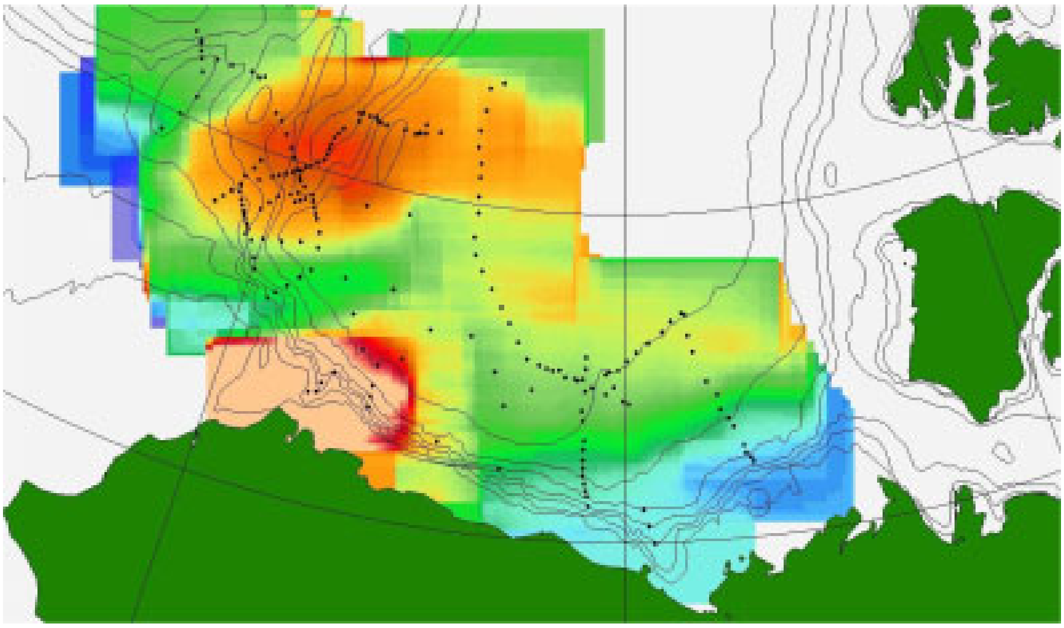


Figure 1.4.5. Spatial distribution of potential temperature on S=31.3 using the all data acquired by R/V Mirai 2002 and CCGS Louis S. At-Laurent 2002 cruises.

1.4.1.2. Western Chukchi Summer Water (WCSW)

The other shallow temperature maximum water in the Western Arctic Ocean is “Western Chukchi Summer Water” reached the Chukchi Borderlands via the Hope and Herald Valleys in the Chikchi Shelf. This water mass is characterized by the temperature maximum water with salinity about 32.6psu or σ_θ=26.2 (Figure 1.4.3). The maximum temperature is much lower than the ECSW. Then the influence of WCSW on the ice cover would be less important relative to ECSW. However the water is also characterized by nutrient rich water. The spatial distribution and spreading pattern can affect the biological activity over the Chukchi Borderlands, middle and outer Chukchi shelf.

Figure 1.4.6 shows the spatial distribution of potential temperature on σ_θ=26.2. Warmest water was observed in the Chukchi Abyssal Plain west of the Chukchi Plateau. However a such kind of warm water was not found east of the Northwind Ridge.

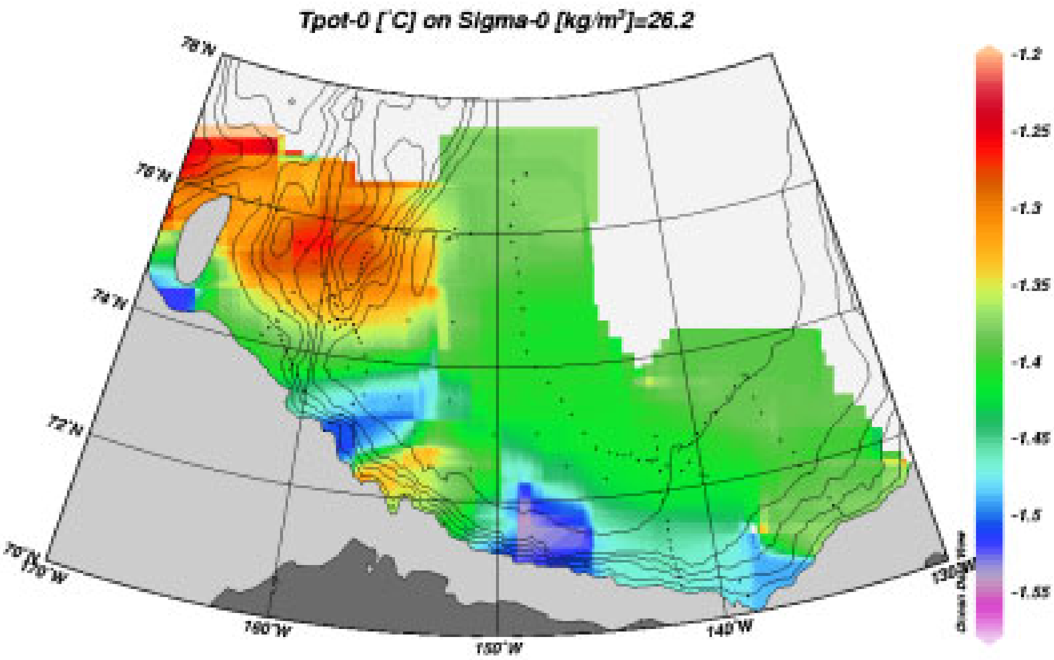


Figure 1.4.6 Spatial distribution of potential temperature on σ_θ=26.2 representing the density of the Western Chukchi Summer Water (WCSW).

1.4.1.3. Atlantic Water

The warming of the Atlantic Water in the Western Arctic has first observed in the vicinity of the Mendeleyev in 1993 (Carmack et al., 1995). After that the warm water anomaly propagated into the Chukchi Borderlands during the SHEBA period of 1997-1998. The Mirai 2002 cruise is opportune to investigate the propagation into the Beaufort Sea.

Figure 1.4.7 shows the temperature profiles on the eastern flank of the Northwind Ridge since early 1990s. The warming was ceased during 1997-1999 on the eastern flank of the Northwind Ridge and Northeastern Chukchi Slope (Figure 1.4.8). This indicates that the circulation over the Chukchi Borderlands are not steady. Some circulation switchyard would occur due to joint effects of seafloor topography and surface forcing associated with sea ice motion.

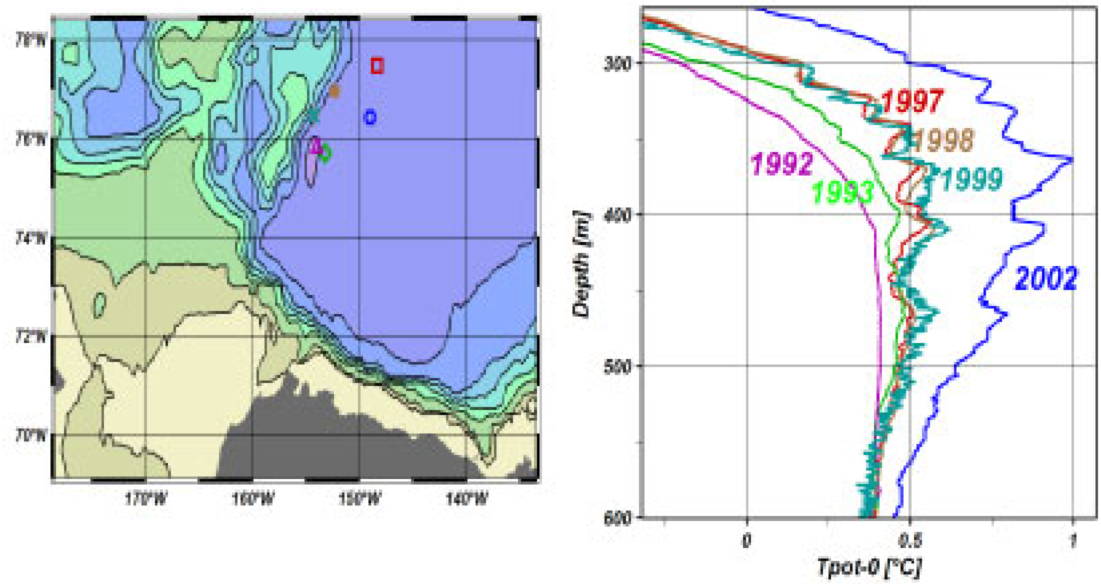


Figure 1.4.7 vertical profiles of temperature on the eastern flank of the Northwind Ridge. Abrupt warming was observed in 2002.

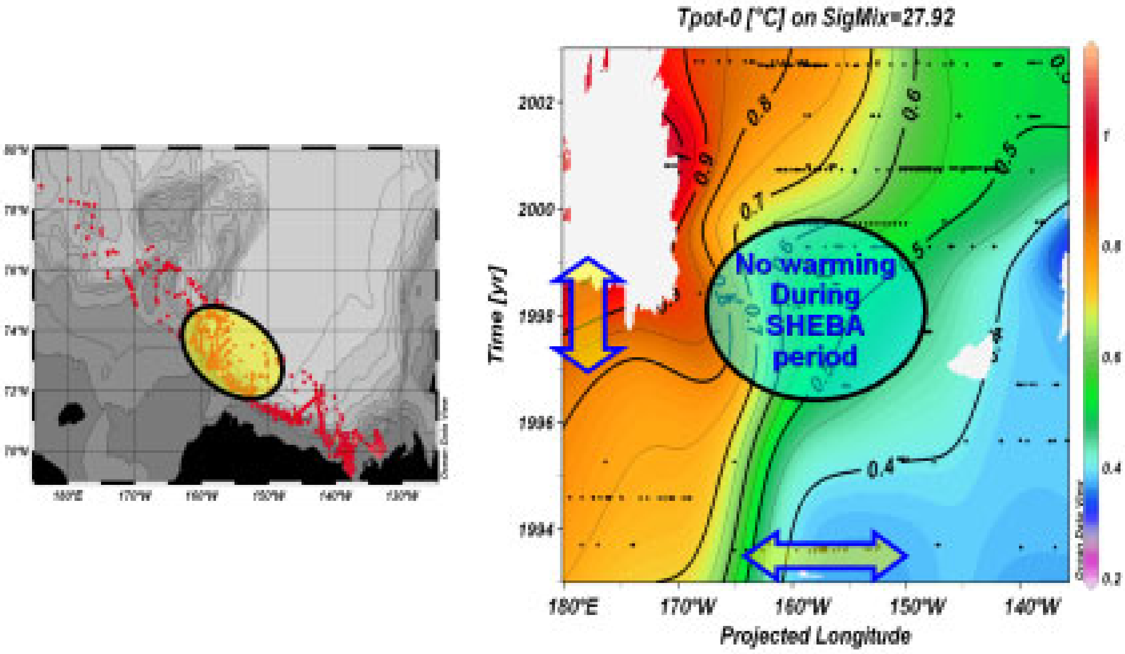


Figure 1.4.8 propagation of Warm Atlantic Water along the western Arctic continental shelf slopes during 1993-2002. Here the SigMix (σ_{mix}) defined by $\sigma_\theta + \theta/60$, where θ and σ_θ are potential temperature and potential density respectively.

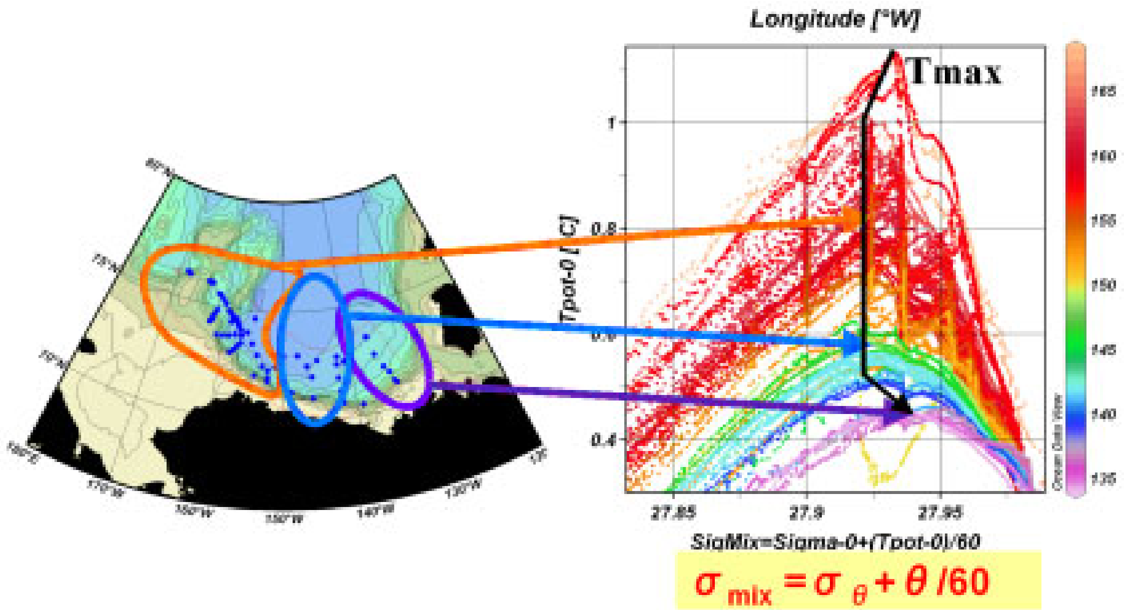


Figure 1.4.9 Three regimes of Atlantic Water in the Canada Basin in 2002.

The hydrographic data of 2002 showed that the Atlantic Water was not uniform properties (Figure 1.4.9). The quantum-like (discrete) distribution of volume being associated with interleaving is consistent in entire Canada Basin. Temperature maximum appeared at some discrete values. In the western Canada Basin west of the 140 ° W, temperature maximum appeared at σ_{mix}=27.925. Large amplitude interleaving structures were observed in the vicinity of the Northwind Ridge. However such large amplitude interleaving structure rarely appeared in the area off Alaskan North Slope. In the area off Mackenzie Canyon small amplitude interleaving structure was observed, however, the feature is different from that near the Northwind Ridge. The interleaving structure occurred at the front between the different type of Atlantic Water with different σ_{mix} at temperature maximum. This suggests that the eastern Canadian Basin off Mackenzie Shelf would be a shadow zone of the Atlantic Water Circulation along the perimeter of the basin.

1.4.2. Barrier layers

1.4.2.1 Mackenzie Water

The Mackenzie Water (MW) is characterized by a freshwater in the Western Arctic Ocean. The MW controls the surface mixed layer depth and inhibits upward heat flux from the underlying ECSW. Therefore the investigation of spreading of MW is significant to identify the region where the upward heat flux from underlying ECSW is apparent. Figure 1.4.10 shows the spatial distribution of salinity at 10 m deep which represents the spreading pattern of MW. The low salinity water lower than 27 psu was distributed in the Canada Basin east of the Northwind Ridge. Then the Northwind Ridge affects not only the circulation pattern ECSW but also MW. The resultant spatial distribution of MW and ECSW specifies region where the interaction between upper ocean and ice cover.

Melt water is also characterized my low-salinity water. Distinction between Mackenzie Water and Melt Water requires chemical properties such as oxygen isotope and Barium.

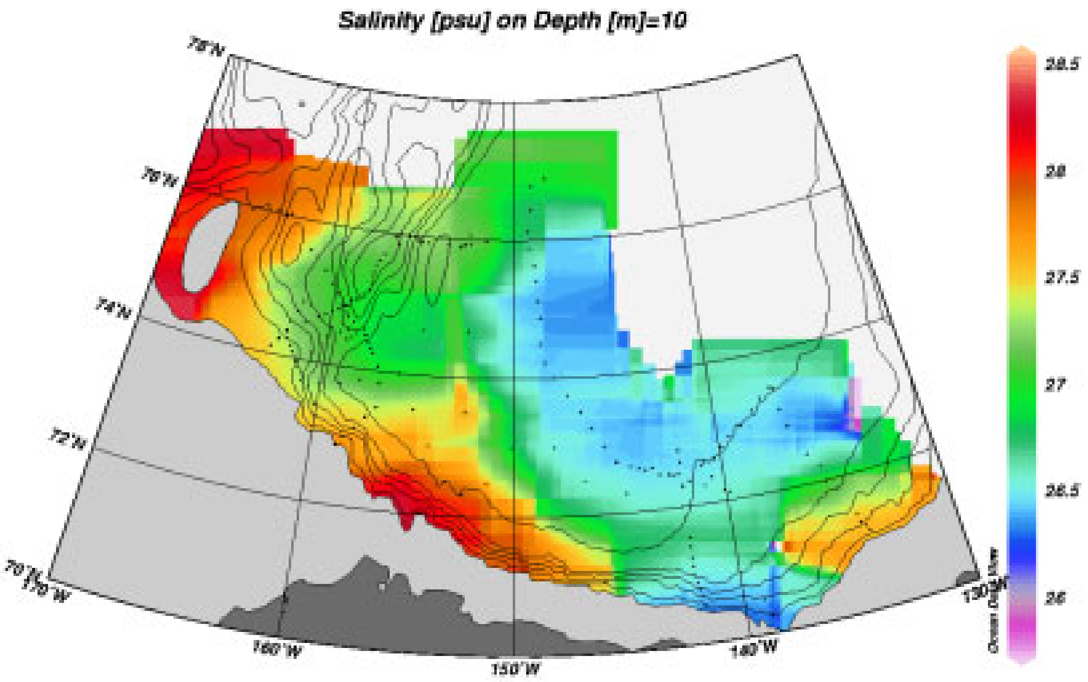


Figure 1.4.10 Spatial distribution of salinity at 10m deep.

1.4.2.2. Winter Shelf Waters (Super dense water)

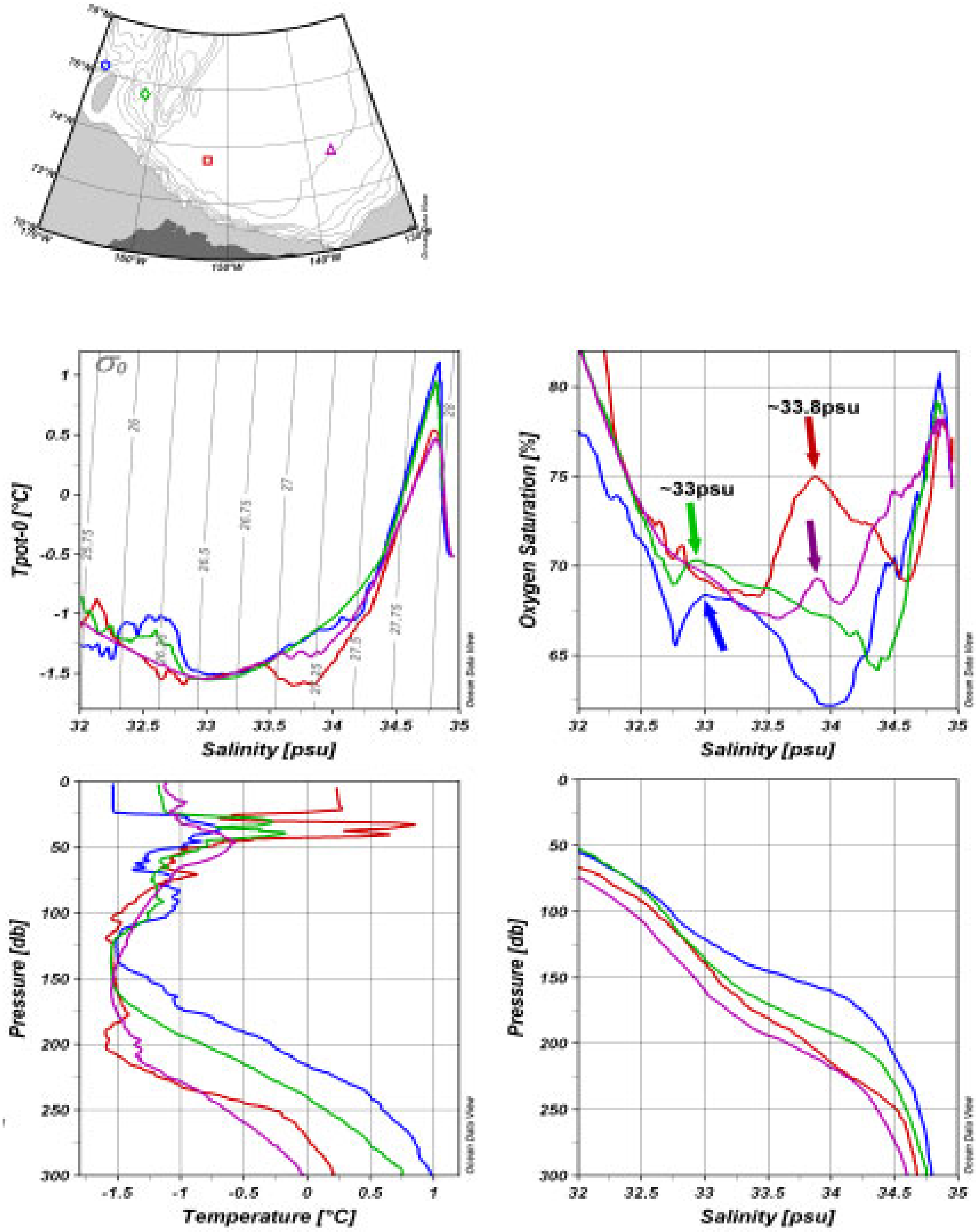


Figure 1.4.11 TS scatter plots (upper-left), relation between salinity and Oxygen saturation (upper right), vertical profiles of temperature (lower left) and salinity (lower right) at selected stations depicted in the map.

Classification of winter waters observed in the Western Arctic Ocean

The winter water in the Western Arctic Basin has been recognized as a temperature minimum water with S=33.1psu. However several varieties of temperature minimum waters were found not only at S=33.1 but also at S=33.5-34.5psu during the MR02K05-Leg1 and Louis S. St-Laurent 2002 cruises (Figure 1.4.11). The later temperature minimum water can be classified into two types. One of them with oxygen poor property was found in the northern half of the Northwind Ridge. The source region was unknown, and would be far west away from the Northwind Ridge. The other with oxygen rich property was observed in the southern Beaufort Sea. The formation region of this kind of temperature minimum water would be in the Chukchi Shelf, since winter water through the Bering Strait from south is generally less than 33.5 psu (Figure 1.4.12, see http://psc.apl.washington.edu/HLD/Bstrait/bstrait.html by *Knut Aagaard (UW), Rebecca Woodgate (UW), Tom Weingartner (UAF)*). This type of temperature minimum water (S>33.5, T~freezing temperature) has been named as "super dense water" by Weingartner et al. (1998). Here we focus on the circulation pattern and formation of the super dense water in southern Canada Basin and northern Chukchi Sea.

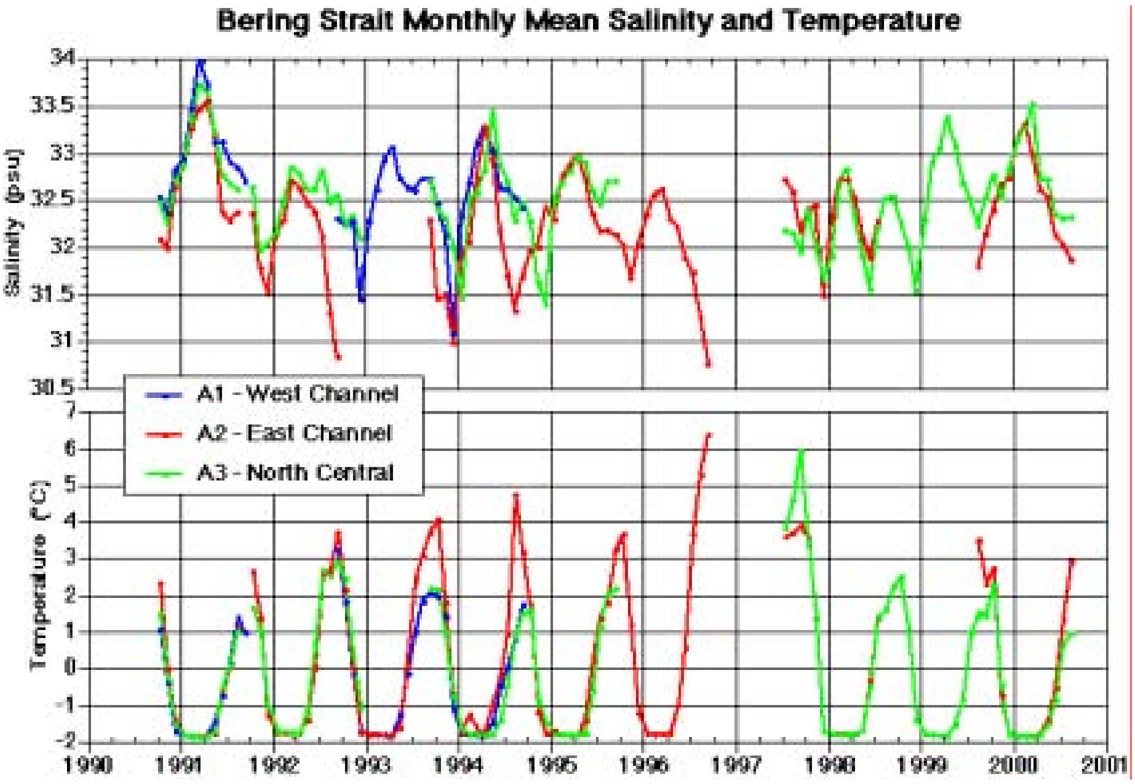


Figure 1.4.12. Monthly mean temperature and salinity in Bering Strait during 1990-2000. After *Knut Aagaard (UW), Rebecca Woodgate (UW), Tom Weingartner (UAF),* http://psc.apl.washington.edu/HLD/Bstrait/bstrait.html).

1.4.2.2.1. Formation of super dense water

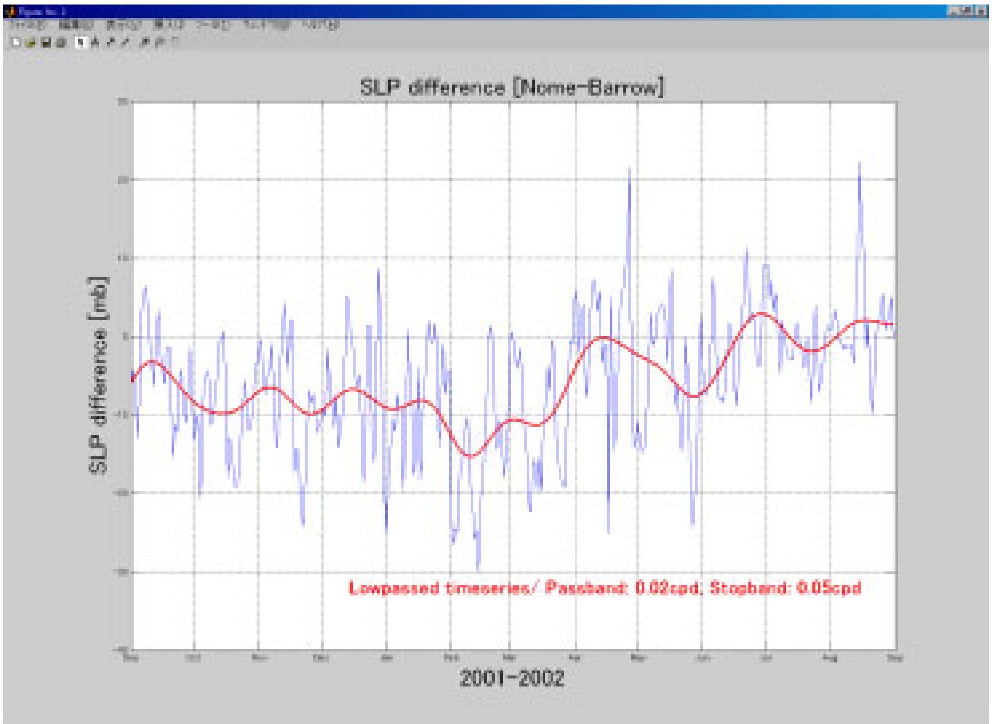


Figure 1.4.13. Daily mean (blue) and lowpassed (red) sea level pressure (SLP) difference between Nome and Barrow

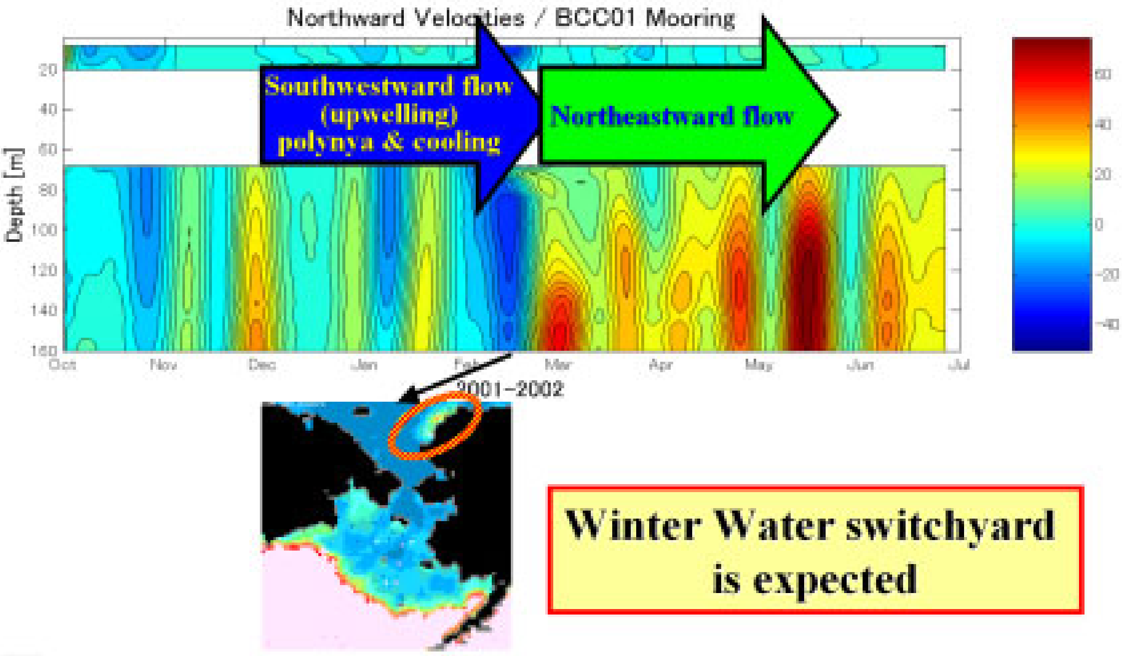


Figure 1.4.14. Northward velocity at the mouth of the Barrow Canyon (71°43.74'N, 155°09.41'W, bottom depth:277m) and sea ice concentration on February 18, 2002.

Figure 1.4.13 shows timeseries of sea level pressure difference; positive value of SLP corresponds to westerly (eastward wind). Strong easterly blew from the late autumn through the end of February. Simultaneously both a coastal polynya formation and strong upwelling were established along the Alaskan Coast (Figure 1.4.14). In February, there was no freezing temperature between 33psu and 34psu (Figure 1.4.15). Dense and cold water was only found near 34.5 psu. From the TS scatter plots at the Barrow Canyon (left panel of Figure 1.4.15), this type of super dense water would be formed by vertical convection due to cooling. After weakening of the easterly, i.e., northward flow regime, super dense water appeared along the freezing temperature, suggesting brine ejection as a major formation mechanism. As a result spreading pathway of the super dense water into the Basin would be different according to the changes in flow pattern (Figure 1.4.16). In early period, the pathway was in the central Chukchi Sea and in the later period in the Barrow Canyon. Spatial distribution of the super dense water in the southern Canada Basin was corresponded to the speculated pathway in the northeastern Chukchi Shelf (Figure 1.4.17-18).

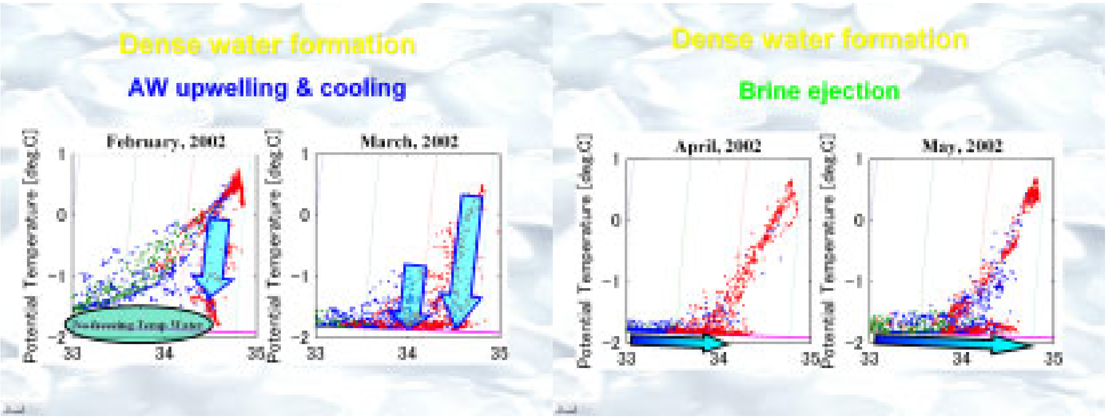


Figure 1.4.15 TS scatter plots at the mouth of the Barrow Canyon during February and May in 2002.

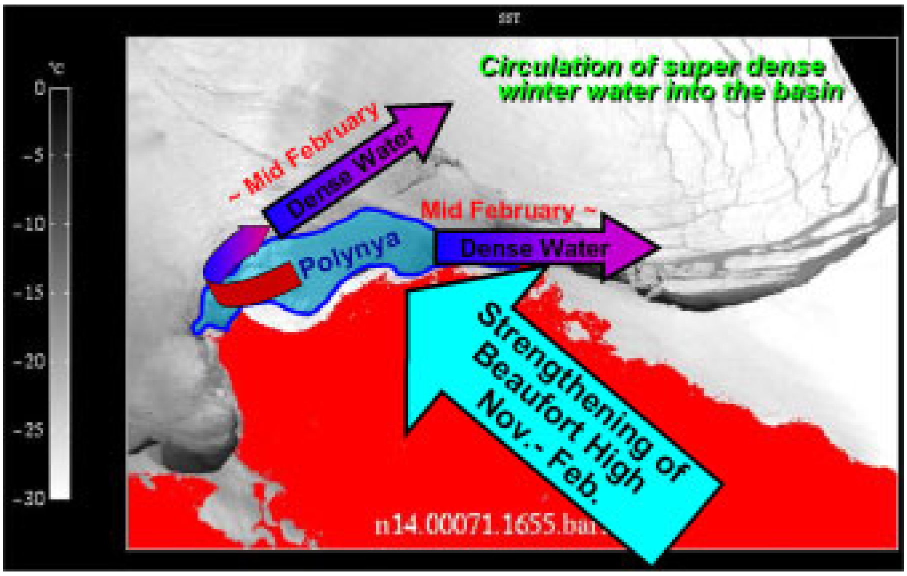


Figure 1.4.16. Schematic image of spreading pathway of dense super dense water in to the basin.

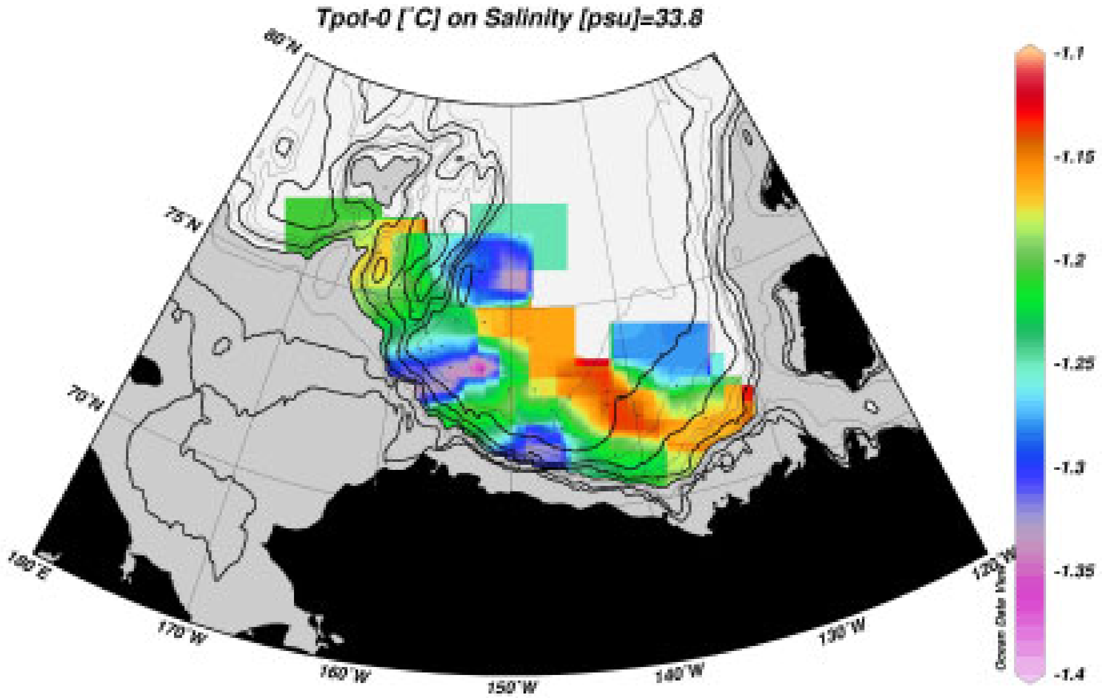


Figure 1.4.17. Spatial distribution of potential temperature on S=33.8psu.

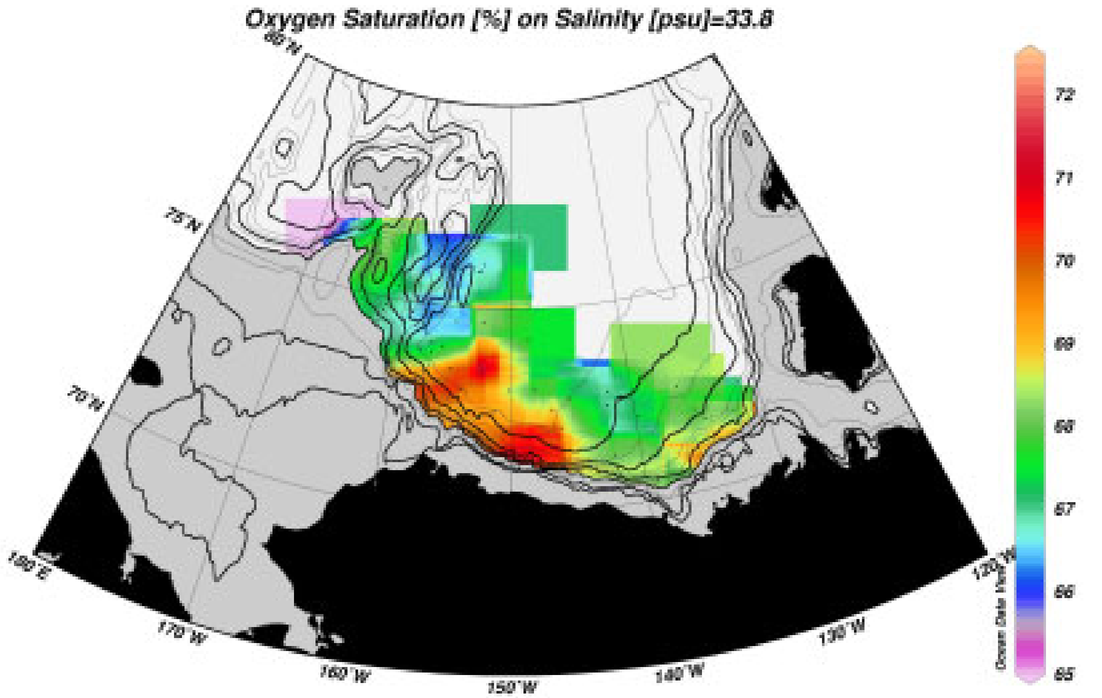


Figure 1.4.18. Spatial distribution of oxygen saturation on S=33.8psu.

2. General observations

2.1 Meteorological observations

2.1.1 Surface meteorological parameters

(1) Personnel

Koji Shimada (JAMSTEC):	Principal Investigator
Satoshi Okumura (GODI):	Operation Leader
Souichiro Sueyoshi (GODI)	
Norio Nagahama (GODI)	
Kunio Yoneyama (JAMSTEC):	(Shore-side participant)

(2) Objective

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

(3) Methods

The surface meteorological parameters were observed throughout MR02-K05 leg1 cruise from the departure of Sekinehama on 25 August 2002 to the arrival of Dutch Harbor on 10 October 2002.

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

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

(3-1) Mirai meteorological observation system

Instruments of Mirai met system are listed in Table 2.1.1-1 and measured parameters are listed in Table 2.1.1-2. Data was collected and processed by KOAC-7800 weather data processor made by Koshin Denki, Japan. The data set has 6-second averaged every 6-second record and 10-minute averaged every 10-minute record.

Table 2.1.1-1: Instruments and their installation locations of Mirai met system

Sensors	Type	Manufacturer	location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24m)
	KE-500	Koshin Denki, Japan	aftermast (36m)
Thermometer	FT	Koshin Denki, Japan	compass deck (21m)
Dewpoint meter	DW-1	Koshin Denki, Japan	compass deck (21m)
Barometer	F451	Yokogawa, Japan	weather observation room captain deck (13m)
Rain gauge	50202	R. M. Young, USA	compass deck (19m)
Optical rain gauge	ORG-115DR	ScTi, USA	compass deck (19m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28m)
Radiometer (long wave)	MS-200	Eiko Seiki, Japan	radar mast (28m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	Bow

Table 2.1.1-2: Parameters of Mirai meteorological observation system

	Parameters	Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Ship's speed	knot	Mirai log, DS-30 Furuno
4	Ship's heading	degree	Mirai gyro, TG-6000, Tokimec
5	Relative wind speed	m/s	6 sec. / 10 min. averaged
6	Relative wind direction	degree	6 sec. / 10 min. averaged
7	True wind speed	m/s	6 sec. / 10 min. averaged
8	True wind direction	degree	6 sec. / 10 min. averaged
9	Barometric pressure	hPa	adjusted to the sea surface level 6 sec. / 10 min. averaged
10	Air temperature (starboard side)	degC	6 sec. / 10 min. averaged
11	Air temperature (port side)	degC	6 sec. / 10 min. averaged
12	Dewpoint temperature (stbd side)	degC	6 sec. / 10 min. averaged
13	Dewpoint temperature (port side)	degC	6 sec. / 10 min. averaged
14	Relative humidity (starboard side)	%	6 sec. / 10 min. averaged
15	Relative humidity (port side)	%	6 sec. / 10 min. averaged
16	Rain rate (optical rain gauge)	mm/hr	6 sec. / 10 min. averaged
17	Rain rate (capacitive rain gauge)	mm/hr	6 sec. / 10 min. averaged
18	Down welling shortwave radiometer	W/m2	6 sec. / 10 min. averaged
19	Down welling infra-red radiometer	W/m2	6 sec. / 10 min. averaged
20	Sea surface temperature	degC	-5m
21	Significant wave height (fore)	m	3 hourly
22	Significant wave height (aft)	m	3 hourly
23	Significant wave period (fore)	second	3 hourly
24	Significant wave period (aft)	second	3 hourly

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

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

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

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

Instruments and their locations are listed in Table 2.1.1-3 and measured parameters are listed in Table 2.1.1-4

Table 2.1.1-3: Instrument installation locations of SOAR system

Sensors	Type	manufacturer	location (altitude from the baseline)
Zeno/Met			
Anemometer	05106	R. M. Young, USA	foremast (25m)
T/RH	HMP45A	Vaisala, USA	foremast (24m)
	with 43408 Gill aspirated radiation shield (R. M. Young)		
Barometer	61201	R. M. Young, USA	foremast (24m)
	with 61002 Gill pressure port (R. M. Young)		
Rain gauge	50202	R. M. Young, USA	foremast (24m)
Optical rain gauge	ORG-815DA	ScTi, USA	foremast (24m)
PRP			
Radiometer (short wave)	PSP	Eppley labs, USA	foremast (25m)
Radiometer (long wave)	PIR	Eppley labs, USA	foremast (25m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25m)

Table 2.1.1-4: Parameters of SOAR system

	Parameters	units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Sog	knot	
4	Cog	degree	
5	Relative wind speed	m/s	
6	Relative wind direction	degree	
7	Barometric pressure	hPa	
8	Air temperature	degC	
9	Relative humidity	%	
10	Rain rate (optical rain gauge)	mm/hr	
11	Precipitation (capacitive rain gauge)	mm	reset at 50mm
12	Down welling shortwave radiation	W/m2	
13	Down welling infra-red radiation	W/m2	
14	Defuse irradiation	W/m2	

(4) Preliminary results

Tair (Mirai meteorological observation system), SST (from EPCS), RH, precipitation, pressure (Mirai meteorological observation system), solar radiation (from SOAR) and Wind (converted to U, V component, from Mirai meteorological observation system), observed during the cruise are shown in Figure 2.1.1-1. In the figures, accumulated precipitation data from Mirai meteorological observation system optical rain gauge was converted to the precipitation intensity and obvious noises were eliminated but not calibrated. Other figures are showing uncorrected data.

(5) Data archives

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

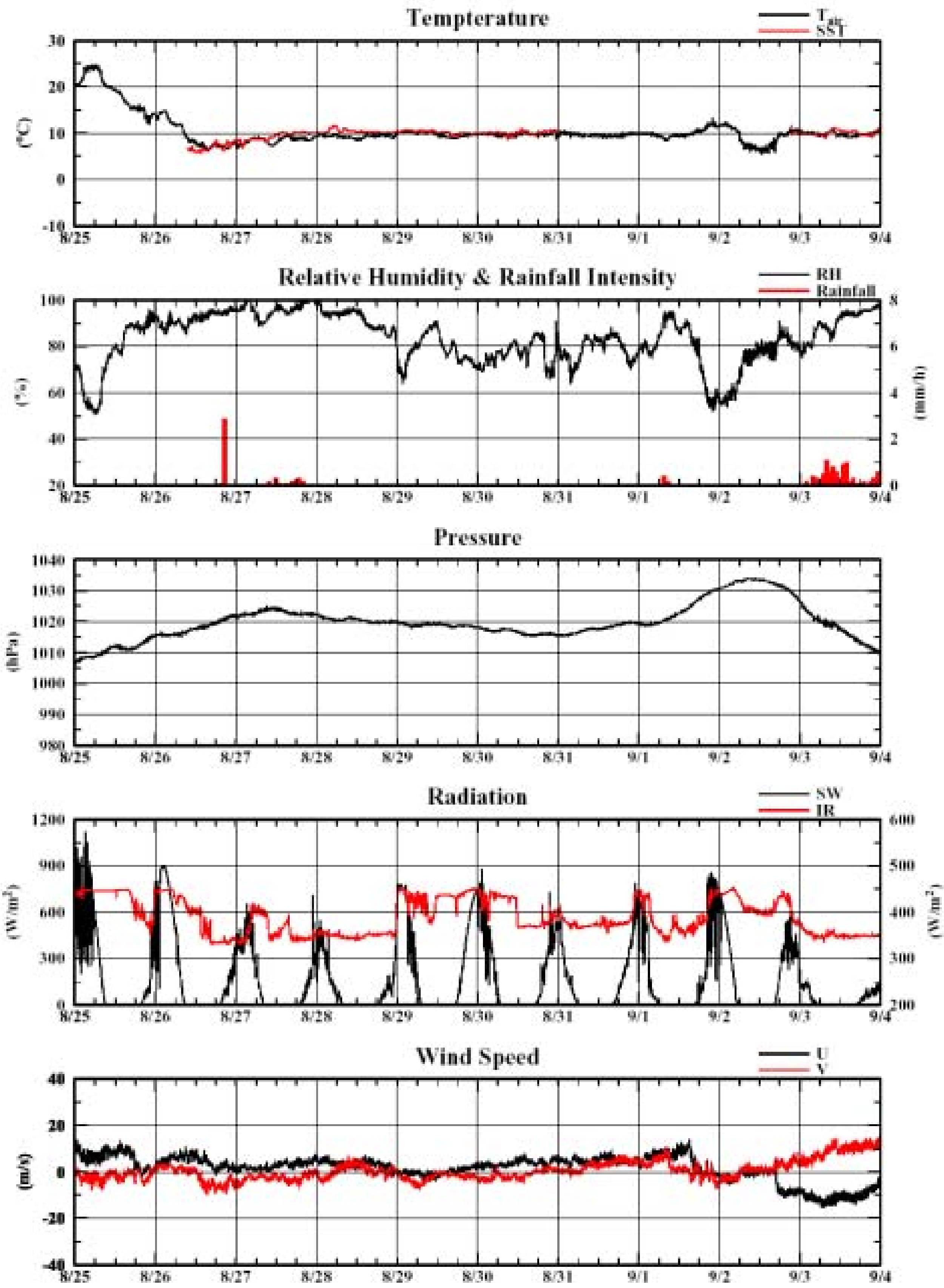


Figure 2.1.1-1 Time series of surface meteorological parameters.

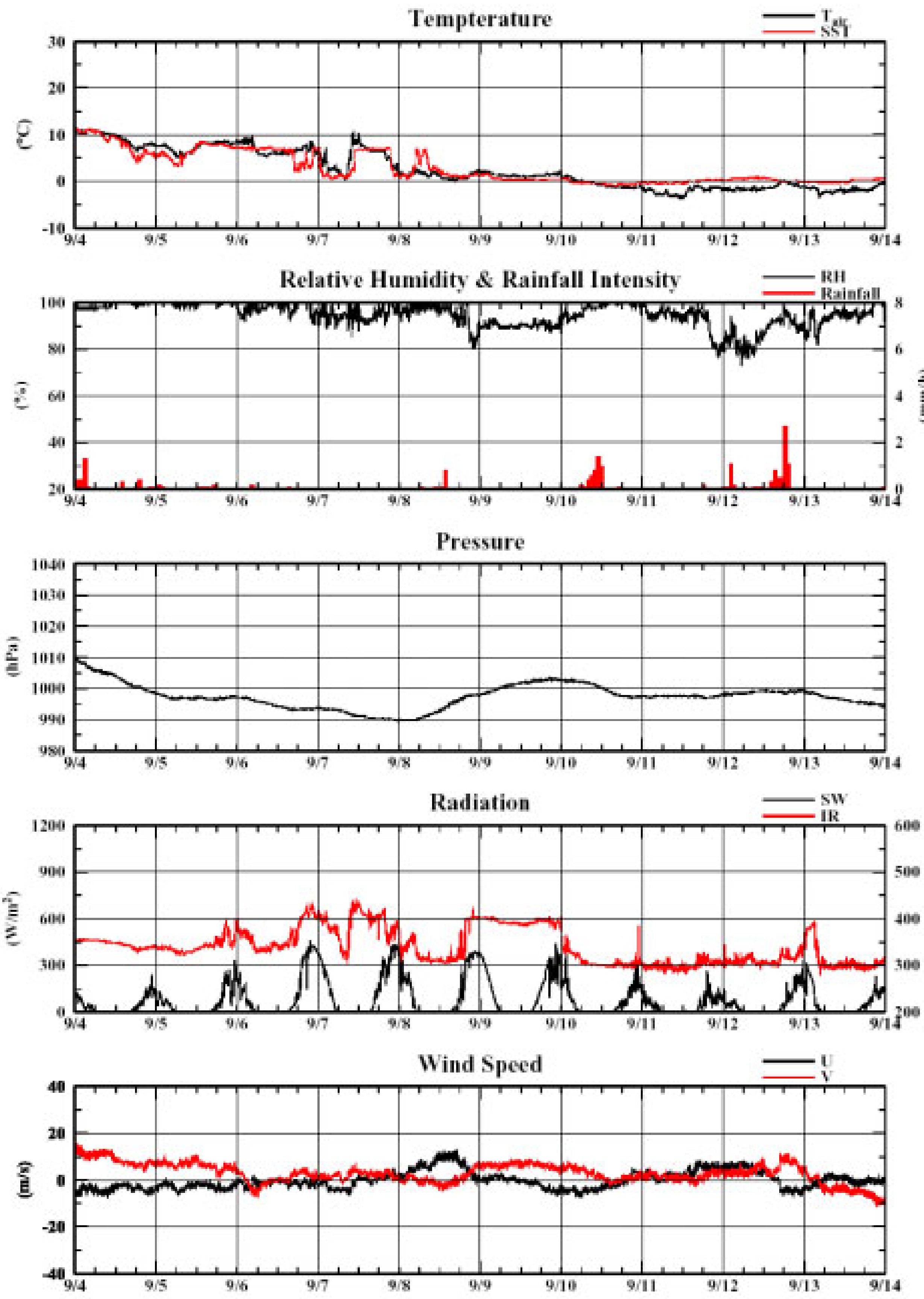


Figure 2.1.1-1 (continued)

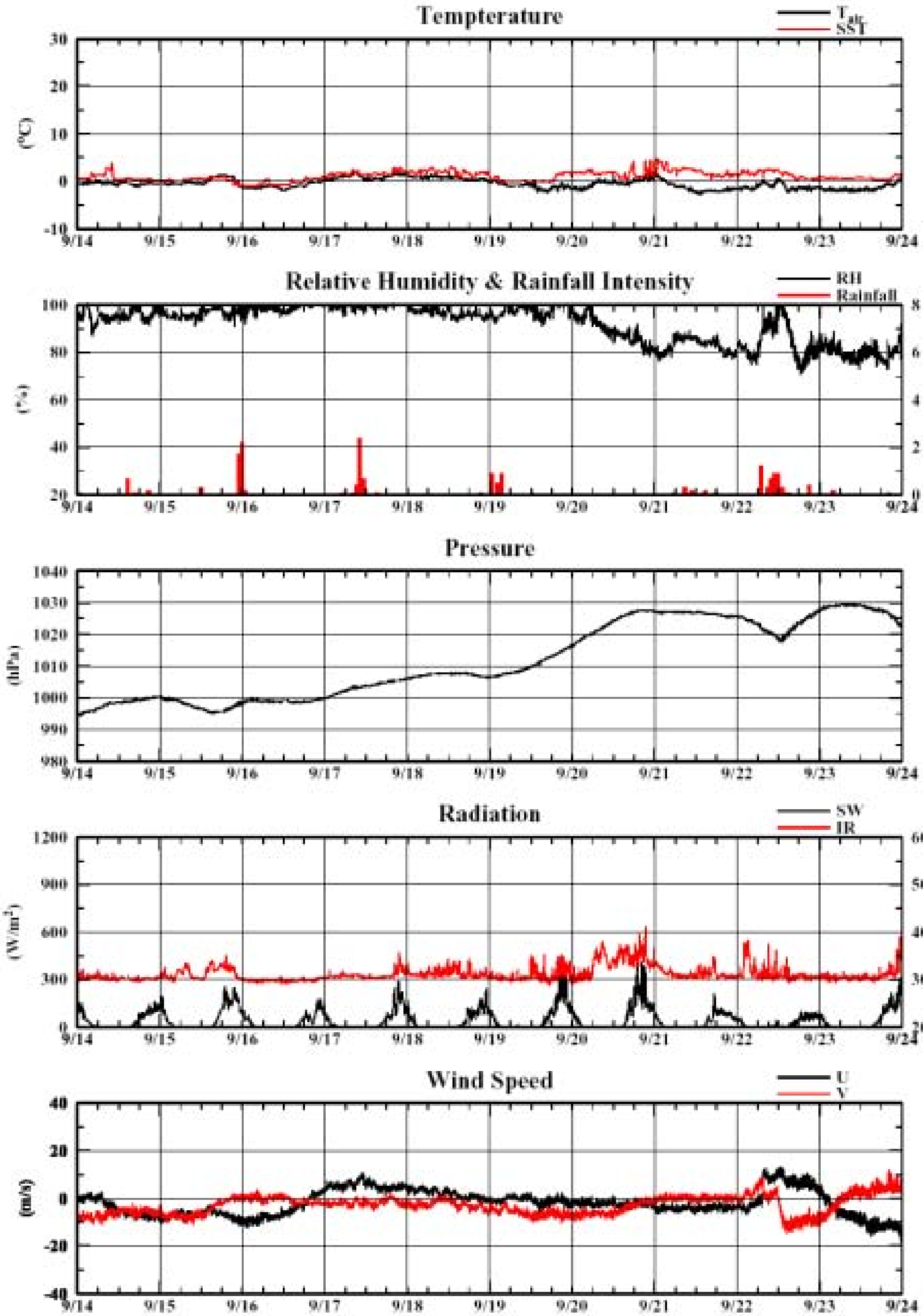


Figure 2.1.1-1 (continued)

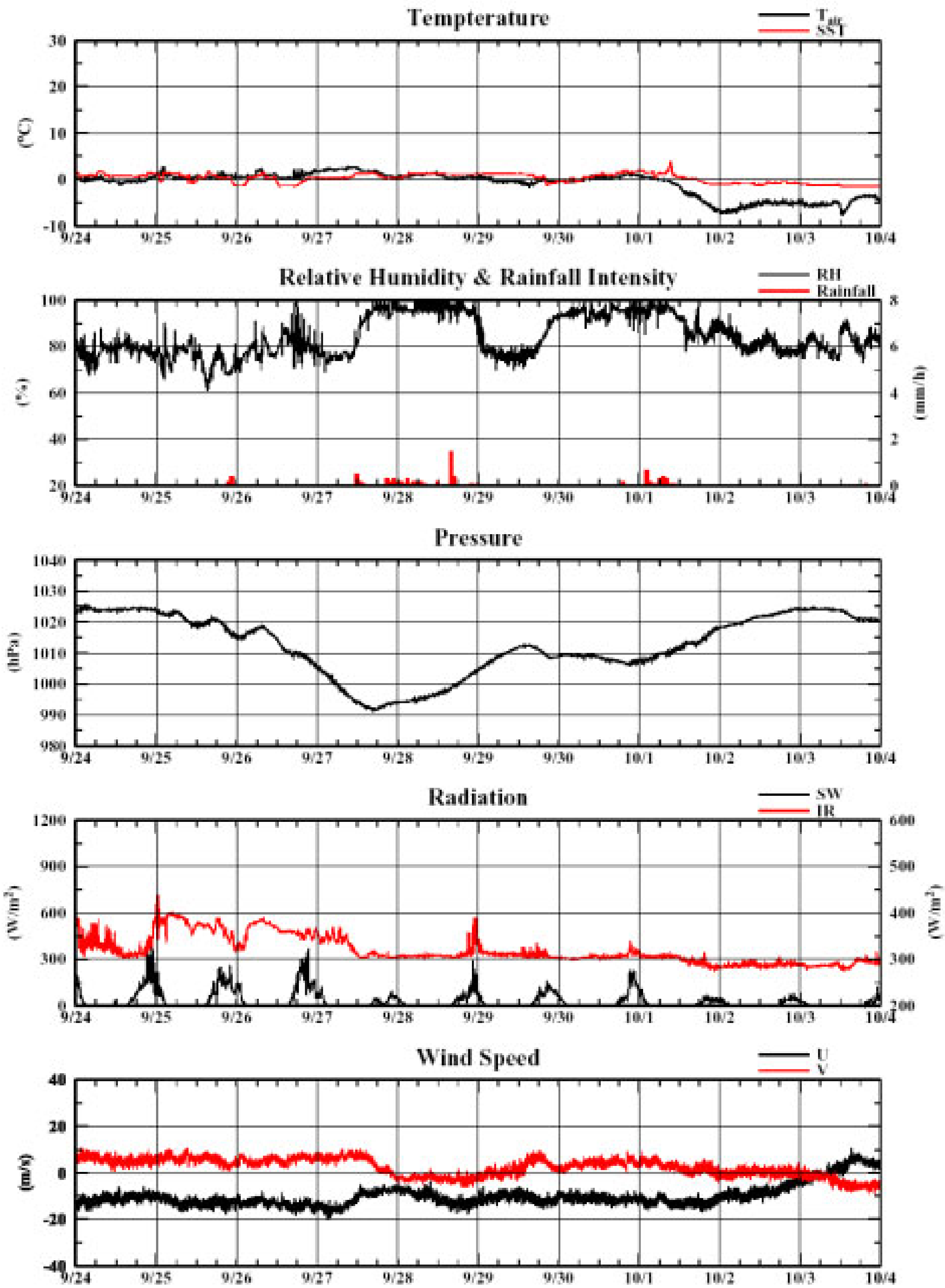


Figure 2.1.1-1 (continued)

2.1.2 Ceilometer

(1) Personnel
Satoshi Okumura (GODI): Operation Leader
Souichiro Sueyoshi (GODI)
Norio Nagahama (GODI)

(2) Parameters
(1.1) Cloud base height [m]
(1.2) Backscatter profile, sensitivity and range normalized at 30 m resolution

(3) Method

We measured cloud base height and backscatter profile using CT-25K (VAISALA, Finland) ceilometer throughout MR02-K05 leg1 cruise from the departure of Sekinehama on 25 August 2002 to the arrival of Dutch Harbor on 10 October 2002.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wave length:	905±5 nm at 25 deg-C
Transmitting average power:	8.9 mW
Repetition rate:	5.5 kHz
Detector:	Silicon avalanche photodiode (APD)
Responsibility at 905 nm:	65 A/W
Measurement range:	0～7.5 km
Resolution:	50 ft in full range
Sampling rate:	60 sec

(4) Preliminary results

The first, second and third lowest cloud base height during the cruise are plotted in Figure 2.1.2-1.

