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R/V Mirai Cruise Report MR17-05C (MR17-Nishino)

Arctic Challenge for Sustainability (ArCS)

Arctic Ocean, Bering Sea, and North Pacific Ocean
23 August 2017 – 1 October 2017

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

Contents

1. Cruise Summary

1.1. Objectives

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 Arctic changes, and their effects on human society.
c. To collect data to provide accurate projections and environmental assessments for stakeholders so that they can make appropriate decisions on the sustainable development of the Arctic region.

1.2. Overview

We conducted meteorological and hydrographic surveys including marine biogeochemical samplings in the northern Bering Sea and the Arctic Ocean on board the R/V Mirai from 23 August to 1 October 2017 under the Arctic Challenge for Sustainability (ArCS) Project (Figure 1.2-1).

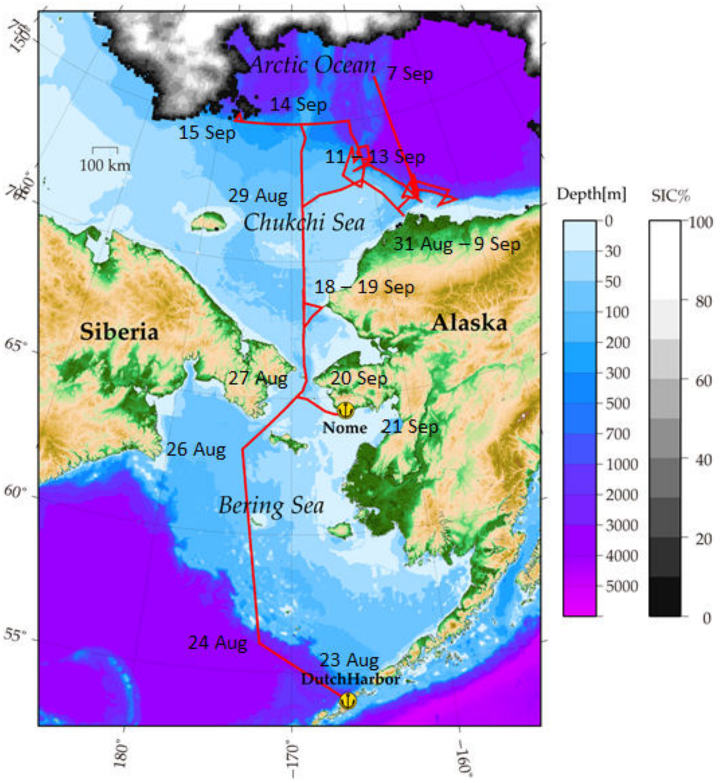

Figure 1.2-1: Cruise track and sea ice concentration (SIC) averaged over 12 to 15 September 2017.

According to a report from National Snow and Ice Data Center (NSIDC), Arctic sea ice appears to have reached its seasonal minimum extent of 4.64 million square kilometers on 13 September 2017, the eighth lowest in the 38-year satellite record. Our research areas in the Pacific sector of the Arctic Ocean were also ice free in a large region (Figure 1.2-2).

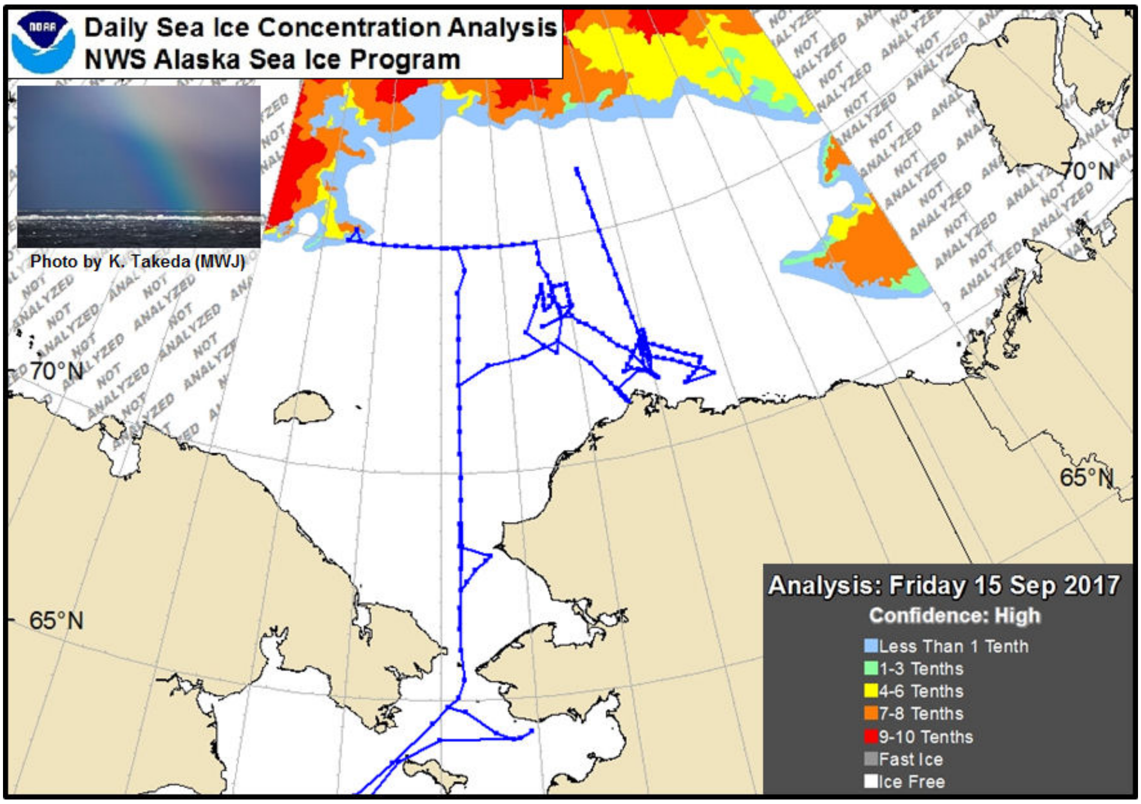

Figure 1.2-2: Colors indicate sea ice concentration on 15 September 2017. The inserted photo was taken on 15 September 2017, when we arrived at an ice-edge area (75° 16' N, 177° 26' W) off Siberia. Blue lines represent the cruise tracks of R/V Mirai. The sea ice data is obtained from Daily Sea Ice Concentration Analysis, NWS Alaska Sea Ice Program, NOAA.

The research areas included the EEZ and the territorial sea of the USA. The observational activities consisted of CTD/LADCP/water samplings, XCTD, ocean microstructure measurements by Turbulence Ocean Microstructure Acquisition Profiler (TurboMAP), drifting buoy deployments, bio-optics measurements, plankton net (NORPAC, closing, and BONGO net) samplings, sediment samplings, incubation experiments, visual observations of marine animals by binoculars, ship-board ocean current and surface water monitorings, meteorological measurements and samplings, aerosol observations, satellite observations, radiosondes, Doppler radar, sea ice radar, sea bottom topography, gravity, and magnetic field measurements, and mooring and sediment trap recoveries and deployments (Figure 1.2-3). At an ice-edge area, we approached to the sea ice by a small working boat (Zodiac) and conducted unique surveys using a UCTD sensor, fluorometer, water sampler, and plankton net.

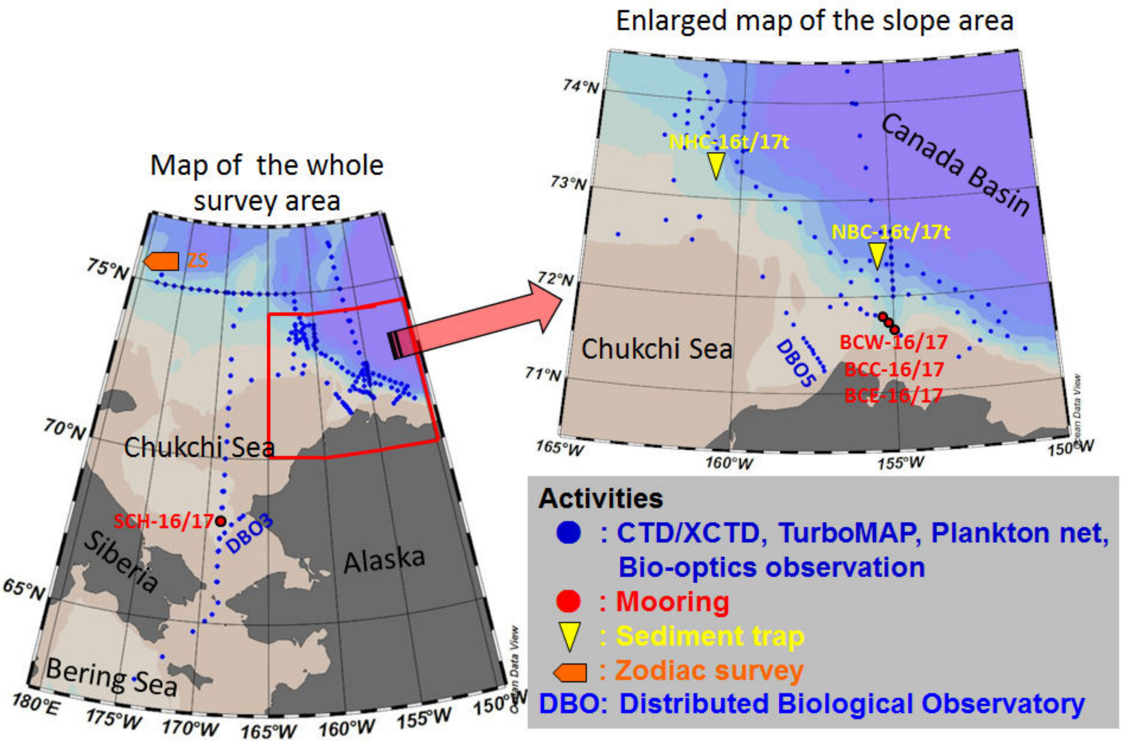

Figure 1.2-3: Map of the research areas in the northern Bering Sea and the Arctic Ocean (left) and an enlarged drawing from the Chukchi shelf slope to the Canada Basin (right). Blue dots indicate stations where we conducted observations using Conductivity-Temperature-Depth (CTD) sensors with water sampling bottles, eXpendable Conductivity-Temperature-Depth (XCTD) sensors, Turbulence Ocean Microstructure Acquisition Profiler (TurboMAP), plankton nets, and bio-optics instruments. Red dots and yellow triangles represent mooring and sediment trap sites, respectively. An orange pentagon is a survey site using a Zodiac boat near an ice-edge. We also carried out intensive oceanographic surveys under an international collaboration (Distributed Biological Observatory) off Pts. Hope and Barrow.

In this cruise, 120 radiosondes were released. We had 186 oceanographic stations (111 CTD and 75 XCTD stations) including 86 water sampling sites, more than 40 TurboMAP sites, 22 bio-optics sites, 80 NORPAC net sites, 4 closing net sites, 46 BONGO net sites, 3 sediment sampling sites, 3 sites for drifting buoy launches, 6 sites for recoveries and deployments of moorings and sediment traps. Continuous meteorological and oceanographic observations/samplings were carried out on the cruise track. These missions were successfully completed thanks to great efforts made by the captain, ice pilot, officers, crew, and all the participants in this cruise (Photo 1.2-1). Based on the data obtained in this cruise, we will be able to shed light on the Arctic change and its controlling factors, and will contribute to the global climate change studies.

Photo 1.2-1: Commemorative photograph for the participants of R/V Mirai Arctic Ocean cruise in 2017.

This cruise included the following 9 studies:

- Studies on board

● Representative of the Science Party [Affiliation]: Jun Inoue [NIPR]

○ Title of proposal: Predictability study on weather and sea-ice forecasts linked with user engagement

● Representative of the Science Party [Affiliation]: Fumikazu Taketani [JAMSTEC]

○ Title of proposal: Ship-borne observations of trace gases/aerosols over the Arctic

● Representative of the Science Party [Affiliation]: Shigeto Nishino [JAMSTEC]

○ Title of proposal: Observational study on environmental changes in the Pacific Arctic Ocean with intensive surveys in the shelf slope area

● Representative of the Science Party [Affiliation]: Naomi Harada [JAMSTEC]

○ Title of proposal: How plankton responses to multi stressors such as ocean warming and acidification?

● Representative of the Science Party [Affiliation]: Toru Hirawake [Hokkaido University]

○ Title of proposal: Response of phytoplankton community under environmental change

● Representative of the Science Party [Affiliation]: Atsushi Yamaguchi [Hokkaido University]

○ Title of proposal: Comparison of zooplankton with differences in net mesh-size, spatial distribution of zooplankton and standing stock and material flux role of Appendicularians

● Representative of the Science Party [Affiliation]: Bungo Nishizawa [Hokkaido University]

○ Title of proposal: Seasonal distribution of krill-eating top predators and their prey in the Chukchi Sea during fall

- Studies not on board

● Representative of the Science Party [Affiliation]: Yasunori Tohjima [NIES]

○ Title of proposal: Ship-board observations of atmospheric greenhouse gases and related species in the Arctic Ocean and the western North Pacific

● Representative of the Science Party [Affiliation]: Akihiko Murata [JAMSTEC]

○ Title of proposal: Spatial and temporal changes of seawater CO_2 and CH_4 in the western Arctic Ocean

1.3. Basic information

Name of vessel	R/V Mirai L x B x D 128.58m x 19.0m x 13.2m Gross Tonnage: 8,706 tons Call Sign JNSR
Cruise code	MR17-05C
Undertaking institute	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Chief scientist	Shigeto Nishino Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Cruise periods	23 August 2017 – 1 October 2017
Ports call	23 August 2017, Dutch Harbor (leave port) 21 September 2017, Off Nome (arrival and leave after an ice pilot, bear watcher, and foreign scientists disembarkation) 1 October 2017, Hachinohe (arrival in port)
Research areas	The Arctic Ocean, Bering Sea and North Pacific Ocean

1.4. Cruise Track

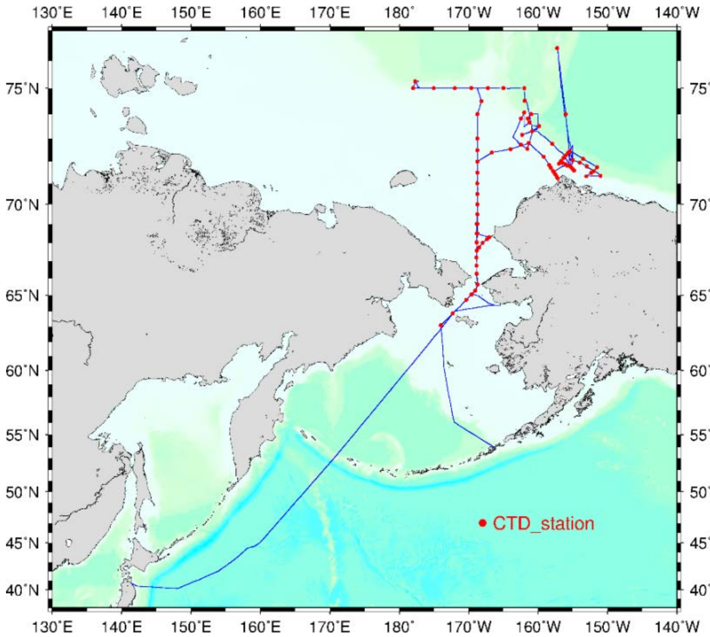

Figure 1.4-1: Cruise track and CTD stations of MR17-05C.

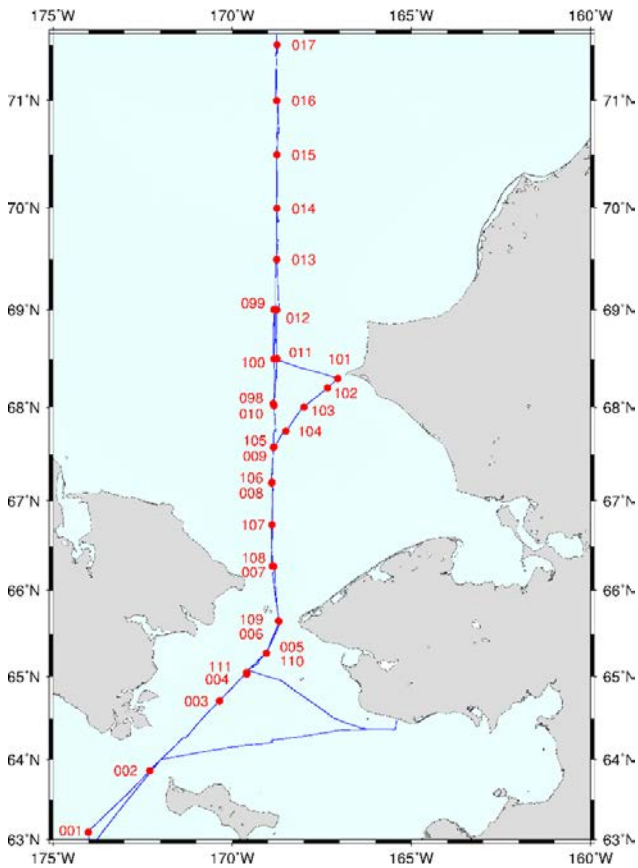

Figure 1.4-2: Cruise track and CTD stations (63°N to 72°N).

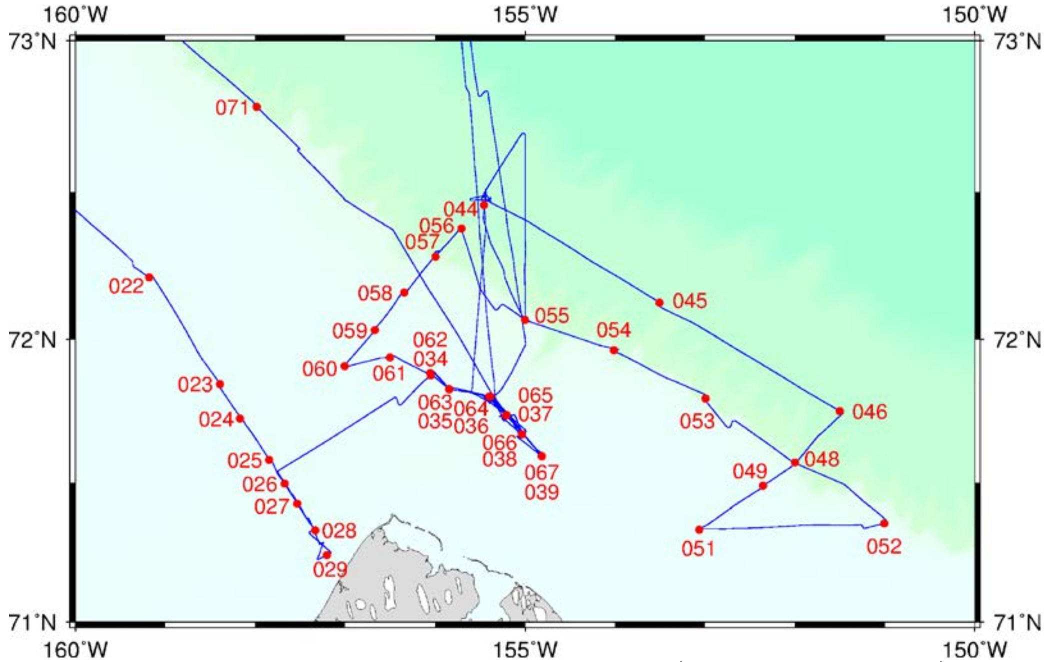

Figure 1.4-3: Cruise track and CTD stations (near the Pt. Barrow).

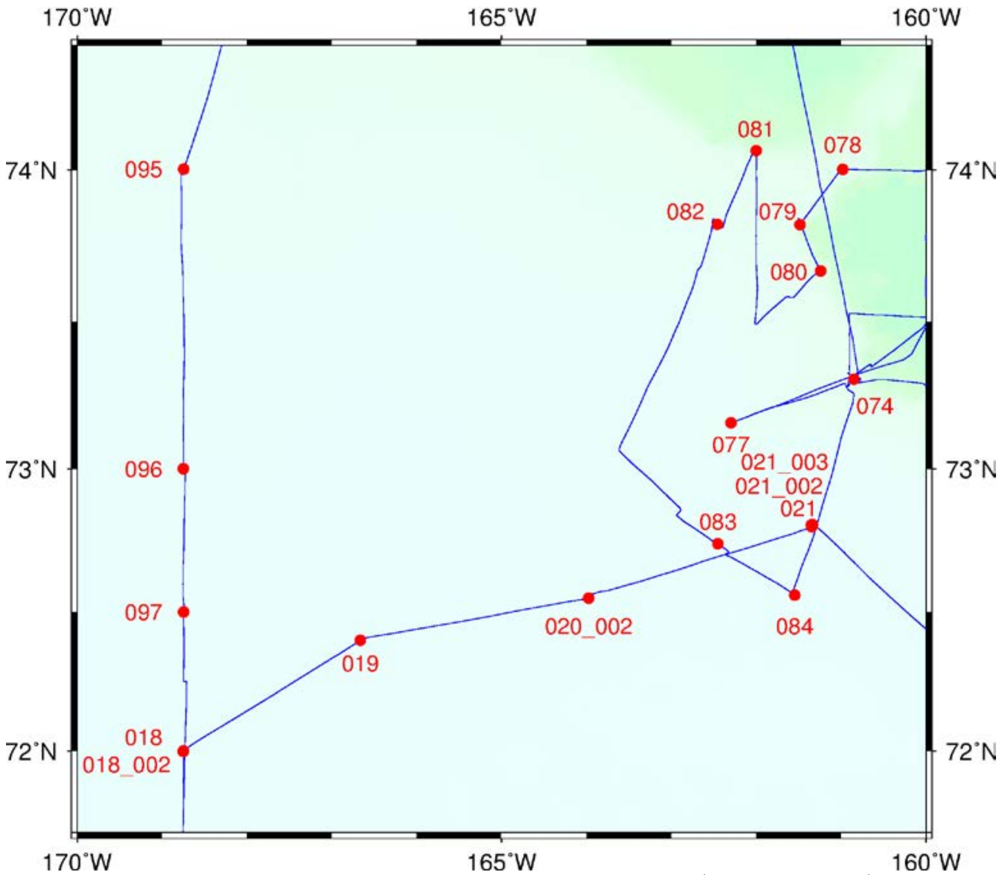

Figure 1.4-4: Cruise track and CTD stations (72°N to74°N).

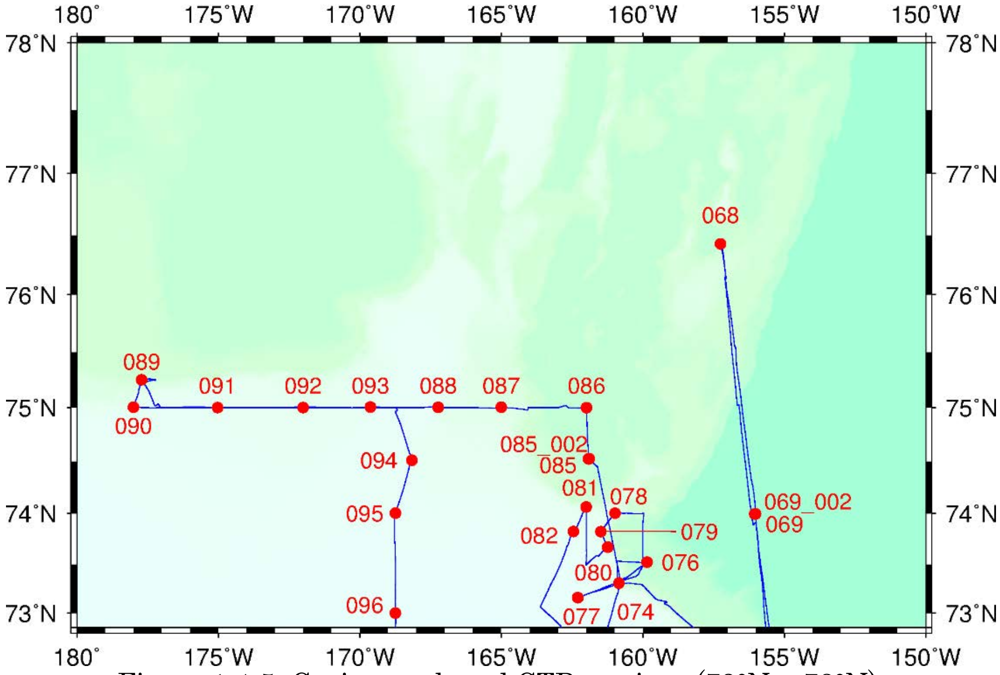

Figure 1.4-5: Cruise track and CTD stations (73°N to78°N).

1.5. List of participants

Table 1.5-1: List of participants of MR17-05C.

No.	Name	Organization	Position
1	Shigeto Nishino	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Senior Research Scientist
2	Yusuke Kawaguchi	Atmosphere and Ocean Research Institute, The University of Tokyo	Assistant Professor
3	Amane Fujiwara	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Research Scientist
4	Jonaotaro Onodera	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Senior Scientist
5	Koji Sugie	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Research Scientist
6	Takuhei Shiozaki	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Project Researcher
7	Saki Kato	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)/Fukuoka Univ.	Research Student/Graduate Student
8	Bungo Nishizawa	Graduate School of Fisheries Sciences, Hokkaido University	Post-Doctoral Researcher
9	Kazutoshi Sato	National Institute of Polar Research	Project Researcher
10	Amy Hendricks	University of Alaska, Fairbanks	Graduate Student
11	Yoshiyuki Abe	Graduate School of Fisheries Sciences, Hokkaido University	Post-Doctoral Researcher
12	Koki Tokuhiro	Graduate School of Fisheries Sciences, Hokkaido University	Graduate Student
13	Rick A. Reynolds	UCSD/SIO	Project Researcher
14	Linhai Li	UCSD/SIO	Post-Doctoral Researcher
15	Hugh S. Runyan	UCSD/SIO	Graduate Student
16	David (Duke) Snider	Martech Polar Consulting Ltd.	Ice Pilot
17	Robert Bruce Lester	NANA Management Services, LLC	Bear Watcher
18	Shinya Okumura	Nippon Marine Enterprises, Ltd.	Technical Staff

19	Kazuho Yoshida	Nippon Marine Enterprises, Ltd.	Technical Staff
21	Yutaro Murakami	Nippon Marine Enterprises, Ltd.	Technical Staff
22	Yoshiki Horiuchi	Nippon Marine Enterprises, Ltd.	Technical Staff
23	Hiroshi Matsunaga	Marine Works Japan Ltd.	Technical Staff
24	Keisuke Matsumoto	Marine Works Japan Ltd.	Technical Staff
25	Shinsuke Toyoda	Marine Works Japan Ltd.	Technical Staff
26	Hiroki Ushiromura	Marine Works Japan Ltd.	Technical Staff
27	Sonoka Tanihara	Marine Works Japan Ltd.	Technical Staff
28	Keisuke Takeda	Marine Works Japan Ltd.	Technical Staff
29	Rio Kobayashi	Marine Works Japan Ltd.	Technical Staff
30	Katsunori Sagishima	Marine Works Japan Ltd.	Technical Staff
31	Masanori Enoki	Marine Works Japan Ltd.	Technical Staff
32	Shinichiro Yokogawa	Marine Works Japan Ltd.	Technical Staff
33	Yoshiko Ishikawa	Marine Works Japan Ltd.	Technical Staff
34	Yasuhiro Arii	Marine Works Japan Ltd.	Technical Staff
35	Misato Kuwahara	Marine Works Japan Ltd.	Technical Staff
36	Masahiro Orui	Marine Works Japan Ltd.	Technical Staff
37	Nagisa Fujiki	Marine Works Japan Ltd.	Technical Staff
38	Keitaro Matsumoto	Marine Works Japan Ltd.	Technical Staff
39	Emi Deguchi	Marine Works Japan Ltd.	Technical Staff
40	Atsushi Ono	Marine Works Japan Ltd.	Technical Staff
41	Erii Irie	Marine Works Japan Ltd.	Technical Staff

42	Takeo Matsumoto	Marine Works Japan Ltd.	Technical Staff
43	Yoshiaki Sato	Marine Works Japan Ltd.	Technical Staff
44	Takehiko Shiribiki	Marine Works Japan Ltd.	Technical Staff
45	Yosuke Yonemori	Marine Works Japan Ltd.	Technical Staff

2. Meteorology
2.1. GPS Radiosonde

(1) Personnel

Jun Inoue	NIPR	- Principal Investigator, not on board
Kazutoshi Sato	NIPR	
Kazuhiro Oshima	JAMSTEC	- not on board
Amy Hendricks	Alaska Univ.	
Shinya Okumura	Nippon Marine Enterprises Ltd. (NME)	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objectives

To understand the thermodynamic structure of the boundary layer, and migratory cyclones and anticyclones, a 6-hourly radiosonde observation was conducted over the Arctic Ocean and Bering Sea from 26 August through 20 September 2017 which includes 3-hourly additional radiosonde observation over the Arctic ocean. The dataset includes 12-hourly observations over the Bering Sea and North Pacific Ocean during 21-29 September 2017. Obtained data will be used mainly for studies of clouds, validation of reanalysis data as well as satellite analysis, and data assimilation.

(3) Parameters

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

(4) Instruments and Methods

Radiosonde observations were carried out from 26 August to 29 September 2017, by using GPS radiosonde (RS41-SPG). 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 all radiosonde observations during the cruise is shown in Figure 2.1.1. Time-height section of observed air temperature and wind during the cruise are shown in Figure 2.1.2.

The former period is characterized by relatively weak wind near center of high pressure system over the Arctic ocean. During middle period, GPS radiosonde observation was primarily conducted under a strong pressure gradient along the outer rim of the cyclone.

On 13 and 17 September, we carried out radiosonde observations near the center of cyclones over the Chukchi Sea. On 17 September, we observed strong warm southwest wind in front of cyclone and precipitation.

Over the Arctic Ocean, to obtain data exceeding 20 hPa level, we used 350g balloons which is lager than that in previous cruises. Although the balloon did not reach 10 hPa level, most of balloons reached 20 hPa levels.

(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.

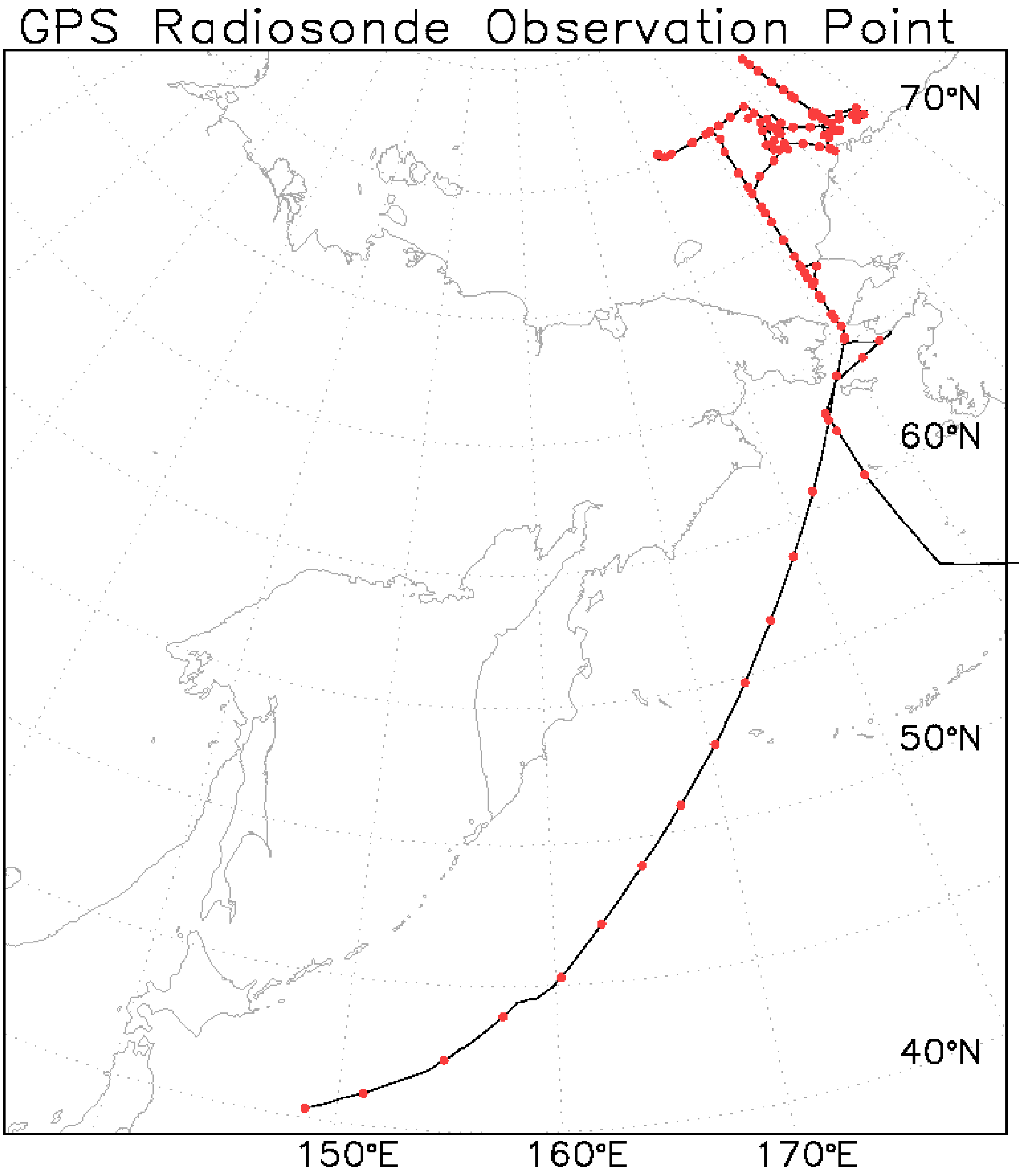

Figure 2.1-1: Sounding stations during the cruise.

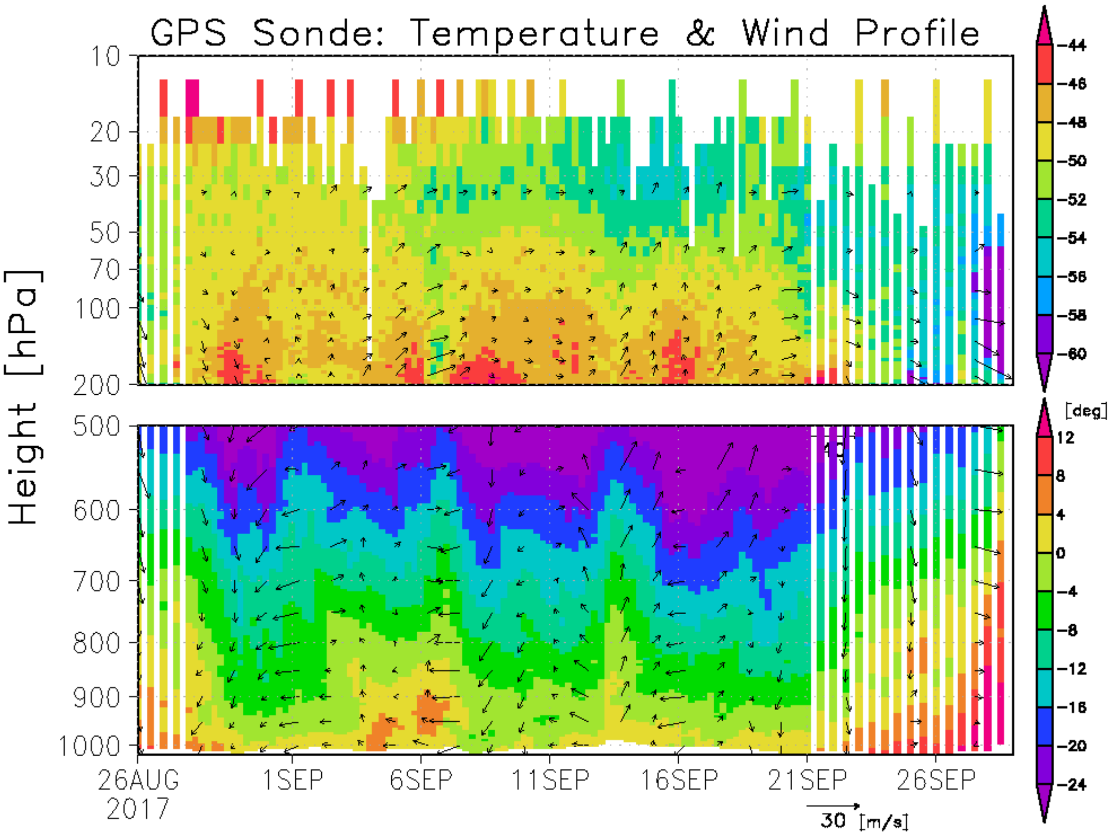

Figure 2.1-2: Time-height section of air temperature (shade) and wind (vectors).

Table 2.1-1: Launch log

ID	Date	Latitude	Longitude	P	T	RH	WD	Wsp	SST	Max height			Cloud	
	YYYYMMDDHH	degN	degE	hPa	degC	%	deg	m/s	degC	hPa	m	Duration	Amount	Type
RS001	2017082600	60.355	−173.613	1011.2	9.2	67	343	7.1	10.09	20.3	26720	6440	4	−
RS002	2017082612	62.333	−173.880	1009.6	8.6	83	359	2.8	10.18	22.0	26172	6775	−	−
RS003	2017082700	63.126	−174.010	1010.3	7.2	78	65	5.0	10.25	11.3	30692	7310	10	St
RS004	2017082712	64.185	−171.547	1009.2	5.5	88	5	11.9	7.98	16.7	28022	7212	−	−
RS005	2017082800	65.278	−169.050	1010.3	5.5	86	13	10.0	4.65	12.5	29975	7516	7	Sc
RS006	2017082806	66.114	−168.850	1011.8	6.4	75	13	9.0	6.41	13.7	29387	7053	0	−
RS007	2017082812	67.033	−168.874	1014.8	5.3	74	21	9.2	7.81	18.3	27375	7576	−	−
RS008	2017082818	67.683	−168.840	1016.0	5.0	72	40	5.4	5.65	17.5	27667	6599	9	Sc
RS009	2017082900	68.246	−168.799	1015.7	5.9	72	69	4.7	7.60	17.7	27585	7100	6	Ci, Cc,Sc
RS010	2017082906	69.002	−168.736	1015.3	5.4	84	33	6.3	8.20	15.0	28714	6605	7	Ci, Cc,Sc
RS011	2017082912	69.802	−168.759	1016.0	4.4	75	72	9.0	7.49	18.2	27391	7044	−	−
RS012	2017082918	70.641	−168.746	1016.6	3.8	61	35	5.0	6.73	15.3	28503	6547	9	Sc
RS013	2017083000	71.364	−168.765	1016.5	2.6	90	31	6.5	6.43	16.2	28151	6868	10	St
RS014	2017083006	72.001	−168.749	1015.2	1.1	86	352	5.9	6.01	18.0	27452	7689	9	Cc,Sc,St
RS015	2017083012	72.401	−166.654	1012.7	1.8	83	357	7.0	5.37	21.8	26164	6732	−	−
RS016	2017083018	72.558	−163.960	1010.7	1.1	94	25	8.9	3.75	10.6	30989	7281	10	St
RS017	2017083100	72.804	−161.349	1010.7	1.4	86	40	5.8	4.38	26.7	24823	5682	8	Ac, St
RS018	2017083106	72.316	−159.539	1010.3	0.8	85	50	9.1	3.79	16.0	28198	6471	3.5	Sc
RS019	2017083112	71.788	−158.297	1009.1	2.6	80	92	9.1	4.10	27.6	24601	6231	−	−
RS020	2017083118	71.425	−157.526	1008.2	1.6	86	57	12.8	4.52	18.6	27182	6431	10	Sc,St
RS021	2017090100	71.232	−157.304	1007.5	1.7	87	65	8.1	3.61	13.8	29170	7143	3	St
RS022	2017090106	71.768	−156.600	1007.0	2.5	86	66	9.5	4.44	13.0	29589	7800	10	St
RS023	2017090112	71.800	−155.401	1006.1	1.7	94	76	12.3	4.55	29.9	24071	6029	−	−
RS024	2017090118	71.665	−155.054	1005.0	2.4	88	80	10.0	4.50	14.6	28797	6635	10	St, Sc
RS025	2017090200	71.767	−155.281	1005.3	3.2	85	91	8.8	4.83	19.2	26972	6476	10	Sc, St
RS026	2017090206	72.468	−155.474	1006.4	2.3	89	85	8.3	4.48	33.3	23346	5644	10	St
RS027	2017090212	72.297	−155.335	1007.3	2.7	89	109	4.7	4.46	10.3	**31081**	8004	−	−
RS028	2017090218	72.523	−155.402	1008.1	2.5	89	67	5.7	4.78	30.6	23905	5854	10	St
RS029	2017090300	72.483	−155.417	1009.6	2.5	91	72	8.3	4.81	19.5	26896	6564	10	St
RS030	2017090306	72.470	−155.387	1010.5	3.1	85	109	5.2	4.94	12.2	29975	7466	9	St, Ac
RS031	2017090312	72.126	−153.523	1012.9	2.6	90	126	5.1	3.77	31.1	23820	6549	−	−
RS032	2017090318	71.751	−151.497	1014.0	4.2	95	141	4.5	4.64	26.4	24885	7078	10	St
RS033	2017090400	71.570	−152.002	1014.8	4.7	97	212	4.8	5.39	160.4	**13079**	3072	10	St
RS034	2017090406	71.420	−152.664	1013.6	4.7	95	133	5.0	4.53	35.9	22908	6102	3	ci, cc
RS035	2017090412	71.348	−151.525	1011.9	5.0	96	81	7.9	5.24	34.8	23129	5880	−	−
RS036	2017090418	71.681	−152.501	1009.7	3.8	100	85	7.8	4.43	14.3	28956	6879	10	St

RS037	2017090500	71.967	−154.015	1008.9	3.2	100	85	7.6	3.81	13.6	29312	6725	10	St
RS038	2017090506	72.075	−155.044	1008.5	2.6	100	88	6.4	4.45	16.2	28152	6952	10	Fog
RS039	2017090512	72.829	−156.002	1009.9	1.7	100	80	6.6	4.27	19.8	26829	6531	−	−
RS040	2017090518	71.975	−156.821	1010.0	2.4	100	116	7.0	4.53	14.8	28740	7088	10	St
RS041	2017090600	71.889	−156.033	1010.7	2.8	99	107	8.6	4.67	12.8	29743	6787	10	St
RS042	2017090606	71.741	−155.197	1010.4	2.7	100	109	9.7	4.67	14.2	29060	6337	10	Fog, St
RS043	2017090612	71.736	−155.197	1009.8	2.9	100	117	8.7	4.69	13.9	29170	6694	−	−
RS044	2017090618	71.734	−155.188	1008.2	2.5	100	91	7.9	4.60	11.5	30447	6823	10	St
RS045	2017090700	71.777	−155.339	1004.8	2.7	98	64	11.5	4.58	14.9	28737	6146	10	St
RS046	2017090706	72.767	−155.384	1006.1	4.5	92	74	12.9	−	14.6	28830	6486	10	St
RS047	2017090712	73.840	−155.973	1009.3	−0.5	92	67	14.7	1.87	12.4	29885	7007	−	−
RS048	2017090718	74.952	−156.572	1013.8	−0.8	91	66	12.7	0.99	15.9	28219	6174	8	Ci, St
RS049	2017090800	76.084	−157.078	1016.8	−1.9	96	89	11.3	−0.63	17.2	27704	6075	10	St
RS050	2017090806	76.438	−157.278	1017.6	−3.3	100	40	5.2	0.15	11.9	30123	7148	10	Fog
RS051	2017090812	75.655	−156.808	1016.2	−2.4	99	46	5.8	1.04	11.7	30180	7698	−	−
RS052	2017090818	74.401	−156.208	1014.8	−1.8	97	24	4.6	1.298	13.6	29222	6395	10	St
RS053	2017090900	73.998	−156.065	1013.2	0.3	92	348	6.8	1.328	15.5	28332	6395	10	Ac
RS054	2017090906	74.001	−156.097	1011.7	0.6	91	340	9.5	1.095	20.5	26499	6070	10	St
RS055	2017090912	72.926	−155.684	1010.9	0.4	94	1	6.1	3.290	13.3	29336	6771	−	−
RS056	2017090918	71.784	−155.349	1010.2	1.5	86	351	4.9	4.584	14.3	28856	7137	10	St
RS057	2017091000	71.798	−155.340	1009.9	2.5	89	356	6.3	4.525	15.6	28266	6176	10	St
RS058	2017091006	71.796	−155.329	1009.9	2.1	87	33	6.4	4.662	13.7	29114	6342	10	St, St
RS059	2017091012	72.588	−157.368	1010.6	−0.4	95	53	5.2	2.825	13.8	29034	7115	−	−
RS060	2017091018	73.062	−159.027	1010.0	−0.3	93	45	6.0	3.611	19.5	26756	5636	10	St
RS061	2017091100	73.318	−160.892	1009.4	0.4	87	43	1.9	3.200	14.9	28489	6018	10	St
RS062	2017091106	73.521	−159.860	1008.1	0.3	87	87	4.9	2.433	18.2	27188	6119	10	St
RS063	2017091112	73.164	−162.239	1006.3	2.0	85	96	5.7	3.380	12.9	29404	7217	−	−
RS064	2017091118	73.286	−161.017	1005.5	2.1	91	109	7.2	3.730	16.8	27664	5974	10	Sc,St
RS065	2017091200	73.319	−160.850	1005.7	2.6	92	115	8.8	2.920	16.1	27938	6278	10	St
RS066	2017091206	74.001	−160.997	1005.9	1.5	97	104	9.2	1.850	16.5	27758	6949	10	St
RS067	2017091212	73.687	−161.275	1004.4	2.1	95	98	10.9	2.810	18.0	27189	6634	−	−
RS068	2017091218	74.070	−162.005	1001.7	1.2	98	87	13.5	2.120	25.9	24824	5814	10	St
RS069	2017091300	73.765	−162.566	997.9	2.3	93	91	12.5	3.340	15.4	28200	6025	10	St
RS070	2017091303	73.237	−163.343	992.5	2.8	94	82	16.5	3.164	22.3	25814	5671	10	St
RS071	2017091306	72.892	−162.997	989.5	4.0	96	100	11.2	4.540	21.8	25936	5933	10	St
RS072	2017091309	72.737	−162.436	988.9	4.7	99	182	7.0	5.100	33.3	23199	5880	−	−
RS073	2017091312	72.558	−161.538	990.2	3.8	99	168	8.9	4.520	15.1	28303	7270	−	−
RS074	2017091318	73.218	−160.873	991.1	3.5	100	183	7.5	2.140	10.7	30562	7599	10	St
RS075	2017091400	73.462	−160.881	993.9	3.5	89	209	8.0	3.410	17.8	27242	6222	8	St
RS076	2017091406	74.523	−162.920	994.8	2.3	100	204	6.5	1.730	34.7	22943	5453	9	St
RS077	2017091412	74.522	−161.876	998.4	2.3	97	211	4.2	1.680	28.2	24268	5282	−	−

RS078	2017091418	74.997	−162.337	1000.7	2.0	96	221	2.7	1.680	27.3	24463	5863	10	St
RS079	2017091500	75.008	−164.983	1003.5	2.6	94	193	3.8	2.530	18.4	27000	6700	8	St
RS080	2017091506	75.009	−167.214	1004.0	2.2	94	161	6.2	1.980	14.9	28298	7451	0	−
RS081	2017091512	75.000	−172.006	1004.0	1.4	98	111	5.5	0.790	24.4	25141	6219	−	−
RS082	2017091518	75.000	−176.945	1003.1	−0.1	99	78	5.9	−1.060	10.9	30378	7130	10	St
RS083	2017091600	75.255	−177.598	1003.7	−0.2	97	51	9.8	−1.150	14.3	28589	6453	10	St
RS084	2017091606	75.218	−177.747	1002.2	−0.8	100	51	9.3	−1.300	27.2	24437	6267	10	St
RS085	2017091612	75.008	−175.825	1003.1	−1.1	100	109	7.7	−0.180	55.0	19899	4636	−	−
RS086	2017091618	75.007	−172.140	1003.4	1.4	97	102	7.9	0.580	22.1	25775	6237	5	Ac
RS087	2017091700	75.008	−169.618	1004.6	0.8	99	117	13.6	2.630	23.0	25509	6313	10	St
RS088	2017091703	75.002	−168.899	1004.4	0.4	98	114	12.6	2.420	14.7	28411	6672	10	St
RS089	2017091706	74.528	−168.183	1003.5	1.0	99	136	12.1	2.200	22.4	25723	5784	10	St
RS090	2017091712	73.998	−168.753	1005.1	0.2	90	233	7.1	2.480	15.0	28280	6829	−	−
RS091	2017091718	72.999	−168.748	1007.2	0.8	80	298	2.7	3.520	20.2	26375	6630	6	Sc
RS092	2017091800	72.308	−168.744	1008.8	1.7	79	328	1.2	5.800	16.2	27839	6437	8	St
RS093	2017091806	71.087	−168.778	1008.6	2.1	83	18	6.5	5.530	60.8	19267	5126	−	−
RS094	2017091812	69.782	−168.760	1008.1	3.0	75	348	10.1	6.590	13.6	28996	7712	−	−
RS095	2017091818	68.590	−168.822	1008.5	3.6	69	342	10.8	6.100	14.7	28512	6843	9	Sc
RS096	2017091900	68.034	−168.878	1010.7	2.5	76	306	5.1	4.290	16.5	27790	6567	9	Sc
RS097	2017091906	68.573	−168.835	1011.8	2.9	73	324	5.9	6.080	18.0	27181	6229	0	−
RS098	2017091912	68.522	−168.838	1013.6	1.8	81	294	2.1	5.940	35.2	22812	5167	−	−
RS099	2017091918	68.200	−167.338	1014.3	3.7	72	19	8.1	6.770	15.1	28316	6816	7	Ci,Sc
RS100	2017092000	67.749	−168.502	1016.3	3.6	72	3	7.6	4.050	13.9	28883	7017	3	Ac,Sc
RS101	2017092006	67.202	−168.894	1018.4	3.5	73	4	9.3	4.900	15.5	28168	6614	2	Sc
RS102	2017092012	66.309	−168.883	1019.5	4.2	64	3	11.0	5.760	12.4	29656	7009	−	−
RS103	2017092018	65.726	−168.720	1019.9	4.1	70	353	9.2	6.400	25.7	24940	5951	8	Sc
RS104	2017092100	65.225	−169.189	1020.9	2.9	84	354	13.7	3.680	18.7	27010	6364	9	Sc,St
RS105	2017092112	64.410	−166.589	1015.4	4.6	79	0	12.1	5.900	35.1	23007	5440	−	−
RS106	2017092200	64.244	−168.709	1014.1	4.5	82	340	12.7	6.710	19.9	26653	5818	10	Sc
RS107	2017092212	62.850	−174.043	1015.9	5.9	62	354	4.7	8.190	27.3	24621	6417	−	−
RS108	2017092300	60.674	−177.789	1016.1	8.5	76	330	5.5	9.170	13.3	29289	6935	3	Sc
RS109	2017092312	58.677	178.954	1016.5	8.9	82	295	10.0	9.800	30.2	23962	5746	−	−
RS110	2017092400	56.717	175.913	1017.5	8.5	78	278	7.0	10.230	13.7	29092	6476	−	−
RS111	2017092412	54.770	173.080	1018.8	10.0	79	293	6.9	10.920	40.7	22017	5751	−	−
RS112	2017092500	52.835	170.346	1021.1	10.8	88	260	5.8	11.130	14.7	28624	6609	10	
RS113	2017092512	50.918	167.644	1023.2	10.5	94	246	7.0	11.260	48.1	20950	5377	−	−
RS114	2017092600	48.970	164.987	1024.4	10.0	84	145	6.5	10.680	12.0	29958	7110	10	Cb
RS115	2017092612	47.067	162.506	1020.9	11.1	83	127	7.5	11.850	20.6	26440	6622	−	−
RS116	2017092700	45.286	160.266	1015.4	12.8	90	141	12.6	12.540	18.8	27028	5944	10	Ac
RS117	2017092712	43.973	157.396	1014.1	11.6	96	193	2.8	12.950	19.9	26681	5228	−	−
RS118	2017092800	42.422	154.659	1012.0	18.2	64	193	7.7	19.150	13.3	29359	6639	10	Ac

RS119	2017092812	41.079	151.123	1000.2	18.9	87	162	19.1	15.990	42.1	21896	5515	–	–
RS120	2017092900	40.327	148.639	1008.0	14.9	65	1	10.6	20.860	15.3	28429	6166	0	–

2.2. C-band Weather Radar

(1) Personnel

Jun Inoue	NIPR	- Principal Investigator, not on board
Kazutoshi Sato	NIPR	
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objectives

Low level clouds over the Arctic Ocean which usually dominate during summer have a key role for sea/ice surface heat budget. In addition, cyclones which modify the sea-ice distributions are substantially important to understand the air-ice-sea interaction. To capture the broad cloud-precipitation systems and their temporal and spatial evolution 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

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

Radar variables, which are converted from the power and phase of the backscattered signal at vertically and horizontally-polarized channels, are as follows:

Radar reflectivity:	Z
Doppler velocity:	Vr
Spectrum width of Doppler velocity:	SW
Differential reflectivity:	ZDR
Differential propagation phase:	ΦDP
Specific differential phase:	KDP
Co-polar correlation coefficients:	ρHV

(4) Instruments and methods

The C-band Weather radar on board R/V Mirai is used. The basic specification of the radar is as follows:

Frequency:	5370 MHz (C-band)
Polarimetry:	Horizontal and Vertical (simultaneously transmitted and received)
Transmitter:	Solid-state transmitter (with pulse compression technique)
Output Power:	6 kW (H) + 6 kW (V)
Antenna Diameter:	4 meters
Beam Width:	1.0 degrees
INU (Inertial Navigation Unit):	PHINS (IXBLUE S.A.S.)

The antenna is controlled to point the commanded ground-relative direction, by controlling the azimuth and elevation to cancel the ship attitude (roll, pitch and yaw) detected by the INU. The Doppler velocity is also corrected by subtracting the ship motion in beam direction.

As the maintenance, internal parameters of the radar are checked at the beginning and the end of the cruise. Meanwhile, the following parameters are checked daily; (1) frequency, (2) peak output power, (3) pulse width, and (4) PRF (pulse repetition frequency).

During the cruise, the radar was operated typically by repeating a volume scan with 17 PPIs (Plan Position Indicators) every 6-minute. A dual PRF mode with the maximum range of typically 100 km is used for the volume scan. A surveillance PPI scan is performed every 30 minutes in a single PRF mode with the maximum range of 300 km. RHI (Range Height Indicator) scans are operated whenever detailed vertical structures are necessary in certain azimuth directions. Vertical Point scans are performed due to collecting data for ZDR calibration. During this cruise, the scan strategy is kept same, as in Table 2.2-1, to provide the same data quality to highlight the temporal variation of the precipitating systems.

(5) Observation log

The radar was operated continuously from 16:59UTC 24 Aug. 2017 to 06:00UTC 29 Sep. 2017.

(6) Preliminary results

Figure 2.2-1, 2.2-2 and 2.2-3 show the PPI image, NOAA satellite image, and weather condition, i.e. SLP, wind and SAT fields, from JMA GPV for precipitating events. During the cruise, several precipitation systems passed near the R/V MIRAI. The C-band weather radar captured strong precipitation systems during MR17-05. The precipitation system was observed around Barrow during September 1 (Figure 2.2-1). The radar captured the cyclone center during September 13 (Figure 2.2-2). Moreover, the rainfall associated with cyclone was observed during September 16-17 (Figure 2.2-3). The further detailed analyses will be performed after the cruise.

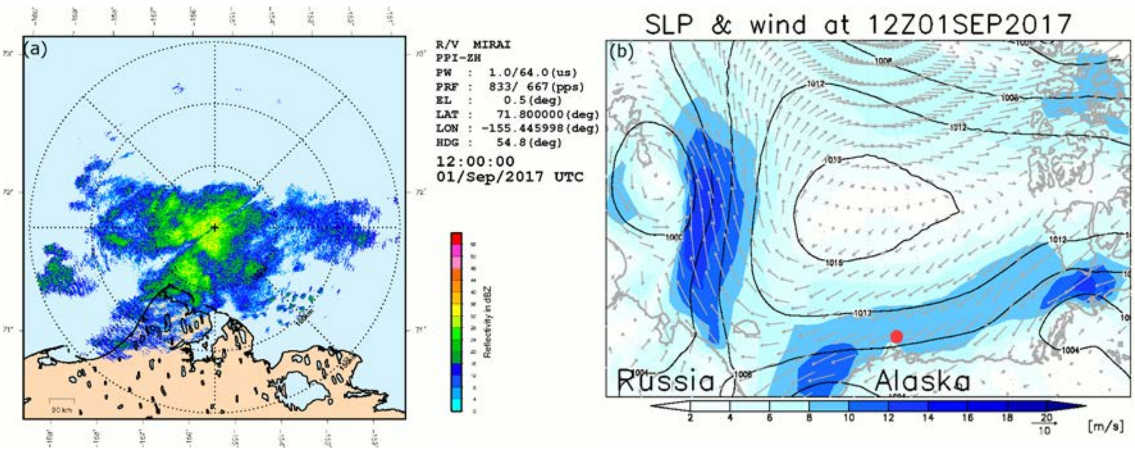

Figure 2.2-1: (a) PPI image obtained by the first volume scan at elevation angle of 0.5 degree, (b) sea level pressure (SLP, contour), wind (vector and shade) fields from JMA GPV on September 01.

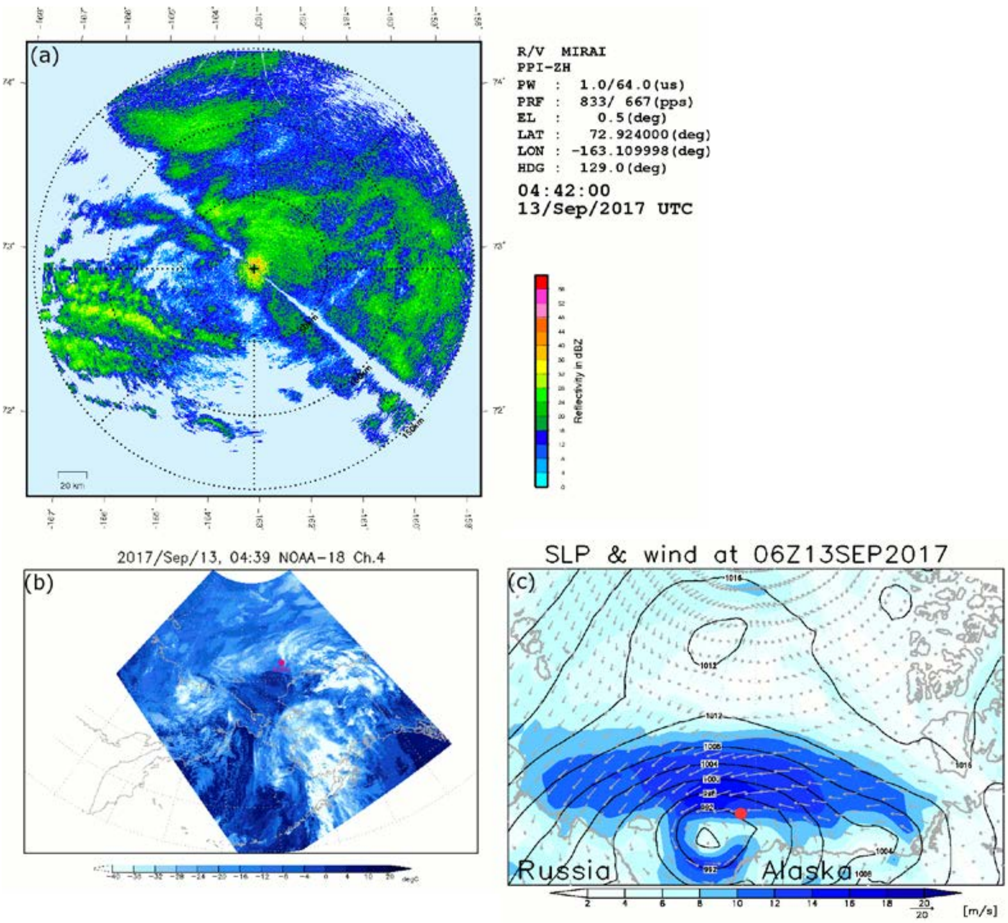

Figure 2.2-2: (a) PPI image obtained by the first volume scan at elevation angle of 0.5 degree, (b) NOAA satellite image, (c) sea level pressure (SLP, contour), wind (vector and shade) fields from JMA GPV on 13 September.

