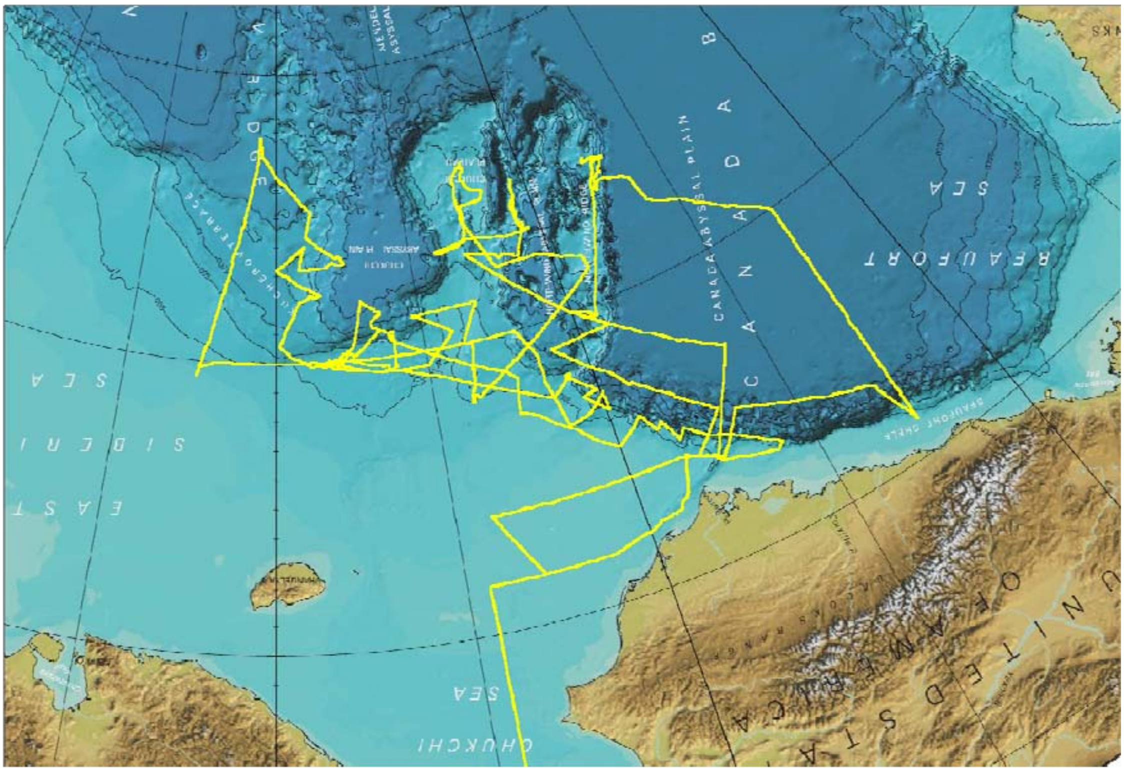
R/V Mirai Cruise Report

MR08-04

(R/V Mirai International Polar Year 2008 cruise)

August 15 - October 9, 2008

(Sekine-hama ~ Dutch Harbor ~ Dutch Harbor)



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Preface

Recent reduction of sea ice cover in the Arctic Ocean is a significant symptom of global climate change. The rate of the sea ice reduction in the Arctic is much greater than the global averaged warming of surface temperature. This implies that a significant positive feedback to reduce the sea ice has initiated in the Arctic climate system. From satellite images, we can just realize the less ice-covered Arctic Ocean after the drastic change. Now we should seek the precondition of the drastic change and mechanism of accelerated reduction of sea ice. The reduction of sea ice is not only caused by sea ice melt but also by less sea ice formation. The origin of sea ice is sea water. Changes in the oceanic structure affecting the drastic Arctic change is now should be carefully investigated by in-situ observation.

The summer minimum sea ice extent in 2008 was resulted in the second minimum record after the passive microwave observation since 1979. The sea ice extent is slightly smaller than that in 2007. This was caused by a further activation of sea ice motion associated with fragmentation of sea ice near the coast of the Banks and Queen Elizabeth Islands. The fragmentation of sea ice suggest the thinning if sea ice associated with less ice formation and increase of sea ice transport from Pacific side of the Arctic Ocean to the Atlantic side of the Arctic Ocean. The anti-cyclonic oceanic Beaufort Gyre driven by the strong sea ice motion in 2007/2008 winter was anomalously accelerated. These preconditioning was identified before the MR08-04 cruise in the summer of 2008.

In this circumstance, MR08-04 entitled as “R/V Mirai International Polar Year 2008 cruise”, was conducted as a mission of 4th International Polar Year (IPY). This was the first Japanese IPY cruise that entered the Arctic basins. The core science mission was organized to capture the mechanism of the drastic Arctic changes and their influences on the biogeochemical environment. In addition the science on the recent drastic changes, paleo-oceanographic observation was also involved to learn the history of Arctic climate system. The science station occupied by MR08-04 covered full span of the southern Canada Basin and Eastern Makarov Basin, especially focusing on the Chukchi Borderland area where the main pathway of the Pacific Water and western margin of oceanic Beaufort Gyre. The data acquired by MR08-04 cruise shows a fruitful feature of the changes in the ocean which was not identified by remote sensing and numerical simulation. The data of Mr08-04 would be a basis to progress our knowledge on Arctic changes. I hope that this cruise will be a legacy for further sustaining development of Japanese Arctic science.

I am very indebted to Captain Akamine and all crews of R/V Mirai, onboard and offboard marine technicians belonged to MWJ and GODI, and all participants who create the MR04-05 cruise together. I am also deeply indebted to Dr. Nobuo Suginohara who was the first director general of Institute of Observational Research for Global Change in JAMSTEC.

Koji Shimada
Chief scientist of MR08-04

1. Outline of MR0804

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

MR08-04

1.1.3 Project Name

R/V Mirai International Polar Year 2008 cruise

1.1.4 Undertaking Institute

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

2-15 Natsushima-cho, Yokosuka 237-0061, Japan

1.1.5 Chief Scientist

Koji Shimada (Tokyo University of Marine Science and Technology / JAMSTEC)

1.1.6 Periods and Ports of Call

Aug. 15, 2008 ~ Oct. 9, 2008

(Sekine-hama ~ Dutch Harbor)

1.1.7 Observation Summary

CTD (+ water sampling) 204 stations

CTD (only) 56 stations

XCTD 195 stations

ADCP Observation Continuously

Oceanic Environment Monitoring Continuously

Surface Meteorology Continuously

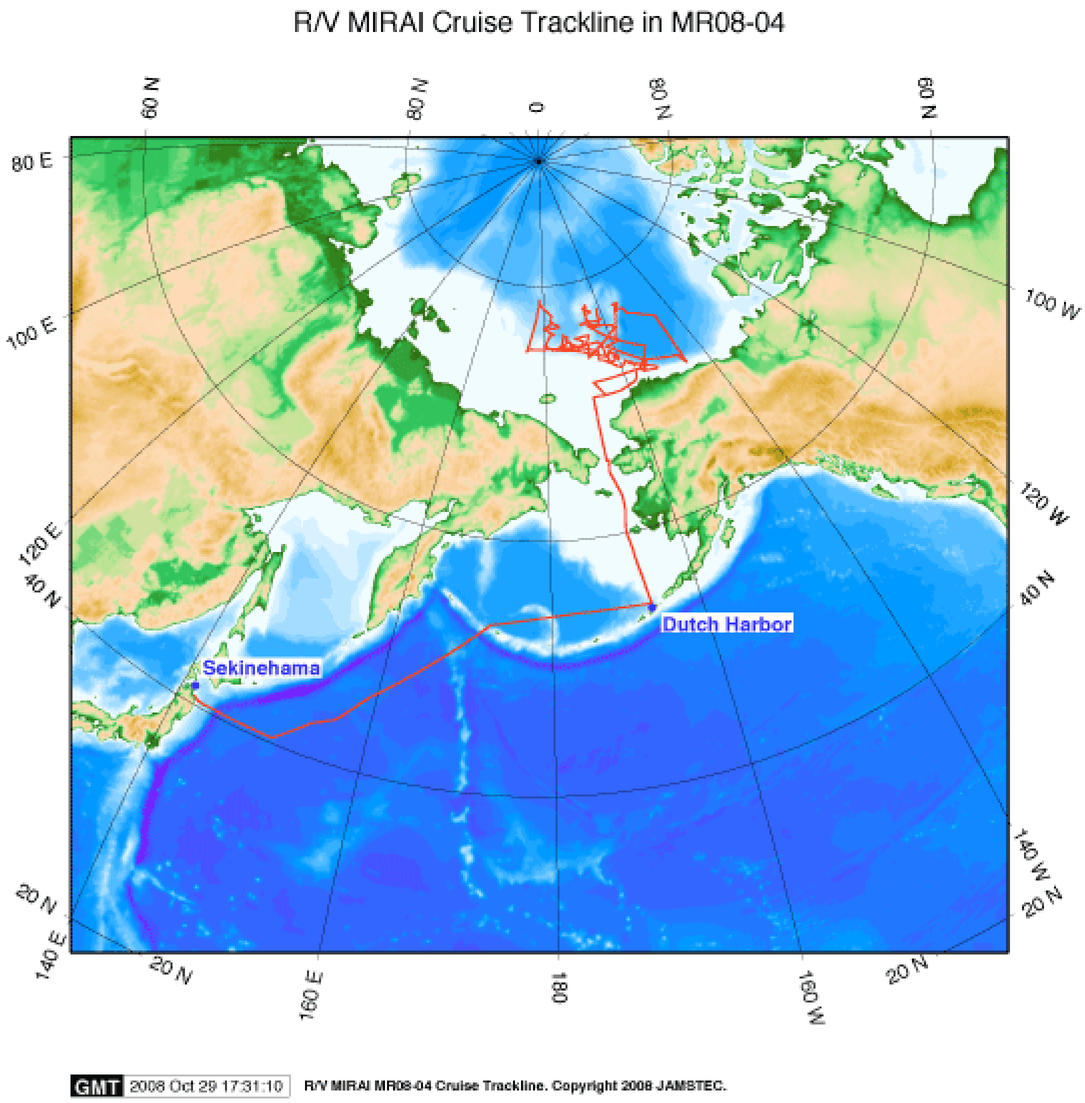
Mooring recoveries 6

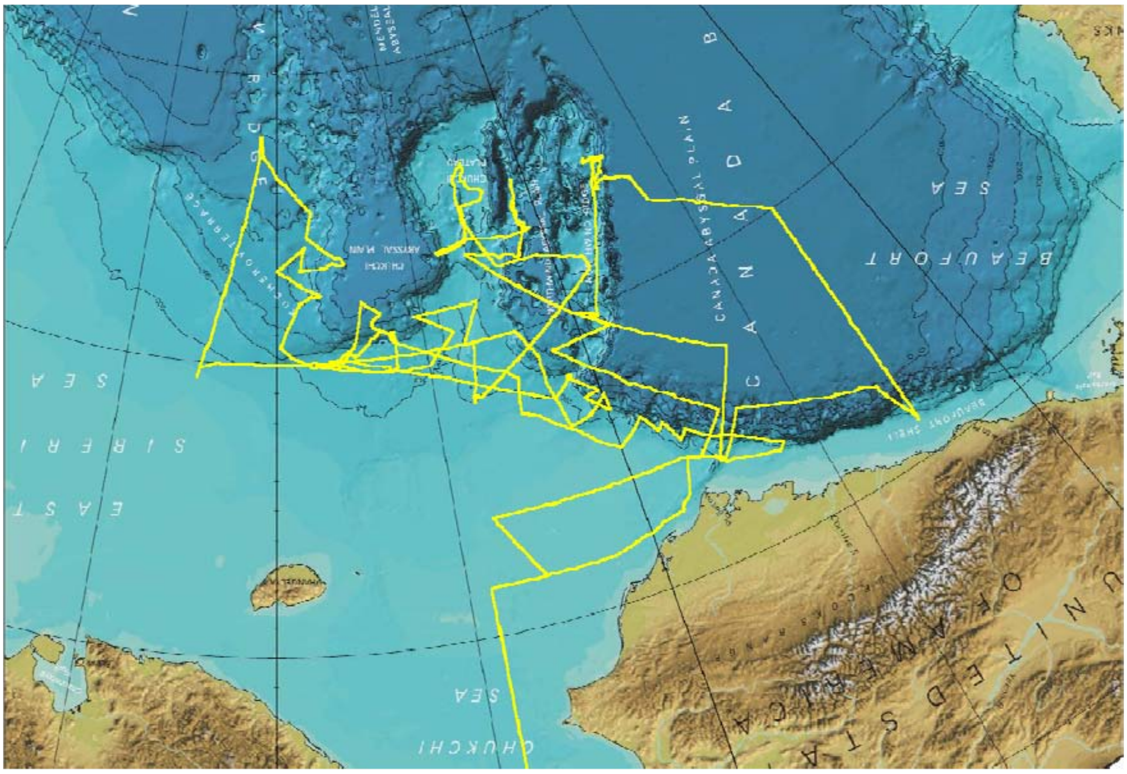
Mooring deployments 3

Plankton Net Sampling (Multi layer) 14 stations

Plankton Net Sampling (Single layer) 54 stations
Sea Floor Topography (Seabeam) Continuously
Radiosonde Launching 95 times
Doppler Radar Observation Continuously
Aerosol measurement Continuously
Dual polarization lidar Continuously
Cloud radar Continuously

1.2. Strategy and cruise track





1.3. Participant list

Scientist on board

Koji Shimada	Chief Scientist	Tokyo University of Marine Science and Technology / JAMSTEC	SD
Motoyo Itoh	Scientist	JAMSTEC	SD
Naoyuki Kurita	Scientist	JAMSTEC	HD
Takashi Kamoshida	Scientist	System Intech Co.,Ltd	SD
Amane Fujiwara	Scientist	Hokkaido University	SD
Kohei Mizobata	Scientist	Tokyo University of Marine Science and Technology	DD
Satoshi Fujita	Scientist	Hokkaido University	SD

Yuta Nakayama	Scientist	Hokkaido University	SD
Kohei Matsuno	Scientist	Hokkaido University	SD
Noriyuki Oya	Scientist	Nagoya University	SD
Michiyo Kawai	Scientist	Institute of Ocean Sciences, Canada	DD
Masao Uchida	Scientist	National Institute for Environmental Studies	DD
Motoo Utsumi	Scientist	University of Tsukuba	DD
Yukiko Kuroki	Scientist	University of Tsukuba	SD
Chie Sato	Scientist	University of Tsukuba	SD
Yuko Tange	Scientist	Tokai University	SD
Celine Gueguen	Scientist	Trent University	DD
Kenichi Katayama	Technician	MWJ	SD
Takayoshi Seike	Technician	MWJ	SD
Shunsuke Tanaka	Technician	MWJ	SD
Satoshi Ozawa	Technician	MWJ	DD
Fujio Kobayashi	Technician	MWJ	DD
Tomohide Noguchi	Technician	MWJ	DD
Akinori Murata	Technician	MWJ	DD
Akira Watanabe	Technician	MWJ	DD
Masanori Enoki	Technician	MWJ	DD
Ayumi Takeuchi	Technician	MWJ	DD
Yohei Taketomo	Technician	MWJ	DD
Yuko Sagawa	Technician	MWJ	DD
Takami Mori	Technician	MWJ	DD
Minoru Kamata	Technician	MWJ	DD
Junji Matsushita	Technician	MWJ	DD
Ayaka Hatsuyama	Technician	MWJ	DD
Miyo Ikeda	Technician	MWJ	DD
Kenichiro Sato	Technician	MWJ	DD
Satoshi Okumura	Technician	GODI	DD
Shinya Okumura	Technician	GODI	SD
Soichiro Sueyoshi	Technician	GODI	DD
Harumi Ota	Technician	GODI	SD
Tomohito Yonemoto	Outreach Staff	JAMSTEC	DD
Toshiaki Umekawa	Outreach Staff	MONTAGE INCORPORATION	DD
Katsutoshi Terakado	Outreach Staff	MONTAGE INCORPORATION	DD

SD: Sekine-hama to Dutch Harbor
HD: Hachinohe to Dutch Harbor
DD: Dutch Harbor to Dutch Harbor
SH: Sekine-hama to Hachinohe

Other scientists

Sei-Ichi Saitoh	Scientist	Hokkaido University
Tohru Hirawake	Scientist	Hokkaido University
Kunio Yoneyama	Scientist	JAMSTEC
Nobuo Sugimoto	Scientist	National Institute of Environmental Studies
Ichiro Matsui	Scientist	National Institute of Environmental Studies
Atsushi Shimizu	Scientist	National Institute of Environmental Studies
Tomoaki Nishizawa	Scientist	National Institute of Environmental Studies
Kenshi Kuma	Scientist	Hokkaido University
Atsushi Yamagushi	Scientist	Hokkaido University
Hiromi Yamazawa	Scientist	Nagoya University
Shigeki Tasaka	Scientist	Gifu University
Kimpei Ichiyanagi	Scientist	JAMSTEC
Hironori Fudeyasu	Scientist	University of Hawaii, International Pacific research Center
Takeshi Matsumoto	Scientist	University of the Ryukyu
Masao Nakanishi	Scientist	Chiba University
Osamu Tsukamoto	Scientist	Okayama University
Hiroshi Ishida	Scientist	Kobe University
Fumiyoshi Kondo	Scientist	Okayama University
Toshiaki Takano	Scientist	Chiba University
Hajime Okamoto	Scientist	Tohoku University
Hideji Abe	Scientist	Chiba University
Kenichi Ookushi	Scientist	Kobe University
Yutarou Asano	Scientist	Kobe University

Hidetoshi Kumata	Scientist	Tokyo University of Pharmacy and Life Sciences
Hisashi Narita	Scientist	Tokai University
Jing Chang	Scientist	Toyama University
Tomomi Nakamura	Scientist	Toyama University
Saori Nakagawa	Scientist	JAMSTEC

Crew Members

Masaharu Akamine	Captain	GODI
Yasushi Ishioka	Chief Officer	GODI
Takeshi Isohi	First Officer	GODI
Nobuo Fukaura	Second Officer	GODI
Hajime Matsuo	Third Officer	GODI
Noriyuki Hatachi	Extra Officer	GODI
Hiroyuki Suzuki	Chief Engineer	GODI
Koji Masuno	First Engineer	GODI
Hiroyuki Tohken	Second Engineer	GODI
Toshio Kiuchi	Third Engineer	GODI
Mitsunobu Asanuma	Technical Officer	GODI
Yosuke Kuwahara	Boat Seaman	GODI
Masami Sugami	Able Seaman	GODI
Kazuyoshi Kudo	Able Seaman	GODI
Tsuyoshi Sato	Able Seaman	GODI
Tsuyoshi Monzawa	Able Seaman	GODI
Shuji Komata	Able Seaman	GODI
Takeharu Aisaka	Able Seaman	GODI
Norimichi Aosaki	Able Seaman	GODI
Yusuke Asano	Ordinary Seaman	GODI
Hideaki Tamotsu	Ordinary Seaman	GODI
Masaya Tanikawa	Ordinary Seaman	GODI
Yukitoshi Horiuchi	No.1 Oiler	GODI
Toshimi Yoshikawa	Oiler	GODI
Yoshihiro Sugimoto	Oiler	GODI

Kazumi Yamashita	Oiler	GODI
Nobuo Boshita	Oiler	GODI
Keisuke Yoshida	Ordinary Oiler	GODI
Hiroki Sato	Extra Oiler	GODI
Kitoshi Sugimoto	Chief Steward	GODI
Sakae Hoshikuma	Cook	GODI
Tatsuya Hamabe	Cook	GODI
Masao Hosoya	Cook	GODI
Kozo Uemura	Cook	GODI
Yoshiteru Hiramatsu	Extra Cook	GODI
Anthony O'Connell	Ice Pilot	GODI

2. Ocean Physics

2.1. CTD cast and water sampling

(1) Personnel

Koji Shimada (JAMSTEC) : Principal Investigator
Motoyo Itoh (JAMSTEC) : Scientist
Kenichi Katayama (MWJ) : Operation Leader
Satoshi Ozawa (MWJ)
Fujio Kobayashi (MWJ)
Tomohide Noguchi (MWJ)
Akinori Murata (MWJ)
Akira Watanabe (MWJ)

(2) Objective

Investigation of oceanic structure.

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary and Secondary)
Fluorescence
CDOM

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler (CWS) 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, dissolved oxygen (Primary and Secondary), oxygen optodes, deep ocean standards thermometer, altimeter, fluorometer, and CDOM sensor. 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.7.17a) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer. We sampled seawater for analysis of salinity, dissolved oxygen, nutrients, and total alkalinity (routine cast).

To save the ship time, we performed the way below to sample the seawater. Usually the package was heightened at a rate of 1.2 m/s.

<Sampling layer>	<Way of sample the seawater>
Bottom-5 – 2000dbar	stop at the layer for 30 seconds to stabilize then fire
1750 – 500dbar	decelerate a rate to 0.5 m/s then fire
450 – 100dbar	heightened at a rate of 1.0 m/s then fire (nonstop)
75 – 5dbar	stop at the layer for 30 seconds to stabilize then fire

A total of 262 casts of CTD measurements were conducted, usually to within 5-10 meters of the bottom (table 2.1-1). No major problems were encountered during the operation.

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.17a) and SEASOFT were as follows:

(The process in order)

DATCNV : Convert the binary raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. We set 2 way of DATCNV processing.

Case1 : sampling layer deeper than 2000 dbar

Scan range duration = 4.4 seconds

Scan range offset = 0.0 second

Case2 : sampling layer shallower than 2000 dbar

Scan range duration = 1.0 second

Scan range offset = -0.5 second

TCORP (original module) : Corrected the pressure sensitivity of the temperature (SBE3) sensor.

S/N 1525 : -5.92243e-09 (degC/dbar)

BOTTLESUM : Create a summary of the bottle data. The data were averaged over 4.4 seconds (Case1) and 1.0 second (Case2), respectively.

ALIGNCTD : Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing oxygen sensor output (oxygen voltage) relative to the temperature data. Prototype of the oxygen optode data (RINKO3) are also delayed by slightly slow response time to the sensor. The delay was compensated by 2 seconds advancing

WILDEDIT : Mark extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 1000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to all variables.

CELLTM : Remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

FILTER : Perform a low pass filter on pressure with a time constant of 0.15 second. In order to produce zero phase lag (no time shift) the filter runs forward first then backwards.

WFILTER : Perform a median filter to remove spikes in the fluorescence data. A median value was determined by 49 scans of the window.

SECTIONU (original module of SECTION) : Select a time span of data based on scan number in order to reduce a file size.

The minimum number was set to be the starting time when the CTD package was beneath the sea-surface after activation of the pump. The maximum number of was set to be the end time when the package came up from the surface. Data for estimation of the CTD pressure drift were prepared before SECTION.

LOOPEDIT : Mark scans where the CTD was moving less than the minimum velocity of 0.0 m/s (traveling backwards due to ship roll).

DESPIKE (original module) : Remove spikes of the data. A median and mean absolute deviation was calculated in 1-dbar pressure bins for both down and up cast, excluding the flagged values. Values greater than 4 mean absolute deviations from the median were marked bad for each bin. This process was performed 2 times for temperature, conductivity, oxygen voltage (SBE43) and oxygen optode data.

DERIVE : Compute oxygen (SBE43)

BINAVG : Average the data into 1-dbar pressure bins.

DERIVE : Compute salinity, potential temperature, and sigma-theta.

SPLIT : Separate the data from an input .cnv file into down cast and up cast files.

Configuration file

MR0804b.con

Specifications of the sensors are listed below.

CTD : SBE911plus CTD system

Under water unit :

SBE9plus (S/N 09P79492-0575, Sea-Bird Electronics, Inc.)

Pressure sensor : Digiquartz pressure sensor (S/N 79492)

Calibrated Date : 04 Aug. 2008

Temperature sensors :

Primary : SBE03-04/F (S/N 031525, Sea-Bird Electronics, Inc.)

Calibrated Date : 16 Jul. 2008

Secondary : SBE03plus (S/N 03P4811, Sea-Bird Electronics, Inc.)

Calibrated Date : 20 Nov. 2007

Conductivity sensors :

Primary : SBE04C (S/N 041088, Sea-Bird Electronics, Inc.)

Calibrated Date : 17 Jul. 2008

Secondary : SBE04C (S/N 041172, Sea-Bird Electronics, Inc.)

Calibrated Date : 27 Jun. 2008

Dissolved Oxygen sensors :

Primary : SBE43 (S/N 430330, Sea-Bird Electronics, Inc.)

Calibrated Date : 28 Jun. 2008

Secondary : SBE43 (S/N 430394, Sea-Bird Electronics, Inc.)

Calibrated Date : 15 Mar. 2008

Oxygen Optode : Oxygen Optode 3830 (S/N 001, Aanderaa Instruments, Inc.)

Prototype Oxygen Optode : Rinko3 (S/N 006, Alec Electronics Co., Ltd.)

Deep Ocean Standards Thermometer :

SBE35 (S/N 0045, Sea-Bird Electronics, Inc.)

Calibrated Date : 08 Feb. 2008

Altimeter : Benthos PSA-916T (S/N 1100, Teledyne Benthos, Inc.)

Fluorometer : Chlorophyll Fluorometer (S/N 2936, Seapoint Sensors, Inc.)

CDOM : CDOM Fluorometer (S/N FLCDRTD-1076, WET Labs, Inc.)

Carousel water sampler :

SBE32 (S/N 3227443-0391, Sea-Bird Electronics, Inc.)

Deck unit : SBE11plus (S/N 11P7030-0272, Sea-Bird Electronics, Inc.)

(5)Observation log

Table 2.1-1 shows CTD cast table of this cruise. At the last column (Remarks), the kinds of CTD cast are indicated as follows.

CTD : CTD cast only

CTD/R : routine sampling

CTD/Fe : sampling for iron (used clean-Niskin bottles)

CTD/1L : sampling for NIES

(6) Results

Fig 2.1-1 shows the time drift and the difference between CTD temperature and SBE35, Fig 2.1-2 shows the time drift and the difference between CTD salinity and BTL salinity, Fig2.1-3 shows the time drift and the difference between CTD oxygen and BTL oxygen, respectively.

(7) Troubles

At the station 099M02, the secondary sensors showed unusual profile between up cast of 2000-1931 dbar due to flowing of jellyfish into the pumped pluming line.

At the station 187M01 and 200M01, Niskin bottle #13 did not trip correctly.

At the station 109M01, the secondary sensors showed unusual profile between down cast of 206-216 dbar due to flowing of jellyfish into the pumped pluming line.

(8) Data Policy

All raw and processed CTD data files were copied onto DVD-ROM. 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 2.1-1 CTD Cast Table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remarks
		(mmddyy)	Start	End	Latitude	Longitude							
001	1	082808	19:34	19:39	65-42.60N	168-14.76W	45.0	34.8	5.9	38.2	38.6	001M01	CTD/R
002	1	082808	20:40	20:45	65-43.30N	168-19.73W	53.0	42.6	6.4	46.7	47.1	002M01	CTD
003	1	082808	21:35	21:46	65-45.28N	168-29.73W	57.0	45.4	6.6	49.7	50.3	003M01	CTD/R
004	1	082808	23:44	23:48	65-47.29N	168-40.11W	53.0	42.3	6.0	46.0	46.5	004M01	CTD
005	1	082908	00:37	00:42	65-48.90N	168-49.17W	49.0	40.3	5.7	43.1	43.6	005M01	CTD/R
006	1	082908	02:06	02:11	66-00.12N	168-50.03W	54.0	43.2	6.2	46.5	47.2	006M01	CTD/R
007	1	082908	04:30	04:35	66-30.17N	168-50.09W	52.0	42.1	5.8	45.1	45.5	007M01	CTD
008	1	082908	06:56	07:02	67-00.08N	168-49.55W	47.0	38.8	4.5	41.9	42.3	008M01	CTD/R
009	1	082908	09:24	09:29	67-30.02N	168-49.61W	50.0	41.2	4.6	44.8	45.2	009M01	CTD
010	1	082908	11:51	11:57	68-00.10N	168-50.16W	58.0	47.2	6.1	51.4	51.9	010M01	CTD/R
011	1	082908	14:24	14:28	68-30.13N	168-50.26W	54.0	44.1	5.9	47.1	47.4	011M01	CTD
012	1	082908	16:48	16:53	69-00.04N	168-49.58W	52.0	43.2	5.5	45.8	46.3	012M01	CTD/R
013	1	082908	19:11	19:16	69-30.10N	168-49.82W	52.0	43.2	5.8	45.5	45.9	013M01	CTD
014	1	082908	21:34	21:43	70-00.06N	168-49.79W	40.0	29.6	5.4	33.7	45.9	014M01	CTD/R
015	1	083008	00:50	00:54	70-30.10N	168-50.09W	39.0	29.3	5.2	33.0	45.9	015M01	CTD
016	1	083008	02:38	02:42	70-50.07N	168-50.02W	39.0	29.5	5.7	32.7	45.9	016M01	CTD/R
017	1	083008	03:47	03:51	70-49.92N	168-20.14W	44.0	34.6	5.2	37.9	45.9	017M01	CTD
018	1	083008	05:03	05:09	70-50.17N	167-49.74W	56.0	46.9	5.5	49.4	45.9	018M01	CTD/R
019	1	083008	06:15	06:20	70-50.13N	167-19.64W	50.0	41.2	5.4	43.9	45.9	019M01	CTD
020	1	083008	07:35	07:40	70-50.22N	166-50.26W	46.0	37.1	5.5	39.9	45.9	020M01	CTD/R
021	1	083008	09:20	09:24	70-50.09N	165-50.09W	42.0	32.0	5.2	36.0	45.9	021M01	CTD
022	1	083008	19:07	19:19	71-04.70N	159-23.12W	80.0	72.1	5.0	74.2	45.9	022M01	CTD/R
023	1	083108	08:05	08:11	72-00.25N	156-44.51W	106.0	91.6	6.5	95.0	45.9	023M01	CTD
024	1	083108	09:14	09:18	71-57.04N	156-22.42W	64.0	51.4	6.1	55.5	45.9	024M01	CTD
025	1	083108	10:31	10:36	71-54.04N	156-00.17W	91.0	79.3	5.8	83.0	45.9	025M01	CTD
026	1	083108	12:12	12:18	71-50.80N	155-37.52W	122.0	110.8	6.0	114.3	45.9	026M01	CTD
027	1	083108	13:20	13:28	71-49.10N	155-18.31W	189.0	180.2	5.2	180.3	45.9	027M01	CTD
028	1	083108	14:37	14:49	71-45.02N	155-04.66W	278.0	273.1	5.1	268.6	45.9	028M01	CTD/R
029	1	083108	16:30	16:36	71-41.02N	154-55.20W	99.0	86.8	8.9	98.0	45.9	029M01	CTD
030	1	083108	17:21	17:25	71-37.57N	154-50.14W	51.0	40.4	5.7	44.1	45.9	030M01	CTD
032	1	090108	10:02	12:34	73-24.68N	151-59.72W	3839.0	3868.4	10.1	3822.9	45.9	032M01	CTD/Fe
032	2	090108	13:26	15:43	73-24.42N	152-00.58W	3841.0	3858.3	10.7	3821.5	45.9	032M02	CTD/R
033	1	090108	17:28	18:10	73-36.17N	152-59.98W	3848.0	1000.0	-	989.7	45.9	033M01	CTD/1L
034	1	090108	19:53	22:11	73-47.97N	154-00.02W	3851.0	3861.4	10.6	3832.2	45.9	034M01	CTD/R
035	1	090208	00:51	01:26	73-59.94N	154-59.72W	3860.0	993.5	-	987.1	45.9	035M01	CTD
036	1	090208	03:11	05:25	74-11.69N	156-01.53W	3858.0	3893.0	10.3	3834.1	45.9	036M01	CTD/R
037	1	090208	07:09	07:46	74-23.96N	157-00.79W	3861.0	995.7	-	988.3	45.9	037M01	CTD
038	1	090208	09:31	10:16	74-36.25N	158-00.54W	946.0	935.6	12.5	930.1	45.9	038M01	CTD/R
039	1	090208	12:00	12:35	74-48.03N	159-00.61W	1253.0	996.3	-	987.7	45.9	039M01	CTD
040	1	090208	14:18	15:32	74-59.99N	160-01.36W	1932.0	1961.1	11.3	1929.4	1958.7	040M01	CTD/R
042	1	090308	08:29	09:12	76-00.06N	156-39.83W	966.0	959.6	10.5	954.3	966.7	042M01	CTD/R
043	1	090308	13:36	14:18	76-44.94N	155-24.97W	893.0	885.8	8.5	882.4	893.7	043M01	CTD/R
044	1	090308	21:50	22:44	77-19.76N	154-58.38W	1318.0	1317.8	8.5	1309.5	1327.1	044M01	CTD/R
046	1	090408	16:06	16:44	76-53.66N	155-00.93W	1037.0	1029.1	9.3	1023.2	1036.8	046M01	CTD
047	1	090408	18:21	19:41	76-55.57N	154-06.16W	1919.0	1974.7	18.8	1947.3	1977.1	047M01	CTD/R
048	1	090408	22:26	00:21	76-52.53N	153-45.20W	3492.0	3538.6	8.4	3511.3	3578.4	048M01	CTD/1L
049	1	090508	02:15	04:27	76-44.98N	152-30.03W	3841.0	3849.2	9.3	3896.4	3820.7	049M01	CTD/R
050	1	090508	07:21	09:36	76-14.94N	152-00.14W	3841.0	3855.2	8.9	3824.0	3899.8	050M01	CTD/R
051	1	090508	13:07	15:23	76-00.13N	149-59.81W	3836.0	3848.3	11.9	3815.1	3890.4	051M01	CTD/R
052	1	090508	17:42	18:27	75-44.97N	148-44.88W	3825.0	994.3	-	986.5	999.2	052M01	CTD/R
053	1	090508	20:42	22:58	75-29.95N	147-30.73W	3812.0	3829.4	10.0	3797.3	3872.2	053M01	CTD/R
054	1	090608	03:15	03:58	75-15.10N	146-08.01W	3790.0	999.4	-	988.1	1000.8	054M01	CTD/R
055	1	090608	06:12	08:22	74-59.92N	144-59.97W	3765.0	3777.3	9.9	3748.1	3821.7	055M01	CTD/R
056	1	090608	11:40	12:17	74-29.91N	144-59.23W	3743.0	995.9	-	988.2	1001.0	056M01	CTD
057	1	090608	15:00	17:08	74-00.09N	144-59.53W	3716.0	3735.8	10.1	3703.0	3775.3	057M01	CTD/R
058	1	090608	19:56	20:32	73-30.00N	144-59.77W	3643.0	997.0	-	988.2	1001.0	058M01	CTD
059	1	090708	01:06	03:12	72-59.30N	144-57.56W	3557.0	3586.6	8.2	3546.7	3614.2	059M01	CTD/R
060	1	090708	05:58	06:41	72-29.97N	144-59.65W	3419.0	997.8	-	988.1	1000.8	060M01	CTD/R
061	1	090708	09:56	11:54	71-59.99N	144-59.94W	3315.0	3328.1	11.8	3301.8	3362.3	061M01	CTD/R
062	1	090708	14:41	15:24	71-30.01N	145-00.77W	3190.0	993.9	-	988.6	1000.3	062M01	CTD/R
063	1	090708	16:59	18:21	71-15.25N	144-59.69W	2279.0	2256.5	14.0	2234.7	2270.9	063M01	CTD/R
064	1	090708	20:31	21:39	71-05.29N	144-59.84W	1761.0	1748.0	11.3	1736.0	1761.1	064M01	CTD/R
065	1	090708	23:39	00:05	70-57.54N	145-00.50W	520.0	510.4	8.9	509.6	515.6	065M01	CTD/1L
066	1	090808	01:26	01:42	70-45.49N	145-00.13W	224.0	212.1	7.9	212.7	215.0	066M01	CTD/R
068	1	090808	02:52	03:00	70-36.86N	145-00.75W	51.0	42.5	4.9	44.9	45.4	068M01	CTD/R
067	1	090808	03:55	04:00	70-41.50N	145-00.35W	102.0	82.2	-	84.5	85.4	067M01	CTD
069	1	090808	09:23	10:00	71-29.69N	146-01.13W	2971.0	1009.7	-	988.7	1001.6	069M01	CTD
070	1	090808	12:19	12:55	71-37.31N	147-00.71W	3034.0	1012.4	-	988.2	1000.9	070M01	CTD
071	1	090808	14:36	16:26	71-44.94N	148-00.64W	3027.0	3039.2	9.9	3012.0	3065.3	071M01	CTD/R
072	1	090808	20:03	20:44	71-52.59N	148-59.58W	3107.0	1008.6	-	1001.5	1014.9	072M01	CTD/1L
073	1	090808	22:28	00:18	71-59.71N	150-00.50W	3102.0	3139.6	9.2	3099.4	3154.2	073M01	CTD/R

Table 2.1-2 CTD Cast Table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	HT Above	Max	Max	CTD	Remarks
		(mmddyy)	Start	End	Latitude	Longitude		Out	Bottom	Depth	Pressure	Filename	
074	1	090908	02:01	02:35	72-07.03N	150-59.83W	3044.0	997.9	-	989.4	1001.9	074M01	CTD
075	1	090908	04:20	06:01	72-14.89N	152-00.28W	2790.0	2803.4	8.6	2781.9	2829.2	075M01	CTD/R
076	1	090908	17:04	17:20	71-48.27N	155-18.08W	193.0	183.2	6.2	184.3	186.3	076M01	CTD/R
078	1	090908	21:34	21:47	71-40.59N	154-58.87W	107.0	99.9	5.2	101.3	102.4	078M01	CTD/R
079	1	091008	01:29	01:47	71-44.09N	155-10.67W	297.0	288.2	6.4	287.8	291.0	079M01	CTD/R
080	1	091008	08:45	10:27	72-30.04N	154-01.18W	2834.0	2836.5	10.2	2813.3	2861.9	080M01	CTD/R
081	1	091008	12:32	13:13	72-44.92N	155-00.49W	3094.0	999.2	-	989.9	1003.0	081M01	CTD/Sal
082	1	091008	15:11	16:59	73-00.87N	155-59.52W	3023.0	3079.8	14.5	2983.5	3036.1	082M01	CTD/R
083	1	091008	19:07	19:49	73-15.39N	157-00.47W	3160.0	1001.8	-	988.5	1001.3	083M01	CTD/1L
084	1	091008	23:23	01:02	73-30.19N	158-05.51W	2805.0	2818.0	12.9	2781.0	2828.7	084M01	CTD/R
085	1	091108	03:07	03:42	73-47.36N	159-00.01W	3139.0	994.8	-	988.1	1000.7	085M01	CTD
086	1	091108	05:53	06:39	73-59.97N	160-00.01W	996.0	1012.4	11.9	1006.1	1018.8	086M01	CTD/R
087	1	091108	09:15	09:55	74-14.96N	161-00.30W	1124.0	1121.1	9.5	1115.0	1129.8	087M01	CTD
088	1	091108	12:13	13:30	74-29.92N	162-00.35W	1634.0	1623.3	9.7	1611.5	1635.0	088M01	CTD/Fe
088	2	091108	14:20	15:24	74-29.90N	162-00.40W	1624.0	1615.4	10.0	1603.4	1626.7	088M02	CTD/R
089	1	091208	08:30	09:48	75-15.06N	161-01.60W	2099.0	2098.3	9.3	2081.7	2114.3	089M01	CTD/R
090	1	091208	11:55	13:01	75-29.98N	161-59.95W	1686.0	1689.6	10.0	1674.3	1698.7	090M01	CTD/R
091	1	091208	14:53	16:09	75-45.04N	163-00.46W	2043.0	2043.0	9.5	2026.6	2057.7	091M01	CTD/R
092	1	091208	19:41	20:24	75-56.53N	163-47.80W	970.0	984.7	9.9	975.4	988.2	092M01	CTD/R
093	1	091308	01:20	01:44	76-15.64N	164-58.49W	482.0	457.4	9.1	455.3	460.5	093M01	CTD/R
094	1	091308	03:42	04:26	76-29.98N	166-00.30W	960.0	954.9	10.3	946.0	958.2	094M01	CTD/R
095	1	091308	06:21	06:49	76-25.04N	164-40.04W	538.0	518.5	11.6	516.4	522.6	095M01	CTD/1L
096	1	091308	08:57	09:34	76-20.02N	163-19.40W	772.0	755.5	9.9	751.4	760.8	096M01	CTD/R
097	1	091308	11:33	12:48	76-14.57N	162-08.61W	2042.0	2036.6	10.1	2023.5	2055.1	097M01	CTD/R
098	1	091308	22:51	23:23	77-31.38N	161-00.32W	619.0	608.2	10.0	605.4	612.8	098M01	CTD/R
099	1	091408	05:14	06:53	76-36.28N	161-09.91W	2125.0	2130.4	8.8	2109.9	2143.2	099M01	CTD/Fe
099	2	091408	09:53	11:13	76-37.44N	161-02.78W	2132.0	2143.6	9.1	2117.1	2150.7	099M02	CTD/R
100	1	091508	01:20	02:26	76-38.34N	168-04.57W	1742.0	1740.2	8.5	1725.7	1751.3	100M01	CTD/R
101	1	091508	03:46	04:20	76-40.20N	167-14.53W	612.0	602.6	9.1	600.9	607.4	101M01	CTD/R
102	1	091508	07:37	08:19	76-58.61N	165-29.92W	936.0	928.1	9.1	920.9	933.0	102M01	CTD/R
103	1	091508	22:38	22:58	77-44.27N	164-51.92W	297.0	283.6	6.2	286.4	289.7	103M01	CTD/R
104	1	091608	15:04	16:21	76-08.92N	160-59.70W	2133.0	2117.4	15.2	2103.3	2136.4	104M01	CTD/1L
105	1	091608	17:50	19:12	76-03.00N	159-59.95W	2106.0	2105.9	10.8	2086.7	2119.5	105M01	CTD/R
106	1	091608	21:42	22:13	75-57.10N	158-58.67W	758.0	755.5	10.1	744.4	753.6	106M01	CTD
107	1	091708	01:20	01:52	75-50.60N	157-57.60W	551.0	542.6	8.4	541.2	547.7	107M01	CTD/R
108	1	091708	03:17	03:52	75-37.57N	157-44.92W	970.0	962.8	9.1	958.0	970.0	108M01	CTD
109	1	091708	05:23	06:18	75-30.18N	158-30.08W	1337.0	1332.5	9.4	1324.7	1342.8	109M01	CTD/R
110	1	091708	07:50	08:35	75-22.59N	159-15.17W	1327.0	1325.5	9.3	1317.6	1335.1	110M01	CTD
111	1	091708	12:53	14:06	75-14.89N	160-03.49W	1974.0	1977.4	10.3	1955.7	1985.6	111M01	CTD/R
112	1	091708	15:39	16:45	75-07.49N	160-45.08W	2095.0	2088.4	10.0	2073.3	2105.6	112M01	CTD
113	1	091708	18:14	19:31	75-00.18N	161-31.23W	1865.0	1864.0	8.9	1853.5	1881.2	113M01	CTD/R
114	1	091708	22:54	00:00	74-52.39N	162-14.68W	1881.0	1883.6	9.5	1869.5	1897.5	114M01	CTD/1L
115	1	091808	01:25	02:26	74-45.01N	163-00.05W	1558.0	1555.8	8.6	1545.7	1568.0	115M01	CTD/R
116	1	091808	04:03	04:40	74-37.45N	163-45.07W	1010.0	999.8	9.5	995.1	1007.4	116M01	CTD
117	1	091808	06:07	06:30	74-30.07N	164-30.10W	398.0	390.6	6.4	389.2	393.7	117M01	CTD/R
118	1	091808	09:18	09:33	74-22.51N	165-15.02W	359.0	345.3	5.7	346.3	349.8	118M01	CTD
119	1	091808	11:04	11:22	74-15.02N	166-00.51W	273.0	265.4	5.8	266.7	269.4	119M01	CTD/R
120	1	091808	12:56	13:05	74-06.63N	166-47.89W	213.0	203.1	5.6	204.9	206.5	120M01	CTD
121	1	091808	14:19	14:39	74-02.34N	167-14.33W	216.0	207.9	4.8	209.9	212.2	121M01	CTD/Fe
121	2	091808	18:07	18:25	73-59.02N	167-36.80W	202.0	198.0	3.8	196.5	198.5	121M02	CTD/R
122	1	091808	21:25	21:45	74-14.98N	167-20.63W	267.0	254.1	9.1	255.2	258.5	122M01	CTD/R
123	1	091808	23:08	23:28	74-30.11N	167-10.58W	322.0	307.9	7.5	308.0	311.7	123M01	CTD/R
124	1	091908	01:05	01:27	74-45.17N	167-00.61W	409.0	394.8	9.7	390.1	395.3	124M01	CTD/R
125	1	091908	02:51	03:16	75-00.08N	166-50.20W	435.0	425.6	8.5	423.2	428.0	125M01	CTD/1L
126	1	091908	04:08	04:23	75-00.08N	167-15.20W	254.0	236.1	9.6	237.8	240.1	126M01	CTD
127	1	091908	05:00	05:13	75-00.00N	167-29.84W	195.0	190.3	8.1	193.7	194.8	127M01	CTD
128	1	091908	10:20	10:54	75-40.84N	166-02.27W	540.0	533.7	9.7	528.8	535.2	128M01	CTD/R
129	1	091908	12:14	12:33	75-40.07N	166-50.20W	263.0	247.5	8.8	251.3	254.1	129M01	CTD/R
130	1	091908	13:50	14:06	75-40.01N	167-40.10W	202.0	187.0	8.6	189.4	192.5	130M01	CTD/R
131	1	091908	17:38	18:49	75-38.00N	170-26.82W	1382.0	1380.7	10.1	1364.4	1382.5	131M01	CTD/Fe
131	2	091908	21:01	22:03	75-38.24N	170-33.91W	1446.0	1440.2	12.8	1430.4	1450.4	131M02	CTD/R
132	1	091908	23:44	00:13	75-32.16N	169-45.81W	570.0	565.4	9.4	556.7	563.6	132M01	CTD/R
133	1	092008	02:02	02:19	75-25.34N	168-59.44W	250.0	233.4	9.9	235.7	239.0	133M01	CTD/R
134	1	092008	04:02	04:18	75-15.07N	168-00.76W	165.0	157.2	6.3	159.4	161.3	134M01	CTD/R
135	1	092008	06:17	06:35	75-00.02N	169-00.76W	215.0	200.6	8.6	203.0	204.5	135M01	CTD/R
136	1	092008	08:33	08:52	74-45.12N	170-01.14W	223.0	207.9	7.1	208.7	210.2	136M01	CTD/R
137	1	092008	10:25	10:49	74-45.09N	171-01.16W	258.0	245.3	8.5	244.2	246.7	137M01	CTD/R
138	1	092008	13:24	13:45	74-45.15N	172-01.68W	309.0	293.3	10.2	295.3	299.9	138M01	CTD/R
139	1	092008	15:19	15:38	74-45.05N	173-00.71W	303.0	286.1	8.7	287.9	290.1	139M01	CTD/R
140	1	092008	17:15	17:35	74-48.05N	174-00.66W	267.0	255.9	8.1	254.1	258.3	140M01	CTD/R
141	1	092108	04:05	04:52	75-25.00N	172-01.09W	1039.0	1032.8	8.5	1023.3	1035.6	141M01	CTD/R

Table 2.1-3 CTD Cast Table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	HT Above	Max	Max	CTD	Remarks
		(mmddyy)	Start	End	Latitude	Longitude		Out	Bottom	Depth	Pressure	Filename	
142	1	092108	07:36	08:01	75-14.99N	172-00.37W	505.0	498.1	9.7	495.6	501.2	142M01	CTD/R
143	1	092108	09:35	10:00	74-59.99N	172-00.94W	382.0	375.6	7.1	374.5	378.9	143M01	CTD/R
144	1	092108	19:16	19:34	74-59.81N	177-06.02W	255.0	243.6	7.1	244.6	247.1	144M01	CTD/R
145	1	092108	22:13	22:31	74-59.88N	176-00.27W	255.0	242.9	10.7	243.7	246.7	145M01	CTD/1L
146	1	092208	00:25	00:44	75-00.22N	175-00.90W	274.0	259.9	10.1	261.0	264.3	146M01	CTD/R
147	1	092208	03:41	03:54	75-00.08N	174-00.09W	298.0	281.6	6.2	283.2	286.1	147M01	CTD
148	1	092208	05:28	05:49	75-00.05N	173-00.41W	345.0	334.1	9.6	333.5	337.4	148M01	CTD/R
149	1	092208	08:44	09:04	75-00.03N	171-00.25W	322.0	307.8	9.7	309.1	312.9	149M01	CTD/R
150	1	092208	10:41	10:59	75-00.08N	170-00.18W	263.0	242.4	10.3	243.5	246.3	150M01	CTD/R
151	1	092208	14:48	15:03	75-00.10N	168-00.14W	170.0	155.1	10.5	156.6	158.7	151M01	CTD/R
152	1	092208	17:16	17:41	75-00.08N	166-30.09W	466.0	452.7	10.2	452.2	457.5	152M01	CTD/1L
153	1	092208	18:41	19:07	75-00.11N	165-59.92W	485.0	471.0	10.5	469.7	475.4	153M01	CTD/R
154	1	092208	20:41	21:08	74-59.93N	165-00.62W	542.0	534.2	10.1	530.1	536.2	154M01	CTD/R
155	1	092208	23:34	00:06	75-00.71N	164-02.20W	631.0	636.3	8.2	624.4	631.3	155M01	CTD/R
156	1	092308	03:22	04:13	74-29.95N	163-00.20W	1196.0	1194.2	10.5	1184.0	1199.9	156M01	CTD/R
157	1	092308	08:14	08:53	74-15.01N	162-59.94W	853.0	838.5	9.5	833.6	844.0	157M01	CTD/R
158	1	092308	10:24	10:45	74-00.05N	163-00.13W	317.0	301.3	10.5	301.4	304.8	158M01	CTD/R
159	1	092308	12:35	12:50	73-42.33N	162-44.73W	194.0	180.4	10.2	182.9	185.0	159M01	CTD/R
160	1	092308	14:23	14:37	73-25.98N	162-32.10W	151.0	134.6	10.1	136.4	138.3	160M01	CTD/R
161	1	092308	16:33	16:59	73-09.31N	162-19.67W	197.0	182.1	10.3	183.8	185.8	161M01	CTD/R+Fe
162	1	092308	21:28	21:50	73-15.17N	161-00.58W	373.0	366.8	10.2	364.5	368.5	162M01	CTD/R
163	1	092408	02:41	03:53	73-30.98N	159-52.83W	1963.0	1973.4	8.0	1955.6	1985.5	163M01	CTD/R
164	1	092408	06:50	07:38	73-23.09N	160-25.69W	1188.0	1194.7	5.9	1181.5	1197.4	164M01	CTD/R
165	1	092408	14:06	14:28	73-57.46N	161-31.86W	367.0	357.8	5.4	357.8	361.8	165M01	CTD/R
166	1	092508	20:44	21:04	74-59.99N	178-00.17W	325.0	313.8	6.2	313.8	217.2	166M01	CTD/R
167	1	092508	22:39	23:00	74-59.94N	179-00.13W	392.0	379.9	6.9	378.3	382.9	167M01	CTD/R
168	1	092608	00:57	01:19	75-00.14N	179-59.55E	405.0	392.8	5.8	391.0	395.3	168M01	CTD/R
169	1	092608	03:28	03:45	74-59.97N	178-59.87E	263.0	251.9	5.2	251.7	254.7	169M01	CTD/R
170	1	092608	05:19	05:35	74-59.98N	177-59.91E	225.0	215.6	5.2	216.0	218.7	170M01	CTD/R
171	1	092608	07:09	07:24	75-00.02N	176-59.79E	187.0	178.8	5.2	181.0	182.8	171M01	CTD/R
172	1	092608	08:58	09:14	75-00.02N	175-59.73E	164.0	151.7	5.1	153.9	155.5	172M01	CTD/R
173	1	092608	12:02	12:13	74-45.08N	174-45.23E	86.0	74.2	5.6	77.7	78.5	173M01	CTD/R
174	1	092608	13:58	14:11	75-00.11N	174-59.86E	160.0	144.7	5.0	146.5	148.4	174M01	CTD/R
175	1	092608	16:10	16:49	75-20.09N	175-20.31E	226.0	212.9	5.9	214.3	216.6	175M01	CTD/R+Fe
176	1	092608	19:23	19:40	75-40.03N	175-40.07E	256.0	246.7	5.5	247.5	250.1	176M01	CTD/R
177	1	092608	22:23	22:45	75-59.91N	176-00.15E	359.0	349.7	4.7	348.9	353.0	177M01	CTD/R
178	1	092708	01:32	02:04	76-20.26N	176-19.85E	640.0	637.4	5.6	631.1	638.9	178M01	CTD/R
179	1	092708	04:06	04:53	76-40.10N	176-40.36E	1109.0	1107.1	5.1	1097.2	1113.0	179M01	CTD/R
180	1	092708	07:08	07:58	77-00.03N	177-00.30E	1225.0	1222.7	5.6	1213.8	1229.9	180M01	CTD/R
181	1	092708	09:59	10:46	77-20.14N	177-21.05E	1083.0	1084.6	5.5	1072.9	1086.9	181M01	CTD/R
182	1	092708	12:44	13:49	77-40.11N	177-40.37E	1282.0	1275.3	10.4	1265.8	1283.4	182M01	CTD/Fe
182	2	092708	16:03	16:58	77-40.59N	177-42.34E	1299.0	1295.3	7.5	1287.4	1305.1	182M02	CTD/R
183	1	092708	18:53	19:59	78-00.19N	177-59.30E	1680.0	1684.5	6.8	1666.6	1691.1	183M01	CTD/R
184	1	092808	00:16	01:26	78-53.62N	178-33.17E	1686.0	1732.8	6.9	1678.8	1702.6	184M01	CTD/R
185	1	092808	06:14	07:16	77-59.93N	178-59.48W	1584.0	1590.3	5.0	1574.1	1597.9	185M01	CTD/R
186	1	092808	10:11	10:50	77-35.92N	177-19.50W	791.0	792.9	4.9	785.4	795.3	186M01	CTD/R
187	1	092808	12:37	13:31	77-20.03N	177-35.32W	1357.0	1360.3	7.4	1345.6	1364.0	187M01	CTD/R
188	1	092808	14:40	15:40	77-09.90N	177-44.73W	1418.0	1434.7	5.1	1409.1	1428.8	188M01	CTD/R
189	1	092808	17:10	18:08	76-59.69N	176-50.14W	1450.0	1450.3	7.7	1431.4	1451.9	189M01	CTD/R
190	1	092808	20:23	21:30	76-50.99N	175-59.98W	1757.0	1760.9	8.7	1744.6	1770.5	190M01	CTD/R
191	1	092808	23:36	00:49	76-40.19N	174-59.95W	2006.0	2007.1	6.1	1990.2	2020.2	191M01	CTD/R
192	1	092908	02:58	04:03	76-38.39N	176-18.76W	1738.0	1743.6	8.2	1725.6	1751.2	192M01	CTD/R
193	1	092908	05:37	06:31	76-37.04N	177-19.19W	1307.0	1301.7	8.6	1287.2	1305.0	193M01	CTD/R
194	1	092908	07:59	08:38	76-35.95N	178-19.73W	826.0	820.8	5.0	817.3	826.9	194M01	CTD/R
195	1	092908	11:26	12:19	77-00.13N	177-54.78W	1337.0	1336.9	8.3	1326.7	1345.2	195M01	CTD/R
196	1	092908	15:49	16:40	76-36.05N	179-59.23W	1172.0	1165.0	5.6	1158.4	1174.1	196M01	CTD/R
197	1	092908	22:36	23:37	76-09.33N	176-53.77W	1522.0	1527.3	7.4	1509.0	1530.2	197M01	CTD/R
198	1	093008	02:44	03:29	76-02.00N	178-24.93W	1024.0	1023.4	5.2	1016.7	1029.9	198M01	CTD/R
199	1	093008	05:02	05:51	75-47.99N	178-50.05W	1140.0	1135.5	4.6	1128.3	1143.1	199M01	CTD/R
200	1	093008	07:26	08:09	75-33.98N	179-20.11W	1017.0	999.0	4.8	1004.7	1017.9	200M01	CTD/R
201	1	093008	10:17	10:54	75-18.00N	179-45.19W	629.0	626.7	4.6	623.7	631.2	201M01	CTD/R
202	1	093008	12:35	13:05	75-06.47N	178-59.34W	581.0	574.3	5.3	569.8	576.3	202M01	CTD/R
203	1	093008	22:42	23:05	75-15.14N	174-45.26W	424.0	414.4	4.5	413.9	418.5	203M01	CTD/R
204	1	100108	00:09	00:57	75-25.03N	174-34.76W	1141.0	1129.5	8.9	1122.2	1137.1	204M01	CTD/R
205	1	100108	02:29	03:36	75-40.00N	174-20.00W	1748.0	1750.6	7.1	1736.2	1761.5	205M01	CTD/R
206	1	100108	05:36	07:02	75-59.85N	174-00.31W	2135.0	2138.7	10.7	2119.6	2152.7	206M01	CTD/R
207	1	100108	09:17	10:25	75-45.11N	172-44.88W	1780.0	1784.9	8.0	1767.3	1793.7	207M01	CTD/R
208	1	100208	04:03	04:16	73-36.90N	165-00.22W	152.0	134.1	5.8	136.6	138.1	208M01	CTD/R
209	1	100208	06:31	06:42	73-30.01N	164-00.13W	110.0	99.3	4.7	103.0	104.1	209M01	CTD/R
210	1	100208	08:54	09:06	73-15.01N	163-00.31W	101.0	89.2	4.9	92.9	94.5	210M01	CTD/R
211	1	100208	11:11	11:26	73-03.00N	161-59.63W	137.0	123.8	6.6	128.7	129.9	211M01	CTD/R

Table 2.1-4 CTD Cast Table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remarks
		(mmddyy)	Start	End	Latitude	Longitude							
212	1	100208	13:45	13:53	72-45.01N	160-59.89W	58.0	39.5	8.1	43.9	44.5	212M01	CTD/R
213	1	100208	15:53	16:01	72-33.02N	159-59.84W	51.0	36.8	6.3	43.1	42.7	213M01	CTD/R
214	1	100208	17:33	17:46	72-41.91N	159-15.00W	116.0	103.5	5.3	106.8	107.4	214M01	CTD/R
215	1	100208	19:34	19:54	72-49.92N	158-40.35W	315.0	308.1	6.3	305.7	308.8	215M01	CTD/R
216	1	100208	22:47	23:05	72-34.90N	157-39.58W	251.0	238.5	4.8	242.1	244.1	216M01	CTD/R
217	1	100308	02:24	02:42	72-18.11N	156-39.91W	298.0	289.4	4.4	288.8	292.1	217M01	CTD/R
218	1	100308	03:51	04:46	72-26.01N	156-13.69W	1365.0	1356.5	8.0	1345.9	1362.3	218M01	CTD/R
219	1	100308	08:57	09:31	72-00.01N	154-00.32W	646.0	642.7	-	641.2	649.0	219M01	CTD/R
220	1	100308	11:35	12:02	71-48.03N	152-58.86W	570.0	545.2	20.5	545.8	551.7	220M01	CTD/R
221	1	100308	14:49	15:34	71-30.11N	151-39.44W	999.0	983.3	12.8	977.1	989.8	221M01	CTD/R
222	1	100308	17:59	18:13	71-23.93N	152-03.26W	159.0	147.4	6.6	149.9	151.2	222M01	CTD/R
223	1	100308	22:28	22:35	71-40.33N	154-59.34W	105.0	90.3	7.5	95.1	96.3	223M01	CTD
224	1	100308	23:35	23:54	71-43.76N	155-10.20W	286.0	275.1	5.8	277.2	280.1	224M01	CTD/1L
225	1	100408	01:01	01:09	71-48.26N	155-20.85W	163.0	149.6	4.2	155.0	157.7	225M01	CTD
226	1	100408	03:49	04:00	72-00.10N	157-06.33W	96.0	78.9	5.6	84.9	85.8	226M01	CTD/R
227	1	100408	05:32	05:41	72-00.09N	158-00.30W	69.0	52.2	4.4	60.0	60.3	227M01	CTD/R
228	1	100408	07:22	07:29	72-00.06N	158-59.98W	54.0	40.1	4.0	46.8	47.0	228M01	CTD/R
229	1	100408	09:10	09:16	72-00.09N	160-00.16W	29.9	17.5	4.9	24.2	24.5	229M01	CTD/R
230	1	100408	10:57	11:01	72-00.05N	161-00.00W	38.0	25.1	5.6	31.3	31.5	230M01	CTD
231	1	100408	12:46	12:52	72-00.08N	162-00.69W	34.0	22.1	4.8	27.8	28.1	231M01	CTD/R
232	1	100408	15:05	15:08	72-00.12N	163-00.52W	41.0	30.0	5.3	34.8	34.9	232M01	CTD
233	1	100408	16:55	17:02	72-00.10N	164-00.24W	41.0	30.0	4.3	34.7	35.0	233M01	CTD/R
234	1	100408	18:54	19:09	72-00.14N	165-00.31W	41.0	29.1	5.2	35.5	35.8	234M01	CTD/1L
235	1	100408	20:50	20:59	72-00.03N	166-00.59W	46.0	32.9	5.2	40.4	40.9	235M01	CTD/R
236	1	100408	22:45	22:49	72-00.08N	167-00.36W	48.0	34.9	4.6	43.2	43.3	236M01	CTD
237	1	100508	00:33	00:40	72-00.07N	168-00.27W	44.0	38.2	4.7	44.6	44.8	237M01	CTD/R
238	1	100508	03:06	03:14	71-36.70N	167-16.83W	48.0	35.7	4.7	42.1	42.8	238M01	CTD/R
239	1	100508	05:40	05:48	71-13.45N	166-33.74W	39.0	34.8	4.4	40.1	40.4	239M01	CTD/R
240	1	100508	08:19	08:29	70-50.04N	165-50.39W	42.0	30.9	4.7	36.2	36.2	240M01	CTD/R
241	1	100508	10:26	10:30	70-50.07N	166-50.40W	46.0	34.8	5.3	39.9	40.2	241M01	CTD
242	1	100508	11:33	11:37	70-50.10N	167-20.20W	51.0	38.4	4.6	44.1	44.9	242M01	CTD
243	1	100508	12:43	12:56	70-50.04N	167-50.50W	56.0	44.8	5.0	49.7	50.3	243M01	CTD/R
244	1	100508	13:59	14:03	70-49.88N	168-20.61W	44.0	34.9	4.3	37.9	38.5	244M01	CTD
245	1	100508	15:05	15:12	70-50.06N	168-50.01W	40.0	27.8	5.3	33.2	33.5	245M01	CTD/R
246	1	100508	16:56	17:07	70-29.86N	168-50.07W	39.0	28.9	5.0	32.9	33.2	246M01	CTD/1L
247	1	100508	19:27	19:36	69-59.87N	168-50.18W	40.0	29.3	4.6	34.2	34.7	247M01	CTD/R
248	1	100508	21:53	21:57	69-29.94N	168-50.12W	52.0	40.6	5.0	45.9	46.4	248M01	CTD
249	1	100608	00:16	00:23	68-59.76N	168-49.87W	45.0	42.1	4.2	46.6	47.2	249M01	CTD/R
250	1	100608	02:46	02:50	68-29.81N	168-50.10W	47.0	42.3	4.7	48.4	48.6	250M01	CTD
251	1	100608	05:12	05:22	68-00.02N	168-49.90W	58.0	48.9	4.3	53.3	54.1	251M01	CTD/R
252	1	100608	07:48	07:52	67-30.00N	168-50.53W	55.0	40.3	4.4	44.7	45.3	252M01	CTD
253	1	100608	10:17	10:26	67-00.00N	168-50.29W	47.0	35.3	4.6	41.6	42.0	253M01	CTD/R
254	1	100608	12:51	12:54	66-29.76N	168-49.88W	52.0	42.1	5.5	45.5	46.9	254M01	CTD
255	1	100608	15:17	15:28	65-59.67N	168-49.59W	54.0	41.0	5.3	47.2	48.0	255M01	CTD/R
256	1	100608	17:10	17:14	65-45.18N	168-29.73W	57.0	47.2	4.4	51.8	51.8	256M01	CTD
257	1	100608	17:55	17:59	65-43.10N	168-20.03W	54.0	44.1	3.8	48.7	49.5	257M01	CTD
258	1	100608	18:28	18:32	65-42.35N	168-15.22W	45.0	35.1	4.3	39.2	39.7	258M01	CTD
259	1	100608	19:39	19:43	65-47.15N	168-40.59W	53.0	43.9	4.3	47.6	48.1	259M01	CTD
260	1	100608	20:21	20:26	65-49.14N	168-50.15W	50.0	38.2	5.0	43.4	43.7	260M01	CTD

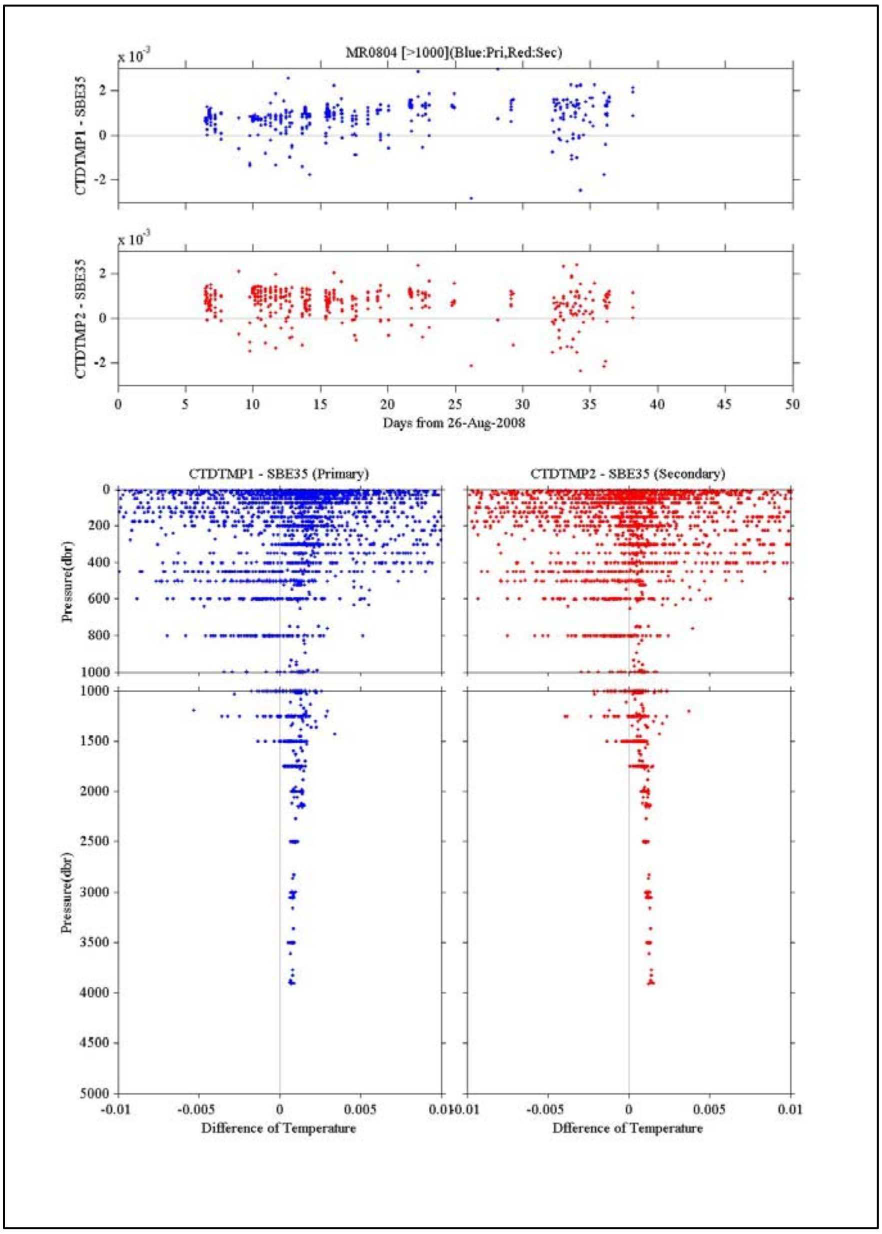


Fig 2.1-1 Time drift and the difference between CTD temperature and SBE35

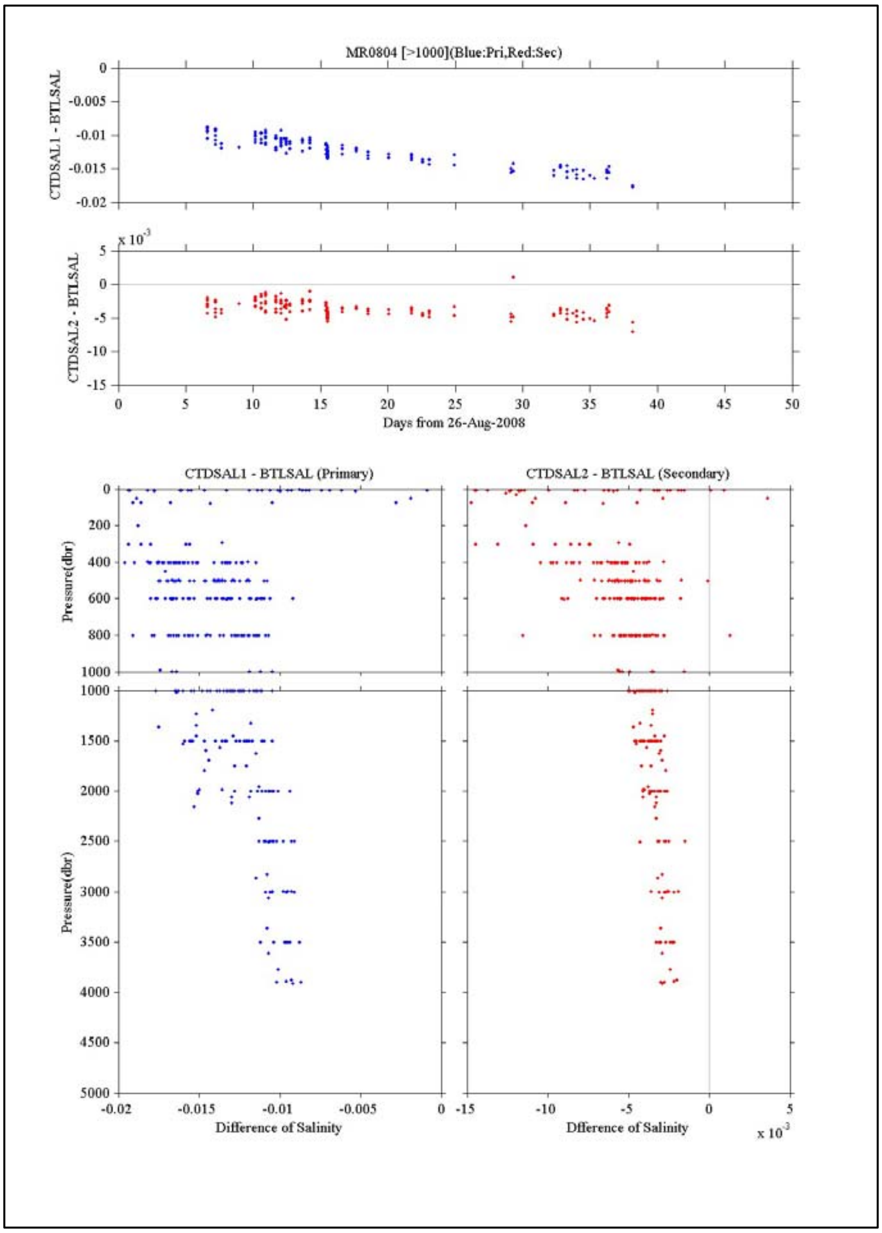


Fig 2.1-2 Time drift and the difference between CTD salinity and BTL salinity

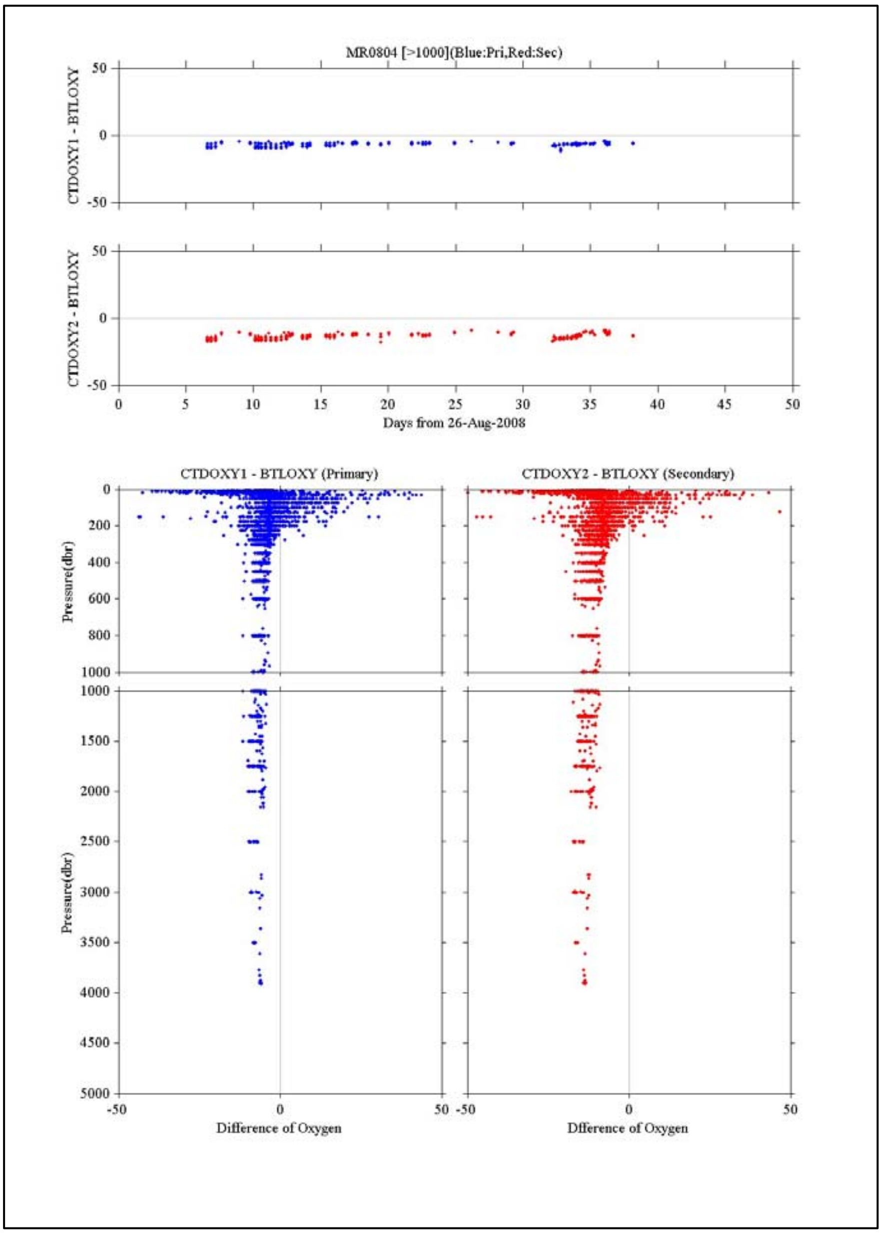


Fig 2.1-3 Time drift and the difference between CTD oxygen and BTL oxygen

2.2. Salinity of sampled water

(1)Personnel

Koji Shimada (JAMSTEC): Principal Investigator
Motoyo Itoh (JAMSTEC)
Fujio Kobayashi, Akinori Murata, Satoshi Ozawa, Kenichi Katayama,
Tomohide Noguchi, Akira Watanabe (MWJ)

(2)Objective

To provide a calibration for the measurement of salinity of bottle water collected on the CTD casts and EPCS.

