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R/V Mirai Cruise Report
MR12-E03

Arctic Ocean, Bering Sea, and North Pacific Ocean

3rd September to 17th October, 2012

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

Photo by Nishizawa

Cruise Report ERRATA of the Nutrients part

page	Error	Correction
71	potassium nitrate CAS No. 7757-91-1	potassium nitrate CAS No. 7757-79-1
68, 69	1N H_2SO_4	1M H_2SO_4

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1. Cruise Narrative

Takashi KIKUCHI (JAMSTEC)

1.1. Brief summary of MR12-E03

The Arctic climate and environmental changes substantially occur due to global warming, attracting public attentions as well as scientists'. In addition, the Arctic changes influence back to global climate, so-called polar amplification. Sea ice extent of the Arctic Ocean recorded its minimum value, 3.48×10^6 km^2, in the satellite observation on September 15th, 2012, which is a half of summer sea ice extent in the late 20th century. Arctic sea ice is shrinking faster than predictions by global climate models. Still, there are lots of open questions regarding Arctic climate and environmental changes.

In the framework of the GRENE (Green Network of Excellence) Program funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Arctic Climate Change Research Project" was initiated in 2011. The Project is funded for 5 years. Four strategic research targets of this project are;

1) Understanding the mechanism of warming amplification in the Arctic,
2) Understanding the Arctic system for global climate and future change,
3) Evaluation of the impacts of Arctic change on weather/climate in Japan and marine ecosystem and fisheries, and
4) Projection of sea ice distribution and Arctic sea routes.

To achieve the strategic research targets, seven research projects were initiated in the GRENE Arctic Climate Change Research Project with close collaborations among them.

R/V Mirai was operated under GRENE Arctic Climate Change Research Project in September-October 2012 (MR12-E03). MR12-E03 was totally 45 days cruise, including 22 days for the field observation in the Arctic Ocean. 20 scientists and 25 technical staffs were onboard. The cruise mainly focused in the Chukchi Sea and the Canada Basin of the Arctic Ocean, where was almost completely ice-free ocean this year. On September 13th, the filed observation in the Arctic Ocean started at the Bering Strait. During the cruise in the Arctic Ocean, lots of unique and important data could be collected. For instance, CTD/water sampling was conducted at 95 stations in the Arctic Ocean during the cruise.

1.2. Basic information

Name of Vessel	R/V Mirai L x B x D 128.58m x 19.0m x 13.2m, Gross Tonnage 8,672 tons Call Sign JNSR
Cruise Code	MR12-E03
Undertaking Institute	Japan Agency for Marine-Earth Science and Technology (JAMSTEC) 2-15 Natsushima-cho, Yokosuka 237-0061, Japan
Chief Scientists	Takashi Kikuchi Arctic Ocean Climate System Research, Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology (RIGC/JAMSTEC)
Cruise Periods and Ports of Call	Sep. 3, 2012 – Oct. 17, 2012 (Sekinehama – Hachinohe – Arctic Ocean – Nome – Hachinohe – Sekinehama)
Research Areas	Arctic Ocean, Bering Sea, and North Pacific Ocean

Overview of MR12-E03 activities

CTD/water samplings	95 stns/101 casts
XCTDs	63 stns
Mooring recoveries	9 stns
Mooring deployments	10 stns
Primary production	10 stns
Spectroradiometer (PRR)	19 stns
Spectral backscattering sensor (HydroScat)	19 stns
Particle meter (LISST-100)	26 stns
NORPAC nets (with other nets)	49 casts (65 casts)
Multiple cores	8 stns
ADCP continuous observation	
Sea surface water monitoring system	
Total carbonate monitoring system	
Green house gases monitoring system (CRDS)	
Meteorological observation system	
Seabeam	
Geophysical continuous observation (Magnetometer, Gravity meter)	

1.3. Cruise Track

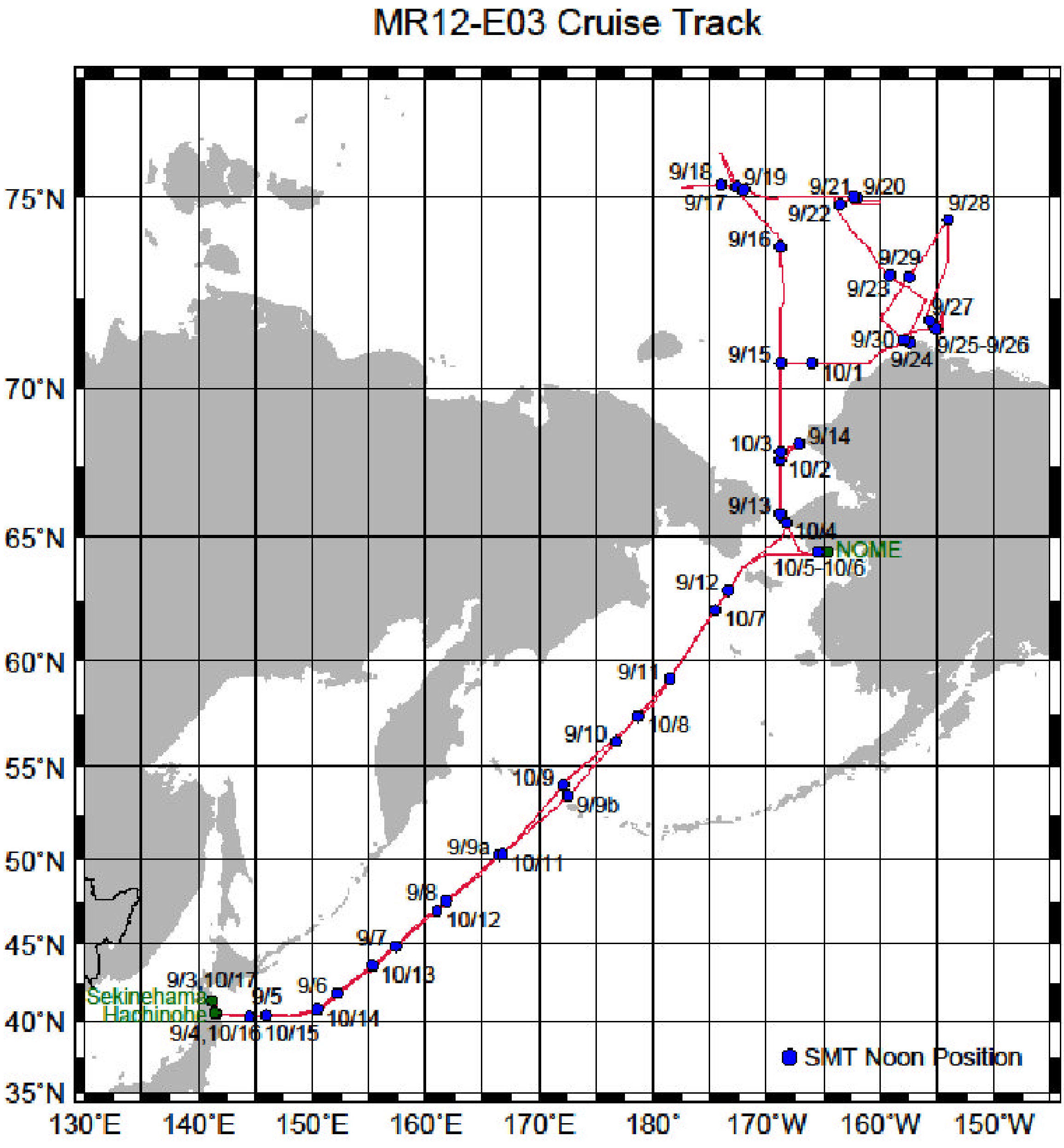


Figure 1.3-1. Cruise Track of MR12-E03

1.4. List of participants

Table 1.4-1. List of participants

Name	Organization	Position
Takashi Kikuchi	JAMSTEC-RIGC	Team Leader
Shigeto Nishino	JAMSTEC-RIGC	Research Scientist
Daisuke Sasano	Meteorological Research Institute	Research Scientist
Toru Hirawake	Hokkaido University	Associate Professor
Amane Fujiwara	National Institute of Polar Research	Postdoctoral Scientist
Ryosuke Futuki	Hokkaido University	University Student
Nanako Hioki	Hokkaido University	Graduate Student
Yuichiro Morita	Hokkaido University	Graduate Student
Nobuyuki Takesue	Hokkaido University	University Student
Atsushi Oki	Hokkaido University	Associate Professor
Shuho Kawasaki	Hokkaido University	University Student
Kohei Matsuno	Hokkaido University	Graduate Student
Yuka Iwahara	Hokkaido University	Graduate Student
Bungo Nishizawa	Hokkaido University	Graduate Student
Mario Uchimiya	National Institute of Polar Research	Postdoctoral Scientist
Yosuke Yamada	University of Tokyo	Graduate Student
Chiaki Motegi	Labal University	Research Scientist
Kentaroh Sugiyama	Tokyo University of Marine Science and Technology	Graduate Student
Takahisa Mifune	Tokyo University of Marine Science and Technology	Graduate Student
Shoko Hirayama	Toyama University	Graduate Student
Toru Idai	MWJ	Technical Staff
Kenichi Katayama	MWJ	Technical Staff
Naoko Miyamoto	MWJ	Technical Staff
Tomoyuki Takamori	MWJ	Technical Staff
Shinsuke Toyoda	MWJ	Technical Staff
Kenichiro Sato	MWJ	Technical Staff
Yoshiko Ishikawa	MWJ	Technical Staff
Masanori Enoki	MWJ	Technical Staff
Makoto Takada	MWJ	Technical Staff
Yasuhiro Arii	MWJ	Technical Staff
Elena Hayashi	MWJ	Technical Staff
Emi Deguchi	MWJ	Technical Staff
Hironori Sato	MWJ	Technical Staff
Shoko Tatamisashi	MWJ	Technical Staff
Misato Kuwahara	MWJ	Technical Staff
Masahiro Orui	MWJ	Technical Staff
Kanako Yoshida	MWJ	Technical Staff
Keitaro Matsumoto	MWJ	Technical Staff
Yasushi Hashimoto	MWJ	Technical Staff
Yasumi Yamada	MWJ	Technical Staff
Kaori Uchiyama	MWJ	Technical Staff

Takuhiro Osumi	MWJ	Technical Staff
Souichiro Sueyoshi	GODI	Technical Staff
Toshimitsu Goto	GODI	Technical Staff
Masanori Murakami	GODI	Technical Staff

2. Meteorology

2.1 Surface Meteorological Observation

(1) Personnel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(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.

(3) Methods

Surface meteorological parameters were observed throughout the MR12-E03 cruise. During this cruise, we used two 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.2.1-1 and measured parameters are listed in Table.2.1-2. 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.2.1-3 and measured parameters are listed in Table.2.1-4.

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.

(4) Preliminary results

Figure 2.1-1 shows the time series of the following parameters;

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

(5) Data archives

These meteorological data will be submitted to the Data Management Group (DMG) of JAMSTEC just after the cruise.

(6) Remarks

i) SST (Sea Surface Temperature) data was available in the following periods.
09:33UTC 04 Sep. 2012 - 21:00UTC 05 Oct. 2012
01:02UTC 07 Oct. 2012 - 06:33UTC 15 Oct. 2012

ii) In the following period, FRSR data acquisition was suspended to prevent damage to the shadow-band from freezing.
06:18UTC 13 Sep. 2012 - 05:06UTC 05 Oct 2012

iii) In the following time, SMet rain gauge amount values were increased because of test transmitting for MF/HF radio.
04:48UTC 11 Sep. 2012 - 04:52UTC 11 Sep. 2012
04:30UTC 13 Oct. 2012 - 04:35UTC 13 Oct. 2012

Table.2.1-1
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	Model-370	Setra System, USA	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-802	EKO Instruments, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	EKO Instruments, Japan	radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	bow (10 m)

Table.2.1-2
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/m^2	6sec. averaged
20	Down welling infra-red radiation	W/m^2	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.2.1-3
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 (23 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 (25 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (25 m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25 m)

Table.2.1-4
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/m^2	
13	Down welling infra-red radiation	W/m^2	
14	Defuse irradiance	W/m^2	

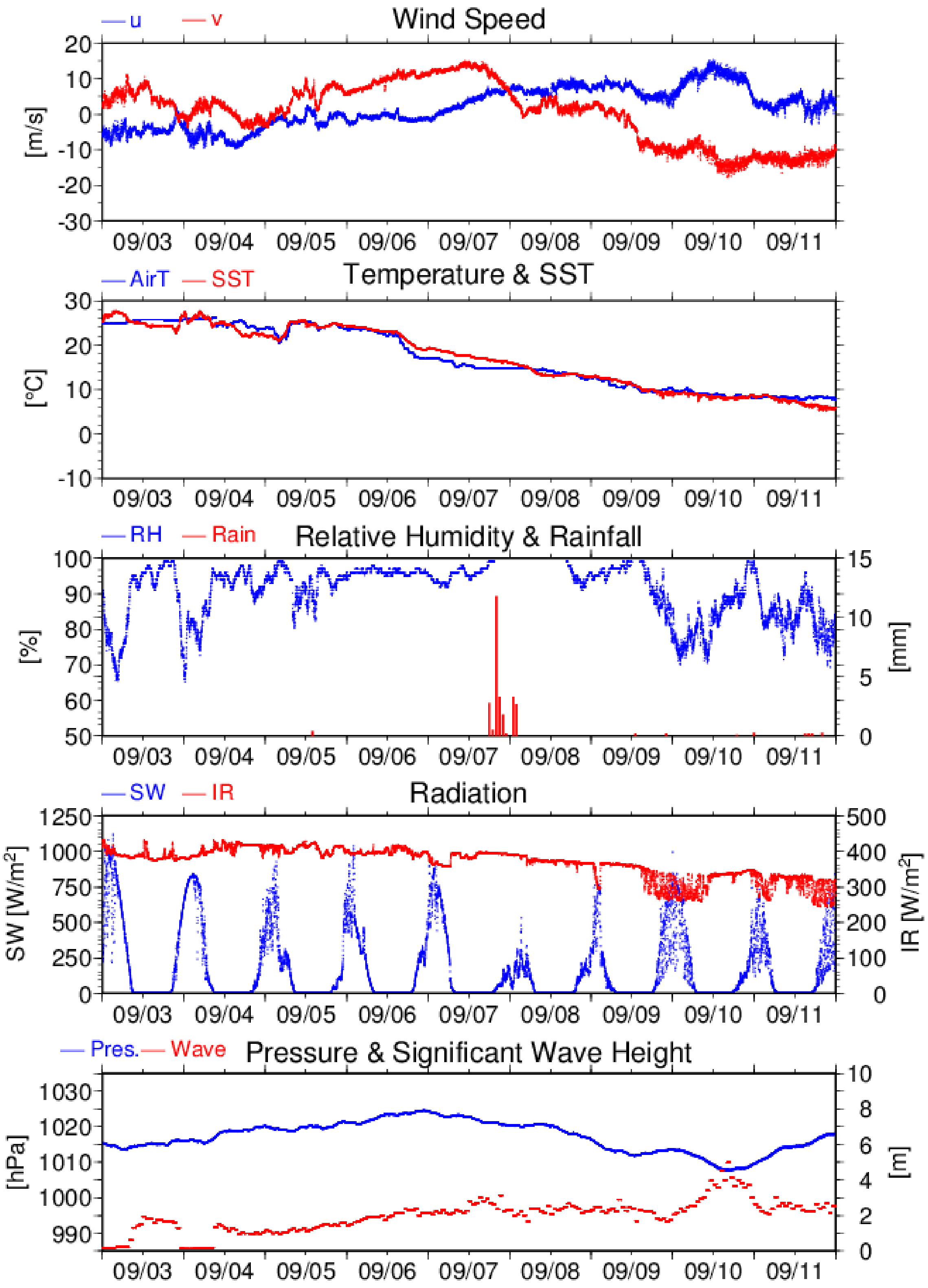


Fig.2.1-1

Time series of surface meteorological parameters during the MR12-E03 cruise

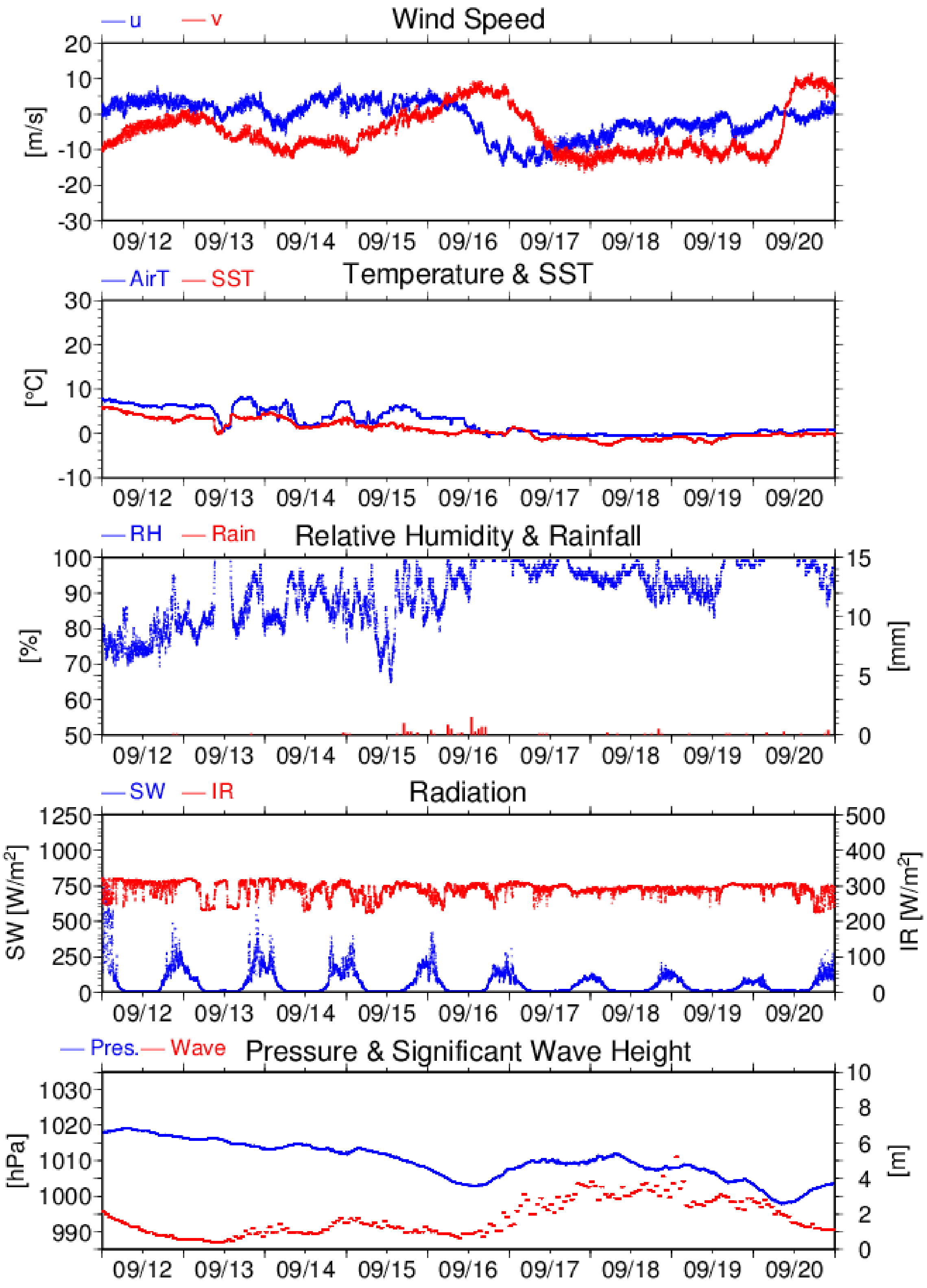


Fig. 2.1-1 (Continued)

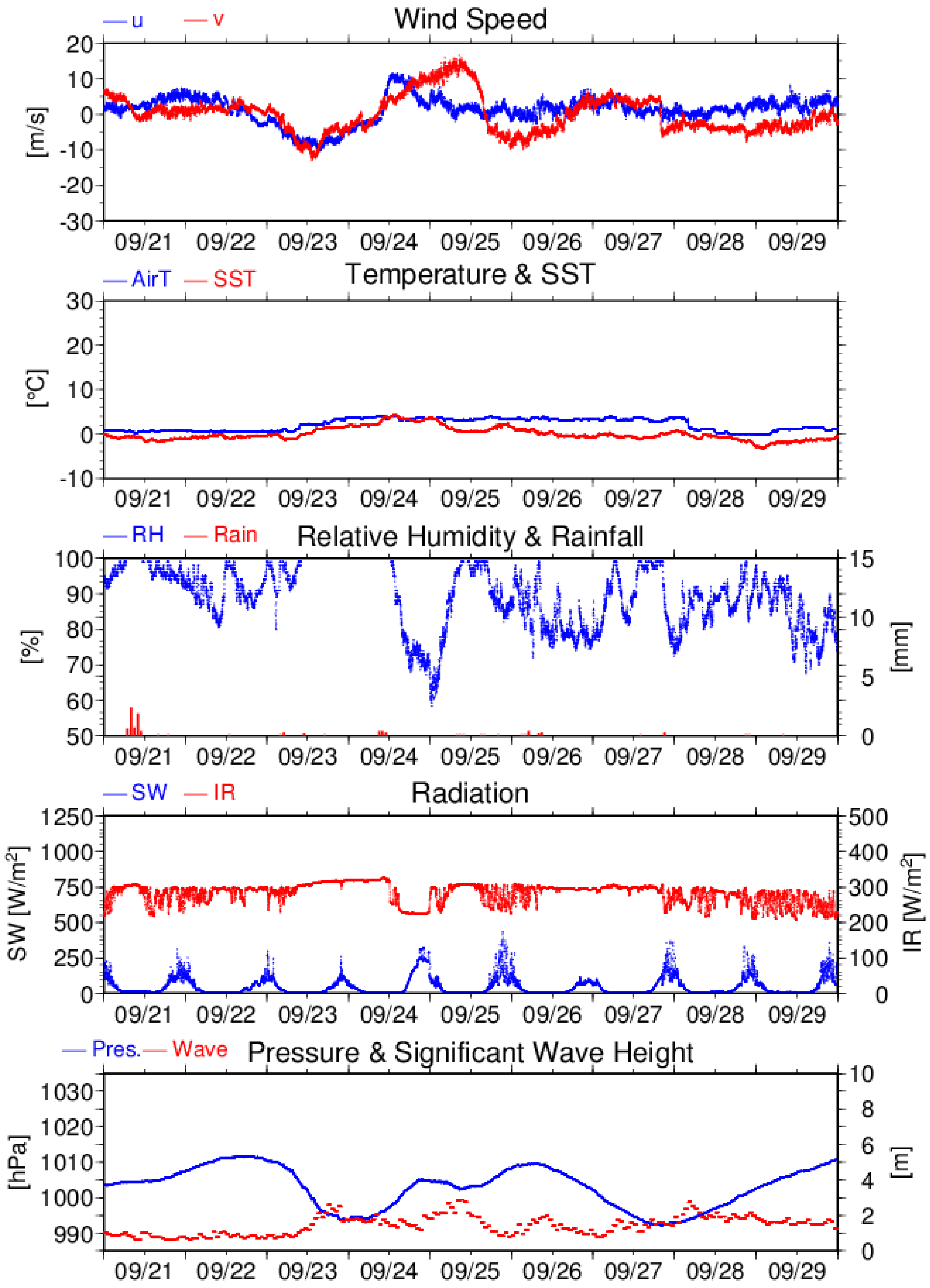


Fig. 2.1-1 (Continued)

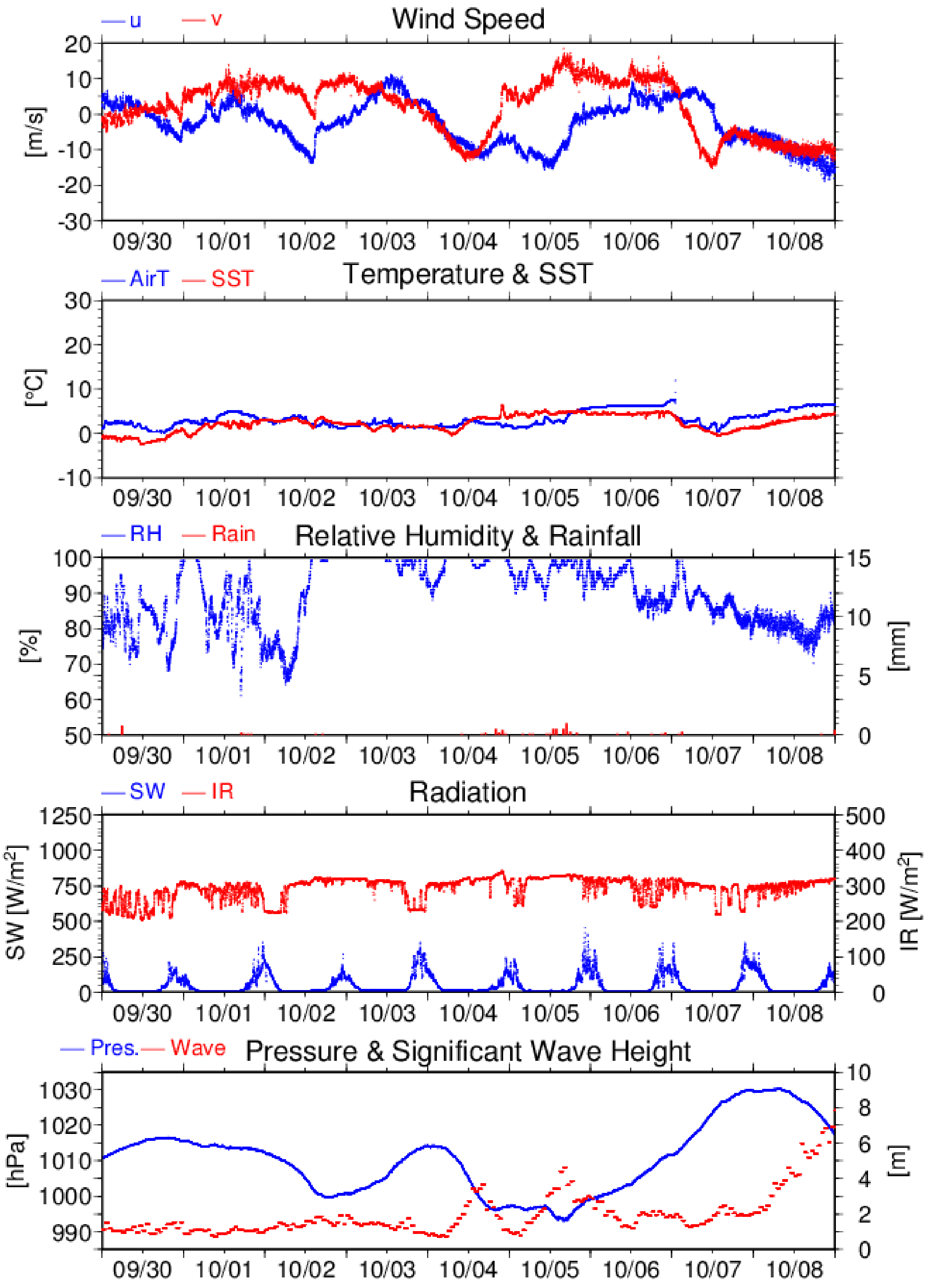


Fig. 2.1-1 (Continued)

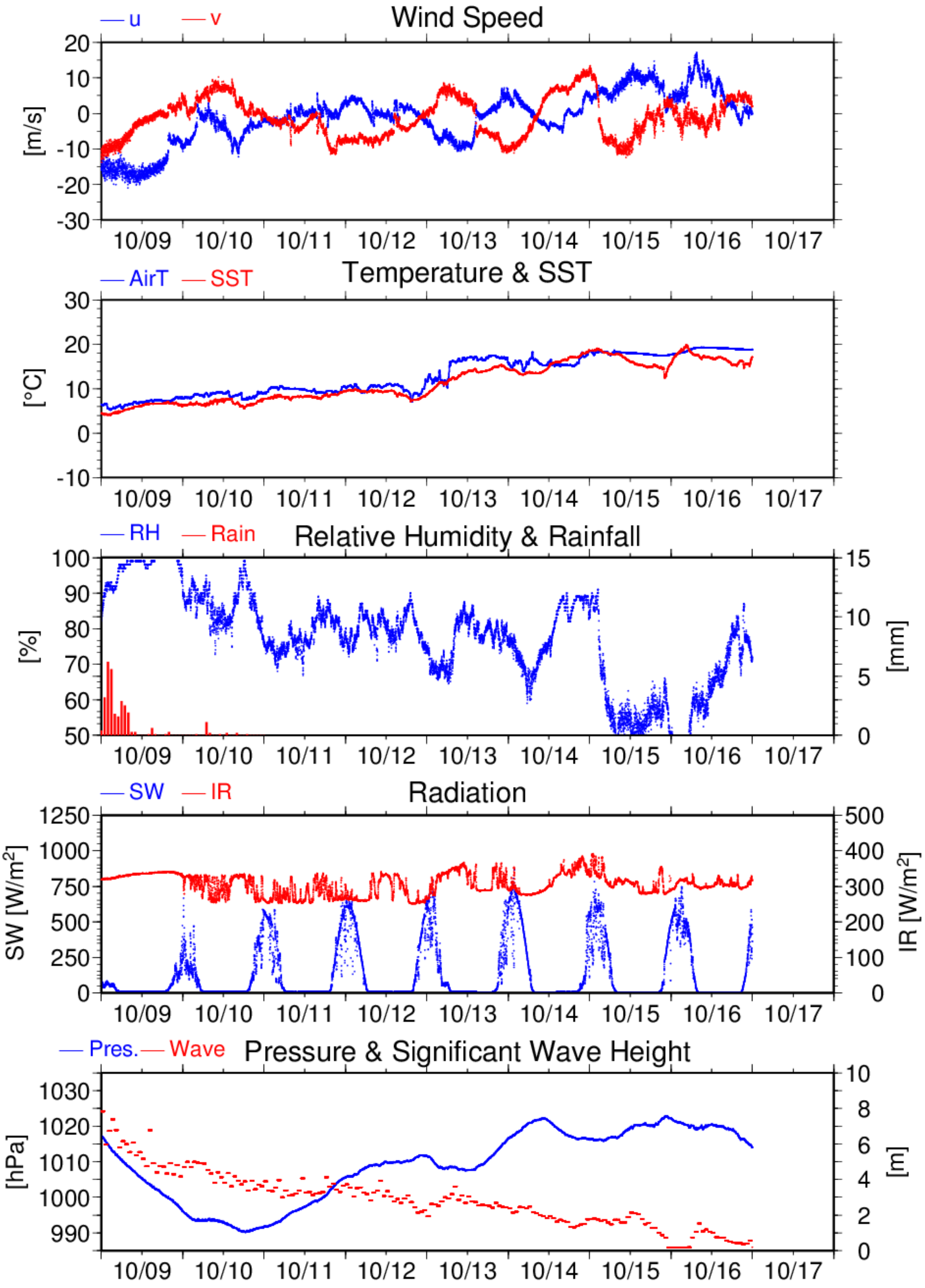


Fig. 2.1-1 (Continued)

2.2. Green house gasses

2.2.1 Shipboard measurements

(1) Personal

Shuji Aoki	Tohoku University: Principal Investigator
Daisuke Sasano	Meteorological Research Institute / JMA
Yasunori Tohjima	National Institute for Environmental Studies
Junji Matsushita	National Institute for Environmental Studies

(2) Objective

In arctic region, there are a lot of vulnerable carbon pools, which have the potential to become strong sources of CO_2 and CH_4 release into the atmosphere when the destabilization occurs through climate change. Therefore, it is important to understand the current situation of the greenhouse gas emissions around the arctic region. The purpose of present study is to observe the atmospheric CO_2 and CH_4 mixing ratios during the cruse, detect the enhanced mixing ratios associated with the regional emissions, and estimate the distribution of the regional emission sources. The atmospheric CO mixing ratios, which are also observed at the same time, can be used as an indicator of the anthropogenic emissions associated with the combustion processes.

(3) Parameters

Atmospheric CO_2, CH_4, and CO mixing ratios.

(4) Instruments and Methods

Atmospheric CO_2, CH_4, and CO mixing ratios were measured by a wavelength-scanned cavity ring-down spectrometer (WS-CRDS, Picarro, G2401). An air intake, capped with an inverted stainless steel beaker covered with stainless steel mesh, was placed on the left-side of the upper deck. A diaphragm pump (GAST, MOA-P108) was used to draw in the outside air at a flow rate of ~5 L min^{-1}. Water vapor in the sample air was removed to a dew pint of about 2°C and about -35°C by passing it through a thermoelectric dehumidifier (KELK, DH-109) and a Nafion drier (PERMA PURE, PD-50T-24), respectively. Then, the dried sample air was introduced into theWS-CRDS at a flow rate of 250 ml min^{-1}. The WS-CRDS were automatically calibrated every 24 hour by introducing 3 standard airs with known CO_2, CH_4 and CO mixing ratios. The analytical precisions for CO_2, CH_4, and CO mixing ratios are about 0.05 ppm, 0.3 ppb and 6 ppb, respectively.

(5) Observation log

The shipboard measurements were conducted during the entire cruse.

(6) Preliminary results

Temporal changes in the atmospheric CO_2, CH_4, and CO mixing ratios observed in the port of Sekine-hama on September 2, 2012 are plotted in Figure 2.2-1.

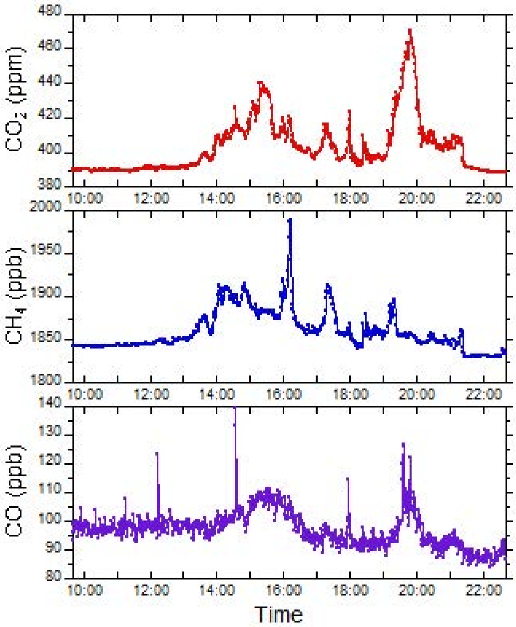


Fig. 2.2-1. Temporal variation of atmospheric (top) CO_2, (middle) CH_4 and (bottom) CO mixing ratios observed at the port of Sekine-hama on September 2, 2012.

(7) Data archives

The data of the atmospheric CO_2, CH_4 and CO mixing ratios with time (UTC) will be submitted to the Data Management Group (DMG) of JAMSTEC.

2.2.2 Whole air sampling

(1) Personal

Shuji Aoki	Tohoku University: Principal Investigator
Shigeyuki Ishidoya	National Institute of Advanced Industrial Science and Technology (AIST)
Shinji Morimoto	National Institute of Polar Research
Daisuke Sasano	Meteorological Research Institute / JMA

(2) Objective

In order to clarify space variations and air-sea exchanges of the green house gases at northern high latitude, air samples were corrected into 43 stainless-steel flasks on the Western North Pacific. The collected air samples will be analyzed for the concentrations of CO_2, O_2, Ar, CH_4, CO, N_2O and SF_6 and the isotopic ratios of CO_2 and CH_4.

(3) Parameters

Atmospheric CO_2 concentration, O_2/N_2 ratio (O_2 concentration), Ar/N_2 ratio (Ar concentration), CH_4 concentration, CO concentration, N_2O concentration, SF_6 concentartion, $\delta^{13}C$ of CO_2, $\delta^{18}O$ of CO_2, $\delta^{13}C$ of CH_4 and δD of CH_4.

(4) Instruments and Methods

The air sampling equipment consisted of an air intake, a piston pump (GAST LOA), a water trap, solenoid valves (CKD), an ethanol bath as refrigerant, a flow meter and an immersion cooler (EYELA ECS-80). Ambient air was pumped using a piston pump from an air intake and dried cryogenically, and filled into a 1 L stainless-steel flask at a pressure of 0.55 MPa.

(5) Observation log

Sampling No.	Date (UTC)	Time (UTC)	Position	
			Lat.	Long.
MR12-E03_AirFlask_A01	2012/09/05	01:06	40-23N	145-26E
MR12-E03_AirFlask_A02	2012/09/06	02:16	41-42N	152-01E
MR12-E03_AirFlask_A03	2012/09/07	03:50	45-07N	157-42E
MR12-E03_AirFlask_A04	2012/09/08	08:14	48-02N	162-30E
MR12-E03_AirFlask_A05	2012/09/09	08:21	51-15N	168-21E
MR12-E03_AirFlask_A06	2012/09/10	04:18	53-57N	173-15E
MR12-E03_AirFlask_A07	2012/09/11	01:26	56-25N	177-01E
MR12-E03_AirFlask_A08	2012/09/12	01:45	59-26N	178-11W
MR12-E03_AirFlask_A09	2012/09/13	00:51	63-14N	172-57W
MR12-E03_AirFlask_A10	2012/09/14	01:44	66-06N	168-45W
MR12-E03_AirFlask_A11	2012/09/15	02:34	68-05N	168-18W
MR12-E03_AirFlask_A12	2012/09/16	00:29	70-57N	168-45W
MR12-E03_AirFlask_A13	2012/09/17	02:58	74-16N	169-36W

MR12-E03_AirFlask_A14	2012/09/18	05:26	75-46N	173-31W
MR12-E03_AirFlask_A15	2012/09/19	07:05	75-15N	176-35W
MR12-E03_AirFlask_A16	2012/09/20	00:48	75-05N	170-56W
MR12-E03_AirFlask_A17	2012/09/22	07:55	75-00N	163-38W
MR12-E03_AirFlask_A18	2012/09/23	00:47	74-42N	163-37W
MR12-E03_AirFlask_A19	2012/09/24	04:46	72-52N	157-47W
MR12-E03_AirFlask_A20	2012/09/25	09:53	71-36N	157-22W
MR12-E03_AirFlask_A21	2012/09/26	06:58	71-49N	155-24W
MR12-E03_AirFlask_A22	2012/09/27	05:54	72-06N	154-30W
MR12-E03_AirFlask_A23	2012/09/28	05:16	72-40N	155-08W
MR12-E03_AirFlask_A24	2012/09/30	10:59	72-23N	159-04W
MR12-E03_AirFlask_A25	2012/10/01	02:38	71-16N	158-17W
MR12-E03_AirFlask_A26	2012/10/02	00:33	70-45N	166-44W
MR12-E03_AirFlask_A27	2012/10/02	09:12	70-10N	168-46W
MR12-E03_AirFlask_A28	2012/10/05	00:38	65-18N	168-01W
MR12-E03_AirFlask_A29	2012/10/07	05:34	64-22N	168-21W
MR12-E03_AirFlask_A30	2012/10/09	09:47	56-04N	176-00E
MR12-E03_AirFlask_A31	2012/10/09	20:43	54-37N	173-00E
MR12-E03_AirFlask_A32	2012/10/10	08:56	52-44N	170-16E
MR12-E03_AirFlask_A33	2012/10/11	02:42	50-07N	166-21E
MR12-E03_AirFlask_A34	2012/10/11	11:15	48-55N	164-18E
MR12-E03_AirFlask_A35	2012/10/11	21:54	47-29N	161-46E
MR12-E03_AirFlask_A36	2012/10/12	09:38	45-53N	159-02E
MR12-E03_AirFlask_A37	2012/10/12	23:40	43-58N	155-51E
MR12-E03_AirFlask_A38	2012/10/13	11:10	42-33N	153-34E
MR12-E03_AirFlask_A39	2012/10/14	08:00	40-25N	149-13E
MR12-E03_AirFlask_A40	2012/10/15	06:04	40-18N	143-59E

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

2.3. Aerosol optical characteristics measured by Ship-borne Sky radiometer

(1) Kazuma Aoki (University of Toyama) Principal Investigator / not onboard

(2) Objective

Objective of the observations in this aerosol is to study distribution and optical characteristics of marine aerosols by using a ship-borne sky radiometer (POM-01 MKII: PREDE Co. Ltd., Japan). Furthermore, collections of the data for calibration and validation to the remote sensing data were performed simultaneously.

(3) Methods and Instruments

Sky radiometer is measuring the direct solar irradiance and the solar aureole radiance distribution, has seven interference filters (0.34, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 μm). Analysis of these data is performed by SKYRAD.pack version 4.2 developed by Nakajima *et al.* 1996.

@ Measured parameters

- Aerosol optical thickness at five wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at five wavelengths
- Size distribution of volume (0.01 μm – 20 μm)

GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of sun. Horizon sensor provides rolling and pitching angles.

(3) Preliminary results

This study is not onboard. Data obtained in this cruise will be analyzed at University of Toyama.

(4) Data archives

Measurements of aerosol optical data are not archived so soon and developed, examined, arranged and finally provided as available data after certain duration. All data will archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) after the quality check and submitted to JAMSTEC.

2.4 Ceilometer

(1) Personnel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(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.

(3) Paramters

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

(4) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR12-E03 cruise.

Major parameters for the measurement configuration are as follows;

Laser source: Indium Gallium Arsenide (InGaAs) Diode
Transmitting wavelength: 905±5 mm 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).

(5) Preliminary results

Fig.2.4-1 shows the time series of the lowest, second and third cloud base height during the cruise.

(6) Data archives

The raw data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC.

(7) Remarks

1. Window cleaning;
    04:50UTC 03 Sep. 2012
    21:11UTC 09 Sep. 2012
    21:30UTC 16 Sep. 2012
    20:05UTC 23 Sep. 2012
    20:15UTC 30 Sep. 2012
    22:53UTC 09 Oct. 2012
    :UTC ** Oct. 2012

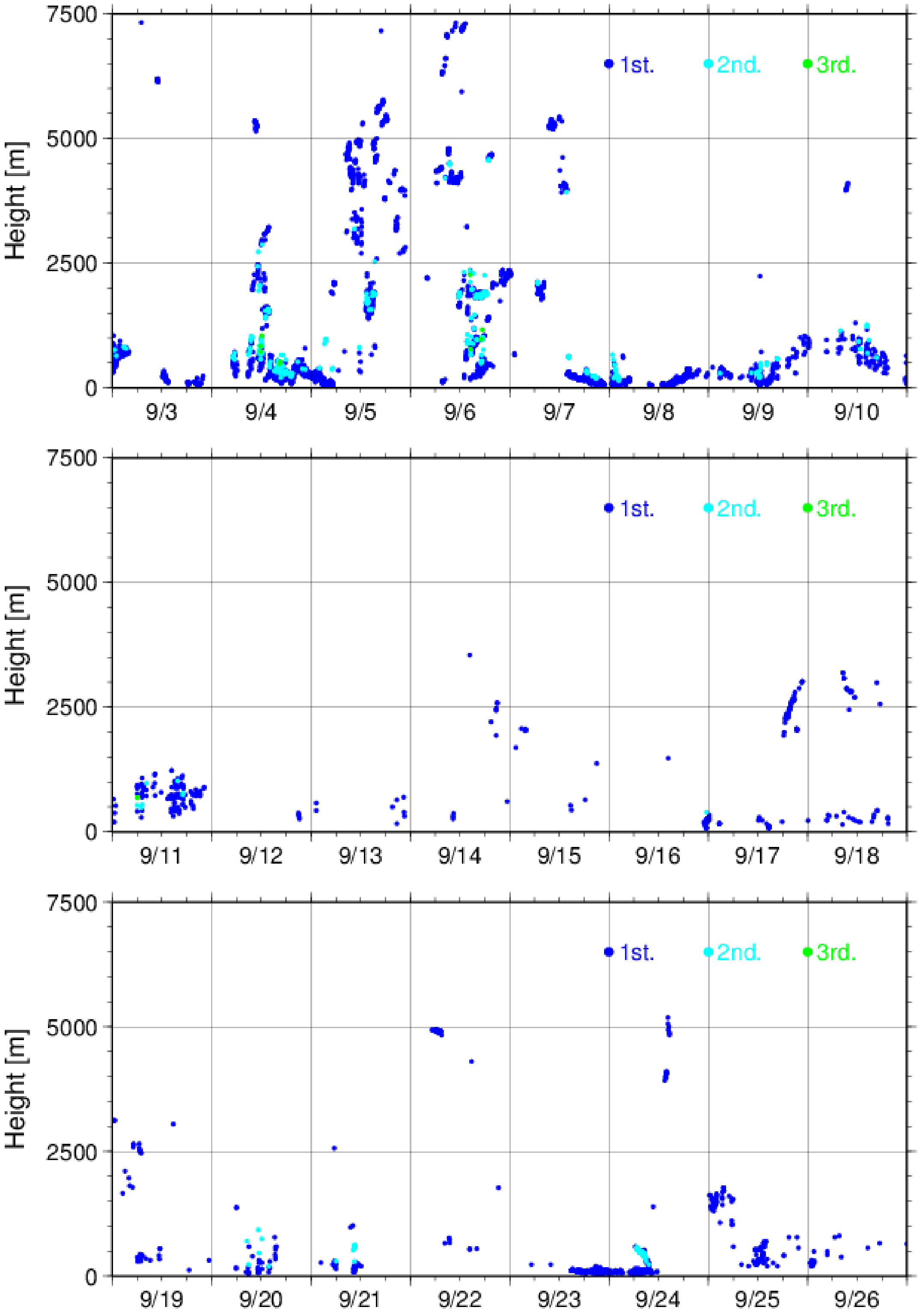


Fig. 2.4-1 Lowest, 2nd and 3rd cloud base height during the MR12-E03 cruise

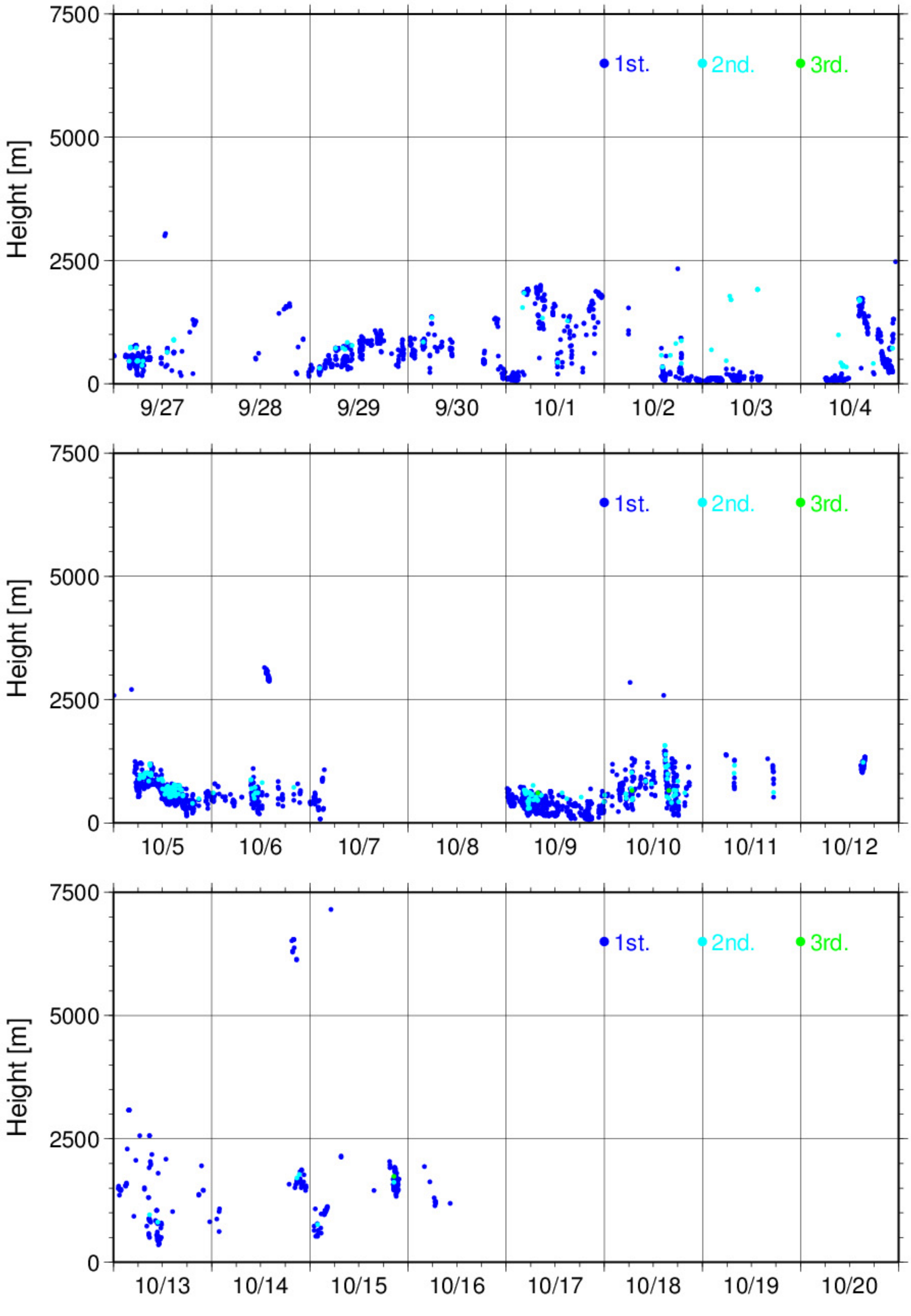


Fig. 2.4-1 (Continued)

3. Physical Oceanography

3.1. CTD cast and water samplings

(1) Personnel

Takashi Kikuchi	(JAMSTEC): Principal investigator
Shigeto Nishino	(JAMSTEC)
Shinsuke Toyoda	(MWJ): Operation leader
Naoko Miyamoto	(MWJ)
Toru Idai	(MWJ)
Kenichi Katauyama	(MWJ)
Tomoyuki Takamori	(MWJ)

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary and Secondary)
Transmission % and voltage
Fluorescence
Photosynthetically Active Radiation
Altimeter

(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 and 10-litter Niskin Bottles, which were washed by alkaline detergent and HCl, 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), transmission, fluorescence, PAR, deep ocean standards thermometer, and altimeter. The Practical 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.7.22) 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 stop at each layer for 30 seconds to stabilize then fire.

