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Hakuho Maru Cruise Report

KH-19-4

Role of turbulence in ecosystem and material cycles in the Kuroshio recirculation region, western subtropical North Pacific

Kuroshio recirculation region

July 20 – 30, 2019

Joint Usage/Research Center for Atmosphere and Ocean Science (JURCAOS)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Contents

1. Cruise Information

Cruise ID: KH-19-4

Name of vessel: R/V Hakuho Maru

Title of cruise: Role of turbulence in ecosystem and material cycles in the Kuroshio recirculation region, western subtropical Pacific

Chief Scientist: Minoru Kitamura (JAMSTEC)

Cruise period: July 20 - 30, 2019

Ports of departure / call / arrival:
Yokosuka / off Choshi (no entry into the port) / Yokosuka

Research area: Kuroshio recirculation region, western subtropical North Pacific

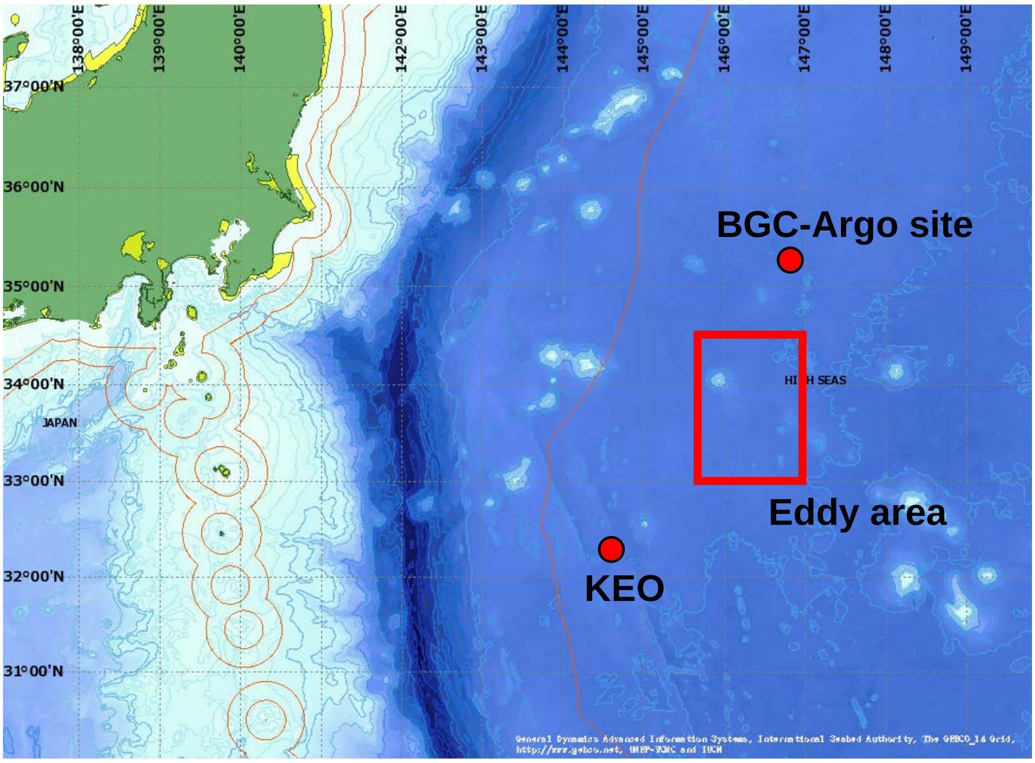


Fig. 1-1. Research area.

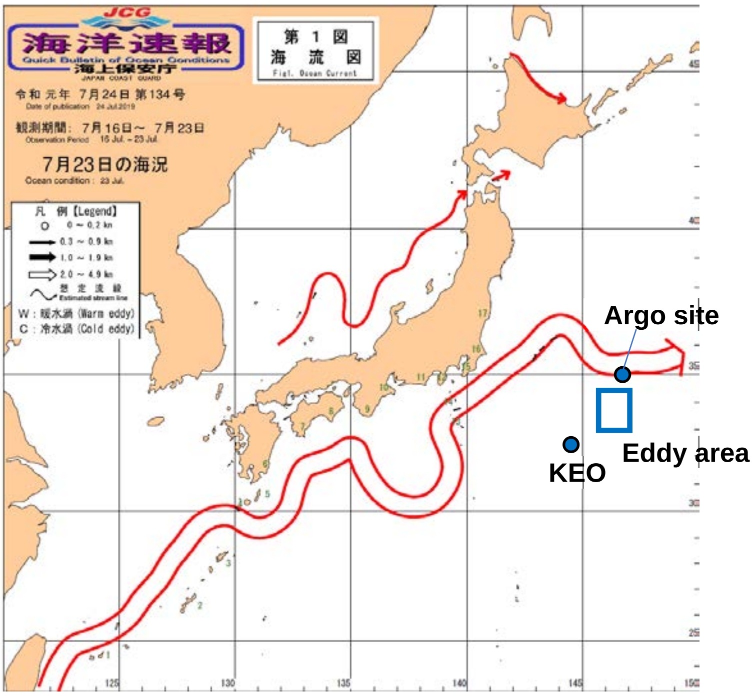


Fig. 1-2. Research area and Kuroshio extension

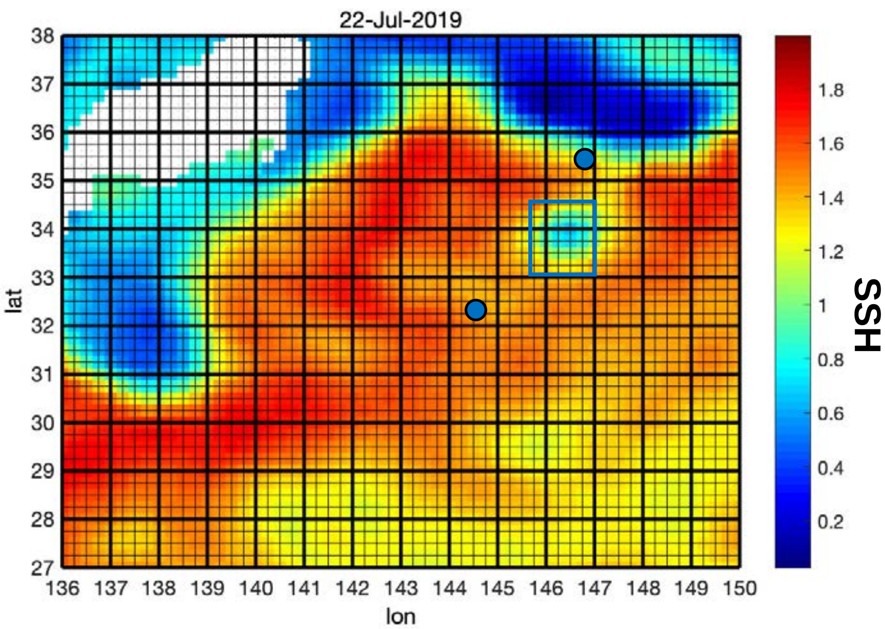


Fig. 1-3. Research stations/area on the contour map of sea surface height in 22 July, 2019.

Observation stations:
Stations in this cruise are summarized in the Table 1-2 and those in the cyclonic eddy are shown in the Fig. 1-4 and 1-5.

Table 1-2. List of the stations and legs in KH-19-4.

Stn./leg	Lat. (N)	Long. (E)	Remarks
KEO	32° 18.0'	144° 36.0'	Time-series station
X1	33° 15.0'	145° 45.0'	SW edge of the cyclonic eddy
X2	34° 30.0'	147° 00.0'	NE edge of the eddy
X3	34° 00.0'	146° 30.0'	Provisional center of the eddy, end of the UCTD transect
X4	33° 45.0'	146° 15.0'	Center of the eddy
X5	34° 06.2'	146° 29.5'	End of the leg 1
X6	33° 49.8'	145° 54.5'	End of the leg 2
X7	33° 31.0'	146° 03.0'	End of the leg 3
X8	34° 00.0'	146° 28.0'	AZFP
Hot Spot #1	33° 51.0'	146° 20.8'	BGC observations
XBT1	33° 21.2'	145° 51.2'	
XBT2	33° 27.3'	141°12.8'	
XBT3	33° 33.5'	146° 03.4'	
XBT4	33° 39.6'	146° 09.5'	
XBT5	33° 45.8'	146° 15.7'	
XBT6	33° 51.9'	146° 21.8'	
XBT7	33° 58.1'	146° 27.9'	Canceled
XBT8	34° 04.5'	146° 34.4'	
XBT9	34° 10.4'	146° 40.3'	
XBT10	34° 16.6'	146° 46.5'	
XBT11	34° 22.7'	146° 52.7'	
L2a	33° 50.1'	145° 56.5'	Leg 2 revisit to understand nitrate distribution
L2b	33° 50.7'	145° 58.9'	Leg 2 revisit to understand nitrate distribution
L2c	33° 51.0'	146° 00.9'	Leg 2 revisit to understand nitrate distribution
L2d	33° 51.3'	146° 03.4'	Leg 2 revisit to understand nitrate distribution
L2e	33° 51.3'	146° 05.8'	Leg 2 revisit to understand nitrate distribution
L2f	33° 50.3'	146° 08.0'	Leg 2 revisit to understand nitrate distribution
L2g	33° 49.0'	146° 10.0'	Leg 2 revisit to understand nitrate distribution
L2h	33° 47.7'	146° 11.6'	Leg 2 revisit to understand nitrate distribution
L2i	33° 46.4'	146° 13.3'	Leg 2 revisit to understand nitrate distribution
Argo site	35° 18.0'	146° 48.0'	
Leg 1	from X4 to X5		
Leg 2	from X4 to X6		
Leg 3	from X4 to X7		

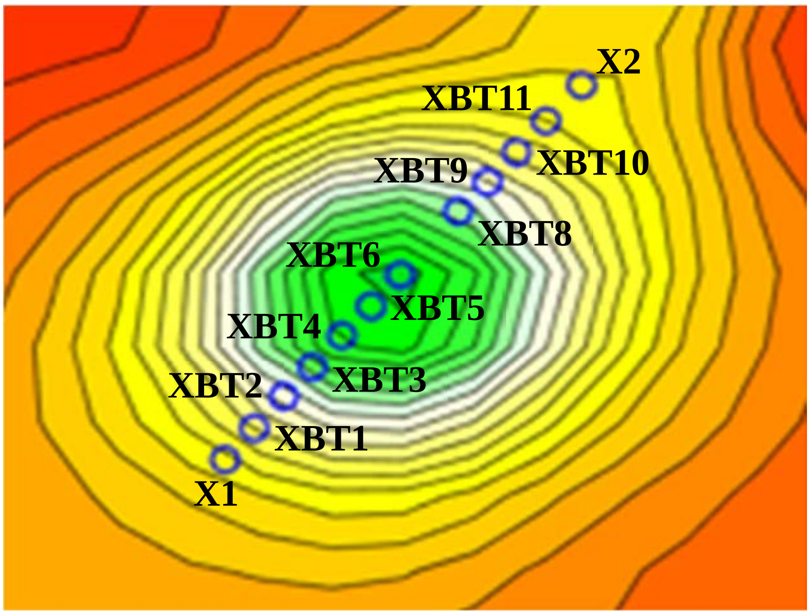


Fig. 1-4. Locations of XBT deployments across the cyclonic eddy.

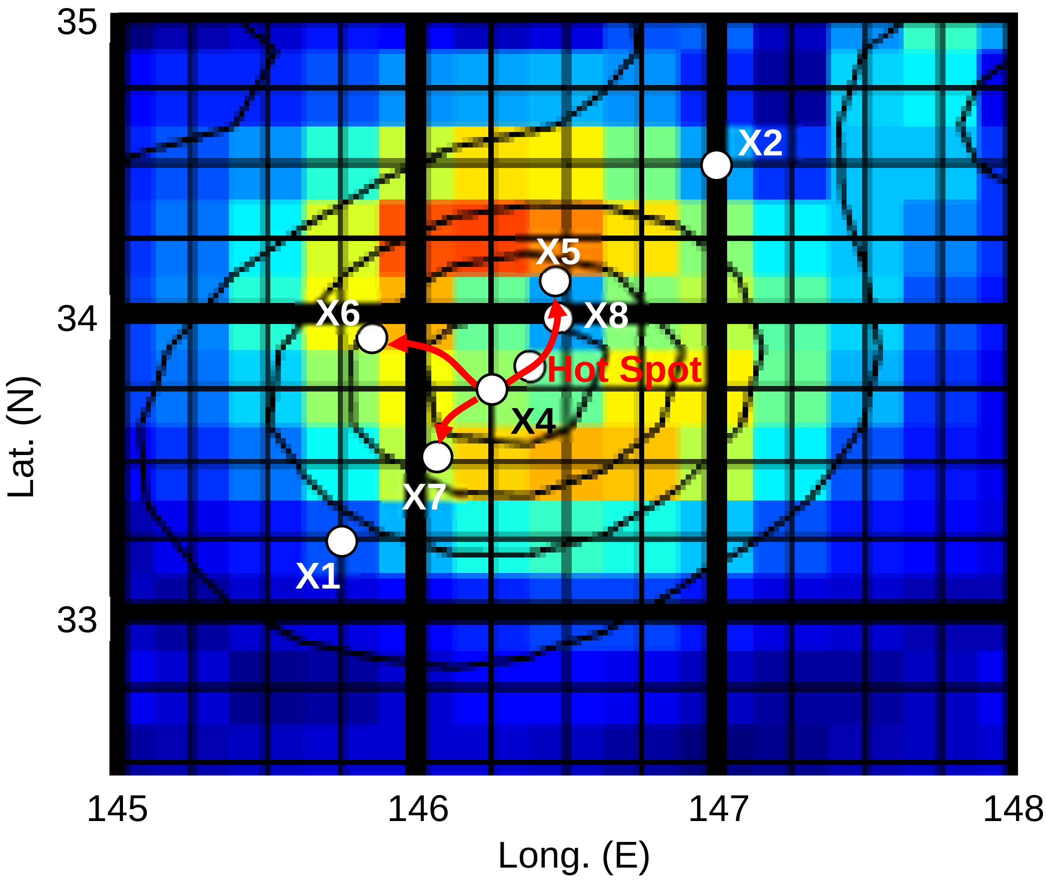


Fig. 1-5. Locations of observation stations in the cyclonic eddy area. Background color contour shows current velocity. Three red arrows show transects of underway VMP and RINKO observations; an arrow from X4 to X5 is leg 1, from X4 to X6 is leg 2, from X4 to X7 is leg 3, respectively.

2. Research Proposal and Science Party

Title of proposal:
Role of turbulence in ecosystem and material cycles in the Kuroshio recirculation region, western subtropical Pacific

Representative of Science Party:
Physical observations: Dr. Takeyoshi Nagai, Tokyo Univ. of Marine Science and Tech.
Suspended and sinking particle observations: Dr. Makio Honda, JAMSTEC
Biological observations: Dr. Minoru Kitamura, JAMSTEC

Science Party (List):
Minoru Kitamura, JAMSTEC
Makio Honda, JAMSTEC
Kazuhiko Matsumoto, JAMSTEC
Yuichiro Kumamoto, JAMSTEC
Yoshikazu Sasai, JAMSTEC
Hidekatsu Yamazaki, Tokyo Univ. of Marine Science and Tech.
Takeyoshi Nagai, Tokyo Univ. of Marine Science and Tech.
Chiho Sukigara, Tokyo Univ. of Marine Science and Tech.
Naho Miyazaki, Tokyo Univ. of Marine Science and Tech.
Takumi Nishi, Tokyo Univ. of Marine Science and Tech.
Shota Nakazawa, Tokyo Univ. of Marine Science and Tech.
Kohyo Wada, Tokyo Univ. of Marine Science and Tech.
Marika Takeuchi, Tokyo Univ. of Marine Science and Tech.
Lizarbe Daniel, Tokyo Univ. of Marine Science and Tech.
Rudi Strickler, Univ. of Wisconsin
Hideki Fukuda, AORI, Tokyo Univ.
Yoshihisa Mino, Nagoya Univ.
Kazuaki Tadokoro, Fisheries Agency
Yuichiro Yamada, Kitazato Univ.
Ayako Oda, Kitazato Univ.
Satomi Komori, Kitazato Univ.
Kohei Matsuno, Hokkaido Univ.
Kanako Amei, Hokkaido Univ.
Ryoji Toda, AORI, Tokyo Univ.
Makoto Takeuchi, AORI, Tokyo Univ.
Hiroki Ushiromura, MWJ

3. Research Activities
3.1. Hydrocasts of CTD and water samplings

Minou Kitamura (JAMSTEC)
Ryoji Toda (AORI, Tokyo Univ.)
Makoto Takeuchi (AORI, Tokyo Univ.)

To investigate oceanic structure and to collect seawater samples, CTD/Carousel water sampler (CWS) was deployed. The sensors attached on the CTD system were pressure, temperature (primary and secondary), conductivity (primary and secondary), dissolved oxygen (primary and secondary), fluorescence, PAR, and nitrate sensors. The practical salinity was calculated by measured values of pressure, conductivity and temperature. Models and serial numbers of these sensors were summarized in Table 3.1-1. After the CTD cast of KH1904_6, the primary sensor of dissolved oxygen was changed (from S/N 3304 to 0775). CWS used in this cruise was a 24-position system, and 12-litter Niskin bottles were attached on the CWS. Acid cleaned Viton O-rings were attached on the three of 24 Niksin bottles (from Niskin #1 to #3) to collect seawater samples for phytoplankton incubation.

Table 3.1-1. Models and serial numbers of CTD sensors.

	Model		Serial No.	
			KH1904_01~06	KH1904_07~26
Pressure	Seabird, SBE9plus		0951	0951
Carousel	Seabird, SBE32		704	704
Pump	Seabird, SBE5T	Pri.	4569	4569
		Sec.	1267	1267
Temperature	Seabird, SBE3	Pri.	5124	5124
		Sec.	5809	5809
Conductivity	Seabird, SBE4	Pri.	4045	4045
		Sec.	3620	3620
DO	Seabird, SBE43	Pri.	3304	0775
		Sec.	0628	0628
Fluorometer	Seapoint, Chlorophyll fluorometer		3834	3834
PAR	Satlantic, PAR LOG 7000m		049	049
DeepSUNA	Satlantic, Deep SUNA		895	895

During this cruise, 26 CTD/CWS casts were carried out. Information of this CTD/CWS casts was summarized in Table 3.1-2.

Table 3.1-2. List of the Hydrocasts of CTD

Cast number	Station	Date & time				Position		Purposes	Max. depth	Items of water sampling
		Local		UTC		Lat.	Long.		(m)	
KH1904_1	KEO	2019/7/21	12:16	2019/7/21	3:16	32 21.826N	144 24.969E	Cesium	800	Cs
KH1904_2	KEO	2019/7/21	13:41	2019/7/21	4:41	32 21.959N	144 24.975E	Routine	2000	DO, DIC & TA, Sal, Chl.a, Nuts, DOC
KH1904_3	KEO	2019/7/21	19:38	2019/7/21	10:38	32 21.783N	144 24.935E	DO experiment, SCM	300	DO exp, Sal, FRRF, POM, Chl.a, TEP
KH1904_4	KEO	2019/7/22	13:03	2019/7/22	4:03	32 21.236N	144 24.724E	POM for Sukigara	2000	Seawater for sedimenttrap, POM
KH1904_5	X4	2019/7/23	12:06	2019/7/23	3:06	33 44.812N	146 15.062E	Routine	2000	DO, DIC & TA, Sal, Chl.a, Nuts, DOC, Incubation, TEP
KH1904_6	X4	2019/7/23	15:37	2019/7/23	6:37	33 43.213N	146 16.686E	Cesium	800	Cs
KH1904_7	X5	2019/7/24	3:14	2019/7/23	18:14	34 06.492N	146 29.148E	Routine	1000	DO, Chl.a, Nuts
KH1904_8	Argo site	2019/7/24	10:01	2019/7/24	1:01	35 17.955N	146 48.044E	Calibration of BGC-Argo censors	2000	DO, Sal, Chl.a, Nuts, POM
KH1904_9	X4	2019/7/26	1959	2019/7/26	10:59	33 45.023N	146 14.832E	Confirmation of position of the eddy center	1000	-
KH1904_10	Hot Spot #1	2019/7/26	22:08	2019/7/26	13:08	33 51.154N	146 20.623E	POM for Fukuda at night	200	DO, Chl.a, Nuts, Size fraction, 18S, TEP, TEP,
KH1904_11	Hot Spot #1	2019/7/27	2:54	2019/7/26	17:54	33 56.621N	146 14.739E	SCM & calibration of RINKO	300	DO, Chl.a, Nuts, DOC, FRRF, POM, PE, HPLC
KH1904_12	Hot Spot #1	2019/7/27	10:00	2019/7/27	1:10	33 51.120N	146 20.725E	PE 1st	300	Chl.a, Nuts, DIC & TA, PE, HPLC, AP, FRRF, POM
KH1904_13	Hot Spot #1	2019/7/27	14:09	2019/7/27	5:09	33 56.080N	146 15.936E	POM for Fukuda during day	200	DO, Chl.a, Nuts, Size fraction, 18S, TEP, TEP
KH1904_14	X6	2019/7/28	3:35	2019/7/27	18:35	33 49.620N	145 54.397E	Leg 2 revisit	200	-
KH1904_15	L2a	2019/7/28	4:32	2019/7/27	19:32	33 50.124N	145 56.470E	Leg 2 revisit	200	-
KH1904_16	L2b	2019/7/28	5:39	2019/7/27	20:39	33 50.727N	145 58.868E	Leg 2 revisit	200	-
KH1904_17	L2c	2019/7/28	6:41	2019/7/27	21:41	33 51.037N	146 00.944E	Leg 2 revisit	200	-
KH1904_18	L2d	2019/7/28	7:47	2019/7/27	22:47	33 51.304N	146 03.352E	Leg 2 revisit	200	-
KH1904_19	L2e	2019/7/28	8:53	2019/7/27	23:53	33 51.343N	146 05.823E	Leg 2 revisit	200	-
KH1904_20	Hot Spot #1	2019/7/28	10:43	2019/7/28	1:43	33 51.250N	146 20.467E	PE 2nd	300	Chl.a, Nuts, DIC & TA, PE, HPLC, AP, FRRF, POM
KH1904_21	L2f	2019/7/28	12:21	2019/7/28	3:21	33 50.318N	146 07.962E	Leg 2 revisit	200	-
KH1904_22	L2g	2019/7/28	13:05	2019/7/28	4:05	33 48.981N	146 09.878E	Leg 2 revisit	200	-
KH1904_23	L2h	2019/7/28	13:49	2019/7/28	4:49	33 48.981N	146 09.878E	Leg 2 revisit	200	-
KH1904_24	L2i	2019/7/28	14:31	2019/7/28	5:31	33 46.350N	146 13.265E	Leg 2 revisit	200	-
KH1904_25	X4	2019/7/28	15:14	2019/7/28	6:14	33 44.996N	146 15.019E	Leg 2 revisit	200	-
KH1904_26*	X4	2019/7/28	18:57	2019/7/28	9:57	33 44.930N	146 15.039E	POM for Sukigara	2000	POM

* Swell compensator trouble during the down cast

3.1.1. Dissolved Oxygen

Yuichiro Kumamoto (onboard)*

Japan Agency for Marine-Earth Science and Technology, 2-15 Natushima-cho, Yokosuka, Kanagawa 237-0061, Japan,

**Correspondence and requests for materials should be addressed to Y. K. (email:).*

The vertical profile of dissolved oxygen was measured at seven stations (KEO, X4, X5, ARGO_Cal, HS_F-POM_Night, HS_SCM_Cal, HS_F-POM_Day) during this cruise. Seawater samples for measurements of dissolved oxygen were collected in an oxygen bottle with a volume of about 100 mL, avoiding contamination from air bubbles. Just after taking seawater sample, 1 mL of $MnCl_2$ solution and 1 mL of KI-NaOH solution were successively added into the bottle. This procedure fixes dissolved oxygen in seawater as $MnO(OH)_2$ precipitate. After standstill for several hours for settling down of the precipitate to the bottom of the bottle, 1 mL of 5M H_2SO_4 solution was added into the bottle to release I_2. Then I_2 was titrated by 0.025 mol/L sodium thiosulfate ($Na_2S_2O_3$) solution, employing an automatic titrator (DOT-15X; Kimoto Electric Co.). The sodium thiosulfate solution was calibrated using 0.01 N potassium iodate (KIO_3) solution. The standard deviation of the measurement, which was derived from measurements of 21 replicate pairs, was calculated to be about 0.2 µmol/kg.