(3)Parameters

The specifications of the AUTOSAL salinometer are shown as follows ;

Salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.)
Measurement Range : 0.005 to 42 (PSU)
Accuracy : Better than ±0.002 (PSU) over 24 hours without re-standardization
Maximum Resolution : Better than ±0.0002 (PSU) at 35 (PSU)

(4) Instruments and Methods

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and EPCS. The salinity sample bottle of the 250ml brown glass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed 3 times with the sample water, and was filled with sample water to the bottle shoulder. All of sample bottles for EPCS and some of them for shallower than 100dbar were sealed with a plastic insert thimble and a screw cap because we took into consideration the possibility of storage for about a week. The thimble was rinsed 3 times with the sample water before use. The bottle was stored for more than 12 hours in the laboratory before the salinity measurement.

The kind and number of samples taken are shown as follows ;

Table 2.2-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD and bucket	1,104
Samples for EPCS	64
Total	1,168

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR08-04 using the salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments

Ltd.: S/N 62827 and S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). S/N 62827 was done for mainly equal and deeper than 100dbar. S/N 62556 was used to measure samples for shallower than 100dbar and EPCS.

Two pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored a bath temperature.

The specifications of the thermometer are shown as follows ;

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

Measurement Range	:	-40 to +180 deg C
Resolution	:	0.001
Limits of error ±deg C	:	0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability	:	±2 least significant digits

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 21 deg C to 25 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion.

The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing 5 times. In the case of the difference between the double conductivity ratio or the salinity of these two fillings being smaller than the criteria* we decided, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to the criteria, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio or the salinity of these two fillings being smaller than the criteria, the average value of the double conductivity ratio was used to calculate the bottle salinity. The cell was cleaned with soap after the measurement of the day.

*criteria:

for equal and deeper than 100dbar : 0.00002 in double conductivity ratio

for shallower than 100dbar and EPCS : 0.01 in salinity

(5) Results

a. Standard Seawater (SSW)

The specifications of SSW used in this cruise are shown as follows ;

Batch	:	P149
conductivity ratio	:	0.99984
salinity	:	34.994
preparation date	:	5-October-2007

Standardization control of the salinometer S/N 62827 was set to 456 (28 Aug.-30 Sep.). The value of STANDBY was 5395 +/- 0002 and that of ZERO was 0.0+0001 or 0.0+0002. As the drift of this salinometer had been significant, the re-standardization was done on 30 Sep., and standardization control of it was set to 466. (30 Sep.-5Oct.) The value of STANDBY was 5402 +/- 0001 and that of ZERO was 0.0+0001. SSW was used as the standard for salinity. 43 bottles of SSW were measured (2 bad bottles were excluded).

Standardization control of the salinometer S/N 62556 was set to 646 and all measurements were done at this setting. The value of STANDBY was 5500 +/- 0001 and that of ZERO was 0.0-0001. SSW was used as the standard for salinity. 20 bottles of SSW were measured.

Fig.2.2-1 shows the history of the double conductivity ratio of the Standard Seawater batch P149 measured by S/N 62827 before correction. The average of the double conductivity ratio was 1.99967 and the standard deviation was 0.00003, which is equivalent to 0.0005 in salinity.

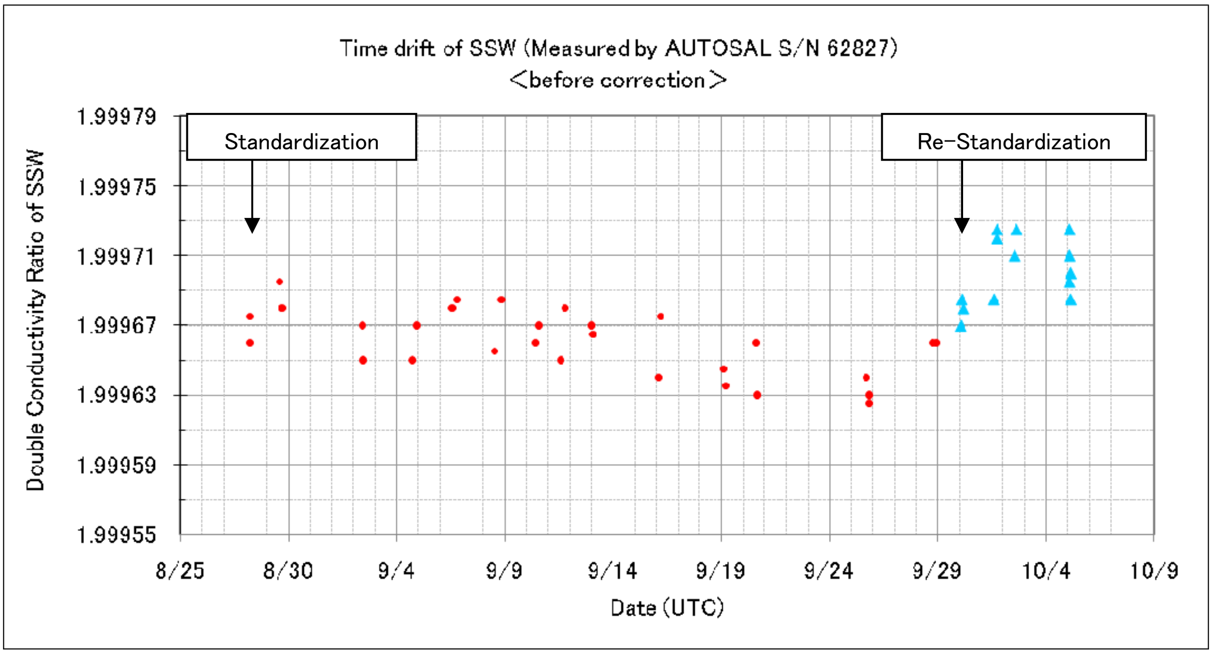


Fig. 2.2-1 History of double conductivity ratio for the Standard Seawater batch P149

(S/N 62827: before correction)

Fig.2.2-2 shows the history of the double conductivity ratio of the Standard Seawater batch P149 measured by S/N 62827 after correction. The average of the double conductivity ratio after correction was 1.99968 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

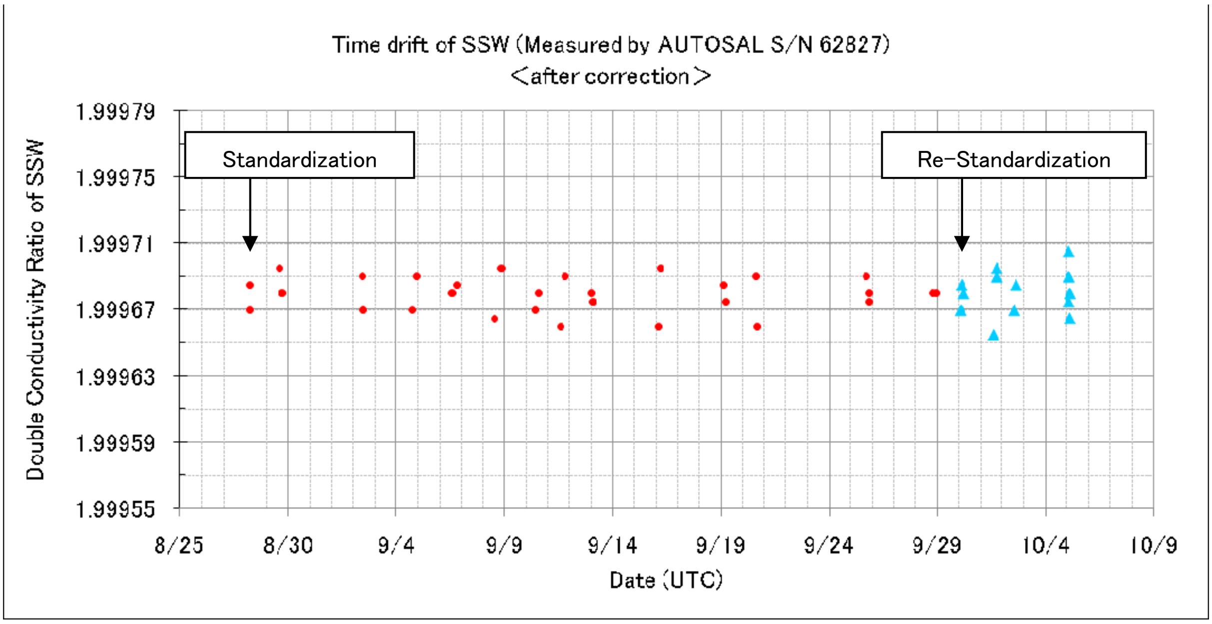


Fig. 2.2-2 History of double conductivity ratio for the Standard Seawater batch P149 (S/N 62827: after correction)

Fig.2.2-3 shows the history of the double conductivity ratio of the Standard Seawater batch P149 measured by S/N 62556. The average of the double conductivity ratio was 1.99966 and the standard deviation was 0.00002, which is equivalent to 0.0004 in salinity.

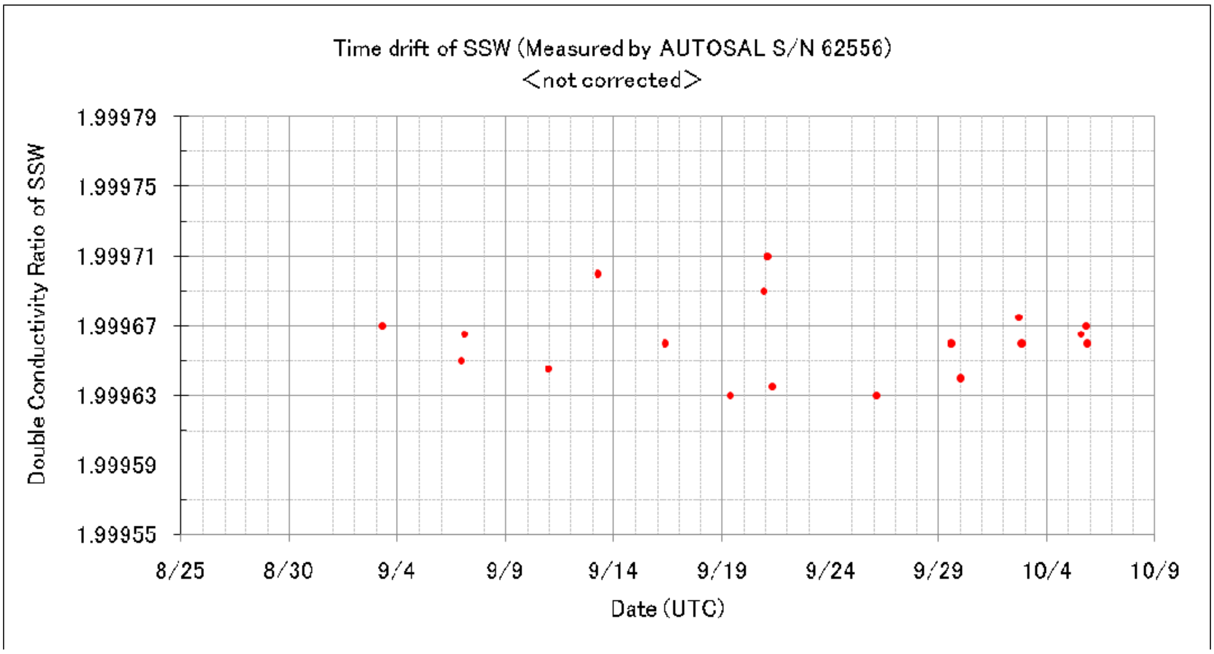


Fig. 2.2-3 History of double conductivity ratio for the Standard Seawater batch P149 (S/N 62556: not corrected)

b. Sub-Standard Seawater

Sub-standard seawater was made from deep-sea water filtered by a pore size of 0.45 micrometer and stored in a 20 liter container made of polyethylene and stirred for at least 24 hours before measuring. It was measured about every 6 samples in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 60 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute difference among 60 pairs of replicate samples were 0.0003 and 0.0003 in salinity, respectively.

d. Data Correction for Samples

For equal and deeper than 100dbar, the data were corrected according to the result of the correction for SSW measured by S/N 62827. For shallower than 100dbar and EPCS, the data were not corrected.

(6) Data Policy and citation

a. Data Policy

These raw datasets will be submitted to JAMSTEC Marine-Earth Data and Information Department and corrected datasets are available from Mirai Web site at http://www.jamstec.go.jp/mirai/.

b. Citation

- Aoyama, M., T. Joyce, T. Kawano and Y. Takatsuki : Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 49, 1103～1114, 2002
- UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. UNESCO Tech. Papers in Mar. Sci., 36, 25 pp., 1981

2.3. Dissolved Oxygen of sampled water

(1) Personnel

Koji SHIMADA (JAMSTEC): Chief Scientist

Motoyo ITOH (JAMSTEC): Principal Investigator

Naoyuki KURITA (JAMSTEC)

Miyo IKEDA (Marine Works Japan Co. Ltd.): Operation Leader

Minoru KAMATA, Masanori ENOKI (Marine Works Japan Co. Ltd.)

(2) Objective

Dissolved oxygen is important parameter to identify water masses of intermediate and deep water in the Arctic Ocean. We measured dissolved oxygen in seawater by Winkler titration.

(3) Parameters

Dissolved oxygen

(4) Instruments and Methods

a. Reagents

Pickling Reagent I: Manganous chloride solution (3M)

Pickling Reagent II: Sodium hydroxide (8M) / sodium iodide solution (4M)

Sulfuric acid solution (5M)

Sodium thiosulfate (0.025M)

Potassium iodate (0.001667M)

b. Instruments:

Burette for sodium thiosulfate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Burette for potassium iodate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Detector and Software;

Automatic photometric titrator (DOT-01) manufactured by Kimoto Electronic Co. Ltd.

c. Sampling

Following procedure is based on the WHP Operations and Methods (Dickson, 1996). Seawater samples were collected with Niskin bottle attached to the CTD-system. Seawater for oxygen measurement was transferred from Niskin sampler bottle to a volume calibrated flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I and II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. A magnetic stirrer bar and 1 cm^3 sulfuric acid solution were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose morality was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise, we measured dissolved oxygen concentration using 2 sets of the titration apparatus. Dissolved oxygen concentration ($\mu mol\ kg^{-1}$) was calculated by sample temperature during seawater sampling, salinity of the sample, and titrated volume of sodium thiosulfate solution without the blank.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant (ca. 0.025M) was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130^oC. 1.7835g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667M). 10 cm^3 of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of sodium thiosulfate titrated gave the morality of sodium thiosulfate titrant.

The blank from the presence of redox species apart from oxygen in the reagents was determined as follows. Firstly, 1 cm^3 of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Secondary, 2 cm^3 of the standard potassium iodate solution was added to a flask using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate.

Table2.3-1 shows results of the standardization and the blank determination during this cruise.

Table2.3-1 Results of the standardization and the blank determinations during this cruise.

Date	KIO_3	$Na_2S_2O_3$	DOT-01(No.1)		DOT-01(No.2)	
			E.P.	Blank	E.P.	Blank
2008/08/27	20080722-01-01	20070613-17-1	3.961	-0.006	3.960	-0.005
2008/08/28	20080722-01-02	20070613-17-1	-	-	3.962	-0.005
2008/08/28	CSK	20070613-17-1	3.958	-0.005	3.957	-0.003
2008/08/31	20080722-01-03	20070613-17-1	3.961	-0.003	3.961	-0.003
2008/08/31	20080722-01-03	20070613-17-2	3.963	-0.005	3.963	-0.004
2008/09/03	20080722-01-04	20070613-17-2	3.958	-	3.958	-
2008/09/03	20080722-01-05	20070613-17-2	3.956	-0.003	3.957	-0.004
2008/09/03	20080722-01-05	20070613-18-1	3.958	-0.004	3.957	-0.004
2008/09/05	20080722-01-06	20070613-18-1	3.957	-	3.957	-
2008/09/06	20080722-01-07	20070613-18-1	3.958	-0.004	3.959	-0.004
2008/09/06	20080722-01-07	20070613-18-2	3.959	-0.004	3.958	-0.004
2008/09/08	20080722-01-08	20070613-18-2	3.959	-0.005	3.959	-0.004
2008/09/08	20080722-02-02	20070613-18-2	3.958	-	3.959	-
2008/09/08	20080722-02-02	20070613-20-1	3.962	-0.005	3.962	-0.005
2008/09/10	20080722-02-01	20070613-20-1	3.959	-	3.960	-
2008/09/11	20080722-02-03	20070613-20-1	3.958	-0.003	3.957	-0.002
2008/09/11	20080722-02-03	20070613-20-2	3.962	-0.005	3.962	-0.003
2008/09/13	20080722-02-04	20070613-20-2	3.959	-0.004	3.960	-0.003
2008/09/13	20080722-02-04	20070613-21-1	3.960	-0.004	3.960	-0.004
2008/09/15	20080722-02-05	20070613-21-1	3.958	-0.004	3.957	-0.003
2008/09/17	20080722-02-06	20070613-21-1	3.959	-0.003	3.958	-0.004
2008/09/17	20080722-02-06	20070613-21-2	3.961	-0.004	3.961	-0.003
2008/09/19	20080722-02-07	20070613-21-2	3.958	-0.005	3.957	-0.005
2008/09/19	20080722-02-07	20070613-22-1	3.959	-0.003	3.959	-0.003
2008/09/21	20080722-02-08	20070613-22-1	3.956	-0.002	3.956	-0.003
2008/09/22	20080722-02-08	20070613-22-2	3.959	-0.004	3.959	-0.003
2008/09/23	20080722-02-09	20070613-22-2	3.957	-0.003	3.958	-0.003
2008/09/23	20080722-02-09	20070613-23-1	3.961	-0.005	3.961	-0.002
2008/09/25	20080722-02-10	20070613-23-1	3.961	-	3.961	-
2008/09/26	20080722-03-01	20070613-23-1	3.961	-0.001	3.961	-0.002
2008/09/26	20080722-03-01	20070613-23-2	3.962	-0.002	3.961	-0.003

2008/09/28	20080722-03-02	20070613-23-2	3.963	-0.003	3.964	-0.002
2008/09/28	20080722-03-02	20070613-24-1	3.965	-0.002	3.963	-0.002
2008/09/29	20080722-03-03	20070613-24-1	3.962	-0.002	3.962	-0.002
2008/09/29	20080722-03-03	20070613-24-2	3.962	-0.004	3.964	-0.003
2008/10/01	20080722-03-04	20070613-24-2	3.961	-0.002	3.961	-0.003
2008/10/01	20080722-03-04	20070613-26-1	3.962	-0.003	3.962	-0.002
2008/10/03	20080722-03-05	20070613-26-1	3.962	-0.002	3.963	-0.002
2008/10/03	20080722-03-05	20070613-26-2	3.962	-0.004	3.962	-0.003
2008/10/06	20080722-03-06	20070613-26-2	3.962	-0.003	3.961	-0.003
2008/10/06	CSK	20070613-26-2	3.957	-	3.956	-

f. Reproducibility of sample measurement

During this cruise we measured oxygen concentration in 3477 seawater samples at 185 stations. Replicate samples were taken at every CTD casts. Results of replicate samples were shown in Table2.3-2 and this histogram shown in Fig2.3-1. The standard deviation was calculated by a procedure in Guide to best practics for ocean CO2 measurements Chapter4 SOP23 Ver.3.0 (2007).

Table2.3-2 Results of the replicate sample measurements

Layer	Number of replicate sample pairs	Oxygen concentration (μmol/kg) Standard Deviation.
1000m>=	43	0.07
>1000m	235	0.43
All	278	0.39

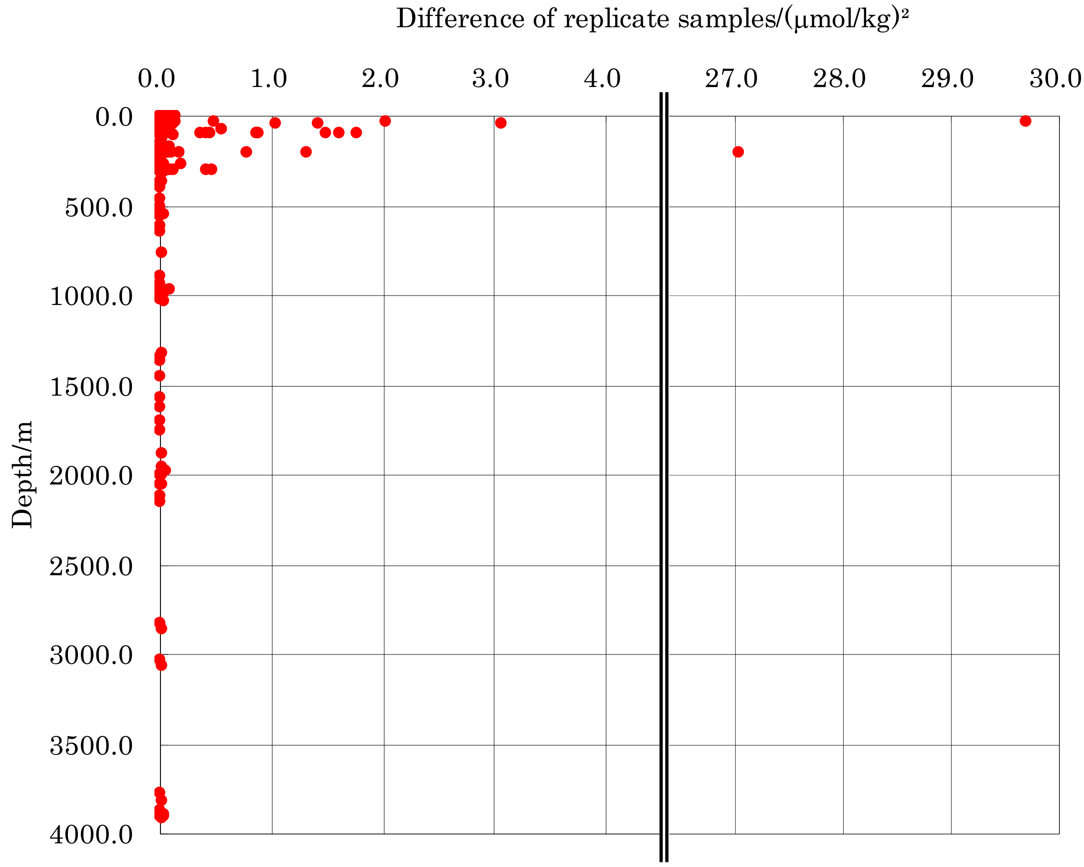


Fig.2.3-1 Differences of replicate samples against sampling depth.

(5) Data policy and citation

All data will be submitted to Chief Scientist.

(6) References

Dickson, Determination of dissolved oxygen in sea water by Winkler titration. (1996)

Dickson et al., Guide to best practices for ocean CO2 measurements. (2007)

Culberson, WHP Operations and Methods July-1991 “Dissolved Oxygen”, (1991)

Japan Meteorological Agency, Oceanographic research guidelines (Part 1). (1999)

KIMOTO electric CO. LTD., Automatic photometric titrator DOT-01 Instruaction manual

2.4. Mooring observations

2.4.1 Recovery

(1) Personnel

Koji Shimada(JAMSTEC): Principal Investigator
Motoyo Itoh(JAMSTEC): Co-Principal Investigator
Akinori Murata (MWJ): Operation leader
Satoshi Ozawa (MWJ): Technical staff
Fujio Kobayashi (MWJ): Technical staff
Kenichi Katayama (MWJ): Technical staff
Tomohide Noguchi (MWJ): Technical staff
Akira Watanabe (MWJ): Technical staff
Yohei Taketomo (MWJ): Technical staff
Yuko Sagawa (MWJ): Technical staff
Takami Mori (MWJ): Technical staff

(2) Objectives

The purpose of mooring measurements is to monitor the variations of Pacific inflows into the Arctic basins. The recovered moorings from MR80-04 cruise were located on the major pathways of the Pacific inflows to evaluate the water mass and volume/heat/salt fluxes. Components of these moorings are depicted in Figure 2-4-1.

(3)Measured parameters

- Oceanic velocities
- Echo intensity, bottom tracking range and velocities for sea ice measurements
- Pressure, Temperature and Conductivity
- Dissolved oxygen

(4)Instruments

1) CTD or CT sensors

SBE37-SM (Sea Bird Electronics Inc.)

SBE16 (Sea Bird Electronics Inc.)

2) Current meters

Workhorse ADCP 300 kHz (Teledyne RD Instruments, Inc.)

RCM-7 (AANDERAA DATA INSTRUMENTS)

RCM-8 (AANDERAA DATA INSTRUMENTS)

RCM-9 (AANDERAA DATA INSTRUMENTS)

S4 current meter (InterOcean systems, Inc.)

* most of the above sensors equip temperature and conductivity sensors

3) Oxygen sensor

Compact-Optode (JFE ALEC Co., Ltd.)

4) Acoustic Releaser

Model- L (Nichiyu giken kogyo co., LTD)

Model-Lti (Nichiyu giken kogyo co., LTD)

8202 (ORE offshore)

8242XS (ORE offshore)

5)Transponder

Model-L-TL-T (Nichiyu giken kogyo co., LTD)

(5) Duration of recovered moorings

Recovery moorings

Mooring ID	Recovery Date (UTC)	Latitude	Longitude	Deployment date (UTC)
BC-E-07	2008/09/09	71-40.479N	154-58.912W	2007/10/08
BC-C-07	2008/08/31	71-43.869N	155-09.664W	2007/10/07
BC-W-07	2008/09/08	71-48.242N	155-20.086W	2007/10/07
HC-E-07	2008/09/23	73-09.567N	162-19.786W	2007/10/06
BC-H-07	2008/08/30	71-06.248N	159-20.094W	2007/10/08
NC-S-06	2008/09/18	73-58.375N	167-34.992W	2006/10/05

(6) Data Policy and citation

All data will be published on JAMSTEC within 2 years after MR08-04 cruise.

2.4.2 Deployment

(1) Personnel

Motoyo Itoh	(JAMSTEC): Principal Investigator
Koji Shimada	(JAMSTEC): Co-Principal Investigator
Akinori Murata	(MWJ): Operation leader
Satoshi Ozawa	(MWJ): Technical staff
Fujio Kobayashi	(MWJ): Technical staff
Kenichi Katayama	(MWJ): Technical staff
Tomohide Noguchi	(MWJ): Technical staff
Akira Watanabe	(MWJ): Technical staff
Yohei Taketomo	(MWJ): Technical staff
Yuko Sagawa	(MWJ): Technical staff
Takami Mori	(MWJ): Technical staff

(2) Objectives

The purpose of mooring measurements is to monitor the variations of Pacific inflows into the Arctic basins. The deployed moorings were located in the Barrow Canyon which is major gateway of Pacific inflow. Components of these moorings are depicted in Figure 2.

(3)Measured parameters

- Oceanic velocities
- Echo intensity, bottom tracking range and velocities for sea ice measurements
- Pressure, Temperature and Conductivity

(4)Instruments

1) CTD or CT sensors

SBE37-SM (Sea Bird Electronics Inc.)

SBE16 (Sea Bird Electronics Inc.)

2) Current meters

Workhorse ADCP 300 kHz (Teledyne RD Instruments, Inc.)

RCM-7 (AANDERAA DATA INSTRUMENTS)

RCM-9 (AANDERAA DATA INSTRUMENTS)

3) Acoustic Releaser

Model- L (Nichiyu giken kogyo co., LTD)

8242XS (ORE offshore)

5)Transponder

XT-6000 (BENTHOS,Inc.)

(5) List of deployed moorings

Deployment moorings

Mooring ID	Deployment date (UTC)	Latitude	Longitude
BC-C-08	2008/08/31	71-43.874N	155-09.662W
BC-E-08	2008/09/08	71-40.481N	154-58.921W
BC-W-08	2008/09/08	71-48.246N	155-20.073W

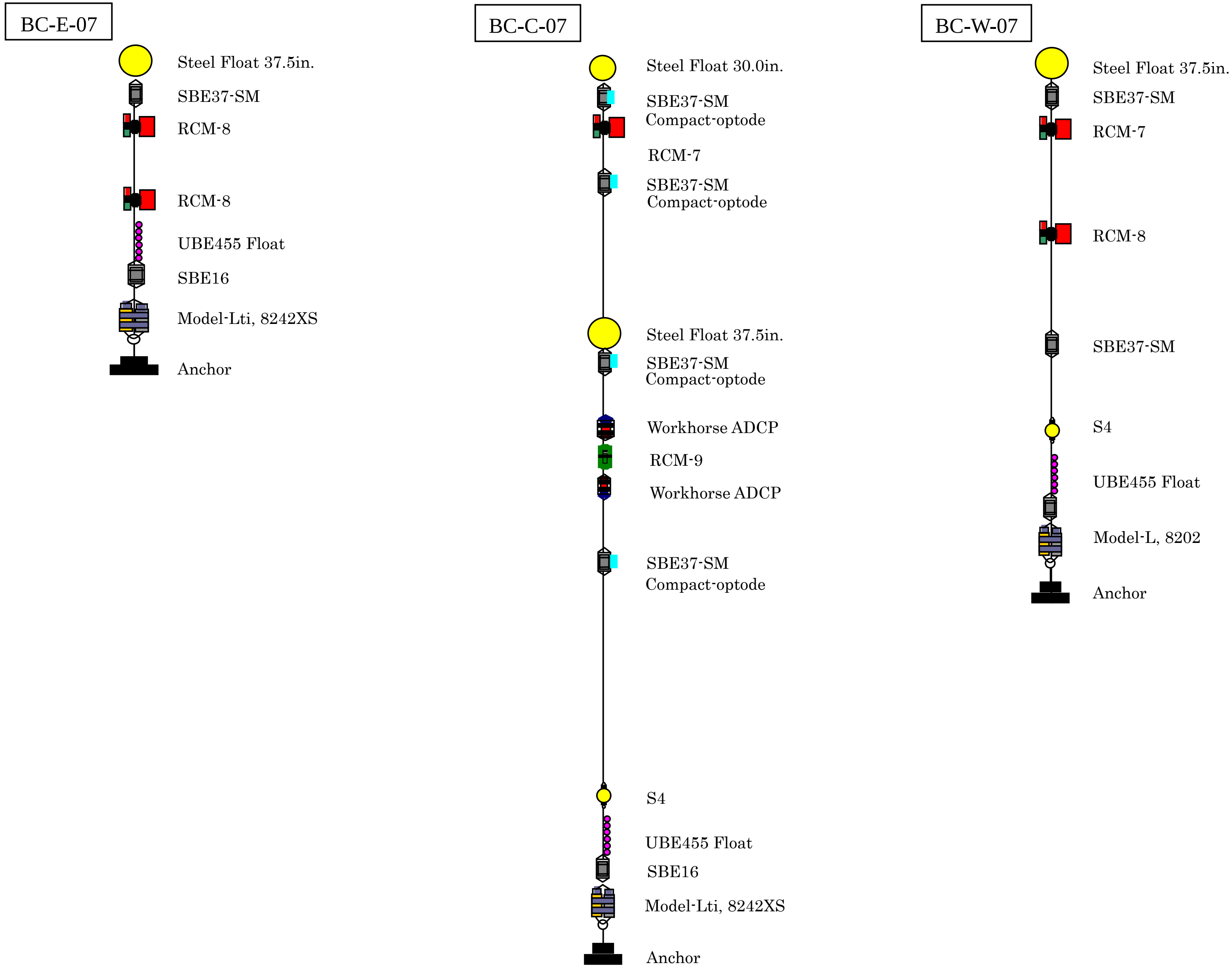


Fig.2-4-1a　Mooring diagram of Recovery moorings

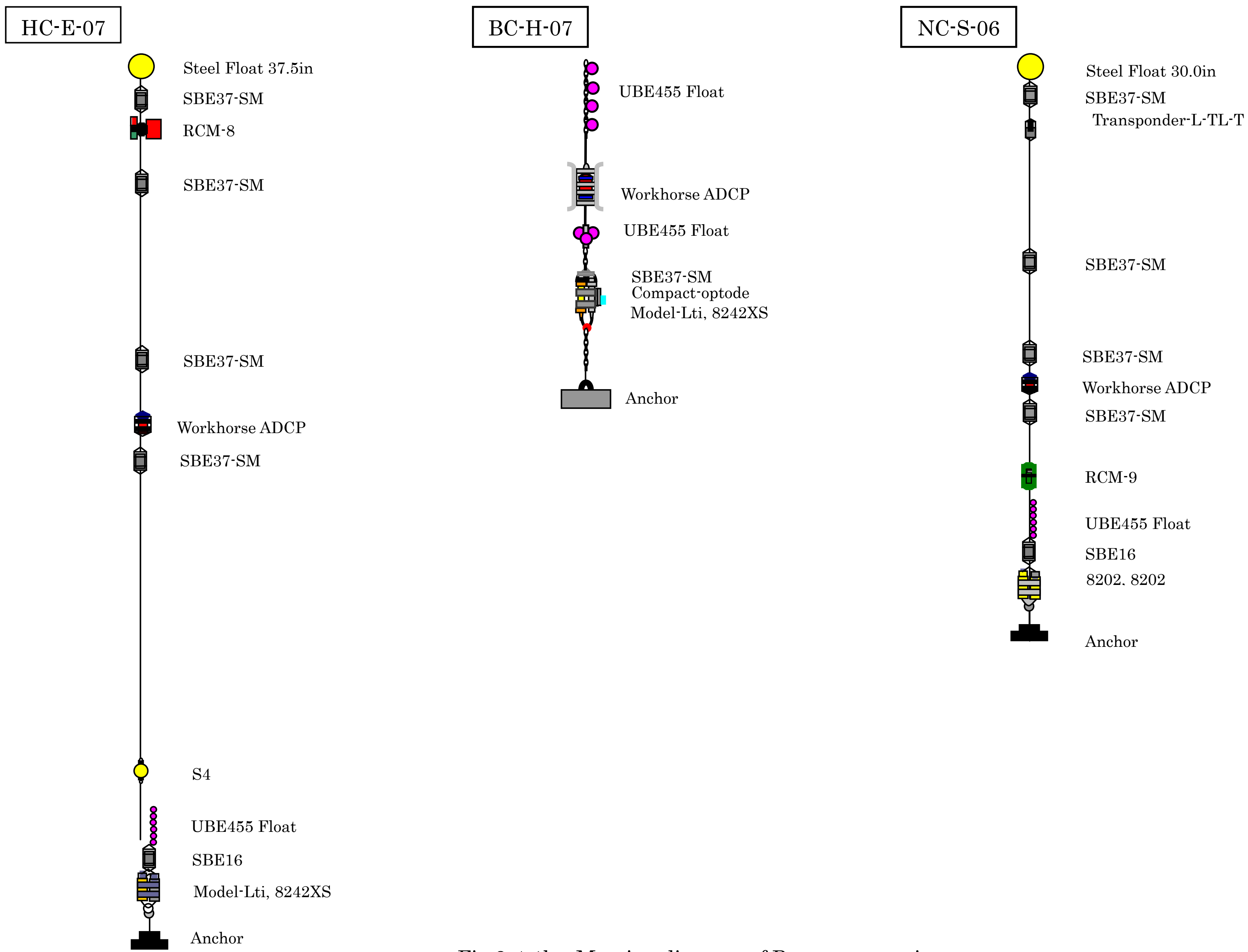


Fig.2-4-1b Mooring diagram of Recovery moorings

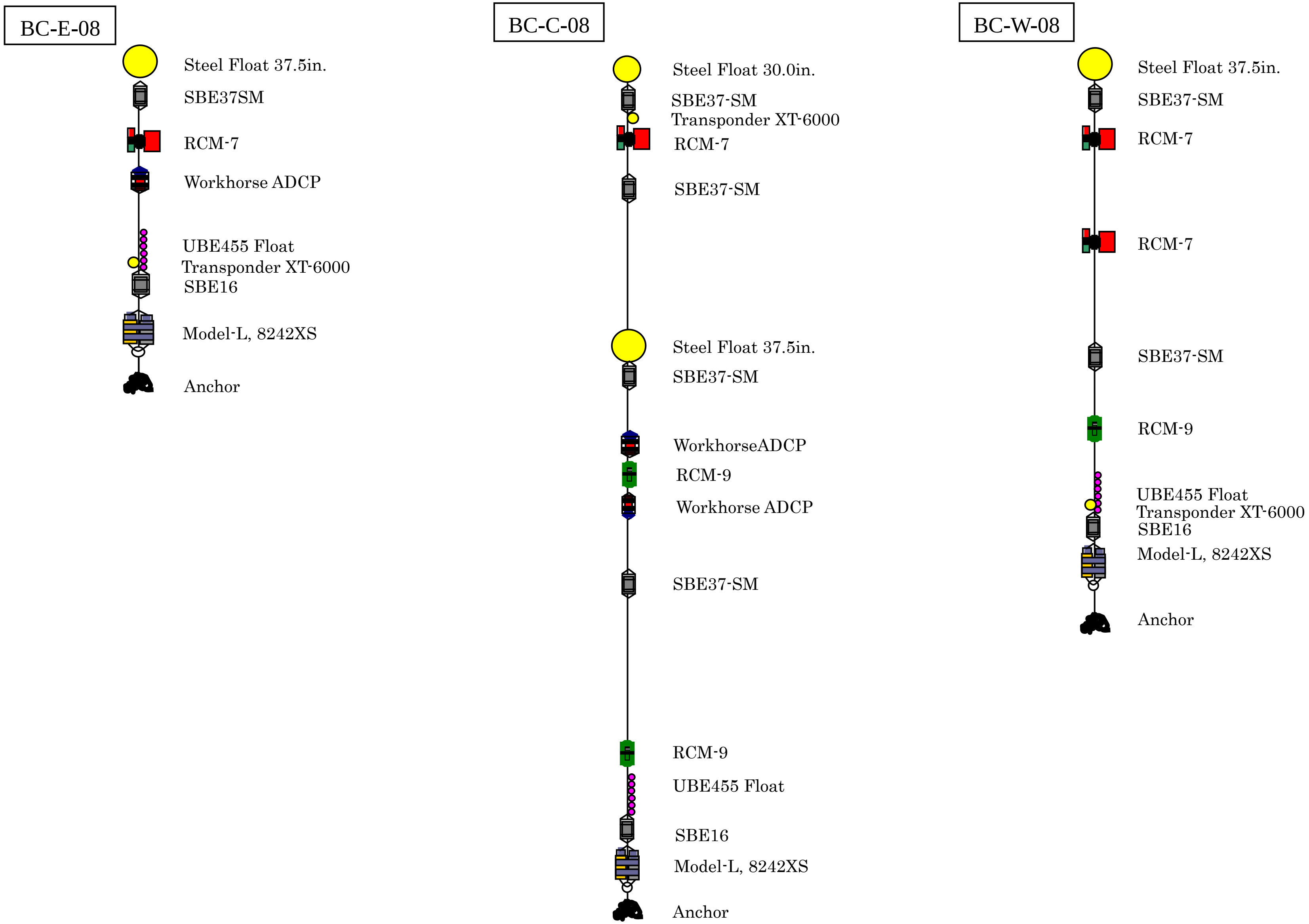


Fig.2-4-2 Mooring diagram of Deployment moorings

2.5. Sea surface water monitoring

(1) Personnel

Naoyuki Kurita	(JAMSTEC): Principal Investigator
Motoyo Itoh	(JAMSTEC)
Koji Shimada	(JAMSTEC)
Minoru Kamata	(MWJ): Operation leader
Masanori Enoki	(MWJ): Technical Staff
Miyo Ikeda	(MWJ): Technical Staff

(2) Objective

To show the basic features of Arctic Ocean, underway monitoring of temperature, salinity, dissolved oxygen and fluorescence were carried out during whole cruise period.

(3) Instruments and methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) that equips five sensors of 1) salinity, 2) temperatures (two sensors), 3) dissolved oxygen and 4) fluorescence can continuously measure their values in near-sea surface water. Salinity is calculated by conductivity on the basis of PSS78. Specifications of these sensors are listed below.

This system is settled in the "*sea surface monitoring laboratory*" on R/V MIRAI, and near-surface water was continuously pumped up to the system through a vinyl-chloride pipe. The flow rate for the system is manually controlled by several valves with its value of 12 L min^{-1} except for the fluorometer (about 0.5 L min^{-1}). Each flow rate is monitored with respective flow meter. The system is connected to shipboard LAN-system, and measured data is stored in a hard disk of PC every 1-minute together with time (UTC) and position of the ship.

a) Temperature and Conductivity sensor

Model:	SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number:	2126391-3126
Measurement range:	Temperature -5 to +35℃, Conductivity 0 to 7 S m^{-1}
Resolution:	Temperatures 0.001℃, Conductivity 0.0001 S m^{-1}
Stability:	Temperature 0.01℃ 6 months^{-1}, Conductivity 0.001 S m^{-1} month^{-1}

b) Bottom of ship thermometer

Model:	SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number:	032607
Measurement range:	-5 to +35℃
Resolution:	±0.001℃
Stability:	0.002℃ year^{-1}

c) Dissolved oxygen sensor

Model:	2127A, Hach Ultara Analytics Japan, INC.
Serial number:	61230
Measurement range:	0 to 14 ppm
Accuracy:	±1% in ±5℃ of correction temperature
Stability:	5% month^{-1}

d) Fluorometer

Model:	10-AU-005, TURNER DESIGNS
Serial number:	5562 FRXX
Detection limit:	5 ppt or less for chlorophyll a
Stability:	0.5% month^{-1} of full scale

e) Flow meter

Model:	EMARG2W, Aichi Watch Electronics LTD.

Serial number: 8672
Measurement range: 0 to 30 L min^{-1}
Accuracy: <= ±1%
Stability: <= ±1% day^{-1}

The monitoring period (UTC) during this cruise are listed below.

LEG1	Start: 2008/08/17 04:58	Stop: 2008/08/24 22:07
LEG2	Start: 2008/08/26 23:44	Stop: 2008/10/08 17:03

(4) Preliminary Result

Preliminary data of temperature, salinity, dissolved oxygen, fluorescence at sea surface are shown in Fig.2.5-1, 2.5-2. We took the surface water samples once a day to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in Fig.2.5-3, 2.5-4. All the salinity samples were analyzed by the Guildline 8400B "AUTOSAL", and dissolve oxygen samples were analyzed by Winkler method.

(5) Date archive

The data were stored on a CD-R, which will be submitted to JAMSTEC, and will be opened to public via "R/V MIRAI Data Web Page" in JAMSTEC homepage.

(6) Remarks

None

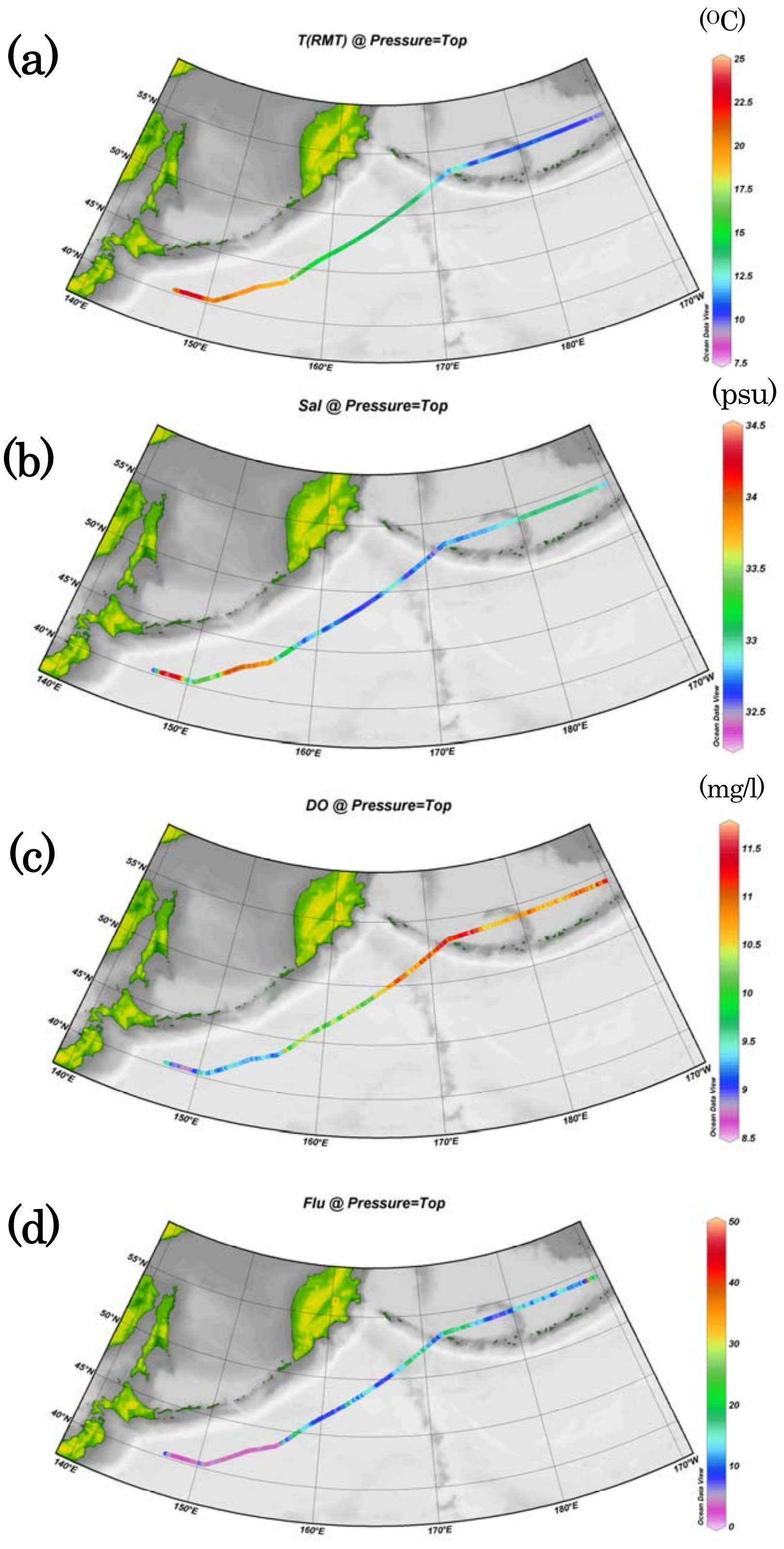


Fig.2.5-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen and (d) fluorescence in MR08-04 LEG1 cruise. Fluorescence is relative value.

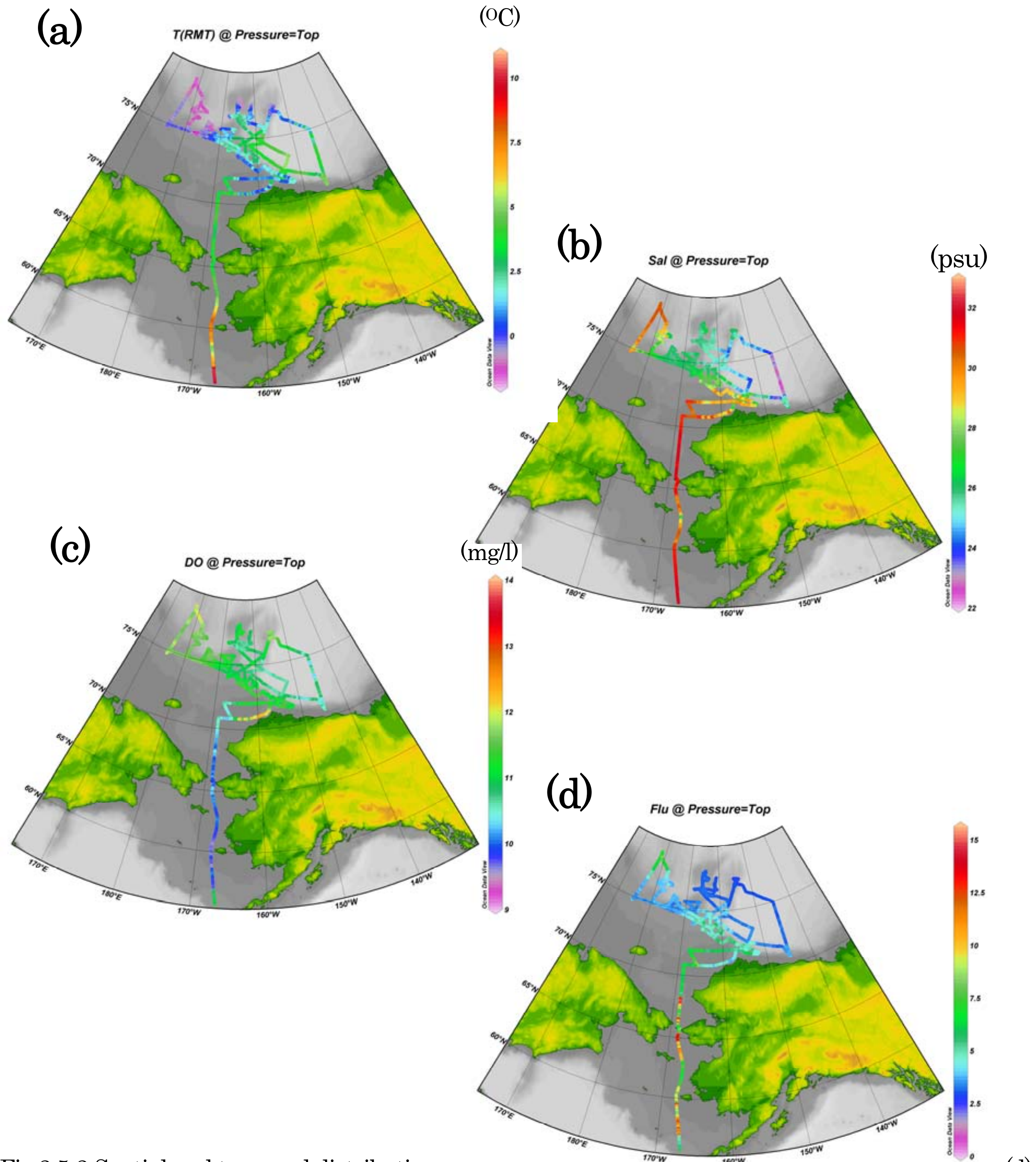


Fig.2.5-2 Spatial and temporal distribution ((d) fluorescence in MR08-04 LEG2 cruise. Fluorescence is relative value.

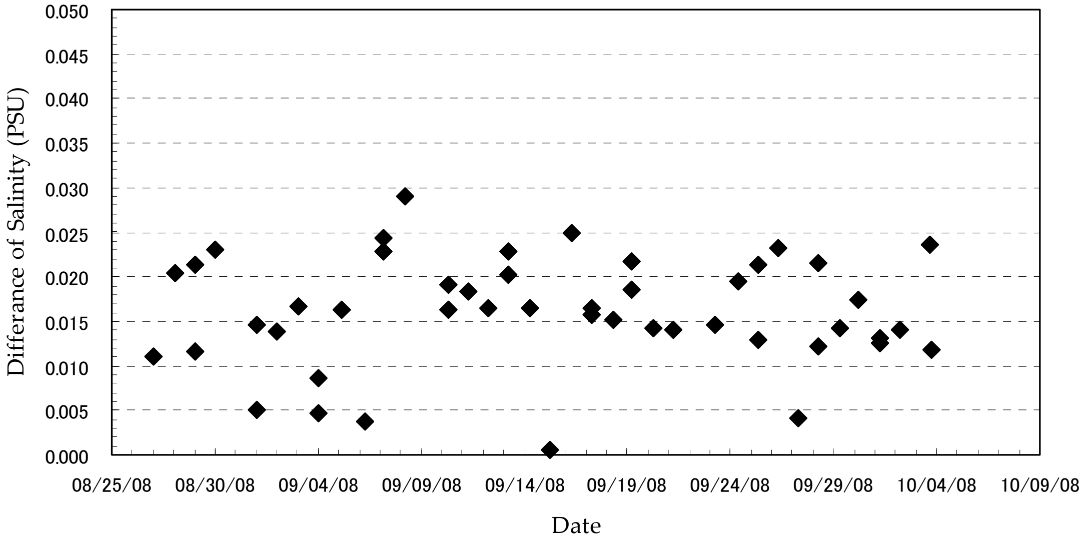


Fig.2.5-3 Difference of salinity between sensor data and bottle data. The mean difference is 0.0161psu.

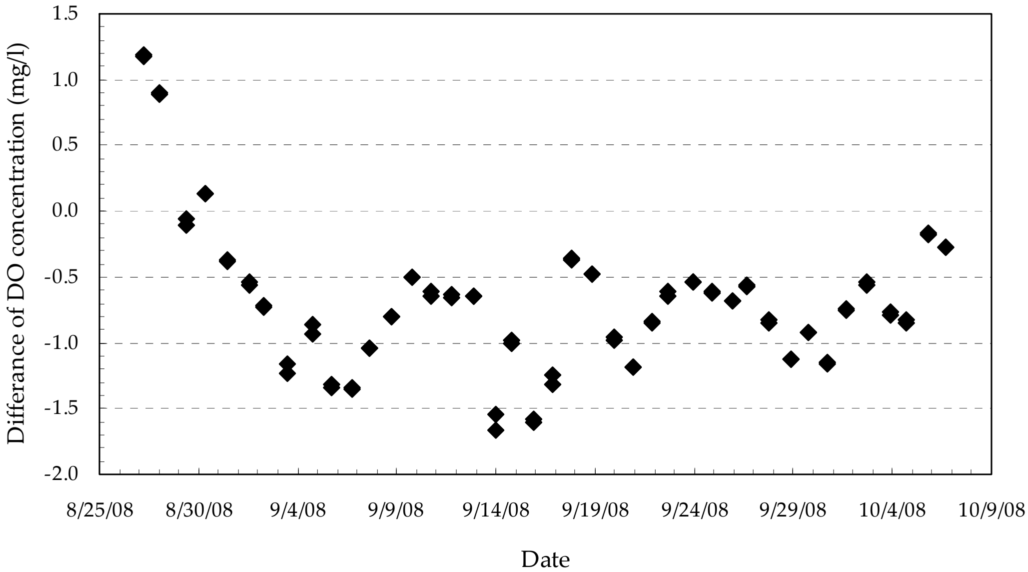


Fig.2.5-4 Difference of dissolved oxygen between sensor data and bottle data. The mean difference is -0.6902 mg/l.

2.6. Shipboard ADCP observation

(1) Personnel

Koji Shimada (JAMSTEC): Principal Investigator
Takashi Kamoshida (System Intech Co.,Ltd)
Shinya Okumura, Satoshi Okumura, Souichiro Sueyoshi, Harumi Ota(GODI)

(2) Objective

To obtain continuous measurement of the current profile along cruise track and on-station.

(3) Methods

Upper ocean current measurements were made throughout MR08-04 cruise, using the hull mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation, the instrument was configured for water-tracking mode recording. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made in shallower water region to get the calibration data for evaluating transducer misalignment angle.

The system consists of following components;

1) R/V MIRAI has installed the Ocean Surveyor for vessel-mount (acoustic frequency 75 kHz; Teledyne RD Instruments). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel.
2) For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (INS) which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3) GPS navigation receiver (Trimble DS4000) provides position fixes.
4) We used VmDas version 1.4.2 (TRD Instruments) for data acquisition.
5) To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute.
6) We have placed ethylene glycol into the fresh water to prevent freezing in the sea chest.
7) The sound speed at the transducerr does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

The data was configured for 4 m processing bin, 4 m intervals and starting 20 m below the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively. We changed the major parameters, and showed the date and time that we changed command file. (See appendix: Direct Command File List.)

(4) Data archive

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

Remarks

We did not collect data close to the boundary of the Russian EEZ from 19:32 to 20:40UTC 25 Sep. 2008.

