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MR17-04

(10 July – 21 August 2017)

Cruise Report

Collaborative Experiment on Biogeochemical and Ecosystem Studies for Sub-Arctic Sea

October 2018

JAMSTEC

Note

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Acknowledgments

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Chief Scientists of MR17-04

Tetsuichi Fujiki (Leg. 1)
Yoshihiro Fujiwara (Leg. 2)
JAMSTEC

Contents of MR17-04 Preliminary Cruise Report

1. Collaborative experiment on Biogeochemical and Ecosystem Studies for sub-Arctic sea

2. Time-series observations for marine ecosystem dynamics research in the subarctic western North Pacific and the Bering Sea (Leg. 1)

2.1.18 Zooplankton

2.2 Ocean observation platforms

2.2.1 Hybrid profiling buoy system

3. “Aleutian Magic” observations in the south-eastern Bering Sea (Leg. 2)

3.1 Ship observations and measurements

3.1.1 Meteorological observations

4. Additional research themes

1. Collaborative experiment on Biogeochemical and Ecosystem Studies for sub-Arctic sea

1.1 Cruise information

Cruise ID: MR17-04

Research vessel: MIRAI

Cruise title: Collaborative experiment on Biogeochemical and Ecosystem Studies for sub-Arctic sea

Cruise period (port call):

Leg.1 10 July (Sekinehama, Aomori, Japan) – 2 August 2017 (Dutch Harbor, Alaska, USA)

Leg.2 5 August (Dutch Harbor, Alaska, USA) – 21 August 2017 (Dutch Harbor, Alaska, USA)

Research area: The subarctic western North Pacific and Bering Sea

Ship Captain: Toshihisa Akutagawa (Nippon Marine Enterprises, Ltd.)

Chief Scientist:

Leg.1 Tetsuichi Fujiki (Research and Development Center for Global Change, JAMSTEC)

Leg.2 Yoshihiro Fujiwara (Department of Marine Biodiversity Research, JAMSTEC)

Deputy Chief Scientist:

Leg.1 Katsunori Kimoto (Research and Development Center for Global Change, JAMSTEC)

Leg.2 Shinji Tsuchida (Department of Marine Biodiversity Research, JAMSTEC)

Representative of the Science Party:

Leg.1 Naomi Harada (Research and Development Center for Global Change, JAMSTEC)

Leg.2 Yoshihiro Fujiwara (Department of Marine Biodiversity Research, JAMSTEC)

Common research:

1. Observation of seawater density and vertical mixing

   Hiroshi Uchida (Research and Development Center for Global Change, JAMSTEC)

2. Spatial observations of aerosols in the marine atmosphere: Toward elucidation of interactions with climate and ecosystems

   Yuko Kanaya (Research and Development Center for Global Change /Institute of Arctic Climate and Environmental Research, JAMSTEC)

3. Cumulus-scale air-sea interaction study by shipboard in-situ observations

   Masaki Katsumata (Research and Development Center for Global Change, JAMSTEC)

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

   Kazuma Aoki (University of Toyama)

1.2 Cruise participants

Leg. 1

Scientists

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Katsunori Kimoto	JAMSTEC
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Kensuke Watari	JAMSTEC
Fumitaka Sugimoto	JAMSTEC
Keisuke Shimizu	JAMSTEC
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Yoshihisa Mino	Nagoya University
Erina Shima	Ishinomaki Senshu University

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Mitsuteru Kuno	Nippon Marine Enterprises, Ltd.

Leg. 2

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Dewi Langlet	JAMSTEC
Agnes Weiner	JAMSTEC
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Atsushi Yamaguchi	Hokkaido University
Keiichi Kakui	Hokkaido University
Naoto Jimi	Hokkaido University
Momoko Koiso	Toho University
James C. Hunt	East Stroudsburg University
Leah Bergman	East Stroudsburg University
Shigeki Watanabe	Idea Consultants, Inc
Tsuyuko Watanabe	TV Asashi Productions
Jiro Nomura	TV Asashi Productions

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Yuki Miyajima	Marine Works Japan, Ltd.
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Mika Yamaguchi	Marine Works Japan, Ltd.
Takehiro Kanii	Marine Works Japan, Ltd.
Takehiko Shiribiki	Marine Works Japan, Ltd.
Soichiro Sueyoshi	Nippon Marine Enterprises, Ltd.
Toshimasa Nasu	Nippon Marine Enterprises, Ltd.

1.3 Research brief

Leg. 1

The subarctic western North Pacific is a cyclonic upwelling gyre (western subarctic gyre; WSG) that extends from the northeast of Japan to near the international dateline. To investigate the spatial and temporal variability of biogeochemical processes in the WSG, time-series observations have been carried out since 1997 at stations KNOT (44°N, 155°E) and /or K2 (47°N, 160°E) in the WSG, indicating that ocean acidification was rapidly progressing in this gyre. However, the effect of ocean acidification on lower trophic levels in this region is not well understood. To better understand the response of lower trophic level ecosystem to multiple environmental stressors (e.g., warming, acidification and deoxygenation), we conducted the following observations and operations at Sta. K2 during this cruise.

(1) Recovery and deployment of hybrid profiling buoy system
(2) CTD cast and water sampling/biochemical analysis
(3) Assessment of phytoplankton productivity by fast repetition rate fluorometry
(4) Zooplankton sampling by using the VMPS, ORI and NORPAC nets
(5) Observation of zooplankton biomass by acoustic zooplankton fish profiler
(6) Particle collection by using in situ filtration system
(7) On-deck incubation experiments
(8) Measurements of shortwave and longwave radiation
(9) Upper ocean current measurements by shipboard ADCP

(10) Sea surface water sampling
(11) Multi observation glider observation
(12) Deployment of biogeochemical profiling floats

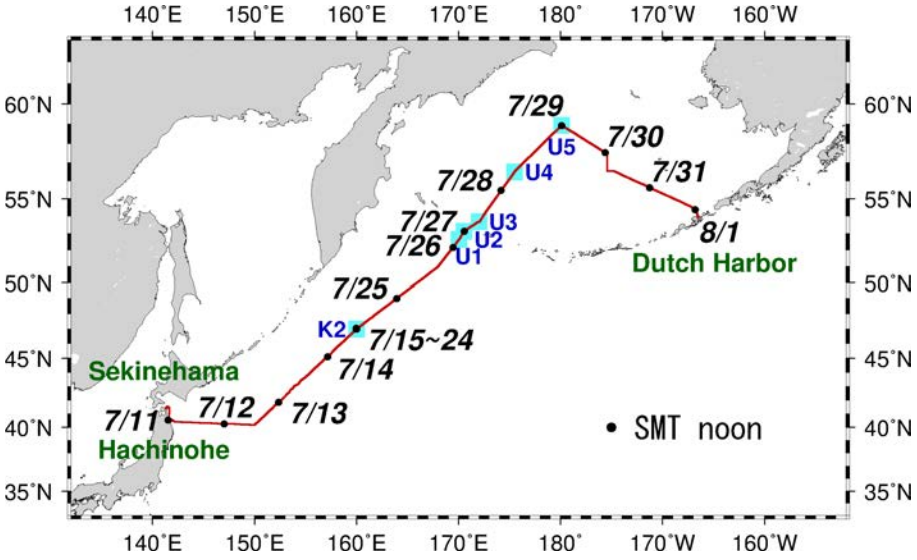
Leg. 2

A highly productive habitat named as “Green Belt” locates along the edge of the continental shelf in the Bering Sea. Enormous seabirds and whales accumulate in a limited area of the south-eastern Bering Sea during summer, which is called as “the Aleutian Magic”. To elucidate the mechanism of this biological phenomenon, we conducted oceanographic researches using R/V Mirai during the period of the Aleutian Magic. This cruise started on August 5, 2017 at Dutch Harbor, Alaska, USA and ended on August 21, 2017 at Dutch Harbor. We conducted bottom observations and biological sampling using a deep-tow camera system equipped with a dredger (11 tows), multi-layer plankton sampling using the Vertical Multiple Plankton Sampler (VMPS, 32 casts), sediment core sampling using a multiple corer (13 casts), water sampling and physico-chemical measurements using a CTD and Niskin bottle carousel (46 casts in total) at depths between 0 – 2500 m. Sediments in areas shallower than 1000 m were coarse and no evidence was seen for extraordinary organic falls. In contrast, sediments in areas deeper than 1500 m were fine, which were similar to “ordinary” deep-sea sediments. About 10 times of the Aleutian Magic were observed during this cruise at a depth of 100 m at the east end of the Bering Canyon. These events occurred in a small region (named as “Station M”), which was similar to that of previous records. CTD/hydro casts and plankton sampling were conducted across Station M. Higher concentrations of turbidity and chlorophyll were observed at downstream location from the station. Many *Limacina* and *Clione* gastropods were collected and a dense aggregation of juvenile cods were observed at Station M.

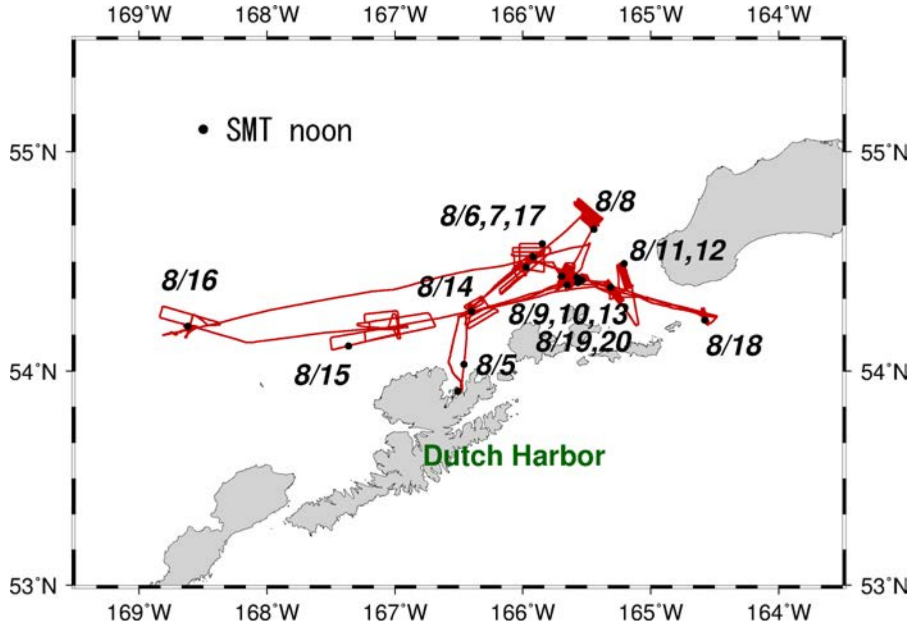
1.4 Cruise track and log

Cruise track:

Leg.1



Leg.2



Cruise log:

Leg. 1

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
7.10	7:00	7.10	16:00	41-23.45N	141-16.75E	Departure from Sekinehama
	10:00		19:00	41-15.59N	141-38.68E	Calibration for magnetometer #01
	23:00	7.11	8:00	40-31.80N	141-32.58E	Arrival at Hachinohe
7.11	6:50		15:50	40-31.80N	141-32.58E	Departure from Hachinohe
	8:30		17:30	40-33.12N	141-47.49E	Continuously observations start
7.12	23:12	7.12	8:12	41-31.07N	151-52.41E	Doppler Rader Start
	13:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC+10h)
7.13	12:00	7.13	22:00	-	-	Time adjustment +1 hour (SMT=UTC+11h)
7.14	18:30	7.15	5:30	46-59.91N	159-59.91E	Arrival at K2
	21:07		8:07	46-59.84N	160-00.32E	CTD cast #01 (5,173 m)
7.15	2:40		13:40	46-59.82N	160-01.64E	MOG Dive Test#1
	3:44		14:44	47-00.38N	160-02.29	MOG deployment#1
	4:46		15:46	47-00.09N	159-58.87E	ORI net #01-01 (700 m)
	5:21		16:21	46-59.86N	159-58.06E	ORI net #01-02 (100 m)
	5:56		16:56	47-00.13N	159-59.45E	POPPS & BGC mooring calibration
	6:42		17:42	47-00.34N	159-58.90E	NORPAC net #01-01 (100 m)
	6:52		17:52	47-00.32N	159-58.95E	NORPAC net #01-02 (100 m)
	7:06		18:06	47-00.27N	159-59.02E	NORPAC net #01-03 (150 m)
	7:22		18:22	47-00.24N	159-59.14E	NORPAC net #01-04 (200 m)
	7:37		18:37	47-00.21N	159-59.29E	NORPAC net #01-05 (100 m)
	7:50		18:50	47-00.16N	159-59.40E	NORPAC net #01-06 (200 m)
	8:09		19:09	47-00.07N	159-59.54E	NORPAC net #01-07 (250 m)
	8:24		19:24	46-59.98N	159-59.64E	NORPAC net #01-08 (50 m)
	13:00					
	21:01	7.16	8:01	47-02.47N	160-12.39E	MOG recovery#1
	22:45		9:45	47-00.68N	159-58.56E	NORPAC net #02-01 (100m)
	22:55		9:55	47-00.67N	159-58.60E	NORPAC net #02-02 (50m)
	23:05		10:05	47-00.65N	159-58.63E	NORPAC net #02-03 (100m)
	23:14		10:14	47-00.62N	159-58.66E	NORPAC net #02-04 (50m)
	23:22		10:22	47-00.60N	159-58.71E	NORPAC net #02-05 (50m)
	23:30		10:30	47-00.58N	159-58.76E	NORPAC net #02-06 (50m)
	23:38		10:38	47-00.56N	159-58.79E	NORPAC net #02-07 (50m)
	23:45		10:45	47-00.55N	159-58.84E	NORPAC net #02-08 (50m)
	23:53		10:53	47-00.54N	159-58.90E	NORPAC net #02-09 (50m)
	0:00		11:00	47-00.54N	159-58.97E	NORPAC net #02-10 (50m)

7.16	0:07		11:07	47-00.53N	159-59.01E	NORPAC net #02-11 (50m)
	0:15		11:15	47-00.49N	159-59.04E	NORPAC net #02-12 (50m)
	0:23		11:23	47-00.45N	159-59.08E	NORPAC net #02-13 (50m)
	1:50		12:50	47-00.50N	159-59.50E	MOG deployment#2
	5:20		16:20	46-59.95N	160-00.03E	CTD cast #02 (3,000 m)
7.17	1:42	7.17	12:42	47-01.26N	160-04.00E	MOG recovery#2
	1:51		13:51	46-59.63N	159-58.73E	POPPS & BGC mooring recovery
	7:14		18:14	47-01.35N	160-00.71E	MOG deployment#3、#4
	7:29		18:29	47-01.37N	160-00.74E	MOG deployment#5
	13:00					
	15:31	7.18	2:31	46-59.12N	160-00.75E	CTD cast #03 (3,000 m)
	16:42		3:42	46-59.61N	160-00.53E	FRRF #01 (100 m)
	17:08		4:08	46-59.73N	160-00.39E	AZFP #01 (150 m)
	17:48		4:48	47-00.04N	160-00.29E	NORPAC net #03 (150m)
	20:06		7:06	47-00.02N	160-00.29E	CTD cast #04 (200 m)
	20:41		7:41	47-00.06N	160-00.26E	AZFP #02 (150 m)
	21:20		8:20	47-00.20N	160-00.26E	NORPAC net #04 (150m)
	23:59		10:59	46-59.95N	160-00.01E	CTD cast #05 (200 m)
7.18	0:32		11:32	46-59.98N	159-59.92E	FRRF #02 (100 m)
	0:53		11:53	47-00.03N	159-59.92E	AZFP #03 (150 m)
	1:28		12:28	47-00.12N	160-00.01E	NORPAC net #05 (150m)
	1:47		12:47	47-00.16N	160-00.01E	CTD cast #06 (500 m)
	4:58		15:58	47-00.00N	159-59.92E	AZFP #04 (150 m)
	5:39		16:39	47-00.23N	159-59.48E	NORPAC net #06 (150m)
	5:47		16:47	47-00.28N	159-59.44E	FRRF #03 (150 m)
	8:56		19:56	47-00.05N	160-00.01E	AZFP #05 (150 m)
	9:40		20:40	47-00.05N	159-59.84E	NORPAC net #07 (150m)
	18:15	7.19	5:15	47-01.75N	160-00.11E	MOG recovery#3
	18:32		5:32	47-01.75N	159-59.67E	MOG recovery#4
	19:32		6:32	47-01.75N	159-59.67E	MOG recovery#5
	19:01		6:01	47-00.05N	159-59.85E	Calibration for magnetometer #02
	21:08		8:08	47-00.03N	160-00.49E	MOG Dive Test#2
	22:48		9:48	47-00.15N	160-00.06E	CTD cast #07 (3,000 m)
7.19	5:03		16:03	47-00.23N	160-00.90E	NORPAC net #08-01 (30m)
	5:09		16:09	47-00.46N	160-00.12E	NORPAC net #08-02 (50m)
	5:14		16:14	47-00.06N	160-00.12E	NORPAC net #08-03 (50m)
	5:21		16:21	47-00.06N	160-00.12E	NORPAC net #08-04 (100m)
	5:30		16:30	47-00.07N	160-00.13E	NORPAC net #08-05 (50m)
	5:36		16:36	47-00.07N	160-00.13E	NORPAC net #08-06 (50m)
	5:42		16:42	47-00.06N	160-00.13E	NORPAC net #08-07 (50m)
	5:49		16:49	47-00.08N	160-00.13E	NORPAC net #08-08 (50m)

	5:55		16:55	47-00.08N	160-00.13E	NORPAC net #08-09 (50m)
	6:01		17:01	47-00.09N	160-00.12E	NORPAC net #08-10 (50m)
	6:07		17:07	47-00.10N	160-00.12E	NORPAC net #08-11 (50m)
	6:14		17:14	47-00.11N	160-00.12E	NORPAC net #08-12 (50m)
	6:19		17:19	47-00.13N	160-00.12E	NORPAC net #08-13 (50m)
	6:25		17:25	47-00.13N	160-00.09E	NORPAC net #08-14 (50m)
	6:31		17:31	47-00.10N	160-00.07E	NORPAC net #08-15 (50m)
	6:37		17:37	47-00.08N	160-00.06E	NORPAC net #08-16 (50m)
	6:42		17:42	47-00.08N	160-00.05E	NORPAC net #08-17 (50m)
	6:47		17:47	47-00.08N	160-00.05E	NORPAC net #08-18 (50m)
	6:54		17:54	47-00.07N	160-00.04E	NORPAC net #08-19 (50m)
	6:57		17:57	47-00.07N	160-00.03E	NORPAC net #08-20 (50m)
	13:57	7.20	0:57	47-00.00N	159-59.99E	AZFP #06 (150 m)
	14:38		1:38	47-00.00N	160-00.00E	NORPAC net #09 (150m)
	14:47		1:47	46-59.96N	160-00.00E	FRRF #04 (100 m)
	15:33		2:33	47-00.08N	159-59.99E	CTD cast #08 (300 m)
	16:37		3:37	46-59.99N	160-00.13E	AZFP #07 (150 m)
	17:22		4:22	47-00.17N	160-00.04E	NORPAC net #10 (150m)
	20:02		7:02	47-00.21N	160-00.56E	CTD cast #09 (200 m)
	20:40		7:40	47-00.36N	160-00.36E	AZFP #08 (150 m)
	21:17		8:17	47-00.62N	160-00.18E	NORPAC net #11 (150m)
	22:12		9:12	47-00.74N	160-00.67E	VMPS net #01-01 (500m)
	22:46		9:46	47-00.72N	160-00.86E	VMPS net #01-02 (150m)
7.20	0:56		11:56	47-00.03N	159-59.97E	FRRF #05 (100 m)
	1:18		12:18	47-00.12N	160-00.03E	AZFP #09 (150 m)
	1:59		12:59	47-00.27N	160-00.25E	NORPAC net #12 (150m)
	2:12		13:12	47-00.30N	160-00.39E	CTD cast #10 (200 m)
	4:55		15:55	47-00.00N	159-59.92E	AZFP #10 (150 m)
	5:39		16:39	47-00.13N	160-00.15E	NORPAC net #13 (150m)
	5:46		16:46	47-00.19N	160-00.22E	FRRF #06 (100 m)
	8:56		19:56	47-00.09N	159-59.99E	AZFP #11 (150 m)
	9:32		20:32	47-00.19N	160-00.29E	NORPAC net #14 (150m)
	9:39		20:39	47-00.22N	160-00.43E	FRRF #07 (100 m)
	10:22		21:22	47-00.15N	160-00.65E	VMPS net #02-01 (500m)
	10:50		21:50	47-00.11N	160-00.79E	VMPS net #02-02 (150m)
7.21	21:02	7.21	8:02	46-59.97N	160-00.07E	POPPS & BGC mooring deployment
	3:26		14:26	47-00.34N	159-58.25E	POPPS & BGC mooring fixed position (D=5,187m)
	13:05	7.22	0:05	47-00.00N	160-00.00E	AZFP #12 (150 m)
	14:39		1:39	46-59.88N	160-00.03E	NORPAC net #15 (150m)

	14:48		1:48	46-59.85N	160-00.02E	FRRF #08 (100 m)
	15:30		2:30	46-59.97N	159-59.97E	CTD cast #11 (300 m)
	16:38		3:38	46-59.87N	159-59.99E	AZFP #13 (150 m)
	17:11		4:11	46-59.79N	159-59.99E	NORPAC net #16 (150m)
	17:43		4:43	47-00.00N	159-59.79E	CTD cast #12 (3,000 m)
	20:56		7:56	46-59.97N	160-00.07E	AZFP #14 (150 m)
	21:44		8:44	47-00.04N	160-00.32E	NORPAC net #17 (150m)
	22:11		9:11	47-00.05N	160-00.32E	VMPS net #03-01 (500m)
	22:36		9:36	47-00.08N	160-00.29E	VMPS net #03-02 (150m)
7.22	0:56		11:56	47-00.04N	160-00.05E	FRRF #09 (100 m)
	1:20		12:20	47-00.01N	160-00.37E	AZFP #15 (150 m)
	2:04		13:04	46-59.92N	160-00.98E	NORPAC net #18 (150m)
	4:57		15:57	46-59.97N	160-00.06E	AZFP #16 (150 m)
	5:31		16:31	46-59.99N	160-00.28E	NORPAC net #19 (150m)
	5:38		16:38	47-00.01N	160-00.37E	FRRF #10 (100 m)
	8:56		19:56	47-00.06N	160-00.06E	AZFP #17 (150 m)
	9:50		20:50	47-00.07N	160-00.23E	NORPAC net #20 (150m)
	9:57		20:57	47-00.08N	160-00.29E	FRRF #11 (100 m)
	10:36		21:36	47-00.11N	160-00.34E	VMPS net #04-01 (500m)
	11:10		22:10	47-00.10N	160-00.28E	VMPS net #04-02 (500m)
	15:45	7.23	2:45	47-00.20N	159-58.47E	POPPS & BGC mooring communication test
	21:04		8:04	47-00.24N	159-58.60E	ORI net #02-01 (700 m)
	21:46		8:46	46-59.87N	159-58.28E	ORI net #02-02 (100 m)
	22:13		9:13	46-59.73N	159-58.23E	NORPAC net #21-01 (50m)
	22:20		9:20	46-59.76N	159-58.26E	NORPAC net #21-02 (50m)
	22:27		9:27	46-59.77N	159-58.35E	NORPAC net #21-03 (50m)
	22:34		9:34	46-59.80N	159-58.40E	NORPAC net #21-04 (50m)
	22:41		9:41	46-59.83N	159-58.48E	NORPAC net #21-05 (50m)
	22:47		9:47	46-59.85N	159-58.53E	NORPAC net #21-06 (50m)
	22:52		9:52	46-59.87N	159-58.58E	NORPAC net #21-07 (50m)
	22:59		9:59	46-59.89N	159-58.64E	NORPAC net #21-08 (50m)
	23:06		10:06	46-59.92N	159-58.71E	NORPAC net #21-09 (50m)
	23:12		10:12	46-59.94N	159-58.78E	NORPAC net #21-10 (50m)
	23:20		10:20	46-59.96N	159-58.87E	NORPAC net #21-11 (50m)
	23:27		10:27	46-59.98N	159-58.96E	NORPAC net #21-12 (50m)
	23:32		10:32	47-00.00N	159-59.03E	NORPAC net #21-13 (50m)
	23:39		10:39	47-00.02N	159-59.10E	NORPAC net #21-14 (50m)
	23:45		10:45	47-00.04N	159-59.17E	NORPAC net #21-15 (50m)
	23:51		10:51	47-00.06N	159-59.24E	NORPAC net #21-16 (50m)
	23:58		10:58	47-00.09N	159-59.30E	NORPAC net #21-17 (50m)
7.23	0:04		11:04	47-00.10N	159-58.36E	NORPAC net #21-18 (50m)
	0:10		11:10	47-00.13N	159-59.42E	NORPAC net #21-19 (50m)

	0:16		11:16	47-00.16N	159-59.48E	NORPAC net #21-20 (50m)
	0:22		11:22	47-00.18N	159-59.54E	NORPAC net #21-21 (50m)
	2:52		13:52	47-00.02N	160-00.16E	Sampling suspension particl #1
	19:08	7.24	6:08	47-00.09N	160-00.43E	CTD cast #13 (5,000 m)
	23:03		10:03	47-00.05N	160-01.32E	ARGO float deploymentment #1
	23:11		10:11	47-00.01N	160-01.33E	Deep NIJJA deploymentment #1
7.24	1:02		12:02	47-00.02N	159-59.69E	Sampling suspension particl #1
	8:01		19:01	47-00.39N	159-58.63E	ORI net #03-01 (700 m)
	8:43		19:43	46-59.85N	159-59.16E	ORI net #03-02 (100 m)
	9:00		20:00	46-59.74N	159-59.33E	Departure from K2
7.25	11:00	7/25A	22:00	-	-	Passing International Date Line and Time adjustment +1 hour(SMT=UTC+12h)
	16:50	7/25B	4:50	51-00.24N	168-00.26E	First entry into the EEZ of the US
7.26	2:55		14:55	52-38.45N	170-02.96E	Arrival at U1
	2:57		14:57	52-38.43N	170-03.02E	CTD cast #14 (6,000 m)
	7:24		19:24	52-37.76N	170-05.22E	VMPS net #05-01 (500m)
	7:53		19:53	52-37.65N	170-05.19E	VMPS net #05-02 (150m)
	8:20		20:20	52-37.59N	170-05.49E	NORPAC net #22-01 (150m)
	8:32		20:32	52-37.58N	170-05.80E	NORPAC net #22-02 (100m)
	8:40		20:40	52-37.56N	170-05.98E	NORPAC net #22-03 (50m)
	8:48		20:48	52-37.53N	170-06.13E	NORPAC net #22-04 (100m)
	8:56		20:56	52-37.48N	170-06.33E	NORPAC net #22-05 (50m)
	9:04		21:04	52-37.46N	170-06.47E	NORPAC net #22-06 (50m)
	10:09		21:09	52-37.43N	170-06.62E	NORPAC net #22-07 (50m)
	10:15		21:15	52-37.42N	170-06.81E	NORPAC net #22-08 (50m)
	10:36		21:36	52-37.68N	170-07.05E	Calibration for magnetometer #03
	14:30	7.26	2:30	52-38.43N	170-03.23E	CTD cast #15 (1,000 m)
	15:13		3:13	52-38.31N	170-04.15E	FRRF #12 (100 m)
	15:48		3:48	52-49.70N	170-14.56E	Departure from U1
	19:00		7:00	53-10.12N	170-34.76E	Arrival at U2
	21:07		9:07	53-08.05N	170-33.28E	CTD cast #16 (1,000 m)
	23:20		11:20	53-07.96N	170-33.68E	VMPS net #06-01 (500m)
7.27	0:01		12:01	53-07.92N	170-33.57E	VMPS net #06-02 (150m)
	0:24		12:24	53-07.98N	170-33.70E	NORPAC net #23-01 (50m)
	0:30		12:30	53-07.99N	170-33.75E	NORPAC net #23-02 (50m)
	0:37		12:37	53-08.00N	170-33.81E	NORPAC net #23-03 (100m)
	0:46		12:46	53-08.02N	170-33.90E	NORPAC net #23-04 (100m)
	0:55		12:55	53-08.04N	170-34.00E	NORPAC net #23-05 (150m)
	1:05		13:05	53-08.07N	170-34.09E	NORPAC net #23-06 (50m)
	1:18		13:18	53-08.53N	170-35.53E	Departure from U2

	6:00		18:00	53-42.07N	171-59.67E	Arrival at U3
	6:04		18:04	53-42.01N	171-59.99E	CTD cast #17 (100 m)
	7:14		19:14	53-41.86N	172-00.18E	VMPS net #07 (500m)
	7:44		19:44	53-41.86N	172-01.04E	CTD cast #18 (3,894 m)
	11:02		23:02	53-40.97N	172-02.95E	FRRF #13 (100 m)
	11:57		23:57	53-40.88N	172-03.70E	VMPS net #08-01 (500m)
	12:50	7.27	0:50	53-40.64N	172-03.19E	VMPS net #08-02 (500m)
	13:11		1:11	53-40.60N	172-03.35E	NORPAC net #24-01 (50m)
	13:17		1:17	53-40.54N	172-03.40E	NORPAC net #24-02 (50m)
	13:23		1:23	53-40.50N	172-03.48E	NORPAC net #24-03 (50m)
	13:36		1:36	53-40.40N	172-03.55E	Departure from U3
						Departure from the EEZ of the US
7.28	6:00		18:00	56-29.96N	175-30.22E	Arrival at U4
	6:03		18:03	56-29.96N	175-30.04E	CTD cast #19 (100 m)
	14:28	7.28	2:28	56-29.99N	175-30.01E	
	15:12		3:12	56-29.92N	175-30.08E	FRRF #14 (100 m)
	16:04		4:04	56-29.86N	175-29.96E	VMPS net #09-01 (500m)
	16:36		4:36	56-29.88N	175-29.85E	VMPS net #09-02 (150m)
	17:00		5:00	56-29.86N	175-29.96E	CTD cast #21 (3,830 m)
	20:12		8:12	56-29.92N	175-29.80E	NORPAC net #25-01 (100m)
	20:20		8:20	56-29.89N	175-29.77E	NORPAC net #25-02 (50m)
	20:26		8:26	56-29.88N	175-29.72E	NORPAC net #25-03 (50m)
	20:32		8:32	56-29.87N	175-29.69E	NORPAC net #25-04 (50m)
	20:38		8:38	56-29.87N	175-29.69E	NORPAC net #25-05 (50m)
	20:45		8:45	56-29.87N	175-29.63E	NORPAC net #25-06 (70m)
	20:55		8:55	56-29.55N	175-29.60E	NORPAC net #25-07 (150m)
	21:06		9:06	56-29.89N	175-29.49E	NORPAC net #25-08 (150m)
	21:21		9:21	56-29.92N	175-29.42E	NORPAC net #25-09 (150m)
	21:33		9:33	56-29.94N	175-29.30E	NORPAC net #25-10 (150m)
	21:48		9:48	56-37.49N	175-42.34E	Departure from U4
						Reentry into the EEZ of the US
7.29	10:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC+13h)
	17:30	7.29	6:30	58-56.18N	179-54.24E	Arrival at U5
	18:57		7:57	58-56.27N	179-54.11E	CTD cast #22 (100 m)
	19:56		8:56	58-56.19N	179-54.30E	VMPS net #10-01 (500m)
	20:25		9:25	58-56.21N	179-54.45E	VMPS net #09-02 (150m)
	20:46		9:46	58-56.11N	179-54.30E	CTD cast #23 (3533 m)
	16:00		5:00	58-56.19N	179-54.30E	CTD cast #21 (3,830 m)
	23:52		12:52	58-55.82N	179-54.34E	NORPAC net #26-01 (100m)
7.30	0:00		13:00	58-55.80N	179-54.30E	NORPAC net #26-02 (50m)
	0:06		13:06	58-55.79N	179-54.26E	NORPAC net #26-03 (50m)

	0:16		13:16	58-55.80N	179-54.13E	NORPAC net #26-04 (200m)
	0:34		13:34	58-55.69N	179-54.15E	NORPAC net #26-05 (300m)
	0:55		13:55	58-55.61N	179-54.10E	NORPAC net #26-06 (300m)
	1:10		14:10	58-55.56N	179-54.04E	NORPAC net #26-07 (50m)
	1:20		14:20	58-55.53N	179-54.00E	NORPAC net #27-08 (300m)
	1:39		14:39	58-55.45N	179-53.89E	NORPAC net #27-09 (300m)
	1:57		14:57	58-55.41N	179-53.85E	NORPAC net #27-10 (300m)
	2:45		15:45	58-55.39N	179-52.72E	Calibration for magnetometer #04
	3:12		16:12	58-55.29N	179-51.28E	Departure from U5
	9:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-11h)
7.30	8:00	7.30	22:00	-	-	Time adjustment +1 hour (SMT=UTC-10h)
7.31	7:00	7.31	22:00	-	-	Time adjustment +1 hour (SMT=UTC-09h)
8.1	17:00	8.1	9:00	54-28.67N	167-00.98W	Continuously observations finish
	21:35		13:35	54-22.24N	166-47.59W	Doppler Rader Stop.
8.2	17:10	8.2	9:10	53-54.44N	166-30.62W	Arrival at Dutch Harbor

Leg. 2

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8.5	18:50	8.5	10:50	53-54.44N	166-30.62W	Departure from Dutch Harbor
	19:30		11:30	53-54.44N	166-30.62W	Continuously observations start
	21:00		13:00	54-13.89N	166-26.59W	Arrival at St:A (Depth1,000m area) .
	21:18		13:18	54-16.67N	166-25.08W	Com'ced MBES mapping survey.
	22:30		14:30	54-18.45N	166-25.90W	Finished MBES mapping survey.
	22:30		14:30	54-17.28N	166-24.34W	Com'ced DeepTow & Dredge #A-1 (1,099m).
8.6	1:22		17:22	54-17.90N	166-23.66W	Finished DeepTow & Dredge.
	2:00		18:00	54-17.80N	166-23.70W	Com'ced SBP and MBES mapping survey.
	3:28		19:28	54-18.65N	166-25.25W	Finished SBP and com'ced MBES mapping survey.
	6:30		22:30	54-15.18N	166-15.49W	Doppler Rader Start
	7:08		23:08	54-11.81N	166-25.13W	Finished MBES mapping survey.
	8:14	8.6	0:14	54-17.72N	166-23.78W	VMPS net #A-01 (75m).
	8:41		0:41	54-17.71N	166-23.78W	VMPS net #A-02 (250m).
	9:19		1:19	54-17.68N	166-23.77W	VMPS net #A-03 (1,000m).
	10:13		2:13	54-17.71N	166-23.85W	Com'ced CTD #A-1(1,092m).
	11:46		3:46	54-17.71N	166-23.85W	Finished CTD #A-1.
	12:34		4:34	54-17.77N	166-23.85W	MulltipullCorer #A-1 (1,112m).
	13:43		5:43	54-17.77N	166-23.85W	MulltipullCorer #A-2 (1,113m).
	14:36		6:36	54-17.89N	166-23.65W	Departure from St:A.
	16:00		8:00	54-27.74N	166-02.85W	Arrival at St:B (Depth500m area).
	16:01		8:01	54-27.83N	166-02.65W	Com'ced MBES mapping survey.
	23:00		15:00	54-20.36N	166-18.34W	Finished MBES mapping survey.
8.7	0:09		16:09	54-28.42N	166-01.54W	VMPS net #B-01 (75m).
	0:31		16:31	54-28.44N	166-01.48W	VMPS net #B-02 (250m).
	0:58		16:58	54-28.42N	166-01.49W	VMPS net #B-03 (500m).
	1:24		17:24	54-28.41N	166-01.50W	VMPS net #B-04 (150m).
	1:41		17:41	54-28.38N	166-01.52W	Com'ced CTD #B-1 (530m).
	2:46		18:46	54-28.53N	166-01.51W	Finished CTD #B-1 .
	3:29		19:29	54-28.41N	166-01.47W	MulltipullCorer #B-1 (535m).
	4:38		20:38	54-28.42N	166-01.43W	MulltipullCorer #B-2 (536m).
	5:40		21:40	54-28.41N	166-01.42W	Com'ced SBP and MBES mapping survey.
	14:02	8.7	6:02	54-21.73N	166-09.01W	Finished SBP and MBES mapping survey.
	15:00		7:00	54-26.62N	165-59.33W	Com'ced Calibration for magnetometer #01
	15:24		7:24	54-26.73N	165-58.79W	Finished Calibration for magnetometer #01
	16:11		8:11	54-27.32N	165-59.94W	Com'ced DeepTow #B-1 (551m).
	22:14		14:14	54-29.45N	165-57.24W	Finished DeepTow #B-1.

	22:30		14:30	54-29.69N	165-57.21W	Departure from St:B.
8.8	0:30		16:30	54-43.51N	165-30.42W	Arrival at St:C (Depth250m area).
	0:45		16:45	54-43.50N	165-30.32W	Com'ced CTD #C-1 (97m).
	0:50		16:50	54-43.50N	165-30.32W	Finished CTD #C-1.
	0:54		16:54	54-43.51N	165-30.24W	Departure from St:C.
	1:39		17:39	54-41.58N	165-24.78W	Com'ced SBP and MBES mapping survey.
	7:43		23:43	54-42.26N	165-25.67W	Finished SBP and MBES mapping survey.
	7:48		23:48	54-42.54N	165-26.42W	Arrival at St:C (Depth250m area).
	8:11	8.8	0:11	54-42.65N	165-26.96W	VMPS net #C-1 (75m).
	8:33		0:33	54-42.67N	165-27.00W	VMPS net #C-2 (210m).
	8:55		0:55	54-42.67N	165-26.99W	VMPS net #C-3 (150m).
	10:02		2:02	54-42.65N	165-27.05W	Com'ced CTD #C-2 (231m).
	11:02		3:02	54-42.65N	165-27.05W	Finished CTD #C-2.
	11:32		3:32	54-42.71N	165-27.01W	MulltipullCorer #C-1 (231m).
	12:20		4:20	54-42.71N	165-27.02W	MulltipullCorer #C-2 (232m).
	13:29		5:29	54-41.00N	165-24.53W	Com'ced SBP and MBES mapping survey.
	19:57		11:57	54-39.11N	165-27.17W	Finished SBP and MBES mapping survey.
	21:06		13:06	54-43.30N	165-31.21W	Com'ced DeepTow #C-1 (234m).
8.9	4:02		20:02	54-41.35N	165-27.83W	Finished DeepTow #C-1.
	6:08		22:08	54-24.15N	165-41.71W	Departure from St:C, and Com'ced SBP and MBES mapping survey.
	15:31	8.9	7:31	54-26.50N	165-38.80W	Finished SBP and MBES mapping survey.
	16:12		8:12	54-24.13N	165-42.30W	Arrival at St:D (Depth100m area).
	16:19		8:19	54-24.13N	165-42.41W	Com'ced DeepTow #D-1 (172m).
	23:06		15:06	54-23.70N	165-36.17W	Finished DeepTow #D-1.
8.10	0:09		16:09	54-25.85N	165-35.03W	Com'ced CTD #D-2 (89.2m).
	0:15		16:15	54-25.85N	165-35.03W	Finished CTD #D-2.
	9:07	8.10	1:07	54-25.86N	165-35.16W	VMPS net #M-1 (75m).
	9:33		1:33	54-24.87N	165-35.18W	VMPS net #M-2 (80m).
	9:51		1:51	54-25.87N	165-35.80W	VMPS net #M-3 (80m).
	10:14		2:14	54-25.87N	165-35.20W	Com'ced CTD #M-1 (93m).
	10:47		2:47	54-25.87N	165-35.20W	Finished CTD #M-1.
	11:08		3:08	54-25.87N	165-35.21W	MulltipullCorer #M-1 (100m).
	11:47		3:47	54-25.86N	165-35.14W	MulltipullCorer #M-2 (103m).
	12:17		4:17	54-25.86N	165-35.19W	MulltipullCorer #M-3 (103m).
	13:12		5:12	54-25.44N	165-33.62W	Departure from St:C, and Com'ced SBP and MBES mapping survey.
	23:29		15:29	54-26.05N	165-32.96W	Finished SBP and MBES mapping survey.
8.11	0:23		16:23	54-25.76N	165-35.12W	Com'ced CTD #M-2 (90m).
	0:30		16:30	54-25.76N	165-35.12W	Finished CTD #M-2.

	0:58		16:58	54-25.57N	165-38.24W	Com'ced DeepTow #M-1 (106m).
	5:42		21:42	54-25.84N	165-33.88W	Finished DeepTow #M-1.
	6:33		22:33	54-24.25N	165-20.55W	Departure from St:M, and Com'ced SBP and MBES mapping survey.
	15:47	8.11	7:47	54-23.69N	165-21.57W	Finished SBP and MBES mapping survey.
	16:24		8:24	54-21.56N	165-16.93W	Arrival at St:E (Depth200m area).
	16:38		8:38	54-21.76N	165-17.19W	Com'ced DeepTow #E-1 (194m).
	22:57		14:57	54-24.21N	165-20.04W	Finished DeepTow #E-1.
	23:25		15:25	54-24.10N	165-20.30W	Com'ced CTD #E-1 (101m).
	23:30		15:30	54-24.10N	165-20.30W	Finished CTD #E-1.
	23:49		15:49	54-24.43N	165-20.28W	Com'ced SBP and MBES mapping survey.
8.12	6:43		22:43	54-19.94N	165-13.00W	Finished SBP and MBES mapping survey.
	8:07	8.12	0:07	54-20.58N	165-16.38W	VMPS net #E2-1 (75m).
	8:25		0:25	54-20.56N	165-16.42W	VMPS net #E2-2 (180m).
	9:25		1:25	54-20.63N	165-16.58W	VMPS net #E2-3 (180m).
	9:44		1:44	54-20.63N	165-16.57W	VMPS net #E2-4 (75m).
	10:07		2:07	54-20.57N	165-16.36W	Com'ced CTD #E2-2 (186m).
	10:49		2:49	54-20.57N	165-16.36W	Finished CTD #E2-2.
	11:15		3:15	54-20.61N	165-16.52W	MulltipullCorer #E2-1 (195m).
	11:58		3:58	54-20.61N	165-16.54W	MulltipullCorer #E2-2 (197m).
	12:47		4:47	54-21.51N	165-14.99W	Departure from St:E, and Com'ced SBP and MBES mapping survey.
	22:28		14:28	54-28.05N	165-13.28W	Finished SBP and MBES mapping survey.
	23:30		15:30	54-18.86N	165-14.22W	Arrival at St:F (Depth173m area).
8.13	0:54		16:54	54-18.73N	165-14.30W	Com'ced DeepTow #E2-1 (160m).
	5:55		21:55	54-21.89N	165-17.32W	Finished DeepTow #E2-1.
	6:12		22:12	54-22.40N	165-17.74W	Departure from St:E2.
	10:12	8.13	2:12	54-28.11N	165-43.59W	Arrival at St:N (Depth350m area).
	9:35		1:35	54-28.19N	165-43.92W	Com'ced CTD #N-1 (347m).
	10:20		2:20	54-28.19N	165-43.92W	Finished CTD #N-1.
	10:30		2:30	54-28.03N	165-43.26W	Departure from St:N.
	11:12		3:12	54-30.39N	165-54.20W	Arrival at St:B (Depth500m area).
	11:35		3:35	54-30.79N	165-56.25W	Com'ced CTD #B-1 (477m).
	12:10		4:10	54-30.79N	165-56.25W	Finished CTD #B-1.
	12:43		4:43	54-30.81N	165-56.34W	MulltipullCorer #B-1 (488m).
	13:18		5:18	54-30.86N	165-55.75W	Departure from St:T.
	15:24		7:24	54-34.96N	165-28.78W	Arrival at St:T (Depth100m area).
	15:39		7:39	54-35.08N	165-28.65W	VMPS net #T-1 (100m).
	16:00		8:00	54-35.12N	165-28.68W	Com'ced CTD #T-1 (111m).
	16:07		8:07	54-35.12N	165-28.68W	Finished CTD #T-1.

	16:12		8:12	54-35.15N	165-28.67W	Departure from St:T.
	17:42		9:42	54-22.28N	165-43.99W	Arrival at St:U (Depth100m area).
	18:07		10:07	54-22.10N	165-44.18W	VMPS net #U-1 (100m).
	18:26		10:26	54-22.21N	165-44.24W	Com'ced CTD #U-1 (109m).
	18:32		10:32	54-22.21N	165-44.24W	Finished CTD #U-1.
	18:36		10:36	54-22.25N	165-44.21W	Departure from St:U.
	19:12		11:12	54-25.57N	165-35.39W	Arrival at St:M2 (Depth100m area).
	22:29		14:29	54-24.62N	165-35.65W	VMPS net #M2-1 (75m).
	22:54		14:54	54-24.37N	165-35.70W	Com'ced CTD #M2-1 (83m).
	23:20		15:20	54-24.37N	165-35.70W	Finished CTD #M2-1.
8.14	3:06		19:06	54-25.31N	165-35.53W	Departure from St:M2.
	8:30	8.14	0:30	54-14.85N	164-29.80W	Arrival at St:Q (Depth100m area).
	9:06		1:06	54-15.14N	164-28.97W	Com'ced CTD #Q-1 (94m).
	9:29		1:29	54-15.14N	164-28.97W	Finished CTD #Q-1.
	9:47		1:47	54-15.16N	164-28.97W	VMPS net #Q-1 (85m).
	10:08		2:08	54-15.11N	164-28.98W	VMPS net #Q-2 (85m).
	10:18		2:18	54-15.08N	164-29.01W	Departure from St:Q.
	11:12		3:12	54-17.55N	164-44.27W	Arrival at St:R (Depth70m area).
	11:28		3:28	54-17.77N	164-45.89W	VMPS net #R-1 (60m).
	11:48		3:48	54-17.78N	164-45.95W	VMPS net #R-2 (60m).
	12:17		4:17	54-17.66N	164-45.89W	Com'ced CTD #R-1 (75m).
	12:23		4:23	54-17.66N	164-45.89W	Finished CTD #R-1.
	12:30		4:30	54-17.52N	164-45.52W	Departure from St:R.
	13:36		5:36	54-20.12N	165-01.01W	Arrival at St:S (Depth100m area).
	13:47		5:47	54-20.17N	165-01.43W	VMPS net #S-1 (70m).
	14:05		6:05	54-20.09N	165-01.57W	Com'ced CTD #S-1 (93m).
	14:25		6:25	54-20.09N	165-01.57W	Finished CTD #S-1.
	14:30		6:30	54-19.86N	165-01.46W	Departure from St:S.
	15:54		7:54	54-22.97N	165-24.94W	Arrival at St:P (Depth100m area).
	16:04		8:04	54-23.14N	165-25.24W	VMPS net #P-1 (75m).
	16:25		8:25	54-23.19N	165-25.50W	Com'ced CTD #P-1 (88m).
	16:48		8:48	54-23.19N	165-25.50W	Finished CTD #P-1.
	16:54		8:54	54-23.30N	165-26.08W	Departure from St:P.
	21:35		13:35	54-13.26N	166-51.72W	Com'ced SBP and MBES mapping survey.
	22:05		14:05	54-12.49N	166-58.43W	Finished SBP and MBES mapping survey.
	22:12		14:12	54-12.13N	166-59.27W	Arrival at St:G (Depth1,500m area).
	22:32		14:32	54-12.30N	166-58.65W	Com'ced CTD #G-1 (100m).
	22:39		14:39	54-12.30N	166-58.65W	Finished CTD #G-1.
	23:00		15:00	54-12.53N	166-57.86W	Com'ced SBP and MBES mapping survey.
8.15	7:21		23:21	54-16.56N	167-00.02W	Finished SBP and MBES mapping survey.
	8:22	8.15	0:22	54-11.73N	166-58.29W	VMPS net #G-1 (1,387m).

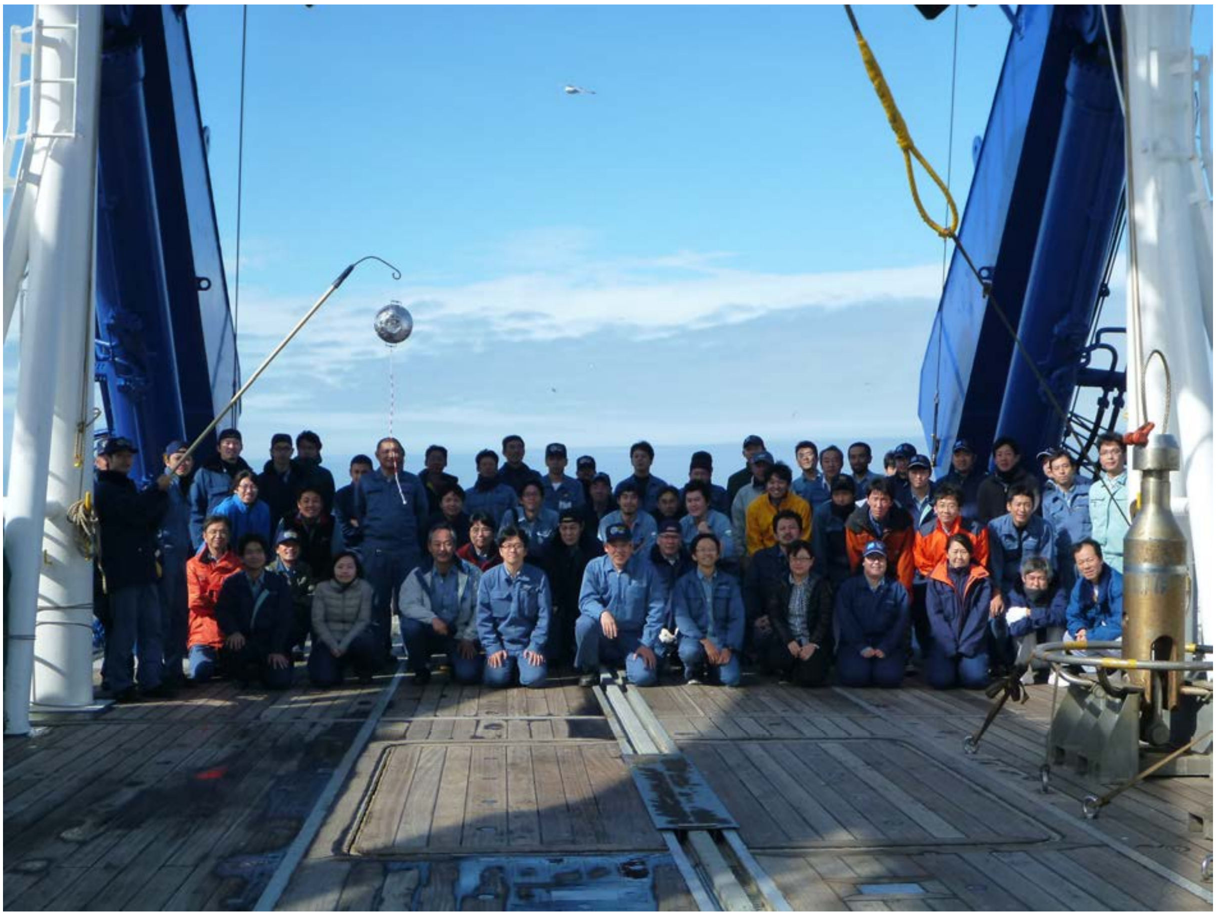
	9:09		1:09	54-11.73N	166-58.28W	VMPS net #G-2 (499m).
	9:35		1:35	54-11.73N	166-58.28W	VMPS net #G-3 (198m).
	10:00		2:00	54-11.69N	166-58.34W	Com'ced CTD #G-2 (100m).
	10:26		2:26	54-11.69N	166-58.34W	Finished CTD #G-2.
	11:16		3:16	54-11.76N	166-58.34W	MulltipullCorer #G-1 (1,536m).
	12:57		4:57	54-11.75N	166-58.30W	MulltipullCorer #G-2 (1,536m).
	14:09		6:09	54-11.00N	166-58.50W	Com'ced CTD #G-3 (1,509m).
	16:03		8:03	54-11.00N	166-58.50W	Finished CTD #G-3.
	17:00		9:00	54-10.60N	166-58.45W	VMPS net #G-4 (1,400m).
	17:49		9:49	54-10.61N	166-58.39W	VMPS net #G-5 (500m).
	18:15		10:15	54-10.58N	166-58.30W	VMPS net #G-5 (100m).
	19:24		11:24	54-08.48N	167-11.64W	Com'ced SBP and MBES mapping survey.
	22:20		14:20	54-13.15N	167-16.70W	Finished SBP and MBES mapping survey.
8.16	0:04		16:04	54-12.04N	166-54.26W	Com'ced DeepTow #G-1 (1,502m).
	6:35		22:35	54-11.64N	166-59.60W	Finished DeepTow #G-1.
	6:42		22:42	54-11.61N	166-59.43W	Departure from St:G.

	10:15	8.16	2:15	54-07.91N	168-09.76W	Com'ced MBES mapping survey.
	14:12		6:12	54-13.47N	168-23.17W	Finished MBES mapping survey.
	15:05		7:05	54-15.45N	168-34.59W	Com'ced SBP and MBES mapping survey.
	16:08		8:08	54-09.49N	168-37.69W	Finished SBP and MBES mapping survey.
	16:48		8:48	54-12.28N	168-33.06W	Arrival at St:H (Depth2,500m area).
	17:06		9:06	54-12.37N	168-33.59W	Com'ced DeepTow #H-1 (2,325m).
	22:26		14:26	54-12.79N	168-39.06W	Finished DeepTow #H-1.
	22:51		14:51	54-11.18N	168-37.83W	Com'ced DeepTow #H-2 (2,510m).
8.17	1:01		17:01	54-10.88N	168-40.46W	Finished DeepTow #H-2.
	1:55		17:55	54-10.40N	168-42.08W	Com'ced CTD #H-1 (2,526m).
	3:20		19:20	54-10.40N	168-42.08W	Finished CTD #H-1.
	4:00		20:00	54-10.67N	168-44.54W	VMPS net #H-1 (100m).
	4:31		20:31	54-10.44N	168-45.54W	VMPS net #H-2 (500m).
	5:14		21:14	54-10.23N	168-46.77W	VMPS net #H-3 (1,250m).
	6:27		22:27	54-09.98N	168-48.04W	VMPS net #H-4 (2,400m).
	7:06		23:06	54-09.87N	168-48.58W	Departure from St:H.

	15:48	8.17	7:48	54-30.90N	165-55.73W	Arrival at St:B (Depth500m area).
8.18	5:02		21:02	54-30.75N	165-56.24W	Com'ced CTD #B2-1 (476m).
	5:21		21:21	54-30.75N	165-56.24W	Finished CTD #B2-1.
	5:30		21:30	54-30.53N	165-55.97W	Departure from St:B.
	6:06		22:06	54-28.27N	165-44.46W	Arrival at St:N (Depth350m area).
	6:16		22:16	54-28.10N	165-43.88W	Com'ced CTD #N2-1 (348m).
	6:31		22:31	54-28.10N	165-43.88W	Finished CTD #N2-1.
	6:36		22:36	54-27.96N	165-43.89W	Departure from St:N.
	7:06		23:06	54-25.91N	165-34.84W	Arrival at St:M (Depth100m area).

	7:12		23:12	54-25.83N	165-34.67W	Com'ced CTD #M2-1 (91m).
	7:19		23:19	54-25.83N	165-34.67W	Finished CTD #M2-1.
	7:24		23:24	54-25.85N	165-34.70W	Departure from St:M.
	8:00	8.18	0:00	54-23.25N	165-25.16W	Arrival at St:P (Depth100m area).
	8:09		0:09	54-23.07N	165-24.97W	Com'ced CTD #P2-1 (83m).
	8:16		0:16	54-23.07N	165-24.97W	Finished CTD #P2-1.
	8:18		0:18	54-23.05N	165-24.93W	Departure from St:P.
	8:48		0:48	54-30.63N	165-55.84W	Arrival at St:E2_2 (Depth196m area).
	9:00		1:00	54-20.55N	165-16.42W	Com'ced CTD #E2_2-1 (187m).
	9:09		1:09	54-20.55N	165-16.42W	Finished CTD #E2_2-1.
	9:18		1:18	54-20.38N	165-16.06W	Departure from St:E2.
	10:00		2:00	54-20.21N	165-02.19W	Arrival at St:S (Depth200m area).
	10:11		2:11	54-20.14N	165-01.49W	Com'ced CTD #S_2-1 (97m).
	10:17		2:17	54-20.14N	165-01.49W	Finished CTD #S_2-1.
	10:24		2:24	54-19.97N	165-01.37W	Departure from St:S.
	11:12		3:12	54-17.87N	164-46.69W	Arrival at St:R (Depth70m area).
	11:22		3:22	54-17.79N	164-46.12W	Com'ced CTD #R_2-1 (70m).
	11:26		3:26	54-17.79N	164-46.12W	Finished CTD #R_2-1.
	11:36		3:36	54-17.59N	164-44.80W	Departure from St:R.
	12:30		4:30	54-15.23N	164-29.39W	Arrival at St:Q (Depth100m area).
	12:39		4:39	54-14.95N	164-29.13W	Com'ced CTD #Q_2-1 (94m).
	12:44		4:44	54-14.95N	164-29.13W	Finished CTD #Q_2-1.
	13:00		5:00	54-14.53N	164-29.65W	Com'ced MBES mapping survey.
	21:56		13:56	54-14.82N	164-34.75W	Finished MBES mapping survey.
	23:01		15:01	54-13.00N	164-33.12W	Com'ced DeepTow #Q_2-1 (114m).
8.19	5:43		21:43	54-15.75N	164-36.79W	Finished DeepTow #H-1.
	5:48		21:48	54-15.75N	164-36.80W	Departure from St:Q.
	8:52	8.19	0:52	54-24.20N	165-34.59W	Com'ced MBES mapping survey.
	21:08		13:08	54-26.46N	165-42.10W	Finished MBES mapping survey.
	21:15		13:15	54-26.44N	165-42.56W	Continuously observations finish
8.20	0:00		16:00	54-29.81N	165-54.38W	Doppler Rader Stop.
	-	8.20	-	-N	-W	Proceeded to Dutch Harbor
8.21	22:00	8.21	14:00	53-54.44N	166-30.62W	Arrival at Dutch Harbor.

2. Time-series observations for marine ecosystem dynamics research in the subarctic western North Pacific and the Bering Sea (Leg. 1)



2.1 Ship observations and measurements

2.1.1 Meteorological observations

2.1.1(a) Surface meteorological observations

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Mitsuteru KUNO	**NME**
Masanori MURAKAMI	**MIRAI crew**

(1) 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.

(2) 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 2.1.1-1 and measured parameters are listed in Table 2.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6 seconds 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 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) 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 data every 6 seconds, CR1000 data every second, air temperature and relative humidity data every 2 seconds and ORG data every 6 seconds.

SCS composed Event data (JamMet) from these data and ship's navigation data. Instruments and their locations are listed in Table 2.1.1-3 and measured parameters are listed in Table 2.1.1-4.

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

i) Young rain gauge (SMet and SOAR)

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

ii) Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB220, VAISALA

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

Comparison with the portable thermometer value, HMP75, VAISALA

(3) Results

Fig. 2.1.1-1 shows the time series of the following parameters;
Wind (SMet)
Air temperature (SOAR)
Relative humidity (SOAR)
Precipitation (SOAR, ORG)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(4) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

(5) Remarks (Times in UTC)

i) The following periods, sea surface temperature of SMet data was available.

08:27 11 Jul. 2017 - 16:57 01 Aug. 2017

Table 2.1.1-1 Instruments and installation locations of
MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side 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
Capacitive 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 2.1.1-2 Parameters of MIRAI Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship’s log speed	knot	Log, DS-30, Furuno
4 Ship’s heading	degree	Gyro,TG-8000,TOKYO-KEIKI
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 2.1.1-3 Instruments and installation locations of SOAR system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Barometer	PTB210	Vaisala, Finland	
with 61002 Gill pressure port		R.M. Young, USA	foremast (23 m)
Capacitive rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
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)

Table 2.1.1-4 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	

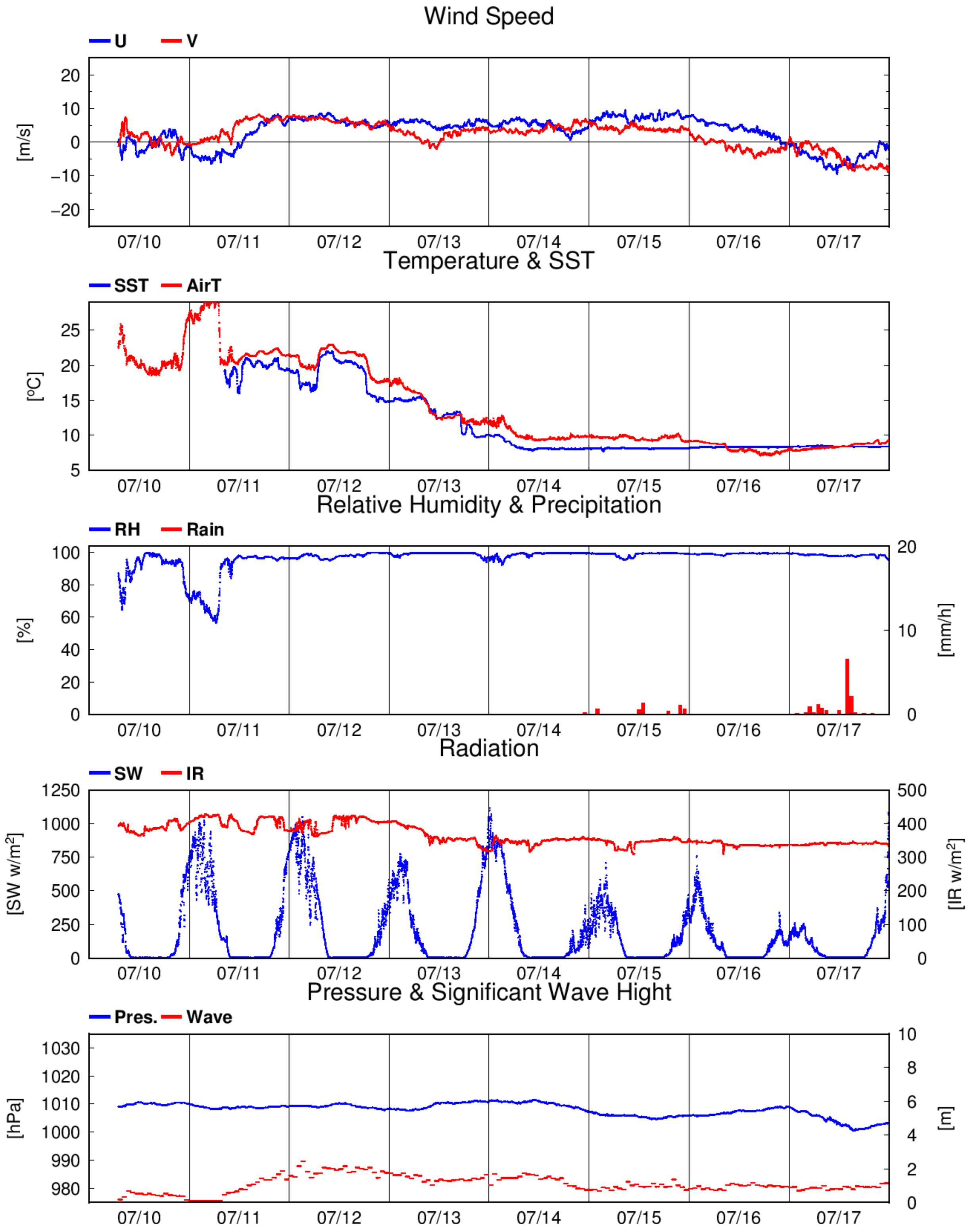

Fig. 2.1.1-1 Time series of surface meteorological parameters during this cruise

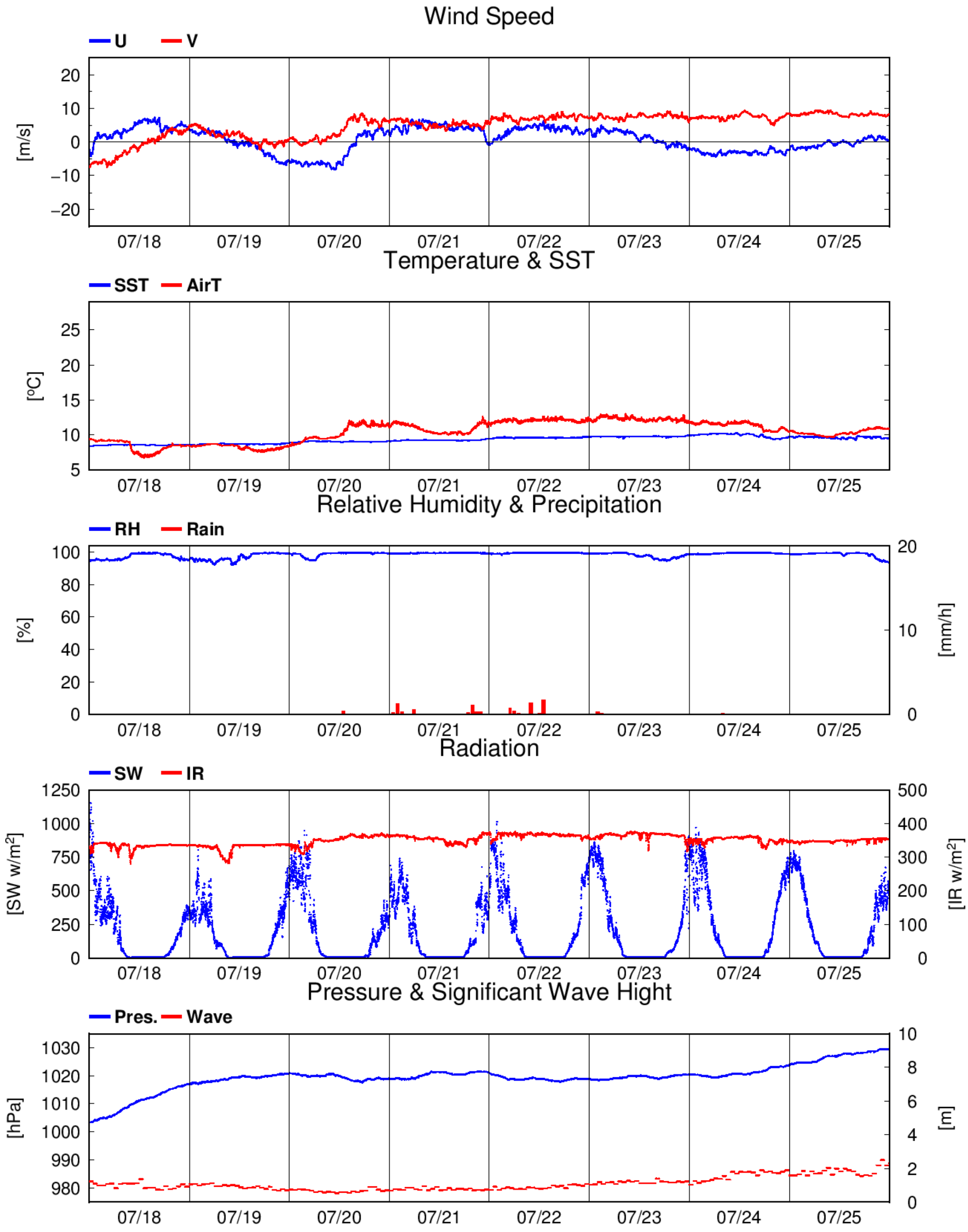

Fig. 2.1.1-1 (Continued)

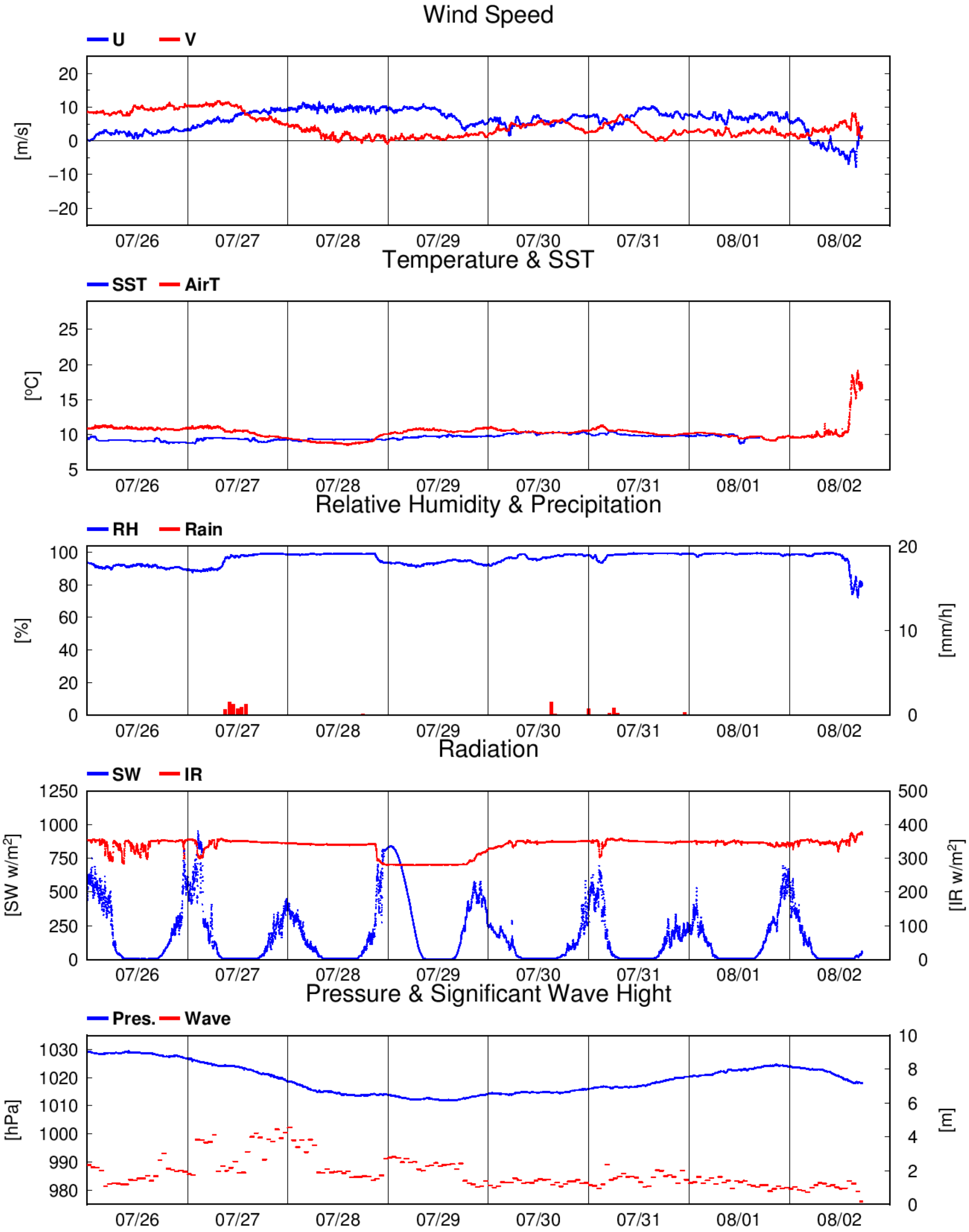

Fig. 2.1.1-1 (Continued)

2.1.1(b) Ceilometer observation

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Mitsuteru KUNO **NME**
Masanori MURAKAMI **MIRAI crew**

(1) Objectives

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

(2) Parameters

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

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland). Major parameters for the measurement configuration are shown in Table 2.1.1-5;

Table 2.1.1-5 Major parameters

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
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)
Responsibility at 905 nm:	65 A/W
Cloud detection range:	0 ~ 13 km
Measurement range:	0 ~ 15 km
Resolution:	10 meter in full range
Sampling rate:	36 sec
Sky Condition:	Cloudiness in octas (0 ~ 9) (0:Sky Clear, 1:Few, 3:Scattered, 5-7:Broken, 8:Overcast, 9:Vertical Visibility)

(4) Results

Fig.2.1.1-2 shows the time series of 1st, 2nd and 3rd lowest cloud base height during this cruise.

(5) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

(6) Remarks

The following time, the window was cleaned.

05:06UTC, 24 Jul. 2017
18:14UTC, 29 Jul. 2017

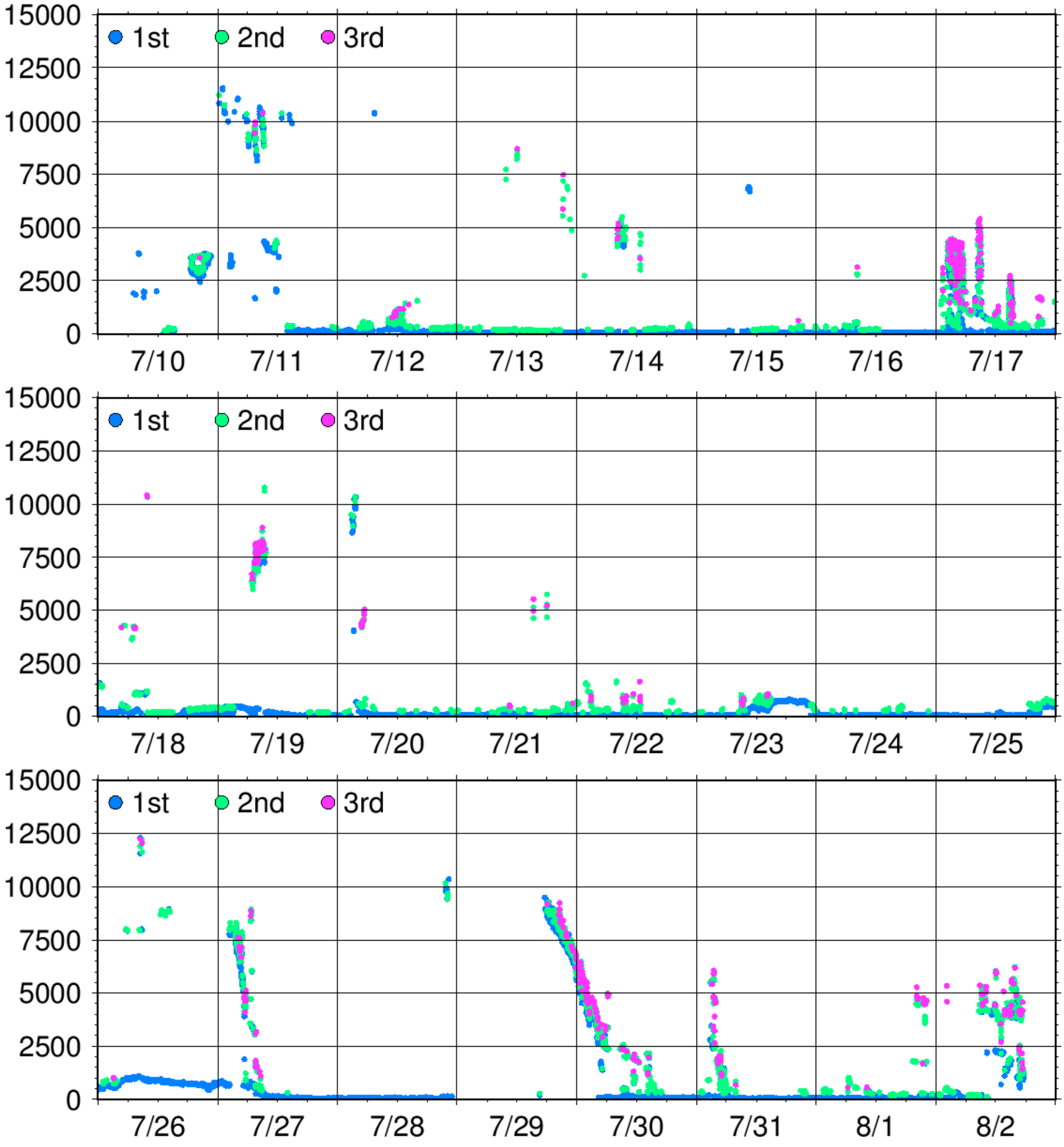

Fig. 2.1.1-2 1st, 2nd and 3rd lowest cloud base height during this cruise

2.1.2 Geophysical observation

2.1.2(a) Swath bathymetric survey

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(1) Introduction

The objective of Multi-Beam Echo Sounding system (MBES) is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global data sets.

(2) Data acquisition

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 multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD and Argo float data by the equation in Del Grosso (1974) during the cruise.

(3) Results

The results will be published after primary processing.

(4) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

2.1.2(b) Sea surface gravity

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Masanori MURAKAMI **MIRAI crew**

(1) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface.

(2) Parameters

Relative Gravity [CU: Counter Unit]
[mGal] = (coef1: 0.9946) * [CU]

(3) Data acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-G LaCoste, LLC) during this cruise.

To convert the relative gravity to absolute gravity, we measured gravity, using portable gravity meter (CG-5, Scintrex), at Sekinehama and Hachinohe as the reference points.

(4) Results

Absolute gravity table is shown in Table 2.1.2(b)-1.

Table 2.1.2(b)-1. Absolute gravity table of the this cruise

No.	Date m/d	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity at Sensor *1 [mGal]	S-116 Gravity [mGal]
#1	7/6	06:49	Sekinehama	980,371.87	244	627	980,372.84	12657.21
#2	8/2	22:15	Dutch Harbor	-----	258	625	-----	13823.06
#3	8/21	21:50	Dutch Harbor	-----	331	608	-----	13822.07
#4	10/3	04:49	Hachinohe	980,354.86	205	640	980,355.74	12637.08

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

(5) Data archive

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

2.1.2(c) Sea surface magnetic field

Tetsuichi FUJIKI	**JAMSTEC RCGC: Principal Investigator**
Wataru TOKUNAGA	**Nippon Marine Enterprises LTD. (NME)**
Mitsuteru KUNO	**NME**
Masanori MURAKAMI	**MIRAI crew**

(1) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during this cruise.

(2) Instruments

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

(3) Principle of ship-board geomagnetic vector measurement

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

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

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

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

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

(4) Results

The results will be published after primary processing.

(5) Data archive

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there

(7) Remarks (Times in UTC)

i) The following periods, we made a “figure-eight” turn (a pair of clockwise and anti-clockwise rotation) for calibration of the ship’s magnetic effect.

09:59 - 10:26 10 Jul. 2017 around 41-15N, 141-39E
19:01 - 19:27 18 Jul. 2017 around 47-00N, 159-59E
09:36 - 10:01 26 Jul. 2017 around 52-38N, 170-07E
02:45 - 03:10 30 Jul. 2017 around 58-55N, 179-52W

2.1.3 Shipboard ADCP

Tetsuichi FUJIKI	**JAMSTEC RCGC: Principal Investigator**
Wataru TOKUNAGA	**Nippon Marine Enterprises LTD. (NME)**
Mitsuteru KUNO	**NME**
Masanori MURAKAMI	**MIRAI crew**

(1) Objectives

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

(2) 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 System (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 every 10 minutes.
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 was configured for "8 m" layer intervals starting about 23m below sea surface, and recorded every ping as raw ensemble data (.ENR). Additionally, 15 seconds averaged data were recorded as short-term average (.STA). 300 seconds averaged data were long-term average (.LTA), respectively.

(3) Parameters

Major parameters for the measurement, Direct Command, are shown in Table 2.1.3-1.

Table 2.1.3-1 Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1,300m 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)
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 (V; C; A; PG; St; Vsum; Vsum^2; #G; P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

(4) Results

Fig.2.1.3-1 shows surface current profile vectors along the ship's track, averaged from 35 m to 59 m with 60 minutes.

(5) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

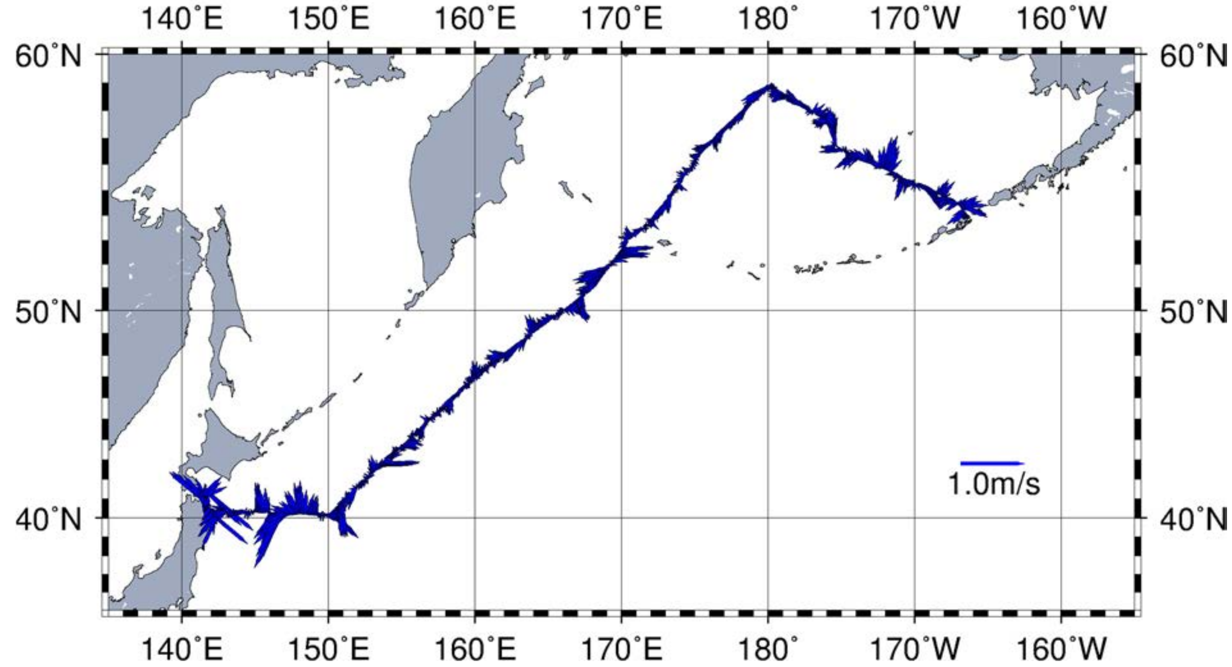

Fig.2.1.3-1 Surface current profile vectors along the ship's track

2.1.4 CTD cast and water sampling

Masahide WAKITA	**JAMSTEC MIO: Principal Investigator**
Hiroshi UCHIDA	**JAMSTEC RCGC)**
Kenichi KATAYAMA	**MWJ: Operation Leader**
Shungo OSHITANI	**MWJ**
Keisuke MATSUMOTO	**MWJ**
Keisuke TAKEDA	**MWJ**

(1) Objective

Investigation of oceanic structure and water sampling.

(2) Parameters

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

(3) Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel Water Sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-liter Niskin Bottles were used for sampling seawater. 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, beam transmission, turbidity (primary and secondary), photosynthetically active radiation, altimeter, deep ocean standards thermometer, and sound velocity. Moreover, Microrider and LADCP are mounted on the CTD frame. Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) 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. We usually stop for 30 seconds to stabilize then fire. 23 casts of CTD measurements were conducted (Table 2.1.4-1).

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 primary temperature (SBE3) sensor.
S/N 031525: +1.714e-008 (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 6 seconds advancing dissolved oxygen sensor 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 (RINKOIII and SBE43) voltage.

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

FILTER: Perform a low pass filter on pressure 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, transmission data, transmission voltage and turbidity. 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.

Configuration file: MR1704A.xmlcon

Specifications of the sensors are listed below.
CTD: SBE911plus CTD system
Under water unit:
SBE9plus (S/N: 09P54451-1027, Sea-Bird Electronics, Inc.)
Pressure sensor: Digiquartz pressure sensor (S/N: 1027_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: 043036, Sea-Bird Electronics, Inc.)
    Calibrated Date: 30 Dec. 2016

Dissolved Oxygen sensor:
  Primary: RINKOIII (S/N: 0278_163010BA, JFE Advantech Co., Ltd.)
    Calibrated Date: 25 Oct 2016
  Secondary: SBE43 (S/N: 430330, Sea-Bird Electronics, Inc.)
    Calibrated Date: 03 May. 2017

Fluorescence:
  Chlorophyll Fluorometer (S/N: 3700, Seapoint Sensors, Inc.)
  Gain setting: 10X, 0-15 ug/l
  Calibrated Date: None
  Offset: 0.000

Transmission meter: C-Star (S/N CST-1363DR, WET Labs, Inc.)
  Calibrated Date: 04 Jan. 2017

Turbidity:
  Primary: Turbidity Meter (S/N: 14953)
    Gain setting: 100X
    Scale factor: 1.000
    Calibrated Date: None
  Secondary: Turbidity Meter (S/N: 14954)
    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

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

Deep ocean standards thermometer:
SBE35(S/N: 0022, Sea-Bird Electronics, Inc.)

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

Submersible Pump:
Primary: SBE5T (S/N: 055816, Sea-Bird Electronics, Inc.)
Secondary: SBE5T (S/N: 054595, Sea-Bird Electronics, Inc.)

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

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

(4) Results

During this cruise, 23 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 2.1.4-1. In deep casts, bottom contact switch was also used.

(5) Data archive

All raw and processed data 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 2.1.4-1 MR17-04 Leg1 CTD cast

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	HT Above	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude	(m)	Out (m)	Bottom (m)	Depth (m)	Pressure (dbar)	Filename	
K02	1	071417	21:16	00:49	46-59.84N	160-00.32E	5200.0	5183.9	9.8	5173.4	5281.0	K02M001	Deep
K02	2	071617	05:27	08:27	46-59.95N	160-00.03E	5186.0	3006.2	-	3002.0	3049.0	K02M002	Middle
K02	3	071717	15:38	16:29	46-59.19N	160-00.74E	5209.0	298.8	-	301.3	304.0	K02M003	Shallow (P.P.)
K02	4	071717	20:11	20:30	47-00.03N	160-00.26E	5209.0	194.8	-	198.2	200.0	K02M004	Shallow (Uchida)
K02	5	071817	00:04	00:23	46-59.95N	160-00.01E	5209.0	195.0	-	199.2	201.0	K02M005	Shallow (Uchida)
K02	6	071817	01:54	02:37	47-00.16N	160-00.06E	5209.0	501.7	-	504.2	509.0	K02M006	Shallow (POM)
K02	7	071817	22:54	04:53	47-00.08N	159-59.99E	5180.0	3005.9	-	3001.0	3048.0	K02M007	Middle
K02	8	071917	15:36	16:26	47-00.08N	159-60.00E	5182.0	297.9	-	300.3	303.0	K02M008	Shallow (P.P.)
K02	9	071917	20:08	20:29	47-00.22N	160-00.06E	5182.0	195.3	-	199.2	201.0	K02M009	Shallow (Uchida)
K02	10	072017	02:18	02:38	47-00.30N	160-00.39E	5182.0	195.5	-	198.2	200.0	K02M010	Shallow (Uchida)
K02	11	072117	15:36	16:28	46-59.96N	159-59.98E	5184.0	298.1	-	300.3	303.0	K02M011	Shallow (P.P.)
K02	12	072117	17:49	20:46	47-00.09N	159-59.79E	5184.0	3004.2	-	3001.0	3048.0	K02M012	Middle
K02	13	072317	19:13	22:49	47-00.09N	160-00.43E	5187.0	5177.3	8.9	5169.5	5277.0	K02M013	Deep
U01	1	072617	03:03	07:03	52-38.45N	170-03.39E	6879.0	6004.8	-	6000.4	6140.0	U01M001	Deep
U01	2	072617	14:35	15:04	52-38.43N	170-03.35E	6869.0	95.6	-	100.1	101.0	U01M002	Shallow (P.P.)
U02	1	072617	21:13	22:45	53-08.04N	170-33.26E	1481.0	1463.1	9.4	1463.7	1482.0	U02M001	Deep
U03	1	072717	06:10	06:39	53-42.01N	171-59.99E	3912.0	95.4	-	100.1	101.0	U03M001	Shallow (P.P.)
U03	2	072717	07:50	10:52	53-41.48N	172-01.03E	3914.0	3952.0	9.9	3894.3	3966.0	U03M002	Deep
U04	1	072817	06:08	06:13	56-29.96N	175-30.04E	3839.0	95.9	-	100.1	101.0	U04M001	Shallow (PAR)
U04	2	072817	14:34	15:03	56-29.99N	175-30.04E	3839.0	95.6	-	100.1	101.0	U04M002	Shallow (P.P.)
U04	3	072817	17:03	19:56	56-29.86N	175-29.96E	3839.0	3828.7	9.0	3822.3	3893.0	U04M003	Deep
U05	1	072917	19:02	19:30	58-56.27N	179-54.11W	3556.0	96.5	-	100.0	101.0	U05M001	Shallow (P.P.)
U05	2	072917	20:52	23:40	58-56.11N	179-54.30W	3559.0	3538.8	9.5	3534.3	3598.0	U05M002	Deep

2.1.5 Salinity measurement

Masahide WAKITA	**JAMSTEC MIO**
Hiroki USHIROMURA	**MWJ**

(1) Objective

To measure bottle salinity obtained by CTD casts, bucket sampling, and the continuous sea surface water monitoring system (TSG).

(2) Methods

a. Salinity sample collection

Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and TSG. The salinity sample bottles of the 250ml brown glass bottles with screw caps were used for collecting the sample water. Each bottle was rinsed three times with the sample water, and filled with sample water to the bottle shoulder. The salinity sample bottles for TSG were sealed with a plastic cone and screw cap because we took into consideration the possibility of storage for about one month. These caps were rinsed three times with the sample water before use. The bottles were stored for more than 24 hours in the laboratory before the salinity measurement.

The Kind and number of samples taken as shown as follows;

Table 2.1.5-1 Kind and number of samples

Kind of samples	Number of samples
Samples for CTD and bucket	531
Samples for TSG	20
Total	551

b. Instruments and method

The salinity measurement on R/V MIRAI was carried out during the cruise of MR17-04Leg1 using the salinometer (Model 8400B “AUTOSAL”; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540; Guildline Instruments Ltd.: S/N 66723 and 62525) were used. The thermometer monitored the ambient temperature and the bath temperature of the salinometer.