3.1.2. DIC and total alkalinity

Minoru Kitamura (JAMSTEC)
Yoshihisa Mino (Nagoya Univ.)
Masahide Wakita (JAMSTEC, MIO) (not onboard)

The ocean plays an important role in buffering the increase of atmospheric CO_2, therefore to clarify the mechanism of the oceanic CO_2 absorption and to estimate the absorption capacity are urgent tasks. When CO_2 dissolves into water, chemical reaction takes place and CO_2 alters its appearance into several species. Concentrations of the individual species of the CO_2 system in solution cannot be measured directly. There are, however, four parameters that can be measured (total dissolved inorganic carbon, total alkalinity, pH, PCO_2). These are used together with ancillary information to obtain a complete description of the CO_2 system in sea water. In this cruise, water samplings to obtain vertical profiles of total dissolved inorganic carbon (DIC) and total alkalinity were carried out in the three stations, the time-series station KEO, X4 where was the center of the cyclonic eddy, and the turbulence hot spot #1 where primary productivities were estimated by incubation experiments (Table 3.1.2-1).

To collect seawater samples, we used 200-ml glass bottles (SHOTT DURAN) that were pre-soaked in 5% non-phosphoric acid detergent solution (pH = 13) at least 3 hours and were cleaned by fresh water for 5 times and by Milli-Q deionized water for 3 times. Using a sampling tube attached to the Niskin bottle, seawater was sampled in the bottle without rinsing and was overflowed for 20 seconds. Bottles after the seawater sampling were sealed using rubber caps with care not to contain any bubble in the bottles. Within one hour after the sampling, 2 ml of seawater samples (1% of the bottle volume) was removed from the bottle and poisoned with 100 µl of over saturated solution of mercury chloride. Then, the samples were sealed using rubber and aluminum caps and stored in a refrigerator at approximately 5ºC until analysis. After the cruise, measurement of DIC and total alkalinity will be carried out in the Mutsu Institute of Oceanography, JAMSTEC.

Table 3.1.2-1. List of DIC/total alkalinity samples

Stn./Cast	Niskin No.	Depth (m)	Bottle ID
KEO	Bucket	0	515
KH1904_2	1	2000	516
	2	1750	517
	3	1500	518
	4	1250	519
	5	1000	520
	6	900	521
	7	800	522
	8	700	523
	9	600	524
	10	500	525
	11	400	526
	12	300	527
	13	250	528
	14	200	529
	15	175	530
	16	150	531
	17	125	532
	18	100	533
	19	75	534
	20	50	535
	21	40	536
	22	30	537
	23	20	538
	24	10	539
X4	1	2000	540
KH1905_5	2	1750	541
	3	1500	542
	4	1250	543
	5	1000	544
	6	750	545
	7	500	546
	8	400	547
	9	300	548
	10	250	549
	11	200	550
	12	150	551
	13	125	552
	14	100	553
	15	80	554
	16	70	555
	17	65	556
	18	60	557
	19	55	558
	20	50	559
	21	40	560
	22	30	561
	23	20	562
	24	10	563
	Bucket	0	564
HotSpot	4	83	565
KH1904_12	5	73	566
	6	63	567
HotSpot	4	53	568
KH1904_20	5	40	569
	6	10	570

3.1.3. Dissolved organic carbon (DOC)

Minoru Kitamura (JAMSTEC)
Yoshihisa Mino (Nagoya Univ.)
Masahide Wakita (JAMSTEC, MIO) (not onboard)

Dissolved organic carbon (DOC) is a major global carbon reservoir and has a great impact on the carbon cycles in the ocean. In this cruise, we collected seawater samples to analyze concentration of DOC at three stations; the time-series station KEO, X4 where is the center of the cyclonic eddy, and turbulence hot spot #1 in the cyclonic eddy. For this water sampling, we used a sampling tube with pre-combusted (450ºC) GF/F inline filter and a 60-ml high density polycarbonate bottle. Seawater in each Niskin bottle was filtered and transferred into the sample bottle. After that, these samples were frozen and preserved at –20ºC until analysis. Measurement of DOC concentration will be conducted in Mutsu Institute of Oceanography, JAMSTEC.

Table 3.1.3-1. List of dissolved organic carbon samples.

Stn./Cast	Niskin No.	Depth (m)	Bottle ID	Stn./Cast	Niskin No.	Depth (m)	Bottle ID	Stn./Cast	Niskin No.	Depth (m)	Bottle ID
KEO	1	2000	641	X4	1	2000	670	HotSpot	1	300	698
KH1904_2	1	2000	642	KH1904_5	2	1750	671	KH1904_11	2	275	699
	2	1750	643		3	1500	672		3	250	700
	3	1500	644		3	1500	673		4	225	701
	4	1250	645		4	1250	674		5	200	702
	5	1000	646		5	1000	675		6	175	703
	6	900	647		6	750	676		7	150	704
	7	800	648		7	500	677		8	125	705
	8	700	649		8	400	678		9	100	706
	8	700	650		9	300	679		10	75	707
	9	600	651		10	250	680		11	50	708
	10	500	652		10	250	681		12	25	709
	11	400	653		11	200	682		13	10	710
	12	300	654		12	150	683		14	5	711
	13	250	655		13	125	684		15	100	712
	14	200	656		14	100	685		16	90	713
	15	175	657		15	80	686		17	80	714
	16	150	658		16	70	687		18	70	715
	17	125	659		16	70	688		19	60	716
	18	100	660		17	65	689				
	18	100	661		18	60	690				
	19	75	662		18	60	691				
	20	50	663		19	55	692				
	21	40	664		20	50	693				
	22	30	665		21	40	694				
	23	20	666		22	30	695				
	24	10	667		23	20	696				
	24	10	668		24	10	697				

3.1.4. Salinity

Takeyoshi Nagai (Tokyo Univ. of Marine Science and Technology)

Salinity was measured in the 5th laboratory of R/V Hakuho maru using an Autosal. Measured conductivity ratio and salinity data are listed in the tables below for each CTD station. The conductivity ratio was measured twice for each bottle and averaged value is used to compute salinity. The measured salinity by CTD is compared against that with Autosal (Figure 3.1.4). The obtained linear regression equation is Y=0.99728X+0.088568.

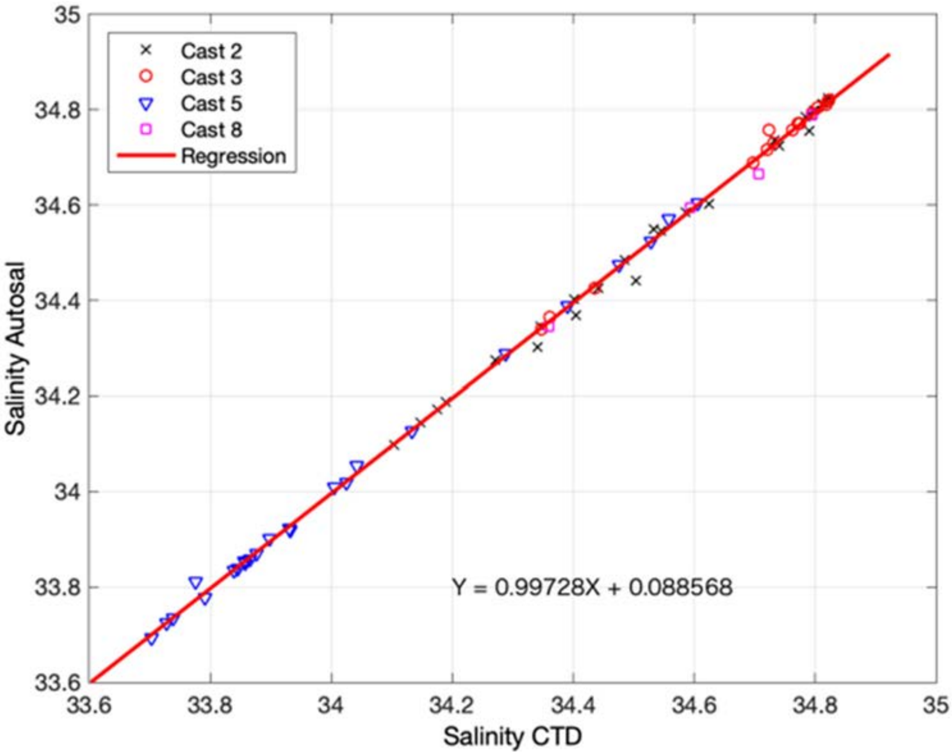


Figure 3.1.4 Scatter plot for salinity measured using CTD and Autosal. The regression line is shown as a red line, and the equation for the regression line is given in the figure. Y=0.99728X+0.088568

Table 3.1.4-1 Salinity measurements for the bottle samples at CTD station near KEO, Cast 2

Cast 2 (KEO_Routine)

Station No. : KEO

PI								
Sampling bottle								
Smpl. No.		m	Salt Bottle	Done	conductivity ratio1	conductivity ratio2	average	Salinity
1		2000	2-1	1	1.97882	1.97882	1.97882	34.58566138
2		1750	2-2	1	1.97673	1.97673	1.97673	34.54481751
3		1500	2-3	1	1.97364	1.97364	1.97364	34.48444455
4		1250	2-4	1	1.96939	1.96939	1.96939	34.40143351
5		1000	2-5	1	1.96276	1.96276	1.96276	34.2719969
6		900	2-6	1	1.95853	1.95852	1.958525	34.18935622
7		800	2-7	1	1.95635	1.95636	1.956355	34.14702309
8		700	2-8	1	1.95412	1.95414	1.95413	34.10362521
9		600	2-9	1	1.95777	1.95777	1.95777	34.17462651
10		500	2-10	1	1.96652	1.96652	1.96652	34.34539382
11		400	2-11	1	1.97612	1.97612	1.97612	34.53289795
12		300	2-12	1	1.98632	1.98632	1.98632	34.73229073
13		250	2-13	1	1.98898	1.98899	1.988985	34.78441577
14		200	2-14	1	1.98967	1.98967	1.98967	34.79781569
15		175	2-15	1	1.99042	1.99042	1.99042	34.81248804
16		150	2-16	1	1.9909	1.9909	1.9909	34.82187884
17		125	2-17	1	1.99081	1.99085	1.99083	34.82050933
18		100	2-18	1	1.98929	1.98934	1.989315	34.79087111
19		75	2-19	1	1.98676	1.98676	1.98676	34.74089592
20		50	2-20	1	1.9808	1.9808	1.9808	34.62436235
21		40	2-21	1	1.97458	1.97461	1.974595	34.50310179
22		30	2-22	1	1.97146	1.97145	1.971455	34.44176332
23		20	2-23	1	1.96958	1.96957	1.969575	34.4050463
24		10	2-24	1	1.96631	1.96633	1.96632	34.34148913
Surface (Bucket)		0	2-0	1	1.97453	1.97453	1.97453	34.50183188

Table 3.1.4-2 Salinity measurements for the bottle samples at CTD station near KEO, Cast 3

Cast 3 (KEO_Calibration, DO exp, SCM)

Station No. : KEO Cast No. : KH1904_03

PI				Nagai				
Sampling bottle								
Smpl. No.	Bottle No.	m	Salt Bottle	Done	conductivity ratio1	conductivity ratio2	average	Salinity
1		300						
2		300						
3		200						
4		200						
5		300	3-5	1	1.98631	1.9863	1.986305	34.73201142
6		275	3-6	1	1.98788	1.98787	1.987875	34.76271775
7		250	3-7	1	1.98836	1.98835	1.988355	34.7721065
8		225	3-8	1	1.98948	1.98948	1.98948	34.79411289
9		200	3-9	1	1.98999	1.99	1.989995	34.80418764
10		175	3-10	1	1.99041	1.99096	1.9907	34.81768655
11		150	3-11	1	1.99096	1.99096	1.9910	34.82306677
12		125	3-12	1	1.99086	1.99084	1.9909	34.82091466
13		100	3-13	1	1.9885	1.98851	1.988505	34.77504056
14		75	3-14	1	1.9845	1.98451	1.984505	34.69681181
15		50	3-15	1	1.98567	1.98569	1.98568	34.71978872
16		25	3-16	1	1.97115	1.97114	1.971145	34.43572256
17		10	3-17	1	1.96734	1.96733	1.967335	34.36132017
18		5	3-18	1	1.96659	1.96665	1.96662	34.34736023
19		SCM+20						
20		SCM+10						
21		SCM	3-21	1	1.98584	1.98588	1.98586	34.72330879
22		SCM						
23		SCM-10						
24		SCM-20						
Surface (Bucket)		-						

Table 3.1.4-3 Salinity measurements for the bottle samples at CTD station Cast 5 at the center of the cyclonic eddy.

Cast 5 (X4_Routine, ver.2)

Station No. : X4 Cast No. : KH1904_05

PI				Nagai				
Sampling bottle								
Smpl. No.	Bottle No.	m	Salt Bottle	Done	conductivity ratio1	conductivity ratio2	average	Salinity
1		2000	X4-1	1	1.97979	1.97984	1.979815	34.60512282
2		1750	X4-2	1	1.97728	1.97744	1.97736	34.55714257
3		1500	X4-3	1	1.97586	1.97585	1.975855	34.52773402
4		1250	X4-4	1	1.97323	1.97322	1.973225	34.47635147
5		1000	X4-5	1	1.96883	1.96886	1.968845	34.39080481
6		750	X4-6	1	1.96362	1.96363	1.963625	34.28889404
7		500	X4-7	1	1.9557	1.95569	1.955695	34.13416319
8		400	X4-8	1	1.95008	1.95009	1.950085	34.02476422
9		300	X4-9	1	1.94195	1.94195	1.94195	33.86621995
10		250	X4-10	1	1.94055	1.94055	1.94055	33.83894636
11		200	X4-11	1	1.94086	1.94087	1.940865	33.84508263
12		150	X4-12	1	1.94151	1.9415	1.941505	33.85755049
13		125	X4-13	1	1.94248	1.9425	1.94249	33.87674064
14		100	X4-14	1	1.9384	1.93786	1.93813	33.79180978
15		80	X4-15	1	1.93538	1.93539	1.935385	33.73835479
16		70	X4-16	1	1.93356	1.9336	1.93358	33.70321188
17		65	X4-17	1	1.93484	1.93487	1.934855	33.72803525
18		60	X4-18	1	1.93729	1.93728	1.937285	33.77535325
19		55	X4-19	1	1.94146	1.94146	1.94146	33.85667382
20		50	X4-20	1	1.94358	1.94357	1.943575	33.89788093
21		40	X4-21	1	1.94527	1.94525	1.94526	33.93071562
22		30	X4-22	1	1.94535	1.94533	1.94534	33.93227466
23		20	X4-23	1	1.94906	1.94903	1.949045	34.00448929
24		10	X4-24	1	1.95097	1.95099	1.95098	34.0422138
Surface (Bucket)		0	X4-0	1	1.94895	1.94893	1.94894	34.00244241

Table 3.1.4-4 Salinity measurements for the bottle samples at CTD station Cast 8 near the BGC Argo float.

Cast 8 (Argo_Calibration)

Station No. : Argo Cast No. : KH1904_8

PI				Nagai				
Sampling bottle								
Smpl. No.	Bottle No.	m	Salt Bottle	Done	conductivity ratio1	conductivity ratio2	average	Salinity
1		2000	8-1	1	1.97924	1.97926	1.97925	34.59407963
2		1750						
3		1500						
4		1250						
5		1000						
6		900						
7		800						
8		700						
9		600						
10		500						
11		400						
12		300						
13		250						
14		200	8-14	1	1.98948	1.98952	1.9895	34.79450414
15		175						
16		150						
17		125						
18		100	8-18	1	1.98499	1.98495	1.98497	34.70590452
19		75						
20		50						
21		40						
22		30						
23		20						
24		10	8-24	1	1.96728	1.96728	1.96728	34.3602463
Surface (Bucket)		0						

3.1.5. Nutrients and Deep-SUNA

Minoru Kitamura (JAMSTEC)
Akihiko Murata (JAMSTEC) (not onboard)
Hiroki Ushiromura (MWJ)

Turbulence may influence vertical uplift of nutrients in the ocean. To understand fine-scale vertical distribution of nitrate, we deployed CTD system with nitrate sensor (Deep-SUNA, Sea-Bird Scientific). Especially, along the leg 2 of underway-VMP observation (see section 3.5.2), the CTD casts were carried out at two mile intervals to obtain horizontal distribution of nitrate (see Table 3.1-2). Specification of the Deep-SUNA and operational settings are summarized in the Table 3.1.5-1 and Table 3.1.5-2, respectively. Pre-cruise calibration of Deep-SUNA was carried out by using Milli-Q deionized water. To calibrate the nitrate values obtained from the Deep-SUNA, seawater samples for nutrients were also collected during the cruise (Table 3.1.5-3). Total usage of the light source was 1,073 minutes.

Table 3.1.5-1. Specification of Deep-SUNA

Rated depth (m)	2000
Weight (kg, in air)	1.8
Length/width (cm)	55.5/5.7
Pathlength (mm)	10
Temperature range (°C)	from −2 to 35
Spectoral range (nm)	from 190 to 370
Light source	UV deuterium lamp
Light source lifetime (hrs)	900
Nitrate measurement accuracy (μM)	2
Nitrate measurement precision (μM)	2.4

Table 3.1.5-2. Setting of Deep-SUNA

General	
Operational Mode	Continous
Frame cycle	30 lights, 1 dark
Sample averaging	1
Logging level	INFO
Max. log file size	2 MB
Telemetry	
Baud rate	57600
Transmitted Frame Format	Full ASCII
Instrument Logging Frame Format	Full ASCII
Log File Creation Method	By Smple Event
Advanced	
Fitting range	from 217 to 240 nm
Integ. Period	250
Nitrate unit	μM
Nitrate range	from −5 to 50 μM
Adaptive Integration	off