Appendix: Direct Command File List

08/15	06:12	OS75_mr0804_BB_ws4wn128bpDEF.txt
08/15	11:26	OS75_mr0804_BB_ws8wn128bpDEF.txt
08/15	11:34	OS75_mr0804_BB_ws4wn128bpDEF.txt
08/16	11:27	OS75_mr0804_BB_ws8wn100wp15DEF.txt
08/16	11:30	OS75_mr0804_BB_ws8wn100wp5DEF.txt
08/16	11:35	OS75_mr0804_BB_ws8wn100wp30DEF.txt
08/16	11:38	OS75_mr0804_BB_ws8wn100wp1DEF.txt
08/16	11:42	OS75_mr0804_BB_ws8wn100wp30DEF.txt
08/16	11:45	OS75_mr0804_BB_ws8wn100wp10DEF.txt
08/16	12:02	OS75_mr0804_BB_ws8wn100wp15DEF.txt
08/17	09:22	OS75_mr0804_BB_ws8wn100wpTE00DEF.txt
08/17	09:31	OS75_mr0804_BB_ws8wn100wpTE00TP00DEF.txt
08/17	09:42	OS75_mr0804_BB_ws8wn100wpTE00DEF.txt
08/19	21:51	testOS75_mr0804_BB_ws8wn100wp10DEF.txt
08/19	21:56	testOS75_mr0804_BB_ws8wn100wp40DEF.txt
08/21	19:16	OS75_mr0804_BB_ws4wn128wp40DEF.txt
08/21	23:59	OS75_mr0804_BB_ws8wn100wpDEF.txt
08/22	00:03	OS75_mr0804_BB_ws4wn128wp40DEF.txt
08/22	00:07	OS75_mr0804_BB_ws4wn128wp39DEF.txt
08/22	00:51	OS75_mr0804_BB_ws4wn128wp57DEF.txt
08/22	00:57	OS75_mr0804_BB_ws4wn128wp40bp01DEF.txt
08/22	01:05	OS75_mr0804_BB_ws8wn100wpDEF.txt
08/22	01:05	OS75_mr0804_BB_ws8wn100wpDEF.txt
08/22	01:20	OS75_mr0804_BB_ws4wn128wp40bp01DEF.txt
08/22	01:57	OS75_mr0804_BB_ws4wn128wp40TP02DEF.txt
08/22	02:01	OS75_mr0804_BB_ws4wn128wp35TP02DEF.txt
08/22	06:44	OS75_mr0804_BB_ws8wn100bpDEF.txt
08/22	06:50	OS75_mr0804_BB_ws4wn128wp57DEF.txt
08/23	00:04	OS75_mr0801_NB_ws8wn100wpDEF.txt
08/23	00:11	OS75_mr0804_BB_ws4wn128wp57DEF.txt
08/23	04:28	OS75_mr0804_BB_ws4wn128wpwf16DEF.txt
08/23	04:41	OS75_mr0804_BB_ws4wn128wpwf8EC1450DEF.txt
08/25	15:36	OS75_mr0804_BB_ws4wn50wp50bp04EC1450DEF.txt
08/25	19:54	OS75_mr0804_BB_ws8wn100bpDEF.txt
08/26	15:28	OS75_mr0804_BB_ws4wn128wp50bp04EC1450DEF.txt
08/27	00:31	OS75_mr0804_BB_ws4wn50wp50bp05EC1450DEF.txt
08/29	19:35	OS75_mr0804_BB_ws4wn50bpEC1450DEF.txt
08/29	19:41	OS75_mr0804_BB_ws4wn50bpES30EC1450DEF.txt
08/29	19:47	OS75_mr0804_BB_ws4wn50bpEC1450DEF.txt
08/30	00:46	OS75_mr0804_BB_ws4wn50bpTP4EC1450DEF.txt
08/30	00:54	OS75_mr0804_BB_ws4wn50bpTP2EC1450DEF.txt
08/31	15:03	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/01	03:47	OS75_mr0804_BB_ws4wn50wpTP2EC1450DEF.txt
09/01	03:56	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/01	07:23	OS75_mr0804_BB_ws4wn128wpwf12TP2EC1450DEF.txt
09/01	07:27	OS75_mr0804_BB_ws4wn128wpwf10TP2EC1450DEF.txt

09/01	07:30	OS75_mr0804_BB_ws4wn128wpwf12TP2EC1450DEF.txt
09/01	19:47	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/02	10:13	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/02	14:11	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/03	08:40	OS75_mr0804_BB_ws8wn100bpDEF.txt
09/03	08:43	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/03	15:08	OS75_mr0804_BB_ws4wn128wpwf12TP2EC1450DEF.txt
09/03	15:18	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/04	10:27	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/04	18:17	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/05	22:03	OS75_mr0803_BB_ws16wn40wpDEF.txt
09/06	00:44	OS75_mr0803_BB_ws16wn40wpwf12DEF.txt
09/06	00:46	OS75_mr0803_BB_ws16wn40wpDEF.txt
09/06	06:04	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/06	18:22	OS75_mr0804_BB_ws8wn100wpTP2DEF.txt
09/06	18:17	OS75_mr0804_BB_ws8wn100wpTP2DEF.txt
09/06	18:23	OS75_mr0803_BB_ws16wn40wpTP2EC1450DEF.txt
09/06	18:29	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/07	18:23	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/07	18:27	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/07	19:34	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/08	06:12	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/09	04:20	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/09	11:05	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/09	12:57	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/10	08:07	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/13	06:32	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/13	09:57	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/13	18:39	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/14	05:15	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/14	17:47	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/15	12:09	OS75_mr0804_BB_ws4wn128bp.txt
09/15	12:21	OS75_mr0804_BB_ws8wn100bpDEF.txt
09/15	12:23	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/17	08:42	OS75_mr0804_BB_ws4wn128bpTP2EC1450DEF.txt
09/18	04:40	OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt
09/18	07:33	OS75_mr0804_BB_ws4wn128wpTP2EC1450DEF.txt
09/19	20:54	OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt
09/22	03:35	OS75_mr0804_BB_ws4wn100bpWF16EA45TP2EC1450DEF.txt
09/22	17:31	OS75_mr0804_BB_ws4wn128bpWF16EA45TP2EC1450DEF.txt
09/24	17:31	OS75_mr0804_BB_ws4wn100bpWF16EA45TP2DEF.txt
09/25	20:37	OS75_mr0804_BB_ws4wn100bpWF16EA45TP2EC1450DEF.txt
09/27	04:18	OS75_mr0804_BB_ws4wn128bpWF16EA90TP2EC1450DEF.txt
09/27	04:25	OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt
09/27	19:20	OS75_mr0804_BB_ws4wn128wpEA45TP2EC1450DEF.txt
09/29	08:37	OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt

10/01 02:50 OS75_mr0804_BB_ws4wn128wpEA45TP2EC1450DEF.txt
10/01 22:53 OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt
10/02 04:46 OS75_mr0804_BB_ws4wn050bpEA45TP2EC1450DEF.txt
10/02 17:44 OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt
10/03 18:33 OS75_mr0804_BB_ws4wn050bpEA45TP2EC1450DEF.txt
10/03 22:27 OS75_mr0804_BB_ws4wn128bpEA45TP2EC1450DEF.txt
10/04 03:46 OS75_mr0804_BB_ws4wn050bpEA45TP2EC1450DEF.txt
10/06 20:17 OS75_mr0804_BB_ws4wn025bpEA45TP2EC1450DEF.txt
10/06 22:22 OS75_mr0804_BB_ws4wn050bpEA45TP2EC1450DEF.txt

2.7. XCTD observations

(1) Personnel

Koji Shimada (JAMSTEC): Principal Investigator
Motoyo Itoh (JAMSTEC)
Shinya Okumura, Satoshi Okumura, Souichirou Sueyoshi, Harumi Ota (GODI)

(2) Objective

The internal deformation radius in the Arctic Ocean is much smaller than that in the mid-latitude ocean. High resolution surveys are required to identify mesoscale eddies. In the Canada Basin, distribution of eddies are necessary to argue the observed chemical and biological properties. Most of XCTD observations were performed between CTD stations.

(3) Parameters

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD (eXpendable Conductivity, Temperature & Depth profiler) are as follows;

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]
Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

(4) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD-1. The signal was converted by digital converter MK-100 and was recorded by WinXCTD software (Ver.1.08). Above system was manufactured by Tsurumi-Seiki Co.. We cast 195 probes by hand and automatic launcher.

(5) Observation log

Table XCTD observation log

	Station No.	Date [YYYY/MM/DD]	Time [hh:mm:ss]	Latitude	Longitude	Depth [m]	SST [degC]	SSS [PSU]	Probe S/N
1	X01	2008/09/01	02:17:17	72-00.0169N	154-40.2942W	1036	4.541	27.289	08069456
2	X02	2008/09/01	02:49:20	72-06.0200N	154-29.0936W	1501	4.916	26.736	08069453
3	X03	2008/09/01	03:39:04	72-16.0044N	154-10.4525W	2224	5.016	25.430	08069451
4	X04	2008/09/01	04:55:21	72-32.0069N	153-42.9837W	3180	4.332	27.63	08069395
5	X05	2008/09/01	07:23:18	73-00.0058N	152-46.9836W	3839	5.170	24.28	08069454
6	X06	2008/09/01	16:31:33	73-30.0851N	152-30.0190W	3847	5.026	24.09	08069394
7	X07	2008/09/01	18:58:00	73-42.0079N	153-30.0376W	3850	4.586	25.07	08069455
8	X08	2008/09/01	23:50:57	73-52.4803N	154-30.0137W	3853	4.368	24.600	08069452

9	X09	2008/09/02	02:16:16	74-06.0414N	155-30.0253W	3855	4.212	24.983	08069561
10	X10	2008/09/02	06:12:56	74-17.5467N	156-30.0037W	3859	4.411	24.754	08069457
11	X11	2008/09/02	08:20:06	74-27.9947N	157-19.9928W	3862	4.284	25.113	08069559
12	X12	2008/09/02	08:48:49	74-31.9455N	157-40.0079W	2433	4.187	25.084	08069466
13	X13	2008/09/02	10:50:26	74-40.4041N	158-20.0221W	1152	4.572	24.970	08069459
14	X14	2008/09/02	11:18:58	74-44.4087N	158-40.0145W	898	4.885	24.664	08069560
15	X15	2008/09/02	13:07:55	74-51.9458N	159-20.0406W	1856	4.141	25.427	08069564
16	X16	2008/09/02	13:36:42	74-55.9815N	159-40.0215W	1871	3.972	25.458	08069458
17	X17	2008/09/03	02:33:14	75-00.0267N	158-19.9964W	940	4.290	25.622	08069566
18	X18	2008/09/03	03:40:15	75-15.0167N	157-55.0610W	1115	4.608	25.032	08069563
19	X19	2008/09/03	04:49:14	75-30.0158N	157-29.5472W	1389	1.660	24.502	08069565
20	X20	2008/09/03	06:25:26	75-45.0068N	157-05.0470W	991	1.818	24.537	08069568
21	X21	2008/09/03	10:37:25	76-15.0046N	156-15.8505W	735	1.312	24.764	08069569
22	X22	2008/09/03	12:01:34	76-29.9980N	155-47.7311W	744	0.937	24.829	08069562
23	X23	2008/09/03	15:35:47	77-00.0042N	155-05.7194W	968	-0.219	25.792	08069570
24	X24	2008/09/03	17:02:54	77-14.9907N	154-33.6827W	1085	-0.566	25.955	08069567
25	X25	2008/09/03	23:58:18	77-22.2000N	155-08.4166W	1863	-0.747	26.060	08069381
26	X26	2008/09/05	01:16:15	76-49.7146N	153-05.6607W	3841	-0.152	25.551	08069379
27	X27	2008/09/05	05:50:09	76-29.9959N	152-15.1973W	3840	1.436	24.177	08069380
28	X28	2008/09/05	11:37:24	76-06.4746N	150-59.9728W	3837	0.541	25.032	08069374
29	X29	2008/09/05	16:26:31	75-52.6172N	149-22.4795W	3830	1.079	24.321	08069373
30	X30	2008/09/05	19:32:04	75-37.5682N	148-07.4527W	3817	2.412	24.428	08069376
31	X31	2008/09/06	01:59:56	75-22.8901N	146-49.4779W	3802	0.674	24.891	08069372
32	X32	2008/09/06	05:00:47	75-07.4663N	145-34.4754W	3778	1.470	23.863	08069371
33	X33	2008/09/06	10:08:26	74-44.9928N	144-59.4169W	3758	1.615	23.114	08069375
34	X34	2008/09/06	13:36:07	74-14.9935N	144-59.6030W	3730	3.255	23.088	08069392
35	X35	2008/09/06	18:30:52	73-44.9922N	144-59.5475W	3701	2.441	22.839	08069393
36	X36	2008/09/06	21:58:06	73-14.9895N	144-59.2184W	3605	3.935	22.855	08069370
37	X37	2008/09/07	04:27:43	72-44.9926N	144-58.8094W	3503	4.069	22.917	08069580
38	X38	2008/09/07	08:03:05	72-14.9940N	145-00.0089W	3364	4.120	22.665	08069572
39	X39	2008/09/07	13:14:06	71-44.9855N	145-00.5855W	3374	3.371	22.735	08069573
40	X40	2008/09/08	11:05:19	71-34.8921N	146-29.9971W	3100	2.552	23.367	08069378
41	X41	2008/09/08	13:43:08	71-40.8743N	147-29.9774W	3041	2.693	23.610	08069377
42	X42	2008/09/08	19:02:11	71-48.2153N	148-30.0028W	3033	3.458	24.158	08069581
43	X43	2008/09/08	21:34:19	71-56.1701N	149-30.0053W	3124	4.498	25.739	08069582
44	X44	2008/09/09	01:06:36	72-03.2403N	150-29.9963W	3135	4.548	25.412	08069578
45	X45	2008/09/09	03:24:43	72-10.7934N	151-30.1437W	3043	4.301	25.519	08069579
46	X46	2008/09/09	08:17:31	72-22.6073N	153-00.0056W	2968	3.640	27.229	08069577
47	X47	2008/09/09	13:07:04	71-40.8059N	154-58.9236W	110	3.857	28.550	08069575
48	X48	2008/09/09	13:57:17	71-44.2556N	155-09.6699W	296	3.614	29.083	08069576
49	X49	2008/09/09	20:08:03	71-44.6631N	155-09.6687W	309	3.470	29.457	08069571
50	X50	2008/09/10	11:28:06	72-38.0075N	154-30.0076W	3086	4.022	25.244	08069385
51	X51	2008/09/10	14:11:10	72-52.4518N	155-29.9778W	2954	4.283	24.833	08069389
52	X52	2008/09/10	18:02:43	73-08.4242N	156-29.9888W	2881	3.887	25.081	08069391
53	X53	2008/09/10	20:47:54	73-22.8182N	157-30.0098W	3036	3.872	26.042	08069574
54	X54	2008/09/11	02:00:03	73-36.9415N	158-30.0041W	2894	4.053	25.087	08069390

55	X55	2008/09/11	04:40:11	73-53.7239N	159-29.9867W	2994	3.728	26.655	08069387
56	X56	2008/09/11	08:07:14	74-07.2212N	160-29.9889W	768	3.687	25.572	08069386
57	X57	2008/09/11	10:54:03	74-22.3237N	161-29.9871W	1597	3.748	25.796	08069640
58	X58	2008/09/11	16:39:56	74-31.5291N	160-59.9885W	1703	3.593	26.278	08069384
59	X59	2008/09/11	17:47:51	74-33.1675N	160-00.0122W	777	3.572	25.406	08069383
60	X60	2008/09/11	18:53:43	74-34.0490N	158-59.9656W	1252	3.828	24.981	08069637
61	X61	2008/09/12	06:32:18	75-07.4969N	160-29.9978W	2089	3.892	25.256	08069382
62	X62	2008/09/12	10:41:37	75-21.9176N	161-30.0035W	2099	3.466	25.244	08069643
63	X63	2008/09/12	13:54:38	75-37.5234N	162-30.0121W	2005	1.912	25.371	08066942
64	X64	2008/09/12	17:54:56	76-52.3243N	163-29.9854W	2022	2.584	25.437	08069641
65	X65	2008/09/12	21:42:48	76-07.2302N	164-30.0012W	910	2.628	25.457	08069364
66	X66	2008/09/13	02:41:57	76-22.8419N	165-29.9938W	757	2.630	25.848	08069639
67	X67	2008/09/13	05:21:18	76-27.5614N	165-20.0075W	669	2.631	25.820	08069632
68	X68	2008/09/13	07:43:12	76-22.5568N	163-59.9943W	745	2.457	25.766	08069638
69	X69	2008/09/13	10:27:05	76-17.4883N	162-39.9666W	2071	1.809	25.520	08069388
70	X70	2008/09/13	15:25:38	76-20.2989N	162-02.1934W	2023	0.401	25.128	08069636
71	X71	2008/09/13	16:24:01	76-29.9973N	161-40.3246W	1711	1.396	25.523	08069473
72	X72	2008/09/13	17:16:46	76-39.4245N	161-23.0274W	649	0.960	25.510	08069474
73	X73	2008/09/13	18:15:44	76-49.9991N	161-34.5122W	602	1.197	25.492	08069475
74	X74	2008/09/13	19:13:19	76-59.9900N	161-30.4215W	545	0.676	25.530	08069479
75	X75	2008/09/13	20:02:28	77-10.0031N	161-18.4603W	929	0.394	25.599	08069633
76	X76	2008/09/13	20:52:33	77-19.9993N	161-11.4114W	1270	-0.112	25.583	08069478
77	X77	2008/09/13	22:13:19	77-30.8102N	161-02.1178W	601	-0.787	25.769	08069635
78	X78	2008/09/14	17:46:52	76-38.7529N	163-09.9804W	787	1.052	25.452	08069483
79	X79	2008/09/14	19:03:44	76-41.2908N	164-19.9948W	644	2.059	25.719	08069484
80	X80	2008/09/14	20:12:34	76-45.0108N	165-30.0106W	1172	2.184	25.781	08069489
81	X81	2008/09/14	21:08:18	76-39.9222N	166-19.9950W	698	2.032	25.879	08069477
82	X82	2008/09/15	03:15:18	76-39.8728N	167-29.0433W	996	0.573	25.572	08069491
83	X83	2008/09/15	15:11:59	77-09.9989N	165-37.7121W	916	-0.286	25.674	08069487
84	X84	2008/09/15	16:03:49	77-19.9947N	165-39.6631W	896	0.200	25.520	08069492
85	X85	2008/09/15	16:50:46	77-29.9987N	165-42.1688W	738	0.365	25.607	08069481
86	X86	2008/09/15	17:41:50	77-39.9941N	165-32.9838W	457	-0.130	25.688	08069480
87	X87	2008/09/15	18:09:28	77-45.3584N	165-33.4747W	388	-0.630	25.740	08069476
88	X88	2008/09/15	18:36:23	77-50.0040N	165-29.3234W	417	-0.568	25.753	08069482
89	X89	2008/09/15	20:30:31	78-01.7438N	164-36.2551W	391	-0.825	26.038	08069494
90	X90	2008/09/15	21:06:58	77-55.0062N	164-28.6570W	276	-0.832	26.139	08069496
91	X91	2008/09/15	21:56:17	77-50.0042N	164-47.5275W	301	-0.879	25.817	08069495
92	X92	2008/09/16	00:31:37	77-36.9971N	164-33.3970W	275	-0.842	26.188	08069488
93	X93	2008/09/16	01:32:31	77-31.0754N	163-44.5190W	303	-0.856	26.236	08069497
94	X94	2008/09/16	02:04:47	77-26.6187N	163-30.9711W	359	-0.893	26.346	08069490
95	X95	2008/09/16	02:48:15	77-19.9691N	164-00.0075W	336	-0.889	26.422	08069498
96	X96	2008/09/16	03:10:32	77-19.8552N	164-20.0113W	335	-0.885	26.398	08069549
97	X97	2008/09/16	03:32:58	77-19.9508N	164-40.0145W	345	-0.868	26.416	08069548
98	X98	2008/09/16	03:55:27	77-19.8504N	165-00.0350W	342	-0.111	25.623	08069493
99	X99	2008/09/16	04:17:43	77-19.9002N	165-19.9985W	777	0.284	25.542	08069550
100	X100	2008/09/16	14:10:08	76-09.0248N	164-30.0106W	2128	0.900	25.385	08069552

101	X101	2008/09/16	17:06:17	76-05.9406N	160-30.0063W	1894	0.000	25.335	08069551
102	X102	2008/09/16	20:50:25	75-59.3281N	159-30.0322W	1560	0.346	25.247	08069547
103	X103	2008/09/16	22:52:34	75-53.9802N	159-29.9788W	565	1.421	24.528	08069553
104	X104	2008/09/19	15:41:46	75-38.9693N	168-54.5952W	235	0.177	25.680	08069557
105	X105	2008/09/19	16:07:30	75-38.7156N	169-17.4218W	306	0.294	25.831	08069554
106	X106	2008/09/19	16:27:18	75-38.4680N	169-35.0695W	498	0.219	25.719	08069605
107	X107	2008/09/19	17:04:36	75-38.1214N	170-08.2693W	1133	-0.196	25.834	08069606
108	X108	2008/09/19	23:00:44	75-34.9983N	170-08.1022W	1025	-0.130	25.874	08069556
109	X109	2008/09/20	00:55:14	75-28.8262N	169-22.9700W	372	1.006	26.000	08069603
110	X110	2008/09/20	18:54:28	74-52.8992N	174-59.9957W	256	0.301	26.088	08069555
111	X111	2008/09/20	20:08:36	74-57.7540N	176-00.0211W	255	-1.253	26.719	08069558
112	X112	2008/09/20	22:27:00	75-07.0158N	175-29.9499W	293	-0.642	26.001	08069601
113	X113	2008/09/20	23:15:39	75-07.4508N	174-59.9871W	299	0.774	26.205	08069598
114	X114	2008/09/21	01:07:42	75-17.2118N	173-45.1951W	506	-0.376	25.799	08069602
115	X115	2008/09/21	02:01:19	75-24.8664N	173-07.8123W	1005	-0.028	25.797	08069604
116	X116	2008/09/23	20:17:08	73-12.3208N	161-40.0684W	256	1.387	28.263	08069596
117	X117	2008/09/23	22:26:35	73-19.0956N	160-42.5404W	507	2.659	27.340	08069597
118	X118	2008/09/23	23:27:06	73-27.5260N	160-07.4927W	1606	2.663	27.725	08069595
119	X119	2008/09/24	04:26:07	73-25.6795N	159-49.9261W	1799	2.686	27.384	08069593
120	X120	2008/09/24	04:56:11	73-19.3234N	159-49.9261W	1428	2.341	27.621	08069594
121	X121	2008/09/24	05:31:12	73-12.9210N	159-50.4486W	754	1.935	27.961	08069600
122	X122	2008/09/24	06:03:54	73-17.9206N	160-07.5081W	1224	2.191	27.668	08069592
123	X123	2008/09/24	08:16:53	73-28.0533N	160-42.5014W	785	2.680	27.792	08069585
124	X124	2008/09/24	08:50:07	73-32.8659N	160-59.9966W	463	2.731	27.734	08069588
125	X125	2008/09/24	09:35:36	73-34.9941N	160-34.9920W	1273	2.654	27.786	08069587
126	X126	2008/09/24	10:16:53	73-36.9314N	160-10.0633W	2097	2.453	27.789	08069586
127	X127	2008/09/24	10:53:59	73-41.9988N	160-30.0969W	1733	2.653	27.879	08069590
128	X128	2008/09/24	11:30:14	73-46.9860N	160-50.1952W	1808	2.672	27.845	08069589
129	X129	2008/09/24	12:08:33	73-52.0061N	161-10.3990W	541	2.653	27.235	08069599
130	X130	2008/09/24	19:24:58	73-49.8531N	162-08.1489W	283	2.217	27.232	08069591
131	X131	2008/09/25	00:56:14	73-50.2706N	163-44.9539W	220	1.628	27.675	08069499
132	X132	2008/09/25	02:07:49	73-57.9611N	164-44.9674W	207	2.254	27.387	08069503
133	X133	2008/09/25	03:20:26	74-05.5459N	165-45.0345W	213	1.596	26.412	08069583
134	X134	2008/09/25	06:03:57	74-22.6325N	168-00.0048W	276	2.226	26.153	08069502
135	X135	2008/09/25	07:16:37	74-29.9883N	168-59.9962W	181	2.360	26.105	08069501
136	X136	2008/09/25	08:24:58	74-35.1312N	170-00.0032W	208	1.824	26.077	08069504
137	X137	2008/09/26	13:08:34	74-52.4944N	174-52.3503E	118	-0.252	29.690	08069509
138	X138	2008/09/26	15:07:18	75-09.9946N	175-09.6241E	190	-0.278	28.881	08069584
139	X139	2008/09/26	18:22:08	75-29.9962N	175-32.1051E	245	-0.642	29.800	08069500
140	X140	2008/09/26	20:36:49	75-49.9983N	175-50.0957E	320	-0.373	30.179	08069506
141	X141	2008/09/27	00:32:02	76-09.9926N	176-09.7420E	502	-0.409	30.151	08069510
142	X142	2008/09/27	03:02:35	76-29.9966N	176-29.7524E	950	-0.375	30.059	08069507
143	X143	2008/09/27	06:02:24	76-50.0044N	176-44.8521E	1202	-0.411	30.284	08069505
144	X144	2008/09/27	08:55:14	77-10.0078N	177-10.3850E	1205	-0.470	30.347	08069466
145	X145	2008/09/27	11:42:26	77-29.9973N	177-29.2956E	1013	-1.036	30.575	08069508
146	X146	2008/09/27	17:52:04	77-50.0038N	177-50.1118E	1529	-1.047	30.481	08069462

147	X147	2008/09/27	20:54:21	78-10.0070N	178-09.1636E	1709	-1.133	30.649	08069465
148	X148	2008/09/27	21:37:08	78-20.0048N	178-19.9786E	1772	-1.264	30.694	08069464
149	X149	2008/09/27	22:19:40	78-30.2624N	178-29.9002E	1820	-1.422	30.591	08069461
150	X150	2008/09/27	22:59:46	78-39.9998N	178-29.9466E	1869	-1.597	30.513	08069463
151	X151	2008/09/28	04:30:46	78-15.0037N	179-51.8912E	1685	-1.505	30.496	08069520
152	X152	2008/09/28	08:38:29	77-47.9972N	178-11.5797W	1305	-1.252	30.492	08069472
153	X153	2008/09/28	09:19:04	77-47.9972N	177-47.0651W	1104	-1.257	30.363	08069467
154	X154	2008/09/28	11:44:18	77-27.9943N	177-28.4278W	1171	-0.850	29.812	08069470
155	X155	2008/09/28	14:03:28	77-15.0011N	177-39.4544W	1407	-1.109	29.314	08069471
156	X156	2008/09/28	16:21:45	77-05.0045N	177-16.7756W	1395	-1.253	29.247	08069468
157	X157	2008/09/28	19:33:01	76-55.4201N	176-27.2694W	1573	-1.369	28.810	08069469
158	X158	2008/09/28	22:41:30	76-47.6931N	175-17.6417W	1892	-1.285	26.119	08069522
159	X159	2008/09/29	01:45:26	76-40.8681N	175-39.4638W	1880	-0.871	26.046	08069514
160	X160	2008/09/29	04:46:13	76-37.6533N	176-50.0114W	555	-0.896	29.348	08069515
161	X161	2008/09/29	07:13:40	76-36.3706N	177-50.0114W	903	-1.041	28.315	08069519
162	X162	2008/09/29	09:45:07	76-47.9945N	178-09.3900W	1051	-0.879	29.192	08069512
163	X163	2008/09/29	13:31:25	76-51.7627N	178-37.3023W	1142	-1.037	28.966	08069518
164	X164	2008/09/29	14:34:24	76-43.7567N	179-18.6510W	1135	-0.855	28.693	08069511
165	X165	2008/09/29	17:31:24	76-30.8382N	179-26.8382W	1093	-1.169	27.961	08069517
166	X166	2008/09/29	18:18:07	76-25.9293N	178-52.0071W	963	-1.171	27.878	08069521
167	X167	2008/09/29	20:40:28	76-14.7837N	177-35.0526W	955	-0.913	28.647	08069516
168	X168	2008/09/30	01:07:19	76-07.4923N	177-16.3038W	1090	-1.273	28.221	08069527
169	X169	2008/09/30	04:13:12	75-55.0061N	178-37.0527W	1116	-1.228	27.123	08069523
170	X170	2008/09/30	06:35:05	75-40.9937N	179-04.6811W	1095	-0.902	28.012	08069524
171	X171	2008/09/30	09:23:11	75-25.9950N	179-32.2772W	899	-1.368	26.760	08069525
172	X172	2008/09/30	11:42:39	75-12.2570N	179-23.1965W	557	-0.594	27.000	08069526
173	X173	2008/10/01	01:40:24	75-32.4992N	174-27.5923W	1509	-0.802	25.998	08069513
174	X174	2008/10/01	04:32:50	75-49.9990N	174-10.1196W	2009	-0.526	25.895	08069528
175	X175	2008/10/01	08:06:43	75-52.4994N	173-21.1056W	1985	-0.805	25.901	08069613
176	X176	2008/10/01	11:46:38	75-38.5553N	173-22.7034W	1645	-1.244	25.932	08069531
177	X177	2008/10/01	12:39:21	75-30.3898N	173-08.2848W	1296	-1.220	25.933	08069530
178	X178	2008/10/01	13:26:52	75-26.0026N	172-29.9085W	1073	-1.305	25.936	08069533
179	X179	2008/10/01	15:24:20	75-08.1900N	171-09.8976W	388	0.559	25.939	08069532
180	X180	2008/10/01	18:32:58	74-47.0874N	168-30.0257W	177	1.719	26.135	08069534
181	X181	2008/10/01	19:23:01	74-41.1976N	167-48.2609W	301	1.899	25.993	08069529
182	X182	2008/10/01	20:55:06	74-31.36.97N	167-31.6418W	332	1.810	26.765	08069610
183	X183	2008/10/02	01:27:56	74-11.5025N	164-37.4691W	289	1.632	26.798	08069615
184	X184	2008/10/02	02:57:50	73-49.5019N	164-52.5149W	171	1.286	26.895	08069618
185	X185	2008/10/02	20:43:46	72-55.8084N	158-18.7686W	1338	1.466	28.908	08069608
186	X186	2008/10/02	21:51:30	72-43.1111N	157-55.3491W	365	1.614	28.960	08069617
187	X187	2008/10/03	00:13:47	72-40.8554N	157-16.2715W	1187	1.596	28.788	08069614
188	X188	2008/10/03	01:09:56	72-29.9976N	156-59.0753W	903	1.503	28.740	08069612
189	X189	2008/10/03	05:55:09	72-17.7016N	155-40.3914W	1144	1.463	28.612	08069631
190	X190	2008/10/03	06:55:55	72-10.0065N	155-07.9833W	855	0.995	29.752	08069630
191	X191	2008/10/03	07:51:10	72-04.8300N	154-34.0139W	1398	1.373	28.669	08069629
192	X192	2008/10/03	10:29:17	71-54.3226N	153-29.8838W	630	0.609	29.532	08069616

193	X193	2008/10/03	13:16:50	71-39.6737N	152-22.6106W	656	1.604	28.456	08069619
194	X194	2008/10/03	17:11:27	71-28.0859N	151-46.6536W	609	1.826	27.620	08069611
195	X195	2008/10/03	17:17:50	71-27.2292N	151-49.4169W	414	1.886	27.564	08069609

Acronyms in Table XCTD observation log are as follows;

Depth: Water Depth [m]

SST: Sea Surface Temperature [deg-C] measured by Continuous Sea Surface Monitoring System

SSS: Sea Surface Salinity [PSU] measured by Continuous Sea Surface Monitoring System

(6) Data archive

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department（MEDID）of JAMSTEC, and will be opened to the public via “R/V Mirai Data Web Page” in JAMSTEC home page.

2.8. Micro Structure observations

(1) Personnel

Koji Shimada (JAMSTEC): Principal Investigator

Motoyo Itoh (JAMSTEC)

Shinya Okumura, Satoshi Okumura, Souichirou Sueyoshi, Harumi Ohta (GODI)

(2)Objective

To understand the Arctic Ocean circulation and mixing, turbulence-scale temperature, conductivity and shear were observed. Turbulence kinetic energy dissipation rate is responsible especially for circulation of Atlantic layer (intermediate layer) in the Arctic Ocean. Most of micro structure observations were performed at CTD stations.

(3)Parameters

According to the manufacture’s nominal specifications, the range, accuracy and sample rate of parameters are as follows;

Parameter	Type	Range	Accuracy	Sample Rate
$\partial u/\partial z$	Shear probe	0～10 /s	5%	512Hz
T+$\partial T/\partial z$	EPO-7 thermistor	－5～45℃	±0.01℃	512Hz
T	Platinum wire thermometer	－5～45℃	±0.01℃	64Hz
Conductivity	Inductive Cell	0～70mS	±0.01mS	64Hz
Depth	Semiconductor strain gauge	0～1000m	±0.2%	64Hz
x- acceleration	Solid-state fixed mass	±2G	±1%	256Hz
y- acceleration	Solid-state fixed mass	±2G	±1%	256Hz
z- acceleration	Solid-state fixed mass	±2G	±1%	64Hz
Chlorophyll	Fluorescence	0～100 μ g/Lm	0.5 μ g/L or ±1%	256Hz
Turbidity	Backscatter	0～100ppm	1ppm or ±2%	256Hz
$\partial u/\partial z$	Shear probe	0～10 /s	5%	512Hz

(4)Instruments and Methods

We used Turbulence Ocean Microstructure Acquisition Profiles (TurboMAP-L, build by Alec Electronics Co Ltd.) to measure turbulence-scale temperature, conductivity, and shear. TorboMap is a quasi-free-falling instrument that measures turbulence parameter ($\partial u/\partial z$ and $\partial T/\partial z$), bio-optical parameters (in vivo fluorescence and back scatter) and hydrographic parameter (C, T, D).

(5) Station list

No.	Date (UTC)	Start			Bottom			Max Depth (m)	Sea Beam Depth (m)
		time	Lat	Lon	time	Lat	Lon		
TM01	2008/09/04	20:53:27	76-55.996N	154-10.143W	21:11:40	76-56.241N	154-10.234W	750	1604
TM02	2008/09/05	23:17:04	75-29.646N	147-29.501W	23:37:03	75-29.302N	147-28.848W	750	3811
TM03	2008/09/06	23:16:43	72-59.928N	144-59.588W	23:35:37	72-59.847N	144-59.014W	680	3561
TM04	2008/09/07	21:50:01	71-05.353N	145-00.090W	22:17:14	71-05.320N	145-00.205W	980	1720
TM04-2	2008/09/07	22:36:42	71-05.195N	145-00.291W	22:39:37	71-05.183N	145-00.317W	87	1654
TM05	2008/09/08	16:39:35	71-44.842N	148-01.840W	17:03:34	71-44.859N	148-02.747W	880	3015
TM06	2008/09/10	00:52:06	71-43.819N	155-11.317W	00:58:39	71-43.865N	155-11.221W	237	294
TM06-2	2008/09/10	01:04:08	71-43.925N	155-11.121W	01:10:45	71-44.001N	155-10.987W	241	293
TM07	2008/09/10	21:47:29	73-29.978N	158-00.383W	22:09:34	73-30.058N	158-01.642W	841	2816
TM08	2008/09/12	16:19:44	75-45.135N	163-01.230W	16:46:49	75-45.334N	163-01.894W	957	2044
TM09	2008/09/12	18:49:58	75-56.595N	163-45.370W	19:09:36	75-56.429N	163-46.393W	700	1160
TM10	2008/09/12	22:40:14	76-15.015N	164-59.776W	22:53:13	76-15.103N	164-59.271W	420	446
TM11	2008/09/14	23:24:09	76-38.759N	168-06.608W	23:53:42	76-38.652N	168-06.445W	1038	1751
TM12	2008/09/15	23:08:17	77-44.285N	164-51.636W	23:16:03	77-44.275N	164-51.534W	287	292
TM12-2	2008/09/15	23:22:02	77-44.234N	164-51.400W	23:29:45	77-44.231N	164-51.667W	280	290
TM13	2008/09/16	19:22:26	76-03.104N	159-58.663W	19:50:57	76-03.072N	159-58.815W	1061	2105
TM14	2008/09/17	00:45:33	75-50.750N	157-58.184W	01:00:13	75-50.671N	157-58.040W	551	550
TM15	2008/09/17	19:40:20	75-00.268N	161-31.068W	20:07:12	75-00.111N	161-30.969W	1013	1879
TM16	2008/09/18	15:02:29	74-02.511N	167-14.889W	15:07:40	74-02.536N	167-15.041W	200	215
TM16-2	2008/09/18	15:14:06	74-02.554N	167-15.160W	15:19:59	74-02.566N	167-15.306W	207	219
TM17	2008/09/19	19:08:16	75-38.186N	170-28.854W	19:28:59	75-38.106N	170-30.042W	743	1406
TM18	2008/09/20	01:39:21	75-25.140N	168-59.390W	01:45:27	75-25.193N	168-59.315W	230	252
TM19	2008/09/21	00:01:53	75-06.995N	174-30.980W	00:08:50	75-08.001N	174-25.863W	240	307
TM20	2008/09/22	22:41:59	75-00.140N	164-00.093W	22:58:52	75-00.337N	164-00.420W	608	687
TM21	2008/09/23	17:08:25	73-09.281N	162-19.511W	17:13:35	73-09.235N	162-19.549W	195	203
TM22	2008/09/26	00:29:15	75-00.019N	179-59.975W	00:39:56	75-00.086N	179-59.843E	385	396
TM23	2008/09/26	21:33:34	76-00.000N	175-59.894E	21:43:34	75-59.966N	176-00.003E	350	353
TM23-2	2008/09/26	21:54:02	75-59.928N	176-00.092E	22:03:32	75-59.896N	176-00.192E	275	357
TM24	2008/09/28	18:18:41	76-59.474N	176-49.729W	18:45:09	76-59.256N	176-50.262W	939	1454
TM25	2008/09/29	19:11:04	76-19.908N	178-18.097W	19:34:04	76-19.648N	178-18.551W	815	852
TM26	2008/09/29	21:37:08	76-09.911N	176-53.740W	22:05:33	76-09.747N	176-54.110W	998	1542

(6) Data policy and Citation

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department（MEDID）of JAMSTEC, and will be opened to the public via “R/V Mirai Data Web Page” in JAMSTEC home page.

3. Ocean Chemistry and Biology

3.1. Nutrient

(1) Personnel

Naoyuki Kurita (JAMSTEC): Principal Investigator
Koji Shimada, Motoyo Itoh, Shigeto Nishino (JAMSTEC)
Ayumi Takeuchi, Kenichiro Sato, Takayoshi Seike, Junji Matsushita,
Shunsuke Tanaka (MWJ)

(2) Objectives

The vertical and horizontal distributions of the nutrients are one of the most important factors on the primary production. On the other hand, nutrients data are used to study of climate changes as chemical tracers of seawater mass movement. During this cruise nutrient measurements will give us the important information on the mechanism of the primary production and/or seawater circulation.

(3) Measured Parameters

Nitrate, Nitrite, Silicate (Although silicic acid is correct, we use silicate because a term of silicate is widely used in oceanographic community), Phosphate and Ammonia. See below for further details.

(4) Instruments and Methods

Nutrient analysis was performed on the BRAN+LUEBBE TRAACS 800 system. The laboratory temperature was maintained between 22-24 deg C.

a. Measured Parameters

Nitrate + nitrite and nitrite are analyzed according to the modification method of Grasshoff (1970). The sample nitrate is reduced to nitrite in a cadmium tube inside of which is coated with metallic copper. The sample stream with its equivalent nitrite is treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid, which reacts with the sulfanilamide to produce a diazonium ion. N1-Naphthylethylene- diamine added to the sample stream then couples with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite react and are measured; without reduction, only nitrite reacts. Thus, for the nitrite analysis, no reduction is performed and the alkaline buffer is not necessary. Nitrate is computed by difference. Absorbance of 550 nm by azo dye in analysis is measured using a 3 cm length cell for Nitrate and 5 cm length cell for nitrite.

The silicate method is analogous to that described for phosphate. The method used is essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid is first formed from the silicic acid in the sample and added molybdic acid; then the silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using L-ascorbic acid as the reductant. Absorbance of 630 nm by silicomolybdous acid in analysis is measured using a 3 cm length cell.

The phosphate analysis is a modification of the procedure of Murphy and Riley (1962). Molybdic acid is added to the seawater sample to form phosphomolybdic acid, which is in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant. Absorbance of 880 nm by phosphomolybdous acid in analysis is measured using a 5 cm length cell.

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

b. Standard

Silicate standard solution, the silicate primary standard, was obtained from Merck, Ltd.. This standard solution, traceable to SRM from NIST was 1000 mg per litter. Since this solution is alkaline solution of 0.5 M NaOH, an aliquot of 30 ml solution were diluted to 500 ml together with an aliquot of 15 ml of 1 M HCl. Primary standard for nitrate (KNO_3) and phosphate (KH_2PO_4) were obtained from Merck, Ltd., nitrite ($NaNO_2$) and ammonia ($(NH_4)_2SO_4$) were obtained from Wako Pure Chemical Industries, Ltd..

c. Sampling Procedures

Samples were drawn into virgin 10 ml polyacrylate vials that were rinsed 3 times before sampling without sample drawing tubes. Sets of 4 different concentrations for nitrate, nitrite, silicate, phosphate and ammonia of the shipboard standards were analyzed at beginning and end of each group of analysis. The standard solutions of highest concentration were measured every 5 - 12 samples and were used to evaluate precision of nutrients analysis during the cruise. We also used reference material for nutrients in seawater, RMNS (KANSO Co., Ltd., lots AS, AT, AU, AR), for every runs to secure comparability on nutrient analysis throughout this cruise.

d. Low Nutrients Sea Water (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.45 μm pore size membrane filter. This water is stored in 20-liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in April 2007.

(4) Results

Analytical precisions were 0.07% (36.6 μM) for nitrate, 0.10% (0.8 μM) for nitrite, 0.06% (85.5 μM) for silicate, 0.11% (3.6 μM) for phosphate, 0.30% (8.0 μM) for ammonia in terms of median of precision, respectively.

Results of RMNS analysis are shown in Table 3.1-1.

(5) Remarks

At station 245 to 255, we found unusual shapes at the chart of all ingredients without ammonia. Therefore, these samples were measured after filtered by 0.45 μm pore size membrane filter.

(6) Archive

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

(7) Reference

Grasshoff, K. (1970), Technicon paper, 691-57.

Grasshoff, K., Ehrhardt, M., Kremling K. et al. (1983), Methods of seawater analysis. 2nd rev. Weinheim: Verlag Chemie, Germany, West.

Murphy, J., and Riley, J.P. (1962), Analytica chim. Acta 27, 31-36.

Table 3.1-1 Summary of RMNS concentrations in this cruise.

μmol/kg

		NO_3	NO_2	SiO_2	PO_4	NH_4
RM-AS	avg	0.11	0.01	1.62	0.069	―
	stdev	0.02	0.00	0.03	0.006	―
	n=	95	95	95	95	―
RM-AT	avg	7.51	0.02	17.94	0.575	―
	stdev	0.02	0.00	0.06	0.006	―
	n=	95	95	95	95	―
RM-AU	avg	29.90	0.01	66.36	2.170	0.55
	stdev	0.05	0.00	0.10	0.008	0.02
	n=	177	177	176	177	95
RM-AR	avg	―	―	―	―	5.27
	stdev	―	―	―	―	0.05
	n=	―	―	―	―	194

3.2. Sea surface nutrient monitoring

(1) Personnel

Naoyuki Kurita (JAMSTEC): Principal Investigator
Koji Shimada, Motoyo Itoh, Shigeto Nishino (JAMSTEC)
Junji Matsushita, Takayoshi Seike, Ayumi Takeuchi, Shunsuke Tanaka,
Kenichiro Sato (Marine Works Japan Ltd.)

(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) Parameters

Nitrate + Nitrite, Nitrite, Silicate, Phosphate

(4) Instruments 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 laboratory 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 standard and base solutions of nutrients were measured each 8 hours. To get more accurate data, we corrected the monitoring data by the reference materials for nutrients based on seawater (THE GENERAL ENVIRONMENTAL TECHNOS CO.,LTD.), which were measured by this system almost daily. 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.

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.

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.

(4) Observation log or Station list

Period of observation: August 27 to October 7, 2008

(5) Preliminary Result

The outline of surface nutrients profile is shown in Figure 3.2-1 and 2.

(6) Data Policy and citation

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

Grasshoff, K. (1970), Technicon paper, 691-57.

Grasshoff, K., Ehrhardt, M., Kremling K. et al. 1983. Methods of seawater anylysis. 2nd rev. Weinheim: Verlag Chemie, Germany, West.

Murphy, J., and Riley, J.P. 1962. Analytica chim. Acta 27, 31-36.

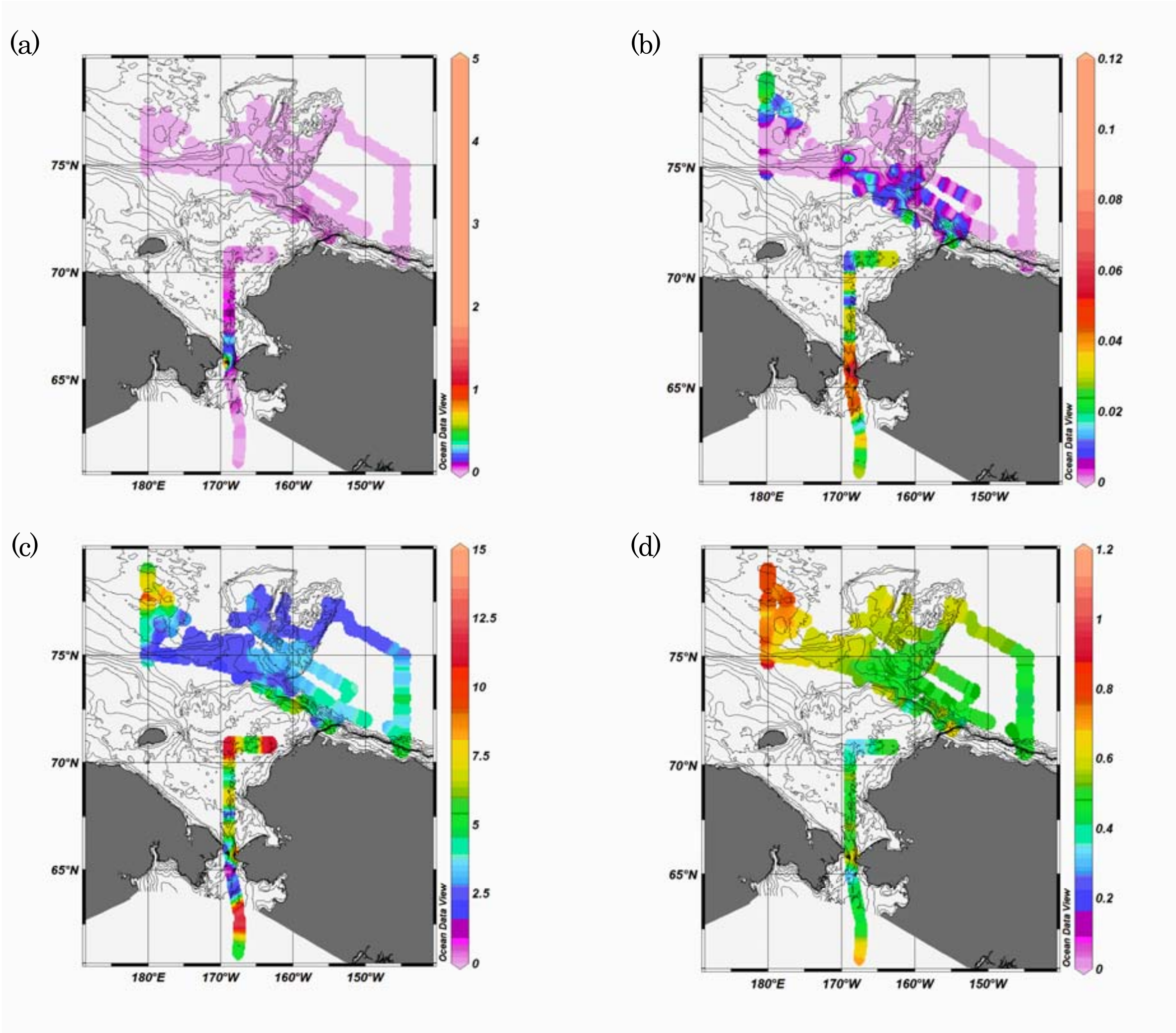


Figure 3.2-1-1. Profile of Sea surface nutrients. (a) Nitrate + Nitrite, (b) Nitrite, (c) Silicate and (d) Phosphate (unit: μM). Period of observation: 27-Aug. -2008 23:53 to 3-Oct -2008 06:21 (UTC).

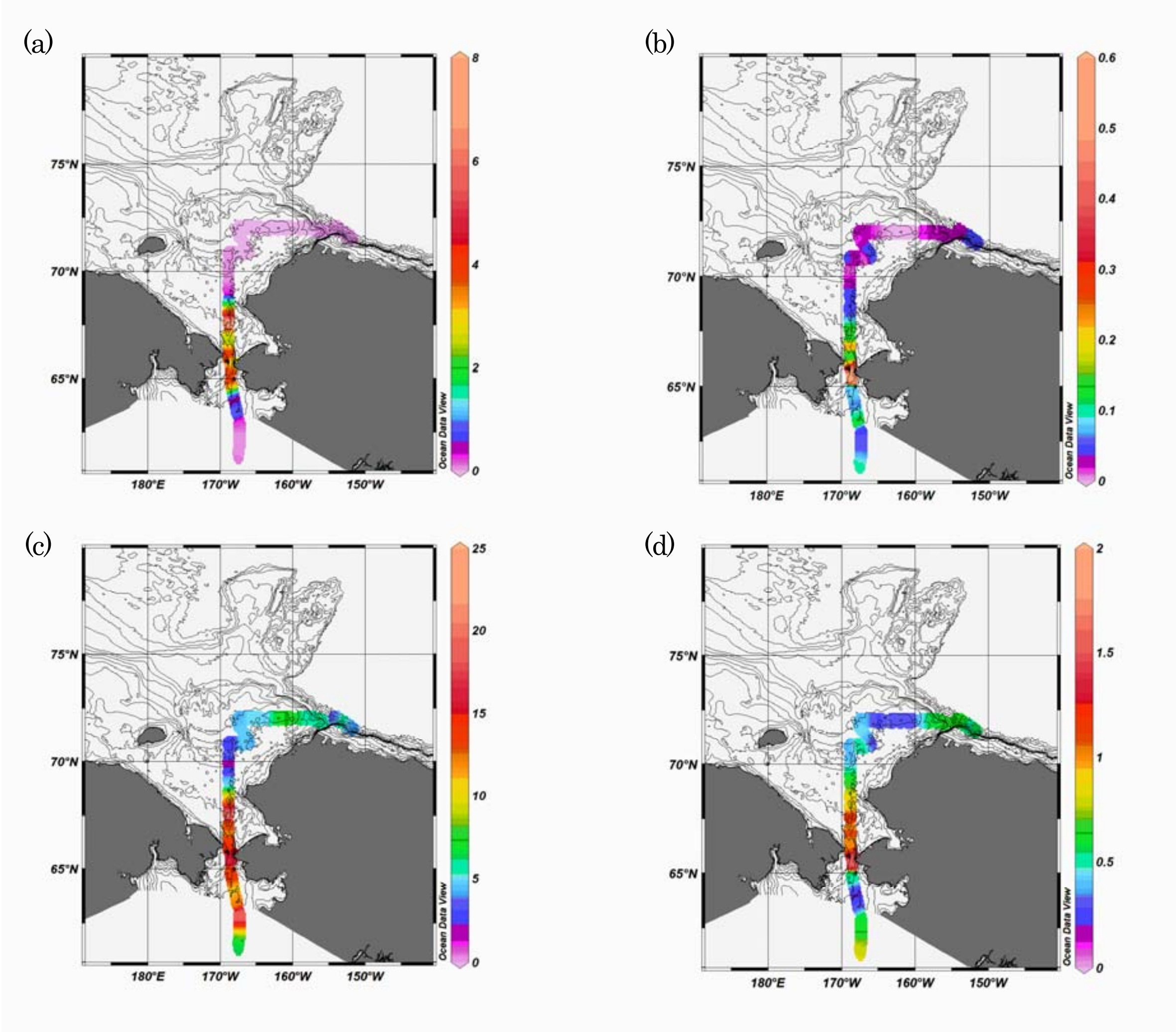


Figure 3.2-1-2. Profile of Sea surface nutrients. (a) Nitrate + Nitrite, (b) Nitrite, (c) Silicate and (d) Phosphate (unit: µM). Period of observation: 3 -Oct. -2008 08:10 to 7-Oct -2008 15:52 (UTC).

3.3. Total Alkalinity

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator
Michiyo YAMAMOTO-KAWAI (IOS)
Ayaka HATSUYAMA (MWJ)

(2) Objective

The Arctic Ocean receives a large amount of river water from the surrounding continents. Since river water carries not only freshwater but also carbon, nutrients, contaminants etc., changes in distribution and residence time of river water in the Arctic Ocean may affect regional and global climate, productivity and human health. In order to trace river water in the Arctic Ocean, we have analyzed total alkalinity (TA) of seawater, with which river runoff (TA~1000 µmol kg^{-1}) can be distinguished from sea ice meltwater (TA~260 µmol kg^{-1}). Moreover, by using TA with oxygen isotope ratio (ref. section 3.4), the source of river water can be further distinguished between North American rivers (TA~1600 µmol kg^{-1}) and Eurasian rivers (TA~800 µmol kg^{-1}). We here report on-board measurements of total alkalinity performed during the MR08-04 cruise.

(2) Measured Parameters

Total Alkalinity, TA

(3) Apparatus and performance

(3)-1 Seawater sampling

Seawater samples were collected at 145 stations in 12L Niskin bottles mounted on the CTD-rosette system. Samples for TA analysis were transferred into 125 ml glass bottles (SCHOTT DURAN) using a sampling tube, filled from the bottom without rinsing, and overflowed for 10 seconds. These bottles were pre-washed by soaking in 5% non-phosphoric acid detergent (pH=13) for more than 3 hours and then rinsed 5 times with tap water and 3 times with Milli-Q deionized water. After the sampling, bottles filled with seawater sample were put in a water bath kept at 25 ºC for one hour before the analysis.

(3)-2 Seawater analysis

Measurement of alkalinity was made using a spectrophotometric systems (Nippon ANS, Inc.).

The system comprises of water dispensing unit and a spectrophotometer (Cary 50 Scan, Varian). For an indicator, bromocresol green sodium (BCG) was used. Calculation of TA was made based on a single step acid addition procedure (Yao and Byrne, 1998).

Sample seawater of approx. 40 ml is transferred from a sample bottle into water-jacketed (25.00± 0.05 ºC) titration and pH cells. The length and volume of the pH cell are 8 cm and 13 ml, respectively. First, absorbencies of seawater itself were measured at three wavelengths (750, 616 and 444 nm). Then, 0.05 M HCl + 4×10^{-5} M BCG in 0.65 M NaCl solution was added using a titrator (Metrohm, Dosimat 765). The concentration of BCG in the final solution was approx. 2-3 µM. Then the solution was stirred and circulated through titration and pH cells with purging N_2 gas for 6 minutes to allow CO_2 degassing and to mix the acid-indicator solution and seawater sufficiently. After the pump was stopped, the absorbencies of solution were measured at the same wavelengths. The excess hydrogen ion concentration was calculated based on the following equation (Yao and Byrne, 1998):

$$pH_T = 4.2699 + 0.002578(35 - S) + \log\left(\frac{A_{616}/A_{444} - 0.00131}{2.3148 - 0.1299(A_{616}/A_{444})}\right) - \log(1 - 0.01005S),$$

where A_{616}/A_{444} indicate absorbance ratio at 25ºC and S is salinity of the sample. The alkalinity of a seawater sample that has been acidified and purged of CO_2 can written as follows:

$$A_T = \left[\left(N_A V_A - (H^+)_{ASW}\, dsw\, V_{ASW}\right)/V_{SW} \times 10^{-6}\right]/dsw,$$

where A_T is the alkalinity of a seawater sample (mol/kg), N_A is the concentration of the added acid (mol/l), V_A is the volume of the added acid (ml), V_{SW} is the volume of the seawater sample (ml), $(H^+)_{ASW}$ is the excess hydrogen ion concentration in the acidified seawater (mol/kg), V_{ASW} is the volume of the acidified seawater calculated as $V_{SW} + V_A$ (ml), dsw is sample seawater density at 25ºC and S.

The acid titrant was made from ~0.6M HCl solution, calibrated by Na_2CO_3 using Gran's plot technique. The concentrations of two batches of acid titrant used during the cruise were 0.049985 and 0.053455mol/l, calculated from concentration, volume and density of ~0.6M HCl and the volume of flask.

(4) Preliminary results

A few duplicate samples were taken at most of stations and the difference between each pair of analyses was plotted on a range control chart (see Figure 2.8-1). The average of the difference was 0.49µmol/kg (n=188). The standard deviation was 0.46µmol/kg, which indicates that the analysis was accurate enough according to Guide to best practices for ocean CO2 measurements (Dickson et al., 2007).

(5) Data Archive

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

(6) References

Yao, W. and Byrne, R. H. (1998), Simplified seawater alkalinity analysis: Use of linear array spectrometers. Deep-Sea Research Part I, Vol. 45, 1383-1392.

Guide to best practices for ocean CO2 measurements (2007) ; PICES Special Publication 3, 199pp. A. G. Dickson, C. L. Sabine & J. R. Christian, Eds.

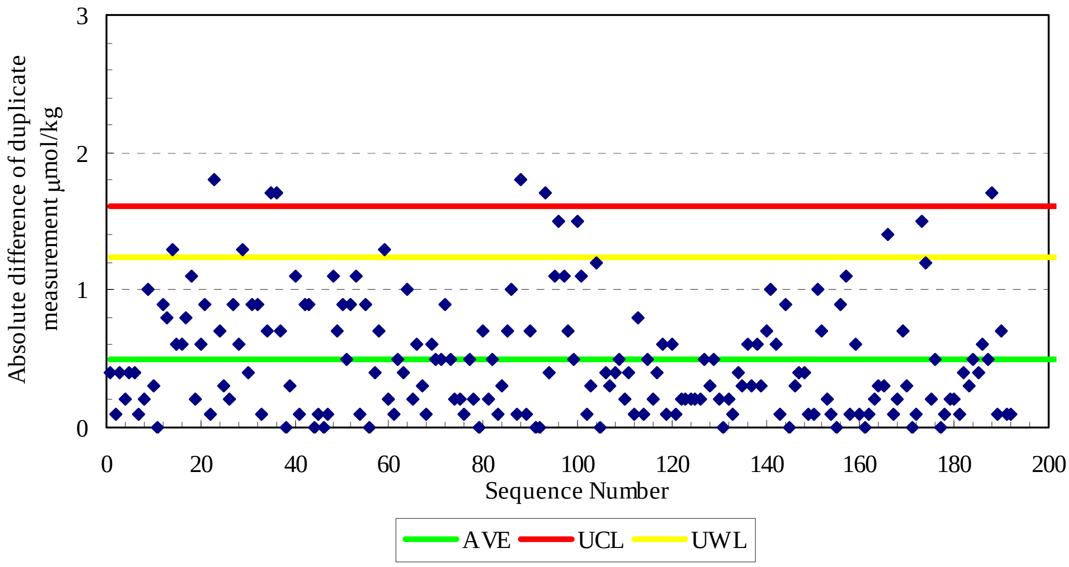


Figure 2.8-1 Range control chart of the absolute differences of duplicate measurements of TA carried out during this cruise.

3.4. Oxygen isotope ratio

(1) Personnel

Naoyuki Kurita (JAMSTEC): Principal Investigator

Michiyo Yamamoto-Kawai (IOS)

(2)Objective

Summer Arctic sea ice cover has reduced dramatically in recent years and, simultaneously, surface seawater has been freshening over the Pacific sector of the Arctic Ocean. Since stratification of Arctic water is largely depends on salinity distribution, changes in salinity influences biological activity, ocean circulation and cycle of geochemical properties, and thus in turn affect the regional and global environment. However, changes in salinity reflect not only melting/formation of sea ice but also distribution of river water.

During the MR08-04 cruise, we have collected seawater samples for oxygen isotope analysis.

Because oxygen isotope ratio of water ($\delta^{18}O$) is low in Arctic river water than sea water or sea ice, causes of salinity changes can be quantitatively estimated from the salinity- $\delta^{18}O$ relationship. Distribution of $\delta^{18}O$ in surface water will be also used to interpolate $\delta^{18}O$ data in water vapor collected over the Arctic Ocean during the cruise (see section 4.3).

(3) Parameters

Oxygen isotope ratio of water: expressed as a permil deviation of oxygen isotope ratio of the sample from that of international standard seawater (VSMOW).

$\delta^{18}O = \{(H_2{}^{18}O/H_2{}^{16}O)_{sample}-(H_2{}^{18}O/H_2{}^{16}O)_{VSMOW}\}/(H_2{}^{18}O/H_2{}^{16}O)_{VSMOW} \times 1000$ [‰].

(4)Sampling

Seawater samples were collected in 12L Niskin bottles mounted on the CTD-rosette system and then transferred into 6 ml glass vials for $\delta^{18}O$ analysis. At 20 stations in the Arctic Ocean, surface seawater was also taken with a bucket. And from Japan to Arctic Ocean, near surface water pumped up to the laboratory was sampled every day (9 samples). Caps of vials were re-tightened when vials had warmed to room temperature.

NO	DATE and TIME	Position	
		Lat. N	Lon. E
	YY-MM-DDTHH:MM	(deg.)	(deg.)
O-01	2008-08-18T00:35	40.3	150.5
O-02	2008-08-19T00:05	43.2	155.5
O-03	2008-08-20T00:10	46.4	160.3
O-04	2008-08-21T00:05	49.5	165.4
O-05	2008-08-21T23:55	52.6	171.2
O-06	2008-08-23T00:20	54.0	178.4
O-07	2008-08-24T00:40	54.2	-174.3
O-08	2008-08-25T00:15	54.2	-169.4
O-09	2008-08-28T00:05	61.1	-167.4
O-10	2008-08-29T00:39	65.8	191.2
O-11	2008-08-29T21:36	70.0	191.2
O-12	2008-08-30T19:09	71.1	200.6
O-13	2008-08-31T14:42	71.8	204.9
O-14	2008-09-02T04:09	74.2	204.0
O-15	2008-09-02T14:50	75.0	200.0
O-16	2008-09-03T22:13	77.3	205.0
O-17	2008-09-05T03:13	76.8	207.5
O-18	2008-09-06T03:33	75.3	213.9
O-19	2008-09-07T02:00	73.0	215.0
O-20	2008-09-08T02:54	70.6	215.0
O-21	2008-09-09T05:05	72.2	208.0

O-22	2008-09-11T06:13	74.0	200.0
O-23	2008-09-13T03:59	76.5	194.0
O-24	2008-09-13T03:59	76.5	194.0
O-25	2008-09-15T01:48	76.6	191.9
O-26	2008-09-15T22:46	77.7	195.1
O-27	2008-09-26T12:04	74.8	174.8
O-28	2008-09-27T01:44	76.3	176.3
O-29	2008-09-28T00:45	78.9	178.6

(5) Data Policy and citation

Samples will be analyzed at IORGC/JAMSTEC. Data will be archived by IORGC/JAMSTEC and submitted to JAMSTEC Data Management Office. All data obtained this cruise will be under the control of the Data Management Office of JAMSTEC after 9th October 2010.

3.5. Colored Dissolved Organic Matter, Alkalinity, Nutrients and Rare Earth Elements

3.5.1. Colored Dissolved Organic Matter,

(1) Personnel

Celine Gueguen (Department of Chemistry, Trent University)

(2) Background and Objectives

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 colored dissolved organic matter (C-DOM). Recent studies have shown that C-DOM may play an important role in radiative transfer of light in the ocean and remote sensing of primary production. Major sources of C-DOM 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, C-DOM 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 C-DOM and its distribution in the Arctic Ocean are poorly understood.

<u>Objectives</u>

1. To evaluate the sensitivity and stability of the in-situ C-DOM sensor,
2. To trace the inflow of terrestrial dissolved organic matter in the Arctic Ocean,
3. To investigate the chemical composition of DOM in the water column and in particular in the cold halocline.

(3) Instruments & Methods

An ECO C-DOM sensor (WETLabs) was attached on the CTD. The C-DOM raw data were acquired on real time from sea surface to about 5m above the bottom of the sea. A total of 258 casts have been carried out during the cruise. Raw data processing was

performed along with the others sensors attached on the CTD (see 2.2 Physical Oceanographic Observations for more details).
C-DOM sensor (property of Dr. E. Carmack, DFO, Canada): S/N FLCDRTD-1076, WETLabs
Calibration: June11/2008

Sea water (125 mL) was collected for filtration through a pre-combusted glass fiber filter (GF/F, Whatman) with a pore size of 0.7 micron. Aliquots of filtrate were then sampled for the determination of C-DOM characteristics. Up to 10 depths were collected at 96 stations.

Absorbance and fluorescence of seawater samples will be measured on a Shimadzu UV/Visible 2550 Spectrophotometer and a Horiba/Jobin Yvon FluoraMax-4 Spectrofluorometer, respectively. Fluorescence analysis will be also used to calibrate the in situ C-DOM sensor. All samples will be measured within 2 years.

(4) Expected Results

The in-situ sensor was successfully deployed for the first time in the Arctic Ocean (see Fig.1). The preliminary results did not show any significant drift on the C-DOM raw data over the 7-week cruise, highlighting the stability of the sensor. The in situ measurements will be compared with the discrete samples to assess its sensitivity. Together with other hydrographic and chemical parameters, the optical properties of C-DOM will be used to investigate the origin and composition of dissolved organic carbon in the Arctic Ocean.

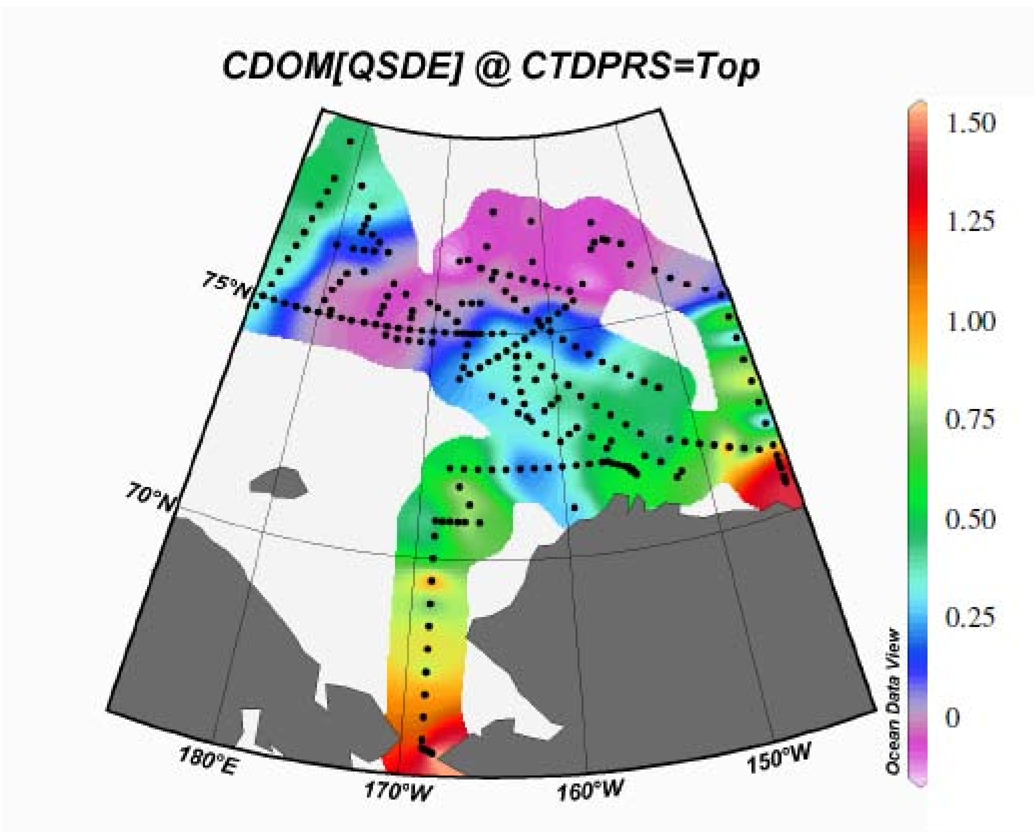


Fig. 1: Spatial variation of C-DOM concentrations at depth 5m. A post-calibration of CDOM concentration is currently underway.

