

R/V Mirai Cruise Report

MR13-06

Arctic Ocean, Bering Sea, and North Pacific Ocean

Leg 1: 28th August to 7th October, 2013

Leg 2: 9th October to 21th October, 2013

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



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1. Cruise Summary

1.1. Overview of Observations

On the basis of our previous observations and theoretical considerations, we have come to realize that the Arctic Ocean plays an important role in global climate changes.

The objectives of this cruise are as follows:

- a. To quantify on-going changes in ocean, atmosphere, and ecosystem, which are related to the recent Arctic warming and sea-ice reduction.
- b. To clarify important processes and interactions among atmosphere, ocean, and ecosystem behind changes of the Arctic Ocean.
- c. To collect data for understanding the effects of the Arctic Ocean changes on global climate.

In this research cruise, we conducted:

- a. Fixed point observations with radiozonde, Doppler radar, general meteorological equipments, CTD (Conductivity, temperature, and depth sensors), XCTD (expendable CTD), seawater samplers, current profilers, turbulence ocean microstructure acquisition profiler, plankton nets, optical instruments, sea surface monitoring system, drifting buoys, and so on.
- b. Wide-area observations with the metrological and oceanographic equipments described above.
- c. Mooring observations to measure annual changes in seawater temperature, salinity, currents, dissolved oxygen, chlorophyll a, zooplankton (by acoustics), marine mammal (by acoustics), and sediments (by sediment traps).
- d. Continuous observations of sea bottom topography, gravity, and magnetic fields along the cruise track, in addition to the continuous meteorological and oceanographic observations by general meteorological equipments and sea surface monitoring system, respectively.

This research cruise included the following publicly-offered studies:

- Studies on board

- Sea-ice reduction in the western Arctic Ocean and its impact on the variation of biogenic particulate fluxes [JAMSTEC-RIGC]
- Study on the response of lower trophic level ecosystem to environmental changes in the Arctic Ocean [Hokkaido University]
- Study on the spatial variations of microbial community and DOM/POM and their controlling mechanism in the Canada Basin of the Arctic Ocean [Atmosphere and Ocean Research Institute, The University of Tokyo]
- Study on the cycles of greenhouse gasses and their climatological responses in the Arctic region [Meteorological Research Institute]
- Assessment of environmental impact on the efflux of chemical materials from the sea-ice due to its melt in the Arctic Ocean [National Institute of Advanced Industrial Science and Technology]

- Studies not on board

- Maritime aerosol optical properties from measurements of ship-borne sky radiometer [Toyoma University]
- Lidar observations of optical characteristics and vertical distribution of aerosols and clouds [National Institute for Environmental Studies]
- Study on material cycles from wide-area observations of maritime gas and aerosol [JAMSTEC-RIGC]
- Tectonics of the mid-Cretaceous Pacific Plate [Chiba University]
- Standardization of marine geophysical data and its application to the ocean floor geodynamics studies [Ryukyu University]

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	MR13-06																											
Undertaking Institute	Japan Agency for Marine-Earth Science and Technology (JAMSTEC) 2-15 Natsushima-cho, Yokosuka 237-0061, Japan																											
Chief Scientists	Shigeto Nishino Arctic Ocean Climate System Research Team, Research Institute for Global Change (RIGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)																											
Cruise Periods	Leg 1: 28 August 2013 – 7 October 2013 Leg 2: 9 October 2013 – 21 October 2013																											
Ports of Call	28 August 2013, Dutch Harbor (leave port) 7 October 2013, Dutch Harbor (arrival in port) 9 October 2013, Dutch Harbor (leave port) 20 October 2013, Hachinohe (arrival in port) 21 October 2013, Sekinehama (arrival in port)																											
Research Areas	Arctic Ocean, Bering Sea, and North Pacific Ocean																											
Research Activities	<table><tr><td>Radiosonde</td><td>319 stns</td></tr><tr><td>Mooring recoveries</td><td>5 stns</td></tr><tr><td>Mooring deployments</td><td>4 stns</td></tr><tr><td>TurboMAP</td><td>7 stns /81 casts</td></tr><tr><td>SVP</td><td>6 stns</td></tr><tr><td>XCTDs</td><td>143 stns</td></tr><tr><td>CTD</td><td>88 stns/213 casts</td></tr><tr><td>Water samplings</td><td>79 stns/155 casts</td></tr><tr><td>Clean samplings</td><td>11 stns/21 casts</td></tr><tr><td>Primary production</td><td>10 stns/18 casts</td></tr><tr><td>Spectroradiometer (PRR)</td><td>17 stns/ 33 casts</td></tr><tr><td>NORPAC nets</td><td>34 stns/ 82 casts</td></tr><tr><td>Ring nets</td><td>10 stns/62 casts</td></tr></table>		Radiosonde	319 stns	Mooring recoveries	5 stns	Mooring deployments	4 stns	TurboMAP	7 stns /81 casts	SVP	6 stns	XCTDs	143 stns	CTD	88 stns/213 casts	Water samplings	79 stns/155 casts	Clean samplings	11 stns/21 casts	Primary production	10 stns/18 casts	Spectroradiometer (PRR)	17 stns/ 33 casts	NORPAC nets	34 stns/ 82 casts	Ring nets	10 stns/62 casts
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Closing PCP nets	1 stn/72 casts
VMPS	2 stns

(Underway observations)
 Doppler Radar
 Dual polarization lidar
 Optical Absorption Spectroscope/MAX-DOAS
 Sky radio meter
 Meteorological observation system
 Sea surface water monitoring system
 Total carbonate monitoring system
 Greenhouse gases monitoring system (CRDS)
 Satellite data observation system
 PAR sensor
 Air samplings
 Sea surface water samplings
 ADCP
 Seabeam/Sub bottom profiler
 Magnetometer
 Gravity meter

Note:

With regard to some stationary observations marked by the double asterisk (**) in the MSR Application to the U.S., scientists originally intended to carry out them not only in the Arctic Ocean but also on the way to there and back to Japan, though it could be read that the stationary observations would be carried out only in the Arctic Ocean from the explanation of the Application.

Those research and observation items are Radiozonde observations (Section 2.1), meteorological samplings detecting CO₂, CH₄, CO (Section 2.5.1), whole airs (Section 2.5.2) and air contaminants (Section 4.13), and sea surface water samplings detecting water contaminants (Section 4.13) and radionuclides (Section 4.16).

Data and the research results obtained from those items, which are both expected and unexpected results such as detected contaminants and radionuclides, are also included in this report.

Those data and the results would be utilized for scientific researches and will be accordingly opened to the public unless otherwise indicated by the U.S. government.

1.3. Cruise Track

Cruise Track of MR13-06Leg1

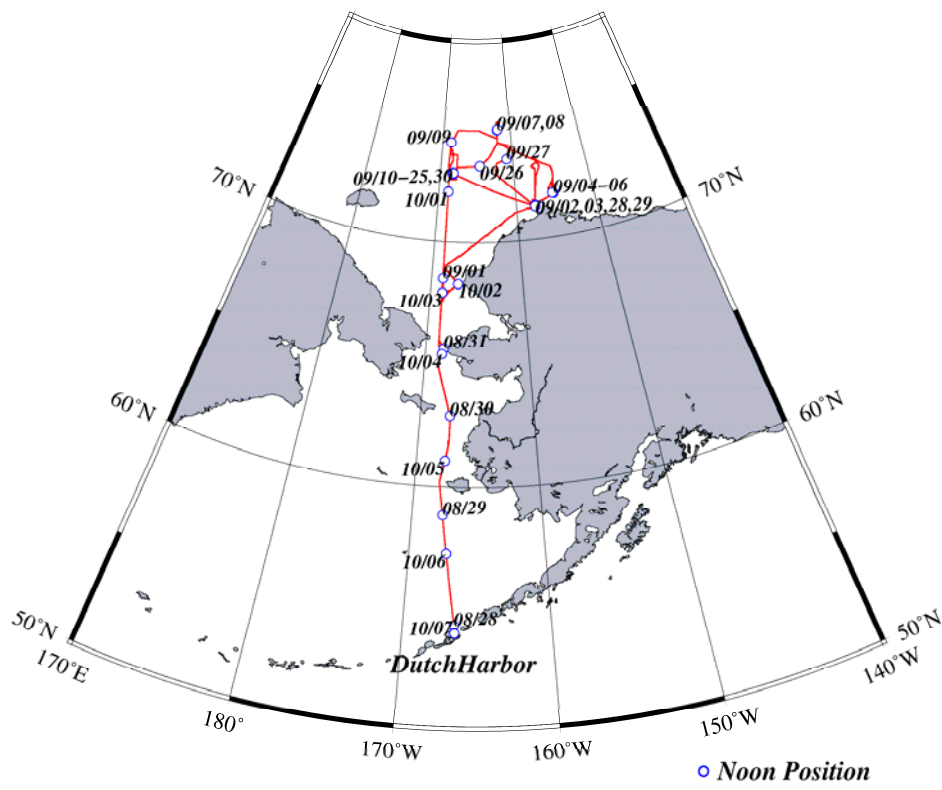


Figure 1.3-1. Research area and cruise track of MR13-06 Leg 1.

Cruise Track of MR13-06Leg2

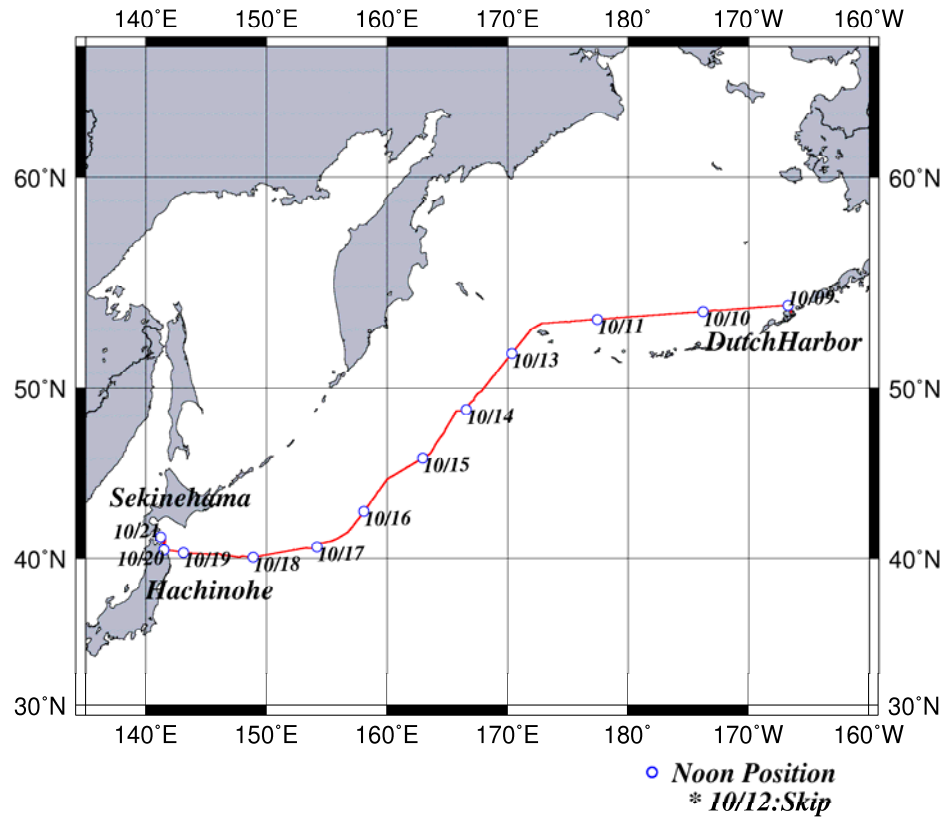


Figure 1.3-2. Research area and cruise track of MR13-06 Leg 2.

1.4. List of Participants

Table 1.4-1. List of participants (Leg 1)

No.	Name	Organization	Position
1	Shigeto Nishino	JAMSTEC	Research Scientist
2	Jun Inoue	JAMSTEC/National Institute of Polar Research	Team Leader/Associate Professor
3	Kazuhiro Oshima	JAMSTEC	Research Scientist
4	Masatake Hori	JAMSTEC	Research Scientist
5	Yusuke Kawaguchi	JAMSTEC	Research Scientist
6	Kazutoshi Sato	JAMSTEC/The Graduate University for Advanced Studies	Graduate Student
7	Taku Mitsui	JAMSTEC/Nagasaki University	Graduate Student
8	Yo Tobase	JAMSTEC/Kyushu University	Graduate Student
9	Ana M. Aguilar-Islas	University of Alaska	Assistant Professor
10	David (Duke) Snider	Martech Polar Consulting Ltd	Ice Pilot
11	Jonaotaro Onodera	JAMSTEC	Research Scientist
12	Katsunori Kimoto	JAMSTEC	Research Scientist
13	Takahito Ikenoue	JAMSTEC/Kyushu University	Postdoctoral Scientist
14	Kohei Matsuno	National Institute of Polar Research	Postdoctoral Scientist
15	Amane Fujiwara	National Institute of Polar Research	Postdoctoral Scientist
16	Ryosuke Futsuki	Hokkaido University	Graduate Student
17	Mario Uchimiya	National Institute of Polar Research	Postdoctoral Scientist
18	Chiaki Motegi	Takuvik Joint International Laboratory	Postdoctoral Scientist
19	Naohiro Kosugi	Meteorological Research Institute	Research Scientist
20	Kushi Kudo	Tokyo Institute of Technology	Graduate Student
21	Sachi Taniyasu	National Institute of Advanced Industrial Science and Technology (AIST)	Research Scientist

22	Soichiro Sueyoshi	Global Ocean Development Inc.	Technical Staff
23	Masanori Murakami	Global Ocean Development Inc.	Technical Staff
24	Katsuhisa Maeno	Global Ocean Development Inc.	Technical Staff
25	Koichi Inagaki	Global Ocean Development Inc.	Technical Staff
26	Kenichiro Sato	Marine Works Japan Ltd.	Technical Staff
27	Hirokatsu Uno	Marine Works Japan Ltd.	Technical Staff
28	Tatsuya Tanaka	Marine Works Japan Ltd.	Technical Staff
29	Shinsuke Toyoda	Marine Works Japan Ltd.	Technical Staff
30	Shungo Oshitani	Marine Works Japan Ltd.	Technical Staff
31	Rei Ito	Marine Works Japan Ltd.	Technical Staff
32	Minoru Kamata	Marine Works Japan Ltd.	Technical Staff
33	Yoshiko Ishikawa	Marine Works Japan Ltd.	Technical Staff
34	Masanori Enoki	Marine Works Japan Ltd.	Technical Staff
35	Tomonori Watai	Marine Works Japan Ltd.	Technical Staff
36	Makoto Takada	Marine Works Japan Ltd.	Technical Staff
37	Elena Hayashi	Marine Works Japan Ltd.	Technical Staff
38	Emi Deguchi	Marine Works Japan Ltd.	Technical Staff
39	Atsushi Ono	Marine Works Japan Ltd.	Technical Staff
40	Hideki Yamamoto	Marine Works Japan Ltd.	Technical Staff
41	Shinichiro Yokogawa	Marine Works Japan Ltd.	Technical Staff
42	Katsunori Sagishima	Marine Works Japan Ltd.	Technical Staff
43	Misato Kuwahara	Marine Works Japan Ltd.	Technical Staff
44	Masahiro Orui	Marine Works Japan Ltd.	Technical Staff
45	Kanako Yoshida	Marine Works Japan Ltd.	Technical Staff
46	Keitaro Matsumoto	Marine Works Japan Ltd.	Technical Staff

Table 1.4-2. List of participants (Leg 2)

No.	Name	Organization	Position
1	Shigeto Nishino	JAMSTEC	Research Scientist
2	Jun Inoue	JAMSTEC/National Institute of Polar Research	Team Leader/Associate Professor
3	Kazuhiro Oshima	JAMSTEC	Research Scientist
4	Kazutoshi Sato	JAMSTEC/The Graduate University for Advanced Studies	Graduate Student
5	Kohei Matsuno	National Institute of Polar Research	Postdoctoral Scientist
6	Kazuho Yoshida	Global Ocean Development Inc.	Technical Staff
7	Masanori Murakami	Global Ocean Development Inc.	Technical Staff
8	Kenichiro Sato	Marine Works Japan Ltd.	Technical Staff
9	Tatsuya Tanaka	Marine Works Japan Ltd.	Technical Staff
10	Shinsuke Toyoda	Marine Works Japan Ltd.	Technical Staff
11	Shungo Oshitani	Marine Works Japan Ltd.	Technical Staff
12	Minoru Kamata	Marine Works Japan Ltd.	Technical Staff
13	Masanori Enoki	Marine Works Japan Ltd.	Technical Staff
14	Tomonori Watai	Marine Works Japan Ltd.	Technical Staff
15	Kanako Yoshida	Marine Works Japan Ltd.	Technical Staff
16	Keitaro Matsumoto	Marine Works Japan Ltd.	Technical Staff

2. Meteorology

2.1. GPS Radiosonde

(1) Personnel

Jun Inoue	JAMSTEC/NIPR :Principal Investigator
Masatake Hori	JAMSTEC
Kazuhiro Oshima	JAMSTEC
Kazutoshi Sato	NIPR
Taku Mitsui	JAMSTEC/Nagasaki Univ.
Yo Tobase	JAMSTEC/Kyushu Univ.
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Kazuho Yoshida	GODI
Ryo Ohyama	MIRAI Crew

(2) Objectives

To understand the thermodynamic structure of the boundary layer, and migratory cyclones and anticyclones, a 3-hourly radiosonde observation was conducted over the Arctic Ocean from 1 September 2013 through 4 October 2013 which includes a stationary observation period during 11-26 September 2013 at the location of 72°45'N, 168°45'W. The dataset includes 12-hourly initial observations and 6-hourly post-observations conducted near the Bering Strait on 30-31 August 2013 and 4-6 October 2013 (it also includes 6-hourly observations in leg2, 9-18 October 2013). Obtained data will be used mainly for studies of clouds, validation of reanalysis data as well as satellite analysis, and data assimilation. This observation is also a part of a joint international observation period conducted on 11-24 September 2013.

(3) Parameters

Atmospheric soundings of temperature, humidity, and wind speed/direction.

(4) Instruments and Methods

Radiosonde observations were carried out from 30 August to 19 October 2013, by using GPS radiosonde (RS92-SGPD). We used software (DigiCORA III, ver.3.64), processor (SPS311), GPS antenna (GA20), UHF antenna (RB21) and balloon

launcher (ASAP) made by Vaisala Oyj. Prior to launch, humidity, air temperature, and pressure sensors were calibrated by using the calibrator system (GC25 and PTB330, Vaisala). In case the relative wind to the ship is not appropriate for the launch, the handy launch was selected.

(5) Station List

Table 2.1-1 summarizes the log of upper air soundings. All data were sent to the world meteorological community by the global telecommunication system (GTS) through the Japan Meteorological Agency immediately after each observation. Raw data was recorded as binary format during ascent. ASCII data was converted from raw data.

(6) Preliminary results

Location of 3-hourly radiosonde observations before and after the stationary observation period is shown in Figure 2.1-1. Before the stationary observation period, R/V Mirai operated in the coastal region of Alaska and near the sea-ice boundary. The northernmost location of observation is 74.86°N on 8 September, where the SST was -0.8°C and ice was visible. During this period, the anticyclone over the Beaufort Sea was strong, and radiosonde observation was primarily conducted under a strong pressure gradient along the outer rim of the anticyclone.

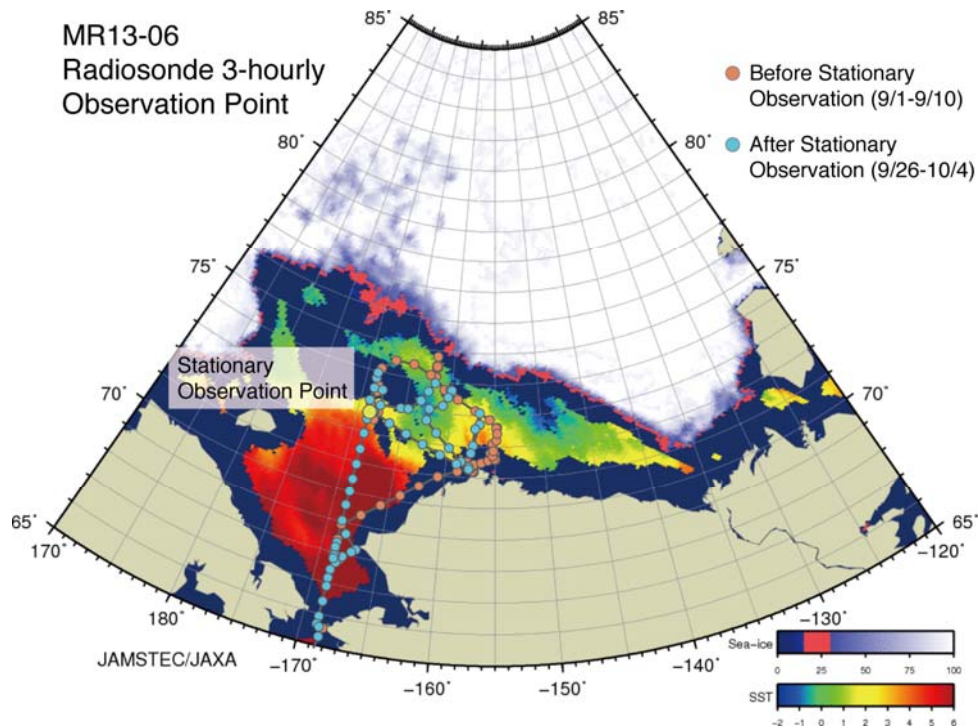


Figure 2.1-1. Sounding stations during the cruise. Ice concentration and sea surface temperature derived from AMSR-2 sensor is shown by shadings.

Time-height section of observed air temperature, wind and relative humidity during the stationary observation period of 11-26 September is given in Figure 2.1-2. The synoptic feature during this period is marked by a strong anticyclone that was prevalent in the north, which remained through the first half of the period. The last 5 days of the period is marked by small polar lows migrating northwestward from Alaska.

The period is characterized by two instances of strong surface wind during 14-15 September and 20-21 September. In the latter case, a dramatic change from northerly to southerly wind in the upper troposphere was observed during 18-19 September, which corresponds to an upper level cyclone vortex. The vortex was coincided with an intrusion of cold air into the middle to lower troposphere, lower tropopause height, and enhanced surface wind.

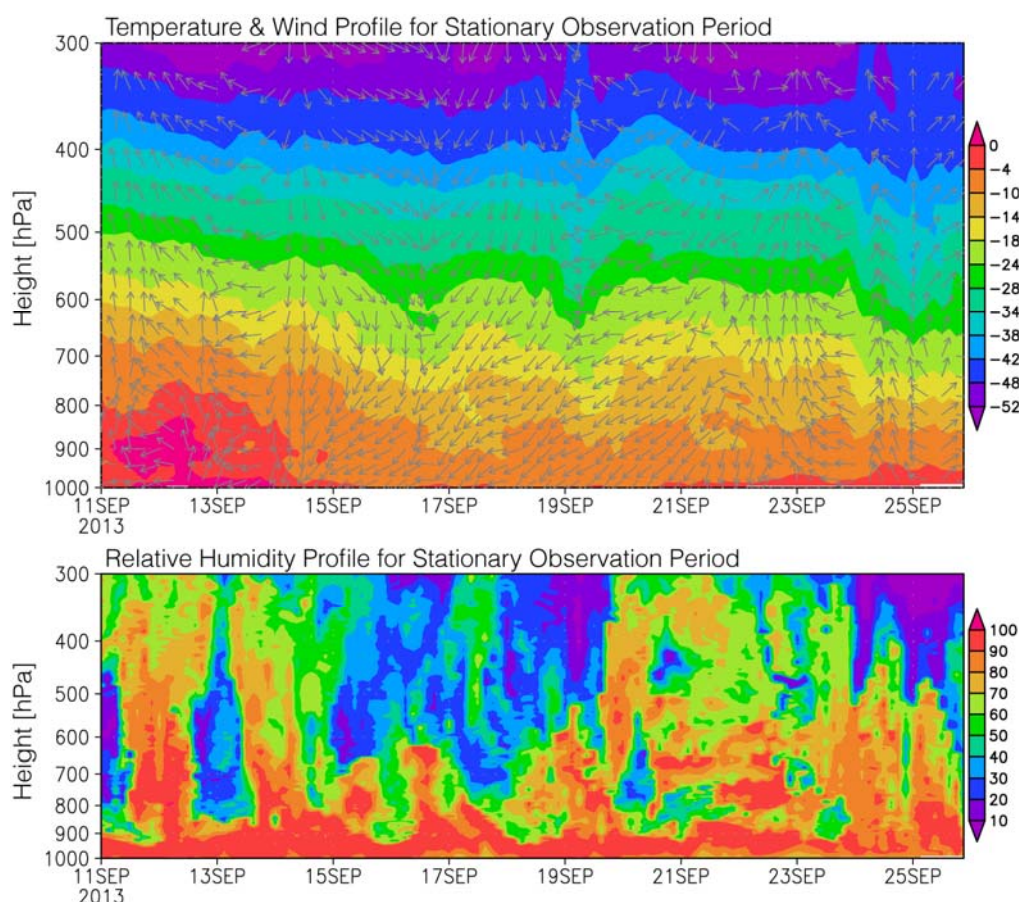


Figure 2.1-2. Time-height cross section of air temperature (shade) and wind (vector) (top), and relative humidity (bottom) during the stationary observation period.

After the stationary observation period, R/V Mirai briefly cruised near the sea-ice boundary and revisited the stationary observation point on 30 September. Small-scale migratory cyclones were observed during this period and frequent change in wind direction and humidity corresponding to cloud base height was visible.

(7) Data Archive

All datasets 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 Webpage” in JAMSTEC web site.

(8) Remarks

RS136 observation has no wind data, because of the trouble on receiving GPS signal.

Table 2.1-1. Launch log

ID	Date	Latitude		Longitude		Psf	Tsfc	RHsfc	WD	Wsp	SST	Max height		Cloud	
	YYYYMMDDHH	degN	degE	degE	degE	hPa	degC	%	deg	m/s	degC	hPa	m	Amount	Type
RS001	2013083000	59.263	-167.760	1014.5	7.8	77	348	6.7	8.117	34.6	23274	10	St		
RS002	2013083012	61.168	-167.611	1015.3	7.1	67	176	1.0	9.452	168.7	13021	-	-		
RS003	2013083100	63.073	-167.468	1013.7	8.4	74	151	4.4	9.502	36.4	22941	10	Sc		
RS004	2013083112	64.871	-168.644	1010.9	6.9	85	51	6.6	5.694	50.7	20767	-	-		
RS005	2013090100	65.665	-168.261	1010.6	7.4	67	53	8.6	10.251	38.3	22579	0	St, Sc		
RS006	2013090103	66.010	-168.747	1011.0	7.3	64	47	7.7	8.435	66.0	19033	4	St, Sc		
RS007	2013090106	66.507	-168.755	1012.0	6.5	68	47	9.8	9.650	38.8	22490	2	St, Sc		
RS008	2013090109	67.003	-168.745	1012.1	5.1	67	50	8.1	7.937	37.2	22750	2	St, Sc		
RS009	2013090112	67.501	-168.749	1011.9	5.3	79	50	6.1	5.953	70.0	18609	0	-		
RS010	2013090115	67.902	-168.198	1011.6	5.4	74	53	7.0	5.322	38.0	22579	1	Sc		
RS011	2013090118	68.003	-168.781	1010.7	5.3	78	46	6.6	5.095	33.0	23499	1	Sc		
RS012	2013090121	68.165	-168.784	1010.2	5.7	73	59	6.3	6.644	35.4	23032	1	Sc		
RS013	2013090200	68.517	-168.745	1009.2	5.8	75	60	5.6	7.791	33.4	23419	4	Cu		
RS014	2013090203	69.004	-168.753	1008.7	4.5	83	72	9.3	6.548	36.6	22829	8	Sc		
RS015	2013090206	69.417	-167.218	1007.9	5.1	79	55	9.0	7.739	44.1	21592	5	Ci, Sc, St		
RS016	2013090209	69.837	-165.632	1007.1	4.2	80	65	10.6	7.462	48.7	20946	4	Ci, Sc		
RS017	2013090212	70.260	-164.009	1006.9	3.3	84	81	11.8	5.582	37.8	22581	3~4	Sc		
RS018	2013090215	70.662	-162.359	1007.0	2.7	91	89	10.1	4.820	54.4	20190	10	St		
RS019	2013090218	71.038	-160.677	1009.0	0.5	83	72	11.0	1.589	40.4	22128	7	St, Sc		
RS020	2013090221	71.257	-158.776	1007.7	0.2	86	76	8.3	2.341	36.5	22793	5	Sc		
RS021	2013090300	71.341	-157.612	1007.8	0.2	85	81	11.3	2.614	53.1	20351	10	Sc, St		
RS022	2013090303	71.327	-157.679	1005.6	0.6	96	74	11.8	2.627	97.4	16393	10	St		
RS023	2013090306	71.343	-157.610	1004.4	0.7	86	80	14.5	2.877	580.5	4310	10	St		
RS024	2013090309	71.588	-157.858	1003.9	1.2	83	77	11.9	3.453	43.9	21609	9	St, Sc		
RS025	2013090312	71.312	-157.294	1001.5	1.4	85	62	16.1	2.151	41.2	22026	10	St, Sc		
RS026	2013090315	71.562	-157.807	1001.8	0.8	84	65	16.0	3.253	39.3	22317	10	St, Sc		
RS027	2013090318	71.449	-157.605	1000.1	1.1	86	65	14.9	1.957	389.2	7222	10	St		
RS028	2013090321	71.260	-157.128	999.0	1.2	87	68	11.7	2.442	42.2	21870	10	St		
RS029	2013090400	71.273	-157.119	998.6	1.2	89	71	13.0	2.506	33.5	23351	10	St		
RS030	2013090403	71.281	-157.258	998.2	1.1	90	68	12.9	2.638	37.3	22647	10	St		
RS031	2013090406	71.378	-157.457	998.6	0.8	91	62	10.7	2.374	54.2	20210	10	St		
RS032	2013090409	71.423	-157.561	999.1	0.8	91	52	11.6	3.005	42.0	21878	10	St		
RS033	2013090412	71.495	-157.140	999.4	0.4	95	47	11.8	3.008	37.0	22699	10	St		
RS034	2013090415	71.546	-156.361	999.7	0.2	95	56	11.2	2.955	34.2	23202	10	St, Sc		
RS035	2013090418	71.628	-155.702	999.6	0.7	85	57	11.0	2.928	85.1	17232	7	Sc, Ci		

RS036	2013090421	71.652	-154.939	1000.8	0.4	92	47	9.9	2.760	39.7	22240	10	St
RS037	2013090500	71.737	-155.112	1002.1	0.6	91	47	10.7	3.196	39.5	22293	9	St
RS038	2013090503	71.861	-155.443	1003.3	-0.8	90	42	11.5	3.218	39.1	22335	9	Ci,Sc,St
RS039	2013090506	72.154	-155.228	1004.7	-1.5	92	48	10.5	2.860	37.1	22668	10	St
RS040	2013090509	72.677	-154.797	1006.7	-2.4	90	31	8.6	-0.120	50.7	20637	10	St
RS041	2013090512	72.673	-154.826	1007.6	-2.1	90	27	5.2	0.322	46.0	21257	10	St
RS042	2013090515	72.285	-154.883	1007.2	-1.1	90	58	5.7	2.812	41.5	21937	10	St
RS043	2013090518	71.839	-154.997	1007.3	0.0	87	89	6.2	3.073	50.3	20675	10	Sc
RS044	2013090521	71.670	-155.007	1008.1	-0.1	87	93	5.0	2.946	30.1	24038	9	St
RS045	2013090600	71.771	-155.284	1008.6	0.1	86	110	6.9	3.072	37.6	22586	10	St
RS046	2013090603	71.733	-155.118	1008.6	0.4	92	98	7.8	2.985	42.1	21855	10	St
RS047	2013090606	71.746	-155.163	1008.6	1.5	90	103	9.7	3.144	47.5	21061	10	Sc, St
RS048	2013090609	71.787	-155.292	1009.1	1.5	96	104	9.8	3.064	42.5	21789	10	St
RS049	2013090612	71.743	-155.181	1009.0	1.6	96	100	8.8	3.071	37.7	22573	10	St
RS050	2013090615	71.870	-155.495	1008.7	1.5	99	82	10.2	3.102	40.7	22071	10	St
RS051	2013090618	71.688	-155.022	1008.3	1.8	99	111	6.0	2.395	43.4	21647	10	St
RS052	2013090621	71.684	-155.025	1008.3	2.3	99	128	5.5	2.854	29.6	24144	9	St, As
RS053	2013090700	71.776	-155.289	1008.0	3.0	95	127	5.3	3.070	36.5	22781	7	Sc, Ac
RS054	2013090703	71.940	-155.213	1007.6	3.3	97	112	5.0	2.987	43.3	21676	4	St,Ac
RS055	2013090706	72.501	-154.800	1008.3	1.0	100	103	8.1	1.890	43.4	21657	10	St
RS056	2013090709	72.929	-155.566	1008.9	0.1	99	98	9.1	0.615	35.7	22907	10	St
RS057	2013090712	73.204	-157.221	1009.1	0.3	99	94	12.4	1.661	37.6	22539	10	St
RS058	2013090715	73.527	-159.164	1009.4	0.0	100	99	11.6	0.281	63.7	18994	10	St
RS059	2013090718	73.818	-160.879	1009.5	-0.1	100	110	12.5	1.574	32.6	23449	10	St
RS060	2013090721	74.211	-162.007	1011.2	-0.6	94	87	10.8	1.318	37.8	22502	10	St
RS061	2013090800	74.505	-161.982	1011.0	-1.1	95	98	10.9	0.235	44.5	21447	10	St
RS062	2013090803	74.860	-161.973	1010.7	-1.4	96	95	8.5	-0.810	35.5	22900	10	St
RS063	2013090806	74.533	-161.929	1009.4	0.2	99	130	9.7	0.328	31.0	23776	10	St
RS064	2013090809	74.549	-161.906	1009.7	0.6	100	180	6.7	0.310	47.6	20988	10	St
RS065	2013090812	74.500	-161.992	1009.8	-0.2	100	168	7.6	0.443	42.6	21700	10	St
RS066	2013090815	74.508	-161.972	1009.2	0.6	97	158	7.8	0.431	41.2	21907	10	St
RS067	2013090818	74.518	-161.849	1009.6	0.6	99	169	7.8	0.434	40.5	22020	10	St
RS068	2013090821	74.557	-161.973	1009.9	0.4	98	184	5.8	0.559	31.9	23581	10	St
RS069	2013090900	74.529	-161.922	1010.1	0.3	100	178	7.0	0.450	34.4	23086	10	St
RS070	2013090903	74.538	-161.969	1010.3	0.8	97	186	7.1	0.500	34.8	23005	10	St
RS071	2013090906	74.541	-161.960	1010.9	0.3	98	165	8.9	0.523	39.9	22116	10	St
RS072	2013090909	74.192	-162.001	1011.0	0.4	90	160	6.3	1.770	44.5	21408	10	St
RS073	2013090912	74.241	-162.612	1010.9	0.1	94	173	5.9	1.059	40.4	22031	3	St

RS074	2013090915	74.500	-164.751	1010.3	-0.5	94	179	5.9	-0.020	39.2	22226	10	St
RS075	2013090918	74.500	-166.982	1009.6	-0.8	96	155	6.8	-0.310	49.7	20666	10	St, Sc
RS076	2013090921	74.156	-168.439	1008.9	-1.2	99	131	8.2	-0.320	39.9	22099	9	St
RS077	2013091000	74.000	-168.742	1008.5	-1.4	99	120	9.5	-0.050	37.9	22438	10	St
RS078	2013091003	73.628	-168.446	1007.6	-0.9	99	111	7.4	-0.980	41.0	21930	10	St
RS079	2013091006	73.408	-168.348	1006.8	-0.9	99	96	7.6	-0.960	91.2	16711	10	St
RS080	2013091009	73.000	-168.749	1005.8	0.9	95	126	7.4	1.657	39.2	22234	10	St
RS081	2013091012	72.751	-168.748	1005.2	0.9	98	130	7.1	2.471	40.7	21987	10	St
RS082	2013091015	72.502	-168.034	1004.6	0.1	95	118	6.7	3.362	33.9	23171	10	St
RS083	2013091018	72.767	-167.741	1004.7	0.2	96	114	6.8	3.311	35.4	22879	10	St
RS084	2013091021	72.790	-168.171	1004.4	0.2	88	110	6.0	3.082	37.0	22604	10	St, Sc
RS085	2013091100	72.759	-168.326	1004.0	0.3	87	111	6.4	3.106	48.7	20831	9	St, Sc
RS086	2013091103	72.760	-168.252	1003.5	0.6	96	91	6.2	3.150	40.7	21989	9	St, Sc, Ci
RS087	2013091106	72.760	-168.241	1003.2	0.7	89	81	7.6	3.117	41.2	21915	10	St, Sc, Ci
RS088	2013091109	72.742	-168.249	1003.6	0.1	93	81	4.1	3.168	38.4	22376	10	St, Sc
RS089	2013091112	72.735	-168.269	1003.2	0.4	98	77	4.9	3.154	39.7	22162	10	St
RS090	2013091115	72.751	-168.243	1002.7	1.1	99	63	6.3	3.138	51.3	20478	10	St
RS091	2013091118	72.753	-168.266	1002.3	0.8	100	69	5.6	3.139	35.9	22810	9	St, Ac
RS092	2013091121	72.750	-168.280	1002.2	1.3	96	71	7.4	3.109	39.9	22127	9	St, As
RS093	2013091200	72.735	-168.275	1001.6	1.4	97	69	8.5	3.114	35.0	22992	10	St
RS094	2013091203	72.767	-168.251	1000.4	1.2	97	55	11.0	3.142	39.1	22279	10	St
RS095	2013091206	72.755	-168.293	999.3	1.8	98	81	11.2	3.133	43.3	21608	10	St
RS096	2013091209	72.735	-168.249	999.8	1.8	100	149	6.2	3.137	34.9	23007	10	St
RS097	2013091212	72.761	-168.223	1001.2	2.7	98	186	4.9	3.271	65.2	18916	10	St
RS098	2013091215	72.752	-168.224	1002.5	2.9	89	195	6.5	3.079	54.4	20102	10	St
RS099	2013091218	72.754	-168.213	1003.9	2.1	93	206	6.9	3.169	43.6	21537	9	St, Ci
RS100	2013091221	72.752	-168.279	1005.4	2.2	92	206	3.8	3.167	61.6	19300	10	St
RS101	2013091300	72.771	-168.346	1005.9	2.7	90	242	1.6	3.153	44.5	21425	10	St
RS102	2013091303	72.752	-168.251	1005.5	2.6	84	14	1.4	3.306	37.5	22539	9	St
RS103	2013091306	72.746	-168.280	1005.0	2.0	96	59	3.9	3.196	37.6	22535	10	St
RS104	2013091309	72.743	-168.260	1005.1	1.6	99	55	3.6	3.289	39.1	22282	10	St
RS105	2013091312	72.742	-168.260	1005.0	2.0	95	71	5.8	3.263	36.4	22745	10	St
RS106	2013091315	72.749	-168.224	1004.6	1.8	99	45	8.2	3.241	41.9	21821	10	St
RS107	2013091318	72.750	-168.259	1005.1	1.5	97	49	8.0	3.252	39.6	22184	10	St
RS108	2013091321	72.750	-168.298	1006.0	1.6	97	42	6.9	3.242	40.0	22120	10	St
RS109	2013091400	72.755	-168.255	1006.8	1.0	97	24	9.3	3.228	35.5	22918	10	St
RS110	2013091403	72.759	-168.251	1008.0	0.3	93	28	9.4	3.201	41.1	21975	10	St
RS111	2013091406	72.742	-168.276	1009.3	-0.4	84	28	10.5	3.180	41.9	21828	10	St

RS112	2013091409	72.742	-168.252	1010.9	-1.2	83	31	10.9	3.206	43.9	21537	10	St
RS113	2013091412	72.743	-168.282	1012.6	-2.1	88	21	14.0	3.175	44.6	21428	10	St
RS114	2013091415	72.750	-168.255	1013.9	-1.2	90	23	10.2	3.097	40.8	21998	10	St
RS115	2013091418	72.745	-168.281	1015.8	-1.1	88	17	10.5	3.099	53.6	20227	10	St
RS116	2013091421	72.761	-168.310	1018.3	-0.8	82	42	14.0	2.876	42.2	21779	10	St, Sc
RS117	2013091500	72.772	-168.291	1020.4	-1.0	89	45	10.7	2.814	36.3	22776	10	St
RS118	2013091503	72.763	-168.251	1022.2	-1.5	89	47	9.4	2.780	40.2	22100	10	St
RS119	2013091506	72.736	-168.261	1024.0	-0.9	83	60	9.0	2.923	43.0	21658	10	St
RS120	2013091509	72.730	-168.254	1026.0	-1.4	78	63	7.9	2.707	37.1	22632	10	St,?
RS121	2013091512	72.756	-168.313	1027.1	-1.3	77	59	9.6	2.720	40.9	21986	10	St
RS122	2013091515	72.749	-168.224	1027.5	-2.3	85	42	6.7	2.889	42.7	21711	10	St
RS123	2013091518	72.747	-168.273	1028.4	-2.6	84	61	7.2	2.849	47.8	20971	10	Sc, St
RS124	2013091521	72.751	-168.297	1028.8	-2.6	88	49	7.4	2.670	47.6	21011	10	Sc
RS125	2013091600	72.753	-168.277	1028.9	-2.7	86	71	8.2	2.734	39.0	22300	9	Sc, St
RS126	2013091603	72.766	-168.250	1028.7	-2.7	86	39	6.5	2.667	38.1	22455	10	St
RS127	2013091606	72.750	-168.299	1028.5	-2.3	85	71	8.0	2.772	40.6	22040	10	St
RS128	2013091609	72.736	-168.260	1028.8	-2.0	84	75	6.6	2.650	45.4	21305	10	St
RS129	2013091612	72.762	-168.276	1028.7	-1.4	79	52	4.7	2.628	41.5	21880	10	St
RS130	2013091615	72.741	-168.219	1028.1	-1.6	80	72	6.3	2.627	48.5	20858	10	St
RS131	2013091618	72.744	-168.275	1028.3	-1.3	86	114	9.1	2.662	42.9	21632	10	St
RS132	2013091621	72.751	-168.280	1028.4	-0.9	69	75	6.9	2.609	43.6	21526	10	St, As
RS133	2013091700	72.776	-168.318	1028.1	-1.2	77	75	7.2	2.615	40.9	21956	10	Sc, St, Ci
RS134	2013091703	72.767	-168.250	1027.6	-1.5	70	44	7.5	2.625	41.7	21823	10	Sc
RS135	2013091706	72.755	-168.275	1027.3	-1.5	72	48	8.0	2.826	41.6	21833	10	Sc,St
RS136	2013091709	72.748	-168.248	1026.8	-1.5	74	55	4.5	2.812	66.8	18758	10	St
RS137	2013091712	72.764	-168.271	1026.2	-1.4	78	42	7.3	2.733	42.1	21754	10	St
RS138	2013091715	72.750	-168.210	1025.4	-1.0	63	42	9.9	2.878	48.9	20763	10	St
RS139	2013091718	72.745	-168.257	1025.9	-1.6	72	36	11.7	2.896	42.7	21649	10	Sc
RS140	2013091721	72.750	-168.303	1025.7	-2.9	76	47	9.0	2.889	42.9	21622	10	Sc
RS141	2013091800	72.760	-168.289	1025.7	-2.6	79	71	10.4	2.868	40.9	21938	10	Sc
RS142	2013091803	72.765	-168.250	1025.6	-2.1	78	42	10.3	2.794	36.9	22600	10	Sc
RS143	2013091806	72.758	-168.280	1025.6	-2.6	85	61	10.4	2.707	42.2	21722	10	Sc,St
RS144	2013091809	72.740	-168.288	1025.5	-2.7	90	35	6.3	2.799	38.1	22373	10	St
RS145	2013091812	72.743	-168.304	1024.5	-2.6	90	65	6.9	2.711	36.5	22645	10	St
RS146	2013091815	72.756	-168.200	1023.7	-2.7	88	58	6.2	2.561	37.7	22413	10	St
RS147	2013091818	72.747	-168.276	1022.5	-2.8	87	41	8.3	2.671	40.4	21973	10	Sc
RS148	2013091821	72.749	-168.293	1021.6	-3.4	84	42	8.3	2.661	41.3	21816	10	Sc
RS149	2013091900	72.745	-168.296	1020.6	-2.8	89	55	10.0	2.512	43.4	21510	10	Sc

RS150	2013091903	72.766	-168.251	1020.5	-2.4	85	41	9.0	2.624	41.1	21912	10	Sc
RS151	2013091906	72.756	-168.284	1019.4	-2.4	84	53	9.4	2.610	42.8	21591	10	SC,St
RS152	2013091909	72.734	-168.252	1018.7	-2.2	82	48	11.5	2.601	60.4	19353	10	St
RS153	2013091912	72.747	-168.311	1018.1	-1.9	82	45	12.7	2.592	33.0	23212	10	Sc
RS154	2013091915	72.749	-168.211	1017.6	-1.9	83	44	10.8	2.556	54.0	20053	10	St
RS155	2013091918	72.750	-168.275	1017.2	-2.7	87	27	11.7	2.584	39.5	22061	10	Sc
RS156	2013091921	72.766	-168.289	1016.8	-3.4	89	43	9.7	2.518	39.7	22022	10	Sc
RS157	2013092000	72.754	-168.295	1016.2	-2.8	89	39	12.4	2.485	40.8	21858	10	Sc
RS158	2013092003	72.763	-168.244	1015.3	-3.3	84	34	13.1	2.450	35.6	22723	10	St,Sc
RS159	2013092006	72.751	-168.288	1014.7	-2.3	86	41	13.2	2.390	38.5	22207	10	St,Sc
RS160	2013092009	72.774	-168.216	1013.9	-2.2	81	48	13.6	2.337	45.2	21176	10	St,Sc
RS161	2013092012	72.755	-168.254	1012.5	-2.5	84	34	14.1	2.297	53.8	20039	10	St
RS162	2013092015	72.758	-168.186	1011.4	-2.0	85	35	14.0	2.075	35.4	22705	10	St
RS163	2013092018	72.762	-168.249	1010.0	-1.6	83	33	14.2	2.007	39.5	22003	10	Sc
RS164	2013092021	72.749	-168.239	1008.6	-2.0	84	45	11.7	2.067	47.4	20839	10	Sc
RS165	2013092100	72.764	-168.285	1007.3	-1.9	85	50	15.7	2.030	47.8	20774	9	Sc, Ac
RS166	2013092103	72.780	-168.250	1006.2	-2.6	89	35	11.6	2.137	36.5	22484	10	St,Sc
RS167	2013092106	72.766	-168.237	1005.6	-2.3	81	22	13.2	2.052	65.3	18723	10	Sc,St,Ac
RS168	2013092109	72.773	-168.217	1004.3	-1.8	70	36	9.3	2.085	39.3	21993	10	St
RS169	2013092112	72.779	-168.254	1003.5	-2.4	77	34	11.6	2.130	41.4	21661	9	St
RS170	2013092115	72.758	-168.179	1003.0	-2.7	81	19	10.9	2.061	47.6	20734	10	St
RS171	2013092118	72.742	-168.284	1002.0	-2.1	72	6	10.0	2.036	32.5	23192	10	Sc
RS172	2013092121	72.750	-168.296	1001.5	-2.6	79	7	6.9	1.942	41.6	20941	10	Sc
RS173	2013092200	72.740	-168.215	1001.2	-2.6	78	23	5.4	1.834	48.9	20562	10	Sc
RS174	2013092203	72.765	-168.249	1000.4	-2.8	82	6	7.4	1.945	50.8	20317	10	Sc,Ci
RS175	2013092206	72.747	-168.278	999.8	-3.0	90	359	7.1	1.824	37.4	22281	10	Sc,St
RS176	2013092209	72.735	-168.250	998.8	-2.6	89	7	4.8	1.984	29.7	23756	10	St?
RS177	2013092212	72.737	-168.251	998.0	-2.5	87	33	4.2	1.605	57.2	19532	10	St?
RS178	2013092215	72.749	-168.249	997.3	-2.1	81	63	3.3	1.865	141.1	13600	10	Sc
RS179	2013092218	72.751	-168.265	997.0	-2.2	83	100	3.4	1.536	40.8	21709	10	Sc
RS180	2013092221	72.750	-168.309	996.8	-1.4	77	156	4.1	1.568	36.3	22458	9	Sc
RS181	2013092300	72.754	-168.238	997.0	-1.2	75	164	5.9	1.714	33.7	22934	9	Sc, Ac
RS182	2013092303	72.772	-168.251	997.5	-1.2	77	132	7.2	1.795	46.7	20838	3	Sc,Ac,Ci
RS183	2013092306	72.755	-168.246	997.7	-1.4	77	133	7.2	1.799	40.8	21714	6	Sc,Ac
RS184	2013092309	72.732	-168.257	998.2	-1.8	77	121	8.3	1.804	38.8	22044	9	Sc
RS185	2013092312	72.746	-168.267	999.0	-2.8	83	130	8.6	1.690	34.0	22879	10	St
RS186	2013092315	72.750	-168.192	999.1	-3.2	85	99	8.9	1.683	53.2	20015	9	St
RS187	2013092318	72.751	-168.266	998.5	-2.6	86	96	8.2	1.628	39.1	22026	10	St

RS188	2013092321	72.750	-168.310	998.1	-2.4	84	73	7.1	1.750	35.9	22563	10	Sc,St
RS189	2013092400	72.756	-168.225	997.5	-2.5	90	68	5.2	1.588	34.1	22905	10	St
RS190	2013092403	72.773	-168.251	997.1	-2.1	92	104	2.0	1.603	41.0	21740	7	Sc,Ci
RS191	2013092406	72.755	-168.223	996.8	-1.8	82	181	6.0	1.619	75.5	17773	10	Sc,Ci
RS192	2013092409	72.733	-168.242	997.4	-0.6	89	154	8.0	1.655	37.6	22282	10	St,Sc
RS193	2013092412	72.757	-168.197	997.3	0.2	89	152	11.0	2.016	45.5	21077	3	Sc,Ci
RS194	2013092415	72.751	-168.156	997.3	0.3	87	158	9.5	1.595	50.8	20359	10	St
RS195	2013092418	72.756	-168.243	997.1	0.3	85	170	3.0	1.581	39.4	22020	8	St, Cu, Ci
RS196	2013092421	72.752	-168.291	997.2	-0.4	85	173	7.4	1.627	36.7	22475	5	Sc, Cu, Cs
RS197	2013092500	72.765	-168.245	997.2	-0.7	84	160	10.3	1.588	42.0	21626	8	Cu, St, Ci
RS198	2013092503	72.776	-168.249	996.7	-1.4	93	122	3.3	1.588	41.5	21712	10	Sc
RS199	2013092506	72.759	-168.265	994.5	0.2	88	114	10.7	1.589	45.0	21190	10	St,Sc
RS200	2013092509	72.725	-168.249	994.0	-0.7	86	257	8.8	1.992	39.5	22026	10?	Sc,Ac
RS201	2013092512	72.745	-168.208	993.8	-1.2	94	230	14.9	1.958	40.4	21881	10	Sc?
RS202	2013092515	72.759	-168.918	993.6	-0.7	79	205	13.5	2.051	45.7	21075	6	Sc
RS203	2013092518	72.737	-168.187	993.9	-0.9	92	281	10.1	2.077	39.1	22104	8	Sc, Ci
RS204	2013092521	72.749	-168.294	994.8	-0.9	82	272	9.1	2.003	43.5	21416	6	Sc, Cu
RS205	2013092600	72.753	-168.231	995.5	-1.5	85	276	8.0	2.084	47.1	20906	8	Sc
RS206	2013092603	73.092	-168.906	995.4	-1.8	84	289	7.1	0.866	50.1	20499	7	Sc
RS207	2013092606	73.812	-168.781	994.6	-3.6	91	277	8.8	-0.990	54.8	19899	8	Sc
RS208	2013092609	74.006	-168.764	995.1	-3.3	84	251	7.1	-1.030	40.3	21905	9	Sc
RS209	2013092612	73.501	-168.757	996.2	-3.6	86	288	3.9	-0.860	46.6	20962	10	Sc?
RS210	2013092615	73.493	-167.760	996.4	-3.5	83	263	5.5	-1.020	47.6	20814	10	Sc
RS211	2013092618	73.001	-167.637	996.8	-2.1	88	331	2.3	0.622	45.7	21093	9	Sc
RS212	2013092621	73.042	-165.446	997.1	-1.6	75	238	4.4	-0.140	46.2	21029	8	St, Sc
RS213	2013092700	73.064	-164.609	997.5	-1.4	64	242	3.1	-0.570	40.0	21977	8	Ac, Sc
RS214	2013092703	73.383	-163.298	997.6	-1.6	80	180	5.1	-0.420	39.0	22152	6	Sc,Ci,As
RS215	2013092706	73.694	-162.653	997.3	-1.3	84	161	3.9	-0.500	45.1	21190	8	Sc,Ci,Ac
RS216	2013092709	74.002	-161.989	997.5	-0.5	91	180	6.5	0.150	41.4	21767	8	Sc,Ci,As
RS217	2013092712	73.821	-160.189	998.2	-0.1	91	180	8.2	0.290	37.2	22465	10	St?
RS218	2013092715	73.804	-159.983	998.8	0.0	81	202	10.4	0.239	54.1	20016	10	Sc
RS219	2013092718	73.807	-159.973	999.6	-0.2	78	187	10.3	-0.330	46.3	21052	4	Ac, Sc, Cu
RS220	2013092721	73.593	-160.341	1000.0	0.1	70	173	11.1	0.791	53.6	20116	6	Ac, As, Sc
RS221	2013092800	73.303	-160.839	1000.5	-0.2	78	179	9.5	0.693	44.5	21351	8	Ac, Sc
RS222	2013092803	73.150	-162.319	999.8	-0.4	83	173	8.2	0.887	56.2	19821	9	Sc,As
RS223	2013092806	72.780	-162.458	1000.4	-1.5	92	294	6.7	-0.220	37.7	22447	9	unknown
RS224	2013092809	72.407	-161.280	1001.2	-0.8	92	215	5.5	0.179	40.1	22047	10?	Sc, Ci
RS225	2013092812	71.972	-159.790	1002.0	-1.4	89	312	1.7	0.145	42.0	21746	2	Ac

RS226	2013092815	71.559	-158.446	1002.0	-0.6	85	338	8.1	0.764	40.2	22024	10	Sc
RS227	2013092818	71.328	-157.661	1002.3	-0.5	91	13	6.1	0.638	74.3	17968	10	Sc, St
RS228	2013092821	71.331	-157.669	1003.3	-1.2	94	358	10.0	0.795	92.2	16516	10	St, Sc
RS229	2013092900	71.406	-157.626	1004.7	-1.4	76	347	10.8	0.943	47.0	20977	10	Sc, St
RS230	2013092903	72.086	-157.279	1006.0	-1.7	64	6	8.1	0.369	47.4	20915	9	Ac,Ci
RS231	2013092906	72.781	-156.653	1007.0	-2.2	64	9	6.4	0.042	42.4	21641	10?	Sc?
RS232	2013092909	73.136	-156.689	1008.1	-2.3	61	313	2.5	0.251	39.0	22175	10	unknown
RS233	2013092912	72.625	-157.147	1009.7	-2.0	57	305	2.1	0.012	41.7	21740	10	unknown
RS234	2013092915	71.850	-157.461	1011.0	-1.7	61	3	3.8	0.611	46.1	21079	10	unknown
RS235	2013092918	71.327	-157.658	1012.3	-1.7	53	27	3.2	1.165	49.4	20630	10	Sc
RS236	2013092921	71.329	-157.648	1013.4	-1.6	58	0	0.8	0.729	34.0	23074	10	Sc,As
RS237	2013093000	71.330	-157.632	1014.2	-1.3	59	278	0.3	0.776	45.1	21224	9	Sc
RS238	2013093003	71.492	-158.850	1014.8	-1.7	62	186	0.4	0.726	47.0	20942	2	Sc,Ci,As
RS239	2013093006	71.740	-160.646	1014.6	-0.9	69	215	3.5	0.242	64.0	18905	2	Sc,Ac
RS240	2013093009	71.994	-162.539	1014.5	-1.3	92	184	5.5	-0.080	38.4	22243	10	unknown
RS241	2013093012	72.251	-164.413	1014.4	-0.9	80	241	3.4	0.034	38.2	22261	1	unknown
RS242	2013093015	72.494	-166.295	1016.2	-1.9	85	10	4.2	0.189	39.4	22043	9	unknown
RS243	2013093018	72.737	-168.152	1017.0	-1.9	79	80	2.8	-0.370	182.1	11957	10	St
RS244	2013093021	72.750	-168.304	1018.1	-1.3	78	147	5.6	-0.370	39.1	22084	6	St, Sc, Cs
RS245	2013100100	72.752	-168.250	1018.8	-1.2	79	134	6.4	-0.300	44.9	21188	8	Sc, St
RS246	2013100103	72.775	-168.251	1019.5	-1.3	83	122	7.4	-0.220	37.0	22435	8	Sc,Ci
RS247	2013100106	72.743	-168.259	1020.0	-1.7	96	92	10.8	-0.050	40.3	21856	10	Sc
RS248	2013100109	72.734	-168.244	1020.5	-0.8	80	141	8.0	0.945	41.6	21663	7	unknown
RS249	2013100112	72.757	-168.223	1020.9	-1.1	82	163	7.2	1.032	39.1	22056	1	unknown
RS250	2013100115	72.750	-168.178	1021.3	-0.7	84	164	5.7	0.897	41.5	21653	2	unknown
RS251	2013100118	72.755	-168.266	1021.2	-1.3	79	135	8.4	0.989	42.4	21498	9	Sc
RS252	2013100121	72.484	-168.745	1020.8	0.0	70	151	8.5	1.760	45.2	21093	4	Sc
RS253	2013100200	72.003	-168.741	1020.3	-0.2	69	150	7.9	2.167	43.7	21324	8	Sc
RS254	2013100203	71.501	-168.747	1019.3	-0.9	84	137	8.3	2.810	43.6	21331	9	Sc,As
RS255	2013100206	70.999	-168.751	1017.9	-0.1	82	124	11.4	2.628	38.5	22128	10	Sc
RS256	2013100209	70.500	-168.751	1016.9	0.2	69	139	8.1	2.957	31.3	23486	10	unknown
RS257	2013100212	70.089	-168.750	1015.9	-0.3	76	129	10.4	2.601	42.5	21501	10	unknown
RS258	2013100215	69.644	-168.750	1014.9	-0.7	85	91	6.9	2.755	37.8	22260	10	unknown
RS259	2013100218	69.132	-168.752	1014.5	-0.2	78	241	0.5	3.932	38.0	22242	10	St, Sc
RS260	2013100221	68.728	-168.111	1014.5	0.1	70	124	1.1	4.056	40.7	21808	9	Sc, St
RS261	2013100300	68.302	-167.046	1014.4	-0.2	77	79	2.0	4.614	123.6	14580	10	St
RS262	2013100303	68.203	-167.330	1014.3	0.3	75	27	2.3	4.307	64.4	18836	10	Sc,St
RS263	2013100306	68.002	-168.003	1014.3	0.9	82	306	4.0	2.610	62.7	19023	10	unknown

RS264	2013100309	67.765	-168.465	1014.6	0.4	78	323	3.3	2.169	42.8	21499	10?	St
RS265	2013100312	68.020	-168.586	1014.2	0.8	85	300	3.9	2.281	34.8	22817	10	unknown
RS266	2013100315	68.422	-168.723	1013.2	1.3	94	349	4.9	4.235	66.4	18627	10	St, fog
RS267	2013100318	68.258	-168.752	1012.7	1.3	83	22	2.2	3.051	41.3	21713	10	Sc
RS268	2013100321	68.000	-168.752	1012.7	1.1	87	10	2.8	2.139	44.1	21298	8	As, St
RS269	2013100400	67.893	-168.748	1012.5	1.2	92	6	3.2	1.567	35.7	22668	10	St
RS270	2013100403	67.530	-168.749	1012.0	1.1	87	19	5.2	2.877	47.4	20819	10	St
RS271	2013100406	67.250	-168.751	1012.0	1.3	82	0	9.4	3.822	36.8	22469	2	St,Sc
RS272	2013100409	67.000	-168.758	1012.3	1.2	86	354	11.9	4.019	32.5	23295	10	St
RS273	2013100412	66.501	-168.760	1012.5	0.9	89	346	8.2	4.558	44.2	21319	8	unknown
RS274	2013100415	66.022	-168.749	1012.8	0.7	86	328	9.3	1.760	42.8	21524	9	unknown
RS275	2013100418	65.781	-168.756	1012.4	0.5	82	337	8.5	1.692	60.2	19363	4	Sc, Cu
RS276	2013100421	65.702	-168.524	1011.9	0.5	82	340	4.0	2.087	40.0	21982	2	As, St
RS277	2013100500	65.386	-168.422	1010.0	0.8	82	93	1.7	2.610	48.0	20841	2	Sc, Ci
RS278	2013100506	64.078	-168.098	1003.5	1.4	80	136	10.3	4.129	75.4	17995	9	Sc
RS279	2013100512	62.833	-167.335	993.7	2.5	88	126	13.6	3.506	38.1	22332	10	unknown
RS280	2013100518	61.886	-167.357	984.6	6.3	100	188	7.6	5.858	43.1	21557	10	St
RS281	2013100600	60.871	-167.736	987.8	7.3	86	232	10.8	7.958	117.6	14993	10	St
RS282	2013100606	59.874	-167.916	993.0	7.2	85	219	12.4	7.838	34.3	23033	2	Sc
RS283	2013100612	58.870	-167.653	995.9	6.6	91	204	13.9	7.438	41.3	21811	9?	unknown
RS284	2013100618	57.885	-167.404	995.9	6.5	94	209	12.2	5.096	128.0	14438	10	St
RS285	2013100700	56.822	-167.150	1000.3	7.9	94	241	13.1	11.800	59.6	19441	7	Ac, Sc
RS286	2013100706	55.786	-166.901	1003.2	7.8	94	216	9.8	13.000	35.1	22873	10	unknown
RS287	2013101000	54.214	-167.514	999.4	7.8	97	188	13.6	6.845	34.9	22915	10	St, Ns
RS288	2013101006	54.144	-169.027	996.2	7.9	91	217	13.5	7.611	39.1	22187	10	St
RS289	2013101012	54.066	-170.791	995.7	7.9	91	238	11.0	8.029	44.8	21285	2	unknown
RS290	2013101018	53.993	-172.613	997.0	7.9	84	260	13.5	8.410	37.4	22425	8	Sc
RS291	2013101100	53.909	-174.487	997.5	7.8	75	242	11.5	8.198	34.1	23014	8	Sc, ,As
RS292	2013101106	53.825	-176.502	993.2	7.1	75	198	6.3	8.342	40.9	21827	7	St, Sc
RS293	2013101112	53.732	-178.610	989.1	7.5	83	269	9.3	8.554	43.0	21495	4?	unknown
RS294	2013101118	53.636	179.238	989.4	6.2	76	334	13.9	8.525	33.8	23041	4	Sc
RS295	2013101200	53.535	176.994	994.1	7.0	80	313	13.1	9.160	44.2	21311	6	Sc, Cu, As,
RS296	2013101206	53.466	175.259	1004.2	7.3	73	339	14.7	9.389	37.9	22323	6	Sc, Nb, Ac
RS297	2013101212	53.382	173.486	1011.5	6.7	68	331	9.8	9.188	34.6	22915	2?	unknown
RS298	2013101218	52.896	171.738	1013.7	6.1	57	291	5.7	9.492	31.3	23584	3	Sc
RS299	2013101300	51.732	170.205	1011.7	6.8	68	161	9.3	8.905	41.7	21808	10?	As, Sc
RS300	2013101306	50.710	168.919	995.6	8.7	97	130	14.5	9.337	621.1	3868	10	St
RS301	2013101312	49.823	167.794	982.5	10.8	100	199	15.0	9.018	47.0	21077	10?	unknown

RS302	2013101318	49.201	166.880	984.4	9.9	88	242	16.3	9.459	35.8	22784	10?	unknown
RS303	2013101400	48.865	166.586	986.3	9.6	78	246	17.0	9.240	49.4	20729	3	St, Sc, Ac
RS304	2013101406	48.597	165.571	990.1	8.4	84	301	8.8	9.555	45.8	21204	9	Sc
RS305	2013101412	47.734	164.828	999.7	8.3	71	326	15.1	9.512	43.2	21584	4	unknown
RS306	2013101418	46.892	164.010	1008.2	8.3	75	306	7.9	10.904	35.1	22858	10?	unknown
RS307	2013101500	46.155	163.070	1017.3	9.1	72	282	12.4	10.801	35.5	22790	5	Sc, Cu, Ci
RS308	2013101506	45.601	161.745	1022.2	9.3	66	263	10.4	12.516	45.6	21214	9	Sc, Ac
RS309	2013101512	45.033	160.393	1022.4	11.8	85	205	11.5	10.701	33.3	23235	10	unknown
RS310	2013101518	44.225	159.362	1021.0	13.6	85	192	12.5	13.099	48.6	20855	9?	St?
RS311	2013101600	43.080	158.226	1019.7	16.0	90	178	13.6	15.787	27.5	24468	9	Ac, As, Cs
RS312	2013101606	42.003	157.151	1010.8	18.8	88	176	13.4	16.765	35.7	22847	10	Ac, As, Ci
RS313	2013101706	40.647	153.402	1018.3	12.3	66	323	11.4	16.009	32.0	23539	6	Cu
RS314	2013101712	40.525	152.275	1023.3	12.0	55	316	8.4	19.285	35.0	22973	1	Cu
RS315	2013101718	40.340	150.877	1024.7	13.0	58	273	6.7	17.665	35.6	22796	3	Cu, Sc
RS316	2013101800	40.134	149.436	1027.3	13.1	69	284	6.8	16.481	32.6	23366	5	Cu, As, Ac,
RS317	2013101806	40.131	148.133	1027.7	12.6	57	322	4.8	14.690	41.3	21879	1	As
RS318	2013101812	40.192	146.521	1029.4	13.7	55	343	4.2	14.068	36.3	22670	6	Ac, As
RS319	2013101818	40.264	145.125	1028.9	13.9	63	6	6.2	18.917	34.0	23048	3	AC?, Sc?