(5) Data archives

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

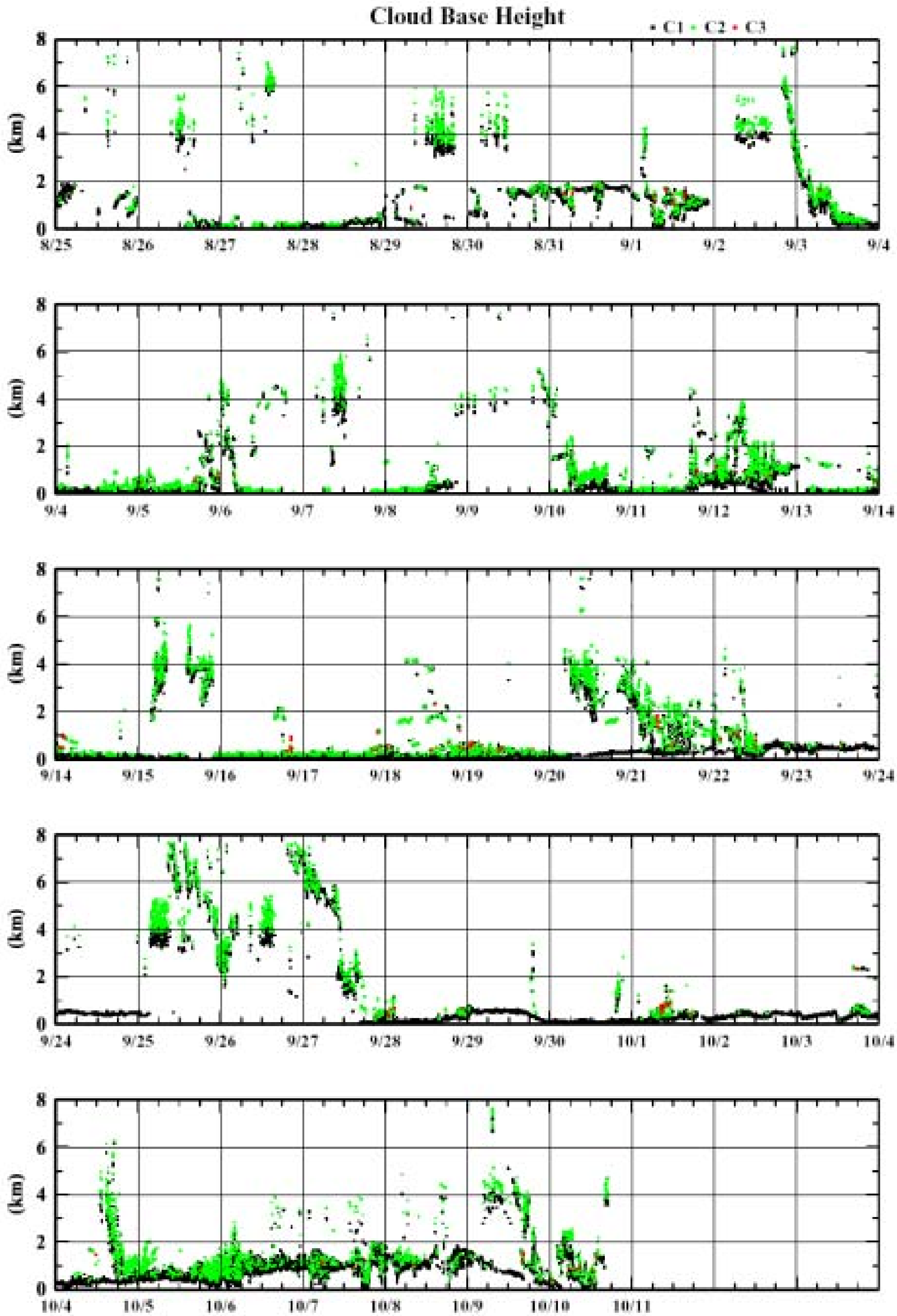


Figure 2.1.2-1 1st, 2nd and 3rd lowest cloud base height during MR02-K05 leg1 cruise

2.2 Physical oceanographic observations

2.2.1 CTD cast and water sampling

(1) Personnel

Koji Shimada	(JAMSTEC)：Principal Investigator
Akihiko Murata	(JAMSTEC)：Scientist
Shigeto Nishino	(JAMSTEC)：Scientist
Motoyo Ito	(JAMSTEC)：Scientist
Satoshi Ozawa	(MWJ)：Operation Leader
Miki Yoshiike	(MWJ)
Kenichi Katayama	(MWJ)
Naoko Takahashi	(MWJ)

(2) Objective

Investigation of oceanic structure.

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (here after D.O.) concentration
Fluorescence
Light Transmission

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler with Sea-Bird Electronics Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, D.O. and fluorometer, transmissometer, altimeter sensors. Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.5.25b) provided by Sea-Bird Electronics,Inc. and stored on the hard disk of the personal computer. Seawater was sampled during up-cast by sending fire commands from the personal computer. We sampled seawater to calibrate salinity data.

Measurement depth was to 10m above the bottom of the sea. Total 152 casts of CTD measurements have been carried out. (See table 2.2.1-1)

The CTD raw data was processed using SBE Data Processing-Win32 (ver.5.25b) and SEASOFT (ver.4.249). SEASOFT (ver.4.249) was used only DERIVE and SPLIT. Data processing procedures and used utilities SBE Data Processing-Win32 and SEASOFT of were as follows:

DATCNV：	Convert the binary raw data to output on physical units. This utility selects the CTD data when bottles closed to output on another file.
SECTION：	Remove the unnecessary data.
ALIGNCTD：	ALIGNCTD aligns oxygen measurements in time relative to pressure. Secondary Conductivity sensor relative to pressure = 0.073 seconds Oxygen sensor relative to pressure = 5.0 seconds
WILDEDIT：	Obtain an accurate estimate of the true standard deviation of the data. Std deviation for pass 1= 2 Std deviation for pass 2= 10

Scan per block= 48
Keep data within this distance of mean= 1000
Exclude Scan Marked Bad = Check

CELLTM： Remove conductivity cell thermal mass effects from measured conductivity.
Primary Alpha = 0.03, 1/beta = 7.0
Secondary Alpha = 0.03, 1/beta = 7.0

FILTER： Filter the high frequency noise on the data
Filter A = 0.15sec
Variable to Filter: Pressure: Low Pass Filter A

LOOPEDIT： Mark scan with ‘badflag’, if the CTD velocity is less than 0 m/s.
Minimum Velocity Type = Fixed Minimum Velocity
Minimum CTD Velocity [m/sec] = 0.0
Exclude Scan Marked Bad = Check

BINAVG： Calculate the averaged data in every 1 db.

DERIVE： Calculate oceanographic parameters.

SPLIT： Splits the data made in CNV files into up-cast and down-cast files.

ROSSUM： Edits the data of water sampled to output a summary file.

Configuration file

MR02K05.con to Stn.A02035-1
MR02K05A.con from Stn.A02035-2

Specifications of the sensors are listed below.

CTD：SBE911plus CTD system

Under water unit：
SBE9plus (S/N 09P27443-0677, Sea-bird Electronics, Inc.)
・Pressure sensor： Digiquartz pressure sensor (S/N 79511)
Calibrated Date: 02 Jul.2002

Temperature sensors：
Primary： SBE03-04/F (S/N 031359, Sea-bird Electronics, Inc.)
Calibrated Date: 11 Jul. 2002
Secondary：SBE03plus (S/N 032453, Sea-bird Electronics, Inc.)
Calibrated Date: 11 Jul. 2002

Conductivity sensors：
・To Stn.A02035-1
Primary： SBE04-04/0 (S/N 041202, Sea-bird Electronics, Inc.)
Calibrated Date: 30 Jul. 2002
Secondary：SBE04C (S/N 042240, Sea-bird Electronics, Inc.)
Calibrated Date: 11 Jul. 2002
・From Stn.A02035-2
Primary： SBE04C (S/N 042240, Sea-bird Electronics, Inc.)
Calibrated Date: 11 Jul. 2002
Secondary：SBE04C (S/N 042435, Sea-bird Electronics, Inc.)
Calibrated Date: 06 Feb. 2002

D.O. sensor： SBE43 (S/N 430069, Sea-bird Electronics, Inc.)
Calibrated Date: 06 Jul. 2001

Altimeter： Datasonics PSA-900 (S/N 396, Datasonics, Inc.)

Fluorometer： (S/N 2148, Seapoint Sensors, Inc.)

C Star Transmissometer： (S/N CST-207RD, WET Labs, Inc.)

Calibration Date: 19 May. 1998

Deck unit： SBE11plus (S/N 11P7030-0272, Sea-bird Electronics, Inc.).
Carousel water sampler： SBE32 (S/N 3227443-0391, Sea-bird Electronics, Inc.).

(5) Results

See §1.4. Preliminary results. The results are based on the CTD observation of this cruise.

(6) Troubles

The primary conductivity sensor was replaced with S/N 042240 from S/N 041202 after Stn.A02035-1 because profile of salinity showed unusual value at Stn.A02035-1. And, it was entailed, and the secondary conductivity sensor was replaced with S/N 042435 from S/N 042240, too.

Spike noises were found on profile of Salinity and D.O. at Stn.A02058-1, Stn.A02059-1. The cause of the noise of Stn.A02058-1 wasn't clear. The cause of the noise of Stn.A02059-1 was leak of the cable of primary conductivity sensor. Therefore, the cable of Primary conductivity sensor was replaced after Stn.A02059-1.

(7) Data archives

All raw and processed CTD data files were copied onto CD-ROMs. The data will be submitted to the Data Management Office (DMO), JAMSTEC, and will be opened to public via “R/V MIRAI Data Web Page” in JAMSTEC home page.

Table 2.2.1-1 CTD Cast Table

Stn.	Date(UTC) yy/mm/dd	Time(UTC) Start	End	Start Position Latitude	Longitude	Raw data file name	Depth (MNB)	Altimeter	Max pressure	Remarks
A02001-1	2002/9/3	1:40	3:46	54-58.30N	169-29.73W	001M01.dat	2934.0	13.3	2960.30	
A02002-1	2002/9/4	22:30	22:39	65-40.90N	168-29.74W	002M01.dat	55.0	9.8	43.40	
A02003-1	2002/9/5	1:54	2:06	66-30.04N	168-30.09W	003M01.dat	53.0	10.4	41.43	
A02004-1	2002/9/5	10:04	10:16	68-15.24N	168-29.98W	004M01.dat	58.0	10.2	45.99	
A02005-1	2002/9/5	12:20	12:32	68-30.37N	167-37.85W	005M01.dat	53.0	10.0	41.94	
A02006-1	2002/9/5	16:59	17:09	69-30.03N	166-59.82W	006M01.dat	40.0	10.0	36.70	Depth:furuno
A02007-1	2002/9/5	22:52	23:00	70-30.00N	163-59.27W	007M01.dat	36.5	10.0	33.14	Depth:furuno
A02008-1	2002/9/6	15:00	15:12	70-49.89N	160-29.59W	008M01.dat	53.0	9.5	42.09	
A02009-1	2002/9/6	18:57	19:20	71-20.08N	157-59.06E	009M01.dat	122.0	10.4	108.21	
A02010-1	2002/9/6	21:07	21:29	71-30.21N	156-43.26W	010M01.dat	156.0	10.1	143.69	
A02011-1	2002/9/6	23:26	0:00	71-41.26N	155-29.51W	011M01.dat	272.0	10.3	259.25	
A02012-1	2002/9/7	1:44	2:15	71-52.90N	154-59.46W	012M01.dat	378.0	10.0	366.00	
A02013-1	2002/9/7	3:59	5:04	72-04.06N	154-30.36W	013M01.dat	1343.0	-	1232.10	
A02014-1	2002/9/8	6:04	6:09	71-36.52N	154-50.63W	014M01.dat	45.0	10.5	33.27	
A02015-1	2002/9/8	6:47	6:53	71-38.48N	154-55.19W	015M01.dat	54.9	10.5	50.73	Depth:furuno
A02016-1	2002/9/8	7:34	7:43	71-40.83N	154-58.43W	016M01.dat	108.0	10.2	97.56	
A02017-1	2002/9/8	8:21	8:30	71-41.90N	155-03.91W	017M01.dat	160.0	10.3	149.47	
A02018-1	2002/9/8	9:07	9:35	71-44.05N	155-07.16W	018M01.dat	258.0	4.8	243.00	
A02019-1	2002/9/8	10:45	10:56	71-45.91N	155-14.27W	019M01.dat	231.0	9.7	220.92	
A02020-1	2002/9/8	11:40	11:51	71-48.74N	155-17.60W	020M01.dat	195.0	7.9	188.39	
A02021-1	2002/9/8	12:45	12:53	71-51.99N	155-29.73W	021M01.dat	156.0	9.1	145.85	
A02022-1	2002/9/8	13:43	13:52	71-55.94N	155-39.41W	022M01.dat	142.0	8.1	133.33	
A02023-1	2002/9/8	15:01	15:08	71-59.91N	156-00.10W	023M01.dat	122.0	9.6	114.04	
A02024-1	2002/9/8	16:37	16:44	72-05.95N	156-47.88W	024M01.dat	133.0	9.5	122.75	
A02025-1	2002/9/8	18:23	18:29	72-11.91N	157-36.05W	025M01.dat	76.0	10.0	63.02	
A02026-1	2002/9/8	20:10	20:15	72-17.97N	158-24.22W	026M01.dat	56.0	9.7	45.33	
A02027-1	2002/9/8	21:50	21:55	72-23.87N	159-11.98W	027M01.dat	51.0	9.7	41.11	
A02028-1	2002/9/8	23:38	23:54	72-30.20N	159-59.85W	028M01.dat	50.0	9.7	38.00	
A02029-1	2002/9/9	1:32	1:43	72-36.02N	159-41.94W	029M01.dat	58.0	10.4	46.45	
A02030-1	2002/9/9	2:52	3:05	72-42.22N	159-23.88W	030M01.dat	90.0	9.6	74.92	
A02031-1	2002/9/9	4:20	4:45	72-48.16N	159-05.98W	031M01.dat	203.0	14.5	188.09	
A02032-1	2002/9/9	7:03	7:40	72-54.08N	158-47.89W	032M01.dat	405.0	9.5	400.17	
A02033-1	2002/9/9	9:04	10:30	73-00.15N	158-29.59W	033M01.dat	1325.0	8.1	1308.77	
A02034-1	2002/9/9	12:08	13:53	73-09.99N	158-00.27W	034M01.dat	2395.0	7.8	2418.50	C-sensor(Pri) trouble
A02035-1	2002/9/9	16:04	16:25	73-20.15N	157-29.99W	035M01.dat	2970.0	-	-	C-sensor(Pri) trouble
A02035-2	2002/9/9	17:10	19:11	73-20.74N	157-28.47W	035M02.dat	3011.0	6.9	3051.70	Change C-sensor
A02036-1	2002/9/9	20:58	23:21	73-29.31N	157-00.77W	036M01.dat	3265.0	9.4	3306.73	
A02036-2	2002/9/10	1:33	1:50	73-29.91N	157-00.65W	036M02.dat	3235.0	-	-	
A02037-1	2002/9/10	4:01	4:55	73-50.16N	156-59.12W	037M01.dat	3850.0	-	1518.82	
A02038-1	2002/9/10	6:32	7:24	74-05.08N	157-10.01W	038M01.dat	3856.0	-	1523.22	
A02039-1	2002/9/10	8:44	9:38	74-14.99N	157-30.46W	039M01.dat	3861.0	-	1526.37	
A02040-1	2002/9/10	10:27	12:39	74-20.08N	157-40.36W	040M01.dat	3860.0	11.9	3908.84	
A02041-1	2002/9/10	13:28	15:31	74-25.06N	157-50.65W	041M01.dat	3183.0	-	3032.55	
A02042-1	2002/9/10	17:09	17:58	74-30.18N	158-00.00W	042M01.dat	1476.0	7.7	1492.64	
A02043-1	2002/9/10	19:07	19:55	74-35.13N	158-10.19W	043M01.dat	1053.0	5.5	1047.37	
A02044-1	2002/9/10	21:05	21:40	74-30.01N	158-29.88W	044M01.dat	907.0	9.3	903.33	
A02045-1	2002/9/10	22:32	23:13	74-27.00N	158-44.65W	045M01.dat	1039.0	9.7	1035.14	
A02046-1	2002/9/11	0:00	0:30	74-24.01N	158-59.93W	046M01.dat	749.0	9.2	739.53	
A02047-1	2002/9/11	19:05	20:04	74-14.78N	162-33.64W	047M01.dat	1088.0	8.4	1089.93	
A02047-2	2002/9/11	21:36	22:00	74-14.85N	162-33.48W	057M02.dat	1093.0	-	504.06	
A02048-1	2002/9/11	23:04	23:39	74-07.43N	162-53.55W	048M01.dat	401.0	9.6	394.80	
A02049-1	2002/9/12	0:46	1:13	74-00.03N	163-13.67W	049M01.dat	302.0	10.4	290.38	
A02050-1	2002/9/12	3:00	3:19	73-48.50N	163-41-99W	050M01.dat	218.0	9.2	205.56	
A02051-1	2002/9/12	4:48	4:59	73-40.09N	164-06.46W	051M01.dat	167.0	11.4	156.52	
A02052-1	2002/9/12	6:27	6:38	73-30.09N	164-33.47W	052M01.dat	112.0	9.5	101.95	
A02053-1	2002/9/12	7:49	8:00	73-30.02N	165-00.49W	053M01.dat	74.0	10.5	61.52	
A02054-1	2002/9/12	17:10	17:51	73-42.86N	161-00.18W	054M01.dat	1187.0	8.3	1151.31	
A02055-1	2002/9/12	19:45	21:08	73-43.75N	159-59.54W	055M01.dat	2517.0	8.5	2547.26	
A02056-1	2002/9/12	22:36	0:13	73-46.65N	158-59.91W	056M01.dat	3113.0	8.8	3146.20	
A02057-1	2002/9/13	1:43	3:37	73-51.17N	157-59.91W	057M01.dat	3614.0	7.6	3675.93	
A02058-1	2002/9/13	6:18	8:15	74-00.22N	156-00.28W	058M01.dat	3865.0	9.7	3911.80	Salinity(Pri)&Oxygen noise
A02059-1	2002/9/13	16:03	16:32	73-30.05N	155-07.58W	059M01.dat	3856.0	-	-	Change (Pri.)C-sensor cable
A02059-2	2002/9/13	17:45	20:14	73-30.12N	155-08.31W	059M02.dat	3859.0	8.5	3913.23	

A02060-1	2002/9/13	23:33	1:34	72-59.95N	154-14.35W	060M01.dat	3711.0	12.9	3773.03	
A02061-1	2002/9/14	5:32	7:10	72-30.35N	153-23.04W	061M01.dat	3213.0	7.3	3219.67	
A02062-1	2002/9/14	11:02	12:03	72-00.06N	152-30.34W	062M01.dat	1649.0	9.7	1625.80	
A02063-1	2002/9/14	16:05	18:36	72-30.05N	151-20.61W	063M01.dat	3687.0	9.0	3746.55	
A02064-1	2002/9/14	22:15	0:21	73-00.19N	150-10.08W	064M01.dat	3753.0	9.5	3813.67	
A02065-1	2002/9/15	4:12	6:14	73-00.09N	148-00.22W	065M01.dat	3698.0	8.9	3754.18	
A02066-1	2002/9/15	10:21	12:15	72-29.94N	146-36.03W	066M01.dat	3565.0	9.6	3622.72	
A02067-1	2002/9/15	15:36	18:02	72-00.13N	145-59.87W	067M01.dat	3470.0	10.3	3520.24	
A02068-1	2002/9/16	2:03	4:17	72-49.11N	141-59.84W	068M01.dat	3392.0	9.5	3444.59	
A02069-1	2002/9/16	15:08	17:15	72-29.40N	142-08.09W	069M01.dat	3259.0	11.1	3304.72	
A02070-1	2002/9/16	20:41	22:41	71-50.88N	142-04.85W	070M01.dat	2889.0	8.5	2926.63	
A02071-1	2002/9/17	2:19	4:21	71-15.43N	142-00.27W	071M01.dat	2829.0	8.4	2875.72	
A02072-1	2002/9/17	15:05	16:49	71-01.69N	141-59.42W	072M01.dat	2327.0	8.6	2354.45	
A02072-2	2002/9/17	18:32	19:22	70-53.97N	141-54.73W	072M02.dat	2095.0	-	1116.22	
A02073-1	2002/9/17	20:12	21:47	70-47.20N	141-51.09W	073M01.dat	1791.0	5.8	1802.23	
A02074-1	2002/9/17	23:25	0:28	70-42.01N	141-46.56W	074M01.dat	1054.0	13.2	1057.64	
A02075-1	2002/9/18	2:00	2:36	70-33.76N	141-43.27W	075M01.dat	494.0	8.1	481.19	
A02076-1	2002/9/18	3:55	4:10	70-25.11N	141-38-57W	076M01.dat	92.0	10.2	85.60	
A02077-1	2002/9/18	5:25	5:34	70-18.37N	141-24.20W	077M01.dat	49.7	10.0	46.23	Depth:furuno
A02078-1	2002/9/19	16:36	16:53	70-52.53N	133-57.96W	078M01.dat	83.0	10.3	70.13	
A02079-1	2002/9/19	18:05	18:13	70-45.96N	133-47.11W	079M01.dat	77.0	10.4	62.85	
A02080-1	2002/9/19	19:38	19:49	70-38.04N	133-40.39W	080M01.dat	74.0	10.5	60.16	
A02081-1	2002/9/19	21:15	21:25	70-30.05N	133-35.42W	081M01.dat	69.0	10.0	57.37	
A02082-1	2002/9/19	23:38	23:49	70-17.11N	134-02.18W	082M01.dat	38.9	10.3	35.22	Depth:furuno
A02083-1	2002/9/20	1:07	1:19	70-22.08N	133-36.38W	083M01.dat	62.0	10.3	48.35	
A02084-1	2002/9/20	3:23	3:31	70-24.90N	133-09.28W	084M01.dat	35.0	10.3	31.67	Depth:furuno
A02085-1	2002/9/20	5:20	5:38	70-08.02N	133-30.10W	085M01.dat	342.0	10.0	30.78	Depth:furuno
A02086-1	2002/9/21	16:04	16:14	70-45.13N	127-59.89W	086M01.dat	52.0	9.5	41.22	
A02087-1	2002/9/21	17:03	17:14	70-45.23N	127-52.40W	087M01.dat	98.0	9.2	83.74	
A02088-1	2002/9/21	18:06	18:19	70-45.26N	127-43.99W	088M01.dat	151.0	9.6	140.04	
A02089-1	2002/9/21	19:06	19:27	70-44.94N	127-26.42W	089M01.dat	193.0	10.3	180.79	
A02090-1	2002/9/21	21:23	21:30	70-33.05N	127-35.13W	090M01.dat	59.0	11.3	44.83	
A02091-1	2002/9/21	22:04	22:13	70-33.69N	127-33.83W	091M01.dat	103.0	10.8	91.21	
A02092-1	2002/9/21	22:45	22:57	70-34.71N	127-29.71W	092M01.dat	192.0	9.0	179.03	
A02093-1	2002/9/22	0:05	0:18	70-36.22N	127-22.96W	093M01.dat	240.0	9.2	230.13	
A02094-1	2002/9/22	2:14	2:27	70-45.07N	128-30.18W	094M01.dat	27.6	4.5	29.54	Depth:furuno
A02095-1	2002/9/22	5:02	5:10	70-54.19N	127-55.30W	095M01.dat	105.0	10.0	93.50	
A02096-1	2002/9/22	6:02	6:10	70-57.56N	128-15.25W	096M01.dat	53.0	4.8	45.78	
A02097-1	2002/9/22	7:41	7:47	71-05.06N	128-59.37W	097M01.dat	36.8	4.3	39.62	Depth:furuno
A02098-1	2002/9/26	16:05	16:16	69-49.92N	140-00.50W	098M01.dat	28.1	10.2	25.08	Depth:furuno
A02099-1	2002/9/26	17:40	17:49	69-53.50N	139-29.67W	099M01.dat	36.2	8.1	34.69	Depth:furuno
A02100-1	2002/9/26	18:44	18:55	69-55.45N	139-16.93W	100M01.dat	58.0	6.5	47.65	
A02101-1	2002/9/26	19:44	20:02	69-56.96N	139-06.32W	101M01.dat	168.0	10.3	155.57	
A02102-1	2002/9/26	21:05	21:29	69-58.16N	138-54.79W	102M01.dat	220.0	9.0	197.69	
A02103-1	2002/9/26	22:14	22:43	69-59.85N	138-39.60W	103M01.dat	285.0	9.3	268.66	
A02104-1	2002/9/27	0:45	1:10	70-15.09N	138-55.14W	104M01.dat	448.0	8.8	431.59	
A02105-1	2002/9/27	2:36	3:34	70-30.34N	139-09.85W	105M01.dat	868.0	8.2	865.77	
A02106-1	2002/9/27	16:03	16:13	69-24.13N	137-59.79W	106M01.dat	59.0	10.0	40.72	
A02107-1	2002/9/27	17:23	17:32	69-33.00N	138-09.86W	107M01.dat	108.0	10.0	92.70	
A02108-1	2002/9/27	18:31	18:48	69-41.93N	138-19.45W	108M01.dat	152.0	10.5	137.56	
A02109-1	2002/9/27	19:49	20:01	69-50.97N	138-30.05W	109M01.dat	200.0	10.0	183.29	
A02110-1	2002/9/27	21:04	21:19	69-59.89N	138-40.19W	110M01.dat	280.0	9.5	267.70	
A02111-1	2002/9/27	22:27	22:48	70-03.72N	138-10.14W	111M01.dat	217.0	5.4	204.50	
A02112-1	2002/9/27	23:47	0:03	70-05.88N	137-50.22W	112M01.dat	129.0	10.3	115.59	
A02113-1	2002/9/28	0:55	1:04	70-08.50N	137-30.19W	113M01.dat	66.0	9.8	51.31	
A02114-1	2002/9/28	2:08	2:18	70-12.08N	137-00.77W	114M01.dat	54.0	10.7	38.20	
A02115-1	2002/9/30	8:08	9:22	71-02.73N	145-56.41W	115M01.dat	1599.0	8.5	1628.25	
A02116-1	2002/9/30	14:24	15:26	71-20.51N	148-58.53W	116M01.dat	1677.0	10.2	1685.62	
A02117-1	2002/9/30	21:02	21:12	71-20.03N	152-30.11W	117M01.dat	65.0	9.6	54.36	
A02118-1	2002/9/30	22:34	22:50	71-30.08N	152-29.87W	118M01.dat	110.0	9.7	100.62	
A02119-1	2002/10/1	0:01	0:34	71-40.14N	152-29.84W	119M01.dat	319.0	10.3	309.22	
A02120-1	2002/10/1	2:00	3:20	71-50.12N	152-30.51W	120M01.dat	1337.0	8.8	1333.03	
A02121-1	2002/10/1	5:43	7:52	72-19.99N	152-30.01W	121M01.dat	2895.0	9.2	2930.66	
A02122-1	2002/10/1	14:25	16:41	73-30.41N	152-29.72W	122M01.dat	3843.0	8.3	3906.97	
A02123-1	2002/10/1	22:58	23:45	74-40.43N	152-29.22W	123M01.dat	3849.0	-	1363.00	c and d.o.sensor froze up.
A02123-2	2002/10/1	23:53	2:35	74-41.00N	152-28.73W	123M02.dat	3851.0	12.0	3906.27	
A02124-1	2002/10/2	6:57	9:09	74-40.15N	154-59.38W	124M01.dat	3857.0	10.4	3910.44	

A02125-1	2002/10/2	15:17	16:08	74-40.23N	158-45.21W	125M01.dat	775.0	7.0	772.19	
A02126-1	2002/10/2	17:09	17:56	74-45.00N	159-04.20W	126M01.dat	1351.0	17.4	1363.55	
A02127-1	2002/10/2	18:42	19:44	74-47.42N	159-11.71W	127M01.dat	1764.0	18.8	1770.10	
A02128-1	2002/10/2	21:09	22:30	74-54.10N	159-30.10W	128M01.dat	1875.0	7.5	1889.98	
A02129-1	2002/10/3	3:43	4:52	75-20.30N	160-45.52W	129M01.dat	2106.0	8.9	2119.65	
A02130-1	2002/10/3	6:34	8:07	75-30.48N	161-20.16W	130M01.dat	2102.0	9.6	2118.99	
A02131-1	2002/10/3	10:13	10:48	75-35.75N	161-48.25W	131M01.dat	943.0	11.4	942.15	
A02132-1	2002/10/3	-	-	-	-	-	-	-	-	Cast cansel due to frozen surface
A02133-1	2002/10/3	19:25	20:38	76-02.47N	163-18.64W	133M01.dat	2070.0	10.8	2081.37	
A02134-1	2002/10/3	21:30	21:59	76-00.64N	163-41.04W	134M01.dat	738.0	10.1	737.56	
A02135-1	2002/10/3	22:46	23:30	75-59.73N	163-36.11W	135M01.dat	1381.0	100.0	1254.51	
A02136-1	2002/10/4	0:40	1:10	76-01.89N	164-10.66W	136M01.dat	864.0	9.2	860.32	
A02137-1	2002/10/4	3:15	3:38	76-00.28N	165-30.41W	137M01.dat	454.0	10.0	446.25	
A02138-1	2002/10/4	5:21	5:53	75-59.92N	166-30.03W	138M01.dat	311.0	8.6	301.17	
A02139-1	2002/10/4	9:11	9:38	75-43.56N	166-58.03W	139M01.dat	262.0	11.6	243.78	
A02140-1	2002/10/4	21:42	23:00	76-14.69N	168-28.15W	140M01.dat	1724.0	9.7	1734.55	
A02141-2	2002/10/5	1:44	2:31	76-08.10N	167-55.87W	141M02.dat	649.0	10.3	626.86	
A02142-1	2002/10/7	21:06	21:13	65-38.93N	168-13.34W	142M01.dat	34.1	6.4	34.16	Depth:furuno
A02143-1	2002/10/7	21:54	22:03	65-39.79N	168-24.15N	143M01.dat	45.3	7.5	44.34	Depth:furuno
A02144-1	2002/10/7	23:10	23:20	65-40.76N	168-34.40W	144M01.dat	51.0	6.8	45.04	
A02145-1	2002/10/8	0:03	0:10	65-42.04N	168-43.36W	145M01.dat	51.0	6.4	44.58	
A02146-1	2002/10/8	0:54	1:00	65-42.96N	168-54.23W	146M01.dat	49.0	6.7	41.99	

2.2.2. Sample Salinity Measurements

(1) Personal

Naoko Takahashi (MWJ):operation reader

Satoshi Ozawa (MWJ)

Miki Yoshiike (MWJ)

Kenichi Katayama (MWJ)

(2) Objective

Calibration of salinity measured by CTD

(3) Measured Parameter

Sample water salinity

(4) Instrument and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR02-K05 by the Guildline Autosal salinometer model 8400B (S/N 62827), modified with addition of an Ocean Scientific International peristaltic-type intake pump.

The salinometer was operated in the air-conditioned ship's constant temperature laboratory 'AUTOSAL ROOM' at a bath temperature of 24 degree C. An ambient temperature varied from approximately 21 to 23 degree C.

Standardization

Autosal model 8400B was standardized only before sequence of measurements with the use of IAPSO Standard seawater (batch P142, Conductivity ratio ; 0.99991, salinity ; 34.997).Since the stability of the Autosal was high, calibration of the Autosal was performed only once at the beginning and the value of the Standardize dial was determined and was not touched after this. However the measuring of standard seawater was carried out once in approximately 50 samples, and the drift check of the measurement was performed. Total 48 ampoules of Standard seawater were measured for the monitoring, whose standard deviation was 0.0007 psu. Among these ampoules, 1 standard was too high to be used. Therefore , this was discarded from data. Linear compensation during measurement was added using the measured value of Standard seawater.

We also used sub-standard seawater that was deep-sea water filtered by Millipore filter (pore size of 0.45 μm) and stored in a 20 liter container made from polyethylene. It was measured every 25 samples in order to check the drift of the AUTOSAL.

We also used IAPSO standard seawater (30L10 and 10L08) to observe whether the value of a low salinity was correctly detected by the measurement device.

The determination of the measured value of a sample made the value the determination salinity, when repetition measurement was carried out a maximum of 5 times and the same value came out, and when the following value came out in ±0.00002, it made the mean value the determination value. By measuring these samples.

The CTD data that to compare the CTD salinity and the measurement data was used by the same C sensor (S/N 042240).

CTD Salinity of secondary sensor were used Stn.A02001-1 to A02035-2.

CTD Salinity of primary sensor were used Stn.A02036-1 to A02140-1.

Samples

Seawater samples were collected with 12 liter NiskinX bottle. The salinity sample bottle of the 250 ml brown grass bottle with screw cap and the about 230 ml white glass bottle with plastic inner cap with outside plastic screw cap was used to collect the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. Its cap was also thoroughly rinsed. The bottle was stored more than 24 hours in ‘Autosal Room’ before the salinity measurement.

A double conductivity ratio was defined as median of 31 times reading of the salinometer. Data collection started 5 seconds and it took about 10 seconds to collect 31 times reading by a personal computer.

Table 1: Kind and number of samples

Kind of samples	**Number of samples**
Samples for CTD	931
Samples for EPCS	32
Reference material for Nutrient analysis	11
Reference material for total carbonic analysis	4
Sample for Niskin bottles with multi core sampler	28
Sampled for CTD of CCGS Louis S. St-Laurent	53
Total	**1059**

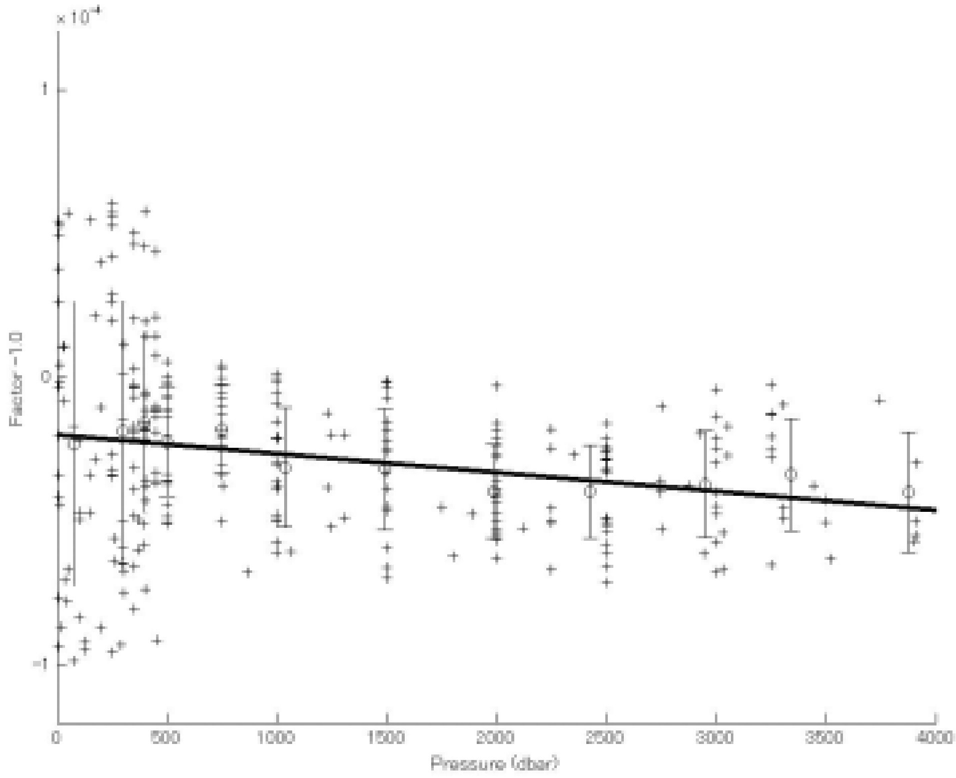
(5) Result

Based on comparison with bottle and CTD data, the conductivity (S/N 042240) was corrected using the following formula:

Corrected Conductivity= Conductivity × Factor

Factor= 0.9999799 − Pressure (dbar) × 6.5473988 × 10^{-9}

The corrected salinities were computed from temperatures (S/N 031359) and the corrected conductivities. The corrected salinities agree with the bottle salinities to within ±0.0016 psu above 300 dbar and ±0.0009 psu below 300 dbar.



(6) Data archive

The data of sample measured and worksheets of calculation of salinity concentration were stored on magnite-optic Disk. The data of sample will be submitted to JAMSTEC Data Management Office (DMO).

2.2.3 Shipboard ADCP Observation

(1) Personnel

Koji Shimada (JAMSTEC): Principal Investigator
Shigeto Nishino (JAMSTEC)
Motoyo Ito (JAMSTEC)
Masahiko Murata (JAMSTEC)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Norio Nagahama (GODI)

(2) Objective

To investigate upper ocean circulation and water mass pathway.
To investigate synoptic circulation of ocean in the vicinity of submarine canyons.

(3) Instruments and Methods

We measured current profiles by VM-75 (RD Instruments Inc. U.S.A.) shipboard ADCP (Acoustic Doppler Current Profiler) from the departure of Hachinohe on 25th of August to the arrival of Dutch Harbor on 10th of October 2002. The E-W (East-West) and N-S (North-South) velocity components of each depth cell [cm/s], and echo intensity of each cell [dB] are measured.

Major parameters for the measurement configuration are as follows;

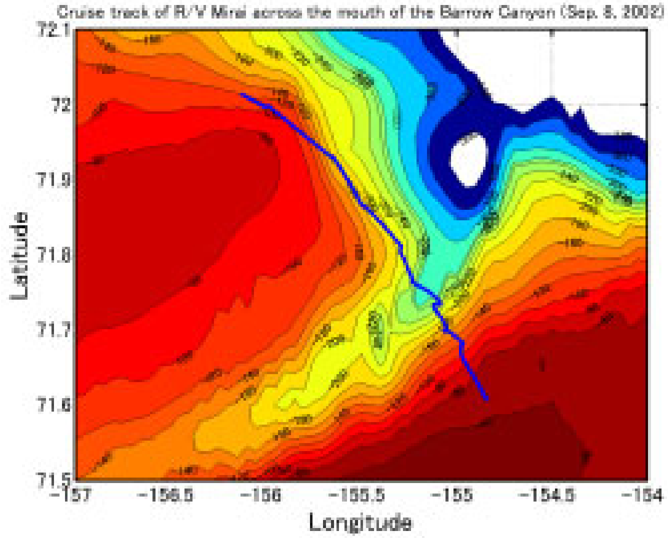
Frequency:	75kHz
Averaging:	every 300 sec.
Depth cell length:	400cm, 800cm, 1600cm (see remarks in item Data archive)
Number of depth cells:	40, 128 (see remarks in item Data archive)
First depth cell position:	18.8m, 22.9m, 30.9m for 400cm, 800cm 1600cm depth cell
Ping per ADCP raw data:	16

(4) Preliminary results

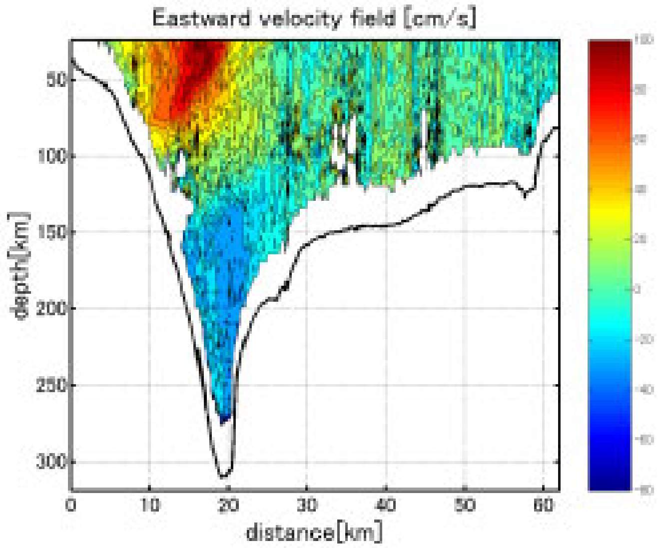
The absolute velocity field calculated using the GPS velocity include anomalous error arising from error in ADCP heading (retarding response of gyro compass). This error was obvious when the direction of the ship changes. Then further data processing should be required for the data without bottom tracking information. Here we show vertical section across the Barrow Canyon. The total volume transport through the Barrow Canyon was 0.9Sv and upper 120m was 1.1Sv. The maximum velocity was observed at a depth of 250m.

(5) Data archives

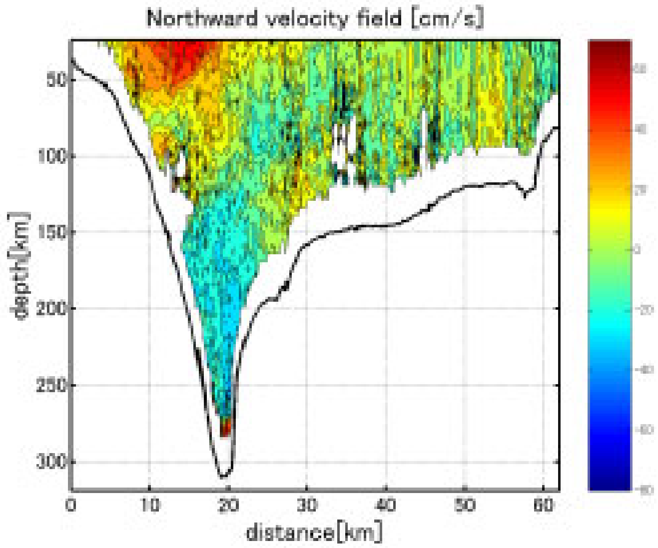
These raw data has been submitted to the Data Management Office (DMO) in JAMSTEC.



Cruise track of R/V Mirai across the mouth of the Barrow Canyon (Sep. 8, 2002)
Latitude
Longitude



Eastward velocity field [cm/s]
depth[km]
distance[km]



Northward velocity field [cm/s]
depth[km]
distance[km]

2.2.4 XCTD

(1) Personnel

Koji Shimada (JAMSTEC): Principal Investigator
Shigeto Nishino (JAMSTEC)
Motoyo Ito (JAMSTEC)
Masahiko Murata (JAMSTEC)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Norio Nagahama (GODI)

(2) Objective

To investigate the oceanic structure and its time variability, vertical profiles of temperature and salinity or temperature were observed by XCTD systems.

(3) Instruments and Methods

XCTD: Probe XCTD-1,
Converter MK-100, Tsurumi Seiki Co., Ltd.
Converter MK-130, Tsurumi Seiki Co., Ltd. (for only XC14)

Specification;

Probe	Parameter	Range	Accuracy	Depth
XCTD	Temperature	-2 ～ +35℃	±0.2℃	0 - 1000 m

Following formula used for the depth calibration;

$Z = A*T + B*(10^{-3})*T^2$

Where Z = depth (m), T = elapsed time (sec), A & B = coefficients

A = 3.425432, B=-4.7026039 for XCTD

We used the hand-launcher.

(4) Results

The locations of XCTD casts are showed in figure 2.2.4-1 and listed in Table 2.2.4-1. In total 25 castings were carried out. The results will be public after he analysis.

(5) Data Archives

The raw data and the 1-m interval data of XCTD will be submitted to the DMO (Data Management Office), in JAMSTEC.

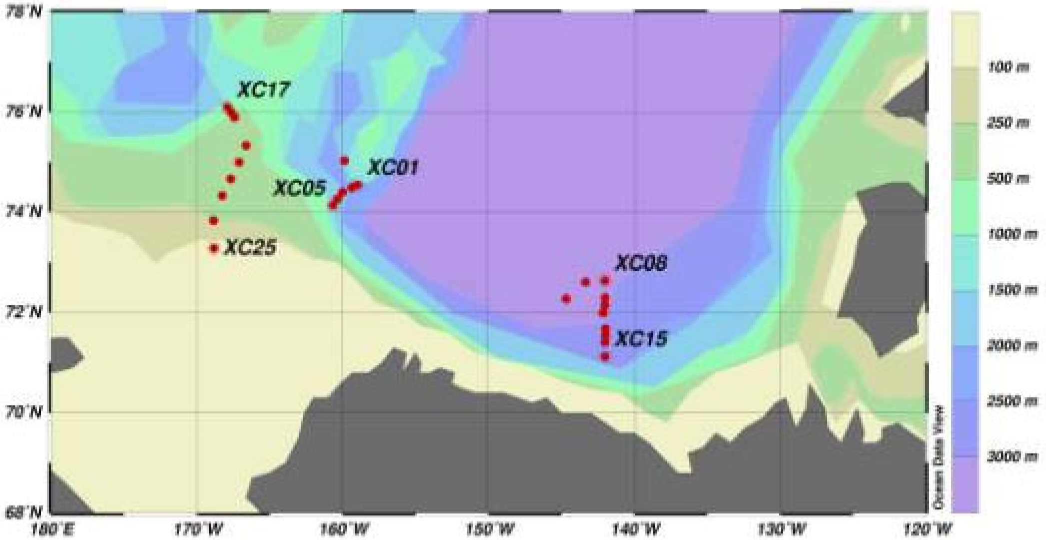


Figure 2.2.4-1 XCTD station for MR02-K05 leg1

Table 2.2.4-1 Observation Summary of XCTD

XCTD Station	Date	Time	Latitude	Longitude	Probe No.	Measured depth	Bottom depth
XC01	11 Sep	10:03	74-32.82N	158-57.66W	02059307	1155	1062
XC02	11 Sep	10:39	74-29.49N	159-21.23W	02059308	765	777
XC03	11 Sep	11:39	74-24.05N	159-59.42W	02059306	509	512
XC04	11 Sep	12:29	74-16.03N	160-19.95W	02059103	494	502
XC05	11 Sep	13:20	74-08.08N	160-39.68W	02059104	569	529
XC06	15 Sep	20:07	72-16.65N	144-40.17W	02059105	1155	3339
XC07	15 Sep	22:32	72-36.61N	143-20.06W	02059100	1155	3404
XC08	16 Sep	5:16	72-38.44N	141-59.76W	02059101	1155	3329
XC09	16 Sep	18:21	72-18.00N	141-59.39W	02059102	1155	3122
XC10	16 Sep	19:05	72-09.02N	141-59.95W	02059097	1155	3045
XC11	16 Sep	19:44	71-59.96N	142-08.06W	02059099	1155	3010
XC12	16 Sep	23:46	71-40.75N	141-57.70W	02059004	1140	2782
XC13	17 Sep	0:25	71-32.79N	141-58.13W	02059003	1155	2889
XC14	17 Sep	1:28	71-24.65N	142-00.30W	02058993	1085	2839
XC15	17 Sep	5:10	71-07.64N	141-59.24W	02058994	1155	2581
XC16	2 Oct	1:20	75-01.90N	159-50.99W	02058997	1155	3849
XC17	5 Oct	2:47	76-06.08N	167-52.94W	02059098	422	510
XC18	5 Oct	2:23	75-59.85N	167-37.96W	02058995	284	280
XC19	5 Oct	3:58	75-53.71N	167-23.93W	02059002	251	245
XC20	5 Oct	7:03	75-19.99N	166-36.21W	02058999	313	316
XC21	5 Oct	9:06	75-00.01N	167-04.72W	02058996	310	307
XC22	5 Oct	11:16	74-40.02N	167-39.66W	02058998	311	333
XC23	5 Oct	13:29	74-20.01N	168-14.86W	02059000	240	243
XC24	5 Oct	16:58	73-50.10N	168-49.93W	02059001	156	163
XC25	5 Oct	21:06	73-16.98N	168-48.66W	02059031	82	87

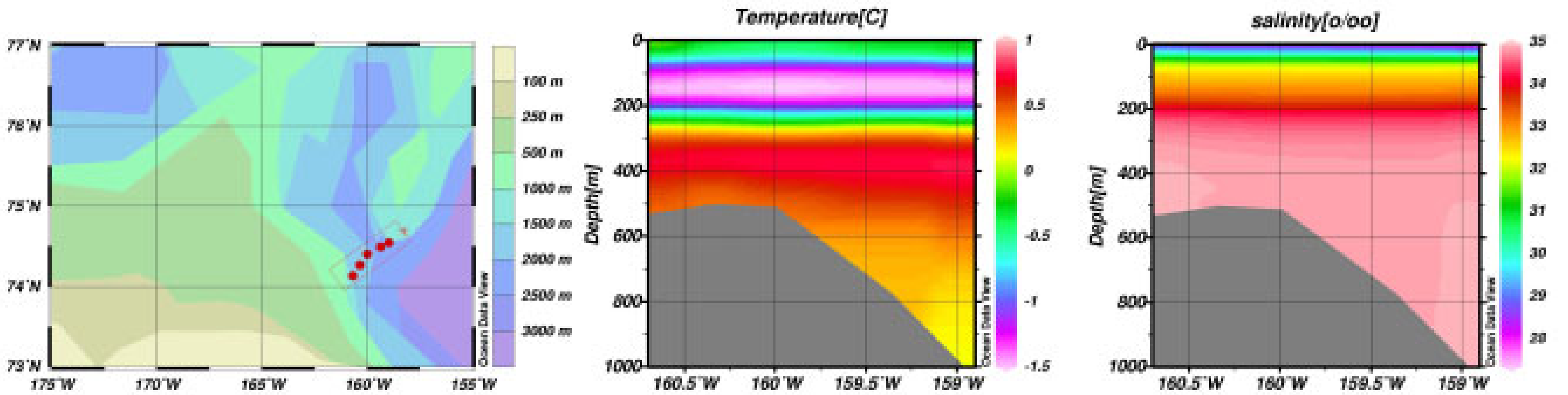


Figure 2.2.4-2 Vertical cross section of temperature and salinity between X01 and XC05

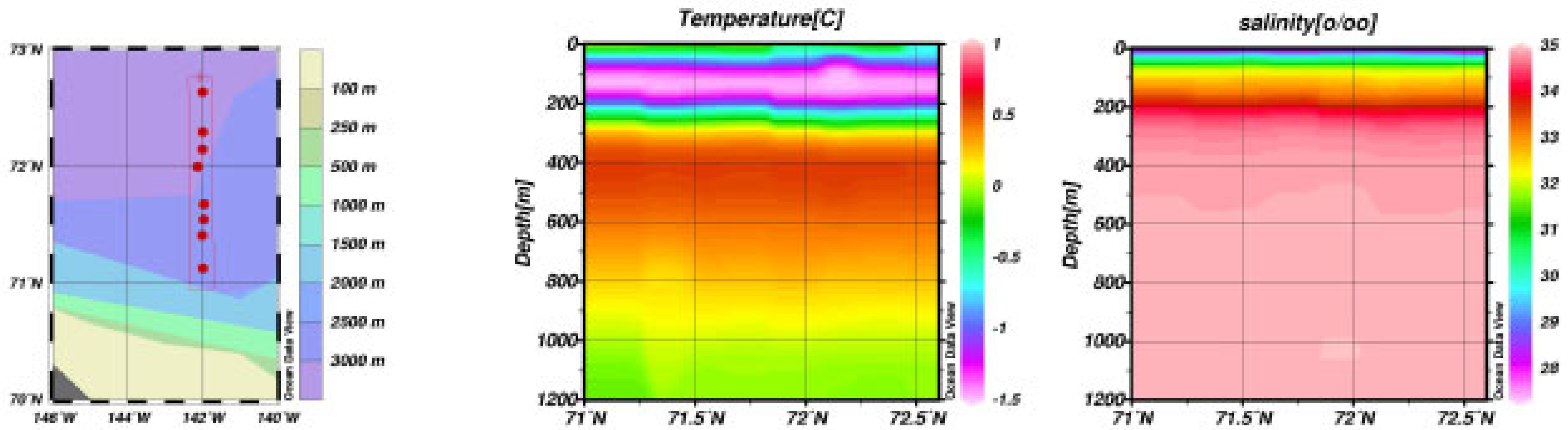


Figure 2.2.4-3 Vertical cross section of temperature and salinity between X08 and XC15.

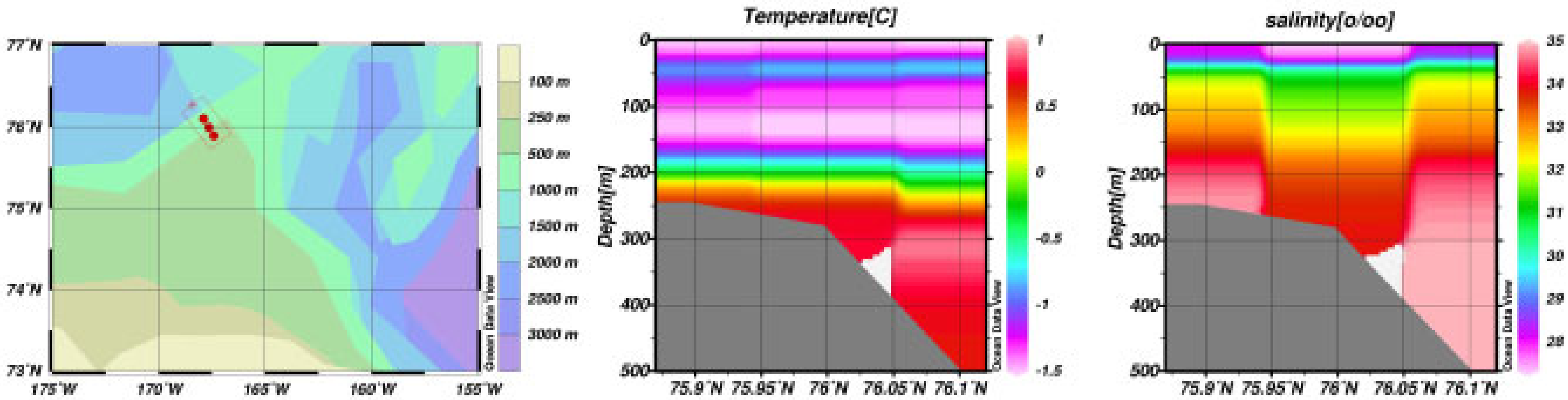


Figure 2.2.4-4 Vertical cross section of temperature and salinity between X17 and XC19.

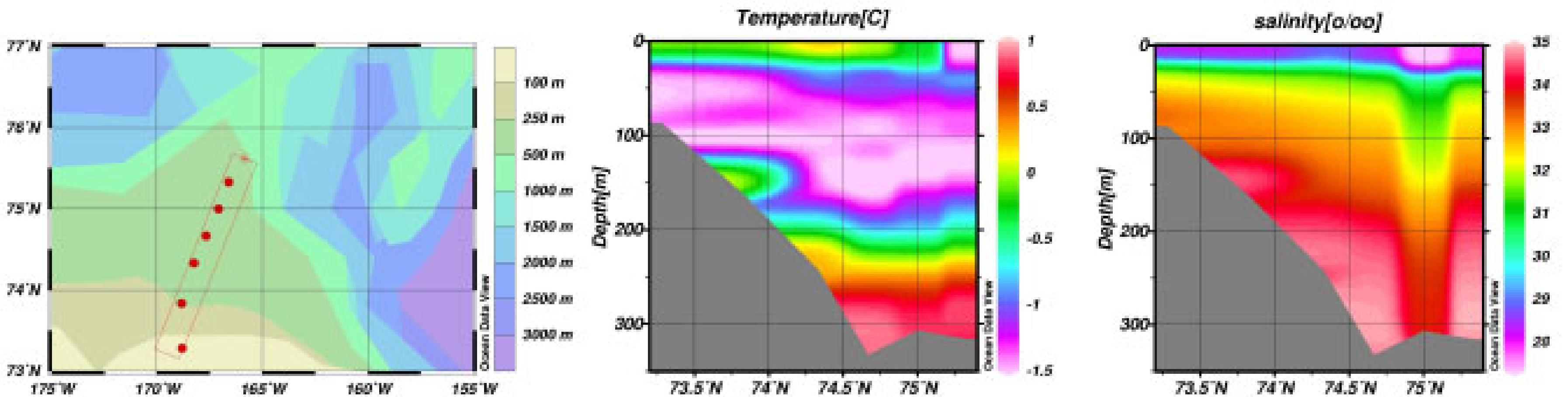


Figure 2.2.4-5 Vertical cross section of temperature and salinity between XC20 and XC25.

2.3 Underway Sea surface water monitoring

1. Personnel

Nobuharu Komai	(MWJ, Japan)
Takayoshi Seike	(MWJ)
Keisuke Wataki	(MWJ)

2. Objectives

To measure the spatial variations in sea surface water

3. Sampling elements

Temperature, salinity, dissolved oxygen, fluorescence, particle size of plankton in the near-surface water

4. Inventory information for the sampling

The measured duration was from September 2 to October 10 2002.

5. Instruments and methods

The *Sea Surface Water Monitoring System* (Nippon Kaiyo Co., Ltd.) is located in the "*sea surface monitoring laboratory*" on R/V Mirai. It can automatically measure temperature, salinity, dissolved oxygen, fluorescence and particle size of plankton in the near-surface water every 1-minute. Sea surface temperature is measured by the ship bottom oceanographic thermometer situated on the suction side of the uncontaminated seawater supply in the forward hold. Measured data are saved every one-minute together with time and the position of ship, and displayed in the data management PC machine. This system is connected to shipboard LAN-system and provides the acquired data for p-CO_2 measurement system, etc. WGS 84 used geodetic reference system for the positioning at this cruise.

Near-surface water was continuously pumped up at the rate of about 200 l/min from the intake at the depth of 4.5 m below the sea surface to the laboratory. Then the water was distributed among the *Sea Surface Water Monitoring System* and p-CO_2 measurement system etc. The flow rate of surface water for this system was 12 l/min, which controlled by some valves and passed through some sensors except with fluorometer (about 0.3 l/min) through vinyl-chloride pipes.

Specification and calibration date of the each sensor in this system were listed below.

(1) Temperature and salinity sensor

SEACAT THERMOSALINOGRAPH

Model:	SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number:	2641
Measurement range:	Temperature -5 to +35 deg-C, Salinity 0 to 6.5 S/m
Accuracy:	Temperature 0.01 deg-C/6month, Salinity 0.001 S/m/month
Resolution:	Temperature 0.001 deg-C, Salinity 0.0001 S/m
Calibration date:	13-Jul-02 (mounted on 2-Sep-02 in this system)

(2) Ship bottom oceanographic thermometer (mounted at the back of the pump for surface water)

Model:	SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number:	032175
Measurement range:	-5 to +35 deg-C
Initial Accuracy:	0.001 deg-C per year typical
Stability:	0.002 deg-C per year typical
Calibration date:	13-Jul-02 (mounted on 2-Sep-02 in this system)

(3) Dissolved oxygen sensor

Model:	2127A, Oubisufair Laboratories Japan INC.
Serial number:	44733
Measurement range:	0 to 14 ppm
Accuracy:	±1% at 5 deg-C of correction range
Stability:	1% per month
Calibration date:	26-Aug-02

(4) Fluorometer

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

(5) Particle size sensor

Model:	P-05, Nippon Kaiyo Co. Ltd.
Serial number:	P5024
Accuracy:	±10% of range
Measurement range:	0.33 mm^3 to 7.45mm^3
Reproducibility:	±5%
Stability:	5% per week
Calibration date:	17-Apr-02

(6) Flow meter

Model:	EMARG2W, Aichi Watch Electronics Ltd.
Serial number:	8672
Measurement range:	0 to 30 L/min
Accuracy:	±1%
Stability:	±1% per day

6. Result

(1) Salinity sensor

We sampled each day for salinity validation and in situ salinity calibration during this cruise. The samples were taken midway of flow line from the intake to the system each day. We collected 35 samples during this cruise and all samples were analyzed on the Guildline 8400B (see section of salinity). The results were shown in table 1 and Fig. 1.

The precision of the sensor at leg 1 was summarized in table 2.

Table 2 Precision of salinity at leg 1

	Difference of salinity (S_{SBE21}-Ssal)
Average	-0.0215
Standard Deviation	0.1578
Average of absolute difference	0.0618
Standard Deviation of absolute difference	0.1465
R.M.S.	0.1110
Min	-0.8379
Max	0.2388
n	35

We calculated the Root Mean Squares (R.M.S.) of difference of salinity for 35 samples which were taken during this cruise. R.M.S. of salinity (one sigma) was 0.1110. There were two samples which difference of salinity was higher than two times of R.M.S. in this cruise. We suspected that the sampling might cause these differences. The final results omitted the two sample were shown in table 3.

Table 3 Precision of salinity omitted two samples at leg 1

	Difference of salinity (S_{SBE21}-Ssal)
Average	-0.0046
Standard Deviation	0.0568
Average of absolute difference	0.0329
Standard Deviation of absolute difference	0.0461
R.M.S.	0.0397
Min	0.1070
Max	0.1884
n	33

These results showed that the validation of salinity was within 0.05. This is very high compared to the other R/V Mirai cruise.

(2) Dissolved Oxygen (D.O.) sensor

D.O. sensor of this system was calibrated just before this cruise. To estimate of accuracy of the sensor, we collected the bottle samples from the course of the system each day when CTD water sampling was done and analyzed by the Winkler method (see section of dissolved oxygen).

The results of leg 1 were shown in table 4 and Fig. 2 and 3. It seemed that D.O. of the sensor tended to be lower than the sample. The average and standard deviation (one sigma) of differences (oxygen sensor – bottle oxygen) in this cruise was summarized in table 5.

Table 5 Precision of the D.O. sensor at leg 1

	Difference (mg/l)
Average	-1.268
Standard Deviation	0.326
n	24

(3) Fluorometer

In order to calibrate the data of fluorescence from this system, we collected surface seawater samples from the course of the system each day and determined the concentrations of chlorophyll *a* board.

Sea surface water samples (0.2 liter) were vacuum-filtered through a GF/F filters (pore diameter: 25 mm) in the dark room. The samples were extracted in 7 ml of N,N'-dimethylformamide (DMF) and then stored at -20 deg-C in the dark until the analysis. Both traditional acidification method and Welschmeyer non-acidification method were used to determine for chlorophyll *a* with two Turner model 10-AU-005 fluorometers. The results were shown in table 6 and Fig. 4.

7. Data archive

All the files of raw data, Microsoft excel files of raw data were stored on a magneto-optical disk. All the data will be submitted to the Data Management Office at JAMSTEC.

8. Remarkable event

(1) Change the flow rate of sea surface water at the freezing area

The flow rate of sea surface water was changed low significantly from 18:54 (UTC) to 21:48 (UTC) at 4-Oct-02. In the cause of this, temperature of the SBE21 and D.O. were also changed from the same time.

The flow rate of sea surface water was changed low again from 23:15 (UTC) at the same day and then, we checked a cause of it. We found that sea ices filled in the seawater sampling pump and these sea ices caused to go down the flow rate. So we turned on the steam to the sea chest during form 23:44 (UTC) at 4-Oct-02 to 16:50 (UTC) at 5-Oct-02 when R/V Mirai passed through the freezing areas. Temperature from the remote temperature sensor was increased about 0.5 degrees during this period. As noted above, take care that the data was not correctly during from 18:54 at 4-Oct-02 to 16:50 at 5-Oct-02.

(2) Change the lamp and clean the cell of the fluorometer

The shift of the fluorescence was sometimes happened so we changed a lamp of the fluorometer at 29-Sep-02. We checked the sensitivity setting of fluorometer due to the lamp was changed at 30-Sep-02. We cleaned the cell of fluorometer and determined the pure-water blank 4 times (5, 9, 20, 29 September) during this cruise. We couldn't obtain the data from fluorometer during these periods.

(3) The system error of EPCS (Electron Plankton Counter System) was happened

Error that the data (Flow, DO, PK(C/L) and PK(V/L)) was not obtained from EPCS was sometimes happened at 30-Sep-02. After the first error was happened, the same errors were happened 26 times to the end of this cruise.