3.5.2. Alkalinity, Nutrients

(1) Personnel

Hisashi Narita (Tokai University) : Principal Investigator

Yuko Tange (Tokai University)

(2) Objectives

The decrease of sea ice coverage and change of river discharge acurrding global warming may great influence on the geochemical processes, including primary production and phytoplankton community in the Arctic Ocean and high latitude ocean environment. For example, coccolithophorid bloom recently finding in the eastern Bearing Sea show shifts in taxonomic composition from diatoms to coccolithophores, it may be indicate that as a part of transformations take place in the Bearing Sea biogeochemistry and ecosystem under climate forcing. Here, we measure total alkalinity, particulate and dissolved organic nutriments, calcium carbonate and Chollopyll a to evaluate the contributions of diatom and coccolithophorids account for chlorophyll biomass and nutrient supply due to change of physical conditions and/or inflow during late summer in the subarctic Pacific the Bering Sea and the Arctic Ocean.

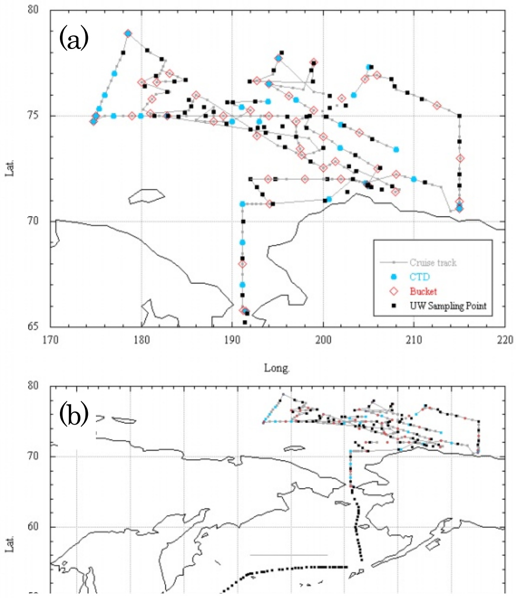


Fig.3.5.2.1. Sampling Point (a) Sampling Point of the Arctic Ocean, (b) Sampling Point of all researched area.

(3) Sampling and Method

Water samples were collected by tree different way, each sampling stations were shown in Figure 3.5.2.1 and Table 3.5.2.2. Vertical water samples were collected at 32 stations from upper 300 m water depth, using CTD systems attached with Niskin-X Sampler of 12 L capacity. In addition, surface seawater samples were collected in the Sea Surface Water navigation (197 stations) and by special bucket (47 stations).

Total alkalinity was determened on-board measurement by the open cell titration method with a newly developed automatic total alkalinity titration system (Kimoto Electric Co., Ltd). A constant volume (about 100 ml) of seawater is acidified to a pH 3.5 ± 0.1 with an aliquot of titrant. The acidified seawater is stirred during 10 min to allow the evolved CO_2 to escape. Then, the titration is continued to a pH of about 3.0. The total alkalinity is computed from the titrant volume and e. m. f. measurements in the pH region 3.0 - 3.5 using a non-linear least-squares approach for the reactions with sulfate and fluoride ions. The SIO-CRM Talk is used as an alkalinity standard to assign a concentration to the titrant. A running standard is measured at least 1or 2 Samples (was measured 2-4 times per 1 sample) every week to check for any drift in the determination system. The coefficient of variation of total alkalinity was less than 0.2 %.

Particulate nutrients and calcium carbonate samples were collected into a 2 L of dark polyethylene bottles and filtered onto 0.5 µm hydrophilic PTFE (polytetrafluoroethylene) membrane fitter (ADVANTEC MFS, Inc.) and grass fiber filter (Whatman GF/F), respectivly. The filter after filtration was stored under –85 °C in a freezer until analysis. Particulate and dissolved organic nutrients were digested by alkaline potassium persulfate solution. Nutrient concentrations in those and surface water determined using an auto analyzer (BRAN+LUEBBE TRAACS 800) in the on-shore laboratory. Calcium carbonate concentrations in seawater were determined by a coulometer in the on-shore laboratory.

Chlorophyll a samples were also collected in 2 L of dark polyethylene bottles and filtered onto grass fiber filter (Whatman GF/F), appling to vacuum less than 100 mmHg. Filtered samples were extracted in 7 ml of N, N-dimethylformamide (DMF) and stored keeping in cold (-85 °C) and dark condition until analysis. Chlorophyll a concentrations were measured by the Holm-Hansen method with a Turner designs Fluorometer in the on-shore laboratory.

(4) Station lists and future works

Lists of the stations for underway and Bucket sampling were shown in Table 3.5.2.1-1 and 3.5.2.1-2, respectivly. Chlorophyll a particulate nutrients, calcium carbonate and nutrients of surface water and dissolved organic matter will be measured within 6 month. The biogeochemical processes, including river runoff to each study area, will be discussed according to total alkalinity, chlorophyll a, particulate and dissolved organic nutrients and calcium carbonate data with nutrients and hydrographic data.

3.5.3. Rare Earth Elements

(1) Personnel

Jing Zhang (University of Toyama)

(2) Background

Recently, river water flux increasing as well as the sea ice decreasing in the high latitude ocean of the northern hemisphere is frequently reported. However, sea ice formation is strongly controlled by the fresh-water flux and temperature. In the other hand, the river waters transport many nutrients into the Arctic regime, and influence the primary productivity and eco-system in the Arctic marine environment. Therefore, the detailed volume and transportation of the riverine waters are the essential issues of the Arctic. In this study, to well understand the relative contribution of the nutrient sources to the Arctic and its variation, we address the detailed structure and the mixing ratios of the different water masses. Water samples were collected for multiple chemical tracers such as dissolved oxygen (DO), salinity, nutrients, oxygen isotope composition ($\delta^{18}O$) and Rare Earth Elements (REEs) determinations.

(3) Objectives

1. To explain the detailed water mass structure of the Arctic.
2. To clarify the proportion of the river water input to the Arctic.
3. To illuminate the nutrient flux transported by the riverine water.

(4) Instrument and Method

Total 47 samples collected for $\delta^{18}O$ and REEs measurement. About REEs on board processing, after sampling, the seawaters were filtered through a 0.1□m membrane filter and acidified immediately to pH< 1.5 with ultrapure HCl (TAMAPURE-AA-100, Co. TAMAKAGAKU). The filtrates were brought to the laboratory on land. Solvent extraction method was used for pre-concentration of REEs from seawaters and precise determination by using Inductive Coupled Plasma Mass Spectrometer (ICP-MS) ELEMENT-II (Co. THERMOFISHER). All operation has been done in clean room at the University of Toyama. The water samples for $\delta^{18}O$ measured by IRMS PRISM (Co. VG).

(5) Expected Results

The heavy Tb – Yb REE patterns, normalized by the values of deep water, in Arctic Ocean expected are similar with those in the typical marginal seas, which have their own deep convection system and abyssal circulation (e.g. the Sea of Japan). The water masses will be characterized by $\delta^{18}O$, REEs and other chemical tracers. And the detailed nutrient fluxes can be calculated by the proportion of varied water masses estimation.

3.6. Biogeochemical carbon cycles and geomicrobiological studies in the Arctic Ocean

(1) Personnel

Masao Uchida (NIES; National Institute for Environmental Studies)
Motoo UTSUMI (Univ. of Tsukuba)
Yukiko KUROKI (Univ. of Tsukuba)
Chie SATO (Univ. of Tsukuba)

(2) Objectives

Marine microbes, especially bacteria, are large and essential components of food webs and elemental cycles in the water column and sediment. Marine bacteria include the two deepest divisions, or domains, Bacteria and Archaea. These domains are identified by genetic distance in the composition of the 16S rRNA gene (Woose et al. 1990). Marine bacteria are small and morphologically simple: rods, spheres and filaments generally less than 1-2 μm in size, but they are highly diverse in terms of both taxonomy and metabolism. There are many different varieties of bacteria existing in the marine ecosystem, but it has been long noted a discrepancy of several orders of magnitude between the number of bacterial cells that can be seen in the oceans by direct count (by epifluorescence microscopy) and the number of colonies that appear on agar plates (e.g. Jannasch and Jones, 1959). In terms of carbon cycling in marine ecosystems, especially for dissolved organic carbon (DOC), one of the most important activities of bacteria is aerobic decomposition. In recent years, it is reported that nonthermophilic Archaea, named crenarchaeota, represent up to 40% of the free-living prokaryotic bacteria community in the water column of the world's oceans (ex. Delong, 1992), and some of their population is chemoautotrophy (ex. Pearson et al. 2001). Therefore, it is important to study the relationship between carbon cycling and archaeal metabolic information in marine systems.

The key aim of this study is to analyze the metabolic characteristics of marine crenarchaeota, and relationship between their biomass, community structures and carbon cycling in Arctic Ocean ecosystem. The objectives of this study are as follow:

1) Collect large volume (ca. 400 L per each sample) of sea-water for measuring stable and radioactive isotope ratio of POC, archaeal cell membrane lipids (especially GDGTs), and for analyzing the bacterial gene information,
2) Collect mega volume (around 100,000 L) of surface sea-water for measuring radioactive isotope ratio of archaeal cell membrane lipids.

We also collected sea-water samples for measuring the radioactive isotope ratio and concentration of DIC and DOC, and for counting bacterial population density (Bacteria and Archaea) in the water column. One of the final goals of this study is making a mass balance model for carbon in the water column of Arctic Ocean.

(3) Parameters

3.1 Sample collection

To collect filter samples for studying the diversity of bacterial community and their functional genes, stable and radioactive carbon isotope ratio of POC and bacterial cell membrane lipids (especially GDGTs), we filtered 200 to 400 L sea-water samples at the stations (Table 1). These samples were collected from one or two depths (from 12 to 3,000 dBar) with X-Niskin water samplers (12 L, General Oceanic). Sea-water in the samplers immediately transferred to 10 L plastic canteens on deck. Surface sea-water also collected from surface sea-water supply system (140 L) on 1 October during PC5 sampling period. All water samples were filtered with quartz fiber filters (Whatman QM-A, with operational pore size of 0.6 μm, 110 mm in diameter) as soon as possible on board. Then, the filtrates filtered again with 0.2 μm isopore membrane filter (Advantec, 147 mm in diameter). The both filters were frozen at -20°C during the cruise.

Water samples were also fixed with formalin (final concentration in the sample was 3.6%, 100 mL x 2 bottles) immediately. About 30 mL of each fixed samples were then filtered with 0.2 μm isopore membrane filter (Whatman, 25 mm in diameter) for counting the population density of Bacteria and Archaea (Table 2). The filters and the bottles in fixed water sample were frozen at -80°C during the cruise.

We also collected filter (POC) and filtrate (DOC) samples, and DIC and $DI^{14}C$ samples from routine water sampling of some CTD stations (Table 3 and 4). Sea-water in the samplers immediately transferred to 5 L plastic canteens for POC and DOC, 250 ml glass bottles for DIC and $DI^{14}C$ on deck. All water samples for POC and DOC were filtered with QM-A filters (47 mm in diameter) and filtrate was collected in 1L PE bottles, as soon as possible on board. The filters and filtrates are frozen at -20°C during the cruise. DIC and $DI^{14}C$ samples were then immediately poisoned with 0.2 mL of a 7.0 % $HgCl_2$ solution and stored at 4 °C during the cruise.

(4) Instruments and methods

To study the radioactive isotope ratio of POC and bacterial cell membrane lipid, and diversity of bacterial community in surface sea-water, we filtered surface sea-water (total 154,740 L, see Table 5) continuously during the cruise. The filtration system was set up in the surface sea-water analysis room in "MIRAI". The equipment was consist of a) steel-wool part, b) 10 μm size filter part, c) 1.0 μm size filter part, d) 0.5μm size filter part, e) 0.2μm size filter part, and f) flowmeters (inflow and outflow, respectively). The maximum filtration velocity was about 8 L/min. Each filter was exchanged new one when the filtration velocity declined under 3 L/min or the filtration period exceeded 10 day. The collected filters were frozen at -20°C during the cruise.

Radiocarbon measurements for DIC, POC, DOC, and biomarkers such as GDGTs derived from marine Crenarchaeota membrane lipids will be measured by Accelerator Mass Spectrometry (AMS) at AMS facility(NIES-TERRA), National Institute for Environmental Studies.

References

Delong, E.F. (1992) Proc. Natl. Acad. Sci. USA 89: 5685-5689.

Jannasch, H. W., and Jones, G. E. (1959) Limnol. Oceanogr. 4:128-139.
Pearson, A., McNichol, A.P., Bentitez-Nelson, B.C., Hayes, J.M. and Eglinton, T.I. (2001) Geochim. Cosmochim. Acta 65: 3123-3137.
Woese, C. R., Kandler, O., and Wheelis, M. L. (1990) Proc. Natl. Acad. Sci. USA 87:4576-4579.

Table 1. List of filtrated sea-water samples for stable and radioactive carbon isotope ratio of POM, DOM and bacterial cell membrane lipids during MR08-04.

date	Station No.	latitude	longitude	bottom depth (dBar)	sampling depth (dBar)	filtrated vol. (L)
2008/9/1	33	73-36.16N	152-59.85W	3848	1000	418
2008/9/5	48	76-52.51N	153-44.83W	3517	3000	395
2008/9/7	65	70-57.54N	145-00.37W	521	500	423
2008/9/8	72	71-52.56N	148-59.82W	3098	1000	420
2008/9/10	83	73-15.20N	157-00.31W	3154	300	407
2008/9/12	95	76-25.02N	164-40.16W	531	b-10 (522)	391
2008/9/16	104	76-08.92N	161-00.09W	2128	b-10 (2120)	419
2008/9/17	114	74-52.45N	162-14.80W	1880	1000	414
2008/9/18	125	75-00.01N	166-50.02W	435	300	418
2008/9/21	145	74-59.90N	176-00.06W	246	150	420
2008/9/22	151	75-00.05N	166-29.99W	469	300	417
2008/10/3	224	71-43.77N	155-10.17W	284	50	425
2008/10/4	234	72-00.13N	165-00.28W	41.4	30	208
	234	72-00.13N	165-00.28W	41.4	17	207
2008/10/5	246	70-29.87N	168-50.08W	38.7	33	206
	246	70-29.91N	168-50.08W	38.7	12	207

Table 2. List of filtrated sea-water samples for bacterial counting during MR08-04.

date M/D/Y	Station No.	latitude	longitude	sampling depth (dBar)
08/29/2008	5	65-48.88N	168-49.18W	5,10,20,30,44
08/29/2008	12	69-00.05N	168-49.58W	10,20,30,46
08/30/2008	22	71-04.67N	159-23.14W	5,10,20,30,50,75
08/31/2008	28	71-45.07N	155-04.66W	10,50,100,200,273
09/01/2008	34	73-48.02N	154-00.03W	50,100,200,300,500,1000,1500,2000,3000, 3841
09/02/2008	40	74-59.95N	160-00.15W	50,100,200,300,500,1000,1500,1922
09/03/2008	44	77-19.73N	154-58.53W	50,100,200,300,500,1000,1308
09/04/2008	48	76-52.51N	153-44.83W	3000
09/06/2008	55	74-59.93N	145-00.11W	50,100,200,300,500,1000,1500,2000,2500, 3000,3755
09/07/2008	63	71-15.10N	144-59.10W	50,100,200,300,500,1000,1500,2000,2269
09/09/2008	75	72-14.86N	152-00.41W	50,100,200,300,500,1000,1500,2000,2780

09/10/2008	83	73-15.20N	157-00.31W	300
09/13/2008	95	76-25.02N	164-40.16W	516
09/15/2008	100	76-38.39N	168-05.16W	50,100,200,300,500,1000,1500,1732
09/16/2008	104	76-08.92N	161-00.09W	2000
09/17/2008	114	74-52.45N	162-14.80W	1000
09/19/2008	125	75-00.01N	166-50.02W	300
09/21/2008	145	74-59.90N	176-00.06W	150
09/22/2008	152	75-00.05N	166-29.99W	300
09/23/2008	156	163-003N	74-499W	50,100,200,300,500,1000,1186
09/26/2008	176	75-40.01N	175-40.04E	10,50,100,200,250
09/28/2008	184	78-00.12N	177-59.89E	50,100,200,300,500,1000,1500,1676
09/29/2008	191	76-40.20N	174-59.90W	10,50,100,200,300,500,1000,1500,1906
09/30/2008	201	75-18.03N	179-45.22W	50,100,200,300,500,624
09/30/2008	203	75-15.13N	174-45.35W	10,50,100,200,300,439
10/01/2008	206	75-59.98N	174-00.12W	50,100,200,300,500,1000,1500,2125
10/03/2008	PC5	74-22.54N	165-14.92W	357
10/03/2008	224	71-43.77N	155-10.17W	50
10/04/2008	234	72-00.13N	165-00.28W	17,30
10/05/2008	246	70-29.87N	168-50.08W	12,33

Table 3. List of samples for stable and radioactive carbon isotope ratio, and concentration of DOC and POC during MR08-04.

date	Station No.	latitude	longtitude	sampling depth (dBar)
2008/8/28	5	65-48.88N	168-49.18W	5,10,20,30,b-5
2008/8/29	12	69-00.05N	168-49.58W	5,10,20,30,b-5
2008/8/30	22	71-04.67N	159-23.14W	5,10,20,30,50,b-5
2008/8/31	28	71-45.07N	155-04.66W	5,10,20,30,50,75,100,125,150,175,200,225,250, b-10
2008/9/1	33	73-36.16N	152-59.85W	1000
2008/9/1	34	73-48.02N	154-00.03W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,3000,3500,b-10
2008/9/2	40	74-59.95N	160-00.15W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,b-10
2008/9/3	44	77-19.73N	154-58.53W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, b-10
2008/9/4	48	76-52.51N	153-44.83W	3000
2008/9/6	55	74-59.93N	145-00.11W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,3000,3500,b-10

2008/9/7	63	71-15.10N	144-59.10W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,b-10
2008/9/7	65	70-57.54N	145-00.37W	500
2008/9/8	72	71-52.56N	148-59.82W	1000
2008/9/9	75	72-14.86N	152-00.41W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,b-10
2008/9/10	83	73-15.20N	157-00.31W	300
2008/9/14	100	76-38.39N	168-05.16W	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,b-10
2008/9/16	104	76-08.92N	161-00.09W	b-10 (2120)
2008/9/17	114	74-52.45N	162-14.80W	1000
2008/9/18	125	75-00.01N	166-50.02W	300
2008/9/21	145	74-59.90N	176-00.06W	150
2008/9/22	151	75-00.05N	166-29.99W	300
2008/9/26	176	75-40.01N	175-40.04E	5,10,20,30,50,75,100,125,150,175,200,225,b-10
2008/9/28	184	78-00.12N	177-59.89E	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,b-10
2008/10/3	224	71-43.77N	155-10.17W	50
2008/10/4	234	72-00.13N	165-00.28W	17,30
2008/10/5	246	70-29.87N	168-50.08W	12,33
2008/10/6	251	68-00.30N	168-49.87W	5,10,30

Table 4. List of samples for DIC and DI^{14}C during MR08-04.

date	**Station No.**	sampling depth (dBar)	collected sample
2008/8/28	5	5,10,20,30,b-5	DIC, DI^{14}C
2008/8/29	12	5,10,20,30,b-5	DIC, DI^{14}C
2008/8/29	14	5,10,20,b-5	DIC, DI^{14}C
2008/8/30	18	5,10,20,30,b-5	DIC, DI^{14}C
2008/8/30	22	5,10,20,30,50,b-5	DIC, DI^{14}C
2008/8/31	28	5,10,20,30,50,75,100,125,150,175,200,225,250, b-10	DIC, DI^{14}C
2008/9/1	33	1000	DIC, DI^{14}C
2008/9/1	34	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,3000,3500,b-10	DIC, DI^{14}C
2008/9/1	36	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,3000,3500,b-10	DIC, DI^{14}C

2008/9/2	38	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,b-10	DIC, DI^{14}C
2008/9/2	40	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,b-10	DIC, DI^{14}C
2008/9/2	PC01	998	DIC, DI^{14}C
2008/9/3	42	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,b-10	DIC, DI^{14}C
2008/9/3	44	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, b-10	DIC, DI^{14}C
2008/9/4	48	3000	DIC, DI^{14}C
2008/9/6	55	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,3000,3500,b-10	DIC, DI^{14}C
2008/9/7	63	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,b-10	DIC, DI^{14}C
2008/9/7	65	500	DIC, DI^{14}C
2008/9/8	72	1000	DIC, DI^{14}C
2008/9/9	75	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,2000,2500,b-10	DIC, DI^{14}C
2008/9/10	83	300	DIC, DI^{14}C
2008/9/11	PC2	936	DIC, DI^{14}C
2008/9/12	93	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,b-10	DIC
2008/9/13	95	522	DIC, DI^{14}C
2008/9/13	97	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,b-10	DIC
2008/9/14	100	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,b-10	DIC, DI^{14}C
2008/9/16	104	2120	DIC, DI^{14}C
2008/9/17	114	1000	DIC, DI^{14}C
2008/9/18	125	300	DIC, DI^{14}C
2008/9/21	145	150	DIC, DI^{14}C
2008/9/22	151(152)	300	DIC, DI^{14}C
2008/9/24	163	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,1750,b-10	DIC, DI^{14}C
2008/9/24	PC3	just bove Mc	DIC, DI^{14}C
2008/9/24	PC4	just bove Mc	DIC, DI^{14}C
2008/9/26	176	5,10,20,30,50,75,100,125,150,175,200,225,b-10	DIC, DI^{14}C

2008/9/28		184	5,10,20,30,50,75,100,125,150,175,200,225,250, 275,300,350,400,450,500,600,800,1000,1250, 1500,b-10	DIC, $DI^{14}C$
2008/9/28		186	10,30,50,75,100,125,150,175,200,250,300,500,b-5	$DI^{14}C$
2008/9/29		191	10,30,50,75,100,125,150,175,200,250,300,500, 1000,1500,b-10	$DI^{14}C$
2008/9/29		194	10,30,50,75,100,125,150,175,200,250,300,500, b-5	$DI^{14}C$
2008/9/30		199	10,30,50,75,100,125,150,175,200,250,300,500, 1000,b-10	$DI^{14}C$
2008/9/30		201	10,30,50,75,100,125,150,175,200,250,300,500, b-5	$DI^{14}C$
2008/9/30		203	10,30,50,75,100,125,150,175,200,250,300,b-5	$DI^{14}C$
2008/10/1		206	10,30,50,75,100,125,150,175,200,250,300,500, 1000,b-10	$DI^{14}C$
2008/10/1	PC5		357	DIC, $DI^{14}C$
2008/10/3		224	50	DIC, $DI^{14}C$
2008/10/4		234	17,30	DIC, $DI^{14}C$
2008/10/5		246	12,33	DIC, $DI^{14}C$

Table 5. List of samples for mega filtration of surface sea-water during MR08-04.

Start Time(M/D/Y)	Stop Time(M/D/Y)	Pore size (µm)	Sample No.	Filtered vol. (L)
08/30/2008	09/08/2008	0.2, 0.5	1	38930
09/08/2008	09/16/2008	0.2, 0.5	2	38510
09/16/2008	09/26/2008	0.2, 0.5	3	43130
09/26/2008	10/03/2008	0.2, 0.5	4	34170
08/30/2008	09/03/2008	1.0, 1.0	1	17850
09/03/2008	09/08/2008	10, 1.0	2	21080
09/08/2008	09/13/2008	10, 1.0	3	25110
09/08/2008	09/16/2008	1.0, 1.0	4	13400
09/16/2008	09/20/2008	1.0, 1.0	5	15250
09/20/2008	09/26/2008	10, 1.0	6	27880
09/26/2008	10/01/2008	10, 1.0	7	24040
10/01/2008	10/03/2008	10, 1.0	8	10130

3.7. Iron

(1) Personnel

Kenshi Kuma (Hokkaido Univ.): Principal Investigator

Satoshi Fujita, Yuta Nakayama (Hokkaido Univ.)

(2) Objective

The objectives of this cruise are to study the iron behavior controlling the primary production in the surface water containing ice melting water and the iron distributions in the deep-water column of the Arctic Ocean.

(3) Parameters

Labile dissolved Fe (D-Fe), Total dissolvable Fe (T-Fe), Nutrient, Chlorophyll a (Chl-a), and dissolved oxygen (DO) concentrations and humic-type fluorescent (H-flu) intensity

(4) Instruments and Methods

We collected water samples for above parameters using acid-cleaned, Teflon-coated, 10~12 liter Niskin X sampling bottles attached to a CTD-RMS. Sample filtration for analyses of D-Fe concentrations and H-flu intensity was carried out by connecting an acid-cleaned 0.22-µm pore size Durapore membrane filter to a sampling bottle spigot and then filtering with gravity filtration. Unfiltered samples were collected for T-Fe, Chl-a, nutrient and DO concentrations. Chl-a, nutrient and DO concentrations were measured in the laboratory on ship. Iron (D-Fe and T-Fe) concentration will be measured by an automated Fe analyzer after pretreatments and H-flu intensity will be measured by a fluorescence spectrophotometer in the laboratory. In addition, we examined the growth potential of natural phytoplankton community by ambient external iron with nutrient and/or siderophore desferrioxamine B (DFB: a strong Fe(III)-complexing agent, which prevent further iron uptake from ambient extracellular Fe) and without any added nutrient and DFB (Control) in shipboard culture experiments.

(5) Observation log

#1 Sta.32:CBa01 (@ Canada Basin)

(73°24'N, 152°00'W; Bottom depth: 3907 db)

Sampling depths (5, 10, 20, 30, 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 750, 1000, 1250, 1500, 2000, 2500, 3000, 3500, 3897 db; 23 depths)

Sampling depth for culture experiment on ship (50 db)

Control, +nutrient , and +nutrient+DFB at 0°C under 150 µmol photons m-2 s–1 fluorescent light (12 h light: 12 h dark) for 7 days

#2 Sta.88 cast1:BS3000-16 (@ Northwind Abyssal Plain)

(74°30'N, 162°00'W; Bottom depth: 1644 db)

Sampling depths (10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 500, 750, 1000, 1250, 1500, 1635 db; 20 depths)

#3 Sta.99 cast1:BS3000-14 (@ Chukchi Abyssal Plain)
(76°36'N, 161°10'W; Bottom depth: 2152 db)
Sampling depths (10, 40, 65, 100, 125, 150, 175, 200, 270, 300, 450, 750, 1000, 1250, 1500, 1750, 2000, 2143 db; 18 depths)
Sampling depth for culture experiment on ship (65 db)
Control, +nutrient , and +nutrient+DFB at 0°C under 150 μmol photons m-2 s–1
fluorescent light (12 h light: 12 h dark) for 7 days

#4 Sta.121 cast1: NCS (@ Chukchi Sea Shelf)
(74°02'N, 167°14'W; Bottom depth: 217 db)
Sampling depths (10, 20, 30, 50, 75, 100, 125, 150, 175, 212 db; 10 depths)

#5 Sta.131 cast1: CAP01 (@ Chukchi Abyssal Plain)
(75°38'N, 170°26'W; Bottom depth: 1392 db)
Sampling depths (10, 20, 30, 50, 75, 100, 120, 150, 175, 190, 210, 250, 300, 350, 400, 750, 1000, 1382 db; 18 depths)

#6 Sta.161: HCE (@ Chukchi Sea Shelf)
(73°09'N, 162°19'W; Bottom depth: 196 db)
Sampling depths (5, 10, 15, 20, 30, 50, 75, 90, 125, 150, 185 db; 11 depths)
Sampling depth for culture experiment on ship (15 db)
Control, +nutrient , and +nutrient+DFB at 5°C under 150 μmol photons m-2 s–1
fluorescent light (12 h light: 12 h dark) for 7 days

#7 Sta.175: MB10 (@ East Siberian Sea Shelf)
(75°20'N, 175°20'W; Bottom depth: 222 db)
Sampling depths (5, 10, 20, 30, 50, 90, 125, 130, 150, 160, 200, 216 db; 12 depths)

#8 Sta.182 cast1: MB17 (@ Macarov Basin)
(77°40'N, 177°40'W; Bottom depth: 1293 db)
Sampling depths (10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 750, 1000, 1222, 1283 db; 18 depths)

Calibration samples for nutrients data of culture experiment on ship were collected for #9 to #11 as follows.

#9 Sta.183: MB18

Sampling depths (5, 10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275,300, 350, 400, 450, 500, 600, 800, 1000, 1250, 1500, 1670 db; 25 depths)

#10 Sta.184: MB19
Sampling depths (5, 10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275,300, 350, 400, 450, 500, 600, 800, 1000, 1250, 1500, 1600, 1702 db; 26 depths)

#11 Sta.188: MR04
Sampling depths (5, 10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275,300, 350, 400, 450, 500, 600, 800, 1000, 1250, 1410 db; 24 depths)

(6) Data policy and citation
In case of using iron data (dissolved Fe and total Fe concentrations), which were obtained in this research cruise, you need to communicate with a principal investigator (Kenshi Kuma) for iron.

3.8. Chlorophyll a concentration

(1) Personnel:
Amane FUJIWARA (Hokkaido University)
Sei-ichi SAITOH (Hokkaido University): Principal Investigator
Kohei MIZOBATA (Tokyo University of Marine Science and Technology)

(2) Objective
The objectives of our study were (1) to clarify the spatial and vertical distribution of Chlorophyll-*a* (Chl-*a*) concentration, (2) the temporal variability of Chl-*a* in Western Arctic, and (3) to validate phytoplankton types in each station and relate them to bio-optical characteristics of seawater.

(3) Parameters
Fluorescense of chlorophyll-*a*

(4) Instruments and Methods
1. Chlorophyll *a* concentration
Seawater samples for Chl-*a* concentration measurements were collected at 132 stations, almost all CTD routine sampling stations (Fig. 3.8-1). Samples measuring 0.2 liters of seawater were collected at up to 11 depths from 5 to 200m with Niskin-X bottles. The samples were gently filtered by low vacuum pressure (<100mmHg) through Whatman GF/F filters (diameter: 25mm) in the dark room.

Phytoplankton pigments were immediately extracted in 6ml of N,N-dimethylformamide after filtration and then, the samples were stored in a freezer (-20 ℃) until the analysis by fluorometer determination. The measurements were performed at room temperature after the samples were taken out of the freezer. Welschmeyer non-acidification methods were examined for the determinations of Chl-*a* with Turner design model 10-AU-005 fluorometer.

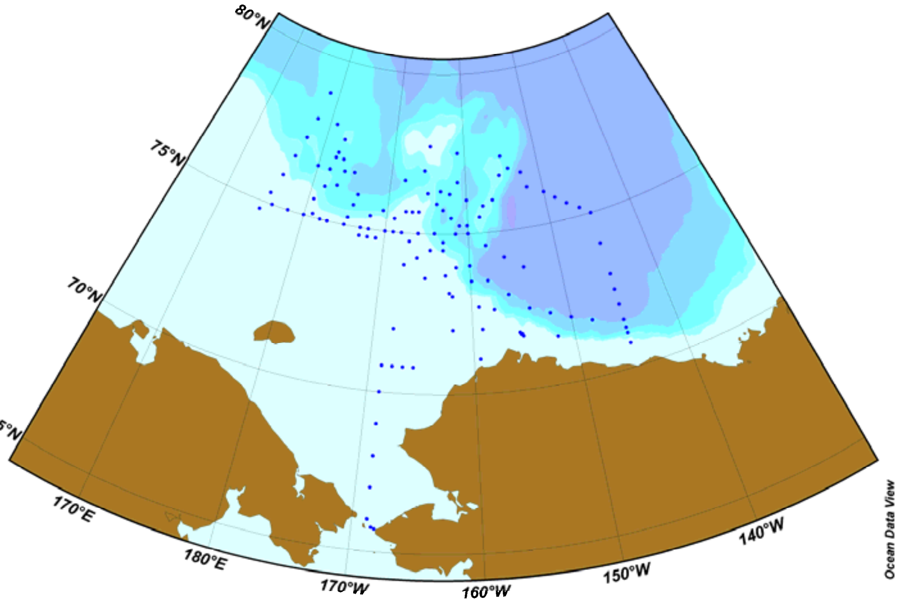


Fig. 3.8-1. Sampling stations for study area. Chl-*a* samples were collected at 132 stations.

(5) Preliminary Result

The horizontal distribution of Chl-*a* in upper layers (5, 10, 20, 30, 50 and 75 m) are shown in Fig. 3.8-2.

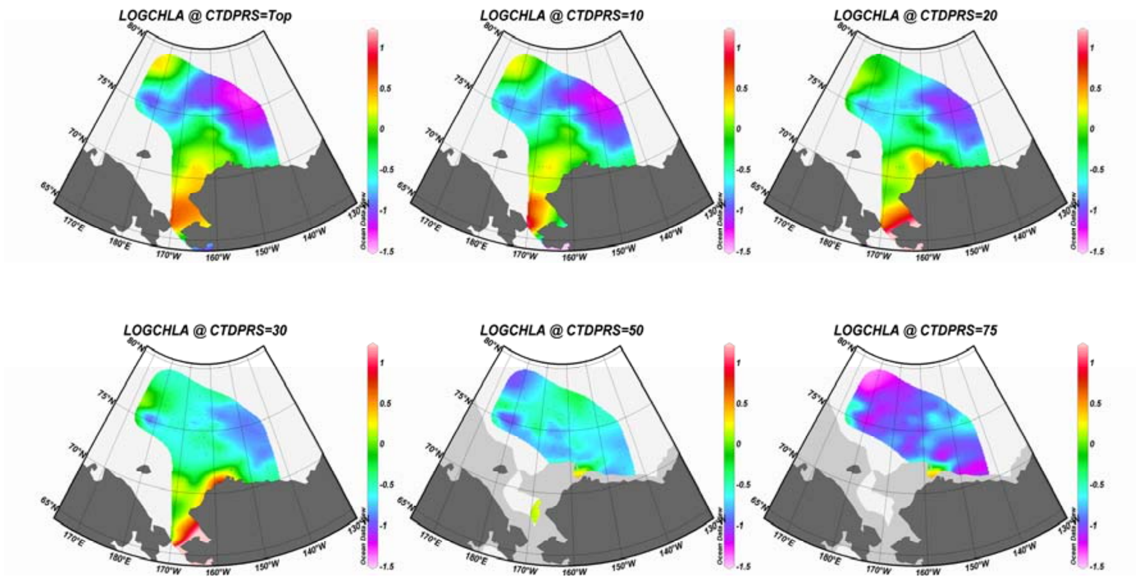


Fig. 3.8-2. Distribution of log-converted Chl-*a* concentrations for observed area at upper layer sampling depths (5, 10, 20, 30, 50 and 75 m).

(6) Data Policy and citation

All processed Chl-*a* concetration data were submitted to Principal Investigator according to the data management policy of JAMSTEC.

3.9. Bio-optical Observations

(1) Personnel

Amane FUJIWARA (Hokkaido University)
Sei-ichi SAITOH (Hokkaido University): Principal Investigator
Kohei MIZOBATA (Tokyo University of Marine Science and Technology)

(2) Objective

It is expected that annual primary productivity in the Western Arctic Ocean could be enhanced due to the recent decrease area covered by sea ice. This is because light conditions are more suitable for algal growth in ice free water than ice covered water. Dominant phytoplankton functional types (PFTs) and their distributions are also expected to be displaced for the same reasons. To assess spatio-temporal variability of primary production and dominant distribution of PFTs, our objective is to develop a optical model to identify the dominant PFTs, which could apply into satellite ocean color observation, in the Western Arctic.

(3) Parameters

Algal pigments concentrations
Light absorbance of particulate matter and detritus
Light absorbance of colored dissolved organic matter (CDOM)
Down-welling irradiance
Up-welling radiance

(4) Instruments and Methods

(a) HPLC pigment analysis

Seawater samples for high performance liquid chromatography (HPLC) were collected at 24 sampling stations (Fig. 3.9-1). The 1 to 2 liters of samples were collected at 6 depths, 5, 10, 20, 30, 50 and 75 m by Niskin-X bottles. The samples were filtered by low vacuum pressure (<100mmHg) through Whatman GF/F (filter diameter: 25 mm) in the dark room. The samples were immediately stored in a deep-freezer (-80 ℃) and will be analyzed in the laboratory after the cruise.

(b) Light absorbance

At 22 of HPLC data sampled stations (Fig. 3.9-1), seawater samples for absorbance of particle and detritus were collected in 1 gallon brown bottles, and 0.2 liters of samples for absorbance of colored dissolved organic material (CDOM) were collected at 6 depths, 5, 10, 20, 30, 50 and 75 m by Niskin-X bottles. For particle absorbance samples, the seawater was filtered using Whatman GF/F (filter diameter: 25m). The filtering volume was decided by the color of filter after filtration. The absorbance measurements were examined using Shimadzu UV-2400PC spectrophotometer. Phytoplankton pigment on filter was extracted using methanol between 24 and 48 hours, and the absorbance of detritus was measured. For measurement of absorbance of CDOM, seawater was filtered using 0.2µm Nuclepore filter, and analyzed using a spectrophotometer. The measurement stations were the same as those for bio-optical measurement stations.

(c) In-water Optical Measurements

In-water optical measurements were done at same observation stations where HPLC samples were obtained (Fig. 3.9-1). Down-welling irradiance ($E_d(\lambda)$) and upwelling radiance $L_u(\lambda)$ measurements in the water column were made with a Profiling Reflectance Radiometer (PRR800) (Biospherical Instruments, Inc.) which has the center channels, 412, 443,465, 490, 510, 532, 555, 565, 589, 625, 665, 694 nm and photosynthetically active radiation (PAR) for $E_d(\lambda)$ sensor, and 380 nm for $L_u(\lambda)$ sensor instead of PAR. Above surface down-welling irradiance ($E_{ds}(\lambda)$) was also measured by an onboard irradiance sensor (PRR810) as a reference. The PRR800 was deployed in a free fall mode through the water column. Optical measurement by PRR800/810 conducted at 24 sampling stations where we stayed during 8:00 – 16:00 (LST). The PRR800 was once taken away from the ship to minimize ship shadowing effects on measurements of the underwater light field when sampling. PRR800 was weighted to fall with a vertical velocity of ~1 m s^{-1}. Both the irradiance and radiance data were collected only during downward casts when the instrument was on free fall.

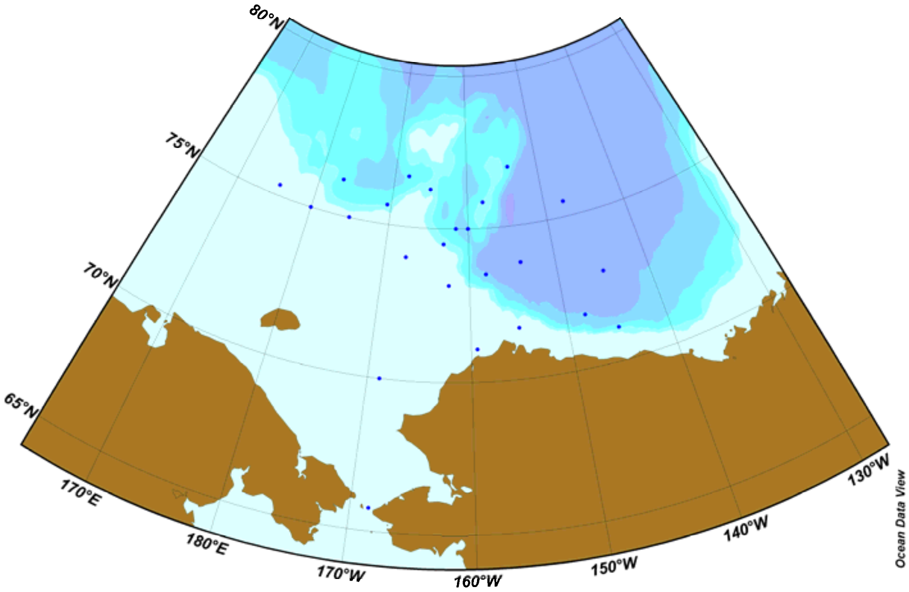


Fig. 3.9-1. Sampling stations for study area. Bio-optical samples were collected at 24 stations.

(5) Expected results and future work

(a) HPLC

HPLC algal pigments data are now under analysis. We will measure the concentration of phytoplankton pigments by HPLC, and investigate the distribution of each phytoplankton group classified with their specific pigment compositions.

(b) Light absorbance

We will analyze the absorption coefficients of phytoplankton (a_{ph}) and detritus (a_d), and then calculate Chl-*a* normalized specific absorption spectra, a^*_{ph} to divide by Chl-*a* concentration. In future study, we will use these Chl-*a* and absorption coefficients for the model parameter to estimate primary production. We will also quantify the relationships between optical properties and PFTs, and develop an optical model to identify them.

(c) In-water optical data

Using in-water optical data $L_u(\lambda)$, $E_d(\lambda)$ and $E_{ds}(\lambda)$, we computed water leaving radiance just above the surface ($L_w(\lambda, 0^+)$), remote sensing reflectance ($R_{rs}(\lambda)$) and diffuse attenuation coefficient of $E_d(\lambda)$ ($K_d(\lambda)$). We will use these data as parameters of identifying dominant PFT or to validate satellite derived data.

(6) Data Policy and citation

All processed bio-optical measurements data were submitted to Principal Investigator according to the data management policy of JAMSTEC.

3.10. FRRF (Fast Repetition Rate Fluorometer)

(1) Personnel

Sei-ichi Saitoh (Hokkaido University): Principal Investigator
Kohei Mizobata (Tokyo University of Marine Science and Technology)
Amane Fujiwara (Hokkaido University)

(2) Objective

In the high latitude ocean like the Arctic Ocean shelf region, the marine primary production is usually higher than that in the lower latitude ocean. Light availability and nutrient availability are quite vital for phytoplankton to grow itself, and those depend on both sea ice cover and ocean circulation in ice-covered ocean. Drastic sea ice melt in the Arctic Ocean have resulted in changes in both duration of open water period and ocean circulation carrying nutrients in last 10 years, meaning increases in light availability and nutrient supply. In other word, the changes in both ice-ocean dynamics and Arctic marine ecosystem can be found, as changes in primary production. Marine primary production can be estimated with satellite multi-sensor remote sensing, however the problem is that current most popular method (e.g., the Vertically Generalized Production Model, *Behrenfeld and Falkowski, 1997*) is based on the assumption of *primary productivity*, which has been empirically derived from *in-situ* measurements mainly in Pacific and Atlantic Oceans, not in the Arctic Ocean. Our objectives are a) to collect parameters for the estimation of primary productivity in the western Arctic Ocean, for better estimation of primary production, and b) to investigate relationship between primary productivity and ice-ocean dynamics.

(3) Parameters

- ✓ Fv/Fm: Ratio of effective PhotoSystem II reaction centers
- ✓ σ PS II : Effective absorption cross section (m^2 auanta^{-1})
- ✓ PAR: Solar radiation (quanta m^{-2} s^{-1})

(4) Instruments and Methods

The FRRF (Fast Repetition Rate Fluorometer, Chelsea Technologies Group) was employed to obtain parameters described above. The FRRF measures the efficiency of the conversion of light energy into chemical potential (normalized active fluorescence, Fv/Fm), and the size of the light-harvesting antenna system associated with the photochemical reaction centre PSII (the cross section of photosystem II , σPSII). The FRRF uses a strong flash of saturating blue light that causes a rise in fluorescence from an initial (Fo) to a maximum (Fm) level (e.g., M.Y. Gorbunov and P.G. Falkowski).

The FRRF was deployed and retrieved at 0.2m/s from sea surface to 100m water depth. At shallow water area (less than 100m water depth), the FRRF was deployed from sea surface to (bottom depth-10.0)m.

(5)Observation log or Station list

24 stations were made in the MR08-04 cruise. Details (location, time, etc…) are shown in table. 1. During this cruise, the FRRF measurements widely occupied the study area, including the Chukchi Sea shelf, Canada basin, shelf-slope area, Northwind Ridge, Chukchi Abyssal Plain, Chukchi Plateau and Makalov Basin (Fig. 3.10-1).

MR08-04 the IPY Arctic Ocean Cruise

FAST REPETITION RATE FLUOROMETER (FRRF) measurements

Operated by Mizobata and Fujiwara

St.	lon	lat	Start Date(JST)	Start Date(LST)	Start Date(UTC)	Weather	Bot.Dpth (m)	Deployed depth (m)	HV0	Up/downcast rate(m/s)	Remarks
003	191.332	65.788	2008/8/29 7:35	2008/8/28 14:35	2008/8/28 22:35	cloudy	49.9	50	550	0.2	Bering Strait
014-CSC09	191.17	70.001	2008/8/30 7:09	2008/8/29 14:09	2008/8/29 22:09	clear sky	40	35	550	〃	Herald Shoal, Chukchi Sea
022-Bch07	200.615	71.078	2008/8/31 4:47	2008/8/30 11:47	2008/8/30 19:47	cloudy	80	65	550	〃	Head of Barrow Canyon
034	206	73.799	2008/9/1 0:15	2008/8/31 7:15	2008/8/31 15:15	cloudy	3845	100	650	〃	Canada Basin
044	205.027	77.329	2008/9/2 7:42	2008/9/1 14:42	2008/9/1 22:42	cloudy	1323	100	650	〃	Northwind Ridge
047	205.897	76.926	2008/9/5 5:04	2008/9/4 12:04	2008/9/4 20:04	cloudy	1947	100	650	〃	Northwind Ridge
053	212.488	75.499	2008/9/6 9:35	2008/9/5 16:35	2008/9/6 0:35	cloudy	3812	100	650	〃	Canada Basin
059	215.041	72.988	2008/9/7 9:24	2008/9/6 16:24	2008/9/7 0:24	cloudy	3558	100	650	〃	Canada Basin
064	215.003	71.088	2008/9/8 4:40	2008/9/7 11:40	2008/9/7 19:40	cloudy	1760	100	650	〃	Canada Basin
071	211.989	71.749	2008/9/9 2:54	2008/9/8 9:54	2008/9/8 17:54	cloudy	3032	100	650	〃	Canada Basin
078	205.019	71.677	2008/9/10 8:47	2008/9/9 15:47	2008/9/9 23:47	cloudy	104	100	600	〃	Mouse of Barrow Canyon
084	201.908	73.503	2008/9/11 7:51	2008/9/10 14:51	2008/9/10 22:51	rain	2808	100	650	〃	Canada Basin
093	195.025	76.261	2008/9/13 9:46	2008/9/12 16:46	2008/9/13 0:46	cloudy	469	100	650	〃	Chukchi Plateau
100	191.924	76.639	2008/9/15 9:48	2008/9/14 16:48	2008/9/15 0:48	cloudy	1742	100	650	〃	Chukchi Plateau
107	202.04	75.843	2008/9/17 9:02	2008/9/16 16:02	2008/9/17 0:02	cloudy	551	100	650	〃	Northwind Abyssal Plain
113	198.48	75.003	2008/9/18 6:02	2008/9/17 13:02	2008/9/17 21:02	cloudy	1865	100	650	〃	Northwind Abyssal Plain
121	192.387	73.984	2008/9/19 4:10	2008/9/18 11:10	2008/9/18 19:10	cloudy	202	100	650	〃	Northwind Abyssal Plain
131	189.435	75.637	2008/9/20 5:18	2008/9/19 12:18	2008/9/19 20:18	cloudy	1446	100	650	〃	Chukchi Abyssal Plain CAPS01
146	184.985	75.004	2008/9/22 9:56	2008/9/21 16:56	2008/9/22 0:56	cloudy	274	100	650	〃	Chukchi Abyssal Plain CAPS16
156	184.985	75.004	2008/9/23 13:28	2008/9/22 20:28	2008/9/23 4:28	cloudy	1196	100	650	〃	Chukchi Sea CS05
161	197.672	73.155	2008/9/24 3:49	2008/9/23 10:49	2008/9/23 18:49	cloudy	197	100	650	〃	Hanna Canyon HCE
168	179.993	75.002	2008/9/26 10:31	2008/9/25 17:31	2008/9/26 1:31	cloudy	405	100	650	〃	Makalov Basin MB03
177	176.003	75.999	2008/9/27 8:03	2008/9/26 15:03	2008/9/26 23:03	cloudy	359	100	650	〃	Makalov Basin MB12
197	183.104	76.156	2008/9/30 9:13	2008/9/29 16:13	2008/9/30 0:13	cloudy	1552	100	650	〃	Mendeleev Ridge MR14

Table 1. Information of FRRF observation (Location, time, weather condition, and water depth.

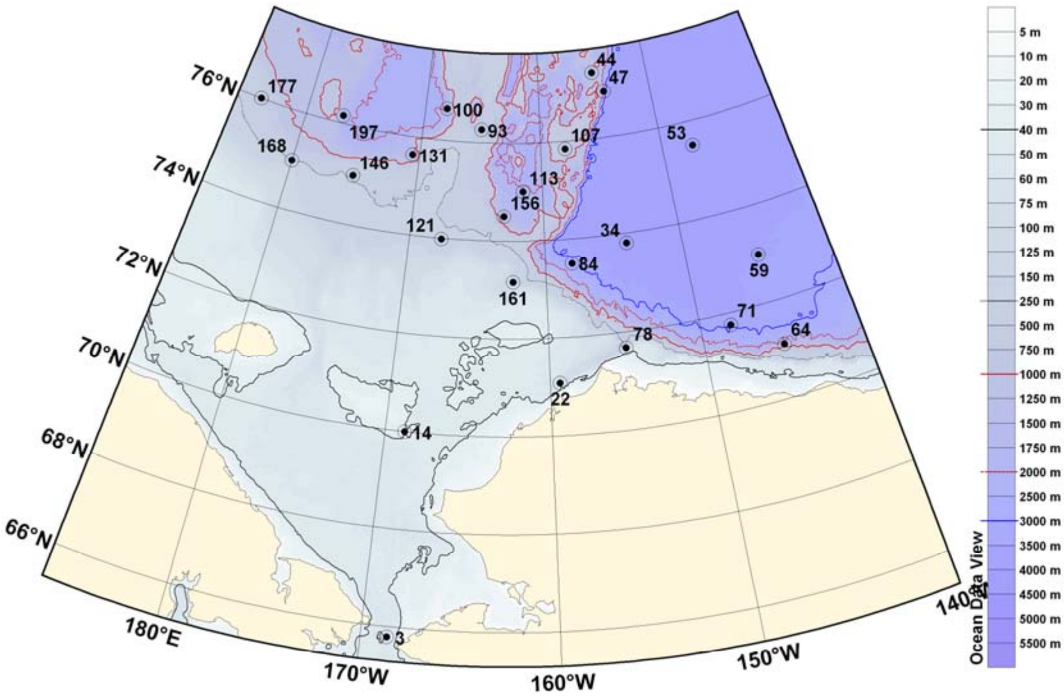
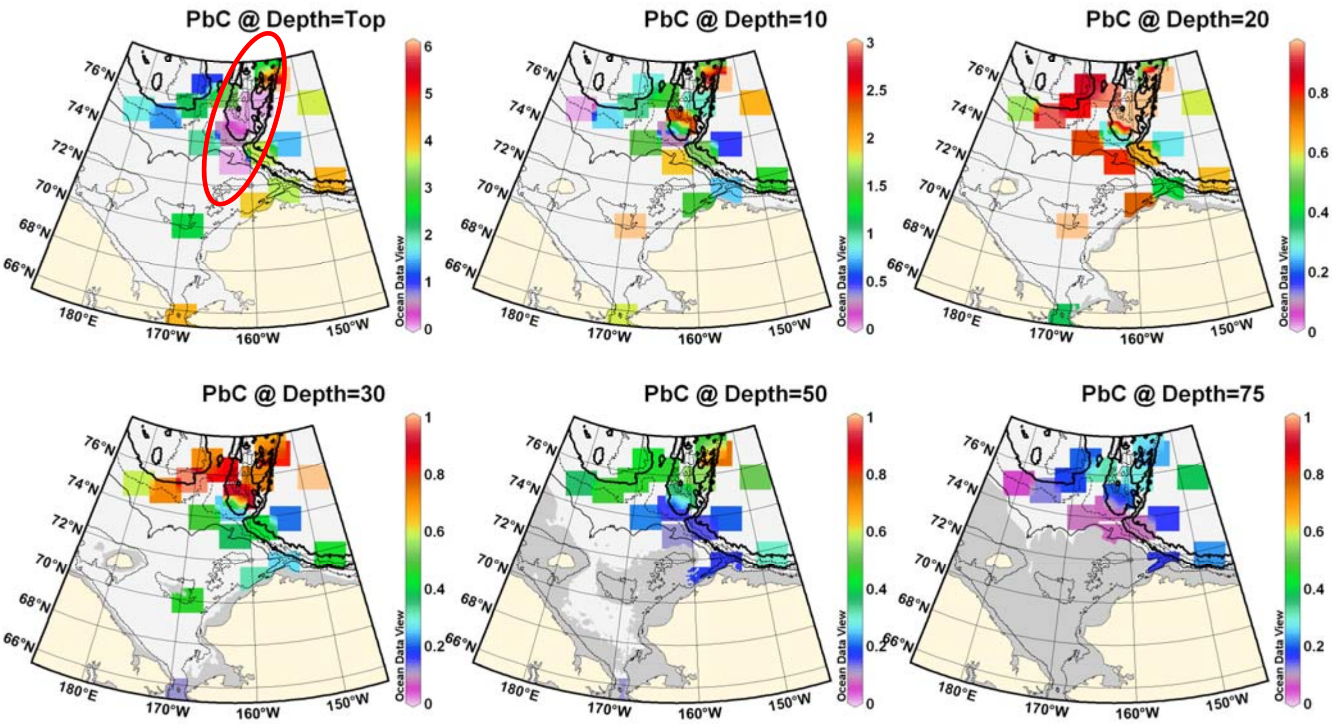
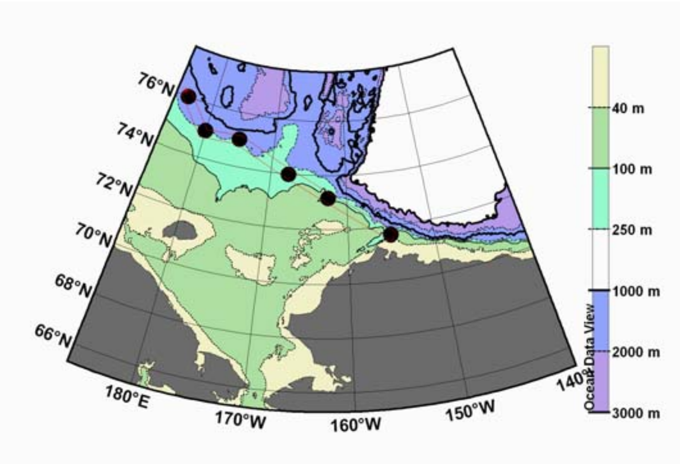


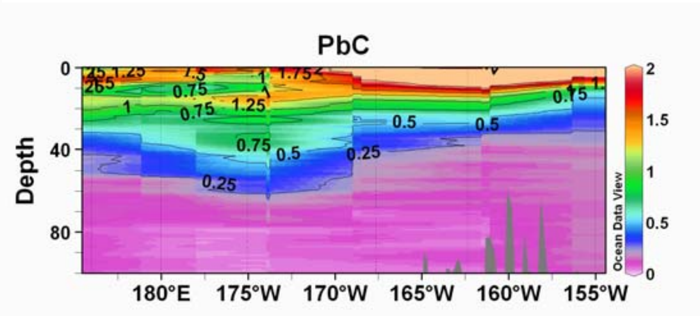
Figure 3.10-1. FRRF stations during the R/V Mirai IPY cruise MR08-04.

(6) Preliminary results



From the FRRF measurements, the rate of daily carbon fixation (PbC, mgC mg Chl^{-1} hour^{-1}) was estimated (Fig. 3.10-2). At the sea surface, relatively high PbC (>6 mgC mg Chl^{-1} hour^{-1}) was found at northern Northwind Ridge area, while quite low PbC was found from the Hanna Canyon to Northwind Ridge (Fig. 3.10-2, red circle). This spatial difference will be due to phytoplankton species composition and/or phytoplankton species composition. During this cruise, subsurface chl-a maximum was common feature except for several stations (not shown). The FRRF measurements indicate relatively high primary productivity at subsurface layer (20m and 30m water depths) in both shelf and basin area.





elfbreak of East Siberian Sea and Chukchi Sea.

Fig. 3.10-3 showed a cross section of PbC along the shelfbreak of East Siberian Sea and the Chukchi Sea. High PbC greater than 2 mgC mg Chl^{-1} $hour^{-1}$ was found at eastern side, where water property is directly influenced by the nutrient-rich Pacific Water inflow, which is modified at the Chukchi Sea. Hence, the primary production at northern Chukchi Sea will respond to changes in nutrient supply and light availability, compared to that at East Siberian Sea. In this manner, the FRRF measurements will be helpful to understand future changes in phytoplankton's response to ice-ocean dynamics. To clarify cause of spatial difference of PbC, further investigation is ongoing now.

(6) Data Policy and citation

The processed dataset was submitted to the JAMSTEC, and will be opened to public via R/V Mirai Data webpage.

3.11. Zooplankton

(1) Personnel

Kohei Matsuno (Hokkaido University)

Atsushi Yamaguchi (Hokkaido University): Principal Investigator

(2) Objective

After 1990s, decreasing of sea ice in the Arctic Ocean is reported in the western Arctic Ocean because of the amount of the warm Pacific water passed into the Arctic Ocean has been increasing. The Pacific water passed through the Bering Strait may induced intrusion of the Pacific originated zooplankton to the Arctic Ocean. Previously, the transported Pacific zooplankton is considered to be died off. It has been reported to be extinct transportation (invalid dispersion) because the amount of the transported zooplankton was few before 1990s. The transported zooplankton by Pacific water is composed by mainly copepods (*Neocalanus cristatus, N. flemingeri*, *N. prumcrus*, *Eucalanus bungii*, *Metridia pacifica*) which dominant components in the North Pacific Ocean.

The zooplankton fauna in the Arctic Ocean is known to be completely varied with that in the North Pacific. Early copepodite stages of the Pacific copepods (e.g. *Neocalanus* spp.) grow and store oil in their body during phytoplankton bloom. Pre-adult stage (C5) of the Pacific copepods descent into deeper layer (>1000 m), mature and spawn at that depth. While the spawning of the Arctic copepods (e.g. *Calanus glacialis*, *C. hyperboreus*, *Metridia longa*) is known to occur at epipelagic zone with grazing during phytoplankton bloom. Thus, the utilization of phytoplankton bloom varied with species fauna: i.e. the Pacific species utilize as energy of growth of young, while the Arctic species as energy of reproduction of adults. Therefore the Pacific copepods may use efficiently the energy of the phytoplankton bloom than the Arctic copepods, and biological efficiency of the Pacific copepods is known to be higher than that of the Arctic copepods (Parsons and Lalli, 1988).

In the western Arctic Ocean where the sea ice is decreasing, the Pacific copepods may induced and inhabited, but the details of their ecological impact has not been evaluated.
The goals of this study are following:

1) Estimate the amount of the transported Pacific copepods into the Arctic Ocean.
2) Evaluate physical conditions (gut pigment, egg production or lipid accumulation) of the Pacific copepods in the Arctic Ocean.
3) Clarify the impact of the transported Pacific copepods to the Arctic Ocean ecosystem.

(3) Sampling

Zooplankton samples were collected by vertical haul of three type nets at 54 stations in the western Arctic Ocean. Twin NORPAC net (mesh: 330 μm and 100 μm, mouth diameter: 45 cm) was towed between surface and 150 m depth or bottom -5 m (stations where the bottom shallower than 150 m) at all stations (Fig. 3-11-1 and Table 3-11-1). Zooplankton samples collected by the NORPAC net were immediately fixed with 5% buffered formalin for zooplankton structure analysis.

80 cm ring net (mesh: 330 μm, mouth diameter: 80 cm) was towed between surface and 150 m depth or bottom -5 m at 30 stations, fresh samples were used for evaluation of the copepod physiological activity (i.e. wet mass, dry mass, ash-free dry mass, gut pigment and egg production rate) (Fig. 3-11-1).

Closing PCP net (mesh: 60 μm, mouth diameter: 60 cm) was towed at 14 stations from 3 to 5 discrete layers which recognized with clear hydrographic structure (temperature and salinity). Fresh samples were used for evaluation of the copepod physiological activity (i.e. wet mass, dry mass, ash-free dry mass, gut pigment and CHN ratio) (Fig. 3-11-1 and Table 3-11-2). The volume of water filtered through the net was estimated from the reading of a flow-meter mounted in the mouth ring.

(4) On-board treatment

Fresh zooplankton samples collected with 80 cm ring net were split with Motoda box splitter, and one aliquot was immediately added with 10% soda water (CO_2 water) used for gut pigment analysis. We sorted with late copepodid stages of the Pacific copepods (*Neocalanus cristatus, N. prumcrus, N. flemingeri, Eucalanus bungii, Metridia Pacifica*) and the Arctic copepods (*Calanus glacialis, C. hyperboreus, M. longa*). Specimens were rinsed with distilled water, transferred into pre-weighted aluminum pan and stored in -30°C.

The remaining aliquot was used for gut pigment analysis. We sorted late copepodid stages of the Pacific and the Arctic copepods, and transfered into cuvette tube immersed with 6 ml dimethylformamide, stored and extracted in refrigerator about 0°C for >24 hours. After extract the pigment, these samples were measured fluorescence with a Turner model 10-AU-005 Filter Fluorimeter.

Zooplankton samples collected with closing PCP net were also split with Motoda box splitter, and one aliquot was immediately fixed with 5% buffered formalin for vertical distribution of zooplankton structure analysis. The remaining aliquot (1/2) was split with Motoda box splitter again, one aliquot

(1/4) was filtered on pre-weighted mesh (30 μm mesh size) under low vacuum and briefly rinsed with distilled water. After filtering, each aliquot was packed with aluminum foil, placed into sealed plastic bags, and stored in a freezer (-30°C) for CHN ratio analysis. The remaining aliquot (1/4) added with soda water immediately, and used for gut pigment analysis mentioned before.

(5) Results

As a preliminary results, we present following items.

Figure 3-11-1: Location of the plankton net sampling stations.
Figure 3-11-2: Geographical distribution of gut pigment of *C. glacialis* C5.
Figure 3-11-3: Geographical distribution of gut pigment of *C. glacialis* C6F.
Figure 3-11-4: Geographical distribution of gut pigment of *C. hyperboreus* C6F.
Figure 3-11-5: Geographical distribution of gut pigment of *M. longa* C6F.

(6) Reference

Parsons, T. R. and C. M. Lalli (1988) Comparative oceanic ecology of the plankton communities of the subarctic Atlantic and Pacific Oceans. *Oceanogr. Mar. Biol. Annu. Rev.*, **26**, 317-359.

Table 3-11-1. Data on plankton samples collected by vertical hauls with twin NORPAC net.
GG54: 0.33 mm mesh, XX13: 0.10 mm mesh.

Station no.	Position Lat. (N)	Lon.	S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
014	70-00	168-49 W	29 Aug	14:07	38	26	34	GG54	1860	322	4.81	
(CSC09)								XX13	1852	258	3.62	
022	71-05	159-22 W	30 Aug	11:41	77	15	74	GG54	1860	650	9.71	1)
(BCH07)								XX13	1852	380	5.33	1)
028	71-45	155-04 W	31 Aug	7:09	156	16	150	GG54	1860	1240	18.53	1)
(HSBC06)								XX13	1852	838	11.76	1)
032	73-25	152-00 W	1 Sept	1:29	153	12	150	GG54	1860	1306	19.51	
(CBa01)								XX13	1852	1087	15.26	
034	73-48	154-01 W	1 Sept	14:34	150	2	150	GG54	1860	1292	19.30	
(CBa03)								XX13	1852	1086	15.24	
040	75-00	160-03 W	2 Sept	7:48	150	2	150	GG54	1860	1330	19.87	
(CBa09)								XX13	1852	1065	14.95	
042	76-00	156-40 W	3 Sept	0:00	150	2	150	GG54	1860	1257	18.78	
(NWR01)								XX13	1852	1172	16.45	
047	76-56	154-08 W	4 Sept	12:00	150	1	150	GG54	1860	1303	19.47	
(CBN01)								XX13	1852	1238	17.38	
051	76-15	152-00 W	5 Sept	1:48	151	8	150	GG54	1860	1235	18.45	
(CBN05)								XX13	1852	1171	16.44	
053	75-29	147-27 W	5 Sept	16:20	150	1	150	GG54	1860	1306	19.51	
(CBN07)								XX13	1852	1197	16.80	
055	75-00	145-00 W	6 Sept	0:33	150	1	150	GG54	1860	1257	18.78	
(CBN09)								XX13	1852	1170	16.42	
059	73-00	144-59 W	6 Sept	16:09	152	9	150	GG54	1860	1315	19.65	
(CBC04)								XX13	1852	1397	19.61	
061	72-00	145-00 W	7 Sept	1:24	150	1	150	GG54	1860	1242	18.56	
(CBC06)								XX13	1852	1164	16.34	
064	71-05	145-00 W	7 Sept	11:27	150	4	150	GG54	1860	1296	19.36	
(CBC09)								XX13	1852	1223	17.17	
069	71-31	146-00 W	8 Sept	0:53	151	6	150	GG54	1860	1308	19.54	
(BS3000_01)								XX13	1852	1332	18.70	
071	71-45	148-04 W	8 Sept	9:49	152	10	150	GG54	1860	1344	20.08	
(BS3000_03)								XX13	1852	1208	16.96	
075	72-15	152-01 W	8 Sept	22:16	173	30	150	GG54	1860	1964	29.34	1)
(BS3000_07)								XX13	1852	1835	25.76	1)
078	71-40	155-00 W	9 Sept	15:38	101	6	100	GG54	1860	826	12.34	1)
(BCE)								XX13	1852	697	9.78	1)
080	72-30	154-01 W	10 Sept	0:15	150	3	150	GG54	1860	1266	18.91	
(BS3000_09)								XX13	1852	1245	17.48	
084	73-30	158-03 W	10 Sept	14:49	150	2	150	GG54	1860	1190	17.78	1)
(BS3000_12)								XX13	1852	1082	15.19	1)
086	74-00	160-00 W	10 Sept	22:50	151	6	150	GG54	1860	1225	18.30	1)
(BS3000_14)								XX13	1852	1059	14.87	1)
089	75-15	161-00 W	12 Sept	0:01	152	10	150	GG54	1860	1308	19.54	
(NAP01)								XX13	1852	1141	16.02	
093	76-15	164-58 W	12 Sept	15:28	150	1	150	GG54	1860	1244	18.59	
(NAP05)								XX13	1852	1138	15.97	
097	76-14	162-08 W	13 Sept	4:59	156	16	150	GG54	1860	1397	20.87	
(NAP09)								XX13	1852	1342	18.84	

1) Exclusively phytoplankton
2) Including appendicularian house

Table 3-11-1. Continued.