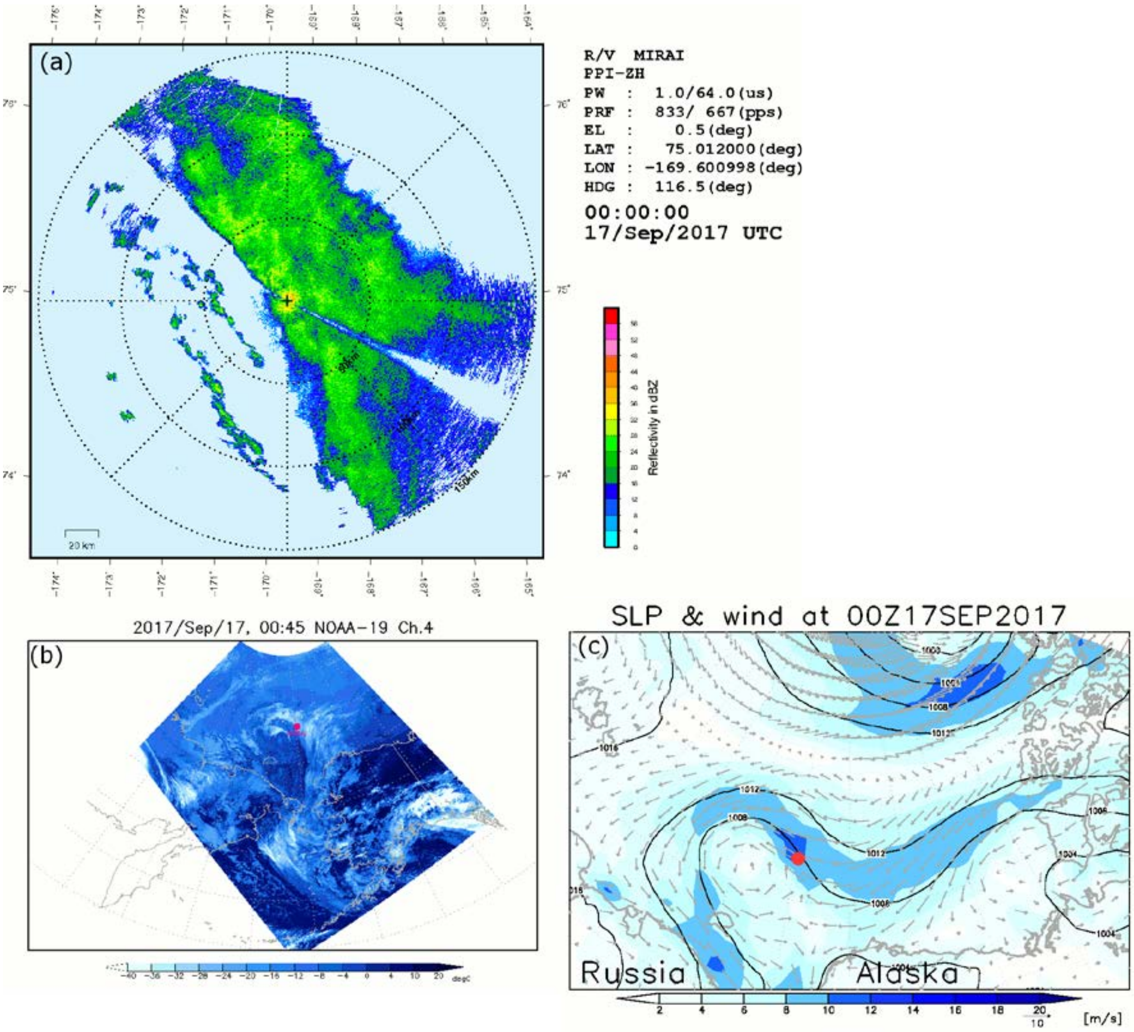

Figure 2.2-3: Same as in Figure 2.2-2, but for September 17.

(7) Data archive

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(8) Remarks (Times in UTC)

i) The following period, data acquisition was suspended due to approach the port of Nome.

11:58 21 Sep. 2017 – 19:48 21 Sep. 2017

Table 2.2-1: Parameters for scan strategy in the Arctic Ocean.

<table>
<tr><th></th><th>Surveillance PPI Scan</th><th colspan="6">Volume Scan</th><th>RHI Scan</th><th>Vertical Point Scan</th></tr>
<tr><td>Repeated Cycle (min.)</td><td>30</td><td colspan="6">6</td><td colspan="2">12</td></tr>
<tr><td>Times in One Cycle</td><td>1</td><td colspan="6">1</td><td>3</td><td>3</td></tr>
<tr><td>Pulse Width (long / short, in microsec)</td><td>200 / 2</td><td colspan="2">64 / 1</td><td colspan="2">32 / 1</td><td colspan="2">32 / 1</td><td>32 / 1</td><td>32/1</td></tr>
<tr><td>Scan Speed (deg/sec)</td><td>18</td><td colspan="2">18</td><td colspan="2">24</td><td colspan="2">36</td><td>9 (in el.)</td><td>36</td></tr>
<tr><td rowspan="2">PRF(s) (Hz)</td><td rowspan="2">400</td><td colspan="6">dual PRF (ray alternative)</td><td rowspan="2">1250</td><td rowspan="2">2000</td></tr>
<tr><td>667</td><td>833</td><td>938</td><td>1250</td><td>1333</td><td>2000</td></tr>
<tr><td>Pulses / Ray</td><td>16</td><td>26</td><td>33</td><td>27</td><td>34</td><td>37</td><td>55</td><td>32</td><td>64</td></tr>
<tr><td>Ray Spacing (deg.)</td><td>0.7</td><td colspan="2">0.7</td><td colspan="2">0.7</td><td colspan="2">1.0</td><td>0.23</td><td>1.0</td></tr>
<tr><td>Azimuth</td><td colspan="7">Full Circle</td><td>Optional</td><td>Full Circle</td></tr>
<tr><td>Bin Spacing (m)</td><td colspan="9">150</td></tr>
<tr><td>Max. Range (km)</td><td>300</td><td colspan="2">150</td><td colspan="2">100</td><td colspan="2">60</td><td>100</td><td>60</td></tr>
<tr><td>Elevation Angle(s) (deg.)</td><td>0.5</td><td colspan="2">0.5</td><td colspan="2">1.0, 1.7, 2.4, 3.1, 3.8, 4.6, 5.5, 6.5, 7.6, 8.9</td><td colspan="2">10.4, 12.0, 13.8, 16.0, 18.3, 21.0</td><td>0.0 to 60.0</td><td>90</td></tr>
</table>

2.3. Surface Meteorological Observations

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objectives

Surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters provide the temporal variation of the meteorological condition surrounding the ship.

(3) Instruments and methods

Surface meteorological parameters were observed during this cruise. In this cruise, we used two systems for the observation.

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) measurement system

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

a) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
b) Analog meteorological data sampling with CR1000 logger manufactured by Campbell Scientific Inc. Canada – wind pressure, and rainfall (by a capacitive rain gauge) measurement.
c) Digital meteorological data sampling from individual sensors - air temperature, relative humidity and rainfall (by optical rain gauge (ORG)) measurement.
d) Photosynthetically Available Radiation (PAR) sensor manufactured by Biospherical Instruments Inc. (USA) - PAR measurement.
e) 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, air temperature, relative humidity, CR1000 and ORG data. SCS composed Event data (JamMet) from these data and ship's navigation data every 6 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, PTB220, VAISALA

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

Comparison with the portable thermometer value, HM70, VAISALA

(4) Observation log

24 Aug. 2017 to Oct. 01 2017

(5) Preliminary results

Figure. 2.3-1 shows 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)

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(7) Remarks (Times in UTC)

ii) The following periods, Sea surface temperature of SMet data was available.
16:00, 24 Aug. 2017- 04: 00, 29 Sep. 2017

iii) The following time, increasing of SMet capacitive rain gauge data were invalid due to test transmitting for MF/HF radio.
20:40, 22 Sep. 2017

iv) The following periods, PRP data acquisition was suspended due to maintenance.
03:11 24 Aug. 2017 - 03:56 24Aug. 2017
20:20 20 Sep. 2017 - 20:29 20 Sep. 2017

v) The following period, FRSR data acquisition was suspended to prevent damage to the shadow-band from freezing.
08:23 24 Aug. 2017 - 20:28 22 Sep. 2017

vi) The following period, the amount of short wave radiation(PSP) contains 30-40[W/m^2] bias in the night time.
07:00 08 Sep. 2017 - 20:20 22 Sep. 2017

Table 2.3-1: Instruments and installation locations of SMet system

Sensors	Type	Manufacturer	Location(altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard and port side
Thermometer: SST	RFN2-0	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	Eko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	Eko Seiki, Japan	radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	bow (10 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, TOKYO-KEIKI, TG-8000
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 (port 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 (Meteorological)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Barometer	PTB210	Vaisala, Finland	foremast (23 m)
with 61002 Gill pressure port, R.M. Young, USA			
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	foremast (23 m)
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Optical rain gauge	ORG-815DR	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)

Sensors (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 (JamMet)

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	
15 PAR	microE/cm2/sec	

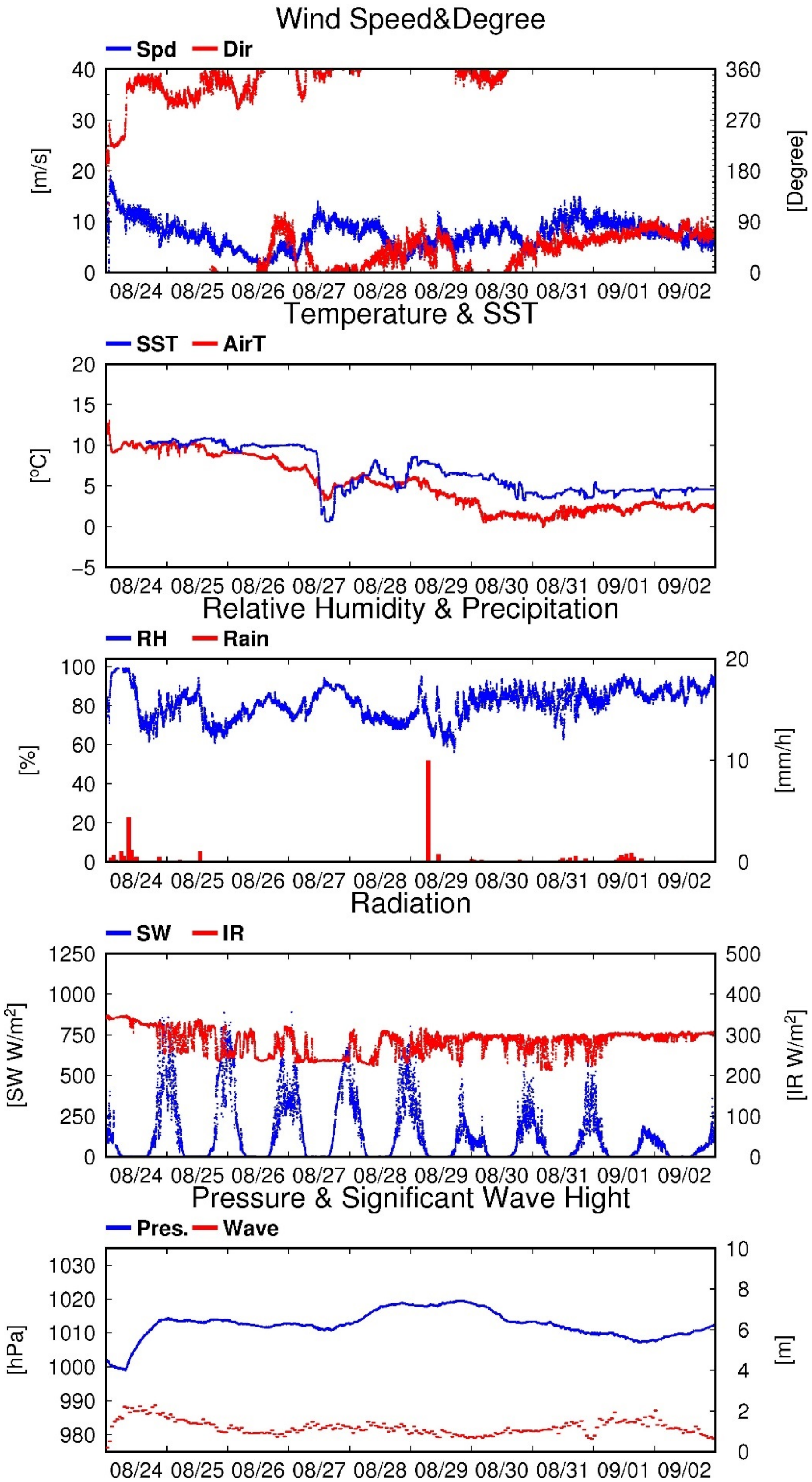

Figure 2.3-1: Time series of surface meteorological parameters during this cruise

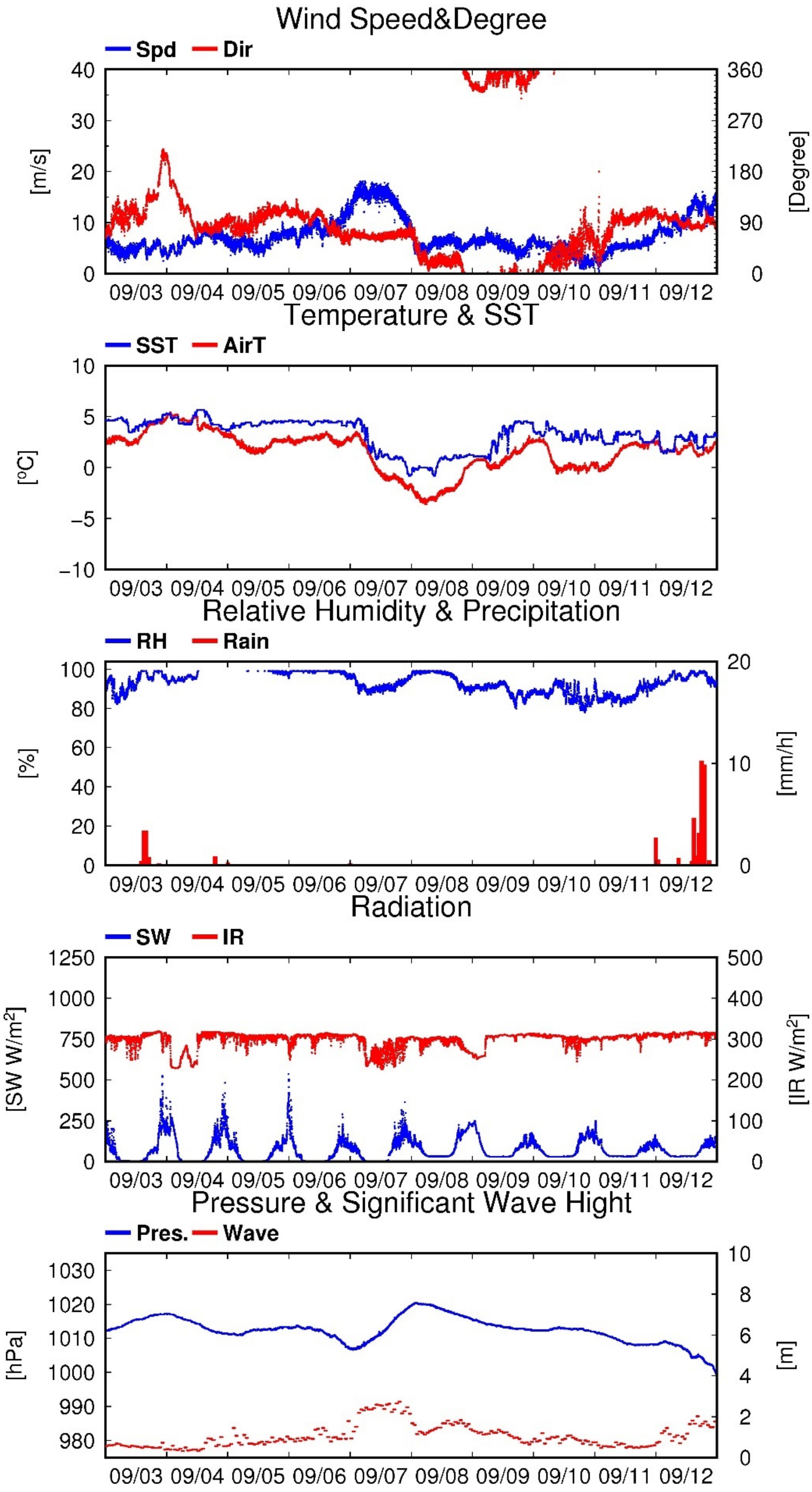

Figure 2.3-1: (Continued)

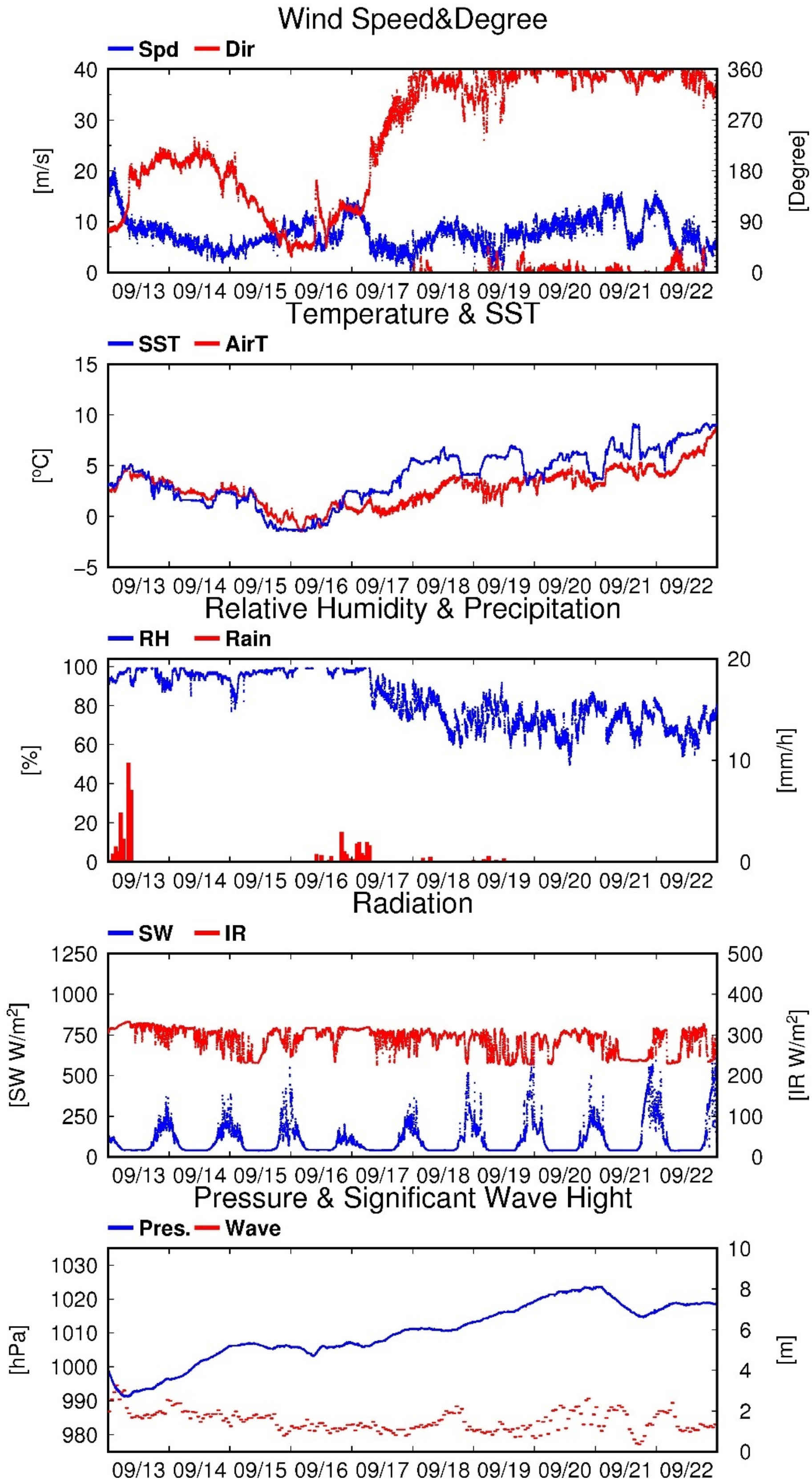

Figure 2.3-1: (Continued)

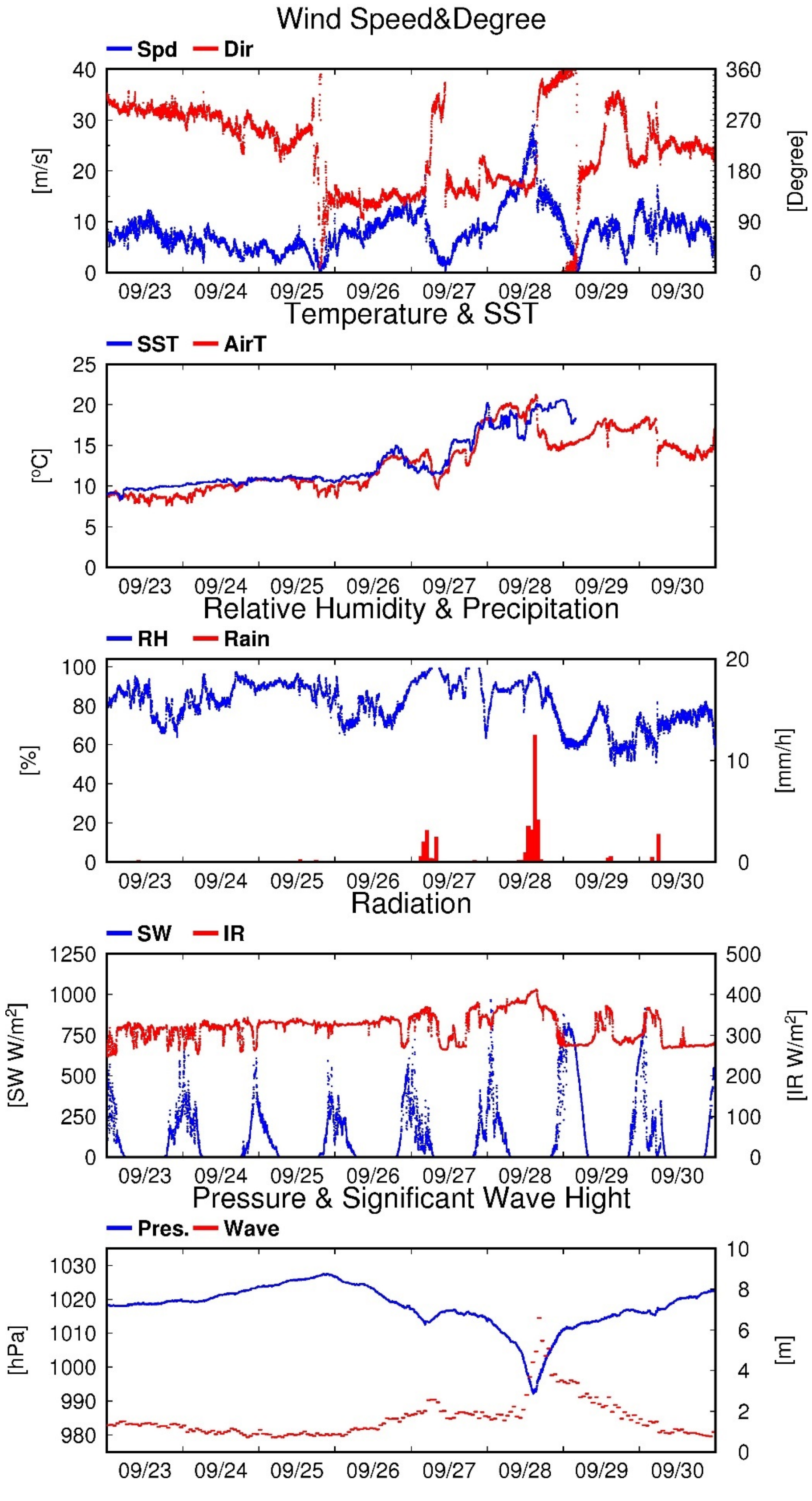

Figure 2.3-1: (Continued)

2.4. Ceilometer

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objectives

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

(3) 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 this 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) Observation period

24 Aug. 2017 - Oct. 01 2017

(6) Preliminary results

Figure 2.4-1 shows the time series of cloud-base heights derived from the ceilometer during this cruise.

(7) Data archives

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

<http://www.godac.jamstec.go.jp/darwin/e>

(8) Remarks (Times in UTC)

Window cleaning

18:09UTC 26 Aug. 2017
02:18UTC 09 Sep. 2017
04:01UTC 20 Sep. 2017
23:05UTC 29 Sep. 2017

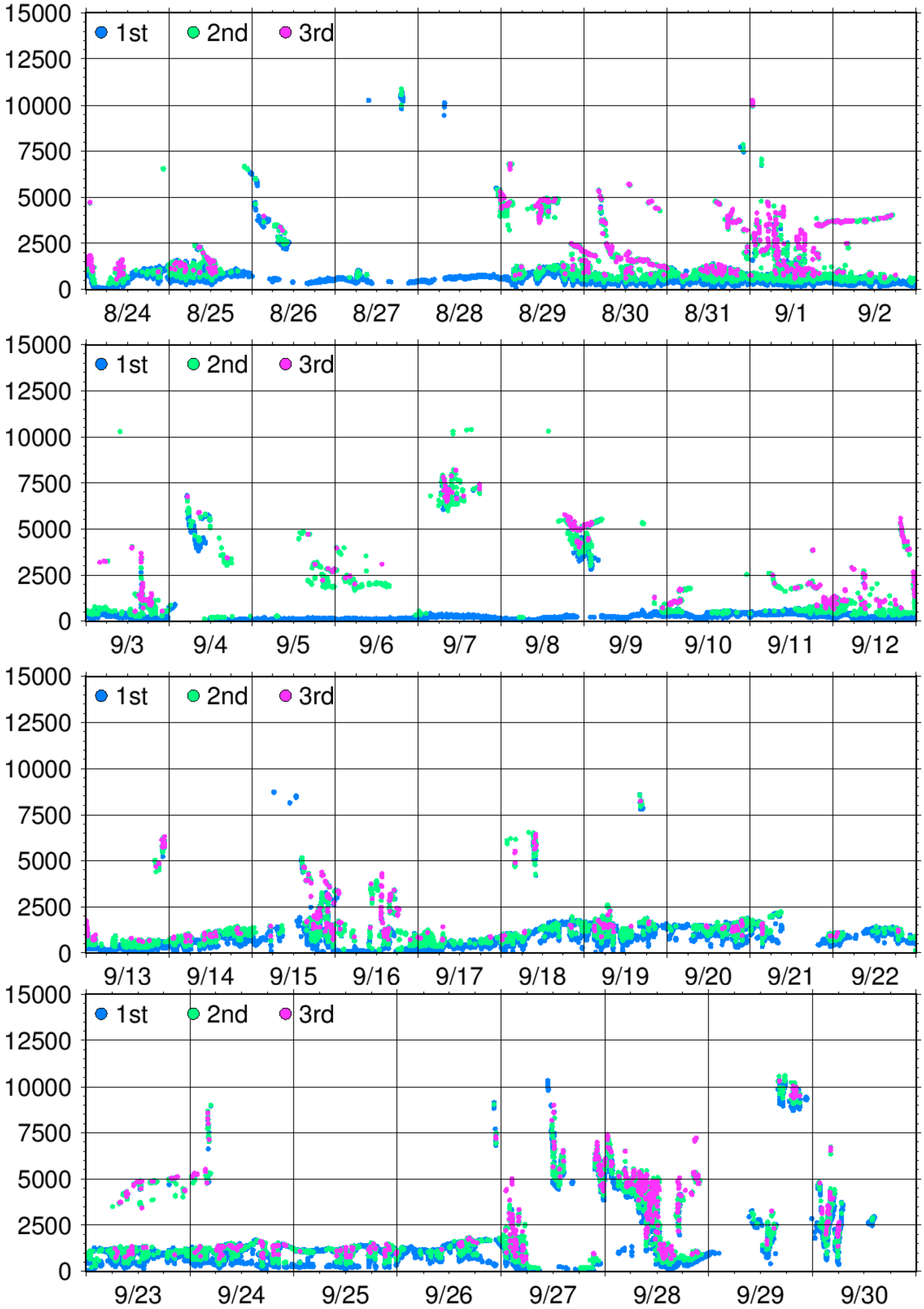

Figure 2.4-1: Time series of cloud base height during this cruise

2.5. Tropospheric gas and particles observation in the Arctic Marine Atmosphere

(1) Personnel

Fumikazu Taketani	JAMSTEC	- Principal Investigator, not on board
Saki Kato	JAMSTEC/Fukuoka Univ.	- on board
Yugo Kanaya	JAMSTEC	- not on board
Takuma Miyakawa	JAMSTEC	- not on board
Hisahiro Takashima	JAMSTEC/Fukuoka Univ.	- not on board
Yutaka Tobo	NIPR	- not on board
Masayuki Takigawa	JAMSTEC	- not on board
Kazuyuki Miyazaki	JAMSTEC	- not on board
Kazuhiro Oshima	JAMSTEC	- not on board
Kazuyo Yamaji	JAMSTEC/Kobe Univ.	- not on board

(2) Objectives

・To investigate roles of aerosols in the marine atmosphere in relation to climate change
・To investigate processes of biogeochemical cycles between the atmosphere and the ocean.
・To investigate contribution of suspended particles to the rain, and snow

(3) Parameters

・Black carbon(BC) and fluorescent particles
・Particle number concentration and size distribution
・Composition of ambient particles
・Composition of snow and rain
・Aerosol extinction coefficient (AEC)
・Surface ozone(O3), and carbon monoxide(CO) mixing ratios

(4) Instruments and methods

(4.1) Online aerosol observations:

(4.1.1) Particle number concentration and size distribution

The number concentration and size distribution of ambient particles was measured by a handheld optical particle counter (OPC) (KR-12A, Rion).

(4.1.2) Black carbon (BC)

Number and mass BC concentrations were measured by an instrument based on laser-induced incandescence, single particle soot photometer (SP2) (model D, Droplet Measurement Technologies). The laser-induced incandescence technique based on intracavity Nd:YVO4 laser operating at 1064 nm were used for detection of single particles of BC.

(4.1.3) Fluorescent property

Fluorescent properties of aerosol particles were measured by a single particle fluorescence sensor, Waveband Integrated bioaerosol sensor (WIBS4) (WIBS-4A, Droplet Measurement Technologies). Two pulsed xenon lamps emitting UV light (280 nm and 370 nm) were used for excitation. Fluorescence emitted from a single particle within 310–400 nm and 420–650 nm wavelength windows was recorded.

For SP2 instrument, the ambient air was commonly sampled from the compass deck by a 3-m-long conductive tube through the dryer to dry up the particles, and then introduced to each instrument installed at the environmental research room. WIBS4 and OPC instruments were installed at the compass deck. The ambient air was directly introduced to the instruments.

(4.2) Ambient air sampling

Ambient air samplings were carried out by air samplers installed at compass deck. Ambient particles were collected on the polycarbonate (ϕ =54mm) filter and nuclepore membrane filter (ϕ =47mm) along cruise track to analyze their composition and ice nuclei ability using NANO sampler (model 3182, Kanomax) and a handmade air sampler operated at flow rate of 40 L/min and 10L/min, respectively. To avoid collecting particles emitted from the funnel of the own vessel, the sampling period was controlled automatically by using a "wind-direction selection system". Particles whose size in the 2.5-10, 1.0-2.5, and 0.5-1.0 μm were collected on each polycarbonate filter, while all size particles were collected on nuclepore membrane filter. These sampling logs are listed in Tables 2.5-1 and 2.5-2. All samples are going to be analyzed in laboratory.

(4.3) Snow and rain sampling

Snow and rain samples were corrected using a hand-made sampler. These sampling logs are listed in Tables 2.5-3. To investigate the interaction from aerosols to rain/snow, these samples are going to be analyzed in laboratory.

(4.4) 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 optical fiber cable. The telescope unit was updated before the cruise; only one-axis scan for elevation angle was attained, while capability of azimuth scan was not employed. The line of sight was in the directions of the portside of the vessel and the scanned elevation angles were 1.5, 3, 5, 10, 20, 30, 90 degrees in the 30-min cycle. The roll motion of the ship was measured to autonomously compensate additional motion of the prism, employed for scanning the elevation angle. 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.

(4.5) CO and O_3

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 48, Thermo Fisher Scientific) and a UV photometric ozone analyzer (Model 49C, Thermo Fisher Scientific), located in the Research Information Center. The data will be used for characterizing air mass origins.

(5) Observation logs

Table 2.5-1: Logs of ambient particles sampling on the polycarbonate filter

On board ID	Date Collected					Latitude			Longitude		
	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W
MR1705C-IN-001	2017	08	22	21:16	UTC	53	54.4500	N	166	30.6000	W
MR1705C-IN-002	2017	08	23	18:39	UTC	53	54.4500	N	166	30.6000	W
MR1705C-IN-003	2017	08	25	19:28	UTC	59	40.4700	N	173	23.1800	W
MR1705C-IN-004	2017	08	27	20:57	UTC	65	4.4259	N	169	33.1536	W
MR1705C-IN-005	2017	08	29	20:04	UTC	71	0.0257	N	168	46.0735	W
MR1705C-IN-006	2017	08	31	20:48	UTC	71	14.9376	N	157	09.2737	W
MR1705C-IN-007	2017	09	02	20:22	UTC	72	28.6449	N	155	23.6744	W
MR1705C-IN-008	2017	09	04	22:55	UTC	71	57.9740	N	154	00.8281	W
MR1705C-IN-009	2017	09	06	19:53	UTC	71	44.2143	N	155	07.2664	W
MR1705C-IN-010	2017	09	08	20:32	UTC	73	59.8604	N	156	02.2233	W
MR1705C-IN-011	2017	09	10	20:12	UTC	73	17.6677	N	160	07.7550	W
MR1705C-IN-012	2017	09	12	21:07	UTC	73	49.7462	N	162	28.2942	W
MR1705C-IN-013	2017	09	14	20:15	UTC	74	59.8757	N	164	45.2127	W
MR1705C-IN-014	2017	09	16	20:39	UTC	74	59.9616	N	170	44.0867	W
MR1705C-IN-015	2017	09	18	21:25	UTC	68	02.0371	N	168	50.6548	W
MR1705C-IN-016	2017	09	20	22:19	UTC	65	16.2496	N	169	02.3723	W
MR1705C-IN-017	2017	09	22	21:46	UTC	60	54.0286	N	177	23.6825	W
MR1705C-IN-018	2017	09	24	22:39	UTC	52	54.1106	N	170	26.4041	W
MR1705C-IN-019	2017	09	29	1:06	UTC	40	12.4027	N	148	16.8790	W

Table 2.5-2: Logs of ambient particles sampling on the nuclepore membrane filter

On board ID	Date Collected					Latitude			Longitude		
	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W
MR1705C-NANO-001	2017	08	22	21:16	UTC	53	54.4500	N	166	30.6000	W
MR1705C-NANO-002	2017	08	23	18:39	UTC	53	54.4500	N	166	30.6000	W
MR1705C-NANO-003	2017	08	27	20:57	UTC	65	4.4259	N	169	33.1536	W
MR1705C-NANO-004	2017	08	31	20:48	UTC	71	14.9376	N	157	09.2737	W
MR1705C-NANO-005	2017	09	04	22:55	UTC	71	57.9740	N	154	00.8281	W
MR1705C-NANO-006	2017	09	08	20:32	UTC	73	59.8604	N	156	02.2233	W
MR1705C-NANO-007	2017	09	12	21:07	UTC	73	49.7462	N	162	28.2942	W
MR1705C-NANO-008	2017	09	16	20:39	UTC	74	59.9616	N	170	44.0867	W
MR1705C-NANO-009	2017	09	20	22:19	UTC	65	16.2496	N	169	02.3723	W
MR1705C-NANO-010	2017	09	22	21:46	UTC	60	54.0286	N	177	23.6825	W
MR1705C-NANO-011	2017	09	24	22:39	UTC	52	54.1106	N	170	26.4041	W
MR1705C-NANO-012	2017	09	29	1:06	UTC	40	12.4027	N	148	16.8790	W

Table 2.5-3: List of snow and rain sampling.

On board ID	Date Collected					Latitude			Longitude		
	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W
MR1705C-R-001	2017	09	01	4:58	UTC	71	45.4281	N	156	39.2725	W
MR1705C-R-002	2017	09	02	4:33	UTC	71	45.4001	N	151	28.8584	W
MR1705C-R-003	2017	09	04	4:44	UTC	71	56.6769	N	156	29.4798	W
MR1705C-R-004	2017	09	12	5:18	UTC	73	48.7841	N	162	24.7737	W
MR1705C-R-005	2017	09	13	4:00	UTC	73	19.0810	N	160	49.5086	W
MR1705C-R-006	2017	09	14	4:35	UTC	75	00.0526	N	165	00.3741	W
MR1705C-R-007	2017	09	16	4:55	UTC	74	59.9616	N	170	44.0867	W
MR1705C-R-008	2017	09	16	20:50	UTC	74	34.5441	N	168	14.4095	W
MR1705C-R-009	2017	09	17	4:40	UTC	72	29.8021	N	168	45.0927	W
MR1705C-R-010	2017	09	18	4:49	UTC	68	10.3603	N	168	48.4779	W
MR1705C-R-011	2017	09	19	4:55	UTC	68	4.9953	N	167	43.8752	W
MR1705C-R-012	2017	09	28	0:31	UTC	42	12.9953	N	154	17.2883	E
MR1705C-R-013	2017	09	28	8:00	UTC	41	4	N	152	0	E

(6) Preliminary results

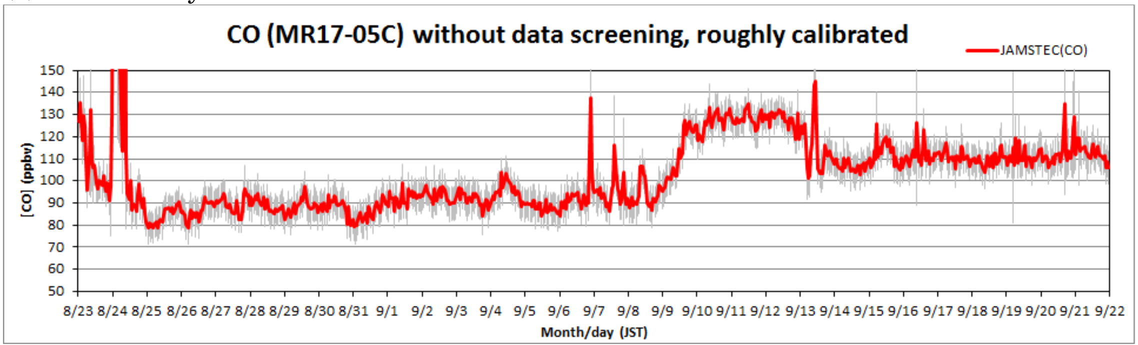

Figure 2.5-1: temporal variation of CO mixing ratio

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

2.6. Greenhouse gasses

2.6.1. Continuous measurements

(1) Personal

Yasunori Tohjima	NIES	- Principal Investigator, not on board
Shigeyuki Ishidoya	AIST	- not on board
Saki Kato	Fukuoka Univ.	- on board
Keiichi Katsumata	NIES	- not on board
Shinji Morimoto	Tohoku Univ.	- not on board
Fumikazu Taketani	JAMSTEC	- not on board
Kentaro Ishijima	JAMSTEC	- not on board
Prabir Patra	JAMSTEC	- not on board

(2) Objective

The Arctic region is considered to be vulnerable to the global warming, which would potentially enhance emissions of the greenhouse gases including CO_2 and CH_4 from the carbon pools in the Arctic regions into the atmosphere. The objective of this study is to detect the increases in the atmospheric greenhouse gas levels associated with the ongoing global warming in the Arctic region in the early stage. The continuous observations of the atmospheric CO_2 and CH_4 mixing ratios during this MR17-05C cruise would allow us to detect the enhanced mixing ratios associated with the regional emissions and to estimate the distribution of the regional emission sources. The atmospheric CO mixing ratios, which were also observed at the same time, can be used as an indicator of the anthropogenic emissions associated with the combustion processes.

(3) Parameters

ratio of atmospheric CO_2, CH_4, and CO.

(4) Instruments and Methods

Atmospheric CO_2, CH_4, and CO mixing ratios were measured by a wavelength-scanned cavity ring-down spectrometer (WS-CRDS, Picarro, G2401). An air intake, capped with an inverted stainless steel beaker covered with stainless steel mesh, was placed on the 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 ~8 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 25 hour by introducing 3 standard airs with known CO_2, CH_4 and CO mixing ratios. The analytical precisions for CO_2, CH_4, and CO mixing ratios are about 0.02 ppm, 0.3 ppb and 3 ppb, respectively.

(5) Observation log

The shipboard measurements were conducted during the entire cruse.

(6) Data archives

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

2.6.2. Discrete flask sampling

(1) Personal

Yasunori Tohjima	NIES	- Principal Investigator, not on board
Shigeyuki Ishidoya	AIST	- not on board
Saki Kato	Fukuoka Univ.	- on board
Fumikazu Taketani	JAMSTEC	- not on board
Shinji Morimoto	Tohoku Univ.	- not on board
Shuji Aoki	Tohoku Univ.	- not on board
Ryo Fujita	Tohoku Univ.	- not on board
Keiichi Katsumata	NIES	- not on board
Daisuke Goto	NIPR	- not on board
Kentaro Ishijima	JAMSTEC	- not on board
Prabir Patra	JAMSTEC	- not on board
Hiroshi Uchida	JAMSTEC	- not on board
Shohei Murayama	AIST	- not on board

(2) Objective

In order to clarify spatial variations and air-sea exchanges of the greenhouse gases at northern high latitude, whole air samples were corrected into 40 stainless-steel flasks on-board R/V MIRAI (MR17-05C). The collected air samples will be analyzed for the mixing ratios of CO_2, O_2, Ar, CH_4, CO, N_2O and SF_6 and the stable isotope ratios of CO_2 and CH_4.

(3) Parameters

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

(4) Instruments and Methods

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

(5) Observation logs

The continuous observations of CO_2, CH_4 and CO mixing ratios were conducted during the entire cruise. Sampling logs of the discrete flask sampling are listed in Table 2.6.2-1.

Table 2.6.2-1: List of logs of the discrete flask sampling

On board ID	Date Collected					Latitude			Longitude		
	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W
MR1705C-Flask_Gas_001	2017	08	24	2:34	UTC	54	08.6038	N	166	51.9998	W
MR1705C-Flask_Gas_002	2017	08	24	23:38	UTC	56	01.8165	N	172	09.3591	W
MR1705C-Flask_Gas_003	2017	08	25	21:22	UTC	60	02.6911	N	173	31.2324	W
MR1705C-Flask_Gas_004	2017	08	27	5:39	UTC	63	39.6004	N	172	43.9482	W
MR1705C-Flask_Gas_005	2017	08	27	22:12	UTC	65	14.5840	N	169	07.4524	W
MR1705C-Flask_Gas_006	2017	08	28	22:32	UTC	68	08.1890	N	168	48.6877	W
MR1705C-Flask_Gas_007	2017	08	29	22:11	UTC	71	10.5750	N	168	45.7634	W
MR1705C-Flask_Gas_008	2017	08	31	2:04	UTC	72	44.4807	N	161	04.7042	W
MR1705C-Flask_Gas_009	2017	09	01	1:20	UTC	71	26.7506	N	157	33.8393	W
MR1705C-Flask_Gas_010	2017	09	02	2:09	UTC	72	07.9586	N	155	33.8393	W
MR1705C-Flask_Gas_011	2017	09	03	5:53	UTC	72	27.1198	N	155	18.3983	W
MR1705C-Flask_Gas_012	2017	09	03	22:11	UTC	71	34.4746	N	151	58.3725	W
MR1705C-Flask_Gas_013	2017	09	04	1:25	UTC	71	32.6716	N	152	05.4540	W
MR1705C-Flask_Gas_014	2017	09	05	1:21	UTC	71	58.5124	N	154	07.4861	W
MR1705C-Flask_Gas_015	2017	09	05	20:51	UTC	71	53.9202	N	156	11.6207	W
MR1705C-Flask_Gas_016	2017	09	07	21:51	5:09	72	47.2044	N	155	23.5833	W
MR1705C-Flask_Gas_017	2017	09	07	19:55	UTC	75	28.9313	N	156	50.7584	W
MR1705C-Flask_Gas_018	2017	09	09	6:31	UTC	73	53.4789	N	155	59.6235	W
MR1705C-Flask_Gas_019	2017	09	10	5:41	UTC	71	50.1796	N	155	25.1364	W
MR1705C-Flask_Gas_020	2017	09	10	20:35	UTC	73	18.1790	N	160	25.3488	W
MR1705C-Flask_Gas_021	2017	09	12	0:05	UTC	73	24.3293	N	160	22.2732	W
MR1705C-Flask_Gas_022	2017	09	13	3:52	UTC	72	59.5775	N	163	21.8813	W
MR1705C-Flask_Gas_023	2017	09	14	3:43	UTC	74	22.7099	N	161	33.0916	W
MR1705C-Flask_Gas_024	2017	09	15	2:11	UTC	74	59.9756	N	166	26.8966	W
MR1705C-Flask_Gas_025	2017	09	16	8:07	UTC	75	00.1817	N	177	56.5685	W
MR1705C-Flask_Gas_026	2017	09	16	21:36	UTC	74	59.8777	N	169	58.5953	W
MR1705C-Flask_Gas_027	2017	09	17	22:34	UTC	72	25.1455	N	168	44.6109	W
MR1705C-Flask_Gas_028	2017	09	18	3:40	UTC	68	18.8816	N	168	50.1463	W
MR1705C-Flask_Gas_029	2017	09	19	21:36	UTC	67	50.7303	N	168	18.9462	W
MR1705C-Flask_Gas_030	2017	09	20	22:42	UTC	65	16.3915	N	169	03.6692	W
MR1705C-Flask_Gas_031	2017	09	22	3:25	UTC	54	04.4760	N	171	01.1754	W
MR1705C-Flask_Gas_032	2017	09	22	22:26	UTC	60	47.1112	N	177	35.7821	W
MR1705C-Flask_Gas_033	2017	09	24	1:34	UTC	56	22.3400	N	175	24.1522	E
MR1705C-Flask_Gas_034	2017	09	24	21:47	UTC	53	02.4278	N	170	38.4879	E
MR1705C-Flask_Gas_035	2017	09	25	7:41	UTC	51	28.4433	N	168	24.6942	E
MR1705C-Flask_Gas_036	2017	09	25	23:16	UTC	48	55.7961	N	164	56.1962	E
MR1705C-Flask_Gas_037	2017	09	27	0:00	UTC	45	09.4530	N	160	04.9505	E
MR1705C-Flask_Gas_038	2017	09	28	1:09	UTC	42	07.3282	N	154	06.4569	E
MR1705C-Flask_Gas_039	2017	09	29	6:35	UTC	40	09.3798	N	147	10.1386	E
MR1705C-Flask_Gas_040	2017	09	30	23:48	UTC	40	21.6489	N	143	03.5362	E

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

3. Physical Oceanography
3.1. CTD casts and water samplings

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Amane Fujiwara	JAMSTEC	
Yusuke Kawaguchi	Atmosphere and Ocean Research Institute, The University of Tokyo	
Shinsuke Toyoda	MWJ	- Operation leader
Hiroki Ushiromura	MWJ	
Keisuke Takeda	MWJ	
Rio Kobayashi	MWJ	

(2) Objective
To investigate oceanic structures and water characteristics.

(3) Parameters
Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary "RINKOIII" and Secondary "SBE43")
Fluorescence (Primary and Secondary)
Beam Transmission
Turbidity
Photosynthetically Active Radiation
Nitrate
Altimeter
Deep Ocean Standards Thermometer
Sound Velocity

(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 sample Bottles were used for sampling seawater. Some sample Bottles were washed by alkaline detergent and HCl. The sensors attached on the CTD were temperature (primary and secondary), conductivity (primary and secondary), pressure, dissolved oxygen (primary, RINKOIII), dissolved oxygen (secondary, SBE43), fluorescence (primary and secondary), beam transmission, turbidity, photosynthetically active radiation, nitrate, altimeter, deep ocean standards thermometer and sound velocity. Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

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: 25 May. 2017

Carousel water sampler:
SBE32 (S/N: 3221746-0278, Sea-Bird Electronics, Inc.)

Temperature sensors:
Primary: SBE03-04/F (S/N: 031525, Sea-Bird Electronics, Inc.)
Calibrated Date: 05 May. 2017
Secondary: SBE03-04/F (S/N: 031359, Sea-Bird Electronics, Inc.)
Calibrated Date: 05 May. 2017

Conductivity sensors:
Primary: SBE04C (S/N: 042435, Sea-Bird Electronics, Inc.)
Calibrated Date: 05 May 2017
Secondary: SBE04C (S/N: 042854, Sea-Bird Electronics, Inc.)
Calibrated Date: 10 May. 2017

Dissolved Oxygen sensor:
Primary: RINKOIII (S/N: 0287_163011BA, JFE Advantech Co., Ltd.)
Calibrated Date: 24 May 2017
Secondary: SBE43 (S/N: 430575, Sea-Bird Electronics, Inc.)
Calibrated Date: 21 Apr. 2017

Fluorescence:
Primary: Chlorophyll Fluorometer (S/N: 3700, Seapoint Sensors, Inc.)
Gain setting: 30X, 0-5 ug/l
Calibrated Date: None
Offset: 0.000
Secondary: Chlorophyll Fluorometer (S/N: 3618, Seapoint Sensors, Inc.)
Gain setting: 10X, 0-50 ug/l
Calibrated Date: None
Offset: 0.000

Transmission meter: C-Star (S/N CST-1726DR, WET Labs, Inc.)
Calibrated Date: 22 Feb. 2017

Turbidity:
Turbidity Meter (S/N: 14953)
Gain setting: 100X
Scale factor: 1.000
Calibrated Date: None

Photosynthetically Active Radiation:
PAR sensor (S/N: 1025, Satlantic Inc.)
Calibrated Date: 06 Jul. 2015

Nitrate sensor:
Deep SUNA (Submersible Ultraviolet Nitrate Analyzer),
(S/N 895, Satlantic Inc.)
Calibrated Date: 02 Feb. 2017

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

Deep ocean standards thermometer:
SBE35(S/N: 0053, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 May 2017

Sound velocity:
miniSVS OEM (S/N: 24001, Valeport, Ltd.)

Submersible Pump:
Primary: SBE5T (S/N: 055816, Sea-Bird Electronics, Inc.)
Secondary: SBE5T (S/N: 054598, Sea-Bird Electronics, Inc.)

Bottom contact switch: (Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P54451-0872, Sea-Bird Electronics, Inc.)

Configuration file: MR1705C_A.xmlcon
000M001 – 017M001, 069M001, 069M002, 015M001 – 011M001
MR1705C_B.xmlcon
018M001 – 068M001, 070M001 – 104M001

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) 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.
For depths where vertical gradient of water properties were exchanged to be large, the bottle was exceptionally fired after waiting from the stop for 60 seconds to enhance exchanging the water between inside and outside of the bottle. 30 seconds below thermo cline to stabilize then fire. 118 casts of CTD measurements were conducted (Table 3.1-1). Stn.20 cast1 was canceled.
Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.23.2) and SEASOFT were as follows:

(The process in order)
DATCNV: Convert the binary raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds, and the offset was set to 0.0 seconds.

TCORP (original module): Corrected the pressure sensitivity of the temperature (SBE3) sensor.
S/N 031525: +1.714e-008 (degC/dbar)
S/N 031359: -2.29885054e-007 (degC/dbar)

RINKOCOR (original module): Corrected the time dependent, pressure induced effect (hysteresis) of the RINKOIII profile data.

RINKOCORROS (original module): Corrected the time dependent, pressure induced effect (hysteresis) of the RINKOIII bottle information data by using the hysteresis corrected profile data.

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

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing dissolved oxygen sensor (SBE43) output (dissolved oxygen voltage) relative to the temperature data. RINKOIII voltage (User polynomial 0) was advanced 1 second, transmission data and transmission voltage were advanced 2 seconds.

WILDEDIT: Mark extreme outliers in the data files. The first pass of WILDEDIT obtained the 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 , dissolved oxygen voltage (SBE43).

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 and depth data with a time constant of 0.15 second. In order to produce zero phase lag (no time shift) the filter runs forward first then backward

WFILTER: Perform a median filter to remove spikes in the fluorescence data (primary and secondary), transmission data, transmission voltage, turbidity and nitrate voltage (User polynomial 1). 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 twice for temperature, conductivity and dissolved oxygen (RINKOIII and SBE43) voltage.

DERIVE: Compute dissolved oxygen (SBE43).

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

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

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

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

(5) Station list
During this cruise, 119 casts (1cast canceled) of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 3.1-1. In bottom attack of shallow casts, bottom contact switch was also used.

(6) Preliminary Results
During this cruise, we judged noise, spike or shift in the data of some casts. These were as follows.