102 casts of CTD measurements were conducted (Table 3.1-1).

In the Stn.000, primary dissolved oxygen voltage was bad data. So we changed primary dissolved oxygen sensor with secondary dissolved oxygen sensor, and attached new secondary dissolved oxygen sensor.

In the Stn.001 - 004, secondary dissolved oxygen voltage was bad data. So we changed secondary dissolved oxygen sensor with the new sensor. But we handled the new sensor data as reference value, because it was calibrated in 2008.

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.22.0) and SEASOFT were as follows:

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. The duration was set to 4.4 seconds, and the offset was set to 0.0 seconds.

TCORP (original module): Corrected the pressure sensitivity of the temperature (SBE3) sensor.
S/N 03 1524: -2.5868e-007 (degC / dbar)
S/N 031359: -1.8386e-007 (degC / dbar)

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 4.4 seconds.

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. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensors and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 6 seconds advancing dissolved oxygen sensors output (dissolved oxygen voltage) relative to the temperature data. Transmission data and voltage 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 pressure, depth, temperature, conductivity and dissolved oxygen voltage.

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 backward

WFILTER: Perform a median filter to remove spikes in the fluorescence data, transmission data and voltage. 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.

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 and dissolved oxygen voltage.

DERIVE: Compute dissolved 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.

* Before SPLIT, we deleted the bottom data of some casts, which we judged the questionable data by BINAVG.

Configuration file

Stn.000 : MR12E03Acon
Stn.001 - 004: MR12E03B.con
Stn.005 - : MR12E03C.con

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system
  Under water unit:
    SBE9plus (S/N 09P54451-1027, Sea-Bird Electronics, Inc.)
      Pressure sensor: Digiquartz pressure sensor (S/N 117457)
        Calibrated Date: 23 Aug. 2012
    Temperature sensors:
      Primary: SBE03-04/F (S/N 031524, Sea-Bird Electronics, Inc.)
        Calibrated Date: 22 Jun. 2012
      Secondary: SBE03-04/F (S/N 031359, Sea-Bird Electronics, Inc.)
        Calibrated Date: 22 Jun. 2012
    Conductivity sensors:
      Primary: SBE04C (S/N 043036, Sea-Bird Electronics, Inc.)
        Calibrated Date: 26 Jun. 2012
      Secondary: SBE04-04/O (S/N 041206, Sea-Bird Electronics, Inc.)

Calibrated Date: 26 Jun. 2012

Dissolved Oxygen sensors:

Primary:

Stn.000: SBE43 (S/N 430394, Sea-Bird Electronics, Inc.)
Calibrated Date: 22 Jun. 2012

Stn.001 - : SBE43 (S/N 430330, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 May 2012

Secondary:

Stn.000: SBE43 (S/N 430330, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 May 2012

Stn.001 - 004: SBE43 (S/N 430205, Sea-Bird Electronics, Inc.)
Calibrated Date: 14 Apr. 2012

Stn.005 - : SBE43 (S/N 430575 Sea-Bird Electronics, Inc.)
Calibrated Date: 12 Feb. 2008

Transmissonmeter:

C-Star (S/N CST-1363DR, WET Labs, Inc.)
Calibrated Date: 25 Jul. 2012

Fluorescence:

Chlorophyll Fluorometer (S/N 3054, Seapoint Sensors, Inc.)

Photosynthetically Active Radiation:

PAR sensor (S/N 0049, Satlantic Inc.)
Calibrated Date: 22 Jan. 2009

Altimeter:

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

Deep Ocean Standards Thermometer:

SBE35 (S/N 0045, Sea-Bird Electronics, Inc.)
Calibrated Date: 15 Apr. 2012

Carousel water sampler:

SBE32 (S/N 3221746-0278, Sea-Bird Electronics, Inc.)

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

(5) Preliminary Results

During this cruise, 102 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 3.1-1.In some casts, we used a bottom contact sensor also.

In some casts, we judged noise or spike in the data. These were as follows.

000M01: Transmission; down 243 db - down 236 db (spike)
018M01: Primary temperature; down 26, 27 db (noise)
020M01: Primary salinity; down 30, 31 db (spike)
027M01: Primary salinity; down 37 db (spike)
033M01: Primary temperature and salinity; down 46 db (spike)
035M01: Primary temperature and salinity; down 158 db and 177 db and 190 db (spike)

Secondary temperature and salinity; down 20 db (spike)

037M01: Primary temperature and salinity; down 59 db and 60db (spike)

040M01: Primary temperature and salinity; down 205 db (spike)

047M01: Primary salinity; down 66 db (spike)

060M01: Primary temperature and salinity; down 15 db (spike)

093M01: Secondary temperature and salinity; down 6 db and 7db (noise)

(6) Data archive

All raw and processed data files will be submitted to Data Management Group (DMG) in JAMSTEC, and will be opened to public via “Data Research for Whole Cruise Information in JAMSTEC” in the JAMSTEC home page.

Table 3.1-1 MR12-E03 CTD casttable

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remark
		(mmddyy)	Start	End	Latitude	Longitude							
000	1	090712	22:07	00:17	47-37.86N	161-48.96E	5592.0	1980.7	-	1978.8	2005.0	000M01	test cast pri. D.O. sensor trouble
001	1	091312	18:29	18:51	65-38.99N	168-15.11W	43.0	31.4	6.3	36.6	37.0	001M01	changed D.O.sensors sec.D.O.sensor trouble
002	1	091312	20:41	20:46	65-42.14N	168-31.40W	54.0	45.0	6.0	47.5	48.0	002M01	sec.D.O.sensor trouble no sampling water
003	1	091312	21:55	22:12	65-46.25N	168-47.47W	52.0	42.6	6.1	45.5	46.0	003M01	sec.D.O.sensor trouble
004	1	091412	00:09	00:27	66-00.01N	168-45.04W	54.0	44.1	6.2	46.5	47.0	004M01	sec.D.O.sensor trouble
005	1	091412	03:39	03:56	66-30.09N	168-45.23W	55.0	41.9	7.2	46.5	47.0	005M01	changed sec.D.O. sensor
006	1	091412	07:04	07:17	67-00.04N	168-44.91W	45.0	33.4	8.4	36.6	37.0	006M01	
007	1	091412	10:11	10:22	67-30.11N	168-44.82W	50.0	38.2	7.6	41.6	42.0	007M01	
008	1	091412	12:24	12:38	67-45.00N	168-29.98W	50.0	39.8	6.6	42.6	43.0	008M01	
009	1	091412	14:34	14:40	67-52.50N	168-14.80W	58.0	47.4	5.5	50.5	51.0	009M01	no sampling water
010	1	091412	17:29	17:55	67-59.91N	168-00.10W	55.0	43.9	5.4	48.5	49.0	010M01	
011	1	091412	19:58	20:03	68-05.94N	167-40.24W	52.0	43.1	5.1	46.5	47.0	011M01	no sampling water
012	1	091412	21:14	21:29	68-11.98N	167-20.06W	48.0	38.2	5.5	41.6	42.0	012M01	
013	1	091412	22:35	22:39	68-14.98N	167-12.39W	45.0	36.3	5.1	39.6	40.0	013M01	no sampling water
014	1	091412	23:34	23:46	68-17.95N	167-03.04W	38.0	29.7	5.5	32.7	33.0	014M01	
015	1	091512	03:27	03:44	67-59.99N	168-44.87W	59.0	45.7	8.6	49.5	50.0	015M01	
016	1	091512	07:11	07:28	68-30.01N	168-44.96W	54.0	42.4	7.5	45.5	46.0	016M01	
017	1	091512	10:45	11:05	69-00.03N	168-45.15W	53.0	42.6	6.7	45.5	46.0	017M01	
018	1	091512	14:53	15:10	69-30.02N	168-45.01W	52.0	40.0	6.2	44.5	45.0	018M01	
019	1	091512	18:02	18:18	70-00.02N	168-44.90W	41.0	30.8	5.4	34.7	35.0	019M01	

020	1	091512	22:36	22:53	70-44.99N	168-44.81W	37.0	27.7	7.4	29.7	30.0	020M01	
021	1	091612	03:50	04:04	71-30.01N	168-44.87W	49.0	36.9	7.3	40.6	41.0	021M01	
022	1	091612	08:11	08:33	72-14.40N	168-44.32W	55.0	42.8	7.9	45.5	46.0	022M01	
023	1	091612	15:51	16:07	73-00.16N	168-35.98W	61.0	48.7	6.8	52.4	53.0	023M01	
024	1	091612	19:45	20:12	73-30.10N	168-44.81W	118.0	102.5	10.1	104.9	106.0	024M01	
025	1	091712	00:21	00:51	74-00.31N	168-46.10W	182.0	169.6	6.9	173.1	175.0	025M01	
027	1	091712	06:58	07:33	74-40.21N	170-55.48W	233.0	217.5	9.8	221.6	224.0	027M01	
028	1	091712	10:01	10:37	75-00.18N	172-00.17W	385.0	371.0	8.8	373.7	378.0	028M01	
029	1	091712	17:56	18:43	75-12.87N	172-34.93W	453.0	442.1	6.2	444.8	450.0	029M01	
029	2	091712	21:06	21:51	75-13.52N	172-37.18W	460.0	397.8	-	396.4	401.0	029M02	
030	1	091812	00:04	00:57	75-21.16N	172-46.48W	785.0	774.7	8.2	771.4	781.0	030M01	
031	1	091812	02:15	03:31	75-29.99N	173-01.47W	1262.0	1257.8	8.0	1246.1	1263.0	031M01	
032	1	091812	06:56	08:32	76-00.04N	174-00.60W	2137.0	2132.4	11.1	2120.6	2154.0	032M01	
033	1	091912	03:23	04:23	75-14.04N	177-30.40W	721.0	699.9	8.7	705.4	714.0	033M01	
034	1	091912	08:40	09:29	75-16.02N	175-30.23W	610.0	595.7	8.3	598.8	606.0	034M01	
035	1	091912	12:03	12:53	75-18.03N	174-00.65W	544.0	529.0	7.1	528.8	535.0	035M01	
036	1	092012	02:17	02:51	74-59.98N	170-00.47W	262.0	244.5	10.2	248.2	251.0	036M01	
037	1	092012	06:23	06:51	74-59.96N	168-00.09W	167.0	151.4	10.0	157.3	159.0	037M01	
038	1	092012	09:55	10:39	74-59.97N	166-00.26W	487.0	473.9	6.7	476.4	482.0	038M01	
039	1	092012	17:48	18:28	75-00.26N	161-53.82W	1987.0	243.6	-	247.3	250.0	039M01	
039	2	092112	02:52	04:17	75-00.08N	162-00.79W	1971.0	1961.2	9.1	1959.0	1989.0	039M02	
040	1	092212	05:34	06:51	74-59.98N	162-59.94W	1787.0	1779.4	8.4	1776.6	1803.0	040M01	
041	1	092212	08:26	09:16	74-59.98N	164-00.07W	690.0	676.4	8.5	676.8	685.0	041M01	
042	1	092312	02:08	03:17	74-36.04N	163-29.87W	1096.0	1085.0	8.1	1084.7	1099.0	042M01	
043	1	092312	06:20	07:23	74-10.15N	162-19.99W	984.0	972.2	9.0	970.5	983.0	043M01	
044	1	092312	11:45	13:09	73-48.57N	161-01.86W	1552.0	1554.2	9.2	1548.9	1571.0	044M01	

045	1	092312	17:16	17:58	73-20.08N	160-01.25W	1390.0	242.9	-	248.3	251.0	045M01	
045	2	092312	19:50	20:58	73-20.63N	160-02.79W	1388.0	1374.6	7.2	1374.1	1393.0	045M02	
046	1	092412	00:28	01:41	73-00.14N	158-40.30W	1249.0	1231.7	12.1	1230.5	1247.0	046M01	
047	1	092412	06:51	07:56	72-49.19N	157-23.67W	1008.0	997.0	10.6	995.2	1008.0	047M01	
048	1	092412	11:23	12:55	72-30.13N	156-00.38W	1896.0	1882.9	9.4	1880.8	1909.0	048M01	
049	1	092412	20:44	20:56	71-14.93N	157-09.37W	49.0	35.2	7.0	39.6	40.0	049M01	
050	1	092412	21:46	21:51	71-17.30N	157-15.07W	59.0	47.9	7.3	50.5	51.0	050M01	no sampling water
051	1	092412	22:39	23:03	71-19.58N	157-19.98W	92.0	79.0	7.4	82.1	83.0	051M01	
052	1	092512	00:04	00:10	71-22.26N	157-24.23W	111.0	100.7	7.1	103.9	105.0	052M01	no sampling water
053	1	092512	00:48	01:12	71-24.84N	157-29.21W	124.0	112.4	8.1	115.8	117.0	053M01	
054	1	092512	05:16	05:23	71-27.27N	157-34.22W	109.0	97.2	7.6	103.9	105.0	054M01	no sampling water
055	1	092512	06:00	06:21	71-29.70N	157-39.33W	87.0	73.3	5.6	81.2	82.0	055M01	
056	1	092512	07:17	07:22	71-32.15N	157-44.74W	75.0	56.7	10.3	60.4	61.0	056M01	no sampling water
057	1	092512	08:00	08:14	71-34.65N	157-50.42W	66.0	52.3	8.5	55.4	56.0	057M01	
058	1	092712	14:06	14:19	71-36.45N	154-50.16W	44.0	33.2	7.5	35.6	36.0	058M01	
059	1	092712	15:21	15:42	71-41.01N	154-57.71W	108.0	95.7	6.8	100.0	101.0	059M01	
060	1	092712	17:16	17:51	71-44.05N	155-07.14W	257.0	248.0	6.1	251.3	254.0	060M01	
060	2	092712	19:43	20:06	71-43.77N	155-07.36W	249.0	242.5	6.8	243.4	246.0	060M02	
061	1	092712	20:56	21:23	71-48.73N	155-17.63W	194.0	180.2	8.6	183.0	185.0	061M01	
062	1	092712	23:00	23:24	71-55.88N	155-39.64W	139.0	126.0	8.1	129.6	131.0	062M01	
063	1	092812	00:34	00:54	71-59.96N	156-00.06W	125.0	114.4	5.9	118.7	120.0	063M01	
064	1	092812	17:20	19:42	74-29.97N	153-59.89W	3852.0	3844.9	9.2	3835.1	3911.0	064M01	
064	2	092912	00:49	03:34	74-29.92N	154-00.24W	3851.0	3844.9	10.1	3834.1	3910.0	064M02	
065	1	092912	06:46	09:22	73-59.94N	155-12.47W	3855.0	3845.8	9.3	3838.1	3914.0	065M01	
066	1	092912	12:33	14:49	73-29.95N	156-24.20W	3684.0	3680.4	9.7	3672.0	3743.0	066M01	
066	2	092912	17:00	19:33	73-29.53N	156-24.69W	3684.0	3684.1	9.3	3672.9	3744.0	066M02	

067	1	092912	22:38	23:52	73-05.23N	157-24.12W	2461.0	2461.5	5.5	2456.7	2497.0	067M01	no sampling water
068	1	093012	03:19	04:43	72-51.92N	157-57.88W	1573.0	1563.0	9.6	1560.8	1583.0	068M01	
069	1	093012	06:59	07:31	72-44.89N	158-11.93W	312.0	297.5	9.0	300.7	304.0	069M01	
070	1	093012	09:19	09:37	72-29.99N	158-47.93W	55.0	42.4	8.5	45.5	46.0	070M01	
071	1	093012	11:53	12:08	72-14.95N	159-23.91W	49.0	37.3	7.5	40.6	41.0	071M01	
072	1	093012	17:45	18:02	72-00.01N	159-59.83W	30.0	16.5	8.4	20.8	21.0	072M01	
073	1	100112	09:00	09:14	70-45.00N	160-59.84W	45.0	31.2	8.3	35.6	36.0	073M01	
074	1	100112	11:17	11:35	70-44.99N	161-59.66W	43.0	31.4	7.5	34.6	35.0	074M01	
075	1	100112	13:52	14:04	70-44.99N	162-59.52W	44.0	32.5	7.1	36.6	37.0	075M01	
076	1	100112	17:51	18:08	70-44.99N	163-59.75W	47.0	36.2	7.0	39.6	40.0	076M01	
077	1	100112	20:34	20:46	70-44.88N	165-00.04W	42.0	31.0	7.8	33.7	34.0	077M01	
078	1	100112	22:41	22:56	70-44.95N	165-59.97W	40.0	29.0	6.1	33.7	34.0	078M01	
079	1	100212	01:24	01:39	70-45.07N	166-59.48W	49.0	36.7	8.1	39.6	40.0	079M01	
080	1	100212	03:35	03:54	70-45.07N	167-59.78W	48.0	35.2	6.9	39.6	40.0	080M01	
081	1	100212	05:52	06:03	70-45.07N	168-44.46W	38.0	25.7	7.6	29.7	30.0	081M01	
082	1	100312	11:03	11:20	68-40.06N	168-45.02W	54.0	41.9	6.7	45.5	46.0	082M01	
083	1	100312	12:50	13:04	68-30.10N	168-45.04W	54.0	41.7	7.5	45.5	46.0	083M01	
084	1	100312	14:02	14:15	68-22.54N	168-44.96W	56.0	41.9	8.4	46.5	47.0	084M01	
085	1	100312	15:13	15:30	68-15.02N	168-44.95W	57.0	44.4	6.6	49.5	50.0	085M01	
086	1	100312	16:43	16:56	68-07.44N	168-44.93W	59.0	44.6	8.4	49.5	50.0	086M01	
087	1	100312	19:08	19:23	68-00.00N	167-59.79W	55.0	44.4	6.3	47.5	48.0	087M01	
088	1	100312	20:35	20:55	68-00.02N	168-22.58W	59.0	46.6	7.6	50.5	51.0	088M01	
089	1	100312	22:04	22:21	67-59.92N	168-44.94W	59.0	48.3	6.8	51.5	52.0	089M01	
090	1	100412	00:04	00:18	67-52.49N	168-45.13W	51.0	41.1	7.3	44.6	45.0	090M01	
091	1	100412	01:24	01:38	67-45.00N	168-45.00W	51.0	40.6	6.2	43.6	44.0	091M01	
092	1	100412	03:00	03:14	67-37.45N	168-44.82W	51.0	36.7	8.9	40.6	41.0	092M01	

093	1	100412	04:18	04:34	67-30.01N	168-45.11W	51.0	36.3	9.9	39.6	40.0	093M01	
094	1	100412	19:02	19:12	65-46.33N	168-47.31W	53.0	40.4	8.1	43.6	44.0	094M01	
095	1	100412	20:44	20:56	65-42.27N	168-31.18W	56.0	44.4	7.1	47.5	48.0	095M01	
096	1	100412	22:03	22:13	65-39.07N	168-15.19W	45.0	33.4	7.0	36.6	37.0	096M01	

3.2. Salinity measurements

(1)Personnel

Takashi Kikuchi (JAMSTEC): Principal investigator
Shigeto Nishino (JAMSTEC)
Kenichi Katayama (MWJ)

(2)Objective

To provide calibrations for the measurements of salinity collected from CTD and TSG (Underway surface water monitoring).

(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 TSG. The salinity sample bottle of 250ml brown glass 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 TSG were sealed with a plastic insert thimble and a screw cap because we took into consideration the possibility of storage for about a month. The thimble was rinsed 3 times with the sample water before use. The bottle was stored for more than 24 hours in the laboratory before the salinity measurement.

Types and numbers (n) of the samples are shown in Table 3.2-1.

Table 3.2-1. Types and numbers (n) of samples

Types	N
Samples for CTD and bucket	1042
Samples for TSG	42
Total	1084

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR12-E03 using the salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.).

One pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored the 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 24 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 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by the 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 of these two fillings being smaller than 0.00002, 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 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, the operator measured a ninth or tenth filling of the cell and calculated the bottle salinity above. The cell was cleaned with detergent after the measurement of the day.

(5) Results

a. Standard Seawater (SSW)

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

Batch	: P153
conductivity ratio	: 0.99979
salinity	: 34.992
expiration date	: 8th March 2014

Standardization control of the salinometer S/N 62556 was set to 680 (6th Sep.) and all measurements were carried out at this setting. The value of STANDBY was 5190 +/- 0001 and that of ZERO was 0.0-0001 +/- 0001. 50 bottles of SSW were measured.

Fig.3.2-1 shows the history of the double conductivity ratio of the Standard

Seawater batch P153 before correction. The average of the double conductivity ratio was 1.99954 and the standard deviation was 0.00002, which is equivalent to 0.0003 in salinity.

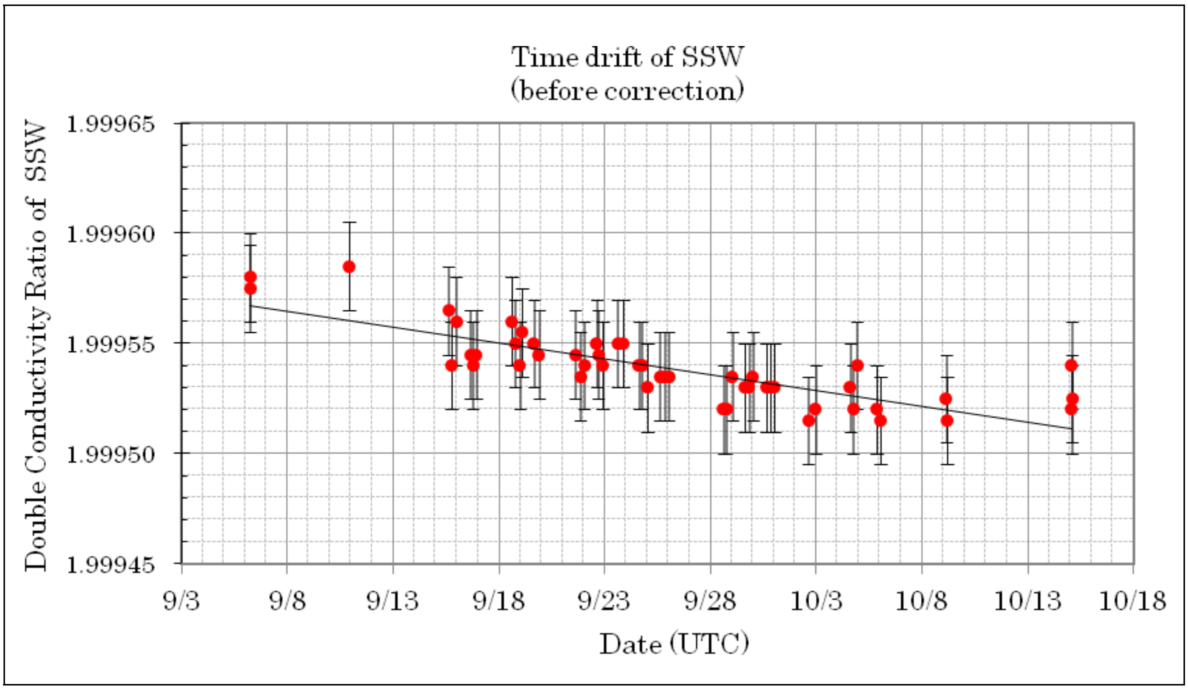


Fig. 3.2-1 History of double conductivity ratio for the Standard Seawater batch P153 (before correction)

Fig.3.2-2 shows the history of the double conductivity ratio of the Standard Seawater batch P153 after correction. The average of the double conductivity ratio after correction was 1.99958 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

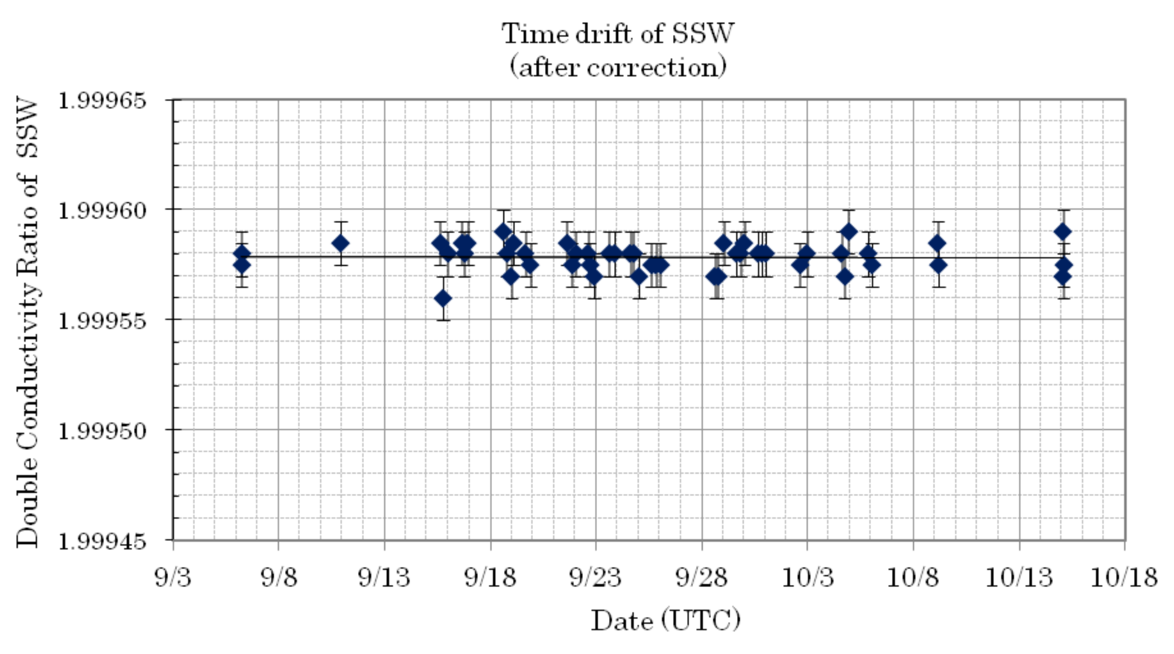


Fig. 3.2-2 History of double conductivity ratio for the Standard Seawater batch P153 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from surface-sea water (poor in nutrient) filtered by a pore size of 0.22 micrometer and stored in a 20 liter container made of polyethylene and stirred for at least 24 hours before measuring. It was measured between every station in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 181 pairs of replicate samples taken from the same Niskin bottle.

122 pairs of replicate samples were to estimate the precision of shallow (<200dbar) samples. Fig.3.2-3 shows the histogram of the absolute difference between each pair of shallow (<200dbar) replicate samples. The average and the standard deviation of absolute difference among 122 pairs were 0.002 and 0.006 in salinity, respectively.

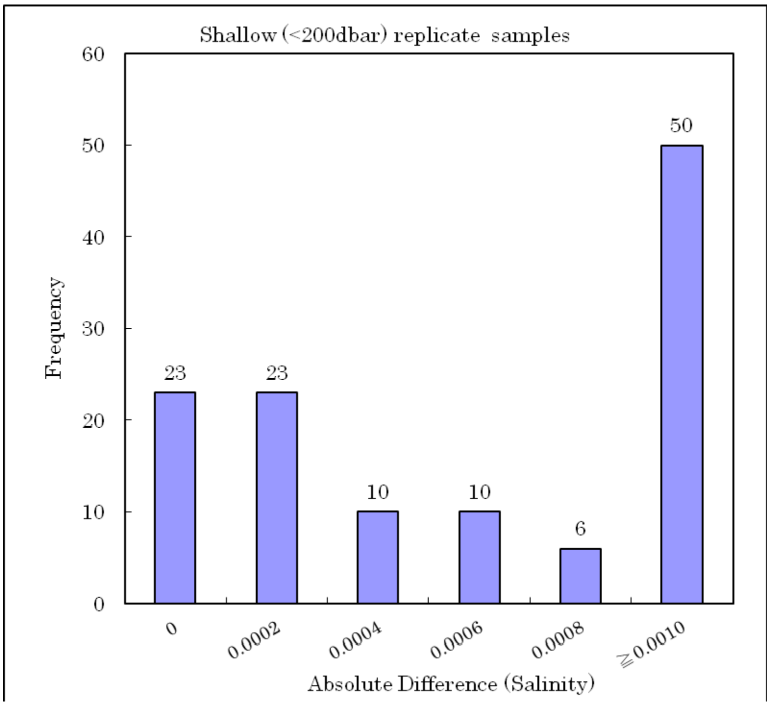


Fig. 3.2-3 Histogram of the Absolute Difference between Shallow (<200dbar) Replicate Samples

59 pairs of replicate samples were to estimate the precision of deep (>200dbar) samples. Fig.3.2-4 shows the histogram of the absolute difference between each pair of deep (>200dbar) replicate samples. The average and the standard deviation of absolute difference among 59 pairs were 0.0002 and 0.0003 in salinity, respectively.

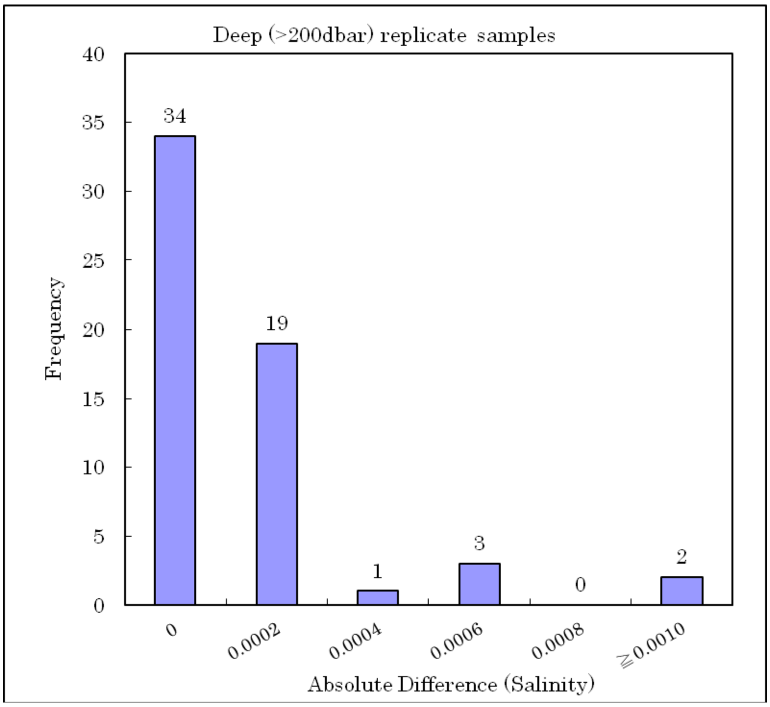


Fig. 3.2-4 Histogram of the Absolute Difference between Deep (>200dbar) Replicate Samples

d. Data Correction for Samples

All data were corrected according to the result of the offset correction for SSW.

(6) Data archives

a. Data Policy

These raw datasets will be submitted to JAMSTEC Data Management Office (DMO) and corrected datasets are available from Mirai Web site.

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

3.3. XCTD

(1) Personnel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

Investigation of oceanic structure.

(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 manufactured by Tsurumi-Seiki Co.. The signal was converted by digital converter MK-150N, and was recorded by AL-12B software (Ver.1.1.4). We launched 63 probes (XCTD-1～XCTD-63) by using automatic launcher. The summary of XCTD observation log is shown in Table 3.3-1.

(5) Observation log

Table3.3-1 XCTD observation log

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [degN]	Longitude [degW]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
1	XCTD-1	2012/09/17	03:12	74-20.08	169-50.00	183	0.650	25.361	11125785
2	XCTD-2	2012/09/18	05:10	75-44.92	173-30.10	1837	-0.404	25.677	11125786
3	XCTD-3	2012/09/18	20:48	75-15.10	173-15.89	423	-0.300	26.824	12036652
4	XCTD-4	2012/09/18	23:55	75-16.99	174-45.38	533	-0.292	26.615	11125644
5	XCTD-5	2012/09/19	02:00	75-15.11	176-30.16	718	-0.195	26.816	11125643
6	XCTD-6	2012/09/20	11:54	75-00.01	165-20.07	531	0.049	25.860	11125793

Table3.3-1 Continued

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [degN]	Longitude [degW]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
7	XCTD-7	2012/09/20	12:47	74-59.99	164-40.05	549	0.294	25.433	11125795
8	XCTD-8	2012/09/20	13:41	75-00.00	163-59.98	688	0.409	25.434	11125790
9	XCTD-9	2012/09/20	14:38	74-59.96	163-30.04	1610	0.757	25.406	11125787
10	XCTD-10	2012/09/20	15:04	75-00.09	162-59.70	1791	0.773	25.497	11125792
11	XCTD-11	2012/09/20	15:45	75-00.02	162-29.93	1892	0.793	25.573	11125789
12	XCTD-12	2012/09/21	09:47	74-52.00	159-59.99	1794	0.383	25.365	12036658
13	XCTD-13	2012/09/21	11:08	74-51.96	160-44.99	1035	0.687	25.412	12036655
14	XCTD-14	2012/09/21	12:27	74-52.02	161-29.97	1945	0.674	25.233	11125796
15	XCTD-15	2012/09/22	23:31	74-47.99	163-44.47	1210	0.491	25.436	11125791
16	XCTD-16	2012/09/23	04:29	74-27.99	163-07.23	1106	0.951	25.766	12036653
17	XCTD-17	2012/09/23	05:10	74-18.97	162-43.99	1130	1.160	25.835	11125788
18	XCTD-18	2012/09/23	08:40	74-03.01	161-54.06	433	1.114	25.969	12036659
19	XCTD-19	2012/09/23	09:38	73-55.00	161-27.17	355	1.944	26.746	11125794
20	XCTD-20	2012/09/23	14:27	73-38.99	160-40.34	1322	1.982	26.377	12036651
21	XCTD-21	2012/09/23	15:34	73-29.99	160-19.98	1818	2.098	26.302	12036656
22	XCTD-22	2012/09/23	22:06	73-13.98	159-33.99	1087	3.545	26.767	12036654
23	XCTD-23	2012/09/23	23:06	73-06.98	159-06.99	1181	3.504	26.891	11125713
24	XCTD-24	2012/09/24	03:47	72-56.00	158-13.89	1579	3.560	28.582	11125714
25	XCTD-25	2012/09/24	04:38	72-51.99	157-46.98	1519	3.728	28.593	12036657
26	XCTD-26	2012/09/24	09:11	72-42.00	156-54.03	1108	4.053	27.197	12036660
27	XCTD-27	2012/09/24	10:11	72-35.03	156-26.96	1971	4.076	27.015	11125715
28	XCTD-28	2012/09/26	02:19	71-36.53	154-50.80	41	3.835	28.857	11125722
29	XCTD-29	2012/09/26	02:53	71-38.48	154-55.07	58	3.472	29.921	11125723
30	XCTD-30	2012/09/26	03:38	71-40.54	155-00.41	111	3.376	29.984	11125721
31	XCTD-31	2012/09/26	04:14	71-41.91	155-05.04	169	3.268	30.141	11125719
32	XCTD-32	2012/09/26	04:57	71-43.55	155-10.99	281	3.245	30.301	11125716
33	XCTD-33	2012/09/26	05:42	71-45.91	155-16.15	212	3.572	29.782	11125717
34	XCTD-34	2012/09/26	06:17	71-47.85	155-20.34	168	3.825	29.245	11125720
35	XCTD-35	2012/09/26	07:38	71-52.00	155-29.70	154	3.796	29.063	11125718
36	XCTD-36	2012/09/26	08:58	71-55.90	155-39.48	139	3.665	28.998	11125799
37	XCTD-37	2012/09/27	05:13	72-09.97	154-29.99	1453	4.012	26.048	11125806
38	XCTD-38	2012/09/27	05:50	72-05.00	154-30.05	1428	3.859	26.060	11125804
39	XCTD-39	2012/09/27	06:29	72-00.01	154-30.03	428	3.836	26.565	11125800
40	XCTD-40	2012/09/27	07:09	71-55.00	154-30.01	195	3.130	30.059	11125797
41	XCTD-41	2012/09/27	07:49	71-50.01	154-29.97	172	3.144	29.860	11125803
42	XCTD-42	2012/09/27	08:28	71-45.01	154-29.97	101	3.120	29.148	11125805
43	XCTD-43	2012/09/27	09:04	71-40.00	154-30.05	46	3.274	29.110	11125801
44	XCTD-44	2012/09/27	14:51	71-38.65	154-54.14	58	3.496	28.692	11125808
45	XCTD-45	2012/09/27	16:24	71-42.43	155-01.85	162	3.354	28.923	11125802
46	XCTD-46	2012/09/27	20:30	71-46.38	155-13.11	237	3.251	29.085	11125807

Table3.3-1 Continued

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [degN]	Longitude [degW]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
47	XCTD-47	2012/09/27	22:11	71-52.36	155-29.45	156	3.557	26.839	11125798
48	XCTD-48	2012/09/28	02:19	72-10.00	155-47.63	290	3.648	26.364	10121328
49	XCTD-49	2012/09/28	02:46	72-15.00	155-41.26	751	3.500	26.477	10121320
50	XCTD-50	2012/09/28	03:14	72-20.01	155-34.41	1331	3.168	26.345	10121326
51	XCTD-51	2012/09/28	03:42	72-24.99	155-27.71	1698	2.826	26.011	10121323
52	XCTD-52	2012/09/28	04:10	72-29.99	155-21.10	2159	1.615	25.413	10121329
53	XCTD-53	2012/09/28	04:53	72-37.51	155-11.26	2648	1.624	25.404	10121327
54	XCTD-54	2012/09/28	05:36	72-44.99	155-01.23	3081	1.091	25.111	10121318
55	XCTD-55	2012/09/28	07:03	73-00.02	154-41.05	3559	0.963	25.046	10121321
56	XCTD-56	2012/09/28	08:26	73-14.99	154-20.77	3852	1.180	25.060	11125647
57	XCTD-57	2012/09/28	09:48	73-29.99	154-00.16	3853	1.256	25.319	11125645
58	XCTD-58	2012/09/28	11:07	73-45.00	153-59.97	3854	1.352	25.493	11125646
59	XCTD-59	2012/09/28	12:44	74-00.00	153-59.85	3847	0.402	24.783	12036662
60	XCTD-60	2012/09/28	14:34	74-15.00	153-59.57	3854	0.323	24.835	10121314
61	XCTD-61	2012/09/29	05:05	74-15.01	154-36.29	3860	0.479	24.889	10121319
62	XCTD-62	2012/09/29	10:52	73-45.01	155-48.30	3809	1.141	25.550	10121325
63	XCTD-63	2012/09/29	21:10	73-15.00	157-00.27	3154	0.886	24.937	10121322

Acronyms in Table XCTD observation log are as follows;

Depth: Water Depth [m]
SST: Sea Surface Temperature [deg-C] measured by TSG (ThermoSalinoGraph).
SSS: Sea Surface Salinity [PSU] measured by TSG.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

3.4. Shipboard ADCP

(1) Personnel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

To obtain continuous measurement of the current profile along the ship's track.

(3) Methods

Upper ocean current measurements were made in MR12-E03 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation in the Arctic Ocean, bottom-tracking mode, interleaved bottom-ping with water-ping, was made 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 76.8 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) DGPS system (Trimble SPS751 & StarFixXP) providing position fixes.
4) We used VmDas version 1.46.5 (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 propylene glycol into the fresh water to prevent freezing in the sea chest.
7) The sound speed at the transducer 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).

Data was configured for 4 m intervals and 4 m blanking distance starting 15 m below the surface, 4 m intervals and 8 m blanking distance starting 19 m below the surface, and 8 m intervals and 8 m blanking distance starting 23 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. Major parameters for the measurement (Direct Command) are shown in Table 3.4-1.

(4) Preliminary results

Fig 3.4-1 and Fig 3.4-2 shows the current vector along the ship's track in the SCH and BC North area.

(5) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

Table 3.4-1 Major parameters

Bottom-Track Commands

BP = 000	Pings per Ensemble (almost over 1300m depth)
	04 Sep. 2012 12:46UTC – 09 Sep. 2012 21:34UTC
	09 Sep. 2012 22:20UTC – 11 Sep. 2012 22:56UTC
	20 Sep. 2012 14:30UTC – 23 Sep. 2012 01:53UTC
	28 Sep. 2012 03:19UTC – 30 Sep. 2012 06:04UTC
	08 Oct. 2012 14:36UTC – 10 Oct. 2012 05:12UTC
	10 Oct. 2012 07:02UTC – 15 Oct. 2012 12:16UTC
BP = 001	Pings per Ensemble (almost less than 1300m depth)
	03 Sep. 2012 06:36UTC – 04 Sep. 2012 12:45UTC
	09 Sep. 2012 21:35UTC – 09 Sep. 2012 22:19UTC
	11 Sep. 2012 22:57UTC – 20 Sep. 2012 14:29UTC
	23 Sep. 2012 01:55UTC – 28 Sep. 2012 03:18UTC
	30 Sep. 2012 06:06UTC – 08 Oct. 2012 14:35UTC
	10 Oct. 2012 05:13UTC – 10 Oct. 2012 07:02UTC
	15 Oct. 2012 12:16UTC – 17 Oct. 2012 00:00UTC

Environmental Sensor Commands

EA = +04500	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)

ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1020001	Sensor Source (C; D; H; P; R; S; T; U)
	C (1): Sound velocity calculates using ED, ES, ET (temp.)
	D (0): Manual ED
	H (2): External synchro
	P (0), R (0): Manual EP, ER (0 degree)
	S (0): Manual ES
	T (1): Internal transducer sensor
	U (0): Manual EU

Timing Commands

TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)

Water-Track Commands

WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (V; C; A; PG; St; Vsum; Vsum^2;#G;P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0400	Blank After Transmit (cm)
	13 Sep. 2012 17:47UTC – 23 Sep. 2012 01:53UTC
WF = 0800	Blank After Transmit (cm)
	03 Sep. 2012 06:36UTC – 13 Sep. 2012 17:46UTC
	23 Sep. 2012 01:55UTC – 17 Oct. 2012 00:00UTC
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0 = OFF, 1 = ON)
WJ = 1	Rcvr Gain Select (0 = Low, 1 = High)
WM = 1	Profiling Mode (1-8)
WN = 100	Number of depth cells (1-100)
	03 Sep. 2012 06:36UTC – 07 Sep. 2012 00:59UTC
	23 Sep. 2012 01:55UTC – 17 Oct. 2012 00:00UTC
WN = 128	Number of depth cells (1-128)
	07 Sep. 2012 00:59UTC – 23 Sep. 2012 01:53UTC
WP = 00001	Pings per Ensemble (0-16384)
WS =0400	Depth Cell Size (cm)

07 Sep. 2012 00:59UTC – 23 Sep. 2012 01:53UTC

WS =0800 Depth Cell Size (cm)

03 Sep. 2012 06:36UTC – 07 Sep. 2012 00:59UTC

23 Sep. 2012 01:55UTC – 17 Oct. 2012 00:00UTC

WT = 000 Transmit Length (cm) [0 = Bin Length]

WV = 0390 Mode 1 Ambiguity Velocity (cm/s radial)

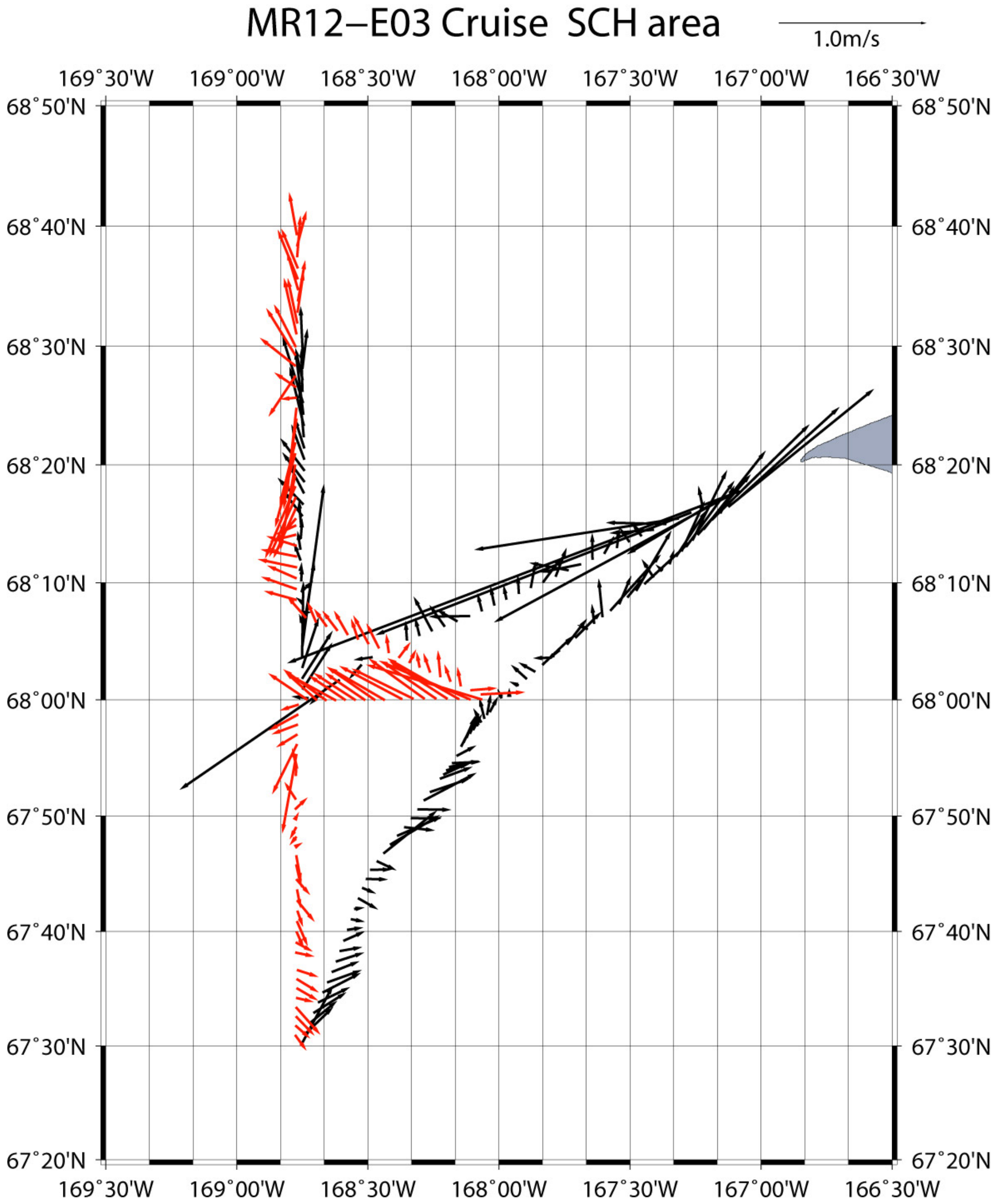


Fig 3.4-1 The current vector in the SCH area.

