

*MR25-04
Preliminary
Cruise report
2025.7.25 - 8.28*

2025 JAMSTEC

Note

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Acknowledgments

We would like to express our gratitude to the captain and crew of the R/V MIRAI for their support during the cruise.

Chief Scientist of MR25-04

Tetsuichi Fujiki
JAMSTEC

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The cover, created by Dr. Kimoto (JAMSTEC), was the winning entry in the MR25-04 cruise report cover design contest. The theme is “space”: the illuminated ocean surface represents Earth, the A-frame resembles a space station, the plankton net looks like a spaceship, and the fishing boat with a red light on the horizon appears as a UFO.

1. Outline of MR25-04

1.1 Cruise information

Cruise ID: MR25-04

Research vessel: MIRAI

Cruise title: Integrated Biogeochemical Study in the Subarctic North Pacific

Cruise period (port call):

24 July (Sekinehama, Aomori, Japan) – 28 August 2025 (Dutch Harbor, Alaska, USA)

Research area: Subarctic North Pacific and Western Subtropical North Pacific

Ship Captain: Akihisa Tsuji (Nippon Marine Enterprises, Ltd.)

Chief Scientist:

Tetsuichi Fujiki (Research Institute for Global Change, JAMSTEC)

Deputy Chief Scientist:

Keisuke Shimizu (Research Institute for Global Change, JAMSTEC)

Representative of the Science Party:

Tetsuichi Fujiki (Research Institute for Global Change, JAMSTEC)

1.2 Cruise participants

Scientists

Tetsuichi Fujiki	JAMSTEC
Keisuke Shimizu	JAMSTEC
Maki Noguchi	JAMSTEC
Katsunori Kimoto	JAMSTEC
Kana Nagashima	JAMSTEC
Minoru Kitamura	JAMSTEC
Koji Sugie	JAMSTEC
Makio Honda	JAMSTEC
Kazuhiko Matsumoto	JAMSTEC
Chiho Sukigara	JAMSTEC
Takuma Miyakawa	JAMSTEC
Yuya Kobayashi	JAMSTEC
Hiroshi Uchida	JAMSTEC
Masahide Wakita	JAMSTEC
Yoshiyuki Nakano	JAMSTEC
Nozomi Mori	JAMSTEC
Kyohei Asano	Hokkaido University

Takuya Ohnishi	Fisheries Resources Institute, FRA
<u>Research Engineers</u>	
Nagisa Fujiki	Marine Works Japan, Ltd.
Kango Fukuyama	Marine Works Japan, Ltd.
Nobuhiro Fujii	Marine Works Japan, Ltd.
Yuki Miyajima	Marine Works Japan, Ltd.
Aine Yoda	Marine Works Japan, Ltd.
Yasuhiro Arie	Marine Works Japan, Ltd.
Masahiro Orui	Marine Works Japan, Ltd.
Misato Kuwabara	Marine Works Japan, Ltd.
Yuko Miyoshi	Marine Works Japan, Ltd.
Shiori Ariga	Marine Works Japan, Ltd.
Takuya Izutsu	Marine Works Japan, Ltd.
Tomoki Nakamura	Marine Works Japan, Ltd.
Kengo Fujita	Marine Works Japan, Ltd.
Masaki Taguchi	Marine Works Japan, Ltd.
Shintaro Amikura	Marine Works Japan, Ltd.
Haruna Yamanaka	Nippon Marine Enterprises, Ltd.
Yutaro Murakami	Nippon Marine Enterprises, Ltd.

1.3 Research brief

The subarctic region is classified as a High-Nutrient, Low-Chlorophyll (HNLC) area, where the supply of micronutrients such as iron limits biological productivity. The sources of iron are broadly categorized into aerosols of both anthropogenic and natural origin transported through the atmosphere, and vertical inputs from intermediate waters. However, studies that quantify the relative contributions of these sources remain limited. This region is also characterized by some of the highest amounts of low-level cloud cover in the world during summer. Both ocean-derived and anthropogenic aerosols play important roles as cloud condensation nuclei. In particular, marine aerosols containing organic matter complicate the cloud formation process, making it more difficult to understand. To accurately distinguish between anthropogenic and natural influences on climate change, it is essential to clarify the properties and contributions of these aerosols. JAMSTEC has conducted a series of research cruises to investigate the impact of Asian anthropogenic activities on the North Pacific ecosystem, including observations of the atmosphere, ocean, and clouds. These efforts have begun to reveal variability in nutrient supply from both the atmosphere and intermediate waters, as well as the responses of lower-trophic-level organisms. Quantitative evaluations of the contributions of ocean-

derived aerosols as cloud condensation nuclei have also progressed. The objective of this cruise is to elucidate the characteristics of nutrient supply processes, the responses of lower-trophic-level organisms, and the impacts on cloud formation in both the western and eastern subarctic North Pacific through comparative observations.

1.4 Cruise track and log

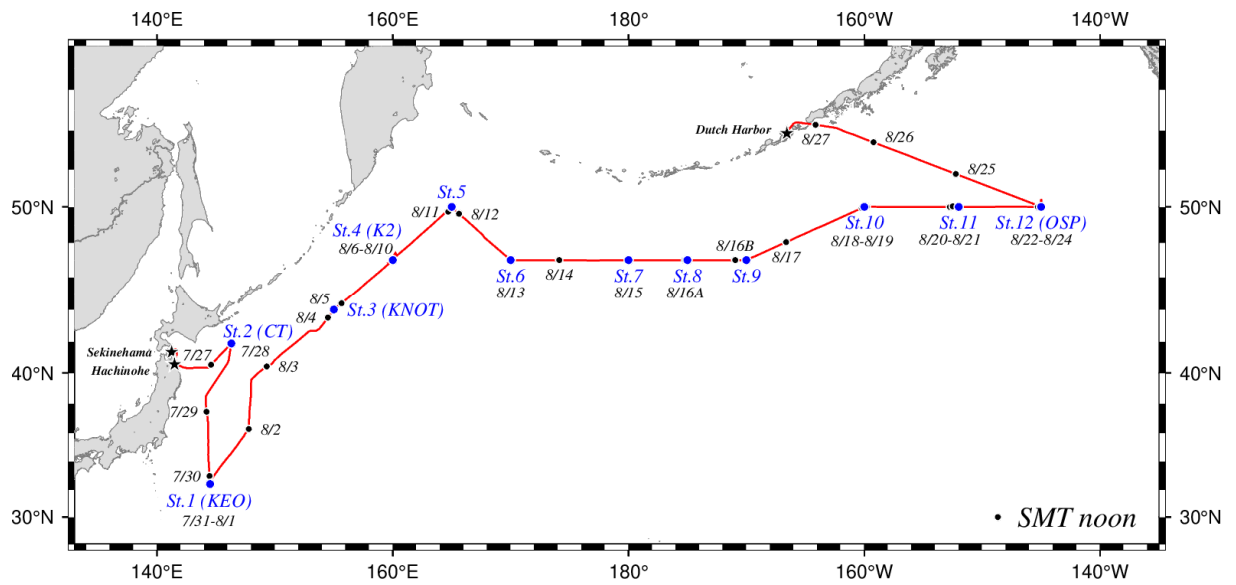


Figure 1.4-1 Cruise track of MR25-04

Table 1.4-1 Cruise Log of MR25-04

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
7/24	7:00	7/24	16:00	41-21.96846N	141-14.37427E	Departure from Sekinehama
	23:50	7/25	8:50	40-33.28678N	141-30.03526E	Arrival at Hachinohe
7/26	8:00	7/26	17:00	40-33.28678N	141-30.03526E	Departure from Hachinohe
	9:30		18:30	40-29.72972N	141-49.31330E	Start sea water pump and SSV pump
	18:00	7/27	3:00	40-19.88087N	144-19.91061E	Arrival at CTD winch cable free fall point
	22:00		7:00	40-20.06615N	144-19.86433E	CTD winch cable free fall (6500 m)
7/27	1:42		10:42	40-19.73749N	144-21.55820E	Departure from CTD winch cable free fall point
	11:42		20:42	41-53.81274N	146-17.96650E	Arrival at St.2 (CT)
	15:03	7/28	0:03	41-54.10322N	146-18.08667E	CTD cast #1 (4000 m) with water sampling
	17:46		2:46	41-54.66692N	146-18.43576E	VMPS #1 (1500 m)
	20:56		5:56	41-54.45727N	146-18.57552E	NORPAC net #1 (50 m)
	23:10		8:10	41-54.05946N	146-18.26791E	CTD cast #2 (6135 m) with water sampling
	23:17		8:17	41-54.06259N	146-18.19686E	XCTD #1
	2:00		11:00	40-21.75752N	144-23.99038E	Bucket surface water sampling
7/28	3:30		12:30	41-54.81662N	146-18.21284E	Departure from St.2 (CT)
7/29	13:00	7/29	22:00	35-26.27478N	144-21.11543E	Time adjustment +1 hour (SMT=UTC+10 h)
7/30	5:18	7/30	15:18	32-21.30913N	144-29.97508E	Arrival at St.1 (KEO)
	5:24		15:24	32-20.97813N	144-30.07370E	CTD cast #3 (5594 m) with water sampling
	5:30		15:30	32-20.98068N	144-30.06659E	XCTD #2
	8:00		18:00	32-21.00120N	144-30.22948E	Bucket surface water sampling
	9:50		19:50	32-20.86850N	144-30.73429E	NORPAC net #2 (150 m)
	11:00		21:00	32-20.43991N	144-31.15305E	FFRF #1 (150 m)
	11:50		21:50	32-19.60685N	144-31.46193E	Calibration for magnetometer #1
	22:51	7/31	8:51	32-21.74439N	144-24.76635E	Recovery KEO Sediment Trap Mooring
7/31	3:48		13:48	32-21.22680N	144-24.79899E	FRRF #2 (150 m)
	4:33		14:33	32-21.16424N	144-24.78254E	Test cast of Water sampling for trace metal (500 m)
	5:08		15:08	32-21.16160N	144-24.83988E	CTD cast #4 (2000 m) with water sampling
	5:14		15:14	32-21.18622N	144-24.82340E	XCTD #3
	6:00		16:00	32-21.19592N	144-24.86233E	Bucket surface water sampling

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/1	3:18	8/1	13:18	32-27.98719N	144-22.69884E	Departure from St.1 (KEO)
	12:00		22:00	33-58.41808N	145-41.84704E	Time adjustment +1 hour (SMT=UTC+11 h)
8/3	1:57	8/3	12:57	40-30.24421N	149-34.01449E	Radiosonde #1
8/4	3:48	8/4	14:48	43-59.62171N	154-59.63171E	Arrival at St.3 (KNOT)
	3:53		14:53	43-59.94963N	154-59.93054E	CTD cast #5 (5300 m) with water sampling
	3:59		14:59	44-00.04022N	155-00.01470E	XCTD #4
	6:59		17:59	44-00.01530N	154-59.90995E	Bucket surface water sampling
	8:13		19:13	44-00.04875N	154-59.89608E	VMPS #2 (1000 m)
	10:12		21:12	44-00.08685N	154-59.84416E	CTD cast #6 (300 m) with water sampling
	10:14		21:14	44-00.09466N	154-59.84767E	Bucket surface water sampling
	11:02		22:02	44-00.20100N	154-59.84977E	FRRF #3 (100 m)
	11:36		22:36	44-00.24782N	155-00.11008E	ORI net #1 (1000 m)
	12:46		23:46	43-59.77275N	155-02.62324E	NORPAC net #3 (50 m)
	13:36	8/5	0:36	44-00.04234N	155-02.66378E	CTD cast #7 (4000 m) without water sampling
	13:43		0:43	44-00.08144N	155-02.68941E	XCTD #5
	16:41		3:41	44-00.92108N	155-03.63211E	Water sampling for trace metal (500 m)
	20:30		7:30	43-59.98819N	155-00.02888E	FRRF #4 (100 m)
	21:00		8:00	44-00.00280N	155-00.31002E	ORI net #2 (1000 m)
	22:00		9:00	44-00.47754N	154-58.25781E	Departure from St.3 (KNOT)
8/5	9:24		20:24	45-29.74620N	157-30.27733E	XCTD #6
	20:12	8/6	7:12	47-00.03469N	159-58.94859E	Arrival at St.4 (K2)
	21:57		8:57	47-00.64502N	159-58.67638E	Recovery K2-HB Mooring
8/6	3:00		14:00	47-00.30901N	159-58.43271E	CTD cast #8 (4000 m) with water sampling
	3:06		14:06	47-00.30841N	159-58.42841E	XCTD #7
	5:28		16:28	47-00.29371N	159-58.56302E	VMPS #3 (1000 m)
	8:00		19:00	47-00.30060N	159-58.38979E	CTD cast #9 (300 m) with water sampling
	8:04		19:04	47-00.30058N	159-58.40252E	Bucket surface water sampling
	9:01		20:01	47-00.34898N	159-58.47809E	FRRF #5 (100 m)

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/6	19:08	8/7	6:08	47-00.99446N	159-58.22363E	Calibration for magnetmeter #2
	21:41		8:41	47-00.32032N	159-59.36126E	Deployment drifting RAS #1
	22:00		9:00	47-00.24911N	159-59.50917E	Deployment drifting trap #1
	23:01		10:01	46-59.99399N	159-59.98189E	In-situ filtration pump #1 (607 m)
8/7	1:06		12:06	47-00.12600N	160-00.12167E	FRRF #6 (100 m)
	1:34		12:34	47-00.15245N	160-00.25711E	ORI net #3 (1000 m)
	2:57		13:57	47-00.03108N	159-59.96712E	CTD cast #10 (5167 m) with water sampling
	3:07		14:07	47-00.00968N	160-00.00843E	XCTD #8
	7:04		18:04	47-00.08434N	159-59.76838E	Deployment BGC argo float #1
	7:07		18:07	47-00.09406N	159-59.77585E	Deployment BGC argo float #2
	7:10		18:10	47-00.09248N	159-59.78359E	Deployment BGC argo float #3
	11:01		22:01	47-00.20258N	159-59.06451E	ORI net #4 (1000 m)
	21:03	8/8	8:03	47-00.01621N	160-00.05626E	CTD cast #11 (5177 m) with water sampling
8/8	0:28		11:28	47-00.01379N	159-59.99540E	Water sampling for trace metal #3 (550 m)
	1:26		12:26	47-00.05231N	160-00.09667E	VMPS #4 (1500 m)
	4:14		15:14	47-00.01966N	160-00.04734E	NORPAC net #4 (50 m)
	9:02		20:02	46-59.99829N	159-59.98369E	Water sampling for trace metal #4 (120 m)
	9:30		20:30	47-00.00233N	160-00.06730E	CTD cast #12 (300 m) with water sampling
	9:32		20:32	46-59.99987N	160-00.06109E	Bucket surface water sampling
	10:38		21:38	46-59.97426N	160-00.04272E	FRRF #7 (100 m)
	21:14	8/9	8:14	47-05.67328N	159-58.28725E	Deployment K2-HB Mooring
8/9	1:33		12:33	47-00.24486N	159-58.39533E	Calibration of mooring position
	2:27		13:27	46-59.77542N	159-58.39973E	FRRF #8 (100 m)
	2:49		13:49	46-59.78091N	159-58.39582E	NORPAC net #5 (50 m)
	4:52		15:52	46-59.72975N	159-58.42035E	CTD cast #13 (4000 m) without water sampling
	21:08	8/10	8:08	46-53.66087N	159-40.14098E	Recovery K2-OA Mooring
8/10	3:24		14:24	47-27.94979N	160-15.77761E	Recovery drifting RAS #1
	5:12		16:12	47-12.68752N	160-15.85436E	Recovery drifting trap #1
	5:48		16:48	47-13.43129N	160-15.84181E	Departure from St.4 (K2)

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/10	15:08	8/11	2:08	48-30.00966N	162-27.79814E	XCTD #9
8/11	2:29		13:29	49-59.07831N	164-59.86730E	Radiosonde #2
	2:30		13:30	49-59.15009N	164-59.83555E	Arrival at St.5
	2:43		13:43	50-00.04431N	165-00.18535E	CTD cast #14 (5498 m) with water sampling
	2:49		13:49	50-00.04763N	165-00.19180E	XCTD #10
	5:31		16:31	50-00.00778N	165-00.01713E	Bucket surface water sampling
	6:57		17:57	49-59.97614N	165-00.00677E	VMPS #5 (1000 m)
	8:19		19:19	50-00.00658N	164-59.97973E	NORPAC net #6 (50 m)
	9:05		20:05	50-00.13839N	165-00.03801E	FRRF #9 (100 m)
	9:37		20:37	50-00.04933N	164-59.93594E	CTD cast #15 (200 m) with water sampling
	9:39		20:39	50-00.04304N	164-59.93028E	Bucket surface water sampling
	10:24		21:24	50-00.17270N	165-00.08831E	ORI net #5 (1000 m)
	18:18	8/12	5:18	49-59.99780N	164-59.96582E	CTD cast #16 (4000 m) without water sampling
	18:23		5:23	50-00.00949N	164-59.97515E	XCTD #11
	20:58		7:58	50-00.63291N	165-00.92558E	ORI net #6 (1000 m)
	22:00		9:00	49-59.84933N	164-59.74335E	FRRF #10
	22:24		9:24	49-59.91510N	164-59.92795E	Departure from St.5
8/12	2:00		13:00	49-29.30264N	165-50.86216E	Radiosonde #3
	9:30		20:30	48-30.02324N	167-31.97200E	XCTD #12
	20:30	8/13	7:30	47-00.73879N	169-58.74604E	Arrival at St.6
	21:08		8:08	47-00.47602N	169-59.60017E	Deployment BGC argo float #4
	21:12		8:12	47-00.45713N	169-59.62079E	Deployment BGC argo float #5
	21:15		8:15	47-00.44048N	169-59.64187E	Deployment BGC argo float #6
	21:19		8:19	47-00.42022N	169-59.66754E	FRRF #11 (100 m)
	21:45		8:45	47-00.40381N	169-59.72956E	ORI net #7 (1000 m)
	22:52		9:52	46-59.85433N	170-00.09363E	CTD cast #17 (4958 m) with water sampling
8/13	1:45		12:45	46-59.98821N	170-00.05989E	Bucket surface water sampling
	2:48		13:48	46-59.99602N	170-00.05749E	VMPS #6 (1000 m)
	4:05		15:05	47-00.01989N	169-59.95056E	NORPAC net #7 (100 m)
	5:03		16:03	46-59.85630N	169-59.84646E	Water sampling for trace metal #5 (300 m)
	5:32		16:32	46-59.98347N	169-59.86490E	CTD cast #18 (4000 m) without water sampling
	8:36		19:36	47-00.02814N	170-00.04629E	CTD cast #19 (300 m) with water sampling
	8:38		19:38	47-00.02820N	170-00.03972E	Bucket surface water sampling
	9:23		20:23	47-00.04174N	170-00.00265E	FRRF #12 (100 m)
	10:31		21:31	47-00.06943N	169-59.94509E	ORI net #8 (1000 m)
	11:24		22:24	47-00.10254N	170-02.39329E	Departure from St.6

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/14	1:59	8/14	12:59	47-00.12845N	174-23.93712E	Radiosonde #4
	4:09		15:09	46-59.97922N	174-59.90653E	XCTD #13
	9:30		20:30	46-58.90715N	176-28.49669E	Radiosonde #5
	11:00		22:00	46-58.52899N	176-53.36391E	Time adjustment +1 hour (SMT=UTC+12 h)
	21:12	8/15	9:12	47-00.05680N	179-59.94897E	Arrival at St.7
	21:14		9:14	47-00.04223N	179-59.96078W	CTD cast #20 (5739 m) with water sampling
8/15	0:27		12:27	47-00.02581N	179-59.99031W	Bucket surface water sampling
	1:34		13:34	47-00.19151N	179-59.70787E	Deployment BGC argo float #7
	1:44		13:44	47-00.08502N	179-59.86724E	FRRF #13 (100 m)
	2:13		14:13	47-00.04127N	179-59.97341E	VMPS #7 (1500 m)
	4:58		16:58	47-00.02844N	179-59.96402E	NORPAC net #8 (100 m)
	7:01		19:01	46-59.97665N	179-59.94105E	CTD cast #21 (200 m) with water sampling
	7:02		19:02	46-59.97487N	179-59.93964E	Bucket surface water sampling
	7:40		19:40	46-59.98070N	179-59.92243E	FRRF #14 (100 m)
	8:06		20:06	46-59.99656N	179-59.95182E	Departure from St.7
8/16	0:48	8/16A	12:48	47-00.09603N	174-59.92571W	Arrival at St.8
	0:56		12:56	47-00.02804N	174-59.95112W	Radiosonde #6
	1:03		13:03	47-00.00901N	174-59.97801W	FRRF #15 (100 m)
	1:29		13:29	46-59.99605N	174-59.97409W	CTD cast #22 (200 m) with water sampling
	1:30		13:30	46-59.99640N	174-59.97401W	Bucket surface water sampling
	2:10		14:10	47-00.04243N	175-00.04308W	VMPS #8 (1000 m)
	3:30		15:30	46-59.99635N	175-00.02483W	CTD cast #23 (5760 m) with water sampling
	6:45		18:45	47-00.01468N	175-00.02699W	Bucket surface water sampling
	7:38		19:38	47-00.03581N	175-00.02092W	Deployment BGC argo float #8
	7:44		19:44	47-00.02540N	175-00.02091W	NORPAC net #9
	8:33		20:33	47-00.10972N	174-59.88831W	FRRF #16 (100 m)
	8:57		20:57	47-00.10383N	174-59.78227W	ORI net #9 (1000 m)
	9:54		21:54	46-58.97682N	174-57.45735W	Departure from St.8
	12:00		24:00	46-59.92552N	174-20.41633W	Time adjustment +1 hour and crossing the international date line (SMT=UTC-11 h)

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/16	23:57	8/16B	12:57	46-59.85616N	170-39.65539W	Radiosonde #7
8/17	2:06		15:06	47-00.17917N	170-00.66783W	Arrival at St.9
	2:14		15:14	46-59.99924N	170-00.08638W	FRRF #17 (100 m)
	2:41		15:41	47-00.01716N	170-00.07707W	CTD cast #24 (5491 m) with water sampling
	5:57		18:57	47-00.00819N	170-00.08495W	Bucket surface water sampling
	6:43		19:43	47-00.10636N	169-59.90407W	Deployment BGC argo float #9
	7:51		20:51	47-00.01249N	170-00.01057W	NORPAC net #10 (50 m)
	8:30		21:30	46-59.98698N	169-59.94758W	FRRF #18 (100 m)
	8:58		21:58	46-59.99429N	169-59.98184W	CTD cast #25 (200 m) with water sampling
	9:00		22:00	46-59.99306N	169-59.98803W	Bucket surface water sampling
	9:45		22:45	46-59.99678N	169-59.99280W	Water sampling for trace metal #6 (300 m)
	10:16		23:16	47-00.11177N	169-59.99268W	ORI net #10 (1000 m)
	11:18	8/17	0:18	47-01.33758N	170-02.35382W	Departure from St.9
8/18	4:43		17:43	48-31.33059N	165-00.04833W	XCTD #14
	7:29		20:29	48-44.82429N	164-16.27480W	Radiosonde #8
	9:00		22:00	48-51.96338N	163-50.88092W	Time adjustment +1 hour (SMT=UTC-10 h)
	22:48	8/18	12:48	49-59.93837N	160-00.03881W	Arrival at St.10
	22:58		12:58	49-59.99103N	160-00.23340W	Radiosonde #9
	23:04		13:04	50-00.05633N	160-00.10629W	CTD cast #26 (4984 m) with water sampling
8/19	1:44		15:44	49-59.99683N	159-59.99673W	Bucket surface water sampling
	2:47		16:47	50-00.01863N	159-59.93604W	Deployment BGC argo float #10
	2:55		16:55	50-00.01418N	159-59.94979W	VMPS #9 (1500 m)
	6:02		20:02	49-59.98303N	159-59.97505W	CTD cast #27 (300 m) with water sampling
	6:04		20:04	49-59.98225N	159-59.97399W	Bucket surface water sampling
	7:13		21:13	49-59.96508N	160-00.00486W	NORPAC net #11 (50 m)
	8:12		22:12	49-59.54101N	159-59.76844W	ORI net #11 (1000 m)
	18:00	8/19	8:00	49-59.99927N	160-00.00630W	CTD cast #28 (4000 m) without water sampling
	20:16		10:16	50-00.02388N	160-00.01359W	ORI net #12 (1000 m)
	21:12		11:12	50-00.97908N	160-00.75276W	Departure from St.10
8/20	6:29		20:29	49-59.51743N	157-18.60321W	Radiosonde #10

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/20	10:12	8/20	0:12	50-00.00726N	156-15.01737W	XCTD #15
	22:54		12:54	50-00.07349N	152-29.95012W	Arrival at St.11
	22:56		12:56	50-00.03827N	152-29.93323W	Radiosonde #11
	23:02		13:02	49-59.99178N	152-29.96058W	CTD cast #29 (4983 m) with water sampling
8/21	1:58	8/21	15:58	50-00.02161N	152-29.99725W	Bucket surface water sampling
	2:55		16:55	49-59.89326N	152-29.99397W	Deployment BGC argo float #11
	3:02		17:02	50-00.02088N	152-30.00050W	VMPS #10 (1000 m)
	4:28		18:28	50-00.03225N	152-29.99578W	NORPAC net #12 (100 m)
	5:31		19:31	50-00.10197N	152-29.82272W	CTD cast #30 (300 m) with water sampling
	5:32		19:32	50-00.10027N	152-29.82961W	Bucket surface water sampling
	6:19		20:19	50-00.07787N	152-29.91371W	FRRF #19 (100 m)
	7:30		21:30	49-59.44849N	152-29.76884W	ORI net #13 (1000 m)
	16:13		6:13	50-05.68403N	152-39.40015W	Calibration for magnetometer #3
	18:33		8:33	50-00.03677N	152-30.02540W	CTD cast #31 (4000 m) with water sampling
8/22	20:57	8/22	10:57	50-00.08329N	152-30.05953W	ORI net #14 (950 m)
	21:54		11:54	50-01.69256N	152-30.57298W	Departure from St.11
	8:00		22:00	49-59.92307N	149-24.77148W	Time adjustment +1 hour (SMT=UTC-9 h)
	10:06		1:06	49-59.92307N	149-24.77148W	XCTD #16
	21:54		12:54	50-00.06173N	144-59.95586W	Arrival at St.12 (OSP)
	21:56		12:56	50-00.15192N	144-59.91243W	Radiosonde #12
	22:12		13:12	50-00.01124N	144-59.97947W	Water sampling for trace metal #7 (300 m)
	22:41		13:41	50-00.24621N	144-59.62951W	Deployment drifting trap
	23:15		14:15	49-59.99395N	145-00.01355W	CTD cast #32 (4238 m) with water sampling
	2:40		17:40	50-00.02897N	144-59.80638W	Deployment BGC argo float #12
8/23	2:49	8/23	17:49	49-59.99431N	144-59.99855W	In-situ filtration pump #2 (600 m)
	5:17		20:17	49-59.99282N	145-00.08605W	Water sampling for trace metal #8 (300 m)
	5:39		20:39	49-59.99715N	145-00.09413W	FRRF #20 (100 m)
	6:10		21:10	50-00.00778N	145-00.05335W	CTD cast #33 (200 m) with water sampling
	6:12		21:12	50-00.00540N	145-00.06940W	Bucket surface water sampling
	7:00		22:00	50-00.10864N	144-59.94160W	ORI net #15 (950 m)
	17:04		8:04	50-00.00856N	144-59.99545W	VMPS #11 (1500 m)
	20:05		11:05	49-59.97876N	145-00.09708W	In-situ filtration pump #3 (20 m)
	20:52		11:52	49-59.97282N	145-00.04828W	FRRF #21 (100 m)
	21:17		12:17	49-59.95672N	145-00.15346W	ORI net #16 (970 m)
8/24	22:28	8/24	13:28	49-59.98391N	145-00.03632W	NORPAC net #13 (100 m)
	23:19		14:19	49-59.99840N	145-00.06885W	Water sampling for trace metal #9 (200 m)
	0:10		15:10	50-00.02318N	144-59.97082W	CTD cast #34 (4000 m) without water sampling

Table 1.4-1 (Continued)

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
8/24	17:52	8/24	8:52	50-01.09301N	144-57.76028W	Recovery drifting trap #2
	18:29		9:29	50-01.04539N	144-57.39147W	In-situ filtration pump #4 (610 m)
	20:36		11:36	50-01.05730N	144-57.23815W	Departure from St.12 (OSP)
8/26	0:30	8/25	15:30	52-01.23788N	153-19.03158W	Stop sea water pump and SSV pump
	5:30		20:30	52-22.13961N	154-47.26924W	Entry into the exclusive economic zone of United States of America
	7:00		22:00	52-28.42620N	155-13.96375W	Time adjustment +1 hour (SMT=UTC-8 h)
8/28	19:40	8/28	11:40	53-54.17868N	166-31.63209W	Arrival at Dutch Harbor

2. Observations

2.1 Meteorology

2.1.1 General weather observations

2.1.1.1 Meteorological observations

Tetsuichi FUJIKI (JAMSTEC) - PI

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (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) Instruments and Methods

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

i) MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table 2.1.1.1-1 and measured parameters are listed in Table 2.1.1.1-2. 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) Analog meteorological data sampling with CR1000 logger manufactured by Campbell Scientific Inc., USA - wind, pressure, and rainfall (by a capacitive rain gauge (CRG)) measurement.
- b) Digital meteorological data sampling from individual sensors - air temperature, relative humidity and rainfall (by optical rain gauge (ORG)) measurement.
- c) Radiation data sampling with CR1000X logger manufactured by Campbell Inc. and radiometers designed by Hukseflux Thermal Sensors B.V. Netherlands. – short and long wave downward radiation measurement.
- d) Photosynthetically Available Radiation (PAR) and Ultraviolet Irradiance (UV) sensor manufactured by Biospherical Instruments Inc., USA. – PAR and UV 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 radiation, air temperature, relative humidity, CR1000, ORG and PAR data. SCS composed Event data (JamMet) from these data and ship's navigation data every 6 seconds. Instruments

and their locations are listed in Table 2.1.1.1-3 and measured parameters are listed in Table 2.1.1.1-4.

iii) Quality control

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

a) 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.

b) Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB330, VAISALA

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

Comparison with the portable thermometer value, HMP75, VAISALA

(3) Preliminary results

Fig.2.1.1.1-1 show the time series of the following parameters;

Wind (SOAR)

Air temperature (SMet)

Relative humidity (SMet)

Precipitation (SOAR, CRG)

Short/long wave radiation (SOAR)

Barometric Pressure (SMet)

Sea surface temperature (SMet)

Significant wave height (SMet)

(4) Data archives

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

< <https://www.godac.jamstec.go.jp/darwin/en> >

(5) Remarks (Times in UTC)

i) The following period, sea surface temperature of SMet data were available.

09:35UTC 26 Jul. 2025 - 00:30UTC 26 Aug. 2025

ii) The following period, increasing of SMet capacitive rain gauge data were invalid due to transmitting for MF/HF or VHF radio.

03:07UTC 06 Aug. 2025

17:52UTC 16 Aug. 2025

- iii) The following period, SOAR rain gauge data, barometer data, wind data and radiation data were invalid due to system trouble.

17:30:13UTC 02 Aug. 2025 - 17:30:43UTC 02 Aug. 2025

- iv) The following period, PAR and UV data were invalid due to system trouble.

00:23:54UTC 06 Aug. 2025 - 05:24:13UTC 06 Aug. 2025

- v) The following period, SOAR temperature/relative humidity data were invalid due to sensor failure.

about 16:00UTC 08 Aug.2025 - the end of this cruise

Table 2.1.1.1-1. Instruments and installation locations of SMet system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KS-5900	Koshin Denki, Japan	Foremast (25 m)
Tair/RH	HMP155	Vaisala, Finland	Compass deck (21 m)
with aspirated radiation shield	43408 Gill	R.M. Young, USA	starboard side and port side
Thermometer: SST	RFN2-0	Koshin Denki, Japan	4th deck (-1 m, inlet -5 m)
Barometer	Model-370	Setra System, USA	Captain deck (13 m)
Capacitive rain gauge	50202	R. M. Young, USA	weather observation room
Optical rain gauge	ORG-815DS	Optical Scientific Inc., USA	Compass deck (19 m)
Radiometer (short wave)	MS-802	Eko Seiki, Japan	Compass deck (19 m)
Radiometer (long wave)	MS-202	Eko Seiki, Japan	Radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	Radar mast (28 m)
			Bow (10 m)
			Stern (8 m)

Table 2.1.1.1-2. Parameters of SMet system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's speed	knot	MIRAI log
4 Ship's heading	degree	MIRAI gyro
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)	degC	6sec. averaged
12 Dewpoint temperature (starboard)	degC	6sec. averaged
13 Dewpoint temperature (port)	degC	6sec. averaged
14 Relative humidity (starboard)	%	6sec. averaged
15 Relative humidity (port)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Precipitation intensity (optical rain gauge)	mm/hr	hourly accumulation
18 Precipitation (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 (stern)	m	hourly
23 Significant wave period (bow)	second	hourly
24 Significant wave period (stern)	second	hourly

Table 2.1.1.1-3. Instruments and installation locations of SOAR system

Sensors (Meteorological)	Type	Manufacturer	Location
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Barometer	PTB210	Vaisala, Finland	foremast (23 m)
with pressure port	61002 Gill	R.M. Young, USA	
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	foremast (23 m)
with aspirated radiation shield	43408 Gill	R.M. Young, USA	
Optical rain gauge	ORG-815DR	Optical Scientific Inc., USA	foremast (24 m)
Sensors (Radiation)	Type	Manufacturer	Location *
Radiometer (short wave)	SR20	Hukseflux Thermal Sensors B.V., Netherlands	foremast (25 m)
Radiometer (long wave)	IR20	Hukseflux Thermal Sensors B.V., Netherlands	foremast (25 m)
Sensor (PAR&UV)	Type	Manufacturer	Location *
PAR&UV sensor	PUV-510	Biospherical Instruments Inc., USA	Navigation deck (18m)

*Location : Altitude from surface

Table 2.1.1.1-4. 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 Precipitation intensity (optical rain gauge)	mm/hr	
11 Precipitation (capacitive rain gauge)	mm/hr	reset at 50 mm
12 Down welling shortwave radiation	W/m ²	
13 Down welling infrared radiation	W/m ²	
14 PAR	microE/cm ² /sec	
15 UV 305 nm	microW/cm ² /nm	
16 UV 320 nm	microW/cm ² /nm	
17 UV 340 nm	microW/cm ² /nm	
18 UV 389 nm	microW/cm ² /nm	

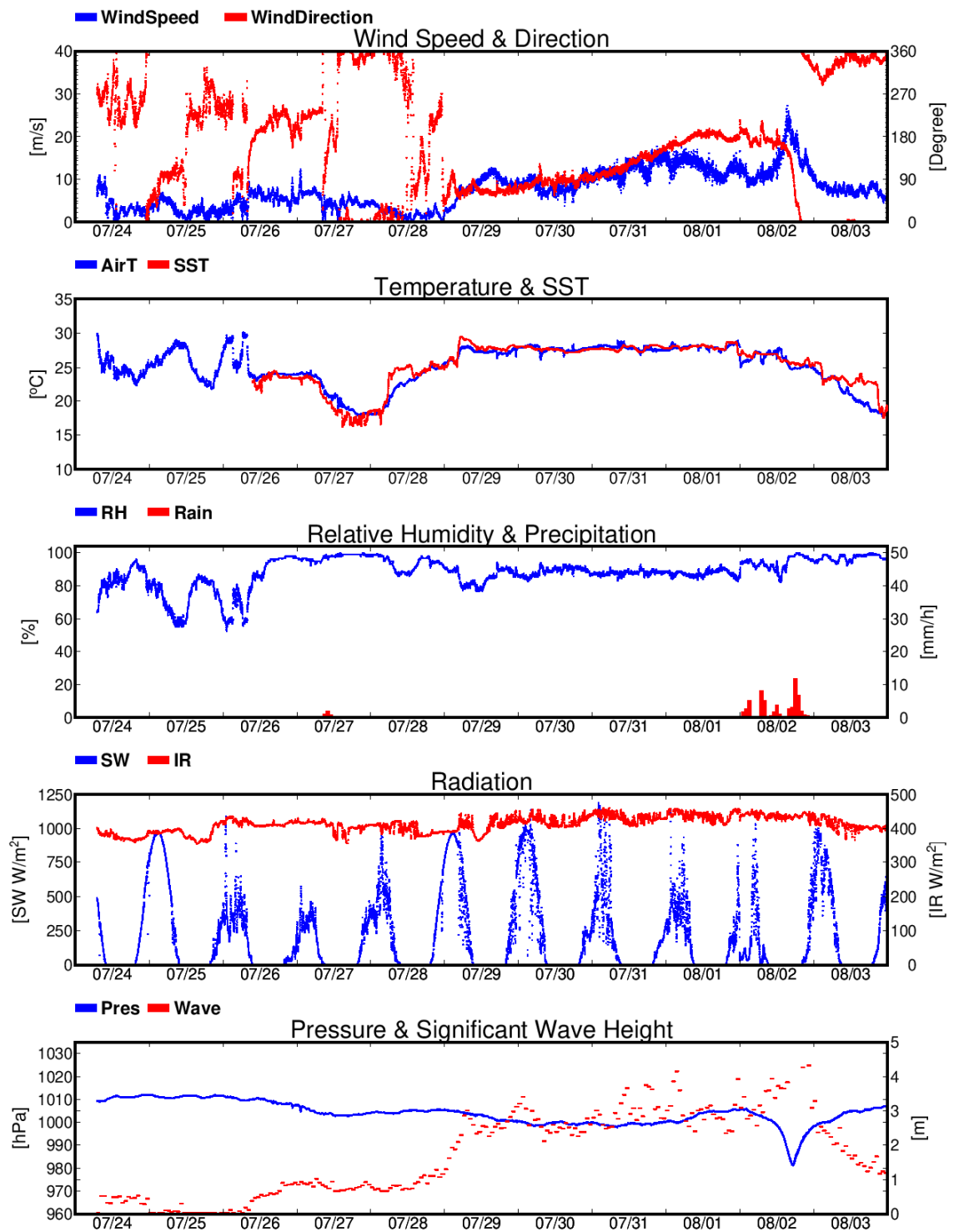


Fig. 2.1.1.1-1 Time series of surface meteorological parameters during MR25-04

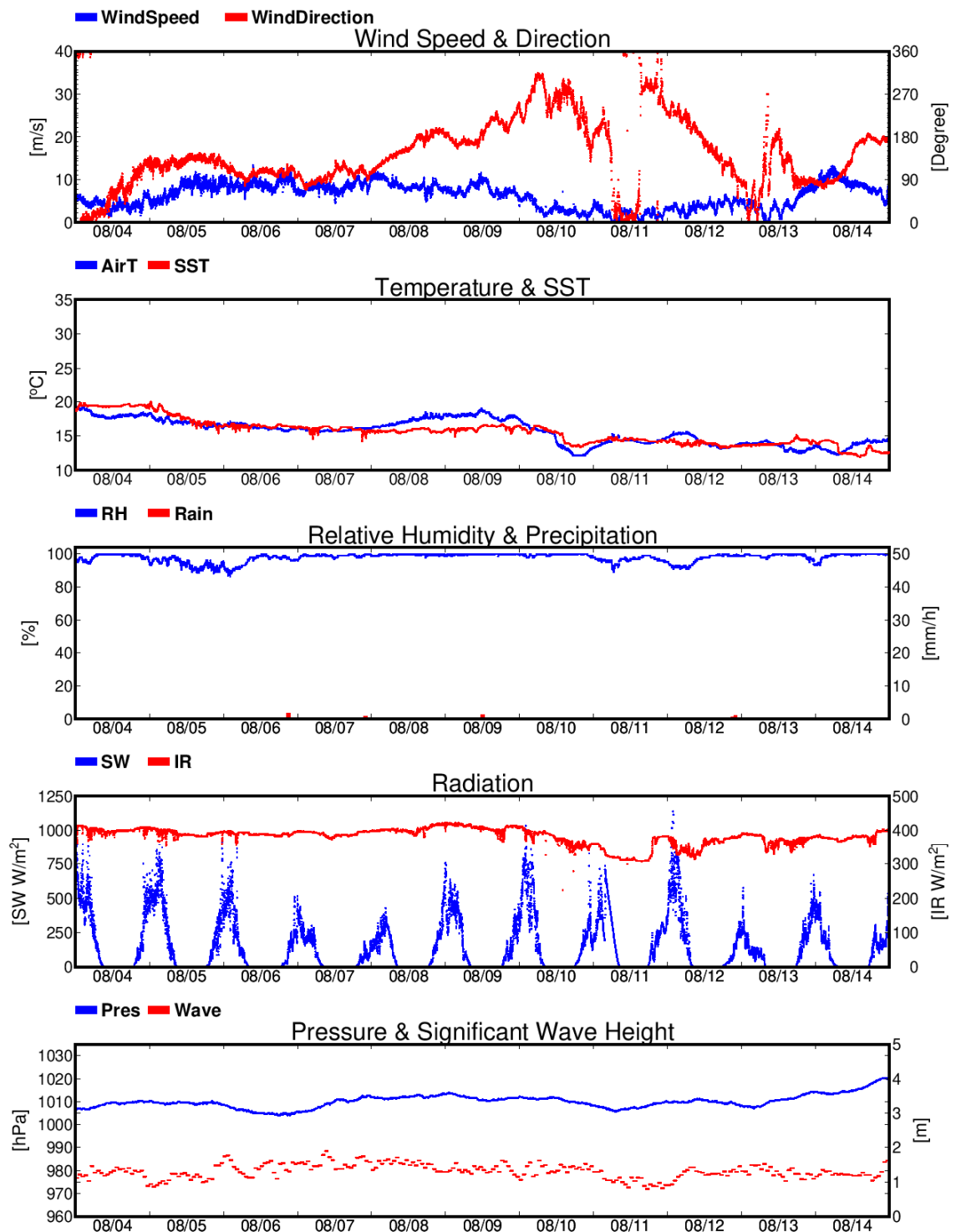


Fig. 2.1.1.1-1 (Continued)

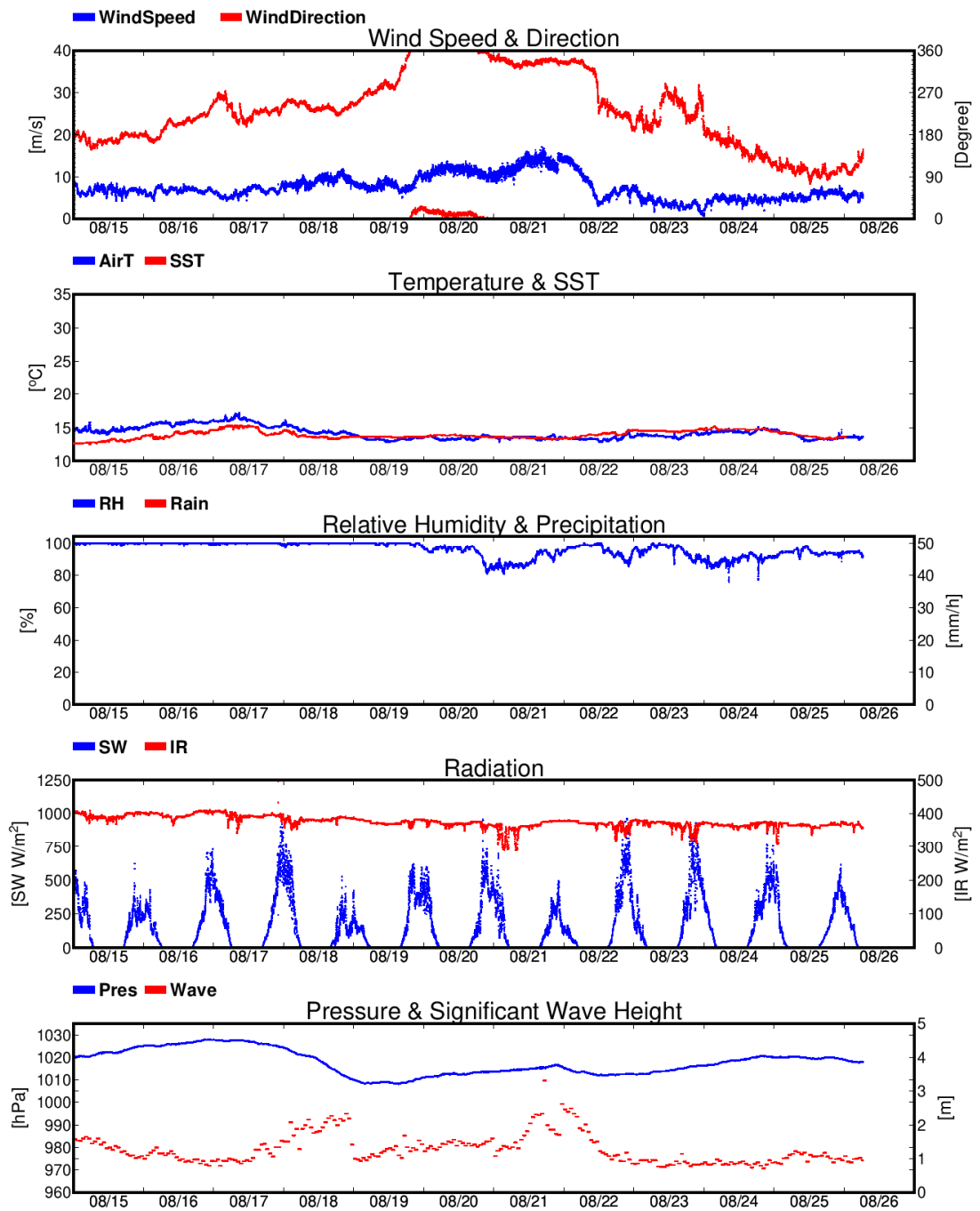


Fig. 2.1.1.1-1 (Continued)

2.1.1.2 Ceilometer

Tetsuichi FUJIKI (JAMSTEC) - PI

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (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) Instruments and methods

Cloud base height and backscatter profile were observed by ceilometer (CL51, VAISALA, Finland). On the archive dataset, the profile was recorded with the resolution of 10 m.

i). Parameters

- a). Cloud base height [m].
- b). Backscatter profile, sensitivity and range normalized at 10 m resolution.
- c). Estimated cloud amount [octas] and height [m]; Sky Condition Algorithm.

ii). The measurement configurations are shown in Table 2.1.1.2-1.

Table 2.1.1.2-1 The measurement configurations

Property	Description
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 m in full range
Sampling rate	36 sec.
Sky Condition	Cloudiness in octas (0 ~ 9) 0 Sky Clear 1-2 Few 3-4 Scattered

5-7 Broken
8 Overcast
9 Vertical Visibility

(3) Preliminary results

Figure 2.1.1.2-1 show the time-series of the lowest, second and third cloud base height during the cruise.

(4) Data archives

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

< <https://www.godac.jamstec.go.jp/darwin/en> >

(5) Remarks

i) Window cleaning

06:26UTC 30 Jul. 2025

05:28UTC 06 Aug. 2025

02:31UTC 13 Aug. 2025

02:44UTC 21 Aug. 2025

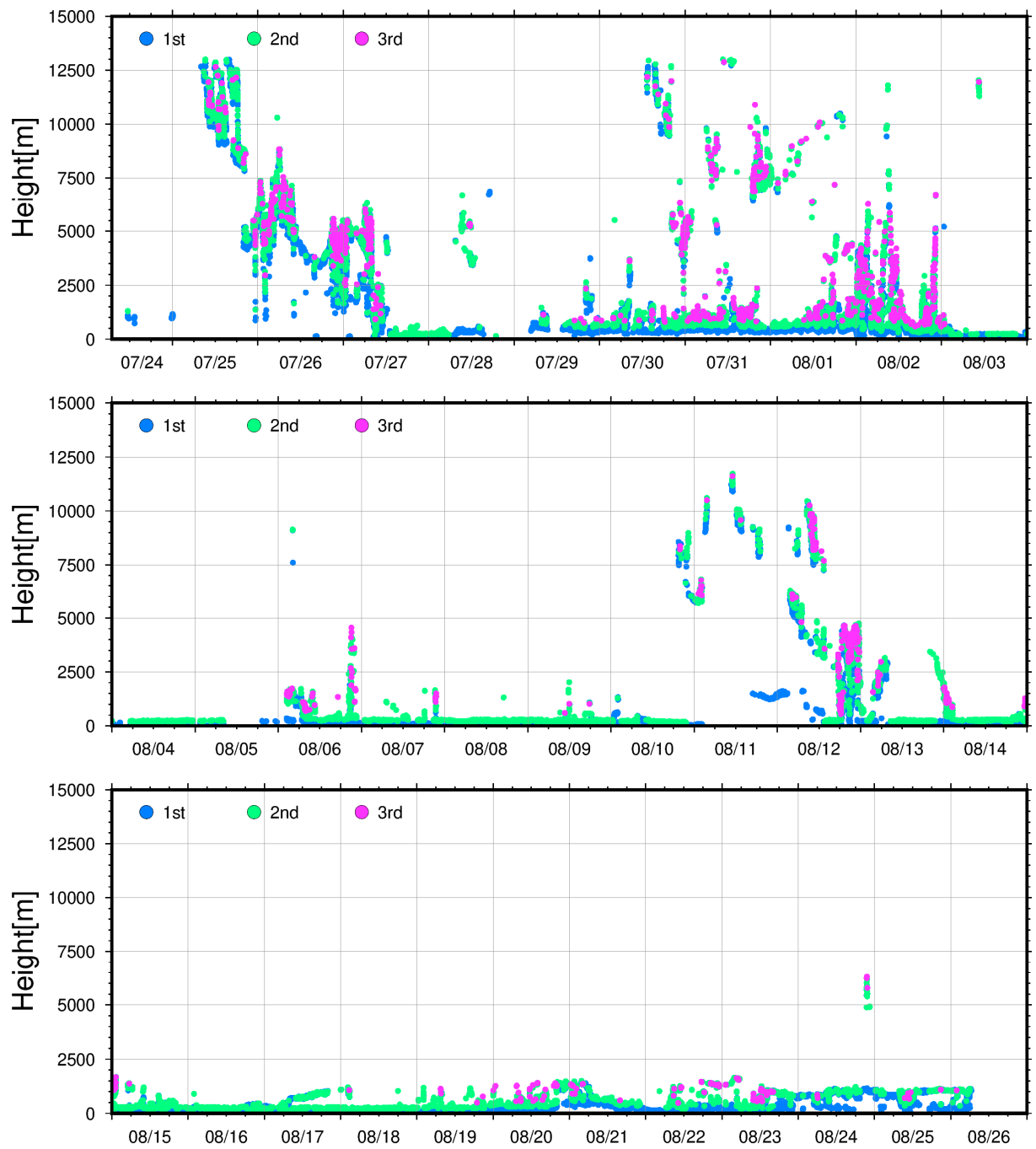


Figure 2.1.1.2-1 Time series of cloud base height during MR25-04

2.1.2 Atmospheric composition observations

Takuma MIYAKAWA (JAMSTEC RIGC)

Yuya KOBAYASHI (JAMSTEC RIGC)

Kyohei ASANO (Hokkaido Univ.)

Fumikazu TAKETANI (JAMSTEC RIGC)

Takeshi KINASE (JAMSTEC RIGC)

Hisahiro TAKASHIMA (JAMSTEC RIGC/Fukuoka Univ.)

Yugo KANAYA (JAMSTEC RIGC)

Yuzo MIYAZAKI (Hokkaido Univ.)

(1) Objectives

We conducted shipborne observations of atmospheric compositions in the marine boundary layer to investigate variabilities of maritime aerosol physicochemical properties over the North Pacific Ocean where the low cloud and sea fog prevail in summer season, and to investigate the role of processes (e.g., sea spraying and atmospheric secondary formation) affecting the variabilities of aerosol particles. Another objective is to investigate the transport process of short-lived climate forcers from the Asian continent to the Northwestern Pacific Ocean in a summer season. To achieve these objectives, we targeted the following parameters in this cruise.

- Particle number size distributions
- Fluorescent aerosol particle number concentrations
- Submicron inorganic aerosol concentrations
- Size-resolved chemical composition and particle mixing state
- Vertical distributions of nitrogen dioxide (NO₂) and iodine monoxide (IO) in the troposphere
- Aerosol Optical depth (AOD) and Aerosol extinction coefficient (AEC) vertical distribution in the troposphere
- Surface carbon monoxide (CO) and ozone(O₃) mixing ratios

(2) Instruments and methods

(2-1) Continuous surface aerosol observations during the cruise:

(2-1-1) Particle number size distributions (PSDs)

The size-resolved number concentration of particles was measured by a scanning mobility particle sizer (SMPS, model 3938, TSI) for the size range between 14 and 724 nm in diameter, and an optical particle counter (OPC) (9300P, ParticlePlus) for the size range between 0.3 and 5 µm in diameter. A custom-made heated inlet system was installed in front of the SMPS to measure the PSDs of total and non-volatile (at 300°C) aerosols (Miyakawa et al., 2023). The particle sizing accuracy was validated before and after the cruise using standard particles (spherical polystyrene latex particles with known diameter).

(2-1-2) Fluorescence measurements of airborne particles

Fluorescent properties of aerosol particles (0.5–5 µm) were measured by a single particle fluorescence sensor, Waveband Integrated bioaerosol sensor (WIBS4) (WIBS-4A, Droplet Measurement Technologies) (Taketani et al., 2025). Two pulsed xenon lamps emitting UV light (280 nm and 370 nm) were used for excitation. Fluorescence emitted from a single particle within

310–400 nm and 420–650 nm wavelength bands was detected by PMTs with the bandpass filters.

(2-1-3) Submicron inorganic aerosol concentrations

Submicron inorganic aerosol concentrations were measured using a refractory aerosol thermal desorption mass spectrometer (rTDMS) (Kobayashi and Takegawa, 2022). Submicron aerosol particles were collected on a graphite particle collector for a selected time. The sampling time was varied considering the particle concentration in the atmosphere and instrument conditions (e.g., 7–10 min for every 30 min and 14–18 min for every 1 hour). The particle collector was irradiated by a carbon dioxide (CO₂) laser for 60 seconds to vaporize non-refractory and refractory inorganic species on it in the vacuum chamber. Evolved gas molecules were analyzed by a quadrupole mass spectrometer. The flowrate of the rTDMS was 110 ccm. The calibration of the rTDMS was conducted at approximately the beginning and end of the observation period. Monodisperse particles at 200 nm in diameter classified by a differential mobility analyzer were used for the calibration.

(2-1-4) Air sampling for the continuous observations

The sample air for particle measurements was commonly drawn from the rooftop of the environmental research room through a custom-made concentric tube-type inlet at the sampling rate of 31 L/min for sampling total suspended particulate matters (TSP) (Miyakawa et al., 2023;2025) to the SMPS and OPC. A part of the sampler air (~1.5 L/min) was isokinetically extracted and was dehumidified using a large diameter Nafion dryer (MD-700, Perma Pure, Inc.) to eliminate water vapor and liquid water contents of airborne particles (typical values of relative humidity (RH) at the exit of the dryer were lower than ~35% for subtropical region and ~30% for subarctic region), and was subsequently introduced via flow splitters to those instruments installed in the environmental research room. Note that the WIBS4 were placed on the compass deck and directly measured particle size distributions of fluorescent aerosols at ambient RH.

The sample air for the fine inorganic aerosol composition analyses (rTDMS) was drawn from the rooftop to the environmental research room through PM_{2.5} cyclone (model URG-2000-30EH, URG, Co.) and the conductive silicone tube. The total flowrate in the PM_{2.5} cyclone was adjusted by an additional pump (~16 L/min).

(2-2) Aerosol sampling for the offline chemical and physical analyses:

Samplings of aerosol particles in atmosphere were performed using various air samplers on the compass deck and in the environmental research room.

(2-2-1) High-volume air sampling for the chemical composition analyses

Aerosol particles were collected on the filter along cruise track using two high-volume air samplers (HVS 1 and 2) located to the forefront of the compass deck to analyze the chemical composition (Miyakawa et al., 2025; Miyazaki et al., 2018). To avoid collecting particles derived from the research vessel's own exhaust, the pumping by the HVSEs were automatically controlled using a “wind-direction selection system”. All the samples will be analyzed in the laboratories at JAMSTEC and Hokkaido University. These sampling logs are listed in Tables 2.2.1-1 and 2.2.1-2.

● HVS 1

A high volume air sampler (120SL, Kimoto Electric) with a 4-stage impactor (TE234, Tisch Environmental) was deployed for analyzing mode-segregated inorganic ions and trace metals of collected aerosols. Cellulose fiber filters (TE-241 (Tisch Environmental) for backup and TE-230-

WH (Tisch Environmental) for 4 cascade stages) were used for the sampling. Size fractionated aerosol particles were separately collected on the filters at the sampling rate of approximately 1133 L/min and the fractionation specification is as follows.

Stage 1: 7.2 μm – TSP

Stage 2: 3.0 μm – 7.2 μm

Stage 3: 1.5 μm – 3.0 μm

Stage 4: 0.95 μm – 1.5 μm

Backup: ~ 0 μm – 0.95 μm

- HVS 2

Another high volume air sampler (120SL, Kimoto Electric) with a 4-stage cascade impactor (TE234, Tisch Environmental) was deployed for analyzing mode-segregated carbonaceous components (elemental and organic carbons, water-soluble organic carbons, some specific molecular markers, and stable isotope of carbon) of collected aerosols. Pre-combusted quartz fiber filters (Pallflex Tissuquartz 2500QAT-UP (Cytiva, MA, US) for backup and TE-230-QZ (Tisch Environmental) for 4 cascade stages) was used for the sampling. The sampling conditions and size fractionation specifications were same as HVS 1.

(2-2-2) Air sampling for the individual particle analyses

Electron microscopic analyses, using Scanning Election Microscopy (SEM) and Transmission Electron Microscopy (TEM), will be performed in order to investigate the morphology and physicochemical properties of aerosol particles. For these purposes, aerosol particles were collected on a TEM grids (formvar) using the following an air sampler (Miyakawa et al., 2025). All samples will be analyzed using SEM or TEM placed in a laboratory of JAMSTEC. These sampling logs are listed in Table 2.2.1-3.

- AS-24W (ARIOS, Inc.) for TEM

This sampler was used for collecting fine particles to the TEM grid. Automated particle samplings were performed using the AS-24W for 30 min every 3 hours for the establishment of the highly time-resolved sampling of aerosol particles. The sampler air was drawn from the rooftop of the environmental research room to the AS-24W placed inside the room through the ~ 5 -m long conductive silicon tube. The sampling flowrate was 2.0 lpm (i.e., the sum of the sampler and assist pump flow rates (1 lpm + 1 lpm)).

(2-3) 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 (Takashima et al., 2022). 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 scanned elevation angles were 2, 4, 6, 10, 20, 30, 90 degrees in the 30-min cycle. The roll motion of the ship was measured to autonomously compensate additional motion of the prism, employed for scanning the elevation angle.

For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO_2 (and other gases) and O_4 ($\text{O}_2\text{-O}_2$, 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. The tropospheric vertical column/profile of NO₂ and other gases (e.g., IO) were retrieved using derived aerosol profiles.

(2-4) CO and O₃:

Ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to a nondispersive infrared (NDIR) CO analyzer (Model 48i-TLE, Thermo Fisher Scientific) and a UV photometric ozone analyzer (model 205, 2B Technologies) (Kanaya et al., 2019), located in the environmental research room.

(4) Summary of the air sampling

Aerosol samplings for the chemical and physical analyses during MR25-04 were summarized as follows.