000M002: Beam Transmission voltage
    down 536, 537: spike
005M001: Primary Fluorescence
    down 3 - down 25, up 24 - up 1: range out
006M001: Primary Fluorescence
    down 14 - down 26, up 32 - up 5: range out
007M001: Primary Fluorescence
    down 4 - down 15, up 10 - up 1: range out
009M001: Primary Fluorescence
    down 4 - down 26, up 23 - up 1: range out
012M001: Secondary temperature, Secondary salinity
    down 20: spike
022M001: Beam Transmission voltage
    down 5 - down 13: spike
023M001: Secondary salinity
    down 48, 49: spike
039M001: Beam Transmission voltage
    down 9 - down 16: spike
046M001: Primary salinity
    down 335: spike
047M001: Secondary salinity
    down 438: spike
065M001: Turbidity
    up 76 - up 51: noise
066M001: Primary salinity
    down 86 - down 98: shift
Secondary salinity
    down 86, 87: spike
Beam Transmission voltage
    down 85, 86: spike
077M001: Primary temperature, Primary salinity
    down 22: spike
088M001: Beam Transmission voltage
    down 20 - down 24, down 29 - down 32, down 34 - down 36,
    down 38 - down 44: spike
093M001: Nitrate
    up 36 - up 1: battery run out
104M001: Secondary salinity
    down 44: spike
Primary Fluorescence
    down 4 - down 16, up 20 - up 1: range out
105M001: Primary Fluorescence
    down 3 - down 22, up 19 - up 1: range out
106M001: Primary Fluorescence
    down 5, 6, up 9 - up 1: range out

107M001: Primary Fluorescence
down 4 - down 37, up 36 - up 1: range out
110M001: Primary Fluorescence
down 4 - down 14, up 10 - up 3: range out
107M001: Primary Fluorescence
down 5 - down 23, up 20 - up 1: range out

(7) Data archive

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

<http://www.godac.jamstec.go.jp/darwin/e>

Table 3.1-1: MR17-05C CTD cast table

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth (m)	Wire Out (m)	HT Above Bottom (m)	Max Depth (m)	Max Pressure (dbar)	CTD Filename	Remark
000	1	082417	22:06	23:13	56-02.11N	172-07.84W	3020.0	988.8	-	990.5	1002.0	000M001	test cast no water sampling
000	2	082417	23:43	00:35	56-01.70N	172-07.17W	3057.0	987.7	-	990.5	1002.0	000M002	test cast no water sampling
001	1	082617	18:31	18:58	63-05.58N	174-00.76W	76.5	61.0	10.8	64.4	65.0	001M001	
002	1	082717	07:25	07:43	63-51.73N	172-17.84W	55.3	46.5	5.5	49.5	50.0	002M001	
003	1	082717	14:35	15:06	64-42.59N	170-20.94W	48.1	39.3	5.3	42.6	43.0	003M001	
004	1	082717	19:01	19:29	65-02.90N	169-35.50W	50.7	42.3	5.1	45.5	46.0	004M001	
005	1	082717	22:51	23:18	65-16.56N	169-02.94W	53.8	44.3	5.0	48.5	49.0	005M001	
006	1	082817	01:52	02:12	65-39.21N	168-41.90W	49.5	44.0	5.7	43.6	44.0	006M001	
007	1	082817	06:29	06:51	66-16.38N	168-50.96W	55.2	46.5	4.9	50.5	51.0	007M001	
008	1	082817	12:14	12:33	67-12.00N	168-54.08W	48.9	39.9	5.9	42.6	43.0	008M001	
009	1	082817	15:41	16:02	67-34.51N	168-50.93W	50.4	40.6	5.2	44.5	45.0	009M001	
010	1	082817	20:15	20:39	68-01.13N	168-50.13W	58.6	49.8	4.7	53.5	54.0	010M001	
011	1	082917	00:59	01:17	68-30.06N	168-45.21W	53.1	45.4	4.6	48.5	49.0	011M001	
012	1	082917	04:18	04:36	69-00.01N	168-44.70W	53.1	43.4	5.0	47.5	48.0	012M001	
013	1	082917	08:26	08:43	69-29.83N	168-45.74W	51.3	42.8	4.9	46.5	47.0	013M001	
014	1	082917	12:32	12:47	69-59.99N	168-45.20W	41.0	31.6	5.9	34.6	35.0	014M001	
015	1	082917	15:59	16:17	70-30.00N	168-45.06W	39.2	26.5	4.9	33.7	34.0	015M001	
016	1	082917	19:38	20:03	70-59.97N	168-45.54W	45.1	36.8	3.9	40.6	41.0	016M001	
017	1	083017	00:28	00:53	71-30.04N	168-44.95W	49.4	40.4	4.8	43.5	44.0	017M001	
018	1	083017	04:51	05:13	72-00.03N	168-44.93W	51.7	40.8	5.1	45.5	46.0	018M001	
018	2	083017	06:27	06:38	71-59.98N	168-44.99W	51.6	41.2	5.2	45.5	46.0	018M002	
019	1	083017	10:51	11:10	72-24.12N	166-39.23W	50.7	41.3	5.3	44.5	45.0	019M001	
020	2	083017	16:22	16:43	72-32.93N	163-58.48W	51.7	41.9	5.1	45.5	46.0	020M002	cast1 canceled
021	1	083017	21:52	22:18	72-47.95N	161-20.83W	50.5	41.3	4.1	44.5	45.0	021M001	
021	2	083117	00:13	00:26	72-48.38N	161-20.92W	51.0	41.0	5.3	43.5	44.0	021M002	
021	3	083117	01:17	01:27	72-48.45N	161-20.17W	50.8	36.8	9.8	39.6	40.0	021M003	
022	1	083117	06:03	06:23	72-12.63N	159-10.30W	50.2	39.3	5.8	43.5	44.0	022M001	
023	1	083117	09:51	10:10	71-50.72N	158-23.84W	58.3	48.1	4.8	52.5	53.0	023M001	
024	1	083117	11:51	12:13	71-42.71N	158-07.13W	58.5	47.6	5.8	51.5	52.0	024M001	

025	1	083117	13:53	14:18	71-34.83N	157-50.98W	65.2	55.1	5.4	58.4	59.0	025M001	
026	1	083117	15:36	16:04	71-29.84N	157-40.40W	84.1	73.3	5.5	77.2	78.0	026M001	
027	1	083117	17:29	18:00	71-25.52N	157-32.41W	120.6	105.8	9.6	109.8	111.0	027M001	
028	1	083117	19:22	19:43	71-19.73N	157-20.98W	91.6	82.3	4.4	86.1	87.0	028M001	
029	1	083117	21:26	21:50	71-14.34N	157-13.04W	48.1	39.7	5.1	42.6	43.0	029M001	
030	1	083117	23:45	23:50	71-16.87N	157-16.63W	56.9	48.5	4.7	51.5	52.0	030M001	no water sampling
031	1	090117	00:41	00:50	71-22.38N	157-25.53W	113.4	104.2	5.3	106.9	108.0	031M001	no water sampling
032	1	090117	01:42	01:50	71-27.33N	157-35.42W	110.3	100.7	5.6	103.9	105.0	032M001	no water sampling
033	1	090117	02:37	02:44	71-32.26N	157-45.31W	71.7	60.1	5.2	65.3	66.0	033M001	no water sampling
034	1	090117	06:33	06:54	71-52.70N	156-02.68W	81.1	70.2	5.2	75.2	76.0	034M001	
035	1	090117	08:53	09:16	71-49.73N	155-50.78W	90.9	80.7	7.0	85.1	86.0	035M001	
036	1	090117	10:53	11:25	71-48.03N	155-24.04W	150.0	135.1	6.6	139.5	141.0	036M001	
037	1	090117	13:31	14:24	71-44.06N	155-13.64W	305.0	298.6	4.5	300.7	304.0	037M001	
038	1	090117	16:29	17:00	71-39.99N	155-01.88W	107.7	97.6	4.6	101.9	103.0	038M001	
039	1	090117	19:16	19:40	71-35.57N	154-48.88W	39.8	30.5	4.2	34.6	35.0	039M001	
040	1	090117	21:29	21:34	71-37.80N	154-54.95W	55.6	47.2	4.8	50.5	51.0	040M001	no water sampling
041	1	090117	22:20	22:28	71-41.98N	155-06.27W	178.0	169.4	5.5	172.1	174.0	041M001	no water sampling
042	1	090117	23:12	23:24	71-46.01N	155-17.13W	203.0	192.2	5.6	195.9	198.0	042M001	no water sampling
043	1	090217	00:18	00:27	71-49.02N	155-35.68W	119.0	113.4	4.9	116.8	118.0	043M001	no water sampling
044	1	090217	04:00	05:40	72-27.80N	155-27.91W	1897.0	1894.0	9.1	1859.2	1887.0	044M001	
045	1	090317	09:29	11:07	72-07.55N	153-30.49W	1812.0	1765.5	11.2	1757.2	1783.0	045M001	
046	1	090317	16:40	18:23	71-45.08N	151-29.70W	1795.0	1762.6	10.0	1759.2	1785.0	046M001	
047	1	090317	20:48	21:29	71-39.65N	151-44.86W	1146.0	1132.5	9.3	1130.2	1145.0	047M001	no water sampling
048	1	090317	22:56	23:59	71-34.16N	152-00.09W	496.0	481.3	9.8	482.4	488.0	048M001	
049	1	090417	02:08	02:44	71-29.37N	152-21.10W	128.0	118.3	6.3	120.7	122.0	049M001	
050	1	090417	05:24	05:33	71-24.47N	152-42.60W	107.8	97.6	5.7	100.9	102.0	050M001	no water sampling
051	1	090417	06:59	07:21	71-19.81N	153-03.99W	79.5	70.7	5.7	73.2	74.0	051M001	
052	1	090417	12:08	12:51	71-21.42N	151-00.42W	225.0	206.0	6.6	208.7	211.0	052M001	
053	1	090417	18:44	19:41	71-47.82N	152-59.81W	471.0	450.9	10.1	451.8	457.0	053M001	
054	1	090417	22:16	23:24	71-57.86N	154-00.81W	684.0	664.1	9.9	664.0	672.0	054M001	
055	1	090517	03:17	04:09	72-04.03N	155-00.58W	387.0	371.2	8.9	374.8	379.0	055M001	
056	1	090517	07:15	08:45	72-22.76N	155-42.34W	1330.0	1324.0	8.4	1324.0	1342.0	056M001	
057	1	090517	10:09	11:18	72-17.14N	156-00.03W	790.0	760.0	10.8	760.7	770.0	057M001	
058	1	090517	13:45	14:27	72-09.85N	156-20.92W	224.0	217.2	5.2	218.6	221.0	058M001	
059	1	090517	15:43	16:17	72-01.88N	156-40.26W	113.0	103.8	5.3	106.9	108.0	059M001	
060	1	090517	17:57	18:23	71-54.51N	157-00.48W	78.4	67.6	5.4	71.3	72.0	060M001	

061	1	090517	19:50	20:12	71-56.58N	156-29.44W	64.9	55.9	4.5	59.4	60.0	061M001	
062	1	090517	21:55	22:29	71-53.07N	156-03.08W	81.4	72.6	5.3	75.2	76.0	062M001	
063	1	090617	00:24	00:50	71-49.64N	155-50.00W	89.9	84.2	4.0	87.1	88.0	063M001	
064	1	090617	02:22	02:58	71-48.10N	155-23.09W	148.7	139.7	5.6	142.5	144.0	064M001	
065	1	090617	04:08	05:06	71-44.18N	155-11.98W	305.3	296.0	6.1	299.7	303.0	065M001	
066	1	090617	06:30	07:00	71-40.12N	155-01.78W	108.3	99.0	5.0	102.9	104.0	066M001	
067	1	090617	08:28	08:43	71-35.59N	154-48.79W	40.0	30.1	5.5	33.7	34.0	067M001	
068	1	090817	02:13	03:49	76-25.93N	157-16.11W	1639.0	1609.3	10.5	1601.8	1625.0	068M001	
069	1	090817	19:50	20:28	73-59.77N	156-01.52W	3863.0	295.1	-	298.7	302.0	069M001	
069	2	090817	21:53	00:42	73-59.81N	156-03.68W	3863.0	3842.3	9.8	3836.2	3912.0	069M002	
070	1	091017	09:44	10:10	72-28.47N	157-00.52W	673.0	645.0	10.2	644.3	652.0	070M001	no water sampling
071	1	091017	12:46	13:54	72-47.32N	158-00.43W	788.0	772.9	8.7	773.5	783.0	071M001	
072	1	091017	16:23	16:56	73-03.28N	159-00.15W	886.0	856.1	10.4	855.3	866.0	072M001	no water sampling
073	1	091017	19:16	19:58	73-17.25N	160-01.15W	1175.0	1169.1	8.2	1163.6	1179.0	073M001	no water sampling
074	1	091017	21:55	22:52	73-18.55N	160-51.69W	385.0	378.2	7.0	377.7	382.0	074M001	
075	1	091117	01:46	02:06	73-31.55N	160-54.23W	493.0	473.2	9.0	472.5	478.0	075M001	no water sampling
076	1	091117	04:00	05:48	73-31.17N	159-51.39W	1996.0	1980.9	9.8	1977.8	2008.0	076M001	
077	1	091117	11:22	11:53	73-09.44N	162-18.74W	197.0	187.1	5.0	191.9	194.0	077M001	
078	1	091217	05:03	05:54	74-00.17N	160-59.52W	459.0	445.6	8.4	446.8	452.0	078M001	
079	1	091217	08:05	09:06	73-49.34N	161-29.37W	515.0	512.3	7.7	508.1	514.0	079M001	
080	1	091217	11:20	12:12	73-39.98N	161-14.26W	484.0	470.0	9.2	471.5	477.0	080M001	
081	1	091217	16:43	17:53	74-04.12N	162-00.22W	632.0	606.2	10.1	608.7	616.0	081M001	
082	1	091217	20:42	21:25	73-49.59N	162-27.95W	256.0	241.6	10.5	245.3	248.0	082M001	
083	1	091317	07:08	07:26	72-44.39N	162-27.23W	49.6	39.5	5.3	43.5	44.0	083M001	
084	1	091317	10:19	10:37	72-33.34N	161-32.06W	46.2	35.6	5.2	39.6	40.0	084M001	
085	1	091417	04:55	06:01	74-31.34N	161-55.23W	1690.0	1674.4	9.9	1672.6	1697.0	085M001	
085	2	091417	07:53	09:32	74-31.50N	161-53.90W	1694.0	1679.0	9.4	1677.5	1702.0	085M002	
086	1	091417	15:16	16:29	74-59.84N	161-59.93W	1973.0	1960.3	9.3	1960.0	1990.0	086M001	
087	1	091417	21:22	22:27	75-00.22N	164-59.95W	546.0	531.1	8.6	533.7	540.0	087M001	
088	1	091517	03:45	04:26	75-00.19N	167-13.73W	257.0	247.0	5.4	250.2	253.0	088M001	
089	1	091617	01:58	03:04	75-15.18N	177-43.29W	776.0	494.1	-	495.2	501.0	089M001	
090	1	091617	06:29	07:19	75-00.05N	178-00.11W	324.0	310.4	5.3	314.5	318.0	090M001	
091	1	091617	12:22	13:08	75-00.02N	174-59.85W	266.0	250.1	4.0	263.1	266.0	091M001	
092	1	091617	18:01	18:58	75-00.15N	172-00.33W	384.0	371.7	9.2	373.7	378.0	092M001	
093	1	091617	22:48	23:36	75-00.46N	169-37.03W	244.0	220.5	9.8	224.5	227.0	093M001	
094	1	091717	05:20	06:00	74-30.16N	168-09.73W	256.0	241.6	5.1	245.3	248.0	094M001	

095	1	091717	09:31	10:07	73-59.99N	168-45.07W	183.0	172.0	5.0	176.1	178.0	095M001	
096	1	091717	16:42	17:08	72-59.97N	168-44.90W	62.0	51.8	5.7	55.4	56.0	096M001	
097	1	091717	20:36	21:07	72-29.93N	168-44.84W	59.1	49.6	4.7	53.4	54.0	097M001	
098	1	091817	22:07	22:40	68-02.15N	168-51.69W	59.0	50.1	4.8	53.5	54.0	098M001	
099	1	091917	07:34	07:54	69-00.08N	168-50.66W	52.0	43.4	5.2	46.5	47.0	099M001	
100	1	091917	11:29	11:47	68-30.00N	168-50.40W	53.7	45.0	5.9	47.5	48.0	100M001	
101	1	091917	15:33	15:50	68-17.94N	167-03.25W	39.4	30.1	5.1	33.7	34.0	101M001	
102	1	091917	17:24	17:44	68-12.03N	167-20.44W	47.8	39.0	4.2	43.6	44.0	102M001	
103	1	091917	19:57	20:17	68-00.12N	168-00.36W	54.4	46.3	4.8	49.5	50.0	103M001	
104	1	091917	22:55	23:15	67-44.97N	168-30.12W	50.4	40.6	5.1	44.5	45.0	104M001	
105	1	092017	01:46	02:01	67-34.65N	168-50.99W	50.5	40.4	5.2	44.5	45.0	105M001	
106	1	092017	04:24	04:44	67-12.09N	168-53.63W	49.1	39.1	4.9	43.6	44.0	106M001	
107	1	092017	08:03	08:20	66-44.07N	168-53.85W	42.6	32.3	5.7	36.6	37.0	107M001	
108	1	092017	11:29	11:49	66-16.49N	168-52.93W	55.8	45.8	5.9	50.5	51.0	108M001	
109	1	092017	18:33	19:01	65-38.93N	168-42.58W	50.1	40.1	5.2	44.6	45.0	109M001	
110	1	092017	21:57	22:15	65-16.23N	169-02.54W	53.3	43.6	5.4	47.5	48.0	110M001	
111	1	092117	00:38	00:58	65-03.60N	169-35.77W	51.1	40.2	5.5	45.5	46.0	111M001	

3.2. Lowered Acoustic Doppler Current Profiler (LADCP)

(1) Personnel

Yusuke Kawaguchi	The University of Tokyo	- Principal Investigator
Motoyo Itoh	JAMSTEC - not onboard	
Shinsuke Toyoda	MWJ	
Hiroki Ushiromura	MWJ	
Keisuke Takeda	MWJ	
Rio Kobayashi	MWJ	

(2) Objectives and methodology

The lowered ADCP (LADCP), Workhorse Monitor WHM300 (Teledyne RD Instrument, San Diego, California, USA), which has 4 downward facing transducers with 20-degree beam angles, rated to 6000 m. Two sets of instrument (upward- and downward-looking transducers), with a unified battery pack, are attached to the CTD frame with a steel collar. The LADCPs measure ocean current over full depth range of the CTD observation. The LADCP was powered during the CTD casts by a nominally 45-volt battery pack. The LADCP units were set for recording internally prior to each CTD cast. After each cast finished, the data that were logged in an internal memory device was downloaded into computers onboard. By using a matlab code (LDEO LADCP software version 8b; Visbeck, 2002), the full-depth current velocity can be obtained by combining the raw data from the two transducers collected during ascending/descending casts. In the velocity calculation, ship navigation data and shipboard ADCP current velocity are utilized for the improvement of data quality.

In total, 23 LADCP measurements were performed during the cruise of MR1705C, targeting at the climate changes in the western region of the Arctic Ocean.

(3) Data collection

During this cruise, the LADCP data were collected in the following configuration.

Bin size: 8.0 m

Number of bins: 25

Pings per ensemble: 1

Ping interval: 1.0 sec

(4) Data archives

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

(5) Reference:

Visbeck, M. (2002): Deep velocity profiling using Acoustic Doppler Current Profilers: Bottom track and inverse solutions, J. Atmos. Oceanic Technol., 19, 794–807.

3.3. XCTD

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objective

To obtain vertical profiles of sea water temperature and salinity (calculated by the function of temperature, pressure (depth), and conductivity).

(3) Parameters

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) Instruments and Methods

We observed the vertical profiles of the sea water temperature and conductivity measured by XCTD-1 manufactured by Tsurumi-Seiki Co.(TSK). The signal was converted by MK-150N(TSK), and was recorded by AL-12B software (Ver.1.1.4, TSK). We launched 77 probes by using the automatic launcher. The summary of XCTD observation log is shown in Table 3.3.-1.

(5) Observation log

Table 3.3-1: XCTD observation log

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [deg]	Longitude [deg]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
1	XCTD01	2017/09/02	01:28	71-59.6622N	155-32.9221W	189	3.825	28.480	16027328
2	XCTD02	2017/09/02	02:22	72-10.4014N	155-29.9947W	396	4.250	27.530	16027342
3	XCTD03	2017/09/02	03:08	72-19.3825N	155-27.2604W	1439	4.613	26.478	16027343
4	XCTD04	2017/09/02	12:26	72-04.9775N	154-59.9393W	413	4.306	26.689	16027326
5	XCTD05	2017/09/02	12:51	72-09.9962N	155-00.0363W	1033	4.690	26.175	16027320
6	XCTD06	2017/09/02	13:15	72-14.9777N	155-00.2164W	1333	4.916	25.999	16027327
7	XCTD07	2017/09/02	13:41	72-20.0025N	154-59.8629W	1984	5.002	25.825	16027323
8	XCTD08	2017/09/02	14:06	72-24.9911N	155-00.0039W	2139	4.967	25.830	16027324
9	XCTD09	2017/09/02	14:31	72-29.9990N	154-59.9200W	2472	4.972	25.810	16027323
10	XCTD10	2017/09/02	14:56	72-34.9931N	154-59.9056W	2690	4.571	25.764	16027321
11	XCTD11	2017/09/02	15:20	72-39.9966N	155-00.0118W	2834	4.492	25.663	16027341
12	XCDT12	2017/09/03	05:39	72-28.2170N	155-24.8508W	1993	4.490	25.818	16027352
13	XCTD13	2017/09/03	06:26	72-24.3765N	154-59.9687W	2076	5.029	25.783	16027351
14	XCTD14	2017/09/03	07:23	72-18.7409N	154-29.9330W	1774	4.681	26.129	16027349
15	XCTD15	2017/09/03	08:21	72-13.1233N	154-59.9417W	2019	4.816	26.028	16027350
16	XCTD16	2017/09/03	13:40	72-01.8833N	152-59.9503W	1915	4.315	27.542	16027345
17	XCTD17	2017/09/03	14:37	71-56.2739N	152-30.0172W	1887	4.350	28.686	16027325
18	XCTD18	2017/09/03	15:32	71-50.5977N	152-00.0236W	1842	4.590	29.038	16027403
19	XCTD19	2017/09/04	15:19	71-30.1299N	151-30.9172W	1143	5.556	27.073	16027404
20	XCTD20	2017/09/04	17:04	71-40.8229N	152-29.9982W	421	4.959	28.616	16027346
21	XCTD21	2017/09/04	20:40	71-52.6162N	153-29.9973W	387	4.237	27.897	16027344
22	XCTD22	2017/09/05	01:59	72-00.8044N	154-30.1503W	713	4.210	27.748	16027347
23	XCTD23	2017/09/05	06:00	72-10.3584N	155-29.9658W	396	4.384	27.314	16027348
24	XCTD24	2017/09/07	01:13	71-59.9968N	155-00.0275W	330	4.296	27.772	16027353
25	XCTD25	2017/09/07	02:50	72-20.0117N	155-10.0452W	1664	4.764	26.623	16027402
26	XCTD26	2017/09/07	04:32	72-40.0314N	155-19.9190W	2686	4.407	25.665	16027406
27	XCTD27	2017/09/07	06:32	73-00.0273N	155-36.4986W	3180	3.566	25.538	16027405
28	XCTD28	2017/09/07	08:19	73-20.0640N	155-45.3463W	3368	1.841	25.495	16027410
29	XCTD29	2017/09/07	10:06	73-40.0107N	155-54.9261W	3829	1.114	25.809	16027409
30	XCTD30	2017/09/07	12:10	74-00.0067N	156-09.9248W	3855	1.707	25.501	16027408
31	XCTD31	2017/09/07	13:54	74-20.0024N	156-18.8672W	3857	1.407	25.905	16027412
32	XCTD32	2017/09/07	15:38	74-39.9935N	156-27.8028W	3858	1.034	26.623	16027411
33	XCTD33	2017/09/07	17:19	75-00.0120N	156-35.4733W	3851	1.143	26.440	16027413
34	XCTD34	2017/09/07	19:10	75-19.9996N	156-46.9078W	1265	0.991	26.648	16027407
35	XCTD35	2017/09/07	20:52	75-40.0124N	156-54.4938W	1195	0.788	26.888	16027356
36	XCTD36	2017/09/07	22:36	76-00.0047N	157-02.2093W	934	-0.430	27.296	16027355
37	XCTD37	2017/09/08	00:40	76-20.0238N	157-10.2761W	710	-0.004	27.160	16027354
38	XCTD38	2017/09/10	08:39	72-22.6099N	156-29.5416W	456	3.866	28.254	16027359
39	XCTD39	2017/09/10	11:20	72-37.7680N	157-30.1040W	348	3.107	28.313	16027357
40	XCTD40	2017/09/10	15:14	72-55.1501N	158-29.9906W	1021	2.926	27.531	16027360
41	XCTD41	2017/09/10	18:05	73-08.2655N	159-30.1755W	790	2.824	27.850	16027358
42	XCTD42	2017/09/11	08:01	73-23.3383N	160-11.0194W	1387	3.075	26.041	16027361
43	XCTD43	2017/09/12	00:52	73-30.0427N	159-59.8003W	1824	3.626	26.560	16027365
44	XCTD44	2017/09/12	01:29	73-37.5022N	160-00.0709W	2243	2.698	25.941	16027366
45	XCTD45	2017/09/12	02:06	73-45.0023N	159-59.9931W	2516	1.682	25.939	16027367
46	XCTD46	2017/09/12	02:44	73-52.4945N	159-59.8112W	2714	1.669	26.316	16027370
47	XCTD47	2017/09/12	03:26	73-59.9419N	160-008134W	951	1.777	26.444	16027363
48	XCTD48	2017/09/12	04:07	74-00.0116N	160-29.9980W	1016	1.637	26.421	16027362
49	XCTD49	2017/09/12	13:04	73-34.9067N	161-36.7935W	260	2.940	27.216	16027371
50	XCTD50	2017/09/12	13:52	73-30.0554N	162-00.9025W	194	3.644	28.931	16027375

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [deg]	Longitude [deg]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
51	XCTD51	2017/09/12	14:28	73-37.4524N	161-59.3532W	230	3.345	28.513	16027376
52	XCTD52	2017/09/12	15:02	73-45.0269N	162-00.0655W	269	2.891	28.071	16027369
53	XCTD53	2017/09/12	15:37	73-52.5077N	161-59.8807W	308	3.207	26.301	16027368
54	XCTD54	2017/09/12	16:13	74-00.0062N	161-59.9880W	362	2.462	26.673	16027372
55	XCTD55	2017/09/12	23:49	73-36.9872N	162-44.7762W	182	3.286	29.794	16027364
56	XCTD56	2017/09/13	22:51	73-24.9994N	160-51.0741W	444	3.054	28.769	17025025
57	XCTD57	2017/09/13	23:41	73-34.9976N	160-58.2465W	580	2.876	27.998	17025019
58	XCTD58	2017/09/14	00:31	73-45.0125N	161-05.7073W	1450	2.771	25.934	17025020
59	XCTD59	2017/09/14	01:21	73-54.9909N	161-13.0489W	456	3.247	27.225	17025021
60	XCTD60	2017/09/14	02:12	74-05.0247N	161-20.0864W	466	1.938	26.307	17025027
61	XCTD61	2017/09/14	03:03	74-15.0166N	161-27.6460W	1468	2.259	26.252	16027373
62	XCTD62	2017/09/14	13:48	74-45.6772N	161-57.7265W	1889	1.463	26.648	17025028
63	XCTD63	2017/09/14	17:55	74-59.9980N	162-59.9892W	1788	1.631	26.745	17025024
64	XCTD64	2017/09/14	19:10	75-00.0203N	164-00.1022W	688	2.538	26.201	17025026
65	XCTD64 *1	2017/09/14	19:18	74-59.5605N	164-04.2772W	659	2.533	26.173	17025029
66	XCTD65	2017/09/15	01:40	75-00.0220N	166-00.1890W	483	2.347	26.851	17025032
67	XCTD66	2017/09/15	02:53	75-00.0026N	167-00.0394W	344	0.970	28.035	16027374
68	XCTD67	2017/09/15	06:08	75-00.0011N	168-00.0106W	173	1.756	27.830	17025034
69	XCTD68	2017/09/15	07:23	75-00.0084N	169-00.0716W	213	2.418	27.420	17025031
70	XCTD69	2017/09/15	08:37	74-59.9922N	169-59.9488W	257	2.572	27.690	17025038
71	XCTD70	2017/09/15	09:49	74-59.9950N	170-59.9606W	317	2.074	28.402	17025022
72	XCTD71	2017/09/15	11:02	75-00.0243N	171-59.9338W	384	0.610	28.545	17025023
73	XCTD72	2017/09/15	12:15	75-00.0145N	172-59.9556W	343	0.851	28.376	17025039
74	XCTD73	2017/09/15	13:30	74-59.9843N	173-59.9860W	299	-0.103	29.198	17025036
75	XCTD74	2017/09/15	14:41	75-00.0011N	175-00.0777W	263	-0.735	29.546	17025033
76	XCTD75	2017/09/15	15:55	75-00.0154N	175-59.9985W	255	-0.264	29.099	17025030
77	XCTD76	2017/09/15	17:09	75-00.0014N	176-59.9954W	251	-0.876	29.348	17025035

*1) remeasurement

SST: Sea Surface Temperature [deg-C] measured by TSG (ThermoSalinoGraph).

SSS: Sea Surface Salinity [PSU] measured by TSG.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

3.4. Shipboard ADCP

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Yusuke Kawaguchi	University of Tokyo	
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objectives

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

(3) Parameters

Major parameters for the measurement, Direct Command, are shown in Table 3.4-1.

Table 3.4-1: 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)
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
EV = 0	Heading Bias(1/100 deg)
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)

WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (Velocity; Correlation; Echo Intensity; Percent Good; Status; none; none; none; none)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0400	Blank After Transmit (cm)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WV = 0390	Radial Ambiguity Velocity (cm/s)

(4) Instruments and methods

Upper ocean current measurements were made in this 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 (Tokyo Keiki, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation Unit (Phins, Ixblue, France) which provide high-precision heading, attitude information, pitch and roll. They are stored in ".N2R" data files with a time stamp.
3. Differential GNSS system (StarPack-D, Fugro, Netherlands) 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 Computer time, the clock of the logging computer is adjusted to GPS time server.
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, and that is calculated from temperature, salinity (constant value; 35.0 PSU) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

Data were configured for "8 m" layer intervals starting about 19m below sea surface. In the shallow water (Depth < 100m), layer interval was changed to "6m" starting about 17m below sea surface. Data were recorded every ping as raw ensemble data (.ENR). Additionally, 20 seconds averaged data were recorded as short-term average (.STA). 300

seconds averaged data were long-term average (.LTA), respectively.

(5) Observation Period

24 Aug. 2017 - 1 Oct. 2017 (UTC)

(6) Remarks

Measurement parameters were changed as follows (Table 3.3-2)

Table 3.4-2 WS[cm], WF[cm], and WN settings in this cruise

DATE	TIME	WS	WF	WN
8/23 - 8/24	23:18 - 2:44	800	800	100
8/24	2:44 - 17:40	1600	800	40
8/24 - 8/25	17:41 - 20:11	800	800	100
8/25 - 8/31	20:12 - 13:53	600	400	18
8/31 - 9/1	13:54 - 1:45	800	400	25
9/1 - 9/17	1:45 - 16:26	800	400	100
9/17 - 9/19	16:27 - 15:36	600	400	18
9/19 - 9/20	15:36 - 2:15	800	400	25
9/20 - 9/22	2:15 - 16:30	600	400	18
9/22 - 9/23	16:30 - 3:42	600	400	128
9/23 - 10/1	3:42 - 0:12	800	400	100

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

3.5. Microstructure measurement

(1) Personnel

Yusuke Kawaguchi	The University of Tokyo	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	NME/Crew	

(2) Objectives and methodology

To understand turbulent mixing and diapycnal heat transfer in the ice-free region of the Western Arctic Ocean, microscale temperature and vertical shear were measured using TurboMAP-L during the JAMSTEC Arctic cruise of MR17-05C. The measurements were generally performed within an hour of the shipboard CTD observation by virtue of the quality control of temperature and salinity.

(3) Parameters

According to the manufacture's nominal specifications, the range, accuracy and sampling rates of acquisition parameters are shown in Table 3.5-1.

Table. 3.5-1

Parameter	Sensor type	Measurable range	Accuracy	Sampling rate
$\partial u/\partial z$ (primary)	Shear probe	0~10 /s	5%	512Hz
$T+\partial T/\partial z$	FPO-7 thermistor	±0.01°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%	64Hz
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	Solid-state fixed mass	0~100 µg/Lm	0.5 µg/L or ±1%	256 Hz
Turbidity	Backscatter	0~100 ppm	1ppm or ±2%	256 Hz
∂u/∂z (Secondary)	∂u/∂z Shear	0~10 s^{-1}	5%	512 Hz

(4) Instrument and Methodology

Turbulence Ocean Microstructure Acquisition Profiler (TurboMAP-L, manufactured by JFE Alec Co Ltd.) was used to measure turbulence-scale temperature and current shear. TurboMap is a quasi-free-falling instrument that obtains turbulent mixing parameters (∂u/∂z and ∂T/∂z), bio-optical parameters (in vivo fluorescence and back scatter) and hydrographic parameters (conductivity, temperature, and pressure). The TurboMAP is a loosely tethered free-fall profiler that carries two airfoil shear probes, a fast-response thermistor (FP07), a light-emitting diode fluorescence/turbidity probe, and a CTD package (Wolk et al. 2002). The TurboMAP collects vertical profiles of microscale velocity shear, high- and low-resolution temperature, conductivity, and pressure, as the underwater device descends from the surface to maximum depth. The free-falling speed of the instrument is roughly at 0.5–0.6 m s^{-1}. Operation of the ship's side thrusters is halted under operation of micro-data acquisition so that they may not create any artificial noise corruption or disturbance in the micro-scale data. The microscale data within 5 m depth are not recommended for the use in analysis as they may include potential noise due to the instrument's initial adjustment to free-falling.

(5) Station list

Operational information for the all TurboMAP observations is listed in Table 3.5-2.

Table. 3.5-2: List of location of the TurboMAP observation

No.	Obs. Date [Y/M/D]	Lat [Deg-min]	Lon [Deg-min]	Logging Time Start	Stop	Stn. Dep. [m]	Obs. Dep. [m]	Sensor S/N FP07	Shear 1	Shear 2	Stn. No.
01	2017/08/26	63-06.083N	174-01.383W	20:07	20:16	76	65	144	505	1232	001
02	2017/08/26	63-06.083N	174-01.383W	20:16	20:20	76	70	144	505	1232	001
03	2017/08/26	63-06.065N	174-01.373W	20:21	20:23	76	68	144	505	1232	001
04	2017/08/27	63-51.728N	172-17.709W	7:57	8:00	55	42	144	505	503	002
05	2017/08/27	63-51.726N	172-17.714W	8:01	8:03	55	44	144	505	503	002
06	2017/08/27	63-51.728N	172-17.722W	8:05	8:06	55	43	144	505	503	002
07	2017/08/27	64-42.682N	170-21.569W	15:37	15:38	47	37	144	505	503	003
08	2017/08/27	64-42.663N	170-21.595W	15:41	15:42	47	41	144	505	503	003
09	2017/08/27	64-42.629N	170-21.657W	15:44	15:46	47	37	144	505	503	003
10	2017/08/27	65-03.513N	169-35.469W	20:30	20:32	50	45	144	505	503	004
11	2017/08/27	65-03.561N	169-35.425W	20:34	20:37	50	44	144	505	503	004
12	2017/08/27	65-03.601N	169-35.372W	20:38	20:40	50	44	144	505	503	004
13	2017/08/28	65-39.803N	168-42.197W	2:33	2:36	50	40	144	505	503	006
14	2017/08/28	65-39.881N	168-42.198W	2:40	2:42	50	43	144	505	503	006
15	2017/08/28	65-39.912N	168-42.222W	2:43	2:44	50	43	144	505	503	006
16	2017/08/28	66-16.671N	168-51.654W	6:58	7:02	55	49	144	505	503	007
17	2017/08/28	66-16.653N	168-51.869W	7:03	7:06	55	49	144	505	503	007
18	2017/08/28	66-16.624N	168-52.070W	7:07	7:10	55	49	144	505	503	007
19	2017/08/28	67-12.079N	168-54.491W	12:55	12:59	49	41	144	505	503	008
20	2017/08/28	67-12.057N	168-54.642W	12:59	13:02	49	42	144	505	503	008
21	2017/08/28	67-12.036N	168-54.758W	13:03	13:05	49	41	144	505	503	008
22	2017/08/28	67-34.603N	168-51.174W	16:12	16:15	50	43	144	505	503	009

23	2017/08/28	67-34.625N	168-51.176W	16:16	16:19	50	43	144	505	503	009
24	2017/08/28	67-34.644N	168-51.188W	16:20	16:22	50	43	144	505	503	009
25	2017/08/29	68-30.142N	168-45.405W	1:25	1:28	53	47	144	505	503	010
26	2017/08/29	68-30.141N	168-45.450W	1:31	1:31	53	47	144	505	503	010
27	2017/08/29	68-30.134N	168-45.497W	1:33	1:36	53	47	144	505	503	010
28	2017/08/29	69-00.174N	168-44.169W	4:58	5:01	53	46	144	505	503	011
29	2017/08/29	69-00.161N	168-44.239W	5:02	5:05	53	46	144	505	503	011
30	2017/08/29	69-00.152N	168-44.317W	5:06	5:08	53	46	144	505	503	011
31	2017/08/29	69-29.786N	168-46.334W	8:50	8:53	52	44	144	505	503	012
32	2017/08/29	69-29.755N	168-46.477W	8:55	8:57	52	45	144	505	503	012
33	2017/08/29	69-29.724N	168-46.606W	8:59	9:00	52	45	144	505	503	012
34	2017/08/30	71-29.995N	168-45.464W	1:52	1:54	50	41	144	505	503	017
35	2017/08/30	71-29.981N	168-45.556W	1:55	1:58	50	41	144	505	503	017
36	2017/08/30	71-29.969N	168-45.624W	1:59	2:00	50	41	144	505	503	017
37	2017/08/30	72-00.026N	168-44.905W	5:46	5:49	51	43	144	505	503	018
38	2017/08/30	71-59.989N	168-44.967W	5:50	5:55	51	43	144	505	503	018
39	2017/08/30	71-59.940N	168-45.018W	5:55	5:57	51	44	144	505	503	018
40	2017/08/30	72-48.235N	161-21.096W	23:32	23:35	50	47	144	505	503	021
41	2017/08/30	72-48.239N	161-21.093W	23:36	23:37	50	46	144	505	503	021
42	2017/08/30	72-48.243N	161-21.094W	23:39	23:41	50	46	144	505	503	021
43	2017/08/30	72-48.247N	161-21.090W	23:41	23:44	50	46	144	505	503	021
44	2017/08/31	72-12.744N	159-10.485W	6:44	6:47	50	40	144	505	503	022
45	2017/08/31	72-12.736N	159-10.599W	6:48	6:50	50	43	144	505	503	022
46	2017/08/31	72-12.730N	159-10.670W	6:51	6:53	50	47	144	505	503	022
47	2017/08/31	71-50.825N	158-24.460W	10:17	10:20	58	51	144	505	503	023
48	2017/08/31	71-50.799N	158-24.687W	10:22	10:24	58	50	144	505	503	023

49	2017/08/31	71-50.788N	158-24.951W	10:25	10:27	58	49	144	505	503	023
50	2017/09/01	71-52.947N	156-02.980W	7:15	7:20	82	73	144	505	503	034
51	2017/09/01	71-52.989N	156-03.027W	7:22	7:25	82	73	144	505	503	034
52	2017/09/01	71-53.046N	156-03.122W	7:26	7:29	82	77	144	505	503	034
53	2017/09/01	71-50.090N	155-51.330W	9:23	9:26	91	82	144	505	503	035
54	2017/09/01	71-50.176N	155-51.414W	9:25	9:31	87	83	144	505	503	035
55	2017/09/01	71-50.226N	155-51.502W	9:35	9:37	91	90	144	505	503	035
56	2017/09/01	71-47.952N	155-26.414W	11:53	11:59	136	130	144	505	503	036
57	2017/09/01	71-48.037N	155-26.892W	12:02	12:07	136	136	144	505	503	036
58	2017/09/01	71-48.073N	155-27.191W	12:10	12:14	136	129	144	505	503	036
59	2017/09/01	71-43.948N	155-15.895W	14:30	14:41	302	302	144	505	503	037
60	2017/09/01	71-43.950N	155-16.450W	14:48	14:56	302	275	144	505	503	037
61	2017/09/01	71-39.781N	155-04.120W	17:27	17:31	112	96	144	505	503	038
62	2017/09/01	71-39.766N	155-04.405W	17:33	17:37	113	103	144	505	503	038
63	2017/09/01	71-39.752N	155-04.676W	17:39	17:43	114	98	144	505	503	038
64	2017/09/01	71-35.537N	154-48.980W	20:30	20:33	39	36	144	505	503	039
65	2017/09/01	71-35.539N	154-49.005W	20:35	20:37	39	35	144	505	503	039
66	2017/09/01	71-35.543N	154-49.009W	20:38	20:39	39	34	144	505	503	039
67	2017/09/04	71-29.686N	152-20.254W	3:35	3:41	134	133	144	505	503	049
68	2017/09/04	71-29.717N	152-20.256W	3:40	3:48	134	118	144	505	503	049
69	2017/09/04	71-29.739N	152-20.250W	3:51	3:56	134	-	144	505	503	049
70	2017/09/04	71-24.501N	152-42.551W	5:42	5:47	108	106	144	505	503	050
71	2017/09/04	71-24.528N	152-42.556W	5:48	5:52	108	106	144	505	503	050
72	2017/09/04	71-24.555N	152-42.548W	5:54	5:58	108	104	144	505	503	050
73	2017/09/04	71-20.047N	153-03.439W	8:05	8:08	79	72	144	505	503	051
74	2017/09/04	71-20.071N	153-03.482W	8:10	8:13	79	76	144	505	503	051

75	2017/09/04	71-20.095N	153-03.533W	8:14	8:17	79	76	144	505	503	051
76	2017/09/05	72-04.208N	155-01.576W	4:17	4:29	402	351	144	505	503	055
77	2017/09/05	72-04.287N	155-01.867W	4:35	4:47	384	367	144	505	503	055
78	2017/09/05	71-53.359N	156-0.1926W	23:25	23:25	80	76	144	505	503	062
79	2017/09/05	71-53.387N	156-01.902W	23:29	23:29	81	71	144	505	503	062
80	2017/09/05	71-53.412N	156-01.825W	23:33	23:33	81	72	144	505	503	062
81	2017/09/06	71-49.874N	155-49.423W	0:56	1:00	92	85	144	505	503	063
82	2017/09/06	71-49.923N	155-49.432W	1:02	1:05	92	82	144	505	503	063
83	2017/09/06	71-49.968N	155-49.429W	1:06	1:09	92	82	144	505	503	063
84	2017/09/06	71-48.231N	155-22.908W	3:05	3:10	150	146	144	505	503	064
85	2017/09/06	71-48.261N	155-22.869W	3:13	3:17	150	136	144	505	503	064
86	2017/09/06	71-44.527N	155-11.863W	5:15	5:24	308	247	144	505	503	065
87	2017/09/06	71-44.621N	155-11.806W	5:28	5:39	308	285	144	505	503	065
88	2017/09/06	71-40.395N	155-02.383W	7:15	7:18	111	94	144	505	503	066
89	2017/09/06	71-40.461N	155-02.396W	7:20	7:23	111	96	144	505	503	066
90	2017/09/06	71-40.511N	155-02.409W	7:25	7:28	111	100	144	505	503	066
91	2017/09/06	71-35.700N	154-48.589W	8:50	8:51	40	37	144	505	503	067
92	2017/09/06	71-35.719N	154-48.625W	8:53	8:55	40	32	144	505	503	067
93	2017/09/06	71-35.737N	154-48.642W	8:55	8:57	40	34	144	505	503	067
94	2017/09/07	76-26.347N	157-16.642W	5:15	5:46	1686	986	144	505	503	068
95	2017/09/09	74-00.093N	156-05.102W	0:50	1:21	3855	997	144	505	507	069
96	2017/09/11	73-31.610N	159-54.647W	6:16	6:38	1988	948	144	505	507	076
97	2017/09/12	74-00.414N	159-58.989W	6:01	6:15	453	430	144	505	507	078
98	2017/09/12	73-50.056N	161-29.818W	9:33	9:43	408	450	144	505	507	079
99	2017/09/13	72-44.522N	162-27.113W	7:34	7:36	49	39	144	505	507	083
100	2017/09/13	72-44.551N	162-27.054W	7:38	7:40	49	41	144	505	507	083

101	2017/09/13	72-44.579N	162-24.053W	7:42	7:43	49	41	144	505	507	083
102	2017/09/14	74-31.331N	161-55.023W	6:07	6:38	1692	993	144	505	507	085
103	2017/09/14	74-31.464N	161-54.244W	6:51	7:23	1692	1064	144	505	507	085
104	2017/09/14	75-00.377N	167-13.013W	4:34	4:42	264	217	144	505	507	088
105	2017/09/14	75-00.465N	167-12.970W	4:45	4:53	264	223	144	505	507	088
106	2017/09/16	75-00.072N	178-00.146W	7:27	7:37	325	266	144	505	507	090
107	2017/09/16	75-00.072N	178-00.146W	7:40	7:50	325	300	144	505	507	090
108	2017/09/17	74--30.513N	168-09.893W	6:07	6:16	257	235	144	505	507	094
109	2017/09/17	74-30.613N	168-09.911W	6:19	6:20	257	240	144	505	507	094
110	2017/09/17	74-00.000N	168-45.112W	10:36	10:42	182	164	144	505	507	095
111	2017/09/17	74-00.000N	168-45.112W	10:44	10:50	182	171	144	505	507	095
112	2017/09/18	68-02.000N	168-49.956W	23:55	23:59	59	55	144	505	507	98
113	2017/09/19	68-02.000N	168-50.062W	23:59	0:02	59	53	144	505	507	98
114	2017/09/19	68-01.980N	168-50.138W	0:02	0:05	59	55	144	505	507	98
115	2017/09/19	69-00.022N	168-51.270W	8:01	8:04	52	43	144	505	507	099
116	2017/09/19	68-59.998N	168-51.338W	8:05	8:07	52	44	144	505	507	099
117	2017/09/19	68-59.975N	168-51.383W	8:08	8:10	52	45	144	505	507	099
118	2017/09/19	67-44.994N	168-30.288W	23:25	23:28	50	46	144	505	507	104
119	2017/09/19	67-44.993N	168-30.295W	23:29	23:30	50	44	144	505	507	104
120	2017/09/19	67-44.993N	168-30.336W	23:31	23:33	50	46	144	505	507	104
121	2017/09/20	67-34.717N	168-51.216W	2:07	2:10	50	45	144	505	507	105
122	2017/09/20	67-34.713N	168-51.272W	2:10	2:12	50	39	144	505	507	105
123	2017/09/20	67-34.713N	168-51.362W	2:13	2:15	50	39	144	505	507	105
124	2017/09/20	67-12.180N	168-53.701W	5:04	5:07	49	39	144	505	507	106
125	2017/09/20	67-12.173N	168-53.754W	5:08	5:09	49	41	144	505	507	106
126	2017/09/20	67-12.179N	168-53.817W	5:10	5:12	49	45	144	505	507	106

127	2017/09/20	66-44.137N	168-54.092W	8:26	8:28	42	38	144	505	507	107
128	2017/09/20	66-44.139N	168-54.166W	8:29	8:31	42	40	144	505	507	107
129	2017/09/20	66-44.150N	168-54.227W	8:32	8:34	42	40	144	505	507	107
130	2017/09/21	65-03.688N	169-35.693W	1:06	1:09	51	41	144	505	507	111
131	2017/09/21	65-03.672N	169-35.729W	1:09	1:12	51	35	144	505	507	111
132	2017/09/21	65-03.648N	169-35.768W	1:12	1:14	51	31	144	505	507	111
133	2017/09/21	65-03.620N	169-35.837W	1:15	1:17	51	35	144	505	507	111

3.6. Drifting buoys

(1) Personnel

Yusuke Kawaguchi	The University of Tokyo	- Principal Investigator
Shigeto Nishino	JAMSTEC	
Amane Fujiwara	JAMSTEC	
Keisuke Matsumoto	MWJ	

(2) Objectives and methodology

We utilized Surface Velocity Profiler (SVP) (manufactured by Zeni Lite Buoy Co., Ltd.), which comprises a surface-floating unit (a geographical-positioning-system (GPS) sensor and Iridium communication system) and a holey-sock drogue at mid-depth; they are connected with a fabric nylon rope with each other. The rope length is changed before deployment on the deck, so that it could pursuit the level of water of interest. Once a buoy is successfully deployed, it sends GPS information at hourly rate to the email addresses registered, whose geographical accuracy is about 15 m. The holey-sock drogue is considered to follow water current with an error of less than 10% of absolute current speed.

(3) Observation logs

Deployment information such as identification number, deployment time and GPS information for each buoy is summarized in Table 3.6-1.

(4) Data archives

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

Table 3.6-1: SVP deployment information

	Deployment info			
Unit ID	Date (UTC)	Long. [deg-min]	Lat. [deg-min]	Drogue Depth [m]
SVP9680	6:15, Sep.8, 2017	76-26.432N	157-17.313W	50 m
SVP7900	21:15, Sep.15, 2017	75-16.078N	177-30.216W	NONE

3.7. Salinity measurements

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Sonoka Tanihara	MWJ	

(2) Objectives

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 3.7-1.

Table 3.7-1: Types and numbers (n) of samples

Types	N
Samples for CTD and bucket	1459
Samples for TSG	36
Total	1495

b. Instruments and method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR17-05C 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 ±deg C	:	0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability	:	±2 least significant digits

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 20.4 deg C to 24.1 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C (S/N 62827) 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) Station list

Table.3.7-2 shows the sampling locations for the salinity analysis in this cruise.

Table. 3.7-2: List of sampling locations of the salinity samples collected from CTD

Stnnbr	Castno	Date(UTC)	BottomPosition		Depth (m)
		(mmddyy)	Latitude	Longitude	
001	1	082617	63-05.58N	174-00.76W	76.5
002	1	082717	63-51.73N	172-17.84W	55.3
003	1	082717	64-42.59N	170-20.94W	48.1
004	1	082717	65-02.90N	169-35.50W	50.7
005	1	082717	65-16.56N	169-02.94W	53.8
006	1	082817	65-39.21N	168-41.90W	49.5
007	1	082817	66-16.38N	168-50.96W	55.2
008	1	082817	67-12.00N	168-54.08W	48.9
009	1	082817	67-34.51N	168-50.93W	50.4
010	1	082817	68-01.13N	168-50.13W	58.6
011	1	082917	68-30.06N	168-45.21W	53.1
012	1	082917	69-00.01N	168-44.70W	53.1
013	1	082917	69-29.83N	168-45.74W	51.3
014	1	082917	69-59.99N	168-45.20W	41.0
015	1	082917	70-30.00N	168-45.06W	39.2
016	1	082917	70-59.97N	168-45.54W	45.1
017	1	083017	71-30.04N	168-44.95W	49.4
018	1	083017	72-00.03N	168-44.93W	51.7
018	2	083017	71-59.98N	168-44.99W	51.6
019	1	083017	72-24.12N	166-39.23W	50.7
020	2	083017	72-32.93N	163-58.48W	51.7
021	1	083017	72-47.95N	161-20.83W	50.5
021	2	083117	72-48.38N	161-20.92W	51.0
021	3	083117	72-48.45N	161-20.17W	50.8
022	1	083117	72-12.63N	159-10.30W	50.2
023	1	083117	71-50.72N	158-23.84W	58.3
024	1	083117	71-42.71N	158-07.13W	58.5
025	1	083117	71-34.83N	157-50.98W	65.2
026	1	083117	71-29.84N	157-40.40W	84.1
027	1	083117	71-25.52N	157-32.41W	120.6
028	1	083117	71-19.73N	157-20.98W	91.6
029	1	083117	71-14.34N	157-13.04W	48.1
034	1	090117	71-52.70N	156-02.68W	81.1
035	1	090117	71-49.73N	155-50.78W	90.9
036	1	090117	71-48.03N	155-24.04W	150.0
037	1	090117	71-44.06N	155-13.64W	305.0
038	1	090117	71-39.99N	155-01.88W	107.7
039	1	090117	71-35.57N	154-48.88W	39.8
044	1	090217	72-27.80N	155-27.91W	1897.0
045	1	090317	72-07.55N	153-30.49W	1812.0
046	1	090317	71-45.08N	151-29.70W	1795.0

Stnnbr	Castno	Date(UTC)	BottomPosition		Depth (m)
		(mmddyy)	Latitude	Longitude	
048	1	090317	71-34.16N	152-00.09W	496.0
049	1	090417	71-29.37N	152-21.10W	128.0
051	1	090417	71-19.81N	153-03.99W	79.5
052	1	090417	71-21.42N	151-00.42W	225.0
053	1	090417	71-47.82N	152-59.81W	471.0
054	1	090417	71-57.86N	154-00.81W	684.0
055	1	090517	72-04.03N	155-00.58W	387.0
056	1	090517	72-22.76N	155-42.34W	1330.0
057	1	090517	72-17.14N	156-00.03W	790.0
058	1	090517	72-09.85N	156-20.92W	224.0
059	1	090517	72-01.88N	156-40.26W	113.0
060	1	090517	71-54.51N	157-00.48W	78.4
061	1	090517	71-56.58N	156-29.44W	64.9
062	1	090517	71-53.07N	156-03.08W	81.4
063	1	090617	71-49.64N	155-50.00W	89.9
064	1	090617	71-48.10N	155-23.09W	148.7
065	1	090617	71-44.18N	155-11.98W	305.3
066	1	090617	71-40.12N	155-01.78W	108.3
067	1	090617	71-35.59N	154-48.79W	40.0
068	1	090817	76-25.93N	157-16.11W	1639.0
069	1	090817	73-59.77N	156-01.52W	3863.0
069	2	090817	73-59.81N	156-03.68W	3863.0
070	1	091017	72-28.47N	157-00.52W	673.0
071	1	091017	72-47.32N	158-00.43W	788.0
074	1	091017	73-18.55N	160-51.69W	385.0
076	1	091117	73-31.17N	159-51.39W	1996.0
077	1	091117	73-09.44N	162-18.74W	197.0
078	1	091217	74-00.17N	160-59.52W	459.0
079	1	091217	73-49.34N	161-29.37W	515.0
080	1	091217	73-39.98N	161-14.26W	484.0
081	1	091217	74-04.12N	162-00.22W	632.0
082	1	091217	73-49.59N	162-27.95W	256.0
083	1	091317	72-44.39N	162-27.23W	49.6
084	1	091317	72-33.34N	161-32.06W	46.2
085	1	091417	74-31.34N	161-55.23W	1690.0
085	2	091417	74-31.50N	161-53.90W	1694.0
086	1	091417	74-59.84N	161-59.93W	1973.0
087	1	091417	75-00.22N	164-59.95W	546.0
088	1	091517	75-00.19N	167-13.73W	257.0
089	1	091617	75-15.18N	177-43.29W	776.0
090	1	091617	75-00.05N	178-00.11W	324.0
091	1	091617	75-00.02N	174-59.85W	266.0
092	1	091617	75-00.15N	172-00.33W	384.0

Stnnbr	Castno	Date(UTC)	BottomPosition		Depth (m)
		(mmddyy)	Latitude	Longitude	
093	1	091617	75-00.46N	169-37.03W	244.0
094	1	091717	74-30.16N	168-09.73W	256.0
095	1	091717	73-59.99N	168-45.07W	183.0
096	1	091717	72-59.97N	168-44.90W	62.0
097	1	091717	72-29.93N	168-44.84W	59.1
098	1	091817	68-02.15N	168-51.69W	59.0
099	1	091917	69-00.08N	168-50.66W	52.0
100	1	091917	68-30.00N	168-50.40W	53.7
101	1	091917	68-17.94N	167-03.25W	39.4
102	1	091917	68-12.03N	167-20.44W	47.8
103	1	091917	68-00.12N	168-00.36W	54.4
104	1	091917	67-44.97N	168-30.12W	50.4
105	1	092017	67-34.65N	168-50.99W	50.5
106	1	092017	67-12.09N	168-53.63W	49.1
107	1	092017	66-44.07N	168-53.85W	42.6
108	1	092017	66-16.49N	168-52.93W	55.8
109	1	092017	65-38.93N	168-42.58W	50.1
110	1	092017	65-16.23N	169-02.54W	53.3
111	1	092117	65-03.60N	169-35.77W	51.1

(6) Preliminary results

a. Standard Seawater (SSW)

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

Batch	:	P160
conductivity ratio	:	0.99983
double conductivity ratio	:	1.99966
salinity	:	34.993
expiration date	:	20th July 2019

Standardization control of the salinometer S/N 62827 was set to 469 (27th Aug.) and 28 measurements were carried out at this setting. The value of STANDBY was 5419 +/- 0001 and that of ZERO was 0.0-0000 +/- 0001. 70 bottles of SSW were measured in this period.

Figure 3.7-1 shows the history of the double conductivity ratio of the Standard Seawater batch P160 before correction in the salinometer S/N 62827. The average of the double conductivity ratio in 70 bottles of SSW was 1.99964 and the standard deviation was 0.00001, which is equivalent to 0.0003 in salinity.

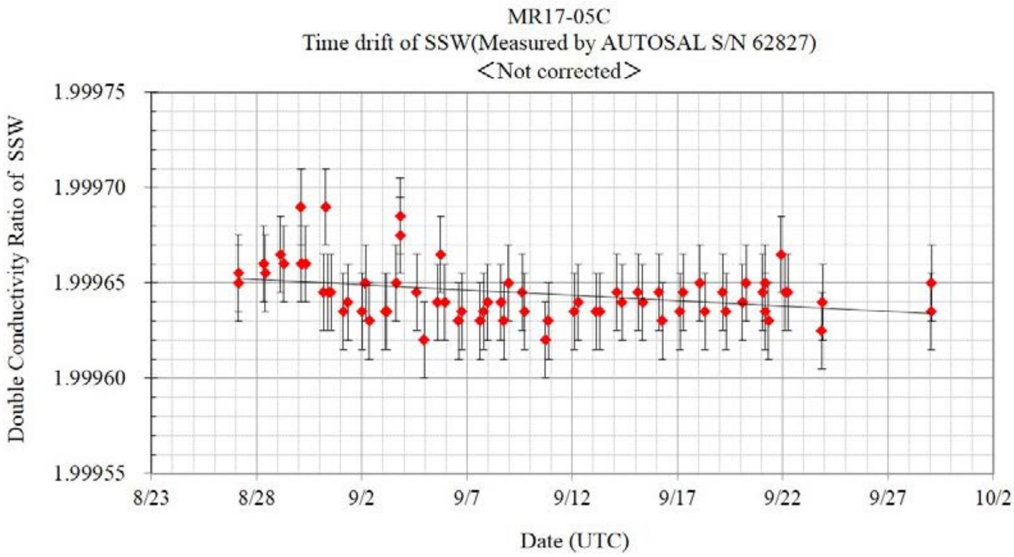

Figure 3.7-1: History of double conductivity ratio for the Standard Seawater batch P160 in the salinometer S/N 62827 (before correction)

Figure 3.7-2 shows the history of the double conductivity ratio of the Standard Seawater batch P160 after correction in the salinometer S/N 62827. The average of the double conductivity ratio in 70 bottles of SSW after correction was 1.99966 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

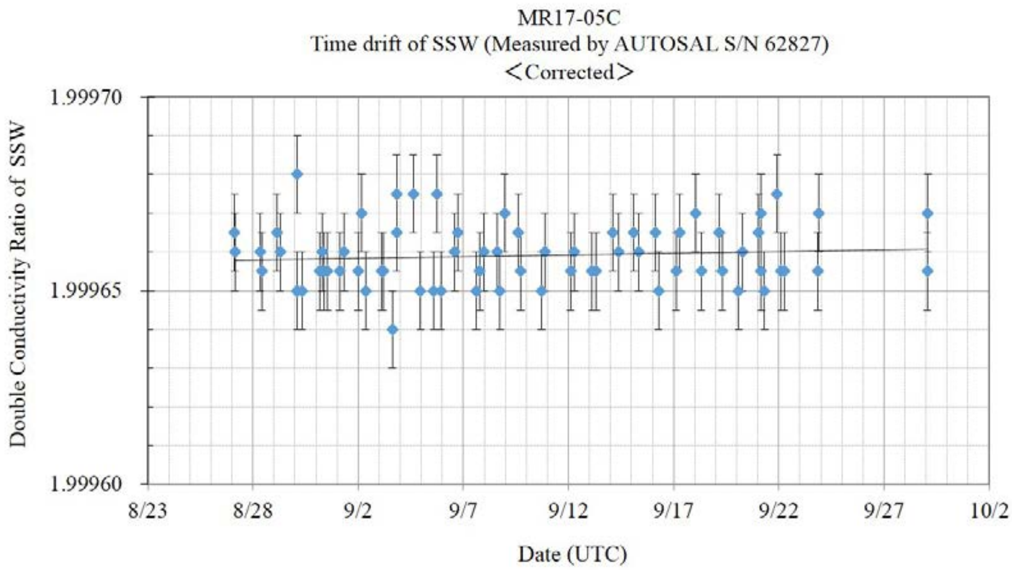

Figure 3.7-2: History of double conductivity ratio for the Standard Seawater batch P160 in the salinometer S/N 62827 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from surface-sea water (poor in nutrient) filtered by a pore size of 0.2 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 252 pairs of replicate samples taken from the same Niskin bottle.

Figure 3.7-3 shows the histogram of the absolute difference between each pair of all replicate samples. The average and the standard deviation of absolute difference among 252 pairs were 0.0008 and 0.0011 in salinity, respectively.

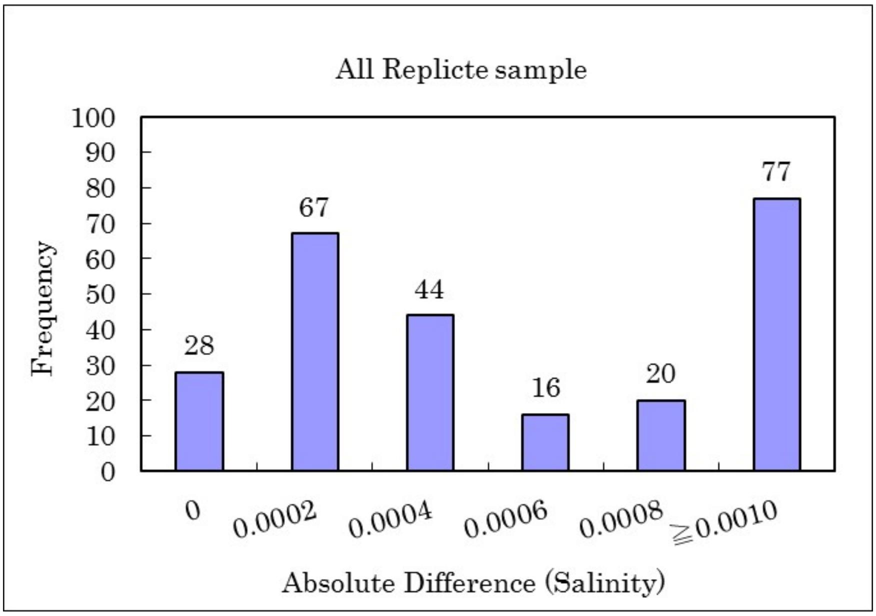

Figure 3.7-3: Histogram of the Absolute Difference of all Replicate Samples

185 pairs of replicate samples were to estimate the precision of shallow (<200dbar) samples. Figure 3.7-4 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 185 pairs were 0.0009 and 0.0013 in salinity, respectively.

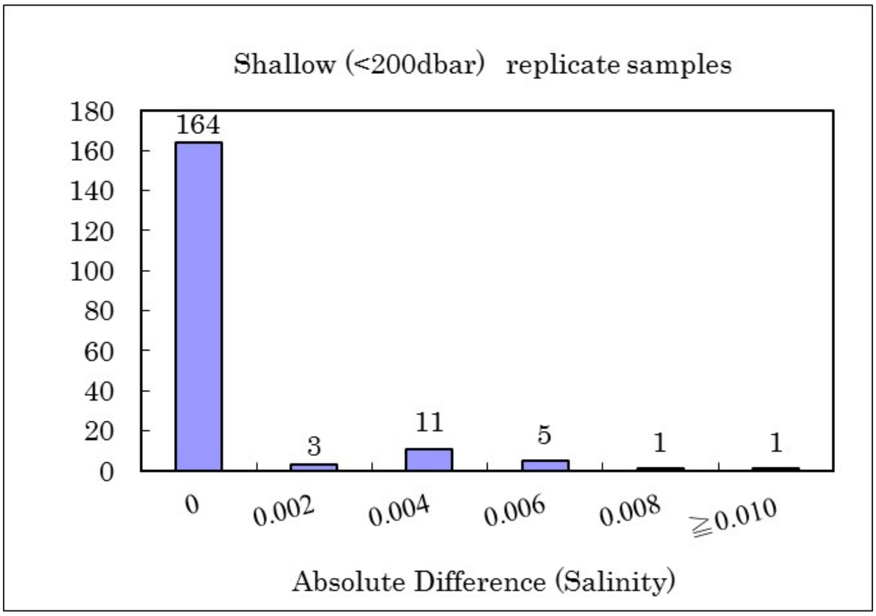

Figure 3.7-4: Histogram of the Absolute Difference between Shallow (<200dbar) Replicate Samples

67 pairs of replicate samples were to estimate the precision of deep (>=200dbar) samples. Figure 3.7-5 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 67 pairs were 0.0004 and 0.0003 in salinity, respectively.

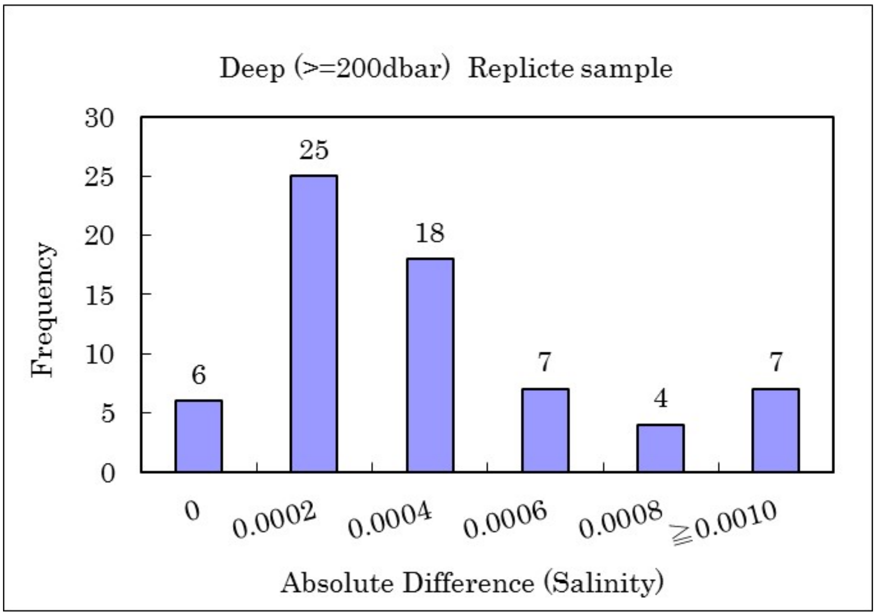

Figure 3.7-5: Histogram of the Absolute Difference between Deep (>=200dbar) Replicate Samples

d. Data Correction for Samples

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

(7) Data archives

a. Data Policy

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

<http://www.godac.jamstec.go.jp/darwin/e>

b. References

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

3.8. Density

(1) Personnel

Hiroshi Uchida	JAMSTEC	- Principal Investigator
Shigeto Nishino	JAMSTEC	
Amane Fujiwara	JAMSTEC	
Hiroshi Matsunaga	MWJ	

(2) Objectives

The objective of this study is to collect absolute salinity (also called "density salinity") data, and to evaluate an algorithm to estimate absolute salinity provided along with TEOS-10 (the International Thermodynamic Equation of Seawater 2010) (IOC et al., 2010).