The specifications of AUTOSAL salinometer and thermometer 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)

Thermometer (Model 9540: Guildline Instruments Ltd.)
Measurement Range : -40 to +180 deg C
Resolution : 0.001
Limits of error ±deg C : 0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability : ±2 least significant digits

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 21.5 deg C to 24.1 deg C, while the bath temperature was very stable and varied within +/- 0.003 deg C on rare occasion.The measurement for each sample was carried out with the double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 10 seconds to collect 31 readings by the personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing five 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 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, we measured a ninth filling of the cell and calculated the bottle salinity. The measurement was conducted in about 8 hours per day and the cell was cleaned with soap after the measurement of the day.

(3) Result

a. Standard seawater

Standardization control of the salinometer was set to 595 and all measurements were carried out at this setting. The value of STANDBY was 24+5126～5127 and that of ZERO was 0.0+0000～0001. The conductivity ratio of IAPSO Standard Seawater batch P159 was 0.99988 (the double conductivity ratio was 1.99976) and was used as the standard for salinity. 25 bottles of P159 were measured.

Fig.2.1.5-1 shows the time series of the double conductivity ratio for the Standard Seawater batch P159 before correction. The average of the double conductivity ratio was 1.99974 and the standard deviation was 0.00002, which is equivalent to 0.0003 in salinity.

Fig.2.1.5-2 shows the time series of the double conductivity ratio for the Standard Seawater batch P159 after correction. The average of the double conductivity ratio after correction was 1.99976 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity
The specifications of SSW used in this cruise are shown as follows；

Batch : P159
conductivity ratio : 0.99988
salinity : 34.995
Use by : 15th Dec 2018

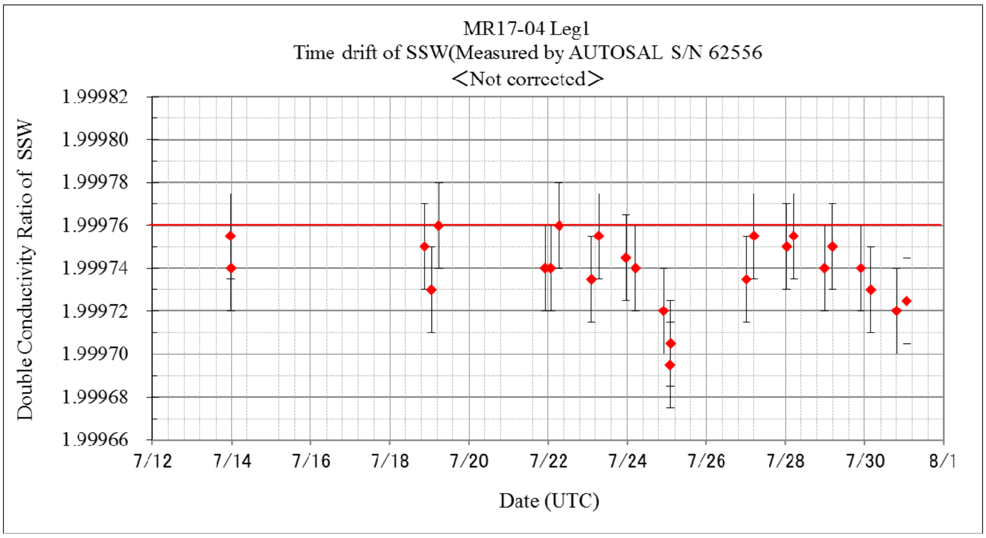

Fig. 2.1.5-1 Time series of the double conductivity ratio for the Standard Seawater batch P159 (Before correction)

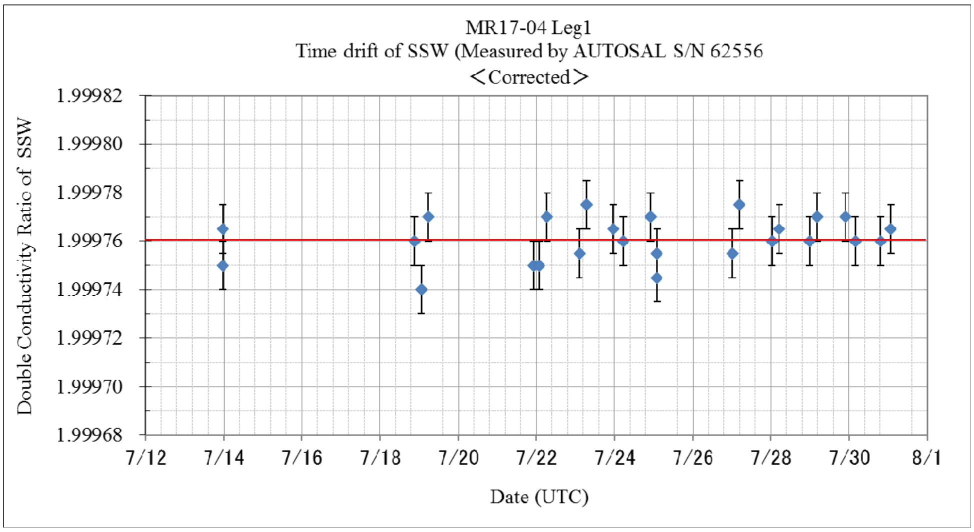

Fig. 2.1.5-2 Time series of the double conductivity ratio for the Standard Seawater batch P159 (After correction)

b. Sub-standard seawater

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

c. Replicate samples

We estimated the precision of this method using 35 pairs of replicate samples taken from the same Niskin bottle. Fig.2.1.5-3 shows the histogram of the absolute difference between each pair of the replicate samples. The average and the standard deviation of absolute deference among 35 pairs of replicate samples were 0.0005 and 0.0006 in salinity, respectively.

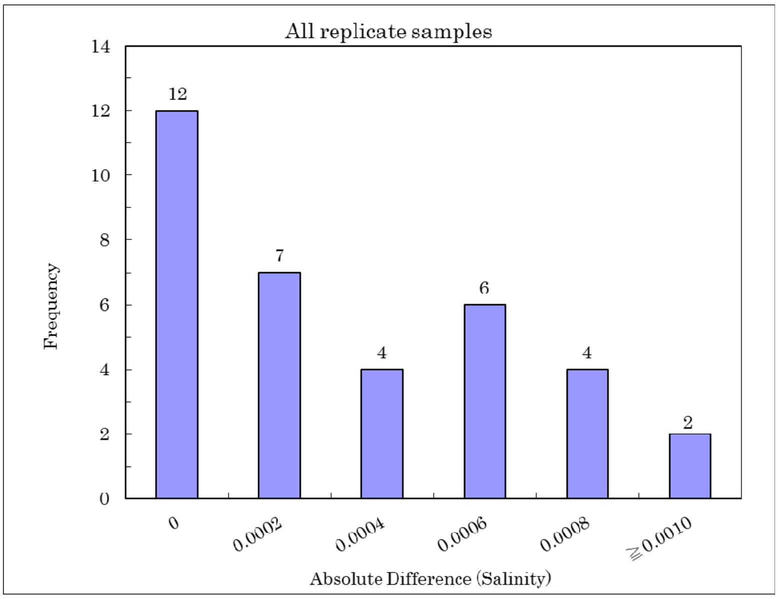

Fig. 2.1.5-3 The histogram of the double conductivity ratiofor the absolute difference of replicate samples

(4) Data archive

These data obtained in this cruise will be submitted to the Data Management Office (DMO) 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>

(5) Reference

・Aoyama, M. , T. Joyce, T. Kawano and Y. Takatsuki: Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 49, 1103～1114, 2002

・ UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. UNESCO Tech. Papers in Mar. Sci., 36, 25 pp., 1981

2.1.6 Dissolved Oxygen

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Hironori SATO	**MWJ: Operation Leader**
Erii IRIE	**MWJ**

(1) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(2) Parameters

Dissolved Oxygen

(3) 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 ºC, 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 2.1.6-1 shows results of the standardization and the blank determination during this cruise.

b. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. The standard deviation of the replicate measurement (Dickson et al., 2007) was 0.11 μmol kg^{-1} (n=40).

(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>

Table 2.1.6-1 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)	
2017/7/14	K1704A01	T1704B	3.964	0.001	3.969	0.004	K02cast1
2017/7/15	K1704A02	T1704B	3.962	-0.002	3.969	0.005	K02cast2, 3, 4, 5, 7, 8, 9, 10
2017/7/21	K1704A03	T1704B	3.961	0.000	3.968	0.005	K02cast11, 12, 13
2017/7/25	K1704A04	T1704B	3.964	0.004	3.972	0.008	
2017/7/25	K1704A04	T1704C	3.963	0.001	3.967	0.004	U01cast1, 2, U02cast1, U03cast2, U04cast2, 3, U05cast2
2017/7/30	K1704A05	T1704C	3.963	0.006	3.967	0.005	
2017/7/30	K1704A05	T1704C	3.963	0.003			
2017/8/6	K1704A06	T1704C	3.965	0.004	3.973	0.006	

(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 Winkler reagents used for the determination of dissolved oxygen. *Deep Sea Res.*, 15, 237-238.

2.1.7 Nutrient

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Tomomi SONE	**MWJ**
Kohei MIURA	**MWJ**

(1) Objectives

The objectives of nutrients analyses during the R/V Mirai MR17-04Leg1 cruise in the Western North Pacific Ocean is as follows:

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

(2) Summary of nutrients analysis

We made 11 QuAAtro 2-HR runs for the samples collected by 17 casts at 6 stations in this cruise. The total amount of layers of the seawater sample reached to 398 in Leg1. We made duplicate measurement at all layers at all stations. The station locations for nutrients measurement is shown in Figure 2.1.7-1 and Table 2.1.7-1. We also measured the samples as listed below. 160 samples collected from RAS and 8 salinity standard samples.

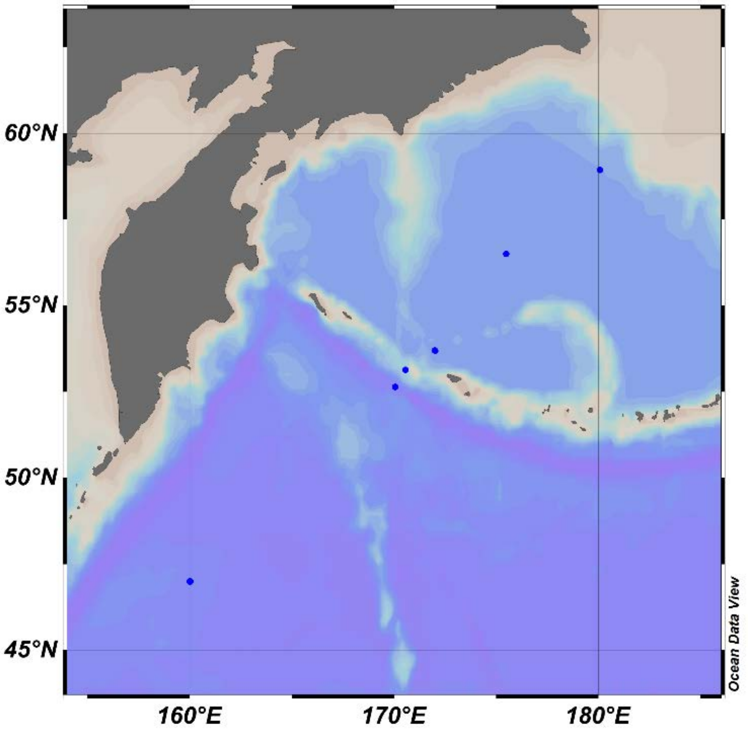

Figure 2.1.7-1 Sampling positions of nutrients sample in MR1704Leg1

Table 2.1.7-1 List of stations of MR1704Leg1

Station	Cast	Station	Date (UTC)	Position		Depth (dbar)
		serial	(mmddyy)	Latitude	Longitude	
K02	1	1	071417	46.9973	160.0053	5,281
K02	2	2	071617	46.9991	160.0005	3,049
K02	3	3	071717	46.9865	160.0123	304
K02	7	4	071917	47.0013	159.9999	3,048
K02	8	5	071917	47.0014	159.9999	303
K02	11	6	072117	46.9993	159.9997	303
K02	12	7	072117	47.0016	159.9966	3,048
K02	13	8	072317	47.0016	160.0072	5,277
U1	1	9	072617	52.6408	170.0565	6,140
U1	2	10	072617	52.6404	170.0558	101
U2	1	11	072617	53.1341	170.5544	1,482
U3	1	12	072717	53.7002	171.9999	101
U3	2	13	072717	53.6913	172.0172	3,965
U4	2	14	072817	56.4999	175.5006	101
U4	3	15	072817	56.4976	175.4993	3,893
U5	1	16	072917	58.9379	180.0982	101
U5	2	17	072917	58.9352	180.0951	3,598

(3) Instrument and Method

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

We applied two units of QuAAtro in this cruise. Unit 1 and Unit 2 were put for R/V Mirai equipment. Configurations of all units are completely same for five parameters, Nitrate, Nitrite, Silicate, Phosphate, and Ammonium.

Nitrate + nitrite and nitrite were analyzed according to the modification method of Grasshoff (1970). The sample nitrate was reduced to nitrite in a cadmium tube inside of which was coated with metallic copper. The sample streamed with its equivalent nitrite was treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacted with the sulfanilamide to produce a diazonium ion. N-1-Naphthylethylenediamine Dihydrochloride added to the sample stream then coupled with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite reacted and were measured; without reduction, only nitrite reacted. Thus, for the nitrite analysis, no reduction was performed and the alkaline buffer was not necessary. Nitrate was computed by difference.

The silicate method was analogous to that described for phosphate. The method used was essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid was first formed from the silicate in the sample and added molybdic acid; then the silicomolybdic acid was reduced to silicomolybdous acid, or "molybdenum blue" using ascorbic acid as the reductant. The analytical methods of the nutrients, nitrate, nitrite, silicate and phosphate, during this cruise were same as the methods used in (Kawano et al. 2009).

The phosphate analysis was a modification of the procedure of Murphy and Riley (1962). Molybdic acid was added to the seawater sample to form phosphomolybdic acid which was in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

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 2.1.7-2 to 2.1.7-6.

(3.2) Nitrate Reagents

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

Dissolve 4 g Imidazole (CAS No. 288-32-4), in 1000 mL DIW, add 2 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL Triton^{TM} X-100 (50 % solution in ethanol) 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 DIW, add 100 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL Triton^{TM} X-100 (50 % solution in ethanol) 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 DIW and add 10 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL Triton^{TM} X-100 (50 % solution in ethanol) is added.

Stored in a dark bottle.

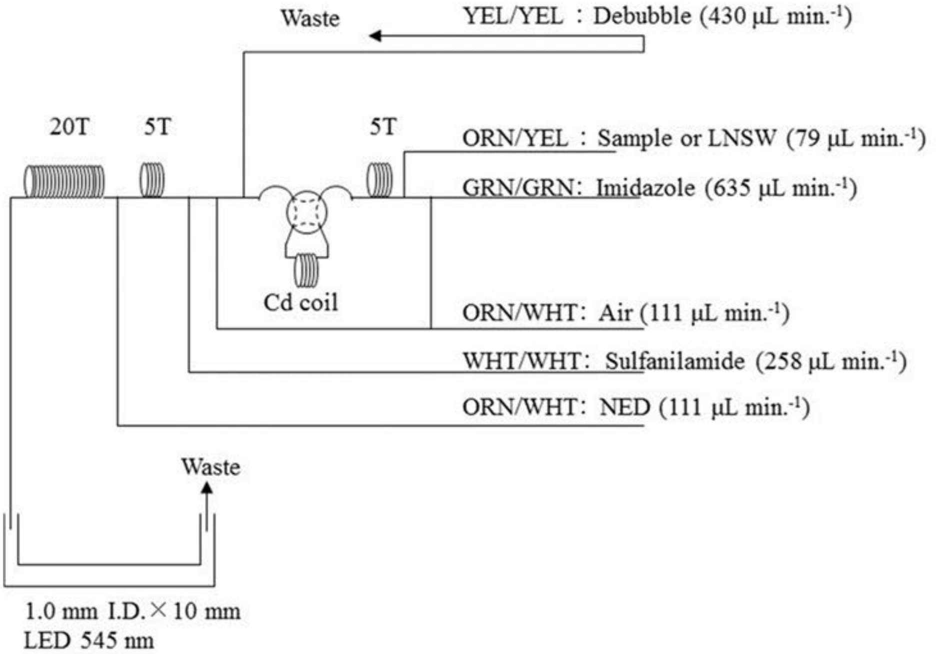

Figure 2.1.7-2 $NO_3 + NO_2$ (1ch.) Flow diagram

(3.3) Nitrite Reagents

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 DIW, add 100 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL Triton^{TM} X-100 (50 % solution in ethanol) 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 DIW and add 10 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL Triton^{TM} X-100 (50 % solution in ethanol) is added. This reagent was stored in a dark bottle.

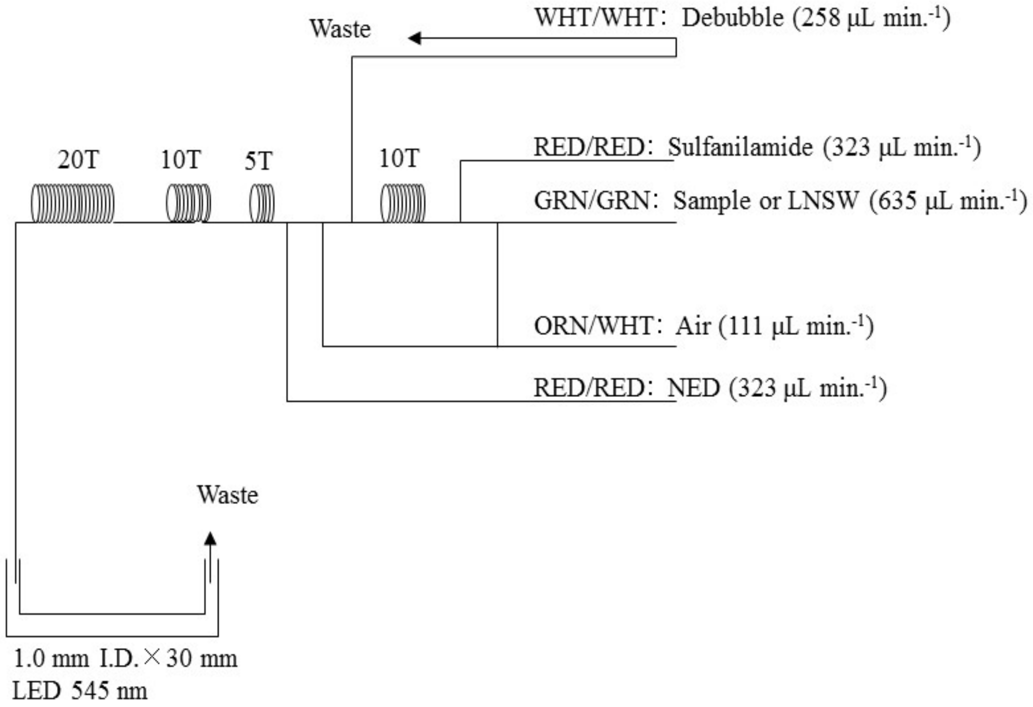

Figure 2.1.7-3 NO_2 (2ch.) Flow diagram

(3.4) Silicate Reagents

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

Dissolve 15 g Sodium molybdate dihydrate (CAS No. 10102-40-6), in 980 mL DIW, add 8 mL Sulfuric acid (CAS No. 7664-93-9). After mixing, 20 mL Sodium dodecyl sulfate (CAS No. 151-21-3), (15 % solution in water) is added.

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

Dissolve 50 g Oxalic Acid (CAS No. 144-62-7), in 950 mL of DIW.

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

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

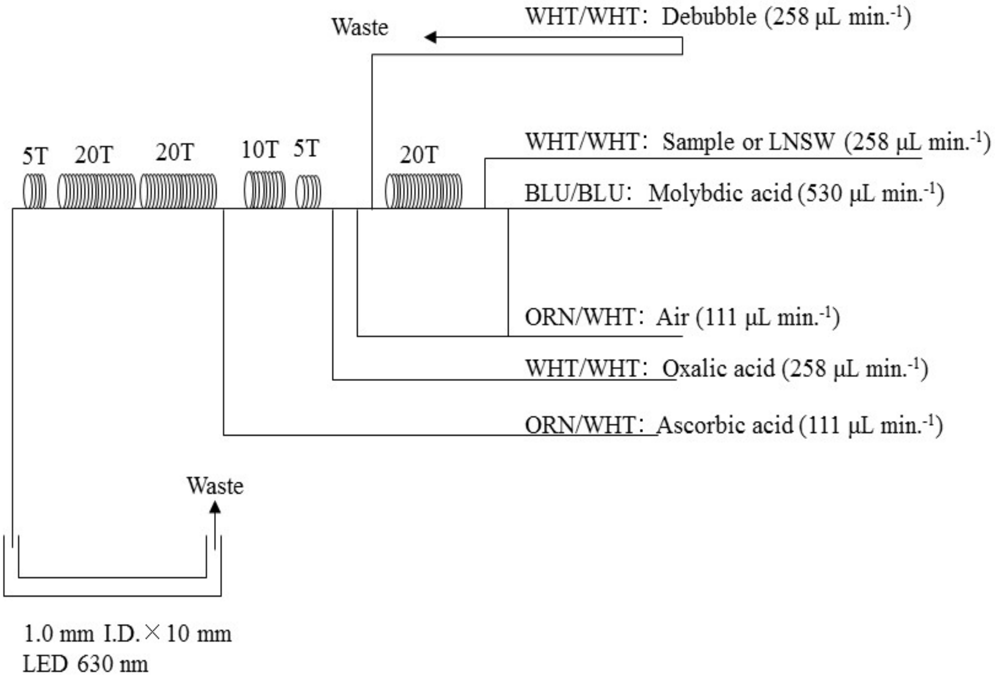

Figure 2.1.7-4 SiO_2 (3ch.) Flow diagram

(3.5) Phosphate Reagents

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 DIW 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 Sodium dodecyl sulfate (CAS No. 151-21-3), (15 % solution in water) was added. This reagent was freshly prepared before every measurement.

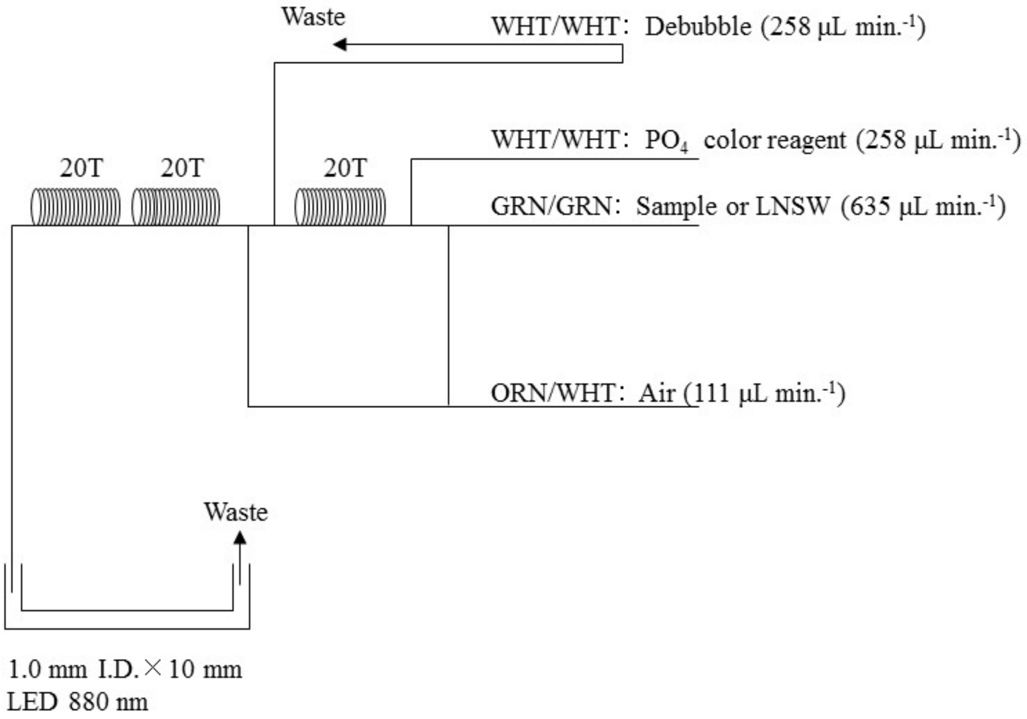

Figure 2.1.7-5 PO4 (4ch.) Flow diagram

(3.6) Ammonium Reagents

EDTA

Dissolve 41 g Tetrasodium EDTA tetrahydrate (CAS No. 13235-36-4), and 2 g Boric acid (CAS No. 10043-35-3), in 200 mL of DIW. After mixing, 1 mL Triton^{TM} X-100 (30 % solution in DIW) is added. This reagent is prepared at a week about.

NaOH

Dissolve 5 g Sodium hydroxide (CAS No. 1310-73-2), and 16 g Tetrasodium EDTA tetrahydrate (CAS No. 13235-36-4) in 100 mL of DIW. 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 DIW and add 0.2 mL 1.0 M H_2SO_4. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

Mix 4 mL stock nitroprusside and 5 mL 1.0 M H_2SO_4 in 500 mL of DIW. After mixing, 2 mL Triton^{TM} X-100 (30 % solution in DIW) is added. This reagent is stored in a dark bottle and prepared at every 2 or 3 days.

Alkaline phenol

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 DIW. Stored in a dark bottle and prepared at a week about.

NaClO solution
Mix 3 mL sodium hypochlorite solution, Sodium hypochlorite (CAS No. 7681-52-9), in 47 mL DIW. Stored in a dark bottle and fleshly prepared before every measurement. This reagent is prepared 0.3 % available chlorine.

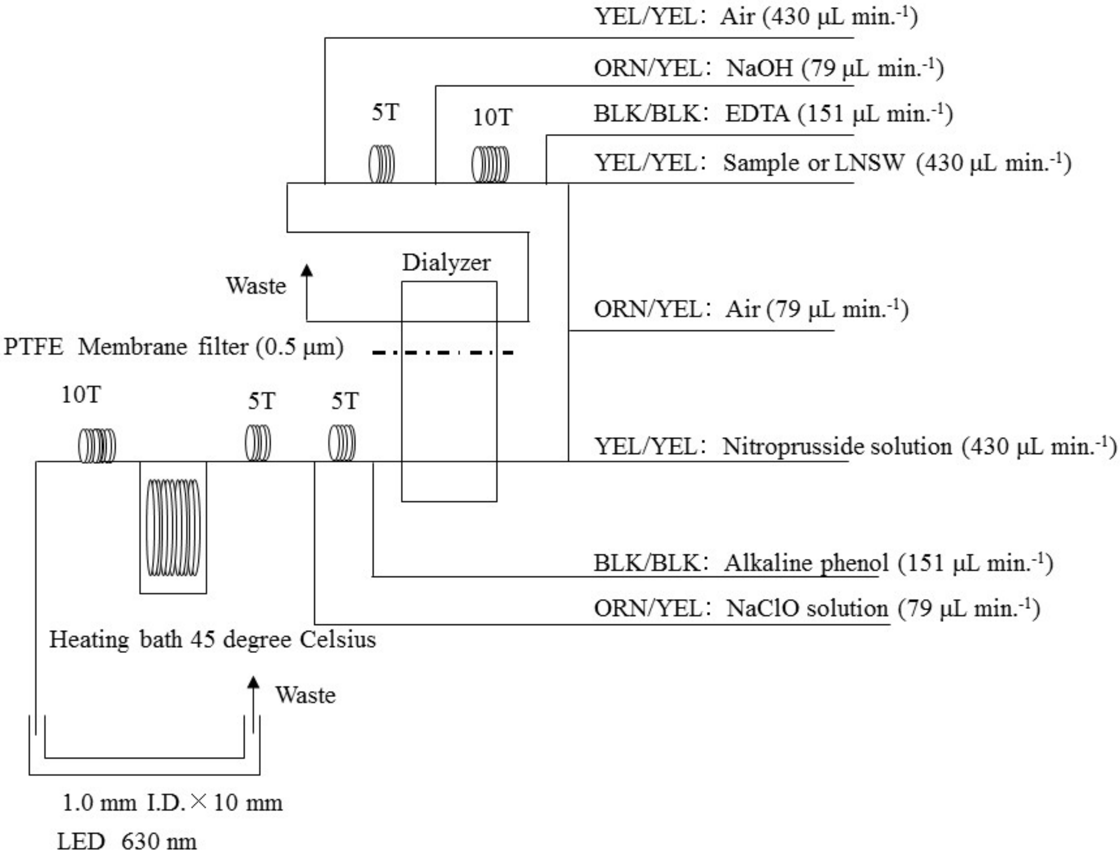

Figure 2.1.7-6 NH_4 (5ch.) Flow diagram

(3.7) Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into two of virgin 10 mL polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and then vials were capped immediately after the drawing. The vials were put into water bath adjusted to ambient temperature, 22 ± 0.3 degree Celsius, in about 30 minutes before use to stabilize the temperature of samples in MR1704Leg1.

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

(3.8) Data processing

Raw data from QuAAtro 2-HR was treated as follows:
- Checked baseline shift.
- Checked the shape of each peak and positions of peak values taken, and then changed 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.
- Loaded pressure and salinity from CTD data to calculate density of seawater. In case of bucket sample, we generally used bottle salinity from AUTOSAL.
- Calibration curves to get nutrients concentration were assumed second order equations.

(4) Certified Reference Material of nutrients in seawater

KANSO CRMs (Lot: BY, CD, BW, CB, BZ) 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 psu.

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.

(4.1) CRMs for this cruise

5 lot of CRMs were used in this cruise. These bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 17- 20 degree Celsius. The concentrations for CRM lots BY, CD, BW, CB and BZ are shown in Table 2.1.7-2.

Table 2.1.7-2 Certified concentration and uncertainty (k=2) of CRMs

unit: μmol kg^{-1}

Lot	Nitrate	Nitrite	Silicate	Phosphate	Ammonia*
BY	**0.02 ± 0.02**	**0.02 ± 0.01**	**1.76 ± 0.06**	**0.039 ± 0.010**	**0.82**
CD	**5.50 ± 0.05**	**0.02 ± 0.00**	**13.93 ± 0.10**	**0.446 ± 0.008**	**1.11**
BW	**24.59 ± 0.20**	**0.07 ± 0.01**	**60.01 ± 0.42**	**1.541 ± 0.014**	**1.03**
CB	**35.79 ± 0.27**	**0.12 ± 0.01**	**109.2 ± 0.62**	**2.520 ± 0.022**	**0.77**
BZ	**43.35 ± 0.33**	**0.22 ± 0.01**	**161.0 ± 0.93**	**3.056 ± 0.033**	**0.49**

*For ammonia values are references

(5) Nutrients standards

(5.1) 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 3 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05 % or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicate from the glass. PMP volumetric flasks were gravimetrically calibrated and used only within 3 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 3 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes were gravimetrically calibrated in order to verify and improve upon the nominal tolerance.

(5.2) Reagents, general considerations

Specifications

For nitrate standard, “potassium nitrate 99.995 suprapur®” provided by Merck, Lot. B0993065709, 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 999 mg L^{-1} at 20 degree Celsius. Expanded uncertainty of calibration (k=2) is 0.7 % for the calibration result.

For phosphate standard, “potassium dihydrogen phosphate anhydrous 99.995 suprapur®” provided by Merck, Lot. B1144508528, CAS No.: 7778-77-0, was used.

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 HC68513536 are used. The silicate concentration is certified by NIST-SRM 3150 with the uncertainty of 0.7 %. HC68513536 is certified as 1000 mg L^{-1}.

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 %.

Treatment of silicate standard due to high alkalinity

Since the silicon standard solution Merck CertiPUR® is in NaOH 0.5 M, we need to dilute and neutralize to avoid make precipitation of $MgOH_2$ etc. When we make B standard, silicon standard solution is diluted by factor 12 with pure water and neutralized by HCl 1.0 M to be about 7. After that B standard solution is used to prepare C standards.

Ultra pure water

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

Low-Nutrient Seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.20 µm pore capsule cartridge filter at MR1505 cruise on January, 2016. This water is stored in 20 liter cubitainer with paper box.

LNSW concentrations were assigned in August 2016 during MR1606 cruise.

(5.3) Concentrations of nutrient for A, B and C standards

Concentrations of nutrients for A, B, C and D standards are set as shown in Table 2.1.7-3. The C standard is prepared according recipes as shown in this table. 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 5 levels, C-1, C-2, C-3, C-4 and C-5 for nitrate, nitrite, phosphate and ammonia and 6 levels, C-1, C-2, C-3, C-4, C-5 and C-6 for silicate. C-1 was LNSW and the other standards were in-house standard.

Table 2.1.7-3 Nominal concentrations of nutrients for A, B and C standards in MR1704Leg1

	A	B	B’	D	C-1	C-2	C-3	C-4	C-5	C-6
NO_3 (μM)	45000	900	-	900	0	9	18	36	54	-
NO_2 (μM)	21800	26	-	870	0	0.3	0.5	1.0	1.6	-
SiO_2 (μM)	35600	2850	4270	-	1	30	58	115	172	257
PO_4 (μM)	6000	60	-	-	0	0.6	1.2	2.4	3.6	-
NH_4 (μM)	8000	160	-	-	0	1.6	3.2	6.4	9.6-	-

(5.4) Renewal of in-house standard solutions.

In-house standard solutions as stated in paragraph (5.2) were renewed as shown in Table 2.1.7-4 (a) to (c).

Table 2.1.7-4(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
B std. (mixture of A-1, D-2, A-3, A-4 and A-5 std.)	maximum 8 days
B’ std. (diluted A-3 std.)	maximum 8 days

Table 2.1.7-4(b) Timing of renewal of in-house standards

Working standards	Renewal
C-1 std. (LNSW)	every 24 hours
C-2, C-3, C-4 and C-5 std. (diluted B std.)	
C-6 std. (diluted B’ std.)	

Table 2.1.7-4(c) Timing of renewal of in-house standards for reduction estimation

Reduction estimation	Renewal
D-1 std. (900 µM NO_3)	**maximum 8 days**
D-2 std. (870 µM NO_2)	**maximum 8 days**
36 µM NO_3	**when C Std. renewed**
35 µM NO_2	**when C Std. renewed**

(6) Quality control

(6.1) Precision of nutrients analyses during this cruise

Precision of nutrients analyses during this cruise was evaluated based on the 7 to 11 measurements, which are measured every 8 to 13 samples, during a run at the concentration of C-5 std. Summary of precisions are shown as Table 2.1.7-5 and Figures 2.1.7-7 to 2.1.7-9, the precisions for each parameter are generally good considering the analytical precisions during the R/V Mirai cruses conducted in 2009 - 2016. Analytical precisions in MR1704Leg1 were 0.15 % for nitrate, 0.15 % for phosphate and 0.12 % for silicate in terms of median of precision, respectively.

Table 2.1.7-5 Summary of precision based on the replicate analyses for unit 2 in MR1704Leg1

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %	Ammonium CV %
Median	**0.14**	**0.18**	**0.11**	**0.15**	**0.43**
Mean	**0.15**	**0.19**	**0.12**	**0.15**	**0.39**
Maximum	**0.25**	**0.34**	**0.19**	**0.26**	**0.48**
Minimum	**0.07**	**0.10**	**0.07**	**0.06**	**0.16**
N	**11**	**11**	**11**	**11**	**9**

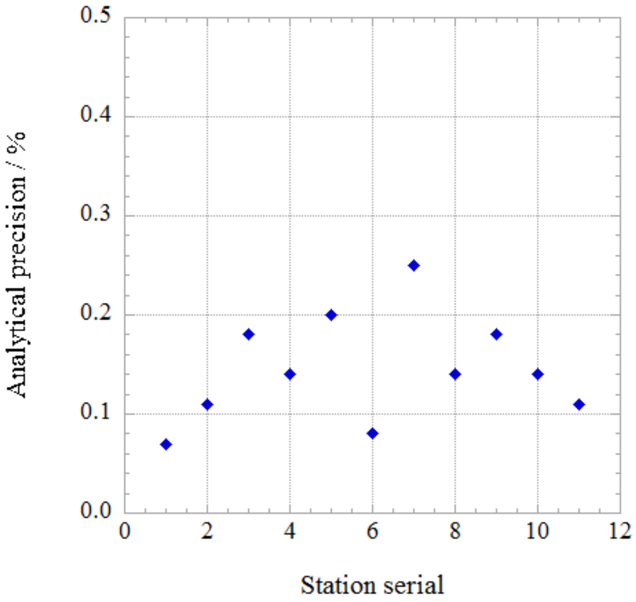

Figure 2.1.7-7 Time series of precision of nitrate in MR1704Leg1

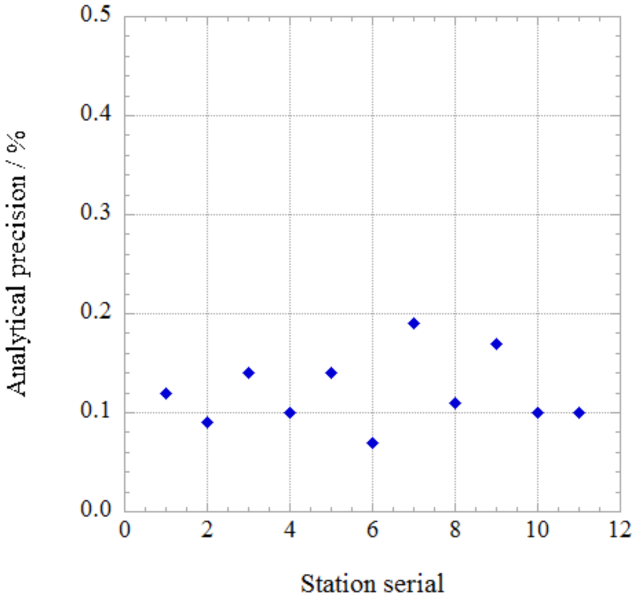

Figure 2.1.7-8 Time series of precision of silicate in MR1704Leg1

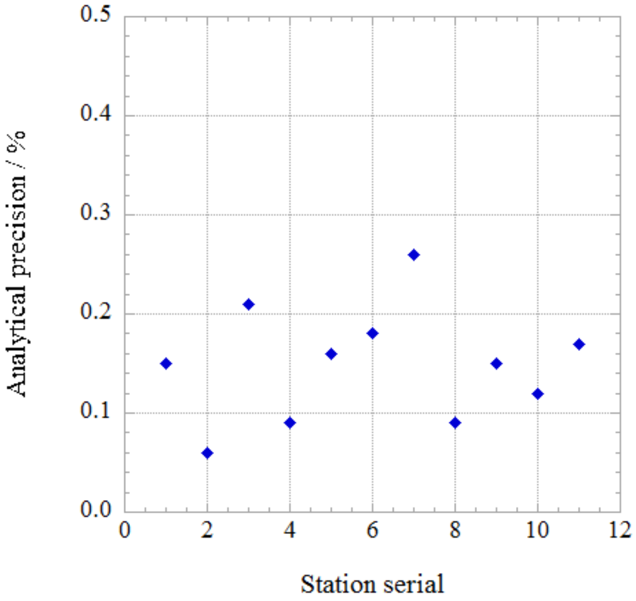

Figure 2.1.7-9 Time series of precision of phosphate in MR1704Leg1

(6.2) CRM lot. CB measurement during this cruise

CRM lot. CB was measured every run to monitor the comparability among runs. The results of lot. CB during this cruise are shown as Figures 2.1.7-10 to 2.1.7-12. Error bars represent analytical precision in Figures 2.1.7-7 to 2.1.7-9.

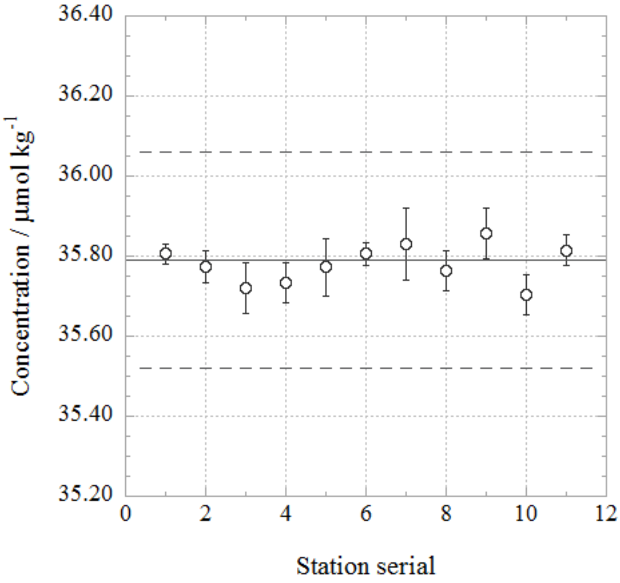

Figure 2.1.7-10 Time series of CRM-CB of nitrate in MR1704Leg1.
Solid line : certified value, broken line : uncertainty of certified value (*k*=2)

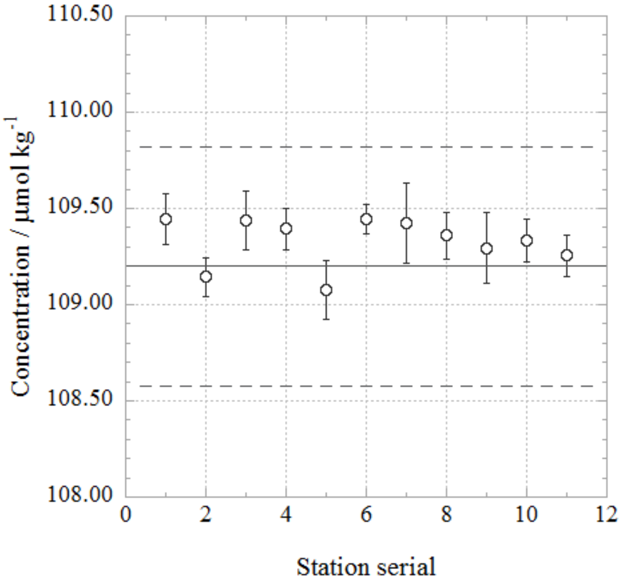

Figure 2.1.7-11 Time series of CRM-CB of silicate in MR1704Leg1
Solid line : certified value, broken line : uncertainty of certified value (*k*=2)

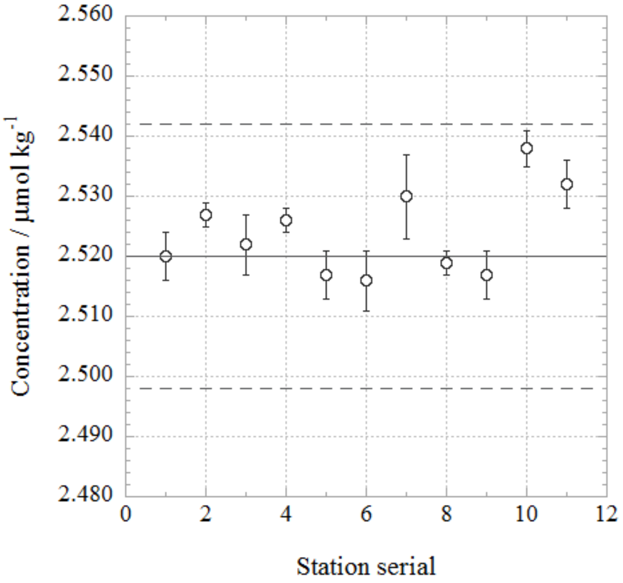

Figure 2.1.7-12 Time series of CRM-CB of phosphate in MR1704Leg1
Solid line : certified value, broken line : uncertainty of certified value (k=2)

(6.3) Carryover

We can also summarize the magnitudes of carryover throughout the cruise. These are small enough within acceptable levels as shown in Table 2.1.7-6 and Figures 2.1.7-13 to 2.1.7-15.

Table 2.1.7-6 Summary of carry over throughout Leg1

	Nitrate CV %	**Nitrite CV %**	**Silicate CV %**	**Phosphate CV %**	**Ammonium CV %**
Median	**0.15**	**0.09**	**0.06**	**0.11**	**0.41**
Mean	**0.15**	**0.07**	**0.06**	**0.10**	**0.43**
Maximum	**0.19**	**0.18**	**0.09**	**0.15**	**0.69**
Minimum	**0.12**	**0.00**	**0.04**	**0.05**	**0.14**
N	**11**	**11**	**11**	**11**	**9**

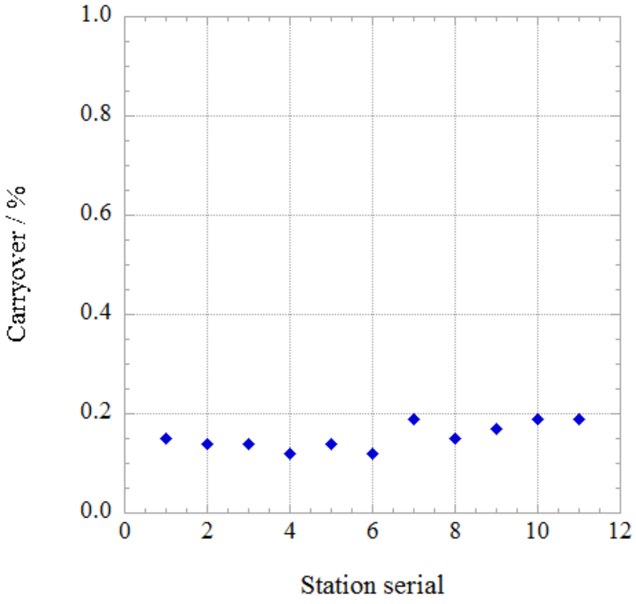

Figure 2.1.7-13 Time series of carryover of nitrate in MR1704Leg1

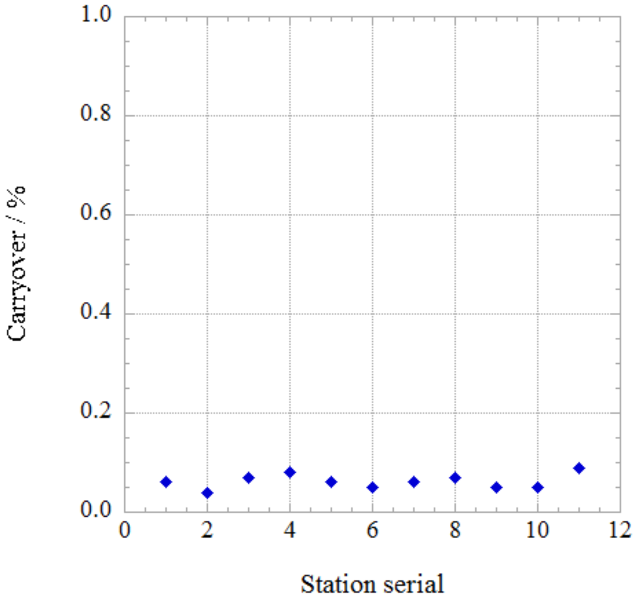

Figure 2.1.7-14 Time series of carryover of silicate in MR1704Leg1

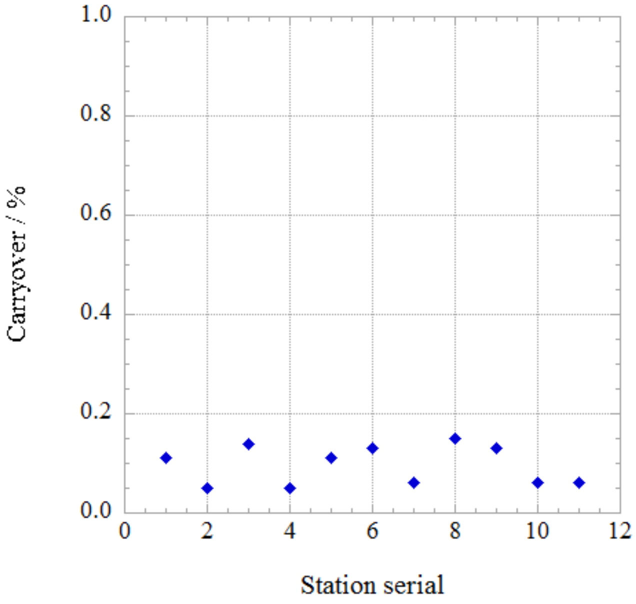

Figure 2.1.7-15 Time series of carryover of phosphate in MR1704Leg1

(6.4) Estimation of uncertainty of phosphate, nitrate and silicate concentrations

We estimate the uncertainty of measurement of nutrient by merging data from both MR1704Leg1 and MR1704Leg2 because the numbers of the run in each leg were small, 11 runs and 9 runs, respectively.

Empirical equations, eq. (1), (2), and (3) to estimate uncertainty of measurement of phosphate, nitrate and silicate are used based on measurements of 20 sets of CRMs during this cruise. Empirical equations, eq. (4), (5) are used to estimate uncertainty of measurement of nitrite and ammonium based on duplicate measurements of the samples. These empirical equations and graphic presentation of equations are as follows, respectively.

Phosphate Concentration Cp in μmol kg^{-1}:
Uncertainty of measurement of phosphate (%) =
$0.161 + 0.217 * (1 / Cp) + 0.00313 * (1 / Cp) * (1 / Cp)$ --- (1)
where Cp is phosphate concentration of sample.

Nitrate Concentration Cno3 in μmol kg^{-1}:
Uncertainty of measurement of nitrate (%) =
$0.10 + 1.35 * (1 / Cno3)$ --- (2)
where Cno3 is nitrate concentration of sample.

Silicate Concentration Cs in μmol kg^{-1}:
Uncertainty of measurement of silicate (%) =
$0.10 + 3.16 * (1 / Cs)$ --- (3)
where Cs is silicate concentration of sample.

Nitrite Concentration Cno2 in μmol kg^{-1}:
Uncertainty of measurement of nitrite (%) =
0.17 + 0.23 * (1 / Cno2) - 0.000012 * (1 / Cno2) * (1 / Cno2) --- (4)
where Ca is ammonium concentration of sample.

Ammonium Concentration Ca in μmol kg^{-1}:
Uncertainty of measurement of ammonium (%) =
0.43 + 1.60 * (1 / Ca) --- (5)
where Ca is ammonium concentration of sample.

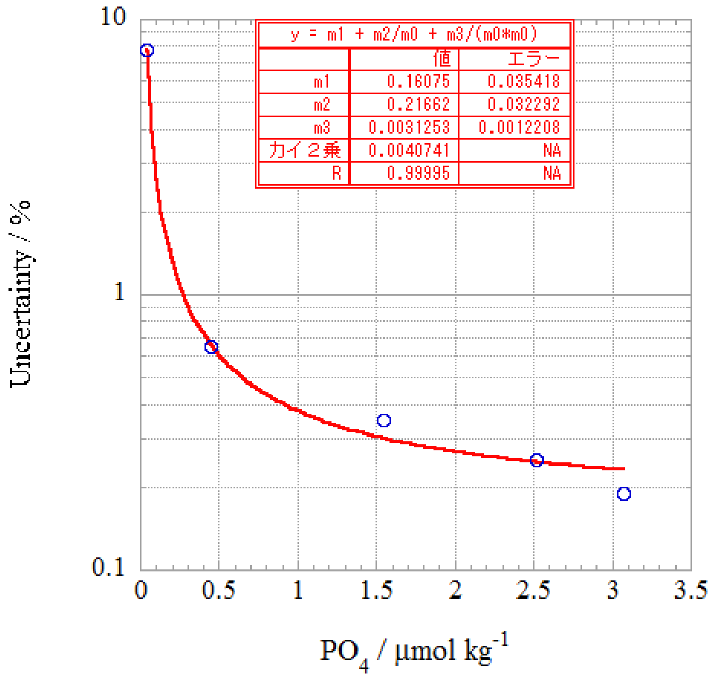

Figure 2.1.7-16 Estimation of uncertainty for phosphate in MR1704

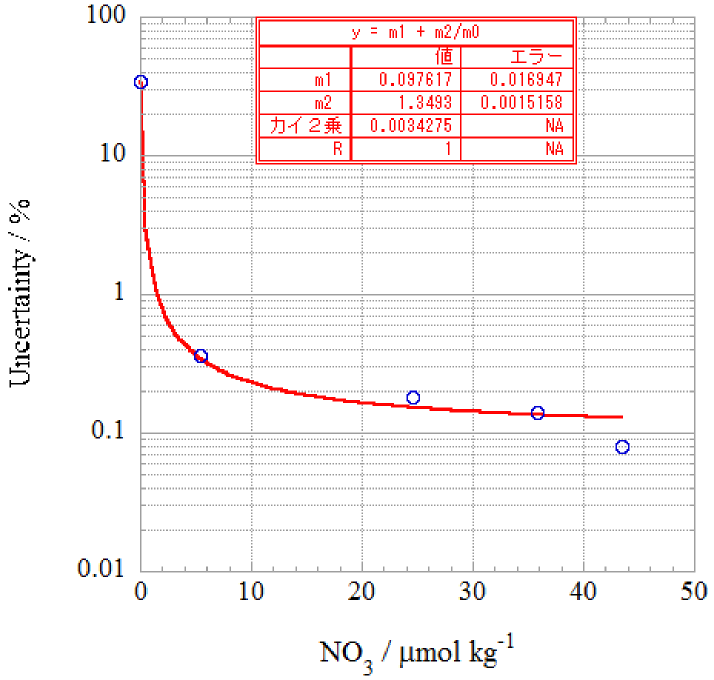

Figure 2.1.7-18 Estimation of uncertainty for nitrate in MR1704

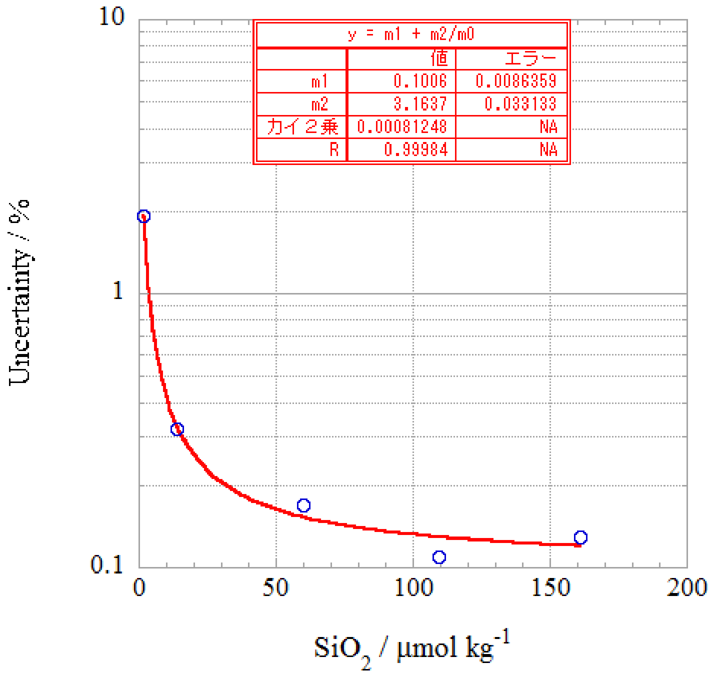

Figure 2.1.7-18 Estimation of uncertainty for silicate in MR1704

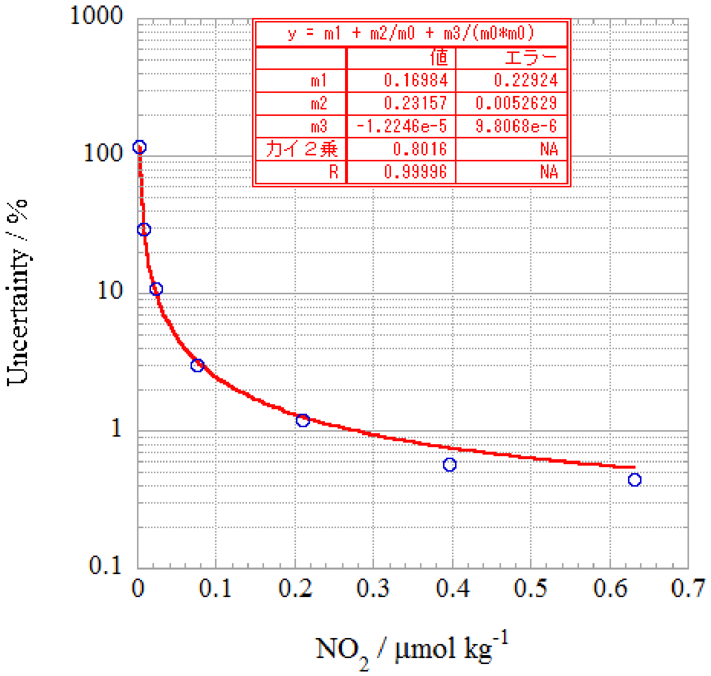

Figure 2.1.7-19 Estimation of uncertainty for nitrite in MR1704

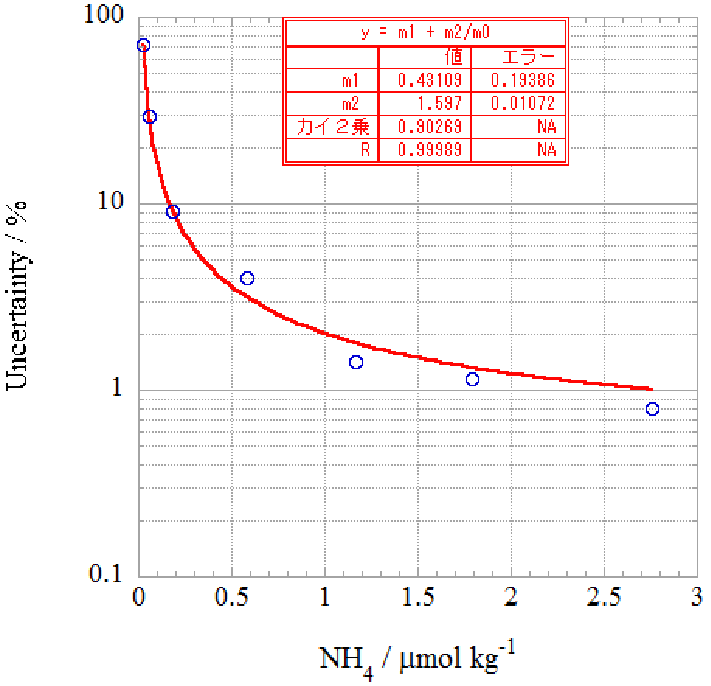

Figure 2.1.7-20 Estimation of uncertainty for ammonium in MR1704

(7) Problems / improvements occurred and solutions

(7.1) Unmixed samples

When we found the value of transparency of the sample was less than 99 % or doubtful for the particles in the sample, we did not mixed the samples before putting them on auto sampler. The unmixed sample list for nutrients is shown in Table 2.1.7-7.

Table 2.1.7-7 Unmixed sample list of MR1704Leg1

Station	Cast	Bottle	Depth (dbar)	Transparency (%)
K02	2	36	4.5	89.444
		35	19.7	93.896
		34	30.0	94.680
		33	50.3	98.252
		32	75.6	98.768
K02	3	0	-	-
		36	4.2	88.966
		35	7.3	88.949
		34	16.8	89.476
		33	20.5	91.977
		32	26.5	95.865
		31	35.4	96.670
		30	44.3	97.519
		29	55.3	98.305
		28	75.6	98.988
		27	101.4	99.230
		26	106.4	99.265
K02	7	36	4.8	94.999
		35	19.9	94.756
		34	30.4	94.019
		33	50.5	97.877
		32	75.8	98.896
K02	8	0	-	-
		36	6.0	94.773
		35	10.5	94.839
		34	21.2	94.237
		33	28.6	94.713
		32	36.5	95.182
		31	47.5	97.796
		30	57.5	98.244
		29	70.8	98.824
K02	11	0	-	-
		36	4.9	95.109
		35	9.0	95.270
		34	21.4	93.823
		33	28.2	92.088
		32	32.3	92.396
		31	39.4	95.946
		30	46.7	96.738
		29	60.9	97.985
		28	80.9	98.624

		27	101.1	98.768
		26	108.9	98.989
K02	12	36	4.9	95.147
		35	20.2	94.296
		34	30.5	91.168
		33	50.7	97.767
		32	75.6	98.570
		31	110.1	98.852
		30	126.2	98.899
K02	13	0	-	-
		36	5.7	95.857
		35	20.1	92.748
		34	30.3	95.685
		33	50.1	98.178
		32	75.4	98.644
		31	100.4	98.991
U01	1	0	-	-
		36	5.5	93.892
		35	20.2	94.166
		34	30.7	94.716
		33	49.9	95.731
		32	75.0	97.840
		31	99.6	98.352
		30	125.1	98.842
		29	150.7	98.748
U01	2	0	-	-
		36	6.8	94.953
		26	7.0	95.026
		35	10.7	94.869
		34	24.4	95.586
		33	30.4	94.994
		32	38.7	95.134
		31	51.7	96.334
		30	63.0	96.941
		29	71.3	97.596
		28	85.9	98.042
		27	101.0	98.441
U02	1	0	-	-
		36	4.7	93.743
		35	20.2	93.212
		34	30.4	94.905
		33	49.8	97.802
		32	74.9	98.506

		31	100.3	98.700
		30	126.0	98.871
		29	150.3	98.888
		28	175.0	98.936
		27	200.6	98.962
		26	249.6	98.971
U03	1	0	-	-
		36	5.5	88.022
		35	10.0	88.048
		34	19.9	88.134
		33	29.7	89.210
		32	40.2	94.998
		31	49.7	96.134
		30	59.8	97.786
		29	71.0	98.562
		28	80.9	98.461
		27	101.1	98.961
U03	2	0	-	-
		36	4.8	89.961
		35	20.3	89.850
		34	30.8	94.012
		33	50.1	97.981
		32	75.2	98.532
		31	100.4	98.784
		30	125.5	98.870
		29	150.3	98.834
		28	175.3	98.863
		27	200.0	98.963
U04	2	0	-	-
		36	5.5	96.109
		35	11.5	96.129
		34	24.4	95.199
		33	30.8	94.908
		32	39.1	95.757
		31	50.7	96.455
		30	58.5	97.592
		19	70.8	98.620
		28	87.1	98.769
		27	101.1	98.846
U04	3	0	-	-
		36	4.8	96.300
		35	20.1	96.117
		34	30.3	95.580

		33	50.0	97.205
		32	75.3	98.672
		31	99.9	98.972
U05	1	0	-	-
		36	5.2	93.239
		35	10.2	93.272
		34	20.4	93.425
		33	30.4	94.979
		32	40.4	96.524
		31	50.6	96.962
		30	60.6	97.989
		29	70.5	98.578
		28	81.0	98.870
		27	101.1	99.283
U05	2	0	-	-
		36	5.2	93.085
		35	20.0	92.696
		34	30.2	93.578
		33	50.1	97.070
		32	75.3	98.407
		31	100.4	99.074
		30	125.2	99.243
		29	150.7	99.223

(7.2) High concentration at SiO2 channel

We found that the SiO_2 concentration of K02_13_1 was higher than that of in-house standard, C-6. There was no problem in measurement, but please be careful when using this data.

(8) Data archive

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

(9) List of reagent

List of reagent is shown in Table 2.1.7-8.

Table 2.1.7-8 List of reagent in MR1704

Parameter	IUPAC name	CAS Number	Formula	Compound Name	Manufacture	Grade
NO_3, NO_2	Hydrogen chloride	7647-01-0	HCl	Hydrochloric acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
SiO_2, PO_4, NH_4	Sulfuric acid	7664-93-9	H_2SO_4	Sulfuric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NO_3, NO_2	Imidazole	288-32-4	$C_3H_4N_2$	Imidazole	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NO_3, NO_2	4-Aminobenzenesulfonamide	63-74-1	$C_6H_8N_2O_2S$	sulfanilamide	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NO_3, NO_2	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
SiO_2	Oxalic Acid	144-62-7	$C_2H_2O_4$	Oxalic Acid	Wako Pure Chemical Industries, Ltd.	Wako Special Grade
SiO_2, PO_4	L-Ascorbic acid	50-81-7	$C_6H_8O_6$	L-ascorbic acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
SiO_2, PO_4	Sodium molybdate dihydrate	10102-40-6	$Na_2MoO_4 \cdot 2H_2O$	Disodium Molybdate(VI) Dihydrate	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
SiO_2, PO_4	Sodium dodecyl sulfate	151-21-3	$C_{12}H_{25}NaO_4S$	Sodium Dodecyl Sulfate	Wako Pure Chemical Industries, Ltd.	for Biochemistry
PO_4	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
NH_4	Boric acid	10043-35-3	H_3BO_3	Boric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NH_4	Phenol	108-95-2	C_6H_6O	Phenol	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NH_4	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
NH_4	Sodium hydroxide	1310-73-2	NaOH	Sodium Hydroxide for Nitrogen Compounds Analysis	Wako Pure Chemical Industries, Ltd.	for Nitrogen Analysis
NH_4	Sodium hypochlorite	7681-52-9	NaClO	Sodium hypochlorite solution	Kanto Chemical co., Inc.	Extra pure
NH_4	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
NH_4	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.	-

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2.1.8 pH

Masahide WAKITA **JAMSTEC MIO: Principal Investigator**
Minoru KAMATA **MWJ**

(1) Objective

Onboard pH measurement of seawater collected in sampling bottles

(2)-1 Methods, apparatus and performance

Seawater samples were collected by 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 6 stations. Seawater was sampled in a 100 mL glass bottle that was previously soaked in non-phosphoric alkaline detergent solution at least 3 hours and was cleaned by fresh water for 5 times and Milli-Q ultrapure water for 3 times. A sampling silicone rubber tube with PFA tip was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (about 10 seconds) with care not to leave any bubbles in the bottle. The water in the bottle was sealed by a glass made cap gravimetrically fitted to the bottle mouth without additional force. After collecting the samples on the deck, the bottles were carried into the lab and put in the water bath kept about 25 °C before the measurement.

(2)-2 Seawater analyses

pH (-log[H+]) of the seawater was measured potentiometrically in the glass bottles. The pH / Ion meter (Radiometer analytical, PHM240) is used to measure the electromotive force (e.m.f.) with combined pH electrode (pHC2001-8) in the sample with its temperature controlled to 25.00 °C ± 0.05 °C.

To calibrate the electrodes, the TRIS buffer (Lot = 170418: pH = 8.0907 pH units at 25 °C, DelValls and Dickson, 1998) and AMP buffer (Lot = 170418: pH = 6.7840 pH units at 25 °C, Dickson and Goyet, 1994) in the synthetic seawater (Total hydrogen ion concentration scale) were applied. pH_T of seawater sample (pH_{spl}) is calculated from the expression:

$$pH_{spl} = pH_{TRIS} + (E_{TRIS} - E_{spl}) / ER,$$

where electrode response ER is calculated as follows:

$$ER = (E_{AMP} - E_{TRIS}) / (pH_{TRIS} - pH_{AMP}).$$

ER value should be equal to the ideal Nernst value as follows:

$$ER = RT\ LN(10) / F = 59.16 \text{ mV / pH units at } 25\ °C,$$

where F is Faraday constant.

(3) Results

A replicate analysis of seawater sample was made at 4 layers (ex. 50, 175, 2200, and 5000 dbar depth) of deep cast or 2 layers (ex. 50 and 175 dbar depth) of shallow cast. The difference between each pair of analyses was plotted on a range control chart (see Fig. 2.1.8-1). The average of the difference was provisionally 0.001 pH units (n = 38 pairs) with its standard deviation of 0.001 pH units. These values were lower than the value recommended by the Guide (Dickson et al., 2007).

(4) Data archive

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>

(5) Reference

DelValls, T. A. & Dickson, A. G. (1998). The pH of buffers based on 2-amino-2-hydroxymethyl-1,3-propanediol ('tris') in synthetic sea water, *Deep-Sea Research I 45*, 1541-1554.

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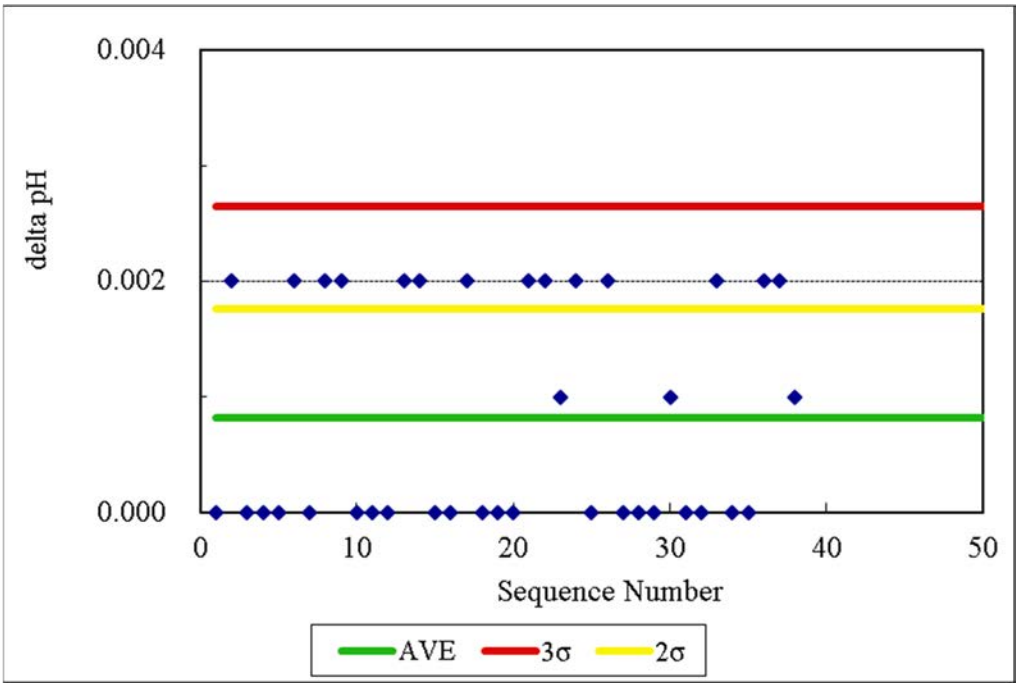

Figure 2.1.8-1 Range control chart of the absolute differences of replicate measurements of pH carried out during the cruise. AVE represents the average of absolute difference, UCL upper control limit (standard deviation of AVE × 3), and UWL upper warning limit (UWL = standard deviation of AVE × 2)

2.1.9 pH-CO_2 Hybrid sensor

Yoshiyuki NAKANO JAMSTEC MARITEC

(1) Objective

We have been developing the compact in situ CO_2 and pH sensor (Hybrid CO_2-pH sensor: HCS) for the AUVs to obtain vertical and horizontal distributions of CO_2 and pH. In this cruise, we aim at testing the new HCS in the open sea. The HCS is attached with CTD and profiling to 3,000m.

(2) Method

The measurement principle for the CO_2 sensor is based on spectrophotometry. The pCO_2 is calculated from the optical absorbance of the pH indicator solution equilibrated with CO_2 in seawater through a gas permeable membrane. On the other hand, we adopt potentiometric analysis using original glass and reference electrodes as a pH sensor because of the most commonly used technique for sea water pH measurements and high-speed response (within 20 seconds). From simultaneously measured data of in situ pCO_2 and pH, we can also calculate dissolved inorganic carbon (DIC) and total alkalinity (TA) as other carbonate species in the ocean. The resolutions of HCS are 1 μatm for pCO_2 and 0.001 pH. In the laboratory experiment, the HCS obtained precisions within 3 μatm and within 0.01 pH, respectively.

(3) Results

Concentrations of CO_2 (pCO_2) and sea water pH profile from 3,000m to 0m are shown in Fig. 2.1.9-1 and Fig. 2.1.9-2 respectively.

(4) Data archive

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

Reference

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) (2007) Guide to best practices for ocean CO_2 measurements. PICES Special Publication 3, 191 pp.

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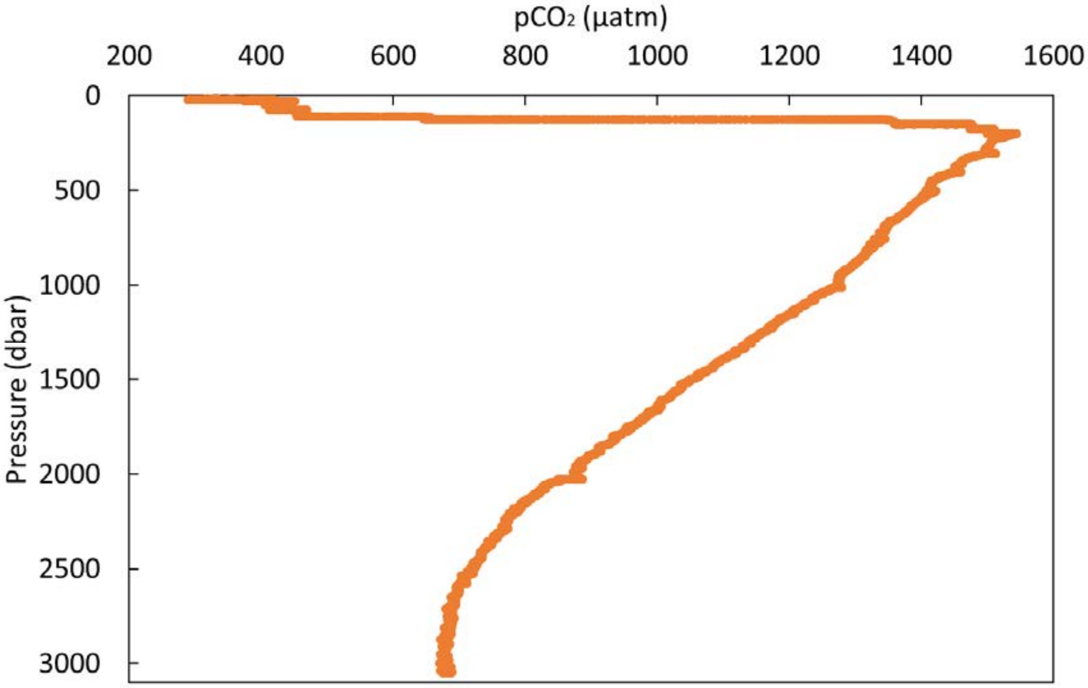


Fig. 2.9.1-1 Vertical distribution of pCO_2 from 3,000 dbar to 0 dbar at station K2

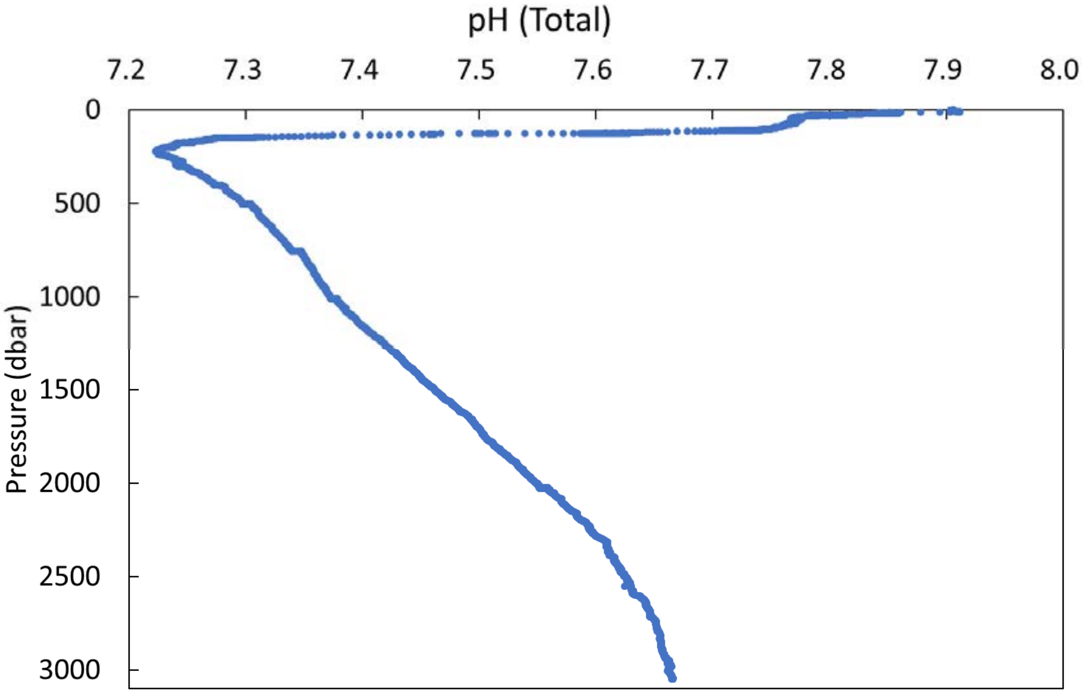


Fig. 2.9.1-2 Vertical distribution of sea water pH from 3,000 dbar to 0 dbar at station K2

2.1.10 Total Alkalinity

Masahide WAKITA **JAMSTEC MIO: Principal Investigator**
Nagisa FUJIKI **MWJ: Operation Leader**
Tomonori WATAI **MWJ**

(1) Objective

Onboard total alkalinity measurement of seawater corrected in sampling bottles

(2) Methods, apparatus and performance

(2)-1 Seawater sampling

Seawater samples were collected by 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 6 stations. The seawater from the Niskin bottle was filled into the 100 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.

(2)-2 Seawater analyses

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 Photonics). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green sodium salt) 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:

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

$$\begin{aligned} A_T = {} & (N_A \times V_A - 10^{pHT} \times \mathrm{DensSW}(T, S) \times (V_S + V_A)) \\ & \times (\mathrm{DensSW}(T, S) \times V_S)^{-1}, \end{aligned} \qquad (2)$$

where R(25) represents the difference of absorbance at 616 nm 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.

(3) Result

The repeatability of this system was provisionally 4.04 μmol kg^{-1} (n = 10) 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 Fig. 2.1.10-1). The average of the difference was provisionally 2.86 μmol kg^{-1} (n = 38) with its standard deviation of 2.92 μmol kg^{-1}.

(4) Data archive

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>

(5) 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.

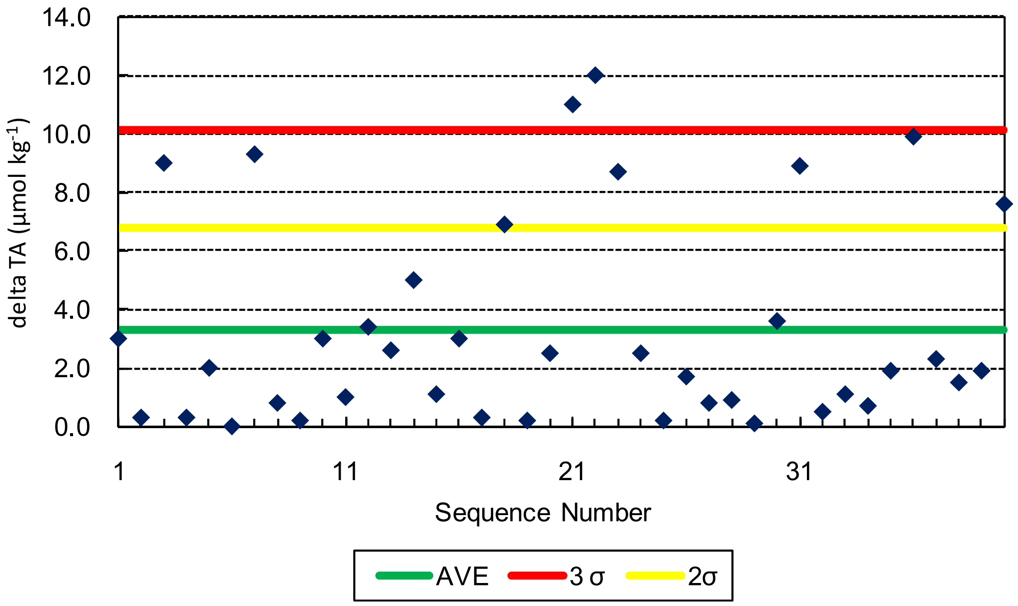


Figure 2.1.10-1 Range control chart of the absolute differences of replicate measurements of TA carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE × 3), and 2σ upper warning limit (standard deviation of AVE × 2)

2.1.11 Dissolved inorganic carbon

Masahide WAKITA	**JAMSTEC MIO: Principal Investigator**
Tomonori WATAI	**MWJ: Operation Leader**
Nagisa FUJIKI	**MWJ**

(1) Objective

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

(2) Methods, apparatus and performance

(2)-1 Seawater sampling

Seawater samples were collected by 12 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 6 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.

(2)-2 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.

(3) 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. 2.1.11-1). The average of the differences was provisionally 1.15 µmol kg^{-1}, with its standard deviation of 0.97 µmol kg^{-1} (n = 37), which indicate the analysis was sufficiently accurate (< 1.5 µmol kg^{-1}) according to Dickson et al. (2007).

(4) Data archive

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>

(5) Reference

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.

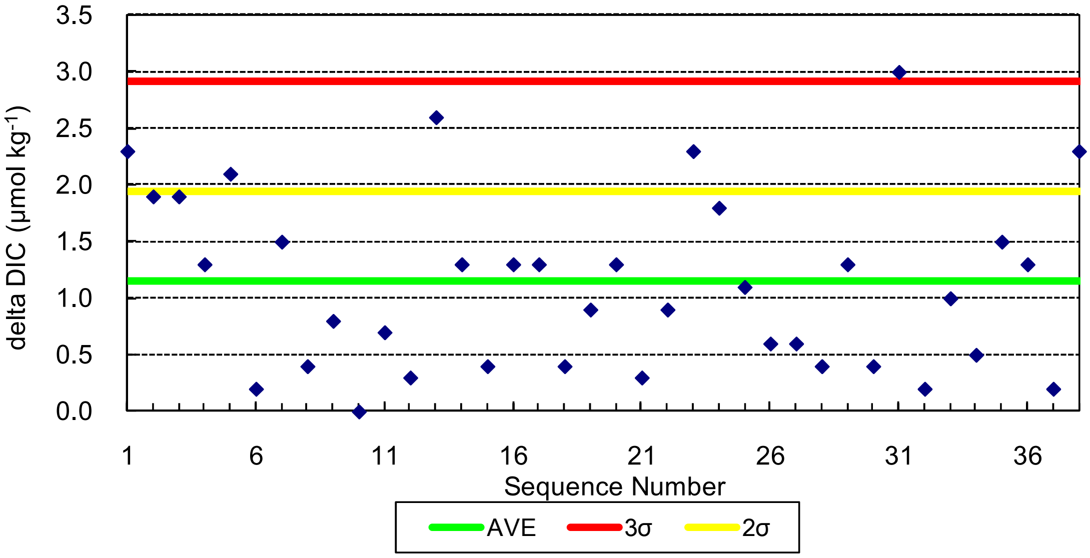


Figure 2.1.11-1 Range control chart of the absolute differences of replicate measurements of DIC carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE × 3), and 2σ upper warning limit (standard deviation of AVE × 2)

2.1.12 Dissolved organic carbon (DOC) and Total dissolved nitrogen (TDN)

Masahide WAKITA JAMSTEC MIO

(1) Purpose of the study

Variabilities in the concentration of dissolved organic carbon (DOC) in seawater have a potentially great impact on the carbon cycle in the marine system, because DOC is a major global carbon reservoir. A change by < 10% in the size of the oceanic DOC pool, estimated to be ~ 700 GtC (IPCC, 2007), would be comparable to the annual primary productivity in the whole ocean. In fact, it was generally concluded that the bulk DOC in oceanic water, especially in the deep ocean, is quite inert based upon ^{14}C-age measurements. Nevertheless, it is widely observed that in the ocean DOC accumulates in surface waters at levels above the more constant concentration in deep water, suggesting the presence of DOC associated with biological production in the surface ocean. This study presents the distribution of DOC in the western subarctic North Pacific and the Bering Sea.

(2) Sampling

Seawater samples of DOC and TDN were collected by 10 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket and brought the total to ~400. Seawater from each Niskin bottle was transferred into 60 ml High Density Polyethylene bottle (HDPE) rinsed with same water three times. Water taken from the surface to bottom is filtered using precombusted (450°C) GF/F inline filters as they are being collected from the Niskin bottle. After collection, samples are frozen upright and preserved at ~ -20 °C cold until analysis in our land laboratory. Before use, all glassware was muffled at 550 °C for 5 hrs.

(3) Analysis

Prior to analysis, samples are returned to room temperature and acidified to pH < 2 with concentrated hydrochloric acid. DOC/TDN analysis was basically made with a high-temperature catalytic oxidation (HTCO) system improved a commercial unit, the Shimadzu TOC-L (Shimadzu Co.). In this system, the non-dispersive infrared was used for carbon dioxide produced from DOC during the HTCO process (temperature: 680 °C, catalyst: 0.5% Pt-Al_2O_3). Non-purgeable dissolved nitrogen compounds are combusted and converted to NO which, when mixed with ozone, chemiluminesces for detection by a photomultiplier

(4) Results

The distributions of DOC and TDN will be determined as soon as possible after this cruise.

2.1.13 Particle organic matters

Yoshihisa MINO **Nagoya University**

(1) Objective

Carbon and nitrogen stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) of particulate organic matters in the ocean can provide insights into biogeochemical processes, formation and microbial transformation of particles since a mass-dependent isotopic fractionation occurs in each pathway. In this study we examined the vertical distribution of $\delta^{13}C$ and $\delta^{15}N$ of suspended particles to elucidate particle dynamics in the upper ocean of the western subarctic North Pacific.

(2) Sampling

About 20 to 80 liters of seawater were collected by CTD-RMS at the depths from surface to 500 m depths, and filtered through pre-combusted GF/F filters (Whatman) and the filters were kept frozen until analysis on shore.

(3) Analysis

The filter samples of suspended particles are exposed to HCl fumes overnight to remove carbonates, dried in vacuum, and then pelletized with a tin disk. Amount of particulate organic carbon and nitrogen (POC, PN) and both isotopes of particles in the pellets are measured with an elemental analyzer combined with a continuous flow isotope-ratio mass spectrometer (EA1112-Delta Plus, Thermo Fisher Scientific).

(4) Data archive

Data will be submitted to JAMSTEC Data Data Management Group (DMG)within 2 years.

2.1.14 Sea surface water monitoring

Hiroshi UCHIDA	**JAMSTEC RCGC: Principal Investigator**
Hironori SATO	**MWJ: Operation leader**
Erii IRIE	**MWJ**

(1) Objective

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

(2) 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) (1 atm, 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

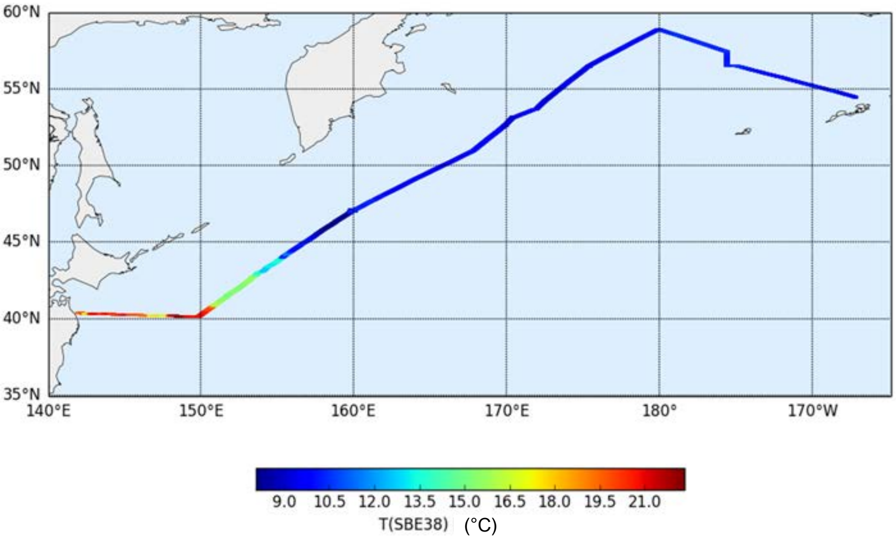
Periods of measurement, maintenance, and problems during this cruise are listed in Table 2.1.14-1.

Table 2.1.14-1 Events list of the Sea surface water monitoring during MR17-04 Leg1

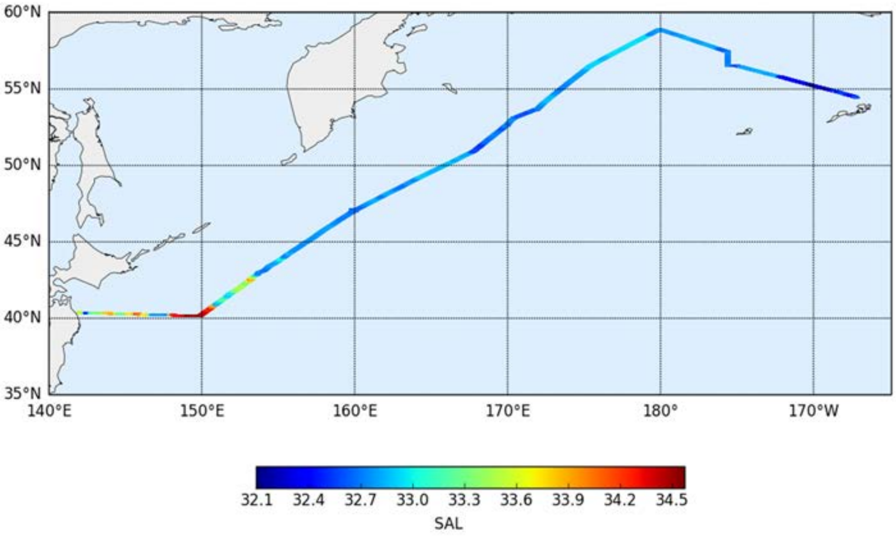
System Date [UTC]	System Time [UTC]	Events	Remarks
2017/07/11	09:51	All the measurements started and data was available.	Start
2017/07/15	11:31	All the measurements stopped.	Add stainless filter to air-trap.
2017/07/15	12:36	All the measurements started.	Logging restart
2017/07/15	21:57	All the measurements stopped.	Remove mesh metal filter in air-trap and replace it by short tube.
2017/07/15	23:06	All the measurements started.	Logging restart
2017/07/16	12:20	All the measurements stopped.	Filter Cleaning
2017/07/16	13:51	All the measurements started.	Logging restart
2017/07/17	06:04	All the measurements stopped.	Filter Cleaning
2017/07/17	07:25	All the measurements started.	Logging restart
2017/07/17	21:44	All the measurements stopped.	Filter Cleaning
2017/07/17	22:50	All the measurements started.	Logging restart
2017/07/18	11:00	All the measurements stopped.	Filter Cleaning
2017/07/18	12:10	All the measurements started.	Logging restart
2017/07/20	05:17	All the measurements stopped.	Filter Cleaning
2017/07/20	06:36	All the measurements started.	Logging restart
2017/07/21	22:48	All the measurements stopped.	Filter Cleaning
2017/07/22	04:20	All the measurements started.	Logging restart
2017/07/22	10:03	All the measurements stopped.	Filter Cleaning
2017/07/22	10:59	All the measurements started.	Logging restart
2017/07/23	07:25	All the measurements stopped.	Filter Cleaning
2017/07/23	08:56	All the measurements started.	Logging restart
2017/07/24	05:10	All the measurements stopped.	Filter Cleaning
2017/07/24	06:18	All the measurements started.	Logging restart
2017/07/26	04:12	All the measurements stopped.	Filter Cleaning
2017/07/26	04:41	All the measurements started.	Logging restart
2017/07/28	16:10	All the measurements stopped.	Filter Cleaning
2017/07/28	17:06	All the measurements started.	Logging restart
2017/08/01	16:57	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 Fig. 2.1.14-2. All the salinity samples were analyzed by the Model 8400B “AUTOSAL” manufactured by Guildline Instruments Ltd. (see 2.1.5), and dissolve oxygen samples were analyzed by Winkler method (see 2.1.6), chlorophyll *a* were analyzed by 10-AU manufactured by Turner Designs. (see 2.1.17(a)).