Table 3.1.5-3. List of seawater samples for nutrient analysis

Station	Cast name	Total cast	Niskin	Nuts sample ID	Depth (m)
KEO	KEO routine	2	1	KH-19-4_2-1	2000
KEO	KEO routine	2	2	KH-19-4_2-2	1750
KEO	KEO routine	2	3	KH-19-4_2-3	1500
KEO	KEO routine	2	4	KH-19-4_2-4	1250
KEO	KEO routine	2	5	KH-19-4_2-5	1000
KEO	KEO routine	2	6	KH-19-4_2-6	900
KEO	KEO routine	2	7	KH-19-4_2-7	800
KEO	KEO routine	2	8	KH-19-4_2-8	700
KEO	KEO routine	2	9	KH-19-4_2-9	600
KEO	KEO routine	2	10	KH-19-4_2-10	500
KEO	KEO routine	2	11	KH-19-4_2-11	400
KEO	KEO routine	2	12	KH-19-4_2-12	300
KEO	KEO routine	2	13	KH-19-4_2-13	250
KEO	KEO routine	2	14	KH-19-4_2-14	200
KEO	KEO routine	2	15	KH-19-4_2-15	174
KEO	KEO routine	2	16	KH-19-4_2-16	150
KEO	KEO routine	2	17	KH-19-4_2-17	125
KEO	KEO routine	2	18	KH-19-4_2-18	100
KEO	KEO routine	2	19	KH-19-4_2-19	75
KEO	KEO routine	2	20	KH-19-4_2-20	50
KEO	KEO routine	2	21	KH-19-4_2-21	40
KEO	KEO routine	2	22	KH-19-4_2-22	30
KEO	KEO routine	2	23	KH-19-4_2-23	20
KEO	KEO routine	2	24	KH-19-4_2-24	10
KEO	KEO routine	2	bucket	KH-19-4_2-B	0
X4	X4 routine	5	1	KH-19-4_5-1	2000
X4	X4 routine	5	2	KH-19-4_5-2	1750
X4	X4 routine	5	3	KH-19-4_5-3	1500
X4	X4 routine	5	4	KH-19-4_5-4	1250
X4	X4 routine	5	5	KH-19-4_5-5	1000
X4	X4 routine	5	6	KH-19-4_5-6	750
X4	X4 routine	5	7	KH-19-4_5-7	500
X4	X4 routine	5	8	KH-19-4_5-8	399
X4	X4 routine	5	9	KH-19-4_5-9	300
X4	X4 routine	5	10	KH-19-4_5-10	250
X4	X4 routine	5	11	KH-19-4_5-11	199
X4	X4 routine	5	12	KH-19-4_5-12	151
X4	X4 routine	5	13	KH-19-4_5-13	125
X4	X4 routine	5	14	KH-19-4_5-14	101
X4	X4 routine	5	15	KH-19-4_5-15	80
X4	X4 routine	5	16	KH-19-4_5-16	70
X4	X4 routine	5	17	KH-19-4_5-17	64
X4	X4 routine	5	18	KH-19-4_5-18	61
X4	X4 routine	5	19	KH-19-4_5-19	55
X4	X4 routine	5	20	KH-19-4_5-20	50
X4	X4 routine	5	21	KH-19-4_5-21	39
X4	X4 routine	5	22	KH-19-4_5-22	30
X4	X4 routine	5	23	KH-19-4_5-23	20
X4	X4 routine	5	24	KH-19-4_5-24	10
X4	X4 routine	5	bucket	KH-19-4_5-B	0
X5	X5 routine	7	1	KH-19-4_7-1	1001
X5	X5 routine	7	2	KH-19-4_7-2	750
X5	X5 routine	7	3	KH-19-4_7-3	500
X5	X5 routine	7	4	KH-19-4_7-4	300
X5	X5 routine	7	5	KH-19-4_7-5	199
X5	X5 routine	7	6	KH-19-4_7-6	150
X5	X5 routine	7	7	KH-19-4_7-7	125
X5	X5 routine	7	8	KH-19-4_7-8	99
X5	X5 routine	7	9	KH-19-4_7-9	75
X5	X5 routine	7	10	KH-19-4_7-10	49
X5	X5 routine	7	11	KH-19-4_7-11	25
X5	X5 routine	7	12	KH-19-4_7-12	10
X5	X5 routine	7	13	KH-19-4_7-13	5
X5	X5 routine	7	14	KH-19-4_7-14	84
Argo_C	Argo Calibration	8	1	KH-19-4_8-1	2001
Argo_C	Argo Calibration	8	2	KH-19-4_8-2	1750
Argo_C	Argo Calibration	8	3	KH-19-4_8-3	1500
Argo_C	Argo Calibration	8	4	KH-19-4_8-4	1250
Argo_C	Argo Calibration	8	5	KH-19-4_8-5	1000
Argo_C	Argo Calibration	8	6	KH-19-4_8-6	900
Argo_C	Argo Calibration	8	7	KH-19-4_8-7	800
Argo_C	Argo Calibration	8	8	KH-19-4_8-8	700
Argo_C	Argo Calibration	8	9	KH-19-4_8-9	600
Argo_C	Argo Calibration	8	10	KH-19-4_8-10	501
Argo_C	Argo Calibration	8	11	KH-19-4_8-11	400
Argo_C	Argo Calibration	8	12	KH-19-4_8-12	300
Argo_C	Argo Calibration	8	13	KH-19-4_8-13	250
Argo_C	Argo Calibration	8	14	KH-19-4_8-14	200
Argo_C	Argo Calibration	8	15	KH-19-4_8-15	176
Argo_C	Argo Calibration	8	16	KH-19-4_8-16	150
Argo_C	Argo Calibration	8	17	KH-19-4_8-17	125
Argo_C	Argo Calibration	8	18	KH-19-4_8-18	100
Argo_C	Argo Calibration	8	19	KH-19-4_8-19	75
Argo_C	Argo Calibration	8	20	KH-19-4_8-20	50
Argo_C	Argo Calibration	8	21	KH-19-4_8-21	40
Argo_C	Argo Calibration	8	22	KH-19-4_8-22	30
Argo_C	Argo Calibration	8	23	KH-19-4_8-23	20
Argo_C	Argo Calibration	8	24	KH-19-4_8-24	10
Argo_C	Argo Calibration	8	bucket	KH-19-4_8-B	0
HS	F-POM_Night	10	1	KH-19-4_10-1	201
HS	F-POM_Night	10	9	KH-19-4_10-9	64
HS	F-POM_Night	10	18	KH-19-4_10-18	150
HS	F-POM_Night	10	19	KH-19-4_10-19	125
HS	F-POM_Night	10	20	KH-19-4_10-20	100
HS	F-POM_Night	10	21	KH-19-4_10-21	75
HS	F-POM_Night	10	22	KH-19-4_10-22	50
HS	F-POM_Night	10	23	KH-19-4_10-23	20
HS	F-POM_Night	10	24	KH-19-4_10-24	10
HS	F-POM_Night	10	bucket	KH-19-4_10-B	0
HS	SCM&C	11	1	KH-19-4_11-1	300
HS	SCM&C	11	2	KH-19-4_11-2	275
HS	SCM&C	11	3	KH-19-4_11-3	250
HS	SCM&C	11	4	KH-19-4_11-4	225
HS	SCM&C	11	5	KH-19-4_11-5	200
HS	SCM&C	11	6	KH-19-4_11-6	175
HS	SCM&C	11	7	KH-19-4_11-7	150
HS	SCM&C	11	8	KH-19-4_11-8	125
HS	SCM&C	11	9	KH-19-4_11-9	100
HS	SCM&C	11	10	KH-19-4_11-10	75
HS	SCM&C	11	11	KH-19-4_11-11	50
HS	SCM&C	11	12	KH-19-4_11-12	25
HS	SCM&C	11	13	KH-19-4_11-13	10
HS	SCM&C	11	14	KH-19-4_11-14	5
HS	SCM&C	11	15	KH-19-4_11-15	100
HS	SCM&C	11	16	KH-19-4_11-16	90
HS	SCM&C	11	17	KH-19-4_11-17	80
HS	SCM&C	11	18	KH-19-4_11-18	70
HS	SCM&C	11	19	KH-19-4_11-19	60
HS	SCM&C	11	bucket	KH-19-4_11-B	0
HS	PE1	12	4	KH-19-4_12-4	83
HS	PE1	12	5	KH-19-4_12-5	73
HS	PE1	12	6	KH-19-4_12-6	63
HS	F-POM_Day	13	1	KH-19-4_13-1	198
HS	F-POM_Day	13	9	KH-19-4_13-9	82
HS	F-POM_Day	13	18	KH-19-4_13-18	151
HS	F-POM_Day	13	19	KH-19-4_13-19	126
HS	F-POM_Day	13	20	KH-19-4_13-20	101
HS	F-POM_Day	13	21	KH-19-4_13-21	76
HS	F-POM_Day	13	22	KH-19-4_13-22	50
HS	F-POM_Day	13	23	KH-19-4_13-23	20
HS	F-POM_Day	13	24	KH-19-4_13-24	11
HS	F-POM_Day	13	bucket	KH-19-4_13-B	0
HS	PE2	20	4	KH-19-4_20-4	73
HS	PE2	20	5	KH-19-4_20-5	40
HS	PE2	20	6	KH-19-4_20-6	10

3.1.6. Fluorometric determination of Chlorophyll *a*

Kazuhiko Matsumoto

Research Institute for Global Change (RIGC), Earth Surface System Research Center, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Introduction

To estimate the vertical distribution of phytoplankton biomass, the chlorophyll *a* (chl-*a*) concentrations are measured by the fluorometric determination.

Sampling and methods

Samplings were conducted vertically at five stations (KEO, X4, X5, ARGO, turbulence_HotSpot) by using the Niskin bottles, and a bucket at the surface. Water samples were filtered (<0.02MPa) through 25mm-diameter Whatman GF/F filter. Phytoplankton pigments retained on the filters were immediately extracted in polypropylene tubes with 7 ml of N,N-dimethylformamide. The tubes were stored in freezer to extract chl-*a* at least for 24 hours.

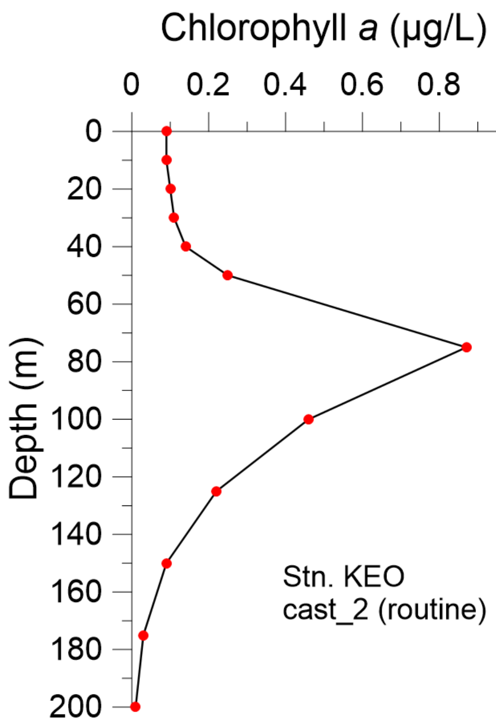
Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* before the observation. The chl-*a* concentrations were determined by “Non-acidification method” (Welschmeyer, 1994).

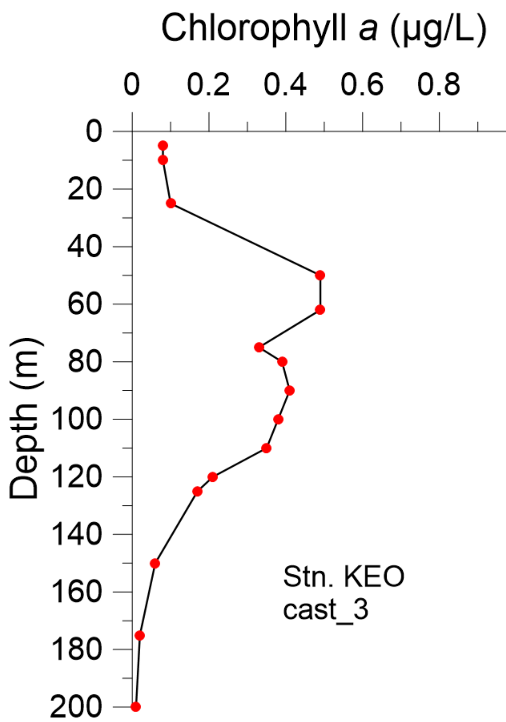
Preliminary results

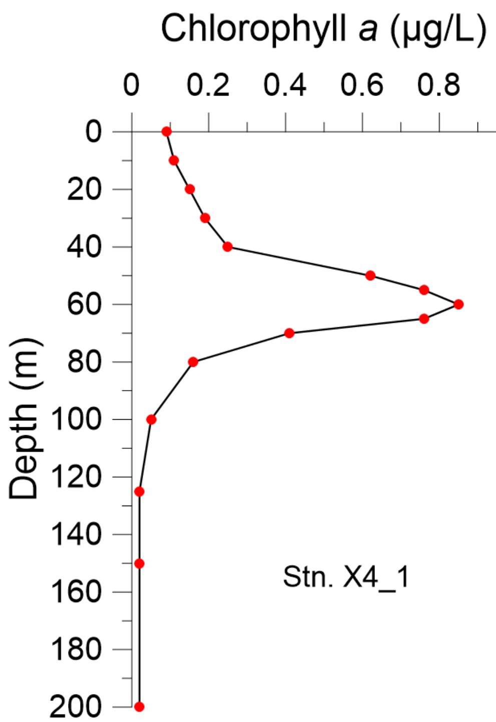
Vertical distributions of chl-*a* were shown at each station (Fig. 1).

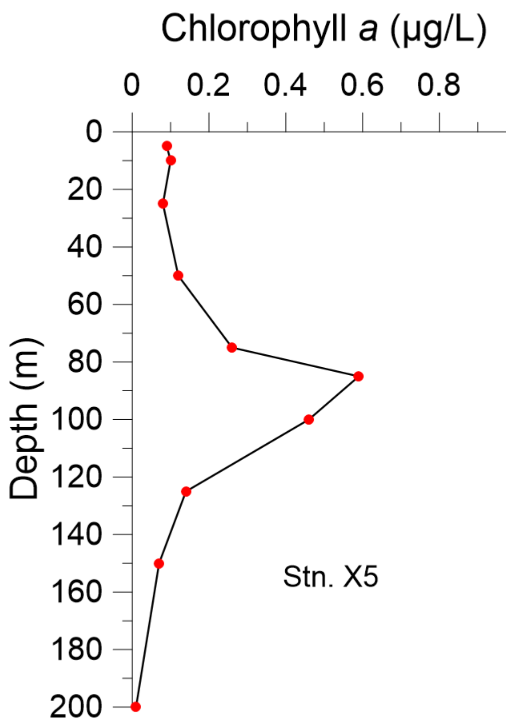
Reference

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


Chlorophyll a (μg/L)
0 0.2 0.4 0.6 0.8 1
Depth (m)
0 20 40 60 80 100 120 140 160 180 200
Stn. KEO
cast_2 (routine)


Chlorophyll a (μg/L)
0 0.2 0.4 0.6 0.8 1
Depth (m)
0 20 40 60 80 100 120 140 160 180 200
Stn. KEO
cast_3


Chlorophyll a (μg/L)
0 0.2 0.4 0.6 0.8 1
Depth (m)
0 20 40 60 80 100 120 140 160 180 200
Stn. X4_1


Chlorophyll a (μg/L)
0 0.2 0.4 0.6 0.8 1
Depth (m)
0 20 40 60 80 100 120 140 160 180 200
Stn. X5

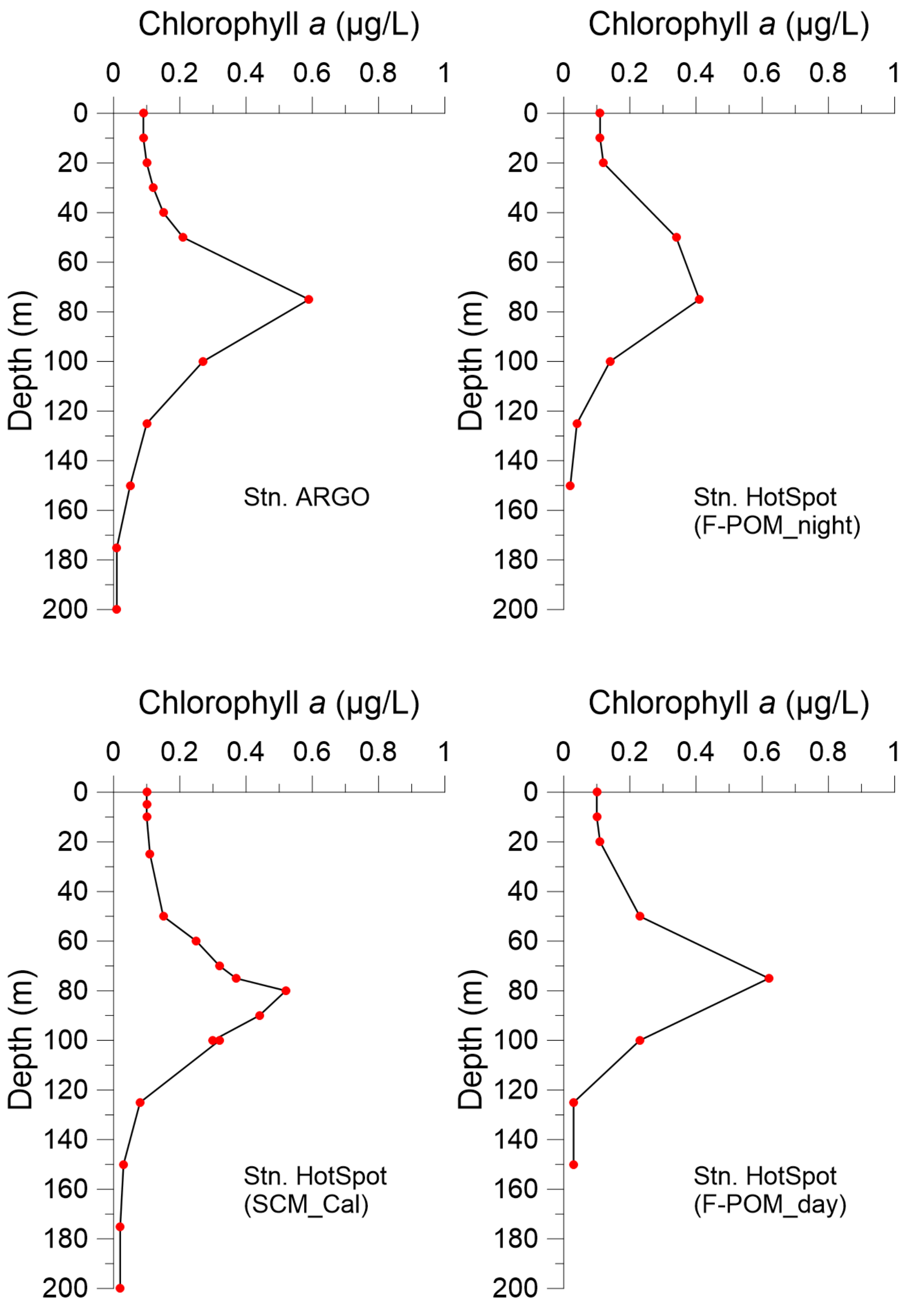


Figure 1. Vertical profiles of chl-*a* at each station.

3.1.7. Calibration of sensors attached to the BGC-Argo float

Minoru Kitamura (JAMSTEC)
Chiho Sukigara (Tokyo Univ. of Marine Science and Technology)
Tetsuichi Fujiki (JAMSTEC) (not onboard)

Before the present cruise, we deployed a BGC-Argo float (Navis) (ID: 2903394) at the station KEO in June 2, 2019 (during MR19-04 cruise). After the deployment, the float drifted northwestward and turned eastward along the Kuroshio extension. And the float reached about 50 miles north of our research area in July 22, 2019 (35º18’N, 146º48’E; Fig. 3.1.7-1). So, we went to the site where the Argo float surfaced and deployed a CTD/CWS (cast number: KH1904_8) to collect seawater samples for sensor validations in July 24, 2019. Items and collected depths of the seawater samples are summarized in the Table 3.1.7-1.

Table 3.1.7-1. List of seawater samples for calibrations of BGC-Argo sesors

Cast No.	Niskin No.	Depth (m)	DO	Salinity	Chlorophyll a	Nutrients	POM
KH1904_8	1	2000	2	1		2	1
	2	1750	1			2	1
	3	1500	1			2	1
	4	1250	1			2	1
	5	1000	1			2	1
	6	900	1			2	1
	7	800	1			2	1
	8	700	1			2	1
	9	600	2			2	1
	10	500	1			2	1
	11	400	1			2	1
	12	300	1			2	1
	13	250	1			2	1
	14	200	1	1	1	2	1
	15	175	1		1	2	1
	16	150	1		1	2	1
	17	125	2		1	2	1
	18	100	1	1	1	2	1
	19	75	1		1	2	1
	20	50	1		1	2	1
	21	40	1		1	2	1
	22	30	1		1	2	1
	23	20	1		1	2	1
	24	10	1	1	1	2	1
	Bucket	0	2		1	2	

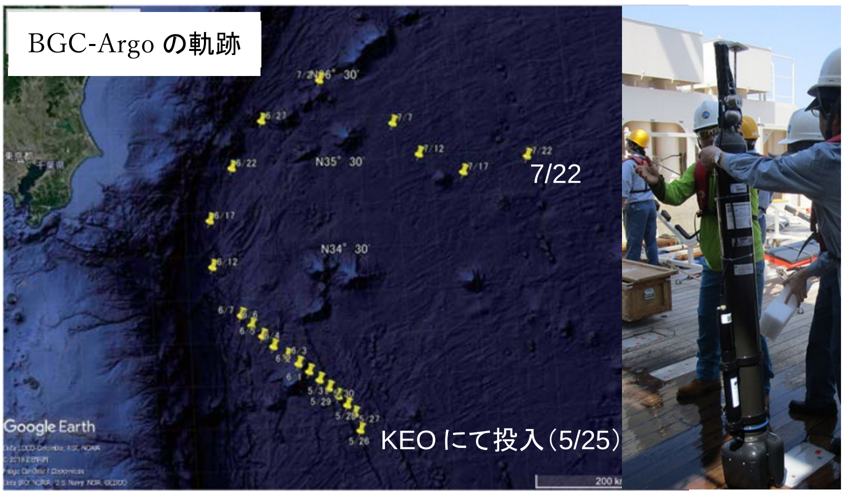


Fig. 3.1.7-1. Drifting truck of BGC-Argo float (ID: 2903394)

3.2. Sea surface monitoring by using AMEMBO II

Minoru Kitamura (JAMSTEC)
Ryoji Toda (AORI)

Sea surface temperature (SST), salinity, and chlorophyll *a* were recorded continuously by using sea surface monitoring system, AMEMBO II (AutoMated Environmental Monitor for Biological Oceanography; Tsuda et al., 1993, MEPS, 97). The monitoring system was located in the laboratory No. 7. Underway pumping-up seawater from about 4 m depth was continuously flowed into the system, and the three parameters were recorded at one minute interval together with GPS time and position. Averaged flow rate was 1.5 l/min. CPU time of the operational PC was 4 minutes and 32 seconds late. No water sampling to validate the monitoring values was carried out in this cruise. Horizontal variabilities of the three parameters along the XBT transect in the cyclonic eddy are showed in this preliminary report.

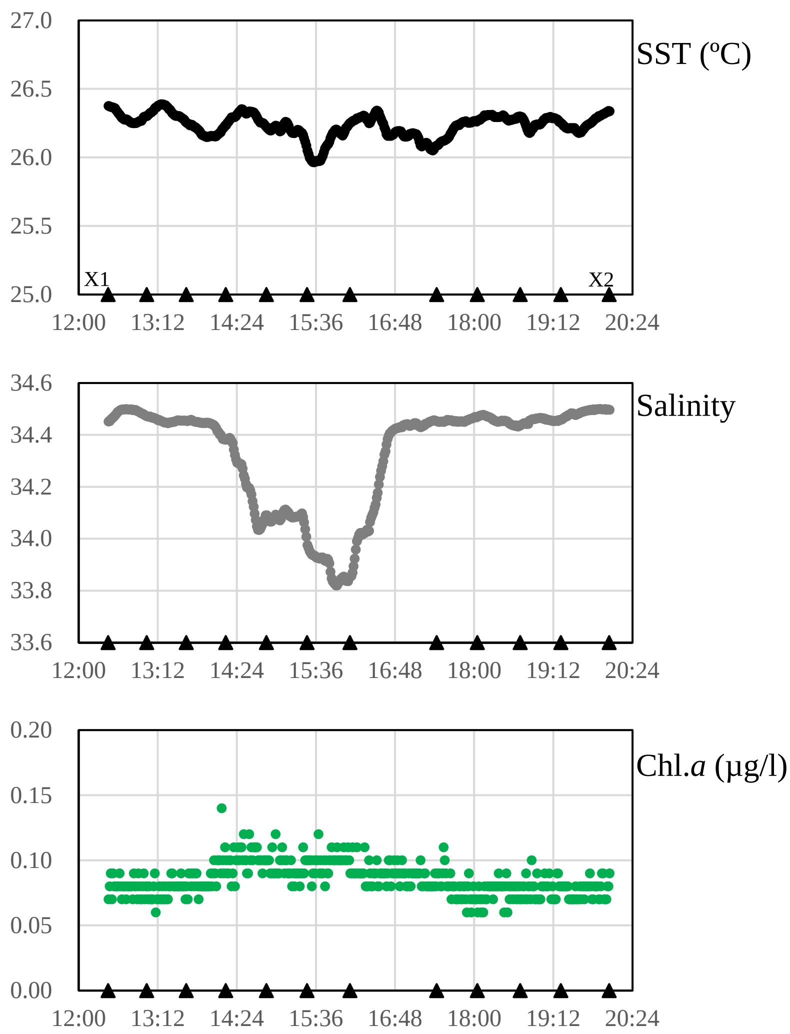


Fig. 3.2-1. Horizontal variabilities of SST, salinity, and chl-*a* along the XBT transect in the cyclonic eddy. Black triangles show timings of XBT deployment.