(3) Materials and methods

Seawater densities will be measured after the cruise with an oscillation-type density meter (DMA 5000M, serial no. 81661961, Anton-Paar GmbH, Graz, Austria) with a sample changer (Xsample 122, serial no. 81683390, Anton-Paar GmbH). The sample changer will be used to load samples automatically from up to ninety-six 12-mL glass vials.

The water samples were collected in 100-mL aluminum bottles (Mini Bottle Can, Daiwa Can Company, Japan). The bottles were stored at room temperature (~23 °C) upside down until measurement after the cruise. The water sample will be filled in a 12-mL glass vial and the glass vial was sealed with Parafilm M (Pechiney Plastic Packaging, Inc., Menasha, Wisconsin, USA) immediately after filling. Densities of the samples will be measured at 20 °C by the density meter two times for each bottle and averaged to estimate the density. When the difference between the two measurements is greater than 0.002, additional measurements will be conducted until two samples satisfying the above criteria is obtained.

Time drift of the density meter will be monitored by periodically measuring the density of ultra-pure water (Milli-Q water, Millipore, Billerica, Massachusetts, USA) prepared from Yokosuka (Japan) tap water in June 2017. The true density at 20 °C of the Milli-Q water was estimated to be 998.2042 kg m^{-3} from the isotopic composition ($\delta D = -8.86$ ‰, $\delta^{18}O = -59.9$ ‰) and International Association for the Properties of Water and Steam (IAPWS)-95 standard. An offset correction will be applied to the measured density by using the Milli-Q water measurements ($\rho_{Milli\text{-}Q}$) with a slight modification of the density dependency (Uchida et al., 2011). The offset (ρ_{offset}) of the measured density (ρ) was evaluated in September 2016 as follows:

$$\rho_{offset} = (\rho_{Milli\text{-}Q} - 998.2042) - (\rho - 998.2042) \times 0.000277 \text{ [kg m}^{-3}\text{]}.$$

The offset correction will be verified by measuring Reference Material for Density in Seawater (prototype Dn-RM1 and PRE18) produced by Kanso Technos Co., Ltd., Osaka, Japan, along with the Milli-Q water.

Density salinity can be back calculated from measured density and temperature (20 °C) with TEOS-10.

(4) Station list

Seawater density samples were taken at the following CTD stations (station_cast): 001_1, 009_1, 015_1, 020_1, 027_1, 037_1, 044_1, 045_1, 052_1, 063_1, 067_1, 068_1, 069_2, 074_1, 081_1, 085_1, 089_1, 090_1, 093_1, 097_1, 098_1, 109_1, and 111_1.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(6) References

IOC, SCOR and IAPSO (2010): The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, United Nations Educational, Scientific and Cultural Organization (English), 196 pp.

Pawlowicz, R., D. G. Wright and F. J. Millero (2011): The effects of biogeochemical processes on ocean conductivity/salinity/density relationships and the characterization of real seawater. *Ocean Science*, 7, 363–387.

Uchida, H., T. Kawano, M. Aoyama and A. Murata (2011): Absolute salinity measurements of standard seawaters for conductivity and nutrients. *La mer*, 49, 237–244.

3.9. Sound velocity

(1) Personnel

Hiroshi Uchida	JAMSTEC	- Principal Investigator
Shigeto Nishino	JAMSTEC	
Shinsuke Toyoda	MWJ	- Operation leader
Hiroki Ushiromura	MWJ	
Keisuke Takeda	MWJ	
Rio Kobayashi	MWJ	

(2) Objectives

The objective of this study is to estimate Absolute Salinity (also called “density salinity”) from sound velocity data with temperature and pressure data from CTD, and to evaluate an algorithm to estimate absolute salinity provided along with TEOS-10 (the International Thermodynamic Equation of Seawater 2010) (IOC et al., 2010).

(3) Materials and methods

Sound velocity profiles were measured at the CTD casts by using a velocimeter (MiniSVS OEM, serial no. 24001, Valeport Ltd., Devon, United Kingdom). The OEM version of velocimeter was inserted in a titanium housing designed for shipboard CTD observations (JFE Advantech Co. Ltd., Hyogo, Japan). The sound velocity sensing elements are a ceramic transducer (signal sound pulse of 2.5 MHz frequency), a signal reflector, and spacer rods to control the sound path length (5 cm), providing a measurement at depths up to 11,000 m. The velocimeter was attached to the CTD frame and level of the sound path of the velocimeter was same as that of the CTD temperature sensor, just next to the primary temperature sensor. Sound velocity data measured at a sampling rate of about 12 Hz will be combined with the CTD temperature and pressure data measured at a sampling rate of 24 Hz to estimate Absolute Salinity.

The estimated Absolute Salinity profiles will be calibrated in situ referred to the Absolute Salinity data measured by a density meter for water samples (see Section 3.8).

(4) Station list

Sound velocity data were obtained at all CTD stations.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(6) Reference

IOC, SCOR and IAPSO (2010): The international thermodynamic equation of seawater

– 2010: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, United Nations Educational, Scientific and Cultural Organization (English), 196 pp.

3.10. Moorings

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Amane Fujiwara	JAMSTEC	
Motoyo Itoh	JAMSTEC	- not on board
Takashi Kikuchi	JAMSTEC	- not on board
Jonaotaro Onodera	JAMSTEC	
Naomi Harada	JAMSTEC	- not on board
Keisuke Matsumoto	MWJ	- Technical leader
Hiroki Ushiromura	MWJ	
Keisuke Takeda	MWJ	

(2) Objectives

We recovered six moorings (BCE-16, BCC-16, BCW-16, SCH-16, NHC-16t, and NBC-16t) and deployed six similar configuration moorings. One mooring was deployed in the southern Chukchi Sea (SCH-17), and three moorings were deployed in the Barrow Canyon (BCE-17, BCC-17, and BCW-17). The locations of the deployed moorings are almost the same as those of the recovered moorings. In addition, two sediment trap moorings were deployed at the north of Barrow Canyon (NBC-17t) and north of Hanna Canyon (NHC-17t), the locations which are almost the same as those of the recovered moorings. Details of the sediment trap moorings are described in section 4.16 (PI: Naomi Harada, JAMSTEC).

The purpose of mooring measurements at the Barrow Canyon (BCE-17, BCC-17, and BCW-17) is to monitor the variations of volume, heat, and fresh water fluxes of Pacific Water. The purpose of mooring measurements at the southern Chukchi Sea (SCH-17) where the biological activity is extremely high and is called a biological hotspot is to understand the ocean environment and its annual changes maintaining the hotspot. Components of these moorings are depicted in Figures 3.10-1 and 3.10-2.

(3) Parameters

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

(4) Instruments and methods

a. CTD or CT sensors

SBE37-SM (Sea-Bird Electronics Inc.)

A7CT-USB (JFE Advantech)

b. Current meters
Workhorse ADCP 300 kHz SC Sentinel (Teledyne RD Instruments, Inc.)
Aquadopp Current Meter 2MHz (NORTEK AS)
S4 current meter (InterOcean systems, Inc.)

c. Dissolved oxygen sensor
AROW-USB (JFE Advantech)

d. Chlorophyll-a and turbidity sensor
ACLW-USB (JFE Advantech)
MFL50W-USB (JFE Advantech)

e. Acoustic transponder
XT-6000-10 (Teledyne Benthos, Inc.)
XT-6001-13 (Teledyne Benthos, Inc.)

f. Acoustic releaser
Model-L (Nichiyu giken kogyo co., LTD)
Model-LGC (Nichiyu giken kogyo co., LTD)
8242XS (ORE offshore /EdgeTech)

(5) Station list

Table 3.10-1: Stations of deployed moorings

Mooring ID	Deployment Date [UTC]	Latitude [N]	Longitude [W]	Bottom depth [m]
SCH-17	2017/09/19	68-01.9728	168-50.1688	58.7
BCE-17	2017/09/10	71-40.3780	155-00.0284	107.1
BCC-17	2017/09/10	71-44.0350	155-09.6701	285.8
BCW-17	2017/09/09	71-47.7669	155-20.6778	170.6
NBC-17t	2017/09/03	72-28.3045	155-25.0015	1,980
NHC-17t	2017/09/13	73-18.2324	160-47.0225	425.0

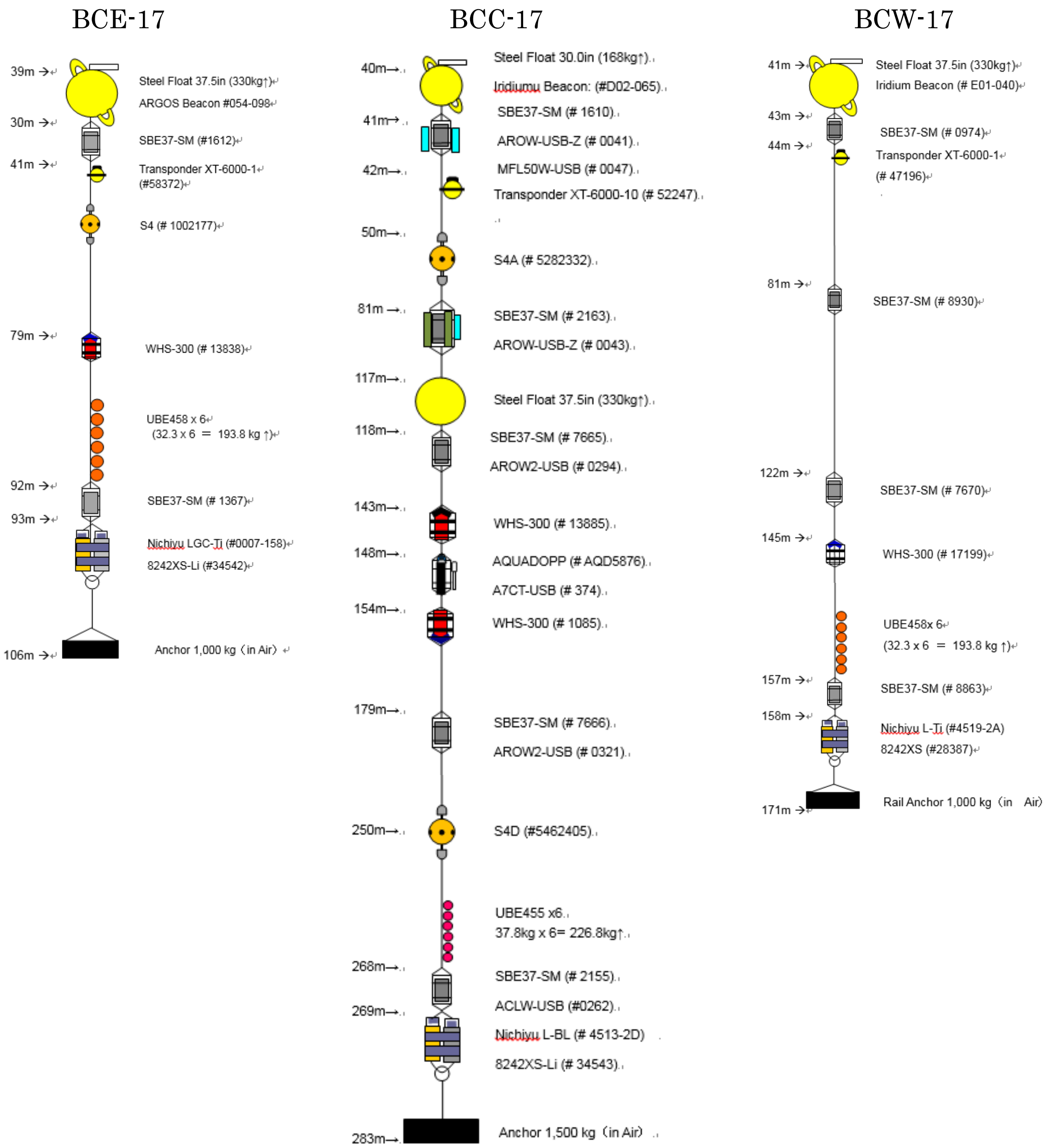

Figure 3.10-1: Diagrams of deployed moorings (BCE-17, BCC-17, and BCW-17).

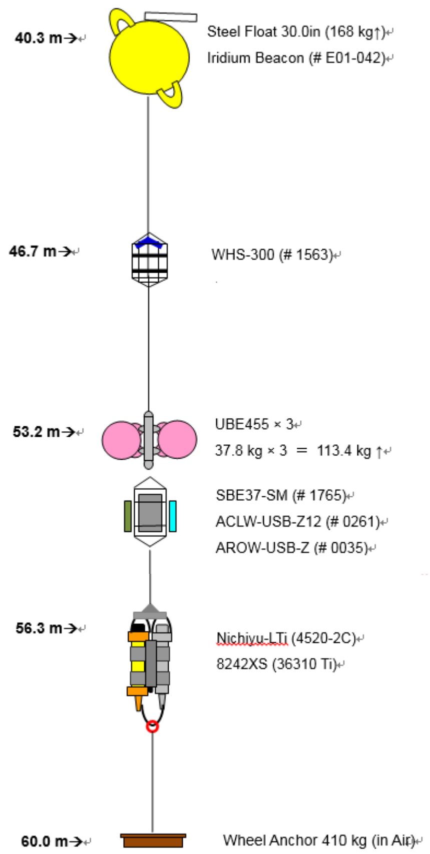

Figure 3.10-2: Diagram of deployed mooring (SCH-17).

(6) Data archives

These mooring data will be opened to the public via a web site below.
<http://www.jamstec.go.jp/arctic/data_archive/mooring/mooring_index.html>

4. Chemical and Biological Oceanography
4.1. Dissolved Oxygen

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Katsunori Sagishima	MWJ	- Operation Leader
Masahiro Orui	MWJ	
Atsushi Ono	MWJ	
Erii Irie	MWJ	

(2) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Parameters

Dissolved Oxygen

(4) Instruments and Methods

Following procedure is based on winkler method (Dickson, 1996; Culberson, 1991).

a. Instruments

Burette for sodium thiosulfate and potassium iodate;

Automatic piston burette (APB-510 / APB-620) manufactured by Kyoto Electronics Manufacturing Co., Ltd. / 10 cm^3 of titration vessel

Detector;

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

Software;

DOT_Terminal Ver. 1.2.0

b. Reagents

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

Pickling Reagent II:

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

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

Sodium thiosulfate (0.025 mol dm^{-3})

Potassium iodate (0.001667 mol dm^{-3})

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD/Carousel Water Sampling System (CTD system). Seawater for oxygen measurement was transferred from the bottle to a volume calibrated flask (ca. 100 cm^3), and three times volume of the flask was overflowed. Temperature was simulteneously measured by digital thermometer during the overflowing. After transfering the sample, two reagent solutions (Reagent I and II) of 1 cm^3 each were added immediately 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

For over two hours after the re-shaking, the pickled samples were measured on board. Sulfuric acid solution with its volume of 1 cm^3 and a magnetic stirrer bar were put into the sample flask and the sample was stirred. The 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. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the sensor on CTD system, flask volume, and titrated volume of sodium thiosulfate solution without the blank. During this cruise, 2 sets of the titration apparatus were used.

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, and 1.7835 g of it was dissolved in deionized water and diluted to final weight of 5 kg in a flask. After 10 cm^3 of the standard potassium iodate solution was added to an another flask using a volume-calibrated dispenser, 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 1 cm^3 of pickling reagent solution II and I were added in order. Amount of titrated volume of sodium thiosulfate for this diluted standard potassium iodate solution (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (1 cm^3) and II (1 cm^3) was assumed to be 7.6×10^{-8} mol (Murray et al., 1968). The blank due to other than oxygen was determined as follows. First, 1 and 2 cm^3 of the standard potassium iodate solution were added to each flask using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, 1 cm^3 of pickling II reagent solution, and same volume of pickling I reagent solution were added into the flask in order. The blank was determined by difference between the first (1 cm^3 of potassium iodate) titrated volume of the sodium thiosulfate and the second (2 cm^3 of potassium iodate) one. The titrations were conducted for 3 times and their average was used as the blank value.

(5) Observation log

a. Standardization and determination of the blank

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 cruise

Date (yyyy/mm/dd)	Potassium iodate ID	Sodium thiosulfate ID	DOT-01X (No.7)		DOT-01X (No.8)		Stations
			E.P. (cm^3)	Blank (cm^3)	E.P. (cm^3)	Blank (cm^3)	
2017/8/24	K1704B01	T1704D	3.969	0.001	3.976	0.007	001, 002, 003, 004, 005, 006
2017/8/24	K1704B01	T1704D	3.969	0.001	3.977	0.007	
2017/8/28	K1704B02	T1704D	3.968	0.001	3.975	0.006	007, 008, 009, 010, 011, 012, 013, 014, 015, 016, 017, 018, 019, 020
2017/8/28	K1704B02	T1704D	3.968	0.001	3.975	0.006	
2017/8/31	K1704B03	T1704D	3.968	0.002	3.973	0.006	021, 022, 023, 024, 025, 026, 027, 028, 029, 034, 035, 036, 037, 038, 039, 044
2017/8/31	K1704B03	T1704D	3.968	0.002	3.974	0.006	
2017/9/3	K1704B04	T1704D	3.970	0.006	3.973	0.006	
2017/9/3	K1704B04	T1704E	3.966	0.001	3.969	0.003	045, 046, 048, 049, 051, 052, 053, 054, 055, 056, 057, 058, 059, 060, 061, 062, 063, 064, 065, 066, 067
2017/9/7	K1704B05	T1704E	3.964	0.005	3.968	0.005	
2017/9/7	K1704B06	T1704E	3.965	0.005	3.969	0.005	068, 069, 071, 074, 076, 077
2017/9/11	K1704B08	T1704E	3.965	0.005	3.967	0.003	
2017/9/11	K1704B08	T1704F	3.971	-0.002	3.970	0.002	078, 079, 080, 081, 082, 083, 084, 085, 086, 087, 088
2017/9/15	K1704B07	T1704F	3.97	0.004	3.97	0.007	

			7		2		
2017/9/15	K1704B09	T1704F	3.971	0.001	3.968	0.003	089, 090, 091, 092, 093, 094, 095, 096, 097
2017/9/18	K1704B10	T1704F	3.975	0.003	3.968	0.003	
2017/9/18	K1704B10	T1704F	3.966	-0.004	3.967	0.003	098, 099, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111
2017/9/23	K1704B11	T1704G	3.962	-0.004	3.968	0.006	
2017/9/23	K1704C01	T1704G	3.965	-0.002	3.971	0.006	

b. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. The standard deviation of the replicate measurement (Dickson et al., 2007) calculated from all replicate samples was 0.33 μmol kg^{-1} (n=228). For more detail, list was shown in Table 4.1-2.

Table 4.1-2: Results of the replicate sample measurements

Layer	Number of replicate sample pairs	Oxygen concentration (μmol kg^{-1}) Standard Deviation.
200 m >	194	0.36
≥ 200 m	34	0.08
All	228	0.33

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site. <http://www.godac.jamstec.go.jp/darwin/e>

(7) References

Culberson, C. H. (1991). *Dissolved Oxygen.* WHPO Publication 91-1.

Dickson, A. G. (1996). Determination of dissolved oxygen in sea water by Winkler titration. In *WOCE Operations Manual*, Part 3.1.3 Operations & Methods, WHP Office Report WHPO 91-1.

Dickson, A. G., Sabine, C. L., & Christian, J. R.(Eds.), (2007). *Guide to best practices for ocean CO_2 measurements, PICES Special Publication 3*: North Pacific Marine Science Organization.

Murray, C. N., Riley, J. P., & Wilson, T. R. S. (1968). The solubility of oxygen in Winklerreagents used for the determination of dissolved oxygen. *Deep Sea Res.*, 15, 237-238.

4.2. Nutrients

(1) Personnel

Michio Aoyama	JAMSTEC/Fukushima Univ.	-Principal Investigator
Shigeto Nishino	JAMSTEC)	
Yasuhiro Arii	MWJ	- Operation Leader
Shinichiro Yokogawa	MWJ	
Keitaro Matsumoto	MWJ	
Takehiko Shiribiki	MWJ	

(2) Objectives

The objectives of nutrients analyses during the R/V Mirai MR17-05C cruise in the Arctic Ocean, of which EXPOCODE is 49NZ20170824, is as follows:

- Describe the present status of nutrients concentration with excellent comparability using certified reference material of nutrient in seawater.

(3) Parameters

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

(4) Instruments and methods

(4.1) Analytical detail using QuAAtro 2-HR systems (BL TEC K.K.)

Nitrate + nitrite and nitrite are analyzed following a modification of the method of Grasshoff (1976). The sample nitrate is reduced to nitrite in a cadmium tube the inside of which is coated with metallic copper. The sample stream after reduction is treated with an acidic, sulfanilamide reagent to produce a diazonium ion. N-1-Naphthylethylenediamine Dihydrochloride added to the sample stream 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. (1999). Silicomolybdic acid is first formed from the silicate in the sample and molybdic acid. The silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using ascorbic acid.

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.

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 details of modification of analytical methods for four parameters, Nitrate, Nitrite, Silicate and Phosphate, used in this cruise are also compatible with the methods described in nutrients section in GO-SHIP repeat hydrography manual (Hydes et al., 2010), while an analytical method of ammonium is compatible with Determination of ammonia in seawater using a vaporization membrane permeability method (Kimura, 2000). The flow diagrams and reagents for each parameter are shown in Figures 4.2-1 to 4.2-5.

(4.2) Nitrate + Nitrite Reagents

50 % Triton solution

50 mL Triton™ X-100 provided by Sigma-Ardrich Japan G. K. (CAS No. 9002-93-1) .were mixed with 50 mL Ethanol (99.5 %).

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

Dissolve 4 g Imidazole (CAS No. 288-32-4), in 1000 mL Ultra-pure water, add 2 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL 50 % Triton solution is added.

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

Dissolve 10 g 4-Aminobenzenesulfonamide (CAS No. 63-74-1), in 900 mL of Ultra-pure water, add 100 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL 50 % Triton solution is added.

NED, 0.004 M (0.1 % w/v)

Dissolve 1 g N-(1-Naphthalenyl)-1,2-ethanediamine, dihydrochloride (CAS No. 1465-25-4), in 1000 mL of Ultra-pure water and add 10 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL 50 % Triton solution is added. This reagent was stored in a dark bottle.

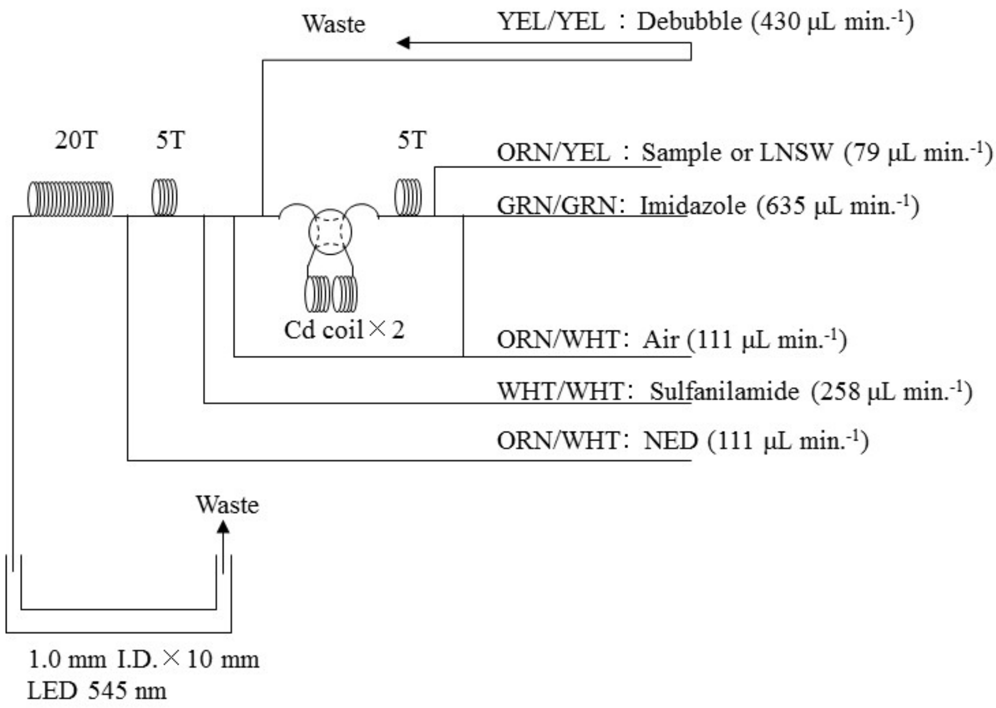

Figure 4.2-1: NO_3+NO_2 (1ch.) Flow diagram.

(4.3) Nitrite Reagents

50 % Triton solution

50 mL Triton™ X-100 provided by Sigma-Ardrich Japan G. K. (CAS No. 9002-93-1) .were mixed with 50 mL Ethanol (99.5 %).

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

Dissolve 10 g 4-Aminobenzenesulfonamide (CAS No. 63-74-1), in 900 mL of Ultra-pure water, add 100 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL 50 % Triton solution is added.

NED, 0.004 M (0.1 % w/v)

Dissolve 1 g N-(1-Naphthalenyl)-1,2-ethanediamine, dihydrochloride (CAS No. 1465-25-4), in 1000 mL of Ultra-pure water and add 10 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL 50 % Triton solution is added. This reagent was stored in a dark bottle.

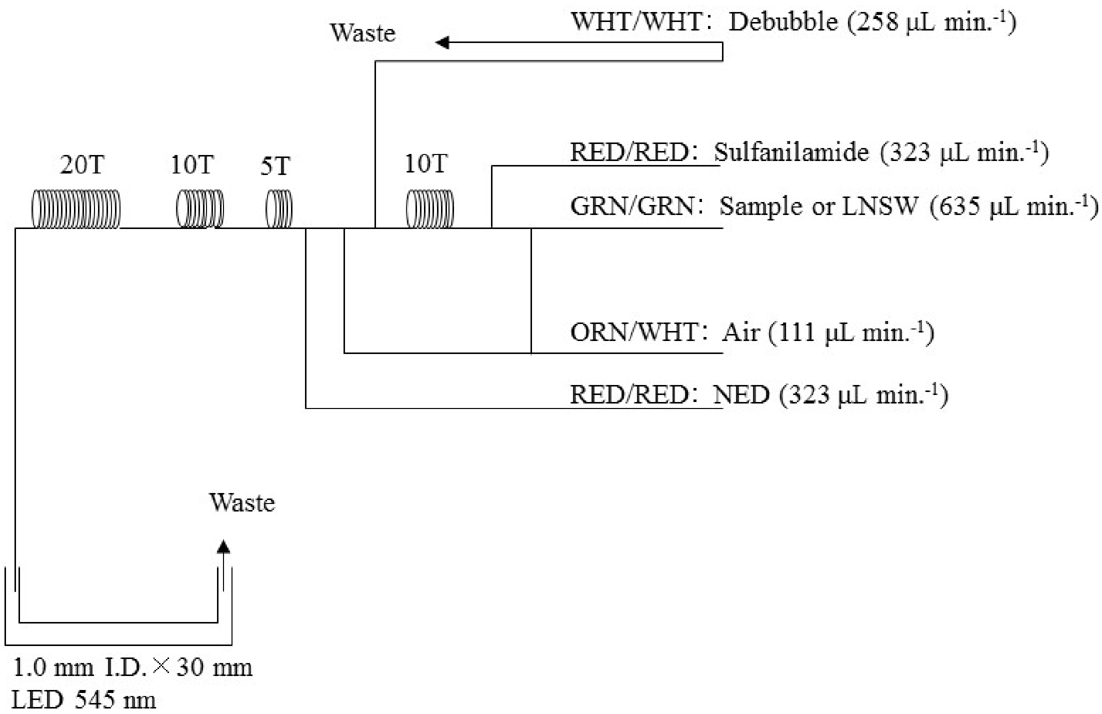

Figure 4.2-2: NO_2 (2ch.) Flow diagram.

(4.4) Silicate Reagents

15 % Sodium dodecyl sulfate solution

75 g Sodium dodecyl sulfate (CAS No. 151-21-3) were mixed with 425 mL Ultra-pure water.

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

Dissolve 15 g Sodium molybdate dihydrate (CAS No. 10102-40-6), in 980 mL Ultra-pure water, add 8 mL Sulfuric acid (CAS No. 7664-93-9). After mixing, 20 mL 15 % Sodium dodecyl sulfate solution is added.

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

Dissolve 50 g Oxalic acid (CAS No. 144-62-7), in 950 mL of Ultra-pure water.

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

Dissolve 2.5 g L-Ascorbic acid (CAS No. 50-81-7), in 100 mL of Ultra-pure water. This reagent was freshly prepared at every day.

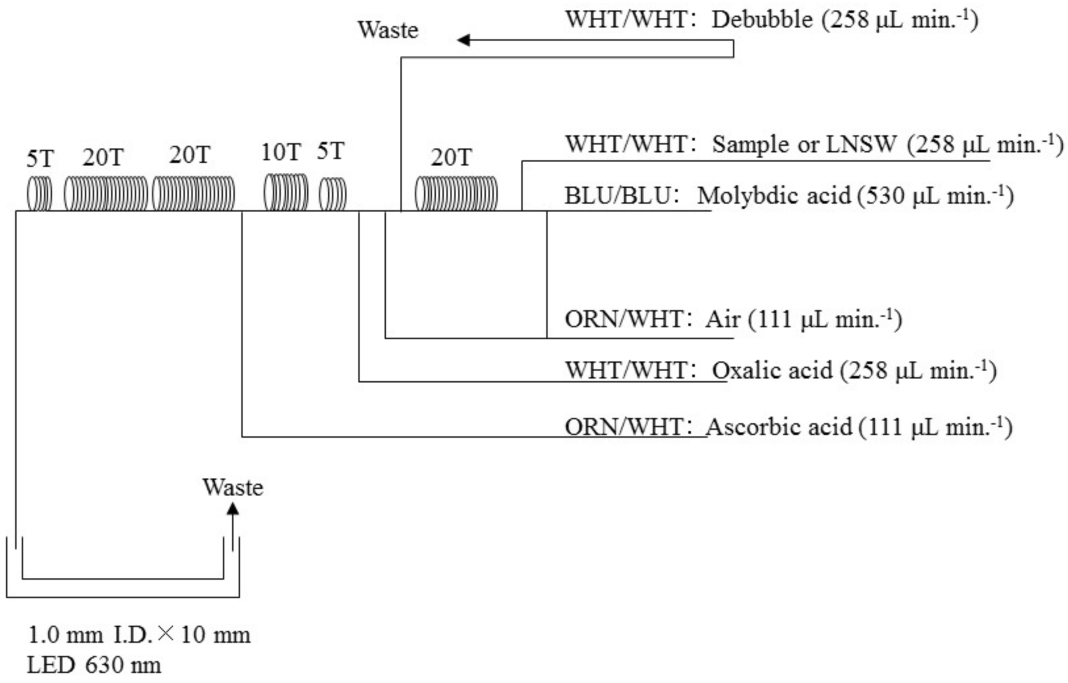

Figure 4.2-3: SiO_2 (3ch.) Flow diagram.

(4.5) Phosphate Reagents

15 % Sodium dodecyl sulfate solution

75 g Sodium dodecyl sulfate (CAS No. 151-21-3) were mixed with 425 mL Ultra-pure water.

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

Dissolve 8 g Sodium molybdate dihydrate (CAS No. 10102-40-6), and 0.17 g Antimony potassium tartrate trihydrate (CAS No. 28300-74-5), in 950 mL of Ultra-pure water and added 50 mL Sulfuric acid (CAS No. 7664-93-9).

PO_4 color reagent

Dissolve 1.2 g L-Ascorbic acid (CAS No. 50-81-7), in 150 mL of stock molybdate solution. After mixing, 3 mL 15 % Sodium dodecyl sulfate solution is added. This reagent was freshly prepared before every measurement.

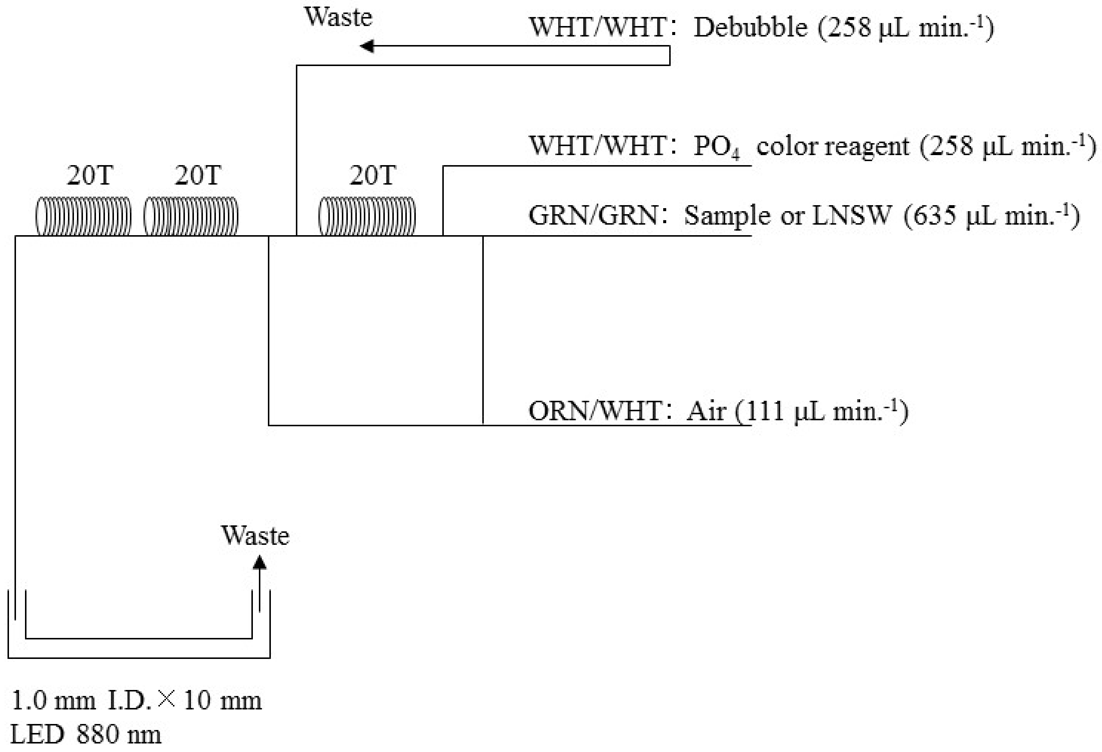

Figure 4.2-4: PO_4 (4ch.) Flow diagram.

(4.6) Ammonia Reagents

30 % Triton solution

30 mL Triton™ X-100 provided by Sigma-Ardrich Japan G. K. (CAS No. 9002-93-1) .were mixed with 70 mL Ultra-pure water.

EDTA

Dissolve 41 g tetrasodium;2-[2-[bis(carboxylatomethyl)amino]ethyl-(carboxylatomethyl)amino]acetate;tetrahydrate (CAS No. 13235-36-4), and 2 g Boric acid (CAS No. 10043-35-3), in 200 mL of Ultra-pure water. After mixing, 1 mL 30 % Triton solution is added. This reagent is prepared at a week about.

NaOH liquid

Dissolve 5 g Sodium hydroxide (CAS No. 1310-73-2), and 16 g tetrasodium;2-[2-[bis(carboxylatomethyl)amino]ethyl-(carboxylatomethyl)amino]acetate;tetrahydrate (CAS No. 13235-36-4) in 100 mL of Ultra-pure water. This reagent is prepared at a week about.

Stock nitroprusside

Dissolve 0.25 g Sodium nitroferricyanide dihydrate (CAS No. 13755-38-9) in 100 mL of Ultra-pure water and add 0.2 mL 1M Sulfuric acid. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

Mix 4 mL stock nitroprusside and 5 mL 1M Sulfuric acid in 500 mL of Ultra-pure water. After mixing, 2 mL 30 % Triton solution is added. This reagent is stored in a dark bottle and prepared at every 2 or 3 days.

Alkaline phenol

Dissolve 10 g Phenol (CAS No. 108-95-2), 5 g Sodium hydroxide (CAS No. 1310-73-2) and 2 g Sodium citrate dihydrate (CAS No. 6132-04-3), in 200 mL Ultra-pure water. Stored in a dark bottle and prepared at a week about.

NaClO solution

Mix 5 mL Sodium hypochlorite (CAS No. 7681-52-9) in 45 mL Ultra-pure water. Stored in a dark bottle and fleshly prepared before every measurement. This reagent is prepared 0.3 % available chlorine.

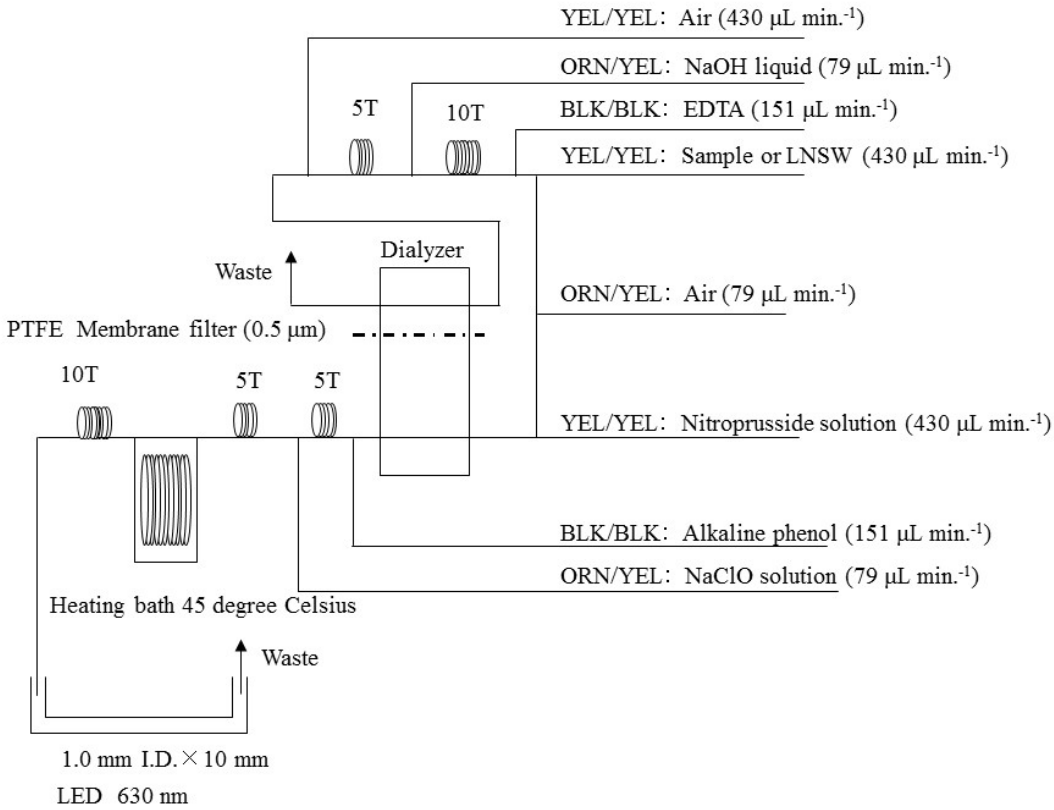

Figure 4.2-5: NH_4 (5ch.) Flow diagram.

(4.7) Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into a virgin 10 mL polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials are put into water bath adjusted to ambient temperature, 21.5 ± 0.5 degree Celsius, in about 30 minutes before use to stabilize the temperature of samples. When we found the value of Xmiss of the sample was less than 95 % or doubtful for the particles in the sample, we carried out centrifuging for the samples by using the centrifuge (type: CN-820, Hsiang Tai). The conditions of centrifuging were set about 2100 rpm for 2.5 minute.

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

(4.8) Data processing

Raw data from QuAAtro 2-HR were treated as follows:

- Check baseline shift.
- Check the shape of each peak and positions of peak values taken, and then change the positions of peak values taken if necessary.
- Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.
- Baseline correction and sensitivity correction were done basically using liner regression.
- Load pressure and salinity from uncalibrate CTD data to calculate density of seawater tentatively. To calculate the final nutrients concentration we used salinity obtained bottle samples for 1205 samples and salinity from uncalibrate CTD data for 36 samples.
- Calibration curves to get nutrients concentration were assumed second order equations.

(4.9) Summary of nutrients analysis

We made 39 QuAAtro runs for the water columns sample collected by 98 casts at 97 stations as shown in Table 4.2-1 during MR17-05C. The total amount of layers of the seawater sample reached to 1241. We made basically duplicate measurement. The station locations for nutrients measurement is shown in Figure 4.2-6.

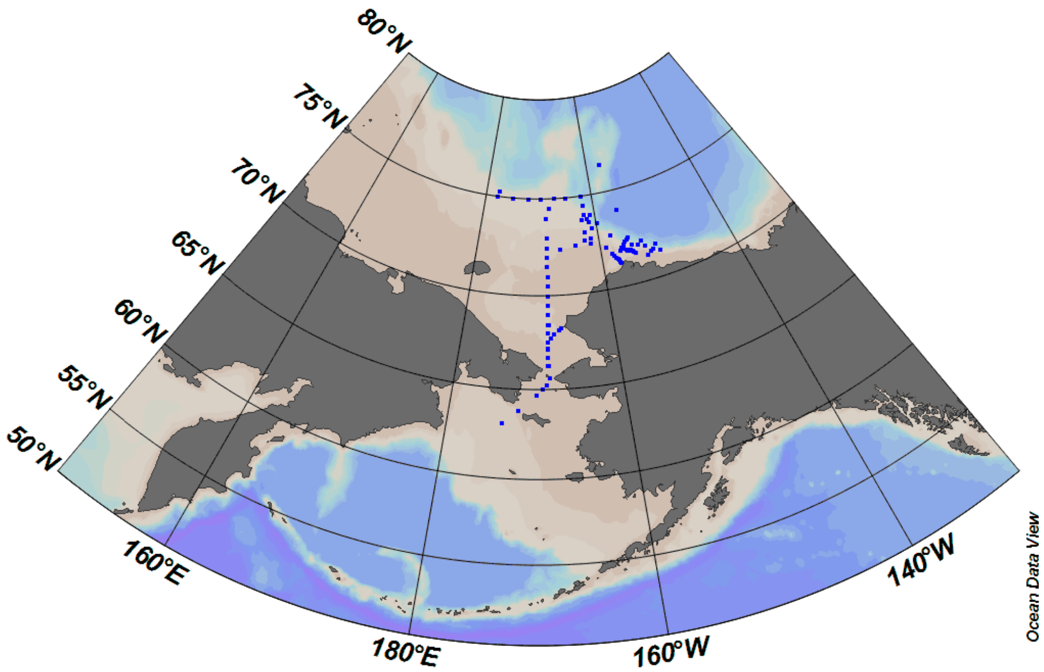

Figure 4.2-6: Sampling positions of nutrients sample.

(5) Station list

The sampling station list for nutrients is shown in Table 4.2-1.

Table 4.2-1: List of stations

Station	Cast	Date (UTC)	Position*		Depth (m)
		(mmddyy)	Latitude	Longitude	
001	1	082617	63-05.58N	174-00.76W	76.5
002	1	082717	63-51.73N	172-17.84W	55.3
003	1	082717	64-42.59N	170-20.94W	48.1
004	1	082717	65-02.90N	169-35.50W	50.7
005	1	082717	65-16.56N	169-02.94W	53.8
006	1	082817	65-39.21N	168-41.90W	49.5
007	1	082817	66-16.38N	168-50.96W	55.2
008	1	082817	67-12.00N	168-54.08W	48.9
009	1	082817	67-34.51N	168-50.93W	50.4
010	1	082817	68-01.13N	168-50.13W	58.6
011	1	082917	68-30.06N	168-45.21W	53.1
012	1	082917	69-00.01N	168-44.70W	53.1
013	1	082917	69-29.83N	168-45.74W	51.3
014	1	082917	69-59.99N	168-45.20W	41.0
015	1	082917	70-30.00N	168-45.06W	39.2
016	1	082917	70-59.97N	168-45.54W	45.1
017	1	083017	71-30.04N	168-44.95W	49.4
018	1	083017	72-00.03N	168-44.93W	51.7
019	1	083017	72-24.12N	166-39.23W	50.7
020	2	083017	72-32.93N	163-58.48W	51.7
021	1	083017	72-47.95N	161-20.83W	50.5

022	1	083117	72-12.63N	159-10.30W	50.2
023	1	083117	71-50.72N	158-23.84W	58.3
024	1	083117	71-42.71N	158-07.13W	58.5
025	1	083117	71-34.83N	157-50.98W	65.2
026	1	083117	71-29.84N	157-40.40W	84.1
027	1	083117	71-25.52N	157-32.41W	120.6
028	1	083117	71-19.73N	157-20.98W	91.6
029	1	083117	71-14.34N	157-13.04W	48.1
034	1	090117	71-52.70N	156-02.68W	81.1
035	1	090117	71-49.73N	155-50.78W	90.9
036	1	090117	71-48.03N	155-24.04W	150.0
037	1	090117	71-44.06N	155-13.64W	305.0
038	1	090117	71-39.99N	155-01.88W	107.7
039	1	090117	71-35.57N	154-48.88W	39.8
044	1	090217	72-27.80N	155-27.91W	1897.0
045	1	090317	72-07.55N	153-30.49W	1812.0
046	1	090317	71-45.08N	151-29.70W	1795.0
048	1	090317	71-34.16N	152-00.09W	496.0
049	1	090417	71-29.37N	152-21.10W	128.0
051	1	090417	71-19.81N	153-03.99W	79.5
052	1	090417	71-21.42N	151-00.42W	225.0
053	1	090417	71-47.82N	152-59.81W	471.0
054	1	090417	71-57.86N	154-00.81W	684.0
055	1	090517	72-04.03N	155-00.58W	387.0
056	1	090517	72-22.76N	155-42.34W	1330.0
057	1	090517	72-17.14N	156-00.03W	790.0
058	1	090517	72-09.85N	156-20.92W	224.0
059	1	090517	72-01.88N	156-40.26W	113.0
060	1	090517	71-54.51N	157-00.48W	78.4
061	1	090517	71-56.58N	156-29.44W	64.9
062	1	090517	71-53.07N	156-03.08W	81.4
063	1	090617	71-49.64N	155-50.00W	89.9
064	1	090617	71-48.10N	155-23.09W	148.7
065	1	090617	71-44.18N	155-11.98W	305.3
066	1	090617	71-40.12N	155-01.78W	108.3
067	1	090617	71-35.59N	154-48.79W	40.0
068	1	090817	76-25.93N	157-16.11W	1639.0
069	1	090817	73-59.77N	156-01.52W	3863.0
069	2	090817	73-59.81N	156-03.68W	3863.0
071	1	091017	72-47.32N	158-00.43W	788.0
074	1	091017	73-18.55N	160-51.69W	385.0
076	1	091117	73-31.17N	159-51.39W	1996.0
077	1	091117	73-09.44N	162-18.74W	197.0
078	1	091217	74-00.17N	160-59.52W	459.0
079	1	091217	73-49.34N	161-29.37W	515.0
080	1	091217	73-39.98N	161-14.26W	484.0
081	1	091217	74-04.12N	162-00.22W	632.0

082	1	091217	73-49.59N	162-27.95W	256.0
083	1	091317	72-44.39N	162-27.23W	49.6
084	1	091317	72-33.34N	161-32.06W	46.2
085	2	091417	74-31.50N	161-53.90W	1694.0
086	1	091417	74-59.84N	161-59.93W	1973.0
087	1	091417	75-00.22N	164-59.95W	546.0
088	1	091517	75-00.19N	167-13.73W	257.0
089	1	091617	75-15.18N	177-43.29W	776.0
090	1	091617	75-00.05N	178-00.11W	324.0
091	1	091617	75-00.02N	174-59.85W	266.0
092	1	091617	75-00.15N	172-00.33W	384.0
093	1	091617	75-00.46N	169-37.03W	244.0
094	1	091717	74-30.16N	168-09.73W	256.0
095	1	091717	73-59.99N	168-45.07W	183.0
096	1	091717	72-59.97N	168-44.90W	62.0
097	1	091717	72-29.93N	168-44.84W	59.1
098	1	091817	68-02.15N	168-51.69W	59.0
099	1	091917	69-00.08N	168-50.66W	52.0
100	1	091917	68-30.00N	168-50.40W	53.7
101	1	091917	68-17.94N	167-03.25W	39.4
102	1	091917	68-12.03N	167-20.44W	47.8
103	1	091917	68-00.12N	168-00.36W	54.4
104	1	091917	67-44.97N	168-30.12W	50.4
105	1	092017	67-34.65N	168-50.99W	50.5
106	1	092017	67-12.09N	168-53.63W	49.1
107	1	092017	66-44.07N	168-53.85W	42.6
108	1	092017	66-16.49N	168-52.93W	55.8
109	1	092017	65-38.93N	168-42.58W	50.1
110	1	092017	65-16.23N	169-02.54W	53.3
111	1	092117	65-03.60N	169-35.77W	51.1

*: Position indicates latitude and longitude where CTD reached maximum depth at the cast.

(6) Certified Reference Material of nutrients in seawater

KANSO CRMs (Lot: CK, CD, CJ, CC, BW) were used to ensure the comparability and traceability of nutrient measurements during this cruise. The details of CRMs are shown below.

Production

KANSO CRMs are certified reference material (CRM) for inorganic nutrients in seawater. These were produced by KANSO Co.,Ltd. This certified reference material has been produced using autoclaved natural seawater on the basis of quality control system under ISO Guide 34 (JIS Q 0034).

KANSO Co.,Ltd. has been accredited under the Accreditation System of National

Institute of Technology and Evaluation (ASNITE) as a CRM producer since 2011. (Accreditation No.: ASNITE 0052 R)

Property value assignment

The certified values are arithmetic means of the results of 30 bottles from each batch (measured in duplicates) analysed by KANSO Co.,Ltd. and Japan Agency for Marine-Earth Science and Technology (JAMSTEC) using the colorimetric method (continuous flow analysis, CFA, method). The salinity of calibration solutions were adjusted to the salinity of this CRM ± 0.5.

Metrological Traceability

Each certified value of nitrate, nitrite, and phosphate of KANSO CRMs were calibrated versus one of Japan Calibration Service System (JCSS) standard solutions for each nitrate ions, nitrite ions, and phosphate ions. JCSS standard solutions are calibrated versus the secondary solution of JCSS for each of these ions. The secondary solution of JCSS is calibrated versus the specified primary solution produced by Chemicals Evaluation and Research Institute (CERI), Japan. CERI specified primary solutionsare calibrated versus the National Metrology Institute of Japan (NMIJ) primary standards solution of nitrate ions, nitrite ions and phosphate ions, respectively.

For a certified value of silicate of KANSO CRM was determined by one of Merck KGaA silicon standard solution 1000 mg L^{-1} Si traceable to National Institute of Standards and Technology (NIST) SRM of silicon standard solution (SRM 3150).

The certified values of nitrate, nitrite, and phosphate of KASNO CRM are thus traceable to the International System of Units (SI) through an unbroken chain of calibrations, JCSS, CERI and NMIJ solutions as stated above, each having stated uncertainties. The certified values of silicate of KANSO CRM are traceable to the International System of Units (SI) through an unbroken chain of calibrations, Merck KGaA and NIST SRM 3150 solutions, each having stated uncertainties.

As stated in the certificate of NMIJ CRMs each certified value of dissolved silica, nitrate ions, and nitrite ions was determined by more than one method using one of NIST (National Institute of Standards and Technology) SRM of silicon standard solution and NMIJ primary standards solution of nitrate ions and nitrite ions. The concentration of phosphate ions as stated information value in the certificate was determined NMIJ primary standards solution of phosphate ions. Those values in the certificate of NMIJ CRMs are traceable to the International System of Units (SI).

One of analytical methods used for certification of NMIJ CRM for nitrate ions, nitrite ions, phosphate ions and dissolved silica was colorimetric method (continuous mode and batch one). The colorimetric method is same as the analytical method (continuous mode only) used for certification of KANSO CRM. For certification of dissolved silica, exclusion chromatography/isotope dilution-inductively coupled plasma mass spectrometry and Ion exclusion chromatography with post-column detection were used. For certification of nitrate ions, Ion chromatography by direct analysis and Ion chromatography after halogen-ion separation were used. For certification of nitrite ions, Ion chromatography by direct analysis was used.

NMIJ CRMs were analysed at the time of certification process for CRM and the results were confirmed within expanded uncertainty stated in the certificate of NMIJ CRMs.

(6.1) CRM for this cruise

CRM lots CK, CD, CJ, CC and BW, which almost cover range of nutrients concentrations in the Arctic Ocean are prepared 37 sets.

These CRM assignments were completely done based on random number. The CRM bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 16.6 degree Celsius - 22.7 degree Celsius.

4 lot of CRMs were used as calibration standards together with the LNSW, C-5 and C-7.

(6.2) CRM concentration

We used nutrients concentrations for CRM lots CK, CD, CJ, CC and BW as shown in Table 4.2-2.

Table 4.2-2: Certified concentration and uncertainty (k=2) of CRMs.

unit: µmol kg^{-1}

Lot	Nitrate	Nitrite	Silicate	Phosphate	Ammonia*
CK	0.02 ± 0.03	0.01 ± 0.01	0.73 ± 0.08	0.048 ± 0.012	0.84
CD	5.50 ± 0.05	0.02 ± 0.00	13.93 ± 0.10	0.446 ± 0.008	1.11
CJ	16.20 ± 0.20	0.03 ± 0.01	38.50 ± 0.40	1.190 ± 0.020	0.77
CC	30.88 ± 0.24	0.12 ± 0.01	86.16 ± 0.48	2.080 ± 0.019	1.05
BW	24.59 ± 0.20	0.07 ± 0.01	60.01 ± 0.42	1.541 ± 0.014	1.03

*For ammonia values are references

(7) Nutrients standards

(7.1) 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 4 K.

(7.1.1) 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 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 4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

(7.1.2) Pipettes

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.

(7.2) Reagents, general considerations

(7.2.1) Specifications

For nitrate standard, “potassium nitrate 99.995 suprapur®” provided by Merck, Lot. B0993065, CAS No. 7757-79-1, was used.

For nitrite standard solution, we used “nitrite ion standard solution (NO_2^- 1000) provided by Wako, Lot DSK6251, Code. No. 140-06451.” This standard solution was certified by Wako using Ion chromatograph method. Calibration result is 1006 mg L^{-1} at 20 degree Celsius. Expanded uncertainty of calibration (k=2) is 0.7 % for the calibration result.

For the silicate standard, we use “Silicon standard solution SiO_2 in NaOH 0.5 M CertiPUR®” provided by Merck, Code. No. 170236, of which lot number is HC54715536 are used. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.7 %. HC54715536 is certified as 1005 mg L^{-1}.

For phosphate standard, “potassium dihydrogen phosphate anhydrous 99.995 suprapur®” provided by Merck, Lot. B1144508, CAS No.: 7778-77-0, was used.

For ammonia standard, “Ammonium Chloride” provided by NMIJ, CAS No. 12125-02-9. We used NMIJ CRM 3011-a. The purity of this standard was greater than 99.9 %. Expanded uncertainty of calibration (k=2) is 0.065 %.

(7.2.2) Ultra-pure water

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

(7.2.3) Low nutrients seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.20 µm pore capsule cartridge filter at MR15-05 cruise on January, 2016. This water is stored in 20 L cubitainer with cardboard box.

LNSW concentrations were assigned to August, 2016 on MR16-06 cruise.

(7.2.4) Concentrations of nutrients for A, D, B and C standards

Concentrations of nutrients for A, D, B and C standards are set as shown in Table 4.2-3. The C standard is prepared according recipes as shown in Table 4.2-4. All volumetric laboratory tools were calibrated prior the cruise as stated in chapter (6.1) 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 7 levels, C-1, C-2, C-3, C-4, C-5, C-6 and C-7. C-2, C-3, C-4 and C-6 were the CRMs.

Table 4.2-3: Nominal concentrations of nutrients for A, D, B and C standards.

	A	D	B	C-1	C-2	C-3	C-4	C-5	C-6	C-7
NO_3 (µM)	45000	1800	1350	LNSW	CK	CD	CJ	27	CC	41
NO_2 (µM)	21900	870	52	LNSW	CK	CD	CJ	1.0	CC	1.6
SiO_2 (µM)	35800		2860	LNSW	CK	CD	CJ	57	CC	86
PO_4 (µM)	6000		120	LNSW	CK	CD	CJ	2.4	CC	3.6
NH_4 (µM)	8000		320	LNSW				6.4		9.6

Table 4.2-4: Working calibration standard recipes.

C Std.	B Std.
C-5	10 mL
C-7	15 mL

(7.2.5) Renewal of in-house standard solutions

In-house standard solutions as stated in paragraph (6.2) were renewed as shown in Table 4.2-5(a) to (c).

Table 4.2-5(a): Timing of renewal of in-house standards.

NO_3, NO_2, SiO_2, PO_4, NH_4	Renewal
A-1 Std. (NO_3)	maximum a month
A-2 Std. (NO_2)	commercial prepared solution
A-3 Std. (SiO_2)	commercial prepared solution
A-4 Std. (PO_4)	maximum a month
A-5 Std. (NH_4)	maximum a month
D-1 Std.	maximum 8 days

D-2 Std.	maximum 8 days
B Std. (mixture of A-1, D-2, A-3, A-4 and A-5 std.)	maximum 8 days

Table 4.2-5(b): Timing of renewal of working calibration standards.

Working standards	Renewal
C Std. (dilute B Std.)	every 24 hours

Table 4.2-5(c): Timing of renewal of in-house standards for reduction estimation.

Reduction estimation	Renewal
36 µM NO_3 (dilute D-1 Std.)	when C Std. renewed
35 µM NO_2 (dilute D-2 Std.)	when C Std. renewed

(8) Quality Control

(8.1) Precision of nutrients analyses during the cruise

Precision of nutrients analyses during this cruise was evaluated based on the 9 to 13 measurements, which are measured every 6 to 13 samples, during a run at the concentration of C-7 std. Summary of precisions are shown as shown in Table 4.2-6 and Figures 4.2-7 to 4.2-11. The precisions for each parameter are generally good considering the analytical precisions during the R/V Mirai cruses conducted in 2009 - 2016. During in this cruise, analytical precisions were 0.14 % for nitrate, 0.16 % for nitrite, 0.13 % for silicate, 0.13 % for phosphate and 0.22 % for ammonia in terms of median of precision, respectively. Then we can conclude that the analytical precisions for nitrate, nitrite, silicate, phosphate and ammonia were maintained throughout this cruise.

Table 4.2-6: Summary of precision based on the replicate analyses.