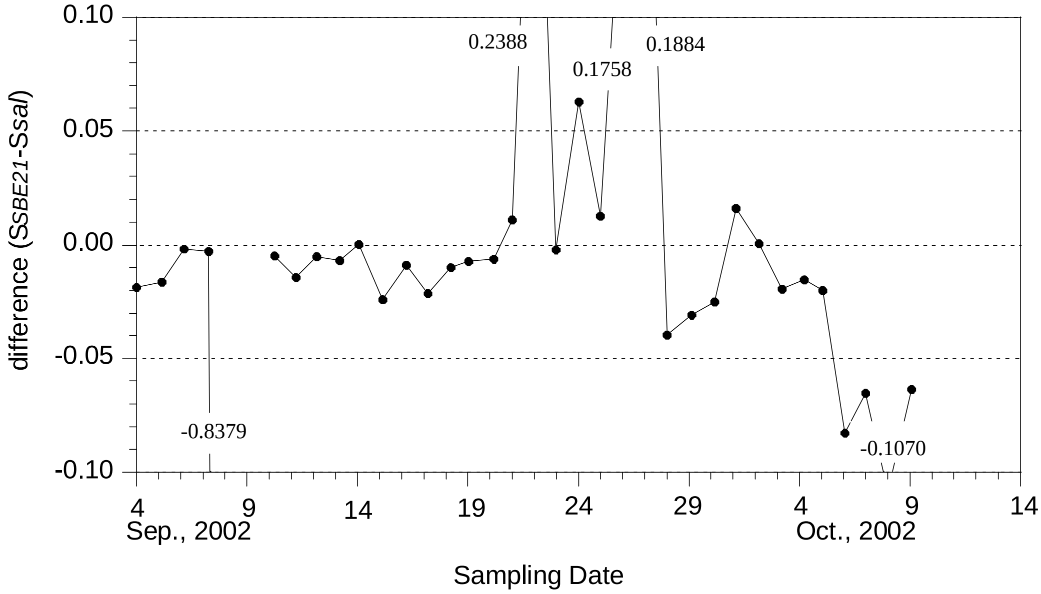


Fig. 1 Difference between the salinities measured by conductivity and temperature sensor (S_{SBE21}) of Sea Surface Monitoring System and the Autosal salinometer (Ssal).

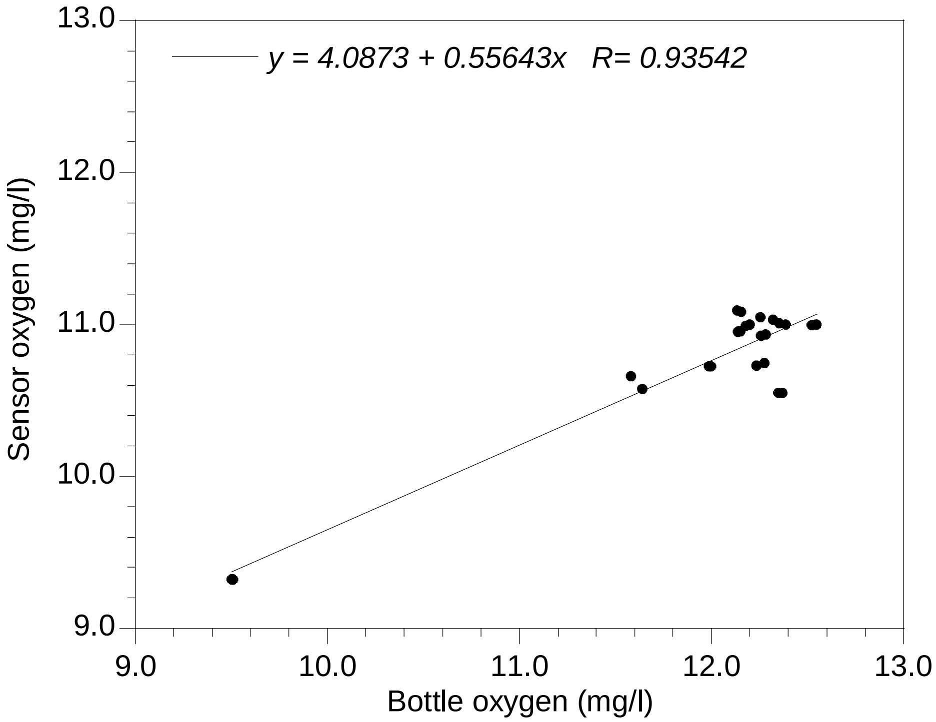


Fig. 2 Comparison between the oxygen values measured by D.O. sensor of Sea Surface

Monitoring System and by the Winkler method.

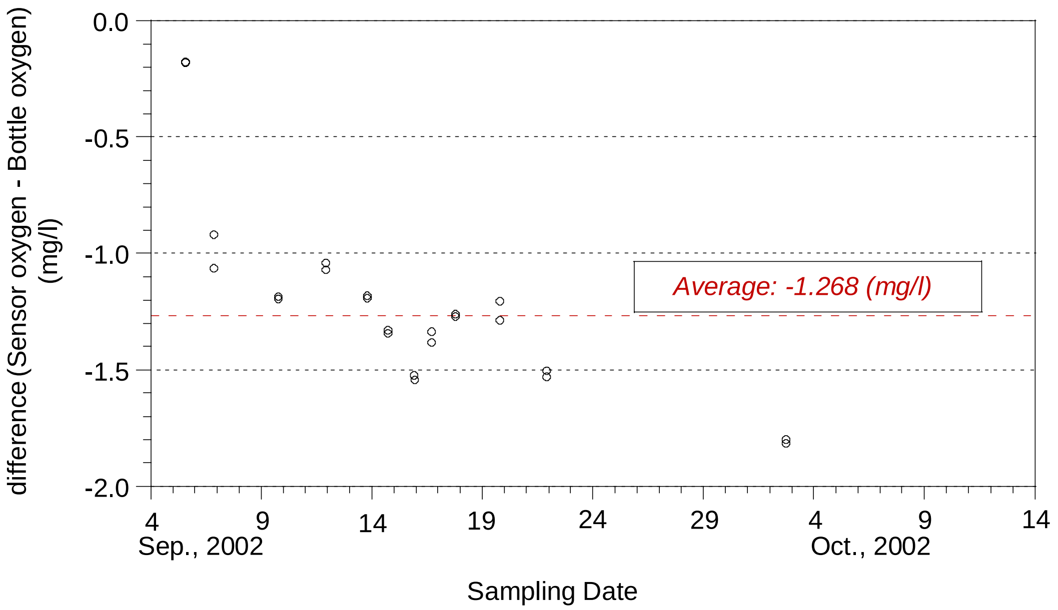


Fig. 3 **Difference between the oxygen values measured by D.O. sensor of Sea Surface Monitoring System and by the Winkler method.**

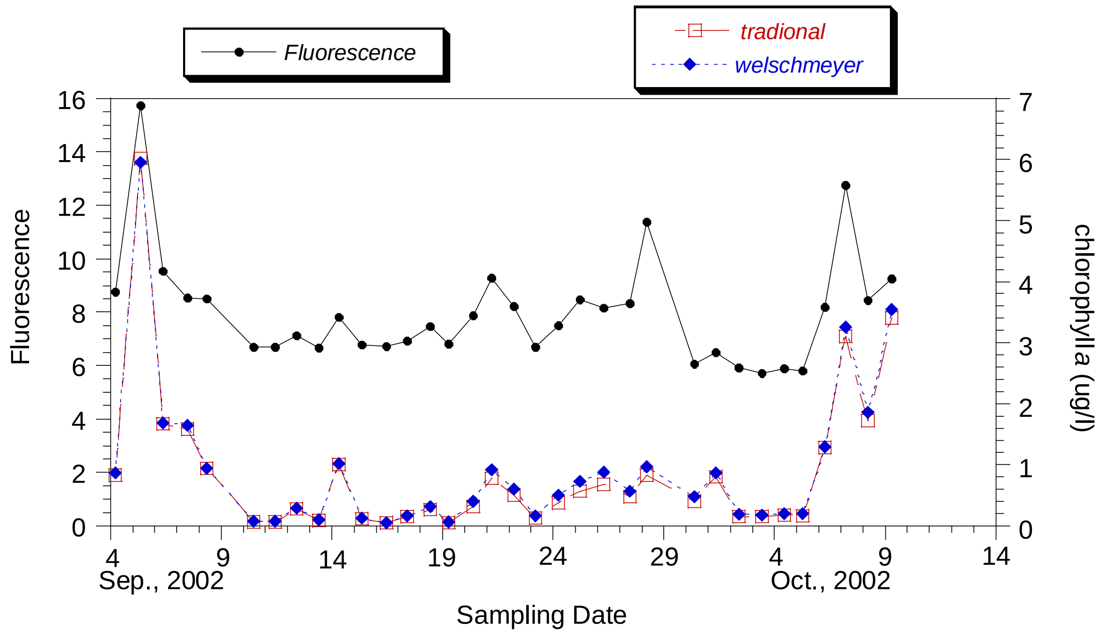


Fig. 4 Comparison between the in-vivo fluorescence measured by fluorometer of Sea Surface Monitoring System and chlorophyll *a* measured by the two methods.

Table 1 Comparison of salinity between salinity sensor of Sea Surface Monitoring System and samples analyzed by Autosal salinometer.

Sampling Date	Sampling Time	Sampling Position		T_{SBE21}	Salinity		Difference	Remarks
	(UTC)	Latitude	Longitude	(ITS-90)	S_{SBE21}	S_{sal}	$S_{SBE21}-S_{sal}$	
9/4/02	05:23	61-40.99110N	168-21.03950W	11.1195	28.5958	28.6144	-0.0186	
9/5/02	08:29	67-56.08740N	168-31.17080W	5.2385	32.1204	32.1368	-0.0164	
9/6/02	08:27	70-50.98280N	160-31.46970W	7.2000	31.0480	31.0498	-0.0018	
9/7/02	11:22	71-18.08170N	157-21.21400W	6.9335	30.4927	30.4955	-0.0028	
9/8/02	08:16	71-41.91270N	155-04.15450W	5.4659	30.2119	31.0498	-0.8379	
9/10/02	11:04	74-19.99420N	157-41.29020W	-0.1941	26.5263	26.5313	-0.0050	
9/11/02	10:43	74-29.46910N	159-21.35710W	-0.2259	26.7760	26.7903	-0.0143	
9/12/02	09:20	73-21.64690N	164-43.01110W	0.9781	28.0911	28.0963	-0.0052	
9/13/02	09:32	73-54.48850N	155-51.44180W	-0.0183	26.6846	26.6914	-0.0068	
9/14/02	07:08	72-30.76360N	153-22.70660W	1.4165	26.8880	26.8878	0.0002	
9/15/02	08:52	72-43.12960N	146-52.72170W	0.5424	26.1033	26.1273	-0.0240	
9/16/02	10:49	72-37.72860N	142-20.48740W	-0.5822	26.0028	26.0117	-0.0089	
9/17/02	09:22	70-44.32780N	142-59.94150W	1.8596	25.4474	25.4689	-0.0215	
9/18/02	10:40	70-08.73620N	140-48.79850W	2.2708	24.6593	24.6691	-0.0098	
9/19/02	06:16	70-53.84800N	133-58.44780W	0.1332	26.2761	26.2834	-0.0073	
9/20/02	09:34	70-09.61990N	133-34.84280W	1.9653	21.5483	21.5545	-0.0062	
9/21/02	05:18	70-42.33940N	131-33.04530W	2.6556	17.4876	17.4767	0.0109	
9/22/02	05:40	70-56.53760N	128-08.58720W	1.7999	20.4875	20.2487	0.2388	
9/23/02	04:46	70-27.31880N	139-01.75820W	0.9400	25.7063	25.7084	-0.0021	
9/24/02	05:51	69-40.62140N	138-02.79290W	1.0873	23.8196	23.7568	0.0628	
9/25/02	05:18	69-40.36120N	137-00.43800W	1.4301	22.6210	22.6084	0.0126	
9/26/02	06:49	70-14.03200N	137-29.02730W	1.0483	22.5094	22.3336	0.1758	
9/27/02	10:48	69-36.91400N	138-12.10660W	1.0395	23.4734	23.2850	0.1884	
9/28/02	05:56	70-24.37990N	135-24.78060W	1.4388	14.8001	14.8396	-0.0395	
9/29/02	07:45	70-22.72730N	135-32.33080W	1.5597	15.7854	15.8161	-0.0307	
9/30/02	09:07	71-03.03030N	145-56.43420W	0.7396	26.5714	26.5965	-0.0251	
10/1/02	08:32	72-25.83440N	152-29.94250W	2.2316	28.8909	28.8748	0.0161	
10/2/02	09:30	74-40.95120N	155-07.35780W	-0.6774	27.0184	27.0180	0.0004	
10/3/02	10:19	75-35.80660N	161-48.44760W	-0.9356	27.5532	27.5725	-0.0193	
10/4/02	10:33	75-48.71060N	166-49.22860W	-1.2302	27.7742	27.7897	-0.0155	
10/5/02	06:38	75-24.52580N	166-34.08990W	-0.9215	27.8270	27.8470	-0.0200	
10/6/02	06:56	71-38.94330N	163-22.39430W	3.4913	31.1730	31.2558	-0.0828	
10/7/02	05:20	68-17.54200N	167-58.29330W	4.9242	31.9086	31.9739	-0.0653	
10/8/02	05:17	65-22.49090N	168-38.17610W	7.0718	29.4987	29.6057	-0.1070	
10/9/02	06:47	58-46.72970N	167-37.25380W	8.1387	31.5786	31.6420	-0.0634	
						Average	-0.0215	
						Std. Dev.	0.1578	
						n	35	

Table 4 Comparison of D.O. value between a D.O. sensor of Sea Surface Monitoring System and water samples using Winkler method.

Sampling Date	Sampling Time (UTC)	Sampling Position Latitude	Longitude	Sctd	T_{SBE21} (ITS-90)	D.O. sensor (mg/l)	Winkler (mg/l)	Difference (mg/l)	Remarks
9/5/02	13:54	68-48.65780N	167-25.55160W	30.9494	8.5407	9.322	9.499	-0.177	
9/5/02	13:57	68-49.43450N	167-25.04360W	30.9518	8.5329	9.326	9.506	-0.181	
9/6/02	20:16	71-25.51300N	157-17.93420W	29.2690	2.9001	10.576	11.640	-1.064	
9/6/02	20:19	71-25.85530N	157-15.43510W	29.2633	3.1390	10.658	11.578	-0.920	
9/9/02	18:39	73-20.68510N	157-27.39810W	27.2117	0.6199	11.001	12.197	-1.196	
9/9/02	18:42	73-20.67460N	157-27.34210W	27.2162	0.6180	10.991	12.175	-1.184	
9/11/02	21:44	74-14.81470N	162-33.43530W	27.4920	0.4716	11.092	12.132	-1.040	
9/11/02	21:47	74-14.81140N	162-33.33180W	27.5040	0.4794	11.084	12.154	-1.070	
9/13/02	19:07	73-30.15860N	55-09.13310W	27.3424	0.6582	10.957	12.149	-1.192	
9/13/02	19:10	73-30.12590N	55-09.17170W	27.3412	0.6611	10.954	12.135	-1.181	
9/14/02	17:19	72-30.46820N	51-21.47710W	26.0937	0.5473	10.937	12.281	-1.344	
9/14/02	17:21	72-30.47590N	51-21.48330W	26.0907	0.5492	10.929	12.258	-1.330	
9/15/02	22:11	72-34.14000N	43-33.69340W	26.0545	-0.4602	10.998	12.520	-1.522	
9/15/02	22:14	72-34.43810N	43-32.06130W	26.0488	-0.4842	11.000	12.544	-1.544	
9/16/02	16:55	72-29.42460N	42-08.65000W	26.2390	0.0590	11.012	12.350	-1.338	
9/16/02	16:58	72-29.42510N	42-08.64750W	26.2205	0.0312	11.000	12.384	-1.384	
9/17/02	18:32	70-53.96940N	41-54.72040W	25.7265	1.6293	10.726	11.997	-1.271	
9/17/02	18:37	70-53.98450N	41-54.71340W	25.7314	1.6042	10.728	11.987	-1.259	
9/19/02	18:48	70-42.74730N	33-45.31990W	26.1988	0.4076	11.034	12.321	-1.287	
9/19/02	18:51	70-42.44060N	33-45.01410W	26.1313	0.5807	11.048	12.254	-1.206	
9/21/02	22:17	70-33.81400N	27-33.71810W	22.9341	1.3690	10.746	12.275	-1.530	
9/21/02	22:20	70-33.88460N	27-33.47120W	22.8516	1.4059	10.729	12.234	-1.505	
9/30/02	22:02	71-27.64240N	52-30.24210W	25.9788	1.7306	10.010	-	-	
9/30/02	22:05	71-28.18620N	52-30.29570W	25.9407	1.7421	10.010	-	-	
10/2/02	17:53	74-45.16710N	59-03.85060W	27.1565	-0.4363	10.549	12.349	-1.800	
10/2/02	17:57	74-45.20290N	59-03.89280W	27.1585	-0.4323	10.552	12.366	-1.815	
							Average	-1.268	
							Std. Dev.	0.326	
							n	24	

Table 6 Results of fluorescence and chl.*a* concentration determined by the two methods for the sea surface samples.

Sampling Date	Sampling Time (UTC)	Sampling Position Latitude	Longitude	Temp (*SBE21*) ITS-90	Fluorescence	Chl. *a* (ug/l) tradional	Chl. *a* (ug/l) welschmeyer	Chl. *a* Factor tradional chl. a/Fluorescence	Remarks
9/4/02	05:28	61-42.18370N	168-19.96790W	11.0679	8.743	0.827	0.860	0.095	
9/5/02	08:33	67-57.03450N	168-31.09830W	5.2576	15.739	6.011	5.953	0.382	
9/6/02	08:29	70-51.00700N	160-31.52110W	7.1938	9.525	1.671	1.680	0.175	
9/7/02	11:24	71-18.08040N	157-21.25550W	6.9326	8.534	1.580	1.647	0.185	
9/8/02	08:17	71-41.90970N	155-04.12840W	5.4641	8.500	0.937	0.936	0.110	
9/10/02	11:01	74-19.97610N	157-41.21050W	-0.1901	6.690	0.065	0.073	0.010	
9/11/02	10:44	74-29.37520N	159-22.01280W	-0.2409	6.685	0.066	0.074	0.010	
9/12/02	09:21	73-21.70030N	164-42.43170W	0.9722	7.131	0.276	0.284	0.039	
9/13/02	09:33	73-54.41310N	155-51.31190W	-0.0243	6.657	0.088	0.104	0.013	
9/14/02	07:09	72-30.77370N	153-22.70990W	1.4020	7.813	1.008	1.017	0.129	
9/15/02	08:53	72-42.94300N	146-52.51890W	0.5689	6.783	0.112	0.128	0.017	
9/16/02	10:50	72-37.74440N	142-20.49720W	-0.5802	6.724	0.051	0.055	0.008	
9/17/02	09:23	70-44.52250N	142-59.93630W	1.8288	6.926	0.145	0.167	0.021	
9/18/02	10:41	70-08.71310N	140-48.78260W	2.2689	7.456	0.265	0.318	0.036	
9/19/02	06:17	70-53.85350N	133-58.43910W	0.1322	6.809	0.054	0.061	0.008	
9/20/02	09:35	70-09.62710N	133-34.86640W	1.9605	7.881	0.321	0.396	0.041	
9/21/02	05:19	70-42.49410N	131-32.41910W	2.6509	9.261	0.781	0.919	0.084	
9/22/02	05:41	70-56.62440N	128-09.12950W	1.8961	8.225	0.497	0.607	0.060	
9/23/02	04:47	70-27.39390N	139-01.23890W	0.9547	6.678	0.126	0.157	0.019	
9/24/02	05:52	69-40.46140N	138-02.53390W	1.0814	7.494	0.376	0.498	0.050	
9/25/02	05:19	69-40.56240N	137-00.39970W	1.4407	8.476	0.572	0.733	0.067	
9/26/02	06:50	70-13.99750N	137-28.53070W	1.0863	8.144	0.680	0.873	0.083	
9/27/02	10:49	69-36.79210N	138-11.96640W	1.0600	8.327	0.471	0.569	0.057	
9/28/02	05:57	70-24.31900N	135-24.63170W	1.4369	11.368	0.832	0.971	0.073	
9/30/02	09:08	71-03.03500N	145-56.43810W	0.7298	6.057	0.402	0.481	0.066	
10/1/02	08:33	72-26.03790N	152-29.95740W	2.2125	6.482	0.800	0.865	0.123	
10/2/02	09:31	74-40.95760N	155-08.10960W	-0.6804	5.910	0.151	0.182	0.026	
10/3/02	10:20	75-35.81700N	161-48.47900W	-0.9406	5.725	0.145	0.180	0.025	
10/4/02	10:34	75-48.78910N	166-49.08440W	-1.2232	5.893	0.169	0.206	0.029	
10/5/02	06:35	75-25.02600N	166-34.77850W	-0.9426	5.817	0.160	0.198	0.028	fiteration Volume 500 ml
10/6/02	06:57	71-38.76500N	163-21.84560W	3.5232	8.190	1.284	1.301	0.157	
10/7/02	05:21	68-17.37280N	167-58.58540W	4.9114	12.753	3.106	3.257	0.244	
10/8/02	05:18	65-22.24070N	168-38.16080W	7.0425	8.436	1.722	1.859	0.204	
10/9/02	06:48	58-46.48580N	167-37.17760W	8.1326	9.238	3.409	3.541	0.369	

2.4 Dissolved Oxygen

1. Personel

Takayoshi Seike (MWJ, Japan)
Nobuharu Komai (MWJ, Japan)

2. Objectives

Correction of the data from CTD oxygen sensor by the measurements of sample Dissolved Oxygen using the whole bottle method

3. Sampling elements

Dissolved Oxygen

4. Inventory information for the sampling

Bottle Oxygen samples were taken from all 57 stations (A02-002, 003, 004, 005, 006,007,008,009,010,011, 012, 013, 028, 029, 030, 031, 032, 033, 034, 035,036, 047, 049, 050, 051, 052, 053, 059, 063, 067,068, 069, 070, 071, 072, 073, 074, 075, 076, 078,082, 083, 084, 086, 087, 089, 117, 118, 119, 120, 123, 125, 130, 138, 139, 140, 141) during the cruise.

5. Instruments and methods

Bottle oxygen samples were taken in calibrated clear glass bottles (100 ml or 200 ml) from the 12-liter Niskin-X water samplers and surface water taken by a bucket. The temperature of the water was measured at the time of the drawing for all bottles to calculate the density of sample. Analysis followed the whole bottle method processed to the WHP Operations and Methods (Dickson, 1996). The normality of thiosulfate was set to be 0.025 when the regents were made up, and checked their changes when new titrant was used. Duplicate samples were taken on every cast.

The endpoint of titration was determined by an electrode method using two Metrohm (Switzerland) titrators with 10 ml cylinder. Titration volumes were almost smaller than 10ml and the smallest increment from burette was 1 microliter.

6. Results

(1) Reproducibility of measurement

During this cruise 841 samples were taken including 108 of duplicates. Statistics and control chart of duplicates are given in Table 1 and Figure 1, respectively.

Table 1 Statistics of duplicates during the cruise

Number of duplicates	Oxygen concentration Std. Dev. (1sigma)
108	0.66 μmol/kg

(2) Comparison of the data from CTD oxygen with bottle oxygen

The discrepancies of the CTD oxygen（SBE43）show linear behavior against the bottle oxygen values at depths (Figure 2). Therefore the simple linear calibration equations are used to calibrate the CTD oxygen data for the up cast and the down cast, respectively (Figure 3).

[Up cast] $y = 1.1266x + 1.6383$ ($r^2 = 0.9602$)

[Down cast] $y = 0.9517x + 14.444$ ($r^2 = 0.9585$)

y; Bottle oxygen value [μmol/kg]

x; CTD oxygen sensor value [μmol/kg]

(3) Contur-lines

The counter-line of bottle D.O. data were shown in Figure 4 to 7.

Contur-line (A02009-A02013) was shown in Fig. 4.

Contur-line (A02028-A02036) was shown in Fig. 5.

Contur-line (A02047-A02053) was shown in Fig. 6.

Contur-line (A02068-A02076) was shown in Fig. 7.

7. Data archives

All processed Dissolved Oxygen data files were submitted to Chief Scientist and JAMSTEC Data Management Office (DMO) according to the data management policy of JAMSTEC.

8. References:

Dickson, A. (1996) Dissolved Oxygen, in WHP Operations and Methods, Woods Hole., pp1-13

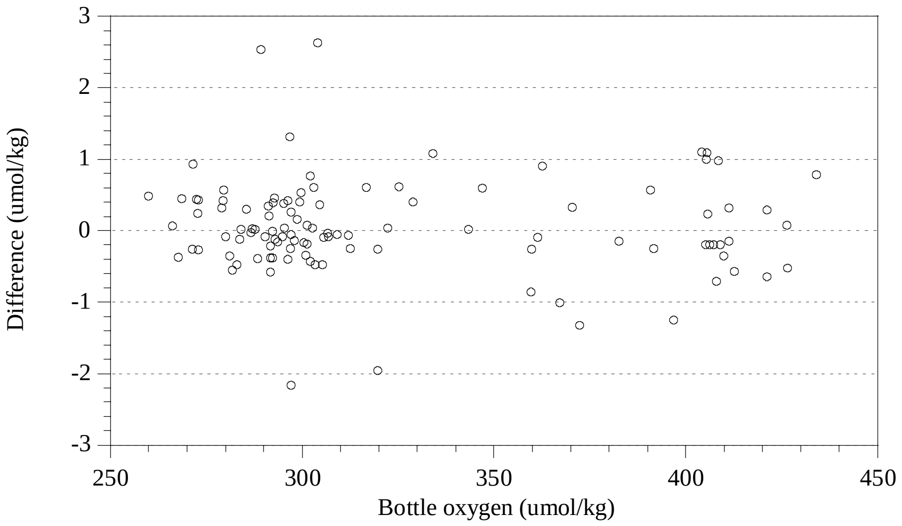


Fig. 1 Control chart of duplicate samples

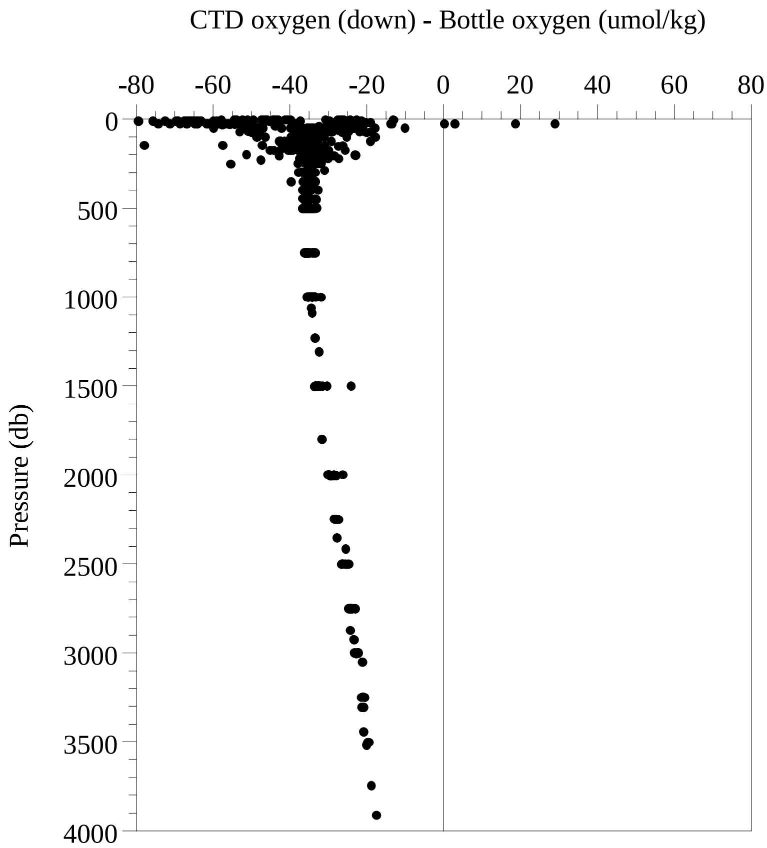


Fig. 2 Vertical distribution of oxygen residuals

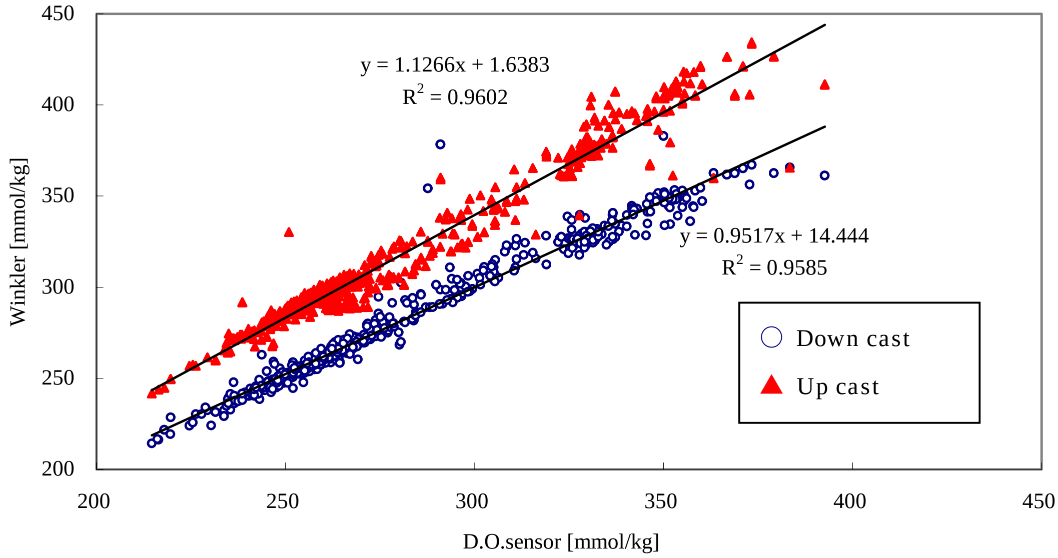


Fig. 3 Comparison of the CTD Oxygen data with bottle oxygen data for the down and up cast, respectively.

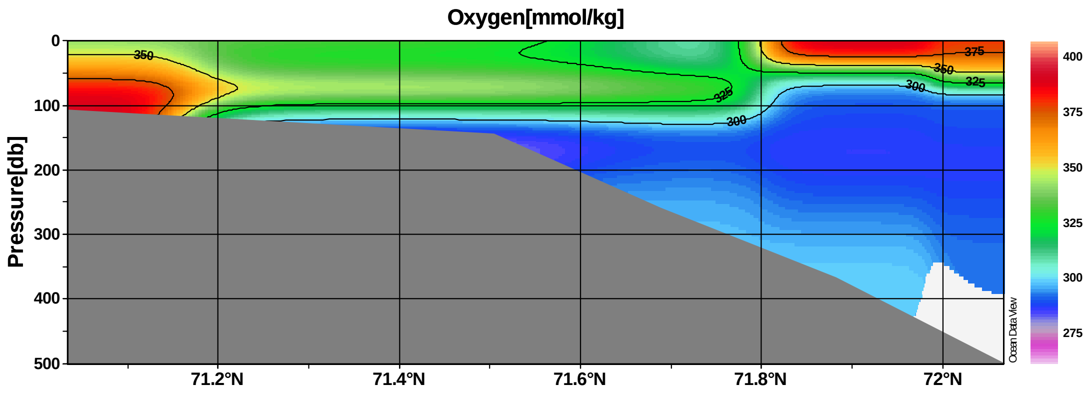


Fig. 4 Contur plot of bottle oxygen (A02009-A02013)

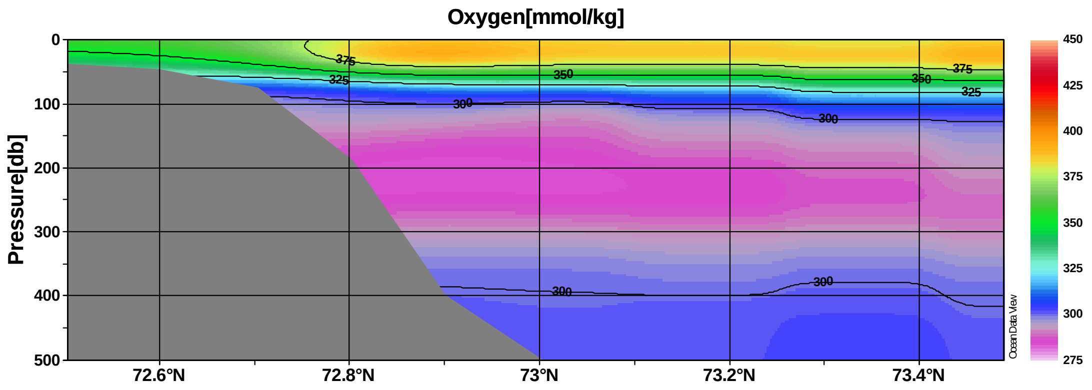


Fig. 5 Contur plot of bottle oxygen (A020028-A02036)

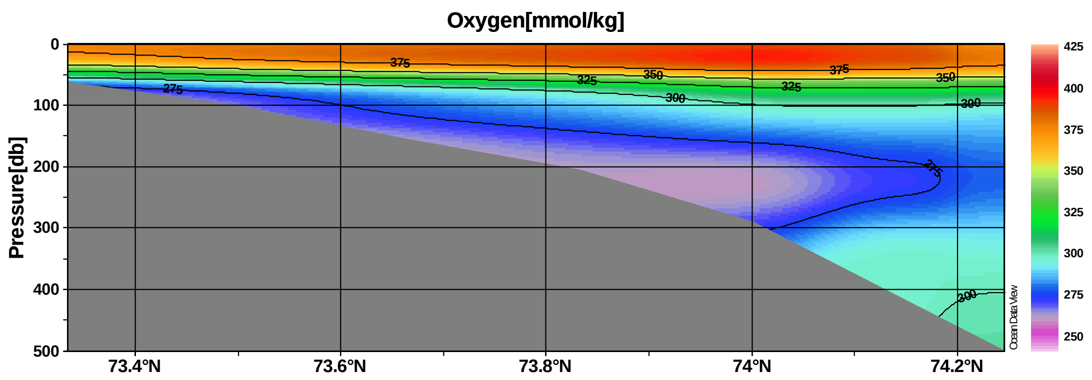


Fig. 6 Contur plot of bottle oxygen (A02047-A02053)

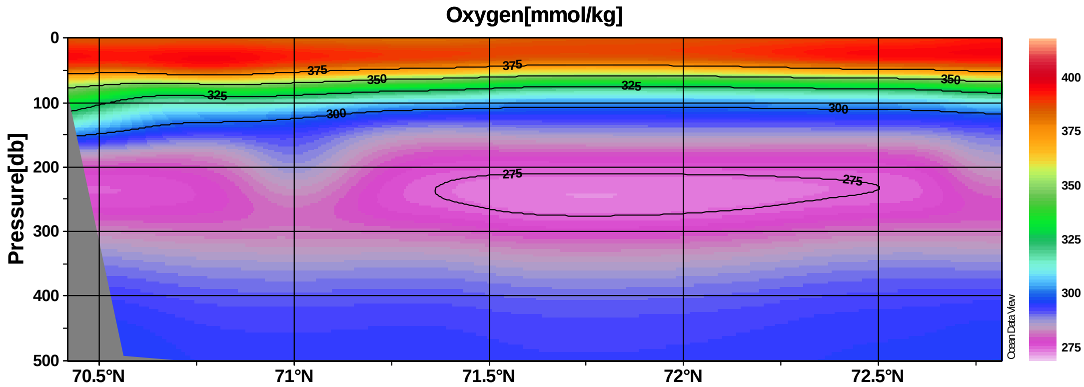


Fig. 7 Contur plot of bottle oxygen (A02068-A02076)

2.5. Nutrients

2.5.1. Water column nutrients

Kenichiro SATO (Marine Works Japan, Ltd: MWJ): Operation Leader
Kaori AKIZAWA (MWJ)
Jyunko HAMANAKA (MWJ)
Ai Yasuda (MWJ)
Akihiko MURATA (JAMSTEC)

(1) Objectives

The vertical and horizontal distributions of the nutrients are one of the most important factors on the primary production. During this cruise nutrient measurements will give us the important information on the mechanism of the primary production or seawater circulation.

(2) Instruments and Methods

Nutrient analysis was performed on two BRAN+LUEBBE TRAACS 800 systems that have 4-channel analyzing systems for nitrate, nitrite, silicate, phosphate and ammonia. The methods used were proposed for nutrients of seawater by BRAN+LUEBBE. The laboratory temperature was maintained between 19 - 25 deg C.

a. Measured Parameters

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

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

Silicate: The standard AAII molybdate-ascorbic acid method was used. Temperature of the sample was maintained at 45-50 deg C using a water bath to reduce the reproducibility problems encountered when the samples were analyzing at different temperatures. The silicomolybdate produced is measured absorbance of 630 nm using a 3 cm length cell.

Phosphate: The method by Murphy and Riley (1962) was used with separate additions of ascorbic acid and mixed molybdate-sulfuric acid-tartrate. Temperature of the samples was adjusted to be 45-50 deg C using a water bath. The phospho-molybdate produced is measured absorbance of 880 nm using a 5 cm length cell.

Ammonia: Ammonia in seawater was mixed with an alkaline solution containing EDTA, ammonia as gas state was formed from seawater. The ammonia(gas) was absorbed in sulfuric acid solution by way of 0.5 um pore size membrane filter (ADVANTEC PTFE) at the dialyzer attached to analytical system. The ammonia absorbed in acid solution was determined by coupling with phenol and hypochlorite solution to from an indophenol blue compound. That compound produced is measured absorbance of 630 nm using a 3 cm length cell.

Nutrients reported in micromoles per kilogram were converted from micromoles per liter by dividing by density calculated at sample temperature.

b. Nutrients Standard

Silicate standard solution, the silicate primary standard, is obtained from Kanto Chemical CO., Inc. This standard solution is 1000 mg per litter with 0.5 M KOH and prepared for ICP analysis. Primary standard for nitrate (KNO_3), nitrite ($NaNO_2$), phosphate (KH_2PO_4), and ammonia ($(NH_4)_2SO_4$) obtained from Wako Pure Chemical Industries, Ltd.

c. Sampling Procedures

Samples were drawn into 10 ml acrylic screw-capped tubes that were rinsed three times before filling. Each sample was analyzed two times as soon as possible. Sets of 5 different concentrations of shipboard standards were analyzed at beginning, halfway and end of each group of analysis.

d. Low Nutrients Sea Water (LNSW)

Twelve containers (20L) of low nutrients seawater were collected in January 2002 at equatorial Pacific and filtered with 0.45um pore size membrane filter (Millipore HA). They are used as preparing the working standard solution.

(3) Results

793 nutrient analysis from the rosette stations were performed including surface seawaters collected by bucket. Duplicate samples were collected from all bottles of each casting. Average of difference between duplicate samples for nitrate, nitrite, silicate, phosphate and ammonia is 0.03, 0.00, 0.08, 0.01 and 0.04, respectively. Figure 2.5.1.-1 to -5 show the vertical sections of nutrients along lines with CTD observations.

(4) Data Archive

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

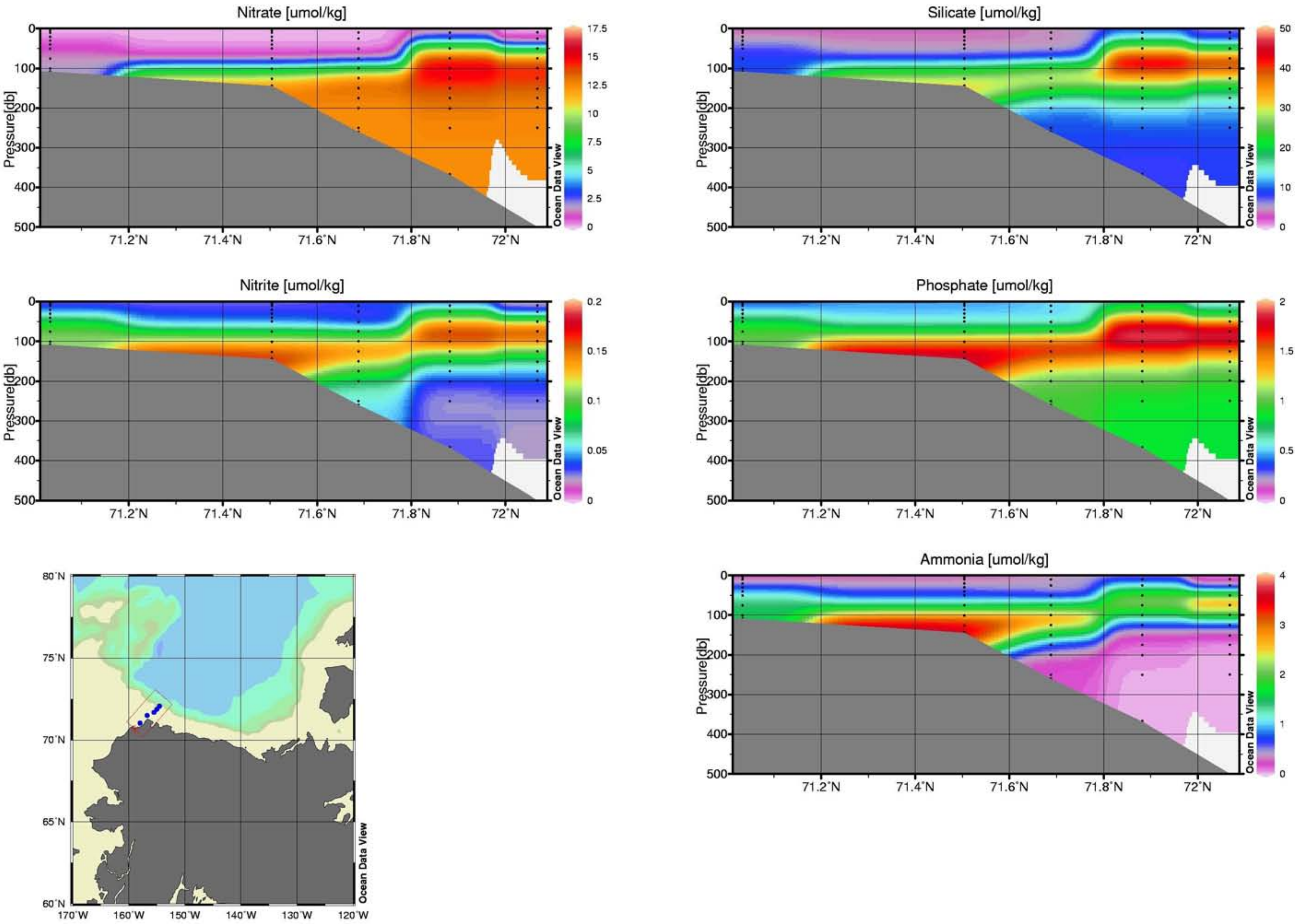


Figure 3.5.1.-1. The vartical section of nutrients along lines with stn. A02009 to A02013.

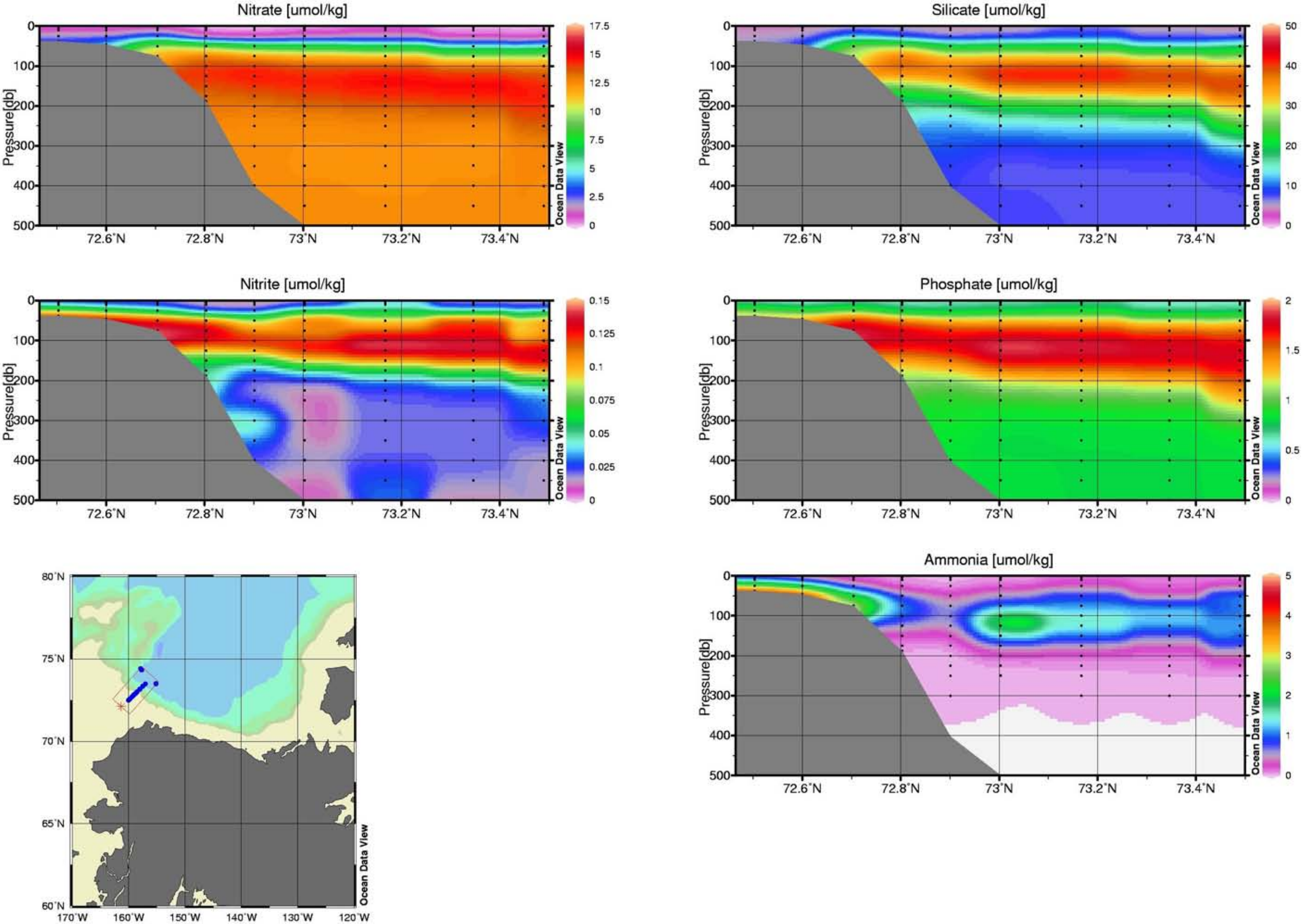


Figure 3.5.1.-2. The vartical section of nutrients along lines with stn. A02028 to A02036.

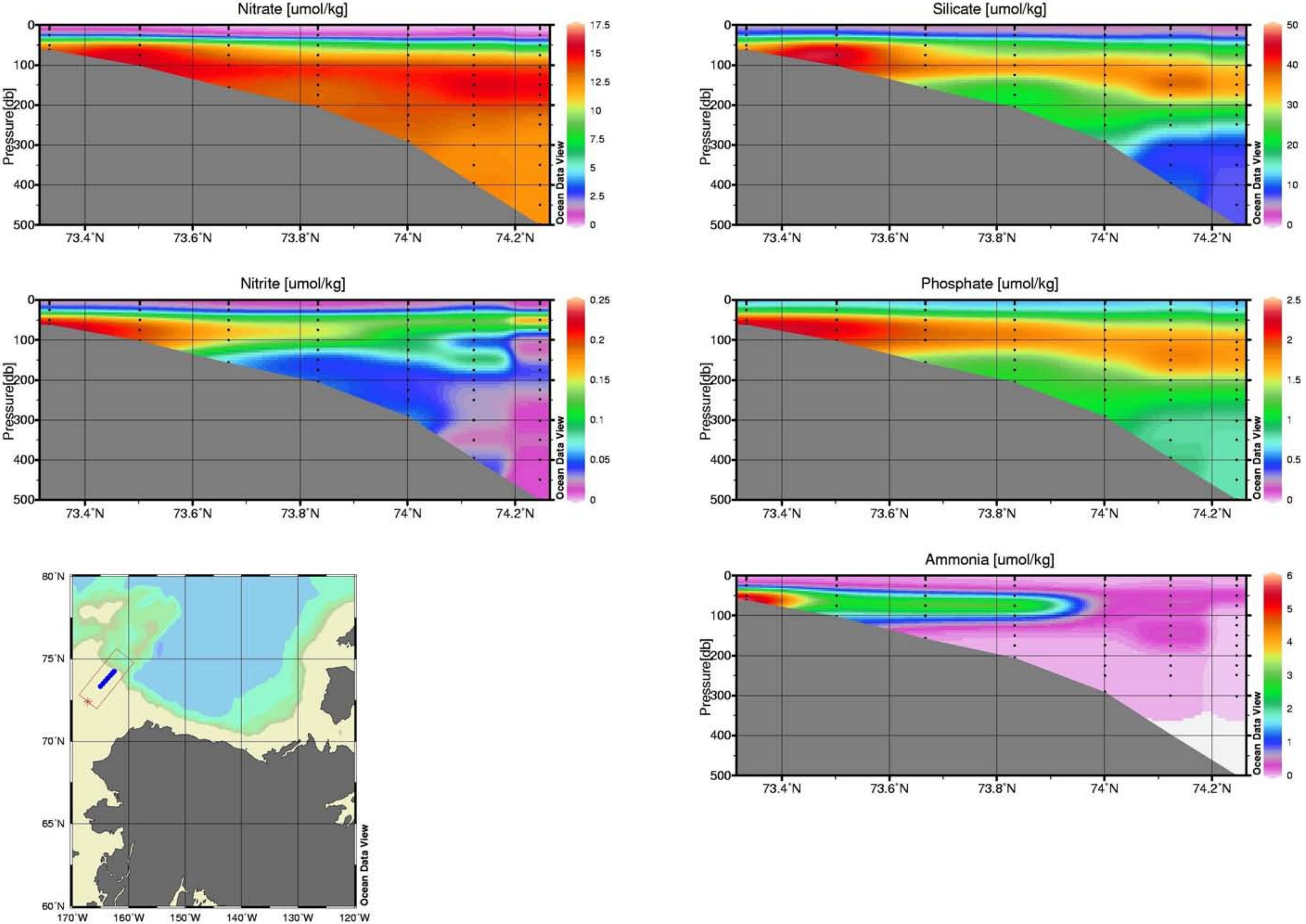


Figure 3.5.1.-3. The vartical section of nutrients along lines with stn. A02047 to A02053.

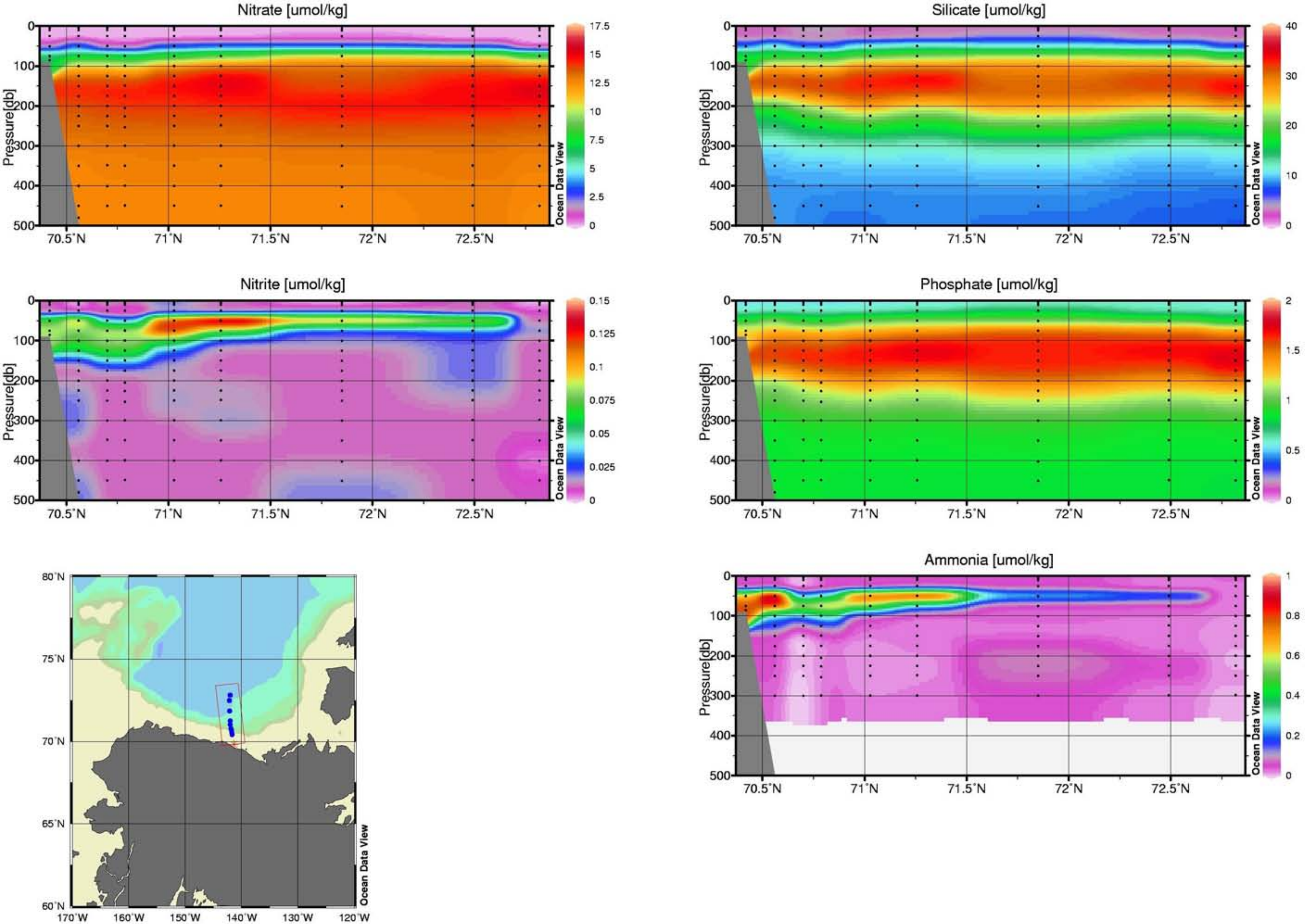


Figure 3.5.1.-4. The vartical section of nutrients along lines with stn. A02068 to A02076.

2.5.2 Sea surface nutrients

1. Personnel

Junko Hamanaka, Kenichiro Sato, Ai Yasuda, Kaori Akizawa (MWJ, Japan)
Akihiko Murata (JAMSTEC, Japan)

2. Objective

Phytoplankton requires nutrient elements for growth, chiefly nitrogen, phosphorus, and silicon. The data of nutrients in surface seawater is important for investigation of phytoplankton productivity.

3. Sampling elements

Nitrate+ Nitrite, Nitrite, Phosphate, Silicate

4. Inventory information for the sampling

Date: September 2 to October 9, 2002

5. Instruments (including setting parameters if required), and methods

The nutrients monitoring system was performed on BRAN+LUEBBE continuous monitoring system Model TRAACS-800 (4 channels). This system was located at the surface seawater laboratory for monitoring in R/V Mirai. Seawater at depth of 4.5 m was continuously pumped up to the laboratory and introduced direct to monitoring system with narrow tube. The methods are as follows.

Nitrate + Nitrite: Nitrate in the seawater was reduced to nitrite by reduction tube (Cd-Cu tube), and the nitrite reduced was determined by the nitrite method as shown below. The flow cell was 3 cm length type.

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

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

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

6. Results (Expected/preliminary results)

We are now arranging the method of data revision.

7. Data archives

All raw and revised data files will be copied onto CD-ROM and submitted to Chief Scientist and JAMSTEC Data Management Office (DMO) according to the data management policy of JAMSTEC.

2.6. Partial Pressure of CO_2 (pCO_2) Measurement

(1) Personnel

Akihiko MURATA (JAMSTEC)
Fuyuki SHIBATA (MWJ)
Mikio KITADA (MWJ)
Toru FUJIKI (MWJ)
Masaki MORO (MWJ)

(2) Introduction

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of these individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. If two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994).

(3) Objective

The current investigation was carried out in order to verify carbon dioxide parameters in the Arctic Ocean and Bering Sea by continuously measuring the partial pressure of CO_2 in the atmosphere and surface seawater. The measurement was carried out in the research vessel MIRAI during this cruise.

(4) Sampling elements

Partial Pressure of CO_2 (pCO_2)

(5) Inventory information for the sampling

Surface seawater was continuously collected from September 2^{nd}, 2002 to October 10^{th}, 2002 during the cruise.

(6) Materials and Methods

Concentrations of CO_2 in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (IR) analyzer (BINOSTM). The automated system ran on one and a half hour cycle during which standard gasses, ambient air sample and a head space sample from the equilibrator were analyzed. During one cycle, standard gasses were measured once each, twice for ambient air sample and 7 times of the sample from the equilibrator. The concentrations of the standard gas used to calibrate the analyzer were 246.68, 297.82, 320.05 and 391.65 ppm.

The ambient air sample taken from the bow was introduced into the IR by passing through a mass flow controller which controlled the air flow rate at about 0.5L/min, a cooling unit, a perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

A fixed volume of the ambient air taken from the bow was equilibrated with a stream of sea water that flowed at a rate of 5-8L/min in the equilibrator. The air passing the equilibrator was circulated with an air pump at 0.5-0.8L/min in a closed loop passing through two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

(7) Preliminary results

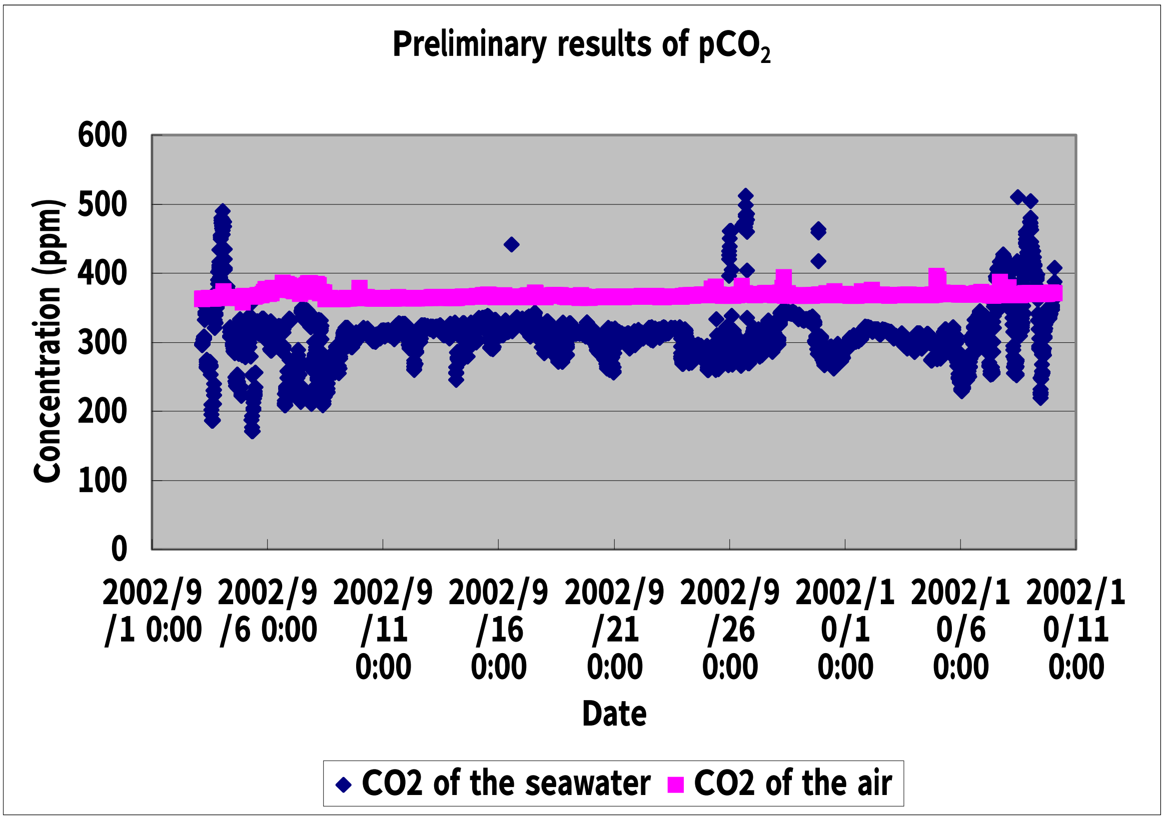
Figure 1. is showing the results of measuring the CO_2 concentration of ambient air sample and the CO_2 concentration of the seawater sample.

(8) Data Archive

All data was submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), *Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water*; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74.



Preliminary results of pCO_2
Concentration (ppm)
600
500
400
300
200
100
0
2002/9/1 0:00
2002/9/6 0:00
2002/9/11 0:00
2002/9/16 0:00
2002/9/21 0:00
2002/9/26 0:00
2002/10/1 0:00
2002/10/6 0:00
2002/10/11 0:00
Date
CO2 of the seawater
CO2 of the air

2.7. Total Dissolved Inorganic Carbon Measurement

(1) Personnel
Akihiko MURATA (JAMSTEC)
Fuyuki SHIBATA (MWJ)
Mikio KITADA (MWJ)
Toru FUJIKI (MWJ)
Masaki MORO (MWJ)

(2) Introduction

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. If two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994).

(3) Objective

The current investigation was carried out in order to verify carbon dioxide parameters in the Arctic Ocean and Bering Sea by measuring TDIC with analytical instruments installed on the research vessel MIRAI during this cruise.

(4) Sampling elements

Total Dissolved Inorganic Carbon (TDIC)

(5) Inventory information

Table 1. is showing the site name, date and the position where the water column samples were collected.

Surface seawater was continuously collected from September 2nd, 2002 to October 9th, 2002 during the cruise.

Table 1. Inventory information of the collected water column samples.