3.3. Shipboard ADCP

Minoru Kitamura (JAMSTEC)

To understand current field in the research area, continuous upper ocean current measurements by using the Acoustic Doppler Current Profiler (ADCP) system were made in this cruise. R/V Hakuho Maru has installed the Ocean Surveyor for vessel-mount ADCP. It has a phased-array transducer with single ceramic assembly and creates four acoustic beams electronically. Data was configured in 16 m intervals starting about 33 m below sea surface. Specification and setup parameters are herein summarized.

Specifications of the shipboard ADCP
- Frequency: 38.4 kHz
- Beam angle: 30º
- Velocity accuracy: 0.5 cm/sec.
- Velocity range: −5 to 9 m/sec.

Setup parameters for data collection
- 1st Bin: –33 m
- Bin size: 16 m
- Number of bins: 80

Acoustic backscattering strength can be estimated by using beam intensities obtained from the ADCP system. In the time-series station S1 near from the present research area, the acoustic backscattering strength was comparable to zooplankton biomass (Inoue et al., 2016). Using the data set of shipboard ADCP obtained during this cruise, we will also analyze zooplankton distribution and will discuss interaction between physical characteristics including turbulence in this study area and zooplankton spatial distribution.

3.4. XBT observations to understand physical structure of mesoscale eddy

Takeyoshi Nagai (Tokyo Univ. of Marine Science and Technology)

XBT (eXpendable BathyThermograph) observations were conducted in July 22-23, 2019 (JST) (Table 3.4.1). The objective of the XBT observations was to determine the location of the cyclonic eddy, detected by sea surface height data (Figure 3.4.1). The obtained XBT data with acoustic Doppler current profiler data suggests that the XBT transect covers a core of the cyclonic eddy, spinning counterclockwise (Figure 3.4.2-3).

Table 1. Time and position of XBT deployments

% KH19-4 2019 XBT											
%	Date and Time (JST)					Latitude			Longitude		
%#	Year	Month	Day	Hour	Min	deg	min	sec	deg	min	sec
1	2019	7	22	21	27	33	15	0.06	145	44	59.88
2	2019	7	22	22	2	33	21	8.958	145	51	7.5
3	2019	7	22	22	38	33	27	19.224	145	57	14.22
4	2019	7	22	23	14	33	33	28.008	146	3	20.76
5	2019	7	22	23	51	33	39	36.228	146	9	28.62
6	2019	7	23	0	28	33	45	46.38	146	15	38.46
7	2019	7	23	1	7	33	51	55.626	146	21	47.52
8	2019	7	23	2	26	34	4	27.006	146	34	19.86
9	2019	7	23	3	3	34	10	22.008	146	40	13.98
10	2019	7	23	3	42	34	16	32.262	146	46	26.94
11	2019	7	23	4	18	34	22	38.532	146	52	37.98
12	2019	7	23	5	2	34	29	57.618	147	0	1.26

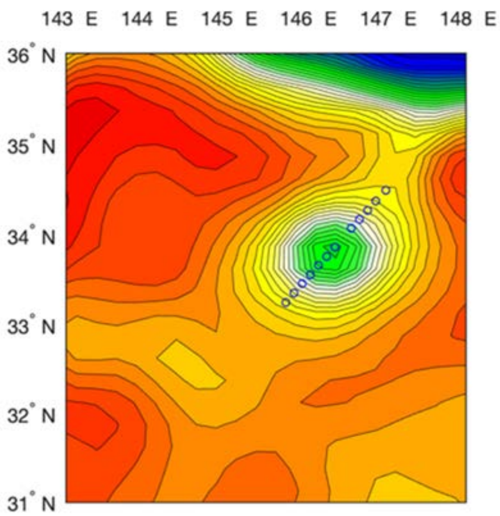


Figure 3.4-1. XBT stations shown as blue circles during July 22-23, 2019, with color showing sea surface height in July 22, 2019.

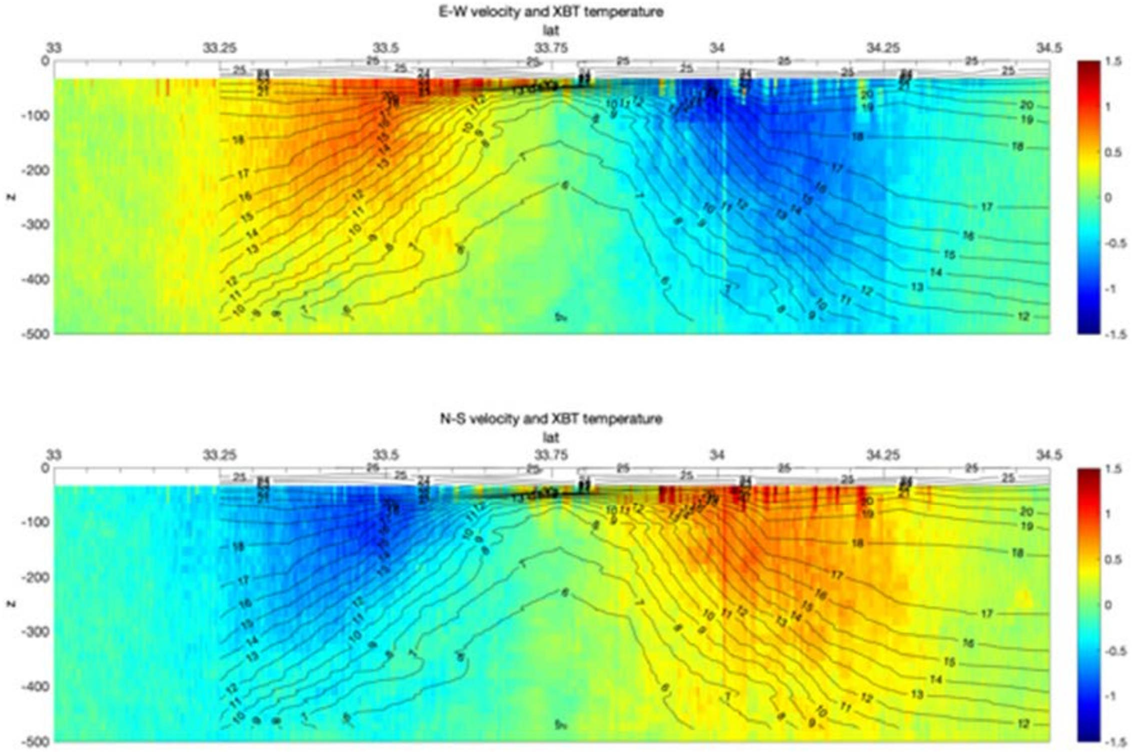


Figure 3.4-2. Color shows horizontal velocity measured by 38kHz shipboard ADCP as a function of latitude for (top) east-west velocity component, and (bottom) north-south component.

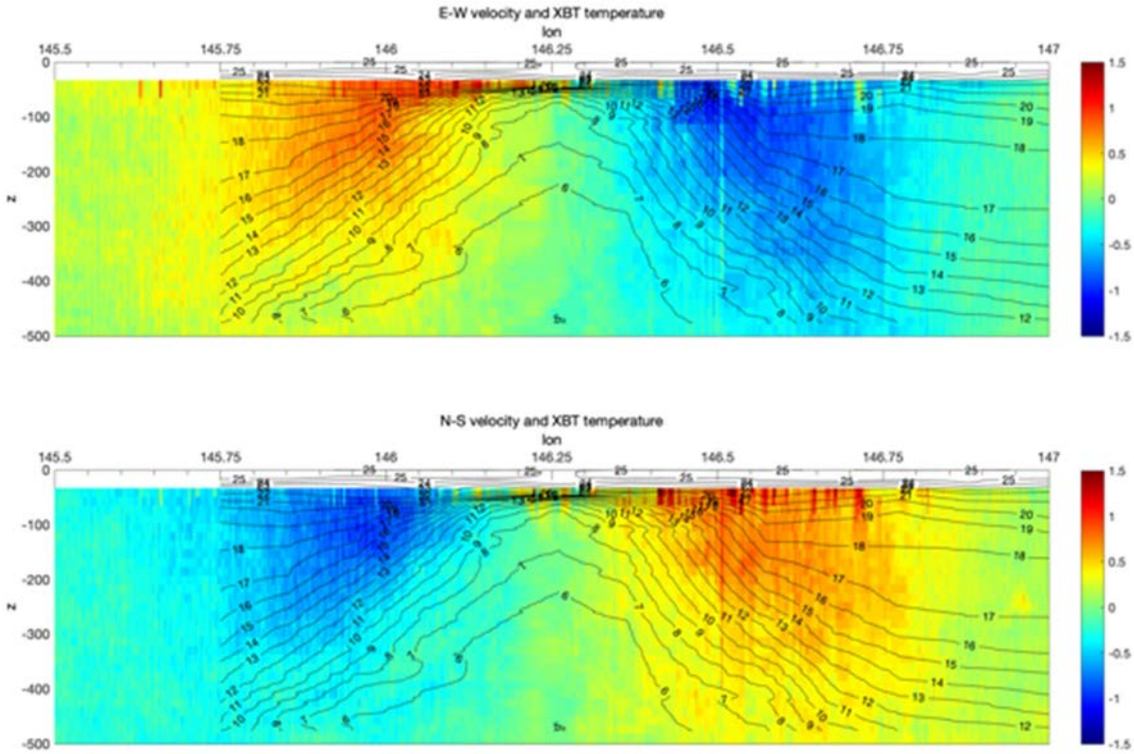


Figure 3.4-3. Same as Figure 3.4.2 but for velocity as a function of longitude.

3.5. Turbulence observations
3.5.1. TurboMAP-L

Takeyoshi Nagai (Tokyo Univ. of Marine Science and Technology)

Turbulence Ocean Microstructure data Acquisition Profiler Laser (TurboMAP-L) is a freefall microstructure profiler. TurboMAP-L carries two shear probes, a FP07 thermistor, an accelerometer, a CTD package, a LED fluorescence turbidity probe, and a laser fluorescence probe.

TurboMAP-L observations were conducted in July 21, 26, and 27, 2019. The LISST was also deployed in between TurboMAP-L deployments in July 21, and 27. The TurboMAP-L was deployed near the KEO buoy in July 21 and 26, and it was deployed at the center of the cyclonic eddy in July 27 (Figure 3.5.1-1).

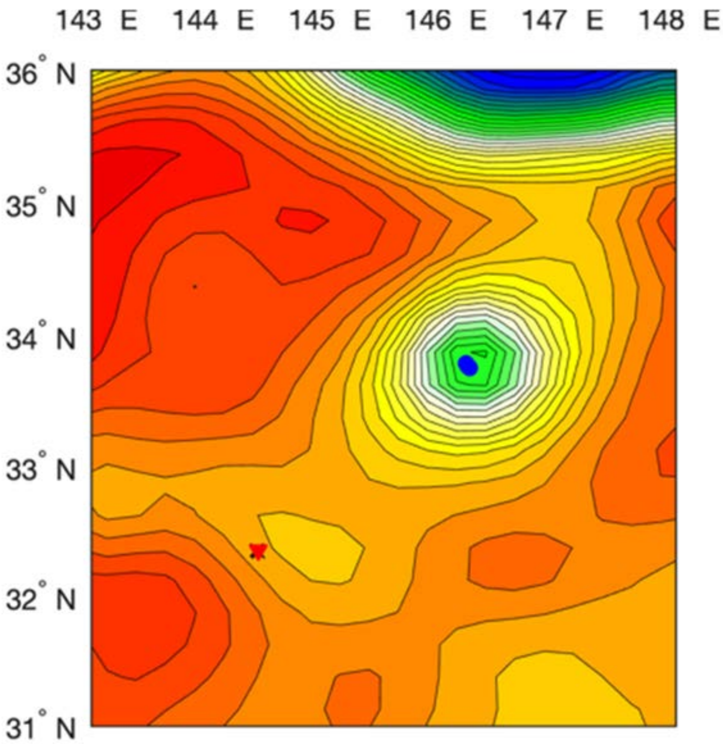


Figure 3.5.1-1. TurboMAP-L observations during (black cross) July 21, and (red triangle) July 26, 2019 were conducted near the KEO buoy. The deployments at the center of the cyclonic eddy in July 27 are shown as blue circles. Background color shows sea surface height in July 23-25, 2019.

Table 3.5.1. Time and locations for the TurboMAP-L observations

% KH19-4 2019 TML									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	21	10	10	32	20.391	144	25.519
2	2019	7	21	22	13	32	21.359	144	24.785
3	2019	7	21	22	53	32	21.185	144	24.636
4	2019	7	21	22	56	32	21.174	144	24.62
5	2019	7	21	23	38	32	21.166	144	24.546
6	2019	7	21	23	43	32	21.169	144	24.547
7	2019	7	26	0	8	32	21.251	144	25.454
8	2019	7	26	0	11	32	21.191	144	25.527
9	2019	7	26	0	18	32	21.164	144	25.572
10	2019	7	26	0	21	32	21.164	144	25.568
11	2019	7	26	0	25	32	21.169	144	25.577
12	2019	7	26	0	31	32	21.182	144	25.567
13	2019	7	26	0	40	32	21.198	144	25.577
14	2019	7	26	0	52	32	21.217	144	25.573
15	2019	7	27	12	10	33	45.463	146	14.389
16	2019	7	27	12	18	33	45.8	146	13.931
17	2019	7	27	12	27	33	46.171	146	13.473

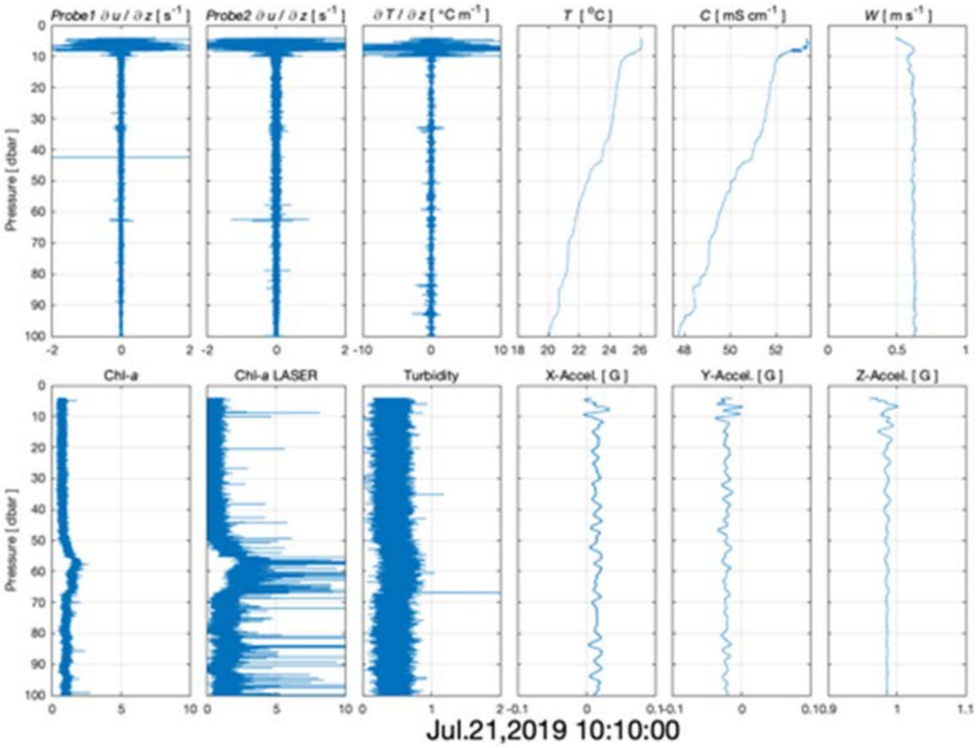


Figure 3.5.1-2. From left upper to right lower, shear#1, shear#2, temperature gradient by FP07, temperature, conductivity, falling speed, LED fluorescence, laser fluorescence, turbidity, acceleration along x, y, and z axis, measured by TurboMAP-L cast 1 in July 21.

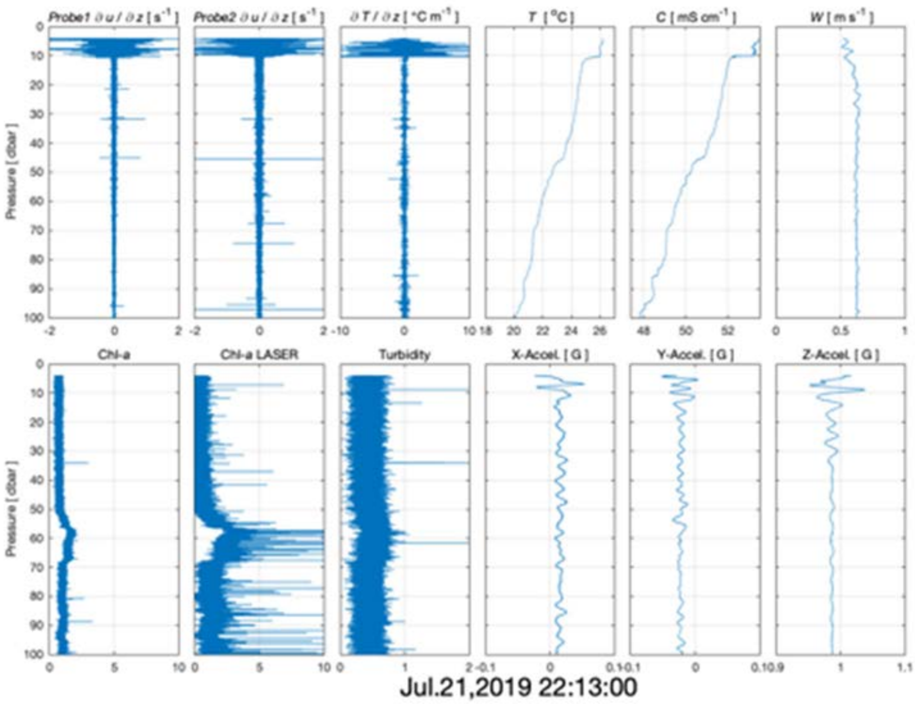


Figure 3.5.1-3. Same as Figure 3.5.1-2 but for cast 2 in July 21.

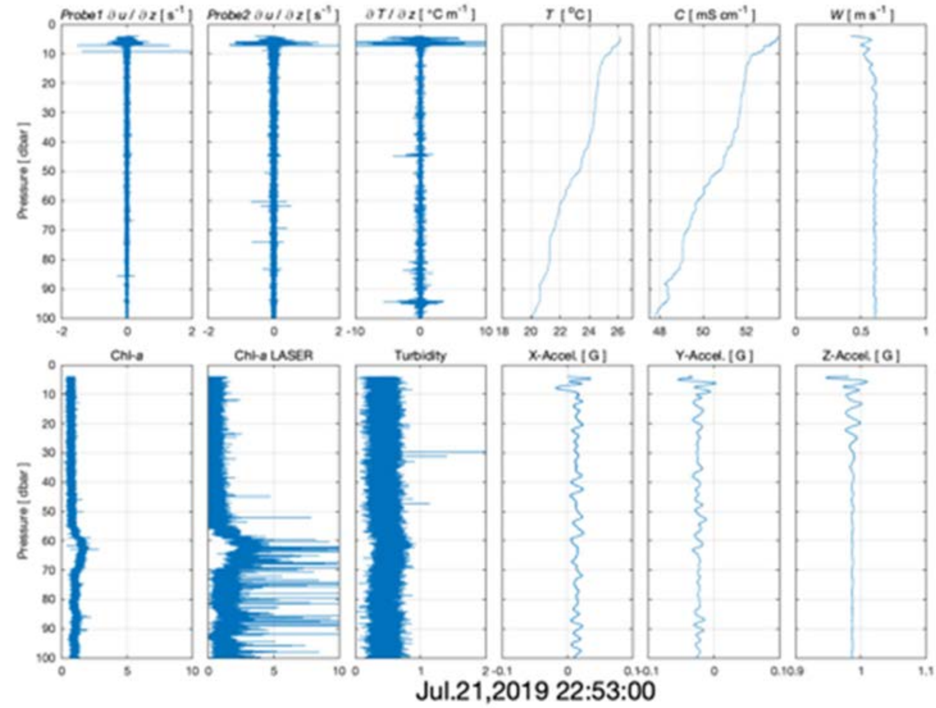


Figure 3.5.1-4. Same as Figure 3.5.1-2 but for cast 3 in July 21.

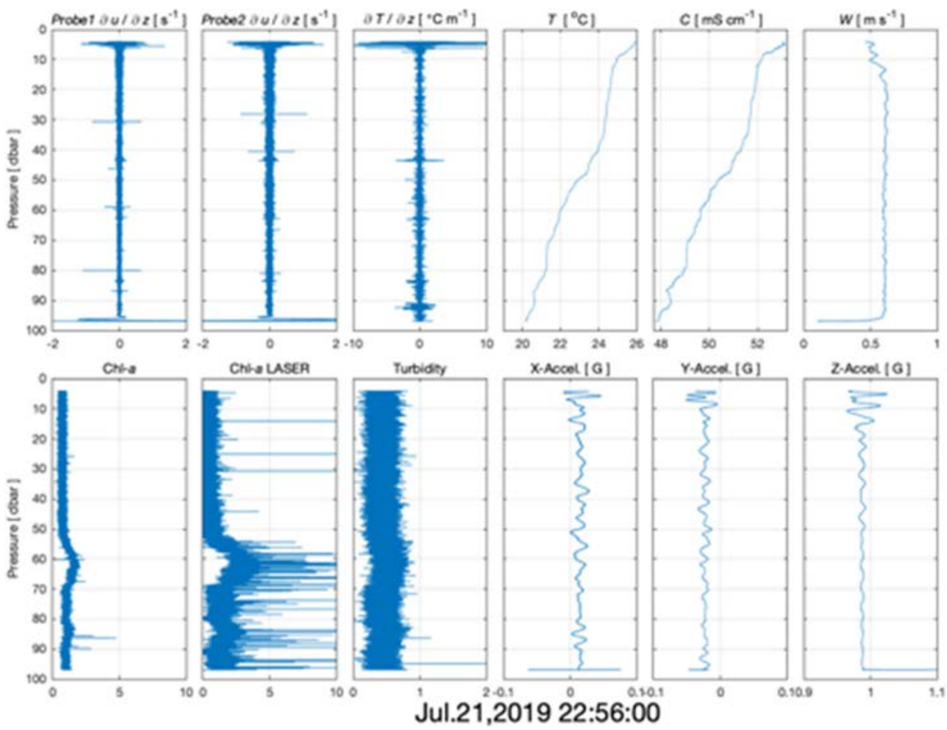


Figure 3.5.1-5. Same as Figure 3.5.1-2 but for cast 4 in July 21.