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %	Ammonia CV %
Median	0.14	0.16	0.13	0.13	0.22
Mean	0.13	0.17	0.13	0.13	0.23
Maximum	0.24	0.35	0.33	0.26	0.54
Minimum	0.06	0.06	0.04	0.03	0.07
N	39	39	39	39	39

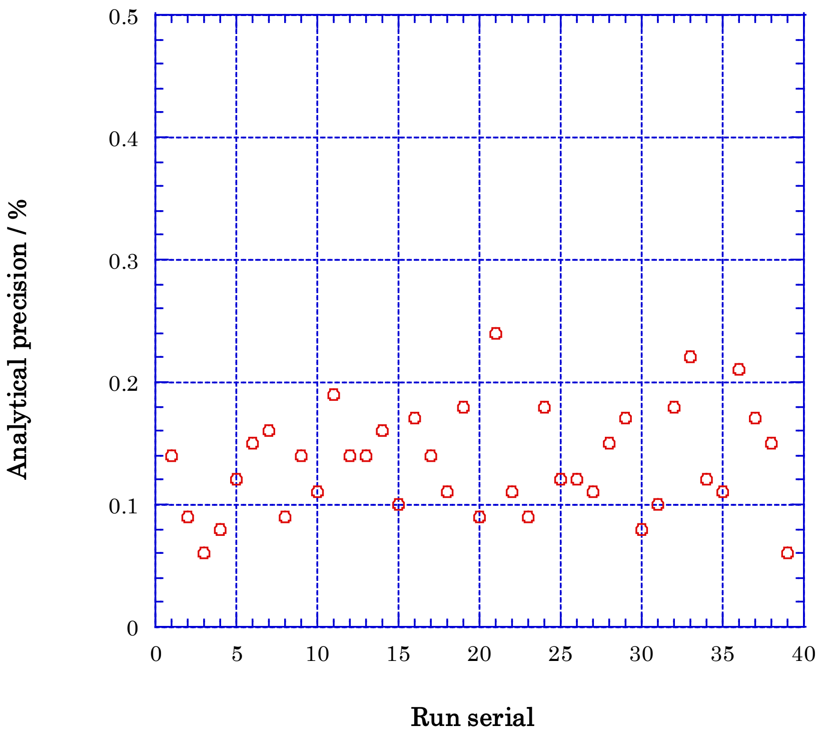

Figure 4.2-7: Time series of precision of nitrate in MR17-05C

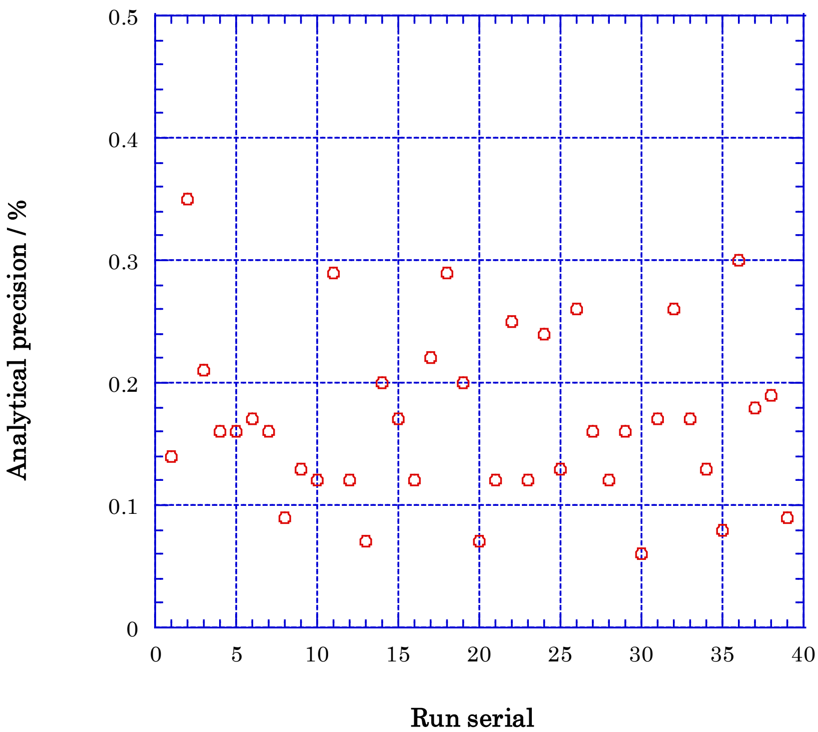

Figure 4.2-8: Time series of precision of nitrite in MR17-05C.

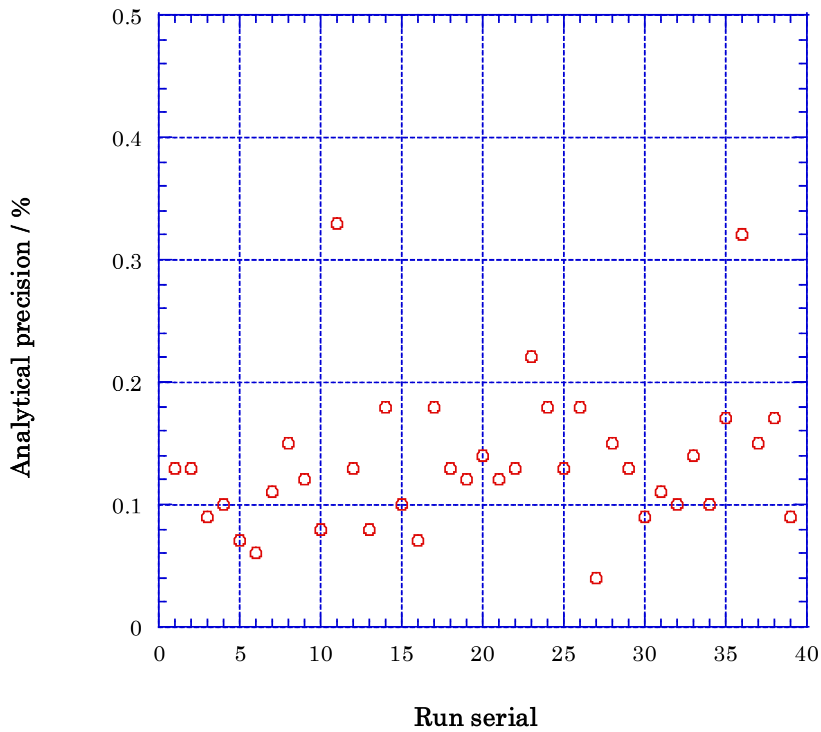

Figure 4.2-9: Time series of precision of silicate in MR17-05C.

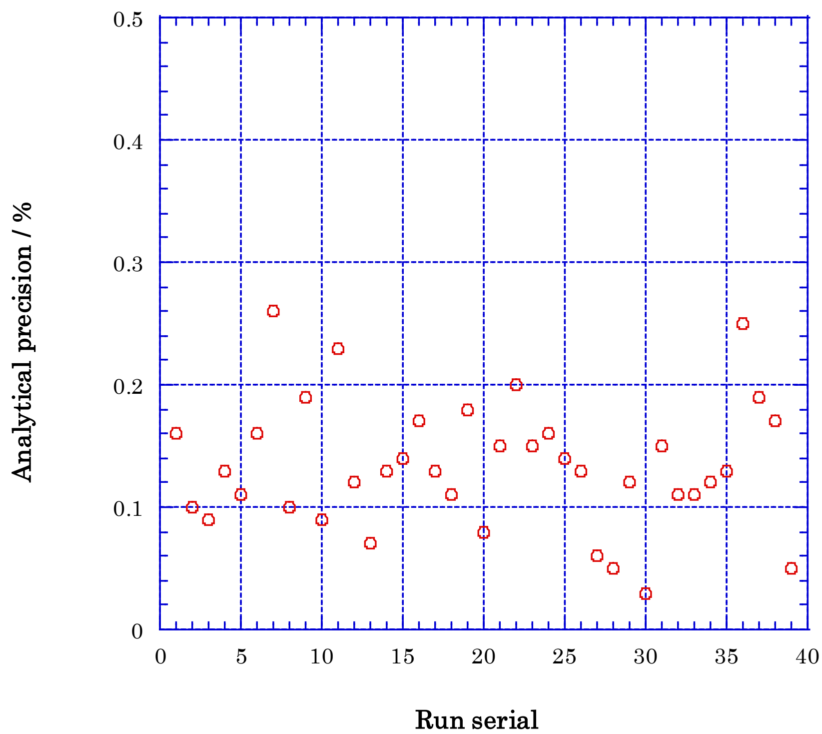

Figure 4.2-10: Time series of precision of phosphate in MR16-06.

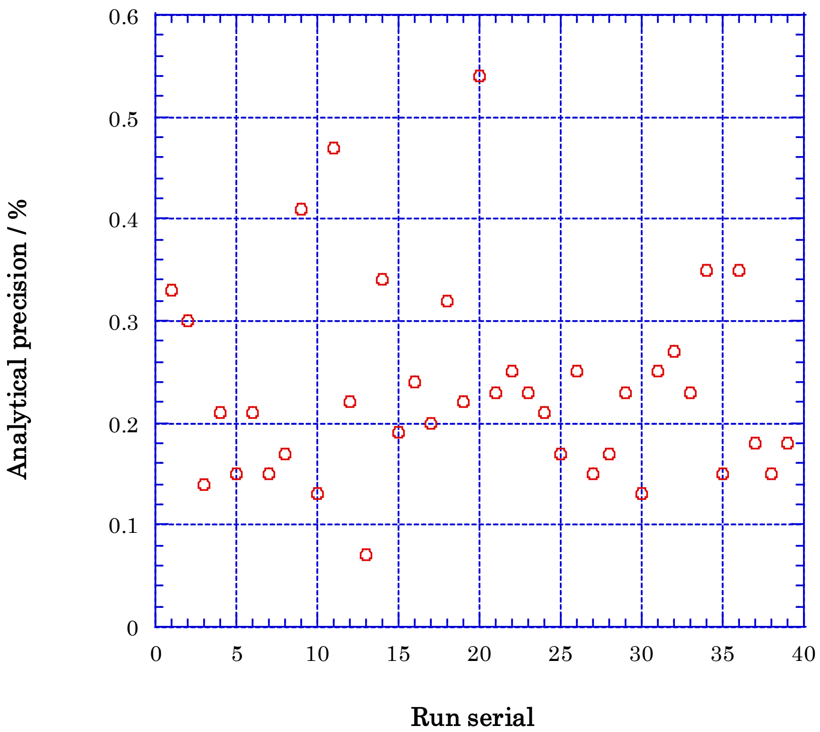

Figure 4.2-11: Time series of precision of ammonia in MR17-05C.

(8.2) CRM lot. BW measurement during this cruise

CRM lot. BW was measured every run to keep the comparability. The results of lot. BW during this cruise are shown as Figures 4.2-12 to 4.2-16.

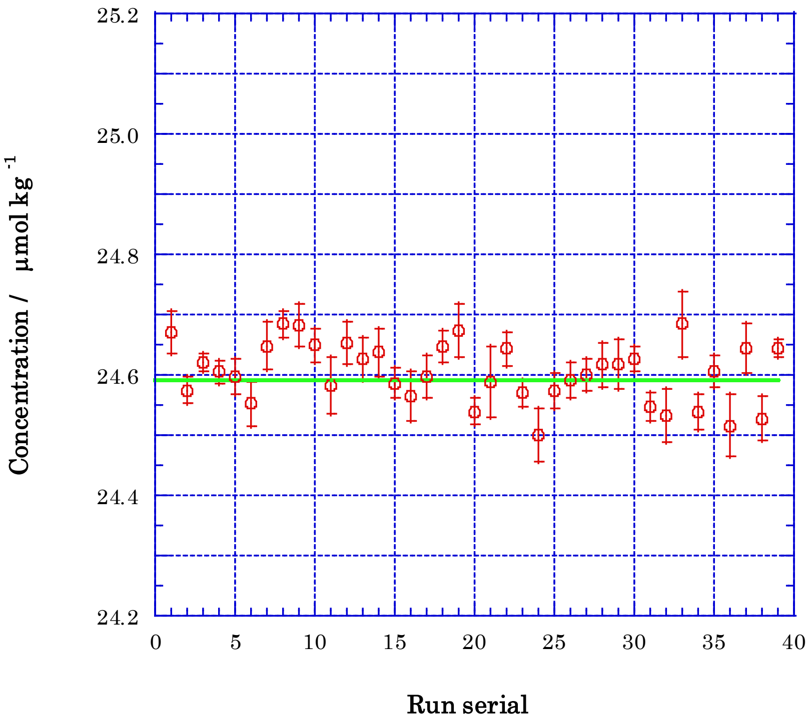

Figure 4.2-12: Time series of CRM-BW of nitrate in MR17-05C. Green line is certified nitrate concentration of CRM.

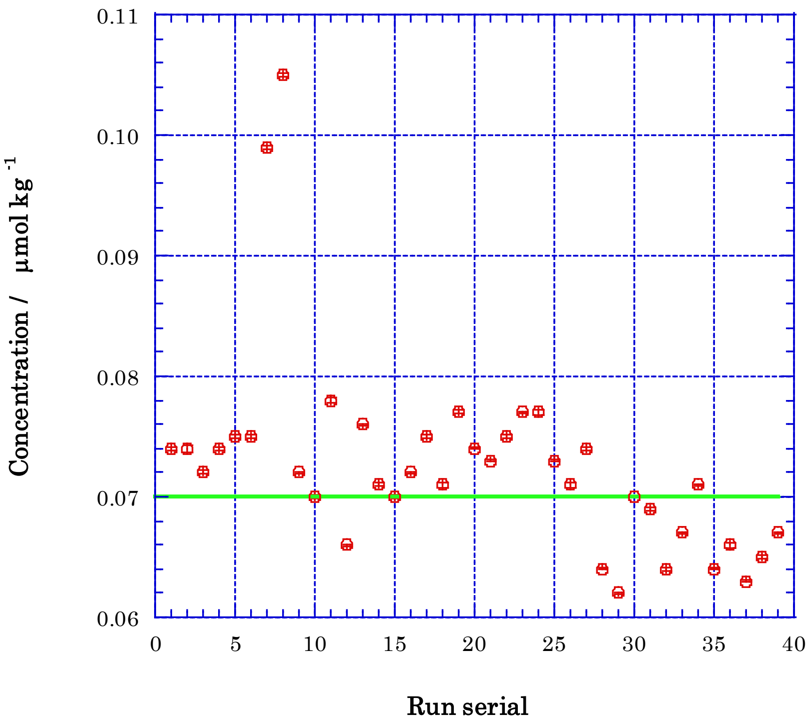

Figure 4.2-13: Time series of CRM-BW of nitrite in MR17-05C. Green line is certified nitrite concentration of CRM.

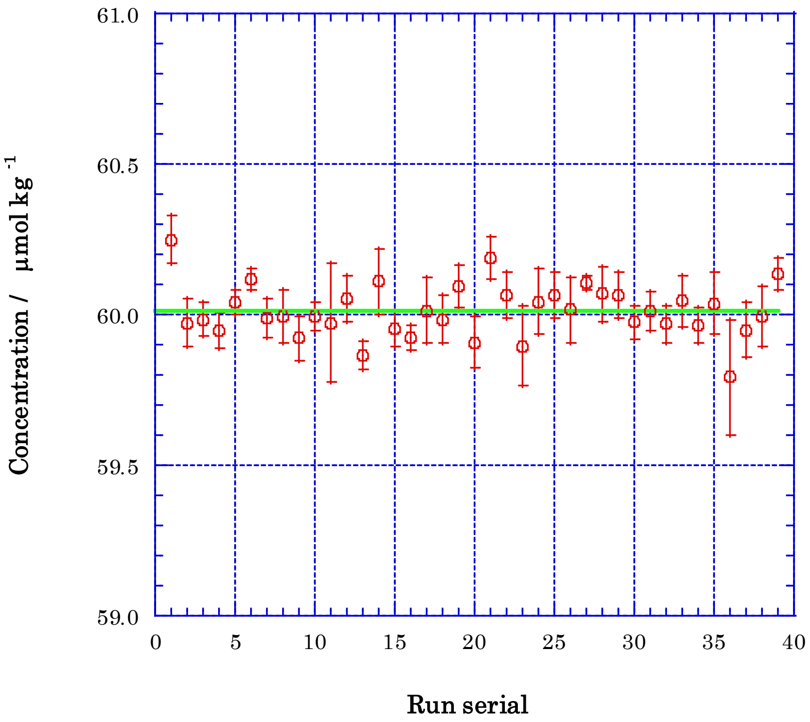

Figure 4.2-14: Time series of CRM-BW of silicate in MR17-05C. Green line is certified silicate concentration of CRM.

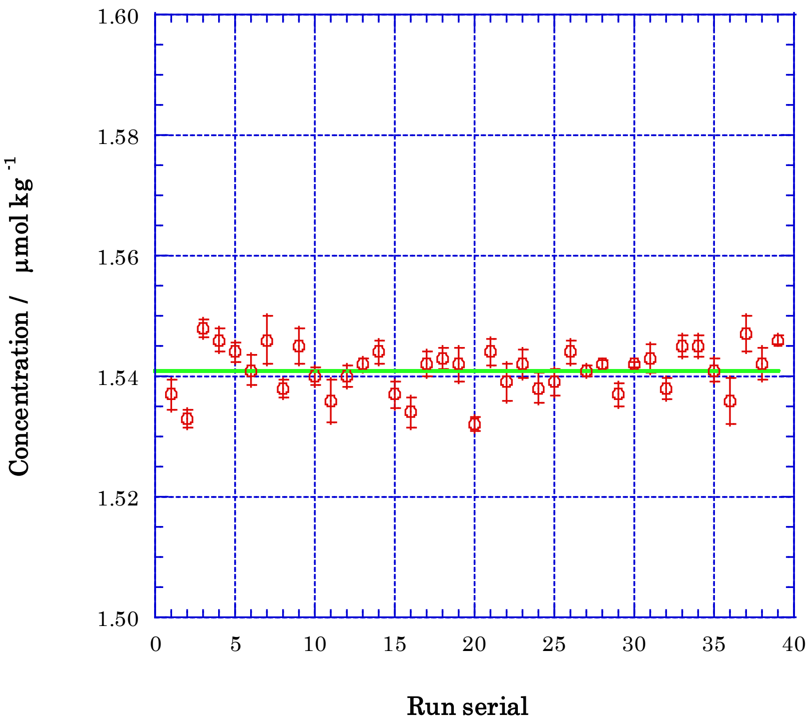

Figure 4.2-15: Time series of CRM-BW of phosphate in MR17-05C. Green line is certified phosphate concentration of CRM.

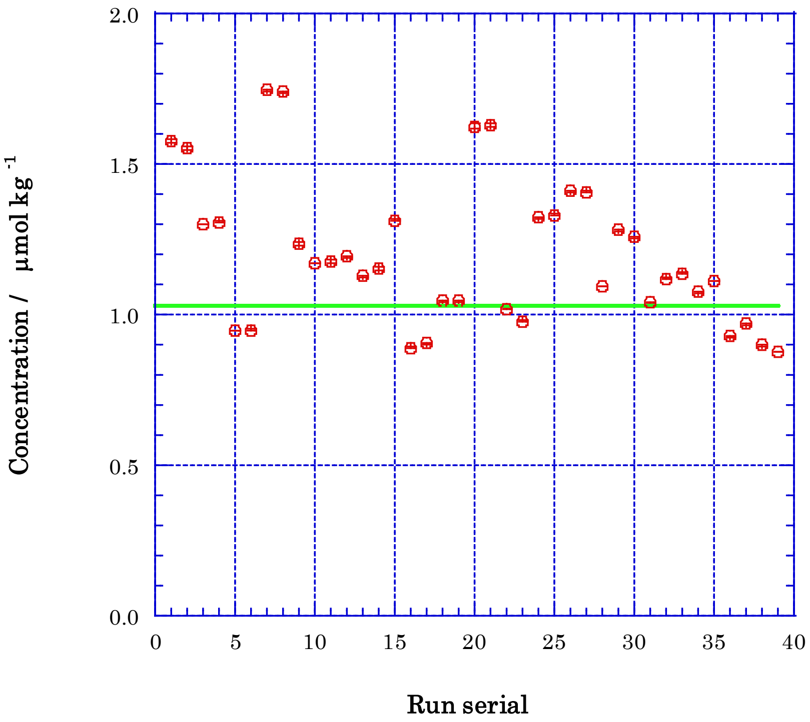

Figure 4.2-16: Time series of CRM-BW of ammonia in MR17-05C. Green line is reference value for ammonia concentration of CRM.

(8.3) 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 4.2-7 and Figure 4.2-17 to 4.2-21.

Table 4.2-7: Summary of carry over throughout MR17-05C.

	Nitrate %	Nitrite %	Silicate %	Phosphate %	Ammonia %
Median	0.16	0.05	0.08	0.12	0.33
Mean	0.15	0.07	0.08	0.12	0.35
Maximum	0.20	0.20	0.12	0.24	0.91
Minimum	0.09	0.00	0.04	0.00	0.00
N	39	39	39	39	39

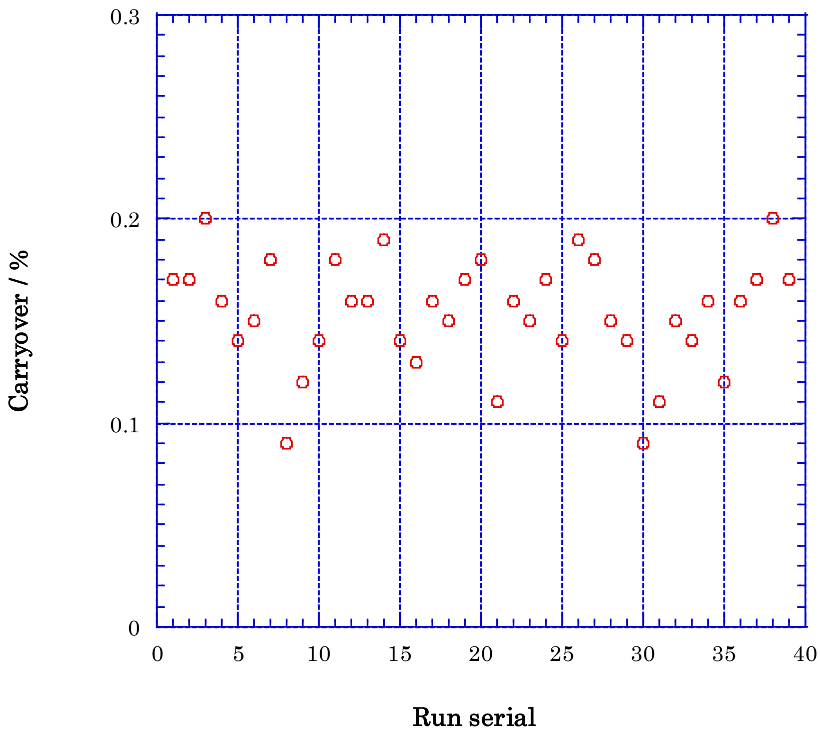

Figure 4.2-17: Time series of carry over of nitrate in MR17-05C.

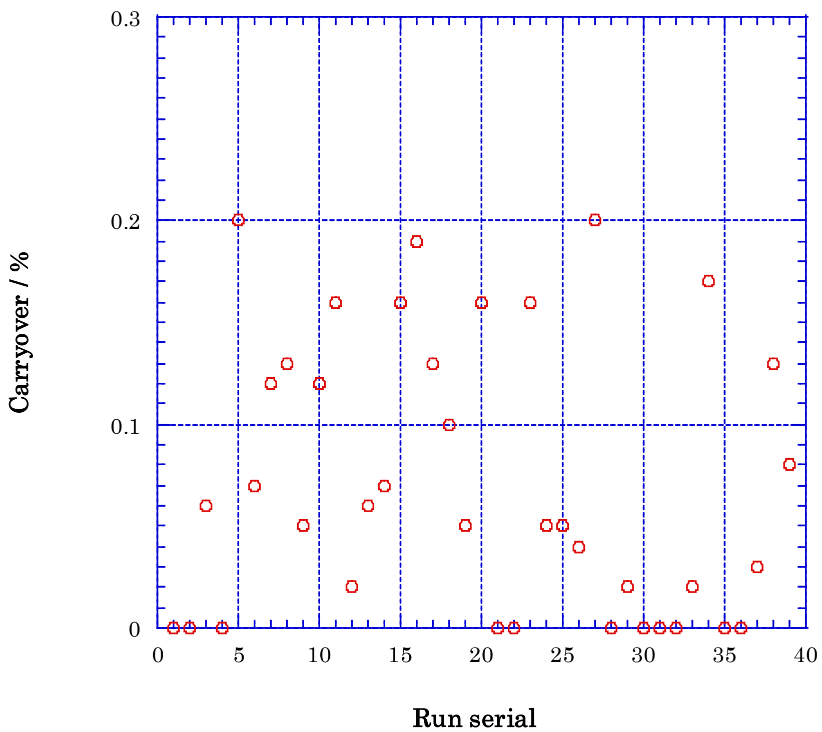

Figure 4.2-18: Time series of carry over of nitrite in MR17-05C.

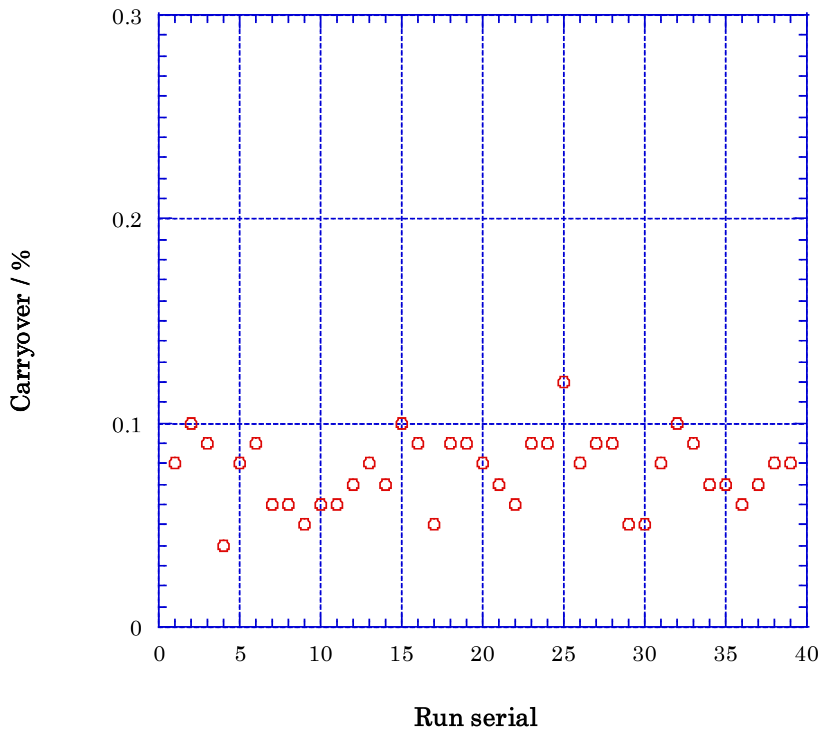

Figure 4.2-19: Time series of carry over of silicate in MR17-05C.

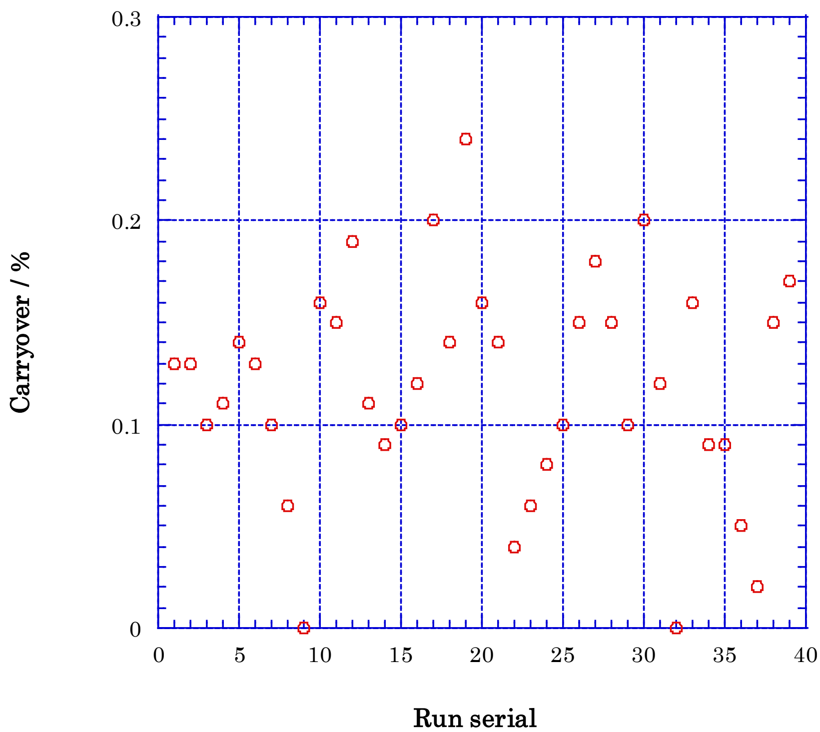

Figure 4.2-20: Time series of carry over of phosphate in MR17-05C.

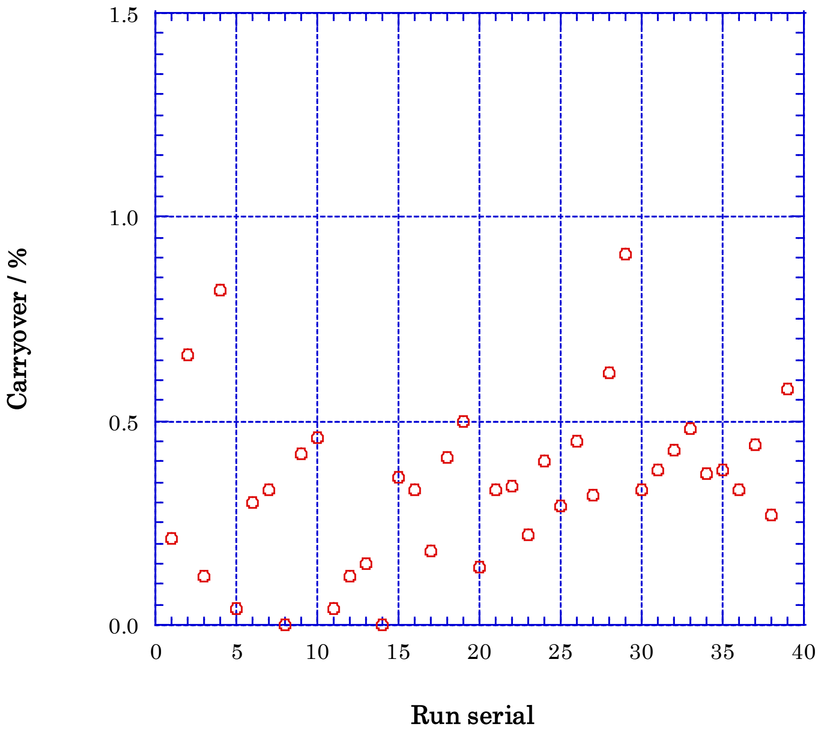

Figure 4.2-21: Time series of carry over of ammonia in MR17-05C.

(8.4) Estimation of uncertainty of nitrate, silicate, phosphate, nitrite and ammonia concentrations

Empirical equations, eq. (1), (2) and (3) to estimate uncertainty of measurement of nitrate, silicate and phosphate are used based on 43 measurements of 25 sets of CRMs (Table 4.2-2) during this cruise. These empirical equations are as follows, respectively.

Nitrate Concentration C_{NO3} in µmol kg^{-1}:
Uncertainty of measurement of nitrate (%) =
$0.11 + 2.532 * (1 / C_{NO3}) – 0.035570 * (1 / C_{NO3}) * (1 / C_{NO3})$ --- (1)
where C_{NO3} is nitrate concentration of sample.

Silicate Concentration C_{SiO2} in µmol kg^{-1}:
Uncertainty of measurement of silicate (%) =
$0.08 + 4.223 * (1/ C_{SiO2})$ --- (2)
where C_{SiO2} is silicate concentration of sample.

Phosphate Concentration C_{PO4} in µmol kg^{-1}:
Uncertainty of measurement of phosphate (%) =
$0.05 + 0.2759 * (1/ C_{PO4})$ --- (3)
where C_{PO4} is phosphate concentration of sample.

Empirical equations, eq. (4) and (5) to estimate uncertainty of measurement of nitrite and ammonia are used based on duplicate measurements of the samples.

Nitrate Concentration C_{NO2} in µmol kg^{-1}:
Uncertainty of measurement of nitrite (%) =
$-0.46 + 0.2686 * (1 / C_{NO2})$ --- (4)
where C_{NO2} is nitrite concentration of sample.

Ammonia Concentration C_{NH4} in µmol kg^{-1}:
Uncertainty of measurement of ammonia (%) =
$-0.01 + 1.6920 * (1 / C_{NH4})$ --- (5)
where C_{NH4} is ammonia concentration of sample.

(9) Problems / improvements occurred and solutions.

Nothing happened during this cruise.

We set the cover on auto sampler (AIM3200) to reduce the contamination from the ambient air.

Temperature of bio-chemical laboratory has been controlled at 21.6 ± 0.3 degree Celsius during this cruise as shown in Figure 4.2-22.

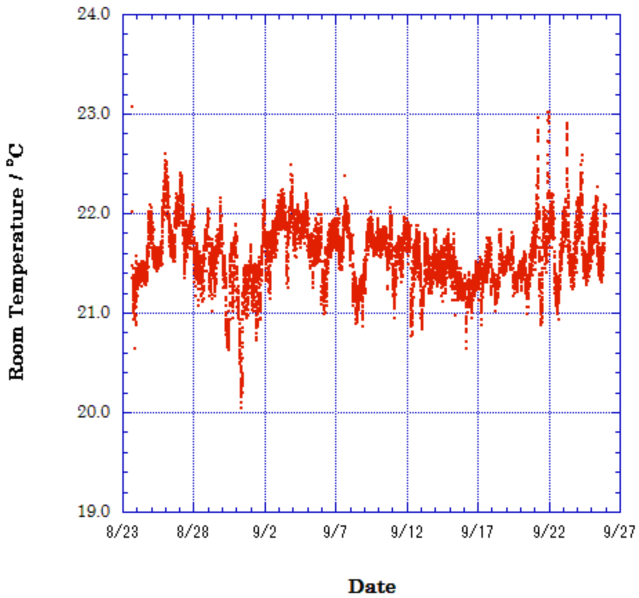

Figure 4.2-22: Temperature of laboratory in MR17-05C.

(10) List of reagent

List of reagent is shown in Table 4.2.8.

Table 4.2.8: List of reagent in MR17-05C.

IUPAC name	CAS Number	Formula	Compound Name	Manufacture	Grade
4-Aminobenzenesulfonamide	63-74-1	$C_6H_8N_2O_2S$	Sulfanilamide	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Antimony potassium tartrate trihydrate	28300-74-5	$K_2(SbC_4H_2O_6)_2\cdot 3H_2O$	Bis[(+)-tartrato]diantimonate(III) Dipotassium Trihydrate	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Boric acid	10043-35-3	H_3BO_3	Boric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Hydrogen chloride	7647-01-0	HCl	Hydrochloric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Imidazole	288-32-4	$C_3H_4N_2$	Imidazole	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
L-Ascorbic acid	50-81-7	$C_6H_8O_6$	L-Ascorbic Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
N-(1-Naphthalenyl)-1,2-ethanediamine, dihydrochloride	1465-25-4	$C_{12}H_{16}Cl_2N_2$	N-1-Naphthylethylenediamine Dihydrochloride	Wako Pure Chemical Industries, Ltd.	for Nitrogen Oxides Analysis
Oxalic acid	144-62-7	$C_2H_2O_4$	Oxalic Acid	Wako Pure Chemical Industries, Ltd.	Wako Special Grade
Phenol	108-95-2	C_6H_6O	Phenol	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Sodium citrate dihydrate	6132-04-3	$Na_3C_6H_5O_7\cdot 2H_2O$	Trisodium Citrate Dihydrate	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Sodium dodecyl sulfate	151-21-3	$C_{12}H_{25}NaO_4S$	Sodium Dodecyl Sulfate	Wako Pure Chemical Industries, Ltd.	for Biochemistry
Sodium hydroxide	1310-73-2	NaOH	Sodium Hydroxide for Nitrogen Compounds Analysis	Wako Pure Chemical Industries, Ltd.	for Nitrogen Analysis
Sodium hypochlorite	7681-52-9	NaClO	Sodium Hypochlorite Solution	Kanto Chemical co., Inc.	Extra pure
Sodium molybdate dihydrate	10102-40-6	$Na_2MoO_4\cdot 2H_2O$	Disodium Molybdate(VI) Dihydrate	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Sodium nitroferricyanide dihydrate	13755-38-9	$Na_2[Fe(CN)_5NO]\cdot 2H_2O$	Sodium Pentacyanonitrosylferrate(III) Dihydrate	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
Sulfuric acid	7664-93-9	H_2SO_4	Sulfuric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
tetrasodium;2-[2-[bis(carboxylatomethyl)amino]ethyl-(carboxylatomethyl)amino]acetate;tetrahydrate	13235-36-4	$C_{10}H_{12}N_2Na_4O_8\cdot 4H_2O$	Ethylenediamine-N,N,N',N'-tetraacetic Acid Tetrasodium Salt Tetrahydrate (4NA)	Dojindo Molecular Technologies, Inc.	-
Synonyms: t-Octylphenoxypolyethoxyethanol 4-(1,1,3,3-Tetramethylbutyl)phenyl-polyethylene glycol Polyethylene glycol tert-octylphenyl ether	9002-93-1	$(C_2H_4O)_nC_{14}H_{22}O$	Triton™ X-100	Sigma-Aldrich Japan G.K.	-

(11) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
http://www.godac.jamstec.go.jp/darwin/e

(12) References

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4.3. Dissolved Inorganic Carbon
4.3.1. Bottled-water analysis

(1) Personnel

Akihiko Murata	JAMSTEC	- Principal Investigator
Shigeto Nishino	JAMSTEC	
Yoshiko Ishikawa	MWJ	- Operation Leader
Takeo Matsumoto	MWJ	

(2) Objective

Onboard total dissolved inorganic carbon (DIC) concentration measurement of seawater collected in sampling bottles.

(3) Parameters

Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

a. Seawater sampling

Seawater samples were collected by 12 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 96 stations. Seawater was sampled in a 250 mL glass bottle (SHOTT DURAN) that was previously soaked in 5 % alkaline detergent solution (decon 90, Decon Laboratories Limited) at least 3 hours and was cleaned by fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling silicone rubber tube with PFA tip was connected to the Niskin bottle when sampling was carried out. The glass bottles were filled from its bottom gently, without rinsing, and were overflowed for 20 seconds. They were sealed using the polyethylene inner lids with its diameter of 29 mm with care not to leave any bubbles in the bottle. Within about one hour after collecting the samples on the deck, the glass bottles were carried to the laboratory to be poisoned. Small volume (3 mL) of the sample (1 % of the bottle volume) was removed from the bottle and 100 µL of over saturated solution of mercury (II) chloride was added. Then the samples were sealed by the polyethylene inner lids with its diameter of 31.9 mm and stored in a refrigerator at approximately 5 °C. About one hour before the analysis, the samples were taken from refrigerator and put in the water bath kept about 20 °C.

b. Seawater analysis

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

The seawater dispensing unit has an auto-sampler (6 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 15 mL volume. The pipette was kept at 20.00 °C ± 0.05 °C by a water jacket, in which water circulated through a thermostatic water bath (NESLAB RTE10, Thermo Fisher Scientific).

The CO_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 extraction unit by adding 10 % phosphoric acid solution. The stripping chamber is made approx. 25 cm long and has a fine frit at the bottom. First, a constant volume of acid is added to the stripping chamber from its bottom by pressurizing an acid bottle with nitrogen gas (99.9999 %). Second, a seawater sample kept in a pipette is introduced to the stripping chamber by the same method. The seawater and phosphoric acid are stirred by the nitrogen bubbles through a fine frit at the bottom of the stripping chamber. The stripped CO_2 is carried to the coulometer through two electric dehumidifiers (kept at 2 °C) and a chemical desiccant (magnesium perchlorate) by the nitrogen gas (flow rate of 140 mL min-1).

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

(5) Observation log

Seawater samples were collected at 96 stations / 97 casts (total 1,460 samples), and their locations were shown in Section 1.4. (Cruise Tracks). However, we didn't collect samples at 15 stations (stn.030-033, stn.040-043, stn.047, stn.050, stn.070, stn.072-073, stn.075, and stn.086).

(6) Preliminary results

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 (fig. 4.3.1-1). The average of the differences was provisionally 1.04 $\mu mol\ kg^{-1}$, with its standard deviation of 0.93 $\mu mol\ kg^{-1}$ (n = 223), which indicate the analysis was sufficiently accurate (< 1.5 $\mu mol\ kg^{-1}$) according to Dickson et al. (2007).

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(8) References

Dickson, A. G., Sabine, C. L. & Christian, J. R. (Eds.). (2007). *Guide to best practices for ocean CO2 measurements, PICES Special Publication 3*: North Pacific Marine Science Organization.

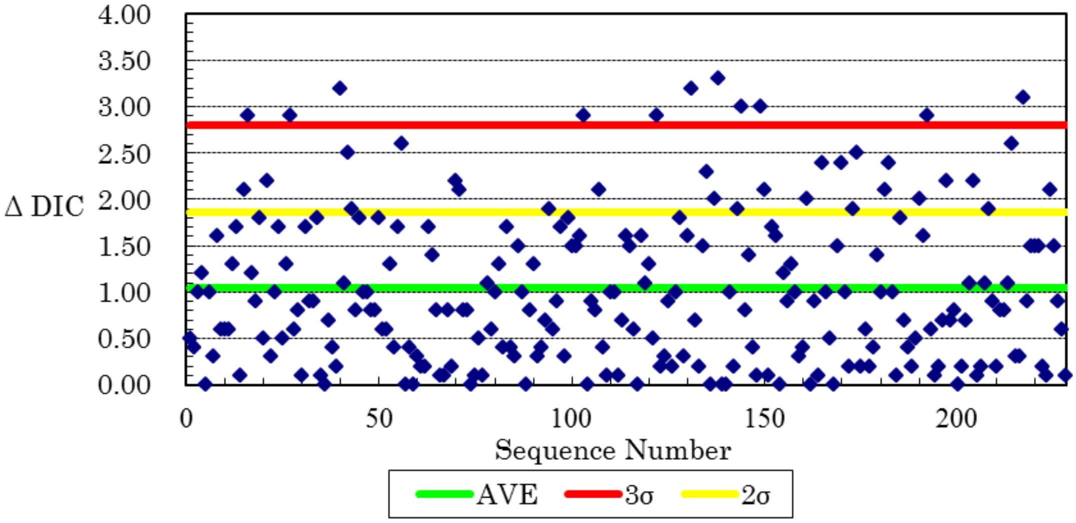


Figure 4.3.1-1: Range control chart of the absolute differences of replicate measurements of DIC carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE × 3), and 2σ upper warning limit (standard deviation of AVE × 2).

4.3.2. Underway DIC

(1) Personnel

Akihiko Murata	JAMSTEC	- Principal Investigator
Shigeto Nishino	JAMSTEC	
Atsushi Ono	MWJ	- Operation Leader

(2) Objective

Our purpose is in-situ measurement of total dissolved inorganic carbon (DIC) concentration in near-sea surface water.

(3) Parameters

DIC

(4) Instruments and Methods

Surface seawater was continuously collected from 25th August 2017 to 28th September 2017 (UTC) during this cruise. Surface seawater was taken from an intake placed at the approximately 4.5 m below the sea surface by a pump, and was filled in a 250 mL glass bottle (SCHOTT DURAN) from the bottom, without rinsing, and overflowed for more than 2 times the amount. Before the analysis, the samples were put in the water bath kept about 20 ˚C for one hour.

Measurements of DIC were made with total CO_2 measuring system (Nihon ANS Inc.). The system was comprised of seawater dispensing unit, a CO_2 extraction unit, and a coulometer (Model 3000A, Nihon ANS Inc.). The seawater dispensing unit has an auto-sampler (6 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 15 mL volume. The pipette was kept at 20.00 °C ± 0.05 °C by a water jacket, in which water circulated through a thermostatic water bath (BH201, Yamato).

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

Measurements of 1.5 % CO_2 standard gas in a nitrogen base, system blank (phosphoric acid blank), and seawater samples (6 samples) were programmed to repeat. Both CO_2 standard gas and blank signals were used to correct the signal drift results from chemical alternation of coulometer solutions. The coulometer solutions were renewed every about 2 days, and a certified reference material (CRM: batch 149) was measured each time to correct systematic difference between measurements.

(5) Observation log

Cruise track during underway DIC observation is shown in Figure 4.3.2-1.

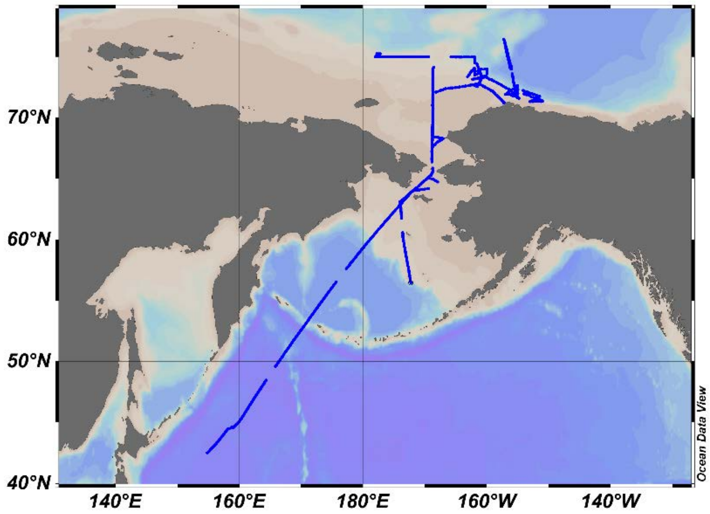


Figure 4.3.2-1 Observation map

(6) Results

The 17 sets of measurement were combined and time-series variation of sea surface DIC concentrations are plotted in Figure 4.3.2-2. The standard deviation of the absolute differences of CRM was 1.8 μmol kg^{-1} (n=17).

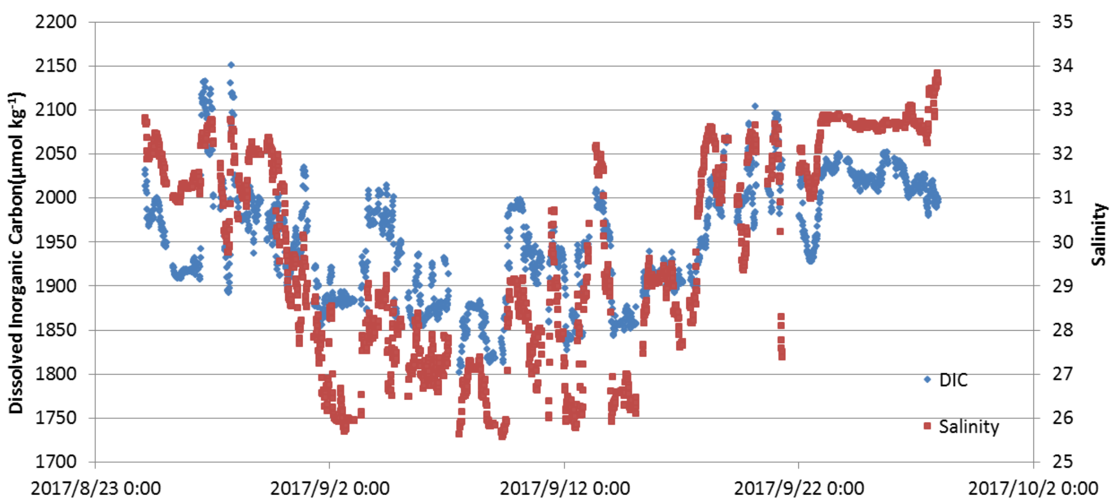


Figure 4.3.2-2 Temporal variations of underway DIC. Blue and red dots represent surface DIC and salinity, respectively.

(7) Date archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will open to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(8) References

Dickson, A. G., Sabine, C. L. & Christian, J. R. (Eds.). (2007). *Guide to best practices for ocean CO2 measurements, PICES Special Publication 3*: North Pacific Marine Science Organization.

4.4. Total Alkalinity

(1) Personnel

Akihiko Murata	JAMSTEC	- Principal Investigator
Shigeto Nishino	JAMSTEC	
Emi Deguchi	MWJ	- Operation Leader
Nagisa Fujiki	MWJ	

(2) Objectives

As described in the Section 4.3.1. (DIC), total Alkalinity (TA) is an essential parameter in carbonate system in the ocean. We have measured TA during the MR17-05C cruise to estimate pH, calcium carbonate saturation state and pCO_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. River water carries freshwater, carbon, nutrients, contaminants etc., and the changes in distribution of river water in the Arctic Ocean may affect regional and global climate, through biological productivity. Distribution of river water in the Chukchi Sea/Canada Basin region during the MR17-05C cruise will be estimated from TA and the 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 by 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 96 stations. The seawater from the Niskin bottle was filled into the 125 mL borosilicate glass bottles (SHOTT DURAN) using a sampling silicone rubber tube with PFA tip. The water was filled into the bottle from the bottom smoothly, without rinsing, and overflowed for 2 times bottle volume (10 seconds). These bottles were pre-washed in advance by soaking in 5 % alkaline detergent (decon90, Decon Laboratories Limited) for more than 3 hours, and then rinsed 5 times with tap water and 3 times with Milli-Q deionized water. The samples were stored in a refrigerator at approximately 5 °C before the analysis, and were put in the water bath with its temperature of about 25 °C for one hour just before analysis.

(4.2) Seawater analysis

The total alkalinity was measured using a spectrophotometric system (Nihon ANS, Inc.) using a scheme of Yao and Byrne (1998). The calibrated volume of sample seawater (ca. 42 mL) was transferred from a sample bottle into the titration cell with its light path length of 4 cm long via dispensing unit. The TA is calculated by measuring two sets of absorbance at three wavelengths (730, 616 and 444) nm applied by the

spectrometer (TM-UV/VIS C10082CAH, HAMAMATSU). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green sodium) and another 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 equipped with periodically renewed TYGON tube 5 minutes before the measurement. Nitrogen bubble were introduced into the titration cell for degassing CO_2 from the mixed solution sufficiently.
The TA is calculated based on the following equation:

$$pH_T = 4.2699 + 0.002578 \times (35 - S) + \log((R(25) - 0.00131) / (2.3148 - 0.1299 \times R(25))) - \log(1 - 0.001005 \times S), \quad (1)$$

$$A_T = (N_A \times V_A - 10^{pHT} \times DensSW(T, S) \times (V_S + V_A)) \times (DensSW(T, S) \times V_S)^{-1}, \quad (2)$$

where R(25) represents the difference of absorbance at 616 and 444 nm between before and after the injection. The absorbance of wavelength at 730 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.

(5) Station list or Observation log

Seawater samples were collected at 96 stations / 97 casts (total 1,454 samples), and their locations were shown in Figure 4.4-1.

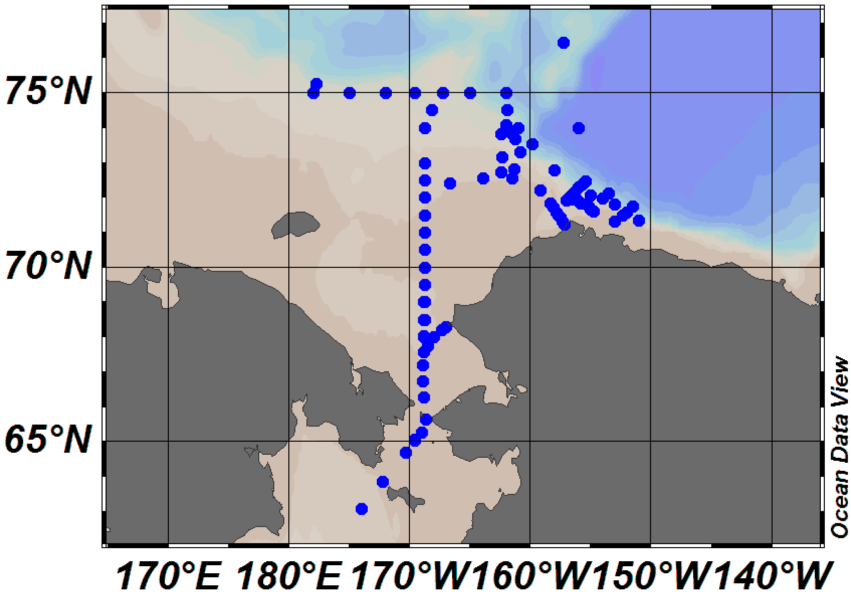


Figure 4.4-1: Map of sampling station.

(6) Preliminary results

The repeatability of this system was provisionally 3.72 μmol kg^{-1} (n = 23) which was estimated from standard deviation of measured CRM value during this cruise. A few replicate samples were taken at most of stations and the difference between each pair of analyses was plotted on a range control chart (see Figure 4.4-2). The average of the difference was provisionally 1.72 μmol kg^{-1} (n = 210) with its standard deviation of 1.57 μmol kg^{-1}.

For seawater samples taken at Stn. 014 and Stn. 015, the rinse-water used for washing the cell and sample lines might be not enough. Then, those samples were not measured properly, and those data was appended flag 3 (see Table 4.4-2).

Table 4.4-1: The layer taken in replicate for waters.

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

Table 4.4-2: Questionable data (flag 3).

Stn	Sample No.	Measured sample	Remarks
014	Sur, #35, #34, #33, #32, #31, #1	TA regular samples	The rinse-water might be not enough.
015	Sur	TA regular sample	The rinse-water might be not enough.
015	#1	DIC sample	Remeasured.

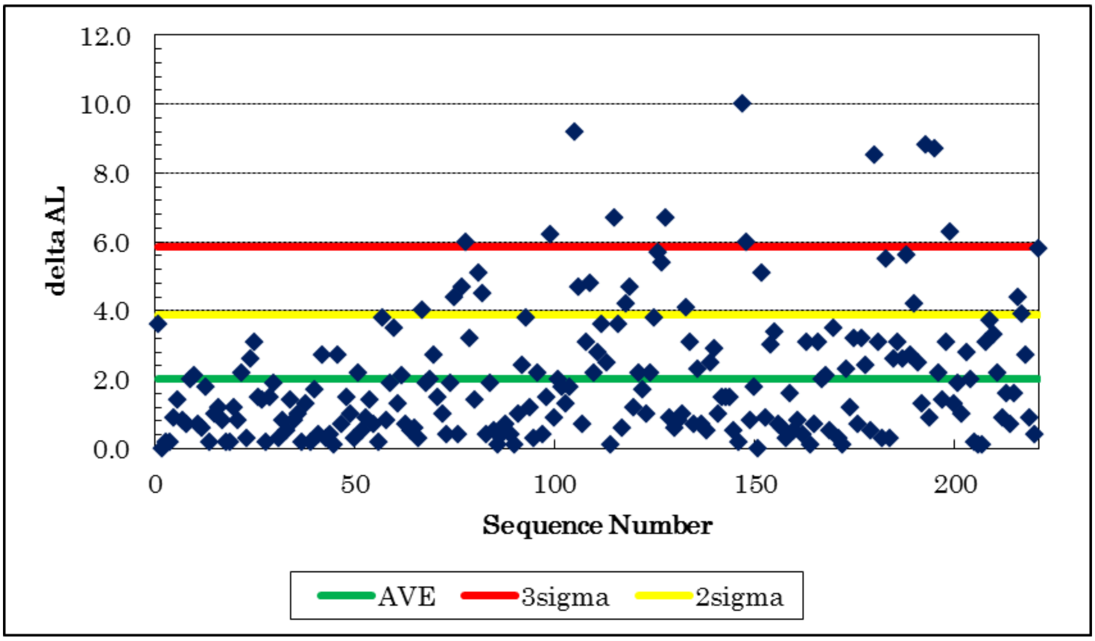


Figure 4.4-2: Range control chart of the absolute differences of replicate measurements of TA carried out during this cruise. AVE represents the average of

absolute difference, 3 sigma the upper control limit (standard deviation of AVE × 3), and 2 sigma upper warning limit (standard deviation of AVE × 2).

(7) Data Archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(8) References

Dickson, A. G., Sabine, C. L. & Christian, J. R. (Eds.). (2007). *Guide to best practices for ocean CO2 measurements, PICES Special Publication 3*: North Pacific Marine Science Organization.

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

4.5. CH_4

(1) Personnel

Akihiko Murata	JAMSTEC	- Principal Investigator, not on board
Sohiko Kameyama	Hokkaido Univ.	- not on board

(2) Objectives

Methane (CH_4) is one of strong greenhouse gases, whose concentrations in the atmosphere have increased over the past decades. In spite of the importance for global CH_4 budget, marine contributions to the global budget of CH_4 reveal substantial uncertainty, because CH_4 observations in the ocean have been limited. For the Arctic Ocean, it is known that the surface waters are usually super-saturated with respect to atmospheric CH_4, implying that the ocean acts as a source for atmospheric CH_4. However, the magnitude of CH_4 emission varies considerably over both time and space. This large variability reflects complicated biogeochemical dynamics in the Arctic Ocean. Our water column observations of CH_4 were made to understand processes, which control large spatial and temporal variability of CH_4 distributions in the Arctic Ocean.

(3) Parameters

Dissolved CH_4 concentration

Carbon isotopic composition of CH_4

(4) Instruments and methods

(4.1) Discrete bottle sampling

Discrete water samples for each station (Table 4.5-1) were collected at multiple depths using 12L Niskin bottles mounted on a CTD system. An aliquot of 100 ml seawater was transferred from Niskin bottles to amber vials (100 ml). The vial was filled with seawater smoothly from the bottom using a drawing tube which extends from the Niskin drain to the bottom of the vial. The seawater was overflowed by about a full and half a vial volume. After sampling, saturated mercuric chloride of 0.5 ml was added to each sample to poison the sample. Then vials were crimp sealed with butyl-rubber stoppers and aluminum caps.

(4.2) Sample storage

The samples were stored at 4°C in the dark on board the *Mirai*, and transported chilled to laboratories on land for analysis when the *Mirai* returned to Japan.

(4.3) Sample measurement

The samples will be measured by a gas chromatography-isotope ratio mass spectrometry (GC-IRMS) coupling with a purge and trap extraction system in Nagoya University.

(5) Station list or Observation log

Water sampling stations for CH_4 are shown in Table 4.5-1.

Table 4.5-1: List of sampling stations for water column CH_4

Stn.	Sampling date (UTC)	Sampling time (UTC)	Latitude (N)	Longitude (W)
003	27 Aug.	14:37	64°42.59"	170°20.95"
005	27 Aug.	22:54	65°16.57"	169°02.94"
007	28 Aug.	06:33	66°16.38"	168°50.96"
008	28 Aug.	12:17	67°12.00"	168°54.08"
010	28 Aug.	20:16	68°01.13"	168°50.13"
012	29 Aug.	04:20	69°00.01"	168°44.70"
014	29 Aug.	12:35	69°59.99"	168°45.20"
016	29 Aug.	19:39	70°59.97"	168°45.55"
018	30 Aug.	04:54	72°00.03"	168°44.93"
019	30 Aug.	10:55	72°24.12"	166°39.23"
020	30 Aug.	16:23	72°32.93"	163°58.48"
021	30 Aug.	21:54	72°47.95"	161°20.83"
022	31 Aug.	06:06	72°12.62"	159°10.30"
025	31 Aug.	13:57	71°34.83"	157°50.98"
026	31 Aug.	15:39	71°29.84"	157°40.40"
027	31 Aug.	17:33	71°25.52"	157°32.41"
028	31 Aug.	19:24	71°19.73"	157°20.98"
029	31 Aug.	21:28	71°14.34"	157°13.04"
035	01 Sep.	08:55	71°49.73"	155°50.78"
036	01 Sep.	11:00	71°48.04"	155°24.04"
037	01 Sep.	13:37	71°44.06"	155°13.64"
038	01 Sep.	16:33	71°39.99"	155°01.88"
039	01 Sep.	19:17	71°35.58	154°48.88"
068	08 Sep.	02:41	76°25.93"	157°16.11"
069	08 Sep.	22:52	73°59.81"	156°03.68"
085	14 Sep.	08:21	74°31.50"	161°53.90"
090	16 Sep.	06:37	75°00.05"	178°00.11"
095	17 Sep.	09:36	73°59.99"	168°45.07"
101	19 Sep.	15:35	68°17.95"	167°03.25"
102	19 Sep.	17:26	68°12.04"	167°20.44"
103	19 Sep.	20:00	68°00.12"	168°00.37"
104	19 Sep.	22:58	67°44.96	168°30.11"

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

4.6. ^{129}I

(1) Personnel

Hisao Nagai	Nihon University	- Principal Investigator
Yuichiro Kumamoto	JAMSTEC	

(2) Objective

Determination of activity concentrations of ^{129}I in the Arctic Ocean and North Pacific Ocean.

(3) Parameters

^{129}I

(4) Instruments and Methods

a. Sampling

Seawater samples for ^{129}I were collected using 12-liter Niskin-X bottles. Surface seawater was collected using a bucket or from continuous pumped-up water at about 4-m depth. The seawater sample was collected into a 1-L plastic bottle after two time washing.

b. Preparation and analysis

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 ($^{129}I/^{127}I$) 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 51 seawater samples for ^{129}I measurement in the Arctic Ocean, Bering Sea, and northern North Pacific Ocean during this cruise (Table 4.6-1).

(6) Data archives

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

Table 4.6-1: Seawater samples collected for ^{129}I measurement.