Station no.	Position Lat. (N)	Lon.	S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
099	76-37	161-08 W	13 Sept	23:08	153	11	150	GG54	1860	1303	19.47	
								XX13	1852	1205	16.92	
100	76-38	168-06 W	14 Sept	16:31	150	4	150	GG54	1860	1277	19.08	
								XX13	1852	1180	16.56	
102	76-59	165-30 W	15 Sept	0:29	150	1	150	GG54	1860	1232	18.41	
								XX13	1852	1172	16.45	
107	75-51	158-00 W	16 Sept	15:48	152	10	150	GG54	1860	1429	21.35	
								XX13	1852	1503	21.10	
111	75-15	160-00 W	17 Sept	1:58	156	15	151	GG54	1860	1377	20.57	
								XX13	1852	1240	17.41	
113	75-00	161-31 W	17 Sept	12:45	163	23	150	GG54	1860	1631	24.37	
								XX13	1852	1767	24.80	
117	74-30	164-30 W	17 Sept	22:42	150	2	150	GG54	1860	1251	18.69	
								XX13	1852	1179	16.55	
121	73-59	167-38 W	18 Sept	10:50	156	15	151	GG54	1860	1435	21.44	
(NCS)								XX13	1852	1330	18.67	
128	75-40	166-00 W	19 Sept	0:47	160	20	150	GG54	1860	1570	23.46	
(NAP33)								XX13	1852	1758	24.68	
131	75-39	170-32 W	19 Sept	11:57	155	14	150	GG54	1860	1580	23.61	
(CAPS01)								XX13	1852	1707	23.96	
138	74-46	172-00 W	20 Sept	4:24	152	9	150	GG54	1860	1540	23.01	
(CAPS08)								XX13	1852	1470	20.63	
141	75-25	172-02 W	20 Sept	21:02	151	7	150	GG54	1860	1367	20.42	
(CAPS11)								XX13	1852	1349	18.94	
146	75-00	175-02 W	21 Sept	17:21	152	10	150	GG54	1860	1350	20.17	
(CAPS16)								XX13	1852	1255	17.62	
150	75-00	170-01 W	22 Sept	3:09	151	7	150	GG54	1860	1653	24.70	
(CAPS20)								XX13	1852	1392	19.54	
155	75-00	164-01 W	22 Sept	15:16	153	12	150	GG54	1860	1385	20.69	
(CS04)								XX13	1852	1308	18.36	
156	74-30	163-01 W	22 Sept	21:00	150	4	150	GG54	1860	1411	21.08	2)
(CS05)								XX13	1852	1087	15.26	2)
161	73-10	162-20 W	23 Sept	10:23	150	2	150	GG54	1860	1170	17.48	2)
(HCE)								XX13	1852	982	13.78	2)
163	73-32	159-50 W	23 Sept	16:13	153	12	150	GG54	1860	1236	18.47	
(HC03)								XX13	1852	1110	15.58	
168	75-06	179-59 E	25 Sept	17:50	151	7	150	GG54	1860	1220	18.23	
(MB03)								XX13	1852	1080	15.16	
173	74-45	174-45 E	26 Sept	4:23	77	12	75	GG54	1860	610	9.11	2)
(MB08)								XX13	1852	443	6.22	2)
175	75-20	175-21 E	26 Sept	9:00	151	7	150	GG54	1860	1132	16.91	2)
(MB10)								XX13	1852	903	12.68	2)
177	76-00	176-00 E	26 Sept	15:30	152	10	150	GG54	1860	1185	17.70	2)
(MB12)								XX13	1852	928	13.03	2)
182	77-41	177-42 E	27 Sept	7:42	150	4	150	GG54	1860	1266	18.91	
(MB17)								XX13	1852	1121	15.74	
195	77-00	177-56 W	29 Sept	2:55	151	5	150	GG54	1860	1295	19.35	
(MR11)								XX13	1852	1190	16.70	

1) Exclusively phytoplankton

2) Including appendicularian house

Table 3-11-1. Continued.

Station no.	Position Lat. (N)	Lon.	S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
197	76-10	176-54 W	29 Sept	16:00	150	4	150	GG54	1860	1263	18.87	
(MR14)								XX13	1852	1249	17.53	
200	75-34	179-20 W	30 Sept	0:18	150	2	150	GG54	1860	1196	17.87	
(MR17)								XX13	1852	1031	14.47	
208	73-37	165-01 W	1 Oct	20:37	128	6	127	GG54	1860	1039	15.52	2)
								XX13	1852	852	11.96	2)
214	72-42	159-15 W	2 Oct	9:55	105	4	105	GG54	1860	879	13.13	
								XX13	1852	709	9.95	
221	71-30	151-40 W	3 Oct	7:58	155	15	150	GG54	1860	1302	19.45	
								XX13	1852	1202	16.87	
231	72-00	162-01 W	4 Oct	5:05	26	12	25	GG54	1860	358	5.35	
								XX13	1852	434	6.09	

1) Exclusively phytoplankton

2) Including appendicularian house

Table 3-11-2. Data on plankton collected by vertical hauls with a closing PCP net.

Station no.	Position Lat. (N)	Lon.	S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Closed net depth (m)	Mesh size	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
093	76-15	164-58 W	12 Sept	15:48	50	2	50	0	60 µm	2555	138	4.40	
(NAP05)				15:55	150	3	150	52	60 µm	2555	502	16.00	
				16:05	200	2	200	164	60 µm	2555	208	6.63	
				16:17	303	5	302	205	60 µm	2555	550	17.53	
				16:32	448	1	448	314	60 µm	2555	754	24.03	
097	76-14	162-08 W	13 Sept	5:18	50	1	50	0	60 µm	2555	280	8.93	
(NAP09)				5:25	152	1	152	53	60 µm	2555	603	19.22	
				5:36	251	4	250	153	60 µm	2555	571	18.20	
				5:50	404	8	400	255	60 µm	2555	846	26.97	
				6:08	1010	8	1000	416	60 µm	2555	3208	102.26	
099	76-37	161-08 W	13 Sept	23:23	50	2	50	0	60 µm	2555	303	9.66	
				23:31	150	1	150	0	60 µm	2555	821	26.17	1)
				23:45	150	2	150	0	60 µm	2555	835	26.62	1)
				23:59	150	2	150	50	60 µm	2555	618	19.70	
			14 Sept	0:10	250	1	250	155	60 µm	2555	406	12.94	
				0:23	450	2	450	244	60 µm	2555	1300	41.44	
				0:42	1893	20	1779	455	60 µm	2555	9674	308.37	
102	76-59	165-30 W	15 Sept	0:43	50	6	50	0	60 µm	2555	322	10.26	
				0:50	150	1	150	49	60 µm	2555	509	16.23	
				1:00	250	1	250	16	60 µm	2555	1240	39.53	1)
				1:18	250	2	250	144	60 µm	2555	623	19.86	
				1:32	908	4	906	458	60 µm	2555	2770	88.30	
				2:03	450	5	448	244	60 µm	2555	1220	38.89	

1) Net closing failed.

2) Net broken.

Table 3-11-2. Continued.

Station no.	Position Lat. (N)	Lon.	S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Closed net depth (m)	Mesh size	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
111	75-15	160-00 W	17 Sept	2:13	50	7	50	0	60 μm	2555	320	10.20	2)
				2:30	50	4	50	0	60 μm	2555	365	11.63	
				2:38	155	14	150	51	60 μm	2555	593	18.90	
				2:50	252	7	250	156	60 μm	2555	538	17.15	
				3:02	450	2	450	232	60 μm	2555	1330	42.40	
				3:21	1025	13	999	0	60 μm	2555	5710	182.01	1)
				4:04	1071	21	1000	458	60 μm	2555	3576	113.99	
117	74-30	164-31 W	17 Sept	22:57	50	1	50	0	60 μm	2555	441	14.06	
				23:04	150	2	150	49	60 μm	2555	589	18.78	
				23:15	253	9	250	156	60 μm	2555	609	19.41	
				23:30	390	2	390	246	60 μm	2555	815	25.98	
128	75-40	160-00 W	19 Sept	1:07	51	12	50	0	60 μm	2555	380	12.11	
(NAP33)				1:15	103	13	100	48	60 μm	2555	432	13.77	
				1:25	202	7	200	102	60 μm	2555	810	25.82	
				1:38	250	2	250	211	60 μm	2555	308	9.82	
				1:50	530	3	529	252	60 μm	2555	1671	53.27	
138	74-46	172-00 W	20 Sept	4:38	50	1	50	0	60 μm	2555	321	10.23	
(CAPS08)				4:46	152	10	150	51	60 μm	2555	640	20.40	
				4:58	301	13	293	154	60 μm	2555	877	27.96	
141	75-26	172-03 W	20 Sept	21:16	53	6	53	0	60 μm	2555	390	12.43	
(CAPS11)				21:23	200	2	200	52	60 μm	2555	915	29.17	
				21:36	300	1	300	205	60 μm	2555	644	20.53	
				21:51	1030	18	980	305	60 μm	2555	4680	149.18	
146	75-00	175-02 W	21 Sept	17:35	50	2	50	0	60 μm	2555	260	8.29	
(CAPS16)				17:42	152	10	150	49	60 μm	2555	563	17.95	
				17:53	270	9	267	155	60 μm	2555	688	21.93	
150	75-00	170-02 W	22 Sept	3:25	50	2	50	0	60 μm	2555	259	8.26	
(CAPS20)				3:33	150	1	150	51	60 μm	2555	569	18.14	
				3:44	253	3	253	153	60 μm	2555	568	18.11	
156	74-30	163-01 W	22 Sept	21:13	50	2	50	0	60 μm	2555	251	8.00	
(CS05)				21:21	151	5	150	53	60 μm	2555	462	14.73	
				21:32	250	1	250	160	60 μm	2555	493	15.72	
				21:46	450	1	450	259	60 μm	2555	1083	34.52	
				22:06	1179	5	1175	461	60 μm	2555	3830	122.09	
163	73-32	159-50 W	23 Sept	16:20	50	2	50	0	60 μm	2555	319	10.17	
(HC03)				16:28	150	1	150	50	60 μm	2555	445	14.18	
				16:37	250	2	250	151	60 μm	2555	590	18.81	
				16:49	451	4	450	234	60 μm	2555	1199	38.22	
				17:13	1800	14	1747	0	60 μm	2555	9633	307.07	1)
182	77-40	177-41 E	27 Sept	6:05	50	3	50	0	60 μm	2555	182	5.80	
(MB17)				6:12	100	4	100	49	60 μm	2555	242	7.71	
				6:21	203	10	200	100	60 μm	2555	548	17.47	
				6:35	510	11	501	203	60 μm	2555	1809	57.66	
				6:55	1280	3	1278	509	60 μm	2555	4446	141.72	

1) Net closing failed.

2) Net broken.

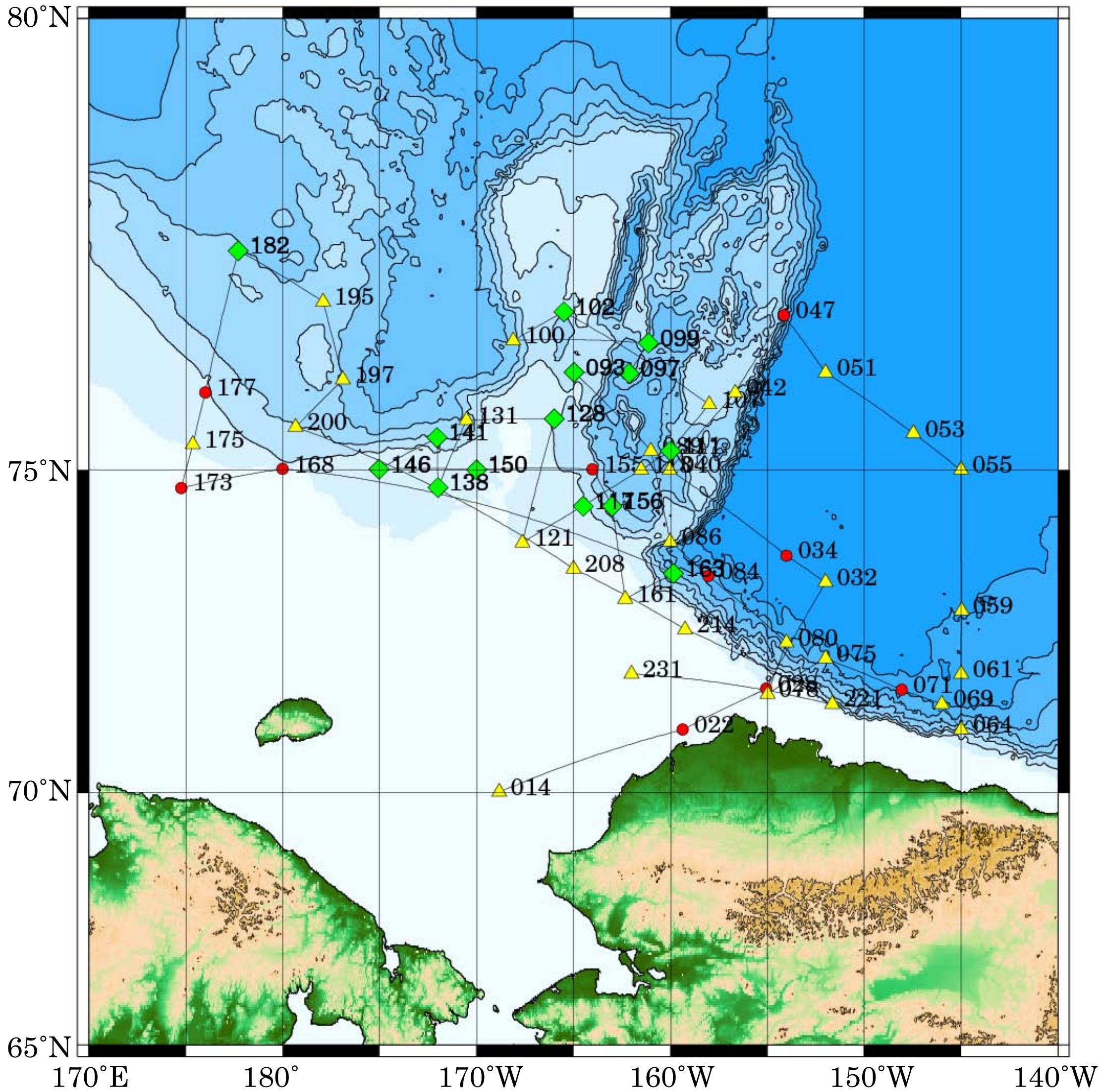


Fig. 3-11-1. Location of the sampling stations in the western Arctic Ocean (circles: NORPAC net, triangles: NORPAC net + 80 cm ring net, diamonds: NORPAC net + closing PCP net).

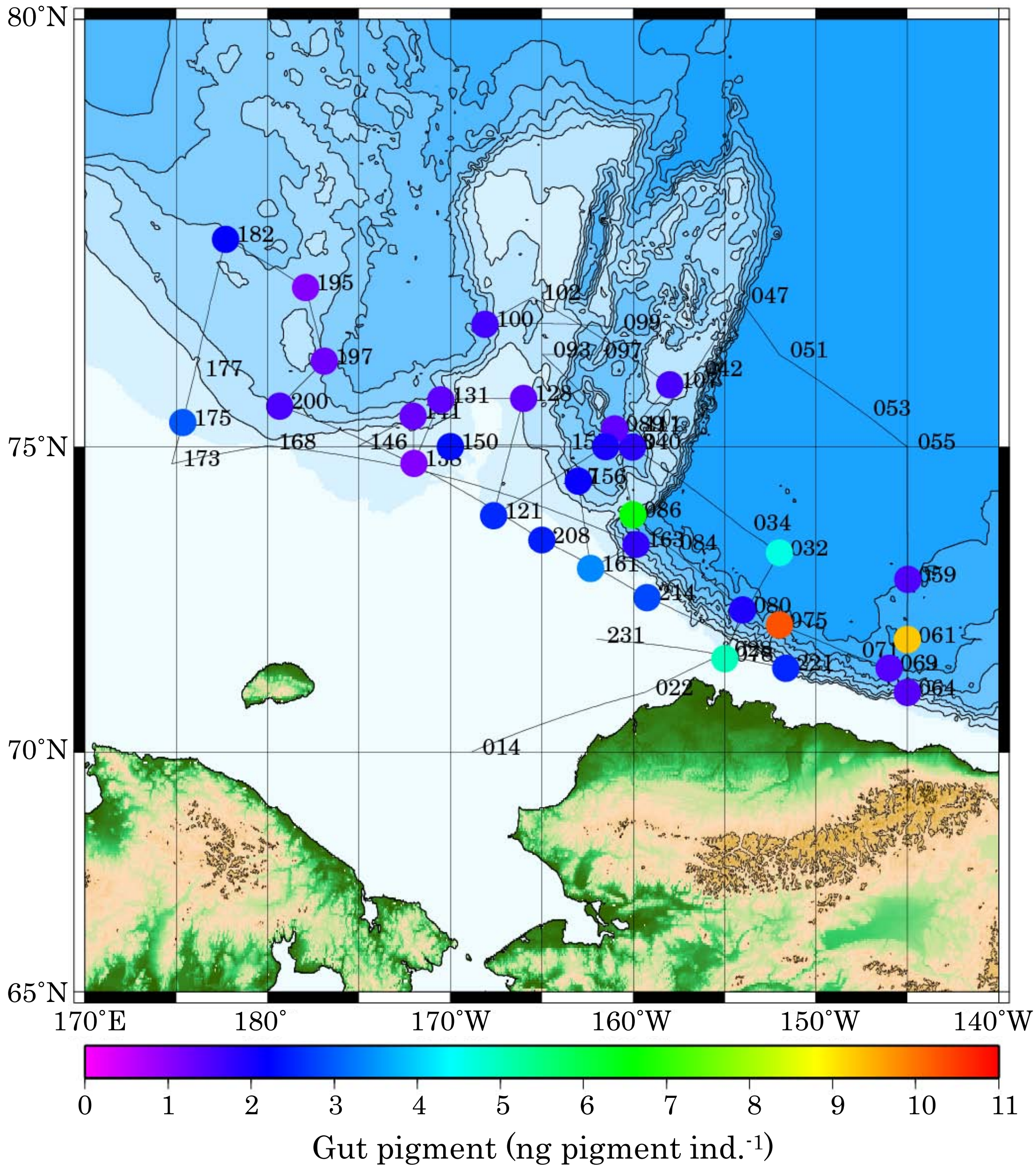


Fig. 3-11-2. Geographical distribution of gut pigment of *Calanus glacialis* C5.

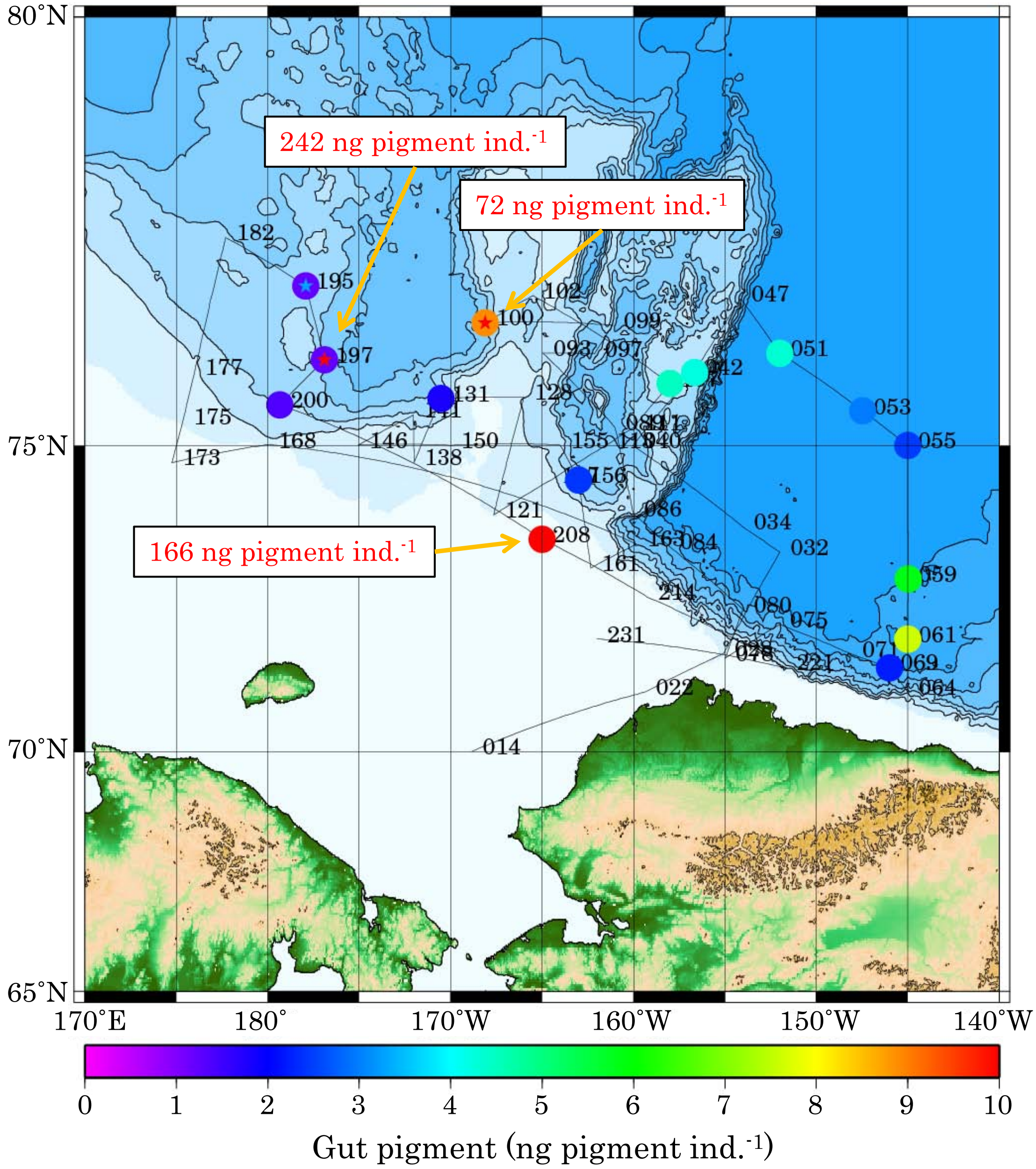


Fig. 3-11-3. Geographical distribution of gut pigment of *Calanus glacialis* C6F. Stars denote gut pigment for parasite (dinoflagellate *Ellobiopsis* sp.) attached individual.

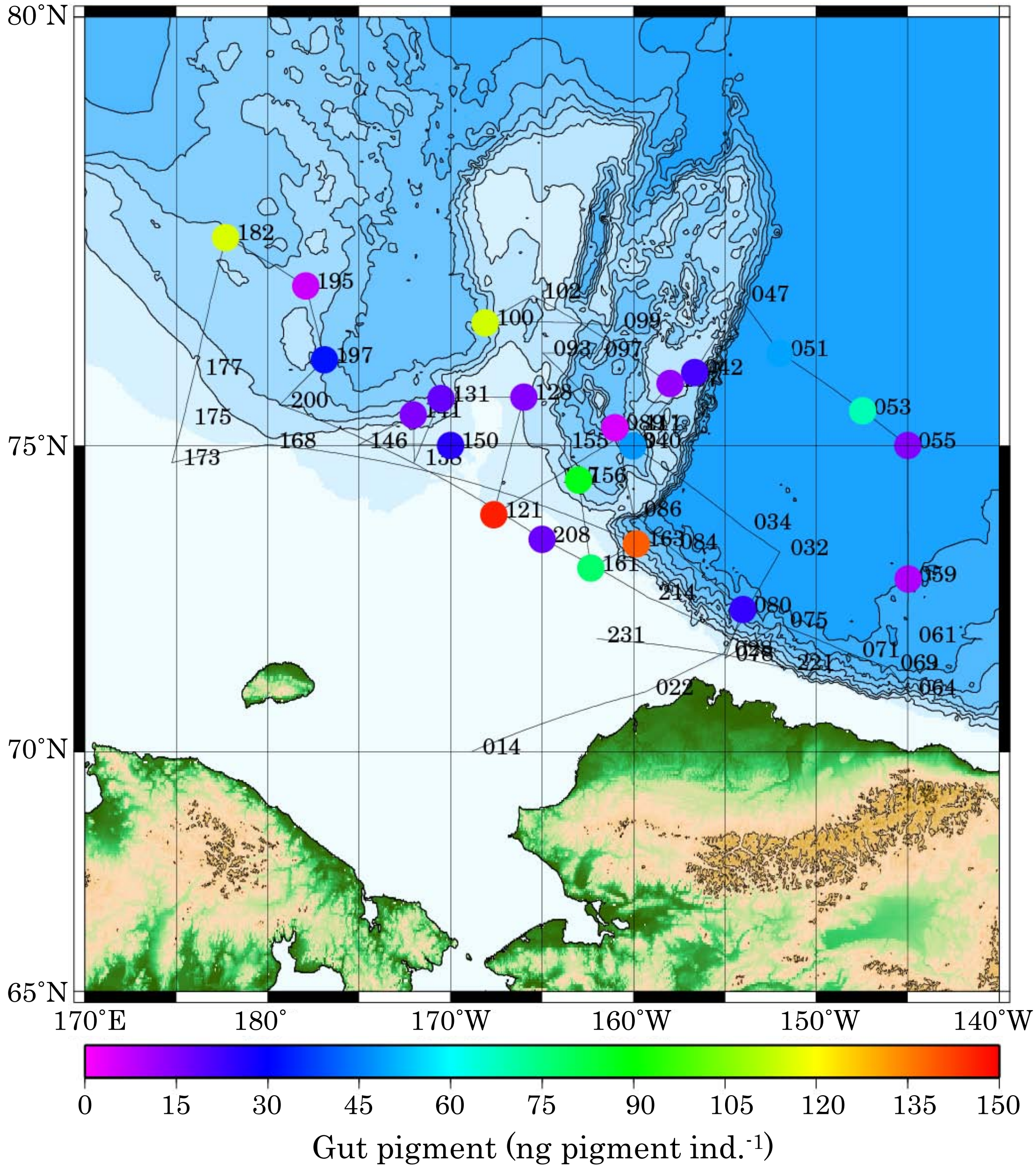


Fig. 3-11-4. Geographical distribution of gut pigment of *Calanus hyperboreus* C6F.

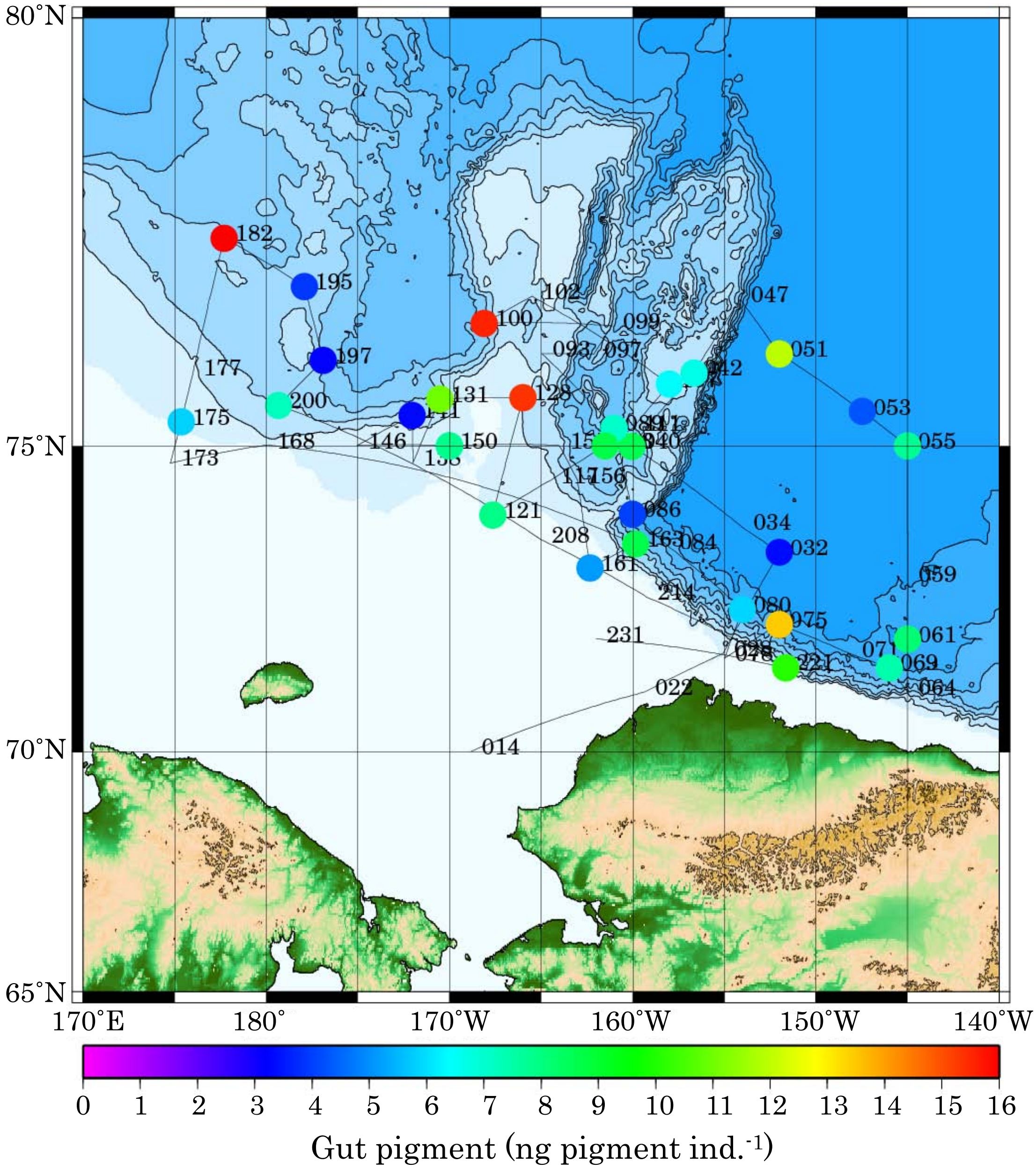


Fig. 3-11-5. Geographical distribution of gut pigment of *Metridia longa* C6F.

3.12. Rn

(1) Personnel

Hiromi Yamazawa (Nagoya Univ.)
Noriyuki Oya (Nagoya Univ.)

(2) Objectives

The concentrations of ^{222}Rn in near-surface seawater and atmosphere were continuously observed in order to measure the ocean radon flux across the air-sea interface. And thirteen near-surface seawater samplings were carried out for the ^{226}Ra concentration measurements. The radon flux was estimated from the measurements of radon concentrations, wind speed and sea surface temperature by using the model of Wanninkhof(1992) for gas transfer velocity.

(3) Instrument and Method

i. Instrument

Radon observation system consisted of two high sensitivity radon detectors, degasification units for radon gas dissolved in seawater, radon free air producing module and radon data collection system. The method of radon detection is electrostatic collection of daughter nuclei of ^{222}Rn, and α-spectrometry using PIN photodiode. The volume of radon detector vessel is 70liter. In order to keep the background at low level, the inside of the vessel is electro-polished. The background level of two radon detectors was measured among a month before this cruise. The result of background run is 12.9(^{214}Po count/day) giving detection limit of 0.01(Bq/m^3). This radon detector was developed for continuous monitoring of low level radon concentration in the Super-Kamiokande experiment (Takeuchi et al 1999).

ii. Method

The sample atmosphere air was taken from the fore mast with air sampling platform at the height of 12.5m from sea level into the sea surface water monitoring laboratory, R/V MIRAI. Sampling air was used as atmosphere air sample. Radon free air producing module was consisted of charcoal(active carbon granular), copper fiber, cooling device and drying machine. Seawater was pumped up from sea surface at depth 4.5m, which is successively flowed into the top of degasification units with average flow rate 2.0liter/min and radon free air was supplied to the bottom of one with average flow rate 2.0liter/min. Radon free air after passing the degasification units was continuously introduced into one of the radon detector after electronic-dehumidifier with dew-point temperature 0.1(deg C). Sample of atmospheric air was directly introduced into other radon detector after electronic-dehumidifier with flow rate 6liter/min.

Real observation data of α -rays energy spectrum from two radon detectors were processed to measure radon concentration of atmospheric air and seawater by note-PC, 10minutes interval. PC was working to measure and analysis, and Web Server. Radon concentration and flow rate, temperature, dew-point of sample air and seawater were browsed and watched in the local area networks.

(4) Preliminary Results

i. Radon Concentration in Atmosphere air

Hourly average of atmospheric radon concentration was measured from August-17 to October-8, 2008. Fig.3.12-1 and Fig.3.12-2 shows atmospheric radon concentration in Cruise MR08-04.

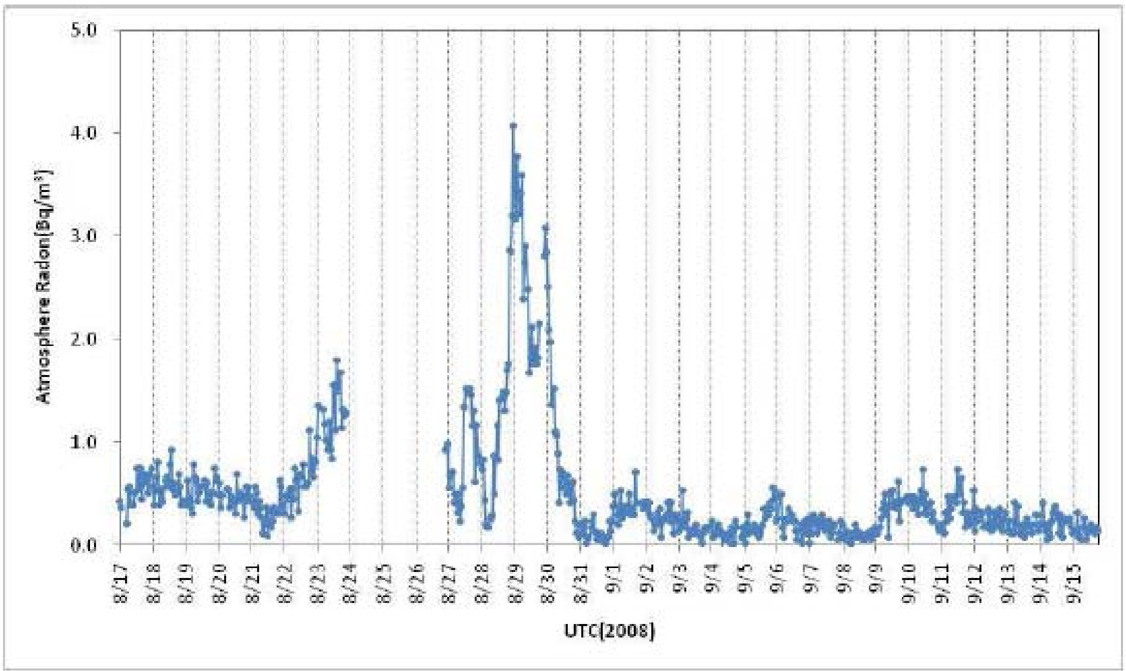


Fig.3.12-1 Atmospheric Radon Concentration in Cruise MR08-04 from August-17 to September-15, 2008.

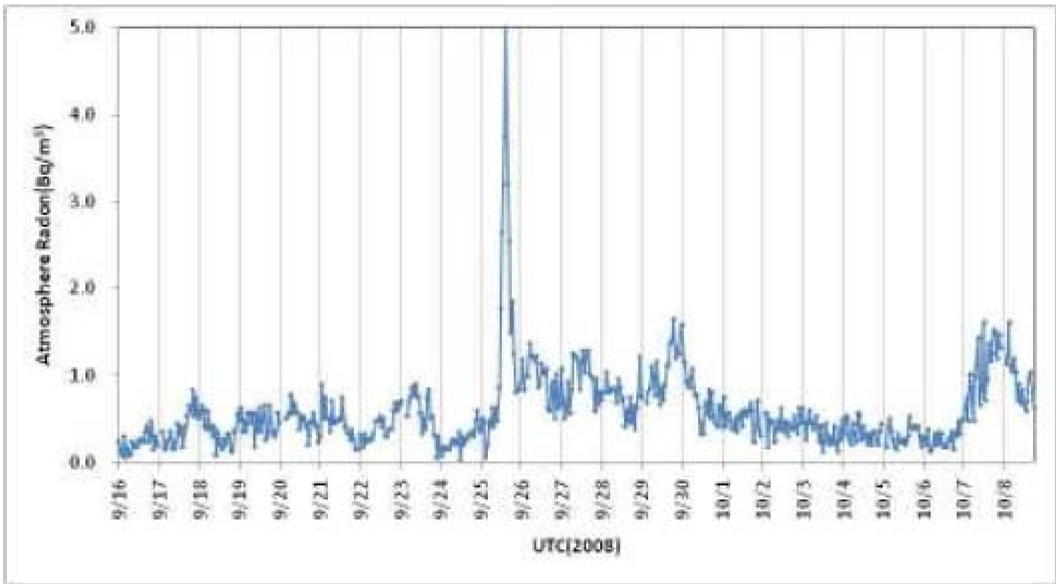


Fig.3.12-2 Atmospheric Radon Concentration in Cruise MR08-04 from September-16 to October-8, 2008.

ii. Radon Concentration in seawater

Seawater radon measurements of RUN#0 ~ RUN#18 were carried out from

August-17 to October-8, 2008. Total live time was 1165hr in all run. Radon trap rate is decrease because performance of charcoal and copper filter is blocked water. So we also re-started new run after changing new charcoal and copper fiber. Seawater radon concentration Cw was estimated by use of blows form,

$Cw=C(1+\alpha)Fa/Fw$ (1)

where C is radon concentration measured by high sensitivity radon detector, Fa and Fw is

the flow rate of radon free air and sample seawater, respectively. Coefficient α is the radon

solubility depend on sample seawater temperature. Fig.3.12-3 and Fig.3.12-4 shows the hourly average of seawater radon concentration in the cruise MR08-04. Table 1 shows RUN#, RUN

time, navigation sea area, in RUN#0 ~ RUN#18, respectively.

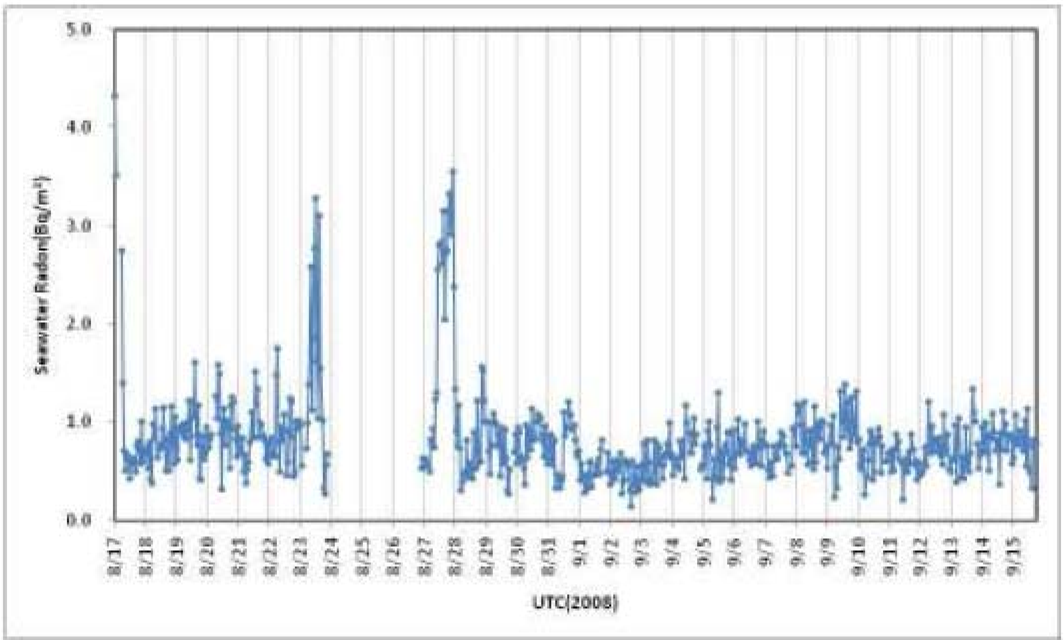


Fig.3.12-3 Seawater Radon Concentration in Cruise MR08-04 from August-17 to September-15, 2008.

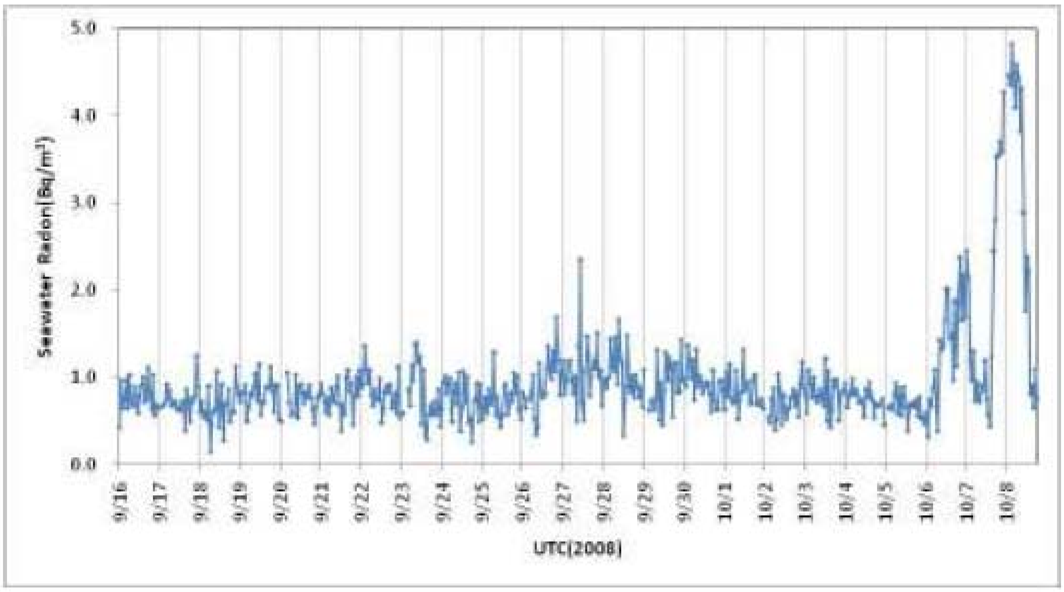


Fig.3.12-4 Seawater Radon Concentration in Cruise MR08-04 from September-16 to October-8, 2008.

No.	run time		observation area			
	start	end	start		end	
			Lat	Lon	Lat	Lon
0	2008/8/17 0:10	2008/8/17 6:13	40-24.04N	145-55.84E	40-23.98N	147-27.43E
1	2008/8/17 7:41	2008/8/20 8:00	40-24.09N	147-48.79E	47-46.86N	162-10.14E
2	2008/8/20 9:08	2008/8/23 6:25	47-55.58N	162-24.22E	54-09.64N	179-23.89W
3	2008/8/23 7:55	2008/8/24 2:26	54-10.92N	178-56.67W	54-22.35N	174-04.47W
4	2008/8/27 0:32	2008/8/30 0:00	55-38.43N	166-51.38W	70-20.48N	168-49.96W
5	2008/8/30 0:57	2008/9/1 23:04	70-30.18N	168-50.13W	73-48.13N	154-01.44W
6	2008/9/1 23:50	2008/9/5 0:12	73-52.35N	154-29.52W	76-52.70N	153-45.47W
7	2008/9/5 1:05	2008/9/7 23:11	76-50.39N	153-15.26W	71-00.89N	145-00.42W
8	2008/9/8 0:11	2008/9/11 0:01	70-57.27N	145-00.27W	73-30.17N	158-05.29W
9	2008/9/11 0:50	2008/9/14 0:00	73-30.05N	158-05.86W	77-29.69N	160-59.14W
10	2008/9/14 0:36	2008/9/17 0:02	77-23.44N	161-09.13W	75-50.95N	157-59.47W
11	2008/9/17 0:40	2008/9/20 1:35	75-50.82N	157-58.27W	75-25.11N	168-59.36W
12	2008/9/20 2:52	2008/9/23 2:31	75-22.54N	168-42.38W	74-37.28N	163-13.94W
13	2008/9/23 3:38	2008/9/26 3:00	74-29.94N	163-00.17W	74-59.92N	179-13.17E
14	2008/9/26 3:30	2008/9/29 1:32	74-59.99N	178-59.93E	76-39.81N	175-29.22W
15	2008/9/29 1:53	2008/10/2 0:17	76-41.66N	175-43.48W	74-22.71N	165-15.33W
16	2008/10/2 1:04	2008/10/5 0:21	74-15.81N	164-50.04W	71-59.92N	167-58.86W
17	2008/10/5 0:43	2008/10/7 23:00	71-24.20N	166-53.28W	60-08.36N	167-57.65W
18	2008/10/8 0:19	2008/10/9 0:00	59-52.78N	167-53.66W	55-50.66N	166-55.33W

Table 1 , RUN#0 to RUN#18 in Cruise MR08-04 from August-17 to October-8, 2008.

iii. Ocean Radon Flux Across Air-Sea Interface

Estimations for ocean radon flux was the used model of Wanninkhoh(1992) for gas transfer velocity containing a quadratic dependence on wind speed. The flux of soluble radon gas across the air-sea interface can be expressed as

$$F=k(Cw-\alpha Ca) \quad (2)$$

where k is the gas transfer velocity, Cw is seawater radon concentration and Ca is atmosphere radon concentration near the air-sea interface, and α is the Ostwald solubility coefficient. The k is a function of the interfacial turbulence, the kinematic viscosity of the seawater μ, and the diffusion coefficient of gas, D. The dependence of k on the last two

terms is expressed as the Schmidt number $Sc=\mu/D$. k is proportional $Sc^{-0.5}$ for an interface

with waves. For steady winds, relationship between gas transfer and wind speed is taken to be following form by Wanninkhoh,

$k=0.31u^2(Sc/660)^{-0.5}$ (3)

where 660 is the Schmidt number of CO_2 in seawater at 20℃ and u is wind speed. In the

Wanninkhoh paper, radon Schmidt number

$Sc=A-Bt+Ct^2-Dt^3$ (4)

where A=3412.8, B=224.3, C=6.7954, D=0.083, and t is sea surface temperature (deg C). And radon solubility coefficient

$\alpha=9.12(273+t)/273(17+t)$ (5)

Ocean radon flux across air-sea interface was obtained by substitution of observation results Ca, Cw, u, t for the form (2), (3), (4), (5).

Fig.3.12-5 and 3.12-6 shows the hourly average of ocean radon flux in RUN#0～RUN#18.

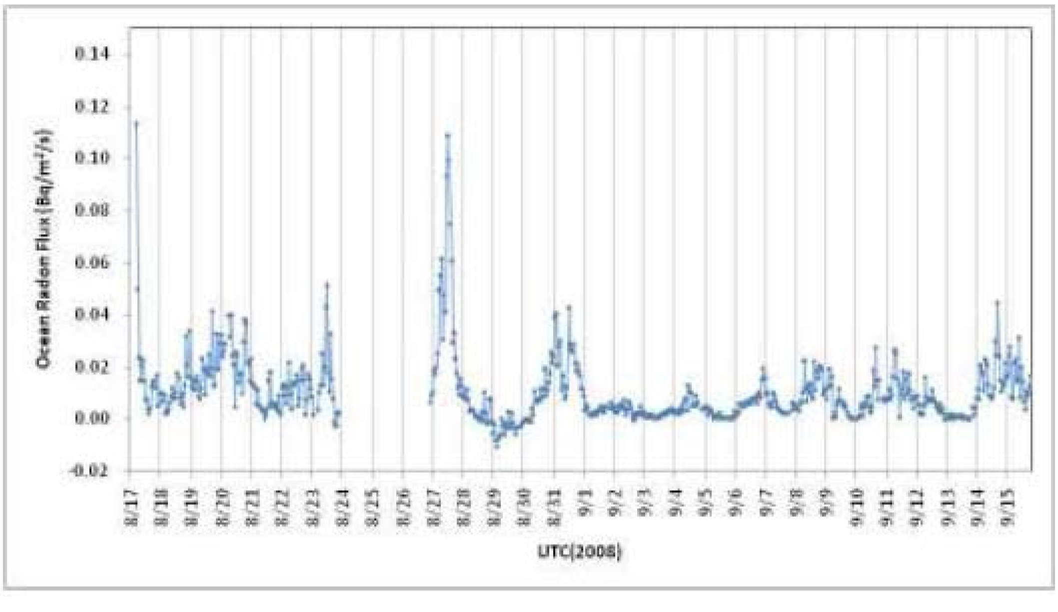


Fig.3.12-5 Ocean Radon Flux in Cruise MR08-04 from August-17 to Semptember-15, 2007.

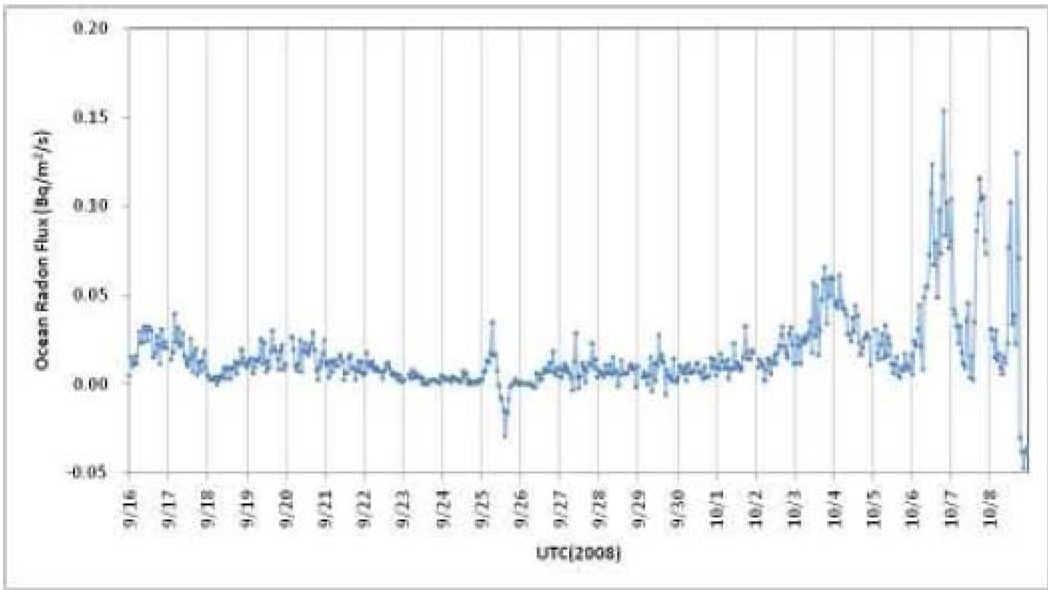


Fig.3.12-6 Ocean Radon Flux in Cruise MR08-04 from Semptember-16 to October-8, 2007.

(5) Further data quality check

These preliminary results will be checked the uncertainty of the calibrated factor of radon concentration and the difference of detection efficiency between two high sensitivity radon detector. $_{226}$Ra concentration of seawater samples will be measured by low background γ- spectrometry method, and $_{222}$Rn and $_{226}$Ra concentration in the surface seawater will be compared with each others.

References

Rik Wanninkhof : Relationship Between Wind Speed and Gas Exchange Over the Ocean, Journal of Geophysical research, Vol. 97, 7373-7382, 1992.

Y. Takeuchi, K.Okumura, T.Kajita, S.Tasaka, H.Hori, M.Nemoto, H.Okazawa : Development of high sensitivity radon detectors, Nuclear Instruments and Methods in Physics Research, A421, 334-341, 1999.

4. Atmospheric Sciences

4.1. GPS Radiosonde

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator
Shinya Okumura (GODI)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Harumi Ota (GODI)

(2) Objective

Recently, the rapid loss of Arctic sea ice is speeding up and the frozen sea areas during late summer have largely shrunken in a few years. Because open-water areas in the Arctic can absorb the sun's heat, melting of the Arctic sea ice must contribute to heat and moisten in the Arctic atmosphere, and it may influence to the global atmospheric circulation. In this study, to examine how increasing of open-water region affects to the Arctic atmosphere, the atmospheric profiles at the both sea ice covered and open water region over the Arctic Ocean were observed by using radiosonde.

(3) Method

Radiosonde observations were carried out from 01 September to 04 October 2008, by using GPS radiosonde (RS92-SGPD). We used DigiCORA III (MW21), GPS antenna (GA20), UHF antenna (RB21) and balloon launcher (ASAP) made by Vaisala. Prior to launch, humidity, air temperature, and pressure sensors were calibrated by using the calibrator system (GC25 and PTB220, Vaisala). Measured parameters are temperature (^{o}C), relative humidity (%), wind direction (deg), wind speed (m/s), air pressure (hPa). Table 4.1.1 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 binary format during ascent. ASCII data was converted from raw data.

(4) Data Archive

All datasets obtained in this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC.

(5) Remark

We couldn't archive RS095 raw data, because of stopping process in DigiCORA software.

Table 4.1.1 Launch log

No.	Date	Latitude	Longitude	Surface P	Surface T	Surface RH	WD	WS	SST	Max height		Cloud	
	YYYYMMDDHH	degN	degE	hPa	degC	%	deg	m/s	degC	hPa	m	Amount	Type
*RS001	2008081921	46.299	159.714	1006.2	13.1	72	261	6.9	11.664	35.2	23115	3	As,Ac ,Cu,Sc
RS002	2008090100	71.732	−155.160	1017.1	1.1	91	92	7.4	0.715	36.4	22916	10	Sc
RS003	2008090106	72.597	−153.621	1017.2	1.5	89	103	5.8	5.341	47.3	21173	10	St
RS004	2008090112	73.412	−151.996	1017.7	0.5	89	78	2.7	4.916	52.6	20465	10	St
RS005	2008090118	73.553	−152.770	1017.5	0.5	89	78	4.4	4.863	35.2	23093	10	St
RS006	2008090200	73.806	−154.040	1017.4	0.8	93	103	4.3	4.525	33.2	23501	10	St
RS007	2008090206	74.189	−156.043	1016.8	0.9	94	109	6.7	4.460	36.3	22887	10	St
RS008	2008090212	74.719	−158.564	1016.8	0.8	95	104	4.7	4.698	42.4	21866	10	St
RS009	2008090218	74.982	−159.872	1016.6	1.6	89	131	9.0	4.168	28.1	24544	10	St
RS010	2008090300	74.808	−158.535	1017.4	3.1	87	148	2.8	4.414	39.4	22355	10	St
RS011	2008090306	75.555	−157.398	1019.0	1.1	97	145	2.4	1.933	36.2	22921	10	St, Sc
RS012	2008090312	76.348	−156.104	1021.2	−0.6	91	10	2.8	1.520	34.9	23158	10	St
RS013	2008090318	77.260	−154.482	1022.9	−3.8	100	325	1.6	−0.579	36.0	22962	4	St
RS014	2008090400	77.328	−155.151	1024.3	−4.2	99	336	3.8	−0.563	42.8	21835	2	St
RS015	2008090406	77.047	−154.377	1025.5	−4.2	100	350	5.4	0.288	53.4	20374	7	St
RS016	2008090412	76.809	−154.975	1026.6	−4.0	100	357	2.9	−0.041	51.2	20643	5	St
RS017	2008090500	76.875	−153.753	1027.4	−4.4	99	22	4.8	0.215	68.6	18739	7	St
RS018	2008090512	76.163	−151.467	1026.1	−4.4	99	53	3.7	0.541	39.7	22285	10	St
RS019	2008090600	75.497	−147.498	1024.2	−4.1	94	52	0.9	1.425	38.3	22523	10	St
RS020	2008090612	74.543	−145.007	1022.8	−2.6	93	346	3.2	3.723	34.8	23111	10	St
RS021	2008090618	74.000	−144.982	1023.1	−1.3	92	337	4.3	2.319	37.6	22594	7	St
RS022	2008090700	73.040	−144.999	1024.1	0.4	87	301	4.4	4.194	37.8	22577	8	St
RS023	2008090706	72.605	−145.056	1023.3	0.8	88	320	6.5	3.961	42.2	21859	9	St
RS024	2008090712	72.000	−144.998	1022.8	−0.2	91	301	6.6	2.968	36.8	22737	10	St
RS025	2008090718	71.254	−145.000	1021.6	−0.2	92	353	1.5	4.767	40.5	22125	10	St
RS026	2008090800	71.022	−145.006	1019.1	0.9	89	9	4.9	4.776	42.2	21861	9	St
RS027	2008090812	71.584	−146.525	1015.7	1.1	95	338	8.2	2.589	53.6	20257	10	St
RS028	2008090900	71.995	−150.005	1015.0	1.9	85	313	7.4	4.630	83.2	17381	9	St
RS029	2008090912	71.931	−154.218	1014.3	2.4	95	48	4.0	3.524	52.3	20367	10	St
RS030	2008091000	71.673	−154.978	1012.5	1.6	87	77	1.3	3.905	38.2	22395	9	St
RS031	2008091012	72.589	−154.353	1007.0	1.0	96	246	5.6	3.976	34.1	23101	10	St
RS032	2008091018	73.036	−156.006	1002.5	2.1	91	299	7.8	4.026	36.5	22636	10	St
RS033	2008091100	73.502	−158.061	999.4	1.7	85	297	7.5	2.844	33.4	23213	10	St
RS034	2008091106	73.961	−159.840	998.8	1.1	91	347	5.9	3.674	41.4	21793	10	St
RS035	2008091112	74.404	−161.631	1001.7	1.6	92	18	10.0	3.826	28.7	24160	10	St
RS036	2008091200	74.602	−158.036	1003.4	1.4	86	357	7.2	3.824	32.7	23312	10	St
RS037	2008091212	75.433	−161.771	1008.3	−0.6	84	1	5.5	2.535	36.1	22675	10	St

RS038	2008091300	76.254	−164.979	1014.2	−2.2	89	24	5.6	2.639	36.2	22670	10	St
RS039	2008091312	76.231	−162.245	1014.0	−2.2	92	245	1.7	0.500	41.3	21793	10	St
RS040	2008091318	76.626	−161.473	1014.3	−2.0	88	5	1.8	0.832	97.8	16169	8	St
RS041	2008091400	77.523	−161.006	1014.7	−4.2	98	67	0.6	−1.072	43.4	21486	10	St
RS042	2008091412	76.626	−161.028	1013.7	−0.9	94	162	7.6	0.484	34.8	22897	10	St
RS043	2008091418	76.610	−162.758	1012.9	0.3	97	200	3.8	0.980	39.4	22085	10	St
RS044	2008091500	76.602	−167.971	1011.7	−0.4	99	201	7.6	−0.271	40.7	21887	10	St
RS045	2008091506	76.699	−166.575	1012.6	0.7	89	229	8.9	1.831	40.2	21947	10	St
RS046	2008091512	76.992	−165.522	1014.0	0.4	92	229	9.3	0.321	37.5	22410	10	St
RS047	2008091518	77.641	−165.551	1014.6	−0.8	95	242	7.9	−0.043	38.0	22338	10	St
RS048	2008091600	77.738	−164.865	1015.9	−0.4	88	232	7.7	−0.705	41.2	21805	10	St
RS049	2008091612	76.151	−163.849	1017.4	1.2	85	168	9.4	2.341	34.4	23009	10	St
RS050	2008091700	75.872	−158.304	1018.5	1.1	80	169	9.4	1.571	38.5	22240	10	St
RS051	2008091712	75.249	−159.999	1015.7	1.0	78	180	9.3	3.130	75.0	17898	10	St
RS052	2008091800	74.875	−162.249	1014.0	1.4	86	148	5.3	2.991	36.6	22547	10	St
RS053	2008091812	74.250	−166.008	1012.5	1.6	83	72	5.3	2.779	42.0	21647	10	St
RS054	2008091900	74.528	−167.166	1012.0	1.9	92	58	3.6	2.987	36.2	22618	9	St, Sc
RS055	2008091906	75.000	−167.500	1011.9	0.3	95	30	6.7	0.797	41.4	21729	6	Sc, St
RS056	2008091912	75.680	−166.163	1012.5	0.2	90	40	7.1	2.071	37.0	22458	10	St
RS057	2008092000	75.570	−170.023	1010.1	−0.7	91	56	7.3	0.404	39.9	21965	9	Sc,St
RS058	2008092012	74.756	−171.183	1007.3	0.2	97	33	7.1	0.935	35.0	22787	10	St
RS059	2008092100	75.149	−175.056	1010.2	−2.1	94	17	6.6	0.636	43.5	21401	10	St
RS060	2008092112	74.885	−172.056	1011.4	−1.2	100	3	7.8	0.598	28.9	24002	10	St
RS061	2008092200	74.996	−175.600	1015.9	−3.5	94	12	5.8	−0.569	38.6	22173	10	St
RS062	2008092212	75.002	−170.012	1017.6	−2.9	91	7	5.3	1.763	31.2	23509	10	St
RS063	2008092300	75.007	−164.014	1018.9	0.8	87	5	4.6	2.799	38.5	22186	7	St, Sc, Cu
RS064	2008092312	73.940	−162.947	1022.2	0.8	85	52	3.5	2.747	31.1	23564	4	St
RS065	2008092318	73.153	−162.326	1023.1	0.1	95	29	5.5	1.707	41.5	21727	7	St
RS066	2008092400	73.441	−160.190	1023.9	0.4	88	3	3.3	2.717	42.4	21600	9	St
RS067	2008092412	73.768	−160.778	1025.3	0.8	97	103	3.5	2.702	42.0	21630	10	St
RS068	2008092500	73.709	−162.739	1025.2	−0.1	96	169	2.2	1.997	37.5	22356	10	St
RS069	2008092512	74.774	−172.467	1019.8	−0.5	99	243	6.5	−0.023	37.6	22273	10	St
RS070	2008092612	74.922	175.140	1020.3	−1.9	90	101	5.1	−0.185	34.8	22791	10	St
RS071	2008092618	75.336	175.358	1019.0	−3.1	92	105	5.8	−0.349	55.1	19848	10	St
RS072	2008092700	76.001	176.002	1019.0	−3.2	93	119	6.6	−0.348	43.3	21373	8	St, Sc
RS073	2008092706	76.690	176.702	1018.6	−3.6	95	127	5.2	−0.490	43.3	21362	8	St
RS074	2008092712	77.442	177.508	1018.6	−4.1	98	157	7.0	−1.003	45.0	21082	4	St
RS075	2008092718	77.732	177.774	1017.1	−3.3	95	193	7.2	−1.035	40.7	21716	10	St
RS076	2008092800	78.694	178.500	1015.7	−2.7	97	198	5.9	−1.628	41.4	21575	10	St
RS077	2008092806	78.132	−179.649	1015.8	−2.0	97	223	4.4	−1.614	58.1	19432	10−	St, Sc

RS078	2008092812	77.543	−177.352	1015.6	−2.0	91	235	6.0	−0.826	39.3	21919	4	St
RS079	2008092818	76.998	−176.839	1015.6	−2.9	98	223	5.7	−1.111	34.6	22732	9	St, Sc
RS080	2008092900	76.705	−175.082	1014.9	−2.1	93	209	8.9	−1.354	37.4	22224	6	Sc, St
RS081	2008092906	76.622	−177.151	1013.2	−2.0	99	215	8.8	−1.029	65.9	18619	8	St,Ac
RS082	2008092912	77.001	−177.927	1011.6	−1.8	97	226	7.0	−0.938	55.2	19738	10	St
RS083	2008092918	76.540	−179.651	1011.4	−1.9	94	246	5.9	−1.184	43.2	21312	9	St
RS084	2008093000	76.155	−176.893	1012.2	−1.7	97	244	8.5	−1.371	36.2	22434	10	St
RS085	2008093012	75.268	−179.677	1014.2	−1.4	87	293	4.7	−0.768	37.7	22170	2	St
RS086	2008100100	75.255	−174.756	1013.5	−1.9	82	293	8.4	−0.570	44.0	21144	5	St
RS087	2008100112	75.689	−173.136	1012.8	−2.9	80	328	6.3	−1.037	41.8	21458	2	St
RS088	2008100200	74.376	−165.249	1011.2	−2.0	83	14	8.8	2.012	41.2	21584	6	Sc, St
RS089	2008100212	73.050	−161.995	1010.9	−0.9	68	353	9.9	0.890	44.9	21024	6	St
RS090	2008100300	72.591	−157.630	1010.7	−2.0	86	6	10.6	1.544	39.9	21773	6	Sc, St
RS091	2008100312	71.822	−153.103	1009.7	−1.4	85	26	9.2	0.645	37.8	22106	4	Sc
RS092	2008100400	71.725	−155.149	1009.3	−1.8	82	33	16.9	0.472	44.4	21098	10	St
RS093	2008100412	72.003	−161.084	1011.8	−1.6	73	48	11.2	0.886	42.9	21284	10	St
RS094	2008100418	72.065	−164.023	1011.8	−2.1	90	24	9.7	0.338	37.0	22201	10	St,Sc
RS095	2008100500	72.005	−167.173	1012.1	−0.8	78	30	9.7	2.829	60.5	19155	10	St, Sc

* : RS001 is a test launch.