2.2. Doppler Radar

(1) Personnel

Jun Inoue	JAMSTEC/NIPR :Principal Investigator
Masatake Hori	JAMSTEC
Kazuhiro Oshima	JAMSTEC
Kazutoshi Sato	NIPR
Taku Mitsui	JAMSTEC/Nagasaki Univ.
Yo Tobase	JAMSTEC/Kyushu Univ.
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Kazuho Yoshida	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

Low level clouds over the Arctic Ocean which usually dominate during summer have a key role for sea/ice surface heat budget. In addition to this, cyclones which modify the sea-ice distributions are substantially important to understand the air-ice-sea interaction. To grasp the broad precipitation system over the Arctic Ocean, three dimensional radar echo structure and wind fields of rain/snow clouds was obtained by C-band Doppler radar observation.

(3) Parameters

C-band Doppler radar observed three dimensional radar echo structure and wind fields of rain/snow cloud.

(4) Instruments and Methods

The specifications of R/V MIRAI shipboard Doppler radar (RC-52B, Mitsubishi Electric Co. Ltd., Japan) are as follows.

Frequency:	5290MHz (C-band)
Beam Width:	better than 1.5 degrees
Transmit Power:	250kW (Peak Power)
Signal Processor:	RVP-7 (Vaisala Inc. Sigmet Product Line, U.S.A)

Inertial Navigation Unit: PHINS (Ixsea SAS, France)

Application Software: IRIS/Open Ver.8.12.4

(Vaisala Inc. Sigmet Product Line, U.S.A)

Measured parameters are Radar reflectivity factor (dBZ), Doppler velocity (m/s), and velocity width (m/s). We checked transmitted frequency, mean output power and pulse repetition frequency (PRF) every day. The transmit pulse width and the receiver performance were checked before and after the observation.

(5) Observation log

The observation was performed throughout in the MR13-06 cruise. During the observation, the volume scan consisting of 21 PPIs was conducted every 10 minutes. Meanwhile, a surveillance PPI scan was performed every 30 minutes. The parameters for above scans are listed in Table 2.2-1.

Observation Period

Leg1: 5:00UTC 29 Aug. 2013 – 15:00UTC 7 Oct. 2013

Leg2: 19:40 UTC 9 Oct. 2013 – 00:00UTC 18 Oct. 2013

(6) Preliminary results

During the latter half of the stationary observation at (72.75N, 168.25W), two polar lows passed over the ship on 23 and 24 September 2013. The Doppler radar picked up almost center of the lows. After that the two polar lows were merged and developed to a larger cyclone on 25 September (Figure 2.2-1). Rapid changes in wind speed and wind direction occurred in the period. We were able to confirm the horizontal structure and temporal variation of those lows by NOAA satellite images as well. In addition, we often observed stratus clouds and cloud cells with snowfall (Figure 2.2-2) during the cruise. Echo top of those clouds were below 1 km and about 2-5 km height, respectively.

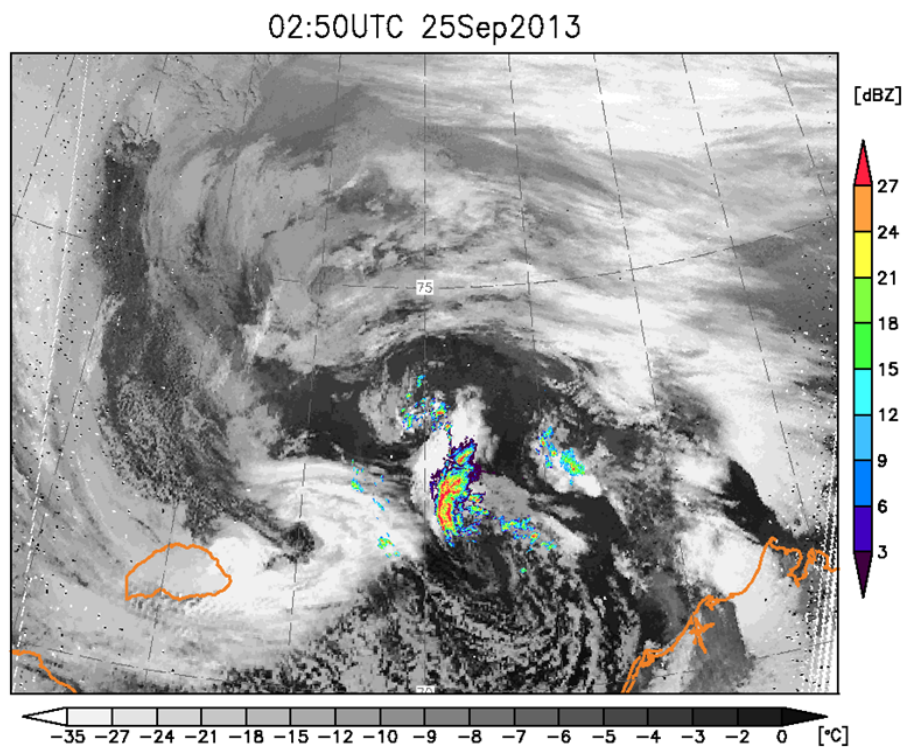


Figure 2.2-1. NOAA/AVHRR infrared image overlaid with the radar reflectivity on 02:50UTC 25 September 2013.

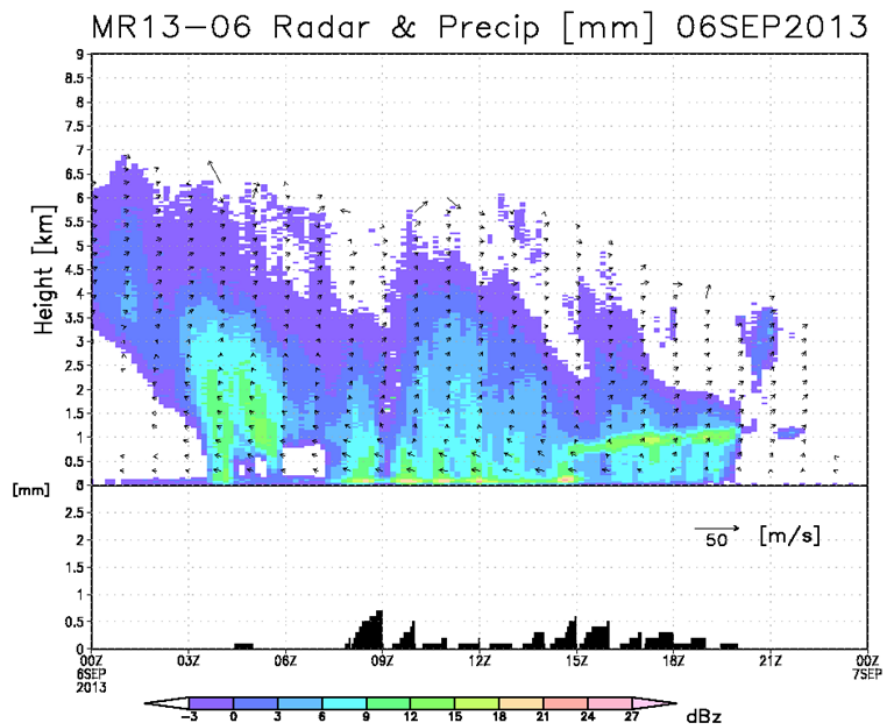


Figure 2.2-2. Top: Time-height cross section of radar reflectivity (shade) and VAD wind (vector). Bottom: Time series of rainfall (bar) on 6 September 2013.

(7) Data Archive

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

(8) Remark

1. Transmit power of 2.0 μ s pulse was reduced as following periods, due to transmitter trouble.

[Transmit power : 225kW] 00:59 UTC 19 Sep. 2013 – 06:59 UTC 5 Oct. 2013

[Transmit power : 200kW] 19:40 UTC 9 Oct. 2013 – 00:00 UTC 18 Oct. 2013

2. Following periods, Surveillance PPI observation was suspended.

07:29 UTC 5 Oct. 2013 – 15:00 UTC 7 Oct. 2013

3. Following periods, observation data was missing

Surveillance PPI:

05:59 UTC 12 Sep. 2013 – 04:29 UTC 15 Sep. 2013 (Recording media trouble)

21:29 UTC 18 Sep. 2013 – 22:29 UTC 18 Sep. 2013 (Transmitter overload)

23:29 UTC 18 Sep. 2013 – 00:29 UTC 19 Sep. 2013 (Transmitter overload)

06:29 UTC 5 Oct. 2013 – 06:59 UTC 5 Oct. 2013 (Transmitter overload)

19:59 UTC 9 Oct. 2013 – 20:29 UTC 9 Oct. 2013 (AFC* trouble)

Volume scan:

21:30 UTC 18 Sep. 2013 – 22:40 UTC 18 Sep. 2013 (Transmitter overload)

23:30 UTC 18 Sep. 2013 (Transmitter overload)

06:30 UTC 5 Oct. 2013 – 07:10 UTC 5 Oct. 2013 (Transmitter overload)

19:40 UTC 9 Oct. 2013 – 20:40 UTC 59Oct. 2013 (AFC trouble)

20:50 UTC 13 Oct. 2013 (Modulator overload)

* AFC: Automatic Frequency Controller

Table 2.2-1. Selected parameters of C-band Doppler radar

	Surveillance PPI	Volume scan	RHI
Pulse width	2.0 [μ s]	0.5 [μ s]	
Scan speed	18 [deg/sec]		Automatic
PRF	260 [Hz]	900/720 [Hz]	
Sweep integration	32 samples	40 samples	
Ray spacing	about 1.0 [deg]		
Bin spacing	250 [m]		
Elevations	0.5	0.5, 1.0, 1.5, 2.1, 2.8, 3.5, 4.3, 5.1, 5.9, 6.8, 7.6, 8.5, 9.4, 10.4, 11.5, 12.7, 14.0, 15.5, 16.8, 18.8, 21.3	0.0 to 60.0
Azimuths	Full Circle		Optional
Range	300 [km]	160 [km]	
Software Filters	No filter	Dual-PRF velocity unfolding	
Gain control	Fixed		

2.3. Surface Meteorological Observations

(1) Personnel

Jun Inoue	JAMSTEC/NIPR: PI
Masatake Hori	JAMSTEC
Kazuhiro Oshima	JAMSTEC
Kazutoshi Sato	NIPR
Taku Mitsui	JAMSTEC/Nagasaki Univ
Yo Tobase	JAMSTEC/Kyushu Univ
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Kazuho Yoshida	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

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) Instruments and Methods

Surface meteorological parameters were observed throughout the MR13-06 cruise. We used two systems for the observation, during this cruise.

i) MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.2.3-1 and measured parameters are listed in Table.2.3-2. 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) 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) Photosynthetically Available Radiation (PAR) sensor manufactured by Biospherical Instruments Inc. (USA) - PAR measurement.
- d) 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.2.3-3 and measured parameters are listed in Table.2.3-4.

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 2.3-1 and Figure 2.3-2 show the time series of the following parameters;

Wind (SOAR)
Air temperature (SMet)
Relative humidity (SMet)
Precipitation (SOAR, ORG)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (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 were available in the following periods.
06:00UTC 28 Aug. 2013 - 22:05UTC 06 Oct. 2013
19:00UTC 09 Oct. 2013 - 07:00UTC 19 Oct. 2013
- ii) At the following time, increasing of SMet capacitive rain gauge data were invalid due to test transmitting for MF/HF or VHF radio.
17:21UTC 02 Sep. 2013
21:27UTC 26 Sep. 2013
00:43UTC 19 Oct. 2013
21:48UTC 19 Oct. 2013

- iii) In the following period, FRSR data acquisition was suspended to prevent damage to the shadow-band from freezing.
23:16UTC 2 Sep. 2013 - 00:30UTC 05 Oct. 2013
- iv) At the following time, air temperature, dew-point temperature and relative humidity data of SMet include invalid data.
23:44UTC 06 Oct. 2013 (Starboard side)
01:56UTC 07 Oct. 2013 (Port side)

Table.2.3-1. 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	HMP155	Vaisala, Finland	compass deck (21 m) starboard and port side
			with 43408 Gill aspirated radiation shield R.M. Young, USA
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-815DS	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-802	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	bow (10 m) port side stern (8 m)

Table.2.3-2. 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, TG6000, 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)	degC	6sec. averaged
11 Air temperature (port side)	degC	6sec. averaged
12 Dewpoint temperature (starboard)	degC	6sec. averaged
13 Dewpoint temperature (side)	degC	6sec. averaged
14 Relative humidity (starboard)	%	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.2.3-3. 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	foremast (23 m)
	with 43408 Gill aspirated radiation shield	R.M. Young, USA	
Barometer	61302V	R.M. Young, USA	foremast (23 m)
	with 61002 Gill pressure port	R.M. Young, USA	
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)

Sensor (PAR)	Type	Manufacturer	Location (altitude from surface)
PAR sensor	PUV-510	Biospherical Instruments Inc., USA	Navigation deck (18m)

Table.2.3-4. 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

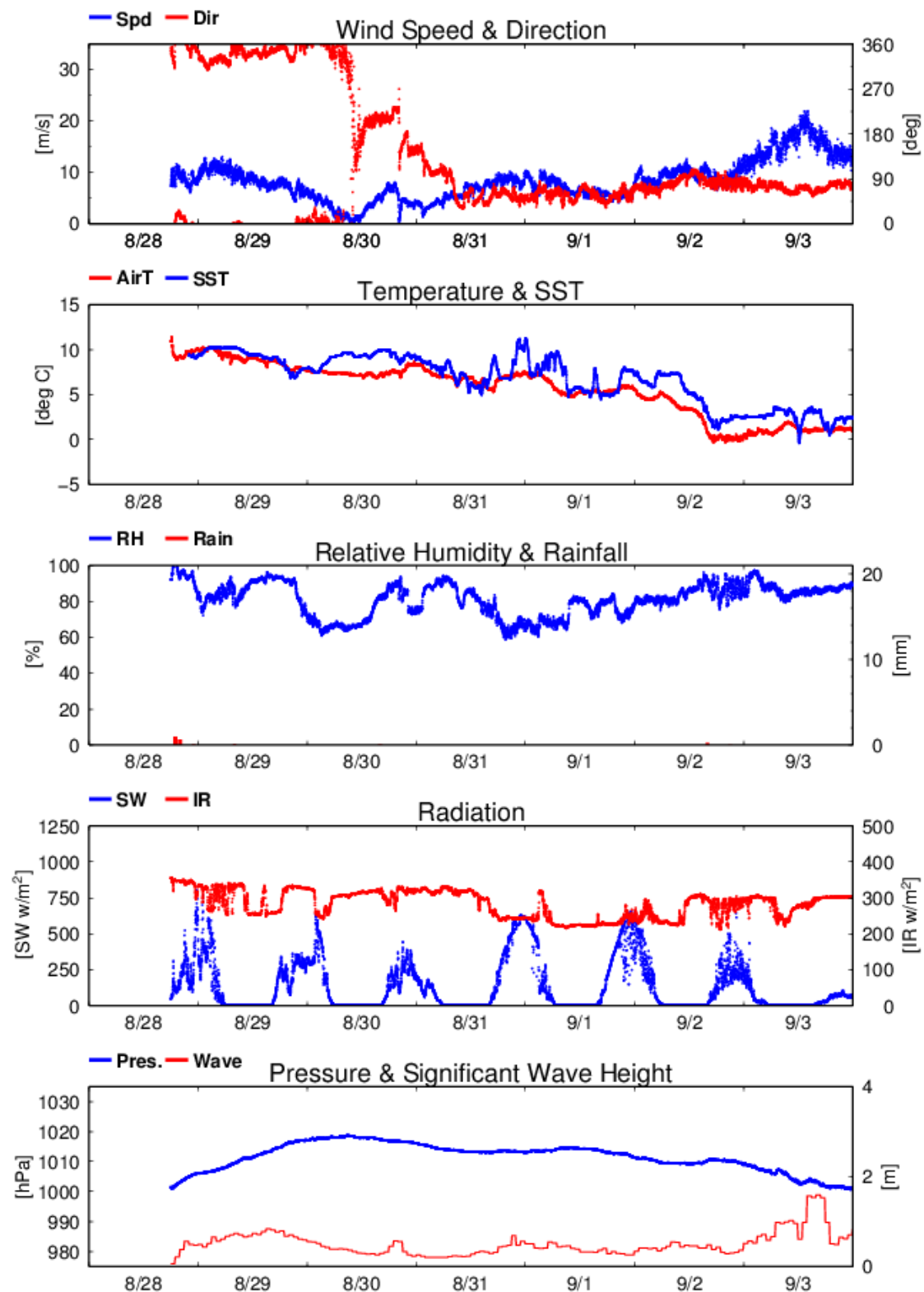


Figure 2.3-1. Time series of surface meteorological parameters during the MR13-06 Leg1.

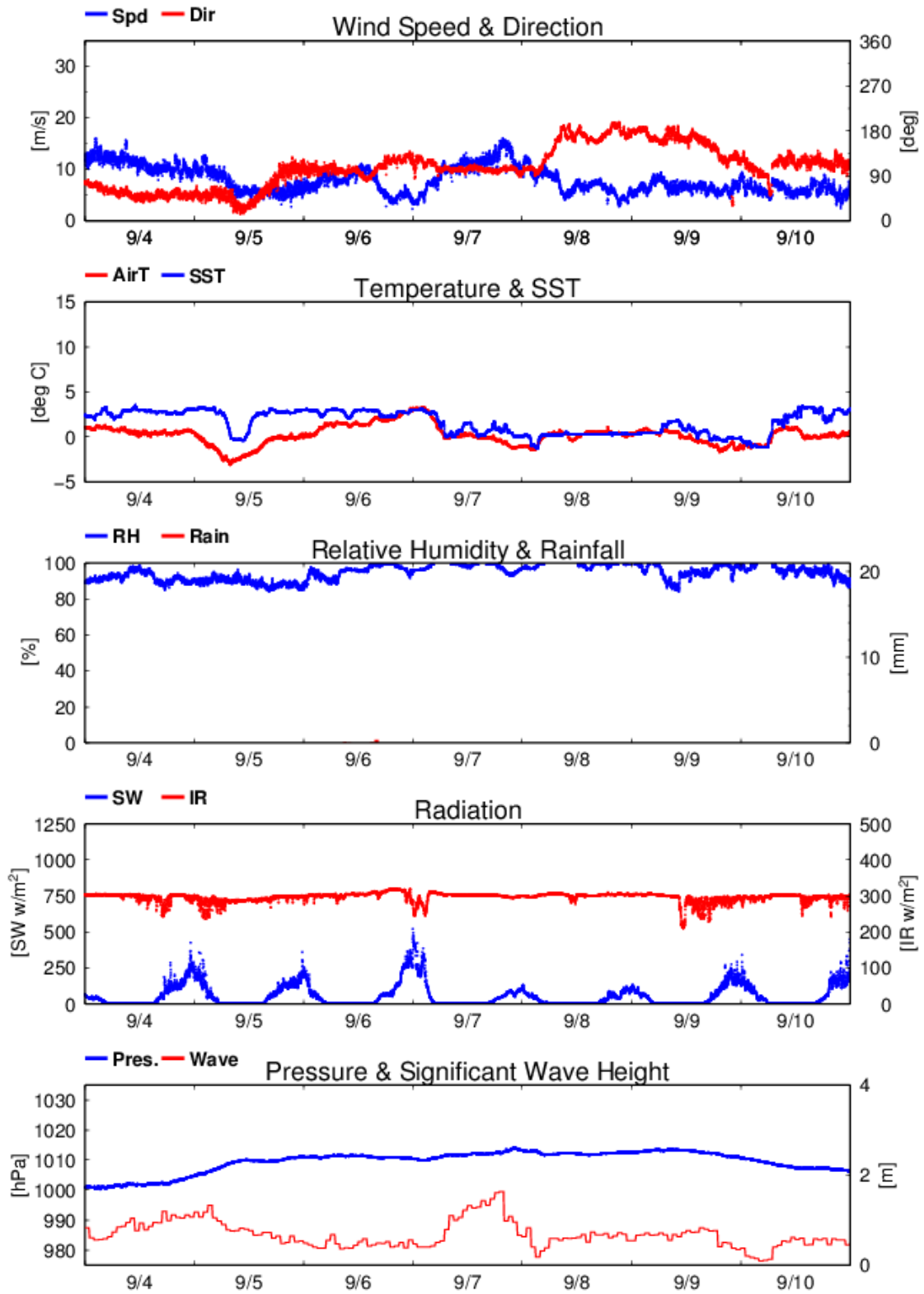


Figure 2.3-1. (Continued).

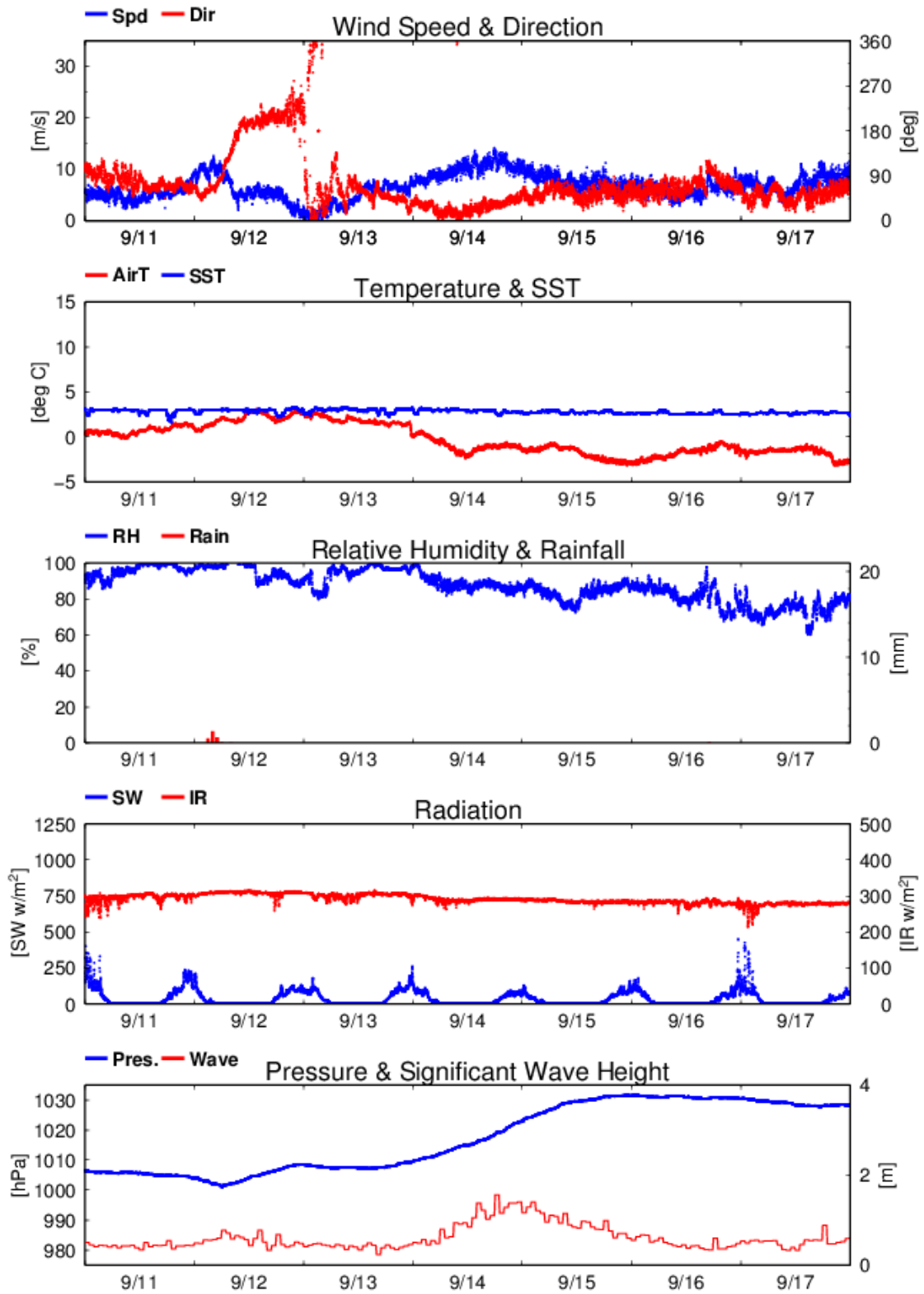


Figure 2.3-1. (Continued).

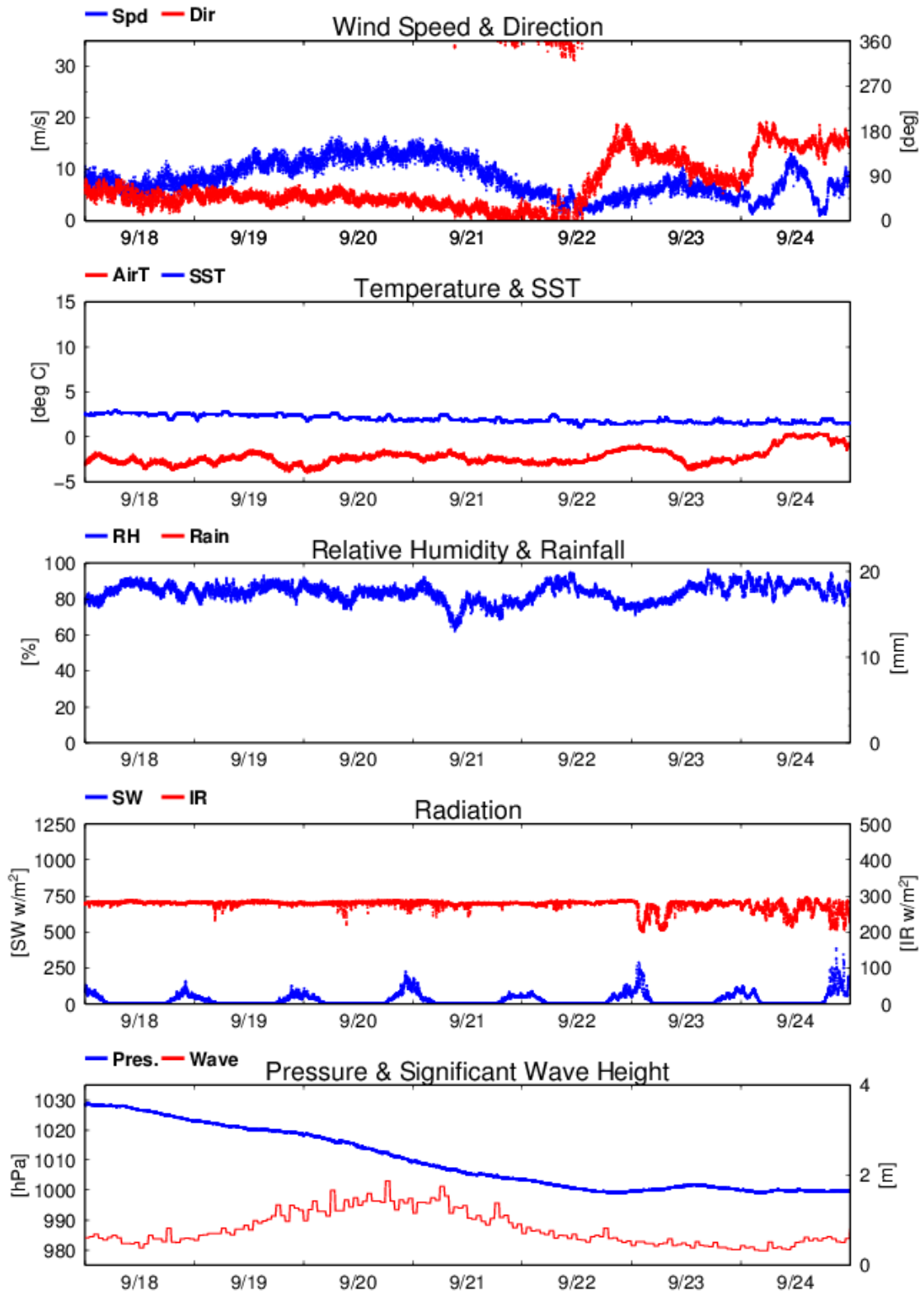


Figure 2.3-1. (Continued).

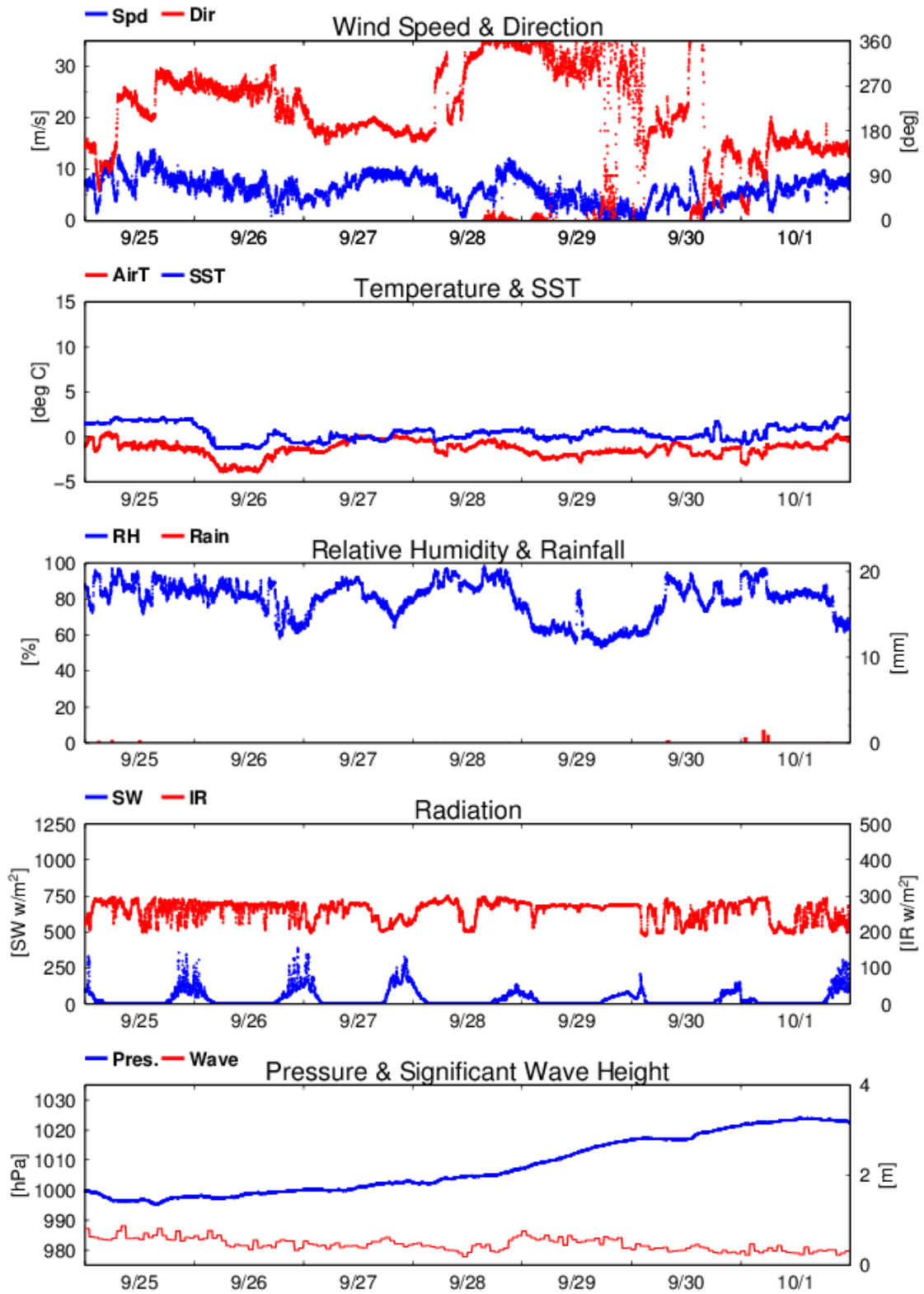


Figure 2.3-1. (Continued).

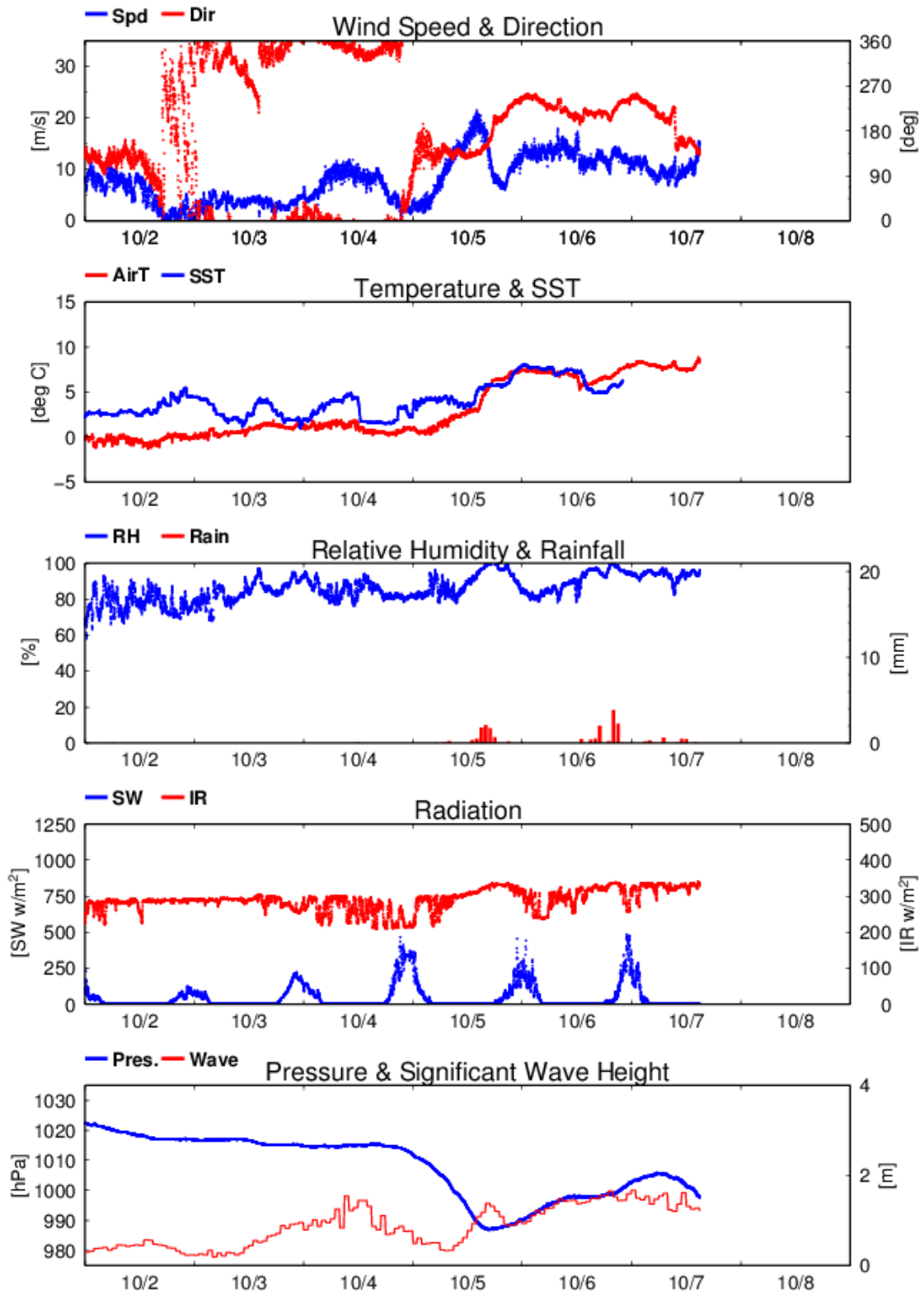


Figure 2.3-1. (Continued).

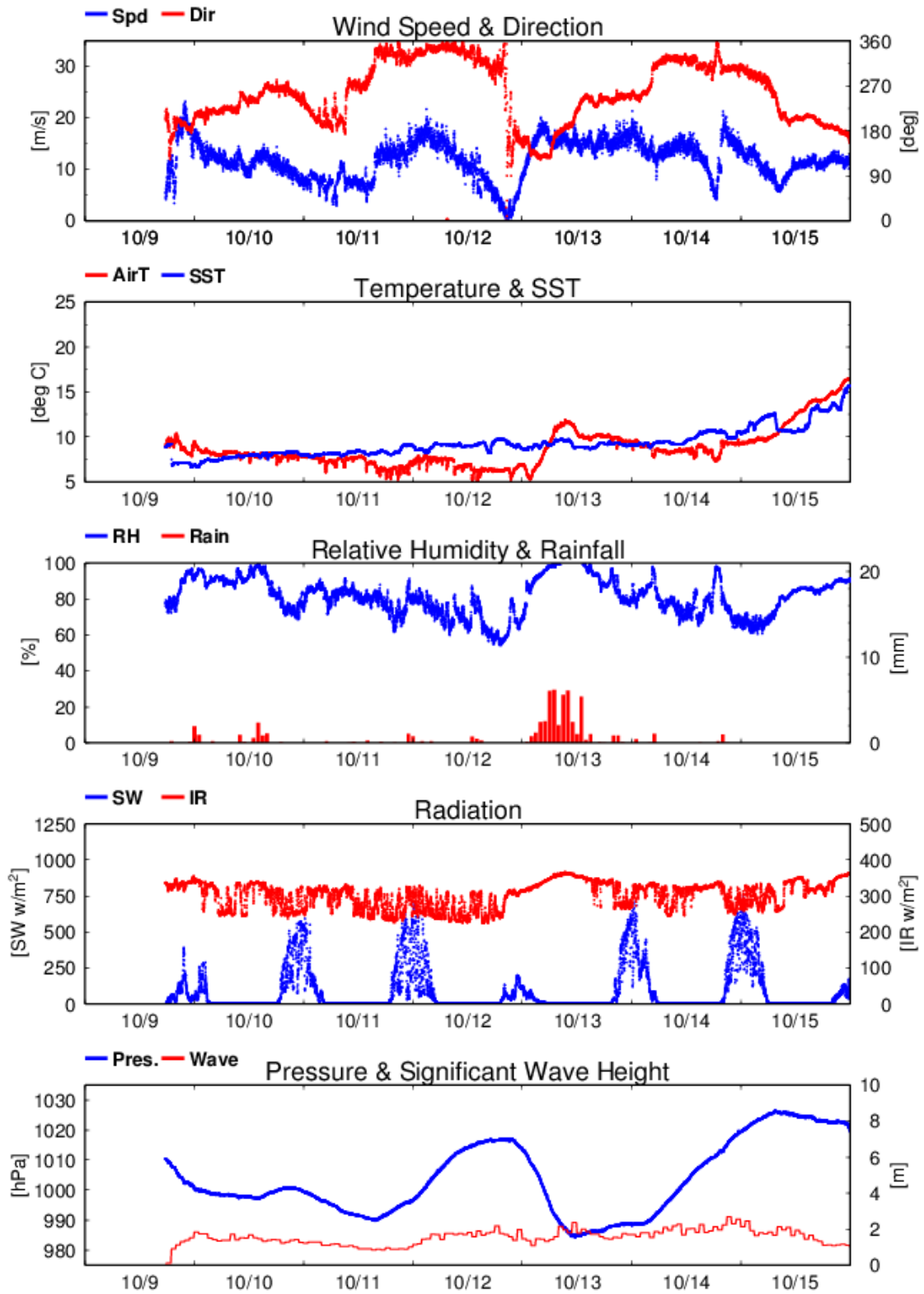


Figure 2.3-2. Time series of surface meteorological parameters during the MR13-06 Leg2.

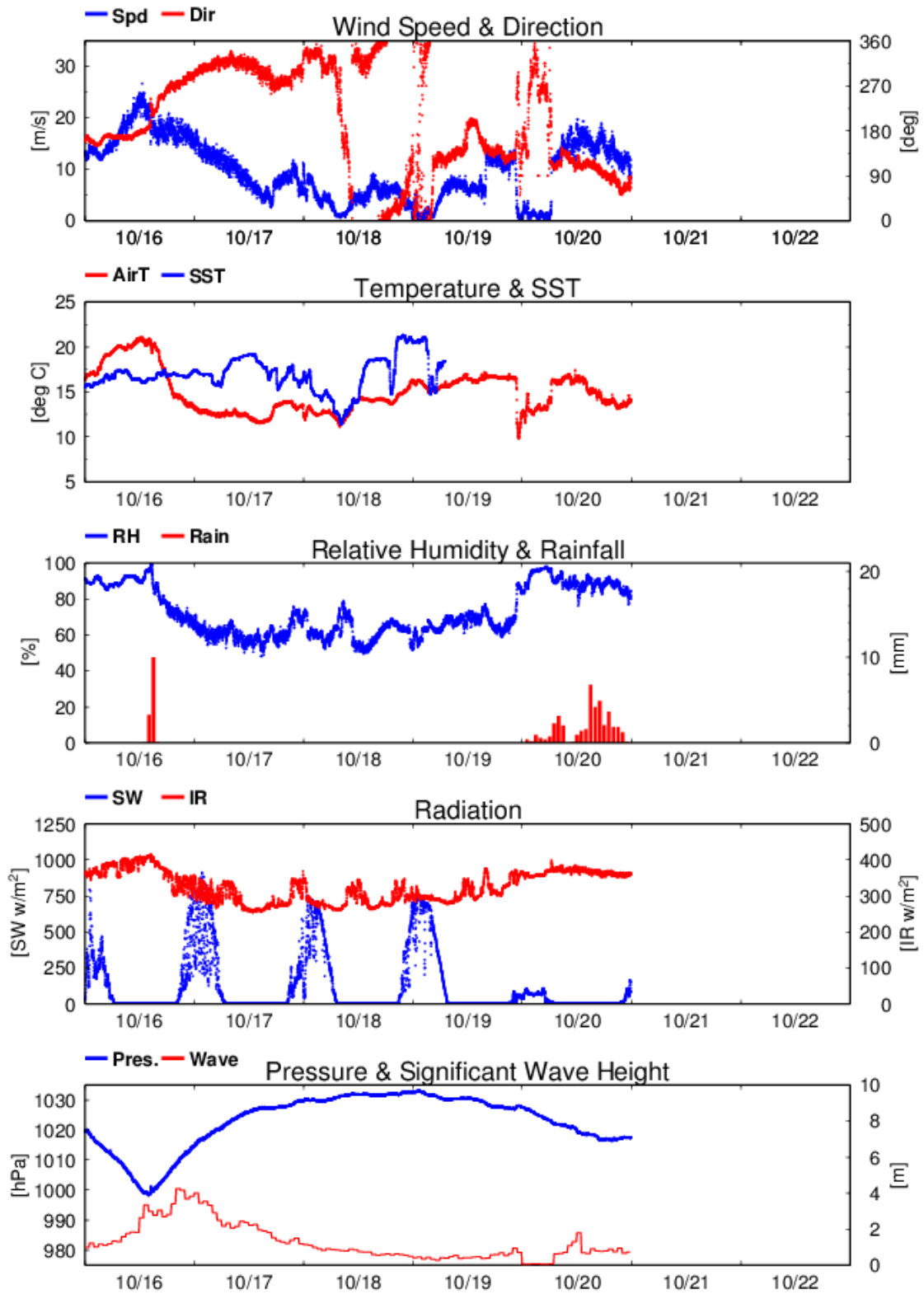


Figure 2.3-2. (Continued).

2.4. Ceilometer

(1) Personnel

Jun Inoue	JAMSTEC/NIPR: PI
Masatake Hori	JAMSTEC
Kazuhiro Oshima	JAMSTEC
Kazutoshi Sato	NIPR
Taku Mitsui	JAMSTEC/Nagasaki Univ
Yo Tobase	JAMSTEC/Kyushu Univ
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Kazuho Yoshida	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

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) Parameters

1. Cloud base height [m].
2. Backscatter profile, sensitivity and range normalized at 10 m resolution.
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

(4) Instruments and Methods

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland) throughout the MR13-06 cruise.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode Laser
Transmitting center wavelength:	910±10 nm at 25 degC
Transmitting average power:	19.5 mW
Repetition rate:	6.5 kHz
Detector:	Silicon avalanche photodiode (APD)
Measurement range:	0 ~ 15 km 0 ~ 13 km (Cloud detection)
Resolution:	10 meter in full range
Sampling rate:	36 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 10 m.

(5) Preliminary results

Figure 2.4-1 shows the time series of cloud-base heights derived from the ceilometer (black line) during this cruise. In most of periods, although the cloud base height was below 500m, it sometimes exceeded 500m.

Figure 2.4-2 shows frequency distribution of the cloud-base heights detected by the ceilometer. The highest frequency of occurrence of lowest cloud base was in the lowest 500 m of the atmosphere. The frequency of cloud-base heights below the 500 m level was about 70%.

(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;

00:55UTC 29 Aug. 2013

20:41UTC 05 Sep. 2013

22:55UTC 14 Sep. 2013

20:52UTC 24 Sep. 2013

22:46UTC 01 Oct. 2013

00:15UTC 09 Oct. 2013

01:17UTC 18 Oct. 2013

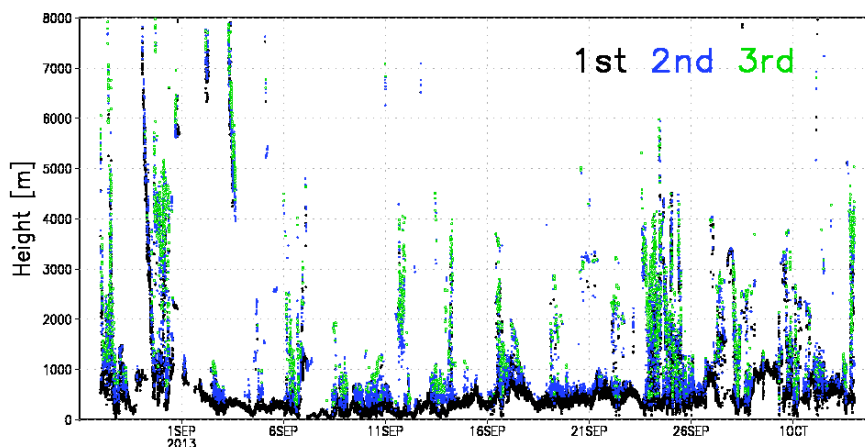


Figure 2.4-1. The time series of cloud-base heights throughout the MR13-06 cruise.

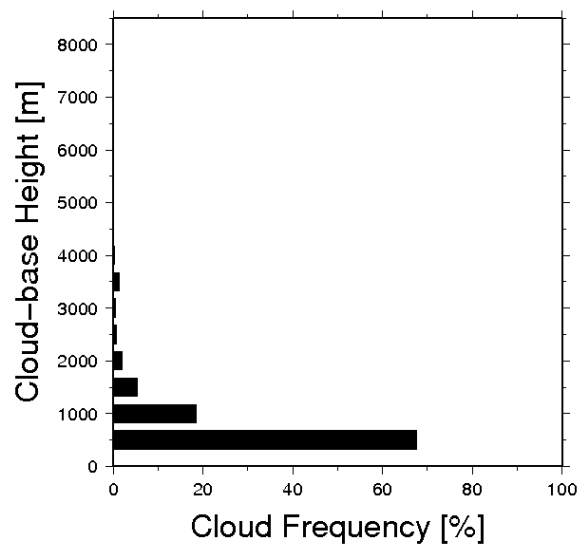


Figure 2.4-2. Frequency distribution of the cloud-base height (km) detected by a ceilometer throughout the MR13-06 cruise.

2.5. Greenhouse Gasses

2.5.1. Shipboard Measurements

(1) Personal

Shuji Aoki	Tohoku University: Principal Investigator
Naohiro Kosugi	Meteorological Research Institute / JMA
Yasunori Tohjima	National Institute for Environmental Studies
Junji Matsushita	National Institute of Polar Research

(2) Objective

In arctic region, there are a lot of vulnerable carbon pools, which have the potential to become strong sources of CO₂ and CH₄ 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 CO₂ and CH₄ mixing ratios during the cruise, 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

Mixing ratio of atmospheric CO₂, CH₄, and CO.

(4) Instruments and Methods

Atmospheric CO₂, CH₄, 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 right-side of the upper deck. A diaphragm pump (GAST, MOA-P108) was used to draw in the outside air at a flow rate of ~10 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 the WS-CRDS at a flow rate of 100 ml min⁻¹. The WS-CRDS were automatically calibrated every 24 hour by introducing 3 standard airs with known CO₂, CH₄ and CO mixing ratios. The analytical precisions for CO₂, CH₄, and CO mixing ratios are about 0.02 ppm,

0.3 ppb and 3 ppb, respectively.

(5) Observation log

The shipboard measurements were conducted during the entire cruise.

(6) Preliminary results

Temporal changes in the atmospheric CO₂, CH₄, and CO mixing ratios observed during MR13-06 cruise (August 28-October 6, 2013) are plotted in Figure 2.5.1-1. The geographical distributions of the observed CH₄ are also depicted in Figure 2.5.1-2. Relatively elevated CH₄ concentrations were observed along the North Slope of Alaska, which is consistent with previous measurements during MR12-E03 cruise.

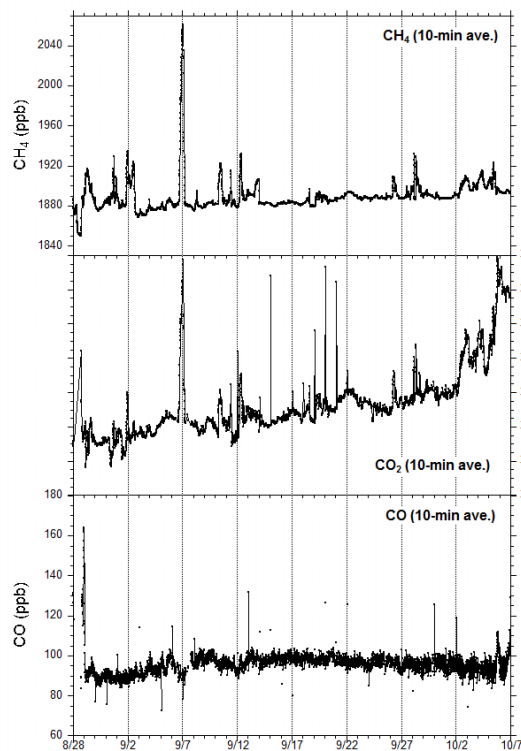


Figure 2.5.1-1. Time series of the atmospheric CH₄, CO₂, and CO concentrations observed during MR13-06 cruise.

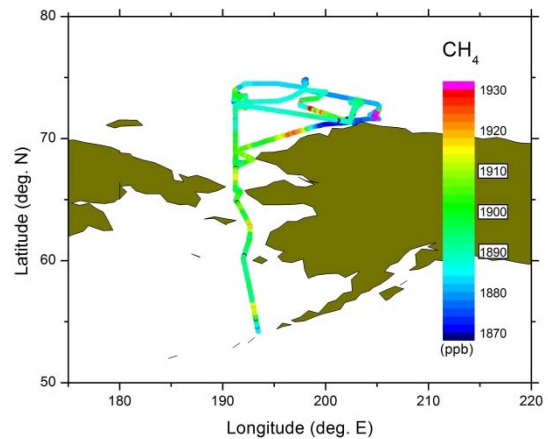


Figure 2.5.2-2. Geographical distribution of the atmospheric CH₄ concentrations observed during MR13-06 cruise.

(7) Data archives

The data of the atmospheric CO₂, CH₄ and CO mixing ratios with time (UTC) will be submitted to the Data Management Group (DMG) of JAMSTEC.

2.5.2. Whole Air Sampling

(1) Personal

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

(2) Objective

In order to clarify space variations and air-sea exchanges of the greenhouse gases at northern high latitude, air samples were corrected into 40 stainless-steel flasks in the Arctic Ocean. The collected air samples will be analyzed for the concentrations of CO₂, O₂, Ar, CH₄, CO, N₂O and SF₆ and the isotopic ratios of CO₂ and CH₄.