Station	mon/day/yr	Lon (ºE)	Lat (ºN)
A02002	9/4/2002	168.496	65.682
A02003	9/5/2002	168.502	66.501
A02004	9/5/2002	168.500	68.254
A02005	9/5/2002	167.631	68.506
A02006	9/5/2002	166.997	69.501
A02007	9/5/2002	163.988	70.500
A02008	9/6/2002	160.493	70.832
A02009	9/6/2002	157.984	71.033
A02010	9/6/2002	156.721	71.504
A02011	9/6/2002	155.492	71.688
A02012	9/7/2002	154.991	71.882
A02013	9/7/2002	154.506	72.068
A02028	9/8/2002	159.998	72.503
A02029	9/9/2002	159.699	72.600
A02030	9/9/2002	159.398	72.704
A02031	9/9/2002	159.100	72.803
A02032	9/9/2002	158.798	72.901
A02033	9/9/2002	158.493	73.003
A02034	9/9/2002	158.005	73.167
A02035	9/9/2002	157.475	73.346
A02036	9/9/2002	157.013	73.489
A02047	9/11/2002	162.561	74.246
A02048	9/11/2002	162.892	74.123
A02049	9/12/2002	163.228	74.001
A02050	9/12/2002	163.700	73.833
A02051	9/12/2002	164.113	73.667

Station	mon/day/yr	Lon (ºE)	Lat (ºN)
A02052	9/12/2002	164.558	73.502
A02053	9/12/2002	165.008	73.334
A02059	9/13/2002	155.138	73.502
A02063	9/14/2002	151.343	72.500
A02067	9/15/2002	146.000	72.000
A02068	9/16/2002	142.000	72.818
A02069	9/16/2002	142.135	72.490
A02070	9/16/2002	142.081	71.850
A02071	9/17/2002	142.000	71.257
A02072	9/17/2002	141.990	71.028
A02073	9/17/2002	141.852	70.787
A02074	9/17/2002	141.776	70.700
A02075	9/18/2002	141.720	70.560
A02076	9/18/2002	141.642	70.418
A02086	9/21/2002	127.998	70.752
A02087	9/21/2002	127.873	70.754
A02089	9/21/2002	127.440	70.749
A02099	9/26/2002	139.495	69.892
A02101	9/26/2002	139.105	69.949
A02103	9/26/2002	138.660	69.997
A02105	9/27/2002	139.164	70.505
A02112	9/27/2002	137.837	70.098
A02114	9/28/2002	137.001	70.201
A02123	10/1/2002	152.479	74.683
A02130	10/3/2002	161.336	75.508
A02140	10/4/2002	168.469	76.245

(6) Water column TDIC

(6)-1. Materials and Methods

(6)-1-1. Seawater sampling

Seawater from different depths was collected by 12L Niskin bottles at 52 stations. To collect the surface seawater, a plastic bucket was used. Seawater from different depths was sampled in a 250ml glass bottle, which was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 2 hours and was cleansed by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 10 seconds with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. Prior to the analysis, 3ml of the sample (1% of the bottle volume) was removed from the glass bottle in order to make a headspace. The samples were then poisoned with 100 μl of 100% saturated solution of mercury chloride within one hour from the sampling point. After poisoning, the samples were sealed using grease (Apiezon M grease) and a stopper-clip. The samples were stored in a refrigerator in darkness at approximately 5℃ until analyzed.

(6)-1-2. Seawater analysis

Using a coulometer (Carbon Dioxide Coulometer Model 5012, UIC Inc.) and an automated sampling system controlled by a computer, the concentration of TDIC was measured as the followings.

The sampling cycle set in the system was composed of 3 measuring factors; 70ml of standard CO_2 gas, 2ml of 10% saturated phosphoric acid solution and 6 seawater samples. The standard CO_2 gas was measured to confirm the constancy of the calibration factor during a run and phosphoric acid was measured for acid blank correction.

The seawater samples were measured as the followings. From the glass bottle, approximately 20ml of seawater was measured in a receptacle and was mixed with 2ml of 10% (v/v) phosphoric acid. The carbon dioxide gas evolving from the chemical reaction was purged by nitrogen gas (carbon dioxide free) for 12 minutes at the flow rate of 130ml/min and was absorbed into an electrolyte solution. In the electrolyte solution, acids forming from the reaction between the solution and the absorbed carbon dioxide were titrated with hydrogen ions in the coulometer and the counts of the titration were stored in the computer.

After the samples were measured, the calibration factor (slope) was calculated by measuring series of sodium carbonate solutions (0~2.5mM) and this calibration factor was applied to all of the data acquired throughout the cruise. By measuring Certified Reference Material (CRM) (Scripps Institution of Oceanography) every time the cell was filled with fresh anode and cathode solutions, the slope was calibrated with the counts of this outcome. The set of cell solutions was changed after approximately 60 seawater samples were measured.

(6)-2. Preliminary results

During the cruise, 15 bottles of CRM, twice for each bottle, was analyzed. Figure 1. is a property control chart showing the results of the measured CRM concentration. The mean value and the standard deviation of the property control chart was calculated using one result from each bottle. Whenever the coulometer cell was refilled, the phosphoric acid was also refilled. However, when batch 55-bottle 11 was measured, the outcome of the measurement tended to be smaller than the others due to insufficient mixing of the refilling phosphoric acid solution. Therefore, the results from the batch 55-bottle 11 were considered to be inappropriate to use for the property control chart and were excluded. All of the results except 2 from this bottle (batch 55 bottle 11) were plotted on the property control chart.

A duplicate analysis was made on every tenth seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.). The average of the differences was 1.28. The standard deviation of the absolute differences was 1.17 μmol/kg (n=96), which indicates that the analysis was accurate enough according to DOE (1994).

The standard deviation of the absolute differences of duplicate measurements from the reference material created by KANSO (KRM) was 0.86 μmol/kg (n=12), which also indicates that the analysis was accurate enough according to DOE (1994).

(7) Surface seawater TDIC

(7)-1. Materials and Methods

Surface seawater was continuously collected by a pump from the depth of 4.5m. The TDIC of the introduced surface seawater was constantly measured by a coulometer that was set to analyze surface seawater specifically. The mechanism of the measurement was the same as described in *(1)-2. Seawater analysis*. However, the seawater measured in a receptacle was 24ml and the flow rate of nitrogen gas was 140ml/min.

(7)-2. Preliminary results

A property control chart showing the results of measuring CRM concentrations could be seen in figure 3. During the analysis, 11 bottles of CRM, twice for each bottle, was analyzed in order to calibrate the slope of the calibration factor. The mean value and the standard deviation of the property control chart were calculated from these 11 bottles, however using only one result from each.

The standard deviation of the absolute differences of duplicate measurements from the reference material created by KANSO (KRM) was 0.83 μmol/kg (n=12), which indicates that the analysis was accurate enough according to DOE (1994).

(8) Data Archive

All data was submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

(9) Reference

DOE (1994), *Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water*; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74.

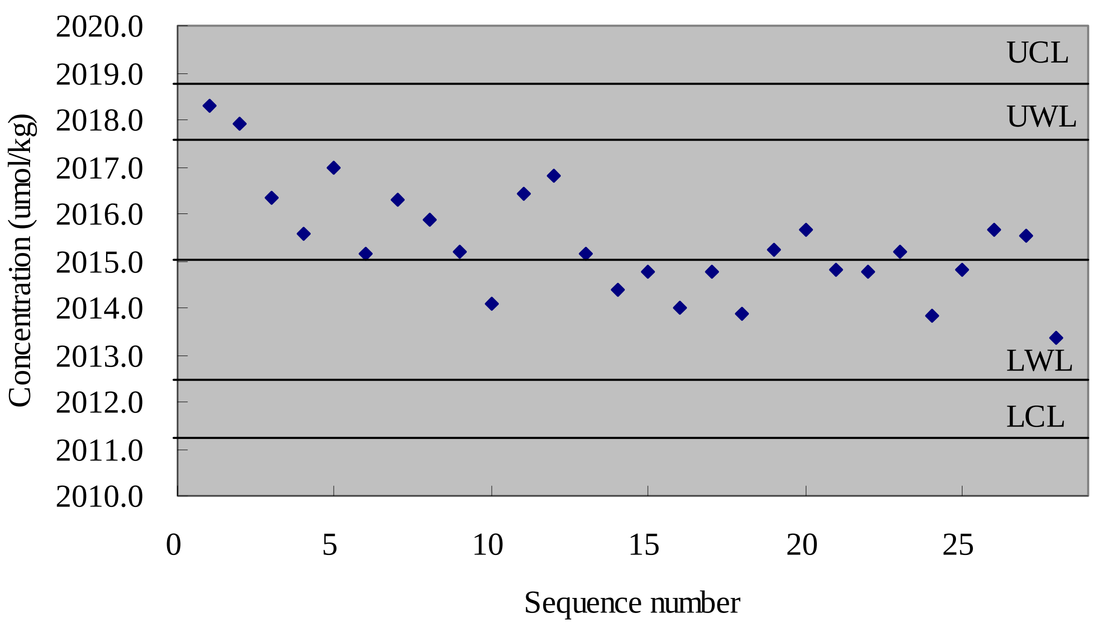


Figure 1. Property control chart of CRM measured by the coulometer used to analyze water column TDIC.

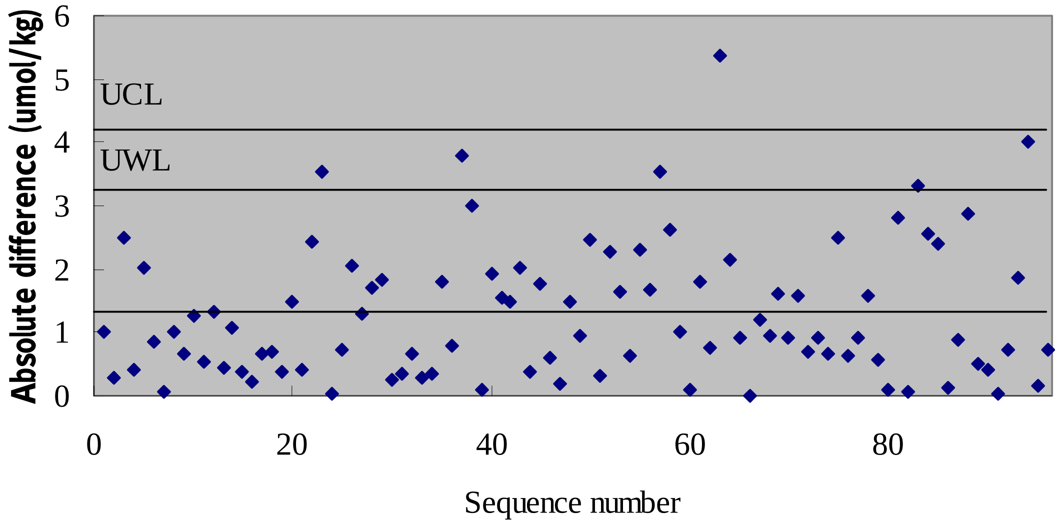


Figure 2. Range control chart of the absolute differences between the analyzed duplicate seawater samples.

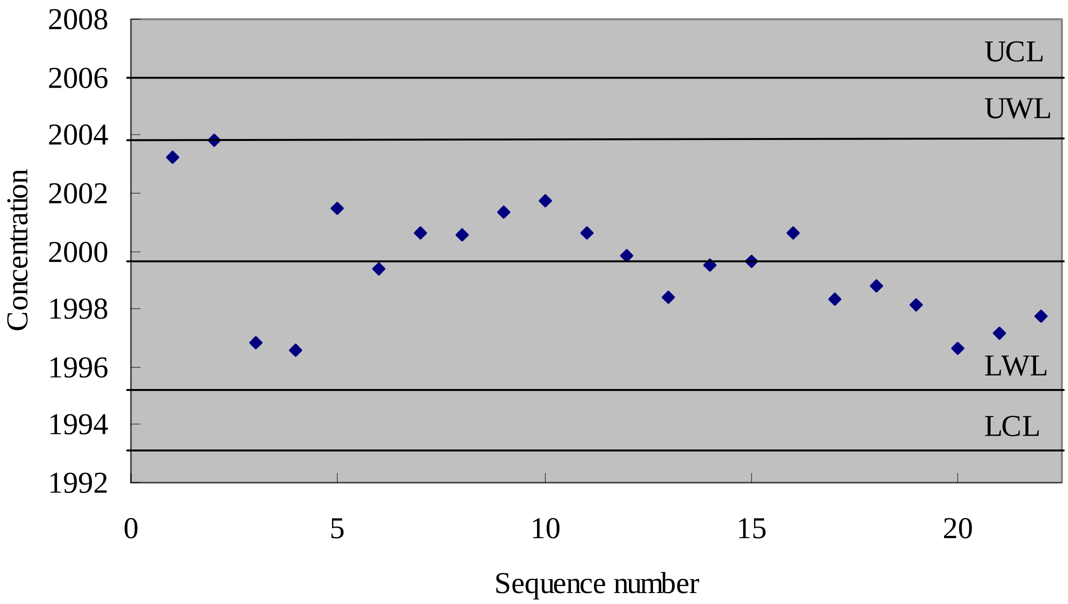


Figure 3. Property control chart of the CRM measured by the coulometer used to analyze seasurface TDIC.

2.8. Total Alkalinity

(1) Personnel
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Mikio KITADA (MWJ)
Toru FUJIKI (MWJ)
Masaki MORO (MWJ)

(2) Introduction

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters alkalinity, total dissolved inorganic carbon, pH and pCO_2 that could be measured. If two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994).

(3) Objective

The current investigation was carried out in order to verify carbon dioxide parameters in the Arctic Ocean and Bering Sea by measuring total alkalinity in the research vessel MIRAI during this cruise.

(4) Sampling elements

Total alkalinity

(5) Inventory information for the sampling

Table 1. is showing the site name, date and the position where the water column samples were collected.

Table 1. Inventory information of the collected water column samples.

Station	mon/day/yr	Lon (ºE)	Lat (ºN)
A02002	9/4/2002	168.496	65.682
A02003	9/5/2002	168.502	66.501
A02004	9/5/2002	168.500	68.254
A02005	9/5/2002	167.631	68.506
A02006	9/5/2002	166.997	69.501
A02007	9/5/2002	163.988	70.500
A02008	9/6/2002	160.493	70.832
A02009	9/6/2002	157.984	71.033
A02010	9/6/2002	156.721	71.504
A02011	9/6/2002	155.492	71.688
A02012	9/7/2002	154.991	71.882
A02013	9/7/2002	154.506	72.068
A02028	9/8/2002	159.998	72.503
A02029	9/9/2002	159.699	72.600
A02030	9/9/2002	159.398	72.704
A02031	9/9/2002	159.100	72.803
A02032	9/9/2002	158.798	72.901
A02033	9/9/2002	158.493	73.003
A02034	9/9/2002	158.005	73.167
A02035	9/9/2002	157.475	73.346
A02036	9/9/2002	157.013	73.489
A02047	9/11/2002	162.561	74.246
A02048	9/11/2002	162.892	74.123
A02049	9/12/2002	163.228	74.001
A02050	9/12/2002	163.700	73.833
A02051	9/12/2002	164.113	73.667

Station	mon/day/yr	Lon (ºE)	Lat (ºN)
A02052	9/12/2002	164.558	73.502
A02053	9/12/2002	165.008	73.334
A02059	9/13/2002	155.138	73.502
A02063	9/14/2002	151.343	72.500
A02067	9/15/2002	146.000	72.000
A02068	9/16/2002	142.000	72.818
A02069	9/16/2002	142.135	72.490
A02070	9/16/2002	142.081	71.850
A02071	9/17/2002	142.000	71.257
A02072	9/17/2002	141.990	71.028
A02073	9/17/2002	141.852	70.787
A02074	9/17/2002	141.776	70.700
A02075	9/18/2002	141.720	70.560
A02076	9/18/2002	141.642	70.418
A02086	9/21/2002	127.998	70.752
A02087	9/21/2002	127.873	70.754
A02089	9/21/2002	127.440	70.749
A02099	9/26/2002	139.495	69.892
A02101	9/26/2002	139.105	69.949
A02103	9/26/2002	138.660	69.997
A02105	9/27/2002	139.164	70.505
A02112	9/27/2002	137.837	70.098
A02114	9/28/2002	137.001	70.201
A02123	10/1/2002	152.479	74.683
A02130	10/3/2002	161.336	75.508
A02140	10/4/2002	168.469	76.245

(6) Materials and Methods

6.1. Seawater sampling

Seawater from different depths was collected by 12L Niskin bottles at 52 stations. To collect the surface seawater, a plastic bucket was used. Seawater from different depths was sampled in a 100ml glass bottle, which was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 1 hour and was cleansed by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 6 seconds with care not to leave any bubbles in the bottle. The bottles were sealed with a plastic screw cap. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. The samples were stored in a refrigerator in darkness at approximately 5℃ for maximum of 36hours prior to analysis.

6.2. Seawater analysis

Approximately 100ml of the seawater sample was transferred into a 200ml tall beaker from the glass bottle using a calibrated pipette. At this point, the water temperature of the sample was recorded in order to calculate the exact water volume that was transferred. The samples were titrated with a solution of 0.05M hydrochloric acid, which was made up in a 0.65M sodium chloride background. The whole titration procedure was carried out by an automated titration system. The titration system was composed of 6 devices; a titration manager (Radiometer, TIM900), an auto-burette (Radiometer, ABU901), a pH glass electrode (Radiometer, pHG201-7), a reference electrode (Radiometer, REF201), a thermometer (Radiometer, T201) and one computer with an installed operating software (Lab Soft, TimTalk9). Prior to the titration, all of the samples were kept in a thermostat bath to bring the water temperature up to 25℃ and the titration was also carried out in a thermostat bath that was kept at 25℃.

The acid used for the titration was calibrated by measuring alkalinity of 4 different concentrations of Na_2CO_3, ranging from 0 to 2500 µmol/kg, in 0.7N NaCl solutions.

Modified Gran functions were applied to calculate the alkalinity of the samples.

(7) Preliminary Results

Figure 1. is a property control chart showing the results of the analyzed CRM. During the cruise, 14 bottles of CRM was analyzed. From each CRM bottles, the sampling ranged from once to six times depending on the amount that was left in. The measurement of the CRM was carried out for 2 to 4 times after samples from couple stations were measured. The values of these measurements were used to calculate the mean value and the standard deviation of the property control chart. The outcome of the values shows a variation, however the drifting sensitivity of the electrodes was considered to be responsible for this.

A duplicate analysis was made on every tenth seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.). The average of the differences was 2.00 and the standard deviation of the absolute differences was 2.17 μmol/kg (n=96), which indicates that the analysis was accurate enough according to DOE (1994).

(8) Data Archive

All data was submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), *Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water*; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74.

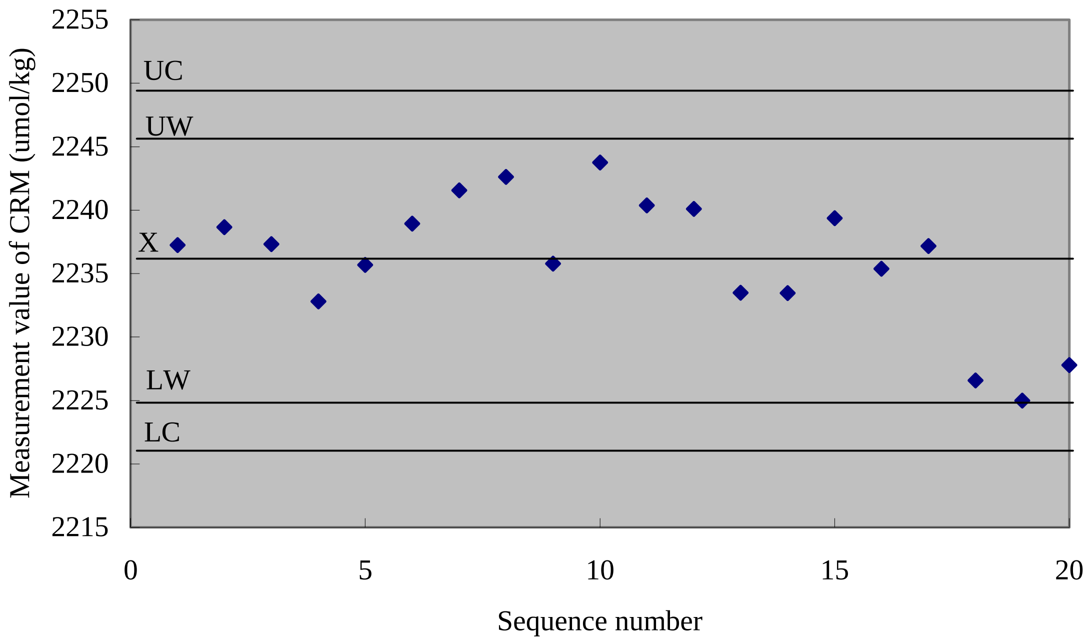


Figure 1. Property control chart

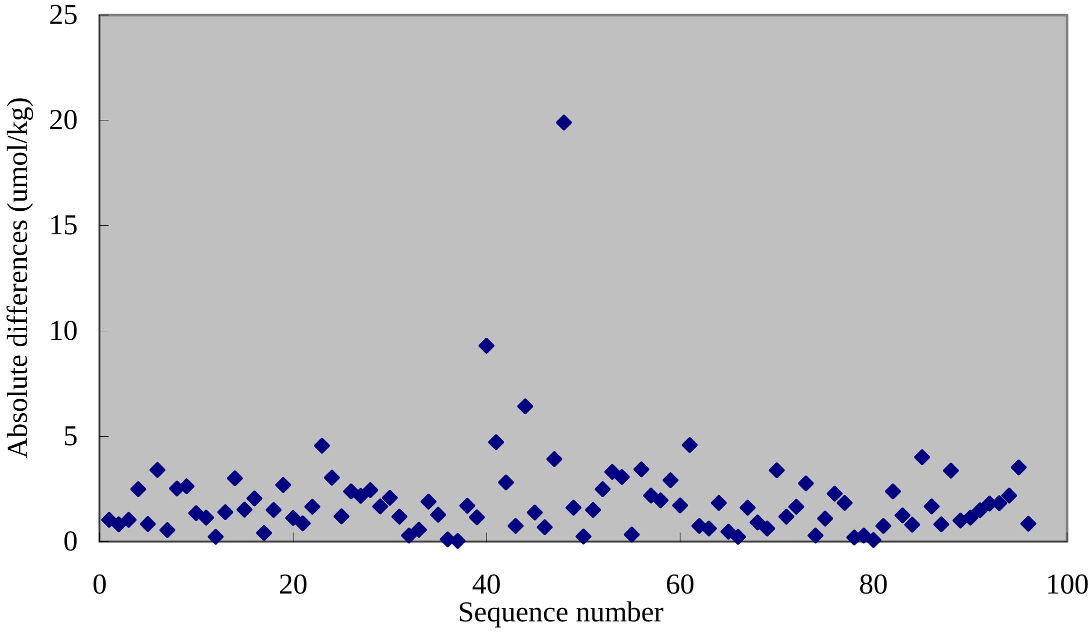


Figure 2. Range control chart

2.9. Chlorophyll *a* concentrations of size-fractionated phytoplankton

(1) Personnel

Keisuke WATAKI (MWJ)

Akihiko MURATA (JAMSTEC)

Sanae CHIBA (JAMSTEC/Frontier)

(2) Objectives

Phytoplankton are existed various species and sizes in the ocean. Phytoplankton species are roughly characterized by size. The object of this study is investigated the vertical distribution of phytoplankton after the size filtration procedure in the Bering Sea, and the Arctic Ocean.

(3) Materials and Method

Seawater samples were collected from upper 200m using Niskin bottles, except for the surface water, which was taken by the bucket. The samples (0.2-0.5L) were filtered separately through Nuclepore filters (diameter 47mm) with pore sizes of 10 and 2μm and a Whatman GF/F filter (diameter 25mm). It was applied to vacuum less than 20cmHg. It was extracted in a polypropylene tube (Sarstedt Co.) with 7ml N-N,dimethylformamide (DMF), stored at –20℃ under a dark condition for extraction of chl-a. Over 24 hours, fluorescence was measured with a Turner Design fluorometer (10-AU-005), which was previously calibrated against a pure chl-a (Sigma chemical Co.). It was done two methods of Acidification and non-acidification. Analytical conditions of methods indicate in table 1. The vertical section of chlorophyll-a concentrations is shown in Figure..

Table 1. Analytical conditions of acidification method and non-acidification method for chlorophyll-a with Turner fluorometer.

	Acidification method	Non-acidification method
Excitation filter (nm)	340-540	436
Emission filter (nm)	>665	680
Lamp	Daylight white F4T5D	Blue F4T5, B2/BP

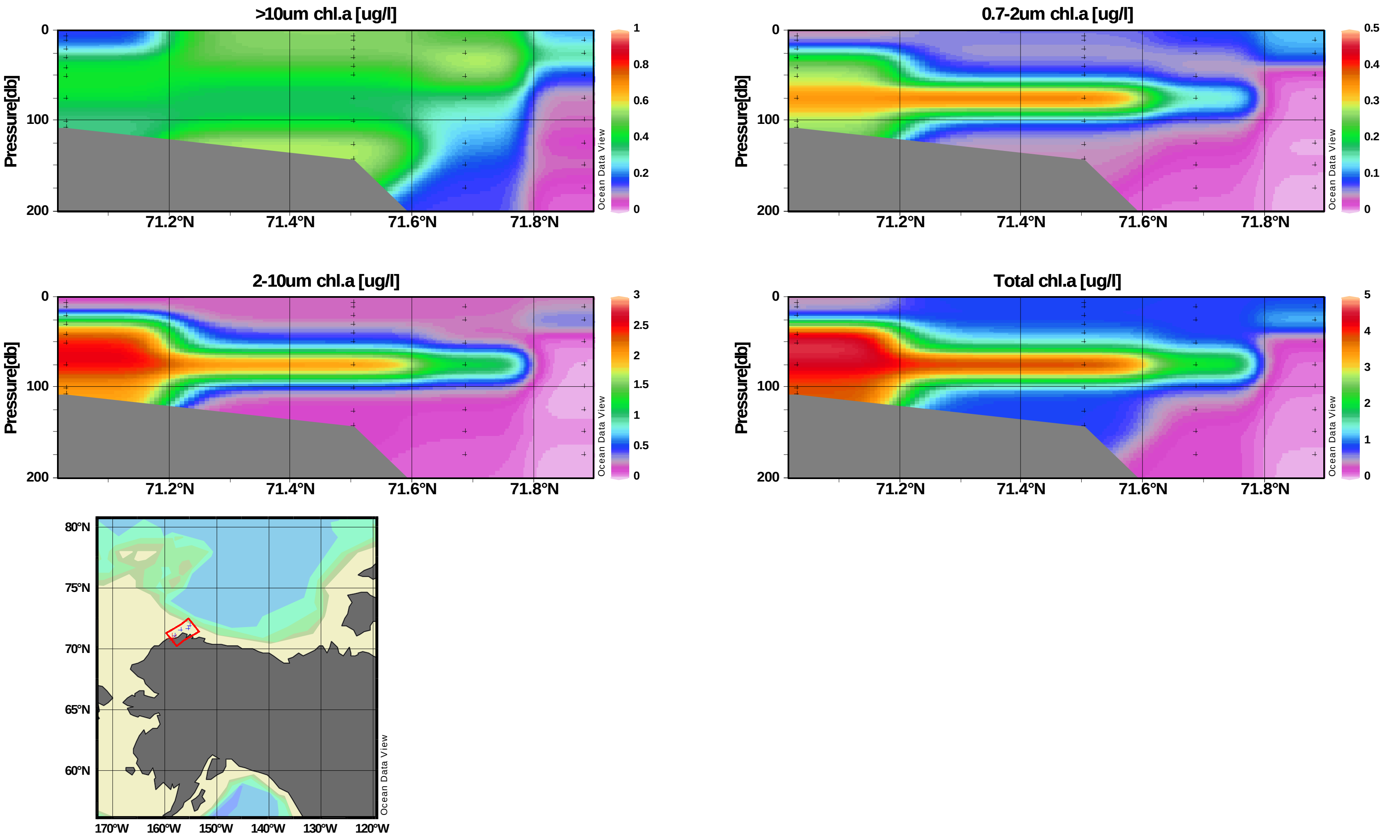


Figure 2.9.-1 Vertical sections of chl-a (>10μm, 2-10μm, 0.7-2μm, Total) concentrations from Stn. A02-009 to 013.

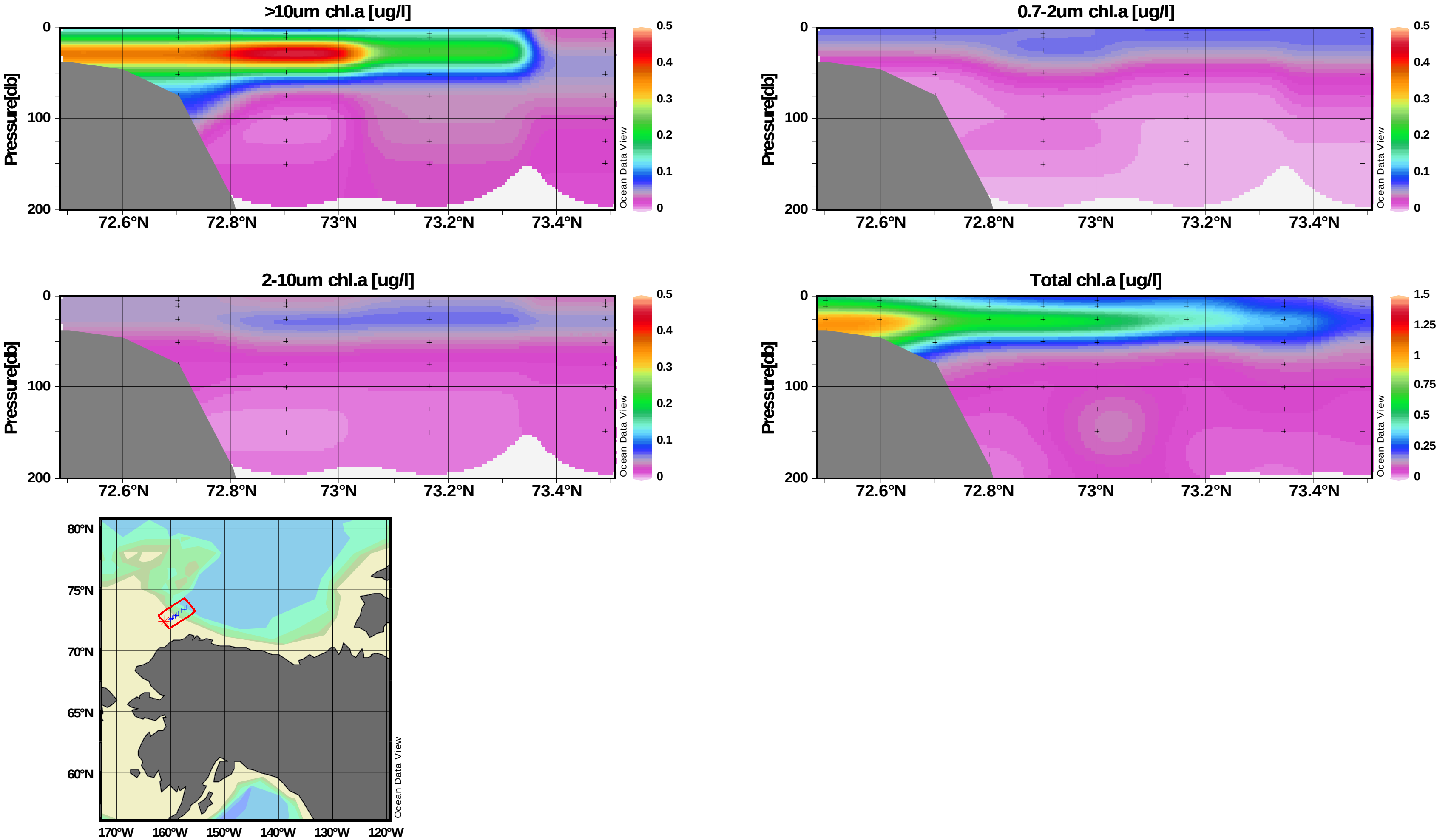


Figure 2.9.-2 Vertical sections of chl-a (>10μm, 2-10μm, 0.7-2μm, Total) concentrations from Stn. A02-028 to 036.

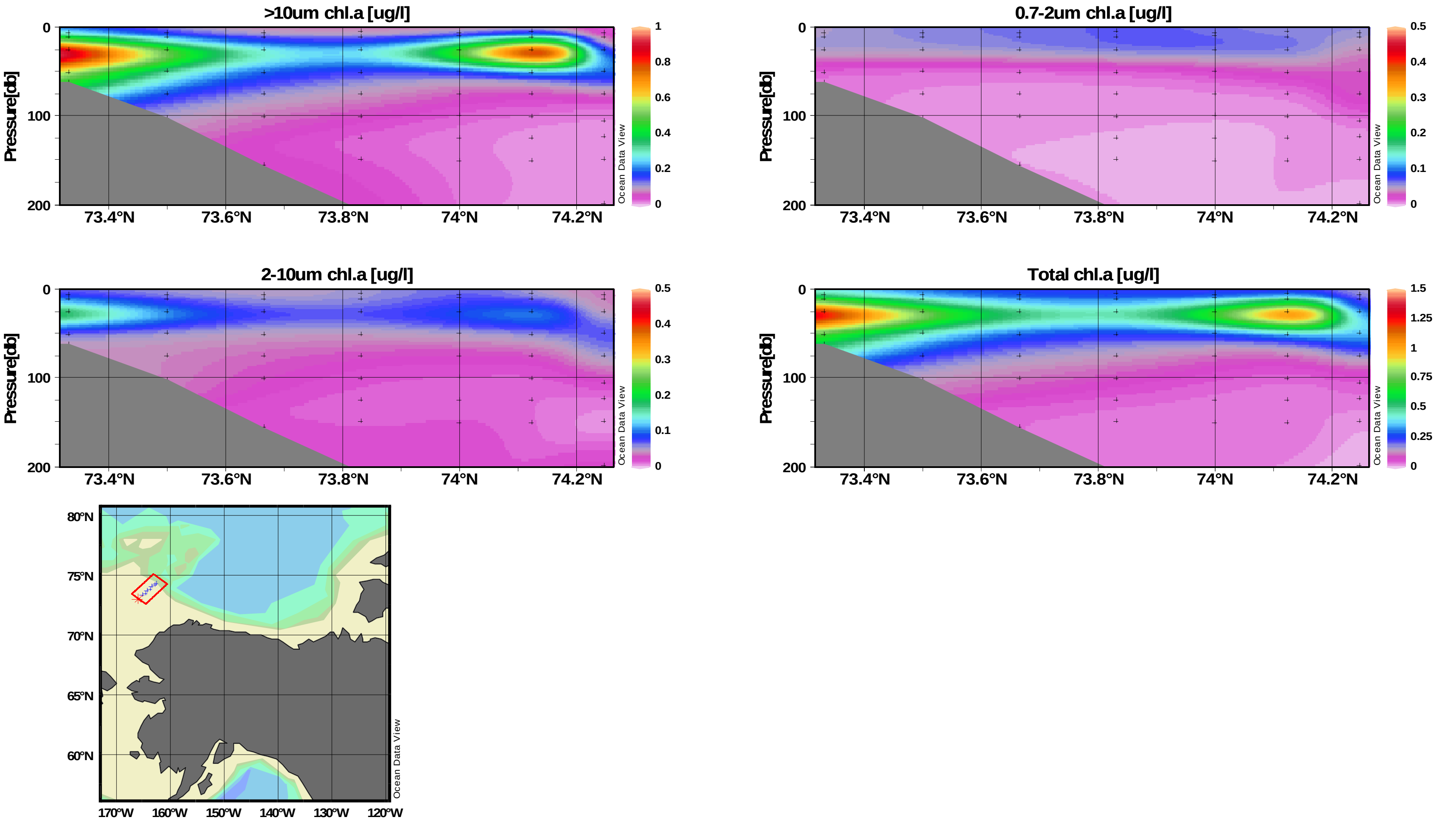


Figure 2.9.-3 Vertical sections of chl-a (>10μm, 2-10μm, 0.7-2μm, Total) concentrations from Stn. A02-047 to 053.

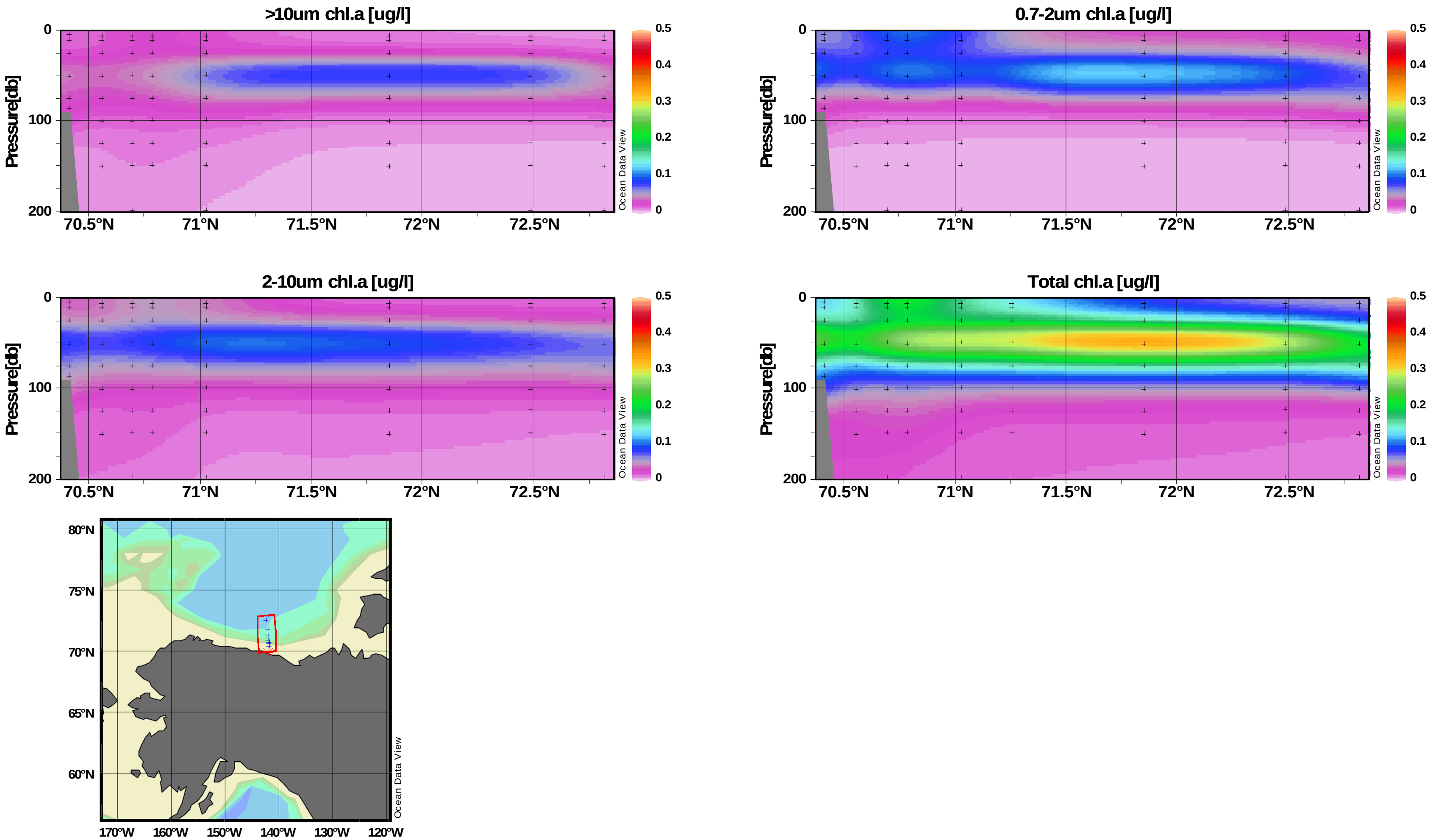


Figure 2.9.-4 Vertical sections of chl-a (>10μm, 2-10μm, 0.7-2μm, Total) concentrations from Stn. A02-068 to 076.

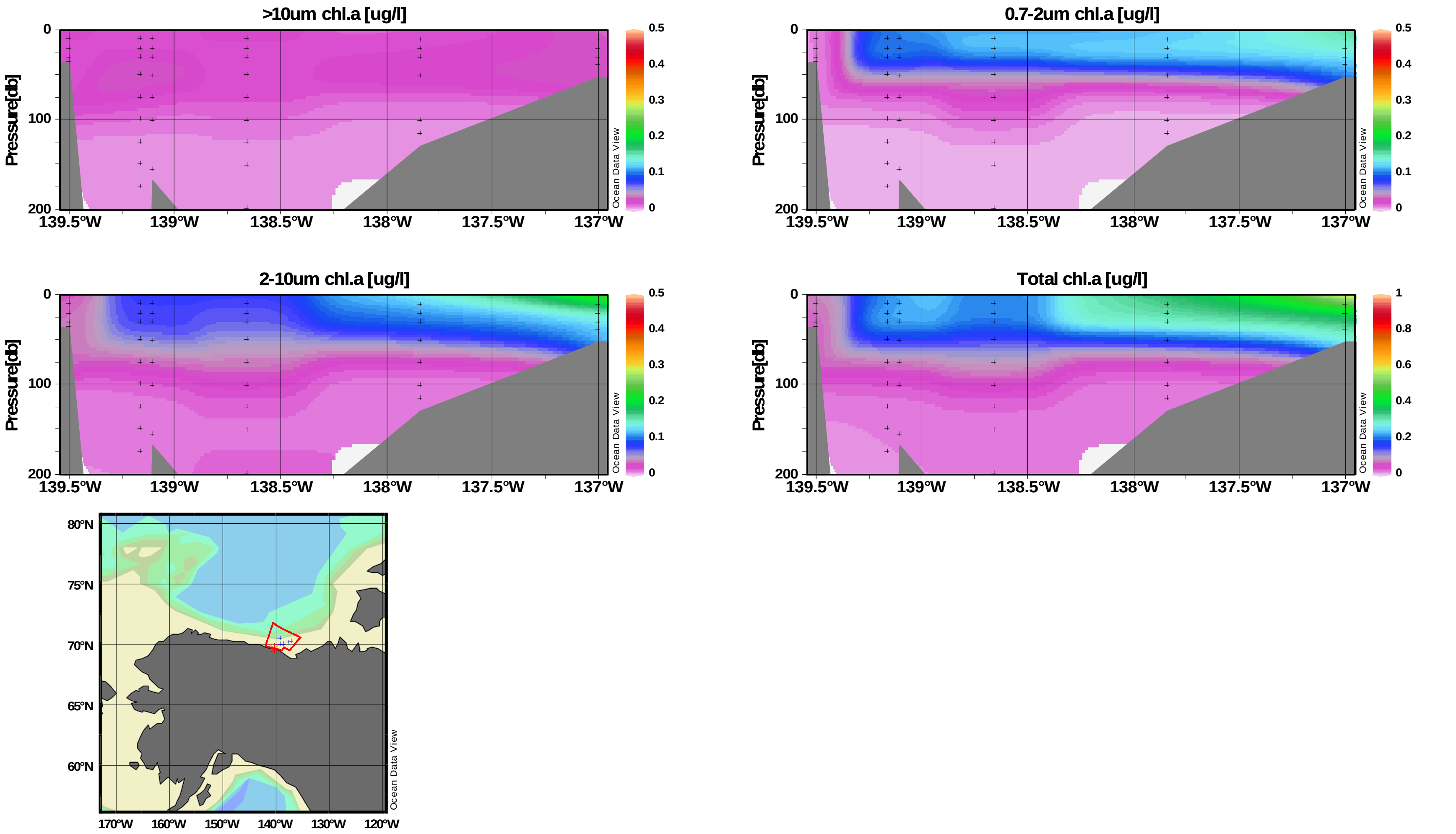


Figure 2..9.-5 Vertical sections of chl-a (>10μm, 2-10μm, 0.7-2μm, Total) concentrations from Stn. A02-099 to 114.

3. Biogeochemistry

Cruise Report (MR-02-K-05)
by
IARC-Frontier Multidisciplinary Group

Personnel:

Laodong Guo, Celine Gueguen, Tomoyuki Tanaka, Michiyo Yamamoto, Noriyuki Tanaka

Part 1. Oxygen Isotope Hydrology

(in coordination with Dr. Hisashi Narita at Hokkaido University)

Objectives

The oxygen isotope ratio provides valuable information to distinguish fresh water sources supplied into the ocean. The objective of this study is to understand mechanisms of redistribution of fresh water and formation of dense shelf water.

Sampling

633 seawater samples for isotope analysis were collected at 43 hydrographic observation stations. In addition, 320 surface waters were also collected during this cruise through underway surface water sampling. The samples were transferred to 50 ml glass or plastic bottles and sealed doubly with a PVC stopper and a screw cap.

Analytical method

Samples will be analyzed for oxygen isotope composition (in terms of $\delta^{18}O$) in the laboratory at the International Arctic Research Center with a mass spectrometer (Finnigan MAT252) connected to a CO_2-H_2O equilibration unit (made by Thermoquest CO., Ltd.).

Expected Results

Temperature and salinity distributions in the upper layer in the observed area show inter-annual variability. The fluctuations of fresh water supply (river runoff, Pacific water, and sea ice melt water) and their distribution pattern may cause this variation. The relationship between salinity and oxygen isotope ratio will identify and quantify the fresh water sources. Effect of these fluctuations on the dense shelf water formation will also be evaluated by isotope composition together with other chemical and hydrographic data, such as nutrients, alkalinity, etc.

Part 2. Characterizations of chromophoric dissolved organic matter and particulate organic matter in the Arctic Ocean

Background

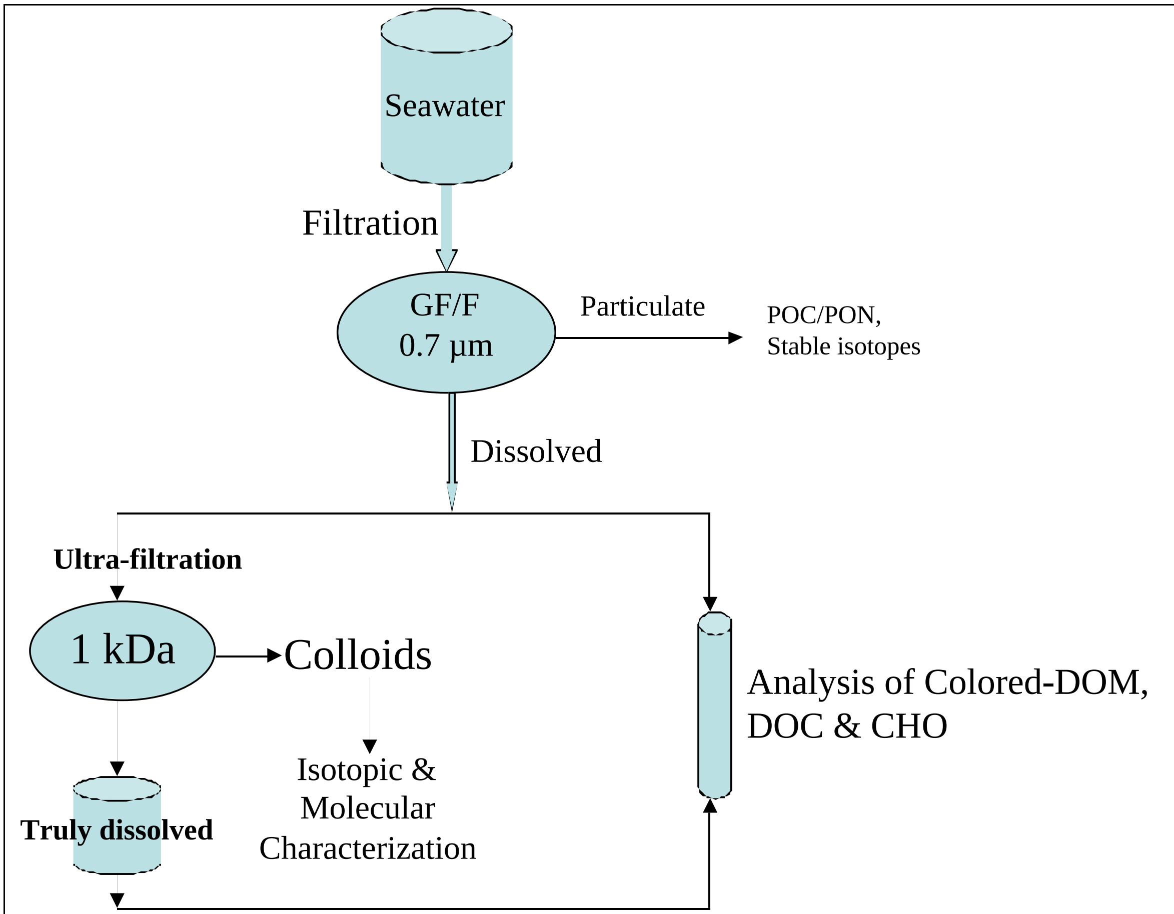
Dissolved organic carbon (DOC) is an important component in global carbon budgets and marine carbon cycling. A portion of the total DOC pool, which absorbs lights in the UV and visible ranges, is referred to chromophoric (or colored) dissolved organic matter (CDOM). Recent studies have shown that CDOM may play an important role in radiative transfer of light in the ocean and remote sensing of primary production. Major sources of CDOM in the ocean are mostly from terrestrially derived humic substances from river runoff, especially in coastal regions, and phytoplankton production. In addition to tracing DOC concentrations in the water column, CDOM can be used as a potential tracer in water mass mixing, especially in the Arctic Ocean where there is a large share of global river discharge and terrigenous DOC. However, characteristics of CDOM and its distribution in the Arctic Ocean are poorly understood.

Objectives

1) To fractionate seawater samples into dissolved (<1 nm), colloidal (1-700 nm) and particulate (>0.7 µm) size fractions using filtration and ultrafiltration techniques for chemical and isotopic characterization;
2) To characterize the absorbing and fluorescing of chromophoric dissolved organic matter (CDOM) as well as nature and quality of dissolved organic matter;
3) To determine elemental (C and N) composition and stable isotopic ($\delta^{13}C$ and $\delta^{15}N$) signatures of particulate organic matter ;
4) To collect filtered seawater samples for DOC method intercomparison (in coordination with Dr. A. Murata at FAMSTEC);
5) To evaluate the potential of CDOM as water mass mixing tracer and to better understand the dynamic cycling of organic carbon in the Arctic Ocean.

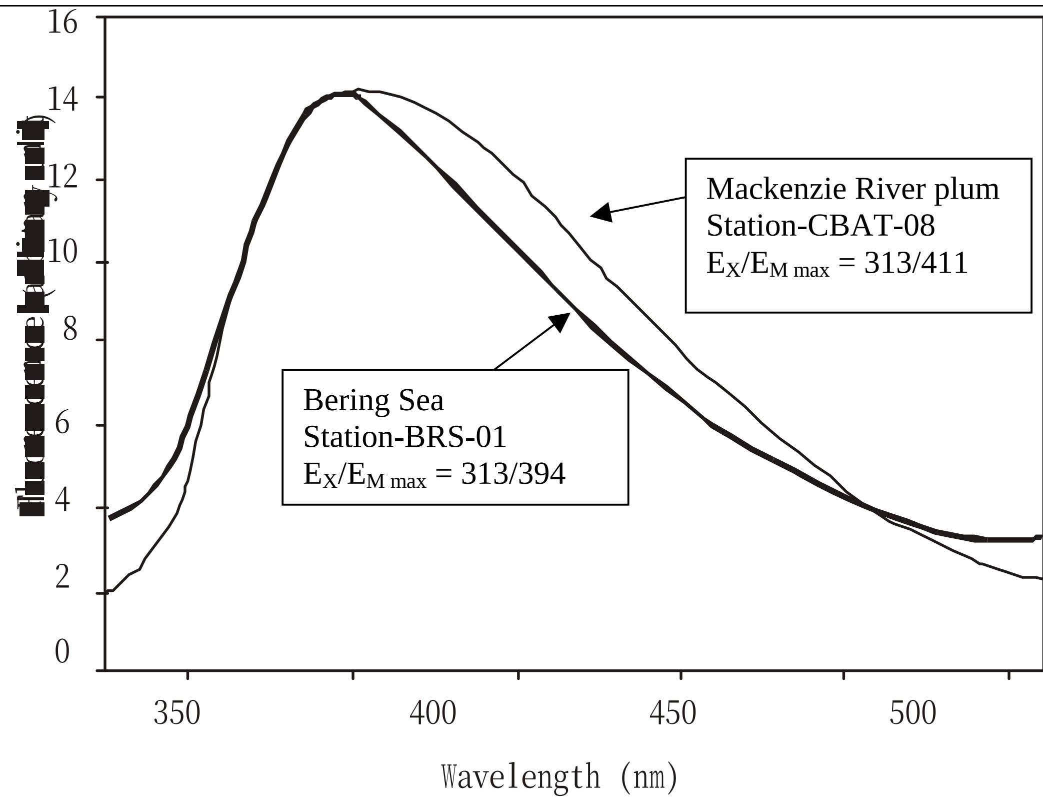
Methods

A schematic showing water sampling procedures is given below. Briefly, sea water (6-8 liters) was collected for filtration through a pre-combusted glass fiber filter (GF/F, Whatman) with a pore size of 0.7 micron to separate particulate organic carbon (POC) from dissolved organic carbon (DOC). Aliquots of filtrate were then sampled for the determination of CDOC characteristics and concentrations of DOC, and selectively for analysis of carbohydrate species.



A schematic diagram showing filtration, ultrafiltration, sampling and measurements of seawater samples collected during MR02-K05 cruise.

Dissolved organic carbon (DOC) concentrations will be measured on a Shimadzu TOC analyzer. Absorbance and fluorescence of seawater samples will be measured on a Aglient 8453 Spectrophotometer and a Yvon FluoraMax-3 Spectroflurometer, respectively. Typical normalized fluorescence spectra (λ_{ex}=313 nm) of a Mackenzie River plume sample and a Bering Sea water sample are shown in the Figure below. It is clear from these fluorescence spectra that there exists a shifting in values of Ex/Em maximum. For example, the Ex/Em maximum for the Mackenzie River plume sample is at 313/411 nm while for the Bering Sea sample is at 313/394 nm. Together with other hydrological and chemical parameters, these distinctive excitation-emission matrix between samples will be used to identify possible water mass types and the shelf-basin interactions in the Arctic Ocean.



Examples of normalized fluorescence spectra (λ_{ex}=313 nm) of seawater samples from the Mackenzie River plume and the Bering Sea. Note that a shifting of an Ex/Em maximum is evident between samples from the Mackenzie River plume and the Bering Sea.

We will examine the relationship between DOC and CDOM concentrations in the water column of the Arctic Ocean. Measurements of DOC will be used for DOC method comparison with JAMSTEC (Dr. A. Murata). Filter samples will be measured for the concentrations of POC and N and stable isotopic ($\delta^{13}C$ and $\delta^{15}N$) composition in the laboratory using a continuous flow isotope ratio mass spectrometry (IR/MS).

A number of large volume seawater samples were processed using a 1 kilo-Dalton ultra-filtration system to isolate colloidal organic matter (COM, >1 nm) from truly dissolved phase. In addition to fluorescent characteristics, isolated COM samples will be further characterized for elemental (C and N), stable isotopic and molecular compositions. Selected COM samples will be measured for radiocarbon using an accelerator mass spectrometry to determine their apparent ^{14}C ages and source functions of DOC in the Arctic Ocean.

Detailed sample information and time line for laboratory analysis are given in a Table below.

Sample list for water column samples collected by IARC-Frontier Group

Sample Type	Sample Description	Parameters to be measured	Sample number	Time line for analysis
Particulate	Filter samples	POC, PON, and their stable isotopes	150	Within 4 months
Dissolved	Liquid <0.7 µm	C-DOM, DOC	200	Within 5 months
Colloidal	Liquid 1nm-0.7µm	C-DOM, DOC	25	Within 5 months
Low molecular weight	Liquid <1 nm	C-DOM, DOC	25	Within 5 months
Colloidal	Powder	OC, N, $\delta^{13}C$, $\delta^{15}N$ and $\Delta^{14}C$	5	Within 1 year

Expected Results

Measurements of CDOM will be used to trace DOC concentrations in the Arctic regions through the relationship between CDOM and DOC concentrations and to examine the interactions of shelf water and Basin waters in the Arctic using data from both DOM and POM. Together with oxygen stable isotopic composition ($\delta^{18}O$), we will evaluate the potential of CDOM as a water mass mixing tracer in the Arctic Ocean, especially in the nearshore and the shelf/Basin regions. The transformation between dissolved, colloidal and particulate organic matter pools and their dynamic cycling in the Arctic Ocean will be further revealed.

We hope to measure a few DOC and colloidal samples for radiocarbon to determine the apparent ^{14}C ages of DOC and colloids in the Arctic to be compared to those from other major world oceans, such as Atlantic and Pacific. This will provide insight into the role of Arctic Ocean in carbon sequestration and carbon cycling as a whole.

4. Barium and Radium-226

Barium as a tracer of Artic water masses and biogeochemical cycle in the Bering Sea and the Arctic Ocean.

Personnel:
Hisashi Narita (Hokkaido University)
Jing Zhang (Toyama University)

Objectives

Barium concentration provides information complementary to oxygen isotope to determine the origin of brines ventilating cold halocline water. In order to find mechanisms of redistribution of riverine water, water originating from Pacific and brines will be analyzed in this study for barium and radium-226 concentration in key regions of the Arctic Ocean and the surrounding sea according to the data of nutrients, oxygen and its isotopes.

Sampling

1077 seawater samples for barium analysis and 70 seawater samples for radium-226 analysis were collected at 81 and 9 hydrographic observation stations using X-Niskin bottles mounted on the CTD/CWS system, respectively. In addition, 381 surface waters for barium analysis and 101 seawater samples for radium-226 analysis were also collected in the Sea Surface Water Monitoring during this cruise. The samples for barium analysis were collected into 100 ml acid cleaned polycarbonate bottles or 10 ml acid cleaned polyethylene vials after pre-rinsing with the sample. The external joints between caps and bodies were wrapped in Parafilm to minimize evaporation, and the unacidified samples were enclosed in plastic bags to store. The samples for radium-226 were collected into 5 l plastic container after pre-rinsing with the sample. All samples were stored at room temperature till analysis in Hokkaido University. For underway seawater, chlorophyll *a*, phytoplankton species composition and POC/PIC samples were also collected to research the removal processes of barium from surface water.

Analytical method

Barium concentrations will be determined by isotope dilution-inductively coupled plasma quadrupole mass spectrometry (ID-ICPMS) in a manner similar to that described by Klinkhanner and Chen (1990). Briefly, 1 ml of seawater sample was spiked with an equal volume of ^{135}Ba-enriched solution (Oak Ridge National laboratories) and diluted 100-flod in 0.16 N ultra pure HNO_3. Samples were introduced into 4500. Radium-226 concentrations will be determined by alpha liquid scintillation technique developed by McDowell and McDowell (1994).

Expected results and future works

The results will indicate possibilities for barium as a water mass tracer in the Arctic Ocean. The source of barium into the Arctic is important not only for Mackenzie River but also for Yukon River. As barium concentration is affected with both biological removal on the surface water and regeneration in the sediment-water interface, the source water of the Bering Sea is more important as a potential source of barium in the Arctic Ocean than the Mackenzie riverine water.

In future, Sr isotope ratio will be analyzed as a useful tracer of the riverine water. The biogeochemical processes in the Bering Sea and the Arctic Ocean will be also discussed according to chlorophyll *a*, phytoplankton species composition and POC/PIC data including nutrients and oxygen data.

5. Methane and HCH

Cruise Report: Mirai 2002

John Harris, Fiona McLaughlin, Institute of Ocean Sciences, Sidney, B.C. Canada

This is summary of the CFC, methane and HCH sampling and analysis program conducted onboard the RV Mirai in the Canada Basin, Sept 06 to Oct 10, 2002.

5.1. CFC Water Column Program

Due to JAMSTEC regulations regarding radionuclides on Japanese vessels, we were unable to bring our GC-ECD aboard the Mirai for CFC analysis. Unfortunately the JAMSTEC Shimadzu GC14 did not provide an appropriate signal and as a result the CFC program was cancelled. I would like to thank Shige and Akahi for their help in troubleshooting.

5.2. Methane Water Column Program

5.2.1. Sampling

Samples were collected from 12L Niskin bottles (36 bottle rosette) after dissolved oxygen samples were collected. An airtight 250 ml syringe was rinsed three times, taking care to remove all bubbles, then filled with approximately 250 ml of seawater. The syringes were kept cold and underwater in a container stored on deck until the samples could be analysed. Storage times ranged from 10 minutes to a maximum of 3 hours. Salinity data for each sample was collected by the JAMSTEC team.