(a)


60°N
55°N
50°N
45°N
40°N
35°N
140°E
150°E
160°E
170°E
180°
170°W
9.0
10.5
12.0
13.5
15.0
16.5
18.0
19.5
21.0
T(SBE38) (°C)

(b)


60°N
55°N
50°N
45°N
40°N
35°N
140°E
150°E
160°E
170°E
180°
170°W
32.1
32.4
32.7
33.0
33.3
33.6
33.9
34.2
34.5
SAL

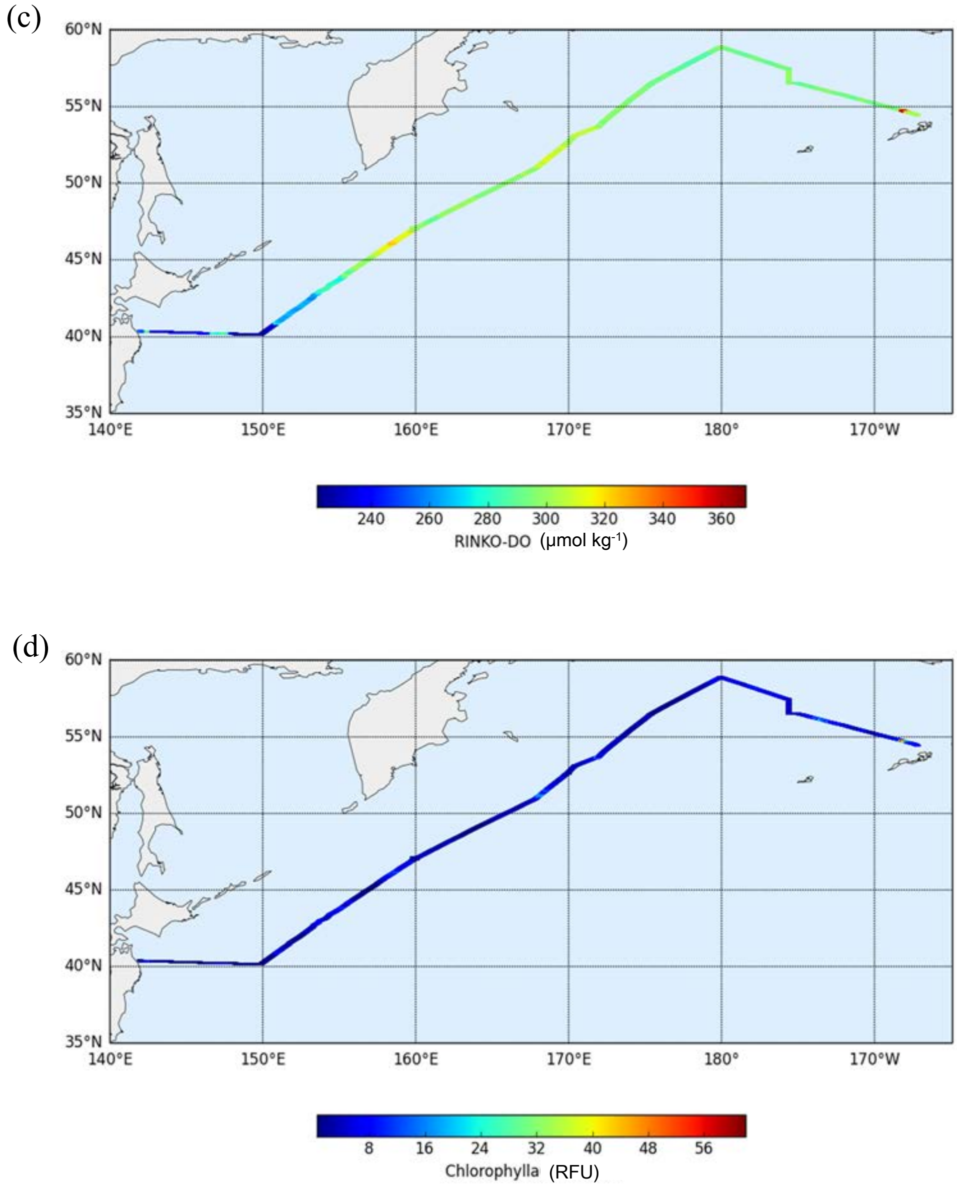


Figure 2.1.14-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in MR17-04 Leg1 cruise

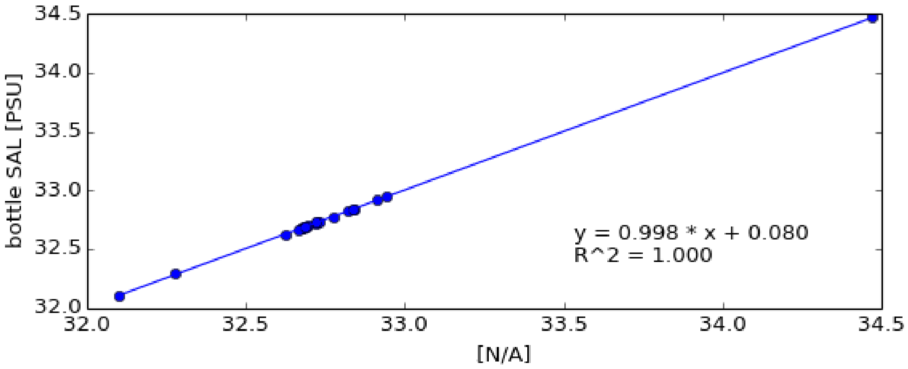


Figure 2.1.14-2-1 Correlation of salinity between sensor data and bottle data

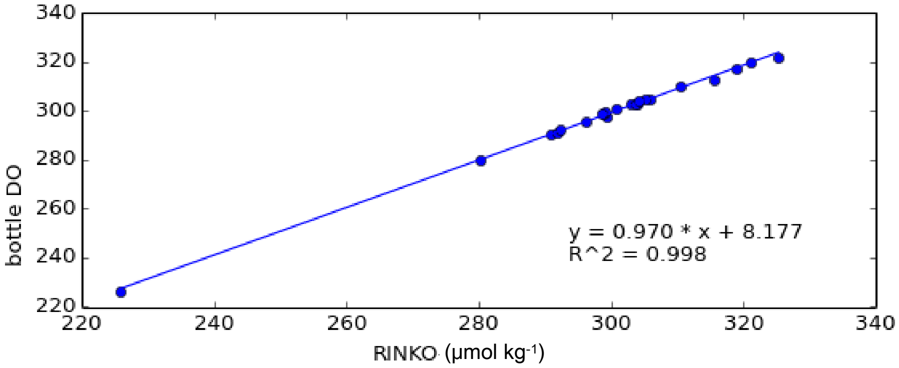


Figure 2.1.14-2-2 Correlation of dissolved oxygen between sensor data and bottle data

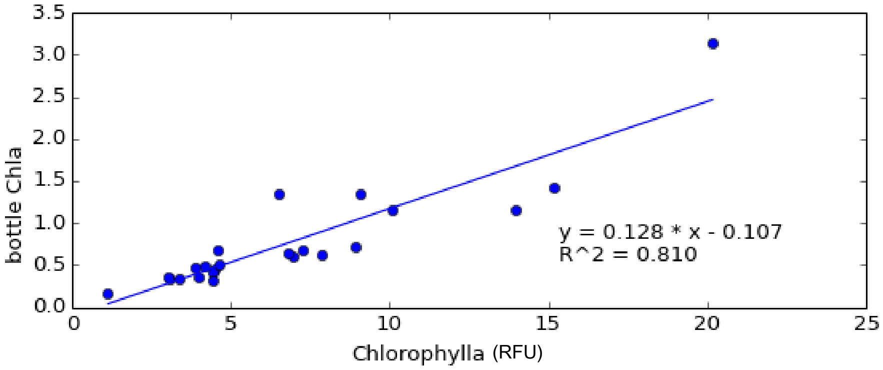


Figure 2.1.14-2-3 Correlation of fluorescence between sensor data and bottle data

(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>

2.1.15 Underway pCO_2

Yoshiyuki NAKANO **JAMSTEC: Principal Investigator**
Tomonori WATAI **MWJ: Operation Leader**
Nagisa FUJIKI **MWJ**

(1) Objective

Our purpose is in-situ measurement of partial pressure of carbon dioxide (pCO_2) in near-sea surface water

(2) Methods, apparatus and performance

Oceanic and atmospheric CO_2 concentrations were measured during the cruise using an automated system equipped with a non-dispersive infrared gas analyzer (NDIR; LI-7000, Li-Cor). Measurements were done every about one hour, and 4 standard gasses, atmospheric air, and the CO_2 equilibrated air with sea surface water were analyzed subsequently. The concentrations of the CO_2 standard gases were provisionally (298, 348, 399, and 450) ppm. Atmospheric air taken from the bow of the ship (approx.13 m above the sea level) was introduced into the NDIR by passing through an electrical cooling unit, a mass flow controller which controls the air flow rate of 0.55 L min^{-1}, and a staring cooler. The CO_2 equilibrated air was the air with its CO_2 concentration was equivalent to the sea surface water. 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 - 0.8) L min^{-1} through two cooling units, the starling cooler, and the NDIR.

(3) Result

Cruise track during pCO_2 observation is shown in Fig. 2.1.15-1, and temporal variations of both oceanic and atmospheric CO_2 concentration (xCO_2) in Fig. 2.1.15-2.

(4) Data archive

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>

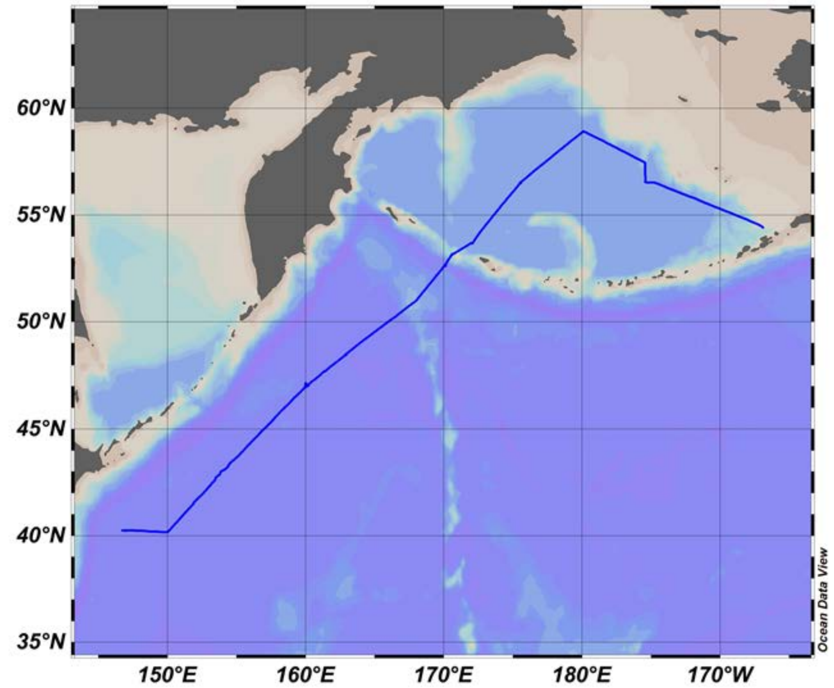


Figure 2.1.15-1 Observation map

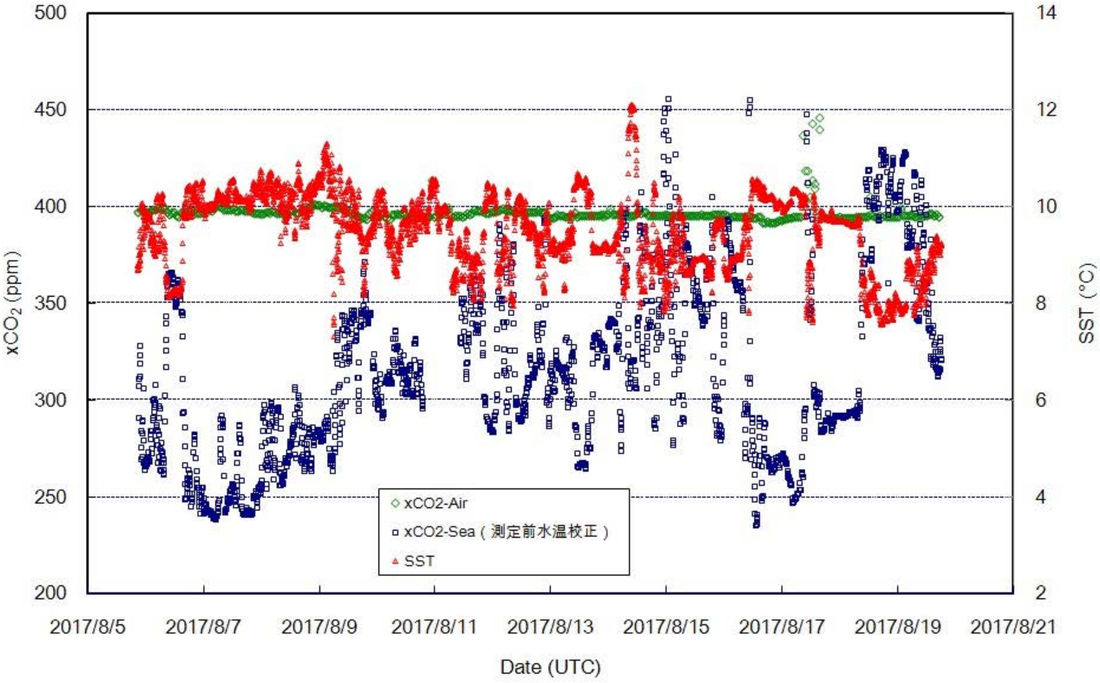


Figure 2.1.15-2 Temporal variations of oceanic and atmospheric CO_2 concentration (xCO_2). Blue dots represent oceanic xCO_2 variation and green atmospheric xCO_2. SST variation (red) is also shown

2.1.16 In situ filtration system

Yoshihisa MINO	**Nagoya University**
Katsunori KIMOTO	**JAMSTEC RCGC**
Tetsuichi FUJIKI	**JAMSTEC RCGC**
Minoru KITAMURA	**JAMSTEC RCGC**
Yoshiyuki NAKANO	**JAMSTEC MARITEC**
Kana NAGASHIMA	**JAMSTEC RCGC**
Takuhei SHIOZAKI	**JAMSTEC RCGC**

(1) Objective

Suspended particulate matter (SPM) in the ocean plays a vital role in the cycling of trace elements and isotopes. Even microanalyses of SPM, however, require filtering hundreds liters of seawater to collect samples. In this cruise, we deployed in situ large volume filtration system at station K2 to measure pigment, DNA, mineral and isotopic compositions as well as foraminifera shells in the suspended particles.

(2) Sampling

In situ pump filtering was conducted two times by using McLane WTS-LV samplers with a customized battery at eight layers as shown in Table 2.1.16-1.

Table 2.2.16-1 Setting for in situ filtration

Date	Depth (m)	Filtration rate (L)	Filters	Measurements	PIC
2017/07/23	50	401	GF/F, 53 μm mesh	Carbonate particle, Mineral dust	Kimoto, Nagashima
	100	511	GF/F, 53 μm mesh		
	150	6	GF/F, 53 μm mesh		
	250	579	GF/F, 53 μm mesh		
	350	0	GF/F, 53 μm mesh		
	500	545	GF/F, 53 μm mesh		
	600	659	GF/F, 53 μm mesh		
	700	606	GF/F, 53 μm mesh		
2017/07/24	10	533	GF/F, 300 μm mesh	HPLC, DNA, Isotopes	Fujiki, Mino Shiozaki
	50	2	GF/F, 300 μm mesh		
	100	157	GF/F, 300 μm mesh		
	200	623	GF/F, 300 μm mesh		
	500	676	GF/F, 300 μm mesh		
	1000	598	GF/F, 300 μm mesh		
	2000	731	GF/F, 300 μm mesh		
	3000	634	GF/F, 300 μm mesh		

(3) Analysis

Particles larger than 53 µm were rinsed by fresh water and fixed by the ethanol (99.5 %). Carbonate shelled foraminifera was picked up by the brush under the stereomicroscope and dried on the assemblage slide at room temperature. Their shell density will be measured by Micro-focus X-ray CT (MXCT, ScanXmate-DF160TS105, Comscan Tecno, Co.Ltd) installed in JAMSTEC HQ.

For mineral analyses, filter samples were stored frozen. Mineral compositions will be measured for particles less than 53 µm using a X-ray diffractometer (X'Pert Pro, PANalytical) at JAMSTEC HQ. In addition, shape, size, and trace elements for each mineral grain will be measured using SEM (Quanta 450 FEG, FEI)-EDS (Octane Elite Plus 30, EDAX) and Cathodoluminescence (Mono CL4 Swift, Gatan) at JAMSTEC.

Phytoplankton pigments in the SPM on GF/F were extracted with *N,N*-dimethylformamide for at least 24 h at –20 °C in the dark and then analyzed with an HPLC modular system (Agilent Technologies) on the sea.

The filters for DNA analysis were kept frozen (-80 °C) until on-shore analysis.

For isotope analysis, filter samples were stored frozen, and their $\delta^{13}C$ and $\delta^{15}N$ will be measured by using EA-IRMS at Nagoya University.

(4) Data archive

Data will be submitted to JAMSTEC Data Data Management Group (DMG) within 2 years.

2.1.17 Phytoplankton

2.1.17(a) Chlorophyll *a* measurements by fluorometric determination

Tetsuichi FUJIKI **JAMSTEC RCGC: Principal Investigator**
Misato KUWAHARA **MWJ: Operation Leader**
Yoshiaki SATO **MWJ**

(1) Objective

Phytoplankton biomass can estimate as the concentration of chlorophyll *a* (chl-*a*), because all oxygenic photosynthetic plankton contain chl-*a*. Phytoplankton exist various species in the ocean, but the species are roughly characterized by their cell size. The objective of this study is to investigate the vertical distribution of phytoplankton and their size fractionations as chl-*a* by using the fluorometric determination.

(2) Sampling

Samplings of total chl-*a* were conducted from 8-15 depths between the surface and 200 m at all observational stations. At the cast for primary production, water samples were collected at 17 depths between the surface and 200 m at the station of K02, U01, U02, U03, U04 and U05.

(3) Instruments and methods

Water samples (0.5 L) for total chl-*a* were filtered (<0.02 MPa) through 25 mm-diameter Whatman GF/F filter. Size-fractionated chl-*a* were obtained by sequential filtration (<0.02 MPa) of 1 L water sample through 10 μm, 3 μm and 1 μm polycarbonate filters (47 mm diameter) and Whatman GF/F filter (25 mm diameter). Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with about 7.7 ml of *N,N*-dimethylmethanamide (Suzuki and Ishimaru, 1990). Those tubes were stored at -20°C under the dark condition to extract chl-*a* for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU), which was calibrated against a pure chl-*a* (Sigma-Aldrich Co., LLC). We applied fluorometric determination for the samples of total and size-fractionated chl-*a*: “Non-acidification method” (Welschmeyer, 1994). Analytical conditions of each method were listed in Table 2.1.17(a)-1.

(4) Results

The results of total chl-*a* at station K2 were shown in Figure 2.1.17(a)-1 and 2.1.17(a)-2. The results of total chl-*a* at station U01 to U05 were shown in Figure 2.1.17(a)-3 and 2.1.17(a)-4. The results of size fractionated chl-*a* were shown in Figure 2.1.17(a)-5 to 2.1.17(a)-11.

(5) Data archives

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

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

(6) Reference

Suzuki, R., and T. Ishimaru (1990), An improved method for the determination of phytoplankton chlorophyll using N, N-dimethylformamide, *J. Oceanogr. Soc. Japan*, 46, 190-194.

Holm-Hansen, O., Lorenzen, C. J., Holmes, R.W. and J. D. H. Strickland (1965), Fluorometric determination of chlorophyll. *J. Cons. Cons. Int. Explor. Mer.* 30, 3-15.

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

Table 2.1.17(a)-1 Analytical conditions of "Non-acidification method" for chlorophyll *a* with Turner Designs fluorometer (10-AU).

	Non-acidification method
Excitation filter (nm)	436
Emission filter (nm)	680
Lamp	Blue Mercury Vapor

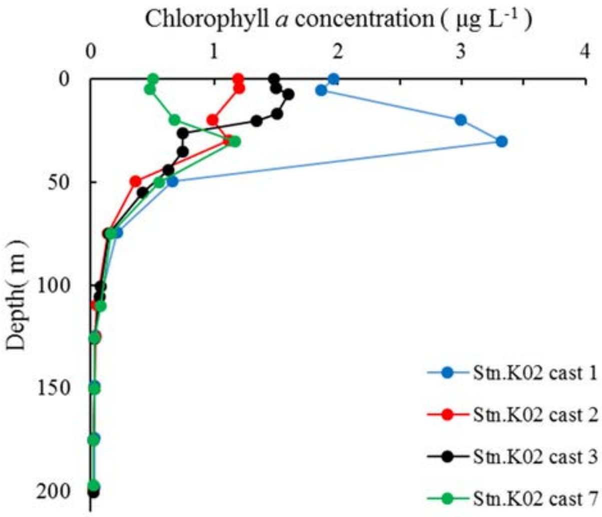


Figure 2.1.17(a)-1 Vertical distribution of chlorophyll *a* at Stn.K02 cast 1, 2, 3 and 7

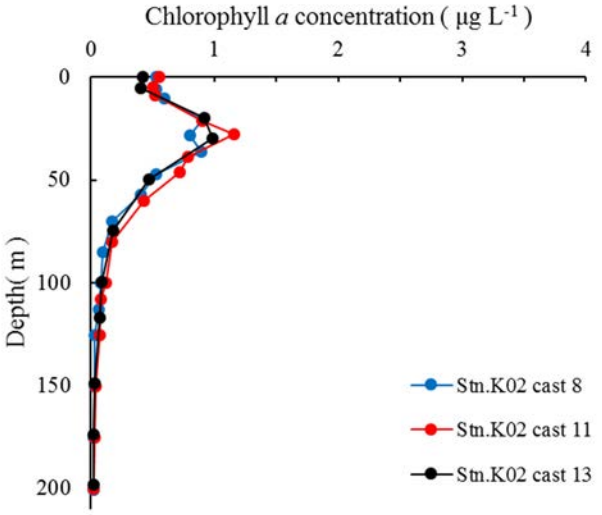


Figure 2.1.17(a)-2 Vertical distribution of chlorophyll *a* at Stn.K02 cast 8, 11, and 13

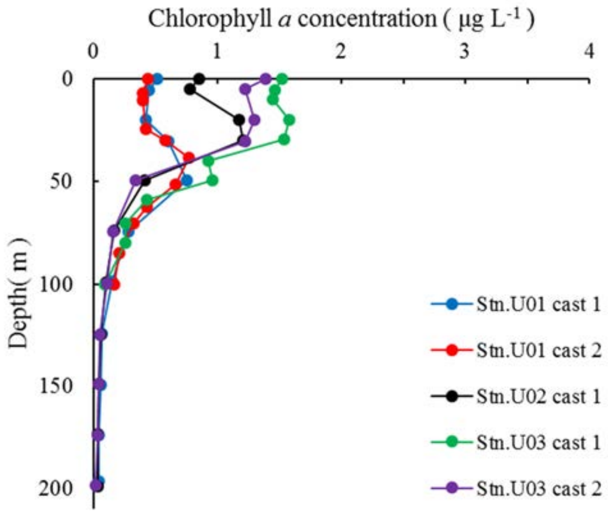


Figure 2.1.17(a)-3 Vertical distribution of chlorophyll *a* at Stn.U01, U02 and U03

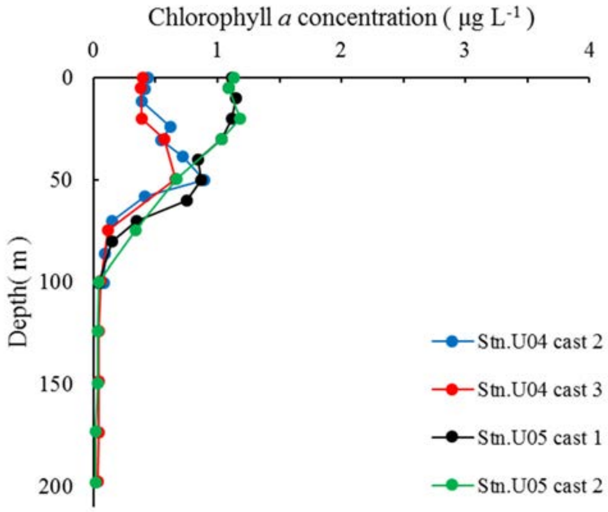


Figure 2.1.17(a)-4 Vertical distribution of chlorophyll *a* at Stn.U04 and U05

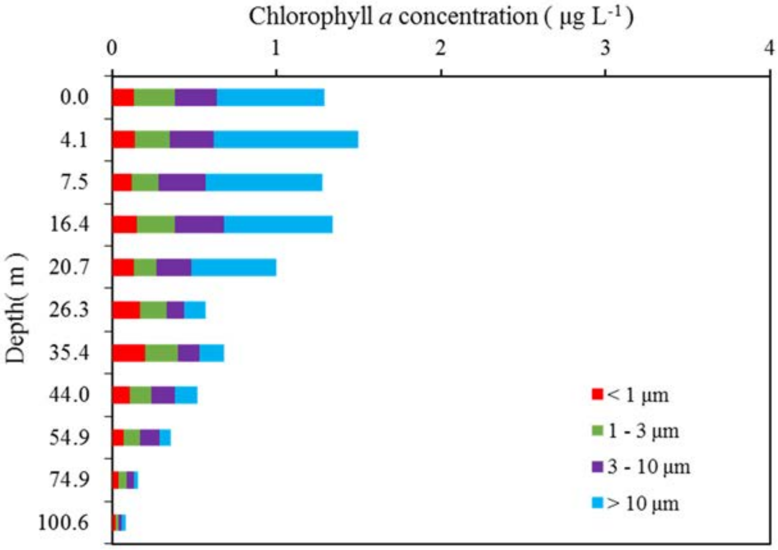


Figure 2.1.17(a)-5 Vertical distribution of size-fractionated chlorophyll *a* at Stn.K02 cast3

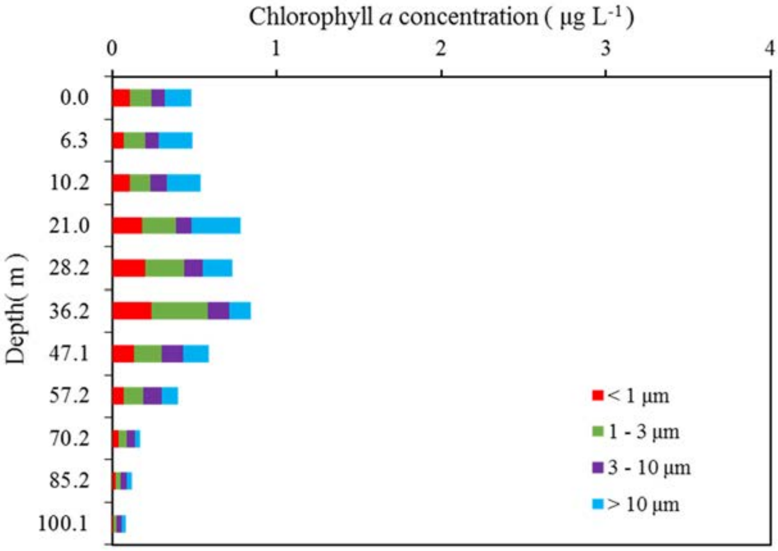


Figure 2.1.17(a)-6 Vertical distribution of size-fractionated chlorophyll *a* at Stn.K02 cast8

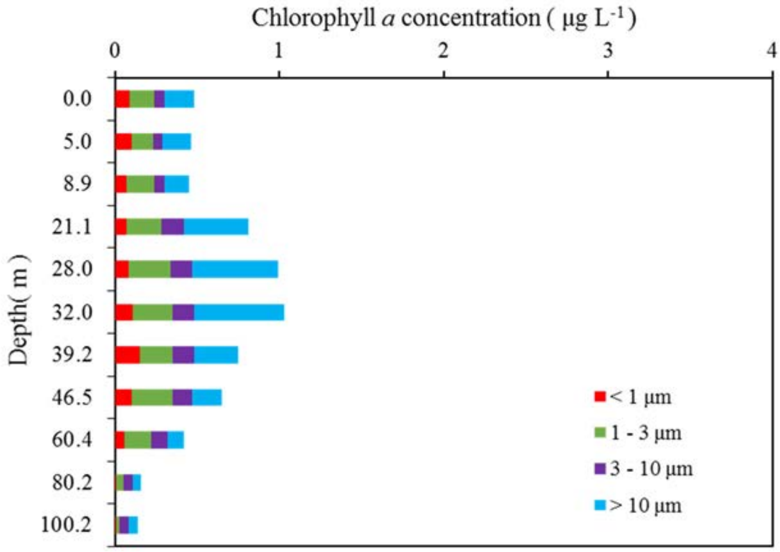


Figure 2.1.17(a)-7 Vertical distribution of size-fractionated chlorophyll *a* at Stn.K02 cast11

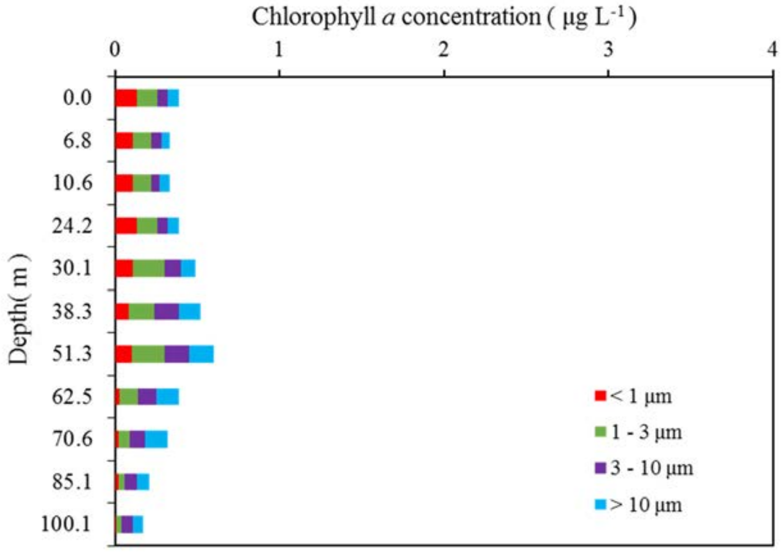


Figure 2.1.17(a)-8 Vertical distribution of size-fractionated chlorophyll *a* at Stn.U01 cast2

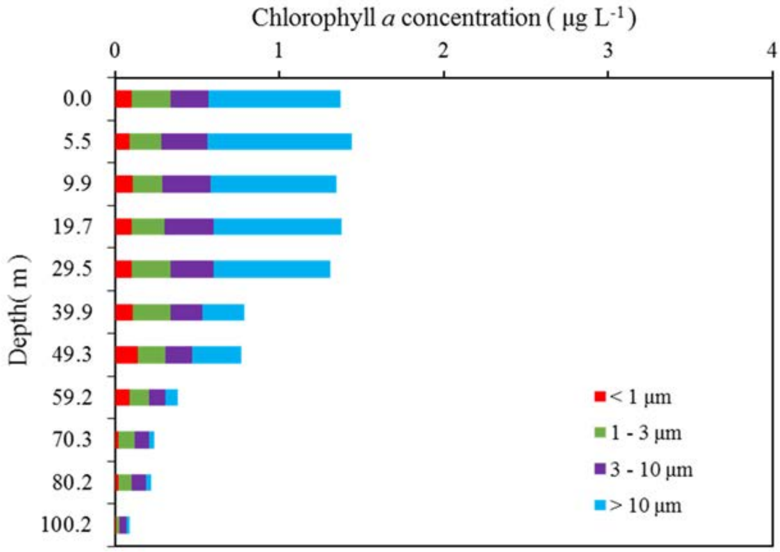


Figure 2.1.17(a)-9 Vertical distribution of size-fractionated chlorophyll *a* at Stn.U03 cast1

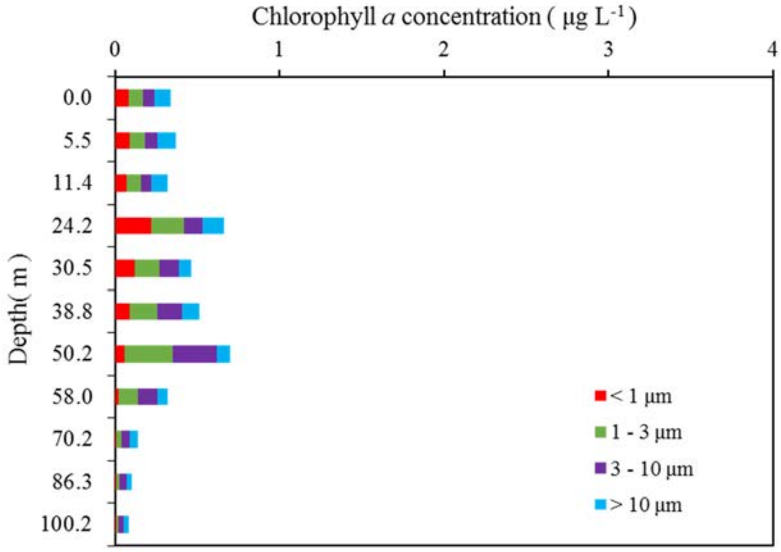


Figure 2.1.17(a)-10 Vertical distribution of size-fractionated chlorophyll *a* at Stn.U04 cast2

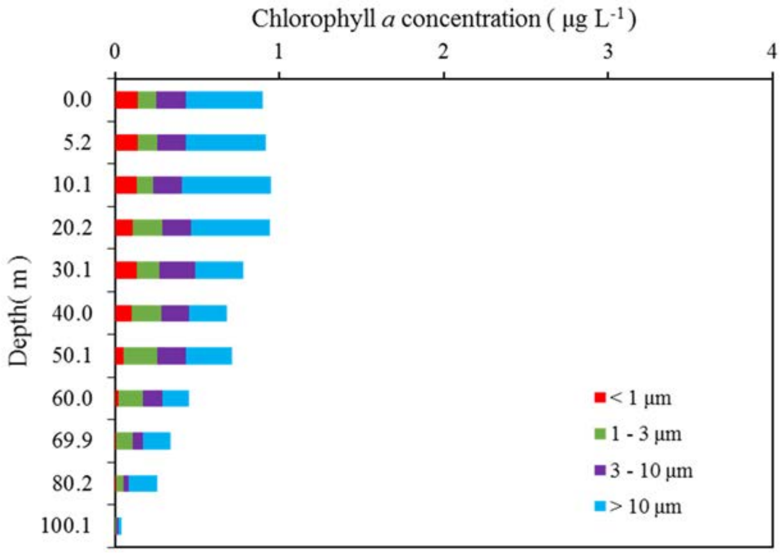


Figure 2.1.17(a)-11 Vertical distribution of size-fractionated chlorophyll *a* at Stn.U05 cast1

2.1.17(b) HPLC measurements of marine phytoplankton pigments

Tetsuichi FUJIKI **JAMSTEC RCGC: Principal Investigator**
Hiroshi HOSHINO **MWJ**

(1) Objective

The chemotaxonomic assessment of phytoplankton populations present in natural seawater requires taxon-specific algal pigments as good biochemical markers. A high-performance liquid chromatography (HPLC) measurement is an optimum method for separating and quantifying phytoplankton pigments in natural seawater. In this cruise, we measured the marine phytoplankton pigments by HPLC to investigate the marine phytoplankton community structure in the western North Pacific and the Bearing Sea.

(2) Methods, apparatus and performance

(2)-1 Seawater sampling

Seawater samples were collected from 11 depths between the surface and 100 m at the cast for the primary production. Seawater samples were collected using Niskin bottles, except for the surface water, which was taken by a bucket. 2 L of seawater samples were filtered through the 47 mm diameter Whatman GF/F filter under the vacuum condition (approx. -0.02 MPa(G)). To remove retaining seawater in the sample filters, GF/F filters were vacuum-dried in a freezer (0 °C) within 7 hours. Subsequently, phytoplankton pigments retained on a filter were extracted in a glass vial with 4 ml of N,N-dimethylformamide (HPLC-grade) for at least 24 hours in a freezer (-20 °C), and analyzed by HPLC system within a few days.

Residua cells and filter debris were removed through PTFE syringe filter (pore size: 0.2 μm) before the analysis. 120 μl of pigment extract was mixed with 125 μl of 28 mmol L^{-1} tetrabutylazanium;acetate (tetrabutylammonium acetate) buffer (pH 6.5) and 5 μl of either N,N-dimethylformamide or internal standard, and then injected into HPLC system. These process were conducted by the autosampler.

Internal standard was not spiked in the alpha-carotene standard, beta-carotene standard and sea water samples, because the impurity peak in the internal standard has the same retention time with them. Phytoplankton pigments were quantified based on C_8 column method (Heukelem & Thomas, 2001).

(2)-2 HPLC system

HPLC System was composed by Agilent 1200 modular system, G1311A quaternary pump (low-pressure mixing system), G1329A autosampler and G1315D photodiode array detector.

(2)-3 Stationary phase

Analytical separation was performed using a ZORBAX Eclipse XDB-C_8 column (150×4.6 mm). The column was maintained at 60 °C in the column heater box.

(2)-4 Mobile phases

The eluant A was the 7:3 (v:v) mixture of methanol and 28 mmol L^{-1} tetrabutyl ammonium acetate buffer (pH 6.5). The eluant B was a methanol. Methanol was the HPLC-grade.

(2)-5 Calibrations

HPLC was calibrated using the standard pigments (Table 2.1.17(b)-1).

(2)-6 Internal standard

trans-β-Apo-8’-carotenal solution was added into the standard samples prior to the injection as the internal standard (Table 2.1.17(b)-1). The mean and coefficient of variation (CV) of chromatogram area were shown below :

126.8 ± 0.7 (n =32), CV=0.6 %

(2)-7 Working standard

500 µg L^{-1} of chlolophyll *a* standard solution was measured with both standard samples and sea water samples as the working standard. The mean and coefficient of variation (CV) of chromatogram area shown below (Figure 2.1.17(a)-1):

216.7 ± 1.5 (n = 34), CV=0.7 %

(2)-8 Pigment detection and identification

Chlorophylls and carotenoids were detected by photodiode array spectroscopy (350 nm - 750 nm). Pigment concentrations were calculated from the chromatogram area at the different two channels (Table 2.1.17(b)-1). First channel was allocated at 450 nm of wavelength for the carotenoids and chlorophyll *b.* Second channel was allocated at 667 nm for the chlorophyll *a* and its metabolites.

(3) Results

Almost data are under the processing. Vertical profiles of major pigments at station K02 were shown in Figure 2.1.17(b)-2.

(4) Data archives

The processed data file of pigments will be submitted to the JAMSTEC Data Management Group (DMG) within a restricted period. Please ask PI for the latest information.

(5) Reference

Heukelem, L. V. & 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

Jeffrey S. W., Mantoura R. F. C. & Wright S. W. (Eds.). (1997) *Phytoplankton pigments in oceanography: guidelines to modern methods*, 7 place de Fontenoy, Paris, United Nations Educational, Scientific and Cultural Organization.

Table 2.1.17(b)-1 Retention time and wavelength of identification for pigment standards.

ID	Pigment[1]	Productions	Retention Time (minute)	Wavelength of identification (nm)
1	Chlorophyll *c*3	DHI Co.	4.026	450
2	Chlorophyllide *a*	DHI Co.	6.650	667
4	Chlorophyll *c*2	DHI Co.	6.140	450
5	Peridinin	DHI Co.	10.244	450
6	Pheophorbide *a*	DHI Co.	8.927	667
7	19'-Butanoyloxyfucoxanthin	DHI Co.	13.406	450
8	Fucoxanthin	DHI Co.	13.650	450
9	9'-*cis*-Neoxanthin	DHI Co.	14.206	450
10	Prasinoxanthin	DHI Co.	14.766	450
11	19'-Hexanoyloxyfucoxanthin	DHI Co.	15.236	450
12	Violaxanthin	DHI Co.	15.092	450
13	Diadinoxanthin	DHI Co.	16.359	450
16	Alloxanthin	DHI Co.	17.591	450
17	Diatoxanthin	DHI Co.	18.211	450
18	Zeaxanthin	DHI Co.	18.808	450
19	Lutein	DHI Co.	18.987	450
20	*trans*-β-Apo-8'-carotenal[2]	Sigma-Aldrich Co.	20.460	450
22	Chlorophyll *b*	DHI Co.	22.962	450
24	Chlorophyll *a* from *Anacystis nidulans* algae	Sigma-Aldrich Co.	24.790	667
25	Pheophytin *a*	DHI Co.	26.268	667
26	Alpha-carotene	DHI Co.	27.850	450
27	Beta-carotene	DHI Co.	27.947	450

[1] IUPAC names of the pigments; see Jeffrey et al., 1997.

[2] IUPAC name; (2E,4E,6E,8E,10E,12E,14E,16E)-2,6,11,15-tetramethyl-17-(2,6,6-trimethylcyclohexen-1-yl)heptadeca-2,4,6,8,10,12,14,16-octaenal

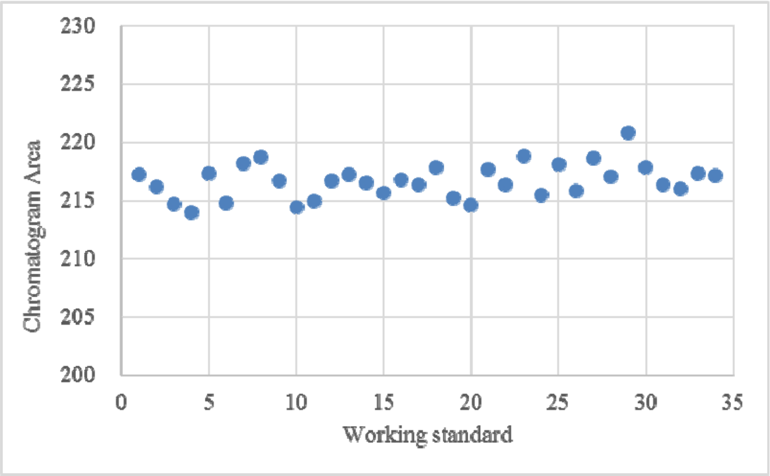


Figure 2.1.17(b)-1 Variability of chromatogram area for working standard

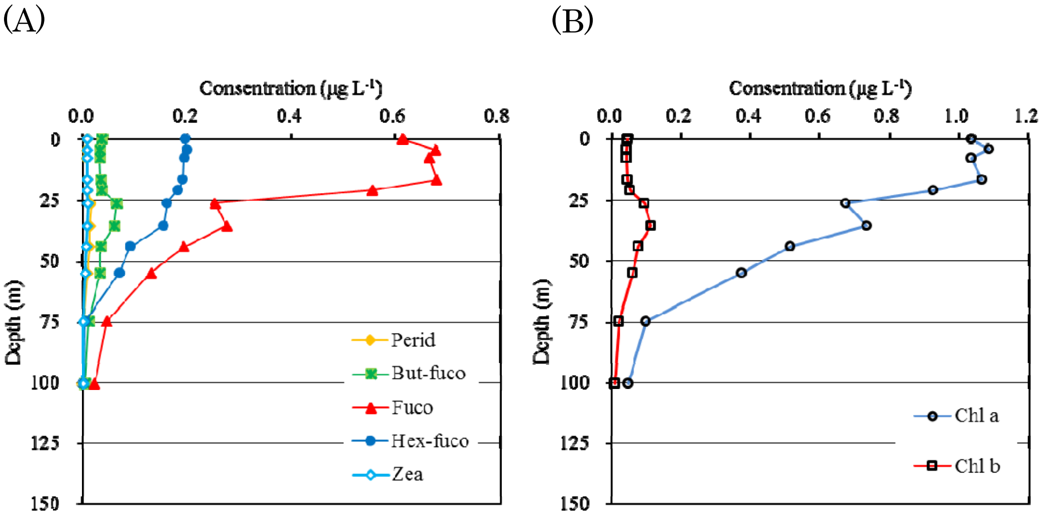


Figure 2.1.17(b)-2-(A). Vertical distributions of major phytoplankton pigments (chlorophyll *a* and chlorophyll *b*) at Stn. K02, cast 3.

Figure 2.1.17(b)-2-(B). Vertical distributions of major phytoplankton pigments (peridinin, 19'-butanoyloxyfucoxanthin, fucoxanthin, 19’-hexanoyloxyfucoxanthin, and zeaxanthin) at Stn. K02, cast 3.

2.1.17(c) Primary production

Tetsuichi FUJIKI	**JAMSTEC RCGC: Principal Investigator**
Keitaro MATSUMOTO	**MWJ: Operation Leader**
Masanori ENOKI	**MWJ**

(1) Objective

Quantitative assessment of temporal and spatial variation in carbon uptake in the surface euphotic layer should be an essential part of biogeochemical studies in the western North Pacific. Primary production (PP) was measured as incorporation of inorganic C^{13} stable isotope tracer at the station of K2, U1, and U4.

(2) Methods

1) Sampling, incubation bottle and filter

Sampling was conducted at predawn immediately before the incubation experiment. Seawater samples were collected using Teflon-coated and acid-cleaned Niskin bottles, except for the surface water, which was taken by a bucket. Samplings were conducted at eight depths in the euphotic layer in response to the light levels of the incubation containers adjusted with the blue acrylic plate. The light levels of the incubation containers in the bath were shown in Table 2.1.17(c)-1. The light depths relative to the surface had been estimated by the underwater optical sensor on the previous day of the sampling. Seawater samples were placed into acid-cleaned clear polycarbonate bottles in triplicate for PP, and in a single for the dark and the time-zero samples. The time-zero sample was filtered immediately after the addition of ^{13}C solution. Filtration of seawater sample was conducted with pre-combusted glass fiber filters (Whatman GF/F 25 mm) with temperature of 450 °C for at least 4 hours.

2) Incubation

Each bottle was spiked with sufficient ^{13}C labeled $NaHCO_3$ (99 atom% 13C; Cambridge Isotope Laboratories, Inc.) just before incubation so that ^{13}C enrichment was about 10 % of ambient dissolved inorganic carbon as final concentration of 200 μmol L^{-1} (Table 2.1.17(c)-2). Incubation was begun at predawn and continued for 24 hours. The simulated *in situ* method was conducted in the on-deck bath cooled by running surface seawater or by immersion cooler.

3) Measurement

After 24 hours incubation, samples were filtered through GF/F filter, and the filters were kept in a freezer (-20 °C). Subsequently, the filters were dried in the oven (45 °C) for at least 20 hours, and inorganic carbon was removed by acid treatment in HCl vapor bath for 30 minutes. All samples were measured by a mass spectrometer ANCA-SL system.

Instruments: preprocessing equipment ANCA-SL (Europa Scientific Ltd.; now SerCon Ltd.)
stable isotope ratio mass spectrometer 20-20 (Europa Scientific Ltd.; now SerCon Ltd.)
Methods: Dumas method, Mass spectrometry
Precision: All specifications are for n=5 samples.

It is a natural amount and five time standard deviation of the analysis as for amount 100 µg of the sample. We measured repeatability 4 times in this cruise. ^{13}C (0.05 - 0.14 ‰)

Reference Material: The third-order reference materials L-Alanine
(SI Science Co.,Ltd.; now SHOKO science Co.,Ltd.)

4) Calculation

Based on the balance of ^{13}C, assimilated organic carbon (ΔPOC) is expressed as follows (Hama *et al.*, 1983):

$$^{13}C_{(POC)} * POC = {}^{13}C_{(sw)} * \Delta POC + (POC - \Delta POC) * {}^{13}C_{(0)}$$

This equation is converted to the following equation;

$$\Delta POC = POC * ({}^{13}C_{(POC)} - {}^{13}C_{(0)}) / ({}^{13}C_{(sw)} - {}^{13}C_{(0)})$$

where $^{13}C_{(POC)}$ is concentration of ^{13}C of particulate organic carbon after incubation, *i.e.*, measured value (%). $^{13}C_{(0)}$ is that of particulate organic carbon before incubation, *i.e.*, that for samples as a blank.

$^{13}C_{(sw)}$ is concentration of ^{13}C of ambient seawater with a tracer. This value for this study was determined based on the following calculation;

$$^{13}C_{(sw)}\ (\%) = [(TDIC * 0.011) + 0.0002] / (TDIC + 0.0002) * 100$$

where TDIC is concentration of total dissolved inorganic carbon at respective bottle depth(mol dm^{-3}) and 0.011 is concentration of ^{13}C of natural seawater (1.1 %). 0.0002 is added ^{13}C (mol) as a tracer. Taking into account for the discrimination factor between ^{13}C and ^{12}C (1.025), primary production (PP) was, finally, estimated by

$$PP = 1.025 * \Delta POC$$

(3) Results

Fig. 2.1.17(c) show the vertical profile of primary production (PP).

(4) Data archives

All data will be submitted to JAMSTEC Data Management Group (DMG).

(5) References

Hama, T., T. Miyazaki, Y. Ogawa, T. Iwakuma, M. Takahashi, A. Otsuki, and S. Ichimura, (1983), Measurement of photosynthetic production of a marine phytoplankton population using a stable 13C isotope. *Mar. Biol., 73*, 31-36.

Table 2.1.17(c)-1 Light levels of the incubation containers

Number	Light Level
#1	100%
#2	55%
#3	34%
#4	11%
#5	5.5%
#6	2.6%
#7	0.9%
#8	0.4.%

Table 2.1.17(c)-2 Sampling cast table and spike ^{13}C concentration

Incubation type	CTD cast	$NaH^{13}CO_3$ (μmol dm^{-3})
simulated *in situ*	K02M03	200
simulated *in situ*	K02M08	200
simulated *in situ*	K02M11	200
simulated *in situ*	U01M02	200
simulated *in situ*	U04M02	200

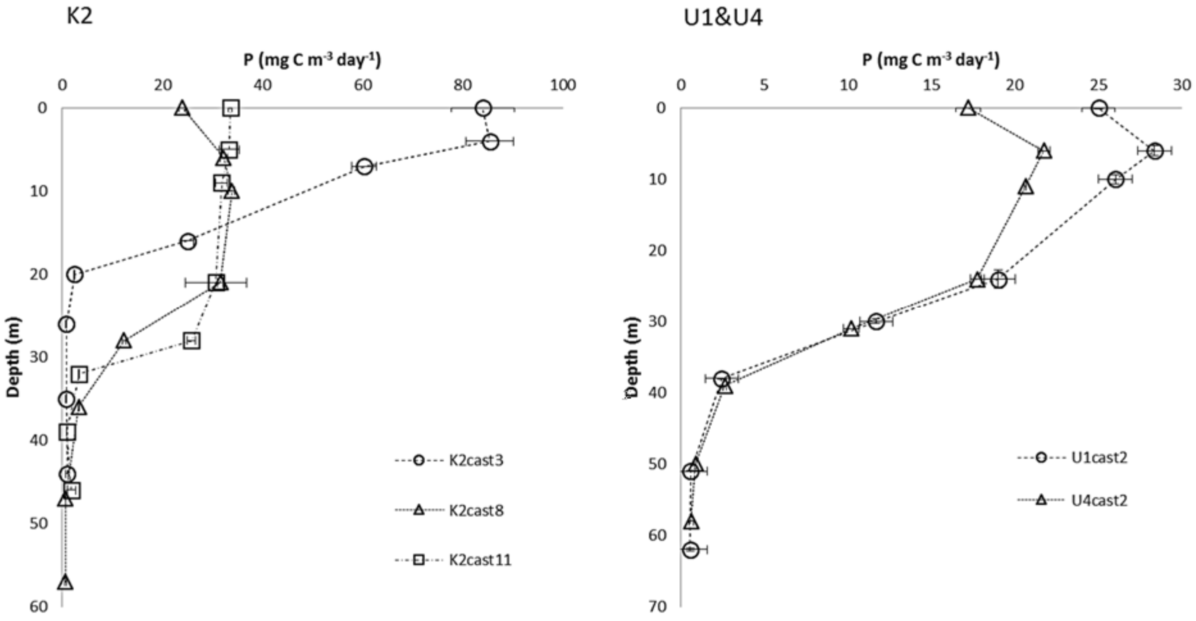


Figure 2.1.17(c) Vertical profile of primary production

2.1.18 Zooplankton

2.1.18(a) Zooplankton sampling by the NORPAC Net

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(1) Objectives

Owing to the anthropogenic CO_2, concentration of the atmospheric CO_2 is rising. The ocean has already absorbed about 30% of the total anthropogenic CO_2 (approximately 155 GtC) since the industrial revolution (IPCC AR5, 2013). This reduces ocean pH and causes wholescale shift in seawater carbonate chemistry. Ocean acidification also give several impacts to the biological processes; one well-known effect is the lowering of calcium carbonate saturation state, which give negative impact to shell-forming marine organisms such as pteropods and planktic foraminifers. Ocean acidification also affect zooplankton other than the shell-forming organisms, and characteristics of the zooplankton community will be probably changed. So, we are acoustically observing long-term change of zooplankton biomass at K2 by using the mooring system, and need measured values of bulk zooplankton biomass to validate the acoustically estimated biomasses.

In this cruise, for better understanding of biological responses to carbonate saturation status, we aimed for following themes,

(a) understanding vertical distributions of pteropods and planktonic foraminifers communities, and change of their shell densities with water depths,
(b) clarifying genetic diversities of planktic foraminifers with water depth in the North Pacific and Bering Sea,
(c) understanding phenotypic and genetic responses against different pCO_2 conditions for pteropods, and their population structure,
(d) trial of long-term rearing for pteropods under the laboratory settings,

(2) Methods

All plankton samplings were conducted at Sta K2, Bering Sea, and their halfway stations (See Table 2.1.18(a)). For the purpose (a), we collected specimens by using the Vertical Multi-depth Plankton Sampler (VMPS-3K, Tsurumi Seiki co., Ltd). VMPS-3K equipped 4 plankton nets (63 µm mesh, NXX25), magnetic flow-meter, fluorometer (Wet Lab) and CTD sensors (Sea-bird Electrics), and was hauled vertically at a speed of 0.5 m/sec. Opening/closing of each net is electrically controlled from the lab on the ship, we can collect vertically stratified sample sets together with the environmental sensing data. Collected samples were immediately fixed by the ethanol (99.5 %) and stored in the refrigerator under 4°C. For the purpose of (b), planktic foraminifers were picked under the stereomicroscope and transported to the microslides with seawater, and naturally dried under the room temperature (~20°C). Then stored in the deep freezer at -80°C.

For the purposes of (c) and (d), a NORPAC net (63 µm mesh, NXX25) with a large cod end (1,000 ml polypropylene bottle) was vertically hauled. Living pteropods were immediately sorted out from NORPAC net samples, and fixed by 99.5 % EtOH. For the culturing experiment, living pteropods were gently picked from the sample bottle and transported to the culture vessels. The water temperatures for the rearing of pteropods was fixed at 4 ºC under the fridge regardless of their sampling temperature.

(3) Onshore study in the future

Pteropod and planktonic foraminiferal shells will be analyzed by the Micro-focus X-ray CT (MXCT) equipped in JAMSTEC HQ in order to elucidate relationships between oceanic carbonate chemistry and individual shell density. The preserved samples of planktic foraminifers will be extracted all DNA and then perform SSU rDNA analysis for genetic diversity analysis. For the population analysis of pteropods, DNA extraction from the preserved specimens and amplifying of gene sequences for the COI region of mtDNA will be performed. After the sequence alignments, population genetic analysis will be performed.

(4) Data archive

All data will be submitted to JAMSTEC Data Management Group (DMG).

Table 2.1.18(a)-1 Observation stations and sample lists in MR17-04 Leg1

No.	Sample ID#	Station	Samples	Station	Latitude			Longitude			water depth (m)	Date					Purposes
1	MR1704-K2-1	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	20	0:00	UTC	For MicroXCT
2	MR1704-K2-2	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	20	0:00	UTC	For MicroXCT
3	MR1704-K2-3	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	20	0:00	UTC	For DNA extraction
4	MR1704-K2-4	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	20	0:00	UTC	For MicroXCT
5	MR1704-K2-5	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	20	0:00	UTC	For MicroXCT
6	MR1704-K2-6	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	20	0:00	UTC	For DNA extraction
7	MR1704-K2-7	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	20	0:00	UTC	For MicroXCT
8	MR1704-K2-8	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	20	0:00	UTC	For MicroXCT
9	MR1704-K2-9	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	20	0:00	UTC	For DNA extraction
10	MR1704-K2-10	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	20	0:00	UTC	For MicroXCT
11	MR1704-K2-11	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	20	0:00	UTC	For MicroXCT
12	MR1704-K2-12	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	20	0:00	UTC	For MicroXCT
13	MR1704-K2-13	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	20	0:00	UTC	For MicroXCT
14	MR1704-K2-14	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	20	0:00	UTC	For MicroXCT
15	MR1704-K2-15	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	20	0:00	UTC	For MicroXCT
16	MR1704-K2-16	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	20	12:00	UTC	For MicroXCT
17	MR1704-K2-17	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	20	12:00	UTC	For MicroXCT
18	MR1704-K2-18	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	20	12:00	UTC	For MicroXCT
19	MR1704-K2-19	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	20	12:00	UTC	For MicroXCT
20	MR1704-K2-20	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	20	12:00	UTC	For MicroXCT
21	MR1704-K2-21	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	20	12:00	UTC	For MicroXCT
22	MR1704-K2-22	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	20	12:00	UTC	For MicroXCT
23	MR1704-K2-23	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	20	12:00	UTC	For MicroXCT
24	MR1704-K2-24	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	20	12:00	UTC	For MicroXCT
25	MR1704-K2-25	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	20	12:00	UTC	For MicroXCT
26	MR1704-K2-26	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	20	12:00	UTC	For MicroXCT
27	MR1704-K2-27	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	20	12:00	UTC	For MicroXCT
28	MR1704-K2-28	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	22	0:00	UTC	For MicroXCT
29	MR1704-K2-29	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	50	2017	7	22	0:00	UTC	For MicroXCT
30	MR1704-K2-30	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	22	0:00	UTC	For MicroXCT
31	MR1704-K2-31	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	100	2017	7	22	0:00	UTC	For MicroXCT
32	MR1704-K2-32	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	22	0:00	UTC	For MicroXCT
33	MR1704-K2-33	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	150	2017	7	22	0:00	UTC	For MicroXCT
34	MR1704-K2-34	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	22	0:00	UTC	For MicroXCT
35	MR1704-K2-35	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	22	0:00	UTC	For MicroXCT
36	MR1704-K2-36	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	22	0:00	UTC	For MicroXCT
37	MR1704-K2-37	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	22	0:00	UTC	For MicroXCT
38	MR1704-K2-38	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	22	0:00	UTC	For MicroXCT
39	MR1704-K2-39	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	22	0:00	UTC	For MicroXCT
40	MR1704-K2-40	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	22	12:00	UTC	For MicroXCT
41	MR1704-K2-41	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	22	12:00	UTC	For MicroXCT
42	MR1704-K2-42	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	22	12:00	UTC	For MicroXCT
43	MR1704-K2-43	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	22	12:00	UTC	For MicroXCT
44	MR1704-K2-44	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	22	12:00	UTC	For MicroXCT
45	MR1704-K2-45	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	22	12:00	UTC	For MicroXCT
46	MR1704-K2-46	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	22	12:00	UTC	For MicroXCT
47	MR1704-K2-47	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	200	2017	7	22	12:00	UTC	For MicroXCT
48	MR1704-K2-48	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	22	12:00	UTC	For MicroXCT
49	MR1704-K2-49	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	300	2017	7	22	12:00	UTC	For MicroXCT
50	MR1704-K2-50	Sta. K2	Planktic foraminifers	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	22	12:00	UTC	For MicroXCT

(continued)

Table 2.1.18(a)-2 (continued)

No.	Sample ID#	Station	Samples	Station	Latitude			Longitude			water depth (m)	Date					Purposes
51	MR1704-K2-51	Sta. K2	Thecosomata	Sta. K2	47	00.00	N	160	00.00	E	500	2017	7	22	12:00	UTC	For MicroXCT
52	MR1704-K2-52	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	50	2017	7	25	8:00	UTC	For MicroXCT
53	MR1704-K2-53	Sta. U1	Thecosomata	Sta. U1	52	36.00	N	170	00.00	E	50	2017	7	25	8:00	UTC	For MicroXCT
54	MR1704-K2-54	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	50	2017	7	25	8:00	UTC	For DNA extraction
55	MR1704-K2-55	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	100	2017	7	25	8:00	UTC	For MicroXCT
56	MR1704-K2-56	Sta. U1	Thecosomata	Sta. U1	52	36.00	N	170	00.00	E	100	2017	7	25	8:00	UTC	For MicroXCT
57	MR1704-K2-57	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	100	2017	7	25	8:00	UTC	For DNA extraction
58	MR1704-K2-58	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	150	2017	7	25	8:00	UTC	For MicroXCT
59	MR1704-K2-59	Sta. U1	Thecosomata	Sta. U1	52	36.00	N	170	00.00	E	150	2017	7	25	8:00	UTC	For MicroXCT
60	MR1704-K2-60	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	150	2017	7	25	8:00	UTC	For DNA extraction
61	MR1704-K2-61	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	200	2017	7	25	8:00	UTC	For MicroXCT
62	MR1704-K2-62	Sta. U1	Thecosomata	Sta. U1	52	36.00	N	170	00.00	E	200	2017	7	25	8:00	UTC	For MicroXCT
63	MR1704-K2-63	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	300	2017	7	25	8:00	UTC	For MicroXCT
64	MR1704-K2-64	Sta. U1	Thecosomata	Sta. U1	52	36.00	N	170	00.00	E	300	2017	7	25	8:00	UTC	For MicroXCT
65	MR1704-K2-65	Sta. U1	Planktic foraminifers	Sta. U1	52	36.00	N	170	00.00	E	500	2017	7	25	8:00	UTC	For MicroXCT
66	MR1704-K2-66	Sta. U1	Thecosomata	Sta. U1	52	36.00	N	170	00.00	E	500	2017	7	25	8:00	UTC	For MicroXCT
67	MR1704-K2-67	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	50	2017	7	26	0:00	UTC	For MicroXCT
68	MR1704-K2-68	Sta. U2	Thecosomata	Sta. U2	53	00.00	N	171	00.00	E	50	2017	7	26	0:00	UTC	For MicroXCT
69	MR1704-K2-69	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	50	2017	7	26	0:00	UTC	For DNA extraction
70	MR1704-K2-70	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	100	2017	7	26	0:00	UTC	For MicroXCT
71	MR1704-K2-71	Sta. U2	Thecosomata	Sta. U2	53	00.00	N	171	00.00	E	100	2017	7	26	0:00	UTC	For MicroXCT
72	MR1704-K2-72	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	100	2017	7	26	0:00	UTC	For DNA extraction
73	MR1704-K2-73	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	150	2017	7	26	0:00	UTC	For MicroXCT
74	MR1704-K2-74	Sta. U2	Thecosomata	Sta. U2	53	00.00	N	171	00.00	E	150	2017	7	26	0:00	UTC	For MicroXCT
75	MR1704-K2-75	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	150	2017	7	26	0:00	UTC	For DNA extraction
76	MR1704-K2-76	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	200	2017	7	26	0:00	UTC	For MicroXCT
77	MR1704-K2-77	Sta. U2	Thecosomata	Sta. U2	53	00.00	N	171	00.00	E	200	2017	7	26	0:00	UTC	For MicroXCT
78	MR1704-K2-78	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	300	2017	7	26	0:00	UTC	For MicroXCT
79	MR1704-K2-79	Sta. U2	Thecosomata	Sta. U2	53	00.00	N	171	00.00	E	300	2017	7	26	0:00	UTC	For MicroXCT
80	MR1704-K2-80	Sta. U2	Planktic foraminifers	Sta. U2	53	00.00	N	171	00.00	E	500	2017	7	26	0:00	UTC	For MicroXCT
81	MR1704-K2-81	Sta. U2	Thecosomata	Sta. U2	53	00.00	N	171	00.00	E	500	2017	7	26	0:00	UTC	For MicroXCT
82	MR1704-K2-82	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	50	2017	7	26	8:00	UTC	For MicroXCT
83	MR1704-K2-83	Sta. U3	Thecosomata	Sta. U3	53	42.00	N	172	00.00	E	50	2017	7	26	8:00	UTC	For MicroXCT
84	MR1704-K2-84	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	50	2017	7	26	8:00	UTC	For DNA extraction
85	MR1704-K2-85	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	150	2017	7	26	8:00	UTC	For MicroXCT
86	MR1704-K2-86	Sta. U3	Thecosomata	Sta. U3	53	42.00	N	172	00.00	E	150	2017	7	26	8:00	UTC	For MicroXCT
87	MR1704-K2-87	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	150	2017	7	26	8:00	UTC	For DNA extraction
88	MR1704-K2-88	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	200	2017	7	26	8:00	UTC	For MicroXCT
89	MR1704-K2-89	Sta. U3	Thecosomata	Sta. U3	53	42.00	N	172	00.00	E	200	2017	7	26	8:00	UTC	For MicroXCT
90	MR1704-K2-90	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	300	2017	7	26	8:00	UTC	For MicroXCT
91	MR1704-K2-91	Sta. U3	Thecosomata	Sta. U3	53	42.00	N	172	00.00	E	300	2017	7	26	8:00	UTC	For MicroXCT
92	MR1704-K2-92	Sta. U3	Planktic foraminifers	Sta. U3	53	42.00	N	172	00.00	E	500	2017	7	26	8:00	UTC	For MicroXCT
93	MR1704-K2-93	Sta. U3	Thecosomata	Sta. U3	53	42.00	N	172	00.00	E	500	2017	7	26	8:00	UTC	For MicroXCT
94	MR1704-K2-94	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	50	2017	7	27	17:00	UTC	For MicroXCT
95	MR1704-K2-95	Sta. U4	Thecosomata	Sta. U4	56	30.00	N	175	30.00	E	50	2017	7	27	17:00	UTC	For MicroXCT
96	MR1704-K2-96	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	50	2017	7	27	17:00	UTC	For DNA extraction
97	MR1704-K2-97	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	100	2017	7	27	17:00	UTC	For MicroXCT
98	MR1704-K2-98	Sta. U4	Thecosomata	Sta. U4	56	30.00	N	175	30.00	E	100	2017	7	27	17:00	UTC	For MicroXCT
99	MR1704-K2-99	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	100	2017	7	27	17:00	UTC	For DNA extraction
100	MR1704-K2-100	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	150	2017	7	27	17:00	UTC	For MicroXCT

(continued)

Table 2.1.18(a)-3 (continued)

No.	Sample ID#	Station	Samples	Station	Latitude			Longitude			water depth	Date					Purposes
101	MR1704-K2-101	Sta. U4	Thecosomata	Sta. U4	56	30.00	N	175	30.00	E	150	2017	7	27	17:00	UTC	For MicroXCT
102	MR1704-K2-102	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	150	2017	7	27	17:00	UTC	For DNA extraction
103	MR1704-K2-103	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	200	2017	7	27	17:00	UTC	For MicroXCT
104	MR1704-K2-104	Sta. U4	Thecosomata	Sta. U4	56	30.00	N	175	30.00	E	200	2017	7	27	17:00	UTC	For MicroXCT
105	MR1704-K2-105	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	300	2017	7	27	17:00	UTC	For MicroXCT
106	MR1704-K2-106	Sta. U4	Thecosomata	Sta. U4	56	30.00	N	175	30.00	E	300	2017	7	27	17:00	UTC	For MicroXCT
107	MR1704-K2-107	Sta. U4	Planktic foraminifers	Sta. U4	56	30.00	N	175	30.00	E	500	2017	7	27	17:00	UTC	For MicroXCT
108	MR1704-K2-108	Sta. U4	Thecosomata	Sta. U4	56	30.00	N	175	30.00	E	500	2017	7	27	17:00	UTC	For MicroXCT
109	MR1704-K2-109	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	50	2017	7	28	22:00	UTC	For MicroXCT
110	MR1704-K2-110	Sta. U5	Thecosomata	Sta. U5	59	00.00	N	180	00.00	E	50	2017	7	28	22:00	UTC	For MicroXCT
111	MR1704-K2-111	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	50	2017	7	28	22:00	UTC	For DNA extraction
112	MR1704-K2-112	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	100	2017	7	28	22:00	UTC	For MicroXCT
113	MR1704-K2-113	Sta. U5	Thecosomata	Sta. U5	59	00.00	N	180	00.00	E	100	2017	7	28	22:00	UTC	For MicroXCT
114	MR1704-K2-114	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	100	2017	7	28	22:00	UTC	For DNA extraction
115	MR1704-K2-115	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	150	2017	7	28	22:00	UTC	For MicroXCT
116	MR1704-K2-116	Sta. U5	Thecosomata	Sta. U5	59	00.00	N	180	00.00	E	150	2017	7	28	22:00	UTC	For MicroXCT
117	MR1704-K2-117	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	150	2017	7	28	22:00	UTC	For DNA extraction
118	MR1704-K2-118	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	200	2017	7	28	22:00	UTC	For MicroXCT
119	MR1704-K2-119	Sta. U5	Thecosomata	Sta. U5	59	00.00	N	180	00.00	E	200	2017	7	28	22:00	UTC	For MicroXCT
120	MR1704-K2-120	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	300	2017	7	28	22:00	UTC	For MicroXCT
121	MR1704-K2-121	Sta. U5	Thecosomata	Sta. U5	59	00.00	N	180	00.00	E	300	2017	7	28	22:00	UTC	For MicroXCT
122	MR1704-K2-122	Sta. U5	Planktic foraminifers	Sta. U5	59	00.00	N	180	00.00	E	500	2017	7	28	22:00	UTC	For MicroXCT
123	MR1704-K2-123	Sta. U5	Thecosomata	Sta. U5	59	00.00	N	180	00.00	E	500	2017	7	28	22:00	UTC	For MicroXCT

2.1.18(b) ORI net

Minoru KITAMURA **JAMSTEC RCGC**

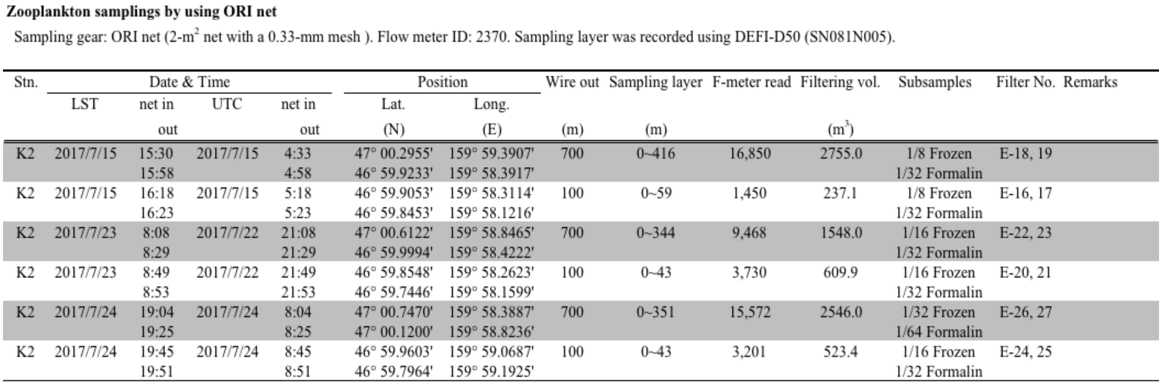
(1) Objective

To understand/discuss influences of ocean acidification on plankton community is one of the themes for MR17-04 cruise. Recent researches suggested that ocean acidification may influence not only maintaining of $CaCO_3$ test but also larval development of crustacean zooplankton such as copepods and euphausiids which are dominated in the zooplankton community. Thus, accurate understanding on long-term dynamics of zooplankton biomass is important as one of the basic information when we detect biological responses against such kind of environmental changes. In this study, we will analyze zooplankton dynamics by using time-series of backscatter intensities obtained by a moored ADCP. To validate acoustically estimated zooplankton biomass, snapshot biomass data based on the zooplankton samples obtained from the net tows are needed.

(2) Methods

The ORI net (1.6 m in diameter, 8 m long, and 0.33 mm in mesh) was obliquely towed at an average ship speed of 2 knots. Target layers of the zooplankton samplings were 0-50 and 0-350 m. Filtering volume of water was estimated using a flow meter (S/N: 2370) mounted in the net mouth. Maximum sampling depth of each trawl was recorded using a depth sensor (DEFI-D50, JFE-Advantec Co. Ltd; S/N 081N005) attached in the net frame. Sampling information were summarized in Table 2.1.17(b)-1. Collected zooplankton samples were quantitatively divided onboard, a subsample (1/8, 1/16 or 1/32) was preserved in –20 ºC for biomass estimation and another subsample (1/16, 1/32 or 1/64) was fixed and preserved in 5% buffered formalin seawater for community structure analysis.

Table 2.1.17(b)-1. Summary of ORI net hauls.



Zooplankton samplings by using ORI net

Sampling gear: ORI net (2-m^2 net with a 0.33-mm mesh). Flow meter ID: 2370. Sampling layer was recorded using DEFI-D50 (SN081N005).

Stn.	Date & Time				Position		Wire out	Sampling layer	F-meter read	Filtering vol.	Subsamples	Filter No.	Remarks
	LST	net in out	UTC	net in out	Lat. (N)	Long. (E)	(m)	(m)		(m^3)			
K2	2017/7/15	15:30 15:58	2017/7/15	4:33 4:58	47° 00.2955' 46° 59.9233'	159° 59.3907' 159° 58.3917'	700	0~416	16,850	2755.0	1/8 Frozen 1/32 Formalin	E-18, 19	
K2	2017/7/15	16:18 16:23	2017/7/15	5:18 5:23	46° 59.9053' 46° 59.8453'	159° 58.3114' 159° 58.1216'	100	0~59	1,450	237.1	1/8 Frozen 1/32 Formalin	E-16, 17	
K2	2017/7/23	8:08 8:29	2017/7/22	21:08 21:29	47° 00.6122' 46° 59.9994'	159° 58.8465' 159° 58.4222'	700	0~344	9,468	1548.0	1/16 Frozen 1/32 Formalin	E-22, 23	
K2	2017/7/23	8:49 8:53	2017/7/22	21:49 21:53	46° 59.8548' 46° 59.7446'	159° 58.2623' 159° 58.1599'	100	0~43	3,730	609.9	1/16 Frozen 1/32 Formalin	E-20, 21	
K2	2017/7/24	19:04 19:25	2017/7/24	8:04 8:25	47° 00.7470' 47° 00.1200'	159° 58.3887' 159° 58.8236'	700	0~351	15,572	2546.0	1/32 Frozen 1/64 Formalin	E-26, 27	
K2	2017/7/24	19:45 19:51	2017/7/24	8:45 8:51	46° 59.9603' 46° 59.7964'	159° 59.0687' 159° 59.1925'	100	0~43	3,201	523.4	1/16 Frozen 1/32 Formalin	E-24, 25	

(3) Sample archive

All formalin fixed or frozen subsamples are stored under Kitamura until analyzing.

2.1.18(c) AZFP (Acoustic Zooplankton Fish Profiler)

Minoru KITAMURA JAMSTEC RCGC

(1) Objective

Current studies on the zooplankton ecology depend heavily on analysis of collected specimens, and researches based on the direct data sampling by using sensors in the field are limited. Thus, temporal and spatial resolutions of many ecological data sets for zooplankton are low. Acoustical technics may solve such a problem, but applying of them to the zooplankton study are still scarce. In this study, I aimed to understand vertical distribution of zooplankton in high spatial resolution (about 1 m) by using the acoustical method.

(2) Methods

To understand vertical distribution of zooplankton in high resolution, a horizontally looking multi-frequency echo sounder (AZFP; Acoustic Zooplankton Fish Profiler, S/N; 55050) was hauled from 150 m to sea surface at a speed of 0.1 m/sec. AZFP sampled acoustic data at 125, 200, 455, and 769 kHz in this study, but I was not able to use the collected data from 455 and 769 kHz due to mechanical problem with the transducer. The settings of the AZFP for acoustic data samplings are summarized in the following table, that is same as the settings in the T/S *Oshoro Maru* cruise (OS026) during June-July 2016. Because AZFP has no depth sensor, depths of the acoustic sampling are recorded by using a depth sensor (DEFI-D50, JFE-Advantec Co. Ltd; S/N 081N005) attached to the AZFP frame. Interval of data sampling of the DEFI-D50 was one second. To identify main acoustic scatterer, a zooplankton sampling between 150 and 10 m by vertical haul of a closing NORPAC net (45 cm in mouth diameter, 0.33 mm in mesh size) was conducted just after every AZFP cast. The collected net samples were quantitatively divided into two subsamples. One of them was fixed and preserved in 5% formalin seawater for taxonomic analysis, and another one was preserved in –20 °C for measurement of bulk biomass.

Table 2.1.18(c)-1. AZFP settings

AZFP parameters and setting files	
Burst interval (s)	0.02
Ping period (s)	1
Pulse length	300
Digitization rate (kS s^{-1})	20
Number of pings per burst (pings)	1
Average burst pings	No
Bin averaging (m)	1
Lockout (m)	0
Deployment file	150901_KARE19.mfawcpl
Configuration file	55050_151209.cfg

(3) Acoustic data analysis after the cruise

Total 17 AZFP casts and net samplings were conducted at K2 as the following tables. After back to the land laboratory, volume backscattering strength will be calculated from the observed acoustic data set.

Table 2.1.18(c)-2. Summary of AZFP casts at K2

Stn.	Cast ID	Date (yyyy/mm/dd) and Time				Position		Max. depth (m)	Sv file	NORPAC cast
		LST		UTC		Lat. (N)	Long. (E)			
K2	AZFP1-1	2017/7/18	4:10	2017/7/17	17:10	46° 59.7367'	160° 00.3866'	153	17071717_55050_C*_###KHZ.sv.csv	N1-1
	AZFP1-2		7:40		20:40	47° 00.0527'	160° 00.2650'	153	17071720_55050_C*_###KHZ.sv.csv	N1-2
	AZFP1-3		11:53	2017/7/18	0:53	46° 59.9857'	159° 59.9044'	153	17071800_55050_C*_###KHZ.sv.csv	N1-3
	AZFP1-4		15:58		4:58	46° 59.9961'	159° 59.9380'	153	17071804_55050_C*_###KHZ.sv.csv	N1-4
	AZFP1-5		19:56		8:56	47° 00.0510'	160° 00.0164'	152	17071808_55050_C*_###KHZ.sv.csv	N1-5
	AZFP2-1	2017/7/20	0:58	2017/7/19	13:58	47° 00.0034'	159° 59.9850'	152	17071913_55050_C*_###KHZ.sv.csv	N2-1
	AZFP2-2		3:38		16:38	46° 59.9853'	160° 00.1249'	152	17071916_55050_C*_###KHZ.sv.csv	N2-2
	AZFP2-3		7:40		20:40	47° 00.3639'	160° 00.0360'	153	17071920_55050_C*_###KHZ.sv.csv	N2-3
	AZFP2-4		12:18	2017/7/20	1:18	47° 00.1135'	160° 00.0337'	153	17072001_55050_C*_###KHZ.sv.csv	N2-4
	AZFP2-5		15:55		4:55	47° 00.0011'	159° 59.9051'	153	17072004_55050_C*_###KHZ.sv.csv	N2-5
	AZFP2-6		19:58		8:58	47° 00.0922'	160° 00.0086'	152	17072008_55050_C*_###KHZ.sv.csv	N2-6
	AZFP3-1	2017/7/22	0:58	2017/7/21	13:58	47° 00.0057'	159° 59.9944'	152	17072113_55050_C*_###KHZ.sv.csv	N3-1
	AZFP3-2		3:39		16:39	46° 59.8739'	159° 59.9841'	153	17072116_55050_C*_###KHZ.sv.csv	N3-2
	AZFP3-3		7:57		20:57	46° 59.9675'	160° 00.0632'	152	17072120_55050_C*_###KHZ.sv.csv	N3-3
	AZFP3-4		12:21	2017/7/22	1:21	47° 00.10126'	160° 00.3786'	152	17072200_55050_C*_###KHZ.sv.csv	N3-4
	AZFP3-5		15:56		4:56	47° 00.0107'	160° 00.0211'	153	17072204_55050_C*_###KHZ.sv.csv	N3-5
	AZFP3-6		19:57		8:57	47° 00.0619'	160° 00.0618'	153	17072208_55050_C*_###KHZ.sv.csv	N3-6

Table 2.1.18(c)-3. Summary of NORPAC net samplings at K2

Stn.	Cast ID	Date (yyyy/mm/dd) and Time				Position		Sampling Layer (m)	Wire out (m)	Flow-meter revolution	Filtering vol. (m^3)	Filter No. of frozen subsample
		LST		UTC		Lat.	Long.					
K2	N1-1	2017/7/18	4:45	2017/7/17	17:45	47° 00.0198'	160° 00.2997'	155-14	150	852	11.9	Ar31-32
	N1-2		8:16		21:16	47° 00.1711'	160° 00.2679'	154-13	150	845	11.8	Ar33
	N1-3		12:24	2017/7/18	1:24	47° 00.1024'	159° 59.9916'	155-14	150	758	10.6	Ar34
	N1-4		16:34		5:34	47° 00.2096'	159° 59.5083'	154-13	150	935	13.1	N98-99
	N1-5		20:34		9:34	47° 00.0472'	159° 59.8491'	154-14	150	770	10.8	N100
	N2-1	2017/7/20	1:32	2017/7/19	14:32	46° 59.9918'	160° 00.0026'	150-10	150	453	6.3	N101-102
	N2-2		4:17		17:17	47° 00.1450'	160° 00.0459'	150-10	150	943	13.2	N103-104
	N2-3		8:15		21:15	47° 00.6121'	160° 00.1603'	150-10	150	750	10.5	N105, 106
	N2-4		12:53	2017/7/20	1:53	47° 00.2471'	160° 00.1981'	150-10	150	560	7.8	N107-109
	N2-5		16:35		5:35	47° 00.1185'	160° 00.1177'	150-10	150	628	8.8	N110, 111
	N2-6		20:26		9:26	47° 00.1760'	160° 00.2354'	150-10	150	990	13.9	N112-114
	N3-1	2017/7/22	1:35	2017/7/21	14:35	46° 59.8878'	160° 00.0138'	150-10	150	540	7.6	N115-117
	N3-2		4:07		17:07	46° 59.7967'	159° 59.9930'	150-10	150	595	8.3	N118-122
	N3-3		8:39		21:39	47° 00.0366'	160° 00.2850'	150-10	150	730	10.2	N123-126
	N3-4		12:59	2017/7/22	1:59	46° 59.9174'	160° 00.9294'	150-10	150	390	5.5	N127-130
	N3-5		16:26		5:26	47° 00.0033'	160° 00.2619'	150-10	150	590	8.3	N131-134
	N3-6		20:47		9:47	47° 00.0609'	160° 00.2136'	150-10	150	802	11.2	N135-137

(4) Data archive

Volume backscattering data of all AZFP casts will be submitted to the Data Management Office, JAMSTEC.

2.1.19 Carbon isotopes

Yuichiro KUMAMOTO JAMSTEC RCGC
Masahide WAKITA JAMSTEC MIO
Tetsuichi FUJIKI JAMSTEC RCGC

(1) Objective

In order to investigate the water circulation and carbon cycle in the Bering Sea, seawaters for measurements of ^{14}C (radiocarbon) and ^{13}C (stable carbon) of total dissolved inorganic carbon (TDIC) were collected by the hydrocasts from surface to near bottom.

(2) Sample collection

The sampling stations and number of samples are summarized in Table 2.1.19-1. All samples for carbon isotope ratios (total 72 samples) were collected at two stations using 12-liter Niskin-X bottles. The seawater sample was siphoned into a 250 cm^3 glass bottle with enough seawater to fill the glass bottle 2 times. Immediately after sampling, 10 cm^3 of seawater was removed from the bottle and poisoned by 0.1 cm^3 μl of saturated $HgCl_2$ solution. Then the bottle was sealed by a glass stopper with Apiezon grease M and stored in a cool and dark space on board.

(3) Sample preparation and measurements

In our laboratory, TDIC in the seawater samples will be stripped cryogenically and split into three aliquots: ^{14}C measurement (about 200 μmol), ^{13}C measurement (about 100 μmol), and archive (about 200 μmol). The extracted CO_2 gas for radiocarbon will be then converted to graphite catalytically on iron powder with pure hydrogen gas. ^{13}C of the extracted CO_2 gas will be measured using Finnigan MAT253 mass spectrometer. ^{14}C in the graphite sample will be measured by Accelerator Mass Spectrometry.

Table 2.1.19-1 Sampling stations and number of samples for carbon isotope ratios

Station	Lat. (N)	Long. (E)	Sampling Date (UTC)	Number of samples	Max. Pressure (dbar)
U04	56-29.86	175-29.96	2017/07/28	36	3893
U05	58-56.11	180-05.71	2017/07/29	36	3598
			Total	72	

2.1.20 Radioactive Cesium

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Tetsuichi FUJIKI **JAMSTEC RCGC**

(1) Objective

In order to investigate water circulation in the subarctic North Pacific Ocean and Bering Sea, seawater samples were collected for measurements of radiocesium (^{134}Cs and ^{137}Cs), which were mainly released from the global fallout in the 1950s and 1960s and the Fukushima Daiichi nuclear power plant after its serious accident on the March 11 of 2011.

(2) Sample collection

The sampling stations and number of samples are summarized in Table 2.1.20-1. 40L of surface seawater was collected at five stations. The surface seawater were sampled from pumping-up water from the bottom of the ship and a bucket at station 1 and K2-U5, respectively.

(3) Sample preparation and measurements

In our laboratory on shore, radiocesium in the seawater samples will be concentrated using ammonium phosphomolybdate (AMP) that forms insoluble compound with cesium. The radiocesium in AMP will be measured using Ge γ-ray spectrometer.