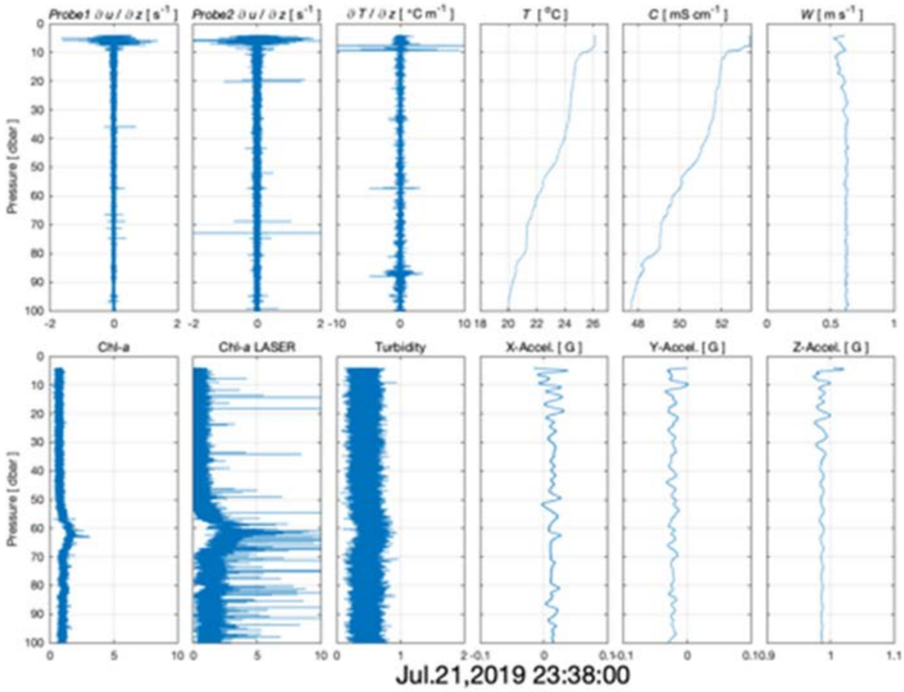


Figure 3.5.1-6. Same as Figure 3.5.1-2 but for cast 5 in July 21.

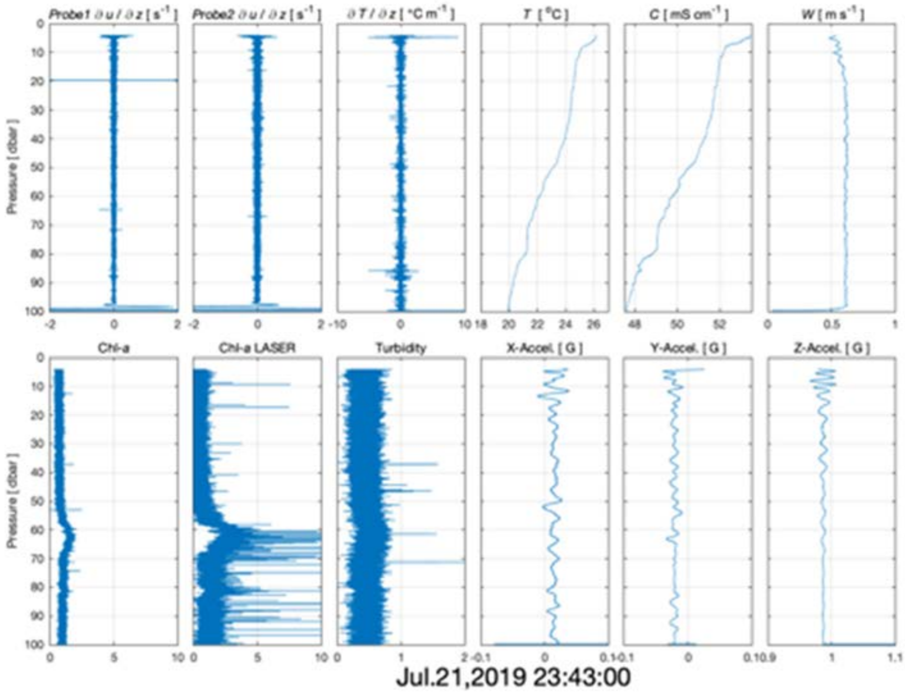


Figure 3.5.1-7. Same as Figure 3.5.1-2 but for cast 6 in July 21.

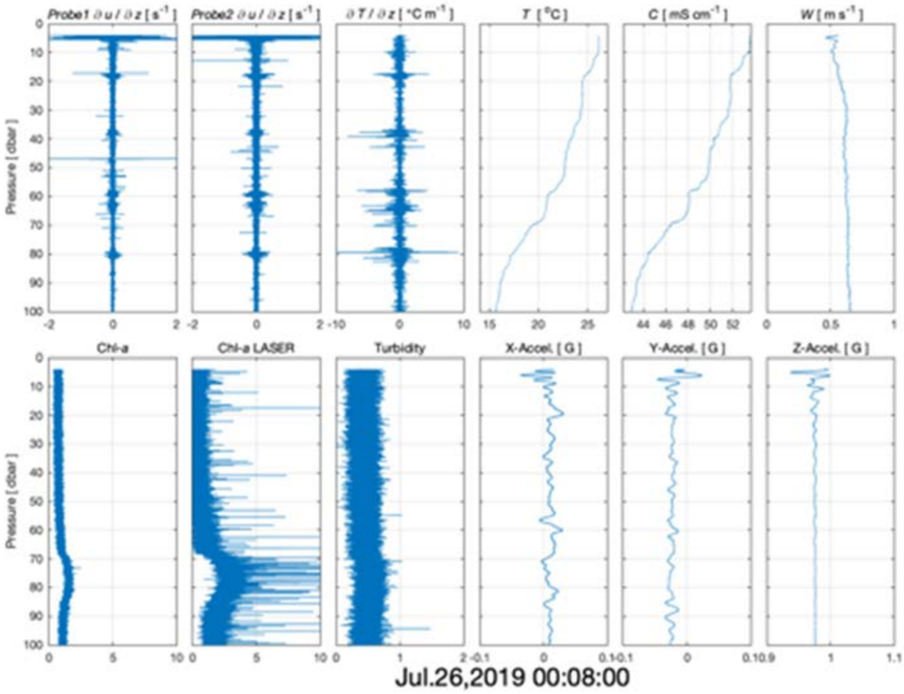


Figure 3.5.1-8. Same as Figure 3.5.1-2 but for cast 7 in July 26.

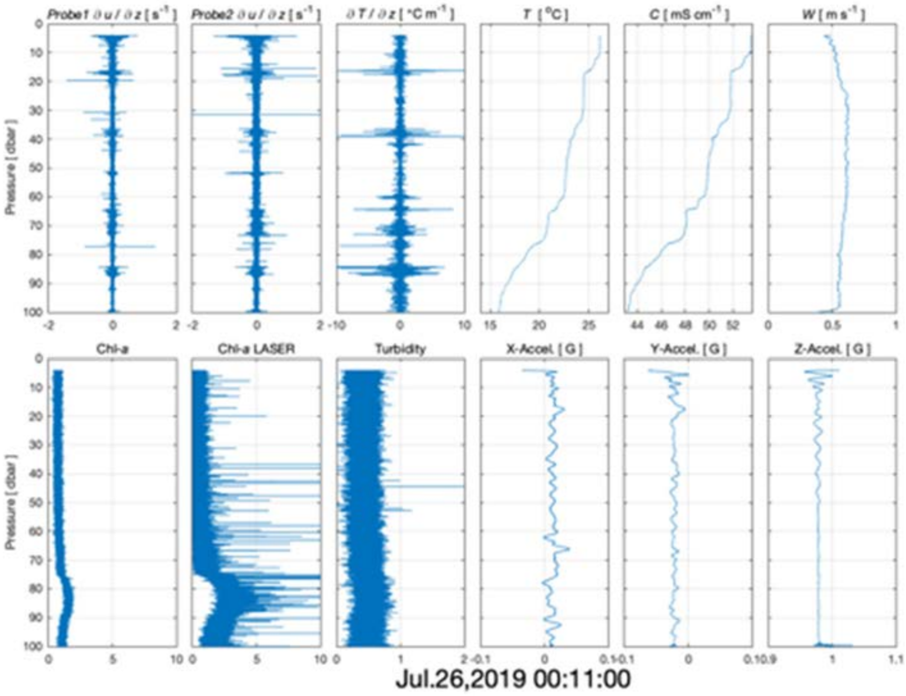


Figure 3.5.1-9. Same as Figure 3.5.1-2 but for cast 8 in July 26.

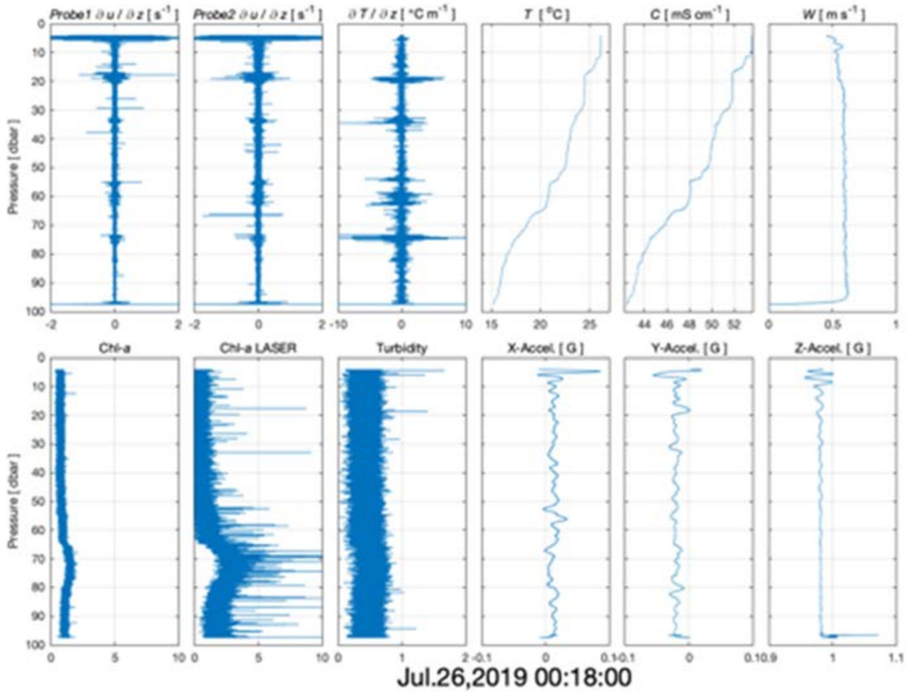


Figure 3.5.1-10. Same as Figure 3.5.1-2 but for cast 9 in July 26.

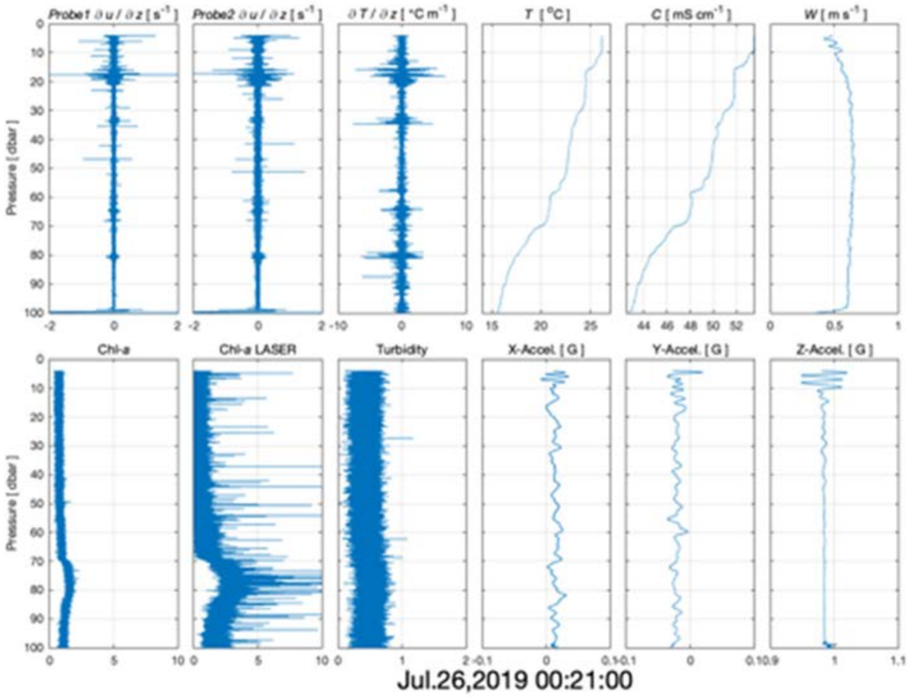


Figure 3.5.1-11. Same as Figure 3.5.1-2 but for cast 10 in July 26.

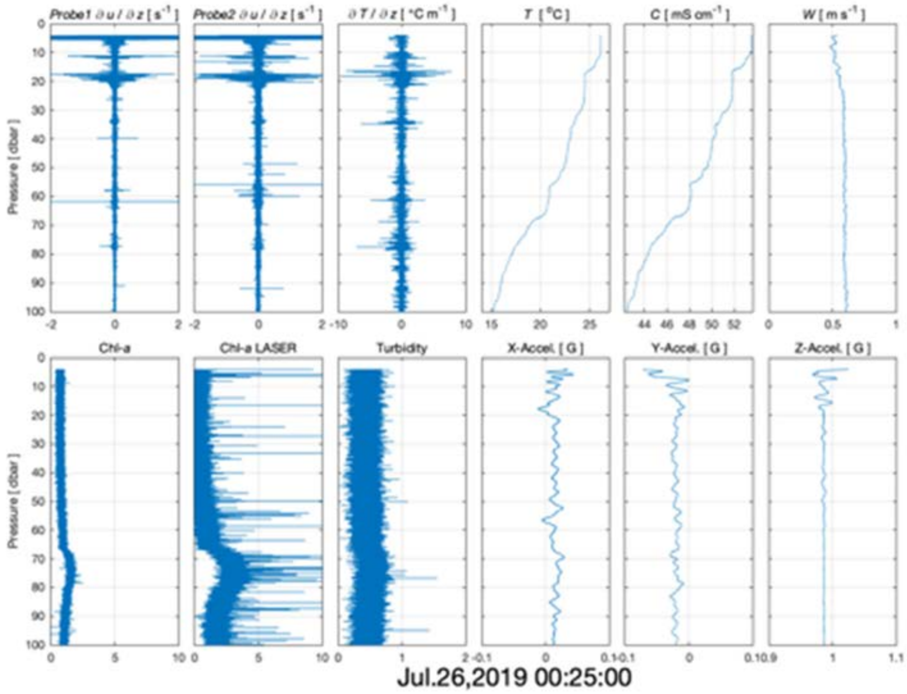


Figure 3.5.1-12. Same as Figure 3.5.1-2 but for cast 11 in July 26.

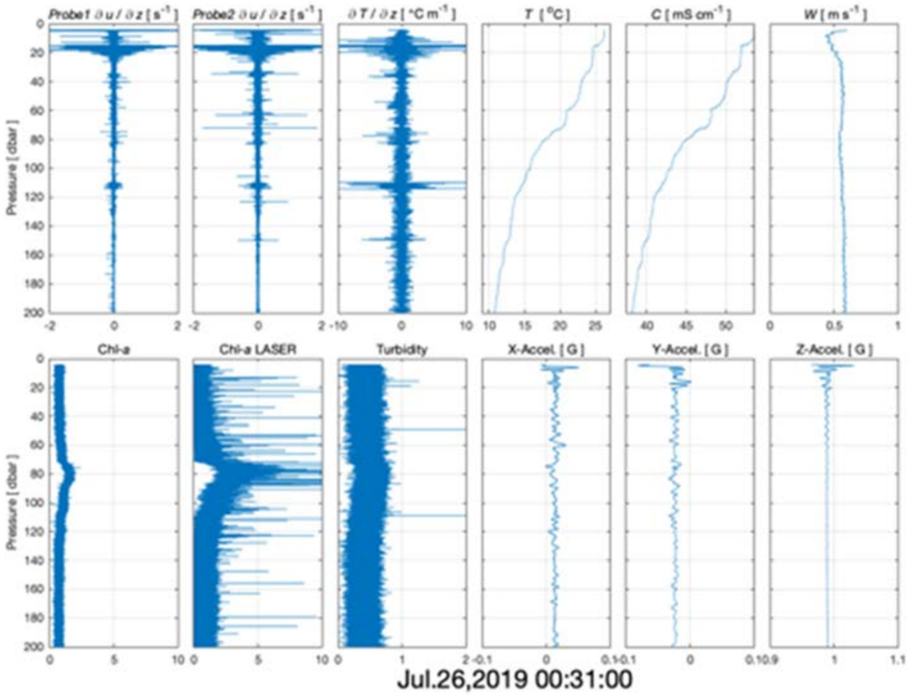


Figure 3.5.1-13. Same as Figure 3.5.1-2 but for cast 12 in July 26.

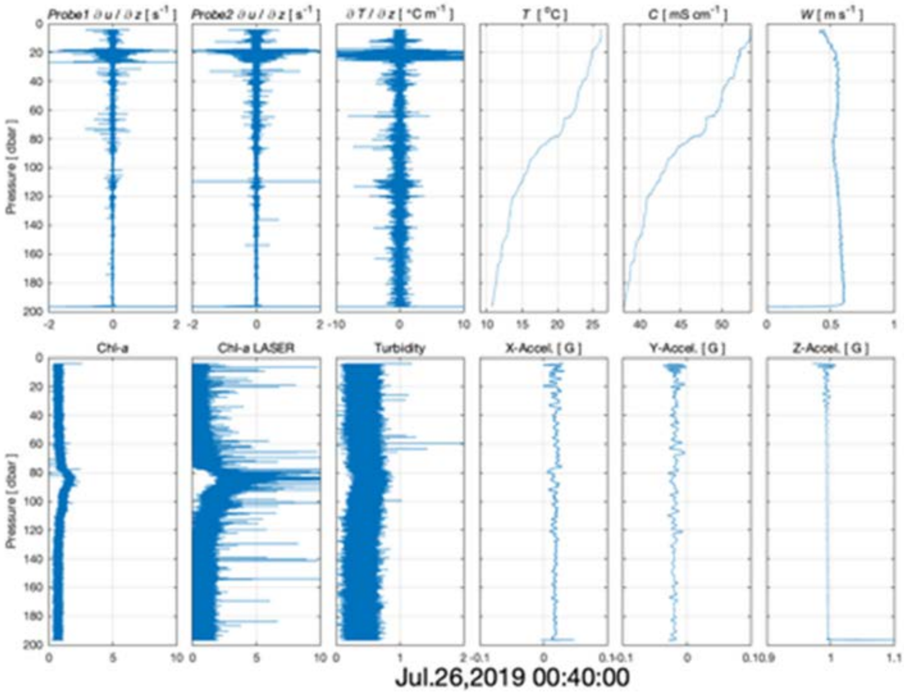


Figure 3.5.1-14. Same as Figure 3.5.1-2 but for cast 13 in July 26.

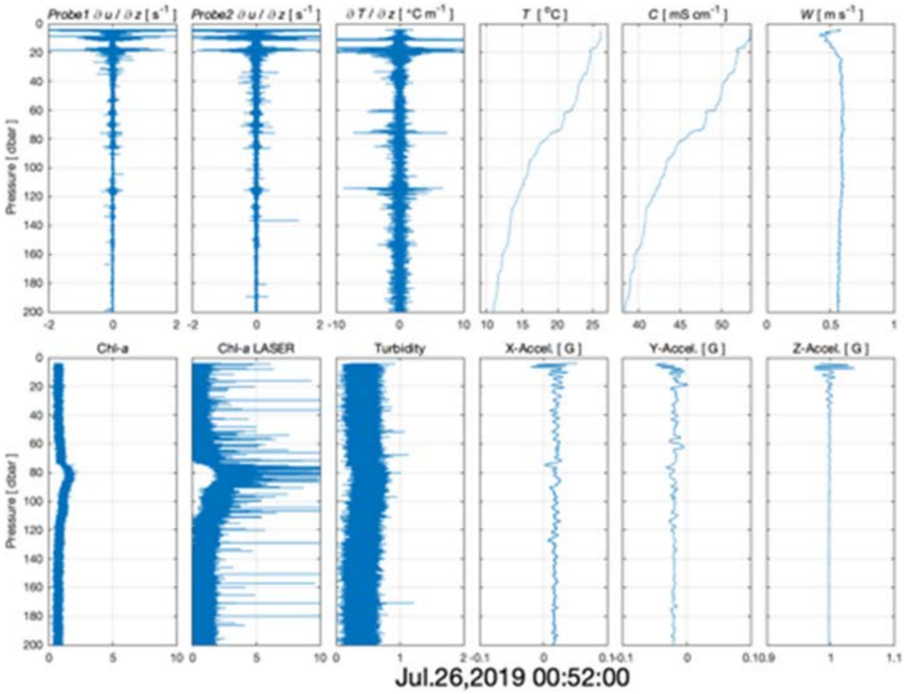


Figure 3.5.1-15. Same as Figure 3.5.1-2 but for cast 14 in July 26.

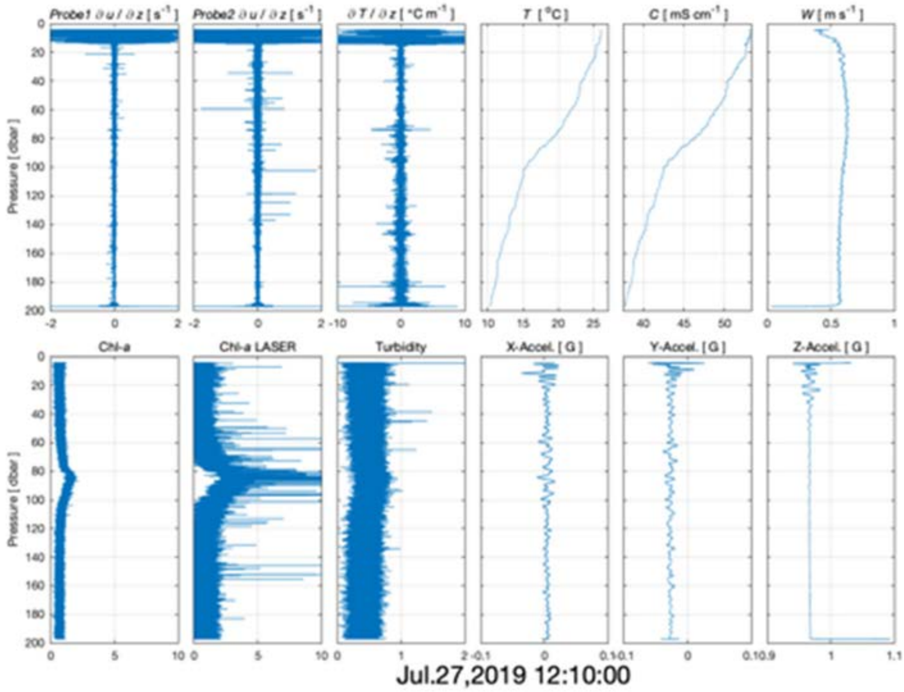


Figure 3.5.1-16. Same as Figure 3.5.1-2 but for cast 15 in July 27.