4.2. Doppler Rader

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator
Shinya Okumura (GODI)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Harumi Ota (GODI)

(2) Objective

Increasing of heat flux from the Arctic Ocean due to expand the open water region might be affect to the Arctic hydrological cycle. In this study, to understand the difference of the characteristics of precipitating system between sea ice covered and open-water area in the Arctic Ocean C-band Doppler radar observation was carried out. Understanding of the precipitating system is also important to improve fresh water budget over the Arctic Ocean. This Doppler radar can observe three dimensional radar echo structure and wind fields of rain/snow cloud.

(3) Method

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 (Vaisala Inc. Sigmet Product Line, U.S.A)
Inertial Navigation Unit:	PHINS (Ixsea SAS, France)
Application Software:	IRIS/Open Ver.8.05.10 (Vaisala Inc. Sigmet Product Line, U.S.A)

Measured parameters are Radar reflectivity factor (dBZ), Doppler velocity (m/s), and velocity width (m/s). We checked transmitted frequency, mean output power and pulse repetition frequency (PRF) every day. The transmit pulse width and the receiver performance were checked before and after the cruise. The observation was performed throughout in this cruise, except for the boundary area of Russian EEZ. During the observation, the volume scan consisting of 21 PPIs was conducted every 10 minutes. Meanwhile, a surveillance PPI scan was performed every 30 minutes. The parameters for above scans are listed in Table 4.2.1

(4) Data Archive

The raw data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC.

Table 4.2.1 Selected parameters of C-band Doppler radar

	Surveillance PPI	Volume scan
Pulse width	2.0 [μs]	0.5 [μs]
Scan speed	18 [deg/sec]	
PRF	260 [Hz]	900/720 [Hz]
Sweep integration	32 samples	40 samples
Ray spacing	about 1.0 [deg]	
Bin spacing	250 [m]	
Elevations	0.5	0.5, 1.0, 1.8, 2.6, 3.4, 4.2, 5.1, 6.1, 7.3, 8.7, 10.6, 13.1, 16.1, 19.7, 23.8, 28.5, 33.8, 39.5 (North Pacific and Bering) 0.5, 1.0, 1.5, 2.1, 2.8, 3.5, 4.3, 5.1, 5.9, 6.8, 7.6, 8.5, 9.4, 10.4, 11.5, 12.7, 14.0, 15.5, 16.8, 18.8, 21.3 (Arctic Ocean)
Azimuths	Full Circle	
Range	300 [km]	160 [km]
Software Filters	No filter	Dual-PRF velocity unfolding
Gain control	Fixed	

4.3. Precipitation and Water Vapor Sampling for Stable Isotope Measurement

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator
Kimpei Ichiyanagi (JAMSTEC)
Hironori Fudeyasu (Hawaii Univ.)

(2) Objective

Stable water isotopes (HDO, $H_2^{18}O$) are powerful tool to study hydrological cycle in the atmosphere. Isotopic variability is related mainly to the source of moisture and the integrated histories of both condensation and evaporation during transportation from source to deposition site. Using this advantage, we examine hydrological cycle and air-sea interaction over the Arctic Ocean through the water sampling for isotope analysis. Sampling of atmospheric moisture, rainwater and surface seawater was performed during the MR08-04 cruise from Hachinohe on August 16, 2008 to Duch Harbor on October 09, 2008.

(3) Instruments, Method and Parameter

Following observation was carried out throughout this cruise.

- Atmospheric moisture sampling:

Water vapor was sampled from the hight about 20m above the sea level. The air was drawn at rate of 3-5L/min through a plastic tube attached to top of the compass deck.The water vapor was trapped in a glass trap submarged into a ethanol cooled to 100 degree C by radiator, and then they are collected every 6 hour during the cruise. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Precipitation sampling

Precipitation samples gathered in rain/snow collector were collected just after precipitation events have ended. The collected sample was then transferred into glass bottle (6ml) immediately after the measurement of precipitation amount.

(4) Observation log

Sampling of water vapor for isotope analysis is summarized in Table 4.3-1 (xx samples). The detail of precipitation sampling (xx samples) is summarized in Table 4.3-2. Described precipitation amount is calculated from the collected amount of precipitation.

(5) Data policy and citation

Isotopes (HDO, $H_2^{18}O$) analysis will be conducted at IORGC/JAMSTEC, and then analyzed isotopes data will be archived by IORGC/JAMSTEC and submitted to JAMSTEC Data Management Office. All data obtained this cruise will be under the control of the Data Management Office of JAMSTEC after 9th October 2010.

Table 4.3-1 Summary of water vapor sampling for isotope analysis.

NO	DATE and TIME	Position		Meteorological data				Collection	
		Lon. E	Lat. N	Ps	T	Q	SST	Total Flow	MASS
	YY-MM-DDTHH:MM	(deg.)	(deg.)	(hPa)	(℃)	(g/kg)	(℃)	(m^3)	(g)
V-01	2008-08-16T01:00	40.558	141.496	1000	20.8	12.172	-99	1.03	14.0
V-02	2008-08-16T06:39	40.558	141.496	1000.9	20.54	12.695	-99	0.97	12.0
V-03	2008-08-16T12:05	40.379	142.727	1001.3	19.66	12.7	-99	1.22	16.0
V-04	2008-08-16T18:54	40.384	144.592	1002.8	18.32	11.273	-99	0.90	10.0
V-05	2008-08-16T23:56	40.400	145.879	1004.4	18.45	10.171	20.4	1.08	11.0
V-06	2008-08-17T05:58	40.397	147.402	1007	18.47	9.207	22.5	1.14	11.0
V-07	2008-08-17T12:19	40.420	148.039	1008.9	18.37	8.642	22.9	1.01	8.0
V-08	2008-08-17T18:00	40.411	149.138	1009.6	17.97	8.538	21.2	1.15	10.0
V-09	2008-08-18T00:25	40.530	150.769	1009.3	17.76	8.546	20.5	1.01	8.0
V-10	2008-08-18T06:02	41.267	151.896	1009.5	16.94	8.887	19.8	1.06	9.0
V-11	2008-08-18T11:58	42.045	153.053	1008.5	16.29	8.71	19.6	1.07	9.0
V-12	2008-08-18T18:02	42.786	154.323	1008.1	15.58	8.187	19	1.04	8.0
V-13	2008-08-18T23:58	43.342	155.783	1006.9	14.74	7.773	18.3	1.05	8.0
V-14	2008-08-19T05:57	44.126	156.976	1006.6	13.6	7.531	16.2	1.10	8.0
V-15	2008-08-19T12:06	45.064	158.040	1006	12.63	6.451	14.8	1.06	6.0
V-16	2008-08-19T18:02	45.940	159.152	1005.7	12.84	6.378	14.7	1.08	7.0
V-17	2008-08-20T00:06	46.739	160.433	1005.3	12.74	6.68	14.3	1.05	7.0
V-18	2008-08-20T06:00	47.528	161.731	1005.9	12.87	6.93	14.2	1.07	7.5
V-19	2008-08-20T12:01	48.299	163.020	1006	12.82	6.846	14	1.08	7.5
V-20	2008-08-20T18:03	49.091	164.367	1006.5	13.17	7.53	13.7	1.07	8.0
V-21	2008-08-21T00:02	49.861	165.705	1006.6	13.47	7.979	13.6	1.14	9.0
V-22	2008-08-21T06:26	50.664	167.142	1007.1	13.11	8.128	13.8	1.10	8.0
V-23	2008-08-21T12:34	51.472	168.575	1007.4	12	7.863	13	0.97	8.0
V-24	2008-08-21T18:02	52.201	169.883	1009.3	11.23	7.042	12.1	1.06	8.0
V-25	2008-08-21T23:59	52.968	171.320	1011.5	11.18	6.685	12	1.15	8.0
V-26	2008-08-22T06:25	53.479	173.151	1013.7	11.06	6.627	11.7	0.99	6.0
V-27	2008-08-22T11:57	53.687	174.938	1015	10.87	7.064	11.3	1.19	8.0
V-28	2008-08-22T18:37	53.886	177.016	1016.3	10.58	6.889	10.8	0.96	6.0
V-29	2008-08-23T00:00	54.028	178.618	1016	10.47	6.981	10.9	1.42	10.0
V-30	2008-08-23T07:56	54.182	181.063	1016	10.5	6.224	11	0.73	4.0
V-31	2008-08-23T12:05	54.251	182.273	1015.4	10.12	6.096	10.9	1.06	6.0
V-32	2008-08-23T18:01	54.322	183.977	1014.5	9.83	6.233	10.5	1.17	7.5
V-33	2008-08-24T00:34	54.354	185.499	1012.2	9.73	6.004	10.3	1.28	8.0
V-34	2008-08-24T07:43	54.375	187.217	1011	9.46	5.936	10.2	0.79	4.0
V-35	2008-08-24T12:08	54.366	188.034	1009.1	9.37	5.91	9.8	1.05	6.0
V-36	2008-08-24T18:01	54.370	188.960	1006.8	9.16	6.278	9.7	1.13	7.0
V-37	2008-08-25T00:20	54.338	190.299	1003.1	9.17	5.897	11	1.02	6.0
V-38	2008-08-25T06:02	54.309	191.499	1000.5	8.25	5.632	-99	1.07	6.0
V-39	2008-08-25T12:00	54.274	192.710	997.9	7.43	5.652	-99	1.06	6.0
V-40	2008-08-27T00:32	55.643	193.143	997.9	9.01	6.374	10	1.01	6.0
V-41	2008-08-27T05:56	56.920	192.827	1000.2	7.66	5.705	9	1.13	6.0
V-42	2008-08-27T11:59	58.334	192.490	1003.6	6.68	4.692	6.7	1.12	5.0

V-43	2008-08-27T17:55	59.757	192.105	1006.5	6.81	4.341	8.7	1.14	5.0
V-44	2008-08-28T00:00	61.239	192.421	1007.3	6.61	4.121	9.7	1.12	4.2
V-45	2008-08-28T05:59	62.654	192.669	1008.5	5.31	3.756	8.6	1.32	4.5
V-46	2008-08-28T13:00	64.264	191.780	1009.8	4.23	3.652	7.1	1.17	4.0
V-47	2008-08-28T17:53	65.422	191.458	1010.4	5.69	4.251	8.4	1.48	6.0
V-48	2008-08-28T23:59	65.791	191.323	1010.8	5.84	4.699	7.2	1.44	6.5
V-49	2008-08-29T05:57	66.821	191.170	1011.2	5.77	4.867	5.6	1.64	8.0
V-50	2008-08-29T12:43	68.131	191.171	1011.2	6.11	4.932	6.2	1.28	6.0
V-51	2008-08-29T18:00	69.250	191.174	1012	6.66	5.387	5.9	1.43	8.0
V-52	2008-08-29T23:56	70.327	191.168	1013.1	4.18	4.882	4.1	1.48	7.0
V-53	2008-08-30T06:04	70.835	192.666	1014.7	5.01	4.943	5.5	1.40	6.0
V-54	2008-08-30T11:55	70.835	195.658	1015.3	1.63	4.108	1.3	1.48	6.0
V-55	2008-08-30T18:00	70.999	200.044	1016.4	2.16	4.144	0.7	1.43	6.0
V-56	2008-08-30T23:53	71.266	202.116	1017.1	2.42	3.874	2.2	1.46	6.0
V-57	2008-08-31T05:53	71.863	203.089	1017.9	2.12	3.861	3.8	1.44	5.5
V-58	2008-08-31T11:50	71.851	204.366	1017.2	1.68	3.788	2.2	1.49	6.0
V-59	2008-08-31T17:59	71.659	205.104	1016.7	1.53	3.656	1	1.42	5.0
V-60	2008-08-31T23:53	71.731	204.837	1015.8	1.62	3.672	3.5	1.51	6.0
V-61	2008-09-01T06:06	72.729	206.675	1016.6	0.74	3.557	5.1	1.40	5.0
V-62	2008-09-01T11:52	73.417	208.008	1016.7	0.73	3.544	4.9	1.51	5.0
V-63	2008-09-01T18:04	73.602	207.001	1016.7	0.98	3.614	4.4	1.45	5.0
V-64	2008-09-02T00:02	73.904	205.389	1016.3	1.06	3.722	4.4	1.78	6.0
V-65	2008-09-02T05:59	74.257	203.646	1016.1	1.1	3.718	4.3	2.02	7.8
V-66	2008-09-02T12:46	74.812	200.921	1015.8	1.42	3.81	4	1.57	6.0
V-67	2008-09-02T18:01	74.927	200.790	1016.3	2.4	3.967	4.3	1.80	7.0
V-68	2008-09-03T00:02	74.807	201.467	1017.5	2.58	3.967	3.5	2.00	8.0
V-69	2008-09-03T06:45	75.806	203.011	1019.5	0.86	3.761	1.6	1.54	5.8
V-70	2008-09-03T11:54	76.478	204.171	1021.3	-1.95	3.082	-0.1	1.80	6.0
V-71	2008-09-03T18:53	77.294	206.289	1023	-3.65	2.768	-0.7	1.84	4.5
V-72	2008-09-03T23:59	77.373	204.867	1024.6	-3.55	2.804	-0.2	3.28	9.0
V-73	2008-09-04T10:50	76.808	205.003	1025.8	-3.66	2.77	0	0.98	2.0
V-74	2008-09-04T14:06	76.834	204.987	1026.1	-3.93	2.706	-0.2	1.31	3.0
V-75	2008-09-04T20:25	76.934	205.848	1026.5	-3.66	2.758	0.1	1.70	4.0
V-76	2008-09-05T00:03	76.878	206.243	1025.9	-3.33	2.843	0.6	1.73	4.0
V-77	2008-09-05T05:47	76.509	207.739	1025.5	-3.45	2.816	0.8	1.79	5.0
V-78	2008-09-05T11:47	76.094	209.129	1024.4	-4.12	2.661	0.5	1.88	5.0
V-79	2008-09-05T18:04	75.749	211.251	1023.6	-3.89	2.661	1.3	1.75	4.4
V-80	2008-09-05T23:56	75.484	212.527	1022.5	-3.84	2.641	1.7	1.79	4.6
V-81	2008-09-06T05:55	75.008	214.968	1021.9	-3.04	2.769	1.7	1.76	4.6
V-82	2008-09-06T11:48	74.499	215.008	1022.1	-1.83	2.976	2.7	1.85	5.6
V-83	2008-09-06T18:00	73.850	215.033	1022.9	-0.29	3.19	3.7	1.82	6.0
V-84	2008-09-07T00:06	72.992	215.018	1022.6	0.71	3.396	4.1	1.73	6.2
V-85	2008-09-07T05:55	72.500	215.001	1022.3	0.35	3.375	3.5	1.71	6.0
V-86	2008-09-07T11:38	71.998	215.000	1021.3	-0.11	3.375	3.7	1.84	6.4
V-87	2008-09-07T17:51	71.255	215.008	1019.4	0.46	3.442	4.8	1.85	6.6
V-88	2008-09-08T00:05	70.958	214.993	1016.7	1.05	3.586	4.8	1.75	6.6

V-89	2008-09-08T06:00	71.036	214.556	1015.4	1.3	3.865	3.8	1.68	6.8
V-90	2008-09-08T11:40	71.624	213.299	1014.5	0.89	3.69	3.2	1.81	7.0
V-91	2008-09-08T17:47	71.743	211.929	1014	1.35	3.634	4.3	1.84	7.0
V-92	2008-09-08T23:59	71.995	209.985	1013.4	2.29	3.986	4.4	2.19	9.0
V-93	2008-09-09T07:20	72.300	207.572	1013.4	2.17	4.089	3.6	1.31	5.4
V-94	2008-09-09T11:48	71.838	205.561	1013	1.88	3.952	3	1.84	7.6
V-95	2008-09-09T18:02	71.804	204.664	1012.2	1.62	3.683	3.5	1.76	6.6
V-96	2008-09-09T23:59	71.669	205.002	1010.2	0.77	3.775	3.6	1.73	6.8
V-97	2008-09-10T05:50	72.202	205.004	1007.6	0.58	3.787	3.9	1.77	7.0
V-98	2008-09-10T11:48	72.676	205.309	1003.5	1.42	3.825	4.3	1.77	7.0
V-99	2008-09-10T17:48	73.112	203.645	999.7	1.94	3.902	3.6	1.87	7.6
V-100	2008-09-11T00:05	73.503	201.910	997.4	1.03	3.653	3.4	1.71	6.6
V-101	2008-09-11T05:48	73.999	200.001	998.2	1.02	3.488	3.7	1.78	6.4
V-102	2008-09-11T11:49	74.467	198.077	1000.7	1.63	3.702	3.7	1.84	7.0
V-103	2008-09-11T18:00	74.558	200.179	1001.4	1.16	3.533	3.8	1.81	6.6
V-104	2008-09-12T00:04	74.605	201.954	1003.6	0.71	3.501	3.9	1.73	6.0
V-105	2008-09-12T05:53	75.071	199.721	1006.3	-0.4	3.273	2.8	1.75	5.8
V-106	2008-09-12T11:46	75.500	198.002	1008.9	-0.68	3.069	2.6	1.87	5.8
V-107	2008-09-12T18:02	75.891	196.429	1012.3	-1.65	2.806	2.6	1.78	5.0
V-108	2008-09-13T00:05	76.258	195.033	1013.8	-2.27	2.692	2.2	1.71	4.6
V-109	2008-09-13T05:49	76.434	195.051	1014.1	-2.56	2.762	2.1	1.80	4.8
V-110	2008-09-13T11:52	76.243	197.857	1013.6	-2.43	2.87	0.7	1.80	5.0
V-111	2008-09-13T17:54	76.765	198.440	1013.6	-4.23	2.538	-0.1	1.77	4.0
V-112	2008-09-13T23:52	77.506	199.026	1013.4	-3.13	2.705	0.4	1.78	4.0
V-113	2008-09-14T05:51	76.605	198.835	1013.1	-1.81	2.998	0.5	1.79	5.4
V-114	2008-09-14T11:50	76.629	199.101	1012.4	-0.2	3.37	0.9	1.71	6.0
V-115	2008-09-14T17:35	76.636	196.972	1010.9	0.23	3.515	1.5	1.94	7.0
V-116	2008-09-15T00:05	76.643	191.892	1011.1	-0.16	3.455	0.7	1.74	6.0
V-117	2008-09-15T05:58	76.733	194.022	1012.4	0.84	3.479	0.7	1.71	6.0
V-118	2008-09-15T11:50	77.004	194.474	1013.5	-0.33	3.333	0.5	1.80	6.0
V-119	2008-09-15T17:46	77.682	194.465	1014.3	-0.91	3.216	-0.7	1.88	6.0
V-120	2008-09-15T23:58	77.719	195.316	1015.4	-0.2	3.284	-0.4	1.81	6.0
V-121	2008-09-16T05:58	76.996	194.507	1015.5	0.78	3.432	2.2	1.73	6.0
V-122	2008-09-16T11:51	76.167	196.669	1016.5	0.48	3.324	0.8	1.78	6.0
V-123	2008-09-16T17:50	76.049	199.994	1017	0.59	3.215	0.8	1.86	6.0
V-124	2008-09-17T00:05	75.849	202.010	1016.7	0.59	3.244	1.8	1.73	5.8
V-125	2008-09-17T05:52	75.503	201.499	1015.4	0.83	3.153	3.2	1.76	5.6
V-126	2008-09-17T11:47	75.250	199.992	1013.9	1.57	3.228	2.8	1.80	5.6
V-127	2008-09-17T17:52	75.014	198.579	1013.1	1.48	3.325	3	1.86	6.0
V-128	2008-09-18T00:05	74.870	197.755	1012.5	1.42	3.333	3.1	1.72	5.8
V-129	2008-09-18T05:52	74.505	195.528	1012	1.23	3.388	2.9	1.78	6.0
V-130	2008-09-18T11:51	74.205	193.761	1011.3	1.23	3.445	2.3	1.77	6.0
V-131	2008-09-18T17:50	73.978	192.411	1010.8	1.41	3.684	2.6	1.87	7.0
V-132	2008-09-19T00:05	74.577	192.812	1011.1	0.78	3.534	1.6	1.71	6.0
V-133	2008-09-19T05:48	75.072	192.673	1011.5	0.09	3.35	1.7	1.79	6.0
V-134	2008-09-19T11:50	75.660	193.332	1011.3	-0.49	3.247	0.6	1.77	5.8

V-135	2008-09-19T17:48	75.634	189.561	1010.4	-0.92	3.046	-0.9	1.88	5.8
V-136	2008-09-20T00:03	75.537	190.233	1007.5	-0.54	3.146	1.1	1.71	5.5
V-137	2008-09-20T05:48	75.035	191.140	1006.2	0.18	3.538	1.6	1.79	6.0
V-138	2008-09-20T11:47	74.748	188.398	1006.7	-1.05	3.279	0.1	1.81	6.0
V-139	2008-09-20T17:50	74.812	185.871	1008.8	-2.53	2.915	-0.5	1.78	5.3
V-140	2008-09-20T23:49	75.087	185.334	1009.2	-2.57	2.878	-0.4	1.87	5.0
V-141	2008-09-21T06:09	75.418	187.926	1010.3	-1.98	3.206	0.2	1.69	5.0
V-142	2008-09-21T11:48	74.766	187.431	1012	-3.18	2.885	-0.3	1.79	4.8
V-143	2008-09-21T17:49	74.941	183.153	1014.6	-3.97	2.653	-1.1	1.86	4.5
V-144	2008-09-22T00:04	75.002	184.993	1015.6	-3.57	2.682	0.1	1.71	4.0
V-145	2008-09-22T05:50	75.001	186.992	1016.4	-3.42	2.707	1	1.78	4.0
V-146	2008-09-22T11:48	75.004	189.976	1016.9	-2.72	2.763	1.5	1.79	4.8
V-147	2008-09-22T17:48	75.003	193.522	1017.6	0.2	3.241	2.8	1.88	6.0
V-148	2008-09-23T00:05	75.013	195.953	1018.9	0.57	3.405	2.9	1.74	6.0
V-149	2008-09-23T05:56	74.503	196.980	1020.7	0.47	3.342	2.9	1.78	6.0
V-150	2008-09-23T11:54	73.797	197.184	1021.9	0.43	3.317	1.9	1.83	6.2
V-151	2008-09-23T18:01	73.160	197.670	1022.8	0.16	3.174	1.9	1.80	5.8
V-152	2008-09-24T00:05	73.534	200.165	1023.4	0.46	3.566	2.5	1.76	6.0
V-153	2008-09-24T06:01	73.293	199.896	1024	0.87	3.588	2.6	1.72	6.0
V-154	2008-09-24T11:47	73.812	199.001	1024.3	0.46	3.564	2.5	1.80	6.5
V-155	2008-09-24T17:49	73.964	198.423	1024.5	0.33	3.457	2.1	1.87	6.5
V-156	2008-09-25T00:06	73.749	196.938	1023.1	-0.63	3.185	2	1.72	5.6
V-157	2008-09-25T05:52	74.357	192.155	1020	-0.22	3.48	1.4	1.77	6.5
V-158	2008-09-25T11:47	74.852	187.192	1018.5	-1.69	3.228	-0.5	1.79	6.0
V-159	2008-09-25T17:48	74.995	183.369	1019.9	-2.43	2.787	-0.6	1.87	5.0
V-160	2008-09-26T00:04	75.000	180.236	1020	-2.17	2.712	-0.3	1.78	4.5
V-161	2008-09-26T06:03	74.999	177.704	1019.5	-2.07	2.79	-0.3	1.94	5.2
V-162	2008-09-26T12:32	74.759	174.760	1018.3	-3.08	2.709	-0.3	1.58	4.0
V-163	2008-09-26T17:51	75.398	175.469	1018.1	-3.5	2.662	-0.5	1.85	4.8
V-164	2008-09-27T00:04	76.075	176.065	1017.8	-3.58	2.615	-0.4	1.74	4.5
V-165	2008-09-27T05:52	76.802	176.712	1017.8	-3.97	2.651	-0.6	1.80	4.8
V-166	2008-09-27T11:54	77.538	177.535	1016.8	-3.95	2.597	-1.1	1.78	4.5
V-167	2008-09-27T17:49	77.825	177.827	1015.5	-3.02	2.788	-1.2	1.89	5.4
V-168	2008-09-28T00:10	78.892	178.509	1014.1	-2.3	2.964	-1.6	1.70	5.0
V-169	2008-09-28T05:54	78.025	180.914	1014.6	-2.14	2.98	-1.2	1.78	5.4
V-170	2008-09-28T11:53	77.437	182.501	1014.5	-2.58	2.851	-1	1.77	4.5
V-171	2008-09-28T17:50	76.994	183.172	1014.1	-2.63	2.986	-1.3	1.85	5.5
V-172	2008-09-29T00:08	76.670	185.001	1012.9	-2.08	3.129	-1.1	1.71	5.4
V-173	2008-09-29T05:55	76.618	182.679	1011.4	-1.89	3.143	-1	1.74	5.4
V-174	2008-09-29T11:48	77.002	182.087	1010.1	-2.25	2.962	-1	1.79	5.4
V-175	2008-09-29T17:50	76.495	180.790	1011	-1.92	3.059	-1.2	1.86	5.8
V-176	2008-09-30T00:05	76.151	183.108	1011.1	-1.4	3.194	-1.3	1.78	5.8
V-177	2008-09-30T06:04	75.773	181.116	1012.5	-1.48	2.983	-1	1.73	5.0
V-178	2008-09-30T11:53	75.180	180.719	1013.3	-1.57	2.841	-0.6	1.77	4.8
V-179	2008-09-30T17:48	74.987	183.006	1013.1	-2	2.398	-0.9	1.87	4.5
V-180	2008-10-01T00:04	75.416	185.419	1011.6	-2.42	2.56	-0.7	1.97	5.0

V-181	2008-10-01T06:43	75.996	185.993	1011.6	-2.58	2.526	-1	1.51	3.4
V-182	2008-10-01T11:47	75.640	186.614	1011.9	-2.42	2.382	-0.1	1.79	4.5
V-183	2008-10-01T17:49	74.865	190.884	1010.7	-1.92	2.424	1.9	1.86	4.5
V-184	2008-10-02T00:05	74.377	194.749	1010.2	-1.55	2.345	0.9	1.72	4.0
V-185	2008-10-02T05:52	73.536	195.689	1009.8	-1.73	2.396	0.5	1.76	4.0
V-186	2008-10-02T11:49	73.009	198.154	1008.9	-1.52	2.514	0.8	1.79	4.5
V-187	2008-10-02T17:50	72.698	200.755	1009.6	-1.55	2.19	1.3	1.81	3.6
V-188	2008-10-02T23:55	72.679	202.627	1009.9	-1.7	2.176	1.7	1.76	3.4
V-189	2008-10-03T05:52	72.300	204.304	1009.4	-1.53	2.282	1.2	1.76	3.8
V-190	2008-10-03T11:47	71.800	207.019	1007.6	-1.49	2.464	1.4	1.81	4.5
V-191	2008-10-03T17:50	71.397	207.954	1007.3	-1.84	2.568	0.9	1.86	4.6
V-192	2008-10-04T00:07	71.736	204.831	1008.9	-2.29	2.315	1	1.69	3.8
V-193	2008-10-04T05:49	72.003	201.982	1010.4	-1.99	2.293	0.9	1.79	4.2
V-194	2008-10-04T11:50	71.993	198.504	1010.6	-2	2.432	0.6	1.79	4.5
V-195	2008-10-04T17:49	71.989	195.586	1010.5	-1.56	2.557	2.2	1.86	5.6
V-196	2008-10-05T00:05	71.996	192.191	1009.4	-1.12	2.779	3.2	1.72	4.8
V-197	2008-10-05T05:50	71.225	193.436	1007.9	-1.48	2.874	3.2	1.77	5.0
V-198	2008-10-05T11:48	70.836	192.613	1008.9	-0.87	3.179	3.5	1.81	5.8
V-199	2008-10-05T17:52	70.335	191.169	1009	-0.11	3.306	3.9	1.84	6.0
V-200	2008-10-06T00:03	69.004	191.168	1008.1	0.51	3.328	3.7	1.76	5.8
V-201	2008-10-06T06:00	67.878	191.175	1007.7	0.86	3.169	3.3	1.72	5.2
V-202	2008-10-06T11:47	66.708	191.170	1007	0.62	3.278	3.7	1.79	6.0
V-203	2008-10-06T17:48	65.719	191.668	1006.8	1.22	3.028	3.9	1.86	6.0
V-204	2008-10-07T00:12	65.242	191.408	1008.2	0.82	3.308	3.7	1.68	5.5
V-205	2008-10-07T05:50	63.859	192.031	1009	1.22	3.283	4.5	1.77	5.6
V-206	2008-10-07T11:47	62.398	192.654	1011.1	1.55	2.83	5.7	1.79	5.0
V-207	2008-10-07T17:48	61.129	192.364	1014.7	2.17	2.566	7.6	1.80	4.8
V-208	2008-10-07T23:52	59.968	192.085	1016.8	2.47	2.944	7.3	1.76	5.2
V-209	2008-10-08T05:47	58.796	192.357	1017.3	3.2	2.285	5.4	1.82	4.5
V-210	2008-10-08T11:54	57.720	192.642	1012.9	4.65	3.343	6.6	1.75	6.0
V-211	2008-10-08T17:55	56.795	192.851	1004.3	6.31	5.114	7.3	1.72	8.5
V-212	2008-10-08T23:47	55.880	193.070	992.3	7.79	6.342	-99	1.88	12.0
V-213	2008-10-09T06:04	54.960	193.281	975.6	8.52	6.601	-99	1.71	12.0

Table 4.3-2 Summary of precipitation sampling for isotope analysis.

NO	DATE and TIME	Start Position		DATE and TIME	End Position		Meteorological data			Collection	
		Lon. E	Lat. N		Lon. E	Lat. N	T	RH	Pr	Vol	Flg
	YY-MM-DDTHH:MM	(deg.)	(deg.)	YY-MM-DDTHH:MM	(deg.)	(deg.)	(℃)	(%)	(mm/h)	(ml)	(S/R)
P-01	08-08-21T21:00	52.584	170.598	08-08-22T00:02	52.976	171.336	11.26	83.87	0	2.5	R
P-02	08-08-30T18:00	70.999	200.044	08-08-30T19:00	71.077	200.611	2.42	97.44	0.08	1.0	R
P-03	08-09-01T09:20	73.400	208.003	08-09-01T13:40	73.403	207.999	0.58	89.9	0.24		
P-04	08-09-02T18:00	74.928	200.775	08-09-02T22:36	74.808	201.468	2.18	89.71	0.4		
P-05	08-09-03T11:00	76.322	203.855	08-09-03T14:00	76.749	204.584	-0.65	91.86	0.57	4.0	S
P-06	08-09-03T11:00	76.322	203.855	08-09-03T14:00	76.749	204.584	-0.65	91.86	0.57		S
P-07	08-09-04T11:00	76.809	205.014	08-09-04T13:46	76.829	204.981	-3.67	97.47	0.34	22.0	S
P-08	08-09-04T13:46	76.829	204.981	08-09-05T00:20	76.878	206.242	-3.82	97.15	2.4	4.8	S
P-09	08-09-05T00:20	76.878	206.242	08-09-05T05:20	76.599	207.659	-3.33	97.63	0.97	6.0	S
P-10	08-09-05T05:20	76.599	207.659	08-09-05T11:30	76.117	208.915	-3.43	97.45	1.28	11.0	S
P-11	08-09-05T11:33	76.113	208.952	08-09-05T18:04	75.749	211.251	-4.09	96.82	1.16	4.5	S
P-12	08-09-05T18:04	75.749	211.251	08-09-06T00:04	75.482	212.532	-3.88	94.99	0.76	1.0	S
P-13	08-09-06T00:04	75.482	212.532	08-09-06T05:49	75.02	214.909	-3.84	93.86	0.68	6.4	S
P-14	08-09-06T05:49	75.020	214.909	08-09-06T11:38	74.5	215.005	-3.07	92.65	0.7	21.0	S
P-15	08-09-06T11:38	74.500	215.005	08-09-06T16:47	74.001	215.013	-1.97	91.35	0.53	5.5	S
P-16	08-09-09T06:00	72.246	207.990	08-09-09T07:30	72.313	207.472	2.73	94.93	0.26	2.0	R
P-17	08-09-09T12:00	71.809	205.464	08-09-09T18:10	71.804	204.664	1.86	91.19	0.25		R
P-18	08-09-10T02:00	71.735	204.824	08-09-10T05:56	72.215	205.046	0.61	95.04	0.66		R
P-19	08-09-10T18:00	73.136	203.522	08-09-11T00:13	73.503	201.906	1.92	88.57	0.63	2.6	R
P-20	08-09-11T00:13	73.503	201.906	08-09-11T06:00	73.999	200	1.02	88.47	1.11		R
P-21	08-09-11T06:00	73.999	200.000	08-09-11T07:46	74.074	199.688	0.98	83.49	0.33		R
P-22	08-09-11T06:00	73.999	200.000	08-09-11T07:46	74.074	199.688	0.98	83.49	0.33		S
P-23	08-09-12T00:04	74.605	201.954	08-09-12T06:00	75.081	199.681	0.68	87.44	2.99	28.0	S
P-24	08-09-12T07:00	75.167	199.332	08-09-12T09:10	75.251	198.972	-0.48	93.4	0.27	20.0	S
P-25	08-09-12T11:50	75.501	198.000	08-09-12T13:50	75.616	197.539	-1.09	84.57	0.27	1.0	S
P-26	08-09-12T16:50	75.756	196.966	08-09-12T18:10	75.912	196.347	-0.61	86.89	0.2	10.0	S
P-27	08-09-12T18:10	75.912	196.347	08-09-13T00:20	76.259	195.032	-1.72	83.98	0.95	1.0	S
P-28	08-09-13T00:20	76.259	195.032	08-09-13T05:55	76.429	195.133	-2.26	84.38	0.63		S
P-29	08-09-13T05:55	76.429	195.133	08-09-13T11:58	76.243	197.857	-2.56	88.6	1	65.0	S
P-30	08-09-13T11:58	76.243	197.857	08-09-13T13:33	76.24	197.871	-2.51	92.61	0.42	72.0	S
P-31	08-09-13T13:33	76.240	197.871	08-09-13T14:41	76.24	197.89	-2.56	92.59	0.27	44.0	S
P-32	08-09-13T14:41	76.240	197.890	08-09-13T17:40	76.715	198.557	-2.36	89.66	0.62	20.0	S
P-33	08-09-13T17:40	76.715	198.557	08-09-13T22:50	77.522	198.989	-3.97	91.13	0.68	1.0	S
P-34	08-09-13T22:50	77.522	198.989	08-09-14T09:34	76.622	198.925	-2.97	90.93	1.3		S
P-35	08-09-14T09:34	76.622	198.925	08-09-14T17:14	76.613	197.207	-0.54	90.78	2.14		S
P-36	08-09-14T17:14	76.613	197.207	08-09-15T00:15	76.642	191.894	0.22	91.59	3.3		R
P-37	08-09-14T17:14	76.613	197.207	08-09-15T00:15	76.642	191.894	0.22	91.59	3.3	7.0	R
P-38	08-09-15T18:00	77.728	194.466	08-09-15T23:15	77.738	195.141	-0.95	92.06	0.62	28.0	S
P-39	08-09-15T23:13	77.738	195.140	08-09-16T06:15	76.947	194.598	-0.23	88.27	4.07	5.0	S
P-40	08-09-17T00:02	75.849	202.009	08-09-17T05:55	75.503	201.499	0.59	82.68	2.4	2.0	S
P-41	08-09-18T06:00	74.500	195.501	08-09-18T11:40	74.225	193.875	1.24	82.04	0.25	3.0	S

P-42	08-09-18T17:46	73.977	192.413	08-09-19T00:15	74.614	192.853	1.42	87.67	0.8	5.5	S
P-43	08-09-19T00:15	74.614	192.853	08-09-19T05:36	75.03	192.581	0.78	88.49	0.79	1.0	S
P-44	08-09-19T05:36	75.030	192.581	08-09-19T11:41	75.656	193.455	0.09	88.17	4.85	10.0	S
P-45	08-09-19T11:41	75.656	193.455	08-09-19T17:41	75.634	189.564	-0.47	89.04	0.69	2.0	S
P-46	08-09-20T10:30	74.751	188.983	08-09-20T11:30	74.747	188.618	0.03	93.61	0.34	38.0	S
P-47	08-09-20T11:50	74.748	188.359	08-09-20T13:40	74.753	187.97	-0.49	93.97	0.28	3.6	S
P-48	08-09-20T13:40	74.753	187.970	08-09-20T17:43	74.806	185.952	-1.29	92.88	0.55	3.6	S
P-49	08-09-20T17:43	74.806	185.952	08-09-20T23:40	75.069	185.24	-2.51	92.71	1.87	3.8	S
P-50	08-09-20T23:40	75.069	185.240	08-09-21T06:00	75.418	187.931	-2.56	91.75	2.21	1.0	S
P-51	08-09-21T12:00	74.764	187.281	08-09-21T18:00	74.952	183.078	-3.23	96.41	1	6.0	S
P-52	08-09-21T18:00	74.952	183.078	08-09-22T00:15	75.004	184.991	-3.97	94.39	1.94	7.0	S
P-53	08-09-22T00:15	75.004	184.991	08-09-22T05:55	75.002	187	-3.58	92.87	1.08	3.2	S
P-54	08-09-22T05:55	75.002	187.000	08-09-22T11:40	75.003	189.978	-3.42	92.71	2.17	18.0	S
P-55	08-09-22T11:40	75.003	189.978	08-09-22T17:40	75.002	193.494	-2.76	89.99	2.59	16.0	S
P-56	08-09-22T17:40	75.002	193.494	08-09-23T00:10	75.014	195.954	0.17	85.13	0.96	6.0	S
P-57	08-09-23T00:35	74.953	196.101	08-09-23T01:10	74.851	196.301	0.18	91.73	0.08	12.0	S
P-58	08-09-23T05:52	74.503	196.981	08-09-23T11:45	73.826	197.159	0.46	86.39	0.15	19.0	S
P-59	08-09-23T11:45	73.826	197.159	08-09-23T17:15	73.154	197.674	0.5	84.95	0.05	1.0	S
P-60	08-09-23T17:15	73.154	197.674	08-09-24T00:35	73.531	200.157	0.16	85.46	0.6	8.0	S
P-61	08-09-24T00:35	73.531	200.157	08-09-24T06:10	73.314	199.82	0.48	92.38	0.25	25.0	S
P-62	08-09-24T06:10	73.314	199.820	08-09-24T11:10	73.737	199.345	0.91	89.62	0.24	10.0	S
P-63	08-09-24T11:10	73.737	199.345	08-09-24T13:26	74.012	198.502	0.52	92.56	0.15	14.0	S
P-64	08-09-24T13:26	74.012	198.502	08-09-24T16:10	73.965	198.425	0.49	92.4	0.26	32.0	S
P-65	08-09-24T16:10	73.965	198.425	08-09-24T17:35	73.964	198.424	0.38	92.72	0.17	30.0	S
P-66	08-09-24T17:35	73.964	198.424	08-09-25T00:20	73.774	196.745	0.32	90.57	0.25	30.0	S
P-67	08-09-25T17:00	74.998	183.990	08-09-25T17:55	74.985	183.334	-2.46	93.6	0.2	3.0	S
P-68	08-09-25T17:55	74.985	183.334	08-09-26T00:01	75	180.274	-2.43	88.91	1.27	3.7	S
P-69	08-09-26T00:01	75.000	180.274	08-09-26T05:58	74.999	177.768	-2.17	84.91	0.62	0.3	S
P-70	08-09-26T14:00	75.002	174.998	08-09-26T17:40	75.361	175.442	-3.32	91.28	0.66	14.0	S
P-71	08-09-26T18:00	75.428	175.489	08-09-27T00:00	76.061	176.051	-3.51	91.9	0.91	30.0	S
P-72	08-09-27T00:00	76.061	176.051	08-09-27T05:48	76.789	176.698	-3.58	90.74	0.93	36.0	S
P-73	08-09-27T05:48	76.789	176.698	08-09-27T11:45	77.51	177.5	-3.96	94.68	0.8	12.0	S
P-74	08-09-27T11:45	77.510	177.500	08-09-27T17:40	77.795	177.797	-3.96	92.58	0.8	26.0	S
P-75	08-09-27T17:40	77.795	177.797	08-09-28T00:10	78.892	178.509	-3.03	92.58	0.71	30.0	S
P-76	08-09-28T06:00	78.008	180.973	08-09-28T11:45	77.463	182.523	-2.14	92.61	0.66	6.8	S
P-77	08-09-28T11:45	77.463	182.523	08-09-28T13:40	77.323	182.424	-2.34	90.32	0.28	11.2	S
P-78	08-09-28T13:40	77.323	182.424	08-09-28T17:50	76.994	183.172	-2.68	92.03	0.52	10.0	S
P-79	08-09-28T17:50	76.994	183.172	08-09-29T00:00	76.669	184.999	-2.63	96.13	0.77	16.0	S
P-80	08-09-29T06:00	76.617	182.680	08-09-29T09:00	76.653	181.715	-1.87	96.05	0.42	6.6	S
P-81	08-09-29T11:48	77.002	182.087	08-09-29T17:50	76.495	180.79	-2.25	92.36	1.26	1.0	S
P-82	08-09-30T06:00	75.785	181.142	08-09-30T07:25	75.568	180.665	-1.42	95.22	1.68	22.0	S
P-83	08-09-30T07:25	75.568	180.665	08-09-30T11:50	75.186	180.69	-1.5	85.9	0.57	20.0	S
P-84	08-09-30T11:50	75.186	180.690	08-09-30T17:40	74.984	182.898	-1.56	84.49	1.45	74.0	S
P-85	08-09-30T20:30	74.934	184.000	08-10-01T00:00	75.414	185.419	-2.04	75.49	0.61	0.5	S
P-86	08-10-01T00:00	75.414	185.419	08-10-01T06:50	75.995	185.994	-2.43	81.04	1.56	7.4	S
P-87	08-10-01T17:48	74.867	190.870	08-10-02T00:00	74.377	194.75	-1.93	73.87	7.02	3.0	S

P-88	08-10-02T00:00	74.377	194.750	08-10-02T06:00	73.526	195.777	-1.55	69.65	0.73	18.0	S
P-89	08-10-02T06:00	73.526	195.777	08-10-02T07:20	73.429	196.291	-2.28	81.69	4.62	220.0	S
P-90	08-10-02T11:50	73.006	198.162	08-10-02T15:45	72.551	200.003	-1.54	75.5	4.2	38.0	S
P-91	08-10-02T15:45	72.551	200.003	08-10-02T17:45	72.698	200.752	-1.47	71.77	0.25	3.0	S
P-92	08-10-02T17:45	72.698	200.752	08-10-03T00:00	72.694	202.663	-1.56	65.09	3.75	15.0	S
P-93	08-10-03T00:00	72.694	202.663	08-10-03T06:00	72.284	204.372	-1.69	65.35	4.62	72.0	S
P-94	08-10-03T06:00	72.284	204.372	08-10-03T11:30	71.8	207.02	-1.54	67.21	4.18	2.0	S
P-95	08-10-03T11:30	71.800	207.020	08-10-03T13:30	71.632	207.74	-1.57	74.4	1.49	10.0	S
P-96	08-10-03T13:30	71.632	207.740	08-10-03T17:50	71.397	207.954	-1.46	71.72	0.77	5.4	S
P-97	08-10-04T06:00	72.002	201.870	08-10-04T11:35	71.991	198.692	-1.99	70.23	0.71	22.0	S
P-98	08-10-04T11:35	71.991	198.692	08-10-04T13:16	72.004	197.978	-1.94	70.09	0.27	6.4	S
P-99	08-10-04T13:16	72.004	197.978	08-10-04T17:06	72.003	195.994	-1.97	74.65	1.17	20.0	S
P-100	08-10-04T17:06	72.003	195.994	08-10-05T00:00	71.995	192.251	-1.63	76.59	2.26	3.5	S
P-101	08-10-05T00:00	71.995	192.251	08-10-05T05:00	71.311	193.277	-1.06	78.49	9.03	20.0	S
P-102	08-10-05T05:50	71.225	193.436	08-10-05T11:30	70.835	192.665	-1.5	84.46	4.15	24.0	S
P-103	08-10-05T11:30	70.835	192.665	08-10-05T14:00	70.832	191.657	-0.8	85.25	0.65	42.0	S
P-104	08-10-05T14:00	70.832	191.657	08-10-05T16:50	70.499	191.166	-0.94	91.13	7.82	278.0	S
P-105	08-10-05T16:50	70.499	191.166	08-10-05T17:50	70.344	191.169	-0.89	93.46	0.19	40.0	S
P-106	08-10-05T17:50	70.344	191.169	08-10-05T20:35	69.773	191.161	-0.26	88.33	0.71	90.0	S
P-107	08-10-05T20:35	69.773	191.161	08-10-06T00:00	69.012	191.168	0	87.74	1.01	148.0	S
P-108	08-10-06T00:00	69.012	191.168	08-10-06T06:00	67.878	191.175	0.51	84.55	3.87	69.0	S
P-109	08-10-06T12:00	66.655	191.168	08-10-06T18:00	65.718	191.665	0.62	82.31	2.51	164.0	S
P-110	08-10-07T00:00	65.292	191.425	08-10-07T06:00	63.818	192.058	0.84	81.73	1.36	142.0	S
P-111	08-10-07T06:00	63.818	192.058	08-10-07T12:00	62.343	192.653	1.23	79.56	0.34	280.0	S
P-112	08-10-07T12:00	62.343	192.653	08-10-07T18:00	61.09	192.347	1.59	65.95	0.85	30.0	S
P-113	08-10-08T18:00	56.784	192.854	08-10-08T23:59	55.849	193.077	6.35	86.3	4.85	10.0	S
P-114	08-10-09T00:00	55.843	193.078	08-10-09T06:00	54.964	193.28	7.81	94.74	6.77	8.8	R

* Meteorological data is calculated by SOAR data.

4.4. Surface Meteorological Measurement

(1) Personnel

Kunio Yoneyama (JAMSTEC) : Principal Investigator (not on board)
Shinya Okumura (Global Ocean Development Inc., GODI)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Harumi Ota (GODI)

(2) Objectives

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

(2) Methods

Surface meteorological parameters were observed throughout the MR08-04 cruise. During this cruise, we used three systems for the observation.

i. MIRAI Surface Meteorological observation (SMet) system

ii. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

i. MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.4.4-1 and measured parameters are listed in Table.4.4-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

ii. Shipboard Oceanographic and Atmospheric Radiation (SOAR) measurement system

SOAR system designed by BNL (Brookhaven National Laboratory, USA) consists of major three parts.

a) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
b) Zeno Meteorological (Zeno/Met) system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.
c) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets.

SCS recorded PRP data every 6 seconds, while Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table.4.4-3 and measured parameters are listed in Table.4.4-4.

For the quality control as post processing, we checked the following sensors, before and after the cruise.

i. Young Rain gauge (SMet and SOAR)

Inspect of the linearity of output value from the rain gauge sensor to change Input value by adding fixed quantity of test water.

ii. Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB220CASE, VAISALA.

iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)

Comparison with the portable thermometer value, HMP41/45, VAISALA.

(3) Preliminary results

Figure 4.4-1 shows the time series of the following parameters;

Wind (SOAR)
Air temperature (SOAR)
Relative humidity (SOAR)
Precipitation (SMet, Optical rain gauge)
Short/long wave radiation (SOAR)
Pressure (SOAR)
Sea surface temperature (SMet)
Significant wave height (SMet)

(4) Data archives

These meteorological data will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC just after the cruise. Corrected data sets will be available from K. Yoneyama of JAMSTEC.

(5) Remarks

i. SST (Sea Surface Temperature) data was available in the following periods.

23:03UTC 16 Aug. 2008 – 06:00UTC 29 Jun. 2008
22:30UTC 26 Aug. 2008 – 00:00UTC 09 Oct 2008

ii. In the following period, FRSR data acquisition was suspended to prevent damage to the shadow-band from freezing.

08:09UTC 30 Aug. 2008 – 16:01UTC 08 Oct 2008

iii. SMet Tair/RH sensor probe of Starboard side was replaced at 00:16UTC 13 Sep 2008, because Tair sensor had showed a significant difference compared to the Port side sensor when relative humidity was high. We confirmed that Starboard side sensor showed low value by comparing with another portable sensor. Thus, we deduced a correction scheme by comparing this sensor with newly replaced sensor (we set old one 1 m below the new one) from September 15 to October 1. As a result, corrected temperature data was obtained from the following equation.

$$T_{corrected} = T_{raw} - 7.2544 + 0.32228 \cdot RH - 0.0047358 \cdot RH^2 + 2.3206E\text{-}05 \cdot RH^3, \quad RH \geq 72\%,$$

$$T_{corrected} = T_{raw} - 0.09062 + 0.0021222 \cdot RH, \quad RH < 72\%$$

where $T_{corrected}$ and T_{raw} are corrected and raw temperature, RH is relative humidity in %.

Table.4.4-1 Instruments and installations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m)
			starboard side and port side
Thermometer: SST	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	AP370	Koshin Denki, Japan	captain deck (13 m)
			weather observation room
Rain gauge	50202	R. M. Young, USA	compass deck (19 m)
Optical rain gauge	ORG-815DR	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-200	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table.4.4-2 Parameters of MIRAI Surface Meteorological observation system

Parameter		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	6sec./10min. averaged
6	Relative wind direction	degree	6sec./10min. averaged
7	True wind speed	m/s	6sec./10min. averaged
8	True wind direction	degree	6sec./10min. averaged
9	Barometric pressure	hPa	adjusted to sea surface level
			6sec. averaged
10	Air temperature (starboard side)	degC	6sec. averaged
11	Air temperature (port side)	degC	6sec. averaged
12	Dewpoint temperature (starboard side)	degC	6sec. averaged
13	Dewpoint temperature (port side)	degC	6sec. averaged

14	Relative humidity (starboard side)	%	6sec. averaged
15	Relative humidity (port side)	%	6sec. averaged
16	Sea surface temperature	degC	6sec. averaged
17	Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18	Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19	Down welling shortwave radiation	W/m2	6sec. averaged
20	Down welling infra-red radiation	W/m2	6sec. averaged
21	Significant wave height (bow)	m	hourly
22	Significant wave height (aft)	m	hourly
23	Significant wave period (bow)	second	hourly
24	Significant wave period (aft)	second	hourly

Table.4.4-3 Instruments and installation locations of SOAR system

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Barometer	61202V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (22 m)
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-815DA	Osi, USA	foremast (24 m)

Sensors (PRP)	Type	Manufacturer	Location (altitude from surface)
Radiometer (short wave)	PSP	Epply Labs, USA	foremast (24 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (24m)

Table.4.4-4 Parameters of SOAR system

Parameter		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 50 mm
12	Down welling shortwave radiation	W/m2	
13	Down welling infra-red radiation	W/m2	
14	Defuse irradiance	W/m2	

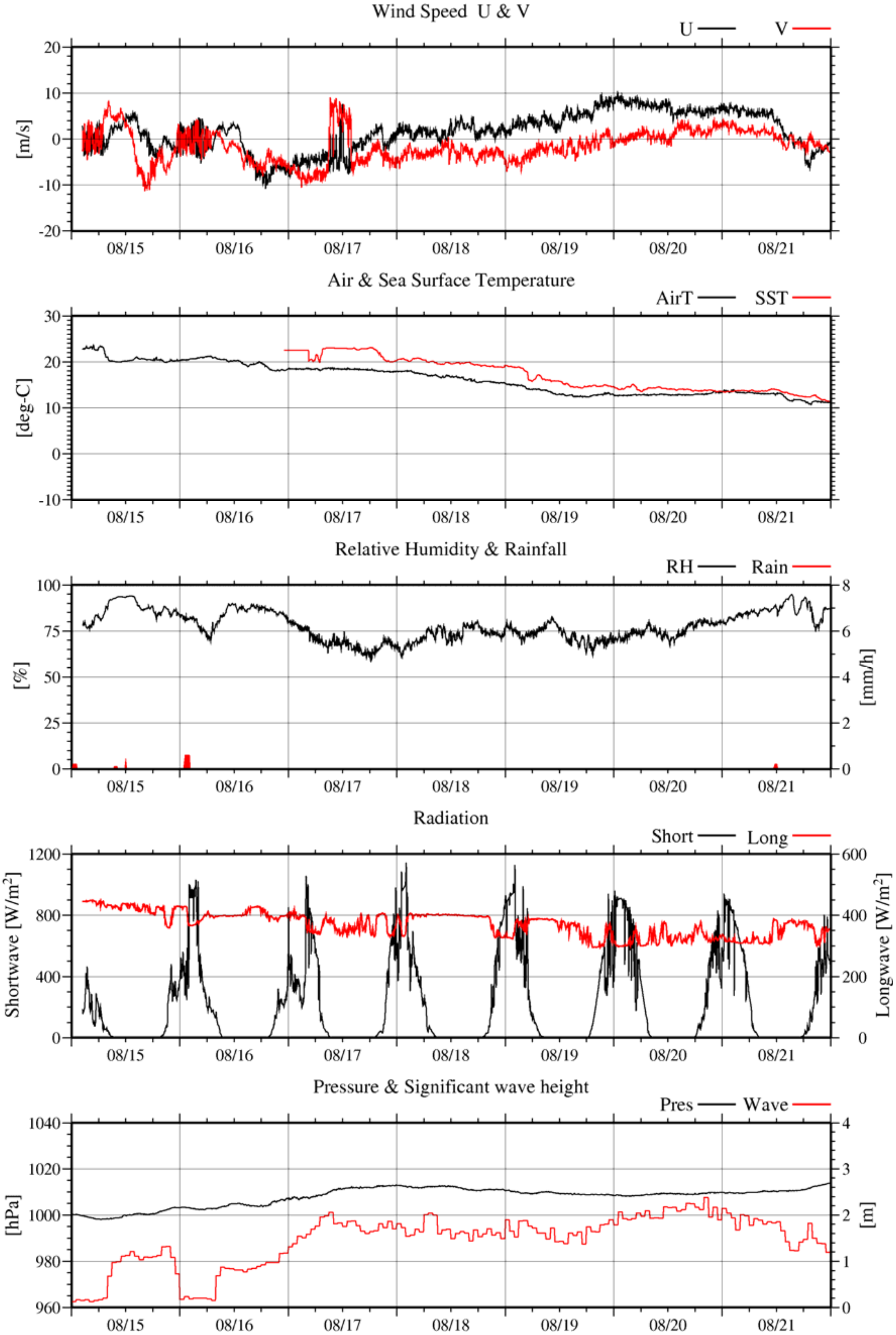


Fig.4.4-1 Time series of surface meteorological parameters during the MR08-04 cruise

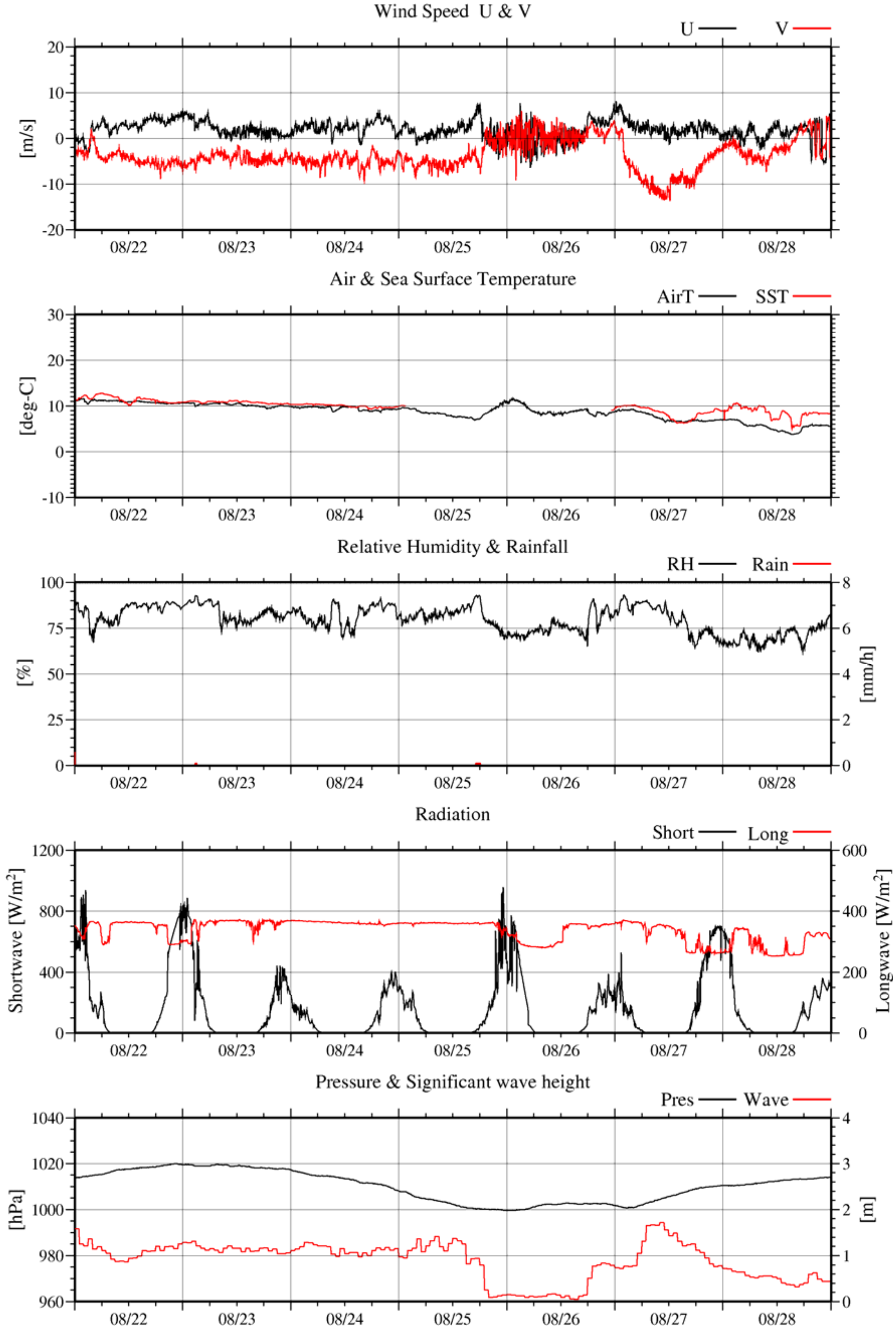


Fig. 4.4.1 (Continued)

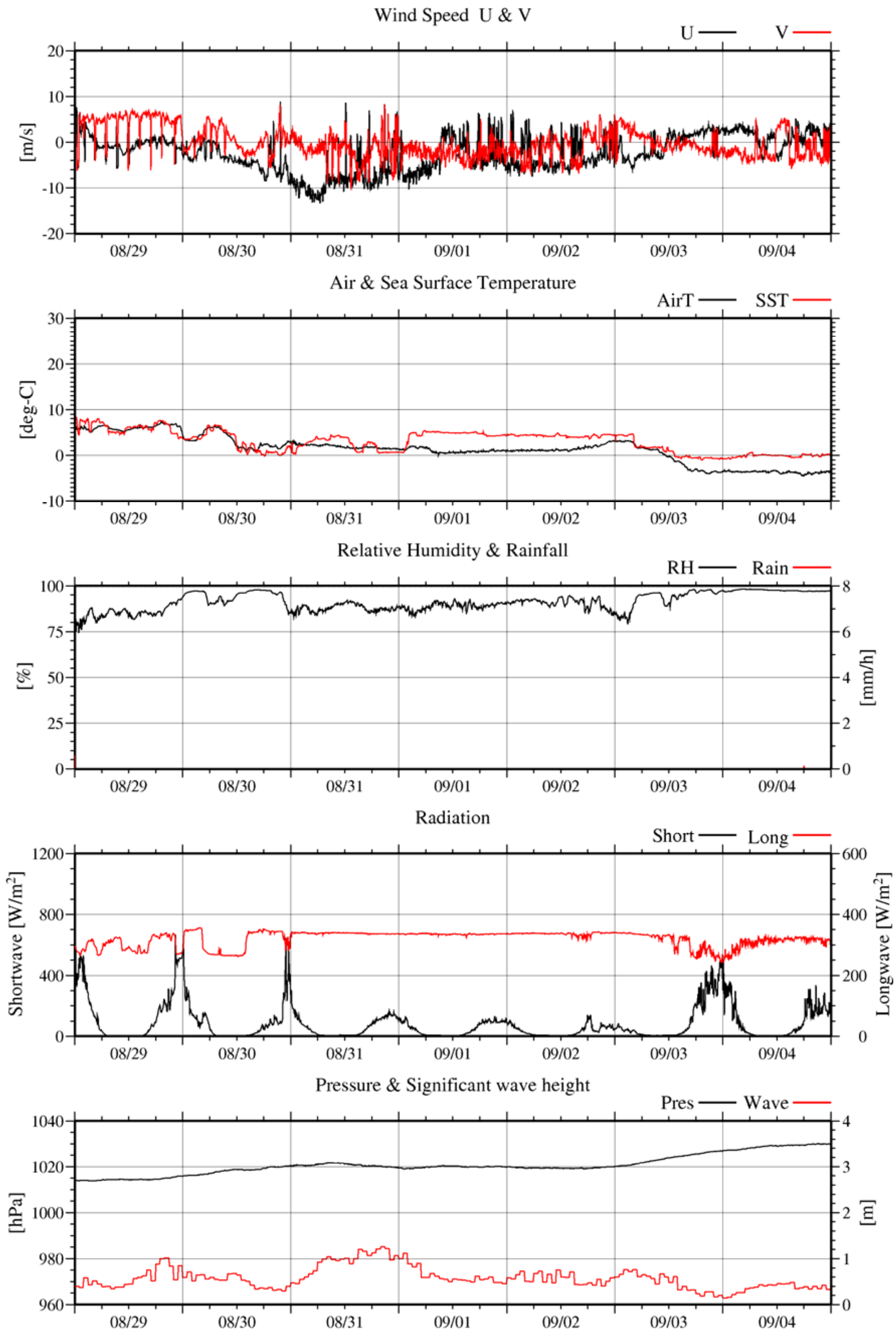
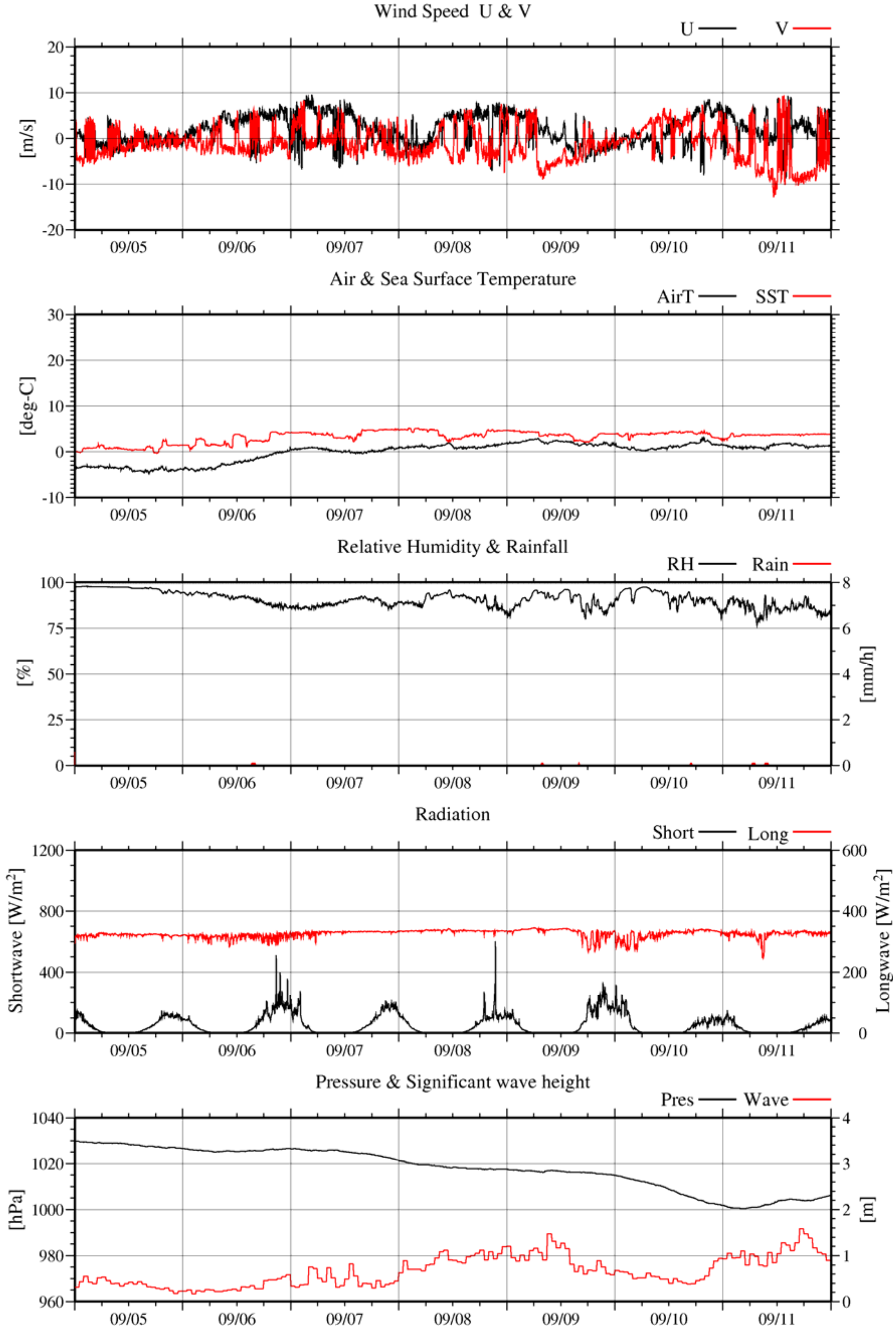


Fig. 4.4.1 (Continued)