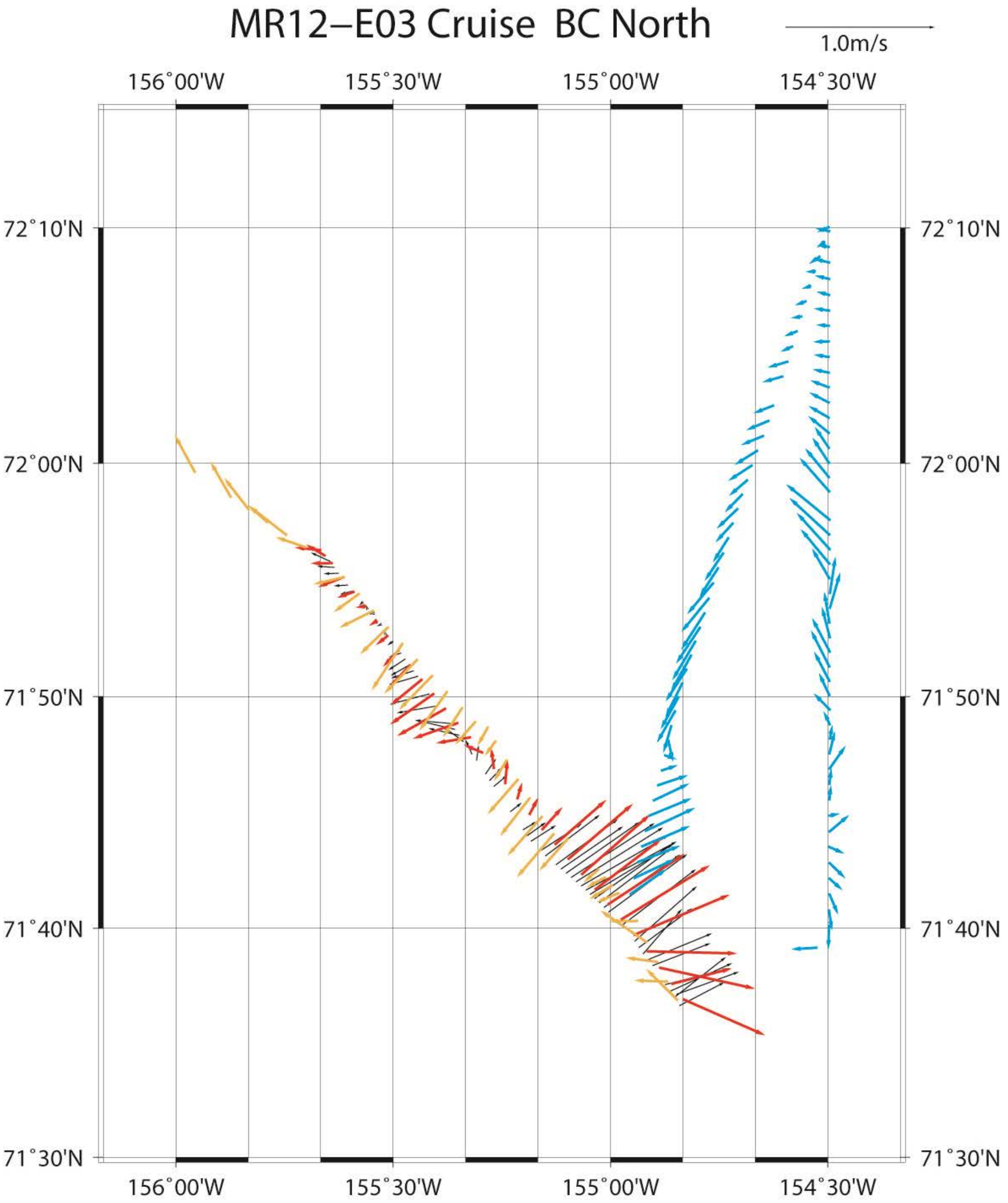


Fig 3.4-2 The current vector in the BC North area.

3.5 Mooring Deployments and Recoveries

We deployed three moorings in the Barrow Canyon (BCE-12, BCC-12, BCW-12) and two moorings at the head of the canyon (BCH-12-2 and BCH-12w-2). Furthermore, one mooring was deployed in the Northwind abyssal Plain (NAP-12) and two mooring in Hope valley are also deployed (SCH-12-2 and SCH-12w-2). In addition, two sediment trap moorings were deployed in the Chukchi Abyssal Plain and Northwind Abyssal Plain (CAP-12t and NAP-12t).

We recovered eight moorings (NAP-12, BCE-10, BCC-10, BCW-10, BCH-12, BCH-12w, SCH-12 and SCH-12w) and one sediment trap mooring (NAP-11t) at the locations which are almost the same as those of the deployed mooring.

Detail of the sediment trap moorings is described in section 4-20 (PI: Naomi Harada, JAMSTEC).

(1) Personnel

Takashi Kikuchi (JAMSTEC): Principal Investigator
Shigeto Nishino (JAMSTEC)
Motoyo Itoh (JAMDTEC)
Toru Idai (MWJ): Operation leader
Tomoyuki Takamori (MWJ): Technical staff
Kenichi Katayama (MWJ): Technical staff
Naoko Miyamoto (MWJ): Technical staff
Shinsuke Toyoda (MWJ): Technical staff
Yasushi Hashimoto (MWJ): Technical staff
Yasumi Yamada (MWJ): Technical staff
Hiroyasu Sato (MWJ): Technical staff

(2) Objectives

The purpose of mooring measurements in the Barrow Canyon (BCE-12, BCC-12, BCW-12) is to monitor the variations of volume, heat and fresh water fluxes of Pacific Water. The mooring in the Northwind Abyssal Plain (NAP-12) was to be monitoring the variations of Pacific Water and East Siberian Shelf Water inflow. Components of these moorings are depicted in Figure 3.5-1.

At the head of Barrow Canyon and the Herald Valley, where biological activities are extremely high and are called biological hot spots, moorings measuring temperature, salinity, dissolved oxygen, chlorophyll *a*, and turbidity were deployed with biological moorings recording whale voices. The purpose of these moorings is to understand the ocean environment and its annual changes maintaining the hot spots and their influences to the ecosystem of higher trophic levels such as whales.

(3)Measured parameters

- Oceanic velocities
- Echo intensity, bottom tracking range and velocities for sea ice measurements
- Pressure, Temperature and Conductivity
- Dissolved oxygen
- Chlorophyll-*a* and turbidity
- Sea ice thickness measurement
- Echo sounder for Zooplankton and Fish
- Whale voice recorder

(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.)

3) Dissolved oxygen sensor
AROW-USB (JFE Advantech)

4) Chlorophyll-*a* and turbidity sensor
ACLW-USB (JFE Advantech)

5) Sea ice thickness measurement sensor
Ice profiling sonar, Model IPS 5 (ALS Environmental Sciences)

6) Scientific echo sounder
Multi-frequency Zooplankton Fish Profiler (ALS Environmental Sciences)

7) Whale voice recorder

Acoustic Monitoring System (Fusion co., LTD)

8) Acoustic Releaser

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

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

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

8242XS (ORE offshore)

Model 865A (Teledyne Benthos Instruments, Inc.)

(5) List of deployed mooring

Deployment mooring

Mooring ID	Deployment Date	Latitude	Longitude
CAP-12t	2012/09/19	75-12.3710N	172-32.9186W
NAP-12t	2012/09/21	75-00.1711N	162-00.1819W
NAP-12	2012/09/22	74-59.9427N	162-28.7319W
BCH-12w-2	2012/09/25	71-20.4492N	157-36.4848W
BCC-12	2012/09/26	71-47.7415N	155-20.7499W
BCW-12	2012/09/26	71-47.7415N	155-20.7499W
BCE-12	2012/10/27	71-40.3527N	154-59.7424W
BCH-12-2	2012/10/01	71-19.6310N	157-39.6674W
SCH-12-2	2012/10/03	68-02.0040N	168-50.0265W
SCH-12w-2	2012/10/03	68-03.0054N	168-50.0019W

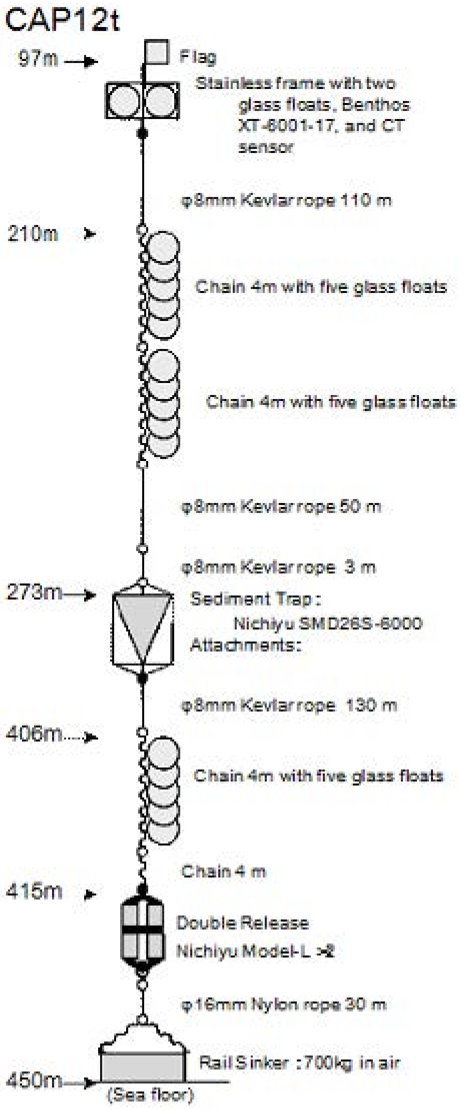


Figure 3.5-1 Mooring diagram of Deployment mooring

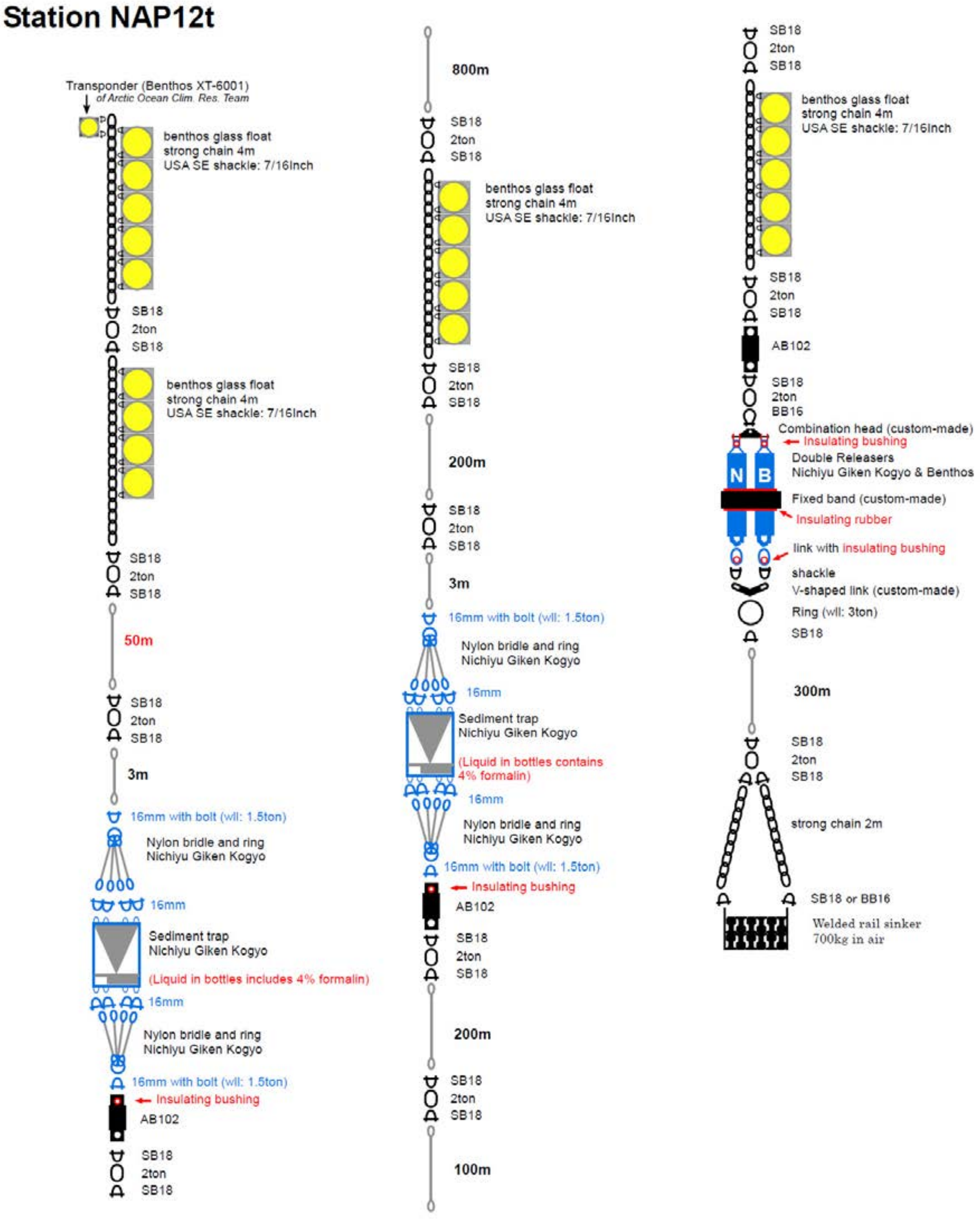


Figure 3.5-2 Mooring diagram of Deployment mooring

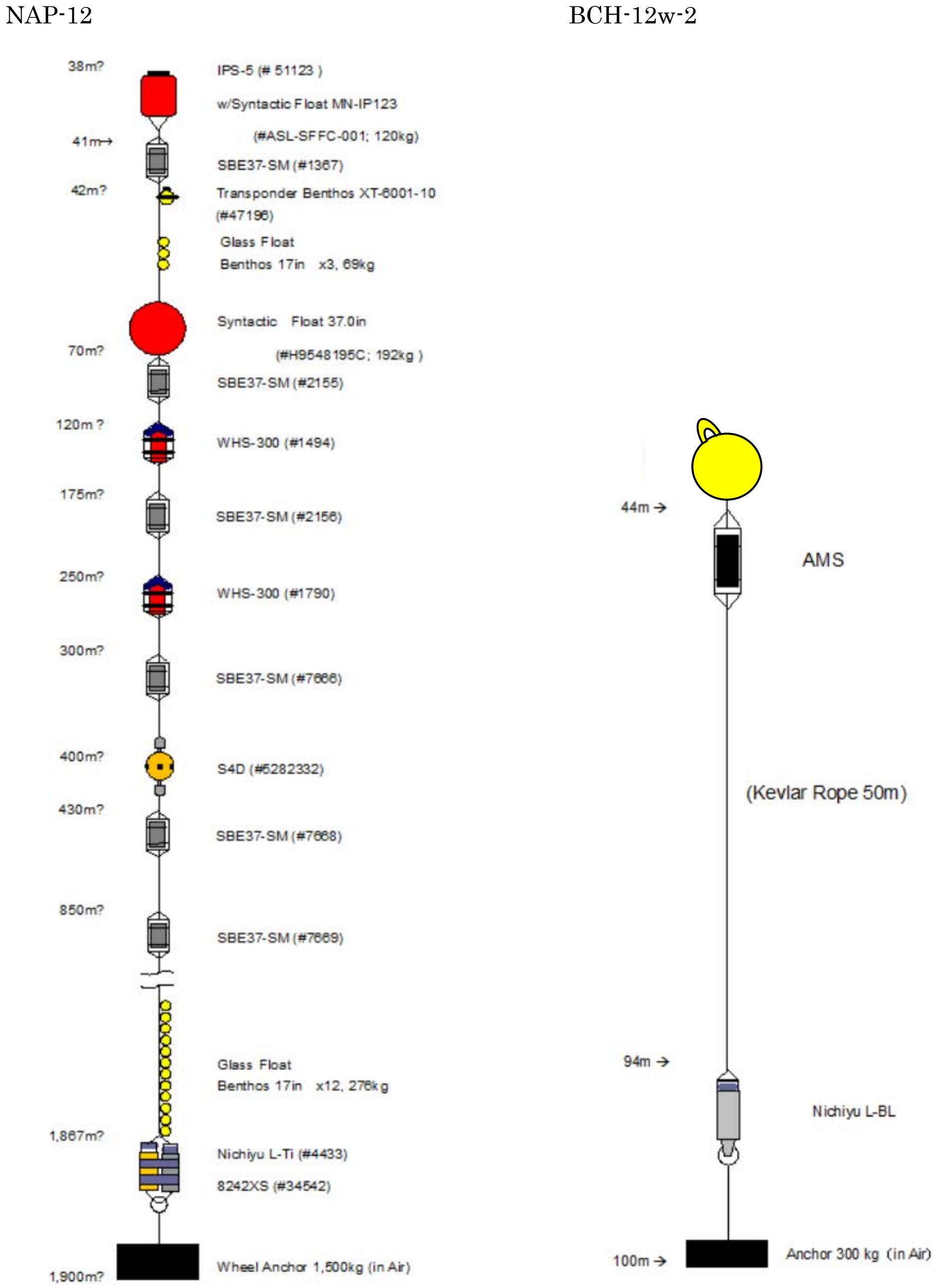


Figure 3.5-3 Mooring diagram of Deployment moorings

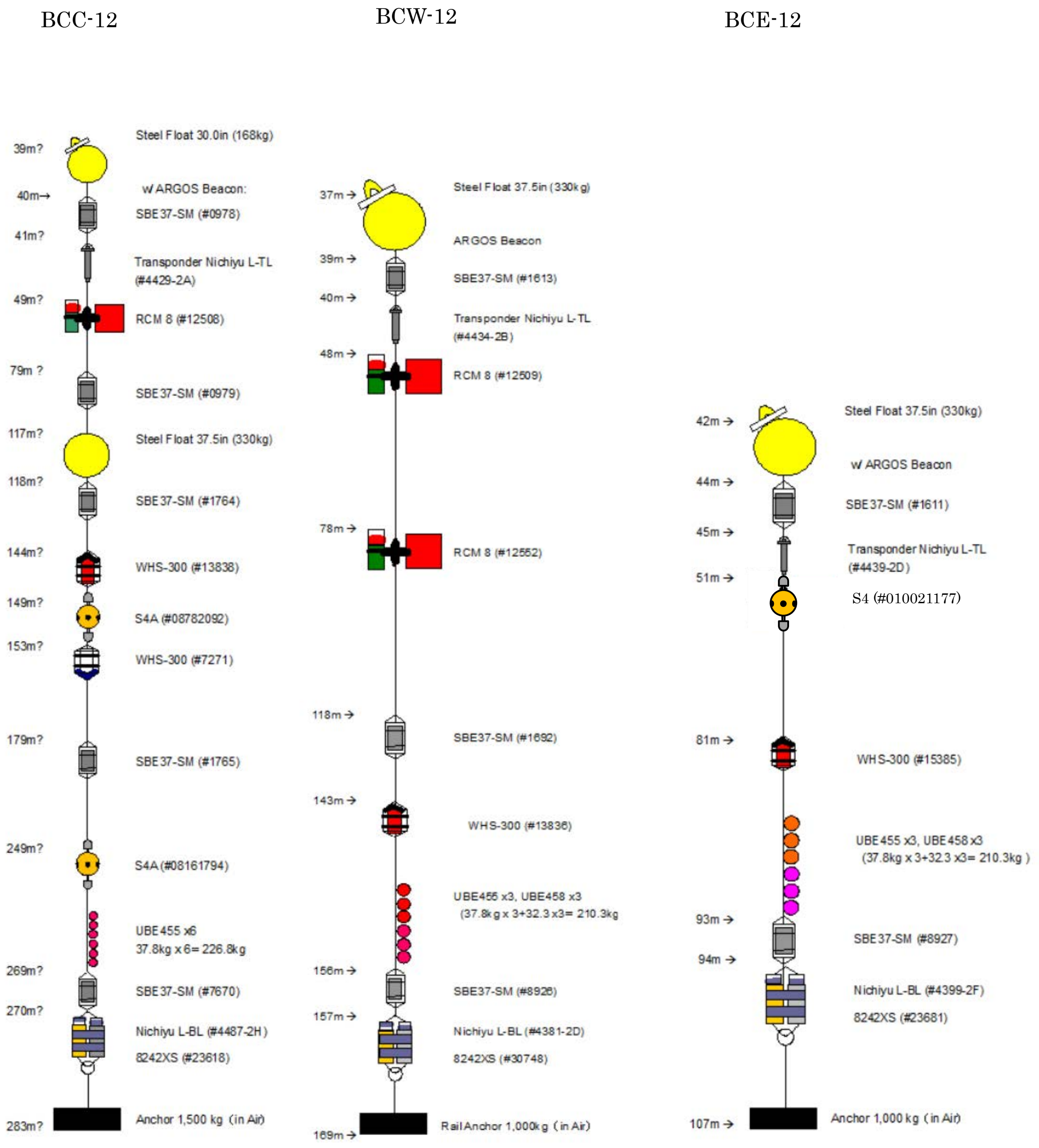
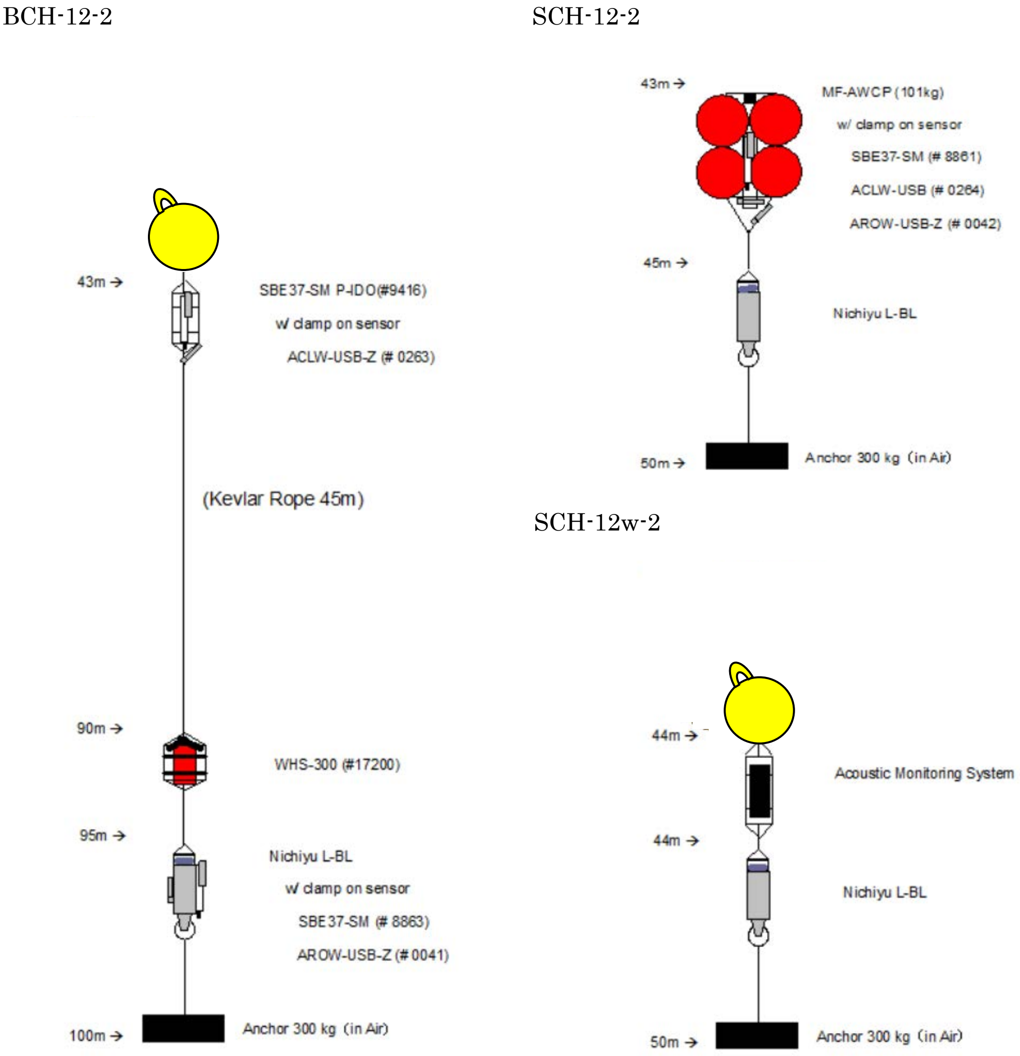


Figure 3.5-4 Mooring diagram of Deployment moorings



BCH-12-2

SCH-12-2

SCH-12w-2

Figure 3.5-5 Mooring diagram of Deployment moorings

4. Chemical and Biological Oceanography

4.1 Dissolved Oxygen

(1) Personnel

Shigeto NISHINO (JAMSTEC): Principal Investigator
Misato KUWAHARA (Marine Works Japan Co. Ltd): Operation Leader
Hironori SATO (Marine Works Japan Co. Ltd)
Keitaro MATSUMOTO (Marine Works Japan Co. Ltd)
Takuhiro OSUMI (Marine Works Japan Co. Ltd)

(2) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Parameter

Dissolved Oxygen

(4) Instruments and Methods

Following procedure is based on an analytical method, entitled by "Determination of dissolved oxygen in sea water by Winkler titration", in the WHP Operations and Methods (Dickson, 1996).

a. Instruments

Burette for sodium thiosulfate and potassium iodate;

APB-510 / APB-620 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Detector;

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

Software;

DOT_Terminal Ver. 1.2.0

b. Reagents

Pickling Reagent I: Manganese chloride solution (3 mol dm^{-3})

Pickling Reagent II:

Sodium hydroxide (8 mol dm^{-3}) / sodium iodide solution (4 mol dm^{-3})

Sulfuric acid solution (5 mol dm^{-3})

Sodium thiosulfate (0.025 mol dm^{-3})
Potassium iodide (0.001667 mol dm^{-3})
CSK standard of potassium iodide:
Lot DCE2131, Wako Pure Chemical Industries Ltd., 0.0100N

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD-system and surface bucket sampler. Seawater for oxygen measurement was transferred from sampler 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. 1 cm^3 sulfuric acid solution and a magnetic stirrer bar 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 (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the CTD sensor, flask volume, and titrated volume of sodium thiosulfate solution without the blank. When we measured high or low concentration samples, titration procedure was adjusted manually.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130 °C. 1.7835 g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 mol dm^{-3}). 10 cm^3 of the standard potassium iodate solution was added to a flask using a volume-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 titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (0.5 cm^3) and II (0.5 cm^3) was assumed to be 3.8 x 10^{-8} mol (Murray *et al.*, 1968). The blank due to other than oxygen was determined as follows. 1 and 2 cm^3 of the standard potassium iodate solution were added to two flasks respectively 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 each were added into the flask in order. The blank was determined by difference between the first (1 cm^3 of KIO_3) titrated volume of the sodium thiosulfate and the second (2 cm^3 of KIO_3) one. The results of 3 times blank determinations were averaged.

Table 4.1-1 shows results of the standardization and the blank determination during this cruise.

Table 4.1-1 Results of the standardization and the blank determinations during this cruise.

Date	KIO_3 ID	$Na_2S_2O_3$	DOT-01X(No.7)		DOT-01X(No.8)		Stations
			E.P.	Blank	E.P.	Blank	
2012/09/05	20120417-02-01	20120615-01	3.973	0.003	3.970	0.003	000
2012/09/05	CSK DCE2131	20120615-01	3.965	0.003	3.963	0.003	
2012/09/11	20120417-02-05	20120615-01	3.971	0.003	3.968	0.004	001, 003, 004, 005, 006, 007, 008, 010, 012, 014, 015, 016, 017, 018, 019, 020, 021, 022, 023, 024, 025, 027, 028, 029 cast1, 029 cast2, 030, 031, 032
2012/09/18	20120417-02-03	20120615-01	3.973	0.001	3.969	0.000	
2012/09/18	20120417-02-03	20120615-02	3.975	0.003	3.972	0.001	033, 034, 035, 036, 037, 038, 039 cast1, 039 cast2, 040, 041, 042, 043, 044, 045 cast1, 045 cast2, 046, 047, 048

2012/09/25	20120417-02-04	20120615-02	3.973	0.004	3.969	0.001	
2012/09/25	20120417-02-04	20120615-03	3.974	0.002	3.971	0.003	049, 051, 053, 055, 057, 058, 059, 060, 061, 062, 063, 064, 065, 066, 068, 069, 070, 071, 072
2012/09/30	20120417-02-08	20120615-03	3.975	0.001	3.970	0.001	073, 074, 075, 076, 077, 078, 079, 080, 081
2012/10/02	20120417-02-07	20120615-03	3.971	0.002	3.970	0.002	
2012/10/02	20120417-02-07	20120615-04	3.974	0.002	3.972	0.001	082, 083, 084, 085, 086, 087, 088, 089, 090, 091, 092, 093, 094, 095, 096
2012/10/05	20120417-02-10	20120615-04	3.974	0.002	3.971	0.002	

f. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 196. The standard deviation of the replicate measurement was 0.12 μmol kg^{-1} that was calculated by a procedure in Guide to best practices for ocean CO$_2$ measurements Chapter4 SOP23 Ver.3.0 (2007). Results of replicate samples were shown in Table 4.1-2 and this diagram shown in Fig. 4.1-1 and -2.

Table 4.1-2 Results of the replicate sample measurements

Layer	Number of replicate sample pairs	Oxygen concentration (μmol kg^{-1}) Standard Deviation.
1000m>=	179	0.12
>1000m	17	0.12
All	196	0.12

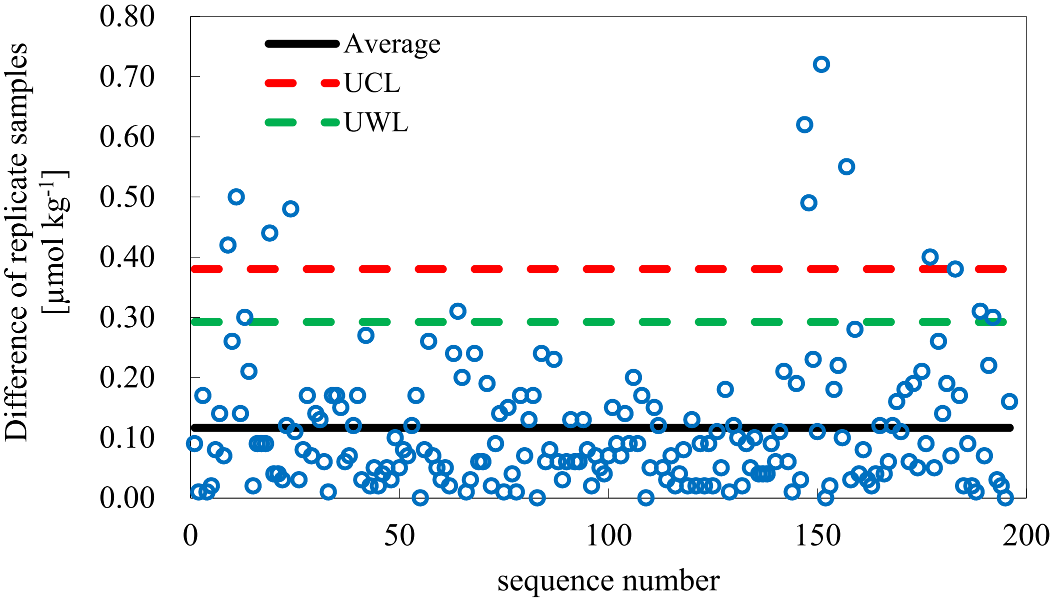


Fig. 4.1-1 Differences of replicate samples against sequence number

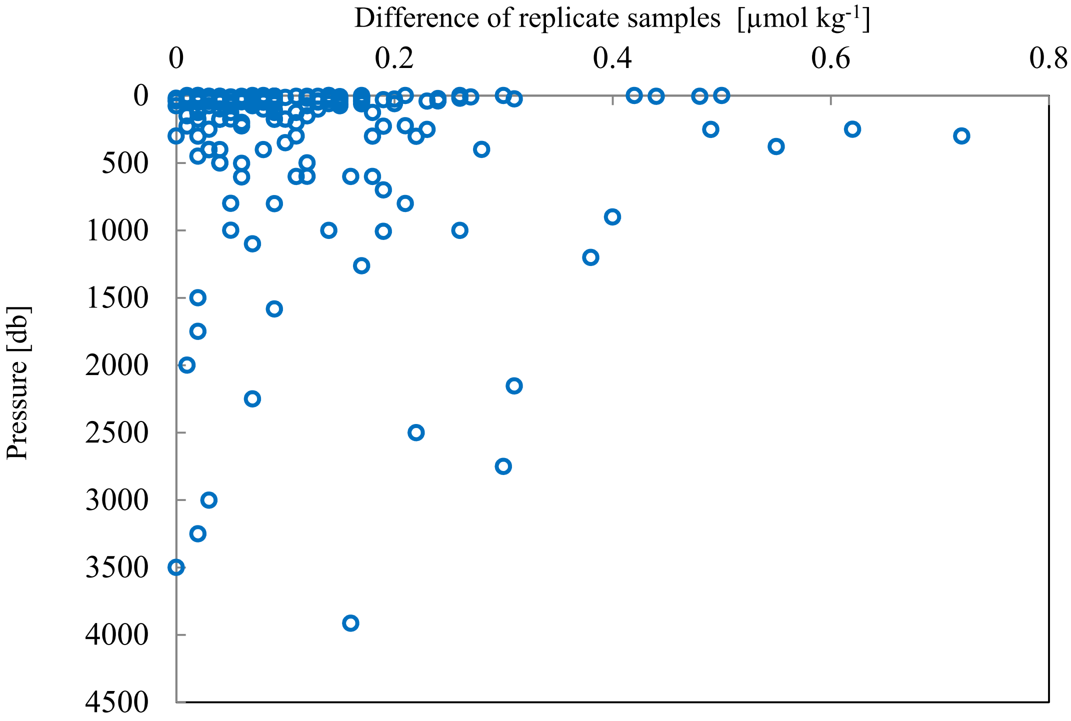


Fig. 4.1-2 Differences of replicate samples against pressure

(5) Data archive

All data will be submitted to Chief Scientist.

(6) References

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

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), Guide to best practices for ocean CO2 measurements. (2007)

Culberson, C.H., 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 Instruction manual

4.2 Nutrients

Ver 2.3 as of 20121101

(1) Personnel

Michio AOYAMA (MRI/JMA) : Principal investigator

Shigeto Nishino (JAMSTEC): Co-principal investigator

Kenichiro SATO (MWJ): Operation leader

Masanori ENOKI (MWJ)

Elena HAYASHI (MWJ)

Kaori UCHIYAMA (MWJ)

(2) Objectives

The objectives of nutrients analyses during the R/V Mirai MR12-E03 cruise in the Arctic Ocean is as follows:

- Describe the present status of nutrients concentration with excellent comparability.

(3) Parameters

The determinants are nitrate, nitrite, phosphate, silicate and ammonia in the Arctic Ocean.

We measured nutrients in pore water, which detail was followed in 4.14.

(4) Summary of nutrients analysis

We made 28 QuAAtro runs for the water columns sample at 94 stations during MR12-E03. The total amount of layers of the seawater sample reached up to 1385. for pore water samples, we made 13 QuAAtro run and measured 426 samples. We made basically single measurement except for deeper stations, stn.29, 32, 33, 39, 40, 41, 64, 65, 66 and 68, which were analyzed duplicate sample. The station locations for nutrients measurement is shown in Figure 4.2.1

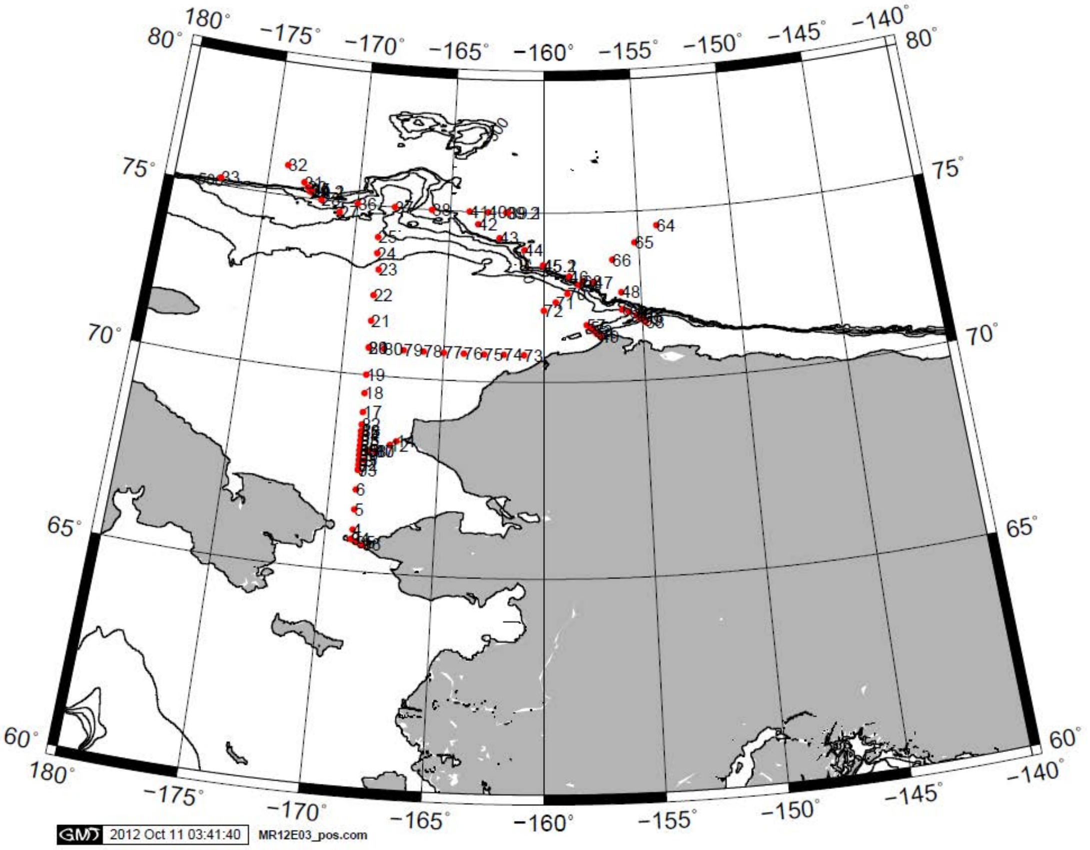


Figure 4.2.1 Sampling positions of nutrients sample.

(5) Instrument and Method

Analytical detail using QuAAtro system

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.

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. N-1-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.

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 silicate in the sample and added molybdic acid; then the silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using ascorbic acid as the reductant. The analytical methods of the nutrients, nitrate, nitrite, silicate and phosphate, during this cruise are same as the methods used in (Kawano et al. 2009).

The ammonia in seawater is mixed with an alkaline containing EDTA, ammonia as gas state is formed from seawater. The ammonia (gas) is absorbed in sulfuric acid by way of 0.5 μm pore size membrane filter (ADVANTEC PTFE) at the dialyzer attached to analytical system. The ammonia absorbed in sulfuric acid is determined by coupling with phenol and hypochlorite to form indophenols blue. Wavelength using ammonia analysis is 630 nm, which is absorbance of indophenols blue.

The flow diagrams and reagents for each parameter are shown in Figures 4.2.2 to 4.2.6.

c. Nitrate + Nitrite Reagents

Imidazole (buffer), 0.06 M (0.4 % w/v)

Dissolve 4 g imidazole, $C_3H_4N_2$, in ca. 1000 ml DIW; add 2 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added.

Sulfanilamide, 0.06 M (1 % w/v) in 1.2M HCl

Dissolve 10 g sulfanilamide, $4\text{-}NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 %f w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2\cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

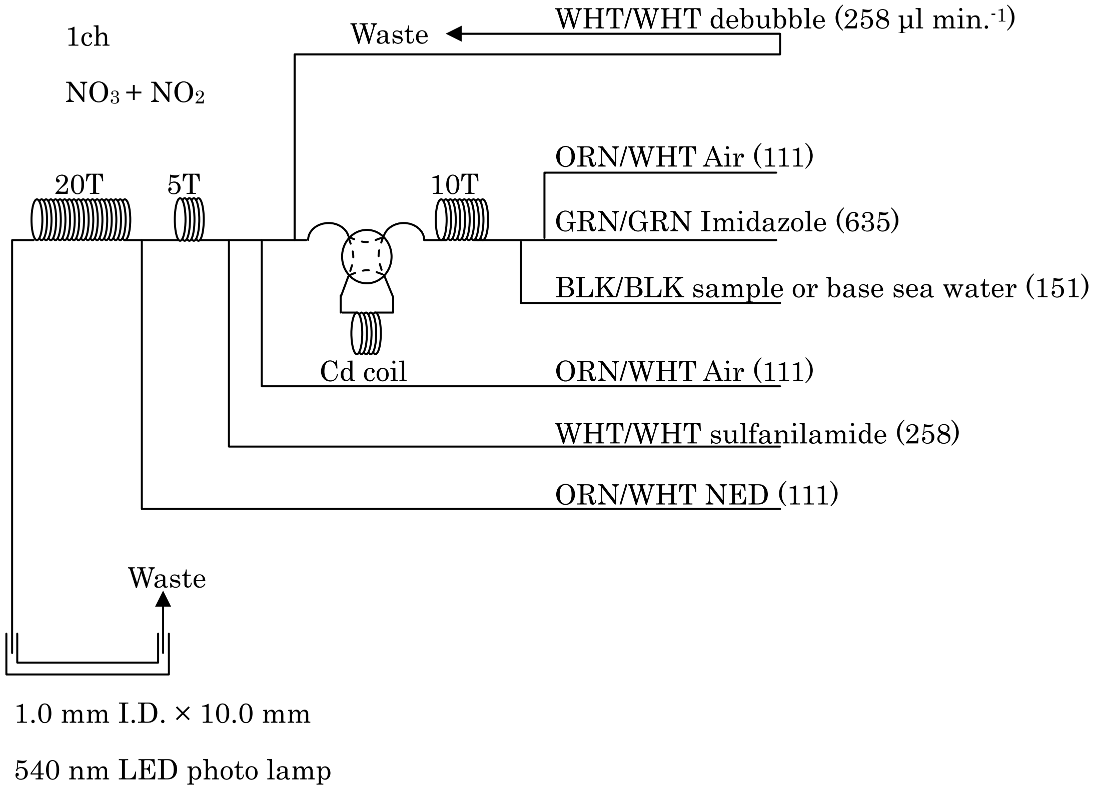


Figure4.2.2 NO_3+NO_2 (1ch.) Flow diagram.

d. Nitrite Reagents

Sulfanilamide, 0.06 M (1 % w/v) in 1.2 M HCl

Dissolve 10g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 % w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

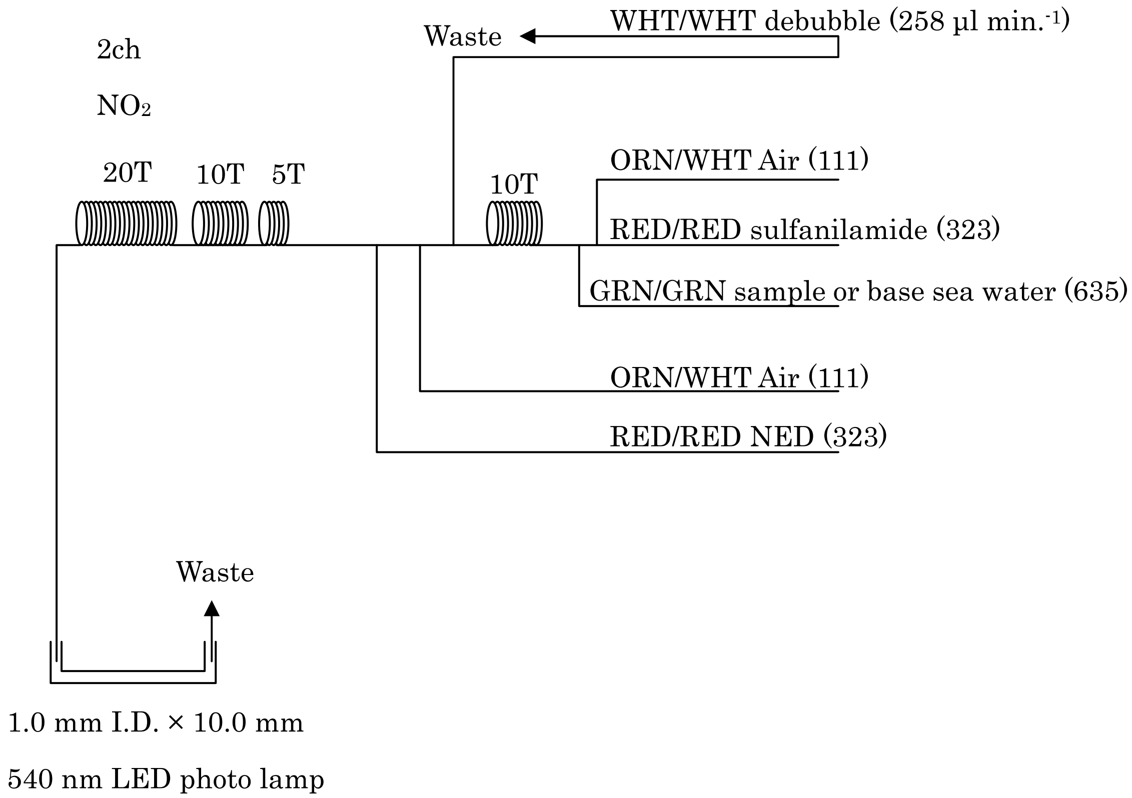


Figure4.2.3 NO_2 (2ch.) Flow diagram.

e. Silicate Reagents

Molybdic acid, 0.06 M (2 % w/v)

Dissolve 15 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \cdot 2H_2O$, in 980 ml DIW, add 8 ml concentrated H_2SO_4. After mixing, 20 ml sodium dodecyl sulphate (15 % solution in water) is added.

Oxalic acid, 0.6 M (5 % w/v)

Dissolve 50 g oxalic acid anhydrous, HOOC: COOH, in 950 ml of DIW.

Ascorbic acid, 0.01M (3 % w/v)

Dissolve 2.5g L (+)-ascorbic acid, $C_6H_8O_6$, in 100 ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

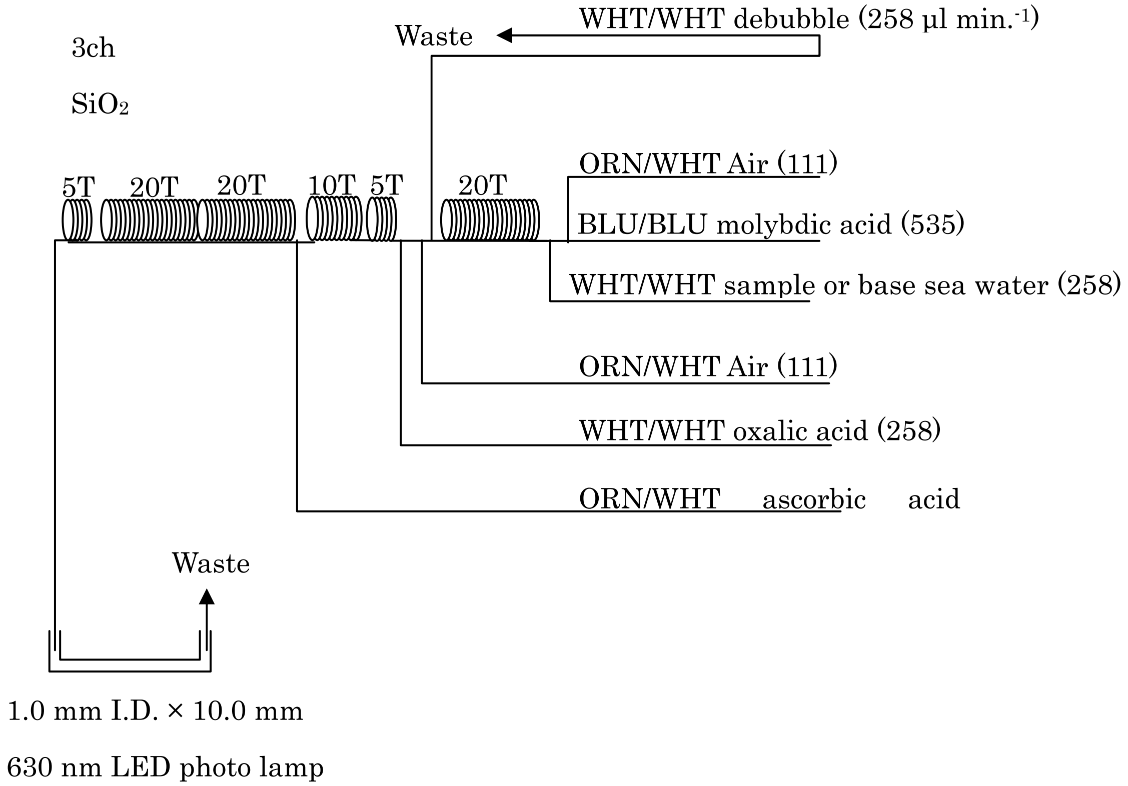


Figure4.2.4 SiO_2 (3ch.) Flow diagram.

f. Phosphate Reagents

Stock molybdate solution, 0.03M (0.8 % w/v)

Dissolve 8 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \cdot 2H_2O$, and 0.17 g antimony potassium tartrate, $C_8H_4K_2O_{12}Sb_2 \cdot 3H_2O$, in 950 ml of DIW and add 50 ml concentrated H_2SO_4.