(3) Parameters

Atmospheric CO₂ concentration, O₂/N₂ ratio (O₂ concentration), Ar/N₂ ratio (Ar concentration), CH₄ concentration, CO concentration, N₂O concentration, SF₆ concentration, $\delta^{13}\text{C}$ of CO₂, $\delta^{18}\text{O}$ of CO₂, $\delta^{13}\text{C}$ of CH₄ and δD of CH₄.

(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 0.45 MPa.

(5) Observation log

Here are lists of collected sample

Sample number	Date (UTC)	Time (UTC)	Position	
			Lat.	Lon.
MR13-06_Flask_Gas_A01	2013/08/29	03:11	55-26N	166-49W
MR13-06_Flask_Gas_A02	2013/08/30	03:56	59-59N	167-57W
MR13-06_Flask_Gas_A03	2013/08/31	04:02	63-49N	167-56W
MR13-06_Flask_Gas_A04	2013/09/01	05:11	66-30N	168-45W
MR13-06_Flask_Gas_A05	2013/09/02	00:33	68-45N	168-45W

MR13-06_Flask_Gas_A06	2013/09/03	06:47	71-27N	157-43W
MR13-06_Flask_Gas_A07	2013/09/04	05:05	71-22N	157-25W
MR13-06_Flask_Gas_A08	2013/09/05	03:42	71-57N	155-40W
MR13-06_Flask_Gas_A09	2013/09/06	07:35	71-52N	155-29W
MR13-06_Flask_Gas_A10	2013/09/07	02:38	72-01N	155-08W
MR13-06_Flask_Gas_A11	2013/09/08	01:00	74-36N	162-01W
MR13-06_Flask_Gas_A12	2013/09/09	08:01	74-14N	162-00W
MR13-06_Flask_Gas_A13	2013/09/10	00:54	73-48N	168-47W
MR13-06_Flask_Gas_A14	2013/09/11	05:53	72-43N	168-15W
MR13-06_Flask_Gas_A15	2013/09/12	06:12	72-40N	168-15W
MR13-06_Flask_Gas_A16	2013/09/13	06:12	72-40N	168-15W
MR13-06_Flask_Gas_A17	2013/09/14	06:31	72-36N	168-15W
MR13-06_Flask_Gas_A18	2013/09/15	00:20	72-52N	168-15W
MR13-06_Flask_Gas_A19	2013/09/16	00:17	72-51N	168-15W
MR13-06_Flask_Gas_A20	2013/09/17	00:16	72-51N	168-15W
MR13-06_Flask_Gas_A21	2013/09/18	00:15	72-52N	168-15W
MR13-06_Flask_Gas_A22	2013/09/19	00:17	72-51N	168-15W
MR13-06_Flask_Gas_A23	2013/09/20	00:16	72-49N	168-13W
MR13-06_Flask_Gas_A24	2013/09/21	00:16	72-50N	168-15W
MR13-06_Flask_Gas_A25	2013/09/22	05:57	72-43N	168-15W
MR13-06_Flask_Gas_A26	2013/09/23	05:56	72-43N	168-15W
MR13-06_Flask_Gas_A27	2013/09/24	00:18	72-51N	168-15W
MR13-06_Flask_Gas_A28	2013/09/25	05:56	72-44N	168-15W
MR13-06_Flask_Gas_A29	2013/09/26	05:38	73-48N	168-47W
MR13-06_Flask_Gas_A30	2013/09/27	10:14	73-54N	160-59W
MR13-06_Flask_Gas_A31	2013/09/28	10:15	72-08N	160-23W
MR13-06_Flask_Gas_A32	2013/09/29	01:37	71-54N	157-22W
MR13-06_Flask_Gas_A33	2013/09/30	00:53	71-22N	157-59W
MR13-06_Flask_Gas_A34	2013/10/01	05:58	72-42N	168-15W
MR13-06_Flask_Gas_A35	2013/10/02	00:55	71-44N	168-45W
MR13-06_Flask_Gas_A36	2013/10/03	10:59	67-68N	168-34W
MR13-06_Flask_Gas_A37	2013/10/04	14:51	66-00N	168-45W
MR13-06_Flask_Gas_A38	2013/10/05	01:34	64-55N	168-39W
MR13-06_Flask_Gas_A39	2013/10/06	02:45	60-19N	167-57W
MR13-06_Flask_Gas_A40	2013/10/06	20:12	57-23N	167-17W

(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 “R/V Mirai Data Web Page” in JAMSTEC home page.

2.6. Sky Radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) Principal Investigator / not onboard
Tadahiro Hayasaka (Tohoku University) Co-worker / not onboard
Sky radiometer operation was supported by Global Ocean Development Inc.

(2) Objective

Objective of this observation 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) 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 the sun. Horizon sensor provides rolling and pitching angles.

(4) Instruments and Methods

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

(5) Data archives

Aerosol optical data are to be archived at University of Toyama (K.Aoki, SKYNET/SKY: <http://skyrad.sci.u-toyama.ac.jp/>) after the quality check and will be submitted to JAMSTEC.

2.7. Tropospheric Aerosol and Gas Observations

(1) Personnel

Yugo KANAYA (JAMSTEC RIGC) Principal Investigator / not on board

Fumikazu TAKETANI (JAMSTEC RIGC, not on board)

Takuma MIYAKAWA (JAMSTEC RIGC, not on board)

Hisahiro TAKASHIMA (JAMSTEC RIGC, not on board)

Xiaole PAN (JAMSTEC RIGC, not on board)

Yuichi KOMAZAKI (JAMSTEC RIGC, not on board)

Operation was supported by Global Ocean Development Inc.

(2) Objective

- To clarify transport processes of atmospheric pollutants from the Asian continent to the ocean
- To investigate processes of biogeochemical cycles between the atmosphere and the ocean
- To advance validation of satellite observations of atmospheric composition

(3) Parameters

1. NO₂ vertical column densities and profiles,
2. Aerosol optical depth and vertical profile of extinction coefficient at 476 nm
3. Black carbon mass concentrations and size distribution
4. Ozone and carbon monoxide mixing ratios

(4) Instruments and Methods

1. MAX-DOAS

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS), a passive remote sensing technique measuring spectra of scattered visible and ultraviolet (UV) solar radiation, was used for atmospheric aerosol and gas profile measurements. Our MAX-DOAS instrument consists of two main parts: an outdoor telescope unit and an indoor spectrometer (Acton SP-2358 with Princeton Instruments PIXIS-400B), connected to each other by a 14-m bundle cable that consists of 60 cores with 100- μ m radii. On the roof top of the anti-rolling system of R/V Mirai, the telescope unit was installed on a gimbal mount, which compensates for the pitch and roll motion of the ship. The line of sight was in directions of the starboard and portside of the vessel. The integration time for UV and visible spectra recording (centered on 340 and 452 nm) was set to 0.20 and 0.08 s. Measurements were made every 30 min at elevation angles of 1.5, 3, 5, 10, 20, 30, 90, 150, 160, 170, 175, and 177 degrees.

For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO₂ (and other gases) and O₄ (O₂-O₂, collision complex of oxygen) for each elevation angle. Then, the O₄ SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information,

retrievals of the tropospheric vertical column/profile of NO₂ and other gases were made.

2. CO, O₃, and black carbon (BC)

Carbon monoxide (CO) and ozone (O₃) measurements were also continuously conducted during the cruise. For CO and O₃ measurements, ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to a gas filter correlation CO analyzer (Model 48C, Thermo Fisher Scientific) and a UV photometric ozone analyzer (Model 49C, Thermo Fisher Scientific) in the Research Information Center.

BC was measured by an instrument based on laser-induced incandescence (SP2, Droplet Measurement Technologies). Ambient air was sampled from the flying bridge by a 3-m-long conductive tube and then introduced to the instrument.

(5) Observation log

The shipboard measurements were conducted during the entire cruise.

(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.

3. Physical Oceanography

3.1. CTD and Water Samplings

(1) Personnel

Shigeto Nishino*¹ (JAMSTEC): Principal Investigator

Shinsuke Toyoda*¹ (MWJ): Operation Leader

Shungo Oshitani *¹ (MWJ)

Hirokatsu Uno*² (MWJ)

Rei Ito*² (MWJ)

*1: Leg1, Leg2

*2: Leg1

(2) Objective

To investigate ocean structure and water characteristics.

(3) Parameters

Temperature

Conductivity

Pressure

Dissolved Oxygen voltage

Dissolved Oxygen

Transmission %, beam attenuation coefficient 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-liter 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, RINKO III (dissolved oxygen sensor), dissolved oxygen (SBE43), 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.7.22.5)

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 1 minute or 30 seconds to stabilize then fire.

213 casts of CTD measurements were conducted (Table 3.1-1). Stn.087 was Leg2.

In the Stn.014, RINKO III (S/N 0079) voltage was bad data. So we detached the sensor.

From the Stn.001 to the Stn.040 and from the Stn.073 to the Stn.086, we used a cable of fluorescence gain 10x. In other Stn, we used a cable of fluorescence gain 30x.

We used a bottom contact switch in some casts.

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.22.5.a) 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 primary temperature (SBE3) sensor.

S/N 031359: -1.8386e-007 (deg-C / 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 (SBE43) 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 plumbing line. This delay was compensated by 5 seconds advancing dissolved oxygen sensors output (dissolved oxygen voltage) relative to the temperature data. RINKO-III voltage, transmission data and voltage are also delayed by slightly slow response time to the sensor. The delay was compensated by 1 second or 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 (SBE43) 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 transmission data, voltage and fluorescence data. A median value was determined by 49 scans of the window.

SECTIONU (original module of SECTION): Select a time span of data based on scan number in order to reduce a file size. The minimum number was set to be the starting time when the CTD package was beneath the sea-surface after activation of the pump. The maximum number of was set to be the end time when the package came up from the surface.

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 (RINKO III and SBE43) voltage.

DERIVE: Compute dissolved oxygen (SBE43).

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

BOTTOMCUT (original module): Deletes discontinuous scan bottom data, if it's created by BINAVG.

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

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

Configuration file

Stn.001 : MR1306A.xmlcon
Stn.002 - 014 : MR1306B.xmlcon
Stn.014 - 042, 073 - 086 : MR1306C.xmlcon
Stn.041 - 072, 087 : MR1306D.xmlcon

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: 10 May 2013

Temperature sensors:

Primary: SBE03-04/F (S/N 031359, Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Jul. 2013

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

Calibrated Date: 31 Aug. 2012

Conductivity sensors:

Primary: SBE04C (S/N 042435 Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Jul. 2013

Secondary: SBE04C (S/N 042854, Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Jul. 2013

Dissolved Oxygen sensors:

RINK III (S/N 0024 (144002), Alec Electronics Co. Ltd.)

Calibrated Date: 09 Aug. 2013

RINK- II (S/N 0079 (1204), Alec Electronics Co. Ltd.)

Calibrated Date: 09 Aug. 2013

Used period: 000M001 - 041M014

SBE43 (S/N 430575, Sea-Bird Electronics, Inc.)

Calibrated Date: 21 May 2013

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

Calibrated Date: 01 May 2012

Transmissonmeter:

C-Star (S/N CST-1363DR, WET Labs, Inc.)

Calibrated Date: 05 Aug. 2013

Fluorescence:

Chlorophyll Fluorometer (S/N 2936, 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 0053, Sea-Bird Electronics, Inc.)

Calibrated Date: 09 May 2013

Carousel water sampler:

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

Submersible Pump:

Primary: SBE5T (S/N 054598, Sea-Bird Electronics, Inc.)

Secondary: SBE5T (S/N 054595, Sea-Bird Electronics, Inc.)

Bottom contact switch:

(Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P9833-0344, Sea-Bird Electronics, Inc.)

(5) Preliminary Results

During this cruise, 213 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.

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

000M001: Fluorescence; down 8 db - down 18 db (outside measurement range)

008M001: Fluorescence; down 7 db and down 18 db, bottle data #1, #2, #3, #4, #28, #29, #33, #35, #36 (outside measurement range)

014M001: RINKO III (S/N 0079); all data were bad

017M001: Secondary temperature and salinity; down 14 db (spike)

019M001: Fluorescence; down 95 db - down 97 db (spike)

029M001: Transmissonmeter data and voltage; down 7 db - down 20 db (spike)

042M003: Secondary salinity; up 13 db - up 8 db (sift)

041M027: Secondary temperature, salinity and dissolved oxygen; up 23 db - up 7 db, bottle data #24, #25, #27 (sift)

044M009: Secondary temperature, salinity and dissolved oxygen; up 19 db - up 15 db (sift)

045M010: Secondary salinity; down 45 db (spike)

Primary temperature and salinity dissolved oxygen; up 50 db - up 40 db
(sift)

Primary dissolved oxygen; up 53 db - up 38 db (sift)

087M001: Transmissonmeter data and voltage; down 816 db - down 822 db (spike)

(6) Data archive

All raw and processed data 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 3.1-1. MR13-06 CTD cast table

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	082813	20:19	20:56	54-15.74N	166-32.45W	1118.0	294.5	-	298.1	301.0	000M001	•A/R test cast, •no sampling water
001	1	083113	19:49	20:17	65-46.18N	168-45.10W	52.0	40.7	-	44.6	45.0	001M001	changed a cable of the fluorescence (gain 30x - gain 10x)
002	1	083113	21:43	21:48	65-42.31N	168-31.39W	54.0	43.5	-	46.5	47.0	002M001	no sampling water
003	1	083113	22:55	23:11	65-39.44N	168-15.15W	43.0	36.0	-	36.6	37.0	003M001	
004	1	090113	01:43	02:00	66-00.24N	168-44.93W	53.0	40.4	-	44.6	45.0	004M001	
005	1	090113	04:43	05:01	66-30.19N	168-45.11W	54.0	42.2	-	45.5	46.0	005M001	
006	1	090113	08:03	08:20	67-00.19N	168-44.69W	44.0	33.0	-	35.6	36.0	006M001	
007	1	090113	11:10	11:27	67-30.09N	168-44.97W	49.0	36.2	-	39.6	40.0	007M001	
008	1	090113	18:46	19:15	68-00.25N	168-45.82W	58.0	49.8	-	52.5	53.0	008M001	
009	1	090113	22:15	22:36	68-30.20N	168-44.78W	53.0	41.5	-	44.5	45.0	009M001	
010	1	090213	01:48	02:05	69-00.15N	168-44.99W	52.0	36.3	-	42.6	43.0	010M001	
011	1	090313	05:06	05:30	71-20.58N	157-36.58W	101.0	86.7	-	92.0	93.0	011M001	
012	1	090313	07:31	07:53	71-34.85N	157-50.66W	64.0	52.7	-	58.4	59.0	012M001	
013	1	090313	09:20	09:25	71-32.25N	157-45.71W	70.0	55.3	-	61.4	62.0	013M001	no sampling water
014	1	090413	00:27	00:40	71-14.71N	157-10.27W	46.0	35.6	-	39.6	40.0	014M001	RINKO III (S/N 0079) data were bad
015	1	090413	03:04	03:11	71-16.73N	157-16.43W	55.0	50.3	-	53.4	54.0	015M001	•RINKO III (S/N 0079) was detached •no sampling water
016	1	090413	03:51	04:15	71-19.58N	157-21.05W	89.0	76.3	-	82.1	83.0	016M001	

017	1	090413	05:27	05:34	71-22.24N	157-25.80W	112.0	98.1	-	100.9	102.0	017M001	no sampling water
018	1	090413	06:47	07:13	71-24.67N	157-30.46W	122.0	110.0	-	113.8	115.0	018M001	
019	1	090413	08:37	08:43	71-27.25N	157-35.50W	110.0	98.4	-	100.9	102.0	019M001	no sampling water
020	1	090413	09:32	09:53	71-29.85N	157-40.56W	85.0	69.8	-	74.2	75.0	020M001	
021	1	090413	11:38	12:09	71-29.54N	156-57.16W	143.0	134.8	6.2	137.5	139.0	021M001	
022	1	090413	13:51	14:24	71-32.81N	156-21.26W	159.0	151.2	-	155.3	157.0	022M001	
023	1	090413	16:15	16:56	71-37.62N	155-45.62W	235.0	226.3	5.3	229.5	232.0	023M001	
024	1	090413	19:19	19:43	71-36.52N	154-51.09W	44.0	32.7	-	35.6	36.0	024M001	
025	1	090413	21:02	21:26	71-40.99N	154-58.54W	109.0	101.1	-	103.9	105.0	025M001	
026	1	090413	22:46	23:24	71-44.19N	155-06.60W	257.0	244.0	9.2	247.3	250.0	026M001	
027	1	090513	01:05	01:39	71-48.78N	155-17.80W	194.0	183.5	8.2	186.0	188.0	027M001	
028	1	090513	02:53	03:23	71-56.09N	155-39.39W	139.0	129.3	-	132.6	134.0	028M001	
029	1	090513	08:10	10:42	72-40.82N	154-47.95W	2931.0	2922.0	8.1	2916.0	2967.0	029M001	
030	1	090713	22:05	00:13	74-30.02N	161-59.06W	1631.0	1619.9	10.5	1614.7	1638.0	030M001	A/R test cast
031	1	090813	05:19	06:56	74-31.83N	161-54.72W	1694.0	1695.1	8.5	1680.5	1705.0	031M001	
032	1	090913	02:00	03:26	74-32.24N	161-58.02W	1685.0	1675.3	9.8	1671.6	1696.0	032M001	
033	1	090913	08:24	09:49	74-10.07N	162-00.34W	1118.0	1104.9	8.9	1103.5	1118.0	033M001	
034	1	090913	21:35	22:12	73-59.83N	168-44.53W	178.0	171.6	4.3	174.1	176.0	034M001	
035	1	091013	08:35	08:55	73-00.21N	168-44.92W	61.0	48.8	-	51.5	52.0	035M001	
036	1	091013	10:35	10:53	72-44.99N	168-44.89W	59.0	46.1	-	49.5	50.0	036M001	
037	1	091013	12:34	12:52	72-30.06N	168-44.97W	58.0	45.9	-	48.5	49.0	037M001	
038	1	091013	14:54	15:13	72-30.07N	167-44.88W	52.0	41.0	-	46.5	47.0	038M001	
039	1	091013	16:45	17:00	72-45.00N	167-44.53W	55.0	46.1	-	49.5	50.0	039M001	
040	1	091013	18:45	19:06	73-00.02N	167-44.83W	65.0	54.7	-	57.4	58.0	040M001	
041	1	091013	21:10	21:33	72-45.19N	168-14.48W	56.0	51.0	-	50.5	51.0	041M001	changed a cable of the fluorescence (gain

													10x - gain 30x)
042	1	091113	00:31	00:35	72-53.95N	168-14.76W	58.0	49.4	-	52.4	53.0	042M001	no sampling water
041	2	091113	02:39	02:56	72-44.97N	168-15.09W	56.0	43.5	-	46.5	47.0	041M002	
043	1	091113	06:37	06:42	72-36.04N	168-14.96W	54.0	41.9	-	45.5	46.0	043M001	no sampling water
041	3	091113	08:41	08:59	72-45.02N	168-14.55W	56.0	43.7	-	46.5	47.0	041M003	
044	1	091113	12:35	12:39	72-45.11N	167-44.65W	55.0	42.8	-	45.5	46.0	044M001	no sampling water
041	4	091113	14:41	14:58	72-44.92N	168-15.00W	56.0	44.4	-	48.5	49.0	041M004	
045	1	091113	18:33	18:38	72-45.17N	168-45.13W	59.0	51.4	-	54.4	55.0	045M001	no sampling water
041	5	091113	20:39	20:56	72-45.03N	168-15.04W	56.0	44.2	-	47.5	48.0	041M005	
042	2	091213	00:32	00:35	72-54.00N	168-14.80W	58.0	47.2	-	50.5	51.0	042M002	no sampling water
041	6	091213	02:39	02:55	72-45.06N	168-15.10W	56.0	41.9	-	46.5	47.0	041M006	
043	2	091213	06:37	06:41	72-36.11N	168-14.92W	54.0	40.7	-	44.5	45.0	043M002	no sampling water
041	7	091213	08:41	08:59	72-44.95N	168-14.79W	56.0	43.0	-	46.5	47.0	041M007	
044	2	091213	12:36	12:40	72-44.87N	167-44.38W	55.0	41.7	-	45.5	46.0	044M002	no sampling water
041	8	091213	14:40	14:57	72-44.99N	168-15.14W	56.0	43.7	-	47.5	48.0	041M008	
045	2	091213	18:33	18:38	72-44.98N	168-45.37W	59.0	48.8	-	52.4	53.0	045M002	no sampling water
041	9	091213	20:39	21:05	72-44.99N	168-15.67W	56.0	44.1	-	47.5	48.0	041M009	
042	3	091313	00:31	00:35	72-53.97N	168-14.71W	59.0	47.7	-	50.5	51.0	042M003	no sampling water
041	10	091313	02:38	02:55	72-44.99N	168-14.71W	56.0	43.1	-	46.5	47.0	041M010	
043	3	091313	06:36	06:41	72-36.08N	168-15.18W	54.0	44.6	-	47.5	48.0	043M003	no sampling water
041	11	091313	08:41	09:03	72-45.02N	168-14.83W	56.0	45.2	8.8	47.5	48.0	041M011	
044	3	091313	12:34	12:38	72-45.04N	167-44.38W	55.0	44.2	-	47.5	48.0	044M003	no sampling water
041	12	091313	14:41	15:00	72-44.98N	168-14.83W	56.0	44.8	-	48.5	49.0	041M012	
045	3	091313	18:40	18:45	72-45.08N	168-45.39W	59.0	50.9	-	54.4	55.0	045M003	no sampling water
041	13	091313	20:39	21:01	72-45.08N	168-15.19W	56.0	47.0	-	50.5	51.0	041M013	
042	4	091413	00:30	00:34	72-54.03N	168-14.98W	59.0	47.5	8.2	50.5	51.0	042M004	no sampling water

041	14	091413	02:39	03:00	72-45.05N	168-14.82W	56.0	47.4	-	50.5	51.0	041M014	
043	4	091413	06:37	06:42	72-36.03N	168-15.21W	54.0	43.3	7.2	47.5	48.0	043M004	no sampling water
041	15	091413	08:40	09:01	72-44.97N	168-15.05W	56.0	46.8	-	51.5	52.0	041M015	
044	4	091413	12:35	12:56	72-45.02N	167-44.99W	55.0	44.8	-	49.5	50.0	044M004	
041	16	091413	14:46	15:07	72-44.97N	168-15.05W	56.0	46.1	-	51.5	52.0	041M016	
045	4	091413	18:33	18:54	72-45.13N	168-45.64W	59.0	46.6	-	54.4	55.0	045M004	
041	17	091413	20:41	21:13	72-44.89N	168-14.74W	56.0	47.0	-	52.5	53.0	041M017	
042	5	091513	00:33	00:53	72-53.93N	168-15.03W	58.0	47.2	-	53.4	54.0	042M005	
041	18	091513	02:39	03:02	72-45.07N	168-14.61W	56.0	42.8	7.7	48.5	49.0	041M018	
043	5	091513	06:37	06:59	72-36.01N	168-14.90W	55.0	43.1	4.8	48.5	49.0	043M005	
041	19	091513	08:42	09:04	72-44.93N	168-14.91W	56.0	43.7	7.8	48.5	49.0	041M019	
044	5	091513	12:37	12:41	72-45.03N	167-44.67W	55.0	45.9	-	50.5	51.0	044M005	no sampling water
041	20	091513	14:40	15:01	72-44.94N	168-15.08W	56.0	44.4	-	51.5	52.0	041M020	
045	5	091513	18:33	18:38	72-45.08N	168-45.43W	59.0	47.5	-	54.4	55.0	045M005	no sampling water
041	21	091513	20:39	20:59	72-45.07N	168-15.25W	56.0	46.3	-	50.5	51.0	041M021	
042	6	091613	00:30	00:34	72-54.06N	168-14.82W	59.0	48.1	-	52.5	53.0	042M006	no sampling water
041	22	091613	02:39	02:59	72-45.02N	168-15.21W	56.0	45.7	-	51.5	52.0	041M022	
043	6	091613	06:37	06:43	72-36.03N	168-14.94W	55.0	45.3	-	49.5	50.0	043M006	no sampling water
041	23	091613	08:41	09:02	72-44.98N	168-14.83W	56.0	48.1	-	51.5	52.0	041M023	
044	6	091613	12:34	12:38	72-45.10N	167-44.38W	55.0	45.9	-	49.5	50.0	044M006	no sampling water
041	24	091613	14:40	15:00	72-44.81N	168-14.57W	56.0	45.0	-	51.5	52.0	041M024	
045	6	091613	18:32	18:37	72-45.06N	168-45.46W	59.0	50.9	-	55.4	56.0	045M006	no sampling water
041	25	091613	20:39	21:14	72-45.09N	168-15.20W	56.0	47.4	-	50.5	51.0	041M025	
042	7	091713	00:31	00:35	72-54.11N	168-14.81W	58.0	45.9	-	50.5	51.0	042M007	no sampling water
041	26	091713	02:39	03:00	72-45.02N	168-14.95W	56.0	46.8	5.9	49.5	50.0	041M026	
043	7	091713	06:38	06:42	72-36.04N	168-14.85W	55.0	45.9	-	50.5	51.0	043M007	no sampling water

041	27	091713	09:01	09:23	72-44.92N	168-14.90W	56.0	45.9	5.9	50.5	51.0	041M027	
044	7	091713	12:34	12:39	72-45.06N	167-44.83W	55.0	46.8	-	50.5	51.0	044M007	no sampling water
041	28	091713	14:40	15:00	72-45.01N	168-14.95W	56.0	45.0	-	51.5	52.0	041M028	
045	7	091713	18:33	18:38	72-45.08N	168-45.25W	59.0	49.4	-	55.4	56.0	045M007	no sampling water
041	29	091713	20:39	20:59	72-44.97N	168-14.92W	56.0	47.2	5.9	50.5	51.0	041M029	
042	8	091813	00:31	00:35	72-54.06N	168-14.77W	59.0	49.6	-	53.4	54.0	042M008	no sampling water
041	30	091813	02:38	02:59	72-45.07N	168-14.90W	56.0	46.6	-	50.5	51.0	041M030	
043	8	091813	06:38	06:43	72-36.07N	168-14.98W	55.0	43.5	-	49.5	50.0	043M008	no sampling water
041	31	091813	08:41	09:02	72-44.96N	168-15.08W	56.0	46.4	-	50.5	51.0	041M031	
044	8	091813	12:34	12:38	72-45.11N	167-44.78W	55.0	44.8	-	48.5	49.0	044M008	no sampling water
041	32	091813	14:40	14:59	72-45.31N	168-14.65W	56.0	43.9	-	49.5	50.0	041M032	
045	8	091813	18:32	18:36	72-45.01N	168-45.40W	59.0	49.0	-	53.4	54.0	045M008	no sampling water
041	33	091813	20:39	21:10	72-44.92N	168-15.02W	56.0	45.3	-	49.5	50.0	041M033	
042	9	091913	00:31	00:35	72-54.05N	168-15.13W	59.0	49.2	-	52.4	53.0	042M009	no sampling water
041	34	091913	02:38	03:00	72-45.08N	168-15.03W	56.0	46.3	5.9	49.5	50.0	041M034	
043	9	091913	06:40	06:45	72-36.06N	168-15.09W	55.0	45.3	-	50.5	51.0	043M009	no sampling water
041	35	091913	08:41	09:03	72-44.91N	168-15.31W	56.0	45.7	-	50.5	51.0	041M035	
044	9	091913	12:37	12:42	72-45.07N	167-45.21W	55.0	45.9	-	50.5	51.0	044M009	no sampling water
041	36	091913	14:42	15:02	72-45.18N	168-15.34W	56.0	44.8	-	51.5	52.0	041M036	
045	9	091913	18:31	18:36	72-45.08N	168-45.31W	59.0	48.1	-	55.4	56.0	045M009	no sampling water
041	37	091913	20:40	21:01	72-44.88N	168-15.13W	56.0	44.4	-	49.5	50.0	041M037	
042	10	092013	00:39	00:44	72-53.94N	168-15.13W	58.0	47.9	-	52.5	53.0	042M010	no sampling water
041	38	092013	02:39	02:59	72-45.05N	168-15.29W	56.0	46.6	-	51.5	52.0	041M038	
043	10	092013	06:39	06:45	72-36.07N	168-15.15W	54.0	44.4	-	49.5	50.0	043M010	no sampling water
041	39	092013	08:45	09:09	72-44.60N	168-15.23W	56.0	46.1	-	51.5	52.0	041M039	
044	10	092013	12:55	13:00	72-45.25N	167-44.92W	55.0	45.0	-	50.5	51.0	044M010	no sampling water

041	40	092013	14:43	15:03	72-44.79N	168-14.91W	56.0	46.3	-	52.5	53.0	041M040	
045	10	092013	18:31	18:36	72-45.07N	168-45.51W	59.0	47.7	-	53.4	54.0	045M010	no sampling water
041	41	092013	20:42	21:17	72-44.93N	168-14.45W	56.0	45.9	-	51.5	52.0	041M041	
042	11	092113	00:37	00:42	72-54.08N	168-15.60W	58.0	46.1	-	53.4	54.0	042M011	no sampling water
041	42	092113	02:43	03:03	72-45.22N	168-15.45W	56.0	45.5	-	51.5	52.0	041M042	
043	11	092113	06:38	07:01	72-36.14N	168-15.40W	54.0	41.9	7.5	47.5	48.0	043M011	
041	43	092113	08:44	09:06	72-45.10N	168-14.37W	56.0	44.8	-	50.5	51.0	041M043	
044	11	092113	12:35	12:40	72-45.02N	167-45.08W	55.0	44.2	-	49.5	50.0	044M011	no sampling water
041	44	092113	14:42	15:03	72-45.04N	168-14.83W	56.0	44.2	-	51.5	52.0	041M044	
045	11	092113	18:31	18:36	72-45.02N	168-45.17W	59.0	49.6	-	55.4	56.0	045M011	no sampling water
041	45	092113	20:38	20:58	72-44.99N	168-15.07W	56.0	47.0	-	50.5	51.0	041M045	
042	12	092213	00:31	00:36	72-54.00N	168-15.33W	59.0	48.1	-	52.5	53.0	042M012	no sampling water
041	46	092213	02:38	03:01	72-45.02N	168-15.13W	56.0	45.2	-	50.5	51.0	041M046	
043	12	092213	06:41	07:02	72-36.04N	168-15.05W	55.0	44.8	-	49.5	50.0	043M012	
041	47	092213	08:39	09:01	72-45.00N	168-15.00W	56.0	47.4	6.1	50.5	51.0	041M047	
044	12	092213	12:33	12:39	72-45.06N	167-44.60W	55.0	46.3	-	50.5	51.0	044M012	no sampling water
041	48	092213	14:38	14:58	72-44.97N	168-14.86W	56.0	45.2	-	50.5	51.0	041M048	
045	12	092213	18:32	18:37	72-45.07N	168-45.15W	59.0	51.0	-	55.4	56.0	045M012	no sampling water
041	49	092213	20:40	21:10	72-44.99N	168-14.95W	56.0	48.1	-	50.5	51.0	041M049	
042	13	092313	00:33	00:38	72-54.05N	168-14.84W	59.0	51.0	-	53.4	54.0	042M013	no sampling water
041	50	092313	02:40	03:01	72-44.98N	168-15.13W	56.0	48.5	-	51.5	52.0	041M050	
043	13	092313	06:39	07:01	72-36.11N	168-14.66W	54.0	46.1	-	49.5	50.0	043M013	
041	51	092313	08:41	09:02	72-44.98N	168-14.81W	56.0	47.2	-	50.5	51.0	041M051	
044	13	092313	12:34	12:40	72-45.13N	167-44.45W	55.0	46.8	-	50.5	51.0	044M013	no sampling water
041	52	092313	14:39	14:59	72-44.95N	168-15.08W	56.0	46.4	-	50.5	51.0	041M052	
045	13	092313	18:31	18:35	72-45.06N	168-45.18W	59.0	48.5	6.5	52.4	53.0	045M013	no sampling water

041	53	092313	20:39	20:57	72-44.93N	168-14.83W	56.0	45.0	9.0	48.5	49.0	041M053	
042	14	092413	00:32	00:36	72-54.00N	168-15.03W	58.0	47.0	-	49.5	50.0	042M014	no sampling water
041	54	092413	02:39	03:01	72-44.99N	168-14.99W	56.0	47.7	-	50.5	51.0	041M054	
043	14	092413	06:39	07:00	72-36.02N	168-14.74W	54.0	47.4	-	49.5	50.0	043M014	
041	55	092413	08:41	09:03	72-45.00N	168-15.01W	56.0	47.5	-	50.5	51.0	041M055	
044	14	092413	12:36	12:41	72-45.00N	167-44.69W	55.0	46.3	-	49.5	50.0	044M014	no sampling water
041	56	092413	14:44	15:04	72-44.94N	168-15.30W	56.0	45.0	-	50.5	51.0	041M056	
045	14	092413	18:30	18:34	72-45.04N	168-44.72W	59.0	50.5	-	54.4	55.0	045M014	no sampling water
041	57	092413	20:40	21:08	72-45.03N	168-14.96W	56.0	47.0	-	50.5	51.0	041M057	
042	15	092513	00:33	00:55	72-54.00N	168-15.00W	59.0	49.9	-	53.4	54.0	042M015	
041	58	092513	02:39	03:00	72-44.96N	168-14.78W	56.0	47.2	-	51.5	52.0	041M058	
043	15	092513	06:40	07:03	72-36.20N	168-14.86W	54.0	46.4	-	49.5	50.0	043M015	
041	59	092513	08:46	09:07	72-45.29N	168-14.92W	56.0	47.5	-	50.5	51.0	041M059	
044	15	092513	12:35	12:41	72-44.92N	167-44.42W	55.0	47.2	-	50.5	51.0	044M015	no sampling water
046	1	092513	13:19	13:41	72-48.43N	167-46.56W	57.0	47.2	-	51.5	52.0	046M001	
041	60	092513	15:01	15:21	72-45.05N	168-14.92W	56.0	46.8	-	51.5	52.0	041M060	
045	15	092513	18:31	18:50	72-44.99N	168-45.27W	59.0	49.2	-	53.4	54.0	045M015	
041	61	092513	20:39	20:59	72-45.11N	168-14.88W	56.0	47.5	-	51.5	52.0	041M061	
047	1	092613	01:11	01:35	72-59.16N	168-55.75W	69.0	60.0	-	63.3	64.0	047M001	
048	1	092613	06:38	07:17	74-00.15N	168-45.05W	180.0	170.1	-	172.1	174.0	048M001	
049	1	092613	11:23	11:49	73-30.05N	168-45.73W	116.0	106.4	-	108.8	110.0	049M001	
050	1	092613	13:34	14:01	73-29.89N	167-45.16W	114.0	104.7	-	106.9	108.0	050M001	
051	1	092613	16:35	16:55	72-59.91N	167-45.02W	64.0	56.2	-	60.4	61.0	051M001	
052	1	092613	22:00	22:35	73-03.75N	164-37.14W	72.0	64.3	5.6	67.3	68.0	052M001	
053	1	092713	02:02	02:22	73-22.96N	163-17.94W	84.0	71.1	5.9	75.2	76.0	053M001	
054	1	092713	04:26	05:01	73-41.58N	162-39.10W	192.0	184.8	6.9	188.0	190.0	054M001	

055	1	092713	07:30	08:23	74-00.04N	161-59.63W	359.0	354.6	-	356.0	360.0	055M001	
056	1	092713	11:42	13:51	73-48.03N	159-59.38W	2652.0	2647.1	9.0	2637.5	2682.0	056M001	
057	1	092713	22:22	23:15	73-18.20N	160-50.02W	407.0	400.5	-	402.4	407.0	057M001	
058	1	092813	02:09	02:45	73-08.99N	162-18.73W	195.0	185.4	6.5	188.0	190.0	058M001	
059	1	092813	05:31	05:47	72-44.32N	162-28.45W	48.0	36.9	-	39.6	40.0	059M001	
045	16	093013	18:30	18:50	72-45.06N	168-45.32W	59.0	47.5	-	50.5	51.0	045M016	
041	62	093013	20:58	21:36	72-45.11N	168-15.42W	56.0	48.3	-	50.5	51.0	041M062	
042	16	100113	00:30	00:51	72-54.01N	168-14.98W	58.0	45.7	-	49.5	50.0	042M016	
041	63	100113	02:40	03:01	72-45.06N	168-14.83W	56.0	48.7	-	51.5	52.0	041M063	
043	16	100113	06:37	06:59	72-35.98N	168-14.79W	54.0	47.0	-	50.5	51.0	043M016	
041	64	100113	08:41	09:02	72-44.98N	168-15.11W	56.0	47.5	-	51.5	52.0	041M064	
044	16	100113	12:34	12:55	72-45.06N	167-44.12W	55.0	46.4	-	49.5	50.0	044M016	
041	65	100113	14:38	14:57	72-44.91N	168-14.94W	56.0	44.4	-	48.5	49.0	041M065	
060	1	100113	19:29	19:59	72-30.17N	168-45.05W	58.0	47.4	-	50.5	51.0	060M001	
061	1	100113	22:44	23:06	72-00.04N	168-44.63W	50.0	41.3	5.1	45.5	46.0	061M001	
062	1	100213	02:03	02:22	71-30.02N	168-44.80W	48.0	39.8	-	42.6	43.0	062M001	
063	1	100213	05:07	05:22	70-59.97N	168-44.98W	44.0	33.8	-	38.6	39.0	063M001	
064	1	100213	08:17	08:33	70-30.00N	168-44.94W	38.0	29.9	5.1	33.6	34.0	064M001	
065	1	100213	12:03	12:20	70-00.06N	168-44.96W	40.0	32.5	4.5	35.6	36.0	065M001	
066	1	100213	15:05	15:21	69-30.00N	168-44.72W	51.0	38.7	-	42.6	43.0	066M001	
067	1	100213	18:02	18:21	69-00.08N	168-44.84W	52.0	43.7	-	46.5	47.0	067M001	
068	1	100213	22:55	23:08	68-18.08N	167-02.75W	38.0	27.5	-	29.7	30.0	068M001	
069	1	100313	00:57	01:01	68-14.98N	167-12.09W	45.0	36.2	-	38.6	39.0	069M001	no sampling water
070	1	100313	01:37	01:55	68-12.12N	167-20.03W	47.0	36.3	-	39.6	40.0	070M001	
071	1	100313	03:53	03:56	68-06.06N	167-40.59W	52.0	41.5	-	44.5	45.0	071M001	no sampling water
072	1	100313	05:05	05:24	68-00.15N	168-00.22W	54.0	42.2	-	45.5	46.0	072M001	

073	1	100313	07:06	07:10	67-52.40N	168-15.08W	57.0	47.5	6.2	50.5	51.0	073M001	• changed a cable of the fluorescence (gain 30x - gain 10x) • no sampling water
074	1	100313	08:38	08:58	67-44.90N	168-30.03W	49.0	40.6	-	43.6	44.0	074M001	
075	1	100313	15:05	15:21	68-30.07N	168-44.98W	53.0	40.2	-	44.5	45.0	075M001	
076	1	100313	17:34	17:53	68-15.01N	168-45.04W	56.0	45.5	-	49.5	50.0	076M001	
077	1	100313	20:29	21:07	68-00.05N	168-45.37W	58.0	47.2	-	50.5	51.0	077M001	
078	1	100413	00:06	00:24	67-45.04N	168-45.03W	50.0	40.9	-	44.6	45.0	078M001	
079	1	100413	02:35	02:52	67-29.97N	168-44.96W	49.0	39.6	-	42.6	43.0	079M001	
080	1	100413	05:08	05:24	67-15.05N	168-45.05W	47.0	36.5	-	40.6	41.0	080M001	
081	1	100413	07:39	07:55	67-00.03N	168-45.33W	45.0	36.5	-	40.6	41.0	081M001	
082	1	100413	11:06	11:25	66-30.07N	168-45.78W	51.0	41.5	-	45.5	46.0	082M001	
083	1	100413	14:39	14:57	65-59.99N	168-45.03W	52.0	39.8	-	44.6	45.0	083M001	
084	1	100413	18:21	18:50	65-45.80N	168-45.44W	51.0	40.0	-	44.6	45.0	084M001	
085	1	100413	20:19	20:24	65-42.28N	168-31.25W	53.0	43.0	-	46.5	47.0	085M001	no sampling water
086	1	100413	21:22	21:38	65-39.05N	168-15.10W	43.0	31.0	-	34.7	35.0	086M001	
087	1	101313	20:02	20:53	48-52.51N	166-36.87E	6111.0	1190.5	-	1190.4	1204.0	087M001	• Leg2 • RM cast • changed a cable of the fluorescence (gain 10x - gain 30x)
087	2	101313	23:04	23:53	48-51.64N	166-35.35E	6092.0	1210.7	-	1188.4	1202.0	087M002	• Leg2 • RM cast

A/R test cast: Acoustic Releasers test cast

RM cast: Reference Material cast

3.2. XCTD

(1) Personnel

Shigeto Nishino	JAMSTEC PI
Jun Inoue	JAMSTEC/NIPR
Yusuke Kawaguchi	JAMSTEC
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

To investigate ocean 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 143 probes (XCTD-1 ~ XCTD-143) by using automatic launcher. The summary of XCTD observation log is shown in Table 3.2-1.

(5) Observation log

Table3.2-1. 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	2013/09/04	20:02	71-38.4943	154-55.2481	61	2.704	27.249	11011561
2	XCTD-2	2013/09/04	21:47	71-41.9048	155-03.8591	159	2.975	25.944	11011560
3	XCTD-3	2013/09/05	00:14	71-45.9112	155-14.3367	228	3.116	26.088	11011563
4	XCTD-4	2013/09/05	02:01	71-51.1150	155-24.7504	159	3.331	27.056	11011562
5	XCTD-5	2013/09/05	02:17	71-53.5134	155-32.2418	156	3.315	27.657	11011569

Table3.2-1. (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
6	XCTD-6	2013/09/05	04:15	72-01.2236	155-29.2257	211	3.335	28.154	11011566
7	XCTD-7	2013/09/05	04:46	72-06.5502	155-18.8737	366	2.372	26.888	11011565
8	XCTD-8	2013/09/05	05:15	72-11.8725	155-08.5420	1016	2.754	25.778	11011558
9	XCTD-9	2013/09/05	05:49	72-17.1837	154-58.1364	1884	2.873	25.601	11011567
10	XCTD-10	2013/09/05	06:18	72-22.4976	154-48.1017	2237	2.680	25.927	11011559
11	XCTD-11	2013/09/05	06:51	72-29.9981	154-48.0435	2521	2.224	25.858	11011564
12	XCTD-12	2013/09/05	07:53	72-39.9791	154-48.1281	2876	0.297	26.265	11011568
13	XCTD-13	2013/09/06	04:03	71-36.5250	154-50.7075	43	2.342	27.740	13041459
14	XCTD-14	2013/09/06	04:16	71-38.4814	154-55.1652	58	2.555	26.810	13041467
15	XCTD-15	2013/09/06	04:29	71-40.8386	154-58.4660	106	2.555	27.363	13041460
16	XCTD-16	2013/09/06	04:43	71-41.9075	155-03.9833	157	2.693	27.421	13041457
17	XCTD-17	2013/09/06	04:56	71-44.0514	155-07.1814	249	2.932	26.146	13041458
18	XCTD-18	2013/09/06	05:12	71-45.9193	155-14.3260	226	3.090	26.118	13041456
19	XCTD-19	2013/09/06	05:42	71-48.7464	155-17.6367	197	3.153	26.043	13041466
20	XCTD-20	2013/09/06	06:08	71-51.9932	155-29.7400	151	3.113	26.711	13041465
21	XCTD-21	2013/09/06	06:34	71-55.8871	155-39.4391	139	3.220	27.214	13041461
22	XCTD-22	2013/09/07	07:09	72-50.3474	155-01.0741	3232	0.328	26.090	13072720
23	XCTD-23	2013/09/07	08:19	72-57.0839	155-41.9493	3100	0.614	26.263	13072715
24	XCTD-24	2013/09/07	09:41	73-04.0381	156-24.3632	2830	0.673	25.833	13072717
25	XCTD-25	2013/09/07	10:51	73-11.0626	157-06.4706	2835	0.951	25.983	13072713
26	XCTD-26	2013/09/07	12:05	73-18.0211	157-47.9944	2664	1.642	26.705	13072718
27	XCTD-27	2013/09/07	13:11	73-24.9754	158-29.9880	2390	1.044	26.172	13072721
28	XCTD-28	2013/09/07	14:16	73-31.8324	159-10.9973	2519	0.287	26.119	13041462
29	XCTD-29	2013/09/07	15:34	73-39.0203	159-54.0830	2408	0.381	26.350	13041463
30	XCTD-30	2013/09/07	16:42	73-46.0096	160-36.0067	2015	0.930	26.085	13041464
31	XCTD-31	2013/09/07	17:55	73-53.0038	161-17.9748	413	1.786	26.146	13072716
32	XCTD-32	2013/09/07	19:02	73-59.9631	161-59.9910	361	0.869	26.056	13072719
33	XCTD-33	2013/09/07	20:19	74-14.9489	162-00.0339	1288	1.524	26.280	13072714
34	XCTD-34	2013/09/07	22:01	74-29.8133	161-59.3492	1631	0.299	26.156	13072710
35	XCTD-35	2013/09/08	01:34	74-45.0001	162-03.7114	1873	0.171	26.200	13072711
36	XCTD-36	2013/09/08	03:27	74-47.9089	161-59.4904	1901	-1.003	25.892	13072722
37	XCTD-37	2013/09/09	11:10	74-15.0743	162-41.4584	1015	1.039	26.060	13072730
38	XCTD-38	2013/09/09	12:09	74-20.0088	163-22.2083	790	0.959	26.131	13072733
39	XCTD-39	2013/09/09	13:08	74-24.9928	164-03.5950	509	0.903	26.398	13072729
40	XCTD-40	2013/09/09	14:09	74-29.9929	164-45.0028	381	0.600	26.011	13072732
41	XCTD-41	2013/09/09	15:26	74-30.0011	165-45.0092	370	0.682	26.163	13072728
42	XCTD-42	2013/09/09	16:45	74-29.9982	166-44.9661	322	0.520	26.066	13072712
43	XCTD-43	2013/09/09	18:06	74-30.0089	167-44.9804	305	0.152	26.274	13072726
44	XCTD-44	2013/09/09	19:37	74-15.0065	168-15.9742	224	-0.246	26.388	13072725
45	XCTD-45	2013/09/10	01:07	73-44.9977	168-44.3918	147	-0.459	26.521	13072734

Table3.2-1. (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
46	XCTD-46	2013/09/10	03:09	73-30.0038	168-17.5372	115	-0.843	26.767	13072724
47	XCTD-47	2013/09/10	06:42	73-14.9909	168-21.0628	74	0.452	28.622	13072727
48	XCTD-48	2013/09/10	13:48	72-30.0254	168-15.0268	53	3.414	31.411	13072723
49	XCTD-49	2013/09/11	01:12	72-49.5034	168-14.9311	57	3.145	31.219	13072739
50	XCTD-50	2013/09/11	07:26	72-40.4950	168-14.9945	55	3.067	31.124	13072740
51	XCTD-51	2013/09/11	13:20	72-44.9973	167-59.9097	57	2.594	31.184	13072741
52	XCTD-52	2013/09/11	19:22	72-45.0109	168-30.0079	55	2.700	30.825	13072742
53	XCTD-53	2013/09/12	01:19	72-49.4985	168-15.0151	57	2.756	31.019	13072743
54	XCTD-54	2013/09/12	07:24	72-40.4950	168-15.0896	55	2.959	31.326	13072736
55	XCTD-55	2013/09/12	13:30	72-44.9932	167-59.8840	57	2.831	31.283	13072737
56	XCTD-56	2013/09/12	19:24	72-45.0149	168-29.9933	55	2.552	30.758	13072738
57	XCTD-57	2013/09/13	01:26	72-49.4988	168-14.9055	57	2.526	30.858	13072748
58	XCTD-58	2013/09/13	05:56	72-40.5055	168-15.0137	55	3.215	31.139	13072747
59	XCTD-59	2013/09/13	13:30	72-45.0169	167-59.8989	57	3.094	31.361	13072746
60	XCTD-60	2013/09/13	18:06	72-44.9997	168-29.9922	55	2.627	30.768	13072744
61	XCTD-61	2013/09/14	01:27	72-49.4991	168-15.0520	55	3.200	31.152	13072755
62	XCTD-62	2013/09/14	05:57	72-40.4989	168-15.0485	55	3.005	31.246	13072745
63	XCTD-63	2013/09/14	13:34	72-44.9865	167-59.8820	57	3.021	31.424	13072749
64	XCTD-64	2013/09/14	18:00	72-44.9999	168-30.0074	55	3.032	31.152	13072750
65	XCTD-65	2013/09/15	01:36	72-49.4902	168-14.9182	56	2.780	31.364	13072735
66	XCTD-66	2013/09/15	05:55	72-40.4969	168-15.0153	55	3.005	31.397	13072751
67	XCTD-67	2013/09/15	13:30	72-45.0056	167-59.9306	57	2.283	31.446	13072752
68	XCTD-68	2013/09/15	17:57	72-44.9971	168-29.9833	55	2.964	31.311	13072753
89	XCTD-69	2013/09/16	01:30	72-49.4916	168-15.0594	54	2.793	31.415	13072760
70	XCTD-70	2013/09/16	05:56	72-40.4970	168-14.9565	55	2.872	31.459	13072754
71	XCTD-71	2013/09/16	13:29	72-45.0191	167-59.9050	58	2.697	31.405	13072756
72	XCTD-72	2013/09/16	17:57	72-45.0057	168-30.0256	55	2.976	31.400	13072757
73	XCTD-73	2013/09/17	01:30	72-49.4869	168-15.0278	54	2.671	31.425	13072758
74	XCTD-74	2013/09/17	06:00	72-40.4958	168-14.9825	55	2.728	31.494	13072759
75	XCTD-75	2013/09/17	13:30	72-45.0078	167-59.9047	58	2.830	31.546	13072763
76	XCTD-76	2013/09/17	17:59	72-44.9938	168-29.9804	55	2.901	31.390	13072762
77	XCTD-77	2013/09/18	01:29	72-49.4861	168-15.0497	56	2.610	31.351	13072761
78	XCTD-78	2013/09/18	06:02	72-40.4903	168-14.9937	55	2.761	31.556	13072646
79	XCTD-79	2013/09/18	13:31	72-45.0006	167-59.9048	57	2.678	31.527	13072645
80	XCTD-80	2013/09/18	17:58	72-44.9989	168-29.9871	55	2.500	31.390	13072644
81	XCTD-81	2013/09/19	01:31	72-49.4882	168-14.9064	55	2.473	31.368	13072643
82	XCTD-82	2013/09/19	05:57	72-45.5037	168-14.9999	55	2.576	31.471	13072702
83	XCTD-83	2013/09/19	13:24	72-44.39892	167-59.9374	57	2.428	31.508	13072703
84	XCTD-84	2013/09/19	17:56	72-44.9881	168-30.0143	55	2.301	31.396	13072704
85	XCTD-85	2013/09/20	01:33	72-49.4801	168-15.0386	56	2.167	31.473	13072705

Table3.2-1. (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
86	XCTD-86	2013/09/20	05:54	72-40.4976	168-15.0311	55	2.612	31.625	13072706
87	XCTD-87	2013/09/20	13:45	72-45.0097	167-59.9018	57	2.158	31.548	13072707
88	XCTD-88	2013/09/20	17:56	72-44.9890	168-30.0029	54	2.086	31.612	13072708
89	XCTD-89	2013/09/21	01:37	72-49.4761	168-15.1431	54	2.038	31.647	13072709
90	XCTD-90	2013/09/21	05:52	72-40.4970	168-14.9510	55	2.455	31.614	13072767
91	XCTD-91	2013/09/21	13:39	72-44.9915	168-00.4158	57	2.013	31.661	13072766
92	XCTD-92	2013/09/21	17:58	72-44.9969	168-29.9936	55	1.730	31.661	13072765
93	XCTD-93	2013/09/22	01:26	72-49.5031	168-14.9642	54	1.852	31.381	13072764
94	XCTD-94	2013/09/22	05:58	72-40.4940	168-15.0722	55	2.229	31.619	13072768
95	XCTD-95	2013/09/22	13:34	72-45.0056	167-59.9079	57	1.743	31.135	13072769
96	XCTD-96	2013/09/22	17:57	72-45.0082	168-30.0117	55	1.643	31.641	13072770
97	XCTD-97	2013/09/23	01:33	72-49.5039	168-15.0659	55	1.626	31.623	13072771
98	XCTD-98	2013/09/23	05:56	72-40.4977	168-15.0040	55	1.970	31.643	13072772
99	XCTD-99	2013/09/23	13:35	72-44.9955	167-59.9149	57	1.705	31.639	13072773
100	XCTD-100	2013/09/23	17:58	72-45.0080	168-29.9944	55	1.971	31.646	13072774
101	XCTD-101	2013/09/24	01:32	72-49.5034	168-15.0005	55	1.896	31.637	13072775
102	XCTD-102	2013/09/24	05:56	72-40.4981	168-14.9984	55	2.113	31.580	13072776
103	XCTD-103	2013/09/24	13:34	72-44.9998	168-00.0287	57	1.670	31.640	13072777
104	XCTD-104	2013/09/24	17:56	72-45.0065	168-30.0294	55	2.115	31.603	13072778
105	XCTD-105	2013/09/25	01:42	72-49.5012	168-15.0035	55	1.519	31.559	13072779
106	XCTD-106	2013/09/25	06:02	72-40.4984	168-14.9812	55	2.008	31.536	13072780
107	XCTD-107	2013/09/25	14:19	72-44.9921	168-59.8954	57	2.066	31.508	13072781
108	XCTD-108	2013/09/25	17:57	72-45.0013	168-30.0076	55	1.907	31.625	13072782
109	XCTD-109	2013/09/27	09:34	73-56.0077	161-19.9924	407	-0.207	26.678	13072783
110	XCTD-110	2013/09/27	10:29	73-52.0366	160-40.4385	2178	-0.308	26.518	13072784
111	XCTD-111	2013/09/27	19:55	73-37.9626	160-16.4763	2206	0.799	27.226	13072785
112	XCTD-112	2013/09/27	21:00	73-27.9156	160-32.9355	1424	0.754	27.504	13072786
113	XCTD-113	2013/09/28	00:29	73-13.3033	161-34.6853	256	0.825	27.476	13072787
114	XCTD-114	2013/09/29	05:55	72-55.5492	156-28.0040	2652	-0.251	25.844	13072796
115	XCTD-115	2013/09/29	06:05	72-57.2794	156-31.4269	2706	-0.133	25.797	13072797
116	XCTD-116	2013/09/29	06:15	72-59.0119	156-34.9086	2659	0.071	26.155	13072805
117	XCTD-117	2013/09/29	06:24	73-00.7506	156-38.2598	2549	0.090	26.292	13072802
118	XCTD-118	2013/09/29	06:34	73-02.4642	156-41.5773	2624	-0.015	26.523	13072788
119	XCTD-119	2013/09/29	06:44	73-04.1954	156-45.0510	2635	0.125	26.504	13072789
120	XCTD-120	2013/09/29	06:54	73-05.9290	156-48.4415	2631	0.233	26.375	13072790
121	XCTD-121	2013/09/29	07:04	73-07.6642	156-51.9865	2556	0.242	26.336	13072791
122	XCTD-122	2013/09/29	07:14	73-09.3829	156-55.3282	2871	0.260	26.378	13072792
123	XCTD-123	2013/09/29	07:25	73-11.1108	156-59.0157	3018	0.035	26.301	13072793
124	XCTD-124	2013/09/29	08:20	73-05.1929	156-39.1546	2717	0.265	26.327	13072794
125	XCTD-125	2013/09/29	08:28	73-04.1880	156-44.9850	2641	0.216	26.380	13072795

Table3.2-1. (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
126	XCTD-126	2013/09/29	08:37	73-03.1771	156-51.0824	2566	0.116	26.476	13072806
127	XCTD-127	2013/09/29	08:44	73-02.1728	156-56.9812	2439	0.207	26.503	13072809
128	XCTD-128	2013/09/29	08:52	73-01.1686	157-02.7193	2230	0.230	26.523	13072810
129	XCTD-129	2013/09/29	09:00	73-00.1579	157-08.5539	2056	0.174	26.553	13072808
130	XCTD-130	2013/09/29	09:08	72-59.1529	157-14.2922	2096	0.210	26.548	13072811
131	XCTD-131	2013/09/29	09:16	72-58.1481	157-20.2942	2183	0.280	26.222	13072804
132	XCTD-132	2013/09/29	09:24	72-57.1411	157-26.3717	2181	0.192	25.948	13072801
133	XCTD-133	2013/09/29	09:32	72-56.1332	157-32.2886	1945	0.219	25.918	13072798
134	XCTD-134	2013/09/29	10:17	72-49.3140	157-05.8386	1723	-0.125	25.865	13072807
135	XCTD-135	2013/09/29	11:03	72-38.5110	157-08.6033	447	0.125	25.852	13072803
136	XCTD-136	2013/09/29	13:39	72-14.1859	157-19.9546	121	-0.014	27.944	13072813
137	XCTD-137	2013/09/29	13:52	71-55.5006	157-26.2338	72	0.653	29.019	13072812
138	XCTD-138	2013/09/30	19:34	72-44.9967	168-30.0071	53	0.348	30.889	13072817
139	XCTD-139	2013/10/01	01:41	72-49.4999	168-15.0857	55	-0.561	29.057	13072816
140	XCTD-140	2013/10/01	05:55	72-40.4965	168-15.0160	55	1.335	31.482	13072815
141	XCTD-141	2013/10/01	12:02	72-45.0005	167-56.1140	57	1.331	31.384	13072814
142	XCTD-142	2013/10/03	23:16	67-52.4912	168-44.8730	52	1.107	32.306	13072818
143	XCTD-143	2013/10/04	01:25	67-37.4985	168-45.0404	49	2.185	31.102	13072819

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 “R/V Mirai Data Web Page” in JAMSTEC web site.

3.3. Shipboard ADCP

(1) Personnel

Yusuke Kawaguchi	JAMSTEC: principal investigator
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Ryo Ohyama	MIRAI Crew

(2) Objectives

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

(3) Instruments and methods

Upper ocean current measurements were made in MR13-06 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 76.8 kHz; Teledyne RD Instruments, USA). 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 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 & Fugro Multifix ver.6) providing precise ship's position.
4. We used VmDas software version 1.46.5 (TRDI) 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. Fresh water is charged in the sea chest to prevent bio fouling at transducer face.
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 "8 m" intervals starting about 23 m below sea

surface. Data was recorded every ping 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 3.3-1.