Table 2.1.20-1 Sampling locations of surface seawater sample for radiocesium measurement

Station	Lat. (S)	Long. (E)	Sampling Date (UTC)	Sample volume (L)	Sampling depth (m)
1	41-36.25	151-57.94	2017/07/13	40	4
K2	46-59.84	160-00.32	2017/07/14	40	0
U01	52-38.45	170-03.39	2017/07/26	40	0
U04	56-29.86	175-29.96	2017/07/28	40	0
U05	58-56.11	180-05.71	2017/07/29	40	0

2.2 Ocean observation platforms

2.2.1 Hybrid profiling buoy system

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Masahide WAKITA	**JAMSTEC MIO**
Yoshiyuki NAKANO	**JAMSTEC MARITEC**
Hiroshi UCHIDA	**JAMSTEC RCGC**
Akira WATANABE	**MWJ**
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Hiroki USHIROMURA	**MWJ**

2.2.1(a) Recovery and deployment

Hybrid profiling buoy is combined two moorings, BGC mooring(biogeochemistry) and POPPS mooring (ocean productivity profiling system). We recovered Hybrid profiling buoy system at Station K-2 which were deployed at OSO26-Leg2 and deployed Hybrid profiling buoy system at Station K-2. Deployment operation took approximately 6 hours. After sinker was dropped, we positioned the mooring systems by measuring the slant ranges between research vessel and the acoustic releaser. The position of the mooring is finally determined as follow:

Table 2.2.1(a)-1 Mooring positions of respective mooring systems

	Recovery	Deployment
Mooring Number	K2H160629	K2H170721
Working Date	Jul. 17 2017	Jul. 21 2017
Latitude	47 ° 00.21N	47 ° 00.35N
Longitude	159 ° 58.28 E	159 ° 58.25 E
Sea Beam Depth	5,190 m	5,218 m

The deployment Hybrid profiling buoy consists of a top buoy with 24lbs(11kg) buoyancy, underwater winch, instruments, wire and ropes, recovery buoy with 496lbs(225kg) buoyancy, glass floats (Benthos 17” glass ball), dual releasers (Edgetech) and 4,911lbs (2,228kg) sinker. An ARGOS compact mooring locator was mounted on underwater winch, and a submersible recovery strobe was mounted on the top buoy. This mooring system was planned to keep the following time-series observational instruments are mounted approximately 120 m below sea surface. On the Hybrid profiling buoy, two Sediment Traps are installed on the 1,000 m and 4,800 m. Two auto sampling systems(RAS) are installed on the 200m and 300m. Extra CTD (SBE-37) and Do Sensor (RINKO and Optode) are mounted on the dual acoustic releaser and inline wire rope, inline SUS frame(2,000 m and 3,000m), Sediment Trap, RAS, underwater winch, top buoy. Details for each instrument are described below (section 2.2.1(c), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.1(h), 2.2.1(i), 2.2.1(j)). Serial number of instruments are as follows:

Table 2.2.1(a)-2 Serial numbers of instruments

	Recover	Deployment
Station and type	K2	K2
Mooring Number	K2H160629	K2H170721
Top Buoy(120m)	-	-
Iridium Transmiter	300025010637290	-
Storobo	233	E10-24
FRRF	M448-4	780263009
PAR	20229	0277
RINKO	0264	20526
CTD (SBE19plusV2)	19-7681	7763
AFP07	-	179,180
Winch(150m)	-	-
Argos Transmitter	C01-081	F01-038
SBE37	1893	1893
OPTODE	03	03
HpHS (HPS-14)	-	505163002
(175m)	Wire	Wire
SBE37	1892	1892
OPTODE	6	6
RAS (200m)	11241-09	11241-09
SBE37	2239	2239
OPTODE	50	50
HpHS(HPS-14)	505061002	505061002
SUNA V2	-	NTR-1016
SUNA Battery	-	BAT-1013
(250m)	Wire	SUS frame
SBE37	2756	2756
RINKO	92	92
RAS (300m)	11241-11	11241-07
SBE37	2289	2289
RINKO	51	51
ADCP(370m)	1533	1434
SBE37	2288	2288
OPTODE	9	9
(475m)	-	Wire
SBE37	-	10737
OPTODE	-	10
Sediment Trap(500m)	ML10236-02	-
SBE37	10737	-
OPTODE	10	-
Sediment Trap(1000m)	-	26S001
SBE37	-	2285

RINKO	-	7
(2000m)	-	SUS frame
SBE37	-	2748
RINKO	-	6
(3000m)	-	SUS frame
SBE37	-	2738
RINKO	-	5
Sediment Trap(4800m)	ML10558-01	ML11241-22
Releaser	27824	28509
Releaser	34040	27809
SBE-37	2731	2731
SBE26	-	0262

Table 2.2.1(a)-3 Recovery record of Hybrid profiling buoy system

Mooring Number K2H160629

Project	Time-Series		Depth	5,190.0	m
Area	North Pacific		Planned Depth	5,206.2	m
Station	K2		Length	5,085.5	m
Target Position	**47°00.35**	**N**	Depth of Buoy	120	m
	159°58.32	**E**	Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27824		34040		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**344674**		**233770**		
Enable C.	361121		221130		
Disable C.	361167		221155		
Battery	2 years		2 years		
Release Test	OK		OK		
RECOVERY					
Recorder	Akira Watanabe		Work Distance	2.8	Nmile
Ship	R/V MIRAI		Send Enable C.	2:35	
Cruise No.	MR17-04Leg1		Slant Renge	-	msec
Date	2017/7/17		Send Release C.	2:39	
Weather	r		Discovery Buoy	2:42	
Wave Hight	1.1	m	Pos. of ship at discovery buoy	46°59.82	N
Seabeam Depth	-	m		159°58.55	E
Ship Heading	<014>		Pos. of Start	46°59.63	N
Ship Ave.Speed	-	knot		159°58.73	E
Wind	<054> 3.5	m/s	Pos. of Finish	47°02.82	N
Current	<070>0.2	knot		159°59.09	E

Table 2.2.1(a)-4 Deployment record of Hybrid profiling buoy system

Mooring Number K2H170721

Project	Time-Series		Depth	5,218.0	m
Area	North Pacific		Planned Depth	5,206.2	m
Station	K2		Length	5,088.3	m
Target Position	**47°00.35**	**N**	Depth of Buoy	120	m
	159°58.32	**E**	Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	28509		27809		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**335704**		**344535**		
Enable C.	377142		360320		
Disable C.	377161		360366		
Battery	2 years		2 years		
Release Test	OK		OK		
DEPLOYMENT					
Recorder	Akira Watanabe		Start	9.7	Nmile
Ship	R/V MIRAI		Overrun	600	m
Cruise No.	MR17-04Leg1		Let go Top Buoy	21:01	
Date	2017/7/20-21		Let go Anchor	2:42	
Weather	f		Sink Top Buoy	3:25	
Wave Hight	1.0	m	Pos. of Start	47°09.82	N
PDR Depth	-	m		159°59.74	E
Ship Heading	<190>		Pos. of Drop. Anc.	46°59.97	N
Ship Ave.Speed	-	knot		159°58.25	E
Wind	<200> 8.1	m/s	Pos. of Mooring	47°00.35	N
Current	<347> 0.2	cm/s		159°58.25	E

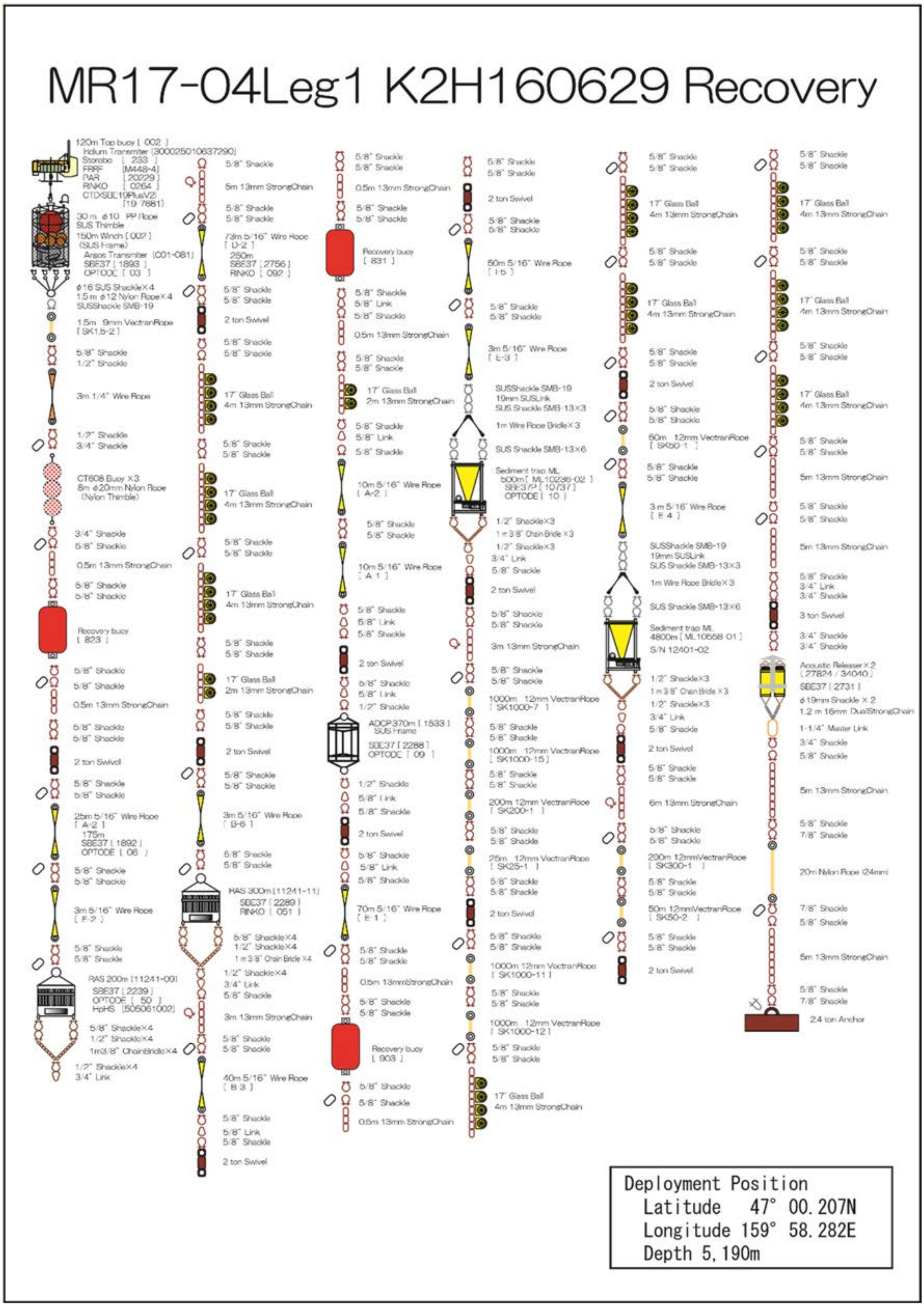


Fig. 2.2.1(a)-1 Recovered Hybrid profiling buoy system

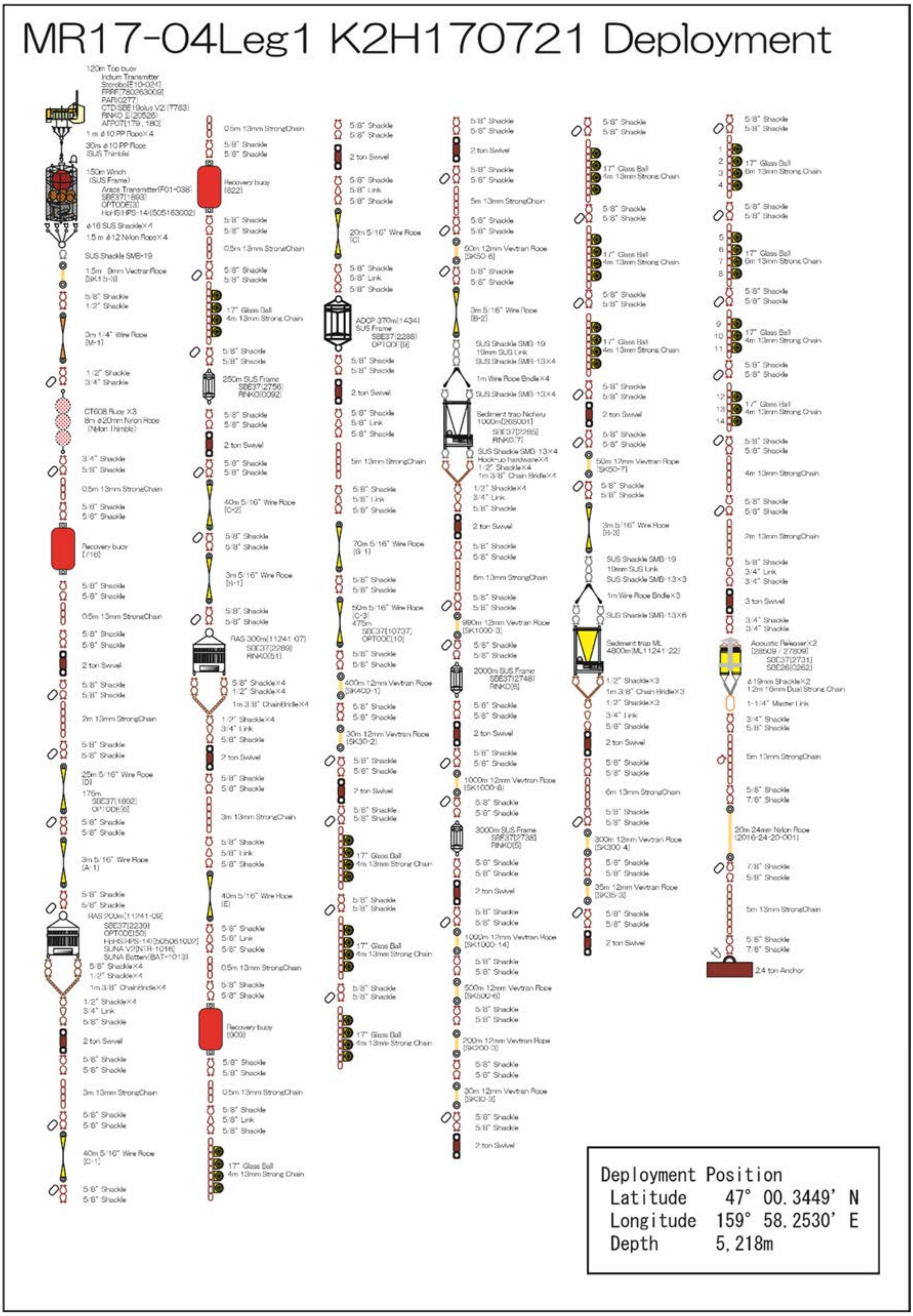


Fig. 2.2.1(a)-2 Deployed Hybrid profiling buoy system

2.2.1(b) Instruments and observation schedule

On mooring systems, instruments for details are as follows:

*Top buoy and underwater winch, RAS, Hybrid pH sensor, ADCP, Sesiment trap,CTD, DO are described below (section 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.1(h), 2.2.1(i), 2.2.1(j)).

(1) ARGOS Beacon

The NOVATECH MMA-7500 ARGOS Beacon contains an ARGOS satellite transmitter designed as a ruggedized incident alerting system for oceanographic applications deployed anywhere in the world. It may be submerged for long periods in ocean depths to 7,500 m(24,000feet). The device can be turned ON or OFF by triggering the internal reed switch with a magnet. The activation of the MMA-7500 is completely automatic and water sensor controlled. The water sensor is located in the antenna base – when submerget , the beacon goes into low-power hibernation mode. The water sensor hysteresis is approx.. 90 seconds. The beacon will continue to transmit for up to 90 seconds when submerged and will begin transmitting within 90 seconds of surfacing. At the surface the beacon transmits an ARGOS position data massage for 90 days.

(Specifications)

Transmitter Output:	1 watt
Harmonics:	-40 db minimum
Batteries:	8 CR123A Lithium cells
BatteryLife:	90days at the surface
Operating Temp:	-40 °C to +60°C
Transmit Freq:	401.6300 MHz - 401.6800 MHz
Antenna:	Field replaceable 1/4 wave whip
Max Depth:	7,500 m
Weight:	In air 1.25lbs(0.56kg) , In water 0.75lbs(0.34kg)
Dimensions:	16.5"long(420mm),1.0"diameter(250mm)

(2) Submersible Recovery Strobe

The NOVATECH MMF-7500 Mini-Flasher is intended to aid in the marking or recovery of oceanographic instruments, manned vehicles, remotely operated vehicles, buoys or structures. Due to the occulting (firing closely spaced bursts of light) nature of this design, it is much more visible than conventional marker strobes, particularly in poor sea conditions.

(Specifications)

Flash Rate:	Double burst 4 second delay.
Visible Range:	Up to 5 Nm
Battery Type:	7×CR123A Lithinm
Life:	Approximately 6 days, standard configuration(Double burst every 4s @ 170 lm)
Max. Depth:	7,500m
Switch:	Water conductivity
Weight:	air 1.44lbs(0.66kg) water 0.96lbs(0.44kg)
Dimensions:	Length 15.00”(381mm) Diameter 1.44”(29mm)

(3) SUNA V2

The SUNA V2 is the ultimate solution for real-time nutrient monitoring. This sensor measures nitrate with industry leading accuracy and stability over a wide range of environmental conditions (including extremely turbid and high CDOM conditions), from blue-ocean nitraclines to storm runoff in rivers and streams. The SUNA V2 incorporates the proven MBARI-ISUS nitrate measurement technology, which is based on the absorption characteristics of nitrate in the UV light spectrum.

Limit of Detection: 0.5 / 0.2μM
Range of Detection: 3000 / 4000μM
Accuracy: 2 / N/AμM
Precision: 0.3 / 2.4μM
Drift: 0.3 / 1μM
Turbidity Range: 625NTU / 1250NTU
PathLength: 10nm & 5nm
Wavelength Range: 190-370nm
Lamp Type: Continuous Wave,Deuterium Lamp
Lamp Lifetime: 900h
Input Voltage: 8-18V
Power Consumption: 7.5W(0.625A or 12V)nominal
Material: Titanium
Depth Rating: 500m
Weight: 5.1kg
Displacement: 1749 ㎤

(4) SBE26

The SBE 26 SEAGAUGE Wave and Tide Recorder combines Sea-Bird's reliable semiconductor-memory electronics with a stable time base and quartz pressure sensor.

Range: 0 to 1 / 5 / 10 / 20 / 60 / 130 / 200 / 270 / 680 / 1300 / 2000 / 4000 / 6800meters
Accuracy: 0.01% of full scale(3mm for 45 psia range)
Repeatability: 0.005% of full scale(1.5mm for 45 psia range)
Hysteresis: 0.005% of full scale(1.5mm for 45 psia range)
Calibration: 0 psia to full scale pressure
Tide Resolution: 0.2mm for 1-minute integration;0.01mm for 15-minute integration
Wave Resolution: 0.4mm for 0.25-second integration;0.1mm for 1-second integration
Weight: 6kg
Housing Materials: titanium

2.2.1(c) Underwater profiling buoy system (POPPS)

Tetsuichi FUJIKI **JAMSTEC RCGC**

(1) Objective

An understanding of the variability in phytoplankton productivity provides a basic knowledge of how aquatic ecosystems are structured and functioning. The primary productivity of the world oceans has been measured mostly by the radiocarbon tracer method or the oxygen evolution method. As these traditional methods use the uptake of radiocarbon into particulate matter or changes in oxygen concentration in the bulk fluid, measurements require bottle incubations for periods ranging from hours to a day. This methodological limitation has hindered our understanding of the variability of oceanic primary productivity. To overcome these problems, algorithms for estimating primary productivity by using satellite ocean color imagery have been developed and improved. However, one of the major obstacles to the development and improvement of these algorithms is a lack of *in situ* primary productivity data to verify the satellite estimates.

During the past decade, the utilization of active fluorescence techniques in biological oceanography has brought marked progress in our understanding of phytoplankton photosynthesis in the oceans. Above all, fast repetition rate (FRR) fluorometry reduces the primary electron acceptor (Q_a) in photosystem (PS) II by a series of subsaturating flashlets and can measure a single turnover fluorescence induction curve in PSII. The PSII parameters derived from the fluorescence induction curve provide information on the physiological state related to photosynthesis and can be used to estimate gross primary productivity. FRR fluorometry has several advantages over the above-mentioned traditional methods. Most importantly, because measurements made by FRR fluorometry can be carried out without the need for time-consuming bottle incubations, this method enables real-time high-frequency measurements of primary productivity. In addition, the FRR fluorometer can be used in platform systems such as moorings, drifters, and floats.

The current study aimed to assess the vertical and temporal variations in PSII parameters and primary productivity in the western Pacific, by using an underwater profiling buoy system that uses the FRR fluorometer (system name: POPPS)

(2) Methods

a) Primary productivity profiler

The POPPS consisted mainly of an observation buoy equipped with a submersible FRR fluorometer (Diving Flash, Kimoto Electric), a scalar irradiance sensor (QSP-2200, Biospherical Instruments), a CTD sensor (SBE19plusV2, Sea-Bird Scientific) and a dissolved oxygen sensor

(RINKO III, JFE Advantech) and an underwater winch (Fig. 2.2.1(a)-2). The observation buoy moved between the winch depth and the surface at a rate of 0.2 m s^{-1} and measured the vertical profiles of phytoplankton fluorescence, irradiance, temperature, salinity and dissolved oxygen. The profiling rate of the observation buoy was set to 0.2 m s^{-1} to detect small-scale variations (approx. 1 m) in the vertical profile. To minimize biofouling of instruments, the underwater winch was placed below the euphotic layer so that the observation buoy was exposed to light only during the measurement period. In addition, the vertical migration of observation buoy reduced biofouling of instruments.

b) Measurement principle of FRR fluorometer

The FRR fluorometer consists of closed dark and open light chambers that measure the fluorescence induction curves of phytoplankton samples in darkness and under actinic illumination. To allow relaxation of photochemical quenching of fluorescence, the FRR fluorometer allows samples in the dark chamber to dark adapt for about 1 s before measurements. To achieve cumulative saturation of PSII within 150 μs — i.e., a single photochemical turnover — the instrument generates a series of subsaturating blue flashes at a light intensity of 25 mmol quanta m^{-2} s^{-1} and a repetition rate of about 250 kHz. The PSII parameters are derived from the single-turnover-type fluorescence induction curve by using the numerical fitting procedure described by Kolber et al. (1998). Analysis of fluorescence induction curves measured in the dark and light chambers provides PSII parameters such as fluorescence yields, photochemical efficiency and effective absorption cross section of PSII, which are indicators of the physiological state related to photosynthesis. Using the PSII parameters, the rate of photosynthetic electron transport and the gross primary productivity can be estimated.

c) Site description and observations

The POPPS deployed at station K2 during the Oshoro-Maru cruise (OS026-Leg2, June – July 2016) was recovered on 17 July 2017. In addition, the POPPS was newly-deployed on 21 July 2017. To gain a better understanding of observational data from the POPPS, separately from the POPPS, we moved up and down a submersible FRR fluorometer between surface and ~100 m at the station K2 using a ship winch, and measured the vertical and spatial variation in PSII parameters.

(3) Results

The POPPS deployed in July 2016 has succeeded in observing vertical and temporal variations in phytoplankton productivity and environmental parameters at station K2 throughout the year, although there was a lack of data in the surface layer because a rough-sea avoidance system excessively actuated (Fig. 2.2.1(c)-1). Unfortunately, because of a problem with the underwater winch, the POPPS newly-deployed during this cruise was not working.

(4) References

Kolber, Z. S., O. Prášil and P. G. Falkowski. 1998. Measurements of variable chlorophyll fluorescence using fast repetition rate techniques: defining methodology and experimental protocols. Biochim. Biophys. Acta. 1367: 88-106.

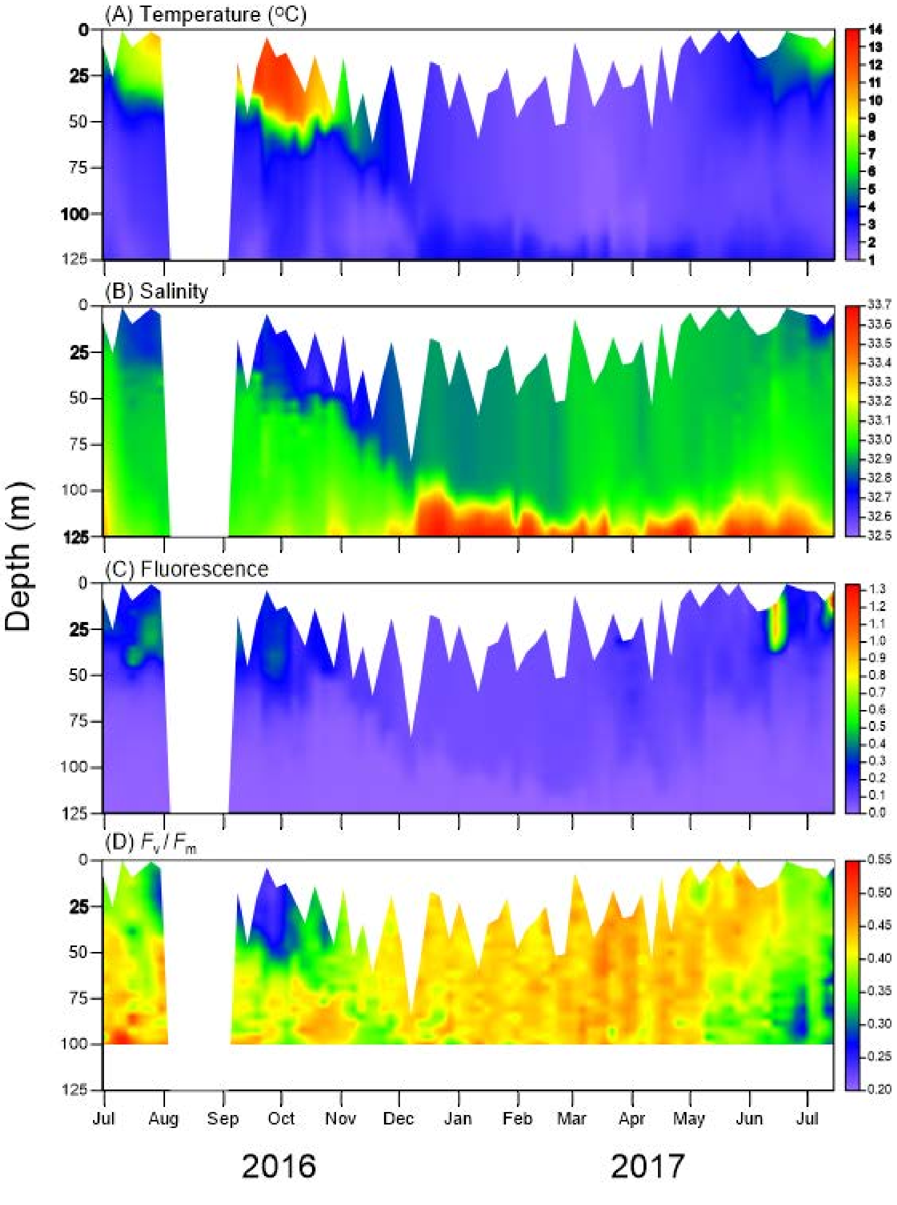


Fig. 2.2.1(c)-1 Vertical and temporal maps of (A) temperature (°C), (B) salinity, (C) fluorescence and (D) potential photosynthetic activity (F_v/F_m) at station K2

2.2.1(d) Remote Automatic water Sampler (RAS)

Masahide WAKITA **JAMSTEC MIO**
Hiroshi UCHIDA **JAMSTEC RCGC**
Yoshihisa MINO **Nagoya University**

(1) Pressure, temperature, salinity and dissolved oxygen at RAS

Pressure, temperature and salinity by SBE-37 SM (Sea-birds) were observed every hour attached on POPPS Winch, RAS, wire and ADCP, sediment trap on Hybrid mooring system. These sensors were located at ~175 db, ~200 db, ~225 db, ~275 db, ~325 db, ~400 db and ~525 db, respectively (Figure 2.2.1(d)-1). The seasonal variation of temperature and salinity were small with depth. However, these sensors were deepened by 150 - 240 db from August 2016 to early September 2016. It is suspected that strong current took place and mooring system might be largely forced to be tilted.

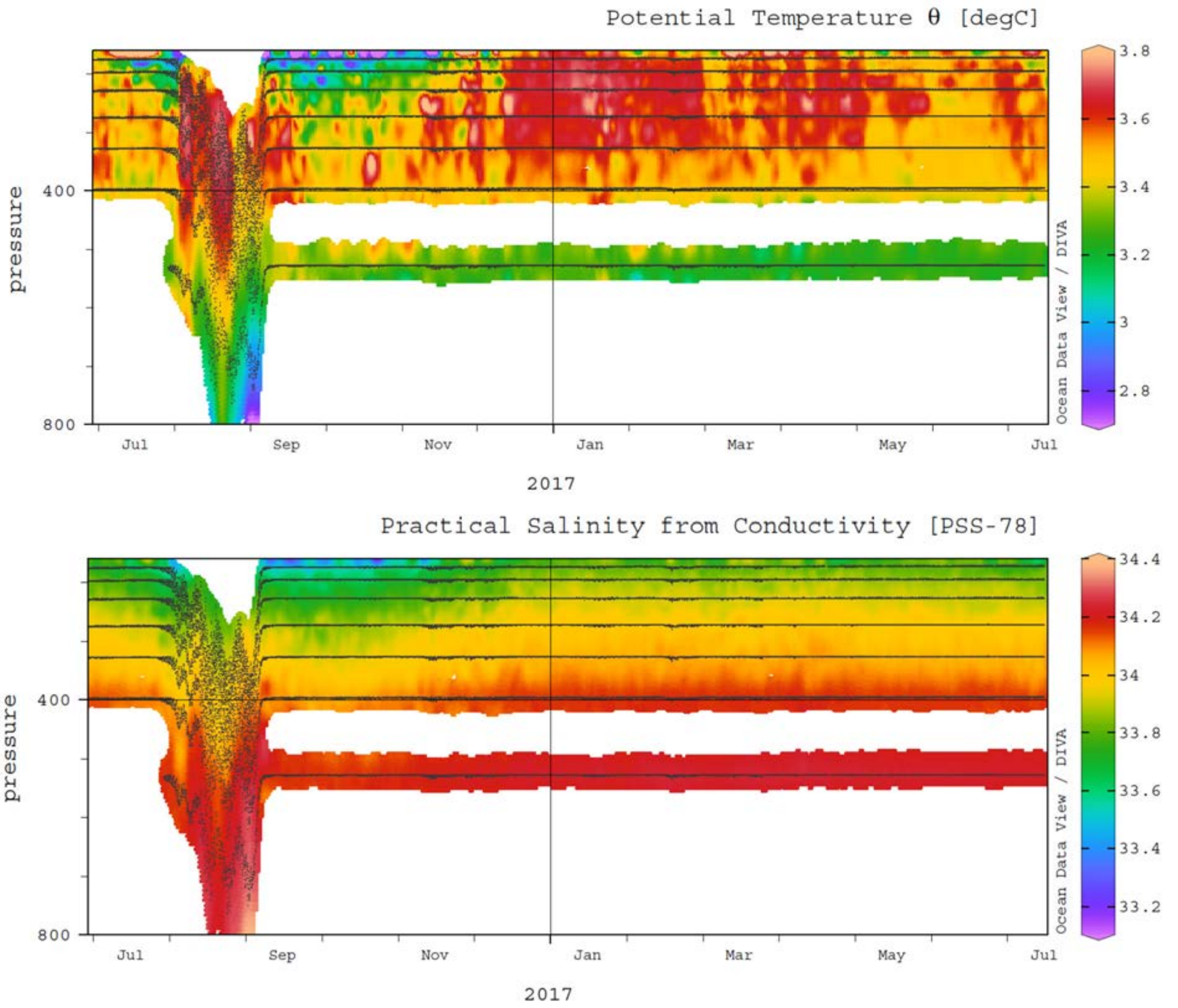


Figure 2.2.1(d)-1 Potential temperature and Salinity at the K2 hybrid mooring during deployment

(2) Chemical analysis of RAS sample

RAS on 225 db and 325 db worked and will obtain samples of dissolved inorganic carbon (DIC), total alkalinity (TA), nutrients (Phosphate, Nitrate + Nitrite, Silicate), $^{15}NO_3^-$ and salinity. DIC, TA, nutrients and salinity were measured on board. $^{15}NO_3^-$ will be measured by Nagoya Univ. These properties were obtained from 10 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System for calibration on RAS samples at K2 during OS026-Leg2 and this cruise. However, the volumes of some sample bags were quite small. These samples (green number in Table 2.2.1(d)-1) leaked with holes and couldn't measure DIC, TA, nutrients, density, $^{15}NO_3^-$ and salinity

Salinity of RAS seawater samples were measured by salinometer (Model 8400B "AUTOSAL" Guildline Instruments). Salinity of RAS samples should be lower than ambient seawater, because RAS samples were diluted with 20% saturated $HgCl_2$ solution. Salinity measured by salinometer will be slightly lower than that observed by SBE-37 sensor (CTD). RAS samples (~500ml) were diluted with 2.5 ml of 20% saturated $HgCl_2$ solution for preservative. For chemical properties, the dilutions of RAS samples by $HgCl_2$ must be corrected by a ratio of salinity by SBE-37 to that by salinometer. However, we will correct measurements of DIC, TA, nutrients.

Table 2.2.1(d)-1 Sampling schedule of RAS on Hybrid mooring at station K2

	RAS 200m		**RAS 300m**			
RAS No.	S/N 11241-09		SN 11241-11		Memo	
	Interval 10 days		Interval 10 days			
#	mm/dd/yyyy	Time(UTC)	mm/dd/yyyy	Time(UTC)		
1	06/30/2016	16:00:00	06/30/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	Interval 1 hour for duplicate sampling
2	06/30/2016	17:00:00	06/30/2016	17:00:00	20% Saturated $HgCl_2$ 0.5ml	
3	07/10/2016	16:00:00	07/10/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
4	07/20/2016	16:00:00	07/20/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
5	07/30/2016	16:00:00	07/30/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
6	08/09/2016	16:00:00	08/09/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
7	08/19/2016	16:00:00	08/19/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
8	08/29/2016	16:00:00	08/29/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
9	09/08/2016	16:00:00			20% Saturated $HgCl_2$ 0.5ml	
10	09/18/2016	16:00:00	09/08/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
11	09/28/2016	16:00:00	09/18/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
12	10/08/2016	16:00:00	09/28/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
13	10/18/2016	16:00:00	10/08/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
14	10/28/2016	16:00:00	10/18/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
15	11/07/2016	16:00:00	10/28/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
16	11/17/2016	16:00:00	~~11/07/2016~~	~~16:00:00~~	20% Saturated $HgCl_2$ 0.5ml	
17	~~11/27/2016~~	~~16:00:00~~	11/17/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
18	12/07/2016	16:00:00	11/27/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
19	12/17/2016	16:00:00	12/07/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	Interval 1 hourfor duplicate sampling
20	12/17/2016	17:00:00	12/17/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
21	12/27/2016	16:00:00	12/17/2016	17:00:00	20% Saturated $HgCl_2$ 0.5ml	
22	01/06/2017	16:00:00	12/27/2016	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
23	~~01/16/2017~~	~~16:00:00~~	01/06/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
24	01/26/2017	16:00:00	01/16/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
25	02/05/2017	16:00:00	01/26/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
26	02/15/2017	16:00:00	~~02/05/2017~~	~~16:00:00~~	20% Saturated $HgCl_2$ 0.5ml	
27	02/25/2017	16:00:00	~~02/15/2017~~	~~16:00:00~~	20% Saturated $HgCl_2$ 0.5ml	
28	03/07/2017	16:00:00	02/25/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
29	03/12/2017	16:00:00	03/07/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	Interval 5 days for winter sampling
30	03/17/2017	16:00:00	03/12/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
31	03/27/2017	16:00:00	03/17/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
32	04/06/2017	16:00:00	~~03/27/2017~~	~~16:00:00~~	20% Saturated $HgCl_2$ 0.5ml	
33	04/16/2017	16:00:00	~~04/06/2017~~	~~16:00:00~~	20% Saturated $HgCl_2$ 0.5ml	
34	04/26/2017	16:00:00	04/16/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
35	05/06/2017	16:00:00			20% Saturated $HgCl_2$ 0.5ml	
36	05/16/2017	16:00:00	04/26/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	Interval 1 hour for duplicate sampling
37			05/06/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
38	05/16/2017	17:00:00	05/16/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
39			05/16/2017	17:00:00	20% Saturated $HgCl_2$ 0.5ml	
40	05/26/2017	16:00:00	05/26/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
41			06/05/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
42	06/05/2017	16:00:00			20% Saturated $HgCl_2$ 0.5ml	
43			06/15/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
44	06/15/2017	16:00:00	06/25/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	Interval 1 hour for duplicate sampling
45			06/25/2017	17:00:00	20% Saturated $HgCl_2$ 0.5ml	
46	06/25/2017	16:00:00	07/05/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
47			07/15/2017	16:00:00	20% Saturated $HgCl_2$ 0.5ml	
48	07/05/2017	16:00:00			20% Saturated $HgCl_2$ 0.5ml	

2.2.1(e) Hybrid pH sensor

Yoshiyuki NAKANO JAMSTEC MARITEC

(1) Objective

We have been developing newly stable and accurate *in situ* system for pH measurement using hybrid technique (potentiometric and spectrophotometric). In this cruise, we aim at testing the new Hybrid pH sensor (HpHS) in the open sea. We recovered HpHS at K2 which was deployed at OS026-Leg2 with Hybrid profiling buoy system (200m). The HpHS was deployed mooring with Hybrid profiling buoy system (200m) in this cruise for about one year.

(2) Method

The HpHS is constituted two types of pH sensors (i.e. potentiometric pH sensor and spectrophotometric pH sensor). The spectrophotometric pH sensor can measure pH correctly and stably, however it needs large power consumption and a lot of reagents in a long period of observation. On the other hand, although the potentiometric pH sensor is low power consumption and high-speed response (within 20 seconds), drifts in the pH of the potentiometric measurements may possibly occur for a long period of observation. The HpHS can measure in situ pH correctly and stably combining advantage of both pH sensors. The HpHS is correcting the value of the potentiometric pH sensor (measuring frequently) by the value of the spectrophotometric pH sensor (measuring less frequently). It is possible to calibrate in situ with standard solution (Tris buffer) on the spectrophotometric pH sensor. Therefore, the drifts in the value of potentiometric pH measurements can be compensated using the pH value obtained from the spectrophotometric pH measurements. Thereby, the sensor can measure accurately the value of pH over a long period of time with low power consumption.

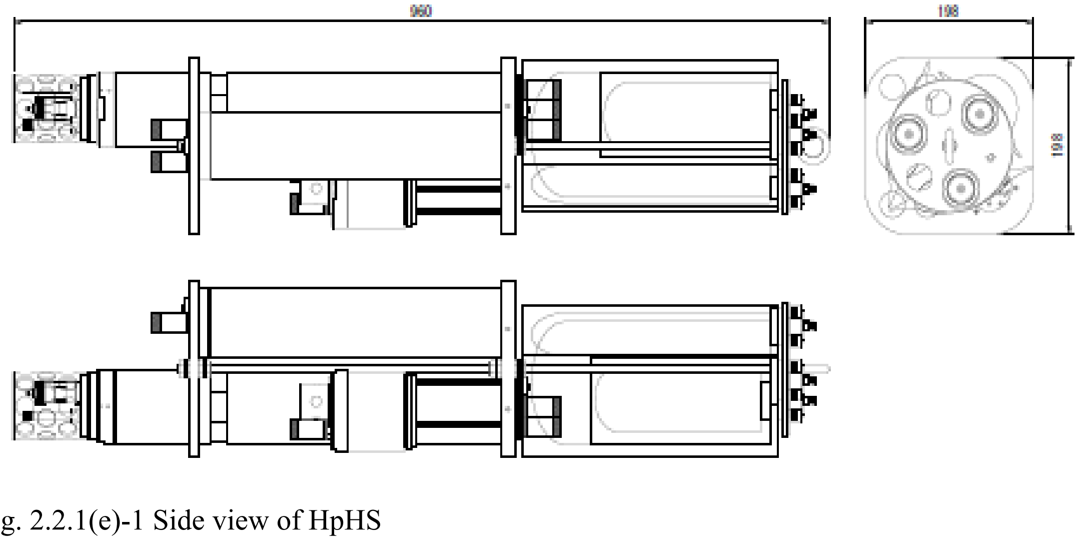


Fig. 2.2.1(e)-1 Side view of HpHS

Table 2.2.1(e)-1 Specification of HpHS

	Potentiometry	Spectrophotometry
Range	6.0～8.3 pH	7.2～8.2 pH
Initial Accuracy	0.01 pH	0.002 pH
Analytical Method	Glass Electrode	m-cresol purple
Response speed	20 sec (90%, 25 deg C)	3 min (90%)
Resolution	0.001 pH	
Sample rate	1 sec	
Temperature range	0～40 deg C (Resolution: 0.01 deg C)	
Dimension	198×198×960 mm	
Weight	10 kg（in air）	
Depth rating	3,000 m	

(3) Results

We succeeded in recovering the HpHS with RAS in Hybrid profiling buoy system and obtaining long term (about one year) pH data every four hours.

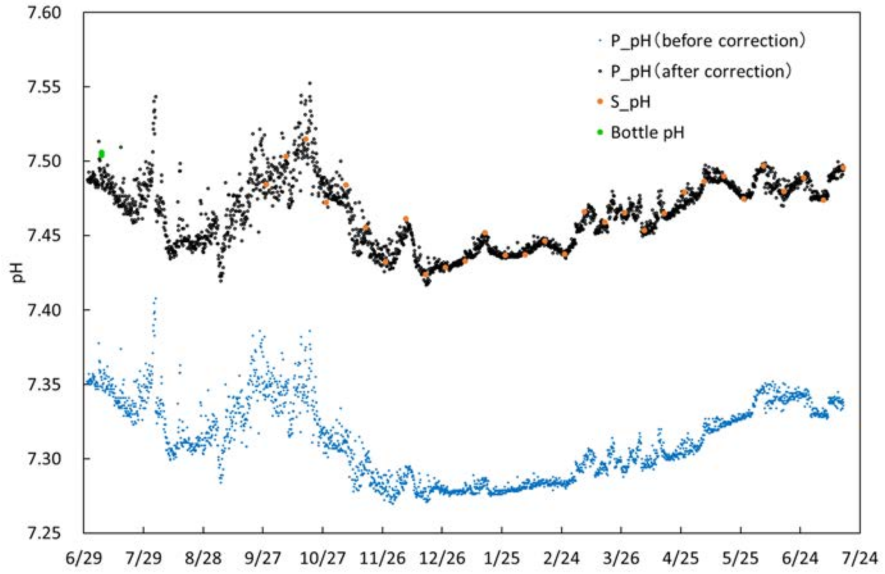


Fig. 2.2.1(e)-2 Diurnal and seasonal changes of pH for a year at 200m depth from 27 June 2016 to 15 July 2017 in the station K2. Variations of potentiometric pH (P_pH (before correction) ●, P_pH (after correction) ●), spectrophotometric pH (S_pH ●) and bottle sampling pH ● by OS026-Leg2. The HpHS succeeded in correcting the drifts of potentiometric pH by using spectrophotometric pH value in early mooring.

(4) Data Archive

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

Reference

DICKSON, A.G., SABINE, C.L. and CHRISTIAN, J.R. (Eds.) (2007) Guide to best practices for ocean CO_2 measurements. PICES Special Publication 3, 191 pp.

LIU, X., PATSAVAS, M.C. and BYRNE, R.H. (2011) Purification and characterization of meta-cresol purple for spectrophoto-metric seawater pH measurements. Environ. Sci. Technol., 45, pp. 4862-4868.

PATSAVAS, M.C., BYRNE, R.H. and LIU, X. (2013) Purification of meta-cresol purple and cresol red by flash chromatography: Procedures for ensuring accurate spectrophotometric seawater pH measurements. Mer. Chem., 150, pp. 19-24.

2.2.1(f) ADCP

Minoru KITAMURA JAMSTEC RCGC

An Acoustic Doppler Current Profiler (ADCP) was installed at a depth of 370 m on the K2 mooring. Purposes of data samplings (and investigators) are as follows;

(1) to observe seasonal current structure fluctuation (A. Nagano and M. Wakita, JAMSTEC),
(2) to understand zooplankton dynamics (M. Kitamura, JAMSTEC)

Using the former data, we will be able to understand mixing/stratifying processes in the surface layer and nutrient supply to the surface layer due to vertical diffusion. On the other hand, ADCP have been used not only physical oceanography but also biological researches. That is, zooplankton biomass can be estimated using acoustic backscattering intensities collected from ADCP. So, we will also analyze zooplankton dynamics at K2.

Specifications

Model: Workhorse LongRanger (Teledyne RD Instruments, Poway, CA, USA)
S/N: 1533 (recovered ADCP), 1434 (deployed ADCP)
Frequency: 75 kHz
Max. depth: 1500m
Dimensions: 1014 mm in length, 550 mm in width
Weights: ADCP; 86 kg in air and 55 kg in water
Frame; 46 kg in water (recovered), 54 kg in air and 47 kg in water (deployed)
Beam angle/width: 20°/4°
DC input: 20-60VDC, four internal alkaline battery packs
Voltage: 42V DC (new), 28V DC (depleted)
Velocity resolution: 1mm/s

Setting parameters for data sampling

Depth cell size: 8 m
Number of depth cells: 60
Ping per ensemble: 30
Intervals: 60 min.
Mode: Broadband mode

2.2.1(g) Sediment trap

Minoru KITAMURA JAMSTEC RCGC

(1) Objective

To observe long-term trend of the sinking carbon flux at K2, the sediment trap experiment is conducted. Two sediment traps which moored at 500 m and 4810 m were recovered from the K2H160629 mooring on 17 July, 2017. And two traps were newly installed at 1000 m and 4810 m in the K2H170721 mooring which deployed on 21 July, 2017.

(2) Description of instruments

Two kinds of sediment trap were used in this experiment, MARK78H-21 (McLane Research Laboratories, INC., MA, USA) and SMD26S-6000 (NiGK Corporation, Tokyo, Japan). The former trap which had 21 sampling cups was installed at 500 and 4810 m of the recovered mooring, and 4810 m of the deployed mooring. Sampling interval of the McLane trap was every 18 days for the recovered mooring and 20 days for the deployed one. The latter model of trap with 26 sampling cups was attached at 1000 m of the deployed mooring. Shorter interval of sampling (10 days) will be scheduled during the season of high primary productivity while samplings will be conducted every 20 days in other seasons. Specifications and serial numbers of the two traps are summarized in the following tables:

Table 2.2.1(g)-1 Specifications of two sediment traps

	SMD26S-6000 (NiGK Corporation)	MARK78H-21 (McLane Research Lab.)
Max. depth (m)	6000	7000
Dimensions (diameter × height, cm)	104 × 160	91 ×164
Mouth area (m^2)	0.5	0.5
sWeights (kg)	86 in air, 46 in water	72 in air, 39 in water
No. of sampling bottles	26	21
Volume of sampling bottles (ml)	270	250
Battery	Alkaline/Lithium pack	14 Alkaline batteries or a Battery pack
Communication cables	RMG4-USB	RMG3-Serial port-USB
Software	N-SMD	Crosscut
OS	Win 7	Win 7

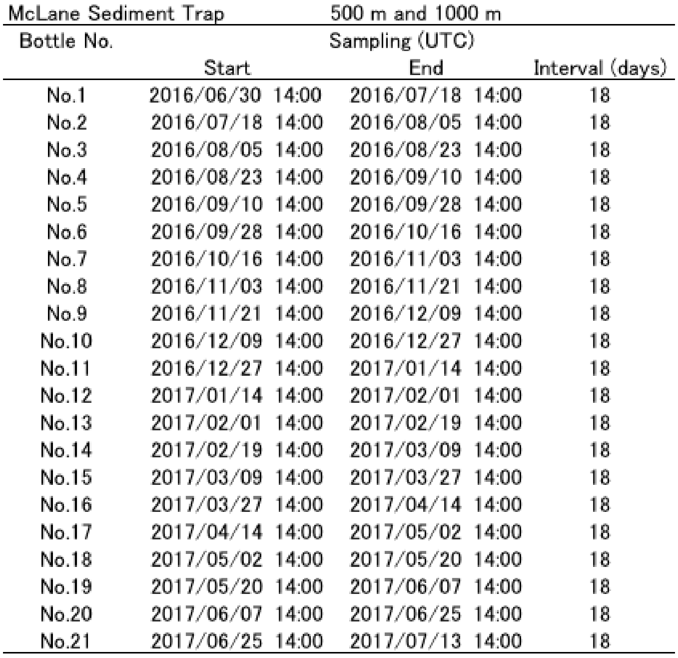
Table 2.2.1(g)-2 Serial numbers and battery types

	Model	S/N	Battery
Recovery from			
500 m	McLane, MARK78H-21	ML10236-02	Battery pack
4810 m	McLane, MARK78H-21	ML10558-01	14 Alkaline batteries
Deployed at			
1000 m	NiGK, SMD26S-6000	26S001	Alkaline/Lithium pack
4810 m	McLane, MARK78H-21	ML11241-22	14 Alkaline batteries

(3) Sampling schedules

Sampling schedules of the recovered and deployed sediment traps were summarized in the following tables. Internal clock of each sediment trap was set in UTC. The deployed mooring systems will be recovered during Mirai cruise held in 2018.

Table 2.2.1(g)-3 Sampling schedules of the recovered trap



McLane Sediment Trap 500 m and 1000 m

Bottle No.	Sampling (UTC)		
	Start	End	Interval (days)
No.1	2016/06/30 14:00	2016/07/18 14:00	18
No.2	2016/07/18 14:00	2016/08/05 14:00	18
No.3	2016/08/05 14:00	2016/08/23 14:00	18
No.4	2016/08/23 14:00	2016/09/10 14:00	18
No.5	2016/09/10 14:00	2016/09/28 14:00	18
No.6	2016/09/28 14:00	2016/10/16 14:00	18
No.7	2016/10/16 14:00	2016/11/03 14:00	18
No.8	2016/11/03 14:00	2016/11/21 14:00	18
No.9	2016/11/21 14:00	2016/12/09 14:00	18
No.10	2016/12/09 14:00	2016/12/27 14:00	18
No.11	2016/12/27 14:00	2017/01/14 14:00	18
No.12	2017/01/14 14:00	2017/02/01 14:00	18
No.13	2017/02/01 14:00	2017/02/19 14:00	18
No.14	2017/02/19 14:00	2017/03/09 14:00	18
No.15	2017/03/09 14:00	2017/03/27 14:00	18
No.16	2017/03/27 14:00	2017/04/14 14:00	18
No.17	2017/04/14 14:00	2017/05/02 14:00	18
No.18	2017/05/02 14:00	2017/05/20 14:00	18
No.19	2017/05/20 14:00	2017/06/07 14:00	18
No.20	2017/06/07 14:00	2017/06/25 14:00	18
No.21	2017/06/25 14:00	2017/07/13 14:00	18

Table 2.2.1(g)-4 Sampling schedules of the deployed traps

NiGK Sediment Trap 1000 m

Bottle No.	Sampling (UTC, yyyy/mm/dd)		
	Start	End	Interval (days)
No.1	2017/07/22 13:00	2017/08/11 13:00	20
No.2	2017/08/11 13:00	2017/08/31 13:00	20
No.3	2017/08/31 13:00	2017/09/20 13:00	20
No.4	2017/09/20 13:00	2017/10/10 13:00	20
No.5	2017/10/10 13:00	2017/10/30 13:00	20
No.6	2017/10/30 13:00	2017/11/19 13:00	20
No.7	2017/11/19 13:00	2017/12/09 13:00	20
No.8	2017/12/09 13:00	2017/12/29 13:00	20
No.9	2017/12/29 13:00	2018/01/18 13:00	20
No.10	2018/01/18 13:00	2018/02/07 13:00	20
No.11	2018/02/07 13:00	2018/02/27 13:00	20
No.12	2018/02/27 13:00	2018/03/19 13:00	20
No.13	2018/03/19 13:00	2018/04/08 13:00	20
No.14	2018/04/08 13:00	2018/04/28 13:00	20
No.15	2018/04/28 13:00	2018/05/08 13:00	10
No.16	2018/05/08 13:00	2018/05/18 13:00	10
No.17	2018/05/18 13:00	2018/05/28 13:00	10
No.18	2018/05/28 13:00	2018/06/07 13:00	10
No.19	2018/06/07 13:00	2018/06/17 13:00	10
No.20	2018/06/17 13:00	2018/06/27 13:00	10
No.21	2018/06/27 13:00	2018/07/07 13:00	10
No.22	2018/07/07 13:00	2018/07/17 13:00	10
No.23	2018/07/17 13:00	2018/07/27 13:00	10
No.24	2018/07/27 13:00	2018/08/06 13:00	10
No.25	2018/08/06 13:00	2018/08/26 13:00	20
No.26	2018/08/26 13:00	2018/09/15 13:00	20

McLane Sediment Trap 4800 m

Bottle No.	Sampling (UTC)		
	Start	End	Interval (days)
No.1	2017/07/22 13:00	2017/08/11 13:00	20
No.2	2017/08/11 13:00	2017/08/31 13:00	20
No.3	2017/08/31 13:00	2017/09/20 13:00	20
No.4	2017/09/20 13:00	2017/10/10 13:00	20
No.5	2017/10/10 13:00	2017/10/30 13:00	20
No.6	2017/10/30 13:00	2017/11/19 13:00	20
No.7	2017/11/19 13:00	2017/12/09 13:00	20
No.8	2017/12/09 13:00	2017/12/29 13:00	20
No.9	2017/12/29 13:00	2018/01/18 13:00	20
No.10	2018/01/18 13:00	2018/02/07 13:00	20
No.11	2018/02/07 13:00	2018/02/27 13:00	20
No.12	2018/02/27 13:00	2018/03/19 13:00	20
No.13	2018/03/19 13:00	2018/04/08 13:00	20
No.14	2018/04/08 13:00	2018/04/28 13:00	20
No.15	2018/04/28 13:00	2018/05/18 13:00	20
No.16	2018/05/18 13:00	2018/06/07 13:00	20
No.17	2018/06/07 13:00	2018/06/27 13:00	20
No.18	2018/06/27 13:00	2018/07/17 13:00	20
No.19	2018/07/17 13:00	2018/08/06 13:00	20
No.20	2018/08/06 13:00	2018/08/26 13:00	20
No.21	2018/08/26 13:00	2018/09/15 13:00	20

(4) Result

Sequential samples of the sinking particles were collected both from the 500 m and 4810 m recovery traps. Onboard, heights of the particle samples in the collecting cups were measured with scale in order to know general view of their seasonal change. Using base area of collecting cup (18.1 cm^2), we estimated volume flux for each collecting period (18 days). We also measured pH of seawater in collecting cups onboard. The volume flux (cm^3/m^2/day), and pH for each sample were summarized in the table. And seasonal change of the volume fluxes at the two depths were shown in the following figure.

Table 2.2.1(g)-5 Time-series of the volume fluxes and pH in the sample bottles

Sta. K2 recoverd sediment trap, Bottle pH and volume flux measured by KK_2017.07.17

500m	pH (NBS Scale)	Height (cm)	Flux (cm3/m2/d)	remarks	**4810m**	pH (NBS Scale)	Height (cm)	Flux (cm3/m2/d)	remarks
#1	7.35	3.8	7.6		#1	7.98	2.0	4.0	
#2	7.58	4.5	9.1		#2	7.97	3.8	7.6	
#3	7.07	0.5	1.0		#3	7.89	1.8	3.6	
#4	7.63	0.5	1.0		#4	7.91	2.5	5.0	
#5	7.54	4.2	8.4		#5	7.99	1.6	3.2	
#6	7.57	3.3	6.6		#6	8.03	1.0	2.0	
#7	7.67	3.0	6.0		#7	8.04	0.9	1.8	
#8	7.60	1.5	3.0		#8	7.72	1.4	2.8	
#9	7.60	1.2	2.4		#9	8.08	0.8	1.6	
#10	7.62	1.5	3.0		#10	8.12	0.8	1.6	
#11	7.55	1.0	2.0		#11	8.20	0.7	1.4	
#12	7.85	0.8	1.6		#12	8.18	0.5	1.0	
#13	7.96	0.8	1.6		#13	8.26	0.5	1.0	
#14	7.92	0.5	1.0		#14	8.25	0.8	1.6	
#15	7.95	0.5	1.0		#15	8.20	0.6	1.2	
#16	7.87	2.0	4.0		#16	8.18	0.8	1.6	
#17	7.67	5.0	10.1		#17	8.22	1.4	2.8	
#18	7.80	3.2	6.4		#18	8.22	2.8	5.6	
#19	7.91	2.2	4.4		#19	8.33	2.5	5.0	
#20	7.14	2.5	5.0	shrimp	#20	8.37	1.8	3.6	
#21	7.50	4.5	9.1		#21	8.39	1.0	2.0	

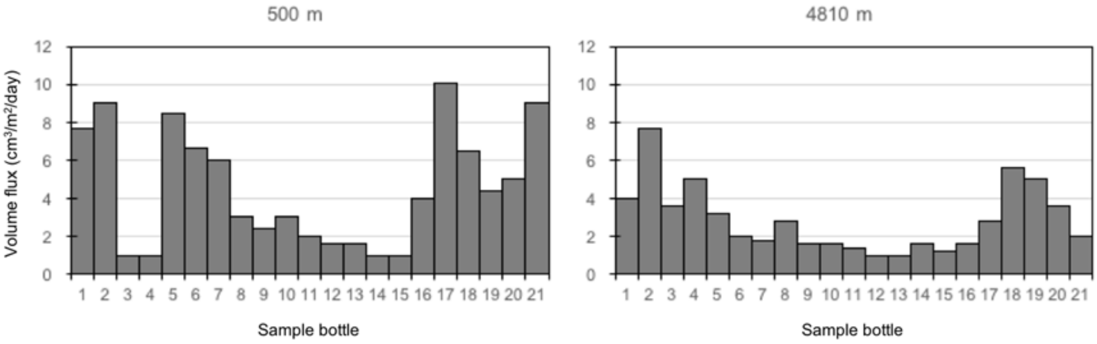


Figure 2.2.1(g)-1 Seasonal changes of volume fluxes at 500 and 4810 m of the station K2

(5) Sample archives

All samples are stored in JAMSTEC/Yokosuka. Each sample will be divided into ten aliquots and these subsamples will be distributed to co-researchers for further analysis by cruise PI.

2.2.2 Multi Observation Glider

Kensuke WATARI	**JAMSTEC MARITEC**
Fumitaka SUGIMOTO	**JAMSTEC MARITEC**
Satoshi TSUBONE	**Interlink Co.Ltd**
Tomohiko SUGIYAMA	**MWJ**

(1) Objective

In the rapidly changing global environment, the problem of the greatest environmental stress is the collapse of the ecosystem. Especially, the influence is remarkable in the Bering Sea from the world's most productive North Pacific Subarctic. Measurement by hanging a sensor from a ship allows precise measurement, while the spatial and temporal degrees of freedom are constrained by ship time. In order to solve this problem, we would like to advance elucidation of the ecological mechanism by collecting wider data by installing FRRF in an autonomous underwater glider and observing the sea area. In this observation, FRRF was mounted on underwater glider and experimental observation was carried out.

(2) Description of instruments deployed

Developed for this observation, the FRRF-mounted underwater glider "MOG" is a testing machine for underwater gliders for observation equipped with a common platform "MOF system" under development by JAMSTEC. It is a underwater glider with a propulsion function equipped with a live primary battery, a buoyancy adjustment mechanism, a pitch adjustment mechanism, and a swing thruster. It has a CTD sensor, depth sensor, acceleration sensor, geomagnetic sensor, gyro sensor, and has a function that can move to any set direction and depth. The main body can transmit and receive data by iridium communication, and the operation period varies depending on the observation sequence and mounted sensors, but the tester assumes observations around 10 days. In this observation, FRRF (manufactured by Kimoto Electronics) was mounted on 3 MOGs and observed. In addition, another tester that evaluated the CTD sensor was inserted separately.

The entry date and observation point are shown in the table below.

Table 2.2.2-1 Launch and Recovery day

Launch Date	Machine No	Recovery Date	Option Sensor
2017/7/15	3	2017/7/16	-
2017/7/16	3	2017/7/17	-
2017/7/17	2	2017/7/19	-
2017/7/17	3	2017/7/19	-
2017/7/17	4	LOST	Dissolved oxygen
2017/7/19	1	2017/7/19	High Rate CTD

All inputs and collections were done with a rubber boat equipped with "MIRAI". Dive depth is 160 m, profile observation of CTD and FRRF at sedimentation is carried out.

Figure 2.2.2-1 State of launch. Can be launched alone

(3) Result

MOG is introduced into the sea area around K2 and is set to observe its vicinity. Fig2.2.2-2 shows GPS coordinates sent from the MOG at the time of levitation. We observe by submerging to interpolate coordinate points. The data observed by the CTD sensor are shown in Fig.2.2.2-3. Since the CTD sensor is attached to the lower part of the main body of the MOG, observation is carried out at the time of settling. This is to improve the introduction of seawater into the sensor.

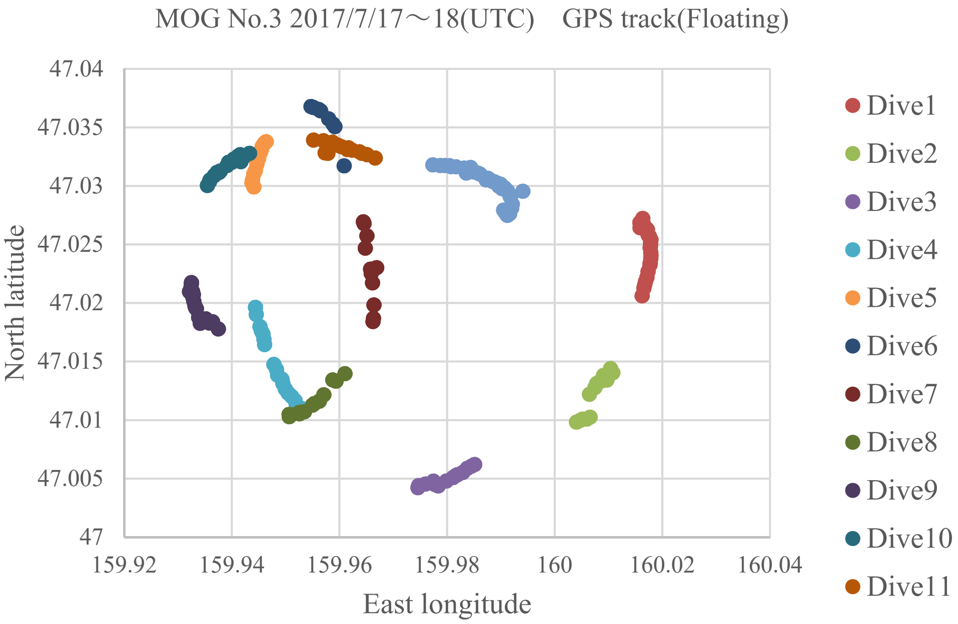


Figure 2.2.2-2 MOG GPS track

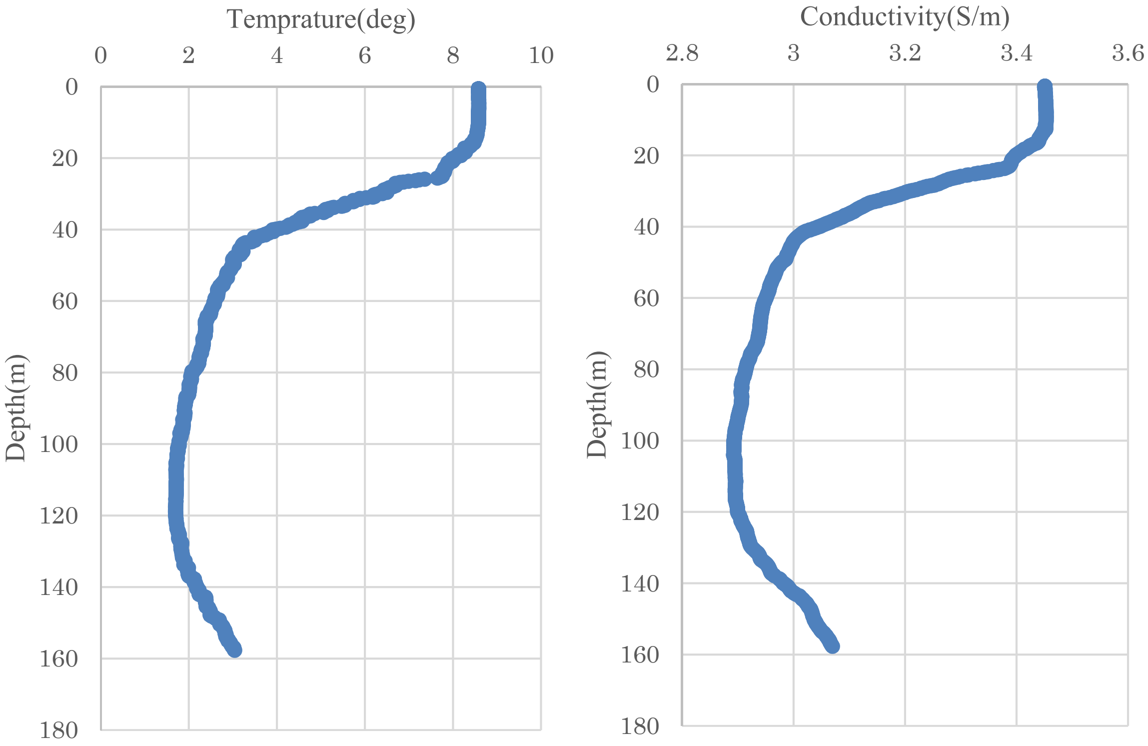


Figure 2.2.2-3 Observation data by MOG

In this voyage, observations were made in a single sequence to shorten the development process. However, in order to reduce the effectiveness of FRRF and power consumption, we would like to observe at arbitrary timing in the future. Furthermore, in order to improve the observation accuracy of each sensor, it is a future subject to control finer dive behavior.

(4) Data archive

These obtained data will be submitted to JAMSTEC Data Management Group (DMG).

2.2.3. Argo floats

Shuhei MASUDA	**JAMSTEC RCGC: Principal Investigator (not on board)**
Shigeki HOSODA	**JAMSTEC RCGC (not on board)**
Mizue HIRANO	**JAMSTEC RCGC (not on board)**
Shingo OSHITANI	**MWJ: Operation Leader**

(1) Objectives

The objective of this study is to clarify the mechanisms of climate and oceanic environment variability for understanding changes of earth system through estimations of heat and material transports, and to improve their long-term forecasts of climate changes, by sustainably monitoring in the global ocean. To achieve the objective, automatically long-term measurements of physical and biogeochemical parameters are carried out to deploy Argo floats at the biogeochemical mooring station K2 in the western North Pacific Ocean.

One biogeochemical Argo (BGC APEX) float measures vertical profiles of biogeochemical parameters with temperature and salinity down to a depth of 2000dbar to clarify changes of phytoplankton and dissolved oxygen concentrations related to physical and biological processes. In collaboration with shipboard and mooring observations, long-term and spatial variability of marine materials and biogeochemical process will be detected in the western subpolar North Pacific region where seasonal variability of primary production is large. The deployed float will also contribute to the international project of biogeochemical (BGC) Argo for the construction of global BGC Argo array.

Also, one deep Argo float (RINKO-Deep NINJA) measures vertical profiles of temperature, salinity and dissolved oxygen down to a depth of 4000dbar to clarify changes of deep ocean environment, circulation and water mass. Since deep Argo float observes frequent vertical profiles with fine vertical resolution, accurate variability in the deeper ocean which was difficult to obtain previous shipboard and mooring observations in the western subpolar North Pacific region where the global ocean circulation is upwelling. The deployed deep Argo float will also contribute to construct global deep Argo array for the purpose to detect changes of heat storage associated with climate changes.

The deep and BGC Argo float data will also apply to the ESTOC, which is 4D-VAR data assimilation system to estimate state of global ocean for climate changes, to investigate whole mechanism of long-term changes in the ocean.

(2) Parameters

Water temperature, salinity, pressure, dissolved oxygen, back scattering, CDOM and chlorophyll

(3) Methods

i. Profiling float deployment for Biogeochemical Argo

We launched APEX Biogeochemical (BGC) float manufactured by Teledyne Webb Research. This float equipps SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc., Optode4330 dissolved oxygen sensor manufactured AANDERAA, and backscattering, CDOM and chlorophyll sensors manufactured by WET Labs.

The float drifts at a depth of 1000 dbar (called the parking depth) during waiting measurement, then goes upward from a depth of 2000 dbar to the sea surface every 2 days. During the ascent, physical and biogeochemical values are measured every 2 dbar or at decided depths in advance following depth table. During surfacing for approximately half an hour, the float sends the all measured data to the land via through the Iridium Rudics system. Those float observation cycle will be continuously conducted for about two years. The status of float and its launching information is shown in Table 2.2.3-1.

Table 2.2.3-1 Status of floats and their launches

APEX BGC Float(2000dbar)

Float Type	APEX BGC float manufactured by Teledyne Webb Research.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Oxygen sensor	Optode 4330 manufactured by AANDERAA
Backscatter Fluorescence Chlorophyll	ECO FLbb-AP2 manufactured by WET Labs, Inc. Backscattering: wavelength: 700nm CDOM: ex/em→ 370/460nm Chlorophyll: ex/em→ 470/695nm
Cycle	2days (approximately 30minutes at the sea surface)
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar
Sampling layers	2dbar interval from 2000 dbar to surface (approximately 1000 levels)

Launches

Float S/N	WMOID	Date and Time of Launch(UTC)	Location of Launch	CTD St. No.
7884	2903210	2017/7/23 23:03	47-00.05[N] 160-01.32[E]	K2

ii. Profiling float deployment for Deep Argo

We also launched Deep float (RINKO Deep NINJA) manufactured by Tsurumi Seiki Co.,Ltd. This float equipps SBE41 CTD for deep sensor manufactured by Sea-Bird Electronics Inc. and RINKO ARO-FT dissolved oxygen sensor by JFE Advantech Co., Ltd.

The float drifts at a depth of 2000 dbar (called the parking depth) during waiting measurement, then goes upward from a depth of 4000 dbar to the sea surface every 10 days. During the ascent, physical and biogeochemical values are measured at decided depths in advance following depth table. During surfacing for approximately half an hour, the float sends the all measured data to the land via through the Iridium Short Burst data (SBD) service. Those float observation cycle will be continuously conducted for about one year. The status of float and its launching information is shown in Table 2.2.3-2.

Table 2.2.3-2 Status of floats and their launches of DeepFloats

DeepFloat(RINKO Deep NINJA)

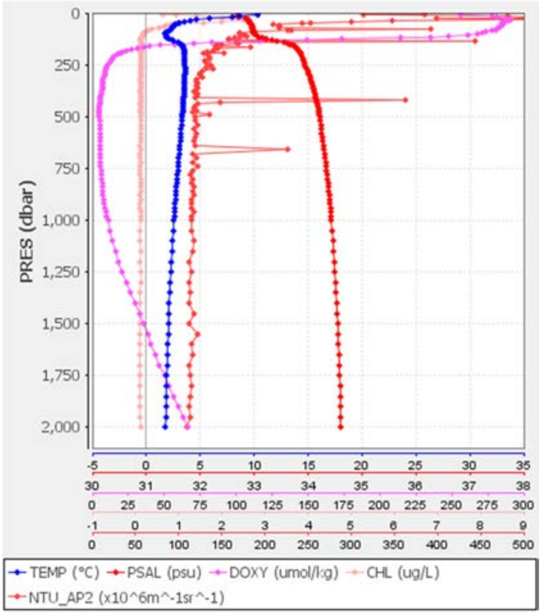
Float Type	DeepNINJA Tsurumi Seiki Co.,Ltd
CTD sensor	SBE41 for Deep manufactured by Sea-Bird Electronics Inc.
Oxygen sensor	RINKO AROD-FT manufactured by JFE Advantech Co., Ltd.
Cycle	10 days (approximately 30minutes at the sea surface)
Iridium transmit type	Short Burst Data Service (SBD)
Target Parking Pressure	2000 dbar
Sampling layers	5dbar interval from 4000 dbar to surface (approximately 800 layers)

Launches

Float S/N	WMOID	Date and Time of Launch(UTC)	Location of Launch	CTD St. No.
23	2903209	2017/7/23 21:49	47-00.01[N] 160-01.33[E]	K2

(5) Data archive

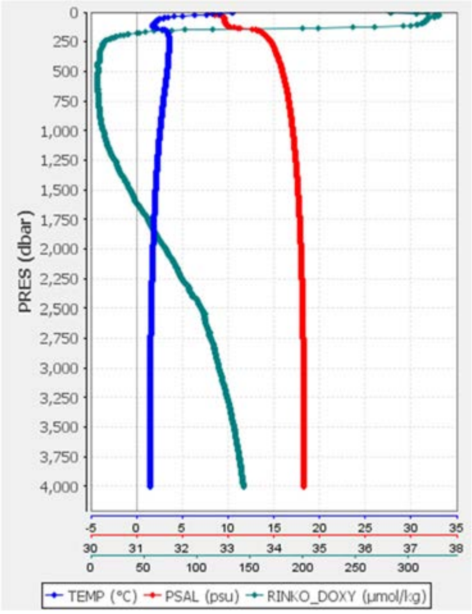
The Argo float data with real-time quality control are provided to meteorological organizations, research institutes, and universities via Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) and Global Telecommunication System (GTS) within 24 hours following the procedure decided by Argo data management team. Delayed mode quality control is conducted for the float data within 6 months ~ 1 year, to satisfy their data accuracy for the use of research. Those quality controlled data are freely available via internet and utilized for not only research use but also weather forecasts and other variable uses. Below figures show vertical profiles of launched BGC APEX (WMO ID:2903210) and RINKO Deep NINJA (WMO ID: 2903209) as samples.



WMO ID:2903210

DATE:2017/07/24 TIME: 20:06:17

POSITION: 47.072N, 160.074E



WMO ID: 2903209

DATE: 2017/07/25 TIME: 2:28:29

POSITION: 47.046N, 160.044E

Fig. 2.2.3-1 Vertical profiles of first measurements on launched BGC and deep Argo floats

2.3. Satellite image acquisition (MCSST from NOAA/HPRT)

Tetsuichi FUJIKI	**JAMSTEC: Principal investigator**
Wataru TOKUNAGA	**NME**
Mitsuteru KUNO	**NME**
Masanori MURAKAMI	**MIRAI crew**

(1) Objectives

The objectives are to collect cloud data in a high spatial resolution mode from the Advance Very High Resolution Radiometer (AVHRR) on the NOAA and MetOp polar orbiting satellites.

(3) Methods

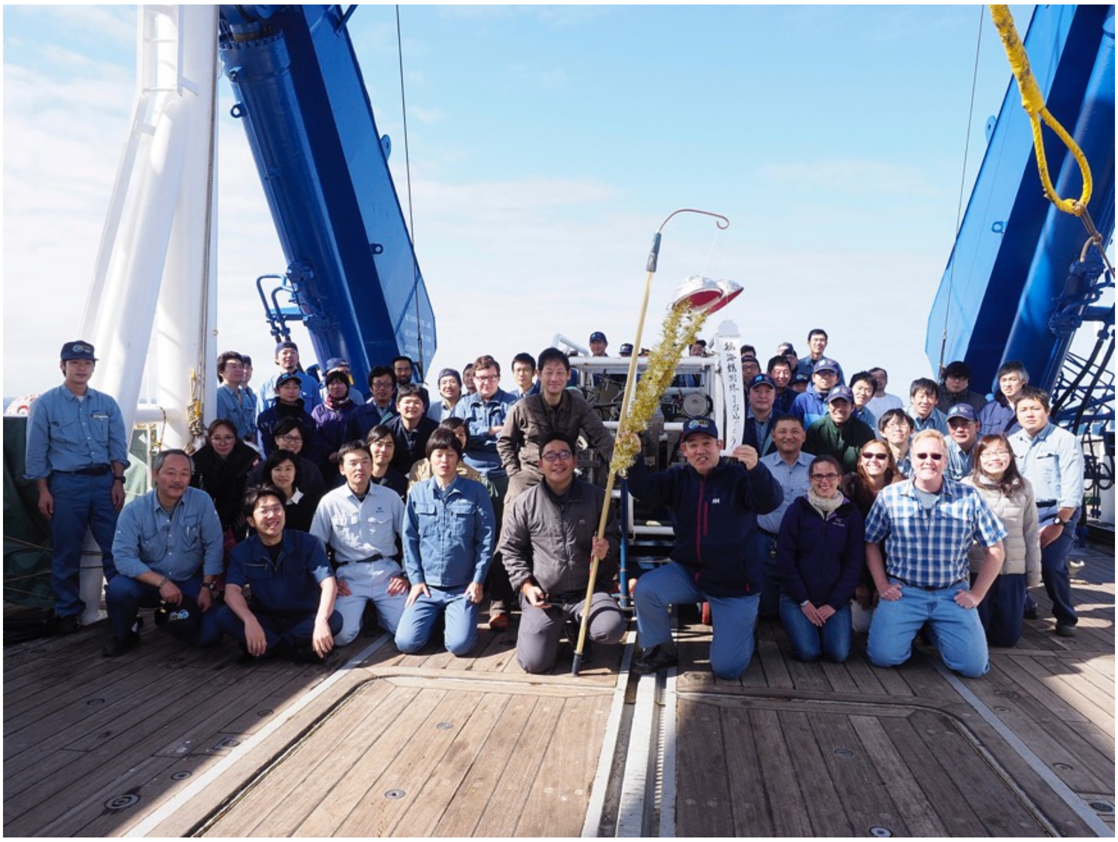
We received the down link High Resolution Picture Transmission (HRPT) signal from satellites, which passed over the area around the R/V MIRAI. We processed the HRPT signal with the in-flight calibration and computed the brightness temperature (MCSST). A cloud image map around the R/V MIRAI was made from the data for each pass of satellites.

We received and processed polar orbiting satellites data throughout this cruise.

(4) Data archives

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

3. “Aleutian Magic” observations in the south-eastern Bering Sea (Leg. 2)



3.1 Ship observations and measurements

3.1.1 Meteorological observations

3.1.1(a) Surface meteorological observations

Yoshihiro FUJIWARA	JAMSTEC: Principal investigator
Souichiro SUEYOSHI	Nippon Marine Enterprises LTD. (NME)
Toshimasa NASU	NME
Masanori MURAKAMI	MIRAI crew

(1) 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.

(2) 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 3.1.1-1 and measured parameters are listed in Table 3.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6 seconds 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 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) 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 data every 6 seconds, CR1000 data every second, air temperature and relative humidity data every 2 seconds and ORG data every 6 seconds. SCS composed Event data (JamMet) from these data and ship's navigation data. Instruments and their locations are listed in Table 3.1.1-3 and measured parameters are listed in Table 3.1.1-4.

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

i) Young rain gauge (SMet and SOAR)
Inspect of the linearity of output value from the rain gauge sensor to change input value by adding fixed quantity of test water.

ii) Barometer (SMet and SOAR)
Comparison with the portable barometer value, PTB220, VAISALA

iii) Thermometer (air temperature and relative humidity) (SMet and SOAR)
Comparison with the portable thermometer value, HM70, VAISALA

(4) Results

Fig. 3.1.1-1 shows the time series of the following parameters;
Wind (SMet)
Air temperature (SOAR)
Relative humidity (SOAR)
Precipitation (SOAR, ORG)
Short/long wave radiation (SOAR)

Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(5) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

(6) Remarks (Times in UTC)

i) The following periods, sea surface temperature of SMet data was available.
19:37 05 Aug. 2017 - 21:15 19 Aug. 2017

Table 3.1.1-1 Instruments and installation locations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side 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
Capacitive 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 3.1.1-2 Parameters of MIRAI Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's log speed	knot	Log, DS-30, Furuno
4 Ship's heading	degree	Gyro,TG-8000,TOKYO-KEIKI
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 3.1.1-3 Instruments and installation locations of SOAR system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Barometer	PTB210	Vaisala, Finland	
with 61002 Gill pressure port		R.M. Young, USA	foremast (23 m)
Capacitive rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
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)

Table 3.1.1-4 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	

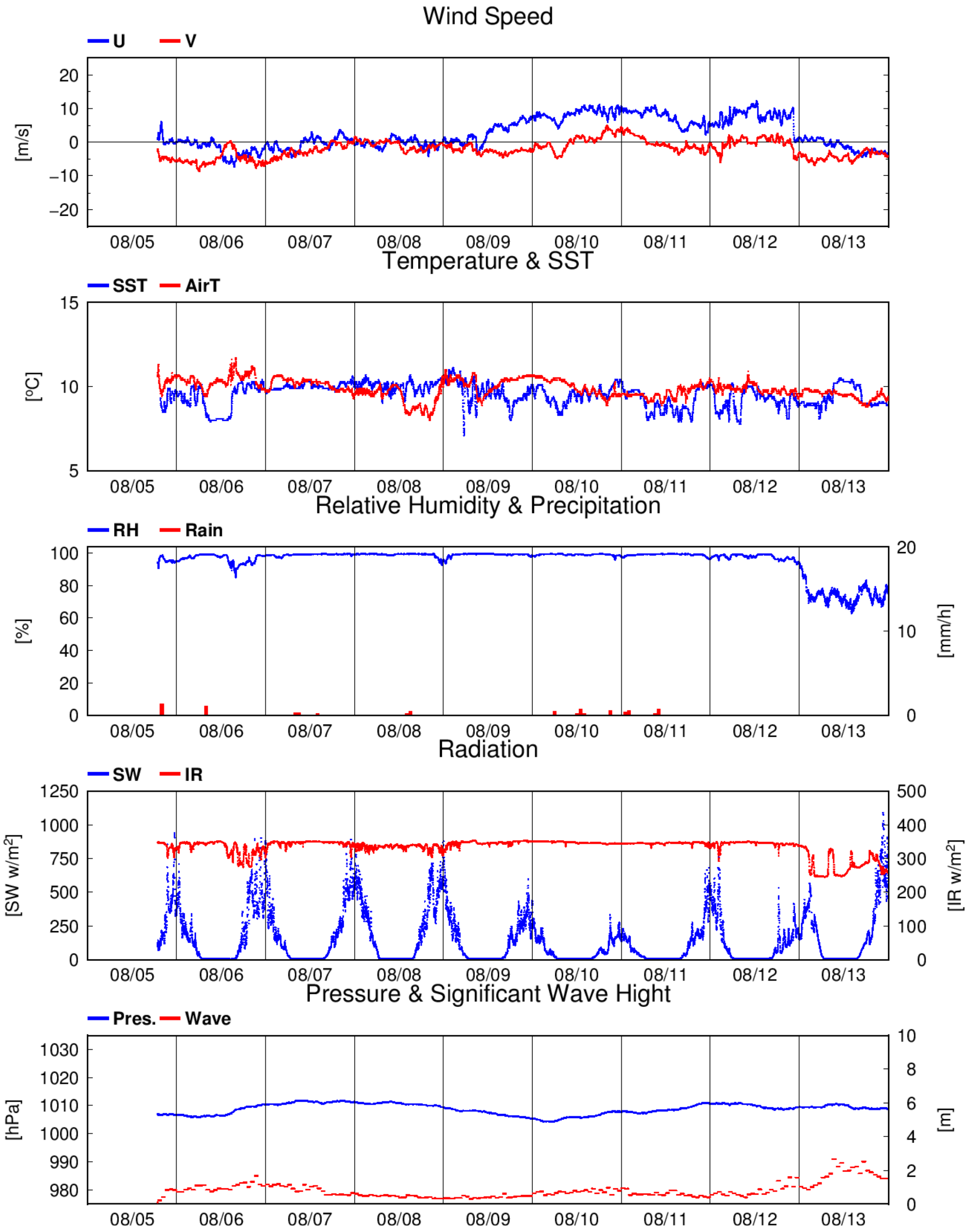


Fig.3.1.1-1 Time series of surface meteorological parameters during this cruise

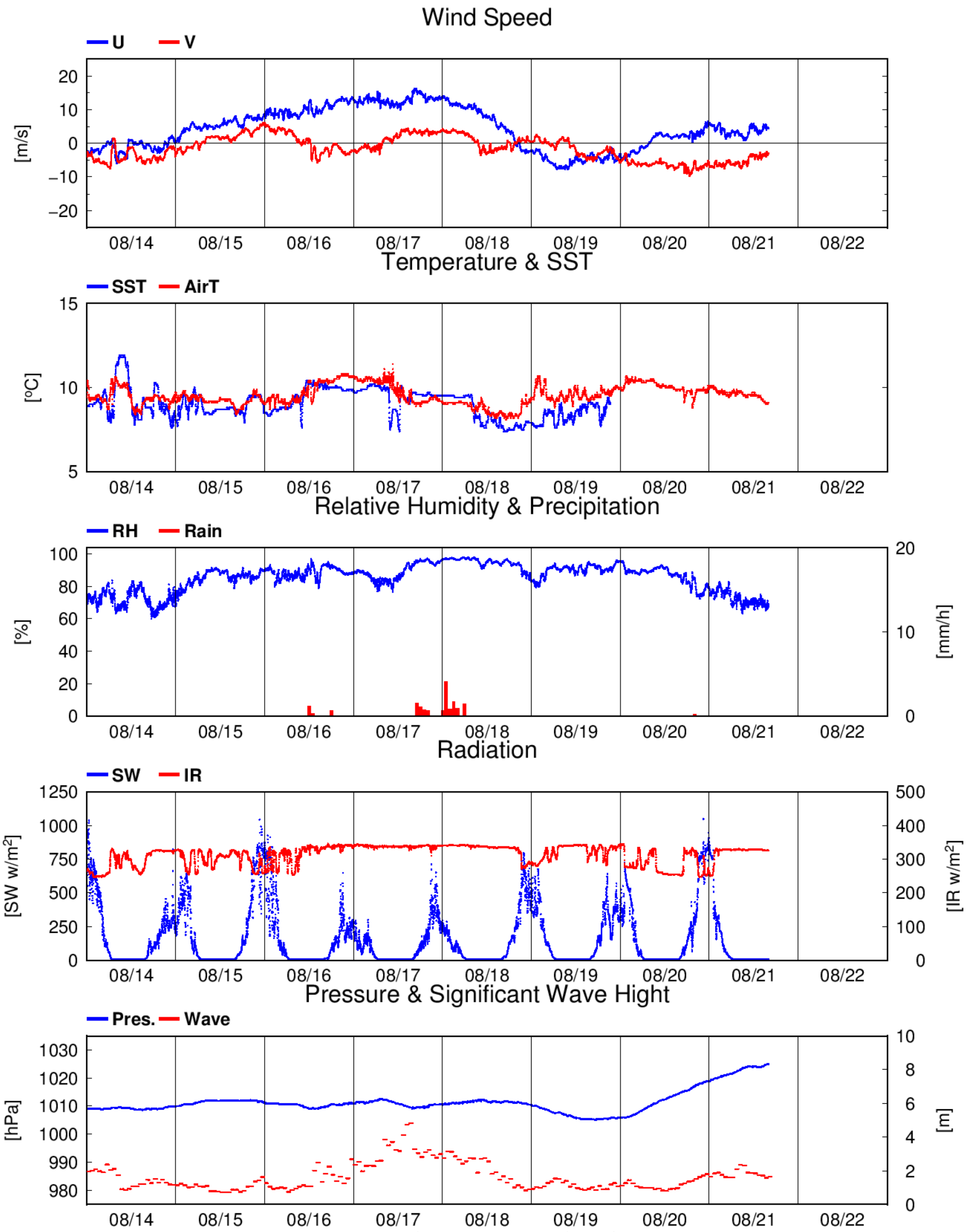


Fig.3.1.1-1 (Continued)

3.1.1(b) Ceilometer observation

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Souichiro SUEYOSHI	Nippon Marine Enterprises LTD. (NME)
Toshimasa NASU	NME
Masanori MURAKAMI	MIRAI crew

(1) Objectives

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

(2) Parameters

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

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland). Major parameters for the measurement configuration are shown in Table 1;

Table 3.1.1-5 Major parameters

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
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)
Responsibility at 905 nm:	65 A/W
Cloud detection range:	0 ~ 13 km
Measurement range:	0 ~ 15 km
Resolution:	10 meter in full range
Sampling rate:	36 sec
Sky Condition:	Cloudiness in octas (0 ~ 9) (0:Sky Clear, 1:Few, 3:Scattered, 5-7:Broken, 8:Overcast, 9:Vertical Visibility)

(4) Results

Fig.3.1.1-2 shows the time series of 1st, 2nd and 3rd lowest cloud base height during this cruise.

(5) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

(6) Remarks

The following time, the window was cleaned.

23:24UTC, 04 Aug. 2017
22:30UTC, 13 Aug. 2017

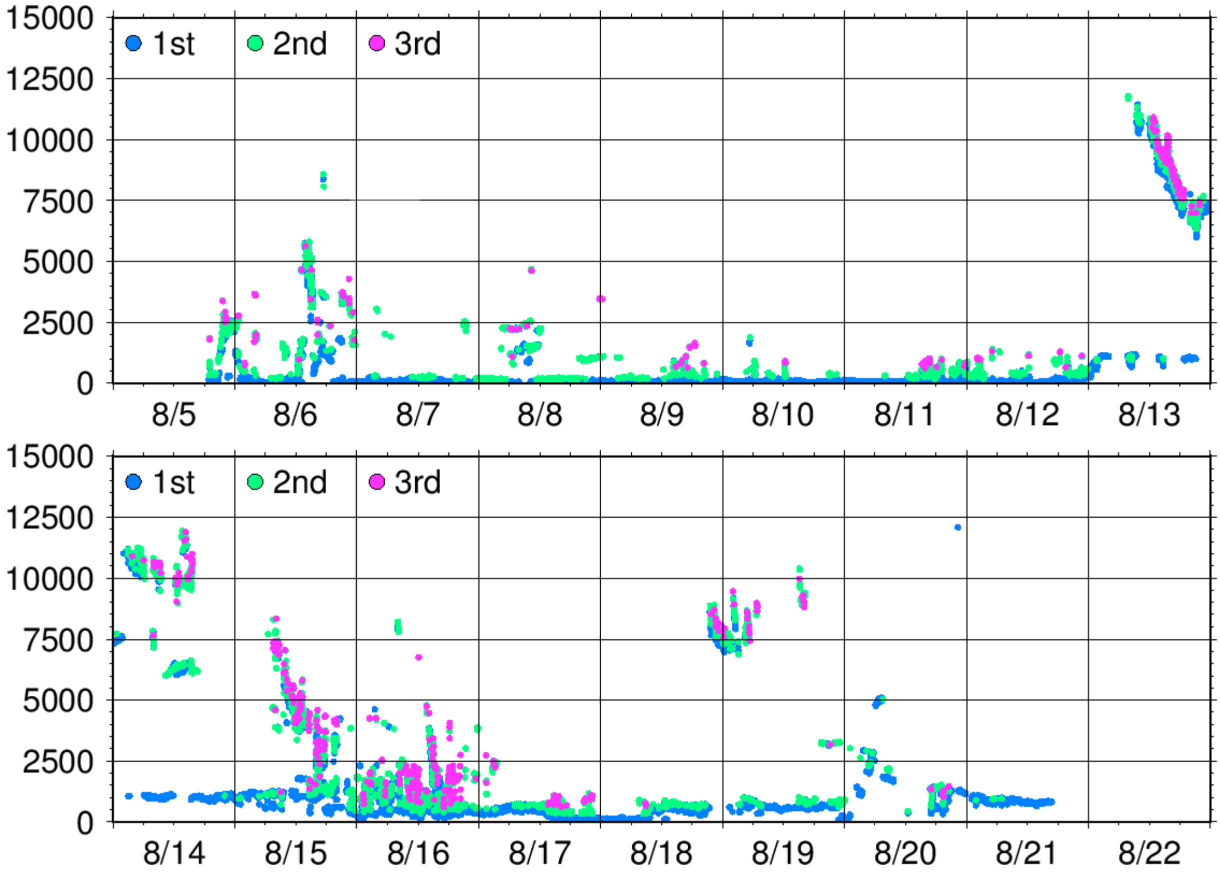

Fig. 3.1.1-2 1st, 2nd and 3rd lowest cloud base height during this cruise.