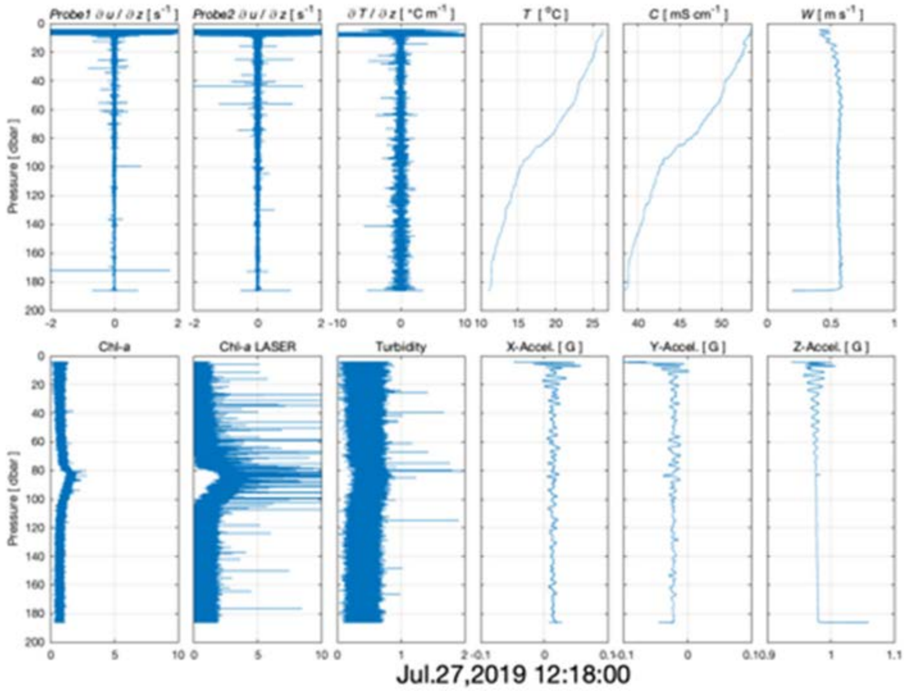


Figure 3.5.1-17. Same as Figure 3.5.1-2 but for cast 16 in July 27.

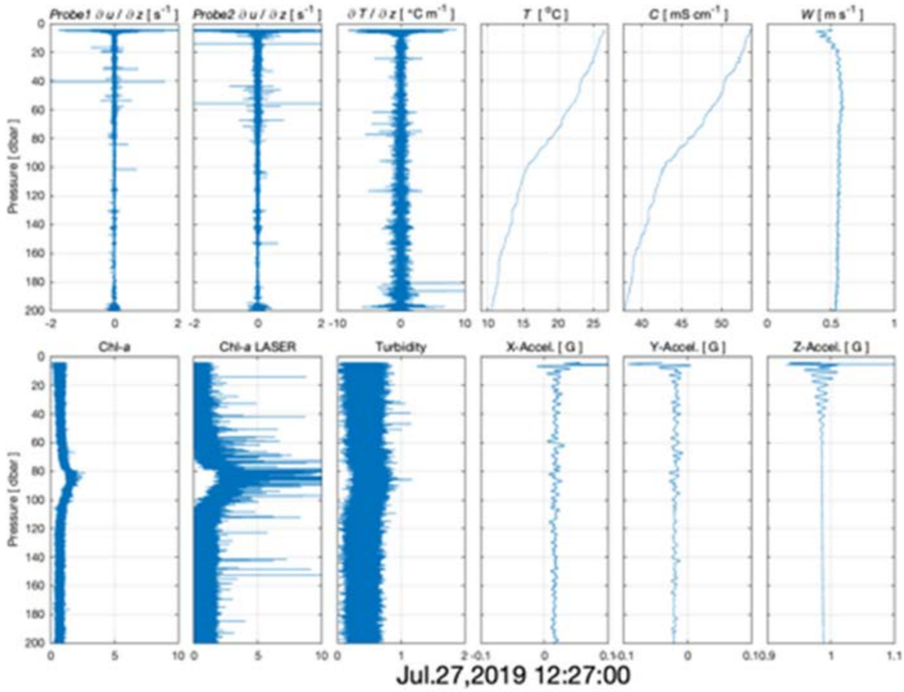


Figure 3.5.1-18. Same as Figure 3.5.1-2 but for cast 17 in July 27.

3.5.2. Underway VMP and RINKO sensors

Takeyoshi Nagai (Tokyo Univ. of Marine Science and Technology)

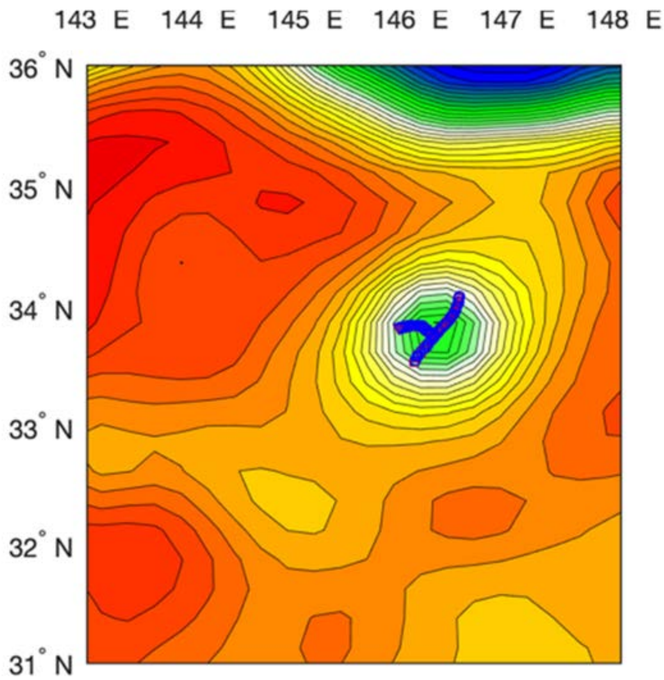


Figure 3.5.2.1 Map of the Underway-VMP and Underway- RINKO observations for (circle) Leg 1, (triangle) Leg2, and (square) Leg3. (blue) indicates Underway- RINKO stations, and (red) represents Underway-VMP stations.

3.5.2-1 Underway-VMP

Underway-VMP (UVMP) consists of a vertical freefall type microstructure profiler, VMP250 (Rockland Scientific International) and an Underway-CTD (UCTD) winch (Teledyne Oceanscience). The VMP250 carries two shear probes, two FP07 thermistors, a CT sensor (JFE-Advantech), an accelerometer, and pressure sensor. It measures microstructure data including turbulent shear and high resolution temperature at 512 Hz, and CTD data at 64Hz. The UVMP observations are conducted by tow-yoing the VMP250 with the UCTD winch.

In this cruise, three sets of UVMP and URINKO observations were carried out from the center of the cyclonic eddy toward its outside (Table 3.5.2.1-3 and Figure 3.5.2.1).

Table 3.5.2.1 time and locations of the Underway-VMP for Leg 1,

% KH19-4 2019 UVMP Leg1									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	23	19	47	33	45.555	146	15.222
2	2019	7	23	20	13	33	46.472	146	16.213
3	2019	7	23	20	40	33	47.669	146	17.399
4	2019	7	23	21	7	33	48.88	146	18.572
5	2019	7	23	21	35	33	50.155	146	19.885
6	2019	7	23	22	3	33	51.405	146	21.234
7	2019	7	23	22	31	33	52.677	146	22.534
8	2019	7	23	22	58	33	53.879	146	23.684
9	2019	7	23	23	25	33	54.918	146	24.67
10	2019	7	23	23	52	33	56.011	146	25.742
11	2019	7	24	0	19	33	57.367	146	26.499
12	2019	7	24	0	45	33	58.744	146	27.154
13	2019	7	24	1	11	34	0.169	146	27.322
14	2019	7	24	1	38	34	1.594	146	28.424
15	2019	7	24	2	4	34	3.137	146	28.844
16	2019	7	24	2	31	34	4.665	146	29.129

Table 3.5.2.2 time and locations of the Underway-VMP for Leg 2.

% KH19-4 2019 UVMP Leg2									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	27	21	4	33	45.236	146	14.721
2	2019	7	27	21	32	33	46.391	146	13.172
3	2019	7	27	21	57	33	47.424	146	11.925
4	2019	7	27	22	21	33	48.332	146	10.755
5	2019	7	27	22	45	33	49.193	146	9.588
6	2019	7	27	23	8	33	49.838	146	8.526
7	2019	7	27	23	33	33	50.595	146	7.544
8	2019	7	27	23	37	33	51.187	146	6.54
9	2019	7	28	0	20	33	51.526	146	5.424
10	2019	7	28	0	44	33	51.515	146	4.055
11	2019	7	28	1	8	33	51.401	146	2.516
12	2019	7	28	1	32	33	51.2	146	1.1
13	2019	7	28	1	58	33	50.926	145	59.639
14	2019	7	28	2	25	33	50.597	145	58.07
15	2019	7	28	2	50	33	50.259	145	56.634
16	2019	7	28	3	15	33	49.955	145	55.262

Table 3.5.2.3 time and locations of the Underway-VMP for Leg 3.

% KH19-4 2019 UVMP Leg3									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	28	22	10	33	44.715	146	14.533
2	2019	7	28	22	56	33	44.286	146	13.117
3	2019	7	28	23	39	33	41.878	146	11.812
4	2019	7	29	0	23	33	40.461	146	10.489
5	2019	7	29	1	6	33	38.959	146	9.008
6	2019	7	29	1	51	33	37.406	146	7.503
7	2019	7	29	2	35	33	35.788	146	5.967
8	2019	7	29	3	1	33	34.696	146	5.144
9	2019	7	29	3	45	33	32.622	146	3.913

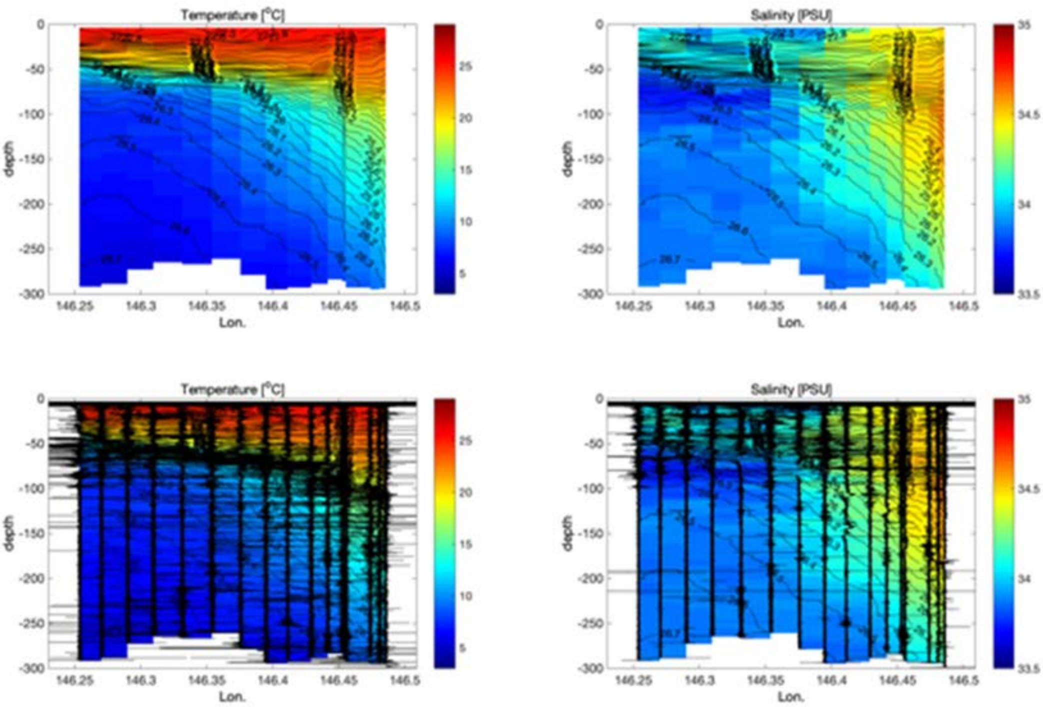


Figure 3.5.2.2 Color shows vertical sections of (left) temperature and (right) salinity measure with Underway-VMP in Leg 1. Black plots in bottom panels show turbulent shear data obtained with (left) shear #1 probe, and (right) shear#2 probe.

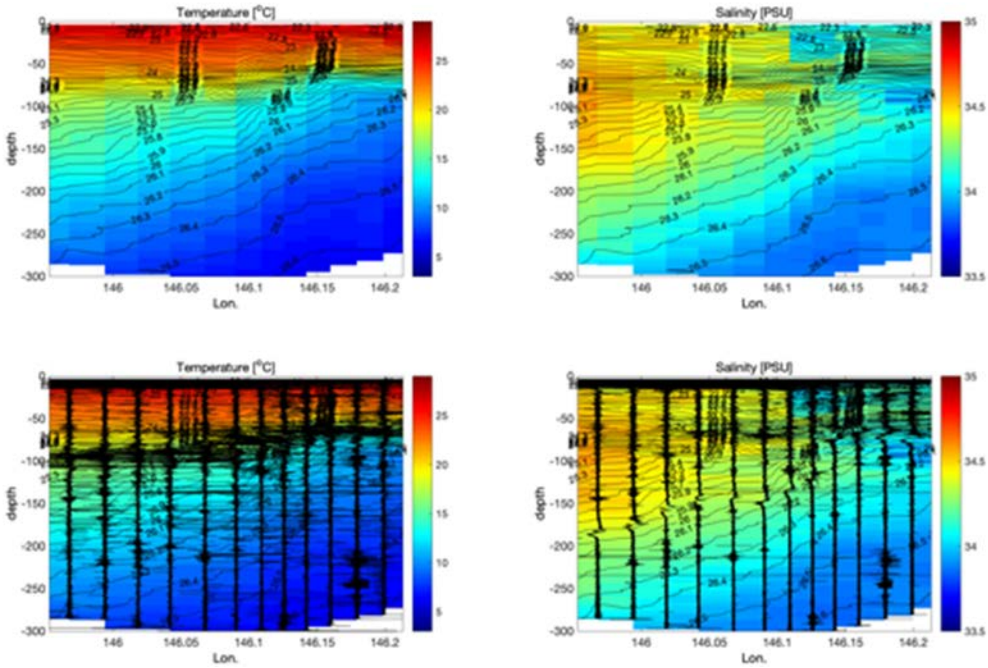


Figure 3.5.2.3 Same as Figure 3.5.2.2 but for Leg 2.

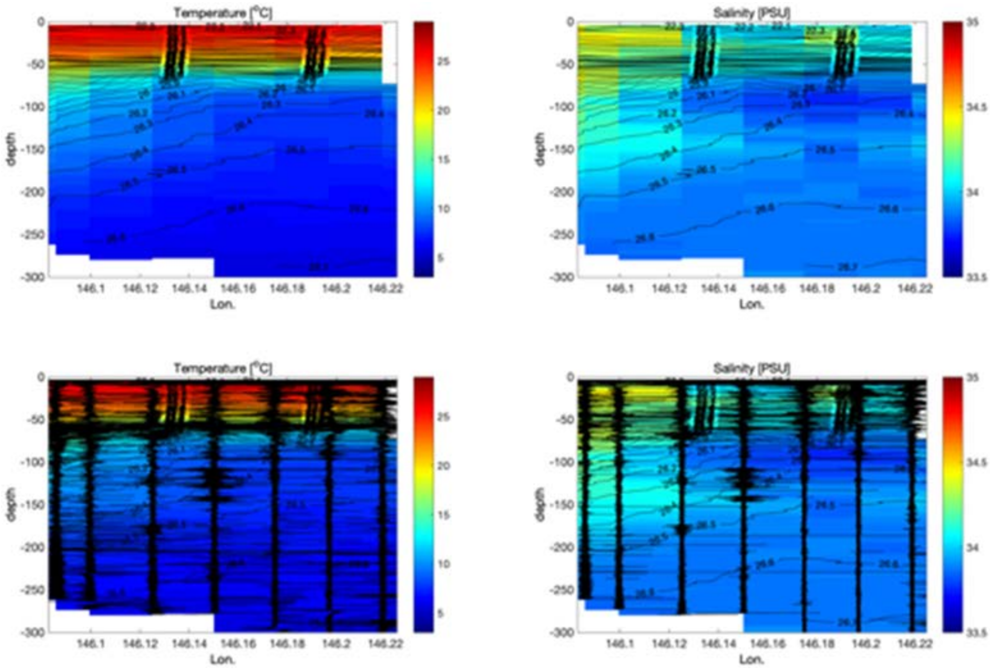


Figure 3.5.2.4 Same as Figure 3.5.2.2 but for Leg 3.

3.5.2-2 Underway-RINKO

Underway-RINKO (URINKO) consists of a RINKO profiler (JFE-Advantech) and an Underway-CTD (UCTD) winch (Teledyne Oceanscience). The RINKO profiler carries a CTD sensor, a fluorescence and turbidity probe, and a RINKO oxygen sensor. The sampling frequency for these parameters is 10 Hz.

In this cruise, three sets of URINKO observations were conducted with quasi simultaneous UVMP profiling. Observations were conducted from the center of the cyclonic eddy toward its outside (Table 3.5.2.4-6 and Figure 3.5.2.1).

Table 3.5.2.4 Time and locations of the Underway-RINKO for Leg 1.

% KH19-4 2019 URinko Leg1									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	23	20	3	33	46.106	146	15.819
2	2019	7	23	20	30	33	47.206	146	16.945
3	2019	7	23	20	58	33	48.488	146	18.228
4	2019	7	23	21	25	33	49.695	146	19.397
5	2019	7	23	21	53	33	50.97	146	20.724
6	2019	7	23	22	20	33	52.188	146	22.054
7	2019	7	23	22	48	33	53.425	146	23.253
8	2019	7	23	23	15	33	54.534	146	24.281
9	2019	7	23	23	42	33	55.601	146	25.354
10	2019	7	23	0	9	33	56.808	146	26.253
11	2019	7	24	0	35	33	58.24	146	26.934
12	2019	7	24	1	1	33	59.631	146	27.549
13	2019	7	24	1	27	34	1.049	146	28.205
14	2019	7	24	1	54	34	2.523	146	28.706
15	2019	7	24	2	20	34	4.085	146	29.008
16	2019	7	24	2	48	34	5.653	146	29.339

Table 3.5.2.5 Time and locations of the Underway-RINKO for Leg 2.

% KH19-4 2019 URinko Leg2									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	27	21	22	33	45.972	146	13.727
2	2019	7	27	21	47	33	47.037	146	12.367
3	2019	7	27	22	12	33	47.989	146	11.202
4	2019	7	27	22	36	33	48.899	146	10.015
5	2019	7	27	23	0	33	49.599	146	8.881
6	2019	7	27	23	24	33	50.333	146	7.881
7	2019	7	27	23	48	33	50.999	146	6.941
8	2019	7	28	0	12	33	51.432	146	5.836
9	2019	7	28	0	34	33	51.548	146	4.635
10	2019	7	28	0	59	33	51.461	146	3.04
11	2019	7	28	1	24	33	51.285	146	1.624
12	2019	7	28	1	49	33	51.0247	146	0.1653
13	2019	7	28	2	15	33	50.745	145	58.646
14	2019	7	28	2	40	33	50.387	145	57.184
15	2019	7	28	3	6	33	50.067	145	55.775

Table 3.5.2.5 Time and locations of the Underway-RINKO for Leg 3.

% KH19-4 2019 URinko Leg3									
%	Date and Time (JST)					Latitude		Longitude	
%#	Year	Month	Day	Hour	Min	deg	min	deg	min
1	2019	7	28	22	0	33	44.999	146	14.778
2	2019	7	28	22	47	33	43.55	146	13.37
3	2019	7	28	23	32	33	42.011	146	11.932
4	2019	7	29	0	15	33	40.76	146	10.746
5	2019	7	29	0	58	33	39.277	146	9.325
6	2019	7	29	1	42	33	37.739	146	7.849
7	2019	7	29	2	26	33	36.09	146	6.262
8	2019	7	29	2	52	33	35.112	146	5.416
9	2019	7	29	3	36	33	33.042	146	4.182

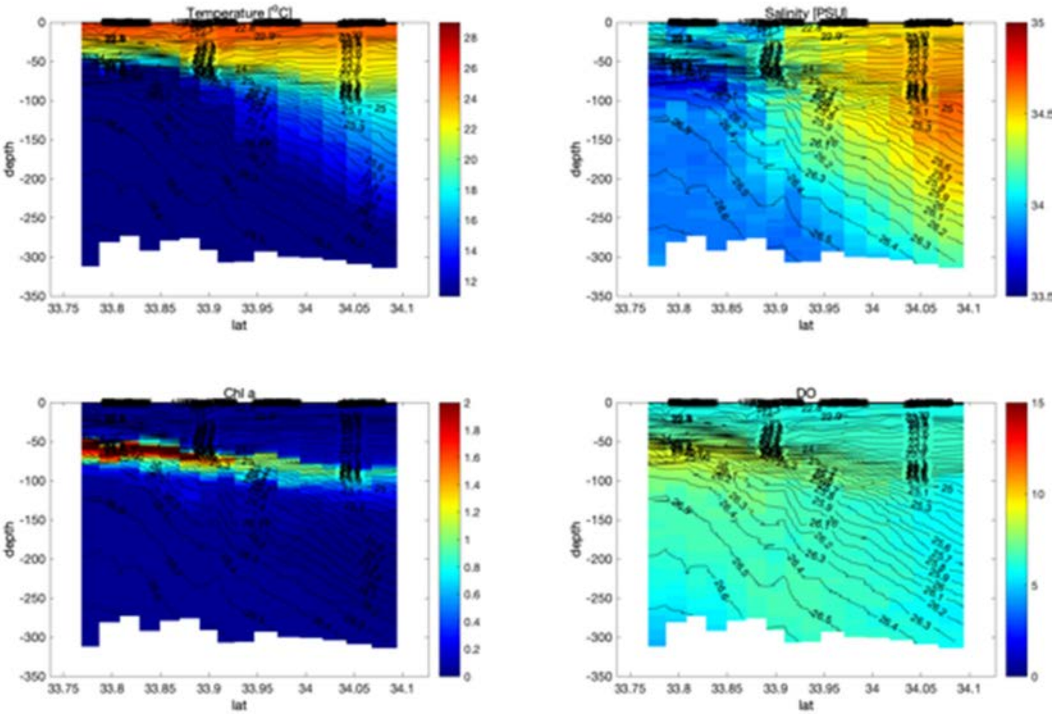


Figure 3.5.2.5 Color shows vertical sections of (upper left) temperature, (upper right) salinity, (lower left) chlorophyll fluorescence [relative], (lower right) dissolved oxygen [relative]. Black contours are sigma-t .