Table 3.3-1. Major parameters

Bottom-Track Commands

BP = 001 Pings per Ensemble (almost less than 1,200m depth)

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 Coordinate Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 10200010 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 = 0800 Blank After Transmit (cm)
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 (1-128)
WP = 00001 Pings per Ensemble (0-16384)
WS = 800 Depth Cell Size (cm)
WT = 000 Transmit Length (cm) [0 = Bin Length]
WV = 0390 Mode 1 Ambiguity Velocity (cm/s radial)

(4) Preliminary results

Based on measurements using the shipboard ADCP, we successfully captured oceanic circulation around an anticyclonic eddy in the Canada Basin (Figure 3.3-1). The eddy was discovered on September 5, 2013, at 200 km offshore in the northwest direction from the Barrow Canyon, and then, the eddy was reinvestigated on September 25 in greater detail. During the time interval between the first and second intense surveys by R/V Mirai, the same eddy had been in pursuit by Surface Velocity Profiler (SVP) (see Section 3.5.), identified as SVP8130. During the latter eddy survey, the shipboard ADCP measurement revealed some characteristic features of the eddy. For example, the eddy has an approximate diameter of 40 km, and it rotates clockwise with 30 cm s^{-1} in azimuthal direction (Figure 3.3-1b). From comparison with the SVP8130 trajectory, the ADCP current represented well the buoy motion along the pathway that it traveled (Figure 3.3-1a).

(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 JAMSTEC home page.

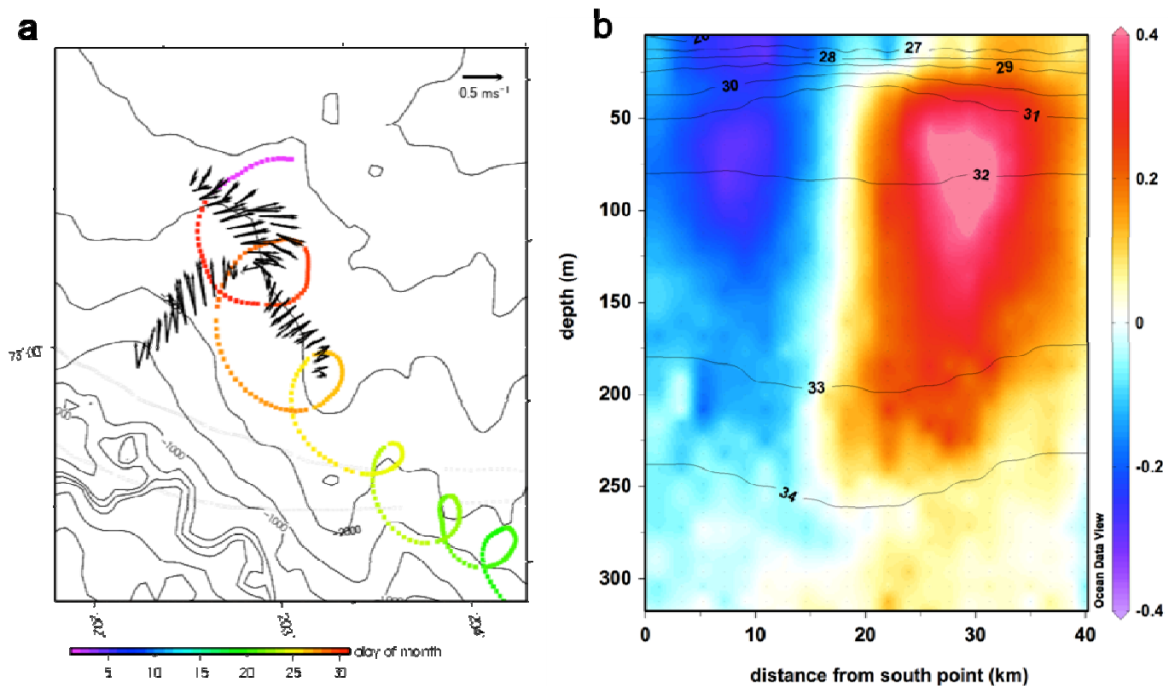


Figure 3.3-1. (a) horizontal current velocity at depths between 40 and 60 m, which were detected by shipboard ADCP. Color dots indicate the course of SVP8130. (b) vertical section of eastward current speed [m s^{-1}] detected by the shipboard ADCP. Velocity for the section was collected during a passage from southeast to northwest points.

3.4. Microstructure Observations

(1) Personnel

Yusuke Kawaguchi (JAMSTEC): Principal Investigator

Soichiro Sueyoshi (GODI): Operation Leader

Katsuhisa Maeno (GODI)

Masanori Murakami (GODI)

Koich Inagaki (GODI)

Ryo Oyama (Mirai crew)

(2) Objectives and methodology

To understand turbulent mixing and diapycnal heat transfer in upper part of the Arctic Ocean, microscale temperature and vertical shear data were collected during MR13-06. During the stationary point observation in the Chukchi Sea, the microstructure measurements were regularly and intensively conducted, where turbulent mixing and its evolution in ocean mixed layer were focuses on. Most of these microstructure measurements were performed at CTD stations for comparison with temporal changes in biogeochemical variables.

(3) Parameters

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

Parameter	Type	Range	Accuracy	Sampling rate
$\partial u / \partial z$ (primary)	Shear probe	0~10 /s	5%	512Hz
$T + \partial T / \partial z$	EPO-7 thermistor	-5~45°C	±0.01°C	512Hz

T	Platinum wire thermometer	-5~45°C	±0.01°C	64 Hz
Conductivity	Inductive Cell	0~70 mS	±0.01 mS	64 Hz
Depth	Semiconductor strain gauge	0~1000 m	±0.2%	64 Hz
x- acceleration	Solid-state fixed mass	±2 G	±1%	256 Hz
y- acceleration	Solid-state fixed mass	±2 G	±1%	256 Hz
z- acceleration	Solid-state fixed mass	±2 G	±1%	64Hz
Chlorophyll	Fluorescence	0~100 µg/Lm	0.5 µg/L or ±1%	256 Hz
Turbidity	Backscatter	0~100 ppm	1ppm or ±2%	256 Hz
$\partial u/\partial z$ (Secondary)	$\partial u/\partial z$ Shear	0~10 s ⁻¹	5%	512 Hz

(4) Instruments

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

(5) Station list

No.	Date [YYYY/MM/DD]	Longitude [deg-min]	Latitude [deg-min]	Logging Time		Depth [m]	Observation Depth [m]
				Start	Stop		
01	2013/09/03	157-51.9889	71-35.5216	8:14	8:18	64	41
02	2013/09/03	157-52.3986	71-35.6039	8:19	8:22	63	53
03	2013/09/12	168-15.5248	72-45.1726	3:05	3:10	56	44.6
04	2013/09/12	168-15.6876	72-45.1945	3:10	3:13	56	43
05	2013/09/13	168-15.5248	72-45.1726	3:05	3:06	56	45
06	2013/09/13	168-19.2859	72-45.3137	3:10	3:13	56	44
07	2013/09/14	168-15.1039	72-45.0856	3:09	3:13	56	50
08	2013/09/14	168-15.1039	72-45.0856	3:14	3:15	56	48
09	2013/09/14	168-15.6485	72-45.0270	15:17	15:20	56	43
10	2013/09/14	168-15.6485	72-45.0329	15:20	15:23	56	41
11	2013/09/15	168-14.9001	72-45.1262	3:11	3:14	56	49
12	2013/09/15	168-14.9461	72-45.1195	3:14	3:16	56	48
13	2013/09/15	168-15.4717	72-45.0244	15:17	15:20	56	46
14	2013/09/15	168-15.5488	72-45.0272	15:21	15:23	56	45
15	2013/09/16	168-15.4136	72-45.0822	3:08	3:11	56	49
16	2013/09/16	168-15.4302	72-45.0835	3:11	3:14	56	48
17	2013/09/16	168-14.6604	72-44.8861	15:10	15:13	56	48
18	2013/09/16	168-14.6484	72-44.9032	15:13	15:15	56	47
19	2013/09/17	168-15.2570	72-45.0550	3:08	3:11	56	47
20	2013/09/17	168-15.4353	72-45.1131	15:55	15:57	56	46
21	2013/09/17	168-15.4948	72-45.1112	15:57	15:59	56	41
22	2013/09/18	168-14.9672	72-45.2180	3:43	3:46	56	48
23	2013/09/18	168-14.9866	72-45.2235	3:46	3:50	56	48
24	2013/09/18	168-15.3952	72-45.4801	15:46	15:48	56	52
25	2013/09/18	168-15.4320	72-45.5002	15:49	15:51	56	47
26	2013/09/18	168-16.6468	72-45.1979	22:15	22:19	56	49

27	2013/09/18	168-16.6984	72-45.2045	22:21	22:24	56	50
28	2013/09/19	168-15.5380	72-45.2943	3:47	3:50	56	46
29	2013/09/19	168-15.5785	72-45.3073	3:51	3:53	56	49
30	2013/09/19	168-16.3999	72-45.7375	15:49	15:52	56	46
31	2013/09/19	168-16.4593	72-45.7620	15:53	15:55	56	51
32	2013/09/19	168-16.6756	72-45.5252	3:45	3:49	56	47
33	2013/09/19	168-16.7856	72-45.5463	3:49	3:51	56	48
34	2013/09/21	168-16.3812	72-45.3203	15:52	15:55	56	49
35	2013/09/21	168-16.4329	72-45.3300	15:56	15:58	56	50
36	2013/09/22	168-15.3386	72-45.0776	3:45	3:48	56	48
37	2013/09/22	168-15.4044	72-45.0820	3:48	3:50	56	49
38	2013/09/22	168-15.1468	72-45.2393	15:46	15:49	56	49
39	2013/09/22	168-15.1776	72-45.2683	15:49	15:52	56	49
40	2013/09/22	168-14.0175	72-45.2273	22:43	22:46	57	47
41	2013/09/22	168-13.9320	72-45.2227	22:48	22:50	57	49
42	2013/09/23	168-14.7729	72-45.1032	3:44	3:48	56	52
43	2013/09/23	168-14.7544	72-45.1174	3:48	3:50	56	51
44	2013/09/23	168-14.6715	72-45.2522	15:49	15:52	56	52
45	2013/09/23	168-14.6604	72-45.2614	15:52	15:54	56	50
46	2013/09/23	168-13.8486	72-45.4622	22:49	22:52	57	49
47	2013/09/23	168-13.8526	72-45.4656	22:53	22:57	57	49
48	2013/09/24	168-14.9544	72-45.1200	3:44	3:48	56	48
49	2013/09/24	168-14.9686	72-45.1362	3:49	3:51	56	47
50	2013/09/24	168-14.4046	72-45.1873	15:54	15:58	56	47
51	2013/09/24	168-14.3460	72-45.2069	15:59	16:01	56	49
52	2013/09/24	168-15.1958	72-45.6839	22:48	22:50	56	49
53	2013/09/24	168-15.1594	72-45.7135	22:51	22:54	56	48
54	2013/09/25	168-15.0410	72-45.3163	3:44	3:46	56	47
55	2013/09/25	168-15.0829	72-45.3411	3:49	3:51	56	48

56	2013/09/25	168-14.5646	72-44.9791	15:29	15:32	56	45
57	2013/09/25	168-14.4815	72-44.9695	15:33	15:36	56	46
58	2013/09/25	168-14.3521	72-45.1553	22:45	22:51	56	50
59	2013/09/25	168-14.2844	72-45.1457	22:51	22:55	56	50
60	2013/09/25	168-14.2257	72-45.1346	22:55	22:58	56	50
61	2013/09/30	168-14.8155	72-45.2836	22:44	22:47	56	50
62	2013/09/30	168-14.7784	72-45.2869	22:48	22:50	56	50
63	2013/10/01	168-14.5075	72-45.1735	3:10	3:13	56	50
64	2013/10/01	168-14.4691	72-45.1813	3:14	3:16	56	50
65	2013/10/01	168-14.3814	72-45.2626	3:32	3:34	56	50
66	2013/10/01	168-14.3700	72-45.2715	3:34	3:36	56	49
67	2013/10/01	168-14.4637	72-45.0134	15:06	15:11	56	48
68	2013/10/01	168-14.3264	72-45.0658	15:12	15:14	56	49
69	2013/10/03	167-02.7653	68-18.3618	0:09	0:12	38	30
70	2013/10/03	167-02.7690	68-18.3689	0:12	0:14	38	31
71	2013/10/03	167-19.7836	68-12.1813	2:18	2:22	47	40
72	2013/10/03	167-19.8162	68-12.2155	2:24	2:26	47	41
73	2013/10/03	167-40.3589	68-06.0753	3:29	3:34	52	46
74	2013/10/03	167-40.4582	68-06.0736	3:35	3:37	52	47
75	2013/10/03	168-00.4503	68-00.1313	5:31	5:36	54	48
76	2013/10/03	168-00.5897	68-00.1552	5:37	5:38	54	48
77	2013/10/03	168-45.5694	67-59.9253	22:18	22:22	58	51
78	2013/10/03	168-45.5625	67-59.9134	22:23	22:25	58	54
79	2013/10/03	168-45.5786	67-59.9105	22:26	22:28	58	53
80	2013/10/04	168-45.2533	65-45.7710	17:34	17:36	52	45
81	2013/10/04	168-45.2578	65-45.7683	17:37	17:39	52	44

(6) Technical report: noise corruption due to side-shift power thrusters

We will make a brief report for a test of side-shift power thrusters equipped at bow and stern sides of right-side gunwale from which the microstructure measurements are usually operated. In the experiment, we tried to clarify as to how much running the thrusters can give noise corruption on the micro-shear profiles as the device descends into water. Since the shallow mixed layer is the special focus at the stationary point observation, it is fairly important to make it clear an approximate noise level of the side-shift power thrusters onto the microscale shear data. The test was performed on September 26, when winds were relatively calm, weaker than 7 m s^{-1} , throughout the three-time falling tests. During the test, the instrument was lowered in the water three times successively (stations 58, 59, and 60). For the first lowering, the thrusters at bow and stern sides were both turned off for 5 minutes before the instrument was landed at water surface, and then, it was kept off while it descends. For the second and third falling experiments, those thrusters were kept purposely on running until the device starts to descend from the water line. Then, the thrusters were turned off as the device started to descend. From these experiments, we know that the thrusters could give huge noise corruption on micro-shear profiles within depths of 5 m below the water surface. Below 8 m depth, the noise corruption was however dramatically reduced, although there were still increased spikes on the profiles (they can be removed in the data processing). Thus, we conclude that the micro-shear profiles are valid to be analyzed for the depths below 8 m.

(7) 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.

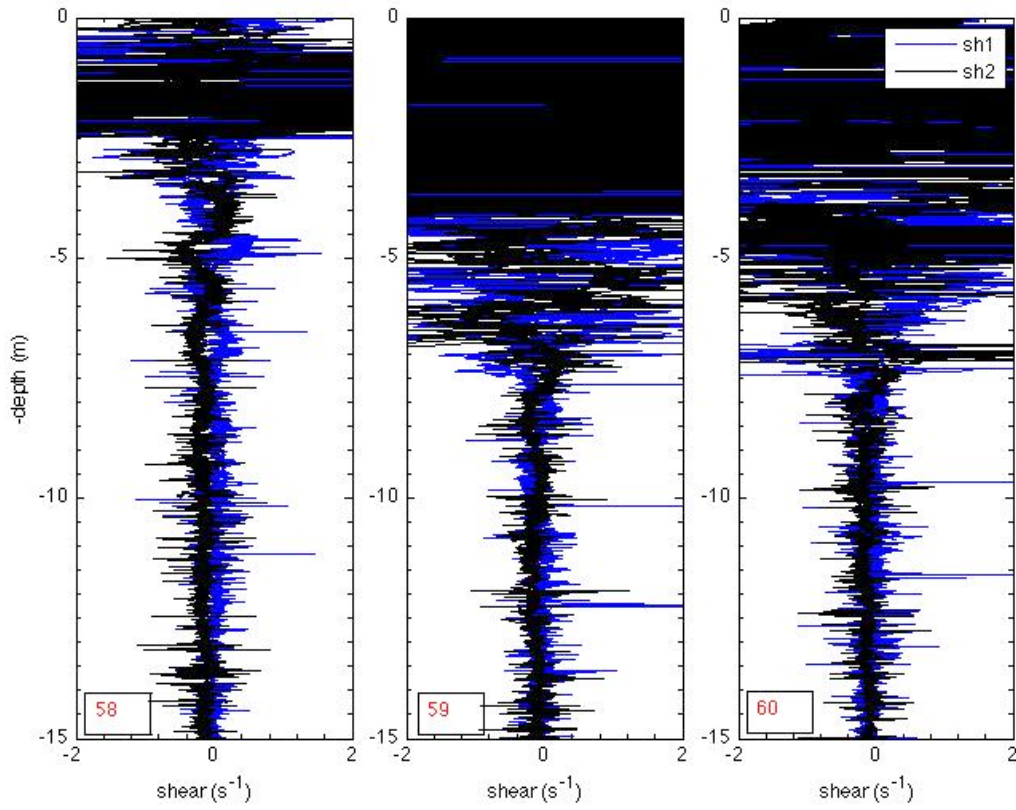


Figure 3.4-1. Micro-shear profiles taken at stations 58, 59 and 60, where noise level due to side-shift power thrusters were tested. Blue and black curves denote current shear [s^{-1}] detected with shear probes 1 and 2, respectively. For station 58, thrusts were turned off 5 minutes before the device was landed at water line, while for the stations 59 and 60 thrusters at bow and stern sides were kept on running until the device starts to descend in the water.

3.5. Subsurface Current Observation with Surface Velocity Profilers

(1) Personnel

Yusuke Kawaguchi (JAMSTEC): Principal investigator

Shigeto Nishino (JAMSTEC)

(2) Objectives

To examine subsurface ocean currents in open water region of the Pacific-side of Arctic Ocean.

(3) Instruments and methodology

We used drifting buoy systems (Surface Velocity Profiler, SVP) for which a storm drogue is tethered into subsurface water from surface floating units. The drogue is designed to capture representative current velocity at depths interested. We deployed four SVPs around jet-like structure at southern part of the Beaufort Gyre, where two buoys, SVP7120 and SVP9130, were deployed right on the jet feature and the other two buoys, SVP8130 and SVP5130, were put adjacent to an anti-cyclonic eddy. For this experiment, the drogues for SVP7120, 9130, and 8130, were uniformly rigged at 50 m depth at which major current is supposed to be centered, according to a prior survey on September 5, 2013. The one for SVP5130 was set at depth of 20 m.

In the stationary point observation between September 12th and 26th in the Chukchi Sea, we investigated vertical heat transfer between atmosphere and ocean during a transition from summer to winter. In the Chukchi Sea observation, we see that there were two distinctive layer systems vertically for thermohaline structure of seawater. For the central observation station, two SVPs were deployed to obtain the upper and lower parts of oceanic current, SVP0500 and SVP3130, which have the drogues at depths of 15 and 40 m from the water surface.

The all SVPs transmitted their GPS positioning data every an hour via the Iridium satellite by email as it drifts.

(4) Buoy deployment positions

Unit NO.	Deployment information			Drogue depth [m]
	Date [YYYY/MM/DD]	Longitude [deg-min]	Latitude [deg-min]	
SVP9130	2013/09/07	72-25.98	-154-53.80	50
SVP 7120	2013/09/07	72-31.95	-154-55.74	50
SVP 8130	2013/09/07	72-41.18	-154-51.56	50
SVP 5130	2013/09/07	72-49.69	-154-57.68	20
SVP 3130	2013/09/17	72-44.62	-168-13.85	15
SVP 0500	2013/09/17	72-45.84	-168-13.97	40

(5) Preliminary results

In the Canada Basin, the positioning data of SVP9130 and SVP7120 indicated that the jet flow goes along a pathway rather close to the shelf-break line of the Chukchi Sea shelf, where the current stream went across the North Wind Ridge to the east and entered a region inside the Chukchi Boarder Land (Figure 3.5-1). The anti-cyclonic eddy, tracked by SVP8130, showed that it traveled roughly along with the pathway of the jet until its middle way. The eddy moved the jet course off around 158°W, and then it went to the further north for the pack ice region.

For the stationary observation in the Chukchi Sea, according to the buoy motion, ocean currents were commonly dominated by an inertial oscillation with a period of ~12.5 hour. On September 26, we also revisited and investigated again the same water masses that we deployed the buoys at on September 17 (Figure 3.5-2). As the results, we could know how the water masses had been changed in their properties after they had drifted for two weeks.

(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 “R/V Mirai Data Web Page” in JAMSTEC web site.

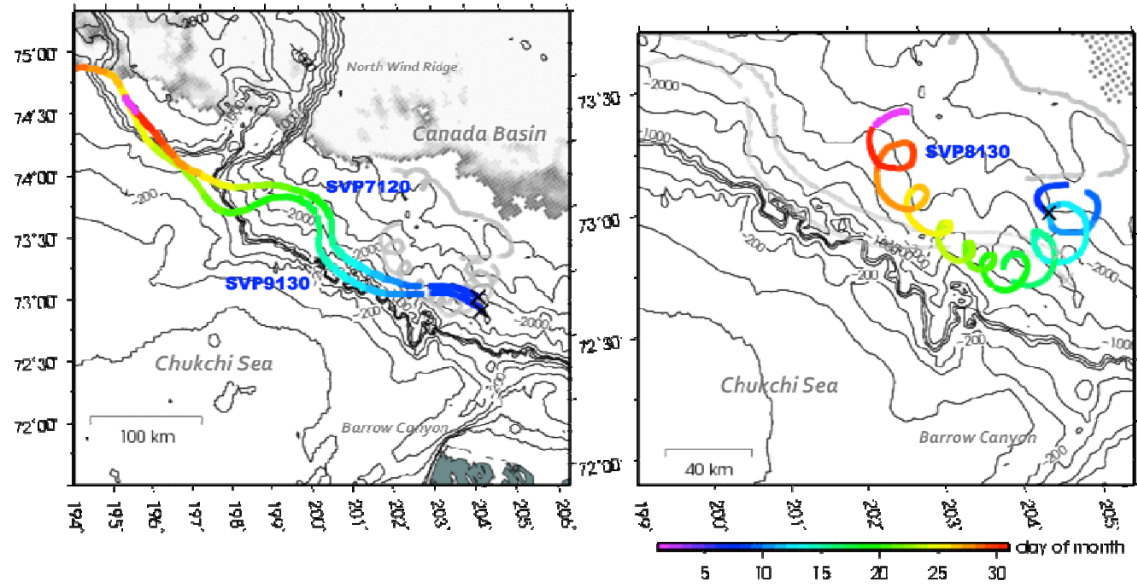


Figure 3.5-1. Drifting courses of buoys that were deployed in the Canada Basin: SVP7120 and SVP9130 (left panel) and SVP8130 (right panel). Color indicates day of each month that starts from September in 2013. Buoys were deployed at positions of × on September 7, 2013. Gray region displays sea ice concentration on September 23.

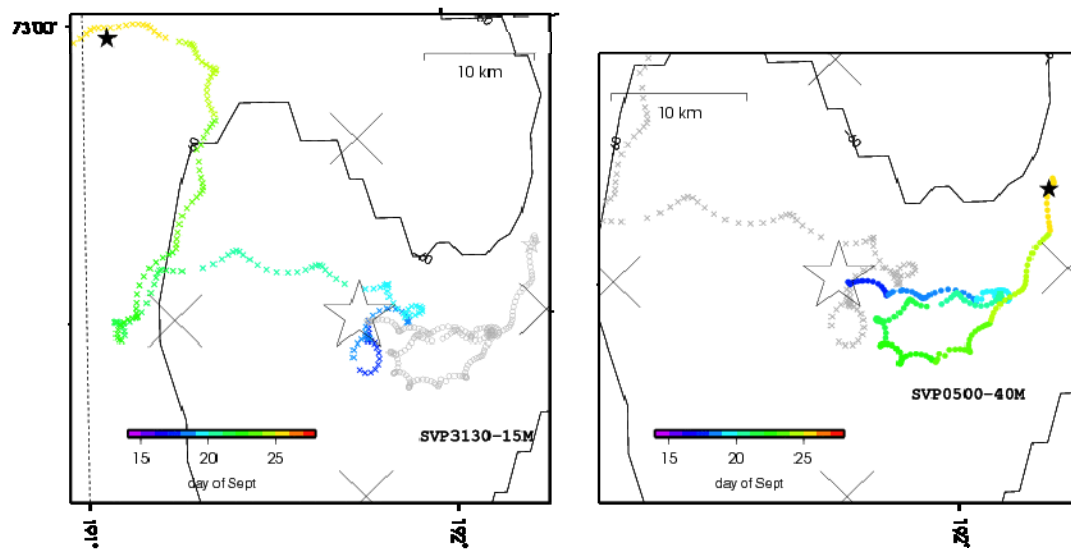


Figure 3.5-2. Travelling courses for SVP3130 (left) and SVP0500 (right) while the stationary observation campaign was conducted, where mid-depth drogues were deployed at 15 and 40 m depths, respectively. Deployment of both buoys were conducted at ☆ on September 17, 2013, and the water masses were tracked throughout the duration and reinvestigated on September 26 at ★.

3.6. Salinity Measurements

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal investigator
Tatsuya Tanaka (MWJ)

(2) Objective

To understand the spatial and temporal variation of salinity and 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 3.6-1.

Table 3.6-1. Types and numbers (n) of samples

Types	N
Samples for CTD and bucket	1738
Samples for TSG in Leg1	35
Samples for TSG in Leg2	9
Total	1782

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR13-06 Leg1 and Leg2 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62827) 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 \pm deg C	: 0.01 (24 hours @ 23 deg C \pm 1 deg C)
Repeatability	: \pm 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 22.5 deg C to 24.5 deg C, while the bath temperature was very stable and varied within \pm 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	: P155
conductivity ratio	: 0.99981
salinity	: 34.993
expiration date	: 19 th Sept 2015

Standardization control of the salinometer S/N 62827 was set to 507 (2th Sep.) and all measurements were carried out at this setting. The value of STANDBY was 5431 \pm 0001 and that of ZERO was 0.0+0000 \pm 0001. 87 bottles of SSW were measured in Leg1 and 2 bottles of SSW were measured in Leg2.

Figure3.6-1 shows the history of the double conductivity ratio of the Standard Seawater batch P155 before correction in Leg1. The average of the double conductivity ratio was 1.99959 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

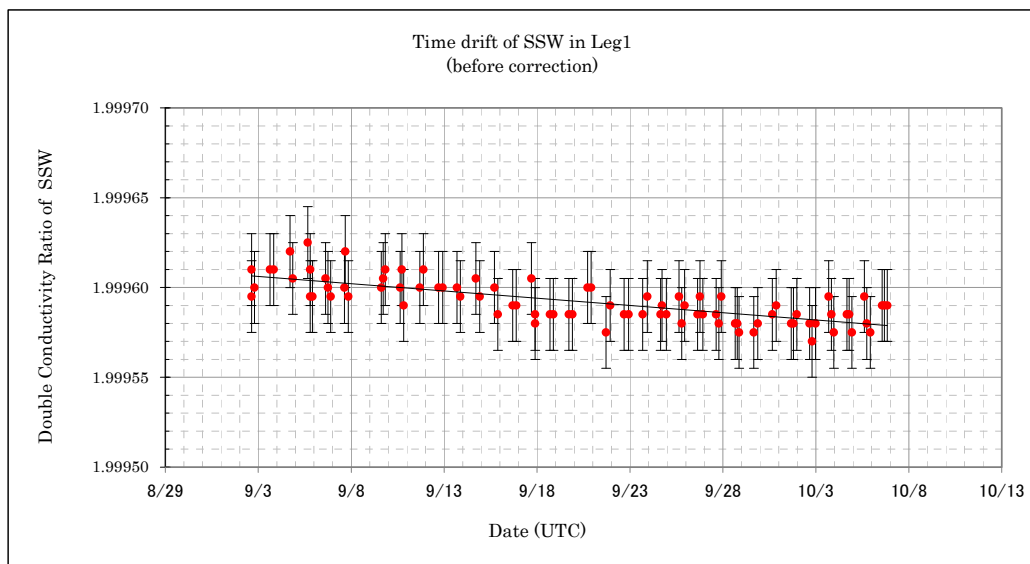


Figure 3.6-1. History of double conductivity ratio for the standard seawater batch P155 in Leg1 (before correction).

Figure3.6-2 shows the history of the double conductivity ratio of the Standard Seawater batch P155 after correction in Leg1. The average of the double conductivity ratio after correction was 1.99962 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

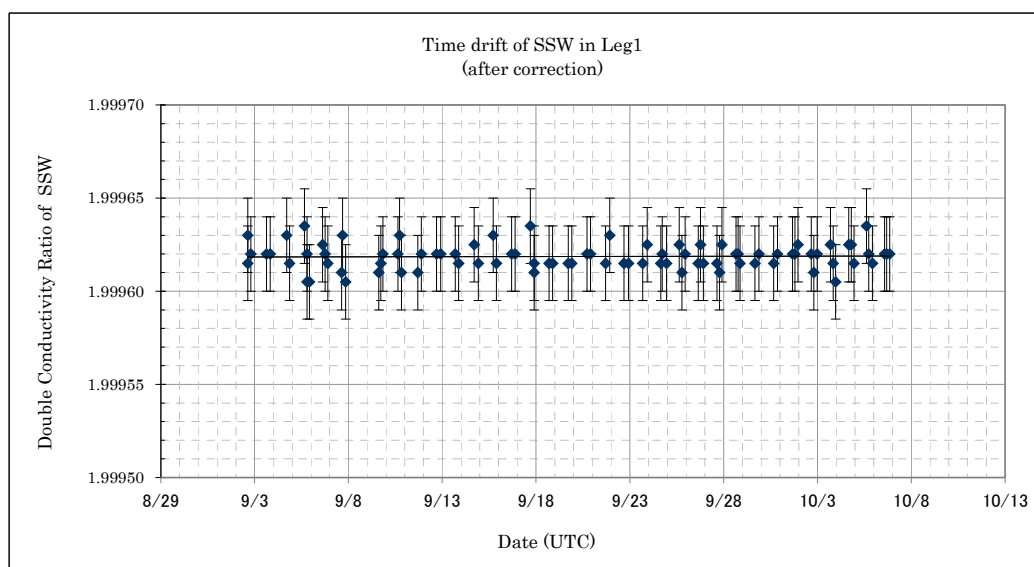


Figure 3.6-2. History of double conductivity ratio for the standard seawater batch P155 in Leg1 (after correction).

Figure 3.6-3 shows the history of the double conductivity ratio of the Standard Seawater batch P155 before correction in Leg1 and Leg2. The average of the double conductivity ratio was 1.99959 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

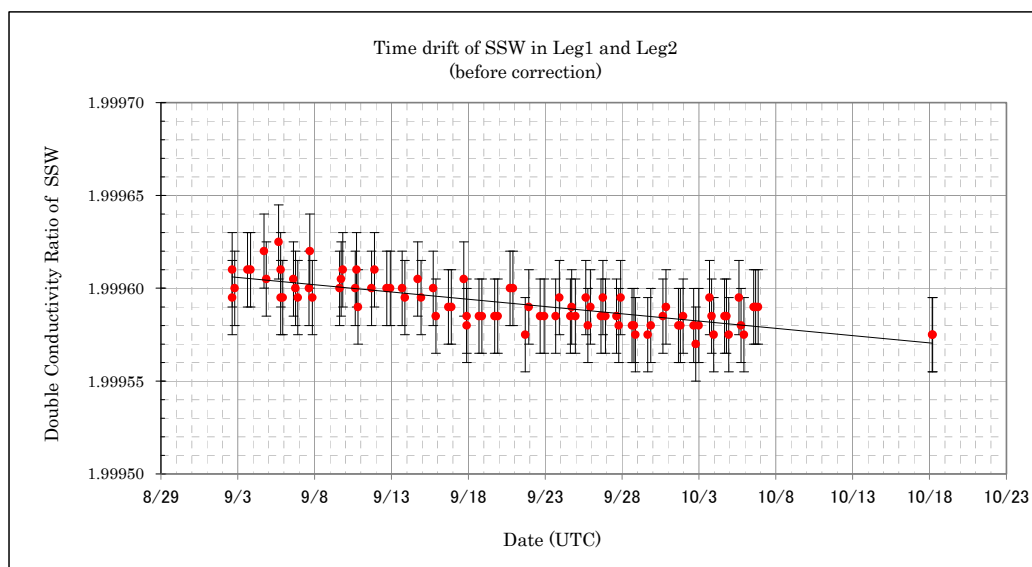


Figure 3.6-3. History of double conductivity ratio for the standard seawater batch P155 in Leg1 and Leg2 (before correction).

Figure 3.6-4 shows the history of the double conductivity ratio of the Standard Seawater batch P155 after correction in Leg1 and Leg2. The average of the double conductivity ratio after correction was 1.99962 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

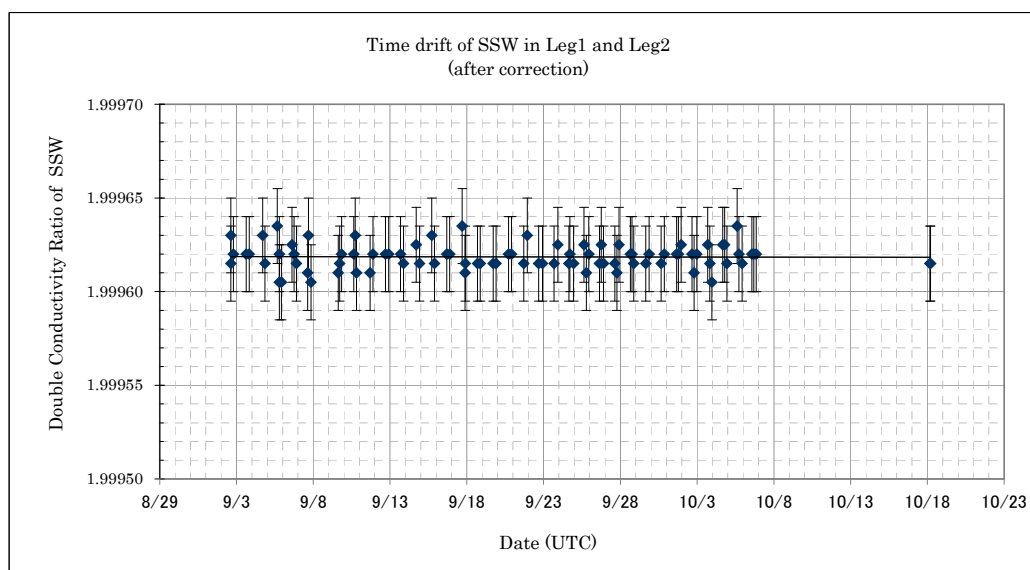


Figure 3.6-4. History of double conductivity ratio for the standard seawater batch P155 in Leg1 and Leg2 (after correction).

b. Sub-Standard Seawater

Sub-standard seawater was made from surface-sea water (poor in nutrient) filtered by a pore size of 0.45 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 314 pairs of replicate samples taken from the same Niskin bottle.

Figure 3.6-5 shows the histogram of the absolute difference between each pair of all replicate samples. The average and the standard deviation of absolute difference among 314 pairs were 0.0022 and 0.0066 in salinity, respectively.

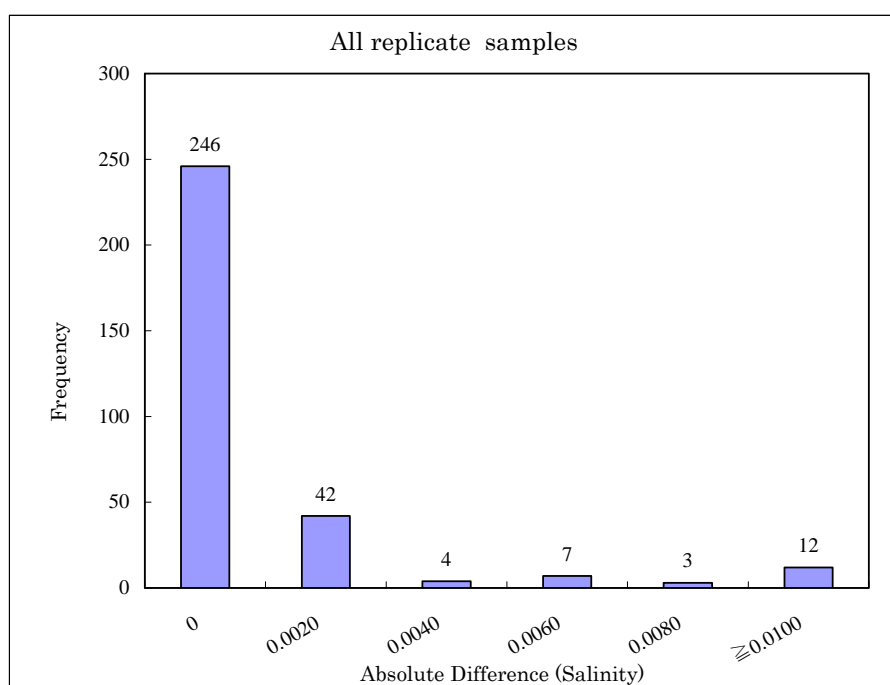


Figure 3.6-5. Histogram of the absolute difference of all replicate samples.

286 pairs of replicate samples were to estimate the precision of shallow (<200dbar) samples. Figure 3.6-6 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 286 pairs were 0.0023 and 0.0068 in salinity, respectively.

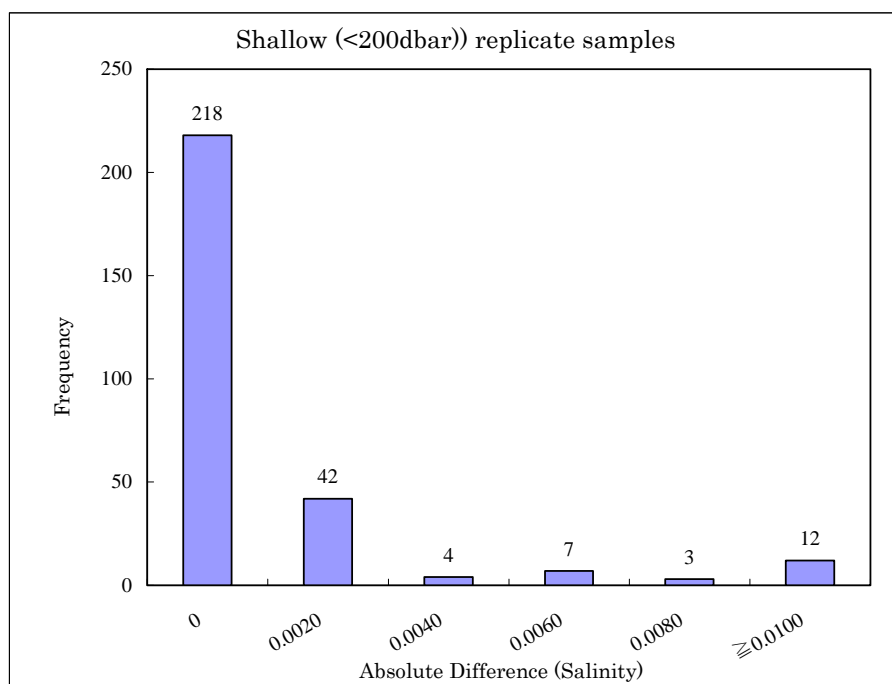


Figure 3.6-6. Histogram of the absolute difference between shallow (<200dbar) replicate samples.

28 pairs of replicate samples were to estimate the precision of deep (>200dbar) samples. Figure 3.6-7 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 28 pairs were 0.0002 and 0.0002 in salinity, respectively.

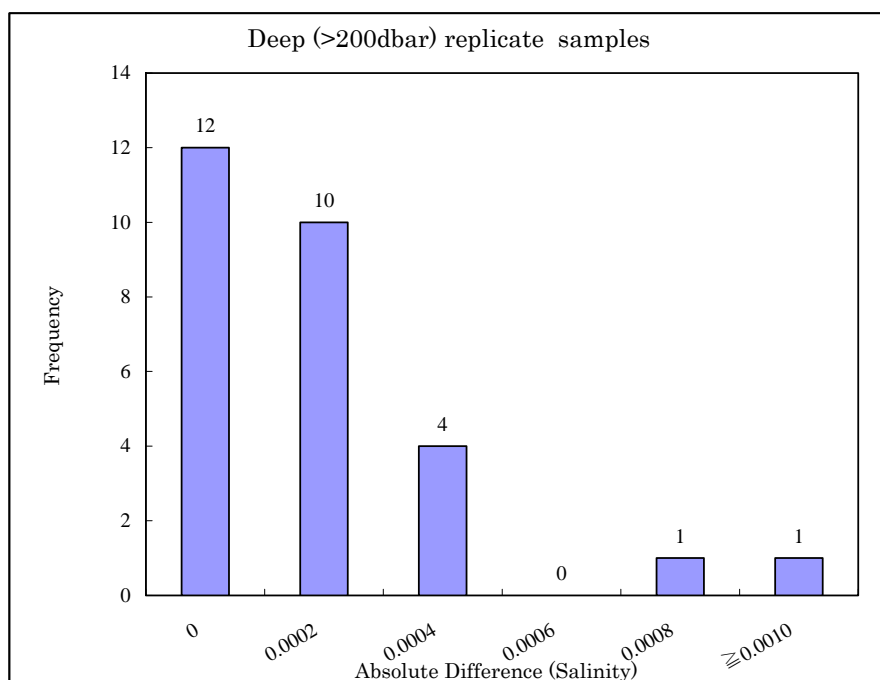


Figure 3.6-7. Histogram of the absolute difference between deep (>200dbar) replicate samples.

d. Data Correction for Samples

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

(6) Data 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.

Citations

- 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

3.7. Mooring Deployments and Recoveries

(1) Personnel

Takashi Kikuchi (JAMSTEC, not onboard)	Principal Investigator
Motoyo Itoh (JAMSTEC, not onboard)	
Shigeto Nishino (JAMSTEC)	
Yusuke Kawaguchi (JAMSTEC)	
Hirokatsu Uno (MWJ)	Operation leader
Kenichiro Sato (MWJ)	Technical staff
Tatsuya Tanaka (MWJ)	Technical staff
Shinsuke Toyoda (MWJ)	Technical staff

(2) Objectives

The purpose of mooring measurements in the Barrow Canyon (BCE-12, -13, BCC-12, -13, and BCW-12, -13) is to monitor the variations of volume, heat and fresh water fluxes of Pacific Water. At the head of Barrow Canyon, where the biological activity is extremely high and is called a biological hot spot, the mooring measuring temperature, salinity, dissolved oxygen, chlorophyll *a*, and turbidity (BCH-12-2) was deployed with a biological mooring recording whale voices (BCH-12w-2). The purpose of these moorings is to understand the ocean environment and its annual changes maintaining the hot spot and its influences to the ecosystem of higher trophic levels such as whales.

We recovered five moorings (BCH-12-2, BCH-12w-2, BCE-12, BCC-12, and BCW-12) and deployed three moorings (BCE-13, BCC-13, and BCW-13) at the locations which are the almost same as those of the deployed moorings in the Barrow Canyon. Components of recovered and deployed moorings are depicted in Figures 3.7-1a (BCH-12-2 and BCH-12w-2), 3.7-1b (BCE-12, BCC-12, and BCW-12), and 3.7-2 (BCE-13, BCC-13, and BCW-13), respectively.

(3) Measured parameters

- Oceanic velocities
- Pressure, Temperature and Conductivity
- Dissolved oxygen
- Chlorophyll *a* and turbidity
- Whale voices

(4) Instruments

1) CTD or CT sensors

SBE37-SM (Sea-Bird Electronics Inc.)

SBE37-SMP-IDO (Sea-Bird Electronics Inc.)

A7CT-USB (JFE Advantech)

2) Current meters

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

Aquadopp Current Meter 2MHz (NORTEK AS)

S4D current meter (InterOcean systems, Inc.)

3) Dissolved oxygen sensors

AROW-USB (JFE Advantech)

SBE37-SMP-IDO (Sea-Bird Electronics Inc.)

4) Chlorophyll-a and turbidity sensors

MFL50W-USB (JFE Advantech)

ACLW-USB (JFE Advantech)

5) Whale voice recorder

Acoustic Monitoring System (Fusion co., LTD)

6) Acoustic transponders

XT-6000-10 (Teledyne Benthos, Inc.)

XT-6001-13 (Teledyne Benthos, Inc.)

7) Acoustic releasers

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

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

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

8242XS (ORE offshore /EdgeTech)

Model 865A (Teledyne Benthos, Inc.)

(5) Lists of recovered and deployed moorings

Table 3.7-1. List of recovered moorings

Mooring ID	Recovery Date [UTC]	Latitude [N]	Longitude [W]	Bottom depth [m]
BCH-12-2	29/09/2013	71-19.6310	157-39.6674	99
BCH-12w-2	03/09/2013	71-20.4868	157-36.3630	101
BCE-12	05/09/2013	71-40.3514	154-59.7409	106
BCC-12	05/09/2013	71-43.5852	155-11.1081	283
BCW-12	05/09/2013	71-47.7415	155-20.7499	170

Table 3.7-2. List of deployed moorings

Mooring ID	Deployment Date [UTC]	Latitude [N]	Longitude [W]	Bottom depth [m]
BCE-13	06/09/2013	71-40.3469	154-59.7276	105
BCC-13	06/09/2013	71-43.5969	155-11.1048	283
BCW-13	07/09/2013	71-47.7647	155-20.7258	171

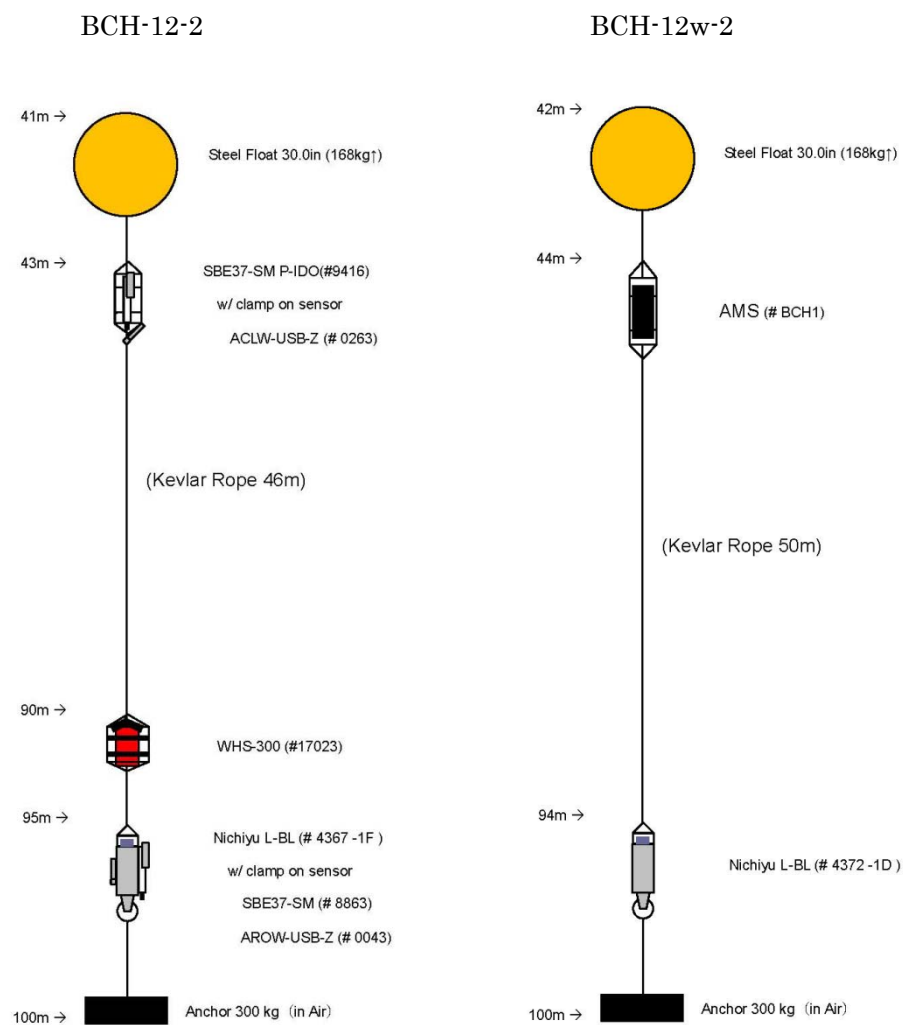


Figure 3.7-1a. Recovered mooring diagrams (BCH-12-2 and BCH-12w-2).

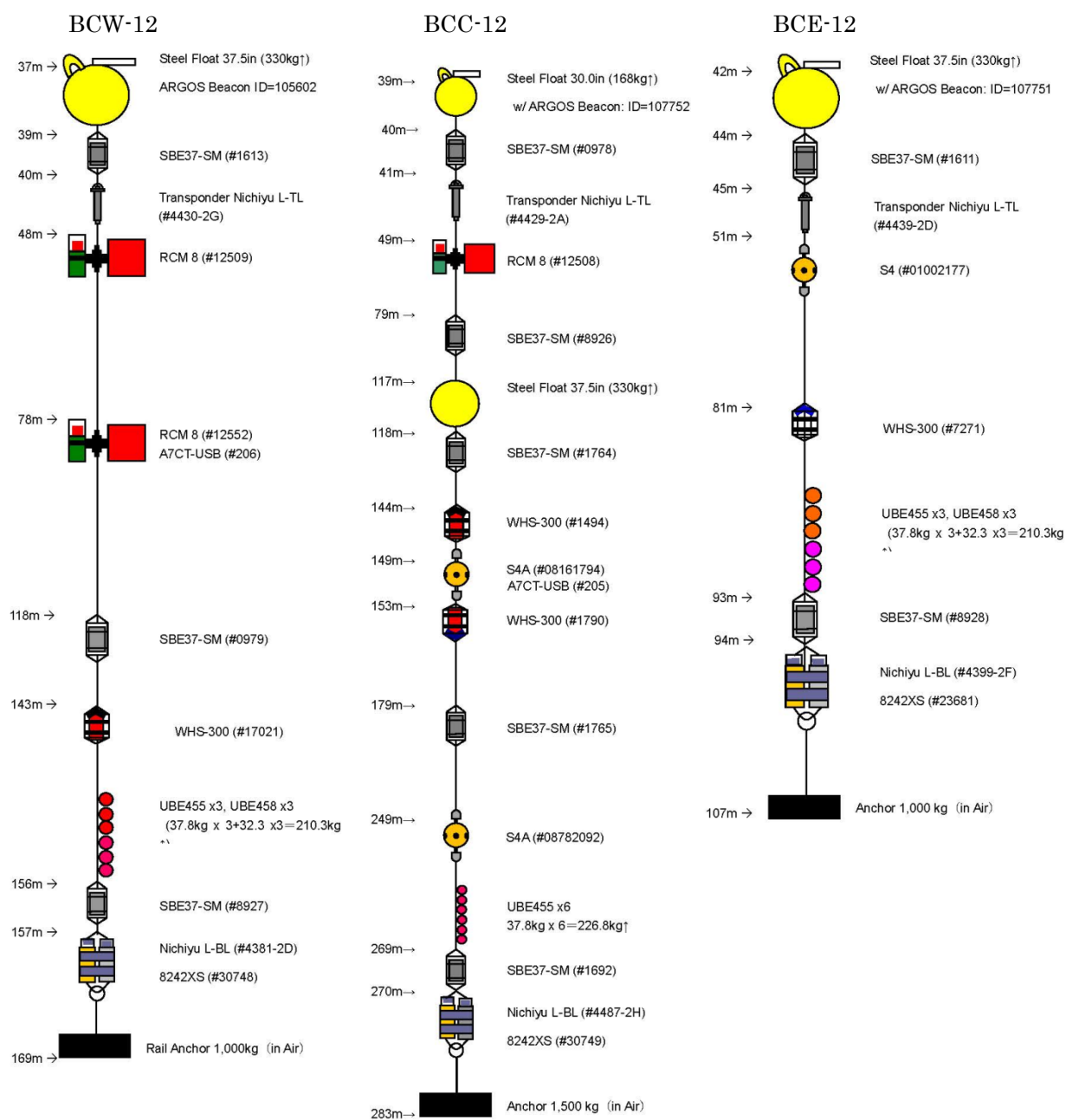


Figure 3.7-1b. Recovered mooring diagrams (BCW-12, BCC-12, and BCE-12).

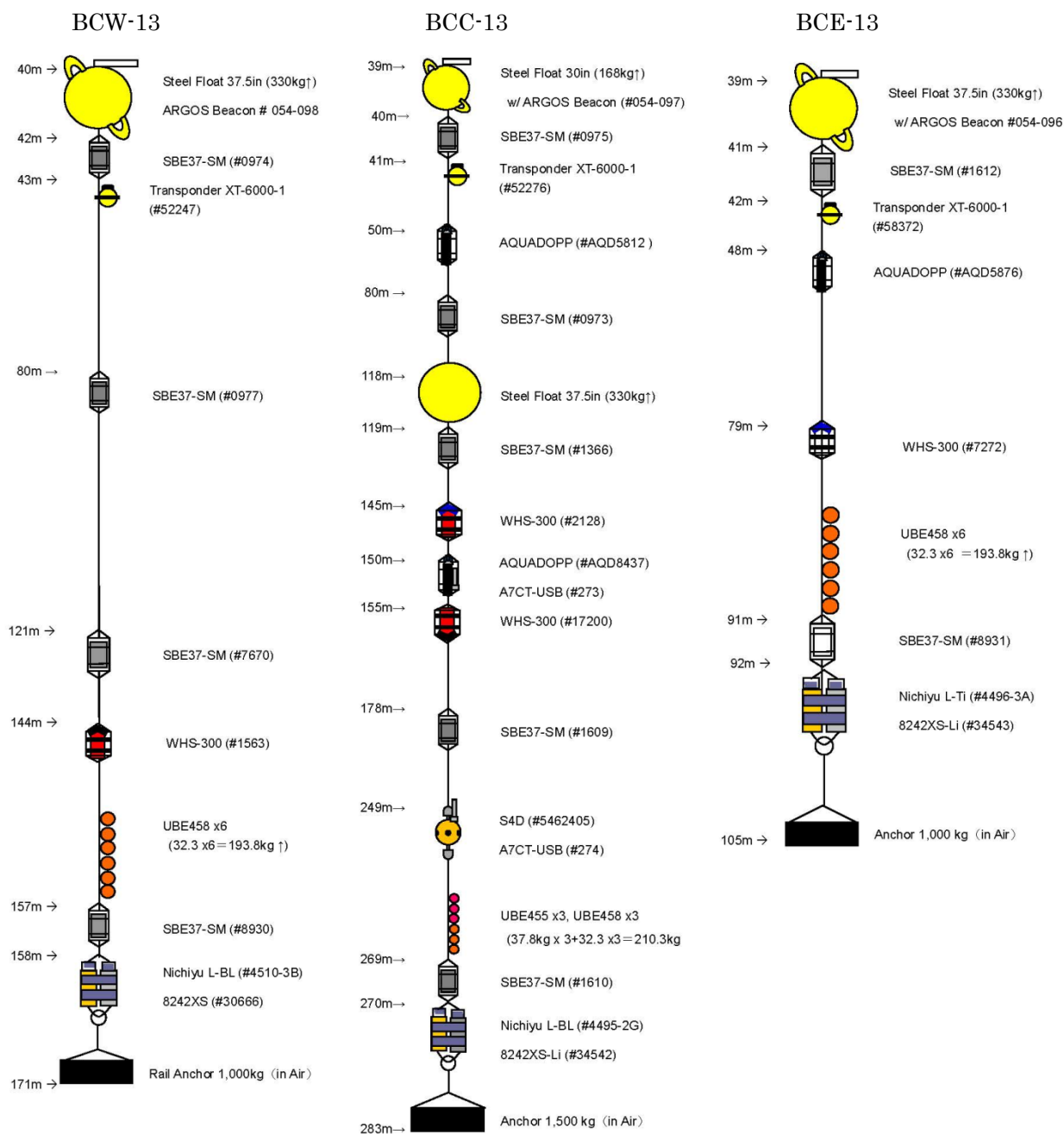


Figure 3.7-2. Deployed mooring diagrams (BCW-13, BCC-13, and BCE-13).

4. Chemical and Biological Oceanography

4.1. Dissolved Oxygen

(1) Personnel

Shigeto NISHINO (JAMSTEC): Principal Investigator

Katsunori SAGISHIMA (Marine Works Japan Co. Ltd): Operation Leader

Shinichiro YOKOGAWA (Marine Works Japan Co. Ltd)

Masahiro ORUI (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 cm³ 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 ($0.025 \text{ mol dm}^{-3}$)

Potassium iodide ($0.001667 \text{ mol dm}^{-3}$)

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 ($\mu\text{mol kg}^{-1}$) was calculated by sample temperature during seawater sampling, salinity of the bottle sampling, flask volume, and titrated volume of sodium thiosulfate solution without the blank.

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 ($0.001667 \text{ mol dm}^{-3}$). 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 cm³) and II (0.5 cm³) 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 cm³ of the standard potassium iodate solution were added to two flasks respectively using a calibrated dispenser. Then 100 cm³ of deionized water, 1 cm³ of sulfuric acid solution, and 0.5 cm³ 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 cm³ of KIO₃) titrated volume of the sodium thiosulfate and the second (2 cm³ of KIO₃) 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 ₂ S ₂ O ₃	DOT-01X(No.7)		DOT-01X(No.8)		Stations
			E.P.	Blank	E.P.	Blank	
2013/08/30	20130509-02-01	20130514-02	3.951	0.001	3.951	-0.001	001, 003, 004, 005, 006, 007, 008, 009, 010, 011, 012, 014, 016, 018, 020, 021, 022, 023, 024, 025, 026, 027, 028, 029, 030, 031
2013/08/31	CSK DCE2131	20130514-02	3.951	-	3.952	-	
2013/09/08	20130509-02-03	20130514-02	3.953	0.002	3.950	0.000	
2013/09/08	20130509-02-03	20130514-03	3.956	0.001	3.954	0.001	032, 033, 034, 035, 036, 037, 038, 039, 040, 041 Cast 001 – 013
2013/09/14	20130509-02-04	20130514-03	3.955	0.000	3.951	0.002	041 Cast 014 – 031
2013/09/18	20130509-02-05	20130514-03	3.955	0.000	3.952	0.000	
2013/09/18	20130509-02-05	20130514-04	3.954	-0.002	3.951	0.000	041 Cast 032 – 061, 043 Cast 011 – 015, 045 Cast 015 046, 047, 048, 049, 050, 051
2013/09/26	20130509-02-06	20130514-04	3.956	0.000	3.953	0.001	
2013/09/26	20130509-02-06	20130514-05	3.955	0.000	3.950	-0.002	052, 053, 054, 055, 056, 057, 058, 059, 060, 061, 062, 063, 064, 065, 066, 067, 068, 070, 072, 074, 075, 076, 078, 079, 080, 081, 082, 083, 086,

							041 Cast062 – 065, 043 Cast016, 044 Cast016, 045 Cast016
2013/10/05	20130509-02-07	20130514-05	3.953	0.002	3.952	0.001	
2013/10/06	20130509-02-07	20130514-06	3.953	0.001	3.950	0.001	

f. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 317. The standard deviation of the replicate measurement was 0.12 $\mu\text{mol kg}^{-1}$ that was calculated by a procedure in Guide to best practices for ocean CO₂ measurements Chapter4 SOP23 Ver.3.0 (2007). Results of replicate samples were shown in Table 4.1-2 and this diagram shown in Figures 4.1-1 and -2.