Table 2.1.2-1: High-volume air samplings using HVS1 for aerosol composition analyses

On board ID	Collection Date1 (start)					Collection Date2 (end)					Latitude1			Longitude1			Depth1 [m]	Latitude2			Longitude2			Depth 2 [m]
	YYYY	MM	DD	hh:mm:ss	UTC/JST	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W		Deg.	Min.	N/S	Deg.	Min.	E/W	
											WGS84			WGS84				WGS84			WGS84			
MR2504_J_B01	2025	7	25	4:30	UTC	2025	7	25	4:30	UTC	40	33.28681	N	141	30.03518	E	0	40	33.28681	N	141	30.03518	E	0
MR2504_J_B02	2025	8	12	3:18	UTC	2025	8	12	3:18	UTC	49	20.31589	N	166	7.52705	E	0	49	20.31589	N	166	7.52705	E	0
MR2504_J_B03	2025	8	25	22:35	UTC	2025	8	25	22:35	UTC	51	52.990	N	152	44.021	W	0	51	52.990	N	152	44.021	W	0
MR2504_J_S01	2025	7	27	5:00	UTC	2025	7	29	5:00	UTC	40	51.25254	N	144	58.77151	E	0	37	2.24908	N	144	17.22524	E	0
MR2504_J_S02	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	58.50102	N	144	18.24271	E	0	32	21.14545	N	144	24.8433	E	0
MR2504_J_S03	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.17424	N	144	24.83223	E	0	36	27.84920	N	147	47.7696	E	0
MR2504_J_S04	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	36	31.87403	N	147	48.02592	E	0	43	51.70800	N	154	51.5715	E	0
MR2504_J_S05	2025	8	4	3:21	UTC	2025	8	6	3:00	UTC	43	55.3129	N	154	55.20999	E	0	47	0.30901	N	159	58.43271	E	0
MR2504_J_S06	2025	8	6	3:20	UTC	2025	8	8	3:00	UTC	47	0.32041	N	159	58.45851	E	0	47	0.03447	N	160	0.0408	E	0
MR2504_J_S07	2025	8	8	3:20	UTC	2025	8	10	3:00	UTC	47	0.02659	N	160	0.01115	E	0	47	25.33657	N	160	13.33472	E	0
MR2504_J_S08	2025	8	10	3:20	UTC	2025	8	12	3:00	UTC	47	27.86302	N	160	15.76318	E	0	49	22.55849	N	166	3.49026	E	0
MR2504_J_S09	2025	8	12	4:00	UTC	2025	8	14	3:00	UTC	49	14.76147	N	166	17.38239	E	0	46	59.86425	N	174	40.77805	E	0
MR2504_J_S10	2025	8	14	3:17	UTC	2025	8	16	3:00	UTC	46	59.76666	N	174	45.66178	E	0	47	0.01531	N	175	0.03654	W	0
MR2504_J_S11	2025	8	16	3:45	UTC	2025	8	18	1:00	UTC	47	0.02344	N	175	0.0503	W	0	48	12.4152	N	166	1.80107	W	0
MR2504_J_S12	2025	8	18	1:18	UTC	2025	8	20	1:00	UTC	48	14.05846	N	165	56.57761	W	0	50	0.00677	N	158	54.70529	W	0
MR2504_J_S13	2025	8	20	1:17	UTC	2025	8	22	1:00	UTC	49	59.96313	N	158	49.67061	W	0	50	0.10178	N	151	34.81298	W	0
MR2504_J_S14	2025	8	22	1:19	UTC	2025	8	24	00:30	UTC	49	59.96313	N	151	28.90078	W	0	50	0.0189	N	144	59.99212	W	0
MR2504_J_S15	2025	8	24	00:48	UTC	2025	8	25	22:00	UTC	50	0.02348	N	144	59.99115	W	0	51	50.416	N	152	33.130	W	0

Table 2.1.2-2: High-volume air sampling using HVS2 for aerosol composition analyses

On board ID	Collection Date1 (start)					Collection Date2 (end)					Latitude1			Longitude1			Depth1 [m]	Latitude2			Longitude2			Depth 2 [m]
	YYYY	MM	DD	hh:mm:ss	UTC/JST	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W		Deg.	Min.	N/S	Deg.	Min.	E/W	
											WGS84			WGS84				WGS84			WGS84			
HV-01	2025	7	25	1:10	UTC	2025	7	25	1:15	UTC	40	33.28681	N	141	30.03518	E	0	40	33.28681	N	141	30.03518	E	0
HVS-001	2025	7	25	1:10	UTC	2025	7	25	1:15	UTC	40	33.28681	N	141	30.03518	E	0	40	33.28681	N	141	30.03518	E	0
HVS-002	2025	7	25	1:10	UTC	2025	7	25	1:15	UTC	40	33.28681	N	141	30.03518	E	0	40	33.28681	N	141	30.03518	E	0
HVS-003	2025	7	25	1:10	UTC	2025	7	25	1:15	UTC	40	33.28681	N	141	30.03518	E	0	40	33.28681	N	141	30.03518	E	0
HVS-004	2025	7	25	1:10	UTC	2025	7	25	1:15	UTC	40	33.28681	N	141	30.03518	E	0	40	33.28681	N	141	30.03518	E	0
HV-19	2025	8	12	3:00	UTC	2025	8	12	3:05	UTC	49	22.55849	N	166	03.49026	E	0	49	21.93818	N	166	04.61660	E	0
HVS-037	2025	8	12	3:00	UTC	2025	8	12	3:05	UTC	49	22.55849	N	166	03.49026	E	0	49	21.93818	N	166	04.61660	E	0
HVS-038	2025	8	12	3:00	UTC	2025	8	12	3:05	UTC	49	22.55849	N	166	03.49026	E	0	49	21.93818	N	166	04.61660	E	0
HVS-039	2025	8	12	3:00	UTC	2025	8	12	3:05	UTC	49	22.55849	N	166	03.49026	E	0	49	21.93818	N	166	04.61660	E	0
HVS-040	2025	8	12	3:00	UTC	2025	8	12	3:05	UTC	49	22.55849	N	166	03.49026	E	0	49	21.93818	N	166	04.61660	E	0
HV-33	2025	8	25	22:22	UTC	2025	8	25	22:25	UTC	51	53.51	N	146	7.79	W	0	51	53.51	N	146	7.79	W	0
HVS-069	2025	8	25	22:22	UTC	2025	8	25	22:25	UTC	51	53.51	N	146	7.79	W	0	51	53.51	N	146	7.79	W	0
HVS-070	2025	8	25	22:22	UTC	2025	8	25	22:25	UTC	51	53.51	N	146	7.79	W	0	51	53.51	N	146	7.79	W	0
HVS-071	2025	8	25	22:22	UTC	2025	8	25	22:25	UTC	51	53.51	N	146	7.79	W	0	51	53.51	N	146	7.79	W	0
HVS-072	2025	8	25	22:22	UTC	2025	8	25	22:25	UTC	51	53.51	N	146	7.79	W	0	51	53.51	N	146	7.79	W	0
HV-02	2025	7	27	5:00	UTC	2025	7	28	5:00	UTC	40	50.05	N	144	57.64	E	0	41	38.700	N	146	15.160	E	0
HV-03	2025	7	28	5:15	UTC	2025	7	29	5:00	UTC	41	38.01	N	146	15.71	E	0	37	2.800	N	144	17.050	E	0
HV-05	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	38.3	N	144	18.2	E	0	32	21.100	N	144	24.800	E	0
HV-06	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.1	N	144	18.2	E	0	36	27.060	N	147	47.600	E	0
HV-08	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	31	32.08	N	147	48.02	E	0	43	50.900	N	154	50.100	E	0
HV-09	2025	8	4	3:21	UTC	2025	8	5	3:00	UTC	43	56.24	N	154	56.25	E	0	47	58.060	N	156	3.100	E	0
HV-11	2025	8	5	3:11	UTC	2025	8	6	3:00	UTC	47	38.06	N	156	3.1	E	0	47	0.390	N	159	58.440	E	0
HV-13	2025	8	6	3:20	UTC	2025	8	7	3:00	UTC	47	0.29	N	159	58.44	E	0	47	0.040	N	159	57.910	E	0
HV-14	2025	8	7	3:10	UTC	2025	8	8	3:00	UTC	47	0.04	N	159	59.91	E	0	47	0.030	N	160	0.060	E	0
HV-15	2025	8	8	3:20	UTC	2025	8	9	3:00	UTC	46	59.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HV-16	2025	8	9	3:15	UTC	2025	8	10	3:00	UTC	46	39.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HV-17	2025	8	10	3:20	UTC	2025	8	11	3:00	UTC	47	27.84	N	160	15.75	E	0	50	0.040	N	165	0.190	E	0
HV-18	2025	8	11	3:10	UTC	2025	8	12	3:00	UTC	50	0.03	N	165	0.16	E	0	49	23.210	N	166	2.330	E	0
HV-20	2025	8	12	4:00	UTC	2025	8	13	3:00	UTC	44	15.5	N	166	16.2	E	0	47	0.000	N	170	0.030	E	0
HV-21	2025	8	13	3:10	UTC	2025	8	14	3:00	UTC	47	0	N	170	0.03	E	0	46	59.880	N	174	39.110	E	0
HV-22	2025	8	14	3:17	UTC	2025	8	15	3:00	UTC	46	59.78	N	174	44.72	E	0	47	0.040	N	179	59.950	E	0
HV-23	2025	8	15	3:10	UTC	2025	8	16	3:00	UTC	47	0.02	N	179	59.95	E	0	47	0.020	N	175	0.020	W	0
HV-24	2025	8	16	3:45	UTC	2025	8	17	3:00	UTC	46	59.98	N	175	0.02	W	0	47	60.020	N	170	0.050	W	0
HV-25	2025	8	17	3:07	UTC	2025	8	18	3:00	UTC	47	60.02	N	170	0.05	W	0	48	12.750	N	166	0.660	W	0
HV-26	2025	8	18	3:18	UTC	2025	8	20	1:00	UTC	48	14.23	N	165	56.02	W	0	50	0.000	N	158	53.640	W	0
HV-27	2025	8	20	1:17	UTC	2025	8	21	1:00	UTC	49	59.95	N	158	49.92	W	0	50	0.000	N	152	30.000	W	0
HV-28	2025	8	21	1:06	UTC	2025	8	22	1:00	UTC	50	0	N	152	30	W	0	50	0.070	N	151	33.510	W	0
HV-29	2025	8	22	1:19	UTC	2025	8	23	0:45	UTC	49	59.98	N	151	28.83	W	0	49	59.990	N	144	59.980	W	0
HV-30	2025	8	23	0:31	UTC	2025	8	24	0:30	UTC	49	49.99	N	144	59.98	W	0	50	0.000	N	145	0.000	W	0
HV-31	2025	8	24	0:48	UTC	2025	8	25	0:30	UTC	50	0	N	145	0	W	0	50	16.890	N	146	7.790	W	0
HV-32	2025	8	25	0:36	UTC	2025	8	25	22:00	UTC	50	16.89	N	146	7.79	W	0	51	53.510	N	152	46.330	W	0

Table 2.1.2-2: continued.

On board ID	Collection Date1 (start)					Collection Date2 (end)					Latitude1			Longitude1			Depth1 [m]	Latitude2			Longitude2			Depth 2 [m]
	YYYY	MM	DD	hh:mm:ss	UTC/JST	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W		Deg.	Min.	N/S	Deg.	Min.	E/W	
WGS84											WGS84			WGS84			WGS84							
HVS-072	2025	8	25	22:22	UTC	2025	8	25	22:25	UTC	51	53.51	N	146	7.79	W	0	51	53.51	N	146	7.79	W	0
HV-02	2025	7	27	5:00	UTC	2025	7	28	5:00	UTC	40	50.05	N	144	57.64	E	0	41	38.700	N	146	15.160	E	0
HV-03	2025	7	28	5:15	UTC	2025	7	29	5:00	UTC	41	38.01	N	146	15.71	E	0	37	2.800	N	144	17.050	E	0
HV-05	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	38.3	N	144	18.2	E	0	32	21.100	N	144	24.800	E	0
HV-06	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.1	N	144	18.2	E	0	36	27.060	N	147	47.600	E	0
HV-08	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	31	32.08	N	147	48.02	E	0	43	50.900	N	154	50.100	E	0
HV-09	2025	8	4	3:21	UTC	2025	8	5	3:00	UTC	43	56.24	N	154	56.25	E	0	47	58.060	N	156	3.100	E	0
HV-11	2025	8	5	3:11	UTC	2025	8	6	3:00	UTC	47	38.06	N	156	3.1	E	0	47	0.390	N	159	58.440	E	0
HV-13	2025	8	6	3:20	UTC	2025	8	7	3:00	UTC	47	0.29	N	159	58.44	E	0	47	0.040	N	159	57.910	E	0
HV-14	2025	8	7	3:10	UTC	2025	8	8	3:00	UTC	47	0.04	N	159	59.91	E	0	47	0.030	N	160	0.060	E	0
HV-15	2025	8	8	3:20	UTC	2025	8	9	3:00	UTC	46	59.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HV-16	2025	8	9	3:15	UTC	2025	8	10	3:00	UTC	46	39.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HV-17	2025	8	10	3:20	UTC	2025	8	11	3:00	UTC	47	27.84	N	160	15.75	E	0	50	0.040	N	165	0.190	E	0
HV-18	2025	8	11	3:10	UTC	2025	8	12	3:00	UTC	50	0.03	N	165	0.16	E	0	49	23.210	N	166	2.330	E	0
HV-20	2025	8	12	4:00	UTC	2025	8	13	3:00	UTC	44	15.5	N	166	16.2	E	0	47	0.000	N	170	0.030	E	0
HV-21	2025	8	13	3:10	UTC	2025	8	14	3:00	UTC	47	0	N	170	0.03	E	0	46	59.880	N	174	39.110	E	0
HV-22	2025	8	14	3:17	UTC	2025	8	15	3:00	UTC	46	59.78	N	174	44.72	E	0	47	0.040	N	179	59.950	E	0
HV-23	2025	8	15	3:10	UTC	2025	8	16	3:00	UTC	47	0.02	N	179	59.95	E	0	47	0.020	N	175	0.020	W	0
HV-24	2025	8	16	3:45	UTC	2025	8	17	3:00	UTC	46	59.98	N	175	0.02	W	0	47	60.020	N	170	0.050	W	0
HV-25	2025	8	17	3:07	UTC	2025	8	18	3:00	UTC	47	60.02	N	170	0.05	W	0	48	12.750	N	166	0.660	W	0
HV-26	2025	8	18	3:18	UTC	2025	8	20	1:00	UTC	48	14.23	N	165	56.02	W	0	50	0.000	N	158	53.640	W	0
HV-27	2025	8	20	1:17	UTC	2025	8	21	1:00	UTC	49	59.95	N	158	49.92	W	0	50	0.000	N	152	30.000	W	0
HV-28	2025	8	21	1:06	UTC	2025	8	22	1:00	UTC	50	0	N	152	30	W	0	50	0.070	N	151	33.510	W	0
HV-29	2025	8	22	1:19	UTC	2025	8	23	0:45	UTC	49	59.98	N	151	28.83	W	0	49	59.990	N	144	59.980	W	0
HV-30	2025	8	23	0:31	UTC	2025	8	24	0:30	UTC	49	49.99	N	144	59.98	W	0	50	0.000	N	145	0.000	W	0
HV-31	2025	8	24	0:48	UTC	2025	8	25	0:30	UTC	50	0	N	145	0	W	0	50	16.890	N	146	7.790	W	0
HV-32	2025	8	25	0:36	UTC	2025	8	25	22:00	UTC	50	16.89	N	146	7.79	W	0	51	53.510	N	152	46.330	W	0
HVS-005	2025	7	27	5:00	UTC	2025	7	29	5:00	UTC	40	50.05	N	144	57.64	E	0	37	2.800	N	144	17.050	E	0
HVS-006	2025	7	27	5:00	UTC	2025	7	29	5:00	UTC	40	50.05	N	144	57.64	E	0	37	2.800	N	144	17.050	E	0
HVS-007	2025	7	27	5:00	UTC	2025	7	29	5:00	UTC	40	50.05	N	144	57.64	E	0	37	2.800	N	144	17.050	E	0
HVS-008	2025	7	27	5:00	UTC	2025	7	29	5:00	UTC	40	50.05	N	144	57.64	E	0	37	2.800	N	144	17.050	E	0
HVS-009	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	38.3	N	144	18.2	E	0	32	21.100	N	144	24.800	E	0
HVS-010	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	38.3	N	144	18.2	E	0	32	21.100	N	144	24.800	E	0
HVS-011	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	38.3	N	144	18.2	E	0	32	21.100	N	144	24.800	E	0
HVS-012	2025	7	29	5:19	UTC	2025	7	31	5:00	UTC	36	38.3	N	144	18.2	E	0	32	21.100	N	144	24.800	E	0
HVS-013	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.1	N	144	18.2	E	0	36	27.060	N	147	47.600	E	0
HVS-014	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.1	N	144	18.2	E	0	36	27.060	N	147	47.600	E	0
HVS-015	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.1	N	144	18.2	E	0	36	27.060	N	147	47.600	E	0
HVS-016	2025	7	31	5:21	UTC	2025	8	2	3:00	UTC	32	21.1	N	144	18.2	E	0	36	27.060	N	147	47.600	E	0

Table 2.1.2-2: continued.

On board ID	Collection Date1 (start)					Collection Date2 (end)					Latitude1			Longitude1			Depth1 [m]	Latitude2			Longitude2			Depth 2 [m]
	YYYY	MM	DD	hh:mm:ss	UTC/JST	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W		Deg.	Min.	N/S	Deg.	Min.	E/W	
WGS84											WGS84			WGS84			WGS84							
HVS-017	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	31	32.08	N	147	48.02	E	0	43	50.900	N	154	50.100	E	0
HVS-018	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	31	32.08	N	147	48.02	E	0	43	50.900	N	154	50.100	E	0
HVS-019	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	31	32.08	N	147	48.02	E	0	43	50.900	N	154	50.100	E	0
HVS-020	2025	8	2	3:20	UTC	2025	8	4	3:00	UTC	31	32.08	N	147	48.02	E	0	43	50.900	N	154	50.100	E	0
HVS-021	2025	8	4	3:21	UTC	2025	8	6	3:00	UTC	43	56.24	N	154	56.25	E	0	47	0.390	N	159	58.440	E	0
HVS-022	2025	8	4	3:21	UTC	2025	8	6	3:00	UTC	43	56.24	N	154	56.25	E	0	47	0.390	N	159	58.440	E	0
HVS-023	2025	8	4	3:21	UTC	2025	8	6	3:00	UTC	43	56.24	N	154	56.25	E	0	47	0.390	N	159	58.440	E	0
HVS-024	2025	8	4	3:21	UTC	2025	8	6	3:00	UTC	43	56.24	N	154	56.25	E	0	47	0.390	N	159	58.440	E	0
HVS-025	2025	8	6	3:20	UTC	2025	8	8	3:00	UTC	47	0.29	N	159	58.44	E	0	47	0.030	N	160	0.060	E	0
HVS-026	2025	8	6	3:20	UTC	2025	8	8	3:00	UTC	47	0.29	N	159	58.44	E	0	47	0.030	N	160	0.060	E	0
HVS-027	2025	8	6	3:20	UTC	2025	8	8	3:00	UTC	47	0.29	N	159	58.44	E	0	47	0.030	N	160	0.060	E	0
HVS-028	2025	8	6	3:20	UTC	2025	8	8	3:00	UTC	47	0.29	N	159	58.44	E	0	47	0.030	N	160	0.060	E	0
HVS-029	2025	8	8	3:20	UTC	2025	8	10	3:00	UTC	46	59.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HVS-030	2025	8	8	3:20	UTC	2025	8	10	3:00	UTC	46	59.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HVS-031	2025	8	8	3:20	UTC	2025	8	10	3:00	UTC	46	59.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HVS-032	2025	8	8	3:20	UTC	2025	8	10	3:00	UTC	46	59.77	N	159	58.39	E	0	47	24.010	N	160	12.110	E	0
HVS-033	2025	8	10	3:20	UTC	2025	8	12	3:00	UTC	47	27.84	N	160	15.75	E	0	49	23.210	N	166	2.330	E	0
HVS-034	2025	8	10	3:20	UTC	2025	8	12	3:00	UTC	47	27.84	N	160	15.75	E	0	49	23.210	N	166	2.330	E	0
HVS-035	2025	8	10	3:20	UTC	2025	8	12	3:00	UTC	47	27.84	N	160	15.75	E	0	49	23.210	N	166	2.330	E	0
HVS-036	2025	8	10	3:20	UTC	2025	8	12	3:00	UTC	47	27.84	N	160	15.75	E	0	49	23.210	N	166	2.330	E	0
HVS-041	2025	8	12	4:00	UTC	2025	8	14	3:00	UTC	44	15.5	N	166	16.2	E	0	46	59.880	N	174	39.110	E	0
HVS-042	2025	8	12	4:00	UTC	2025	8	14	3:00	UTC	44	15.5	N	166	16.2	E	0	46	59.880	N	174	39.110	E	0
HVS-043	2025	8	12	4:00	UTC	2025	8	14	3:00	UTC	44	15.5	N	166	16.2	E	0	46	59.880	N	174	39.110	E	0
HVS-044	2025	8	12	4:00	UTC	2025	8	14	3:00	UTC	44	15.5	N	166	16.2	E	0	46	59.880	N	174	39.110	E	0
HVS-045	2025	8	14	3:17	UTC	2025	8	16	3:00	UTC	46	59.78	N	174	44.72	E	0	47	0.020	N	175	0.020	E	0
HVS-046	2025	8	14	3:17	UTC	2025	8	16	3:00	UTC	46	59.78	N	174	44.72	E	0	47	0.020	N	175	0.020	E	0
HVS-047	2025	8	14	3:17	UTC	2025	8	16	3:00	UTC	46	59.78	N	174	44.72	E	0	47	0.020	N	175	0.020	E	0
HVS-048	2025	8	14	3:17	UTC	2025	8	16	3:00	UTC	46	59.78	N	174	44.72	E	0	47	0.020	N	175	0.020	E	0
HVS-049	2025	8	16	3:45	UTC	2025	8	18	3:00	UTC	46	59.98	N	175	0.02	W	0	48	12.750	N	166	0.660	W	0
HVS-050	2025	8	16	3:45	UTC	2025	8	18	3:00	UTC	46	59.98	N	175	0.02	W	0	48	12.750	N	166	0.660	W	0
HVS-051	2025	8	16	3:45	UTC	2025	8	18	3:00	UTC	46	59.98	N	175	0.02	W	0	48	12.750	N	166	0.660	W	0
HVS-052	2025	8	16	3:45	UTC	2025	8	18	3:00	UTC	46	59.98	N	175	0.02	W	0	48	12.750	N	166	0.660	W	0
HVS-053	2025	8	18	3:18	UTC	2025	8	20	1:00	UTC	48	14.23	N	165	56.02	W	0	50	0.000	N	158	53.640	W	0
HVS-054	2025	8	18	3:18	UTC	2025	8	20	1:00	UTC	48	14.23	N	165	56.02	W	0	50	0.000	N	158	53.640	W	0
HVS-055	2025	8	18	3:18	UTC	2025	8	20	1:00	UTC	48	14.23	N	165	56.02	W	0	50	0.000	N	158	53.640	W	0
HVS-056	2025	8	18	3:18	UTC	2025	8	20	1:00	UTC	48	14.23	N	165	56.02	W	0	50	0.000	N	158	53.640	W	0
HVS-057	2025	8	20	1:17	UTC	2025	8	22	1:00	UTC	49	59.95	N	158	49.92	W	0	50	0.070	N	151	33.510	W	0
HVS-058	2025	8	20	1:17	UTC	2025	8	22	1:00	UTC	49	59.95	N	158	49.92	W	0	50	0.070	N	151	33.510	W	0
HVS-059	2025	8	20	1:17	UTC	2025	8	22	1:00	UTC	49	59.95	N	158	49.92	W	0	50	0.070	N	151	33.510	W	0
HVS-060	2025	8	20	1:17	UTC	2025	8	22	1:00	UTC	49	59.95	N	158	49.92	W	0	50	0.070	N	151	33.510	W	0

Table 2.1.2-2: continued.

On board ID	Collection Date1 (start)					Collection Date2 (end)					Latitude1			Longitude1			Depth1 [m]	Latitude2			Longitude2			Depth 2 [m]
	YYYY	MM	DD	hh:mm:ss	UTC/JST	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W		Deg.	Min.	N/S	Deg.	Min.	E/W	
	WGS84					WGS84					WGS84			WGS84				WGS84			WGS84			
HVS-061	2025	8	22	1:19	UTC	2025	8	24	0:30	UTC	49	59.98	N	151	28.83	W	0	50	0.000	N	145	0.000	W	0
HVS-062	2025	8	22	1:19	UTC	2025	8	24	0:30	UTC	49	59.98	N	151	28.83	W	0	50	0.000	N	145	0.000	W	0
HVS-063	2025	8	22	1:19	UTC	2025	8	24	0:30	UTC	49	59.98	N	151	28.83	W	0	50	0.000	N	145	0.000	W	0
HVS-064	2025	8	22	1:19	UTC	2025	8	24	0:30	UTC	49	59.98	N	151	28.83	W	0	50	0.000	N	145	0.000	W	0
HVS-065	2025	8	24	0:48	UTC	2025	8	25	22:00	UTC	50	0	N	145	0	W	0	51	53.510	N	152	46.330	W	0
HVS-066	2025	8	24	0:48	UTC	2025	8	25	22:00	UTC	50	0	N	145	0	W	0	51	53.510	N	152	46.330	W	0
HVS-067	2025	8	24	0:48	UTC	2025	8	25	22:00	UTC	50	0	N	145	0	W	0	51	53.510	N	152	46.330	W	0
HVS-068	2025	8	24	0:48	UTC	2025	8	25	22:00	UTC	50	0	N	145	0	W	0	51	53.510	N	152	46.330	W	0

Table 2.1.2-3: Aerosol sampling for electron microscopic analyses

On board ID	Collection Date1 (start)					Collection Date2 (end)					Latitude1			Longitude1			Depth1 [m]	Latitude2			Longitude2			Depth 2 [m]
	YYYY	MM	DD	hh:mm:ss	UTC/JST	YYYY	MM	DD	hh:mm:ss	UTC/JST	Deg.	Min.	N/S	Deg.	Min.	E/W		Deg.	Min.	N/S	Deg.	Min.	E/W	
											WGS84			WGS84				WGS84			WGS84			
MR2504-TEM-F01	2025	8	3	23:00	UTC	2025	8	6	23:00	UTC	43	8.60812	N	154	8.1368	E	0	46	59.99738	N	159	59.98021	E	0
MR2504-TEM-C01	2025	8	3	23:00	UTC	2025	8	6	23:00	UTC	43	8.60812	N	154	8.1368	E	0	46	59.99738	N	159	59.98021	E	0
MR2504-TEM-F02	2025	8	7	2:00	UTC	2025	8	10	2:00	UTC	46	59.80896	N	160	1.43229	E	0	47	14.37930	N	160	2.68185	E	0
MR2504-TEM-C02	2025	8	7	2:00	UTC	2025	8	10	2:00	UTC	46	59.80896	N	160	1.43229	E	0	47	14.37930	N	160	2.68185	E	0
MR2504-TEM-F03	2025	8	10	5:00	UTC	2025	8	13	5:00	UTC	47	12.69355	N	160	16.02449	E	0	46	59.84155	N	169	59.83088	E	0
MR2504-TEM-C03	2025	8	10	5:00	UTC	2025	8	13	5:00	UTC	47	12.69355	N	160	16.02449	E	0	46	59.84155	N	169	59.83088	E	0
MR2504-TEM-F04	2025	8	13	8:00	UTC	2025	8	16	8:00	UTC	46	59.99122	N	169	59.99109	E	0	47	0.06521	N	175	0.02033	W	0
MR2504-TEM-C04	2025	8	13	8:00	UTC	2025	8	16	8:00	UTC	46	59.99122	N	169	59.99109	E	0	47	0.06521	N	175	0.02033	W	0
MR2504-TEM-F05	2025	8	16	11:00	UTC	2025	8	19	11:00	UTC	46	59.47815	N	174	38.80479	W	0	49	59.42899	N	160	6.61333	W	0
MR2504-TEM-C05	2025	8	16	11:00	UTC	2025	8	19	11:00	UTC	46	59.47815	N	174	38.80479	W	0	49	59.42899	N	160	6.61333	W	0
MR2504-TEM-F06	2025	8	19	14:00	UTC	2025	8	22	14:00	UTC	50	2.17974	N	160	14.43244	W	0	50	0.06686	N	147	33.08277	W	0
MR2504-TEM-C06	2025	8	19	14:00	UTC	2025	8	22	14:00	UTC	50	2.17974	N	160	14.43244	W	0	50	0.06686	N	147	33.08277	W	0
MR2504-TEM-F07	2025	8	22	17:00	UTC	2025	8	25	17:00	UTC	49	59.98811	N	146	35.90016	W	0	51	28.38579	N	151	1.34513	W	0
MR2504-TEM-C07	2025	8	22	17:00	UTC	2025	8	25	17:00	UTC	49	59.98811	N	146	35.90016	W	0	51	28.38579	N	151	1.34513	W	0
MR2504-TEM-F08	2025	8	25	20:00	UTC	2025	8	26	2:00	UTC	51	41.39800	N	151	55.82195	W	0	52	8.2591	N	153	46.6972	W	0
MR2504-TEM-C08	2025	8	25	20:00	UTC	2025	8	26	2:00	UTC	51	41.39800	N	151	55.82195	W	0	52	8.2591	N	153	46.6972	W	0

(5) Preliminary results

(5-1) Temporal variations in particle number concentrations

Temporal variations in particle number size distributions (PSDs) of total and non-volatile (at 300 °C) particles were measured using the SMPS with 5-min resolution. Temporal variations of integrated particle number concentrations from July 27 to August 21, 2025 are shown in Figure 2.1.2-1. Number concentrations greatly varied (about 2 orders for total and 3 orders for non-volatile particles). A highlight event occurred August 11–12, 2025, when R/V Mirai cruised over the northwestern Pacific Ocean around Stn5 (°50N, 165°E). Wind conditions for this period were calmed, and fog was not observed. Evolution of PSDs was shown in Figure 2.1.2-2. Not only the high concentrations but also rapid changes (i.e. particle growth) in the shape of PSDs occurred during this period. This result suggests that there is a mechanism to strongly supply the particles with diameter smaller than 50 nm and high concentrations of semi-volatile vapors to stimulate the growth of the preexisting particles over this region.

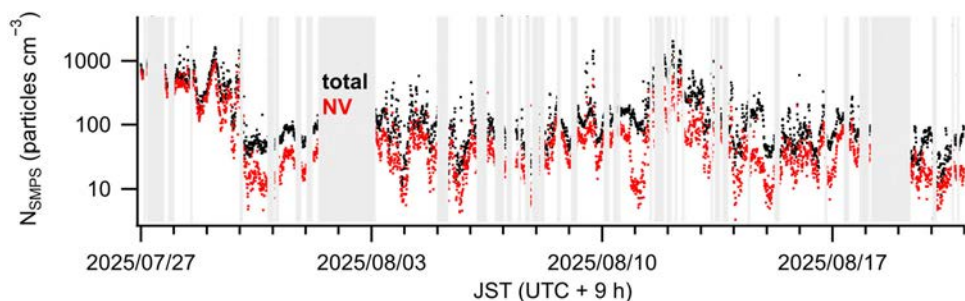


Figure 2.1.2-1: Temporal variations in number concentrations of total and non-volatile particles

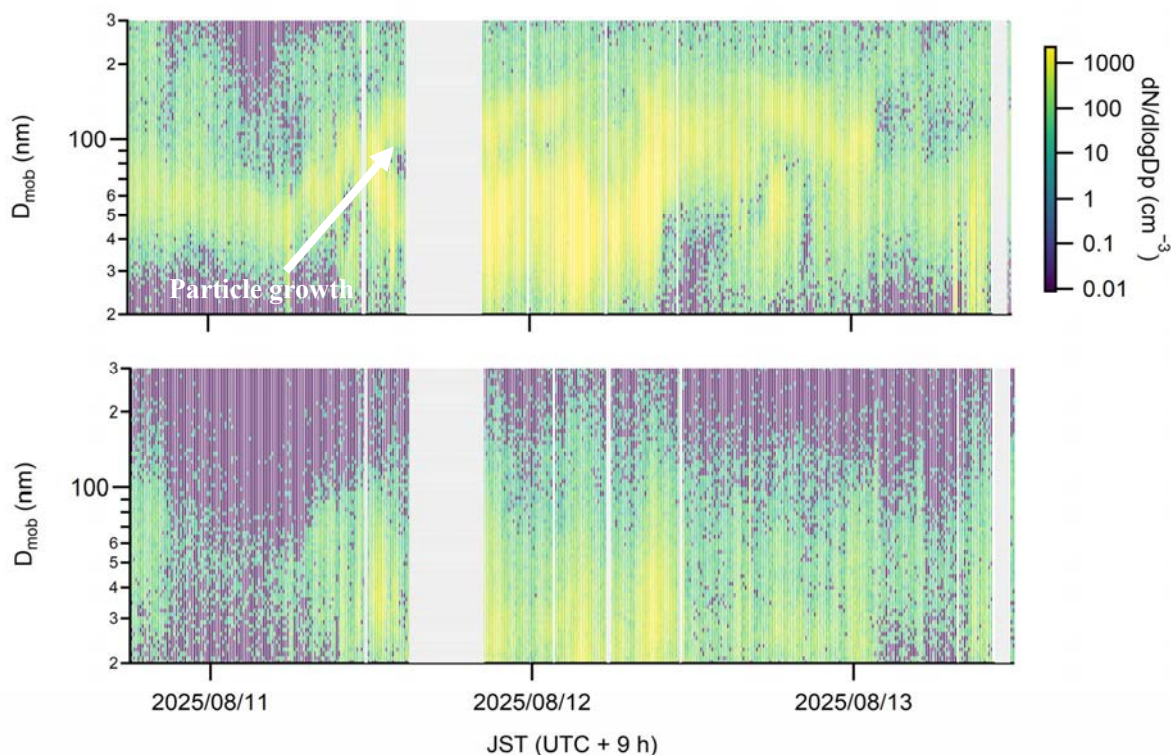


Figure 2.1.2-2: Temporal evolutions of PSDs of total and non-volatile particles for the event period.

References:

- Kanaya et al. (2019), Ozone and carbon monoxide observations over open oceans on R/V *Mirai* from 67° S to 75° N during 2012 to 2017: testing global chemical reanalysis in terms of Arctic processes, low ozone levels at low latitudes, and pollution transport, *Atmos. Chem. Phys.*, 19, 7233–7254, <https://doi.org/10.5194/acp-19-7233-2019>
- Kobayashi and Takegawa (2022), A new method to quantify particulate sodium and potassium salts (nitrate, chloride, and sulfate) by thermal desorption aerosol mass spectrometry, *Atmos. Meas. Tech.*, 15, 833–844, <https://doi.org/10.5194/amt-15-833-2022>
- Miyakawa et al. (2023), Measurements of aerosol particle size distributions and INPs over the Southern Ocean in the late austral summer of 2017 on board the R/V *Mirai*: Importance of the marine boundary layer structure, *Earth Space Sci.*, 10, e2022EA002736, <https://doi.org/10.1029/2022EA002736>
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- Miyazaki et al. (2018), Chemical transfer of dissolved organic matter from surface seawater to sea spray water-soluble organic aerosol in the marine atmosphere, *Sci Rep.* 8, 14861, <https://doi.org/10.1038/s41598-018-32864-7>
- Takashima et al. (2022), Full latitudinal marine atmospheric measurements of iodine monoxide, *Atmos. Chem. Phys.*, 22, 4005–4018, <https://doi.org/10.5194/acp-22-4005-2022>
- Taketani et al. (2025), Impact of Siberian Wildfires on Ice-Nucleating Particle Concentrations over the Northwestern Pacific, *Environ. Sci. Technol.*, 59, 5, 2565–2574, <https://doi.org/10.1021/acs.est.4c04889>

(6) Data archives

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

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

2.1.3 Microwave Radiometer

Masaki KATSUMATA (JAMSTEC RIGC)
Akira KUWANO-YOSHIDA (Kyoto Univ.)
Masahiro MINOWA (Furuno Electric Co., Ltd.)

(1) Objective

To retrieve the integrated and vertical profile of water vapor

(2) Method

The microwave radiometer (hereafter MWR; manufactured by Furuno Electric Co., Ltd.) is used. The MWR received natural microwave within the angle of 20 deg. from zenith. The MWR observes at the frequencies around 22 GHz, to retrieve the column integrated water vapor (or precipitable water), and the vertical profile of the water vapor. The observation was made approximately every 20 seconds except when periodic auto-calibration was on-going (once in several minutes). The rain sensor is equipped to identify the period of rainfall.

In addition to the MWR, the whole sky camera was installed beside the MWR. This is to monitor cloud cover, which also affects the microwave signals. The camera obtained the whole-sky image every 2 minutes.

All instruments were installed at the top of the roof of aft wheelhouse, as in Fig. 2.1.3-1. The data was continuously obtained all through the cruise period.

(3) Results

The data has been obtained all through the cruise. Further analyses will be carried out after the cruise.

(4) Data archive

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

(5) Acknowledgment

The observation was supported by the JSPS KAKENHI Grant 23H00519. Nippon Marine Enterprise Ltd. kindly supported the operation.

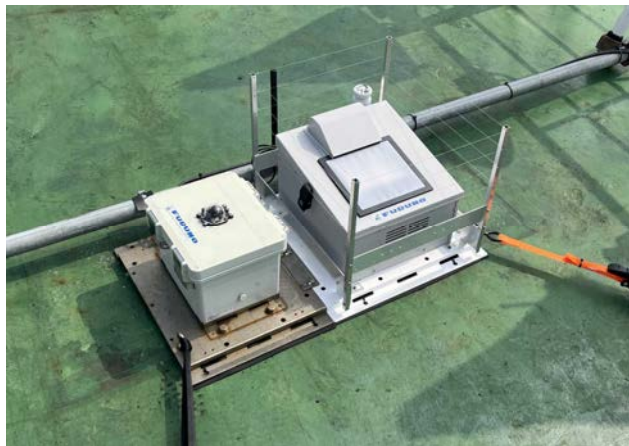


Fig. 2.1.3-1: Outlook of the instruments installed at the roof of the aft wheelhouse; the microwave radiometer for the air temperature (right), microwave radiometer for the water vapor (middle), and the whole-sky camera (left).

2.1.4 Mie / Raman Lidar Observation

Takuma MIYAKAWA (JAMSTEC RIGC)

Masaki KATSUMATA (JAMSTEC RIGC)

Kyoko TANIGUCHI (JAMSTEC RIGC)

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (NME)

Masanori MURAKAMI (MIRAI Crew)

(1) Objective

The objective of this observation is to capture the vertical distribution of clouds, aerosols, and water vapor in high spatio-temporal resolution.

(2) Parameters

355nm Mie scattering signal

532nm Mie scattering signal

1064nm Mie scattering signal

387nm Raman nitrogen scattering signal (nighttime only)

408nm Raman water vapor scattering signal (nighttime only)

607nm Raman nitrogen scattering signal (nighttime only)

660nm Raman water vapor scattering signal (nighttime only)

(3) Instruments and methods

The Mirai Lidar system transmits a 10-Hz pulse laser in three wavelengths: 1064nm, 532nm, 355nm. For cloud and aerosol observation, the system detects Mie scattering at these wavelengths. The separate detections of polarization components at 532 nm and 355 nm obtain additional characteristics of the targets. The system also detects Raman water vapor signals at 660 nm and 408nm, Raman nitrogen signals at 607 nm and 387nm at nighttime. Based on the signal ratio of Raman water vapor to Raman nitrogen, the system offers water vapor mixing ratio profiles.

(4) Observation period

24 July 2025 to 26 August 2025 UTC

(5) Preliminary Results

The lidar system observed the lower atmosphere throughout the cruise. All data will be reviewed after the cruise to maintain data quality.

(6) Data Archive

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

2.1.5 GPS radiosonde

Takuma MIYAKAWA (JAMSTEC RIGC)

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (NME)

Masanori MURAKAMI (Mirai Crew)

(1) Objectives

To obtain vertical profiles and temporal variations of air temperature, relative humidity, and wind speed/direction and compare the results with continuous ceiling and laser lidar measurements.

(2) Instruments and methods

Vaisala RS-41 was used as a sensor for radiosonde observation. The ground check device (RI41, Vaisala) operated by MW41 software (Vaisala) prepared and calibrated the sensor before launch. The value of pressure measured using a reference barometer (PTB-330, Vaisala) near RI41 was applied in the calibration. The sensor and balloon (TA-200, TOTEX) were placed in the shipboard balloon launcher (Fig. 2.1.5-1). Meteorological data which was continuously obtained at the compass deck was referred as the surface condition at launch. MW41 also recorded and processed the sounding data, with a processor (SPS-311, Vaisala), GPS antenna (GA20, Vaisala), and UHF antenna (RB21, Vaisala).

(3) Preliminary result

During this cruise, radiosonde observation obtained 12 profiles, as listed in Table 2.1.5-1

(4) Data archive

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



Fig. 2.1.5-1 Photograph of balloon released from the R/V *Mirai* shipboard launcher (taken by Dr. Maki Aita Noguchi)

Table 2.1.5-1 Summary of radiosonde measurements

ID	Sensor SN	Date YYYYMMDDHH	Latitude deg		Longitude deg		Psfc hPa	Tsfc degC	RHsfc %	WD deg	Wsp m/s	SST degC	Max height hPa	m
RS001	X0914423	2025080302	40.481	N	149.457	E	997.6	24.2	95	307	11.0	25.55	22.4	26180
RS002	X0914251	2025081102	49.901	N	164.933	E	1005.6	13.8	96	194	3.1	14.34	24.3	25717
RS003	X0914240	2025081202	49.545	N	165.750	E	1007.9	15.2	91	233	3.9	14.31	24.0	25798
RS004	X0914288	2025081402	47.007	N	174.279	E	1012.1	13.0	96	82	14.0	14.26	24.2	25701
RS005	X0914239	2025081409	46.997	N	176.363	E	1012.2	12.8	99	106	11.7	12.49	87.2	17567
RS006	X0912300	2025081601	47.004	N	175.047	W	1023.1	15.3	99	180	6.7	13.82	23.9	25751
RS007	X0914273	2025081700	46.999	N	170.791	W	1025.6	16.0	99	257	7.2	14.62	35.9	23118
RS008	X0912296	2025081808	48.704	N	164.393	W	1018.5	14.5	99	250	9.9	13.78	25.9	25203
RS009	X0912471	2025081823	49.981	N	160.051	W	1008.1	14.1	99	238	11.0	13.63	23.5	25856
RS010	X0912457	2025082006	49.998	N	157.442	W	1009.8	13.2	97	16	13.4	13.91	19.9	26961
RS011	X0914252	2025082023	50.004	N	152.586	W	1011.4	13.6	85	339	11.6	13.56	31.6	23969
RS012	X0914261	2025082222	50.000	N	145.116	W	1010.4	14.2	87	212	6.0	14.52	29.9	24343

2.1.6 Aerosol optical characteristics measured by shipborne sky radiometer

Kazuma Aoki (University of Toyama) not onboard

Sky radiometer operation was supported by Nippon Marine Enterprises, Ltd.

(1) Objectives

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) Instruments and methods

i) Sky radiometer measurement

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 and 2020.

ii) 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) Data archive

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

(4) References

Nakajima,T., G.Tonna, R.Rao, P.Boi, Y.Kaufman and B.Holben (1996) Use of sky brightness measurements from ground for remote sensing of particulate polydispersions, Appl. Opt., 35, 2672–2686, <https://doi.org/10.1364/AO.35.002672>.

Aoki. K., T.Takemura, K.Kawamoto, and T.Hayasaka (2013), Aerosol climatology over Japan site measured by ground-based sky radiometer, AIP Conf. Proc. 1531, 284-287 (2013); doi: 10.1063/1.4804762.

Nakajima,T., Campanelli,M., Che,H., Estellés,V., Irie,H., Kim,S.-W., Kim,J., Liu,D., Nishizawa,T., Pandithurai,G., Soni,V.K., Thana,B., Tugjsurn,N.-U., Aoki,K., Hashimoto,M., Higurashi,A., Kazadzis,S., Khatri,P., Kouremeti,N., Kudo,R., Marengo,F., Momoi,M.,

Ningombam,S. S., Ryder,C.L., and Uchiyama,A.(2020) An overview and issues of the sky radiometer technology and SKYNET, Atmos. Meas. Tech., 13, 4195–4218, 2020, <https://doi.org/10.5194/amt-13-4195-2020>.

2.1.7 Next-Generation SBAS in the Arctic

Toru TAKAHASHI (ENRI MPAT)

Mitsunori KITAMURA (ENRI MPAT)

(1) Objectives

The aviation and maritime activities in the Arctic are growing with the recession of the Arctic sea ice. A model study suggested that the Global Navigation Satellite System (GNSS), which operates with the augmentation system such as the Satellite-based augmentation systems (SBAS) and Advanced Receiver Autonomous Integrity Monitoring (ARAIM), is effective for the navigation of aviation and maritime in the Arctic because of poor infrastructures (Reid et al., 2016). However, the current L1 SBAS broadcasts augmentation messages from geostationary (GEO) satellites, which are not available practically in the polar region at a latitude of 72 degrees or higher.

The Dual Frequency Multi Constellation Satellite Based Augmentation System (DFMC SBAS) has been standardized by the International Civil Aviation Organization (ICAO). Broadcasting augmentation messages from the Inclined Geosynchronous Orbit (IGSO) satellite is considered to be included in the future updates. The Electronic Navigation Research Institute (ENRI) developed the DFMC SBAS prototype based on the draft standards (Kitamura et al., 2018), and test messages are broadcasted from the Japanese Quasi-Zenith Satellite System (QZSS).

In the polar region, an auroral activity often generates the irregularity ionospheric plasma density and the ionospheric electric field is intensified simultaneously. The carrier phase of the GNSS signal is fluctuated by the auroral activity. Since the fluctuation sometimes causes the loss of lock on GNSS signals, the impact the auroral activity on the GNSS carrier phase should be investigated.

The main objective of this study is to evaluate the performance DFMC SBAS broadcasted from Japanese QZSS in the Arctic and mid-high latitude regions. To test the DFMC SBAS in the Arctic, we installed the GNSS antenna, GNSS receivers, DFMC SBAS receivers, and Inertial Measurement Unit (IMU) to oceanographic research vessel MIRAI.

(2) Parameters

Signals from GNSS satellites and Dual Frequency and Multi-Constellation (DFMC) Satellite Based Augmentation System (SBAS) messages transmitted from the Quasi-Zenith Satellite System (QZSS) are recorded by GNSS receivers. Performance (accuracy and integrity) of the DFMC SBAS from QZSS is evaluated in the on-board environment at mid to high latitudes.

(3) Instruments and methods

i. GNSS Receiver

A NovAtel OEM6 receiver recorded signals from GPS, Galileo, GLONASS, BeiDou, and QZSS at the frequency of L1, L2, and L5 bands. The receiver recorded the observation message, including the pseudorange and carrier phase, with a sampling rate of 10 Hz. The navigation message, including the satellite orbit information were also recorded.

A u-blox F9P also observed the GPS, Galileo, GLONASS, BeiDou, and QZSS signals and provided the antenna position by the NMEA format. A u-blox D9C recorded the MADOCA message broadcasted from QZSS satellite to derive the precise antenna position by a post processing.

ii. DFMC SBAS Message receivers

To obtain DFMC SBAS messages, a Furuno prototype DFMC SBAS receiver and CORE Chronosphere receivers were installed. The DFMC SBAS messages were generated by Electronic Navigation Research Institute (ENRI) and broadcasted from QZS02 and OZS04 satellites with a frequency of 1 Hz.

iii. Scintillation receiver

The GNSS signals are sometimes fluctuated by a combination of the ionospheric irregularity and electric field. The fluctuation is called scintillation and becomes a cause of the loss-of-lock GNSS signal. Since we need to receive the carrier phase with high and precise sampling to observe the scintillation, the Septentrio PolaRx5S, which records the GNSS signals with a sampling rate of 100 Hz.

iv. GNSS Antenna

The GNSS Antenna used was a Trimble GA830 capable of receiving L1, L2, and L5 bands. The antenna was designed for maritime and cold weather specification.

v. Inertial Measurement Unit (IMU)

It is challenging to differentiate GNSS signal fluctuations caused by ionospheric irregularities from those caused by vessel motion. The IMU recorded velocity and acceleration at the antenna's position, which are planned to be used to compensate for the vessel's motion.

(4) Station list or Observation log

This observation continuously conducted from 22 July 2025 to 25 August 2025.

(5) Preliminary Results

We successfully received ranging signals from GPS, Galileo, GLONASS, BeiDou, and QZSS using NovAtel receivers, as well as the DFMC SBAS messages transmitted from QZSS-02, and QZSS-04 during the cruise.

(6) Data archives

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

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

2.2 Geophysical survey

2.2.1 Sea Surface Gravity

Tetsuichi FUJIKI (JAMSTEC) - PI

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (NME)

Masanori MURAKAMI (MIRAI crew)

(1) Objectives

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

(2) Instruments and methods

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-G LaCoste, LLC) during this cruise. To convert the relative gravity to absolute gravity at Shimizu as the reference points. Parameters of gravity meter are as follows:

$$\begin{aligned} &\text{Relative Gravity [CU: Counter Unit]} \\ &[\text{mGal}] = (\text{coef1: } 0.9946) * [\text{CU}] \end{aligned}$$

(3) Preliminary results

Absolute gravity table is shown in Table 2.2.1-1.

Table 2.2.1-1 Absolute gravity table of this cruise

No.	Date m/d	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity Sensor *1 [mGal]	at S-116 Gravity [mGal]
#1	7/20	06:43	Sekinehama	980371.88	251	618	980372.85	12646.36
#2 *2	10/*	**.*	Shimizu	*****.*	***	***	*****.*	*****.*

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

*2: The scheduled date and port of the end of the next cruise.

(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.

< <https://www.godac.jamstec.go.jp/darwin/en> >

(5) Remarks

2.2.2 Sea surface three component magnetic field

Tetsuichi FUJIKI (JAMSTEC) - PI

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (NME)

Masanori MURAKAMI (MIRAI crew)

(1) Objectives

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 and methods

A shipboard three-component magnetometer system (Tierra Tecnica SFG2018) 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, PHINS). 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, $\mathbf{H}_{ob}$, (in the ship's fixed coordinate system) and the geomagnetic field vector, $\mathbf{F}$, (in the Earth's fixed coordinate system) is expressed as:

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

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

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

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

(4) Preliminary result

The results will be published after primary processing.

(5) 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.

< <https://www.godac.jamstec.go.jp/darwin/en> >

(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.

11:50UTC 30 Jul. 2025 - 12:16UTC 30 Jul. 2025 (32-20N, 144-32E)

19:08UTC 06 Aug. 2025 - 19:34UTC 06 Aug. 2025 (47-01N, 159-58E)

16:13UTC 21 Aug. 2025 - 16:36UTC 21 Aug. 2025 (50-05N, 152-39W)

- ii) The following period, navigation data (speed over ground, gyro, longitude, latitude and sea depth) were invalid.

23:20:37UTC 02 Aug. 2025 - 01:30:00UTC 03 Aug. 2025

- iii) The following periods, data acquisition was suspended due to system trouble.

00:15:40UTC 03 Aug. 2025 - 00:16:42UTC 03 Aug. 2025

00:18:03UTC 03 Aug. 2025 - 00:19:44UTC 03 Aug. 2025

00:29:24UTC 03 Aug. 2025 - 00:31:03UTC 03 Aug. 2025

00:37:24UTC 03 Aug. 2025 - 00:38:40UTC 03 Aug. 2025

00:39:14UTC 03 Aug. 2025

2.2.3 Swath bathymetry

Tetsuichi FUJIKI (JAMSTEC) - PI

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (NME)

Masanori MURAKAMI (MIRAI crew)

(1) Objectives

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

(2) Instruments and methods

The “SEABEAM 3012” on R/V MIRAI was used for bathymetry mapping during this cruise. To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data (6.62m), 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. The system configuration and performance are shown in Table 2.2.3-1.

Table 2.2.3-1 SEABEAM 3012 System configuration and performance

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

(3) Preliminary result

The results will be published after primary processing.

(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.

< <https://www.godac.jamstec.go.jp/darwin/en> >

(5) Remarks

- i) The following periods, data acquisition was suspended due to operating of ANS system.
 - 19:55UTC 30 Jul. 2025 - 23:06UTC 30 Jul. 2025
 - 20:51UTC 05 Aug. 2025 - 21:47UTC 05 Aug. 2025
 - 01:06UTC 09 Aug. 2025 - 02:07UTC 09 Aug. 2025
 - 19:10UTC 09 Aug. 2025 - 21:39UTC 09 Aug. 2025

- ii) The following period, data acquisition was suspended at the stationary observation point (47-00N, 180-00E).
 - 21:10UTC 14 Aug. 2025 - 08:12UTC 15 Aug. 2025

2.3 Physical oceanography

2.3.1 CTD

2.3.1.1 Routine measurements of CTDO₂

September 22, 2025

Hiroshi UCHIDA (JAMSTEC) (Principal Investigator)

Aine YODA (MWJ) (Operation Leader)

Nobuhiro FUJII (MWJ)

Yuki MIYAJIMA (MWJ)

Shintaro AMIKURA (MWJ)

(1) Objective

The CTDO₂/water sampling measurements were conducted to obtain vertical profiles of seawater properties by sensors and water sampling.

(2) Instruments and method

Instruments used in this cruise are as follows:

Winch and cable

Traction winch system (3.0 ton) (Dynacon, Inc., Bryan, Texas, USA) (Fukasawa et al. 2004)

Armored cable ($\phi = 9.53$ mm) (Rochester Wire & Cable LLC, Virginia, USA)

Compact underwater slip ring swivel (Hanayuu Co., Shizuoka, Japan) (Uchida et al., 2018)

Frame

592 kg stainless steel frame for 36-position 12-L water sample bottles

Aluminum rectangular fin (54 × 90 cm) to resist frame's rotation

Water sampler and sampling bottle

36-position carousel water sampler, SBE 32 (Sea-Bird Scientific, Washington, USA)

Serial no. 3254451-0826

12-L sample bottle, model OTE 110 (OceanTest Equipment, Inc., Florida, USA)

(Viton O-rings for #1 to #15, Nitril O-rings for #16 to #36, no TEFLON coating)

Deck unit

SBE11plus (Sea-Bird Scientific, Washington, USA)

Serial no. 11P39850-0705

Underwater unit

Pressure sensor, SBE 9plus (Sea-Bird Scientific)

Serial no. 09P54451-1027 (117457) (calibration date: December 6, 2024)

Deep ocean standard thermometer, SBE 35 (Sea-Bird Scientific)

Serial no. 22 (calibration date: February 11, 2025)

Temperature sensor, SBE 3Plus (Sea-Bird Scientific)

Primary, Serial no. 031525 (calibration date: Jun 14, 2024)

Secondary, Serial no. 034818 (calibration date: December 4, 2024)

Conductivity sensor, SBE 4C (Sea-Bird Scientific)

Primary, Serial no. 043036 (calibration date: November 27, 2024)

Secondary, Serial no. 041088 (calibration date: Jun 6, 2024)

Dissolved oxygen sensor, Primary, RINKO III (JFE Advantech Co., Ltd., Hyogo, Japan)

Serial no. 0287, Sensing foil no. 163011(in situ calibrated on MR25-02 cruise)
 Dissolved oxygen sensor, Secondary, SBE 43 (Sea-Bird Scientific)
 Serial no. 432211 (calibration date: October 11, 2024) for stations 1_1 to 4_4
 Serial no. 430949 (calibration date: December 16, 2023) for stations 4_4 to 12_3
 Transmissometer, C-Star, (Sea-Bird Scientific)
 Serial no. 2532DR (in situ calibrated on MR24-03 cruise)
 Chlorophyll fluorometer (Seapoint Sensors Inc., New Hampshire, USA)
 Serial no. 3701, Gain: 10X (0-15 ug/L)
 PAR sensor, PAR-Log ICSW (Sea-Bird Scientific)
 Serial no. 1026 (calibration date: July 6, 2015)
 Backscatter sensor, ECO BB(RT)D (Sea-Bird Scientific)
 Serial no. BBRTD-9098 (calibration date: September 13, 2024)
 Altimeter, PSA-916T (Teledyne Benthos, Inc., Massachusetts, USA)
 Serial no. 1100
 Pump, SBE 5T (Sea-Bird Scientific)
 Primary, Serial no. 055816
 Secondary, Serial no. 054598
 Bottom contact switch (Sea-Bird Scientific)

Other additional sensors

Upward and downward looking lowered acoustic Doppler current profilers (section 2.3.5)
 MicroRider (two FP07 micro temperature sensors) (section 2.3.4)
 Underwater Vision Profiler (UVP-6HF) (section 2.5.3)
 Other additional digital sensors (section 2.3.1.2)
 Refractive index density sensor
 Deep ocean fluorometer/turbidity sensor
 Deep ocean FDOM sensor
 PAR sensor
 Velocimeter
 CTDs for Deep ARGO float (see also section 2.3.8)

Software

Data acquisition software, SEASAVE-Win32, version 7.26.7.121
 Data processing software, SBEDataProcessing-Win32, version 7.26.7.129
 and some original modules

(3) Pre-cruise calibration

(3.1) Pressure

Pre-cruise sensor calibration for linearization was performed at Sea-Bird Scientific. The time drift of the pressure sensor was adjusted by periodic recertification corrections by using electric dead-weight testers (model E-DWT-H A70M, Fluke Co., Arizona, USA) and a barometer (model RPM4 BA100Ks, Fluke):

Serial no. 181 (A70M) (for 10-70 MPa) (calibration date: January 6, 2023)

Serial no. 1453 (BA100Ks) (for 0 MPa) (calibration date: January 6, 2023)

These reference pressure sensors were calibrated by Ohte Giken, Inc. (Ibaraki, Japan) traceable to National Institute of Standards and Technology (NIST) pressure standards. The pre-cruise

correction was performed at JAMSTEC (Kanagawa, Japan) by Marine Works Japan Ltd. (MWJ) (Kanagawa, Japan).

(3.2) Temperature sensors

Pre-cruise sensor calibrations of the SBE 3s were performed at Sea-Bird Scientific. Pre-cruise sensor calibration of the SBE 35s for linearization were also performed at Sea-Bird Scientific. The slow time drift of the SBE 35 was adjusted by periodic recertification corrections by measurements in thermodynamic fixed-point cells (water triple point [0.01 °C] and gallium melt point [29.7646 °C]) (Uchida et al., 2015). Since 2016, pre-cruise calibration was performed at JAMSTEC by using fixed-point cells traceable to National Institute of Standards and Technology (NIST) and National Metrology Institute of Japan (NMIJ) temperature standards (Fig. 2.3.1-1).

Triple Point of Water cell: serial no. 1094 (model 5901D-Q, Fluke)

Melting Point of Gallium cell: serial no. Ga-43129 (model 5943, Fluke)

Temperature dependency of the SBE 3 was corrected as follows.

$$T_{cor} = T - c_0 P$$

where T is raw data, T_{cor} is corrected temperature, P is pressure in dbar, and c₀ is the correction coefficient.

c₀ = 4.82189276e-09 (for primary temperature sensor [serial no. 031525])

The correction coefficient for the secondary temperature sensor was not determined yet since the probe of the secondary sensor was new.

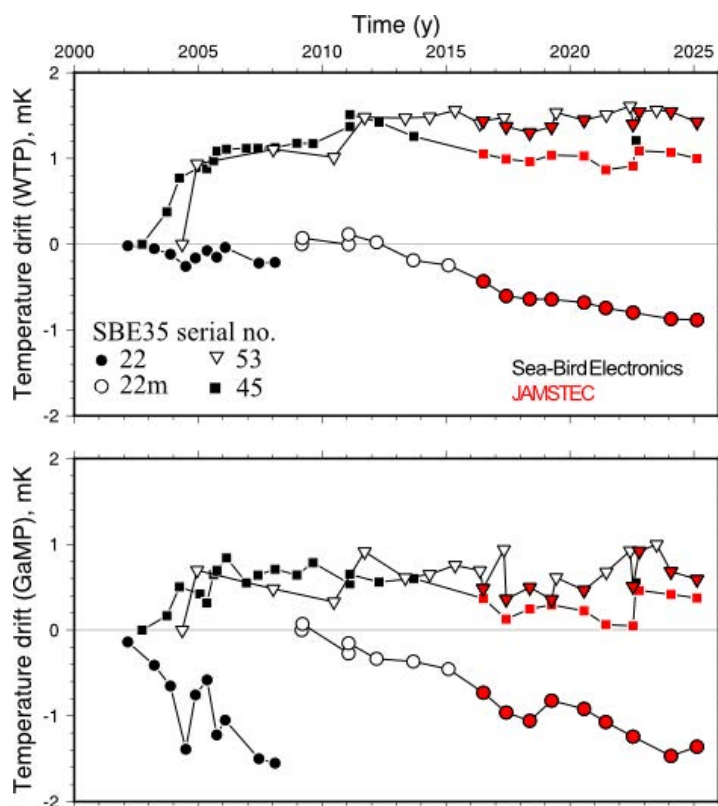


Fig. 2.3.1-1. Time drifts (temperature offsets relative to the first calibration) of four SBE 35s based on laboratory calibrations in fixed-point cells (water triple point: WTP, gallium melt

point: GaMP).

(3.3) Conductivity sensors

Pre-cruise sensor calibrations were performed at Sea-Bird Scientific.

(3.4) Dissolved oxygen sensors

Pre-cruise sensor in-situ calibration of RINKO sensor was performed on the previous cruise. Pre-cruise sensor calibration of SBE 43 was performed at Sea-Bird Scientific.

(3.5) Transmissometer

Light transmission (T_r in %) is calibrated as

$$T_r = (V - V_d) / (V_r - V_d) \times 100$$

where V is the measured signal (voltage), V_d is the dark offset for the instrument, and V_r is the signal for clear water. V_d can be obtained by blocking the light path. Pre-cruise sensor in-situ calibration of transmissometer was performed on the previous cruise.

(3.6) Chlorophyll fluorometer, PAR, backscatter sensor, altimeter

Periodic recertification was not performed by the manufacturer for these sensors.

(4) Data Collection and processing

(4.1) Data collection

The CTD system was powered on at least 15 minutes in advance of the data acquisition to stabilize the pressure sensor. The data was acquired at least two minutes before and after the CTD cast to collect atmospheric pressure data on the ship's deck.

The CTD package was lowered into the water from the starboard side and held 10 m beneath the sea-surface to activate the pump. After the pump was activated, the package was lifted to the surface and lowered at a rate of 1.0 m/s to 200 m then the package was stopped to operate the heave compensator of the crane. The package was lowered again and at 1.0 m/s and after passing the depths where vertical gradient of water properties was large, it was lowered at a rate of 1.2 m/s to the bottom. For the up cast, the package was lifted at a rate of 1.2 m/s except for bottle firing stops. As a rule, the bottle was fired after waiting from the stop for more than 30 seconds and the package was stayed at least 5 seconds for measurement of the SBE 35 at each bottle firing stops. For depths where vertical gradient of water properties was expected to be large, the bottle was fired after waiting from the stop for 60 seconds to enhance changing the water between inside and outside of the bottle. At 200 m from the surface, the package was stopped to stop the heave compensator of the crane.

(4.2) Data collection problems

At station 004_3, data from the SBE 43 sensor were noisy between 744 and 811 dbar, and between 1919 and 1942 dbar during the down cast. Although the connectors were cleaned and the cables connected to the sensor were replaced after the cast, data from the sensor were still noisy at the next cast (004_4). Therefore, the SBE 43 sensor was replaced with another SBE 43 (serial no. 0949) after the cast (004_4).

(4.3) Data Processing

The following are the data processing software (SBEDataProcessing-Win32) and original software data processing module sequence and specifications used in reduction of CTD data in this cruise.

(The process in order)

DATCNV converted the raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. The scan duration to be included in bottle file was set to 4.4 seconds, and the offset was set to 0.0 seconds. The hysteresis correction for the SBE 43 data (voltage) was applied for both profile and bottle information data.

TCORP (original module, version 1.1) corrected the pressure sensitivity of the temperature (SBE3) sensor for both profile and bottle information data.

RINKOCOR (original module, 1.0) 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 created a summary of the bottle data. The data were averaged over 4.4 seconds.

ALIGNCTD converted 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. For a SBE 9plus CTD with the ducted temperature and conductivity sensors and a 3000-rpm pump, the typical net advance of the conductivity relative to the temperature is 0.073 seconds. So, the SBE 11plus deck unit was set to advance the primary and the secondary conductivity for 1.75 scans ($1.75/24 = 0.073$ seconds). Oxygen data are also systematically delayed with respect to depth mainly because of the long-time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing the SBE 43 oxygen sensor output (voltage) relative to the temperature data. Delay of the RINKOIII data was also compensated by 1 second advancing sensor output (voltage) relative to the temperature data. Delay of the transmissometer data was also compensated by 2 seconds advancing sensor output (voltage) relative to the temperature data.

WILDEDIT marked 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, and SBE 43 output.

CELLTM used a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. Typical values for SBE 9plus with TC duct and 3000 rpm pump which were 0.03 for thermal anomaly amplitude alpha and 7.0 for the time constant $1/\beta$ were used.

FILTER performed a low-pass filter on pressure and depth 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 performed as a median filter to remove spikes in transmissometer data and fluorometer data. A median value was determined by 49 scans of the window.

SECTIONU (original module, version 1.1) selected 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 was set to be the end time when the depth of the package was 1 dbar below the surface. The minimum and maximum numbers were automatically calculated in the module.

LOOPEDIT marked 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, version 1.0) removed 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 RINKO III output.

DERIVE was used to compute dissolved oxygen (SBE43), salinity, potential temperature, and sigma-theta.

BINAVG averaged the data into 1-decibar pressure bins and 1-sec time bins. The center value of the first bin was set equal to the bin size. The bin minimum and maximum values are the center values plus and minus half the bin size. Scans with pressures greater than the minimum and less than or equal to the maximum were averaged. Scans were interpolated so that a data recorded exist every dbar.

BOTTOMCUT (original module, version 0.1) deleted the deepest pressure bin when the averaged scan number of the deepest bin was smaller than the average scan number of the bin just above.

SPLIT was used to split data into down cast and up cast.

Remaining spikes in the CTD data were manually eliminated from the 1-dbar-averaged data. And the data gaps resulting from the elimination were linearly interpolated with a quality flag of 6. The transmissometer data between 681 and 2243 dbar of down cast at station 006_1 were noisy. Therefore, the up cast data at those depths were inserted into the down cast profile to eliminate the noise.

(5) Post-cruise calibration

(5.1) Pressure

The CTD pressure sensor offset (-0.11 dbar) in the period of the cruise was estimated from the pressure readings on the ship's deck at the pre- and post-cast by subtracting the atmospheric pressure deviation from a standard atmospheric pressure (1013.25 hPa) (Fig. 2.3.1-2). The post-cruise correction of the pressure data is not deemed necessary for the pressure sensor.

(5.2) Temperature

The CTD temperature sensors (SBE 3) were calibrated with the SBE 35 under the assumption that discrepancies between SBE 3 and SBE 35 data were due to pressure sensitivity, the viscous heating effect, and time drift of the SBE 3 (Uchida et al., 2015). The CTD temperature was calibrated as

$$\text{Calibrated temperature} = T - (c0 \times P + c1 \times t + c2)$$

where T is CTD temperature in °C, P is pressure in dbar, t is time in days from pre-cruise calibration date of the CTD temperature and c0, c1, and c2 are calibration coefficients. The coefficients for the primary temperature sensor were determined using the data for the depths deeper than 950 dbar.

$$c0 = 0.0, c1 = 3.67282322e-06, c2 = -7.1960e-04 \text{ (for primary sensor)}$$

Since the pressure sensitivity of the primary sensor have been corrected through the pre-cruise calibration, so the correction coefficient (c0) was set to zero here. The result of the post-cruise calibration for the CTD temperature is shown in Fig 2.3.1-3.

(5.3) Conductivity

The discrepancy between the CTD conductivity and the conductivity calculated from the bottle sampled salinity data with the CTD temperature and pressure data is considered to be a function of conductivity, pressure and time. The CTD conductivity was calibrated as

$$\text{Calibrated conductivity} = C - (c0 \times C + c1 \times P + c2 \times C \times P + c3 \times P^2 + c4 \times t + c5)$$

where C is CTD conductivity in S/m, P is pressure in dbar, t is time in days and c0 – c5 are calibration coefficients. The coefficients for the primary conductivity sensor were determined.

$$c0 = 1.9118732055e-04, c1 = -1.7816216398e-06, c2 = 6.0286143497e-07,$$

$$c3 = -2.5588792860e-11, c4 = 6.8192542701e-07, c5 = -5.3969483565e-04$$

(for primary conductivity sensor)

The result of the post-cruise calibration for the CTD salinity is shown in Fig. 2.3.1-4.