3.1.2 Shipboard ADCP

Yoshihiro FUJIWARA	JAMSTEC: Principal investigator
Souichiro SUEYOSHI	Nippon Marine Enterprises LTD. (NME)
Toshimasa NASU	NME
Masanori MURAKAMI	MIRAI crew

(1) Objectives

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

(2) 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 System (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 every 10 minutes.
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 was configured for "8 m" layer intervals starting about 23m below sea surface, and recorded every ping as raw ensemble data (.ENR). Additionally, 15 seconds averaged data were recorded as short-term average (.STA). 300 seconds averaged data were long-term average (.LTA), respectively.

(3) Parameters

Major parameters for the measurement, Direct Command, are shown in Table 3.1.2-1.

Table 3.1.2-1: Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1,300m 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)

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 (V; C; A; PG; St; Vsum; Vsum^2; #G; P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

(4) Data archives

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

3.1.3 CTD cast and water sampling

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Hidetaka NOMAKI (JAMSTEC)
Shinsuke TOYODA (MWJ) *Operation Leader
Shungo OSHITANI (MWJ)
Rio KOBAYASHI (MWJ)

(1) Objective

Investigation of oceanic structure and water sampling.

(2) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary “RINKOⅢ” and Secondary “SBE43”)
Beam Transmission
Fluorescence
Turbidity (Primary and Secondary)
Photosynthetically Active Radiation
Altimeter
Sound Velocity

(3) Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel Water Sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-liter Niskin Bottles were used for sampling seawater. The sensors attached on the CTD were temperature (primary and secondary), conductivity (primary and secondary), pressure, dissolved oxygen (primary, RINKOIII), dissolved oxygen (secondary, SBE43), beam transmission, fluorescence, turbidity (primary and secondary), photosynthetically active radiation, altimeter and sound velocity. Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) 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. We usually stop for 60 seconds to stabilize then fire. 30 casts of CTD measurements were conducted (Table3.1.3-1).

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 3.0 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 3.0 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 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 (RINKOIII and SBE43) voltage.

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

FILTER: Perform a low pass filter on pressure 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, transmission data, transmission voltage and turbidity. 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-m depth and 1-dbar pressure 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.

Configuration file: MR1704A.xmlcon

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:
SBE9plus (S/N: 09P54451-1027, Sea-Bird Electronics, Inc.)
Pressure sensor: Digiquartz pressure sensor (S/N: 1027_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: 043036, Sea-Bird Electronics, Inc.)
Calibrated Date: 30 Dec. 2016

Dissolved Oxygen sensor:
Primary: RINKOIII (S/N: 0278_163010BA, JFE Advantech Co., Ltd.)
Calibrated Date: 25 Oct 2016
Secondary: SBE43 (S/N: 430330, Sea-Bird Electronics, Inc.)
Calibrated Date: 03 May. 2017

Fluorescence:
Chlorophyll Fluorometer (S/N: 3700, Seapoint Sensors, Inc.)
Gain setting: 10X, 0-15 ug/l
Calibrated Date: None
Offset: 0.000

Transmission meter: C-Star (S/N CST-1363DR, WET Labs, Inc.)
Calibrated Date: 04 Jan. 2017

Turbidity:
Primary: Turbidity Meter (S/N: 14953)
Gain setting: 100X
Scale factor: 1.000
Calibrated Date: None
Secondary: Turbidity Meter (S/N: 14954)
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

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

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

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

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

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

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

(4) Results

During this cruise, 30 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table3.1.3-1.

(5) Data archive

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>

(6) Results

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

00AM001: Beam Transmission voltage
down 847 dbar – down 849 dbar: spike
00MM002: Primary temperature, Primary conductivity, Dissolved oxygen (SBE43)
up 90 dbar – up 1 dbar : shift , noise
00BM002: Beam Transmission voltage
down 196 dbar - down 198 dbar : spike
down 441 dbar - down 443 dbar : spike
down 456 dbar - down 458 dbar : spike
00GM003: Dissolved oxygen (SBE43)
up 1000 dbar – up 999 dbar : spike
00BM003: Primary conductivity
down 263 dbar: spike
00MM003: Primary temperature, Primary conductivity
down 52 dbar : spike

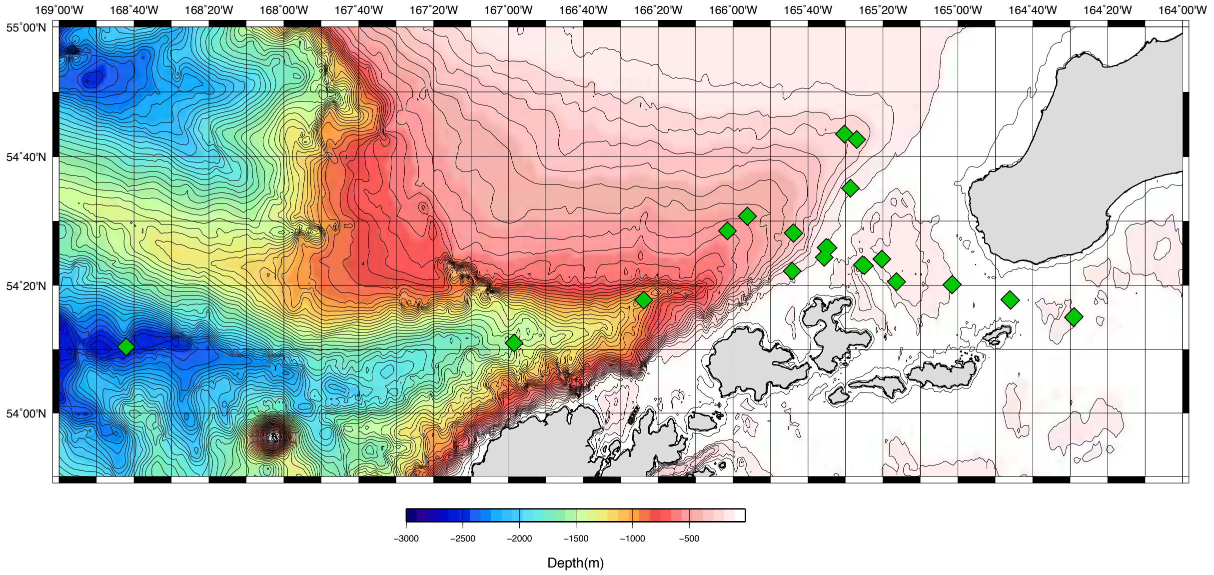

MR17−04_Leg2_CTD_Position

Table3.1.3-1 MR17-04 Leg2 CTD cast table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth (m)	Wire Out (m)	HT Above Bottom (m)	Max Depth (m)	Max Pressure (dbar)	CTD Filename
		(mmddyy)	Start	End	Latitude	Longitude						
00A	1	080617	10:18	11:43	54-17.70N	166-23.88W	1108.0	1093.3	11.1	1092.2	1105.0	00AM001
00B	1	080717	01:46	02:43	54-28.47N	166-01.54W	536.0	523.9	7.4	526.6	532.0	00BM001
00C	1	080817	00:45	00:50	54-43.50N	165-30.32W	241.0	97.0	-	100.1	101.0	00CM001
00C	2	080817	10:02	11:02	54-42.65N	165-27.05W	231.0	217.2	10.3	219.9	222.0	00CM002
00D	1	081017	00:09	00:15	54-25.85N	165-35.03W	102.0	86.2	10.9	89.2	90.0	00DM001
00M	1	081017	10:14	10:47	54-25.87N	165-35.20W	104.0	89.1	9.1	93.1	94.0	00MM001
00M	2	081117	00:23	00:30	54-25.76N	165-35.12W	100.0	86.9	9.6	90.2	91.0	00MM002
00E	1	081117	23:25	23:30	54-24.10N	165-20.30W	181.0	98.9	80.2	101.1	102.0	00EM001
0E2	1	081217	10:07	10:49	54-20.57N	165-16.36W	197.0	182.7	10.1	186.2	188.0	0E2M001
00N	1	081317	09:35	10:20	54-28.19N	165-43.92W	358.0	345.8	10.0	347.6	351.0	00NM001
00B	2	081317	11:35	12:10	54-30.79N	165-56.25W	488.0	475.2	8.4	477.1	482.0	00BM002
00T	1	081317	16:00	16:07	54-35.12N	165-28.68W	127.0	108.0	12.1	111.0	112.0	00TM001
00U	1	081317	18:26	18:32	54-22.21N	165-44.24W	122.0	104.4	11.8	109.0	110.0	00UM001
0M2	1	081317	22:54	23:20	54-24.37N	165-35.70W	93.0	78.3	9.1	83.2	84.0	0M2M001
00Q	1	081417	09:06	09:29	54-15.14N	164-28.97W	106.0	91.1	10.5	94.1	95.0	00QM001
00R	1	081417	12:17	12:23	54-17.66N	164-45.89W	82.7	71.7	10.9	75.3	76.0	00RM001
00S	1	081417	14:05	14:25	54-20.09N	165-01.57W	105.0	89.7	10.5	93.1	94.0	00SM001
00P	1	081417	16:25	16:48	54-23.19N	165-25.50W	96.0	84.9	11.0	88.2	89.0	00PM001
00G	1	081417	22:32	22:39	54-12.30N	166-58.65W	1555.0	97.4	-	100.1	101.0	00GM001
00G	2	081517	10:00	10:26	54-11.69N	166-58.34W	1540.0	97.4	-	100.1	101.0	00GM002
00G	3	081517	14:09	16:03	54-11.00N	166-58.50W	1526.0	1519.7	10.1	1509.8	1529.0	00GM003
00H	1	081717	01:55	03:20	54-10.40N	168-42.08W	2542.0	2579.4	8.5	2526.6	2565.0	00HM001
00B	3	081817	05:02	05:21	54-30.75N	165-56.24W	486.0	474.1	10.1	476.1	481.0	00BM003
00N	2	081817	06:16	06:31	54-28.10N	165-43.88W	358.0	345.8	8.1	348.5	352.0	00NM002
00M	3	081817	07:12	07:19	54-25.83N	165-34.67W	103.0	86.9	10.1	91.2	92.0	00MM003
00P	2	081817	08:09	08:16	54-23.07N	165-24.97W	94.0	79.0	10.0	83.2	84.0	00PM002
0E2	2	081817	09:00	09:09	54-20.55N	165-16.42W	196.0	183.8	10.1	187.2	189.0	0E2M002
00S	2	081817	10:11	10:17	54-20.14N	165-01.49W	106.0	93.5	9.5	97.1	98.0	00SM002
00R	2	081817	11:22	11:26	54-17.79N	164-46.12W	79.4	67.3	9.9	70.4	71.0	00RM002
00Q	2	081817	12:39	12:44	54-14.95N	164-29.13W	104.0	90.8	10.0	94.1	95.0	00QM002

3.1.4 Salinity measurement

Masahide WAKITA (JAMSTEC MIO)
Sonoka TANIHARA (MWJ)

(1) Objective
To measure bottle salinity obtained by CTD casts, bucket sampling, and the continuous sea surface water monitoring system (TSG).

(2) Methods
a. Salinity sample collection
Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and TSG. The salinity sample bottles of the 250ml brown glass bottles with screw caps were used for collecting the sample water. Each bottle was rinsed three times with the sample water, and filled with sample water to the bottle shoulder. The salinity sample bottles for TSG were sealed with a plastic cone and screw cap because we took into consideration the possibility of storage for about one month. These caps were rinsed three times with the sample water before use. The bottles were stored for more than 24 hours in the laboratory before the salinity measurement.
The Kind and number of samples taken as shown as follows;

Table 3.1.4-1 Sample type and number

Sample type	Number of sample
Samples for CTD and bucket	186
Samples for TSG	13
Total	199

b. Instruments and method
The salinity measurement on R/V MIRAI was carried out during the cruise of MR17-04Leg2 using the salinometer (Model 8400B “AUTOSAL”; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540; Guildline Instruments Ltd.: S/N 66723 and 62525) were used. The thermometer monitored the ambient temperature and the bath temperature of the salinometer.
The specifications of AUTOSAL salinometer and thermometer 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)

Thermometer (Model 9540: Guildline Instruments Ltd.)
Measurement Range : -40 to +180 deg C
Resolution : 0.001
Limits of error ±deg C : 0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability : ±2 least significant digits

The measurement system was almost the same as Aoyama et al. (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 21.5 deg C to 23.4 deg C, while the bath temperature was very stable and varied within +/- 0.003 deg C on rare occasion. The measurement for each sample was carried out with the double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 10 seconds to collect 31 readings by the personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing five 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 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, we measured a ninth filling of the cell and calculated the bottle salinity. The measurement was conducted in about 8 hours per day and the cell was cleaned with soap after the measurement of the day.

(3) Results

a. Standard seawater

Standardization control of the salinometer was set to 605 and all measurements were carried out at this setting. The value of STANDBY was 24+5133±0001 and that of ZERO was 0.0+0000～0001. The conductivity ratio of IAPSO Standard Seawater batch P159 was 0.99988 (the double conductivity ratio was 1.99976) and was used as the standard for salinity. 15 bottles of P159 were measured.

Fig.3.1.4-1 shows the time series of the double conductivity ratio for the Standard Seawater batch P159 before correction. The average of the double conductivity ratio was 1.99973 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

Fig.3.1.4-2 shows the time series of the double conductivity ratio for the Standard Seawater batch P159 after correction. The average of the double conductivity ratio after correction was 1.99976 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity

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

Batch : P159
conductivity ratio : 0.99988
salinity : 34.995
Use by : 15th Dec 2018

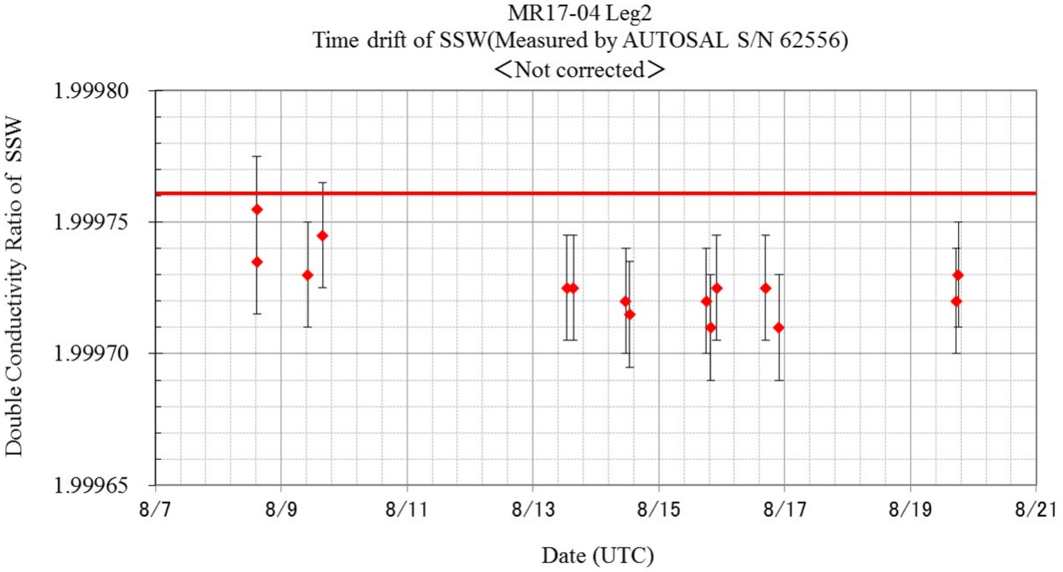


Fig. 3.1.4-1 Time series of the double conductivity ratio for the Standard Seawater batch P159 (Before correction)

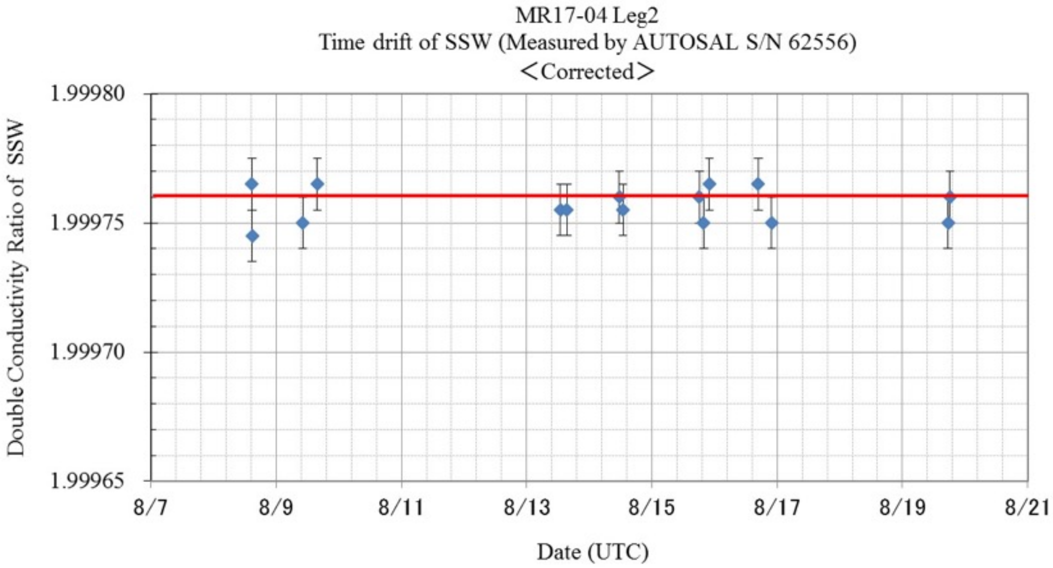


Fig. 3.1.4-2 Time series of the double conductivity ratio for the Standard Seawater batch P159 (After correction)

b. Sub-standard seawater
Sub-standard seawater was made from sea water filtered by a pore size of 0.22 micrometer and stored in a 20-liter container made of polyethylene and stirred for at least 24 hours before start measuring. It was measured about every 6 samples in order to check for the possible sudden drifts of the salinometer.

c. Replicate samples
We estimated the precision of this method using 8 pairs of replicate samples taken from the same Niskin bottle. Fig.3.1.4-3 shows the histogram of the absolute difference between each pair of the replicate samples. The average and the standard deviation of absolute deference among 8 pairs of replicate samples were 0.0002 and 0.0002 in salinity, respectively.

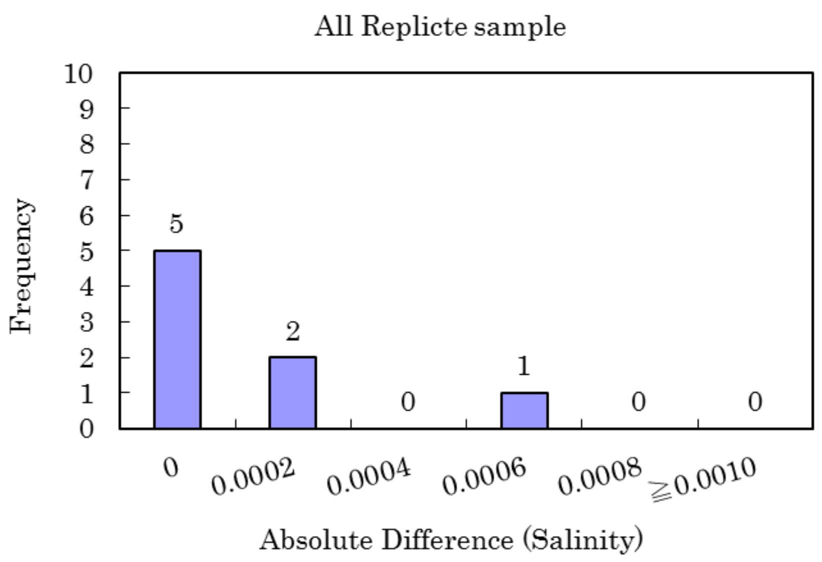


Fig. 3.1.4-3 The histogram of the double conductivity ratiofor the absolute difference of replicate samples

(4) Data archive
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>

(5) Reference

- 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

3.1.5 Dissolved Oxygen

Yoshihiro FUJIWARA (JAMSTEC): Principal Investigator
Katsunori SAGISHIMA (MWJ): Operation Leader
Takehiko SHIRIBIKI (MWJ)

(1) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(2) Parameters

Dissolved Oxygen

(3) 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 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 ºC, 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.

(4) Observation log

a. Standardization and determination of the blank

Table 3.1.5-1 shows results of the standardization and the blank determination during this cruise.

Table 3.1.5-1 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)		
2017/08/06	K1704A06	T1704C	3.965	0.003	3.973	0.006	00A001,00B001, 00C002,00M001
2017/8/11	K1704A07	T1704C	3.966	0.004	3.974	0.007	0E2001,00N001, 0M2001,00Q001, 00S001,00P001, 00G002,00G003
2017/8/16	K1704A08	T1704C	3.966	0.005	3.972	0.008	

b. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. The standard deviation of the replicate measurement (Dickson et al., 2007) was 0.18 μmol kg^{-1} (n=27).

(5) Data archives

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

(6) 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.

3.1.6 Nutrients

Masahide WAKITA(JAMSTEC MIO) : Principal Investigator
Tomomi SONE (MWJ)
Kohei MIURA (MWJ)

(1) Objectives

The objectives of nutrients analyses during the R/V Mirai MR17-04Leg2 cruise in the Western North Pacific Ocean is as follows:

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

(2) Summary of nutrients analysis

We made 9 QuAAtro 2-HR runs for the samples collected by 12 casts at 11 stations in this cruise. The total amount of layers of the seawater sample reached to 178 in Leg2. We made duplicate measurement at all layers at all stations. The station locations for nutrients measurement is shown in Figure 3.1.6-1 and Table 3.1.6-1. We also measured 104 pore water samples.

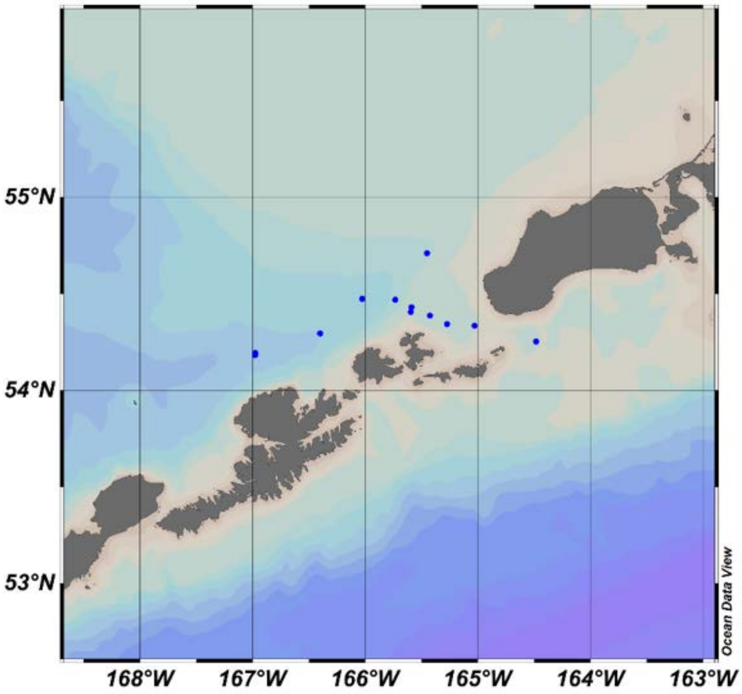


Figure 3.1.6-1 Sampling positions of nutrients sample in MR1704Leg2.

Table 3.1.6-1 List of stations of MR1704Leg2.

Station	Cast	Station serial	Date (UTC)	Position		Depth (dbar)
			(mmddyy)	Latitude	Longitude	
00A	1	1	080617	54-17.42N	166-23.52W	1,105
00B	1	2	080717	54-28.28N	166-1.32W	529
00C	2	3	080817	54-42.39N	165-27.2W	222
00M	1	4	081017	54-25.51N	165-35.12W	94
0E2	1	5	081217	54-20.34N	165-16.21W	187
00N	1	6	081317	54-28.11N	165-43.54W	350
0M2	1	7	081317	54-24.22N	165-35.41W	83
00Q	1	8	081417	54-15.8N	164-28.58W	95
00S	1	9	081417	54-20.5N	165-1.34W	94
00P	1	10	081417	54-23.11N	165-25.29W	88
00G	2	11	081517	54-11.41N	166-58.20W	101
00G	3	12	081517	54-10.59N	166-58.29W	1,528

(3) Instrument and Method

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

We applied two units of QuAAtro in this cruise. Unit 1 and Unit 2 were put for R/V Mirai equipment. Configurations of all units are completely same for five parameters, Nitrate, Nitrite, Silicate, Phosphate, and Ammonium.

Nitrate + nitrite and nitrite were analyzed according to the modification method of Grasshoff (1970). The sample nitrate was reduced to nitrite in a cadmium tube inside of which was coated with metallic copper. The sample streamed with its equivalent nitrite was treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacted with the sulfanilamide to produce a diazonium ion. N-1-Naphthylethylenediamine Dihydrochloride added to the sample stream then coupled with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite reacted and were measured; without reduction, only nitrite reacted. Thus, for the nitrite analysis, no reduction was performed and the alkaline buffer was not necessary. Nitrate was computed by difference.

The silicate method was analogous to that described for phosphate. The method used was essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid was first formed from the silicate in the sample and added molybdic acid; then the silicomolybdic acid was reduced to silicomolybdous acid, or "molybdenum blue" using ascorbic acid as the reductant. The analytical methods of the nutrients, nitrate, nitrite, silicate and phosphate, during this cruise were same as the methods used in (Kawano et al. 2009).

The phosphate analysis was a modification of the procedure of Murphy and Riley (1962). Molybdic acid was added to the seawater sample to form phosphomolybdic acid which was in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

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 3.1.6-2 to 3.1.6-6

(3.2) Nitrate Reagents

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

Dissolve 4 g Imidazole (CAS No. 288-32-4), in 1000 mL DIW, add 2 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL Triton^{TM} X-100 (50 % solution in ethanol) 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 DIW, add 100 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL Triton^{TM} X-100 (50 % solution in ethanol) 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 DIW and add 10 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL Triton^{TM} X-100 (50 % solution in ethanol) is added.
Stored in a dark bottle.

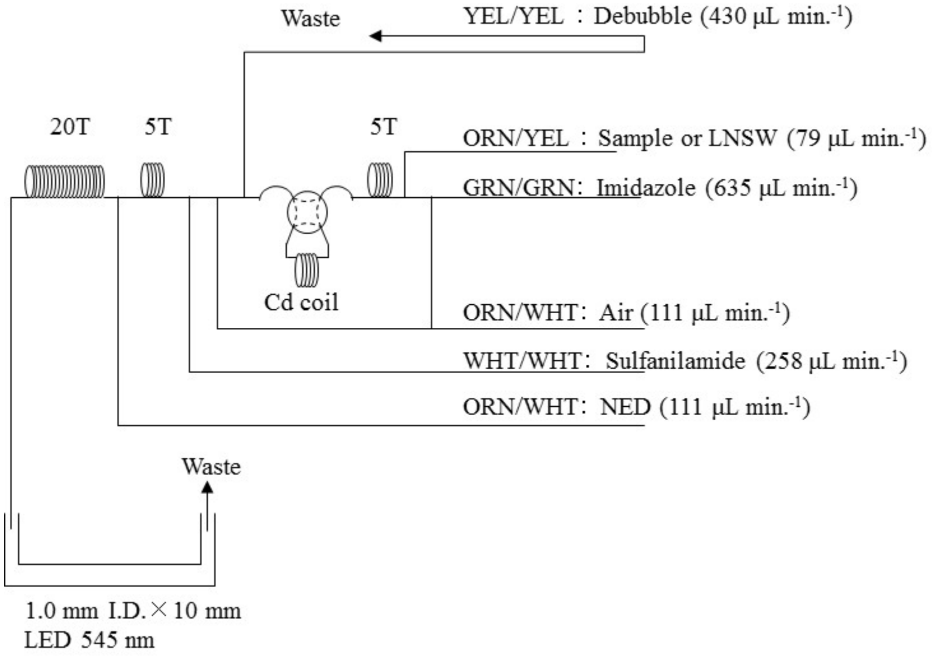


Figure 3.1.6-2 NO_3 + NO_2 (1ch.) Flow diagram.

(3.3) Nitrite Reagents
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 DIW, add 100 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL Triton^{TM} X-100 (50 % solution in ethanol) 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 DIW and add 10 mL Hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL Triton^{TM} X-100 (50 % solution in ethanol) is added. This reagent was stored in a dark bottle.

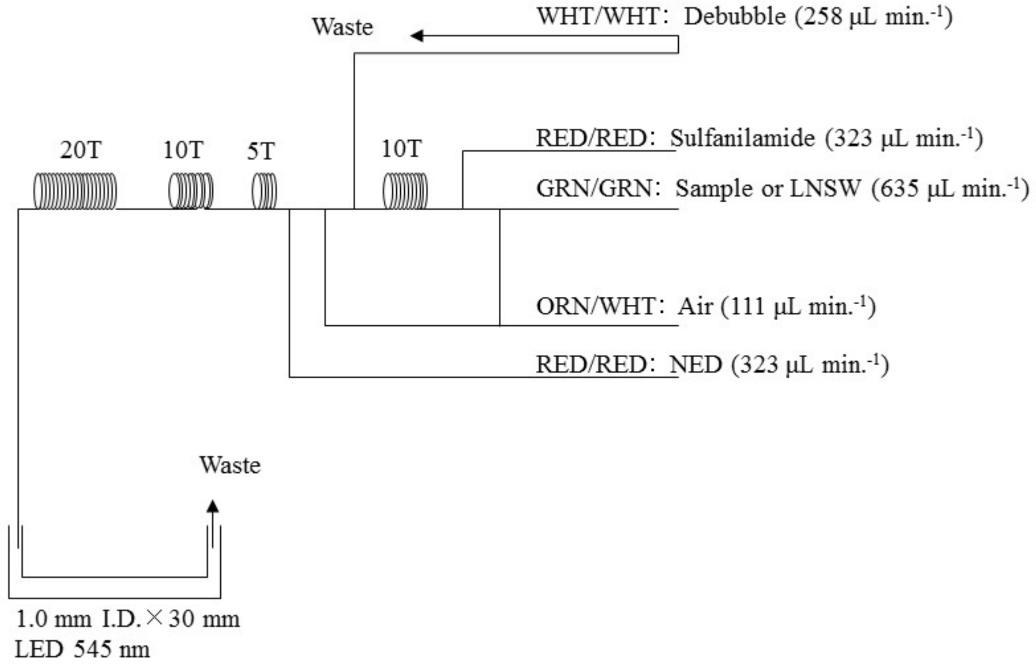


Figure 3.1.6-3 NO_2 (2ch.) Flow diagram.

(3.4) Silicate Reagents
Molybdic acid, 0.06 M (2 % w/v)
Dissolve 15 g Sodium molybdate dihydrate (CAS No. 10102-40-6), in 980 mL DIW, add 8 mL Sulfuric acid (CAS No. 7664-93-9). After mixing, 20 mL Sodium dodecyl sulfate (CAS No. 151-21-3), (15 % solution in water) is added.

Oxalic acid, 0.6 M (5 % w/v)
Dissolve 50 g Oxalic Acid (CAS No. 144-62-7), in 950 mL of DIW.

Ascorbic acid, 0.01 M (3 % w/v)
Dissolve 2.5 g L-Ascorbic acid (CAS No. 50-81-7), in 100 mL of DIW. This reagent was freshly prepared at every day.

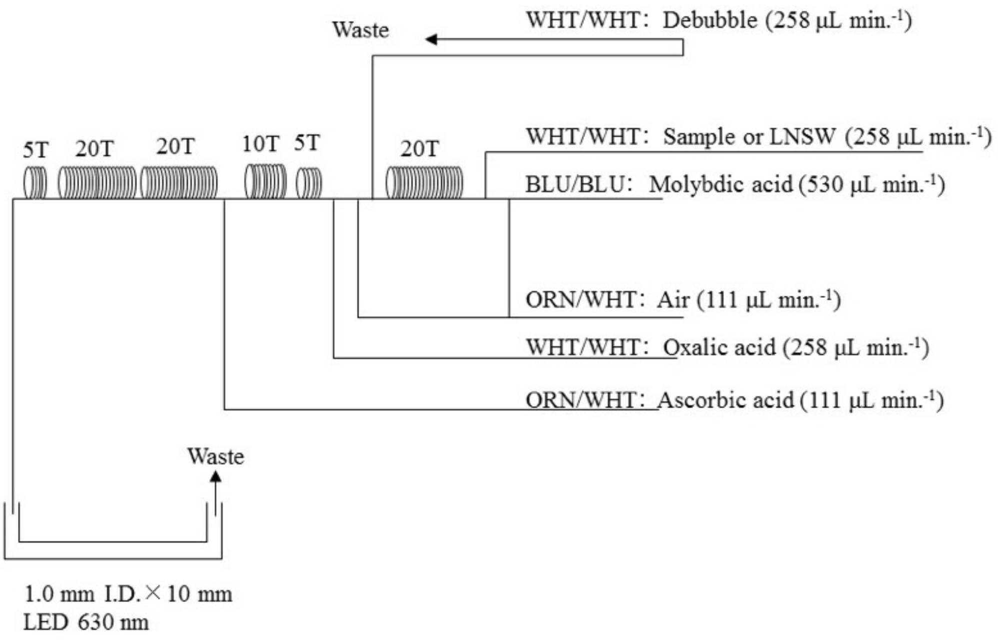


Figure 3.1.6-4 SiO_2 (3ch.) Flow diagram.

(3.5) Phosphate Reagents

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 DIW 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 Sodium dodecyl sulfate (CAS No. 151-21-3), (15 % solution in water) was added. This reagent was freshly prepared before every measurement.

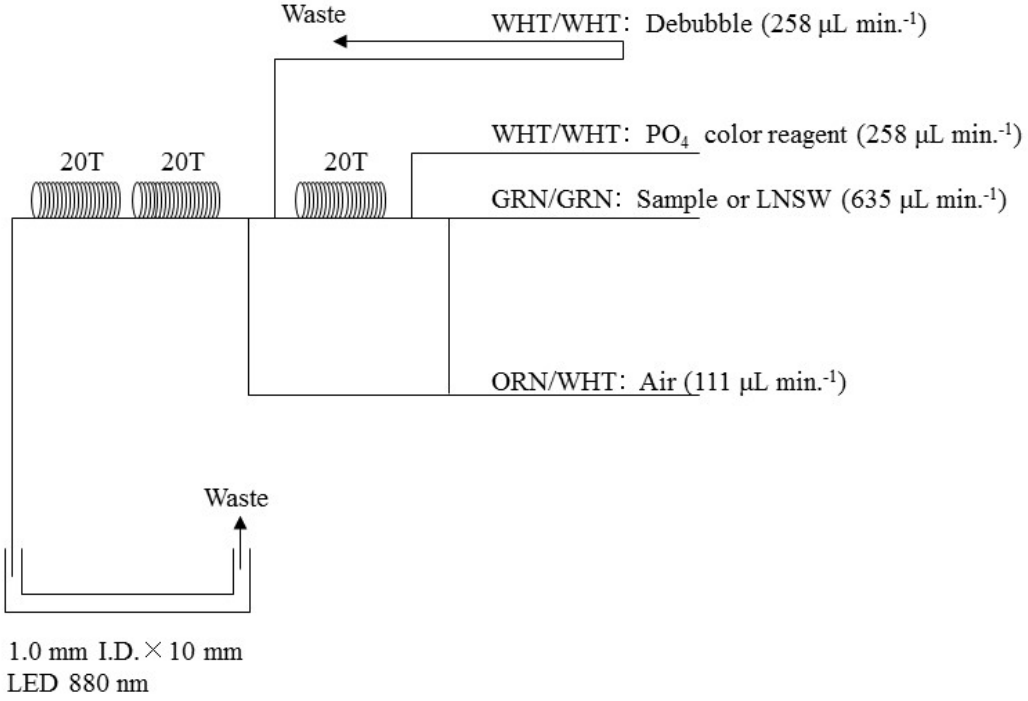


Figure 3.1.6-5 PO4 (4ch.) Flow diagram.

(3.6) Ammonium Reagents

EDTA

Dissolve 41 g Tetrasodium EDTA tetrahydrate (CAS No. 13235-36-4), and 2 g Boric acid (CAS No. 10043-35-3), in 200 mL of DIW. After mixing, 1 mL Triton^{TM} X-100 (30 % solution in DIW) is added. This reagent is prepared at a week about.

NaOH
Dissolve 5 g Sodium hydroxide (CAS No. 1310-73-2), and 16 g Tetrasodium EDTA tetrahydrate (CAS No. 13235-36-4) in 100 mL of DIW. 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 DIW and add 0.2 mL 1.0 M H_2SO_4. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution
Mix 4 mL stock nitroprusside and 5 mL 1.0 M H_2SO_4 in 500 mL of DIW. After mixing, 2 mL Triton^{TM} X-100 (30 % solution in DIW) is added. This reagent is stored in a dark bottle and prepared at every 2 or 3 days.

Alkaline phenol
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 DIW. Stored in a dark bottle and prepared at a week about.
NaClO solution
Mix 3 mL sodium hypochlorite solution, Sodium hypochlorite (CAS No. 7681-52-9), in 47 mL DIW. Stored in a dark bottle and fleshly prepared before every measurement. This reagent is prepared 0.3 % available chlorine.

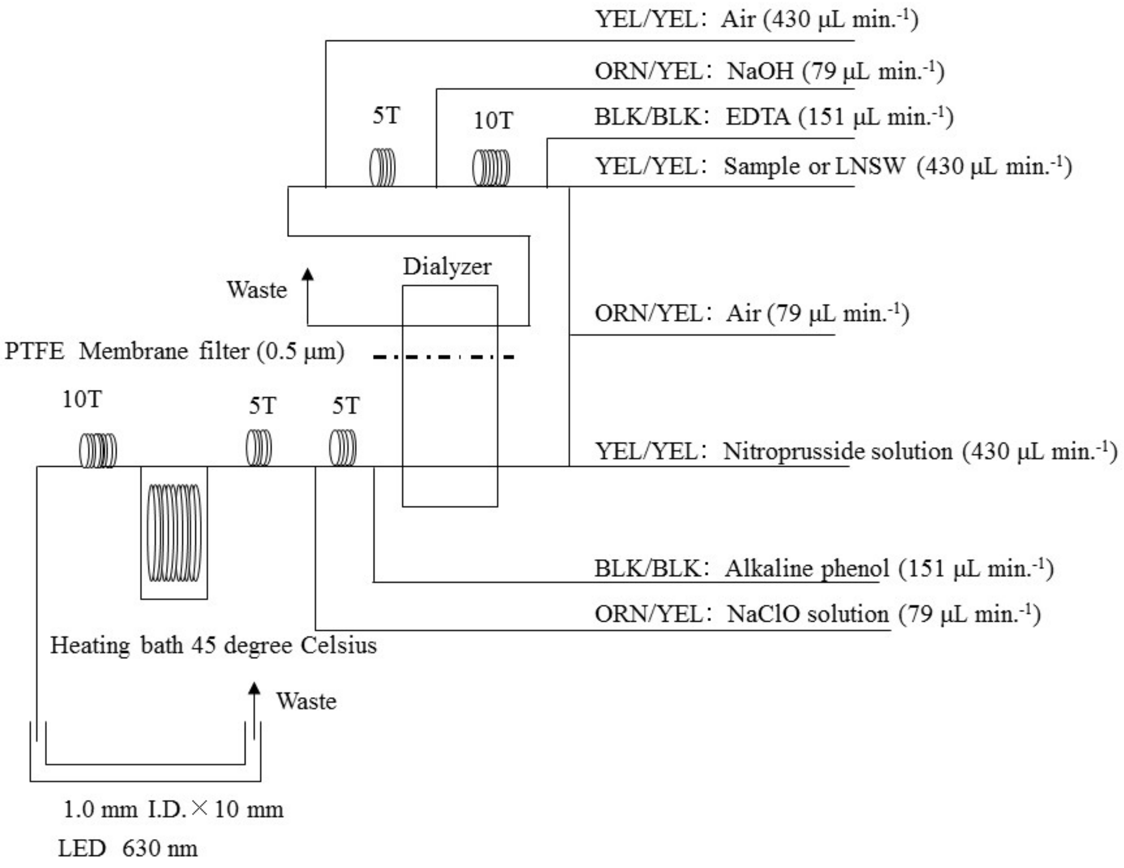


Figure 3.1.6-6 NH_4 (5ch.) Flow diagram.

(3.7) Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into two of virgin 10 mL polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and then vials were capped immediately after the drawing. The vials were put into water bath adjusted to ambient temperature, 22 ± 0.1 degree Celsius, in about 30 minutes before use to stabilize the temperature of samples in MR1704Leg2.

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

(3.8) Data processing

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

- Checked baseline shift.
- Checked the shape of each peak and positions of peak values taken, and then changed 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.
- Loaded pressure and salinity from CTD data to calculate density of seawater. In case of bucket sample, we generally used bottle salinity from AUTOSAL.
- Calibration curves to get nutrients concentration were assumed second order equations.

(4) Certified Reference Material of nutrients in seawater

KANSO CRMs (Lot: BY, CD, BW, CB, BZ) 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 psu.

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.

(4.1) CRMs for this cruise

5 lot of CRMs were used in this cruise. These bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 17- 20 degree Celsius. The concentrations for CRM lots BY, CD, BW, CB and BZ are shown in Table 3.1.6-2.

Table 3.1.6-2 Certified concentration and uncertainty (k=2) of CRMs.

unit: µmol kg^{-1}

Lot	Nitrate	Nitrite	Silicate	Phosphate	Ammonia*
BY	0.02 ± 0.02	0.02 ± 0.01	1.76 ± 0.06	0.039 ± 0.010	0.82
CD	5.50 ± 0.05	0.02 ± 0.00	13.93 ± 0.10	0.446 ± 0.008	1.11
BW	24.59 ± 0.20	0.07 ± 0.01	60.01 ± 0.42	1.541 ± 0.014	1.03
CB	35.79 ± 0.27	0.12 ± 0.01	109.2 ± 0.62	2.520 ± 0.022	0.77
BZ	43.35 ± 0.33	0.22 ± 0.01	161.0 ± 0.93	3.056 ± 0.033	0.49

*For ammonia values are references

(5) Nutrients standards

(5.1) 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 3 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05 % or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicate from the glass. PMP volumetric flasks were gravimetrically calibrated and used only within 3 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 3 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes were gravimetrically calibrated in order to verify and improve upon the nominal tolerance.

(5.2) Reagents, general considerations

Specifications

For nitrate standard, “potassium nitrate 99.995 suprapur®” provided by Merck, Lot. B0993065709, 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 999 mg L^{-1} at 20 degree Celsius. Expanded uncertainty of calibration (k=2) is 0.7 % for the calibration result.
For phosphate standard, “potassium dihydrogen phosphate anhydrous 99.995 suprapur®” provided by Merck, Lot. B1144508528, CAS No.: 7778-77-0, was used.
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 HC68513536 are used. The silicate concentration is certified by NIST-SRM 3150 with the uncertainty of 0.7 %. HC68513536 is certified as 1000 mg L^{-1}.
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 %.

Treatment of silicate standard due to high alkalinity

Since the silicon standard solution Merck CertiPUR® is in NaOH 0.5 M, we need to dilute and neutralize to avoid make precipitation of $MgOH_2$ etc. When we make B standard, silicon standard solution is diluted by factor 12 with pure water and neutralized by HCl 1.0 M to be about 7. After that B standard solution is used to prepare C standards.

Ultra pure water

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

Low-Nutrient Seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.20 µm pore capsule cartridge filter at MR1505 cruise on January, 2016. This water is stored in 20 liter cubitainer with paper box.
LNSW concentrations were assigned in August 2016 during MR1606 cruise.

(5.3) Concentrations of nutrient for A, B and C standards

Concentrations of nutrients for A, B, C and D standards are set as shown in Table 3.1.6-3. The C standard is prepared according recipes as shown in this table. 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 5 levels, C-1, C-2, C-3, C-4 and C-5 for nitrate, nitrite, phosphate and ammonia and 6 levels, C-1, C-2, C-3, C-4, C-5 and C-6 for silicate. C-1 was LNSW and the other standards were in-house standard.

Table 3.1.6-3 Nominal concentrations of nutrients for A, B and C standards in MR1704Leg2.

	A	B	B’	D	C-1	C-2	C-3	C-4	C-5	C-6
NO_3 (µM)	45000	900	-	900	0	9	18	36	54	-
NO_2 (µM)	21800	26	-	870	0	0.3	0.5	1.0	1.6	-
SiO_2 (µM)	35600	2850	4270	-	1	30	58	115	172	257
PO_4 (µM)	6000	60	-	-	0	0.6	1.2	2.4	3.6	-
NH_4 (µM)	8000	160	-	-	0	1.6	3.2	6.4	9.6-	-

(5.4) Renewal of in-house standard solutions.

In-house standard solutions as stated in paragraph (5.2) were renewed as shown in Table 3.1.6-4 (a) to (c).

Table 3.1.6-4(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
B std. (mixture of A-1, D-2, A-3, A-4 and A-5 std.)	maximum 8 days
B’ std. (diluted A-3 std.)	maximum 8 days

Table 3.1.6-4(b) Timing of renewal of in-house standards.

Working standards	Renewal
C-1 std. (LNSW) C-2, C-3, C-4 and C-5 std. (diluted B std.) C-6 std. (diluted B’ std.)	every 24 hours

Table 3.1.6-4(c) Timing of renewal of in-house standards for reduction estimation.

Reduction estimation	Renewal
D-1 std. (900 µM NO_3)	maximum 8 days
D-2 std. (870 µM NO_2)	maximum 8 days
36 µM NO_3	when C Std. renewed
35 µM NO_2	when C Std. renewed

(6) Quality control

(6.1) Precision of nutrients analyses during this cruise

Precision of nutrients analyses during this cruise was evaluated based on the 7 to 11 measurements, which are measured every 8 to 13 samples, during a run at the concentration of C-5 std. Summary of precisions are shown as Table 3.1.6-5 and Figures 3.1.6-7 to 3.1.6-9, the precisions for each parameter are generally good considering the analytical precisions during the R/V Mirai cruses conducted in 2009 - 2016. Analytical precisions in MR1704Leg2 were 0.16 % for nitrate, 0.11 % for phosphate and 0.12 % for silicate in terms of median of precision, respectively.

Table 3.1.6-5 Summary of precision based on the replicate analyses for unit 2 in MR1704Leg2.

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %	Ammonium CV %
Median	0.16	0.19	0.12	0.11	0.30
Mean	0.16	0.18	0.12	0.15	0.35
Maximum	0.24	0.30	0.17	0.32	0.81
Minimum	0.06	0.05	0.08	0.10	0.21
N	9	9	9	9	9

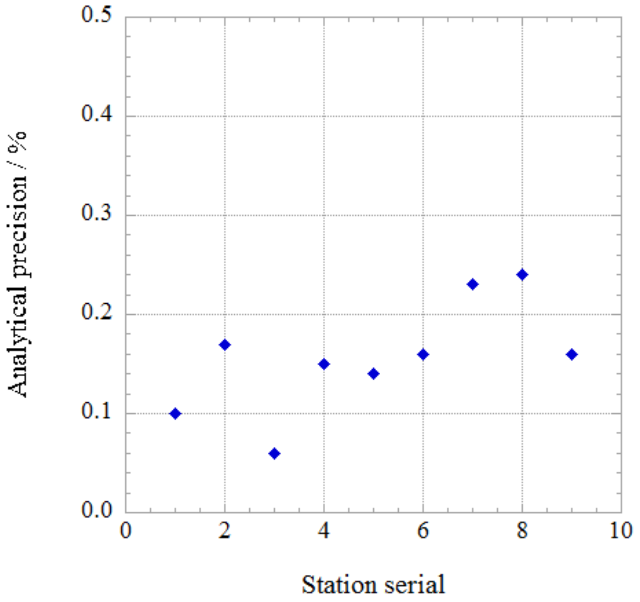


Figure 3.1.6-7 Time series of precision of nitrate in MR1704Leg2.

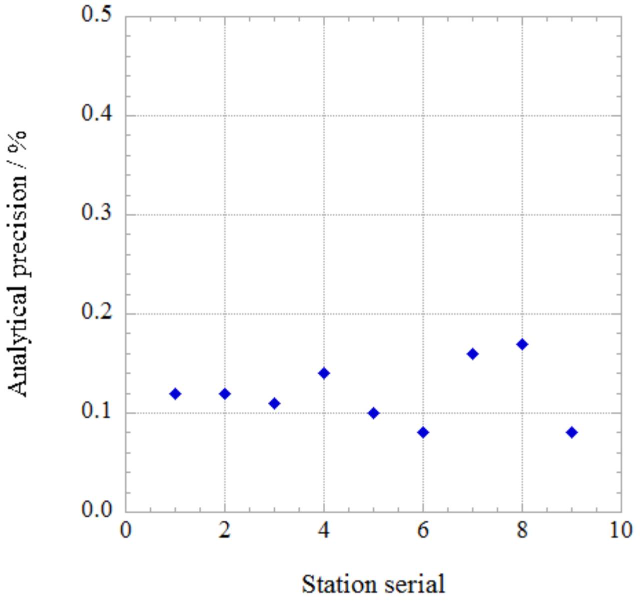


Figure 3.1.6-8 Time series of precision of silicate in MR1704Leg2.

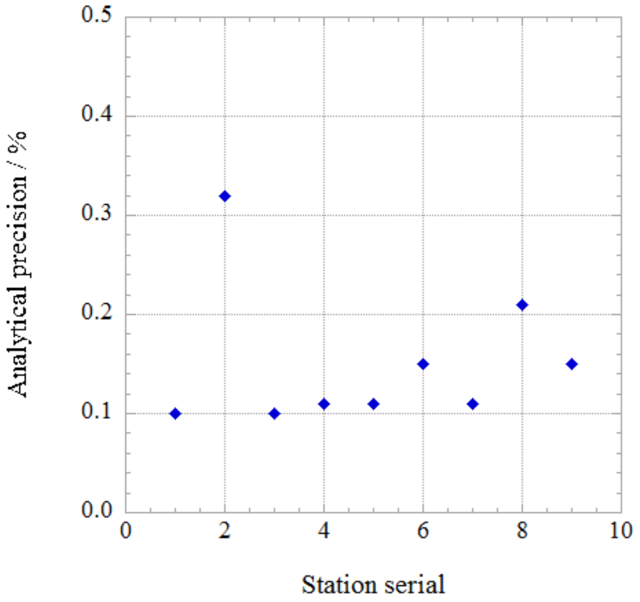


Figure 3.1.6-9 Time series of precision of phosphate in MR1704Leg2.

(6.2) CRM lot. CB measurement during this cruise

CRM lot. CB was measured every run to monitor the comparability among runs. The results of lot. CB during this cruise are shown as Figures 3.1.6-10 to 3.1.6-12. Error bars represent analytical precision in Figures 3.1.6-7 to 3.1.6-9.

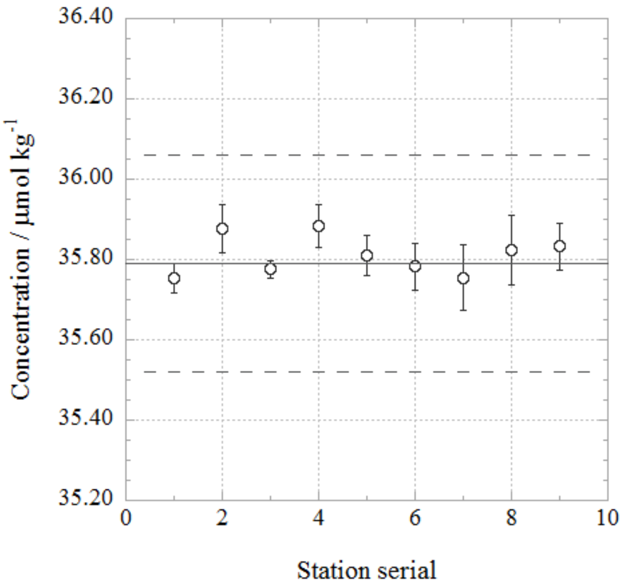


Figure 3.1.6-10 Time series of CRM-CB of nitrate in MR1704Leg2.
Solid line : certified value, broken line : uncertainty of certified value (k=2)

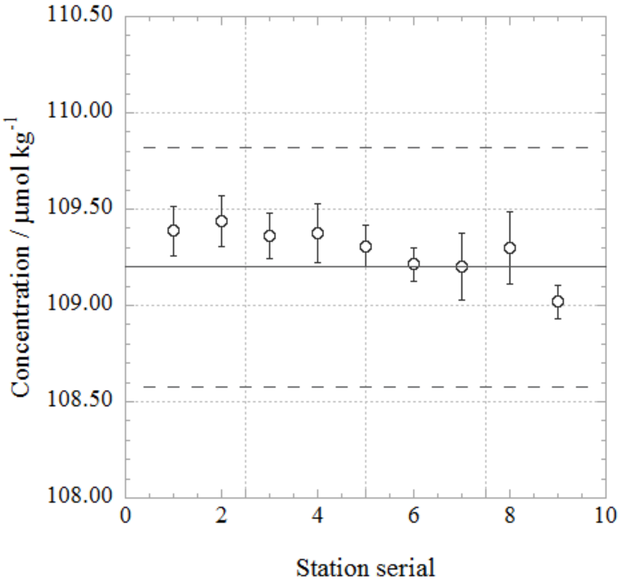


Figure 3.1.6-11 Time series of CRM-CB of silicate in MR1704Leg2.
Solid line : certified value, broken line : uncertainty of certified value (k=2)

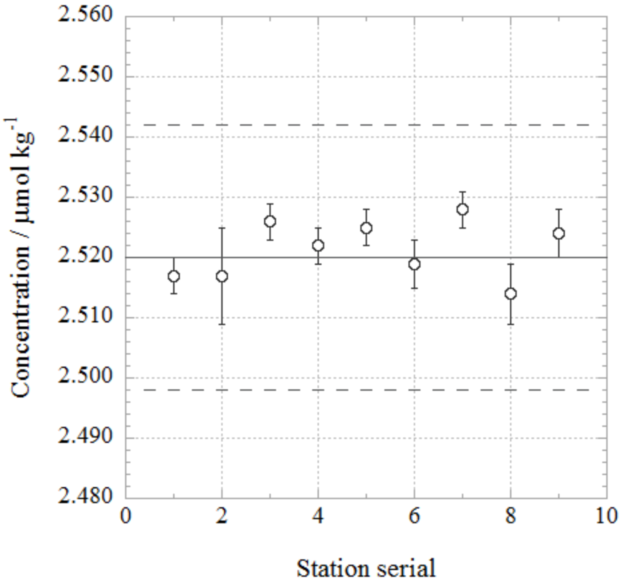


Figure 3.1.6-12 Time series of CRM-CB of phosphate in MR1704Leg2.
Solid line : certified value, broken line : uncertainty of certified value (k=2)

(6.3) Carryover

We can also summarize the magnitudes of carryover throughout the cruise. These are small enough within acceptable levels as shown in Table 3.1.6-6 and Figures 3.1.6-13 to 3.1.6-15.

Table 3.1.6-6 Summary of carry over throughout Leg2.

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %	Ammonium CV %
Median	0.16	0.10	0.10	0.16	0.55
Mean	0.15	0.11	0.10	0.16	0.50
Maximum	0.20	0.20	0.12	0.23	0.76
Minimum	0.11	0.00	0.05	0.10	0.26
N	9	9	9	9	9

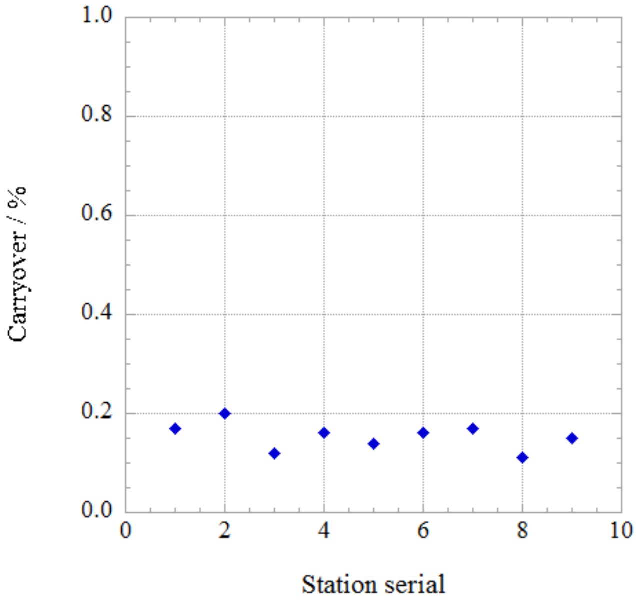


Figure 3.1.6-13 Time series of carryover of nitrate in MR1704Leg2.

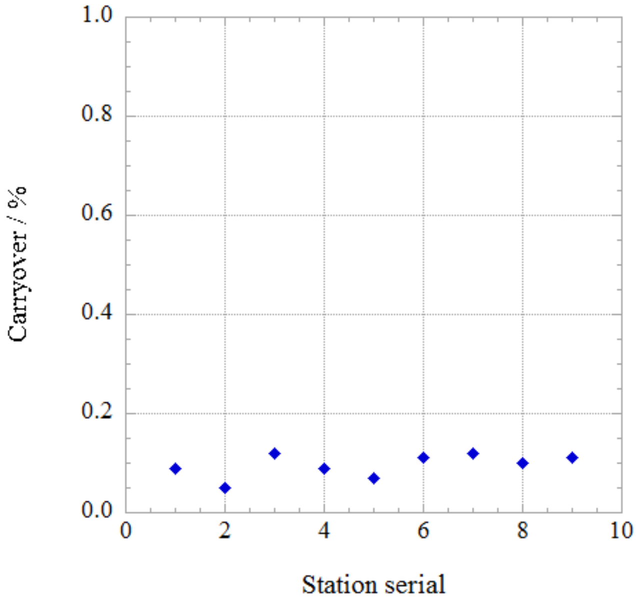


Figure 3.1.6-14 Time series of carryover of silicate in MR1704Leg2.

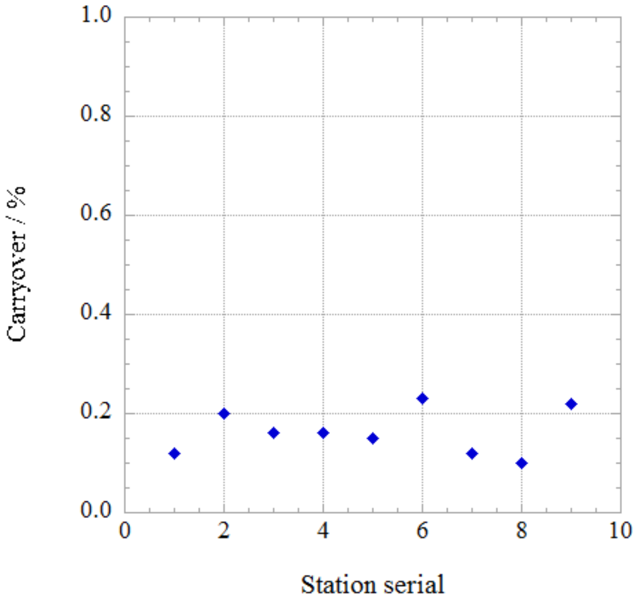


Figure 3.1.6-15 Time series of carryover of phosphate in MR1704Leg2.

(6.4) Estimation of uncertainty of phosphate, nitrate and silicate concentrations

We estimate the uncertainty of measurement of nutrient by merging data from both MR1704Leg1 and MR1704Leg2 because the numbers of the run in each leg were small, 11 runs and 9 runs, respectively.

Empirical equations, eq. (1), (2), and (3) to estimate uncertainty of measurement of phosphate, nitrate and silicate are used based on measurements of 20 sets of CRMs during this cruise. Empirical equations, eq. (4), (5) are used to estimate uncertainty of measurement of nitrite and ammonium based on duplicate measurements of the samples. These empirical equations and graphic presentation of equations are as follows, respectively.

Phosphate Concentration Cp in μmol kg^{-1}:
Uncertainty of measurement of phosphate (%) =
$0.161 + 0.217 * (1 / Cp) + 0.00313 * (1 / Cp) * (1 / Cp)$ --- (1)
where Cp is phosphate concentration of sample.

Nitrate Concentration Cno3 in μmol kg^{-1}:
Uncertainty of measurement of nitrate (%) =
$0.10 + 1.35 * (1 / Cno3)$ --- (2)
where Cno3 is nitrate concentration of sample.

Silicate Concentration Cs in μmol kg^{-1}:
Uncertainty of measurement of silicate (%) =
$0.10 + 3.16 * (1 / Cs)$ --- (3)
where Cs is silicate concentration of sample.

Nitrite Concentration Cno2 in μmol kg^{-1}:
Uncertainty of measurement of nitrite (%) =
$0.17 + 0.23 * (1 / Cno2) - 0.000012 * (1 / Cno2) * (1 / Cno2)$ --- (4)
where Ca is ammonium concentration of sample.

Ammonium Concentration Ca in μmol kg^{-1}:
Uncertainty of measurement of ammonium (%) =
$0.43 + 1.60 * (1 / Ca)$ --- (5)
where Ca is ammonium concentration of sample.

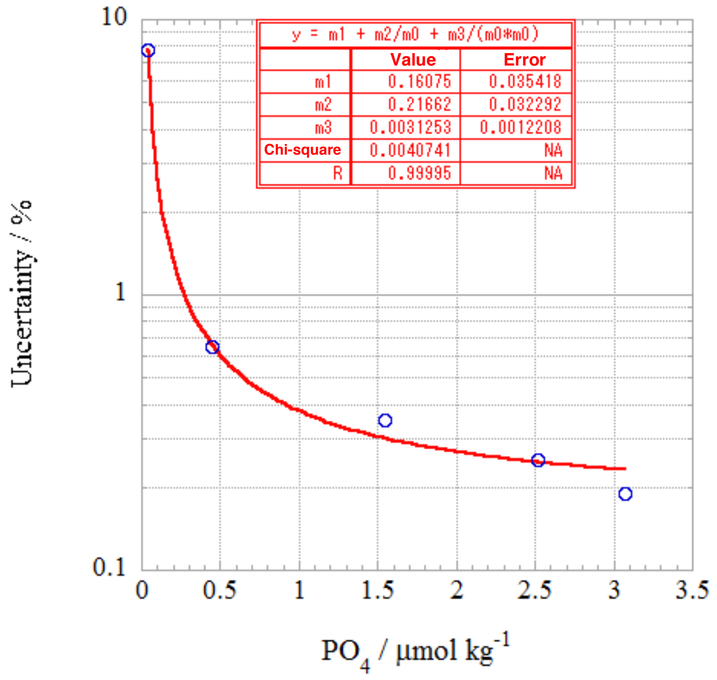


Figure 3.1.6-16 Estimation of uncertainty for phosphate in MR1704.

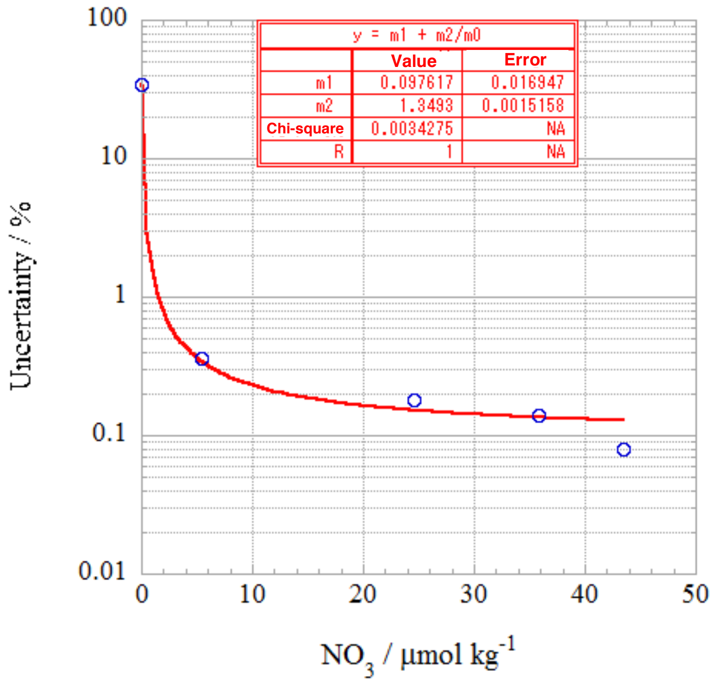
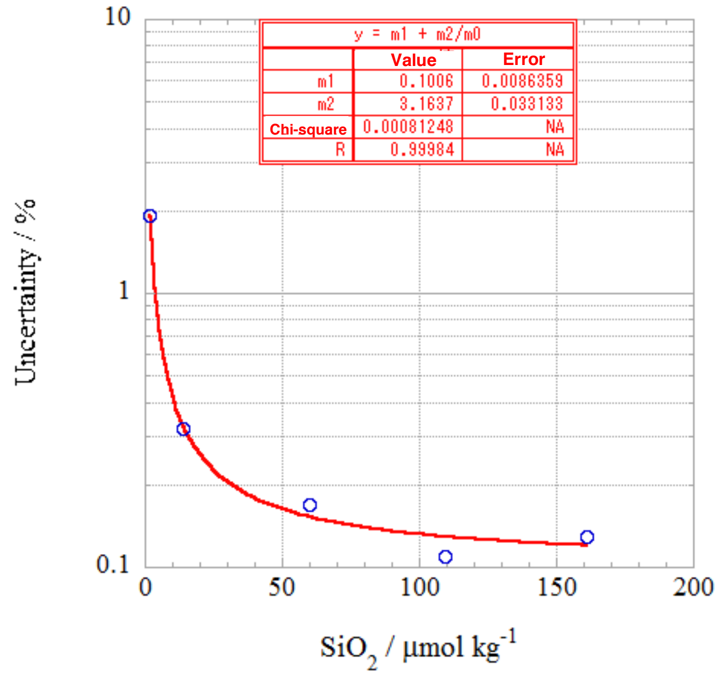


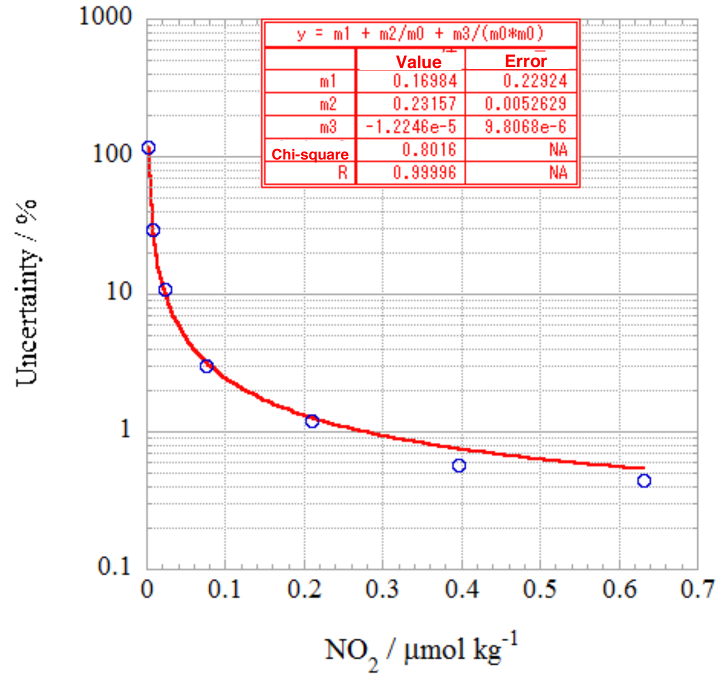
Figure 3.1.6-17 Estimation of uncertainty for nitrate in MR1704.



y = m1 + m2/m0

	Value	Error
m1	0.1006	0.0086359
m2	3.1637	0.033133
Chi-square	0.00081248	NA
R	0.99984	NA

Figure 3.1.6-18 Estimation of uncertainty for silicate in MR1704.



y = m1 + m2/m0 + m3/(m0*m0)

	Value	Error
m1	0.16984	0.22924
m2	0.23157	0.0052629
m3	-1.2246e-5	9.8068e-6
Chi-square	0.8016	NA
R	0.99996	NA

Figure 3.1.6-19 Estimation of uncertainty for nitrite in MR1704.

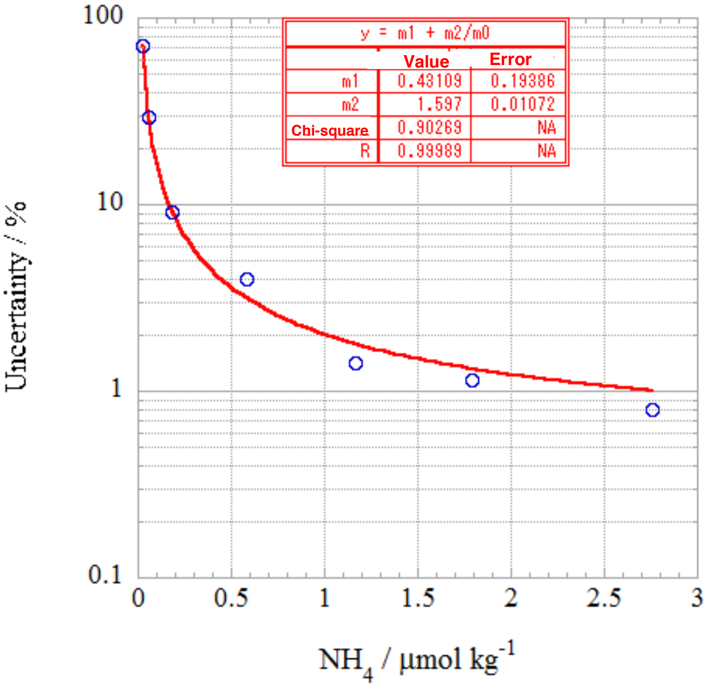


Figure 3.1.6-20 Estimation of uncertainty for ammonium in MR1704.

(7) Problems / improvements occurred and solutions

(7.1) Unmixed samples

When we found the value of transparency of the sample was less than 99 % or doubtful for the particles in the sample, we did not mixed the samples before putting them on auto sampler. The unmixed sample list for nutrients is shown in Table 3.1.6-7.

Table 3.1.6-7 Unmixed sample list of MR1704Leg2.

Station	Cast	Bottle	Depth (dbar)	Transparency (%)
00A	1	0	-	-
		36	5.2	89.559
		6	10.2	93.035
		35	20.1	94.858
		34	30.8	95.324
		33	50.7	97.793
		32	76.0	98.397
		31	101.1	98.583
		30	126.7	98.542
		29	151.8	98.654
		28	176.3	98.862
		27	200.5	98.863
00B	1	0	-	-
		36	5.4	84.631
		3	12.6	85.384
		35	20.4	95.785
		34	30.7	97.701
		33	50.5	98.298
		32	75.8	98.750
		31	101.2	98.560
		30	126.2	98.715
		29	151.6	98.879
00C	2	0	-	-
		7	3.9	86.833

Station	Cast	Bottle	Depth (dbar)	Transparency (%)
		6	6.2	87.160
		20	9.0	88.159
		5	13.3	91.428
		4	18.0	94.433
		3	22.2	97.066
		2	29.4	97.682
		1	35.3	98.040
		33	50.7	98.533
		32	75.8	98.647
		31	101.2	98.742
		30	126.8	98.777
		29	151.7	98.826
		28	175.5	99.075
		27	202.5	99.002
		16	221.9	98.990
00M	1	0	-	-
		7	4.1	86.017
		6	6.0	86.153
		20	10.2	85.930
		5	13.0	85.878
		4	19.5	94.224
		3	27.4	96.734
		34	30.2	97.143
		2	41.1	97.334
		33	50.4	97.657
		1	53.5	97.831
		32	75.8	98.440
		16	93.7	98.438
0E2	1	0	-	-
		7	3.1	86.454
		6	5.2	86.686
		5	10.1	87.202
		4	14.3	92.329
		3	18.1	94.424
		35	20.1	93.494
		2	23.2	93.073
		1	28.5	93.810
		34	30.7	94.300
		33	50.6	97.128
		32	76.0	97.474
		31	101.6	97.835
		30	126.9	98.047
		29	152.3	97.953
		28	176.6	97.940
		16	187.3	98.027
00N	1	0	-	-
		36	3.2	90.252
		6	13.5	93.867
		3	17.5	96.550
		35	20.3	96.794

Station	Cast	Bottle	Depth (dbar)	Transparency (%)
		34	31.3	97.633
		33	52.1	97.857
		32	77.9	98.273
		31	100.7	98.436
		30	125.3	98.643
		29	150.9	98.839
		28	177.1	99.027
		27	203.5	99.173
		26	253.3	99.280
		25	303.2	99.129
		2	350.2	98.820
0M2	1	0	-	-
		36	5.9	92.541
		6	10.2	92.886
		3	14.9	92.602
		35	20.0	95.031
		34	30.8	96.402
		33	50.0	97.923
		32	76.1	98.623
		2	83.4	98.612
00Q	1	0	-	-
		36	5.6	96.029
		6	9.9	95.932
		35	19.4	94.675
		3	26.1	93.611
		34	29.9	94.359
		33	50.0	97.828
		32	75.3	97.109
		2	95.1	97.180
00S	1	0	-	-
		36	5.4	94.258
		3	17.2	93.930
		35	20.5	94.942
		34	30.5	96.101
		33	50.7	97.829
		32	76.4	97.924
		2	93.7	97.969
00P	1	0	-	-
		36	5.0	91.991
		3	9.0	91.910
		6	15.2	93.383
		35	19.9	94.369
		34	30.1	95.827
		33	50.4	96.817
		32	75.7	97.727
		2	88.3	97.854
00G	2	0	-	-
		7	3.5	89.449
		6	6.7	89.560
		5	14.1	91.117

Station	Cast	Bottle	Depth (dbar)	Transparency (%)
		4	20.3	94.681
		3	26.0	95.549
		2	36.4	96.761
		1	45.8	97.874
		33	50.9	97.945
		32	76.4	98.147
		31	100.8	98.168
00G	3	0	-	-
		36	5.5	88.729
		3	11.9	93.083
		6	15.0	93.184
		35	20.2	96.035
		34	30.8	96.409
		33	50.6	97.329
		32	75.6	98.131
		31	101.4	98.097
		30	126.5	98.228
		29	151.8	98.285
		28	177.1	98.688
		27	201.9	98.681
		26	251.8	99.160

(8) Data archive

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

(9) List of reagent

List of reagent is shown in Table 3.1.6-8.

Table 3.1.6-8 List of reagent in MR1704.

Parameter	IUPAC name	CAS Number	Formula	Compound Name	Manufacture	Grade
NO_3, NO_2	Hydrogen chloride	7647-01-0	HCl	Hydrochloric acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
SiO_2, PO_4, NH_4	Sulfuric acid	7664-93-9	H_2SO_4	Sulfuric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NO_3, NO_2	Imidazole	288-32-4	$C_3H_4N_2$	Imidazole	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NO_3, NO_2	4-Aminobenzenesulfonamide	63-74-1	$C_6H_8N_2O_2S$	sulfanilamide	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NO_3, NO_2	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
SiO_2	Oxalic Acid	144-62-7	$C_2H_2O_4$	Oxalic Acid	Wako Pure Chemical Industries, Ltd.	Wako Special Grade
SiO_2, PO_4	L-Ascorbic acid	50-81-7	$C_6H_8O_6$	L-ascorbic acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
SiO_2, PO_4	Sodium molybdate dihydrate	10102-40-6	$Na_2MoO_4 \cdot 2H_2O$	Disodium Molybdate(VI) Dihydrate	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
SiO_2, PO_4	Sodium dodecyl sulfate	151-21-3	$C_{12}H_{25}NaO_4S$	Sodium Dodecyl Sulfate	Wako Pure Chemical Industries, Ltd.	for Biochemistry
PO_4	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
NH_4	Boric acid	10043-35-3	H_3BO_3	Boric Acid	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NH_4	Phenol	108-95-2	C_6H_6O	Phenol	Wako Pure Chemical Industries, Ltd.	JIS Special Grade
NH_4	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
NH_4	Sodium hydroxide	1310-73-2	$NaOH$	Sodium Hydroxide for Nitrogen Compounds Analysis	Wako Pure Chemical Industries, Ltd.	for Nitrogen Analysis
NH_4	Sodium hypochlorite	7681-52-9	$NaClO$	Sodium hypochlorite solution	Kanto Chemical co., Inc.	Extra pure
NH_4	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
NH_4	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.	-

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3.1.7 pH

Minoru KAMATA (MWJ)
Akira WATANABE (MWJ)

(1) Objective

Onboard pH measurement of seawater collected in sampling bottles

(2)-1 Methods, apparatus and performance

Seawater samples were collected by 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 11 stations. Seawater was sampled in a 100 mL glass bottle that was previously soaked in non-phosphoric alkaline detergent solution at least 3 hours and was cleaned by fresh water for 5 times and Milli-Q ultrapure water for 3 times. A sampling silicone rubber tube with PFA tip was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (about 10 seconds) with care not to leave any bubbles in the bottle. The water in the bottle was sealed by a glass made cap gravimetrically fitted to the bottle mouth without additional force. After collecting the samples on the deck, the bottles were carried into the lab and put in the water bath kept about 25 °C before the measurement.

(2)-2 Seawater analyses

pH (-log[H+]) of the seawater was measured potentiometrically in the glass bottles. The pH / Ion meter (Radiometer analytical, PHM240) is used to measure the electromotive force (e.m.f.) with combined pH electrode (pHC2001-8) in the sample with its temperature controlled to 25.00 °C ± 0.05 °C.

To calibrate the electrodes, the TRIS buffer (Lot = 170418: pH = 8.0907 pH units at 25 °C, DelValls and Dickson, 1998) and AMP buffer (Lot = 170418: pH = 6.7840 pH units at 25 °C, Dickson and Goyet, 1994) in the synthetic seawater (Total hydrogen ion concentration scale) were applied. pH_T of seawater sample (pH_{spl}) is calculated from the expression:

$$pH_{spl} = pH_{TRIS} + (E_{TRIS} - E_{spl}) / ER,$$

where electrode response ER is calculated as follows:

$$ER = (E_{AMP} - E_{TRIS}) / (pH_{TRIS} - pH_{AMP}).$$

ER value should be equal to the ideal Nernst value as follows:

$$ER = RT\ LN(10) / F = 59.16\ mV / pH\ units\ at\ 25\ °C,$$

where F is Faraday constant.

(3) Results

A replicate analysis of seawater sample was made at 4 layers (ex. 50, 175, 2200, and 5000 dbar depth) of deep cast or 2 layers (ex. 50 and 175 dbar depth) of shallow cast. The difference between each pair of analyses was plotted on a range control chart (see Fig. 3.1.7-1). The average of the difference was provisionally 0.001 pH units (n = 17 pairs) with its standard deviation of 0.001 pH units. These values were lower than the value recommended by the Guide (Dickson et al., 2007).

(4) Data archive

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>

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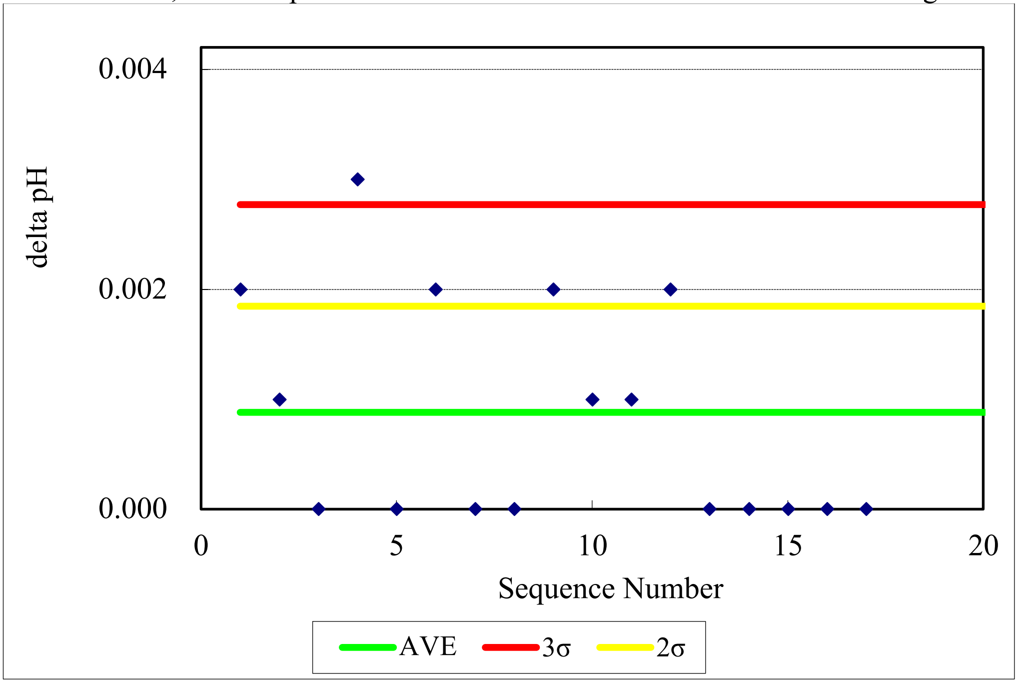

Figure 3.1.7-1 Range control chart of the absolute differences of replicate measurements of pH carried out during the cruise. AVE represents the average of absolute difference, UCL upper control limit (standard deviation of AVE × 3), and UWL upper warning limit (UWL = standard deviation of AVE × 2).

3.1.8 Total Alkalinity

Masahide WAKITA (JAMSTEC MIO): Principal Investigator
Tomonori WATAI (MWJ): Operation Leader
Minoru KAMATA (MWJ)

(1) Objective

Onboard total alkalinity measurement of seawater corrected in sampling bottles

(2) Methods, apparatus and performance

(2)-1 Seawater sampling

Seawater samples were collected by 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 11 stations. The seawater from the Niskin bottle was filled into the 100 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.

(2)-2 Seawater analyses

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 Photonics). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green sodium salt) 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:

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

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

where R(25) represents the difference of absorbance at 616 nm 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.

(3) Results

The repeatability of this system was provisionally 2.23 μmol kg^{-1} (n = 5) 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 Fig. 3.1.8-1). The average of the difference was provisionally 3.73 μmol kg^{-1} (n = 18) with its standard deviation of 3.22 μmol kg^{-1}.

(4) Data archive

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>

(5) References

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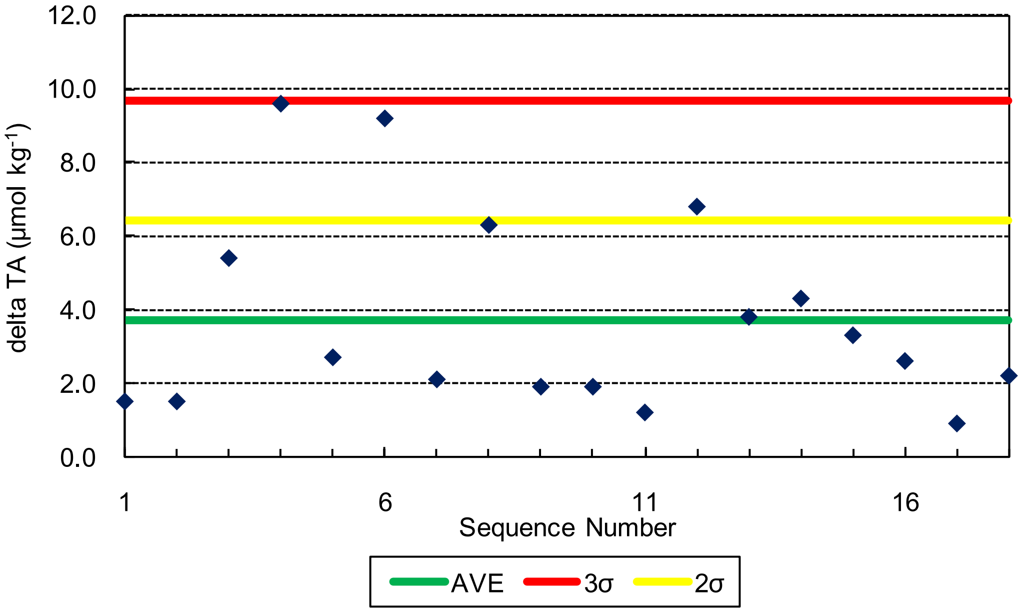


Figure 3.1.8-1 Range control chart of the absolute differences of replicate measurements of TA carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE × 3), and 2σ upper warning limit (standard deviation of AVE × 2).

3.1.9 Dissolved inorganic carbon

Masahide WAKITA (JAMSTEC MIO): Principal Investigator
Tomonori WATAI (MWJ): Operation Leader
Minoru KAMATA (MWJ)

(1) Objective

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

(2) Methods, apparatus and performance

(2)-1 Seawater sampling

Seawater samples were collected by 12 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 11 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.

(2)-2 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.

(3) 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. 3.1.9-1). The average of the differences was provisionally 1.46 μmol kg^{-1}, with its standard deviation of 1.16 μmol kg^{-1} (n = 17), which indicate the analysis was sufficiently accurate (< 1.5 μmol kg^{-1}) according to Dickson et al. (2007).

(4) Data archive

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>

(5) Reference

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.

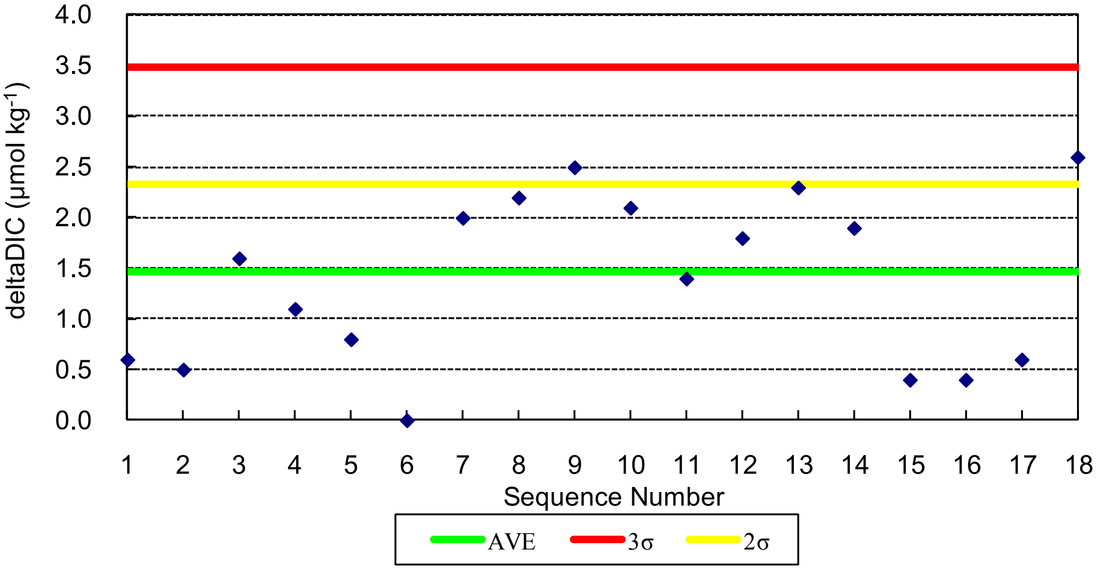


Figure 3.1.9-1 Range control chart of the absolute differences of replicate measurements of DIC carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE × 3), and 2σ upper warning limit (standard deviation of AVE × 2).

3.1.10 Sea surface water monitoring

Hiroshi Uchida (JAMSTEC): Principal Investigator
Masahiro Orui (MWJ) : Operation leader
Katsunori Sagishima (MWJ)

(1) Objective

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

(2) Parameters

Temperature
Salinity
Dissolved oxygen
Fluorescence
Turbidity
Total dissolved gas pressure

(3) 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 ^{o}C - +35 ^{o}C
Conductivity 0 S m^{-1} - 7 S m^{-1}
Initial accuracy: Temperature 0.002 ^{o}C
Conductivity 0.0003 S m^{-1}
Typical stability (per month): Temperature 0.0002 ^{o}C
Conductivity 0.0003 S m^{-1}
Resolution: Temperature 0.0001 ^{o}C
åConductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model: SBE 38, SEA-BIRD ELECTRONICS, INC.
Serial number: 3852788-0457
Measurement range: -5 ^{o}C - +35 ^{o}C
Initial accuracy: ±0.001 ^{o}C
Typical stability (per 6 month): 0.001 ^{o}C
Resolution: 0.00025 ^{o}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) (1 atm, 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: å0.02 % per year max (0.001 % typical)

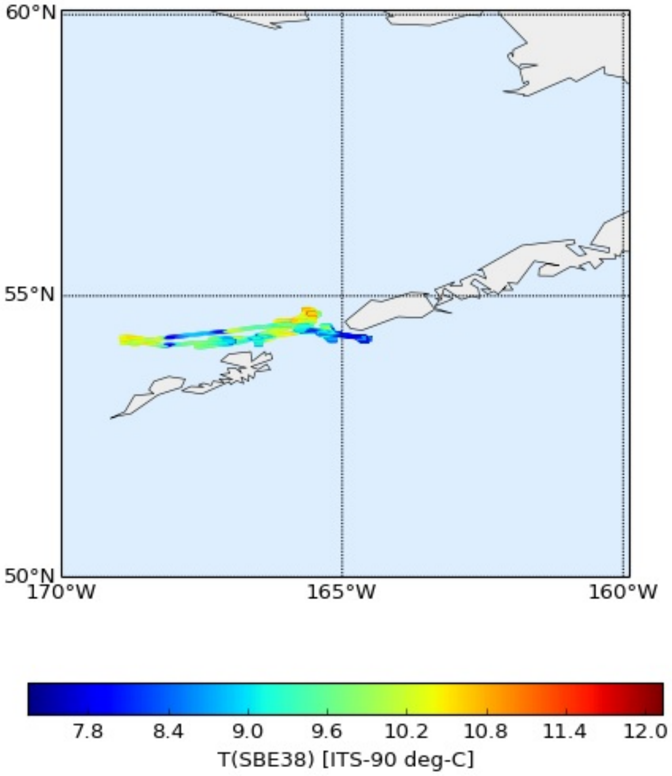
(4) Observation log
Periods of measurement, maintenance, and problems during this cruise are listed in Table 3.1.10-1.