Table 4.1-2. Results of the replicate sample measurements

Layer	Number of replicate sample pairs	Oxygen concentration ($\mu\text{mol kg}^{-1}$) Standard Deviation.
100m>=	281	0.79
>100m	36	0.09
All	317	0.74

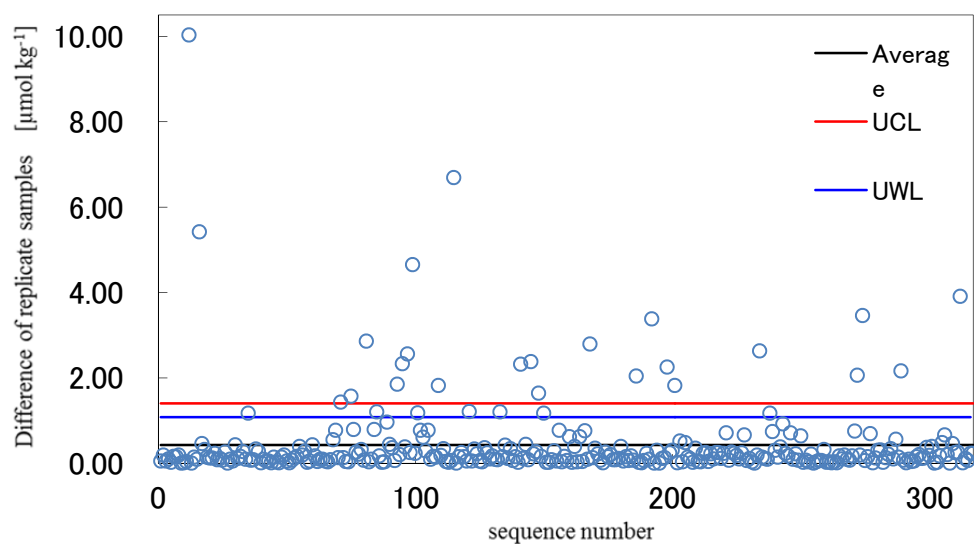


Figure 4.1-1. Differences of replicate samples against sequence number.

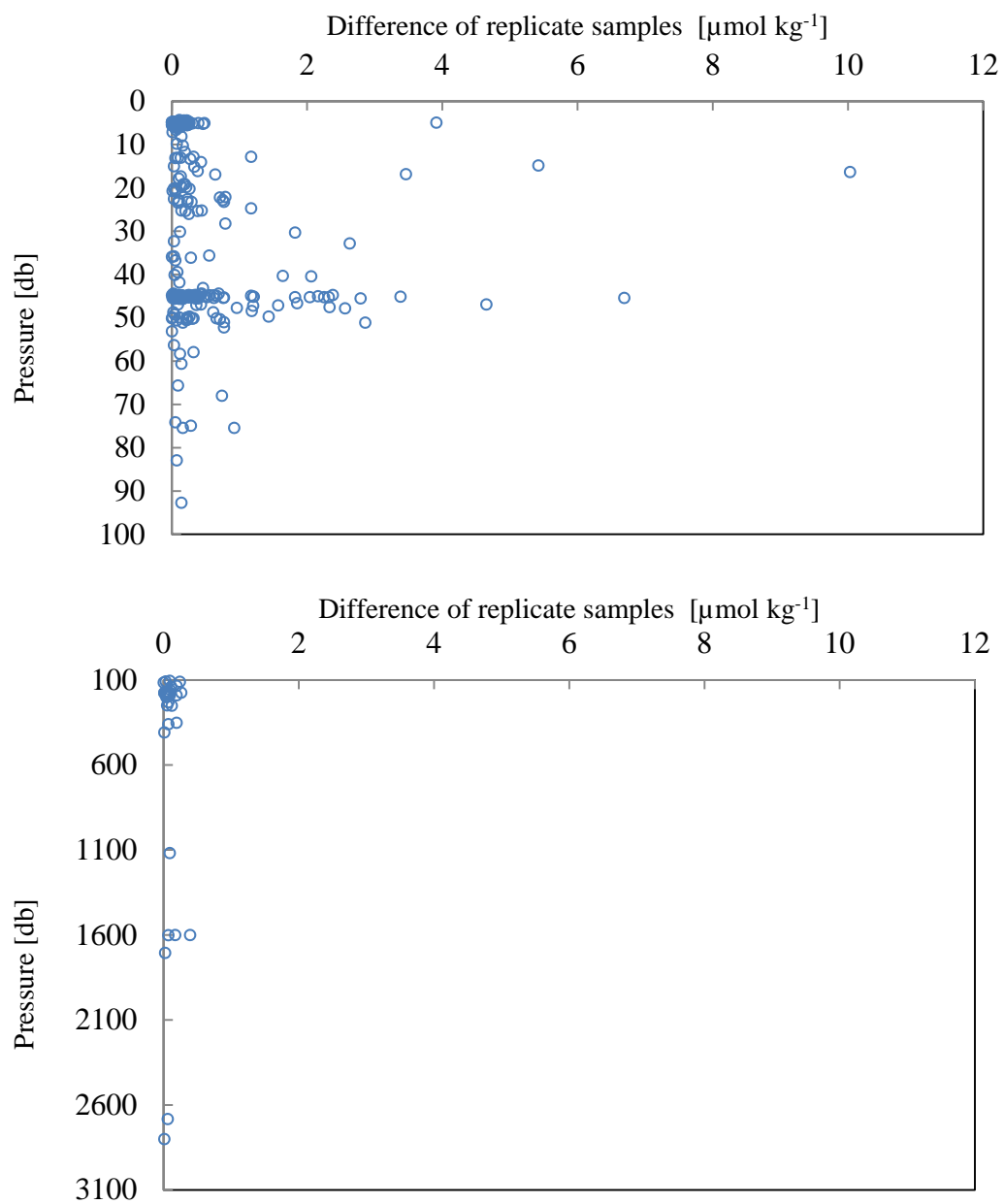


Figure 4.1-2. Differences of replicate samples against pressure.

(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.

(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

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal investigator

Masanori ENOKI (MWJ): Operation leader

Elena HAYASHI (MWJ)

Yoshiko ISHIKAWA (MWJ)

Minoru KAMATA (MWJ)

(2) Objective

The objective of nutrient analyses during the R/V Mirai MR13-06 cruise in the Arctic Ocean is as follows:

- Describe the present status of nutrient concentrations with excellent comparability.

(3) Parameters

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

(4) Summary of nutrients analysis

We made 57 QuAatro runs for the water columns sample at 150 casts during MR13-06. The total amount of layers of the seawater sample reached up to 1537. We made basically duplicate measurement. The station locations for nutrients measurement is shown in Figure 4.2.1

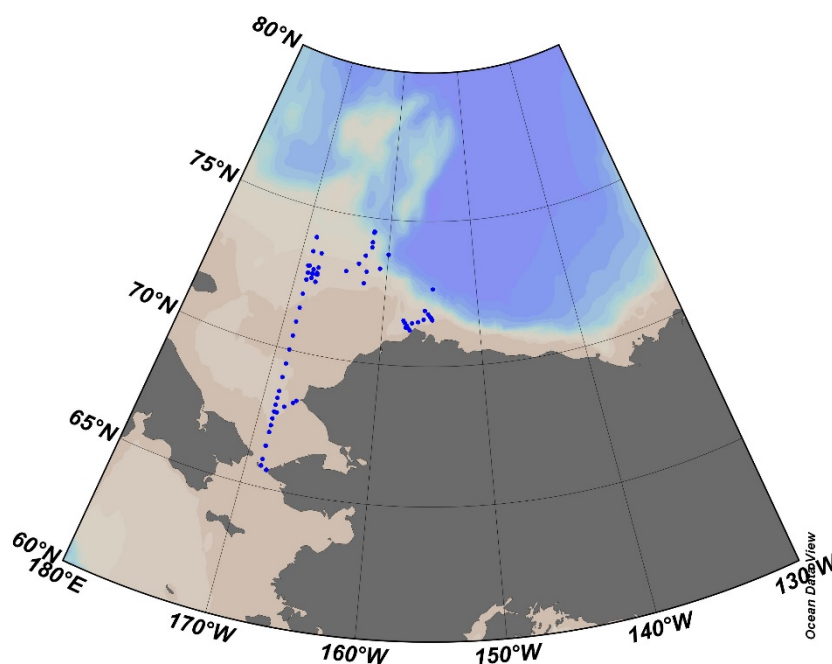


Figure 4.2-1. Sampling positions of nutrients sample.

(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, $\text{C}_3\text{H}_4\text{N}_2$, 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, $4\text{-NH}_2\text{C}_6\text{H}_4\text{SO}_3\text{H}$, 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-Naphthylethylene-diamine dihydrochloride, 0.004 M (0.1 %f w/v)

Dissolve 1 g NED, $\text{C}_{10}\text{H}_7\text{NHCH}_2\text{CH}_2\text{NH}_2 \cdot 2\text{HCl}$, 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.

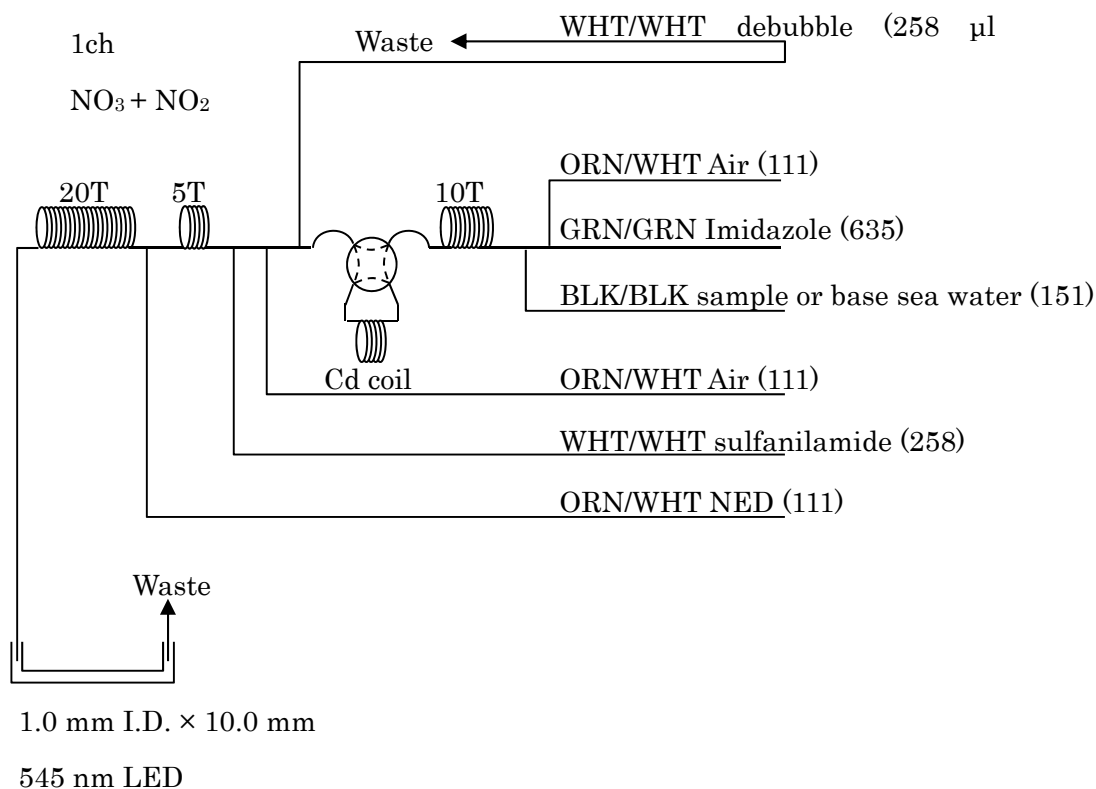


Figure 4.2-2. NO₃+NO₂ (1ch.) Flow diagram.

d. Nitrite Reagents

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

Dissolve 10g sulfanilamide, 4-NH₂C₆H₄SO₃H, 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-Naphthylethylene-diamine dihydrochloride, 0.004 M (0.1 % w/v)

Dissolve 1 g NED, C₁₀H₇NHCH₂CH₂NH₂ · 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.

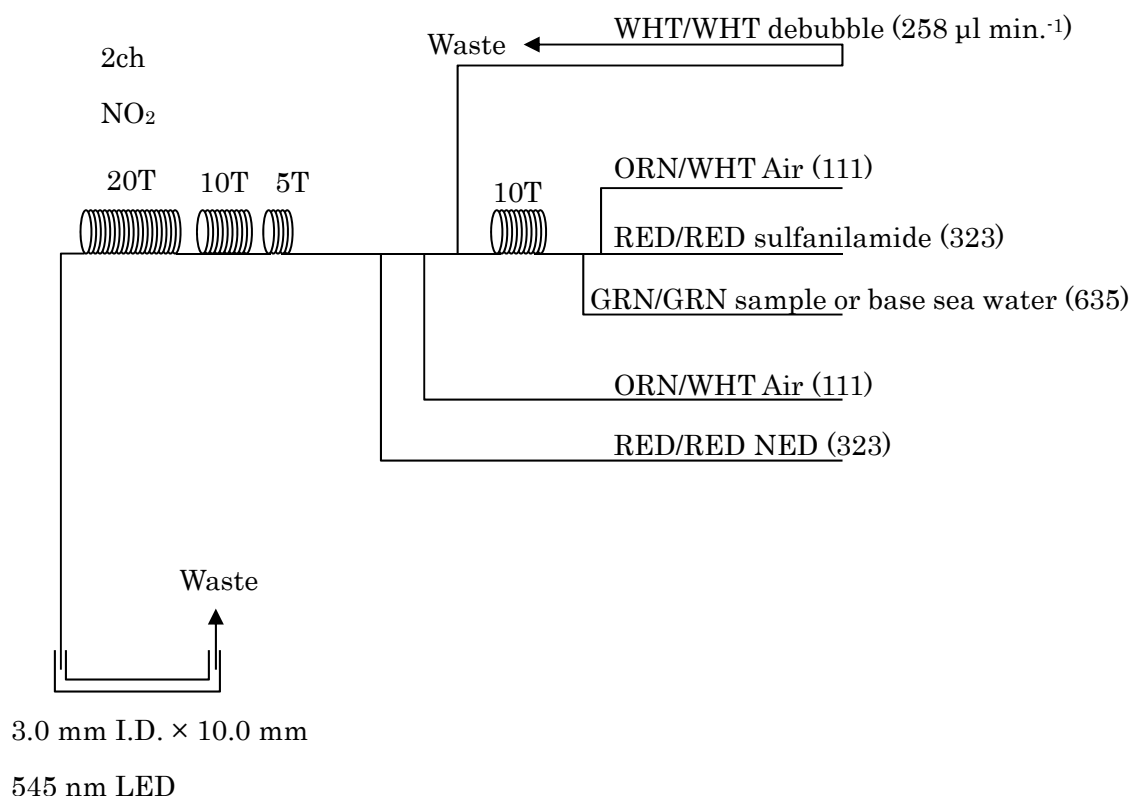


Figure 4.2-3. NO₂ (2ch.) Flow diagram.

e. Silicate Reagents

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

Dissolve 15 g disodium molybdate(VI) dihydrate, Na₂MoO₄•2H₂O, in 980 ml DIW, add 8 ml concentrated H₂SO₄. 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, C₆H₈O₆, in 100 ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

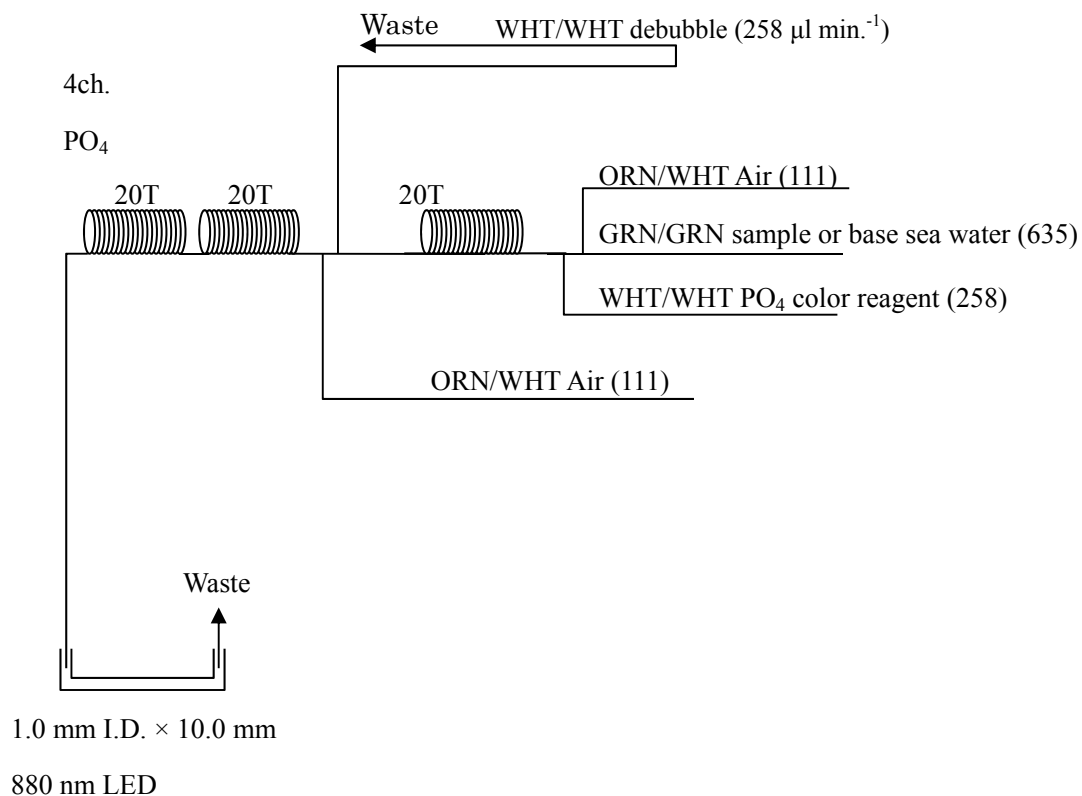


Figure 4.2-5. PO₄ (4ch.) Flow diagram.

g. Ammonia Reagents

EDTA

Dissolve 41 g EDTA (ethylenediaminetetraacetic acid tetrasodium salt), C₁₀H₁₂N₂O₈Na₄•4H₂O, and 2 g boric acid, H₃BO₃, 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), Na₂[Fe(CN)₅NO], in 100 ml of

DIW and add 0.2 ml 1N H₂SO₄. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

Mixed 4 ml stock nitroprusside and 5 ml 1N H₂SO₄ 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, C₆H₅OH, 5 g sodium hydroxide and citric acid, C₆H₈O₇, 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 freshly prepared before every measurement. This reagent is prepared 0.3% available chlorine.

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 SiO₂ 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 13 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 MR13-06 to keep comparability for silicate concentration.

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 August 2012.

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.

For high concentration of ammonia in Chukchi Sea at MR12-E03 cruise, we used 5 levels calibration curve adding to C-5 standard in Chukchi Sea observation.

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 4.2-3a. 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 4.2-3b. 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 4.2-3c. 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 $0.5 \mu\text{mol kg}^{-1}$ for 345 crossovers at world oceans, though the maximum was $1.7 \mu\text{mol kg}^{-1}$ (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. 32 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 18.5 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: $\mu\text{mol kg}^{-1}$				
	Nitrate	Nitrite	Phosphate	Silicate	Assigned year
BS	0.07	0.02	0.063	1.61	2011
BU	3.96	0.07	0.378	20.27	2011
BT	18.18	0.47	1.318	40.94	2011
BD	29.82	0.05	2.191	64.30	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 0.11% for nitrate, 0.19% for nitrite, 0.16% for phosphate, 0.11% for silicate and 0.30% 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	Nitrite	Phosphate	Silicate	Ammonia
	CV %	CV %	CV %	CV %	CV%
Median	0.11	0.19	0.11	0.16	0.30
Mean	0.11	0.19	0.12	0.16	0.31
Maximum	0.23	0.39	0.24	0.33	0.96
Minimum	0.04	0.05	0.05	0.07	0.10
N	59	59	59	59	58

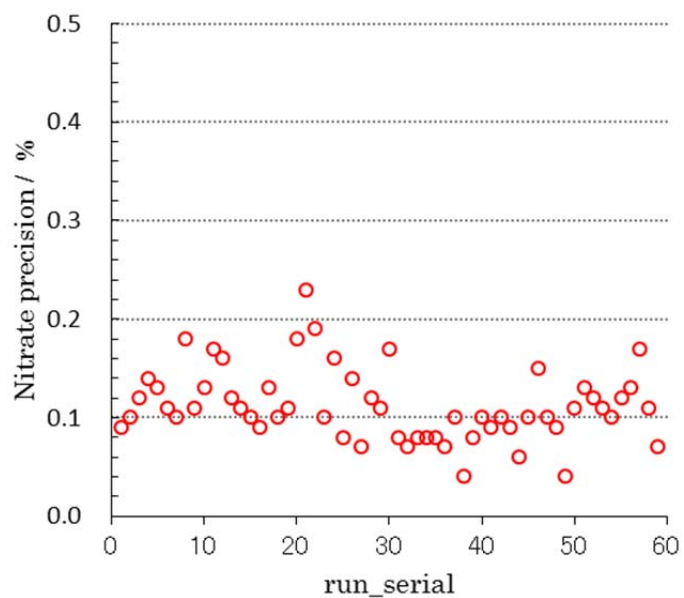


Figure 4.2-8. Time series of precision of nitrate for MR13-06.

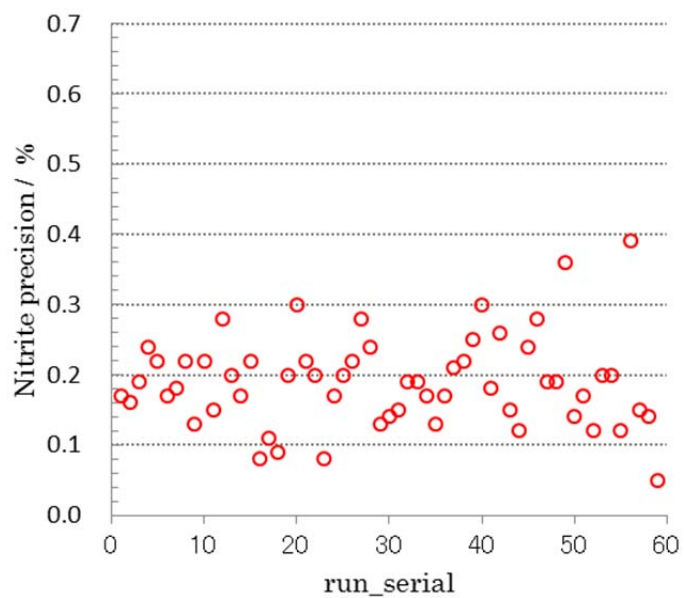


Figure 4.2-9. Time series of precision of nitrite for MR13-06.

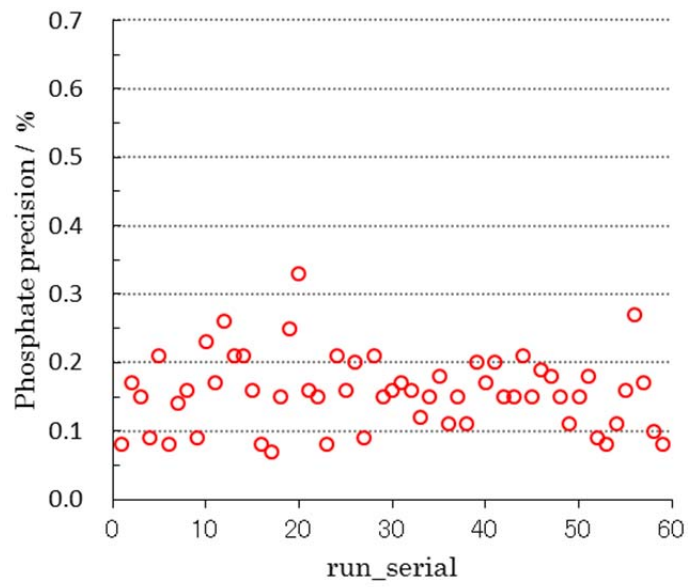


Figure 4.2-10. Time series of precision of phosphate for MR13-06.

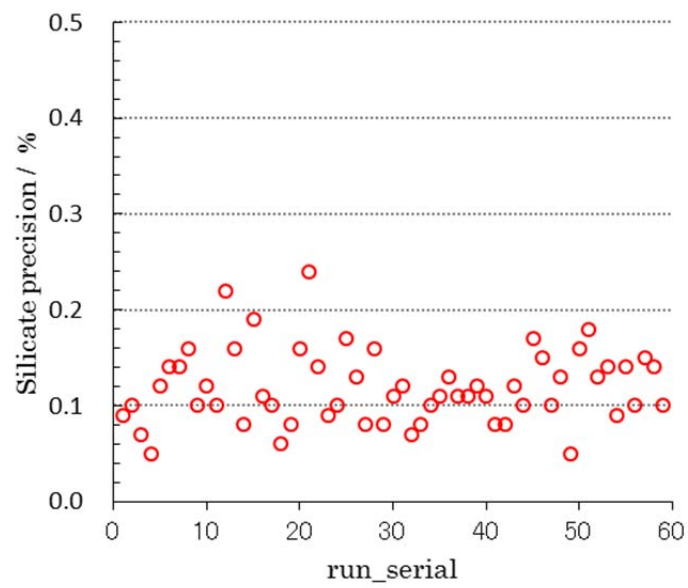


Figure 4.2-11. Time series of precision of silicate for MR13-06.

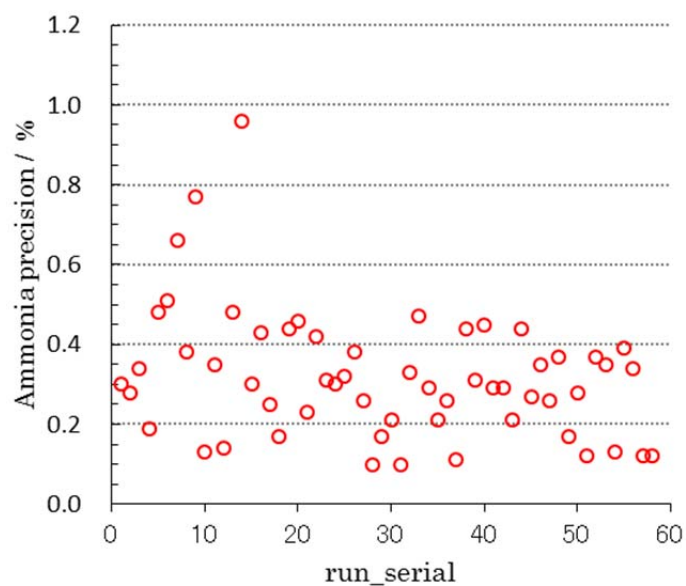


Figure 4.2-12. Time series of precision of ammonia for MR13-06.

b. Results of RMNS measurements

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.

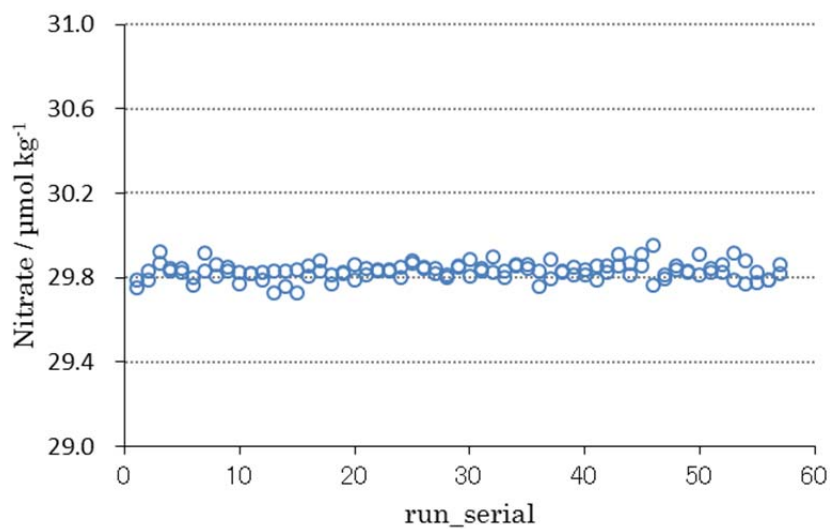


Figure 4.2-13. Summary of nitrate concentration of RM-BD.

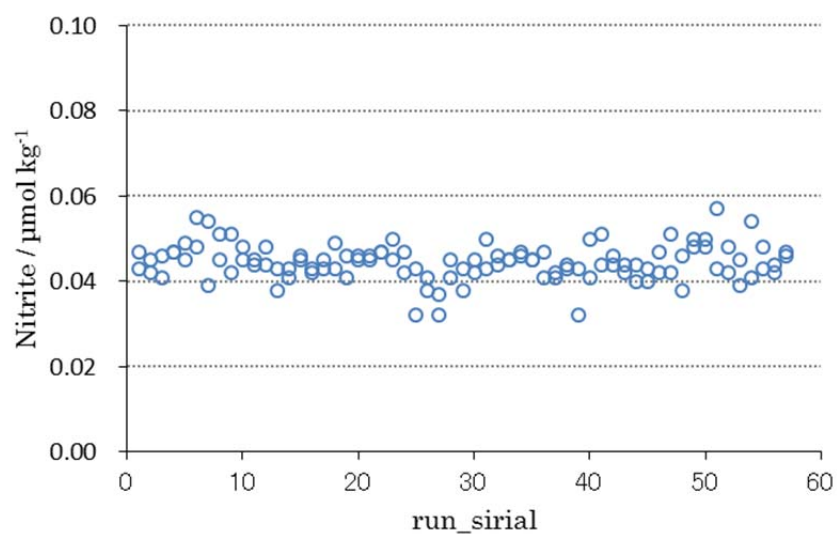


Figure 4.214. Summary of nitrite concentration of RM-BD.

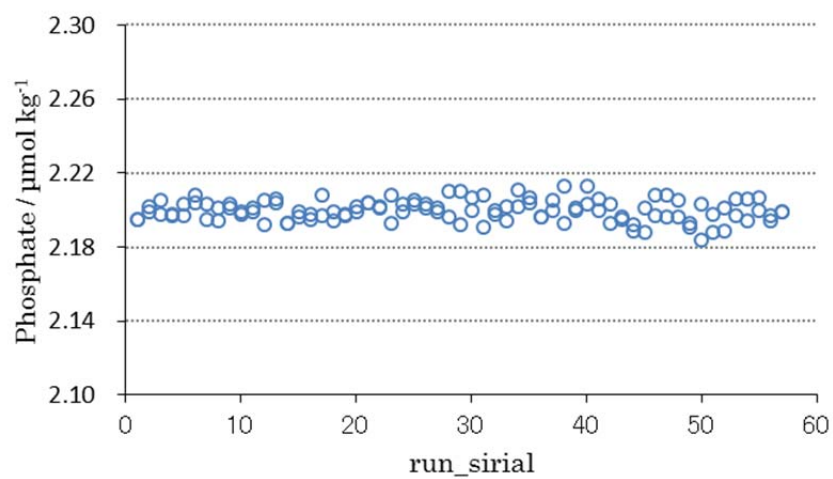


Figure 4.2-15. Summary of phosphate concentration of RM-BD.

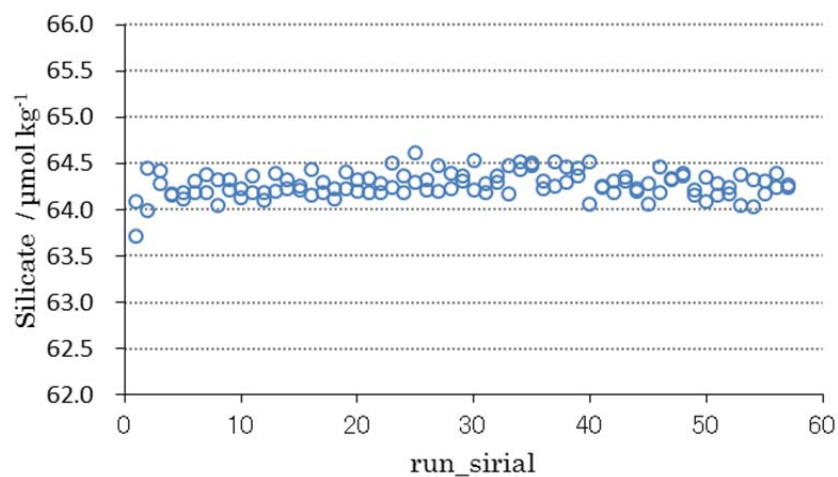


Figure 4.2-16. Summary of silicate concentration of RM-BD.

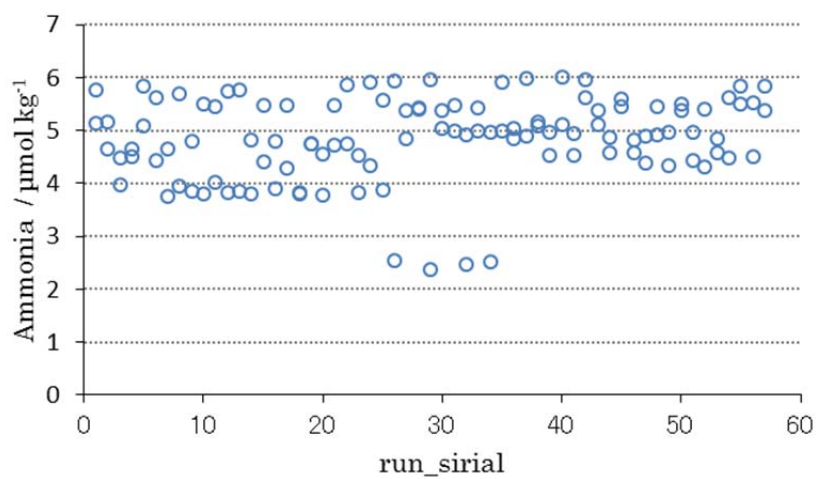


Figure 4.2-17. Summary of ammonia concentration of RM-BD.

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 MR13-06

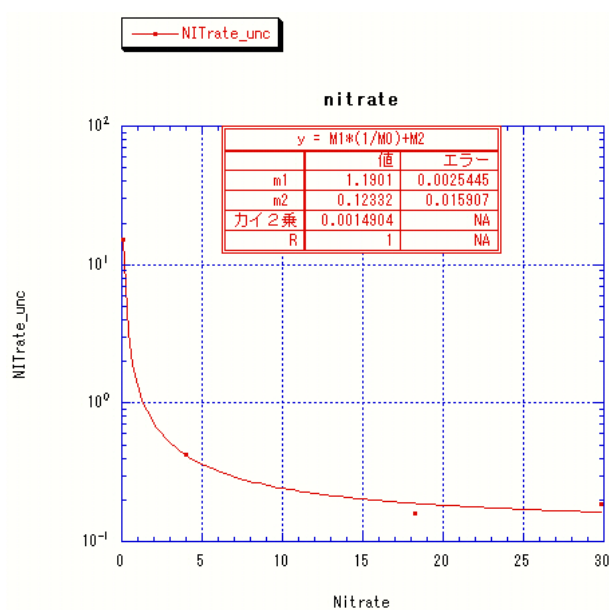
	Nitrate	Nitrite	Phosphate	Silicate	Ammonia
	%	%	%	%	%
Median	0.15	0.13	0.21	0.33	0.62
Mean	0.15	0.23	0.21	0.34	0.61
Maximum	0.32	1.50	0.40	0.77	1.21
Minimum	0.00	0.00	0.03	0.00	0.00
N	59	59	59	59	58

d. Concentration dependent uncertainty

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

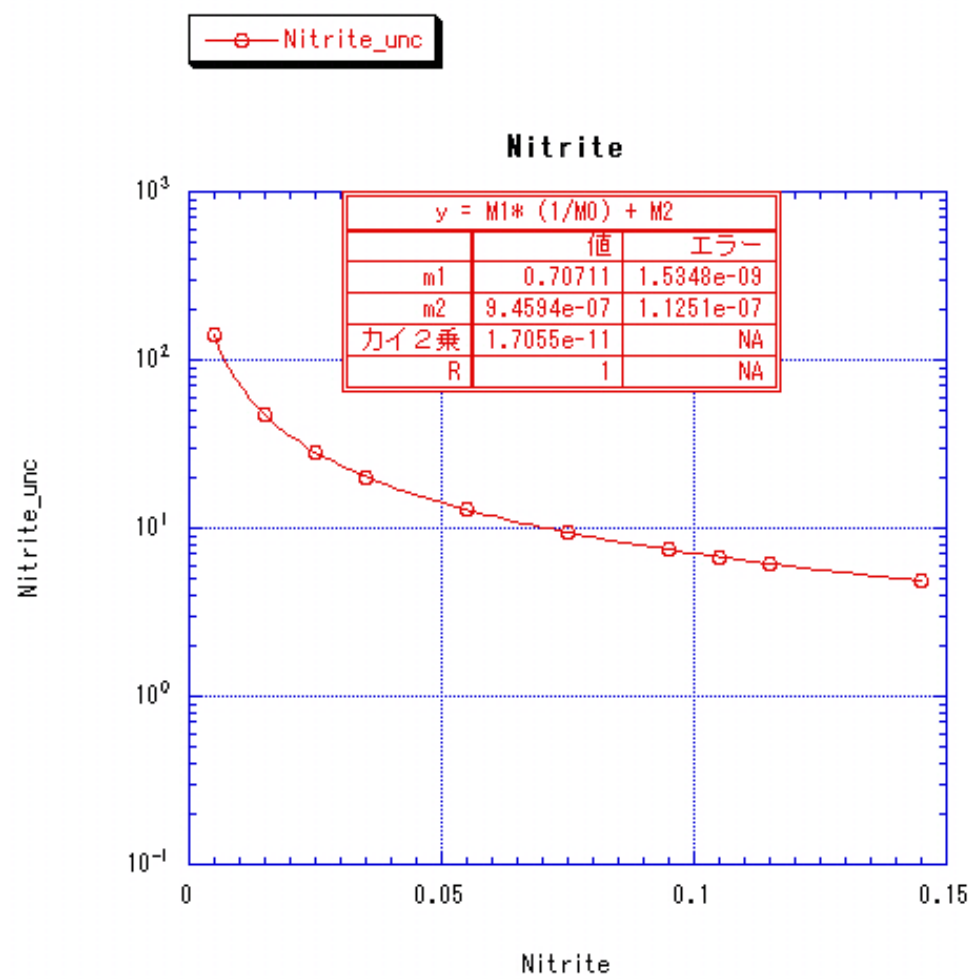
For Nitrate, uncertainty in terms of % is expressed by eq. (1)

$$\text{Unc (\%)} = 0.12 + 1.19 / C_{\text{no}3} \quad (1)$$



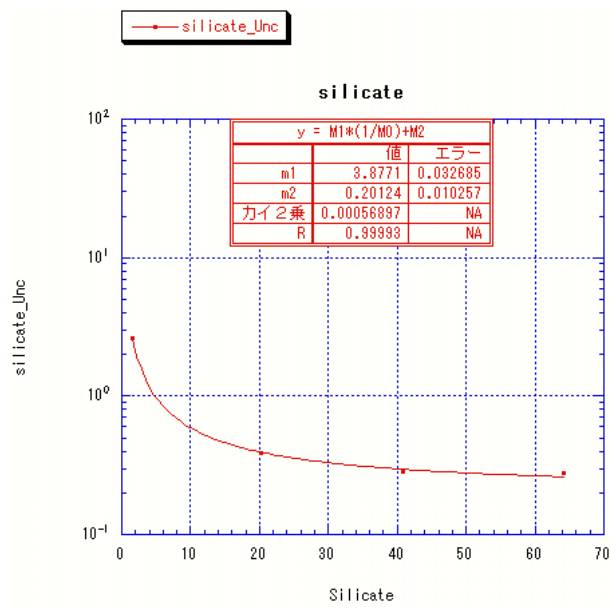
For nitrite, uncertainty in terms of % is expressed by eq. (2)

$$\text{Unc (\%)} = 0.009 + 0.707 / C_{\text{no2}} \tag{2}$$



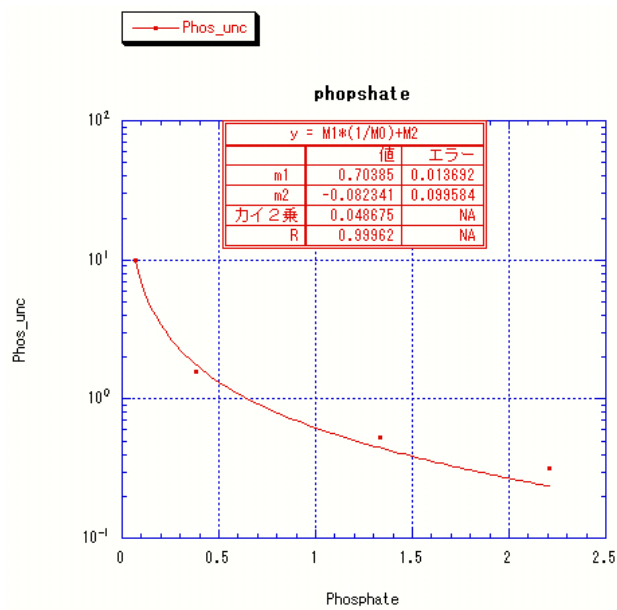
For silicate, uncertainty in terms of % is expressed by eq. (3)

$$\text{Unc (\%)} = 0.20 + 3.88 / C_{\text{sil}} \tag{3}$$



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

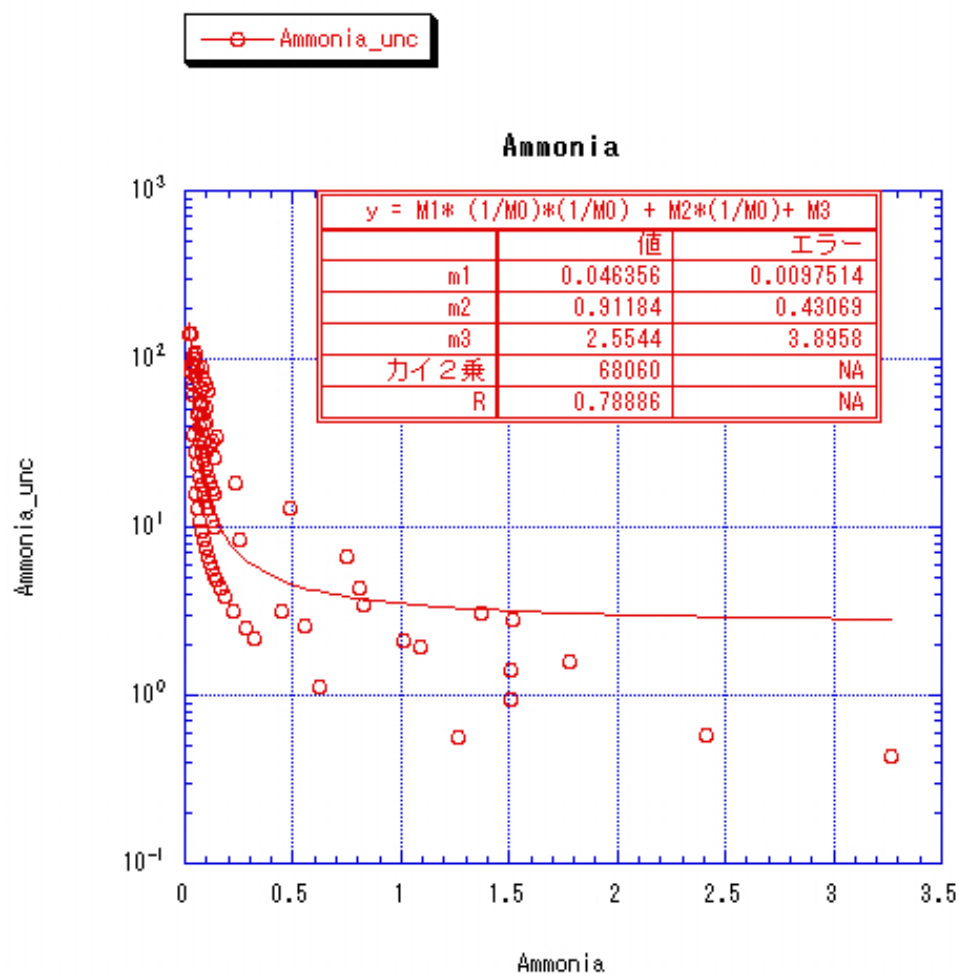
$$\text{Unc (\%)} = -0.08 + 0.703 / C_{\text{p04}} \quad (4)$$



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

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

$$\text{Unc (\%)} = 2.554 + 0.912 / C_{\text{NH}_4} + 0.046 / C_{\text{NH}_4} \quad (5)$$



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

$$\text{Unc (\%)} = a + b / C_{\text{sil}} \quad (4)$$

(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.

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.
Ammonia	Stn. 037 cast1 # 1
	Stn. 041 cast1 # 1

(9) Station list

The sampling station list for nutrients is shown in Table 4.2.7.

Station 87 cast1 and cast2 collected RMNS originwater.

Table 4.2-7. List of stations

Station	Cast	Latitude	Longitude
1	1	65.7697	191.2483
3	1	65.6573	191.7475
4	1	66.004	191.2512
5	1	66.5032	191.2482
6	1	67.0032	191.2552
7	1	67.5015	191.2505
8	1	68.0042	191.2363
9	1	68.5033	191.2537
10	1	69.0025	191.2502
11	1	71.343	202.3903
12	1	71.5808	202.1557
14	1	71.2452	202.8288
16	1	71.3263	202.6492
18	1	71.4112	202.4923
20	1	71.4975	202.324
21	1	71.4923	203.0473

Station	Cast	Latitude	Longitude
22	1	71.5468	203.6457
23	1	71.627	204.2397
24	1	71.6087	205.1485
25	1	71.6832	205.0243
26	1	71.7365	204.89
27	1	71.813	204.7033
28	1	71.9348	204.3435
29	1	72.6803	205.2008
31	1	74.5305	198.088
33	1	74.1678	197.9943
34	1	73.9972	191.2578
35	1	73.0035	191.2513
36	1	72.7498	191.2518
37	1	72.501	191.2505
38	1	72.5012	192.252
39	1	72.75	192.2578
40	1	73.0003	192.2528
41	1	72.7532	191.7587
41	2	72.7495	191.7485
41	3	72.7503	191.7575
41	4	72.7487	191.75
41	5	72.7505	191.7493
41	6	72.751	191.7483
41	7	72.7492	191.7535
41	8	72.7498	191.7477
41	9	72.7498	191.7388
41	10	72.7498	191.7548
41	11	72.7503	191.7528
41	12	72.7497	191.7528

Station	Cast	Latitude	Longitude
41	13	72.7513	191.7468
41	14	72.7508	191.753
41	15	72.7495	191.7492
41	16	72.7495	191.7492
41	17	72.7482	191.7543
41	18	72.7512	191.7565
41	19	72.7488	191.7515
41	20	72.749	191.7487
41	21	72.7512	191.7458
41	22	72.7503	191.7465
41	23	72.7497	191.7528
41	24	72.7468	191.7572
41	25	72.7515	191.7467
41	26	72.7503	191.7508
41	27	72.7487	191.7517
41	28	72.7502	191.7508
41	29	72.7495	191.7513
41	30	72.7512	191.7517
41	31	72.7493	191.7487
41	32	72.7552	191.7558
41	33	72.7487	191.7497
41	34	72.7513	191.7495
41	35	72.7485	191.7448
41	36	72.753	191.7443
41	37	72.748	191.7478
41	38	72.7508	191.7452
41	39	72.7433	191.7462
41	40	72.7465	191.7515
41	41	72.7488	191.7592

Station	Cast	Latitude	Longitude
41	42	72.7537	191.7425
41	43	72.7517	191.7605
41	44	72.7507	191.7528
41	45	72.7498	191.7488
41	46	72.7503	191.7478
41	47	72.75	191.75
41	48	72.7495	191.7523
41	49	72.7498	191.7508
41	50	72.7497	191.7478
41	51	72.7497	191.7532
41	52	72.7492	191.7487
41	53	72.7488	191.7528
41	54	72.7498	191.7502
41	55	72.75	191.7498
41	56	72.749	191.745
41	57	72.7505	191.7507
41	58	72.7493	191.7537
41	59	72.7548	191.7513
41	60	72.7508	191.7513
41	61	72.7518	191.752
41	62	72.7518	191.743
41	63	72.751	191.7528
41	64	72.7497	191.7482
41	65	72.7485	191.751
42	5	72.8988	191.7495
42	15	72.9	191.75
42	16	72.9002	191.7503
43	5	72.6002	191.7517
43	11	72.6023	191.7433

Station	Cast	Latitude	Longitude
43	12	72.6007	191.7492
43	13	72.6018	191.7557
43	14	72.6003	191.7543
43	15	72.6033	191.7523
43	16	72.5997	191.7535
44	4	72.7503	192.2502
44	16	72.751	192.2647
45	4	72.7522	191.2393
45	15	72.7498	191.2455
45	16	72.751	191.2447
46	1	72.8072	192.224
47	1	72.986	191.0708
48	1	74.0025	191.2492
49	1	73.5008	191.2378
50	1	73.4982	192.2473
51	1	72.9985	192.2497
52	1	73.0625	195.381
53	1	73.3827	196.701
54	1	73.693	197.3483
55	1	74.0007	198.0062
56	1	73.8005	200.0103
57	1	73.3033	199.1663
58	1	73.1498	197.6878
59	1	72.7387	197.5258
60	1	72.5028	191.2492
61	1	72.0007	191.2562
62	1	71.5003	191.2533
63	1	70.9995	191.2503
64	1	70.5	191.251

Station	Cast	Latitude	Longitude
65	1	70.001	191.2507
66	1	69.5	191.2547
67	1	69.0013	191.2527
68	1	68.3013	192.9542
70	1	68.202	192.6662
72	1	68.0025	191.9963
74	1	67.7483	191.4995
75	1	68.5012	191.2503
76	1	68.2502	191.2493
77	1	68.0008	191.2438
78	1	67.7507	191.2495
79	1	67.4995	191.2507
80	1	67.2508	191.2492
81	1	67.0005	191.2445
82	1	66.5012	191.237
83	1	65.9998	191.2495
84	1	65.7633	191.2427
86	1	65.6508	191.7483
87	1	48.8752	166.6145
87	2	48.8607	166.5892

(10) Data archive

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

(11) Acknowledgment

We would like to express our sincere thanks to Dr. Michio Aoyama in Geochemical Research Department, Meteorological Research Institute, who largely contributed to

the quality control of the data with valuable suggestions from his laboratory.

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4.3. Dissolved Inorganic Carbon

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator

Makoto Takada (MWJ): Operation Leader

Atsushi Ono (MWJ)

(2) Objective

The Arctic Ocean has a feature that Dissolved Inorganic Carbon (DIC) concentration is low because of the influence of inflow of the large amount of river water, dilution by sea-ice melt water and high biological productivity. Recently, the undersaturation of the calcium carbonate and a change of $p\text{CO}_2$ have been observed in the Arctic Ocean. It is considered that the change of seawater pH and decrease of calcium carbonate affect a growth of the species which forms shells of calcium carbonate. Therefore, quantitative understanding of the cause of these changes is necessary for better assessments and future predictions. The percentage saturation of seawater in respect to calcium carbonate can be computed from DIC and Total Alkalinity (TA; ref. Section 4.4.). Accordingly, we measured DIC on-board during the MR13-06 cruise.

(3) Parameters

Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

I. Seawater sampling

Seawater samples were collected by 12 L Niskin bottles and a bucket at 75 stations (total 1823 samples). Seawater was transported into a 300 mL glass bottle (SCHOTT DURAN) which 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 conducted. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds. They were sealed using the 29 mm polyethylene inner lids with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the sampling bottles were moved to the laboratory. Prior to the analysis, 3 mL of the samples (1% of the bottle volume) was removed from the glass bottles to make a headspace. The samples were then poisoned with 100 μL of over saturated solution of mercury chloride within one hour after samplings. The samples

were sealed with 31.9 mm polyethylene inner lids and stored in a refrigerator at approximately 5 °C until the analysis.

II. Seawater analysis

Measurements of DIC were made with total CO₂ measuring system (System D; Nippon ANS, Inc.). The system comprises of seawater dispensing system, a CO₂ 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 15 mL volume by PC control. The pipette was kept at 20 ± 0.05 °C by a water jacket, in which water is circulated from a thermostatic water bath (RTE10, Thermo) set at 20 °C.

The CO₂ dissolved in a seawater sample is extracted in a stripping chamber of the CO₂ extraction system by phosphoric acid (10% v/v). The stripping chamber is made approximately 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 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 CO₂ is carried by the nitrogen gas (flow rate of 140 mL min⁻¹) to the coulometer through a dehydrating module consists of two electronic dehumidifiers (kept at 2 °C) and a chemical desiccant (Mg(ClO₄)₂).

Measurements of 1.5% CO₂ 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 solution.

(5) Observation log

The sampling stations for DIC were shown in Figure 4.3-1.

(6) Preliminary results

During the cruise, 1823 samples were analyzed for DIC. A few replicate samples were taken at most of the stations and difference between each pair of analyses was plotted on a range control chart (Figure 4.3-2). The average of the differences was 1.01 μmol kg⁻¹ (n = 315), and the standard deviation was 1.07 μmol kg⁻¹ (n = 315), which indicates the analysis was accurate enough according to the Guide to the best practices

for ocean CO₂ measurements (Dickson et al., 2007).

(7) 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.

(8) References

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

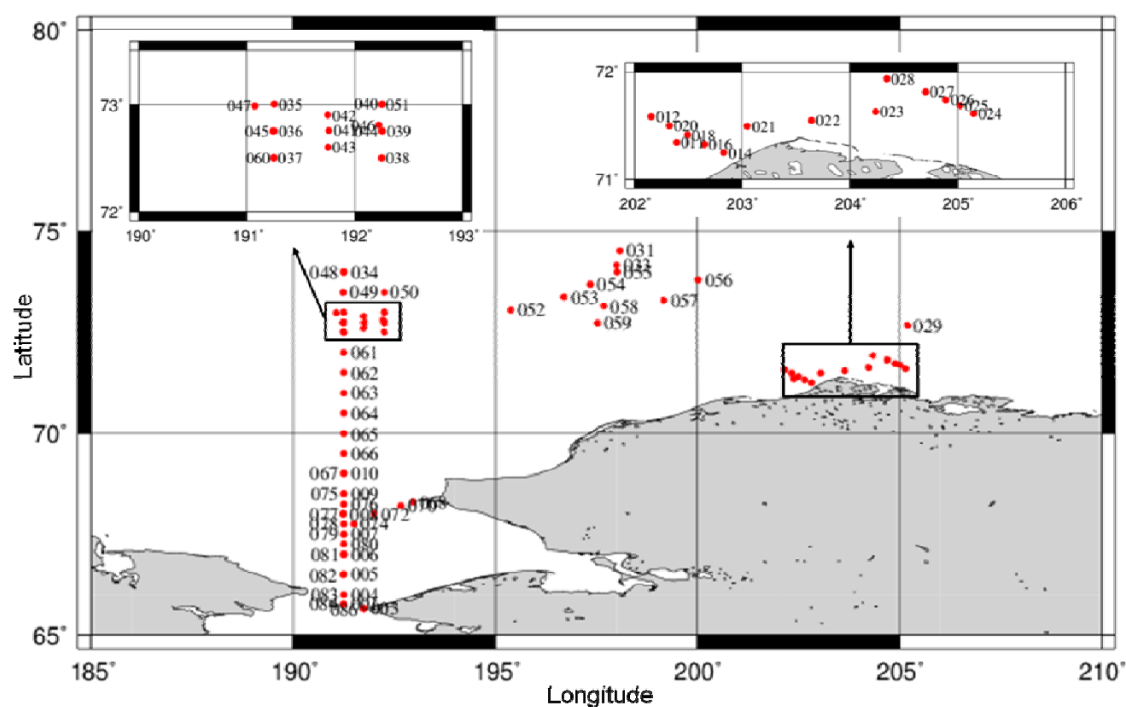


Figure 4.3-1. DIC sampling stations.

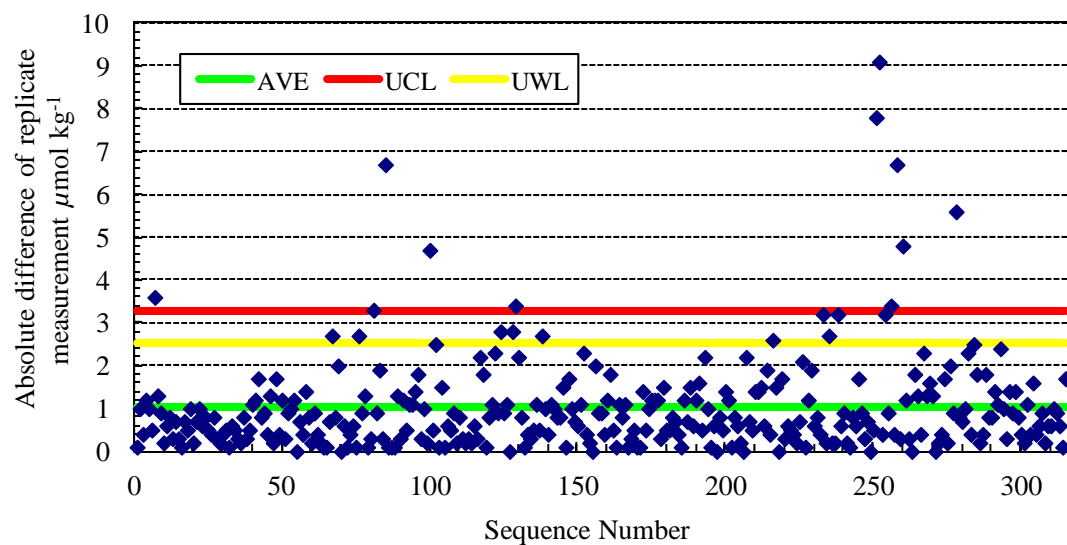


Figure 4.3-2. Range control chart of the absolute differences of replicate measurements carried out in the analysis of DIC during the MR13-06.

4.4. Total Alkalinity

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator

Tomonori Watai (MWJ): Operation Leader

Emi Deguchi (MWJ)

(2) Objective

As described in the Section 4.3. (DIC), total Alkalinity (TA) is an essential parameter in carbonate system in the ocean. We have measured TA during the MR13-06 cruise to estimate pH, calcium carbonate saturation state and $p\text{CO}_2$. 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 MR13-06 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 75 stations / 150 casts 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 ($\text{pH} = 13$) 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:

$$\begin{aligned} \text{pH}_T &= 4.2699 + 0.002578 \times (35 - S) \\ &+ \log ((R(25) - 0.00131) / (2.3148 - 0.1299 \times R(25))) \\ &- \log (1 - 0.001005 \times S), \end{aligned} \quad (1)$$

$$\begin{aligned} A_T &= (N_A \times V_A - 10^{\text{pH}_T} \times \text{DensSW} (T, S) \times (V_S + V_A)) \\ &\times (\text{DensSW} (T, S) \times V_S)^{-1}, \end{aligned} \quad (2)$$

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.

(5) Station list or Observation log

Seawater samples were collected at 75 stations / 150 casts (Figure 4.4-1).