Mixed Reagent

Dissolve 1.2 g L (+)-ascorbic acid, $C_6H_8O_6$, in 150 ml of stock molybdate solution. After mixing, 3 ml sodium dodecyl sulphate (15 % solution in water) is added. Stored in a dark bottle and freshly prepared before every measurement.

Reagent for sample dilution

Dissolve sodium chloride, NaCl, 10 g in ca. 950 ml of DIW, add 50 ml acetone and 4 ml concentrated H_2SO_4. After mixing, 5 ml sodium dodecyl sulphate (15 % solution in water) is added.

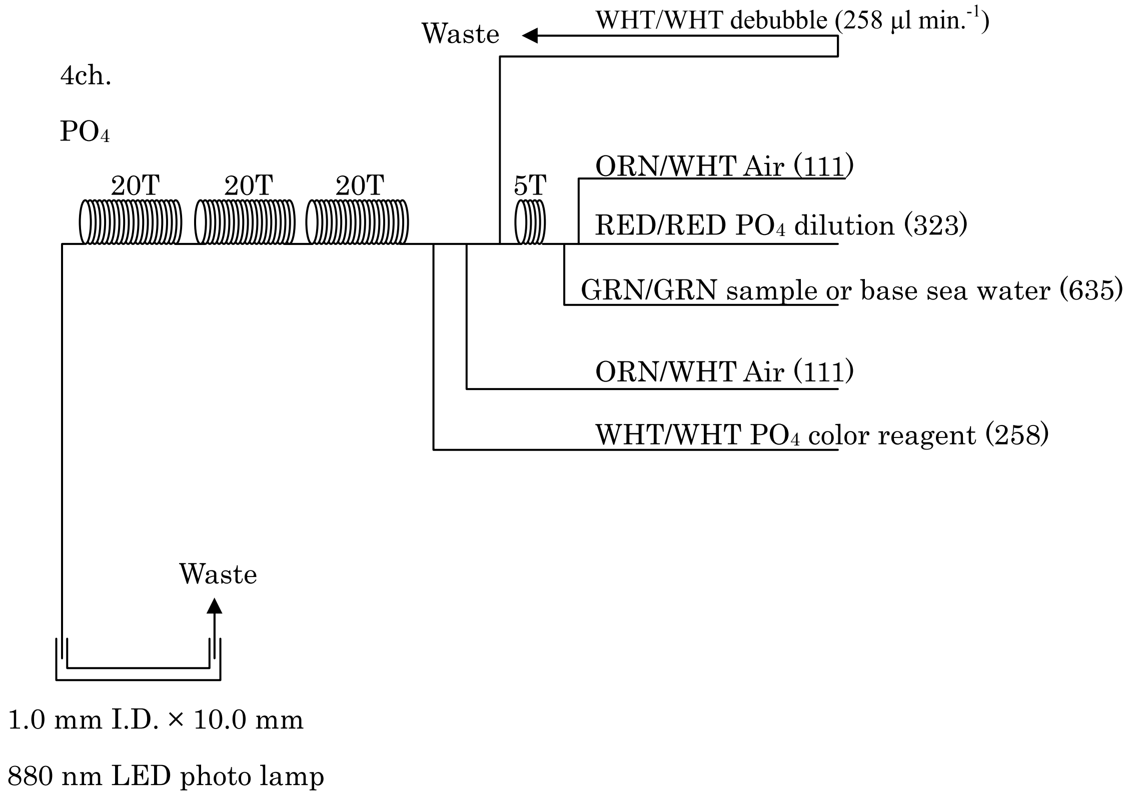


Figure 4.2.5 PO_4 (4ch.) Flow diagram.

g. Ammonia Reagents

EDTA

Dissolve 41 g EDTA (ethylenediaminetetraacetatic acid tetrasodium salt), $C_{10}H_{12}N_2O_8Na_4 \cdot 4H_2O$, and 2 g boric acid, H_3BO_3, in 200 ml of DIW. After mixing, 1 ml Triton®X-100 (30 % solution in DIW) is added. This reagent is prepared at a week about.

NaOH

Dissolve 5 g sodium hydroxide, NaOH, and 16 g EDTA in 100 ml of DIW. This reagent is prepared at a week about.

Stock Nitroprusside

Dissolved 0.25 g sodium pentacyanonitrosylferrate(II), $Na_2[Fe(CN)_5NO]$, in 100 ml of DIW and add 0.2 ml 1N H_2SO_4. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

Mixed 4 ml stock nitroprusside and 5 ml 1N H_2SO_4 in 500 ml of DIW. After mixing, 1 ml Triton®X-100 (30 % solution in DIW) is added. This reagent is stored in a dark bottle and prepared at every 2 or 3 days.

Alkaline phenol

Dissolved 10 g phenol, C_6H_5OH, 5 g sodium hydroxide and citric acid, $C_6H_8O_7$, in 200 ml DIW. Stored in a dark bottle and prepared at a week about.

NaClO solution

Mixed 3 ml sodium hypochlorite solution, NaClO, in 47 ml DIW. Stored in a dark bottle and fleshly prepared before every measurement. This reagent is prepared 0.3% available chlorine.

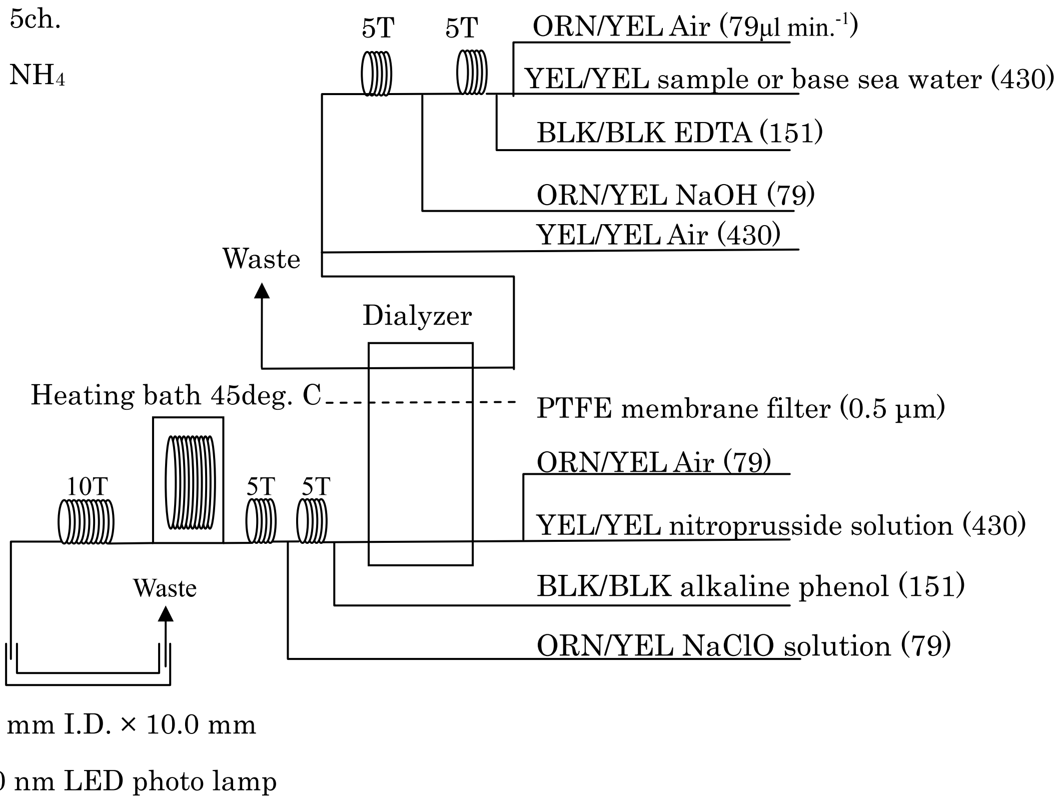


Figure 4.2.6 NH_4 (5ch.) Flow diagram.

i. Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into a virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials are put into water bath adjusted to ambient temperature, 24 ± 1.5 deg. C, in about 30 minutes before use to stabilize the temperature of samples.

No transfer was made and the vials were set an auto sampler tray directly. Samples were analyzed after collection basically within 24 hours.

j. Data processing

Raw data from QuAAtro were treated as follows:

- Check baseline shift.
- Check the shape of each peak and positions of peak values taken, and then change the positions of peak values taken if necessary.
- Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.
- Baseline correction and sensitivity correction were done basically using liner regression.
- Load pressure and salinity from CTD data due to calculate density of seawater.
- Calibration curves to get nutrients concentration were assumed second order equations.

(5) Nutrients standards

a. Volumetric laboratory ware of in-house standards

All volumetric glass ware and polymethylpentene (PMP) ware used were gravimetrically calibrated. Plastic volumetric flasks were gravimetrically calibrated at the temperature of use within 0 to 4 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05 % or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicate from the glass. PMP volumetric flasks were gravimetrically calibrated and used only within 0 to 4 K of the calibration temperature.

The computation of volume contained by glass flasks at various temperatures other than the calibration temperatures were done by using the coefficient of linear expansion of borosilicate crown glass.

Because of their larger temperature coefficients of cubical expansion and lack of tables constructed for these materials, the plastic volumetric flasks were gravimetrically calibrated over the temperature range of intended use and used at the temperature of calibration within 0 to 4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes have nominal calibration tolerances of 0.1 % or better. These were gravimetrically calibrated in order to verify and improve upon this nominal tolerance.

b. Reagents, general considerations

Specifications

For nitrate standard, "potassium nitrate 99.995 suprapur®" provided by Merck, Lot. B0771365211, CAS No.: 7757-91-1, was used.

For phosphate standard, "potassium dihydrogen phosphate anhydrous 99.995 suprapur®" provided by Merck, Lot. B0691108204, CAS No.: 7778-77-0, was used.

For nitrite standard, "sodium nitrate" provided by Wako, CAS No.: 7632-00-0, was used. And assay of nitrite was determined according JIS K8019 and assays of nitrite salts were 98.73 %. We use that value to adjust the weights taken.

For the silicate standard, we use "Silicon standard solution SiO_2 in NaOH 0.5 mol/l CertiPUR®" provided by Merck, CAS No.: 1310-73-2, of which lot number is HC122701 are used. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.5 %. HC122701 is certified as 1000+-5 mg L-1, however, our direct comparison between two Merck standards and estimation based on 4 lots of RMNS gave us a factor of 975 mg L-1 for HC074650 which was exceed 5mg of certification by Merck. We use this factor throughout MR12-E03 to keep comparability for silicate concentration. Add more previous compar.

For ammonia standard, “ammonia sulfate” provided by Wako, CAS No.: 7783-20-2, was used. The purity of this standard was greater than 99.5%.

Ultra pure water

Ultra pure water (Milli-Q) freshly drawn was used for preparation of reagent, standard solutions and for measurement of reagent and system blanks.

Low-nutrients seawater (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 January 2011.

c. Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards are set as shown in Table 4.2.1. The C standard is prepared according recipes as shown in Table 4.2.2. All volumetric laboratory tools were calibrated prior the cruise as stated in chapter (5)a. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric laboratory wares.

The calibration curves for each run were obtained using 4 levels, C-1, C-2, C-3 and C-4.

Few samples were over the calibration range of ammonia in Chukchi Sea. In this case, we used 5 levels calibration curve adding to C-5 standard.

Table 4.2.1 Nominal concentrations of nutrients for A, B and C standards.

	A	B	C-1	C-2	C-3	C-4	C-5
NO_3 (μM)	22000	680	0.03	7	20	34	-

NO_2 (μM)	4000	20	0.00	0.2	0.6	1.0	-
SiO_2 (μM)	36000	1400	1.3	15	42	70	-
PO_4 (μM)	3000	60	0.04	0.6	1.8	3.0	-
NH_4 (μM)	4000	160	0.00	1.6	3.2	6.4	12.8

Table 4.2.2 Working calibration standard recipes.

C Std.	B-1 Std.	B-2 Std.	B-3 Std.	DIW
C-1	0 ml	0 ml	0 ml	70 ml
C-2	5 ml	5 ml	5 ml	55 ml
C-3	15 ml	15 ml	10 ml	30 ml
C-4	25 ml	25 ml	20 ml	0 ml

B-1 Std.: Mixture of nitrate, silicate and phosphate
B-2 Std.: Nitrite
B-3 Std.: Ammonia

d. Renewal of in-house standard solutions

In-house standard solutions as stated in paragraph c were renewed as shown in Table 4.2.3(a) to (c).

Table 4.2.3(a) Timing of renewal of in-house standards.

NO_3, NO_2, SiO_2, PO_4, NH_4	Renewal
A-1 Std. (NO_3)	maximum a month
A-2 Std. (NO_2)	maximum a month
A-3 Std. (SiO_2)	commercial prepared solution
A-4 Std. (PO_4)	maximum a month
A-5 Std. (NH_4)	maximum a month
B-1 Std. (mixture of NO_3, SiO_2, PO_4)	maximum a week
B-2 Std. (NO_2)	maximum a week
B-3 Std. (NH_4)	maximum a week

Table 4.2.3(b) Timing of renewal of working calibration standards.

C Std.	Renewal
C Std. (mixture of B-1 , B-2 and B-3 Std.)	every 24 hours

Table 4.2.3(c) Timing of renewal of in-house standards for reduction estimation.

Reduction estimation	Renewal
D-1 Std. (3600 μM NO_3)	maximum a week
22 μM NO_3	when C Std. renewed
24 μM NO_2	when C Std. renewed

(6) Reference material of nutrients in seawater

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., 2006, 2007, 2008, 2009). In the previous worldwide expeditions, such as WOCE cruises, the higher reproducibility and precision of nutrients measurements were required (Joyce and Corry, 1994). Since no standards were available for the measurement of nutrients in seawater at that time, the requirements were described in term of reproducibility. The required reproducibility was 1 %, 1 to 2 %, 1 to 3 % for nitrate, phosphate and silicate, respectively. Although nutrient data from the WOCE one-time survey was of unprecedented quality and coverage due to much care in sampling and measurements, the differences of nutrients concentration at crossover points are still found among the expeditions (Aoyama and Joyce, 1996, Mordy et al., 2000, Gouretski and Jancke, 2001). For instance, the mean offset of nitrate concentration at deep waters was 0.5 μmol kg^{-1} for 345 crossovers at world oceans, though the maximum was 1.7 μmol kg^{-1} (Gouretski and Jancke, 2001). At the 31 crossover points in the Pacific WHP one-time lines, the WOCE standard of reproducibility for nitrate of 1 % was fulfilled at about half of the crossover points and the maximum difference was 7 % at deeper layers below 1.6 deg. C in potential temperature (Aoyama and Joyce, 1996).

a. RMNS for this cruise

RMNS lots BS, BU, BT and BD, which cover full range of nutrients concentrations in the Arctic ocean are prepared. 40 sets of BS, BU, BT and BD are prepared.

These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 20 deg. C.

b. Assigned concentration for RMNSs

We assigned nutrients concentrations for RMNS lots BS, BU, BT and BD as shown in Table 4.2.4.

Table 4.2.4 Assigned concentration of RMNSs.

unit: µmol kg^{-1}

	Nitrate	Nitrite	Phosphate	Silicate	Assigned year
BS	0.07 ± 0.01	0.02 ± 0.00	0.064 ± 0.003	1.61 ± 0.02	2011
BU	3.97 ± 0.01	0.07 ± 0.00	0.379 ± 0.004	20.30 ± 0.06	2011
BT	18.21 ± 0.03	0.47 ± 0.00	1.320 ± 0.005	41.00 ± 0.05	2011
BD	29.86 ± 0.02	0.05 ± 0.00	2.194 ± 0.004	64.39 ± 0.08	2011

(7) Quality control

a. Precision of nutrients analyses during the cruise

Precision of nutrients analyses during this cruise was evaluated based on the 5 to 7 measurements, which are measured every 8 to 14 samples, during a run at the concentration of C-4 std. Summary of precisions are shown as shown in Table 4.2.5 and Figures 4.2.8 to 4.2.12, Analytical precisions previously evaluated were 0.08 % for nitrate, 0.10 % for phosphate and 0.07 % for silicate in CLIVAR P21 revisited cruise of MR09-01 cruise in 2009, respectively. During in this cruise, analytical precisions were 0.12% for nitrate, 0.21% for nitrite, 0.19% for phosphate, 0.11% for silicate and 0.34% for ammonia in terms of median of precision, respectively. Then we can conclude that the analytical precisions for nitrate, nitrite, phosphate and silicate were maintained throughout this cruise. The time series of precision are shown in Figures 4.2.8 to 4.2.12.

Table 4.2.5 Summary of precision based on the replicate analyses.

	Nitrate CV %	Nitrite CV %	Phosphate CV %	Silicate CV %	Ammonia CV%
Median	0.12	0.21	0.19	0.11	0.34
Mean	0.12	0.21	0.19	0.12	0.39
Maximum	0.20	0.37	0.33	0.22	1.11
Minimum	0.03	0.04	0.08	0.06	0.15
N	28	28	28	28	28

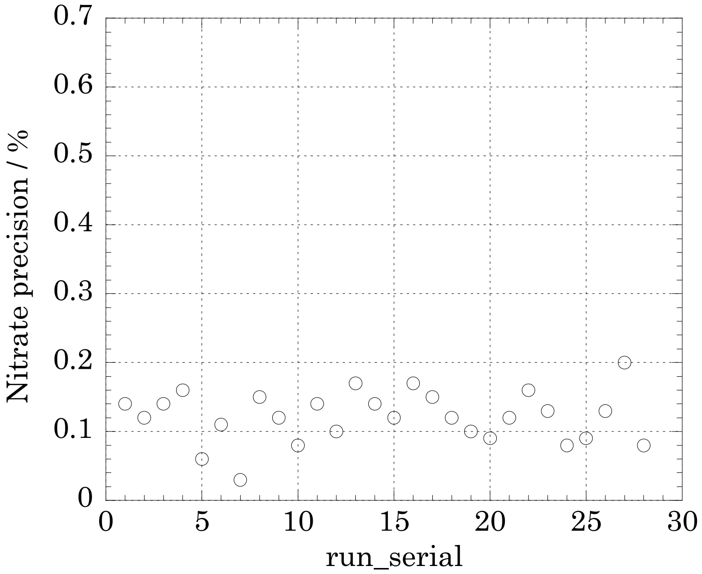


Figure 4.2.8 Time series of precision of nitrate for MR12-E03.

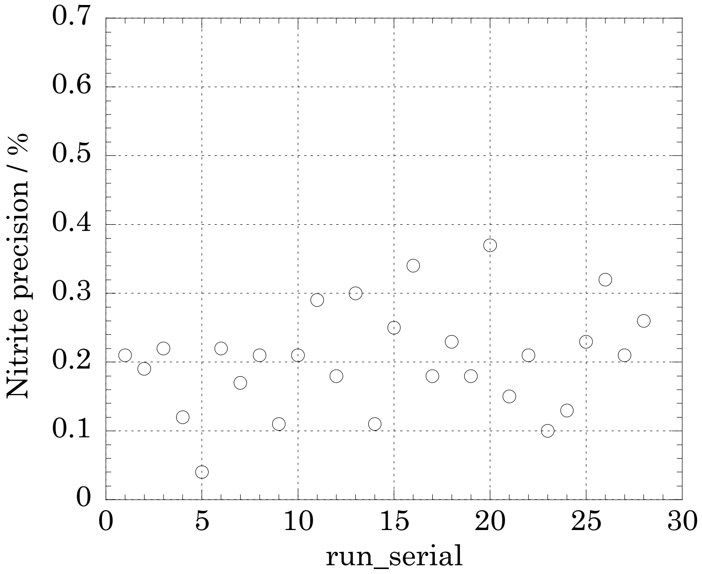


Figure 4.2.9 Time series of precision of nitrite for MR12-E03.

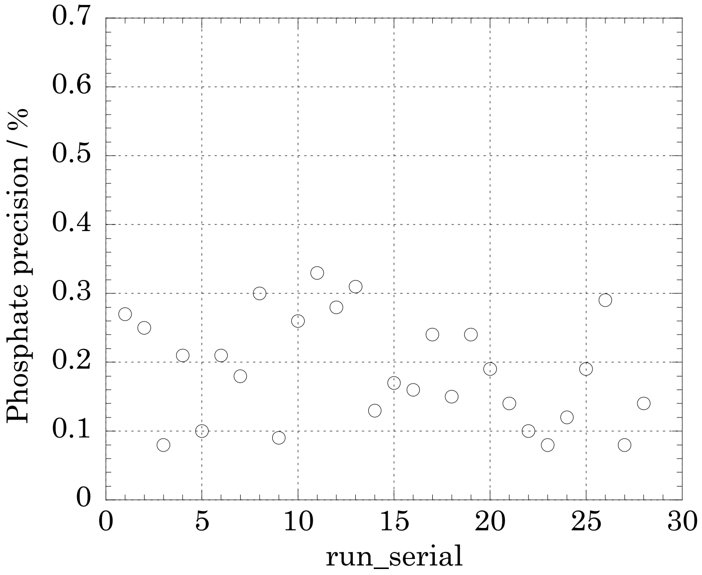


Figure 4.2.10 Time series of precision of phosphate for MR12-E03.

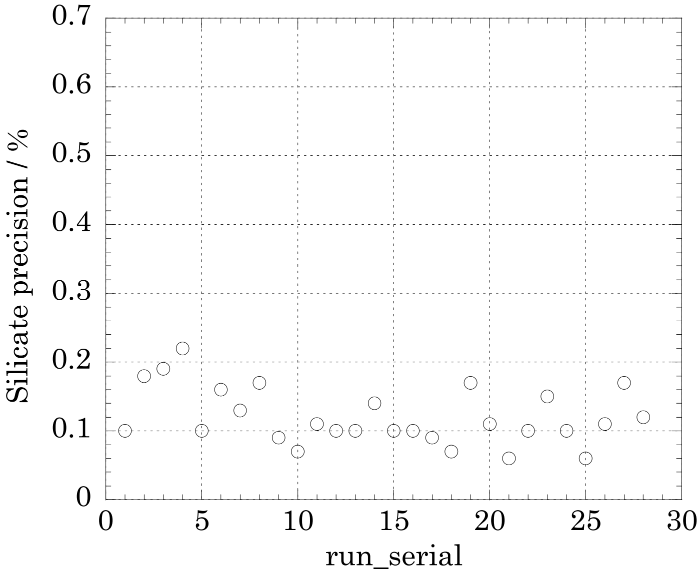


Figure 4.2.11 Time series of precision of silicate for MR12-E03.

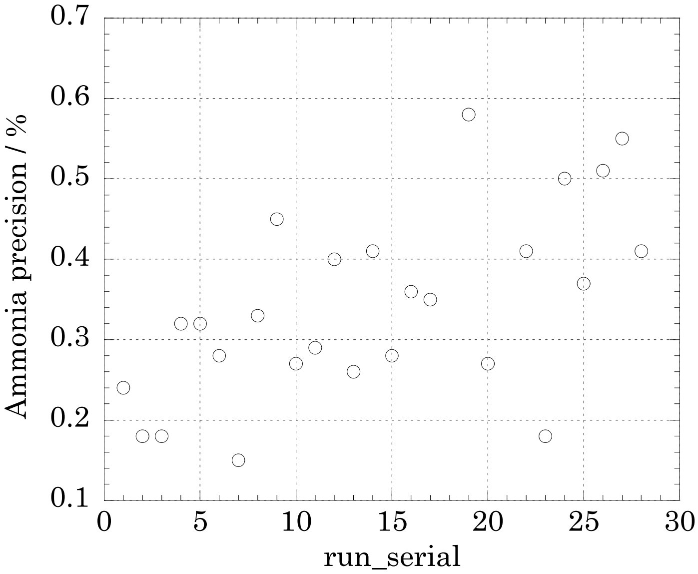


Figure 4.2.12 Time series of precision of ammonia for MR12-E03.

b. Results of RMNS mesurements

We measured RMNSs in every run during this cruise. The control chart of RM-BD are shown in Figures 4.2.13 to 4.2.17.

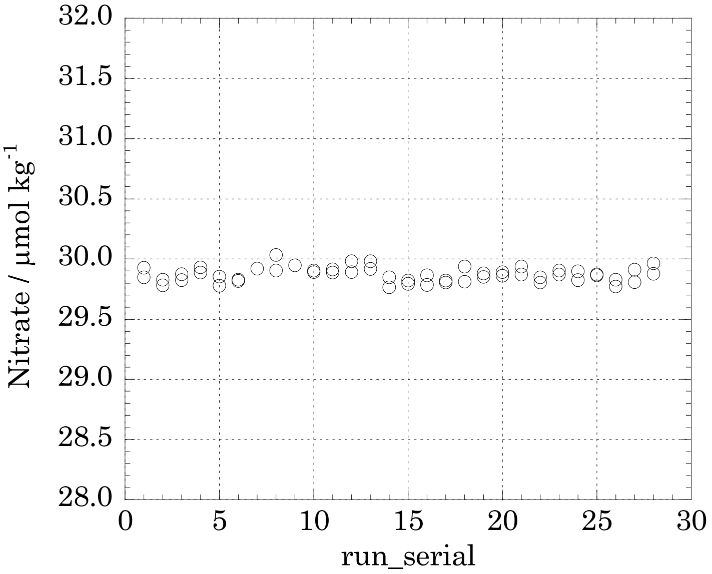


Figure 4.2.13 Summary of nitrate concentration of RM-BD.

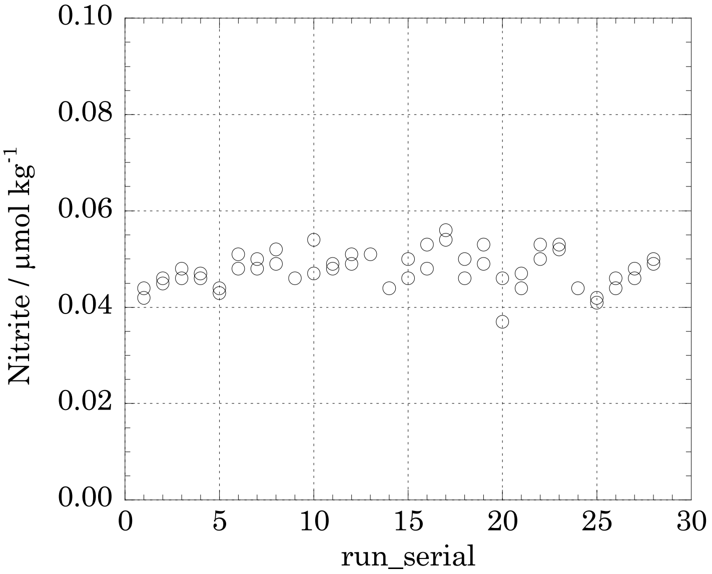


Figure 4.2.14 Summary of nitrite concentration of RM-BD.

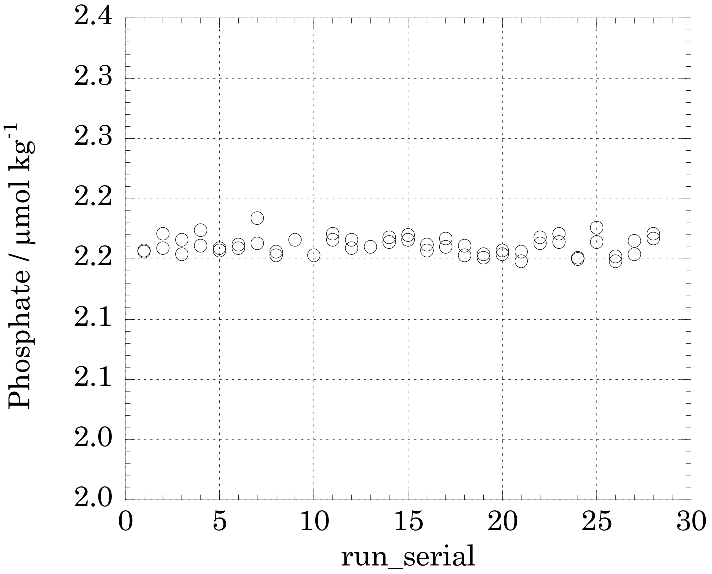


Figure 4.2.15 Summary of phosphate concentration of RM-BD.

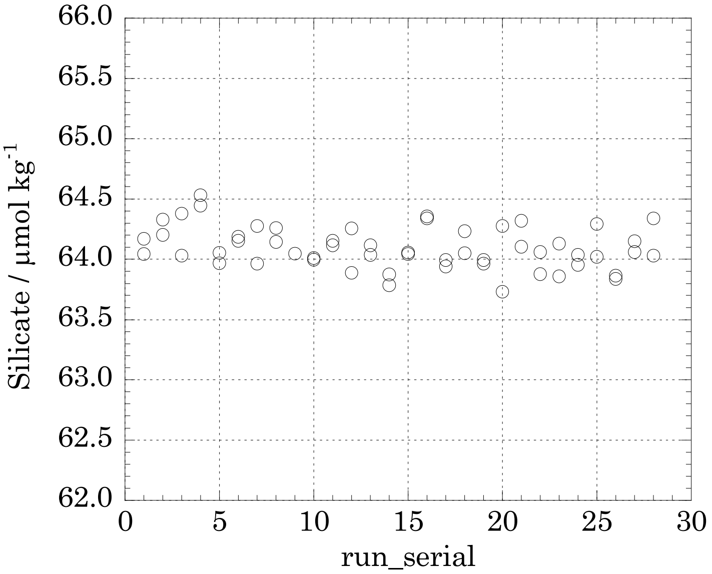


Figure 4.2.16 Summary of silicate concentration of RM-BD.

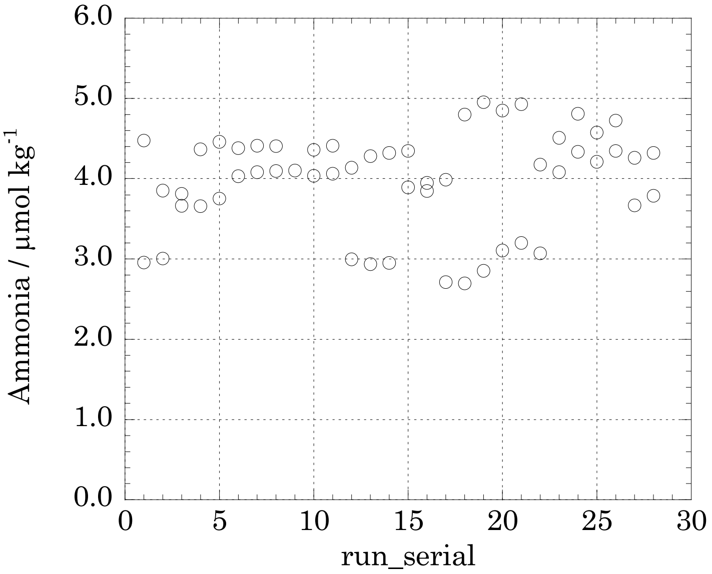


Figure 4.2.17 Summary of ammonia concentration of RM-BD.

c. Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are small enough within acceptable levels as shown in Table 4.2.6.

Table 4.2.6 Summary of carry over throughout MR12-E03.

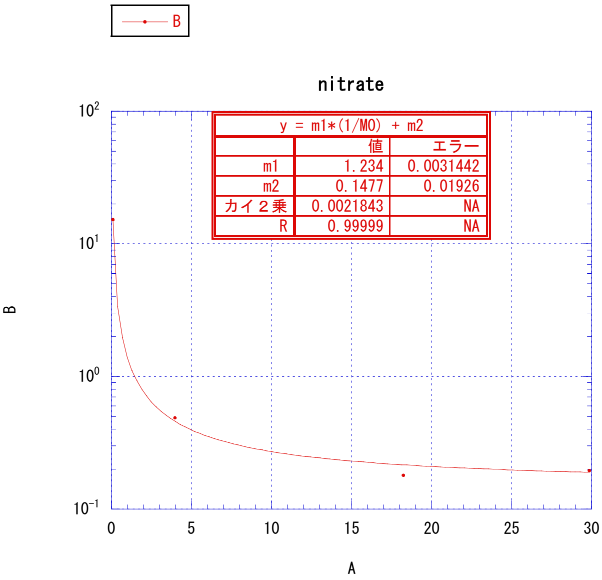
	Nitrate	Nitrite	Phosphate	Silicate	Ammonia
	%	%	%	%	%
Median	0.25	0.22	0.34	0.25	0.65
Mean	0.26	0.24	0.36	0.24	0.67
Maximum	0.54	0.67	0.70	0.38	1.47
Minimum	0.12	0.00	0.08	0.06	0.20
N	28	28	28	28	28

d Concentration dependent uncertainty

We can evaluate concentration dependent uncertainty based on repeat RMNS measurements.

For Nitrate, uncertainty in terms of % is expressed by eq. （1）

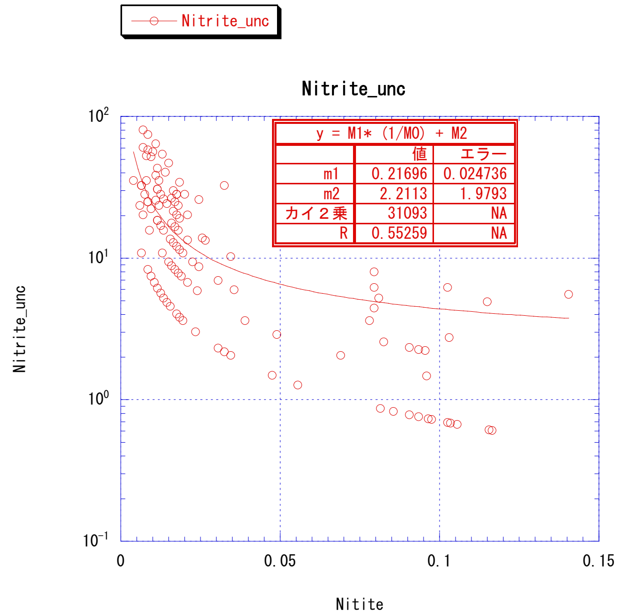
$$\text{Unc (\%)} = 0.148 + 1.234 / C_{no3} \qquad (1)$$



We can also evaluate concentration dependent uncertainty for nitrite based on 67 pairs of duplicate measurements of the samples.

For nitrite, uncertainty in terms of % is expressed by eq. (2)

$$\text{Unc (\%)} = 2.21 + 0.217 / C_{no2} \qquad (2)$$

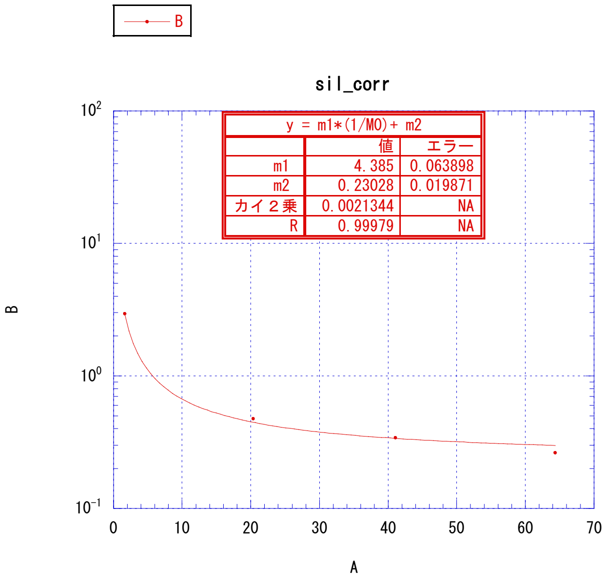


y = M1* (1/M0) + M2

	値	エラー
m1	0.21696	0.024736
m2	2.2113	1.9793
カイ２乗	31093	NA
R	0.55259	NA

For silicate, uncertainty in terms of % is expressed by eq. （3）

Unc (%) = 0.232 + 4.385 / C_{sil} (3)

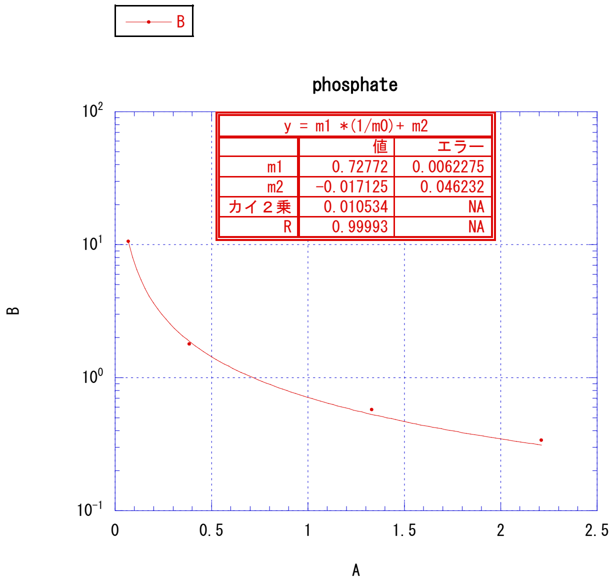


y = m1*(1/M0)+ m2

	値	エラー
m1	4.385	0.063898
m2	0.23028	0.019871
カイ２乗	0.0021344	NA
R	0.99979	NA

For phosphate, uncertainty in terms of % is expressed by eq. (4)

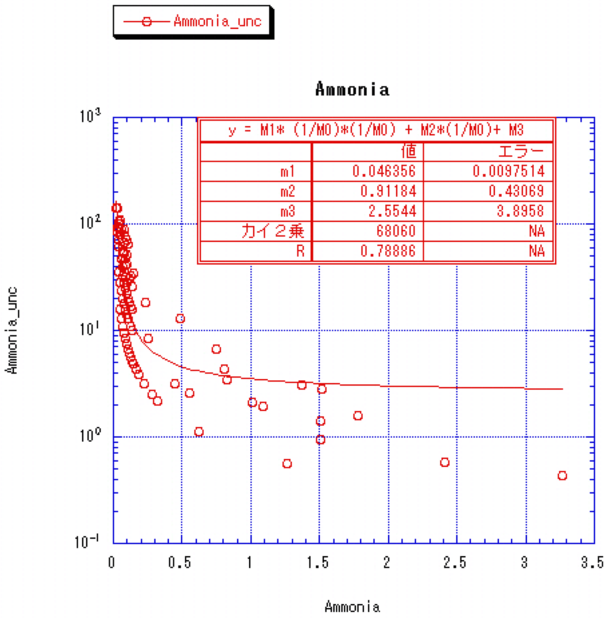
Unc (%) = -0.017 + 0.728 / C_{po4} (4)



We can also evaluate concentration dependent uncertainty for ammonia based on 200 pairs of duplicate measurements of the samples.

For ammonia, uncertainty in terms of % is expressed by eq. （5）

Unc (%) = 2.554+ 0.912 / C_{NH4}+0.046/C_{NH4}/C_{NH4} (5)



(8) Problems/improvements occurred and solutions.

a. Precipitation at ammonia line

There was a precipitation at the point of mixed seawater sample, EDTA and NaOH in ammonia line. We changed the concentration of EDTA by twice due to avoid the production of the precipitation. We need to examine the quantity of EDTA.

b. LED photo lamp

When the rough condition, noises were detected in all parameter chart. Therefore we changed from standard photo lamp to LED photo lamp in our instruments. The noise by rolling and pitching was dissolved drastically.

c. Over range samples

We obtained over range samples in Chukchi Sea. These samples were measured by extrapolating calibration curve. Over range sample list was shown in Table 4.2.7.

Table 4.2.7 Over range samples.

Parameter	Station and Sample No.
Silicate	Stn. 085 #18, 1 Stn. 089 #1
Phosphate	Stn. 089 #1
Ammonia	Stn. 023 #18, 1 Stn. 085 #18, 1

(9) Station list

The sampling station list for nutrients is shown in Table appendix1.

(10) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC home page.

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Appendix1 list of stations add cast

Station	Cast	Latitude	Longitude
1	1	65.6498	191.7482
3	1	65.7708	191.2088
4	1	66.0002	191.2493
5	1	66.5015	191.2462
6	1	67.0007	191.2515
7	1	67.5018	191.253
8	1	67.75	191.5003
10	1	67.9985	191.9983
12	1	68.1997	192.6657
14	1	68.2992	192.9493
15	1	67.9998	191.2522
16	1	68.5002	191.2507
17	1	69.0005	191.2475
18	1	69.5003	191.2498
19	1	70.0003	191.2517
20	1	70.7498	191.2532
21	1	71.5002	191.2522
22	1	72.24	191.2613
23	1	73.0027	191.4003
24	1	73.5017	191.2532
25	1	74.0052	191.2317
27	1	74.6702	189.0753
28	1	75.003	187.9972
29	1	75.2145	187.4178
29	2	75.2253	187.3803
30	1	75.3527	187.2253
31	1	75.4998	186.9755
32	1	76.0007	185.99

33	1	75.234	182.4933
34	1	75.267	184.4962
35	1	75.3005	185.9892
36	1	74.9997	189.9922
37	1	74.9993	191.9985
38	1	74.9995	193.9957
39	1	75.0043	198.103
39	2	75.0013	197.9868
40	1	74.9997	197.001
41	1	74.9997	195.9988
42	1	74.6007	196.5022
43	1	74.1692	197.6668
44	1	73.8095	198.969
45	1	73.3347	199.9792
45	2	73.3438	199.9535
46	1	73.0023	201.3283
47	1	72.8198	202.6055
48	1	72.5022	203.9937
49	1	71.2488	202.8438
51	1	71.3263	202.667
53	1	71.414	202.5132
55	1	71.495	202.3445
57	1	71.5775	202.1597
58	1	71.6075	205.164
59	1	71.6835	205.0382
60	1	71.7342	204.881
61	1	71.8122	204.7062
62	1	71.9313	204.3393
63	1	71.9993	203.999
64	2	74.4987	205.996
65	1	73.999	204.7922

66	2	73.4922	203.5885
68	1	72.8653	202.0353
69	1	72.7482	201.8012
70	1	72.4998	201.2012
71	1	72.2492	200.6015
72	1	72.0002	200.0028
73	1	70.75	199.0027
74	1	70.7498	198.0057
75	1	70.7498	197.008
76	1	70.7498	196.0042
77	1	70.748	194.9993
78	1	70.7492	194.0005
79	1	70.7512	193.0087
80	1	70.7512	192.0037
81	1	70.7512	191.259
82	1	68.6677	191.2497
83	1	68.5017	191.2493
84	1	68.3757	191.2507
85	1	68.2503	191.2508
86	1	68.124	191.2512
87	1	68	192.0035
88	1	68.0003	191.6237
89	1	67.9987	191.251
90	1	67.8748	191.2478
91	1	67.75	191.25
92	1	67.6242	191.253
93	1	67.5002	191.2482
94	1	65.7722	191.2115
95	1	65.7045	191.4803
96	1	65.6512	191.7468

4.3 Underway surface water monitoring

(1) Personnel

Shigeto NISHINO (JAMSTEC): Principal Investigator
Hiroshi UCHIDA (JAMSTEC)
Misato KUWAHARA (Marine Works Japan Co. Ltd): Operation Leader
Hironori SATO (Marine Works Japan Co. Ltd)
Keitaro MATSUMOTO (Marine Works Japan Co. Ltd)
Takuhiro OSUMI (Marine Works Japan Co. Ltd)

(2) Objective

Our purpose is to obtain temperature, salinity, dissolved oxygen, and fluorescence data continuously in near-sea surface water.

(3) Parameters

Temperature (surface water)
Salinity (surface water)
Dissolved oxygen (surface water)
Fluorescence (surface water)

(4) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has five sensors and automatically measures temperature, salinity, dissolved oxygen and fluorescence in near-sea surface water every one minute. This system is located in the "*sea surface monitoring laboratory*" and connected to shipboard LAN-system. Measured data, time, and location of the ship were stored in a data management PC. The near-surface water was continuously pumped up to the laboratory from about 4.5 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to be 5 dm^3 min^{-1}.

a. Instruments

Software

Seamoni-kun Ver.1.30

Sensors

Specifications of the each sensor in this system are listed below.

Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.
Serial number:	4552788-0264
Measurement range:	Temperature -5 to +35 °C Conductivity 0 to 7 S m^{-1}
Initial accuracy:	Temperature 0.002 °C Conductivity 0.0003 S m^{-1}
Typical stability (per month):	Temperature 0.0002 °C Conductivity 0.0003 S m^{-1}
Resolution:	Temperatures 0.0001 °C Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model:	SBE 38, SEA-BIRD ELECTRONICS, INC.
Serial number:	3852788-0457
Measurement range:	-5 to +35 °C
Initial accuracy:	±0.001 °C
Typical stability (per 6 month):	0.001 °C
Resolution:	0.00025 °C

Dissolved oxygen sensor

Model:	OPTODE 3835, AANDERAA Instruments.
Serial number:	985
Measuring range:	0 - 500 μmol dm^{-3}
Resolution:	< 1 μmol dm^{-3}
Accuracy:	< 8 μmol dm^{-3} or 5 % whichever is greater
Settling time:	< 25 s

Dissolved oxygen sensor

Model:	RINKO II, ARO-CAR/CAD
Serial number:	13
Measuring range:	0 - 540 μmol dm^{-3}
Resolution:	< 0.1 μmol dm^{-3}

or 0.1 % of reading whichever is greater

Accuracy: < 1 μmol dm^{-3}

or 5 % of reading whichever is greater

Fluorometer

2010/08/25 ~ 2010/09/23

Model:	C3, TURNER DESIGNS
Serial number:	2300123

b. Measurements

Periods of measurement, maintenance, and problems during MR12-E03 are listed in Table 4.3-1.

Table 4.3-1 Events list of the Sea surface water monitoring during MR12-E03

System Date [UTC]	System Time [UTC]	Events	Remarks
2012/09/04	10:21	All the measurements started and data was available.	Cruise start
2012/09/13	17:40	All the measurements stopped.	Filter cleaning
2012/09/13	18:16	All the measurements started.	Logging restart
2012/10/05	21:00	All the measurements stopped.	Sensor cleaning
2012/10/07	02:33	All the measurements started.	Logging restart
2012/10/15	04:34	All the measurements stopped.	Cruise end

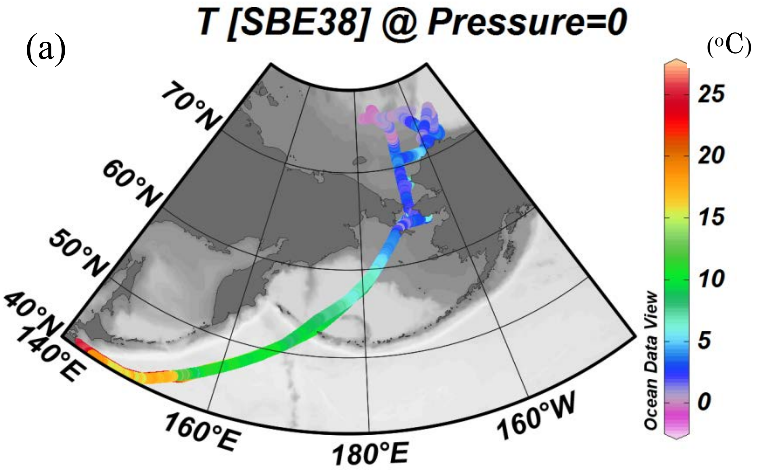
(5) Preliminary Result

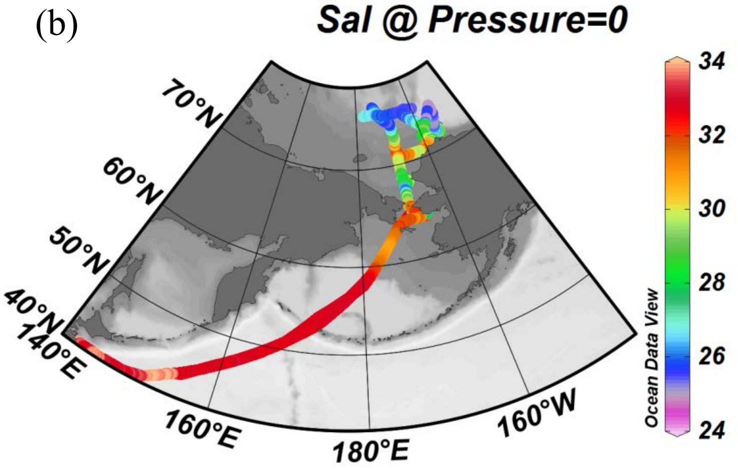
Preliminary data of temperature, salinity, dissolved oxygen and fluorescence at sea surface is shown in Fig. 4.3-1.