Table 3.1.10-1 Events list of the Sea surface water monitoring during MR17-04 Leg2

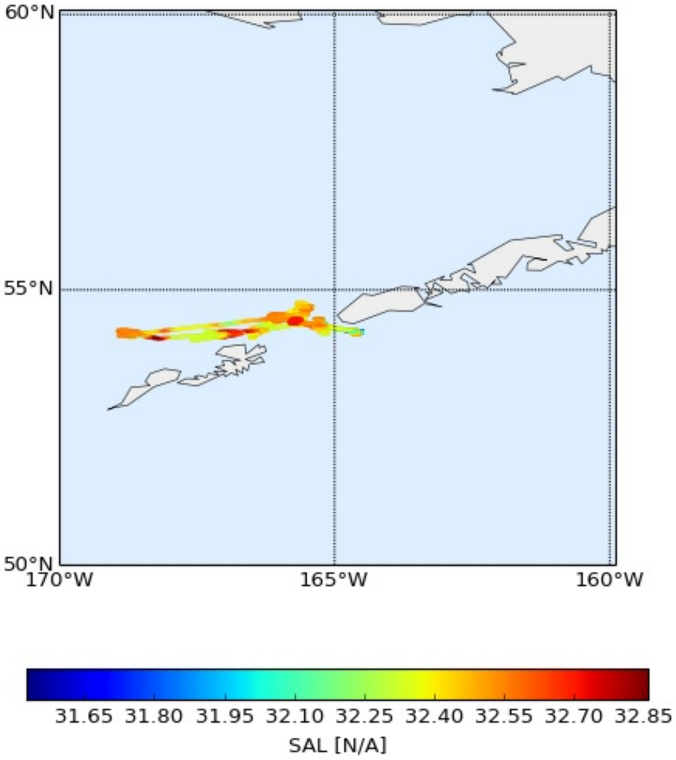
System Date [UTC]	System Time [UTC]	Events	Remarks
2017/08/05	20:30	All the measurements started and data was available.	Start
2017/08/07	16:45	All the measurements stopped.	Filter Cleaning
2017/08/07	17:52	All the measurements started.	Logging restart
2017/08/10	09:57	All the measurements stopped.	Filter Cleaning
2017/08/10	11:05	All the measurements started.	Logging restart
2017/08/16	21:21	All the measurements stopped.	Filter Cleaning
2017/08/16	22:10	All the measurements started.	Logging restart
2017/08/19	17:39	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 Fig. 3.1.10 -2. All the salinity samples were analyzed by the Model 8400B "AUTOSAL" manufactured by Guildline Instruments Ltd. (see 3.1.4), and dissolve oxygen samples were analyzed by Winkler method (see 3.1.5), chlorophyll a were analyzed by 10-AU manufactured by Turner Designs. (see 3.1.13(a)).

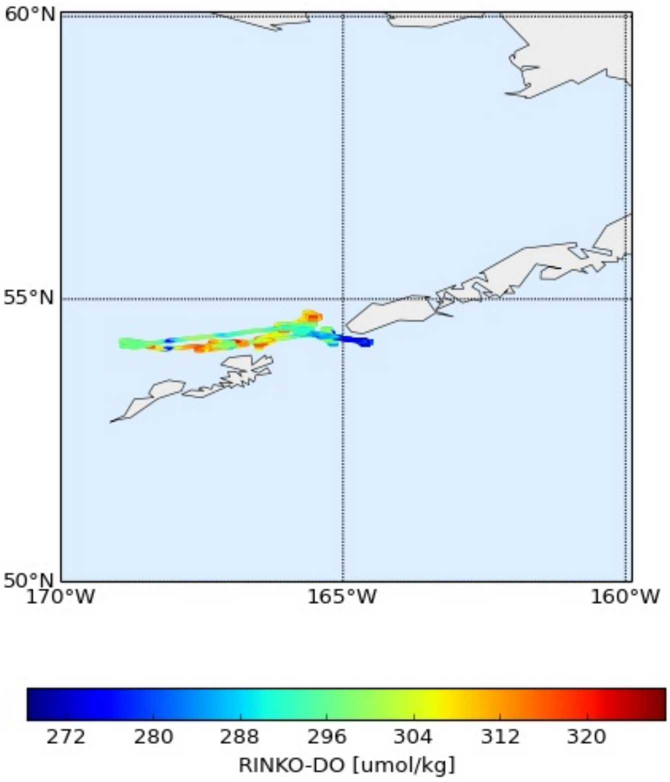
(a)


60°N
55°N
50°N
170°W
165°W
160°W
7.8
8.4
9.0
9.6
10.2
10.8
11.4
12.0
T(SBE38) [ITS-90 deg-C]

(b)


60°N
55°N
50°N
170°W
165°W
160°W
31.65
31.80
31.95
32.10
32.25
32.40
32.55
32.70
32.85
SAL [N/A]

(c)



(d)

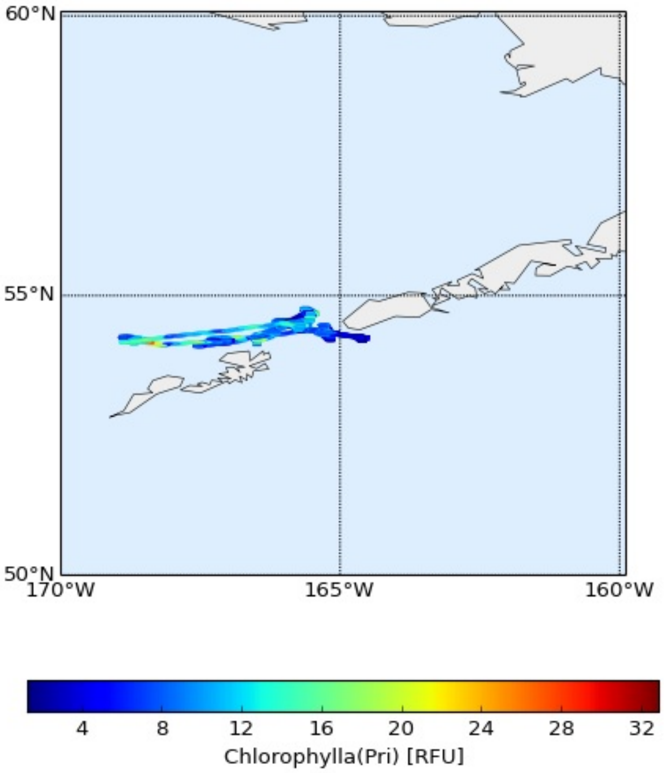


Figure 3.1.10-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in MR17-04 Leg2 cruise.

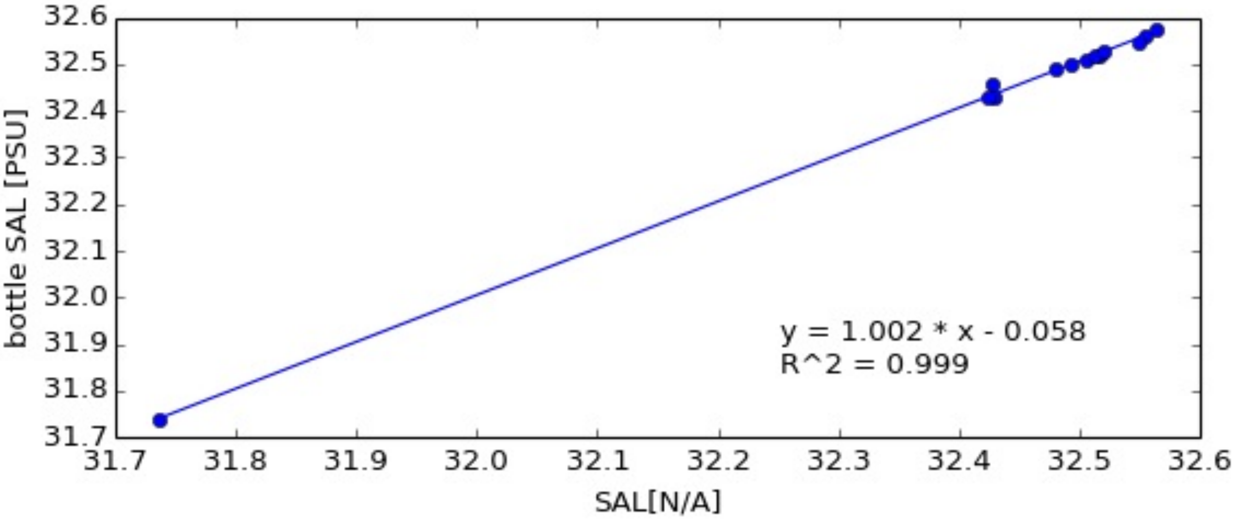


Figure 3.1.10-2-1 Correlation of salinity between sensor data and bottle data.

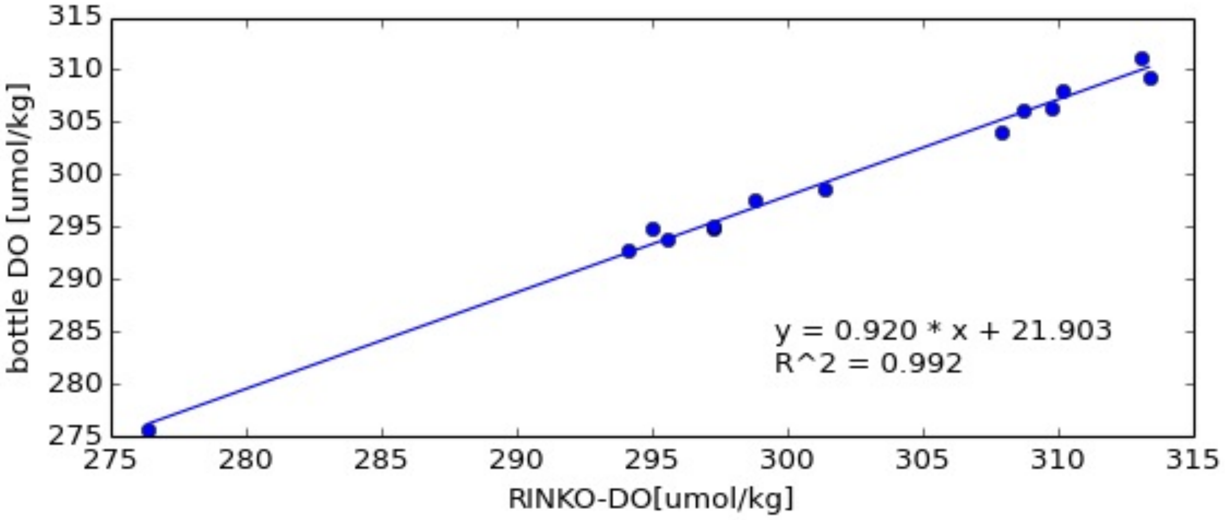


Figure 3.1.10-2-2 Correlation of dissolved oxygen between sensor data and bottle data.

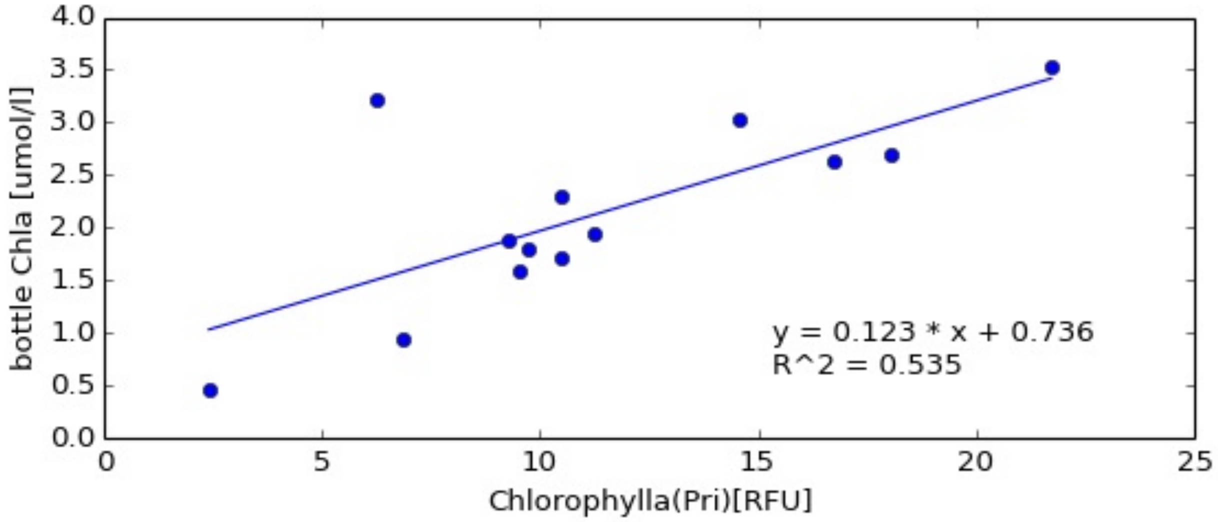


Figure 3.1.10-2-3 Correlation of fluorescence between sensor data and bottle data.

(5) Data archives

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

3.1.11 Underway pCO_2

Yoshiyuki NAKANO (JAMSTEC): Principal Investigator
Tomonori WATAI (MWJ): Operation Leader
Minoru KAMATA (MWJ)

(1) Objective

Our purpose is in-situ measurement of partial pressure of carbon dioxide (pCO_2) in near-sea surface water

(2) Methods, apparatus and performance

Oceanic and atmospheric CO_2 concentrations were measured during the cruise using an automated system equipped with a non-dispersive infrared gas analyzer (NDIR; LI-7000, Li-Cor). Measurements were done every about one hour, and 4 standard gasses, atmospheric air, and the CO_2 equilibrated air with sea surface water were analyzed subsequently. The concentrations of the CO_2 standard gases were provisionally (298, 348, 399, and 450) ppm. Atmospheric air taken from the bow of the ship (approx.13 m above the sea level) was introduced into the NDIR by passing through an electrical cooling unit, a mass flow controller which controls the air flow rate of 0.55 L min^{-1}, and a staring cooler. The CO_2 equilibrated air was the air with its CO_2 concentration was equivalent to the sea surface water. 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 - 0.8) L min^{-1} through two cooling units, the starling cooler, and the NDIR.

(3) Results

Cruise track during pCO_2 observation is shown in Fig. 3.1.11-1, and temporal variations of both oceanic and atmospheric CO_2 concentration (xCO_2) in Fig. 3.1.11-2.

(4) 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>

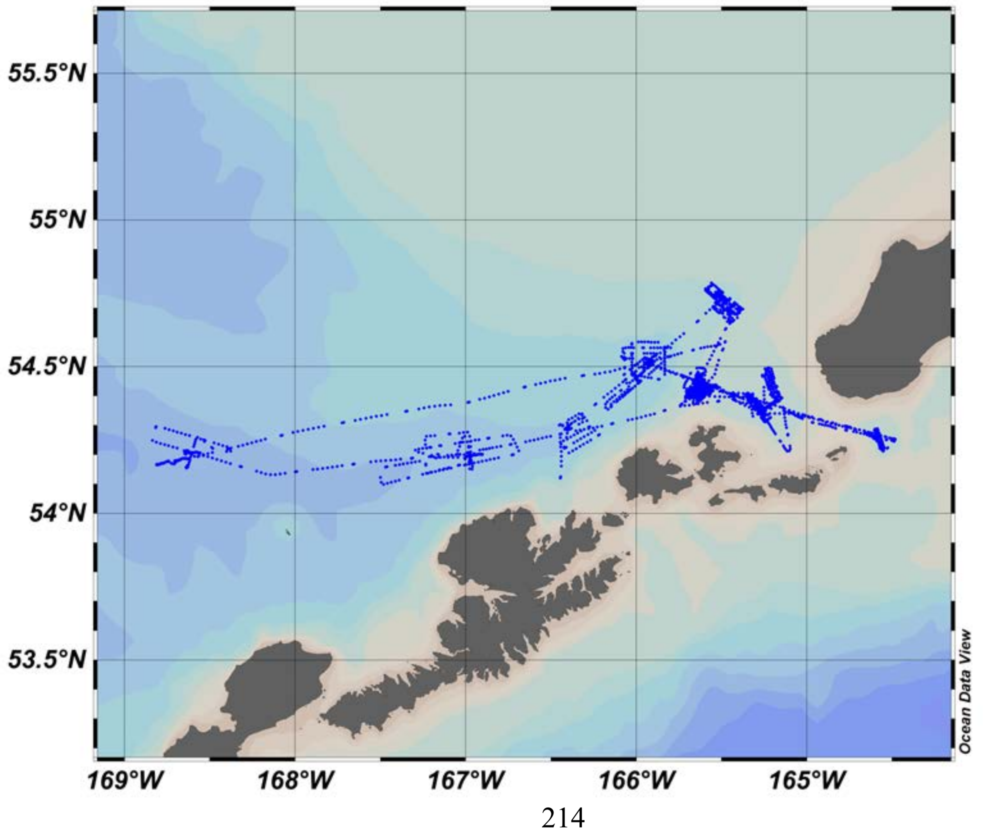


Figure 3.1.11-1 Observation map

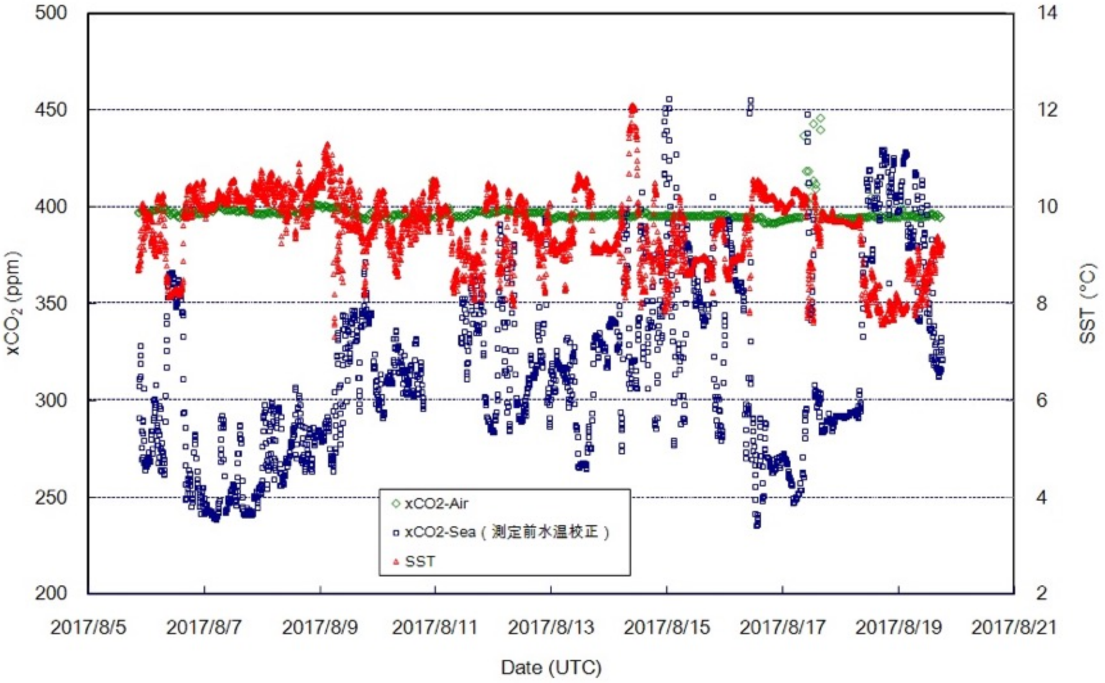


Figure 3.1.11-2 Temporal variations of oceanic and atmospheric CO_2 concentration (xCO_2). Blue dots represent oceanic xCO_2 variation and green atmospheric xCO_2. SST variation (red) is also shown.

3.1.12 Phytoplankton

3.1.12 (a) Chlorophyll a measurements by fluorometric determination

Yoshihiro Fujiwara (JAMSTEC) : Principal Investigator
Masahiro Orui (MWJ) : Operation Leader
Yoshiaki SATO (MWJ)

(1) Objective

Phytoplankton biomass can estimate as the concentration of chlorophyll a (chl-a), because all oxygenic photosynthetic plankton contain chl-a. Phytoplankton exist various species in the ocean, but the species are roughly characterized by their cell size. The objective of this study is to investigate the vertical distribution of phytoplankton and their size fractionations as chl-a by using the fluorometric determination.

(2) Sampling

Samplings of total chl-a were conducted from 8-16 depths between the surface and 200 m at all observational stations. At the cast for primary production, water samples were collected at 8 depths between the surface and 200 m at the station of 00M, 0E2, 00C and 00G.

(3) Instruments and Methods

Water samples (0.5L) for total chl-a were filtered (<0.02 MPa) through 25 mm-diameter Whatman GF/F filter. Size-fractionated chl-a were obtained by sequential filtration (<0.02 MPa) of 1 L water sample through 10 μm, 3 μm and 1 μm polycarbonate filters (47 mm diameter) and Whatman GF/F filter (25 mm diameter). Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylmethanamide (Suzuki and Ishimaru, 1990). Those tubes were stored at -20°C under the dark condition to extract chl-a for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU), which was calibrated against a pure chl-a (Sigma-Aldrich Co., LLC). We applied fluorometric determination for the samples of total and size-fractionated chl-a: “Non-acidification method” (Welschmeyer, 1994). Calibration was carry out at MR17-04 Leg1.Analytical conditions of each method were listed in table 1.

(4) Results

The results of total chl-a at station all stations were shown in Figure 3.1.12(a)-1, 3.1.12(a)-2 and 3.1.12(a)-3. The results of size fractionated chl-a were shown in Figure 3.1.12(a)-4, 3.1.12(a)-5, 3.1.12(a)-6 and 3.1.12(a)-7.

(5) Data archives

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

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

(6) Reference

Suzuki, R., and T. Ishimaru (1990), An improved method for the determination of phytoplankton chlorophyll using N, N-dimethylformamide, J. Oceanogr. Soc. Japan, 46, 190-194.

Holm-Hansen, O., Lorenzen, C. J., Holmes, R.W. and J. D. H. Strickland (1965), Fluorometric determination of chlorophyll. J. Cons. Cons. Int. Explor. Mer. 30, 3-15.

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

Table 3.1.12(a)-1 Analytical conditions of "Non-acidification method" for chlorophyll a with Turner Designs fluorometer (10-AU).

	Non-acidification method
Excitation filter (nm)	436
Emission filter (nm)	680
Lamp	Blue Mercury Vapor

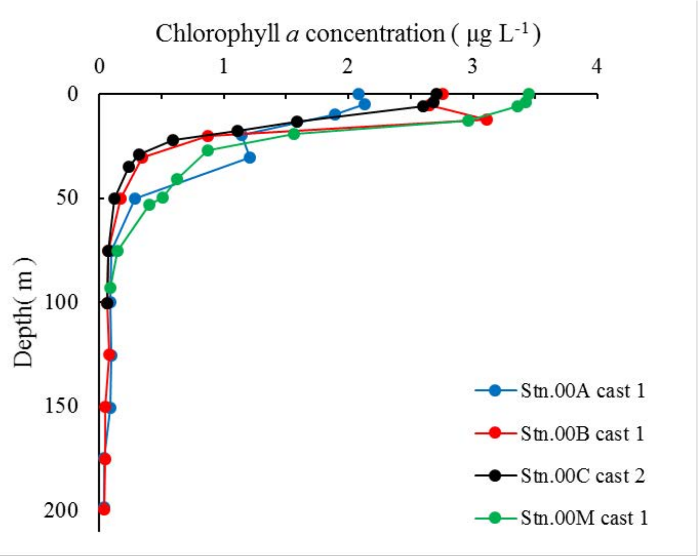


Figure 3.1.12(a)-1 Vertical distribution of total chlorophyll a at Stn.00A, 00B, 00C cast2 and 00M.

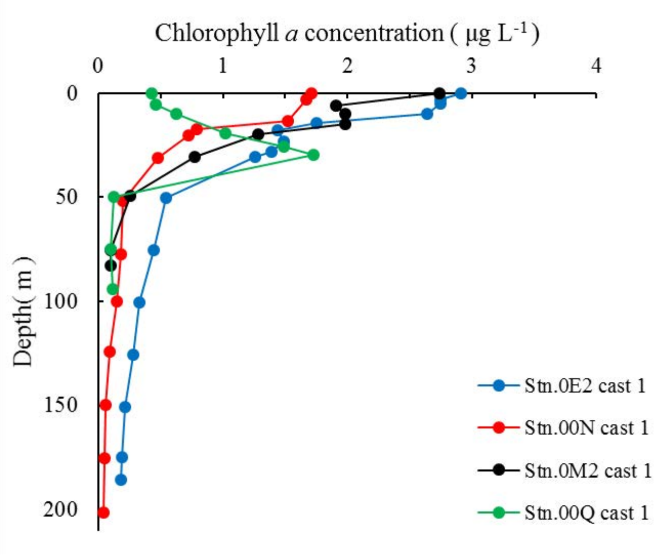


Figure 3.1.12(a)-2 Vertical distribution of total chlorophyll a at Stn.0E2, 00N, 0M2 and 00Q.

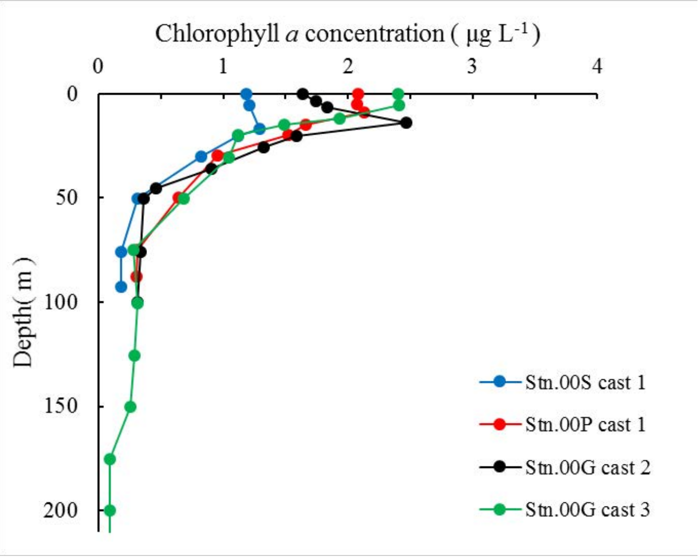


Figure 3.1.12(a)-3 Vertical distribution of total chlorophyll a at Stn.00S, 00P, 00G cast2 and cast3.

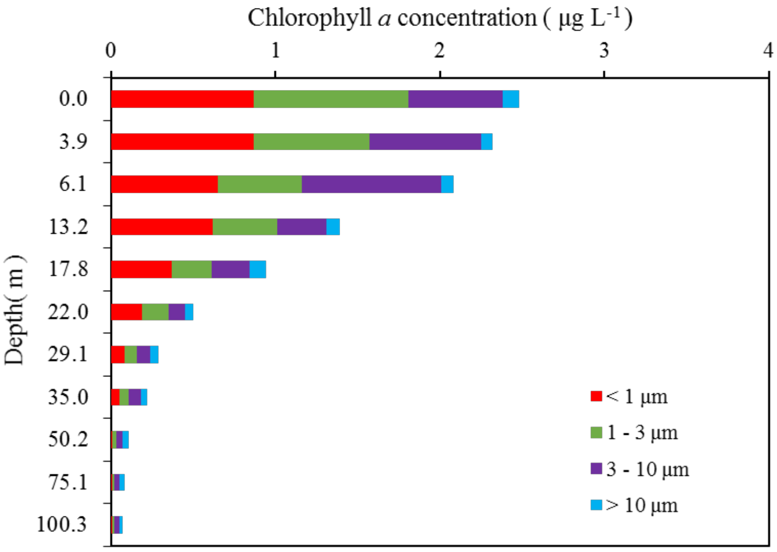


Figure 3.1.12(a)-4 Vertical distribution of size-fractionated chlorophyll a at Stn.00C.

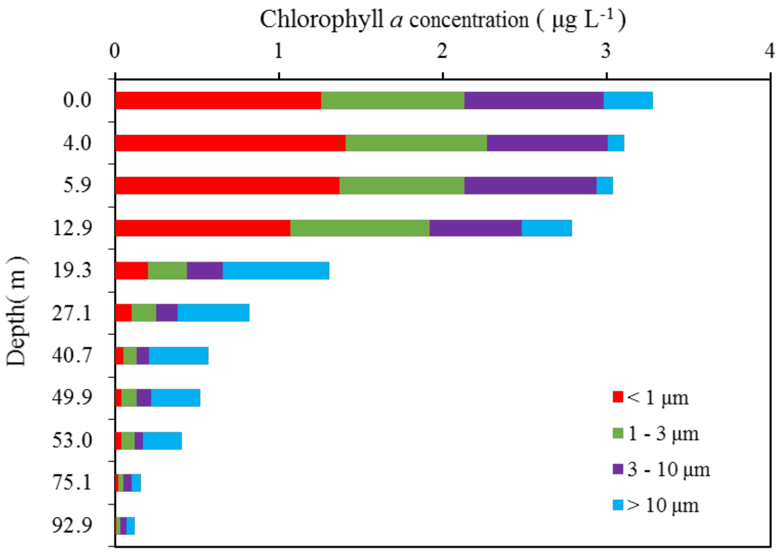


Figure 3.1.12(a)-5 Vertical distribution of size-fractionated chlorophyll a at Stn.00M.

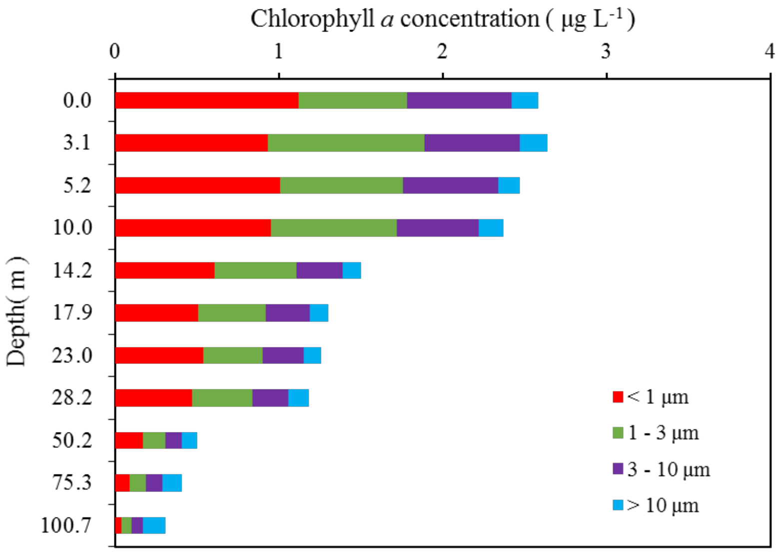


Figure 3.1.12(a)-6 Vertical distribution of size-fractionated chlorophyll a at Stn.0E2.

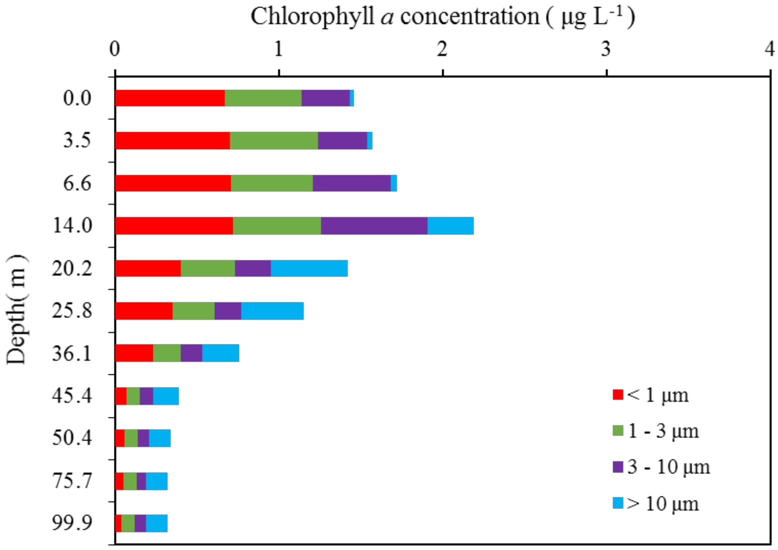


Figure 3.1.12(a)-7 Vertical distribution of size-fractionated chlorophyll a at Stn.00G.

3.1.12 (b) HPLC measurements of marine phytoplankton pigments

Yoshihiro FUJIWARA (JAMSTEC): Principal Investigator
Hironori SATO (MWJ)

(1) Objective

The chemotaxonomic assessment of phytoplankton populations present in natural seawater requires taxon-specific algal pigments as good biochemical markers. A high-performance liquid chromatography (HPLC) measurement is an optimum method for separating and quantifying phytoplankton pigments in natural seawater. In this cruise, we measured the marine phytoplankton pigments by HPLC to investigate the marine phytoplankton community structure in the Bearing Canyon.

(2) Methods, apparatus and performance

(2)-1 Sea water sampling

Seawater sampling, sample treatments and HPLC measurement were the almost same as the first leg (see chapter 2.1.17(b)). Only difference was the drying time of sample filter to remove retaining seawater. Drying time was within 7.5 hours in the second leg.

HPLC was calibrated using the standard pigments in the first leg, and pigment concentrations were calculated from the chromatogram area.

(2)-2 Working standard

500 µg L^{-1} of chlolophyll a standard solution was measured with sea water samples as the working standard. The mean and coefficient of variation (CV) of chromatogram area shown below (Figure 3.1.12(b)-1):

217.7 ± 1.7 (n = 15), CV=0.8 %

(3) Results

Almost data are under the processing. Vertical profiles of major pigments at station 00C were shown in Figure 3.1.12(b)-2.

(4) Data archives

The processed data file of pigments will be submitted to the JAMSTEC Data Management Group (DMG) within a restricted period. Please ask PI for the latest information.

(5) Reference

All references were listed in the chapter 2.1.17(b).

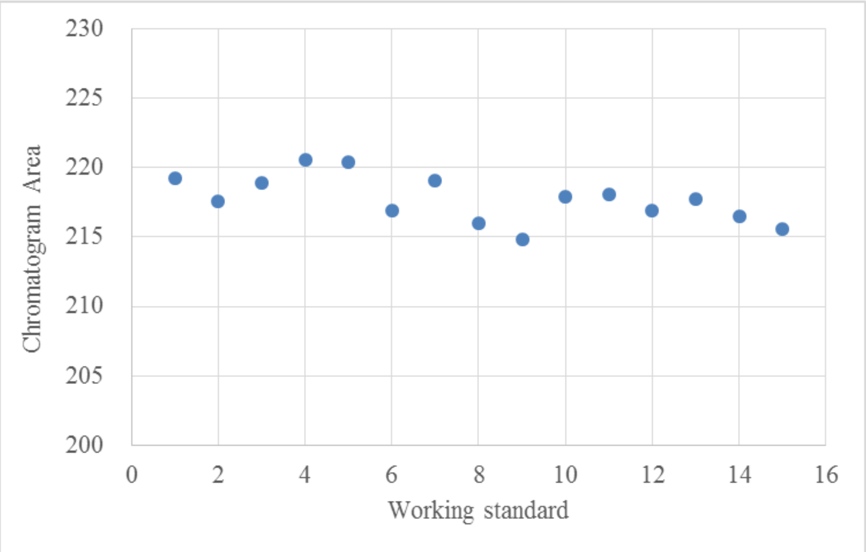
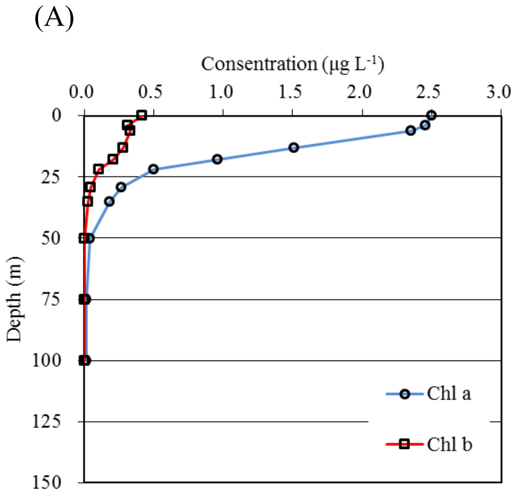


Figure 3.1.12(b)-1 Variability of chromatogram area for working standard.



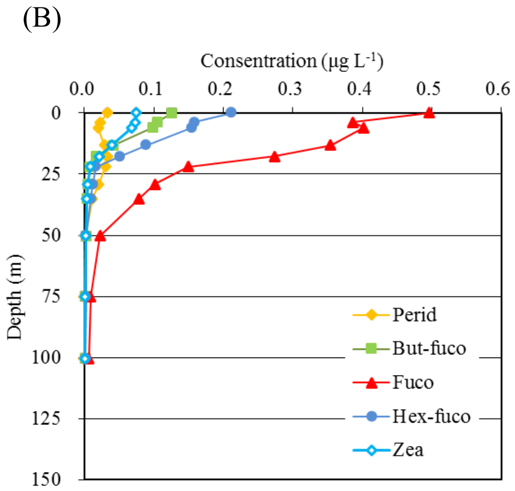


Figure 3.1.12(b)-2-(A) Vertical distributions of major phytoplankton pigments (chlorophyll a and chlorophyll b) at Stn. 00C, cast 2.

Figure 3.1.12(b)-2-(B) Vertical distributions of major phytoplankton pigments (peridinin, 19'-butanoyloxyfucoxanthin, fucoxanthin, 19’-hexanoyloxyfucoxanthin, and zeaxanthin) at Stn. 00C, cast 2.

3.1.12(c) Primary production

Yoshihiro FUJIWARA (JAMSTEC) : Principal Investigator
Hiroshi HOSHINO (MWJ) : Operation Leader
Katsunori SAGISHIMA (MWJ)

(1) Objective

Quantitative assessment of carbon uptake in the surface euphotic layer should be an essential part of the studies for biodiversity and trophic relationships of the Bering Canyon. Primary production (PP) was measured as incorporation of inorganic ^{13}C stable isotope tracer at the four stations in the Bering Canyon.

(2) Methods

1) Sampling, incubation bottle and filter

Sampling and sample treatments were conducted with the almost same procedures as the first leg (see chapter 2.1.17(c)). The only difference was that seawater samples were collected using acid-cleaned Niskin bottles instead of Teflon-coated Nisikin bottles.

2) Incubation

Incubation procedures were same as the first leg (Table 3.1.12(c)).

3) Measurement

Sample treatment, instruments, analysis method and reference material were the same as the first leg. Precisions of four ^{13}C reference material measurements in the second leg was 0.05 - 0.23 ‰.

4) Calculation

Assimilated organic carbon (ΔPOC) is calculated in accordance with Hama et al. (1983) as same as the first leg.

(3) Results

Fig. 3.1.12(c)-1 show the vertical profile of primary production (PP).

(4) Data archives

All data will be submitted to JAMSTEC Data Management Group (DMG).

(5) References

Hama, T., T. Miyazaki, Y. Ogawa, T. Iwakuma, M. Takahashi, A. Otsuki, and S. Ichimura, (1983), Measurement of photosynthetic production of a marine phytoplankton population using a stable 13C isotope. Mar. Biol., 73, 31-36.

Table 3.1.12(c)-1 Light levels of the incubation containers

Number	Light Level
#1	100 %
#2	55 %
#3	34 %
#4	11 %
#5	5.5 %
#6	2.6 %
#7	0.9 %
#8	0.4 %

Table 3.1.12(c)-2 Sampling cast table and spike ^{13}C concentration

Incubation type	CTD cast	$NaHCO_3$ (μmol L^{-1})
simulated in situ	00CM02	200
simulated in situ	00MM01	200
simulated in situ	0E2M01	200
simulated in situ	00GM02	200

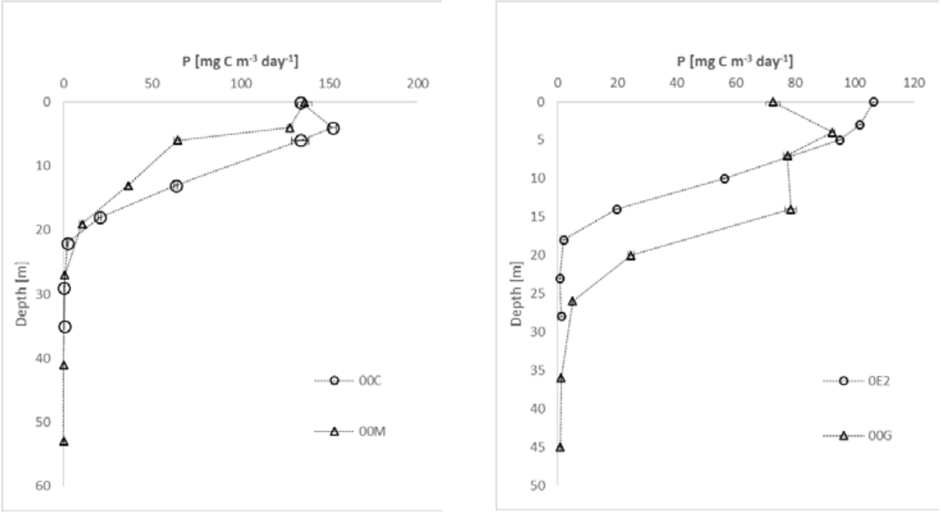


Figure 3.1.12(c)-1 Vertical profile of primary production

3.1.13. Zooplankton

Atsushi YAMAGUCHI (Hokkaido University)
Agnes WEINER (JAMSTEC)

(1) Objective

The goals of this study are following:

1) Evaluate spatial and vertical distribution of zooplankton around Unimak Pass.
2) Evaluate the genetic diversity of planktic Foraminifera in the Northern Pacific.

(2) Sampling

Zooplankton samples were collected by vertical hauls of VMPS (0.25 m^2 mouth opening, equipped 62 μm) at 15 stations around Unimak Pass. VMPS was lowered to desired depth and electrically open/close the net (Terazaki and Tomatsu, 1997). Three net samples were available by one cast. Through this cruise, 32 casts were made by VMPS. Basically, for the shallower stations (depths around 100 m), VMPS was lowered to bottom -20 m, and for the deeper stations (depths around 1000-2000 m), VMPS was lowered to bottom -100 m. Towing speed of VMPS was 0.7 m s^{-1}. Filtered volume of each net sample was estimated from flowmeter reading. Filtering efficiency of the nets was at 85.8-90.9%. All zooplankton sampling data (location, date, time, depth interval, and filtered volume) were summarized in Table 3.1.13-1. Zooplankton samples were split to aliquot by using Motoda box splitter (1/1, 1/2, 1/4) (Motoda, 1959), and following three preservative or sorting were made: formalin preserve, ethanol preserve and Foraminifera sorting. Details on amount of aliquot for each material, see Table 3.1.13-1.

(3) Results

Objective 1) Notable changes in zooplankton samples

From eye/microscopic observation on zooplankton samples, following topics were marked for the zooplankton community: 1. Euphausiids may key component for making "Aleutian Magic" and 2. Dominance of Pteropoda and geographical changes in their body size. Below, preliminary descriptions are made as memorandum.

For issue on euphausiids, one euphausiid species: Thysanoessa raschii was predominated at St. M where the Aleutian Magic (anomalous gathering of birds, fishes and whales) was observed. Since depths of all Aleutian Magic observed locations were limited around 100-150 m depths, following time-successive schema was considered for the forming mechanism of the Aleutian Magic.

1. Upwelling occurred around valley.
2. Phytoplankton bloom occurred at surface.
3. Euphausiids (Thysanoessa raschii) gathered at the shallower depths.
4. Because of the shallow depth topography (100-150 m), euphausiids form high density (e.g. swarm) near bottom during daytime (limitation in diel vertical migration).
5. Baleen whale made hunting on euphausiid swarm (start of Aleutian Magic).
6. Birds and fishes are also feed on euphausiid swarm near surface which made by hunting by whale.
7. Since the volume of euphausiid swarm is limited, predators (birds, fishes and whales) may feed up euphausiids within ca. three hours (end of Aleutian Magic).

It is noted that from Deep-Tow camera, anomalously high density of euphausiids was recorded during this cruise.

For issue on Pteropoda, Limacina helicina dominated for several stations. Interestingly, their vertical distribution and body size composition showed clear regional patterns. Thus, for the Bering Sea side, pteropods abundant near surface layer and their body sizes were dominated by large-sized specimens. While for the Pacific side, their vertical distribution was extended for whole water column and their body sizes were dominated by small-sized specimen. The boundary of these two communities was at around between St. E and S.

After the cruises, above two issues (euphausiids and pteropods) would be studied more detail.

Objective 2)

All living Foraminifera specimens were individually picked from the plankton sample under a stereomicroscope as soon as possible after sampling and transferred to a dish with fresh filtered seawater. After cleaning with a fine brush some individuals were put in RNALater or Urea buffer for preservation, whereas the majority was placed on a cardboard faunal slide and frozen at -20°C.

Three different morphospecies of planktic Foraminifera were encountered in the Bering Sea, Globigerina bulloides, Neogloboquadrina pachyderma and Turborotalita quinqueloba. All three morphospecies were found at every station sampled. However, the number of specimens varied greatly between the stations. The stations in the western part of the sampling area (stations A, B, G and H) had a large number of specimens, as is usually the case in open sea locations. Surprisingly, there were also many specimens in the samples of stations C, M and E, which are located on the shelf and therefore are not the typical habitat of Foraminifera. However, the fact that planktic Foraminifera were found in these shallow shelf stations shows that upwelling is occuring in this area, which transports the specimens up onto the shelf from the open ocean. Samples from station Q on the Pacific side, however, did not contain many planktic Foraminifera, as is typically expected from such a shallow site. At all stations the majority of specimens was encountered in the upper 50m of the water column.

Planktic Foraminifera will be genetically analyzed at JAMSTEC to conduct a screening of the SSU rDNA of a representative number of specimens of all species for every station in search for genetic diversity. The obtained sequences will be added to already available datasets as well as samples obtained during MR17-04 Leg 1 in order to be able to detect potential new genotypes and to analyze their biogeographic distribution patterns in the Northern Pacific. Samples preserved in RNALater will be analyzed by next-generation sequencing to examine the microbial association within an individual Foraminifera.

(4) References

Motoda, S., 1959. Devices of simple plankton apparatus. Memoirs of Faculty of Fisheries, Hokkaido University 7: 73–94.

Terazaki, M., Tomatsu, C., 1997. A vertical multiple opening and closing plankton sampler. Journal of Advanced Marine Science Technological Society 3: 127–132.

MR17–04_Leg2_VMPS_Position

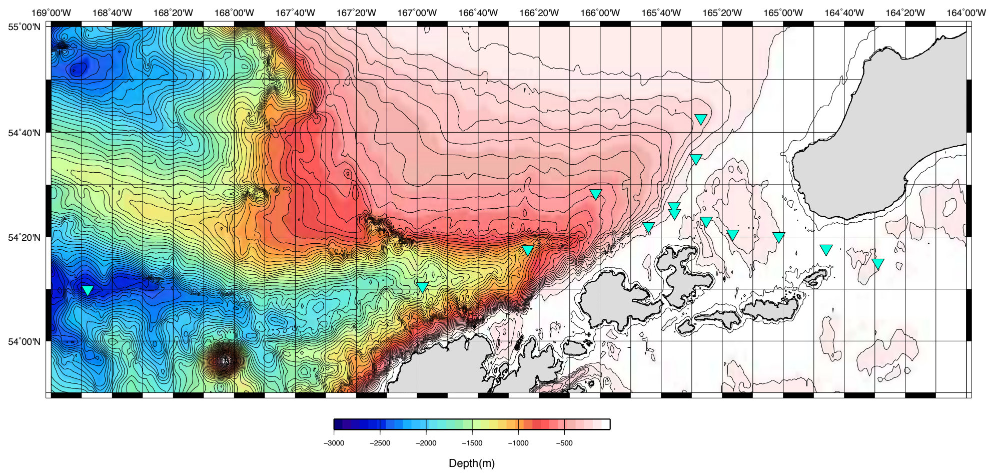


Table 3.1.13-1. Data on plankton samples collected by vertical hauls with VMPS. Sorting on Foraminifera was also made for marked samples (Sorting).

Station	Position		Local Time (UTC-9, ST+1)				Depth (m)			Filtered	Samples (aliquot)			Sample	
(depth)	Lat. (N)	Lon. (W)	Date	Start	-	End	interval			water (m^3)	Formalin	Ethanol	Sorting	no.	Remark
A	54-17.7229	166-23.7795	6 Aug.	0:16	-	0:17	0	-	25	5.50	1/2	1/2	1/1	V-1	Pteropods abundant
(1102 m)				0:15	-	0:16	25	-	50	5.33	1/2	1/2	1/1	V-2	
Nighttime				0:15	-	0:15	50	-	75	5.33	1/2	1/2	1/1	V-3	
				0:45	-	0:45	73	-	97	5.68	1/2	1/2	1/1	V-4	
				0:44	-	0:45	97	-	148	11.72	1/2	1/2	1/1	V-5	
				0:42	-	0:44	148	-	250	21.66	1/2	1/2	1/1	V-6	
				1:28	-	1:32	247	-	497	49.54	1/2	1/2	1/1	V-7	
				1:25	-	1:28	497	-	748	50.25	1/2	1/2	1/1	V-8	
				1:20	-	1:25	748	-	999	50.95	1/2	1/2	1/1	V-9	
B	54-28.416	166-01.5412	6 Aug.	16:11	-	16:11	0	-	25	5.87	1/2	1/2	-	V-10	
(536 m)				16:10	-	16:11	25	-	51	5.67	1/2	1/2	-	V-11	
Daytime				16:09	-	16:10	51	-	75	5.47	1/2	1/2	-	V-12	
				16:34	-	16:34	76	-	99	5.47	1/2	1/2	-	V-13	
				16:33	-	16:34	99	-	151	11.94	1/2	1/2	-	V-14	
				16:31	-	16:33	151	-	250	20.85	1/2	1/2	-	V-15	
				16:59	-	17:03	247	-	500	59.31	1/2	1/2	-	V-16	
				17:27	-	17:28	0	-	49	11.54	-	-	1/1	Net 1	
				17:26	-	17:27	49	-	101	11.34	-	-	1/1	Net 2	
				17:25	-	17:26	101	-	150	10.93	-	-	1/1	Net 3	
				17:03	-	17:05	149	-	247	22.27	-	-	1/1	Net 4	
C	54-42.6585	165-26.9507	8 Aug.	0:12	-	0:13	0	-	25	5.49	1/2	1/2	-	V-17	
(231 m)				0:12	-	0:12	25	-	50	5.68	1/2	1/2	-	V-18	
Nighttime				0:11	-	0:12	50	-	75	5.30	1/2	1/2	-	V-19	
				0:35	-	0:36	74	-	98	5.68	1/2	1/2	-	V-20	
				0:34	-	0:35	98	-	150	11.36	1/2	1/2	-	V-21	
				0:33	-	0:34	150	-	210	12.88	1/2	1/2	-	V-22	
				0:57	-	0:57	0	-	50	10.41	-	-	1/1	Net 5	
				0:56	-	0:57	50	-	100	10.98	-	-	1/1	Net 6	
				0:55	-	0:56	100	-	150	11.17	-	-	1/1	Net 7	
M2	54-25.8653	165-35.1813	10 Aug.	1:09	-	1:10	0	-	24	5.30	1/4	1/4	1/2	V-23	Euphausiids abundant
(103 m)				1:09	-	1:09	24	-	47	5.30	1/4	1/4	1/2	V-24	
Nighttime				1:08	-	1:09	47	-	75	5.49	1/4	1/4	1/2	V-25	
E2	54-20.5684	165-16.4110	12 Aug.	0:08	-	0:09	0	-	25	5.34	1/2	1/2	-	V-26	Pteropods abundant
(197 m)				0:08	-	0:08	25	-	50	5.00	1/2	1/2	-	V-27	
Nighttime				0:07	-	0:08	50	-	75	4.83	1/2	1/2	-	V-28	
				0:27	-	0:28	75	-	100	4.31	1/2	1/2	-	V-29	
				0:26	-	0:27	100	-	150	11.55	1/2	1/2	-	V-30	
				0:26	-	0:26	150	-	180	7.41	1/2	1/2	-	V-31	
				1:46	-	1:47	0	-	25	5.34	-	-	1/1	Net 8	
				1:46	-	1:46	25	-	50	6.21	-	-	1/1	Net 9	
				1:45	-	1:46	50	-	75	6.03	-	-	1/1	Net 10	
T	54-35.0584	165-28.6804	13 Aug.	7:41	-	7:42	0	-	24	5.71	1/1	-	-	V-32	
(125 m)				7:41	-	7:41	24	-	51	5.71	1/1	-	-	V-33	
Daytime				7:40	-	7:41	51	-	100	10.53	1/1	-	-	V-34	
U	54-22.1728	165-44.2172	13 Aug.	10:09	-	10:09	0	-	27	6.61	1/1	-	-	V-35	Pteropods dominated
(121 m)				10:08	-	10:09	27	-	47	5.00	1/1	-	-	V-36	
Daytime				10:07	-	10:08	47	-	99	12.14	1/1	-	-	V-37	
M	54-24.6368	165-35.6462	13 Aug.	14:31	-	14:31	0	-	22	4.53	1/1	-	-	V-38	
(93 m)				14:30	-	14:31	22	-	53	6.56	1/1	-	-	V-39	
Daytime				14:30	-	14:30	53	-	75	5.47	1/1	-	-	V-40	
Q	54-15.1489	164-28.9730	14 Aug.	1:48	-	1:49	0	-	20	4.41	1/1	-	-	V-41	Small-sized pteropods abundant
(105 m)				1:48	-	1:48	20	-	51	6.62	1/1	-	-	V-42	
Nighttime				1:47	-	1:48	51	-	85	7.72	1/1	-	-	V-43	
				2:09	-	2:10	0	-	25	5.33	-	-	1/1	Net 11	
				2:09	-	2:09	25	-	49	5.15	-	-	1/1	Net 12	
				2:08	-	2:09	49	-	85	8.09	-	-	1/1	Net 13	
R	54-17.7766	164-45.9165	14 Aug.	3:49	-	3:50	0	-	14	2.96	1/1	-	-	V-44	Small-sized pteropods abundant
(81 m)				3:49	-	3:49	14	-	41	5.43	1/1	-	-	V-45	
Nighttime				3:48	-	3:49	41	-	63	5.43	1/1	-	-	V-46	
S	54-20.2329	165-01.4064	14 Aug.	5:49	-	5:50	0	-	23	5.19	1/1	-	-	V-47	
(107 m)				5:49	-	5:49	23	-	52	5.84	1/1	-	-	V-48	
Nighttime				5:48	-	5:49	52	-	86	7.47	1/1	-	-	V-49	
P	54-23.1288	165-25.1730	14 Aug.	8:06	-	8:07	0	-	23	5.33	1/1	-	-	V-50	
(107 m)				8:06	-	8:06	23	-	50	5.12	1/1	-	-	V-51	
Daytime				8:05	-	8:06	50	-	75	5.94	1/1	-	-	V-52	
G	54-11.7123	166-58.2586	15 Aug.	1:37	-	1:37	0	-	24	4.86	1/4	1/4	1/2	V-53	
(1536 m)				1:36	-	1:37	24	-	51	6.08	1/4	1/4	1/2	V-54	
Nighttime				1:35	-	1:36	51	-	101	11.46	1/4	1/4	1/2	V-55	
				1:14	-	1:15	99	-	151	11.86	1/4	1/4	1/2	V-56	
				1:13	-	1:14	151	-	251	22.45	1/4	1/4	1/2	V-57	
				1:09	-	1:13	251	-	501	55.47	1/4	1/4	1/2	V-58	
				0:33	-	0:36	500	-	743	52.42	1/4	1/4	1/2	V-59	
				0:29	-	0:33	743	-	1000	58.12	1/4	1/4	1/2	V-60	
				0:23	-	0:29	###	-	1399	89.14	1/4	1/4	1/2	V-61	
G	54-10.6207	166-58.4840	15 Aug.	10:17	-	10:18	0	-	24	5.80	1/2	1/2	-	V-62	
(1524 m)				10:17	-	10:17	24	-	52	6.58	1/2	1/2	-	V-63	
Daytime				10:16	-	10:17	52	-	100	10.45	1/2	1/2	-	V-64	
				9:55	-	9:56	99	-	141	9.70	1/2	1/2	-	V-65	
				9:53	-	9:55	141	-	251	24.07	1/2	1/2	-	V-66	
				9:49	-	9:53	251	-	500	54.10	1/2	1/2	-	V-67	
				9:09	-	9:13	500	-	750	53.02	1/2	1/2	-	V-68	
				9:06	-	9:09	750	-	1000	55.15	1/2	1/2	-	V-69	
				9:00	-	9:06	###	-	1400	86.68	1/2	1/2	-	V-70	
H	54-10.5894	168-44.3679	16 Aug.	20:02	-	20:03	0	-	25	4.97	1/4	1/4	1/2	V-71	
(2568 m)				20:02	-	20:02	25	-	50	5.30	1/4	1/4	1/2	V-72	
Daytime				20:01	-	20:02	50	-	103	12.58	1/4	1/4	1/2	V-73	
				20:37	-	20:38	100	-	144	9.02	1/4	1/4	1/2	V-74	
				20:35	-	20:37	144	-	246	22.31	1/4	1/4	1/2	V-75	
				20:31	-	20:35	246	-	499	57.28	1/4	1/4	1/2	V-76	
				21:23	-	21:26	496	-	711	47.54	1/2	1/2	-	V-77	Net mesh broken
				21:18	-	21:23	711	-	995	62.15	1/2	1/2	-	V-78	
				21:14	-	21:18	995	-	1248	54.23	1/2	1/2	-	V-79	
				22:40	-	22:46	###	-	1500	56.77	1/2	1/2	-	V-80	
				22:23	-	22:40	###	-	2001	113.10	1/2	1/2	-	V-81	

3.1.14 Geophysical observation

3.1.14 (a) Swath bathymetry and Sub-bottom profile survey

Yoshihiro FUJIWARA	JAMSTEC: Principal Investigator
Souichiro SUEYOSHI	Nippon Marine Enterprises LTD. (NME)
Toshimasa NASU	NME
Masanori MURAKAMI	MIRAI crew

(1) Introduction

The objective of Multi-Beam Echo Sounding system (MBES) is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global data sets. The objective of Sub-bottom profiler (SBP) is collecting sub-bottom sediment data around the multiple corer sampling point.

(2) Data acquisition

R/V MIRAI is equipped with a Multi-narrow Beam Echo Sounding system (MBES), SEABEAM3012 (L3 Communications ELAC Nautik GmbH) and Sub-Bottom Profiler (SBP), Bathy 2010 (SyQwest Incorporated). In order to determine an accurate sound velocity of water column for the ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD and Argo float data by the equation in Del Grosso (1974) during the cruise.

(3) Results

Figure 3.1.14(a)-1 shows bathymetric map of each observation area. Figure 3.1.14(a)-2 shows SBP images.

(4) Data Archives

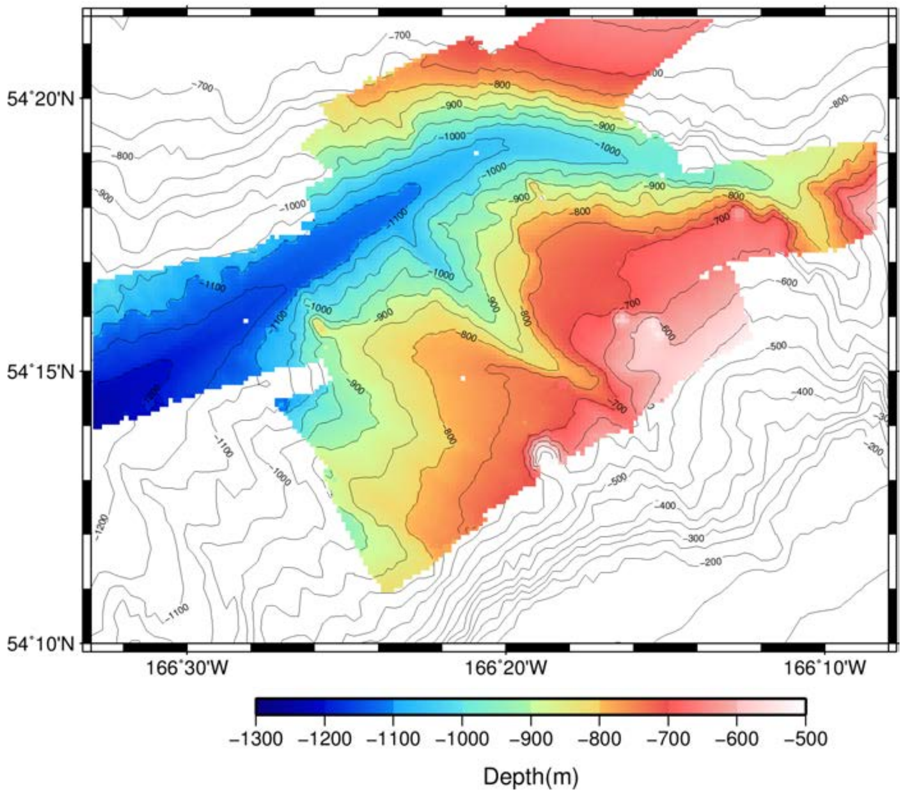
All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

Table 3.1.14(a)-1 System configuration and performance of SEABEAM 3012 (12 kHz system)

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
Beam spacing:	Equi-Angle
Number of beams:	301 beams
Swath width:	60 to 150 degree (max)
Depth accuracy:	< 1 % of water depth (average across the swath)

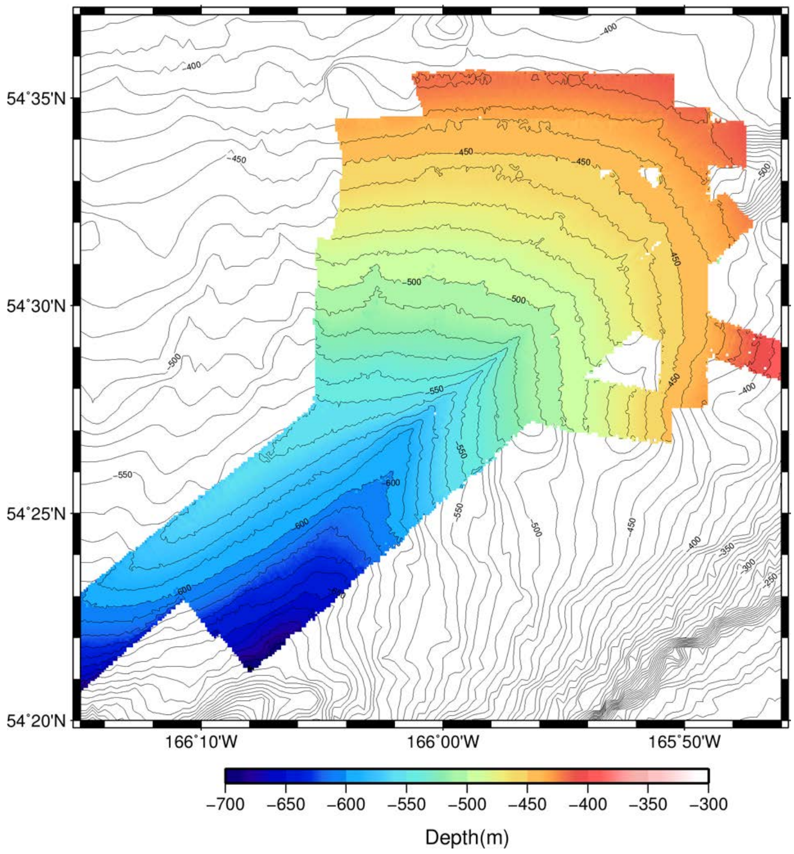
Table 3.1.14(a)-2 Bathy2010 System configuration and performance

Frequency:	3.5 KHz (FM sweep)
Transmit beam width:	23 degree
Transmit pulse length:	0.5 to 50 msec
	Strata resolution: Up to 8 cm with 300 m of bottom penetration according to bottom type
Depth resolution:	0.1 feet, 0.1 m
Depth accuracy:	±10 cm to 100 m, ± 0.3% to 6,000 m
Sound velocity:	1,500 m/s (fix)



A area

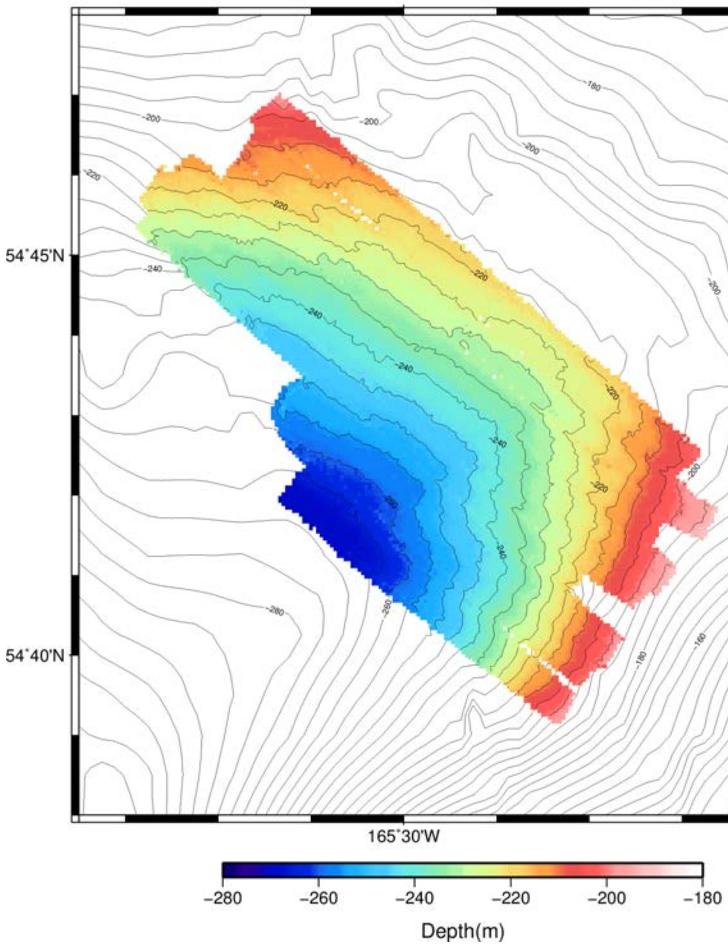
54°20'N
54°15'N
54°10'N
166°30'W
166°20'W
166°10'W
−1300
−1200
−1100
−1000
−900
−800
−700
−600
−500
Depth(m)



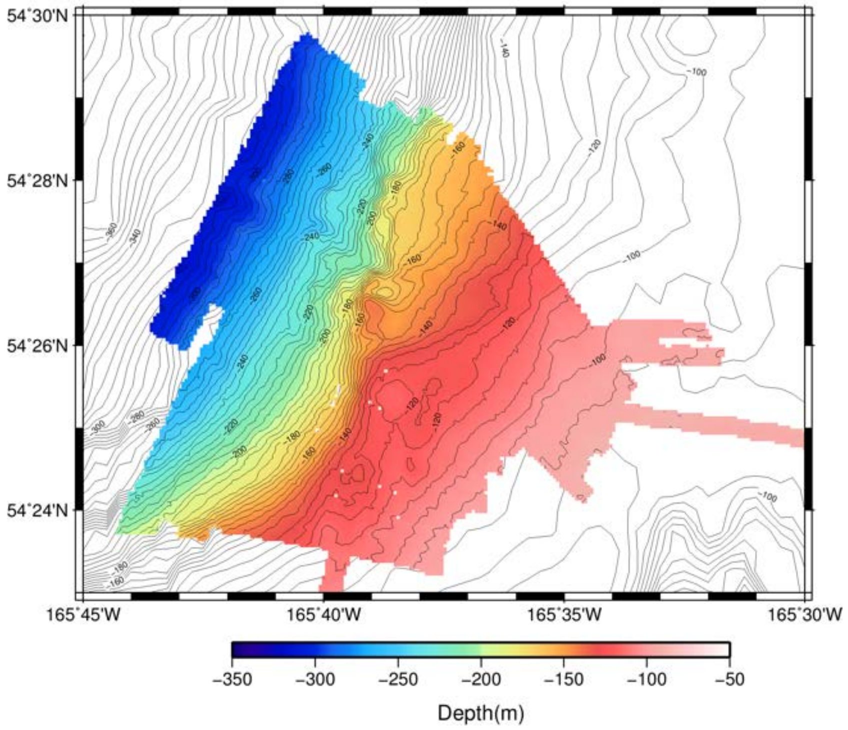
B area

54°35'N
54°30'N
54°25'N
54°20'N
166°10'W
166°00'W
165°50'W
−700
−650
−600
−550
−500
−450
−400
−350
−300
Depth(m)

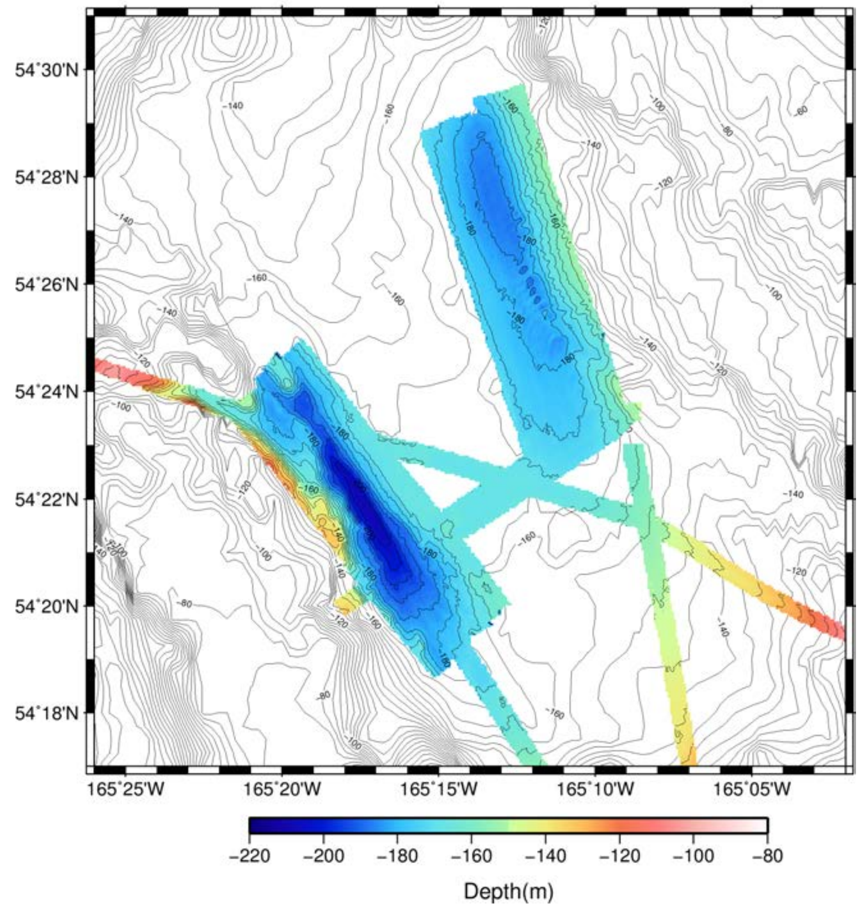
C area



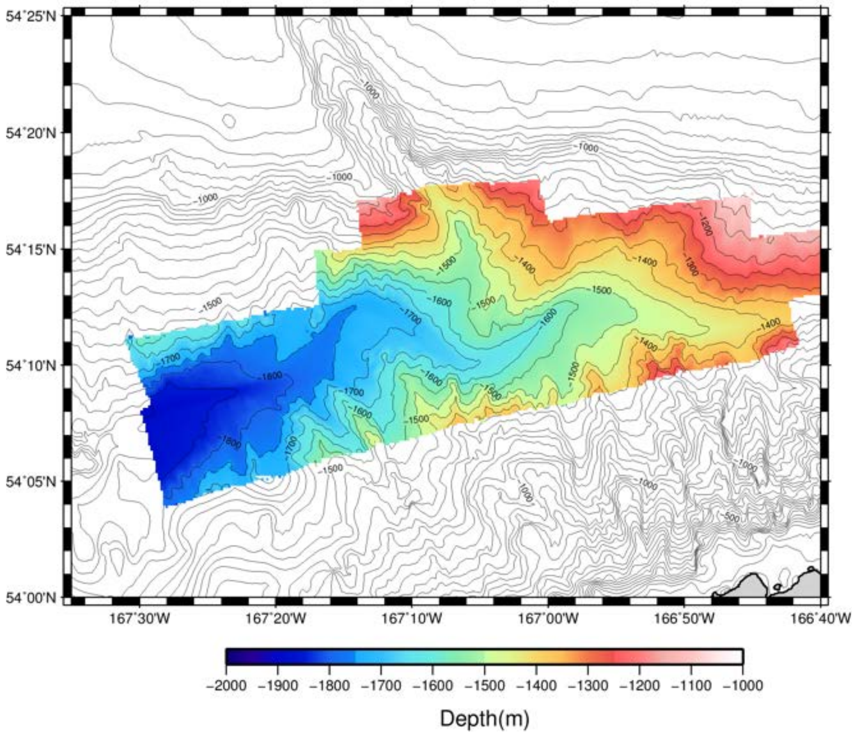
D, M area



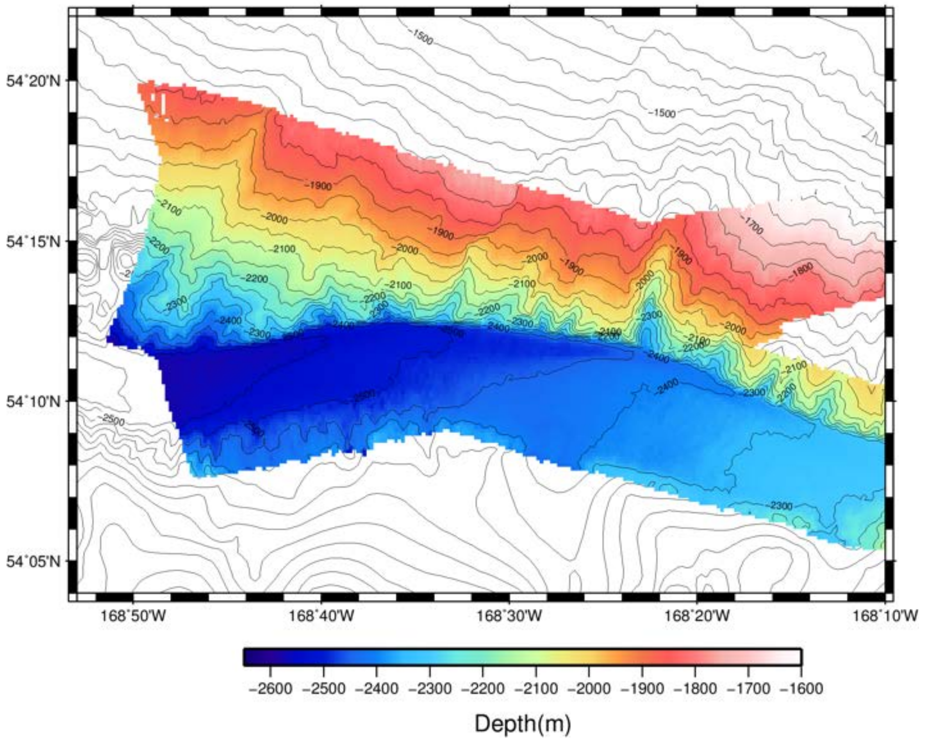
E area


54°30'N
54°28'N
54°26'N
54°24'N
54°22'N
54°20'N
54°18'N
165°25'W
165°20'W
165°15'W
165°10'W
165°05'W
−220
−200
−180
−160
−140
−120
−100
−80
Depth(m)

G area


54°25'N
54°20'N
54°15'N
54°10'N
54°05'N
54°00'N
167°30'W
167°20'W
167°10'W
167°00'W
166°50'W
166°40'W
−2000
−1900
−1800
−1700
−1600
−1500
−1400
−1300
−1200
−1100
−1000
Depth(m)

H area



Q area

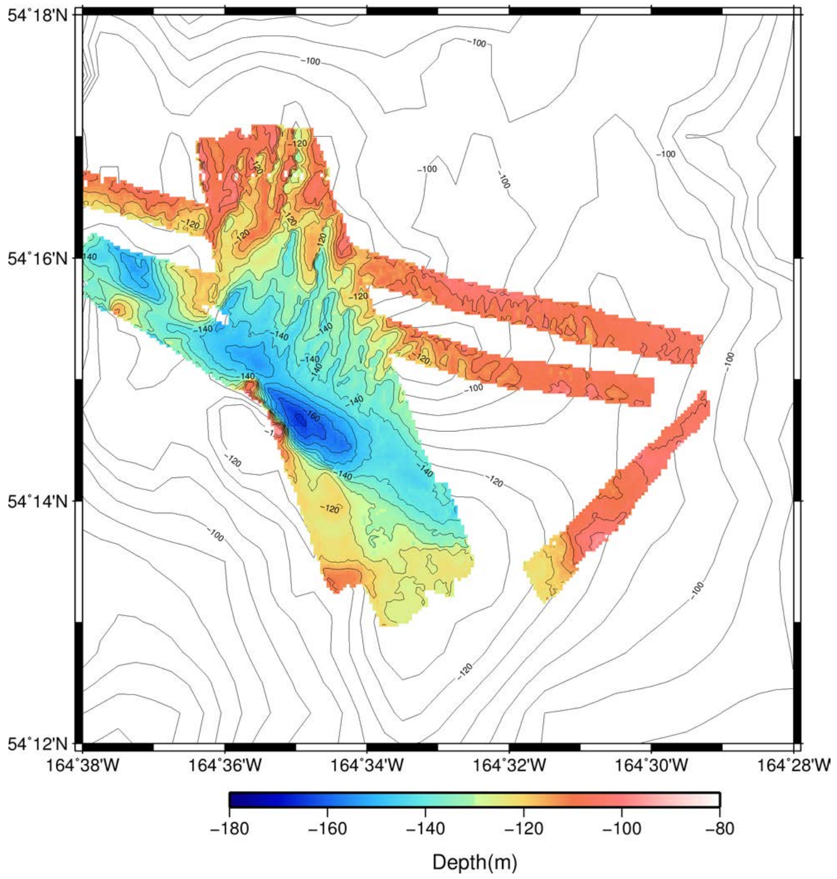
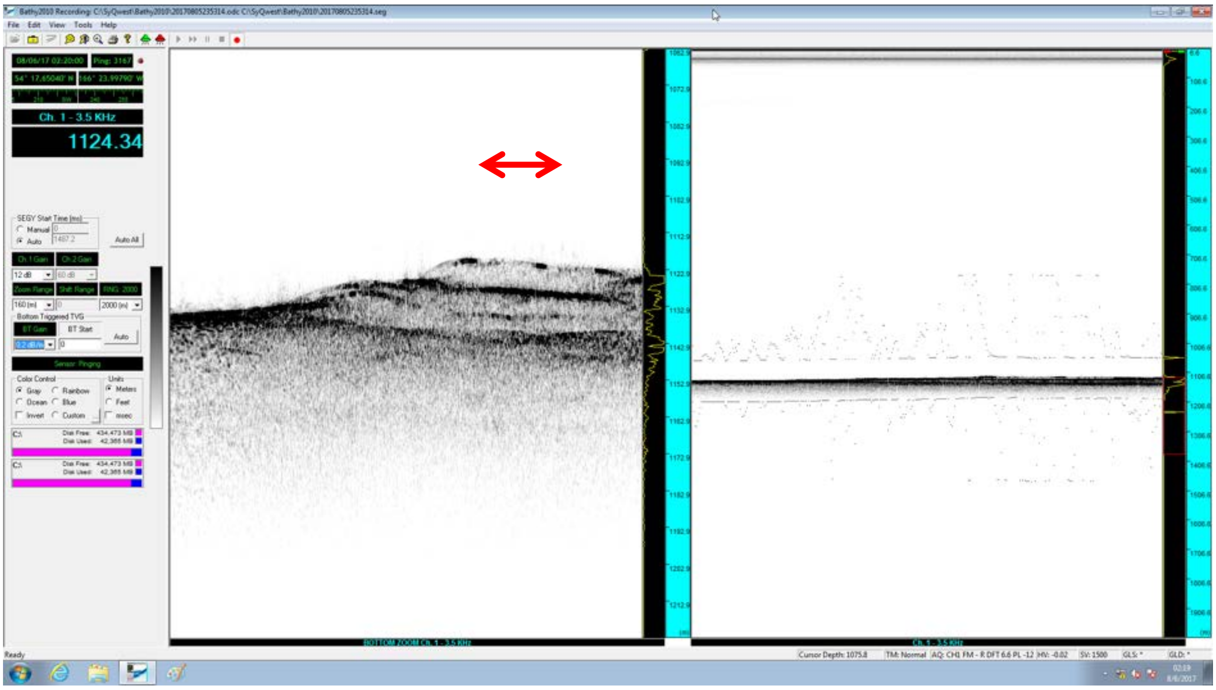


Fig. 3.1.14(a)-1 Bathymetric maps


Bathy2010 Recording: C:\SyQwest\Bathy2010\20170805235314.odc C:\SyQwest\Bathy2010\20170805235314.seg

08/06/17 02:20:00 Ping: 3167

54° 17.65040' N 166° 23.99790' W

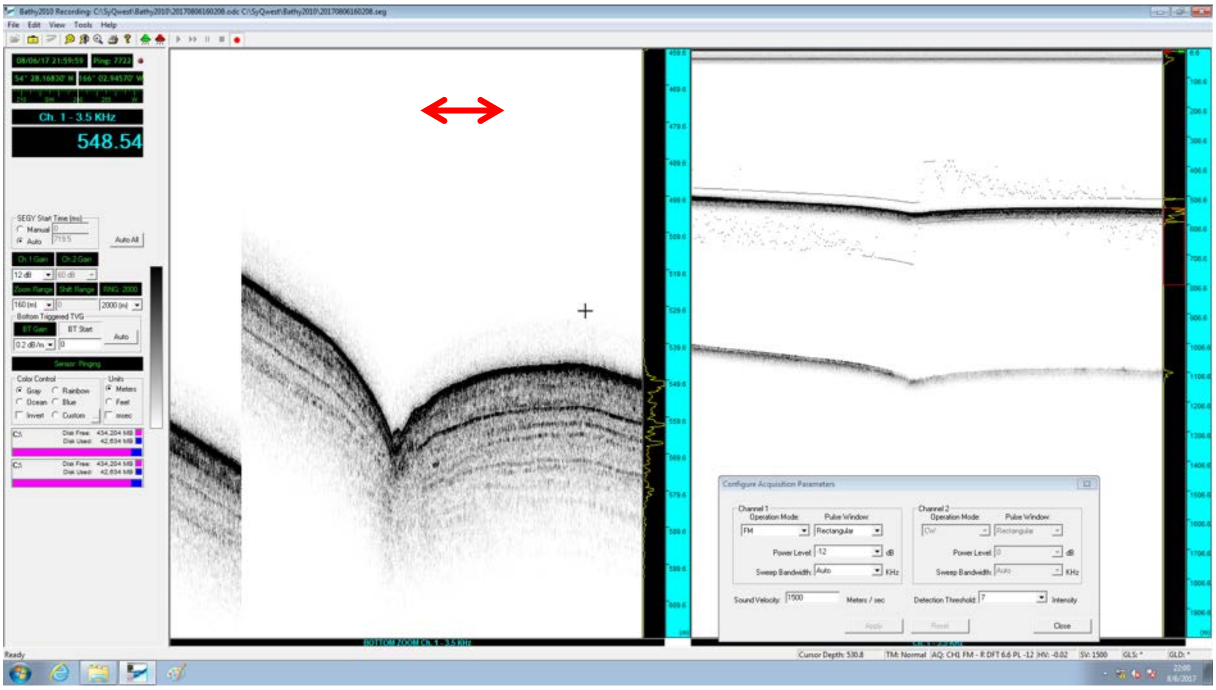
Ch. 1 - 3.5 KHz

1124.34

Cursor Depth: 1075.8 | TM: Normal | AQ: CH1 FM - R DFT 6.6 PL -12 | HV: -0.02 | SV: 1500 | GLS: * | GLD: *

SBP image station A

SBP image station B


Bathy2010 Recording: C:\SyQwest\Bathy2010\20170806160208.odc C:\SyQwest\Bathy2010\20170806160208.seg

08/06/17 21:59:59 Ping: 7722

54° 28.16830' N 166° 02.94570' W

Ch. 1 - 3.5 KHz

548.54

Configure Acquisition Parameters

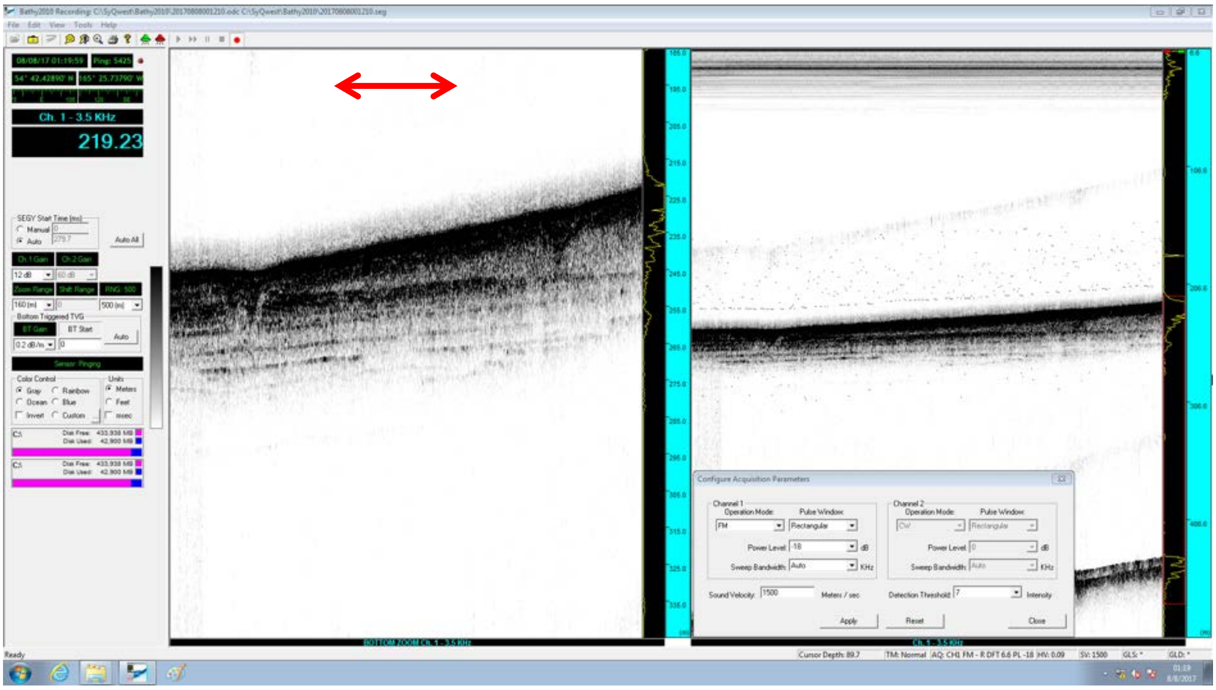
Channel 1
Operation Mode: FM
Pulse Window: Rectangular
Power Level: -12 dB
Sweep Bandwidth: Auto KHz

Channel 2
Operation Mode: CW
Pulse Window: Rectangular
Power Level: 0 dB
Sweep Bandwidth: Auto KHz

Sound Velocity: 1500 Meters / sec

Detection Threshold: 7 Intensity

Cursor Depth: 530.8 | TM: Normal | AQ: CH1 FM - R DFT 6.6 PL -12 | HV: -0.02 | SV: 1500 | GLS: * | GLD: *



Bathy2010 Recording: C:\SyQwest\Bathy2010\20170808001210.odc C:\SyQwest\Bathy2010\20170808001210.seg

08/08/17 01:19:59
Ping: 5425
54° 42.42890' N
165° 25.73790' W
Ch. 1 - 3.5 KHz
219.23

SEGY Start Time (ms):
○ Manual 0
● Auto 279.7

Ch.1 Gain: 12 dB
Ch.2 Gain: 60 dB
Zoom Range: 160 (m)
Shift Range: 0
RNG: 500: 500 (m)
Bottom Triggered TVG
BT Gain: 0.2 dB/m
BT Start: 0

Sensor: Pinging

Color Control: ● Gray ○ Rainbow ○ Ocean ○ Blue ☐ Invert ○ Custom
Units: ● Meters ○ Feet ☐ msec

C:\ Disk Free: 433,938 MB Disk Used: 42,900 MB
C:\ Disk Free: 433,938 MB Disk Used: 42,900 MB

Configure Acquisition Parameters

Channel 1
Operation Mode: FM
Pulse Window: Rectangular
Power Level: -18 dB
Sweep Bandwidth: Auto KHz

Channel 2
Operation Mode: CW
Pulse Window: Rectangular
Power Level: 0 dB
Sweep Bandwidth: Auto KHz

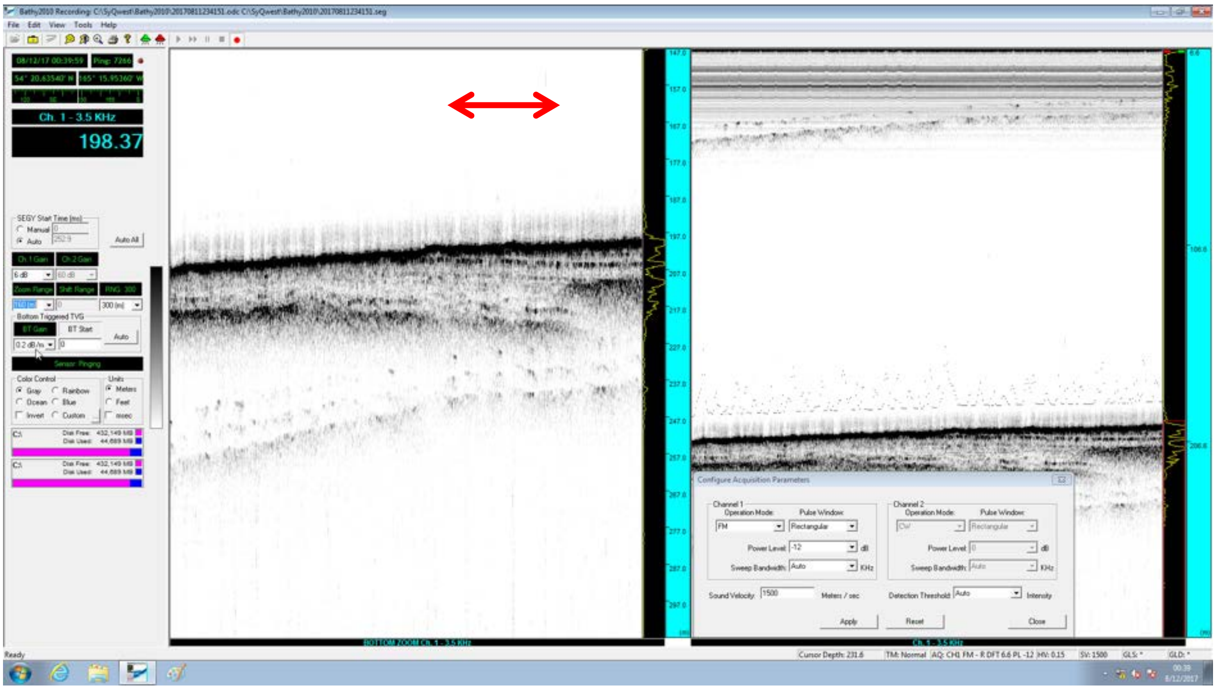
Sound Velocity: 1500 Meters / sec
Detection Theshold: 7 Intensity

Cursor Depth: 89.7
TM: Normal
AQ: CH1 FM - R DFT 6.6 PL -18
HV: 0.09
SV: 1500
GLS: *
GLD: *

01:19
8/8/2017

SBP image station C

SBP image station E2



Bathy2010 Recording: C:\SyQwest\Bathy2010\20170811234151.odc C:\SyQwest\Bathy2010\20170811234151.seg

08/12/17 00:39:59
Ping: 7266
54° 20.63540' N
165° 15.95360' W
Ch. 1 - 3.5 KHz
198.37

SEGY Start Time (ms):
○ Manual 0
● Auto 252.9

Ch.1 Gain: 6 dB
Ch.2 Gain: 60 dB
Zoom Range: 160 (m)
Shift Range: 0
RNG: 300: 300 (m)
Bottom Triggered TVG
BT Gain: 0.2 dB/m
BT Start: 0

Sensor: Pinging

Color Control: ● Gray ○ Rainbow ○ Ocean ○ Blue ☐ Invert ○ Custom
Units: ● Meters ○ Feet ☐ msec

C:\ Disk Free: 432,149 MB Disk Used: 44,689 MB
C:\ Disk Free: 432,149 MB Disk Used: 44,689 MB

Configure Acquisition Parameters

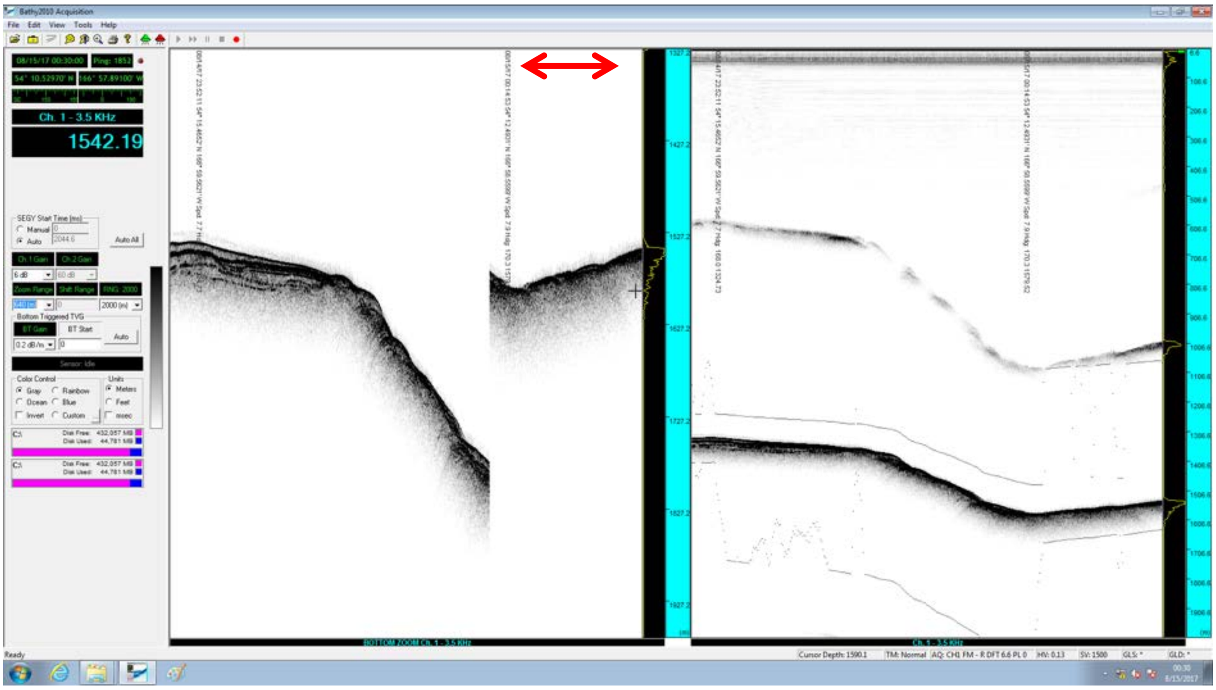
Channel 1
Operation Mode: FM
Pulse Window: Rectangular
Power Level: -12 dB
Sweep Bandwidth: Auto KHz

Channel 2
Operation Mode: CW
Pulse Window: Rectangular
Power Level: 0 dB
Sweep Bandwidth: Auto KHz

Sound Velocity: 1500 Meters / sec
Detection Theshold: Auto Intensity

Cursor Depth: 231.6
TM: Normal
AQ: CH1 FM - R DFT 6.6 PL -12
HV: 0.15
SV: 1500
GLS: *
GLD: *

00:39
8/12/2017



08/15/17 00:30:00 Ping: 1852

54° 10.52970' N 166° 57.89100' W

SEGY Start Time (ms)
○ Manual 0
● Auto 2044.6

6 dB
60 dB
540 (m) 0 2000 (m)

Bottom Triggered TVG
0.2 dB/m 0

Color Control
● Gray ○ Rainbow
○ Ocean ○ Blue
☐ Invert ○ Custom

Units
● Meters
○ Feet
☐ msec

C:\ Disk Free: 432,057 MB Disk Used: 44,781 MB

C:\ Disk Free: 432,057 MB Disk Used: 44,781 MB

Cursor Depth: 1590.1 | TM: Normal | AQ: CH1 FM - R DFT 6.6 PL 0 | HV: 0.13 | SV: 1500 | GLS: * | GLD: *

00:30 8/15/2017

SBP image station G

Fig. 3.1.14(a)-2 SBP images

3.1.14 (b) Sea surface gravity

Yoshihiro FUJIWARA	JAMSTEC: Principal investigator
Souichiro SUEYOSHI	Nippon Marine Enterprises LTD. (NME)
Toshimasa NASU	NME
Masanori MURAKAMI	MIRAI crew

(1) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface.