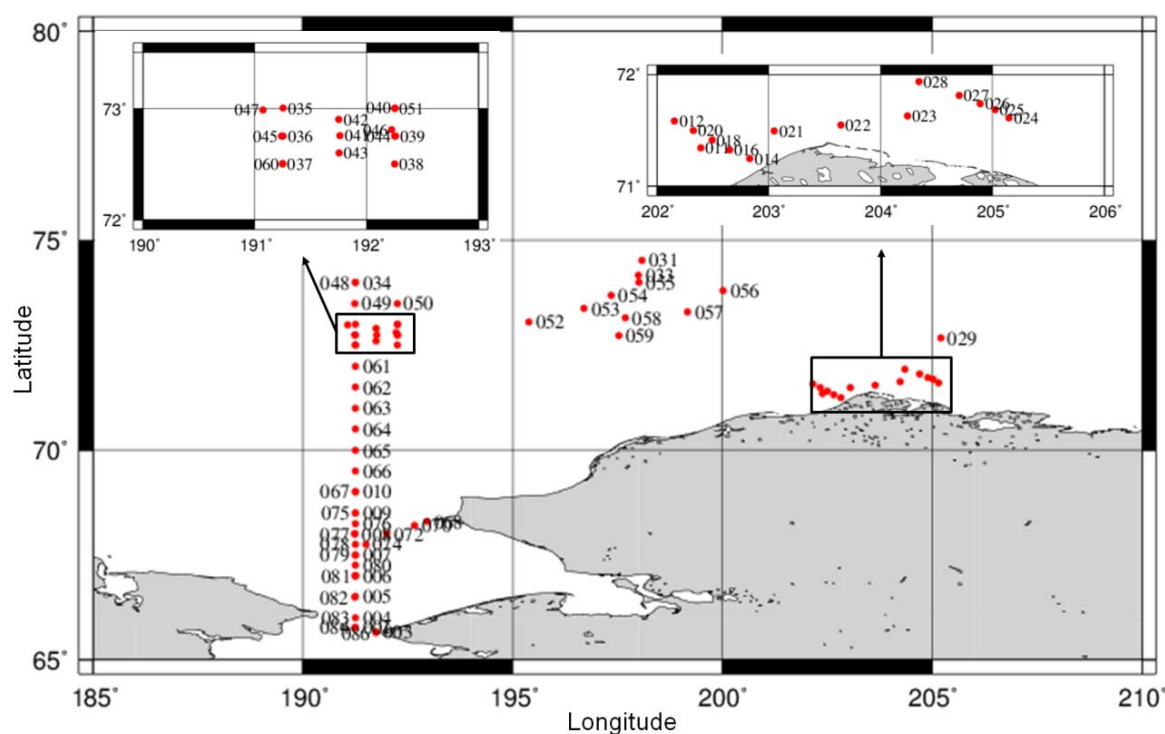


Figure 4.4-1. Map of sampling station.

(6) Preliminary results

At each station, samples were taken in duplicate for waters of the following table 4.4-1. The difference between each pair of analyses was plotted on a range control chart (Figure 4.4-2). The average of the difference was $0.88 \mu\text{mol kg}^{-1}$ ($n = 299$ pair) with its standard deviation of $0.80 \mu\text{mol kg}^{-1}$, which indicates that the analysis was accurate enough according to Guide to best practices for ocean CO_2 measurements (Dickson et al., 2007).

Table 4.4-1. The layer taken in duplicate for waters

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

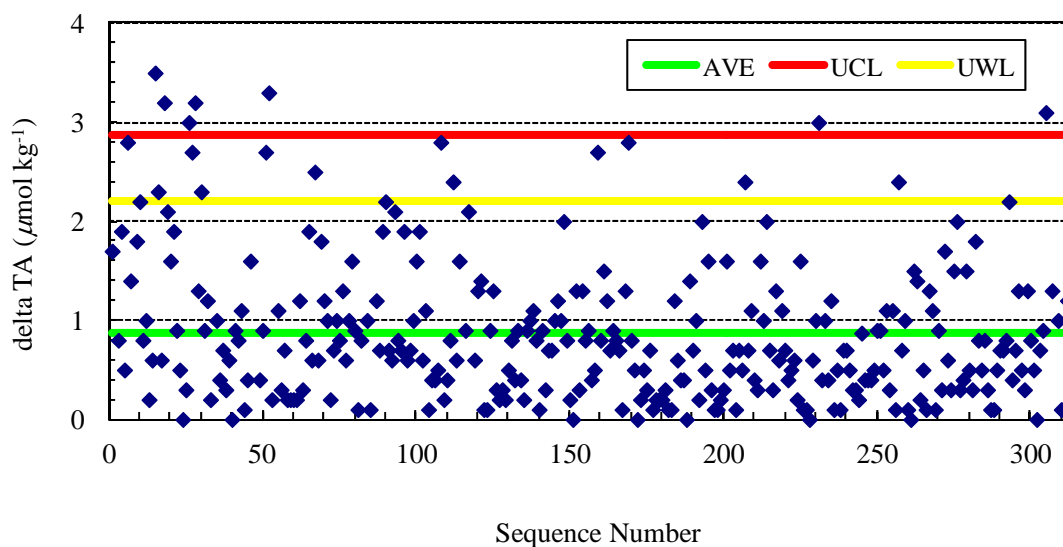


Figure 4.4-2. Range control chart of the absolute differences of duplicate measurements of TA carried out during this cruise.

(7) 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.

(8) 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, 199

4.5. Chlorophyll *a* Measurements of Total and Size-fractionated Phytoplankton

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator (PI)

Amane Fujiwara (National Institute of Polar Research)

Ryosuke Futuki (School of Fisheries Sciences, Hokkaido University)

Hideki Yamamoto (MWJ)

Misato Kuwahara (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* maximum 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 (0.25L) 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

10µm 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 4.5-1.

(5) Results

Samples for total and size-fractionated chl-*a* were collected at 144 and 43 stations, respectively (see Figure 4.5-1). The numbers of samples for total and size-fractionated chl-*a* were 1407 and 502, respectively.

(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.

(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 4.5-1. 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

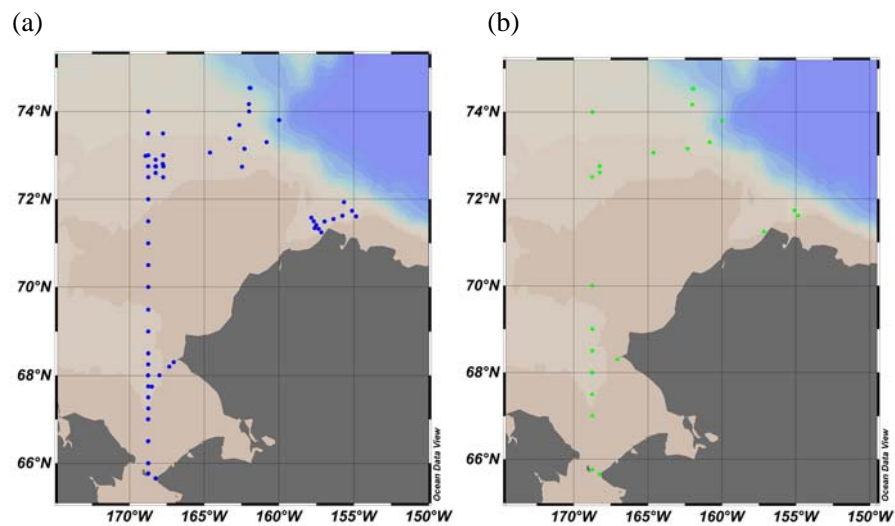


Figure 4.5-1. Maps of stations for (a) total and (b) size-fractionated chlorophyll *a* measurements.

4.6. Primary Production

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator

Toru Hirawake (Hokkaido University)

Amane Fujiwara (National Institute of Polar Research /Hokkaido University)

Ryosuke Futuki (Hokkaido University)

Kanako Yoshida (MWJ): Operation Leader

Keitaro Matsumoto (MWJ)

(2) Objective

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

(3) Parameter

Primary production

(4) Instruments and methods

a. Instruments

Stable isotope analyzer

ANCA-SL by Europa Scientific Ltd.; now SerCon Ltd.

Software

ANCA Ver.3.6

b. Methods

Primary production was measured at 10 stations (Sts. 001, 008, 024, 034, 041, 052, 057, 060, 077 and 084) by simulated in situ incubation method (see Figure 4.6-1 and Table 4.6-1). 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%, 14%, 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 ($\text{NaH}^{13}\text{CO}_3$) for the measurements of primary production. The concentration of labeled carbon ($\text{NaH}^{13}\text{CO}_3$) 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 4.6-1 shows a station list including optical depths, incubation times, and measured parameters with or without zero time (natural abundance) measurements.

(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.

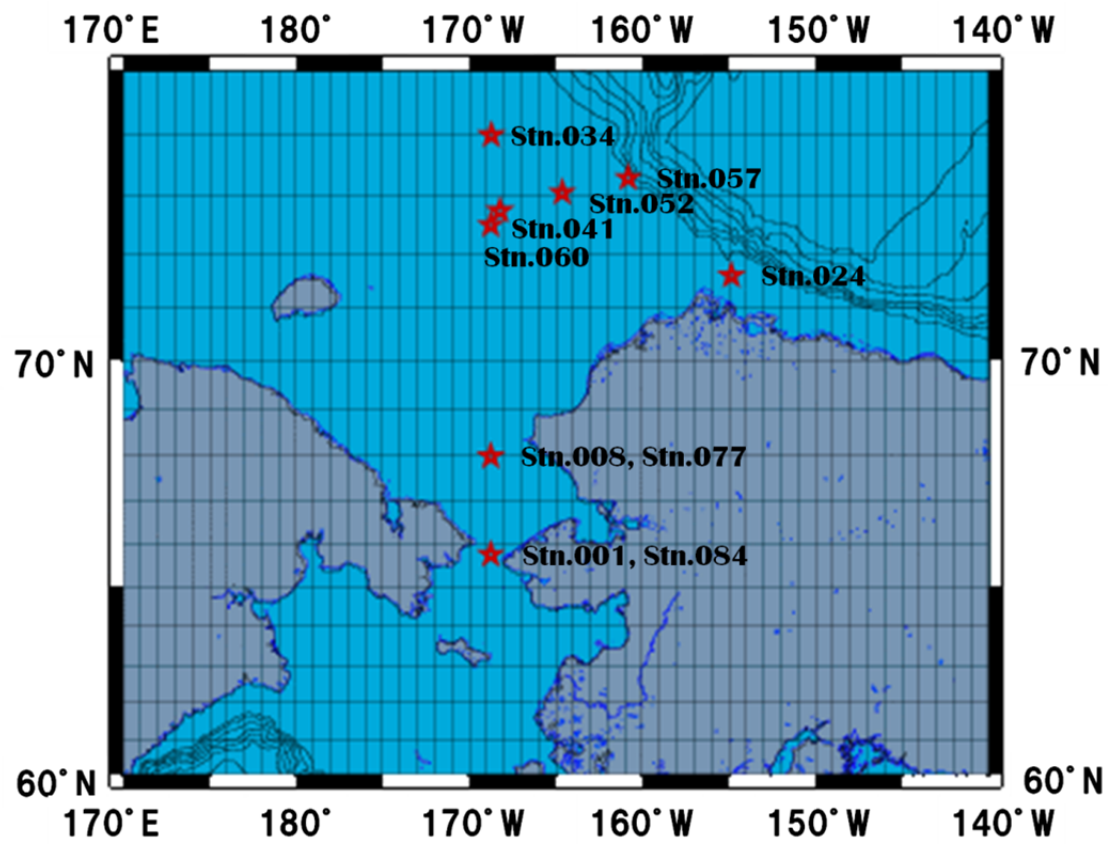


Figure 4.6-1. Map of stations with station numbers for the measurements of primary production (red stars).

Table 4.6-1. List of stations, optical depths, incubation times, and measured parameters with or without zero time (natural abundance) measurements

Stations	Optical depths (%)	Incubation time (hrs)	Primary Production
001Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
008Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
024Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
034Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
041Cast.1	1, 4, 7, 13, 38, 100	24	x&0
041Cast.9	0.6, 1, 4, 7, 13, 38, 100	24	x
041Cast.17	0.6, 1, 4, 7, 13, 38, 100	24	x
041Cast.25	0.6, 1, 4, 7, 13, 38, 100	24	x
041Cast.33	0.6, 1, 4, 7, 13, 38, 100	24	x
041Cast.41	0.6, 1, 4, 7, 13, 38, 100	24	x
041Cast.49	0.6, 1, 4, 7, 13, 38, 100	24	x
041Cast.57	0.6, 1, 4, 7, 13, 38, 100	24	x
052 Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
057 Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
041Cast.62	0.6, 1, 4, 7, 13, 38, 100	24	x
060 Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x
077 Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0
084 Cast.1	0.6, 1, 4, 7, 13, 38, 100	24	x&0

x: measurements without zero time

x&0: measurements with zero time

4.7. Bio-optical Observations

(1) Personnel

Toru Hirawake (Faculty of Fisheries Sciences, Hokkaido University; not onboard): PI
Amane Fujiwara (National Institute of Polar Research)
Ryosuke Futuki (School of Fisheries Sciences, Hokkaido University)

(2) Objectives

- 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 differences of grazing properties between mesozooplankton species from the Pacific and Arctic Ocean.
- D) To investigate phytoplankton community structure

(3) Parameters

- A) Underwater spectral irradiance and radiance (PRR-800/810)
- B) Incident photosynthetic available radiation (PAR)
- C) Light absorption coefficients of particles and colored dissolved organic materials (CDOM)
- D) Phytoplankton pigments (HPLC)
- E) Grazing experiment
- F) Daily net primary productivity of phytoplankton (NPP) (*see description of '4.6 Primary production' by Nishino (JAMSTEC) et al. in this report*)
- G) Bulk and size fractionated chlorophyll *a* concentration (*see description of '4.5 Chlorophyll a' by Nishino (JAMSTEC) et al. in this report*)

(4) Instruments and Methods

Sampling stations for each measurement and experiment are shown in Table 4.7-1.

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

Underwater spectral downwelling irradiance $E_d(\lambda, z)$ ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and upwelling radiance $L_u(\lambda, z)$ ($\mu\text{W cm}^{-2} \text{ nm}^{-1} \text{ str}^{-1}$) 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 $E_d(\lambda, 0+)$ ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) was monitored by reference spectroradiometer, PRR-810 (Biospherical Instrument Inc.) with same specification as the underwater sensor. Before each deployment of the instrument, 10 minutes averaged dark values were recorded. For NPP measurements, underwater photosynthetic available radiation (PAR), $E_q(z)$, was also calculated by converting the $E_d(\lambda, z)$ to quantum unit, $E_q(\lambda, z)$ ($\mu\text{mol photons m}^{-2} \text{ s}^{-1}$), and integrating the $E_q(\lambda, z)$ from 412 to 710 nm.

B) 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.

C) 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, UV-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 determined subtracting $a_d(\lambda, z)$ from $a_p(\lambda, z)$.

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

D) 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 N₂. 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.

E) 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.). Copepods sample was collected with 80 cm ring net.

Seawater sample was transferred into 2500 ml clear polycarbonate bottles. Copepods sample was sorted and several species of copepod 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.

F) Daily net primary productivity of phytoplankton (NPP)

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

G) 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 by Nishino (JAMSTEC) et al.

(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 4.7-1. Sampling summary

Stn ID	Cast	Stn type	Lat.	Lon.	Date (UTC)	Time (UTC)	Weather*	Depth(m)	SST(°C)	samples collected							operation
										total chla	size chla	CDOM	QFT	PP	HPLC	incubation	PRR800
1	1	Vertical	65.7697	-168.752	08/31/2013	19:51	b	54	6.95	X	X	X	X	X	X	X	X
3	1	Surface	65.6573	-168.253	08/31/2013	22:58	b	43	11.12	X	X	X	X		X		X
8	1	Vertical	68.0042	-168.764	09/01/2013	18:48	b	58	5.30	X	X	X	X	X	X	X	X
9	1	Surface	68.5033	-168.746	09/01/2013	22:17	b	53	7.98	X	X	X	X		X		X
14	1	Vertical	71.2452	-157.171	09/04/2013	0:29	s	46	2.47	X	X	X	X		X		X
18	1	Surface	71.4112	-157.508	09/04/2013	6:50	-	122	2.40							X	
24	1	Vertical	71.6087	-154.852	09/04/2013	19:21	o	44	2.74	X	X	X	X	X	X		X
26	1	Surface	71.7365	-155.1100	09/04/2013	22:51	o	257	3.13	X	X	X	X		X		X
32	1	Surface	74.5373	-161.9670	09/09/2013	2:27	s	1685	0.49	X	X	X	X		X		X
34	1	Vertical	73.9972	-168.742	09/09/2013	21:39	o	178	0.01	X	X	X	X	X	X		X
41	1	Vertical	72.7532	-168.2413	09/10/2013	21:13	o	56	3.20	X	X	X	X	X	X		X
41	5	Vertical	72.7505	-168.2507	09/11/2013	20:42	o	56	3.19	X	X	X	X		X		X
41	9	Vertical	72.7498	-168.2612	09/12/2013	20:41	o	56	3.22	X	X	X	X	X	X		X
41	13	Vertical	72.7513	-168.2532	09/13/2013	20:42	o	56	3.22	X	X	X	X		X		X
41	17	Vertical	72.7482	-168.2457	09/14/2013	20:44	s	56	2.78	X	X	X	X	X	X		X
41	21	Vertical	72.7512	-168.2542	09/15/2013	20:42	0	56	2.56	X	X	X	X		X		X
41	25	Vertical	72.7515	-168.2533	09/16/2013	20:42	s	56	2.60	X	X	X	X	X	X		X
41	29	Vertical	72.7495	-168.2487	09/17/2013	20:41	o	56	2.78	X	X	X	X		X		X
41	33	Vertical	72.7487	-168.2503	09/18/2013	20:41	o	56	2.50	X	X	X	X	X	X		X
41	37	Vertical	72.7480	-168.2522	09/19/2013	20:43	o	56	2.38	X	X	X	X		X		X
41	41	Vertical	72.7488	-168.2408	09/20/2013	20:45	o	56	2.00	X	X	X	X	X	X		X
41	45	Vertical	72.7498	-168.2512	09/21/2013	20:41	o	56	1.71	X	X	X	X		X		X
41	49	Vertical	72.7498	-168.2492	09/22/2013	20:42	o	56	1.51	X	X	X	X	X	X		X
41	53	Vertical	72.7488	-168.2472	09/23/2013	20:41	o	56	1.73	X	X	X	X		X		X
41	57	Vertical	72.7505	-168.2493	09/24/2013	20:42	bc	56	1.58	X	X	X	X	X	X		X
41	59	incubation	72.7548	-168.2487	09/25/2013	8:48	-	56	1.95							X	
41	61	Vertical	72.7518	-168.2480	09/25/2013	20:41	c	56	2.00	X	X	X	X		X		X
52	1	Vertical	73.0625	-164.6190	09/26/2013	22:03	bc	84	-0.59	X	X	X	X	X	X		X
57	1	Vertical	73.3033	-160.8337	09/27/2013	22:32	bc	410	0.71	X	X	X	X	X	X		X
58	1	Vertical	73.1498	-162.3122	09/28/2013	2:13	bc	200	0.90	X	X	X	X		X		X
41	62	Vertical	72.7518	-168.2570	09/30/2013	21:00	o	56	0.42	X	X	X	X	X	X		X
41	64	incubation	72.7497	-168.2518	10/01/2013	8:43	-	56	1.00							X	
60	1	Vertical	72.5028	-168.7508	10/01/2013	19:31	bc	58	1.25	X	X	X	X	X	X		X
68	1	Vertical	68.3013	-167.0458	10/02/2013	22:56	o	38	4.51	X	X	X	X		X		X
77	1	Vertical	68.0008	-168.7562	10/03/2013	20:31	o	58	2.16	X	X	X	X	X	X	X	X
84	1	Vertical	65.7633	-168.7573	10/04/2013	18:23	c	52	1.69	X	X	X	X	X	X		X

4.8. Microbes and DOC/N

(1) Personnel

Toshi Nagata (Atmosphere and Ocean Research Institute, Univ. of Tokyo; not onboard): PI

Mario Uchimiya (National Institute of Polar Research)

Chiaki Motegi (Université Laval)

(2) Objective

To clarify the spatial variations in and regulation of microbes and dissolved organic matter in the Chukchi Sea, western Arctic.

(3) Parameters

i) Microbes

- a) Prokaryote abundance
- b) Heterotrophic prokaryote production
- c) Prokaryote and viral community composition

ii) Dissolved organic matter

- d) Dissolved organic carbon and nitrogen (DOC/N)

(4) Methods and Instruments

i) Microbes

a) Prokaryote 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 abundance will be determined by flow cytometry in a land laboratory.

b) Heterotrophic prokaryote production

1.5 mL of seawater sample was amended with ³H-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) 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 Pyrosequencing 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) Dissolved organic matter

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.

(5) Observation log

Information about sample and data collection is summarized in Table 4.8-1.

(6) Data archive

All the data obtained during MR13-06 cruise will be submitted to the Data Management Group (DMG) of JAMSTEC after the sample analysis and validation.

Table 4.8-1. Observation log. Sta.#, station number; FCM, flow cytometry for prokaryote abundance; HPP, heterotrophic prokaryote production; CC, community composition of prokaryote and virus; DOC/N, dissolved organic carbon and nitrogen. For each parameter, the information is indicated by “1” when the sample (or data) collection was conducted, whereas indicated by “-“ when not conducted.

Sta. #	Cast #	Date	FCM	ProkP	CC	DOC/N
1	1	2013.8.31	1	1	1	1
3	1	2013.8.31	1	1	1	1
8	1	2013.9.1	1	1	1	1
9	1	2013.9.1	1	1		1
26	1	2013.9.4	1	1	1	1
31	1	2013.9.7	1	1	1	1
34	1	2013.9.9	1	1	1	1
35	1	2013.9.9	1	1	1	1
37	1	2013.9.10	1	1	1	1
41	1	2013.9.10	1	1		1
41	5	2013.9.11	1	1		1
41	9	2013.9.12	1	1		1
41	13	2013.9.13	1	1	1	1
41	15	2013.9.14	1	1		
41	17	2013.9.14	1	1	1	1
41	19	2013.9.14	1	1		
41	21	2013.9.15	1	1		1
41	23	2013.9.16	1	1		
41	25	2013.9.16	1	1	1	1
41	26	2013.9.17	1	1		
41	27	2013.9.17	1	1		
41	28	2013.9.17	1	1		
41	29	2013.9.17	1	1		1
41	30	2013.9.18	1	1		
41	31	2013.9.18	1	1		
41	32	2013.9.18	1	1		
41	33	2013.9.18	1	1	1	1
41	34	2013.9.19	1	1		

41	35	2013.9.19	1	1		
41	36	2013.9.19	1	1		
41	37	2013.9.19	1	1		1
41	38	2013.9.20	1	1		
41	39	2013.9.20	1	1		
41	40	2013.9.20	1	1		
41	41	2013.9.20	1	1	1	1
41	42	2013.9.21	1	1		
41	43	2013.9.21	1	1		
41	44	2013.9.21	1	1		
41	45	2013.9.21	1	1		1
41	46	2013.9.22	1	1		
41	47	2013.9.22	1	1		
41	48	2013.9.22	1	1		
41	49	2013.9.22	1	1	1	1
41	50	2013.9.23	1	1		
41	51	2013.9.23	1	1		
41	52	2013.9.23	1	1		
41	53	2013.9.23	1	1		1
41	54	2013.9.24	1	1		
41	55	2013.9.24	1	1		
41	56	2013.9.24	1	1		
41	57	2013.9.24	1	1	1	1
41	58	2013.9.25	1	1		
41	59	2013.9.25	1	1		
46	1	2013.9.25	1	1	1	1
47	1	2013.9.26	1	1	1	1
48	1	2013.9.26	1		1	
52	1	2013.9.26	1	1	1	1
56	1	2013.9.27	1	1	1	1
58	1	2013.9.28	1	1	1	1
41	62	2013.9.30	1	1		1
41	63	2013.10.1	1	1		
41	64	2013.10.1	1	1		
41	65	2013.10.1	1	1		

61		2013.10.1	1	1	1	1
65		2013.10.2	1	1	1	1
77		2013.10.3	1	1	1	1
84		2013.10.4	1	1		
86		2013.10.4	1	1	1	1

4. 9. Trace Metals

(1) Personnel

Ana M. Aguilar-Islas (University of Alaska Fairbanks): Principal Investigator

Shigeto Nishino (JAMSTEC): Co-PI

Kenichiro Sato (MWJ)

Robert Rember (International Arctic Research Center, not on board)

(2) Objectives

Investigate the distribution and partitioning of iron (Fe) and other trace metals.

(3) Parameters

A. Dissolved Fe, Cu, Zn, Cd, Pb

B. Leachable particulate Al, Mn, Fe, Cu,

C. Total particulate Al, Mn, Fe, Cu

D. Organic Fe speciation

(4) Instruments and Methods

Seawater samples were collected using a “clean” 12-position rosette water sampling system. The system consists of a powder-coated aluminum frame, titanium exposed metal surfaces, a Sea-Bird Electronics, Inc. 19plus unit, a Wet Labs EcoView fluorometer, a Wet Labs C-Star transmissometer, and a Sea-Bird Electronics Inc. auto fire module (AFM) which is programmed to fire bottles at the desired depths. The 5-liter bottles used are Teflon-coated with external-spring. These were washed with phosphate-free detergent and 0.5 M Trace-Metal Grade hydrochloric acid, and were rinsed and stored with Milli-Q water prior to use. The rosette was deployed using the ship’s Kevlar wire. A maximum of 9 bottles were deployed during casts due to weight restrictions on the Kevlar wire. During rough sea conditions, bottles were hung directly on the Kevlar wire, and messengers were used to fire the bottles. Upon recovery bottles were taken to a wet lab and water was subsampled in line using acid cleaned Teflon tubing and ultra-pure nitrogen gas to pressurize the bottles. Seawater samples were filtered inside a plastic enclosure under a positive pressure atmosphere through 0.4 μ m polycarbonate track-etched filters (Nuclepore). Filtered seawater samples were collected into acid-washed polyethylene bottles and stored at room temperature. Filters were folded, placed into 7 ml vials and stored frozen.

Snow events were sampled from above the wheel house. Snow was collected using polyethylene bottles attached to a plastic-covered bamboo pole and facing into the wind. This method resulted in low recovery due to changing wind direction, and was abandoned for the use of a large polyethylene funnel attached to a 500 ml polyethylene bottle. After collection, snow was allowed to melt inside a plastic enclosure under a positive pressure atmosphere. In general melted snow yielded less than 30 ml, and samples were not filtered. When snow events yielded more than 30 ml, samples were filtered through 0.4 μ m polycarbonate track-etched filter, and an unfiltered subsample was also collected. When snow events yielded less than 3 ml, the sample was discarded.

One sea ice sample was collected using a net, and was stored frozen.

Samples will be analyzed onshore using a high-resolution inductively-coupled plasma mass spectrometer (HR-ICPMS) at the International Arctic Research Center of the University of Alaska, Fairbanks.

(5) List of Stations and Samples

A total of 21 vertical profiles were collected from 11 stations (Figure 4.9-1). Eleven of the 21 profiles were collected from the stationary point observation main station (Stn 41) (Table 4.9-1). Station 48 was a re-occupation of Station 34. Collected seawater samples (120) are listed on Table 4.9-1. Subsamples collected for organic iron speciation are denoted with an asterisk. A total of 11 snow samples were collected and are listed on Table 4.9-2. One sea ice sample was collected.

(6) Preliminary Results

The two-layer system at the stationary observation point main station (Stn 41) exhibited a narrow (c.a. 10 m) and variable benthic boundary layer (BBL) as determined by the change in beam transmission data of the bottom 20 m (Figure 4.9-2). Sedimentary input is likely the main source of trace metals over the Chukchi shelf, and this variability in the BBL is expected to affect primarily the dissolved and particulate distribution of trace metals in the bottom layer at this station. The resuspended sediment was mainly composed of organic aggregates (Figure 4.9-3), and it is expected that these will yield a high percentage of leachable particulate iron similar to the resuspended sediment over the Bering Sea shelf (Hurst et al., 2010). Within the narrow BBL a linear relationship was found for the concentration of oxygen (CTD sensor data) as a function of % beam transmission (CTD transmissometer data) (Figure 4.9-4) suggesting that coupling between resuspension of particles and the mixing of dissolved constituents from the surface sediment. Indeed, similar relationships were found between % beam transmission and nutrients within the BBL, with the best correlation obtained for nitrite (Figure 4.9-5). This relationship was disrupted during a 2 day period, likely as a result of a mixing event that brought high-dissolved oxygen, low-nutrient, low particle water down into the BBL (Figures 4.9-2, 4.9-4, and 4.9-5). It is expected that the dissolved and particulate trace metal distributions were also affected by this mixing event. Surprisingly the relationship between dissolved oxygen and % beam transmission was unique for each of the closely clustered stationary point observation stations (Stn 41-45) (Figure 4.9-6), suggesting that sedimentary inputs/sinks of trace elements are possibly quite variable over the Chukchi shelf.

(7) Data Archive

The data obtained from samples collected during 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.

(8) References

Hurst, M. P., A.M. Aguilar-Islas, K.W. Bruland, 2010. Iron in the southeastern Bering Sea: Elevated leachable particulate Fe in shelf bottom waters as an important source for surface waters. *Continental Shelf Research*, doi: 10.1016/j.csr.2010.01.001

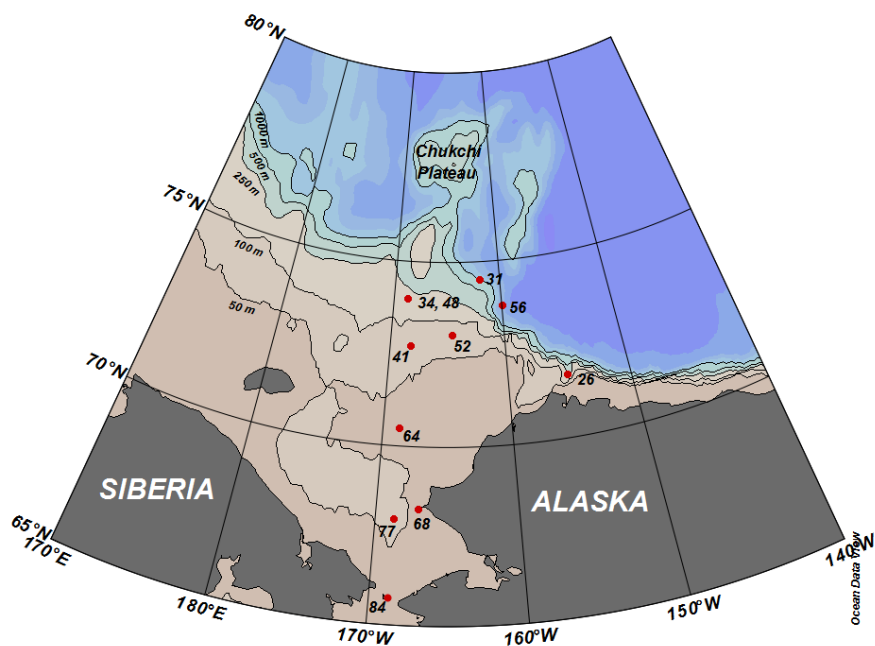


Figure 4.9-1. Trace metal station locations.

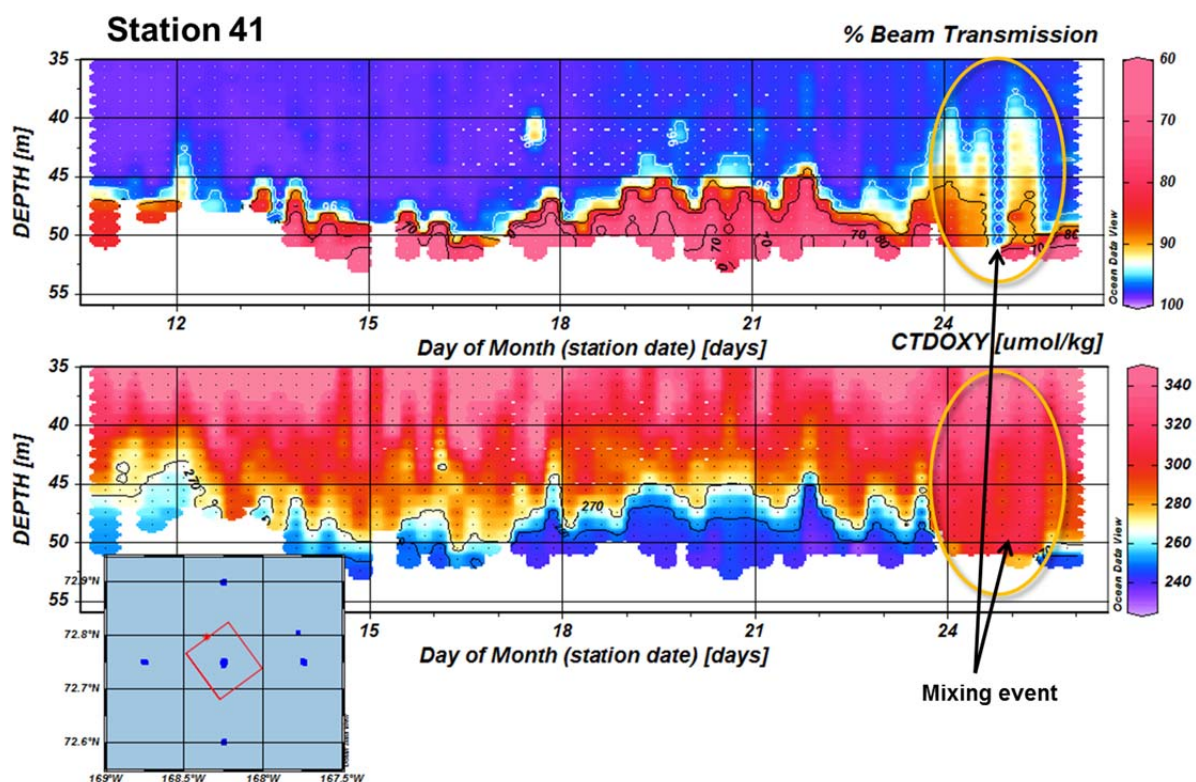


Figure 4.9-2. Variability in % beam transmission and dissolved oxygen within the bottom 20 m at Station 41.

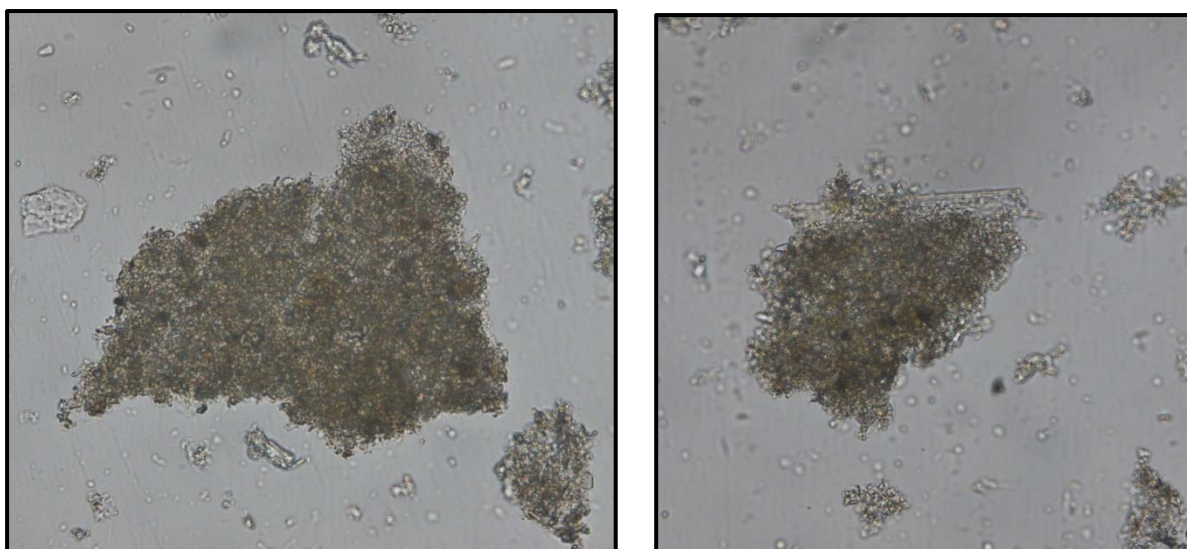


Figure 4.9-3. Suspended sediment from 50 m at Station 041, cast 45 (22 September). Photos by Katsunori Kimoto.

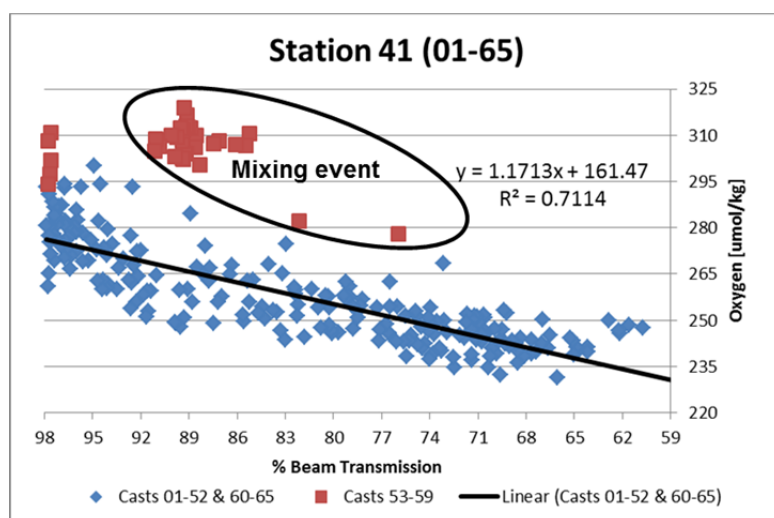


Figure 4.9-4. Dissolved oxygen as a function of % beam transmission at the Station 41. Data was taken from 47 m and below. The data from the mixing event (casts 53 to 59) are not included in the linear regression.

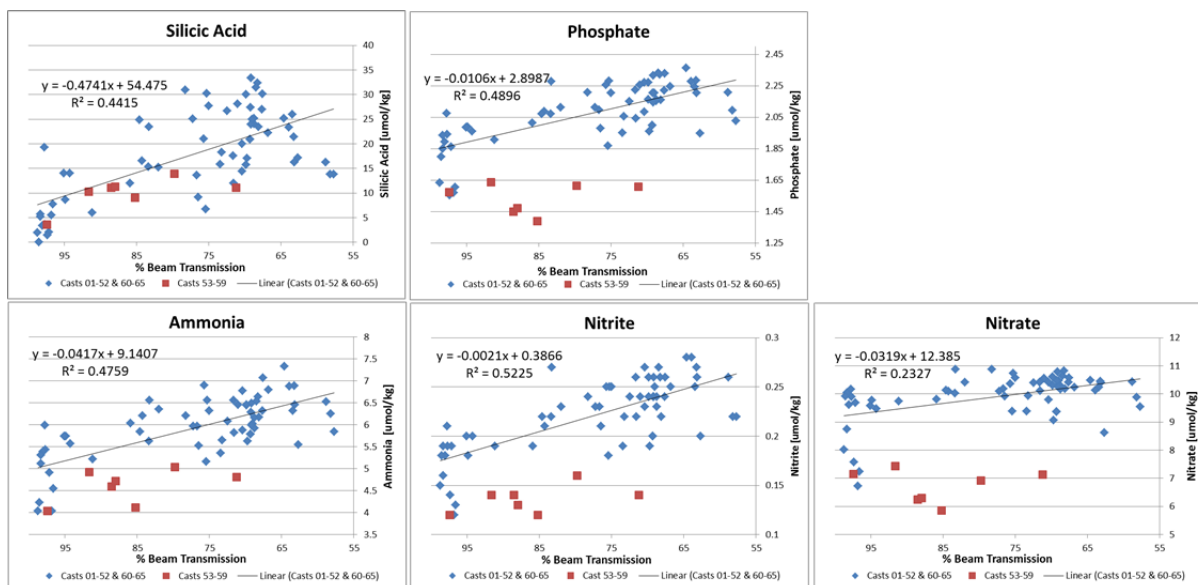


Figure 4.9-5. Dissolved nutrients as a function of % beam transmission at the Station 41. Data was taken from 46 m and below. The data from the mixing event (casts 53 to 59) are not included in the linear regression.

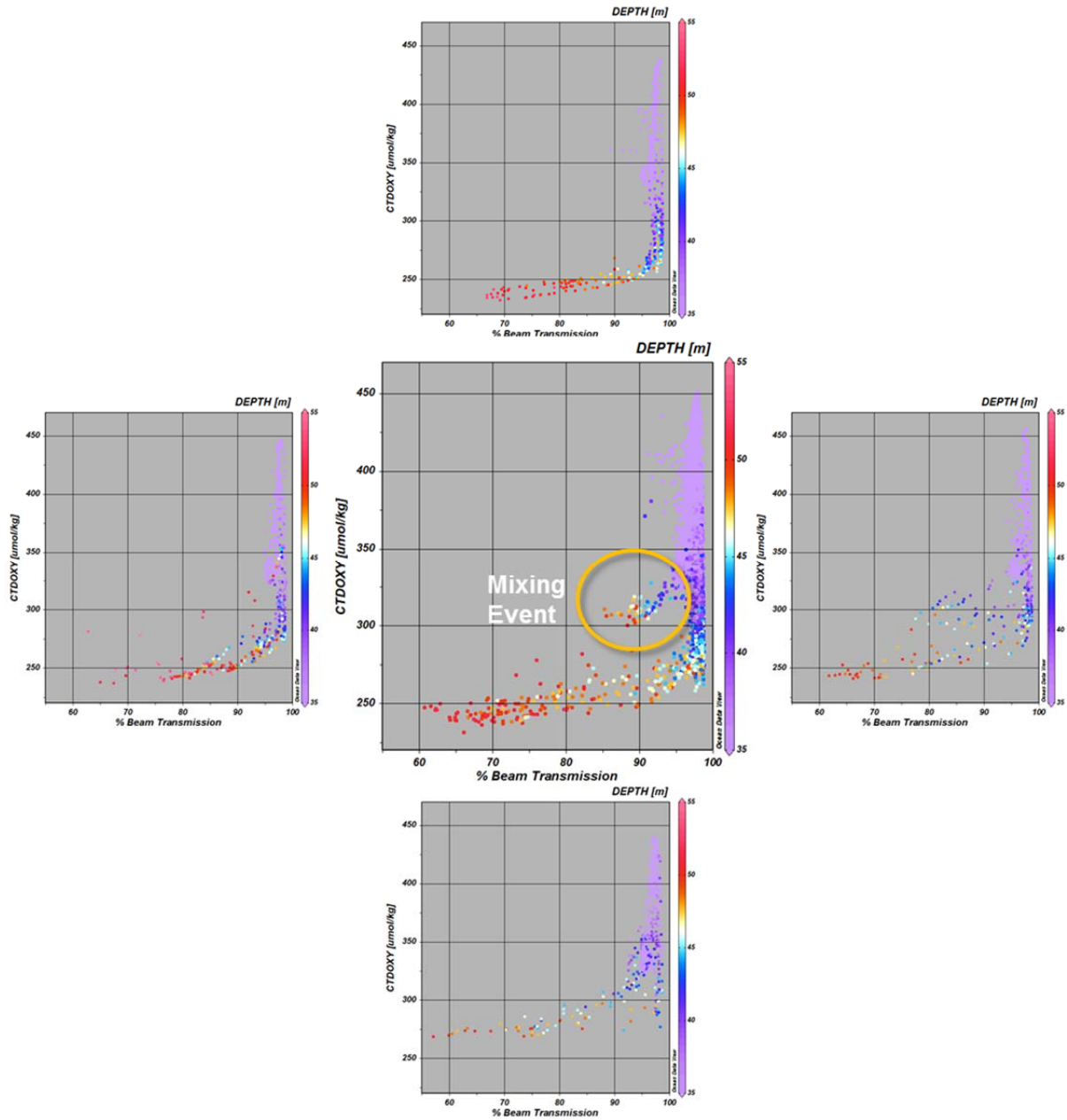


Figure 4.9-6. Dissolved oxygen as a function of % beam transmission at the Stations 41-45. Unique signature at each of the fix point observation stations.

Table 4.9-1. Seawater and Suspended Particles Sample List. ** Denotes duplicate sample

Date	Station #	"Clean" Cast ID	Depth	Sample #	Date	Station #	"Clean" Cast ID	Depth	Sample #
5/09/13	026	TM01-26r	15 m	1	23/09/13	041-53	TM11-41-53	15 m	60
			25 m	2				25 m	61
			40 m	3				30 m	62
			65 m	4				40 m	63
			90 m	5				45 m	64
			120 m	6				50 m	65
			150 m	7	24/09/13	041-57	TM12-41-57	15 m	66
			200 m	8				25 m	67
			240 m	9				30 m	68
8/09/13	031	TM02-31	15 m	10*				40 m	69
			55 m	11*				45 m	70
			125 m	12*				50 m	71
			200 m	13*	25/09/13	041-61	TM13-41-61	15 m	72*
			250 m	14*				25 m	73*
			400 m	15*				30 m	74
			600 m	16*				40 m	75
			800 m	17*				45 m	76
			1000 m	18*				50 m	77
9/09/13	034	TM03-34	15 m	19*	25/09/13	048	TM14-48	15 m	78
			25 m	20*				25 m	79
			40 m	21*				40 m	80
			90 m	22*				60 m	81
			** 90 m	23				120 m	82
			150 m	24*	26/09/13	052	TM15-52	15 m	83
			165 m	25*				25 m	84
11/09/13	041-05	TM04-41-05	15 m	26*				45 m	85
			25 m	27*				50 m	86
			30 m	28*				60 m	87
			40 m	29*				70 m	88
			50 m	30*	27/09/13	056	TM16-56	15 m	89*
13/09/13	041-13	TM05-41-13	15 m	31				40 m	90*
			25 m	32				100 m	91
			30 m	33				150 m	92
			40 m	34				200 m	93
			50 m	35				430 m	94
15/09/13	041-21	TM06-41-21	15 m	36				600 m	95
			25 m	37				800 m	96
			30 m	38				1000 m	97
			40 m	39	30/09/13	041-62	TM17-41-62	15 m	98
			50 m	40				25 m	99
17/09/13	041-29	TM07-41-29	15 m	41				30 m	100
			25 m	42				40 m	101
			30 m	43				45 m	102
			40 m	44				50 m	103
			50 m	45	01/10/13	064	TM18-64	15 m	104
19/09/13	041-37	TM08-41-37	15 m	46				20 m	105
			31 m	47				30 m	106
21/09/13	041-45	TM09-41-45	15 m	48				34 m	107
			25 m	49	02/10/13	068	TM19-68	15 m	108
			30 m	50				25 m	109
			40 m	51				34 m	110
			45 m	52	03/10/13	077	TM20-77	15 m	111
			50 m	53				25 m	112
22/09/13	041-49	TM10-41-49	15 m	54				35 m	113
			25 m	55				45 m	114
			30 m	56				50 m	115
			40 m	57				54 m	116
			45 m	58	04/10/13	084	TM21-84	15 m	117
			50 m	59				25 m	118
								35 m	119
								46 m	120

Table 4.9-2. Snow Sample List

Date	Notes	Sample #	Date	Notes	Sample #
8 September	< 3 ml Discarded	0	24-25 September	< 3 ml Discarded	0
13 September	< 3 ml Discarded	0	27-28 September	30 ml Filtered	8
15-16 September	7.5 ml Unfiltered	1		30 ml Unfiltered	9
16 September	18 ml Unfiltered	2	30 September	30 ml Unfiltered	10
16-18 September	13.5 ml Unfiltered	3		75 ml Filtered	11
18-19 September	5.5 ml Unfiltered	4	1-2 October	< 3 ml Discarded	0
21-22 September	24.5 ml Unfiltered	5			
22-24 September	30 ml Filtered	6			
	12 ml Unfiltered	7			

4.10. Underway Surface Water Monitoring

(1) Personnel

Shigeto NISHINO (JAMSTEC): Principal Investigator

Hiroshi Uchida (JAMSTEC)

Shinichiro YOKOGAWA (Marine Works Japan Co. Ltd): Leg1 Operation Leader

Katsunori SAGISHIMA (Marine Works Japan Co. Ltd): Leg1

Masahiro ORUI (Marine Works Japan Co. Ltd): Leg1

Keitaro MATSUMOTO (Marine Works Japan Co. Ltd): Leg2 Operation Leader

Kanako YOSHIDA (Marine Works Japan Co. Ltd): Leg2

(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 dm³ min⁻¹.

a. Instruments

Software

Seamoni-kun Ver.1.50

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:	1519
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

Accuracy: or 0.1 % of reading whichever is greater
 $< 1 \mu\text{mol dm}^{-3}$
or 5 % of reading whichever is greater

Fluorometer

Model: C3, TURNER DESIGNS
Serial number: 2300384

b. Measurements

Periods of measurement, maintenance, and problems during MR13-06 are listed in Table 4.10-1.

Table 4.10-1. Events list of the Sea surface water monitoring during MR13-06

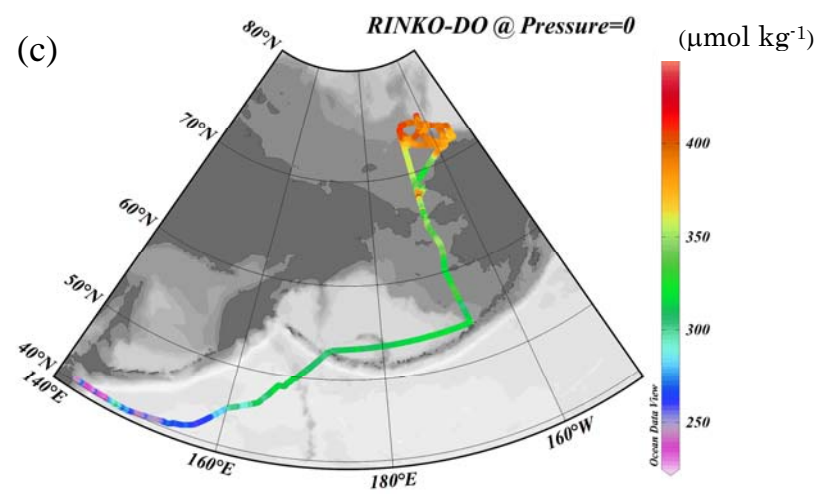
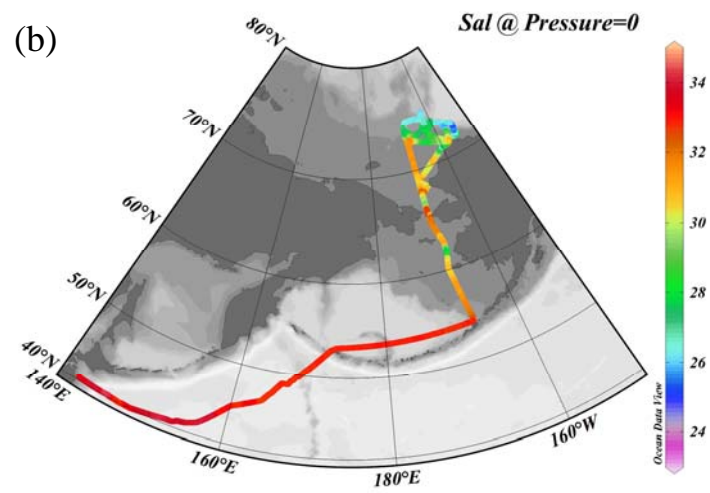
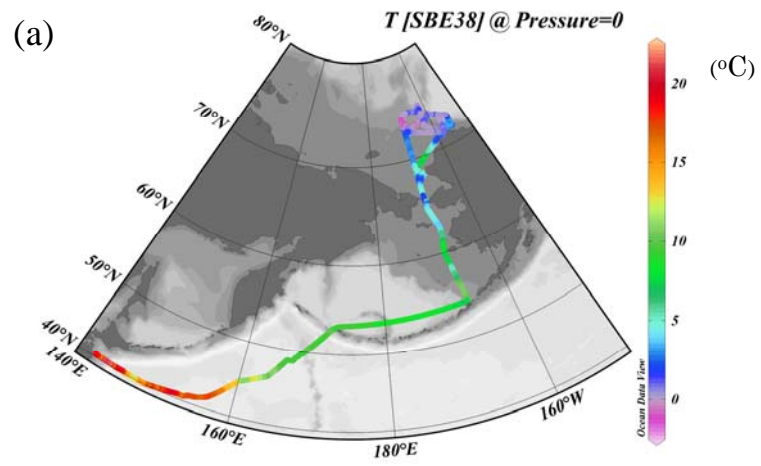
System Date [UTC]	System Time [UTC]	Events	Remarks
2013/08/28	23:31	All the measurements started and data was available.	Cruise start
2013/09/08	21:08	All the measurements stopped.	Filter cleaning
2013/09/08	22:31	All the measurements started.	Logging restart
2013/10/06	10:06	All the measurements stopped.	Leg1 end
2013/10/09	19:55	All the measurements started.	Leg2 start
2013/10/19	07:00	All the measurements stopped.	Cruise end

(5) Preliminary Results

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 Figures 4.10-1 to -3. All the salinity samples were analyzed by the Guideline 8400B “AUTOSAL” (see Section 3.6), and dissolve oxygen samples were analyzed by Winkler method (see Section 4.1), and fluorescence were analyzed by 10-AU (see Section 4.5).

(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.



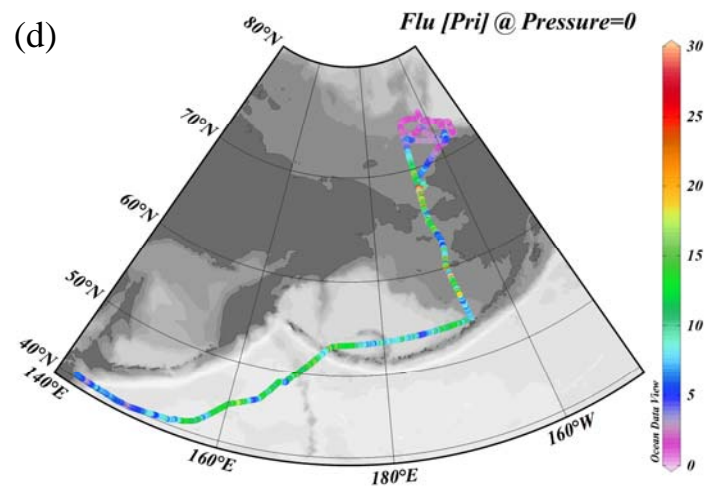


Figure 4.10-1. Spatial and temporal distribution of (a) temperature, (b) salinity, and (c) dissolved oxygen and (d) fluorescence in MR13-06 cruise.

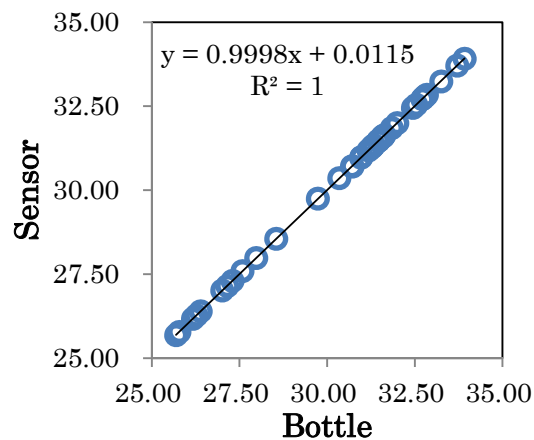


Figure 4.10-2. Correlation of salinity between sensor data and bottle data.

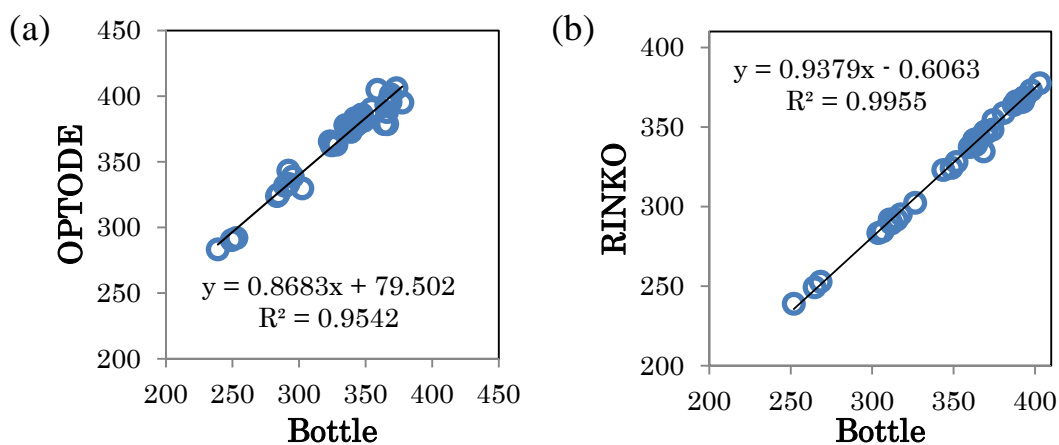


Figure 4.10-3. Correlation of dissolved oxygen between sensor data and bottle data.
(a: OPTODE, b: RINKO)

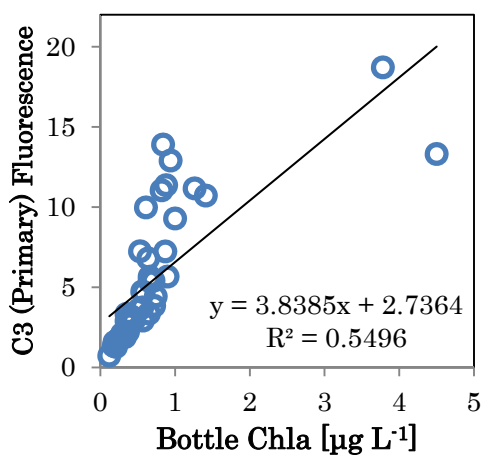


Figure 4.10-4. Correlation of fluorescence between sensor data and bottle data.

4.11. Dissolved Greenhouse Gases

4.11.1. Continuous Measurement of Surface $p\text{CO}_2/p\text{CH}_4$ by CRDS

(1) Personnel

Shuji Aoki (Tohoku University): Principal Investigator

Masao Ishii (Meteorological Research Institute / JMA)

Daisuke Sasano (Meteorological Research Institute / JMA)

Naohiro Kosugi (Meteorological Research Institute / JMA)

Hisayuki Yhoshikawa-Inoue (Hokkaido University)

Hiroshi Uchida (JAMSTEC)

Sakae Toyoda (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology)

Kushi Kudo (Interdisciplinary Graduate School of Science and Engineering
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 $p\text{CO}_2$ and $p\text{CH}_4$ in the atmosphere and in surface seawater to clarify the distributions of $p\text{CO}_2$ and $p\text{CH}_4$ and their controlling mechanisms in the Arctic Ocean.

(3) Parameters

Partial pressure of CO_2 ($p\text{CO}_2$) and CH_4 ($p\text{CH}_4$) in the atmosphere and in near-surface seawater

(4) Instruments and Methods

We made simultaneous measurements of the CO₂ and CH₄ 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 CO₂ and CH₄ mixing ratios once a day. Corrections for the temperature-rise from the seachest to the equilibrator are also to be made. Partial pressure of CO₂ and CH₄ will be calculated from the concentration of CO₂ and CH₄ by taking the water vapor pressure and the atmospheric pressure into account.

(5) Observation log

The shipboard continuous measurements were conducted from 2013/08/28 (UTC) to 2013/10/07 (UTC).