(5.4) Dissolved oxygen

Data from the RINKO can be corrected for the time-dependent, pressure-induced effect by means of the same method as that developed for the SBE 43 (Edwards et al., 2010). The calibration coefficients, H1 (amplitude of hysteresis correction), H2 (curvature function for hysteresis), and H3 (time constant for hysteresis) were determined to minimize the down cast and up cast data.

$$H1 = 0.005, H2 = 5000.0, H3 = 2000.0$$

Outputs from RINKO are the raw phase shift data. The RINKO can be calibrated by the modified Stern-Volmer equation slightly modified from a method by Uchida et al. (2010):

$$O_2 (\mu\text{mol/l}) = [(V0 / V)^E - 1] / K_{sv}$$

where V is voltage, V0 is voltage in the absence of oxygen, Ksv is Stern-Volmer constant. The coefficient E corrects nonlinearity of the Stern-Volmer equation. The V0 and the Ksv are assumed to be functions of temperature as follows.

$$K_{sv} = c0 + c1 \times T + c2 \times T^2$$

$$V0 = 1 + d0 \times T$$

$$V = d1 + d2 \times Vb + d3 \times t + d4 \times t \times Vb$$

where T is CTD temperature (°C) and Vb is raw output (volts). V0 and V are normalized by the output in the absence of oxygen at 0°C, and t is working time (days) integrated from the first CTD cast. The oxygen concentration is calculated using accurate temperature data from the CTD temperature sensor instead of temperature data from the RINKO. The pressure-compensated oxygen concentration O2c can be calculated as follows.

$$O2c = O2 (1 + cp \times P / 1000)$$

where P is CTD pressure (dbar) and cp is the compensation coefficient. Since the sensing foil of

the optode is permeable only to gas and not to water, the optode oxygen must be corrected for salinity. The salinity-compensated oxygen can be calculated by multiplying the factor of the effect of salt on the oxygen solubility (García and Gordon, 1992).

$$\begin{aligned} c0 &= 4.164828385574897e-03, c1 = 1.526960195983685e-04, \\ c2 &= 3.383520108341076e-06, \\ d0 &= -1.249139230710780e-03, d1 = -7.446960851432075e-02, \\ d2 &= 3.180458169660472e-01, \\ d3 &= -1.035079239242855e-03, d4 = 5.650087574386256e-04, \\ E &= 1.2, cp = 0.025 \end{aligned}$$

The result of the post-cruise calibration for the RINKO oxygen is shown in Fig. 2.3.1-5.

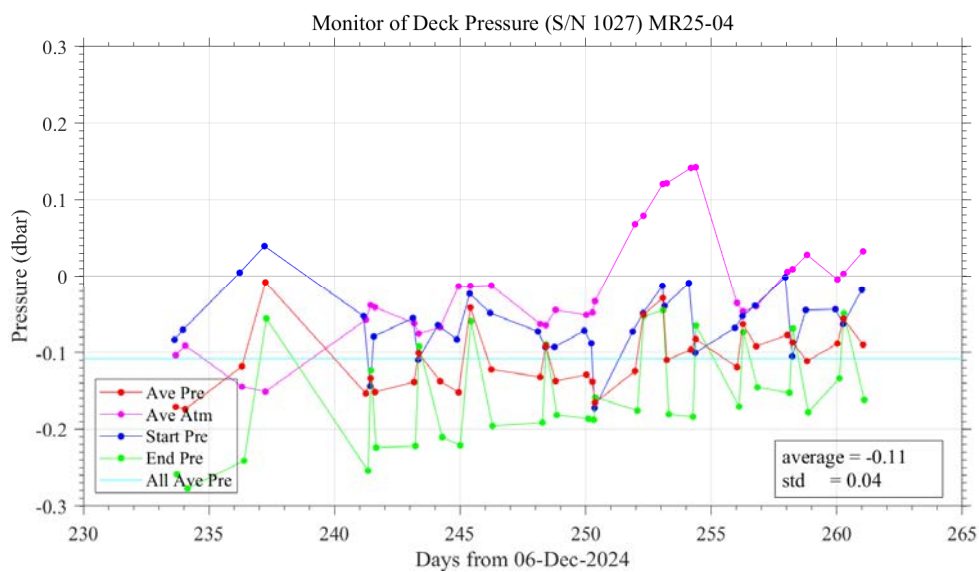


Fig. 2.3.1-2. Time series of the CTD deck pressure. Atmospheric pressure deviation from a standard atmospheric pressure (magenta dots) was subtracted from the CTD deck pressure. Blue and green dots indicate pre- and post-cast deck pressures, respectively. Red dots indicate averages of the pre- and the post-cast deck pressures.

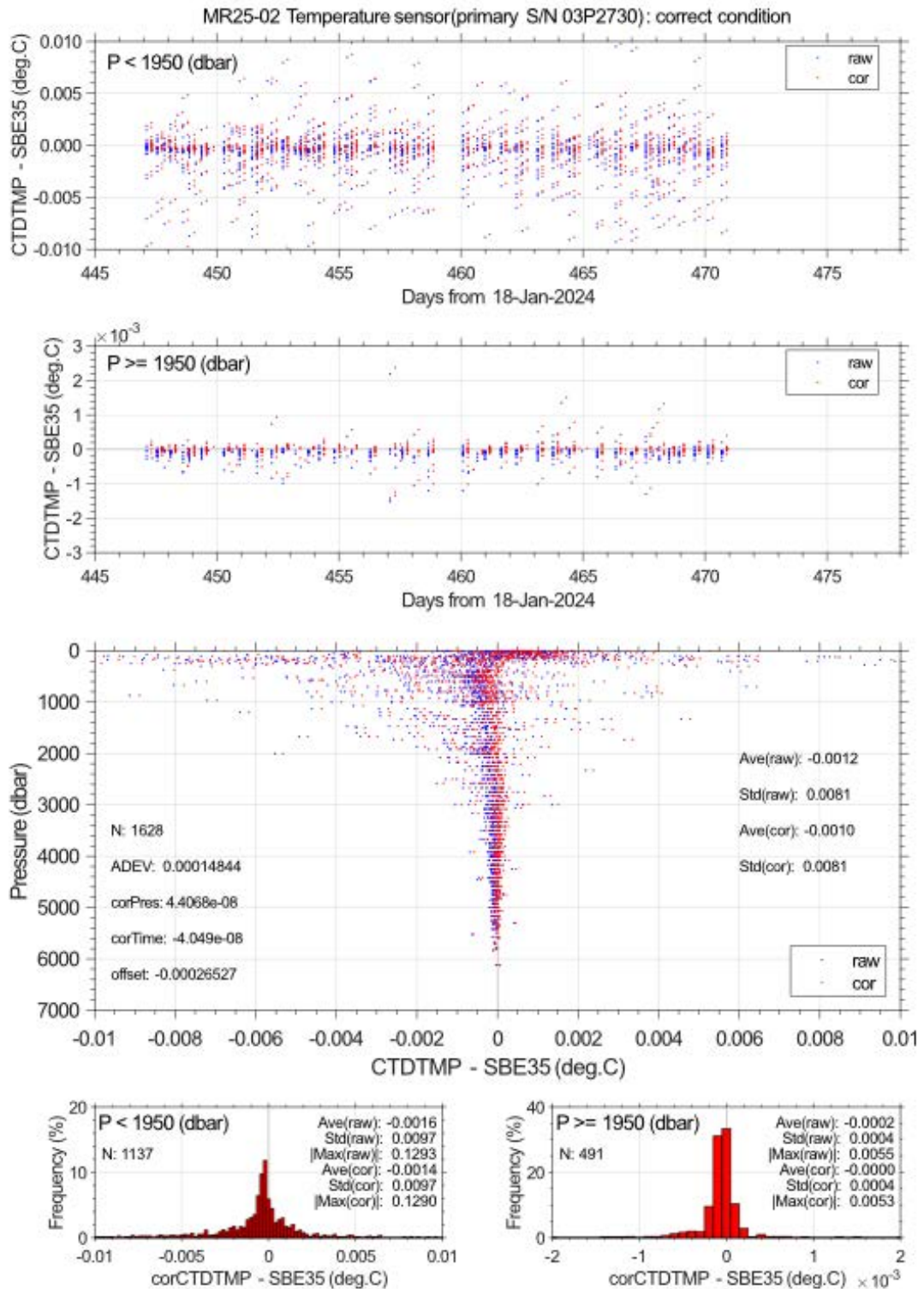


Fig. 2.3.1-3. Difference between the CTD temperature (primary) and the SBE 35. Blue and red dots indicate before and after the post-cruise calibration using the SBE 35 data, respectively.

Salinity (primary) S/N:043036 MR25-04

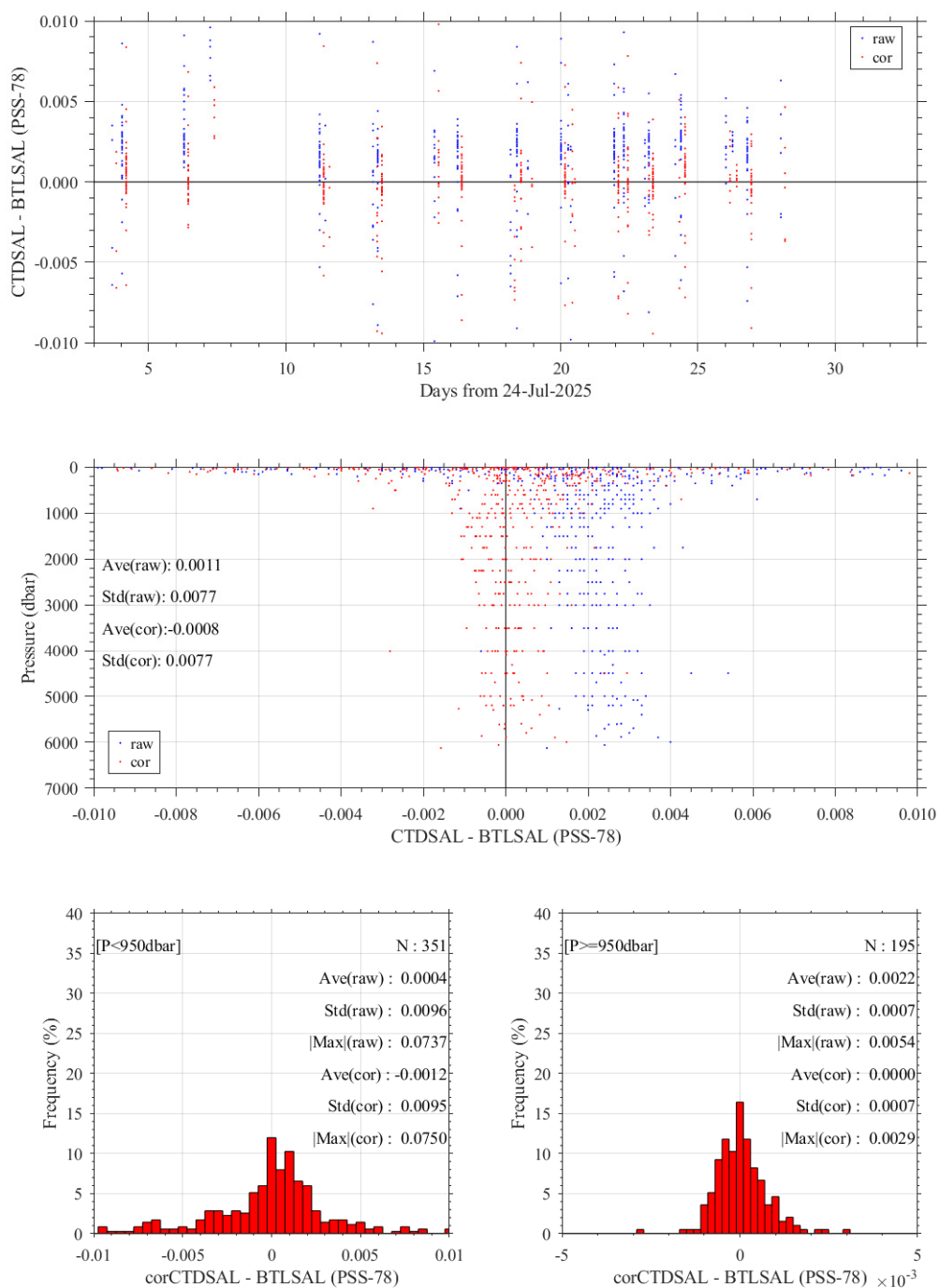


Fig. 2.3.1-4. Difference between the CTD salinity (primary) and the bottle salinity. Blue and red dots indicate before and after the post-cruise calibration, respectively.

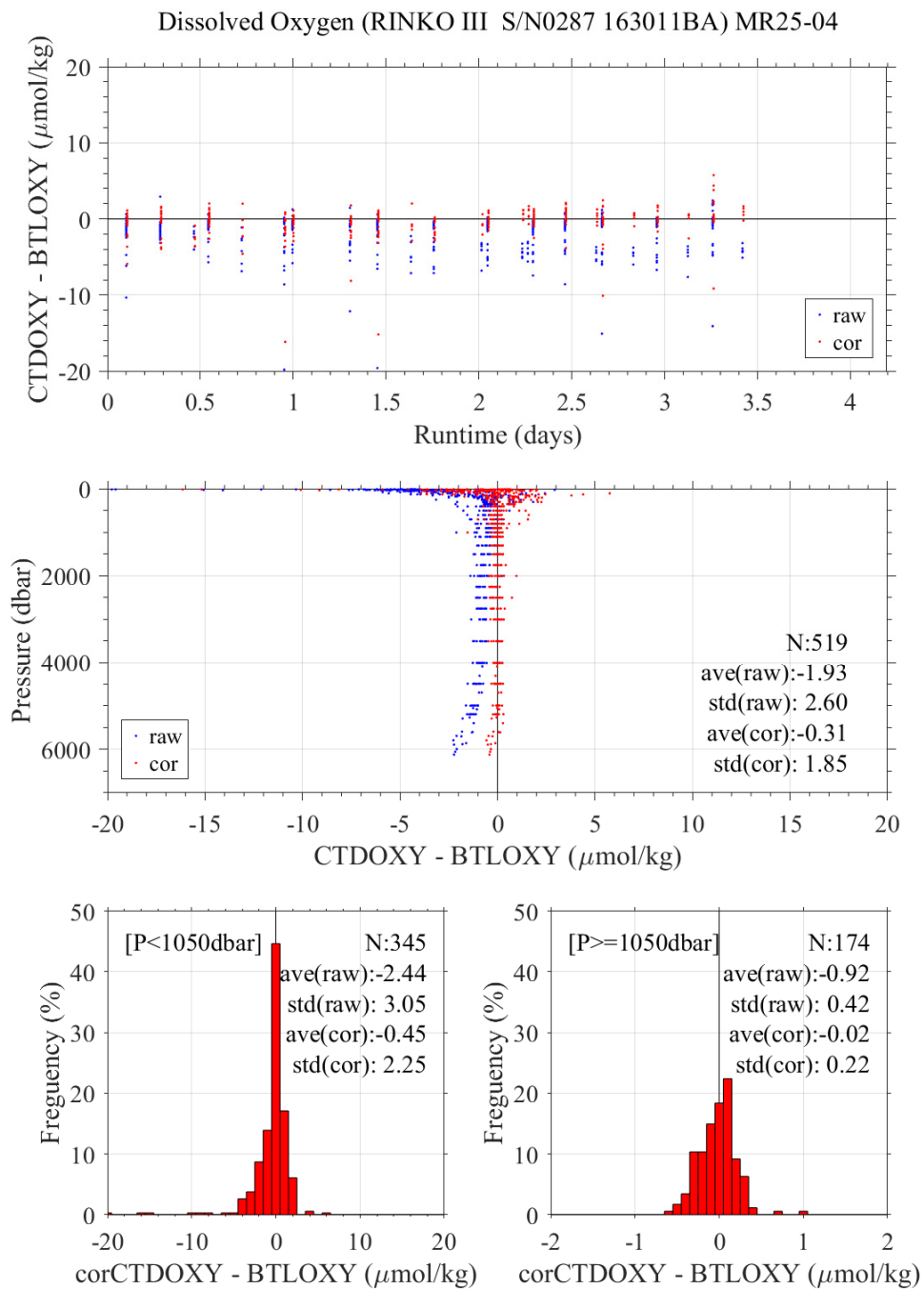


Fig. 2.3.1-5. Difference between the CTD oxygen and the bottle oxygen. Blue and red dots indicate before and after the post-cruise calibration, respectively.

(6) References

- Edwards, B., D. Murphy, C. Janzen and N. Larson (2010): Calibration, response, and hysteresis in deep-sea dissolved oxygen measurements, *J. Atmos. Oceanic Technol.*, 27, 920–931.
- Fukasawa, M., T. Kawano and H. Uchida (2004): Blue Earth Global Expedition collects CTD data aboard Mirai, BEAGLE 2003 conducted using a Dynacon CTD traction winch and motion-compensated crane, *Sea Technology*, 45, 14–18.
- García, H. E. and L. I. Gordon (1992): Oxygen solubility in seawater: Better fitting equations. *Limnol. Oceanogr.*, 37 (6), 1307–1312.
- Uchida, H., G. C. Johnson, and K. E. McTaggart (2010): CTD oxygen sensor calibration procedures, The GO-SHIP Repeat Hydrography Manual: A collection of expert reports and guidelines, IOCCP Rep., No. 14, ICPO Pub. Ser. No. 134.
- Uchida, H., Y. Maeda and S. Kawamata (2018): Compact underwater slip ring swivel: Minimizing effect of CTD package rotation on data quality, *Sea Technology*, 11, 30–32.
- Uchida, H., T. Nakano, J. Tamba, J. V. Widiatmo, K. Yamazawa, S. Ozawa and T. Kawano (2015): Deep ocean temperature measurement with an uncertainty of 0.7 mK, *J. Atmos. Oceanic Technol.*, 32, 2199–2210.

(7) Data archive

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

2.3.1.2 Additional digital sensors for CTD measurement

September 18, 2025

Hiroshi UCHIDA (JAMSTEC RIGC)

(1) Objective

To obtain vertical profiles of seawater properties by using a data logger and several digital sensors, including sensors currently under development, that cannot be connected to the CTD to acquire data.

(2) Instruments and method

Instruments used in this cruise are as follows:

Refractive index density sensor (Uchida et al. 2019)

Serial no. 2

(internal memory with the external battery [56 D size alkaline batteries])

Data logger (two 16 bit A/D channels and four serial [RS-232C] channels, JAMSTEC)

Serial channel for the data logger #1

Deep-ocean fluorometer/turbidity sensor, ACLD70-CAR (JFE Advantech)

Serial no. 0002

Deep-ocean FDOM sensor, AOMD-CAR (JFE Advantech)

Serial no. 0001

PAR sensor, MPE-PAR-HP (Biospherical Instruments Inc., California, USA)

Serial no. 3551

Velocimeter, MiniSVS OEM (Teledyne Valeport Ltd., Totnes, UK)

Serial no. 24001 (sound path length: 5 cm)

Serial channel for the data logger #2 (see section 2.3.8)

CTD for Deep ARGO float, SBE 61 (Sea-Bird Scientific)

Serial no. 61-6160

CTD for Deep ARGO float, SBE 61 (Sea-Bird Scientific)

Serial no. 61-6188

CTD for Deep ARGO float, SBE 41CP (Sea-Bird Scientific)

Serial no. 41-20600

The refractive index density sensor was powered from an external battery synchronized with the power supply of the CTD and recorded data in its internal memory at a rate of 32 Hz.

The data logger and its connected sensors were powered from the CTD9plus and the data logger recorded data from the connected sensors in its internal memory at a rate of 12 Hz for the data logger #1. No data was obtained for station 010_3 due the data logger failure.

The deep ocean FDOM sensor data were largely affected by the deep ocean fluorometer/turbidity sensor signal. Therefore, the two sensors were installed at a distance (more than 1 meter) from each other.

(3) Data Processing
(unfinished)

(4) Post-cruise calibration

The refractive index density sensor, the sound velocity sensor, the FDOM sensor (AOMD-CAR), and the fluorometer (ACLD70-CAR) will be calibrated in situ by using analyzed data for the seawater samples after the cruise.

These obtained data will be combined with the CTD data.

(5) Reference

Uchida, H., Y. Kayukawa, and Y. Maeda (2019): Ultra high-resolution seawater density sensor based on a refractive index measurement using the spectroscopic interference method. Sci. Rep., 9:15482, doi:10.1038/s41598-019-52020-z.

(6) 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.

2.3.2 Salinity

September 11, 2025

Hiroshi UCHIDA (JAMSTEC)

(1) Objective

Bottle salinities were measured to calibrate the CTD and thermo-salinograph salinity data and to collect bucket sampling salinity data. Salinity samples collected by the Remote Automatic Sampler (RAS) were also measured.

(2) Instruments and method

Salinity measurement was conducted basically based on the method by Kawano (2010) with modification of the time drift correction method (Uchida et al., 2020). Materials used in this cruise are as follows:

Standard Seawater: IAPSO Standard Seawater, Ocean Scientific International Ltd., Hampshire, UK
Batch P168

Salinometer: Autosal model 8400B; Guildline Instruments, Ltd., Ontario, Canada
Serial no. 72824

A peristaltic-type sample intake pump: Ocean Scientific International Ltd.

Thermometers: PRT model 1502A, Fluke Co., Everett, Washington, USA

Serial no. B81550 (for monitoring the bath temperature)

Serial no. B78466 (for monitoring the room temperature)

Stabilized power supply: model PCR1000LE, Kikusui Electronics Co., Japan
Serial no. XH004198

Data acquisition software: Vs8400B, Virtual Systems Co., Japan
Version 1.05T, Rev.02

Sample bottles:

250 mL brown borosilicate glass bottles with translucent screw caps (PTFE packing)

Secondary Standard Seawater: Multiparametric Standard Seawater, KANSO TECHNOS Co., Ltd.
Lot PRE20, PRE21

The bath temperature of the salinometer was set to 24 °C. The salinometer was standardized previously by using the IAPSO Standard Seawater (SSW). The standardization dial was set to 481 for serial no. 72824 and never changed during the cruise. The mean with standard deviation of the STANDBY, ZERO value, the bath temperature, and the ambient temperature was listed in Table 2.3.2-1.

The double conductivity ratios measured by the salinometer were used to calculate Practical Salinity using the algorithm for Practical Salinity Scale 1978 (IOC et al., 2010). A constant temperature of 24 °C was used in the calculation instead of using the measured bath temperature.

Table 2.3.2-1. Mean with standard deviation of the STANDBY, ZERO, bath temperature and room temperature.

Variable	Salinometer sn. 72824
STANDBY	5959 ± 1.4
ZERO	0.00000 ± 0.00001
Bath temperature	24.024 ± 0.0008 °C
Room temperature	22.5 ± 0.8 °C

(3) Results

Ultra-pure water (Milli-Q water, Millipore, Billerica, Massachusetts, USA) and the IAPSO SSW were measured at the beginning and the end of the measurements for each day. Time-series of the measured Practical Salinity are shown in Fig. 2.3.2-1. Correction factors of the salinometer were estimated from the mean Practical Salinity value of the SSW measurements and the certified Practical Salinity value for each day (Uchida et al., 2020). The measured Practical Salinities for the water samples were corrected by using the correction factors. The standard deviation of the IAPSO SSW measurements was 0.0002 in Practical Salinity.

A total of 37 pairs of replicate samples was collected and the SD of the replicate samples was 0.00040 in Practical Salinity.

Results of the Multiparametric Standard Seawater (MSSW) (Uchida et al., 2025) measurements are listed in Table 2.3.2-2.

Table 2.3.2-2. Mean with standard deviation of the MSSW measurements.

Lot	Number of measurements	Mean	SD
PRE20	4	34.2771	0.0007
PRE21	5	34.3156	0.0002

(4) 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, UNESCO (English), 196 pp.
- Kawano, T. (2010): Salinity. The GO-SHIP Repeat Hydrography Manual: A collection of Expert Reports and Guidelines, IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1.
- Uchida, H., T. Kawano, T. Nakano, M. Wakita, T. Tanaka and S. Tanihara (2020): An updated batch-to-batch correction for IAPSO standard seawater. *J. Atmos. Oceanic Technol.*, 37, 1507-1520, doi:10.1175/JTECH-D-19-0184.1.
- Uchida, H., et al. (2025): Development of Multiparametric Standard Seawater (MSSW) for CO₂ parameters, dissolved oxygen, and density of seawater. *Springer Oceanography*, doi:10.1007/978-981-96-2520-8_12

(5) Data archive

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

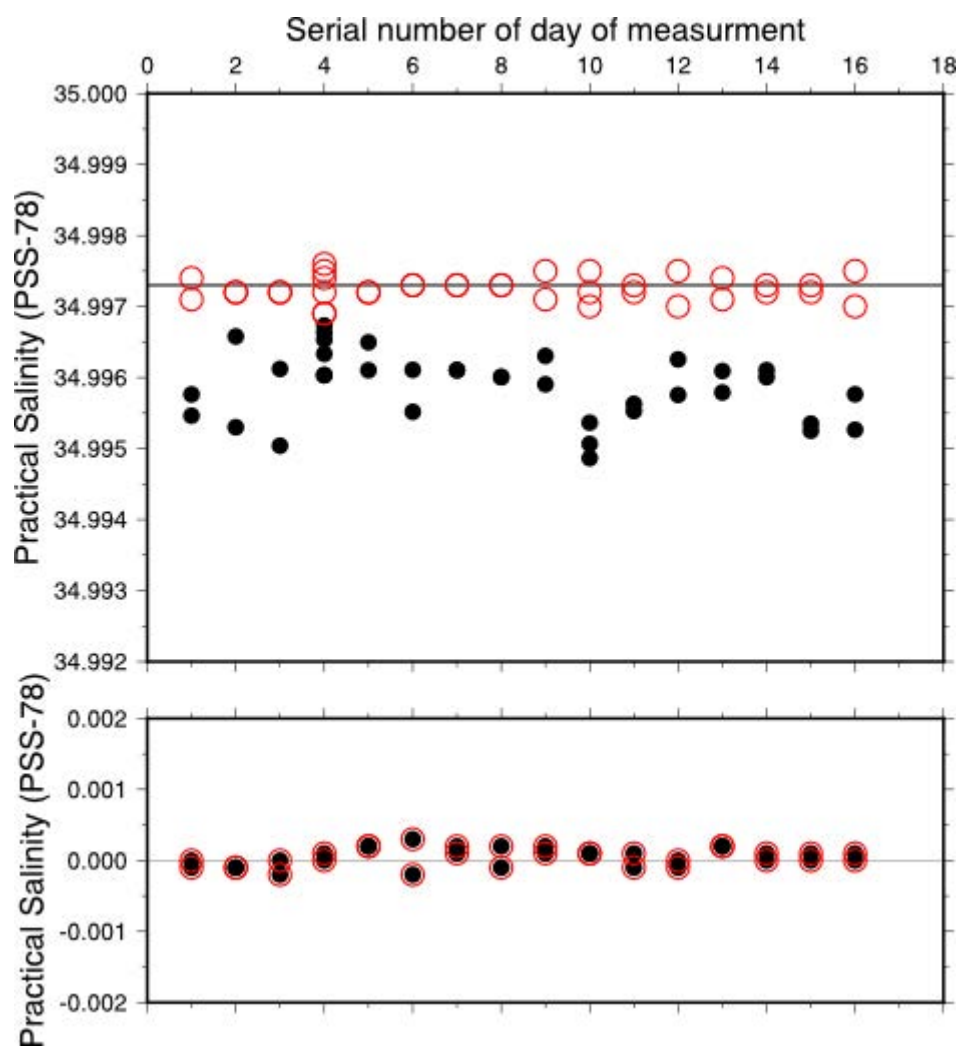


Figure 2.3.2-1. Time-series of the measured Practical Salinities for the ultra-pure water (lower panel) and the IAPSO SSW (upper panel) (black circles). The time-drift corrected Practical Salinities for the IAPSO SSW were also shown (red circles).

2.3.3 Seawater density

September 11, 2024

Hiroshi UCHIDA (JAMSTEC RIGC)

(1) Objective

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

(2) Instruments and method

Seawater density for water samples was measured with a vibrating-tube density meter (DMA 5000M [serial no. 80570578], Anton-Paar GmbH, Graz, Austria) with a sample changer (Xsample 122 [serial no. 8548492], Anton-Paar GmbH). The sample changer was used to load samples automatically from up to ninety-six 12-mL glass vials.

The water samples collected in 250 mL brown borosilicate glass bottles with translucent screw caps (PTFE packing) for practical salinity measurement were measured by taking the water sample into a 12-mL glass vial for each bottle just before practical salinity measurement. 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 °C by the density meter.

The density meter was initially calibrated by measuring air and pure water according to the instrument manual. However, measured density for IAPSO Standard Seawater deviates from density of TEOS-10 calculated from practical salinity and composition of seawater, probably due to non-linearity of the density meter (Uchida et al., 2011). The non-linearity can be corrected by measuring a reference sample simultaneously as:

$$\rho_{\text{corr}} = \rho - (\rho_{\text{ref}} - \rho_{\text{ref_true}}) + c (\rho - \rho_{\text{ref_true}}),$$

where ρ_{corr} is the corrected density of the sample, ρ is measured density of the sample, ρ_{ref} is measured density of the reference, $\rho_{\text{ref_true}}$ is true density of the reference, and c is non-linearity correction factor.

Time drift of the density meter was monitored by periodically measuring the density of ultra-pure water (Milli-Q water, Millipore, Billerica, Massachusetts, USA) produced on the R/V Mirai and pure water (Pure Water [water hardness 0], Ako Kasei Co. Ltd., Ako Hygo, Japan) made from seawater collected from a depth of 344 m off Muroto, Kochi, Japan, by filtering twice with a reverse osmosis membrane. In addition, Pure Water was deionized using ion exchange resin (Pure Maker, Sanei Corp., Arao, Kumamoto, Japan) conducted on 6 October 2019 and stored in a 2-L PET bottle at room temperature. The true density at 20 °C of the Pure Water was estimated to be 998.2074 kg m⁻³ from the isotopic composition ($\delta\text{D} = -3.4 \text{ ‰}$, $\delta^{18}\text{O} = -1.3 \text{ ‰}$) and International Association for the Properties of Water and Steam (IAPWS)-95 standard.

Although the non-linearity factor is estimated to be 0.000341 for the density meter (serial no. 80570578), additional correction for time drift of the non-linearity factor of the density meter was carried out by periodically measuring the density of the IAPSO Standard Seawater (batch P168). True density at 20 °C for the batch P167 at August 2025 is estimated to be 1024.7666 kg/m³ from Practical Salinity and composition changes of Standard Seawater using TEOS-10 (see Uchida et al. 2025).

(3) Results

Absolute Salinity (also called density salinity, “DNSSAL”) can be back calculated from the measured density and temperature (20 °C) with TEOS-10. A total of 21 pairs of replicate samples was measured and the standard deviation of the replicate samples was 0.0015 g/kg. The measured Absolute Salinity anomalies (δS_A) are shown in Fig. 2.3.3-1. The measured δS_A were well agree with the δS_A estimated from Pawlowicz et al. (2011) which exploits the correlation between δS_A and nutrient concentrations and carbonate system parameters based on mathematical investigation using a model relating composition, conductivity and density of arbitrary seawaters.

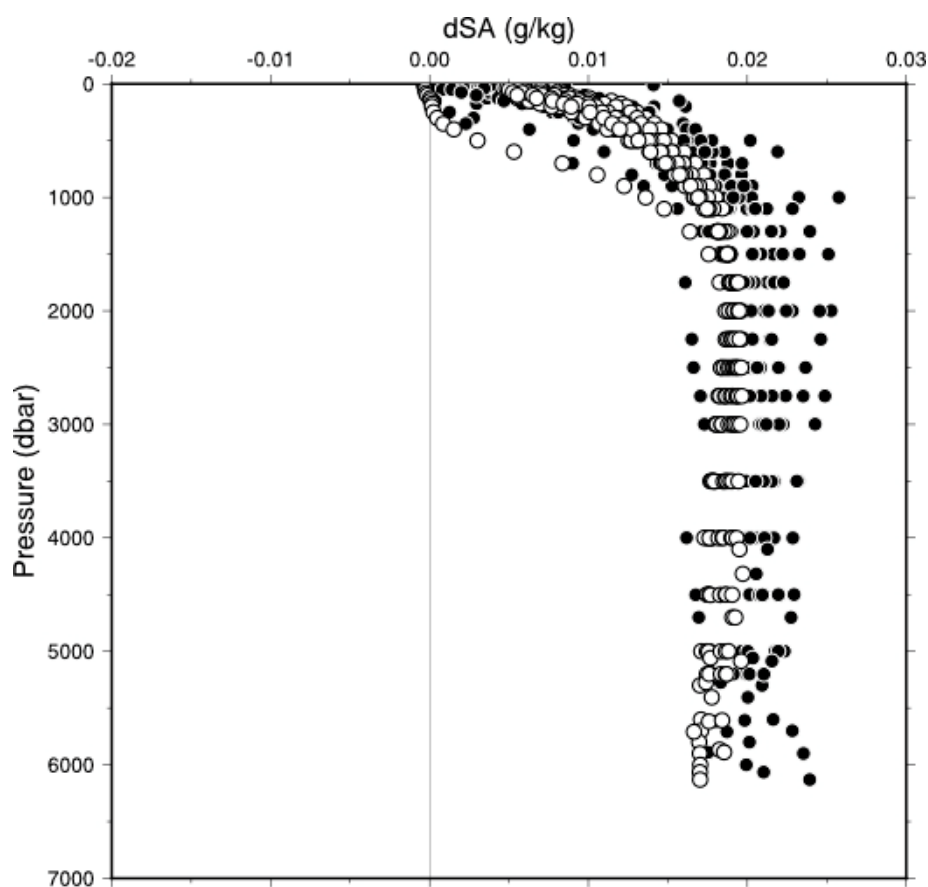


Figure 2.3.3-1. Vertical distribution of density salinity anomaly measured by the density meter (closed circles). Absolute salinity anomaly estimated from nutrients and carbonate system parameters (Pawlowicz et al., 2011) are also shown (open circles).

(4) 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, UNESCO (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.

Uchida, H., M. Wakita, A. Makabe, A. Murata and A. Petrovic (2025): Changes of the Composition of International Association for the Physical and Sciences of the Ocean Standard Seawater. In: Aoyama, M., Cheong, C., Murata, A. (eds) *Chemical Reference Materials for Oceanography*. Springer Oceanography. Springer, Singapore. https://doi.org/10.1007/978-981-96-2520-8_10

(6) Data archive

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

2.3.4 Ocean turbulence

September 10, 2025

Shinya KOUKETSU (JAMSTEC RIGC) (not onboard)

Hiroshi UCHIDA (JAMSTEC RIGC)

Aine YODA (MWJ)

Nobuhiro FUJII (MWJ)

Yuki MIYAJIMA (MWJ)

Shintaro AMIKURA (MWJ)

(1) Objective

The objective is to measure microstructure in temperature to evaluate ocean mixing.

(2) Instruments and method

Microstructure observations were carried out by MR6000 (Rockland Scientific International Inc.), which were mounted on the CTD rosette and were powered from the CTD (SBE 9plus). We installed two fast response thermistors (FP07) on MR6000 to measure microstructure in temperature. We had to replace probes for performance evaluation of the probes. Low-frequency profiles of temperature and conductivity were recorded in MR6000 with the input from the secondary SBE 3 and SBE 4 sensors on the CTD system. We downloaded the raw data from the instruments after each cast. We plan to examine methods for calibration and quality check of the data after the cruise.

(3) Measurements

Microstructure measurements were conducted by using the following thermistors (FP07):

Sensor socket 1:

T1973 for the CTD casts from 002_01 to 006_01, from 011_01 to 012_03

T1341 for the CTD casts from 006_02 to 010_03

Sensor socket 2:

T2787 for the CTD casts from 002_01 to 009_02, from 011_01 to 012_03

T1320 for the CTD casts from 010_01 to 010_03

(4) Data archive

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

2.3.5 Lowered ADCP

September 10, 2025

Shinya KOUKETSU (JAMSTEC RIGC) (not onboard)

Hiroshi UCHIDA, (JAMSTEC RIGC)

Aine YODA (MWJ)

Nobuhiro FUJII (MWJ)

Yuki MIYAJIMA (MWJ)

Shintaro AMIKURA (MWJ)

(1) Overview of the equipment

Two acoustic Doppler current profilers (ADCP) were integrated with the CTD/RMS package. The lowered ADCP (LADCP)s, Workhorse Monitor WHM300 (Teledyne RD Instruments, San Diego, California, USA), which has 4 facing transducers with 20-degree beam angles, rated to 6000 m, make direct current measurements at the depth of the CTD, thus providing a full profile of velocity. The LADCPs were powered during the CTD casts by a 48 volts battery pack. The LADCP unit was set for recording internally prior to each cast. After each cast the internally stored observed data were downloaded to the computer in the onboard laboratory. After the cruise, by combining the measured velocity of the sea water and ocean bottom relative to the instrument, shipboard navigation data, and pressure time series from the CTD, the absolute velocity profiles will be obtained with the software implemented by A.Thunherr. The software is based on the method of Visbeck (2002) and available online at <ftp://ftp.ldeo.columbia.edu/pub/LADCP>.

The instruments used in this cruise were as follows.

WHM300 (serial no. 24545; downward)

WHM300 (serial no. 20754; upward)

(2) Data collection

In this cruise, data were collected with the following configuration.

Bin size: 8.0 m

Number of bins: 12

(3) Reference

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

(4) Data archive

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

2.3.6 Shipboard ADCP

Tetsuichi FUJIKI (JAMSTEC) – PI

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (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 during 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. Major parameters for the measurement, Direct Command, are shown in Table 2.3.6-1. The system consists of following components;

- i) 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.
- ii) For heading source, we use ship's gyro compass (Tokyo Keiki, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation Unit (Phins, Ixblue, France) which provide high-precision heading, attitude information, pitch and roll. They are stored in ".N2R" data files with a time stamp.
- iii) Differential GNSS system (StarPack-D, Fugro, Netherlands) providing precise ship's position.
- iv) We used VmDas software version 1.50.19 (TRDI) for data acquisition.
- v) To synchronize time stamp of ping with Computer time, the clock of the logging computer is adjusted to GPS time server by using NTP (Network Time Protocol).
- vi) Fresh water is charged in the sea chest to prevent bio fouling at transducer face.
- vii) 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).
- viii) Data were configured for "8 m" layer intervals starting about 19 m below sea surface. Data were recorded every ping as raw ensemble data (.ENR). Additionally, 30 seconds averaged data were recorded as short-term average (.STA). 300 seconds averaged data were long-term average (.LTA), respectively.

Table 2.3.6-1 Major parameters

Bottom-Track Commands

BP = 001

Pings per Ensemble (almost less than 1,300 m depth)

Environmental Sensor Commands

EA = 04500	Heading Alignment (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coordinate Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 10200010	Sensor Source (C; D; H; P; R; S; T; U)
	C (1): Sound velocity calculates using ED, ES, ET (temp.)
	D (0): Manual ED
	H (2): External synchro
	P (0), R (0): Manual EP, ER (0 degree)
	S (0): Manual ES
	T (1): Internal transducer sensor
	U (0): Manual EU
EV = 0	Heading Bias (1/100 deg)

Timing Commands

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

Water-Track Commands

WA = 255	False Target Threshold (Max) (0-255 count)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (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	Radial Ambiguity Velocity (cm/s)

(3) Preliminary results

Horizontal velocity along the ship's track is shown in Fig. 2.3.6-1. In vertical direction, the data are averaged from 39 to 55 m. Longitude cross section of current profiles along this cruise track is shown in Fig.2.3.6-2.

(4) Data archives

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

< <https://www.godac.jamstec.go.jp/darwin/en> >

(5) Remarks

The following period, data acquisition was suspended at stationary observation point (47-00N, 180-00E).

21:12UTC 14 Aug. 2025 - 08:12UTC 15 Aug. 2025

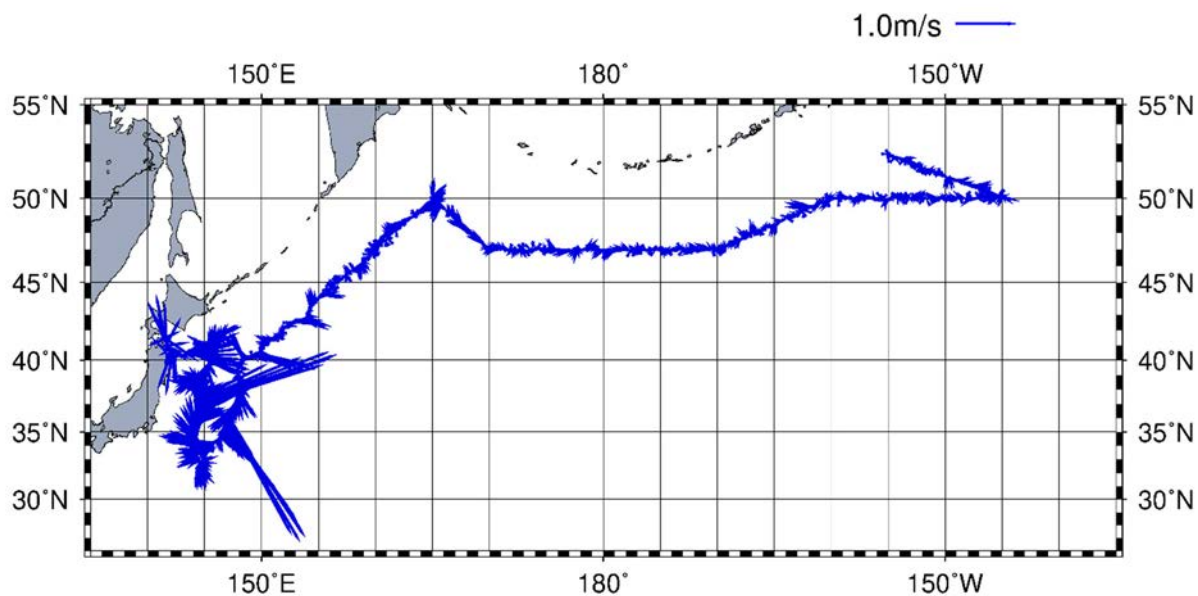


Fig. 2.3.6-1. Horizontal velocity along the ship's track of this cruise.

(15 min. Average / Layer: 39-55 m)

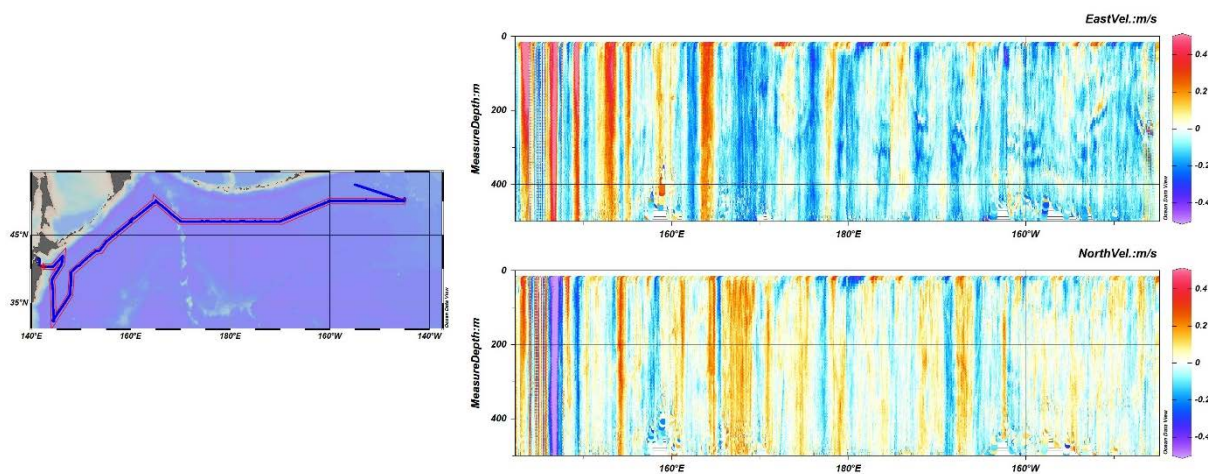


Fig. 2.3.6-2. Longitude cross section of current profiles along this cruise track.

2.3.7 XCTD

September 11, 2025

Hiroshi UCHIDA (JAMSTEC RIGC)

Haruna YAMANAKA (NME)

Yutaro MURAKAMI (NME)

(1) Objective

The objective of this study is to evaluate XCTDs (eXpendable Conductivity, Temperature and Depth profiler) data by side-by-side comparisons with the shipboard CTD (Conductivity, Temperature and Depth profiler) measurements, and to obtain temperature and salinity profiles as an alternative to CTD measurements.

(2) Instruments and method

The XCTD used were XCTD-4A (up to 2000 m) and its test probes (Tsurumi-Seiki Co., Ltd., Yokohama, Kanagawa, Japan) (Table 2.3.7-1) with an MK-150P portable converter or an MK-150N deck unit and a data acquisition software AL12 version 1.8.0 (Tsurumi-Seiki). The XCTD probes were deployed during the down cast of the shipboard CTD measurements by using a hand launcher with the MK-150P portable converter. For the underway measurement, the XCTD were deployed using a 12-loading automatic launcher with the MK-150N deck unit (Tables 2.3.7-2 and 2.3.7-3). The test probes were prepared as modified versions of the normal probe to investigate the cause of the thermal bias (see Uchida et al. 2011)

Table 2.3.7-1. List of XCTD probes used in this cruise. The test probes were modified versions of XCTD-4A to investigate cause of the thermal bias. Coefficients of the fall rate equation are 3.68081 (terminal velocity [m/s]) and -0.00047 (acceleration [m/s^2]) for all probes.

Probe type	Board version	Resolution of A/D converter		Depth interval (m)	Note
		Temperature (°C)	Conductivity (mS/cm)		
XCTD-4A	XCTP R1.2	0.001 (16 bit)	0.001 (16 bit)	0.27	
XCTD-4A ¹	XCTP R1.2	0.001 (16 bit)	0.001 (16 bit)	0.27	Test probe 1
XCTD-4A ²	XCTP R1.2	0.001 (16 bit)	0.001 (16 bit)	0.27	Test probe 2
XCTD-4A ³	XCTP R1.2	0.001 (16 bit)	0.001 (16 bit)	0.27	Test probe 3
XCTD-4A ⁴	XCTP R1.2	0.001 (16 bit)	0.001 (16 bit)	0.27	Test probe 4
XCTD-4A ⁶	XCTP R1.2	0.001 (16 bit)	0.001 (16 bit)	0.27	Test probe 6

Table 2.3.7-2. List of the side-by-side comparisons with the shipboard CTD measurements.

Probe type	Serial no.	CTD pressure	Note
<i>Station 002_2, 41° 54.06'N, 146° 18.21'E, 6768 m, SST 18.132 °C, SSS 33.138</i>			
XCTD-4A ⁴	25031204	36–529 dbar	
XCTD-4A ⁶	25041007	627–1261 dbar	
XCTD-4A	25045600	1334–1999 dbar	
<i>Station 001_1, 32° 20.98'N, 144° 30.07'E, 5615 m, SST 27.619 °C, SSS 34.447</i>			
XCTD-4A ⁶	25041008	14–383 dbar	up to 1968 m
XCTD-4A ³	24109003	459–1067 dbar	
XCTD-4A	25045599	1142–1806 dbar	
<i>Station 001_2, 32° 21.19'N, 144° 24.82'E, 5794 m, SST 27.660 °C, SSS 34.410</i>			
XCTD-4A ⁶	25041009	15–348 dbar	up to 1870 m
XCTD-4A ¹	24113004	451–1077 dbar	
XCTD-4A	25045598	1151–1750 dbar	up to 1728 m
<i>Station 003_1, 44° 00.04'N, 155° 00.02'E, 5314 m, SST 19.355 °C, SSS 32.424</i>			
XCTD-4A	25045595	11–497 dbar	
XCTD-4A ²	24106004	592–1259 dbar	
XCTD-4A ⁶	25041010	1318–2039 dbar	
<i>Station 003_3, 44° 00.08'N, 155° 02.69'E, 5318 m, SST 19.325 °C, SSS 32.421</i>			
XCTD-4A ³	24109004	58–546 dbar	
XCTD-4A ⁴	25031203	602–1236 dbar	
XCTD-4A	25045596	1311–2030 dbar	
<i>Station 004_1, 47° 00.31'N, 159° 58.43'E, 5218 m, SST 16.228 °C, SSS 32.347</i>			
XCTD-4A ¹	24113003	13–505 dbar	
XCTD-4A ⁶	25041006	547–1241 dbar	no data for 0-12 m
XCTD-4A	25045597	1299–2025 dbar	
<i>Station 004_3, 47° 00.02'N, 160° 00.00'E, 5187 m, SST 16.270 °C, SSS 32.349</i>			
XCTD-4A	24018894	202–743 dbar	
XCTD-4A	24018893	809–1145 dbar	
<i>Station 005_1, 50° 00.05'N, 165° 00.19'E, 5516 m, SST 14.383 °C, SSS 32.623</i>			
XCTD-4A ²	24106003	13–517 dbar	
XCTD-4A	25010013	647–1312 dbar	
XCTD-4A	24018895	1379–2101 dbar	
<i>Station 005_3, 50° 00.01'N, 164° 59.98'E, 5514 m, SST 14.241 °C, SSS 32.622</i>			
XCTD-4A	24018896	15–551 dbar	
XCTD-4A	24018897	611–1279 dbar	

Table 2.3.7-3. List of the underway XCTD (XCTD-4) measurements. The automatic launcher was used to deploy the XCTD. The measurement was terminated at 1716 m for the station 6–7.

Station	Serial no.	Date, Time (UTC)	Position Latitude, Longitude	Depth (m)	SST (°C)	SSS (PSU)
3–4	24018889	Aug. 5, 09:24	45° 29.79'N, 157° 30.34'E	4959	18.116	32.504
4–5	24018892	Aug. 10, 15:08	48° 30.04'N, 162° 27.84'E	5709	13.896	32.604
5–6	24018890	Aug. 12, 09:30	48° 29.99'N, 167° 32.02'E	5828	14.054	32.431
6–7	25010014	Aug. 14, 04:09	46° 59.99'N, 175° 00.00'E	5637	14.357	32.691
9–10	25010015	Aug. 18, 04:43	48° 31.34'N, 165° 00.00'W	5169	13.665	32.201
10–11	25010016	Aug. 20, 10:12	49° 59.97'N, 156° 15.01'W	4986	13.946	32.173
11–12	25045594	Aug. 22, 10:06	50° 00.02'N, 148° 45.03'W	4683	13.894	32.096

(3) Results

For the side-by-side comparisons with the shipboard CTD, three or two XCTD probes were deployed at each CTD cast by using a hand launcher (Table 2.3.7-2). At station 004_1, the second probe was deployed before the data converter was fully prepared. As a result, surface-layer data (0–12 m) is missing. The results of the side-by-side comparisons with the shipboard CTD will be combined with the results of the side-by-side comparisons obtained in the R/V Mirai cruises MR23-05 leg 2, MR23-07, MR25-02, and MR25-05C, and will be used to determine coefficients of the fall rate equation for XCTD-4A and magnitude of the thermal bias.

For the underway measurements, seven XCTD probes (XCTD-4A) were deployed between the CTD stations 3 and 12 (Figs. 2.3.7-1 and 2.3.7-2). Low-salinity biases (about -0.06 for serial no. 24018*** and 25045*** and -0.03 for serial no. 25010***) were observed in the XCTD salinity data. These salinity biases likely due to the thermal bias (Uchida et al. 2011), and the XCTD data will be calibrated by using the results of the side-by-side comparisons.

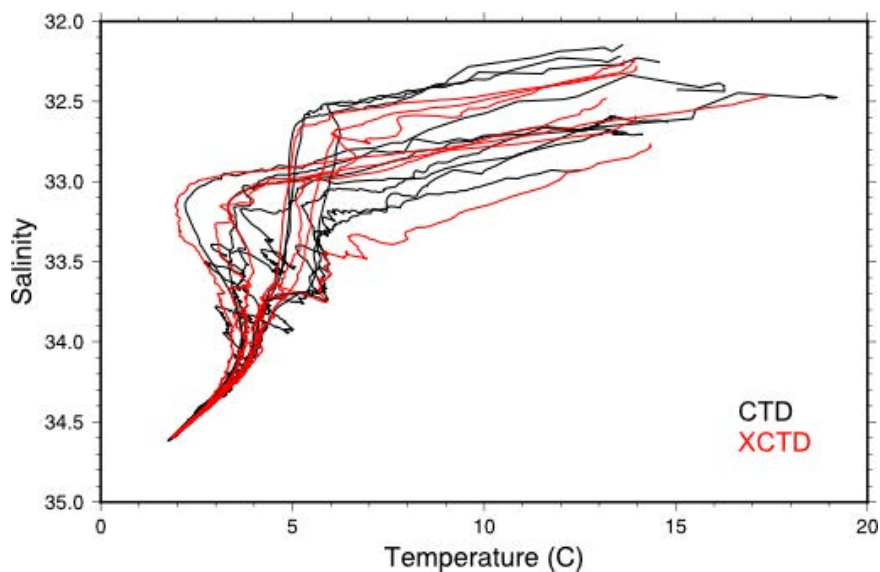


Figure 2.3.7-1. Temperature–salinity relationships for the CTD (black lines) and the XCTD (red lines) obtained between the stations 3 and 12. The data for depths shallower than 2000 m were plotted. A simple bias correction ($+0.06$ or $+0.03$) was applied to the XCTD salinity data for this plot.

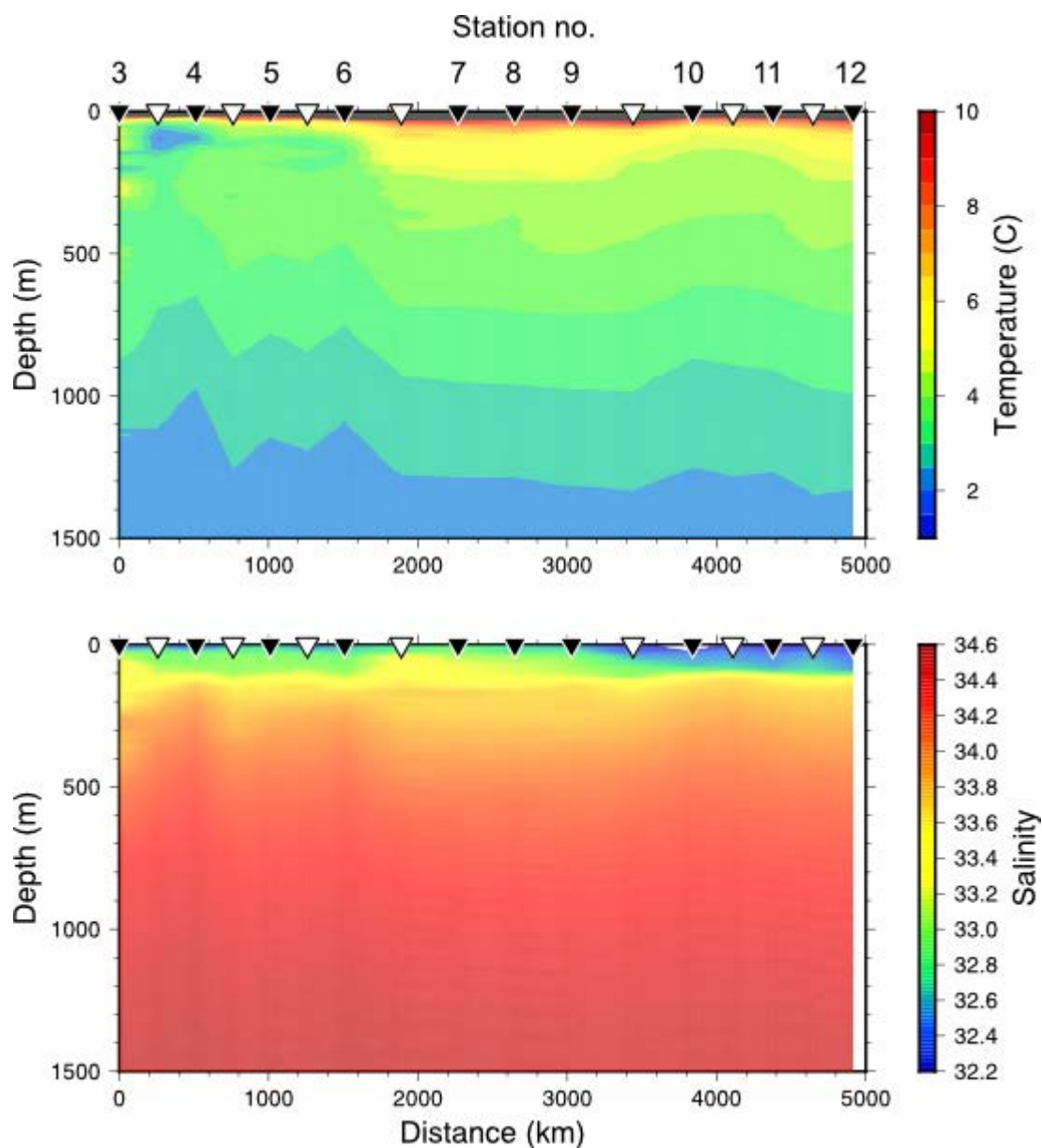


Figure 2.3.7-2. Vertical sections of temperature (upper) and salinity (lower) obtained by the CTD and XCTD measurements between the stations 3 and 12. The open inverted triangles indicate the locations of the XCTD deployment. A simple bias correction (+0.06 or +0.03) was applied to the XCTD salinity data for this plot.

(4) References

Uchida, H., K. Shimada, and T. Kawano (2011): A method for data processing to obtain high-quality XCTD data. *J. Atmos. Oceanic Technol.*, **28**, 816–826.

(5) Data archive

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

2.3.8 In situ comparison between shipboard CTD and CTDs for Argo floats

September 10, 2025

Hiroshi UCHIDA, (JAMSTEC RIGC)

Shigeki HOSODA (JAMSTEC RIGC) (not onboard)

Taiyo KOBAYASHI (JAMSTEC RIGC) (not onboard)

Aine YODA (MWJ)

Nobuhiro FUJII (MWJ)

Yuki MIYAJIMA (MWJ)

Shintaro AMIKURA (MWJ)

(1) Objective

The objective of this study is to evaluate CTDs for the Deep ARGO floats by comparing them with the shipboard CTD in situ.

(2) Instruments and method

Two SBE 61 CTDs (Sea-Bird Scientific, USA) and one SBE 41CP CTD (Sea-Bird Scientific) for the Deep ARGO floats were attached to the CTD/water sampling frame (Fig. 2.3.8-1). For the SBE 41CP, the pressure-resistant container for the sensor head was manufactured by Tsurumi Seiki Co., Ltd., Japan). The SBE 61 and SBE 41CP are capable of depths up to 7000 m and 4000 m, respectively. Therefore, the SBE 41 was used at the CTD casts whose maximum depth was shallower than 4000 m.

The SBE 61s and SBE 41CP were connected to the data logger (JAMSTEC, Japan), and the SBE 61 data were recorded at 2-second intervals and the SBE 41 data were recorded at 4-second intervals. The submersible pumps of the SBE 61 and SBE 41CP were operated at slow speed during the measurements. Height difference between the SBE 41CP pressure sensor and the SBE 61 pressure sensor was about 60 cm, and height difference between the SBE 61 pressure sensor and the SBE 9plus CTD was about -15 cm. The serial numbers of the SBE 61 and SBE 41CP were as follows.

Data logger ch.1: SBE 61, serial no. 61-6160

Data logger ch. 2: SBE 61, serial no. 61-6188

Data logger ch. 3: SBE 41CP, serial no. 41-20600

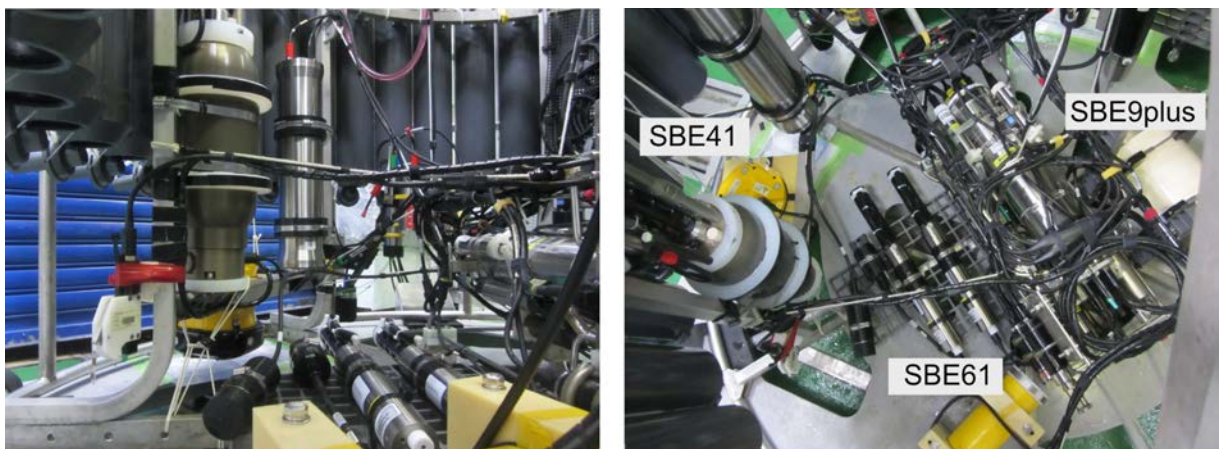


Figure 2.3.8-1. Photos of the CTDs for Deep ARGO floats attached to the CTD/water sampling frame.

(3) Results

The data from the SBE 61s were obtained at all CTD casts and the data from the SBE 41CP was obtained at 9 CTD casts for depths up to 4000 m. The obtained data will be combined with the SBE 9plus CTD data for comparisons after the cruise.

(4) Data archive

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

2.4 Chemical Oceanography

2.4.1 Underway surface water monitoring

September 18, 2025

Hiroshi UCHIDA (JAMSTEC): Principal Investigator

Shiori ARIGA (MWJ): Operation leader

Nobuhiro FUJII(MWJ)

Yuki MIYAJIMA (MWJ)

Aine YODA (MWJ)

(1) Objective

The objective of this measurement is to obtain sea surface temperature, salinity, dissolved oxygen, fluorescence, turbidity, and total dissolved gas pressure data continuously along the cruise track.

(2) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co, Ltd., Kanagawa, Japan) automatically measures salinity, temperature, dissolved oxygen, fluorescence, turbidity, total dissolved gas pressure in surface seawater at a sampling interval of 1 minute. This system is installed in the sea surface monitoring laboratory and bottom of the ship (only thermometer) and connected to shipboard LAN system. Measured data along with time and position of the ship were displayed on a monitor and stored in a personal computer. Seawater was continuously pumped up to the laboratory from about 5 m water depth and flowed into the system through a vinyl-chloride pipe or a tube. One thermometer is located just before the seawater pump at bottom of the ship. Flow rate in the system was manually adjusted about 1.2~1.5 L per minute. Software and instruments used in this cruise are as follows:

Data acquisition Software

Seamoni Ver.1.2.0.0 (Marine Works, Japan Co., Ltd.)

Thermosalinograph (TSG)

SBE 45 (Sea-Bird Scientific, Washington, USA)

Serial no. 4557820-0319

Ship bottom thermometer

SBE 38 (Sea-Bird Scientific)

Serial no. 3857820-0540

Dissolved oxygen sensor

RINKO II (JFE Advantech Co., Ltd., Hyogo, Japan)

Serial no. 0035

Fluorescence and turbidity sensor

C3 submersible fluorometer (Turner Designs, California, USA)

Serial no. 2300707 (Chlorophyll in vivo [blue excitation] and turbidity)

Total dissolved gas pressure sensor

Mini TDGP (Pro-Oceanus Systems Inc., Nova Scotia, Canada)

Serial no. 45-450-3

(3) Pre-cruise calibration

Pre-cruise sensor calibrations for the SBE 38, SBE 45, and Mini TDGP were performed by the manufacturer.