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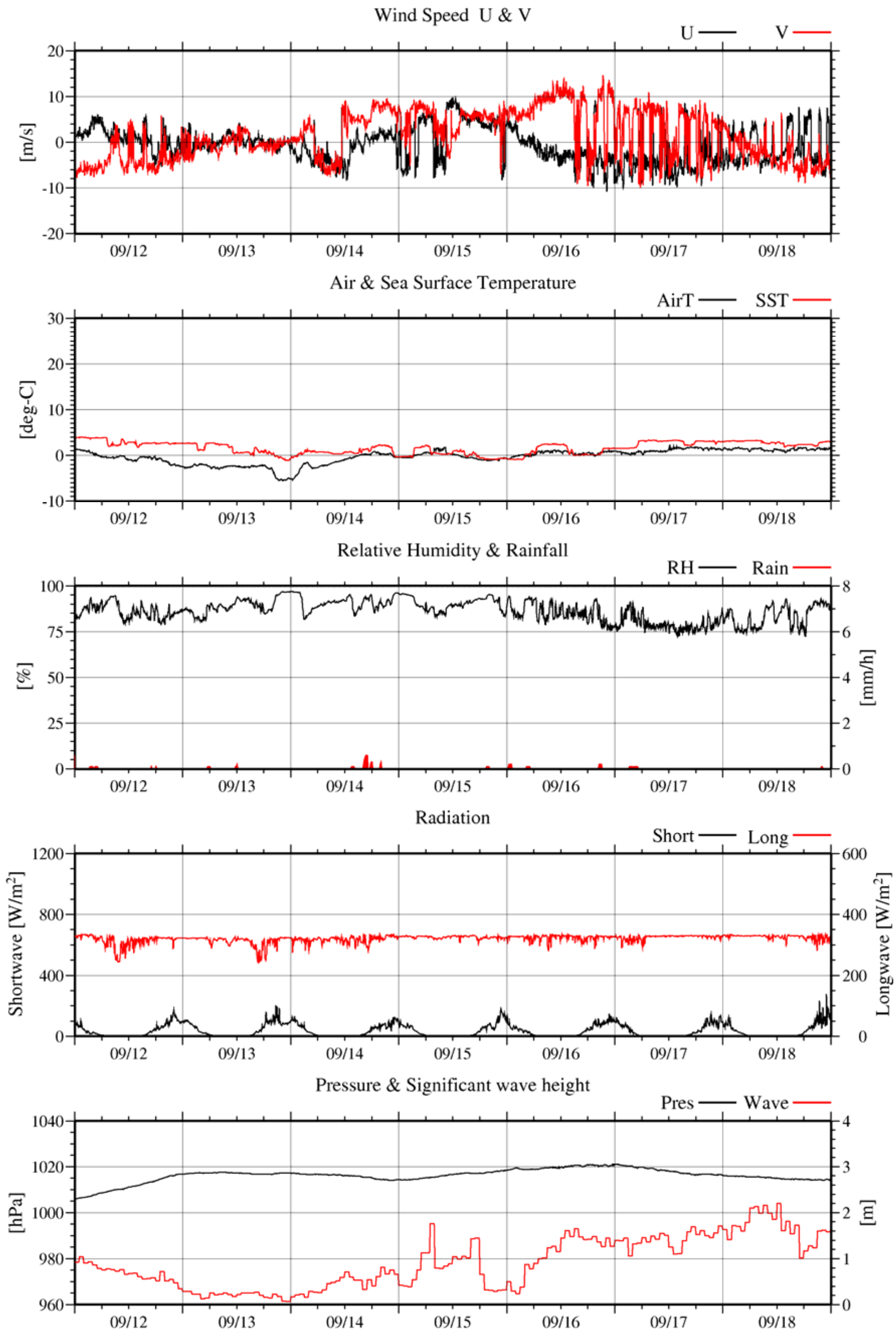


Fig. 4.4.1 (Continued)

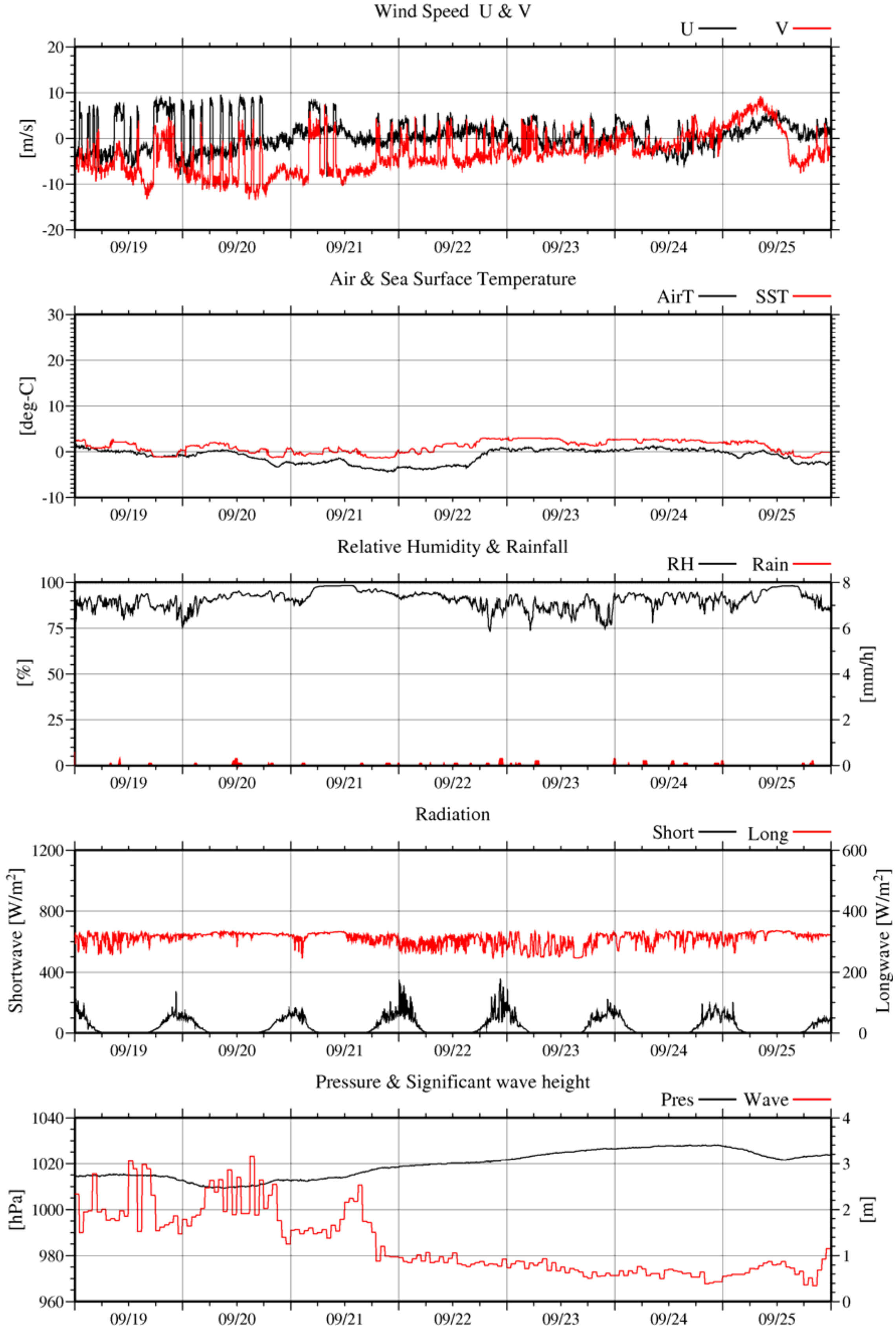


Fig. 4.4.1 (Continued)

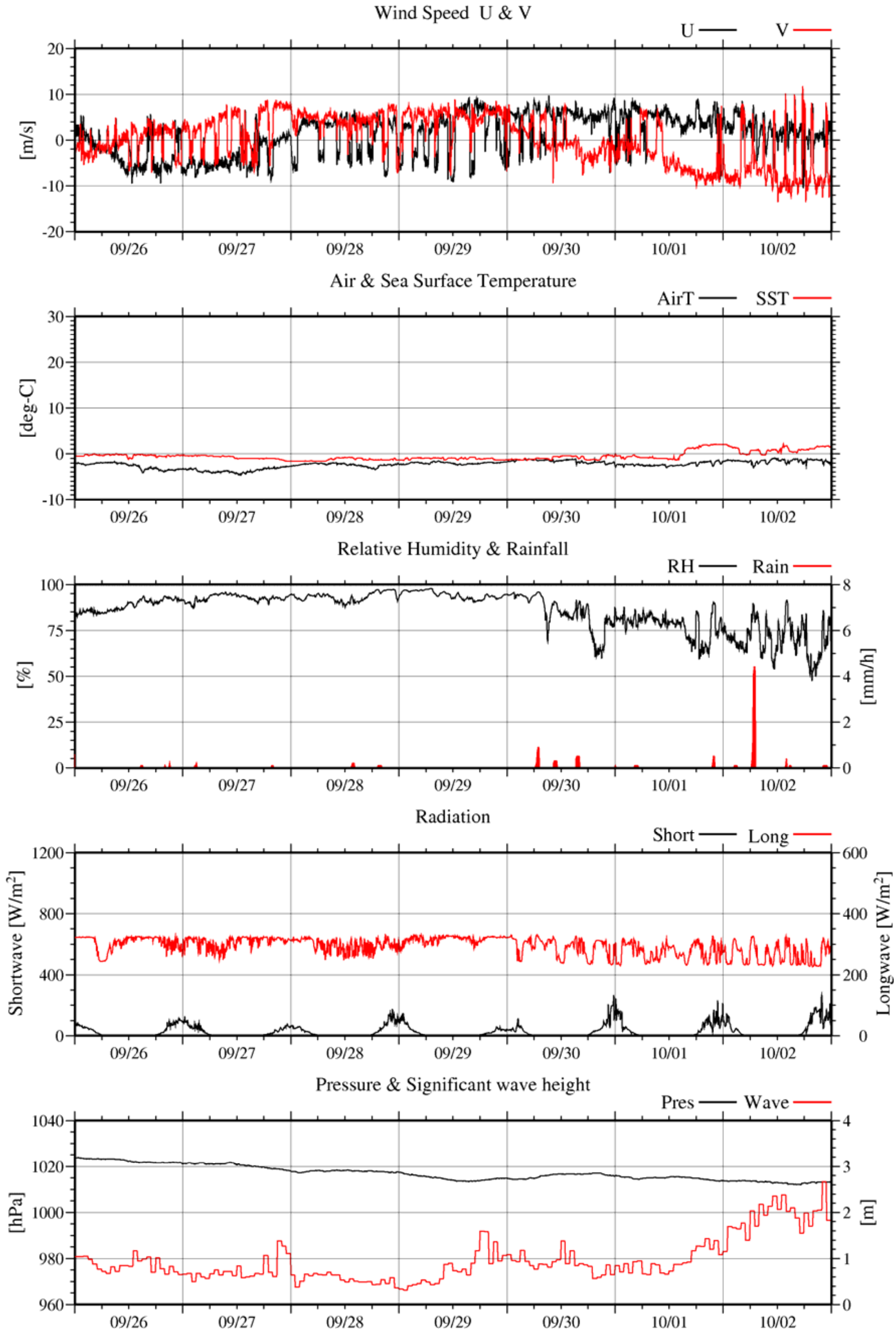


Fig. 4.4.1 (Continued)

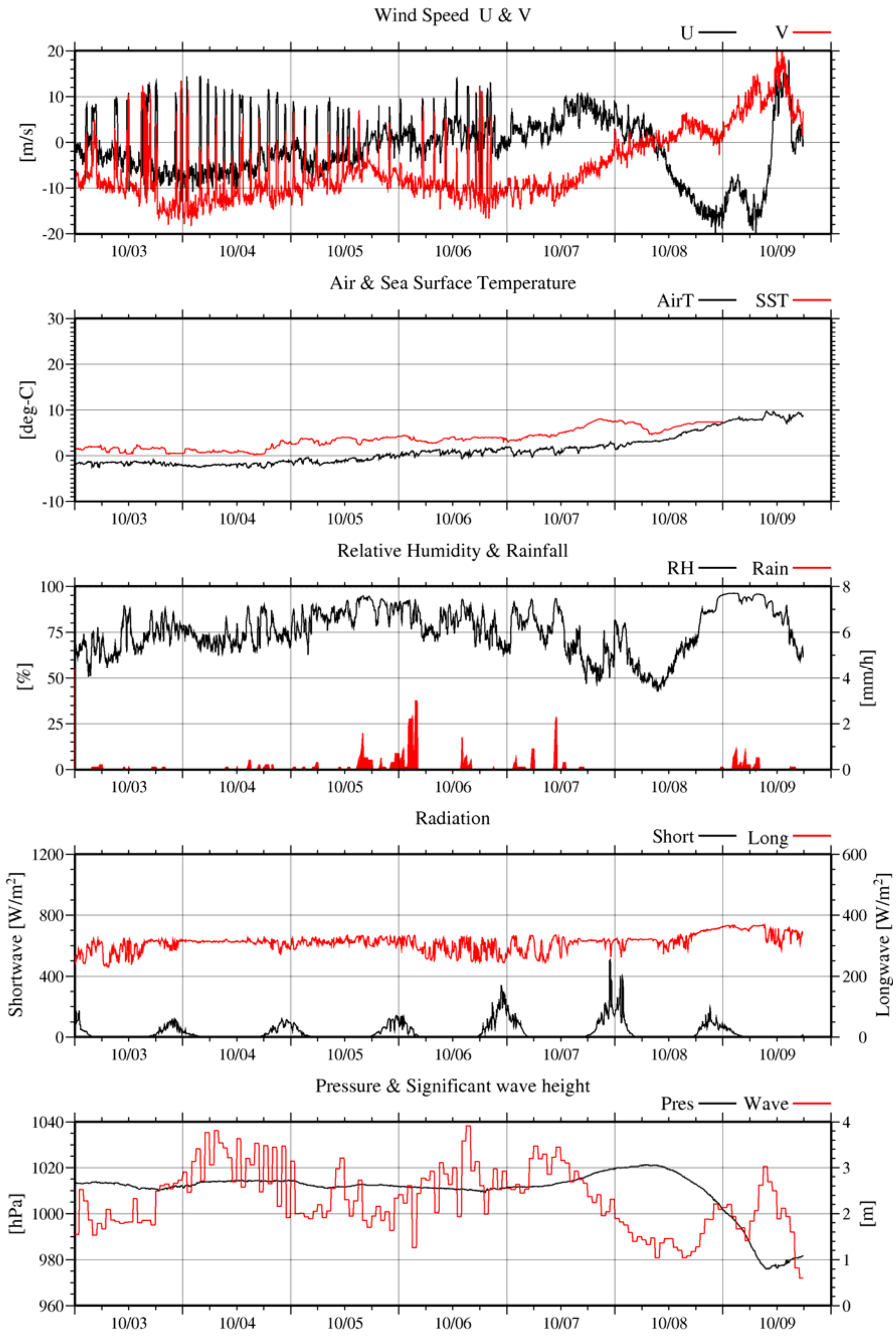


Fig. 4.4.1 (Continued)

4.5. Ceilometer

(1) Personnel

Kunio Yoneyama (JAMSTEC) : Principal Investigator (Not on-board)
Shinya Okumura (Global Ocean Development Inc., GODI)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Harumi Ota (GODI)

(2) Objectives

The information of cloud base height and the liquid water amount around cloud base is important to understand the process on formation of the cloud. As one of the methods to measure them, the ceilometer observation was carried out.

(2) Parameters

1. Cloud base height [m].
2. Backscatter profile, sensitivity and range normalized at 30 m resolution.
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR08-04 cruise from the departure of Sekinehama on 15 August 2008 to arrival of Dutch Harbor on 09 October 2008.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wavelength:	905±5 nm at 25 degC
Transmitting average power:	8.9 mW
Repetition rate:	5.57 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
Sky Condition	0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility)
	(0:Sky Clear, 1:Few, 3:Scattered, 5-7:Broken, 8:Overcast)

On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 30 m (100 ft).

(4) Preliminary results

Figure 4.5-1 shows the time series of the lowest, second and third cloud base height during this cruise.

(5) Data archives

The raw data obtained during this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) in JAMSTEC.

(6) Remarks

1. Window cleaning;
   01:03UTC 16 Aug. 2008
   03:15UTC 06 Sep. 2008
   23:33UTC 12 Sep. 2008

02:38UTC 06 Oct. 2008

2. We did not collect data near the boundary of the EEZ of Russia in the following period.
   19:32UTC 25 Sep. 2008□20:40UTC 25 Sep. 2008

3. Data acquisition was suspended because of PC reboot in the following period.
   00:41UTC 26 Sep. 2008□00:47UTC 26 Sep. 2008

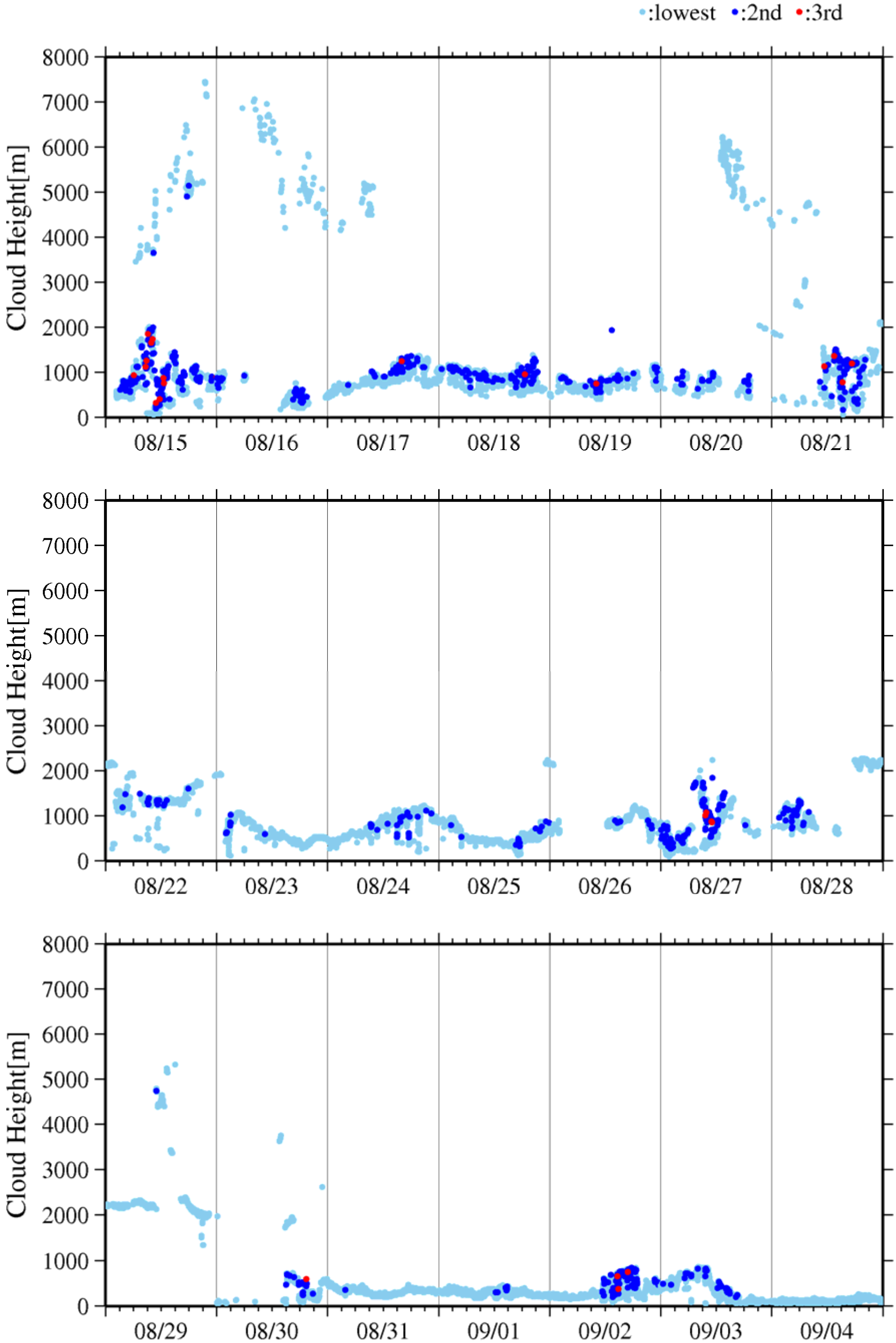


Fig.4.5-1 Lowest, 2nd and 3rd cloud base height during the cruise.

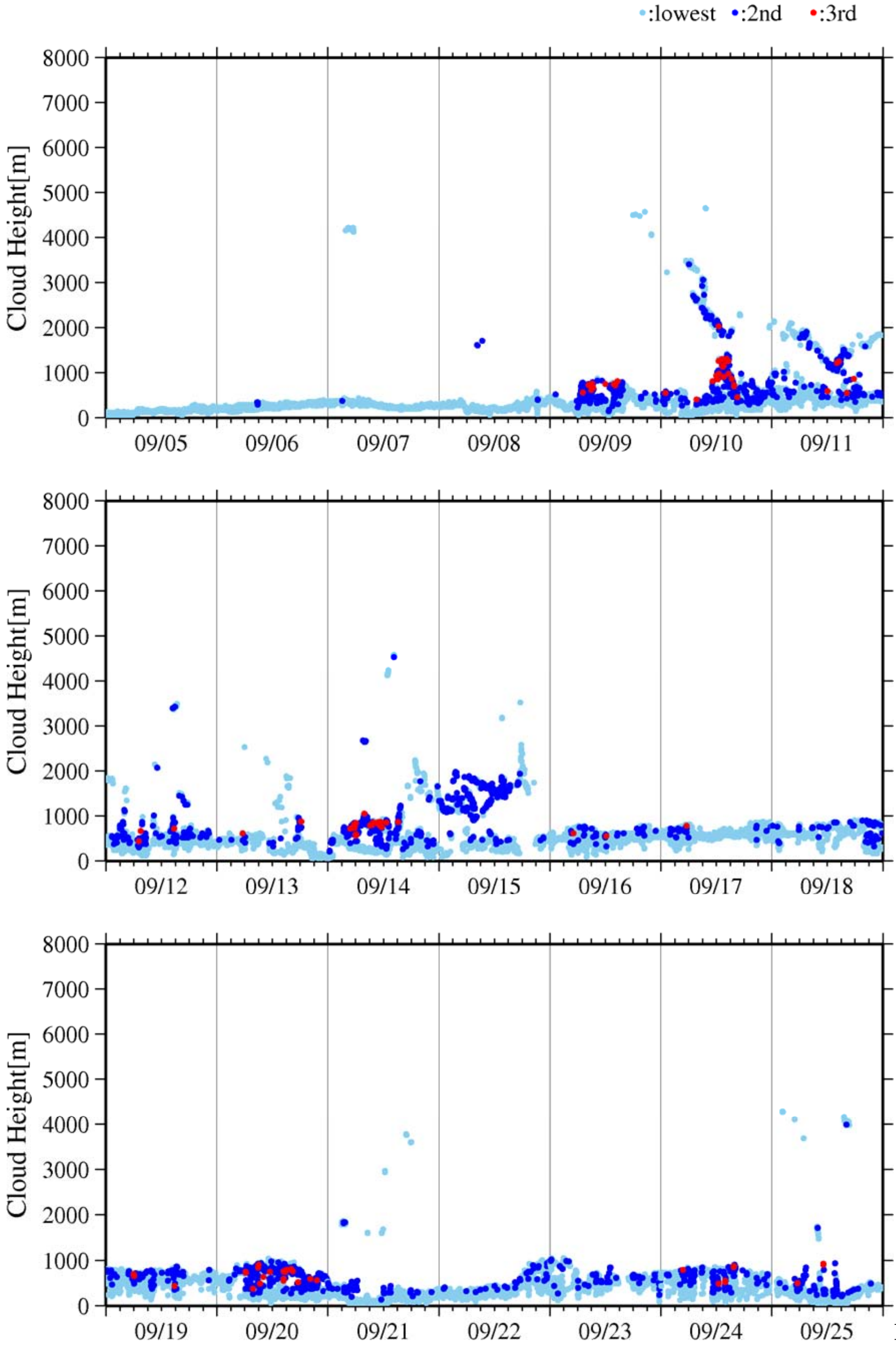


Fig.4.

5-1 (Continued)

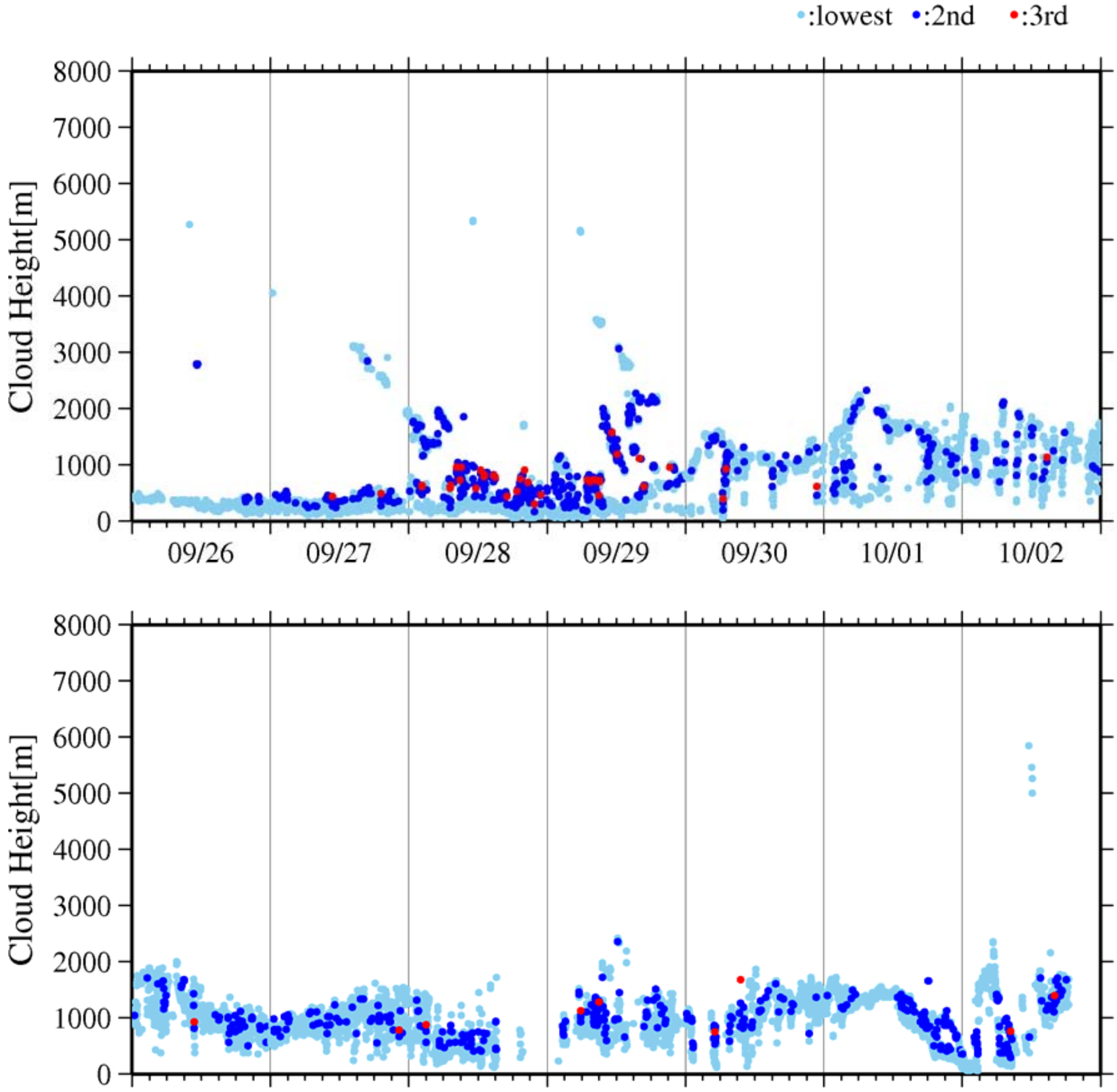


Fig.4. 5-1 (Continued)

4.6. 95GHz Cloud Profiling Radar (operated by T.Takano et al., Chiba Univ.)

(1) Personnel

TAKANO Toshiaki (Chiba University): Principal Investigator
ABE Eiji (Chiba University) : Student, Doctor Course 2
YAMAGUCHI Jun (Chiba University) : Student, Doctor Course 2
OKAMOTO Hajime (Tohoku University)
SUGIMOTO Nobuo (National Institute for Environmental Studies)

(2) Objective

Main objective for the 95GHz cloud radar is to detect vertical structure of cloud and precipitation in the observed region. Combinational use of the radar and lidar is recognized to be a powerful tool to study vertical distribution of cloud microphysics, i.e., particle size and liquid/ice water content (LWC/IWC).

(3) Method

Basic output from data is cloud occurrence, radar reflectivity factor and cloud microphysics. In order to derive reliable cloud amount and cloud occurrence, we need to have radar and lidar for the same record.

Radar / lidar retrieval algorithm has been developed in Tohoku University. The algorithm is applied to water cloud in low level and also cirrus cloud in high altitude. In order to analyze the radar data, it is first necessary to calibrate the signal to convert the received power to radar reflectivity factor, which is proportional to backscattering coefficient in the frequency of interest. Then we can interpolate radar and lidar data to match the same time and vertical resolution. Finally we can apply radar/lidar algorithm to infer cloud microphysics.

(4) Results

The time height cross-section of radar reflectivity factor obtained on Sept. 29. and, Oct. 4. 2008, during MR-08-04 cruise are shown in Fig.4.6.-1, and -2, respectively. Vertical extent is 20km. On Sept.29, heavy fog was seen above the sea level. On Oct.4, it is seen that there are thick cloud layers from 3 to 7 km in height and week rain layers below them.

Fig 4.6.-1. Time height cross section of radar reflectivity factor in dBZe on Sept. 29, 2008 during MR08-04 cruise.

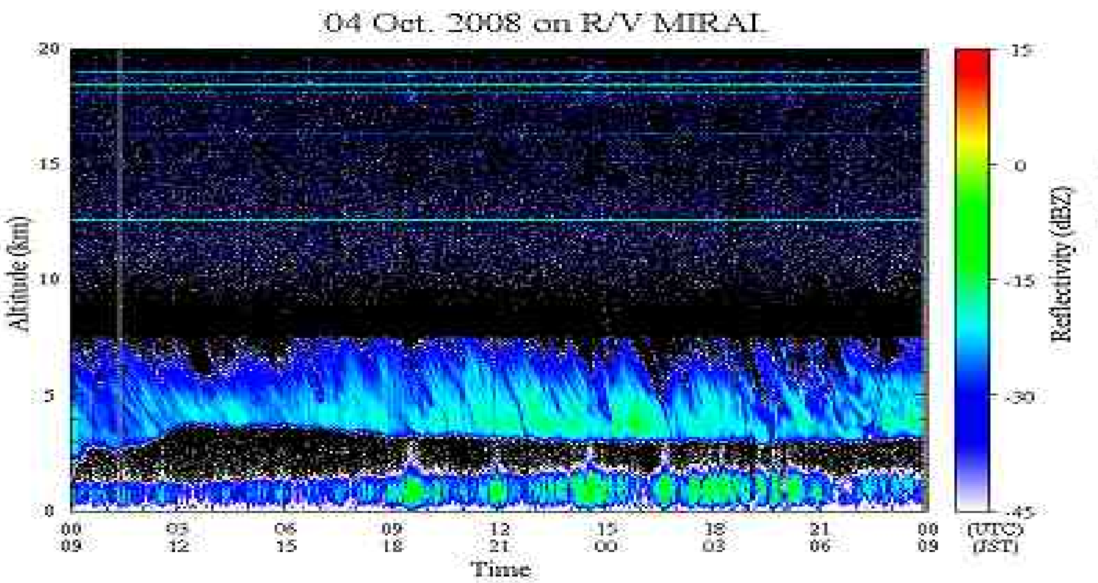


Fig 4.6.-2. Time height cross section of radar reflectivity factor in dBZe on Oct. 04, 2008 during MR08-04 cruise.

(5) Data archive

The data archive server is set inside Chiba University and the original data and the results of the analyses will be available from us.

(6) Remarks

The cloud radar is successfully operated for 24 hours during the cruise.

4.7. Infrared Radiometer (operated by H.Okamoto et al., Tohoku Univ.)

(1) Personnel

TAKANO Toshiaki (Chiba University): Principal Investigator
ABE Eiji (Chiba University) : Student, Doctor Course 2
YAMAGUCHI Jun (Chiba University) : Student, Doctor Course 2
OKAMOTO Hajime (Tohoku University)
SUGIMOTO Nobuo (National Institute for Environmental Studies)

(2) Objective

The infrared radiometer (hereafter IR) is used to derive the temperature of the cloud base and emissivity of the thin ice clouds. Main objectives are to use study clouds and climate system in tropics by the combination of IR with active sensors such as lidar and 95GHz cloud radar. From these integrated approach, it is expected to extend our knowledge of clouds and climate system. Special emphasis is made to retrieve cloud microphysics in upper part of clouds, including sub-visual clouds that are recognized to be a key component for the exchange of water amount between troposphere and stratosphere. Since June 2006, spaceborn radar and lidar systems, CloudSat and CALIPSO are providing vertical and global distribution of clouds and aerosols. One important aim is to observe the same clouds and aerosols by the observational systems on R/V Mirai. Combination of space-based and ship based observations should provide the unique opportunity to study the complete system of theses clouds and aerosols in relation to its environments. We also added the new function for the protection of precipitation.

(3) Method

IR instrument directly provides broadband infrared temperature (9.6-10.5μm).

General specifications of IR system (KT 19II, HEITRONICS)

Temperature range	-100 to 100°C
Accuracy	0.5 °C
Mode	24hours
Time resolution	1 min.
Field of view	Less than 1° (will be estimated later)
Spectral region	9.6-10.5μm

This is converted to broadband radiance around the wavelength region. This is further combined with the lidar or radar for the retrieval of cloud microphysics such as optical thickness at visible wavelength, effective particle size. The applicability of the retrieval technique of the synergetic use of radar/IR or lidar/IR is so far limited to ice clouds. The microphysics of clouds from these techniques will be compared with other retrieval technique such as radar/lidar one or radar with multi-parameter.

When the rain is observed by the rain sensor installed in the IR observing system, the radiometer is automatically rotated and stops at the downward position in order to prevent from the rain drops attached on the lens surface.

(4) Results

Fig. 4.7.-1 displays the temperature measured by IRT on September 29 , 2008.

The horizontal line denotes the hours (UTC) and vertical axis is the temperature. The location is

76.40°N and 170.00° W. The very low temperature of below -70°C corresponds to clear sky. One of the key feature of infrared temperature in the high latitude region is that there is very weak contribution of water vapor and the infrared temperature is almost determined by the emission due to clouds under cloudy conditions.

The temperature between -20°C and -10°C actually in good correspondence to the occurrence of ice clouds detected by the radar and lidar.

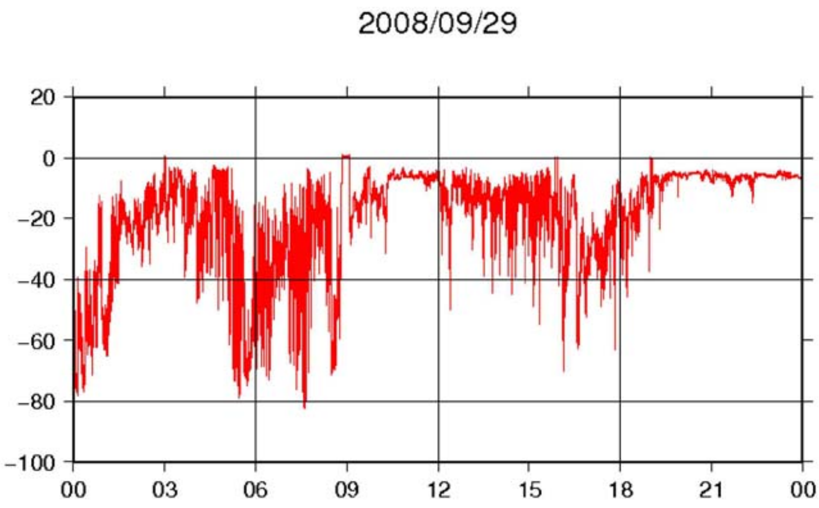


Fig 4.7.-1. Temperature measured with the IRT in Sept.29, 2008, during MR08-04.

(5) Data archive

The data archive server is set inside Tohoku University and the original data and the results of the analyses will be available from us.

(6) Remarks

Basically the IRT is operated for 24 hours. The automatic rain protection system works very fine.

4.8. Lider Observations (operated by N.Sugimoto et al., NIES.)

(1) Personnel

TAKANO Toshiaki (Chiba University): Principal Investigator
ABE Eiji (Chiba University) : Student, Doctor Course 2
YAMAGUCHI Jun (Chiba University) : Student, Doctor Course 2
OKAMOTO Hajime (Tohoku University)
SUGIMOTO Nobuo (National Institute for Environmental Studies)

(2) Results

Fig. 4.8.-1 shows the data obtained with Lidar on Sept. 29 , 2008, during MR08-04 cruise. The horizontal line denotes the hours (UTC) and vertical axis is the temperature. The location is 76.40°N and 170.00° W.

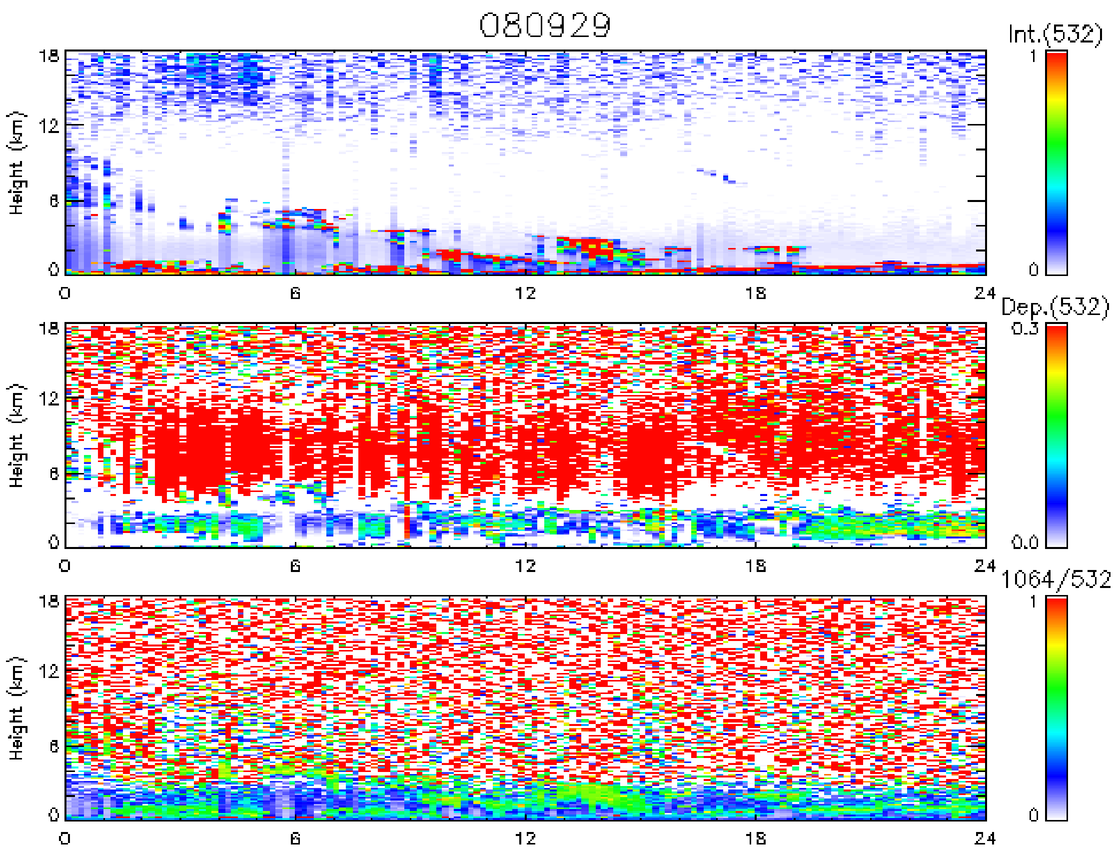


Fig 4.8.-1. Lidar data on Sept.29, 2008, during MR08-04.

The data archive server is set inside NIES and the original data and the results of the analyses will be available from us.

Lidar was successfully operated for 24 hours during the cruise.

4.9. Air-sea Surface Eddy Flux Measurement

(1) Personnel

Osamu Tsukamoto(Okayama University): Principal Investigator * not on board
Fumiyoshi Kondo (Okayama University) * not on board
Hiroshi Ishida(Kobe University) * not on board
Satoshi Okumura (Global Ocean Development Inc. (GODI))
Shinya Okumura (GODI)

(2) Objective

To better understand the air-sea interaction, accurate measurements of surface heat and fresh water budgets are necessary as well as momentum exchange through the sea surface. In addition, the evaluation of surface flux of carbon dioxide is also indispensable for the study of global warming. Sea surface turbulent fluxes of momentum, sensible heat, latent heat, and carbon dioxide were measured by using the eddy correlation method that is thought to be most accurate and free from assumptions. These surface heat flux data are combined with radiation fluxes and water temperature profiles to derive the surface energy budget.

(3) Instruments and Methods

The surface turbulent flux measurement system (Fig. 4.9-1) consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). The turbulence sensors include a three-dimensional sonic anemometer-thermometer (Kaijo, DA-600) and an infrared hygrometer (LICOR, LI-7500). The sonic anemometer measures three-dimensional wind components relative to the ship. The ship motion sensors include a two-axis inclinometer (Applied Geomechanics, MD-900-T), a three-axis accelerometer (Applied Signal Inc., QA-700-020), and a three-axis rate gyro (Systron Donner, QRS-0050-100). LI7500 is a CO2/H2O turbulence sensor that measures turbulent signals of carbon dioxide and water vapor simultaneously. These signals are sampled at 10 Hz by a PC-based data logging system (Labview, National Instruments Co., Ltd.). By obtaining the ship speed and heading information through the Mirai network system it yields the absolute wind components relative to the ground. Combining wind data with the turbulence data, turbulent fluxes and statistics are calculated in a real-time basis. These data are also saved in digital files every 0.1 second for raw data and every 1 minute for statistic data.

(4) Observation log

The observation was carried out throughout this cruise.

(5) Data Policy and citation

All data are archived at Okayama University, and will be open to public after quality checks and corrections. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department.

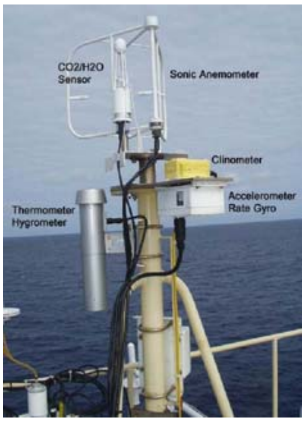


Fig. 4.9-1 Turbulent flux measurement system on the top deck of the foremast.

5. Geology

5.1. Paleoceanographic reconstructions in the Arctic Ocean

(1) Personnel

Masao Uchida (NIES; National Institute for Environmental Studies)
: Principal Investigator
Motoo Utsumi, Yukiko Kuroki, Chie Sato (University of Tsukuba)
Yohei Taketomo, Yuko Sagawa, Takami Mori (MWJ)

(2) Objective

During the last glacial maximum sea level was lowered by ~125m. The size of Bering, Chukchi and Beufort Seas increased dramatically, and the flow of fresher, nutrient rich Pacific water into the Chukchi Sea was cut off due to the resulting emergence of the Bering Strait. These conditions affected the Arctic climate, especially during the warming interstadial periods, the fresh water budget of the Arctic Ocean, and ocean circulation as they changed through time, but exactly how is not understood. This lack of understanding is partly due to the fact that relative sea level in Beringia is likely to have differed from eustatic sea level as a result of tectonic and possible glacio-eustatic effects as a results of dynamic changes of ice volume such as the Laurentide ice sheet . However, very little high-resolution proxy data reconstructing sea surface conditions such as biological productivity and sea ice existence and ocean circulation during past climate are very sparse. In this study, we try to reconstruct ocean conditions on past warm periods such as the medieval warm period(0.1 ka), the last deglaciation (10-18ka) and the last interstadial periods (125 ka) . On these periods, it is clear that the ocean exerts tremendous control over Arctic climate through its temperature, salinity, ice extent, albedo, and sea level. Yet the history of these variables in the Arctic Ocean including the Chukchi Borderland is not known well enough to integrate with the evidence for terrestrial climate change. Our proposed work will recover sediment cores and geophysical data that will provide new constraints on the spatial and temporal variability of climate in the Arctic Ocean. This approach will also yield data necessary to understand the important linkages within inter-hemispheric climate change as well as its importance in Earth's climate system.

On the basis of observations and theoretical considerations, we have come to realize that the Arctic region plays an important role in past global climate change in the Quarternary. The purposes of this cruise are as follows;

a. to investigate past surface sea temperature using several paleoproxies such as marine phytoplankton moleculars (biomarkers) and TEX_{86} preserved in sediments.
b. to investigate past ocean circulation using several paleoproxies such as stable carbon isotopes ratio, ^{14}C ages of planktonic and benthic foraminifera, Nd isotopes, $^{231}Pa/^{230}Th$ and others.
c. to investigate relationships between past climate changes related to methane hydrate

dissociation which is widely distributed in continental shelf in Arctic Ocean.

d. to investigate past biological productivity from total organic carbon and nitrogen content, biomarkers compositions, and compound-specific stable isotopic and radiocarbon analysis.
e. to investigate fate, preservation, and transport of terrestrial organic matter in marine sediment and relationships with climate change using molecular-level terrestrial organic matter including plant debris and black carbon.
f. to investigate chemical properties in order to understand the distribution of trace elements, such as Cd, Co, Cu, Fe, Ni, Zn, V, Zr, Hf, Nb, Ta, Mo, W, U, and Mn, in sediments.
g. to investigate variations of diversity of planktonic and benthic foraminifera associated with climate change.
h. to develop compound-specific radiocarbon based age model for the Arctic Ocean sediments over past 50,000 years BP because the glacial sediments are barren for carbonate fossils.

(3) Parameters

Piston corer system (PC)

Piston corer system consists of 1.25t-weight, 5m-long duralmin barrel with polycarbonate liner tube and a pilot core sampler. The inner diameter (I.D.) of polycarbonate liner tube is 74mm. The total weight of the system is approximately 1.5t. The length of the core barrel was 5m, 15m and 20m that was decided by site survey data. We used a small multiple corer (“Ashura”) for a pilot core sampler.

In this cruise, we used two types of piston, Normal type, Outer type. Normal type piston is composing of stainless steel body and two O-rings (size: P63). That was used three times (PC-01, 02 and 04). Outer type piston was put four O-rings (size: P67).

Multiple corer (MC)

A Multiple core sampler was used for taking the surface sediment. This core sampler consists of a main body of 620kg-weight and 8 sub-core samplers (I.D. 74mm and length of 60cm).

(4) Instruments and methods

Winch operation

When we started lowering PC and MC, a speed of wire out was set to be 0.2 m/s., and then gradually increased to the maximum of 1.0 m/s. The corers were stopped at a depth about 100 m above the seafloor for 2-3 minutes to reduce some pendulum motion of the system. After the corers were stabilized, the wire was stored out at a speed of 0.3 m/s., and we carefully watched a tension meter. When the corers touched the bottom, wire tension abruptly decreases by the loss of the corer weight. Immediately after confirmation that the corers hit the bottom, wire out was stopped and winding of the wire was started at a speed of 0.3m/s., until the tension gauge indicates that the corers were lifted off the bottom. After leaving the bottom, winch wire was wound in at the maximum speed.

Soft-X ray photographs

Soft-X ray photographs were taken to observe sedimentary structures of cores.

Sediment samples were put into the original plastic cases (200x3x7mm) from cores. Each case has a TEPURA sheel showing cruise code, core number, section number, case number, and section depth (cm), and was rimmed by PARAFILM to seal the sediment.

Soft-X ray photographs were taken to using the device SOFTEX PRO-TEST 150 on board. The condition of X-ray was decided from results of test photographs by each core section. The condition was ranged between 40~50KVp, 2mA, and 150~200 seconds.

All photographs were developed into the negative films by the device FIP-1400 on board.

Core Photographs

After splitting each section of piston, pilot and multiple cores into working and archive halves, sectional photographs of archive were taken using a digital camera (Camera body: Nikon D1x / Lens: Nikon AF Zoom-Nikkor 24-50mm). When using the digital camera, shutter speed was 1/160 ~ 1/10 sec (partly 1/160~1/15 sec, 1/160~1/8 sec), F-number was 6.3 (partly 8). sensitivity was ISO 400. File format of raw data is Exif-JPEG. Details for settings were included on property of each file.

Core Photographs

Radiocarbon measurements for sedimentary organic carbon, foraminifera, and biomarkers such as GDGTs derived from marine Crenarchaeota membrane lipids for making age model of sediment cores will be measured by Accelerator Mass Spectrometry (AMS) at AMS facility(NIES-TERRA), National Institute for Environmental Studies.

(5) results

PC

PC core were collected on the Northwind Ridge and core sites were shown in Figure 5-1. Results of the PC are summarized in table 5-1-1.

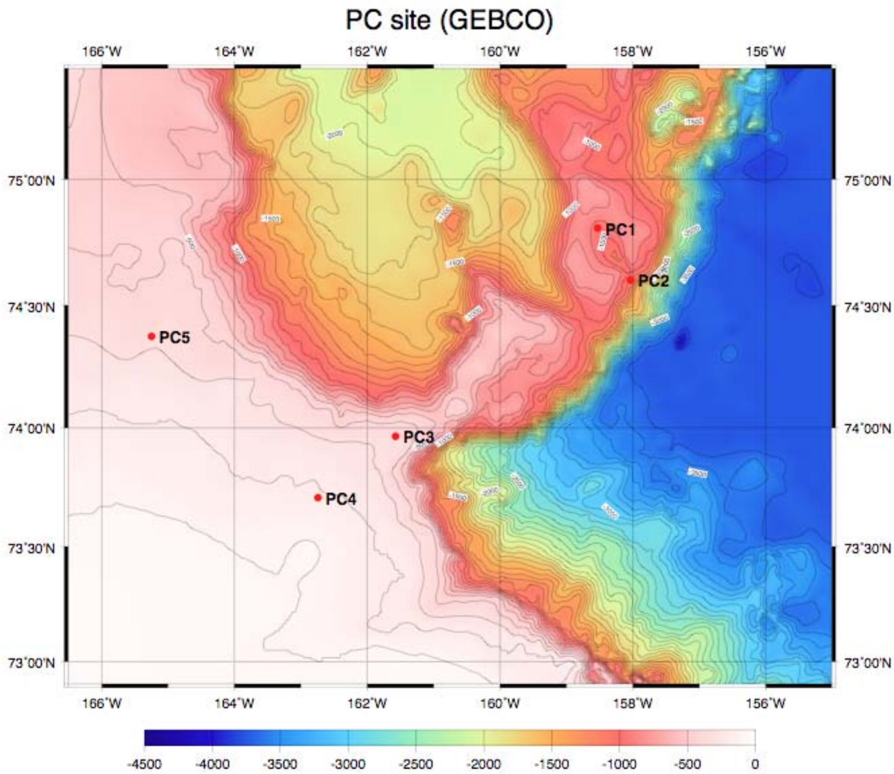


Figure 5-1 Core sites

Table 5-1-1. Coring summary of the PC.

Core ID	Date (UTC)	Latitude (°)	Longitude (°)	Depth(m)	Core length (cm)	remarks
PC-01	2008/9/3	74-48.4973N	158-31.8507W	998	906.8	Pipe 20m. Flow in 1.7m
PC-02	2008/9/11	74-36.1058N	158-02.2354W	936	805.6	Pipe 15m. Flow in 1.4m.
PC-03	2008/9/24	73-57.8957N	161-34.5097W	360	448.0	Pipe 5m.
PC-04	2008/9/24	73-42.5741N	162-44.5802W	197	432.9	Pipe 5m.
PC-05	2008/10/1	74-22.5421N	165-14.9262W	357	1070.1	Pipe 15m. Flow in 5.5m.

Multiple corer (MC)

Results of the MC are summarized in table 5-1-2. Each MC-01, MC-02, MC-03, and MC-04 cores were collected on sites of PC-01, PC02, PC03, and PC4, respectively.

Table 5-1-2. Coring summary of the MC.

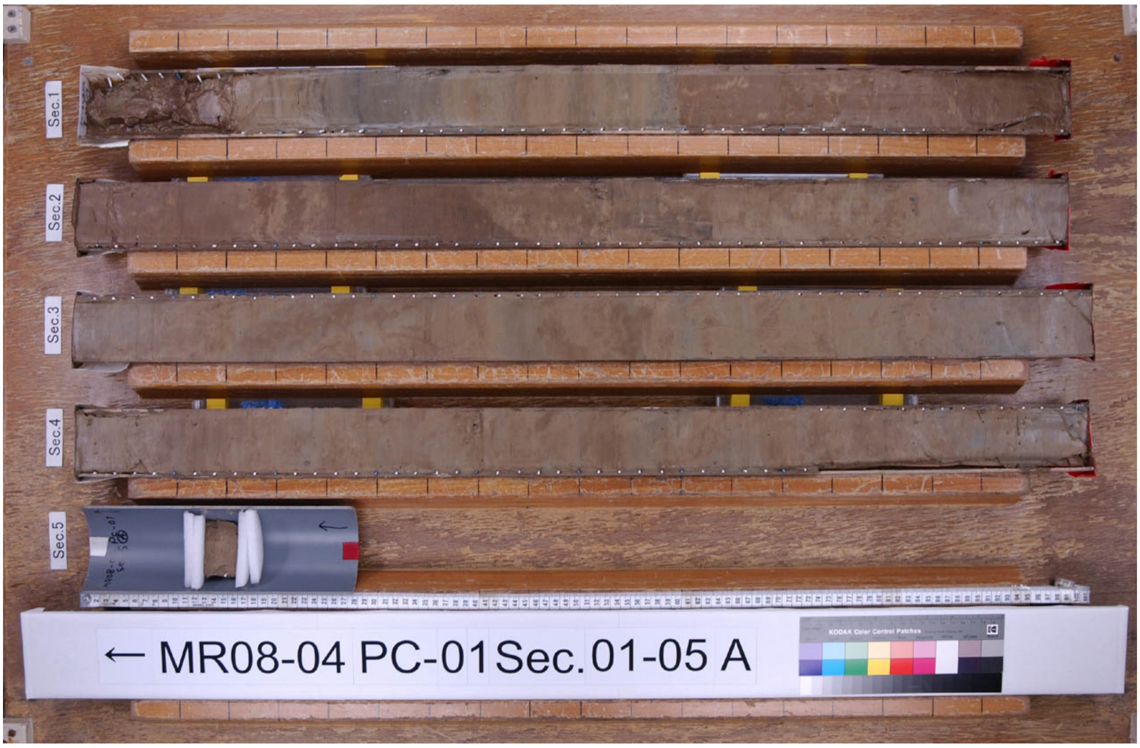
Core ID	Date (UTC)	HAND No.	Core length (cm)	Core ID	Date (UTC)	HAND No.	Core length (cm)
MC-01	2008/9/2	HAND1	28.8	MC-03	2008/9/24	HAND1	34.0
		HAND2	31.3			HAND2	34.0
		HAND3	28.4			HAND3	34.0
		HAND4	30.5			HAND4	34.5
		HAND5	30.5			HAND5	31.5
		HAND6	30.7			HAND6	33.0
		HAND7	30.8			HAND7	33.5
		HAND8	31.4			HAND8	33.5
MC-02	2008/9/11	HAND1	31.0	MC-04	2008/9/24	HAND1	41.0
		HAND2	31.0			HAND2	39.0
		HAND3	30.5			HAND3	38.0
		HAND4	30.5			HAND4	36.0
		HAND5	30.5			HAND5	38.0
		HAND6	30.5			HAND6	36.0
		HAND7	23.0			HAND7	38.0
		HAND8	30.0			HAND8	40.0

Soft-X ray photographs

In this cruise, the total 173 sediment sample cases were collected from cores, and the total 62 negative films were taken X-ray photograph and developed. These results will be stored at NIES.

Core Photographs

Photographs of each core are shown in Fig.5-2-1~5-2-8.



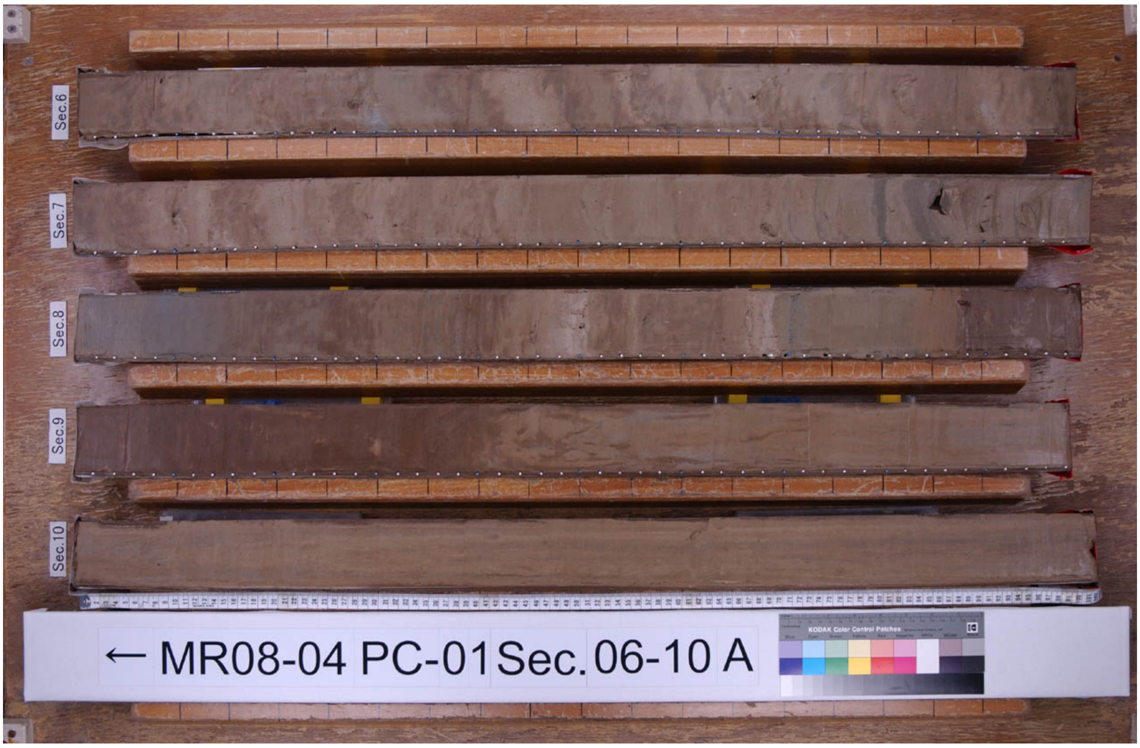
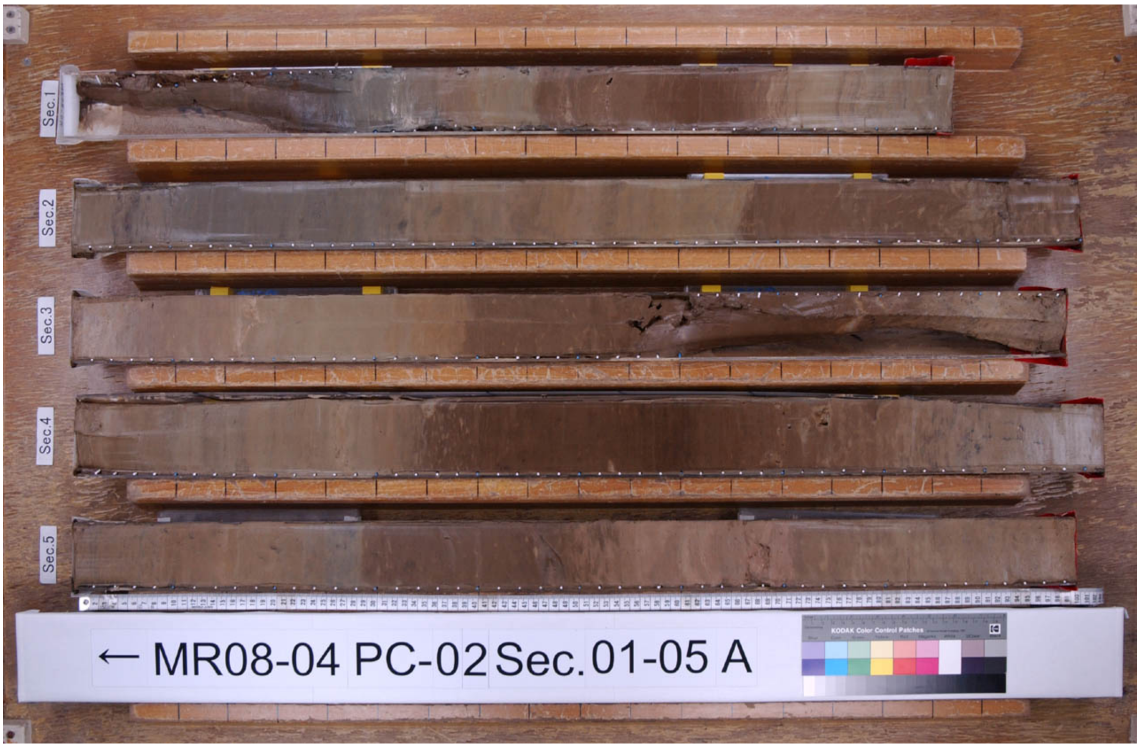


Fig.5-2-1 Photographs of A-half core PC-01. (F6.3, 1/50 sec)



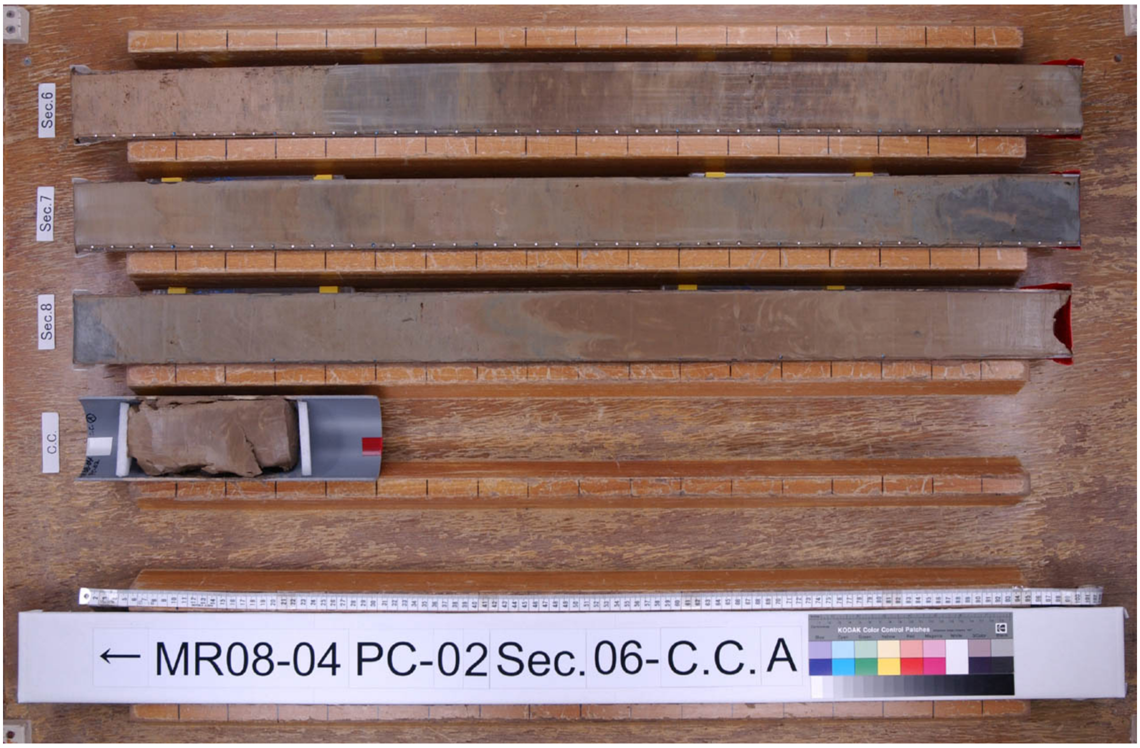


Fig.5-2-2 Photographs of A-half core PC-02. (F6.3, 1/50 sec)

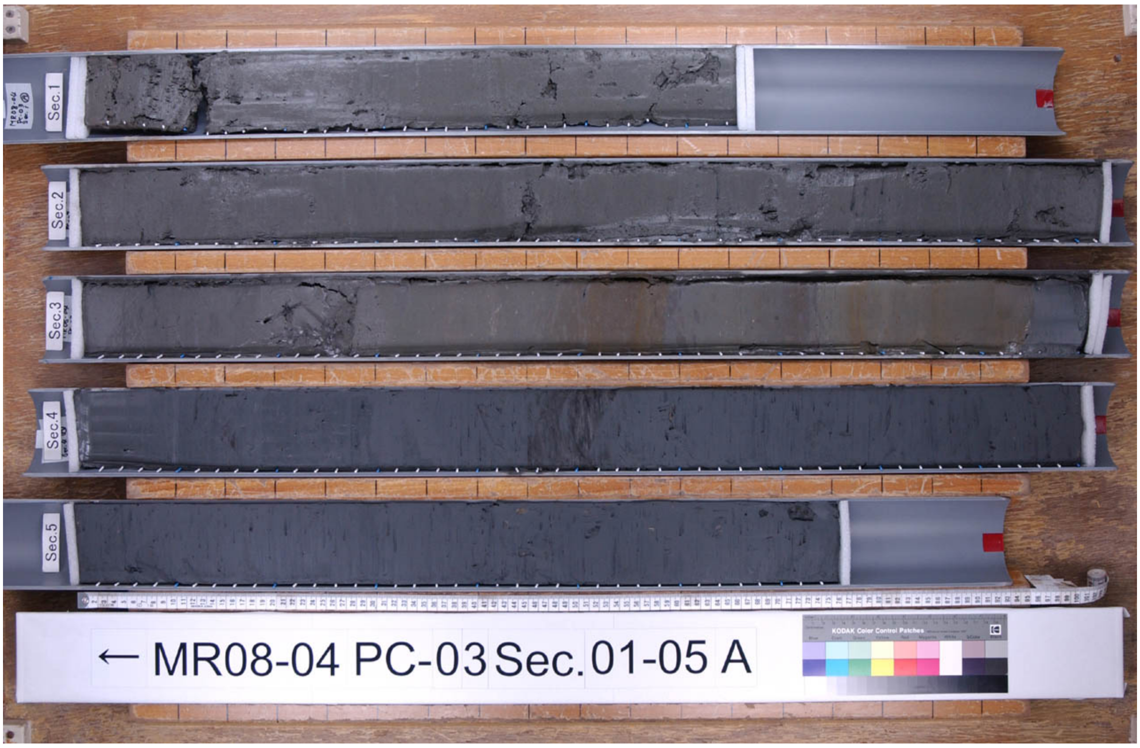


Fig.5-2-3 Photographs of A-half core PC-03. (F6.3, 1/30 sec)

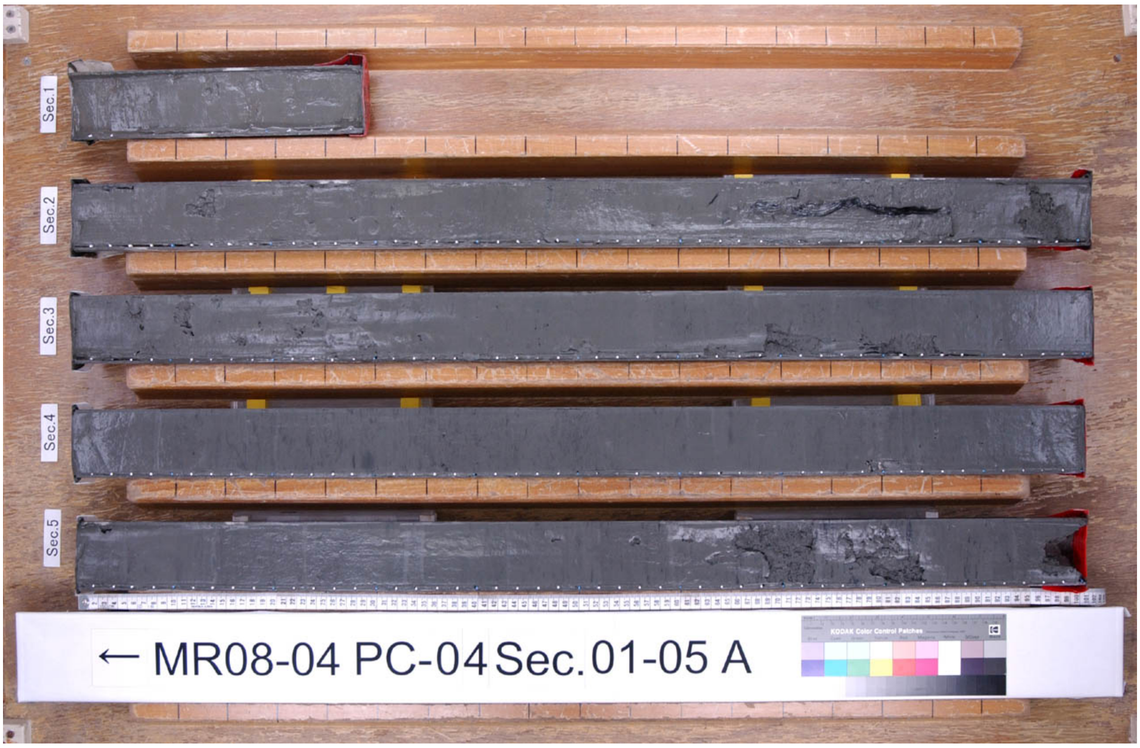


Fig.5-2-4 Photographs of A-half core PC-04. (F6.3, 1/25 sec)

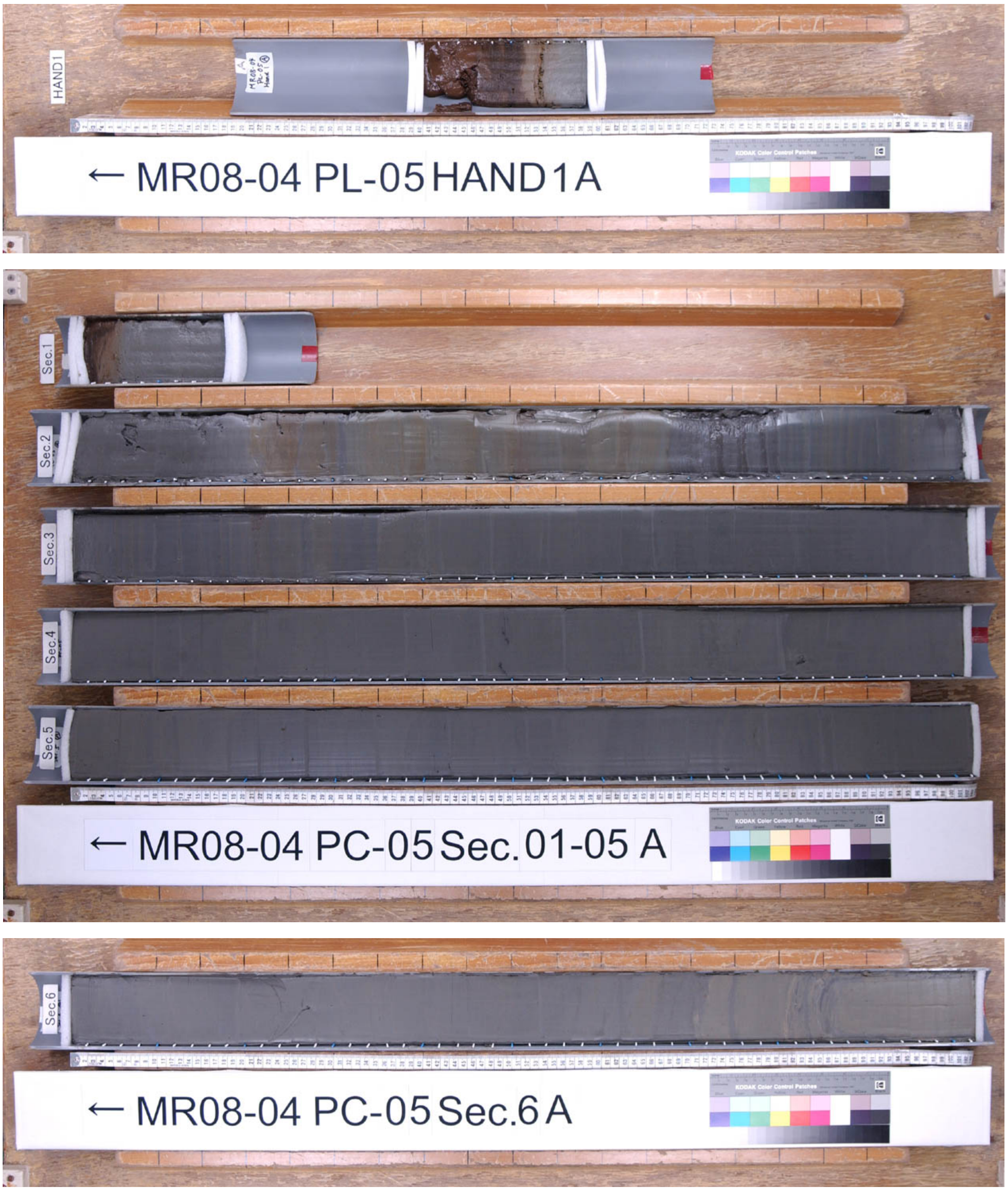


Fig.5-2-5 Photographs of A-half core PL-05 Hand1 and PC-05. (F6.3, 1/20 sec)

Fig.5-1-6 Photographs of A-half core MC-02 Hand8. (F6.3, 1/30 sec)

Fig.5-1-7 Photographs of A-half core MC-03 Hand8. (F6.3, 1/13 sec)

Fig.5-2-8 Photographs of A-half core MC-04 Hand8. (F6.3, 1/15 sec)

(6) Observation log

Observation logs are shown in table 5-1-3~5-1-11.