(6) Preliminary results

Preliminary data of CO₂ and CH₄ concentrations in surface water are shown in Figure 4.11.1-1.

(7) 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 home page.

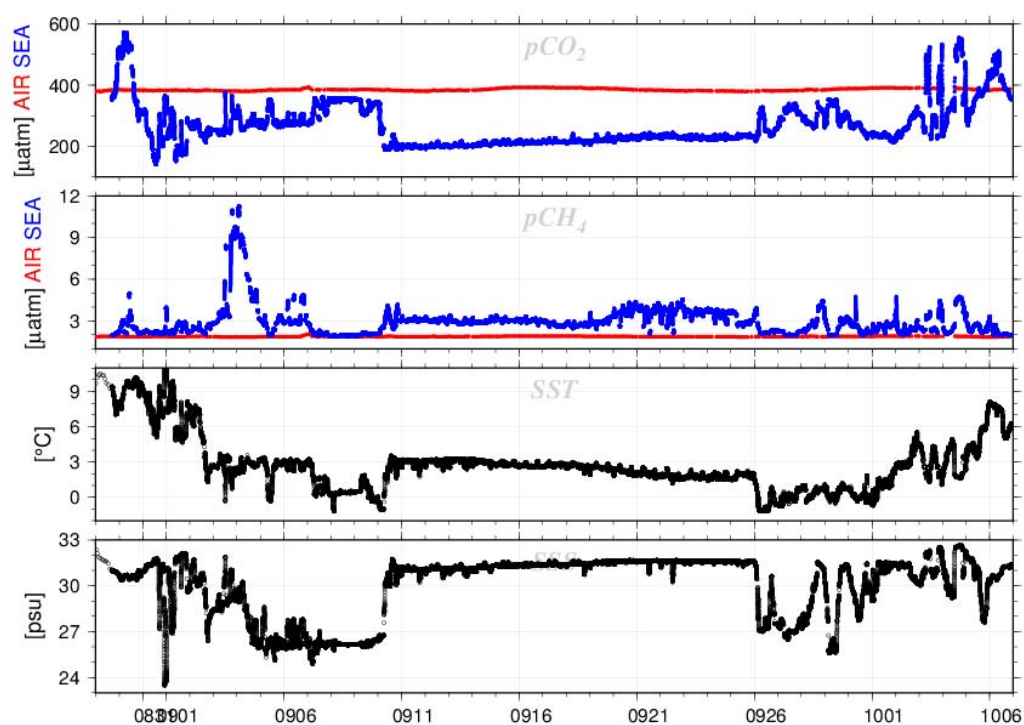


Figure 4.11.1-1. Time series of pCO_2 , pCH_4 , SST and SSS. As for pCO_2 and pCH_4 , red and blue bots indicate partial pressure of atmosphere and surface seawater respectively.

4.11.2. Dissolved Methane (CH₄) and Nitrous Oxide (N₂O)

(1) Personnel

Sakae Toyoda (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology): PI

Keita Yamada (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology)

Kushi Kudo (Interdisciplinary Graduate School of Science and Engineering
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Florian Breider (Interdisciplinary Graduate School of Science and Engineering
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Ayako Fujii (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology)

Naohiro Yoshida (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology)

(2) Objective

Methane

Atmospheric methane (CH₄) is a trace gas playing an important role in the global carbon cycle as an one of the greenhouse gases. 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 CH₄ cycle, it is necessary to quantify its sources and sinks. At present, there remain large uncertainties in the estimated CH₄ fluxes from sources. The ocean's source strength for atmospheric CH₄ should be examined in more detail, even though it might be a relatively minor source, previously reported to be 0.005 to 3% of total input to the atmosphere (Cicerone and Oremland, 1988; Bange et al., 1994; Lelieveld et al., 1998).

Potentially important source of CH₄ from the Arctic Ocean have been reported recently, including degradation of subsea permafrost on the eastern Siberian shelf (ESAS) (Shakhova et al., 2010), aerobic CH₄ production by methylophilic methanogenesis in the central Arctic Ocean (Damm et al., 2010) and sea ice absorbs CH₄ in atmosphere potentially related to both photochemical and biochemical oxidation (He et al., 2013). However, the distribution of CH₄ in the Arctic Ocean is not widely investigated, and there have been few isotopic study of CH₄ dissolved in the Arctic Ocean, which would help understand its production processes. Here we survey distribution of CH₄ dissolved in the surface water, the water column and the oversea atmosphere (using to investigate the atmosphere-ocean interaction of CH₄) of the Arctic

Ocean and analyze the production and consumption processes of CH₄ using stable isotope ratios.

Nitrous oxide

Nitrous oxide (N₂O) is another trace greenhouse gas present in the troposphere. Unlike CH₄, it also has a large stratospheric ozone-depleting potential because its photochemical decomposition products catalytically decompose ozone (Crutzen, 1970). Atmospheric concentration of N₂O increased from 270 ppb during pre-industrial era to 319 ppb in 2005 (IPCC, 2007). The global annual flux of N₂O into the atmosphere is estimated to be about 16 Tg-N yr⁻¹, and the oceans are believed to contribute more than 20% of the global flux (IPCC, 2007).

In the seawater or sediments, N₂O is known to be produced by microbial processes such as nitrification and denitrification. In nitrification, which likely to occur under aerobic conditions, N₂O is produced as a byproduct during the oxidation of hydroxylamine (NH₂OH) to nitrite (NO₂⁻) by ammonia oxidizing bacteria (AOB) or archaea (Yoshida and Alexander, 1970). In denitrification, which likely to occur under anaerobic conditions, N₂O is produced as an intermediate during the reduction of nitrate (NO₃⁻) to N₂ by denitrifying bacteria. Denitrification can be a sink of N₂O under strongly depleted O₂ conditions. Some AOB can produce N₂O by reducing NO₂⁻ generated by NH₃ oxidation, which is often called nitrifier-denitrification (Wrage et al., 2001). Because of these complex pathways, great uncertainty remains in estimation of magnitude of N₂O flux from the oceans, and isotopic analysis is expected to provide qualitative information on N₂O produced and emitted from the oceans.

In the Bering and Chukchi Seas, a single study has been conducted on dissolved N₂O and its isotope ratios (Hirota et al., 2009). The N₂O was found to be supersaturated (up to 157% saturation) in continental shelf water columns between August and September, 2006 (MR06-04 cruise). The authors also observed that the ¹⁵N and ¹⁸O in N₂O are respectively depleted and enriched relative to atmospheric N₂O, and deduced that N₂O is primarily produced through denitrification in sediments. The purpose of the present study is to extend the previous observation area to the wider area of the Arctic Ocean and to obtain additional new isotopic parameter, ¹⁵N-site preference (SP) in NNO molecule, to elucidate the production and consumption mechanisms of N₂O more in detail.

(3) Parameters

Concentration, stable carbon and hydrogen isotope ratios of dissolved CH₄

Concentration, stable nitrogen and oxygen isotope ratios including SP in dissolved N₂O

(4) Instruments and Methods

Seawater samples were collected using CTD-CAROUSEL system equipped with 12-L Niskin bottles. Surface water samples were taken at 0 m depth from sea surface in order to compare with on board continuous monitoring system for dissolved CH₄ operated by MRI. Vertical sampling of the water column was conducted at several deep stations. Sampling locations and depth profile are shown in the station list (Tables 4.11.2-1 to 4.11.2-4). Each sample was subsampled into 30, 125, 600, and 225 (duplicate) ml glass vials to avoid air contamination for analysis of CH₄ concentration, stable carbon and hydrogen isotope ratio of CH₄ and N₂O isotope ratios, respectively. These seawater samples were sterilized by adding saturated mercuric chloride (HgCl₂) solution (HgCl₂ concentration: ca. 0.5% (Tilbrook and Karl, 1995; Watanabe et al., 1995)) to avoid excess CH₄ emission from microbe, and were sealed with rubber stoppers and aluminum caps. They will be stored in a dark and cool place until concentration and stable isotope ratio measurement at Tokyo Institute of Technology.

In addition, air samples were collected at 16 m oversea height using a 2-L stainless flask and were stored at room temperature until analysis (Yamada et al., 2005). Sampling locations are shown in the station list (Table 4.11.2-5).

Concentration of dissolved CH₄ 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 ratio 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 CH₄ is further concentrated in a cryogenic trap in the case of isotopic measurement. Precisions of repeated analyses of CH₄ concentration, and carbon and hydrogen isotope ratio are estimated to be better than 5%, 0.3‰ and 3‰, respectively.

Dissolved N₂O concentrations and its isotopic compositions will be measured similarly by mass spectrometry, although the extracted and purified N₂O is directly introduced into the mass spectrometry (GC-IRMS) which was modified for site-specific ¹⁵N analysis (Yoshida and Toyoda, 2000)

(5) Sampling lists

Table 4.11.2-1. Sampling list for concentration of dissolved CH₄

Station No.	Lat.	Long.	Sampling Depth[m]
1	65°50'N	168°50'W	0, 20, 30, 45
12	71°34'N	159°30'W	0, 20, 40, 59
22	71°40. 83'N	154°58. 42'W	0, 50, 150, 157
23	71°45'N	155°14'W	0, 50, 100, 150, 232
30	74°50. 03'N	161°98. 43'W	0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615
37	72°45. 00'N	168°45. 00'W	0, 40, 49
38	72°30. 00'N	168°15. 00'W	0, 40, 47
41#10	72°45. 00'N	168°15. 00'W	0, 40, 51
41#14			0, 40, 51
41#21			0, 40, 51
41#25			0, 20, 40, 51
41#33			0, 20, 40, 50
41#41			0, 20, 40, 52
41#43			0, 5, 10, 20, 30, 40, 45, 51
41#51			0, 5, 10, 20, 30, 40, 45, 51
41#57			0, 20, 40, 51
48	74°00. 00'N	168°45. 00'W	0, 20, 50, 100, 150, 174
56	73°48. 00'N	160°00. 00'W	0, 10, 20, 50, 100, 150, 200, 500, 800, 1000, 1500, 2000, 2500, 2682
41#63	72°45. 00'N	168°15. 00'W	0, 20, 40, 52
62	71°30. 00'N	168°45. 00'W	0, 10, 20, 30, 40, 47
68	68°18. 00'N	167°3. 00'W	0, 5, 10, 20, 30, 37
77	68°0. 00'N	168°45. 00'W	0, 10, 20, 30, 40, 50
84	65°45. 80'N	168°45. 60'W	0, 10, 20, 30, 40, 47

Table 4.11.2-2. Sampling list for ¹³C of dissolved CH₄

Station No.	Lat.	Long.	Sampling Depth[m]
1	65°50'N	168°50'W	0, 20, 30, 45
12	71°34'N	159°30'W	0, 20, 40, 59
22	71°40. 83'N	154°58. 42'W	0, 50, 150, 157
23	71°45'N	155°14'W	0, 50, 100, 150, 232
30	74°50. 03'N	161°98. 43'W	0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615
37	72°45. 00'N	168°45. 00'W	0, 40, 49
38	72°30. 00'N	168°15. 00'W	0, 40, 47
41#10	72°45. 00'N	168°15. 00'W	0, 40, 51
41#14			0, 40, 51
41#21			0, 40, 51
41#25			0, 20, 40, 51
41#33			0, 20, 40, 50
41#41			0, 20, 40, 52
41#43			0, 5, 10, 20, 30, 40, 45, 51
41#51			0, 5, 10, 20, 30, 40, 45, 51
41#57			0, 20, 40, 51
48	74°00. 00'N	168°45. 00'W	0, 20, 50, 100, 150, 174
56	73°48. 00'N	160°00. 00'W	0, 10, 20, 50, 100, 150, 200, 500, 800, 1000, 1500, 2000, 2500, 2682
41#63	72°45. 00'N	168°15. 00'W	0, 20, 40, 52
62	71°30. 00'N	168°45. 00'W	0, 10, 20, 30, 40, 47
68	68°18. 00'N	167°3. 00'W	0, 5, 10, 20, 30, 37
77	68°0. 00'N	168°45. 00'W	0, 10, 20, 30, 40, 45, 50
84	65°45. 80'N	168°45. 60'W	0, 10, 20, 30, 40, 47

Table 4.11.2-3. Sampling list for D of dissolved CH₄

Station No.	Lat.	Long.	Sampling Depth[m]
1	65°50`N	168°50`W	0, 30, 45
12	71°34`N	159°30`W	0, 40, 59
22	71°40. 83`N	154°58. 42`W	0, 50, 150, 157
23	71°45`N	155°14`W	0, 50, 100, 232
30	74°50. 03`N	161°98. 43`W	0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615
37	72°45. 00`N	168°45. 00`W	0, 40, 49
38	72°30. 00`N	168°15. 00`W	0, 40, 47
41#10	72°45. 00`N	168°15. 00`W	0, 40, 51
41#14			0, 40, 51
41#21			0, 40, 51
41#25			0, 20, 40, 51
41#33			0, 20, 40, 50
41#41			0, 20, 40, 52
41#43			0, 5, 10, 20, 30, 40, 45, 51
41#57			0, 20, 40, 51
48	74°00. 00`N	168°45. 00`W	0, 20, 50, 100, 150, 174
56	73°48. 00`N	160°00. 00`W	0, 10, 20, 50, 100, 150, 200, 500, 800, 1000, 1500, 2000, 2500, 2682
41#63	72°45. 00`N	168°15. 00`W	0, 20, 40, 52
62	71°30. 00`N	168°45. 00`W	0, 20, 47
68	68°18. 00`N	167°3. 00`W	0, 20, 37
84	65°45. 80`N	168°45. 60`W	0, 20, 47

Table 4.11.2-4. Sampling list for dissolved N₂O

Station No.	Lat.	Long.	Sampling Depth[m]
1	65°50`N	168°50`W	0, 30, 45
12	71°34`N	159°30`W	0, 40, 59
22	71°40. 83`N	154°58. 42`W	0, 50, 150, 157
23	71°45`N	155°14`W	0, 50, 100, 150, 232
30	74°50. 03`N	161°98. 43`W	0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615
37	72°45. 00`N	168°45. 00`W	0, 40, 49
38	72°30. 00`N	168°15. 00`W	0, 40, 47
41#10	72°45. 00`N	168°15. 00`W	0, 40, 51
41#14			0, 40, 51
41#21			0, 40, 51
41#25			0, 20, 40, 51
41#33			0, 20, 40, 50
41#41			0, 20, 40, 52
41#43			0, 5, 10, 20, 30, 40, 45, 51
41#57			0, 20, 40, 51
56	73°48. 00`N	160°00. 00`W	0, 20, 50, 100, 200, 500, 1000, 1500, 2000, 2500, 2682
41#63	72°45. 00`N	168°15. 00`W	0, 20, 40, 52
62	71°30. 00`N	168°45. 00`W	0, 20, 47
77	68°0. 00`N	168°45. 00`W	0, 20, 50

Table 4.11.2-5. Sampling list for atmospheric CH₄

Station No.	Lat.	Long.
12	71°34`N	159°30`W
23	71°45`N	155°14`W
30	74°50. 03`N	161°98. 43`W
37	72°45. 00`N	168°45. 00`W
38	72°30. 00`N	168°15. 00`W
41#10	72°45. 00`N	168°15. 00`W
62	71°30. 00`N	168°45. 00`W
77	68°0. 00`N	168°45. 00`W
84	65°45. 80`N	168°45. 60`W

(6) Expected results

Preliminary data obtained by on-board continuous monitoring system indicated that surface water of the broad shelves of the Bering Sea and near shore area of Barrow is often supersaturated with CH₄ and the atmospheric concentration of CH₄ over the Chukchi Sea is often increased. Concentration of CH₄ in the seawater and the air samples collected simultaneously with the on-board measurements will be used to cross-check the both observations. Isotope ratios of CH₄ and their depth profiles along with concentration would provide the information on origin of the CH₄ and isotopic character of CH₄ emitted from Arctic Ocean, which is valuable for modeling the isotope budget of atmospheric CH₄.

Based on the previous study, concentration of N₂O is expected to be higher than that expected under air-sea equilibrium in continental shelf regions. In the deeper sea area, however, it may show different vertical profile. Along with concentration, isotope ratios including SP will be used to analyze possible sources and sinks of N₂O and its mixing.

(7) 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 “R/V Mirai Data Web Page” in JAMSTEC web site.

After the measurements and quality check, concentration and isotopic data will be submitted to JAMSTEC.

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4.12. Underway DIC

(1) Personnel

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Naohiro Kosugi (Meteorological Research Institute / JMA)

Hiroshi Uchida (JAMSTEC)

(2) Objective

CO₂ in the atmosphere is increasing at nearly 2 $\mu\text{mol mol}^{-1} \text{ yr}^{-1}$ 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 CO₂.

On the other hand, accumulation of surplus CO₂ alters budgets of ions and decreases saturation state of calcium carbonate (CaCO₃) in seawater. This phenomenon called “Ocean acidification” may be harmful to some creatures which have Skelton or shell made of CaCO₃. Furthermore, not only accumulation of CO₂ but also the dilutions of seawater by the increase of sea ice meltwater will reduce the saturation state of CaCO₃ in the Arctic Ocean. Comprehensive carbonate measurement is needed for better understanding of ocean acidification.

As for oceanic carbonate system, in case that two of 4 primary parameters (pCO₂, DIC, TA, and pH) were determined, we can calculate the others and additional parameters such as the saturation state of CaCO₃ and buffer factor (Revelle factor). Hence, underway DIC measurements were conducted to calculate other carbonate parameters in combination with continuous measurements of pCO₂ (see section 4.11.1)

(3)Parameter

Total Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

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 DIC were made with total CO₂ measuring system (Nippon ANS, Inc.).

The system was comprised of seawater dispensing unit, a CO₂ extraction unit, and a coulometer (Model 3000, Nippon ANS, Inc.) The seawater dispensing unit had 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).

Dissolved CO₂ in seawater was extracted in a stripping chamber of the CO₂ extraction unit by adding phosphoric acid (10 % v/v). The stripping chamber was made approx. 25 cm long and has a fine frit at the bottom. First, the certain amount (~2ml) of acid was 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 was introduced to the stripping chamber by the same method as that for an acid. The seawater and phosphoric acid were stirred by the nitrogen bubbles through a fine frit at the bottom of the stripping chamber. The stripped CO₂ was carried to the coulometer through two electric dehumidifiers (kept at 2-10 deg C) and a chemical desiccant (Mg(ClO₄)₂) by the nitrogen gas (flow rates of 140 ml min⁻¹).

(5) Observation log

The underway measurements were conducted from 2013/08/29 (UTC) to 2013/10/05 (UTC).

(6) Results

During the cruise, 26 bottles of CRM (Scripps Institute of Oceanography; Batch 113) were measured in order to check a stability of the system and to determine the calibration factor. Duplicate measurements were conducted from single bottle. Average and standard deviation of difference between duplicate measurements (2nd – 1st) were -0.46 ± 1.78 μmol kg⁻¹, respectively. Standard deviations of the mean of 26 bottles were 2.00 μmol kg⁻¹.

Preliminary data of underway DIC during MR13-06 are shown in Figure 4.12-1.

(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.

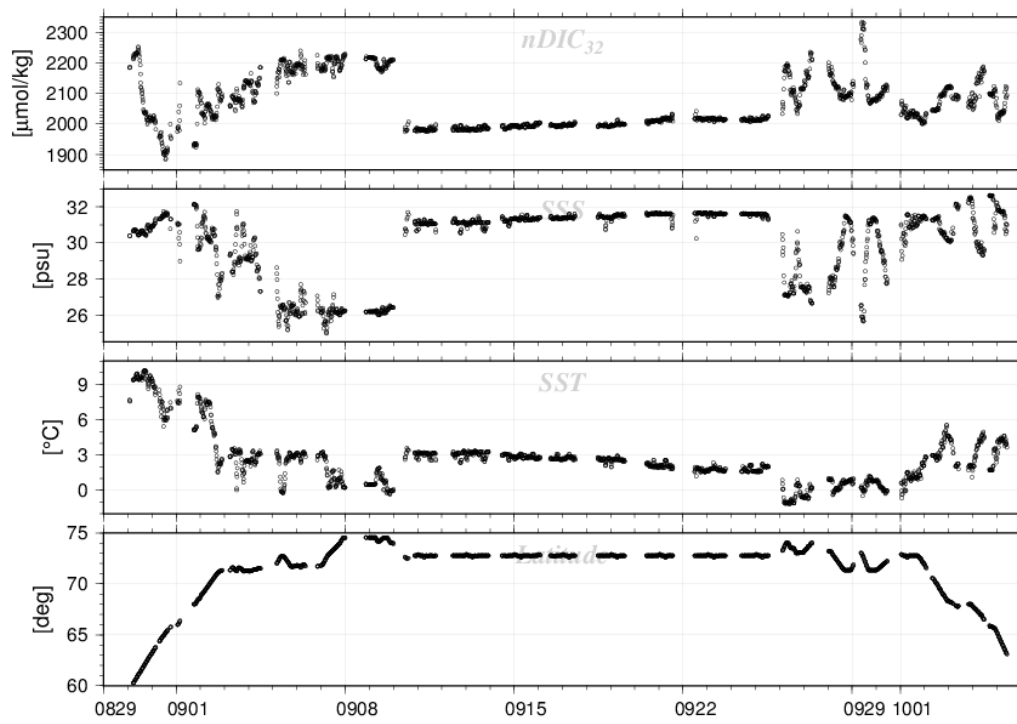


Figure 4.12-1. Time series of $nDIC_{32}$ ($= DIC / SSS * 32$; salinity normalized DIC), SSS, SST.

4.13. PFCs•POPs

(1) Personnel

Nobuyoshi YAMASHITA	National Institute of Advanced Industrial Science and Technology (AIST): PI
Sachi TANIYASU	AIST

(2) Objective

The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted in 2001 with twelve POPs that potentially damage human health and the environment. They are divided into three categories: pesticides, industrial chemicals and by-products or unintentionally produced POPs (POPs 2010). Moreover, in 2009 a new list of nine POPs was added to the Convention, and in 2011 endosulfan and its related isomers were included. All POPs are categorized in three annexes. Annex A refers to “elimination”, Annex B to “restriction” and Annex C to “unintentional production”.

The global monitoring plan (GMP) for POPs is an important component of the effectiveness evaluation of the Stockholm Convention, providing a harmonized organizational framework for the collection of comparable monitoring data on the presence of POPs from all regions, in order to identify changes in levels over time, as well as provide information on their regional and global environmental transport.

To evaluate whether the levels of POPs listed under the Stockholm Convention have actually been reduced or eliminated as requested by Articles 3 and 5 of the Convention, information on environmental levels of the chemicals should enable detection of trends over time. Therefore, focus is upon monitoring of background levels of POPs at locations not influenced by local sources.

The objective of the POPs Global Monitoring Plan can therefore be described as to: Provide a harmonized organizational framework for the collection of comparable monitoring data on the presence of the POPs listed in Annexes A, B and C of the Convention in order to identify changes in concentrations over time as well as to provide information on their regional and global environmental transport. Reports on these activities form one of the components of information to be compiled by the global coordination group and the Secretariat to enable periodic effectiveness evaluations of the Convention by the Conference of the Parties.

The GMP focuses on generation of core media data from ambient air and human milk and blood. The programme started with an evaluation of the effectiveness of the Convention through regional monitoring reports that use existing national and international programs. There are regions/sub-regions which are not represented in the first global monitoring report where major data gaps have been identified. Such regions have been identified during the regional organization group inception workshops, and The Stockholm Convention Secretariat is supporting monitoring activities in these regions.

A newly added compound to Annex B with specific exemptions (decision SC-4/17) is the perfluorooctane sulfonic acid (PFOS). PFOS, as well as PFOA (perfluorooctanoic acid), not included in Annex B, are part of the broad class of perfluorocarboxylic acids (PFCAs), which in turn belong to the family of perfluoroalkylated substances (PFAS).

In addition to PFOS also two perfluorooctance sulfonamidoethanol (FOSEs), i.e. (NMEFOSE and NetFOSE), and two perfluorooctane sulphonamides (FOSAs), i.e. (NMeFOSA and NEtFOSA) have been included in Annex B. For the water monitoring, PFOS and PFOSA are recommended.

Environmentally persistent perfluoroalkyl substances (PFASs, shown in Figure 4.13- 1) have appeared as a new class of global pollutants for the last thirteen years.

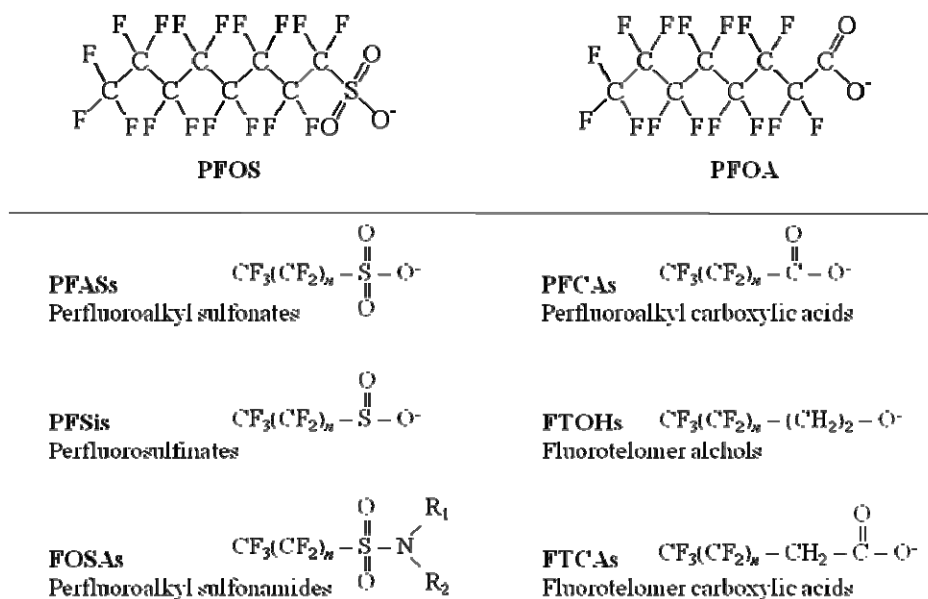


Figure 4.13- 1. Perfluoroalkyl substances (PFASs).

These compounds have recently emerged as a priority environmental pollutant due to its widespread finding in biota including both Arctic and Antarctic species and its persistent and bioaccumulative nature. The physicochemical properties of PFASs, especially of PFSAs (perfluoro sulfonic acids) and PFCAs (perfluoro carboxylic acids) are unique in that they have high water solubility despite the low reactivity of carbon-fluorine bond, which also imparts high stability in the environment. However, little is known on the distribution of PFASs in the oceans around the world, so far. We have conducted several international joint cruises, including South China Sea and Sulu Seas (KH-02-4), the central to Eastern Pacific Ocean (KH03-1 and MR11-08), , North and middle Atlantic Ocean, Southern Pacific and Antarctic Ocean (KH04-5, MR12-05), Labrador Sea and coastal seawater from Asian countries (Japan, China, Hong Kong, Korea) ^(1, 2, 3). Vertical profiles of PFASs in the marine water column were associated with the global ocean circulation theory. We found that vertical profiles of PFASs in water columns from the Labrador Sea reflected the influx of the North Atlantic Current in surface waters, the Labrador Current in subsurface waters, and the Denmark Strait Overflow Water in deep layers below 2000 m. Striking differences in the vertical and spatial distribution of PFASs, depending on the oceans, suggest that these persistent organic acids can serve as useful chemical tracers to allow us to study oceanic transportation by major water currents. The results provide evidence that PFAS concentrations and profiles in the oceans adhere to a pattern consistent

with the global “Broecker’s Conveyor Belt” theory of open ocean water circulation.

In MR13-06, we tried to confirm the vertical profiles of PFASs found in water columns from above cruises and the Pacific Ocean (KH03-1 and MR11-08) and obtained open ocean samples for further analysis.

(3) Parameters

Perfluoroalkyl substances (PFASs)

(4) Instruments and Methods

Water samples were stored in clean 1 L polypropylene bottles and were kept frozen until analysis. Samples were thawed at room temperature, and a solid phase extraction method using WAX® cartridge (Waters Co.) was used for the determination of PFASs by HPLC tandem mass spectrometry (HPLC-MS/MS) as described elsewhere^(4,5). Briefly, after preconditioning with 4 mL ammonium hydroxide in methanol, 4 mL methanol, and then 4 mL Millipore water, the cartridges were loaded with 900-1000 mL samples at approximately 1 drop sec⁻¹. The cartridges were then washed with 4mL of 25 mM ammonium acetate buffer (pH 4) in Millipore water and dried by centrifugation at 3000 rpm for 2 min. The elution was then divided into two fractions. The first fraction was carried out with 4 mL methanol and the second with 4 mL 0.1% ammoniumhydroxide in methanol. Both fractions were reduced to 0.5 mL under a nitrogen stream and analyzed separately. HPLC-MS/MS, composed of a HP1100 liquid chromatograph (Agilent Technologies, Palo Alto, CA) interfaced with a Micromass® (Beverly, MA) Quattro Ultima Pt mass spectrometer was operated in the electrospray negative ionization mode. A 5 or 10-μL aliquot of the sample extract was injected into a Betasil C18 column (2.1 mm i.d. × 50 mm length, 5 μm; Termo Hypersil-Keystone, Bellefonte, PA). The capillary is held at 1.2 kV. Cone-gas and desolvation-gas flows are kept at 60 and 650 L/h, respectively. Source and desolvation temperatures were kept at 120 and 420°C respectively. MS/MS parameters are optimized so as to transmit the [M-K]⁻ or [M-H]⁻ ions.

MR13-06 is the sixth international research cruise that conducted measurement of POPs in Open ocean waters using ISO method (ISO25101). Because of recent scene of analytical chemistry, uncertainty and reliability of measurement supported by suitable quality assurance and quality control (QAQC) becoming to the essential issue. Our experimental result with ISO25101 supported by the international QAQC (ISO17025 with Guide45) and Japanese Industrial Standard (JIS) will provide the most reliable information of environmental chemistry in Open ocean research for now.

(5) Observation log

List of seawater samples (surface, subsurface and deep water) collected were presented in Table 4.13- 1 and Table 4.13- 2 as follows. Deep seawater samples were taken by Conductivity temperature depth profiler-Carousel multiple sampling system (CTD-CMS) attached X-Niskin samplers of 12 L, together with surface seawater samples taken by stainless bucket at all the water sampling stations. Subsurface waters were also collected from the out let tube of surface water analysis facility in MIRAI during Leg1 (on board ID: MR1306-WS01~WS31). The same sample collection

were kindly carried out by Marine Works Japan Co. Ltd during Leg 2 (on board ID: MR1306-WS32~WS41).

Atmospheric samples were taken with a comprehensive cryogenic moisture sampler (CMS; prototype) which was developed by AIST and SIBATA Co. The air sampler was operated with a flow rate of 10-20 L/min. Samples were collected during underway to avoid contamination from exhaust gas from ship. Operation of CMS was carried out by AIST (Leg 1, on board ID: MR1306-AR01 ~ AR15) and GODI (Leg 2, on board ID: MR1306-AR16 ~ AR18). List of air samples were presented in Table 4.13- 3.

Precipitation samples containing rain water and snow samples were also collected using polypropylene funnel (16.5 cm ϕ). List of precipitation samples were presented in Table 4.13- 4.

Sea ice sample was collected from one site during Leg 1. List of sea ice sample was presented in Table 4.13- 5.

All collected samples were stored at below -20°C until chemical analysis in AIST laboratory.

(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.

PI is requested to participate to “Global Monitoring Plan of the Stockholm Convention by UNEP”. Result of survey in this cruise supposed to be useful data to make risk profile of new emerging chemicals according to the Stockholm Convention on Persistent Organic Pollutants (POPs).

(7) References

- 1) Yamashita N, Kannan K, Taniyasu S, Horii Y, Petrick G, Gamo T, A global survey of perfluorinated acids in oceans, *Marine Pollution Bulletin* 51 (2005) 658–668
- 2) Wei S, Chen LQ, Taniyasu S, So MK, Murphy MB, Yamashita N, Yeung LWY, Lam PKS, Distribution of perfluorinated compounds in surface seawaters between Asia and Antarctica, *Marine Pollution Bulletin* 54 (2007) 1813–1838
- 3) Yamashita N, Taniyasu S, Petrick G, Wei S, Gamo T, Lam PKL, Kannan K, Perfluorinated acids as novel chemical tracers of global circulation of ocean waters, *Chemosphere* 70 (2008) 1247–1255
- 4) Yamashita N, Kannan K, Taniyasu S, Horii Y, Okazawa T, Petrick G, Gamo T, Analysis of Perfluorinated Acids at Parts-Per-Quadrillion Levels in Seawater Using Liquid Chromatography-Tandem Mass Spectrometry, *Environ. Sci. Technol.* (2004) 38, 5522-5528
- 5) Taniyasu S, Kannan K, So MK, Gulkowskad A, Sinclair E, Okazawa T, Yamashita N, Analysis of fluorotelomer alcohols, fluorotelomer acids, and short- and long-chain perfluorinated acids in water and biota, *Journal of Chromatography A*, 1093 (2005) 89–97
- 6) ISO 25101 (2009) Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry

Table 4.13- 1. Summary of surface and deep seawater sampling for PFASs analysis

On board ID	Sta	Cast	Date collected					Latitude			Longitude			Sampling Depth m
			YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W	
MR1306-WB01	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	0
MR1306-W01	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	18.9
MR1306-W02	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	4.8
MR1306-W03	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	9.8
MR1306-W04	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	20.0
MR1306-W05	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	29.3
MR1306-W06	1	1	2013	08	31	19:51	UTC	65	46.18	N	168	14.90	W	44.4
MR1306-WB02	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	0
MR1306-W07	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	17.7
MR1306-W08	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	5.3
MR1306-W09	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	10.3
MR1306-W10	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	20.0
MR1306-W11	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	29.9
MR1306-W12	3	1	2013	08	31	22:58	UTC	65	39.44	N	168	44.85	W	36.4
MR1306-WB03	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	0
MR1306-W13	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	10.1
MR1306-W14	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	5.0
MR1306-W15	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	10.1
MR1306-W16	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	20.2
MR1306-W17	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	30.1
MR1306-W18	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	39.7
MR1306-W19	4	1	2013	09	01	01:45	UTC	66	0.24	N	168	15.07	W	44.2
MR1306-WB04	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	0
MR1306-W20	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	8.1
MR1306-W21	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	5.1
MR1306-W22	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	9.9
MR1306-W23	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	19.9
MR1306-W24	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	29.9
MR1306-W25	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	39.7
MR1306-W26	8	1	2013	09	01	18:48	UTC	68	0.25	N	168	14.18	W	52.5
MR1306-WB05	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	0
MR1306-W27	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	12.9
MR1306-W28	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	4.6
MR1306-W29	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	9.5
MR1306-W30	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	19.8
MR1306-W31	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	29.4
MR1306-W32	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	39.7
MR1306-W33	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	49.7
MR1306-W34	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	74.4
MR1306-W35	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	99.2
MR1306-W36	18	1	2013	09	04	06:50	UTC	71	24.67	N	157	29.54	W	113.2
MR1306-WB06	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	0
MR1306-W37	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	19.6
MR1306-W38	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	5.5
MR1306-W39	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	10.1
MR1306-W40	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	19.7
MR1306-W41	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	29.8
MR1306-W42	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	49.1
MR1306-W43	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	99.0
MR1306-W44	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	148.5
MR1306-W45	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	198.4
MR1306-W46	26	1	2013	09	04	22:51	UTC	71	44.19	N	155	53.40	W	246.5
MR1306-WB07	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	0
MR1306-W47	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	10.3
MR1306-W48	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	25.1
MR1306-W49	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	49.8
MR1306-W50	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	99.5
MR1306-W51	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	148.7
MR1306-W52	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	198.7
MR1306-W53	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	491.2
MR1306-W54	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	791.0
MR1306-W55	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	987.4
MR1306-W56	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	1479.9
MR1306-W57	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	1971.7
MR1306-W58	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	2752.6
MR1306-W59	29	1	2013	09	05	08:55	UTC	72	40.82	N	154	12.05	W	2915.3

Table 4.13- 1. (continued)

On board ID	Sta	Cast	Date collected					Latitude			Longitude			Sampling Depth m
			YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W	
MR1306-WB08	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	0
MR1306-W60	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	46.4
MR1306-W61	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	4.6
MR1306-W62	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	9.8
MR1306-W63	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	19.8
MR1306-W64	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	49.3
MR1306-W65	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	99.0
MR1306-W66	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	148.5
MR1306-W67	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	198.0
MR1306-W68	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	495.2
MR1306-W69	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	789.4
MR1306-W70	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	986.4
MR1306-W71	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	1480.3
MR1306-W72	31	1	2013	09	08	05:47	UTC	74	31.83	N	161	5.28	W	1680.0
MR1306-WB09	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	0
MR1306-W73	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	35.2
MR1306-W74	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	4.7
MR1306-W75	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	9.8
MR1306-W76	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	19.7
MR1306-W77	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	29.4
MR1306-W78	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	39.5
MR1306-W79	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	49.3
MR1306-W80	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	99.0
MR1306-W81	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	148.2
MR1306-W82	34	1	2013	09	09	21:39	UTC	73	59.83	N	168	15.47	W	173.8
MR1306-WB10	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	0
MR1306-W84	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	22.3
MR1306-W85	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	5.0
MR1306-W86	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	10.5
MR1306-W87	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	20.2
MR1306-W88	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	30.0
MR1306-W89	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	39.9
MR1306-W90	37	1	2013	09	10	12:36	UTC	72	30.06	N	168	15.03	W	48.6
MR1306-WB11	41	5	2013	09	10	12:36	UTC	72	45.03	N	168	44.96	W	0
MR1306-W91	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	24.9
MR1306-W92	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	5.3
MR1306-W93	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	10.2
MR1306-W94	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	20.0
MR1306-W95	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	29.9
MR1306-W96	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	39.8
MR1306-W97	41	5	2013	09	11	20:42	UTC	72	45.03	N	168	44.96	W	47.2
MR1306-WB12	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	0
MR1306-W98	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	4.8
MR1306-W99	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	19.3
MR1306-W100	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	30.0
MR1306-W101	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	39.8
MR1306-W102	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	9.8
MR1306-W103	41	25	2013	09	16	20:42	UTC	72	45.09	N	168	44.80	W	50.8
MR1306-WB13	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	0
MR1306-W104	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	5.2
MR1306-W105	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	10.1
MR1306-W106	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	20.0
MR1306-W107	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	29.5
MR1306-W108	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	39.8
MR1306-W109	41	45	2013	09	21	20:41	UTC	72	44.99	N	168	44.93	W	50.7
MR1306-WB14	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	0
MR1306-W110	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	5.2
MR1306-W111	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	10.3
MR1306-W112	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	19.8
MR1306-W113	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	29.5
MR1306-W114	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	39.7
MR1306-W115	46	1	2013	09	25	13:22	UTC	72	48.43	N	167	13.44	W	51.7

Table 4.13- 1. (continued)

On board ID	Sta	Cast	Date collected					Latitude			Longitude			Sampling Depth m
			YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W	
MR1306-WB15	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	0
MR1306-W116	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	10.2
MR1306-W117	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	20.4
MR1306-W118	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	30.1
MR1306-W119	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	39.8
MR1306-W120	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	49.7
MR1306-W121	47	1	2013	09	26	01:14	UTC	72	59.16	N	168	4.25	W	63.2
MR1306-WB16	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	0
MR1306-W122	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	5.1
MR1306-W123	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	10.3
MR1306-W124	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	20.1
MR1306-W125	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	30.0
MR1306-W126	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	39.7
MR1306-W127	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	49.7
MR1306-W128	52	1	2013	09	26	22:03	UTC	73	3.75	N	164	22.86	W	67.3
MR1306-WB17	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	0
MR1306-W129	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	5.2
MR1306-W130	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	10.0
MR1306-W131	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	19.8
MR1306-W132	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	49.6
MR1306-W133	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	98.8
MR1306-W134	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	148.7
MR1306-W135	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	197.6
MR1306-W136	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	494.5
MR1306-W137	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	791.3
MR1306-W138	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	988.2
MR1306-W139	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	1970.2
MR1306-W140	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	2460.5
MR1306-W141	56	1	2013	09	27	12:25	UTC	73	48.03	N	159	0.62	W	2637.3
MR1306-WB18	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W	0
MR1306-W142	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W	4.7
MR1306-W143	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W	9.7
MR1306-W144	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W	20.0
MR1306-W145	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W	30.1
MR1306-W146	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W	40.0
MR1306-WB19	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	0
MR1306-W147	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	4.9
MR1306-W148	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	9.5
MR1306-W149	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	19.5
MR1306-W150	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	29.5
MR1306-W151	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	39.4
MR1306-W152	41	62	2013	09	30	21:00	UTC	72	45.11	N	168	44.58	W	50.8
MR1306-WB20	65	1	2013	10	02	12:05	UTC	70	0.06	N	168	15.04	W	0
MR1306-W153	65	1	2013	10	02	12:05	UTC	70	0.06	N	168	15.04	W	4.9
MR1306-W154	65	1	2013	10	02	12:05	UTC	70	0.06	N	168	15.04	W	9.9
MR1306-W155	65	1	2013	10	02	12:05	UTC	70	0.06	N	168	15.04	W	20.1
MR1306-W156	65	1	2013	10	02	12:05	UTC	70	0.06	N	168	15.04	W	29.9
MR1306-W157	65	1	2013	10	02	12:05	UTC	70	0.06	N	168	15.04	W	35.3
MR1306-WB21	68	1	2013	10	02	22:56	UTC	68	18.08	N	167	57.25	W	0
MR1306-W158	68	1	2013	10	02	22:56	UTC	68	18.08	N	167	57.25	W	5.0
MR1306-W159	68	1	2013	10	02	22:56	UTC	68	18.08	N	167	57.25	W	9.9
MR1306-W160	68	1	2013	10	02	22:56	UTC	68	18.08	N	167	57.25	W	19.9
MR1306-W161	68	1	2013	10	02	22:56	UTC	68	18.08	N	167	57.25	W	30.1

Table 4.13- 2. Summary of sub-surface seawater sampling for PFASs analysis

On board ID	Sta	Cast	Date collected					Latitude			Longitude		
			YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W
MR1306-WS01	-	-	2013	08	28	22:30	UTC	54	33.00	N	166	37.44	W
MR1306-WS02	-	-	2013	08	29	17:40	UTC	58	11.38	N	167	29.33	W
MR1306-WS03	-	-	2013	08	30	20:50	UTC	62	43.55	N	167	20.76	W
MR1306-WS04	1	-	2013	08	31	19:03	UTC	65	45.87	N	168	45.59	W
MR1306-WS05	3	-	2013	08	31	23:02	UTC	65	39.54	N	168	45.27	W
MR1306-WS06	4	-	2013	09	01	01:56	UTC	66	0.38	N	168	44.91	W
MR1306-WS07	8	-	2013	09	01	18:07	UTC	68	45.13	N	168	45.38	W
MR1306-WS08	-	-	2013	09	02	10:18	UTC	70	7.29	N	164	32.27	W
MR1306-WS09	18	-	2013	09	03	06:21	UTC	71	23.71	N	157	29.94	W
MR1306-WS10	26	-	2013	09	04	22:40	UTC	71	44.14	N	155	6.55	W
MR1306-WS11	-	-	2013	09	05	20:20	UTC	71	40.29	N	155	0.28	W
MR1306-WS12	-	-	2013	09	07	06:06	UTC	72	40.06	N	154	47.95	W
MR1306-WS13	-	-	2013	09	08	03:36	UTC	74	46.15	N	161	59.71	W
MR1306-WS14	31	1	2013	09	08	05:42	UTC	74	31.82	N	161	54.78	W
MR1306-WS15	31	2	2013	09	09	00:37	UTC	74	32.12	N	161	57.95	W
MR1306-WS16	34	1	2013	09	09	23:02	UTC	73	60.00	N	168	44.47	W
MR1306-WS17			2013	09	10	12:25	UTC	72	30.01	N	168	45.00	W
MR1306-WS18	41	5	2013	09	11	20:55	UTC	72	45.07	N	168	14.89	W
MR1306-WS19	41	25	2013	09	16	20:55	UTC	72	45.20	N	168	15.38	W
MR1306-WS20	41	45	2013	09	21	20:55	UTC	72	45.04	N	168	14.97	W
MR1306-WS21	46	1	2013	09	25	13:20	UTC	72	48.43	N	167	46.61	W
MR1306-WS22	47	1	2013	09	26	01:26	UTC	72	59.17	N	168	55.84	W
MR1306-WS23	52	1	2013	09	26	21:50	UTC	73	3.80	N	164	37.40	W
MR1306-WS24	56	1	2013	09	27	12:41	UTC	73	48.06	N	159	59.28	W
MR1306-WS25	59	1	2013	09	28	05:33	UTC	72	44.32	N	162	31.55	W
MR1306-WS26	41	62	2013	09	30	21:07	UTC	72	45.13	N	168	0.00	W
MR1306-WS27	65	1	2013	10	02	11:59	UTC	70	0.03	N	168	44.99	W
MR1306-WS28	68	1	2013	10	02	23:05	UTC	68	18.12	N	167	2.73	W
MR1306-WS29	77	-	2013	10	03	22:11	UTC	67	59.95	N	168	45.64	W
MR1306-WS30	-	-	2013	10	05	23:12	UTC	60	51.73	N	167	44.43	W
MR1306-WS31	-	-	2013	10	06	20:35	UTC	57	18.29	N	167	15.99	W
MR1306-WS32	-	-	2013	10	9	22:43	UTC	54	13.09	N	167	24.52	W
MR1306-WS33	-	-	2013	10	10	19:29	UTC	53	58.12	N	173	18.05	W
MR1306-WS34	-	-	2013	10	11	20:12	UTC	53	35.27	N	178	7.63	E
MR1306-WS35	-	-	2013	10	12	20:42	UTC	52	15.49	N	170	53.79	E
MR1306-WS36	-	-	2013	10	14	3:33	UTC	48	46.70	N	165	51.58	E
MR1306-WS37	-	-	2013	10	15	1:34	UTC	45	57.30	N	162	35.25	E
MR1306-WS38	-	-	2013	10	16	2:07	UTC	42	32.79	N	157	42.34	E
MR1306-WS39	-	-	2013	10	17	3:04	UTC	40	38.89	N	153	49.33	E
MR1306-WS40	-	-	2013	10	18	3:39	UTC	40	6.30	N	148	31.21	E
MR1306-WS41	-	-	2013	10	19	6:02	UTC	40	23.26	N	142	26.46	E

Table 4.13- 3. Summary of air sampling by CMS for PFASs analysis

On board ID		Date collected					Latitude			Longitude		
		YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W
MR1306-AR01	start	2013	08	28	08:00	UTC	54	14.45	N	166	32.41	W
	stop	2013	08	30	01:21	UTC	59	36.55	N	167	50.94	W
MR1306-AR02	start	2013	08	30	03:22	UTC	59	55.17	N	167	55.71	W
	stop	2013	08	31	17:04	UTC	65	37.71	N	168	28.13	W
MR1306-AR03	start	2013	09	02	02:26	UTC	69	2.02	N	168	37.90	W
	stop	2013	09	02	21:56	UTC	71	19.63	N	157	39.59	W
MR1306-AR04	start	2013	09	07	01:30	UTC	71	49.88	N	155	18.97	W
	stop	2013	09	08	03:59	UTC	73	59.67	N	161	58.25	W
MR1306-AR05	start	2013	09	09	06:19	UTC	74	30.94	N	161	57.00	W
	stop	2013	09	10	03:31	UTC	73	28.89	N	168	21.34	W
MR1306-AR06	start	2013	09	10	06:31	UTC	73	20.51	N	168	20.65	W
	stop	2013	09	11	02:35	UTC	72	44.97	N	168	15.00	W
MR1306-AR07	start	2013	09	12	17:33	UTC	72	44.99	N	168	16.08	W
	stop	2013	09	13	04:50	UTC	72	44.56	N	168	17.36	W
MR1306-AR08	start	2013	09	13	04:50	UTC	72	44.56	N	168	17.36	W
	stop	2013	09	14	02:01	UTC	72	46.38	N	168	15.09	W
MR1306-AR09	start	2013	09	14	03:13	UTC	72	45.08	N	168	15.09	W
	stop	2013	09	15	07:30	UTC	72	38.69	N	168	15.23	W
MR1306-AR10	start	2013	09	15	16:08	UTC	72	44.75	N	168	15.54	W
	stop	2013	09	16	16:58	UTC	72	43.61	N	168	16.69	W
MR1306-AR11	start	2013	09	22	23:04	UTC	72	45.26	N	168	14.21	W
	stop	2013	09	23	22:36	UTC	72	45.45	N	168	13.76	W
MR1306-AR12	start	2013	09	26	02:51	UTC	73	14.50	N	168	53.03	W
	stop	2013	09	28	04:40	UTC	72	52.37	N	162	25.78	W
MR1306-AR13	start	2013	09	30	00:14	UTC	71	20.69	N	157	40.37	W
	stop	2013	09	30	17:39	UTC	72	44.75	N	168	18.60	W
MR1306-AR14	start	2013	10	01	17:35	UTC	72	44.46	N	163	15.73	W
	stop	2013	10	04	05:22	UTC	67	15.05	N	168	45.02	W
MR1306-AR15	start	2013	10	04	22:21	UTC	65	33.83	N	168	18.32	W
	stop	2013	10	07	04:05	UTC	55	58.90	N	166	56.67	W
MR1306-AR16	start	2013	10	09	22:50	UTC	54	13.05	N	167	26.79	W
	stop	2013	10	13	01:30	UTC	51	22.99	N	169	45.80	E
MR1306-AR17	start	2013	10	14	01:40	UTC	48	46.64	N	166	19.19	E
	stop	2013	10	16	03:43	UTC	42	15.84	N	157	24.06	E
MR1306-AR18	start	2013	10	16	04:10	UTC	42	10.77	N	157	18.94	E
	stop	2013	10	18	23:15	UTC	40	19.44	N	143	46.30	E

Table 4.13- 4. Summary of precipitation sampling for PFASs analysis

On board ID		Date collected					Latitude			Longitude		
		YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W
MR1306-R01	start	2013	08	27	00:36	UTC	53	54.21	N	166	31.55	W
	stop	2013	08	28	17:30	UTC	"	"	N	"	"	W
MR1306-R02	start	2013	08	31	01:51	UTC	63	29.74	N	167	43.58	W
	stop	2013	08	31	16:42	UTC	65	35.02	N	168	29.06	W
MR1306-R03	start	2013	09	02	19:13	UTC	71	12.56	N	159	25.41	W
	stop	2013	09	03	23:57	UTC	71	14.82	N	157	9.90	W
MR1306-R04	start	2013	09	03	23:57	UTC	71	14.82	N	157	9.90	W
	stop	2013	09	06	20:54	UTC	71	43.03	N	155	8.32	W
MR1306-R05	start	2013	09	06	20:54	UTC	71	43.03	N	155	8.32	W
	stop	2013	09	09	20:07	UTC	74	9.80	N	168	25.37	W
MR1306-R06	start	2013	09	09	20:07	UTC	74	9.80	N	168	25.37	W
	stop	2013	09	12	17:08	UTC	72	44.28	N	168	12.79	W
MR1306-R07	start	2013	09	12	17:08	UTC	74	9.80	N	168	25.37	W
	stop	2013	09	16	15:53	UTC	72	44.52	N	168	14.29	W
MR1306-R08	start	2013	09	16	15:53	UTC	72	44.52	N	168	14.29	W
	stop	2013	09	19	22:16	UTC	72	45.25	N	168	15.74	W
MR1306-R09	start	2013	09	19	22:16	UTC	72	45.25	N	168	15.74	W
	stop	2013	09	24	16:10	UTC	72	45.31	N	168	14.14	W
MR1306-R10	start	2013	09	24	16:10	UTC	72	45.31	N	168	14.14	W
	stop	2013	09	28	21:32	UTC	71	19.62	N	157	39.66	W
MR1306-R11	start	2013	09	28	21:32	UTC	71	19.62	N	157	39.66	W
	stop	2013	10	01	02:17	UTC	72	45.79	N	168	15.06	W
MR1306-R12	start	2013	10	01	02:17	UTC	72	45.79	N	168	15.06	W
	stop	2013	10	02	20:04	UTC	68	44.58	N	168	9.02	W
MR1306-R13	start	2013	10	02	20:04	UTC	68	44.58	N	168	9.02	W
	stop	2013	10	06	02:13	UTC	60	22.01	N	167	55.99	W
MR1306-R14	start	2013	10	06	02:13	UTC	60	22.01	N	167	55.99	W
	stop	2013	10	06	23:22	UTC	56	47.24	N	167	7.94	W
MR1306-R15	start	2013	10	06	23:22	UTC	56	47.24	N	167	7.94	W
	stop	2013	10	07	17:58	UTC	53	56.66	N	166	29.09	W

Table 4.13- 5. Summary of sea ice sampling for PFASs analysis

On board ID	Date collected					Latitude			Longitude		
	YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W
MR1306-Ice01	2013	09	08	03:34	UTC	74	46.65	N	161	59.58	W

4.14. Zooplankton

(1) Personnel

Kohei Matsuno (National Institute of Polar Research)

Atsushi Yamaguchi (Hokkaido University, not onboard)

Toru Hirawake (Hokkaido University, not onboard): Principal Investigator

Naomi Harada (JAMSTEC, not onboard)

Katsunori Kimoto (JAMSTEC)

Takahito Ikenoue (Kyushu University)

(2) Objective

After 1990s, decreasing of sea ice in the Arctic Ocean is reported in the western Arctic Ocean because of increasing amount of the warm Pacific water passed into the Arctic Ocean. The Pacific water passed through the Bering Strait may induce 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 mainly composed by large-sized copepods (*Neocalanus cristatus*, *N. flemingeri*, *N. plumchrus*, *Eucalanus bungii*, *Metridia pacifica*), which are 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 be intruded and inhabited, but the details of their ecological impact have 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 36 stations in the western Arctic Ocean. Twin NORPAC net (mesh sizes: 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. 4.14-1 and Table 4.14-1). 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 fixed with 99.5% ethanol for analysis on Foraminifera and Radiolaria (investigator: Katsunori Kimoto [JAMSTEC] and Takahito Ikenoue [Kyushu University]). 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 water samples from five depths (0, 5, 10, 20 and 30 m) at 18 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 8 stations (Fig. 4.14-1 and Table 4.14-2), fresh samples were used for grazing experiments (8 times at 5 stations) and evaluation of the copepod physiological activity (i.e. wet mass, dry mass, ash-free dry mass and gut pigment) (51 times at 1 fixed station). Also, the 80 cm ring net was towed between surface and bottom -5 m at 5 stations, the fresh samples were immediately fixed with 5% buffered formalin for collecting Euphausiacea (investigator: Minoru Kitamura [JAMSTEC]).

Closing PCP net (mesh size: 62 μm , mouth diameter: 60 cm) was towed at 1 fixed station from 2 layers (0–20 m and 20–49 m) when the clear stratification was identified by temperature and salinity. VMPS (mesh size: 62 μm , open mouth area: 0.276 m^2) was towed from 4 layers (0–100–250–500–1000 m) at 2 stations. The volume of water filtered through the net was estimated from the reading of a flow-meter mounted in the mouth ring. Zooplankton samples collected by closing PCP net and VMPS were split

with Motoda box splitter. One aliquot was immediately fixed with 5% buffered formalin for zooplankton structure analysis (Fig. 4.14-1 and Table 4.14-3). The remaining aliquot was fixed with 99.5% ethanol for analysis on Foraminifera and Radiolaria (investigator: Katsunori Kimoto [JAMSTEC] and Takahito Ikenoue [Kyushu University]).

(4) On-board treatment

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

Fresh zooplankton samples collected with 80 cm ring net were immediately added with 10% soda water (CO₂ 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. At land laboratory, these samples will be weighed for wet weight, dry weight, and 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). Sorting was made only for individuals that were actively swimming and undamaged. These specimens were re-sorted into an experiments bottle (2.2 L) filled with 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 preliminary results, we present following items.

Figure 4.14-1: Location of the plankton net sampling stations.

Figure 4.14-2: Time-series changes on gut pigment of *C. glacialis* C5 at fixed station.

(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 4.14-1. Data on plankton samples collected by vertical hauls with twin NORPAC net.
GG54: 335 μ m mesh.