Pre-cruise sensor calibration for C3 was performed by Marine Works Japan. The C3 chlorophyll fluorometer was calibrated with 100 ppb uranine solution, then the Secondary Solid Standard (SSS) was calibrated using the calibrated chlorophyll fluorometer.

Pre-cruise sensor calibration for RINKO was performed at JAMSTEC. The oxygen sensor was immersed in fresh water in a 1-L semi-closed glass vessel, which was immersed in a temperature-controlled water bath. Temperature of the water bath was set to 1, 10, 20 and 29°C. Temperature of the fresh water in the vessel was measured by a thermistor of the portable dissolved oxygen sensor (expanded uncertainty of smaller than 0.01°C, ARO-PR, JFE Advantech, Co., Ltd.). At each temperature, the fresh water in the vessel was bubbled with standard gases (4, 10, 17, and 25% oxygen consisted of the oxygen-nitrogen mixture, whose relative expanded uncertainty is 1%, Japan Fine Products, Tochigi, Japan). Nitrogen standard gas (0% oxygen) (G1) and air (21% oxygen) were also used. Absolute pressure of the vessel's headspace was measured by a reference quartz crystal barometer (expanded uncertainty of 0.01% of reading, RPM4 BA100Ks, Fluke Co., Arizona, USA) and ranged from about 1040 to 1070 hPa. The data were averaged over 5 minutes at each calibration point (a matrix of 24 points). As a reference, oxygen concentration of the fresh water in the calibration vessel was calculated from the oxygen concentration of the gases, temperature, and absolute pressure at the water depth (about 6 cm) of the sensor's sensing foil as follows:

$$O_2 (\mu\text{mol/L}) = \{1000 \times c(T) \times (A_p - p_{H_2O})\} / \{0.20946 \times 22.3916 \times (1013.25 - p_{H_2O})\}$$

where $c(T)$ is the oxygen solubility, A_p is absolute pressure (in hPa), and p_{H_2O} is the water vapor pressure (in hPa). The RINKO was calibrated by the modified Stern-Volmer equation slightly modified from a method by Uchida et al. (2010):

$$O_2 (\mu\text{mol/L}) = [(V_0 / V)^E - 1] / K_{sv}$$

where V is raw phase difference, V_0 is raw phase difference in the absence of oxygen, K_{sv} is Stern-Volmer constant. The coefficient E corrects nonlinearity of the Stern-Volmer equation. The V_0 and the K_{sv} are assumed to be functions of temperature as follows.

$$K_{sv} = C_0 + C_1 \times T + C_2 \times T^2$$

$$V_0 = 1 + C_3 \times T$$

$$V = C_4 + C_5 \times (N/10000)$$

where T is temperature (°C) and N is raw output.

(4) Data collection

Data from the Continuous Sea Surface Water Monitoring System were obtained at 1-minute intervals. Periods of measurement, maintenance and problems are listed in Table 2.4.1-1. Seawater samples for salinity, dissolved oxygen and chlorophyll-a analysis were taken from the Continuous Sea Surface Water Monitoring System once a day to calibrate the sensors in situ. Details of these analyses are described in elsewhere of the cruise report.

For the total dissolved gas pressure sensor (Mini TDGP), pressure data in air were compared with a barometer (TERPS 8100 [serial no. 11733716], Druck Ltd., Baker Hughes, Leicester, UK), before and after the measurements. A bias of the barometer (+0.29 hPa) was estimated from the comparison with the accurate reference barometer (RPM4 BA100Ks) before the cruise (29 May, 2025) and subtracted from the pressure reading. The pressure data were averaged over three minutes and the difference will be used to correct the Mini TDGP pressure data (Table 2.4.1-2).

Table 2.4.1-1 Events of the Sea Surface Water Monitoring System operation.

System Date [UTC]	System Time [UTC]	Events
2025/07/26	11:00	All the measurements started, and data was available.
2025/08/04	04:57 - 05:31	All the measurements stopped for electricity leakage inspection in the ship. At the same time cleaned filter.
2025/08/04	05:32	All the measurements restarted.
2025/08/12	20:26 - 22:00	The seawater flow rate decreased. Affected sensor: SBE45 RINKO II Mini TDGP
2025/08/13	03:47 - 04:07	Cleaned the filter.
2025/08/26	00:30	All the measurements stopped.

Table 2.4.1-2 Comparison of air pressure (with $\pm$ SD) between the Mini TDGP and the TERPS 8100 before and after the measurements.

Date of measurement [UTC]	Mini TDGP pressure [hPa]	TERPS 8100 pressure [hPa]	Difference [hPa]
25 July, 2025, 01:26	1014.22 $\pm$ 0.10	1011.51 $\pm$ 0.07	2.71
27 August, 2025, 23:10	1005.80 $\pm$ 0.12	1003.03 $\pm$ 0.07	2.77

(5) Post-cruise calibration

Data from the Continuous Sea Surface Water Monitoring System were processed as follows. Spikes in the temperature and salinity data were removed using a median filter with a window of 3 scans (3 minutes) when difference between the original data and the median filtered data was larger than 0.1°C for temperature and 0.5 for salinity. Data gaps were linearly interpolated when the gap was $\leq$ 13 minutes. Fluorometer and turbidity data were low-pass filtered using a median filter with a window of 3 scans (3 minutes) to remove spikes. Raw data from RINKO oxygen sensor, C3 fluorometer/turbidity sensor, and Mini TDGP sensor were low-pass filtered using a Hamming filter with a window of 15 scans (15 minutes). The remaining erroneous data were manually removed.

Salinity (S [PSU]), dissolved oxygen (O [μ mol/kg]), and fluorescence (Fl [RFU]) data were corrected using the water sampled data. Corrected salinity (S_{cor}), dissolved oxygen (O_{cor}), and estimated chlorophyll-*a* (Chl-*a*) were calculated from following equations

$$S_{\text{cor}} [\text{PSU}] = c_0 + c_1 S + c_2 t$$

$$O_{\text{cor}} [\mu\text{mol/kg}] = c_0 + c_1 O + c_2 T + c_3 t + c_4 t^{0.5}$$

$$\text{Chl-}a [\mu\text{g/L}] = c_0 + c_1 \text{Fl}$$

where S is practical salinity, t is days from a reference time (2025/07/26 11:00 [UTC]), T is temperature in °C. The best fit sets of calibration coefficients (c_0 ~ c_4) were determined by a least square technique to minimize the deviation from the water sampled data. The calibration coefficients were listed below.

Salinity

For $t < 8$

$$c_0 = 4.748598224195497e-02$$

$$c_1 = 0.9991831302496553$$

$$c_2 = 2.790360117054832e-03$$

For $8 \leq t < 17$

$$c_0 = 8.129606864405278e-03$$

$$c_1 = 0.9993049698072247$$

$$c_2 = 5.809657907876332e-03$$

For $17 \leq t$

$$c_0 = 6.141220550894267e-02$$

$$c_1 = 1.000269155801373$$

$$c_2 = 7.207378835239273e-03$$

Oxygen

$$c_0 = 8.419993073588339e-02$$

$$c_1 = 1.025806661601892$$

$$c_2 = 0.1896616420569922$$

$$c_3 = 0.4139409874396586$$

$$c_4 = -3.402579329400189$$

Chlorophyll-a

$$c_0 = 2.374602796720222e-02$$

$$c_1 = 0.1731417052365523 \text{ (} T \geq 19 \text{ }^\circ\text{C)}$$

$$c_1 = 0.1022512487670458 \text{ (} T < 19 \text{ }^\circ\text{C)}$$

Comparisons between the Continuous Sea Surface Water Monitoring System data and water sampled data are shown in Figs. from 2.4.1-1 to 2.4.1-4.

The total dissolved gas pressure data will be calibrated after the cruise.

(7) Reference

Uchida, H., G. C. Johnson, and K. E. McTaggart (2010): CTD oxygen sensor calibration procedures, The GO-SHIP Repeat Hydrography Manual: A collection of expert reports and guidelines, IOCCP Rep., No. 14, ICPO Pub. Ser. No. 134.

(8) 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>>

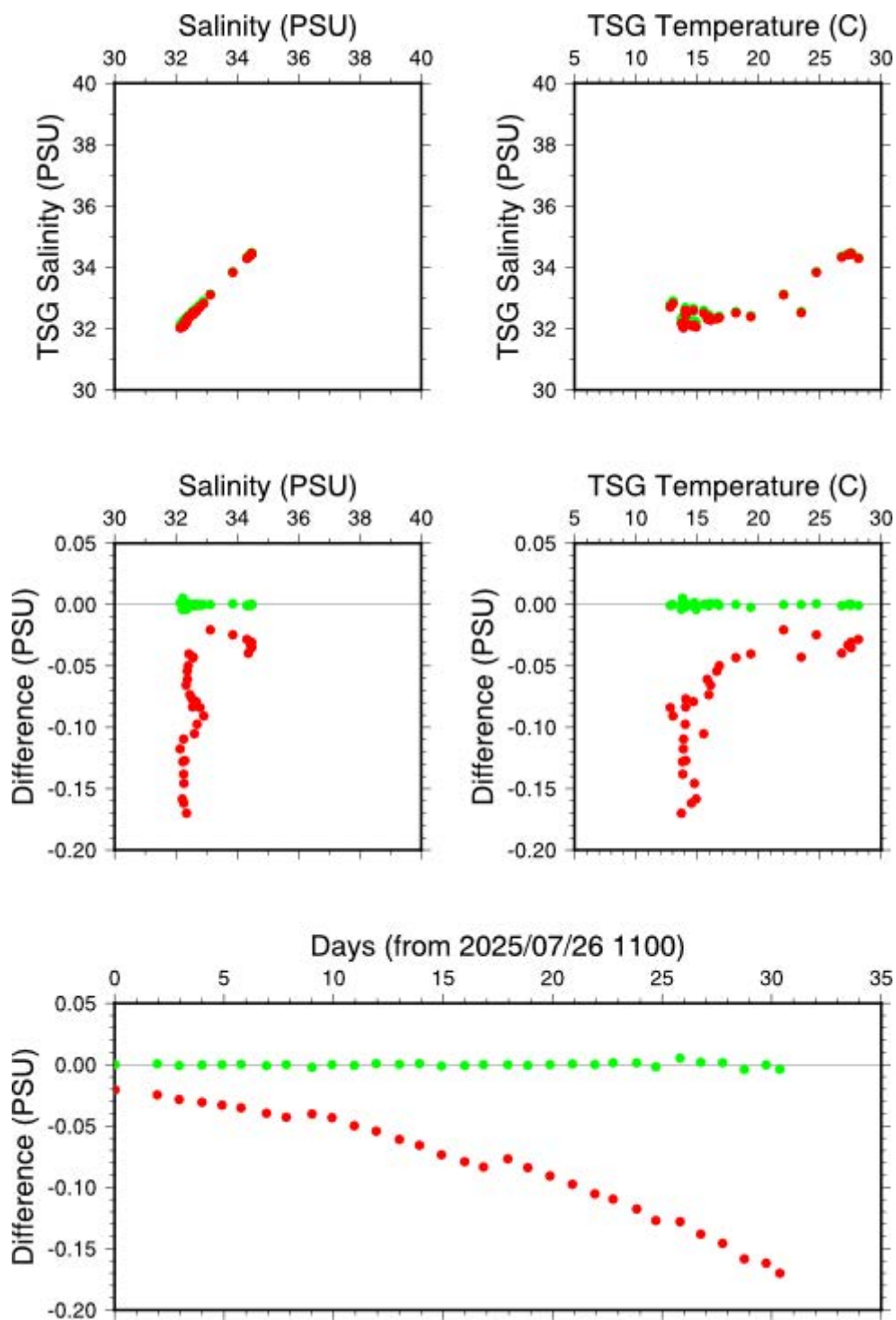


Fig. 2.4.1-1. Comparison between TSG salinity (red: before correction, green: after correction) and sampled salinity.

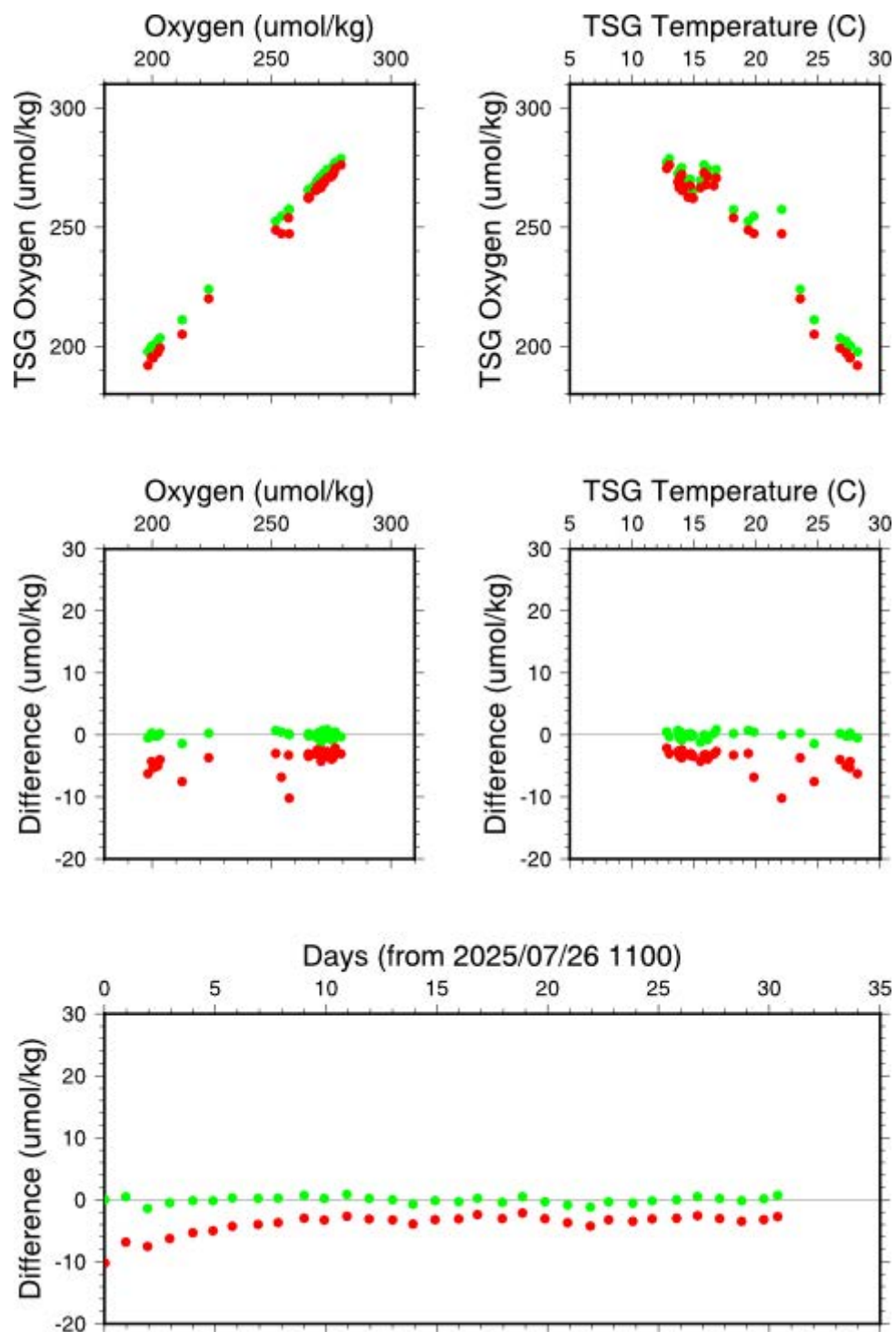


Fig. 2.4.1-2. Same as Fig. 2.4.1-1, but for dissolved oxygen.

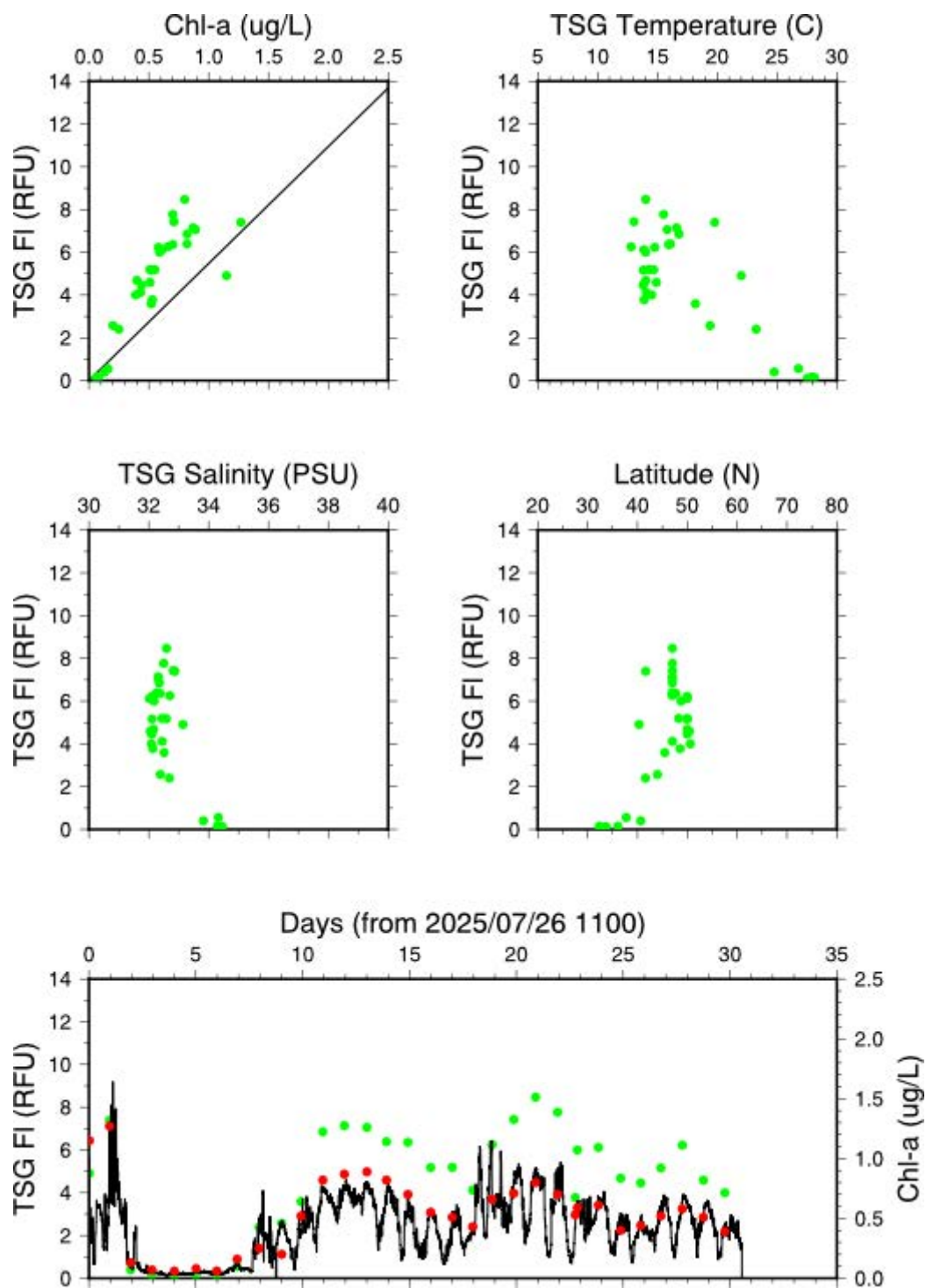


Fig. 2.4.1-3. Comparison between TSG fluorescence and sampled chlorophyll-a. For the lowest panel, green dots are TSG fluorescence, and red dots and line are sampled chlorophyll-a and estimated chlorophyll-a from TSG fluorescence, respectively.

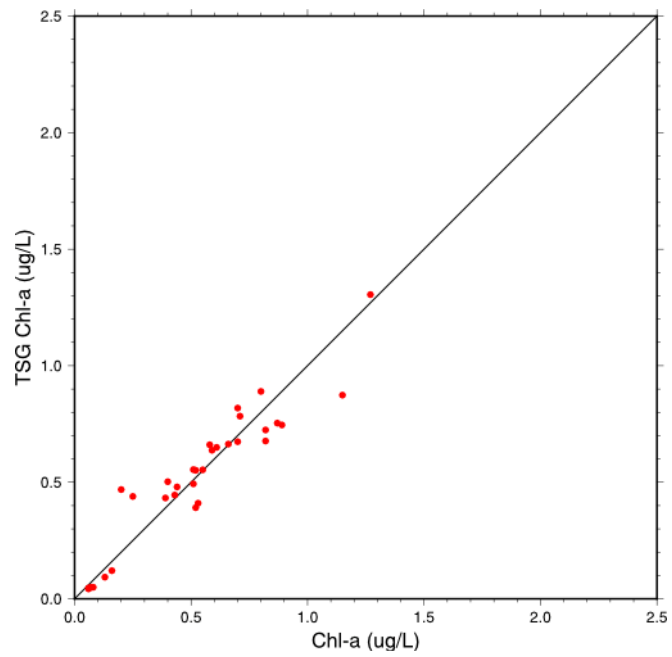


Fig. 2.4.1-4. Comparison between TSG chlorophyll-a and sampled chlorophyll-a.

2.4.2 Dissolved Oxygen

Masahide Wakita (JAMSTEC MIO)

Shiori Ariga (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-610) manufactured by Kyoto Electronics Manufacturing Co., Ltd. / 10 cm³ of titration vessel

Detector;

Automatic photometric titrator (DOT-15X) manufactured by Kimoto Electric Co., Ltd.

Software;

DOT_Terminal Ver. 1.3.1

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 cm³), and three times volume of the flask was overflowed. Temperature was simultaneously measured by digital thermometer during the overflowing. After transferring the sample, two reagent solutions (Reagent I and II) of 1 cm³ 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 cm³ 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 or salinity analyzed on ship, flask volume, and titrated volume of sodium thiosulfate solution without the blank. During this cruise, 2 sets of the titration apparatus were used.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130 °C, and 1.7835 g of it was dissolved in deionized water and diluted to final weight of 5 kg in a flask. After 10 cm³ of the standard potassium iodate solution was added to another flask using a volume-calibrated dispenser, 90 cm³ of deionized water, 1 cm³ of sulfuric acid solution, and 1 cm³ 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 cm³) and II (1 cm³) 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 cm³ of the standard potassium iodate solution were added to each flask using a calibrated dispenser. Then 100 cm³ of deionized water, 1 cm³ of sulfuric acid solution, 1 cm³ 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 cm³ of potassium iodate) titrated volume of the sodium thiosulfate and the second (2 cm³ 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 2.4.2.1 shows results of the standardization and the blank determination during this cruise.

Table 2.4.2.1 Results of the standardization and the blank determinations during cruise

Date (yyyy/mm/dd)	Potassium iodate ID	Sodium thiosulfate ID	DOT-15X (No.9)		DOT-15X (No.10)		Stations
			E.P. (cm ³)	Blank (cm ³)	E.P. (cm ³)	Blank (cm ³)	
2025/07/26	K25D01	T-24F	3.945	-0.002	3.946	-0.002	002M002
2025/07/29	K25D02	T-24F	3.947	-0.002	3.950	-0.002	001M001 001M002
2025/08/02	K25D03	T-24F	3.948	-0.001	3.948	-0.001	003M001 003M002
2025/08/06	K25D04	T-24F	3.948	-0.001	3.948	-0.001	004M002 004M003 004M005
2025/08/10	K25D05	T-24F	3.950	0.000	3.951	-0.001	005M001 005M002 006M001 006M003
2025/08/14	K25D06	T-24F	3.950	0.000	3.952	0.002	007M001 007M002 008M001 008M002 009M001 009M002
2025/08/18	K25D07	T-24F	3.951	0.001	3.955	0.002	010M001 010M002 011M001 011M002
2025/08/22	K25D08	T-24F	3.953	0.001	3.955	0.003	012M001 012M002

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 0.13 $\mu\text{mol kg}^{-1}$ (n=50).

(6) Data archives

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

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

(7) References

Culberson, C. H. (1991). *Dissolved Oxygen*. WHP O 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 WHP O 91-1.

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.

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.

2.4.3 Nutrients

Masahide WAKITA ¹⁾: Principal Investigator

Yuko MIYOSHI ²⁾: Operation Leader

Kengo FUJITA ²⁾

1) Japan Agency for Marine-Earth Science and Technology

2) Marine Works Japan Ltd.

(1) Objectives

The objective of this document is to present the current status of nutrient measurements conducted during the R/V MIRAI MR25-04 cruise (EXPOCODE: 49NZ20250724) in the North Pacific Ocean.

(2) Parameters

The parameters measured include nitrate, nitrite, silicate, phosphate, and ammonia in seawater.

(3) Instruments and methods

The analytical platform was upgraded from QuAAtro 2-HR to QuAAtro 39 in March 2021. However, following this replacement, several issues were reported with the QuAAtro 39 system (see the cruise report of MR21-05C). In July 2022, to address these issues and improve analytical precision, the following modifications were made: (1) the pumps were replaced with a 14-tube pump (model number: TRA+B014-02, BL TEC K.K.), instead of the original 13-tube pump (model number: 166+B214-01, BL TEC K.K.); (2) the motor brackets were upgraded to a new type that is a stainless model (model number: Motor-Bracket-01-Rev-1 and Motor-Bracket-02-Rev-1, BL TEC K.K.); and (3) the light source units were secured to reduce vibration. The modified platform, referred to as the “QuAAtro 39-J” was used for this cruise.

We used a nitrogen gas generator (model number: ITN2-04-1, IBS Inc.) to prevent contamination of ammonia. Nitrogen gas was filled up into autosamplers at 5Lmin⁻¹. There was a possibility that samples evaporated, so we made simple fumidifier and installed it into autosamplers

The analytical methods for nitrate, nitrite, silicate, and phosphate used in this cruise align with those described in the GO-SHIP repeat hydrography nutrients manual (Hydes et al., 2010; Becker et al., 2019). The method for ammonium follows a vaporization membrane permeability approach (Kimura, 2000)

(3.1) Nitrate + nitrite and nitrite

Nitrate + nitrite and nitrite were analyzed using a methodology modified from Grasshoff (1976). The flow diagrams are shown in Fig. 2.4.3.1 for nitrate + nitrite and Fig. 2.4.3.2 for nitrite. In the nitrate + nitrite analysis, samples were mixed with the alkaline imidazole buffer and then pushed through a cadmium coil coated with metallic copper. This step facilitated the reduction of nitrate to nitrite in the sample, allowing for the determination of total nitrate + nitrite in seawater. For the nitrite analysis, the samples were mixed with reagents without undergoing the reduction step. In the flow system, the seawater sample – either with or without the reduction step - was mixed with an acidic

sulfanilamide reagent through a mixing coil to produce a diazonium ion. The mixture was then combined with the N-1-naphthylethylenediamine dihydrochloride (NED), producing a red azo dye. This azo dye was subsequently directed to the spectrophotometric detection to monitor the signal at 545 nm. Therefore, for the nitrite analysis, sample bypassed the Cd coil, and nitrate concentrations were calculated by the difference between nitrate + nitrite and nitrite concentrations.

Reagents

- 50 % Triton solution: 50 mL of Triton[®] X-100 (CAS No. 9002-93-1) was mixed with 50 mL of ethanol (99.5 %).
- Imidazole (buffer), 0.06 M (0.4 % w/v): Dissolved 4 g of the imidazole (CAS No. 288-32-4) in 1000 mL ultra-pure water, and then added 2 mL of the hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL of the 50 % triton solution was added.
- Sulfanilamide, 0.06 M (1 % w/v) in 1.2 M HCl: Dissolved 10 g of 4-aminobenzenesulfonamide (CAS No. 63-74-1) in 900 mL of ultra-pure water, and then add 100 mL of the hydrogen chloride (CAS No. 7647-01-0). After mixing, 2 mL of the 50 % triton solution was added.
- NED, 0.004 M (0.1 % w/v): Dissolved 1 g of N-(1-naphthalenyl)-1,2-ethanediamine dihydrochloride (CAS No. 1465-25-4) in 1000 mL of ultra-pure water and then added 10 mL of hydrogen chloride (CAS No. 7647-01-0). After mixing, 1 mL of the 50 % triton solution was added. This reagent was stored in a dark bottle.

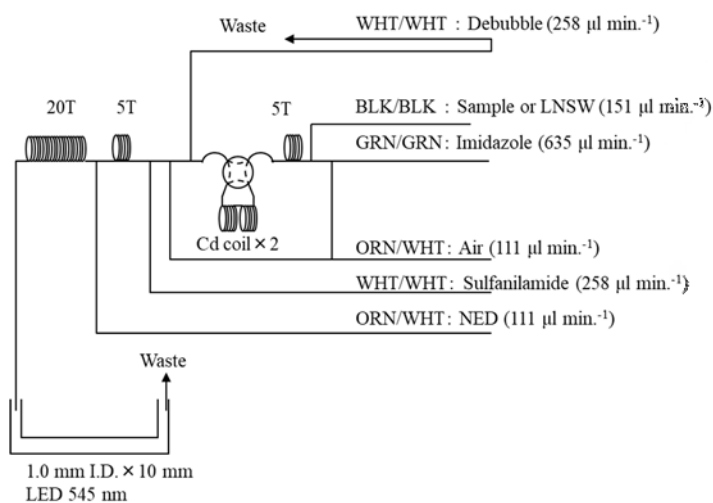


Figure 2.4.3.1 NO₃+NO₂ (1ch.) flow diagram.

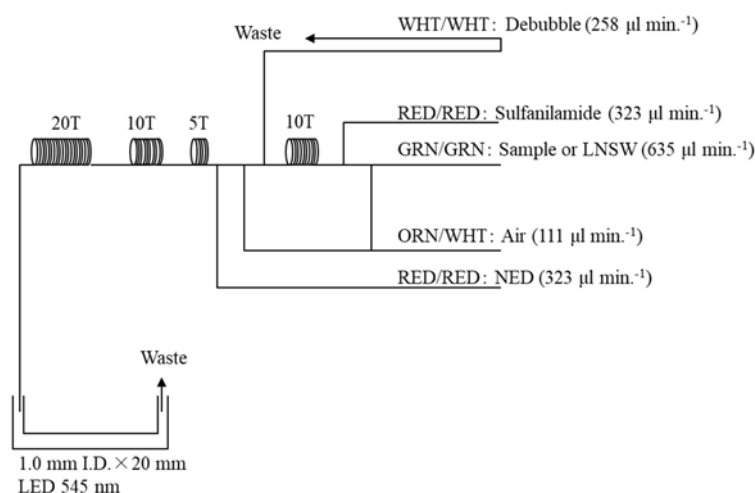


Figure 2.4.3.2 NO₂ (2ch.) flow diagram.

(3.2) Silicate

The method for silicate is analogous to that described for phosphate (4.3) and is essentially based on the method outlined by Grasshoff et al. (1999). The flow diagram is shown in Fig. 2.4.3.3. Silicomolybdic acid compound was first formed by mixing the silicate in the sample with the molybdic acid. This silicomolybdic acid was then reduced to silicomolybdous acid, known as "molybdenum blue," using L-ascorbic acid as the reductant. The signal was monitored at 630 nm.

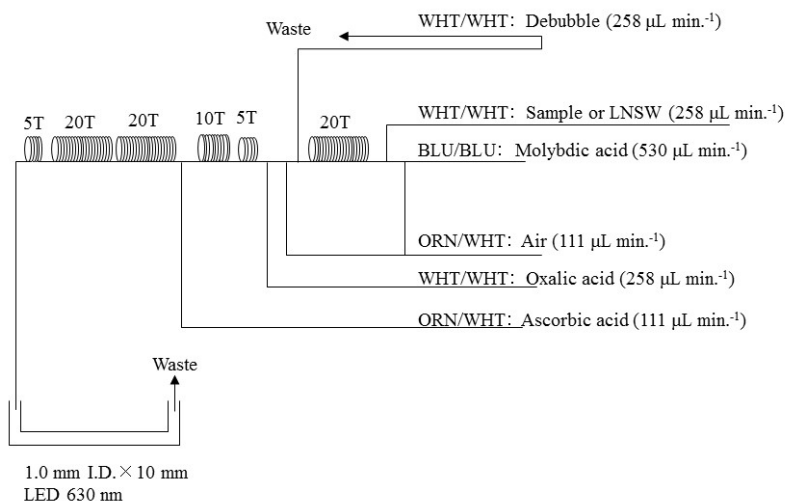


Figure 2.4.3.3 SiO₂ (3ch.) flow diagram.

Reagents

- 15 % Sodium dodecyl sulfate solution: 75 g of sodium dodecyl sulfate (CAS No. 151-21-3) was mixed with 425 mL ultra-pure water.
- Molybdic acid, 0.03 M (1 % w/v): Dissolved 7.5 g of sodium molybdate dihydrate (CAS No. 10102-40-6) in 980 mL ultra-pure water, and then added 12 mL of 4.5M sulfuric acid. After mixing, 20 mL of the 15 % sodium dodecyl sulfate solution was added. Note that the amount of sulfuric acid was

reduced from the previous report (MR19-03C) since we have modified the method of Grasshoff et al. (1999).

- c) Oxalic acid, 0.6 M (5 % w/v): Dissolved 50 g of oxalic acid (CAS No. 144-62-7) in 950 mL of ultra-pure water.
- d) Ascorbic acid, 0.01 M (3 % w/v): Dissolved 2.5 g of L-ascorbic acid (CAS No. 50-81-7) in 100 mL of ultra-pure water. This reagent was freshly prepared every day.

(3.3) Phosphate

The methodology for the phosphate analysis is a modified procedure based on Murphy and Riley (1962). The flow diagram is shown in Fig. 2.4.3.4. Molybdic acid was added to the seawater sample to form the phosphomolybdic acid compound, which was then reduced to phosphomolybdous acid using L-ascorbic acid as the reductant. The signal was monitored at 880 nm.

Reagents

- a) 15 % Sodium dodecyl sulfate solution: 75 g of sodium dodecyl sulfate (CAS No. 151-21-3) was mixed with 425 mL of ultra-pure water.
- b) Stock molybdate solution, 0.03 M (0.8 % w/v): Dissolved 8 g of sodium molybdate dihydrate (CAS No. 10102-40-6) and 0.17 g of antimony potassium tartrate trihydrate (CAS No. 28300-74-5) in 950 mL of ultra-pure water, and then added 50 mL of sulfuric acid (CAS No. 7664-93-9).
- c) PO₄ color reagent: Dissolved 1.2 g of L-ascorbic acid (CAS No. 50-81-7) in 150 mL of the stock molybdate solution. After mixing, 3 mL of the 15 % sodium dodecyl sulfate solution was added. This reagent was freshly prepared before every measurement.

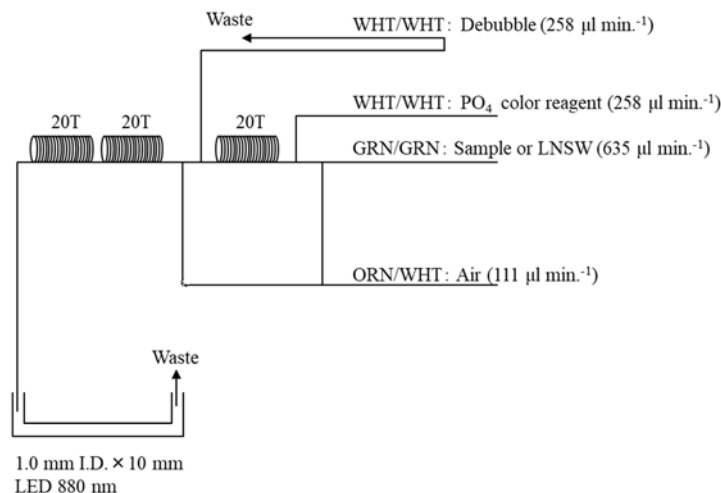


Figure 2.4.3.4 PO₄ (4ch.) flow diagram.

(3.4) Ammonia

The ammonia in seawater was determined using the flow diagrams shown in Fig. 2.4.3.5. The sample was mixed with an alkaline solution containing EDTA, which converted ammonia into its gaseous state. The ammonia gas was then absorbed in a sulfuric acid through a 0.5 µm pore-size membrane filter (ADVANTEC PTFE) at the dialyzer attached to the analytical system. The ammonia absorbed in sulfuric acid was subsequently determined by coupling it with phenol and hypochlorite to

form indophenols blue, with the signal monitored at 630 nm.

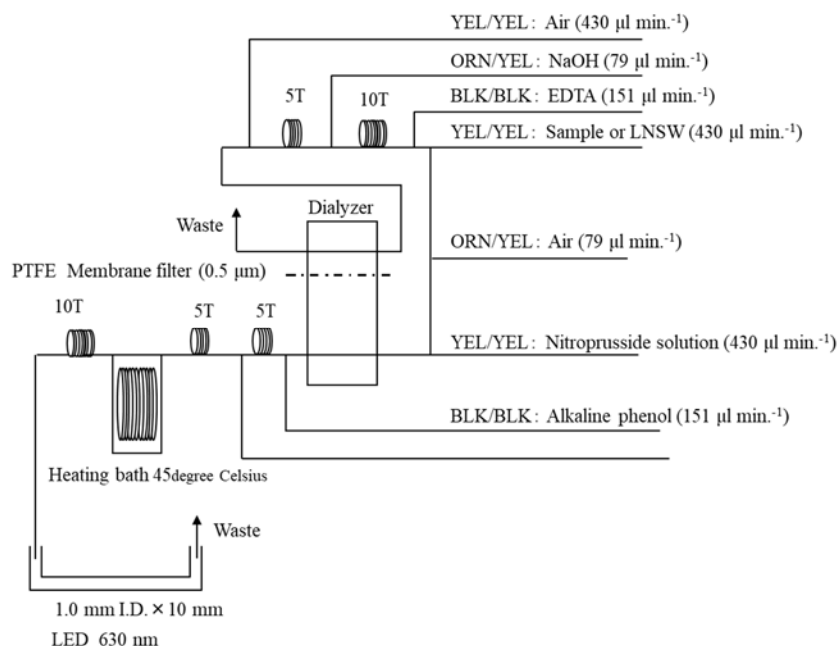


Figure 2.4.3.5 NH_4 (5ch.) flow diagram.

Reagents

- 30 % Triton solution: 30 mL of the Triton[®] X-100 (CAS No. 9002-93-1) was mixed with 70 mL ultra-pure water.
- EDTA: Dissolved 41 g of tetrasodium;2-[2-[bis(carboxylatomethyl)amino]ethyl-(carboxylatemethyl)amino]acetate;tetrahydrate (CAS No. 13235-36-4) and 2 g of boric acid (CAS No. 10043-35-3) in 200 mL of ultra-pure water. After mixing, 1 mL of the 30 % triton solution was added. This reagent is prepared every week.
- NaOH liquid: Dissolved 1.5 g of sodium hydroxide (CAS No. 1310-73-2) and 16 g of tetrasodium;2-[2-[bis(carboxylatomethyl)amino]ethyl-(carboxylatemethyl)amino]acetate;tetrahydrate (CAS No. 13235-36-4) in 100 mL of ultra-pure water. This reagent was prepared every week. Note that we reduced the amount of sodium hydroxide from 5 g to 1.5 g because pH of C standard solutions has been lowered 1 pH unit due to the change of recipe of B standards solution (the details of those standard solutions, see (5.4)).
- Stock nitroprusside: Dissolved 0.25 g of sodium nitroferricyanide dihydrate (CAS No. 13755-38-9) in 100 mL of ultra-pure water, and then added 0.2 mL of 1M sulfuric acid. Stored in a dark bottle and prepared every month.
- Nitroprusside solution: Added 4 mL of the stock nitroprusside and 4 mL of 1M sulfuric acid in 500 mL of ultra-pure water. After mixing, 2 mL of the 30 % triton solution was added. This reagent was stored in a dark bottle and prepared every 2 or 3 days.
- Alkaline phenol: Dissolved 10 g of phenol (CAS No. 108-95-2), 5 g of sodium hydroxide (CAS No. 1310-73-2) and 2 g of sodium citrate dihydrate (CAS No. 6132-04-3) in 200 mL of ultra-pure water. Stored in a dark bottle and prepared every week.
- NaClO solution: Mixed 3 mL of sodium hypochlorite (CAS No. 7681-52-9) in 47 mL of ultra-pure water. Stored in a dark bottle and freshly prepared before every measurement. This reagent needs to be 0.3 % available chlorine.

(3.5) Sampling procedures

Sampling for the nutrient samples was conducted after collecting samples for other gas parameters and salinity. Seawater samples were collected in two new 10 mL polyacrylate vials without using the sample drawing tube typically used for the oxygen samples. Each vial was rinsed three times before filling and sealed immediately without any head space. The vials were then placed in a water bath at 21.0 degree Celsius for over 30 minutes before measurement. Note that the sample in the original vial was placed directly on an autosampler (AIM 4000, BL TEC K.K.) tray for analysis. The seawater samples were analyzed within 24 hours of collection.

(4.6) Data processing

Raw data from QuAAtro 39-J were processed as follows:

- a) Checked if there were any baseline shifts.
- b) Checked the shape of each peak and positions of peak values. If necessary, a change was made for the positions of peak values.
- c) Conducted carry-over correction and baseline drift correction followed by sensitivity correction to apply to the peak height of each sample.
- d) Conducted baseline correction and sensitivity correction using linear regression. Conducted baseline correction and sensitivity correction using linear regression.
- e) Using the salinity (from CTD data* or determined data on the ship) and the laboratory room temperature (20 degree Celsius), the density of each sample was calculated. The obtained density was used to calculate the final nutrient concentration with the unit of $\mu\text{mol kg}^{-1}$.
- f) Calibration curves to obtain the nutrient concentrations were assumed second-order equations.

* Raw CTD pre-calibrated data have been used.

(4) Certified Reference Material of nutrients in seawater

Certified reference materials (CRMs) produced by KANSO Co., Ltd. were used to ensure the comparability and traceability of nutrient measurements during this cruise. The KANSO CRMs cover inorganic nutrients (nitrate, nitrite, silicate, phosphate, and ammonia) in seawater and are produced using autoclaved natural seawater, following a quality control system based on ISO Guide 34 (JIS Q 0034). KANSO Co., Ltd. has been accredited as a CRM producer under the National Institute of Technology and Evaluation (ASNITE) System since 2011. (ASNITE 0052 R)

Certified values for the CRMs were calculated as the arithmetic means of measurements from 30 bottles per batch (measured in duplicates), performed by both KANSO Co., Ltd. and Japan Agency for Marine-Earth Science and Technology (JAMSTEC) using the colorimetric method (continuous flow analysis, CFA). The salinity of the calibration standards solution for each calibration curve was adjusted to match the CRM salinity within ± 0.5 .

Each certified value of nitrate, nitrite, and phosphate in KANSO CRMs was calibrated using Japan Calibration Service System (JCSS) standard solutions for the respective ions. The JCSS standard solutions were in turn calibrated using JCSS secondary solutions, which was calibrated with primary solutions produced by the Chemicals Evaluation and Research Institute (CERI), Japan. CERI primary solutions were further calibrated with the National Metrology Institute of Japan (NMIJ) primary standards solution of nitrate, nitrite, and phosphate ions, respectively. The certified value of silicate of KANSO CRM was calibrated using a newly developed silicon standards solution ("exp31" produced by

JAMSTEC and KANSO, and Lot. AA produced by KANSO), produced via an alkaline dissolution technique. The mass fraction of silicon in this solution was calibrated based on NMIJ CRM 3645-a Si standard solution through the technology consulting system of the National Institute of Advanced Industrial Science and Technology (AIST), providing traceability to the International System of Units (SI).

During this cruise, 19 sets of CRM lots CQ, CU, CS, CT, CN were used (Table 2.4.3.1), with serial numbers selected randomly. The CRM bottles were stored in the ship's "BIOCHEMICAL LABORATORY" at a maintained temperature of approximately 19.80 degree Celsius – 21.81 degree Celsius.

Table 2.4.3.1 Certified concentration and the uncertainty ($k=2$) of CRMs ($\mu\text{mol kg}^{-1}$).

Lot	Nitrate	Nitrite*	Silicate	Phosphate	Ammonia**
CQ	0.06 ± 0.03	0.075 ± 0.07	2.20 ± 0.07	0.030 ± 0.009	1.76 ± 0.07
CU	3.06 ± 0.05	0.04 ± 0.04	7.77 ± 0.09	0.262 ± 0.011	1.02 ± 0.04
CS	16.65 ± 0.16	0.18 ± 0.07	33.8 ± 0.4	1.069 ± 0.019	0.73 ± 0.06
CT	40.1 ± 0.4	0.35 ± 0.07	85.3 ± 0.9	2.13 ± 0.03	0.79
CN	43.6 ± 0.4	0.02 ± 0.004	152.7 ± 0.8	2.94 ± 0.03	0.46

* For nitrite concentration, there is a trend that the value has been increased $0.004 \pm 0.002 \mu\text{mol kg}^{-1}$ per year. The values of CQ, CS and CN were determined by JAMSTEC in April 2025.

** Ammonia values are all reference value. The value of CQ, CU and CS were reported by KANSO. The other values were determined by JAMSTEC.

(5) Standards

To obtain the calibration curves, we prepared in-house standard solutions because (1) nutrient concentrations in seawater samples may exceed CRM, (2) the ammonia concentrations in the CRMs are not certified values.

(5.1) Volumetric laboratory-ware of in-house standards

All volumetric glassware and polymethylpentene (PMP) volumetric flasks were gravimetrically calibrated.

(5.2) Reagents

For nitrate standard, we used "potassium nitrate 99.995 suprapur[®]" provided by Merck, Batch B1983565, CAS No. 7757-79-1. For nitrite standard solution, nitrite ion standard solutions (NO_2^- 1000) from Wako Chemicals (Lots KSK1433, Code. No. 146-06453) was used, with the certified standard solutions from Wako Chemicals. The calibration result was 1006 mg L^{-1} at 20 degrees Celsius respectively, with an expanded uncertainty of 0.8 % ($k=2$). For the silicate standard solution, Si standard solutions Lot. AA produced by KANSO, was used. The silicon mass fraction in the Lot. AA solution was calibrated based on NMIJ CRM 3645-a Si standard solution. For the phosphate standard, "potassium dihydrogen phosphate anhydrous 99.995 suprapur[®]" provided by Merck (Batch B2076208, CAS No.: 7778-77-0), was used. For the ammonia standard, we used ammonium chloride (CRM 3011-a) from NMIJ, CAS No. 12125-02-9, with a reported purity of >99.9 % by the manufacturer. The expanded uncertainty of calibration ($k=2$) was 0.026 %.

(5.3) Low nutrients seawater (LNSW)

Surface water with low nutrient concentrations was taken and filtered using a 0.20 µm pore capsule cartridge filter near 13°N and 136°E during the MR21-03 cruise in June 2021. The filtered seawater was drained into multiple 20 L Cubitainer (flexible containers) and stored in cardboard boxes. This water has since been used as low-nutrients seawater (LNSW) for nutrients measurements. The concentrations in each LNSW container were measured in June 2022, yielding average values of 0.01, 0.003, 1.08, 0.075, and 0.01 µmol L⁻¹ for nitrate, nitrite, silicate, phosphate, and ammonia, respectively. The concentrations of nitrate, nitrite and ammonia were below the detection limit.

(5.4) Standard solutions and calibration curves

Concentrations of nutrients for standard solutions A, B, C, and D are shown in Table 2.4.3.2. The KANSO Si standard solution was used for the A standard of silicate, which doesn't require neutralization with hydrochloric acid. The B standard was diluted from the A standard following the recipes shown in Table 2.4.3.3. To match the salinity and the density of the B standard solution to those of the LNSW, 15.00 g of sodium chloride powder was dissolved in the B standard solution, and then the final volume was adjusted to 500 mL. The C standard solution was prepared in the LNSW following the recipes shown in Table 2.4.3.4. The actual concentrations of nutrients in each standard solution were calculated based on the solution temperature and the calibrated factors of volumetric laboratory wares. Calibration curves for each run of nitrate, nitrite, silicate, and phosphate were obtained using six levels: C-2, C-3, C-4, C-6, C-7, C-8. For ammonia, calibration was achieved using three levels: C-1, C-5, C-8. C-1 was LNSW, C-2, C-3, C-4, C-6 and C-7 were the CRM of nutrients in seawater, and C-5 and C-8 were diluted using the B standard solution. The D standard solutions, used to calculate the reduction rate of the Cd coil, were diluted from the A standard solution with pure water (milli-Q). In-house standard solutions were remade according to the "renewal time" intervals listed in Table 2.4.3.5.

Table 2.4.3.2 Nominal concentrations of nutrients for A, D, B and C standards (µmol L⁻¹).

	A	B	D	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
NO ₃	45000	900	900	-	CQ	CU	CS	-	CT	CN	53.8
NO ₂	21900	26	870	-	CQ	CU	CS	-	CT	CN	1.6
SiO ₂	35500	2840		-	CQ	CU	CS	-	CT	CN	171.5
PO ₄	6000	60		-	CQ	CU	CS	-	CT	CN	3.7
NH ₄	4000	80		LNSW	-	-	-	2.4	-	-	4.8

Table 2.4.3.3 B standard recipes. Final volume was 500 mL.

	A Std.
NO ₃	10 mL
NO ₂ *	15 mL
SiO ₂	40 mL
PO ₄	5 mL
NH ₄	10 mL

*NO₂ was D standard solution which was diluted from A standard.

Table 2.4.3.4 Working calibration standard recipes. Final volume was 500 mL.

C Std.	B Std.
C-5	15 mL
C-8	30 mL

Table 2.4.3.5 Renewal times of in-house standards.

Standard	Renewal time
A-1 Std. (NO ₃)	maximum a month
A-2 Std. (NO ₂)	commercial prepared solution
A-3 Std. (SiO ₂)	commercial prepared solution
A-4 Std. (PO ₄)	maximum a month
A-5 Std. (NH ₄)	maximum a month
D-1 Std.	maximum 8 days
D-2 Std.	maximum 8 days
B Std.	maximum 8 days
(mixture of A-1, D-2, A-3, A-4 and A-5 Std.)	maximum 8 days
C Std.	every 24 hours
36 µM NO ₃	when C Std. renewed
(diluted D-1 Std. for reduction estimate)	
35 µM NO ₂	when C Std. renewed
(diluted D-2 Std. for reduction estimate)	

(6) Data quality

During this cruise, a total of the 28 runs were conducted to measure samples collected by 24 casts across 12 stations. In total, 547 seawater samples were collected. The samples were collected into two vials and measured independently as basically replicate measurements.

(6.1) Precision

The highest-concentration standard solution (C-8) was repeatedly determined every some samples to assess the analytical precision of the nutrient analyses during this cruise. Analytical precision for each run was calculated from these C-8 results, and overall precision for this cruise were calculated from the combined precision across all runs (Table 2.4.3.6). The overall median precisions during this cruise were 0.11%, 0.21%, 0.11%, 0.13%, and 0.50% for nitrate, nitrite, silicate, phosphate, and ammonia, respectively. These values are comparable to those obtained during the previous cruises conducted from 2009 to 2025

Table 2.4.3.6 Overall precisions ($k=1$)

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %	Ammonia CV %
Median	0.11	0.21	0.11	0.13	0.50
Mean	0.11	0.21	0.11	0.13	0.51
Maximum	0.17	0.36	0.17	0.20	0.94
Minimum	0.04	0.07	0.06	0.06	0.24
n	28	28	27	28	28

(6.2) Comparability

CRM lot CN was measured during each run to evaluate the comparability across the measurements during this cruise. All measured concentrations were within the uncertainty of certified values for nitrate, nitrite, silicate, and phosphate (Table 2.4.3.7).

Table 2.4.3.7 CRM lot CN measurements ($\mu\text{mol kg}^{-1}$).

	Nitrate	Nitrite	Silicate	Phosphate	Ammonia
Median	43.66	0.02	152.68	2.931	1.08
Mean	43.66	0.02	152.70	2.931	1.14
STDEV	0.07	0.002	0.28	0.007	0.37
n	28	28	27	28	28

(6.3) Carryover

We also summarized the magnitudes of carry over, which refers to sample-to-sample contamination during flow analysis. To evaluate carryover in each run, we measured the C-8 standard solution followed by two consecutive measurements of the LNSW solution. The difference from LNSW-1 to LNSW-2 was used to estimate the carryover (%) using the following equation (1) where [] denotes concentrations.

$$\text{Carryover (\%)} = ([\text{LNSW-1}] - [\text{LNSW-2}]) / ([\text{C-8}] - [\text{LNSW-2}]) * 100 \quad (1)$$

The carryover (%) are shown in Table 2.4.3.8. Overall, the results indicated low carryover percentages. These low percentages suggest that there was no significant issue during this cruise.

Table 2.4.3.8 Carryovers (%)

	Nitrate	Nitrite	Silicate	Phosphate	Ammonia
Median	0.21	0.19	0.25	0.24	0.69
Mean	0.21	0.19	0.25	0.24	0.77
Maximum	0.25	0.48	0.30	0.47	1.35
Minimum	0.16	0.00	0.22	0.05	0.16
n	28	28	27	28	28

(6.4) Detection limit

The LNSW was measured every some samples to estimate the detection limit of nutrient analyses during this cruise. The detection limit was calculated based on the LNSW results from all runs using the following equation:

$$\text{Detection limit} = 3 * \text{standard deviation of repeated measurement of LNSW} \quad (2)$$

The estimated detection limits are shown in Table 2.4.3.9.

Table 2.4.3.9 Detection limit.

	Nitrate $\mu\text{mol kg}^{-1}$	Nitrite $\mu\text{mol kg}^{-1}$	Silicate $\mu\text{mol kg}^{-1}$	Phosphate $\mu\text{mol kg}^{-1}$	Ammonia $\mu\text{mol kg}^{-1}$
Detection limit	0.02	0.004	0.09	0.006	0.02

Replicate samples were taken at most of the layers. The summary of average and standard deviation of the difference between each replicate pair of analysis was shown in Table 2.4.3.10.

Table 2.4.3.10 Average and standard deviation of the difference between each replicate pair of analysis.

	Nitrate $\mu\text{mol kg}^{-1}$	Nitrite $\mu\text{mol kg}^{-1}$	Silicate $\mu\text{mol kg}^{-1}$	Phosphate $\mu\text{mol kg}^{-1}$	Ammonia $\mu\text{mol kg}^{-1}$
Average	0.04	0.003	0.13	0.004	0.02
Standard deviation	0.04	0.002	0.12	0.003	0.01
n	545	544	545	520	536

(7) Problems

There is no significant issue of this data set during this cruise.

(8) List of reagents

List of reagents used in this cruise is shown in Table 2.4.3.11.

Table 2.4.3.11 List of reagents used in this cruise

IUPAC name	CAS Number	Formula	Compound Name	Manufacture	Grade
4-Aminobenzenesulfonamide	63-74-1	$C_6H_5N_2O_2S$	Sulfanilamide	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Ammonium chloride	12125-02-9	NH_4Cl	Ammonium Chloride	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Antimony potassium tartrate trihydrate	28300-74-5	$K_2(SbC_4H_4O_6)_2 \cdot 3H_2O$	Bis[(+)-tartrato]diantimonate(III) Dipotassium Trihydrate	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Boric acid	10043-35-3	H_3BO_3	Boric Acid	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Hydrogen chloride	7647-01-0	HCl	Hydrochloric Acid	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Imidazole	288-32-4	$C_3H_4N_2$	Imidazole	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
L-Ascorbic acid	50-81-7	$C_6H_8O_6$	L-Ascorbic Acid	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
N-(1-Naphthalenyl)-1,2-ethanediamine, dihydrochloride	1465-25-4	$C_{12}H_{16}Cl_2N_2$	N-1-Naphthylethylenediamine Dihydrochloride	FUJIFILM Wako Pure Chemical Corporation	for Nitrogen Oxides Analysis
Oxalic acid	144-62-7	$C_2H_2O_4$	Oxalic Acid	FUJIFILM Wako Pure Chemical Corporation	Wako Special Grade
Phenol	108-95-2	C_6H_6O	Phenol	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Potassium nitrate	7757-79-1	KNO_3	Potassium Nitrate	Merck KGaA	Suprapur®
Potassium dihydrogen phosphate	7778-77-0	KH_2PO_4	Potassium dihydrogen phosphate anhydrous	Merck KGaA	Suprapur®
Sodium chloride	7647-14-5	$NaCl$	Sodium Chloride	FUJIFILM Wako Pure Chemical Corporation	TraceSure®
Sodium citrate dihydrate	6132-04-3	$Na_3C_6H_5O_7 \cdot 2H_2O$	Trisodium Citrate Dihydrate	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Sodium dodecyl sulfate	151-21-3	$C_{12}H_{25}NaO_4S$	Sodium Dodecyl Sulfate	FUJIFILM Wako Pure Chemical Corporation	for Biochemistry
Sodium hydroxide	1310-73-2	$NaOH$	Sodium Hydroxide for Nitrogen Compounds Analysis	FUJIFILM Wako Pure Chemical Corporation	for Nitrogen Analysis
Sodium hypochlorite	7681-52-9	$NaClO$	Sodium Hypochlorite Solution	Kanto Chemical co., Inc.	Extra pure
Sodium molybdate dihydrate	10102-40-6	$Na_2MoO_4 \cdot 2H_2O$	Disodium Molybdate(VI) Dihydrate	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Sodium nitroferrocyanide dihydrate	13755-38-9	$Na_2[Fe(CN)_5NO] \cdot 2H_2O$	Sodium Pentacyanonitrosylferrate(III) Dihydrate	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
Sulfuric acid	7664-93-9	H_2SO_4	Sulfuric Acid	FUJIFILM Wako Pure Chemical Corporation	JIS Special Grade
tetra sodium 2-[2-[bis(carboxylatomethyl)amino]ethyl-(carboxylatomethyl)amino]acetate tetrahydrate	13235-36-4	$C_{10}H_{12}N_2Na_4O_8 \cdot 4H_2O$	Ethylenediamine-N,N,N',N'-tetraacetic Acid Tetrasodium Salt Tetrahydrate (4NA)	Dojindo Molecular Technologies, Inc.	-
Synonyms: t-Octylphenoxypolyethoxyethanol 4-(1,1,3,3-Tetramethylbutyl)phenyl- polyethylene glycol Polyethylene glycol tert-octylphenyl ether	9002-93-1	$(C_2H_4O)_n C_{14}H_{22}O$	Triton®X-100	MP Biomedicals, Inc.	-

(9) Data archives

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

(10) References

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2.4.4 Dissolved inorganic carbon

Masahide WAKITA (JAMSTEC)

Masahiro ORUI (MWJ)

Tomoki NAKAMURA (MWJ)

(1) Objective

To discuss CO₂ dynamics in seawater of the subarctic North Pacific, total dissolved inorganic carbon was measured on board during the MR25-04 cruise.

(2) Methods, Apparatus and Performance

(2)-1 Seawater sampling

Seawater samples were collected by 12-liter sampling bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 5 stations. Seawater was sampled in a 250 mL glass bottle (SCHOTT 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 sampling 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 25 °C.

(2)-2 Seawater analysis

Measurements of DIC were made with total CO₂ measuring system (Nihon ANS Inc.). The system comprises of seawater dispensing unit, a CO₂ extraction unit, and a coulometer (Model 3000, Nihon ANS Inc.).

The seawater dispensing unit has an auto-sampler (10 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 15 mL volume. The pipette was kept at 25.00 °C ± 0.05 °C by a water jacket, in which water circulated through a thermostatic water bath (NESLAB RTE10, Thermo Fisher Scientific).

The CO₂ dissolved in a seawater sample is extracted in a stripping chamber of the CO₂

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) 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) Preliminary result

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. 2.4.4-1). The average of the differences was 0.8 $\mu\text{mol kg}^{-1}$, with its standard deviation of 0.8 $\mu\text{mol kg}^{-1}$ (n = 45).

(4) Data archive

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

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

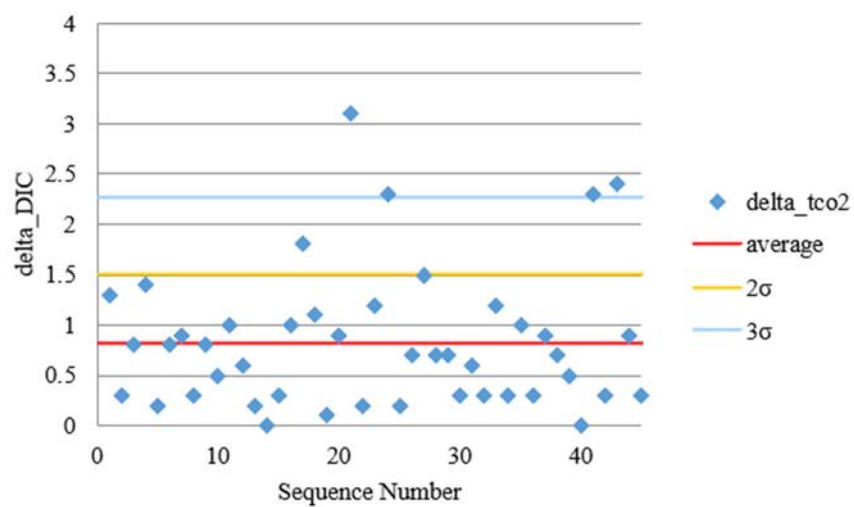


Figure 2.4.4-1 Range control chart of the absolute differences of replicate measurements of DIC carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE $\times 3$), and 2σ upper warning limit (standard deviation of AVE $\times 2$).

2.4.5 Dissolved organic carbon and total dissolved nitrogen

Masahide WAKITA (MIO, JAMSTEC)

(1) Objectives

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, 2013), 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 ¹⁴C-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 Ocean.

(2) Sampling

Seawater samples of DOC and TDN were collected by surface bucket sampling and 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System and brought the total to ~450. Seawater from the Niskin bottle or surface water monitoring was transferred into 60 ml High Density Polyethylene bottle (HDPE) for DOC/TDN and 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 or surface bucket sampling. 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 with a TNM-L units (Shimadzu Co.). In this system, the non-dispersive infrared was used for carbon dioxide produced from DOC during the HTCO process (temperature: 720 °C, catalyst: 0.5% Pt-Al₂O₃). Non-purgeable dissolved nitrogen compounds are combusted and converted to NO which, when mixed with ozone, chemiluminesces for detection by a photomultiplier. The consensus reference material for DOC and TDN (Hansell 2005) was analyzed during the sample measurements.

(3) Preliminary result

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

(4) Data archive

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

2.4.6 pH

September 12, 2025

Hiroshi UCHIDA (JAMSTEC RIGC)

(1) Objective

The objective of this study is to understand pH change in the western North Pacific.

(2) Instruments and method

Seawater pH for water samples was measured with a glass electrode pH meter (F-73 [serial no. A35D0004], Horiba, Japan) with two long glass electrodes (9680S-10D [serial no. 9Z3A0104 and 9Z5D0008], Horiba).

The water samples were collected in 100-mL aluminum bottles (Mini Bottle Can, Daiwa Can Company, Japan). Each bottle was rinsed three times with sample water and was filled without air space after overflowed the sample water two times of volume of the bottle (about 5 seconds) by using a plastic drawing tube (PFA tubing connected to silicon rubber tubing).

Before measurements, the sample bottles were immersed in a water bath whose temperature was controlled to about 25 °C by a thermostat (HT-90D, AS ONE), whose temperature was set to 25.8 °C. The pH measurements were conducted at 25 °C in a refrigerated temperature control bath (TRL-108H, THOMAS KAGAKU Co., Ltd.), whose temperature was set to 25.0 °C.

Two buffers (*2-aminophyridine*, AMP [016-28183, lot ELN3835, expiration date: April 2027, Fujifilm Wako Chemicals Co.], and *2-amino-2-hydroxy-1,3-propanediol*, TRIS, [013-28193, lot ELN3834, expiration date: April 2027, Fujifilm Wako Chemicals]) and Multiparametric Standard Seawater (MSSW, lot PRE21, KANSO TECHNOS Co., Ltd.) (Uchida et al., 2025) were used as references.