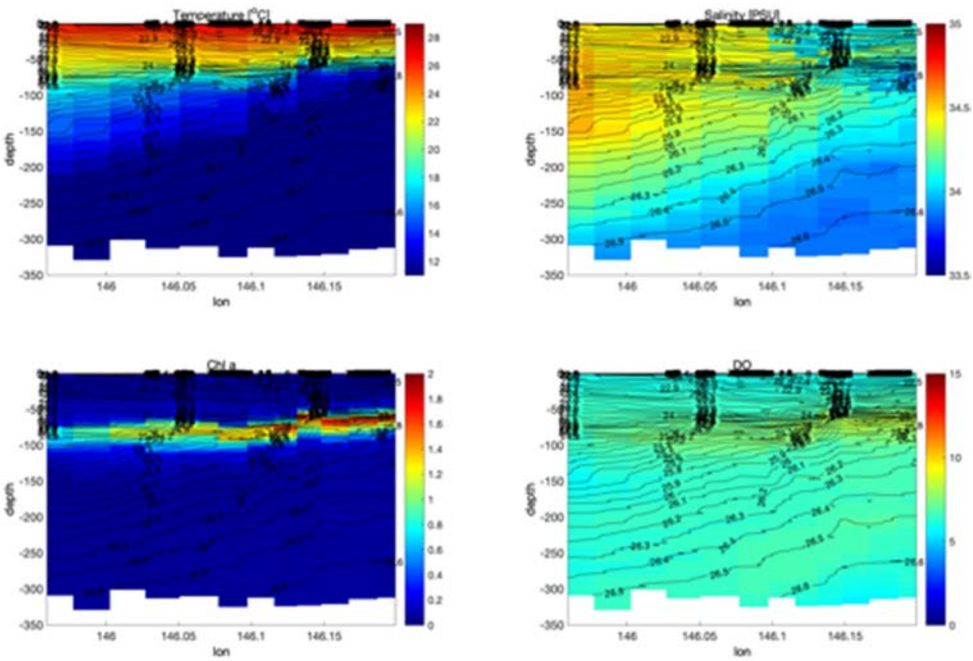


Figure 3.5.2.6 Same as Figure 3.5.2.5 but for Leg 2.

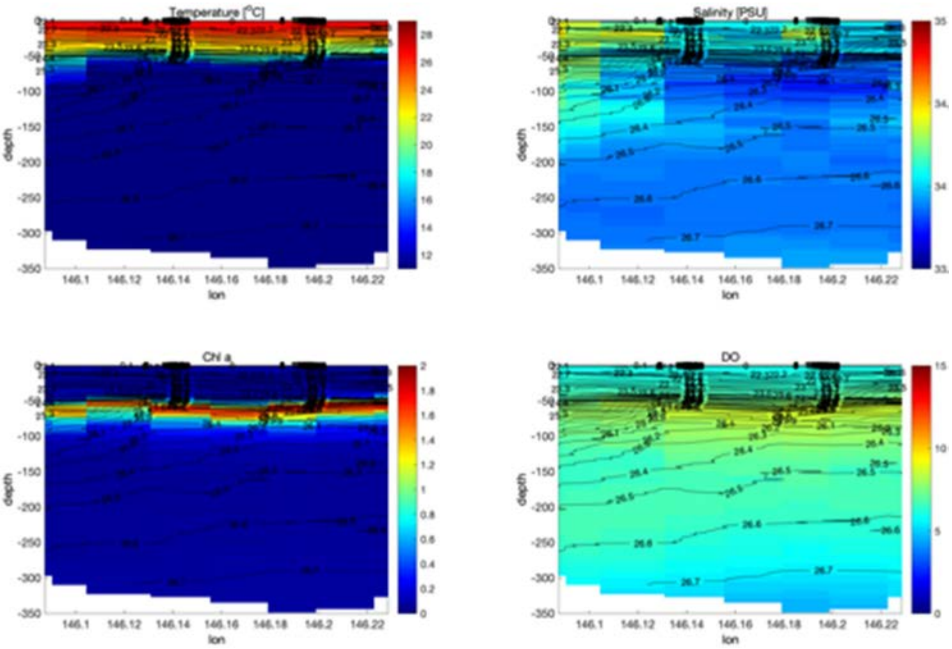


Figure 3.5.2.7 Same as Figure 3.5.2.5 but for Leg 3.

3.6. Influence of turbulence on suspended particles

Hideki Fukuda[1], Takeyoshi Nagai[2] and Hidekatsu Yamazaki[2]*

1: International Coastal Research Center, Atmosphere and Ocean Research Institute, The University of Tokyo, 1-19-8 Akahama, Otsuchi Town, Kamihei County, Iwate Prefecture, 028-1102, Japan
2: Tokyo University of Marine Science and Technology, Department of Ocean Sciences, 4-5-7 Konan, Minato-ku, Tokyo 108-8477, Japan

**Correspondence and requests for materials should be addressed to H. F. (email:).*

Marine aggregate is one of the key components of sinking materials transporting fixed carbon in the surface layer to the ocean interior and the seafloor. Nevertheless microscopic observation on marine aggregates shows that small phytoplankton including cyanobacteria can be incorporated into marine aggregate, transport efficiency of each species to them is not clear. In this study, molecular species composition of eukaryote in 6 different size class of POM (<0.4, 0.4-2, 2-5, 5-20, 20-120 and >120 µm) and particle size distribution (PSD) was examined under different shear intensity in the mixed layer. Species composition of eukaryote was examined by 18S rRNA V9 metabarcoding. POM were collected from two fixed layers (10 and 200 m) at station Hot spot 1 at which high turbulence was observed during the transect observation (Section 3.5.2. "Underway VMP and RINKO sensors") on turbulent dissipation rate in this cruise, in the daytime and in the nighttime. Simultaneously depth profiles of PSD and turbulent dissipation rate from the surface to 200 m were determined by using an *in situ* particle sizing instrument (LISST-100X and LISST-Holo, Sequoia Scientific, USA) and a free-fall microstructure profiler (TurboMAP-L, JFE Advantech Co, Japan).

Additionally, depth profiles of PSD were observed at stations KEO and X4 for comparison with those obtained by a free-fall submersible camera (see Section 3.5.1 "TurboMAP-L") and at station Hot spot 1 for comparison with POC optical observation (see Section "3.9.3. POC optical observation").

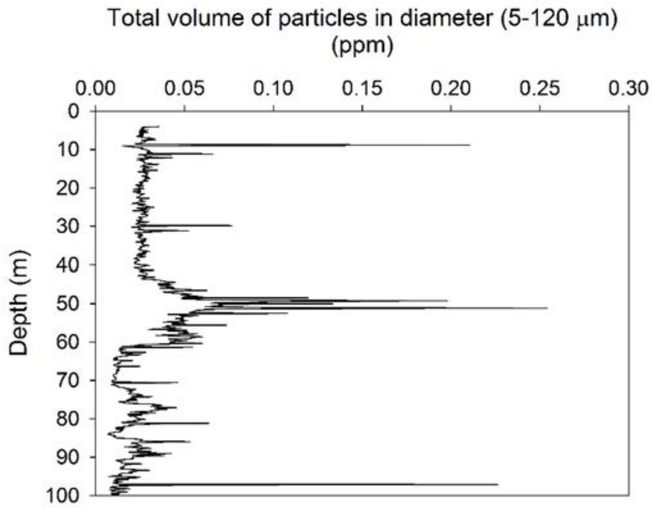


Figure 1. Depth profile of total particle volume at station KEO. Because of overestimation in the upper LISST bins (>120 μm) (Styles, 2006: Mar. Geol., 227: 151–162) and underestimation in the lower LISST bins (<5 μm) (Andrews et al., 2011: Water Resour. Res., 47, W06509), 20 LISST bins (5.2-119 μm) was used for calculation.

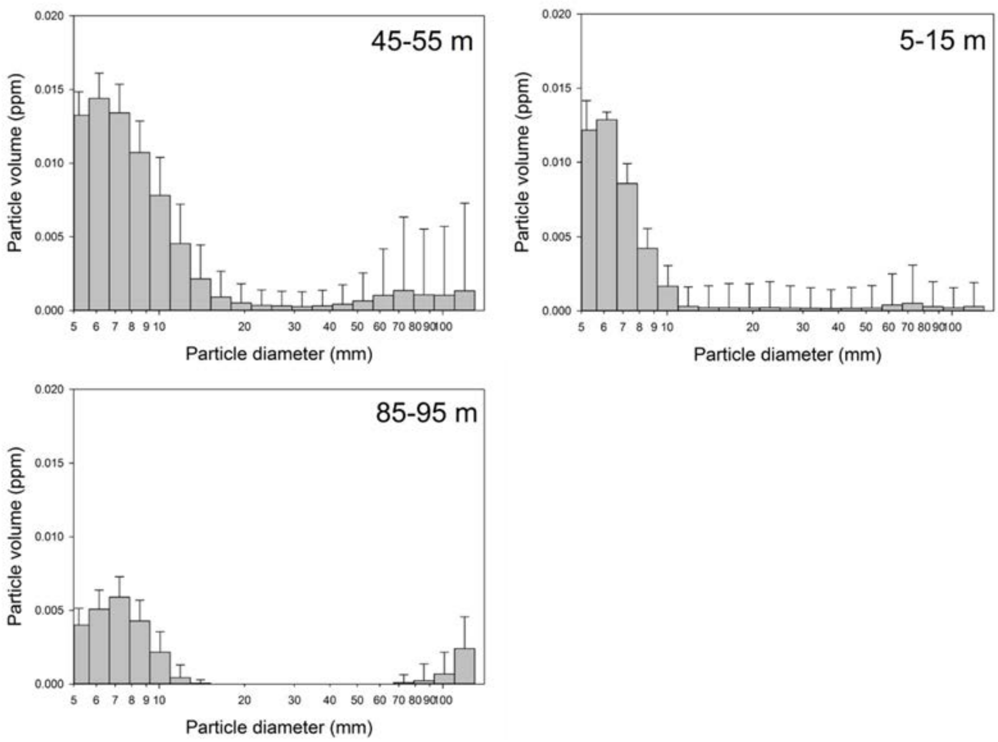


Figure 2. PSD in three selected layers (5-15, 45-55 and 85-95 m) at station KEO. Mean and SE in each LIST bin were estimated from all of data obtained in an each layer (ca. 55 measurements).

3.7. Influence of turbulence on phytoplankton production

Kazuhiko Matsumoto

Research Institute for Global Change (RIGC), Earth Surface System Research Center, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Introduction

To understand the variability of primary productivity depending on the nutrient supply associated with the turbulence, oceanic primary productivity is estimated by the incubation experiments. To characterize the optimal productivity in response to light, the relationship between phytoplankton photosynthetic rate (P) and scalar irradiance (E) are estimated by the P vs. E curve experiment.

Sampling

Seawater samples were collected at the turbulence_HotSpot station around the sub-surface chlorophyll maximum by Niskin bottles attached acid-cleaned O-ring, and by a bucket at the surface. Bucket sampling of seawater was also conducted at the station KEO. Seawater samples were transferred into the acid-cleaned, transparent bottles. Seawater sampling and subsequent filtration procedure for use in high performance liquid chromatography were also conducted to estimate the phytoplankton taxonomic composition.

P vs. E curve experiment

Just before the incubation, $NaH^{13}CO_3$ was added to each bottle at a final concentration of 0.2 mM, sufficient to enrich the bicarbonate concentration by about 10%. Additionally, to estimate the impact of nutrient supply via the aerosol, nutrient addition experiments of $K^{15}NO_3$ or $(^{15}NH_4)_2SO_4$ were conducted at the KEO. Three incubators were filled with water, and water temperature was controlled appropriately by circulating water coolers. Each incubator was illuminated at one end by a 500W halogen lamp, and bottles were arranged linearly against the lamp and controlled light intensity by shielding with a neutral density filter on lamp side. Incubations for the P vs. E curve experiment were conducted during daytime for 3 h.

Measurement

After the incubation, water samples were immediately filtered through a pre-combusted GF/F filter, then the filters were dehydrated in a dry oven (45 ºC), and the remained inorganic carbon in the filter was removed by fuming HCl. The ^{13}C and ^{15}N content of the particulate fraction will be measured with a stable isotope ratio mass spectrometer (Sercon, Ltd.) based on the method of Hama et al. (1983) after the cruise. The analytical function and parameter values used to describe the relationship between the photosynthetic rate (P) and scalar irradiance (E) are best determined using a least-squares procedure from the following equation (Platt et al., 1980).

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

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.

References

Hama T, Miyazaki T, Ogawa Y, Iwakuma T, Takahashi M, Otsuki A, Ichimura S (1983) Measurement of photosynthetic production of a marine phytoplankton population using a stable ^{13}C 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.

3.8. Influence of turbulence on spatial distribution of zooplankton

Minoru Kitamura (JAMSTEC)
Kazuo Amakasu (Tokyo Univ. of Marine Science and Technology) (not onboard)
Hongsheng Bi (Chesapeake Biological Laboratory, Univ. of Maryland) (not onboard)

To understand influence of the small-scale flow field on the zooplankton, fine-scale vertical distribution of zooplankton was investigated by using acoustical and optical methods. As the acoustical method, we used Acoustic zooplankton and Fish Profiler (AZFP) and shipboard ADCP. Setup parameters of the AZFP deployment is summarized in Table 3.8-1. A small depth sensor (DEFID-II, JFE Advantech Co. Ltd.) and a micro CTD (RINKO Profiler, ASTD100, JFE Advantech Co. Ltd.) were attached to the AZFP frame. From the vertical cast of the AZFP, we can observe vertical distribution of backscattering strength (a proxy of zooplankton biomass) in one meter resolution. Total four deployments of the AZFP was carried out during the cruise (Table 3.8-2), and three of the four deployments (except a cast at the station X8) were conducted just after/before the turbulence observations by using Turbo-MAP. During the AZFP deployment, shipboard ADCP observation was suspended to avoid interference of sound wave between AZFP and ADCP. Cable release and heaving speed were 1.0 and 0.1 m/sec, respectively. Maximum depth of the AZFP cast was 150 m. Horizontal distribution of zooplankton will also investigate by using continuous data of shipboard ADCP. Frequency of the ADCP was 38 kHz and bin size in this acoustical sampling was 16 m. This vertical resolution was more fine compared with distribution observation by net samplings. Details of the shipboard ADCP observation was described in the section 3.3.

Table 3.8-1. Setup parametrs of AZFP

	units	
Burst interval	s	0.02
Ping period	s	1
Pulse length	ms	300
Digitization rate	kS s-1	20
Nubmer of pings per burst	pings	1
Average burst pings		no
Bin averaging	m	1
Lockout	m	0
Fdeployment file		15091_KARE19.mfawcpl
Cnfiguration file		55050_151209.cfg

Table 3.8-2. List of AZFP deployments

Stn.	Cast ID	Date (yyyy/mm/dd) and Time				Position		Max. depth	Remarks
		SMT		UTC		Lat. (N)	Long. (E)	(m)	
KEO	AZFP-1	2019/7/22	1:04	2019/7/21	16:04	32° 15.379'	144° 27.080'	148	without mCTD
Hot Spot	AZFP-2	2019/7/27	1:19	2019/7/26	16:19	33° 55.891'	146° 16.562'	150	
Hot Spot	AZFP-3	2019/7/27	10:56	2019/7/27	1:56	33° 52.495'	146° 19.592'	151	
X8	AZFP-4	2019/7/27	16:04	2019/7/27	7:04	34° 00.282'	146° 27.930'	149	

As the optical method, we deployed Visual Plankton recorder (VPR). The VPR captures images 15 frames per second, and field of view of the image was 14 x 14 x 23 mm (visual field setting; S1), giving an image volume of 4.5 mL. At the station KEO, the VPR was vertically casted up to 200 m in depth as a test. Both cable release and heaving speeds were 0.2 m/sec. After that, two tows of the VPR were carried out along parts of the underway MVP and RINKO transects (Legs 1 and 2, see section 3.5.2) in the cyclonic eddy area. The VPR was towed from stern of the vessel at a speed of about 2 knot, and continuously lowered and raised seven times between the surface and about 80–130 m in depth. Total distances of the VPR tows were 5.0 and 4.6 miles in the leg 1 and 2, respectively. Before the deployment of VPR in the leg 1, we changed batteries because there was a trouble in the power supply (flashlights went off within 2 minutes after turning on). Although two batteries (battery cases) were connected in series during the VPR deployment in the station KEO and leg 1, power supply from one of the battery cases seemed to be unstable. Thus, after the recovery of VPR from the leg 1, we removed the battery case. At recovery of the VPR in the leg 2 (about two hours after the deployment), flashlight was also stopped. And along the leg 3 in the cyclonic eddy area, we towed underway RINKO sensor, underway VMP (turbulence sensor), and VPR in turns. Vessel and cable speeds were same as deployment in the leg 1 and 2. Total distance of the VPR observation along the leg 3 was about 6.8 miles. Among the three tows of the VPR, first two tows were carried out during the day and the final one was conducted during the night.

Table 3.8-3. List of VPR deployment

Stn/leg	Cast	Date (SMT)	Start			Finish			Distance	Max. depth	Remarks
			Time (SMT)	Lat. (N)	Long. (E)	Time (SMT)	Lat. (N)	Long. (E)	(miles)	(m)	
KEO		2019/7/22	0:18	32º 16.449'	144º 26.542'	0:56	32º 15.554'	144º 26.968'			
Leg 1	Leg1_1	2019/7/27	7:35	33º 46.343'	146º 16.161'	7:58	33º 46.990'	146º 16.780'	0.8	129	
	Leg1_2	2019/7/27	7:58	33º 46.990'	146º 16.780'	8:25	33º 47.885'	146º 17.687'	1.2	108	
	Leg1_3	2019/7/27	8:25	33º 47.885'	146º 17.687'	8:41	33º 48.404'	146º 18.227'	0.7	83	
	Leg1_4	2019/7/27	8:41	33º 48.404'	146º 18.227'	8:58	33º 48.912'	146º 18.727'	0.7	86	1
	Leg1_5	2019/7/27	8:58	33º 48.912'	146º 18.727'	9:09	33º 49.293'	146º 19.088'	0.5	86	
	Leg1_6	2019/7/27	9:09	33º 49.293'	146º 19.088'	9:21	33º 49.691'	146º 19.446'	0.5	85	2
	Leg1_7	2019/7/27	9:21	33º 49.691'	146º 19.446'	9:38	33º 50.201'	146º 19.729'	0.6	87	
Leg 2	Leg2_1	2019/7/28	15:51	33º 45.078'	146º 14.846'	16:08	33º 45.348'	146º 14.487'	0.4	98	
	Leg2_2	2019/7/28	16:08	33º 45.348'	146º 14.487'	16:24	33º 45.880'	146º 13.785'	0.8	95	
	Leg2_3	2019/7/28	16:24	33º 45.880'	146º 13.785'	16:42	33º 46.380'	146º 13.179'	0.7	92	
	Leg2_4	2019/7/28	16:42	33º 46.380'	146º 13.179'	17:00	33º 46.799'	146º 12.650'	0.6	94	
	Leg2_5	2019/7/28	17:00	33º 46.799'	146º 12.650'	17:18	33º 47.322'	146º 11.994'	0.8	89	
	Leg2_6	2019/7/28	17:18	33º 47.322'	146º 11.994'	17:35	33º 47.788'	146º 11.438'	0.7	89	
	Leg2_7	2019/7/28	17:35	33º 47.788'	146º 11.438'	17:54	33º 48.217'	146º 10.856'	0.6	92	3
Leg 3	Leg3_1	2019/7/28	22:25	33º 44.244'	146º 14.057'	22:46	33º 43.559'	146º 13.387'	0.9	94	
	Leg3_2	2019/7/28	23:10	33º 42.764'	146º 12.660'	23:30	33º 42.009'	146º 11.930'	1.0	84	
	Leg3_3	2019/7/28-29	23:55	33º 41.379'	146º 11.324'	0:14	33º 40.761'	146º 10.744'	0.8	96	
	Leg3_4	2019/7/29	0:36	33º 39.884'	146º 09.912'	0:58	33º 39.291'	146º 09.335'	0.8	87	
	Leg3_5	2019/7/29	1:23	33º 38.360'	146º 08.415'	1:41	33º 37.738'	146º 07.844'	0.8	88	
	Leg3_6	2019/7/29	2:07	33º 36.740'	146º 06.835'	2:26	33º 36.076'	146º 06.248'	0.8	61	4
	Leg3_7	2019/7/29	3:17	33º 33.909'	146º 04.628'	3:35	33º 33.091'	146º 04.198'	0.9	92	
	Leg3_8	2019/7/29	4:03	33º 31.706'	146º 03.376'	4:19	33º 30.974'	146º 03.020'	0.8	90	

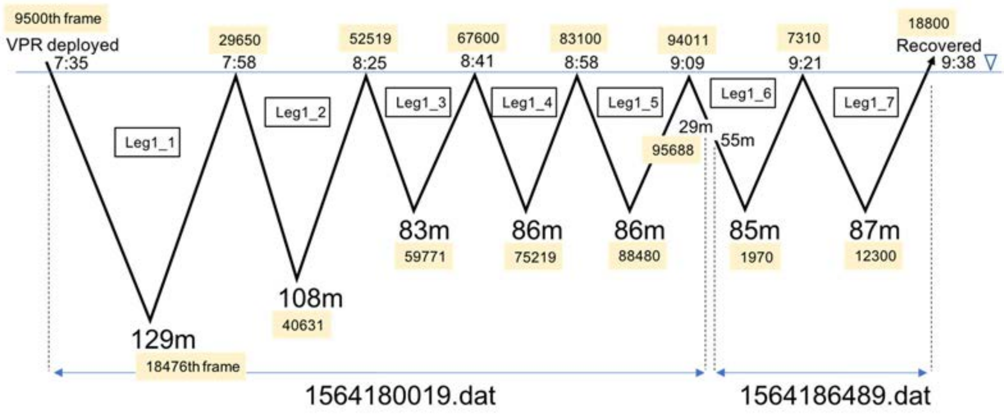
1) flashing light and shooting image was not synchronized after about 80000th frame

2) data record was stopped and restarted at 29 and 55 m, respectively, during the downcast