Station no.	Position		S.M.T.		Length of wire (m)	Angle of wire ($^{\circ}$)	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	65-46	168-45 W	31 Aug.	8:28	45	3	45	GG54	1039	310	5.39	
								62 μ m	2771	168	2.99	1)
003	65-41	168-17 W	31 Aug.	12:38	38	5	38	GG54	1039	325	5.65	
								62 μ m	2771	265	4.72	1)
005	66-30	168-45 W	31 Aug.	18:10	48	4	48	GG54	1039	408	7.09	
								62 μ m	2771	86	1.53	1)
007	67-30	168-45 W	1 Sep.	0:41	42	9	41	GG54	1039	390	6.78	
								62 μ m	2771	197	3.51	1)
008	68-00	168-45 W	1 Sep.	7:10	52	5	52	GG54	1039	397	6.90	
								62 μ m	2771	250	4.45	1)
009	68-30	168-45 W	1 Sep.	11:46	46	1	46	GG54	1039	361	6.27	
								62 μ m	2771	278	4.95	1)
011	71-21	157-37 W	2 Sep.	18:52	100	15	97	GG54	1039	822	14.29	
								62 μ m	2771	510	9.08	1)
014	71-15	157-10 W	3 Sep.	13:52	39	9	39	GG54	1039	332	5.77	
								62 μ m	2771	212	3.77	1)
018	71-25	157-31 W	3 Sep.	20:24	115	9	114	GG54	1039	1035	17.99	
								62 μ m	2771	757	13.48	1)
022	71-33	156-21 W	4 Sep.	3:35	150	3	150	GG54	1039	1230	21.38	
								62 μ m	2771	839	14.94	1)
024	71-36	154-51 W	4 Sep.	8:05	37	2	37	GG54	1039	388	6.74	
								62 μ m	2771	315	5.61	1)
026	71-44	155-06 W	4 Sep.	12:36	150	4	150	GG54	1039	1198	20.82	
								62 μ m	2771	750	13.35	1)
028	71-56	155-40 W	4 Sep.	16:34	132	4	132	GG54	1039	1097	19.07	
								62 μ m	2771	768	13.67	1)
031	74-32	161-54 W	7 Sep.	20:07	150	3	150	GG54	1039	1185	20.60	
								62 μ m	2771	761	13.55	1)
033	74-10	162-01 W	8 Sep.	23:00	150	2	150	GG54	1039	1164	20.23	
								62 μ m	2771	756	13.46	1)
034	74-00	168-44 W	9 Sep.	11:23	150	3	150	GG54	1039	1149	19.97	
								62 μ m	2771	736	13.10	1)

S.M.T. was GMT+11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-1. (Continued)

Station no.	Position		S.M.T.		Length of wire	Angle of wire	Depth estimated by wire	Kind of cloth	Flowmeter		Estimated volume of water filtered (m ³)	Remark
	Lat. (N)	Lon.	Date	Hour	(m)	(°)	angle (m)		No.	Reading		
035	73-00	168-45 W	9 Sep.	21:16	54	5	54	GG54	1039	442	7.68	
								62 µm	2771	334	5.95	1)
041	72-45	168-15 W	10 Sep.	9:45	49	4	49	GG54	1039	409	7.11	
(Fixed station)								62 µm	2771	297	5.29	1)
041	72-45	168-15 W	10 Sep.	22:12	49	5	49	GG54	1039	406	7.06	
(Fixed station)								62 µm	2771	268	4.77	1)
041	72-45	168-15 W	11 Sep.	10:52	49	1	49	GG54	1039	392	6.81	
(Fixed station)								62 µm	2771	264	4.70	1)
041	72-45	168-15 W	11 Sep.	22:10	49	1	49	GG54	1039	405	7.04	
(Fixed station)								62 µm	2771	260	4.63	1)
041	72-45	168-15 W	12 Sep.	10:25	49	2	49	GG54	1039	372	6.47	
(Fixed station)								62 µm	2771	275	4.90	1)
041	72-45	168-15 W	12 Sep.	22:14	49	1	49	GG54	1039	410	7.13	
(Fixed station)								62 µm	2771	268	4.77	1)
041	72-45	168-15 W	13 Sep.	10:56	49	2	49	GG54	1039	411	7.14	
(Fixed station)								62 µm	2771	300	5.34	1)
041	72-45	168-15 W	13 Sep.	22:13	49	2	49	GG54	1039	435	7.56	
(Fixed station)								62 µm	2771	286	5.09	1)
041	72-45	168-15 W	14 Sep.	10:35	49	1	49	GG54	1039	503	8.74	
(Fixed station)								62 µm	2771	357	6.36	1)
041	72-45	168-15 W	14 Sep.	22:16	49	1	49	GG54	1039	460	8.00	
(Fixed station)								62 µm	2771	330	5.88	1)
041	72-45	168-15 W	15 Sep.	10:50	49	1	49	GG54	1039	412	7.16	
(Fixed station)								62 µm	2771	313	5.57	1)
041	72-45	168-15 W	15 Sep.	22:14	49	6	49	GG54	1039	420	7.30	
(Fixed station)								62 µm	2771	270	4.81	1)
041	72-45	168-15 W	16 Sep.	10:35	49	1	49	GG54	1039	448	7.79	
(Fixed station)								62 µm	2771	280	4.98	1)
041	72-45	168-15 W	16 Sep.	22:35	49	4	49	GG54	1039	416	7.23	
(Fixed station)								62 µm	2771	265	4.72	
041	72-45	168-15 W	17 Sep.	4:13	49	2	49	GG54	1039	440	7.65	
(Fixed station)								62 µm	2771	312	5.55	
041	72-45	168-15 W	17 Sep.	10:48	49	1	49	GG54	1039	415	7.21	
(Fixed station)								62 µm	2771	295	5.25	
041	72-45	168-15 W	17 Sep.	16:08	49	1	49	GG54	1039	462	8.03	
(Fixed station)								62 µm	2771	318	5.66	
041	72-45	168-15 W	17 Sep.	22:12	49	2	49	GG54	1039	425	7.39	
(Fixed station)								62 µm	2771	300	5.34	
041	72-45	168-15 W	18 Sep.	4:09	49	1	49	GG54	1039	400	6.95	
(Fixed station)								62 µm	2771	275	4.90	
041	72-45	168-15 W	18 Sep.	10:29	49	1	49	GG54	1039	423	7.35	
(Fixed station)								62 µm	2771	271	4.82	
041	72-45	168-15 W	18 Sep.	16:10	49	1	49	GG54	1039	489	8.50	
(Fixed station)								62 µm	2771	350	6.23	
041	72-45	168-15 W	18 Sep.	22:14	49	1	49	GG54	1039	443	7.70	
(Fixed station)								62 µm	2771	285	5.07	
041	72-45	168-15 W	19 Sep.	4:12	49	3	49	GG54	1039	564	9.80	
(Fixed station)								62 µm	2771	398	7.09	
041	72-45	168-15 W	19 Sep.	10:51	49	2	49	GG54	1039	478	8.31	
(Fixed station)								62 µm	2771	313	5.57	
041	72-45	168-15 W	19 Sep.	16:08	49	2	49	GG54	1039	461	8.01	
(Fixed station)								62 µm	2771	340	6.05	

S.M.T. was GMT+11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-1. (Continued)

Station no.	Position		S.M.T.		Length of wire	Angle of wire	Depth estimated by wire	Kind of cloth	Flowmeter		Estimated volume of water filtered (m ³)	Remark
	Lat. (N)	Lon.	Date	Hour	(m)	(°)	angle (m)		No.	Reading		
041	72-45	168-15 W	19 Sep.	22:21	49	2	49	GG54	1039	489	8.50	
(Fixed station)								62 µm	2771	364	6.48	
041	72-45	168-15 W	20 Sep.	4:13	49	3	49	GG54	1039	447	7.77	
(Fixed station)								62 µm	2771	333	5.93	
041	72-45	168-15 W	20 Sep.	10:46	49	8	49	GG54	1039	460	8.00	
(Fixed station)								62 µm	2771	409	7.28	
041	72-45	168-15 W	20 Sep.	16:14	49	2	49	GG54	1039	526	9.14	
(Fixed station)								62 µm	2771	366	6.52	
041	72-45	168-15 W	20 Sep.	22:18	49	7	49	GG54	1039	446	7.75	
(Fixed station)								62 µm	2771	401	7.14	
041	72-45	168-15 W	21 Sep.	4:13	49	3	49	GG54	1039	463	8.05	
(Fixed station)								62 µm	2771	370	6.59	
041	72-45	168-15 W	21 Sep.	11:01	49	1	49	GG54	1039	476	8.27	
(Fixed station)								62 µm	2771	321	5.71	
041	72-45	168-15 W	21 Sep.	16:10	49	2	49	GG54	1039	423	7.35	
(Fixed station)								62 µm	2771	303	5.39	
041	72-45	168-15 W	21 Sep.	22:11	49	4	49	GG54	1039	506	8.80	
(Fixed station)								62 µm	2771	336	5.98	
041	72-45	168-15 W	22 Sep.	4:08	49	2	49	GG54	1039	416	7.23	
(Fixed station)								62 µm	2771	285	5.07	
041	72-45	168-15 W	22 Sep.	11:09	49	1	49	GG54	1039	395	6.87	
(Fixed station)								62 µm	2771	262	4.66	
041	72-45	168-15 W	22 Sep.	16:10	49	2	49	GG54	1039	400	6.95	
(Fixed station)								62 µm	2771	258	4.59	
041	72-45	168-15 W	22 Sep.	22:12	49	1	49	GG54	1039	395	6.87	
(Fixed station)								62 µm	2771	230	4.09	
041	72-45	168-15 W	23 Sep.	4:10	49	1	49	GG54	1039	413	7.18	
(Fixed station)								62 µm	2771	268	4.77	
041	72-45	168-15 W	23 Sep.	10:39	49	1	49	GG54	1039	397	6.90	
(Fixed station)								62 µm	2771	268	4.77	
041	72-45	168-15 W	23 Sep.	16:10	49	1	49	GG54	1039	424	7.37	
(Fixed station)								62 µm	2771	266	4.74	
041	72-45	168-15 W	23 Sep.	22:13	49	1	49	GG54	1039	405	7.04	
(Fixed station)								62 µm	2771	251	4.47	
041	72-45	168-15 W	24 Sep.	4:15	49	4	49	GG54	1039	425	7.39	
(Fixed station)								62 µm	2771	295	5.25	
041	72-45	168-15 W	24 Sep.	11:10	49	1	49	GG54	1039	459	7.98	
(Fixed station)								62 µm	2771	294	5.23	
041	72-45	168-15 W	24 Sep.	16:09	49	1	49	GG54	1039	468	8.13	
(Fixed station)								62 µm	2771	312	5.55	
041	72-45	168-15 W	24 Sep.	22:17	49	1	49	GG54	1039	405	7.04	
(Fixed station)								62 µm	2771	260	4.63	
041	72-45	168-15 W	25 Sep.	10:50	49	2	49	GG54	1039	422	7.34	
(Fixed station)								62 µm	2771	250	4.45	1)
049	73-30	168-45 W	26 Sep.	0:03	110	5	110	GG54	1039	838	14.57	
								62 µm	2771	560	9.97	1)
052	73-04	164-37 W	26 Sep.	11:45	66	1	66	GG54	1039	545	9.47	
								62 µm	2771	349	6.21	1)
054	73-42	162-39 W	26 Sep.	18:11	151	8	150	GG54	1039	1188	20.65	
								62 µm	2771	779	13.87	1)
056	73-48	159-59 W	27 Sep.	3:00	150	2	150	GG54	1039	1218	21.17	
								62 µm	2771	867	15.44	1)

S.M.T. was GMT+11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-1. (Continued)

Station no.	Position		S.M.T.		Length of wire	Angle of wire	Depth estimated by wire	Kind of cloth	Flowmeter		Estimated volume of water filtered (m ³)	Remark
	Lat. (N)	Lon.	Date	Hour	(m)	(°)	angle (m)		No.	Reading		
058	73-09	162-17 W	27 Sep.	15:54	151	8	150	GG54	1039	1185	20.60	
								62 µm	2771	830	14.78	1)
061	72-00	168-44 W	1 Oct.	12:16	43	3	43	GG54	1039	368	6.40	
								62 µm	2771	258	4.59	1)
063	71-00	168-45 W	1 Oct.	18:32	37	8	37	GG54	1039	321	5.58	
								62 µm	2771	180	3.20	1)
065	70-00	168-45 W	2 Oct.	0:45	34	1	34	GG54	1039	302	5.25	
								62 µm	2771	175	3.12	1)
067	69-00	168-45 W	2 Oct.	7:30	46	9	45	GG54	1039	406	7.06	
								62 µm	2771	250	4.45	1)
068	68-18	167-03 W	2 Oct.	12:59	31	5	31	GG54	1039	263	4.57	
								62 µm	2771	195	3.47	1)
070	68-12	167-20 W	2 Oct.	15:04	40	6	40	GG54	1039	313	5.44	
								62 µm	2771	239	4.25	1)
072	68-00	168-00 W	2 Oct.	18:48	47	6	47	GG54	1039	376	6.54	
								62 µm	2771	188	3.35	1)
074	67-45	168-30 W	2 Oct.	22:07	42	4	42	GG54	1039	351	6.10	
								62 µm	2771	250	4.45	1)
077	68-00	168-45 W	3 Oct.	10:16	51	1	51	GG54	1039	436	7.58	
								62 µm	2771	270	4.81	1)
081	67-00	168-45 W	3 Oct.	21:04	38	3	38	GG54	1039	376	6.54	
								62 µm	2771	282	5.02	1)
083	66-00	168-45 W	4 Oct.	4:06	46	1	46	GG54	1039	377	6.55	
								62 µm	2771	319	5.68	1)
084	65-46	168-45 W	4 Oct.	7:58	45	1	45	GG54	1039	374	6.50	
								62 µm	2771	264	4.70	1)
086	65-39	168-15 W	4 Oct.	10:48	35	3	35	GG54	1039	311	5.41	
								62 µm	2771	245	4.36	1)

S.M.T. was GMT+11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-2. Data on plankton samples collected by vertical hauls with 80 cm ring net.

GG54: 335 µm mesh.

Station no.	Position		S.M.T.		Length of wire	Angle of wire	Depth estimated by wire	Kind of cloth	Flowmeter		Estimated volume of water filtered (m ³)	Remark
	Lat. (N)	Lon.	Date	Hour	(m)	(°)	angle (m)		No.	Reading		
008	68-00	168-45 W	1 Sep.	7:17	52	2	52	GG54	3691	381	20.79	2)
008	68-00	168-45 W	1 Sep.	7:27	52	1	52	GG54	3691			1)
009	68-30	168-45 W	1 Sep.	11:54	46	7	46	GG54	3691	358	19.54	2)
018	71-25	157-31 W	3 Sep.	20:34	113	3	113	GG54	3691			1)
041	72-45	168-15 W	10 Sep.	9:52	49	4	49	GG54	3691			1)
041	72-45	168-15 W	10 Sep.	22:20	49	3	49	GG54	3691			1)
041	72-45	168-15 W	11 Sep.	11:00	49	6	49	GG54	3691			1)
041	72-45	168-15 W	11 Sep.	22:18	49	4	49	GG54	3691			1)
041	72-45	168-15 W	12 Sep.	10:33	49	4	49	GG54	3691			1)
041	72-45	168-15 W	12 Sep.	22:21	49	1	49	GG54	3691			1)
041	72-45	168-15 W	13 Sep.	11:04	49	5	49	GG54	3691			1)
041	72-45	168-15 W	13 Sep.	11:12	25	1	25	GG54	3691			1)
041	72-45	168-15 W	13 Sep.	22:22	49	1	49	GG54	3691			1)
041	72-45	168-15 W	13 Sep.	22:31	25	1	25	GG54	3691			1)
041	72-45	168-15 W	14 Sep.	10:43	49	1	49	GG54	3691			1)

S.M.T. was GMT+11h.

1) for gut pigment or grazing experiment

2) JAMSTEC Kitamura sample

Table 4.14-2. (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		
041	72-45	168-15 W	14 Sep.	22:25	49	2	49	GG54	3691			1)
041	72-45	168-15 W	15 Sep.	10:57	49	5	49	GG54	3691			1)
041	72-45	168-15 W	15 Sep.	22:23	49	2	49	GG54	3691			1)
041	72-45	168-15 W	16 Sep.	10:43	49	3	49	GG54	3691			1)
041	72-45	168-15 W	16 Sep.	22:42	49	2	49	GG54	3691			1)
041	72-45	168-15 W	17 Sep.	4:20	49	1	49	GG54	3691			1)
041	72-45	168-15 W	17 Sep.	10:55	49	1	49	GG54	3691			1)
041	72-45	168-15 W	17 Sep.	16:15	49	1	49	GG54	3691			1)
041	72-45	168-15 W	17 Sep.	22:19	49	4	49	GG54	3691			1)
041	72-45	168-15 W	18 Sep.	4:15	49	12	48	GG54	3691			1)
041	72-45	168-15 W	18 Sep.	10:35	49	6	49	GG54	3691			1)
041	72-45	168-15 W	18 Sep.	16:17	49	1	49	GG54	3691			1)
041	72-45	168-15 W	18 Sep.	22:21	49	4	49	GG54	3691			1)
041	72-45	168-15 W	19 Sep.	4:17	49	3	49	GG54	3691			1)
041	72-45	168-15 W	19 Sep.	10:58	49	3	49	GG54	3691			1)
041	72-45	168-15 W	19 Sep.	16:15	49	3	49	GG54	3691			1)
041	72-45	168-15 W	19 Sep.	22:29	49	2	49	GG54	3691			1)
041	72-45	168-15 W	20 Sep.	4:19	49	4	49	GG54	3691			1)
041	72-45	168-15 W	20 Sep.	10:55	49	1	49	GG54	3691			1)
041	72-45	168-15 W	20 Sep.	16:19	49	2	49	GG54	3691			1)
041	72-45	168-15 W	20 Sep.	22:26	49	3	49	GG54	3691			1)
041	72-45	168-15 W	21 Sep.	4:20	49	1	49	GG54	3691			1)
041	72-45	168-15 W	21 Sep.	11:10	49	1	49	GG54	3691			1)
041	72-45	168-15 W	21 Sep.	16:16	49	1	49	GG54	3691			1)
041	72-45	168-15 W	21 Sep.	22:20	49	2	49	GG54	3691			1)
041	72-45	168-15 W	22 Sep.	4:14	49	2	49	GG54	3691			1)
041	72-45	168-15 W	22 Sep.	11:15	49	2	49	GG54	3691			1)
041	72-45	168-15 W	22 Sep.	16:17	49	1	49	GG54	3691			1)
041	72-45	168-15 W	22 Sep.	22:18	49	3	49	GG54	3691			1)
041	72-45	168-15 W	23 Sep.	4:16	49	1	49	GG54	3691			1)
041	72-45	168-15 W	23 Sep.	10:47	49	4	49	GG54	3691			1)
041	72-45	168-15 W	23 Sep.	16:17	49	2	49	GG54	3691			1)
041	72-45	168-15 W	23 Sep.	22:22	49	2	49	GG54	3691			1)
041	72-45	168-15 W	24 Sep.	4:21	49	4	49	GG54	3691			1)
041	72-45	168-15 W	24 Sep.	11:17	49	1	49	GG54	3691			1)
041	72-45	168-15 W	24 Sep.	16:17	49	3	49	GG54	3691			1)
041	72-45	168-15 W	24 Sep.	22:24	49	1	49	GG54	3691			1)
041	72-45	168-15 W	25 Sep.	10:59	49	1	49	GG54	3691			1)
054	73-42	162-39 W	26 Sep.	18:21	150	5	149	GG54	3691			1)
058	73-09	162-17 W	27 Sep.	16:05	150	18	143	GG54	3691			1)
041	72-45	168-15 W	30 Sep.	11:20	49	8	49	GG54	3691			1)
041	72-45	168-15 W	30 Sep.	22:10	49	3	49	GG54	3691			1)
072	68-00	168-00 W	2 Oct.	18:54	47	4	47	GG54	3691	359	19.59	2)
077	68-00	168-45 W	3 Oct.	10:24	51	2	51	GG54	3691	416	22.70	2)
077	68-00	168-45 W	3 Oct.	10:32	51	5	51	GG54	3691			1)
079	67-30	168-45 W	3 Oct.	16:00	42	1	42	GG54	3691	347	18.94	2)

S.M.T. was GMT-11h.

1) for gut pigment or grazing experiment

2) JAMSTEC Kitamura sample

Table 4.14-3. Data on plankton collected by vertical hauls with a closing PCP net or VMPS.

Station no.	Position		S.M.T.		Length of wire (m)	Angle of wire (°)	Depth estimated by wire (m)	Closed net depth (m)	Mesh size	Flowmeter		Estimated volume of water filtered (m ³)	Remark
	Lat. (N)	Lon.	Date	Hour						No.	Reading		
032	74-32	161-58 W	8 Sep.	14:24	100		100	0	62 µm		137	22.47	1)
				14:22	250		250	100	62 µm		183	30.02	1)
				14:18	500		500	250	62 µm		267	43.80	1)
				14:10	1000		1000	500	62 µm		533	87.44	1)
041	72-45	168-15 W	14 Sep.	10:55	20	1	20	0	62 µm	1852	222	3.42	1)
(Fixed station)				11:34	49	2	49	20	62 µm	1852	306	4.72	1)
041	72-45	168-15 W	14 Sep.	22:35	20	2	20	0	62 µm	1852	173	2.67	1)
(Fixed station)				22:40	49	3	49	20	62 µm	1852	200	3.08	1)
041	72-45	168-15 W	16 Sep.	10:52	20	1	20	0	62 µm	1852	160	2.47	1)
(Fixed station)				10:57	49	1	49	20	62 µm	1852	236	3.64	1)
041	72-45	168-15 W	16 Sep.	22:53	20	1	20	0	62 µm	1852	160	2.47	1)
(Fixed station)				22:59	49	2	49	21	62 µm	1852	274	4.23	1)
041	72-45	168-15 W	16 Sep.	4:29	20	1	20	0	62 µm	1852	178	2.75	
(Fixed station)				4:35	49	1	49	20	62 µm	1852	288	4.44	
041	72-45	168-15 W	17 Sep.	11:21	20	1	20	0	62 µm	1852	180	2.78	1)
(Fixed station)				11:33	49	1	49	20	62 µm	1852	207	3.19	1)
041	72-45	168-15 W	17 Sep.	16:23	20	1	20	0	62 µm	1852	140	2.16	
(Fixed station)				16:29	49	1	49	20	62 µm	1852	228	3.52	
041	72-45	168-15 W	17 Sep.	22:29	20	1	20	0	62 µm	1852	180	2.78	1)
(Fixed station)				22:35	49	1	49	20	62 µm	1852	178	2.75	1)
041	72-45	168-15 W	18 Sep.	4:23	20	2	20	0	62 µm	1852	140	2.16	
(Fixed station)				4:30	49	2	49	20	62 µm	1852	250	3.86	
041	72-45	168-15 W	18 Sep.	10:43	20	2	20	0	62 µm	1852	147	2.27	1)
(Fixed station)				10:49	49	1	49	20	62 µm	1852	215	3.32	1)
041	72-45	168-15 W	18 Sep.	16:25	20	1	20	0	62 µm	1852	209	3.22	
(Fixed station)				16:31	49	2	49	20	62 µm	1852	213	3.29	
041	72-45	168-15 W	18 Sep.	22:32	20	1	20	0	62 µm	1852	221	3.41	1)
(Fixed station)				22:37	49	2	49	20	62 µm	1852	250	3.86	1)
041	72-45	168-15 W	19 Sep.	4:25	20	1	20	0	62 µm	1852	240	3.70	
(Fixed station)				4:31	49	2	49	20	62 µm	1852	336	5.18	
041	72-45	168-15 W	19 Sep.	11:09	20	3	20	0	62 µm	1852	169	2.61	1)
(Fixed station)				11:14	49	2	49	20	62 µm	1852	319	4.92	1)
041	72-45	168-15 W	19 Sep.	16:24	20	3	20	0	62 µm	1852	213	3.29	
(Fixed station)				16:30	49	4	49	20	62 µm	1852	270	4.16	
041	72-45	168-15 W	19 Sep.	22:40	20	8	20	0	62 µm	1852	340	5.24	1)
(Fixed station)				22:47	49	3	49	20	62 µm	1852	358	5.52	1)
041	72-45	168-15 W	20 Sep.	4:28	20	4	20	0	62 µm	1852	222	3.42	
(Fixed station)				4:35	49	6	49	19	62 µm	1852	374	5.77	
041	72-45	168-15 W	20 Sep.	11:05	20	5	20	0	62 µm	1852	338	5.21	1)
(Fixed station)				11:25	49	4	49	20	62 µm	1852	497	7.67	1)
041	72-45	168-15 W	20 Sep.	16:26	20	3	20	0	62 µm	1852	239	3.69	
(Fixed station)				16:34	49	3	49	19	62 µm	1852	343	5.29	
041	72-45	168-15 W	20 Sep.	22:37	20	4	20	0	62 µm	1852	269	4.15	1)
(Fixed station)				22:44	49	1	49	20	62 µm	1852	494	7.62	1)
041	72-45	168-15 W	21 Sep.	4:30	20	4	20	0	62 µm	1852	198	3.05	
(Fixed station)				4:36	49	2	49	18	62 µm	1852	300	4.63	
041	72-45	168-15 W	21 Sep.	11:20	20	1	20	0	62 µm	1852	260	4.01	1)
(Fixed station)				11:26	49	1	49	21	62 µm	1852	258	3.98	1)
041	72-45	168-15 W	21 Sep.	16:23	20	2	20	0	62 µm	1852	159	2.45	
(Fixed station)				16:32	49	1	49	20	62 µm	1852	359	5.54	
041	72-45	168-15 W	21 Sep.	22:31	20	1	20	0	62 µm	1852	168	2.59	1)
(Fixed station)				22:36	49	1	49	20	62 µm	1852	250	3.86	1)
041	72-45	168-15 W	22 Sep.	4:23	20	1	20	0	62 µm	1852	157	2.42	
(Fixed station)				4:30	49	1	49	19	62 µm	1852	240	3.70	
041	72-45	168-15 W	22 Sep.	11:25	20	2	20	0	62 µm	1852	91	1.40	1)
(Fixed station)				11:31	49	3	49	20	62 µm	1852	194	2.99	1)
041	72-45	168-15 W	22 Sep.	16:25	20	1	20	0	62 µm	1852	143	2.21	
(Fixed station)				16:31	49	1	49	20	62 µm	1852	186	2.87	

S.M.T. was GMT-11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-3. (Continued)

Station no.	Position		S.M.T.		Length of wire	Angle of wire	Depth estimated by wire	Closed net depth	Mesh size	Flowmeter		Estimated volume of water filtered	Remark
	Lat. (N)	Lon.	Date	Hour	(m)	(°)	(m)	(m)		No.	Reading	(m ³)	
041	72-45	168-15 W	22 Sep.	22:27	20	1	20	0	62 μ m	1852	150	2.31	1)
(Fixed station)				22:33	49	1	49	21	62 μ m	1852	220	3.39	1)
041	72-45	168-15 W	23 Sep.	04:26	20	1	20	0	62 μ m	1852	153	2.36	
(Fixed station)				04:32	49	2	49	20	62 μ m	1852	250	3.86	
041	72-45	168-15 W	23 Sep.	10:56	20	2	20	0	62 μ m	1852	148	2.28	1)
(Fixed station)				11:01	49	1	49	20	62 μ m	1852	212	3.27	1)
041	72-45	168-15 W	23 Sep.	16:24	20	1	20	0	62 μ m	1852	150	2.31	
(Fixed station)				16:30	49	1	49	20	62 μ m	1852	222	3.42	
041	72-45	168-15 W	23 Sep.	22:31	20	1	20	0	62 μ m	1852	163	2.51	1)
(Fixed station)				22:37	49	1	49	20	62 μ m	1852	218	3.36	1)
041	72-45	168-15 W	24 Sep.	4:30	20	2	20	0	62 μ m	1852	197	3.04	
(Fixed station)				4:37	49	2	49	20	62 μ m	1852	283	4.37	
041	72-45	168-15 W	24 Sep.	11:28	20	1	20	0	62 μ m	1852	172	2.65	1)
(Fixed station)				11:34	49	1	49	20	62 μ m	1852	250	3.86	1)
041	72-45	168-15 W	24 Sep.	16:25	20	2	20	0	62 μ m	1852	163	2.51	
(Fixed station)				16:31	49	1	49	20	62 μ m	1852	257	3.96	
041	72-45	168-15 W	24 Sep.	22:35	20	1	20	0	62 μ m	1852	125	1.93	1)
(Fixed station)				22:41	49	1	49	20	62 μ m	1852	185	2.85	1)
056	73-48	159-59 W	27 Sep.	6:36	100		100	0	62 μ m		106	17.39	1)
				6:34	250		250	100	62 μ m		160	26.25	1)
				6:30	500		500	250	62 μ m		274	44.95	1)
				6:22	1000		1000	500	62 μ m		550	90.23	1)

S.M.T. was GMT+11h.

1) shared 1/2 sample with JAMSTEC Kimoto

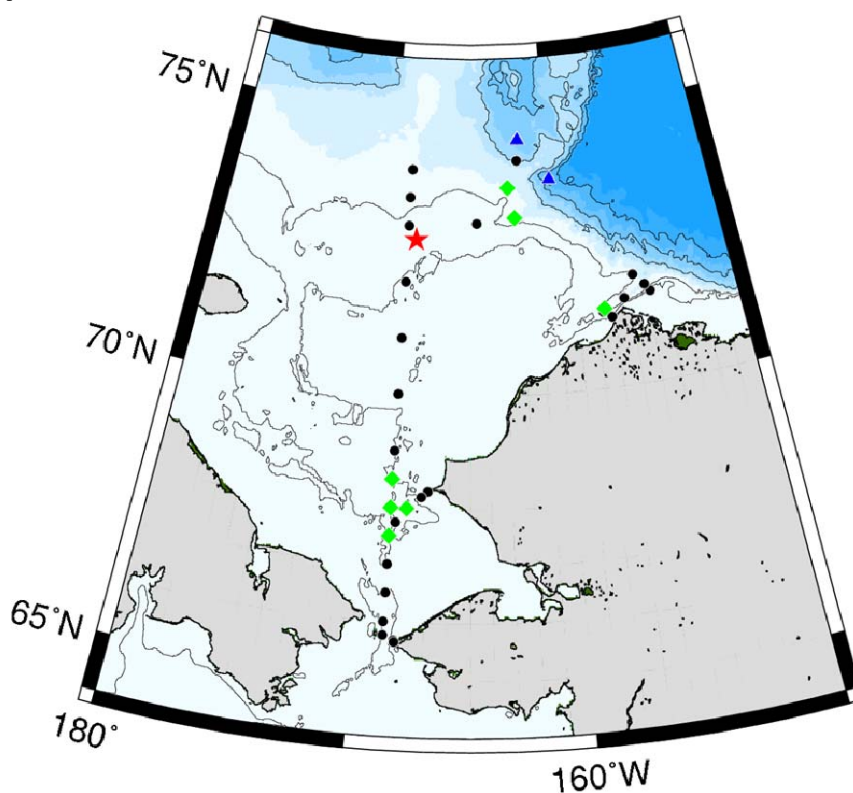


Fig. 4.14-1. Location of the sampling stations in the western Arctic Ocean (circles: NORPAC net, diamonds: NORPAC net + 80 cm ring net, triangles: NORPAC net + VMPS). Star indicates a fixed station during 10–25 September 2013.

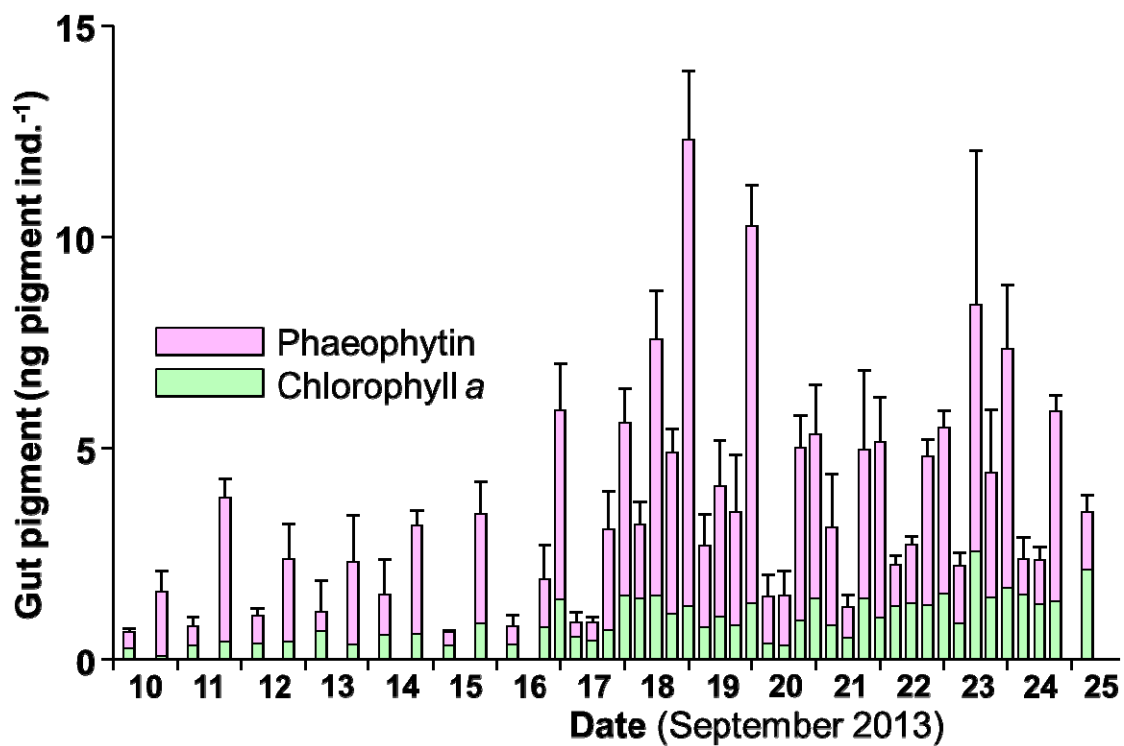


Figure 4.14-2. Temporal changes in gut pigment of *C. glacialis* C5 at a fixed station during 10–25 September 2013.

4.15. Sediment trap moorings

(1) Personnel

Naomi Harada (JAMSTEC, not onboard): Principal Investigator
Yuichiro Tanaka (AIST, not onboard)
Shigeto Nishino (JAMSTEC)
Takahashi Kikuchi (JAMSTEC, not onboard)
Katsunori Kimoto (JAMSTEC)
Yusuke Okazaki (Kyushu Univ./JAMSTEC, not onboard)
Takahito Ikenoue (Kyushu Univ.)
Makio C. Honda (JAMSTEC, not onboard)
Kana Nagashima (JAMSTEC, not onboard)
Sanae Chiba (JAMSTEC, not onboard)
Atsushi Yamaguchi (Hokkaido Univ., not onboard)
Manami Satoh (Tsukuba Univ., not onboard)
Miyako Satoh (JAMSTEC, not onboard)
Jonaotaro Onodera (JAMSTEC)
Hirokatsu Uno (MWJ): Technical staff for mooring deployment
Soh-ichiro Sueyoshi (GODI): Technical staff for bathymetry survey

(2) Objectives

The objectives of this task are to understand the relationship between marine lower ecosystem and rapid environmental change such as the recent sea-ice decrease in the western Arctic Ocean. We have continued time-series monitoring of sinking particle fluxes in the Northwind Abyssal Plain and the shelf slope of Chukchi Abyssal Plain since October 2010 (Figure 4.15-1). The recovery and deployment operations of two sediment trap moorings were planned in this cruise.

(3) Instruments and methods

The mooring IDs for recovery are NAP12t and CAP12t. These moorings were deployed by the R/V Mirai Cruise MR12-E03 in the last summer. The instruments with recovery moorings are sediment trap, DO sensor, C-T sensor, acoustic transponder, and tandem acoustic releasers. In addition to those equipments, deployment moorings newly contain ice profiling sonar, ADCP, electromagnetic current meter, SeaGuard monitoring system with pCO₂ sensor, EXO multi water quality profiler, pH sensor, multi-wave length excitation fluorescence photometer (Multi-Exciter), and submarine camera

system. The method of mooring operation on deck is basically the same as the works in MR12-E03. Before the deployment work, the response test of double releasers and water sampling was conducted at 1613 m depth with CTD observation at Station 30 near NAP13t. As mentioned below, the deployment position of NAP13t was changed from NAP12t position because of sea-ice condition. Therefore, bathymetric survey and revision of mooring design (change of rope length) were conducted around NAP13t (Figures 4.15-2 and 4.15-3).

(4) Station list or Observation log

Sediment trap recovery

No recovery operations of sediment trap moorings were conducted due to inadequate sea-ice condition around NAP12t and CAP12t.

Sediment trap deployment

The log of deployment operation in Table 4.15-1

The layout of sediment trap moorings in Figures 4.15-4.

(5) Results

Cancelled recovery of sediment trap moorings NAP12t and CAP12t

Because of ice edge situation around the mooring stations, the R/V Mirai could not reach the area within the range of available acoustic communication between transducer from ship and moored transponder or acoustic releasers. Therefore, the mooring recovery operations at Stations NAP12t and CAP12t were totally cancelled. The presence of mooring was not also confirmed. The revisit and recoveries of NAP12t and CAP12t are to be planned in next summer season.

Deployment of sediment trap mooring NAP13t

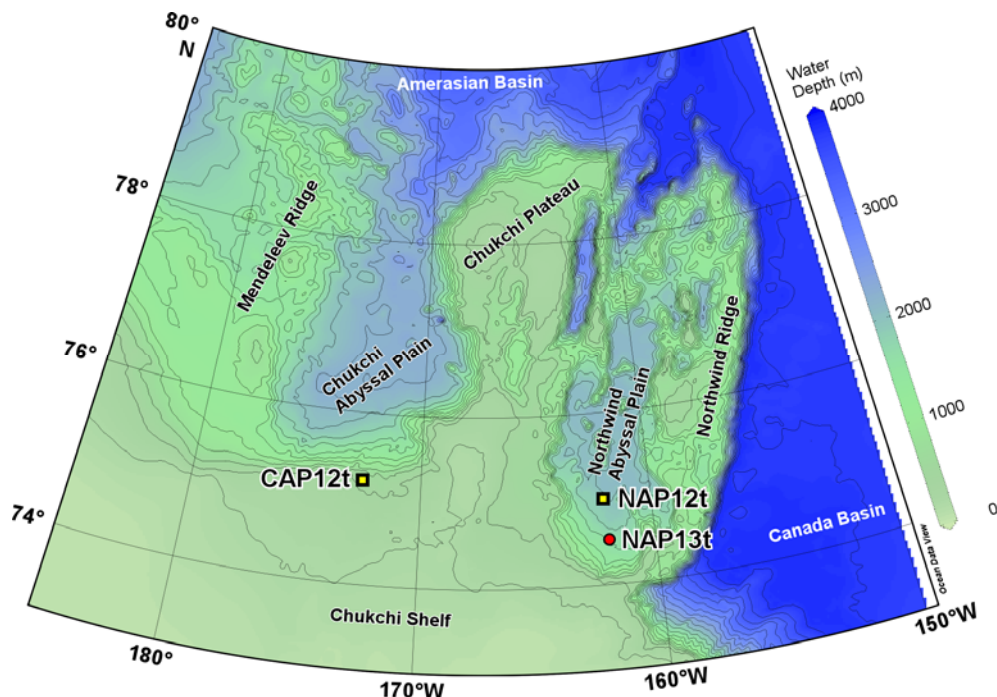
The deployment of NAP13t was conducted at alternative location, 30 nautical miles south from NAP12t (Figure 4.15-2). The bottom depth at NAP13t is about 300 m shallower than that at original NAPt station. Therefore, some shorter Kevlar ropes, which were the spare or the recovered mooring ropes from Barrow Canyon, were applied for NAP13t. The deployment operation was successful without any injuries. According to transponder at the upper part of NAP13t, the estimated water depth at the top of mooring is about 37 m.

Cancelled deployment of sediment trap mooring CAP13t

The R/V Mirai could not take a chance to enter the western Chukchi Sea due to inadequate ice condition. The deployment of CAP13t was cancelled.

Table 4.15-1. Deployment log of sediment trap mooring NAP13t (by Dr. Kawaguchi)

Mooring ID	NAP13t
Project	MR13-06
Ship	R/V Mirai
Start Time of Deploy (UTC)	8 Sep. 2013, 20:02
Start Position of Deploy	74°33.4316'N 161°58.4060'W
Depth of Start Position	1715 m
Submersion Time of Instruments (UTC)	
Ice Profiling Sonar (s/n 51123)	20:04
w/ C-T Sensor (s/n 1367)	
w/ Multi-Exciter (s/n 19)	
Transponder XT6001-13 (s/n 60645)	20:04
Benthos Glass Floats	20:04
ADCP WHS-300 (s/n 13838)	20:08
Benthos Glass Floats	20:11
SeaGuard Sensor (s/n 67)	20:18
w/ EXO Sensor (s/n 12E101329)	
w/ C-T Sensor (s/n 2155)	
w/ pH Sensor (s/n 346259004)	
Sediment Trap (s/n ST98058)	20:30
w/ C-T Sensor (s/n 2156)	
w/ Camera System (s/n 12E101339)	
Electromag. Current Meter S4D (s/n 5282332)	20:30
Benthos Glass Floats	20:57
Sediment Trap (s/n ST98083)	21:18
w/ C-T Sensor (s/n 2163)	
Benthos Glass Floats	21:36
Releaser Nichiyu-LGC (s/n LGC0021)	21:37
Releaser Benthos 865A (s/n 1078)	21:37
Time of Sinker Release (UTC)	8 Sep. 2013, 21:59
Position of Sinker Release	74°31.1885'N 161°55.3575'W
Depth of Sinker Release Position	1680-1689 m

**Figure 4.15-1.** The locality map of sediment-trap mooring Stations NAP12t, NAP13t, and CAP12t. The contours are drawn by IBCAO bathymetry data.

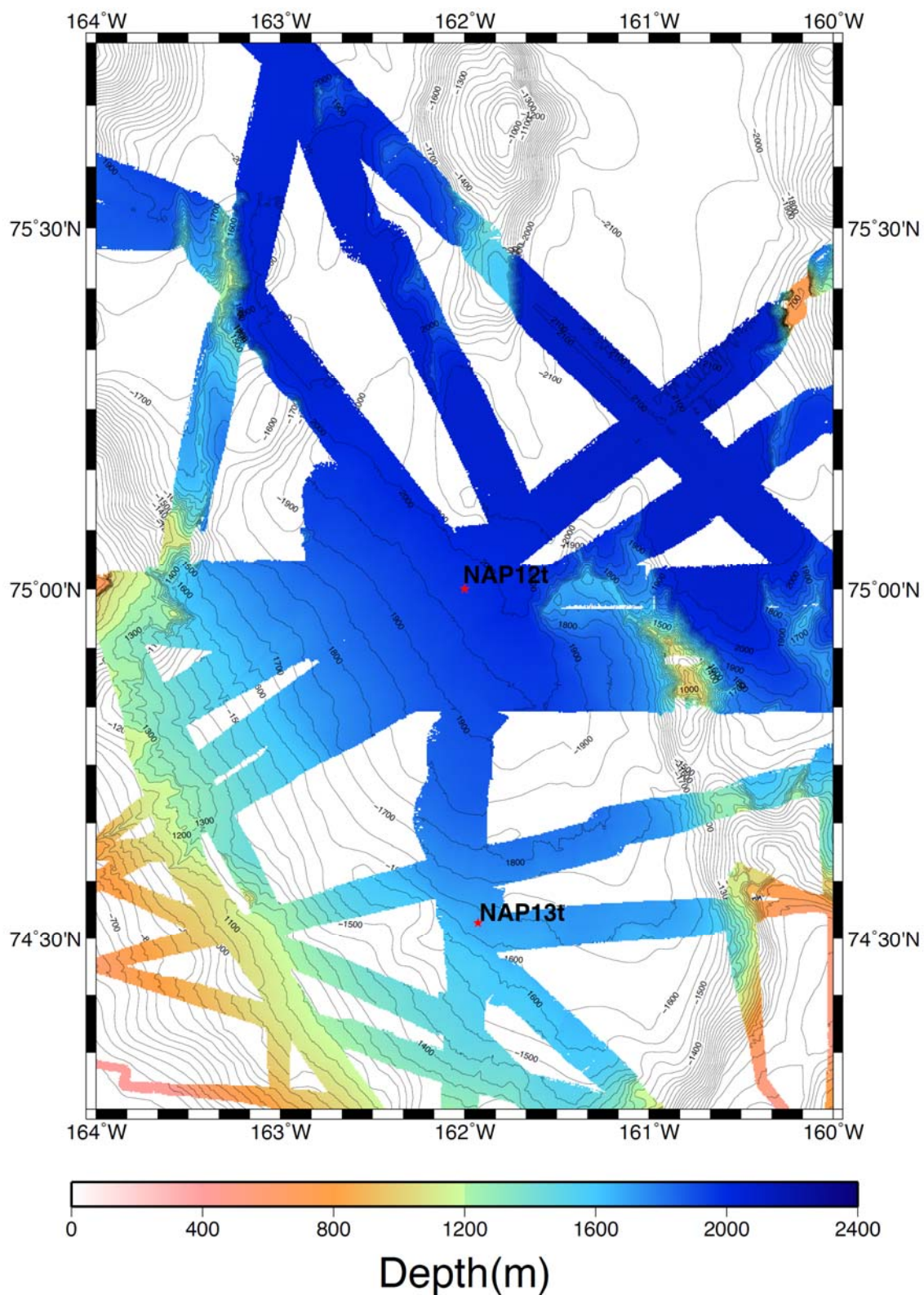


Figure 4.15-2. The bottom survey map around Stations NAP12t and NAP13t. The survey data obtained by previous R/V Mirai cruises are also used. The background contours are drawn based on IBCAO bathymetry data.

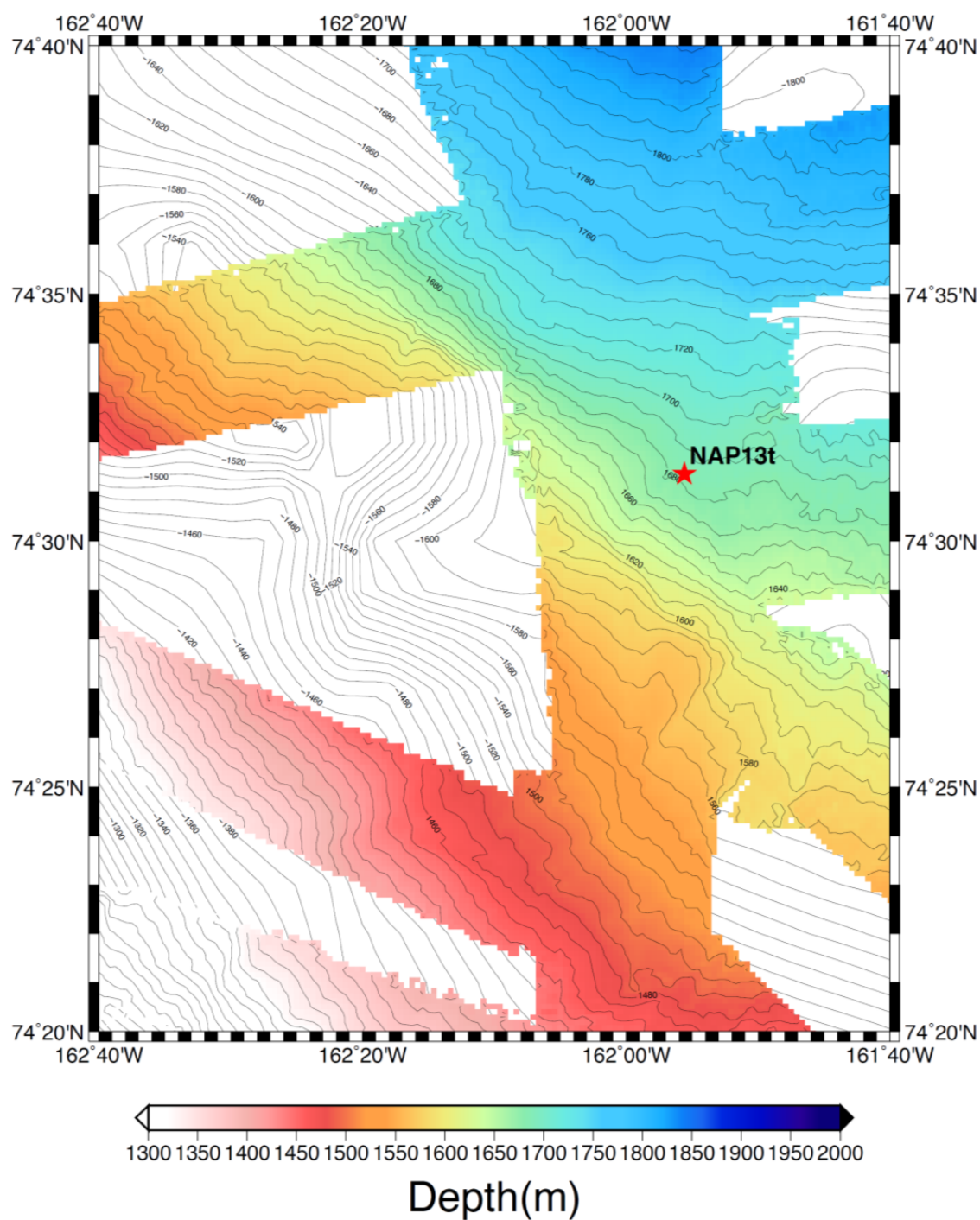


Figure 4.15-3. The bottom survey map around Stations NAP13t. The survey data obtained by previous R/V Mirai cruises are also used. The background contours are drawn based on IBCAO bathimetric data.

Deployment Station NAP13t

74°31.3611'N 161°55.5919'W
1681 m water depth, transponder at 39 m

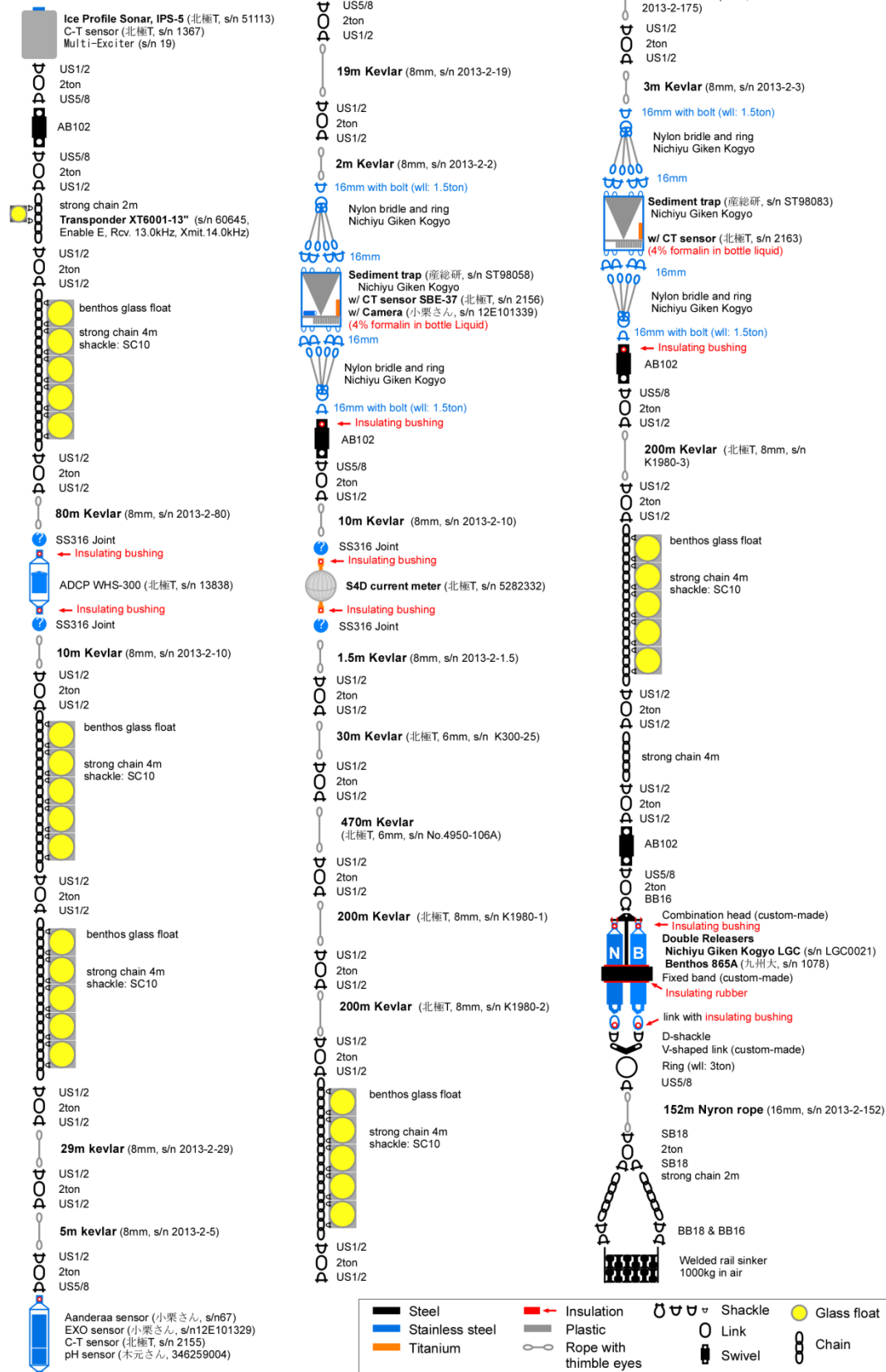


Figure 4.15-4. The mooring layout of NAP13t.

4.16. Radionuclides

(1) Personnel

Yuichiro KUMAMOTO (JAMSTEC): Principal Investigator

Hisaki NAGAI (Nihon University)

(2) Objective

Determination of activity concentrations of radionuclides, including radiocesium and radioiodine.

(3) Parameters

^{134}Cs , ^{137}Cs , and ^{129}I

(4) Instruments and Methods

a. Sampling

Seawater samples for the radionuclides were collected using 12-liter Niskin-X bottles and a bucket. In addition, surface seawater was also collected from continuous pumped-up water from about 4-m depth. The seawater sample was collected into a 20-L plastic container after two time washing. In our laboratory on shore, a seawater sample was divided into two for radiocesium (about 20-L) and radioiodine (about 1-L). The seawater for radiocesium was then acidified by 40-cm³ of concentrated nitric acid. The seawater for radioiodine was siphoned into 1-L plastic bottle.

b. Preparation and analysis

In our laboratory on shore, radiocesium in the seawater samples will be concentrated using ammonium phosphomolybdate (AMP) that forms insoluble compound with cesium. The radiocesium (^{134}Cs and ^{137}Cs) in AMP will be measured using Ge γ -ray spectrometer. Measurements of radioiodine will be also conducted at our laboratory on shore. Iodine in the seawater samples is extracted by the solvent extraction technique. Extracted iodine is then precipitated as silver iodide by the addition of the silver nitrate. Iodine isotopic ratios ($^{129}\text{I}/^{127}\text{I}$) of the silver iodide are measured by the Accelerator Mass Spectrometry (AMS). To evaluate the ^{129}I concentration in the seawater samples, iodine concentration (^{127}I) will be measured by the inductively coupled plasma mass spectrometry (ICP-MS) and/or the voltammetry.

(5) Sample list

We collected 22 seawaters for the radionuclide measurement in Arctic Sea, Bering Sea, and northern North Pacific Ocean during this cruise (Table 4.16-1).

(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 “R/V Mirai Data Web Page” in JAMSTEC web site.

Table 4.16-1. Seawater samples collected for the radionuclide measurement.

No.	Station	Sampling depth (m)	Method	Latitude (N)	Longitude (E)	Date (UTC)
1	surface	4	pump	71.70	205.08	6 Sep. 2013
2	32	0	bucket	74.54	199.97	9 Sep. 2013
3	32	25	niskin	74.54	199.97	9 Sep. 2013
4	32	65	niskin	74.54	199.97	9 Sep. 2013
5	32	100	niskin	74.54	199.97	9 Sep. 2013
6	32	150	niskin	74.54	199.97	9 Sep. 2013
7	32	200	niskin	74.54	199.97	9 Sep. 2013
8	32	300	niskin	74.54	199.97	9 Sep. 2013
9	32	400	niskin	74.54	199.97	9 Sep. 2013
10	32	600	niskin	74.54	199.97	9 Sep. 2013
11	32	800	niskin	74.54	199.97	9 Sep. 2013
12	34	0	bucket	74.00	192.74	9 Sep. 2013
13	41	0	bucket	72.75	192.24	24 Sep. 2013
14	48	0	bucket	74.00	192.75	26 Sep. 2013
15	67	0	bucket	69.00	192.75	2 Oct. 2013
16	84	0	bucket	65.76	192.76	4 Oct. 2013
17	surface	4	pump	57.67	193.36	6 Oct. 2013
18	surface	4	pump	54.22	193.45	9 Oct. 2013
19	surface	4	pump	53.58	178.04	11 Oct. 2013
20	surface	4	pump	48.77	165.81	14 Oct. 2013
21	surface	4	pump	42.51	157.67	16 Oct. 2013
22	surface	4	pump	40.11	148.43	18 Oct. 2013

5. Geophysics

5.1. Sea bottom topography measurement

(1) Personnel

Masao Nakanishi	Chiba University: PI (not on-board)
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Kazuho Yoshida	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), Bathym2010 (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) Instruments and Methods

The "SEABEAM 3012 Upgrade Model" on R/V MIRAI was used for bathymetry mapping during the MR13-06 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 5.1-1 and Table 5.1-2.

Table 5.1-1. 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 ± 1 m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or ± 1 m, whichever is greater)

Table 5.1-2. Bathymetry2010 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 m of bottom penetration; bottom type dependant
Depth resolution:	0.1 feet, 0.1m
Depth accuracy:	± 10 cm to 100 m, $\pm 0.3\%$ 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 “R/V Mirai Data Web Page” in JAMSTEC web site.

5.2. Sea surface gravity measurement

(1) Personnel

Masao Nakanishi	Chiba University: PI (not on-board)
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Masanori Murakami	GODI
Koichi Inagaki	GODI
Kazuho Yoshida	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 during the MR13-06 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 the 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 5.2-1

Table 5.2-1. 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	08/12	01:05	Sekinehama	980371.95	263	640	980373.01	12663.39
#2	10/21	08:20	Sekinehama	980371.93	231	625	980372.86	12665.70

*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 “R/V Mirai Data Web Page” in

JAMSTEC web site.

5.3. Surface magnetic field measurements

1) Three-components magnetometer

(1) Personnel

Masao Nakanishi	Chiba University: PI (not on-board)
Souichiro Sueyoshi	GODI
Katsuhisa Maeno	GODI
Kazuho Yoshida	GODI
Masanori Murakami	GODI
Koichi Inagaki	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 MR13-06 cruise.

(3) Instruments and Methods

A shipboard three-component magnetometer system (SFG1214, Tierra Tecnica) 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, \mathbf{H}_{ob} , (in the ship's fixed coordinate system) and the geomagnetic field vector, \mathbf{F} , (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}_{ob} = \tilde{\mathbf{A}} \tilde{\mathbf{R}} \tilde{\mathbf{P}} \tilde{\mathbf{Y}} \mathbf{F} + \mathbf{H}_p \quad (a)$$

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

$$\tilde{\mathbf{R}} \mathbf{H}_{ob} + \mathbf{H}_{bp} = \tilde{\mathbf{R}} \tilde{\mathbf{P}} \tilde{\mathbf{Y}} \mathbf{F} \quad (b)$$

where $\tilde{\mathbf{R}} = \tilde{\mathbf{A}}^{-1}$, and $\mathbf{H}_{bp} = -\tilde{\mathbf{R}} \mathbf{H}_p$. The magnetic field, \mathbf{F} , can be obtained by measuring $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$, $\tilde{\mathbf{Y}}$ and \mathbf{H}_{ob} , if $\tilde{\mathbf{R}}$ and \mathbf{H}_{bp} are known. Twelve constants in $\tilde{\mathbf{R}}$ and \mathbf{H}_{bp} can be determined by measuring variation of \mathbf{H}_{ob} with $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$ and $\tilde{\mathbf{Y}}$ at a place where the geomagnetic field, \mathbf{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 “R/V Mirai Data Web Page” 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.

06 Sep. 2013, 17:35 to 18:00 UTC 71-39.9N, 155-00.0W

01 Oct. 2013, 09:43 to 10:16 UTC 72-45.3N, 168-10.9W

18 Oct. 2013, 06:00 to 06:24 UTC 40-07.7N, 147-54.7E

2) Cesium magnetometer

(1) Personnel

Masao Nakanishi	Chiba University: PI (not on-board)
Kazuho Yoshida	GODI
Masanori Murakami	GODI
Ryo Ohyama	MIRAI Crew

(2) Objective

Measurement of total magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure.

(3) Data Period

03:39UTC 15 Oct. 2013 - 13:39UTC 15 Oct. 2013

(4) Instruments and Methods

We measured total geomagnetic field using a cesium marine magnetometer (G-882, Geometrics Inc.) and recorded by G-882 data logger (Ver.1.0.0, Clovertech Co.). The G-882 magnetometer uses an optically pumped Cesium-vapor atomic resonance system. The sensor fish towed 500 m behind the vessel to minimize the effects of the ship's magnetic field. Table 5.3-1 shows system configuration of MIRAI cesium magnetometer system.

Table 5.3-1. System configuration of MIRAI cesium magnetometer system

Dynamic operating range: 20,000 to 100,000 nT

Absolute accuracy: $< \pm 2$ nT throughout range

Setting: Cycle rate; 0.1 sec
 Sensitivity; 0.001265 nT at a 0.1 second cycle rate
 Sampling rate; 1 sec

(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 “R/V Mirai Data Web Page” in JAMSTEC web site.