Actual temperature measured by the glass electrode were slightly different from 25 °C. It's mean $\pm$ SD was 24.99 ± 0.07 °C (minimum of 24.8 °C and maximum of 25.2 °C). Voltage changes due to this slight temperature deviation from 25 °C were corrected by using temperature dependencies of the voltage for AMP, TRIS, and PRE20 measurements conducted in the R/V Mirai MR23-05 cruise (Fig. 2.4.6-1). The temperature coefficients were 0.68 mV/°C, 1.07 mV/°C, and 0.16 mV/°C for AMP, TRIS, and PRE20, respectively. For seawater samples, the temperature coefficients were assumed to be the same as that of the standard seawater (PRE20). The temperature coefficient of the standard seawater was smaller than that of AMP and TRIS. The magnitude of the correction for seawater samples was within ± 0.001 pH units for temperature deviation of ± 0.3 °C.

The voltage values of AMP and TRIS measured at the beginning and the end of the measurements for each day were used to estimate time drift of the pH meter, and the time drift was corrected linearly for each day of measurements.

The pH of the sample was measured simultaneously with two electrodes, but since the response of the older electrode (serial no. 9Z3A0104) used in the previous cruises was very slow, only data from the newly introduced second electrode was used in this cruise.

In the R/V Mirai cruise MR23-05, the measured pH (7.6756 ± 0.0034 [total scale]) of PRE20 calibrated by AMP (6.7866 in pH units of total scale at 25 °C) and TRIS (8.0936 in pH units of total scale at 25 °C) based on a method by Dickson et al. (2007) was largely different from the calculated pH (7.6400 in pH units of total scale) estimated from Practical Salinity (34.2768), dissolved inorganic

carbon (2191.4 $\mu\text{mol/kg}$), total alkalinity (2301.3 $\mu\text{mol/kg}$), phosphate (1.991 $\mu\text{mol/kg}$), silicate (61.44 $\mu\text{mol/kg}$), temperature (25 °C), and pressure (0 dbar) by using CO2SYS program developed by Lewis and Wallace (1998) (K1, K2 from Lueker et al., 2000). Therefore, the pH of seawater samples was calibrated by AMP (TPH2930, pH: 6.7866) and PRE20 whose pH value was assumed to be 7.6400 in the previous cruises (MR23-05, MR23-07, and MR24-07).

In this cruise, PRE21 was measured as a reference instead of PRE20, and pH value of PRE21 was estimated to be 7.8450 from the measurement of PRE19 and PRE20 to match with the pH values measured in the previous cruises (Table 2.4.6-1). Also, lot number of AMP (ELN3835) was changed from the previous cruises. Therefore, these buffers (AMP and TRIS, Fujifilm Wako Chemicals Co.) and MSSW (lot PRE20, KANSO TECHNOS Co., Ltd.) were compared and pH value of the AMP lot ELN3835 was estimated to be 6.7721 to establish comparability (Table 2.4.6-2).

The seawater samples were measured usually within 24 hours after water sampling. When the time from sampling to measurement exceeded a few hours, the samples were stored in a refrigerator ($\sim 4^{\circ}\text{C}$) until measurement.

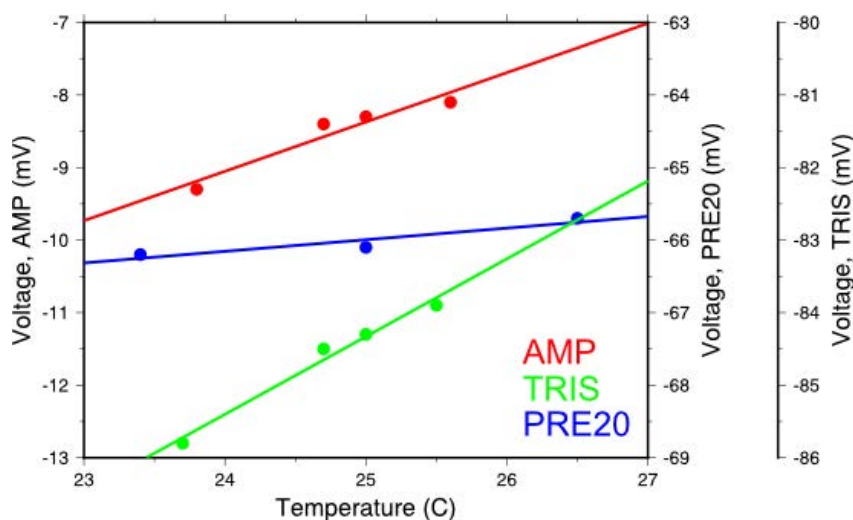


Figure 2.4.6-1. Temperature dependencies of the voltage for AMP, TRIS, and PRE20 measurements.

Table 2.4.6-1. Results of pH measurements for MSSW lots PRE19 and PRE20.

Lot no.	Serial no.	pH (total scale)	Note
PRE19		7.7541	Ref. PRE20 (MR23-05)
PRE19		7.7539	Ref. PRE20 (MR24-07 Leg 2)
PRE21		7.8468	Ref. PRE20 (MR24-07 Leg 2)
PRE19	116	7.7546	
PRE19	210	7.7556	
PRE19	254	7.7519	
PRE19	267	7.7542	
		<i>Average $\pm$ SD: 7.7562$\pm$0.0019</i>	Ref. PRE21 (7.8450)
PRE20	29	7.6378	Ref. PRE21 (7.8450)

Table 2.4.6-2. Results of pH measurements for AMP and TRIS.

Sample	Lot no.	pH (total scale)	Note
AMP	ELN3835	6.7721	expiration date: April 2027
AMP	TPH2930	6.7866 (ref.)	expiration date: August 2024
AMP	ACM3193	6.7821	expiration date: May 2025
TRIS	ELN3834	8.0704	expiration date: April 2027
TRIS	TPG2979	8.0555	expiration date: October 2024
TRIS	ACM3192	8.0601	expiration date: May 2025

(3) Results

A total of 23 pairs of replicate samples was measured and SD of the replicate samples was 0.0015.

Vertical profiles of pH at stations K2, KNOT, and CT are shown in Fig. 2.4.6-2, comparing with the profiles obtained in the previous cruises.

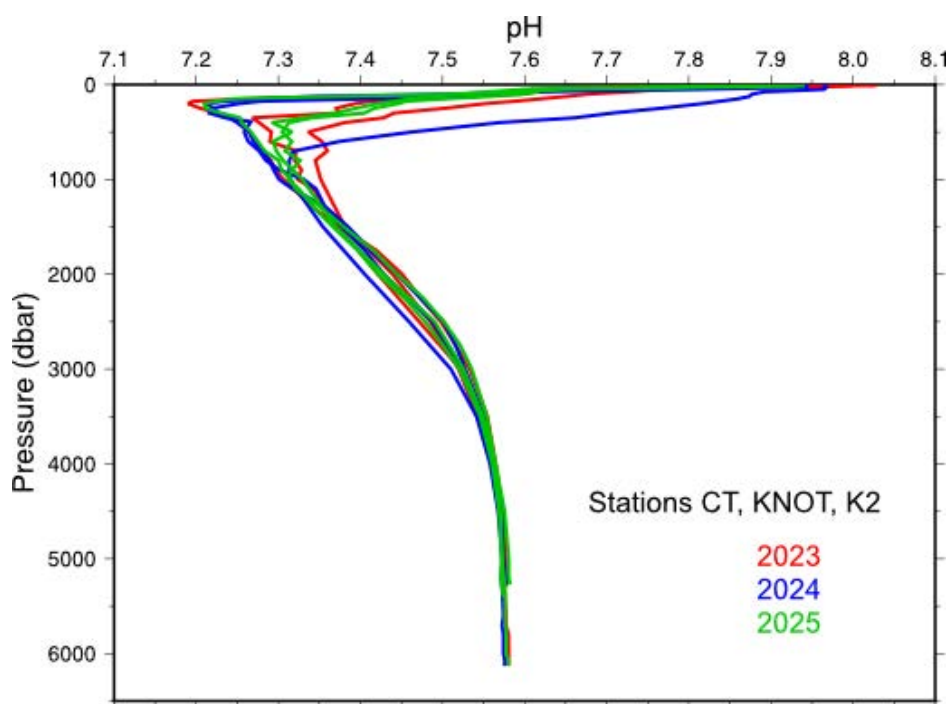


Figure 2.4.6-2. Vertical profiles of pH for stations 004 (K2), 003 (KNOT), and 002 (CT) obtained in the cruises MR23-05 (red lines) and MR24-07 (blue lines).

(4) References

- Dickson, A. G., C. L. Sabine, and J. R. Christian (Eds.) (2007): Determination of the pH of sea water using a glass/reference electrode cell. In Guide to best practices for ocean CO₂ measurements. PICES Special Publication 3, IOCCP report no. 8.
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33 pp., Oak Ridge, TN: Oak Ridge National Laboratory. Retrieved from <https://cdiac.esd.ornl.gov/oceans/co2rpert.html>.

Uchida, H., et al. (2025): Development of Multiparametric Standard Seawater (MSSW) for CO₂ parameters, dissolved oxygen, and density of seawater. Springer Oceanography, doi:10.1007/978-981-96-2520-8_12

(5) Data archive

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

2.4.7 Trace metals

Koji SUGIE (JAMSTEC, RIGC)

Minako KURISU (University of Tokyo)

(1) Objectives

Some trace metals such as iron, manganese and zinc are essential for phytoplankton growth because they are co-factors of many essential enzymes in photosynthesis and respiration. However, the relationship between trace metal distribution and its biogeochemistry in the subarctic Pacific is still room for investigation. Specifically, iron availability is one of the most important factors for regulating phytoplankton productivity during summer in the subarctic Pacific region. In this cruise, we collected seawater samples for multiple trace metals using R/V Mirai in the subarctic Pacific region. Furthermore, we collected samples for $\delta^{56}\text{Fe}$ of dissolved Fe to estimate the origin and the fate of Fe in the western subarctic Pacific. The goal of this study is to identify the west to east gradient of trace metal distributions mainly in the upper 200 m depth.

(2) Instruments and methods

Water sampling with Teflon-coated Niskin-X sampling bottles were conducted with (a) attaching to a CTD-AFM water sampling system (Sea-Bird Scientific) or (b) directly attaching to Kevlar rope with firing using messengers. Sampling depth is checked with salinity (only for (b) sampling) and macronutrient concentrations and their ratios (NO_3 , NO_2 , PO_4 , $\text{Si}(\text{OH})_4$) by comparing our sampling bottles with routine samplings conducted at the same station. The samples for dissolved trace metals were obtained the filtrate of 0.2 μm Acropac capsule cartridge filter (Pall Co. Ltd.) under gravity pressure which was connected directly to the spigot of Niskin-X sampling bottles. For total dissolvable sample, unfiltered seawater was directly collected into the sampling bottles. Sampling bottles (Teflon[®] PFA for dissolved and total dissolvable trace metals and LDPE for $\delta^{56}\text{Fe}$ of dissolved Fe) were rigorously acid-washed and rinsed with pure-water ($>18.2\text{ M}\Omega$, Millipore). Samples were acidified using pure-HCl (TAMAPURE AA10, Tama Chemicals) to pH ~ 1.8 aboard in clean booth. Seawater samples will be measured using HR-ICP-MS and Neptune-ICP-MS in on-land laboratory according to the method of Sohrin et al. (2008, Anal. Chem.) for dissolved trace metals and Conway et al. (2013, Anal. Chim. Acta) for $\delta^{56}\text{Fe}$ of dissolved Fe, respectively.

(3) Parameters

Dissolved and total dissolvable Al, Mn, Fe, Co, Ni, Cu, Zn and Cd, and $\delta^{56}\text{Fe}$ of dissolved Fe, and macronutrients (NO_3 , NO_2 , NH_4 , PO_4 , $\text{Si}(\text{OH})_4$).

(4) Observation log

Station	Date (d/m/y)	Position	Sampling depth (m)	Gear
St. 3	5/8/2025	44°00.77'N, 155°03.41'E	10, 12, 23, 40, 100, 200	CTD-AFM
St. 4	8/8/2025	47°00.01'N, 160°00.00'E	10, 12, 50, 100, 200, 500	CTD-AFM
St. 4	8/8/2025	47°00.00'N, 159°59.98'E	10, 12, 14, 16, 21, 32	CTD-AFM
St. 6	13/8/2025	46°59.85'N, 169°59.84'E	10, 15, 30, 55, 100, 200	CTD-AFM
St. 9	17/8/2025	46°59.99'N, 169°59.99'W	10, 12, 17, 32, 100, 200	CTD-AFM
St. 12	23/8/2025	50°00.01'N, 144°59.97'W	10, 11, 12, 16, 17, 18	CTD-AFM

St. 12	23/8/2025	49°59.99'N, 145°00.06'W	10, 14, 28, 47, 100, 200	CTD-AFM
St. 12	24/8/2025	49°59.99'N, 145°00.06'W	10, 30, 50, 100, 200	Direct attach

(5) Data archives

All data obtained during MR25-04 cruise will be submitted to Data Management Group (DMG) of JAMSTEC after the sample analysis and validation. The data will be opened to the public via “Data Research System for Whole Cruise Information (DARWIN)” in JAMSTEC web site or elsewhere.

2.4.8 Particulate organic carbon (POC)

Chiho SUKIGARA (JAMSTEC)

Makio C. HONDA (JAMSTEC)

(1) Objectives

Particulate matter in the ocean plays an important role in the sequestration of carbon in the ocean. Understanding the distribution and transport of particulate matter is a subject that needs to be urgently resolved in the global carbon cycle. In this study, we will determine the concentration of particulate organic carbon (POC) and particulate nitrogen (PN) by filtering sea water and measuring them with an elemental analyzer to clarify the distribution of POC and PN in the water column. In addition, a backscatter meter (see Chapter 2.3.1), which provides a good correlation with particle concentrations, was connected to the CTD to investigate the vertical variation of backscatter due to particles in the water. The objective of this study is to make equations of relationship between the POC and PN concentrations determined from sea water and the backscattering values by comparing them, and to reveal the distribution of POC and PN with high resolution from the backscattering values.

(2) Methods

i. Sampling and filtration for POC and PN

Water samples were collected at 14 depths (Table 2.4.8-1) at each station using Niskin-X bottles. Water samples were filtered through pre-combusted (450 °C, 5 hours) 25 mm GF/F filters. The filters were kept in the freezer (–20 °C) until analysis.

Table 2.4.8-1

St.2 (CT)	St.1(KEO)	St.3 (KNOT)	St.4 (K2), St.5, 7-9	St.6, 10,11	St.12 (OSP)
10 m	10 m	10 m	10 m	10 m	10 m
30 m	30 m	30 m	30 m	30 m	30 m
50 m	50 m	50 m	50 m	50 m	50 m
100 m	100 m	100 m	100 m	100 m	100 m
150 m	150 m	150 m	150 m	150 m	150 m
200 m	200 m	200 m	200 m	200 m	200 m
300 m	300 m	300 m	300 m	300 m	300 m
500 m	500 m	600 m	600 m	600 m	600 m
700 m	700 m	800 m	800 m	800 m	800 m
1000 m	1100 m	1100 m	1100 m	1100 m	1100 m

2000 m	1500 m	1500 m	1500 m	1500 m	1500 m
3000 m	2000 m	2000 m	2000 m	2000 m	2000 m
5000 m	3000 m	3000 m	3000 m	3000 m	3000 m
6000 m	5000 m	5000 m	4500 m	4700 m	4000 m

ii. Measurement

The filters will be exposed to HCl vapor for one night to remove particulate inorganic carbon and then dried in a vacuum oven (< 60 °C). The POC and PN will be measured with an elemental analyzer (FLASH EA 1112, Thermo Fischer Scientific, USA) on land.

iii. Backscatter meter (ECO BB(RT)D, S/N: 9098, SEA-BIRD Scientific, USA)

The backscatter meter was connected to the CTD for observation. The measured values (output values) were converted to particle backscatter using the following equations (Sullivan et al., 2013);

$$\text{Beta}(\lambda) = \text{scale factor} \times (\text{output} - \text{dark count}) \quad (1)$$

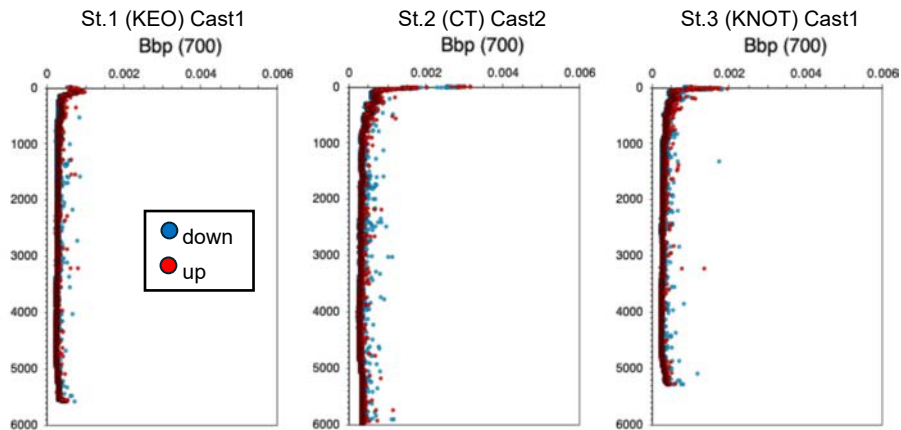
$$\text{Beta}_w(\lambda) = 1.38 \times (\lambda / 500)^{-4.32} \times (1 + 0.3 \times \text{salinity} / 35) \times 0.0001 \times (1 + \cos(\theta))^2 \times (1 + \text{Delta}) / (1 - \text{Delta}) \quad (2)$$

$$\text{Beta}_p(\lambda) = \text{Beta}(\lambda) - \text{Beta}_w(\lambda) \quad (3)$$

$$b_{bp}(\lambda) = \text{Beta}_p(\lambda) \times 2\pi \times \chi \quad (4)$$

where λ is the wavelength of the backscatter (700 nm), θ is the scattering centroid angle (124°), Delta is the Cabbanes factor of water (0.039) (Zhang et al., 2009), and χ is a conversion coefficient for b_b (1.076) (Sullivan et al., 2013).

(3) Preliminary results



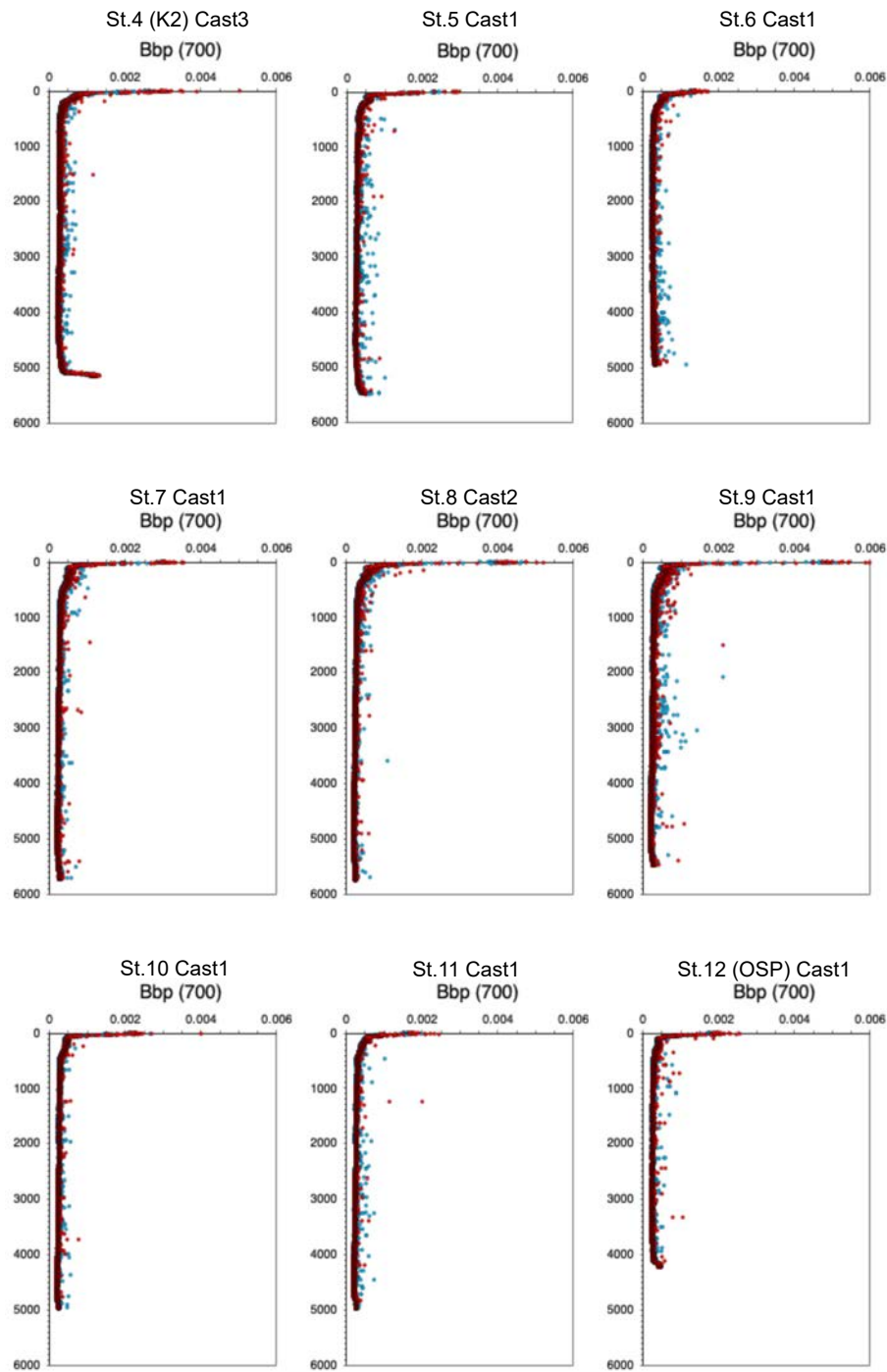


Figure 2.4.8-1 Vertical profiles of backscatter of particles (Bbp, 700 nm) at each station.

(4) Data archive

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

(5) References

- Sullivan, J. M., M.S. Twardowski, J.R.V. Zaneveld and C. C. Moore, Chapter 6, Measuring optical backscattering in water. In: A.A. Kokhanovsky ed. Light Scattering Reviews 7: Radiative Transfer and Optical Properties of Atmosphere and Underlying Surface, S Praxis Books, doi:10.1007/978-3-642-21907-8_6, 2013
- Zhang, X., L. Hu, M-X, He. Scattering by pure seawater: Effect of salinity: Optics Express. 17, 7, 5698, doi:10.1364/OE.17.005698, 2009

2.4.9 Chlorophyll *a* measurement by fluorometric determination

Kazuhiko Matsumoto

(JAMSTEC) : Principal Investigator

Misato Kuwahara

(MWJ): Operation Leader

Takuya Izutsu

(MWJ)

(1) Objective

Phytoplankton biomass can estimate as the concentration of chlorophyll *a*, because all oxygenic photosynthetic plankton contain chlorophyll *a*. Phytoplankton exists 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 fractionation by using the fluorometric determination.

(2) Parameters

Total chlorophyll *a*

Size-fractionated chlorophyll *a*

(3) Instruments and Methods

We collected seawater samples for total chlorophyll *a* at ~18 depths and size-fractionated chlorophyll *a* at 6 depths between the surface and 300 meters including a chlorophyll *a* maximum layer. The chlorophyll *a* maximum layer was determined by a chlorophyll fluorometer (Seapoint Sensors, Inc.) attached to the CTD system.

Seawater samples for total chlorophyll *a* were vacuum-filtered (< 0.02 MPa) through a glass microfiber filter (Whatman GF/F, 25 mm diameter). Seawater samples for size-fractionated chlorophyll *a* were vacuum-filtered (< 0.02 MPa) through 10 µm, 3 µm and 1 µm polycarbonate filters (Nuclepore filter, 47 mm diameter) and a glass microfiber filter (Whatman GF/F, 25mm diameter). Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethyl formamide (FUJIFILM Wako Pure Chemical Corporation Ltd.) (Suzuki and Ishimaru, 1990). The tubes were stored at -20 °C in the dark for at least 24 hours to extract chlorophyll *a*.

Chlorophyll *a* concentrations were measured by the fluorometer (10-AU, TURNER DESIGNS), which was previously calibrated against a pure chlorophyll *a* (Sigma-Aldrich Co., LLC). The "non-acidification method" (Welschmeyer, 1994) was applied to estimate chlorophyll *a* concentrations .

(4) Preliminary Results

The results for total chlorophyll *a* at each station are shown in Fig. 2.4.9.1. The results for size fractionated chlorophyll *a* at each station are shown in Fig. 2.4.9.2. Replicate samples were collected at depths of 20 and 75 meters at each station. The results of replicate sample measurements are shown in Table 2.4.9.1.

(5) Data archives

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

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

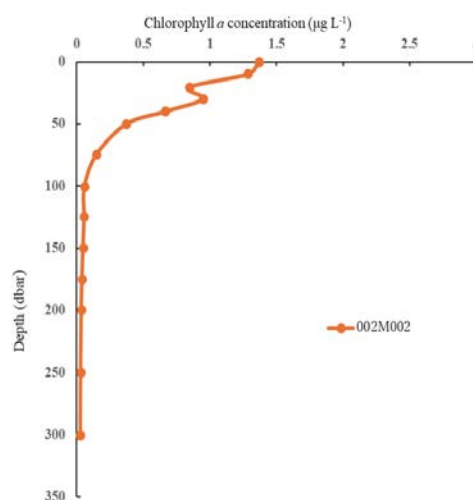
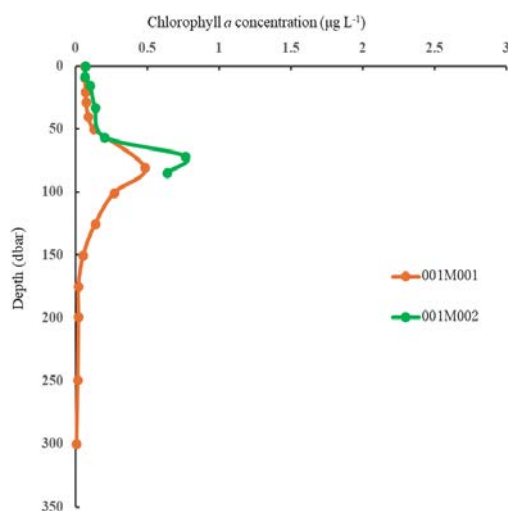
(6) Reference

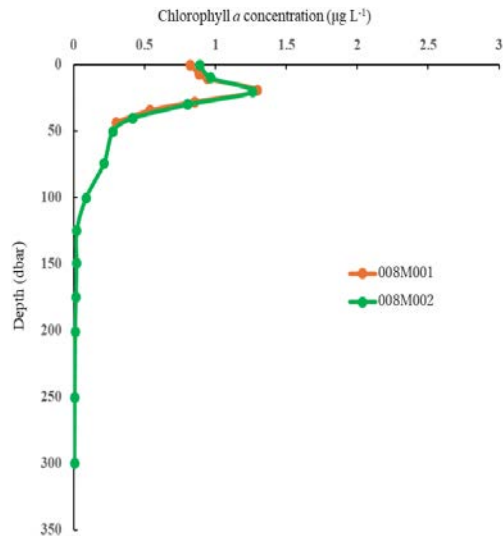
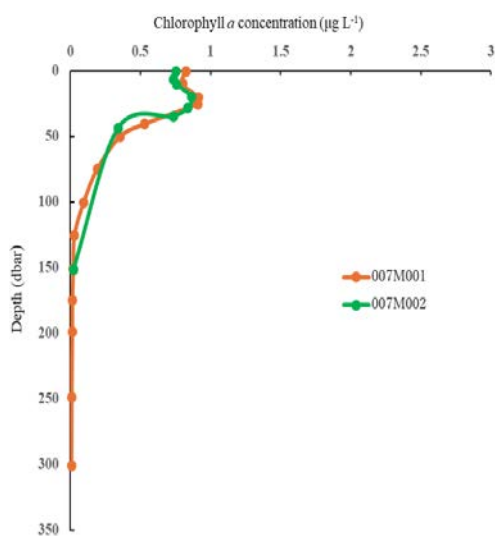
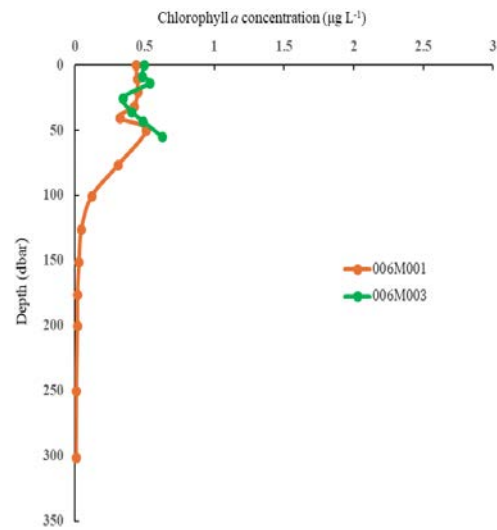
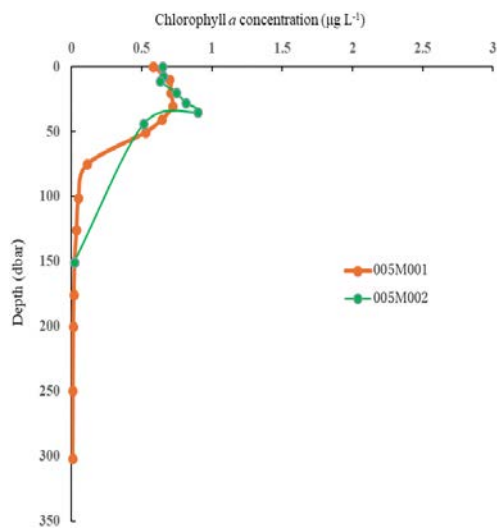
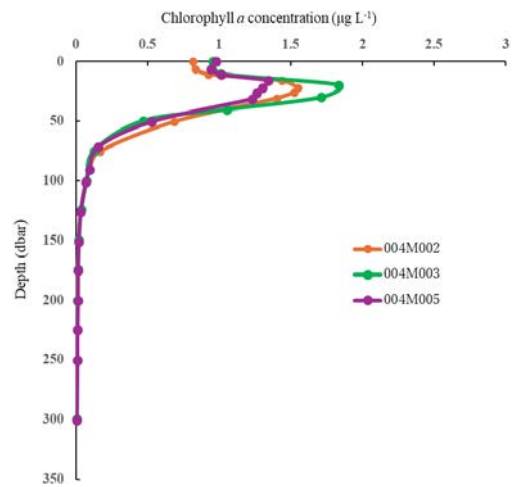
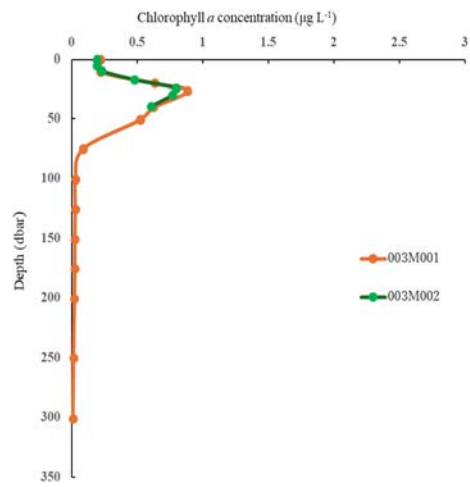
Suzuki, R., and T. Ishimaru (1990), An improved method for the determination of phytoplankton chlorophyll using N, N-dimethyl formamide, *J. Oceanogr. Soc. Japan*, 46, 190-194.

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

Table 2.4.9.1. Results of the replicate sample measurements.

	All samples
Number of replicate sample pairs	30
Standard deviation ($\mu\text{g L}^{-1}$)	0.01





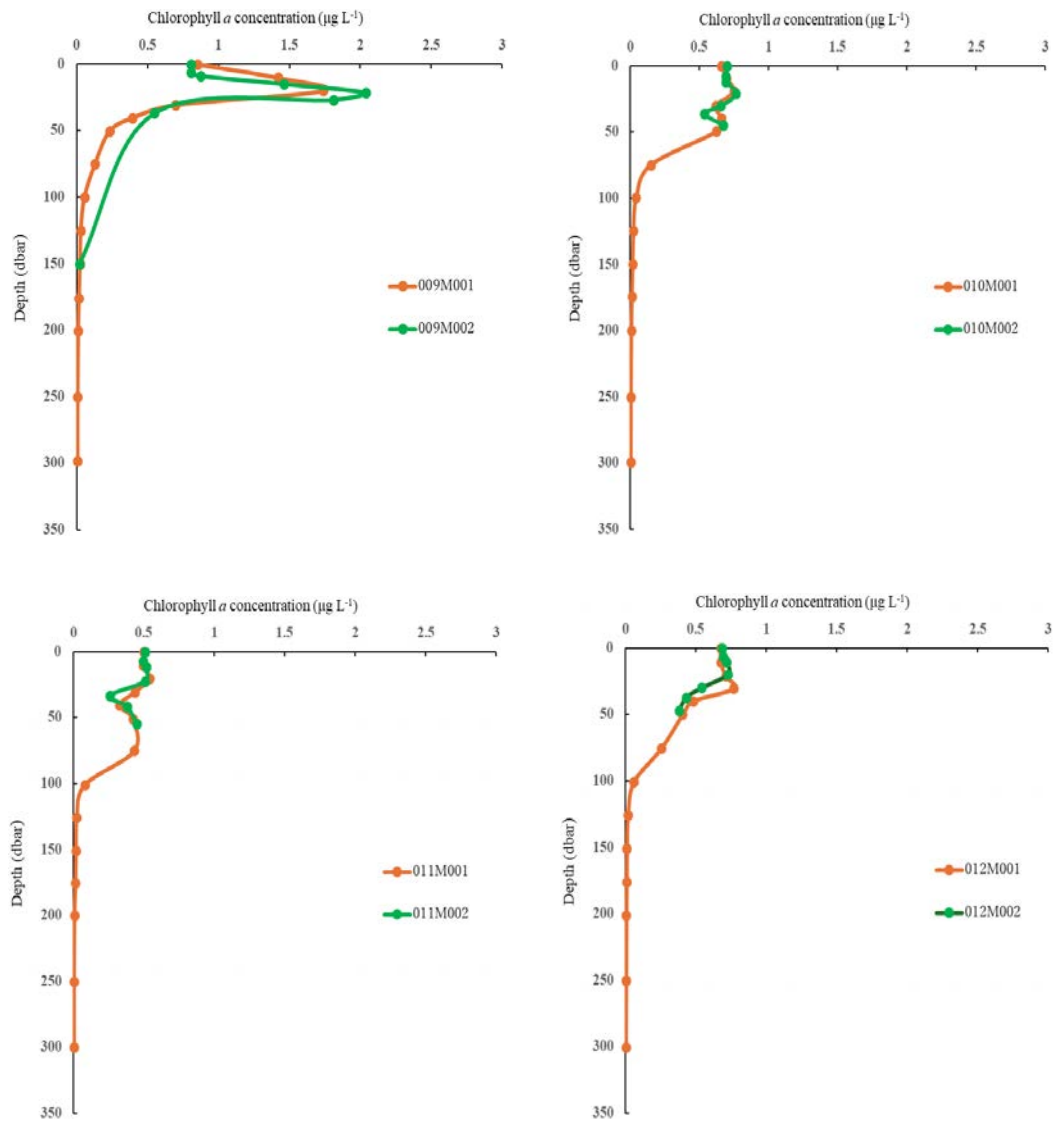
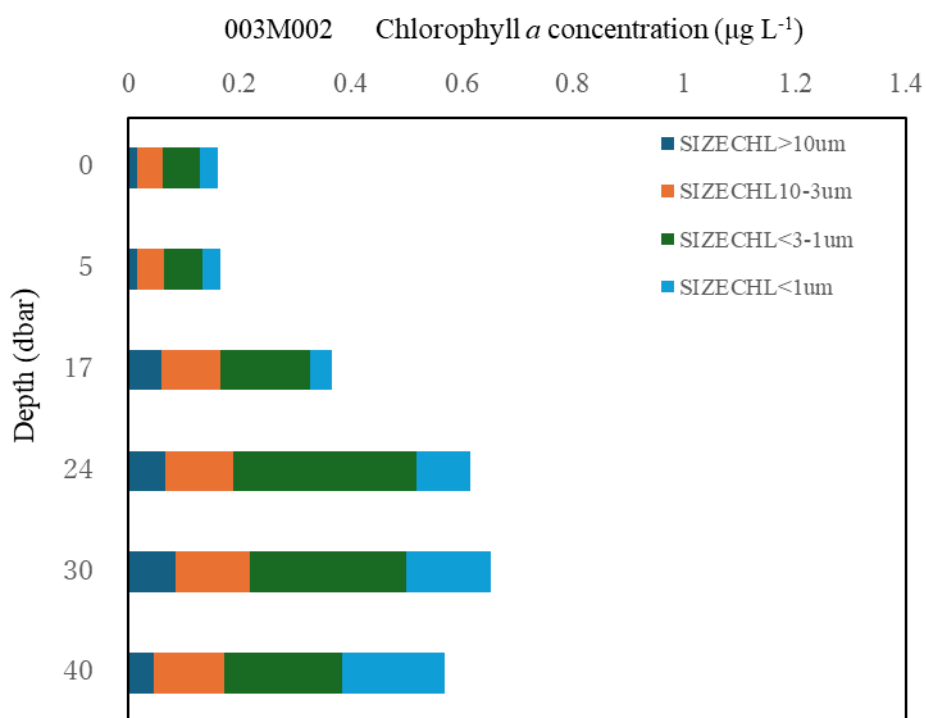
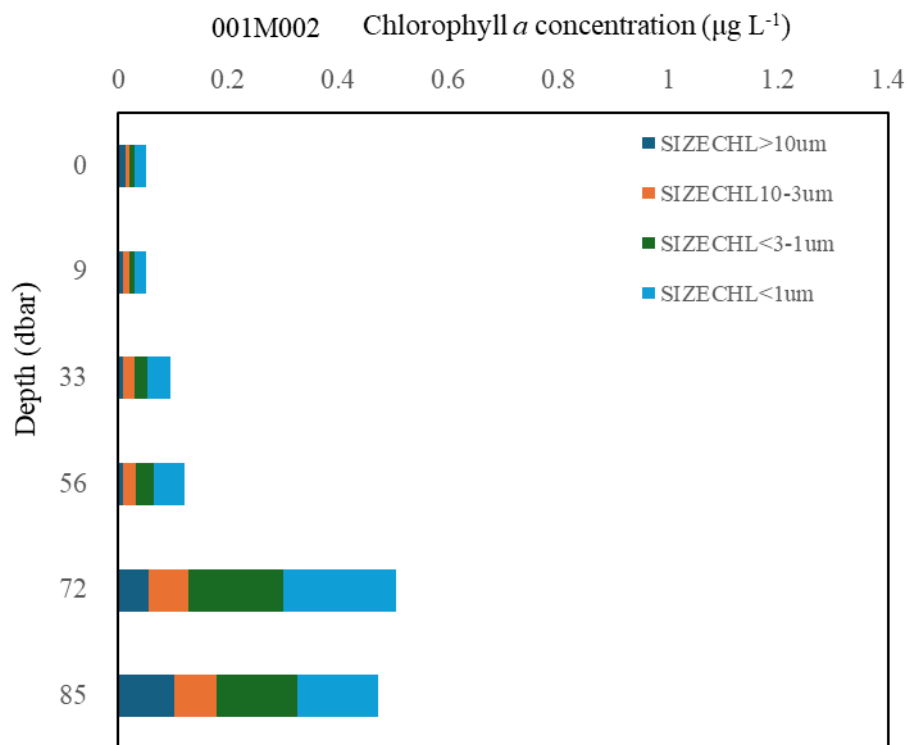
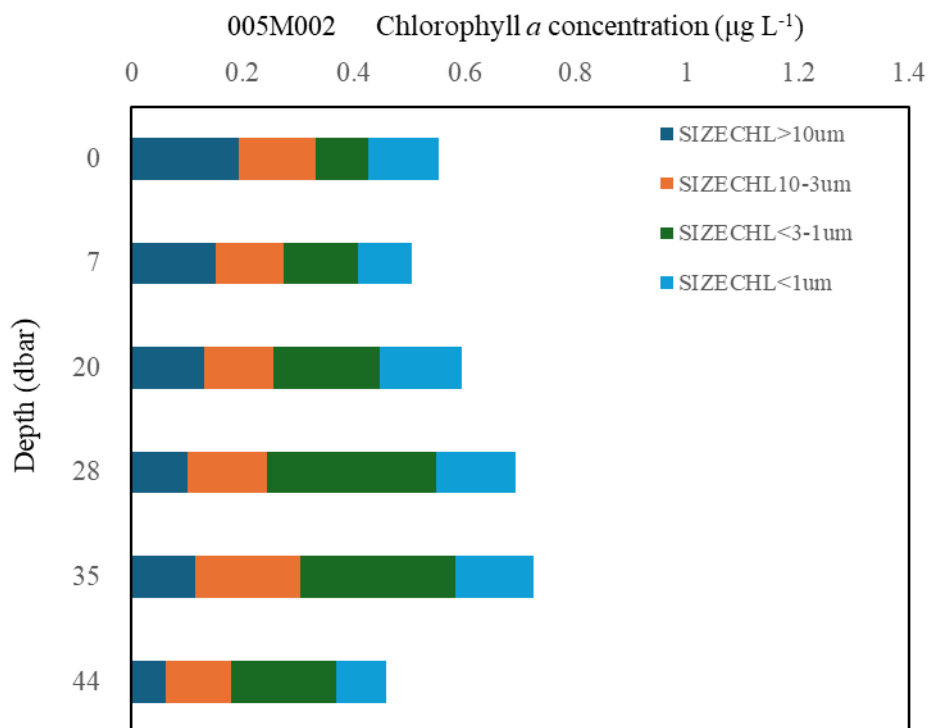
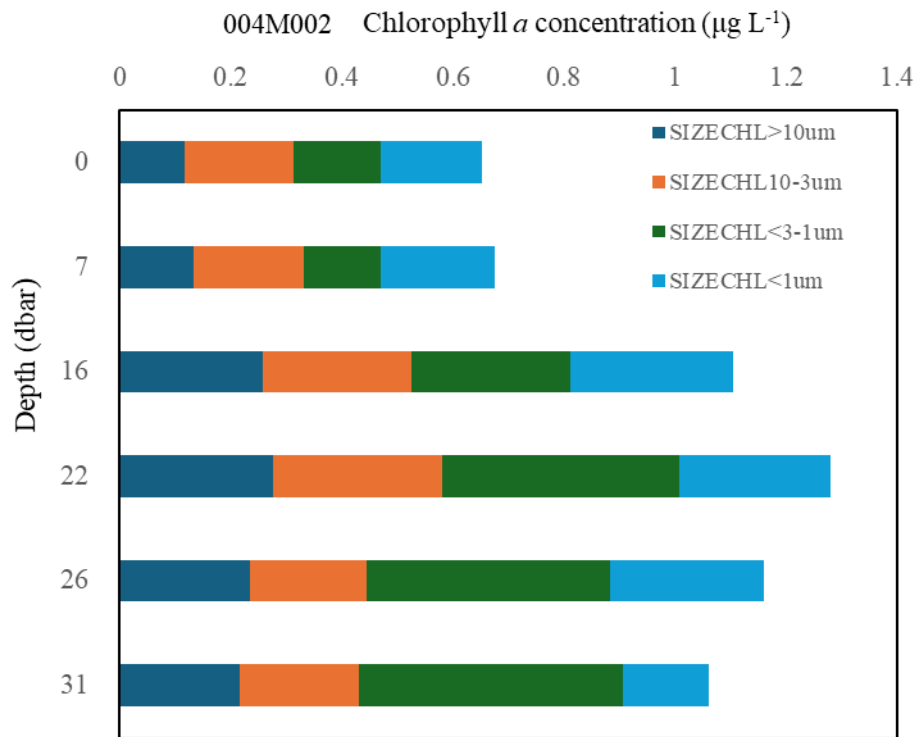
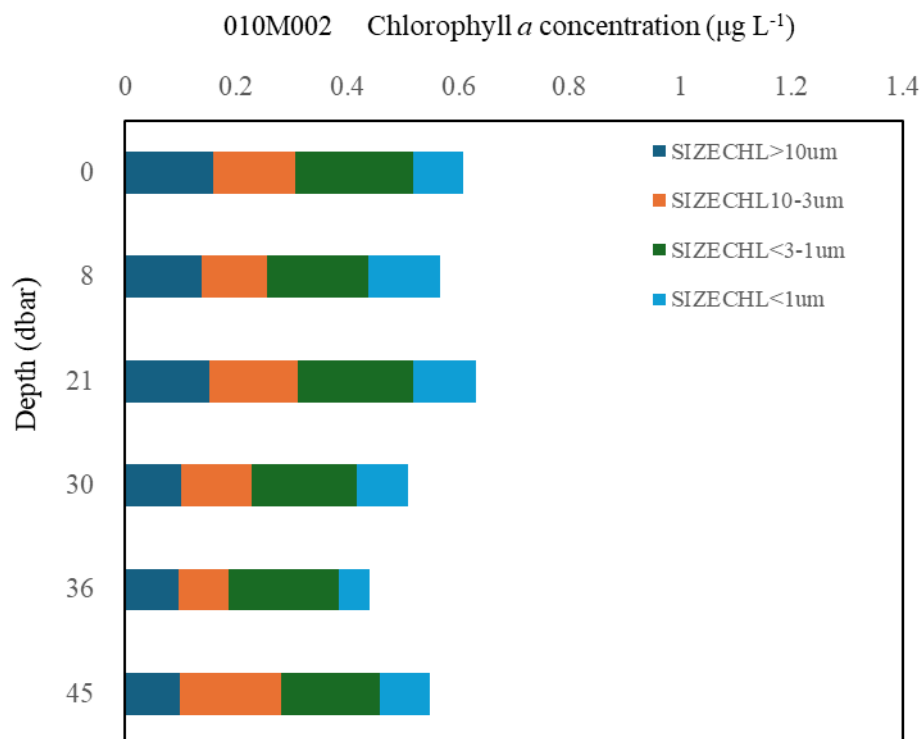
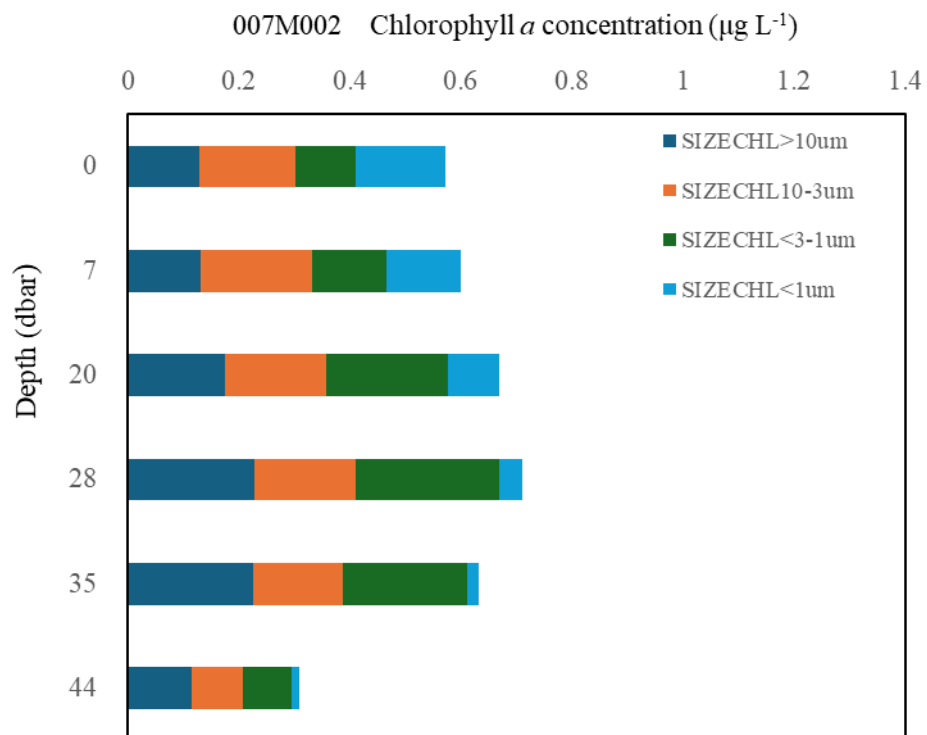


Figure 2.4.9.1. Vertical distribution of chlorophyll *a* at Stn.001 to Stn.012.







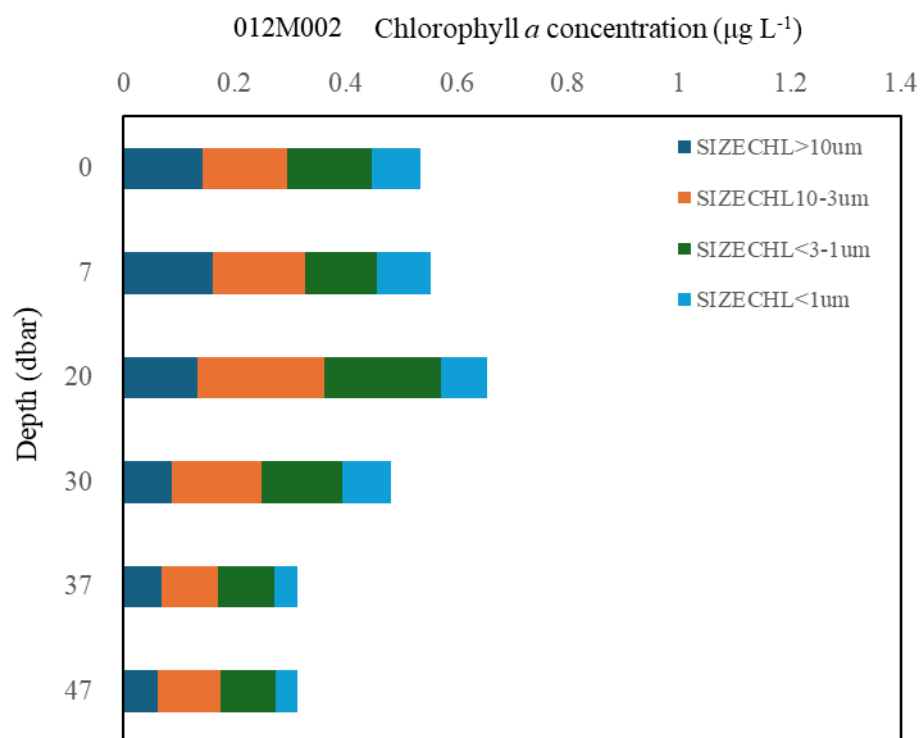


Figure 2.4.9.2. Vertical distribution of size-fractionated chlorophyll *a* at Stn.001 to Stn.012.

2.4.10 HPLC measurements of marine phytoplankton pigments

Kazuhiko Matsumoto (JAMSTEC RIGC)

Nozomi Mori (JAMSTEC RIGC)

Misato Kuwahara (MWJ)

Takuya Izutsu (MWJ)

(1) Objectives

To provide information on the influence of the chemotaxonomic composition of the phytoplankton community, analyses of phytoplankton pigments are performed using a high-performance liquid chromatography (HPLC) system.

(2) Methods

Water samples were collected at seven depths (100%, 44%, 28%, 11%, 4%, 2%, and 1% of surface light intensity) using Niskin-X bottles and a bucket. The sampling depths were determined using a PAR (photosynthetically active radiation) sensor (Sea-Bird Scientific, Washington, USA) from the previous CTD cast. Seawater samples were vacuum filtered (< 0.02 MPa) through glass microfiber filters (Whatman GF/F). The filters with moisture wiped off and vacuum dried in the freezer for several hours are stored in a deep-freezer (−80 °C) until analysis on land. Pigment concentrations will be quantified as described by Van Heukelem and Thomas (2001) using an HPLC system (Agilent Technologies, Inc.), but the extraction of phytoplankton pigments will be conducted by using N,N-dimethylformamide.

(3) Data archive

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

(4) References

Van Heukelem, L., and C. S. Thomas (2001), Computer-assisted high-performance liquid chromatography method development with applications to the isolation and analysis of phytoplankton pigments, *J. Chromatogr. A*, 910(1), 31-49.

2.4.11. DIC, TA, Nutrients-UV

Yoshiyuki NAKANO (JAMSTEC RIMTE)

(1) Objective

When measuring DIC in seawater, mercury (II) chloride is usually added to the sample to kill organisms in the seawater. However, mercury (II) chloride is a highly poisonous chemical that requires careful handling, and liquid waste disposal must be entrusted to a waste disposal company. Furthermore, it is highly likely that the use of mercury (II) chloride will be discontinued in a few years due to international mercury control treaties, so alternative sterilization methods are needed. Therefore, we have been developing a water sampling sterilization device that utilizes a new ultraviolet (UV) light source. Our objective in this cruise is to test the water sampling sterilization device using each layer water sampling of Niskin bottles.

(2) Method

We utilize a UV Luminous Array Film (UV-LAFi) for the water sampling sterilization device. UV-LAFi is a new deep-UV light source featuring surface emission and broad wavelength, and it can be expected to have higher bactericidal effect than UV-LED at the same output. UV-LAFi technologies were developed by Shikoh Tech Co., Ltd. The Basic structure for UV-C light source is based on mercury-free plasma emission technology. We wound the UV-LAFi onto a 230 mm long, $\Phi 50$ mm quartz tube. The mechanism of the water sampling sterilization device is that while seawater passes through the quartz tube, it is irradiated with UV-C from all directions, killing organisms in the seawater.

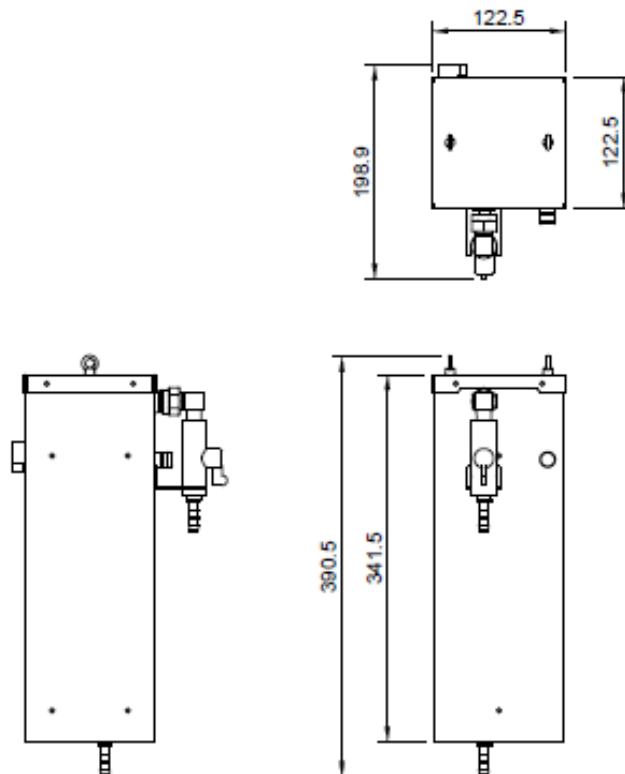


Fig. 2.4.11-1. Dimensions of the water sampling sterilization device.

(3) Observation log

Station	Date (m/d/y)	Sampling depth (dbar)
2(CT)	7/27/2025	Chla. Max (10), 100, 150, 1000

(4) Data Archive

Water sampling data by the water sampling sterilization device will not be made public because it is test data.

Reference

Kosako, T., Guo, B., Tanaka, H., Hirakawa, H., Awamoto, K., Shinoda, T. (2013) Progress in Luminous Array Film (LAFi) with Plasma Tube Technology for Seamless Tilling Super-large-area Display. SID Dig., 44(1), pp. 49-52.

Awamoto, K., Hirakawa, H., Takahashi, J., Hidaka, T. and Shinoda, T. (2016) Development of the Flexible Surface Light Source Using Luminous Array Film Technology. Proceeding of IDW '16, pp. 504-507.

Awamoto, K., Hirakawa, H., Hidaka, T., Takahashi, J., Makino, T. and Shinoda, T. (2018) Development of the Mercury Free Deep UV Surface Light Source with Plasma Technologies. Proceeding of the 2018 IEICE Society Conference, pp. 158.

2.4.12. Automated water sampling system

Yoshiyuki NAKANO (JAMSTEC RIMTE)

(1) Objective

In recent years, the number of onboard researchers in Japan has been decreasing and aging, and there are concerns about whether the current level of observation by research vessels can be maintained. Observation of seawater parameters by water sampling is a fundamental part of oceanographic observation, but there is a possibility that the water sampling process, which is one of the most labor-intensive aspects of shipboard observation, cannot be maintained at the current level. Therefore, we are developing an automated water sampling system that can automatically take routine samples from a Niskin water sampler. Our objective in this cruise is to perform water sampling from the Niskin water sampler using the newly developed automated water sampling system and compare the data with samples taken by researchers.

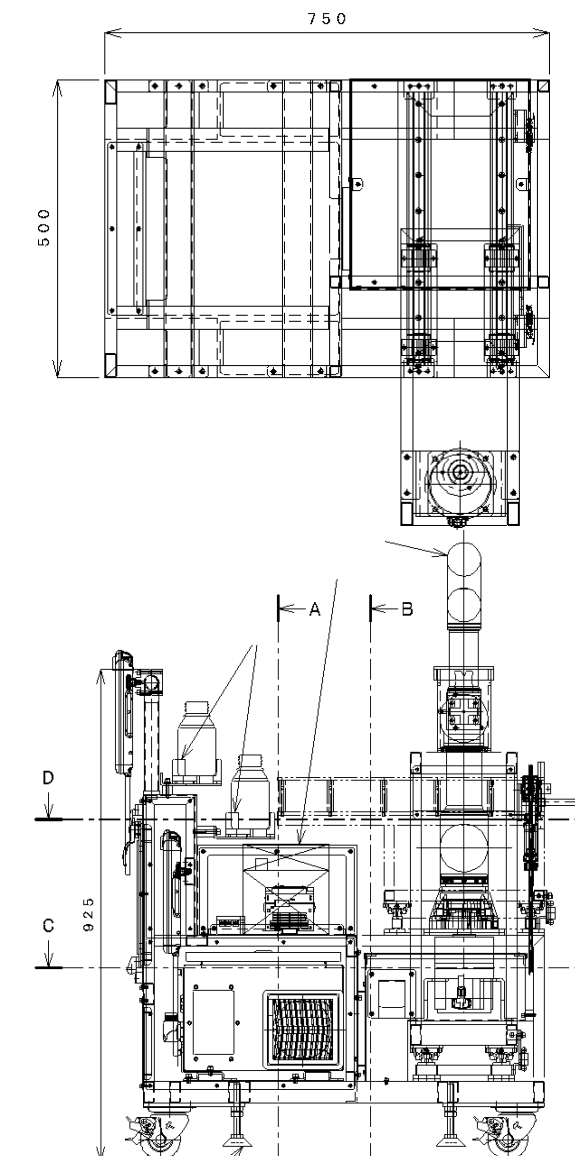


Fig. 2.4.12-1. Dimensions of the Automated water sampling system.

(2) Observation log

Station	Date (m/d/y)	Sampling depth (dbar)
5	8/11/2025	7, 44, 150
7	8/15/2025	7, 43, 150
9	8/18/2025	6, 36, 150
11	8/21/2025	1000, 2000, 3000, 4000

Sampling item

Dissolved inorganic carbon (DIC), Total Alkalinity (TA), Salinity, Nutrients, Chlorophyll *a*

(3) Data Archive

Water sampling data by the automated water sampling system will not be made public because it is test data.

2.4.13 In-situ filtration system

Minako KURISU (The University of Tokyo, AORI) -not on board

Maki NOGUCHI Aita (JAMSTEC RIGC)

Kana NAGASHIMA (JAMSTEC RIGC)

(1) Objective

Iron (Fe) is an important micronutrient in surface seawater (Martin and Fitzwater, 1988; Moore et al., 2023). The subarctic North Pacific is one of the Fe-limiting regions, where Fe is primarily supplied by atmospheric aerosols, dissolution of Fe from coastal or benthic sediments, hydrothermal activity. However, detailed Fe cycles in the ocean, such as the relative contributions of these sources and the mechanisms of Fe transport, remain unclear.

Suspended particulate matters (SPM) in the ocean play significant role in transport of Fe. SPM includes biological, lithogenic, and authigenic Fe, which behave differently in the ocean, and their relative abundance and each role in the Fe cycle are poorly understood. Thus, we aimed to identify their characteristics and relative abundance in SPM using X-ray absorption fine structure analysis, combined with particulate characterization by cathodoluminescence (CL).

(2) Sampling Operations

Large-volume water samplers (Plafilt, Offshore Technologies, LLC) were deployed by attaching them directly to Kevlar rope to collect suspended particles from seawater. During this cruise, casts were carried out at depths of 10, 200, and 600 m, or at 30, 50, and 600 m, depending on the station. For quartz grain samples, three units were set at a depth of ~ 5 m and operated for a specific time interval (see Table 1). Supor800 filters were used for all casts.

(3) Analysis

i) Speciation of Fe

Speciation of Fe is conducted by X-ray absorption fine structure (XAFS) analysis at the Photon Factory, KEK (Tsukuba, Japan) and SPring-8 (Sayo, Japan). SPM collected on the filter are freeze-dried before the analysis. Bulk (at the BL-12C) and individual particle analyses (with a high spacial resolution X-ray irradiation at the BL-4A and 19A) will be conducted.

ii) Mineral grains analysis

CL spectra of single quartz particles will be measured using an SEM (FEI Quanta 450 FEG) combined with a CL system (Gatan, Mono CL4 Swift) at JAMSTEC to estimate the source areas. In addition, the number of mineral particles and the sizes will be measured using the SEM. Taken together, we could estimate the volume of natural aerosols from each desert in the East Asia (*e.g.* the Taklimakan Desert and the Gobi Desert), North Africa (Saharan Desert), and Arabia (Arabian Desert) within the shallow waters of the eastern North Pacific.

(4) Data archive

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

Table 1 Information on each sampling cast

Date & station	Depth (m)	Filtration rate (L)	Filters	Measurements
2025/8/06 St.4(K2)	10	12.764	Supor800	Suspended particulate matter (SPM)
	200	115.931		
	600	108.566		
2025/8/22 St.12(OSP) #1	10	15.802	Supor800	Suspended particulate matter (SPM)
	200	125.876		
	600	—		
2025/8/23 St.12(OSP) #2	5	9.063	Supor800	Quarts grains
	5	24.191		
	5	12.102		
2025/8/24 St.12(OSP) #3	50	36.961	Supor800	(Plankton analysis)
	600	110.054		SPM

2.4.14 Mineral particles

Kana NAGASHIMA (JAMSTEC RIGC)

Naoko NAGATSUKA (JAMSTEC RIGC) -not on board

Maki NOGUCHI Aita (JAMSTEC RIGC)

(1) Objective

The Asian dust emitted from East Asia, mainly from the Taklimakan and Gobi Deserts, are known to be transported to the North Pacific through the westerlies. In addition, recently, dust from Sahara Desert and Arabia Desert, as well as volcanic ash derived from the Kamchatka Peninsula and the Aleutian Islands is also expected to supply significant amount of dust to the North Pacific. To clarify the exact emission sources and the deposition flux from each source, and estimate the iron supply from Asian/Saharan/Arabian dust and volcanic ash to the Subarctic Pacific, known as a high-nutrient and low-chlorophyll region, we collected seawater samples for the measurements of provenance and vertical concentrations of mineral particles in the seawater.

(2) Sampling

Water samples were collected using Niskin-X bottles on a CTD-rosette system and a bucket for surface seawater (0 m depth). For the analysis of chemical and physical properties of mineral particles and particle concentrations in seawater, 2–3 L of seawater were collected from the following stations and depths. The samples were filtered on board using 0.4 µm Isopore membrane filters (47 mm diameter) and stored in a refrigerator until analysis.