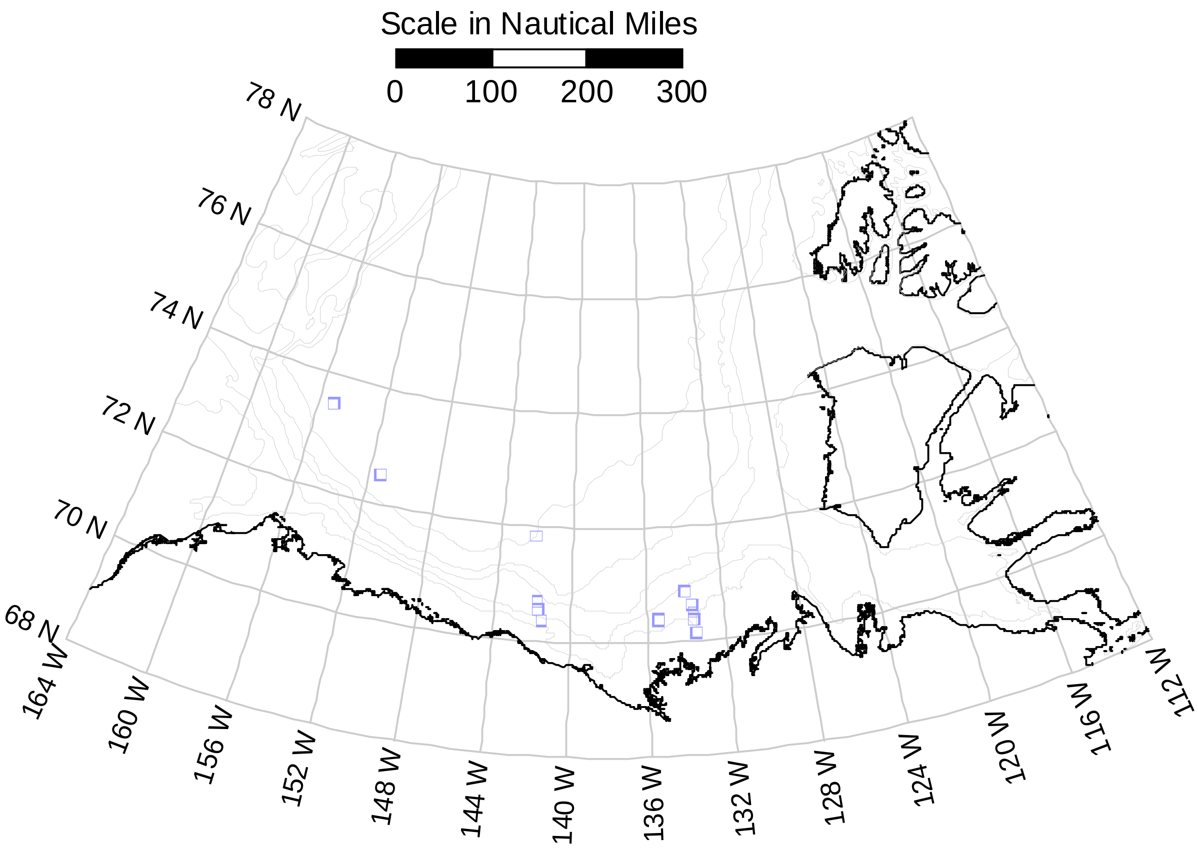
5.2.2. Analytical procedure and performance

Methane analysis was performed using a purge and trap extraction system built at IOS. Seawater samples were injected from the syringe into one of two selectable standard volumes (77.8 ml or 16.5ml) then transferred to a purge vessel using helium as the carrier gas (flowrate: 60 ml/min). Helium was bubbled through the water sample for 5 minutes, stripping the methane and other volatile components out of the water phase and into the gas stream. The helium gas stream then flowed through a cryogenic adsorbent (Poracil B in liquid nitrogen) which trapped the hydrocarbons. After 5 minutes of stripping the Poracil B trap was isolated and warmed to 40^{0}C. The sample was then backflushed by a second stream of helium (flowrate:18 ml/min) into a 60m GS GasPro column in a Hewlett Packard 6890 gas chromatograph. Low molecular weight hydrocarbons were separated on the column by temperature programming (40^{o}C for 4 minutes, ramp to 80^{o}C at 20^{o}C/min, hold for 4 minutes) detected by flame ionization detectector (FID) and quantitated by peak area. A low molecular weight hydrocarbon gas standard, purchased from Matheson, was injected into standard volume loops and extracted the exact same way as the samples. The standard was introduced into a number of different volumes to create calibration curves for methane, ethane, ethylene, propane and propylene. This system has a detection limit of 0.1 nM methane and an analytical range from 0.5 – 1100 nM methane.

5.2.3. Results

Methane samples were collected at stations shown in Figure 1. At Station CB02 in the Canada Basin samples were collected from the entire water column. Subsequently samples at basin stations were collected from the upper water column only. Samples at stations located on the Beaufort Shelf included a sample collected 10 m above the seafloor.

Figure 1 Methane station locations



Stations CB02, CB06 and SHEBA07 are typical of a deep oxic basin (Figure 2). At Station CB02 surface methane was slighty supersaturated with regard to atmospheric equilibrium (~4nM). Methane concentrations decreased from the surface to a subsurface maximum, due to ocean/atmosphere flux. This subsurface maximum (10-20 nM) was located between 50-200m (Figure 3). This maximum is present in many deep oceans and the subject of speculation. The maximum is usually close to the photic zone, but well below the 1% light level. Ward and Kilpatrick (1993) report that methane oxidising organisms likely utilise methane at that depth despite the low light levels. Tilbrook and Karl (1994) also suggest that the subsurface methane maximum found in the Pacific is associated with sinking particles. They report that methane is a dissolved constituent of the interstitial fluids of particulate biogenic materials and mixes into the water column as it sinks. Both explanations are possible in the Canada Basin. Methane concentrations near the bottom of the Canada Basin are very low (<0.5 nM). Scranton and Brewer (1978) concluded that methane consumption virtually stops within 100 years of water mass isolation and that residual methane persists either because pressure and temperature effects prevent its consumption or the methane concentration is below the threshold level for bacteria.

Figure 2: Methane Profile for Station CB02

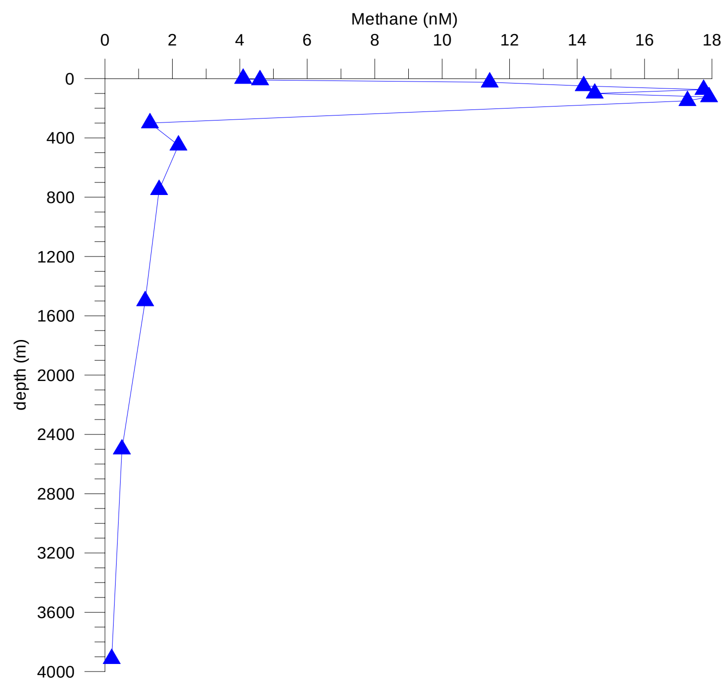
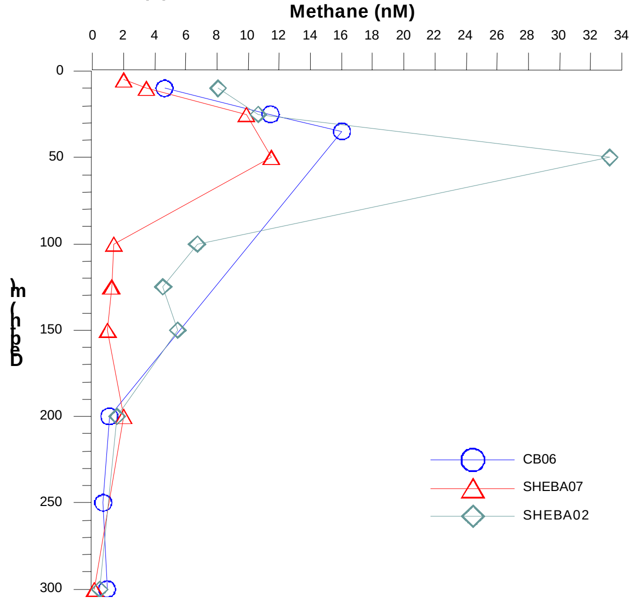
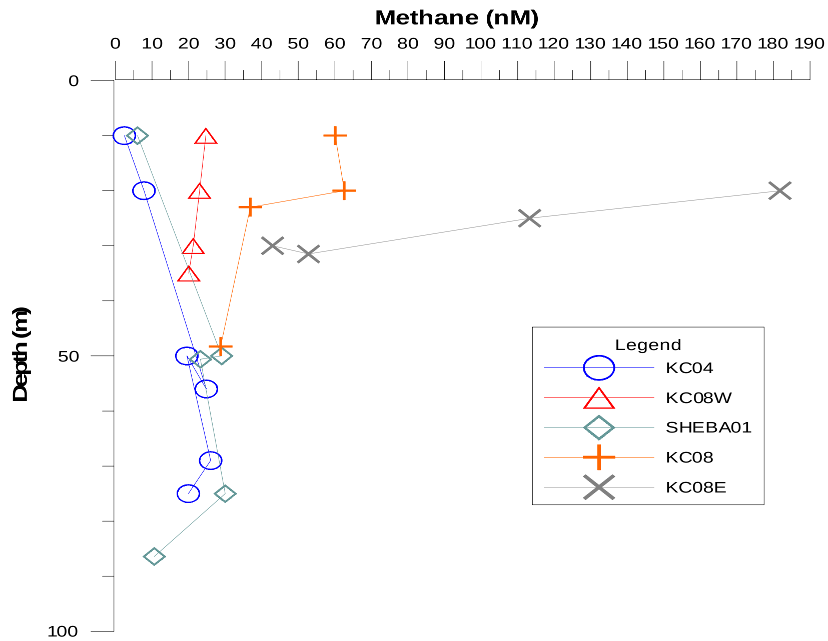


Figure 3: Methane profiles in the upper waters of stations CB02, SHEBA07 and SHEBA02



Methane profiles in Kugmallit Canyon (Figure 4) show a methane concentration increase at depth, perhaps due to anaerobic methane production. Methane concentrations are higher in the sediment at the shallower stations in Kugmallit Canyon, and also at stations near Mackenzie River outflow.

Figure 4: Methane profile in the Kugmallit Canyon



5.2.4. Storage study:

In addition to onboard measurements, water samples were preserved with various amounts of $HgCl_2$ to test whether samples can be stored for any length of time.

5.3. Methane in sediment cores

5.3.1. Sampling:

Samples for methane measurement were collected at two coring stations – one at the Kopanoar site and another at a reference site about 1km away. Samples were collected by a gravity multicorer outfitted with 7.4 cm ID by 60 cm plastic tubes. Each sample collected contained bottom water and sediment core. The water was first sampled for analysis and then pumped away. The core was manually pushed out of the tube onto a rack , measured and subsampled at 2-5 evenly spaced depths and placed into a 4L paint can equipped with two septa in the lid. The volume subsampled was about 172-430 cm^3. Degassed seawater was added to the brim of the can, then a measured volume was removed to produce a headspace of 0.5-1L. The headspace was purged with helium (30ml/min) for three times the headspace volume. The lid was then put on the can which was then shaken vigorously for 15 minutes. The headspace was subsampled for methane analysis by injecting 10 ml degassed seawater into the first septa while collecting 10ml of the headspace gas in the second syringe inserted into the second septa. Multiple headspace extractions were carried out on one sample as a modification of McAuliffe (1971) in order to determine a partition coefficient. All other samples were measured once, then corrected using this factor, making the analysis semi-quantitative.

5.3.2. Analytical procedure and performance

The methane in the sediment headspace was analysed using direct injection. The entire headspace sample in the 10ml syringe was injected into one of six standard volume loops (0.05 – 2 ml). Carrier gas (Helium - 18 mL/min) transported the sample through the short Poracil B column (at 40^{o}C) and into the gas chromatograph and GSGasPro column using the same system described above. Calibration curves for methane, ethane, ethylene, propane and propylene were obtained from injecting standard volumes of a commercial gas standard (BOC) in the same manner as the samples. The detection limit is 0.5 uL/L wet sediment and the analytical range is 1 – 1000 uL/L.

5.3.3. Results

Please refer to Appendix A for the compiled results of the core analysis. An attempt was made to measure multiple headspace extractions on the shallowest pingo sample. Results showed no decrease in methane concentration, however, indicating that the system was not at equilibrium. On opening the lid of the sample from the reference site, there were still large chunks of core despite the 15 minutes of vigorous shaking. Subsequently, samples were left at room temperature for 36 hours and shaken periodically to achieve equilibrium before analysis – results suggest that this was sufficient to reach equilibrium conditions. The reference core shows moderate methane values from 3.9 to 3.1 uL/L wet sediment. The water just above the sediment at 60m was 27 nM. These numbers are similar to past shelf work of Tom Lorenson and Keith Kvenvolden (1996). The methane concentrations at the PLF site are higher and increase with depth from 20.5 to 39.1 uL/L wet sediment indicating a methane source below the core depth. The water just above the sediment at a depth of 36.8m was 23 nM.

5.3.4. Isotope sampling

Two samples of the PLF core and two from the reference core were subsampled into cans for isotope analysis. These were prepared by subsampling 10cm of core (diameter 7.4cm) into the can, adding degassed seawater to the brim, then pouring some of the water out to create a 1L headspace and adding 2g $HgCl_2$ then purging with helium to three times the volume of the headspace. The samples were shaken vigorously then frozen. During ship transfer, the samples were thawed for 26 days then put in a fridge here at IOS. They will be analysed within the next few months. Sansone, Popp and Rust (1997) have determined that a similar storage method for seawater is good for 4 months for isotopes and 2 years for methane.

5.4. HCH in the Water Column

5.4.1. Sampling

Samples were collected at four stations: CS01, NCS03, CB10 and SHEBA08 at predetermined depths. Water was taken from two Niskin bottles sampled at the same depth and a rinsed pressure can was filled to about 18L. The samples were kept cold on deck until processed, not longer than 2 hours. The water was first spiked with 500uL of surrogate standard, then mixed and passed, using positive UHP nitrogen pressure (10psi), through a particulate filter, then an adsorbent column rinsed with methanol and water. The volume of water processed was measured accurately. The filter was placed inside the adsorbent column and stored in a whirlpack bag in the freezer. The samples were kept frozen until Oct 10/02 where they were stored at ambient temperature during ship transport to IOS. At IOS they were refrozen on Nov 4/02. Salinity data will be provided by JAMSTEC.

5.5. Methane References

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6. Ocean Biology

6.1. Sampling for DNA and microscopical analysis

Mirai Cruise Report 7-20 Sept 2002

C. Lovejoy (Current adderess : Institut de Ciències del Mar CMIMA)

Objectives :

Recently several new groups of micro-organisms have been found in the marine environment. These organisms are eukaryotic (cells containing organelles) but very small (1-3µm, picoeukaryotes) and were discovered using molecular techniques. My objective was to collect samples for DNA and microscopical analysis to determine if these organisms are also present in the Arctic where they have not been previously described. The extracted DNA will be analysed by both an environmental fingerprinting technique, denaturing gradient gel electrophoresis (DGGE) and construction of clone libraries. The ecological role of these organisms is little understood and they may be bacterial predators or able to use organic matter directly. For temperate waters, in a given environment, the picoeukarotes are more diverse than bacteria and complementary samples for determining bacterial diversity (using DNA) were also collected on board the Mirai. Changes in relative abundance of different groups of micro-organisms (bacteria, and picoeukaryotes) will be determined microscopically using fluorescent in situ hybridization (FISH). Finally, samples for determining the standing stocks of the total phytoplankton , picoeukaryotes and bacterial populations were collected (buffered fomalin, filtering and mounting onto microscope slides, and preserving and freezing for flow cytometry (FCM) respectively). Stations where all parameters were collected (Profiles) were sampled at 10, 50, 75, 100, 125, 150, 200, 400 and 750 m. Additional samples for environmental DNA were collected at 10 and 50 m.

Table summarizing data collected;

Date	Station	Type	DNA (Euks & Bacteria	FISH	Phyto-plankton	Biomass slides	Biomass FCM
9 Sept	CS08-1	Profile	X	X	X	X	X
10 sept	NWR08	DNA-only	X		X		X
11 Sept	NCS02 47-1	Profile	X	X	X	X	X
14 Sept	CB06	Profile	X	X	X	X	X
17 Sept	Sheba 05	DNA-only	X		X		X

6.2. Zooplankton and fish larvae observation

Personnel

Richard Crawford (Freshwater Institute)
Sanae Chiba (Frontier Research System for Global Change)

Objective

The western Arctic Ocean holds a complex hydrographic structure, in which both Pacific-oriented and Atlantic-oriented waters enter and mix to affect biological distribution. The western Arctic is also surrounded by broad continental shelves, and the ecosystem is subject to the influence of various physical events/conditions derived by shelf-basin interaction, such as coastal upwelling. In addition, the shelf domain is of seasonal ice cover that is indispensable for biological productivity and will be affected by climate variability. The goal of this study is to detect the ecological variability of the Western Arctic in relation to the physical/chemical environments, and to understand processes and possible consequences of the observed variability. Particular focus was on zooplankton community structure and larval fish distribution.

Approach

Zooplankton is the direct link between primary producers and the higher trophic level organisms including Arctic cod and bowhead whales in the Arctic Ocean food web. In addition, zooplankton play an important role in the biological carbon pump by efficiently transporting particulated organic matters to the deep. Thus, with both aspects of fisheries/conservation and the biogeochemical cycle, we conducted our investigation with three approaches: <u>1. multivariate analyses of zooplankton community structure, 2. grazing rate measurement of major copepod species, and 3. analysis of vertical distribution of larval fish.</u>

Sampling

Zooplankton were collected using a bongo net system with 330 and 505 μm meshes and protected cod ends at 34 stations (Table 1). The bongo net was towed obliquely at a ship speed of 2 to 3 kt between the surface and either 100 m or 10 to 15 m above the sea floor at the shallow stations. A flow meter was installed on the net to estimate volume of the water filtered, and at several occasions an environmental data logger (Yellow Springs Instruments, Inc. Model 6600) was mounted to record hydrographic condition (conductivity, salinity, temperature, turbidity, DO and Chl *a*). Samples taken with 330 μm mesh were for biomass and community structure analyses, and fixed by 5% neutral formalin solution soon after sampling. Samples taken with 505 μm mesh were used for an experiment to estimate the grazing rate of major copepod species. See the next section for the detailed handling and analytical procedures for the experiment.

<u>1. Multivariate analyses of zooplankton community structure</u> (by Chiba and Crawford)

Methods

Zooplankton samples taken by 330 μm mesh are to be sorted and counted by species level by microscopic analysis, so that we can estimate abundance and species composition at each sampling station. Based on the similarity in the species composition between stations, cluster analysis and non-metric multi-dimensional scaling (NMDS) method will be applied to classify zooplankton communities into several groups and to determine their distribution pattern. When data sets and interpretation of other biological components (bacteria, nanoplankton, phytoplankton, fish, marine mammals) and physical/chemical components (including ADCP data) become available, local variability of food web structure and environmental factors that determined the structure will be clarified by multivariate technique.

Preliminary Results: local characteristics of zooplankton community (Fig. 1)

As the study results will come out after the sorting procedure is completed, we here mention a brief impression from our observations. Two offshore, herbivorous copepods, *Calanus glacialis* and *C. hyperboreus* were commonly observed and dominant zooplankton at most of the stations. However, their abundance and maturity stage composition differed among locations. Advanced maturity stage individuals dominated in the offshore area around the Northwind Ridge, while younger individuals dominated along the shelf slope particularly between east of Mackenzie Canyon and west of the Cape Bathurst. This might be caused by differences in the local sea ice conditions that was likely to affect the reproductive timing and growth efficiency of herbivorous copepods. Pteropods seemed to be indicator along the shelf both east and west of Mackenzie Canyon, and euphausiid abundance markedly increased in the Mackenzie Canyon. At the western end of the Beaufort Sea Shelf (St. CS03, west of Barrow, Alaska), abundance of *Calanus* was low and chaetognaths were predominant, in marked contrast to samples collected to the east, for example near Cape Bathurst (St. CBAT04) (Fig 2).

2. Grazing rate measurement of major copepod species (by Chiba).

Methods

Gut fluorescence technique (e.g. Mackas & Bohrer 1976) was applied to estimate daily individual grazing rate of major copepod species. This technique requires information of in situ individual gut pigment concentration and gut evaluation rate.

[In situ gut pigment concentration]

Gut pigment was measured at 30 stations (Table 1). Part of the Zooplankton collected by 550 μm mesh were drained on the 330 μm mesh, rinsed with filtered sea water, frozen in liquid nitrogen, and stored in the -80°C deep freezer. Copepodite 4^{th} and 5^{th} stages (CIV and CV) of *Calanus glacialis*, and copepodite 5^{th} (CV) and mature female (CFVI) of *C. hyperboreus* were examined as the target species. After thawing a sample with filtered sea water, 5 ~ 15 individuals of a target species were placed in a tube using a dissection microscope under the dim light as quickly as possible, and the gut pigment was extracted by dimethyleformamid solution for at least 24 hours. Then the pigment concentration was measured by fluorometric technique (Yentsch & Menzel 1963) using a fluorometer (Turner Designs 10-AU-005).

[Gut evacuation rate]

An experiment to measure gut evacuation rate of the target species was conducted 4 times, twice during night (Sts. CS05 & SHEBA01) and twice during day (Sts. NWR08 & KC04). Zooplankton collected by 505 μm mesh were rinsed with filtered sea water, and placed in a 20 L plastic container filled with filtered sea water of ambient water temperature. A subsample of a target species in the container were collected by 330 μm mesh every 5 to 10 minutes during 1 hour, and were immediately frozen by liquid nitrogen. Gut pigment of the target species for the every collection was measured by the same procedure shown previously. Gut evacuation coefficient 'k (min^{-1})' was estimated from the exponential decrease of gut pigment during the experiment. Because the rate is known to decline for copepods being cultured for a long time, only the gut pigment data collected before the rate started to decline was used to estimate the coefficient. The daily individual grazing rate '*G* (ng Chl *a* ind^{-1} day^{-1}) for each target species was estimated from in situ gut pigment concentration '*P*' (ng Chl *a* ind^{-1})' and '*k*' using the following equation:

$$G_{day} = P \times k*60*24.$$

Preliminary Results

In situ individual gut pigment was highest in CVI female of *C. hyperboreus* and lowest in CIV of *C. glacialis* as expected from the body size (Fig. 3). The pigment tended to be low on the west side and high on the east side of the Mackenzie canyon for all copepodite stages of both species. Gut clearance coefficient '*k* (min^{-1})' was estimated as 0.0925 and 0.0534 for CIV and CV *C. glacialis*, respectively, and 0.0180 and 0.0315 for CV and CVI female *C. hyperboreus*, respectively (Table 2). These were the maximum values among the 4 trials (2 daytime & 2 nighttime). Daily individual grazing rate (μg Chl *a* ind^{-1} d^{-1}) was markedly higher in CVI female *C. hyperboreus*, yet were of similar levels among other 3 cases because of larger '*k*' values of small-sized *C. glacialis* (Fig. 4). When data on abundance and maturity stage composition of each species become available, population grazing pressure on the local primary production will be estimated, indispensable information for determining function and efficiency of biological carbon pump.

<u>3. Vertical distribution of larval fish in relation to oceanographic conditions (by Crawford).</u>

Methods

Prior to each plankton tow with the bongo net, the echosounder (Lowrance X-15B, 192 kHz, single 9 ^{o} beam) was used to examine for the presence of fish in the water column and their vertical distribution. Data was recorded to a paper echogram which will be digitized in the lab for analysis of fish depth distribution and relative abundance in relation to oceanographic conditions (e.g., salinity, temperature, chlorophyll concentration). Oceanographic conditions were determined primarily by the ship's CTD system, which was used immediately before a plankton tow. At several shallow stations (> 60 m), data were also collected with the YSI 6600 during the tow. Where fish abundance was high and fish targets were observed to be within a relatively narrow depth range or layer, the plan was to conduct a second plankton tow. It would be a horizontal tow within the depth range occupied by the fish to identify them**.**

Along areas of the ship's cruise track where the echosounder detected fish, relative fish abundance will be compared with echo intensity recorded by the ship's ADCP system, and with CTD data, to search for correlation that may provide broader scale information about the horizontal distribution of fish.

Larvae of Arctic cod, *Boreogadus saida*, were removed from our collections (both 330 μm and 505 μm mesh) and preserved in non-aqueous ethyl alcohol for Dr. John Nelson, University of Victoria, British Columbia, who is studying genetic diversity in Arctic cod populations.

Preliminary Results

We caught fish larvae (almost exclusively Arctic cod) at 18 stations. Fish were detected in the echograms at most of these stations and at several more where we did not catch any. Fish were limited to the continental shelf area and were collected (and detected by sonar) from Barrow to Cape Bathurst. Fish depth distribution was limited to the slightly warmer waters in the upper portion of the water column. Fish abundance was highest several meters above the chlorophyll maximum. At one station (HC01; 73.20.00 N, 165.00.00 W), an abundance of fish were detected in a layer at roughly 14 – 18 m deep. A horizontal tow at 16 m for 3 minutes collected 17 Arctic cod larvae. Given the known predominance of this species in these waters and the low diversity of Arctic fish species in general, it was assumed that fish echoes detected by the echo sounder at other stations during this cruise were Arctic cod.

References

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Table 1 Information on Bongo net sampling and grazing rate measurement

	Date	Station	Latitude (N)	Longitude (W)	Towtype	Depth (m)	Wire out (m)	Angle (degree)	Sampling depth (m)	YSI (CTD logger) depths 1st descent (m)	YSI (CTD logger) depths 2nd descent (m)	Towing time (LST) net-in	Towing time (LST) at depth	Towing time (LST) net-out	FM-read	Grazing rate gut pigment measurement	Grazing rate gut evaluation experiment
1	9.05	CHU04	70.50.00	164.00.00	oblique	43	28	0	28			1558	1559	1601	na		
2	9.08	CS001	70.50.00	160.00.00	oblique	50	35	0	35			1610	1611	1613	1795	○	
3	9.08	CS03	72.42.00	159.42.00	oblique	92	78	0	78			1922	1925	1928	1530	○	
4	9.08	CS05	72.54.00	158.48.00	oblique	420	105	0	100			2356	2359	0003	2290	○	○
5	9.09	CS07	73.10.00	158.00.00	oblique	2420	110	10–20	100			0609	0612	0616	2440	○	
6	9.09	CS09	73.30.00	157.00.00	oblique	>3000	105	<10	100			1558	1602	1608	2395	○	
7	9.10	NWR08	74.25.00	158.00.00	oblique	>3000	105	<10	100			0750	0753	0758	2365	○	○
8	9.10	NWR10	74.35.00	157.50.00	oblique	>2000	110	10–20	100			1207	1212	1216	2395	○	
9	9.11	NSC02	74.15.00	162.33.58	oblique	>1000	105	<10	100			1213	1217	1222	2125	○	
10	9.11	NSC04	74.00.00	163.13.51	oblique	300	105	10–20	100			1720	1725	1728	2710	○	
11	9.11	NSC06	73.40.00	164.06.75	oblique	160	105	10–20	100			2108	2111	2115	2560	○	
12	9.12	HC01_1	73.20.00	165.00.00	oblique	72	59	10–20	57			0003	0013	0018	1500		
13	9.11	HC01_2	73.20.00	165.00.00	target	72	12	10	12			0026	0003	0031	2090		
14	9.17	SHEBA02	70.33.72	141.42.72	oblique	493	105	10–20	100			1847	1850	1854	2360	○	
15	9.17	SHEBA01	70.25.20	141.37.80	oblique	89	75	<10	75			2021	2023	2026	2485	○	○
16	9.17	SHEBA00	70.11.94	141.30.48	oblique	58	43	<10	43			2146	2147	2149	1485	○	
17	9.19	KC04	70.52.50	133.58.00	oblique	80	65	<10	65			0906	0908	0910	1990	○	○
18	9.19	KC08W	70.17.00	134.02.00	oblique	45	30	<10	30			1605	1607	1609	1490		
19	9.19	KC08	70.22.00	133.36.00	oblique	60	45	<10	45			1733	1734	1736	1440	○	
20	9.19	KC08E	70.25.00	133.10.00	oblique	41	26	<10	26	23.87	——	1943	1944	1946	1420	○	
21	9.20	MSH01	70.35.00	132.00.00	yo-yo	43	30	<10	30	28.21	28.75	2021	*2022,2024	2025	1920	○	
22	9.20	MSH02	70.50.00	131.00.00	yo-yo	47	32	<10	32	29.25	29.54	2236	*2238,2240	2241	2440	○	
23	9.21	CBAT01	70.45.00	128.00.00	oblique	50	35	<10	35	33.86	——	0827	0829	0830	1315	○	
24	9.21	CBAT04_1	70.45.00	127.20.00	oblique	196	185	10–20	180			1139	1143	1150	5650		
25	9.21	CBAT04_2	70.45.00	127.20.00	target	196	8	10	8			1139	0003	1143	2480	○	
26	9.21	CBAT11	70.33.00	127.35.00	oblique	73	58	10–20	58	54.30	——	1341	1343	1345	1850	○	
27	9.21	CBAT09_1	70.34.67	127.30.00	oblique	200	185	10–20	180			1510	1513	1520	5420		
28	9.21	CBAT09_2	70.34.67	127.30.00	oblique	200	110	10–20	100			1527	1530	1534	2235	○	
29	9.21	CBAT12	70.45.00	128.30.00	yo-yo	34	20	<10	20	20.26	19.66	1835	*1837,1839	1840	1865	○	
30	9.21	CBAT14	70.57.50	128.15.00	oblique	50	35	>20	35	34.28	——	2222	2223	2225	1720	○	
31	9.22	CBAT15	71.05.00	129.00.00	yo-yo	40	25	10–20	25	25.11	26.12	0002	*0003,0005	0006	2040	○	
32	9.22	PINGO	70.24.00	135.25.00	oblique	75	50	10–20	50	49.52	——	1317	1319	1321	2250	○	
33	9.26	MCZ02	69.53.75	139.30.00	oblique	35	20	>20	20	22.10	23.25	1000	*1000,1003	1004	2340	○	
34	9.26	MCJZ	70.00.00	138.40.00	yo-yo	277	105	>20	100			1502	1506	1510	4050	○	
35	9.27	MCM01	69.24.00	138.00.00	oblique	50	35	10–20	35	37.10	——	0825	0827	0828	1450	○	
36	9.27	MCZ09	70.12.00	137.00.00	oblique	51	36	<10	36	35.26	——	1825	1830	1833	1360	○	
37	10.02	NWA04_1	74.53.84	159.30.00	oblique	>1000	105	<10	100			1442	1445	1448	3035		
38	10.02	NWA04_2	74.53.84	159.30.00	oblique	>1000	210	<10	200			1458	1503	1510	5345		

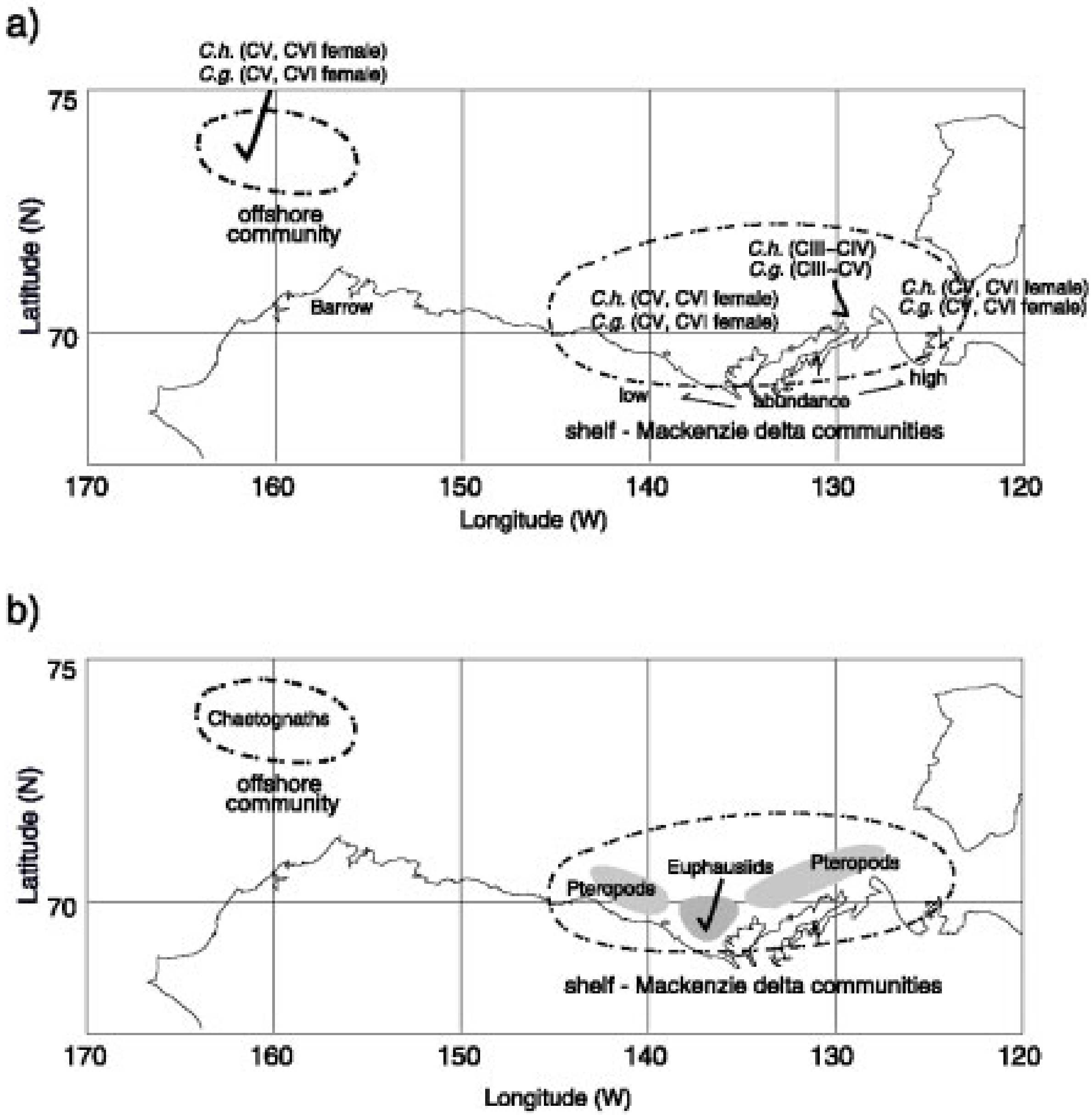

Fig.1 Preliminary remark of zooplankton community distribution. a) Regional difference of dominant maturity stages of two major copepods, *Calanus hyperboreus* (C.h.) and *C. glacialis* (C.g.). CIII, CIV, CV and CVI indicate copepodite 3rd, 4th, 5th and 6th (adult) stage, respectively. b) Indicator plankton other than copepods that were peculiar to the regions.

Fig. 2 Comparison of samples taken at St. CS03 (left) and St. CBAT04 (right).

Table 2 Gut clearance coefficient (k) of major copodpods. t: duration of experiment, n: number of data point.

Species & copepodite stage	k (min^{-1})	R^2	t (min)	n
C. glacialis (CIV)	0.0925	0.80	16	4
C. glacialis (CV)	0.0534	0.99	25	5
C. hyperboreus (CV)	0.0180	0.64	52	6
C. hyperboreus (CVI Female)	0.0315	0.96	25	4

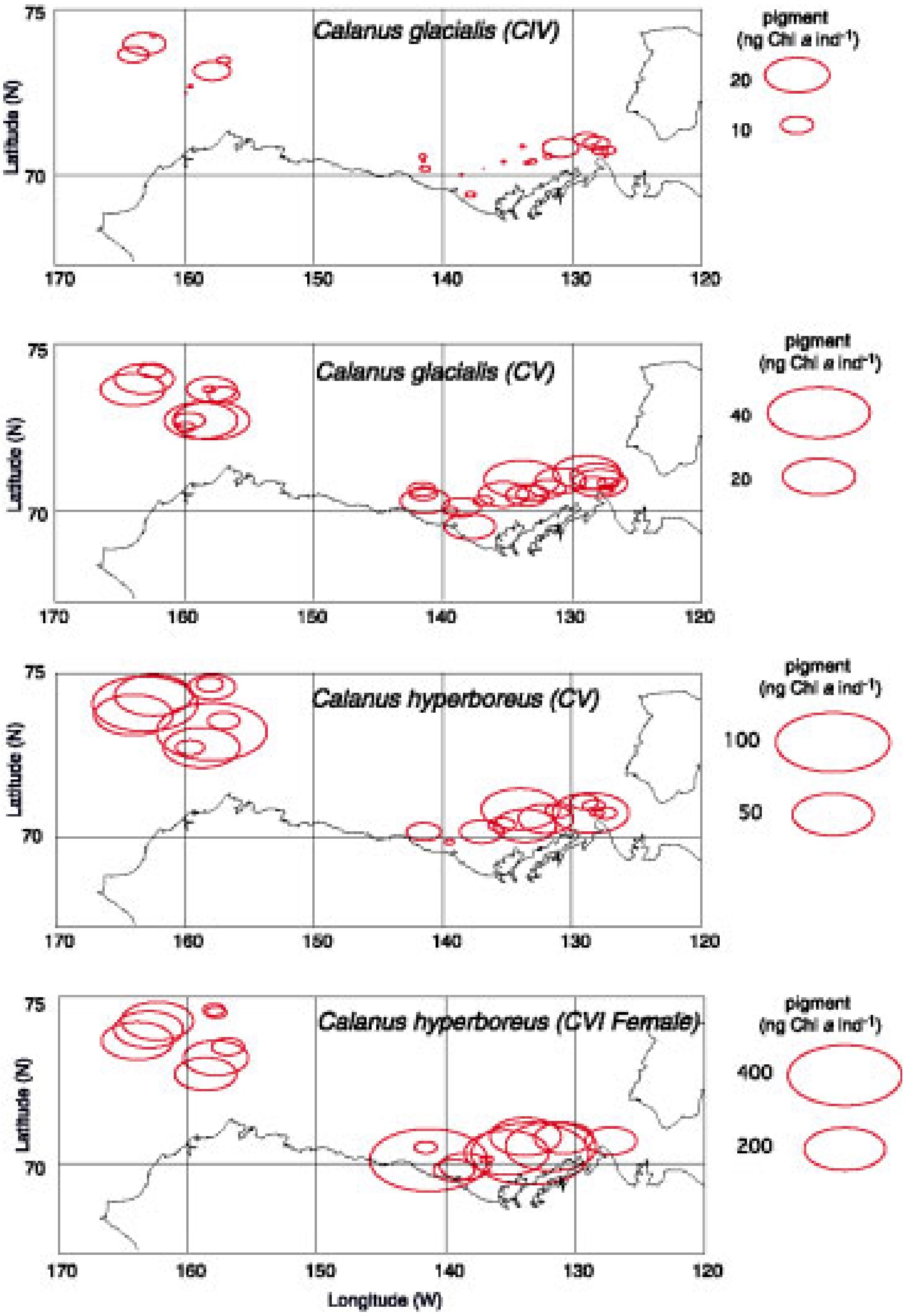

Fig. 3 Local variation of individual gut pigment concentration (ng Chl *a* ind^{-1}) of major copepod species, *Calanus glacialis* and *C. hyperboreus*. CIV, CV and CVI indicate 4th, 5th and 6th (adultf) copepodite stage, respectively. Note that scale differs among the figures.

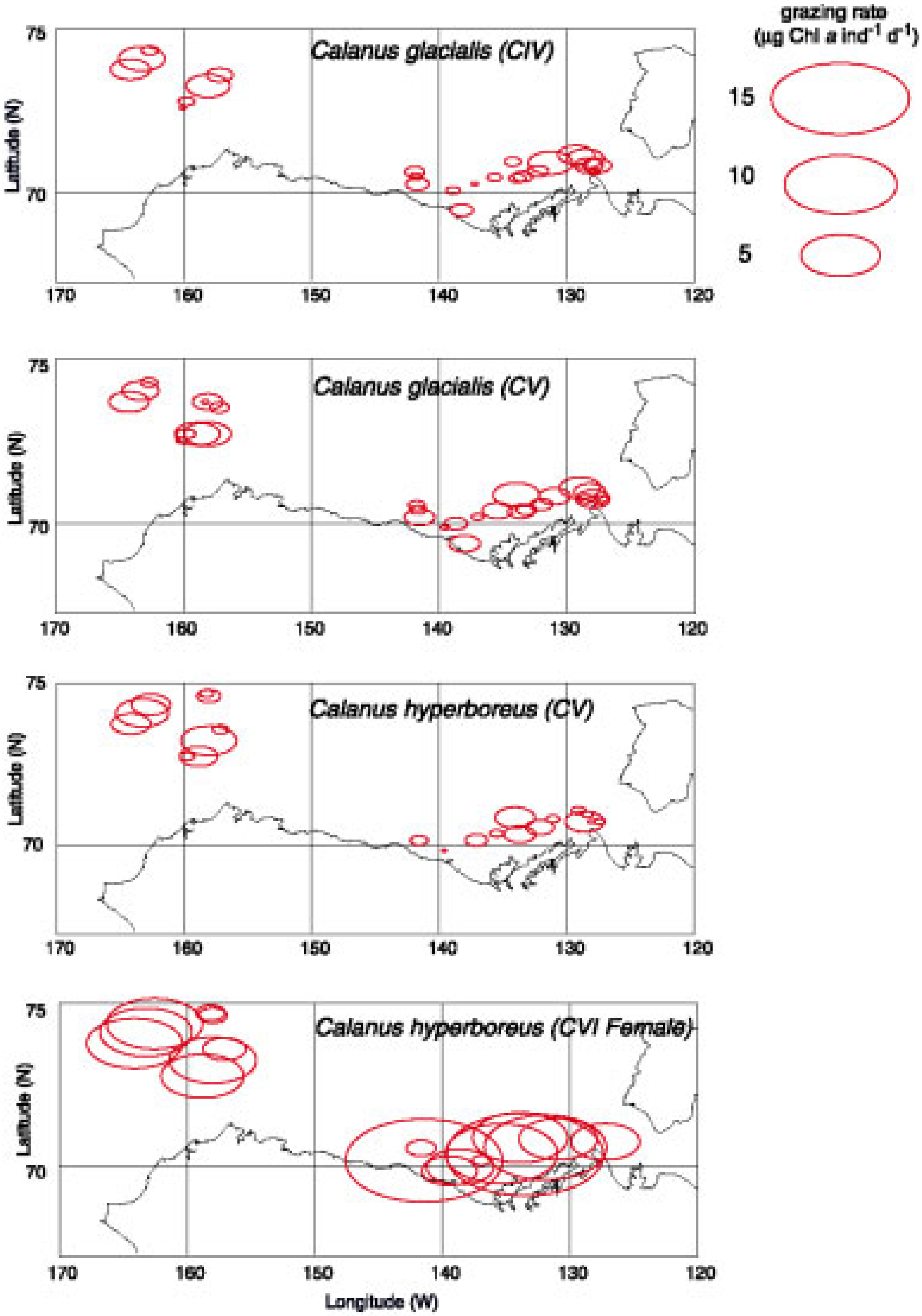

Fig.4 Local variation of daily individual grazing rate (µg Chl *a* ind^{-1} d^{-1}) of major copepod species, *Calanus glacialis* and *C. hyperboreus*. CIV, CV and CVI indicate 4th, 5th and 6th (adultf) copepodite stage, respectively.

7. Marine mammal

(1) Personnel

Lois Harwood (DFO)
Ronald Allen (DFO)

(2) Objective

Observation of marine mammal.

(3) Preliminary results

See Tables.

Marine Mammal Sightings, Sept 7-19, 2002 R/V Mirai
Note: survey effort and bird sightings to be added later

Date	Species	number	Lat	Long	comments	watch number or or bridge (B)	location
Sep-08	walrus	1	72 23	159 04	starboard	B	Chukchi
Sep-08	walrus	1	72 24.0	159 11.2	starboard, surfaced 3 x	4	Chukchi
Sep-08	walrus	2	72 33	159 50.8		B	Chukchi
Sep-09	walrus	1	73 20.8	157 28.0	ad male, agress, + 1hr circled ship then headed off N	6	Chukchi
Sep-09	walrus	1	73 30.1	157 04.6	juv, touched ship,circled ship	aft deck	Chukchi
Sep-11	polar bear	1	73 51.2	163 32.5	on floe	B	Chukchi
Sep-11	polar bear	1	73 50	163 36.6	on floe	B	Chukchi
Sep-12	walrus	2	73 45.4	159 2.8	port, touching each other	14	Chukchi
Sep-16	ringed seal	1	71 58.8	142 9.1	dove	21	Sheba Line
Sep-16	polar bear	1	71 51	142 5.11	on floe; reared; dove; followed	21&22	Sheba Line
Sep-18	bowhead	2 or 3	70 6.1	138 23.9	>4km away	B	transit in Mackenzie Canyon
Sep-18	ringed seal	1	70 9.8	136 45	loc approx, port	28	transit to KC
Sep-18	ringed seal	2	70 9.8	136 45	port	28	transit to KC
Sep-18	ringed seal	1	70 12.3	136 31.3	location approx.; ahead	28	transit to KC
Sep-19	ringed seal	1	70 52.2	133 57.0	starboard	29	Kugmallit Canyon
Sep-19	ringed seal	1	70 40.6	133 43.2		29	Kugmallit Canyon
Sep-19	bowhead	1	70 24.7	133 37.6	starboard, cue blow, S	30	Kugmallit Canyon
Sep-19	ringed seal	1	70 18.9	133 45.4	starboard head	30	Kugmallit Canyon
Sep-19	bowhead	2	70 16.8	133 47.4	port, cue blow, N	30	Kugmallit Canyon
Sep-19	bowhead	1	70 15.2	133 48.8	port, cue blow, N	30	Kugmallit Canyon
Sep-19	ringed seal	1	70 24.0	133 18.8	port	31	Kugmallit Canyon

updated L. Harwood Sept 20

<u>Birds identified</u>
Eider ducks, males and females
Guillemot
Glaucous Gulls
Black Legged Kittiwakes
Jaegers

October 9, 2002 - data is preliminary, times & locations of observations to be added.
Weather and sea conditions were poor throughout and not conducive to making observations of marine mammals.

Marine Mammal Sightings, Sept 21-29, 2002 R/V Mirai

2002 Date	Species	number	Lat	Long	comments	Observer Location / Watch Number	location
Sept 21	-				no marine mammal sightings	Compass Bridge/32	
Sept 21	ringed seal	1	70 34 247	127 31 811	forward/port side, dove. Ship underway	Compass Bridge/33	
Sept 21	bowhead	2	70 56	128 01	Reported by officers on the bridge	Bridge	
Sept 22	-				no marine mammal sightings	Compass Bridge/34	
Sept 22	-				no marine mammal sightings	Compass Bridge/35	
Sept 23	-				no marine mammal sightings	Compass Bridge/36	
Sept 23	-				no marine mammal sightings	Compass Bridge/37	
Sept 24	-				no marine mammal sightings	Compass Bridge/38	
Sept 24	-				no marine mammal sightings	Compass Bridge/39	
Sept 25	-				no marine mammal sightings	Compass Bridge/40	
Sept 25	-				no marine mammal sightings	Compass Bridge/41	
Sept 26	-				no marine mammal sightings	Compass Bridge/42	
Sept 26	-				no marine mammal sightings	Compass Bridge/43	
Sept 27	-				no marine mammal sightings	Compass Bridge/44	
Sept 27	-				no marine mammal sightings	Compass Bridge/45	
Sept 28	-				no marine mammal sightings	Compass Bridge/46	
	-						
Sept 29	bowhead	1	70 01 440	138 268 96	port side; 1 blow. Not seen again	Compass Bridge/47	
Sept 29	bowhead	1	70 01 205	138 48 495	starboard side; 1 blow. Not seen again	Compass Bridge/47	
Oct 4	walrus	1	76 13	168 20	off stern of ship. Report by R. Crawford. Walrus attempting to get on new ice	Stern Working Deck	

October 9, 2002 - data is preliminary.

Bird Observations made by R. ALLEN from R/V MIRAI Sept 21 to Sept 29, 2002

Time	Long	Lat	Sky	Sea	Ice	Vis	Wind	Species	#	Comments	Ship
Sept 21/02		**R. ALLEN**	**Watch # 32**			**Compass Deck**				**Survey period 0930 through 1100hrs Ship Time**	
0930	70 45 102	127 47 279	OC	1	0	G	L	-		Ship moving very slowly. Minus 1 C.	slow
0945			OC	1	0	G	L	-		snow flurries	
1000	70 45 108	127 44 483	OC	1	0	F	L	-			Underway
1030	70 45 206	127 40 186	OC	1	0	G	L	-			Underway
1055	70 44 972	127 28 626	OC	2	0	G	L	-			Underway
1100			OC	2	0	G	L	-		Minus 1 C	Underway
Sept 21/02		**R. ALLEN**	**Watch # 33**			**Compass Deck**				**Survey period 1330 through 1600hrs Ship Time**	
1330	70 33 119	127 35 131	OC	3	0	G	M	-		Minus 1 C	Stopped
1352	70 33 614	127 33 706	OC	3	0	G	M	G Gull	1	came across ahead of bow from st to port & went aft.	Stopped
1411	70 33 614	127 33 706	OC	2	0	G	L	G Gull	1	came toward bow, veered to st.	Stopped
1418	70 33 821	127 33 689	OC	2	0	G	L	G Gull	1	approached from ahead on st side, veered across bow and flew off to port.	Stopped
1430	70 34 247	127 31 811	OC	2	0	G	L	-		1 Ringed seal, forward/port side- dove	Underway
1432	70 34 466	127 30 759	OC	2	0	G	L	G Gull	1	flew across in front of ship from st to port.	Underway
1434			OC	2	0	G	L	G Gull	2	both immature. Came from aft along st side & flew off forward.	Underway
1441	70 34 693	127 29 818	OC	2	0	G	L	-			Stopped
1444	70 34 693	127 29 818	OC	2	0	G	L	G Gull	1	came toward bow, veered to port, went down port side & flew off to port.	Stopped
1453	70 34 693	127 29 818	OC	2	0	G	L	G Gull	1	immature. Came from st side & flew off to stern.	Stopped
1503	70 34 693	127 29 818	OC	2	0	G	L	G Gull	1	came from ahead on st side, down along ship & back up port side, flew off to port.	Started moving
1517	70 34	127 29	OC	3	0	F	M	-			slow
1523	70 35 111	127 27 583	OC	3	0	G	M	G Gull	5	came from ahead, flew down st side & flew off to stern.	slow
1547	70 35 660	127 24 792	OC	2	0	F	L	-		Snowing	
1600	70 36 230	127 23 044	OC	2	0	F	L	-		Snowing, Minus 1 C	stopping
Sept 22/02		**R. ALLEN**	**Watch # 34**			**Compass Deck**				**Survey period 0900 through 1100hrs Ship Time**	
0855	70 36 227		OC	4	0	G	S	-		Zero C. Occasional pieces of ice in the distance	Underway
0925	70 27 742	134 00 266	OC	4	0	G	S	G Gull **	3	Stayed with the ship about 4 minutes. Flew forward. *	Underway
0936	70 26 454	134 00 997	OC	4	0	G	S	Eiders	3	Crossed in front, from port to st. *	Underway
0943	70 26 261	134 05 810	OC	4	0	G	S	G Gull **	1	came up port side & flew off forward. *	Underway
0949	70 26 164	134 07 980	OC	4	0	G	S	G Gull **	1	came up port side & flew off forward. *	Underway
0954	70 25 056	134 10 503	OC	4	0	G	S	G Gull **	1	came from stern on st side, crossed over bow & flew off forward. *	Underway
0958	70 25 937	134 13 164	OC	4	0	G	S	G Gull **	2	came from stern along port side & flew off forward. *	Underway
1016	70 25 488	134 22 599	OC	4	0	G	S	-		*	Underway
1030	70 25 124	134 30 956	OC	4	0	G	S	-		*	Underway
1033	70 25 67	134 32 612	OC	4	0	G	S	G Gull **	1	came from stern along port side & flew off forward. *	Underway
1043	70 24 974	134 37 663	OC	4	0	G	S	G Gull **	1	came from stern along st side & flew off forward. *	Underway
1045			OC	4	0	G	S	G Gull **	3	came from stern along port side & flew off forward. *	Underway
1100	70 24 775	134 45 712	OC	4	0	G	S	-		Minus 1 C. *	Underway

* Occasional pieces of ice in the distance

** All G Gulls flying very low, close to water.

Sept 22/02		**R. ALLEN**	**Watch # 35**			**Compass Deck**				**Survey period 1330 through 1535hrs Ship Time**	
1335	70 23 640	135 29 798	OC	4	0	G	S	-		Zero C	Underway
1351	70 23 678	135 40 557	OC	4	0	G	S				Underway
1400	70 23 701	135 47 002	OC	4	0	G	S				Underway
1415	70 23 758	135 57 988	OC	4	0	G	S				Underway
1428	70 23 814	136 07 010	OC	4	0	G	S				Underway
1450	70 23 873	136 22 561	OC	4	0	G	S				Underway
1500	70 23 876	136 29 867	OC	4	0	G	S			a few pieces of ice	Underway
1525			OC	4	0	G	S	G Gull	1	Came from forward/port, crossed in front of bow & flew down st side & off stern.	Underway
1535	70 27 528	136 43 759	OC	4	0	G	S				Underway

Sept 23/02		**R. ALLEN**	**Watch # 36**			**Compass Deck**				**Survey period 0820 through 0930hrs Ship Time**	
0820	70 24 410	139 21 229	OC	4	0	G	M	-		Occasional bits of ice	Underway
0825	70 24 443	139 21 543	OC	4	0	G	M	G Gull	1	came from stern along port side & flew off forward.	Underway
0839	70 24 333	139 20 528	OC	4	0	G	M	G Gull	1	came from stern along port side & flew off forward.	Underway
0839	70 24 333	139 20 528	OC	4	0	G	M	Eider	18	crossed in front from port to st. Flying low, near water.	Underway
0851	70 24 333	139 20 528	OC	4	0	G	M				Stopping
0903	70 24 157	139 18 652	OC	4	0	G	M	Eider	14	crossed in front from port to st. Flying low, near water.	Stopped
0924	70 24 143	139 18 562	OC	4	0	G	M	G Gull	1	Came from forward along st side, across stern, to port side & flew off to stern	Stopped
0929	70 24 144	139 18 582	OC	4	0	G	M				Stopped

Sept 23/02		**R. ALLEN**	**Watch # 37**			**Compass Deck**				**Survey period 1340 through 1630hrs Ship Time**	
1340	70 06 928	139 40 087	OC	4	0	G	M	-		plus 1 degree C	Underway
1359	70 03 748	139 44 498	OC	4	0	G	M				Underway
1418	70 00 655	139 48 406	OC	4	0	G	M				Underway
1436	69 57 701	139 52 137	OC	4	0	G	S	Duck	1	unidentified - crossed in front from port to st	Underway
1455	69 54 630	139 56 066	OC	5	0	G	S				Underway
1512	69 51 800	139 59 783	BK	5	0	G	S	G Gull	1	stayed with the ship for about 10 minutes	Underway
1530	69 49 455	140 05 764	CL	5	0	G	S				Underway
1541	69 50 231	140 02 191	SC	5	0	G	S				Underway
1556	69 50 870	139 55 440	BK	5	0	G	S	Eider	1	on the water, flew off to port	Underway
1615	69 51 673	139 57 053	BK	5	0	G	S				Underway
1626	69 52 426	139 40 791	BK	5	0	G	S				Underway
1630			BK	5	0	G	S			plus 1 degree C	Underway

Sept 24/02		**R. ALLEN**	**Watch # 38**			**Compass Deck**				**Survey period 1020 through 1145hrs Ship Time**	
1023	69 55 038	138 22 749	OC	4	0	G	M	-		Zero degrees C	Underway
1045	69 51 134	138 17 403	OC	4	0	G	M	-			Underway
1058	69 48 109	138 13 224	OC	4	0	G	M	-			Underway
1115	69 44 996	138 08 811	OC	4	0	G	M	-			Underway
1128	69 44 015	138 07 316	OC	4	0	G	M	-			Underway
1143	69 42 735	138 05 435	OC	4	0	G	M	-		Zero degrees C	Underway

Sept 24/02		**R. ALLEN**	**Watch # 39**			**Compass Deck**				**Survey period 1400 through 1545hrs Ship Time**	
1400	69 34 079	137 52 775	BK	3	0	G	M	-			Underway
1402	69 34	137 52	BK	3	0	G	M	G Gull	1	Came from forward and passed down port side	Underway
1430	69 34 214	137 53 698	BK	3	0	G	M				Underway
1500	69 33 704	137 52 334	BK	3	0	G	M				Stopped
1530	69 33 704	137 52 333	BK	3	0	G	M				Stopped
1545	69 33 704	137 52 333	BK	3	0	G	M				Stopped

Sept 25/02		**R. ALLEN**	**Watch # 40**			**Compass Deck**				**Survey period 0820 through 1130hrs Ship Time**	
0820	70 09 832	137 00 657	BK	4	0	G	S	-		plus 2 degrees C	Underway
0838	70 13 015	137 02 400	BK	4	0	G	S				Underway
0906	70 17 535	137 13 905	BK	4	0	G	S	G Gull	1	passed in front from st to port	Underway
0927	70 20 573	137 22 255	BK	4	0	G	S				Underway
1001	70 24 417	137 36 311	BK	4	0	G	S				Underway
1014	70 24 938	137 44 005	BK	4	0	G	S	G Gull	1	flew off to forward/port	Underway
1021	70 25 179	137 48 487	BK	4	0	G	S	G Gull	1	crossed in front from port to st	Underway
1030	70 25 522	137 53 929	BK	4	0	G	S	Eider	1	crossed in front from st to port	Underway
1059	70 26 601	137 12 044	BK	4	0	G	S				Underway
1113	70 27 144	138 20 497	BK	4	0	G	S	G Gull	1	flew off to forward/port	Underway
1116	70 27 280	138 22 596	BK	4	0	G	S	G Gull	1	flew off forward on port side	Underway
1130	70 27 855	138 31 148	BK	4	0	G	S				Underway

Sept 25/02		**R. ALLEN**	**Watch # 41**			**Compass Deck**				**Survey period 1555 through 1700hrs Ship Time**	
1555	69 59 781	139 49 107	BK	5	0	G	S	-			Underway
1604	69 58 420	139 50 495	BK	5	0	G	S	G Gull	1	passed in front from port to st	Underway
1613	69 56 759	139 52 116	BK	5	0	G	S	G Gull	1	passed in front from port to st	Underway
1617	69 56 135	139 52 707	BK	5	0	G	S	G Gull	1	passed in front from port to st	Underway
1647	69 50 958	139 58 598	BK	5	0	G	S				Underway
1700	69 49 901	140 00 21	BK	5	0	G	S				Underway

Sept 26/02		**R. ALLEN**	**Watch # 42**			**Compass Deck**				**Survey period 0825 through 1040hrs Ship Time**	
0825	69 50 388	139 58 612	SC	5	0	G	S	-		Zero degrees C	Underway
0859	69 52 943	139 40 147	SC	5	0	G	S				Underway
0906	69 53 427	139 36 345	SC	5	0	G	S	Eiders	9	passed in front from port to st	Underway
0923	69 53 468	139 25 729	SC	5	0	G	S				Underway
0957	69 53 683	139 29 129	SC	5	0	G	S				Underway
1027	69 55 302	139 19 823	SC	5	0	G	S				Underway
1037	69 55 247	139 16 939	SC	5	0	G	S				Underway
1040			SC	5	0	G	S				Underway

Sept 26/02		R. ALLEN	Watch # 43			Compass Deck				Survey period 1530 through 1650hrs Ship Time	
1530	70 01 448	138 42 597	SC	5	0	G	S	-			Underway
1600	70 07 974	138 49 156	SC	5	0	G	S				Underway
1627	70 14 067	138 54 557	SC	5	0	G	S				Underway
1638	70 15 039	138 55 005	SC	5	0	G	S	G Gull	2	crossed in front from port to st	Underway
1650	70 15 202	138 55 454	SC	5	0	G	S				Underway

Sept 27/02		R. ALLEN	Watch # 44			Compass Deck				Survey period 0927 through 1130hrs Ship Time	
0927	69 33 025	138 09 897	OC	3	0	G	M	-		plus 3 degrees C	Underway
1000	69 37 397	138 14 808	OC	3	0	G	M				Underway
1016	69 40 975	138 19 109	OC	3	0	G	M	unknown	1	small brown/beige, perhaps a snow bunting? Crossed over ship st to port	Underway
1058	69 42 670	138 19 952	OC	3	0	G	M				Underway
1129	69 49 279	138 28 233	OC	3	0	G	M				Underway

Sept 27/02		R. ALLEN	Watch # 45			Compass Deck				Survey period 1400 through 1430hrs Ship Time	
1359	70 02 390	138 19 417	OC	4	0	P	M	-		rain/fog	Underway
1405	70 02 241	138 15 885	OC	4	0	P	M	loon	2	on water - flew & came over ship for a couple of minutes. Flew off to port	Underway
1425	70 03 899	138 10 058	OC	4	0	P	M			fog	Underway

Sept 28/02		R. ALLEN	Watch # 46			Compass Deck				Survey period 1400 through 1505hrs Ship Time	
1400	70 25 347	135 33 699	BK	4	0	F	S	-		Snow squalls, ship drifting	drifting
1409	70 25 477	135 34 361	BK	4	0	F	S	G Gull	1	crossed in front fromport to st	drifting
1418	70 25 660	135 35 419	BK	4	0	F	S	G Gull	1	crossed in front fromport to st	drifting
1505	70 25 669	135 35 450	BK	4	0	F	S	-		Snow squalls, ship drifting	drifting

Sept 29/02		R. ALLEN	Watch # 47			Compass Deck				Survey period 0928 through 1115hrs Ship Time	
0928	70 07 568	137 37 543	OC	4	0	G	S	-			Underway
956	70 06 252	137 56 182	OC	4	0	G	S	-			Underway
1031	70 02 300	138 19 669	OC	4	0	G	S	-			Underway
Off Watch											
1041	70 01 440	138 26 896	OC	4	0	G	S	-		bowhead port side	Underway
1044	70 01 205	138 48 495	OC	4	0	G	S	-		bowhead starboard side	Underway
1115	69 58 750	138 48 495	OC	4	0	G	S	-			Underway

<u>Birds identified Sept 20 to Oct 9</u>

Eider ducks
loon
Glaucous Gulls
Black Legged Kittiwakes
Ross' Gull
Snow Bunting
Murres
Pelagic Comorant

8. Piston and Sediment Core Sampling

JAMSTEC

Cruise MR02-K05 on Board the RV Mirai

JWACS 2002

Joint Western Arctic Climate Study

GEOSCIENCE PROGRAM

LEG 2 – Tuktoyaktuk (Northwest Territories, Canada)

to Dutch Harbor (Alaska, USA) – 20 September to 10 October, 2002

Fisheries and Oceans Canada Pêches et Océans Canada

Natural Resources Canada Ressources naturelles Canada

Table of content

Authors

Rochon, André; Blasco, Stephan; Travaglini, Paola; Narita, Hisashi; Guo, Laodong; Guéguen, Céline

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※ Page numbers in this list should be referred to the right upper corner.