We took the surface water samples once a day to compare sensor data with bottle data of salinity, dissolved oxygen and fluorescence. The results are shown in Fig. 4.3-1 ~ 4. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL" (see 3.2), and dissolve oxygen samples were analyzed by Winkler method (see 4.1), and fluorescence were analyzed by 10-AU (see 4.8).

(6) Data archive

All data will be submitted to Chief Scientist.





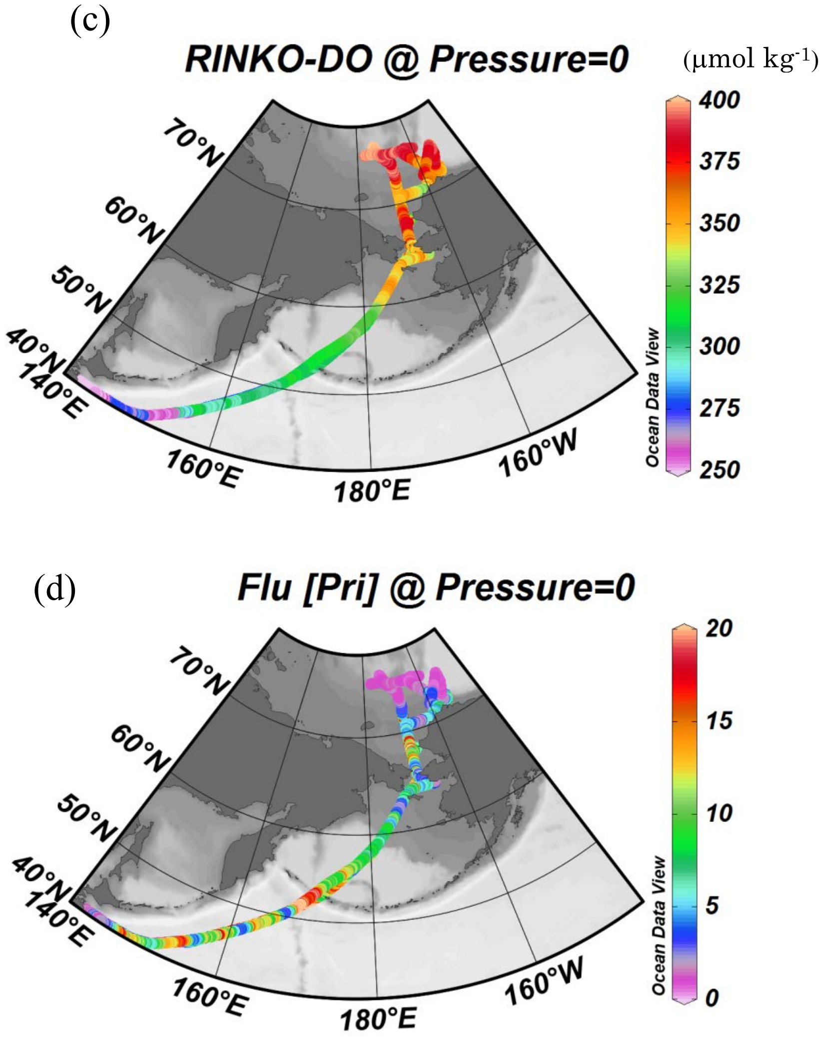


Fig 4.3-1. Spatial and temporal distribution of (a) temperature, (b) salinity, and (c) dissolved oxygen and (d) fluorescence in MR12-E03 cruise.

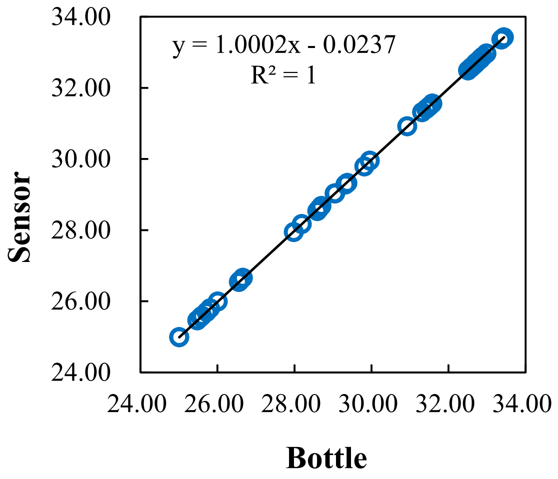


Fig 4.3-2 Correlation of salinity between sensor data and bottle data.

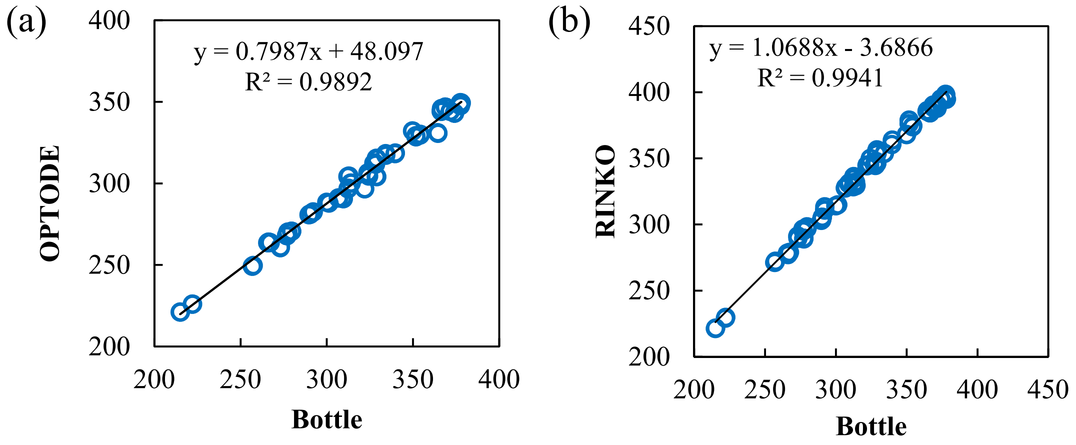


Fig 4.3-3 Correlation of dissolved oxygen between sensor data and bottle data.
(a: OPTODE, b: RINKO)

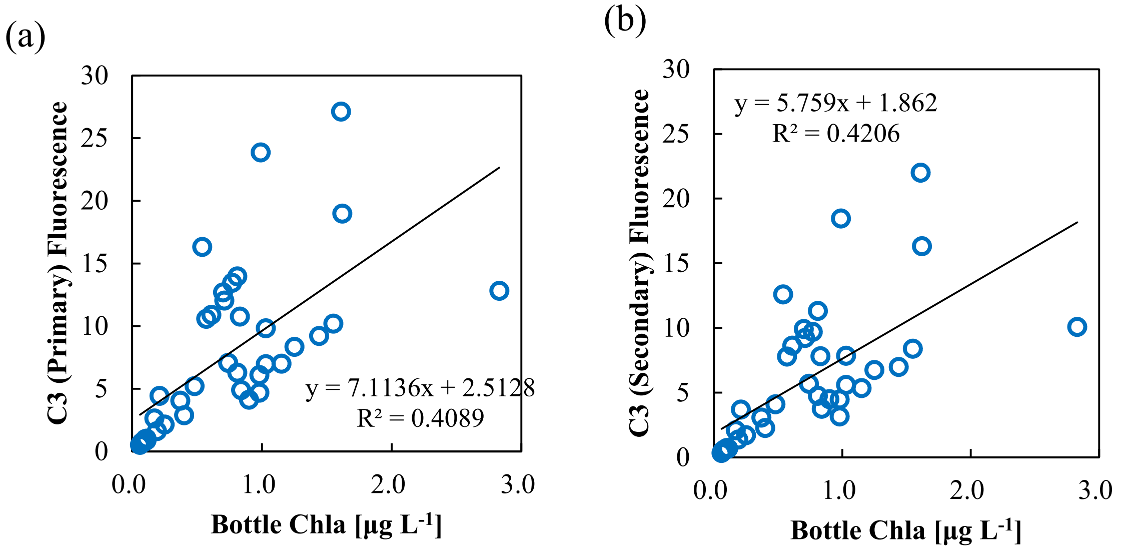


Fig 4.3-4 Correlation of fluorescence between sensor data and bottle data.
(a: Primary, b: Secondary)

4.4 pCO_2

(1) Personnel

Akihiko Murata(JAMSTEC): Principal Investigator
Shigeto NISHINO (JAMSTEC)
Yoshiko ISHIKAWA (MWJ) : Operation Leader

(2) Objective

Magnitude of the anticipated global warming depends on the levels of CO_2 in the atmosphere. However, the ocean plays an important role because one third of the 6 Gt of carbon emitted into the atmosphere by human activities each year is absorbed by the ocean. Hence, the clarification of both mechanism and capacity of oceanic CO_2 uptake is an urgent task. Furthermore, in recent years, sea ice in the Arctic Ocean melts in a vast area in summer relative to decades ago. The CO_2 flux between atmosphere and ocean directly depends on the CO_2 partial pressure (pCO_2) difference between. Therefore the recent Arctic summer open ocean is considered to play an important role for global carbon cycle. We here report onboard measurements of pCO_2 during MR12-E03 cruise.

(3) Parameter

Atmospheric and oceanic CO_2 partial pressure (pCO_2)

(4) Instruments and Method

Oceanic and atmospheric CO_2 concentrations were measured during the cruise using an automated system equipped with a non-dispersive infrared gas analyzer (NDIR; LI-7000, Li-Cor). Measurements were done every about one and half an hour. 4 standard gases, atmospheric air, and the CO_2 air equilibrated with sea surface water were analyzed continuously within one and half an hour. CO_2 standard gases of 249.25, 299.01, 348.98 and 398.93 ppmv were used in the Arctic Ocean, while those of 249.25, 299.01, 348.98 and 448.91 ppmv were used in the Bering Sea and North Pacific Ocean. Atmospheric air taken from the bow of the ship (approx.30 m above the sea level) was introduced into the NDIR by passing through a electrical cooling unit, a mass flow controller which controls the air flow rate of 0.5 L min^{-1}, a membrane dryer (MD-110-72P, perma pure llc.), and chemical desiccant ($Mg(ClO_4)_2$). Seawater was taken from an intake placed at the approximately 4.5 m below the sea surface and introduced into the equilibrator at the flow rate of 4 - 5 L min^{-1} by a pump.

The equilibrated air was circulated in a closed loop by a pump at flow rate of 0.7 - 0.8 L min^{-1} through two cooling units, a membrane dryer, the chemical desiccant, and the NDIR.

(5) Observation log

Cruise track during pCO_2 observation is shown in Figure 4.4-1.

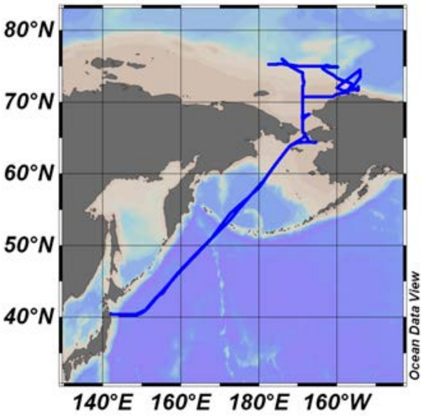


Figure 4.4-1 Observation map

(6) Results

Temporal variations of both oceanic and atmospheric CO_2 concentration (xCO_2) are shown in Fig. 4.4-2.

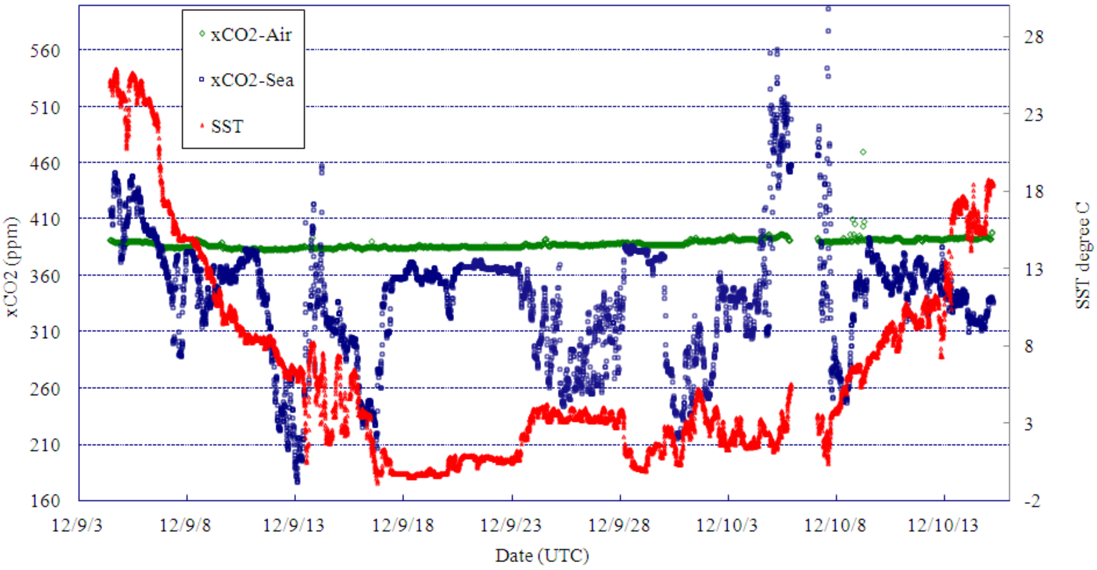


Figure 4.4-2 Time series of atmospheric and oceanic CO_2 concentration (xCO2). Green dots represent atmosphere xCO2 variation and blue oceanic xCO2. SST variation (red) is also shown.

(6) Date archives

Data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be open to public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

4.5. Watar column TDIC

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator
Michiyo Yamamoto-Kawai (Tokyo University of Marine Science and Technology)
Takahisa Mifune (Tokyo University of Marine Science and Technology)
Makoto Takada (MWJ) : Operation Leader
Emi Deguchi (MWJ)

(2) Objectives

In recent years, changes in seawater pH, calcium carbonate saturation state, and pCO_2 have been observed in the Pacific sector of the Arctic Ocean. Because these changes can have significant impact on biological productivity and ecosystem in the Arctic Ocean, quantitative understanding of the cause of these changes is necessary for better assessment and future predictions. During the MR12-E03 cruise, we have measured DIC, Total Alkalinity (TA; ref. Section 4.7) to calculate pH, calcium carbonate saturation state and pCO_2 in seawater. Results will be compared with physical and biological parameters such as temperature, salinity, nutrients, DO, 18O and Chl a, in order to understand factors controlling carbonate system in the resent changing Arctic Ocean.

(3) Parameter

Total Dissolved Inorganic Carbon (TDIC)

(4) Instruments and methods

a. Seawater sampling

Seawater samples were collected by 12L Niskin bottles and by a bucket at 88 stations. Seawater was then transferred into a 300ml glass bottle (SCHOTT DURAN) that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution at least 3 hours, and rinsed with fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds. They were sealed using the 29mm polyethylene inner lids with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were moved to the lab to be measured. Prior to the analysis, 3ml of the sample (1% of the bottle volume) was removed from the glass bottle in order to make a headspace. The samples were then poisoned with 100μl of over saturated solution of mercury chloride within one hour after the sampling. After poisoning, the samples were sealed using the 31.9mm polyethylene inner lids and stored in a refrigerator at approximately 5degC until being analyzed.

b. Seawater analysis

Measurements of DIC were made with total CO_2 measuring system (systems D; Nippon ANS, Inc.). The system comprise of seawater dispensing system, a CO_2 extraction system and a coulometer (Model 3000, Nippon ANS, Inc.).

The seawater dispensing system has an auto-sampler (6 ports), which takes seawater from a glass bottle to a pipette of nominal 15ml volume by PC control. The pipette was kept at 20 ± 0.05 degC by a water jacket, in which water is circulated from a thermostatic water bath (RTE10, Thermo) set at 20 degC.

The CO_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 extraction system by adding phosphoric acid (10% v/v). The stripping chamber is made approx. 25 cm long and has a fine frit at the bottom. A constant volume of acid is added to the stripping chamber from its bottom by pressurizing an acid bottle with nitrogen gas (99.9999%). A seawater sample kept in a constant volume pipette is then introduced to the stripping chamber by the same method. Nitrogen gas is bubbled through a fine frit at the bottom of the stripping chamber to make the reaction well. The stripped CO_2 is carried by the nitrogen gas (flow rates of 140ml min^{-1}) to the coulometer through a dehydrating module consists of two electric dehumidifiers (kept at 0.5 degC) and a chemical desiccant ($Mg(ClO_4)_2$).

Measurements of 1.5 % CO_2 standard gas in a nitrogen base, system blank (phosphoric acid blank), and seawater samples (6 samples) were programmed to repeat. The variation of our own made JAMSTEC DIC reference material or 1.5 % CO2 standard gas signal was used to correct the signal drift results from chemical alternation of coulometer solutions.

(5) Preliminary results

During the cruise, 1005 samples were analyzed for DIC. A few replicate samples were taken at most of stations and the difference between each pair of analyses was plotted on a range control chart (see Figure 4.5-1). The average of the differences was 0.7 μmol/kg (n=162). The standard deviation was 0.7 μmol/kg, which indicates that the analysis was accurate enough according to the Guide to best practices for ocean CO_2 measurements (Dickson et al., 2007).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to the public via “R/V Mirai Data Web Page” in JAMSTEC home page.

(7) Reference

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO_2 measurements; PICES Special Publication 3, 199pp.

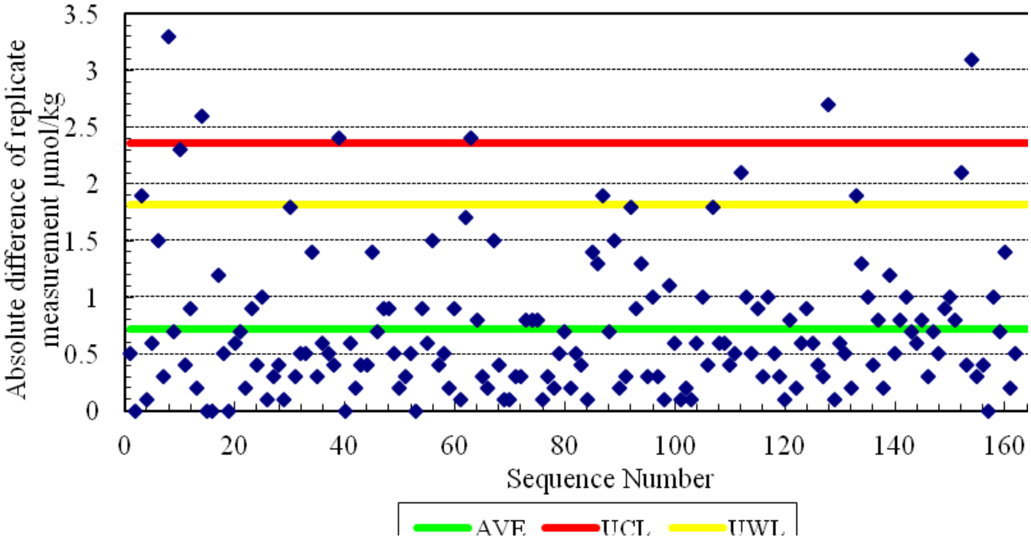


Figure 4.5-1. Range control chart of the absolute differences of replicate measurements carried out in the analysis of DIC during the MR12-E03 cruise. UCL and UWL represents the upper control limit (UCL=AVE*3.267) and upper warning limit (UWL=AVE*2.512), respectively.

4.6. Underway TDIC

(1) Personnel

Akihiko Murata(JAMSTEC): Principal Investigator
Shigeto NISHINO (JAMSTEC)
Yoshiko ISHIKAWA (MWJ) : Operation Leader

(2) Objective

Concentration of CO_2 in the atmosphere is now increasing at a rate of 1.5 μmol mol^{-1} yr^{-1} owing to human activities such as burning of fossil fuels, deforestation, and cement production. The ocean plays an important role in buffering the increase of atmospheric CO_2, therefore the urgent tasks are to clarify the mechanism of the oceanic CO_2 absorption and to estimate of CO_2 absorption capacity of the ocean. Oceanic biosphere, especially primary production, has an important role in oceanic CO_2 cycle through photosynthesis and respiration. However, the diverseness and variability of the biological system make it difficult to reveal their mechanism and quantitative understanding of the CO_2 cycle. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Concentrations of the individual species of the CO_2 system in solution cannot be measured directly, but calculated from two of four parameters: total alkalinity, total dissolved inorganic carbon, pH and pCO_2 (Dickson et al., 2007). Furthermore, in recent years, sea ice in the Arctic Ocean melts in a vast area in summer relative to decades ago. Accordingly the recent Arctic summer open ocean is considered to play an important role for global carbon cycle. We here report onboard measurements of underway total dissolved inorganic carbon during MR12-E03 cruise.

(3) Parameters

Total Dissolved Inorganic Carbon (TDIC)

(4) Instruments and Methods

Surface seawater was continuously collected from 7th Sep 2012 to 15th Oct 2012 during this cruise. Surface seawater was taken from an intake placed at the approximately 4.5 m below the sea surface by a pump, and was filled in a 300 ml glass bottle (SCHOTT DURAN). The glass bottles were filled from the bottom, without rinsing, and were overflowed for more than 2 times the amount. Before the analysis, the samples were put in the water bath kept about 20 deg C for one hour.

Measurements of TDIC were made with total CO_2 measuring system (Nippon ANS, Inc.). The system comprise of seawater dispensing unit, a CO_2 extraction unit, and a coulometer (Model 3000, Nippon ANS, Inc.)

The seawater dispensing unit has an auto-sampler (6 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 15 ml volume. The pipette was kept at 20 ± 0.05 deg C by a water jacket, in which water circulated through a thermostatic water bath (BH201, Yamato).

The CO_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 extraction unit by adding phosphoric acid (10 % v/v). The stripping chamber is made approx. 25 cm long and has a fine frit at the bottom. First, the certain amount of acid is taken to the constant volume tube from an acid bottle and transferred to the stripping chamber from its bottom by nitrogen gas (99.9999 %). Second, a seawater sample kept in a pipette is introduced to the stripping chamber by the same method as that for an acid. The seawater and phosphoric acid are stirred by the nitrogen bubbles through a fine frit at the bottom of the stripping chamber. The stripped CO_2 is carried to the coulometer through two electric dehumidifiers (kept at 2-10 deg C) and a chemical desiccant ($Mg(ClO_4)_2$) by the nitrogen gas (flow rates of 140 ml min^{-1}).

Measurements of 1.5 % CO_2 standard gas in a nitrogen base, system blank (phosphoric acid blank), and seawater samples (8 samples) were programmed to repeat. The variation of our own made reference material (RM) or 1.5 % CO_2 standard gas signal was used to correct the signal drift results from chemical alternation of coulometer solutions.

(5) Observation log

Cruise track during underway Total Dissolved Inorganic Carbon observation is shown in Figure 4.6-1.

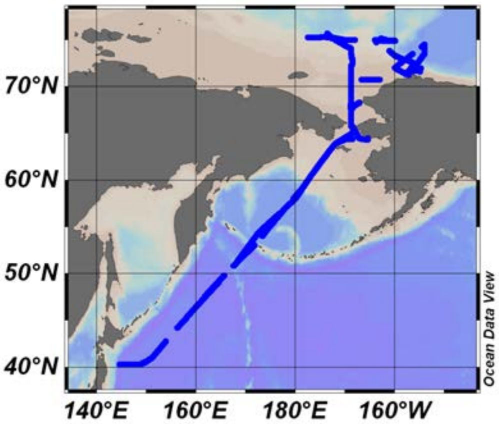


Figure 4.6-1 Observation map

(6) Results

Figure 4.6-2 is showing the results of measuring the TDIC concentration of surface seawater samples. During the cruise, 18 bottles of RM (batch Q27) was analyzed in order to calibrate the slope of the calibration factor. The standard deviation of the absolute differences of duplicate measurements was 1.5 μmol kg-1 (n=18).

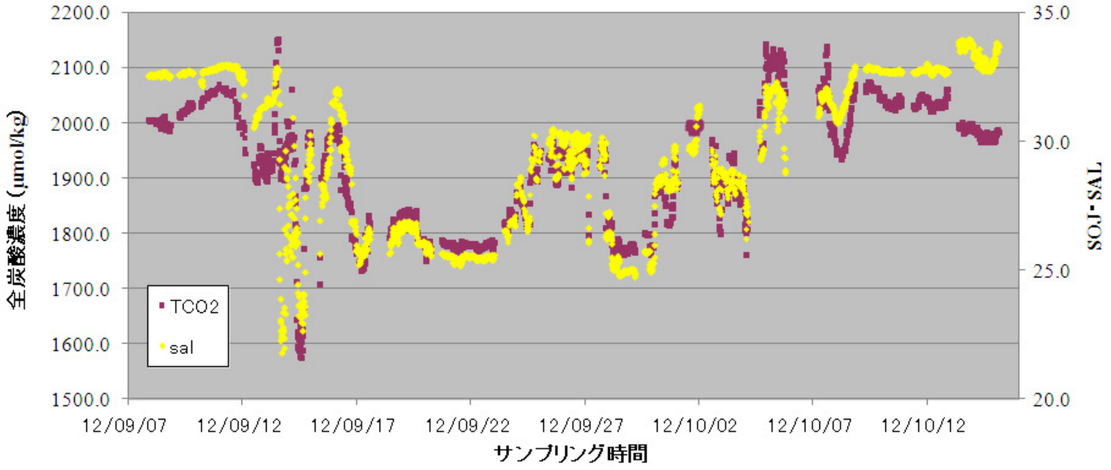


Figure 4.6-2 Temporal variations of underway TDIC. Purple and yellow dots represent surface TDIC and salinity, respectively.

(7) Date archives

Data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

(8) References

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO_2 measurements; PICES Special Publication 3, 199pp.

4.7 Total Alkalinity

(1) Personel

Shigeto Nishino (JAMSTEC): Principal Investigator
Akihiko Murata (JAMSTEC)
Michiyo Yamamoto-Kawai (Tokyo University of Marine Science and Technology)
Takahisa Mifune (Tokyo University of Marine Science and Technology)
Yasuhiro Arii (MWJ): Operation Leader

(2) Objective

As described in the Section 4.5 (DIC), total Alkalinity (TA) is an essential parameter in carbonate system in the ocean. We have measured TA during the MR12-E03 cruise to estimate pH, calcium carbonate saturation state and pCO2. Furthermore, TA is a useful tracer for river water in the Arctic Ocean: TA is high in river runoff (especially in North American rivers) and low in sea ice meltwater. Because river water carries freshwater, carbon, nutrients, contaminants etc., changes in distribution of river water in the Arctic Ocean may affect regional and global climate, productivity and human health. Distribution of river water in the Chukchi Sea/Canada Basin region during the MR12-E03 cruise will be estimated from TA and results will be compared with those observed in previous years.

(3) Parameters

Total Alkalinity, TA

(4) Instruments and Methods

(4)-1 Seawater sampling

Seawater samples were collected at 86 stations in 12 L Niskin bottles mounted on the CTD-rosette system. A sampling silicone rubber with PFA tip was connected to the Niskin bottle when the sampling was carried out. The 125 ml borosilicate glass bottles (SHOTT DURAN) were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (10 seconds) with care not to leave any bubbles in the bottle. 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 collecting the samples on the deck, the bottles were carried into the lab and put in the water bath kept about 25° C for one hour before the measurement.

(4)-2 Seawater analysis

Measurement of alkalinity was made using a spectrophotometric system (Nippon ANS, Inc.) using a scheme of Yao and Byrne (1998). The sampled seawater in the glass bottle is transferred to a sample cell in the spectrophotometer (Carry 50 Scan, Varian) via dispensing unit. The length and volume of the cell are 8 cm and 13 ml, respectively, and its temperature is kept at 25° C in a thermostated compartment. The TA is calculated by measuring two sets of absorbance at three wavelengths (750, 616 and 444 nm). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green) and another is the one after the injection. For mixing the acid with indicator solution and the seawater sufficiently, they are circulated through the line by a peristaltic pump 8 and half minutes before the measurement.

The TA is calculated based on the following equation:

$$\begin{aligned} pH_T = {} & 4.2699 + 0.002578 * (35 - S) \\ & + \log((R(25) - 0.00131) / (2.3148 - 0.1299 * R(25))) \\ & - \log(1 - 0.001005 * S), \end{aligned} \tag{1}$$

$$\begin{aligned} A_T = {} & (N_A * V_A - 10 \wedge pH_T * \mathrm{DensSW}(T, S) * (V_S + V_A)) \\ & * (\mathrm{DensSW}(T, S) * VS)^{-1}, \end{aligned} \tag{2}$$

where R(25) represents the difference of absorbance at 616 and 444 nm between before and after the injection. The absorbance of wavelength at 750 nm is used to subtract the variation of absorbance caused by the system. DensSW (T, S) is the density of seawater at temperature (T) and salinity (S), N_A the concentration of the added acid, V_A and V_S the volume of added acid and seawater, respectively.

To keep the high analysis precision, some treatments were carried out during the cruise. The acid with indicator solution stored in 1 L DURAN bottle is kept in a bath with its temperature of 25° C, and about 10 ml of it is discarded at first before the batch of measurement. Furthermore, we injected the acid so that pH_T of a sample might become the range of 3.6 to 4.6 values. For mixing the seawater and the acid with indicator solution sufficiently, TYGON tube used on the peristaltic pump was periodically renewed. Absorbance measurements were done 10 times during each analysis, and the stable last five and three values are averaged and used for above listed calculation for before and after the injection, respectively.

(4) Station list or Observation log

Seawater samples were collected at 86 stations (Figure 4.7-1).

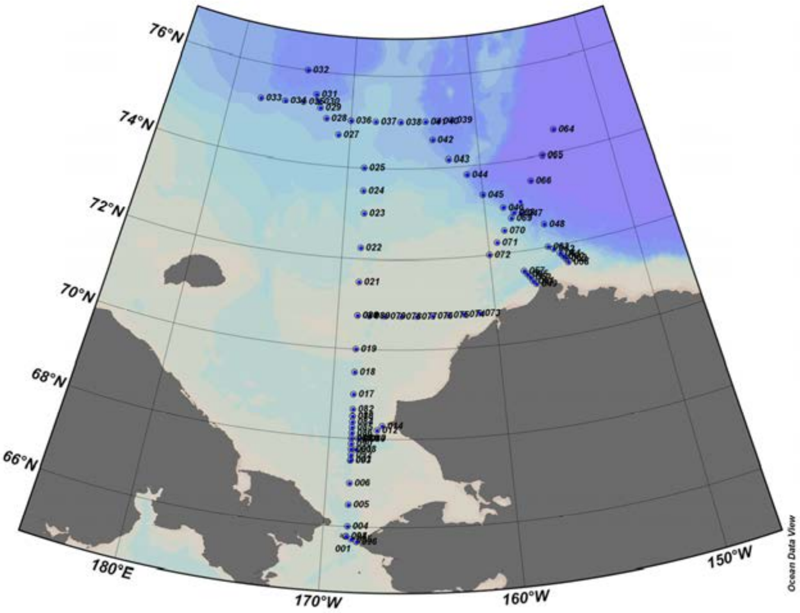


Figure 4.7-1 Map of sampling station.

(5) Preliminary results

At each station, samples were taken in duplicate for waters of the following table 4.7-1. The difference between each pair of analyses was plotted on a range control chart (Figure 4.7-2). The average of the difference was 0.67 μmol kg^{-1} (n = 174 pair) with its standard deviation of 0.57 μmol kg^{-1}, which indicates that the analysis was accurate enough according to Guide to best practices for ocean CO_2 measurements (Dickson et al., 2007).

Table 4.5-1 The layer taken in duplicate for waters.

Bottom depth	Duplicate layer
< 100 m	10 m, bottom
100 ~ 400 m	50 m, 100 m
> 400 m	100 m, 400 m

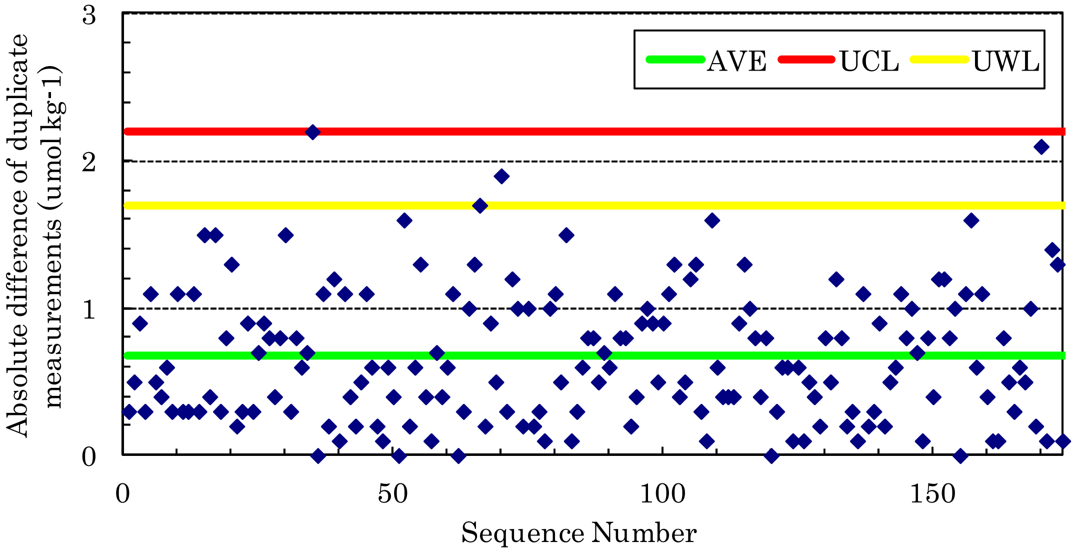


Figure 4.7-2 Range control chart of the absolute differences of duplicate measurements of TA carried out during this cruise.

(6) Data Archives

All data will be submitted to Data Management Group (DMG) in JAMSTEC and is currently under its control.

(7) 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.

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

4.8. Chlorophyll *a* measurements of total and size-fractionated phytoplankton

(1) Personnel

Toru Hirawake (Faculty of Fisheries Sciences, Hokkaido University): Principal Investigator (PI)
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Shoko Tatamisashi (MWJ)

(2) Objective

Phytoplankton distributes in various species and sizes in the ocean were examined. Phytoplankton species are roughly characterized by the cell size. The object of this study is to investigate the vertical and horizontal distributions of phytoplankton in the Arctic Ocean by using the size-fractionated filtration method.

(3) Parameters

Total chlorophyll *a*
Size-fractionated chlorophyll *a*

(4) Instruments and methods

We collected samples for chlorophyll *a* (chl-*a*) from 12 depths between the surface and 200 m depth including a chl-*a* maxmum layer at routine casts. The chl-*a* maximum layer was determined by a fluorometer (Seapoint Sensors, Inc.) attached to the CTD system.

At the casts where the primary productivity measurements were conducted, we collected samples for total chl-*a* from 12 depths and size-fractionated chl-*a* from two depths, which correspond to the surface and a chl-*a* maximum layer, within the euphotic layer and the layer below down to 200 m. The euphotic layer was determined by a downward irradiance sensor for the experiments of primary productivity, and the sampling depths were determined as light intensities of 38, 13, 7, 4, 1 and 0.6% for the surface incident irradiance.

Water samples for total chl-*a* were vacuum-filtrated (<0.02MPa) through 25mm-diameter Whatman GF/F filter. Water samples for size-fractionated chl-*a* were sequentially vacuum-filtrated (<0.02MPa) through the four types of 47mm-diameter

Nylone filters(pore size of 20.0μm) ,47mm-diameter nuclepore filters (pore size of 10.0μm, 5.0μm and 2.0μm) and the 25mm-diameter Whatman GF/F filter. Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylformamide. The tubes were stored at –20°C under the dark condition to extract chl-*a* for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma chemical Co.). We applied fluorometric determination for the samples of chl-*a*: "Non-acidification method" (Welschmeyer, 1994). Analytical conditions of this method were listed in Table 4.8-1.

(5) Results

Samples for total and size-fractionated chl-*a* were collected at 50 and 21 stations, respectively (See Fig. 4.8-1). The numbers of samples for total and size-fractionated chl-*a* were 367 and 165, respectively.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC home page.

(7) Reference

Welschmeyer, N. A. (1994): Fluorometric analysis of chlorophyll *a* in the presence of chlorophyll *b* and pheopigments. *Limnol. Oceanogr.*, 39, 1985–1992.

Table 4.8-1. Analytical conditions of non-acidification method for chlorophyll *a* with Turner Design fluorometer (10-AU-005).

	Non-acidification method
Excitation filter (nm)	436
Emission filter (nm)	680
Lamp	Blue F4T5,B2/BP

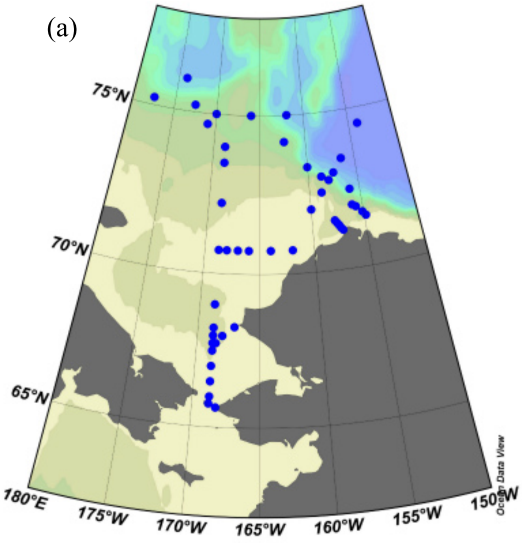

Figure 4.8-1. Maps of stations for (a) total and (b) size-fractionated chlorophyll *a* measurements.

4.9. Primary production

(1) Personnel

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Kanako Yoshida (MWJ): Operation Leader
Masahiro Orui (MWJ)

(2) Objective

Primary production was measured to estimate underwater photosynthesis by phytoplankton in the Arctic Ocean.

(3) Parameters

Primary production

(4) Instruments and methods

a. Instruments

Stable isotope analyzer
ANCA-SL SYSTEM by Europa Scientific Ltd.; now SerCon Ltd.
Software
ANCA Ver.3.6

b. Methods

Primary production was measured at 10 stations (Sts. 001, 010, 024, 029, 039, 045, 060, 064, 072 and 076) by simulated in situ incubation method (See Figure 4.9-1 and Table 4.9-1). We sampled seawater using shading and acid-treatment bottles and tubes connected to the Niskin bottles, which are derived from 7 optical depths, 100%, 38%, 13%, 7%, 4%, 1% and 0.6% of surface irradiance.

After sampling, the seawater was dispensed into 1L Nalgene polycarbonate bottles for incubation in a dark room. The Nalgene bottles were used after acid treatment. These seawater samples were inoculated with labeled carbon substrate ($NaH^{13}CO_3$) for the measurements of primary production. The concentration of labeled carbon ($NaH^{13}CO_3$) was 200 µM that was ca. 10 % enrichment to the total inorganic carbon in the ambient water. The bottles were placed into incubators with neutral density filters corresponding to light levels at the seawater sampling depths. Incubations using dark bottles were also conducted at each light level.

Samples for the measurements of primary production were incubated in a bath on the deck for 24 hours. At the end of the incubation period, samples were filtered through glass fiber filters (Whatman GF/F 25mm, pre-combusted under 450 degC over 4 hours). The filters were kept to freeze -20 degC until measurements. Before the measurements, the filters were oven-dried at 45 degC for at least 20 hours and treated with hydrochloric acid to remove the inorganic carbon. The measurements were performed on board the ship using a stable isotope analyzer (ANCA-SL, Europa Scientific Ltd.; now SerCon Ltd.).

(5) Station list

Table 4.9-1 shows a station list including optical depths, incubation times, and measured parameters with or without zero time (natural abundance) measurements.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

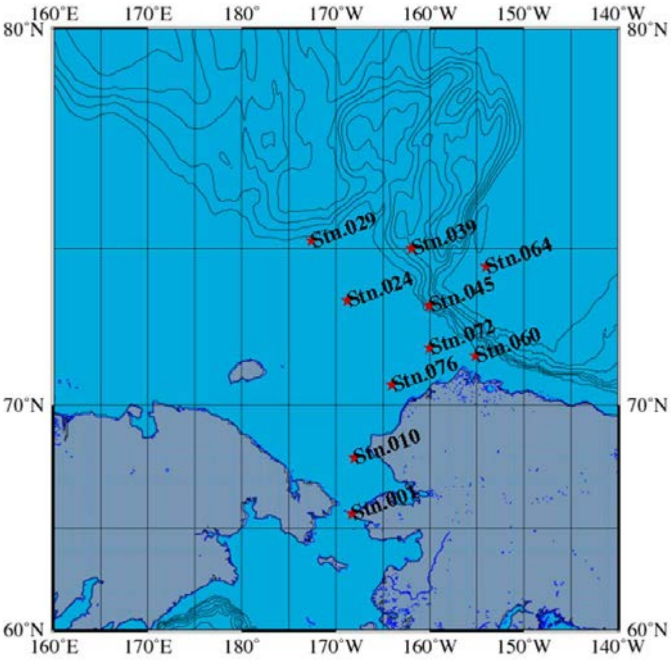

Figure 4.9-1. Map of stations with station numbers for the measurements of primary production (red stars).

Table 4.9-1. List of stations, optical depths, incubation time, and measured parameters with or without zero time (natural abundance) measurements.

Stations	Optical Depths (%)	Incubation time (hrs)	Primary Production
001	0.6, 1, 4, 7, 100	24	x&0
010	0.6, 1, 4, 7, 13, 38, 100	24	x&0
024	0.6, 1, 4, 7, 13, 38, 100	24	x&0
029	0.6, 1, 4, 7, 13, 38, 100	24	x&0
039	0.6, 1, 4, 7, 13, 38, 100	24	x&0
045	0.6, 1, 4, 7, 13, 38, 100	24	x
060	1, 4, 13, 38, 100	24	x&0
064	2.6, 1, 4, 7, 13, 38, 100	24	x
072	7, 13, 38, 100	24	x
076	0.6, 1, 4, 7, 13, 38, 100	24	x&0

x: measurements without zero time

x&0: measurements with zero time

4.10. Phytoplankton and optical properties

(1) Personnel

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(Non-boadring)

Koji Suzuki	Faculty of Environmental Earth Science, Hokkaido University
Takafumi Hirata	Faculty of Environmental Earth Science, Hokkaido University
Takahiro Iida	National Institute of Polar Research
Sei-ichi Saitoh	Faculty of Fisheries Sciences, Hokkaido University

(2) Objective

A) To carry out validation of optical algorithms to derive inherent optical properties, pigments concentration, size structure and primary productivity.
B) To estimate effect of phytoplankton productivity at subsurface chlorophyll maximum on satellite derived primary productivity.
C) To investigate change in photosynthetic characteristics to temperature increase to apply it to ecological modeling.
D) To investigate differences of grazing pressure between zooplankton species from the Pacific and Arctic Ocean.
E) To investigate phytoplankton community structure

(3) Parameters

A) Underwater spectral irradiance and radiance (PRR-800/810)
B) Backscattering coefficients (HydroScat-6)
C) Incident photosynthetic available radiation (PAR)
D) Light absorption coefficients of particles and colored dissolved organic materials (CDOM)
E) Phytoplankton pigments (HPLC)
F) Photosynthesis versus irradiance curve (P-E)
G) Phytoplankton community
H) Grazing experiment
I) Daily net primary productivity of phytoplankton (NPP) (*see description of '4.9 Primary production in this report*)
J) Bulk and size fractionated chlorophyll *a* concentration (*see description of '4.8 Chlorophyll a' in this report*)

(4) Instruments and Methods

Sampling stations for each measurement and experiment are shown in Table 4.10-1.

A) Underwater spectral irradiance and radiance (PRR-800/810)

Underwater spectral downwelling irradiance $E_d(\lambda, z)$ (μW cm^{-2} nm^{-1}) and upwelling radiance $L_u(\lambda, z)$ (μW cm^{-2} nm^{-1} str^{-1}) at 17 wavelengths over 380-765 nm were measured with a spectroradiometer, PRR-800 (Biospherical Instrument Inc.). The PRR-800 was deployed in free-fall mode up to 80-120 m deep distancing from the stern of ship to avoid her shadow. Incident downwelling irradiance to sea surface $E_d(\lambda, 0+)$ (μW cm^{-2} nm^{-1}) was monitored by reference spectroradiometer, PRR-810 (Biospherical Instrument Inc.) with same specification as the underwater sensor. After each deployment of the instrument, dark values were recorded for about ten seconds. For NPP measurements, underwater photosynthetic available radiation (PAR), $E_q(z)$, was also calculated by converting the $E_d(\lambda, z)$ to quantum unit, $E_q(\lambda, z)$ (μmol photons m^{-2} s^{-1}), and integrating the $E_q(\lambda, z)$ from 412 to 710 nm.

Measurements were carried out 30 minute after sun rise for NPP measurements and around noon for ocean color remote sensing.

B) Backscattering coefficient (HydroScat-6)

Backscattering coefficient of particulate matter (b_{bp}) at 6 wavelengths was measured with a spectral backscattering sensor HydroScat-6 (HOBI Labs). It was deployed up to 70 m deep.

C) Incident photosynthetically available radiation (PAR)

Incident PAR, E_q (0+), was monitored with a LI-190SB air quantum sensor. Mean value for five minutes was recorded to a LI-1400 data logger (LI. COR Inc.) during the cruise.

D) Light absorption coefficients of particles and colored dissolved organic materials (CDOM)

Seawater samples for absorption coefficients measurement were collected from the sea surface and depths corresponding to 13% of incident PAR and subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.).

For measurements of spectral absorption coefficient of particles, particles in 1-4 liter(s) of water sample were concentrated on a glass fiber filter (Whatman GF/F, 25 mm). Optical density (*OD*) of particles on the filter pad was measured with a spectrophotometer, MPS-2400 (Shimadzu) equipped an end-on type detector, and absorption coefficient of particles ($a_p(\lambda, z)$) was determined from the *OD* according to the Quantitative Filter Technique (QFT) (Mitchell, 1990). The filter was then soaked in methanol to extract and remove the pigments (Kishino *et al.*, 1985) and absorption coefficient of detritus ($a_d(\lambda, z)$) was quantified again. Absorption coefficient of phytoplankton, $a_{ph}(\lambda, z)$, was calculated as a difference between values before and after the pigments extraction. To optimize the QFT, pathlength amplitude factor (ß) was determined. Approximately 50-100 liters of pumped up water was concentrated to 20 ml using 5 μm nylon mesh. After optical density of the suspended sample (OD_s) was measured, the sample was filtrated on a GF/F filter and its optical density (OD_f) was measured.

For measurements of spectral absorption coefficient of CDOM ($a_{CDOM}(\lambda, z)$), 250 ml of water sample was filtrated through a 0.2 μm Nuclepore filter (Whatman, 47 mm). *OD* of the filtrate water against pure water (Milli-Q) was measured with 10 cm cylindrical quartz cell and spectrophotometer, MPS-2400 (Shimadzu), and calculated $a_{CDOM}(\lambda, z)$.

E) Phytoplankton pigments (HPLC)

Seawater samples for phytoplankton pigments were collected from the sea surface and depths corresponding to 13% of incident PAR and subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.).

Phytoplankton in 2 liters of water sample were concentrated on a glass fiber filter (Whatman GF/F, 25 mm) and stored in liquid N_2. Pigments concentration will be determined with a high performance liquid chromatography (HPLC) according to a method of Van Heukelem and Thomas (2001) at a laboratory after the cruise.

F) Photosynthesis versus irradiance curve (P-E)

Seawater sample for P-E curve experiment was collected from the depth of subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.).

Carbon assimilation number of phytoplankton was determined using the stable ^{13}C isotope method (Hama *et al.*, 1983). For incubation, samples were transferred into ten 250 ml clear bottles. After adding $NaH^{13}CO_3$ (ISOTEC Inc.) with approximately 10% of the total carbonate, the samples were exposed to ca. 0-700 μ mol photons m^{-2} s^{-1} with an artificial light source in a water bath. The incubation was carried out 2 hours under temperatures of *in situ* and +5°C. After the incubation, the water samples were filtered onto the glass fiber filters (Whatman GF/F, 25 mm diameter) precombusted at 450 °C for four hours and stored in liquid N_2. The isotope ratio of ^{12}C and ^{13}C and POC will be determined by a stable isotope GCMS in a laboratory after the cruise. Photosynthetic rate of each light intensity and temperature will be calculated from the ratio and DIC data using the equation of Hama *et al.* (1983).