[2 L water samples]

Station (Cast#): Sampling depth (dbar)

St. 1 KEO (C1): 0 (bucket), 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 2 CT (C1): 0, 10, 20, 50, 100, 500, 1000, 4000, 6130

St. 3 KNOT (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 4 K2 (C3): 10, 20, 50, 100, 350 (3 L), 400 (3 L), 500 (3 L), 1000, 4000, B-10

St. 5 (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 6 (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 6 (C3): 300 (12 L)

St. 7 (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 8 (C2): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 9 (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 10 (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 11 (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

St. 12 OSP (C1): 10, 20, 50, 100, 500, 1000, 4000, B-10

[3 L water samples]

Station (Cast#): Sampling depth (irradiance %)

St. 3 KNOT (C2): 1, 2, 4, 11, 28, 44, 100 (bucket)

St. 4 K2 (C2): 1, 2, 4, 11, 28, 44, 100

St. 4 K2 (C5): 1, 2, 4, 11, 28, 44, 100
St. 5 (C2): 1, 2, 4, 11, 28, 44, 100
St. 6 (C3): 1, 2, 4, 11, 28, 44, 100
St. 7 (C2): 1, 2, 4, 11, 28, 44, 100
St. 8 (C1): 1, 2, 4, 11, 28, 44, 100
St. 9 (C2): 1, 2, 4, 11, 28, 44, 100
St. 10 (C2): 1, 2, 4, 11, 28, 44, 100
St. 11 (C2): 1, 2, 4, 11, 28, 44, 100
St. 12 OSP (C2): 1, 2, 4, 11, 28, 44, 100

(3) Analysis

We will examine chemical and physical properties of quartz particles using scanning electron microscope–cathodoluminescence (SEM–CL) analysis of single quartz particles on filters to estimate the source and calculate the number of particles from Asian deserts. The measurements will be conducted using an SEM (FEI Quanta 450 FEG) equipped with CL (Gatan, Mono CL4) at JAMSTEC.

In addition, we will analyze other microparticles using SEM–energy dispersive X-ray spectroscopy (SEM–EDS) to determine their size and composition, thereby identifying their origin (continental or volcanic) and spatial distribution. These measurements will also be conducted using an SEM equipped with an EDS (EDAX, Octane Elite 30) at JAMSTEC.

(4) Data archive

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

2.4.15 Radiocarbon

Yusuke YOKOYAMA (University of Tokyo, AORI)

Yosuke MIYAIRI (University of Tokyo, AORI)

Maki NOGUCHI (JAMSTEC RCGC)

Masahide WAKITA (JAMSTEC MIO)

(1) Objectives

The objective of this study is to collect seawater and measure its radiocarbon content in order to determine the concentrations of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC). Radiocarbon is used not only to determine the chronology of geological materials, but also as a reliable tracer to understand water mixing from a global to regional scale. The North Pacific is a particularly important location for monitoring global ocean circulation due to the large-scale upwelling observed there. In this study, we will measure the radiocarbon content of DIC and DOC in samples collected during the MR25-4 cruise.

(2) Instruments and methods

i) Seawater sampling

Samples for radiocarbon measurements were collected in the northwestern Pacific Ocean during an R/V Mirai cruise from July to August 2025. The seawater samples were obtained using a CTD (conductivity, temperature, and depth) rosette sampler equipped with 36 Niskin bottles (12-liter type). The samples were collected at 14 different depths, including surface water collected using a bucket, ranging from 0 to 6,130 meters (Table 1). Water samples for DIC measurements were transferred from Niskin bottles to 250 mL glass bottles. For DIC, a three-fold volume overflow was conducted to prevent contamination from ambient air. Then, a saturated mercuric chloride (HgCl_2) solution was added for preservation. The bottles were sealed with APIEZON(R) grease-coated, ground-glass stopper caps and stored in the dark at room temperature. For DOC samples, seawater was filtered by gravity through a pre-combusted, 47-mm-diameter, 0.7- μm -pore-size Watman GF/F glass fiber filter. The filtrate was collected in 250ml Duran(R) Screw-Top bottle treated with nitric acid cleaning and stored below -20°C in the dark until analysis.

ii) Laboratory experiment procedures

Radiocarbon measurements will be conducted at the Atmosphere and Ocean Research Institute (AORI) at the University of Tokyo, which houses an Accelerator Mass Spectrometer (AMS). This machine is designed for radiocarbon measurements and has a terminal voltage of 240 kV (Yokoyama et al., 2019). Due to rare abundance of radiocarbon in nature (i.e., less than 10^{-12}), careful laboratory treatment is required for the two-step experimental process, which includes CO_2 extraction from seawater and graphitization (Lan et al., 2024; Yokoyama et al., 2022). DIC samples undergo carbon dioxide extraction using the bubbling method (Servettaz et al., 2019; Lan et al., 2024). Approximately 2 mL of phosphoric acid is added to seawater samples, and bubbling is conducted for 15 minutes in a glass tube filled with 60 kPa of helium gas to remove the CO_2 liberated from DIC. Water vapor is initially removed by two cryogenic traps (cooled ethanol at -100°C) during the 15-minute degassing

process under a helium atmosphere. Then, the trapped CO₂ is transferred to a liquid nitrogen trap at -196 °C. Subsequently, the CO₂ samples are reduced to graphite using a high-vacuum line under a pure hydrogen atmosphere (Yokoyama et al., 2007; 2010).

iii) Radiocarbon measurements

The radiocarbon content of the processed graphite samples is measured using AMS. The radiocarbon is expressed as follows (F: fraction modern).

$$F = [({}^{14}\text{C}/{}^{12}\text{C})_{\text{SN}}] / [({}^{14}\text{C}/{}^{12}\text{C})_{\text{ON}}] \quad (1)$$

where $({}^{14}\text{C}/{}^{12}\text{C})_{\text{SN}}$ and $({}^{14}\text{C}/{}^{12}\text{C})_{\text{ON}}$ are respectively radiocarbon concentration for samples and standard that are normalized by $\delta^{13}\text{C}$ measured by AMS.

Expression of measured radiocarbon is then converted to $\Delta^{14}\text{C}$ as follows (cf. Stuiver and Polach 1977; Stenström et al. 2011).

$$\Delta^{14}\text{C} = (Fe^{\lambda T} - 1) \times 1000 \quad \text{‰} \quad (2)$$

The $\Delta^{14}\text{C}$ value is the per mil difference between the initial ${}^{14}\text{C}/{}^{12}\text{C}$ of a sample (normalized for isotopic fractionation) and the ${}^{14}\text{C}/{}^{12}\text{C}$ of a standard; the standard has a value similar to the initial ${}^{14}\text{C}/{}^{12}\text{C}$ ratio of 19th century wood. The $\Delta^{14}\text{C}$ is defined and discussed in (Stuiver and Polach 1977), where F is the fraction modern (Donahue et al. 1990), λ is the decay constant that corresponds to the 5730 year half-life, and T is the age of measurements.

(3) Data archive

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

(4) References

- Lan, H., Yokoyama, Y., Hirabayashi, S., Miyairi, Y., Jiang, S., Saito, H., Hasumi, H., and Yasuda, I. (2024); Mixing dynamics within the Kuroshio area reflected in dissolved inorganic radiocarbon values. *Journal Geophysical Research: Oceans*, 10.1029/2023JC020261
- Servettaz, A. P., Yokoyama, Y., Hirabayashi, S., Kienast, M., Miyairi, Y., & Mohtadi, M. (2019). Dissolved inorganic radiocarbon content of the Western Coral sea: Implications for intermediate and deep water circulation. *Radiocarbon*, 61(6), 1685–1696.
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- Yokoyama, Y., Koizumi, M., Matsuzaki, H., Miyairi, Y., & Ohkouchi, N. (2010). Developing ultra small-scale radiocarbon sample measurement at the University of Tokyo. *Radiocarbon*, 52(2), 310–318.
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University of Tokyo. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 455, 311–316.

Yokoyama, Y., Miyairi, Y., Aze, T., Sawada, C., Ando, Y., Izawa, S., et al. (2022). Efficient radiocarbon measurements on marine and terrestrial samples with single stage accelerator mass spectrometry at the atmosphere and Ocean Research Institute, University of Tokyo. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 532, 62–67.

Table 1. Sampling sites

Station No.	1	2	3	4	5	6	7	8	9	10	11	12
Sampling time (Start time)	2025/7/30 9:39	2025/7/28 3:30	2025/8/4 8:06	2025/8/7 7:02	2025/8/11 6:48	2025/8/13 2:52	2025/8/15 1:30	2025/8/13 2:52	2025/8/17 6:40	2025/8/19 2:46	2025/8/21 2:51	2025/8/23 2:36
Sampling time (Finish Time)		2025/7/28 5:02	2025/8/4 9:21	2025/8/7 5:56	2025/8/11 8:05	2025/8/13 3:56	2025/8/15 2:42	2025/8/13 3:56	2025/8/17 7:51	2025/8/19 4:01	2025/8/21 4:03	2025/8/13 4:02
Sampling Depth(m)	0	0	0	0	0	0	0	0	0	0	0	0
	10	10	10	10	10	10	10	10	10	10	10	10
	50	50	50	50	50	50	50	50	50	50	50	50
	150	150	150	150	150	150	150	150	150	150	150	150
	200	200	200	200	200	200	200	200	200	200	200	200
	300	300	300	300	300	300	300	300	300	300	300	300
	400	400	400	400	400	400	400	400	400	400	400	400
	500	500	500	500	500	500	500	500	500	500	500	500
	600	600	600	600	600	600	600	600	600	600	600	600
	800	800	800	800	800	800	800	800	800	800	800	800
	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
	3000	4000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
	5601	6130	5308	5178	5507	4961	5752	5766	5500	4991	4990	4248
Sample quantity at each depth:250mlCommon Sliding Reagent Bottle 250mL (for DIC- ¹⁴ C)	1	1	1	1	1	1	1	1	1	1	1	1
Sample quantity at each depth:250ml Duran Screw- Top bottle (for DOM- ¹⁴ C)	1	1	1	1	1	1	1	1	1	1	1	1

2.4.16 Fluorescent dissolved organic matter

September 10, 2025

Hiroshi UCHIDA, (JAMSTEC RIGC)

Masahito SHIGEMITSU (JAMSTEC RIGC) (not onboard)

Masahide WAKITA (JAMSTEC MIO)

(1) Objective

The objective of this study is to collect calibration data for in situ fluorometer (e.g. Shigemitsu et al., 2020), and to examine spatial distribution and temporal change of fluorescent dissolved organic matter (FDOM).

(2) Instruments and method

Seawater samples for FDOM were collected in 40 ml pre-combusted glass vials with acid-washed Teflon-lined caps. Filtrations were carried out by connecting the spigot of the Niskin bottle through a silicone tube to an inline plastic filter holder. The samples will be stored frozen in the dark until laboratory analysis after the cruise.

A benchtop fluorometer (Aqualog, Horiba Scientific, Japan, HGS no. U54CX17C) will be used to measure EEM fluorescence spectra. Emission scans from 248–829 nm will be obtained at 2.33 nm intervals for sequential excitations from 240–560 nm at 5 nm intervals, with an integration time of 12 s and using the high Charge-Coupled Device (CCD) gain mode. The glass cell folder also serves as a water jacket and will be connected to a refrigerated temperature control bath (NCB-1220B, TOKYO RIKAKIKAI Co., Ltd.), whose temperature will be set to 20 °C, to maintain the sample temperature to 20 °C during measurement (about 15 minutes).

(3) Results

The samples were collected at stations 002 (CT), 004 (K2), and 012 (PAPA), and stored in the freezer on board. The sample will be measured in a laboratory of JAMSTEC after the cruise. MSSW lot PRE21 will be measured as a reference.

(4) Reference

Shigemitsu, M., Uchida, H., Yokokawa, T., Arulananthan, K., and Murata, A., 2020, Determining the distribution of fluorescent organic matter in the Indian Ocean using in situ fluorometry. *Front. Microbiol.* 11:589262. doi:10.3389/fmicb.2020.589262.

(5) Data archive

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

2.4.17 Transparent exopolymer particles

Kazuhiko Matsumoto (JAMSTEC RIGC)

(1) Objectives

Transparent exopolymer particles (TEP), i.e., polysaccharide-rich microgels that are produced primarily by the abiotic coagulation of phytoplankton exudates, are identifying as organic gels in the ocean interior. TEP is very sticky, and it aggregates with other suspended particles, resulting in the formation of sinking marine snow. In addition, TEP becomes enriched in the surface microlayer and expected to produce marine organic aerosol directly at the sea surface due to the interaction between wind and waves. To understand the processes of settling particles and organic aerosol formation, the concentrations of TEP are measured.

(2) Sampling and measurement procedure

Seawater samples were collected with Niskin-X bottles and a bucket vertically at Stations 1, 4, 5, and 12. Samples were fixed with 1% (v/v) formalin and stored in refrigerator. The analyses will be conducted after the cruise on land as follows. The water samples of 200 mL are filtered onto 0.4- μm polycarbonate filters, and the filters are stained with 1 mL alcian blue solution which adjusted to pH 2.5 and rinsed with 1 mL of Milli-Q water. Stained filter samples are stored in freezer until analysis. Filter samples are soaked for 2 - 5 h in 80% sulfuric acid (H_2SO_4) to elute the dye and then the absorbance of the solution is measured at 787 nm in a 1 cm cuvette. The calibration curve is produced by using a xanthan gum solution (XG, Sigma-Aldrich), and the TEP concentrations are represented as XG equivalent (Passow and Alldredge, 1995).

(3) Data archive

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

(4) Reference

Passow, U., and A. L. Alldredge (1995), A dye-binding assay for the spectrophotometric measurement of transparent exopolymer particles (TEP) in the ocean, *Limnol. Oceanogr.*, 40(7): 1326-1335.

2.4.18 Nitrate and ammonium stable isotopes

Akiko MAKABE (JAMSTEC X-star)

Masahide WAKITA (JAMSTEC MIO)

(1) Objectives

Nitrogen nutrients such as nitrate and ammonium are one of the limiting factors for primary production in the surface ocean. Stable isotope ratios of nitrate have been used to study the nitrogen cycle in oceans. However, there is no data on the stable isotope ratio of ammonium in a pelagic ocean. The objectives of this cruise are to reveal the temporal and spatial distributions of the nitrate and ammonium isotopic compositions and to improve our understanding of the nitrogen cycle in the subarctic ocean.

(2) Instruments and methods

i) Nitrate isotope ratio

Samples for ammonium stable isotope analysis were collected directly from Niskin samplers into 15 mL PP bottles through glass fiber filters (GF/F). The seawater samples were frozen until laboratory processing. Both nitrogen and oxygen stable isotope ratio of nitrate will be measured by a GC-IRMS after conversion to N_2O using the bacterial method.

ii) Ammonium isotope ratio

Samples for ammonium stable isotope analysis were collected directly from Niskin samplers into 50 mL PE bottles through glass fiber filters (GF/F). The seawater samples were frozen until laboratory processing. The ammonium in seawater will be extracted by the diffusion method and converted to nitrate by the wet oxidation method. The nitrogen stable isotope ratio of nitrate will be measured by a GC-IRMS after conversion to N_2O using the bacterial method.

(3) References

- Holmes, R.M., J.W. McClelland, D.M. Sigman, B. Fry, and B.J. Peterson, (1998) Measuring ^{15}N - NH_4^+ in marine, estuarine and fresh waters: An adaptation of the ammonia diffusion method for samples with low ammonium concentrations. *Marine Chemistry*, 235-243.
- Casciotti, K.L., D.M. Sigman, M. Galanter Hastings, J.K. Böhlke, and A. Hilkert, (2002) Measurement of the Oxygen Isotopic Composition of Nitrate in Seawater and Freshwater Using the Denitrifier Method. *Analytical Chemistry*, 74, 19, 4905–4912

2.4.19 pH sensor

September 24, 2025

Shigeki HOSODA (JAMSTEC RIGC) (not onboard)

Yoshiyuki NAKANO (JAMSTEC RIMTE) (onboard)

Akihiko MURATA (JAMSTEC RIGC) (not onboard)

Hajime KAYANNE (The University of Tokyo) (not onboard)

Nori FUJITA (The University of Tokyo) (not onboard)

(1) Objective

The objective of this study is to evaluate a compact, lightweight pH sensor for a drifting float by comparing it with the water sampling measurement.

(2) Instruments and method

The project is being conducted as part of the research theme “Elucidation of CO₂ absorption and storage mechanism of subtropical mode water by Argo” in the CREST project of “Carbon-Blue X” funded by JST. The ultimate goal is to develop a domestically next-generation pH sensor onto a domestically produced general-purpose compact drifting float (named “MOF”) and deploy it into subtropical mode water (STMW) to observe carbon chemistry. During this cruise, as part of the field testing, the pH sensor unit itself will be mounted on the CTD frame. The goal is to acquire vertical profiles down to 2000m depth to understand the sensor characteristics.

The pH sensor used in this test outputs voltage values and samples at one-second intervals. We also performed calibration tests of the pH sensor itself before the deployment. During this cruise, we acquired vertical profiles down to 2000m depth at the following locations and dates/times.

Observation Point: KEO Location: 32.3532N, 144.4141E

Date: Jul. 31, 2025 Time: 5:08-6:45 (UTC) Water Depth: 5,793m

(3) Results

Several test observations were planned; however, a small leak was detected from the pH sensor unit after the first observation, resulting in only one observation being completed. Future verification will be conducted using pH measurements from water samples collected at the same location during the Mirai voyage, with plans to correct the pH profile.



2.4.20 Total Alkalinity

Masahide WAKITA (JAMSTEC)

Tomoki NAKAMURA (MWJ)

Masahiro ORUI (MWJ)

(1) Objective

Onboard total alkalinity measurement of seawater collected in sampling bottles.

(2) Methods, Apparatus and Performance

(2)-1 Seawater sampling

Seawater samples were collected by 12 L sampling bottles mounted on the CTD/Carousel Water Sampling System and a bucket at 12 stations. The seawater from the sampling bottle was filled into the 100 mL borosilicate glass bottles (SCHOTT 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 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 bubbles were introduced into the titration cell for degassing CO₂ from the mixed solution sufficiently.

The TA is calculated based on the following equation:

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

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

where $R(25)$ represents the difference of absorbance at 616 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) Preliminary result

The repeatability of this system was $1.01 \mu\text{mol kg}^{-1}$ ($n = 7$) which was estimated from standard deviation of measured CRM value during this cruise. A few replicate samples were taken at most stations and the difference between each pair of analyses was plotted on a range control chart (see fig. 2.4.20-1). The average of the difference was provisionally $0.82 \mu\text{mol kg}^{-1}$ ($n = 50$) with its standard deviation of $0.63 \mu\text{mol kg}^{-1}$.

(4) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC and will be opened to the public via “Data Research 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.

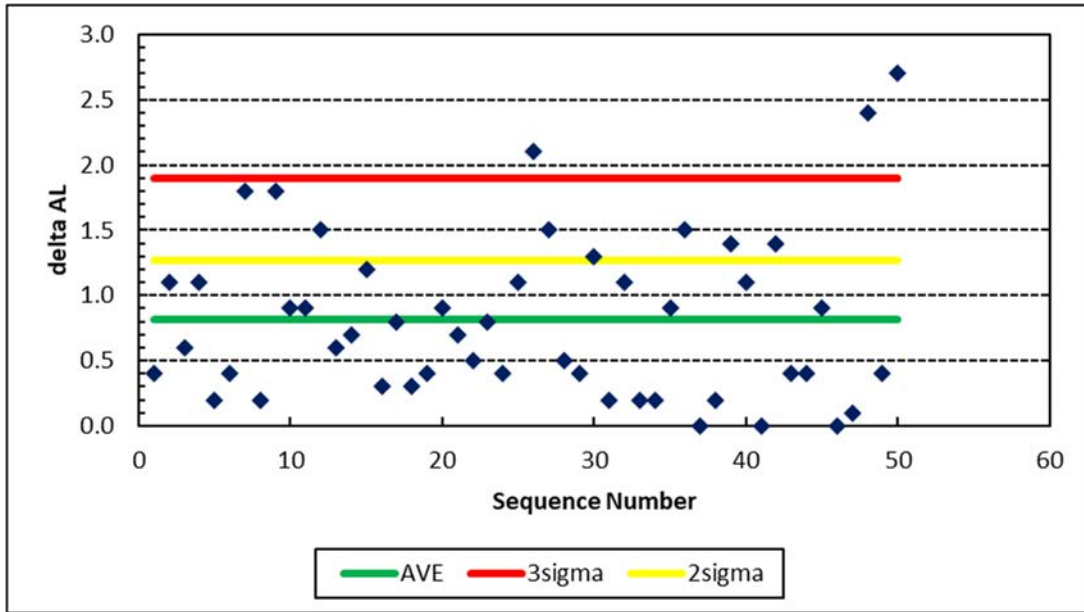


Figure 2.4.20-1 Range control chart of the absolute differences of replicate measurements of TA carried out during this cruise. AVE represents the average of absolute difference, 3σ the upper control limit (standard deviation of AVE $\times 3$), and 2σ upper warning limit (standard deviation of AVE $\times 2$).

2.5 Biological oceanography

2.5.1 Primary productivity

Kazuhiko Matsumoto (JAMSTEC RIGC): Principal Investigator

Nozomi Mori (JAMSTEC RIGC)

Misato Kuwahara (MWJ)

Takuya Izutsu (MWJ)

(1) Objectives

To investigate the photosynthetic performance of marine phytoplankton in the subtropical and subarctic regions of the North Pacific, primary productivity was measured by the on-deck incubation and the photosynthesis-irradiance ($P-E$) curve experiments.

(2) Methods

i. Sampling

Water samples were collected using Niskin-X bottles installed acid-cleaned O-ring at the appropriate optical depths (100%, 44%, 28%, 11%, 4%, 2%, and 1% of surface light intensity), and a bucket at the surface. Sampling depths for the on-deck incubation (Table 2.5.1) were determined using a PAR (photosynthetically active radiation) sensor (Sea-Bird Scientific, Washington, USA) from the previous CTD cast. $P-E$ curve experiments were conducted at the depths of 100%, 44%, 4%, and 1% of surface light intensity. Seawater at each depth was transferred into acid-cleaned, four transparent polycarbonate bottles and a dark polyethylene bottle for the on-deck incubation. Seawater samples for the $P-E$ curve experiments were transferred into the acid-cleaned, eight transparent polystyrene bottles.

ii. Incubation

Just before the incubation, $\text{NaH}^{13}\text{CO}_3$ dissolved in water was added to each bottle to a final concentration of 0.2mM, increasing the bicarbonate concentration by approximately 10 %. The initial water samples were filtered immediately after the addition of $\text{NaH}^{13}\text{CO}_3$ solution.

a) on-deck incubation:

The incubation was conducted in two on-deck baths, the temperature of which was maintained by either a surface seawater overflow or an immersion cooler, depending on the temperature of the water at each sampling depth. The light intensity for each depth was adjusted by coating the culture cylinder with blue film and by covering it with a light-shielding sheets. The incubation period began overnight. It continued from night until dawn the following day. This allowed for the calculation of net primary production over a 24-hour period, with respiratory losses subtracted

from the amount of carbon incorporated through photosynthesis from one dawn to the next.

b) *P-E* curve experiment:

Four incubators were filled with water, and their water temperature were controlled appropriately by water chillers. Each incubator was illuminated at one end by a 500W halogen lamp attached infrared cut-off filter, and eight bottles were arranged linearly against the lamp and controlled light intensity by shielding with a neutral density filter on lamp side. Incubations were conducted for 3 h during daytime.

iii. Measurement

After incubation, water samples were immediately filter through pre-combusted (450°C, 5 hours) GF/F filter. The filters were exposed to HCl vapor for an hour to remove the inorganic carbon, after which they were dried in an oven. The incorporation of ¹³C contents of the particulate fraction will be measured with an isotope ratio mass spectrometer system (EcovisION; Elementar Japan, Co., Ltd.) based on the method of Hama et al. (1983) on land.

For the *P-E* curve experiment, the photosynthetic rate normalized to the fluorometrically measured chl-*a* concentration is fitted to the photoinhibition model (Platt et al., 1980).

$$P = P_{\max}(1 - e^{-\alpha E/P_{\max}})e^{-b\alpha E/P_{\max}}$$

where, $P_{\max}$ is the light-saturated maximum photosynthetic rate, α is the initial slope of the *P* vs. *E* curve, *b* is a dimensionless photoinhibition parameter. The chl-*a* specific, light absorption coefficient spectrum of phytoplankton is measured according to the glass-fiber filter-pad technique with methanol extraction (Kishino et al., 1985), then the *P-E* data are corrected for the spectrum of the lamp source following the method of Kyewalyanga et al. (1997).

(3) Data

For any questions regarding the obtained data, please contact the Principal Investigator.

(4) References

- Hama T. et al. (1983), Measurement of photosynthetic production of a marine phytoplankton population using a stable ¹³C isotope. *Marine Biology* 73: 31-36.
- Platt T, Gallegos CL, Harrison WG (1980), Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. *Journal of Marine Research* 38: 687-701.
- Kishino, M., M. Takahashi, N. Okami, and S. Ichimura (1985), Estimation of the spectral absorption coefficients of phytoplankton in the sea, *Bulletin of Marine Science*, 37, 634-642.
- Kyewalyanga, M. N., T. Platt, and S. Sathyendranath (1997), Estimation of the photosynthetic action spectrum: implication for primary production models, *Marine Ecology Progress Series*, 146: 207-223.

Table 2.5.1: Sampling depths of the on-deck incubation

Light intensity	Depth [db]									
	St.1	St.3	St.4	St.5	St.6	St.7	St.9	St.10	St.11	St.12
100%	0	0	0	0	0	0	0	0	0	0
44%	9	5	6	7	8	6	6	8	7	7
28%	16	9	10	11	14	10	9	12	12	11
11%	33	17	16	20	25	19	15	21	22	20
4%	56	24	22	28	36	28	22	30	34	30
2%	70	30	26	35	43	34	27	36	42	37
1%	85	40	31	44	55	43	37	45	55	47

2.5.2 Plankton

2.5.2.1 Shelled zooplankton (Planktic foraminifers and thecosomatous pteropods)

Katsunori Kimoto (RIGC, JAMSTEC)

Keisuke Shimizu (RIGC, JAMSTEC)

Minoru Kitamura (RIGC, JAMSTEC)

Takuya Ohnishi (FRA)

Maki Noguchi (RIGC, JAMSTEC)

(1) Objectives

The ocean has already absorbed about 30% of the total anthropogenic CO₂ (approximately 155 GtC) since the industrial revolution (IPCC AR5, 2013). This reduces ocean pH (Ocean acidification, OA) and causes wholesale shift in seawater carbonate chemistry. OA 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 etc. OA also affect zooplankton other than the shell-forming organisms, and characteristics of the zooplankton community will be changed. Therefore, we are observing long-term change of zooplankton biomass at K2 and adjacent areas in the North Pacific by using the plankton collecting apparatus and performing some biological/geochemical analysis to evaluate the biological impact to OA.

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

- a) Analysis of plankton communities in each layer at depths shallower than 1000 m using VMPS net
- b) Understanding the vertical distribution of pteropod and planktonic foraminiferal communities and changes in shell density with depth
- c) Elucidating the relationship between population dynamics of planktonic foraminifera and biogeochemical cycles with depth using protein concentrations in the North Pacific
- d) Understanding the phenotypic and genetic variation of pteropods in the mixed layer and their population structure
- e) Relationships between morphology and geochemistry of planktonic foraminiferal shells

(2) Methods

Zooplankton sampling was conducted at 10 stations by using the Vertical Multi-depth Plankton Sampler (VMPS-3K, Tsurumi Seiki co., Ltd, Fig. 2.5.2-1) and twin NORPAC net (Rigosha, co., Ltd, Fig. 2.5.2-1). VMPS-3K equipped 2 or 3 plankton nets (63 µm mesh, NXX25), magnetic flow-meter, fluorometer (Wet Lab Inc.) 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. For shallow depths (0-100 m), in addition to the VMPS nets, sample collection by twin NORPAC net (Aperture 45 cm, 63 µm mesh, NXX25, 2 m length) was performed. Sampling locations during this cruise were shown in Table 2.5.2-1 and 2.5.2-2.

Collected samples were fixed for each research purpose. For morphologic analysis, samples were immediately fixed by ethanol (99.5 %) stored at the room temperature (ca. 20 °C). For genetic analysis, they were stored in the RNA storage solution and kept in the deep freezer (-80°C). Planktonic foraminifera for measuring protein biomass were picked up from those samples and transferred into a bath of micro-filtered seawater, cleaned with a brush to remove all particles stuck to the specimen including organic matter. Each planktonic foraminifera were individually stored in an 1.5 ml micro tube, and frozen at -80 °C.

(3) Onshore study in the future

Thecosomatous 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 the multiple stressors and individual shell morphology/density. 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. Also planktonic foraminiferal samples separated into the microtubes will be individually measured for protein content and correlated with their shell size. Then, we will determine the total biomass of planktonic foraminifera in this area from the correlation between protein content and shell size.

(4) Data Archive

All data will be submitted to JAMSTEC Data Management Office (DMO).

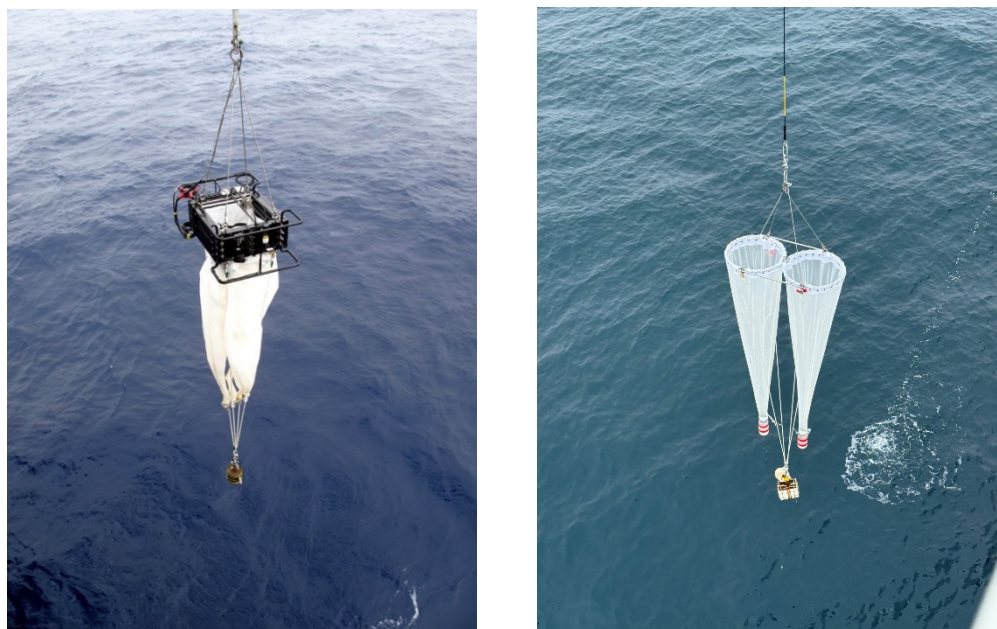


Fig. 2.5.2-1 The apparatus of plankton sampling. VMPS (Vertical Multi-layer Plankton Sampler, left) and twin NORPAC net (right).

Table 2.5.2-1 Information for zooplankton sampling by VMPS during the MR25-04.

Station	Date/time (Timezone)					Latitude			Longitude			water depth (m)	Fixiation
MR2504_Sta.2	2025	07	28	18:00	UTC	41	54	N	146	18	E	50	EtOH/room temp
MR2504_Sta.2	2025	07	28	18:00	UTC	41	54	N	146	18	E	150	EtOH/room temp
MR2504_Sta.2	2025	07	28	18:00	UTC	41	54	N	146	18	E	300	EtOH/room temp
MR2504_Sta.2	2025	07	28	18:00	UTC	41	54	N	146	18	E	500	EtOH/room temp
MR2504_Sta.2	2025	07	28	18:00	UTC	41	54	N	146	18	E	700	EtOH/room temp
MR2504_Sta.2	2025	07	28	18:00	UTC	41	54	N	146	18	E	1000	EtOH/room temp
MR2504_Sta.3	2025	08	6	05:30	UTC	47	00	N	160	00	E	50	EtOH/room temp
MR2504_Sta.3	2025	08	6	05:30	UTC	47	00	N	160	00	E	150	EtOH/room temp
MR2504_Sta.3	2025	08	6	05:30	UTC	47	00	N	160	00	E	300	EtOH/room temp
MR2504_Sta.3	2025	08	6	05:30	UTC	47	00	N	160	00	E	500	EtOH/room temp
MR2504_Sta.3	2025	08	6	05:30	UTC	47	00	N	160	00	E	700	EtOH/room temp
MR2504_Sta.3	2025	08	6	05:30	UTC	47	00	N	160	00	E	1000	EtOH/room temp
MR2504_Sta.4	2025	08	08	03:00	UTC	47	00	N	160	00	E	50	EtOH/room temp
MR2504_Sta.4	2025	08	08	03:00	UTC	47	00	N	160	00	E	150	EtOH/room temp
MR2504_Sta.4	2025	08	08	03:00	UTC	47	00	N	160	00	E	300	EtOH/room temp
MR2504_Sta.4	2025	08	08	03:00	UTC	47	00	N	160	00	E	500	EtOH/room temp
MR2504_Sta.4	2025	08	08	03:00	UTC	47	00	N	160	00	E	700	EtOH/room temp
MR2504_Sta.4	2025	08	08	03:00	UTC	47	00	N	160	00	E	1000	EtOH/room temp
MR2504_Sta.5	2025	08	11	07:00	UTC	50	00	N	165	00	E	50	EtOH/room temp
MR2504_Sta.5	2025	08	11	07:00	UTC	50	00	N	165	00	E	150	EtOH/room temp
MR2504_Sta.5	2025	08	11	07:00	UTC	50	00	N	165	00	E	300	EtOH/room temp
MR2504_Sta.5	2025	08	11	07:00	UTC	50	00	N	165	00	E	500	EtOH/room temp
MR2504_Sta.5	2025	08	11	07:00	UTC	50	00	N	165	00	E	700	EtOH/room temp
MR2504_Sta.5	2025	08	11	07:00	UTC	50	00	N	165	00	E	1000	EtOH/room temp
MR2504_Sta.6	2025	08	13	03:00	UTC	47	00	N	170	00	E	50	EtOH/room temp
MR2504_Sta.6	2025	08	13	03:00	UTC	47	00	N	170	00	E	150	EtOH/room temp
MR2504_Sta.6	2025	08	13	03:00	UTC	47	00	N	170	00	E	300	EtOH/room temp
MR2504_Sta.6	2025	08	13	03:00	UTC	47	00	N	170	00	E	500	EtOH/room temp
MR2504_Sta.6	2025	08	13	03:00	UTC	47	00	N	170	00	E	700	EtOH/room temp
MR2504_Sta.6	2025	08	13	03:00	UTC	47	00	N	170	00	E	1000	EtOH/room temp
MR2504_Sta.7	2025	08	15	04:00	UTC	47	00	N	180	00	E	50	EtOH/room temp
MR2504_Sta.7	2025	08	15	04:00	UTC	47	00	N	180	00	E	150	EtOH/room temp
MR2504_Sta.7	2025	08	15	04:00	UTC	47	00	N	180	00	E	300	EtOH/room temp
MR2504_Sta.7	2025	08	15	04:00	UTC	47	00	N	180	00	E	500	EtOH/room temp
MR2504_Sta.7	2025	08	15	04:00	UTC	47	00	N	180	00	E	700	EtOH/room temp
MR2504_Sta.7	2025	08	15	04:00	UTC	47	00	N	180	00	E	1000	EtOH/room temp

Table 2.5.2-1 (continued) Information for zooplankton sampling by VMPS during the MR25-04.

Station	Date/time (Timezone)					Latitude			Longitude			water depth (m)	Fixiation
MR2504_Sta.8	2025	08	16	02:00	UTC	47	00	N	175	00	W	50	EtOH/room temp
MR2504_Sta.8	2025	08	16	02:00	UTC	47	00	N	175	00	W	150	EtOH/room temp
MR2504_Sta.8	2025	08	16	02:00	UTC	47	00	N	175	00	W	300	EtOH/room temp
MR2504_Sta.8	2025	08	16	02:00	UTC	47	00	N	175	00	W	500	EtOH/room temp
MR2504_Sta.8	2025	08	16	02:00	UTC	47	00	N	175	00	W	700	EtOH/room temp
MR2504_Sta.8	2025	08	16	02:00	UTC	47	00	N	175	00	W	1000	EtOH/room temp
MR2504_Sta.10	2025	08	18	04:00	UTC	50	00	N	160	00	W	50	EtOH/room temp
MR2504_Sta.10	2025	08	18	04:00	UTC	50	00	N	160	00	W	150	EtOH/room temp
MR2504_Sta.10	2025	08	18	04:00	UTC	50	00	N	160	00	W	300	EtOH/room temp
MR2504_Sta.10	2025	08	18	04:00	UTC	50	00	N	160	00	W	500	EtOH/room temp
MR2504_Sta.10	2025	08	18	04:00	UTC	50	00	N	160	00	W	700	EtOH/room temp
MR2504_Sta.10	2025	08	18	04:00	UTC	50	00	N	160	00	W	1000	EtOH/room temp
MR2504_Sta.11	2025	08	21	03:00	UTC	50	00	N	152	30	W	50	EtOH/room temp
MR2504_Sta.11	2025	08	21	03:00	UTC	50	00	N	152	30	W	150	EtOH/room temp
MR2504_Sta.11	2025	08	21	03:00	UTC	50	00	N	152	30	W	300	EtOH/room temp
MR2504_Sta.11	2025	08	21	03:00	UTC	50	00	N	152	30	W	500	EtOH/room temp
MR2504_Sta.11	2025	08	21	03:00	UTC	50	00	N	152	30	W	700	EtOH/room temp
MR2504_Sta.11	2025	08	21	03:00	UTC	50	00	N	152	30	W	1000	EtOH/room temp
MR2504_Sta.12	2025	08	23	17:00	UTC	50	00	N	145	00	W	50	EtOH/room temp
MR2504_Sta.12	2025	08	23	17:00	UTC	50	00	N	145	00	W	150	EtOH/room temp
MR2504_Sta.12	2025	08	23	17:00	UTC	50	00	N	145	00	W	300	EtOH/room temp
MR2504_Sta.12	2025	08	23	17:00	UTC	50	00	N	145	00	W	500	EtOH/room temp
MR2504_Sta.12	2025	08	23	17:00	UTC	50	00	N	145	00	W	700	EtOH/room temp
MR2504_Sta.12	2025	08	23	17:00	UTC	50	00	N	145	00	W	1000	EtOH/room temp

Table 2.5.2-2 Information for zooplankton sampling using the twin NORPAC net during MR25-04.

Station	Apparatus	Area	Date			Time (UTC)		Latitude			Longitude			Depth (m)	No. of cast
St.2 (CT)	NORPAC	North Pacific	2025	07	27	21:30	40	54.0633	N	146	18.1851	E	50	5	
St.1 (KEO)	NORPAC	North Pacific	2025	07	30	9:30	32	20.8911	N	144	30.7542	E	150	5	
St.3 (KNOT)	NORPAC	North Pacific	2025	08	04	12:45	43	59.7757	N	155	02.6169	E	50	5	
St.4 (K2)-1st	NORPAC	North Pacific	2025	08	08	4:15	47	00.0363	N	159	59.9768	E	30	1	
St.4 (K2)-1st	NORPAC	North Pacific	2025	08	08	4:15	47	00.0363	N	159	59.9768	E	50	4	
St.4 (K2)-2nd	NORPAC	North Pacific	2025	08	09	2:50	46	59.78	N	159	58.39	E	10	1	
St.4 (K2)-2nd	NORPAC	North Pacific	2025	08	09	2:50	46	59.78	N	159	58.39	E	20	1	
St.4 (K2)-2nd	NORPAC	North Pacific	2025	08	09	2:50	46	59.78	N	159	58.39	E	30	6	
St.4 (K2)-2nd	NORPAC	North Pacific	2025	08	09	2:50	46	59.78	N	159	58.39	E	50	2	
St.5	NORPAC	North Pacific	2025	08	11	8:20	50	00.0039	N	164	59.9672	E	50	6	
St.6 (K2-East)	NORPAC	North Pacific	2025	08	13	4:05	47	00.0194	N	169	59.9501	E	50	4	
St.6 (K2-East)	NORPAC	North Pacific	2025	08	13	4:05	47	00.0194	N	169	59.9501	E	70	2	
St.6 (K2-East)	NORPAC	North Pacific	2025	08	13	4:05	47	00.0194	N	169	59.9501	E	100	1	
St.7	NORPAC	North Pacific	2025	08	15	4:55	47	00.0267	N	179	59.9641	E	30	4	
St.7	NORPAC	North Pacific	2025	08	15	4:55	47	00.0267	N	179	59.9641	E	50	2	
St.7	NORPAC	North Pacific	2025	08	15	4:55	47	00.0267	N	179	59.9641	E	100	1	
St.8	NORPAC	North Pacific	2025	08	16	6:40	47	00.0219	N	174	59.6694	W	50	6	
St.8	NORPAC	North Pacific	2025	08	16	6:40	47	00.0219	N	174	59.6694	W	100	1	
St.9	NORPAC	North Pacific	2025	08	17	7:45	47	00.0259	N	169	59.9828	W	50	5	
St.10	NORPAC	North Pacific	2025	08	19	7:50	49	59.6518	N	159	59.8753	W	30	3	
St.10	NORPAC	North Pacific	2025	08	19	7:50	49	59.6518	N	159	59.8753	W	50	2	
St.11	NORPAC	North Pacific	2025	08	21	4:30	50	00.0367	N	152	29.9874	W	30	3	
St.11	NORPAC	North Pacific	2025	08	21	4:30	50	00.0367	N	152	29.9874	W	50	3	
St.11	NORPAC	North Pacific	2025	08	21	4:30	50	00.0367	N	152	29.9874	W	100	1	
St.12 (OSP)	NORPAC	North Pacific	2025	08	23	22:30	49	59.9735	N	145	00.0525	W	10	1	
St.12 (OSP)	NORPAC	North Pacific	2025	08	23	22:30	49	59.9735	N	145	00.0525	W	30	1	
St.12 (OSP)	NORPAC	North Pacific	2025	08	23	22:30	49	59.9735	N	145	00.0525	W	50	4	
St.12 (OSP)	NORPAC	North Pacific	2025	08	23	22:30	49	59.9735	N	145	00.0525	W	100	1	

2.5.2.2 Mesozooplankton

Minoru KITAMURA (JAMSTEC RIGC)

(1) Objectives

Mesozooplankton community plays a crucial role in ocean ecosystems and biogeochemical cycles. For example, they influence the fate of primary production and are the main trophic link that connects primary producers with larger predators. Mesozooplankton also has important roles in the biological pump such as fecal pellet production, vertical carbon transport via diel/seasonal vertical migration, or repackaging of the sinking particles. However, despite the presumed importance of the mesozooplankton, we know comparatively little about their ecology. In the MR25-04 cruise, I get a chance to collect mesozooplankton across a wide range of subarctic Pacific from the station KNOT (44°N, 155°E) to the ocean station Papa (50°N, 145°W). Although I have studied zooplankton ecology in the western subarctic Pacific since 2006, this is the first opportunity for comparative study of mesozooplankton between the western and eastern subarctic Pacific. In this study, I am aiming towards understanding east-west differences on biomasses, abundances, assemblage structures, and species diversities of mesozooplankton and active carbon fluxes by them in the subarctic Pacific.

(2) Methods

To collect zooplankton including crustacean micronekton, 32 oblique tows of ORI net (Omori, 1965) were carried out at nine stations (Table 2.5.2.2-1, Fig. 2.5.2.2-1). The ORI net has 1.6-m mouth diameter (2 m² of mouth area) with a conical net of 6 m long. Mesh size of the conical net is 330 µm. A calibrated flow-meter (RIGO, Saitama, Japan) was installed in the mouth of net to estimate volume of water filtered. And a depth sensor (DEFI-D50, JFE Advantech, Hyogo, Japan) was attached at the mouth ring to record maximum depths of samplings. Target depths of sampling were from 0 to 50 m and from 0 to 500 m, and indeed maximum depths of samplings were 34–55 m and 522–665 m in the shallow and deep samplings, respectively. During each net tow, ship speed was about 2.0 knot and speed of wire reeling was from 0.7 to 1.0 m/sec. At seven of the nine stations (Stns. 3, 4, 5, 6, 10, 11 and 12), samplings were carried out during both the day and night whereas daytime samplings were not conducted at stations 8 and 9. After each net tow, collected zooplankton samples were immediately divided onboard: 1/4 or 1/8 subsamples were filtered and frozen for further analyzing of bulk zooplankton biomass, and remained 3/4 or 7/8 subsamples were fixed and preserved by 5% formalin-seawater to analyze assemblage structure, species diversity and active carbon flux due to diel vertical migration of mesozooplankton/micronekton.

(3) Preliminary result

Bulk zooplankton biomasses seems to be high and low in the western and eastern stations, respectively. From the preliminary comparison between K2 (Stn. 4) and ocean station Papa (Stn. 12), following differences were observed, (1) in the copepod assemblages, *Metridia pacifica* and *Neocalanus plumchrus* were abundant at K2 whereas *Neocalanus cristatus* was dominated at Papa, (2) in the planktonic cnidarian assemblages, *Aglantha digitale* was abundant at K2 but abundance of hydromedusae was quite low at Papa, (3) chaetognaths were also abundant at K2 but they showed low abundance at Papa, (4) for euphausiids, *Euphausia pacifica* occupied 75% of krill abundance at K2 while they occupied a little bit less than 50% at Papa. Supplementary memorandum: many fishing boats got together to fish Pacific saury around the station 5, many whales were observed at the station 6 located above the Emperor Seamount Chain, diatom bloom was observed at the station 9.

(4) Data and sample archive

All zooplankton/micronekton samples collected by means of ORI net are stored in Yokosuka head quarter of JAMSTEC. Biomass and assemblage data for zooplankton and micronekton will be obtained from further analysis, and these data will be submitted to the Data Management Group of JAMSTEC.

(5) References

Omori, M. (1965) A 160 cm opening-closing plankton net. 1. Description of the gear. *J. Oceanogr. Soc. Japan*, 21, 212-220.

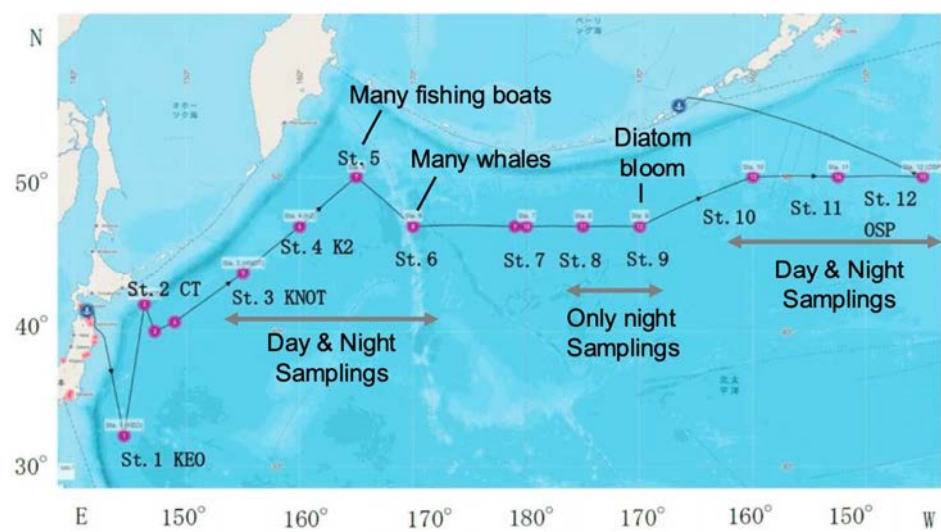
Table 2.5.2.2-1. A list of mesozooplankton/micronekton samplings during MR25-04 cruise.

Zooplankton samplings by using ORI net

Sampling gear: ORI net (2-m² net with 0.33-mm mesh). Flow meter ID: 2370. Maximum depth of sampling was recorded using DEFI-D50 (S/N: AZ6003).

Stn.	Day/Night	Date & Time				Position		Wire out	Sampling layer	F-meter read	Filtering vol.	Subsamples	Filter No.	Remarks
		SMT	net in out	UTC	net in out	Lat. (N)	Long. (E/W)							
3 (KNOT)	Night	2025/8/4	22:34 22:43	2025/8/4	11:34 11:43	44° 00.27' 44° 00.19'	155° 00.01'E 155° 00.43'E	100	0-51	2,943	481.2	1/4: flozen 1/4, 1/2: folmalin	25A-1	
3 (KNOT)	Night	2025/8/4	22:57 23:35	2025/8/4	11:57 12:35	44° 00.07' 43° 59.72'	155° 01.10'E 155° 02.73'E	1000	0-569	22,450	3670.6	1/4: flozen 1/4, 1/2: folmalin	25A-2, 3	
3 (KNOT)	Day	2025/8/5	8:02 8:07	2025/8/4	21:02 21:07	44° 00.22' 44° 00.06'	155° 00.25'E 155° 00.08'E	100	0-42	2,965	484.8	1/4: flozen 1/4, 1/2: folmalin	25A-4	
3 (KNOT)	Day	2025/8/5	8:22 8:55	2025/8/4	21:22 21:55	44° 00.20' 44° 00.43'	154° 59.60'E 154° 58.42'E	1000	0-590	22,340	3652.6	1/4: flozen 1/4, 1/2: folmalin	25A-5, 6	
4 (K2)	Day	2025/8/7	12:33 12:43	2025/8/7	1:33 1:43	47° 00.16' 47° 00.05'	160° 00.23'E 160° 00.64'E	100	0-34	4,738	774.7	1/4: flozen 1/4, 1/2: folmalin	25A-7	
4 (K2)	Day	2025/8/7	12:55 13:27	2025/8/7	1:55 2:27	46° 59.88' 46° 59.44'	160° 01.20'E 160° 02.64'E	1000	0-532	22,892	3742.8	1/4: flozen 1/4, 1/2: folmalin	25A-8, 9	
4 (K2)	Night	2025/8/7	22:02 22:07	2025/8/7	11:02 11:07	47° 00.19' 47° 00.15'	159° 59.12'E 159° 59.35'E	100	0-55	2,608	426.4	1/4: flozen 1/4, 1/2: folmalin	25A-10	
4 (K2)	Night	2025/8/7	22:22 22:55	2025/8/7	11:22 11:55	47° 00.02' 46° 59.72'	160° 00.16'E 160° 01.87'E	1000	0-529	24,062	3934.1	1/4: flozen 1/4, 1/2: folmalin	25A-11, 12	
5	Night	2025/8/11	21:25 21:30	2025/8/11	10:25 10:30	50° 00.15' 50° 00.03'	165° 00.10'E 165° 00.11'E	100	0-52	2,689	439.7	1/4: flozen 1/4, 1/2: folmalin	25A-13	many fishing boats
5	Night	2025/8/11	21:44 22:15	2025/8/11	10:44 11:15	49° 59.76' 49° 59.05'	165° 00.10'E 165° 00.00'E	1000	0-587	22,235	3635.4	1/4: flozen 1/4, 1/2: folmalin	25A-14, 15	
5	Day	2025/8/12	7:59 8:09	2025/8/11	20:59 21:09	49° 59.97' 50° 00.42'	164° 59.91'E 165° 00.60'E	100	0-36	3,217	526.0	1/4: flozen 1/4, 1/2: folmalin	25A-16	
5	Day	2025/8/12	8:17 8:52	2025/8/11	21:17 21:52	50° 00.30' 49° 59.71'	165° 00.42'E 164° 59.56'E	1000	0-559	217,733	35599.3	1/4: flozen 1/4, 1/2: folmalin	25A-17, 18	
6	Day	2025/8/13	8:46 8:56	2025/8/12	21:46 21:56	47° 00.40' 47° 00.18'	169° 59.74'E 169° 59.90'E	100	0-46	3,140	513.4	1/4: flozen 1/4, 1/2: folmalin	25A-19	Emperor Seamount Cains many whoales
6	Day	2025/8/13	9:06 9:34	2025/8/12	22:06 22:34	47° 00.12' 46° 59.28'	169° 59.96'E 170° 00.38'E	1000	0-580	21,313	3484.7	1/4: flozen 1/4, 1/2: folmalin	25A-20	
6	Night	2025/8/13	21:32 21:36	2025/8/13	10:32 10:36	47° 00.07' 47° 00.08'	169° 59.99'E 170° 00.17'E	100	0-48	2,650	433.3	1/4: flozen 1/4, 1/2: folmalin	25A-21	
6	Night	2025/8/13	21:47 22:17	2025/8/13	10:47 11:17	47° 00.10' 47° 00.09'	170° 00.68'E 170° 02.01'E	1000	0-576	21,980	3593.7	1/4: flozen 1/4, 1/2: folmalin	25A-22, 23	
8	Night	2025/8/16a	20:58 21:03	2025/8/16	8:58 9:03	47° 00.08' 46° 59.96'	174° 59.75'W 174° 59.57'W	100	0-47	2,911	475.9	1/4: flozen 1/4, 1/2: folmalin	25A-24	
8	Night	2025/8/16a	21:16 21:51	2025/8/16	9:16 9:51	46° 59.73' 46° 59.10'	174° 59.09'W 174° 57.71'W	1000	0-618	20,969	3428.4	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-25	
9	Night	2025/8/16b	23:15 23:21	2025/8/17	10:15 10:21	47° 00.09' 47° 00.21'	169° 59.94'W 170° 00.20'W	100	0-48	2,390	390.8	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-26	diatom bloom
9	Night	2025/8/16b	23:35 0:06	2025/8/17	10:35 11:06	47° 00.45' 47° 00.93'	170° 00.68'W 170° 01.79'W	1000	0-594	20,587	3366.0	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-27	
10	Night	2025/8/18	22:13 22:19	2025/8/19	8:13 8:19	49° 59.53' 49° 59.48'	159° 59.82'W 160° 00.14'W	100	0-46	2,733	446.8	1/4: flozen 1/4, 1/2: folmalin	25A-28	
10	Night	2025/8/18	22:30 22:58	2025/8/19	8:30 8:58	49° 59.37' 49° 59.30'	160° 00.75'W 160° 02.33'W	1000	0-526	23,100	3776.9	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-29	
10	Day	2025/8/19	10:16 10:25	2025/8/19	20:16 20:25	50° 00.02' 50° 00.19'	160° 00.01'W 160° 00.17'W	100	0-43	3,330	544.5	1/4: flozen 1/4, 1/2: folmalin	25A-30	
10	Day	2025/8/19	10:31 11:08	2025/8/19	20:31 21:08	50° 00.31' 50° 00.99'	160° 00.27'W 160° 00.98'W	1000	0-665	19,737	3227.0	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-31	
11	Night	2025/8/20	21:32 21:38	2025/8/21	7:32 7:38	49° 59.50' 49° 59.67'	152° 29.79'W 152° 29.84'W	110	0-45	3,771	616.6	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-32	rough sea state
11	Night	2025/8/20	21:51 22:24	2025/8/21	7:51 8:24	50° 00.06' 50° 00.80'	152° 30.00'W 152° 30.85'W	1000	0-590	22,524	3682.7	1/8: flozen 1/8, 1/4, 1/2: folmalin	25A-33	
11	Day	2025/8/21	10:59 11:05	2025/8/21	20:59 21:05	50° 00.14' 50° 00.32'	152° 30.07'W 152° 30.12'W	100	0-53	4,095	669.5	1/4: flozen 1/4, 1/2: folmalin	25A-34	rough sea state
11	Day	2025/8/21	11:23 11:46	2025/8/21	21:23 21:46	50° 00.85' 50° 01.59'	152° 30.29'W 152° 30.55'W	950	0-521	21,438	3505.1	1/4: flozen 1/4, 1/2: folmalin	25A-35	
12 (OSP)	Night	2025/8/22	22:01 22:07	2025/8/23	7:01 7:07	50° 00.08' 49° 59.94'	144° 59.99'W 145° 00.23'W	100	0-54	3,010	492.1	1/4: flozen 1/4, 1/2: folmalin	25A-36	
12 (OSP)	Night	2025/8/22	22:20 22:48	2025/8/23	7:20 7:48	49° 59.69' 49° 59.15'	145° 00.78'W 145° 01.98'W	950	0-522	21,603	3532.1	1/4: flozen 1/4, 1/2: folmalin	25A-37	
12 (OSP)	Day	2025/8/23	12:20 12:24	2025/8/23	21:20 21:24	49° 59.90' 49° 59.81'	145° 00.27'W 145° 00.43'W	100	0-47	3,144	514.0	1/4: flozen 1/4, 1/2: folmalin	P30	8x8 cm filter
12 (OSP)	Day	2025/8/23	12:35 13:06	2025/8/23	21:35 22:06	49° 59.58' 49° 58.92'	145° 00.86'W 145° 02.05'W	970	0-546	22,036	3602.9	1/4: flozen 1/4, 1/2: folmalin	25A-38	

Fig. 2.5.2.2-1. Sampling sites.



2.5.2.3 Physiological Responses and Gene Expression of *Neocalanus* Copepods

Takuya OHNISHI (FRA)

(1) Objectives

This study aims to quantify east–west contrasts in the life-history traits and physiological responses of *Neocalanus* spp. across the subarctic North Pacific. Specifically, we will (i) determine stage composition and depth distribution from VMPS and NORPAC samples preserved in formalin, (ii) evaluate transcriptional and physiological responses from RNAlater-preserved individuals via real-time PCR and RNA-seq on shipboard rearing experiments under controlled temperature and food regimes, and (iii) relate these biological metrics to concurrently observed hydrographic and biogeochemical conditions to identify in situ biomarkers of environmental response.

(2) Instruments and methods

Zooplankton were collected with a NORPAC net at all stations (Sta. 1–12), and the samples were preserved in both formalin and RNAlater for subsequent analyses.

At Sta. 4 and 10, zooplankton were collected using a plankton net with a 2-L cod-end. Individuals of *Neocalanus* spp. were sorted from the plankton samples and used in shipboard rearing experiments.

Vertical Multiple Plankton Sampler (VMPS) tows were conducted at Sta. 2, 4, 7, 10, and 12. Stratified samples were obtained from three depth layers (0–200 m, 200–500 m, and 500–1500 m) at each station. These samples were preserved in both formalin and RNAlater.

(3) Preliminary result

All planned zooplankton collections were successfully completed during the cruise. NORPAC net samples were collected at all 12 stations and preserved in both formalin and RNAlater. VMPS tows were conducted at five stations (Sta. 2, 4, 7, 10, and 12), and stratified samples from three depth layers (0–200 m, 200–500 m, and 500–1500 m) were obtained without technical difficulties.

At Sta. 4 and 10, sufficient numbers of *Neocalanus* spp. were collected with the 2-L cod-end plankton net, allowing shipboard rearing experiments. Preliminary observations indicated that copepods were abundant in the upper layers at several stations, although detailed quantitative analyses will be performed after returning to the laboratory.

The samples collected during this cruise will be used for life-history analyses, RNA-seq, and real-time PCR to assess regional differences in the physiology and gene expression of *Neocalanus* spp.

(4) Data archive

Details of the collected samples have been archived in the cruise metadata file. The samples will be stored at the FRA Kushiro field station under appropriate conditions after the cruise.

2.5.2.4 Ecological study of picophytoplankton

Toshiya KATANO (Tokyo University of Marine Science and Technology)

Ayane TANAKA (Tokyo University of Marine Science and Technology)

Tetsuichi FUJIKI (JAMSTEC)

(1) Objective

Picophytoplankton is an important primary producer especially in oligotrophic environment. Among the picophytoplankton we focus on cyanobacterium *Synechococcus*. *Synechococcus* is highly diverse in ecotypes, especially in their pigmentation; *Synechococcus* produces more phycoerythrobilin (PEB) in phycoerythrin to adapt green environment of mesotrophic environment, while more phycourobilin (PUB) in blue oligotrophic environment due to their phenotypic plasticity. In our study we will compare the ratio of PUB to PEB with the light intensity, to explore the contribution of the diverse pigmentation to the *Synechococcus* community organization under the natural light environment in the Northwestern Pacific subarctic ocean.

(2) Methods

Flow cytometer samples were vertically collected by Niskin samplers at 175, 150, 125, 100, 75, 50, 40, 30, 20, 10 m and surface; 80 m was sampled instead of 75 m at St.1, 26 m was sampled instead of 30 m at St.3, 25 m was sampled instead of 30 m at St.7. Samples were immediately fixed with 0.2% paraformaldehyde, and stored in a -80°C deep freezer until further analysis. Samples will be analyzed with flow cytometer (Luminex BG-11) equipped with blue (488 nm) and green lasers (532 nm) to analyze the pigment type composition of *Synechococcus* and the ratio of PUB to PEB of each population.

(3) Data archive

Flow cytometer samples will be analyzed in the laboratory after October 2025

2.5.2.5. Surface microprotist assemblage composition

(1) Personnel

Kohei Matsuno (Hokkaido University) - Principal Investigator

Masahide Wakita (JAMSTEC RIGC MIO)

(2) Objective

The object of this study is to collect surface microprotist assemblage composition data in the subarctic North Pacific and Bering Sea for assigning to a general dissimilarity model with satellite data.

(3) Parameters

Phytoplankton community in cell number

Phytoplankton cell size

(4) Sampling and treatment

Surface water was taken from the underway system once a day for microscopic analysis. The water sample was fixed with glutaraldehyde (1% final concentration), and stored in cool and dark conditions. After back to the land laboratory, the fixed samples will be concentrated and analyzed under an inverted microscope and a FlowCam.

(5) Data archives

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

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

(6) Station list

Date UTC yyyy/mm/dd	Time UTC hh:mm:ss	Latitude	Longitude	Temp (SBE45) deg-C(ITS-90)	Salinity
2025/7/26	11:17:00	40-19.43737N	142-16.79206E	22.215	33.388
2025/7/27	10:00:37	41-38.13580N	145-57.92045E	19.824	33.226
2025/7/28	9:34:51	40-42.17718N	146-03.05492E	24.672	33.816
2025/7/29	9:33:51	36-07.18279N	144-19.78569E	28.204	34.276
2025/7/30	10:43:21	32-20.58153N	144-31.04749E	27.550	34.441
2025/7/31	8:32:34	32-21.23388N	144-26.04901E	27.207	34.407
2025/8/1	5:30:06	32-48.97428N	144-41.27534E	27.616	34.437
2025/8/2	9:19:18	37-44.26109N	147-53.20171E	26.763	34.309
2025/8/3	7:02:11	41-13.38440N	150-33.77596E	23.577	32.496
2025/8/4	11:12:18	44-00.23648N	154-59.86221E	19.383	32.384
2025/8/5	9:04:19	45-27.54560N	157-26.78334E	18.246	32.510
2025/8/6	9:36:16	47-00.76302N	159-58.15563E	16.811	32.354
2025/8/7	9:44:38	47-00.45429N	159-56.74785E	16.603	32.317
2025/8/8	11:07:20	46-59.81591N	160-00.13286E	15.815	32.317
2025/8/9	9:04:10	46-56.93117N	159-51.93905E	16.141	32.269
2025/8/10	9:05:10	47-40.74522N	161-04.10137E	15.994	32.383
2025/8/11	10:42:17	49-59.79369N	165-00.09209E	14.697	32.586
2025/8/12	7:03:26	48-49.70746N	166-59.17455E	13.960	32.408
2025/8/13	9:53:14	47-00.04577N	169-59.99128E	14.075	32.446
2025/8/14	7:50:51	46-59.77837N	176-01.42266E	12.796	32.703
2025/8/15	8:01:08	46-59.97224N	179-59.92898E	13.004	32.818
2025/8/16	8:37:50	47-00.12389N	174-59.87428W	14.002	32.594
2025/8/17	9:15:41	47-00.00049N	169-59.98712W	15.531	32.499
2025/8/18	5:20:46	48-33.91596N	164-51.51533W	13.958	32.134
2025/8/19	7:06:22	49-59.97208N	160-00.00137W	13.863	32.022
2025/8/20	4:04:09	49-59.94260N	158-00.67502W	14.081	32.163
2025/8/21	6:37:31	50-00.03861N	152-29.93197W	13.810	32.097
2025/8/22	5:17:56	50-00.03463N	150-15.35037W	13.839	32.113
2025/8/23	5:17:53	49-59.99571N	145-00.07577W	14.773	32.114
2025/8/24	5:05:17	50-24.78402N	144-59.67464W	14.954	32.052
2025/8/25	5:03:37	50-36.50792N	147-27.90144W	14.537	32.093
2025/8/25	20:01:42	51-41.53009N	151-56.34941W	13.710	32.176

2.5.3 Underwater vision profiler (UVP)

Chiho SUKIGARA (JAMSTEC)

(1) Objectives

The distribution of particles and plankton within the ocean water column contain crucial information for studies of material cycles and ecosystems. However, observing the actual state of particulate matters, such as their size and shape, has been difficult. In recent years, imaging technology for particles in water has advanced, enabling the capture of microscopic plankton and particles. This study aims to observe particles and plankton within the water column using the UVP6 and to obtain insights into material transport and circulation from their distribution.