Table 5-1-3. Observation log of the PC-01.

Cruise Name:	MR08-04			
Date: (UTC)	2008/9/2-3		Operator:	Y. TAKETOMO
Core Number:	PC-01			
Pilot Number:	PL-01			
Area:	Chukchi Sea			
Sampling Site:	Sta.041			
Corer type:	Inner type piston corer			
Pipe length:	20	m		
Pilot type:	Ashura			
Pilot weight:	100	kg		
Pilot wire length:	28.60	m		
Main wire length:	28.80	m		
Free fall:	4.7	m		
Weather:	Cloudy			
Wind direction:	307.0	deg	Wind speed:	5.6 m/s
Current direction:	66.1	deg	Current speed:	0.3 knt

Time (UTC)	Wire length (m)	Latitude	Longitude	Depth (m)	Tension (ton)	Wire speed (m/sec.)		Remarks
23:28	-				-	-	-	Operation start
23:59	-				-	-	-	Connected Ashura corer
0:01:33	0	74°48.4358 N	158°32.0132 W	997	1.2	-	0	PC (balance) on surface, Reset the wire length
0:12	200				1.3	↓	～1.0	Swell Compensator start, Wire restart
0:18	500				1.6	↓	1.0	
0:24	900				2.0	-	0	Stop the wire out (to stabilize the PC)
0:26	900				2.0	↓	～0.3	Restart the wire out
0:30:04	**967**	**74°48.4973 N**	**158°31.8507 W**	**998**	**Min. 0.3**	**↓**	**0.3**	**Hit the bottom, Start the wire in****
		74°48.4564 N	**158°31.9211 W**					
0:31:32	**940**	**74°48.4980 N**	**158°31.8522 W**	**997**	**Max. 3.4**	**↑**	**0.3**	**Left the bottom****
		74°48.4652 N	**158°31.9086 W**					
0:38	500				1.8	↑	1.0	
0:43	200				1.2	↑	～1.0	Swell Compensator stop, Wire restart
0:52:12	0	74°48.4358 N	158°32.3370 W	998	1.2	-	0	PC (balance) on surface
	-				-	-	0	Ashura on deck
	-				-	-	0	PC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the transponder's position.

Table 5-1-4. Observation log of the PC-02.

Cruise Name:	MR08-04				
Date: (UTC)	2008/9/11-12		Operator:	Y. SAGAWA	
Core Number:	PC-02				
Pilot Number:	PL-02				
Area:	Chukchi Sea				
Sampling Site:	Sta.088				
Corer type:	Inner type piston corer				
Pipe length:	15	m			
Pilot type:	Ashura				
Pilot weight:	100	kg			
Pilot wire length:	22.76	m			
Main wire length:	22.80	m			
Free fall:	3.9	m			
Weather:	Cloudy				
Wind direction:	7.0	deg	Wind speed:	7.3	m/s
Current direction:	45.8	deg	Current speed:	0.2	knt

Time (UTC)	Wire length (m)	Latitude	Longitude	Depth (m)	Tension (ton)	Wire speed (m/sec.)		Remarks
22:16	-				-	-	-	Operation start
22:49	-				-	-	-	Connected Ashura corer
22:51:34	0	74°36.1444 N	158°02.1704 W	938	1.3	-	0	PC (balance) on surface, Reset the wire length
22:59	200			938	1.3	↓	～1.0	Swell Compensator start, Wire restart
23:06	500			936	1.6	↓	1.0	
23:11	850			936	1.9	-	0	Stop the wire out (to stabilize the PC)
23:14	850			935	1.9	↓	～0.3	Restart the wire out
23:18:19	**911**	**74°36.1058 N**	**158°02.2354 W**	**936**	**Min. 0.5**	**↓**	**0.3**	**Hit the bottom, Start the wire in****
		74°36.1531 N	**158°02.1874 W**					
23:19:28	**889**	**74°36.1049 N**	**158°02.2257 W**	**937**	**Max. 3.2**	**↑**	**0.3**	**Left the bottom****
		74°36.1473 N	**158°02.1722 W**					
23:26	500			938	1.7	↑	1.0	
23:32	200			938	1.4	↑	～1.0	Swell Compensator stop, Wire restart
23:39:25	0	74°36.2487 N	158°02.2410 W	937	1.1	-	0	PC (balance) on surface
23:42	-				-	-	0	Ashura on deck
0:05	-				-	-	0	PC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the transponder's position.

Table 5-1-5. Observation log of the PC-03.

Cruise Name:	MR08-04				
Date: (UTC)	2008/9/24		Operator:	T. MORI	
Core Number:	PC-03				
Pilot Number:	PL-03				
Area:	Chukchi Sea				
Sampling Site:	P2				
Corer type:	Outer type piston corer				
Pipe length:	5	m			
Pilot type:	Ashura				
Pilot weight:	100	kg			
Pilot wire length:	13.60	m			
Main wire length:	12.80	m			
Free fall:	4.7	m			
Weather:	Cloudy occasional snow				
Wind direction:	142.0	deg	Wind speed:	2.5	m/s
Current direction:	2.3	deg	Current speed:	0.5	knt

Time (UTC)	Wire length (m)	Latitude	Longitude	Depth (m)	Tension (ton)	Wire speed (m/sec.)		Remarks
16:53	-				-	-	-	Operation start
17:13	-				-	-	-	Connected Ashura corer
17:22:38	0	73°57.8535 N	161°34.5242 W	360	1.1	-	0	PC (balance) on surface, Reset the wire length
17:31	200			358	1.3	↓	～1.0	Wire restart
17:34	310			361	1.4	-	0	Stop the wire out (to stabilize the PC)
17:37	310			359	1.4	↓	～0.3	Restart the wire out
17:39:04	**344**	**73°57.8957 N**	**161°34.5097 W**	**360**	**Min. 0.1**	**↓**	**0.3**	**Hit the bottom, Start the wire in****
		73°57.8543 N	**161°34.5183 W**					
17:39:45	**334**	**73°57.8950 N**	**161°34.5097 W**	**359**	**Max. 5.7**	**↑**	**0.3**	**Left the bottom****
		73°57.8546 N	**161°34.5273 W**					
17:43	200			359	1.3	↑	～1.0	Wire restart
17:50:20	0	73°57.8499 N	161°34.7226 W	358	1.2	-	0	PC (balance) on surface
17:54	-				-	-	0	Ashura on deck
18:16	-				-	-	0	PC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the transponder's position.

Table 5-1-6. Observation log of the PC-04.

Cruise Name:	MR08-04				
Date: (UTC)	2008/9/24		Operator:	Y. TAKETOMO	
Core Number:	PC-04				
Pilot Number:	PL-04				
Area:	Chukchi Sea				
Sampling Site:	P1				
Corer type:	Inner type piston corer				
Pipe length:	5	m			
Pilot type:	Ashura				
Pilot weight:	100	kg			
Pilot wire length:	13.60	m			
Main wire length:	12.80	m			
Free fall:	4.7	m			
Weather:	Cloudy occasional snow				
Wind direction:	176.0	deg	Wind speed:	1.8	m/s
Current direction:	289.1	deg	Current speed:	0.2	knt

Time (UTC)	Wire length (m)	Latitude	Longitude	Depth (m)	Tension (ton)	Wire speed (m/sec.)		Remarks
21:31	-				-	-	-	Operation start
21:41	-				-	-	-	Connected Ashura corer
21:52:18	0	73°42.5680 N	162°44.4638 W	195	1.2	-	0	PC (balance) on surface, Reset the wire length
22:01	150			198	1.4	-	0	Stop the wire out (to stabilize the PC)
22:03	150			199	1.4	↓	～0.3	Restart the wire out
22:05:18	**178**	**73°42.5741 N**	**162°44.5802 W**	**197**	**Min. 0.1**	↓	**0.3**	**Hit the bottom, Start the wire in****
		73°42.5676 N	**162°44.4432 W**					
22:06:19	**162**	**73°42.5746 N**	**162°44.5735 W**	**197**	**Max. 1.4**	↑	**0.3**	**Left the bottom****
		73°42.5677 N	**162°44.4425 W**					
22:08	100			195	1.3	-	-	
22:18:00	0	73°42.5622 N	162°44.1478 W	202	1.2	-	0	PC (balance) on surface
22:19	-				-	-	0	Ashura on deck
22:35	-				-	-	0	PC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the transponder's position.

Table 5-1-7. Observation log of the PC-05

Cruise Name:	MR08-04				
Date: (UTC)	2008/10/1		Operator:	Y. TAKETOMO	
Core Number:	PC-05				
Pilot Number:	PL-05				
Area:	Chukchi Sea				
Sampling Site:	sta. 119				
Corer type:	Outer type piston corer				
Pipe length:	15	m			
Pilot type:	Ashura				
Pilot weight:	100	kg			
Pilot wire length:	23.60	m			
Main wire length:	22.80	m			
Free fall:	4.7	m			
Weather:	Cloudy occasional snow				
Wind direction:	342.0	deg	Wind speed:	7.9	m/s
Current direction:	15	deg	Current speed:	0.2	knt

Time (UTC)	Wire length (m)	Latitude	Longitude	Depth (m)	Tension (ton)	Wire speed (m/sec.)		Remarks
22:47	-				-	-	-	Operation start
23:09:00	0	74°22.5527 N	165°14.9163 W	357	1.4	-	0	PC (balance) on surface, Reset the wire length
23:36	280			358	1.5	-	0	Stop the wire out (to stabilize the PC)
23:38	280			357	1.4	↓	～0.3	Restart the wire out
23:40:30	**327**	**74°22.5421 N**	**165°14.9262 W**	**357**	**Min. 0.1**	**-**	**-**	**Hit the bottom, Start the wire in**
23:41:36	**310**	**74°22.5424 N**	**165°14.9314 W**	**357**	**Max. 3.3**	↑	**0.3**	**Left the bottom**
23:44	200			358	1.4	-	-	
23:48:00	0	74°22.5671 N	165°14.9131 W	360	-	-	0	PC (balance) on surface
0:15	-				-	-	0	PC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the ship's position.

Table 5-1-8. Observation log of the MC-01

Cruise Name:	MR08-04						
Date:(UTC)	2008/9/2				Operator	Y. SAGAWA	
Core Number:	MC-01						
Area:	Chukchi Sea						
Sampling Site	Sta. 041						
Corer type:	corer only						
Pipe length	0.6 m						
Weather:	Cloudy						
Wind direction:	128 deg		Wind speed:	3.7	m/s		
Current direction:	69 deg		Current speed:	0.3	knt		
Time(UTC)	**Wire length(m)**	**Latitude**	**Longitude**	**Depth(m)**	**Tension(ton)**	**Wire speed (m/sec.)**	**Remarks**
22:10	-				-	- -	Operation start
22:19:12	0	74°48.5238 N	158°31.7406 W	1002	0.6	- 0	MC on surface, Reset the wire length
22:30	500			996	0.9	↓ ～1.0	Swell Compensator start, Wire restart
22:38	950			1003	1.2	- 0	Stop the wire out (to stabilize the MC)
22:42	950			998	1.2	↓ ～0.3	Restart the wire out
22:44:36	**994**	**74°48.4606 N**	**158°31.9210 W**	**997**	**Min. 0.7**	**↓ 0.3**	**Hit the bottom**
22:44	999			997	0.7	- 0	Winch stop (Waiting for 30 sec)
22:45	999			1001	0.7	↑ ～0.3	Start the wire in
22:46:15	**991**	**74°48.4641 N**	**158°31.9362 W**	**998**	**Max. 2.3**	**↑ 0.3**	**Left the bottom**
22:56	500			995	1.0	↑ ～1.0	Swell Compensator stop, Wire restart
23:07:16	0	74°48.4837 N	158°32.1562 W	996	0.6	- 0	MC on surface
23:10	-				-	- 0	MC on deck
*LST: UTC -8h							*GPS: WGS84
**Latitude and Longitude was used the ship's position..							

Table 5-1-9. Observation log of the MC-02

Cruise Name:	MR08-04						
Date:(UTC)	2008/9/11				Operator	T. MORI	
Core Number:	MC-02						
Area:	Chukchi Sea						
Sampling Site	Sta. 088						
Corer type:	corer only						
Pipe length	0.6 m						
Weather:	Cloudy						
Wind direction:	2 deg		Wind speed:	8.1	m/s		
Current direction:	26.1 deg		Current speed:	0.1	knt		
Time(UTC)	**Wire length(m)**	**Latitude**	**Longitude**	**Depth(m)**	**Tension(ton)**	**Wire speed (m/sec.)**	**Remarks**
21:05	-				-	- -	Operation start
21:14:00	0	74°36.1188 N	158°02.2175 W	936	0.5	- 0	MC on surface, Reset the wire length
21:25	500			946	0.9	↓ ～1.0	Swell Compensator start, Wire restart
21:32	890			937	1.2	- 0	Stop the wire out (to stabilize the MC)
21:35	890			939	1.2	↓ ～0.3	Restart the wire out
21:38:01	**932**	**74°36.1392 N**	**158°02.1962 W**	**935**	**Min. 0.7**	**↓ 0.3**	**Hit the bottom**
21:38	935			935	0.7	- 0	Winch stop (Waiting for 30 sec)
21:38	932			937	0.7	↑ ～0.3	Start the wire in
21:39:12	**929**	**74°36.1378 N**	**158°02.2168 W**	**936**	**Max. 2.3**	**↑ 0.3**	**Left the bottom**
21:47	500			937	0.9	↑ ～1.0	Swell Compensator stop, Wire restart
21:58:00	0	74°36.1599 N	158°02.2207 W	937	0.5	- 0	MC on surface
22:00	-				-	- 0	MC on deck
*LST: UTC -8h							*GPS: WGS84
**Latitude and Longitude was used the ship's position..							

Table 5-1-10. Observation log of the MC-03

Cruise Name:	MR08-04		
Date:(UTC)	2008/9/24	Operator	T. MORI
Core Number:	MC-03		
Area:	Chukchi Sea		
Sampling Site	Sta. P2		
Corer type:	corer only		
Pipe length	0.6 m		
Weather:	Snow		
Wind direction:	324 deg	Wind speed:	3 m/s
Current direction:	349.3 deg	Current speed:	0.4 knt

Time(UTC)	Wire length(m)	Latitude	Longitude	Depth(m)	Tension(ton)	Wire speed (m/sec.)		Remarks
16:09	-				-	-	-	Operation start
16:19	0	73°57.8574 N	161°34.4646 W	360	0.6	-	0	MC on surface, Reset the wire length
16:27	310			359	0.7	-	0	Stop the wire out (to stabilize the MC)
16:29	310			359	0.7	↓	～0.3	Restart the wire out
16:32:17	**354**	**73°57.8572 N**	**161°34.4804 W**	**358**	**Min. 0.2**	**↓**	**0.3**	**Hit the bottom**
16:32	357			358	0.2	-	0	Winch stop (Waiting for 30 sec)
16:32	357			359	0.2	↑	～0.3	Start the wire in
16:33:33	**353**	**73°57.8575 N**	**161°34.4615 W**	**360**	**Max. 1.3**	**↑**	**0.3**	**Left the bottom**
16:42	0	73°57.8460 N	161°34.4273 W	359	0.6	-	0	MC on surface
16:44	-				-	-	0	MC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the ship's position.

Table 5-1-11. Observation log of the MC-04

Cruise Name:	MR08-04		
Date:(UTC)	2008/9/24	Operator	Y. TAKETOMO
Core Number:	MC-04		
Area:	Chukchi Sea		
Sampling Site	Sta. P1		
Corer type:	corer only		
Pipe length	0.6 m		
Weather:	Cloudy occasional snow		
Wind direction:	324 deg	Wind speed:	3 m/s
Current direction:	349.3 deg	Current speed:	0.4 knt

Time(UTC)	Wire length(m)	Latitude	Longitude	Depth(m)	Tension(ton)	Wire speed (m/sec.)		Remarks
20:57	-				-	-	-	Operation start
21:04	0	73°42.5722 N	162°44.4452 W	195	0.5	-	0	MC on surface, Reset the wire length
21:09	150			195	0.6	-	0	Stop the wire out (to stabilize the MC)
21:11	150			195	0.6	↓	～0.3	Restart the wire out
21:13:58	**192**	**73°42.5692 N**	**162°44.4359 W**	**195**	**Min. 0.1**	**↓**	**0.3**	**Hit the bottom**
21:14	195			195	0.1	-	0	Winch stop (Waiting for 30 sec)
21:14	195			198	0.1	↑	～0.3	Start the wire in
21:14:58	**191**	**73°42.5708 N**	**162°44.4187 W**	**195**	**Max. 1.2**	**↑**	**0.3**	**Left the bottom**
21:20	0	73°42.5702 N	162°44.4207 W	202	0.5	-	0	MC on surface
21:22	-				-	-	0	MC on deck

*LST: UTC -8h *GPS: WGS84

**Latitude and Longitude was used the ship's position.

5.2 Swath bathymetry

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus)
: Principal Investigator (Not on-board)
Masao Nakanishi (Chiba University)
:Principal Investigator (Not on-board)

Shinya Okumura	(Global Ocean Development Inc., GODI)
Satoshi Okumura	(GODI)
Souichiro Sueyoshi	(GODI)
Harumi Ota	(GODI)

(2) Introduction

R/V MIRAI equipped a Multi Beam Echo Sounding system (MBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.)
The main objective of MBES survey is collecting continuous bathymetry data along ship's track to make a contribution to geological and geophysical investigations and global datasets. We had carried out bathymetric survey during the MR08-04 cruise from Sekinehama on 15 August 2008 to Dutch Harbor on 09 October 2008.

(2) Data Acquisition

MBES was used for bathymetry mapping during this cruise. To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data for the surface (6.2m) sound velocity, and below that the sound velocity profile calculated from temperature and salinity data obtain CTD or XCTD based on the equation in Mackenzie (1981).

System configuration and performance of SEABEAM 2112.004

Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m

Depth accuracy: Within < 0.5% of depth or +/-1m,
whichever is greater, over the entire swath.
(Nadir beam has greater accuracy; typically within < 0.2% of depth or +/-1m, whichever is greater)

(3) Data Archives

Bathymetry data obtained during this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC.

Remarks

We did not collect data close to the EEZ of Russia from 19:28UTC 25 Sep. 2008 to 20:35UTC 25 Sep. 2008.

5.3 Sea surface gravity

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus)
: Principal Investigator (Not on-board)
Masao Nakanishi (Chiba University)
: Principal Investigator (Not on-board)
Shinya Okumura (Global Ocean Development Inc., GODI)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Harumi Ota (GODI)

(2) Introduction

The distribution of local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the observation of MR08-04 cruise from Sekinehama, JAPAN on 15 August 2008 to Dutch Harbor, USA on 09 October 2008.

(2) Parameters

Relative Gravity [CU: Counter Unit]
[mGal] = (coefl: 0.9946) * [CU]

(3) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during this cruise. To convert the relative gravity to absolute one, we measured gravity using portable gravity meter (Scintrex gravity meter CG-3M), at Sekinehama Port as reference point.

(4) Preliminary Results

Absolute gravity shown in Tabel 5.3-1

Table 5.3-1

Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *1 [mGal]	L&R*2 Gravity [mGal]
Aug/15	00:42	Sekinehama	980371.834	304	630	980377.082	12710.72

*1: Gravity at Sensor= Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431

*2: LaCoste and Romberg air-sea gravity meter S-116

(5) Data Archives

Gravity data obtained during this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC.

5.4 Magnet meter

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus)
: Principal Investigator (Not on-board)
Masao Nakanishi (Chiba University)
: Principal Investigator (Not on-board)
Shinya Okumura (Global Ocean Development Inc., GODI)
Satoshi Okumura (GODI)
Souichiro Sueyoshi (GODI)
Harumi Ota (GODI)

(2) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR08-04 cruise from Sekinehama on 15th August 2008 to Dutch Harbor on 09th October 2008.

(2) Principle of ship-board geomagnetic vector measurement

The relation between a magnetic-field vector observed on-board, Hob, (in the ship's fixed coordinate system) and the geomagnetic field vector, F, (in the Earth's fixed coordinate system) is expressed as:

$$Hob = \widetilde{\mathbf{A}}\, R\, P\, Y\, F + Hp \qquad \text{(a)}$$

where R, P and Y are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\widetilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and Hp is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (a) makes

$$B\, Hob + Hbp = R\, P\, Y\, F \qquad \text{(b)}$$

where $B = A^{-1}$, and $Hbp = -B\, Hp$. The magnetic field, F, can be obtained by measuring R, P, Y and Hob, if B and Hbp are known. Twelve constants in B and Hbp can be determined by measuring variation of Hob with R, P and Y at a place where the geomagnetic field, F, is known.

(3) Instruments on R/V MIRAI

A shipboard three-component magnetometer system (Tierra Tecnica SFG1214) is equipped on-board R/V MIRAI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs from the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch, and roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

(4) Data Archives

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC.

Remarks

For calibration of the ship’s magnetic effect, we made a “figure-eight” turn (a pair of clockwise and anti-clockwise rotation). This calibration was carried out on 14 Sep. 2008, 11:46 to 12:07 around 76-38N, 160-53W

6. Outreach

(1) Personnel

Shozo Tashiro (JAMSTEC): Group Leader

Tomohito Yonemoto, Saori Nakagawa, Koichi Ibe (JAMSTEC), Toshiaki Umekawa, Katsutoshi Terakado (Montage)

(2)Objective

To record the research activity performed by “Mirai” in the Arctic Ocean for its diffusion and the development of oceanography and geoscience through such as web and media publication and so on.

(3)Instruments and Methods

We recorded the activity of “Mirai” such as observation of climatic factor, sea water and bottom strata with High Definition movie camera and still camera including interview with the crews. This footage was stored in the tapes as master copy and the optical media for backup copy.

(4)Results and Use

We accomplished recording the activity listed below.

CTD/R/Fe, PRR800/810, XCTD, Moorings, TurboMAP, FRRT, Plankton Net, Multiple Corer, Piston Corer, Radiosonde, Doppler Radar, SBP and other instruments on ”Mirai” with analytical and operational scenes of each. The landscapes of the Arctic Ocean were taken such as sky, clouds, aurora, sea, ice and life as well. For the prompt publicity activity, progress of the voyage was continuously reported on the JAMSTEC web site.

(5) Data Policy and citation

Any movie or photo data is available for the participants in the MR08-04 without charge as far as non-commercial use like an educational programme. The data is stored at Marine-Earth Data and Information Department. Those who need to access the data should contact to the public relations division. Data is also exploited for the public and media relation under the control of JAMSTEC. Information about the way of use and details will be informed to the people concerned beforehand.

Region	CTD /Sampling Number	Cast	Cast Start (UTC)		Latitude	Longitude	Bottom Depth	Layers	CTD/ROS Cast																				Bucket								PRR	FRRF	Plankton Net		
									Routine Cast														CleanCast		Toukai Univ.				Routine Cast				Toukai Univ.								
			yyyy-mm-dd	hh:mm					DO	Sal	DIC	TA	Bact	Nuts	18O	CDOM	Chl.a	DOC	AP	AY	HPLC	PO14C	Nuts	Fe	Nuts	Chl.a	REE	TA	Sal	TA	Nut	18O	Nuts	Chl.a	REE	TA			Closing	Ring 80cm	NORPAC
BS01s	001	1	2008-08-28	19:30	65 42.36 N	168 15.12 W	38	5	X			X		X	X	X	X																								
BS02s	002	1	2008-08-28	20:36	65 43.14 N	168 19.86 W	47	NA																																	
BS03s	003	1	2008-08-28	21:32	65 45.18 N	168 29.94 W	50	5	X			X		X	X	X	X		X	X	X				X	X											X	X			
BS04s	004	1	2008-08-28	23:40	65 47.28 N	168 40.32 W	46	NA																																	
BS05s	005	1	2008-08-29	0:37	65 49.14 N	168 49.80 W	43	5	X		X	X	X	X	X	X		X											X	X	X	X	X	X	X	X					
CSC01	006	1	2008-08-29	2:03	66 0.00 N	168 50.00 W	47	5	X					X			X																								
CSC02	007	1	2008-08-29	4:27	66 30.15 N	168 50.90 W	45	NA																																	
CSC03	008	1	2008-08-29	6:52	67 0.06 N	168 49.60 W	45	5	X			X		X	X	X	X								X	X															
CSC04	009	1	2008-08-29	9:21	67 30.02 N	168 49.67 W	45	NA																																	
CSC05	010	1	2008-08-29	11:48	68 0.00 N	168 50.00 W	58	5	X			X		X	X	X	X																X	X	X	X					
CSC06	011	1	2008-08-29	14:20	68 30.00 N	168 50.00 W	47	NA																																	
CSC07	012	1	2008-08-29	16:43	69 0.05 N	168 49.58 W	46	5	X		X	X	X	X	X	X	X	X							X	X															
CSC08	013	1	2008-08-29	19:08	69 30.00 N	168 49.92 W	52	NA																																	
CSC09	014	1	2008-08-29	21:30	69 59.93 N	168 49.97 W	40	4	X		X	X		X	X	X	X		X	X	X								X	X	X	X					X	X		X	X
CSC10	015	1	2008-08-30	0:46	70 30.03 N	168 50.02 W	39	NA																																	
CCn01	016	1	2008-08-30	2:38	70 49.88 N	168 20.19 W	38	4	X			X		X	X	X	X								X	X															
CCn02	017	1	2008-08-30	3:44	70 49.91 N	168 20.14 W	38	NA																																	
CCn03	018	1	2008-08-30	4:55	70 50.00 N	167 50.00 W	49	5	X		X			X			X																								
CCn04	019	1	2008-08-30	6:11	70 50.10 N	167 19.67 W	44	NA																																	
CCn05	020	1	2008-08-30	7:29	70 50.20 N	166 50.50 W	40	5	X					X			X																								
CCn06	021	1	2008-08-30	1:17	70 50.02 N	165 50.23 W	36	NA																																	
BCH07	022	1	2008-08-30	8:05	71 4.67 N	159 23.14 W	74	7	X		X	X	X	X	X		X	X	X	X	X				X	X			X	X	X	X					X	X			X
HSBC01	023	1	2008-08-31	7:59	72 0.21 N	156 44.55 W	96	NA																																	
HSBC02	024	1	2008-08-31	9:10	71 57.03 N	156 22.40 W	61	NA																																	
HSBC03	025	1	2008-08-31	10:28	71 54.02 N	156 0.30 W	83	NA																																	
HSBC04	026	1	2008-08-31	12:09	71 50.79 N	155 37.49 W	115	NA																																	
HSBC05	027	1	2008-08-31	13:16	71 48.97 N	155 18.28 W	180	NA																																	
HSBC06	028	1	2008-08-31	14:43	71 45.07 N	155 4.66 W	269	14	X		X	X	X	X	X		X	X											X	X	X	X						X			X
HSBC07	029	1	2008-08-31	16:26	71 40.87 N	154 55.79 W	100	NA																																	
HSBC08	030	1	2008-08-31	17:17	71 37.52 N	154 50.33 W	52	NA																																	
CBa01	032	1	2008-09-01	9:59	73 24.40 N	152 0.53 W	3823	24															X	X																	
CBa01	032	2	2008-09-01	13:22	73 24.18 N	151 59.84 W	3830	30	X	X		X		X	X	X	X								X	X														X	X
CBa02	033	1	2008-09-01	17:25	73 36.16 N	152 59.85 W	3845	1														X																			
CBa03	034	1	2008-09-01	19:50	73 36.10 N	152 59.80 W	3848	30	X	X	X	X	X	X	X	X	X	X	X	X	X																X	X			X
CBa04	035	1	2008-09-02	0:50	73 59.99 N	154 59.82 W	3862	NA																																	
CBa05	036	1	2008-09-02	3:05	74 11.94 N	156 0.37 W	3857	30	X	X	X	X		X	X	X	X	X											X	X	X	X	X	X	X	X					
CBa06	037	1	2008-09-02	7:06	74 24.02 N	157 0.37 W	3861	NA																																	
CBa07	038	1	2008-09-02	9:30	74 36.00 N	158 0.00 W	930	21	X	X	X	X		X	X	X	X								X	X															
CBa08	039	1	2008-09-02	11:56	74 48.06 N	159 0.22 W	988	NA																																	
CBa09	040	1	2008-09-02	14:14	74 59.95 N	160 0.15 W	1940	25	X	X	X	X	X	X	X	X	X	X											X	X	X	X					X	X		X	X
NWR01	042	1	2008-09-03	8:25	76 0.05 N	156 39.79 W	955	22	X	X	X	X		X	X	X	X	X							X	X														X	X
NWR02	043	1	2008-09-03	13:32	76 49.90 N	155 25.10 W	882	22	X	X		X		X	X	X	X																X	X	X	X					
NWR05	044	1	2008-09-03	21:47	77 19.73 N	154 58.53 W	1323	24	X	X	X	X	X	X	X	X	X	X							X	X			X	X	X	X									
NWR03	046	1	2008-09-04	16:02	76 53.70 N	155 0.55 W	1032	NA																																	
CBN01	047	1	2008-09-04	18:16	76 55.51 N	154 4.93 W	1947	32	X	X		X		X	X	X	X	X	X	X	X												X	X	X	X	X	X			X
CBN02	048	1	2008-09-04	22:22	76 52.51 N	153 44.83 W	3517	36																																	
CBN03	049	1	2008-09-05	2:11	76 45.02 N	152 30.13 W	3841	30																					X	X	X	X									
CBN04	050	1	2008-09-05	7:18	76 15.02 N	151 59.16 W	3841	30	X	X		X		X	X		X																								
CBN05	051	1	2008-09-05	13:07	76 0.06 N	149 59.82 W	3901	30	X	X		X		X	X	X	X																							X	X
CBN06	052	1	2008-09-05	18:38	76 18.75 N	148 45.00 W	3825	22	X	X		X		X	X		X																								

Appendix Summary of water sampling

Region	CTD /Sampling Number	Cast	Cast Start (UTC) yyyy-mm-dd	Cast Start (UTC) hh-mm	Latitude	Longitude	Bottom Depth	Layers	CTD/ROS Cast																				Bucket								PRR	FRRF	Plankton Net		
									Routine Cast														CleanCast		Toukai Univ.				Routine Cast				Toukai Univ.								
									DO	Sal	DIC	TA	Bact	Nuts	18O	CDOM	Chl.a	DOC	AP	AY	HPLC	PO14C	Nuts	Fe	Nuts	Chl.a	REE	TA	Sal	TA	Nut	18O	Nuts	Chl.a	REE	TA			Closing	Ring 80cm	NORPAC
CBC08	063	1	2008-09-07	16:55	71 15.10 N	144 59.10 W	2347	27	X	X	X	X	X	X	X		X	X																							
CBC09	064	1	2008-09-07	20:28	71 5.20 N	144 59.68 W	1760	25	X	X		X		X	X		X		X	X	X																X	X		X	X
CBC10	065	1	2008-09-07	23:35	70 57.54 N	145 0.48 W	521	1														X																			
CBC11	066	1	2008-09-08	1:24	70 45.50 N	144 59.89 W	220	1	X	X		X		X	X		X								X	X			X	X	X	X									
CBC13	068	1	2008-09-08	2:49	70 36.88 N	145 0.30 W	51	1	X	X		X		X	X		X								X	X							X	X	X	X					
CBC12	067	1	2008-09-08	3:51	70 41.50 N	145 0.23 W	100	NA																																	
BS3000-01	069	1	2008-09-08	9:20	70 29.85 N	146 0.76 W	2985	NA																																X	X
BS3000-02	070	1	2008-09-08	12:15	71 37.54 N	146 59.96 W	3042	NA																																	
BS3000-03	071	1	2008-09-08	14:33	71 44.98 N	148 0.06 W	3032	29	X	X		X		X	X		X		X	X	X																X	X			X
BS3000-04	072	1	2008-09-08	20:00	71 52.50 N	148 59.82 W	3098	1														X																			
BS3000-05	073	1	2008-09-08	22:25	72 0.03 N	149 59.91 W	3116	29	X					X		X	X								X	X															
BS3000-06	074	1	2008-09-08	1:58	72 7.19 N	150 59.74 W	3048	NA																																	
BS3000-07	075	1	2008-09-08	4:18	72 14.86 N	152 0.42 W	2793	28	X	X	X	X	X	X	X	X	X	X											X	X	X	X	X	X	X	X				X	X
BCW	076	1	2008-09-08	17:22	71 48.28 N	155 18.21 W	184	10	X					X			X								X	X															
BCE	078	1	2008-09-09	21:31	71 40.13 N	154 58.73 W	104	7	X					X			X		X	X	X				X	X											X	X		X	X
BCC	079	1	2008-09-10	1:24	71 43.95 N	155 11.07 W	293	14	X	X		X		X	X		X								X	X							X	X	X	X					
BS3000-09	080	1	2008-09-10	8:38	72 29.99 N	154 1.35 W	2818	29	X	X		X		X	X	X																	X	X	X	X				X	X
BS3000-08	081	1	2008-09-10	12:27	72 44.94 N	155 0.30 W	3097	1		X																															
BS3000-10	082	1	2008-09-10	15:06	73 0.24 N	155 59.91 W	2990	28	X	X		X		X	X	X	X																								
BS3000-12	084	1	2008-09-10	23:20	73 30.17 N	158 4.20 W	2808	32	X	X		X		X	X	X	X		X	X	X				X	X											X	X			X
BS3000-13	085	1	2008-09-11	3:03	73 47.29 N	158 59.96 W	3134	NA																																	
BS3000-14	086	1	2008-09-11	5:50	73 59.97 N	160 0.05 W	990	21	X	X		X		X	X	X	X												X	X	X	X	X	X	X	X				X	X
BS3000-15	087	1	2008-09-11	9:10	74 14.97 N	161 0.09 W	1115	NA																																	
BS3000-16	088	1	2008-09-11	12:09	74 29.96 N	162 0.17 W	1620	20															X	X																	
BS3000-16	088	2	2008-09-11	14:16	74 30.02 N	162 0.12 W	1613	25	X	X		X		X	X	X	X																								
NAP01	089	1	2008-09-12	8:20	75 15.02 N	161 1.02 W	2190	27	X	X		X		X	X	X	X																X	X	X	X				X	X
NAP02	098	1	2008-09-12	11:51	75 30.05 N	162 0.03 W	1685	25	X					X		X	X																								
NAP03	091	1	2008-09-12	14:40	75 45.01 N	163 0.12 W	2035	26	X	X		X		X	X	X	X								X	X															
NAP04	092	1	2008-09-12	19:36	75 56.58 N	163 48.39 W	975	22	X					X		X	X																X	X	X	X					
NAP05	093	1	2008-09-12	1:15	76 15.65 N	164 58.59 W	455	18	X	X	X	X		X	X	X	X		X	X	X																X	X	X		X
NAP06	094	1	2008-09-13	3:39	76 29.99 N	166 0.35 W	959	21	X	X		X		X	X	X	X								X	X			X	X	X	X	X	X	X	X					
NAP07	095	1	2008-09-13	6:19	76 25.02 N	164 40.23 W	516	1														X																			
NAP08	096	1	2008-09-13	8:54	76 19.93 N	163 19.77 W	751	1	X					X			X																								
NAP09	097	1	2008-09-13	11:30	76 14.53 N	162 8.86 W	2042	26	X	X	X	X		X	X		X																						X		X
IE	098	1	2008-09-13	22:47	77 31.35 N	161 0.44 W	622	20	X	X		X		X	X	X	X								X	X							X	X	X	X					
IE	099	1	2008-09-14	5:11	76 36.17 N	161 10.33 W	2127	18															X	X																	
IE	099	2	2008-09-14	9:50	76 37.23 N	161 4.89 W	2133	27	X	X		X		X	X		X																						X		X
IE	100	1	2008-09-15	1:17	76 38.39 N	168 5.16 W	1757	25	X	X	X	X	X	X	X	X	X	X	X	X	X											X					X	X		X	X
IE	101	1	2008-09-15	4:27	76 40.32 N	167 15.05 W	606	20	X	X		X		X	X	X																	X	X	X	X					
IE	102	1	2008-09-15	7:33	76 58.50 N	165 29.90 W	937	22	X	X		X		X	X		X											X											X		X
IE	103	1	2008-09-15	22:34	77 44.25 N	164 52.00 W	295	24	X	X		X		X	X		X								X	X							X	X	X	X					
NAP10	104	1	2008-09-16	15:01	76 8.92 N	161 0.09 W	2128	36														X																			
NAP11	105	1	2008-09-16	17:47	76 2.97 N	160 0.48 W	2097	27	X	X		X		X	X		X																								
NAP12	106	1	2008-09-16	21:39	75 56.95 N	158 59.97 W	757	NA																																	
NAP13	107	1	2008-09-16	1:17	75 50.59 N	157 57.90 W	553	26	X	X		X		X	X	X	X		X	X	X												X	X	X	X	X	X		X	X
NAP14	108	1	2008-09-17	3:14	75 37.59 N	157 45.17 W	970	NA																																	
NAP15	109	1	2008-09-17	5:19	75 30.11 N	158 30.09 W	1325	24	X	X		X		X	X	X	X																								
NAP16	110	1	2008-09-17	7:47	75 22.57 N	159 15.21 W	1330	NA																																	
NAP17	111	1	2008-09-17	12:50	75 14.90 N	160 2.36 W	1974	26	X	X		X		X	X		X																						X		X
NAP18	112	1	2008-09-17	15:36	75 7.52 N	160 44.81 W	2091	NA																																	

Appendix Summary of water sampling

Region	CTD /Sampling Number	Cast	Cast Start (UTC) yyyy-mm-dd	hh-mm	Latitude	Longitude	Bottom Depth	Layers	CTD/ROS Cast																				Bucket								PRR	FRRF	Plankton Net		
									Routine Cast														CleanCast		Toukai Univ.				Routine Cast				Toukai Univ.								
									DO	Sal	DIC	TA	Bact	Nuts	18O	CDOM	Chl.a	DOC	AP	AY	HPLC	PO14C	Nuts	Fe	Nuts	Chl.a	REE	TA	Sal	TA	Nut	18O	Nuts	Chl.a	REE	TA			Closing	Ring 80cm	NOR PAC
NAP19	113	1	2008-09-17	18:10	75 0.10 N	161 30.88 W	1844	32	X	X		X		X	X		X		X	X	X																X	X		X	X
NAP20	114	1	2008-09-17	22:51	74 52.46 N	162 14.71 W	1882	1														X																			
NAP21	115	1	2008-09-18	1:23	74 45.00 N	163 0.00 W	1557	25	X	X		X		X	X	X	X																X	X	X	X					
NAP22	116	1	2008-09-18	4:00	74 37.45 N	163 44.93 W	1008	NA																																	
NAP23	117	1	2008-09-18	6:04	74 30.05 N	164 30.08 W	398	16	X	X		X		X	X		X																						X		X
NAP24	118	1	2008-09-18	9:14	74 22.50 N	165 14.97 W	355	NA																																	
NAP25	119	1	2008-09-18	10:58	74 15.11 N	166 0.15 W	275	14	X	X		X		X	X		X																								
NAP26	120	1	2008-09-18	12:52	74 6.62 N	166 47.89 W	211	NA																																	
NCS	121	1	2008-09-18	14:15	74 2.33 N	167 14.23 W	220	10															X	X																X	X
NCS	121	2	2008-09-18	18:07	73 59.01 N	167 36.54 W	200	11	X	X		X		X	X		X		X	X	X				X	X							X	X	X	X	X	X			
NAP27	122	1	2008-09-18	21:22	74 14.96 N	167 20.33 W	270	13	X	X		X		X	X	X																									
NAP28	123	1	2008-09-18	23:05	74 30.07 N	167 10.32 W	318	15	X	X		X		X	X	X	X																								
NAP29	124	1	2008-09-19	1:01	74 43.07 N	167 0.39 W	340	17	X	X		X		X	X										X	X															
NAP30	125	1	2008-09-19	2:48	74 59.96 N	166 49.96 W	439	1														X																			
NAP31	126	1	2008-09-19	4:05	75 0.05 N	167 14.90 W	255	NA																																	
NAP32	127	1	2008-09-19	4:56	74 59.99 N	167 29.61 W	202	NA																																	
NAP33	128	1	2008-09-19	10:17	75 40.81 N	166 2.21 W	540	20	X	X		X		X	X		X								X	X													X		X
NAP34	129	1	2008-09-19	12:11	75 40.07 N	166 49.95 W	263	13	X	X		X		X	X		X																								
NAP35	130	1	2008-09-19	13:46	75 40.03 N	167 39.98 W	204	11	X	X		X		X	X		X																								
CAPS01	131	2	2008-09-19	20:57	75 38.20 N	170 33.70 W	1430	24	X	X		X		X	X	X	X		X	X	X																X	X		X	X
CAPS02	132	1	2008-09-19	23:41	75 32.08 N	169 45.37 W	565	16	X	X		X		X	X	X																									
CAPS03	133	1	2008-09-20	1:58	75 25.24 N	168 59.30 W	249	21	X	X		X		X	X	X	X								X	X															
CAPS04	134	1	2008-09-20	3:58	75 15.09 N	168 0.96 W	167	10	X	X		X		X	X																		X	X	X	X					
CAPS05	135	1	2008-09-20	6:13	74 59.96 N	169 0.16 W	219	11	X	X		X		X	X		X																								
CAPS06	136	1	2008-09-20	8:29	74 45.17 N	170 1.53 W	215	12	X	X		X		X	X	X									X	X															
CAPS07	137	1	2008-09-20	10:22	74 45.00 N	171 0.33 W	244	13	X	X		X		X	X		X																								
CAPS08	138	1	2008-09-20	13:20	74 45.11 N	172 1.11 W	305	15	X	X		X		X	X	X	X																X	X	X	X			X		X
CAPS09	139	1	2008-09-20	15:15	74 45.30 N	173 0.17 W	310	15	X	X		X		X	X		X																								
CAPS10	140	1	2008-09-20	17:10	74 48.06 N	174 1.30 W	265	13	X	X		X		X	X	X																									
CAPS11	141	1	2008-09-21	4:01	75 25.02 N	172 0.56 W	1036	23	X	X		X		X	X	X	X																						X		X
CAPS12	142	1	2008-09-21	7:32	75 15.01 N	171 59.76 W	495	29	X	X		X		X	X	X																									
CAPS13	143	1	2008-09-21	9:32	74 59.98 N	172 0.32 W	383	18	X	X		X		X	X	X	X																								
CAPS14	144	1	2008-09-21	19:11	74 59.82 N	177 5.77 W	250	13	X	X		X		X	X	X	X								X	X							X	X	X	X					
CAPS15	145	1	2008-09-22	22:10	74 59.90 N	176 0.06 W	259	NA														X																			
CAPS16	146	1	2008-09-22	0:40	75 0.23 N	175 1.09 W	270	14	X	X		X		X	X	X	X		X	X	X																X	X	X		X
CAPS17	147	1	2008-09-22	3:39	75 0.04 N	174 0.07 W	294	NA																																	
CAPS18	148	1	2008-09-22	5:25	75 0.04 N	173 0.33 W	333	16	X	X		X		X	X	X	X																								
CAPS19	149	1	2008-09-22	8:42	75 0.00 N	172 0.00 W	309	16	X	X		X		X	X	X																	X	X	X	X					
CAPS20	150	1	2008-09-22	10:38	75 0.05 N	169 59.97 W	243	13	X	X		X		X	X	X	X																						X		X
CAPS21	151	1	2008-09-22	14:44	75 0.08 N	168 0.12 W	167	10	X	X		X		X	X		X																								
CS01	152	1	2008-09-22	17:12	75 0.05 N	166 29.99 W	467	1														X																			
CS02	153	1	2008-09-22	18:38	75 0.09 N	165 59.97 W	480	19	X	X		X		X	X	X	X																X	X	X	X					
CS03	154	1	2008-09-22	20:38	74 59.96 N	165 0.37 W	546	19	X	X				X	X	X																									
CS04	155	1	2008-09-23	23:30	75 0.72 N	164 2.22 W	635	21	X	X		X		X	X	X	X																								X
CS05	156	1	2008-09-23	3:20	74 30.12 N	163 0.70 W	1190	23	X	X		X	X	X	X		X		X	X	X																X	X	X		X
CS06	157	1	2008-09-23	8:12	74 14.97 N	162 59.80 W	847	22	X	X		X		X	X																										
CS07	158	1	2008-09-23	10:21	74 0.03 N	162 59.99 W	320	17	X	X		X		X	X																										
CS08	159	1	2008-09-23	12:32	73 42.32 N	162 44.52 W	195	12	X	X		X		X	X		X																								
CS09	160	1	2008-09-23	14:21	73 25.98 N	162 32.04 W	146	9	X	X		X		X	X																		X	X	X	X					
HCE	161	1	2008-09-23	16:25	73 9.32 N	162 19.77 W	184	13	X	X		X		X	X	X	X		X	X	X		X	X									X	X	X	X	X	X	X		X

Appendix Summary of water sampling

Region	CTD /Sampling Number	Cast	Cast Start (UTC) yyyy-mm-dd	hh-mm	Latitude	Longitude	Bottom Depth	Layers	CTD/ROS Cast																				Bucket								PRR	FRRF	Plankton Net		
									Routine Cast														CleanCast		Toukai Univ.				Routine Cast				Toukai Univ.								
									DO	Sal	DIC	TA	Bact	Nuts	18O	CDOM	Chl.a	DOC	AP	AY	HPLC	PO14C	Nuts	Fe	Nuts	Chl.a	REE	TA	Sal	TA	Nut	18O	Nuts	Chl.a	REE	TA			Closing	Ring 80cm	NORPAC
HC01	162	1	2008-09-23	21:25	73 15.12 N	161 0.35 W	374	17	X	X		X		X	X	X																									
HC03	163	1	2008-09-24	2:38	73 30.95 N	159 53.05 W	2000	26	X	X	X	X		X	X	X	X																						X		X
HC02	164	1	2008-09-24	6:47	73 23.14 N	160 25.87 W	1198	22	X	X		X		X	X	X																									
PC2	165	1	2008-09-24	14:02	73 57.41 N	161 31.78 W	360	16	X	X				X			X																								
MB01	166	1	2008-09-25	20:42	74 59.98 N	178 0.00 W	325	16	X	X		X		X	X	X	X																								
MB02	167	1	2008-09-25	22:35	74 59.96 N	179 0.04 W	392	17	X	X		X		X	X	X																									
MB03	168	1	2008-09-26	0:53	75 0.13 N	179 59.62 E	403	17	X	X		X		X	X	X	X		X	X	X				X	X											X	X		X	X
MB04	169	1	2008-09-26	3:25	74 59.98 N	178 59.85 E	252	13	X	X		X		X	X																		X	X	X	X					
MB05	170	1	2008-09-26	5:16	74 60.00 N	177 59.90 E	216	12	X	X		X		X	X	X	X																								
MB06	171	1	2008-09-26	7:05	75 0.02 N	176 59.84 E	181	11	X	X		X		X	X										X	X															
MB07	172	1	2008-09-26	8:54	75 0.00 N	176 0.00 E	154	10	X	X		X		X	X	X	X																								
MB08	173	1	2008-09-26	11:58	74 45.00 N	174 45.26 E	78	6	X	X		X		X	X	X	X								X	X						X	X	X	X	X					X
MB09	174	1	2008-09-26	13:55	75 0.08 N	174 59.91 W	159	9	X	X		X		X	X										X	X							X	X	X	X					
MB10	175	2	2008-09-26	16:06	75 20.07 N	175 20.22 W	220	16	X	X		X		X	X	X	X								X	X														X	X
MB11	176	1	2008-09-26	19:20	75 40.01 N	175 40.04 W	255	13	X	X	X	X	X	X	X	X		X																							
MB12	177	1	2008-09-26	22:19	75 59.88 N	176 0.17 W	359	15	X	X		X		X	X	X	X		X	X	X				X	X											X	X			X
MB13	178	1	2008-09-27	1:25	76 20.16 N	176 20.09 W	631	21	X	X		X		X	X	X																X									
MB14	179	1	2008-09-27	4:03	76 39.97 N	176 40.14 W	1098	23	X	X		X		X	X		X																								
MB15	180	1	2008-09-27	7:05	76 59.97 N	177 0.15 W	1214	24	X	X		X		X	X	X									X	X															
MB16	181	1	2008-09-27	9:55	77 20.01 N	177 20.24 W	1075	23	X	X		X		X	X		X																								
MB17	182	1	2008-09-27	12:44	77 40.09 N	177 40.06 W	1075	19															X	X																	
MB17	182	2	2008-09-27	15:58	77 40.58 N	177 42.51 W	1280	24	X	X		X		X	X	X																							X		X
MB18	183	1	2008-09-27	18:49	78 0.12 N	177 59.89 W	1680	25	X	X		X		X	X	X	X																								
MB19	184	1	2008-09-28	0:11	78 53.55 N	178 31.13 W	1703	26	X	X		X		X	X	X	X								X	X			X			X	X	X	X	X					
MR01	185	1	2008-09-28	6:08	77 59.99 N	179 0.21 W	1574	26	X	X		X		X	X		X																								
MR02	186	1	2008-09-28	10:08	77 35.99 N	177 20.14 W	785	22	X	X	X	X		X	X	X	X																								
MR03	187	1	2008-09-28	12:34	77 20.00 N	177 36.20 W	1346	23	X	X		X		X	X	X																									
MR04	188	1	2008-09-28	14:37	77 9.96 N	177 45.93 W	1420	24	X	X		X		X	X	X	X																								
MR05	189	1	2008-09-28	17:10	76 59.60 N	176 49.60 W	1440	24	X	X		X		X	X	X	X																X	X	X	X					
MR06	190	1	2008-09-28	20:19	76 50.86 N	176 0.14 W	1758	25	X	X		X		X	X	X																									
MR07	191	1	2008-09-28	23:36	76 40.20 N	174 59.90 W	2003	26	X	X	X	X	X	X	X	X	X																								
MR08	192	1	2008-09-29	2:55	76 38.40 N	176 19.50 W	1726	25	X	X		X		X	X		X																								
MR09	193	1	2008-09-29	5:34	76 37.20 N	177 19.79 W	1295	24	X	X		X		X	X																										
MR10	194	1	2008-09-29	7:56	76 35.96 N	178 19.97 W	818	22	X	X	X	X		X	X	X	X																X	X	X	X					
MR11	195	1	2008-09-29	11:22	77 0.07 N	177 55.11 W	1327	24	X	X		X		X	X	X	X																							X	X
MR12	196	1	2008-09-29	15:45	76 36.40 N	179 59.70 W	1164	23	X	X		X		X	X		X																X	X	X	X					
MR14	197	1	2008-09-29	22:31	76 9.58 N	176 54.13 W	1522	24	X	X		X		X	X		X		X	X	X																X	X		X	X
MR15	198	1	2008-09-30	2:41	76 1.98 N	178 25.06 W	1028	24	X	X		X		X	X	X	X																								
MR16	199	1	2008-09-30	4:58	75 48.03 N	178 50.16 W	1129	23	X	X	X	X		X	X	X	X																X	X	X	X					
MR17	200	1	2008-09-30	7:23	75 34.05 N	179 20.07 W	1006	21	X	X		X		X	X	X	X																							X	X
MR18	201	1	2008-09-30	10:13	75 18.03 N	179 45.22 W	625	21	X	X	X	X	X	X	X	X																									
MR19	202	1	2008-09-30	12:35	75 6.44 N	178 59.88 W	570	20	X	X		X		X	X		X																X	X	X	X					
CAPW01	203	1	2008-09-30	22:28	75 15.13 N	174 45.35 W	425	17	X	X	X	X	X	X	X	X	X											X													
CAPW02	204	1	2008-10-01	0:05	75 24.97 N	174 34.88 W	1130	23	X	X		X		X	X	X												X													
CAPW03	205	1	2008-10-01	2:25	75 39.99 N	174 20.17 W	1736	25	X	X		X		X	X	X	X											X													
CAPW04	206	1	2008-10-01	5:32	76 0.00 N	174 0.15 W	2119	27	X	X	X	X	X	X	X	X	X											X					X	X	X	X					
CAPW05	207	1	2008-10-01	9:15	75 45.27 N	172 44.63 W	1767	25	X	X				X																											
Beaofort Slope	208	1	2008-10-02	4:00	73 36.97 N	165 0.12 W	136	9	X					X	X																									X	X
Beaofort Slope	209	1	2008-10-02	6:28	73 30.04 N	164 0.05 W	103	7	X					X																											
Beaofort Slope	210	1	2008-10-02	8:50	73 15.04 N	163 0.11 W	93	7	X					X																											

Appendix Summary of water sampling

Region	CTD /Sampling Number	Cast	Cast Start (UTC)		Latitude	Longitude	Bottom Depth	Layers	CTD/ROS Cast																				Bucket								PRR	FRRF	Plankton Net		
			yyyy-mm-dd	hh-mm					Routine Cast														CleanCast		Toukai Univ.				Routine Cast				Toukai Univ.								
									DO	Sal	DIC	TA	Bact	Nuts	18O	CDOM	Chl.a	DOC	AP	AY	HPLC	PO14C	Nuts	Fe	Nuts	Chl.a	REE	TA	Sal	TA	Nut	18O	Nuts	Chl.a	REE	TA			Closing	Ring 80cm	NORPAC
Beaufort Slope	211	1	2008-10-02	11:08	73 3.03 N	161 59.86 W	128	8	X					X																											
Beaufort Slope	212	1	2008-10-02	13:42	72 45.02 N	160 59.88 W	44	5	X					X																											
Beaufort Slope	213	1	2008-10-02	15:50	72 33.03 N	159 59.83 W	49	5	X					X																											
Beaufort Slope	214	1	2008-10-02	17:30	72 34.92 N	157 39.59 W	115	7	X					X			X																							X	X
Beaufort Slope	215	1	2008-10-02	19:35	72 49.98 N	158 40.22 W	315	15	X	X				X																											
Beaufort Slope	216	1	2008-10-03	22:45	72 34.91 N	157 39.58 W	250	13	X	X		X		X			X																								
Beaufort Slope	217	1	2008-10-03	2:19	72 18.05 N	156 39.85 W	289	14	X	X		X		X																											
Beaufort Slope	218	1	2008-10-03	3:48	72 25.93 N	156 13.28 W	1345	24	X	X				X																											
Beaufort Slope	219	1	2008-10-03	8:54	72 0.00 N	154 0.62 W	642	20	X					X																											
Beaufort Slope	220	1	2008-10-03	11:32	71 47.98 N	152 58.83 W	545	20	X	X		X		X																											
Beaufort Slope	221	1	2008-10-03	15:40	71 30.05 N	151 39.54 W	1000	24	X	X				X			X																							X	X
Beaufort Slope	222	1	2008-10-03	17:55	71 23.91 N	152 3.14 W	160	9	X					X																			X	X	X	X					
Hanna Shoal	226	1	2008-10-04	3:45	72 0.08 N	157 6.24 W	85	7	X					X																											
Hanna Shoal	227	1	2008-10-04	5:29	72 0.04 N	157 59.92 W	60	6	X					X	X																		X	X	X	X					
Hanna Shoal	228	1	2008-10-04	7:19	72 0.05 N	158 59.99 W	47	5	X					X	X		X																								
Hanna Shoal	229	1	2008-10-04	9:07	72 0.05 N	159 59.93 W	24	4	X					X	X																										
Hanna Shoal	230	1	2008-10-04	10:53	72 0.00 N	160 59.80 W	37	NA																																	
Hanna Shoal	231	1	2008-10-04	12:45	72 0.01 N	162 0.37 W	27	4	X					X	X																		X	X	X	X				X	X
Hanna Shoal	232	1	2008-10-04	15:02	72 0.00 N	163 0.47 W	40	NA																																	
Hanna Shoal	233	1	2008-10-04	16:51	72 0.00 N	164 0.00 W	39	5	X					X	X																										
Hanna Shoal	234	1	2008-10-04	18:50	72 0.00 N	165 0.28 W	40	NA																																	
Hanna Shoal	235	1	2008-10-04	20:47	72 0.00 N	166 0.46 W	45	5	X					X	X																		X	X	X	X					
Hanna Shoal	236	1	2008-10-04	22:45	72 0.00 N	167 0.30 W	47	NA																																	
Hanna Shoal	237	1	2008-10-05	0:29	72 0.00 N	168 0.22 W	49	5	X					X			X																								
Hanna Shoal	238	1	2008-10-05	3:02	71 36.68 N	167 16.73 W	42	5	X					X																											
Hanna Shoal	239	1	2008-10-05	5:37	71 13.45 N	166 33.72 W	40	5	X					X																											
Hanna Shoal	240	1	2008-10-05	8:16	70 50.03 N	165 50.22 W	36	7	X					X			X																X	X	X	X					
Central Channe	241	1	2008-10-05	10:22	70 50.07 N	166 50.35 W	40	NA																																	
Central Channe	242	1	2008-10-05	11:30	70 50.04 N	167 20.02 W	44	NA																																	
Central Channe	243	1	2008-10-05	12:40	70 50.00 N	167 50.36 W	50	8	X					X			X																								
Central Channe	244	1	2008-10-05	13:56	70 49.98 N	168 20.30 W	44	NA																																	
Herald Shoal	245	1	2008-10-05	15:04	70 50.06 N	168 50.01 W	33	4	X					X			X																								
Herald Shoal	246	1	2008-10-05	16:52	70 29.87 N	168 50.01 W	38	NA																																	
Herald Shoal	247	1	2008-10-05	19:24	69 59.80 N	168 50.17 W	32	6	X					X																											
US-EEZ	248	1	2008-10-05	21:53	69 29.94 N	168 50.06 W	51	NA																																	
US-EEZ	249	1	2008-10-06	0:13	68 59.80 N	168 49.90 W	46	5	X					X			X								X																
US-EEZ	250	1	2008-10-06	2:42	68 29.88 N	168 50.11 W	48	NA																																	
US-EEZ	251	1	2008-10-06	5:08	68 0.30 N	168 49.87 W	53	6	X					X			X	X							X																
US-EEZ	252	1	2008-10-06	7:45	67 30.02 N	168 50.22 W	50	NA																																	
US-EEZ	253	1	2008-10-06	10:13	67 0.01 N	168 50.14 W	42	6	X					X			X																								
US-EEZ	254	1	2008-10-06	12:47	66 29.95 N	168 49.97 W	52	NA																																	
US-EEZ	255	1	2008-10-06	15:13	65 59.70 N	168 49.63 W	52	NA																																	
Bering Strait	256	1	2008-10-06	17:06	65 45.18 N	168 29.73 W	55	NA																																	
Bering Strait	257	1	2008-10-06	17:51	65 43.09 N	168 20.00 W	52	NA																																	
Bering Strait	258	1	2008-10-06	18:24	65 42.35 N	168 15.19 W	43	NA																																	
Bering Strait	259	1	2008-10-06	19:35	65 47.18 N	168 40.50 W	51	NA																																	
Bering Strait	260	1	2008-10-06	20:17	65 19.14 N	168 50.11 W	48	NA																																	

Appendix Summary of water sampling