(2) Parameters

Relative Gravity [CU: Counter Unit]
[mGal] = (coef1: 0.9946) * [CU]

(3) Data acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-G LaCoste, LLC) during this cruise.

To convert the relative gravity to absolute gravity, we measured gravity, using portable gravity meter (CG-5, Scintrex), at Sekinehama and Hachinohe as the reference points.

(4) Results

Absolute gravity table is shown in Table 3.1.14(b)-1.

Table 3.1.14(b)-1 Absolute gravity table of this cruise

No.	Date m/d	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity at Sensor *1 [mGal]	S-116 Gravity [mGal]
#1	7/6	06:49	Sekinehama	980,371.87	244	627	980,372.84	12657.21
#2	8/2	22:15	Dutch Harbor	-----	258	625	-----	13823.06
#3	8/21	21:50	Dutch Harbor	-----	331	608	-----	13822.07
#4	10/3	04:49	Hachinohe	980,354.86	205	640	980,355.74	12637.08

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

(5) Data Archive

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

3.1.14 (c) Sea surface magnetic field

Yoshihiro FUJIWARA	JAMSTEC: Principal investigator
Souichiro SUEYOSHI	Nippon Marine Enterprises LTD. (NME)
Toshimasa NASU	NME
Masanori MURAKAMI	MIRAI crew

(1) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during this cruise.

(2) Instruments

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

(3) Principle of ship-board geomagnetic vector measurement

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

$$\mathrm{Hob} = A * R * P * Y * F + \mathrm{Hp} \quad (a)$$

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

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

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

(4) Results

The results will be published after primary processing.

(5) Data archive

All data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there

(6) Remarks (Times in UTC)

i) The following periods, we made a “figure-eight” turn (a pair of clockwise and anti-clockwise rotation) for calibration of the ship’s magnetic effect.
15:00 - 15:24 7 Aug. 2017 around 54-27N, 165-59W

3.1.15 Deep-tow camera survey

3.1.15(a) Tow list

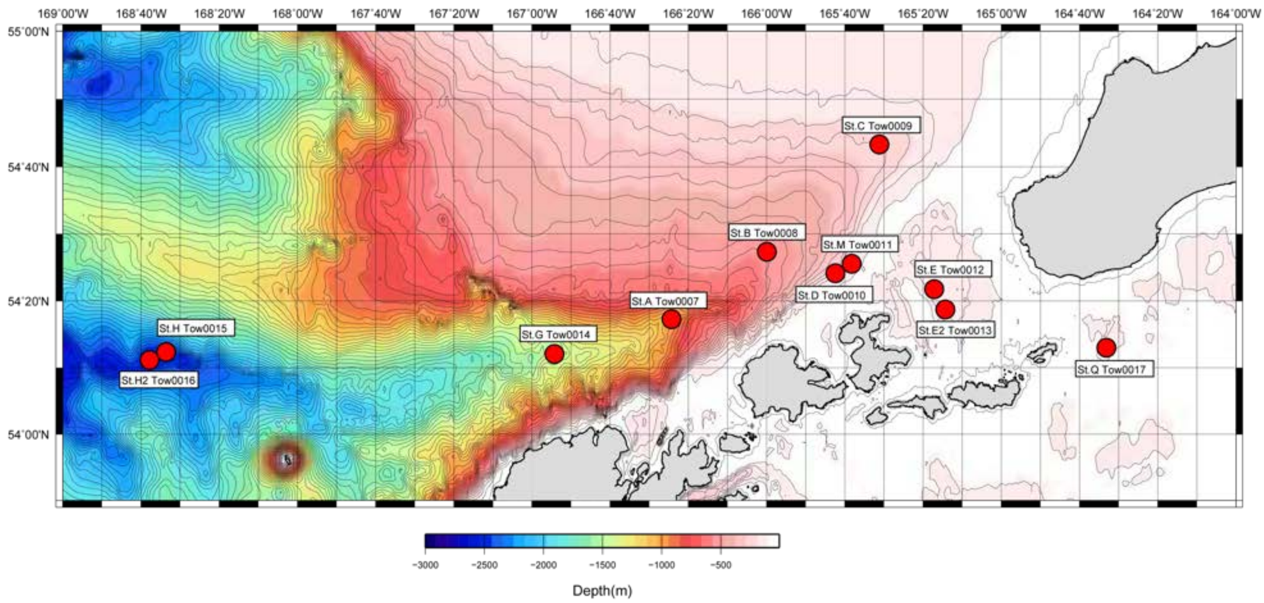
Date (LST)	Dive No. (6KCDT)		Time (LST)	Lat. (N)	Lon. (W)	Depth (m)	Altitude (m)	Water depth (m)
8/5/17	0007	Start	15:54	54-17.4500	166-24.2745	1088	3.9	1092
		End	16:50	54-17.7495	166-23.8136	1114	2.6	1117
8/7/17	0008	Start	8:36	54-27.5423	166-00.1005	562	3.0	565
		End	13:50	54-29.0824	165-57.2371	522	2.6	525
8/8/17	0009	Start	13:29	54-43.2900	165-31.4168	245	3.0	248
		End	19:41	54_41.4400	165_27.9516	234	3.0	237
8/9/17	0010	Start	8:36	54-24.1093	165-42.4836	181	2.8	184
		End	14:48	54-23.6922	165-36.9067	90	3.2	93
8/10/17	0011	Start	17:14	54-25.5478	165-38.3884	116	4.2	120
		End	21:29	54-25.8734	165-33.4496	89	3.6	93
8/11/17	0012	Start	8:54	54-21.7668	165-17.1963	204	2.9	207
		End	14:41	54-24.2118	165-20.0102	162	2.8	165
8/12/17	0013	Start	17:10	54-18.7281	165-14.3873	170	2.9	173

		①	20:11	54-20.5946	165-16.4771	196	2.1	198
		End	21:39	54-21.6664	165-17.1600	192	3.2	195
8/15/17	0014	Start	16:59	54-12.0310	166-54.0010	1502	2※	1504
		①	20:45	54-11.7325	166-58.4873	1535	2※	1537
		End	21:59	54-11.6336	166-59.4198	1557	2※	1559
8/16/17	0015	Start	10:10	54-12.4699	168-34.9547	2411	2※	2413
		①	12:53	54-12.4549	168-37.7019	2509	2.4	2511
		End	13:37	54-12.5341	168-37.9560	2256	4※	2260
8/16/17	0016	Start	15:52	54-11.2021	168-39.0285	2523	3.0	2526
		End	16:08	54-11.2118	168-39.4177	2515	2.5	2518
8/18/17	0017	Start	15:16	54-13.0033	164-33.1209	123	3.2	126
		①	17:24	54-14.2534	164-34.0812	140	2.6	143
		End	21:30	54-15.7159	164-36.7870	131	2.6	134

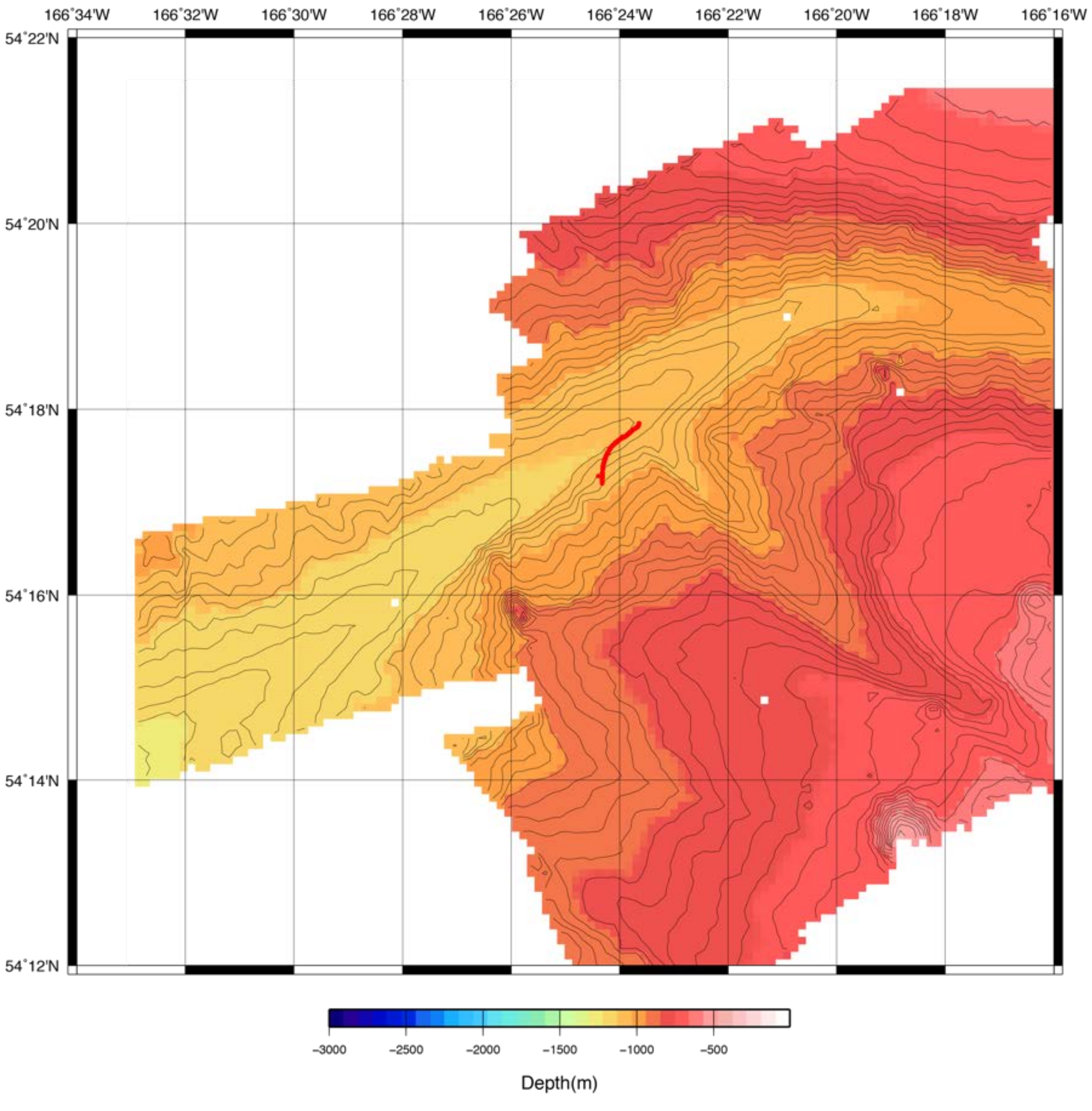
①: passing point

3.1.15(b) Route map

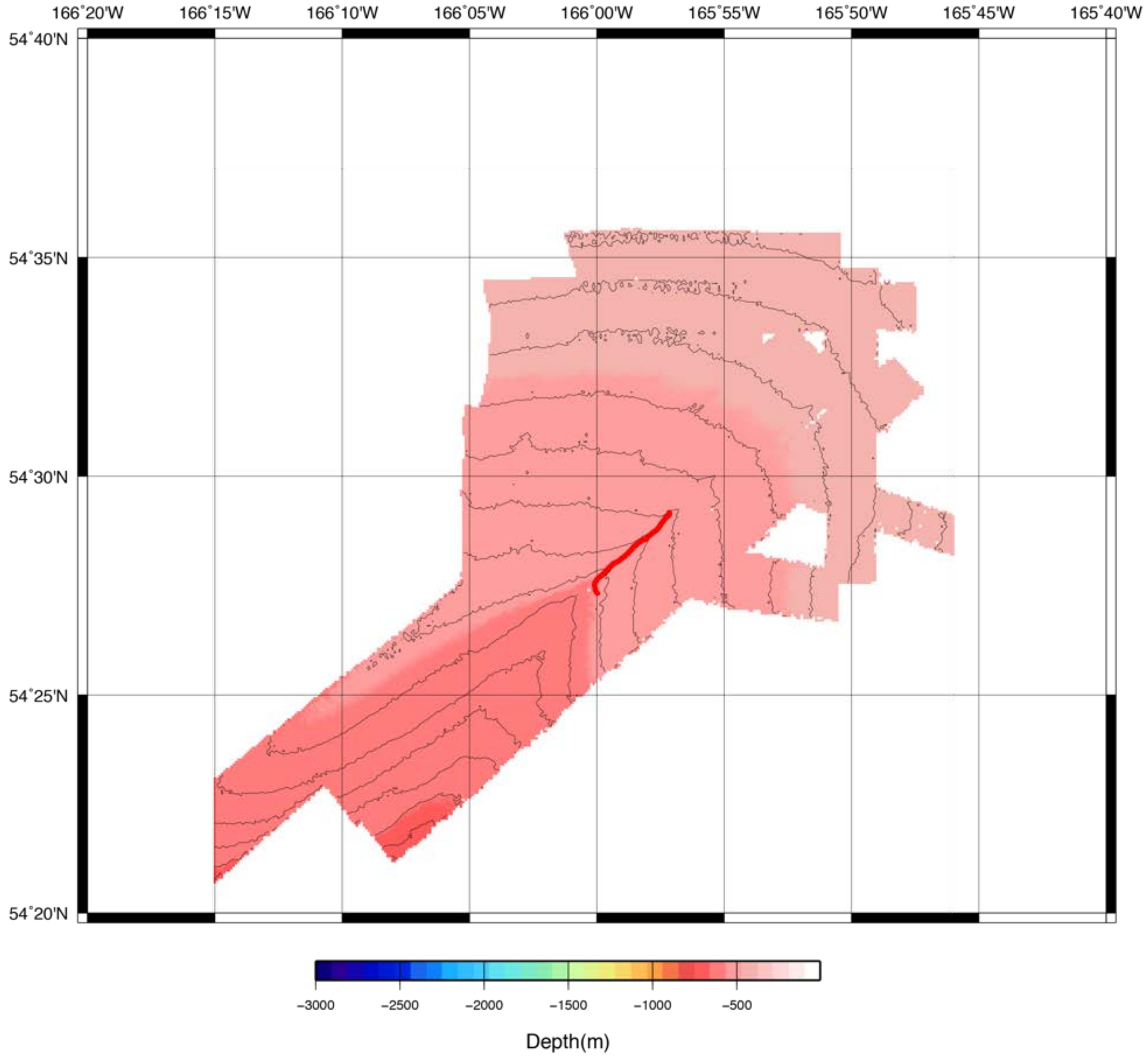
MR17-04_Leg2_DeepTow_StartPosition

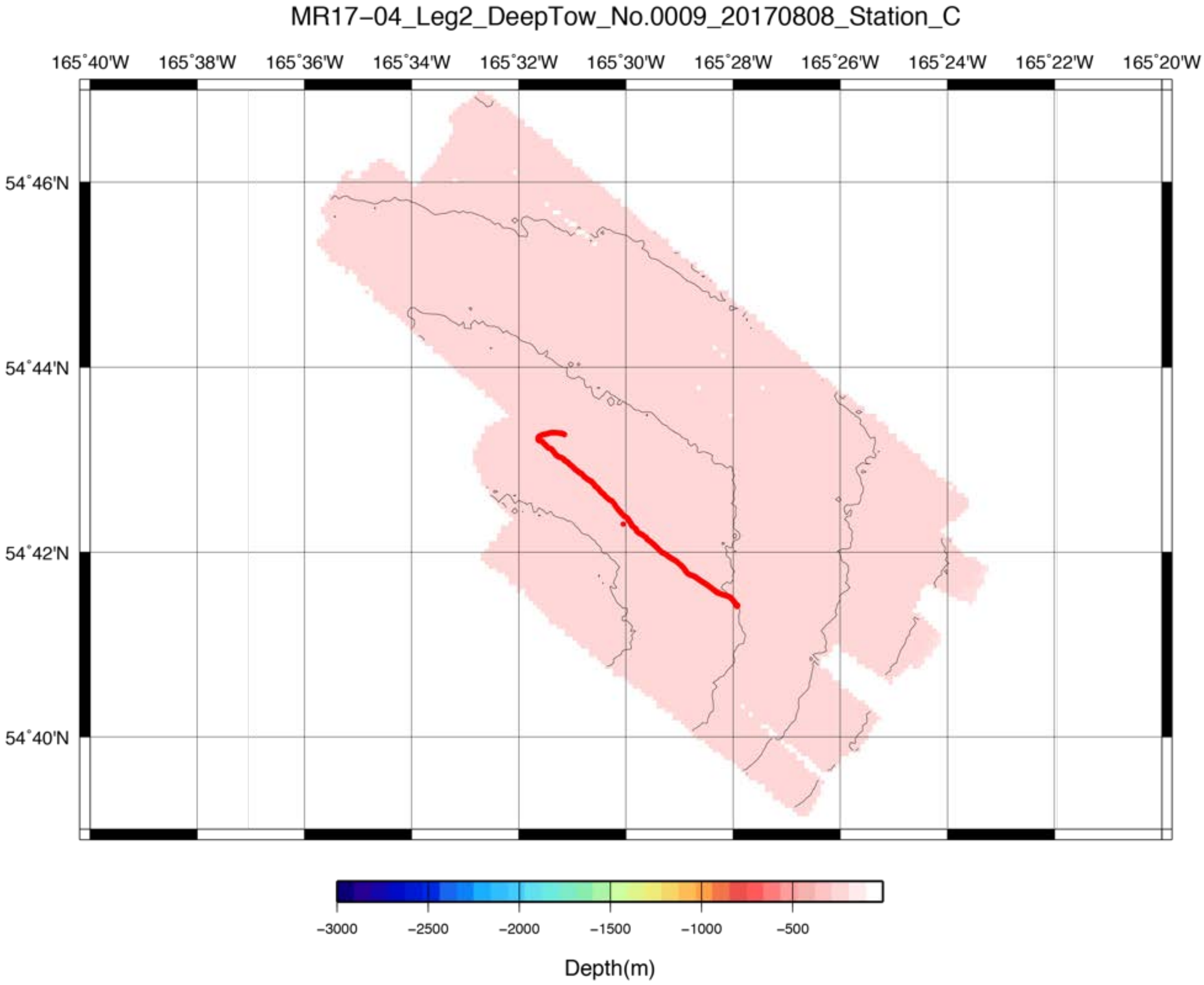


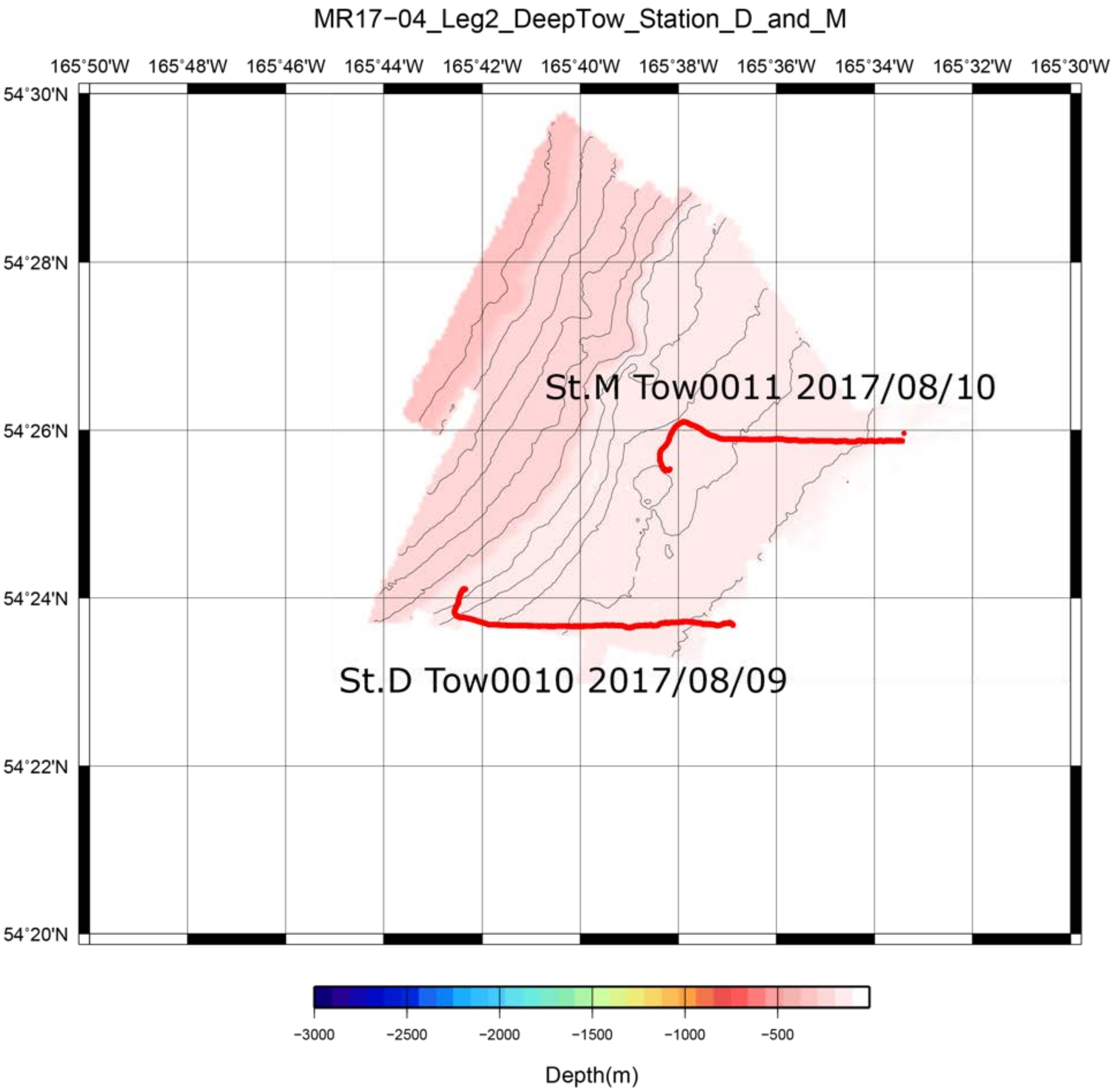
MR17-04_Leg2_DeepTow_No.0007_20170805_Station_A

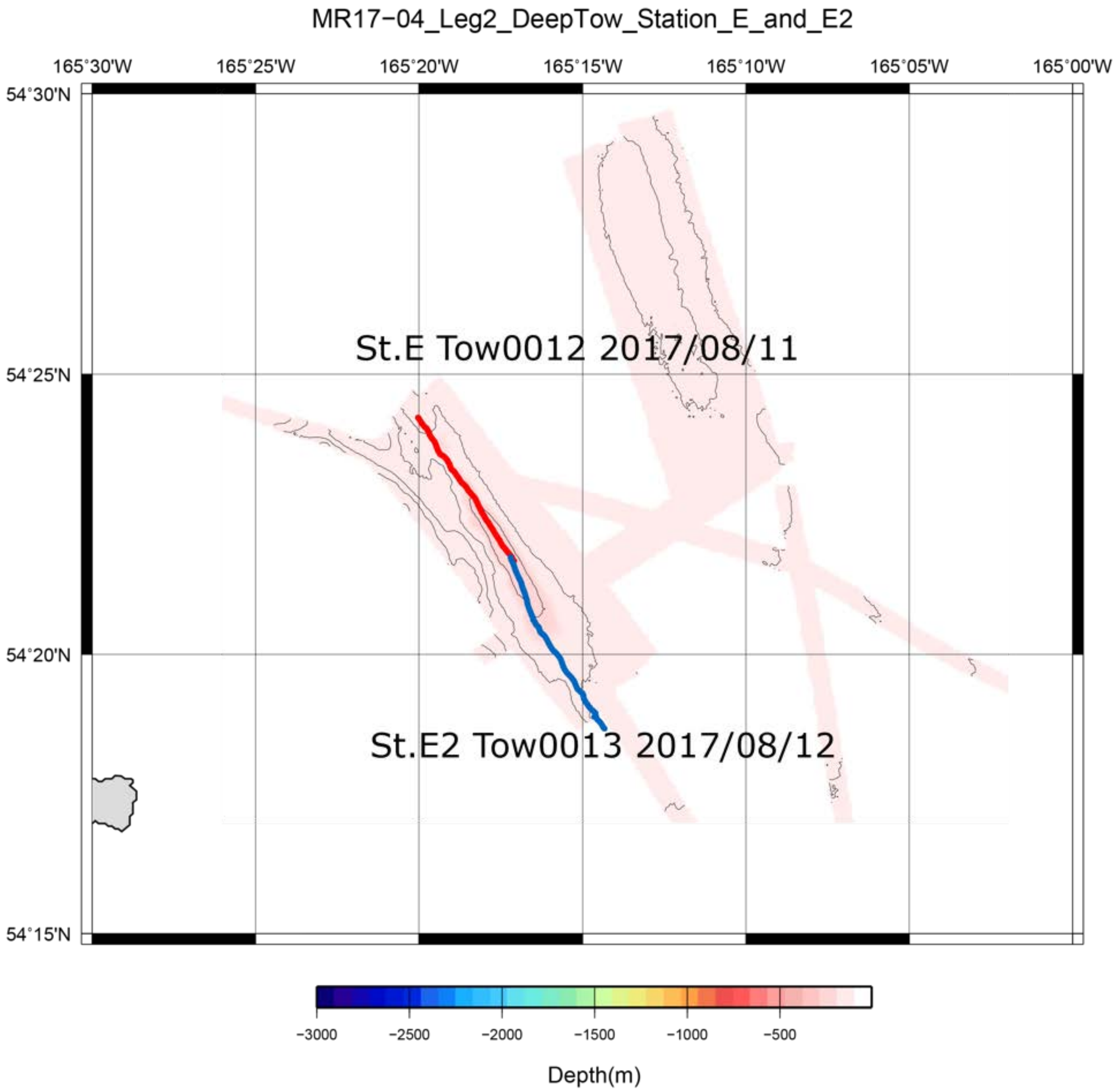


MR17-04_Leg2_DeepTow_No.0008_20170807_Station_B




MR17−04_Leg2_DeepTow_No.0009_20170808_Station_C
165˚40'W
165˚38'W
165˚36'W
165˚34'W
165˚32'W
165˚30'W
165˚28'W
165˚26'W
165˚24'W
165˚22'W
165˚20'W
54˚46'N
54˚44'N
54˚42'N
54˚40'N
−3000
−2500
−2000
−1500
−1000
−500
Depth(m)


MR17-04_Leg2_DeepTow_Station_D_and_M
165°50'W
165°48'W
165°46'W
165°44'W
165°42'W
165°40'W
165°38'W
165°36'W
165°34'W
165°32'W
165°30'W
54°30'N
54°28'N
54°26'N
54°24'N
54°22'N
54°20'N
St.M Tow0011 2017/08/10
St.D Tow0010 2017/08/09
−3000
−2500
−2000
−1500
−1000
−500
Depth(m)


MR17−04_Leg2_DeepTow_Station_E_and_E2
165°30'W
165°25'W
165°20'W
165°15'W
165°10'W
165°05'W
165°00'W
54°30'N
54°25'N
54°20'N
54°15'N
St.E Tow0012 2017/08/11
St.E2 Tow0013 2017/08/12
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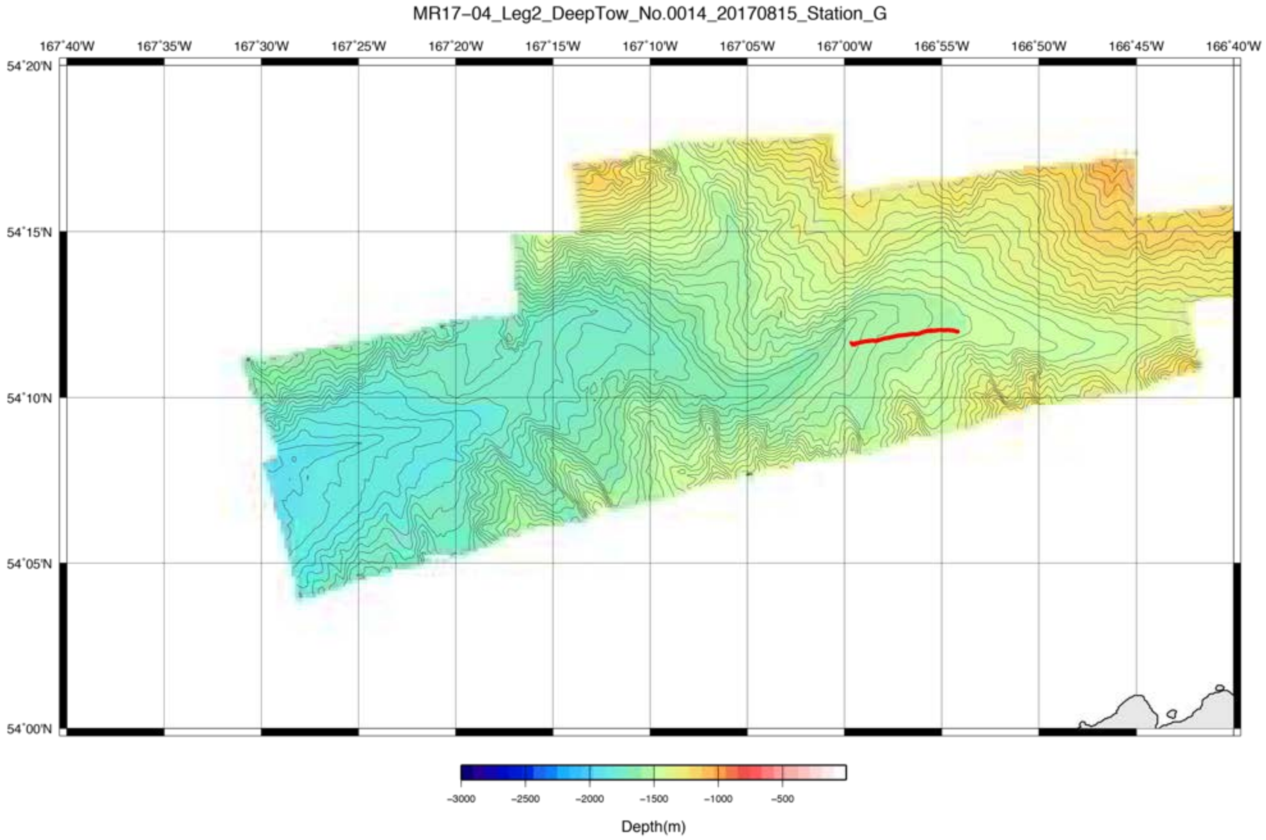
−1500
−1000
−500
Depth(m)


MR17-04_Leg2_DeepTow_No.0014_20170815_Station_G
167°40'W
167°35'W
167°30'W
167°25'W
167°20'W
167°15'W
167°10'W
167°05'W
167°00'W
166°55'W
166°50'W
166°45'W
166°40'W
54°20'N
54°15'N
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54°05'N
54°00'N
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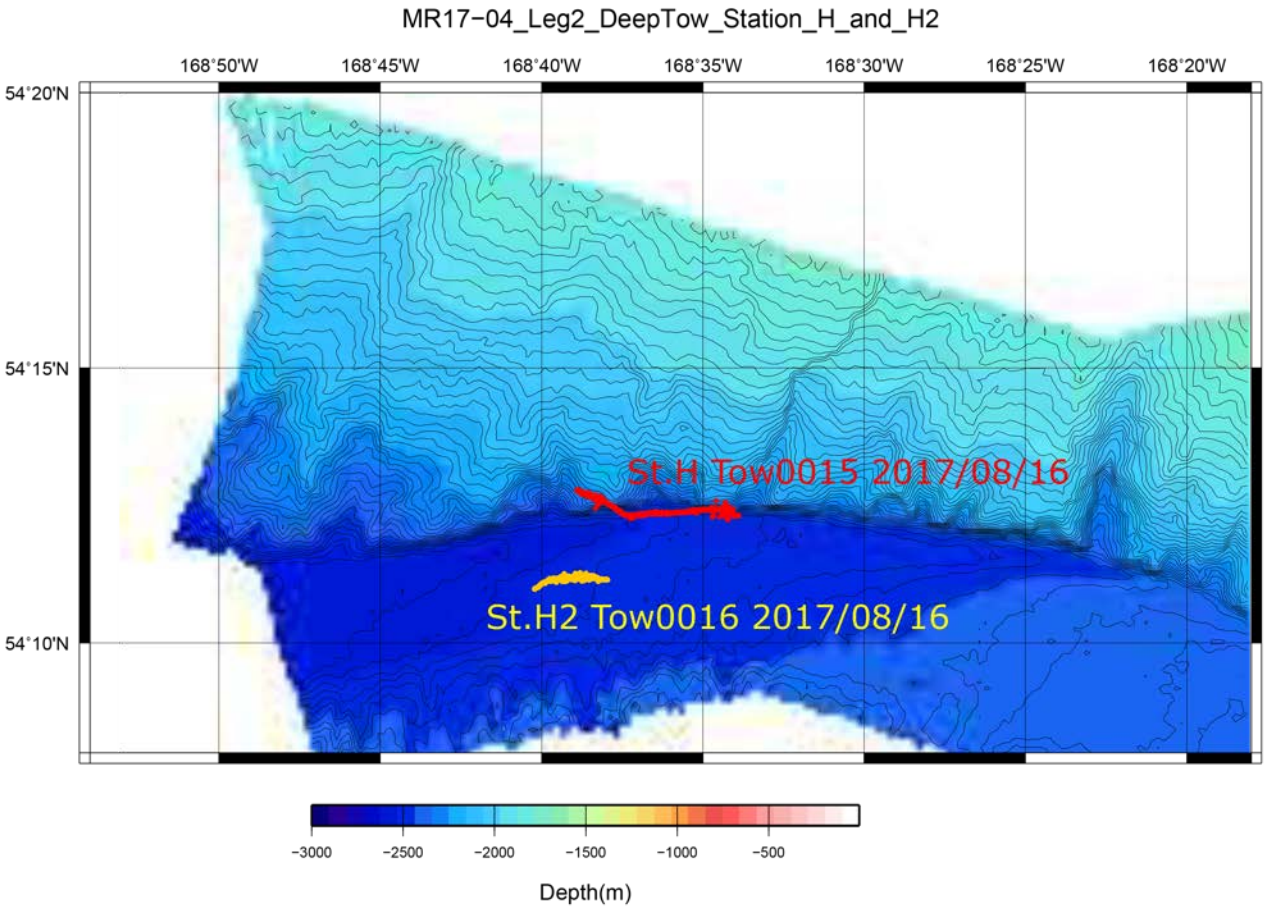
−1500
−1000
−500
Depth(m)


MR17−04_Leg2_DeepTow_Station_H_and_H2
168°50'W
168°45'W
168°40'W
168°35'W
168°30'W
168°25'W
168°20'W
54°20'N
54°15'N
54°10'N
St.H Tow0015 2017/08/16
St.H2 Tow0016 2017/08/16
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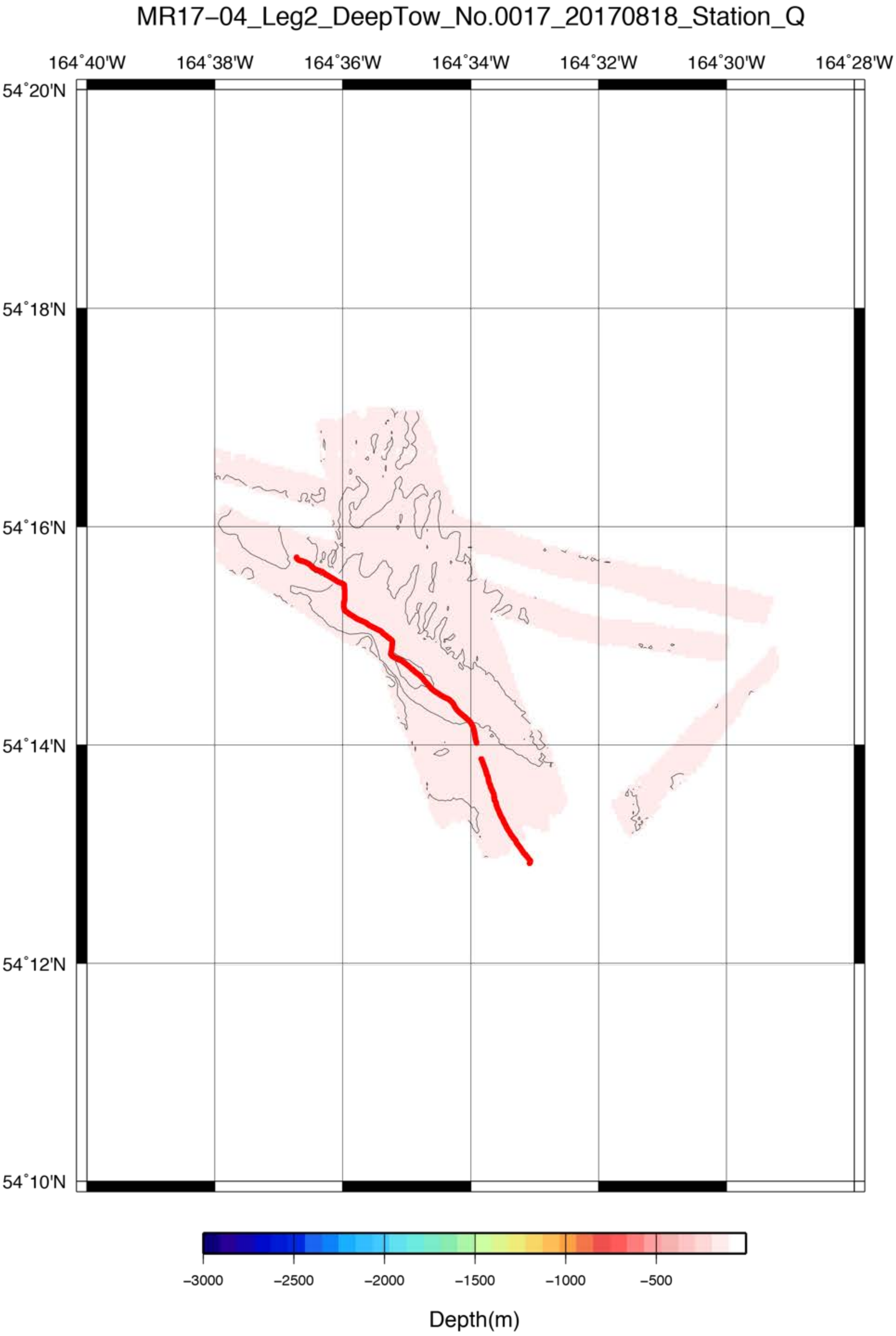
−2000
−1500
−1000
−500
Depth(m)


MR17−04_Leg2_DeepTow_No.0017_20170818_Station_Q
164°40'W
164°38'W
164°36'W
164°34'W
164°32'W
164°30'W
164°28'W
54°20'N
54°18'N
54°16'N
54°14'N
54°12'N
54°10'N
−3000
−2500
−2000
−1500
−1000
−500
Depth(m)

3.1.15(c) Results

Tow number:	6KCDT0007
Date:	August 5, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°17.5956'N, 166°24.7849'W, 1100.7 m (+Alt: 4 m)
End of Dredge:	54°17.7495'N, 166°23.8130'W, 1102 m (+Alt: 2.6 m)
Chief observer:	Yoshihiro FUJIWARA (JAMSTEC)
Main purpose:	Bottom observation at a depth of 1000 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x2 (Downward, Forward)

Summary:
The first 6K Deep Tow Camera observation during MR17-04LEG2 was conducted around a depth of 1000 m in Bering Canyon. The sediments were sandy mud with many outcrops (Fig. 1), on which many sponges were attached. A dense aggregation of ophiuroids was observed patchily through the tow (Fig. 2). Snow crabs, king crabs, skates, rattails, gorgonians, asteroids and gastropods were seen at the bottom (Fig. 3). Several pieces of kelps were found, which were consumed by echinoids (Fig. 4). Dredge sampling was conducted at the end of towing at a depth of 1115 m.

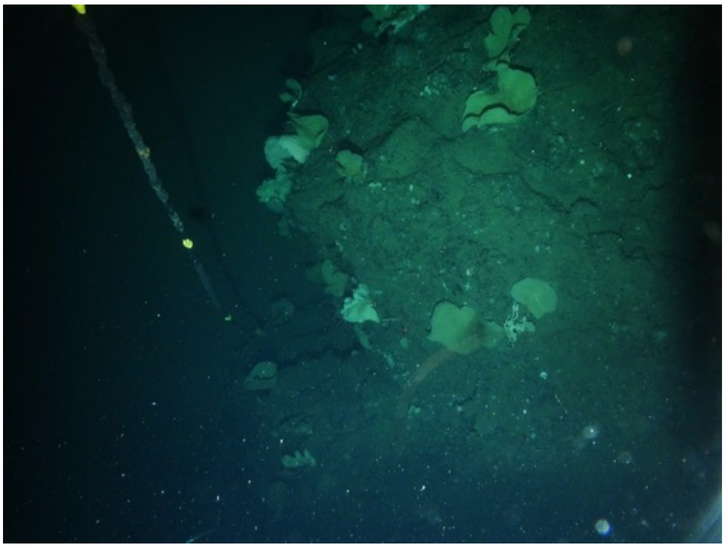


Fig.1. Outcrops. Many sponges were attached.

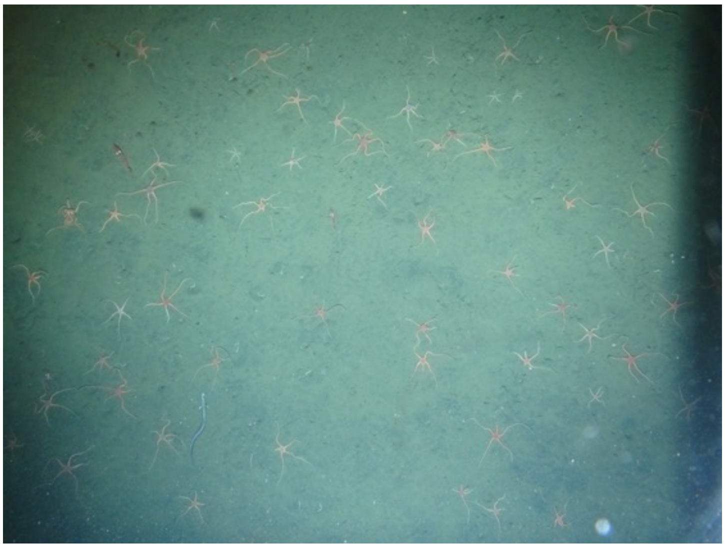


Fig.2. Aggregation of ophiuroids.

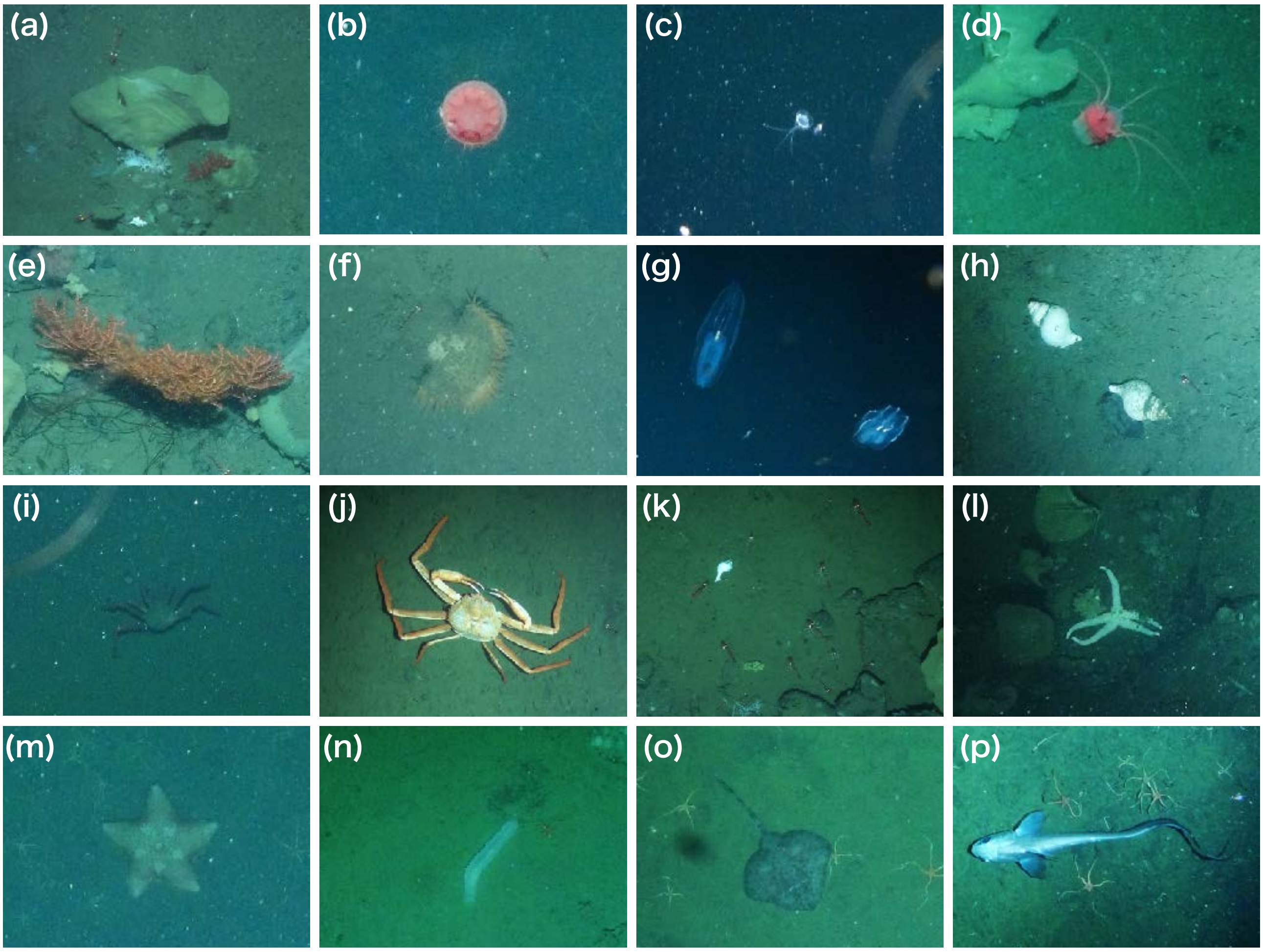


Fig.3. Species observed during 6KCDT0007. (a) prifera, (b) jellyfish, (c) jellyfish, (d) jellyfish, (e) Alcyonaria, (f) Actinostolidae, (g) Ctenophore, (h) Gastropods, (i) king crab, (j) snow crab, (k) shrimps, (l) asteroid, (m) asteroid, (n) holothurian, (o) skate, (p) rattail.

Fig. 4. A piece of kelp that was consumed by echinoids.

Tow number:	6KCDT0008
Date:	August 7, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°27.5412’N, 166°00.0992’W, 564 m (+Alt: 4 m)
End of Dredge:	54°29.0824’N, 165°57.2371W, 520m (+Alt: 2.6 m)
Chief observer:	Shinji Tsuchida (JAMSTEC)
Main purpose:	Bottom observation at a depth of 500 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, backward)

Summary:

The 6K Deep Tow#0008 was conducted around a depth of 564 m at the Point B in Bering Canyon. During the descent around 400m where was about 160m from the bottom, many mid-water fish was observed. At the start point of towing, the bottom was covered by muddy sediment with ophiuroid bed and many holothurians, Pannychia sp. (identified by Ogawa) were seen (Fig. 1). These animals were appeared everywhere through this towing. The 6K Deep Tow moved to the northeast for around 0.5 mile/h speed. As a result, observation was conducted for three miles along with the center of the deep-sea canyon (Fig. 2). We found other benthic animals such as, thornhead (Sebastolobus sp.), several kinds of macrourid fish, king crabs, starfish, flat fish, etc, and also some of debris patches (Fig. 3). Dredge sampling was conducted at the end of towing at a depth of 520 m.

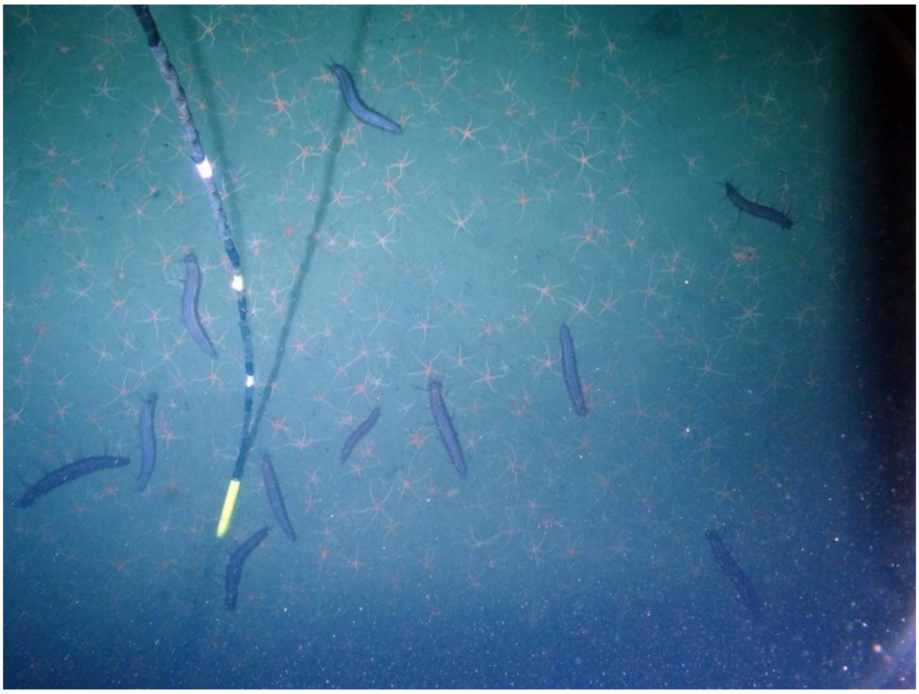


Fig.1. Ophiuroid bed and lots of holothurians observed in this towing.

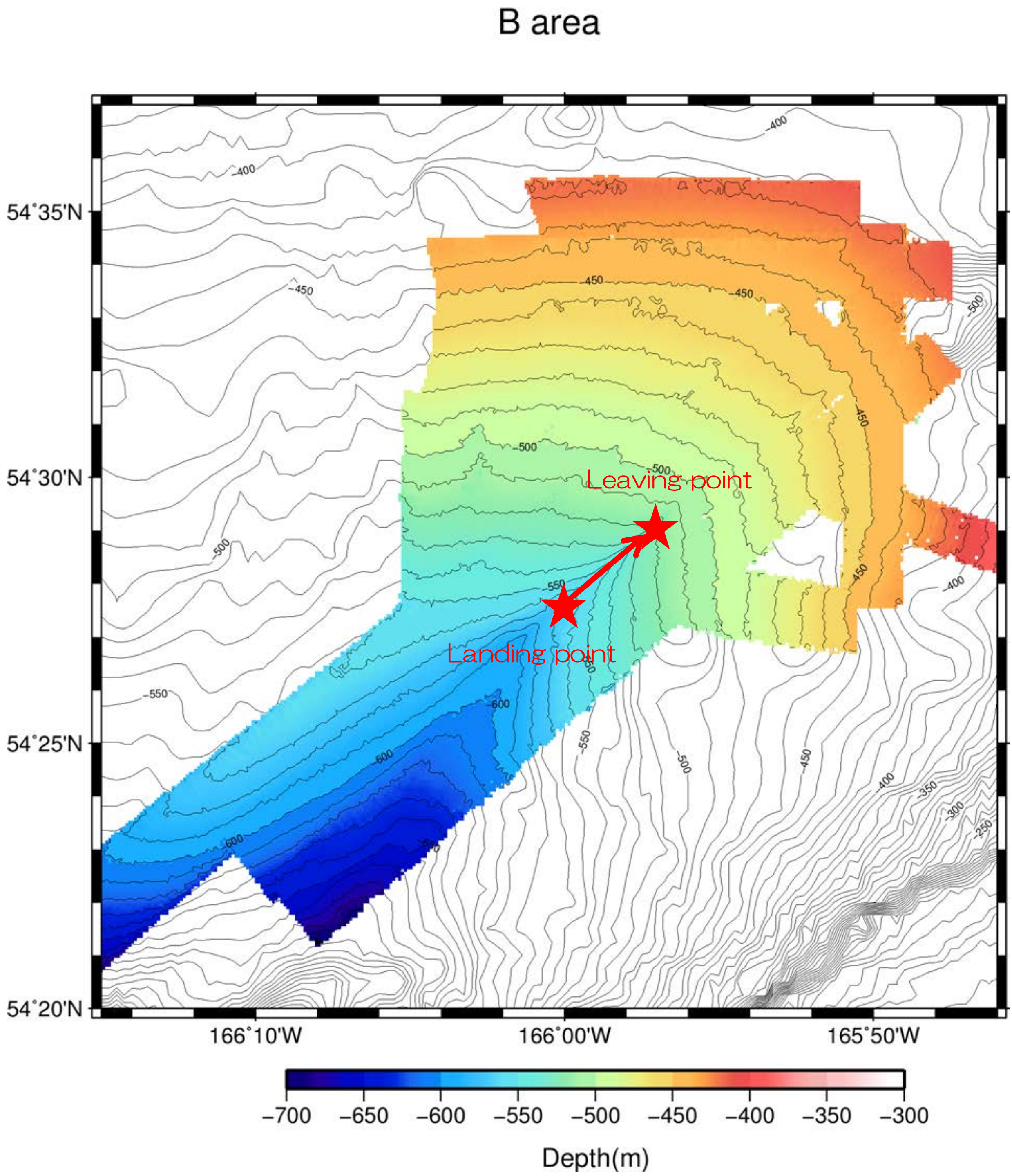


Fig.2. 6KCDT0008 towing line.

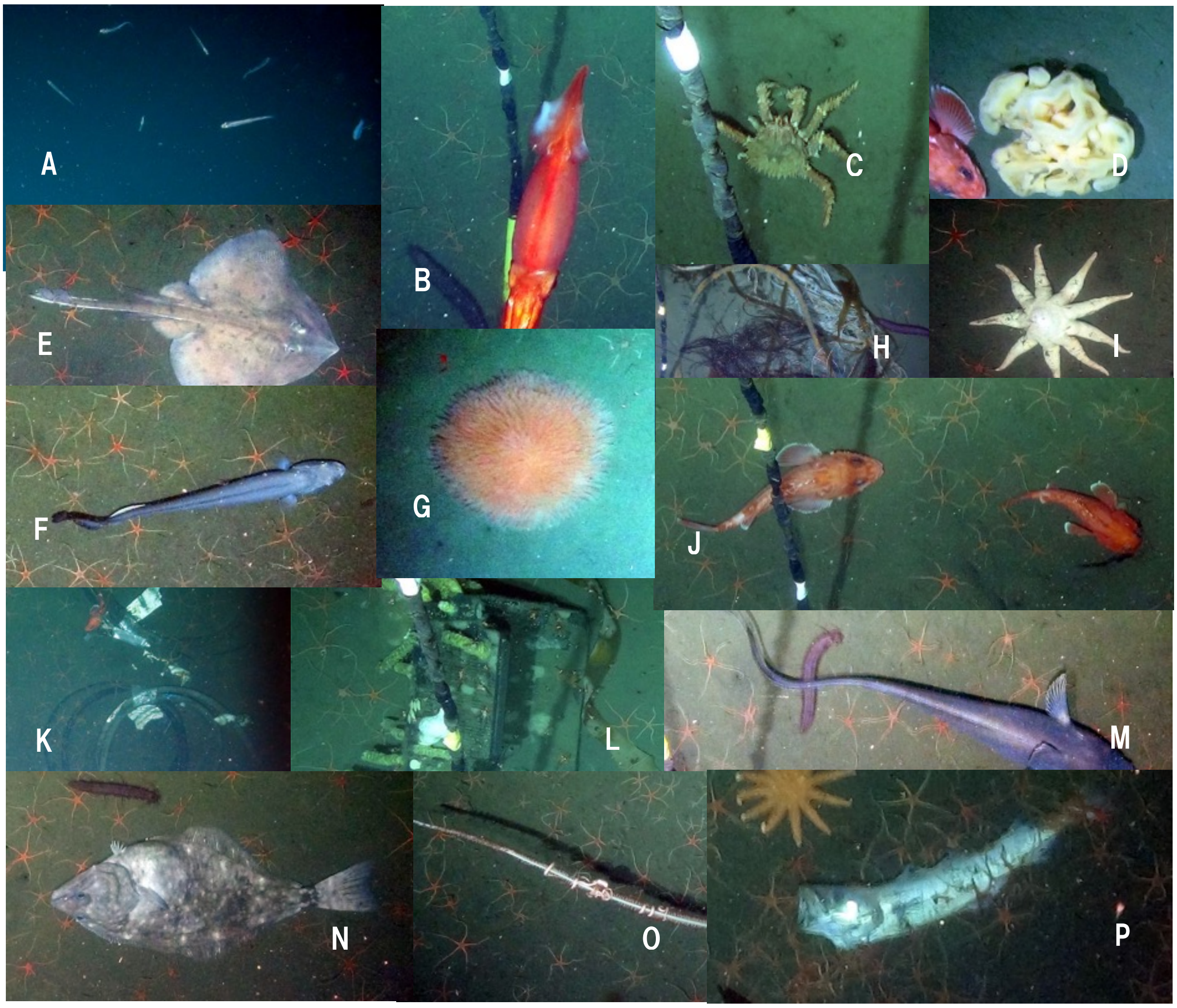


Fig.3. Species observed during 6KCDT0008. (A) mid-water fish, (B) squid, (C) Lithodid crab, (D) sponge, (E) skate, (F) fish, (G) darian anemone, (H) debri patch, (I) asteroid, (J) thornhead fish, (K) debris patch, (L) deployed fishing gear, (M) macuroid fish, (N) flat fish, (O) gorgonian, (P) dead cod.

Tow number:	6KCDT0009
Date:	August 8, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°43.2900’N, 165°31.4168’W, 245 m (+Alt: 3 m)
End of Dredge:	54°41.4400’N, 165°27.9516’W, 234m (+Alt: 3 m)
Chief observer:	James C. Hunt
Main purpose:	Bottom observation at a depth of 250 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, backward)

Summary:

Overall observations for the day: deep tow performed well. Site at 250m did not seem to unusual, though it was distinctly different that previous two dives (0007 and 0008). Great presence of demersal fishes, both flatfish and cod. Far fewer brittle stars and sea cucumbers (zero as compared to sea floor coverage at 500m in 0008). Presence of drift kelp clearly important in benthic ecology of the area. Cod attracted to the lights, presumably to aid in feeding. One feeding strike observed by cod in the back camera. For midwater, no jellies including siphonophores and ctenophores, with the exception of Chrysaora melanaster.

Tow number:	6KCDT0010
Date:	August 9, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°24.1093'N, 165°42.4836'W, 181 m (+Alt: 2.8 m)
End of Dredge:	54°23.6922'N, 165°36.9067'W, 90m (+Alt: 3.2 m)
Chief observer:	Leah Bergman
Main purpose:	Bottom observation at a depth of 100 m in Bering Canyon
Payload equipment:	GoPro Hero3+ 3 (Downward, Forward, backward)

Summary:

This site was at the location where the Aleutian Magic was observed. We expected thick, organic-rich sediments but the sediments were relatively coarse. Holothurians were sparse unlike the previous deep-tow observations. Density of ophiuroids, asteroids benthic fishes were sometimes high. Fishing gears were seen at the beginning of this tow.

Tow number:	6KCDT0011
Date:	August 10, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°17.5956’N, 166°24.7849’W, 1100.7 m (+Alt: 4 m)
End of Dredge:	54°17.7495’N, 166°23.8130’W, 1102 m (+Alt: 2.6 m)
Chief observer:	Keiichi KAKUI (Hokkaido University)
Main purpose:	Bottom observation at a depth of 100 m in the “Aleutian Magic” region
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, Backward)

Summary:

The fifth 6K Deep Tow Camera observation during MR17-04LEG2 was conducted around a depth of 100 m in the “Aleutian Magic” region. The tow started in the region with bottom covered with sand and dead bivalve shells (Fig. 1). After a while, orange zoantharians attached to hard substrata (e.g., dead shells and rocks) appeared on the bottom (Fig. 2); their density was gradually increasing (Fig. 3), followed by the region with wide outcrops (Fig. 4). The zoantharian-rich bottom appeared again, but then its abundance became low. Following that region, many large rocks covered by sponges began to be found (Fig. 5). Finally, the bottom became similar condition to that at the starting point of this tow (Fig. 6; cf. Fig. 1). Dredge sampling was conducted at the end of towing at a depth of 93 m under that bottom condition. Echinoids (incl. Echinothuriidae) and asteroids (Fig. 7) were observed throughout the tow. And, sponges, hydrozoans, zoantharians, anomurans, brachyurans, bivalves, gastropods, fishes were observed (Fig. 7).

Fig. 1. Bottom covered with black sand and dead bivalve shells.


Fig. 2. Orange zoantharians.

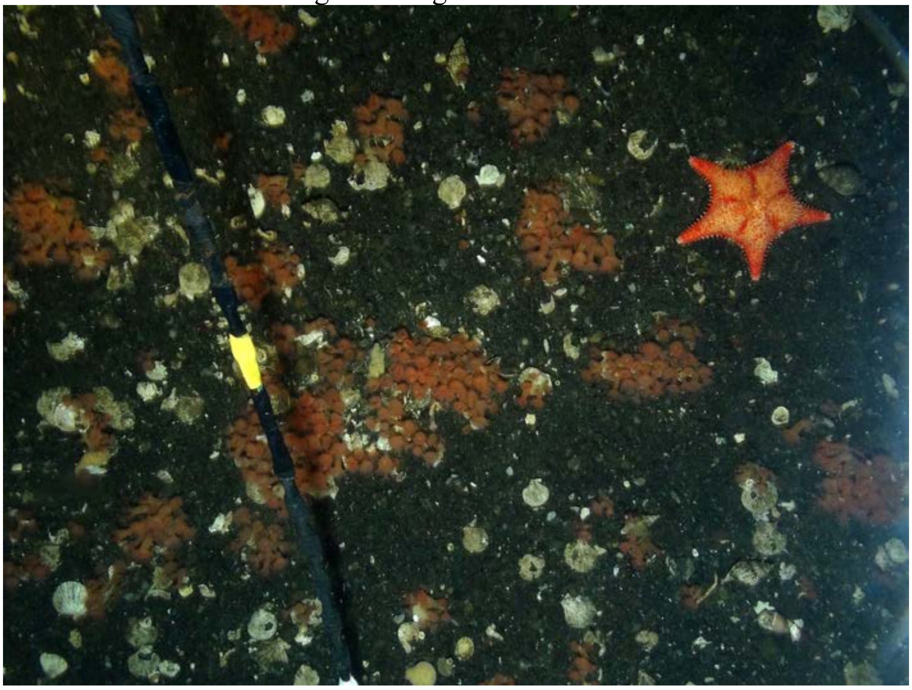


Fig. 3. Zoantharian rich area.

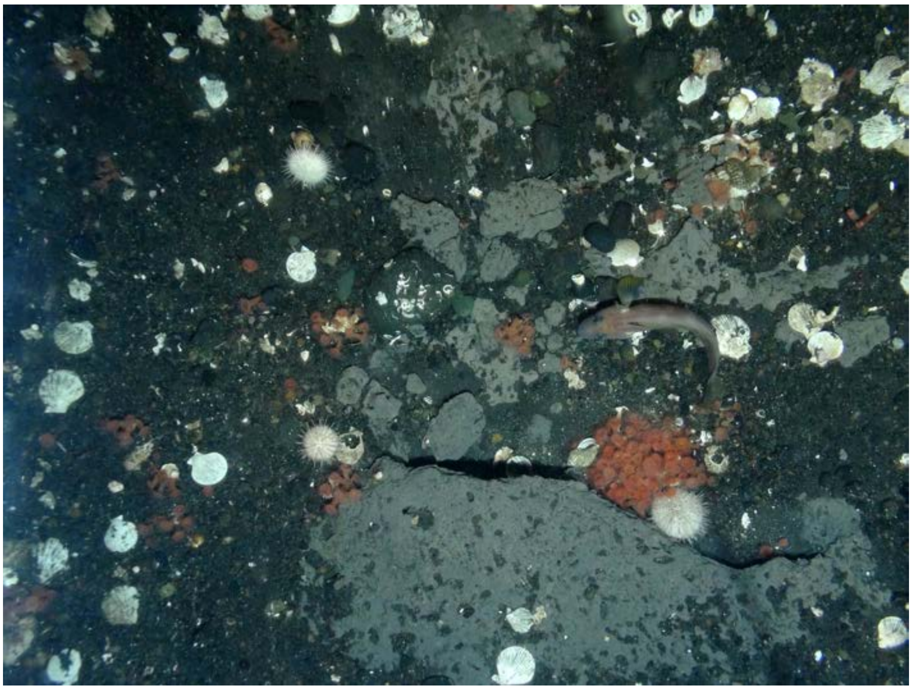


Fig. 4. Wide outcrops.

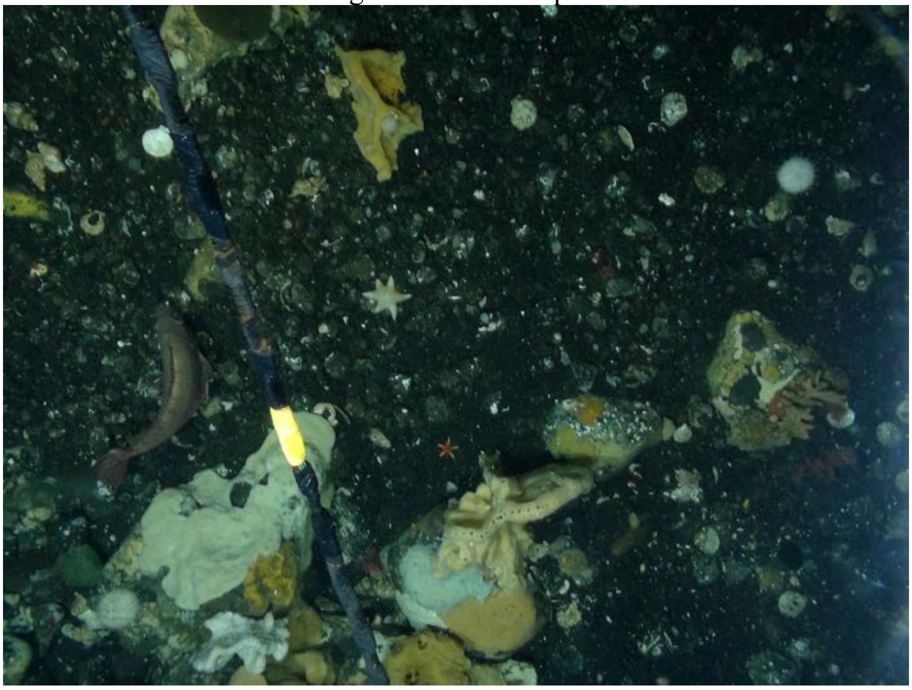


Fig. 5. Large rocks covered by sponges.

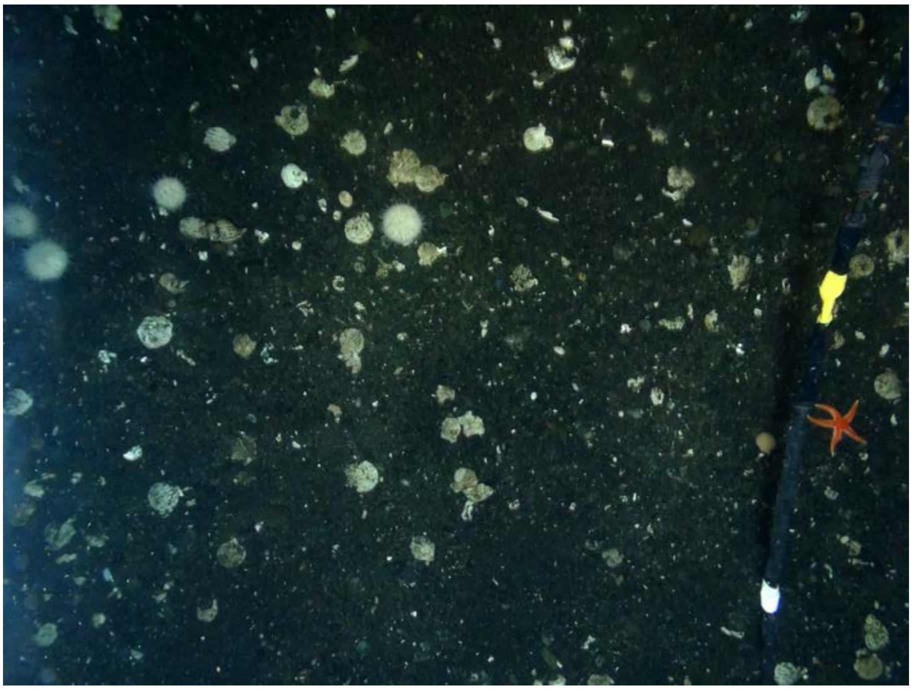


Fig. 6. Bottom covered with black sand and dead bivalve shells around the dredging site.

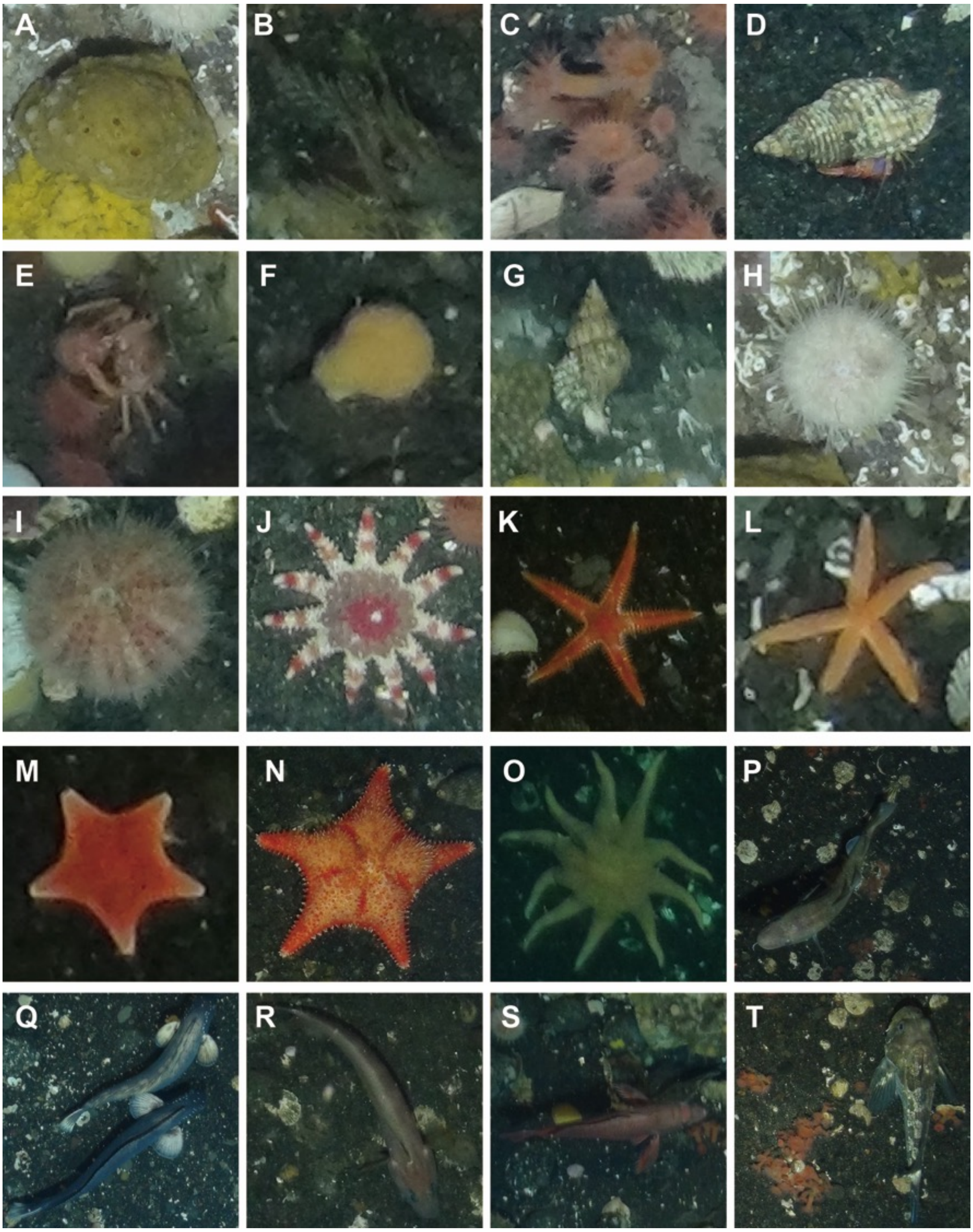


Fig. 7. Animals observed during 6KCDT0011. A, sponge (poriferan); B, hydrozoans; C, zoantharians; D, anomuran; E, brachyuran; F, bivalve covered with sponge; G, gastropod; H, I, echinoids; J–O, asteroids; P–T, fishes.

Tow number:	6KCDT0012
Date:	August 11, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°21.75500’N, 165°17.18260’W, 204.3 m (+Alt: 3.3 m)
End of Dredge:	54°24.2118’N, 165°20.0102W, 162.0 m (+Alt: .3.3 m)
Chief observer:	Naoto JIMI (Hokkaido University)
Main purpose:	Bottom observation at a depth of 200 m in the Unimak pass
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, Backward)

Summary:
The 7th 6K Deep Tow Camera observation during MR17-04LEG2 was conducted around a depth of 200 m in the Unimak pass. The sediments were mixture of mud and sands (Fig. 1). Sponges, anthozoans, holothurians, sea urchins, asteroids, scallops, snails, bryozoans, and fish were seen at the bottom (Fig. 2). Dredge sampling was conducted at the end of towing at a depth of 162 m. Many bryozoans and anthozoans settled on rocks (Fig. 1). At first, bottom of the sea was flat but after a while it became waved (Fig. 3). The left camera flashlight was sometimes in bad condition (Fig. 3).

Fig.1. Situation of sediments. Mixture of mud and sands.

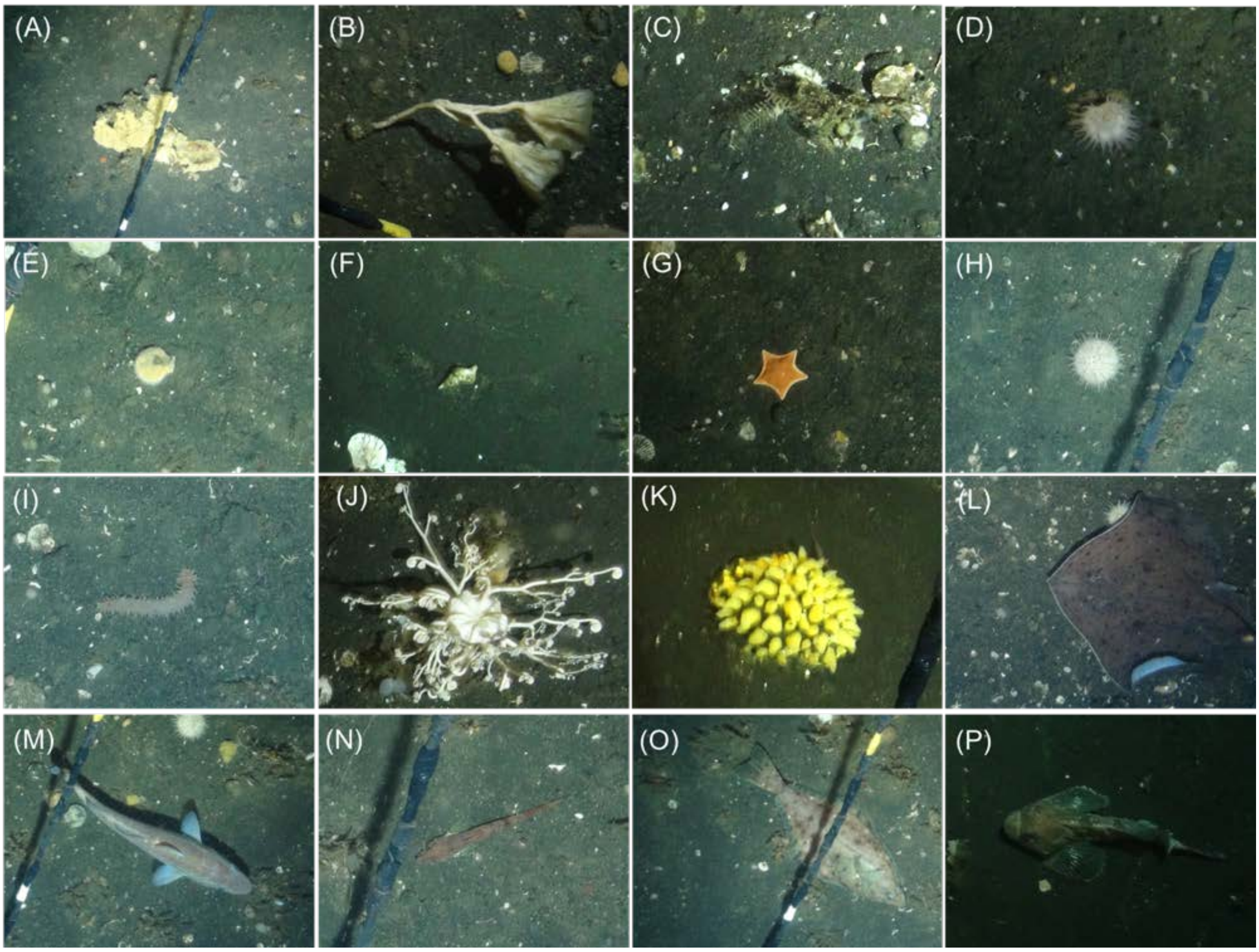


Fig.2. Species observed during 6KCDT00012. (a) porifera sp. 1, (b) porifera sp. 2, (c) anthozoans and bryozoans, (d) anthozoan, (e) scallop, (f) snail, (g) asteroid, (h) Echinothurioida sp., (i) Synallactes sp., (j) Gorgonocephalidae sp., (k) eggs of fish?, (l) skate, (m) cod, (n) unidentified fish, (o) halibut, (p) Cottidae sp.

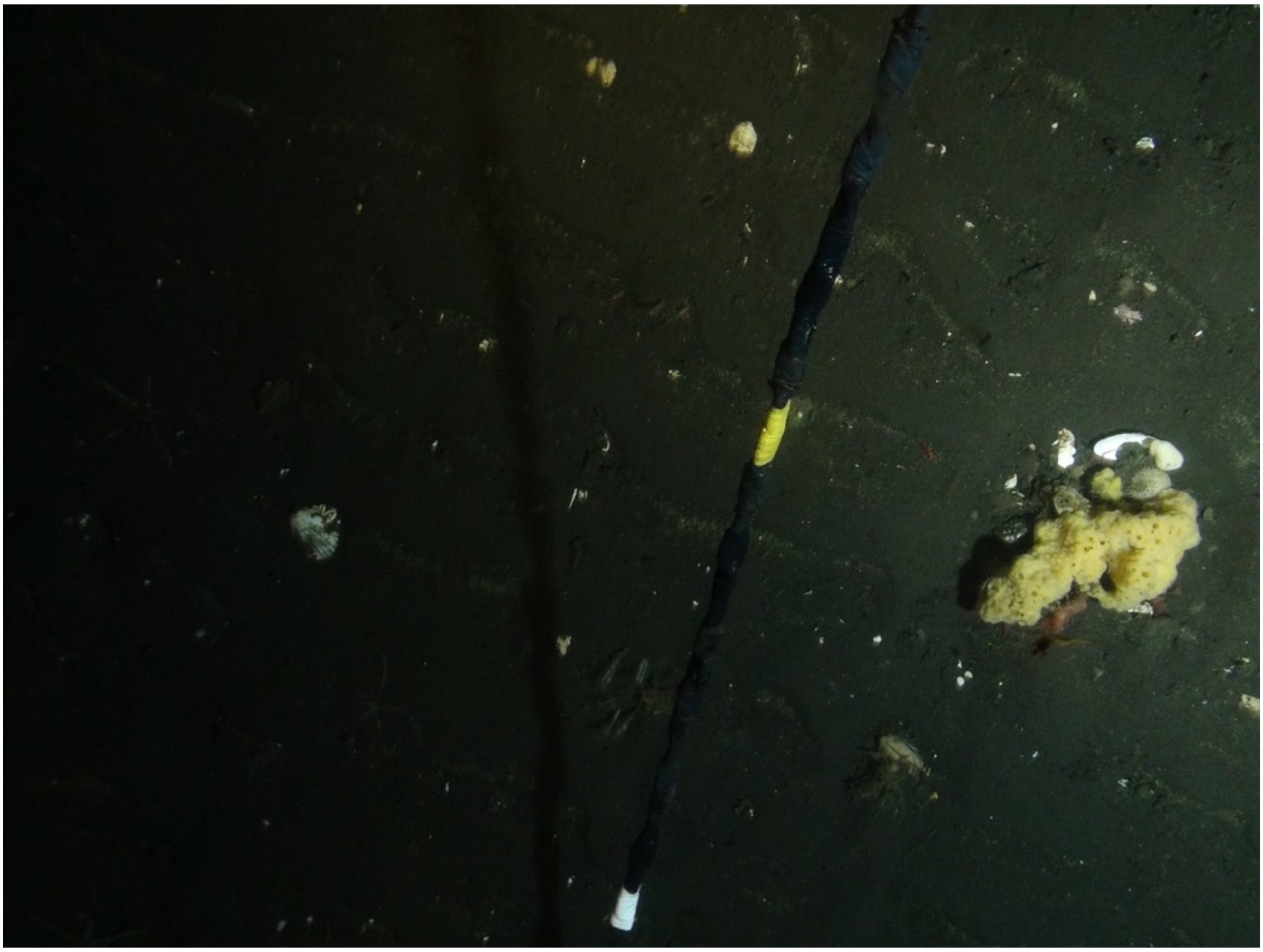


Fig.3. The state of the left camera lightning during 6KCDT0012.

Tow number:	6KCDT0013
Date:	August 12 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°18.7281’N, 165°14.3873’W, 170m (+Alt: 2.9 m)
End of Dredge:	54°21.6664N, 166°17.1600’W, 205 m (+Alt: 3.2 m)
Chief observer:	Hidetaka NOMAKI (JAMSTEC)
Main purpose:	Bottom observation at a depth of ~200 m in the big depression
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, Backward)

Summary:

The 6K Deep Tow Camera observation “6KCDT0013” was carried out at a depth of 170 to 209 m in the depression southeast from the station M. Just after the landing, an extremely dense aggregation of krill was observed with the camera and then turned into dark due to the massive gathering around the light sources (Fig. 1). After turning off the light for several minutes, most krill left from the Deep-tow, however, some krill were always confirmed in the camera view behind.

The sediments mainly consist of coarse sand, with some shell fragments and gravels (Fig. 2). The abundances of bivalve shells were much less than that of observed at Stn M, which is a closer site to this area.