G) Phytoplankton community

To determine phytoplankton community structure, seawater samples for microscopy, flow cytometric (FCM) and DNA analyses were collected from the sea surface and the depth of subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.). For microscopic analysis, 500 ml of seawater was refrigerated after adding glutaraldehyde-lugor solution. For FCM analysis, 2 ml of seawater was frozen after adding paraformaldehyde solution. All samples are processed and analyzed in a laboratory on land.

H) Grazing experiment (Incubation)

Seawater sample for grazing experiment was collected from the depth of subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.). Zooplankton sample was collected with 80 cm ring net.

Seawater sample was transferred into 3000 ml clear polycarbonate bottles. Zooplankton sample was sorted and several species from the Arctic and Pacific were isolated and put into the seawater sample separately. The samples were covered by black plastic bag and incubated in a water bath for 24 hours. Temperature in the water bath was maintained with running water from the sea surface.

Total and size fractionated chlorophyll *a* concentrations of water samples before and after the incubation were measured. Filtering rate of each species will be calculated from the chlorophyll *a* concentrations.

I) Daily net primary productivity of phytoplankton (NPP)

Net primary productivity of phytoplankton was determined using the stable ^{13}C isotope method (Hama *et al.*, 1983). The details were described in the section '4.9 Primary production' in this report.

J) Bulk and size fractionated chlorophyll *a* concentration

Bulk and size fractionated chlorophyll *a* concentration was measured fluorometrically. The details were described in the section '4.8 Chlorophyll *a*' in this report.

Table 4.10-1. Sampling summary

Station No.	station ty	Lat			Long			UTC	LUT			samples collected											operation	
		deg.		min	deg.		min	Date Time	Date Time	Depth	SST(˚C)	Chla (total)	Chla (size)	CDOM	QFT	PP	PE curve	HPLC	microscopy	FCM	DNA	incubation	PRR800/810	Hydroscat6
001	vertical	65	N	39.00	168	W	15.00	12-Sep 20:00	13-Sep 07:00	43	8.1	x	x	x	x	x		x	x	x	x		x	x
004	surface	66	N	0.00	168	W	45.00	13-Sep 01:45	13-Sep 12:45	54	5.6	x	x	x	x			x					x	x
010	vertical	68	N	0.00	168	W	0.00	13-Sep 19:00	14-Sep 06:00	55	3.8	x	x	x	x	x	x	x	x	x	x	x	x	x
014	surface	68	N	18.00	167	W	3.00	14-Sep 01:15	14-Sep 12:15	38	6.9	x	x	x	x			x					x	x
020	surface	70	N	45.00	168	W	45.00	15-Sep 00:10	15-Sep 11:10	37	3.6	x	x	x	x			x					x	x
024	vertical	73	N	30.00	168	W	45.00	15-Sep 20:40	16-Sep 07:40	115	-0.1	x	x	x	x	x		x	x	x	x		x	x
025	surface	74	N	0.00	168	W	45.00	16-Sep 01:40	16-Sep 12:40	178	1.6	x	x	x	x			x					x	x
029	vertical	75	N	12.40	172	W	32.80	16-Sep 19:30	17-Sep 06:30	447	-0.3	x	x	x	x	x		x	x	x	x	x	x	x
032	vertical	76	N	0.00	174	W	0.00	17-Sep 08:45	17-Sep 19:45	2150	-0.4	x	x					x						
033	vertical	75	N	14.00	177	W	30.00	18-Sep 05:00	18-Sep 16:00	705	0.0	x	x					x						
039	vertical	75	N	0.00	162	W	0.00	19-Sep 19:30	20-Sep 06:30	2000	0.9	x	x	x	x	x	x	x	x	x	x	x	x	x
045	vertical	73	N	20.00	160	W	0.00	22-Sep 19:00	23-Sep 06:00	1400	2.7	x	x	x	x	x		x	x	x	x	x	x	x
046	surface	73	N	0.00	158	W	40.00	23-Sep 02:00	23-Sep 13:00	1274	3.9	x	x	x	x			x					x	x
051	surface	71	N	19.80	157	W	19.90	24-Sep 00:00	24-Sep 11:00	92	3.9	x	x	x	x			x					x	x
060	vertical	71	N	44.00	155	W	7.00	26-Sep 19:00	27-Sep 06:00	273	3.2	x	x	x	x	x	x	x	x	x	x	x	x	x
063	surface	72	N	0.00	156	W	0.00	27-Sep 02:10	27-Sep 13:10	127	3.9	x	x	x	x			x					x	x
064	vertical	74	N	30.00	154	W	0.00	27-Sep 19:00	28-Sep 06:00	3850	0.1	x	x	x	x	x		x	x	x	x		x	x
067	surface	73	N	5.00	157	W	24.00	29-Sep 00:10	29-Sep 11:10	2454	1.1	x	x	x	x			x					x	x
072	vertical	72	N	0.00	160	W	0.00	29-Sep 16:00	30-Sep 03:00	30	0.2	x	x	x	x	x		x	x	x	x	x	x	x
076	vertical	70	N	45.00	164	W	0.00	30-Sep 19:30	01-Oct 06:30	47	4.6	x	x	x	x	x	x	x	x	x	x	x	x	x
079	surface	70	N	45.00	167	W	0.00	01-Oct 02:17	01-Oct 13:17	47	3.1	x	x	x	x			x					x	x

4.11. Microbes and related biogeochemical parameters

(1) Personnel

Toshi Nagata (Atmosphere and Ocean Research Institute, AORI): Principal investigator
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Hideki Fukuda (AORI)
Mario Uchimiya (National Institute of Polar Research/AORI)
Chiaki Motegi (Université Laval/AORI)
Yosuke Yamada (AORI)
Connie Lovejoy (Université Laval)
Marcel Babin (Université Laval)

(2) Objective

To clarify the spatial variations in and regulation of microbes and related biogeochemical parameters in the Chukchi Sea and Canada Basin, western Arctic.

(3) Parameters

i) Microbes
  a) Prokaryote and viral abundance
  b) Heterotrophic prokaryote production
  c) Viral production
  d) Prokaryote and viral community composition

ii) Biogeochemical parameters
  e) Dissolved organic carbon and nitrogen (DOC/N)
  f) Particulate organic carbon and nitrogen (POC/N)
  g) Transparent exopolymer particles (TEP)
  h) Size distribution of suspended particles

(4) Methods and Instruments

i) Microbes

a) Prokaryote and viral abundance

2 mL of seawater sample was fixed by glutaraldehyde (final concentration of 1%), frozen in liquid nitrogen, and then stored in a deep freezer (-80°C). Prokaryote and viral abundance will be determined by flow cytometry in a land laboratory.

b) Heterotrophic prokaryote production

1.5 mL of seawater sample was amended with ^{3}H-leucine (final concentration of 10 nM) and incubated for 2–24 h in the dark at *in situ* temperature. After the incubation, the sample was centrifuged and precipitates were extracted. The radioactivity will be determined using a liquid scintillation counter in a land laboratory.

c) Viral production

^{3}H-Thymidine was amended to triplicate samples (3.5 ml, final concentration 10 nM) and incubated for 24 h at *in situ* temperature in the dark. The incubation was terminated by filtering the samples through 0.2 µm filter. Filtrates (1.0 ml) were treated with enzymes, and precipitates were collected by centrifugation. The precipitates were then hydrolyzed. The radioactivity will be measured using a liquid scintillation counter in a land laboratory.

d) Prokaryote and viral community composition

6–9 L of seawater sample was filtered through a 3 µm polycarbonate filter and then through a 0.22 µm Sterivex filter. Filters were kept in a freezer (-20°C). Prokaryotes community composition will be determined by 454 Pyrosequence in a land laboratory. For viral community, 3–5 L of filtrate (<0.22 µm) was concentrated with 100 kDa cartridge (final volume 30 mL, Vivaflow200). Viral community composition will be determined by 454 Pyrosequence in a land laboratory.

ii) Biogeochemical parameters

e) DOC/N

Seawater sample was filtered through a pre-combusted GF/F filter and the filtrate was collected in a glass bottle. The aliquot was transferred to glass ampoules and stored in a freezer (-20°C). The concentration of DOC and total dissolved nitrogen (TDN) will be determined by high temperature catalytic oxidation method in a land laboratory. The concentration of DON will be calculated by subtracting the concentration of dissolved inorganic nitrogen from that of TDN.

f) POC/N

Seawater sample was filtrated through a pre-combusted GF/F filter and the filter was stored in a freezer (-20°C). Total mass of POC/N collected on the filter will be determined by CHN elemental analyzer in a land laboratory.

g) TEP

Seawater sample was filtered through a polycarbonate filter (pore size, 0.4 µm). The filter was stained with cationic dye Alcian Blue and stored in a freezer (-20°C). The concentration of TEP collected on the filter will be determined by colorimetry in a land laboratory.

h) Size distribution of suspended particles

Vertical size distribution of suspended particles in the upper layer (<200 m) was determined by an *in situ* size-scattering instrument, LISST-100 (Sequoia Scientific Inc.).

(5) Observation log

Information about sample and data collection is summarized in Table 4.11-1.

(6) Data archives

All the data obtained during MR12-E03 cruise will be submitted to Data Management Group (DMG) of JAMSTEC after the sample analysis and validation.

Table 4.11-1. Observation log. Sta.#, station number; FCM, flow cytometry for prokaryote and viral abundance; HPP, heterotrophic prokaryote production; VP, viral production; CC, community composition of prokaryote and virus; DOC/N, dissolved organic carbon and nitrogen; POC/N, particulate organic carbon and nitrogen; TEP, transparent exopolymer particles; LISST, laser *in situ* scattering and transmissometry for vertical size distribution of suspended particles. For each parameter, the information is indicated by “1” when the sample (or data) collection was conducted, whereas indicated by “-“ when not conducted.

Sta.#	FCM	HPP	VP	CC	DOC/N	POC/N	TEP	LISST
1	1	1	1	1	1	1	1	1
4	1	1	1	1	-	1	1	1
8	1	1	1	1	-	1	1	1
10	1	1	1	1	1	1	1	1
17	1	1	-	-	-	1	1	1
20	1	1	1	1	-	1	1	1
22	1	1	-	-	-	1	1	1
24	1	1	1	1	1	1	1	1
27	1	1	-	-	-	1	1	1
29	1	1	1	1	1	1	1	1
32	1	1	-	1	-	1	1	1
33	1	1	-	1	-	1	1	1
39	1	1	-	1	-	1	1	1
44	1	1	-	-	-	1	1	1
45	1	1	1	1	1	1	1	1
46	1	1	-	-	-	1	1	1
47	1	1	-	-	-	1	1	1
48	1	1	1	1	-	1	1	1
60	1	1	1	1	-	1	1	1
64	1	1	1	1	1	1	1	1
65	1	1	-	-	1	-	-	-
66	1	1	1	1	1	1	1	1
68	1	1	-	-	1	1	1	1
70	-	-	-	-	-	-	-	1
72	-	-	-	-	-	-	-	1
81	-	-	-	-	-	1	1	1
82	1	1	-	1	-	1	1	1
89	-	-	-	-	-	1	1	1

90	1	1	1	1	-	-	-	-
93	1	1	1	-	-	1	1	1

4.12. Clean water samplings

(1) Personnel

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Hajime Obata (The University of Tokyo)

Youhei Yamashita (Hokkaido University)

(2) Objective

The objectives of this cruise are to study the iron and nutrients behavior from shelf – slope – basin regions and their influence upon the primary production. In addition, we will study the distributions of dissolved organic matter, which is probably originated from the shelf sediment and related to the primary production. Moreover, we will study the distributions of dissolved trace metals, such as Zn, Fe, Mn, and others, in the Arctic Ocean.

(3) Parameters

Dissolved Fe (D-Fe) and total Fe (T-Fe) concentrations, Humic-type fluorescent intensity (H-flu), Chromophoric dissolved organic matter (CDOM), Dissolved and total concentrations of trace metals.

(4) Instruments and Methods

We collected water samples for above parameters using acid-cleaned Teflon-coated 10 liter Niskin X sampling bottles attached to a CTD-RMS. Sample filtration for analyses of D-Fe and dissolved trace metals, H-flu and CDOM 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.

a. Iron and H-flu

Iron samples were acidified to pH<1.7 with ultrapure HCl (Tamapure AA-100) and stored. D-Fe and T-Fe concentrations will be measured by an automated Fe analyzer after pretreatments. H-flu intensity will be measured by a fluorescence spectrophotometer in the laboratory.

b. CDOM

The filtrate for CDOM was subsequently placed in a pre-combusted glass bottle and frozen at −20°C. In the laboratory, water samples will be allowed to stand until reaching room temperature prior to fluorescence and absorption analysis. Excitation emission matrix fluorescence spectra will be obtained using a Horiba Fluoromax-4 fluorometer. Forty-one emission scans from 290 to 600 nm at 2-nm intervals will be acquired at excitation wavelengths between 250 and 450 nm at 5-nm intervals. UV–visible absorbance spectra will be measured by a spectrophotometer.

c. Trace metal

Water samples for trace metals, such as Zn, Fe, and Mn, in seawater were acidified to pH<1.8 with ultrapure HCl (Tamapure AA-100) and stored. Concentrations of dissolved and total trace metals will be determined with a high-resolution inductively coupled plasma mass spectrometer (HR-ICPMS, Thermo Fisher) after preconcentration with a chelating resin column.

(5) Observation log

Table. 4. 12 – 1 Station data of clean water sampling

Station	Latitude	Longitude	Sampling Depth (m)	Parameter
sta. 015	68-0.00 N	168-45.00 W	5, 10, 20, 30,40	Fe, H-flu, CDOM
sta. 017	69-0.00 N	168-45.00 W	5, 10, 20, 30, 40, 46	Fe, H-flu, CDOM
sta. 020	70-45.00 N	168-45.00 W	5, 10, 20, 30, 36	Fe, H-flu, CDOM
sta. 022	72-15.00 N	168-45.00 W	5, 10, 20, 30, 40, 46	Fe, H-flu, CDOM
sta. 024	73-30.00 N	168-45.00 W	5, 10, 20, 30, 40, 50, 60, 75, 117	Fe, H-flu, CDOM
sta. 027	74-40.00 N	170-55.00 W	5, 10, 30, 50, 75, 100, 125, 150, 175, 200, 222	Fe, H-flu, CDOM
sta. 029	75-15.00N	173-0.00 W	5, 10, 30, 50, 75, 100, 125, 150, 175, 200, 250, 300	Fe, H-flu, CDOM
sta. 032	76-0.00 N	174-0.00 W	5, 20, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM
sta. 033	75-14.00 N	177-30.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM
sta. 034	75-16.00 N	175-30.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM
sta. 036	75-0.00 N	170-0.00 W	5, 10, 30, 50, 75, 100, 125, 150, 175, 200, 225, 249	Fe, H-flu, CDOM
sta. 037	75-0.00 N	168-0.00 W	5, 10, 20, 30, 40, 50, 60, 75, 100, 125, 150, 157	Fe, H-flu, CDOM
sta. 038	75-0.00 N	166-0.00 W	5, 10, 30, 50, 75, 100, 125, 150, 175, 200, 250, 300	Fe, H-flu, CDOM
sta. 039	75-0.00 N	162-0.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM
sta. 041	75-0.00 N	164-0.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM
sta. 043	74-10.00 N	162-20.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu
sta. 045	73-20.00 N	160-0.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM
sta. 048	72-30.00 N	156-0.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu
sta. 064	74-30.00 N	154-0.00 W	5, 10, 25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350	Fe, H-flu, CDOM, Trace metal
			400, 450, 500, 600, 800, 1000, 1500, 2000, 2500, 3000	Fe, H-flu, CDOM, Trace metal
sta. 066	73-30.00 N	156-24.00 W	5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM, Trace metal
sta. 068	72-55.00 N	157-48.00 W	5, 10, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500	Fe, H-flu, CDOM, Trace metal
sta. 070	72-30.00 N	158-48.00 W	5, 10, 20, 30, 40, 46	Fe, H-flu, CDOM, Trace metal
sta. 072	72-0.00 N	160-0.00 W	5, 10, 20	Fe, H-flu, CDOM, Trace metal
sta. 074	70-45.00 N	162-0.00 W	5, 10, 20, 30, 35	Fe, H-flu, CDOM

sta. 076	70-45.00 N	164-0.00 W	5, 10, 20, 30, 40	Fe, H-flu, CDOM
sta. 078	70-45.00 N	166-0.00 W	5, 10, 20, 30, 33	Fe, H-flu, CDOM
sta. 080	70-45.00 N	168-0.00 W	5, 10, 20, 30, 40	Fe, H-flu, CDOM
sta. 085	68-15.00 N	168-45.00 W	5, 10, 20, 30, 40, 50	Fe, H-flu, CDOM
sta. 089	68-0.00 N	168-45.00 W	5, 10, 20, 30, 40, 52	Fe, H-flu, CDOM
sta. 091	67-45.00 N	168-45.00 W	5, 10, 20, 30, 40, 43	Fe, H-flu, CDOM

(6) Data policy and citation

In case of using iron (dissolved Fe and total Fe concentrations), CDOM and trace metals data, which were obtained in this research cruise, you need to communicate with a principal investigator (Kenshi Kuma), Youhei Yamashita and Hajime Obata for iron, CDOM and trace metals, respectively.

4.13. Volatile Organic Compound (VOC)

(1) Personnel

Atsushi Ooki (Hokkaido University): PI
Shuho Kawasaki (Hokkaido University)

(2) Objective

Measurements of volatile organic compounds (VOCs) in sea water and air in the Arctic Sea.

(3) Parameters

Surface seawater (dry air mole fraction or partial pressure)

CFC-11, HCFC-22, CH_3Cl, CH_2Cl_2, $CHCl_3$, CH_3Br, CH_2Br_2, CH_3I, CH_2ClI, C_2H_5I, C_5H_8, COS

Air (dry air mole fraction or partial pressure)

CFC-11, HCFC-22, CH_3Cl, CH_2Cl_2, $CHCl_3$, C_2Cl_4, CH_3Br, CH_2Br_2, $CHBr_3$ CH_3I, CH_2ClI, C_2H_5I, C_5H_8, COS

Bottle seawater from CTD-Niskin (unit: mol/L)

CH_2Br_2, $CHBr_3$ CH_3I, CH_2ClI, C_2H_5I, CH_2I_2, C_5H_8

(4) Instruments and Methods

Underway surface seawater measurement

Surface seawater was pumped from a seawater intake on the bottom of the ship (5-m depth), and supplied to the wet-laboratory-2. The surface seawater was continuously supplied to a silicone membrane tube equilibrator at a flow rate of 10 L min^{-1}. Pure air was continuously supplied to the silicone tubes at a flow rate of 20 mL min^{-1}, regulating the inner pressure to +0.14 MPa. The gas-phase sample of VOCs at equilibrium with the seawater could be obtained from the outlet of the silicone tube. The gas phase sample was dehumidified by means of Nafion® dryer and then transferred to a pre-concentration/GC-MS system. The dry air mole fraction of VOCs (ppt) in the sample were measured at 90 min intervals. Two gravimetrically prepared standard gases (Taiyo Nissan, Inc., Tokyo) containing these chemical species at concentrations of 100–500 ppt and 10–50 ppb was quantified according to the same procedures. The detection limits (S/N = 3) were 0.1–1 pptv for all species. The VOC concentrations (mol/L) are calculated from the Henry's law constant (mol/L/atm)and the partial pressure (atm) of VOC.

Air measurement

Outside air was collected on the uppermost deck by two ways, (a) canister sampling, and (b) cold-trap sampling.

(a) The air was collected in the stainless canister using a metal bellows pump. The air sample in the canister (with inner pressure of 1.4 atm) was transferred to the same GC-MS system within 3 hours after the collection.

(b) We prepared cold-trap stainless 1/16" tubes, which have 10 mg of TenaxTA, to concentrate VOCs at -100°C. Air was continuously pumped through a $Mg(ClO_4)_2$ dehumidifier tube and then transferred to the cold-trap at < -100°C for 12–24 hours using a metal bellows pump. VOC collected in the cold-trap was thermally desorbed at 210°C and transferred to the GC-MS system within 2 days after sampling.

Bottle water measurement

Seawater samples were collected with Niskin bottles. Seawater aliquots (124 ml) were collected in glass bottles, overflowing approximately 250 ml of seawater. To arrest microbial activity, 50 μl of saturated mercuric chloride ($HgCl_2$) solution, which had been previously bubbled with high-purity helium for 30 min at 90–100 °C to remove possible contaminating gases, was added to each bottle. The bottles were crimp-sealed using a soft septum (Nichiden-Rika Glass Co., Ltd, Kobe, Japan) and an aluminum cap. The sample bottles were kept in the dark at 4 °C until analysis, typically within 2 weeks. Dissolved VOCs were collected from the seawater samples by the purge-and-trap method. The total volume of seawater in each bottle was transferred to a bubbling vessel (temperature, 45–55 °C) by means of helium carrier gas. The dissolved VOCs in the seawater sample were purged with helium (flow rate, 55 ml min^{-1}) for 50 min and were transferred to the cold-trap. The VOC sample in the cold-trap will be measured by the GC-MS system after the cruise.

(5) Preliminary results

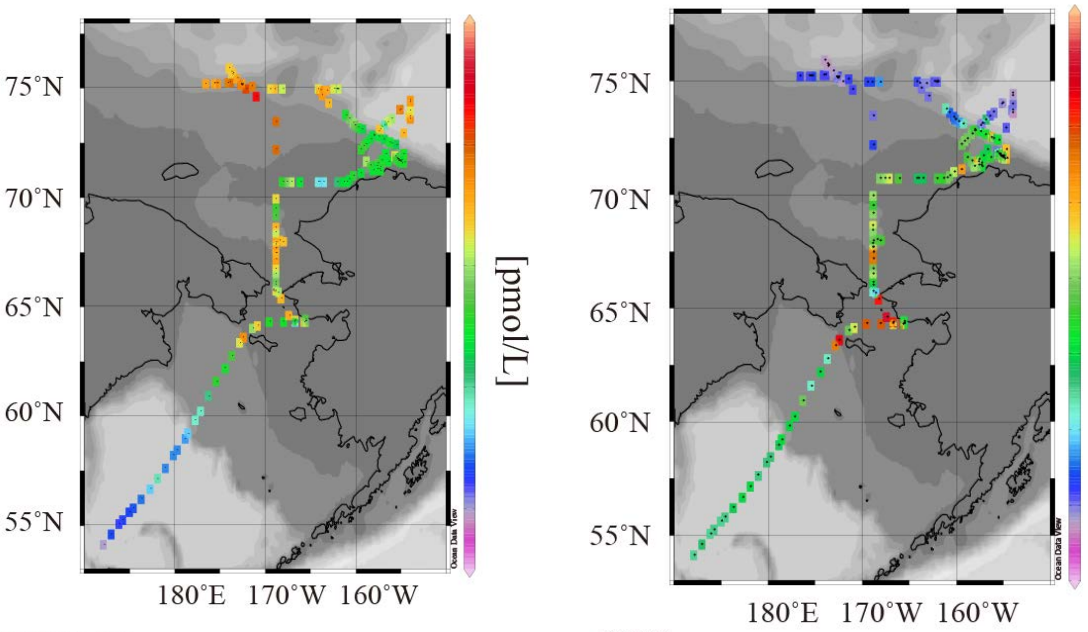
(5-1) Seawater sampling

Discrete seawater samples to obtain depth profiles were collected at 24 stations and layers listed below.

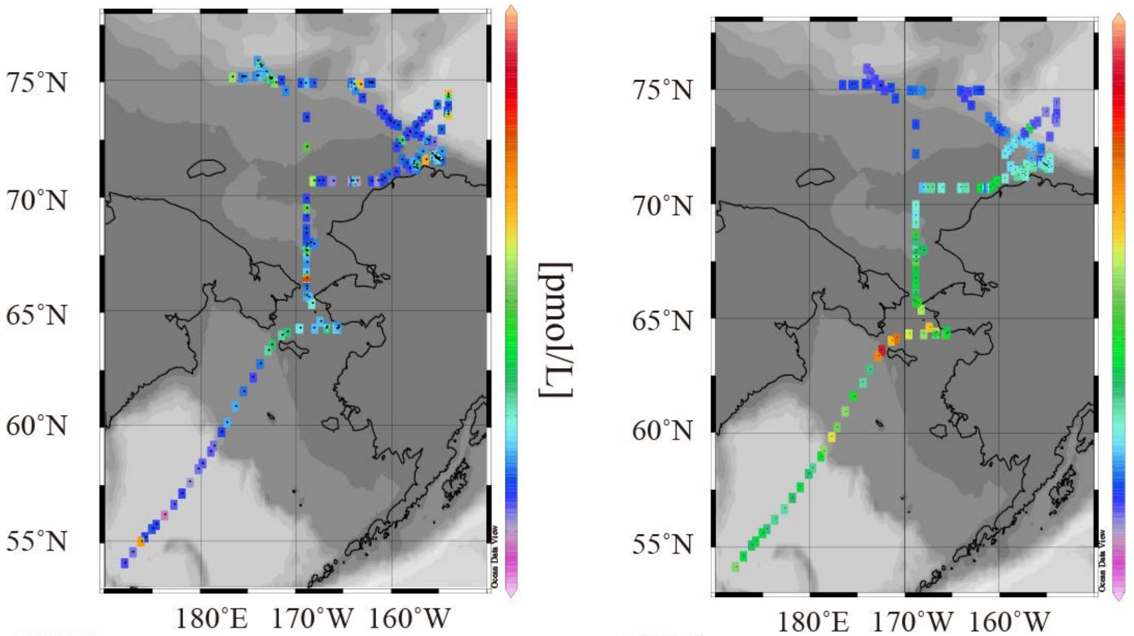
Stations
St. 1, 3, 10, 14, 17, 20, 22, 24, 27, 29, 32, 33, 39, 45, 48, 53, 60, 64, 68, 72, 74, 76, 78, 80
Layers
0m, 5m, 10m, 20 or 30m, 50m, 100m, 200m, 500m, 1000m, 2000m, Bottom-10m

(5-2) Underway surface seawater and air measurements

Preliminary results of contour of VOC concentrations in surface seawater are shown in figure 4.13.1. Air samples (n = 63) were collected along the ship track shown in figure 4.13.1.

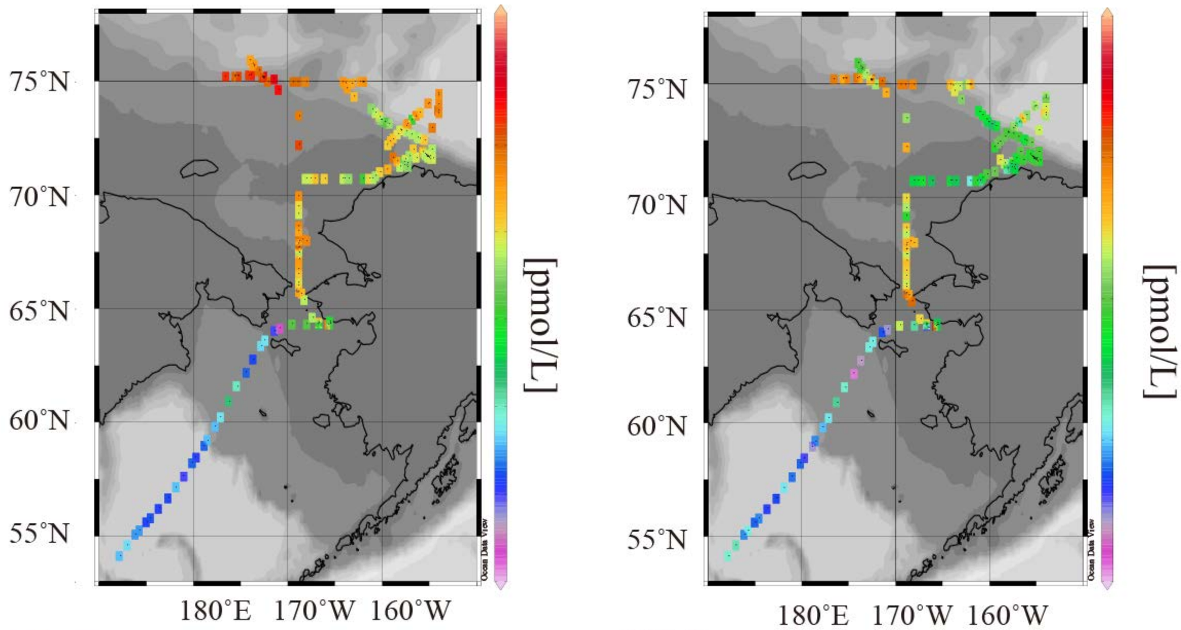


HCFC-22 COS

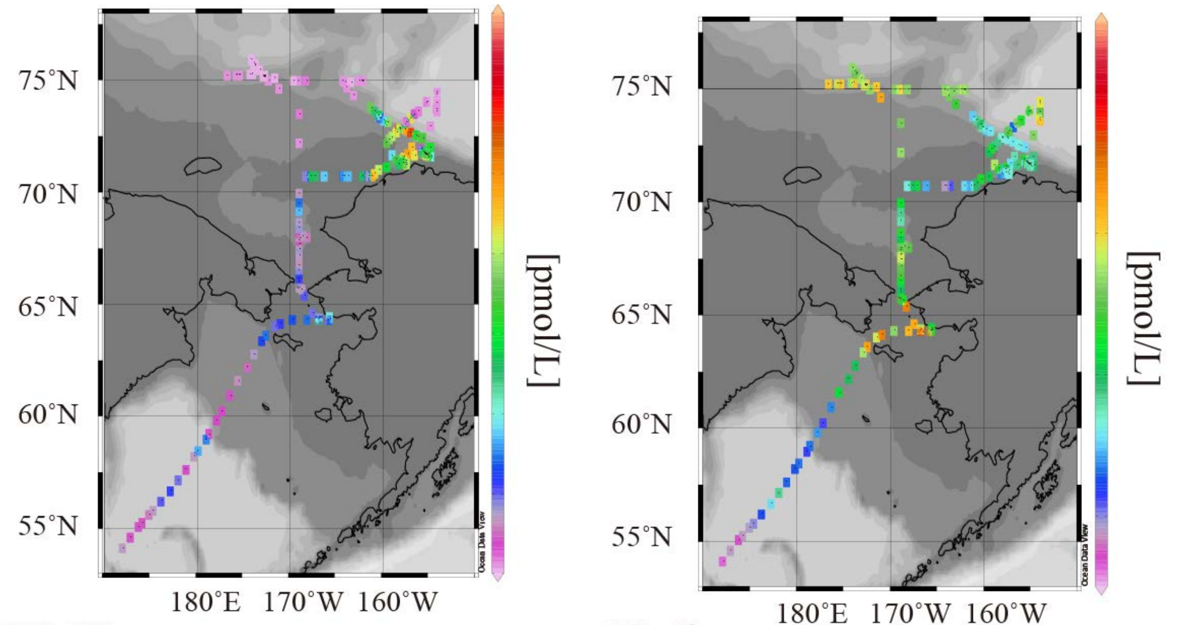


$CHCl_3$ CH_3I

Figure 4.13.1 Contour plots of VOC concentrations in surface seawater by underway measurement using silicone membrane tube equilibrator – GC-MS system.

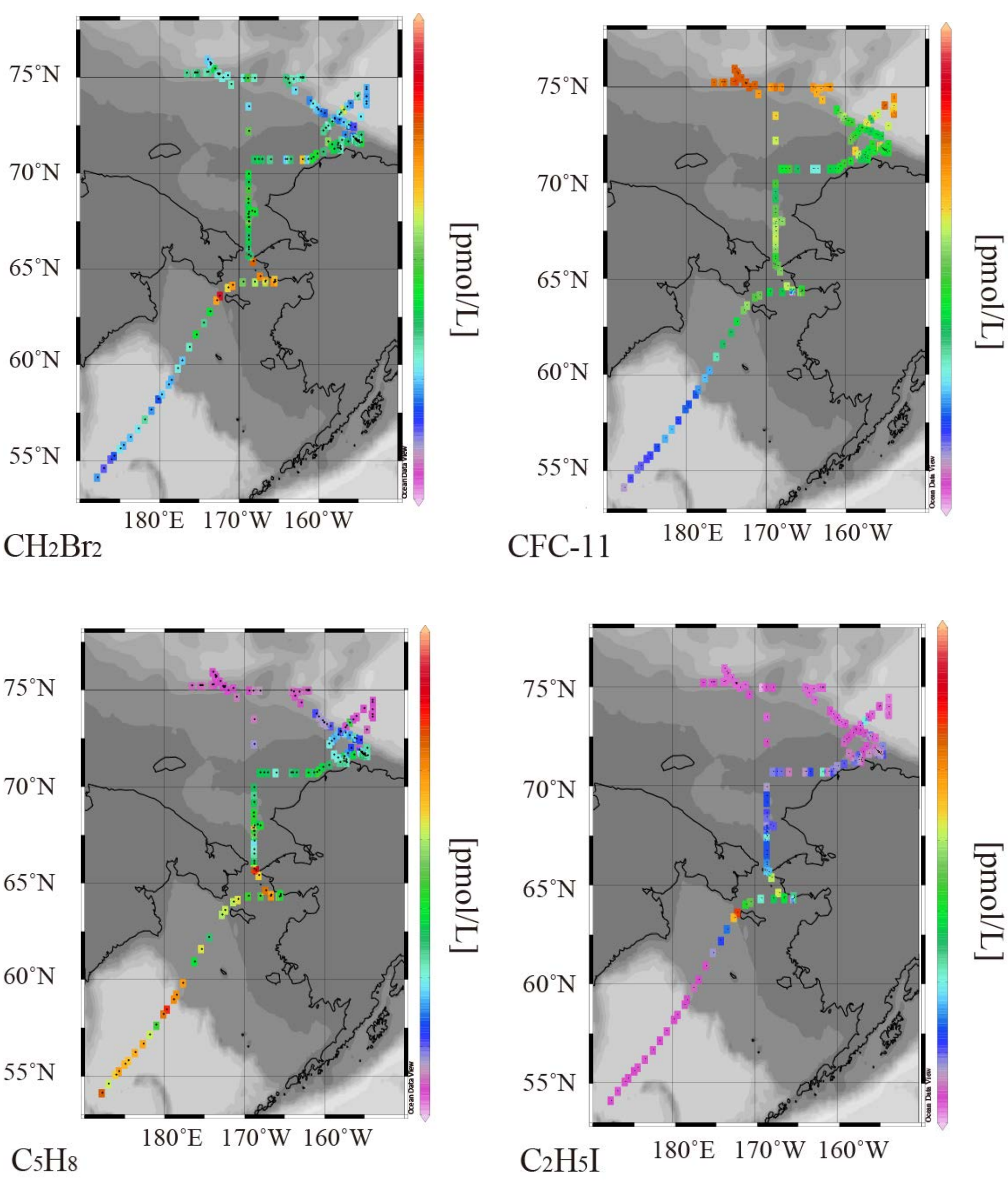


CH_3Cl CH_3Br



CH_2ClI CH_2Cl_2

Figure 4.13.1 *Continued*



CH_2Br_2 $CFC\text{-}11$ C_5H_8 C_2H_5I

Figure 4.13.1 *Continued*

(9) Data archives

The raw data obtained during this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC.

4.14. Rare Earth Elements, O-, Sr-, Nd- isotopes from seawater and Nutrients, Rare Earth Elements in pore water from sediment

4.14.1. Seawater samples

(1) Personnel

Jing Zhang (University of Toyama): Principal Investigator
Shoko Hirayama (University of Toyama)

(2) Objectives

Recently, changes in river water flux and decreasing in sea ice in the high latitudal ocean are frequently reported. Sea ice formation is strongly controlled by the fresh water flux and temperature. River water transports many nutrients into the Arctic regime giving strong influence on the primary productivity and the eco-system in the Arctic marine environment. Therefore, information of the detailed amount of river water to the Arctic is essential. In this study, we address the detailed structure and mixing ratio of different water masses and their variation in order to better understand the relative contribution of nutrient sources to the Arctic. Water samples were collected to determine multiple tracers such as Rare Earth Elements (REEs), oxygen, strontium and Neodymium isotopes ($^{18}O/^{16}O$, $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$).

Our objectives are as follows:

1. To clarify the detailed water mass structure of the Arctic
2. To estimate the fluxes of river water to the Arctic, and
3. To characterize the nutrient flux by riverine water

(3) Parameters

(A) Rare Earth Elements (REEs)
(B) Oxygen ($\delta^{18}O$) and Strontium ($^{87}Sr/^{86}Sr$) and Neodymium isotopes ($^{143}Nd/^{144}Nd$)

(4) Analytical Instruments and Methods

(A) Dissolved Rare Earth Elements

Total ~~of~~ 472 samples, each about 500ml, were collected from 53 stations for dissolved REE determination using X-NISKIN bottles.(Table 4.14.1-1) Immediately after the sampling, the seawaters were filtered through 0.22μm membrane filter and acidified to pH <1.6 with ultrapure HCl (TAMAPURE AA-100, Tama Chemicals) at the Clean Room on board for later analysis in the (land) laboratory. Solid-phase extraction method using CM-PEHA resin (Kagaya et al., 2009) was used for pre-concentration of REEs in seawater in preparation for. REEs concentrations in the samples will be analyzed with a SF-ICP-MS (Sector Field Inductively-Coupled Plasma Mass Spectrometer, Thermo Fisher Scientific, KK) at the University of Toyama.

(B) Oxygen ($\delta^{18}O$) and Strontium ($^{87}Sr/^{86}Sr$) and Neodymium isotopes ($^{143}Nd/^{144}Nd$)

Total 847 samples, each about 50ml, were collected for oxygen and strontium isotope ratios (Table 4.14.1-1). They will be analyzed for oxygen isotopes by IR-MS (Isotope Ratio Mass Spectrometry) and strontium isotopes by TIMS (Thermal Ionization Mass Spectrometry), respectively. Total 3 seawater samples were collected at 2 stations for the measurements of Nd isotopes (Table 4.14.1-2). Immediately after the sampling, the seawaters were filtered through 0.22μm membrane filter and acidified to pH <2 with ultrapure HCl (TAMAPURE AA-100, Tama Chemicals) at the Clean Room on board for later analysis in the (land) laboratory. Pre-concentration of Nd will be made by adsorption onto C18 SeaPak cartridges. Then, they will be measured for $^{143}Nd/^{144}Nd$ ratios with MC-ICP-MS (Inductively-Coupled Plasma Mass Spectrometer).

(5) Data Archive

All of the raw and processed data of the samples we collected will be submitted to Data Management Group (DMG) of JAMSTEC when ready.

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
1	1	0	09/13/2012	18:31	65-38.988	N	169-44.892	W	1	
		23							2	1
		22							3	2
		21							4	3
		20							5	4
		19							6	
		9							9	
		8								7
3	1	0	09/13/2012	21:58	65-46.248	N	169-12.528	W	10	
		23							11	
		22							12	8
		21							13	9
		20							14	10
		19							15	11
		18							16	12
		1							18	14
4	1	0	09/14/2012	0:12	66-0.012	N	169-19.958	W	19	
		1							27	
5	1	0	09/14/2012	3:42	66-30.09	N	169-14.772	W	28	
		23							29	
		22							30	15
		21							31	16
		20							32	17
		19							33	18
		18							34	19
		1							36	21
6	1	0	09/14/2012	7:06	67-0.042	N	169-15.09	W	37	
		23							38	
		22							39	22
		21							40	23
		20							41	24
		19							42	25
		1							45	28
7	1	0	09/14/2012	10:13	67-30.108	N	169-15.18	W	46	
		23							47	
		22							48	29
		21							49	30
		20							50	31
		19							51	32
		1							54	35
8	1	0	09/14/2012	12:27	67-45	N	169-30.018	W	55	
		23							56	
		22							57	36
		21							58	37
		20							59	38
		19							60	39
		1							63	42
10	1	0	09/14/2012	17:32	67-59.91	N	169-59.898	W	64	
		22							66	43
		21							67	44
		20							68	45
		19							69	46
		18							70	47
		1							72	49
12	1	0	09/14/2012	21:17	68-11.982	N	168-39.942	W	73	
		22							75	50
		21							76	51
		20							77	52
		19							78	53
		1							81	56
14	1	0	09/14/2012	23:37	68-17.952	N	168-56.958	W	82	
		22							84	57
		21							85	58
		20							86	59
		1							88	61
15	1	0	09/15/2012	3:29	67-59.988	N	169-15.132	W	89	
		23							90	
		22							91	62
		21							92	63
		20							93	64
		19							94	65
		18							95	66
		1							97	68
16	1	0	09/15/2012	7:15	68-30.012	N	169-15.042	W	98	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		1							106	
17	1	0	09/15/2012	10:51	69-0.03	N	169-14.85	W	107	
		22							109	69
		21							110	70
		20							111	71
		19							112	72
		18							113	73
		1							115	75
18	1	0	09/15/2012	14:55	69-30.018	N	169-14.988	W	116	
		1							117	
19	1	0	09/15/2012	18:04	70-0.018	N	169-15.102	W	118	
		23							119	
		22							120	76
		21							121	77
		20							122	78
		19							123	79
		1							126	82
20	1	0	09/15/2012	22:38	70-44.988	N	169-15.192	W	127	
		1							128	
21	1	0	09/16/2012	3:52	71-30.012	N	169-15.132	W	129	
		23							130	
		22							131	83
		21							132	84
		20							133	85
		19							134	86
		1							137	89
22	1	0	09/16/2012	8:16	72-14.4	N	169-15.678	W	138	
		1							139	
23	1	0	09/16/2012	15:53	73-0.162	N	169-24.018	W	140	
		21							143	91
		20							144	92
		19							145	93
		18							146	94
		6							144	90
		1							148	96
24	1	0	09/16/2012	19:49	73-30.012	N	169-15.192	W	149	
		23							150	
		22							151	113
		21							152	114
		20							153	115
		19							154	116
		18							155	117
		17							156	118
		16							157	119
		15							158	120
		9							159	121
25	1	0	09/17/2012	0:26	74-0.312	N	169-13.902	W	160	
		23							161	
		22							162	
		21							163	
		20							164	
		19							165	
		17							166	
		15							167	
		14							168	
		13							169	
		1							171	
27	1	0	09/17/2012	7:04	74-40.212	N	171-4.518	W	174	
		23							175	
		22							176	122
		21							177	123
		20							178	124
		19							179	125
		18							180	
		17							181	126
		16							182	
		15							183	127
		14							184	128
		13							185	
		12							186	129
		11							187	
		10							188	130
		1							191	132
28	1	0	09/17/2012	10:10	75-0.18	N	173-59.832	W	192	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		1							193	
29	1	0	09/17/2012	18:07	75-12.87	N	173-25.068	W	194	
		23							195	
		22							196	133
		21							197	134
		20							198	135
		19							199	136
		18							200	137
		17							201	138
		16							202	139
		15							203	
		14							204	140
		13							205	
		12							206	141
		11							207	
		10							208	142
		9							209	143
30	1	0	09/18/2012	0:22	75-21.162	N	173-13.518	W	210	
		22							211	144
		21							212	145
		20							213	146
		19							214	147
		18							215	148
		17							216	149
		15							217	150
		14							218	151
		13							219	
		12							220	152
		10							221	153
		8							222	154
		7							223	155
		6							224	
		5							225	156
		4							226	
		1							228	158
31	1	0	09/18/2012	2:40	75-29.988	N	174-58.53	W	229	
		22							230	159
		21							231	160
		20							232	11
		19							233	162
		18							234	163
		17							235	164
		15							236	165
		14							237	166
		13							238	
		12							239	167
		10							240	168
		8							241	169
		7							242	170
		6							243	
		5							244	171
		4							245	172
		3							246	
		2							247	173
		1							248	174
32	1	0	09/18/2012	7:32	76-0.042	N	175-59.4	W	249	
		23							250	
		21							251	175
		20							252	176
		19							253	177
		17							254	178
		16							255	179
		15							256	180
		14							257	
		13							258	
		12							259	182
		10							260	183
		8							261	184
		7							262	185
		6							263	
		5							264	186
		4							265	187
		3							266	
		2							267	188

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		1							268	189
33	1	0	09/19/2012	3:38	75-14.04	N	178-29.598	W	293	
		23							294	
		22							295	204
		21							296	205
		20							297	206
		19							298	207
		18							299	
		17							300	208
		16							301	
		15							302	209
		14							303	210
		13							304	
		12							305	211
		11							306	
		10							307	212
		9							308	213
		8							309	213
		7							310	214
		6							311	215
		5							312	216
		4							313	
		1							314	217
34	1	0	09/19/2012	8:53	75-16.02	N	176-29.772	W	271	
		23							272	
		22							273	190
		21							274	191
		20							275	192
		19							276	193
		18							277	
		17							278	194
		16							279	
		15							280	195
		14							281	196
		13							282	
		12							283	197
		11							284	
		10							285	198
		9							286	
		8							287	199
		7							288	200
		6							289	201
		5							290	202
		1							292	203
35	1	0	09/19/2012	12:17	75-18.03	N	175-59.352	W	269	
		1							270	
36	1	0	09/20/2012	2:25	74-59.982	N	171-59.532	W	315	
		23							316	
		22							317	218
		21							318	219
		20							319	
		19							320	220
		18							332	
		17							322	221
		16							323	
		15							324	222
		14							325	223
		13							326	224
		12							327	225
		11							328	
		10							329	226
		9							330	
		1							333	229
37	1	0	09/20/2012	6:28	74-59.958	N	169-59.91	W	334	
		22							336	230
		21							337	231
		20							338	
		19							339	232
		18							340	
		17							341	233
		16							342	
		15							343	234
		14							344	235
		13							345	236