No.	Station	Sampling depth (m)	Method	Latitude (N)	Longitude (E)	Date (UTC)
1	Stn.044	0	bucket	72.46	204.07	02-Sep-17
2	Stn.044	20	niskin	72.46	204.07	02-Sep-17
3	Stn.044	50	niskin	72.46	204.07	02-Sep-17
4	Stn.044	99	niskin	72.46	204.07	02-Sep-17
5	Stn.044	149	niskin	72.46	204.07	02-Sep-17
6	Stn.044	199	niskin	72.46	204.07	02-Sep-17
7	Stn.044	297	niskin	72.46	204.07	02-Sep-17
8	Stn.044	397	niskin	72.46	204.07	02-Sep-17
9	Stn.044	596	niskin	72.46	204.07	02-Sep-17
10	Stn.044	793	niskin	72.46	204.07	02-Sep-17
11	Stn.044	990	niskin	72.46	204.07	02-Sep-17
12	Stn.044	1483	niskin	72.46	204.07	02-Sep-17
13	Stn.044	1859	niskin	72.46	204.07	02-Sep-17
14	Stn.068	0	bucket	76.43	202.46	08-Sep-17
15	Stn.068	20	niskin	76.43	202.46	08-Sep-17
16	Stn.068	49	niskin	76.43	202.46	08-Sep-17
17	Stn.068	99	niskin	76.43	202.46	08-Sep-17
18	Stn.068	148	niskin	76.43	202.46	08-Sep-17
19	Stn.068	197	niskin	76.43	202.46	08-Sep-17
20	Stn.068	297	niskin	76.43	202.46	08-Sep-17
21	Stn.068	396	niskin	76.43	202.46	08-Sep-17
22	Stn.068	595	niskin	76.43	202.46	08-Sep-17
23	Stn.068	791	niskin	76.43	202.46	08-Sep-17
24	Stn.068	988	niskin	76.43	202.46	08-Sep-17
25	Stn.068	1601	niskin	76.43	202.46	08-Sep-17
26	Stn.085	0	bucket	74.53	197.20	14-Sep-17
27	Stn.085	20	niskin	74.53	197.20	14-Sep-17
28	Stn.085	50	niskin	74.53	197.20	14-Sep-17
29	Stn.085	100	niskin	74.53	197.20	14-Sep-17
30	Stn.085	149	niskin	74.53	197.20	14-Sep-17
31	Stn.085	198	niskin	74.53	197.20	14-Sep-17
32	Stn.085	297	niskin	74.53	197.20	14-Sep-17
33	Stn.085	395	niskin	74.53	197.20	14-Sep-17
34	Stn.085	593	niskin	74.53	197.20	14-Sep-17
35	Stn.085	791	niskin	74.53	197.20	14-Sep-17
36	Stn.085	986	niskin	74.53	197.20	14-Sep-17

Table 4.6-1: continued.

No.	Station	Sampling depth (m)	Method	Latitude (N)	Longitude (E)	Date (UTC)
37	Stn.085	1479	niskin	74.53	197.20	14-Sep-17
38	Stn.085	1677	niskin	74.53	197.20	14-Sep-17
39	surface	4	pump	74.00	190.50	17-Sep-17
40	surface	4	pump	72.00	190.54	18-Sep-17
41	surface	4	pump	69.99	190.48	18-Sep-17
42	surface	4	pump	68.00	191.98	19-Sep-17
43	surface	4	pump	65.48	190.31	20-Sep-17
44	surface	4	pump	64.31	191.84	21-Sep-17
45	surface	4	pump	63.20	186.13	22-Sep-17
46	surface	4	pump	60.42	181.64	23-Sep-17
47	surface	4	pump	56.54	176.39	24-Sep-17
48	surface	4	pump	52.47	170.64	25-Sep-17
49	surface	4	pump	47.48	163.08	26-Sep-17
50	surface	4	pump	45.04	160.85	27-Sep-17
51	surface	4	pump	42.19	154.46	28-Sep-17

4.7. Underway surface water monitoring

(1) Personnel

Hiroshi Uchida	JAMSTEC	- Principal Investigator
Amane Fujiwara	JAMSTEC	
Masahiro Orui	MWJ	- Operation leader
Katsunori Sagishima	MWJ	
Erii Irie	MWJ	

(2) Objective

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

(3) Parameters

Temperature
Salinity
Dissolved oxygen
Fluorescence
Turbidity

(4) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has four sensors and automatically measures temperature, salinity, dissolved oxygen, fluorescence, and turbidity 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. Sea water was continuously pumped up to the laboratory from an intake placed at the approximately 4.5 m below the sea surface and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to 10 dm^3 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:	4563325-0362

Measurement range:	Temperature -5 °C - +35 °C
	Conductivity 0 S m^{-1} - 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:	Temperature 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 °C - +35 °C
Initial accuracy:	±0.001 °C
Typical stability (per 6 month):	0.001 °C
Resolution:	0.00025 °C

Dissolved oxygen sensor

Model:	RINKO II, JFE ADVANTECH CO. LTD.
Serial number:	13
Measuring range:	0 mg L^{-1} - 20 mg L^{-1}
Resolution:	0.001 mg L^{-1} - 0.004 mg L^{-1} (25 °C) Accuracy:

Saturation±2%F.S. (non-linear) (1atm, 25°C)

Fluorescence & Turbidity sensor

Model:	C3, TURNER DESIGNS
Serial number:	2300384
Measuring range:	Chlorophyll *in vivo* 0 µg L^{-1} – 500 µg L^{-1}
Minimum Detection Limit:	Chlorophyll *in vivo* 0.03 µg L^{-1}
Measuring range:	Turbidity 0 NTU - 1500 NTU
Minimum Detection Limit:	Turbidity 0.05 NTU

Total dissolved gas pressure sensor

Model:	HGTD-Pro, PRO OCEANUS
Serial number:	37-394-10
Temperature range:	-2 °C - 50 °C
Resolution:	0.0001 %
Accuracy:	0.01 % (Temperature Compensated)
Sensor Drift:	0.02 % per year max (0.001 % typical)

(5) Observation log

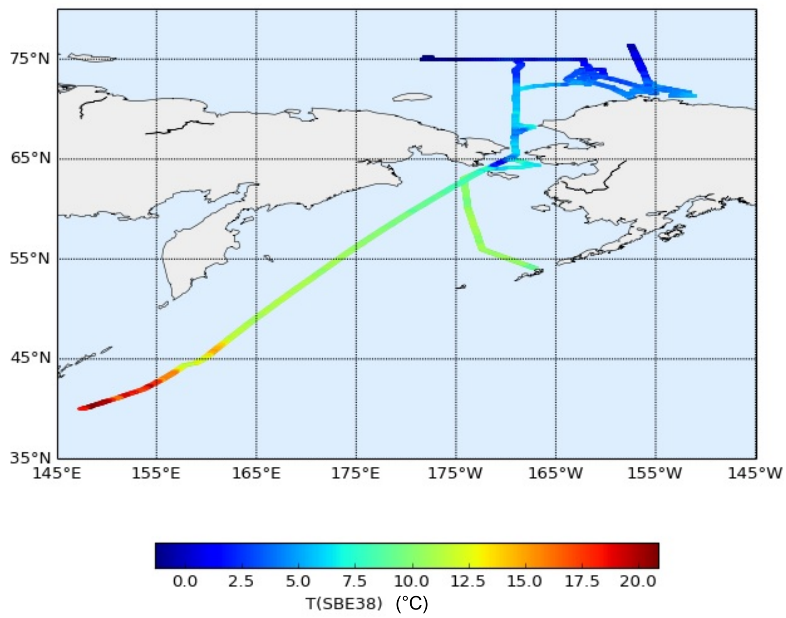
Periods of measurement, maintenance, and problems during this cruise are listed in Table 4.7-1.

Table 4.7-1: Events list of the Sea surface water monitoring during MR17-05C

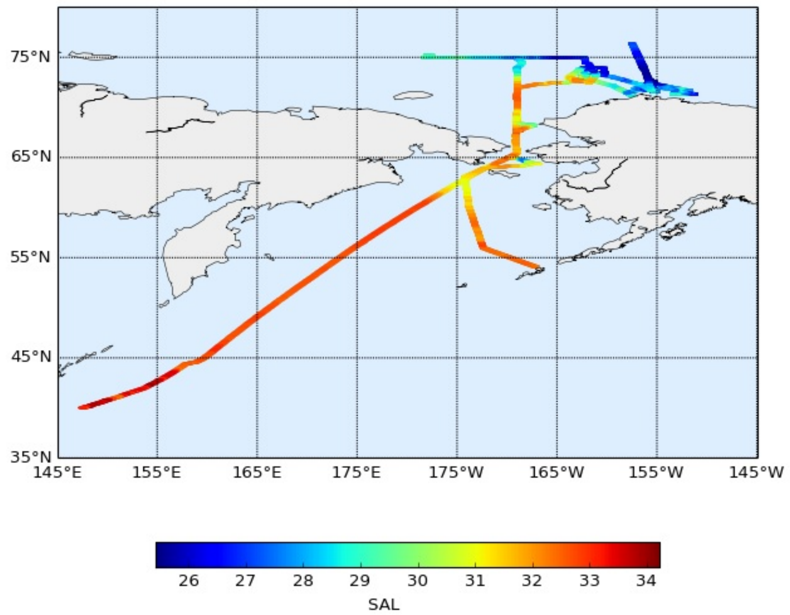
System Date [UTC]	System Time [UTC]	Events	Remarks
2017/08/24	02:07	All the measurements started and data was available.	Start
2017/08/30	04:43	All the measurements stopped.	Filter Cleaning
2017/08/30	05:44	All the measurements started.	Logging restart
2017/09/15	23:41	All the measurements stopped.	Filter Cleaning
2017/09/16	00:50	All the measurements started.	Logging restart
2017/09/21	11:06	All the measurements stopped.	Filter Cleaning
2017/09/21	20:33	All the measurements started.	Logging restart
2017/09/29	04:00	All the measurements stopped.	End

We took the surface water samples from this system once a day to compare sensor data with bottle data of salinity, dissolved oxygen, and chlorophyll *a*. The results are shown in Figure 4.7-2. All the salinity samples were analyzed by the Model 8400B "AUTOSAL" manufactured by Guildline Instruments Ltd. (see 3.7), and dissolve oxygen samples were analyzed by Winkler method (see 4.1), chlorophyll *a* were analyzed by 10-AU manufactured by Turner Designs. (see 4.9).

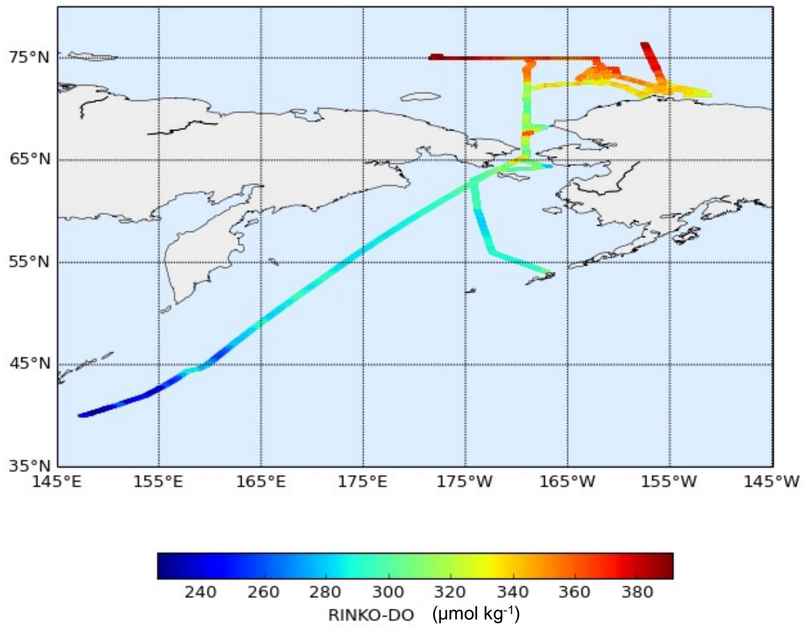
(a)



(b)


75°N
65°N
55°N
45°N
35°N
145°E
155°E
165°E
175°E
175°W
165°W
155°W
145°W
26
27
28
29
30
31
32
33
34
SAL

(c)


75°N
65°N
55°N
45°N
35°N
145°E
155°E
165°E
175°E
175°W
165°W
155°W
145°W
240
260
280
300
320
340
360
380
RINKO-DO (μmol kg-1)

(d)

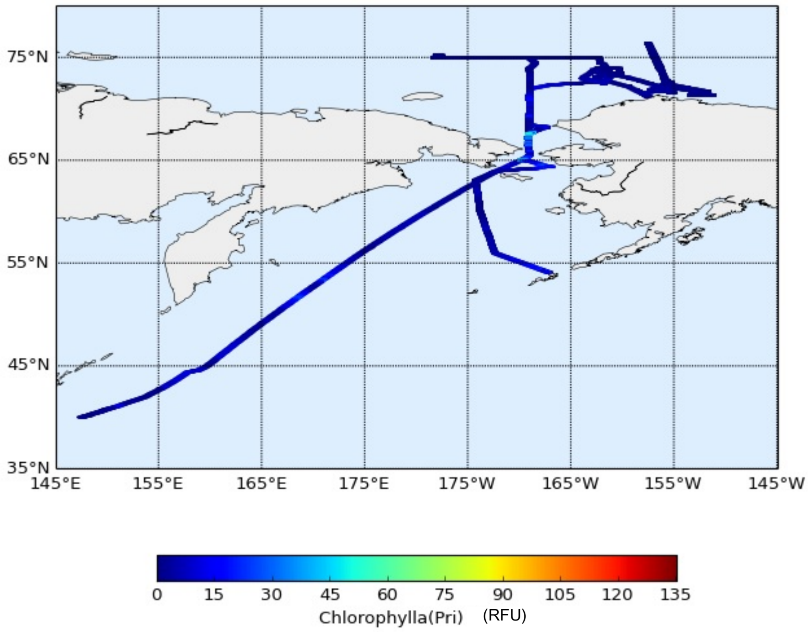


Figure 4.7-1: Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in MR17-05C cruise.

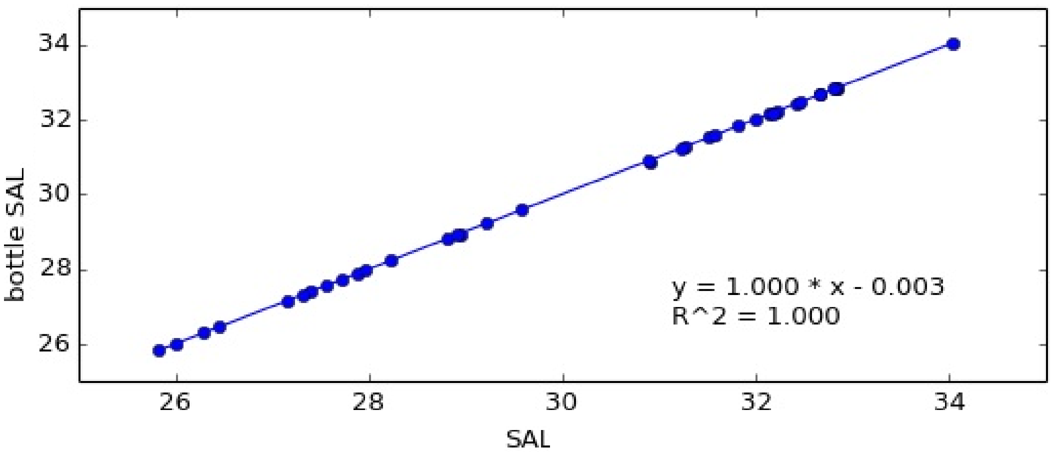


Figure 4.7-2: Correlation of salinity between sensor data and bottle data.

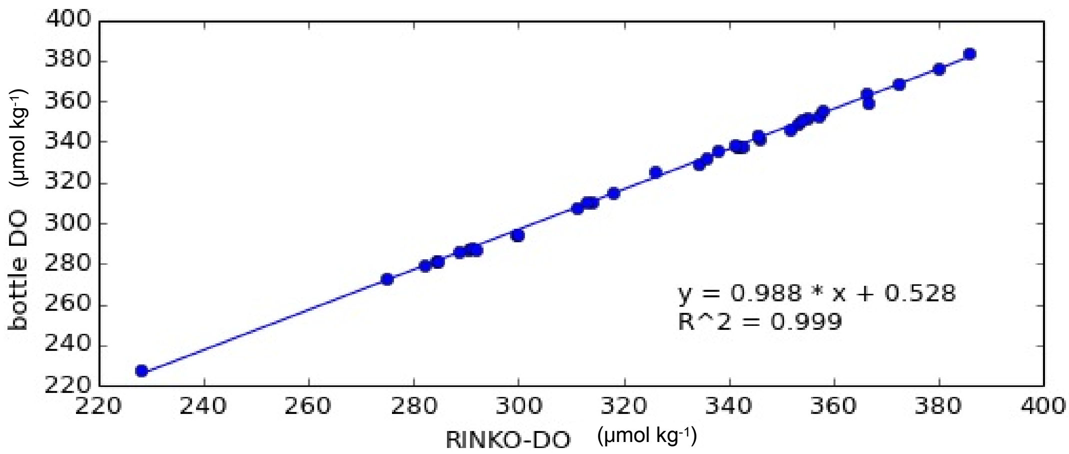


Figure 4.7-3 Correlation of dissolved oxygen between sensor data and bottle data.

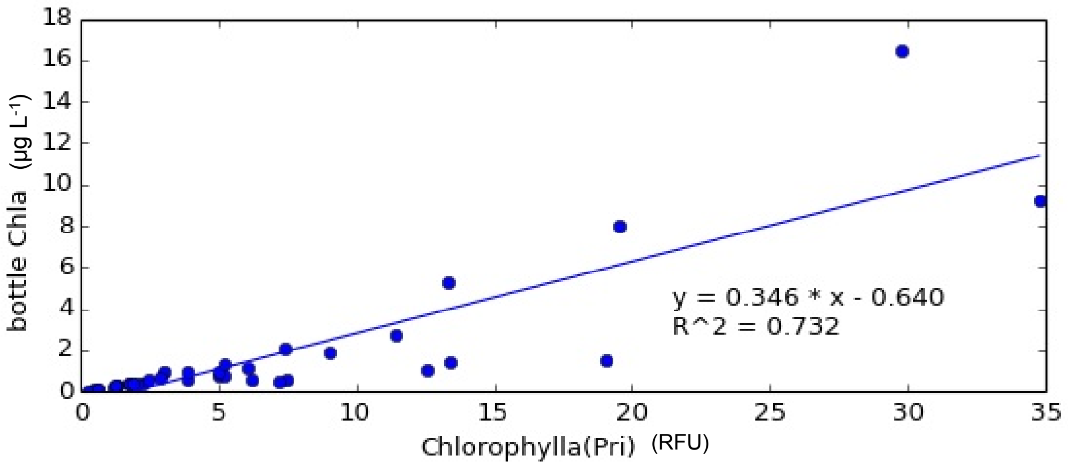


Figure 4.7-4 Correlation of fluorescence between sensor data and bottle data.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

4.8. Continuous measurement of pCO_2 and pCH_4

(1) Personnel

Akihiko Murata JAMSTEC - Principal Investigator
Nagisa Fujiki MWJ - Operation Leader
Emi Deguchi MWJ

(2) Objective

Our purpose is in-situ measurement of partial pressure of both carbon dioxide (pCO_2) and methane (pCH_4) in near-sea surface water.

(3) Methods, Apparatus and Performance

CO_2 and CH_4 standard gases (Table 4.8-1), atmospheric air, the both CO_2 and CH_4 equilibrated air with sea surface water were analyzed using an automated system equipped with both a non-dispersive infrared gas analyzer (NDIR; LI-7000, Li-Cor) and Off-Axis Integrated-Cavity output Spectroscopy gas analyzer (Off-Axis ICOS; 911-0011, Los Gatos Research) developed on the basis of Cavity Ring-Down.Spectroscopy. Standard gases and atmospheric air taken from the bow of the ship (approx.13 m above the sea level) were measured every about two hours. Seawater was taken from an intake placed at the approximately 4.5 m below the sea surface and introduced into the equilibrator at the flow rate of (4 - 5) L min^{-1} by a pump. The equilibrated air was circulated in a closed loop by a pump at flow rate of (0.6 - 0.7) L min^{-1} through two electric cooling units, a starling cooler, the NDIR and the Off-Axis ICOS.

(4) Preliminary result

Cruise track during pCO_2 and CH_4 observation is shown in Figure 4.8-1. Temporal variations of CO_2 and CH_4 concentrations were not shown in this report because data process was not fixed.

(5) Data archive

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 System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

Table 4.8-1: Concentrations of CO_2 and CH_4 standard gases

	CO_2 (ppm)	CH_4 (ppb)
STD 1	230	-
STD 2	290	-
STD 3	370	-
STD 4	430	-
STD 5	241	1630
STD 6	380	1920
STD 7	471	2120

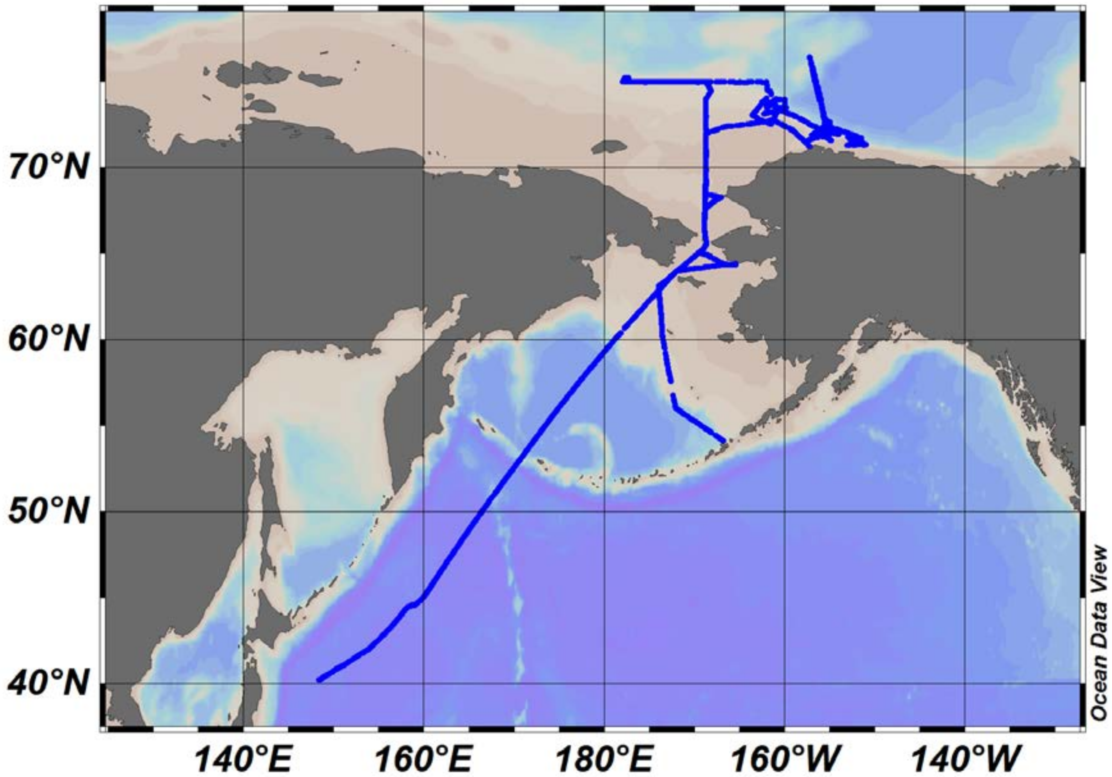


Figure 4.8-1: Observation map

4.9. Chlorophyll *a*

(1) Personnel

Amane Fujiwara	JAMSTEC	- Principal Investigator
Misato Kuwahara	MWJ	- Operation leader
Masanori Enoki	MWJ	
Yoshiaki Sato	MWJ	
Yosuke Yonemori	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 objective of this study is to investigate the vertical and horizontal distributions of phytoplankton biomass and size in the Arctic Ocean, in terms of phytoplankton pigment, chlorophyll *a*, by using the size-fractionated filtration method.

(3) Parameters

Total chlorophyll *a*

Size-fractionated chlorophyll *a*

(4) Instruments and methods

We collected samples for total chlorophyll *a* (chl-*a*) from 6 to 14 depths and size-fractionated chl-*a* from 2 to 8 depths between the surface and 200 m depth including a chl-*a* maximum layer. The chl-*a* maximum layer was determined by a fluorometer (Seapoint Sensors, Inc.) attached to the CTD system.

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 passed through 20 μm pore-size Nylon filter (47 mm in diameter), and 2μm pore-size PETE membrane filters (47 mm in diameter), and Whatman GF/F filter (25 mm in diameter) under gentle vacuum (<0.02MPa). Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylformamide (Wako Pure Chemical Industries Ltd.). The tubes were stored at –20°C under the dark condition to extract chl-*a* at least for 24 hours.

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 4.9-1.

(5) Station list

Samples for total and size-fractionated chl-*a* were collected at 97 (see Figure 4.9-1) and 80 casts (see Figure 4.9-2), respectively. The numbers of samples for total and size-fractionated chl-*a* were 1118 and 1485, respectively.

(6) Preliminary results

At each station, water samples were taken in replicate for water of chl-*a* maximum layer. Results of replicate samples were shown in Table 4.9-2.

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN) in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(8) Reference

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

Table 4.9-1: Analytical conditions of non-acidification method for chlorophyll *a* with Turner Design fluorometer (10-AU).

Excitation filter (nm)	: 436
Emission filter (nm)	: 680
Lamp	: Blue F4T5,B2/BP

Table 4.9-2: Results of the replicate sample measurements.

	All samples	Samples over 1.0 µg/L	Samples under 1.0 µg/L
Number of replicate sample pairs	97	53	44
Standard deviation (µg/L)	0.09	0.13	0.01
Relative error (%)	3.2	2.9	3.6

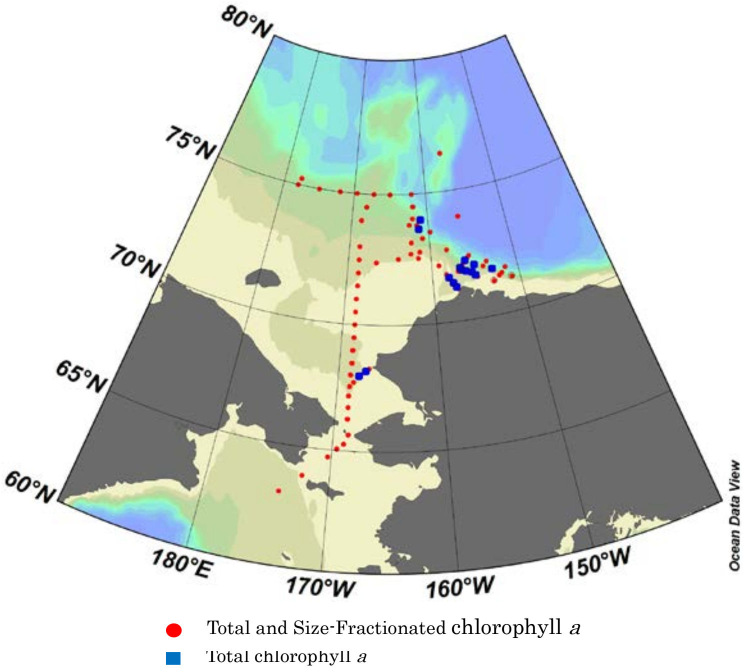


Figure 4.9-1: Sampling positions of Total and Size-fractionated chlorophyll *a*.

4.10. Bio-Optical Observations

(1) Personnel

Toru Hirawake	Hokkaido Univ., non-boarding	- Principal Investigator
Rick Reynolds	Scripps Institution of Oceanography, UC San Diego (SIO)	
Linhai Li	SIO	
Hugh Runyan	SIO	
Amane Fujiwara	JAMSTEC	

(2) Objectives

The objective of these observations is to develop and evaluate ocean color algorithms to estimate phytoplankton community composition and algal size using optical properties of seawater. Results from these investigations will be applied to satellite remote sensing and used to clarify the responses of phytoplankton to the recent climate change in the western Arctic Ocean.

(3) Parameters

A. Surface and underwater spectral radiance and irradiance
B. Inherent optical properties of seawater
C. Characterization of particle and phytoplankton abundance, composition, and size distribution

(4) Instruments and Methods

A. Surface and underwater spectral radiance and irradiance

Two submersible spectral radiometers were used to measure properties of surface and underwater light fields.

Underwater spectral downwelling planar irradiance, $E_d(\lambda, z)$ [μW cm^{-2} nm^{-1}], and upwelling radiance, $L_u(\lambda, z)$ [μW cm^{-2} nm^{-1} str^{-1}], at 17 wavelengths over the spectral range 380 – 765 nm were measured with a PRR-800 spectroradiometer (Biospherical Instrument Inc.). The PRR was deployed in free-fall mode up to 120 m deep at a distance from the stern of ship to avoid ship shadows. Downwelling irradiance incident upon the sea surface $E_d(\lambda, z = 0+)$ was also monitored by a reference sensor with the same specifications as the underwater sensor. Before each deployment of the instrument, 10 minutes of averaged dark values were recorded. Underwater photosynthetically available radiation (PAR) was also calculated by converting the $E_d(\lambda, z)$ to quantum units, $E_{d,q}(\lambda, z)$ [μmol photons m^{-2} s^{-1}], and integrating the $E_{d,q}(\lambda, z)$ from 395 to 710 nm.

In parallel with the PRR deployment, a HyperPro spectroradiometer (HPROII, Satlantic Inc.) equipped with a float was deployed from the stern to provide hyperspectral measurements of incident planar irradiance at the sea surface, $E_d(\lambda, 0+)$, and upwelling radiance at a depth of 20 cm below the sea surface, $L_u(\lambda , z = 20$ cm).

Observations span the range of 350 – 800 nm at ~ 3 nm resolution, with measurements of dark currents obtained during operation using a shutter system. Time series measurements of 5 – 10 minutes were collected and used to calculate the spectral water-leaving radiance and remote-sensing reflectance (ocean color) at each station.

B. Inherent optical properties of seawater

An instrument package equipped with sensors for measuring vertical profiles of light scattering properties of seawater was deployed to a depth of 300 m, or within 5 m of the bottom in shallower waters. This "IOP" package consisted of two Hydroscat-6 instruments, a LISST-100X laser diffractometer, and a LISST-HOLO holographic particle imager.

The two Hydroscat-6 sensors (HOBI Labs Inc.) provided measurements of the in situ volume scattering function, $\beta(\Psi, \lambda)$, at a scattering angle $\Psi = 140°$ at twelve light wavelengths (394, 420, 442, 470, 510, 532, 550, 589, 649, 730, and 852 nm; 550 nm common to both instruments) to determine the optical backscattering coefficient of seawater, $b_b(\lambda)$, and particles, $b_{bp}(\lambda)$ (Reynolds et al., 2016). The LISST 100-X (Sequoia Instruments Inc.) obtained measurements of $\beta(\Psi, \lambda)$ at 32 forward scattering angles ($\Psi = 0.08 – 13.5°$) and beam transmission at a light wavelength of 532 nm. This information is used to estimate the particle size distribution over the particle diameter range of 1 – 200 μm (Reynolds et al., 2010). The LISST-HOLO digital particle imager (Sequoia) captured holographic images of particles present in seawater, which provides estimate of the particle size distribution over the diameter range 25 – 2500 μm and allows identification of the types of particles present.

C. Characterization of particle and phytoplankton abundance, composition, and size distribution

Water samples were obtained from the CTD/R in conjunction with optical measurements to further determine the spectral absorption and scattering coefficients of seawater constituents, and characterize the suspended particle and phytoplankton assemblages.

Optical measurements: The absorption coefficient of particles, $a_p(\lambda)$, over the spectral range 300 – 800 nm at 1 nm resolution was determined by concentrating particles on a glass-fiber filter (Whatman GF/F, 25 mm) and measuring the filter optical density in a Perkin-Elmer Lambda 18 spectrophotometer equipped with an integrating sphere (Stramski et al., 2015). Following measurement, the filter was extracted in methanol to remove plant pigments and remeasured to estimate the absorption coefficient of non-algal particles, $a_{NAP}(\lambda)$ (Kishino et al., 1985). The absorption coefficient of phytoplankton, $a_{ph}(\lambda)$, was determined by the difference $a_p(\lambda) – a_{NAP}(\lambda)$.

For measurements of the spectral absorption coefficient of colored dissolved organic material (CDOM), $a_{CDOM}(\lambda)$, ~250 ml of water sample was filtered through a 0.2 μm

Nuclepore filter (Whatman, 47 mm). Optical density of the filtered water relative to pure water (Milli-Q) was measured with 10 cm cylindrical quartz cell in a UV-2600 spectrophotometer (Shimadzu), and used to determine $a_{CDOM}(\lambda)$.

The volume scattering function, $\beta(\Psi, \lambda)$, at 18 scattering angles spanning the range 22 – 147° was measured on discrete seawater samples onboard using a DAWN-EOS photometer (Wyatt Technologies) equipped with a 532 nm laser. A Meadowlark Optics liquid crystal variable retarder interfaced with the instrument provided the capability to make measurements with both vertically and horizontally polarized incident laser beams.

Particle and phytoplankton characterization: The bulk concentration and composition of particulate matter was determined by concentrating particles on glass fiber filters that will be subject to further analysis in onshore laboratory. Total particle dry mass concentration, SPM [g m^{-3}], was determined gravimetrically by filtration on pre-rinsed, combusted, and pre-weighed glass fiber filters, rinsed to remove sea salt, dried at 60 °C, and dry particle mass will be measured after the cruise with a Mettler-Toledo MT5 microbalance with 1 □g precision. The particulate organic carbon (POC) content was also measured by filtration through precombusted GF/F filters that were then dried at 60 °C. Organic carbon content of each filter following acidification to remove inorganic carbon will be determined after the cruise using standard CHN analysis involving high temperature combustion of sample filters.

Seawater samples for phytoplankton pigments were collected from the sea surface and other depths using a bucket or Niskin-X bottles on the CTD/R. 1 – 4 L of water sample were filtered on a glass fiber filter (GF/F, 47 mm) and stored in a super freezer (-80 °C). Pigment concentrations will be analyzed on land using high performance liquid chromatography (HPLC) (Agilent Technologies 1300 series) following to the method of van Heukelem and Thomas (2004) after the cruise, and will provide information on phytoplankton biomass and community structure.

The particle size distribution (PSD) [N m^{-3} in discrete size intervals] of seawater samples was measured with a Beckman-Coulter Multisizer III using 0.2 μm filtered seawater as the diluent and blank. Samples were routinely measured with a combination of two aperture sizes (30 μm and 200 μm), which when combined span the particle diameter range of 0.7 – 120 μm. Both apertures were calibrated using solutions containing NIST-traceable microsphere standards of known size.

(5) Work completed

A total of 25 stations with bio-optical observations were completed onboard. 20 of these stations comprise the full suite of all optical and particle measurements, and the remaining 5 stations include a partial suite of these measurements. The location of stations is provided in Figure 4.10-1, and Table 4.10-1 summarizes the number of instrument deployments and the number of discrete water sample for analyses taken onboard the cruise.

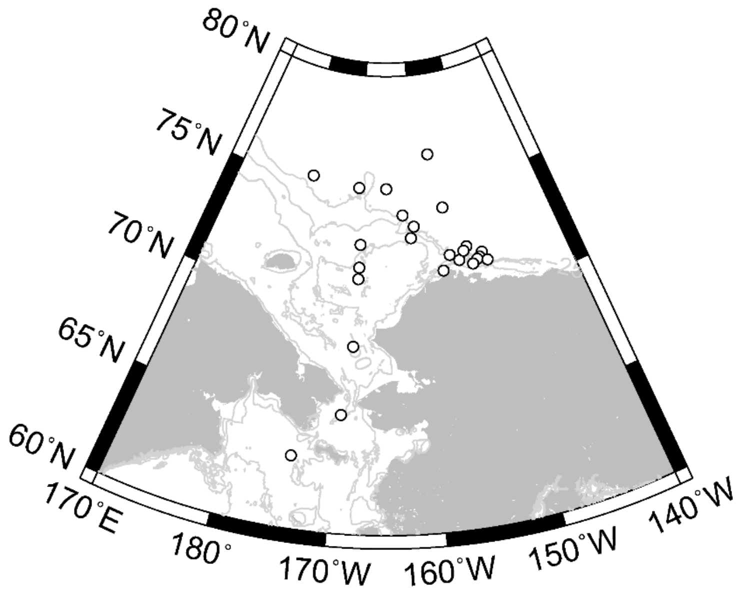


Figure 4.10-1: Sampling locations of bio-optical observations.

Table 4.10-1: Number of instrument deployments or discrete water samples collected for each parameter on the cruise.

Instrument	*Number of stations*
PRR	23
HPRO	20
IOP	25
Parameter	*Number of samples*
$a_p(\lambda)$	74
$a_{CDOM}(\lambda)$	62
β(Ψ, 532 nm) (DAWN)	56
SPM	94
POC	95
Phytoplankton pigments (HPLC)	74
PSD (Coulter counter)	45

(6) Data archives

Following processing and quality control procedures, data obtained on this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site. <http://www.godac.jamstec.go.jp/darwin/e>

(7) References Cited

Kishino, M., M. Takahashi, N. Okami, and S. Ichimura. 1985. Estimation of the spectral absorption coefficients of phytoplankton in the sea. *Bull. Mar. Sci.*, 37, 634–642.

Reynolds, R. A., D. Stramski, and G. Neukermans. 2016. Optical backscattering of particles in Arctic seawater and relationships to particle mass concentration, size distribution, and bulk composition. *Limnol. Oceanogr.*, 61, 1869-1890. doi: 10.1002/lno.10341.

Reynolds, R. A., D. Stramski, V. M. Wright, and S. B. Woźniak. 2010. Measurements and characterization of particle size distributions in coastal waters. *J. Geophys. Res.*, 115, C08024. doi: 10.1029/2009JC005930.

Stramski, D., R. A. Reynolds, S. Kaczmarek, J. Uitz and G. Zheng. 2015. Correction of pathlength amplification in the filter-pad technique for measurements of particulate absorption coefficient in the visible spectral region. *Appl. Opt.*, 54, 6763-6782. doi: 10.1364/AO.54.006763.

Van Heukelem, L, Thomas C. S. 2001. Computer-assisted high-performance liquid chromatography method development with applications to the isolation and analysis of phytoplankton pigments. *J Chromatogr A*, 910, 31–49.

4.11. Nitrogen Cycles

(1) Personnel

Takuhei Shiozaki JAMSTEC - Principal Investigator

(2) Objectives

The ocean contains the largest active reservoir of carbon on Earth and determines atmospheric carbon dioxide. Understanding the efficiency and the factors limiting the carbon export from the sunlit surface waters to the ocean interior is consequently essential for tracing anthropogenic carbon dioxide which causes global warming and ocean acidification. The efficiency of microbe-mediated carbon sequestration, the biological carbon pump, is commonly evaluated by comparing so-called new production with primary production. Marine primary production is generally limited by nitrogen availability, and scales with the input of new nitrogen to the photic zone. New production is defined as production based on nitrogenous nutrient newly introduced from outside of the productive layer, and is balanced with sinking particle flux in a steady-state system. To elucidate new production in the Arctic Ocean, we conducted following experiments during this cruise.

(3) Parameters

Nitrogen fixation rate
Nitrate assimilation rate
Ammonium assimilation rate
Urea assimilation rate
Ammonia oxidation rate
Ammonia regeneration rate
Urea oxidation rate
Primary production
Chlorophyll *a*
Nutrients
Microbial community (DNA and RNA)

(4) Instruments and methods

Water samples for incubation experiments, nutrients, chlorophyll *a*, and DNA analysis were collected in an acid-cleaned bucket and Niskin-X bottles from those layers having surface light intensities of 100, 10, 1, and 0.1%. Further, samples for ammonia oxidation and DNA were collected from additional depths (100 m, 200 m, 1000 m, and bottom depth minus 10 m). The depth profiles of light intensity were obtained using Profiling Reflectance Radiometer system 800 (Biospherical Instruments) before the sampling.

Nitrogen fixation, nitrate assimilation, ammonium assimilation, urea assimilation, ammonia oxidation, urea oxidation and ammonia regeneration rates were evaluated using ^{15}N tracer. Nitrogen fixation rate was determined by the gas dissolution method (Mohr et al., 2010, PLoS one). Primary production was determined using ^{13}C tracer. After addition of the tracers, the incubation bottles were placed into on-deck incubators cooled by flowing surface seawater. Light levels were adjusted using neutral-density screens. Samples of 1 or 2 L collected for estimating the initial ^{15}N and ^{13}C enrichment of particulate organic matter were filtered immediately at the beginning of the incubation. The incubations for nitrogen fixation, nitrate assimilation, ammonia assimilation, and urea assimilation were terminated by gentle vacuum filtration of the seawater samples through a precombusted GF/F filter. Those for ammonia oxidation, urea oxidation, and ammonia regeneration were terminated by filtration using 0.2 μm pore-size filters, and filtrate was collected. The filters and filtrate except for ammonia regeneration were kept frozen (-20 °C) for on-shore analysis. The filtrate for ammonia regeneration was incubated in room temperature for 5 days after added MgO and H_2SO_4-soaked filter pack (ammonium diffusion method), and then, the filter pack was stored in glass bottle with silica gel.

Samples for nutrients analysis were collected in 10 mL acrylic tubes and were immediately determined on board using a QuAAtro system (see a report of S. Nishino and colleagues in this issue). Samples for chlorophyll *a* of 290 ml were filtered onto 25-mm Whatman GF/F filters, and the chlorophyll *a* concentrations were measured fluorometrically using a Turner Design 10-AU fluorometer after extraction with N', N'-dimethylformamide on board. Samples for DNA and RNA analyses were filtered onto Sterivex-GP pressure filter units with a 0.22 μm pore size (Millipore). RNA samples were filtered within 30 min of the water sampling and then added to RNA*later* Stabilization Solution (Life Technologies). The Sterivex filter units were frozen at -80°C until onshore analyses.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC when ready.

4.12. Phytoplankton incubations
4.12.1. 12-L scale experiment
(1) Personnel

Koji Sugie	JAMSTEC	- Principal Investigator
Amane Fujiwara	JAMSTEC	
Jonaotaro Onodera	JAMSTEC	

(2) Objective

On-deck incubation experiment was conducted to assess the synergistic impacts of ocean acidification and global warming on phytoplankton community structure and grazing pressure.

(3) Parameters

Size fractionated chlorophyll-*a* (>10 µm and ~0.7–10 µm), nutrients (NO_3, NO_2, NH_4, PO_4, $Si(OH)_4$), diatoms (microscopy), pico- and nano-sized phytoplankton, heterotrophic bacteria, phytoplankton pigments, temperature, photosynthetic active radiation, dissolved inorganic carbon, total alkalinity

(4) Instruments and methods

For 12-L scale experiment, acid-washed, Teflon® coated, Niskin-X sampling bottle attached to a CTD-CMS was used to collect seawater samples from a depth of 10 m for incubation at 72.8°N, 161.3°W. Six treatments were prepared as follows:

LT:	Unamended controls
LT750:	High CO_2 condition was achieved by adding CO_2 saturated (at 1 atm) filtered seawaters to the controls to make the seawater pCO_2 ca. 750 µatm.
LT1500:	Increased seawater pCO_2 ca. 1500 µatm by adding CO_2 saturated filtered seawater.
HT:	+4°C relative to the controls
HT750:	+4°C relative to the LT750
HT1500:	+4°C relative to the LT1500

Seawater for the experiment was sieved by 200 µm acid-cleaned Teflon-mesh to eliminate mesozooplankton and poured into 18 of 12-L acid-washed polyethylene bag. Carbonate chemistry was manipulated by adding CO_2 saturated (at 1 atm) seawater. The 12-L bags were prepared in triplicate per treatment. Temperature of the incubation tanks were set at 4 (LT series) and 8°C (HT series). Incubations were lasted for 9 days. Chlorophyll-*a* and nutrient samples were obtained once in two days, and other parameters were collected periodically during the exponential growth phase of phytoplankton. Microzooplankton grazing was examined by dilution method (Landry & Hasset, 1997; Chen 2015) on days 4 (HT series) and 5 (LT series). In brief, an acid-washed 600 mL polycarbonate bottle was filled with the seawater in the incubation bags and another one 600 mL polycarbonate bottle was filled with the seawater in the incubation bag (64 mL) and filtered seawater passing through 0.2 μm cartridge filter (536 mL). Undiluted and filtered seawater diluted samples were incubated for 24 h. The samples for nutrient, small phytoplankton community composition and size fractionated chlorophyll-*a* were obtained at the beginning and the end of the incubation. Phytoplankton growth rate in the diluted seawater represents net growth rate (μ). Phytoplankton growth in the undiluted seawater represent μ minus grazing pressure (g) (μ_m). Then, slope between dilution factor (64/(64+536)) and delta $\mu - \mu_m$ represents grazing rate of microzooplankton.

(5) Observation log
August 30 (UTC), 2017 at 72.8°N, 161.3°W

(6) Preliminary results
Temporal change in Figure 4.12.1.1 PAR and temperature, Figure 4.12.1.2 Chlorophyll-*a*, Figure 4.12.1.3 nutrients and Figure. 4.12.1.4 grazing rates are shown below.

(7) Data archives
All data obtained during MR17-05C cruise will be submitted to Data Management Group (DMG) of JAMSTEC after the sample analysis and validation. The data will be opened to the public via "Data Research System for Whole Cruise Information (DARWIN)" in JAMSTEC web site.

4.12.2. Dilution experiment

(1) Personnel
Koji Sugie JAMSTEC - Principal Investigator

(2) Objective
Short term (24–48 h) on-deck experiment was performed to test the effects of temperature and CO_2 levels on phytoplankton dynamics and microzooplankton grazing pressure. Although sample size (600 mL) was limited in the dilution experiment compared with the previous 12-L scale experiment, this experiment can perform several times during the research cruise indicating the better spatial coverage than the above large volume experiment.

(3) Parameters
Size fractionated chlorophyll-*a* (>10 μm and ~0.7–10 μm), nutrients (NO_3, NO_2, NH_4, PO_4, $Si(OH)_4$), diatoms (microscopy), pico- and nano-sized phytoplankton, heterotrophic

bacteria, temperature, photosynthetic active radiation, dissolved inorganic carbon, total alkalinity

(4) Instruments and methods

For short-term dilution experiment, seawater was collected from 5 or 10 m depth using the same sampling system as 12-L scale experiment. First, each of seawater and 0.2 µm filtered seawater were collected in 9-L polycarbonate tanks and added phosphate and ammonia. Seawater samples were dispensed into each of four 2-L polycarbonate bottles for seawater and filtered seawater, respectively. To achieve high CO_2 conditions for HC treatment (see below), CO_2 saturated seawater was added into each of seawater and filtered seawater filled 2-L polycarbonate bottles. Two of seawater and filtered seawater filled 2-L polycarbonate bottles were incubated in *in situ* temperature and 3–5°C higher temperature water tanks for 24 h to acclimate incubation conditions and to avoid growth lag phase after the seawater collection. After the 24 h acclimation, dilution experiment was conducted as described in method section of 4.12.1. This 600 mL dilution experiment was lasted for 24 to 48 hour depending on *in situ* temperature and phytoplankton biomass at the beginning of the experiment. Four treatment was established in the 600 mL scale experiment as follows:

LT: Unamended controls

LTHC: High CO_2 condition, which was achieved by adding CO_2 saturated (at 1 atm) filtered seawaters to the controls to make the seawater pCO_2 ca. 700–1000 µatm.

HT: Plus 3–5°C relative to the LT treatment

HTHC: Plus 3–5°C relative to the LTHC treatment

Bottles were prepared in duplicate per treatment.

(5) Observation log

1st: August 27 (UTC), 2017 at 65.0°N, 169.6°W

2nd :August 30 (UTC), 2017 at 72.8°N, 161.3°W

3rd: Sept. 10 (UTC), 2017 at 73.3°N, 161.8°W

4th: Sept. 16 (UTC), 2017 at 75.3°N, 177.7°W

5th: Sept. 19 (UTC), 2017 at 68.3°N, 167.0°W

(6) Preliminary results

Figure 4.12.2.1 Net growth rate of >10 µm and Figure 4.12.2.2 <10 µm phytoplankton and Figure 4.12.2.3 grazing pressure on small-sized phytoplankton at each station are shown below.

(7) Data archives

All data obtained during MR17-05C cruise will be submitted to Data Management Group (DMG) of JAMSTEC after the sample analysis and validation. The data will be opened to the public via "Data Research System for Whole Cruise Information (DARWIN)" in JAMSTEC web site.

4.12.3. Sediment incubations

(1) Personnel

Takuhei Shiozaki	JAMSTEC	- Co-Principal Investigator
Amane Fujiwara	JAMSTEC	- Co-Principal Investigator
Koji Sugie	JAMSTEC	

(2) Objective

In the northern Chuckchi Sea of the Arctic Ocean, phytoplankton blooms were frequently found nearly at the bottom of water column where light can penetrate at the seafloor because of very low chlorophyll-*a* levels at the oligotrophic surface. However, the formation mechanisms and community structure of such benthic algal blooms were not examined before. We hypothesize that the diatoms in the resting stages at the surface of sediment may germinate owing to the light penetration, which is the first trigger of benthic algal bloom formation. To test our hypothesis in the northern Chuckchi Sea, we performed incubation experiment using the mixture of filtered seawater (algae free) and seafloor sediment (probable algal seed).

(3) Parameters

Chlorophyll-*a*, nutrients (NO_3, NO_2, NH_4, PO_4, $Si(OH)_4$), PSII parameters (Fv/Fm, σ_{PSII}), pico- and nano-sized phytoplankton, heterotrophic bacteria, microscopy, phytoplankton pigments, dissolved organic carbon (DOC), DNA, photosynthesis-irradiance pattern (PI-curve).

(4) Instruments and methods

A 300 L of seawater for incubation was collected from 45 m depth at St. 18. Seawater was filtered through 0.2 μm cartridge filter (PALL) and dispensed into twelve 20-L polyethylene bags. Each sediment sample collected at Sts. 16 and 21 using Smith-McIntyer grab were added to each six 20-L bags. For each station sediment-added seawater samples, three bags were treated under dim light condition (<10 μmol photon s^{-1} m^{-2}) representing 0.1–1 % light levels relative to the surface (Light treatment), and another three were treated complete darkness by covering black plastic bag (Dark treatment). Experiment were lasted for 25 days. Sampling frequencies of each parameter are listed as follows.

Sampling frequency of the series resuspended sediment at St.16

Day	0	2	4	6	8	10	12	14	16	18	20	22	24
Chl *a*	○	○	○	○	○	○	○	○	○	○	○	○	○
Nutrients	○	○	○	○	○	○	○	○	○	○	○	○	○

PSII	○	○	○	○	○	○	○	○	○	○	○	○	○
Pico-Nano	○	○	○		○		○			○			○
Bacteria	○	○	○		○		○			○			○
Microscopy	○	○			○					○			○
Pigments	○	○			○					○			○
DOC	○	○			○					○			○
DNA	○	○			○					○			○
PI-curve		○								○			

Sampling frequency of the series resuspended sediment at St.21

Day	**0**	**1**	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**19**	**22**	**24**
Chl *a*	○	○	○	○	○	○	○	○	○	○	○	○	○
Nutrients	○	○	○	○	○	○	○	○	○	○	○	○	○
PSII	○	○	○	○	○	○	○	○					○
Pico-Nano	○	○	○			○		○		○			○
Bacteria	○	○	○			○		○		○			○
Microscopy	○	○						○					○
Pigments	○	○						○					○
DOC	○	○						○					○
DNA	○	○						○					○
PI-curve		○											

(5) Observation log

Seawater sample:

August 30 (UTC), 2017 at 72.0°N, 168.7°W (St.18)

Sediment sample:

August 29 (UTC), 2017 at 71.0°N, 168.8°W (St.16)

August 30 (UTC), 2017 at 72.8°N, 161.3°W (St.21)

(6) Data archives

All data obtained during MR17-05C cruise will be submitted to Data Management Group (DMG) of JAMSTEC after the sample analysis and validation. The data will be opened to the public via “Data Research System for Whole Cruise Information (DARWIN)” in JAMSTEC web site.

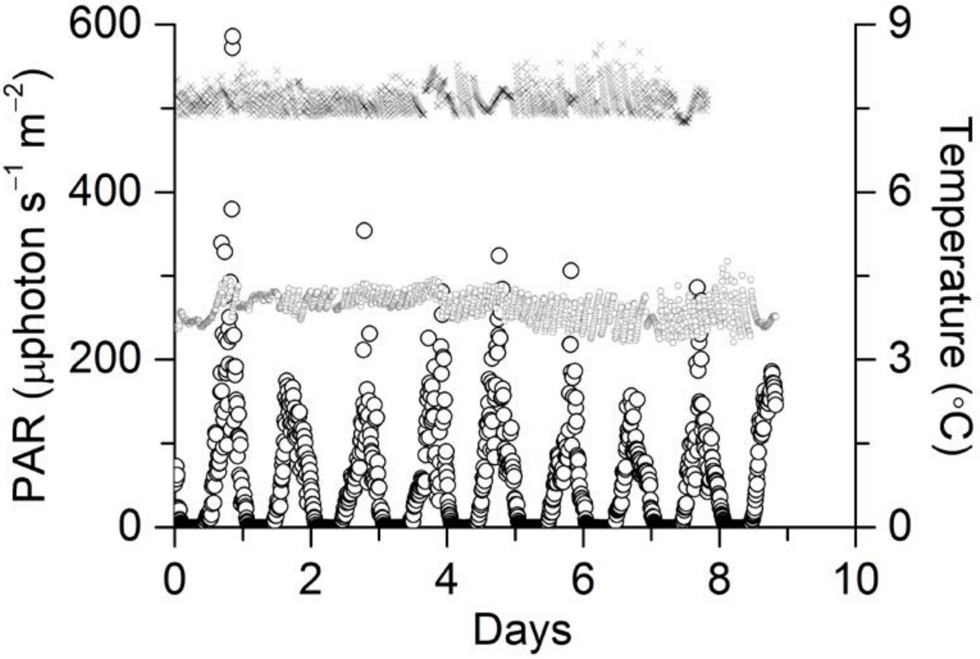


Figure. 4.12.1-1: Temporal change in photosynthetic active radiation (PAR, black open circle) and temperature (gray open circle and black cross represent for low- and high-temperature tank, respectively) during the incubation.

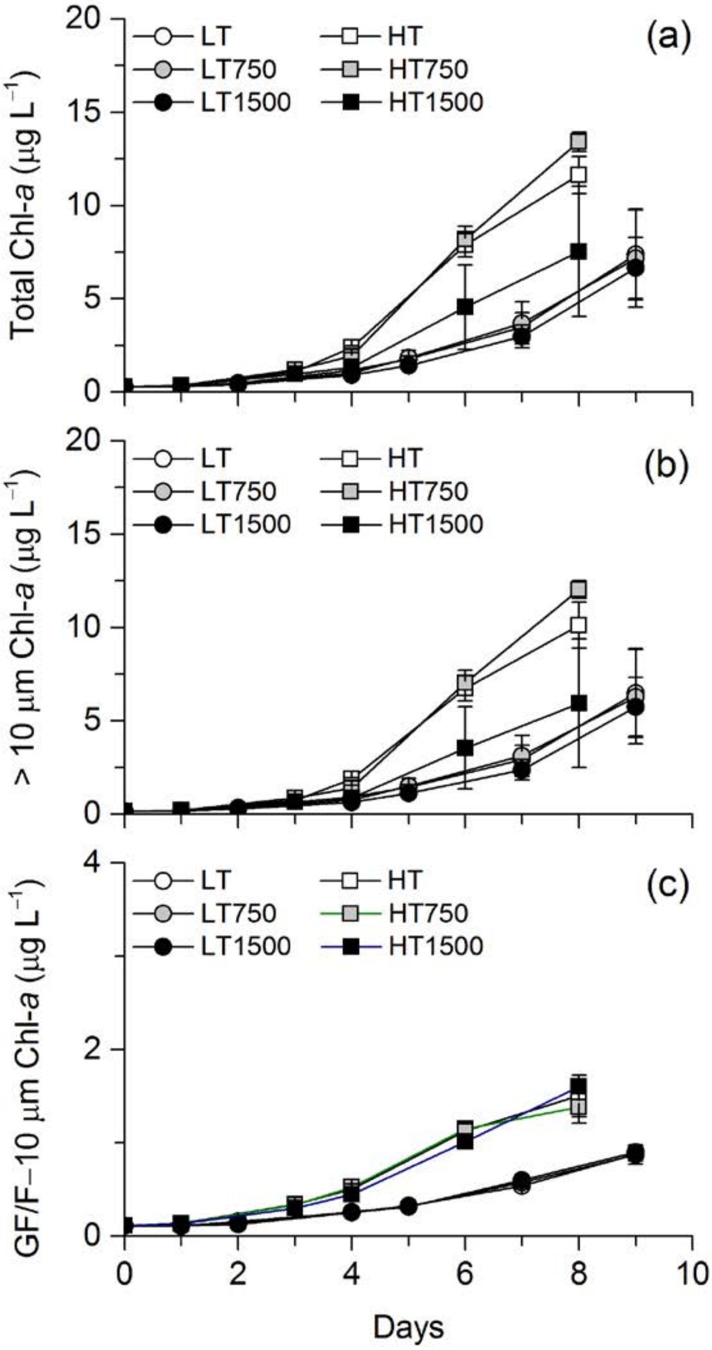


Figure 4.12.1-2: Temporal change in chlorophyll-*a* concentration of (a) total (b) >10 μm, and (c) 0.7–10 μm during the incubation.

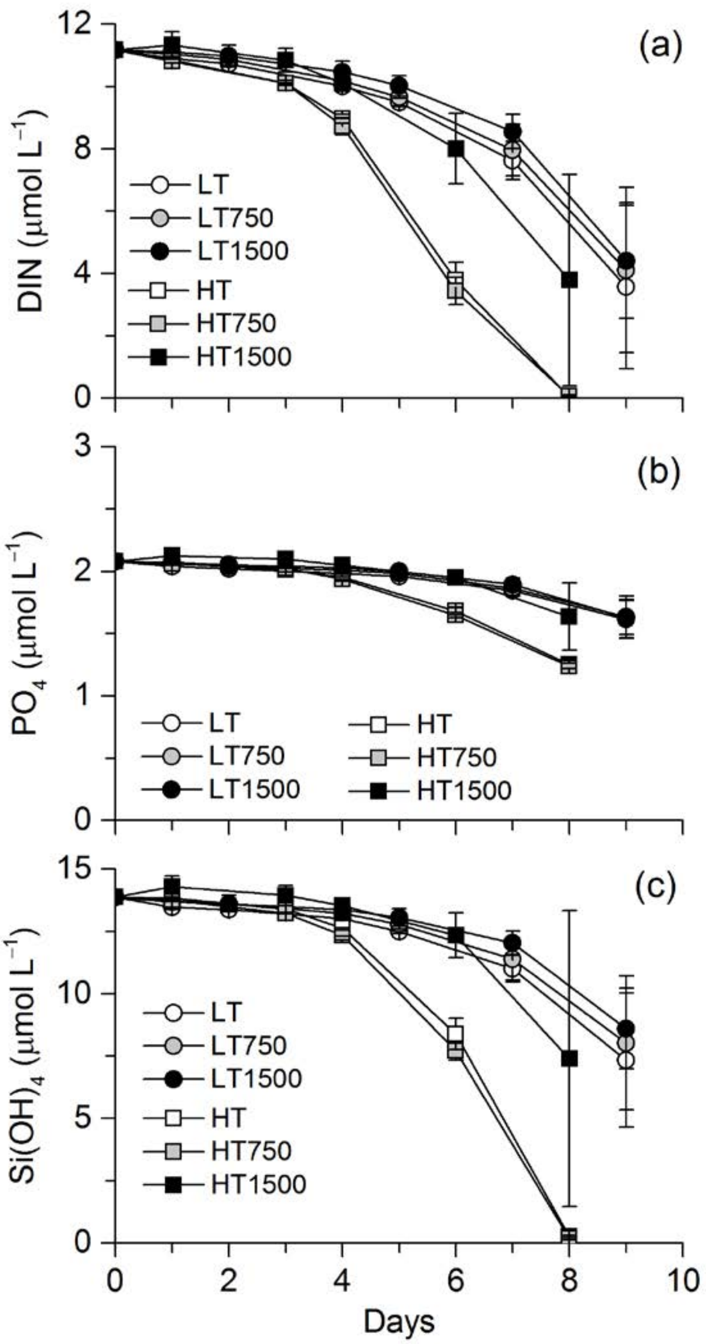


Figure 4.12.1-3: Temporal change in nutrients. (a) dissolved inorganic nitrogen (nitrate + nitrite + ammonia), (b) phosphate, and (c) silicic acid.