1. OBJECTIVES OF JWACS

The Joint Western Arctic Climate Study (JWACS) is a collaborative project between Canada and Japan to study the relationships between the physical environment and the biota from the Northwind Ridge (Chukchi Sea) to the Mackenzie Shelf (Beaufort Sea). The specific objectives of JWACS are:

- study the relationships between the atmospheric processes (Arctic Oscillation) and ocean circulation in the Arctic
- understand the impacts of global change on biological communities
- understand the impacts of global change on sea ice and fresh water input in the Arctic
- understand the impact of global change on carbon cycle and greenhouse gas sources and sink

In addition to the main JWACS program, research components were carried out in support of other national and international programs and partnership. JWACS is also strongly linked to scientific programs funded by other national and international sources (NSERC, NOAA, NSF) and include science done from the RV Mirai, but also from the following vessels: CCGS Louis S. St-Laurent, CCGS Sir Wilfrid Laurier, and Sedna IV.

2. OBJECTIVES OF THE PALEOCEANOGRAPHY PROGRAM

Over the past 30 years, important changes have been documented in the Arctic with respect to temperature, which have been related to the emission of greenhouse gases, and particularly to the extent and thickness of the ice cover. Sea ice plays a major role in regulating the ocean-atmosphere heat exchange, as well as controlling the pelagic and benthic ecologies, the production of carbon in shelf areas, and its subsequent transport and storage in deeper basins. The observed decrease of ~14% in sea ice extent has raised concerns in the scientific community, government and populations that live in those areas. General circulation models (GCMs) experiments suggest that global warming will be amplified in the polar regions due to the positive feedback induced by the reduction of sea ice cover. A temperature increase of up to 3-4ºC is predicted for the Arctic by 2070, which will have an important impact on sea ice, albedo, and on the ecology of Arctic flora and fauna. According to the present forecasts, most of the Canadian Arctic Archipelago should be ice-free by 2030, which will lead to the opening of the Northwest Passage, the shortest route between Europe and Asia, to commercial shipping transport. This will affect on the economy and safety of shipping transport in the Northwest Passage, but will also completely alter the subsistence and economy of the Arctic populations.

Present day circulation models lack the resolution necessary to accurately predict the effects of future climate change, especially in high latitudes. There is also a need for high resolution geological proxy data in order to provide realistic initial values for calibrating the climate models. Oscillations in proxy-sea ice data have been observed for the mid-Holocene of the Laptev and Chukchi seas in the Arctic Ocean (Kunz-Pirrung, 1998) but those data are low resolution (millennial scale). However, in order to be useful to GCMs, the resolution must be on a scale to years or decade. High-resolution decadal-scale studies of Hudson and Nares Strait show similar oscillations of temperature and sea ice, with each cold-warm cycle developing in ~50 years, and lasting ~500 years. The mid-Holocene period (6-5 ka) was also characterized by “warmer than present” conditions that prevailed over most of the Arctic, despite variations in timing, duration and intensity. We hypothesize that the sedimentary record of the western Beaufort Sea will provide a decadal-centennial scale record of paleoceanographic changes for the Holocene.

The objective of the Geoscience Program is to provide temporal and spatial record of climate change for the last ca. 10,000 years in the Western Arctic. The specific objectives of the program are:

- to reconstruct the variations of sea ice cover and sea surface parameters (temperature and salinity in summer and winter) for the last ~10,000 years along a transect in the Mackenzie Canyon area using dinoflagellate cyst assemblages as proxy data.

- to document the influx of freshwater in the Mackenzie Canyon area, and the influence of the Mackenzie plume in relation with the sea ice history of the study area using freshwater and terrestrial palynomorphs as proxy indicators.

3. OBJECTIVES OF THE GREENHOUSE GAS EMISSION PROGRAM

It is hypothesized that, among the 400 pingo-like-features that have been mapped on the Beaufort Shelf, 25% are mud volcanoes created by thermogenic gas escaping from depth. It is furthermore hypothesized that sufficient gas is venting from these features to be a contributing factor to atmospheric greenhouse gases. The objectives of the program are:

- to sample a representative of one of the larger mud volcanoes, in this case the Kopanoar mud volcano
- to collect 2 sediment cores from the volcano crest and surrounding seabed
- to analyze those cores, as well as the sea water above the volcano, for gas emission
- to determine the origin, the volume and rate of gas emission from the mud volcano to estimate the total potential greenhouse gas emission from such features

4. OBJECTIVES OF THE SHELF EDGE PALEODYNAMICS PROGRAM

The Beaufort Shelf edge has been an area of discontinuous sedimentation during the Holocene. It is hypothesized that the shelf-slope break is a zone of intermittent sediment deposition and bypass resulting from episodic high velocity current activity. Sediment accumulation has been interrupted overtime by slope failures induced by episodic shelf edge dynamics and sediment instabilities. The objectives of the program are:

- to run a zigzag multibeam/sub-bottom profile survey track along the shelf edge from the outer shelf to upper slope from west to east

- to acquire detailed bathymetric and sub-bottom profile data to map seabed morphology, depositional stratigraphy and structures across the transition zone from the outer shelf to upper slope
- to integrate the multibeam/sub-bottom profile data with the results of shelf break physical and chemical oceanography conducted during JWACS
- to use the results to identify future multibeam survey tracks and sediment coring sites to establish shelf edge stratigraphy

5. ON BOARD PARTICIPANTS

Name	Position	Affiliation
Masaharu Akamine	Master	
Hiroki Maruyama	Chief Officer	
Haruhiko Inoue	1st Officer	
Takeshi Isohi	2nd Officer	
Shingo Fujita	3rd Officer	
Koichi Higashi	Chief Engineer	
Akiteru Ono	1st Engineer	
Kyoichi Hashimoto	2nd Engineer	
Takahiro Machino	3rd Engineer	
Shuji Nakabayashi	C.R. Officer	
Naoto Morioka	2nd R. Officer	
Kenetsu Ishikawa	Boatswain	
Hirokazu Kinoshita	Able Seaman	
Yasuyuki Yamamoto	Able Seaman	
Seiichiro Kawata	Able Seaman	
Hisao Oguni	Able Seaman	
Yukiharu Suzuki	Able Seaman	
Masaru Suzuki	Able Seaman	
Yosuke Kuwahara	Able Seaman	
Takeharu Aisaka	Able Seaman	
Tsuyoshi Monzawa	Able Seaman	
Masashige Okada	Able Seaman	
Shuji Komata	Able Seaman	
Yukitoshi Horiuchi	No. 1 Oiler	

Hideo Yanai	Oiler	
Yoshihiro Sugimoto	Oiler	
Toshio Matsuo	Oiler	
Nobuo Boshita	Oiler	
Kazumi Yamashita	Oiler	
Takaaki Yamaguchi	Chief Steward	
Takayuki Akita	Cook	
Hatsuji Hiraishi	Cook	
Tatsuya Hamabe	Cook	
Kozo Uemura	Cook	
Kanjyuro Murakami	Cook	
Koji Shimada	chief scientist	JAMSTEC
Akihiko Murata	scientific staff	JAMSTEC
Shigeto Nishino	scientific staff	JAMSTEC
Tomoyuki Tanaka	scientific staff	IARC-Frontier
Laodong Guo	scientific staff	IARC-Frontier
Céline Guéguen	scientific staff	IARC-Frontier
Yasushi Fujiyoshi	scientific staff	Hokkaido University
Kazuho Yoshida	scientific staff	Hokkaido University
Munehito Kimura	scientific staff	KANSO
Motoyo Itoh	scientific staff	JAMSTEC
John W. Harris	scientific staff	Fisheries and Oceans Canada
Stefan M. Blasco	scientific staff	Natural Resources Canada
André Rochon	scientific staff	Natural Resources Canada
Paola Travaglini	scientific staff	Canadian Hydrographic Service
Richard E. Crawford	scientific staff	Freshwater Institute
Cindy M. Frederikson	scientific staff	University of British Columbia
Lisa Pickell	scientific staff	University of Western Ontario
Ronald M. Allen	scientific staff	Fisheries and Oceans Canada
Hisashi Narita	scientific staff	Hokkaido University
Sanae Chiba	scientific staff	Frontier
Fuyuki Shibata	technician	Marine Works Japan
Toru Fujiki	technician	Marine Works Japan
Tomomi Kondo	technician	Marine Works Japan
Masumi Ishimori	technician	Marine Works Japan
Sawako Araki	technician	Marine Works Japan
Nobuharu Komai	technician	Marine Works Japan
Ai Yasuda	technician	Marine Works Japan

Keisuke Wataki	technician	Marine Works Japan
Masaki Moro	technician	Marine Works Japan
Toru Koizumi	technician	Marine Works Japan
Satoshi Ozawa	technician	Marine Works Japan
Naoko Takahashi	technician	Marine Works Japan
Mikio Kitada	technician	Marine Works Japan
Kaori Taguchi	technician	Marine Works Japan
Kenichiro Sato	technician	Marine Works Japan
Junko Hamanaka	technician	Marine Works Japan
Takayoshi Seikev	technician	Marine Works Japan
Miki Yoshiike	technician	Marine Works Japan
Kenichi Katayama	technician	Marine Works Japan
Soichiro Sueyoshi	technician	Marine Works Japan
Norio Nagahama	technician	Marine Works Japan
Satoshi Okumura	technician	Marine Works Japan
David Alan Snider	ice pilot	Martech Polar

6. SITE SURVEY

The piston core and multicorer sites were selected using a Seabeam 2112 system (12 KHz) for multibeam surface mapping, and a 4 KHz sub-bottom profiler. Steve Blasco (Geological Survey of Canada – Atlantic), and Paola Travaglini (Canadian Hydrographic Service) were in charge of analyzing the multibeam data to select the most appropriate coring locations. A continuous line was surveyed from north to south in the longitudinal axis of the Mackenzie Canyon. The three sites for piston coring were selected on the basis of sub-bottom profiles. Care was taken to avoid areas that showed signs of sediment failure or ice scouring. The Kopanoar mud volcano site is located on the shelf in ~70 m water depth. Survey of the site was done over an area of approximately 5 km^2. Multibeam data were collected along 44 lines, for a total of approximately 80 km in length. One core was collected on the seabed, north of the volcano crest, and a second core was collected from the crest itself. Prior to coring, the water at the sediment-water interface was analyze for gas content as a preventive measure. Similar analyses were done on surface sediment samples near the mud volcano. Figure 1 shows the location of the 3 piston and the 2 mud volcano cores.

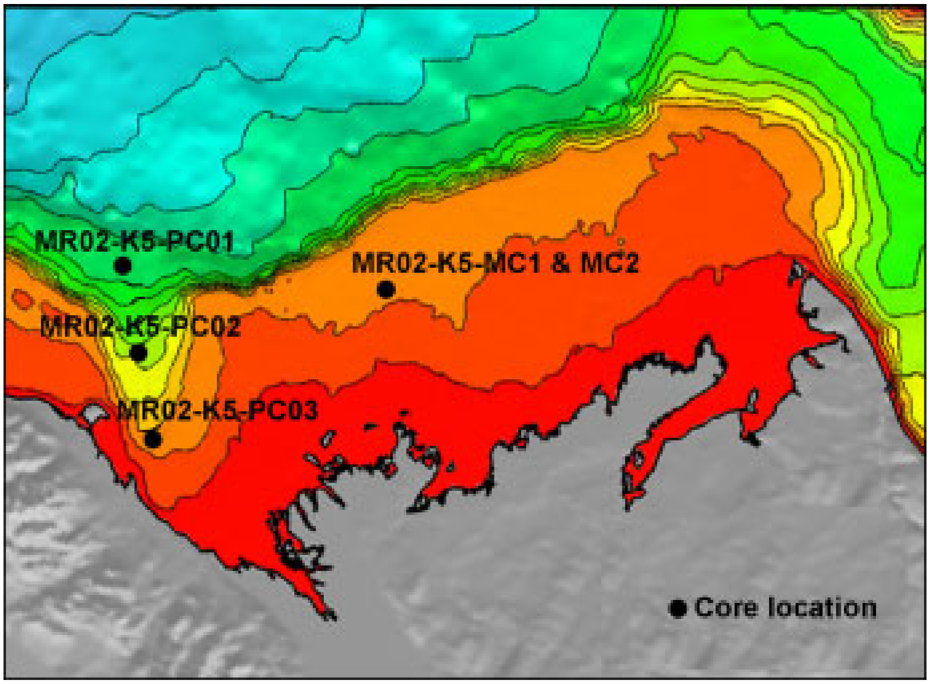

Figure 1. Location of the 3 piston core along the Mackenzie Canyon and the mud volcano multicore on the shelf.

7. CORING OPERATIONS

7.1 Piston coring

Piston coring was performed using a JAMSTEC-built piston/trigger weight coring system. The head of the corer is composed of several lead disks, each weighting 50 kg, for a total weight of 1.25 ton (fig. 2). The core barrels measure 5 metres in length by 7.2 cm wide (inside diameter), and are made of an aluminum-titanium alloy. The joints between the core barrels are 100 cm in length, and join 2 sections with a set of 24 screws. The piston is one piece (fig. 2). A core catcher and a catcher ring are located at the bottom of the corer, or pilot corer. The corer head is attached to a trigger arm, to which is attached a triple head trigger weight corer. The triple head corer is composed of a metal frame, to which are attached three pieces of transparent Plexiglas tubing 60 cm long (fig. 3a). The bottom of each piece of tubing is open, and there is no core catcher. When the triple head corer is pulled out of the sediment, a set of clamps with two lids closes the top and bottom of each Plexiglas tube, so the sediment is not disturbed while it is being brought back to the surface. When the triple head corer is on the deck the entire clamp-lid-Plexiglas tubes assembly is taken inside for subsequent subsampling (figs. 3a, b).

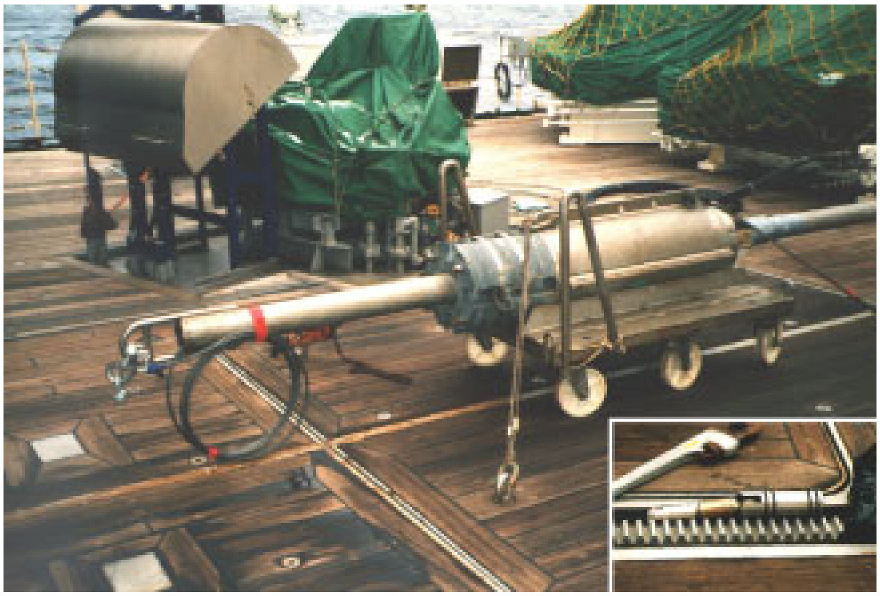

Figure 2. Detail of the piston corer head with the attached tripping cable. The insert shows the one-piece piston.

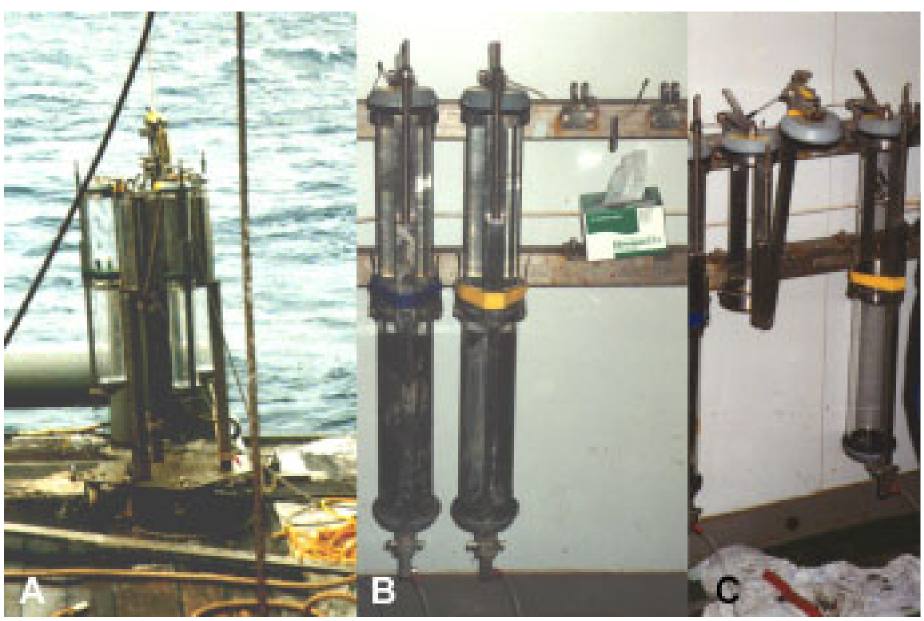

Figure 3. a) Detail of the Triple head corer that acts as a trigger for the piston corer. Note the three Plexiglas tubes are already attached. b) When coring is

done the Plexiglas tubes are removed from the corer with the clamps in place and stored in the lab. c) Detail of a set of clamps in open position.

There is no plastic lining inside the corer. In order to recover the sediment, the metal barrels are cut in 1 metre long sections using a ribbon saw (fig. 4b). The sediment is then extruded into half round PVC lining using a hydraulic piston, or a hand held piston (fig. 4a). This causes the sediment to be compacted, resulting in an erroneous, or apparent

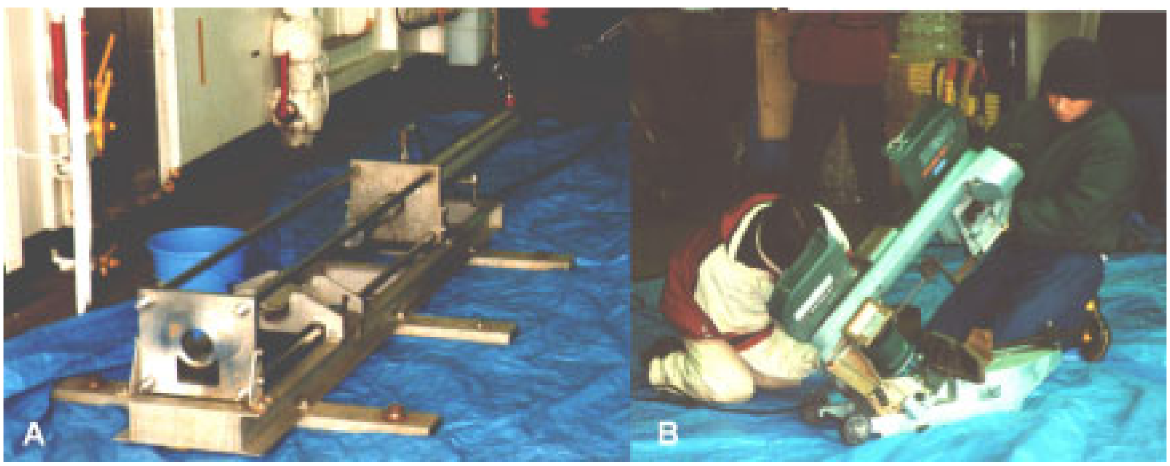

Figure 4. a) Detail of the hydraulic piston used to extrude the sediment out of the metal barrel once it had been cut. b) Ribbon saw used to cut the metal barrel into 1 metre length sections.

length, rather than the actual length. The sediment is measured using a meter tape, and small plastic pieces are manually inserted every 2 cm in the sediment to marked depth (fig. 5). The sediment section is then covered with another half round PVC section, which is taped to the bottom one, to minimize dehydration and oxidation. The section is then wrapped with plastic film, put in a sealed plastic sleeve, and stored in a cold room for further analysis.

The process of extrusion is compressing the sediment, so the length of the core as it is measured will be the “apparent length”. Also, after being cut, the sediment can sometimes expand, which also contributes to an apparent length, rather than the real length. This is the case for piston core MR02-K05-PC1, where the actual length of the corer is 20 metres, but the core length totals 20.04 metres (see Appendix 2).

Figure 5. Measurement and insertion of plastic pins in the sediment at 2 cm intervals to mark depth.

7.2 Multiple corer

The multiple corer, also engineered by JAMSTEC, is composed of a metal frame with lead weights in the middle portion where the cable is attached. It uses the same system of Plexiglas tubing as in the triple head corer, except that eight pieces of transparent Plexiglas tubing are used instead of three, 4 on each side of the weights (fig. 6). Again, the system of clamps with two lids that close the top and bottom of each Plexiglas tube is used. This system proved to be extremely useful as it allows collecting replicate cores at sites where multiple analyses are to be performed. The entire coring apparatus weights 480 kg.

Figure 6. A. Multicorer being prepared by installing 4 Plexiglas tubes on each side of the central weight assembly. B. The 4 Plexiglas tubes filled with water and sediments.

8. ONBOARD PROCESSING

After being extruded in the plastic lining, each core section is stored horizontally in a cold room for a few days. Each section is then analyzed through a Geotek Multi Sensor core logger to measure the physical and magnetic properties of the sediment. The sections were then split into working and archive halves.

The working half was prepared for color analysis using a Minolta CM2002 spectrophotometer by covering the sediment with Saran Wrap plastic film. The measures were taken continuously every 2 cm down each section. The sections were then photographed using a digital Minolta camera. Each section was photographed in one frame using a Minolta digital camera. In order to obtain a more detailed image record, they were subsequently photographed at 40 cm interval using a 35 mm K1000 Pentax camera and two flashes mounted on an aluminum frame (Bedford Institute of Oceanography). The sections were then sealed in plastic sleeve for further description and X-ray photography at Hokkaido University where they will also be sampled at 2 cm interval by Dr. Hisashi Narita.

The archive halves were usually those containing less sediment, due to the particular shape of the plastic lining. The latter are a bit more than a half circle, so when two are joined together, the resulting shape is ovoid, rather than circular, which causes the “bottom half” half to contain more sediment during splitting. The archive halves were described and sampled onboard. The remaining portion of each section will then be stored and archived at JAMSTEC, in Japan.

A team of 4 technicians from Marine Works Japan was responsible for the coring operations and subsequent sediment processing and analysis. They are:

- Tomomi Kondo (team leader)
- Masumi Ishimori
- Sawako Araki
- Toru Koizumi

9. ONBOARD SAMPLING

Sampling was done on a 2 cm slice every 10 cm in each core by Dr. Laodong Guo from the International Arctic Research Center/university of Alaska, Fairbanks (a US component of JAMSTEC), and Dr. André Rochon from the Geological Survey of Canada - Atlantic. Bulk sediment samples (10 cm slices) were collected by Dr. Guo in the upper part of each of the 3 piston cores to provide enough material for compound-specific analyses. Dr. Guo will be performing measurements on the ^{14}C of bulk samples, on size fractions, and on lignin, which is transported in the sediments via the Mackenzie River. A. Rochon collected ~15-20 cc samples for palynology and foraminifer analysis, in addition to one sample per section for bulk density analysis, and two samples per section for pore water and grain size analyses.

10. CORE DETAILS

Core #	Sample type	Date Julian Day	Latitude N	Longitude W	Water Depth (m)	Length (cm)
MR02-K5-PC-1	Piston	23/09/2002 266	70º27' 31.68"	139º04' 29.16"	664.0	1993.5
MR-02-K5-PL-1	Pilot (3 cores)					21.5
MR02-K5-PC-2	Piston	24/09/2002 267	69º55' 30.51"	138º23' 05.76"	226.0	1562.0
MR-02-K5-PL-2	Pilot (3 cores)					39.0
MR02-K5-PC-3	Piston	24/09/2002 267	69º33' 41.47"	137º52' 18.07"	65.0	736.5
MR-02-K5-PL-3	Pilot (3 cores)					37.0
MR02-K5-MC-2	Multicorer (8 cores)	28/09/2002 271	70º23' 57.048"	135º25' 02.286"	67.0	36.0
MR02-K5-MC-3	Multicorer (8 cores)	28/09/2002 271	70º23' 23.874"	135º25' 07.416"	65	25.0

Core MR02-K05-PC-1

Date: 23/09/2002

Julian day: 266

Latitude: 70º27’ 31.68”N

Longitude: 139º04’ 29.16”W

Water depth: 664m

Cable length: 630m

Corer length: 20m

Apparent penetration: ~12m

Core length: ~20m

Comments:

No problems were encountered during coring. The core cutter was removed and bagged. Then, the corer was cut into 20 x 1 metre sections. The sediment was extruded from the metallic tubing using the processed described above, and the sediment sections stored in a cold room at 4ºC for a few days before being split opened. See table 1 for the length of each working and archive sections.

Core MR02-K05- PC-2

Date: 24/09/2002

Julian day: 267

Latitude: 69º55’ 30.51”N

Longitude: 138º23’ 05.76”W

Water depth: 226m

Cable length: 194m

Corer length: 20m

Apparent penetration: ~11m

Core length: ~16m

Comments:

The bottom metre of the core came up empty, with only a “ring” of sediment at the very bottom around the inside of the corer with the middle portion empty. Suction while the corer was being pulled out of the sediment may have been the cause for sediment loss.

Core MR02-K05-PC-3

Date: 24/09/2002
Julian day: 267
Latitude: 69º33’ 41.47”N
Longitude: 137º52’ 18.07”W
Water depth: 65.0m
Cable length: 33.3m
Corer length: 20m
Apparent penetration: ~12m
Core length: ~7m

Comments:

The corer came up bent in the middle portion, at the joint between the 2nd and 3rd barrel sections (10 m), but each barrel was separated without too much problem. Several portions of the lower 10 metres of the core were empty.

Core MR02-K05-MC-2

Date: 28/09/2002
Julian day: 271
Latitude: 70º23’ 57.048”N
Longitude: 135º25’ 02.286”W
Water depth: 67.0m
Cable length: 62.3m
Corer length: 60cm
Apparent penetration: na
Core length: ~36cm
Location: Mud volcano reference site

Comments:

Two of the eight small cores were kept intact for transport back to the Bedford Institute of Oceanography, cores MR02-K5-MC8 & MC11. For each, the sediment was extruded in the plastic lining using the manual piston.

Core MR02-K05-MC-3

Date: 28/09/2002
Julian day: 271
Latitude: 70º23’ 23.874”N
Longitude: 135º25’ 07.416”W

Water depth: 40.0m
Cable length: 49.5m
Corer length: 60cm
Apparent penetration: na
Core length: ~25cm
Location: Mud volcano crest

Comments:

Two of the eight small cores were kept intact for transport back to the Bedford Institute of Oceanography, cores MR02-K5-MC7 & MC10. For each, the sediment was extruded in the plastic lining using the manual piston. The top cm of core MC7 is preserved in a plastic bag because it was squeezed out of the plastic lining by mistake during extrusion. The bottom 3-4 cm of that same core is also in a plastic bag, as the sediment had expanded after extrusion and was cut by mistake.

11. PRELIMINARY RESULTS

The multibeam system used on the RV Mirai is set to work in water depths between ~500-11,000 m. The transducers ping every 1.3 seconds, which results in data gaps between each ping when working in shallow waters. Therefore, several passes over the mud volcano had to be done in order to obtain a 100% coverage (fig. 7). During the survey, gas emissions were observed above the volcano crest. As a safety precaution to avoid sudden degassing and a possible explosion of the cores, water samples were collected above and near the volcano and analyzed for methane content prior to coring. The water samples above the crest contained 20-30 nM of methane, wich is 3-5 times the amounts usually measured in sea water. However, no alarmingly high concentrations were measured, so coring proceeded as planned. During the description of the core from the volcano crest, the sediment reacted to hydrochloric acid, while those from the reference seabed did not. The formation of methane-related carbonate cement has been observed in pockmarks from the North Sea (Hovland et al., 1987) and in other areas. The light isotopic composition of the calcite and aragonite cement suggests that the carbonates are produced by oxydation of biogenic methane, with traces of thermogenic methane. Therefore, we can assume that the carbonate content of the mud volcano crest sediment possibly has a similar origin. The only difference between our site and the North Sea pockmarks is that the surface sediments were not indurated and no crust or cementation was observed.

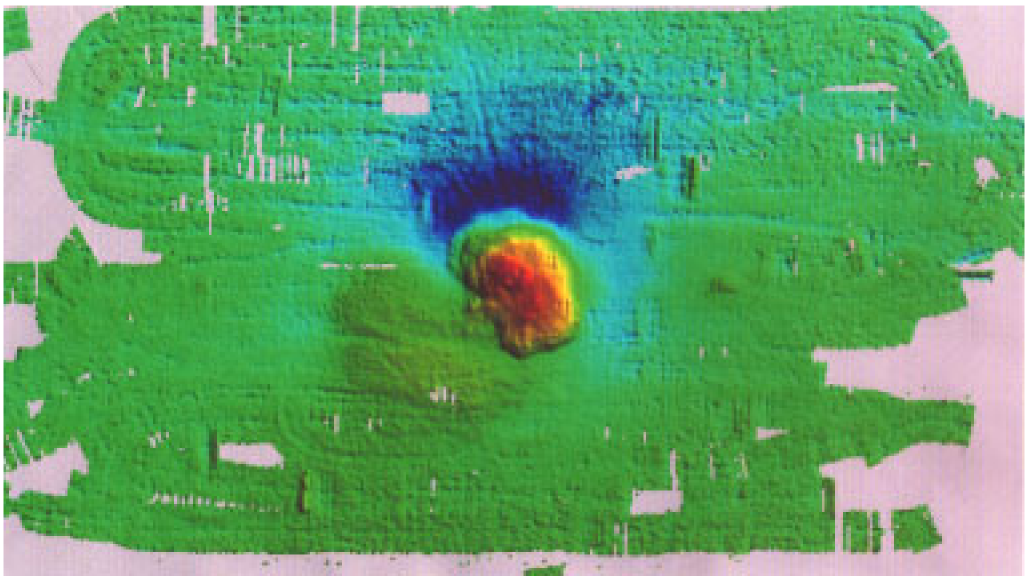

Figure 7. Multibeam image of the Kopanoar mud volcano at 3 metre resolution. Note the depression immediately north of the volcano, which is interpreted as being the sediments source for those that are ejected to form the volcano crest.

The multibeam ans subbottom data collected during this cruise allowed us to observe features that have not been noticed during previous surveys of the area. Seismic data collected in the late 80s, early 90s, suggested that the Holocene sediment layer that covers the bottom of the Mackenzie Canyon extended down to about 500 m water depth. The data collected during this cruise indicate that the sediment layer extends further offshore, to a depth of at least 700 m. Based on seismic stratigraphy, and on the sea level curve established by Hill and colleagues (1991), we were able to provide a rough estimation of the age of each core. Core MR02-K5-PC-1 (fig. 8) covers approximately from 0-10,000 ± 2000 years; PC-2 (fig. 9) covers ~0-6000 ± 2000 years, and PC-3 (fig. 10) covers ~0-3000 ± 1000 years.

The shelf edge was also investigated to address the question of sediment failure and instability. Seismic surveys in the early 1990s showed that the Mackenzie shelf edge is characterized by sediment disturbance, probably due to sediment overload during deglaciation, and also by failure, or slumping at the shelf edge. These events, although not dated, were interpreted as being recent, possibly holocene. The subbottom survey from this cruise provided a more detailed image of the distrubed sediments at the shelf edge, and in particular, it showed a surface layer of sediment, approximately 3-5 metres thick, covering disturbed sediments. This suggests that the sediment disturbance is probably older that what was originally estimated. The undisturbed surface layer is probably composed of Holocene sediment overlaying older sediment formations.

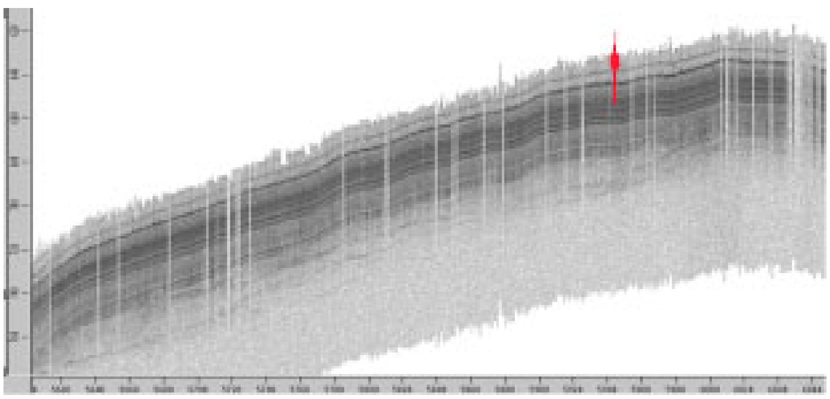

Figure 8. Sub-bottom profile of core MR02-K5-PC-1

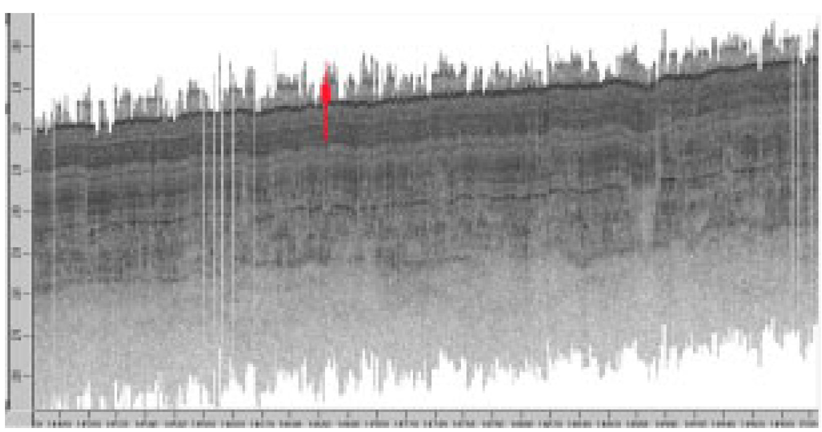

Figure 9. Sub bottom profile of core MR02-K5-PC-2

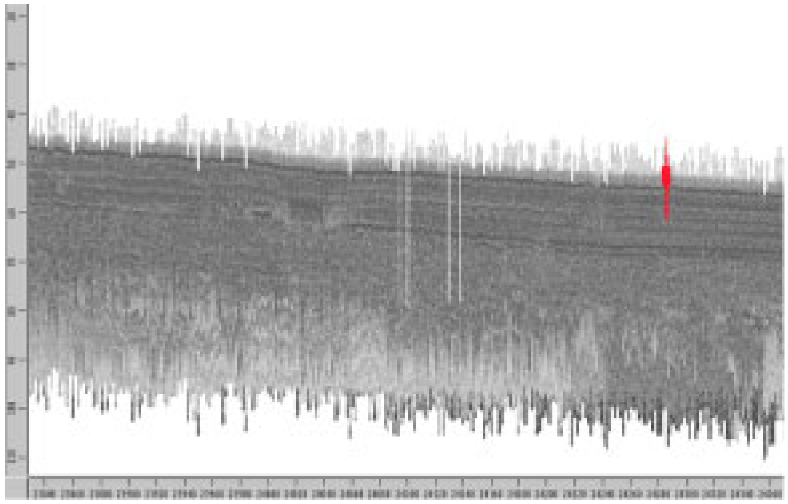

Figure 9. Sub bottom profile of core MR02-K5-PC-3

APPENDIX 1: Photo list

Film 1

MR02-K5-PC1 – Section 5 (3 shots)
MR02-K5-PC1 – Section 6 (3 shots)
MR02-K5-PC1 – Section 7 (3 shots)
MR02-K5-PC1 – Section 1 (3 shots)
MR02-K5-PC1 – Section 2 (3 shots)
MR02-K5-PC1 – Section 8 (3 shots)
MR02-K5-PC1 – Section 3 (3 shots)*
MR02-K5-PC1 – Section 4 (3 shots)@
MR02-K5-PC1 – Section 9 (3 shots)

* The 3rd shot of section 3 should read 80 cm on the depth card, rather than 40 cm.
@ The 4 shots following those of section 3 are NOT GOOD. Those labeled “section 4”, and with the depth 0, 40 and 80 cm are the good ones

Film 2

MR02-K5-PC1 – Section 10 (3 shots)
MR02-K5-PC1 – Section 11 (3 shots)
MR02-K5-PC2 – Section 1 (3 shots)
MR02-K5-PC2 – Section 2 (3 shots)
MR02-K5-PC2 – Section 3 (3 shots)
MR02-K5-PC2 – Section 4 (3 shots)
MR02-K5-PC2 – Section 5 (3 shots)
MR02-K5-PC2 – Section 6 (3 shots)
MR02-K5-PC2 – Section 7 (3 shots)
MR02-K5-PC2 – Section 8 (3 shots)
MR02-K5-PC2 – Section 9 (3 shots)

Film 3

MR02-K5-PC2 – Section 10 (3 shots)*
MR02-K5-PC3 – Section 1 (3 shots)@
MR02-K5-PC3 – Section 2 (3 shots)
MR02-K5-PC3 – Section 3 (3 shots)
MR02-K5-PC3 – Section 4 (3 shots)
MR02-K5-PC3 – Section 5 (3 shots)
MR02-K5-PC3 – Section 6 (3 shots)
MR02-K5-PC3 – Section 7 (3 shots)

* The second picture reads 0cm, while it should read 40cm.
@ The first picture is bad because the flash was not plugged in.

APPENDIX 2: Core Section Length

Core MR02-K5-PC1

MR02-K5-PC1	Whole core Length (cm)	Archive half Length (cm)	Working half Length (cm)	Note
Section 1	89.0	89.0	91.5	
Section 2	101.0	102.5	102.5	
Section 3	101.0	101.5	101.5	
Section 4	102.5	102.5	102.5	
Section 5	103.5	103.5	104.5	
Section 6	103.0	103.0	103.0	Thin laminations
Section 7	104.0	104.5	104.5	Thin laminations
Section 8	102.5	102.5	102.5	Thin laminations
Section 9	99.0	100.0	100.0	Thin laminations
Section 10	99.0	99.0	99.0	Thin laminations, Sediment flowed in below 16 cm
Section 11	98.0	98.5	98.5	Sediment flowed in
Section 12	96.0	96.5	96.5	Sediment flowed in
Section 13	98.0	98.5	98.5	Sediment flowed in
Section 14	97.0	97.5	97.5	Sediment flowed in
Section 15	96.0	96.5	96.5	Sediment flowed in
Section 16	96.0	96.0	96.0	Sediment flowed in
Section 17	94.5	95.5	95.5	Sediment flowed in
Section 18	98.5	98.5	98.5	Sediment flowed in
Section 19	98.0	98.5	98.5	Sediment flowed in
Section 20	98.0	99.0	99.0	Sediment flowed in
Core cutter	19.0	19.0	19.0	
Total length	**1993.5**	**2002.0**	**2005.5**	
MR02-k5-PL1				
#1	21.5	20.0	20.0	
#2	-	-	-	
#3	-	-	-	

Core MR02-K5-PC2

MR02-K5-PC2	Whole core Length (cm)	Archive half Length (cm)	Working half Length (cm)	Note
Section 1	79.0	84.0	83.0	
Section 2	100.0	102.5	102.5	
Section 3	100.0	101.5	101.5	
Section 4	100.0	99.5	100.5	
Section 5	99.5	99.5	99.5	
Section 6	100.5	100.5	100.5	
Section 7	100.0	100.7	100.7	
Section 8	100.5	101.3	101.0	
Section 9	100.5	100.5	100.5	
Section 10	98.5	99.5	99.5	Sediment flowed in below 26 cm
Section 11	100.0	100.0	100.0	Sediment flowed in
Section 12	99.0	99.5	99.5	Sediment flowed in
Section 13	98.0	98.0	98.0	Sediment flowed in
Section 14	96.5	97.0	97.0	Sediment flowed in
Section 15	30.0	29.0	29.0	Sediment flowed in
Section 16	-	-	-	Lost section
Section 17	-	-	-	Lost section
Section 18	58.5	47.0	58.5	Part of sediment lost
Section 19	43.5	43.5	44.0	Part of sediment lost
Section 20	58.0	59.5	59.5	Part of sediment lost
Core cutter	12.5	11.0	12.0	
Total length	**1562.0**	**1563.0**	**1574.7**	
MR02-k5-PL2				
#1	39.0	39.0	39.0	
#2	36.5	-	-	
#3	35.0	-	-	

Core MR02-K5-PC3

MR02-K5-PC3	Whole core Length (cm)	Archive half Length (cm)	Working half Length (cm)	Note
Section 1	77.5	81.0	84.0	
Section 2	103.0	103.5	103.5	
Section 3	102.0	102.5	102.5	
Section 4	100.0	101.0	101.0	
Section 5	100.5	100.0	100.0	
Section 6	100.0	100.0	100.0	
Section 7	68.0	67.5	67.5	
Section 8	12.0	13.0	13.0	Upper 15 cm lost
Section 9	-	-	-	Lost section
Section 10	-	-	-	Lost section
Section 11	-	-	-	Lost section
Section 12	-	-	-	Lost section
Section 13	-	-	-	Lost section
Section 14	-	-	-	Lost section
Section 15	10.0	10.5	10.5	Part of section lost
Section 16	54.5	54.0	54.5	Part of section lost
Section 17	-	-	-	Lost section
Section 18	-	-	-	Lost section
Section 19	-	-	-	Lost section
Section 20	-	-	-	Lost section
Core cutter	9.0	8.0	9.0	
Total length	**736.5**	**741.0**	**745.5**	
MR02-k5-PL3				
#1	37.0	37.0	36.5	
#2	35.0	-	-	
#3	-	-	-	

APPENDIX 3: Geophysical Properties of Sediments

Core MR02-K5-PC1					
Section #	Depth (cm)	Soiltest CL 700 Pocket Penetrometer		Soiltest CL 600 Torvane	
		Vane used	Reading (Pa)	Vane used	Reading
1	17	25mm	0.70	-	-
2	17	20mm	0.80	-	-
3	17	20mm	1.05	-	-
4	3	20mm	1.60	-	-
5	17	20mm	1.45	-	-
6	17	20mm	1.55	-	-
7	17	20mm	1.55	-	-
8	17	20mm	1.80	-	-
9	3	20mm	1.85	-	-
10	17	20mm	2.55	-	-
11	4	15mm	1.50	-	-
Core MR02-K5-PC2					
Section #	Depth (cm)	Soiltest CL 700 Pocket Penetrometer		Soiltest CL 600 Torvane	
		Vane used	Reading (Pa)	Vane used	Reading
1	23	5mm	0.30	-	-
2	49	10mm	0.40	-	-
3	3	10mm	0.46	-	-
	17			Large	1.75
4	17	10mm	0.50		
	3			Large	1.40
5	16	10mm	0.70		
	3			Large	0.60
6	5	10mm	0.70		
	17			Large	0.30
7	5	10mm	0.65		
	26			Medium	0.10
8	8	10mm	0.90		
	35			Large	1.25
9	16	10mm	0.90		
	3			Large	1.00
10	3	10mm	1.00		
	17			Large	0.40
Core MR02-K5-PC3					
Section #	Depth (cm)	Soiltest CL 700 Pocket Penetrometer		Soiltest CL 600 Torvane	
		Vane used	Reading (Pa)	Vane used	Reading
1	45	20mm	1.30		
	66			Large	0.50
2	3	20mm	1.15		
	46			Large	0.30
3	3	20mm	1.35		
	16			Large	0.20
4	3	20mm	1.30		
	17			Large	0.60
5	36	20mm	1.90	-	-
6	3	20mm	1.95	-	-
7	16	20mm	2.00	-	-

APPENDIX 4: List of sediment samples

Core MR02-K5-PC1 (P = palynology; B = bulk density; G = grain size; C = chemical characterization)									
Section 1		**Section 2**		**Section 3**		**Section 4**		**Section 5**	
depth	type	depth	type	depth	type	depth	type	depth	type
3–4	P, C	10–12	P, C	10–12	P, C	10–12	P, C	10–12	P, C
10–12	P, C	20–22	P, C	20–22	P, C	20–22	P, C	20–22	P, C
20–22	P, C	30–32	P, C	30–32	P, C	30–32	P, C	30–32	P, C
30–32	P, C	40–42	P, C	40–42	P, C	40–42	P, C	40–42	P, C
40–42	P, C	50–52	P, C	50–52	P, C	50–52	P, C	50–52	P, C
50–52	P, C	60–62	P, C	60–62	P, C	60–62	P, C	60–62	P, C
60–62	P, C	70–72	P, C	70–72	P, C	70–72	P, C	70–72	P, C
70–72	P, C	80–82	P, C	80–82	P, C	80–82	P, C	80–82	P, C
80–82	P, C	90–92	P, C	90–92	P, C	90–92	P, C	90–92	P, C
89–90	P, C	100–102	P, C	98–100	P, C	99–101	P, C	100–102	P, C
25–25	B	6–8	B	6–8	B	6–8	B	6–8	B
28–30	G	12–14	G	12–14	G	12–14	G	12–14	G
72–74	G	72–74	G	72–74	G	72–74	G	72–74	G
Section 6		**Section 7**		**Section 8**		**Section 9**		**Section 10**	
depth	type	depth	type	depth	type	depth	type	depth	type
10–12	P	10–12	P	10–12	P, C	10–12	P, C	1–3	P, C
20–22	P, C	20–22	P, C	20–22	P, C	20–22	P, C	10–12	P, C
30–32	P, C	30–32	P, C	30–32	P, C	30–32	P, C	20–22	P, C
40–42	P, C	40–42	P, C	40–42	P, C	40–42	P, C	30–32	P, C
50–52	P, C	50–52	P, C	50–52	P, C	50–52	P, C	40–42	P, C
60–62	P, C	60–62	P, C	60–62	P, C	60–62	P, C	50–52	P, C
70–72	P, C	70–72	P, C	70–72	P, C	70–72	P, C	60–62	P, C
80–82	P, C	80–82	P, C	80–82	P, C	80–82	P, C	70–72	P, C
90–92	P, C	90–92	P, C	90–92	P, C	90–92	P, C	80–82	P, C
100–102	P, C	100–102	P, C	100–102	P, C	6–8	B	90–92	P, C
6–8	B	6–8	B	6–8	B	12–14	G	6–8	B
12–14	G	12–14	G	12–14	G	72–74	G	12–14	G
72–74	G	72–74	G	72–74	G			72–74	G
Section 11		**P, Cilote core**							
depth	type	depth	type						
1–3	P, C	0–2	P, C						
11–13	P, C	4–6	P, C						
14–16	P, C	8–10	P, C						
6–8	B	12–14	P, C						
		16–18	P, C						

Core MR02-K5-PC2 (P = palynology; B = bulk density; G = grain size; C = chemical characterization)									
Section 1		**Section 2**		**Section 3**		**Section 4**		**Section 5**	
depth	type	depth	type	depth	type	depth	type	depth	type
4–6	P, C	10–12	P, C	10–12	P, C	10–12	P, C	10–12	P, C
10–12	P, C	20–22	P, C	20–22	P, C	20–22	P, C	20–22	P, C
20–22	P, C	30–32	P, C	30–32	P, C	30–32	P, C	30–32	P, C
30–32	P, C	40–42	P, C	40–42	P, C	40–42	P, C	40–42	P, C
40–42	P, C	50–52	P, C	50–52	P, C	50–52	P, C	50–52	P, C
50–52	P, C	60–62	P, C	60–62	P, C	60–62	P, C	60–62	P, C
60–62	P, C	70–72	P, C	70–72	P, C	70–72	P, C	70–72	P, C
70–72	P, C	80–82	P, C	80–82	P, C	80–82	P, C	80–82	P, C
80–82	P, C	90–92	P, C	90–92	P, C	89–91	P, C	90–92	P, C
17–19	B	100–102	P, C	99–101	P, C	98–100	P, C	6–8	B
25–25	G	7–9	B	6–8	B	6–8	B	12–14	G
78–80	G	12–14	G	12–14	G	12–14	G		
Section 6		**Section 7**		**Section 8**		**Section 9**		**Section 10**	
depth	type	depth	type	depth	type	depth	type	depth	type
1–3	P, C	10–12	P, C	10–12	P, C	10–12	P, C	10–12	P, C
10–12	P, C	20–22	P, C	20–22	P, C	20–22	P, C	20–22	P, C
20–22	P, C	30–32	P, C	30–32	P, C	30–32	P, C	24–26	P, C
30–32	P, C	40–42	P, C	40–42	P, C	40–42	P, C	50–52	P, C
40–42	P, C	50–52	P, C	50–52	P, C	50–52	P, C	12–14	G
50–52	P, C	60–62	P, C	60–62	P, C	60–62	P, C		
60–62	P, C	70–72	P, C	70–72	P, C	70–72	P, C		
70–72	P, C	80–82	P, C	80–82	P, C	80–82	P, C		
80–82	P, C	90–92	P, C	90–92	P, C	90–92	P, C		
90–92	P, C	98–100	P, C	98–100	P, C	98–100	P, C		
6–8	B	6–8	B	6–8	B	6–8	B		
12–14	G	12–14	G	12–14	G	12–14	G		
P, Cilote core									
depth	type								
0–2	P, C								
10–12	P, C								
20–22	P, C								
30–32	P, C								
37–38.5	P, C								

Core MR02-K5-PC3 (P = palynology; B = bulk density; G = grain size; C = chemical characterization)									
Section 1		**Section 2**		**Section 3**		**Section 4**		**Section 5**	
depth	type	depth	type	depth	type	depth	type	depth	type
15–17	P	10–12	P	10–12	P	10–12	P	10–12	P
20–22	P	20–22	P	20–22	P	20–22	P	20–22	P
30–32	P	30–32	P	30–32	P	30–32	P	30–32	P
40–42	P	40–42	P	40–42	P	40–42	P	40–42	P
50–52	P	50–52	P	50–52	P	50–52	P	50–52	P
60–62	P	60–62	P	60–62	P	60–62	P	60–62	P
70–72	P	70–72	P	70–72	P	70–72	P	70–72	P
80–82	P	80–82	P	80–82	P	80–82	P	80–82	P
57–59	B	90–92	P	90–92	P	89–91	P	90–92	P
42–44	G	100–102	P	99–101	P	98–100	P	23–25	B
		6–8	B	6–8	B	6–8	B	26–28	B
		22–24	G	12–14	G	22–24	G	12–14	G
		62–64	G	72–74	G	68–70	G	62–64	G
Section 6		**Section 7**		**Pilote core**					
depth	type	depth	type	depth	type				
1–3	P	1–3	P	0–2					
10–12	P	10–12	P	4–6					
20–22	P	20–22	P	8–10					
30–32	P	30–32	P	12–14					
40–42	P	40–42	P	16–18					
50–52	P	50–52	P	20–22					
60–62	P	60–62	P	24–26					
70–72	P	67–68	P	28–30					
80–82	P	4–6	B	32–34					
90–92	P	12–14	G	36–37					
6–8	B	53–55	G						
22–24	G								
72–74	G								

APPENDIX 5

Core description

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID **Mirai MR02-K5-PL1**	CALENDAR DATE **29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 20 cm** **PL1**
CORE BARREL TYPE **Pilot**	GEOGRAPHIC LOCATION **Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70º24'06.71"N
LONGITUDE 139º18'28.07"W
DESCRIBED BY: **André Rochon**

Page 1 Of 1

Wavy Laminae	Parallel Laminae	Dropstone
Bioturbation	Shell intact	Wood
Mud clast	Shell fragment	Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soft + Sticky		5YR 3/1	oxydated sediment		Palynology (0-2 cm)
				7.5YR 2.5/1	transition zone		
				10YR 3/1 5Y 3/2	The sediment consist in fine silty clay with the oxydation zone at the top (~0-2 cm), followed by a transition zone (~2-3 cm), then by a another zone, where laminae are present. Those laminae appear drier and harder, or at least stiffer. The sediment in those is slightly coarser and it contains benthic foraminifers, which react to HCl.	Burrow???	Palynology (4-6 cm) Palynology (8-10 cm) Palynology (12-14 cm) Palynology (16-18 cm)
10			++ ++				
20					End of core		

There is a possibility of a gap between the pilot core and the piston core, as the color of the surface sediment in each core is quite different. Also, there are no bioturbations visible in the pilot core, while they are present at the top of PC1.

This feature could be due to air bubbles and folds in the plastic film that covered the sediment prior to description. However, the structure was still present after the sediment surface had been scraped with a spatula.

30

40

50

60

70

80

90

100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 90 cm** **section 1**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70°24'06.71"N
LONGITUDE 139°18'28.07"W
DESCRIBED BY: **André Rochon**

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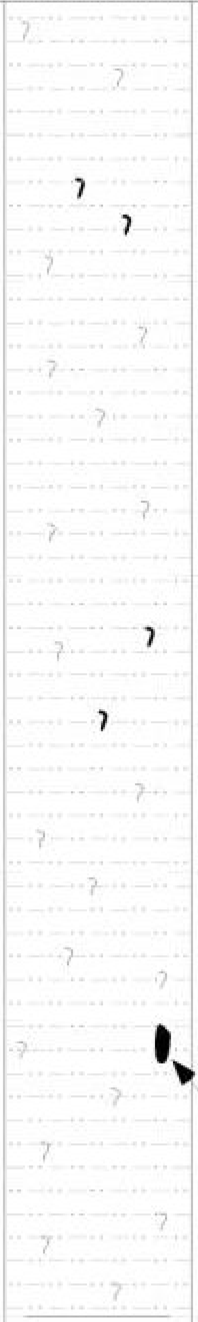
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–90		Soupy → Soft + Sticky	Very little if any	2.5Y 3/1 Very dark grey	The sediment consist in a relatively massive fine silty clay with scattered bioturbations (burrows) filled with black material (probably pyritized). The sediment surface has a relatively high water content and is quite soupy. The rest of the section is relatively soft. A striated angular black dropstone (3 cm long x 1 cm wide) was found at ~72 cm depth in the section. The dropstone has the typical shape of glacially transported stones. Approx-imately 2.5 cm of sediment is missing at the top of the section, relative to the working half. There are a few large bioturbations (thick lines), and scattered small ones (thin lines).		Palynology (2-4 cm) Palynology (10-12 cm) Palynology (20-22 cm) Bulk density (23-25 cm) bottle A787, sampler B2 Grain size (28-30 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Palynology (60-62 cm) Palynology (70-72 cm) Grain size (72-74 cm) striated dropstone (collected) Palynology (80-82 cm) Palynology (88-90 cm) or ~~89-91, or 89-90 (CHECK)~~
90					End of Section		

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 102.5 cm** **section 2**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70º24'06.71"N
LONGITUDE 139º18'28.07"W

DESCRIBED BY: **André Rochon**

	Wavy Laminae		Parallel Laminae		Dropstone
	Bioturbation		Shell intact		Wood
	Mud clast		Shell fragment		Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description
0		Soft + Sticky	Very little if any	2.5Y 3/1 Very dark grey	The sediment consist in a relatively massive fine silty clay with scattered bioturbations (burrows) in upper 66 cm filled with black material (probably pyritized). There is a slight smell of sulfur. There are a few large bioturbations (thick lines), and scattered smaller ones (thin lines). The lower 42.5 cm of the section have fewer bioturbations.
66				5Y 3/2 Dark olive grey	This section only has very few bioturbations compare to above.

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Lithology and Sedimentary structures

Subsamples

- Bulk density (6-8 cm) bottle A788, sampler B2
- Palynology (10-12 cm)
- Grain size (12-14 cm)
- Palynology (20-22 cm)
- Palynology (30-32 cm)
- Palynology (40-42 cm)
- Palynology (50-52 cm)
- Palynology (60-62 cm)
- Palynology (70-72 cm)
- Grain size (72-74 cm)
- Palynology (80-82 cm)
- Palynology (90-92 cm)
- Palynology (100-102 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 101 cm** **section 3**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70º24'06.71"N
LONGITUDE 139º18'28.07"W

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Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Very little if any	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with scattered bioturbations (burrows) in upper 40 cm filled with black material (probably pyritized). The bioturbations increase in number down to 85 cm, where they become abundant down to 91 cm. The remainder of the section has very few bioturbations. There are a few large bioturbations (thick lines), and scattered smaller ones (thin lines).		Bulk density (6-8 cm) bottle A789, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Palynology (60-62 cm) Palynology (70-72 cm) Grain size (72-74 cm) Palynology (80-82 cm) Palynology (90-92 cm) Palynology (98-100 cm)
85–91					This section is heavily bioturbated.		
91–100					This section only has very few bioturbation.		

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	Mirai MR02-K5-PC1	CALENDAR DATE	29/09/2002	CORE INTERVAL CORE SECTION	0 - 102 cm section 4
CORE BARREL TYPE	Piston	GEOGRAPHIC LOCATION	Mackenzie Canyon	PROJECT NUMBER	JWACS & PS-2019

LATITUDE 70º24'06.71"N
LONGITUDE 139º18'28.07"W

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Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soft + Sticky	Very little if any	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with scattered to rare bioturbations (burrows), all filled with black material (probably pyritized). Two areas are heavily bioturbated between 60-76 cm and 95-92 cm. There are a few large bioturbations (thick lines), and smaller ones (thin lines).		Bulk density (6-8 cm) bottle A792, sampler B2
10							Palynology (10-12 cm) Grain size (12-14 cm)
20							Palynology (20-22 cm)
30							Palynology (30-32 cm)
40							Palynology (40-42 cm)
50				2.5Y 3/1 Very dark grey			Palynology (50-52 cm)
60					This section is heavily bioturbated.		Palynology (60-62 cm)
70							Palynology (70-72 cm) Grain size (72-74 cm)
80							Palynology (80-82 cm)
90					This section is heavily bioturbated.		Palynology (90-92 cm)
100							Palynology (99-101 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	Mirai MR02-K5-PC1	CALENDAR DATE	30/09/2002	CORE INTERVAL CORE SECTION	0 - 104 cm section 5
CORE BARREL TYPE	Piston	GEOGRAPHIC LOCATION	Mackenzie Canyon	PROJECT NUMBER	JWACS & PS-2019

LATITUDE 70º24'06.71"N
LONGITUDE 139º18'28.07"W

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Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Very little if any	2.5Y 3/2 Very dark grey	The sediment consist in laminated fine silty clay. The laminations are an alternance of heavily bioturbated and less bioturbated layers. The bioturbations (burrows) are all filled with black material (probably pyritized).The lower part of the section, between ~64 and ~86 cm does not have laminations, but they reappear from 86 cm and down. There are a few large bioturbations (thick lines), and smaller ones (thin lines). The darker layers are 5Y 3/2 – Dark olive grey.		Bulk density (6-8 cm) bottle A793, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Palynology (60-62 cm) Palynology (70-72 cm) Grain size (72-74 cm) Palynology (80-82 cm) Palynology (90-92 cm) Palynology (100-102 cm)

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**30/09/2002**	CORE INTERVAL CORE SECTION	**0 - 103 cm** **section 6**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70°24'06.71"N
LONGITUDE 139°18'28.07"W

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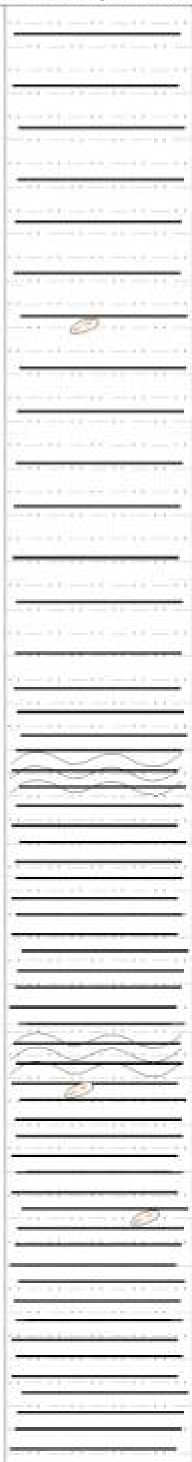
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Very little if any	0–47: 5Y 3/2 Dark olive green; 47–100: 2.5Y 3/1 Very dark grey	The sediment consist in fine laminated silty clay. The laminations in the upper 47 cm are relatively thick (~0.5 cm) and not well defined. From 47 cm down, the laminations are thinner, sharper and mostly parallel, although a few undulating ones are present. The lamination alternate between light and dark color. No sediment sorting is observed in the laminations. Three mud clasts of a lighter color were found (ice rafted?). All the laminae are deformed on the edges of the core (they bend downward)		Bulk density (6-8 cm) bottle A794, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Palynology (60-62 cm) Palynology (70-72 cm) Grain size (72-74 cm) Palynology (80-82 cm) Palynology (90-92 cm) Palynology (100-102 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 104 cm** **section 7**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**
LATITUDE LONGITUDE	70°24'06.71"N 139°18'28.07"W	Page 7 Of 11			
DESCRIBED BY:	**André Rochon**				

Legend: Wavy Laminae · Parallel Laminae · Dropstone · Bioturbation · Shell intact · Wood · Mud clast · Shell fragment · Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky (0–100)	Very little if any (0–52); + + (54); + + (90)	2.5Y 4/1 Very dark grey (0–100)	The entire section consist in laminated fine silty clay. The laminations are alternating dark/lighter color (some are of an intermediate color). The dark laminae are usually thinner (~0.2 cm), and the light ones thicker (0.3 to 0.5 cm), but it varies. There are no signs of sediment sorting, or bioturbation like in the upper part o the core. 2.5Y 4/1 Dark grey (light layers) 5Y 4/1 Dark grey (intermediate layers) 2.5Y 3/1 Very dark grey (dark layers) Could it be distal end of a mud flow? Or annual laminations, or just laminated marine sediment? Most laminae are more or less parallel, but a few are slightly undulating. Some layers have a different texture, almost like they are drier and harder, or at least stiffer. The sediment in those is slightly coarser and it contains benthic foraminifers. They appear as thick line in the lithology column to the right. They are also darker than the rest of the sediment: 10Y 3/1 very dark grey. All the laminae are deformed on the edges of the core (they bend downward)		Bulk density (6-8 cm) bottle A790, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Palynology (60-62 cm) Palynology (70-72 cm) Grain size (72-74 cm) Palynology (80-82 cm) Palynology (90-92 cm) Palynology (100-102 cm)

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 102.5 cm** **section 8**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**
LATITUDE LONGITUDE	70º24'06.71"N 139º18'28.07"W				
DESCRIBED BY:	**André Rochon**				

Legend: Wavy Laminae | Parallel Laminae | Dropstone | Bioturbation | Shell intact | Wood | Mud clast | Shell fragment | Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Medium soft + Sticky					
6-8					The entire section consist in laminated fine silty clay. The laminations are alternating dark/lighter color (some are of an intermediate color). The dark laminae are usually thinner (~0.2 cm), and the light ones thicker (0.3 to 0.5 cm), but it varies. There are no signs of sediment sorting, or bioturbation like in the upper part o the core. The sediment has the consistency of peanut butter		Bulk density (6-8 cm) bottle A791, sampler B2
10			+ +				Palynology (10-12 cm) Grain size (12-14 cm)
17			+ +				
20					5Y 3/1 Very dark grey (light layers)		Palynology (20-22 cm)
25			+ +				
27			+ +		5Y 3/2 Dark olive grey (intermediate layers)		
30					10Y 3/1 Very dark grey (dark layers)		Palynology (30-32 cm)
33			+ +		Most laminae are more or less parallel, but a few are slightly undulating.		
40			+ +		Some layers have a different texture, almost like they are drier and harder, or at least stiffer. The sediment in those is slightly coarser and it contains benthic foraminifers, which react to HCl. They appear as thick line in the lithology column to the right. They are also darker than the rest of the sediment: 10Y 3/1 very dark grey.		Palynology (40-42 cm)
46			+ +				
50							Palynology (50-52 cm)
55					All the laminae are deformed on the edges of the core (they bend downward)		
60							Palynology (60-62 cm)
70							Palynology (70-72 cm) Grain size (72-74 cm)
76			+ +				
80							Palynology (80-82 cm)
90							Palynology (90-92 cm)
100							Palynology (100-102 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID **Mirai MR02-K5-PC1**	CALENDAR DATE **01/10/2002**	CORE INTERVAL CORE SECTION	**0 - 99.5 cm** **section 9**
CORE BARREL TYPE **Piston**	GEOGRAPHIC LOCATION **Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70°24'06.71"N
LONGITUDE 139°18'28.07"W
DESCRIBED BY: **André Rochon**

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Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Medium soft + Sticky	++ (at ~5 cm, ~23 cm, ~26 cm, ~63 cm)		See below		See below

Sedimentologic Description:

The entire section consist in laminated fine silty clay. The laminations are alternating dark/lighter color (some are of an intermediate color). Contrary to the previous section, the dark laminae are usually thicker (~0.3-0.5 cm), and the light ones thinner (0.2 cm), but it varies. There are no signs of sediment sorting, or bioturbation like in the upper part o the core. The sediment has the consistency of peanut butter

5Y 3/1 Very dark grey (light layers)

5Y 3/2 Dark olive grey (intermediate layers)

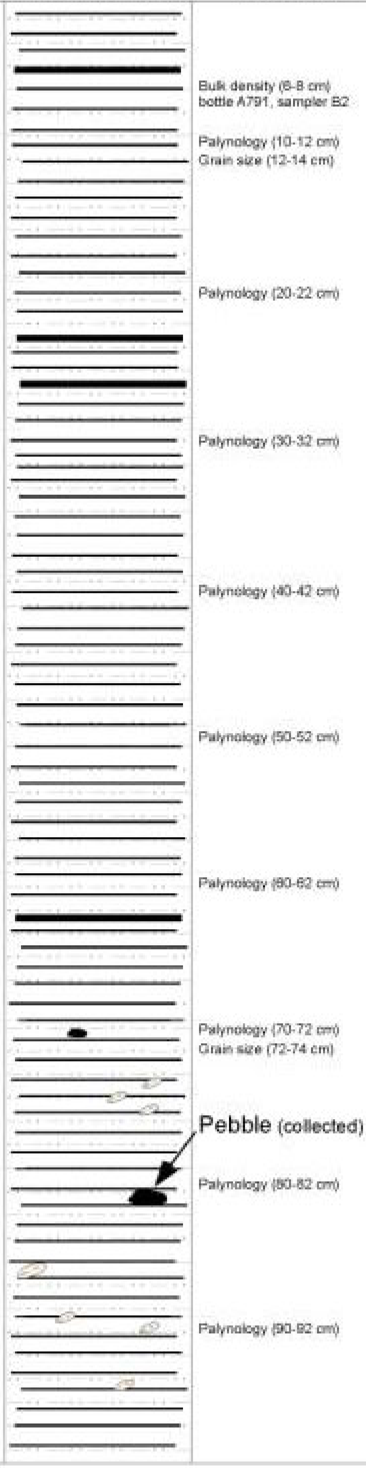
10Y 3/1 Very dark grey (dark layers)

Most laminae are more or less parallel, but a few are slightly undulating.