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		12							346	237
		1							352	241
38	1	0	09/20/2012	10:06	74-59.97	N	167-59.742	W	353	
		23							354	
		22							355	242
		21							356	243
		20							357	
		19							358	244
		18							359	
		17							360	245
		16							361	
		15							362	246
		14							363	247
		13							364	248
		12							365	249
		11							366	
		10							367	250
		9							368	
		8							369	251
		7							370	252
		1							371	253
39	1	0	09/20/2012	17:53	75-0.258	N	162-6.18	W	372	
		23							373	
		22							374	254
		21							375	255
		20							376	
		19							377	256
		18							378	
		17							379	257
		16							380	
		15							381	258
		14							382	259
		13							383	260
		12							384	261
		11							385	
		10							386	262
		9							387	263
39	2	0	09/21/2012	3:24	75-0.078	N	163-59.208	W	388	
		23							389	264
		21							390	265
		19							391	266
		17							392	267
		15							393	268
		13							394	
		11							395	269
		9							396	270
		7							397	275
		5							399	272
		4							400	273
		3							401	274
		1							403	276
40	1	0	09/22/2012	6:03	74-59.982	N	163-0.06	W	404	
41	1	0	09/22/2012	8:39	74-59.982	N	165-59.928	W	405	
		22							407	
		21							408	277
		20							409	278
		19							410	
		18							411	279
		17							412	
		16							413	280
		15							414	
		14							415	281
		13							416	2828
		12							417	282
		11							418	284
		10							419	285
		9							420	
		8							421	286
		7							422	287
		6							423	288
		5							424	
		4							425	289
		1							426	290
42	1	0	09/23/2012	2:29	74-36.042	N	164-30.132	W	427	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.		Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs						Latitude		Longtitude		δ^{18}O/Sr	REEs
		1							428		45	1	0	09/23/2012	17:21	73-20.082	N	161-58.752	W	465	
43	1	0	09/23/2012	6:39	74-10.152	N	163-40.008	W	429				22							466	306
		22							430	291			21							467	307
		21							431	292			20							468	
		20							432				19							469	308
		19							433	293			18							470	
		18							434				17							471	309
		17							435	294			15							472	310
		15							436	295			14							473	311
		14							437	296			13							474	312
		13							438	297			12							475	313
		12							439	298			10							476	314
		10							440	299			8							477	315
		8							441	300	45	2	7	09/23/2012	20:14	73-20.628	N	161-57.21	W	478	316
		7							442	301			5							479	317
		5							443	302			3							480	318
		3							444	303			2							481	319
		1							446	305			1							482	320
44	1	0	09/23/2012	12:13	73-48.57	N	162-58.14	W	447		46	1	0	09/24/2012	0:51	73-0.138	N	159-19.698	W	483	
		24							445				22							484	
		22							448				21							485	
		21							449				20							486	
		20							450				19							487	
		19							451				18							488	
		18							452				17							489	
		17							453				15							490	
		15							454				14							491	
		14							455				13							492	
		13							456				12							493	
		12							457				10							494	
		10							458				8							495	
		8							459				7							496	
		7							460				5							497	
		5							461				3							498	
		3							462				2							499	
		2							463				1							500	
		1							464		47	1	0	09/24/2012	7:10	72-49.188	N	158-36.33	W	501	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		$\delta^{18}O$/Sr	REEs
		22							502	
		21							503	
		20							504	
		19							505	
		18							506	
		17							507	
		15							508	
		14							509	
		13							510	
		12							511	
		10							512	
		8							513	
		7							514	
		5							515	
		3							516	
		2							517	
		1							518	
48	1	0	09/24/2012	11:55	72-30.132	N	157-59.622	W	519	
		22							520	321
		21							521	322
		20							522	
		19							523	323
		18							524	
		17							525	324
		16							526	325
		15							527	326
		14							528	327
		13							529	328
		12							530	329
		10							531	330
		8							532	331
		7							533	332
		5							534	333
		3							535	334
		2							536	335
		1							537	336
49	1	0	09/24/2012	20:47	71-14.928	N	158-50.628	W	538	
		22							540	337
		21							541	338
		20							542	
		19							543	339
		1							547	341
51	1	0	09/24/2012	22:43	71-19.578	N	158-40.02	W	548	
		22							550	
		21							551	
		20							552	
		19							553	
		18							554	
		17							555	
		16							556	
		15							557	
		1							559	
53	1	0	09/25/2012	0:52	71-24.84	N	158-30.792	W	560	
		23							561	
		22							562	342
		21							563	343
		20							564	
		19							565	344
		18							566	
		17							567	345
		16							568	
		15							569	346
		14							570	347
		1							572	349
55	1	0	09/25/2012	6:03	71-29.7	N	158-20.67	W	573	
		23							574	
		22							575	
		21							576	
		20							577	
		19							578	
		18							579	
		17							580	
		16							581	
		15							582	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		1							584	
57	1	0	09/25/2012	8:02	71-34.65	N	158-9.582	W	585	354
		23							586	
		22							587	350
		21							588	351
		20							589	
		19							590	352
		18							591	
		17							592	353
		1							594	354
58	1	0	09/27/2012	14:08	71-36.45	N	155-9.84	W	608	
		22							609	365
		21							610	366
		20							611	
		19							612	367
		1							617	371
59	1	0	09/27/2012	15:25	71-41.01	N	155-2.292	W	618	
		22							619	
		21							620	
		20							621	
		19							622	
		18							623	
		17							624	
		15							625	
		1							627	
60	1	0	09/27/2012	17:21	71-44.052	N	156-52.86	W	595	
		22							596	355
		21							597	356
		20							598	
		19							599	357
		18							600	
		17							601	358
		15							602	360
		14							603	359
		13							604	361
		12							605	362
		10							606	363
		8							607	364
61	1	0	09/27/2012	21:00	71-48.732	N	156-42.372	W	628	
		22							629	
		21							630	
		20							631	
		19							632	
		18							633	
		17							634	
		15							635	
		14							636	
		13							637	
		12							638	
		1							639	
62	1	0	09/27/2012	23:04	71-55.878	N	156-20.358	W	640	
		22							641	372
		21							642	373
		20							643	
		19							644	374
		18							645	
		17							646	375
		15							647	376
		14							648	377
		13							613	
		1							649	378
63	1	0	09/28/2012	0:37	71-59.958	N	157-59.94	W	650	
		22							651	
		21							652	
		20							653	
		19							654	
		18							655	
		17							656	
		15							657	
		14							658	
		1							659	
64	2	0	09/29/2012	1:48	74-29.922	N	155-59.76	W	660	
		36							661	379
		35							662	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		34							663	380
		33							664	
		32							665	381
		31							666	382
		30							667	
		29							668	383
		28							669	385
		27							670	384
		26							671	386
		25							672	387
		24							673	388
		23							674	389
		22							675	390
		21							676	391
		20							677	3921
		19							678	393
		18							679	394
		17							680	395
		16							681	
		15							682	396
		14							683	
		13							684	397
		12							685	398
		2							686	399
		1							687	400
65	1	0	09/29/2012	7:43	73-59.94	N	156-47.532	W	688	
		36							689	
		35							690	
		34							691	
		33							692	
		32							693	401
		31							694	
		30							695	
		29							696	402
		28							697	403
		27							698	404
		26							699	405
		25							700	406
		24							701	407
		23							702	408
		22							703	409
		21							704	410
		20							705	411
		19							706	412
		18							707	413
		17							708	414
		16							709	
		15							710	415
		14							711	
		13							712	416
		12							713	417
		2							714	418
		1							715	419
66	2	0	09/29/2012	17:55	73-29.532	N	157-35.31	W	716	
		36							717	
		35							718	
		34							719	
		33							720	
		32							721	420
		31							722	
		30							723	
		29							724	421
		28							725	422
		27							726	423
		26							727	424
		25							728	425
		24							729	426
		23							730	427
		22							731	428
		21							732	429
		20							733	430
		19							734	431
		18							735	432
		17							736	433

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		15							737	434
		13							738	435
		12							739	436
		2							740	437
		1							741	438
68	1	0	09/30/2012	3:48	72-51.918	N	158-2.118	W	765	
		22							766	739
		21							767	440
		20							768	
		19							769	441
		18							770	
		17							771	442
		15							772	443
		14							773	444
		13							774	445
		12							775	446
		10							776	447
		8							777	448
		7							778	449
		6							779	
		5							780	450
		3							781	451
		2							782	452
		1							783	453
69	1	0	09/30/2012	7:06	72-44.892	N	159-48.072	W	743	
		22							744	
		21							745	
		20							746	
		19							747	
		18							748	
		17							749	
		15							750	
		14							751	
		13							752	
		12							753	
		10							754	
		8							755	
		1							756	
70	1	0	09/30/2012	9:22	72-29.988	N	159-12.072	W	757	
		22							758	454
		21							759	455
		20							760	456
		19							761	457
		18							762	458
		1							764	460
71	1	0	09/30/2012	11:55	72-14.952	N	160-36.09	W	784	
		1							785	
72	1	0	09/30/2012	17:46	72-0.012	N	160-0.168	W	786	
		23							787	461
		22							788	462
		21							789	
		9							796	466
73	1	0	10/01/2012	9:01	70-45	N	161-0.162	W	797	
		1							798	
74	1	0	10/01/2012	11:20	70-44.988	N	162-0.342	W	799	
		22							800	467
		21							801	468
		20							802	469
		19							803	470
		1							807	473
75	1	0	10/01/2012	13:54	70-44.988	N	163-0.48	W	808	
		1							809	
76	1	0	10/01/2012	17:53	70-44.988	N	164-0.252	W	810	
		22							811	474
		21							812	475
		20							813	476
		19							814	477
		9							818	480
77	1	0	10/01/2012	20:35	70-44.88	N	166-59.958	W	819	
		1							820	
78	1	0	10/01/2012	22:42	70-44.952	N	166-0.03	W	821	
		22							822	481
		21							823	482
		20							824	483

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		$\delta^{18}O$/Sr	REEs
		19							825	484
		1							829	487
79	1	0	10/02/2012	1:26	70-45.072	N	167-0.522	W	830	
		1							831	
80	1	0	10/02/2012	3:36	70-45.072	N	168-0.222	W	832	
		36								495
		35								496
		34								497
		33								498
		25								501
		22							833	488
		21							834	489
		20							835	490
		19							836	491
		1							840	494
81	1	0	10/02/2012	5:53	70-45.072	N	169-15.54	W	841	
		1							842	
82	1	0	10/03/2012	11:06	68-40.062	N	169-14.982	W	843	
		22							844	
		21							845	
		20							846	
		19							847	
		18							848	
		0							850	
83	1	36	10/03/2012	12:52	68-30.102	N	169-14.958	W	851	
		22							852	502
		21							853	503
		20							854	504
		19							855	505
		18							856	506
		1							859	509
84	1	0	10/03/2012	14:04	68-22.542	N	169-15.042	W	860	
		22							861	
		21							862	
		20							863	
		19							864	
		18							865	
		1							867	
85	1	0	10/03/2012	15:15	68-15.018	N	169-15.048	W	868	
		22							869	510
		21							870	511
		20							871	512
		19							872	513
		18							873	514
		1							876	517
86	1	0	10/03/2012	16:44	68-7.44	N	169-15.072	W	877	
		22							878	
		21							879	
		20							880	
		19							881	
		18							882	
		1							885	
87	1	0	10/03/2012	19:09	68-0	N	168-0.21	W	886	
		22							887	518
		21							888	519
		20							889	520
		19							890	521
		18							891	522
		1							894	525
88	1	0	10/03/2012	20:37	68-0.018	N	169-37.422	W	895	
		22							896	
		21							897	
		20							898	
		19							899	
		18							900	
		1							903	
89	1	0	10/03/2012	22:02	67-59.922	N	169-15.06	W	904	
		22							905	526
		21							906	527
		20							907	528
		19							908	529
		18							909	530
		1							912	533
90	1	0	10/04/2012	0:06	67-52.488	N	169-14.868	W	913	

Table 4.14.1-1 Sampling list

Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position				Parameters and bottle No.	
					Latitude		Longtitude		δ^{18}O/Sr	REEs
		22							914	
		21							915	
		20							916	
		19							917	
		1							921	
91	1	0	10/04/2012	1:26	67-45	N	169-15	W	922	
		22							923	534
		21							924	535
		20							925	536
		19							926	537
		1							930	541
92	1	0	10/04/2012	3:01	67-37.452	N	169-15.18	W	931	
		1							932	
93	1	0	10/04/2012	4:20	67-30.012	N	169-14.892	W	933	
		22							934	542
		21							935	543
		20							936	544
		19							937	545
		1							941	549
94	1	0	10/04/2012	19:04	65-46.332	N	169-12.69	W	942	
		22							943	
		21							944	
		20							945	
		19							946	
		1							950	
95	1	0	10/04/2012	20:46	65-42.27	N	169-28.818	W	951	
		22							952	
		21							953	
		20							954	
		19							955	
		18							956	
		1							959	
96	1	0	10/04/2012	22:04	65-39.072	N	169-44.808	W	960	
		22							961	
		21							962	
		20							963	
		19							964	
		1							968	

Table 4.14.1-2 Sampling List of Neodymium Isotopes

Sample No.	Station No.	Cast No.	Niskin No.	Sampling Date and Times(UTC)		Sampling Position			
						Latitude		Longtitude	
1	003	1	16	09/13/2012	21:58	65-46.248	N	169-12.528	W
2	064	1	8	09/28/2012	0:37	71-59.958	N	157-59.94	W
3		1	17	09/28/2013	1:37	71-59.959	N	157-59.95	W

4.14.2. Sediment Core and Pore water samples

(1) Personnel

Jing Zhang (University of Toyama): Principal Investigator
Shoko Hirayama (University of Toyama)
Shigeto Nishino for Nutrients (JAMSTEC)
Kenichiro Sato for Nutrients (MWJ): Operation Leader

(2) Objectives

Approximately one third of the Arctic Ocean is surrounded by the continental shelf that contributes significant sediment constituents to the seawater that are used to evaluate material circulation. An evaluation of the contribution and flux of nutrients from the sediment is essential for understanding the primary production and its temporal variation in the Arctic and surrounding environment. However, there are a few studies have been done in this regard. Objective of sediment coring in this study is to understand and biogeochemical processes on the continental shelf and fate of lithogenic materials transported from rivers to the Arctic Ocean with seawater analysis. Sediment core samples and pore water samples squeezed from the cores were collected for analysis of nutrients and rare earth elements.

(3) Parameters

(A) Nutrients (NO_3, NO_2, NH_4, SiO_2, PO_4)
(B) Rare Earth Elements

(4) Analytical Instruments and Methods

During the cruise, pore water samples were taken from multiple cores from 8 stations (Table. 4.14.2-1). Sediment samples were consecutively sliced at every 0.5cm interval from the top to 5.0 cm depth, 1.0 cm interval from 5.0 cm to 15.0 cm depth, and 2.0 cm interval for depth >15.0 cm on board. Then, pore water was squeezed out on board. The squeezing was carried out by pressure filtration through 0.45μm Millipore filter for nutrients and 0.45 μm and 0.20 μm Millipore filters for REEs, using a stainless steel clamp (Fig. 4.14.2-1) at 4 deg C.

(A) Nutrients

Nutrient analysis were done by MWJ on board. See "Instrument and Methods" followed *4.2. Nutrients*. When the nutrient concentration was higher than that in STD solutions, samples were diluted with seawater whose nutrients are low concentration and reanalyzed.

(B) Rare Earth Elements (REEs)

After filtration, the pore water was acidified immediately to pH <1.6 with ultrapure HCl (TAMAPURE AA-100, Tama Chemicals). The samples will be brought to the laboratory on land where pretreatment and analysis of REE concentrations will be made using a SF-ICP-MS in clean laboratories at the University of Toyama.

(5) Data Archive

All the raw processed data of seawater will be submitted to the Data Management Group (DMG) of JAMSTEC when ready.

Table. 4.14.2-1 Sampling List

Core #	Station	Subcore #	Sampling Date (UTC)	Sampling Position				Objectives
				Latitude		Longitude		
MC Sta021	021	HAND1	09/16/2012	71-30.00	N	168-45.00	W	Nutrients
		HAND2						Archive
		HAND3						REEs
MC Sta024	024	HAND2	09/16/2012	73-30.00	N	168-45.00	W	Archive
		HAND5						Nutrients
		HAND8						REEs
MC Sta027	027	HAND2	09/17/2012	74-40.00	N	170-55.00	W	Archive
		HAND5						Nutrients
		HAND8						REEs
MC Sta039	039	HAND2	09/20/2012	75-0.00	N	162-0.00	W	Archive
		HAND6						Nutrients
		HAND7						REEs
MC Sta064	064	HAND2	09/28/2012	74-30.00	N	154-0.00	W	Archive
		HAND3						Nutrients
		HAND5						REEs
MC Sta068	068	HAND2	09/30/2012	72-51.90	N	157-57.90	W	Archive
		HAND4						Nutrients
		HAND5						REEs
MC Sta072	072	HAND2	09/30/2012	72-0.00	N	160-0.00	W	Archive
		HAND3						Nutrients
		HAND7						REEs
MC Sta089	089	HAND2	10/03/2012	68-0.00	N	168-45.00	W	Archive
		HAND3						Nutrients
		HAND5						REEs

Fig. 4.14.2-1. System of squeezing pore water from sediment samples

4.15 pCO_2 and pCH_4 by CRDS and Dissolved methane (CH_4)

4.15.1 pCO_2 and pCH_4 by CRDS

(1) Personnel

Daisuke Sasano	Meteorological Research Institute / JMA
Shuji Aoki	Tohoku University: Principal Investigator
Masao Ishii	Meteorological Research Institute / JMA
Hisayuki Yhoshikawa-Inoue	Hokkaido University
Naohiro Kosugi	Meteorological Research Institute / JMA
Hiroshi Uchida	JAMSTEC
Sakae Toyoda	Tokyo Institute of Technology

(2) Objective

The oceans have strong interactions with the atmosphere and are the major sinks for the increasing CO_2. Although it is believed that the Arctic Ocean is playing an important role for the variations of greenhouse gases in the atmosphere, their spatial and temporal variations in the Arctic Ocean is not well known. Furthermore, sea ice in the Arctic Ocean has been decreasing in summer, leading to change the air-sea interaction and biological activity due to increasing the area of open sea, and possibly leading to affect the global carbon cycle.

Recently, a new CO_2 analyzer WS-CRDS (Picarro) was developed on the basis of Cavity Ring-Down Spectroscopy. The advantage of this analyzer is a high precision and stability. In addition, the analyzer can simultaneously measure other trace gases such as CH_4. In this study, we challenge to apply WS-CRDS to the underway measurements of pCO_2 and pCH_4 in the atmosphere and in surface seawater to clarify the distributions of pCO_2 and pCH_4 and their controlling mechanisms in the Arctic Ocean.

(3) Parameters

CO_2 partial pressure (pCO_2) in the atmosphere and in near-surface seawater
CH_4 partial pressure (pCH_4) in the atmosphere and in near-surface seawater

(4) Instruments and Methods

We made simultaneous measurements of the CO_2 and CH_4 concentrations in the dry air equilibrated with the great excess of surface seawater during the whole cruise using an automated measuring system (Nippon ANS Co.). Seawater was taken continuously from the seachest located ca.4.5 m below the sea level and introduced into the MRI-shower-type equilibrator. Wavelength-scanned cavity ring-down spectrometer (WS-CRDS, Picarro, G2301) was used as a detector. We used three standard gases with known CO_2 and CH_4 mixing ratios once a day. Corrections for the temperature-rise from the seachest to the equilibrator are also to be made. Partial pressure of CO_2 and CH_4 will be calculated from the concentration of CO_2 and CH_4 by taking the water vapor pressure and the atmospheric pressure into account.

(5) Observation log

The shipboard continuous measurements were conducted during the entire cruse.

(6) Preliminary results

Preliminary data of CO_2 and CH_4 concentrations in near-surface water are shown in Fig. 4.15-1.

(9) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “ Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

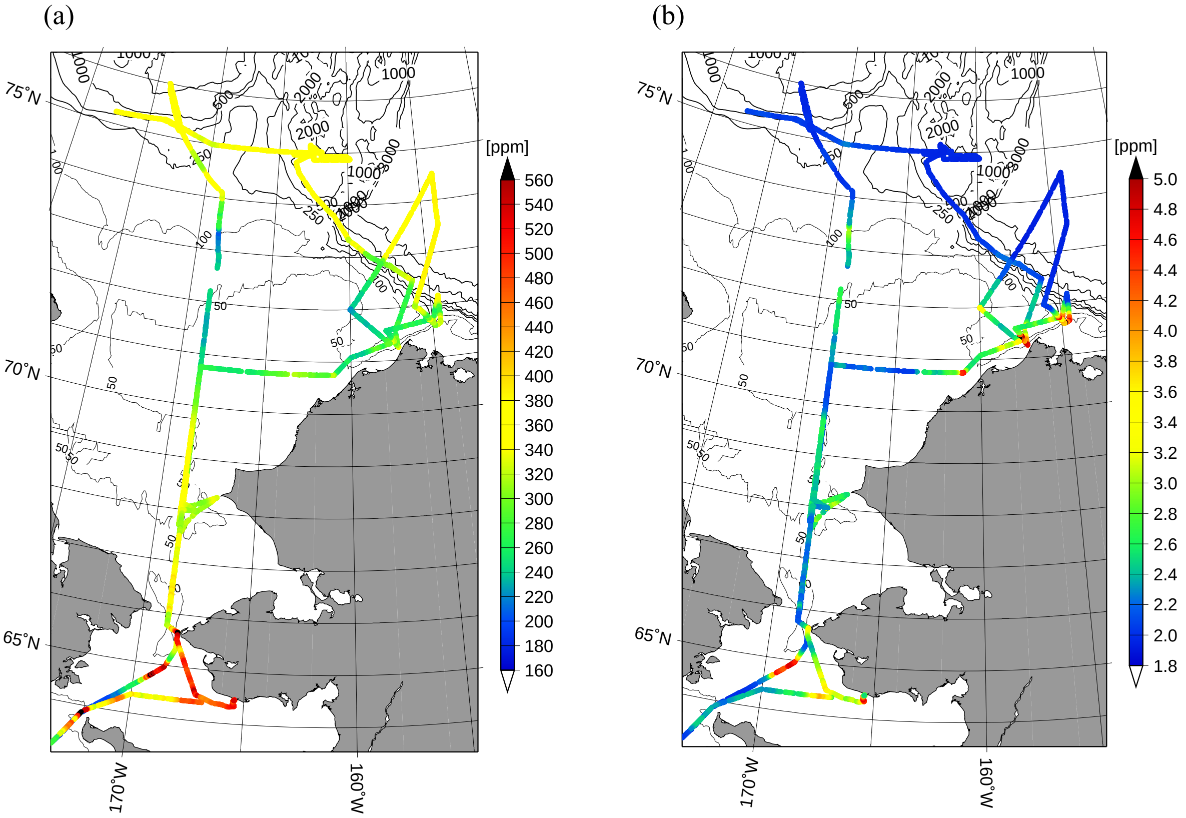


FIg. 4.15-1. Spatial distribution of (a) CO_2 and (b) CH_4 concentrations in near surface water in the Arctic Ocean in MR12-E03 cruise.

4.15.2 Dissolved methane (CH4)

(1) Personnel

Sakae Toyoda, Keita Yamada, Kushi Kudo, and Naohiro Yoshida

Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology

(2) Objectives

Atmospheric methane (CH_4) is a trace gas playing an important role in the global carbon cycle as a greenhouse gas. Its concentration has increased by about 1050 ppbv from 700 ppbv since the pre-industrial era (IPCC, 2007). In order to understand the current global methane cycle, it is necessary to quantify its sources and sinks. At present, there remain large uncertainties in the estimated methane fluxes from sources. The ocean's source strength for atmospheric methane should be examined in more detail, even though it might be a relatively minor source, previously reported to be 0.005 to 3% of the total input to the atmosphere (Cicerone and Oremland, 1988; Bange et al., 1994; Lelieveld et al., 1998).

Potentially important source of CH_4 from the Arctic Ocean have been reported recently, including degradation of subsea permafrost on the eastern Siberian shelf (Shakhova et al., 2010) and aerobic CH_4 production by methylotrophic methanogenesis in the central Arctic Ocean (Damm et al., 2010). However, the distribution of CH_4 in the Arctic Ocean is not widely investigated, and there have been few isotopic study of CH_4 dissolved in the Arctic Ocean, which would help understand its production processes. Here we survey distribution of CH_4 dissolved in the surface water and the water column of Arctic Ocean and analyze the production and consumption processes of CH_4 using stable isotope ratios.

(3) Parameters

Concentration, stable carbon and hydrogen isotope ratios of dissolved CH_4

(4) Instruments and methods

All the seawater samples were collected using CTD-CAROUSEL system equipped with 12-L Niskin samplers. Surface seawater samples were taken at 5 m depth in order to enable comparison with on-board continuous monitoring system for dissolved CH_4 operated by MRI. At several hydrographic stations, vertical sampling of the water column was conducted. Sampling locations and depths are shown in the station list.

Each sample was carefully subsampled into 30, 125, 600 ml glass vials to avoid air contamination for analysis of methane concentration, carbon isotope ratio, and hydrogen isotope ratio respectively. The seawater samples were sterilized by adding saturated mercuric chloride ($HgCl_2$) solution to make $HgCl_2$ concentration of ca. 0.5% (Tilbrook and Karl, 1995; Watanabe et al., 1995), and were sealed with rubber stoppers and aluminum caps. They will be stored in a dark and cool place until concentration and isotope ratio measurements at Tokyo Tech.

Concentration of dissolved CH_4 will be measured with a gas chromatograph equipped with a flame ionization detector (GC-FID). Stable carbon isotope ratio will be measured with gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS). Stable hydrogen isotope ratios will be measured with gas chromatography-high temperature conversion-isotope ratio mass spectrometry (GC-TC-IRMS). Each analytical system is equipped with a purge and trap unit, and CH_4 is further concentrated in a cryogenic trap in the case of isotopic measurement. Precisions of repeated analyses of methane concentration, and carbon and hydrogen isotope ratios are estimated to be better than 5%, and 0.3‰ and 3‰, respectively.

(5) Station list

Table 4.15-1 Sampling list for concentration of dissolved CH4

Station No.	Lat.	Long.	Sampling depth (m)
7	67-30N	168-45W	5
17	69-00N	168-45W	5
27	74-40N	170-55W	5
31	75-30N	173-00W	5
33	75-14N	177-30W	5
38	75-00N	166-00W	5
41	75-00N	164-00W	5
43	74-10N	162-20W	5
47	72-48N	157-20W	5
55	71-30N	157-40W	5
64	74-30N	154-00W	5, 10, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1750, 2000, 2250, 2500, 2750, 3000, 3250, 3500, 3911

65	74-00N	155-12W	5, 3500, 3913
66	73-30N	156-24W	5, 10, 25, 50, 75, 100, 125, 150, 200, 250, 300, 400, 600, 800, 1000, 1500, 2000, 3000, 3500, 3744
68	72-52N	157-58W	5, 10, 20, 30, 40, 50, 60, 75, 100, 125, 150, 175, 200, 225,250, 300, 400, 500, 600, 800, 1000, 1583
69	72-45N	158-12W	5, 20, 50, 100, 303
72	72-00N	160-00W	5, 21
73	70-45N	161-00W	0, 5
81	70-45N	168-45W	0, 5
83	68-30N	168-45W	5, 46
89	68-00N	168-45W	5, 52
93	67-30N	168-45W	0, 5, 40
96	65-39N	168-15W	0, 5, 36

Table 4.15-2 Sampling list for carbon isotope ratio of dissolved CH4

Station No.	Lat.	Long.	Sampling depth (m)
64	74-30N	154-00W	5, 10, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1750, 2000, 2250, 2500, 2750, 3000, 3250, 3500, 3911
65	74-00N	155-12W	5, 3500, 3913
66	73-30N	156-24W	5, 10, 25, 50, 75, 100, 125, 150, 200, 250, 300, 400, 600, 800, 1000, 1500, 2000, 3000, 3500, 3744
68	72-52N	157-58W	5, 10, 20, 30, 40, 50, 60, 75, 100, 125, 150, 175, 200, 225, 250, 300, 400, 500, 600, 800, 1000, 1583
69	72-45N	158-12W	5, 20, 50, 100, 303
72	72-00N	160-00W	5, 21
83	68-30N	168-45W	5, 46
89	68-00N	168-45W	5, 52
93	67-30N	168-45W	5, 40

96	65-39N	168-15W	5, 36

Table 4.15-3 Sampling list for hydrogen isotope ratio of dissolved CH4

Station No.	Lat.	Long.	Sampling depth (m)
72	72-00N	160-00W	5

(6) Expected results

Preliminary data obtained by on-board continuous monitoring system indicated that surface water of the broad shelves of the Bering and Chukchi Sea is often supersaturated with CH_4. Concentration of CH_4 dissolved in the seawater collected simultaneously with the on-board measurements will be used to cross-check the both observations. Isotope ratios of CH_4 and their depth profiles along with concentration would provide the information on origin of the CH_4 and isotopic character of CH_4 emitted from Arctic Ocean, which is valuable for modeling the isotope budget of atmospheric CH_4.

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via " Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC home page.

(8) References

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4.16. Denitrification and anammox in sediment

(1) Personnel

Michiyo Yamamoto-Kawai (TUMSAT): Principal Investigator
Kentaro Sugiyama (TUMSAT)
Yasushi Hashimoto (MWJ)
Yasumi Yamada (MWJ)

(2) Objectives

Nitrogen is the limiting nutrient for primary production in the Pacific sector of the Arctic Ocean. This is largely due to denitrification and anammox processes in the sediment on Bering and Chukchi Sea shelves. Therefore, understanding of these processes in these regions is needed to better predict future nitrogen cycle and productivity in the Arctic Ocean. It is known by now that denitrification and anammox responses to increasing temperature are different. However, there is no study quantifying these two processes separately on Chukchi and Bering shelves. During the MR12-E03 cruise, we have collected surface sediments and bottom water to perform experiments to quantify denitrification, anammox and nitrogen flux from the sediment.

(3) Methods

Surface sediment core samples were collected at 8 stations (Stns. 021, 024, 027, 039, 064, 068, 072, 089) using a multiple corer (Table 4.16-1). Core samples were stored in the cooler (at 4 ℃) until being processed for the following experiments; slurry incubation, core incubation (Isotope Pairing Technique), and analysis for organic carbon content, nitrate and ammonium flux and porosity (Table 4.16-2).

(3)-1. Slurry incubation

Surface sediments from top 0-4 (Stn.021) or 2-5 (Stns. 024, 027, 039, 064, 068, 089) cm of core were used in this experiment. Deoxygenated seawater was prepared as follows. A tropical surface seawater with undetectable content of nutrients was filtered with Dismic-25CS (Advantec). For each station, this water was adjusted to *in situ* salinity by adding Milli-Q water and bubbled with He gas to remove oxygen in the seawater. In a portable glove box purged with Ar gas, 2ml of well-mixed sediment and 10mL of deoxygenated seawater were homogenized in a 12ml gas-tight glass vial. The slurries were kept in a water bath (temperature varied between 0-1.5 ℃) for 1-3 days to remove remaining oxygen or NOx^- before addition of ^{15}N tracers. Then, $Na^{15}NO_3$, $K^{14}NO_3^-$,

$(^{15}NH_4)_2SO_4$ were added to the slurries to have final concentrations 50μM of 1)$^{15}NO_3^-$, 2)$^{15}NH_4^+$, 3)$^{15}NH_4^+$+$^{14}NO_3^-$. 12 vials of for each of these tracer concentrations and 3 vials without tracer addition (control) were prepared and incubated in the 0-1.5 ℃ water bath. A headspace of 5ml with He gas were introduced and 50%w/v $ZnCl_2$ were added to stop biological activities for 3 control vials before incubation and for each of 3 vials for each concentration after 3 incubation periods (Table 4.16-3). The samples were then stored upside-down until the analysis in the lab on land with a mass spectrometer connected to an elemental analyzer (ANCA-GSL, SerCon Ltd., UK). The 5ml of water samples replaced by He gas were filtered with Dismic-25CS (Advantec) into sample tubes and frozen at -20 ℃. These will be analyzed for NO_3^-, NO_2^-, NH_4^+ after the cruise.

(3)-2. Core incubation (Isotope Pairing Technique)

Total 3 (stn.068) or 4 (stns.021, 024, 027, 089) sub-cores were taken from 2 sediment cores into acrylic tubes (i.d.=31mm, L=22cm) with bottom silicon stoppers. These sub-cores were placed in a bucket filled with bottom water collected at the core sampling site by 8L Niskin bottles attached to the multiple corer. The water column in each core was stirred by small magnets driven by a large external rotating magnet. After ~12hours, the tubes were closed with top lids and kept at 0 ℃. The water column in the core tubes were stirred by stir bars hanging from the top lids. Oxygen concentration of the water column was kept constant by bubbling air which was purified by bubbling through pure water. After 12 hours, $^{15}NO_3^-$ was added to water column in 3 core tubes to have concentration of 40 μM and mixed with an acrylic stick. 5ml of water from 4 core tubes (1 without and 3 (2 for stn. 068) with $^{15}NO_3^-$) were then sampled, filtered with Dismic-25CS (Advantec), and frozen at -20 ℃ for NO_3^- concentration measurement. The core without $^{15}NO_3^-$ addition was processed immediately and other 3 cores were put back into the bucket filled with bottom water and left for 12 hours until $^{15}NO_3^-$ penetrate through the denitrification layer. Then, incubation was terminated at 12 hours intervals (0, 12 and 24 hours). At the termination, 5ml of water was sampled for NO_3^- measurement. Sediment and water were then mixed well with glass stick. Supernatant was transferred to a gas-tight syringe and 50%w/v $ZnCl_2$ were added to stop biological activities. The samples were then stored upside-down until the analysis in the lab on land with a mass spectrometer connected to an elemental analyzer (ANCA-GSL, SerCon Ltd., UK).

(3)-3. Nitrate and ammonium flux

Core samples (i.d.=75mm, L=60cm) in contact with bottom water were incubated at

0-1.5 ℃. The lengths of the sediment cores are listed in table 4.16-4. The bottom water was collected at the core sampling site by a 8L Niskin bottles attached to the multiple corer. A core tube filled with 2.6L of bottom water (no sediment) was also incubated as a control experiment. 9ml of water was sampled four times at ~12hr intervals for analysis of NO_3^-, NO_2^-, NH_4^+. After the sampling, the same volume of bottom water was added to the core tube.

(3)-4. Porosity

The cores were sliced and sampled with a 5ml plastic tube with a plunger (made from a syringe) and frozen in plastic bags. These samples will be freeze-dried and weighed to estimate porosity of sediment.

(3)-5. Organic carbon content

Samples for organic carbon content were taken from cores used for slurry incubation (Stns.021, 024, 027, 089) or cores for organic carbon content only (Table 4.16-2). Sediment samples were frozen in plastic bags at -20 ℃. These samples will be analyzed for organic carbon content.

Table 4.16-1. List of core samples collected by multiple corer.

Station no.	Latitude	Longitude	Date (UTC)	Depth (m)
021	71 - 30.00 N	168 - 45.00 W	16-Sep	49
024	73 - 30.00 N	168 - 45.00 W	16-Sep	117
027	74 - 40.00 N	170 - 55.00 W	17-Sep	233
039	75 - 00.00 N	162 - 00.00 W	21-Sep	1971
064	74 - 30.00 N	154 - 00.00 W	28-Sep	3851
068	72 - 51.90 N	157 - 57.90 W	30-Sep	1569
072	72 - 00.00 N	160 - 00.00 W	30-Sep	30
089	68 - 00.00 N	168 - 45.00 W	3-Oct	60

Table 4.16-2. Number of cores used in each experimental procedure.

Station no.	Slurry incubation and organic carbon content	Core incubation	Nitrate and ammonium flux and porosity	Organic carbon content only	Porosity only
021	1	2	1		
024	1	2	1		
027	1	2	1		
039	1			2	1
064	1			2	1
068	1	2			1
072				3	1
089	1	2	1		

Table 4.16-3. Time courses of the slurry incubations.

Station no.	Incubation time (h)			
021	0	8	13	25
024	0	9	19	37
027	0	11	23	36
039	0	19	34	79
064	0	16	44	68
068	0	15	36	60
089	0	12	36	43

Table 4.16-4. Length of the cores used for nitrate and ammonium flux experiments.

Station no.	length of sediment (cm)	length of water column (cm)
021	22	38
024	28	32
027	25	35
089	27	33

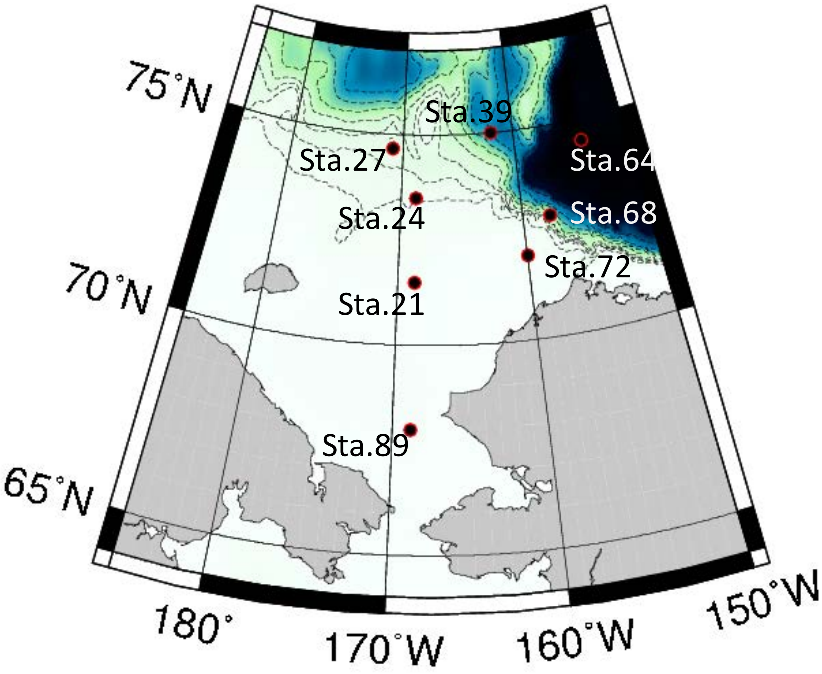

Fig. 4.16-1. Map of sediment core sampling stations.

4.17. 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 large-sizd copepods (*Neocalanus cristatus, N. flemingeri*, *N. plumchrus*, *Eucalanus bungii*, *Metridia pacifica*) which dominant components in the North Pacific Ocean (Matsuno et al., 2011, 2012).

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* and *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 and lipid accumulation) of the Pacific and Arctic copepods in the Arctic Ocean.
3) Clarify the grazing impact of the transported Pacific copepods in the Arctic Ocean

ecosystem.

(3) Sampling

Zooplankton samples were collected by vertical haul of two type nets at 49 stations in the western Arctic Ocean. Twin NORPAC net (meshes: 335 and 62 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. 4.17-1 and Table 4.17-1). Zooplankton samples collected by the NORPAC net with 335 μm mesh were immediately fixed with 5% buffered formalin for zooplankton structure analysis. Other samples collected with 62 μm mesh were split with Motoda box splitter. One aliquot was immediately fixed with 5% buffered formalin for zooplankton structure analysis later. The remaining aliquot was used for evaluation of the copepod physiological activity (i.e. wet mass, dry mass, ash-free dry mass and gut pigment) and for analysis on shell density of Foraminifera (investigator: Katsunori Kimoto [JAMSTEC]). The volume of water filtered through the net was estimated from the reading of a flow-meter mounted in the mouth ring. Also, we collected some water samples from chlorophyll maximum layer at towed NORPAC stations to investigate microplankton community in the western Arctic Ocean. The samples were immediately fixed with 1% glutaraldehyde.

80 cm ring net (mesh: 335 μm, mouth diameter: 80 cm) was towed between surface and 150 m depth or bottom -5 m at 12 stations (Table 4.17-2), fresh samples were used for grazing experiments (7 stations) or for collecting Euphausiacea (5 stations). Also, the 80 cm ring net was towed between surface and 1000 m depth at 2 stations, the fresh samples were immediately sorted and fixed with RNA later or 99.5% ethyl alcohol for analysis RNA of copepods (investigator: Yasushi Shigeri [AIST]) and Radiolaria (investigator: Yasuhide Nakamura [Hokkaido University]).

Also, we collected whole core samples using a multiple corer at 8 stations in western Arctic Ocean (Table 4.17-3). The whole core samples were cut every 1 cm between 0-3 cm and every 1.5 cm from 3 cm to core bottom, and preserved at cord and dark. In the land laboratory, we reveal the phytoplankton cyct abundance using Most Probable Number (MPN) method (investigator: Kohei Matsuno and Masafumi Natsuike [Hokkaido University]).

(4) On-board treatment

[Individual wet weight, dry weight, ash-free dry mass and gut pigment]

Fresh zooplankton samples collected with NORPAC net were 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. plumchrus, N. flemingeri, Eucalanus bungii, Metridia pacifica*) and the Arctic copepods (*Calanus glacialis, C. hyperboreus, M. longa*). Some specimens were rinsed with distilled water, transferred into pre-weighted aluminum pan and stored in -30°C. On land laboratory, these samples will be weighed for wet weight, dry weight, ash-free dry mass with a precision of 0.01 g using an electronic balance. Other specimens transferred into a cuvette tube immersed with 6 ml dimethylformamide, stored and extracted for >24 hours. After extract the pigment, these samples were measured fluorescence with a Turner model 10-005-R Filter Fluorometer.

[Grazing rate experiment] (by Matsuno, Fujiwara, Yamaguchi and Hirawake [Hokkaido University])

Fresh zooplankton samples collected with 80 cm ring net were sorted with Pacific copepods (*Neocalanus cristatus* C5, *N. plumchrus* C5, *N. flemingeri* C5) and Arctic copepods (*Calanus glacialis* C5, *C. hyperboreus* C6F and *Metridia longa* C6F). This selection was made only individuals that were actively swimming and undamaged. These specimen were resorted into an experiments bottle (2.2 L) that was filled ambient sea water from chlorophyll maximum layer, and were incubated for 24h in a experiment cistern on-deck with running surface sea water and ambient light condition. After incubation, the experiment water filtered 10, 2 and 0.45 μm size-fractioned.

(5) Results

As a preliminary results, we present following items.

Figure 4.17-1: Location of the plankton net sampling stations.
Figure 4.17-2: Geographical distribution of gut pigment of *C. glacialis* C5.
Figure 4.17-3: Geographical distribution of gut pigment of *M. longa* C6F.

(6) References

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.

Matsuno, K., A. Yamaguchi, T. Hirawake and I. Imai (2011) Year-to-year changes of the mesozooplankton community in the Chukchi Sea during summers of 1991, 1992 and 2007, 2008. *Polar Biol.*, **34**, 1349-1360.

Matsuno, K., A. Yamaguchi and I Imai (2012) Biomass size spectra of mesozooplankton in the Chukchi Sea during the summers of 1991/1992 and 2007/2008: an analysis using optical plankton counter data. *ICES J. Mar. Sci.*, **69**, 1205-1217.

Table 4.17-1. Data on plankton samples collected by vertical hauls with twin NORPAC net.
GG54: 335 μm mesh.

Station no.	Position		S.M.T.		Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter		Estimated volume of water filtered (m^3)	Remark
	Lat. (N)	Lon.	Date	Hour					No.	Reading		
001	65-40	168-15 W	13 Sept	8:26	35	1	35	GG54	1039	418	5.73	2)
								62μm	2771	334	4.80	
003	65-48	168-48 W	13 Sept	11:21	46	11	45	GG54	1039	546	7.49	
								62μm	2771	446	6.42	
005	66-30	168-46 W	13 Sept	17:08	45	1	45	GG54	1039	459	6.30	
								62μm	2771	436	6.27	
007	67-30	168-45 W	13 Sept	23:40	42	1	42	GG54	1039	467	6.41	
								62μm	2771	397	5.71	1)
008	67-45	168-30 W	14 Sept	2:14	42	2	42	GG54	1039	452	6.20	
								62μm	2771	382	5.50	1)
008	67-45	168-30 W	14 Sept	2:23	42	1	42	GG54	1039	450	6.17	
								62μm	2771	246	3.54	3)
010	68-00	168-00 W	14 Sept	7:34	45	2	45	GG54	1039	430	5.90	
								62μm	2771	320	4.60	4)
012	68-12	167-20 W	14 Sept	10:39	40	2	40	GG54	1039	459	6.30	
								62μm	2771	436	6.27	
014	68-18	167-03 W	14 Sept	13:03	30	1	30	GG54	1039	376	5.16	
								62μm	2771	242	3.48	
015	68-00	168-45 W	14 Sept	17:02	50	1	50	GG54	1039	575	7.89	
								62μm	2771	498	7.16	1)
015	68-00	168-45 W	14 Sept	17:10	50	2	50	GG54	1039	588	8.07	
								62μm	2771	500	7.19	
017	69-00	168-45 W	15 Sept	0:30	45	1	45	GG54	1039	480	6.58	
								62μm	2771	312	4.49	
019	70-00	168-45 W	15 Sept	7:30	34	4	34	GG54	1039	436	5.98	
								62μm	2771	240	3.45	
021	71-30	168-45 W	15 Sept	16:34	42	2	42	GG54	1039	466	6.39	
								62μm	2771	242	3.48	
023	73-00	168-36 W	16 Sept	4:34	54	3	54	GG54	1039	566	7.76	
								62μm	2771	390	5.61	
024	73-30	168-45 W	16 Sept	10:05	109	1	109	GG54	1039	1143	15.68	
								62μm	2771	753	10.83	
025	74-00	168-45 W	16 Sept	12:48	150	3	150	GG54	1039	1526	20.93	
								62μm	2771	1106	15.91	
027	74-40	170-55 W	16 Sept	19:35	150	4	150	GG54	1039	1858	25.49	
								62μm	2771	1347	19.38	
029	75-13	172-39 W	17 Sept	9:02	154	13	150	GG54	1039	1713	23.50	
								62μm	2771	1631	23.46	
033	75-14	177-31 W	18 Sept	18:24	150	2	150	GG54	1039	1696	23.26	
								62μm	2771	1359	19.55	
036	75-00	170-00 W	19 Sept	16:01	150	3	150	GG54	1039	1570	21.54	
								62μm	2771	1125	16.18	

S.M.T. is Alaska local time (GMT-8h)

1) JAMSTEC Kitamura sample

2) Appendicularian hauses abundant

3) Including large Medusa

4) Including fish larva

Table 4.17-1. (Continued)

Station no.	Position		S.M.T.		Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter		Estimated volume of water filtered (m^3)	Remark
	Lat. (N)	Lon.	Date	Hour					No.	Reading		
038	75-00	166-00 W	19 Sept	23:50	150	1	150	GG54	1039	1510	20.71	
								62µm	2771	1166	16.77	
039	75-00	162-00 W	20 Sept	13:31	150	1	150	GG54	1039	1475	20.23	
								62µm	2771	1160	16.69	
041	75-00	164-00 W	21 Sept	22:25	150	3	150	GG54	1039	1450	19.89	
								62µm	2771	1118	16.08	
043	74-10	162-20 W	22 Sept	20:33	151	6	150	GG54	1039	1457	19.99	
								62µm	2771	1111	15.98	
045	73-20	160-02 W	23 Sept	8:10	150	2	150	GG54	1039	1470	20.16	
								62µm	2771	1135	16.33	
047	72-49	157-23 W	23 Sept	19:30	152	9	150	GG54	1039	1497	20.53	
								62µm	2771	1241	17.85	
049	71-15	157-10 W	24 Sept	9:30	40	3	40	GG54	1039	482	6.61	
								62µm	2771	440	6.33	4)
051	71-20	157-20 W	24 Sept	12:22	83	3	83	GG54	1039	959	13.15	
								62µm	2771	788	11.34	
053	71-25	157-28 W	24 Sept	14:22	117	1	117	GG54	1039	1115	15.29	
								62µm	2771	917	13.19	
055	71-30	157-37 W	24 Sept	19:33	80	10	79	GG54	1039	898	12.32	4)
								62µm	2771	847	12.18	
057	71-35	157-49 W	24 Sept	21:25	59	2	59	GG54	1039	698	9.57	
								62µm	2771	621	8.93	
058	71-36	154-50 W	27 Sept	3:29	37	4	37	GG54	1039	495	6.79	
								62µm	2771	410	5.90	
059	71-41	154-58 W	27 Sept	4:53	100	1	100	GG54	1039	1048	14.38	
								62µm	2771	970	13.95	
060	71-44	155-08 W	27 Sept	8:06	150	4	150	GG54	1039	1642	22.52	
								62µm	2771	1437	20.67	
061	71-49	155-18 W	27 Sept	10:31	150	1	150	GG54	1039	1453	19.93	
								62µm	2771	1026	14.76	
062	71-56	155-39 W	27 Sept	11:40	135	1	135	GG54	1039	1362	18.68	
								62µm	2771	988	14.21	
063	72-00	156-01 W	27 Sept	14:14	116	1	116	GG54	1039	1153	15.82	
								62µm	2771	955	13.74	
064	74-30	154-00 W	28 Sept	9:50	150	1	150	GG54	1039	1497	20.53	
								62µm	2771	1113	16.01	
066	73-30	156-24 W	29 Sept	4:56	150	1	150	GG54	1039	1489	20.42	
								62µm	2771	1213	17.45	
068	72-52	157-58 W	29 Sept	18:41	150	2	150	GG54	1039	1499	20.56	
								62µm	2771	1199	17.25	
069	72-45	158-12 W	29 Sept	19:40	151	7	150	GG54	1039	1425	19.55	
								62µm	2771	1085	15.61	
070	72-30	158-48 W	29 Sept	23:00	48	2	48	GG54	1039	526	7.22	
								62µm	2771	366	5.27	
072	72-00	160-00 W	30 Sept	2:55	23	1	23	GG54	1039	176	2.41	
								62µm	2771	139	2.00	

S.M.T. is Alaska local time (GMT-8h)

1) JAMSTEC Kitamura sample

2) Appendicularian hauses abundant

3) Including large Medusa

4) Including fish larva

Table 4.17-1. (Continued)

Station no.	Position		S.M.T.		Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter		Estimated volume of water filtered (m^3)	Remark
	Lat. (N)	Lon.	Date	Hour					No.	Reading		
074	70-45	161-59 W	1 Oct	0:45	36	1	36	GG54	1039	413	5.67	
								62μm	2771	333	4.79	
076	70-45	163-59 W	1 Oct	7:25	40	1	40	GG54	1039	423	5.80	
								62μm	2771	218	3.14	
078	70-45	166-00 W	1 Oct	12:04	33	1	33	GG54	1039	390	5.35	
								62μm	2771	283	4.07	
080	70-45	167-59 W	1 Oct	17:03	41	3	41	GG54	1039	505	6.93	
								62μm	2771	403	5.80	
085	68-15	168-45 W	3 Oct	4:41	50	4	50	GG54	1039	541	7.42	
								62μm	2771	412	5.93	
086	68-07	168-45 W	3 Oct	6:11	52	2	52	GG54	1039	609	8.35	
								62μm	2771	404	5.81	1)
087	68-00	168-00 W	3 Oct	8:32	48	3	48	GG54	1039	585	8.02	
								62μm	2771	412	5.93	
089	68-00	168-45 W	3 Oct	11:35	52	1	52	GG54	1039	518	7.11	
								62μm	2771	315	4.53	1)
089	68-00	168-45 W	3 Oct	11:44	52	1	52	GG54	1039	500	6.86	
								62μm	2771	342	4.92	
091	67-45	168-45 W	3 Oct	14:49	44	4	44	GG54	1039	428	5.87	
								62μm	2771	206	2.96	

S.M.T. is Alaska local time (GMT-8h)

1) JAMSTEC Kitamura sample

2) Appendicularian hauses abundant

3) Including large Medusa

4) Including fish larva

Table 4.17-2. Data on plankton samples collected by vertical hauls with 80 cm ring net.
GG54: 0.335 mm mesh.