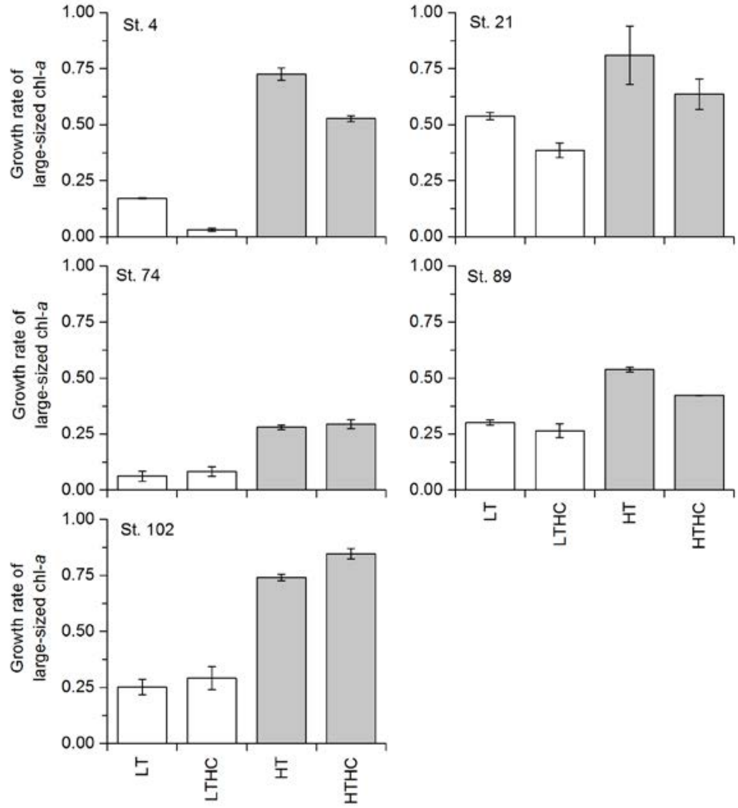


Figure 4.12.2-1: Net growth rate of >10 µm-sized phytoplankton at each station.

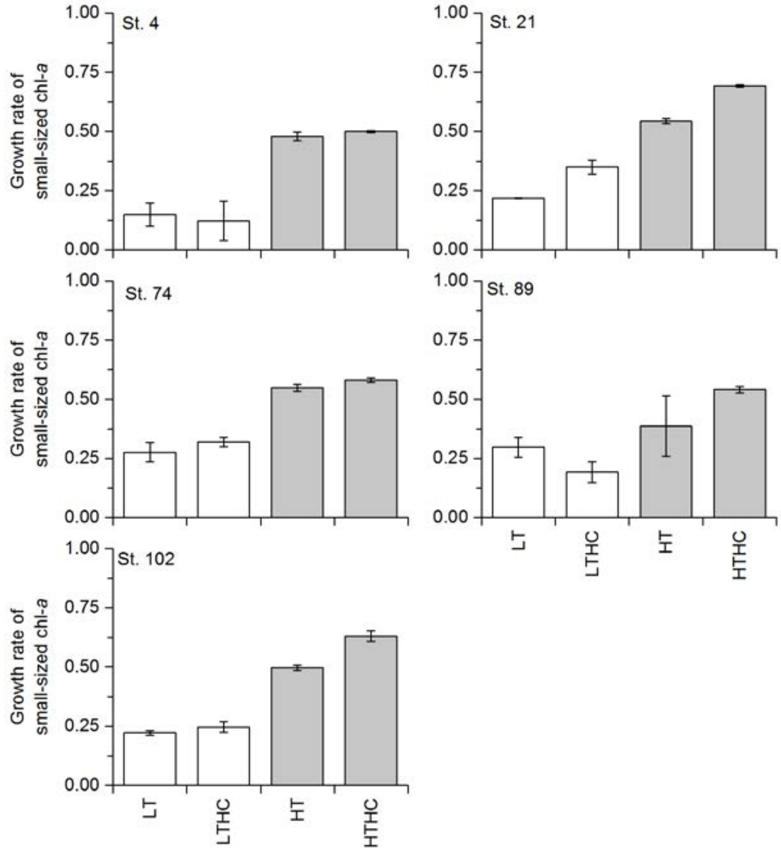


Figure 4.12.2-2: Net growth rate of 0.7–10 µm-sized phytoplankton at each station.

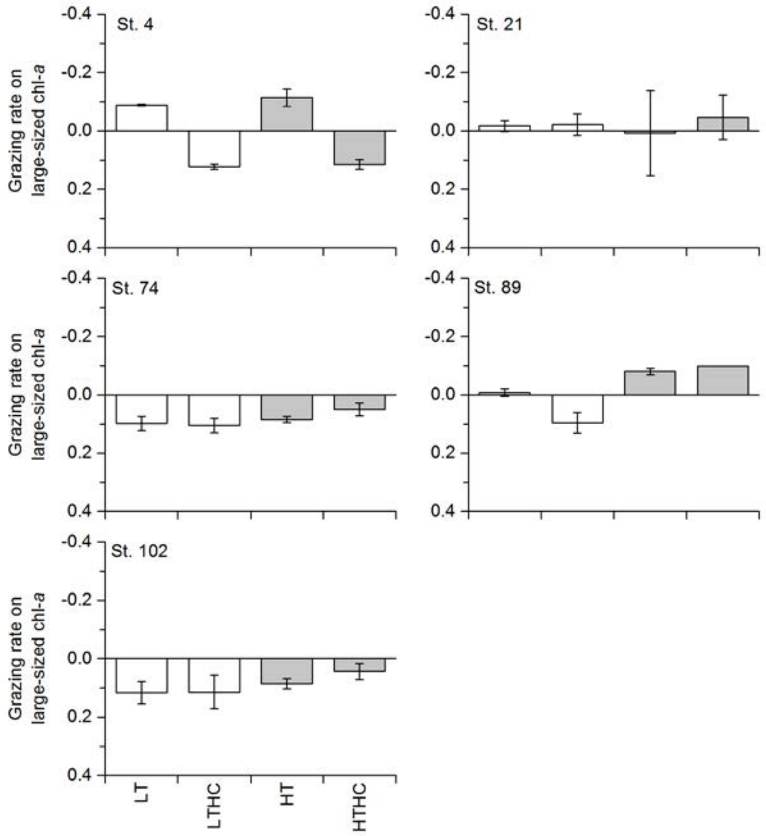


Figure 4.12.2-3: Grazing rate on large-sized phytoplankton at each station.

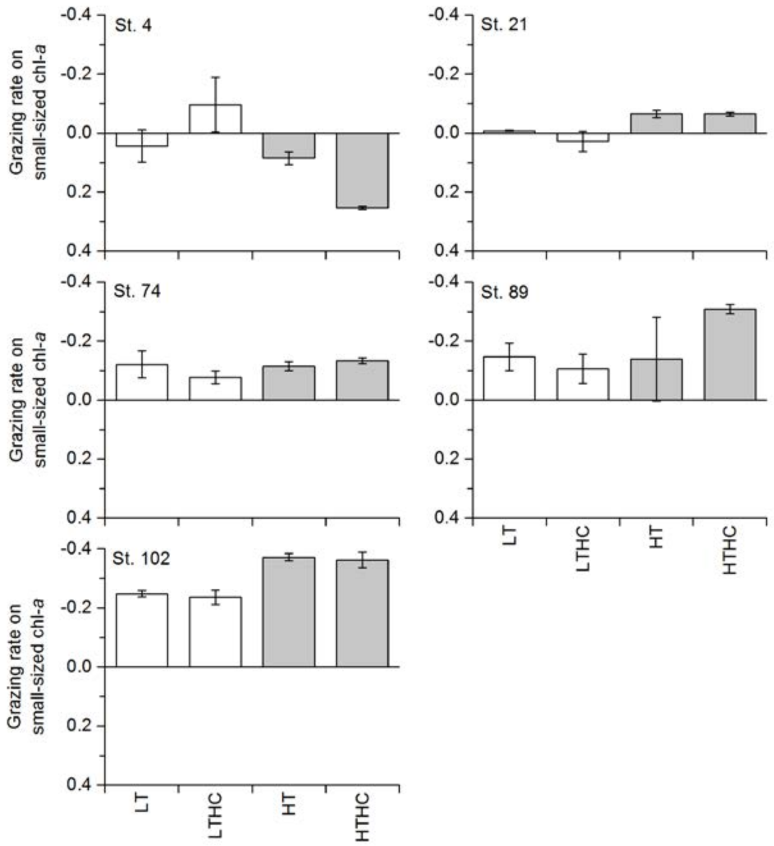


Figure 4.12.2-4: Grazing rate on small-sized phytoplankton at each station.

4.13. Zooplankton net samplings

(1) Personnel

Toru Hirawake	Hokkaido University	- Principal Investigator
Yutaka Watanuki	Hokkaido University	
Atsushi Yamaguchi	Hokkaido University	
Naomi Harada	JAMSTEC	
Katsunori Kimoto	JAMSTEC	
Bungo Nishizawa	Hokkaido University	
Yoshiyuki Abe	Hokkaido University	
Koki Tokuhiro	Hokkaido University	
Kohei Matsuno	Hokkaido University	

(2) Objective

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 and appendicularians in the Arctic Ocean.
3) Clarify the grazing impact of the arctic copepods and appendicularians in the Arctic Ocean ecosystem.
4) Evaluate the effect of ocean acidification on pteropods in the western Arctic Ocean.
5) Evaluate the spatial distribution of abundance and biomass in euphausiids (krill).

(3) Sampling

Zooplankton samples were collected by vertical haul of quadruple NORPAC nets at 67 stations in the western Arctic Ocean. Quadruple NORPAC net (mesh sizes: 335, 150 and two 62 μm [one is for fixed sample and the other has large size cod-end to collected fresh samples for incubation], 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 (Figure 4.13-1 and Table 4.13-1). Zooplankton samples collected by the NORPAC net with 335 and 150 μm mesh were immediately fixed with 5% buffered formalin for zooplankton structure analysis. Samples collected with 62 μm mesh at 58 stations were fixed with 99.5% ethanol for analysis on pteropods, foraminifera and radiolaria (investigator: Katsunori Kimoto [JAMSTEC]). The remaining 62 μm mesh samples at 13 stations were immediately fixed with 5% buffered formalin for zooplankton structure analysis later. The volume of water filtered through the net was estimated from the reading of a flow-meter mounted in the mouth ring.

Bucket net with large size cod-end (mesh: 62 μm, mouth diameter: 45 cm) was towed between surface and 150 m depth or bottom -5 m at 80 stations (Figure 4.13-1 and Table 4.13-2), fresh samples were used for evaluation of the copepod physiological activity (i.e.

wet mass, dry mass, ash-free dry mass and gut pigment).

Closing PCP net (mesh size: 63 µm, mouth diameter: 45 cm) was towed at 4 stations from 5 layers (0–50, 50–100, 100–250, 250–300, 300–500, 500–1000 and 1000-1500 m). 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 were split with Motoda box splitter. One aliquot was immediately fixed with 5% buffered formalin for zooplankton structure analysis (Figure 4.13-1 and Table 4.13-3). The remaining aliquot was demineralized and fixed with 99.5% ethanol for analysis on foraminiferans and pteropods (investigator: Katsunori Kimoto [JAMSTEC]).

Macrozooplankton samples were collected at 46 stations in the western Arctic Ocean. Bongo nets (335 µm mesh size, 70 cm mouth diameter) were obliquely towed from a 200 m depth to the surface at a speed of 2 knots. After collection, the samples were immediately preserved with v/v 5% borax-buffered formalin-seawater. The filtered water volumes were estimated from the readings of a flow-meter (Rigosha Co. Ltd., Tokyo) mounted on a net ring.

(4) On-board treatment

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

Fresh zooplankton samples collected with Bucket net were immediately added with 10% soda water (CO_2 water) used for gut pigment analysis. We sorted with late copepodid stages of the Pacific copepods (*Neocalanus cristatus, N. plumchrus, N. flemingeri, Eucalanus bungii, Metridia pacifica*), the Arctic copepods (*Calanus glacialis, C. hyperboreus, M. longa*) and appendicularians (*Oikopleura vanhoeffeni* and *O. labradoriensis*). 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, 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.

(5) Station list

Table 4.13–1: Data on plankton samples collected by vertical hauls with quadruple NORPAC net. GG54: 335 µm mesh.

Table 4.13–2: Data on plankton samples collected by vertical hauls with closing net (mesh size 63 µm).

Table 4.13–3: Data on macrozooplankton collected by obliquely towed with BONGO nets.

Table 4.13-1. Data on plankton samples collected by vertical hauls with quadruple NORPAC net.

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg.	Lon. Min.		S.M.T. Date	Hour	Depth estimated to be lowered (m)	Mesh size of net (μm)	Flowmeter No.	Reading	Estimated volume of water filtered (m³)	Remark
St. 001	63	5.65	N	174	0.97	W	26 August	08:47	71	335	2446	545	9.49	
										150	3690	542	8.49	
										62	3691	330	5.06	1)
										62	–	–	–	2)
St. 002	63	51.57	N	172	17.8	W	26 August	19:58	50	335	2446	703	12.25	
										150	3690	792	12.40	
										62	3691	513	7.86	
										62	–	–	–	2)
St. 003	64	42.69	N	170	20.92	W	27 August	04:15	43	335	2446	440	7.67	
										150	3690	450	7.05	
										62	3691	208	3.19	
										62	–		–	2)
St. 004	65	3.35	N	169	35.53	W	27 August	09:17	46	335	2446	380	6.62	
										150	3690	392	6.14	
										62	3691	103	1.58	1)
										62	–		–	2)
St. 005	65	16.18	N	169	2.78	W	27 August	11:28	48	335	2446	361	6.29	
										150	3690	375	5.87	
										62	3691	169	2.59	
										62	–		–	2)
St. 006	65	39.2	N	168	41.91	W	27 August	15:21	44	335	2446	405	7.06	
										150	3690	385	6.03	
										62	3691	103	1.58	
										62	–		–	2)
St. 007	66	16.21	N	168	50.55	W	27 August	19:05	50	335	2446	432	7.53	
										150	3690	239	3.74	
										62	3691	155	2.38	1)
										62	–		–	2)
St. 008	67	11.95	N	168	53.99	W	28 August	01:40	43	335	2446	398	6.93	
										150	3690	378	5.92	
										62	3691	220	3.37	1)
										62	–		–	2)
St. 009	67	34.45	N	168	50.65	W	28 August	04:19	45	335	2446	429	7.47	
										150	3690	381	5.97	
										62	3691	209	3.20	
										62	–		–	2)
St. 010	68	1.2	N	168	50.48	W	28 August	10:25	54	335	2446	432	7.53	
										150	3690	418	6.55	
										62	3691	186	2.85	1)
										62	–		–	2)
St. 011	68	30	N	168	45	W	28 August	13:39	48	335	2446	385	6.71	
										150	3690	382	5.98	
										62	3691	112	1.72	
										62	–		–	2)
St. 012	69	0	N	168	45	W	28 August	17:46	48	335	2446	415	7.23	
										150	3690	346	5.42	
										62	3691	120	1.84	1)
										62	–		–	2)
St. 013	69	30	N	168	45	W	28 August	20:58	46	335	2446	450	7.84	
										150	3690	415	6.50	
										62	3691	158	2.42	
										62	–		–	2)
St. 014	70	0.7	N	168	45.28	W	29 August	01:50	36	335	2446	334	5.82	
										150	3690	283	4.43	
										62	3691	150	2.30	1)
										62	–		–	2)
St. 015	70	30	N	168	45.15	W	29 August	04:41	34	335	2446	319	5.56	
										150	3690	310	4.85	
										62	3691	92	1.41	
										62	–		–	2)

S.M.T. was UTC-11h.
1) sample for JAMSTEC Kimoto
2) sample for experiments

Table 4.13-1. (Continued)

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg	Lon. Min.		S.M.T. Date	Hour	Depth estimated to be lowered (m)	Mesh size of net (μm)	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
St. 016	71	0.13	N	168	46.84	W	29 August	09:47	40	335	2446	381	6.64	
										150	3690	379	5.94	
										62	3691	203	3.11	1)
										62	-		-	2)
St. 017	71	30	N	168	45.27	W	29 August	14:40	44	335	2446	407	7.09	
										150	3690	419	6.56	
										62	3691	241	3.69	
										62	-		-	2)
St. 018	72	0.1	N	168	45.02	W	29 August	18:23	46	335	2446	442	7.70	
										150	3690	400	6.26	
										62	3691	122	1.87	1)
										62	-		-	2)
St. 019	72	24.12	N	166	39.13	W	30 August	00:19	45	335	2446	468	8.15	
										150	3690	480	7.52	
										62	3691	210	3.22	1)
										62	-		-	2)
St. 020	72	32.87	N	163	58.46	W	30 August	04:37	46	335	2446	418	7.28	
										150	3690	392	6.14	
										62	3691	182	2.79	1)
										62	-		-	2)
St. 021	72	48.17	N	161	20.93	W	30 August	12:08	45	335	2446	397	6.92	
										150	3690	418	6.55	
										62	3691	141	2.16	1)
										62	-		-	2)
St. 022	72	12.61	N	159	10.33	W	30 August	19:34	45	335	2446	643	11.20	
										150	3690	629	9.85	
										62	3691	301	4.61	1)
										62	-		-	2)
St. 023	71	50.68	N	158	23.42	W	30 August	22:35	53	335	2446	575	10.02	
										150	3690	580	9.08	
										62	3691	280	4.29	
										62	-		-	2)
St. 024	71	42.71	N	158	7.14	W	31 August	01:20	53	335	2446	518	9.02	
										150	3690	528	8.27	
										62	3691	395	6.05	1)
										62	-		-	2)
St. 025	71	34.74	N	157	50.64	W	31 August	02:30	60	335	2446	580	10.10	
										150	3690	512	8.02	
										62	3691	228	3.49	
										62	-		-	2)
St. 026	71	29.94	N	157	40.86	W	31 August	05:13	81	335	2446	750	13.07	
										150	3690	772	12.09	
										62	3691	493	7.56	
										62	-		-	2)
St. 027	71	25.52	N	157	31.43	W	31 August	06:02	116	335	2446	1075	18.73	
										150	3690	1084	16.98	
										62	3691	222	3.40	1)
										62	-		-	2)
St. 028	71	19.67	N	157	21.61	W	31 August	08:51	87	335	2446	917	15.98	
										150	3690	782	12.25	
										62	3691	343	5.26	
										62	-		-	2)
St. 029	71	14.09	N	157	14.55	W	31 August	11:30	44	335	2446	403	7.02	
										150	3690	421	6.59	
										62	3691	171	2.62	1)
										62	-		-	2)
St. 034	71	52.53	N	156	2.84	W	31 August	20:00	74	335	2446	710	12.37	
										150	3690	690	10.81	
										62	3691	370	5.67	
										62	-		-	2)

S.M.T. was UTC-11h.
1) sample for JAMSTEC Kimoto
2) sample for experiments

Table 4.13-1. (Continued)

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg.	Lon. Min.		S.M.T. Date	Hour	Depth estimated to be lowered (m)	Mesh size of net (μm)	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
St. 035	71	49.31	N	155	50.08	W	31 August	21:33	53	335	2446	868	15.12	
										150	3690	765	11.98	
										62	3691	330	5.06	
										62	–		–	2)
St. 036	71	48.03	N	155	24.03	W	1 September	00:35	139	335	2446	1525	26.57	
										150	3690	1530	23.96	
										62	3691	672	10.30	1)
										62	–		–	2)
St. 037	71	44.02	N	155	12.37	W	1 September	02:06	150	335	2446	1472	25.65	
										150	3690	1470	23.02	
										62	3691	475	7.28	
										62	–		–	2)
St. 038	71	39.95	N	155	2.4	W	1 September	06:08	104	335	2446	942	16.41	
										150	3690	1078	16.88	
										62	3691	340	5.21	
										62	–		–	2)
St. 039	71	35.54	N	154	48.86	W	1 September	09:26	34	335	2446	340	5.92	
										150	3690	331	5.18	
										62	3691	228	3.49	1)
										62	–		–	2)
St. 044	72	28.08	N	155	28.37	W	1 September	16:48	150	335	2446	1415	24.65	
										150	3690	1480	23.18	
										62	3691	530	8.12	1)
										62	–		–	2)
St. 045	72	7.6	N	153	31.23	W	3 September	00:56	150	335	2446	1240	21.60	
										150	3690	1270	19.89	
										62	3691	400	6.13	1)
										62	–		–	2)
St. 046	72	45.43	N	151	28.83	W	3 September	08:15	150	335	2446	1173	20.44	
										150	3690	1078	16.88	
										62	3691	343	5.26	1)
										62	–		–	2)
St. 048	71	33.95	N	152	0.06	W	3 September	13:59	150	335	2446	1045	18.21	
										150	3690	1105	17.31	
										62	3691	181	2.77	
										62	–		–	2)
St. 049	71	29.57	N	152	20.37	W	3 September	16:18	129	335	2446	955	16.64	
										150	3690	1088	17.04	
										62	3691	70	1.07	
										62	–		–	2)
St. 051	71	19.81	N	153	3.97	W	3 September	21:50	73	335	2446	590	10.28	
										150	3690	550	8.61	
										62	3691	120	1.84	1)
										62	–		–	2)
St. 052	71	21.46	N	151	1.66	W	4 September	02:30	150	335	2446	1225	21.34	
										150	3690	1290	20.20	
										62	3691	429	6.57	1)
										62	–		–	2)
St. 053	71	47.64	N	152	59.77	W	4 September	07:20	150	335	2446	1112	19.37	
										150	3690	1278	20.01	
										62	3691	113	1.73	1)
										62	–		–	2)
St. 054	71	58.13	N	154	0.92	W	4 September	13:20	150	335	2446	1180	20.56	
										150	3690	1100	17.23	
										62	3691	289	4.43	1)
										62	–		–	2)
St. 055	72	3.98	N	155	0.03	W	4 September	16:52	150	335	2446	1105	19.25	
										150	3690	1140	17.85	
										62	3691	220	3.37	1)
										62	–		–	2)
St. 057	72	17.17	N	156	0.08	W	5 September	00:25	150	335	2446	1363	23.75	
										150	3690	1540	24.12	
										62	3691	530	8.12	1)
										62	–		–	2)

S.M.T. was UTC-11h.
1) sample for JAMSTEC Kimoto
2) sample for experiments

Table 4.13-1. (Continued)

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg	Lon. Min.		S.M.T. Date	Hour	Depth estimated to be lowered (m)	Mesh size of net (μm)	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
St. 058	72	9.49	N	156	20.2	W	5 September	02:20	150	335	2446	1140	19.86	
										150	3690	1215	19.03	
										62	3691	290	4.44	
										62	–		–	2)
St. 059	72	1.87	N	156	40.26	W	5 September	05:26	105	335	2446	843	14.69	
										150	3690	819	12.83	
										62	3691	105	1.61	1)
										62	–		–	2)
St. 060	71	54.36	N	157	0.46	W	5 September	06:38	72	335	2446	610	10.63	
										150	3690	638	9.99	
										62	3691	107	1.64	
										62	–		–	2)
St. 068	76	26.3	N	157	16.71	W	7 September	17:48	150	335	2446	1252	21.81	
										150	3690	1240	19.42	
										62	3691	680	10.42	1)
										62	–		–	2)
St. 069	73	59.79	N	156	2.97	W	8 September	10:25	150	335	2446	1402	24.43	
										150	3690	1465	22.94	
										62	3691	910	13.95	1)
										62	–		–	2)
St. 071	72	47.52	N	158	0.8	W	10 September	03:01	150	335	2446	1140	19.86	
										150	3690	1200	18.79	
										62	3691	358	5.49	1)
										62	–		–	2)
St. 074	73	19.32	N	169	53.98	W	10 September	12:52	150	335	2446	1112	19.37	
										150	3690	1117	17.49	
										62	3691	273	4.18	1)
										62	–		–	2)
St. 076	73	31.4	N	159	52.06	W	10 September	18:56	150	335	2446	1160	20.21	
										150	3690	1175	18.40	
										62	3691	269	4.12	1)
										62	–		–	2)
St. 077	73	9.43	N	162	18.73	W	11 September	01:00	150	335	2446	1178	20.52	
										150	3690	1110	17.38	
										62	3691	203	3.11	1)
										62	–		–	2)
St. 079	73	49.53	N	161	29.34	W	11 September	22:13	150	335	2446	1326	23.10	
										150	3690	1265	19.81	
										62	3691	528	8.09	1)
										62	–		–	2)
St. 081	74	4.59	N	162	0.44	W	12 September	07:01	150	335	2446	1334	23.24	
										150	3690	1250	19.58	
										62	3691	613	9.39	1)
										62	–		–	2)
St. 082	73	50.18	N	162	29.37	W	12 September	11:20	150	335	2446	1178	20.52	
										150	3690	1223	19.15	
										62	3691	351	5.38	
										62	–		–	2)
St. 083	72	44.31	N	162	27.31	W	12 September	19:47	42	335	2446	592	10.31	
										150	3690	580	9.08	
										62	3691	350	5.36	1)
										62	–		–	2)
St. 084	72	33.34	N	161	32.06	W	12 September	23:44	40	335	2446	385	6.71	
										150	3690	375	5.87	
										62	3691	169	2.59	1)
										62	–		–	2)
St. 085	74	31.43	N	161	53.4	W	13 September	22:39	150	335	2446	1308	22.79	
NAP										150	3690	1317	20.63	
										62	3691	821	12.58	1)
										62	–		–	2)
St. 087	75	0.47	N	164	58.42	W	14 September	12:32	150	335	2446	1275	22.21	
										150	3690	1280	20.05	
										62	3691	825	12.64	1)
										62	–		–	2)

S.M.T. was UTC-11h.
1) sample for JAMSTEC Kimoto
2) sample for experiments

Table 4.13-1. (Continued)

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg	Lon. Min.		S.M.T. Date	Hour	Depth estimated to be lowered (m)	Mesh size of net (μm)	Flowmeter No.	Reading	Estimated volume of water filtered (m³)	Remark
St. 088	75	0.06	N	167	14.16	W	14 September	16:14	150	335	2446	1293	22.53	
										150	3690	1168	18.29	
										62	3691	672	10.30	1)
										62	-		-	2)
St. 089 Zodiac	75	14.97	N	177	46.58		15 September	17:00	150	335	2446	1476	25.71	
										150	3690	1470	23.02	
										62	3691	882	13.52	1)
										62	-		-	2)
St. 091	75	0.05	N	174	59.92	W	16 September	02:16	150	335	2446	1160	20.21	
										150	3690	1032	16.16	
										62	3691	470	7.20	1)
										62	-		-	2)
St. 092	75	0	N	172	0.43	W	16 September	06:36	150	335	2446	1318	22.96	
										150	3690	1293	20.25	
										62	3691	831	12.74	1)
										62	-		-	2)
St. 093	75	0	N	169	35.94	W	16 September	13:25	150	335	2446	1310	22.82	
										150	3690	1340	20.99	
										62	3691	878	13.46	1)
										62	-		-	2)
St. 095	74	0	N	168	45.15	W	16 September	23:15	150	335	2446	1210	21.08	
										150	3690	1260	19.73	
										62	3691	795	12.18	1)
										62	-		-	2)
St. 096	73	0.03	N	168	45.02	W	17 September	05:23	57	335	2446	452	7.87	
										150	3690	455	7.13	
										62	3691	193	2.96	1)
										62	-		-	2)
St. 098 SCH	68	1.94	N	168	50.45	W	17 September	13:15	54	335	2446	531	9.25	
										150	3690	532	8.33	
										62	3691	262	4.02	1)
										62	-		-	2)
St. 099	68	59.84	N	168	50.18	W	17 September	20:10	47	335	2446	440	7.67	
										150	3690	400	6.26	
										62	3691	231	3.54	1)
										62	-		-	2)
St. 101	68	17.89	N	167	3.42	W	19 September	04:59	34	335	2446	298	5.19	
										150	3690	310	4.85	
										62	3691	132	2.02	1)
										62	-		-	2)
St. 102	68	12.01	N	167	20.15	W	19 September	05:58	42	335	2446	378	6.59	
										150	3690	382	5.98	
										62	3691	172	2.64	1)
										62	-		-	2)
St. 103	68	0.16	N	168	0.41	W	19 September	09:25	50	335	2446	440	7.67	
										150	3690	448	7.02	
										62	3691	125	1.92	1)
										62	-		-	2)
St. 104	67	44.88	N	168	29.97	W	19 September	11:37	45	335	2446	332	5.78	
										150	3690	315	4.93	
										62	3691	78	1.20	1)
										62	-		-	2)
St. 106	67	12.02	N	168	53.61	W	19 September	17:51	44	335	2446	407	7.09	
										150	3690	405	6.34	
										62	3691	140	2.15	1)
										62	-		-	2)
St. 108	66	16.47	N	168	52.83	W	20 September	00:53	51	335	2446	501	8.73	
										150	3690	520	8.14	
										62	3691	288	4.41	1)
										62	-		-	2)
St. 109	65	39.01	N	168	42.65	W	20 September	08:09	44	335	2446	388	6.76	
										150	3690	382	5.98	
										62	3691	209	3.20	1)
										62	-		-	2)

S.M.T. was UTC-11h.
1) sample for JAMSTEC Kimoto
2) sample for experiments

Table 4.13-1. (Continued)

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg.	Lon. Min.		S.M.T. Date	Hour	Depth estimated to be lowered (m)	Mesh size of net (µm)	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
St. 110	65	16.2	N	169	2.7	W	20 September	10:29	48	335	2446	442	7.70	
										150	3690	458	7.17	
										62	3691	203	3.11	1)
										62	-		-	2)
St. 111	65	3.59	N	169	35.93	W	20 September	14:26	45	335	2446	465	8.10	
										150	3690	455	7.13	
										62	3691	229	3.51	1)
										62	-		-	2)

S.M.T. was UTC-11h.
1) sample for JAMSTEC Kimoto
2) sample for experiments

Table 4.13-2. Data on plankton collected by vertical hauls with closing net.

Station no.	Position Lat. Deg.	Lat. Min.		Lon. Deg	Lon. Min.		S.M.T. Date	Hour	Depth of closed (m)		Depth estimated to be lowered (m)	Mesh size of net (µm)	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
St. 044 NBC	72	29.62	N	155	26.42	W	1 Sep.	19:47	0	–	50	63	2885	332	4.59	1)
								19:54	51	–	100	63	2885	210	2.90	1)
								20:04	102	–	250	63	2885	440	6.08	1)
								20:19	253	–	300	63	2885	260	3.59	1)
								20:36	301	–	500	63	2885	1125	15.54	1)
								21:01	503	–	1000	63	2885	1280	17.69	1)
								21:45	964	–	1501	63	2885	1360	18.79	1)
St.044 NBC	72	28.65	N	155	24.15	W	2 Sep.	11:00	0	–	50	63	2885	171	2.36	1)
								11:06	50.8	–	100	63	2885	97	1.34	1)
								11:15	102	–	250	63	2885	531	7.34	1)
								11:30	252	–	300	63	2885	242	3.34	1)
								11:46	303	–	500	63	2885	801	11.07	1)
								12:18	501	–	1000	63	2885	1489	20.57	1)
								13:05	1000	–	1500	63	2885	1445	19.96	1)
St.069	74	0.08	N	156	05.54	W	8 Sep.	14:44	0	–	50	63	2885	372	5.14	1)
								14:51	49.8	–	100	63	2885	390	5.39	1)
								15:01	102	–	250	63	2885	810	11.19	1)
								15:18	252	–	300	63	2885	450	6.22	1)
								15:37	304	–	500	63	2885	1200	16.58	1)
								16:06	501	–	1000	63	2885	1690	23.35	1)
								16:56	1011	–	1500	63	2885	2892	39.96	1)
St.074 NHC	73	18.33	N	160	49.73	W	11 Sep.	10:27	0	–	49.9	63	2885	257	3.55	1)
								10:34	49	–	100	63	2885	75	1.04	1)
								10:46	100	–	250	63	2885	806	11.14	1)
								11:14	252	–	300	63	2885	278	3.84	1)
								11:34	305	–	370	63	2885	465	6.42	1)

S.M.T. was UTC-11h.
1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.13-3. Data on macrozooplankton collected by obliquely towed with BONGO nets.

Station no.	Position Lat. Deg.	Lat. Min.	Lon. Deg.	Lon. Min.	S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated to be lowered (m)	Mesh size of net (µm)	Flowmeter No.	Reading	Estimated volume of water filtered (m^3)	Remark
St. 002	63	52.73 N	172	16.36 W	26 August	21:48	70	50	45	335 335	1852	2683	108.49	Depth: 55 m Logger: 38.5 m
St. 005	65	17.2 N	169	2.73 W	27 August	12:31	73	52	44.9	335 335	1852	2229	90.13	Depth: 53 m Logger: 40.2 m
St. 010	68	1.2 N	168	50.48 W	28 August	10:45	85	40	65.1	335 335	1852	2438	98.58	Depth: 59 m Logger: 54.9 m
St. 013	69	30 N	168	45 W	28 August	22:13	69	42	51.3	335 335	1852	2152	87.02	Depth: 51.9 m Logger: 39.9 m
St. 016	71	0.4 N	168	47.14 W	29 August	10:11	65	42	48.3	335 335	1852	1786	72.22	Depth: 45 m Logger: 39.9 m
St. 018	72	0.12 N	168	44.38 W	29 August	19:48	72	45	50.9	335 335	1852	3132	126.64	Depth: 51.8 m Logger: 35.0 m
St. 020	72	23.15 N	163	58.24 W	30 August	05:54	72	48	48.2	335 335	1852	3295	133.23	Depth: 51.7 m Logger: 40.5 m
St. 022	72	12.86 N	159	10.22 W	30 August	20:05	75	50	48.2	335 335	1852	2588	104.64	Depth: 50.5 m Logger: 41 m
St. 025	71	35.1 N	157	50.85 W	31 August	03:29	85	51	53.5	335 335	1852	2968	120.01	Depth: 65 m Logger: 49 m
St. 027	71	25.37 N	157	33.25 W	31 August	07:10	140	48	93.7	335 335	1852	3862	156.16	Depth: 121m Logger: 91 m
St. 029	71	13.5 N	157	18.33 W	31 August	11:45	70	50	45	335 335	1852	2461	99.51	Depth: 49m Logger: 46.3 m
St. 034	71	53.19 N	156	2.83 W	31 August	20:42	110	49	72.2	335 335	1852	4090	165.38	Depth: 82m Logger: 62.1 m
St. 037	71	43.93 N	155	17.31 W	1 September	04:15	250	49	164	335 335	1852	7238	292.67	Depth: 281m Logger: 173.8 m
St. 039	71	35.58 N	154	48.09 W	1 September	09:49	55	50	35.4	335 335	1852	3080	124.54	Depth: 39m Logger: 28.3 m
St. 044	72	28.87 N	155	28.38 W	1 September	19:42	360	52	222	335 335	1852	9610	388.58	Depth: 1960m Logger: 201.6 m
St. 045	72	7.17 N	153	32.34 W	3 September	01:19	330	40	253	335 335	1852	6060	245.03	Depth: 1915 m Logger: 226.9 m
St. 046	72	45.36 N	151	28.76 W	3 September	08:31	350	48	234	335 335	1852	7814	315.96	Depth: 1910 m Logger: 236 m
St. 049	73	29.62 N	157	20.1 W	3 September	17:10	150	42	111	335 335	1852	3620	146.37	Depth: 134 m Logger: 102.3 m
St. 051	71	20.12 N	153	2.96 W	3 September	21:28	95	49	62.3	335 335	1852	3045	123.12	Depth: 77 m Logger: 56.1 m
St. 052	71	21.75 N	151	0.64 W	4 September	02:53	260	42	193	335 335	1852	5700	230.48	Depth: 223 m Logger: 192.7 m
St. 054	71	58.09 N	154	0.98 W	4 September	13:42	340	51	214	335 335	1852	7542	304.96	Depth: 705 m Logger: 225.3 m
St. 057	72	17.94 N	155	59.28 W	5 September	00:47	330	52	203	335 335	1852	8125	328.53	Depth: 985 m Logger: 215.9 m
St. 060	71	54.55 N	157	0.13 W	5 September	07:34	90	41	67.9	335 335	1852	2705	109.38	Depth: 78 m Logger: 54.4 m
St. 068	76	26.55 N	157	16.68 W	7 September	19:20	325	50	209	335 335	1852	9019	364.68	Depth: 1690 m Logger: 201.2 m
St. 069	74	0.31 N	156	5.41 W	8 September	18:19	300	44	216	335 335	1852	8569	346.48	Depth: 3858 m Logger: 187.2 m
St. 074	73	19.56 N	160	55.22 W	10 September	13:13	320	44	230	335 335	1852	5765	233.11	Depth: 372 m Logger: 263.8 m
St. 077	73	9.47 N	162	17.69 W	11 September	01:22	250	47	170	335 335	1852	5695	230.28	Depth: 201 m Logger: 163.3 m
St. 083	72	44.43 N	162	26.67 W	12 September	20:54	58	40	44.4	335 335	1852	3672	148.48	Depth: 49 m Logger: 30.3 m
St. 084	72	33.47 N	161	32.02 W	13 September	00:00	65	49	42.6	335 335	1852	4203	169.95	Depth: 45 m Logger: 37.3 m
St. 085	74	31 N	161	53.1 W	14 September	00:55	325	48	217	335 335	1852	9805	396.46	Depth: 1685 m Logger: 184.1 m
St. 087	75	0.29 N	164	58.27 W	14 September	12:51	335	49	220	335 335	1852	9091	367.59	Depth: 550 m Logger: 212.3 m
St. 089	75	14.88 N	177	46.22 W	15 September	17:25	330	47	225	335 335	1852	7692	311.02	Depth: 762 m Logger: 217.9 m
St. 093	75	0.74 N	169	35.2 W	16 September	13:46	290	49	190	335 335	1852	7708	311.67	Depth: 231 m Logger: 180.5 m
St. 095	73	59.95 N	168	45.2 W	17 September	00:04	250	47	170	335 335	1852	6668	269.62	Depth: 189 m Logger: 169.8 m
St. 096	73	0.08 N	168	44.85 W	17 September	06:17	88	46	61.1	335 335	1852	2192	88.63	Depth: 62 m Logger: 53.0 m
St. 097	72	29.86 N	168	45.17 W	17 September	10:54	82	43	60	335 335	1852	2581	104.36	Depth: 59 m Logger: 44.9 m
St. 098	68	2.3 N	168	50.74 W	18 September	14:43	87	47	59.3	335 335	1852	3957	160.00	Depth: 59.2 m Logger: 47.1 m
St. 099	69	0 N	168	51.09 W	17 September	21:21	65	30	56.3	335 335	1852	145	5.86	Depth: 52 m Logger: 50.3 m
St. 102	68	12.11 N	167	20.84 W	19 September	06:54	85	51	53.5	335 335	1852	2583	104.44	Depth: 48 m Logger: 44.0 m
St. 104	67	45.87 N	168	30.18 W	19 September	13:13	55	40	42.1	335 335	1852	454	18.36	Depth: 50.4 m Logger: 45.9 m
St. 106	67	12.18 N	168	53.73 W	19 September	18:24	50	30	43.3	335 335	1852	1260	50.95	Depth: 49 m Logger: 34.4 m
St. 107	66	44.17 N	168	53.97 W	19 September	21:43	44	20	41.3	335 335	1852	694	28.06	Depth: 42 m Logger: 29.2 m
St. 108	66	16.92 N	168	52.88 W	20 September	01:12	62	37	49.5	335 335	1852	2730	110.39	Depth: 56 m Logger: 34.8 m
St. 109	65	39.2 N	168	42.67 W	20 September	08:20	68	50	43.7	335 335	1852	3150	127.37	Depth: 50 m Logger: 35.1 m
St. 110	65	16.42 N	169	2.38 W	20 September	11:24	76	48	50.9	335 335	1852	2759	111.56	Depth: 54.0 m Logger: 45.4 m
St. 111	65	3.78 N	169	36.03 W	20 September	14:38	72	51	45.3	335 335	1852	2535	102.50	Depth: 51.0 m Logger: 42.1 m

(6) Preliminary results

As preliminary results, we present following items.

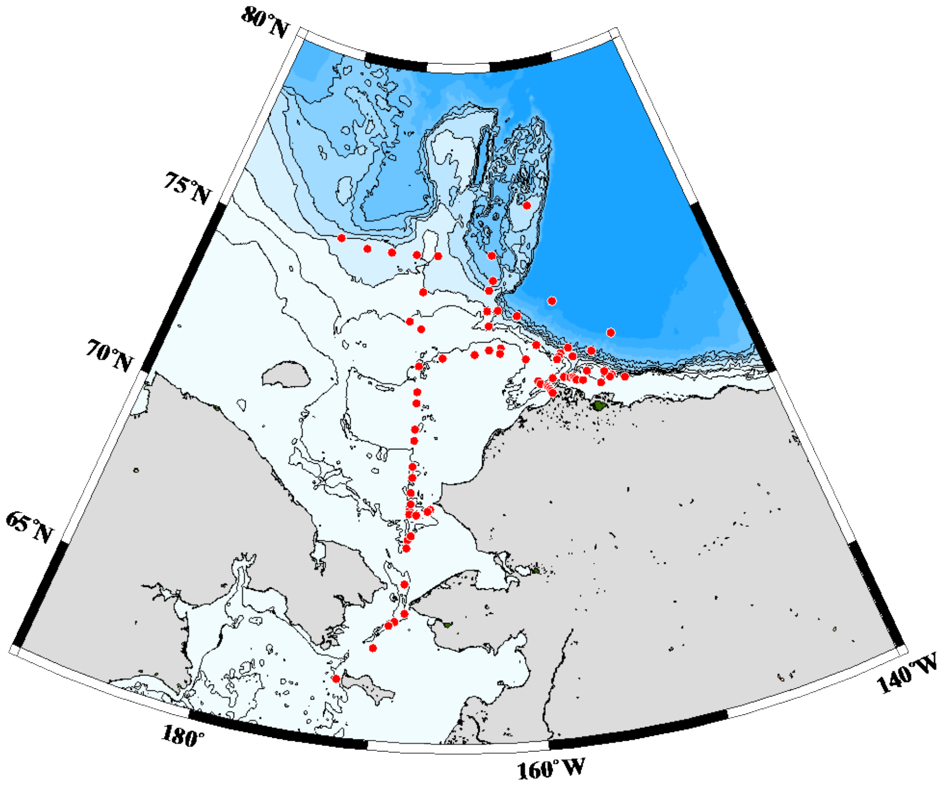


Figure 4.13-1: Location of the NORPAC net sampling stations.

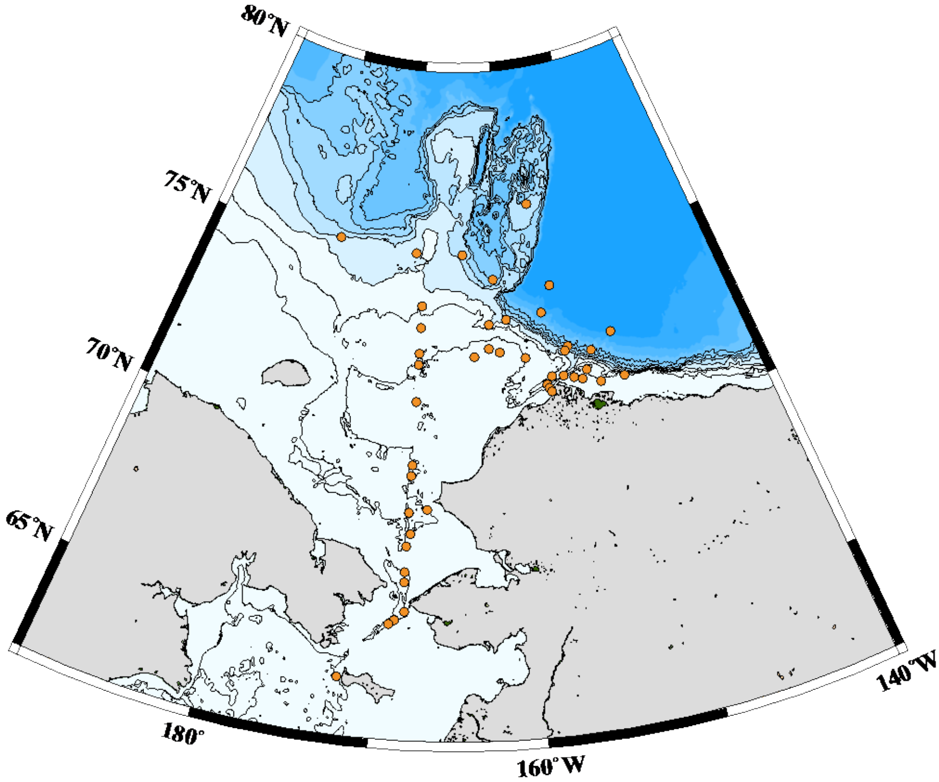


Figure 4.13-2: Location of the BONGO net sampling stations in the western Arctic Ocean.

4.14. Zooplankton incubation

(1) Personnel

Toru Hirawake	Hokkaido University	- Principal Investigator
Atsushi Yamaguchi	Hokkaido University	
Yoshiyuki Abe	Hokkaido University	
Koki Tokuhiro	Hokkaido University	
Kohei Matsuno	Hokkaido University	

(2) Objective

The goals of this study are following:

1) Evaluate gut evacuation rates of the Arctic appendicularians in the Arctic Ocean.
2) Determine total clearance rates (*TCR*) of appendicularians in incubation bottles.

(3) Sampling and treatment

Fresh appendicularians samples were collected by Bucket net with large size cod-end (mesh: 62 µm, mouth diameter: 45 cm) in the western Arctic Ocean. Bucket net was towed between surface and 150 m depth or bottom -5 m (stations where the bottom shallower than 150 m) at st. 89, 92 and 96. Fresh appendicularians specimens (*Oikopleura vanhoeffeni*) were immediately sorted and poured into a bucket filled filtered 10-L seawater. Appendicularians rearing was conducted at 5°C in the temperature-controlled room.

(4) Station list

Incubation specimens were collected at st. 89, 92 and 96. Sampling station detail is described at Table 4.13-1

(5) Preliminary results

As a preliminary result, we present following items.

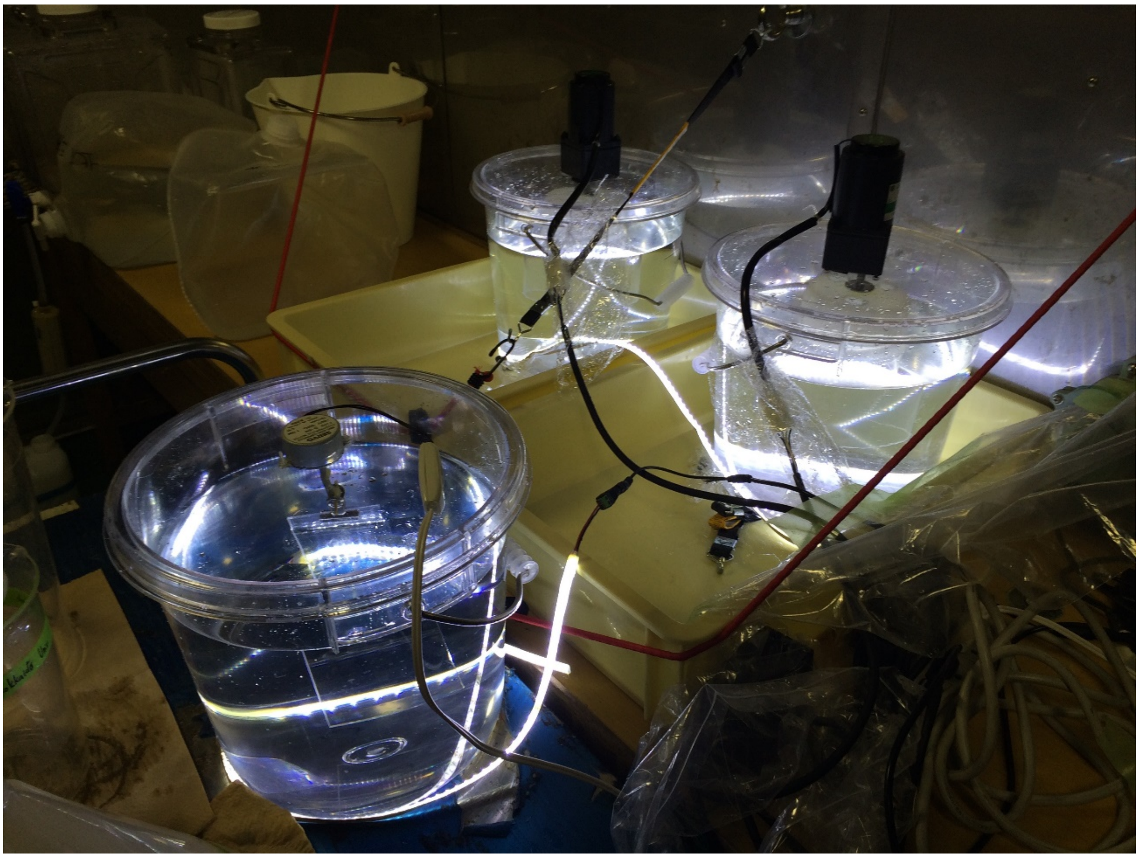


Figure 4.14-1: The picture of appendicularian incubation in the temperature-controlled room.

4.15. Water sampling for microscopic observation

(1) Personnel

Jonaotaro Onodera JAMSTEC - Principal Investigator

Koji Sugie JAMSTEC as a support of filtering water samples

(2) Objectives

To check the component of suspended particles and to see the distribution of diatom species which is one of major phytoplankton in the Chukchi Sea.

(3) Parameters

Concentration of suspended particle numbers and shell-bearing microplankton remains in water samples.

(4) Instruments and methods

Water samples were taken by CTD-Niskin sampler system for sub sea surface and bucket for sea surface waters. The sampled depth are sea surface and sub sea-surface chlorophyll maximum (SCM). One sea-ice sample was taken in Zodiac observation. The ice sample was melted at 4° C, and then the 1L of melt water was supplied for this observation (the filter number is #099 in Table 4.15-1). Water samples of 0.1-2.0L were gently filtered on membrane filter (diameter = 47mm, pore size = 0.45μm). The filter was desalted with Milli-Q water, and then it was dried in disposal petri dish at room temperature. These filter samples are brought to JAMSTEC HQ, and it will be observed in light microscope or scanning electron microscope later.

(5) Station list

Table 4.15-1: Sample list for the microscopy observation. CTD cast number at each station is 1 except for St. 85 (cast 2). The coordinate of each station is tabulated in Section 3.1.

Filter #	Station	Date and Time (UTC)	Sampled Depth (m)	Filtered Volume (mL)
1	1	26 Aug.,	0	750
2		18:26-19:00	27	750
3	4	27 Aug.	0	350
4		18:56-19:30	13	350
5	6	28 Aug.	0	300
6		01:47-02:15	7	300
7	7	28 Aug.	0	300
8		06:23-06:55	15	300
9	8	28 Aug.	0	500
10		12:08-12:37	28	500
11	9	28 Aug.	0	700
12		15:36-16:05	14	700
13	11	29 Aug.	0	700
14		00:55-01:22	15	700
15	12	29 Aug.	0	700
16		04:11-04:39	21	750

Filter #	Station	Date and Time (UTC)	Sampled Depth (m)	Filtered Volume (mL)
51	55	5 Sep.,	0	1000
52		03:10-04:12	37	1000
53	57	5 Sep.,	0	1000
54		10:05-11:20	34	1000
55	59	5 Sep.	0	1000
56		15:39-16:20	13	1000
57	68	8 Sep.	0	1000
58		02:07-03:52	59	1000
59	71	10 Sep.	0	1000
60		12:40-13:58	41	1000
61	74	10 Sep.	0	2000
62		21:51-22:55	25	2000
63	76	11 Sep.	0	2000
64		03:53-05:50	63	2000
65	77	11 Sep.	0	1000
66		11:16-11:56	15	1000

17	14	29 Aug.	0	700
18		12:26-12:49	8	700
19	16	29 Aug.	0	800
20		19:34-20:05	17	1000
21	18	30 Aug.	0	1000
22		04:45-05:16	31	800
23	19	30 Aug.	0	800
24		10:45-11:12	9	1000
25	20	30 Aug.	0	1000
26		16:16-16:45	38	800
27	21	30 Aug.	0	1000
28		21:49-22:22	16	1000
29	22	31 Aug.	0	1000
30		05:56-06:25	31	1000
31	24	31 Aug.	0	1000
32		11:45-12:15	34	1000
33	29	31 Aug.	0	300
34		21:22-21:53	4	300
35	36	1 Sep.	0	1000
36		10:49-11:29	12	1000
37	39	1 Sep.	0	1000
38		19:11-19:42	12	1000
39	44	2 Sep.	0	1000
40		03:55-05:45	60	1000
41	45	3 Sep.	0	1000
42		09:25-11:09	23	1000
43	46	3 Sep.	0	1000
44		16:35-18:05	32	1000
45	51	4 Sep.	0	970
46		06:53-07:25	19	1000
47	52	4 Sep.	0	1000
48		12:00-12:55	7	1000
49	54	4 Sep.	0	1000
50		22:10-23:26	23	1000

67	79	12 Sep.	0	2000
68		07:58-09:09	68	2000
69	81	12 Sep.	0	1700
70		16:40-17:55	19	2000
71	83	13 Sep.	0	1000
72		07:05-08:30	14	1000
73	84	13 Sep.	0	1000
74		10:14-10:40	15	1000
75	85	14 Sep.	0	2000
76		07:47-09:37	49	2000
77	87	14 Sep.	0	2000
78		21:15-22:34	21	2000
79	88	15 Sep.	0	2000
80		03:40-04:30	17	2000
81	89	16 Sep.	zodiac 0	1000
82		01:52-03:06	zodiac 0	1000
83			0	1000
84			33	1000
85	90	16 Sep.	0	1000
86		06:23-07:23	35	1000
87	91	16 Sep.	0	1000
88		12:16-13:10	27	1000
89	92	16 Sep.	0	1000
90		17:56-19:00	33	1000
91	93	16 Sep.	0	1500
92		22:43-23:39	36	1500
93	95	17 Sep.	0	2000
94		09:25-10:10	24	2000
95	96	17 Sep.	0	1000
96		16:38-17:10	15	1000
97	97	17 Sep.	0	500
98		20:31-21:10	25	500
99	89	16 Sep. 01:52-03:06	Melted sea ice	400
100	101	19 Sep. 15:28-15:53	7	500

(6) Preliminary results

(not available)

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

4.16. Sediment trap

(1) Personnel

Naomi Harada	JAMSTEC	- Principal Investigator
Jonaotaro Onodera*	JAMSTEC	
Yuichiro Tanaka	AIST	
Motoyo Itoh	JAMSTEC	
Takeshi Tamura	NIPR	
Katsunori Kimoto	JAMSTEC	
Kazumasa Oguri	JAMSTEC	
Kohei Mizobata	TUMSAT	
Eiji Watanabe	JAMSTEC	
Takuhei Shiozaki*	JAMSTEC	
Koki Tokuhiro*	Hokkdaido Univ.	
Keisuke Matsumoto*	MWJ as technical staff leader for mooring operation,	
Shinya Okumura*	NME as the staff leader for SSBL acoustic survey.	
	*: onboard members	

(2) Objectives

For the below objectives, two sediment trap moorings have been deployed at Stations NBC and NHC in the shelf slope in the southwestern Canada Basin.

- To monitor hydrographic condition regarding to ocean acidification and warming.
- To understand lateral transportation of shelf materials to basin with physical oceanographic condition.
- To investigate biodiversity in the study region.

(3) Parameters

Settling particles, temperature, salinity, current, pH, pCO2, dissolved oxygen, turbidity, chlorophyll-a, camera (only for new deployment)

(4) Instruments and methods

<Instruments>

All instruments on recovered and deployed moorings are listed in Tables 4-16.1 to 4-16.4.

<Methods>

All equipment has passed export at the Hachinohe Custom. The all required procedure at the custom was performed by the Hachinohe Kowan, Co. Ltd. Acoustic communication of all releasers to be deployed in this cruise were examined between this ship and 1000 m deep in the northeastern Aleutian Basin. The battery of acoustic releasers is for continuous two-years deployment. For the deployment sensors, log file or photograph of configuration process were taken. Sample cup of sediment bottles were filled-in by filtered sea water taken at 1000 m depth in the southwestern Canada Basin in MR16-06 cruise. The water contains formalin (4v/v%) and sodium hydroborate as pH adjustment (pH ~8.2).

Before the mooring recovery, mooring position, the distance and direction from the ship was confirmed by SSBL, and then release command was transmitted to the Benthos acoustic releaser of the mooring. Short safety meeting was conducted just before each mooring operation on the working deck at stern. The rope from the work deck at stern was connected to the top buoy of the mooring by zodiac. By taking-up the rope, the mooring was recovered from the top buoy on deck.

All serial numbers of deploying equipment and connection of all parts were checked by Dr. Nishino, S. as a third-party inspector, just before the deployment and/or during the deployment operation. Mooring deployment starts from the throw-in of top buoy into water. The ships go forward with slow speed (~1.0knot). Before the dropping sinker, the slow towing of mooring continued until the ship reaches at the planned target position of the mooring. Deepening and vanish of top buoy from sea surface was confirmed, and then acoustic ranging and determination of mooring position was conducted using SSBL and transducer for Nichiyu releaser. The position, water depth, top depth, and recovery plan (season and ship) of the newly deployed moorings were noticed by Dr. Itoh, M. to AOOS and related persons in the world during the cruise.

(5) log tables of sediment trap mooring operation. Date and time is UTC in the tables.

Table 4.16-1: Recovery of NBC16t on September 2nd, 2017.

Transmission of release command (72°28.1776' N 155°25.8173'W, 1980 m water depth)	18:22
Finding of top buoy at sea surface	18:23
Connection of ship's rope and top buoy by zodiac	19:07
Zodiac on deck	19:16

Time of instruments out of water

Frame#	Type	Model	Serial Number	Time
-	Float	34" aluminum float	Float-Al-101	19:24
1	Transponder CT Multi-Exciter	EdgeTech CAT A7CT2-USB MFL50W-USB	36221 274 19	19:24
2	MMP	McLane Moore Profiler	ML12870-2	19:47

3	ADCP	WHS-300	24023	19:53
-	Floats	Benthos 17" x5	-	19:57
4	CT DO	SBE37SM ARO-USB	8889 136	19:58
5	CT	SBE37SM	8888	20:05
-	Trap CT	SMD26S-6000 A7CT-USB	98052 613	20:12
-	Floats	Benthos 17" x8	-	20:45
-	Trap	SMD26S-6000	98083	21:04
-	Floats	Benthos 17" x8	-	21:23
-	Releaser Releaser	Benthos 865A Nichiyu LGC	537 0066	21:23

End of recovery operation (72°28.7667'N 155°22.7309'W, 2034 m water depth)	21:23

Table 4.16-2: Recovery of NHC16t on September 11, 2017.

Transmission of release command (73°18.2291'N 160°48.2416'W, 415 m water depth)				19:59
Finding of top buoy at sea surface				20:00
Connection of ship's rope and top buoy by zodiac				20:24
Zodiac out of water				20:29
Time of instruments out of water				
Frame#	Type	Model	Serial Number	Time
-	Transponder Float	XT6001-17" Benthos 17" x1	55947 -	20:39
1	CT pH Multi-Exciter	A7CT2-USB SPS-14 MFL50W-USB	36221 390262005 41	20:39
-	Float	Benthos 17" x8	7	20:41
2	Logger └ CO2 pH DO CTD	SeaGuard CO2 SPS-14 ARO-USB SBE37SM	1889 70 390262006 135 8860	20:46
3	CT	SBE37SM	8858	20:51
4	ADCP	WHS-300	17021	20:56
-	Floats	Benthos 17" x8	-	20:58
-	Trap CT	SMD26S-6000 A7CT-USB	98058 626	21:07
-	Floats	Benthos 17" x8	-	21:18
-	Releaser Releaser	Benthos 865A Nichiyu LGC	537 0066	21:18

End of recovery operation (73°18.3059'N 160°49.2461'W, 415 m water depth)	21:18

Table 4.16-3: Deployment of NBC17t on September 3rd, 2017.