Some layers have a different texture, almost like they are drier and harder, or at least stiffer. They are ~ 0.3-0.4 cm thick. The sediment in those is slightly coarser and it contains benthic foraminifers, which react to HCl. They appear as thick line in the lithology column to the right. They are also darker than the rest of the sediment: 10Y 3/1 very dark grey.

All the laminae are deformed on the edges of the core (they bend downward).

There are 2 pebbles and a few mud clast of lighter color in the bottom part of the section and they react to HCl. The larger pebble is polished and striated. The mud clasts are 2.5Y 5/2 grayish brown.



Subsamples:

- Bulk density (6-8 cm) bottle A791, sampler B2
- Palynology (10-12 cm)
- Grain size (12-14 cm)
- Palynology (20-22 cm)
- Palynology (30-32 cm)
- Palynology (40-42 cm)
- Palynology (50-52 cm)
- Palynology (60-62 cm)
- Palynology (70-72 cm)
- Grain size (72-74 cm)
- Palynology (80-82 cm)
- Palynology (90-92 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**29/09/2002**	CORE INTERVAL CORE SECTION	**0 - 99 cm** **section 10**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70º24'06.71"N
LONGITUDE 139º18'28.07"W

DESCRIBED BY: **André Rochon**

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Legend: Wavy Laminae | Parallel Laminae | Dropstone | Bioturbation | Shell intact | Wood | Mud clast | Shell fragment | Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Medium soft + Sticky	+ +		The entire section consist in laminated fine silty clay. The laminations are alternating dark/lighter color (some are of an intermediate color). Contrary to the previous section, the dark laminae are usually thicker (~0.3-0.5 cm), and the light ones thinner (0.2 cm), but it varies. There are no signs of sediment sorting, or bioturbation like in the upper part o the core. The sediment has the consistency of peanut butter		Palynology (1-3 cm) Bulk density (6-8 cm) bottle A796, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm)
20					2.5Y 3/1 Very dark grey (light layers) 5Y 3/1 Dark olive grey (intermediate layers)		Palynology (20-22 cm)
30			+ +		10Y 3/1 Very dark grey (dark layers)		Palynology (30-32 cm)
			+ +		Most laminae are more or less parallel, but a few are slightly undulating. Some seem deformed, as if contouring and object, and there is a lamina that pinches out at the top of this section (see drawing to the right.		
40			+ +		Some layers have a different texture, almost like they are drier and harder, or at least stiffer. They are ~ 0.3-0.4 cm thick). The sediment in those is slightly coarser and it contains benthic foraminifers, which react to HCl. They appear as thick line in the lithology column to the right. They are also darker than the rest of the sediment: 10Y 3/1 very dark grey.		Palynology (40-42 cm) Palynology (50-52 cm)
60					These look like current laminations. They start and gradually increase in curvature from ~75 cm and stop at 59-60 cm with the return to parallel laminae.		Palynology (60-62 cm) Palynology (70-72 cm) Grain size (72-74 cm)
70			+ +				
80					All the laminae are deformed on the edges of the core (they bend downward).		Palynology (80-82 cm)
90					There are several mud clast of lighter color in this section and they react to HCl. They are 2.5Y 5/3 light olive brown.		Palynology (90-92 cm)
100					end of section		

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC1**	CALENDAR DATE	**02/10/2002**	CORE INTERVAL CORE SECTION	**0 - 98.5 cm** **section 11**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70°24'06.71"N
LONGITUDE 139°18'28.07"W

DESCRIBED BY: **André Rochon**

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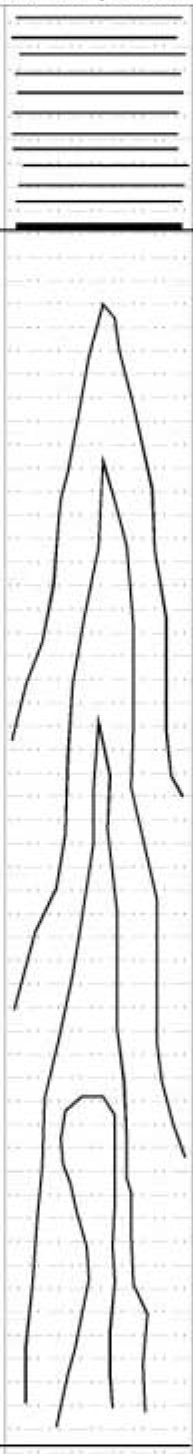
Legend: Wavy Laminae, Parallel Laminae, Dropstone, Bioturbation, Shell intact, Wood, Mud clast, Shell fragment, Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–16		Medium soft + Sticky	+ + (at 16 cm)		The upper 16 cm of the section consist in laminated fine silty clay. The laminations are alternating dark/ligh. There are no signs of sediment sorting, or bioturbation like in the upper part o the core. The sediment has the consistency of peanut butter The laminations are 2.5Y 3/2, 5Y 3/1, and 5Y 3/2. Most laminae are more or less parallel, but a few are slightly undulating. One layer has a different texture, almost like it is drier and harder, or at least stiffer. It is ~ 0.3-0.4 cm thick). The sediment in it is slightly coarser and it contains benthic foraminifers, which react to HCl. It appears as thick line in the lithology column to the right. It is also darker than the rest of the sediment: 10Y 3/1 very dark grey. Below 16 cm the sediment has been sucked in, and all the structures are vertical. No sampling has been done in that part of the core. The remainder 9 sections of the core show the same characteristic. All the laminae are deformed on the edges of the core (they bend downward).		Palynology (1-3 cm) Bulk density (6-8 cm) bottle A797, sampler B2 Palynology (11-13 cm) Palynology (14-16 cm) No sampling below this line
98.5					end of section		

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PL2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 39.5 cm** **PL2**
CORE BARREL TYPE	**Pilot**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W

DESCRIBED BY: **André Rochon**

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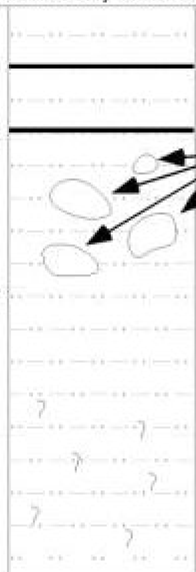
Legend: Wavy Laminae, Parallel Laminae, Dropstone, Bioturbation, Shell intact, Wood, Mud clast, Shell fragment, Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soupy		7.5YR 3/1			Palynology (0-2 cm)
10		Soft + Sticky		7.5YR 3/2	~transition zone		Palynology (10-12 cm) Dark reddish brown spots 7.5YR 3/2
20				5Y 3/2 Dark olive grey	The sediment consist in brownish fine silty clay at the top with some laminae. There seems to be a transition zone marked by reddish brown spots. The sediment then changes color gradually to olive gray with burrows filled with darker (pyritized) material.		Palynology (20-22 cm)
30							Palynology (30-32 cm)
40					End of core		Palynology (37-39 cm)



50

60

70

80

90

100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**25/09/2002**	CORE INTERVAL CORE SECTION	**0 - 83 cm** **section 1**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W

DESCRIBED BY: **André Rochon**

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Wavy Laminae | Parallel Laminae | Dropstone
Bioturbation | Shell intact | Wood
Mud clast | Shell fragment | Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–83		Soupy → Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The upper part of the core is relatively disturbed and incompletely filled. The sediment consist in relatively massive fine silty clay with numerous bioturbations filled with darker (pyritized) material. Some faint darker laminae are present. The sediment surface has a relatively high water content and is quite soupy. The rest of the section is relatively soft. There are a few large bioturbations (thick lines), and scattered small ones (thin lines).		Palynology (4-6 cm) Palynology (10-12 cm) Bulk density (17-19 cm) bottle A769, sampler B2 Palynology (20-22 cm) Grain size (25-27 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Palynology (60-62 cm) Palynology (70-72 cm) Grain size (78-80 cm) Palynology (80-82 cm)
83					End of Section		

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**25/09/2002**	CORE INTERVAL CORE SECTION	**0 - 102 cm** **section 2**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W
DESCRIBED BY: **André Rochon**

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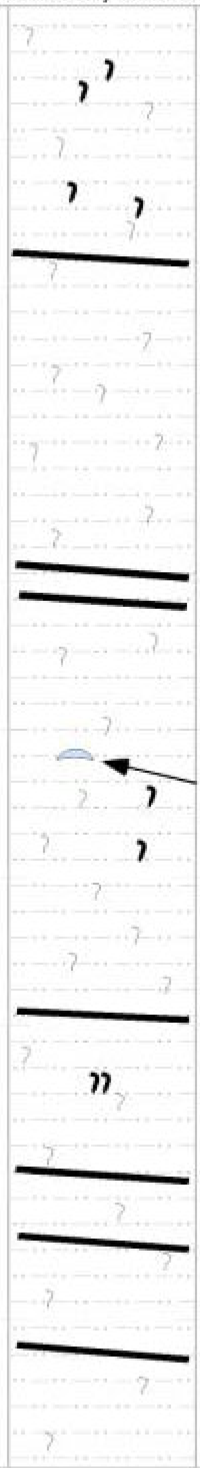
Wavy Laminae | Parallel Laminae | Dropstone
Bioturbation | Shell intact | Wood
Mud clast | Shell fragment | Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive dark olive grey fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. Some darker (5Y 2.5/1) laminae are also present. They were at an angle in the section There are a few large bioturbations (thick lines), and scattered small ones (thin lines).		Bulk density (7-9 cm) bottle A770, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm) Shell (sampled) Palynology (60-62 cm) Palynology (70-72 cm) Palynology (80-82 cm) Palynology (90-92 cm) Palynology (100-102 cm)

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 101 cm** **section 3**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W

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Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–101		Soft + Sticky	Not tested	5Y 3/1 Very dark grey	The sediment consist in a relatively massive dark olive grey fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. Two areas in the lower part of the section have more numerous bioturbations than the rest of the section, from ~53 cm to ~71 cm, and from ~78 cm down to the bottom of the section at 101 cm)		Bulk density (6-8 cm) bottle A771, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) Palynology (50-52 cm)
~53–71					Area with more bioturbations		Palynology (60-62 cm) Palynology (70-72 cm)
~78–101					Area with more bioturbations		Palynology (80-82 cm) Palynology (90-92 cm) Palynology (99-101 cm)

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	Mirai MR02-K5-PC2	CALENDAR DATE	26/09/2002	CORE INTERVAL CORE SECTION	0 - 100 cm section 4
CORE BARREL TYPE	Piston	GEOGRAPHIC LOCATION	Mackenzie Canyon	PROJECT NUMBER	JWACS & PS-2019

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W

DESCRIBED BY: **André Rochon**

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Wavy Laminae | Parallel Laminae | Dropstone
Bioturbation | Shell intact | Wood
Mud clast | Shell fragment | Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive dark olive grey fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material.		Bulk density (6-8 cm) bottle A772, sampler B2
10							Palynology (10-12 cm) Grain size (12-14 cm)??? CHECK
20							Palynology (20-22 cm)
30					The area between ~15 and 50 cm has larger and more numerous burrows/bioturbations than the rest of the core.		Palynology (30-32 cm)
40							Palynology (40-42 cm)
50							Palynology (50-52 cm)
60							Palynology (60-62 cm)
70					There are a few large bioturbations (thick lines), and scattered small ones (thin lines).		Palynology (70-72 cm)
80							Palynology (80-82 cm)
90							Palynology (89-91 cm)
100							Palynology (98-100 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 99.5 cm** **section 5**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69°55'30.68"N
LONGITUDE 138°18'23.03.69"W

DESCRIBED BY: **André Rochon**

Wavy Laminae	Parallel Laminae	Dropstone
Bioturbation	Shell intact	Wood
Mud clast	Shell fragment	Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Subsamples
0		Soft + Sticky	Not tested	5Y 3/1 Very dark grey	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. An area between ~78 and 83 cm has a lot of bioturbations, while the area from 83 to 99.5 cm has very few. There are a few large bioturbations (thick lines), and scattered small ones (thin lines).	Bulk density (6-8 cm) bottle A773, sampler B2
10						Palynology (10-12 cm) Grain size (12-14 cm)
20						Palynology (20-22 cm)
30						Palynology (30-32 cm)
40						Palynology (40-42 cm)
50						Palynology (50-52 cm)
60						Palynology (60-62 cm)
70						Palynology (70-72 cm)
80					Area with more bioturbations.	Palynology (80-82 cm)
90				5Y 3/2 Dark olive grey	Area with less bioturbations.	Palynology (89-91 cm)
100						

Lithology and Sedimentary structures

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 100 cm** **section 6**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**
LATITUDE LONGITUDE	69°55'30.68"N 138°18'23.03.69"W	Page 6 Of 10			
DESCRIBED BY:	**André Rochon**				

Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soft + Sticky	Not tested	5Y 3/1 Very dark grey	Area with more bioturbations.		Palynology (1-3 cm) Bulk density (6-8 cm) bottle A774, sampler B2
10					The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. Two areas have lots of bioturbations: from 0-~12 cm, ~40-45 cm, while another one is almost devoided of them, from ~85 down to 100 cm. There are a few large bioturbations (thick lines), and scattered small ones (thin lines).		Palynology (10-12 cm) Grain size (12-14 cm)
20							Palynology (20-22 cm)
30							Palynology (30-32 cm)
40					Area with more bioturbations.		Palynology (40-42 cm)
50							Palynology (50-52 cm)
60							Palynology (60-62 cm)
70						Shell (collected)	Palynology (70-72 cm)
80				5Y 3/2 Dark olive grey			Palynology (80-82 cm)
90					Area with less bioturbations.		Palynology (90-92 cm) Palynology (98-100 cm)
100							

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 100.5 cm** **section 7**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69°55'30.68"N
LONGITUDE 138°18'23.03.69"W
DESCRIBED BY: **André Rochon**

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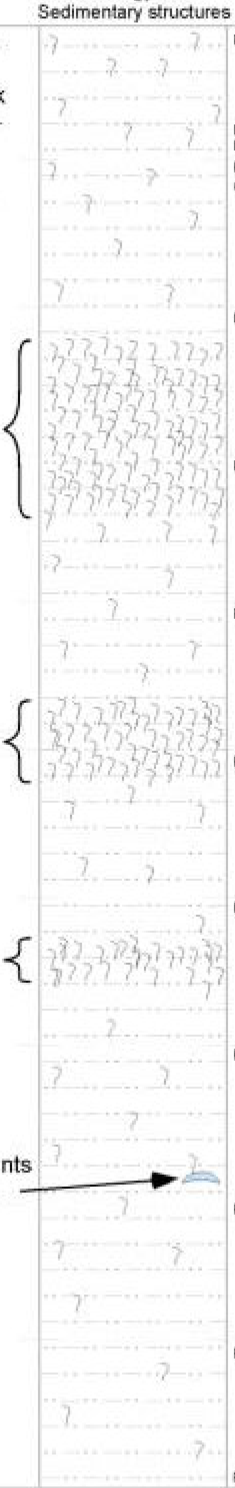
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. A shell at 78 cm was collected by Hisashi Narita fo [14]C analysis Three areas have lots of bioturbations: from 22-~35 cm, ~46-51 cm, and ~64 to 66 cm.		Palynology (1-3 cm)
							Bulk density (6-8 cm) bottle A775, sampler B2
10							Palynology (10-12 cm)
							Grain size (12-14 cm)
20							Palynology (20-22 cm)
					Area with more bioturbations.		
30							Palynology (30-32 cm)
40							Palynology (40-42 cm)
50					Area with more bioturbations.		Palynology (50-52 cm)
60							Palynology (60-62 cm)
					Area with more bioturbations.		
70							Palynology (70-72 cm)
80					Shell fragments (collected by H. Narita for [14]C)		Palynology (80-82 cm)
90							Palynology (90-92 cm)
100							Palynology (98-100 cm)



GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 100.5 cm** **section 9**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W

DESCRIBED BY: **André Rochon**

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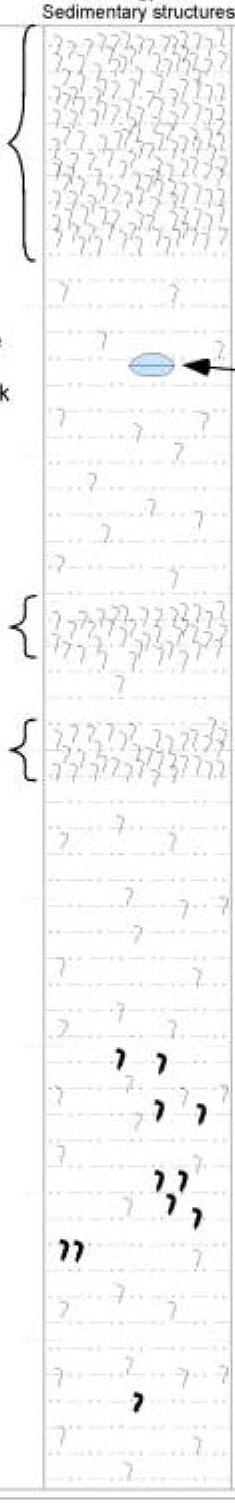
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Subsamples
0		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey		
10					Area with more bioturbations.	Bulk density (6-8 cm) bottle A777, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm)
20						Palynology (20-22 cm)
					The sediment consist in a relatively massive fine silty clay with numerous "layers" of burrows/bioturbations that are filled with dark (pyritized) material. Some area have more bioturbations, and some others have less. There are a few large bioturbations (thick lines), and scattered small ones (thin lines).	shell in life position (collected)
30						Palynology (30-32 cm)
40					Area with more bioturbations.	Palynology (40-42 cm)
50					Area with more bioturbations.	Palynology (50-52 cm)
60						Palynology (60-62 cm)
70						Palynology (70-72 cm)
80						Palynology (80-82 cm)
90						Palynology (90-92 cm)
100						Palynology (98-100 cm)

Lithology and Sedimentary structures



GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC2**	CALENDAR DATE	**26/09/2002**	CORE INTERVAL CORE SECTION	**0 - 99.5 cm** **section 10**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º55'30.68"N
LONGITUDE 138º18'23.03.69"W

DESCRIBED BY: **André Rochon**

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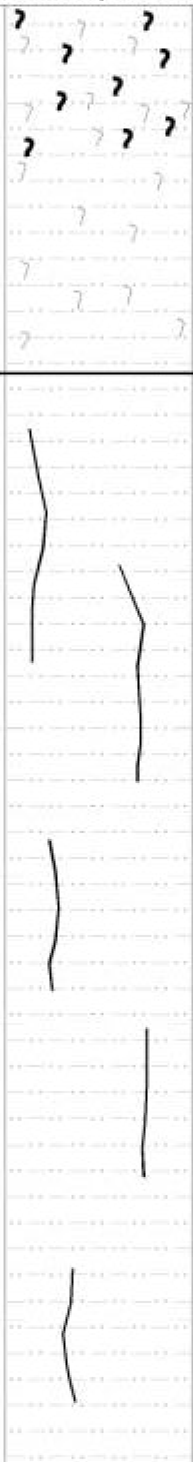
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–26		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. There are a few large bioturbations (thick lines), and scattered small ones (thin lines).		Bulk density (6-8 cm) bottle A777, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Palynology (20-22 cm) Palynology (24-26 cm)
26–100					All sedimentary structures below this line are vertical, indicating that sediment has been sucked into the corer. This prevails down to 14.5 metres. This is followed by a 3 metre gap, and then by ~50 cm of completely mixed sediments		Only one sample below this line Palynology (50-52 cm)



Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PL3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 36.5 cm** **PL3**
CORE BARREL TYPE	**Pilot**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W

DESCRIBED BY: **André Rochon**

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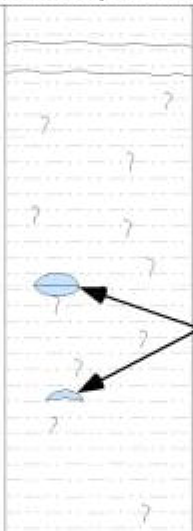
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	CaCO$_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soft + Sticky		10YR 3/2	oxydated sediment		Palynology (0-2 cm)
				2.5Y 3/2	transition zone		Palynology (4-6 cm)
10				5Y 3/2	The sediment consist in a relatively massive fine silty clay with the oxydation zone at the top (~0-3 cm), followed by a transition zone (~3-5 cm), then by a bioturbated zone, where burrows are filled with black material (probably pyritized).		Palynology (8-10 cm)
							Palynology (12-14 cm)
							Palynology (16-18 cm)
20							Palynology (20-22 cm)
							Shells (collected)
							Palynology (24-26 cm)
30							Palynology (28-30 cm)
							Palynology (32-34 cm)
							Palynology (36-37 cm)
					End of core		

Depth scale: 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 84 cm** **section 1**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W

DESCRIBED BY: **André Rochon**

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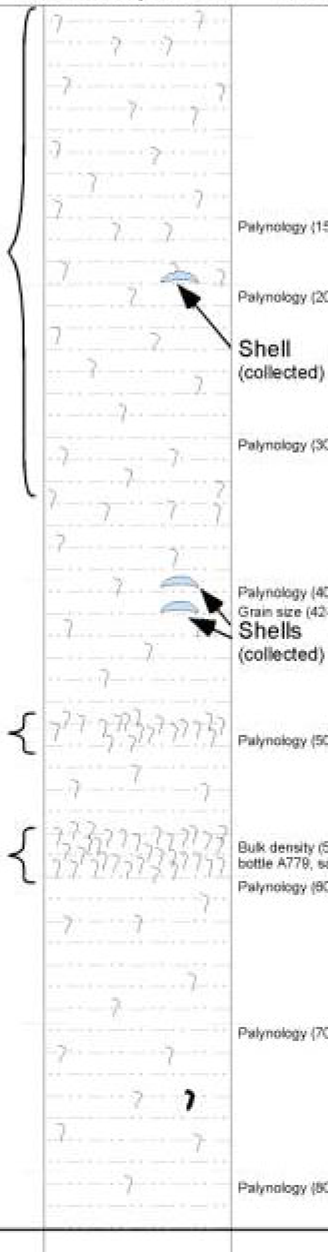
Legend: Wavy Laminae | Parallel Laminae | Dropstone | Bioturbation | Shell intact | Wood | Mud clast | Shell fragment | Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soupy	Not tested	2.5Y 3/1 Very dark grey	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. Several shells are present and have been collected for further analysis. The upper 35 cm of sediment are very soupy and contains very little sediment, so sampling is worth what its worth. The first 2-3 cm are missing due to uneven distribution of sediment in plastic lining (they ended up in the "Working" half). There are areas which are more heavily bioturbated: from ~49-51 cm, and from ~46-60 cm.	SOUPY	
15							Palynology (15-17 cm)
20						Shell (collected)	Palynology (20-22 cm)
30							Palynology (30-32 cm)
35		Soft + Sticky					
40						Shells (collected)	Palynology (40-42 cm) Grain size (42-44 cm)
50					Area with more bioturbations.		Palynology (50-52 cm)
57					Area with more bioturbations.		Bulk density (57-59 cm) bottle A779, sampler B2
60				5Y 3/2 Dark olive grey			Palynology (60-62 cm)
70							Palynology (70-72 cm)
80							Palynology (80-82 cm)
84					End of section		



Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID **Mirai MR02-K5-PC3**	CALENDAR DATE **27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 103 cm** **section 2**
CORE BARREL TYPE **Piston**	GEOGRAPHIC LOCATION **Mackenzie Canyon**	PROJECT NUMBER **JWACS & PS-2019**	

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W
DESCRIBED BY: **André Rochon**

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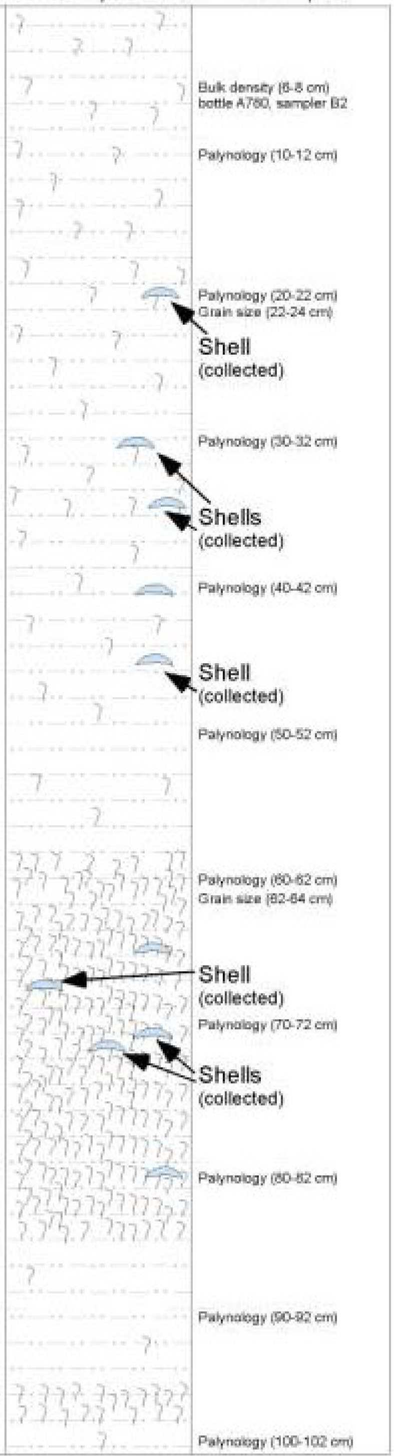
Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	CaCO$_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. Several shells are present and have been collected for further analysis. There are areas which are more heavily bioturbated: from ~60-85 cm, and from ~95-97 cm. The former contains several shells, which have been collected. On the opposite, there are two areas which have almost no bioturbations: from 85-95 cm, and from 97-103 cm.		

60–85 cm: Area with more bioturbations.

85–95 cm: Area with almost no bioturbations.

95–97 cm: Area with more bioturbations.

97–100 cm: Area with almost no bioturbations.

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 102 cm** **section 3**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W

DESCRIBED BY: **André Rochon**

Wavy Laminae — Parallel Laminae — Dropstone — Bioturbation — Shell intact — Wood — Mud clast — Shell fragment — Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. The base of the section (84-102 cm) seems to have less bioturbations. One shell with both valves was collected at 10 cm. Two more shell halves were collected at 47 and 61 cm. (84–102 cm) Area with almost no bioturbations.		Bulk density (6-8 cm) bottle A780, sampler B2 Palynology (10-12 cm) Shell (whole+fragments) (collected) Palynology (20-22 cm) Grain size (22-24 cm) Palynology (30-32 cm) Palynology (40-42 cm) Shell (collected) Palynology (50-52 cm) Palynology (60-62 cm) Shell (collected) Palynology (70-72 cm) Grain size (72-74 cm) Palynology (80-82 cm) Palynology (90-92 cm) Palynology (100-102 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 99.5 cm** **section 4**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W
DESCRIBED BY: **André Rochon**

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Legend: Wavy Laminae · Parallel Laminae · Dropstone · Bioturbation · Shell intact · Wood · Mud clast · Shell fragment · Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey (0–72 cm); 5Y 3/1 Very dark grey (72–100 cm)	The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. The base of the section (84-102 cm) seems to have less bioturbations. One shell with both valves was collected at 10cm. Two more shell half were collected at 47 and 61 cm. One worm tube approximately 13 cm long was recovered.		Bulk density (6-8 cm) bottle A782, sampler B2 Palynology (10-12 cm) Palynology (20-22 cm) Grain size (22-24 cm) Palynology (30-32 cm) Palynology (40-42 cm) Worm tube (collected) Palynology (50-52 cm) Palynology (60-62 cm) Grain size (68-70 cm) Palynology (70-72 cm) Wood fragment (collected) Palynology (80-82 cm) Shells (collected) Palynology (90-92 cm) Wood fragment (collected) Palynology (98-100 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 100 cm** **section 5**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W
DESCRIBED BY: **André Rochon**

Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Subsamples
0		Soft + Sticky	Not tested	5Y 3/1 Very dark grey		
5–10					Area with more bioturbations.	Palynology (10-12 cm) Grain size (12-14 cm)
15					Area heavily bioturbated.	Worm tube (filled)
18–20				5Y 3/2 Dark olive grey	Area without bioturbations.	
22					Area heavily bioturbated.	Palynology (20-22 cm) Bulk density (23-25 cm) bottle A783, sampler B2
25–60					The sediment consist in a relatively massive fine silty clay with numerous burrows/bioturbations that are filled with dark (pyritized) material. There is one area, which have a lot of bioturbations, and one "layer" without any. Two areas are heavily bioturbated and are marked by sharp boundaries. Two worm tubes filled up with sediment are present, one of which cuts through the bioturbated layering near the surface of the section. One mussel shell with both valves was collected at 92 cm, and a shelf half was also collected at 42 cm.	Bulk density (26-28 cm) bottle A784, sampler B1 Palynology (30-32 cm) Palynology (40-42 cm) Shell (collected) Palynology (50-52 cm) Palynology (60-62 cm) Grain size (62-64 cm)
65					Area with more bioturbations.	
70–100						Palynology (70-72 cm) Worm tube (filled) Palynology (80-82 cm) Palynology (90-92 cm) Mussel shell (collected)

Lithology and Sedimentary structures

0 10 20 30 40 50 60 70 80 90 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL / CORE SECTION	**0 - 99.5 cm section 6**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69º33'41.94"N
LONGITUDE 137º52'23.19.51"W

DESCRIBED BY: **André Rochon**

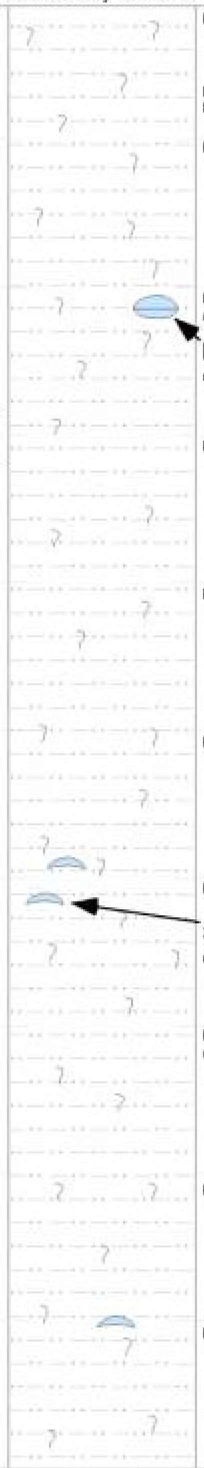
Page 6 Of 7

Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–100		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with scattered bioturbations (burrows) filled with black material (probably pyritized). A small zone (27-32 cm) has very few bioturbations).		

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

~30 cm: This section only has few bioturbations.



Subsamples:
- Palynology (1-3 cm)
- Bulk density (6-8 cm) bottle A785, sampler B2
- Palynology (10-12 cm)
- Palynology (20-22 cm)
- Grain size (22-24 cm)
- Mussel shell (collected)
- Palynology (30-32 cm)
- Palynology (40-42 cm)
- Palynology (50-52 cm)
- Palynology (60-62 cm)
- Shell (collected)
- Palynology (70-72 cm)
- Grain size (72-74 cm)
- Palynology (80-82 cm)
- Palynology (90-92 cm)

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

BOREHOLE ID	**Mirai MR02-K5-PC3**	CALENDAR DATE	**27/09/2002**	CORE INTERVAL CORE SECTION	**0 - 68 cm** **section 7**
CORE BARREL TYPE	**Piston**	GEOGRAPHIC LOCATION	**Mackenzie Canyon**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 69°33'41.94"N
LONGITUDE 137°52'23.19.51"W

DESCRIBED BY: **André Rochon**

Page 7 Of 7

Legend: Wavy Laminae; Parallel Laminae; Dropstone; Bioturbation; Shell intact; Wood; Mud clast; Shell fragment; Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–68		Soft + Sticky	Not tested	5Y 3/2 Dark olive grey	The sediment consist in a relatively massive fine silty clay with scattered bioturbations (burrows) filled with black material (probably pyritized).		Palynology (1-3 cm) Bulk density (4-6 cm) bottle A785, sampler B2 Palynology (10-12 cm) Grain size (12-14 cm) Shell (collected) Palynology (20-22 cm) Palynology (30-32 cm) Palynology (40-42 cm) ShellS (2X) (collected) Palynology (50-52 cm) Grain size (53-55 cm) Palynology (60-62 cm) Palynology (67-68 cm)
68					End of section		
68–100					Below this depth, there are only small amounts of sediments separated by large gaps.		

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

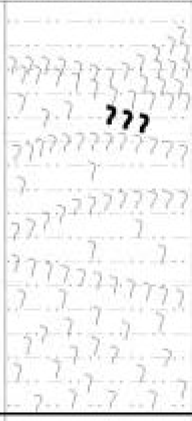
BOREHOLE ID	**Mirai MR02-K5-MC1**	CALENDAR DATE	**30/09/2002**	CORE INTERVAL CORE SECTION	**0 - 29 cm**
CORE BARREL TYPE	**Multicorer**	GEOGRAPHIC LOCATION	**Pingo crest**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70º23'23.822"N
LONGITUDE 135º25'05.039'W

DESCRIBED BY: **André Rochon**

Page 1 Of 1

Legend: Wavy Laminae · Parallel Laminae · Dropstone · Bioturbation · Shell intact · Wood · Mud clast · Shell fragment · Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0		Soupy	+++	5Y 3/2 Dark olive green	The upper part of the core consist in soupy sandy clay/silt and reacts with HCl and has no visible bioturbations. It also smells strongly of sulfur when in contact with HCl (galena?)		
10		Soft + Sticky	+				
			+		The rest of the core consist of heavily bioturbated sandy clay/silt and reacts weakly to HCl. The bioturbations appear as fine laminations that are irregularly distributed, as if the sediment has been disturbed. Fragments of foraminifers were observed, but none whole.		
20			+				
			+				
30					End of core		
40							
50							
60							
70							
80							
90							
100							

GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

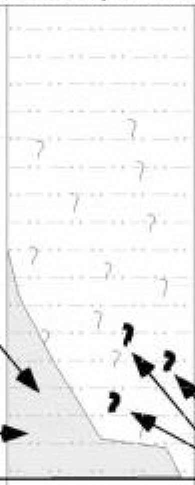
BOREHOLE ID	**Mirai MR02-K5-MC2**	CALENDAR DATE	**30/09/2002**	CORE INTERVAL / CORE SECTION	**0 - 33 cm**
CORE BARREL TYPE	**Multicorer**	GEOGRAPHIC LOCATION	**Pingo reference site**	PROJECT NUMBER	**JWACS & PS-2019**

LATITUDE 70º23'56.08"N
LONGITUDE 135º25'02.7"W

DESCRIBED BY: **André Rochon**

Page 1 Of 1

Legend: Wavy Laminae, Parallel Laminae, Dropstone, Bioturbation, Shell intact, Wood, Mud clast, Shell fragment, Silty clay

Depth (cm)	Deformation	Consistency	$CaCO_3$	Colour (Munsell)	Sedimentologic Description	Lithology and Sedimentary structures	Subsamples
0–33		Soupy → Soft + Sticky	Very faint if any	5Y 3/2 Dark olive green	Soupy zone Upper layer is composed of soupy silty clay and no bioturbation is visible. The rest of the core is also composed of bioturbated soft silty clay. There is a zone at the base of the core that seems to have been replace by darker, totally bioturbation free sediment. Very dark grey 5Y 3/1	 Empty burrow (holes)	
33					End of core		

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

APPENDIX 6

Onboard measurements and Core photography

Multisensor core logging

Tomomi Kondo (Marine Works Japan Ltd.)

Gamma-ray attenuation (GRA) and magnetic susceptibility (MS) were measured on whole-core section before splitting using the onboard GEOTEK multisensor core logger (MSCL).

The principle of GRA is based on the facts that medium-energy gamma rays (0.1-1 MeV) interact with the formation material mainly by Compton scattering, that the elements of most rock-forming minerals have similar Compton mass attenuation coefficients, and that the electron density measured can easily be related to the material bulk density. The ^{137} Ce source used transmits gamma rays at 660 keV. A standard NaI scintillation detector is used in conjunction with a universal counter. GRA calibration assumes a two-phase system model for sediments and rocks, where the two phases are the minerals and the interstitial water. Aluminum has an attenuation coefficient similar to common minerals and is used as the mineral phase standard. Pure water is used as the interstitial-water phase standard. The actual standard consists of a telescoping aluminum rod (five elements of varying thickness) mounted in a piece of core liner and filled with distilled water. GRA measurement was carried on every 1 -cm whole-core with 10 seconds counting. GRA data provide wet bulk density and fractional porosity for core thickness (pilot core: 74mm, piston core: 75mm).

MS was measured using Bartington MS2C system within the MSCL. The main unit is the widely used, versatile MS2 susceptometer for rapid measurements with a number of sensors. The unit has a measuring range of 1 x 10-5 to 9999 x 10-5 (SI, volume specific). It has five front panel controls: on-off switch, sensitivity range switch, SI or cgs unit switch, zero button, measure button, and continuous measurement switch. The unit switch should always be on SI. This loop sensor has an internal diameter of 100 mm. It operates at a frequency of 0.565 kHz and an alternating field (AF) intensity of 80 A/m (= 0.1 mT). MS data measurement was carried on every 1 or 2-cm whole-core with 1 second. MS data is used mostly as a relative proxy indicator for changes in composition that can be linked to paleoclimatic controlled depositional processes.

The results of measurements on PC-1 with PL-1, PC-2 with PL-2, PC-3 with PL-3, MC-2 and MC-3 are shown in Fig. A6-1, A6-2, A6-3 A6-4 and A6-5, respectively.

Color reflectance

Sawako Araki, Toru Koizumi (Marine Works Japan Ltd.)

Color reflectance was measured by using the Minolta CM-2002 reflectance photospectrometer using 400 to 700 nm in wavelengths. This is a compact and hand-held instrument, and can measure spectral reflectance of sediment surface with a scope of 8 mm diameter. To ensure accuracy, the CM-2002 was used with a double-beam feedback system, monitoring the illumination on the specimen at the time of measurement and automatically compensating for any changes in the intensity or spectral distribution of the light.

Calibration was carried out using the zero and white calibration pieces (Minolta CM-2002 standard accessories) before measurement of core samples. The color of the sediment surface of split working half core was measured on every 2-cm through crystal clear polyethylene wrap.

The color reflectance data are indicated by color parameters of L*, a*, and b* (L*: black and white, a*: red and green, b*: yellow and blue). L* value indicates lightness and corresponds to black (L* = 0) and white (L* = 100). a* and b* are chromaticity. The plus value of a* correspond to reddish, the minus one to greenish. For b* value, the plus values correspond to yellowish, the minus one to bluish. The Munsell colors (H: hue, V: value, C: chroma) and spectral data were also available as the result of the measurements. Spectral data can be used to estimate the abundance of certain components of sediments. The results of L*, a*, and b* on PC-1 with PL-1, PC-2 with PL-2, PC-3 with PL-3, MC-2 and MC-3 are shown in Fig. A6-1, A6-2, A6-3 A6-4 and A6-5, respectively.

Core photography

Masumi Ishimori (Marine Works Japan Ltd.)

Longitudinal section of each obtained core section was pictured using two cameras Nikon F90X and Nikon D1X, the former is a still camera with a single lens reflex (still camera as follows), and the latter is a digital camera also having a single lens reflex (digital camera as follows). The digital photographs of PC-1 with PL-1, PC-2 with PL-2, PC-3 with PL-3 and MC-2 & MC-3 are shown in Fig. A6-6, A6-7, A6-8 and A6-9, respectively.

The still camera was equipped by negative film (ISO 400), and was used under the S mode (Single frame shooting (**S**) mode: prioritize shutter speed) condition with the shutter speed of 1/320. Four pictures were taken for one scene (5core sections). The digital camera was operated by a manual mode of ISO 400 quality ("Exposure f" = 22, shutter speed = 1/250 and 1/320).

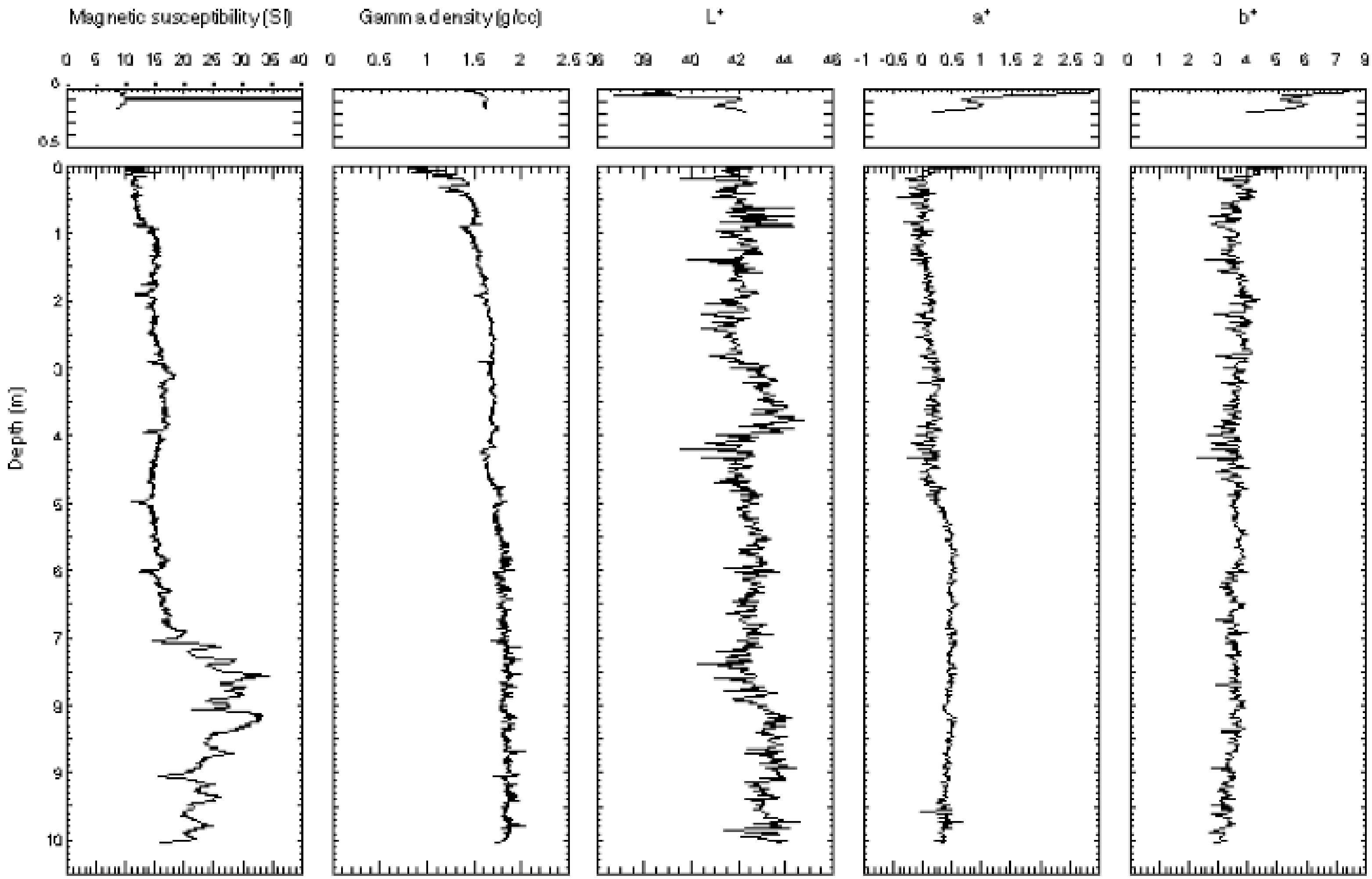


Fig. A6-1: Down-core variations of physical properties in core PC-1 and PL-1.

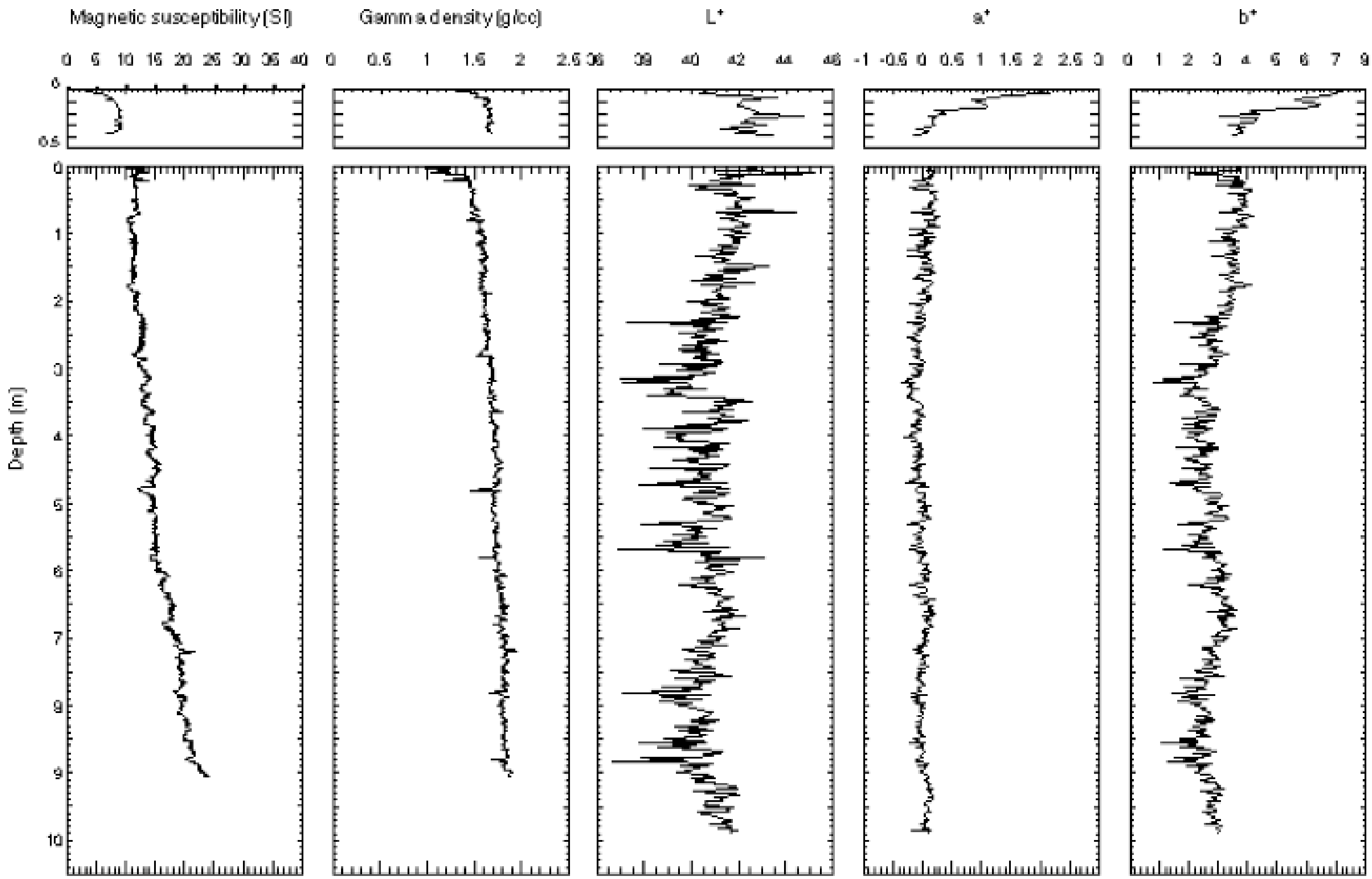


Fig. A6-2: Down-core variations of physical properties in core PC-2 and PL-2.

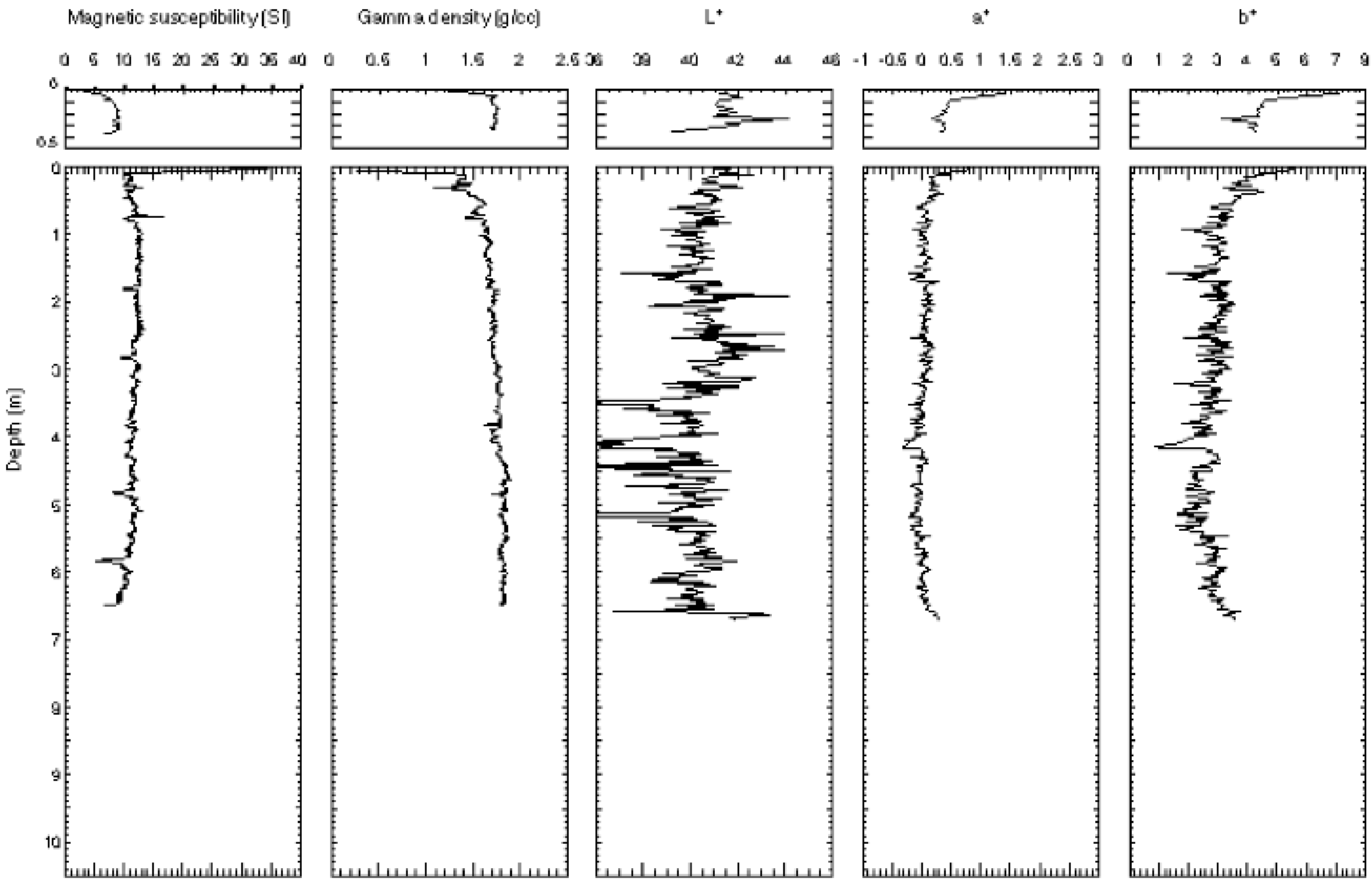


Fig. A6-3: Down-core variations of physical properties in core PC-3 and PL-3.

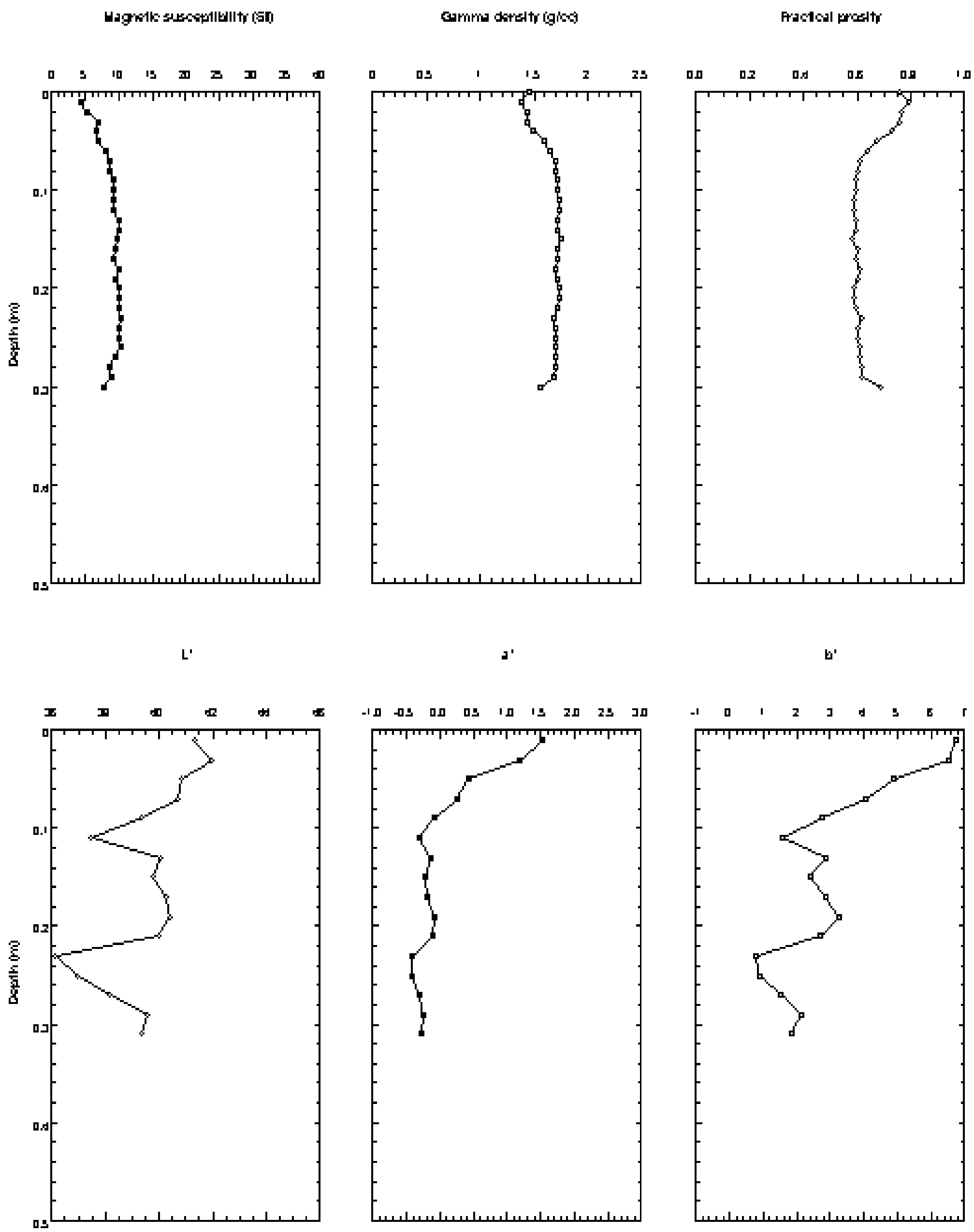


Fig. A6-4: Down-core variations of physical properties in core MC-2.

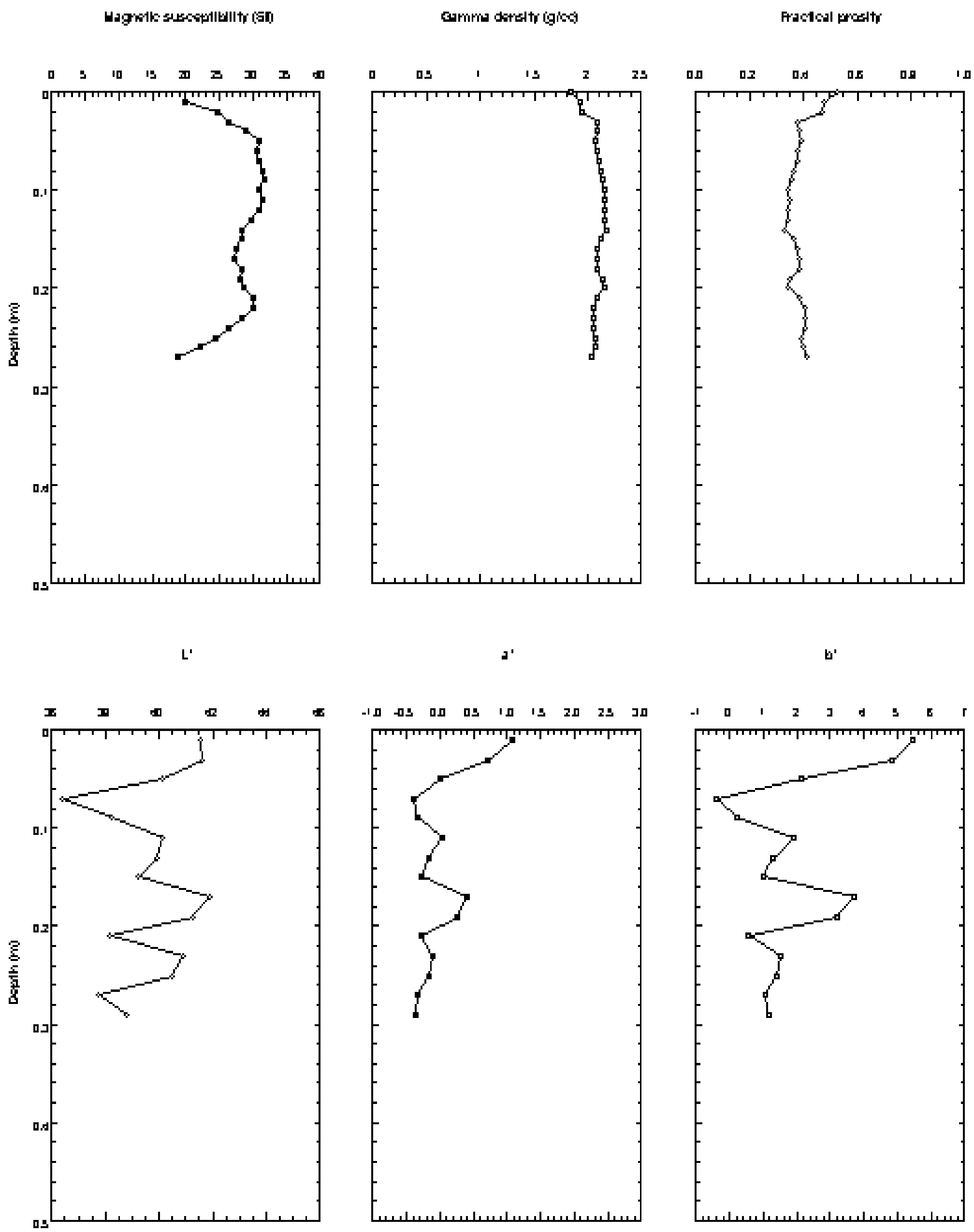


Fig. A6-5: Down-core variations of physical properties in core MC-3.