(2) Methods

i. UVP6

During this cruise, we used the UVP6 (Figure 2.5.3-1) for the observation. The UVP is designed to count and size in situ large ($> 80 \mu\text{m}$) particles in a known volume of water. The UVP also records images of larger aggregates and zooplankton ($> 700 \mu\text{m}$). The instrument details are as follows.

UVP-6HF: Underwater Vision Profiler for high-frequency version

Manufacturer: Hydroptic, France

Operational depth: 6,000 m

Lighting: 635nm

Resolution: 5 M Pixels ($73 \times 73 \mu\text{m}$)

Image volume: 0.65 L ($180 \times 151 \text{ mm}$)

Image frequency: up to 20 Hz

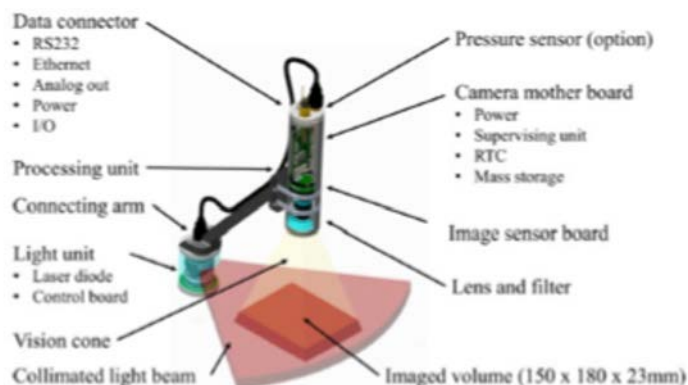


Figure 2.5.3-1. Diagram of the UVP6 camera and light unit (Picheral et al., 2022).

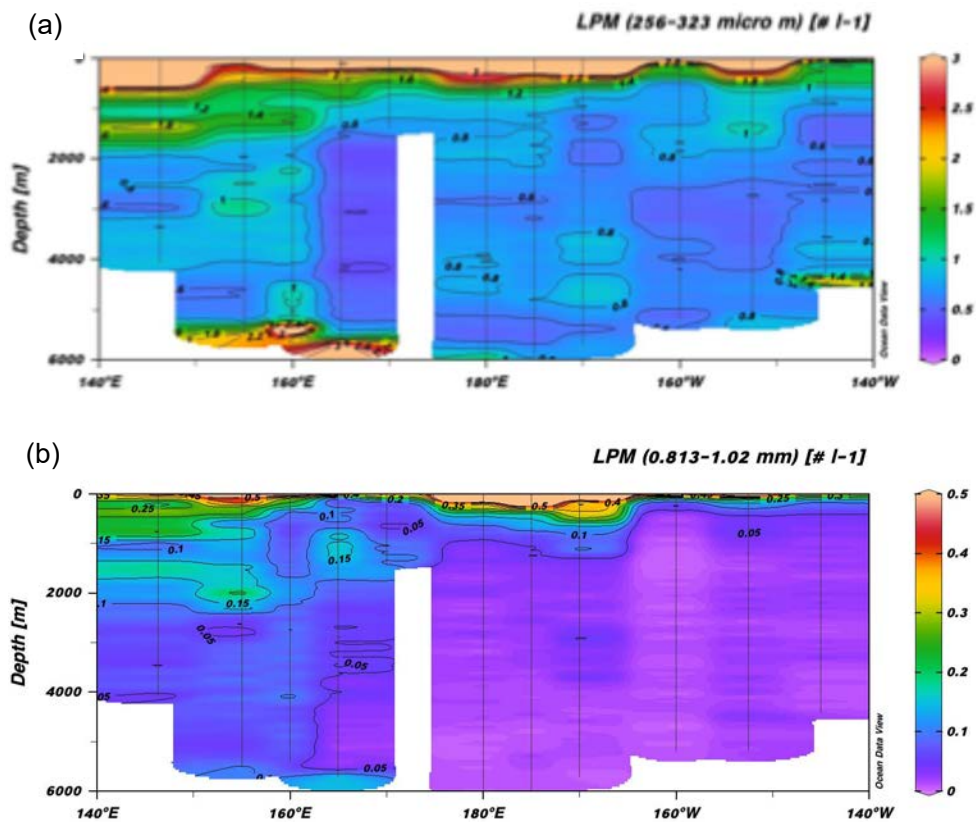
ii. Observation

The backscatter meter was connected to the CTD for observation. The UVP observation were conducted on all CTD casts except for the second of St.2 (CT), which was observed down to depths exceeding 6,000 db. At St.6, due to the battery running out, the data could only be acquired up to approximately 1,000 m.



Figure 2.5.3-2. Photo of the UVP mounted on the CTD.

(3) Preliminary results



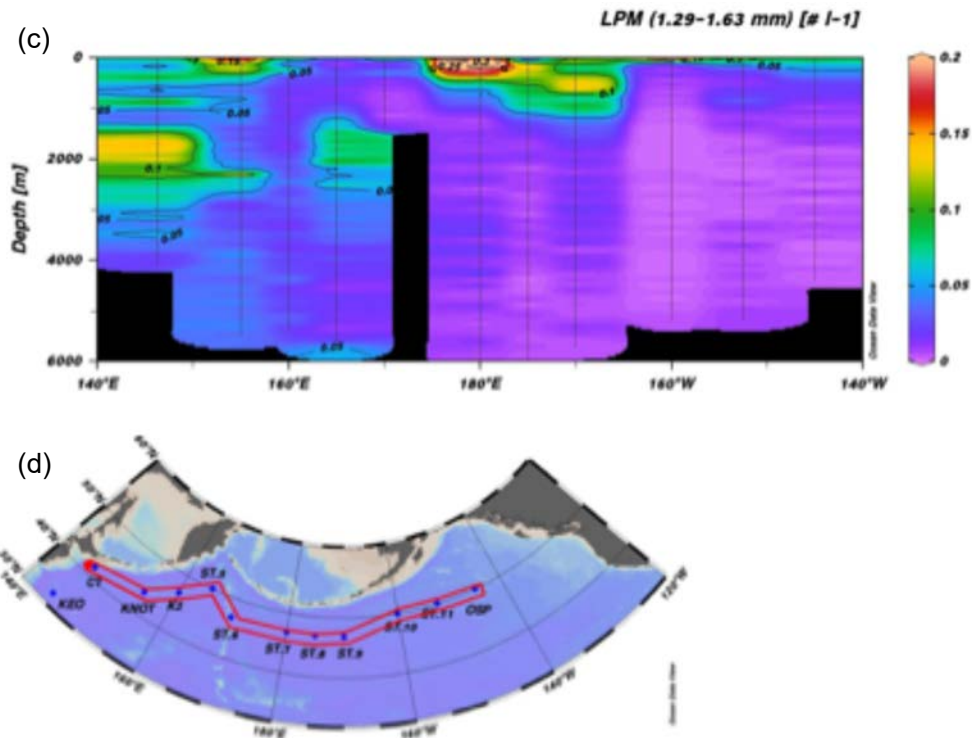


Figure 2.5.3-3. Zonal distributions of particle count for each particle size; (a) 256 to 323 μm , (b) 0.813 to 1.02 mm, (c) 1.29 to 1.63 mm. (d) map of the observation stations.

(4) Data archive

The data obtained will be submitted to ECOTAXA (<http://ecotaxa.obs-vlfr.fr>).

(5) References

Picheral, M., C. Catalano, D. Brousseau, H. Claustre, L. Coppola, E. Leymarie, J. Coindat, F. Dias, S. Fevre, L. Guidi, J. O. Irisson, L. Legendre, F. Lombard, L. Mortier, C Penkerch, A, Rogge, C. Schmechtig, S. Thibault, T. Tixier, A. Waite, L. Stemann. The underwater Vision Profiler 6: an imaging sensor of particle size spectra and plankton, for autonomous and cabled platforms, *Limnology and Oceanography: Methods*, 20, 115-129, doi:10.1002/lom3.10475, 2022.

2.5.4 Fast repetition rate fluorometer

Tetsuichi FUJIKI (JAMSTEC RIGC)

(1) Objective

Over the past decade, the application of active fluorescence techniques in biological oceanography has greatly advanced our understanding of phytoplankton productivity in the ocean. Among these, fast repetition rate (FRR) fluorometry reduces the primary electron acceptor (Q_a) in photosystem II (PSII) through a series of subsaturating flashlets, allowing measurement of a single-turnover (ST) fluorescence induction curve of PSII. From this curve, PSII parameters such as the potential photosynthetic activity (F_v/F_m) and the functional absorption cross section of PSII (σ_{PSII}) can be derived, providing insights into the physiological state related to photosynthesis and enabling estimation of chlorophyll *a* concentration and gross primary productivity. In this study, to better understand the variability in phytoplankton productivity in the North Pacific, we measured PSII parameters and primary productivity using FRR fluorometry.

(2) Methods

Using an FRR fluorometer (Kimoto Electric Co., Ltd., Japan), vertical variations in PSII parameters were examined at stations 1–12, except station 2. The FRR fluorometer was moved up and down between the surface and 100 m at a rate of 0.2 m s^{-1} using the ship's winch. The profiling speed of the observation buoy was set to a minimum to detect fine-scale ($\sim 0.5 \text{ m}$) variations in the measurements.

(3) Preliminary results

The profiles of F_m (an indicator of chlorophyll *a* biomass) and F_v/F_m (an indicator of nutrient limitation) at each station measured using the FRR fluorometer are shown in Figure 2.5.4.1.

(4) Data archives

All data have been submitted to the JAMSTEC Data Management Group (DMG) and are currently under their control.

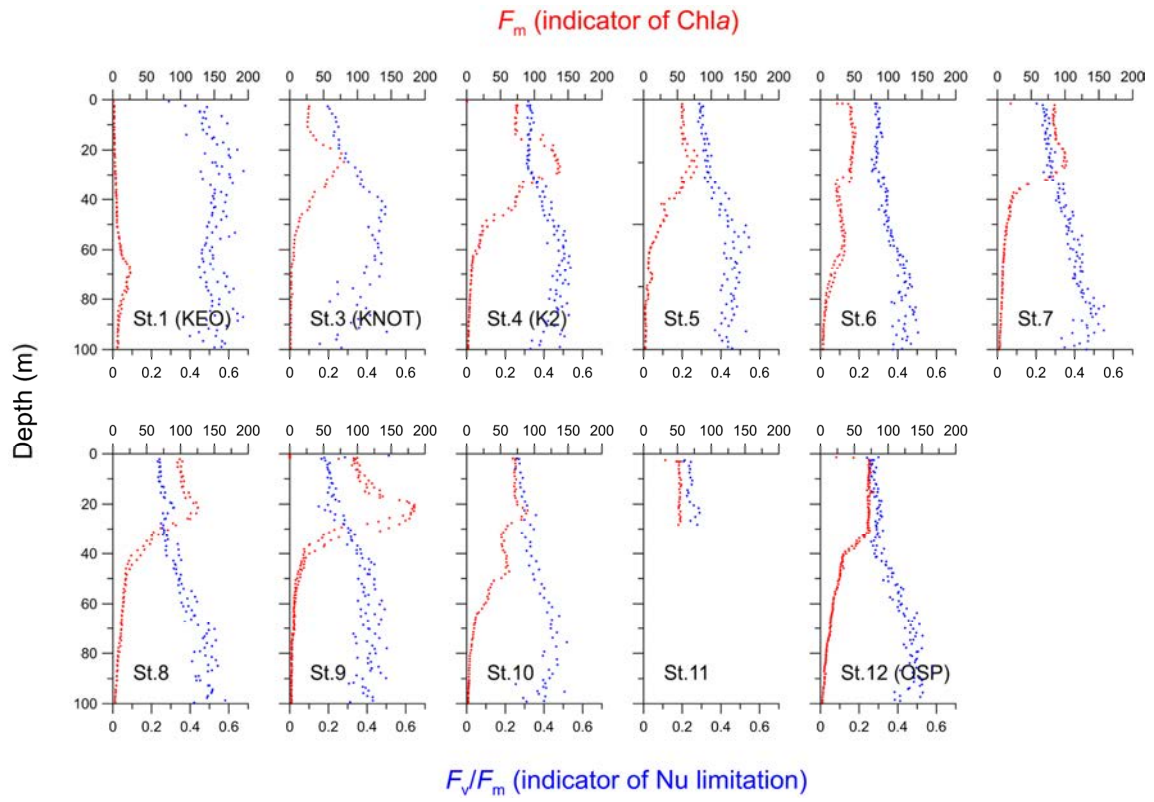


Fig. 2.5.4.1. Vertical profiles of F_m and F_v/F_m at stations 1–12, except station 2.

2.5.5 Incubation experiments

Koji SUGIE (RIGC, JAMSTEC)

Yoshiko KONDO (Nagasaki University)

(1) Objectives

Iron (Fe) is an essential trace element involving co-factors of enzymes in photosynthesis, nitrogen assimilations, and respirations. The study area of MR25-04 cruise, subarctic Pacific region is known as Fe-limited high-nutrient low-chlorophyll (HNLC) region. Although, all biogeochemical processes are driven and regulated by iron availability in the HNLC region, iron availability and relating biogeochemical processes were mostly investigated by measuring its concentration and the concentration of iron-binding ligands. However, whether the measured iron is biologically available or not must be measured using in situ organisms of interest, there are few studies biological processes in the ocean. One of the reasons for the lack of the studies in iron-related biological processes is the difficulty of biogenic iron, which is usually measured using radio isotope ^{55}Fe , that the use of radio isotope is heavily regulated in Japan aboard research vessels. In this study, we developed for measuring Fe uptake rate by using stable isotope ^{57}Fe and applied in subarctic Pacific to understand iron-related biogeochemical processes. In addition, we have conducted Fe addition experiment to determine the concentration and bioavailability of iron for phytoplankton growth. In the Fe addition experiments, we applied dilution technique to eliminate microzooplankton grazing in the incubation bottles that should substantially mask phytoplankton growth. Iron addition experiments were conducted two temperature series that in situ and 4°C higher temperatures to investigate the effect of temperature on iron bioavailability and physiological performance of marine phytoplankton. Finally, we investigate the possibility of zinc limitation of phytoplankton assemblage in the western subarctic Pacific because zinc concentration in the study area is very low during summer.

(2) Instruments and methods

i) Fe, Zn and C uptake experiments

Seawater samples were collected using acid-washed Teflon-coated Niskin-X sampling bottles as described in section 2.4.7 from four light level depths of 10 m (100%), 20%, 5%, and 0.9%. Light levels were estimated from the routine CTD sampling at the same sampling station before sampling for incubation. Seawater samples were collected into acid-washed 600 mL polycarbonate bottles for light treatment and 1-L black polypropylene bottles for dark treatment. Each treatment was conducted in duplicate at each light levels. Immediately after the seawater samplings, ^{57}Fe and ^{67}Zn stock solutions were added to incubation bottles at ~10 pmol/L in final concentrations and the bottles were bagged into light level-adjusted black mesh and/or cloth bags. For carbon uptake experiment, seawater samples were poured into triplicate 300 mL polycarbonate bottles and one 300 mL black polypropylene bottle for each light level depths and added $\text{NaH}^{13}\text{CO}_3$ solution. Incubations were conducted on-board water tanks, the temperature of which were adjusted at the surface mixed layer (100% and 20% light levels) and below one (5% and 0.9% levels). Note that to avoid trace metal contaminations from the ship, the 100% light

level seawater samples were taken from 10 m depth. Incubations were lasted for 24 hs. Samples for particulate Fe and ^{57}Fe was collected on to the acid-washed 0.45 μm omnipore filter (Millipore) at the beginning and the end of the incubation. Particulate samples will be digested using concentrated HNO_3 and HF, evaporated, redissolve using 2% HNO_3 for high-resolution inductively coupled plasma mass spectrometry (HR-ICP-MS) in on-land laboratory.

ii) Fe addition experiment

Seawater samples were collected using acid-washed Teflon-coated Niskin-X sampling bottles as stated above. Seawater samples for filtered seawater (FSW) was passed through 0.22- μm cartridge filter (Pall Inc.) and pooled two acid-washed 12-L polycarbonate carboys. Seawater samples for phytoplankton was obtained by passing through acid-washed 200- μm Teflon mesh to eliminate large plankton to avoid uneven contamination of mesozooplankton in the incubation bottles. About 500 mL of FSW was poured into acid-washed 600-mL polycarbonate bottles and added series of Fe concentrations of 0 (control), 0.05, 0.1, 0.25, 0.5, and 1.0 nmol L^{-1} in final concentration in St. 4 experiment and 0 (control), 0.05, 0.1, 0.25, and 1.0 nmol L^{-1} in final concentration in St. 12 experiment. Then 72 mL of 200- μm Teflon mesh sieved seawater was added to incubation bottles and finally adjusted water volume using FSW. Incubation bottles were prepared in triplicates in controls and 1.0 nmol L^{-1} treatments and in duplicates in other Fe concentrations for two water temperature series. Seawater samples were incubated on-board water tanks which were set at in situ temperature and plus 4°C, and obtained on days 1 and 3. Incubation bottles were sacrificed in each interval. In the St. 12 experiment, four treatments (control (in situ temperature without Fe addition), +Fe (control temperature with Fe in 1 nmol L^{-1} in final concentration, HT (plus 4°C temperature without Fe addition), and HTFe (plus 4°C temperature with Fe in 1 nmol L^{-1} in final concentration)) using 200- μm Teflon mesh sieved seawater were prepared to estimate grazing pressure by microzooplankton in the incubation bottles.

ii) Zn addition experiment

In St. 4, Zn addition experiment was performed to investigate Fe-Zn co-limitation of the plankton assemblage in the western subarctic Pacific during summer. The 200- μm mesh sieved seawater as described above was poured into acid-washed 600 mL polycarbonate bottles. Four treatments were set as follows: control (no addition), +Fe (Fe addition at 1 nmol L^{-1} in final concentration), +Zn (Zn addition at 1 nmol L^{-1} in final concentration), and +FeZn (Fe and Zn additions at 1 nmol L^{-1} in final concentration). Incubation bottles were prepared in triplicates for each treatment and incubated on-board water tank that was set at in situ temperature. The bottles were collected on day 1 and 3, that those were sacrificed at each interval.

(3) Parameters

Size fractionated chlorophyll-*a* (>10 μm and ~0.7–10 μm), nutrients (NO_3 , NO_2 , NH_4 , PO_4 , Si(OH)_4), and pico- and nano-sized phytoplankton with flowcytometry, microscopy, dissolved inorganic carbon, total alkalinity, dissolved Fe, total dissolvable Fe, particulate Fe, particulate ^{57}Fe , ^{67}Zn and particulate organic ^{13}C .

(4) Observation log

Station	Date (d/m/y)	Position	Depth (m)	Exp. No.
St. 3	5/8/2025	44°00.77'N, 155°03.41'E	10, 12, 23, 40	(i)
St. 4	8/8/2025	47°00.01'N, 160°00.00'E	10, 12	(ii), (iii)
St. 4	8/8/2025	47°00.00'N, 159°59.98'E	10, 12, 14, 16, 21, 32	(i), (ii)
St. 6	13/8/2025	46°59.85'N, 169°59.84'E	10, 15, 30, 55	(i)
St. 9	17/8/2025	46°59.99'N, 169°59.99'W	10, 12, 17, 32	(i)
St. 12	23/8/2025	50°00.01'N, 144°59.97'W	10, 11, 12, 16, 17, 18	(ii)
St. 12	23/8/2025	49°59.99'N, 145°00.06'W	10, 14, 28, 47	(i), (ii)

(5) Data archives

All data obtained during MR25-04 cruise will be submitted to Data Management Group (DMG) of JAMSTEC after the sample analysis and validation. The data will be opened to the public via “Data Research System for Whole Cruise Information (DARWIN)” in JAMSTEC web site or elsewhere.

2.6 Mooring

2.6.1 Recovery and Deployment of mooring systems

2.6.1-1 Kuroshio Extension Observatory (KEO) mooring - Time-series sediment trap observation -

Makio HONDA (JAMSTEC RIGC)
Chiho SUKIGARA (JAMSTEC RIGC)
Keisuke SHIMIZU (JAMSTEC RIGC)
Kango FUKUYAMA (MWJ)
Masaki TAGUCHI (MWJ)

(1) Recovery

In 2024, KEO sediment trap mooring system with two sediment traps at 1000 m and 4800 m was deployed in June during R/V MIRAI MR24-07 Leg.2 cruise at station KEO.

On 31 July 2025, thanks to great efforts by cruise participants, marine technicians from Marine Works Japan Ltd. and ship crews from NME, sediment trap mooring system was successfully recovered although several grass floats were broken. Time-series sediment trap sample at both depths between November 2024 and July 2025 was successfully collected (Fig.2.6.1, Table 2.6.1).

(2) Redeployment

Unfortunately, because of the bad weather and the bad sea condition caused by the Typhoon approaching, redeployment of sediment trap mooring system was suspended. The next cruise for the redeployment is not planned.

2025 KEO BGC Recovery

Mooring Number : KEOBGC

Deployment Data : 2024/11/10~2025/07/31

Cruise No. : MR25-04

Position : LAT 32 -22.0385' N

LONG 144-24.9336' E

Depth : 5789 m

KEO

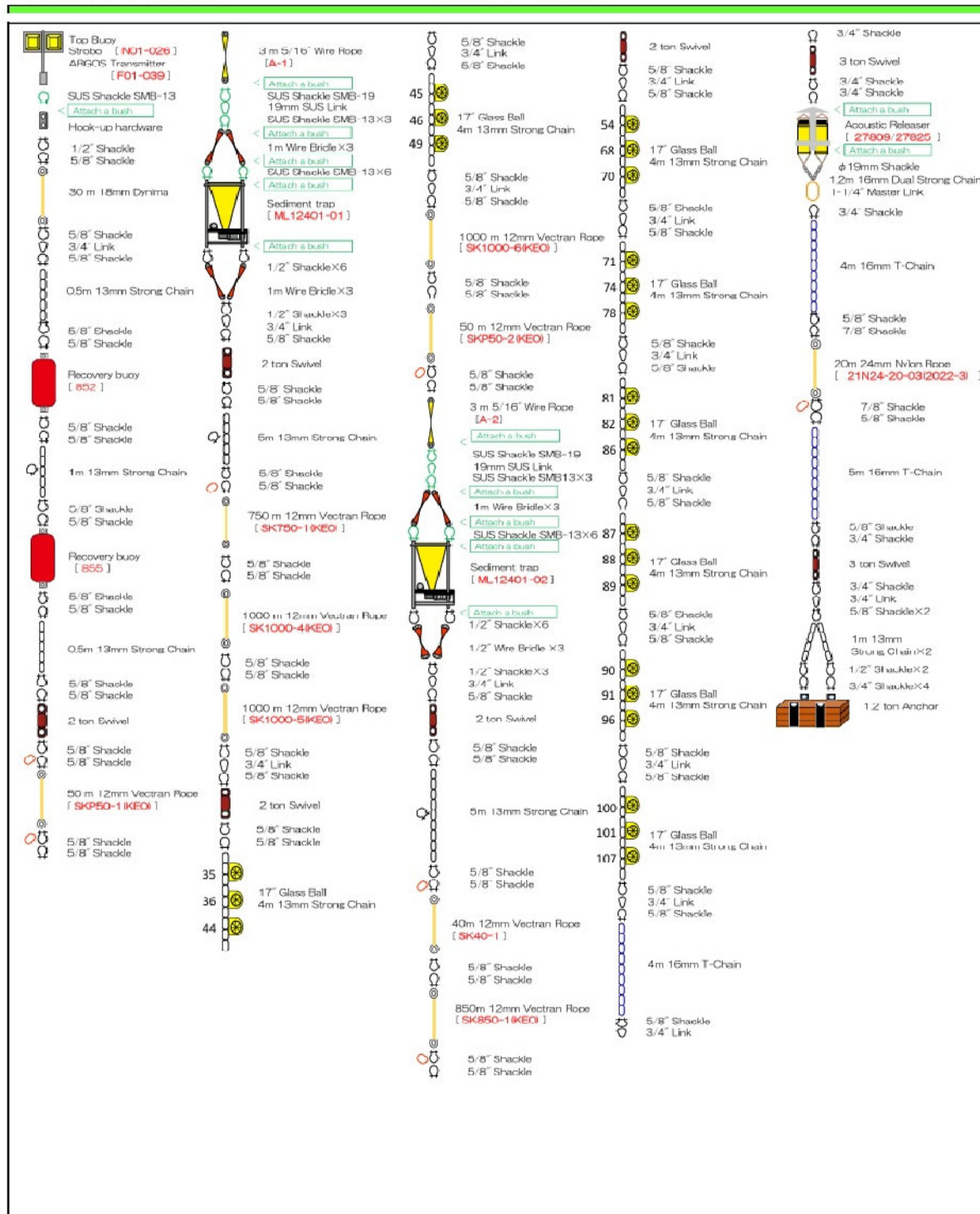


Fig.2.6.1 KEO sediment trap mooring system recovered

Table 2.6.1 Recovery KEO BGC profiling buoy system record.

MOORING RECORD DEPLOYMENT AND RECOVERY

Mooring Number 2025 KEO BGC Recovery			
Project	Time-Series	Depth	5800 m
Area	North Pacific	Planned Depth	5780 m
Station	KEO	Length	4878 m
Target Position	32°22.00 N	Depth of Buoy	900 m
	144°25.00 E	Period	1 year
ACOUCTIC RELEASERS			
Type	Edgetech	Edgetech	
Serial Number	27809	27825	
Receive F.	11.0 kHz	11.0 kHz	
Transmit F.	14.0 kHz	14.0 kHz	
RELEASE C.	344535	344176	
Enable C.	360320	356736	
Disable C.	360366	356770	
Battery	2 years	2 years	
Release Test	OK	OK	
RECOVERY			
Recorder	Kango FUKUYAMA	Work Distance	0.8 Nmile
Ship	R/V MIRAI	Send Enable C.	20:06
Cruise No.	MR25-04	Releaser Depth	5755 m
Date	2025/8/8~9	Send Release C.	22:09
Weather	bc	Discovery Buoy	23:55
Wave Hight	2.6 m	Pos. of Top Buoy	32-21.01 N
SeaBeam Depth	- m		144-24.67 E
Ship Heading	90 deg	Pos. of Start	32-21.61 N
Ship Ave.Speed	- knot		144-25.34 E
Wind	< 090 deg > 11.5 m/s	Pos. of Finish	32-21.21 N
Current	< 138deg > 0.7 knot		144-24.99 E

2.6.1-2 Hybrid profiling buoy system

Tetsuichi FUJIKI (JAMSTEC ESS)
Hiroshi UCHIDA(JAMSTEC GOORC)
Katsunori KIMOTO (JAMSTEC ESS)
Minoru KITAMURA (JAMSTEC ESS)
Masahide WAKITA (JAMSTEC MIO)
Yoshiyuki NAKANO (JAMSTEC MARE³)
Chiho SUKIGARA (JAMSTEC ESS)
Keisuke SHIMIZU(JAMSTEC ESS)
Kango FUKUYAMA(MWJ)
Masaki TAGUCHI(MWJ)

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 MR24-07 Leg1 and deployed Hybrid profiling buoy system at Station K-2. Deployment operation took approximately 5 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 2.6.2 Mooring positions of respective mooring systems.

	Recovery	Deployment
Mooring Number	K2H241022	K2H250809
Working Date	Oct. 22 2024	Aug. 09 2025
Latitude	47 ° 00.35 N	47 ° 00.34 N
Longitude	159 ° 58.32 E	159 ° 58.46 E
Sea Beam Depth	5,213 m	5,213 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 160 m below sea surface. On the Hybrid profiling buoy, three Sediment Traps are installed on the 500 m, 1,000 m and 4,800 m. two Auto Sampling Systems (RAS) are installed on the 200 m and 300m. CTD (SBE-37) and DO Sensor (RINKO and Optode) are mounted on the dual acoustic releaser and inline SUS frame (175 m, 225 m, 250 m and 780 m), Sediment Trap, RAS, underwater winch, top buoy. Details for each instrument are described below (section 2.6.3, 2.6.4, 2.6.5, 2.6.7). Serial number of instruments are as follows:

Table 2.6.3. Serial numbers of instruments.

Recover		Deployment	
Station and type Mooring Number	K2 K2H241022	Station and type Mooring Number	K2 K2H250809
Top Buoy (CT608B ABS BUOY)		Top Buoy (CT608B ABS BUOY)	
Recovery Bouy Argos Transmitter Storobe	M12-028(ID:260740) N01-061	Recovery Bouy Argos Transmitter Storobe	K10-022(ID:225989) H12-010
SUS frame (175m) SBE37 OPTODE	SUS frame 1892 6	SUS frame (175m) SBE37 OPTODE	SUS frame 1892 6
RAS (200m) SBE37 OPTODE HpHS DEFI-D (Depth) UV fluorometer + RBR data logger	ML11241-11 2239 50 60100364001 0AGG026 6238, 205142	RAS (200m) SBE37 OPTODE HpHS UV fluorometer + RBR data logger	ML11241-10, ML1124-11 2239 50 60100364001 6238, 205142
SUS frame (225m) SBE37 RINKO	SUS frame 2730 0004	SUS frame (225m) SBE37 RINKO	SUS frame 2730 0004
SUS frame (250m) SBE37 RINKO	SUS frame 2756 0092	SUS frame (250m) SBE37 RINKO	SUS frame 2756 0092
RAS (300m) SBE37 RINKO	ML11241-07 2289 051	RAS (300m) SBE37 RINKO	ML16407-01 2289 051
ADCP (370m) SBE37 OPTODE	1434 2288 9	ADCP (370m) SBE37 OPTODE	1533 2288 9
Sediment Trap, NGK (500m) SBE37	26S029 2287	Sediment Trap,NGK (500m) SBE37	26S001 2287

OPTODE	10		OPTODE	10
SUS frame (780m)	SUS frame		SUS frame (780m)	SUS frame
SBE37	2738		SBE37	2738
OPTODE	5		OPTODE	5
Sediment Trap, MARK78H-21 (1000m)	26S003		Sediment Trap, MARK78-H21 (1000m)	ML15362-02
SBE37	2285		SBE37	2285
RINKO	7		RINKO	7
			pH/CO ₂ sensor	-
Sediment Trap, MARK78-H21 (4800m)	15362-01		Sediment Trap, MARK78-H21 (4800m)	ML11241-01
SBE37	2742		SBE37	2742
OPTODE	2		OPTODE	2
Chlorophyll/turbidity meter	0002		Chlorophyll/turbidity meter	0002
Density sensor				
Releaser	27864		Releaser	36229
Releaser	34040		Releaser	336230
SBE-37	2731		SBE-37	2731
OPTODE	08		OPTODE	08
Chlorophyll/turbidity	0003		Chlorophyll/turbidity	0003

Table 2.6.4 Recovery Hybrid profiling buoy system record.

MOORING RECORD DEPLOYMENT AND RECOVERY

Mooring Number K2H250805			
Project	Time-Series	Depth	5,213.0 m
Area	North Pacific	Planned Depth	5,220.0 m
Station	K2	Length	5,089.8 m
Target Position	47°00.35 N	Depth of Buoy	160 m
	159°58.32 E	Period	1 year
ACOUSTIC RELEASERS			
Type	Edgetech	Edgetech	
Serial Number	34040	27824	
Receive F.	11.0 kHz	11.0 kHz	
Transmit F.	14.0 kHz	14.0 kHz	
RELEASE C.	233770	344421	
Enable C.	221130	357724	
Disable C.	221155	357762	
Battery	4.5 years (lithiumBattery)	2 years	
Release Test	OK	OK	
RECOVERY			
Recorder	Kango FUKUYAMA	Work Distance	4.3 Nmile
Ship	R/V MIRAI	Send Enable C.	20:52
Cruise No.	MR25-04	Releaser Depth	5179 m
Date	2025/8/5~6	Send Release C.	20:55
Weather	c	Discovery Buoy	20:58
Wave Hight	1.4 m	Pos. of Top Buoy	47-00.49 N
SeaBeam Depth	- m		159-58.51 E
Ship Heading	340 deg	Pos. of Start	47-00.58 N
Ship Ave.Speed	- knot		159-59.25 E
Wind	< 144 deg > 10.3 m/s	Pos. of Finish	47-04.47 N
Current	< 007deg > 0.2 knot		159-56.81 E

Table 2.6.5 Deployment Hybrid profiling buoy system record.

MOORING RECORD DEPLOYMENT AND RECOVERY

Mooring Number		K2H250809		
Project	Time-Series		Depth	5,213.0 m
Area	North Pacific		Planned Depth	5,220.0 m
Station	K2		Length	5,089.8 m
Target Position	47°00.35 N	Depth of Buoy	160	m
	159°58.32 E		Period	1 year
ACOUCTIC RELEASERS				
Type	Edgetech		Edgetech	
Serial Number	36229		36230	
Receive F.	11.0	kHz	11.0 kHz	
Transmit F.	9.0	kHz	14.0 kHz	
RELEASE C.	426612		426631	
Enable C.	407210		407256	
Disable C.	407233		407275	
Battery	4.5 years (lithiumBattery)		4.5 years (lithiumBattery)	
Release Test	OK		OK	
DEPLOYMENT				
Recorder	Kango FUKUYAMA		Start	5.9 Nmile
Ship	R/V MIRAI		Overrun	500 m
Cruise No.	MR25-04		Let go Top Buoy	21:14
Date	2025/8/8~9		Let go Anchor	00:50
Weather	f		Sink Top Buoy	01:31
Wave Hight	1.8	m	Pos. of Start	47-05.67 N
SeaBeam Depth	5,213	m		159-58.29 E
Ship Heading	180	deg	Pos. of Drop. Anc.	47-00.01 N
Ship Ave.Speed	-	knot		159-58.29 E
Wind	< 194 deg >	10.2 m/s	Pos. of Mooring	47-00.3414 N
Current	< 029 deg >	0.6 cm/s		159-58.4670 E

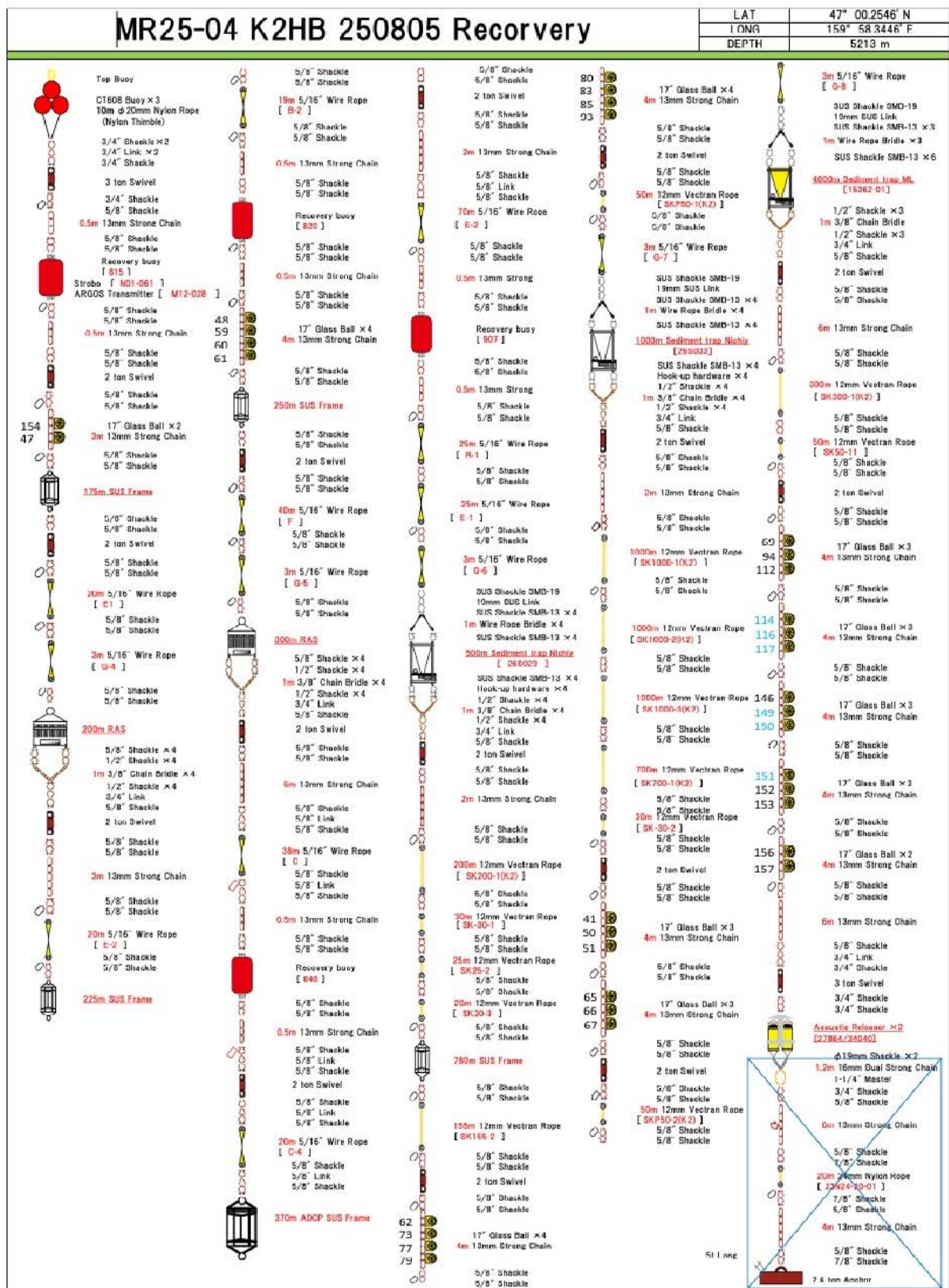


Fig. 2.6.2 Hybrid profiling buoy system recovered.

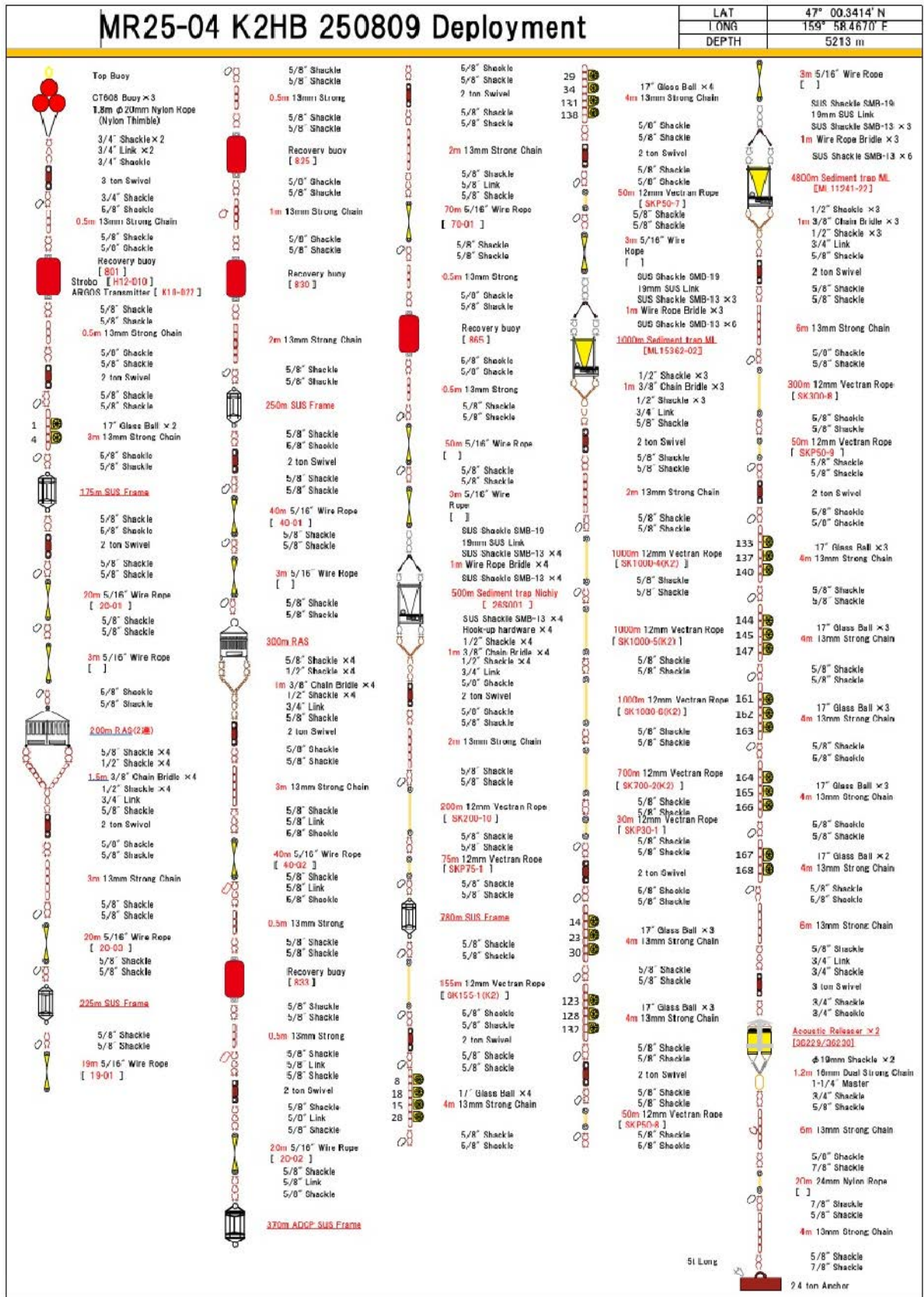


Fig. 2.6.3 Hybrid profiling buoy system deployed.

2.6.1-3 Ocean Acidification (K2-OA) buoy system

Katsunori KIMOTO (JAMSTEC ESS)

Maki NOGUCHI (JAMSTEC ESS)

Makio HONDA(JAMSTEC ESS)

Hiroshi UCHIDA(JAMSTEC GOORC)

Minoru KITAMURA (JAMSTEC ESS)

Masahide WAKITA (JAMSTEC MIO)

Chiho SUKIGARA(JAMSTEC ESS)

Yoshiyuki NAKANO (JAMSTEC MARE³)

Kango FUKUYAMA(MWJ)

Masaki TAGUCHI(MWJ)

We recovered Hybrid profiling buoy system at Station K2-PO at MR25-04. Recovery operation took approximately 2 hours.

Table 2.6.6 Mooring positions of respective mooring systems.

	Recover
Mooring Number	K2-OA241015
Working Date	Aug. 09 2025
Latitude	46 ° 53.57 N
Longitude	159 ° 40.21 E
Sea Beam Depth	5,155.41 m

The recovered Hybrid profiling buoy consists of a top buoy with 2640lbs (1200kg) 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 80 m below sea surface. On the Hybrid profiling buoy, one Sediment Traps are installed on the 150 m. Auto Sampling Systems (RAS) are installed on the 80 m. CTD (SBE-37) and DO Sensor (RINKO and Optode) are inline SUS frame (100 m and 150 m), Sediment Trap, RAS, underwater winch, top buoy. Details for each instrument are described below (section2.6.4,2.6.7,2.6.8). Serial number of instruments are as follows:

Table 2.6.7 Serial numbers of instruments.

Recovery	
Station and type Mooring Number	K2-OA K2-OA241015
Top Buoy (Recovery Buoy 4pcs) Argos transmitter Strobe DEFI-D50HG ACTW-WF-L	N02-016 N02-017 085I001 0049
RAS (80m) ACTW-WF-L AROW-WF-L HpHS DEFI-D Backscatter	16095-01 0050 0040 505063001 082U009 891
SUS frame (100m) SBE37 RINKO	SUS frame 8836 0009
SUS frame (125m) SBE37 RINKO	SUS frame 8839 0010
Sediment Trap (150m) SBE37 RINKO Backscatter ISFET pH/pCO ₂ sensor	ML16094-01 8840 0017 1742 -

Table2.6.8 Deployment Hybrid profiling buoy system record.

MOORING RECORD DEPLOYMENT AND RECOVERY

Mooring Number		K2-OA241015		
Project	Time-Series	Depth	5155.41	m
Area	North Pacific	Planned Depth	5150	m
Station	K2-PO	Length	5090.72	m
Target Position	46°53.60 N	Depth of Buoy	60	m
	159°40.30 E	Period	1	year
ACOUCTIC RELEASERS				
Type	Edgetech	Edgetech		
Serial Number	28533	27824		
Receive F.	11.0 kHz	11.0 kHz		
Transmit F.	14.0 kHz	14.0 kHz		
RELEASE C.	223307	344674		
Enable C.	201054	361121		
Disable C.	201077	361167		
Battery	2 years (Battery Pack)	2 years		
Release Test	OK	OK		
RECOVERY				
Recorder	Kango FUKUYAMA	Work Distance	1.2	Nmile
Ship	R/V MIRAI	Send Enable C.	19:11	
Cruise No.	MR25-04	Releaser Depth	5117	m
Date	2025/8/9	Send Release C.	20:35	
Weather	f	Discovery Buoy	20:36	
Wave Hight	1.7 m	Pos. of Top Buoy	46-49.64	N
SeaBeam Depth	- m		159-37.24	E
Ship Heading	180 deg	Pos. of Start	46-53.36	N
Ship Ave.Speed	- knot		159-39.91	E
Wind	< 198 deg > 8.2 m/s	Pos. of Finish	46-52.81	N
Current	< 301 deg > 0.1 knot		159-40.27	E

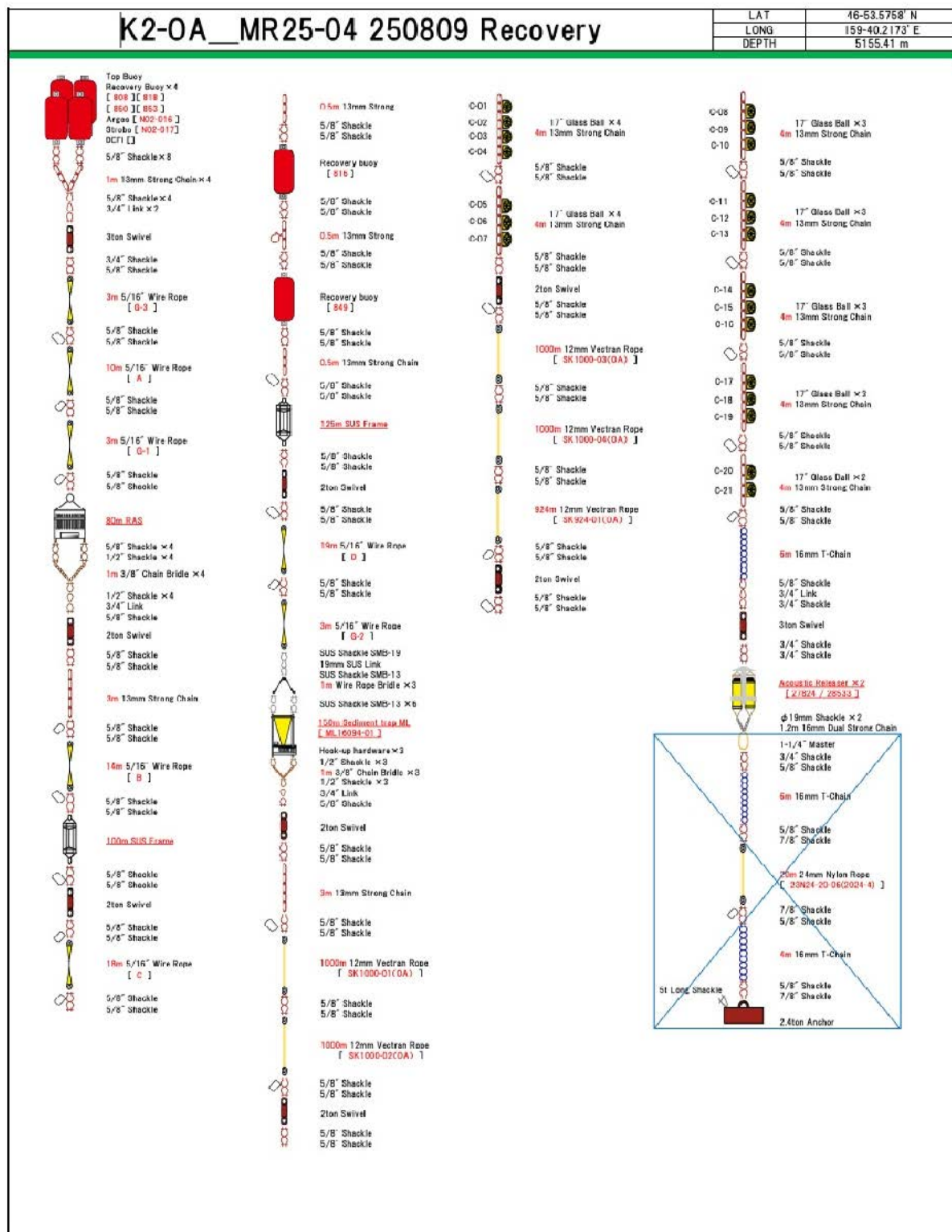


Fig. 2.6.4 Hybrid profiling buoy system deployed.

2.6.2 KEO time-series sediment trap observation

Makio HONDA (JAMSTEC RIGC)

Chiho SUKIGARA (JAMSTEC RIGC)

Keisuke SHIMIZU (JAMSTEC RIGC)

Kango FUKUYAMA (MWJ)

Masaki TAGUCHI (MWJ)

(1) Objective

Based on the comparison study of biogeochemistry in the northwestern North Pacific eutrophic subarctic region and oligotrophic subtropical region (“K2S1 project” in 2010 - 2013), it was clarified that surface biological activity (primary productivity) in the subtropical region is comparable to or slightly larger than that in the subarctic region (Special issue of Journal of Oceanography vol.72 no.3 2016; Honda et al. 2017) although particulate organic carbon in the subarctic region is transported to the deep efficiently (Honda 2020). In order to verify the support mechanism of biological activity, that is the mechanism of nutrient supply, time-series sediment trap experiment was initiated in 2014 at about 4900 m of the station KEO. This station is the time-series station maintained by National Ocean and Atmosphere Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL) (URL: <https://www.pmel.noaa.gov/ocs/data/disdel/>). Surface buoy with meteorological sensors and physical oceanographic sensors have been deployed at station KEO since 2004. Therefore, these time-series data of meteorology and physical oceanography can be utilized to interpret time-series variability in sediment trap data. Owing to simultaneous analysis of time-series data obtained by NOAA surface buoy and JAMSTEC sediment trap between 2014 and 2016, it was verified that mesoscale cyclonic eddy potentially plays a role in nutrient supplier (Honda et al. 2018). In order to evaluate other potential mechanisms such as typhoon and aeolian dust input, sediment trap experiment has been continued at station KEO.

(2) Preliminary result: total mass flux

On 31 July 2025, the sediment trap mooring system that was deployed in June 2024 was successfully recovered. Time-series sediment trap sample at both depths between November 2024 and July 2025 was successfully collected. Onboard, the volume flux of collected samples (settling particles) in collecting cups were measured roughly with scale (Fig. 2.6.2.1). Qualitatively, the large peak of sinking particle was observed in late March and April 2024 at 1000 m. At 4800 m, flux peak was also observed in late March and April 2025. During same period, the volume flux at 4800 m also increased.

(3) Future analysis

The above preliminary result is qualitative. In order to evaluate settling particles quantitatively, on land laboratory, sediment trap sample will be pretreated (splitting, filtration, dry-up, pulverization) and major chemical components such as organic carbon, inorganic carbon, biogenic opal, CaCO_3 and Al will be analyzed.

(4) Data archive

Obtained data will be submitted to KEO sediment trap database (URL: https://ebcrpa.jamstec.go.jp/egcr/e/oal/oceansites_keo/).

References

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- Honda MC, Sasai Y, Siswanto E, Kuwano-Yoshida A, Aiki H, Cronin MF (2018) Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on biogeochemical/physical/meteorological time-series at station KEO. *Progress in Earth and Planetary Science*. doi.org/10.1186/s40645-018-0196-3
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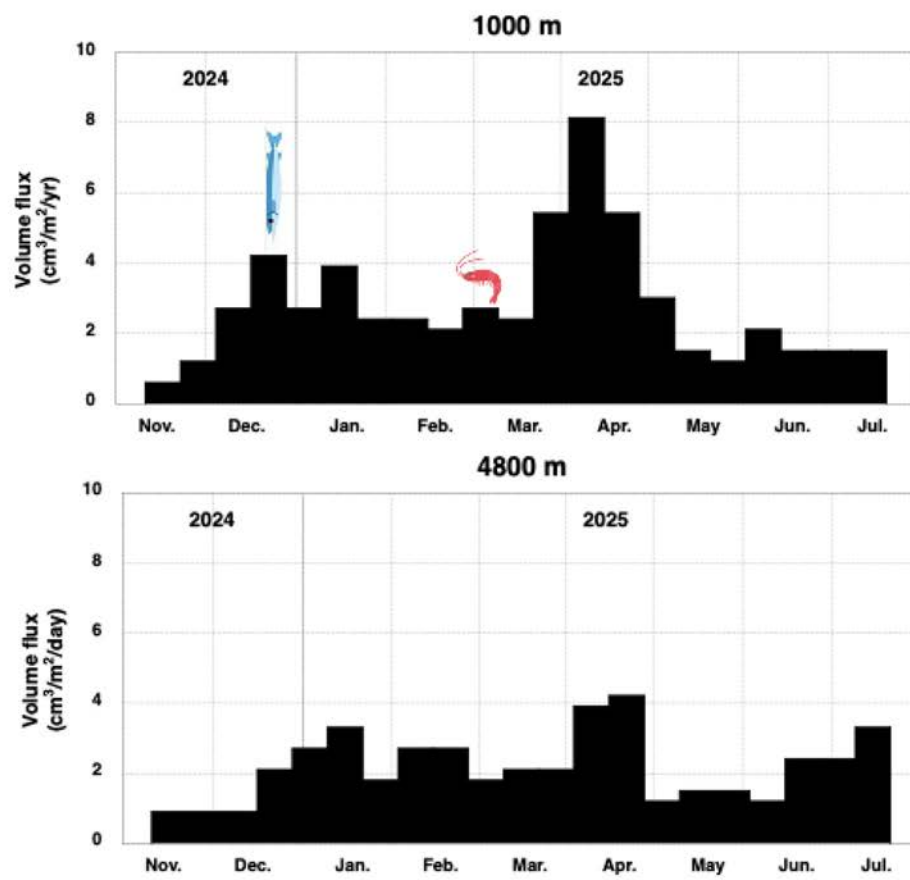


Fig. 2.6.2.1 Seasonal variability in Total Mass flux (volume of collected material)

2.6.3. Sediment trap at K2

Keisuke SHIMIZU (JAMSTEC)
Katsunori KIMOTO (JAMSTEC)
Makio Honda (JAMSTEC)
Chiho SUKIGARA (JAMSTEC)
Maki NOGUCHI (JAMSTEC)

(1) Objective

To evaluate magnitude and efficiency of the biological carbon pump in the Western Subarctic Gyre of the North Pacific, the sediment trap experiment has been carried out since 2005 at the time-series station K2.

(2) Description of deployed instruments (K2H250809)

In this cruise, we installed two kinds of moorings K2H250809 at station K2 (47°00'N, 159°58'E). This instrument has been used for routine observations since 2005 and contains three traps at depths of 500 m, 1,000 m, and 4,800 m. One sediment traps was manufactured by NiGK Corporation (SMD26S-001) with 26 sampling bottles were installed at depths of 500 m (table 2.6.3.-1). Other two sediment traps were manufactured by McLane Research Laboratories (ML15362-02 and ML11241-22) with 21 sampling bottles was also installed at depths of 1000 and 4800 m (table 2.6.3.-1). All sampling bottles were filled with 10% Formalin neutral buffer solution with excess sodium tetraborate dissolved in filtered seawater using 0.22 μ m pore-size filter. Internal clock of each sediment trap was set in UTC, and sampling schedules of the recovered and deployed sediment traps were summarized in the tables (table 2.6.3.-3). Sample collection interval was set 14 or 28 days.

Table 2.6.3-1. Specifications of sediment traps

	SMD26S-6000	MARK78H-21_old model	MARK78H-21_new model
Company	NiGK Corporation	McLane Research Lab.	McLane Research Lab.
Max. depth (m)	6000	7000	7000
Dimensions (diameter $\times$ height, cm)	104 $\times$ 160	91 $\times$ 164	91 $\times$ 164
Mouth area (m ²)	0.5	0.5	0.5
Weights (kg)	86 in air, 46 in water	72 in air, 39 in water	72 in air, 39 in water
No. of sampling bottles	26	21	21
Volume of sampling bottles (ml)	270	250	250
Battery	Alkaline/Lithium pack	14 Alkaline batteries	14 Alkaline batteries
Communication cables	RMG4-USB	RMG3-Serial port-USB	SUBCOM6-USB (Cable model: M4787)
Software	N-SMD	Crosscut	MacLanePro
OS	Win 7	Win 7	Win 10

Table 2.6.3-2. Serial numbers and battery types

Mooring ID	Depth	Model	S/N	Battery
K2H241022	500 m	NIGK, SMD26S-6000	26S029	Alkaline/Lithium pack
K2H241022	1000 m	NIGK, SMD26S-6000	26S003	Alkaline/Lithium pack
K2H241022	4810 m	McLane, MARK78H-21_old	ML15362-01	Alkaline batteries
K2OA241015	150 m	McLane, MARK78H-21_new	ML16094-01	Alkaline batteries
K2H250809	500 m	NIGK, SMD26S-6000	26S001	Alkaline/Lithium pack
K2H250809	1000 m	McLane, MARK78H-21_new	ML15362-02	Alkaline batteries
K2H250809	4810 m	McLane, MARK78H-21_old	ML11241-22	Alkaline batteries

Table 2.6.3-3. Sampling schedules of the deployed sediment trap.

a) 500 m				(b) 1000 m and 4800 m			
Bottle No.	Sampling (UTC, yyyy/mm/dd)		Interval (days)	Bottle No.	Sampling (UTC, yyyy/mm/dd)		Interval (days)
Start	End			Start	End		
1	2025/8/15 0:00	2025/9/12 0:00	28	1	2025/8/15 0:00	2025/9/12 0:00	28
2	2025/9/12 0:00	2025/10/10 0:00	28	2	2025/9/12 0:00	2025/10/10 0:00	28
3	2025/10/10 0:00	2025/11/7 0:00	28	3	2025/10/10 0:00	2025/11/7 0:00	28
4	2025/11/7 0:00	2025/12/5 0:00	28	4	2025/11/7 0:00	2025/12/5 0:00	28
5	2025/12/5 0:00	2026/1/2 0:00	28	5	2025/12/5 0:00	2026/1/2 0:00	28
6	2026/1/2 0:00	2026/1/30 0:00	28	6	2026/1/2 0:00	2026/1/30 0:00	28
7	2026/1/30 0:00	2026/2/27 0:00	28	7	2026/1/30 0:00	2026/2/27 0:00	28
8	2026/2/27 0:00	2026/3/27 0:00	28	8	2026/2/27 0:00	2026/3/27 0:00	28
9	2026/3/27 0:00	2026/4/24 0:00	28	9	2026/3/27 0:00	2026/4/24 0:00	28
10	2026/4/24 0:00	2026/5/8 0:00	14	10	2026/4/24 0:00	2026/5/22 0:00	28
11	2026/5/8 0:00	2026/5/22 0:00	14	11	2026/5/22 0:00	2026/6/19 0:00	28
12	2026/5/22 0:00	2026/6/5 0:00	14	12	2026/6/19 0:00	2026/7/17 0:00	28
13	2026/6/5 0:00	2026/6/19 0:00	14	13	2026/7/17 0:00	2026/8/14 0:00	28
14	2026/6/19 0:00	2026/7/3 0:00	14	14	2026/8/14 0:00	2026/9/11 0:00	28
15	2026/7/3 0:00	2026/7/17 0:00	14	15	2026/9/11 0:00	2026/10/9 0:00	28
16	2026/7/17 0:00	2026/7/31 0:00	14	16	2026/10/9 0:00	2026/11/6 0:00	28
17	2026/7/31 0:00	2026/8/14 0:00	14	17	2026/11/6 0:00	2026/12/4 0:00	28
18	2026/8/14 0:00	2026/8/28 0:00	14	18	2026/12/4 0:00	2027/1/1 0:00	28
19	2026/8/28 0:00	2026/9/25 0:00	14	19	2027/1/1 0:00	2027/1/29 0:00	28
20	2026/9/25 0:00	2026/10/23 0:00	28	20	2027/1/29 0:00	2027/2/26 0:00	28
21	2026/10/23 0:00	2026/11/20 0:00	28	21	2027/2/26 0:00	2027/3/26 0:00	28
22	2026/11/20 0:00	2026/12/18 0:00	28				
23	2026/12/18 0:00	2027/1/15 0:00	28				
24	2027/1/15 0:00	2027/2/12 0:00	28				
25	2027/2/12 0:00	2027/3/12 0:00	28				
26	2027/3/12 0:00	2027/4/9 0:00	28				

(3) Preliminary result (K2H241022 and K2OA241015)

In the recovered K2H241022 mooring, three sediment traps were installed at depths of 500 m, 1,000 m and 4,810 m at station K2 in 2024 were operated as scheduled (table 2.6.3.-4). After the recovery, the pH of the formaldehyde solution in each bottle was measured onboard and was mostly about pH 8.3-8.5 (table 2.6.3.-5). Average pH of samples at depth of 500 m, 1000 m, and 4810 m were pH 8.41 ± 0.26 (excluded bottle #13), 8.44 ± 0.06 , and 8.48 ± 0.04 , respectively. Amount of the collected material in each bottle was also measured (Figure 2.6.3.-1). A distinct peak in the particle flux collected at the depth of 500 and 4,800 m was observed in summer (July-August) and autumn (November). Although none of the bottles became stuck with too many particles, the #14 to #21 bottles at depth of 1,000 m contained almost no particles.

In addition, one sediment trap was also installed at depth of 150 m in another mooring (K2OA241015) at station K2 too (table 2.6.3.-4). Average pH of samples was lower than other three sediment traps in K2H241022 mooring (Table 2.6.3.-5). Many copepods were collected in early summer (May-July), but they were decayed in the bottles. Because of the low pH of the solution inside the bottle (table 2.6.3.-5), it is most likely that 10% formalin neutral buffer solution that filled in the bottle has gone outside.

Amount of the collected material in each bottle was also measured (Figure 2.6.3.-1). A distinct peak in the particle flux collected at the depth of 500 and 4,800 m was observed in summer (July-August) and autumn (November). Although none of the bottles became stuck with too many particles, the #14 to #21 bottles at depth of 1,000 m contained almost no particles.

Table 2.6.3-4. Sampling schedules of the recovered sediment trap (K2H241022 and K2OA241015).