Relatively diverse benthic fauna was observed at this area. Some different kind of sea urchins, asteroids, fishes, and filter feeders were observed on the bottom. Dredge sampling was conducted at a water depths from 206 m to 205 m for 2 to 3 minutes immediately before the ascending. The dredge sample contained many Mytilidae, which were not clearly observed during the deep-tow camera observation.

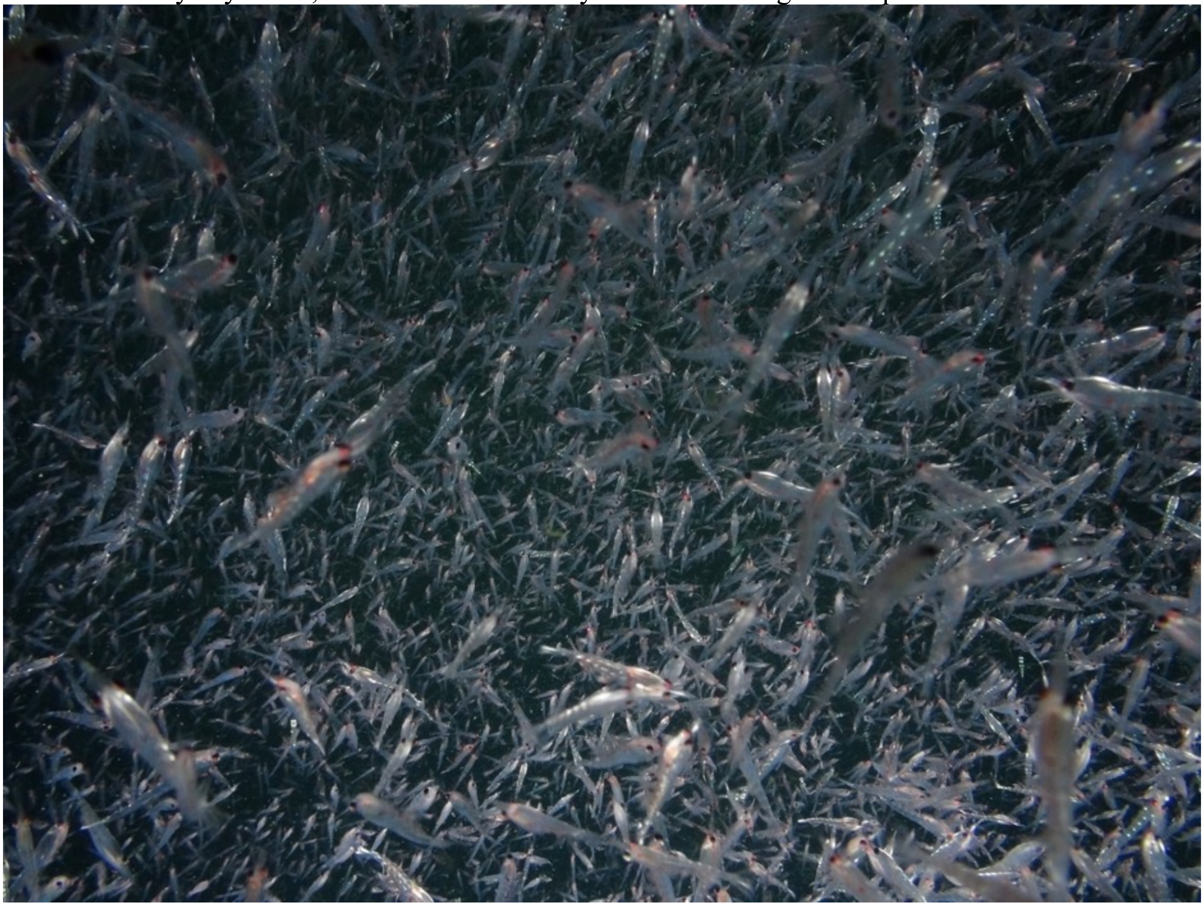


Fig. 1. A dense aggregation of krill just after the landing.

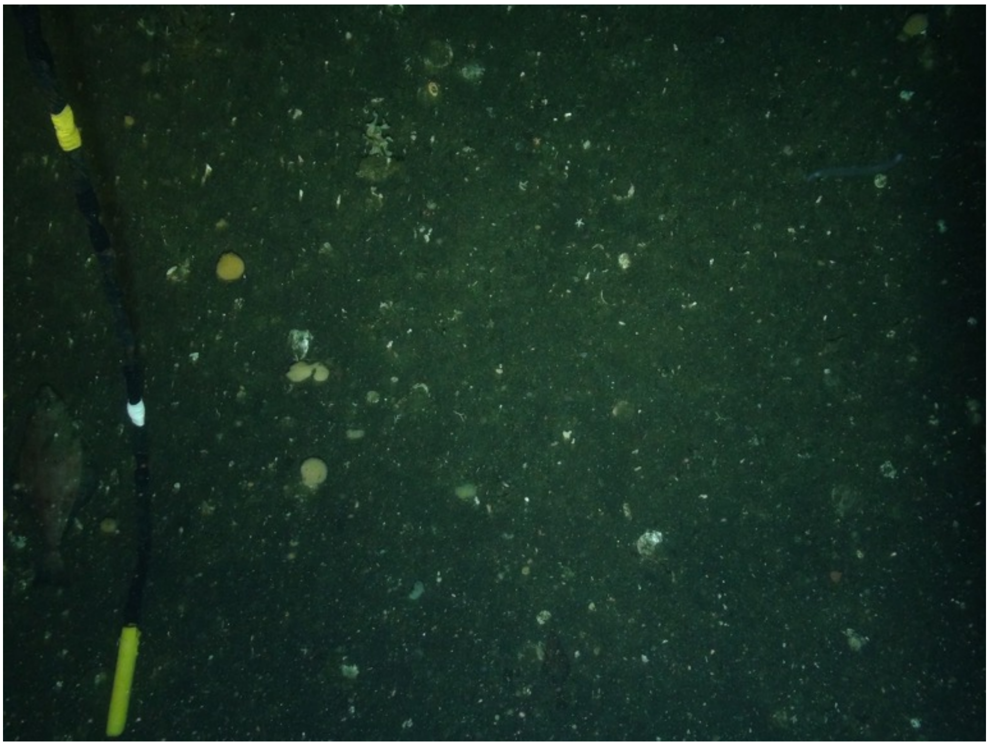


Fig. 2. Seafloor covered with coarse sand and some shell fragments.

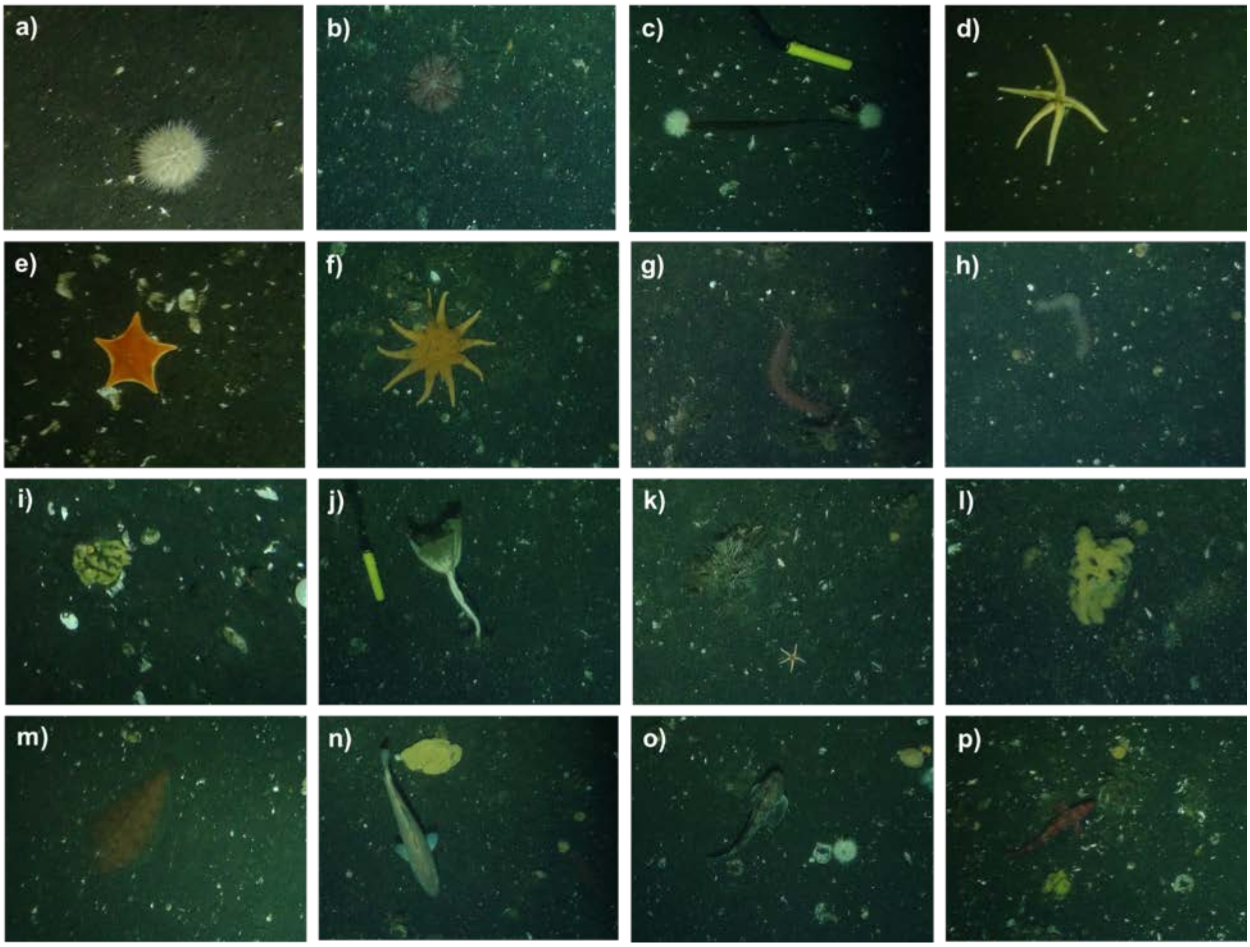


Fig. 3. Benthic organisms observed during 6KCDT0013. (a) Echinoidea, (b) Echinoidea, (c) Echinoidea attached on a kelp, (d) Henricia, (e) Astropectiniidae, (f) Solasteridae, (g) Synallactes (h) holothurian (Synallactes?), (i) unknown, (j) Crinoidea?, (k) ??, (l) Porifera, (m) Pleuronectiformes, (n) Gadiformes, (o) Scorpaeniformes, (p) fish.

Tow number:	6KCDT0014
Date:	August 15, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°12.0310’N, 166°24.7849’W, 1504 m (+Alt: 2* m)
End of Dredge:	54°11.6336’N, 166°59.4198’W, 1557m (+Alt: 2 *m) *Data was measured by chain length because an altimeter was broken.
Chief observer:	Akito OGAWA (The University of Tokyo)
Main purpose:	Bottom observation at a depth of 1500 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, Backward)

Summary:

The eighttth 6K Deep Tow Camera observation during MR17-04LEG2 was conducted around a depth of 1500 m in Bering Canyon.　Some Jerrys were observed in middle depth water (Fig.1).The sediments were silty mud, on which occurred many sea-anemones (Fig.2). Some basket-star (Gorgonocephalidae sp.) climbing on Oct-coral (Nephtheidae sp.) was observed (Fig. 3). Jerry fish, rattails, asteroids and gastropods were seen at the bottom (Fig. 4). Amphiurids Ophioroids hid their body in mud and raised their arms (Fig. 5). Dredge sampling was conducted at the end of towing at a depth of 1557 m.

Fig.1. Solmissus Jerrys were observed in middle depth water.

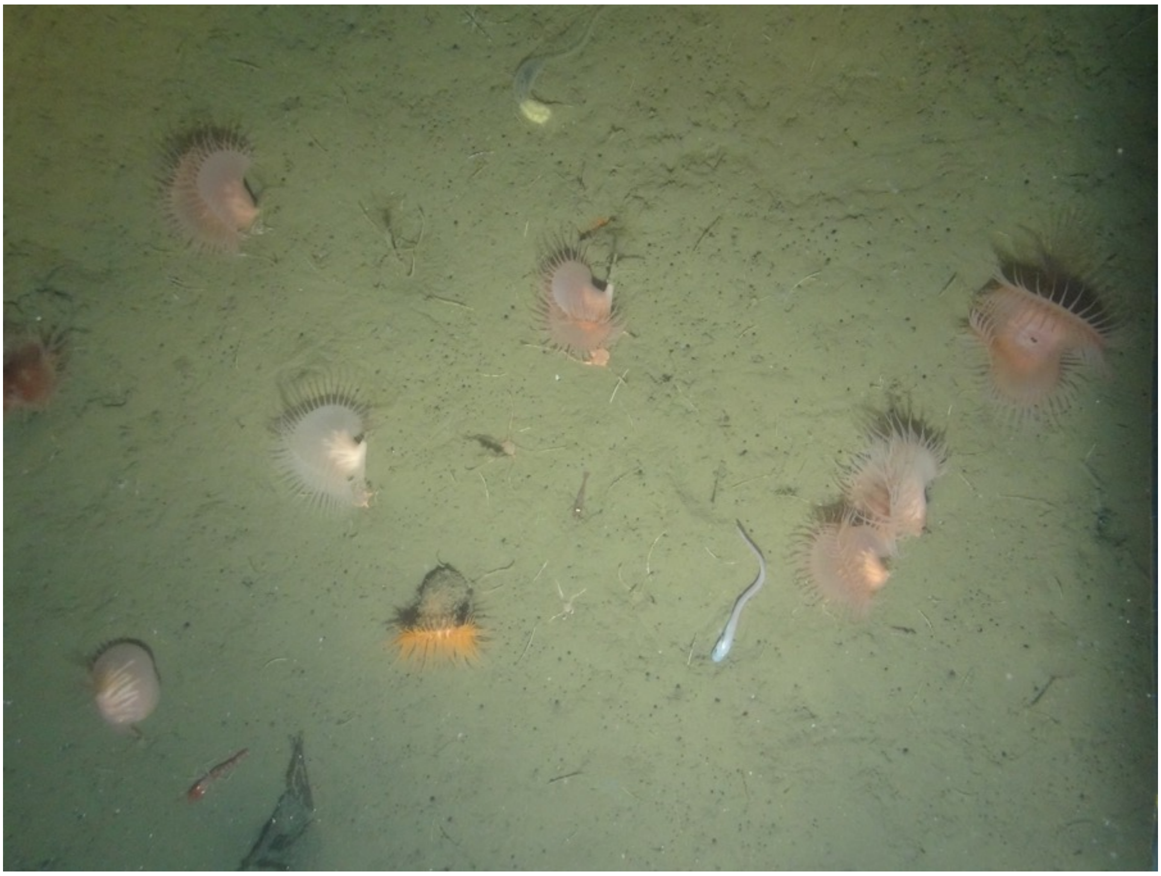


Fig.2. Sea-anemones were living on silty mud bottoms.

Fig.3. Some Basket-star climbed on an Octo-corals.

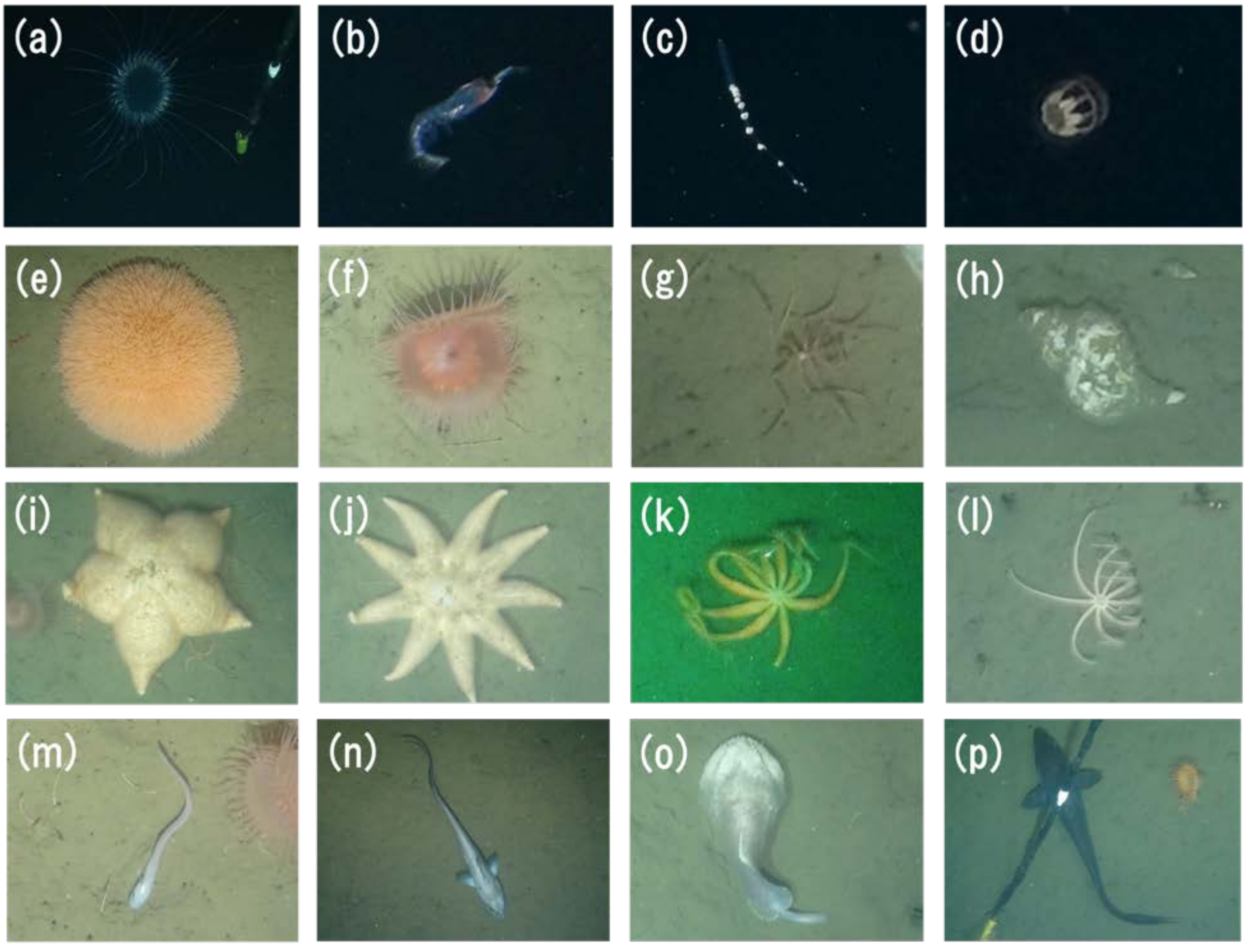


Fig.4. Species observed during 6KCDT0014. (a) Solmissus sp., (b) Krill, (c) Siphonophora sp., (d) Botrynema brucei, (e) Liponema brevicornis, (f) Actinostolidae sp., (g) Sea-spider, (h) Snail, (i) Pedicellasteridae sp., (j) Solasteridae sp., (k) Freyellidae sp., (l) Brisngidae sp., (m) Zoarcidae sp., (n) Macrouridae sp., (o) Psychrolutes phrictus, (p) Coryphanoides acrolepis.

Fig. 5. Amphiurids Ophioroids hid their body in mud and raised their arms.

Tow number:	6KCDT0015
Date:	August 16, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°12.4699’N, 168°34.9547’W, 2413 m (+Alt: 2.0 m)※
End of Dredge:	54°12.5341’N, 168°37.9560’W, 2260 m (+Alt: 4.0 m)※
	*Data was measured by chain length because an altimeter was broken.
Chief observer:	Shigeki WATANABE (IDEA Consultants, Inc.)
Main purpose:	Bottom observation at a depth of 2500 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x2 (Downward, Forward)

Summary:
This point locates the slope of the Bering canyon where the water depth of about 2,500 m.
The northern part of the canyon were characterized by the steep cliff or slope consist of sedimentary rocks and thinly covered by the silty to sandy sediments (Fig.1).
On the slope area, sponges, Crinoidea and Actiniaria were attached to the substrates, and these organisms showed higher abundances at steep slopes than gentle slopes.
In addition to the above mentioned organisms, Macrouridae, veracruciformes such as Benthodytes and shrimp such as Munidopsis were also observed, but the overall abundances were less than the other areas.
Also, on the base of the slope, characteristic linear-edge shape rocks were occasionally observed (Fig. 2). In some cases, there was collapsed sponges on the seafloor assumed to be fell down from the cliff (Fig. 3).
At the flat part in the middle of the slope, silty sediments tended to be thicker than the slope part.
Among the dominant organisms, Benthodytes and Bonellidae were particularly common (Fig. 4e, 4f).
In addition, Zoarcidae, Macrouridae, Halosauridae, Moridae and Rajiformes were observed among fish.
Octopoda, Teuthida, squirrels, crabs such as Majidae and Alcyonaria in association with Euryalida adhering to them were also observed.
Pieces of kelp leaf were occasionally found at the flat part, but there was no obvious organisms attached to them.
The dredge sampling was carried out at the end of towing at a water depth of 2282 m.

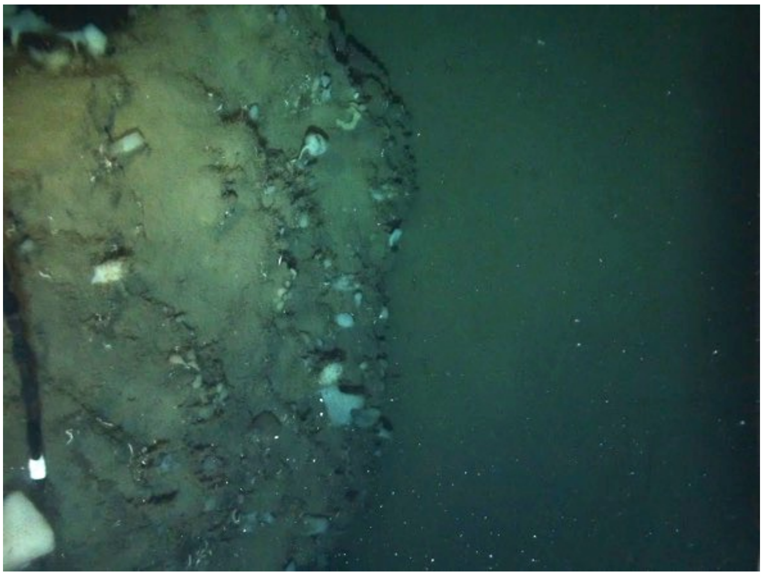


Fig.1. Ravine Slope. sponges were attached.

Fig.2. Rock form with characteristic shape.

Fig.3. collapsed sponges classified as falling down.

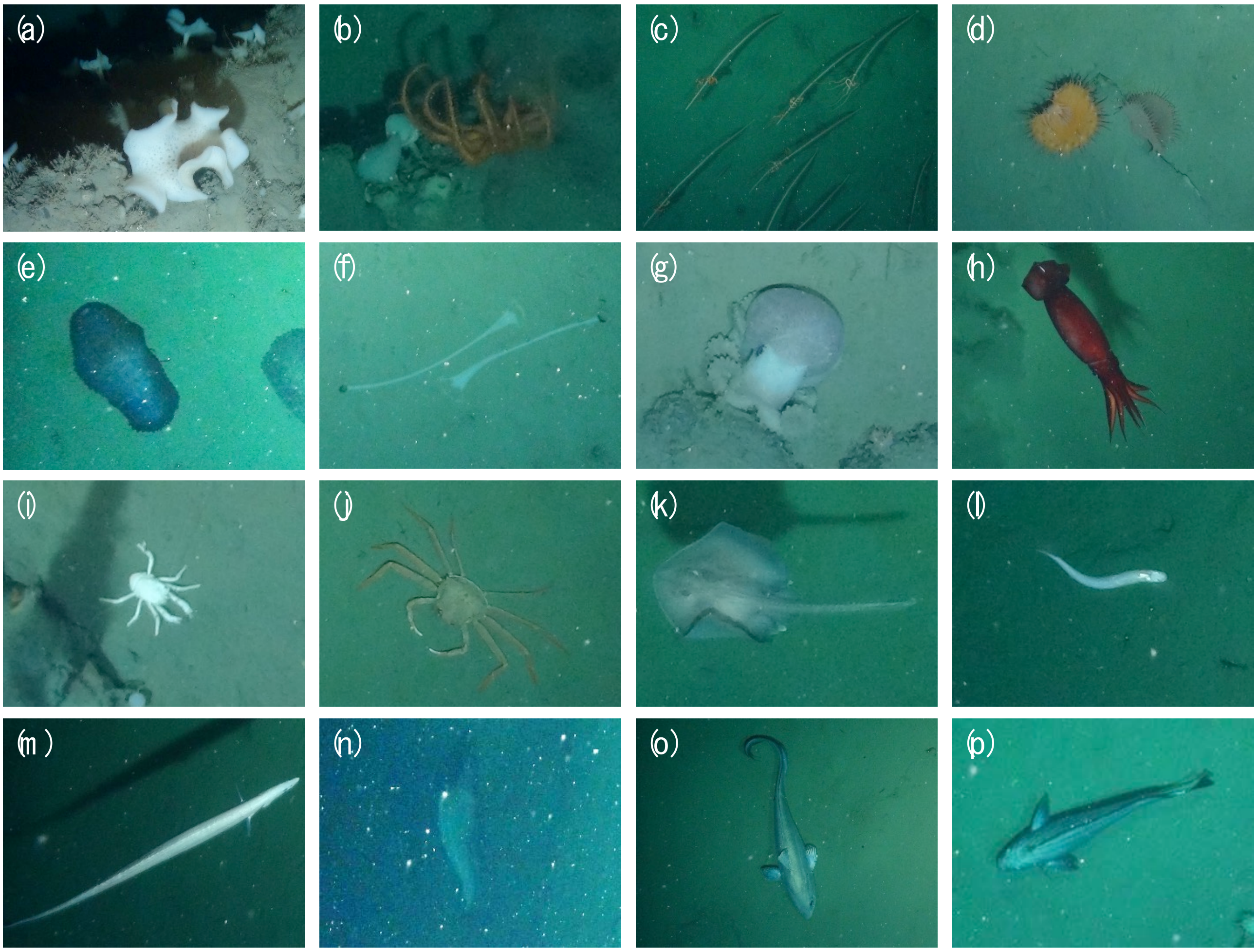


Fig.4. Species observed during 6KCDT0015. (a) sponges, (b) Crinoidea, (c) Alcyonaria, (d) Actiniaria, (e) Benthodytes, (f) Bonellidae, (g) Octopoda, (h) Teuthida, (i) Munidopsidae, (j) Majidae, (k) Rajiformes, (l) Zoarcidae, (m) Halosauridae, (n) Moridae, (o) Macrouridae, (p) Unidentified species.

Tow number:	6KCDT0016
Date:	August 16, 2017 (Local Time)
Site:	Southeast Bering Sea
Arrival on bottom:	54°11.2021’N, 168°39.0285’W, 2526 m (+Alt: 3.0 m)※
End of Dredge:	54°11.2118’N, 168°39.4177’W, 2518 m (+Alt: 2.5 m)※
	*Data was measured by chain length because an altimeter was broken.
Chief observer:	Shigeki WATANABE (IDEA Consultants, Inc.)
Main purpose:	Bottom observation at a depth of 2500 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, Backword)

Summary:
This point hits near the bottom of the valley of the Bering valley, and the water depth is about 2,500 m.
A flat topography expanded, and silt deposits were confirmed on almost the entire surface (Fig.1).
Veracruciformes such as Benthodytes as dominant species, Bonellidae the like, Zoarcidae in fish other than the above, Macrouridae and Moridae is, Majidae, Actiniaria compound was confirmed in invertebrates.
Moreover, fine irregularities are confirmed number patchy the bottom surface, be due to some biological activity has been suggested (Fig.2).
Sampling by the dredge was done at the end of towing at a water depth of 2545 m.

Fig.1. Flat topography. Veracruciformes such as Benthodytes , Bonellidae were observed.

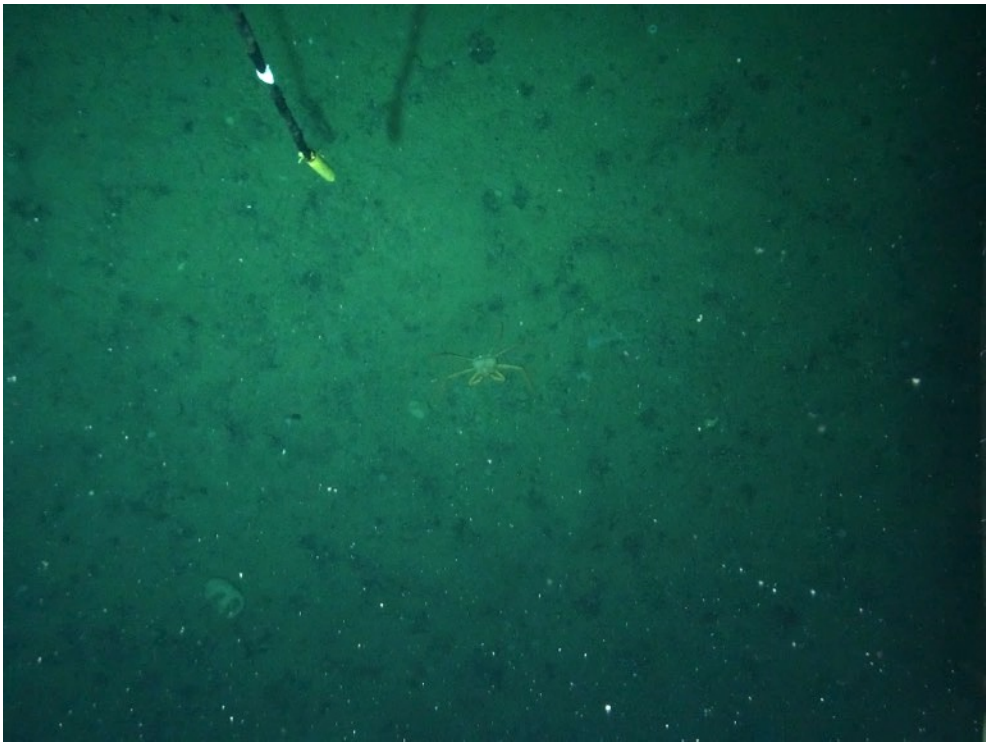


Fig.2. Fine irregularities, be due to some biological activity has been suggested.

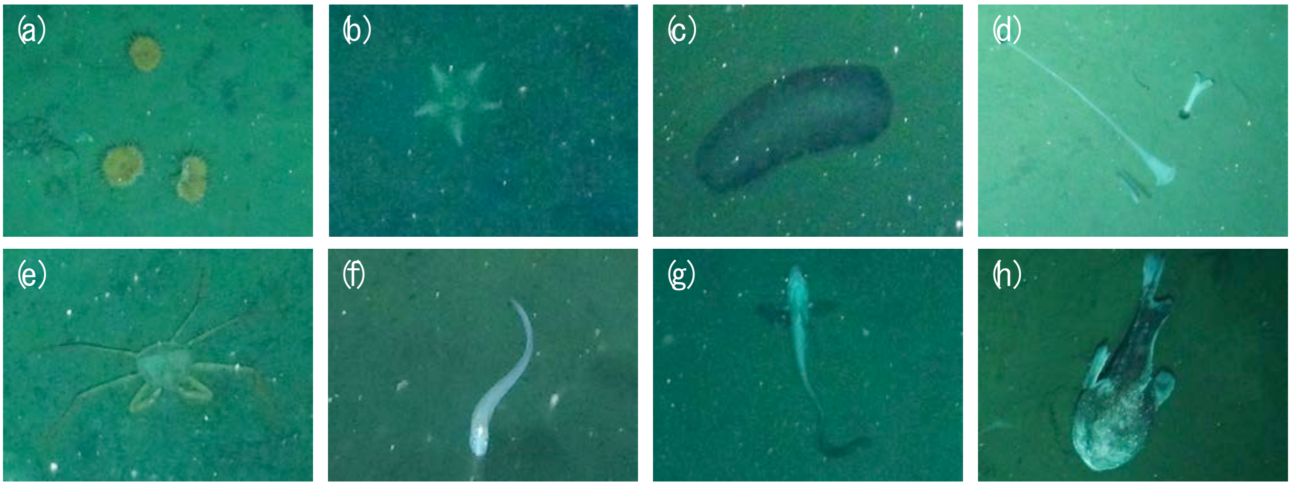


Fig.3. Species observed during 6KCDT0016. (a) Actiniaria, (b) Asteroidea, (c) Benthodytes, (d) Bonellidae, (e) Majidae, (f) Zoarcidae, (g) Macrouridae, (h) Scorpaeniformes

Tow number:	6KCDT0017
Date:	August 18, 2017 (Local Time)
Site:	Point Q, Southeast Bering Sea
Arrival on bottom:	54°13.0633’N, 164°33.1209’W, 127 m (+Alt: 6.9 m)
End of Dredge:	54°15.7159’N, 164°36.7870W, 137m (+Alt: 2.6 m)
Chief observer:	Shinji Tsuchida (JAMSTEC)
Main purpose:	Bottom observation at a depth of 130 m in Bering Canyon
Payload equipment:	GoPro Hero3+ x3 (Downward, Forward, backward)

Summary:

The 6K Deep Tow#0017 was conducted around a depth of 130 m at the Point Q where located at the east edge of the survey area in this cruise. We landed at southeast from the bank about 130m depth. In the point, see bottom was covered by sandy-gravel with numerous dead shells and some of alive scallops (Fig. 1). - Then, we moved to the Northwestward for the shallow bank. During this course, sea urchins, sponges, many kinds of starfish were observed on the shells and gravel bottom. From the center of the bank, dense mussel beds were seen on the slope (Fig. 2). Beyond the bank, bottom was largely changed from shells and gravel to sand with a few scattered shells (Fig. 3). Near the leaving point, we found few animals on the steep sandy bottom with a patch of dense accumulation of shells (Fig. 4). In this towing, several kinds of sponges, anemones, urchins, ophiuroids, flat fishes, cods, rockfishes, and lots of scallops were observed. Dredge sampling was conducted at the end of towing at a depth of 137 m.

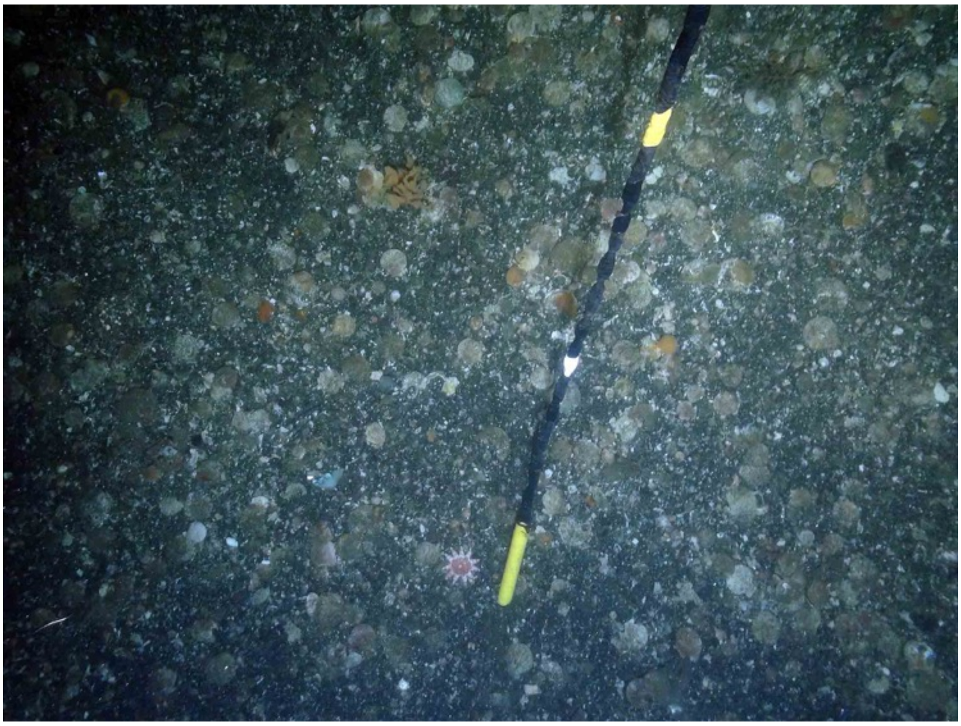


Fig.1. Bottom covered by gravels and scallop shells near the landing point.

Fig.2. Dense mussel bed observed on the bottom inside the bank.

Fig.3. Bottom covered by sand and scattered shells beyond the bank.

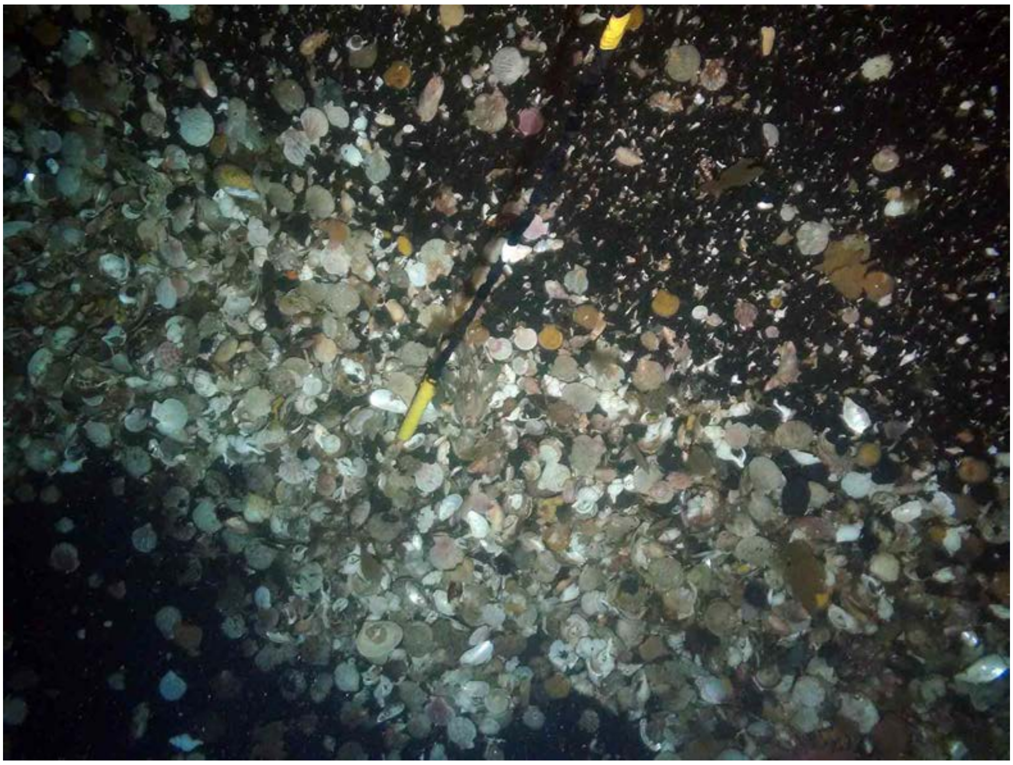


Fig.4. Dense accumulated shells on the steep sandy slope.

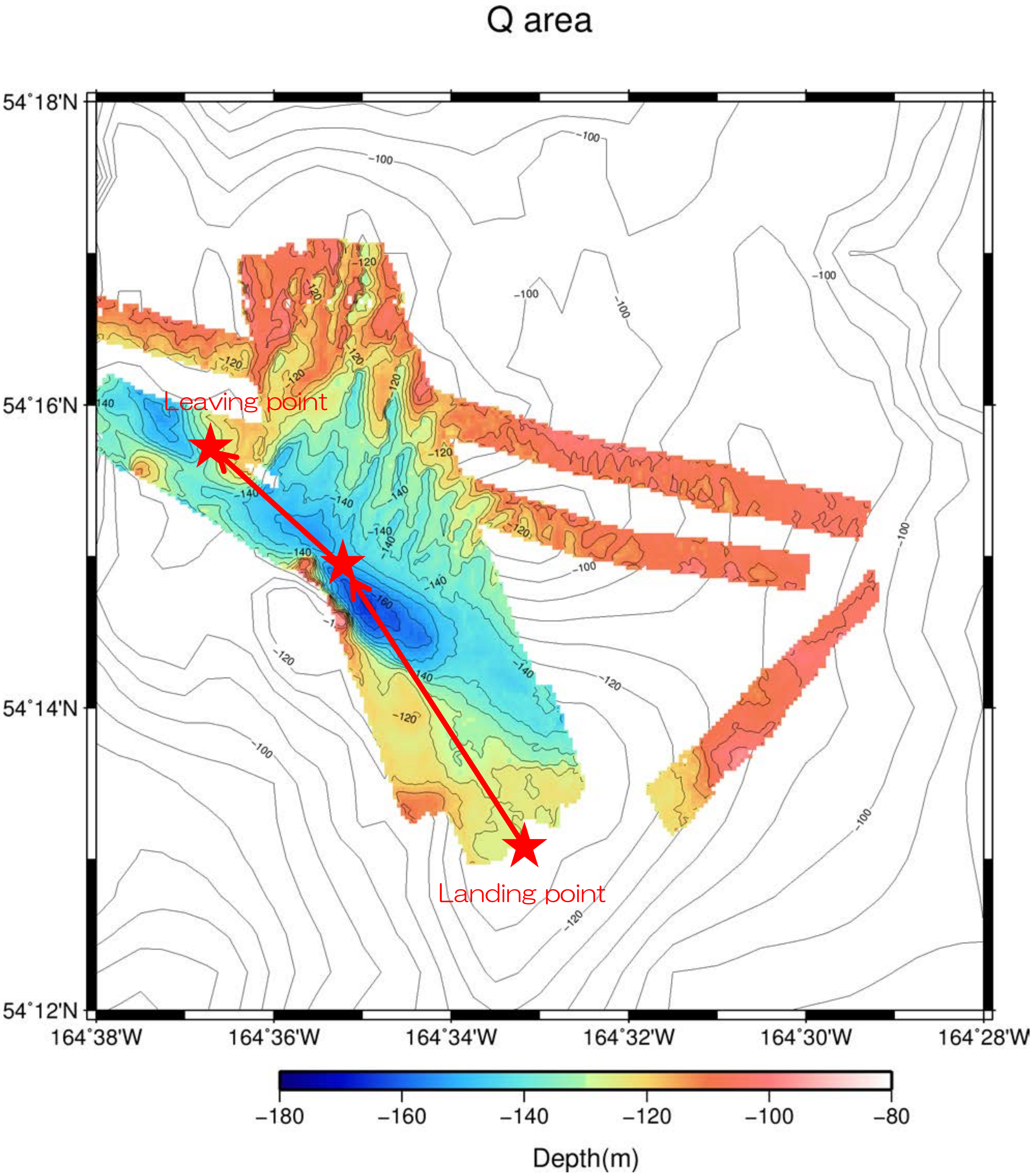


Fig.5. 6KCDT0017 towing line.

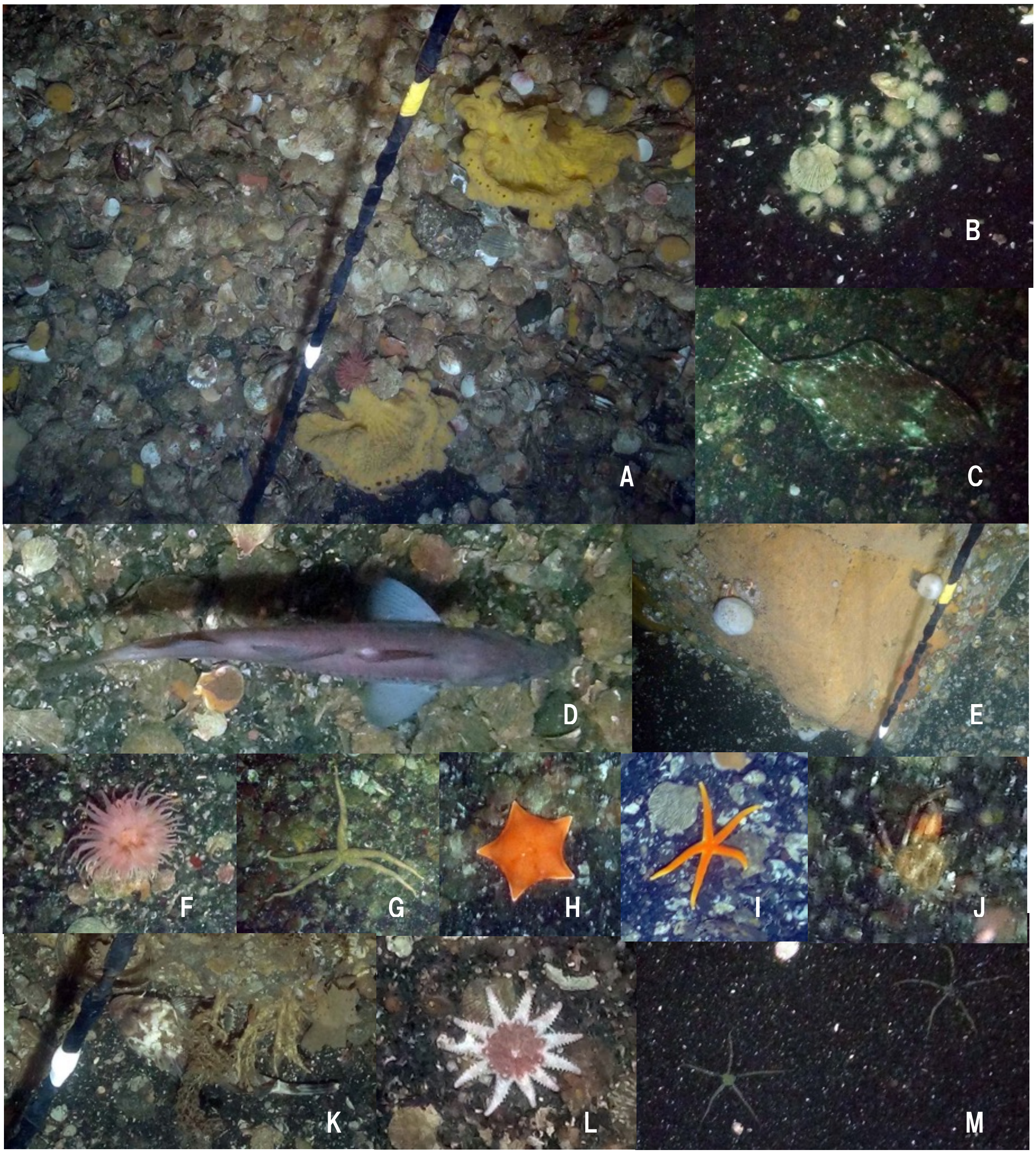


Fig.6. Species observed during 6KCDT0017. (A) Dense bed of scallop, (B) Sea-urchin, (C) Flat fish, (D) Cod, (E) Sponge, (F) sea anemone, (G) Starfish, (H) Starfish, (I) Starfish, (J) Spider crab, (K) Rock fish, (L) Starfish, (M) Ophiuroid.

3.1.15 (d) Dredge samples

Authors: Keiichi KAKUI, Naoto JIMI (Hokkaido University); Akito OGAWA (The University of Tokyo); Momoko KOISO (Toho University); Shigeki WATANABE (IDEA Consultants,Inc.)
Sampling gear: Dredger on Deep Tow. Except stations M, E, and E2, a 0.45-mm opening mesh was additionally attached on the inner surface of dredger-end (i.e., on the metal-mesh). Station M and subsequent stations (except H(2)), a metal-plate with many holes was additionally attached on the outer surface of dredger-end. At Station H(2), we used a dredger for backup purpose (almost same in shape to the "main" dredger in this cruise) and carried out tow and dredging; it was done to shorten the preparation time before tow and carry out second cast within a single day.

Summary

Station A (6KCDT0007)

Date: August 5, 2017
Start of Dredge: 54-17.8114N, 166-23.7820W (16:45 LST)*
End of Dredge: 54-17.7495N, 166-23.8136W (16:49 LST)**
Depth range: 1120_1119 m (ca 4 minutes)***
* The time was based on "6KCDT0007_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.
**Time in the soq file corresponding to the Long/Lat data in the "6KCDT0007_Dive_Record.pdf" was presented.
***The depth data was based on "6KCDT0007_Dive_Record.pdf." First and second values were for start and end of dredge, respectively.
Immediately after the bottom-arrival of the dredger, the dredger moderately sunk into the sea-bottom, and huge amount of muddy sediments seemed to enter the dredger, suggesting the soft bottom condition. Camera observation indicated that the dredger was immediately filled with mud and not smoothly pulled. Dredger arrived on board was packed almost full of sediment, which consisted of mud with sands and gravels; the abundant macrobenthos in it was ophiuroids. After most sediment removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 200 ml.

Station B (6KCDT0008)

Date: August 7, 2017
Start of Dredge: 54-29.1044N, 165-57.2516W (13:44 LST)*
End of Dredge: 54-29.0824N, 165-57.2371W (13:50 LST)**
Depth range: 521_520 m (ca 6 minutes)***
* The time was based on "6KCDT0008_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.
**Time in the soq file corresponding to the Long/Lat data in the "6KCDT0008_Dive_Record.pdf" was presented.
***The depth data was based on "6KCDT0008_Dive_Record.pdf." First and second values were for start and end of dredge, respectively.
Immediately after the bottom-arrival of the dredger, the dredger moderately sunk into the sea-bottom, and huge amount of muddy sediments seemed to enter the dredger, suggesting the soft bottom condition. Camera observation indicated that the dredger was immediately filled with mud and not smoothly pulled. Dredger arrived on board was packed almost full of sediment, which consisted of mud. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 250 ml.

Station C (6KCDT0009)

Date: August 8, 2017
Start of Dredge: 54_41.3949N, 165_27.9111W (19:40 LST)*
End of Dredge: 54_41.4400N, 165_27.9516W (19:41 LST)**
Depth range: 240_240 m (ca 1 minutes)***
* The time was based on "6KCDT0009_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.

**Time in the soq file corresponding to the Long/Lat data in the “6KCDT0009_Dive_Record.pdf” was presented.
***The depth data was based on “6KCDT0009_Dive_Record.pdf.” First and second values were for start and end of dredge, respectively.
The dredger landed on the bottom, and slightly sunk into the sediment, meaning relatively hard bottom condition. Dredger scraped the bottom-surface. On board, the amount of sediment was about 1/4 volume of dredger, which consisted of black sand. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 100 ml.

Station D (6KCDT0010)
Date: August 9, 2017
Start of Dredge: 54-23.7154N, 165-36.8641W (14:45 LST)*
End of Dredge: 54-23.6922N, 165-36.9067W (14:49 LST)**
Depth range: 94_94 m (ca 4 minutes)***
* The time was based on “6KCDT0010_Dive_Record.pdf,” and corresponding Long/Lat data in the soq file was presented.
**Time in the soq file corresponding to the Long/Lat data in the “6KCDT0010_Dive_Record.pdf” was presented.
***The depth data was based on “6KCDT0010_Dive_Record.pdf.” First and second values were for start and end of dredge, respectively.
The dredger landed on the bottom, and slightly sunk into the sediment, meaning relatively hard bottom condition. Dredger scraped the bottom-surface. On board, the amount of sediment was about half volume of dredger, which consisted of sand with dead shells and gravels. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 150 ml.

Station M (6KCDT0011)
Date: August 10, 2017
Start of Dredge: 54-25.8668N, 165-33.5049W (21:20 LST)*
End of Dredge: 54-25.8734N, 165-33.4496W (21:31 LST)**
Depth range: 96_96 m (ca 11 minutes)***
* The time was based on “6KCDT0011_Dive_Record.pdf,” and corresponding Long/Lat data in the soq file was presented.
**Time in the soq file corresponding to the Long/Lat data in the “6KCDT0011_Dive_Record.pdf” was presented.
***The depth data was based on “6KCDT0011_Dive_Record.pdf.” First and second values were for start and end of dredge, respectively.
The dredger landed on the bottom, and slightly sunk into the sediment, meaning relatively hard bottom condition. Dredging area has many large rocks covered by sponges; dredger once got stuck with them. Dredger scraped the bottom-surface. Dredger arrived on board was packed almost full of sediment, which consisted of sandy mud with dead shells and gravels. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 100 ml.

Station E (6KCDT0012)
Date: August 11, 2017
Start of Dredge: 54_24.2237N, 165_20.0067W (14:35 LST)*
End of Dredge: 54-24.2669N, 165-20.0555W** (14:41 LST)
Depth range: 165_166 m (ca 6 minutes)***
* The time was based on “6KCDT0012_Dive_Record.pdf,” and corresponding Long/Lat data in the soq file was presented.
**As the Long/Lat data in “6KCDT0012_Dive_Record.pdf” was different to those for 14:41 in the soq file, Long/Lat in soq file (at 14:41) was presented.
***The depth data was based on “6KCDT0012_Dive_Record.pdf.” First and second values were for start and end of dredge, respectively.

The dredger landed on the bottom, and slightly sunk into the sediment, meaning relatively hard bottom condition. Dredger scraped the bottom-surface. On board, the amount of sediment was about half volume of dredger, which consisted of black sands with dead shells and gravels. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 100 ml.

Station E2 (6KCDT0013)

Date: August 12, 2017
Start of Dredge: 54_21.6454N, 165_17.1370W (21:33 LST)*
End of Dredge: 54-21.6664N, 165-17.1588W** (21:39 LST)
Depth range: 297_207 m (ca 6 minutes)***
* The time was based on "6KCDT0013_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.
**As the Longitude data in "6KCDT0013_Dive_Record.pdf" was different to that for 21:39 in the soq file, the latter was presented.
***The depth data was based on "6KCDT0013_Dive_Record.pdf." First and second values were for start and end of dredge, respectively.

The dredger landed on the bottom, and slightly sunk into the sediment, meaning relatively hard bottom condition. Dredger scraped the bottom-surface. Dredger arrived on board was packed almost full of sediment, which consisted of sandy mud with shells and gravels; the abundant macrobenthos in it was bivalves including mussels. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 250 ml.

Station G (6KCDT0014)

Date: August 15, 2017
Start of Dredge: 54-11.6378N, 166-59.3735W (21:56 LST)*
End of Dredge: 54-11.6336N, 166-59.4198W (21:59 LST)*
Depth range: 1566_1569 m (ca 3 minutes)**
* The time and Long/Lat data were based on "6KCDT0014_Dive_Record.pdf.".
**The depth data was based on "6KCDT0014_Dive_Record.pdf." First and second values were for start and end of dredge, respectively.

Immediately after the bottom-arrival of the dredger, the dredger moderately sunk into the sea-bottom, and huge amount of muddy sediments seemed to enter the dredger, suggesting the soft bottom condition. The dredger seemed to be pulled smoothly. Dredger arrived on board was packed almost full of sediment, which consisted of creamy silt. Easily recognized macrobenthos during sieving was ophiuroids. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 100 ml.

Station H(1) (6KCDT0015)

Date: August 16, 2017
Start of Dredge: 54_12.6214N, 168_38.1096W (13:35 LST)*
End of Dredge: 54-12.5341N, 168-37.9560W (13:38 LST)**
Depth range: 2282_2273 m (ca 3 minutes)***
* The time was based on "6KCDT0015_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.
**Time in the soq file corresponding to the Long/Lat data in the "6KCDT0015_Dive_Record.pdf" was presented.
***The depth data was based on "6KCDT0015_Dive_Record.pdf." First and second values were for start and end of dredge, respectively.

Immediately after the bottom-arrival of the dredger, the dredger moderately sunk into the sea-bottom, and huge amount of muddy sediments seemed to enter the dredger, suggesting the soft bottom condition. The dredger seemed to be pulled smoothly. On board, the amount of sediment was about half volume of dredger, which consisted of mud. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 100 ml. After washing, only little sediment remained in the tray.

Station H(2) (6KCDT0016)

Date: August 16, 2017
Start of Dredge: 54_11.2197N, 168_39.3360W (16:04 LST)*
End of Dredge: 54-11.2118N, 168-39.4177W (16:08 LST)**
Depth range: 2545_2523 m (ca 4 minutes)***

* The time was based on "6KCDT0016_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.

**As the longitude value (168-39.4177W) was not found in the soq file, the time and Long/Lat data in "6KCDT0016_Dive_Record.pdf" was presented.

***The depth data was based on "6KCDT0016_Dive_Record.pdf." First and second values were for start and end of dredge, respectively. It should be noted that the depth data for start of dredge (2545 m) was far different to that in two close time periods (2526 m at 16:00; 2528 m at 16:05); the depth for start of dredge will be mismeasured (or miswritten?) value.

Immediately after the bottom-arrival of the dredger, the dredger moderately sunk into the sea-bottom, and huge amount of sediments seemed to enter the dredger, suggesting the soft bottom condition. The dredger seemed to be pulled smoothly. On board, the amount of sediment was about 1/3 volume of dredger, which consisted of creamy mud, black sand, and black gravels. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 100 ml.

Station Q (6KCDT0017)

Date: August 18, 2017
Start of Dredge: 54_15.6976N, 164_36.7102W (21:24 LST)*
End of Dredge: 54-15.7159N, 164-36.7870W (21:30 LST)**
Depth range: 135_137 m (ca 6 minutes)***

* The time was based on "6KCDT0017_Dive_Record.pdf," and corresponding Long/Lat data in the soq file was presented.

**As the latitude value (54-15.7159N) was not found in the soq file, the time and Long/Lat data in "6KCDT0017_Dive_Record.pdf" was presented.

***The depth data was based on "6KCDT0017_Dive_Record.pdf." First and second values were for start and end of dredge, respectively.

The dredger landed on the bottom, meaning hard bottom condition. Camera observation indicated that the dredger was immediately filled with sediment. On board, the amount of sediment was about 1/3 volume of dredger, which consisted of black sand and dead shells. After most sediment (and heavy organisms) removed by gentle washing using a sieve of 0.45 mm opening mesh to isolate specimens, the amount of residue on the mesh was ca 25 ml.

Remarks

Mr. Yuki Miyajima (MWJ) told us the following things: dredgers on bottom will be always packed full of sediment; during their stay near the sea-surface related to recovering process, a few or much sediment in dredgers will be washed and lost, which result in not-full contained dredgers on board (e.g., Station C, 6KCDT0009); this is caused especially when wave is high.

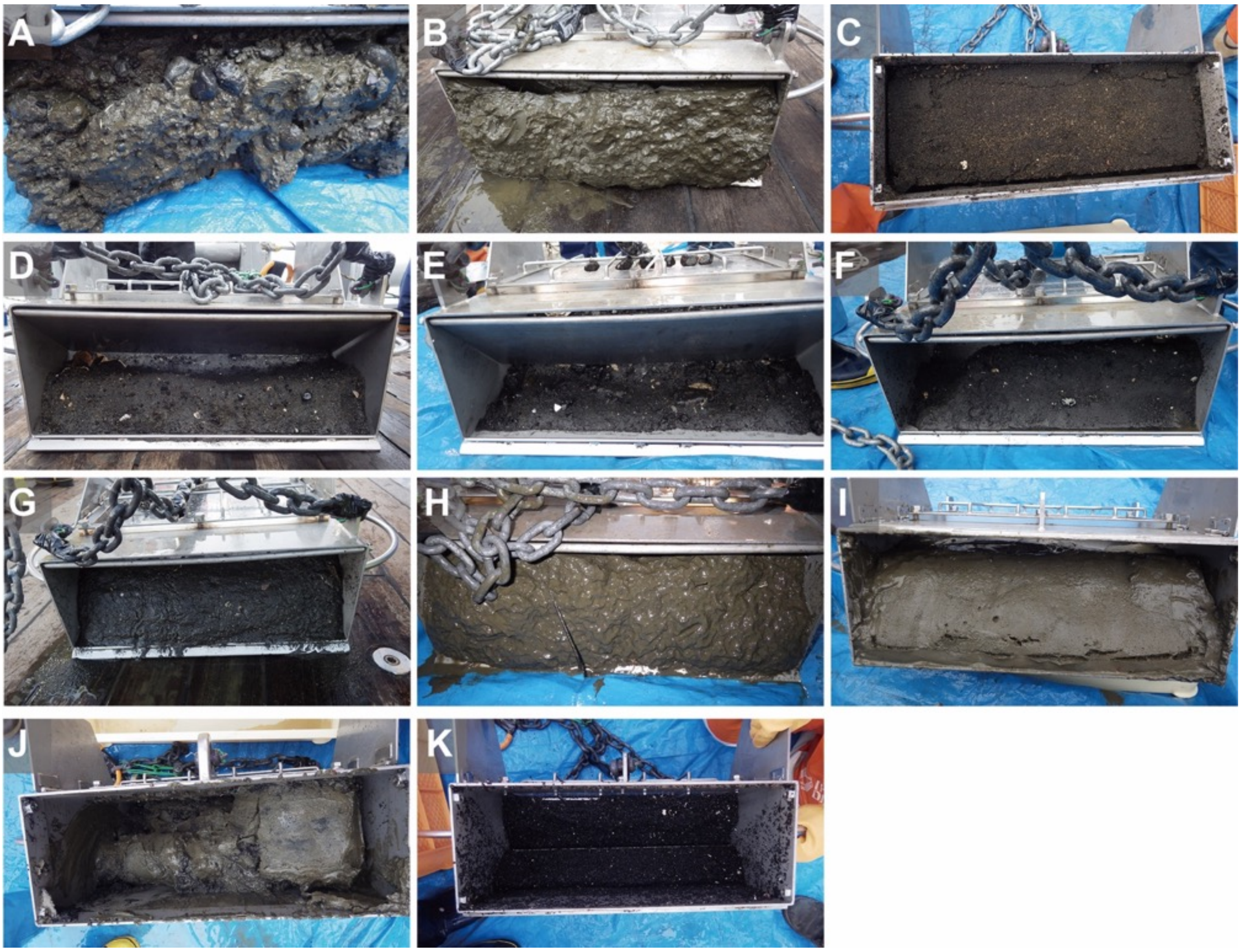


Fig.1 The contents of the dredger on board. A–K, Stations A, B, C, D, M, E, E2, G, H(1), H(2), and Q, respectively. A, B, D–H, front views; others, back view.

3.1.16. Multiple corer samplings

Hidetaka Nomaki (JAMSTEC)
Dewi Langlet (JAMSTEC)
MR 17-04 Leg2 onboard scientists and technicians

We carried out 13 multiple corer samplings at 7 stations, from the water depths of 103 m to 1536 m. All sites were selected based on the SeaBeam bottom topography surveys and the Sub-Bottom Profiling (SBP) surface sediment surveys. Numbers of the core (4 or 8) at each deployment were determined based on the expected sediment characteristics by SBP and the length of the obtained core from the first cast of the site.

MC01 was carried out at the Stn A (water depth: 1120 m) on 6th Aug. Due to the hard substrate, all 8 cores contained approximately 1 to 2 cm thickness of sandy/rocky sediments including fine particles.

MC02 and MC03 were carried out at the Stn B (water depth: 536 m) on 6th Aug. We obtained in total 16 cores having ~20 cm length from this site. The sediment consists of silty sediment including fine sand, and some ophiuroids were found on the surface sediments.

MC04 and MC05 were carried out at the Stn C (water depth: 230 m) on 8th Aug. Eight cores were equipped to MC04 cast and 4 cores were equipped to MC05 cast, resulting core length were ~12 cm for MC04 and ~18 cm for MC05. The sediments consist of medium to coarse sand, and sometimes include several cm size of riverine rocks.

MC06, MC07, and MC08 were carried out at the Stn M (water depth: 97 m) on 10th Aug., with 4 cores per every cast. The sediments consist of coarse sand and gravels, but contained fine sediment on the surface only in two cores from the cast MC07. The MC08 samples contained grayish silty clay layer at the bottom of the core; i.e. 6 to 10 cm depth in sediments. Some sediment cores contained zoantharian.

MC09 and MC10 were carried out the Stn E2 (water depth: 197 m) on 12th Aug., with 8 cores for MC09 cast and 4 cores for MC10 cast, resulting ~12 cm in length from MC09 and ~18 cm in length from MC10. There was a grayish clay/silt layer at the bottom of the cores from the cast MC10.

MC11 were carried out at the Stn B2 (water depth: 486 m), which is several miles northeast from the Stn B, on 13th Aug. Sediment looks similar to the one from the Stn B.

MC12 and MC13 were carried out at the Stn G (water depth: 1536 m) on 15th Aug. Sediment mainly consists of silt, except the black colored fine to medium sand layer from 18 cm to ~26 cm in depth.

The obtained cores at each site were used for some different analysis/samplings by on-board scientists; sedimentological analysis (Nomaki), sediment geochemistry (Nomaki, Nakato), pore water chemistry (Nomaki, Nakato), microbial abundances and their diversities (Nomaki), foraminiferal fauna and their metabolisms (Nomaki, Langlet), metazoan meiofauna community and taxonomy (Watanabe, Kakui, Jimi), and macrofaunal community and taxonomy (Kakui, Jimi). The multiple corer samples at Stn A and B2 were used only for some selected analysis among those.

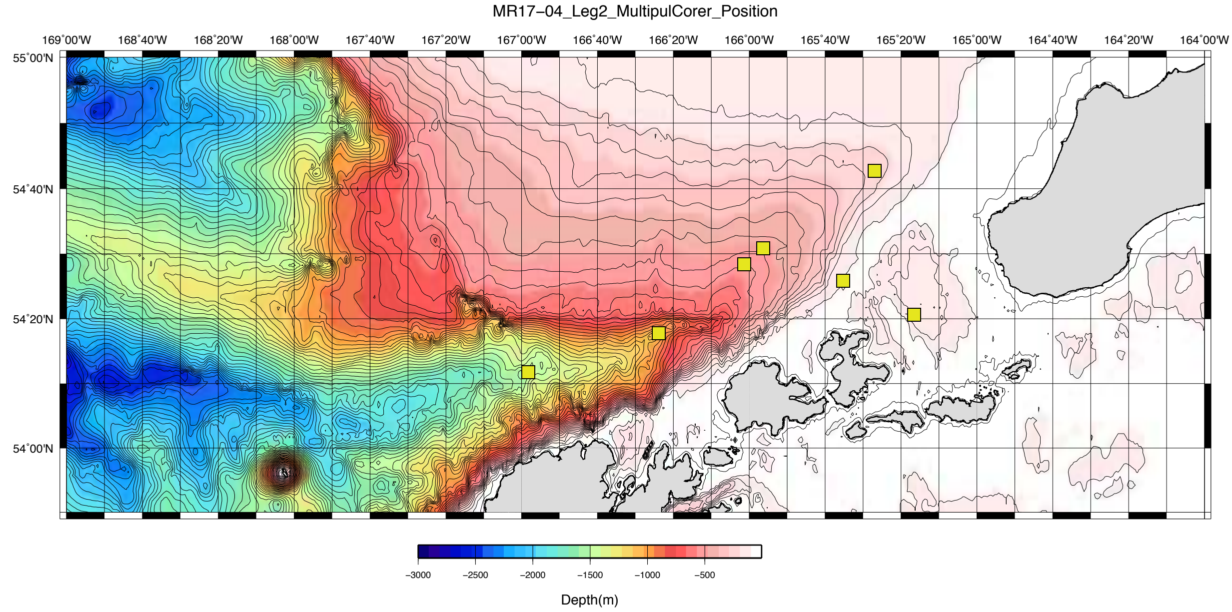


Fig. 1 Sampling location of multiple cores.

4. Additional research themes

4.1 Observation of seawater density and vertical mixing

Hiroshi UCHIDA	**JAMSTEC RCGC**
Masahide WAKITA	**JAMSTEC MIO**
Shinya KOUKETSU	**JAMSTEC RCGC**
Kenichi KATAYAMA	**MWJ**
Keisuke MATSUMOTO	**MWJ**
Shungo OSHITANI	**MWJ**
Keisuke TAKEDA	**MWJ**

(1) Objectives

The objective of this study is to collect Absolute Salinity (also called “density salinity”) data in the subarctic North Pacific and the Bering Sea whose Absolute Salinity anomaly is large among the World Ocean and to evaluate the algorithm to estimate Absolute Salinity provided along with TEOS-10 (the International Thermodynamic Equation of Seawater 2010) (IOC et al., 2010), and to evaluate vertical mixing by measuring microstructure of temperature and current profiles.

(2) Instruments and methods

i) Seawater density measurement

Seawater densities were measured during the cruise with an oscillation-type density meter (DMA 5000M, serial no. 80570578, Anton-Paar GmbH, Graz, Austria) with a sample changer (Xsample 122, serial no. 80548492, Anton-Paar GmbH). The sample changer was 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 ºC) upside down usually for 12 to 24 hours to make the temperature of the sample equal to the room temperature. The water sample was 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 were measured at 20 ºC by the density meter two times for each bottle and averaged to estimate the density. When the difference between the two measurements was greater than 0.002 kg/m^3, additional measurements were conducted until two samples satisfying the above criteria were obtained.

Time drift of the density meter was 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 ºC of the Milli-Q water was estimated to be 998.2041 $kg\ m^{-3}$ 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 was applied to the measured density by using the Milli-Q water measurements ($\rho_{Milli-Q}$) with a slight modification of the density dependency (Uchida et al., 2011). The offset (ρ_{offset}) of the measured density (ρ) was reevaluated for the serial no. 80570578 in November 2014 as follows:

$$\rho_{offset} = (\rho_{Milli-Q} - 998.2041) - (\rho - 998.2041) \times 0.000411\ [kg\ m^{-3}].$$

The offset correction was verified by measuring the IAPSO Standard Seawater (P156) and the Reference Material for Density in Seawater (prototype Dn-RM1 and PRE18) developing with Marine Works Japan, Ltd., Kanagawa, Japan, and 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 ºC) with TEOS-10.

ii) Seawater sound velocity measurement

Sound velocity profiles were measured at the CTD casts by using a velocimeter (MiniSVS OEM, serial no. 24001, Valeport Ltd., Devon, United Kingdom). 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 7000 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 were obtained through serial uplink port of the CTD at a sampling rate of 12 Hz and the data will be combined with the CTD temperature and pressure data measured at a sampling rate of 24 Hz to estimate Absolute Salinity.

Absolute Salinity can be back calculated from measured sound velocity, temperature and pressure and will be calibrated in situ referred to the Absolute Salinity measured by a density meter for water samples.

iii) Microstructure of temperature measurement

Microstructure observations were carried out by using Micro-Rider 6000 (MR6000, Rockland Scientific International, Inc., Victoria, British Colombia, Canada, serial no. 154). The MR6000 was mounted on the CTD/water sampling frame and the power was supplied through the CTD. Two thermistors (FP07, seroal no. T1112 for primary temperature socket and T1510 for secondary temperature socket) were used to obtain high-frequency changes in temperature. Pressure and acceleration were also obtained by the MR6000 with high-frequency. Temperature profile obtained by the CTD secondary temperature sensor with low-frequency were also stored in the MR6000.

iv) Current measurement

Current profiles were measured by acoustic Doppler current profilers (ADCP) (Workhorse Monitor WHM300, Teledyne RD Instruments, Inc., Poway, California, USA, serial no. 20754 [downward looking] and 18324 [upward looking]) attached to the CTD/water sampling frame. The ADCP has four acoustic transducers with 20-degree beam angles, rated in water depths up to 6000 m. The lowered ADCPs (LADCP) makes direct current measurements at the depths of the CTD, thus providing a full profile of current velocity. The LADCPs were powered during the CTD casts by a 48 volts battery pack. By combining the measured seawater velocity and seafloor velocity relative to the CTD frame, and shipboard navigation data during the CTD cast, the absolute velocity profile can be obtained (e.g. Visbeck, 2002).

In this cruise, the LADCP data were collected with the following configuration.

Bin size: 4.0 m
Number of bins: 25
Pings per ensemble: 1
Ping interval: 1.0 second

(3) Result

Results of density measurements of the IAPSO Standard Seawater (P156) and the Reference Material for Density in Seawater (Dn-RM1 and PRE18) were shown in Table 4.1-1. A total of 14 pairs of replicate samples were measured. The root-mean square of the absolute difference of replicate samples was 0.0007 g/kg. The measured density salinity anomalies (δS_A) are shown in Fig. 4.1-1.

Table 4.1-1 Result of density measurements of the IAPSO Standard Seawater (P156) and the Reference Material for Density in Seawater (prototype Dn-RM1 and PRE18). Number in parentheses shows number of measurements

Date	Stations	Mean density of Dn-RM1 (kg/m^3)	Mean density of PRE18 (kg/m^3)	Mean density of P156(kg/m^3)
2017/07/15	K02_1		1024.2419 (7) *	1024.7636 (1)
				1024.7609 (1)
				1024.7620 (1)
				1024.7625 (2)
2017/07/24-25	K02_13	1024.2657 (3)		
2017/07/27-28	U01-U03	1024.2653 (3)	1024.2246 (14)	
2017/07/29-30	U04-U05	1024.2637 (3)	1024.2237 (10)	
	Average:	1024.2649 ± 0.0011	1024.2242	1024.7623 ± 0.0011

* The result of PRE18 serial no. 119 was excluded for average

(4) Data archive

These obtained data will be submitted to JAMSTEC Data Management Group (DMG).

(5) 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.

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

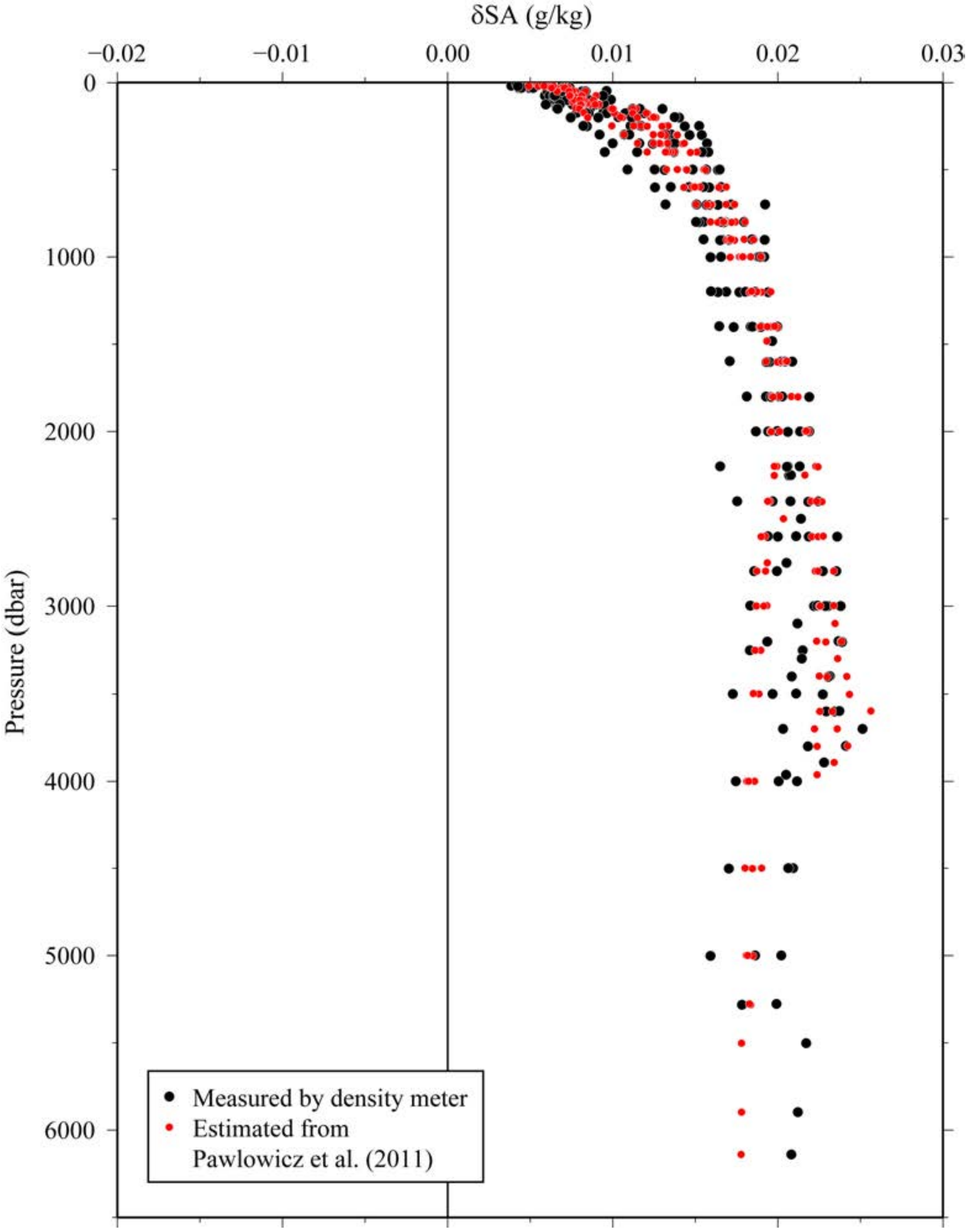


Figure 4.1-1 Vertical distribution of density salinity anomaly measured by the density meter. Absolute Salinity anomaly estimated from nutrients and carbonate parameters (Pawlowicz et al., 2011) are also shown for comparison

4.2 Spatial observations of aerosols in the marine atmosphere: Toward elucidation of interactions with climate and ecosystems

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Fumikazu TAKETANI **JAMSTEC RCGC/IACE (not onboard)**
Takuma MIYAKAWA **JAMSTEC RCGC/IACE (not onboard)**
Hisahiro TAKASHIMA **JAMSTEC RCGC (not onboard)**
Petr MORDOVSKOI **JAMSTEC IACE (not onboard)**
Masayuki TAKIGAWA **JAMSTEC IACE (not onboard)**
Hitoshi MATSUI **JAMSTEC RCGC (not onboard)**
Operation was supported by NME

(1) Objective

We observed atmospheric black carbon (BC) particles over the oceanic regions between Asia and the Arctic, to investigate atmospheric long-range transport processes. This aims to comprehensive analysis incorporating observations at Poker Flat, Alaska. We also observed other aerosol species/properties and gases to analyze causes of spatio-temporal variations and their climate impact.

(2) Description of instruments deployed

1) Online aerosol observations: black carbon (BC) and fluorescent properties

BC and fluorescent properties of aerosol particles were measured by the instruments based on laser-induced incandescence (SP2, Droplet Measurement Technologies) and on flash-lamp-induced fluorescence (WIBS4, Droplet Measurement Technologies). The measurements of fluorescent properties by WIBS4 were made on the flying bridge. Two pulsed xenon lamps emitting UV light (280 nm and 370 nm) were used for excitation and fluorescence emitted from a single particle within 310–400 nm and 420–650 nm wavelength windows was recorded.

For SP2, ambient air was sampled from the flying bridge by a 3-m-long conductive tube through a Diffusion Dryer (model TSI) to dry up the particles, and then introduced to the instrument for detection of single particles of BC.

2) 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 line of sight was in the directions of the portside of the vessel and the measurements were made at several elevation angles of 1.5, 3, 5, 10, 20, 30, 90 degrees using a movable prism, which repeated the same sequence of elevation angles every ~15-min. For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO_2 (and other gases) and O_4 (O_2-O_2, collision complex of oxygen) for each elevation angle. Then, the O_4 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 NO_2 and other gases were made.

3) 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 48iTLE, 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.

S

(3) Result

N/A (All the data analysis is to be conducted.)

(4) 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>

4.3 Cumulus-scale air-sea interaction study by shipboard in-situ observations

4.3.1 C-band polarimetric Doppler weather radar

Masaki KATSUMATA	**JAMSTEC RCGC: Principal Investigator (not on board)**
Biao GENG	**JAMSTEC RCGC (not on board)**
Wataru TOKUNAGA	**NME (Leg-1)**
Mitsuteru KUNO	**NME (Leg-1)**
Soichiro SUEYOSHI	**NME (Leg-2)**
Toshimasa NASU	**NME (Leg-2)**
Masanori MURAKAMI	**MIRAI crew**

(1) Objective

The objective of the radar observations in this cruise is to investigate structure and evolution of precipitating systems over the globe, especially those related to the mid-latitude low-pressure system and stratiform clouds under the high-pressure system.

(2) Radar specifications

The C-band polarimetric weather Doppler radar on board the R/V Mirai is used. Basic specifications of the radar are as follows:

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

(3) Available variables

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) Operational methodology

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 movement in beam direction.

For the maintenance, internal signals of the radar are checked and calibrated 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).

The operational mode of the radar during the cruise is shown in Tables 4.3.1-1. A dual PRF mode is used for a volume scan. For a RHI, vertical point, and surveillance PPI scans, a single PRF mode is used.

(5) Results

The Doppler radar observations were conducted all through the cruise, except over the EEZ without permission. Detailed analyses of the obtained data will be performed after the cruise.

(6) Data archive

All data of the Doppler radar observations during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

Table 4.3.1-1 Operational mode of the radar

	Surveillance PPI Scan	Volume Scan						RHI Scan	Vertical Point Scan
Repeated Cycle (min.)	30	6						12	
Times in One Cycle	1	1						3	3
Pulse Width (long / short, in microsec)	200 / 2	64 / 1		32 / 1		32 / 1		32 / 1	32 / 1
Scan Speed (deg/sec)	18	18		24		36		9	36
PRF(s) (Hz)	400	dual PRF (ray alternative)						1250	2000
		667	833	938	1250	1333	2000		
Pulses / Ray	16	26	33	27	34	37	55	32	64
Ray Spacing (deg.)	0.7	0.7		0.7		1.0		0.2	1.0
Azimuth (deg)	Full Circle							Option	Full Circle
Bin Spacing (m)	150								
Max. Range (km)	300	150		100		60		100	60
Elevation Angle(s) (deg.)	0.5	0.5		1.0, 1.8, 2.6, 3.4, 4.2, 5.1, 6.2, 7.6, 9.7, 12.2, 15.2		18.7, 23.0, 27.9, 33.5, 40.0		0.0~ 60.0	90

4.3.2 Disdrometers

Masaki KATSUMATA **JAMSTEC RCGC: Principal Investigator (not on board)**
Kyoko TANIGUCHI **JAMSTEC RCGC (not on board)**
Biao GENG **JAMSTEC RCGC (not on board)**

(1) Objectives

The disdrometer can continuously obtain size distribution of raindrops. The objective of this observation is (a) to reveal microphysical characteristics of the rainfall, depends on the type, temporal stage, etc. of the precipitating clouds, (b) to retrieve the coefficient to convert radar reflectivity to the rainfall amount, and (c) to validate the algorithms and the product of the satellite-borne precipitation radars; TRMM/PR and GPM/DPR.

(2) Methods

Three different types of disdrometers are utilized to obtain better reasonable and accurate value on the moving vessel. Two of them are installed in one place, the starboard side on the roof of the anti-rolling system of R/V Mirai, as in Fig. 4.3.2-1. The other one, named “micro rain radar”, is installed at the starboard side of the anti-rolling systems (see Fig. 4.3.2-2).

The details of the sensors are described below. All the sensors archive data every one minute.

Fig. 4.3.2-1: The two disdrometers (Parsivel and LPM), installed on the roof of the anti-rolling tank.

Fig. 4.3.2-2: The micro rain radar, installed on the starboard side of the anti-rolling tank.

(4-1) Laser Precipitation Monitor (LPM) optical disdrometer

The “Laser Precipitation Monitor (LPM)” (Adolf Thies GmbH & Co) is an optical disdrometer. The instrument consists of the transmitter unit which emit the infrared laser, and the receiver unit which detects the intensity of the laser come thru the certain path length in the air. When a precipitating particle fall thru the laser, the received intensity of the laser is reduced. The receiver unit detect the magnitude and the duration of the reduction and then convert them onto particle size and fall speed. The sampling volume, i.e. the size of the laser beam “sheet”, is 20 mm (W) x 228 mm (D) x 0.75 mm (H).

The number of particles are categorized by the detected size and fall speed and counted every minutes. The categories are shown in Table 4.3.2-1.

(4-2) “Parsivel” optical disdrometer

The “Parsivel” (OTT Hydromet GmbH) is another optical disdrometer. The principle is same as the LPM. The sampling volume, i.e. the size of the laser beam “sheet”, is 30 mm (W) x 180 mm (D). The categories are shown in Table 4.3.2-2.

(4-3) Micro rain radar

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 4.3.2-3. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 4.3.2-2), and wired to the junction box and laptop PC inside the vessel.

The data was averaged and stored every one minute. The vertical profile of each parameter was obtained every 200 meters in range distance (i.e. height) up to 6200 meters, i.e. well beyond the melting layer. The drop size distribution is recorded, as well as radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

(3) Results

The data were obtained continuously thru the cruise, except over the EEZs without permissions. The result will be examined after the cruise.

(4) Data Archive

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

(5) Acknowledgment

The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM). The operations are supported by the on-board technical staff of Nippon Marine Enterprise Ltd.

Table 4.3.2-1 Categories of the size and the fall speed for LPM

Particle Size			Fall Speed		
Class	Diameter [mm]	Class width [mm]	Class	Speed [m/s]	Class width [m/s]
1	≥ 0.125	0.125	1	≥ 0.000	0.200
2	≥ 0.250	0.125	2	≥ 0.200	0.200
3	≥ 0.375	0.125	3	≥ 0.400	0.200
4	≥ 0.500	0.250	4	≥ 0.600	0.200
5	≥ 0.750	0.250	5	≥ 0.800	0.200
6	≥ 1.000	0.250	6	≥ 1.000	0.400
7	≥ 1.250	0.250	7	≥ 1.400	0.400
8	≥ 1.500	0.250	8	≥ 1.800	0.400
9	≥ 1.750	0.250	9	≥ 2.200	0.400
10	≥ 2.000	0.500	10	≥ 2.600	0.400
11	≥ 2.500	0.500	11	≥ 3.000	0.800
12	≥ 3.000	0.500	12	≥ 3.400	0.800
13	≥ 3.500	0.500	13	≥ 4.200	0.800
14	≥ 4.000	0.500	14	≥ 5.000	0.800
15	≥ 4.500	0.500	15	≥ 5.800	0.800
16	≥ 5.000	0.500	16	≥ 6.600	0.800
17	≥ 5.500	0.500	17	≥ 7.400	0.800
18	≥ 6.000	0.500	18	≥ 8.200	0.800
19	≥ 6.500	0.500	19	≥ 9.000	1.000
20	≥ 7.000	0.500	20	≥ 10.000	10.000
21	≥ 7.500	0.500			
22	≥ 8.000	unlimited			

Table 4.3.2-2 Categories of the size and the fall speed for Parsivel

Particle Size			Fall Speed		
Class	Average Diameter [mm]	Class spread [mm]	Class	Average Speed [m/s]	Class Spread [m/s]
1	0.062	0.125	1	0.050	0.100
2	0.187	0.125	2	0.150	0.100
3	0.312	0.125	3	0.250	0.100
4	0.437	0.125	4	0.350	0.100
5	0.562	0.125	5	0.450	0.100
6	0.687	0.125	6	0.550	0.100
7	0.812	0.125	7	0.650	0.100
8	0.937	0.125	8	0.750	0.100
9	1.062	0.125	9	0.850	0.100
10	1.187	0.125	10	0.950	0.100
11	1.375	0.250	11	1.100	0.200
12	1.625	0.250	12	1.300	0.200
13	1.875	0.250	13	1.500	0.200
14	2.125	0.250	14	1.700	0.200
15	2.375	0.250	15	1.900	0.200
16	2.750	0.500	16	2.200	0.400
17	3.250	0.500	17	2.600	0.400
18	3.750	0.500	18	3.000	0.400
19	4.250	0.500	19	3.400	0.400
20	4.750	0.500	20	3.800	0.400
21	5.500	1.000	21	4.400	0.800
22	6.500	1.000	22	5.200	0.800
23	7.500	1.000	23	6.000	0.800
24	8.500	1.000	24	6.800	0.800
25	9.500	1.000	25	7.600	0.800
26	11.000	2.000	26	8.800	1.600
27	13.000	2.000	27	10.400	1.600
28	15.000	2.000	28	12.000	1.600
29	17.000	2.000	29	13.600	1.600
30	19.000	2.000	30	15.200	1.600
31	21.500	3.000	31	17.600	3.200
32	24.500	3.000	32	20.800	3.200

Table 4.3.2-3 Specifications of the MRR-2

Transmitter power	50 mW
Operating mode	FM-CW
Frequency	24.230 GHz (modulation 1.5 to 15 MHz)
3dB beam width	1.5 degrees
Spurious emission	< -80 dBm / MHz
Antenna Diameter	600 mm
Gain	40.1 dBi

4.3.3 GNSS precipitable water

Masaki KATSUMATA	**JAMSTEC RCGC: Principal Investigator (not on board)**
Mikiko FUJITA	**JAMSTEC RCGC (not on board)**
Kyoko TANIGUCHI	**JAMSTEC RCGC (not on board)**

(1) Objective

Recording the GNSS satellite data to estimate the total column integrated water vapor content of the atmosphere.

(2) Method

The GNSS satellite data was archived to the receiver (Trimble NetR9) with 5 sec interval. The GNSS antenna (Margrin) was set on the roof of radar operation room. The observations were carried out all thru the cruise.

(3) Results

We will calculate the total column integrated water from observed GNSS satellite data after the cruise.

(4) Data archive

Raw data is recorded as T02 format and stream data every 5 seconds. These raw datasets are available from Mikiko Fujita of JAMSTEC. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department and will be archived there.

4.4 Aerosol optical characteristics measured by ship-borne sky radiometer

Kazuma AOKI	**University of Toyama: Principal Investigator (not onboard)**
Tadahiro HAYASAKA	**Tohoku University (not onboard)**
Masahiro HORI	**JAXA (not onboard)**

Sky radiometer operation was supported by NME

(1) Objective

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

(2) Parameters

- Aerosol optical thickness at five wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at five wavelengths
- Size distribution of volume (0.01 µm – 20 µm)
- # GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of the sun. Horizon sensor provides rolling and pitching angles.

(3) Instruments and Methods

The sky radiometer measures the direct solar irradiance and the solar aureole radiance distribution with seven interference filters (0.315, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 µm). Analysis of these data was performed by SKYRAD.pack version 4.2 developed by Nakajima *et al.* 1996.

(4) Data archives

Aerosol optical data are to be archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) after the quality check and will be submitted to JAMSTEC. However, we had no data due to some instruments trouble at MR17-04.