Fig. A6-6: Digital Core Photograph of core PC-1 (Top) and PL-1 (Bottom).

Fig. A6-7: Digital Core Photograph of PC-2 (Top) and PL-2 (Bottom).

Fig. A6-8: Digital Core Photograph of PC-3 (Top) and PL-3 (Bottom).

Fig. A6-9: Digital Core Photograph of MC-2 (Top) and MC-3 (Bottom).

9. Underway geophysical observations

9.1 Sea bottom topography

(1) Personnel

Satoshi Okumura[1], Souichiro Sueyoshi[1], Norio Nagahama[1], Stefan Blasco[2], Andre Rochon[2], Paola Travaglini[3], Hisashi Narita[4]

(1. Global Ocean Development Inc., 2. Geological Survey of Canada, 3. Canadian Hydrographic Service, 4. Hokkaido University)

(2) Objective

R/V Mirai has installed a multi narrow beam echo sounding system(MNBES), SeaBeam 2112.004 (SeaBeam Inc., USA). The objective of MNBES observation is collecting continuous bathymetry data along ship's track to make a contribution to geological and geophysical investigations, and also get accurate topographic map around the objective position of sediment core sampling.

(3) Method

We had carried out bathymetric survey from the departure of Sekinehama on 25 August 2002 to the arrival of Dutch Harbor on 10 October 2002. Around the Kopanoar mud volcano and Mackenzie trough, we performed detail bathymetrical survey to determine several positions of sediment core sampling. With the 4kHz system, we also got sub-bottom data along the survey lines providing some information about the sediments below the bottom.

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

System configuration and performance

(12kHz system)

Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 KW
Transmit pulse width:	3 msec to 20 msec
Depth range:	100 to 11,000 m (depth to 50 m can be obtained but with less accuracy)
Beam spacing:	1 ° athwart ship
Swath width:	max 150 °

120 ° to 4,500 m
100 ° to 6,000 m
90 ° to 11,000m

Depth accuracy: Within < 0.5% of depth or ±1 m,
(whichever is greater, over the entire swath)
Nadir beam has greater accuracy
Within < 0.2% of depth or ±1 m,
(whichever is greater)

(Sub-Bottom Profiler; 4kHz system)

Frequency:	4kHz
Transmit beam width:	5 degree
Receive beam width:	5 degree
Transmit pulse width:	5 msec to 100 msec
Depth range:	100 to 11,000 m

(4) Preliminary result

Following figure shows the topography around Kopanoar mud volcano and sediment core sampling sites in the Mackenzie Trough.

(5) Data archives

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

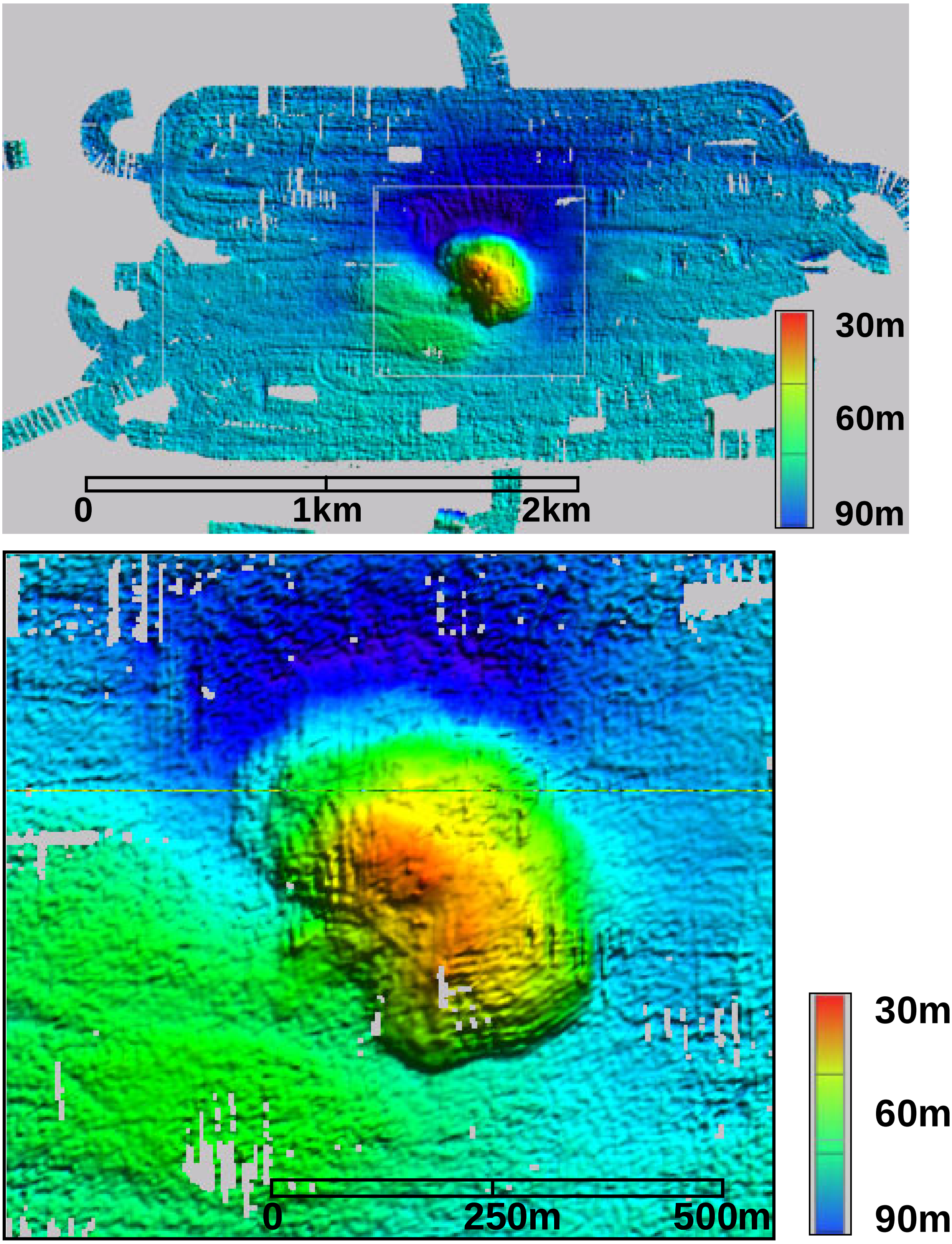


Fig. 9.1-1　Kopanoar mud volcano (Topography)

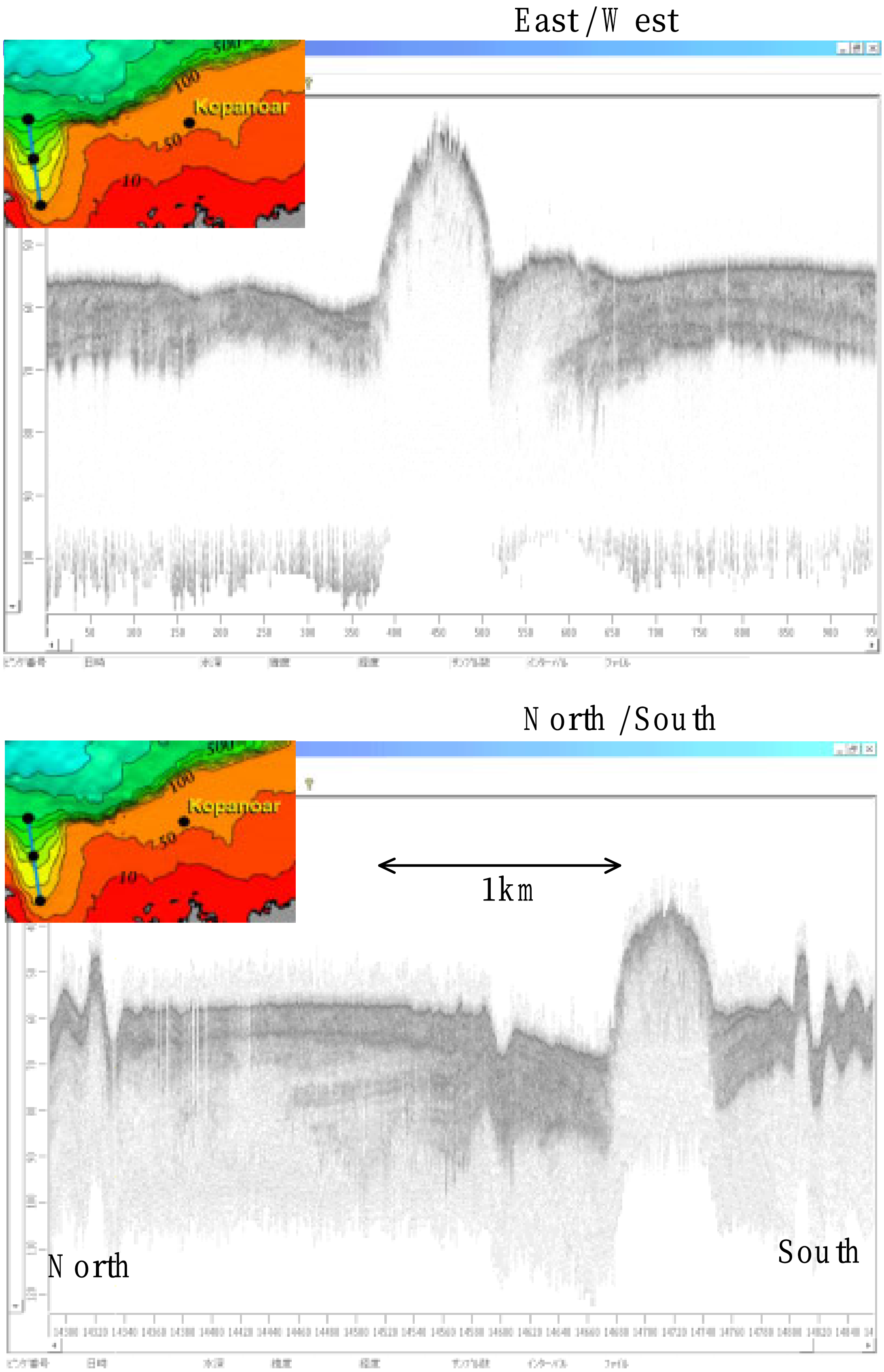


Fig. 9.1-2 Kopanoar mud volcano (Sub-bottom profile)

PC-1

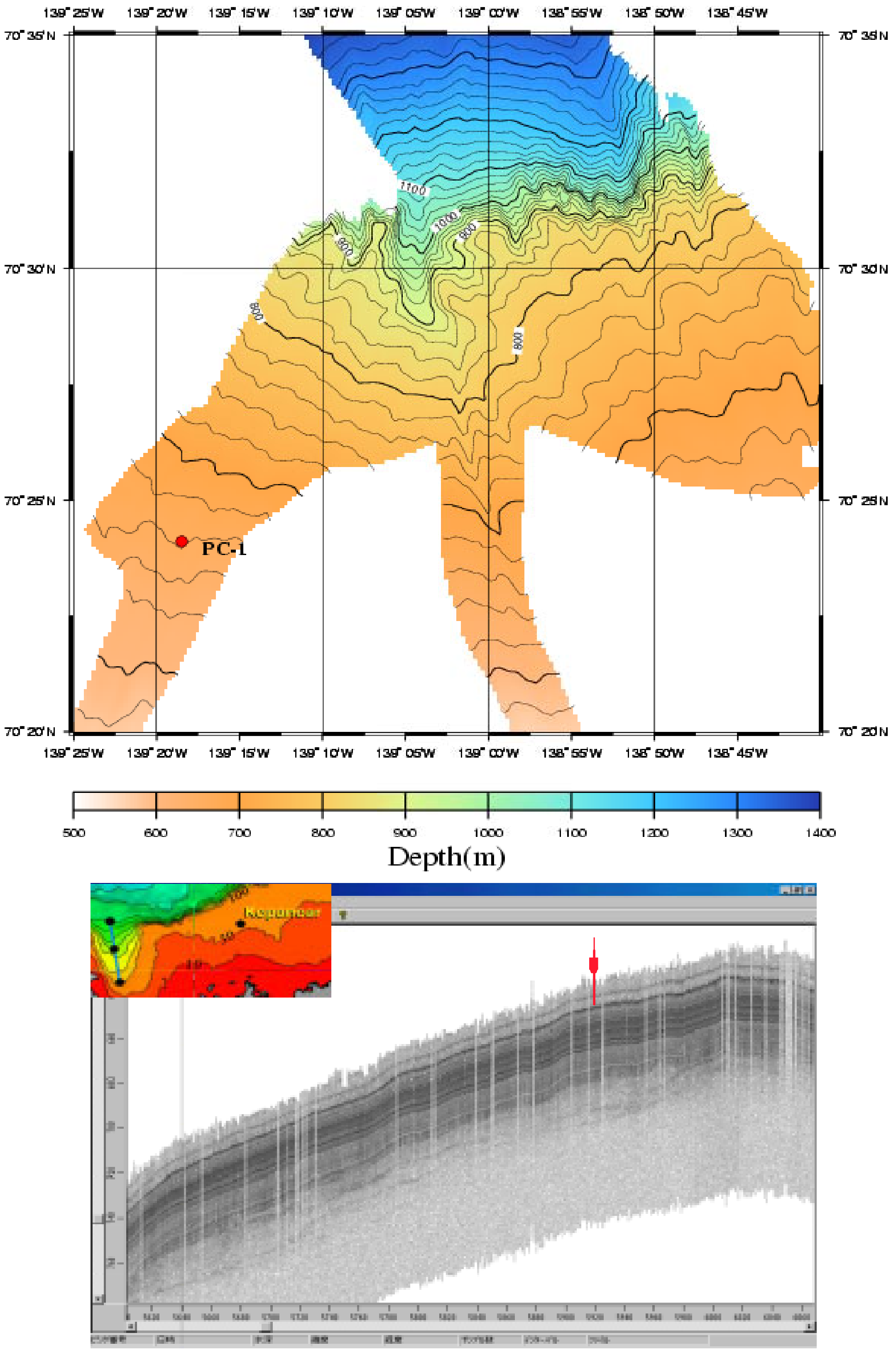


Fig. 9.1-3　Piston core sampling site (PC-1)

PC-2

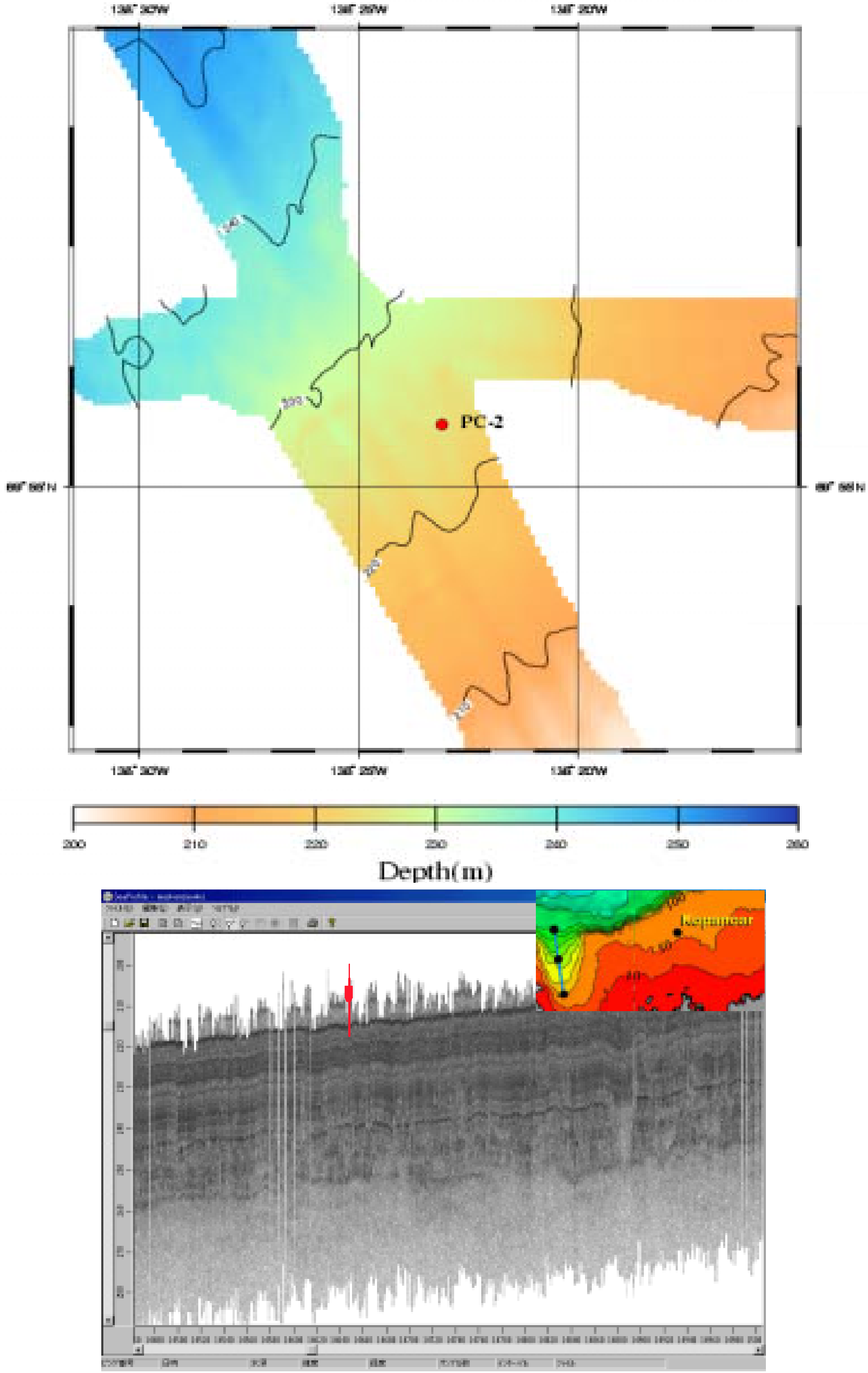
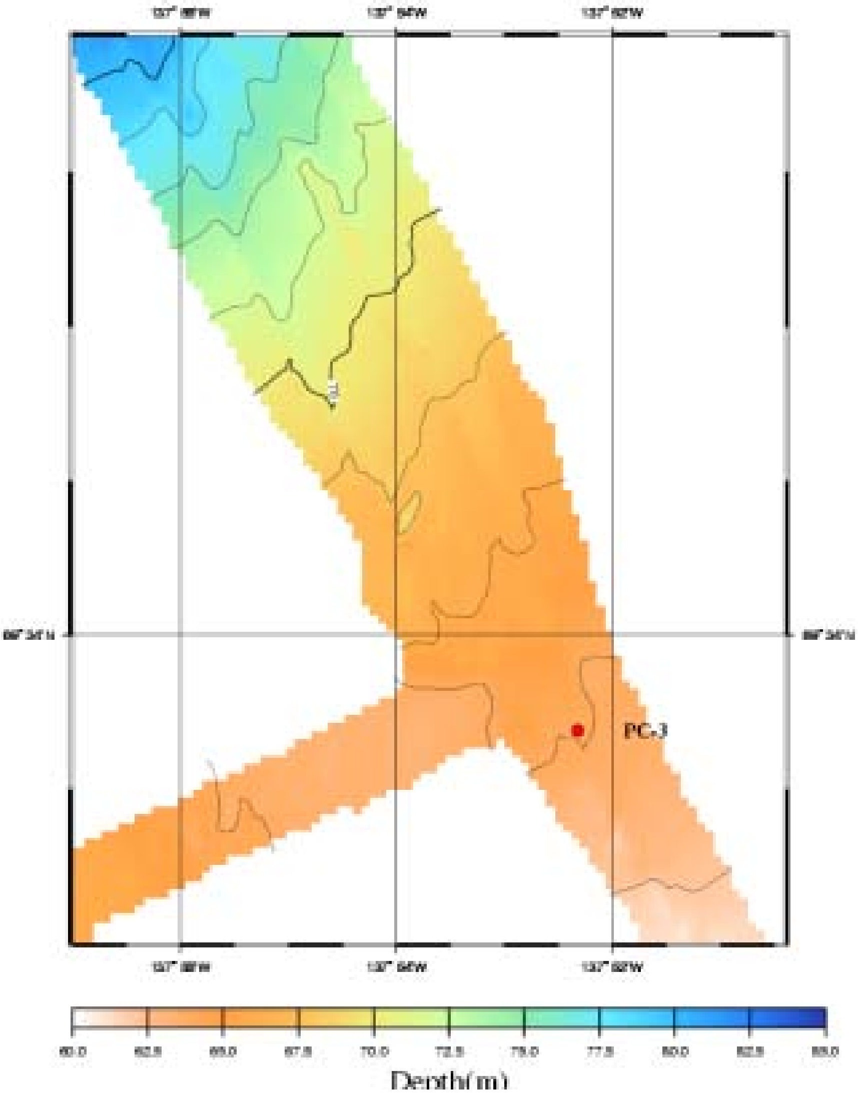


Fig. 9.1-4　Piston core sampling site (PC-2)

PC-3



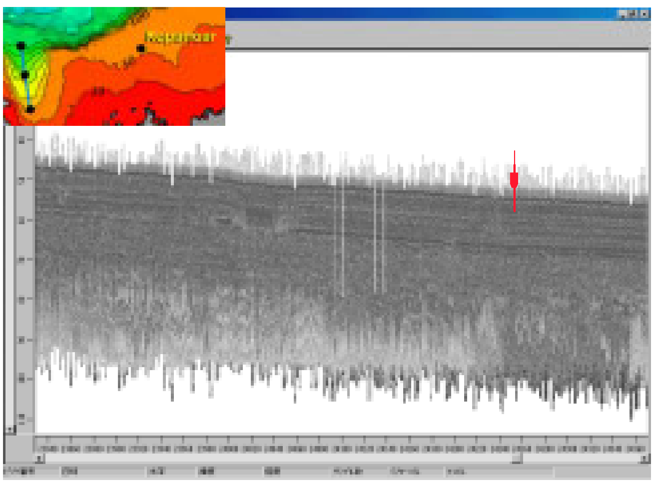


Fig. 9.1-5 Piston core sampling site (PC-3)

9.2 Sea surface gravity

(1) Personnel

Satoshi Okumura (GODI)

Souichiro Sueyoshi (GODI)

Norio Nagahama (GODI)

(2) Objective

To obtain the continuous gravity data for contribution of geophysical investigation.

(3) Sampling elements

Gravity at sea surface [mgal]

(4) Inventory information for sampling

We measured relative gravity values throughout MR02-K05 cruise from the departure of Sekinehama, Japan 24 August 2002 to arrival of Sehinehama, Japan on 6 November 2002.

(5) Instruments

LaCoste-Romberg onboard gravity meter S-116

(6) Calibration

For calibrating mechanical drift, we caliculate absolute gravity values in comparison with absolute values of reference point at Sekinehama Ports are shown in following table.

No	Date	UTC	Port	Absolute Gravity (mGal)	Sea Level (cm)	Draft (cm)	Gravity at sensor (mGal)*	L&R (mGal)
1	Aug/24	20:30	Sekinehama	980371.85	252.0	615	980372.66	12662.6
2	Sep/01	22:50	Dutch-Harbor	-	833.0	640	-	13819.2
3	Oct/10	20:00	Dutch-Harbor	-	322.0	629	-	13815.7
4	Nov/06	04:09	Sekinehama	980371.85	233.5	600	980372.60	12661.1

*: Gravity values at the sensor position of onboard gravimeter are calculated the follows;

Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431

Diff. L&R gravity	-1.5 mGal	(a)
Diff. Gravity at sensor	-0.06 mGal	(b)
L&R drift (a-b)	-1.44 mgal	(c)
Cruise term	73.32 days	(d)
Drift rate (c/d)	-0.02 mGal/day	

(5) Data archives

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

9.3 Surface three components magnetic field

(1) Personnel

Satoshi Okumura (GODI)

Souichiro Sueyoshi (GODI)

Norio Nagahama (GODI)

(2) Objective

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

(3) Sampling elements

Three component magnetic force	[nT]
Ship's attitude (Pitch, Roll and Heading)	[1/100 deg]

(4) Inventory information for sampling

The magnetic force is continuously measured during MR02-K05 (Leg1) cruise from the departure of Sekinehama, Japan 24 August 2002 to arrival of Dutch-Harbor, USA on 10 October 2002.

(5) Instruments

3-component magnetometer SFG-1214 (Tera Technica, Japan)

(6) Calibration

Turnning around at same potision using bow & stern thruster for calibration of magnetometer was performed near the Bering strait from 3:38 to 4:00 on October 8.

(5) Data archives

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

10. Cloud Science study over the Arctic Sea

10.1 Personnel

On board
Yasushi Fujiyoshi (FRSGC/Inst. Low Temp. Sci., Hokkaido Univ., Japan)
Kazuho Yoshida (Graduate School of Environmental Earth Science, Hokkaido Univ., Japan)
Souichiro Sueyoshi, Satoshi Okumura, Norio Nagahama (GODI, Japan)

Co-workers not on board
Sachio Ohta (Graduate school of Engineering, Hokkaido Univ., Japan)
Sadamu Yamagata (Graduate school of Engineering, Hokkaido Univ., Japan)
Yuji Fujitani (Graduate school of Engineering, Hokkaido Univ., Japan)
Tatsuo Endoh (Institute of Low Temperature Science, Hokkaido Univ., Japan)
Nobuo Sugimoto, Ichiro Matsui, Atsushi Shimizu (National Institute for Environmental Studies, Japan)
Hiroshi Kumagai, Hiroshi Kuroiwa, Hiroaki Horie, Akihide Kamei, Yuichi Ohno (Communications Research Laboratory, Japan)
Masayuki Sasaki (NASDA, EORC, Japan)
Osamu Tsukamoto (Department of Earth Sciences, Okayama University, Japan)
Hiroshi Ishida (Kobe Maritime University/FORSGC, Japan)

10.2 Objective

The purpose of this study is to make clear the dynamical and thermo-dynamical, micro-physical and radiative properties of the Arctic Stratus Cloud. A focus on polar clouds is motivated by poor understanding of the physical processes at work in the polar cloud boundary layer, and poor simulation of polar cloud, radiation, and boundary layer models by current climate models.

10.3 Instruments, methods and measured parameters

10.3.1 Radiosonde

Radiosonde observations were carried out from August 28 to October 7, 2002, by using GPS radiosondes (RS80-15G and RS80-15GH). We used DigiCORA MW11 (Vaisala Co. Ltd), GPS antenna (GA20), UHF antenna (RB21) and balloon launcher (ASAP). Prior to launch, humidity, air temperature, and pressure sensors were calibrated by using the calibrator system (Shinyei, C-1 and General Eastern, HYGRO-M4-RH + D-2-SR, PTB220). Measured parameters are temperature (℃), relative humidity (%), wind direction (deg), wind speed (m/s), air pressure (hPa).

Table 10.1 summarizes the log of upper air soundings. All data were sent to the world meteorological community by the global telecommunication system (GTS) through the Japan Meteorological Agency immediately after each observation. Raw data was recorded as ASCII format every 2-seconds during ascent.

Table 10.1 Radiosonde launch log.

No	Time(UTC) YYMMDDHH	Lat (deg)	lon (deg)	Surface Pres (hPa)	Surface Temp (degC)	Surface RH (%)	Surface WD (deg)	Surface WS (m/s)	Max Altitude (hPa)	Max Altitude (m)	Cloud Amt	Cloud Type
1	02082802	48.85N	160.32	1021.3	9.4	94	311	6.4	30.4	24069	10	St

			E									
2	02082814	50.51N	164.46 E	1002.2	9.0	93	254	5.5	30.2	23984	-	-
3	02082902	52.18N	168.73 E	1017.6	10.3	68	348	3.0	29.3	24274	0	St
4	02082913	53.51N	172.90 E	1017.4	9.5	83	82	1.6	28.2	24558	-	-
5	02083001	53.70N	178.22 E	1018.0	9.9	70	324	4.0	32.3	23672	6	Ac,Cu
6	02083013	53.90N	176.33 W	1014.4	10.0	76	297	5.8	33.2	23536	9	-
7	02083101	54.10N	171.07 W	1013.8	10.3	75	278	4.8	32.6	23672	9	Sc,St
8	02083112	54.30N	166.83 W	1015.7	9.7	82	239	5.0	38.1	22678	10	-
9	02090100	54.30N	166.81 W	1017.6	10.1	77	217	6.0	32.6	23686	4	Ci,Ac,At
10	02090400	60.05N	168.54 W	1008.2	10.8	97	161	13.6	25.2	25306	10	St
11	02090412	63.18N	167.43 W	1002.4	10.0	100	162	11.0	30.3	24131	-	-
12	02090500	65.52N	168.31 W	996.9	8.0	100	147	8.1	27.9	24618	10	St
13	02090512	68.36N	168.12 W	995.2	7.0	99	164	8.2	31.0	23932	10	-
14	02090600	70.50N	163.98 W	995.5	8.2	100	152	5.0	29.3	24236	10	As,St
15	02090612	70.85N	160.43 W	992.6	6.2	100	325	0.6	32.5	23551	5	St
16	02090700	71.67N	155.61 W	991.9	5.9	97	146	3.0	29.2	24172	1	Cu,Ci,As,St
17	02090706	72.07N	154.53 W	991.2	2.3	94	119	5.1	31.4	2706	6	As
18	02090712	71.31N	157.34 W	989.3	8.8	95	184	3.6	29.6	24057	1	As
19	02090718	71.35N	156.97 W	988.4	6.4	96	197	3.5	33.0	23345	4	Ci,As,St
20	02090800	71.83N	156.84 W	988.0	2.8	98	229	1.4	28.6	24247	1	Cu,Ci,As,St
21	02090806	71.72N	154.88 W	990.1	2.5	98	271	6.7	32.1	23516	10	St
22	02090812	71.77N	155.24 W	990.7	1.4	97	271	9.4	32.8	23368	10	St
23	02090818	72.11N	156.89 W	994.5	0.8	93	280	9.0	34.9	22958	10	Sc
24	02090900	72.48N	159.81 W	996.2	2.4	88	190	4.6	31.3	23627	1	Cu
25	02090906	72.83N	159.07 W	998.1	1.4	89	183	6.4	32.4	23439	0	-
26	02090912	73.05N	158.33	999.9	1.1	89	179	7.0	34.1	23139	0	-

			W									
27	02090918	73.35N	157.48 W	1000.7	1.3	91	164	6.9	45.8	21187	1	As
28	02091000	73.51N	157.06 W	1000.9	1.1	92	140	6.9	103. 4	15853	5	St
29	02091006	73.84N	157.01 W	1000.4	0.0	94	127	7.2	31.1	23700	10	St
30	02091012	74.33N	157.71 W	998.4	-0.7	99	115	3.3	34.1	23104	-	-
31	02091018	74.50N	158.01 W	995.8	-1.2	100	67	2.5	39.7	22144	10	Sc,St
32	02091100	74.45N	158.74 W	995.5	-1.1	98	237	3.3	33.9	23116	10	St
33	02091106	74.26N	158.26 W	995.9	-2.8	96	190	0.4	29.5	24026	10	St
34	02091112	74.46N	159.59 W	995.7	-3.4	95	254	1.5	40.4	21981	10	St
35	02091118	73.96N	161.53 W	995.5	-1.3	97	278	5.9	34.3	23025	10	St
36	02091200	74.12N	162.89 W	997.0	-1.6	81	229	6.2	37.4	22434	10	St
37	02091206	73.67N	164.11 W	996.7	-1.6	79	235	7.7	34.0	23074	10	St
38	02091212	73.6N	163.65 W	997.3	-1.4	85	207	7.8	36.2	22655	10	-
39	02091218	73.71N	161.00 W	996.9	0.0	93	151	10.2	29.2	24022	9	As,Sc,St
40	02091300	73.78N	159.00 W	997.6	-1.3	90	125	6.3	33.7	23060	9	Sc,St
41	02091306	73.94N	156.89 W	995.6	-2.6	92	344	2.9	41.9	21704	10	St
42	02091312	73.80N	155.66 W	994.7	-2.1	96	339	3.4	31.9	23492	10	St
43	02091318	73.50N	155.13 W	993.6	-2.0	96	17	4.6	33.8	23087	10	St
44	02091400	73.05N	154.34 W	992.3	-0.5	100	0	8.8	29.7	23985	10	Ns
45	02091406	72.49N	153.52 W	994.7	0.0	92	1	7.0	32.5	23361	10	St
46	02091412	72.00N	152.51 W	996.8	-0.7	96	48	7.0	28.0	24329	10	St
47	02091418	72.51N	151.36 W	997.5	-0.8	97	55	8.6	31.9	23485	10	St
48	02091500	73.00N	150.18 W	998.2	-0.5	99	55	9.6	33.1	23263	10	St
49	02091506	73.00N	148.02 W	997.1	-0.6	95	37	10.6	78.6	17669	9	Ac,As,St
50	02091512	72.50N	146.62 W	994.9	-0.5	98	48	10.4	32.0	23506	10	St
51	02091518	72.01N	146.00	993.9	1.2	100	69	6.2	27.2	24563	9	As,Sc

			W									
52	02091600	72.64N	143.15 W	996.5	-1.1	99	93	12.1	145.6	13656	10	St
53	02091606	72.71N	141.99 W	997.1	-1.4	99	80	7.4	33.1	23298	10	St
54	02091612	72.64N	142.35 W	997.2	-1.8	97	100	3.8	32.0	23529	10	St
55	02091618	72.49N	142.44 W	997.0	-0.8	100	66	3.6	30.4	23840	10	St
56	02091700	71.83N	142.08 W	997.9	0.2	100	312	3.1	39.9	22115	10	St
57	02091706	71.14N	142.00 W	1000.3	1.1	98	283	5.9	30.1	23925	10	As
58	02091712	71.08N	143.00 W	1002.0	0.5	88	280	5.9	37.1	22585	10	-
59	02091718	71.01N	141.99 W	1003.0	0.9	98	288	4.7	31.0	23709	10	St
60	02091800	70.73N	141.79 W	1004.1	1.4	100	291	5.4	29.3	24074	10	St
61	02091806	70.31N	141.44 W	1005.3	0.8	99	312	4.8	32.5	23410	10	As,Sc,St
62	02091812	70.13N	140.82 W	1005.8	0.8	97	280	3.3	34.7	23000	-	-
63	02091818	70.16N	139.97 W	1005.8	0.3	96	11	3.0	31.3	23650	10	As,St
64	02091900	70.25N	136.29 W	1004.6	0.1	94	6	5.2	32.1	23486	10	St
65	02091906	70.89N	133.99 W	1005.8	-0.9	97	353	5.1	41.9	21760	10	St
66	02091912	70.84N	134.12 W	1007.7	-0.7	100	353	6.9	43.2	21568	-	-
67	02091918	70.87N	133.96 W	1011.0	-1.7	94	7	5.0	36.0	22747	10	St
68	02092000	70.24N	133.95 W	1014.6	-1.5	95	7	7.4	37.1	22504	10	St
69	02092006	70.14N	133.49 W	1018.3	-0.9	96	11	7.1	39.4	22122	-	-
70	02092012	70.17N	133.62 W	1022.1	-0.5	89	3	7.7	37.9	22367	-	-
71	02092018	70.10N	133.42 W	1025.0	-0.1	84	40	4.2	45.3	21242	8	Sc,St
72	02092100	69.92N	133.26 W	1025.6	0.5	82	71	2.9	46.3	21096	9	Sc
73	02092106	70.69N	131.62 W	1025.2	-0.6	86	86	4.7	46.7	21023	10	Ns
74	02092112	71.00N	129.06 W	1025.0	-2.1	86	94	5.4	47.7	20884	-	-
75	02092118	70.75N	127.87 W	1024.6	-1.9	84	87	4.0	41.8	21719	8	Ac,As,St
76	02092200	70.58N	127.49	1023.9	-1.4	79	84	3.9	39.0	22213	10	Ns

			W									
77	02092206	70.90N	127.92 W	1021.5	-1.3	77	147	5.6	38.5	22295	-	-
78	02092212	70.86N	130.52 W	1017.1	-0.1	98	256	11.4	53.9	20125	10	Ns
79	02092218	70.47N	133.81 W	1022.0	-1.4	75	331	8.8	44.7	21291	10	St
80	02092300	70.40N	136.42 W	1026.1	-1.1	79	331	9.0	37.5	22553	10	St
81	02092306	70.44N	138.83 W	1027.4	-1.9	81	56	5.3	40.5	22007	-	-
82	02092312	70.48N	138.80 W	1027.4	-1.9	77	103	10.9	54.3	20093	10	St
83	02092318	70.40N	139.31 W	1026.1	-1.5	80	122	13.3	39.9	22065	10	As,Sc,St
84	02092400	69.89N	139.96 W	1021.5	0.3	87	105	16.7	68.5	18637	2	Cs,St
85	02092406	69.72N	138.13 W	1022.5	0.0	78	124	14.4	50.5	20636	8	Sc,St
86	02092412	69.94N	138.47 W	1022.2	-0.3	77	114	13.7	44.6	21387	10	St
87	02092418	69.92N	138.39 W	1022.5	-0.3	80	125	12.0	36.5	22662	10	St
88	02092500	69.56N	137.87 W	1022.1	0.6	74	123	11.9	39.0	22261	4	Sc
89	02092506	69.63N	137.01 W	1021.8	0.3	74	112	11.9	49.3	20790	0	-
90	02092512	69.77N	139.10 W	1017.3	0.6	84	111	13.7	52.8	20344	0	-
91	02092518	70.29N	137.23 W	1019.3	0.7	74	107	9.2	62.8	19232	8	Cs
92	02092600	70.13N	139.63 W	1014.3	0.4	75	107	8.8	57.1	19866	9	Sc,St
93	02092606	70.24N	138.26 W	1016.2	0.5	87	111	13.0	43.8	21586	1	Cs,As
94	02092612	69.99N	138.76 W	1013.2	1.2	76	112	15.3	49.3	20807	1	St
95	02092618	69.89N	139.60 W	1008.6	0.3	84	111	16.0	64.2	19150	4	Ci,Cu,As
96	02092700	69.99N	138.64 W	1004.5	1.7	77	112	11.4	47.0	21121	6	Ci,Ac,St
97	02092706	70.35N	139.01 W	998.7	2.0	76	109	14.9	47.4	21063	8	Ac,As
98	02092712	69.57N	138.15 W	992.7	2.5	86	123	13.0	51.5	20452	10	-
99	02092718	69.51N	138.10 W	999.0	1.9	96	107	9.0	44.7	21380	10	St
100	02092800	70.06N	138.17 W	992.2	0.7	99	72	8.5	46.1	21178	10	Ns
101	02092806	70.39N	135.39	993.1	1.1	97	77	9.8	55.2	19941	10	Ns

			W									
102	02092812	70.38N	135.43 W	995.0	1.4	96	84	10.1	57.6	19675	10	St
103	02092818	70.40N	135.43 W	998.0	0.4	98	77	14.4	48.9	20688	10	St
104	02092900	70.41N	135.57 W	1002.8	0.8	86	91	14.2	48.3	20706	9	Sc
105	02092906	70.41N	135.56 W	1006.7	-0.4	74	91	11.9	54.2	20024	10	St
106	02092912	70.38N	135.42 W	1009.9	-0.5	75	100	7.8	54.2	19999	10	-
107	02092918	70.15N	137.43 W	1009.6	-0.6	81	126	13.0	47.0	20908	10	St
108	02093000	70.06N	141.12 W	1007.0	-0.1	92	99	12.3	41.0	21832	10	St
109	02093006	70.73N	144.55 W	1007.4	-0.3	93	110	9.7	45.8	21119	10	St
110	02093012	71.16N	147.02 W	1007.0	0.3	93	115	11.4	60.1	19373	10	St
111	02093018	71.34N	149.93 W	1005.6	0.8	96	119	12.4	42.8	21503	10	St
112	02100118	73.57N	152.49 W	1012.0	-3.6	85	94	10.5	46.3	20946	10	St
113	02100218	74.75N	159.07 W	1021.1	-5.1	77	79	8.9	51.8	20222	10	St
114	02100301	74.97N	159.82 W	1022.5	-5.3	75	57	3.3	48.3	20668	10	As,St
115	02100318	76.32N	162.48 W	1019.1	-3.9	81	312	8.5	47.9	20671	10	St
116	02100400	75.99N	163.61 W	1018.8	-4.3	82	325	6.2	41.2	21614	10	St
117	02100418	75.98N	167.36 W	1011.6	-8.0	81	303	12.9	44.2	21125	10	St
118	02100518	73.84N	168.83 W	1000.3	-3.9	82	276	21.0	48.3	20556	10	Ns
119	02100621	69.81N	164.82 W	998.0	1.7	66	260	12.6	37.5	22124	10	Sc,St
120	02100723	65.64N	168.42 W	1004.1	-0.3	77	327	11.9	35.7	22508	10	Ns

10.3.2 Tethered balloon

Tethered balloon observations were conducted under calm condition (wind speed was less than 10 m/s). Air temperature, relative humidity and air pressure were measured by using GPS sondes. SW/LW radiation were measured by using a MR-40 (EKO Co. Ltd). Aerosol and condensation nuclei were measured by Handheld Particle Counter (RION, HHPC-6-KR-12A) and Condensation Particle Counter (TSI, Model 3007), respectively. Size distribution of cloud droplets was measured by a specially designed instrument. These instruments were attached to a string of tethered balloon. Table 10.2 summarizes the period of observations and measured components.

Table 10.2 Tethered balloon observation

	1	2	3	4	5
Y/M/D	2002/09/14	2002/09/16	2002/09/19	2002/09/20	2002/10/02
Time	02:00-04:00 UTC	20:48-21:40 UTC	21:30-22:56 UTC	21:08-22:32 UTC	23:21-24:35 UTC
Position	73-00N, 153-22.5 W	71-50.775N, 142-04.440W	70-21N, 133-40W	69-57.415N, 133-12.369 W	74-53.98N, 153-31.836 W
Measured components	T, RH, P, HHP, CN, Cloud droplets	T, RH, P, HHP, radiation, Cloud droplets	T, RH, P, HHP, CN, radiation	T, RH, P, HHP, CN, radiation	T, RH, P, HHP, CN, radiation
Highest level	500 m	400 m	600 m	985 m	740 m

10.3.3 Aerosol measurement

Sky Radiometer (POM-01MKⅡ; PREDE), equipped on deck, measured direct and aureole sun light intensity every 5min. The sensor provides optical thickness, Åangstrom exponent and size distribution of atmospheric aerosols. *In-situ* measurement was conducted during this cruise. Sample air was drawn through inlets 5m height on compass deck, to manifold in research room. Particle larger than 2 μm in diameter were removed by cyclone separators. From the manifold, the sample air was distributed to Particle Soot / Absorption Photometer (PSAP; Radiance Research), Integrating Nephelometer (IN; M903; Radiance Research) and Optical Particle Counter (OPC; KC-01C; RION). PSAP measured volume absorption coefficient, IN measured volume scattering coefficient and OPC counted number concentration of aerosols larger than 0.3, 0.5, 1.0, 2.0 and 5.0 μm in diameter. All measurements were conducted every 1min. The aerosols were also collected on filter for chemical analysis. Aerosol sampling was performed with the special cautions not to be contaminated with chimney exhaust. The samples were stored in the refrigerator.

10.3.4 Doppler radar (C-band)

C-band Doppler radar observed three dimensional radar echo structure and wind fields of rain/snow cloud. Measured parameters are Radar reflectivity factor (dBZ), Doppler velocity (m/s), and velocity width (m/s). The specifications of R/V MIRAI shipboard Doppler radar (RC-52B, Mitsubishi Electric Co. Ltd., Japan) are as follows.

Frequency: 5290MHz (C-band)
Beam Width: better than 1.5 degrees
Transmit Power: 250kW (Peak Power)
Signal Processor: RVP-7 (Sigmet Inc., U.S.A)
Inertial Navigation Unit: DRUH (Honeywell Inc., U.S.A)
Application Software: IRIS/Open Ver.7.25 (Sigmet Inc., U.S.A)

We checked transmitted frequency, mean output power and pulse repetition frequency (PRF) once per a few days. Pulse width and the amplifier were checked before and after the cruise. The observation was performed continuously except for 6 to 8 Sep., 2002. During the observation, the programmed “tasks” were repeated every 10 minutes. One cycle consists of one-elevation “Surveillance” PPI with Intensity-mode (300-km range for reflectivity), one “volume scan” (consists of 21 PPI scans) with Doppler-mode (160-km range for reflectivity, Doppler velocity and velocity width). RHI (Range Height Indicator) scans with Doppler-mode were intermittently operated to obtain detailed vertical cross sections of precipitating clouds. The parameters for the above three tasks are listed in Table10.3

Table 10.3 Selected parameters of C-band Doppler radar

	Surveillance PPI	Volume scan	RHI
Pulse width	2.0 [μs]	0.5 [μs]	
Scan speed	18 [deg/sec]		Automatically determined
PRF	260 [Hz]	900/720 [Hz]	
Sweep integration	32 samples		
Ray spacing	about 1.0 [deg]		0.2 [deg]
Bin spacing	250 [m]	125 [m]	
Elevations	0.5	0.5, 1.2, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.1, 11.3, 12.8, 14.6, 16.6, 18.9, 21.6, 25.0, 29.0, 34.0, 40.0	0.0 to 70.0
Azimuths	Full Circle		Optional
Range	300 [km]	160 [km]	
Software Filters	No filter	Dual-PRF velocity unfolding	
Gain control	Fixed		

10.3.5 Doppler sodar

We used a Doppler sodar (Remtech Co. Ltd, PA1-NT). The phased array Doppler sodar continuously and reliably measure wind speed and direction, vertical motions and turbulence at heights ranging from 15 m up to 2,000 m. Briefly, this measurement is accomplished by emitting a strong acoustic pulse in the audio band and detecting the Doppler frequency shift of the received backscattered echo. This backscattered echo signal is due to thermal turbulence in the atmosphere. The Doppler sodar system basically consists of one sole antenna (phase array type) and an electronic case. In the electronic case are the computer, transceiver, and power amplifier. Also included are interconnecting cables and a small mount for the antenna. The system allows for full control of the antenna beams: four of the electronically steered beams are tilted or from vertical and turned 90 deg from each other to provide the horizontal component of wind velocity. The last bema is pointed vertically and provides that component of the wind. The system software controls the sequence and rate of operation for each beam. These are non system parameters which can be changed through keyboard input. Table 10.4 summarizes the specifications of the Doppler sodar. Measured parameters are wind direction (deg), wind speed (m/s), and standard deviation of wind direction and speed.

Table 10.4 Specifications of Doppler sodar

Number of elements	52
Type of elements	Motorola 1025
Nominal central operating frequency (Hz)	2100
Antenna size (m)	0.65 x 0.65
Antenna weight	25 Kg
Acoustic Power	1W
Maximum range	2,000 m
Average range in typical conditions	1,300 m

Raw data (echo strength, wind speed, wind direction, vertical speed, standard deviation of wind speed and direction) were averaged for 10 minutes. Maximum height and height interval were set to be 800 m and 30 m, respectively. Continuous observation started on Sep. 2 and terminated on Sep. 10, 2002. The wind speed and direction must be corrected, because “Mirai” changed its moving speed and direction.

10.3.6 Dual polarization lidar

Vertical profiles of aerosols and clouds were measured with a dual polarization lidar. The lidar employs a Nd:YAG laser as a light source. The receiver telescope has a diameter of 25 cm. The detected signals were recorded with a digital oscilloscope and stored on a hard disk with a computer. The lidar system was installed in a 20-ft container with the cloud profiling radar (CPR) of the Communications Research Laboratory (CRL). The container has a glass window on the roof, and the lidar was operated continuously regardless of weather. Measured parameters are Vertical profiles of backscattering coefficient and depolarization ratio. Heightl and temporal resolutions are 6 m and 10 seconds, respectively. The lidar was continuously operated from 09021820 to 10101320 UTC, except for 09100140-09100625 UTC and 09231750- 09232010 UTC.

10.3.7 Cloud radar and microwave radiometer

CRL has developed an airborne W-band CPR named SPIDER operating at 95GHz. For the cruise of Mirai vessel, the CPR system was modified to be suitable for shipborne measurements. The CPR and the lidar system (National Institute for Environmental Studies: NIES) were co-located in the same container on the upper deck of Mirai to study vertical distribution and microphysics of clouds. The microwave radiometer with dual-frequencies (23.8GHz and 31.4GHz) was also installed. The CPR was continuously operated during the cruise. The basic operating parameters for CPR measurements are listed in Table 10.5.

The basic elements of observations are cloud boundaries, cloud microphysics such as effective radius and ice/liquid water content (IWC/LWC), fall velocity of the cloud particles, depolarizations (non-sphericity), and vertical distribution of aerosols. The microwave radiometer provides precipitable water and liquid water path.

Table 10.5 Basic operating parameters for CPR measurements.

<table>
<tr><td>Pulse Width (nsec)</td><td colspan="2">1100</td><td colspan="2">2125</td></tr>
<tr><td>Filter (MHz)</td><td colspan="2">1.0</td><td colspan="2">0.5</td></tr>
<tr><td>Polarized Wave</td><td colspan="4">VVHV</td></tr>
<tr><td>Doppler</td><td colspan="4">cc, cc, cc</td></tr>
<tr><td>Pulse Repetition Time (sec)</td><td>120×3, 4640</td><td>150×3, 6550</td><td>220×3, 4340</td><td>220×3, 2840</td></tr>
<tr><td>Number of Noise Samples</td><td colspan="4">8</td></tr>
<tr><td>Number of Range Gates</td><td>180</td><td>241</td><td>92</td><td>123</td></tr>
<tr><td>Gate Spacing (m)</td><td colspan="2">82.5</td><td colspan="2">162.5</td></tr>
<tr><td>Range Gate Delay (m)</td><td colspan="4">150</td></tr>
<tr><td>Maximum Range (m)</td><td>15000</td><td>20032.5</td><td>15100</td><td>20137.5</td></tr>
<tr><td>Average Number</td><td>44</td><td>32</td><td>88</td><td>64</td></tr>
<tr><td>External Average</td><td colspan="4">1</td></tr>
<tr><td>Acquisition Time (msec)</td><td>220</td><td>224</td><td>440</td><td>224</td></tr>
</table>

10.3.8 Eddy flux measurement

We deployed an automatic eddy flux measurement system on R/V MIRAI, which includes ship motion correction for the eddy correlation method. Direct eddy covariance system requires fast response turbulence sensors including a sonic anemometer-thermometer and an infrared hygrometer. The MIRAI eddy flux system consists of a 3D sonic anemometer- thermometer (Kaijo DA-600) and an infrared hygrometer(Kaijo AH-300). These turbulence sensors were installed at the top of the foremast to optimally reduce the ship body dynamical and thermal effects. Ship motions were also measured simultaneously by a inclinometer (Applied Geomechanics, MD-900-T) and three axis accelerometers(Applied Signals, QA700-020) and rate gyros(Systron Donners, QRS11-0050-100). Figures 1 and 2 show the sensor installation at the top of the foremast and block diagram of the observation.

The signals from turbulence sensors and motion sensors were sent to a PC based data acquisition system including “Labview”(National Instruments). The sampling frequency of all data was 10Hz. After filtering out high frequency noises and low frequency trends, ship motion correction was applied to the wind velocity data. Although air temperature signal was well calibrated, the calibration factor of humidity sensor varied with time. So we included real time calibration unit in the Labview system with a standard hygrometer as a low frequency reference. This is called “Dynamic calibration”. After these correction procedures, 10 minutes eddy fluxes and statistics were obtained in real-time and filed as well as raw turbulence data.

10.4 Preliminary results

Figure 10-1 shows the time-height cross section of relative humidity and air temperature from Sep. 7 to Sep. 31, 2002. High humidity (>90 %) was found only below the level of 500 m except for Sep. 21-23 and Sep.27-29, 2002, when cold fronts passed over “MIRAI”. When warm air (>0 ℃) advected above 500m, strong temperature inversion was formed below 500 m (Sep. 14-20 and Sep. 25-28). During these periods of time, multi-cloud layers appeared as shown in Fig. 10-2.

The radar echo structure observe on Sep. 17, 2002, clearly indicates the seeder-feeder process, that is, ice particles formed in the upper level cloud seeded the lower level clouds. When the feeder-seeder process occurred, the special type of snow crystals were found as shown in Fig. 10-3a. The name of the crystal is “column with dendrites”. When the feeder-seeder process did not occur, combination of bullets or bullets were the typical shape of snow crystals (see Fig. 10-3b). Although the seeder-feeder process was often found during the cruise, most of snow crystals evaporated during their fall as shown in Fig. 10-2. This fact indicates that water cycle below the Arctic stratus cloud is almost independent of that above the cloud.

Although radars and lidar are very useful instruments to study the fine structure of clouds, in situ measurement is indispensable to verify these remote sensing data. Figure 10-4 shows an example of microscopic image of cloud droplets collected on Sep. 14., 2002, by specially designed cloud sampler attached to the string of the tethered balloon (see Fig. 10-5). The size of cloud droplet in the figure ranged from 5 μm to 30 μm in diameter.

Figure 10-6 shows the vertical profiles of the total number of condensation nuclei (CN) on Sept. 14, 19, 20 and Oct. 02, 2002. The total number of CN below the low-level cloud base was almost constant with height, and that just above the low-level cloud was generally much larger than that below the cloud base.

In summary, we should pay much attention to multi-layer structure of both cloud and aerosols to study water and material cycles in the Arctic region.

10.5 Archives

All data will be archived by Hokkaido University and submitted to JAMSTEC Data Management Office.

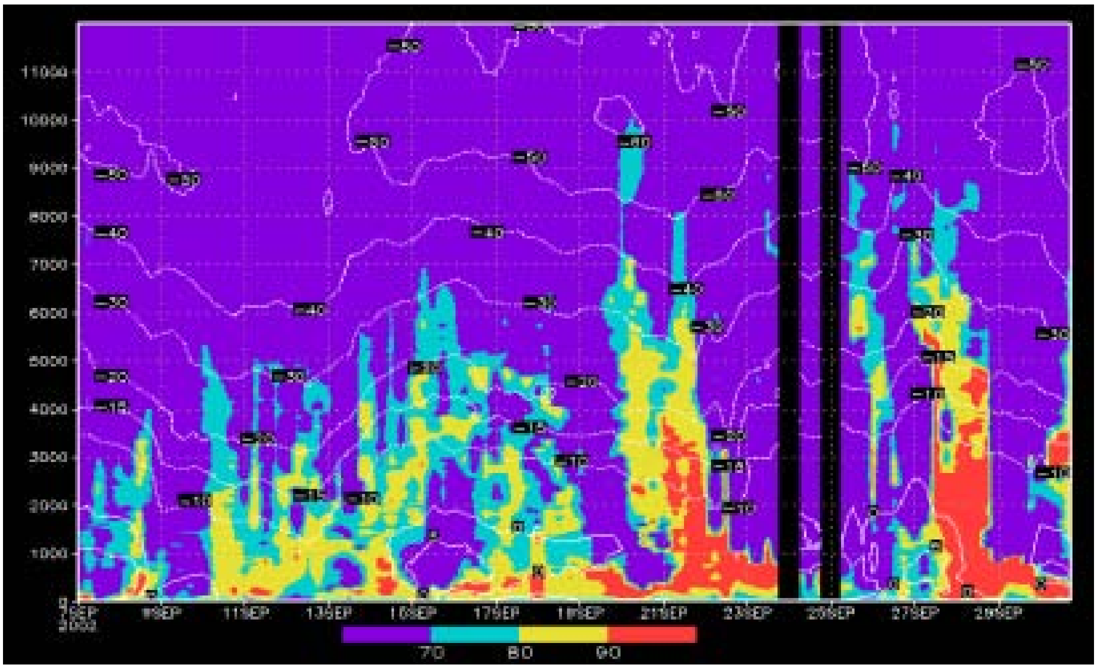


Fig. 10-1 Time-height cross section of relative humidity (shaded) and air temperature (contour) from 7 to 29 Sep., 2002.

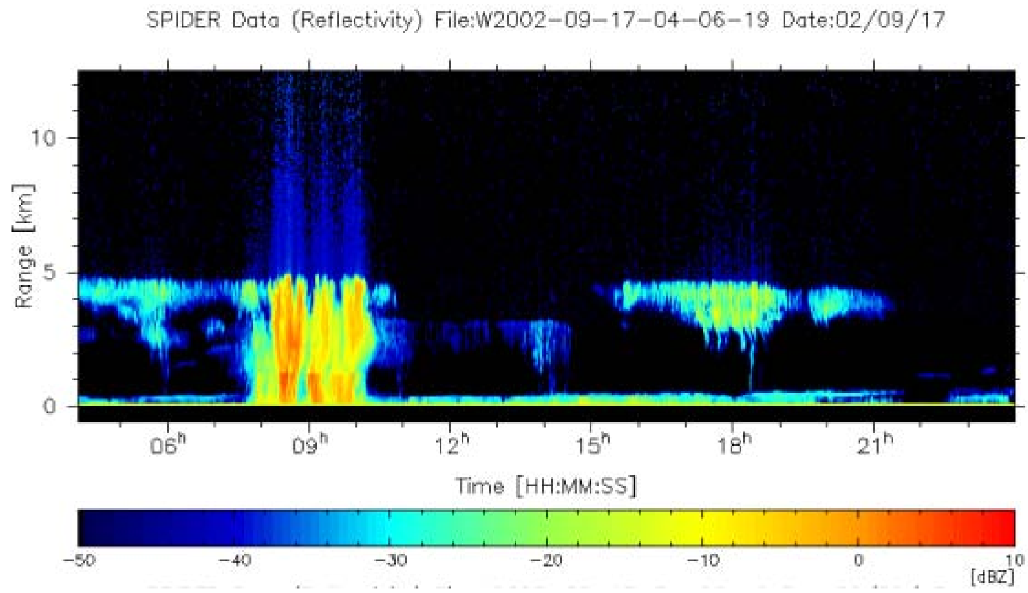


Fig. 10-2 Time-height cross section of radar reflectivity factor (dBZ) from 05 – 24 UTC on Sep. 17, 2002.

Fig.10-3a A column with dendrite type of snow crystal.

Fig.10-3b Combination of bullets and bullet type of snow crystals.

Fig. 10-4
An example of microscopic picture of cloud droplets sampled on Sep. 14, 2002, by using a specially designed cloud droplet sampler.

Fig. 10-5
A picture of the tethered balloon. Attached to the string are cloud droplet sampler, condensation nuclei counter, aerosol counter, and radiosonde.

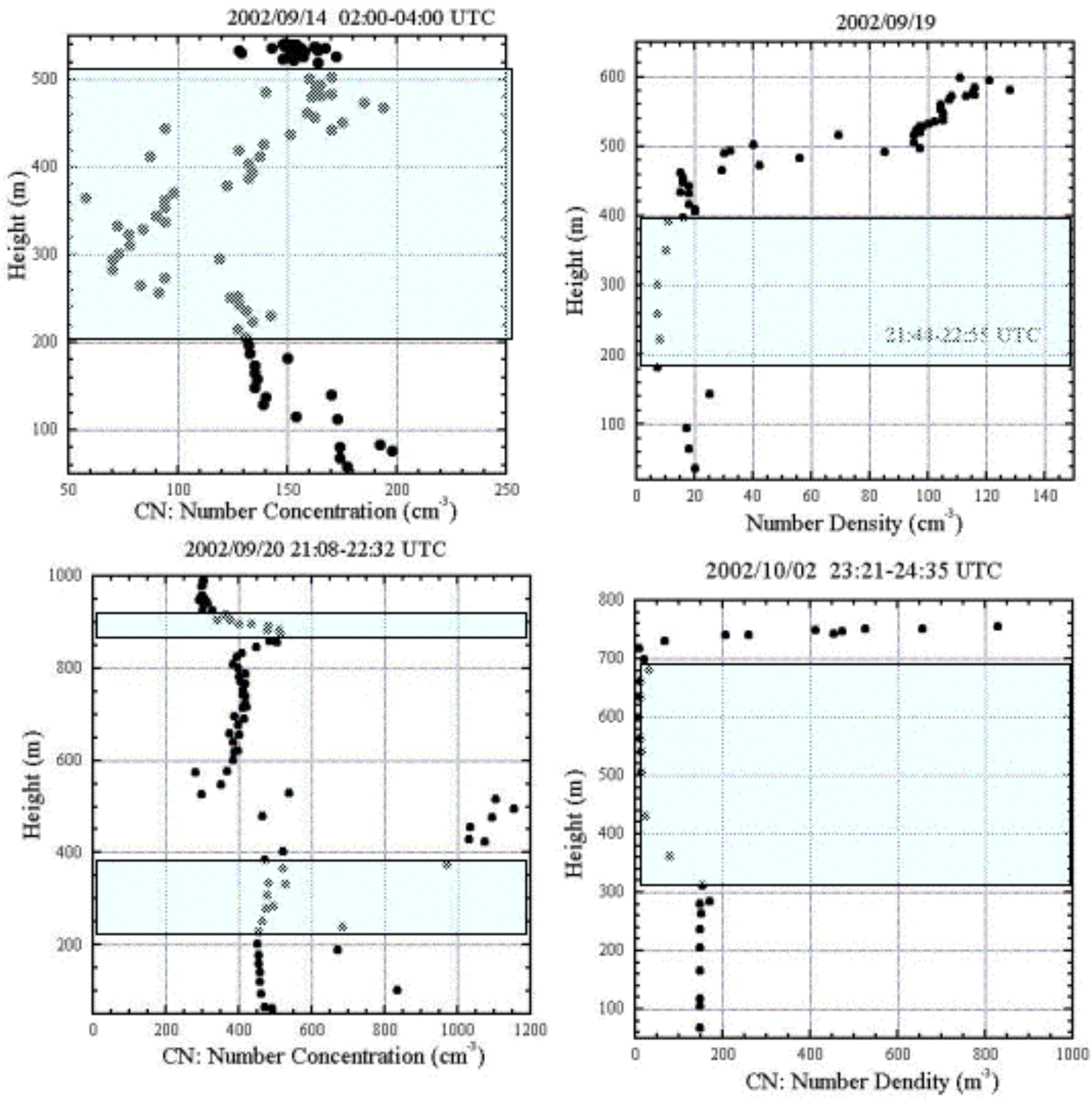


Fig. 10-6　Vertical profiles of the total number of condensation nuclei (CN) on Sept. 14, 19. 20 and Oct. 02. 2002.　The shaded regions indicates the cloud layers.