(a) 500 m and 1000 m (K2H241022)				(b) 4800 m (K2H241022)				(c) 150 m (K2OA241015)			
Bottle No.	Sampling (UTC, yyyy/mm/dd)		Interval (days)	Bottle No.	Sampling (UTC, yyyy/mm/dd)		Interval (days)	Bottle No.	Sampling (UTC, yyyy/mm/dd)		Interval (days)
	Start	End			Start	End			Start	End	
1	2024/10/23 0:00	2024/11/3 0:00	11	1	2024/10/23 0:00	2024/11/03 0:00	11	1	2024/10/20 0:00	2024/11/3 0:00	14
2	2024/11/3 0:00	2024/11/17 0:00	14	2	2024/11/03 0:00	2024/11/17 0:00	14	2	2024/11/3 0:00	2024/11/17 0:00	14
3	2024/11/17 0:00	2024/12/1 0:00	14	3	2024/11/17 0:00	2024/12/01 0:00	14	3	2024/11/17 0:00	2024/12/1 0:00	14
4	2024/12/1 0:00	2024/12/15 0:00	14	4	2024/12/01 0:00	2024/12/15 0:00	14	4	2024/12/1 0:00	2024/12/15 0:00	14
5	2024/12/15 0:00	2024/12/29 0:00	14	5	2024/12/15 0:00	2024/12/29 0:00	14	5	2024/12/15 0:00	2024/12/29 0:00	14
6	2024/12/29 0:00	2025/1/12 0:00	14	6	2024/12/29 0:00	2025/01/12 0:00	14	6	2024/12/29 0:00	2025/1/12 0:00	14
7	2025/1/12 0:00	2025/1/26 0:00	14	7	2025/01/12 0:00	2025/01/26 0:00	14	7	2025/1/12 0:00	2025/1/26 0:00	14
8	2025/1/26 0:00	2025/2/9 0:00	14	8	2025/01/26 0:00	2025/02/09 0:00	14	8	2025/1/26 0:00	2025/2/9 0:00	14
9	2025/2/9 0:00	2025/2/23 0:00	14	9	2025/02/09 0:00	2025/02/23 0:00	14	9	2025/2/9 0:00	2025/2/23 0:00	14
10	2025/2/23 0:00	2025/3/9 0:00	14	10	2025/02/23 0:00	2025/03/09 0:00	14	10	2025/2/23 0:00	2025/3/9 0:00	14
11	2025/3/9 0:00	2025/3/23 0:00	14	11	2025/03/09 0:00	2025/03/23 0:00	14	11	2025/3/9 0:00	2025/3/23 0:00	14
12	2025/3/23 0:00	2025/4/6 0:00	14	12	2025/03/23 0:00	2025/04/06 0:00	14	12	2025/3/23 0:00	2025/4/6 0:00	14
13	2025/4/6 0:00	2025/4/20 0:00	14	13	2025/04/06 0:00	2025/04/20 0:00	14	13	2025/4/6 0:00	2025/4/20 0:00	14
14	2025/4/20 0:00	2025/5/4 0:00	14	14	2025/04/20 0:00	2025/05/04 0:00	14	14	2025/4/20 0:00	2025/5/4 0:00	14
15	2025/5/4 0:00	2025/5/18 0:00	14	15	2025/05/04 0:00	2025/05/18 0:00	14	15	2025/5/4 0:00	2025/5/18 0:00	14
16	2025/5/18 0:00	2025/5/25 0:00	7	16	2025/05/18 0:00	2025/06/01 0:00	14	16	2025/5/18 0:00	2025/6/1 0:00	14
17	2025/5/25 0:00	2025/6/1 0:00	7	17	2025/06/01 0:00	2025/06/15 0:00	14	17	2025/6/1 0:00	2025/6/15 0:00	14
18	2025/6/1 0:00	2025/6/8 0:00	7	18	2025/06/15 0:00	2025/06/29 0:00	14	18	2025/6/15 0:00	2025/6/29 0:00	14
19	2025/6/8 0:00	2025/6/15 0:00	7	19	2025/06/29 0:00	2025/07/13 0:00	14	19	2025/6/29 0:00	2025/7/13 0:00	14
20	2025/6/15 0:00	2025/6/22 0:00	7	20	2025/07/13 0:00	2025/07/27 0:00	14	20	2025/7/13 0:00	2025/7/27 0:00	14
21	2025/6/22 0:00	2025/6/29 0:00	7	21	2025/07/27 0:00	2025/08/01 0:00	5	21	2025/7/27 0:00	2025/8/1 0:00	5
22	2025/6/29 0:00	2025/7/6 0:00	7								
23	2025/7/6 0:00	2025/7/13 0:00	7								
24	2025/7/13 0:00	2025/7/20 0:00	7								
25	2025/7/20 0:00	2025/7/27 0:00	7								
26	2025/7/27 0:00	2025/8/1 0:00	5								

Table 2.6.3-5. pH of the recovered samples.

Bottle No.	Depth			
	500m	1000m	4800m	150m
1	8.41	8.35	8.43	7.09
2	8.34	8.31	8.44	6.5
3	8.39	8.32	8.45	7.16
4	8.42	8.38	8.46	7.18
5	8.48	8.46	8.42	-
6	8.48	8.41	8.45	7.27
7	8.46	8.38	8.44	7.24
8	8.44	8.40	8.47	7.24
9	8.5	8.45	8.54	7.22
10	8.5	8.44	8.54	7.17
11	8.46	8.5	8.53	7.29
12	8.48	8.49	8.51	7.1
13	7.17	8.46	8.53	6.21
14	8.49	8.43	8.51	6.09
15	8.5	8.45	8.51	6.27
16	8.52	8.46	8.5	6.13
17	8.5	8.54	8.43	5.92
18	8.54	8.48	8.5	5.63
19	8.54	8.45	8.51	6
20	8.5	8.56	8.48	6.73
21	8.48	8.49	8.51	7.31
22	8.47	8.45		
23	8.4	8.49		
24	8.36	8.47		
25	8.37	8.5		
26	8.38	8.44		

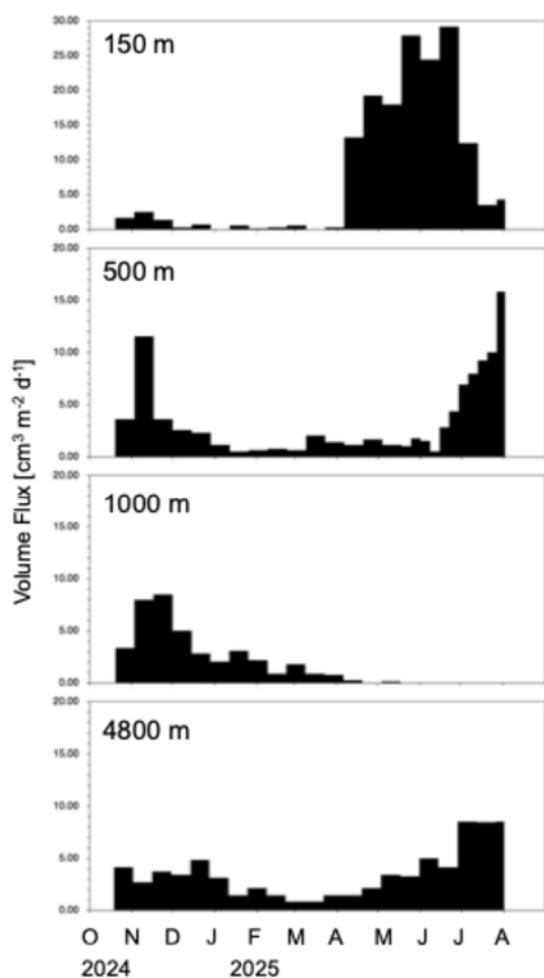


Figure 2.6.3-1. Seasonal changes of volume fluxes at 150, 500, 1000 and 4810 m in the station K2.

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

2.6.4. Remote Automatic Sampler (RAS)

Masahide WAKITA (JAMSTEC)

Hiroshi Uchida (JAMSTEC)

Yoshihisa Mino (Nagoya University)

(1) Objectives and Sampling

In order to investigate the seasonal variation of pH in the winter mixed layer and intermediate layer, and the vertical gradients of biogeochemical properties which affects vertical diffusion flux across the boundary with the thermocline, RAS on 200m and 300m (Figure 1) will work following schedule (Table 1) and collect samples of dissolved inorganic carbon (DIC), total alkalinity (TA), nutrients (Phosphate, Nitrate + Nitrite, Silicate), $^{15}\text{NO}_3$ and salinity. We will compare these properties from 12 L Niskin bottles mounted on the CTD/Carousel Water Sampling System for calibration on RAS samples at K2.

Salinity of RAS seawater samples were measured by salinometer (Model 8400B “AUTOSAL” Guildline Instruments). Salinity measured by salinometer were slightly lower than that observed by SBE-37 sensor (CTD). RAS samples (~400ml) were diluted with 2.5 ml of 25% 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. We will correct measurements of DIC, TA and nutrients. We used coulometric technique and spectrophotometric system to measure DIC and TA, respectively. Nutrient (silicate, phosphate, and nitrate) concentrations were measured with a continuous flow analyzer. $^{15}\text{NO}_3$ will be measured by Tokai University.



Figure 1 Remote Automatic Samplers deployed on 200m (left) and 300m (right).

Table 1 Sampling schedule of RAS in 200m and 300m on the moorings at station K2.

	RAS 200m-1		RAS 200m-2		RAS 300m		
RAS No.	ML11241-11		ML11241-10		ML16407-01		Memo
	Interval 7days		Interval 7days		Interval 14days		Sample volume 400ml / 25% saturated HgCl2
#	mm/dd/yyyy	Time(UTC)	mm/dd/yyyy	Time(UTC)	mm/dd/yyyy	Time(UTC)	
1	08/20/2025	00:00:00	07/08/2026	00:00:00	08/20/2025	00:00:00	繰返し精度確認
2	08/20/2025	01:00:00	07/08/2026	01:00:00	08/20/2025	01:00:00	
3	08/27/2025	00:00:00	07/15/2026	00:00:00	09/03/2025	00:00:00	
4	09/03/2025	00:00:00	07/22/2026	00:00:00	09/17/2025	00:00:00	
5	09/10/2025	00:00:00	07/29/2026	00:00:00	10/01/2025	00:00:00	
6	09/17/2025	00:00:00	08/05/2026	00:00:00	10/15/2025	00:00:00	
7	09/24/2025	00:00:00	08/12/2026	00:00:00	10/29/2025	00:00:00	
8	10/01/2025	00:00:00	08/19/2026	00:00:00	11/12/2025	00:00:00	
9	10/08/2025	00:00:00	08/26/2026	00:00:00	11/26/2025	00:00:00	
10	10/15/2025	00:00:00	09/02/2026	00:00:00	12/10/2025	00:00:00	
11	10/22/2025	00:00:00	09/09/2026	00:00:00	12/24/2025	00:00:00	
12	10/29/2025	00:00:00	09/16/2026	01:00:00	01/07/2026	00:00:00	
13	11/05/2025	00:00:00	09/23/2026	00:00:00	01/21/2026	00:00:00	
14	11/12/2025	00:00:00	09/30/2026	00:00:00	02/04/2026	00:00:00	
15	11/19/2025	00:00:00	10/07/2026	00:00:00	02/18/2026	00:00:00	
16	11/26/2025	00:00:00	10/14/2026	00:00:00	03/04/2026	00:00:00	繰返し精度確認
17	12/03/2025	00:00:00	10/21/2026	00:00:00	03/18/2026	01:00:00	
18	12/10/2025	00:00:00	10/28/2026	00:00:00	04/01/2026	00:00:00	
19	12/17/2025	00:00:00	11/04/2026	00:00:00	04/15/2026	00:00:00	
20	12/24/2025	00:00:00	11/11/2026	00:00:00	04/29/2026	00:00:00	
21	12/31/2025	00:00:00	11/18/2026	00:00:00	05/13/2026	00:00:00	
22	01/07/2026	00:00:00	11/25/2026	01:00:00	05/27/2026	00:00:00	
23	01/14/2026	00:00:00	12/02/2026	00:00:00	06/10/2026	00:00:00	
24	01/21/2026	00:00:00	12/09/2026	00:00:00	06/24/2026	00:00:00	
25	01/28/2026	00:00:00	12/16/2026	00:00:00	07/08/2026	00:00:00	
26	02/04/2026	00:00:00	12/23/2026	00:00:00	07/22/2026	00:00:00	
27	02/11/2026	00:00:00	12/30/2026	00:00:00	08/05/2026	00:00:00	
28	02/18/2026	00:00:00	01/06/2027	00:00:00	08/19/2026	00:00:00	
29	02/25/2026	00:00:00	01/13/2027	00:00:00	09/02/2026	00:00:00	
30	03/04/2026	00:00:00	01/20/2027	00:00:00	09/16/2026	00:00:00	
31	03/11/2026	00:00:00	01/27/2027	00:00:00	09/30/2026	00:00:00	繰返し精度確認
32	03/18/2026	00:00:00	02/03/2027	01:00:00	10/14/2026	00:00:00	
33	03/25/2026	00:00:00	02/10/2027	00:00:00	10/28/2026	00:00:00	
34	04/01/2026	00:00:00	02/17/2027	00:00:00	11/11/2026	00:00:00	
35	04/08/2026	00:00:00	02/24/2027	00:00:00	11/25/2026	00:00:00	
36	04/15/2026	00:00:00	03/03/2027	00:00:00	12/09/2026	00:00:00	
37	04/22/2026	00:00:00	03/10/2027	00:00:00	12/23/2026	00:00:00	
38	04/29/2026	00:00:00	03/17/2027	00:00:00	01/06/2027	00:00:00	
39	05/06/2026	00:00:00	03/24/2027	00:00:00	01/20/2027	00:00:00	
40	05/13/2026	00:00:00	03/31/2027	00:00:00	02/03/2027	00:00:00	
41	05/20/2026	00:00:00	04/07/2027	00:00:00	02/17/2027	00:00:00	
42	05/27/2026	00:00:00	04/14/2027	01:00:00	03/03/2027	00:00:00	
43	06/03/2026	00:00:00	04/21/2027	00:00:00	03/17/2027	00:00:00	
44	06/10/2026	00:00:00	04/28/2027	00:00:00	03/31/2027	00:00:00	
45	06/17/2026	00:00:00	05/05/2027	00:00:00	04/14/2027	00:00:00	
46	06/24/2026	00:00:00	05/12/2027	00:00:00	04/28/2027	00:00:00	繰返し精度確認
47	06/24/2026	00:00:00	05/19/2027	01:00:00	04/28/2027	00:00:00	
48	07/01/2026	00:00:00	05/26/2027	00:00:00	05/12/2027	00:00:00	

2.6.5. Hybrid pH sensor

Yoshiyuki NAKANO (JAMSTEC RIMTE)

(1) Objective

We have developed newly stable and accurate *in situ* system for pH measurement using hybrid technique (potentiometric and spectrophotometric). In this cruise, we aim to long-term monitoring of accurate in-situ pH by the Hybrid pH sensor (HpHS) in the open sea. We recovered two HpHS at K2 which were deployed at MR24-07 with Hybrid mooring (Remote Automatic Sampler (RAS), 200m) and K2-OA mooring (RAS, 80m). A HpHS was installed to the RAS (200m) of the K2 Hybrid mooring. In-situ data of pH will be measured every 4 hours during mooring observation in both mooring.

(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 over a long period of observation. On the other hand, although the potentiometric pH sensor has low power consumption and high-speed response (within 20 seconds), drifts in the pH of the potentiometric measurements may occur for a long observation period. The HpHS can measure in situ pH correctly and stably combining the 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 accurately measure the pH value over a long period of time with low power consumption.

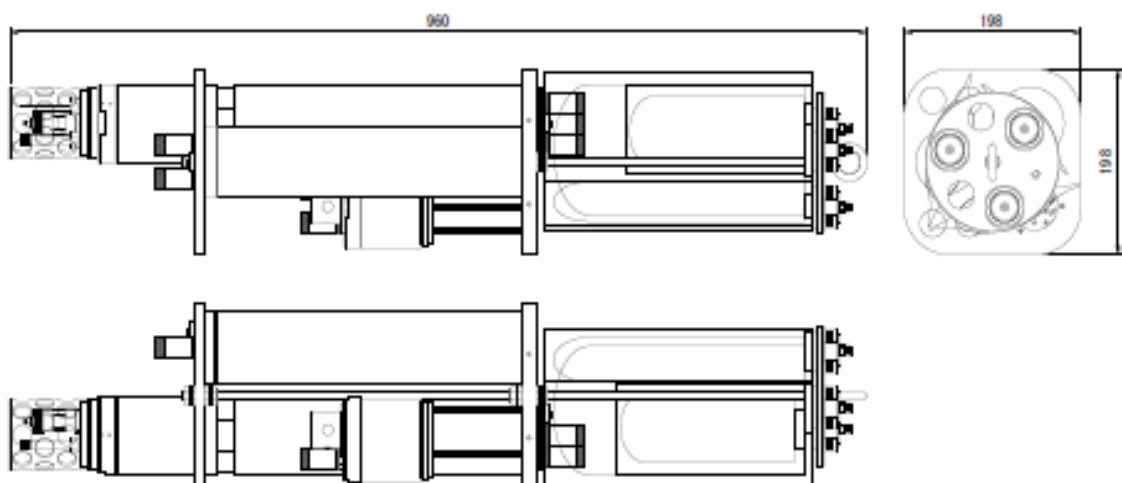


Fig. 2.6.5-1. Side view of HpHS.

Table 2.6.5-1. 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)	1 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) Preliminary results

We succeeded in recovering the HpHS with RAS in K2 Hybrid and K2-OA moorings and obtaining long term (about one year) pH data every four hours.

(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 CO₂ 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.

Takeshita, Y., Martz, T. R., Coletti, L. J., Dickson, A. G., Jannasch H. W., Johnson, K. S. (2017) The effects of pressure on pH of Tris buffer in synthetic seawater. Mer. Chem., 188, pp. 1-5.

2.6.6 ADCP

Akira NAGANO (JAMSTEC CCOAR)

Tetsuichi FUJIKI (JAMSTEC ESS)

Masahide WAKITA (JAMSTEC MIO)

Kango FUKUYAMA, Masaki TAGUCHI (MWJ)

(1) Objectives

The objective of this study is to collect a time series of the current velocity vector profile at station K2 in the western subarctic North Pacific by an Acoustic Doppler Current Profiler (ADCP). We obtain knowledge on vertical mixing by combined use of the ADCP and CTD data, as in Nagano et al. (2021).

(2) Instruments and methods

Current velocity vector profiles were measured at intervals of 1 h by a Work Horse ADCP (Teledyne RD Instruments, Inc., Poway, California) attached upward to the mooring system at a depth of 370 m. We replaced old ADCP to new one.

The configuration of the recovered ADCP is as follows:

Serial number: 1434
Bin size: 8.0 m
Number of bins: 60
Pings per ensemble: 1

The configuration of the replaced ADCP is as follows:

Serial number: 1533
Bin size: 8.0 m
Number of bins: 60
Pings per ensemble: 1

(3) Preliminary result

Current velocity data were obtained from near surface to approximately 300m. As of this recovery, we obtained approximately 10-year time series of current velocity vector profile at K2.

Obtained data will be corrected with sound speed estimated from CTD data and the difference between true north and geo- magnetic north based on the 12-th generation of the international geomagnetic reference field (Thébault et al., 2015).

(4) Data archive

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

(5) References

Nagano, A., M. Wakita, T. Fujiki, and H. Uchida (2021) El Niño-related vertical mixing enhancement under the winter mixed layer at western subarctic North Pacific station K2, *Journal of*

Geophysical Research, 126, e2020JC016913. <https://doi.org/10.1029/2020JC016913>

Thébault, E., Finlay, C. C., Beggan, C. D., Alken, P., Aubert, J., Barrois, O., et al. (2015). International geomagnetic reference field: The 12th generation. *Earth Planets and Space*, 67(79). <https://doi.org/10.1186/s40623-015-0313-0>

2.6.7 CTD/DO sensors

September 16, 2025

Hiroshi UCHIDA (JAMSTEC RIGC)

Masahide WAKITA (JAMSTEC MIO)

(1) Objective

The objective of this study is to grasp variability of temperature, salinity, oxygen etc. at the K2 mooring site (two moorings: K2 hybrid mooring and K2-OA mooring).

(2) Instruments and method

K2 hybrid mooring

Pressure, temperature, and salinity are measured by CTDs (SBE37SM, Sea-Bird Scientific, Bellevue, Washington, USA). Dissolved oxygen is measured by optical oxygen sensors (Oxygen Optode model 3830, Aanderaa Data Instruments AS, Bergen, Norway, and RINKO-I [ARO-USB] and RINKO-I DSP [AROD-USB], JFE Advantech Co. Ltd., Japan). The Oxygen Optode sensor was attached to a datalogger with an internal battery and memory in a titanium housing (Compact-OPTODE, Alec Electronics Co., Ltd., Japan). Fluorescent dissolved organic matter (FDOM) is measured by UV fluorometer (Seapoint Sensors Inc.). The UV fluorometer was connected to a datalogger (RBRduo³ V.V, RBR Ltd., Canada). Chlorophyll, turbidity and temperature are measured by chlorophyll-turbidity meters (ACLD70-USB, JFE Advantech).

A sampling interval was set to 1 hour for all sensors, except for the chlorophyll-turbidity meters, whose sampling interval was set to 2 hours. Sensors used in the K2 hybrid mooring are summarized in Table 2.6.7-1.

K2-OA mooring

Pressure, temperature, and salinity are measured by CTDs (SBE37SM, Sea-Bird Scientific). Temperature and salinity are measured by CTs (ACTW-WF-L, JFE Advantech). Pressure is measured by depth meter (DEFI-D50HG, JFE Advantech). Dissolved oxygen is measured by optical oxygen sensors (EPSA-RINKO [AROW-WF-L], RINKO-I [ARO-USB] and RINKO-I DSP [AROD-USB], JFE Advantech).

A sampling interval was set to 1 hour for all sensors. Sensors used in the K2-OA mooring are summarized in Table 2.6.7-2.

(3) Results

All sensor data deployed in 2024 was successfully recovered. Time series of temperature measured by the moored CTDs is shown in Fig. 2.6.7-1.

(4) Data archive

These obtained data will be submitted to JAMSTEC Data Management Group (DMG) after recovery of the instruments.

Table 2.6.7-1 Serial number of the sensors deployed in the K2 hybrid mooring.

Planned depth	Serial number (Instrument)	Note
175 m	1892 (SBE37SM), 0006 (CompactOPTODE)	SUS frame
200 m	2239 (SBE37SM), 0050 (CompactOPTODE) 6238 (UV fluorometer)+205142 (RBR data logger)	RAS
225 m	2730 (SBE37SM), 0004 (RINKO-IDSP)	SUS frame
250 m	2756 (SBE37SM), 0092 (RINKO-I)	SUS frame
300 m	2289 (SBE37SM), 0051 (RINKO-I)	RAS
370 m	2288 (SBE37SM), 0009 (CompactOPTODE)	ADCP
500 m	2787 (SBE37SM), 0010 (CompactOPTODE)	Trap
780 m	2738 (SBE37SM), 0005 (CompactOPTODE)	SUS frame
1000 m	2285 (SBE37SM), 0007 (CompactOPTODE)	Trap
4800 m	2742 (SBE37SM), 0002 (CompactOPTODE), 0002 (ACLD70)	Trap
30 m above bottom	2731 (SBE37SM), 0008 (CompactOPTODE), 0003 (ACLD70)	Releasers

Table 2.6.7-2 Serial number of the sensors deployed in the K2-OA mooring.

Planned depth	Serial number (Instrument)	Note
60 m	0049 (ACTW-WF-L) 085I001 (DEFI-D50HG)	Top buoy
80 m	0050 (ACTW-WF-L), 0040 (AROW-WF-L) 082U009 (DEFI-D50HG)	RAS
100 m	8836 (SBE37SM), 0009 (RINKO-IDSP)	SUS frame
125 m	8839 (SBE37SM), 0010 (RINKO-IDSP)	SUS frame
150 m	8840 (SBE37SM), 0017 (RINKO-I)	Trap

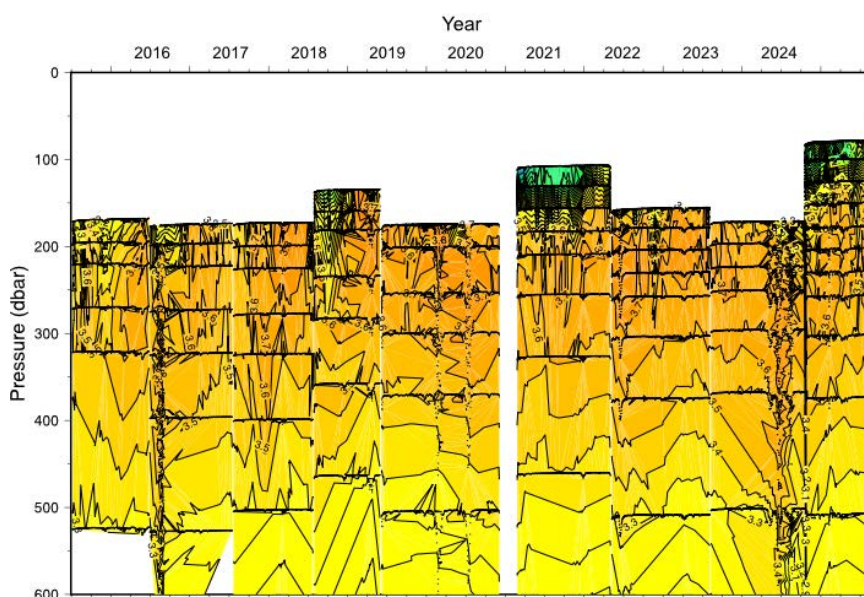


Figure 2.6.7-1. Time series of temperature measured by the moored CTDs.

2.6.8 pH/pCO₂ sensor experiment

Kiminori SHITASHIMA (Tokyo University of Marine Science and Technology) PI

Katsunori KIMOTO (JAMSTEC)

Tetsuichi FUJIKI (JAMSTEC)

(1) Objective

The objective of this study is to long-term monitoring of in-situ pH and pCO₂ by sensor.

(2) Instruments and methods

The in-situ pH sensor employs an Ion Sensitive Field Effect Transistor (ISFET) as a pH electrode, and the Chloride ion selective electrode (Cl-ISE) as a reference electrode. The ISFET is a semiconductor made of p-type Si coated with SiO₂ and Si₃N₄ that can measure H⁺ ion concentration in aqueous phase. New ISFET-pH electrode specialized for oceanographic use was developed. The Cl-ISE is a pellet made of several chlorides having a response to the chloride ion, a major element in seawater. The electric potential of the Cl-ISE is stable in the seawater, since it has no inner electrolyte solution. The in-situ pH sensor has a quick response (less than a second), high accuracy (± 0.003 pH) and pressure-resistant performance. The pCO₂ sensor was devised to incorporate the above-mentioned newly developed in-situ pH sensor to measure the in-situ pCO₂ in seawater. The principle of pCO₂ measurement by the pCO₂ sensor is as follows. Both the ISFET-pH electrode and the Cl-ISE of the pH sensor are sealed in a unit with a gas permeable membrane whose inside is filled with inner electrolyte solution with 1.5 % of NaCl. The pH sensor can detect pCO₂ change as pH change of inner solution caused by permeation of carbon dioxide gas species through the membrane. An amorphous Teflon membrane (Teflon AF™) manufactured by DuPont was used as the gas permeable membrane. The in-situ (3,000m, 1.8°C) response time of the pCO₂ sensor was less than 60 seconds. The diode on ISFET can measure the temperature of seawater simultaneously. ISFET and Cl-ISE are connected to pH converter circuit in the pressure housing through the underwater cable connector. The pressure housing includes pH converter circuit, A/D converter, data logger RS-232C interface and Li ion battery.

Before the observation, the pH sensor was calibrated using two different standard buffer solutions, 2-aminopyridine (AMP; pH 6.7866) and 2-amino-2-hydroxymethyl-1,3-propanediol (TRIS; pH 8.0893) described by Dickson and Goyet, for the correction of electrical drift of pH data. The calibration of the pCO₂ sensor was conducted using two different seawaters, surface and deep

seawaters which measured $p\text{CO}_2$ concentration, before the observation.

A pH/ $p\text{CO}_2$ sensor was installed to the McLane sediment trap (1000 m) of the K2 mooring, and in-situ data of pH and $p\text{CO}_2$ were measured every 5 minutes during mooring observation.

Another pH/ $p\text{CO}_2$ sensor was installed to the Deep-Ninja float that was deployed at K2-East and in-situ data of pH and $p\text{CO}_2$ from surface to 2000 m deep were measured.

(3) Parameters

In-situ pH and $p\text{CO}_2$

(4) Data archives

All data will be archived at Tokyo University of Marine Science and Technology after checking of data quality and submitted to Data Management Group (DMG) of JAMSTEC.

2.6.9 Backscatter

Makio HONDA (JAMSTEC)

Chiho SUKIGARA (JAMSTEC)

(1) Objectives

Settling particle in the ocean, sometimes called “marine snow”, plays a crucial role in the “biological carbon pump”, which transports atmospheric carbon dioxide to the ocean interior. Traditionally the study of settling particle has been conducted by using sediment trap. On the other hand, much attention has been paid to optical observation of settling particles recently. Optical sensor such as backscatter meter is installed on drifting buoy and spatio-temporal variability of marine particle has been observed all over the world ocean and, consequently, biogeochemistry has been discussed. In order to study time-series variability in in situ particles, mainly particulate organic carbon (POC), optically, backscatter meters were installed on K2-OA mooring system and deployed during MR24-07 Leg.1 cruise (October 2024). During MR25-04 (July-August 2025). The K2-OA mooring system and backscatter meters were successfully recovered.

(2) Instruments and methods

Backscatter meters recovered were as follows:

Maker	Model	S/N	Depth deployed (m)	sensors
Seabird Sci.	Triplet	891	80 (installed on RAS)	bbp ₍₇₀₀₎ , bbp ₍₄₇₀₎ , Chl-a, Temp
Seabird Sci.	BBSB	1742	150 (installed on Sediment Trap)	bbp ₍₇₀₀₎

Data were collected as follows:

Sampling frequency: ~ 1 Hz (~ 1 data per a second)

Sampling number (n): 30

Sampling interval: 6 hours

≈

(3) Preliminary result

Backscatter data (BS₍₇₀₀₎) at both depths and other data (BS₍₄₇₀₎, temperature and Chlorophyll) at 80 m each 6 hours were successfully acquired by the recovery day (10 August 2023). The average of each sampling (n = 30) (and the maximum value for the backscatter data) were plot in Fig. 2.6.9.1.

1) Temperature (Fig.2.6.9.1a)

Temperature data were scattered between 2 – 4°C between late October and early January (S/N are between 0 – 300) and, then, became relatively constant and decreased by 1.5°C in March 2025 (S/N: 600). After that, temperature gradually increased by 3°C middle July (S/N: ~ 1050) while scattering again.

2) Chlorophyll (Fig.2.6.9.1b)

Chlorophyll-a concentration (Chl-a) was less than 0.1 mg m⁻³ late October 2024 (S/N: 0). The smooth curve shows that Chl-a began to increase from November (S/N: 150) and reached at 0.4 mg m⁻³ around January (S/N: 250-400). However, it is noted that Chl-a data jumped (drifted) largely at around middle December (each plot around S/N: 200). Chl-a was about 0.6 mg m⁻³ in late March (S/N: ~ 600) and then decreased toward August (S/N: 1150). The rapid increase in Chl-a in

December 2024 and higher Chl-a in March 2025 were indeed unexpected.

3) Backscatter (Fig. 2.6.9.1c, d, e)

a. 80 m

It is suspected that average and max of backscatter of 700 nm wave length light ($bbp_{(700)}$) (red color) are index of smaller particles (suspended and / or slow sinking particles) and larger particles (fast sinking particles), respectively. Although $bbp_{(700)}$ at 80 m scattered largely, smooth curve shows that the average and maximum $bbp_{(700)}$ at 80 m began to increase in late February 2025 (S/N: ~ 425) and became the annual maximum of 0.01 m^{-1} in middle March (S/N: ~ 580) (Fig. 2.6.9.1c). The $bbp_{(700)}$ were also relatively higher in summer (S/N: 1000 – 1159). The backscatter of 470 m wave length light ($bbp_{(470)}$) (blue color) show almost the same seasonal variability for $bbp_{(700)}$ (Fig. 2.6.9.1d).

b. 150 m

The variability in the $bbp_{(700)}$ at 150 m were smaller than that at 80 m. The $bbp_{(700)}$ at 150 m increased in middle February (S/N: 450), middle May (S/N: 800) and after July (S/N: 1000). These increases did not synchronized with the increase of $bbp_{(700)}$ and $bbp_{(470)}$ at 80 m.

Time-series sediment trap data at 150 m show that collected particle largely increased between early April and early July 2025 and these were mainly attributed to the increase of the copepods species (see section 2.6.3 K2 sediment trap). Our data does not synchronized with this observation.

BS data will be converted to particulate organic carbon (POC) concentration and used for the discussion about POC flux in future.

(4) Data archive

This observation is just the performance test of backscatter meter and, thus, data is not opened.

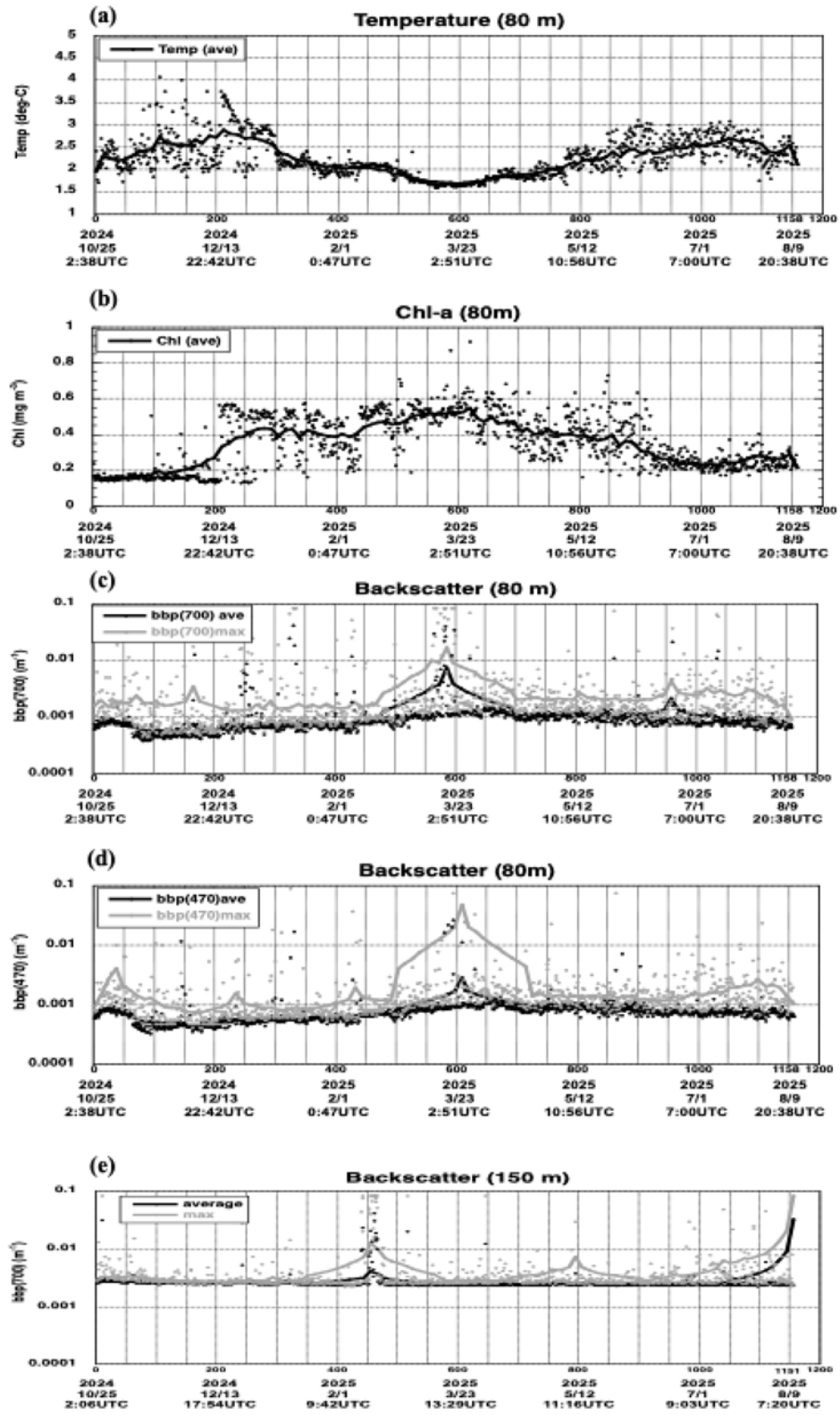


Fig. 2.6.9.1 Seasonal variabilities in (a) temperature, (b) Chl-a, (c) $bbp_{(700)}$ at 80 m, (d) $bbp_{(470)}$ at 80 m and (e) $bbp_{(700)}$ at 150 m. Details are described in the text.

2.7 BGC floats

Tetsuichi FUJIKI (JAMSTEC RIGC)

Shigeki HOSODA (JAMSTEC RIGC)

Kanako SATO (JAMSTEC RIGC)

Mizue HIRANO (JAMSTEC RIGC)

Katsunori KIMOTO (JAMSTEC RIGC)

Kiminori SHITASHIMA (Tokyo University of Marine Science and Technology)

Nobuhiro FUJII (MWJ)

Yuki MIYAJIMA (MWJ)

Aine YODA (MWJ)

(1) Objectives

The objective of this study is to clarify the mechanisms underlying climate and oceanic environmental variability, to understand changes in the Earth system through estimates of heat and material transports, and to improve long-term climate change forecasts by conducting global ocean monitoring. To achieve these goals, long-term, automated measurements of physical and biogeochemical (BGC) parameters are being conducted using BGC floats deployed in the North Pacific.

Eight BGC APEX floats, two BGC NAVIS floats, and two BGC NINJA floats have been deployed in the North Pacific to measure biogeochemical parameters, temperature, and salinity down to a depth of 2000 dbar (Fig. 2.7.1). The primary goal of these observations is to identify changes in the phytoplankton community in relation to environmental parameters. In collaboration with shipboard and mooring observations, these measurements aim to capture the long-term and spatial variability of biogeochemical processes in the North Pacific. The deployed floats will also contribute to the international BGC Argo program, which aims to construct a global array. Data from the BGC floats will be assimilated into the ESTOC system, a 4D-VAR data assimilation model used to estimate the state of the global ocean and to investigate the mechanisms driving long-term oceanic changes.



Fig. 2.7.1 BGC APEX float

(2) Parameters

Water temperature, salinity, pressure, dissolved oxygen, optical backscattering, FDOM, chlorophyll *a*, nitrate, pH, irradiance, pCO₂, and PSII parameters

(3) Methods

i) BGC float deployment

We deployed eight BGC APEX floats manufactured by Teledyne Webb Research, two BGC Navis floats manufactured by Sea-Bird Scientific, and two BGC NINJA floats manufactured by Tsurumi Seiki. Each float drifts at a depth of approximately 1000 dbar (referred to as the parking depth) until the next vertical profile. It then ascends from 2000 dbar to the sea surface. During the ascent, physical and biogeochemical parameters are measured every 2 dbar or at depths specified in a predefined depth table.

Upon surfacing, which lasts for several minutes, the float transmits all collected data to land via the Iridium satellite communication system. The float specifications and deployment details are summarized in Table 2.7.1.

Table 2.7.1 Status and launches of BGC floats

BGC NAVIS Float (2000dbar) (WMO ID: 7900885)

Float Type	BGC Navis float manufactured by Sea-Bird Scientific
CTD sensor	SBE41 manufactured by Sea-Bird Scientific
Oxygen sensor	SBE63 optical DO sensor by Sea-Bird Scientific
Backscatter CDOM Chlorophyll sensors	FLBBBCD manufactured by WET Labs Backscattering: wavelength: 700nm CDOM[FDOM]: ex/em→ 370/460nm Chlorophyll: ex/em→ 470/695nm
Nitrate sensor	Deep SUNA manufactured by Sea-Bird Scientific
Cycle	Every 5 days
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar
Sampling layers	2 dbar or given depth interval from 2000 dbar to surface

BGC NAVIS Float (2000dbar) (WMO ID: 7900886)

Float Type	BGC Navis float manufactured by Sea-Bird Scientific
CTD sensor	SBE41 manufactured by Sea-Bird Scientific
Oxygen sensor	SBE63 optical DO sensor by Sea-Bird Scientific
Backscatter CDOM Chlorophyll sensors	FLBBBCD manufactured by WET Labs Backscattering: wavelength: 700nm CDOM[FDOM]: ex/em→ 370/460nm Chlorophyll: ex/em→ 470/695nm
pH sensor	Deep-Sea DuraFET manufactured by Sea-Bird Scientific
Cycle	Every 5 days
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar
Sampling layers	2 dbar or given depth interval from 2000 dbar to surface

BGC APEX Float (2000dbar) (WMO ID: 5906605, 5906613, 7900882, 7900883, 7900884)

Float Type	BGC APEX float manufactured by Teledyne Webb Research
CTD sensor	SBE41 manufactured by Sea-Bird Scientific
Oxygen sensor	ARO-FT optical DO sensor by JFE Advantech
Backscatter CDOM Chlorophyll sensors	FLBBBCD manufactured by WET Labs Backscattering: wavelength: 700nm CDOM[FDOM]: ex/em→ 370/460nm Chlorophyll: ex/em→ 470/695nm

Nitrate sensor	Deep SUNA manufactured by Sea-Bird Scientific
Irradiance sensor	OCR504 manufactured by Sea-Bird Scientific Measurement wavelengths: 380nm, 412nm, 490nm and PAR
Cycle	Every 5.03 days
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar
Sampling layers	2 dbar or given depth interval from 2000 dbar to surface

BGC APEX Float (2000dbar) (WMO ID: 5906606, 5906611, 5906612)

Float Type	BGC APEX float manufactured by Teledyne Webb Research
CTD sensor	SBE41 manufactured by Sea-Bird Scientific
Oxygen sensor	ARO-FT optical DO sensor by JFE Advantech
Cycle	Every 10 days
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar
Sampling layers	2 dbar or given depth interval from 2000 dbar to surface

BGC NINJA Float (200dbar) (Float S/N 39)

Float Type	BGC NINJA float manufactured by Tsurumi Seiki
CTD sensor	SBE41 manufactured by Sea-Bird Scientific
Oxygen sensor	SBE63 optical DO sensor by Sea-Bird Scientific
FRRF	DF-14 manufactured by Kimoto Electric
Cycle	Every 12 hours
Iridium transmit type	Short Burst Data (SBD)
Target Parking Pressure	200 dbar
Sampling layers	4 dbar or given depth interval from 200 dbar to surface

BGC NINJA Float (2000dbar) (Float S/N 34)

Float Type	BGC NINJA float manufactured by Tsurumi Seiki
CTD sensor	SBE41 manufactured by Sea-Bird Scientific
Oxygen sensor	SBE63 optical DO sensor by Sea-Bird Scientific
pH/pCO ₂	custom-built sensor
Cycle	Every 1 day
Iridium transmit type	Short Burst Data (SBD)
Target Parking Pressure	2000 dbar
Sampling layers	2 dbar or given depth interval from 2000 dbar to surface

Launch

Float S/N	WMOID	Date and Time of Launch (UTC)	Location of Launch	Station
F1589	7900886	2025/08/07 07:04	47-00.08 [N] 159-59.76 [E]	Stn. 4 (K2)
F1174	7900885	2025/08/07 07:07	47-00.09 [N] 159-59.78 [E]	Stn. 4 (K2)
F10770	5906605	2025/08/07 07:10	47-00.09 [N] 159-59.78 [E]	Stn. 4 (K2)
F10771	5906613	2025/08/12 21:08	47-00.47 [N] 169-59.59 [E]	Stn. 6
F34	-	2025/08/12 21:12	47-00.45 [N] 169-59.62 [E]	Stn. 6
F39	-	2025/08/12 21:15	47-00.43 [N] 169-59.64 [E]	Stn. 6
F10775	5906606	2025/08/15 01:34	47-00.20 [N] 179-59.70 [E]	Stn. 7
F10780	5906611	2025/08/16 07:38	47-00.03 [N] 175-00.02 [W]	Stn. 8
F10782	5906612	2025/08/17 06:43	47-00.10 [N] 169-59.90 [W]	Stn. 9
F10772	7900882	2025/08/18 02:47	50-00.02 [N] 159-59.91 [W]	Stn. 10
F10773	7900883	2025/08/21 02:55	49-59.89 [N] 152-30.00 [W]	Stn. 11
F10774	7900884	2025/08/23 02:40	50-00.02 [N] 144-59.84 [W]	Stn. 12 (OSP)

(4) Data archive

Data from the BGC APEX and BGC NAVIS floats, with real-time quality control applied, are provided to meteorological organizations, research institutes, and universities via the Global Data Assembly Centers (GDAC: <http://www.usgoda.gov/argo/argo.html>, <http://www.coriolis.eu.org/>) and the Global Telecommunication System (GTS) within 24 hours, following the procedures established by the Argo Data Management Team (ADMT). For physical parameters, delayed-mode quality control is performed within 6 months to 1 year to ensure data accuracy for research use. For BGC parameters, the procedures for delayed-mode quality control are still under development. All data are freely available online and are used not only for scientific research but also for weather forecasting and other operational applications. Data from the BGC NINJA float are not publicly available because the system is still under development.

2.8 Drifting

2.8.1 Drifting Sediment Trap

Chiho SUKIGARA (JAMSTEC)

Makio C. HONDA (JAMSTEC)

(1) Objectives

Sinking particles have been considered as the important vehicle, by which the biological pump sequesters carbon in the ocean interior (Buesseler et al., 2007). However, the sinking particle fluxes vary significantly across ocean regions (Berelson, 2001, Honjo et al., 2008) and seasons (Honda et al., 2016). It is known that particle sinking efficiency changes due to physical (water mixing or subduction: Dall’Olmo et al., 2016, Levy et al., 2013, Omand et al., 2015, particle aggregation and fragmentation: Boyd and Trull, 2007, Buesseler and Boyd, 2009, McDonnell et al., 2015, Durkin et al., 2015, Sukigara et al., 2019, etc) and biological (phytoplankton species: Iversen and Proug, 2013, Laurenceau-Cornec et al., 2015, primary productivity: Epply and Peterson, 1979, Le Moigne et al., 2016, zooplankton feeding and fecal production: Steinberg and Landry, 2017, and bacterial decomposition: Fontanes et al., 2015, Cavan et al., 2017, etc.) processes. Due to the complex processes surrounding particle sinking, particle fluxes in the ocean mesopelagic zone remain difficult to predict accurately, and the factors driving these flux variations have not been fully identified. To investigate sinking particle fluxes, capturing particles directly using moored or drifting sediment traps is effective, however, these require mooring and drifting equipment and technical expertise. Consequently, the particle flux data are insufficient for analysis, and the scarcity of data makes flux research challenging.

At the time-series observation stations, KEO and K2, visited during the MR25-04 cruise, continuous mooring sediment trap experiments are underway. The depths of mooring traps are 1,000 and 4,800 m at KEO, and 150, 500, 1,000 and 4,800 m at K2. However, data on particle flux variation near the surface, where particles flux attenuates most significantly in line with the Martin curve (Martin et al., 1987), is scarce. Therefore, we planned drifting sediment trap experiments during this cruise at St.1 (KEO), St.4 (K2), and St.12 (OSP) to measure sinking particle fluxes near the surface (depths of 60, 100, and 150 m).

(2) Methods

i. Drifting sediment trap experiments

In order to collect sinking particles in multipul layers near the surface layer, the drifting system (Figure 2.8.1-1) was deployed at the stations K2 and OSP. Regarding the station KEO, the drifting exiperiment was cancelled due to stormy weather. On this system, “Knauer” type sediment trap (Knauer et al., 1979) at 3 layers (depths of 60, 100, 150 m) was installed together.

The trap tubes were filled with filtered surface seawater, added with NaCl (Fujifilm Wako Pure Chemical Corp., Japan, Guaranteed Reagent, No. 195-01663) to increase its salinity by 10 psu. Pressure sensors (DEFI2-D50HG, JFE Advantech co., Japan) were attached to each rack of the trap. The drifter system was deployed at 22:22 on 6 August (UTC) at the station K2 and at 23:02 on 22 August (UTC) at the station OSP. The positions of the drifting system were monitored by GPS (AS-900A, MetOcean Telematics for K2 and MMA-7500, MetOcean Telematics for OSP). The tracks of the drifter systems shows on Figure 2.8.1-2). The drifter system was recovered at 5:43 on 10 August (UTC) at the station K2 and at 17:50 on 24 August (UTC) at the station OSP. The drift (experimental) duration was 79h 21m for K2 and 42h 48m for OSP.

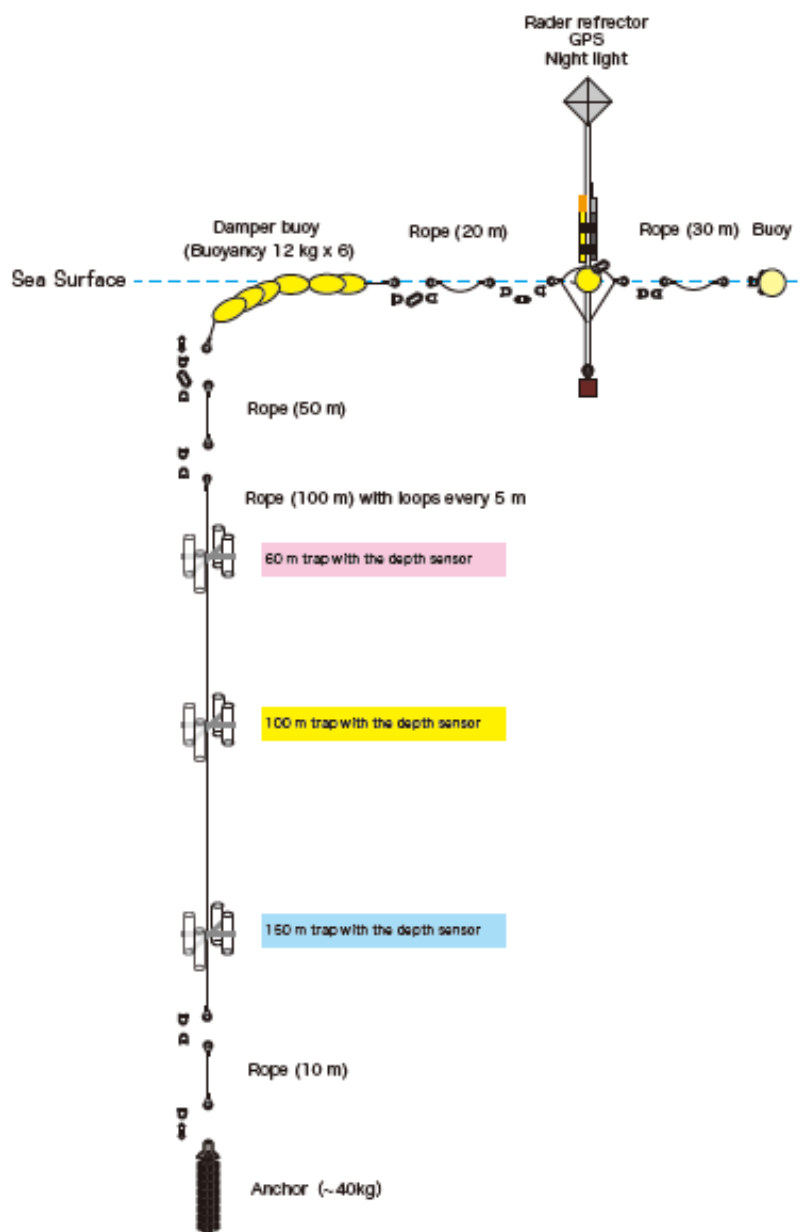


Figure 2.8.1-1 The drifting system with sediment traps at Station K2 and OSP.

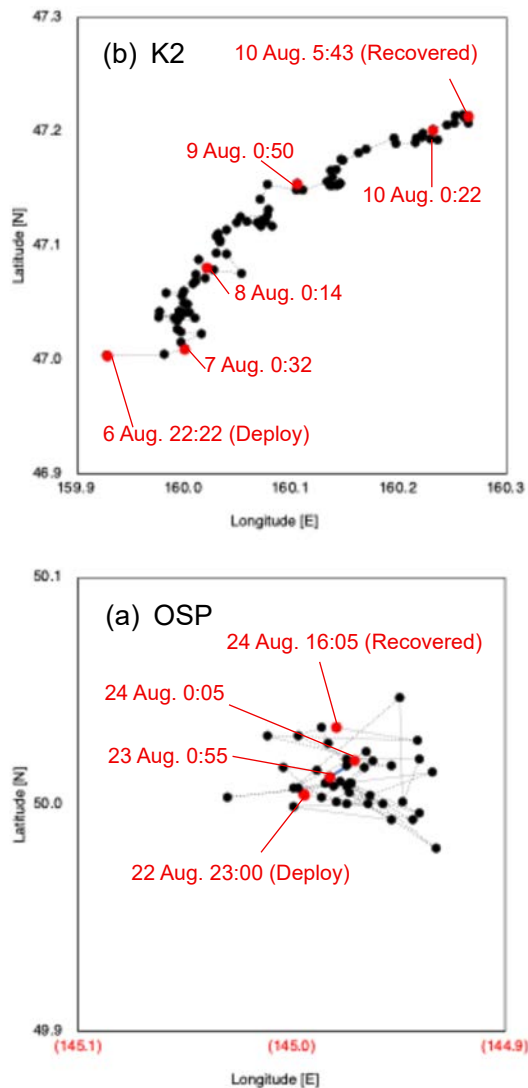


Figure 2.8.1-2 Track of the drifting system (GPS) at (a) station K2 and (b) station OSP.

ii. Sample processing

Once traps were recovered, the trap tubes were covered with plastic bags and let them stand undisturbed for about 2 hours to settle particles. Then, remove the supernatant using a siphon and take out the sample cups. The eight trap cups per one layer were divided into four analyses, two cups each.

- For the total mass flux measurement: Filtered by a weighted Nuclepore filters (Track-Etch membrane: pore size: 0.4 μm , diameter: 47 mm, Cytiva Life Science, USA) and stored in the freezer ($-20\text{ }^{\circ}\text{C}$) for analyses.
- For the organic carbon and nitrogen flux measurements: Filtered by a weighted and pre-combusted grade GF/F grass fiber filter (24-mm diameter, Cytiva Life Science, USA) and stored in the freezer ($-20\text{ }^{\circ}\text{C}$) for chemical analyses using an elemental analyzer.
- For the isotope ratios of organic carbon and nitrogen measurements: Filtered by a pre-combusted

grade GF/F glass fiber filter (25-mm diameter, Cytiva Life Science, USA) and stored in the freezer (-20°C) for chemical analyses using a mass spectrometer.

- For microscopic analysis: Transferred to a sealable cup, added 20 mL of formalin (5% of total volume), and stored in the refrigerator (4°C).

(3) Preliminary results

Sinking particles at station K2 appear to be more abundant than those at station OSP, even when collection times were longer.

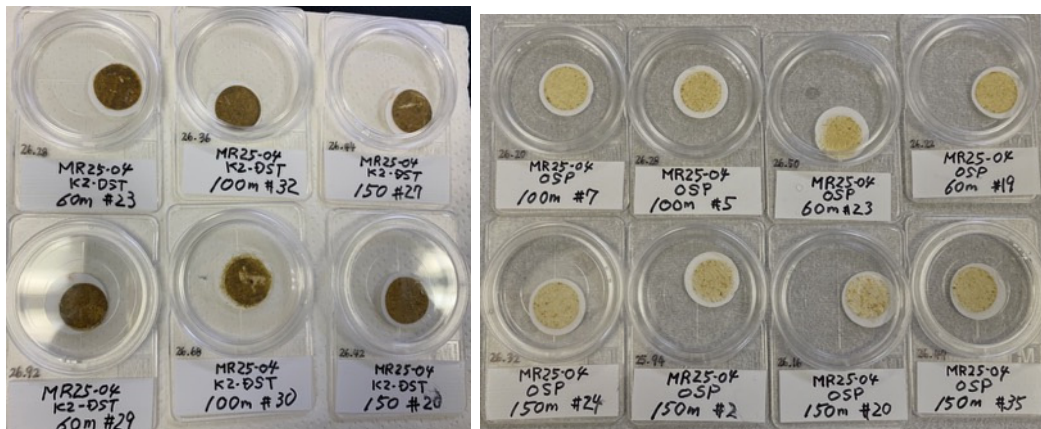


Figure 2.8.1-3. Photos of filtered sinking particles.

(4) Data archive

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

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2.8.2 Drifting remote access sampler

Koji SUGIE (RIGC, JAMSTEC)

(1) Objectives

Open ocean observation on the basis of ship of opportunity is mostly snapshot of the timing of the arrival. Although such observation strategy could be useful in areal coverage of the ocean, the temporal changes in ecosystem processes within the same water mass is difficult. In this study, I have developed drifter with time-series sampler to clarify short-term changes, such as day-night and a few days of the concentration of trace metals.

(2) Instruments and methods

Remote access sampler (RAS) was hanged with Keblar rope with buoys to take water samples from approximately 20 m depth (Fig. 2.8.2.1). All apparatuses of RAS which will be passed through seawater samples were thoroughly acid-washed and rinsed with Milli-Q water ($18.2 \text{ M}\Omega\cdot\text{cm}$). The time of sampling was set every 1 hour for the first day, every 2 hours for the second day, and every 6 hours thereafter to elucidate diurnal to a few days dynamics of measured parameters. Position of the drifter was chased using GPS system.

(3) Parameters

Temperature, conductivity, depth and dissolved and total dissolvable trace metals. Phytoplankton abundance and composition was monitored using MultiExciter (JFE-Advantech Co. Ltd.).

(4) Observation log

	Station	Date (d/m/y)	Position
Deployment	St. 4	6/8/2025	47°00.36'N, 159°59.30'E
Recovery		10/8/2025	47°27.08'N, 160°15.65'E

The track of the drifter is shown in Figure 2.8.2.2.

(5) Data archives

No data were obtained because the Kevlar cable connecting the RAS and other sensors broke, resulting in the loss of the instruments.

漂流系の構成

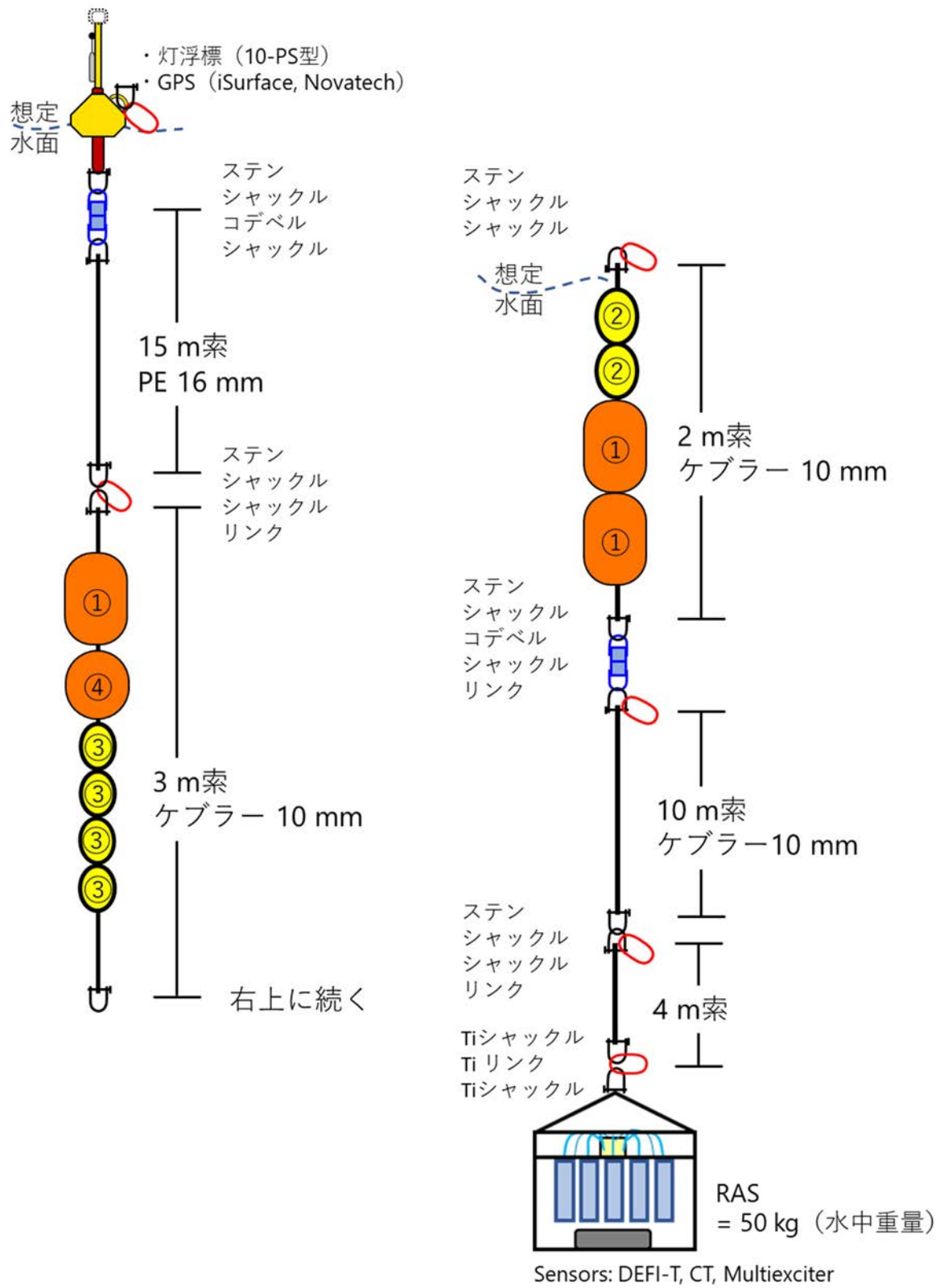


Figure 2.8.2.1. The structure of drifting RAS.

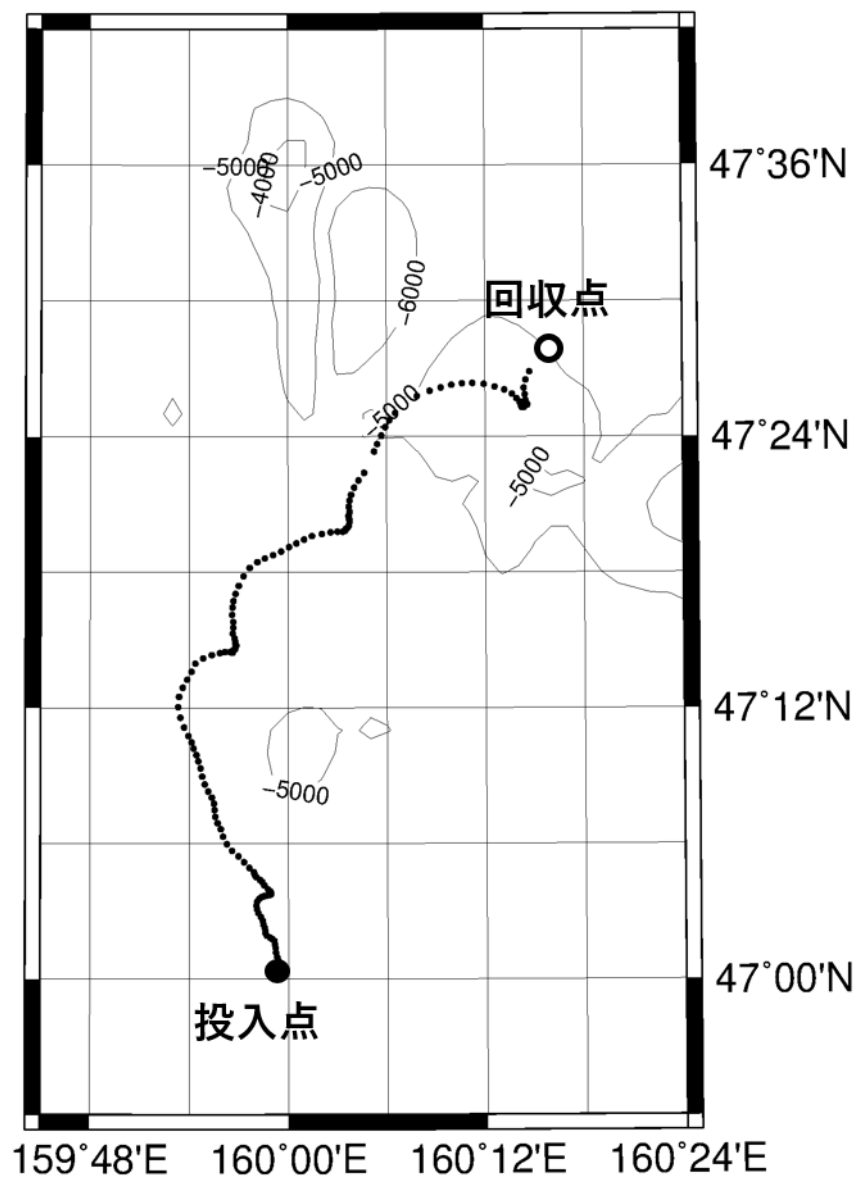


Fig. 2.8.2.2. GPS position and track of drifter RAS.

3. Notice on using

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