Station no.	Position		S.M.T.		Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter		Estimated volume of water filtered (m^3)	Remark
	Lat. (N)	Lon.	Date	Hour					No.	Reading		
007	67-30	168-45 W	13 Sept	23:33	42	2	42	GG54	1333	370	18.14	2)
008	67-45	168-30 W	14 Sept	2:07	42	2	42	GG54	1333	375	18.39	2)
010	68-00	168-00 W	14 Sept	7:41	45	1	45	GG54	1333		0.00	1)
015	68-00	168-45 W	14 Sept	16:55	50	1	50	GG54	1333	569	27.90	2)
029	75-13	172-39 W	17 Sept	9:14	150	1	150	GG54	1333		0.00	1)
039	75-00	162-00 W	20 Sept	13:42	150	1	150	GG54	1333		0.00	1)
045	73-20	160-02 W	23 Sept	8:20	150	1	150	GG54	1333		0.00	1)
060	71-44	155-08 W	27 Sept	8:06	150	4	150	GG54	1333		0.00	1)
064	74-30	154-00 W	28 Sept	9:50	1000	1	1000	GG54	1333	7639	374.61	3)
066	73-30	156-24 W	29 Sept	4:56	150	1	150	GG54	1333	7663	375.79	3)
072	72-00	160-00 W	30 Sept	2:55	23	1	23	GG54	1333		0.00	1)
076	70-45	163-59 W	1 Oct	23:00	40	1	40	GG54	1333		0.00	1)
086	68-07	168-45 W	3 Oct	6:05	52	9	51	GG54	1333	519	25.45	2)
089	68-00	168-45 W	3 Oct	11:29	52	4	52	GG54	1333	498	24.42	2)

S.M.T. is Alaska local time (GMT-8h)

1) for grazing experiment

2) JAMSTEC Kitamura sample

3) AIST Takenaka and HU Nakamura ethanol sample

Table 4.17-3. Data on core samples collected by multiple corer.

Station no.	Position Lat. (N)	Lon.	S.M.T. Date	Bottom depth (m)	Handling no.	Core length (cm)	Remark
021	71-30	168-45 W	15 Sept	49	8	21	
024	73-30	168-45 W	16 Sept	117	7	30	
027	74-40	170-55 W	16 Sept	234	7	28	
039	75-00	162-00 W	20 Sept	1973	8	30	
064	74-30	154-00 W	28 Sept	3852	8	23.5	
068	72-52	157-58 W	29 Sept	1573	8	38.5	
072	72-00	160-00 W	30 Sept	30	8	13.5	Sand
089	68-00	168-45 W	3 Oct	59	1	31.5	Amphipoda abundant at surface layer

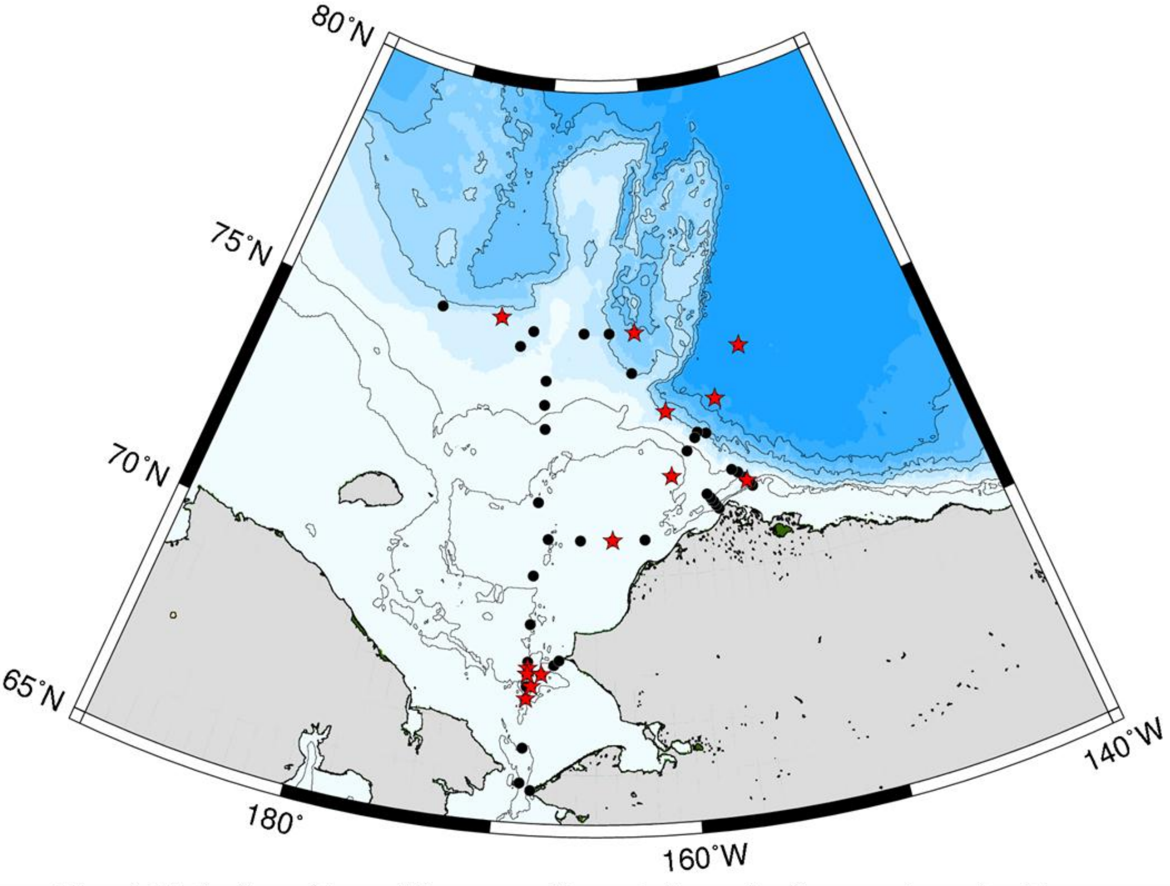

Fig. 4.17-1. Location of the sampling stations in the western Arctic Ocean (circles: NORPAC net, stars: NORPAC net + 80 cm ring net).

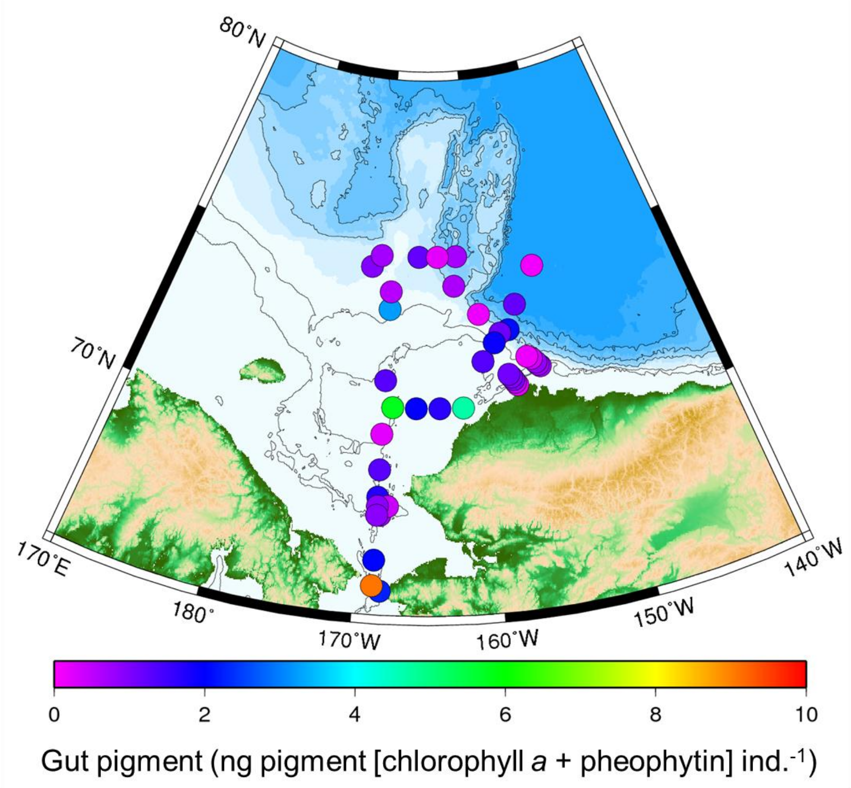

Fig. 4.17-2. Geographical distribution of gut pigment of *Calanus glacialis* C5.

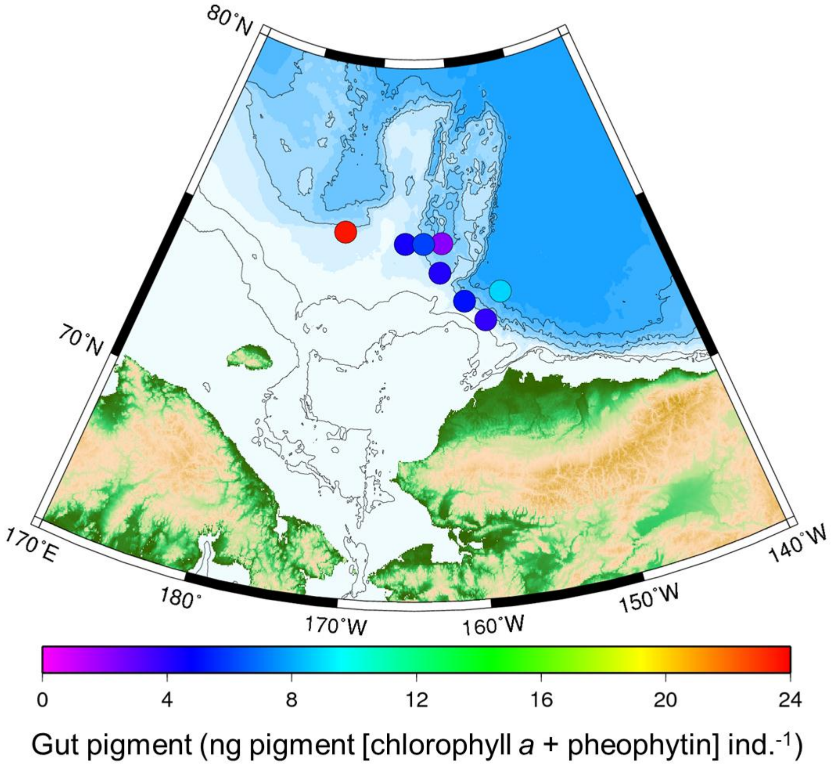

Fig. 4.17-3. Geographical distribution of gut pigment of *Metridia longa* C6F.

4.18. Sediment trap moorings

(1) Personnel

Naomi Harada	(JAMSTEC): Principal Investigator
Yuichiro Tanaka	(AIST)
Shigeto Nishino	(JAMSTEC)
Takahashi Kikuchi	(JAMSTEC)
Katsunori Kimoto	(JAMSTEC)
Yusuke Okazaki	(JAMSTEC)
Kana Nagashima	(JAMSTEC)
Makio C. Honda	(JAMSTEC)
Sanae Chiba	(JAMSTEC)
Jonaotaro Onodera	(JSPS/JAMSTEC)
Toru Idai	(MWJ): Technical staff for moorings deployment
Tomoyuki Takamori	(MWJ): Technical staff for moorings deployment

(2) Objectives

Recovery and deployment of sediment trap moorings

In order to monitor the time-series changes of biogeochemical cycles in the Arctic Ocean, sediment trap study has been continued from MR10-05 cruise. It has been considered that the pronounced decline of summer sea-ice area significantly influences to the sea-ice ecosystem and biogeochemical cycles. Multi-year monitoring of sinking particle flux will be helpful for the understanding of rapid environmental change in the study area.

(3) Instruments and Methods

Sediment trap moorings

Sediment trap deployments were carried out at two locations in the Northwind Abyssal Plain and the Chuckhi Sea (Table 4.18-1, Fig. 4-18-1). The deployment ID of sediment trap moorings is NAP11t for recovery, and NAP12t and CAP12t for deployment in this cruise, respectively.

Instruments of sediment trap moorings are as shown in Figures 4.18-2, 4.18-3, and 4.18-4. As the ownership remarks, the acoustic releases of Nichiyu Giken Kogyo, all sediment traps, and almost glass buoys were supplied by Dr. Yuichiro Tanaka, AIST. The Benthos acoustic releaser was supplied by Kyushu University. Transponder for NAP12t, CT sensor and DO sensor for CAP12t are from Arctic Ocean Climate System Research Team, JAMSTEC.

Sea waters to fill sampling-cups were taken from 1000m water depth in the Northwind Abyssal Plain in the last summer cruise of CCGS Sir Wilfrid Laurier. Before the start of this cruise, the waters were filtered by membrane filter with 0.45μm pore size in order to remove particle matters. As antiseptic of collected samples, formalin was added to the filtered water. The concentration of formalin was 4-5%. The pH of filtered sea water with formalin was neutralized to approx. 8.0 by sodium tetraborate.

In order to avoid the malfunction of acoustic releasers during their deployment, the response from all acoustic releasers to be deployed in this cruise were tested at 2000 m and 500 m water depths before her arrival in the Arctic Ocean. The any responses from releasers, which were attached with CTD frame and were sunk to 2000m water depth, were not detected probably due to the noise from engine and/or thruster to keep the ship position in bad weather condition. Another response test was successful when we sunk the releasers to 500m water depth with clean wire winch. These examined releasers were applied for the deployments of CAP12 and NAP12t.

The mooring operation at stern board was carried out from the top buoy first. The recovery and deployment log is as listed in Table 4.18-2 and 4.19-3.

(4) Station list or Observation log

Sediment trap recovery

The log of recovery operation in Table 4.18-2

The layout of sediment trap mooring NAP11t in Figures 4.18-2.

Sediment trap deployment

The log of deployment operation in Table 4.18-3

The layout of sediment trap moorings in Figures 4.18-3 and 4.18-4.

(5) Results

Recovery of sediment trap mooring NAP11t

The top buoy of mooring was found less than three minutes from the sending release command. All grass floats of the mooring were found at sea surface in 26 minutes after the sending release command. The top buoy was picked up by small boat of R/V Mirai. During the recovery operation, the lower connection part of top buoy frame and rope broke because of heavy electrolytic etching without anode (Fig. 4.18-5a). The detached rope fall into ocean, and thus the small boat had to pick up the mooring in twice. The one stainless-steel ring in the bridle of sediment trap also showed significant electrolytic etching (Fig. 4.18-5b). The transponder did not work due to malfunction with water immersion. Although there were several problems in the recovered mooring, the sinking particle samples were successfully obtained from all sampling cups of both sediment traps (Fig. 4.18-6). The water depths of sediment traps are estimated at about 260 m and 1360 m based on the log of pressure sensor (Fig. 4.18-7).

Deployment of sediment trap mooring NAP12t

The nine glass buoys became the top of mooring because the top buoy frame could not be re-used by broken joint ring (Figs. 4.18-3, 4.18-5a). In addition, the recovered transponder could not be re-used. Instead, the applied transponder for NAP12t is the extra one of the Arctic Ocean Climate System Research Team, JAMSTEC. The length of upper rope was changed from 100m to 50m in order to avoid the possible touch of sea-ice. The deployment operation was successful without injury accident.

Deployment of sediment trap mooring CAP12t

The deployment of sediment trap mooring was successful without injury accident. Instead of no mooring for physical oceanographic monitoring, the CT sensor SBE37-SM and the DO sensor AROW-USB-Z was attached to the top buoy frame and sediment trap, respectively (Fig. 4.18-4).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC home page.

Table 4.18-1. Summary of sediment trap moorings in the R/V Mirai Cruise MR12-E03.

Deployment ID	Coordinates	Water Depth (m)	Trap Depth (m)	Transponder Depth (m)	Trap Type	Acoustic Release Type	Sampling Duration
Recovery							
NAP11t	75°59.98' N 175°00.28' W	1975	260 1360	80	SMD 26S-6 000[a]	Model L[a]/865A[b]	4 Oct. 2011-18 Sep. 2012
Deployment							
NAP12t	75°00.1711' N 162°00.1819' W	1975	260 1360	200		Model L[a]/865A[b]	4 Oct. 2011-18 Sep. 2012
CAP12t	75°12.3710' N 172°32.9186' W	447	317 1349	90.7		Model L[a]	4 Oct. 2011-18 Sep. 2012

[a] Nichiyu Giken Kobyo, Co. Ltd.; [b] Benthos (Teledyne Benthos)

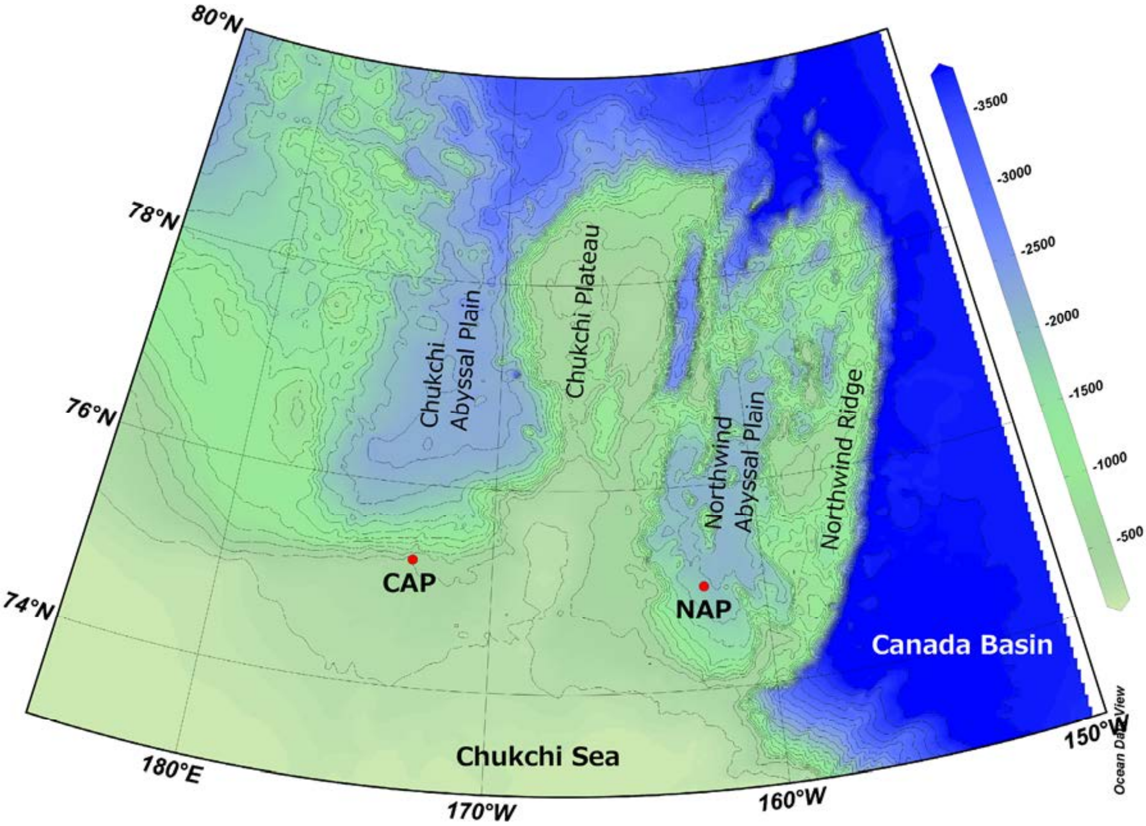

Fig. 4.18-1. The locality map of Stations NAP and CAP

Table 4.18-2. Recovery log of sediment trap mooring (by T. Kikuchi).

Mooring ID	NAP-10t
Project	MR10-05
Ship	R/V Mirai
Send Time of Release (UTC)	2012/9/20 19:10
Send Position of Release	75°00.1229'N 161°58.9980'W
Depth of Release Position	1977 m
Time of instruments out of water (UTC)	
Top Buoy (ABS resin)	20:14
Frame with Flag	20:18
Connection between top frame and rope broke. Small boat went to pick up the rope in water	20:26
Five Glass Buoys	21:04
Four Glass Buoys	21:04
Shallower Sediment Trap (300m)	21:12
Five Glass Buoys	21:28
Deeper Sediment Trap (1300m)	21:39
Four Glass Buoys	21:52
Double release	21:52
End Time of Recovery (UTC)	2012/9/20 21:52
Position of Recovery	75°01.2080'N 161°58.2315'W
Depth of Recovery Position	1982 m

Table 4.18-3. Deployment log of sediment trap moorings (by T. Kikuchi).

Mooring ID	NAP-12t	CAP-12t
Project	MR12-E03	MR12-E03
Ship	R/V Mirai	R/V Mirai
Start Time of Deploy (UTC)	2012/9/21 19:05	2010/9/19 17:28
Start Position of Deploy	75°00.9152'N 161°54.6395'W	75°11.4416'N 172°34.5917'W
Depth of Start Position	1990 m	435 m
	SAT -1.3°C, SST 0.85°C, SSS 25.612, wave ~0.7 m, wind ~0.6 m/s, 255°T	SAT -0.5°C, SST -0.217°C, SSS 26.056, wave 2~3 m, wind ~11 m/s, 20-25°T
Time in Water of Instruments (UTC)		
Top Buoy (ABS resin)	*N.A.*	17:29
Frame with Flag, SBE37-SM, and transponder	*N.A.*	17:29
Five Glass Buoys	19:09	17:40
Transponder	19:09	*N.A.*
Four Glass Buoys	19:09	17:40
Shallower Sediment Trap	19:16	17:49
w/ DO sensor ARO-USB-Z	*N.A.*	17:49
Five Glass Buoys	19:39	*N.A.*
Deeper Sediment Trap	19:50	*N.A.*
Five Glass Buoys	20:04	18:03
Double release	20:04	18:04
Time of Sinker Release (UTC)	2012/9/21 20:28	2010/9/19 18:26
Position of Sinker Release	75°59.90'N 174°59.68'W	75°12.4234'N 172°32.6681'W
Depth of Sinker Release	1971 m	447 m

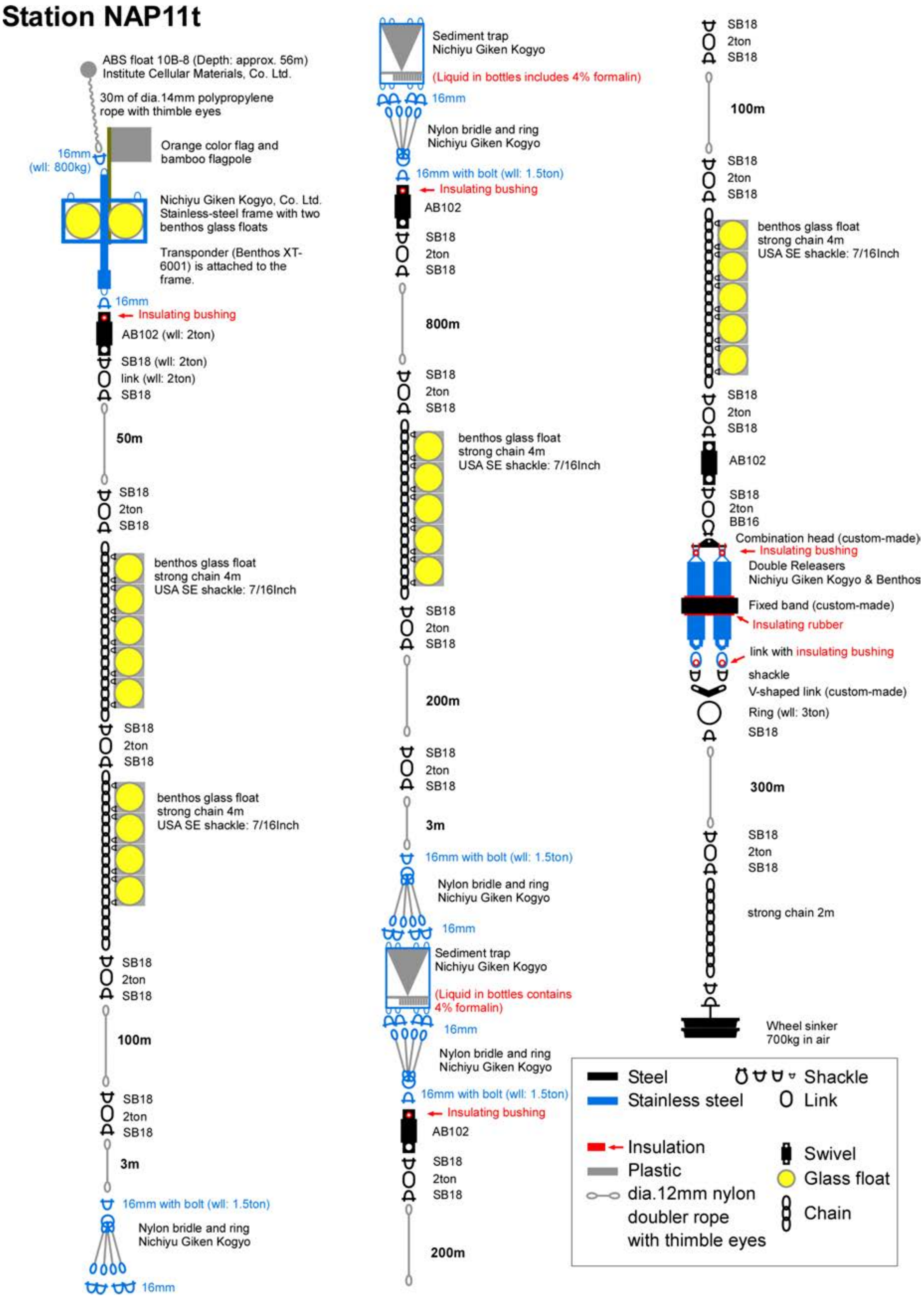

Figure 4.18-2. The layout of sediment trap mooring at Station NAP11t.

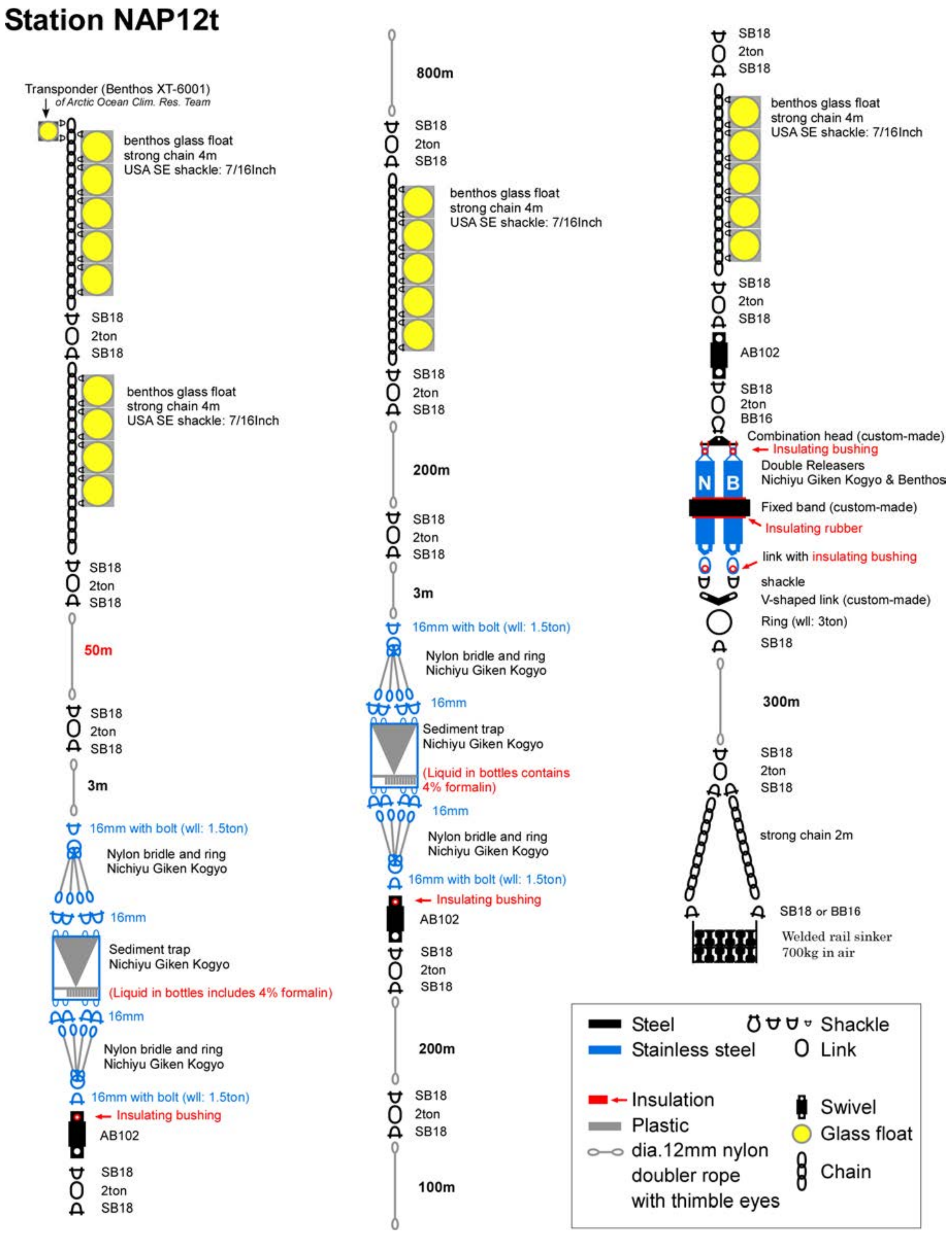

Figure 4.18-3. The layout of sediment trap mooring at Station NAP12t.

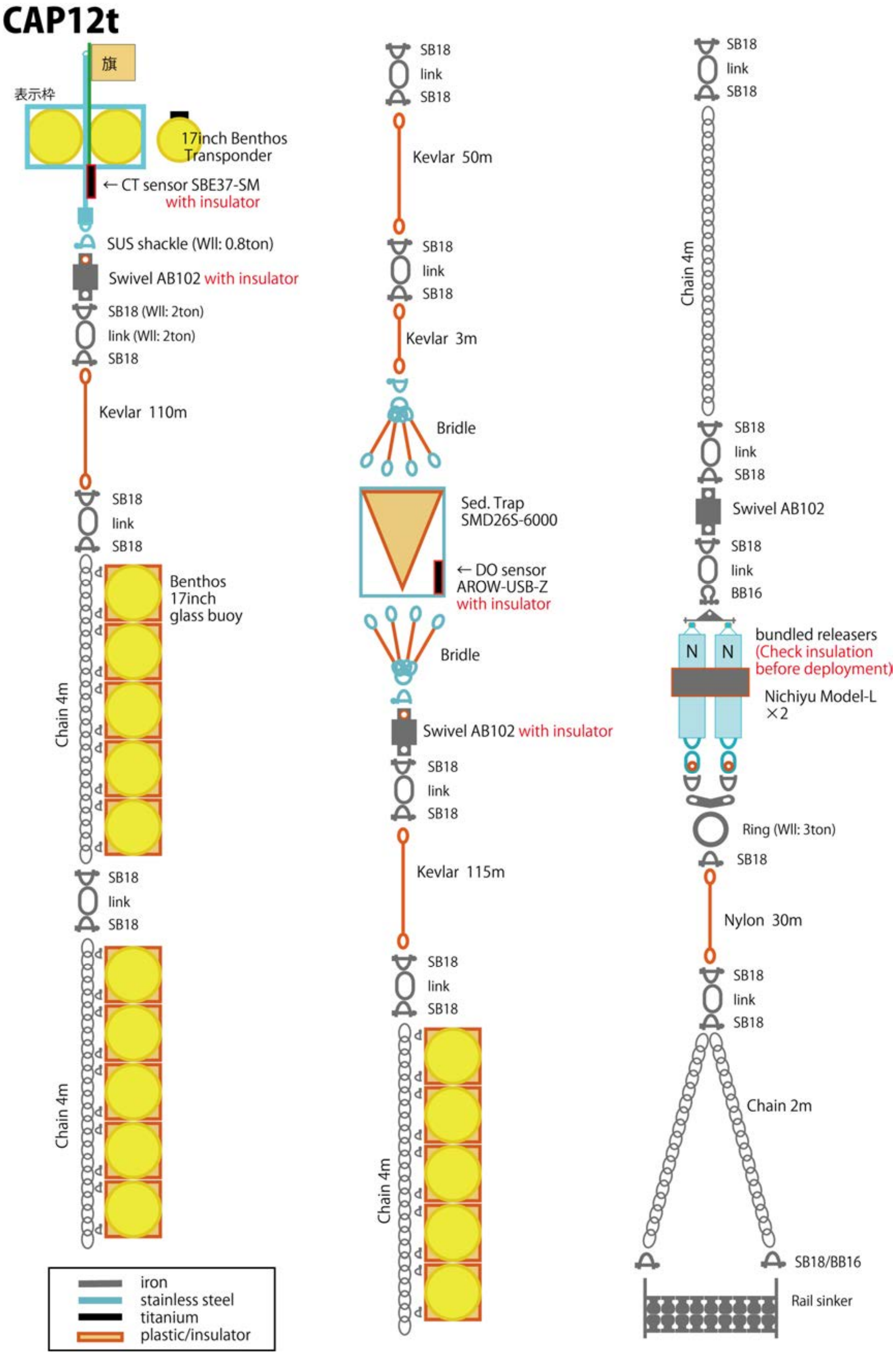

Figure 4.18-4. The layout of sediment trap mooring at Station NAP12t.

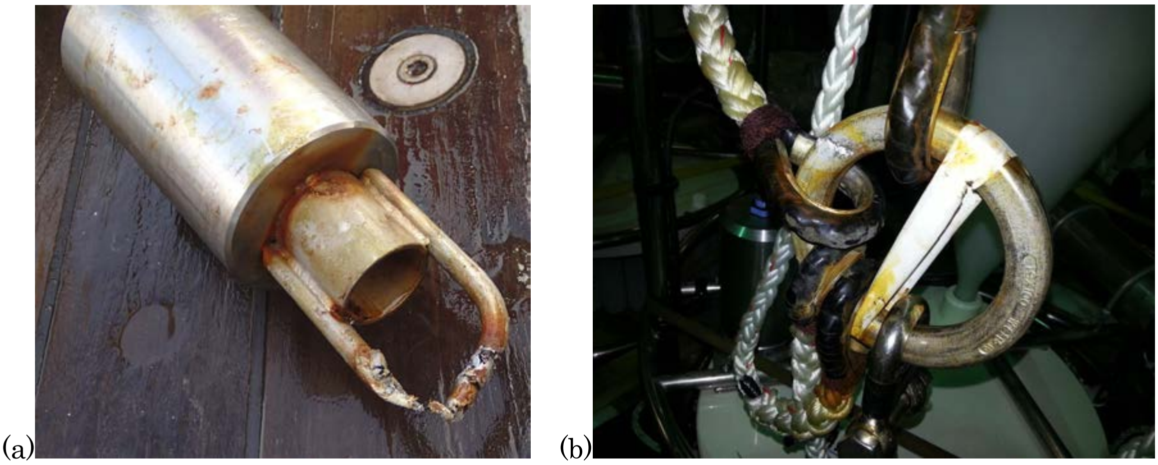

Fig. 4.18-5. The electrolytic etching of the top buoy frame and the bridal of sediment trap of NAP11t mooring. The material is stainless steel. (a) the lower end of top buoy frame; (b) the bridal ring of sediment trap.

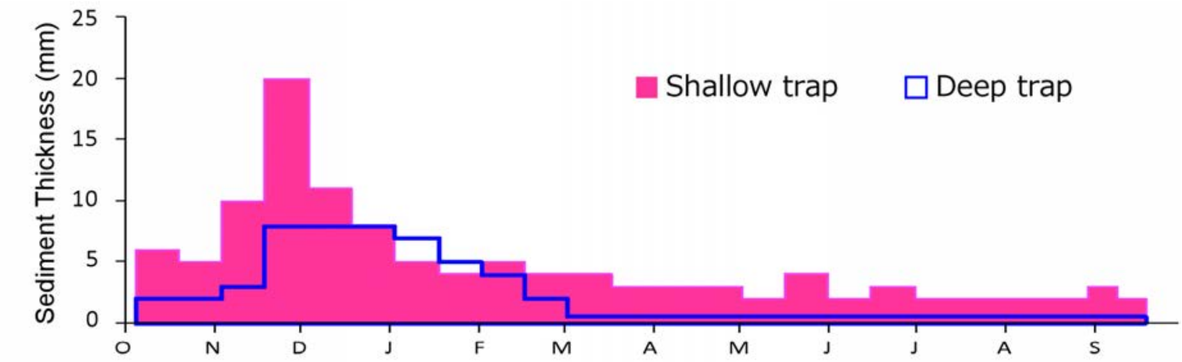

Fig. 4.18-6. The thickness of sinking particle matter and swimmers in the sampling cup of recovered sediment trap NAP11t.

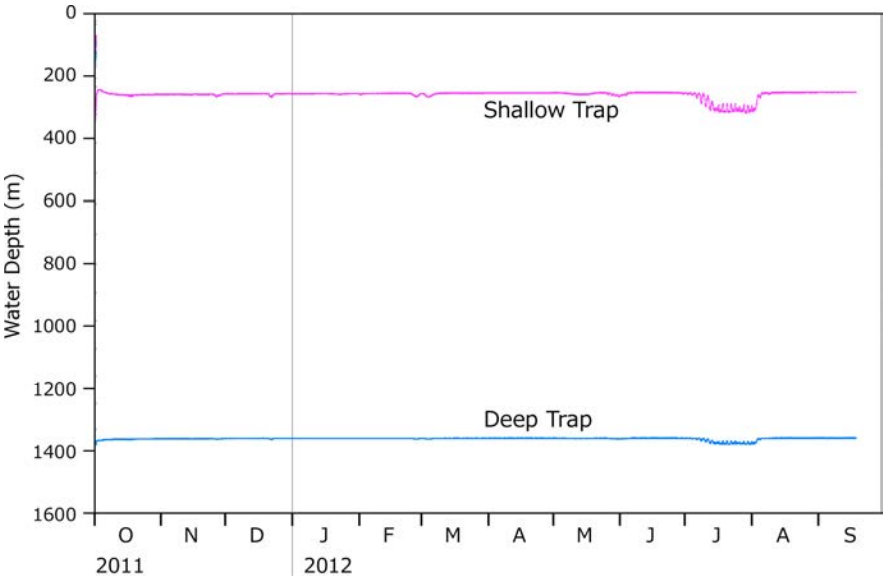

Fig. 4.18-7. The water depths of the deployed sediment traps at Station NAP11t.

5. Geology

5.1. Multiple core samplings

(1) Personnel

Michiyo Yamamoto-Kawai (Tokyo University of Marine Science and Technology)
Jota Kanda (Tokyo University of Marine Science and Technology)
Kentaro Sugiyama (Tokyo University of Marine Science and Technology)
Jing Zhang (Toyama University)
Shoko Hirayama (Toyama University)
Atsushi Yamaguchi (Hokkaido University)
Kohei Matsuno (Hokkaido University)
Yasushi Hashimoto (Marine Works Japan Co. Ltd)
Yasumi Yamada (Marine Works Japan Co. Ltd)

(2) Objectives

Collection of sediment core samples to measure the denitrification and anamox rates, nutrient fluxes from the sediment to the bottom water, nutrient and trace metal concentrations in pore water, and phytoplankton cyst.

(3) Parameters

A Multiple Corer (MC) was used during this cruise, consists of main body (524~620kg weight) and 4~8 pipes, which are 3~7 acryl pipes and 1 polycarbonate pipe. Core barrel is 60cm length and 74mm inside diameter. In this cruise, we added the Water Sampling System to MC. The Water Sampling System consists of 4 Niskin Bottles (8-liter), TD (Temperature and Depth) sensor and Magnet Switch Data Logger (Kanji-kun).

(4) Instruments and Method

Winch operation

When we started lowering the MC, a speed of wire out was gradually increased to be 1.0m/s. The MC was stopped at a depth about 30~50m above the sea floor for 3minutes to stabilize of the sampler. After the sampler was stabilized, the wire was wound off at 0.3m/s, and we watched carefully a tension meter. When the MC touches the bottom, wire tension leniently decreases by the loss of the sampler weight. After confirmation that is the MC touch seafloor, the wire out was stopped then another 2~6m rewinding. After waited 20~40 seconds, the wire was wound in at 0.3m/s until the tension gauge indicates that is the corer left the bottom. After left the bottom, which wire was wound in at the maximum speed. The MC came back the ship deck, the core barrel was detached from main body.

MSCL measurements

A GEOTEK multi-sensor core logger (MSCL) has three sensors, which is gamma-ray attenuation (GRA), P-wave velocity (PWV), and magnetic susceptibility (MS). There were measured on whole-core section before splitting using the onboard MSCL. These data measurement was carried on every 1 cm.

GRA was measured a gamma ray source and detector. These mounted across the core on a sensor stand that aligns them with the center of the core. A narrow beam of gamma ray is emitted by Caesium-137 (^{137}Cs) with energies principally at 0.662 MeV. Also, the photon of gamma ray is collimated through 5mm diameter in rotating shutter at the front of the housing of ^{137}Cs. The photon passes through the core and is detected on the other side. The detector comprises a scintillator (a 2" diameter and 2" thick NaI crystal).

GRA calibration assumes a two-phase system model for sediments, where the two phases are the minerals and the interstitial water. Aluminum has an attenuation coefficient similar to common minerals and is used as the mineral phase standard. Pure water is used as the interstitial-water phase standard. The actual standard consists of a telescoping aluminum rob (five elements of varying thickness) mounted in a piece of core liner and filled with distilled water. GRA was measured with 10 seconds counting.

PWV was measured two oil filled Acoustic Rolling Contact (ARC) transducers, which are mounted on the center sensor stand with gamma system. These transducers measure the velocity of P-Wave through the core and the P-Wave pulse frequency.

MS was measured using Bartington loop sensor that has an internal diameter of 100 mm installed in MSCL. An oscillator circuit in the sensor produces a low intensity (approx. 80 A/m RMS) non-saturating, alternating magnetic field (0.565 kHz). MS was measured with 1 second.

Core splitting

The sediment sections are longitudinally cut into working and archive halves by a splitting devise and a stainless wire. After that, it marks with the white and blue pins in the 2 cm interval.

CCR measurements

Core color reference (CCR) was measured by using the Konica Minolta CM-700d (CM-700d) reference photo spectrometer using 400 to 700nm in wavelengths.

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

The CM-700d has a switch that allows the specular component to be include (SCI) or excluded (SCE). We chose setting the switch to SCE. The SCE setting is the recommended mode of operation for sediments in which the light reflected at a certain angle (angle of specular reflection) is trapped and absorbed at the light trap position on the integration sphere.

Calibrations are zero calibration and white calibration before the measurement of core samples. Zero calibration is carried out into the air. White calibration is carried out using the white calibration piece (CM-700d standard accessories) without crystal clear polyethylene wrap. The color of the split sediment (Working half core) was measured on every 2 cm through crystal clear polyethylene wrap.

There are different systems to quantify the color reference for soil and sediment measurements, the most common is the $L^*a^*b^*$ system, also referred to as the CIE (Commision International d'Eclairage) LAB system. It can be visualized as a cylindrical coordinate system in which the axis of the cylinder is the lightness variable L^*,ranging from 0 % to 100 %, and the radii are the chromaticity variables a^* and b^*. Variable a* is the green (negative) to red (positive) axis, and variable b* is the blue (negative) to yellow (positive) axis. Spectral data can be used to estimate the abundance of certain components of sediments.

Measurement parameters are displayed Table 5.1-1.

Table 5.1-1. Measurement parameters.

Instrument	Konica Minolta Photospectrometer CM-700d
Software	Spectra Magic NX CM-S100w Ver.2.02.0002
Illuminant	d/8 (SCE)
Light source	D65
Viewing angle	10 degree
Color system	$L^*a^*b^*$ system

Core Photographs

After splitting each section of multiple cores into working and archive halves, sectional photographs of working were taken using a single-lens reflex digital camera (Body: Nikon D90 / Lens: Nikon AF-S Micro NIKKOR 60mm F2.8G ED). When using the digital camera, shutter speed was 1/60 ~ 1/160 sec, F-number was 4.5 ~ 8, sensitivity was ISO 400. File format of raw data is Exif-JPEG. Details for settings were included on property of each file.

Soft X-ray photograph

Soft X-ray photograph is taken to observe sedimentary structures of cores.

Sediment samples were put into the original plastic cases (200 x 3 x 7 mm) from cores. Each case has a TEPURA seal showing cruise code, core number, section number, case number, and section depth (cm) Each case was sealed rim by PARAFILM.

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 45 KVp, 2 mA, and 150 or 200 seconds. All photographs were developed into the negative films by the device FIP-1400 on board.

The negative films were scanned by Epson Offirio ES-10000G to digital image files. The file quality is 300dpi and the file format is TIFF. Afterward the images were carried out histogram coordination. In this cruise, the total 15 sediment sample cases were collected from cores, and the total 9 negative films were taken X-ray photograph and developed.

5.2. Sea bottom topography measurement

(1) Personnel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 3012 Upgrade Model (L3 Communications ELAC Nautik) and with a Sub-bottom Profiler (SBP), Bathy2010 (SyQwest). The objective of MBES and SBP is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

(3) Insruments and Methods

The "SEABEAM 3012 Upgrade Model" on R/V MIRAI was used for bathymetry mapping during the MR12-E03 cruise.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD, XCTD and Argo float data by the equation in Del Grosso (1974) during the cruise.

The system configuration and performance are shown in Table 5.2-1 and Table 5.2-2.

Table 5.2-1 SEABEAM 3012 System configuration and performance

Frequency:	12 kHz
Transmit beam width:	1.6 degree
Transmit power:	20 kW
Transmit pulse length:	2 to 20 msec.
Receive beam width:	1.8 degree
Depth range:	100 to 11,000 m
Beam spacing:	0.5 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)

Table 5.2-2 Bathy2010 System configuration and performance

Frequency:	3.5 kHz
Transmit beam width:	23 degree
Transmit pulse length:	0.5 to 50 msec
Strata resolution:	Up to 8 cm with 300 Meters of bottom penetration; bottom type dependant
Depth resolution:	0.1 Feet, 0.1 Meters
Depth accuracy:	±10 cm to 100 m, ±0.3% to 6,000 m

(4) Preliminary Results

The results will be published after primary processing.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

5.3. Sea surface gravity measurement

(1) Personnel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface throughout the MR12-E03 cruise.

(3) Parameters

Relative Gravity [CU: Counter Unit]

[mGal] = (coefl: 0.9946) * [CU]

(4) Instruments and Methods

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-5), at Sekinehama Port as reference point.

(5) Preliminary Results

Absolute gravity table is shown in Table 5.3-1

Table 5.3-1 Absolute gravity table

No	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *1 [mGal]	L&R*2 Gravity [mGal]
#1	09/02	00:04	Sekinehama	980,371.92	310	613	980,373.07	12613.33
#2	10/17	03:23	Sekinehama	980,371.94	248	614	980372.89	12610.72

*1: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2222

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

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

5.4. Surface three component magnetic field measurements

(1) Personel

Takashi Kikuchi	JAMSTEC: PI
Souichiro Sueyoshi	Global Ocean Development Inc.: GODI
Toshimitsu Goto	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

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 MR12-E03 cruise.

(3) Insruments and Methods

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.

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:

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

where $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{P}}$ and $\widetilde{\mathbf{Y}}$ 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

$$\widetilde{\mathbf{R}}\ \mathrm{Hob} + \mathrm{Hbp} = \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} \qquad \text{(b)}$$

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

(4) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

(5) Remarks

a) 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 as below.

13 Sep. 2012, 06:57 to 07:23 UTC	64-13.8N, 170-56.6W
21 Sep. 2012, 04:46 to 05:11 UTC	74-59.5N, 161-59.9W
14 Oct. 2012, 06:20 to 06:45 UTC	40-28.9N, 149-28.0E