Start of mooring deployment (72°28.2624'N 155°36.6236'W, 1826 m water depth)	01:49

Time of instruments and anchor in water				
Frame#	Type	Model	Serial Number	Time
-	Transponder Floats	XT6001-13" Benthos 17" x2	60644 -	01:54
1	CT DO Multi-Exciter	A7CT2-USB ARO-USB MFL50W-USB	324 20 131	01:54
-	Floats	Benthos 17" x10	-	01:55
2	CTD	SBE37SM	13677	01:58
3	CTD	SBE37SM	13678	02:01
4	ADCP	WH-300	13836	02:04
5	Logger ├ADCP ├ Pressure ├ DO ├ CO2 └ pH pH CT	SeaGuard II DCP DCPS5402 4117E 4330IW CO2 (prototype) SP-11 A7CT-USB	8888 1658 1272 2709 78 38 390261009 613	02:10
6	CT	SBE37SM	7668	02:16
-	Floats	Benthos 17" x6	-	02:16
-	Trap Housing └ Camera LED light	SMD26S-6000 (Handmade) GZV570 (Handmade)	98063 13G1 157K0542 13G1	02:24
-	Floats	Benthos 17" x5	-	03:00
-	Trap	SMD26S-6000	98057	03:14
-	Floats	Benthos 17" x8	-	03:46
-	Releaser Releaser	Nichiyu LGC Nichiyu LGC	0078 0079	03:46
(towing with 0.6~1.6 knot to planned mooring position)				
-	Anchor (72°28.3190'N 155°24.2798'W, 1999 m)	Rail 750kg in air	-	04:42

Releaser ranging at 700m away from anchor position		
(distance = 2136 m, 2127 m)	0078	05:05
(distance = 2103 m, 2105 m)	0079	05:08

SSBL transponder survey		
position	72°28.3045'N	155°25.0015'W
water depth	1980 m	
depth of transponder	48.19 m	

Table 4.16-3: Deployment of NHC17t on September 13, 2017.

Start of mooring deployment (73°18.5582'N 160°47.6367'W, 422 m water depth)	20:05

Time of instruments and anchor in water				
Frame#	Type	Model	Serial Number	Time
-	Transponder Floats	XT6001-13" Benthos 17" x2	60645 -	20:09
1	CT DO Multi-Exciter	A7CT2-USB ARO-USB MFL50W-USB	274 19 130	20:09
-	Floats	Benthos 17" x8	-	20:09
2	CTD	SBE37SM	6937	20:13
3	Logger ├ Current ├ Pressure ├ DO └ CO2 pH CT	SeaGuard DCS4520IW 4117E 4330IW CO2 SP-11 A7CT-USB	1889 1144 1273 2710 70 346259009 324	20:16
4	ADCP	WH-300	17023	
-	Floats	Benthos 17" x8	-	20:26
5	CT	SBE37ODO	15706	20:26
-	Trap CT Housing └ Camera LED light	SMD26S-6000 SBE37SM (Handmade) Raspberry Pi/Pi+ (Handmade)	98042 15456 13G2 bbe538e6 15G1	20:34
-	Floats	Benthos 17" x8	-	20:47
-	Releaser Releaser	Nichiyu LGC Nichiyu LGC	0021 0077	20:47
(towing with 0.3~1.6 knot to planned mooring position)				
-	Anchor (73°18.1333'N 160°46.8721'N, 422.2 m water depth)	Rail 750kg in air	-	21:13
(vanish of top buoy by the deepening from sea surface)				21:15

Releaser ranging at 600m away from anchor position (distance = 653 m, 514 m, 662 m)	0077	21:35
Releaser ranging at 770m away from anchor position (distance = 762 m, 774 m)	0021	21:37

SSBL transponder survey		
position	73°18.2324'N	160°47.0225'W
water depth	425 m	
depth of transponder	48.92 m	

(6) Preliminary results

The design of sediment trap moorings is shown in Figures 4.16-1, 2, and 3. Nichiyu sediment trap takes pressure data every minute from automatic detect of water condition to the initial two hours (Figure 4.16-4). This pressure data, which was taken in the deployment operation during MR16-06 cruise, recorded that the overshooting just after the anchor arrival at sea floor reached to ~120 m for the shallower sediment trap at NBC16t (Figure 4.16-4a). The averaged depth of moored sensors throughout the deployment period (after the overshoot deepening during deployment work) was ~10 m deeper than the planed depth at NBC16t. The moored depth of each sensor at NHC16t was 10-15m shallower than the planed depth. There is no malfunction of all recovered sensors. McLane Moored Profiler (MMP) stopped to run on March 7, 2017 because of the deployment configuration. It should be note for data user that pCO2 raw data of NHC16t might show a drift with time in later half of the deployment period.

The settling particle samples by sediment trap at Station NBC16t were taken until trap cone clogged at the bottle neck structure of lower part of the cone in July 2017 (Figures 4.16-5, -6). The cause of trap clogging is due to large amount supply of particles into the cone for short time period. Hand-made attachment to decrease the opening area of trapping cone from $0.5m^2$ to $0.25m^2$ was mounted on the trap cone of NBC17t (Figure 4.16-7). The trap samples at Station NHC16t were successfully taken in all 26 bottles. No hand-made attachment was mounted on the sediment trap for NHC17t (trapping area of the cone = $0.5m^2$).

(7) Data archives-1

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

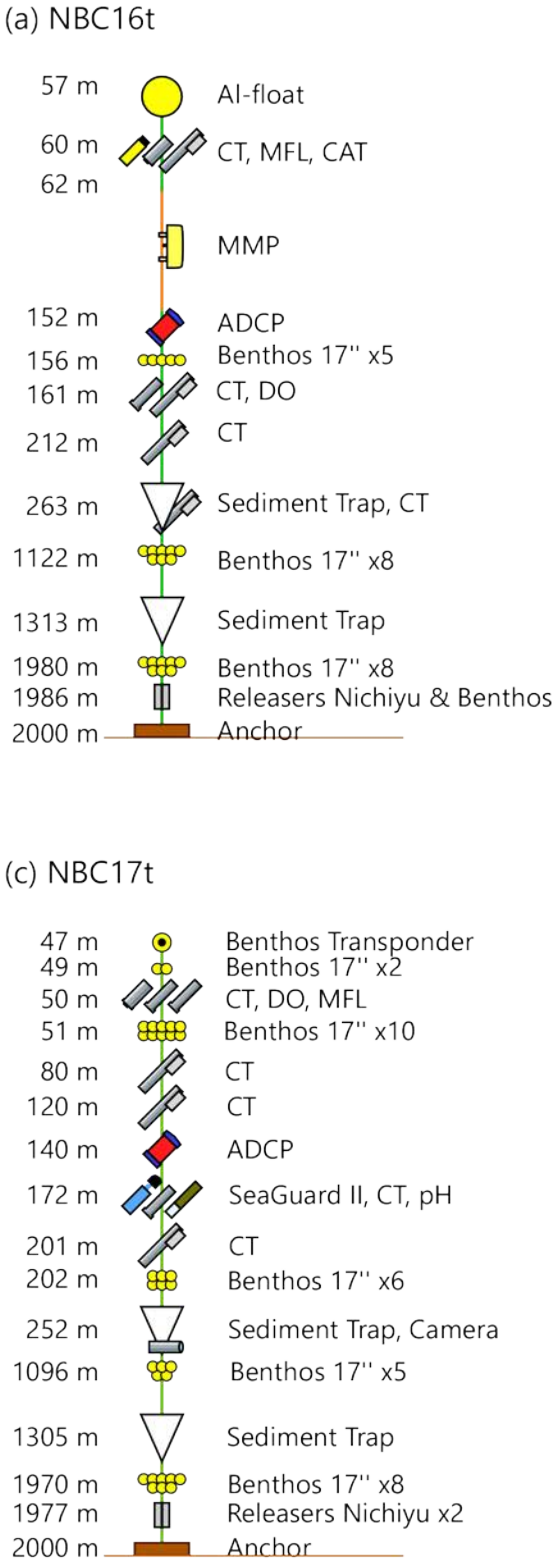


Figure 4.16-1: Outline of mooring design on recovered moorings (a) NBC16t and (b) NHC16t, and deployed moorings (c) NBC17t and (d) NHC17t.

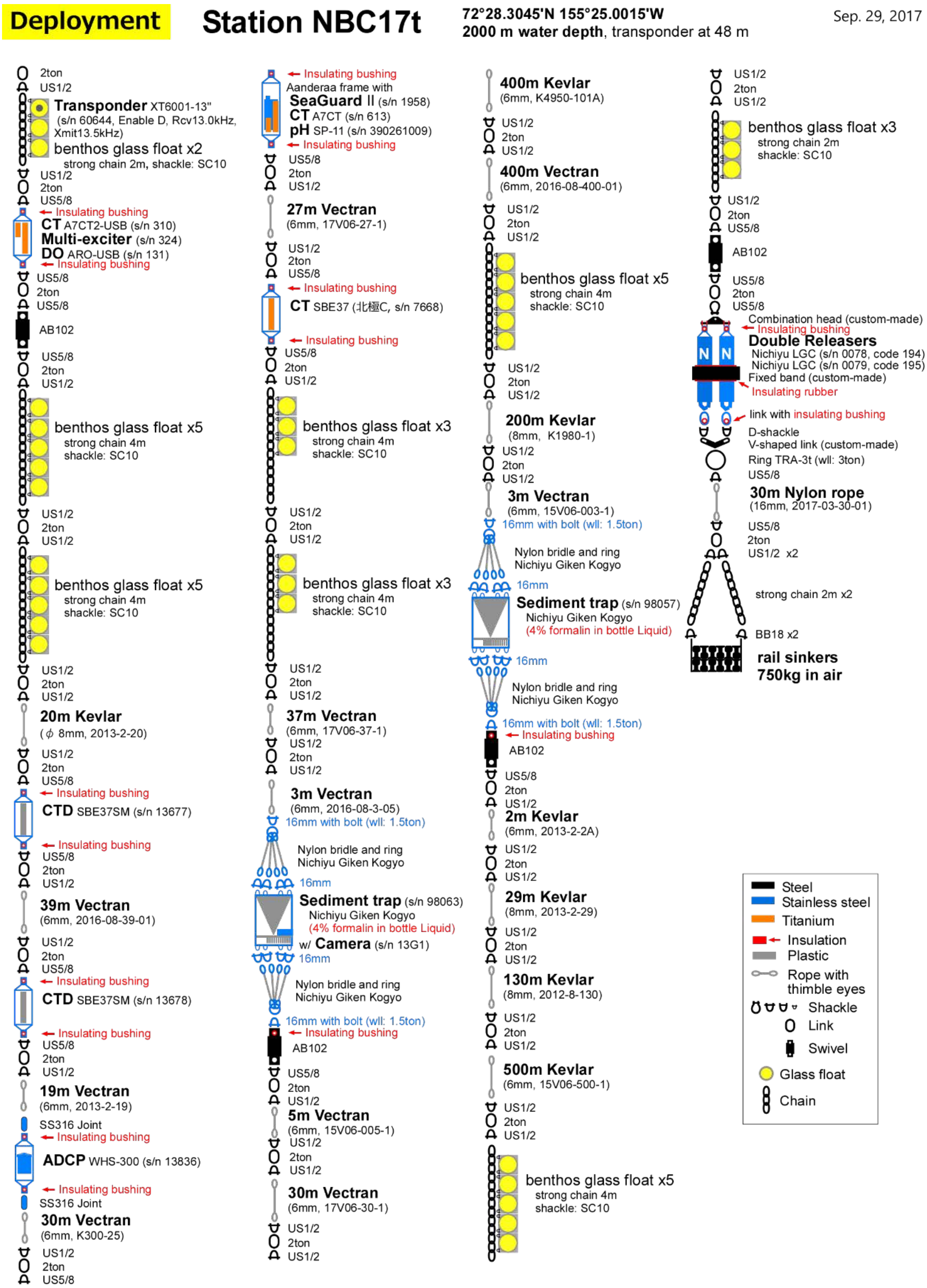


Figure 4.16-2: Design of deployed sediment trap mooing NBC17t.

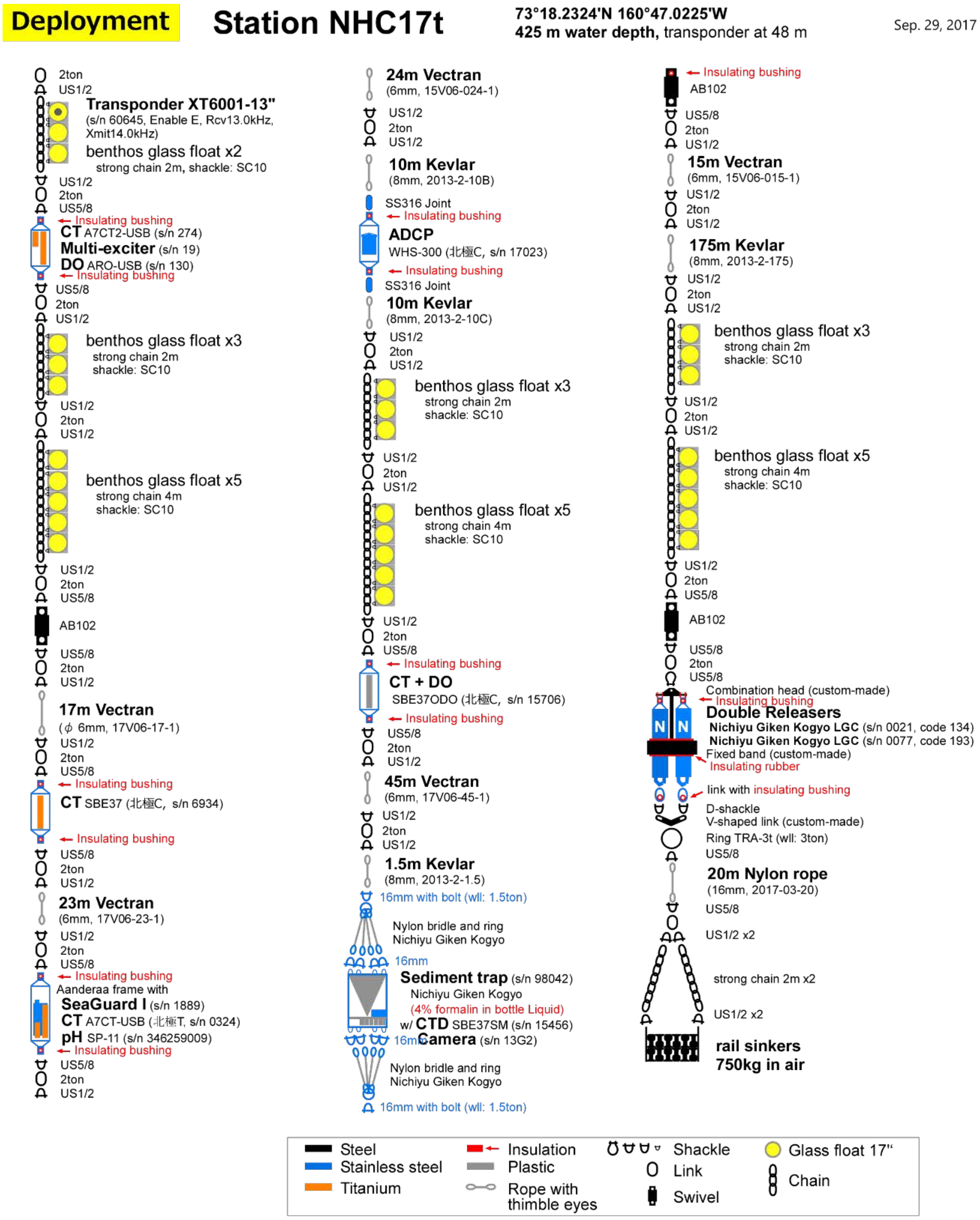


Figure 4.16-3: Design of deployed sediment trap mooing NHC17t.

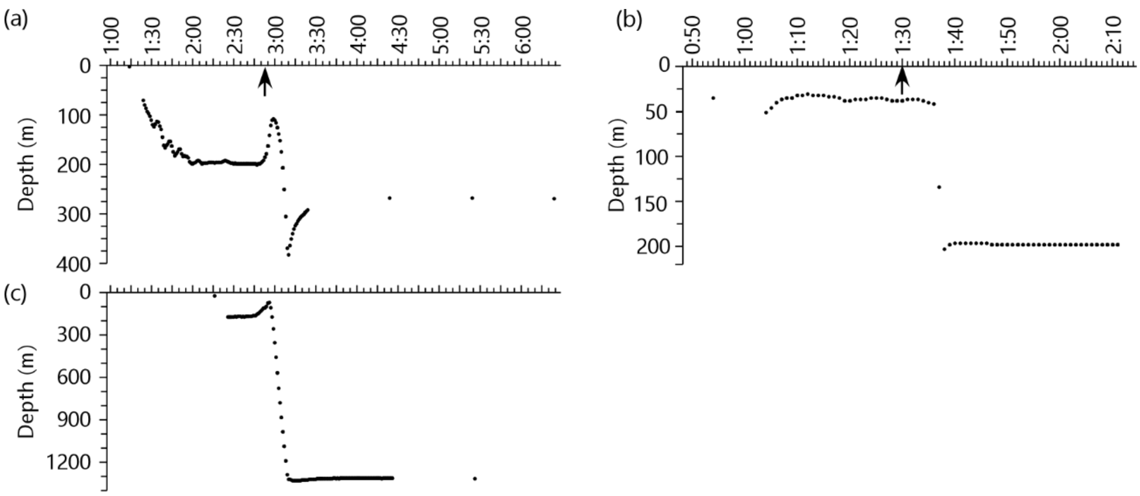


Figure 4.16-4: Depth log of sediment trap moorings NBC16t and NHC16t for deployment operation in MR16-06 cruise. Arrow shows the time of anchor release from the ship. (a) NBC16t shallower trap, (b) NHC16t, and (c) NBC16t deeper trap.

Figure 4.16-5: Recovered sediment trap bottles. Upper bottle line with yellow neck and middle line with blue neck is from the upper and lower sediment trap of NBC16t, respectively. Lower bottle line with pale green neck is from NHC16t. Left side is older (autumn 2016) and right end is this summer (Sep. 2, 2017). Arrows show the period for the clogging of trap cone.

Figure 4.16-6. Sample bottle of upper sediment trap of NBC16t (#26) with clogged particles on the top of bottle. The clogging trouble probably occurs when the loophole of bottle water is closed by supply of aggregated particle mass from the bottom of trap cone.

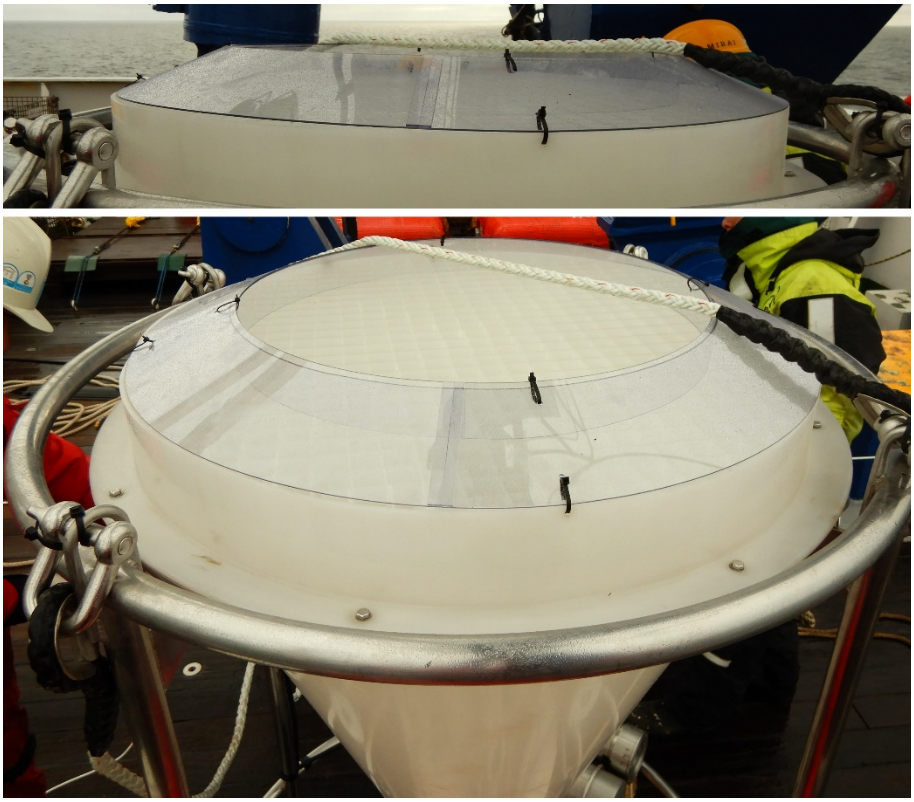


Figure 4.16-7: Hand-made attachment on sediment trap cone for NBC17t. The upper opening area of the attachment is 0.25 m^2. The height of attachment is 5.0cm.

4.17. Seabird observation

(1) Personnel

Yutaka Watanuki	Hokkaido University	- Principal Investigator
Bungo Nishizawa	Hokkaido University	

(2) Objectives

The marine ecosystems of the Bering Sea and adjacent Chukchi Sea are experiencing rapid changes due to reductions in sea ice. In the Bering Sea and Chukchi Sea shelf regions, seabirds, as homoeothermic top predators, play a significant role in the trophic energy flow. As mobile predators that can respond quickly to shifts in the distribution of prey (i.e., by switching foraging areas or prey species), changes in their distribution can potentially serve as indicators of fluctuations of trophic relationships. Thus, knowledge of recent changes in the distributions of top predators and their prey should provide useful information about large-scale ecosystem changes in these regions with seasonal sea ice. Short-tailed shearwaters (*Ardenna tenuirostris*) visit this region between the summer and fall during non-breeding season, and show highest biomass among seabirds distributed in the region during the periods. The main objective of this study is to understand the links between seasonal distribution of short-tailed shearwaters, their prey (i.e., krill) and marine environments.

(3) Parameters

Seabird distribution, abundance, and behaviors (flying, sitting on water or foraging) at sea.

(4) Instruments and methods

As the ship cruised during the daytime, one observer recorded numbers and behaviors (flying, sitting on water or foraging) of seabirds at every 1-minute detected within a 300 m arc (from the bow to 90° to port or to starboard) of the side of the vessel that afforded the best observation conditions (i.e., least sun glare). The Observer confirmed species identification and counted the number of seabirds using a 8 × binocular (Victory FL 8 x 56, ZEISS, Germany) from the ship's bridge, approximately 16 m eye-height above the sea surface. Ship-following birds were recorded when they first entered the survey range, and were ignored thereafter. We also collected macrozooplankton including krill, potential prey of seabirds, using Bongo net (335 μm mesh size, 70 cm mouth diameter) at 46 stations in the northern Bering Sea and Chukchi Sea. The detailed information of this sampling is shown in the section of 4.13. Zooplankton net samplings in the present cruise report.

(5) Observation log

Table 4.17-1: Seabird observation effort

Transect_ID	Start/End	UTC_date (yyyymmdd)	UTC (hhmm)	Latitude (decimal degrees)	Longitude (decimal degrees)
1	Start	20170825	1745	59.32574	-173.26716
	End	20170825	1815	59.42878	-173.30438
2	Start	20170825	1828	59.47364	-173.31985
	End	20170825	1905	59.59636	-173.36118
3	Start	20170825	1913	59.62273	-173.36969
	End	20170825	2212	60.18367	-173.56343
4	Start	20170826	0026	60.54363	-173.59840
	End	20170826	0308	60.98745	-173.66455
5	Start	20170826	0347	61.09520	-173.67798
	End	20170826	0615	61.51424	-173.72285
6	Start	20170827	0219	63.16507	-173.87069
	End	20170827	0256	63.25456	-173.66374
7	Start	20170827	0434	63.49495	-173.10318
	End	20170827	0636	63.80739	-172.40845
8	Start	20170827	2058	65.07531	-169.54885
	End	20170827	2225	65.26771	-169.05038
9	Start	20170828	0007	65.34858	-168.96406
	End	20170828	0144	65.64757	-168.69602
10	Start	20170828	0303	65.68574	-168.70925
	End	20170828	0404	65.90527	-168.78481
11	Start	20170828	0454	66.08659	-168.84282
	End	20170828	0554	66.26513	-168.83405
12	Start	20170828	1716	67.72318	-168.83977
	End	20170828	1857	68.02955	-168.83379
13	Start	20170828	2225	68.10925	-168.81484
	End	20170828	2256	68.21701	-168.80335
14	Start	20170828	2321	68.30505	-168.78630
	End	20170829	0036	68.49855	-168.74787
15	Start	20170829	0148	68.51120	-168.75941
	End	20170829	0408	68.99752	-168.74983
16	Start	20170829	1714	70.66823	-168.74703
	End	20170829	1900	70.99712	-168.73677
17	Start	20170829	2152	71.10838	-168.76448
	End	20170829	2357	71.49680	-168.74266
18	Start	20170830	0224	71.53849	-168.75527
	End	20170830	0434	71.98845	-168.74823
19	Start	20170830	1834	72.63303	-163.09078
	End	20170830	2114	72.79498	-161.34092
20	Start	20170831	0151	72.77309	-161.19202
	End	20170831	0359	72.46596	-160.10447
21	Start	20170831	0451	72.34740	-159.65699
	End	20170831	0552	72.21113	-159.17813
22	Start	20170831	2357	71.28196	-157.28947
	End	20170901	0030	71.37273	-157.40828
23	Start	20170901	0056	71.37367	-157.43475
	End	20170901	0126	71.45384	-157.58075
24	Start	20170901	0157	71.45789	-157.59493
	End	20170901	0227	71.53554	-157.75288
25	Start	20170901	0354	71.64466	-157.21301
	End	20170901	0555	71.82020	-156.23649
26	Start	20170901	2144	71.63527	-154.93004
	End	20170901	2210	71.69822	-155.09882

Table 4.17-1: (Continued)

Transect_ID	Start/End	UTC_date (yyyymmdd)	UTC (hhmm)	Latitude (decimal degrees)	Longitude (decimal degrees)
27	Start	20170901	2236	71.70272	-155.11478
	End	20170901	2302	71.76568	-155.28164
28	Start	20170902	0035	71.81982	-155.59469
	End	20170902	0350	72.45591	-155.45751
29	Start	20170903	2137	71.65997	-151.74990
	End	20170903	2217	71.56465	-151.99504
30	Start	20170904	0115	71.56283	-152.00850
	End	20170904	0157	71.49084	-152.35483
31	Start	20170904	2014	71.84152	-153.24146
	End	20170904	2134	71.95621	-153.99477
32	Start	20170905	0135	71.98770	-154.25684
	End	20170905	0246	72.06401	-154.99282
33	Start	20170905	2024	71.93912	-156.44230
	End	20170905	2110	71.87410	-156.04136
34	Start	20170905	2354	71.86755	-155.95506
	End	20170906	0012	71.82720	-155.84496
35	Start	20170906	0121	71.83226	-155.80425
	End	20170906	0203	71.80125	-155.39585
36	Start	20170906	0330	71.80125	-155.36879
	End	20170906	0358	71.73632	-155.20430
37	Start	20170907	0034	71.88744	-155.14667
	End	20170907	0250	72.33072	-155.16568
38	Start	20170907	0353	72.53888	-155.26976
	End	20170907	0517	72.81108	-155.40440
39	Start	20170907	1706	74.95543	-156.57394
	End	20170907	1841	75.23854	-156.74490
40	Start	20170907	2150	75.85150	-156.97827
	End	20170907	2302	76.07372	-157.07266
41	Start	20170907	2337	76.14501	-157.06267
	End	20170908	0109	76.41331	-157.25585
42	Start	20170910	1735	73.11028	-159.16186
	End	20170910	1905	73.28378	-160.00257
43	Start	20170910	2007	73.29224	-160.05696
	End	20170910	2107	73.29344	-160.80007
44	Start	20170911	0052	73.36697	-160.90221
	End	20170911	0137	73.52221	-160.90735
45	Start	20170911	0214	73.52749	-160.88878
	End	20170911	0348	73.51715	-159.86099
46	Start	20170911	2322	73.35168	-160.68421
	End	20170912	0246	73.87955	-159.99701
47	Start	20170912	0323	74.00057	-159.97715
	End	20170912	0450	74.00205	-160.98363
48	Start	20170912	2322	73.69993	-162.63409
	End	20170913	0113	73.35771	-163.13489
49	Start	20170913	0126	73.31961	-163.20527
	End	20170913	0250	73.06609	-163.61661
50	Start	20170913	0320	73.03669	-163.52997
	End	20170913	0455	72.90353	-163.03806
51	Start	20170913	2222	73.31563	-160.79602
	End	20170913	2302	73.45373	-160.87417
52	Start	20170913	2332	73.55288	-160.95195
	End	20170914	0150	74.01157	-161.28568

Table 4.17-1: (Continued)

Transect_ID	Start/End	UTC_date (yyyymmdd)	UTC (hhmm)	Latitude (decimal degrees)	Longitude (decimal degrees)
53	Start	20170914	0200	74.04467	-161.30702
	End	20170914	0256	74.22641	-161.44510
54	Start	20170914	0317	74.29438	-161.49185
	End	20170914	0440	74.52098	-161.90730
55	Start	20170914	1821	75.00017	-163.33369
	End	20170914	2035	74.99560	-164.98627
56	Start	20170915	0059	74.99656	-165.48751
	End	20170915	0305	75.00031	-167.14620
57	Start	20170915	1805	75.11807	-177.40431
	End	20170915	2002	75.26079	-177.41741
58	Start	20170916	1911	75.00848	-171.91674
	End	20170916	2203	74.99511	-169.62937
59	Start	20170917	0245	74.92650	-168.69123
	End	20170917	0506	74.50490	-168.15978
60	Start	20170917	1817	72.86708	-168.73489
	End	20170917	2002	72.49804	-168.73177
61	Start	20170917	2319	72.26663	-168.74665
	End	20170918	0301	71.52191	-168.75958
62	Start	20170918	0325	71.43670	-168.76465
	End	20170918	0501	71.09095	-168.77820
63	Start	20170918	1800	68.39412	-168.77076
	End	20170918	1940	68.03426	-168.82831
64	Start	20170919	0316	68.25578	-168.83736
	End	20170919	0502	68.57045	-168.83518
65	Start	20170919	1903	68.08991	-167.70859
	End	20170919	1945	68.00106	-167.99267
66	Start	20170919	2038	68.00511	-168.02389
	End	20170919	2216	67.74531	-168.48797
67	Start	20170920	0231	67.55657	-168.85256
	End	20170920	0413	67.20115	-168.88875
68	Start	20170920	2002	65.56946	-168.75517
	End	20170920	2135	65.27052	-169.04012
69	Start	20170920	2334	65.15820	-169.26575
	End	20170921	0028	65.05954	-169.59046
70	Start	20170921	0340	65.02334	-169.19306
	End	20170921	0515	64.91711	-168.52469
71	Start	20170921	2348	64.19950	-169.00189
	End	20170922	0124	64.15905	-169.88303
72	Start	20170922	0147	64.14532	-170.09603
	End	20170922	0452	64.01273	-171.82480
73	Start	20170922	1913	61.34406	-176.64375
	End	20170922	2135	60.93439	-177.33636
74	Start	20170922	2218	60.81036	-177.55070
	End	20170922	2302	60.68425	-177.77050
75	Start	20170923	0010	60.49546	-178.04264
	End	20170923	0440	59.74231	-179.33922
76	Start	20170923	1925	57.31873	176.83861
	End	20170923	2302	56.73309	175.93869
77	Start	20170924	0019	56.56138	175.72758
	End	20170924	0431	55.88159	174.67835
78	Start	20170924	2014	53.29104	171.00363
	End	20170925	0006	52.69865	170.14236

(6) Preliminary results

As preliminary results we show following items.

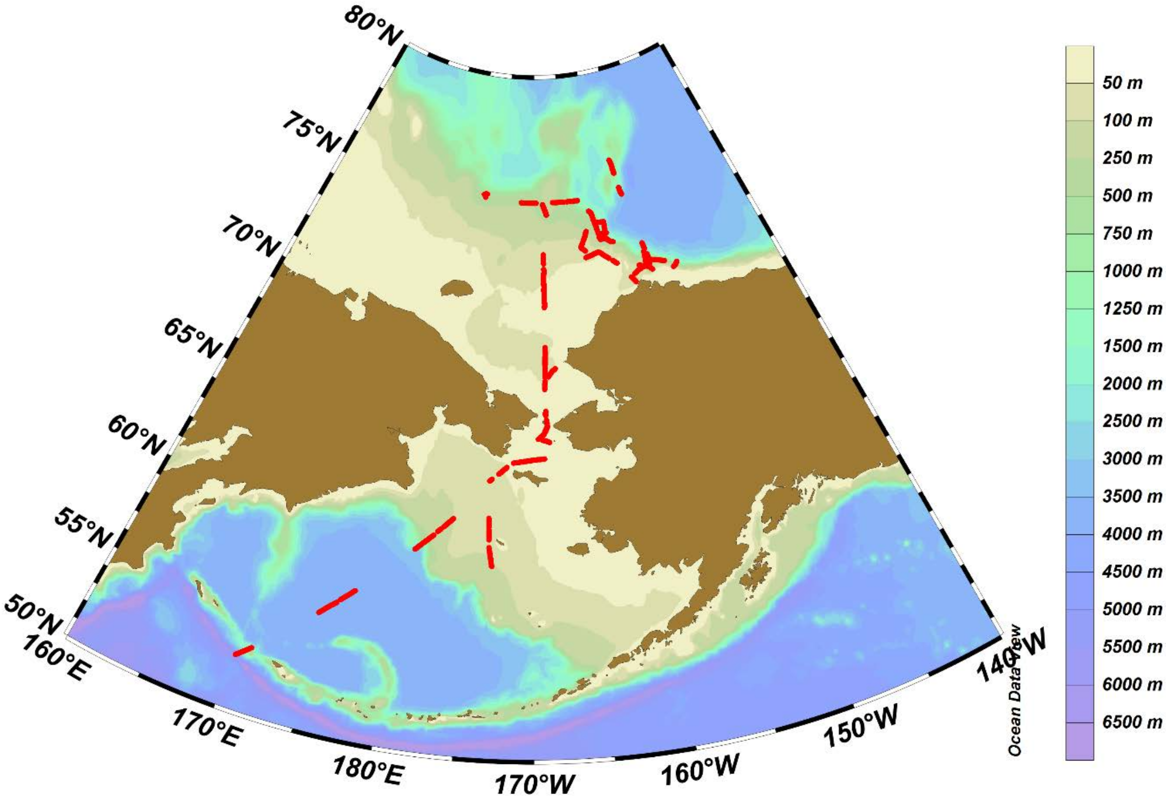


Figure 4.17-1: Ship tracks where seabird observations were conducted during the cruise

Table 4.17-2: Summary of species identified during seabird observations

Common Name	Scientific Name	Overall count	Overall (%)
Crested Auklet	*Aethia cristatella*	2902	20.2
Fork-tailed Storm Petrel	*Oceanodroma furcata*	2722	19.0
Least Auklet	*Aethia pusilla*	2567	17.9
Short-tailed Shearwater	*Ardenna tenuirostris*	2471	17.2
Northern Fulmar	*Fulmarus glacialis*	1065	7.4
Black-legged Kittiwake	*Rissa tridactyla*	812	5.7
Unidentified Murre	*Uria spp.*	456	3.2
Red-necked Phalarope	*Phalaropus lobatus*	289	2.0
Parakeet Auklet	*Aethia psittacula*	160	1.1
Thick-billed Murre	*Uria lomvia*	151	1.1
Tufted Puffin	*Fratercula cirrhata*	101	0.7
Horned Puffin	*Fratercula corniculata*	84	0.6
Glaucous Gull	*Larus hyperboreus*	75	0.5
Ancient Murrelet	*Synthliboramphus antiquus*	70	0.5
Mottled Petrel	*Pterodroma inexpectata*	66	0.5
Unidentified Phalarope	*Phalaropus spp.*	56	0.4
Common Murre	*Uria aalge*	48	0.3
Long-tailed Duck	*Clangula hyemalis*	46	0.3
Laysan Albatross	*Phoebastria immutabilis*	39	0.3
Pomarine Jaeger	*Stercorarius pomarinus*	37	0.3
Short-tailed Albatross	*Phoebastria albatrus*	23	0.2
Unidentified Eider	*Somateria spp.*	23	0.2
Glaucous-winged Gull	*Larus glaucescens*	13	0.1
Vega Gull	*Larus vegae*	13	0.1
Black Guillemot	*Cepphus grylle*	11	0.1
Pacific Loon	*Gavia pacifica*	9	0.1
Unidentified Loon	*Gavia spp.*	8	0.1
Parasitic Jaeger	*Stercorarius parasiticus*	8	0.1
Buller's Shearwater	*Puffinus bulleri*	5	< 0.1
Arctic Tern	*Sterna paradisaea*	3	< 0.1
Cassin's Auklet	*Ptychoramphus aleuticus*	3	< 0.1
Slaty-backed Gull	*Larus schistisagus*	3	< 0.1
Black-footed Albatross	*Phoebastria nigripes*	2	< 0.1
Yellow-billed Loon	*Gavia adamsii*	2	< 0.1
Sooty Shearwater	*Ardenna grisea*	2	< 0.1
Whiskered Auklet	*Aethia pygmaea*	1	< 0.1
Sabine's Gull	*Xema sabini*	1	< 0.1
Total		14347	100.0

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

5. Challenges in sea ice areas
5.1. Sea ice radar

(1) Personnel

Jun Inoue	NIPR	-Principal Investigator, not on board
Kazutoshi Sato	NIPR	
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objectives

In the sea ice areas, Marine radar provides an important tool for the detection of sea ice and icebergs. It is importance to monitor the sea ice daily and produce ice forecasts to assist ship traffic and other marine operations. In order to select route optimally, ice condition prediction technology is necessary, and image information of ice-sea radar is used for constructing a route selection algorithm.

(3) Parameters

Capture format: JPEG
Capture interval: 30 seconds
Resolution: 1,280×1,024 pixel
Color tone: 256 gradation

(4) Instruments and methods

R/V MIRAI is equipped with an Ice Navigation Radar, "sigma S6 Ice Navigator (Rutter Inc.)". The ice navigation radar, the analog signal from the x-band radar is converted by a modular radar interface and displayed as a digital video image (Figure 5.1). The sea ice radar is equipped with a screen capture function and saves at arbitrary time intervals.

(5) Observation Period

15 Sep. 2017 - 17 Sep. 2017

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

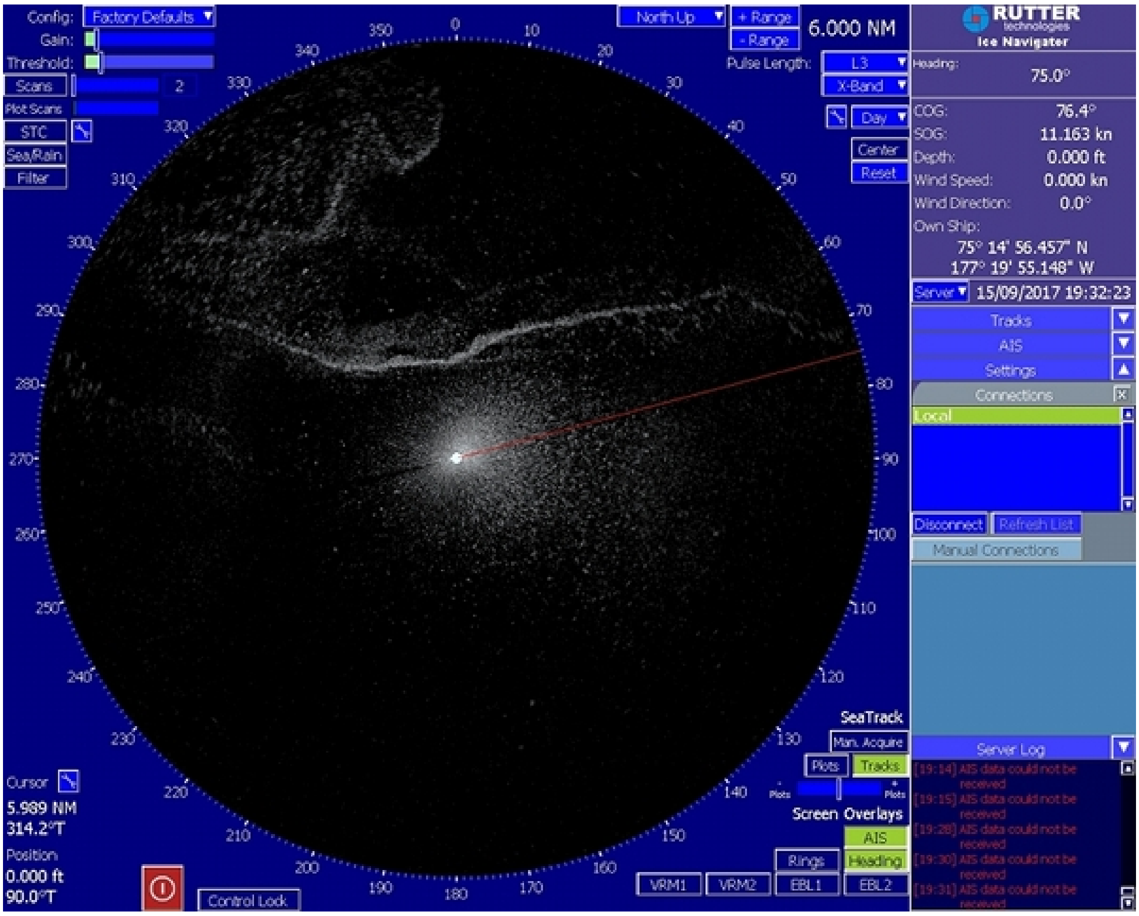


Figure 5.1-1: Image of sea ice from Sea ice radar

5.2. Ice-edge observation

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal investigator
Amane Fujiwara	JAMSTEC	
Jonaotaro Onodera	JAMSTEC	
Takuhei Shiozaki	JAMSTEC	
Koji Sugie	JAMSTEC	
Yusuke Kawaguchi	Atmosphere and Ocean Research Institute, The University of Tokyo	
Bungo Nishizawa	Hokkaido University	
Keisuke Takeda	MWJ	- Operation Leader
Keisuke Matsumoto	MWJ	

(2) Objectives

There are very few data near ice-edges in the Arctic Ocean because of limited accesses by vehicles. However, ocean environments near the ice-edges are quite different from the surroundings and may play an important role in the ecosystem in those regions. Based on a guideline for the navigation in the Arctic Ocean by R/V Mirai, the ship must keep a distance more than 1000 m from an ice-edge. Thus, at an ice-edge area set up in this cruise (75° 16' N, 177° 26' W), we approached to the sea ice by a small working boat (Zodiac) and conducted unique surveys using a UCTD sensor, fluorometer (Multi-Exciter), water sampler (Niskin-X bottle), and plankton net. Sea ice was also sampled for chemical and biological analyses. In addition, a drifting buoy was launched from the Zodiac to assess a sea-ice motion.

(3) Parameter

UCTD:

Conductivity (salinity), temperature, and depth.

Fluorometer (Multi-Exciter):

Multi-spectral excitation/emission fluorescence

Sea water sampled by a Niskin-X bottle:

Salinity, dissolved oxygen, dissolved inorganic carbon, total alkalinity, nutrients, total chlorophyll *a*, size-fractionated chlorophyll *a*, planktons observed by microscopes, pigments, and microbial communities.

Sea ice:

Salinity, nutrients, total chlorophyll *a*, planktons observed by microscopies, pigments, and microbial communities.

Plankton net:
Zooplankton

Drifting buoy:
GPS positions

(4) Instruments and methods
UCTD:
A probe of UCTD system (The Oceanscience Group Ltd.) contains a high-accuracy Sea-Bird CTD sensor. The probe was launched into the water in free fall (~4 m s^{-1}) and recovered from the water using a fishing reel attached to a davit of the Zodiac boat.

Fluorometer (Multi-Exciter):
Multi-Exciter (JFE-Advantech Inc.) detects fluorescence signals from 630 to 1000 nm which were excited at 9 bands (375, 400, 420, 435, 470, 505, 525, 570, and 590 nm). The sensor was deployed from the surface to ~120 m depth with a sinking rate of ~0.5 m s^{-1} using a fishing reel in the same manner as UCTD operations.

Sea water sampled by a Niskin-X bottle:
Sea water at a depth of 5 m was sampled by a Niskin-X bottle (General Oceanics), which was closed by dropping a messenger into the water from the Zodiac boat. The sea water sample was brought back to the R/V Mirai and was analyzed onboard or will be analyzed in onshore laboratories after the cruise. Details in each analytical procedure are described in each section in this cruise report. Refer to sections 3.7 (salinity), 4.1 (dissolved oxygen), 4.3 (dissolved inorganic carbon), 4.4 (total alkalinity), 4.2 (nutrients), 4.9 (total and size-fractionated chlorophyll *a*), 4.15 (planktons observed by microscopes), 4.10 (pigments), and 4.11 (microbial communities).

Sea ice:
Floating sea ice was sampled by hands with polyethylene gloves. The sea ice sample was brought back to the R/V Mirai and was analyzed onboard or will be analyzed in onshore laboratories after the cruise. Details in each analytical procedure are described in each section in this cruise report. Refer to sections 3.7 (salinity), 4.2 (nutrients), 4.9 (total chlorophyll *a*), 4.15 (planktons observed by microscopes), 4.10 (pigments), and 4.11 (microbial communities).

Plankton net:
Surface zooplankton were collected by a horizontal tow with a neuston net (rectangular net mouth 0.5 m × 0.5 m, mesh size 0.35 mm) at one station. The volume of water filtered through the net was estimated using a flow-meter mounted in the mouth of the net. Zooplankton samples collected by the net were immediately fixed with 5% buffered

formalin for zooplankton structure analysis.

Drifting buoy:

A drifting buoy (Zeni Lite Buoy Co., Ltd.) was put on the sea surface near the ice-edge from the Zodiac boat. Details are described in section 3.6.

(5) Observation log

Table 5.2-1: List of observation activities carried out in the ice-edge region.

Activities	Date	Time (UTC)	Longitude	Latitude
Drifting buoy deployment	15 September	21:15	177° 30.216' W	75° 16.078' N
Water sampling	15 September	21:21	177° 29.88' W	75° 15.96' N
UCTD #1	15 September	21:29	177° 29.860' W	75° 15.988' N
Fluorometer	15 September	21:34	177° 30.037' W	75° 15.915' N
Sea ice sampling	15 September	21:44	177° 30.475' W	75° 15.876' N
Plankton net	15 September	22:01	177° 31.558' W	75° 15.885' N
UCTD #2	15 September	22:14	177° 33.615' W	75° 15.480' N

(6) Results

UCTD:

Vertical profiles of descent rate, salinity, temperature, and density at UCTD #1 and #2 sites are shown in Figures 5.2-1 and 5.2-2, respectively. The profile at UCTD #1 site would be incorrect because the descent rate was extraordinary large (14 to 15 m s^{-1}) between the surface and 18 db compared with the free-fall rate (~4 m s^{-1}). The large descent rate was probably caused by a failure of pressure sensor. On the other hand, the profile at UCTD #2 site seems to be correct since the descent rate was approximately the free-fall rate. At this site, temperature decreases with depth in a surface layer and has its minimum at a depth of ~50 db. This temperature minimum water would be formed by winter cooling and identified with winter water. Below the depth of 50 db, temperature increases with depth due to an influence of the Atlantic water. As for salinity, it increases with depth and halocline is found above ~100 db. The profiles of temperature and salinity at UCTD #2 site are typical structures north of the East Siberian Sea in recent years (Nishino et al., 2011, 2013).

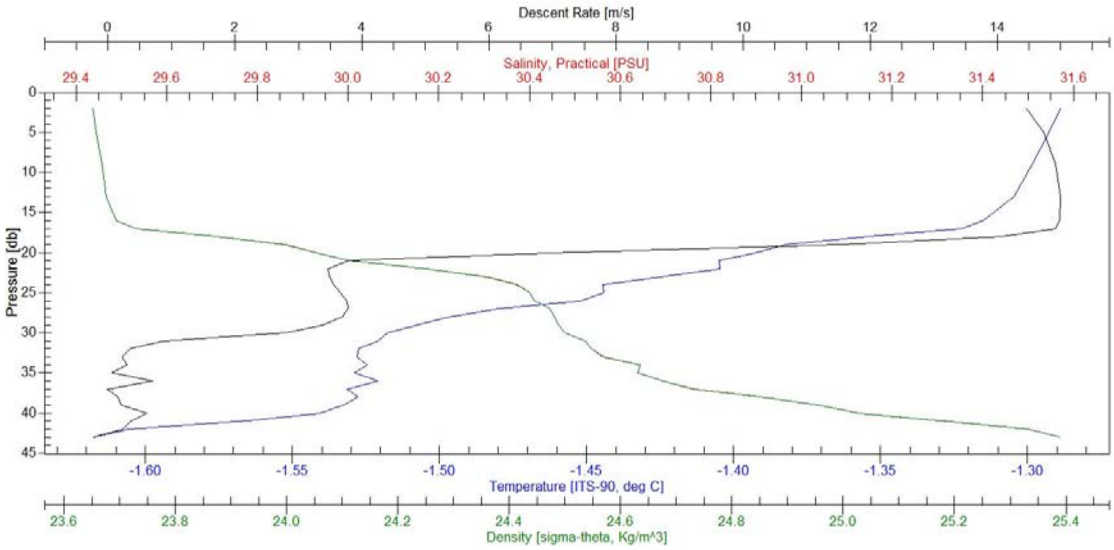


Figure 5.2-1: Vertical profiles of descent rate, salinity, temperature, and density at UCTD #1 site.

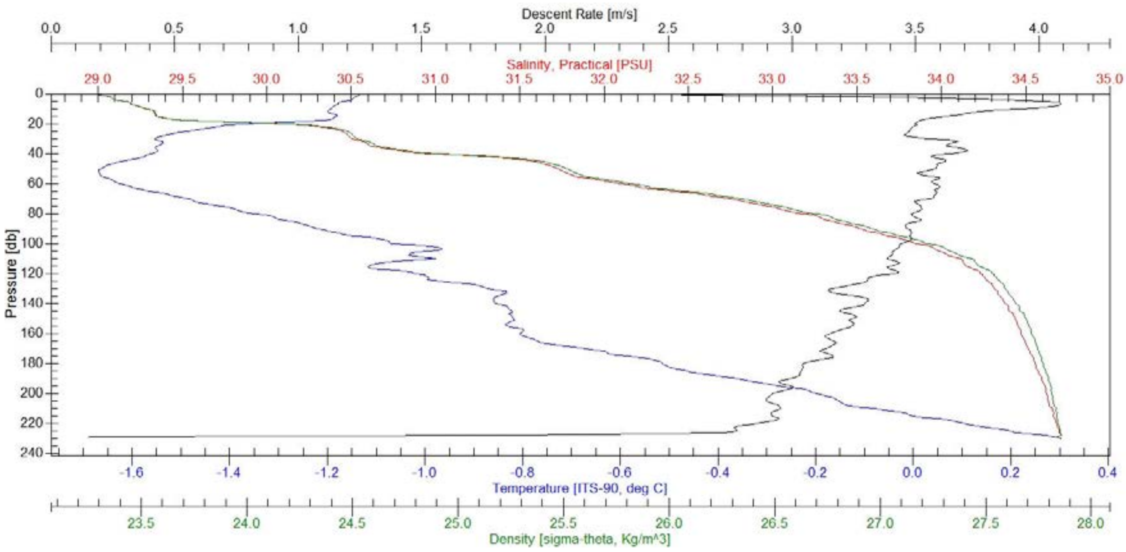


Figure 5.2-2: Vertical profiles of descent rate, salinity, temperature, and density at UCTD #2 site.

<u>Fluorometer (Multi-Exciter)</u>:

Vertical profile of spectral fluorescence is shown in Figure 5.2-3. Fluorescence signal at 470 nm roughly explain vertical profile of chlorophyll *a* concentration. It showed clear double peak in 20- and 40-m depth; The 1st peak appeared just below the surface mixed layer and the 2nd peak appeared above a winter water layer. The spectral fluorescence signal is expected to detect vertical profiles of phytoplankton community structure without water samplings.

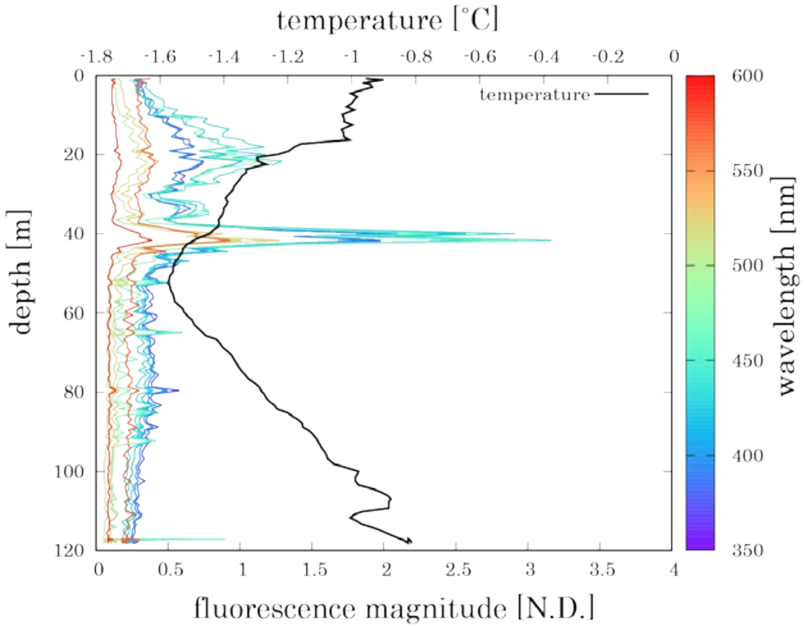


Figure 5.2-3: Vertical profile of spectral fluorescence colored by excited wavelength at UCTD #1 site. Temperature profile is also shown as a black solid line.

Sea water and sea ice:

Results of the onboard analyses of sea water and ice samples in the ice-edge region are summarized in Tables 5.2-2, 5.2-3, and 5.2-4. Other parameters will be obtained in onshore laboratories after the cruise.

Table 5.2-2: Salinity, dissolved oxygen (DO), dissolved inorganic carbon (DIC), and total alkalinity (TA) concentrations in sea water and sea ice in the ice-edge region.

	Salinity	DO [µmol/kg]	DIC [µmol/kg]	TA [µmol/kg]
Sea water	29.1945	378.38	1911.7	2029.4
Sea ice	1.3107	NA	NA	NA

Table 5.2-3: Nutrient concentrations in sea water and sea ice in the ice-edge region.

	Nitrate [µmol/kg]	Nitrite [µmol/kg]	Silicate [µmol/kg]	Phosphate [µmol/kg]	Ammonium [µmol/kg]
Sea water	0.02	0.00	4.33	0.845	0.01
Sea ice	0.26	0.00	0.23	0.074	0.02

Table 5.2-4: Total and size-fractionated (cell size >20µm, 20-2µm, and <2µm) chlorophyll *a* concentrations in sea water and sea ice in the ice-edge region.

	Chl-a [µg/L]	Chl-a (>20µm) [µg/L]	Chl-a (20-2µm) [µg/L]	Chl-a (<2µm) [µg/L]
Sea water	0.425	0.221	0.104	0.072
Sea ice	0.351	NA	NA	NA

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(8) References

Nishino, S., T. Kikuchi, M. Yamamoto-Kawai, Y. Kawaguchi, T. Hirawake, and M. Itoh (2011), Enhancement/reduction of biological pump depends on ocean circulation in the sea-ice reduction regions of the Arctic Ocean, J. Oceanogr., 67, 305-314, DOI: 10.1007/s10872-011-0030-7.

Nishino, S., M. Itoh, W. J. Williams, and I. Semiletov (2013), Shoaling of the nutricline with an increase in near-freezing temperature water in the Makarov Basin, J. Geophys. Res. Oceans, 118, 635-649, doi:10.1029/2012JC008234.

6. Geology
6.1. Sea bottom topography measurements

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objective

R/V MIRAI is equipped with the Multi Beam Echo Sounding system (MBES; SEABEAM 3012 (L3 Communications ELAC Nautik, Denmark)). The objective of MBES is collecting continuous bathymetric data along ship track to make a contribution to geological and geophysical studies.

(3) Instruments and Methods

The "SEABEAM 3012" on R/V MIRAI was used for bathymetry mapping during this cruise.

To get accurate sound velocity of water column for ray-path correction of acoustic beams, we determined sound velocities at the depth of 6.62m, the bottom of the ship, by a surface sound velocimeter. We made sound velocity profiles based on the observations of CTD, XCTD and Argo float conducted in this cruise by the equation in Del Grosso (1974).

The system configuration and performance are shown in Table 6.1-1.

Table 6.1-1: SEABEAM 3012 System configuration and performance

Frequency:	12 kHz
Transmit beam width:	2.0 degree
Transmit power:	4 kW
Transmit pulse length:	2 to 20 msec.
Receive beam width:	1.6 degree
Depth range:	50 to 11,000 m
Number of beams:	301 beams (Spacing mode: Equi-angle)
Beam spacing:	1.5 % of water depth (Spacing mode: Equi-distance)
Swath width:	60 to 150 degrees
Depth accuracy:	< 1 % of water depth (average across the swath)

(4) Preliminary Results

The results will be published after the primary processing.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

6.2. Sea surface gravity measurements

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	MIRAI Crew	

(2) Objective

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data during this 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 to Hachinohe port as the reference points.

(5) Preliminary Results

Absolute gravity table is shown in Table 6.2-1

Table 6.2-1: Absolute gravity table of the MR17-05C cruise

No.	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity at Sensor * [mGal]	S-116 Gravity [mGal]
#1	6-Jul.	06:49	Sekinehama	980,371.87	244	627	980,372.84	12657.21
#2	3-Oct.	04:49	Hachinohe	980,354.86	205	640	980,355.74	12637.08

*: Gravity at Sensor

= Absolute Gravity + Sea Level×0.3086/100 + (Draft-530)/100×0.2222

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

6.3. Surface magnetic field measurement

(1) Personnel

Shigeto Nishino	JAMSTEC	- Principal Investigator
Shinya Okumura	NME	
Kazuho Yoshida	NME	
Yutaro Murakami	NME	
Yoshiki Horiuchi	NME	
Masanori Murakami	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 this 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. Yaw (heading), Pitch and Roll are measured by the Inertial Navigation Unit (INU) for controlling attitude of a Doppler radar. Ship's position (Differential GNSS), speed over ground and gyro data are taken from LAN every second.

The relation between a magnetic-field vector observed on-board, $\mathbf{H}_{\mathrm{ob}}$, (in the ship's fixed coordinate system) and the geomagnetic field vector, $\mathbf{F}$, (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}_{\mathrm{ob}} = \widetilde{\mathbf{A}}\ \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} + \mathbf{H}_{\mathrm{p}} \qquad \text{(a)}$$

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

$$\widetilde{\mathbf{B}}\,\mathbf{H}_{\mathrm{ob}} + \mathbf{H}_{bp} = \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} \quad \text{(b)}$$

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

(4) Preliminary Results

The results will be published after the primary processing.

(5) Data archives

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

(i) For calibration of the ship's magnetic effect, we made "figure-eight" turns (a pair of clockwise and anti-clockwise rotation) at the following period and positions.

17:00 - 17:24 26 Aug. 2017 around 65-05N, 174-00W
12:34 - 12:55 20 Sep. 2017 around 66-16N, 168-49W

(ii) The following period, data were invalid due to the system trouble and its reboot.

20:38UTC 05 Sep. 2017 - 01:21UTC 06 Sep. 2017
23:26UTC 08 Sep. 2017 - 02:05UTC 09 Sep. 2017
15:35UTC 09 Sep. 2017 - 16:05UTC 09 Sep. 2017
20:10UTC 18 Sep. 2017 - 00:45UTC 19 Sep. 2017
02:25UTC 20 Sep. 2017 - 04:00UTC 20 Sep. 2017
22:56UTC 25 Sep. 2017 - 02:04UTC 26 Sep. 2017
22:46UTC 26 Sep. 2017 - 00:09UTC 27 Sep. 2017
04:17UTC 27 Sep. 2017 - 05:29UTC 27 Sep. 2017
06:32UTC 27 Sep. 2017 - 08:08UTC 27 Sep. 2017
09:45UTC 28 Sep. 2017 - 10:42UTC 28 Sep. 2017
23:23UTC 29 Sep. 2017 - 23:34UTC 29 Sep. 2017
07:59UTC 30 Sep. 2017 - 10:57UTC 30 Sep. 2017

7. Notice on using

This cruise report is a preliminary but final documentation as of the end of the cruise. This report may not be corrected even if changes on contents (e.g. taxonomic classifications) are found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for the latest information.
Users of data or results on this cruise report are requested to submit their results to Planning Group, Research Fleet Department, Marine Technology and Engineering Center of JAMSTEC.
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