3) data record was stopped at 23 m during the upcast

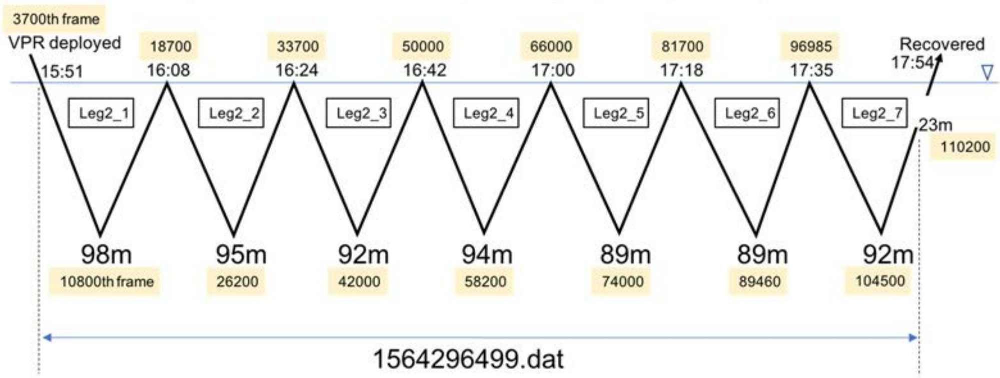
4) data record was stopped at 61 m during the downcast

Schematic diagram of VPR tow along the leg 1 (27 July, 2019)



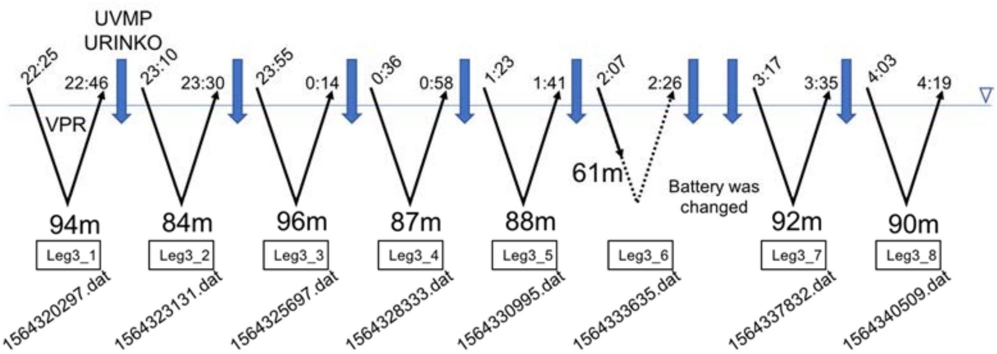
Data record was stopped at 29 m but automatically restarted at 55 m during the cast 6
Flashlights and shooting images were not synchronized after about 80000th frame

Schematic diagram of VPR tow along the leg 2 (28 July, 2019)



Data record was stopped at 23 m during the cast 7

Schematic diagram of VPR tow along the leg 3 (28-29 July, 2019)



Data record was stopped at 61 m during the cast 6
Sunrise was in 4:33

3.9. Other studies for suspended particles

3.9.1. In situ filtration

Makio Honda[1] and Yoshihisa Mino[2] (onboard)*
[1]Japan Agency for Marine-Earth Science and Technology, 2-15 Natushima-cho, Yokosuka, Kanagawa 237-0061, Japan,
[2]Institute for Space-Earth Environmental Research, Nagoya University, Nagoya 464-8601, Japan
**Correspondence and requests for materials should be addressed to M. H. (email:).*

We deployed in situ large volume filtration system (McLane WTS-LVP) at station KEO to measure organic and inorganic carbon, pigments as well as isotopic compositions in the suspended particles. In situ pump filtering was conducted at multi-layers as shown in Table 1.

Table 1. Setting for in situ filtration.

Date & station	Depth (m)	Filtration rate (L)	Filters	Measurements	PI
2019/07/22	50	615	GF/F, 300 μm mesh	POC, PIC, Pigments,	Honda, Mino,
KEO	100	561	GF/F, 300 μm mesh	$\delta^{13}C$, $\delta^{15}N$	Mino
	200	710	GF/F, 300 μm mesh		
	1700	713	GF/F, 300 μm mesh		
	1700	474	GF/F, 300 μm mesh		
	2700	720	GF/F, 300 μm mesh		

Total carbon (TC) and organic carbon (OC) of the particles on GF/F are measured by using an elemental analyzer (EA) at JAMSTEC. Inorganic carbon is determined from the difference between the TC and OC. Phytoplankton pigments are analyzed with an HPLC modular system. Carbon and nitrogen stable isotope ratios of particulate organic matters are measured by using an EA combined with a continuous flow isotope-ratio mass spectrometer at Nagoya University.

3.9.2. Particulate organic matters

Chiho Sukigara
Tokyo University of Marine Science and Technology, 4-5-6, Konan, Minato-ku, Tokyo 108-8477, Japan,
email:

Water samples for measurement of particulate organic carbon (POC) and nitrogen (PN) in suspended particles were taken from 3 stations (cast#4 near KEO, cast#8 near BGC Argo float, cast#26 at X4 as the center of the cyclonic eddy). Sampling depths and water weights were shown in Table 3.9.2-1 to 3.9.2-3. Seawater samples were filtered through pre-combusted glass filters (GF/F with 47 mm diameter, Whatman). The filters were kept in freezer (-20 ^{o}C) until analysis on shore. In the laboratory on shore, suspended particles collected on filters will be exposed in HCl fume for 12 hours to remove carbonates, dried in vacuum, and pelletized with a tin foil to measure POC and PN using an elemental analyzer (EA1000, Carlo Elba, or FlashEA1112, Parkin Elmer).

Table 3.9.2-1

Cast #4	2019/7/22	
Niskin #	Depth (m)	Water weight (kg)
1	2000	-
2	2000	-
3	2000	8.95
4	1500	9.35
5	1250	10.10
6	1000	9.20
7	800	7.70
8	700	7.85
9	600	8.90
10	500	10.35
11	450	9.30
12	400	7.90
13	350	9.85
14	300	8.35
15	250	10.45
16	200	9.30
17	175	9.10
18	150	10.35
19	125	9.95
20	100	9.80
21	75	10.35
22	50	10.30
23	25	8.40
24	10	7.50
Surface	0	7.15

Table 3.9.2-2

Cast #8	2019/7/24	
Niskin #	Depth (m)	Water weight (kg)
1	2000	7.80
2	1750	7.55
3	1500	8.30
4	1250	10.10
5	1000	9.15
6	900	10.25
7	800	7.75
8	700	8.30
9	600	7.80
10	500	8.85
11	400	9.15
12	300	9.65
13	250	8.20
14	200	8.15
15	175	7.60
16	150	7.30
17	125	7.90
18	100	8.50
19	75	9.50
20	50	8.10
21	40	9.25
22	30	9.25
23	20	8.95
24	10	9.30
Surface	-	-

Table 3.9.2-3

Cast #26	2019/7/28	
Niskin #	Depth (m)	Water weight (kg)
1	2000	9.20
2	1750	10.40
3	1500	10.20
4	1250	10.20
5	1000	10.00
6	900	10.75
7	800	10.75
8	700	9.50
9	600	10.75
10	500	7.80
11	400	10.15
12	300	9.90
13	250	9.85
14	200	10.20
15	175	10.20
16	150	10.45
17	125	10.80
18	100	9.85
19	75	9.95
20	50	10.40
21	40	10.40
22	30	9.45
23	20	9.80
24	10	8.45
Surface	-	-

3.9.3. POC optical observation

Makio HONDA (JAMSTEC RIGC)
Yoshihisa MINO (Nagoya University)
Chiho SUKIGARA (Tokyo University of Marine Science and Technology)
Hiroki USHIROMURA (MWJ)

(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. However, 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 settling particles, mainly particulate organic carbon (POC), optically, backscatter meters were deployed during this cruise. Main purpose was that data obtained by backscatter meter (pressure, temperature, chlorophyll and backscatter) are compared with data obtained by well-calibrated CTD and onboard-measured chlorophyll and land-measured POC data and to propose empirical equation.

(2) Instruments and methods

1) Backscatter meter

Principal specification of backscatter meters (BS) used during this cruise are as follows:

Maker	model	S/N	Max depth (m)	Depth sensor	Temp	Fluorometer	Backscatter bbp470	Backscatter bbp700
Wetlab	Eco Triplet	905	600	O	O	O	O	O
Seabird Sci.	FLBBSB	5172	300	-	-	O	-	O
Seabird Sci.	FLBBSB	5175	300	-	-	O	-	O
Seabird Sci.	BBSB	1741	300	-	-	-	-	O

These BSs were installed on carousel water sampling system with CTD (Photo 1) and in situ filtration system (McLane WTS-LV) (Photo 2).

2) Underwater video camera

Underwater video camera (UVC) consists of Raspberry Pi camera module / computer circuit system and transparent pressure hull (maximum depth: 200 m). This UVC and underwater light were developed by Dr. Kazumasa Oguri from JAMSTEC. This UVC camera was installed on in situ filtration system (McLane LVP) (photo 2).

(3) Preliminary result

1) Comparison of chlorophyll and backscatter data between sensors

When backscatter sensors were installed on CTD water sampling system and deployed, chlorophyll data and backscatter meter data that were obtained at water sampling depths were compared (Fig.1). In general, chlorophyll data between sensors correlated well (Fig. 1 left). On the other hand, although backscatter meter data between sensors correlated positively, correlation coefficient were lower than that for chlorophyll and respective intercepts were different (Fig. 1 right).

2) Vertical profiles in chlorophyll and backscatter data

Sensors were deployed three times (cast #3, cast #12, cast #20) when shallow water sampling upper 200 m for measurement of primary productivity were conducted (Fig.2). Every vertical profile shows that subsurface chlorophyll maximum appeared at around 80 m and backscatter data also increased. It is notable that backscatter meter data for S/N T905 (left panel in the low layer) were very “noisy” or “spiky”. This reason is open question.

(3) Future plan

Chlorophyll and backscatter meter data will be compared with onboard-measured chlorophyll a data and land-measured POC data, respectively.

(4) Data archive

These obtained data will be submitted to JAMSTEC Data Management Group (DMG) or will be opened on original data base.

Funding

This observation is financially supported by MEXT KAKENHI: grant-in-aid for scientific research “Mathematization of POC vertical attenuation by using optical method: Proposition of Martin curve in the Western Pacific Ocean”.

Photo: backscatter meters on water sampling system (upper panel), backscatter meters and underwater video camera on in situ pumping system (lower panel).

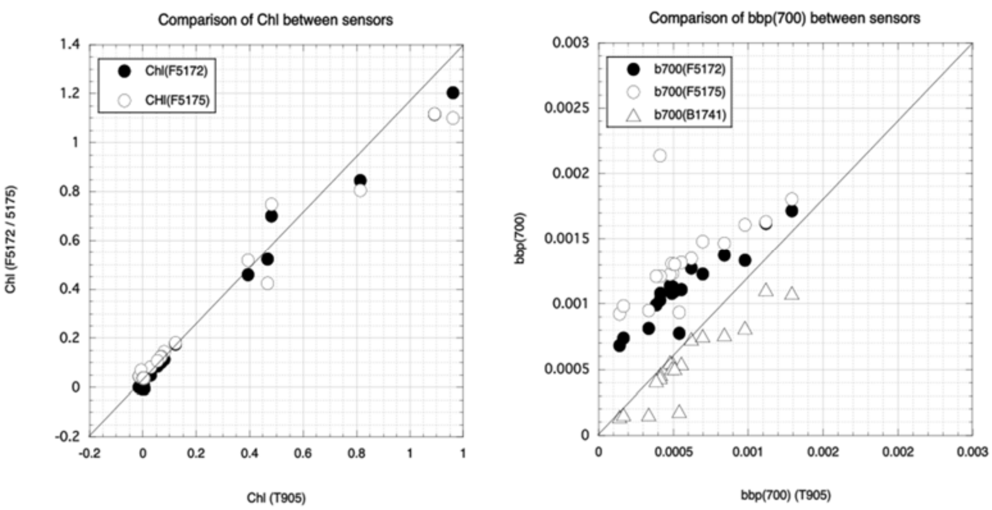


Fig.1 Comparison of chlorophyll (left) and backscatter meter data (right) between sensors

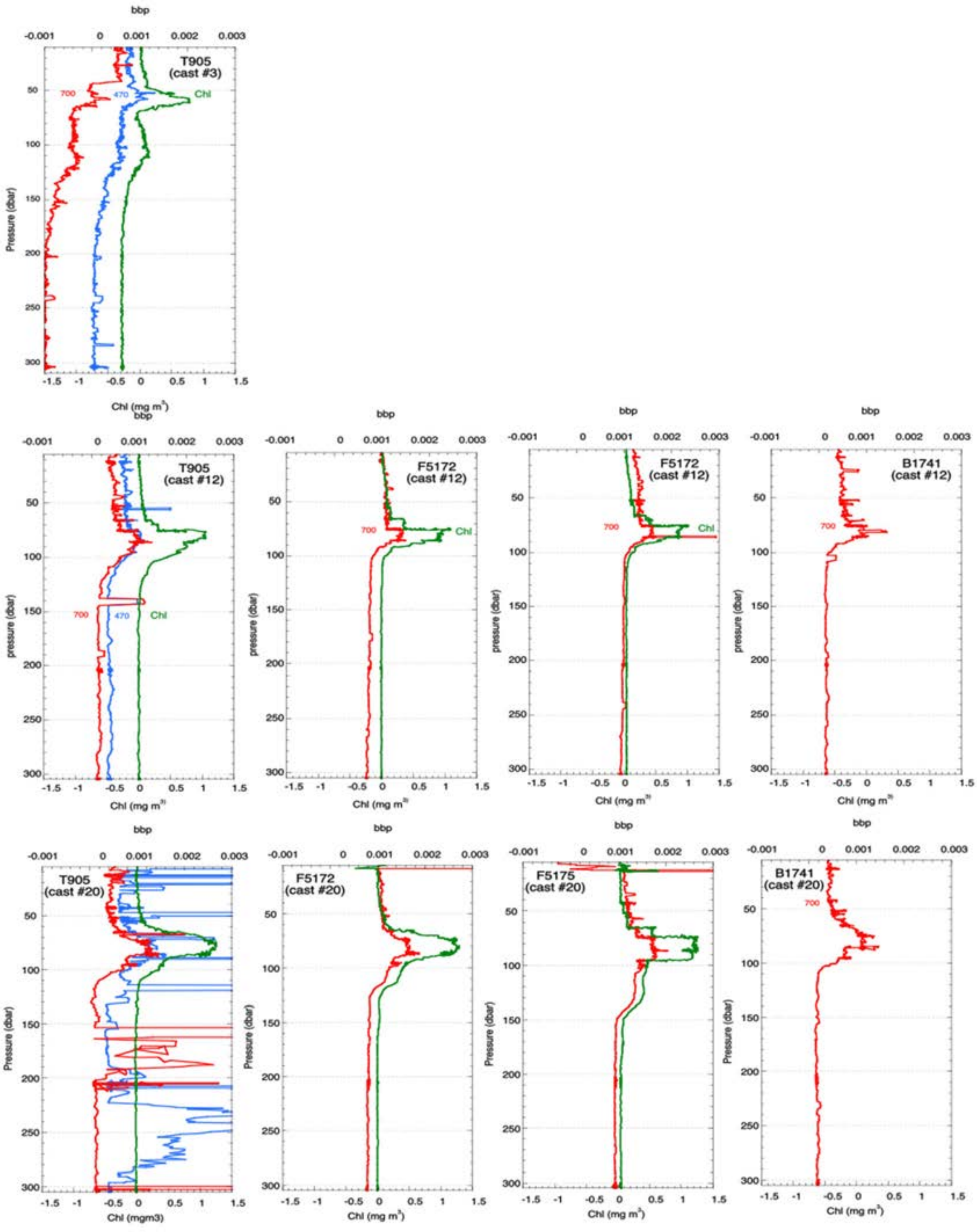


Fig. 2 Vertical profiles in chlorophyll and backscatter data for cast #3 (top layer), cast #12 (middle layer) and cast #20 (bottom layer) for respective sensors.

3.10. Other phytoplankton studies

3.10.1. Phytoplankton physiological parameters by using a fast repetition rate fluorometer

Yoshihisa Mino[1], Naho Miyazaki[2] (onboard)*
Institute for Space-Earth Environmental Research, Nagoya University, Nagoya 464-8601, Japan
Department of Ocean Sciences, Tokyo University of Marine Science and Technology, Tokyo 108-8477, Japan

**Correspondence and requests for materials should be addressed to Y. M. (email:).*

Physiological parameters including the maximum photochemical quantum efficiency (F_V/F_M) and the functional absorption cross section of PSII (σ_{PSII}) were measured using a fast repetition rate (FRR) fluorometry. At three stations, KEO, HS, and X4 in the nighttime, we deployed a submersible FRR fluorometer (DF-14, Kimoto Electric) in profiling mode using a stand-alone frame to 150–200 m depth at a speed of 0.2 m s^{-1}. In addition, this active fluorescence measurement was performed on discrete samples that collected by Niskin bottles attached to CTD-RMS (cast# 3, 5, 11, 12, and 20) by using another FRR fluorometer in bench-top mode. These samples were left in the dark for >2 h before measurement to eliminate the influence of nonphotochemical quenching.

3.10.2. TEP

Naho Miyazaki (Tokyo Univ. of Marine Science and Technology) (onboard)

Department of Ocean Sciences, Tokyo University of Marine Science and Technology, Tokyo 108-8477, Japan

Correspondence and requests for materials should be addressed to N. M. (email:).

Although the importance of TEP (Transparent Exopolymer Particle) in the oceanic carbon cycle is widely accepted, little is known about the diversity of microorganisms attached to natural TEP. We report the characteristics of TEP microbes' communities stained with Alcian Blue under a light microscope for seawater samples taken from the surface chlorophyll maxima at three stations, KEO, HS, and X4. Seawater sample was collected from Niskin bottles attached to CTD-RMS and screened through a 10 µm Nylon mesh for concentrate by gentle reverse filtration. The biotic and abiotic particles were immediately observed qualitatively by inverted microscopy onboard. Concentrated sample was settled into a 70ml poly-D-resin coating plastic bottle, and then left to stand for two hours in a 25 cm^3 composite chamber. Alcian blue staining solution (pH2.5, Fujifilm Wako Pure chemical Corporation) was pre-filtered through a 0.2 µm filter was prepared to add as final concentration to 1%, and sulphated TEP stain particles were left at least 0.5 hour at room temperature for estimating the abundance.
An inverted microscope was used for observation the smaller perticles (<100 µm, 400 × magnification) and more larger (≧100 µm, 100 × magnification). Microplankton was identified to the species level when possible, and finally classified into four groups: diatoms, dinoflagellates, coccolithophores, silicoflagellates.

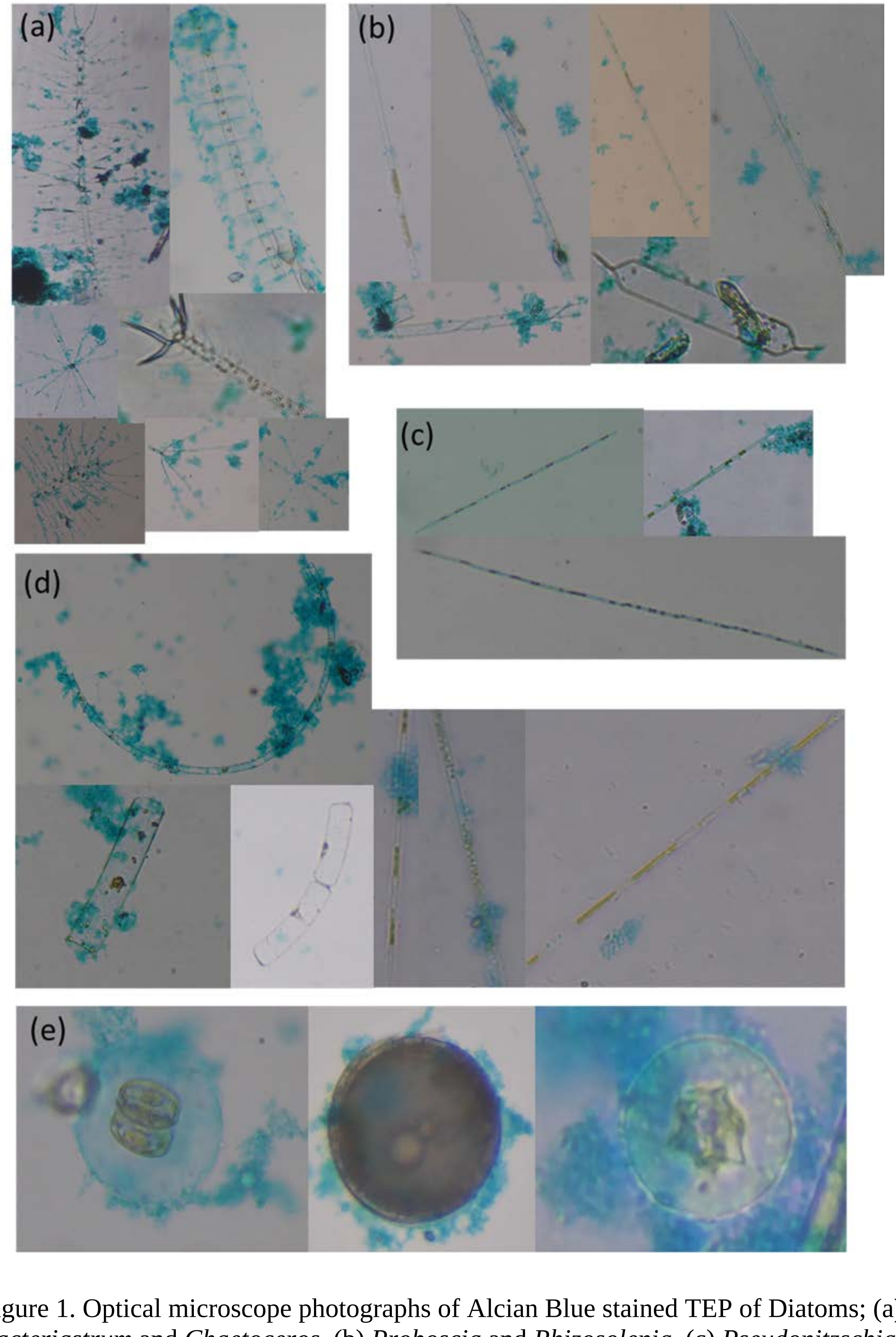


Figure 1. Optical microscope photographs of Alcian Blue stained TEP of Diatoms; (a) *Bacteriastrum* and *Chaetoceros*, (b) *Proboscia* and *Rhizosolenia*, (c) *Pseudonitzschia*, (d) *Guinardia* and *Dactyliosolen*, (e) some Centric diatoms. All images are photos of TEP stained cells.

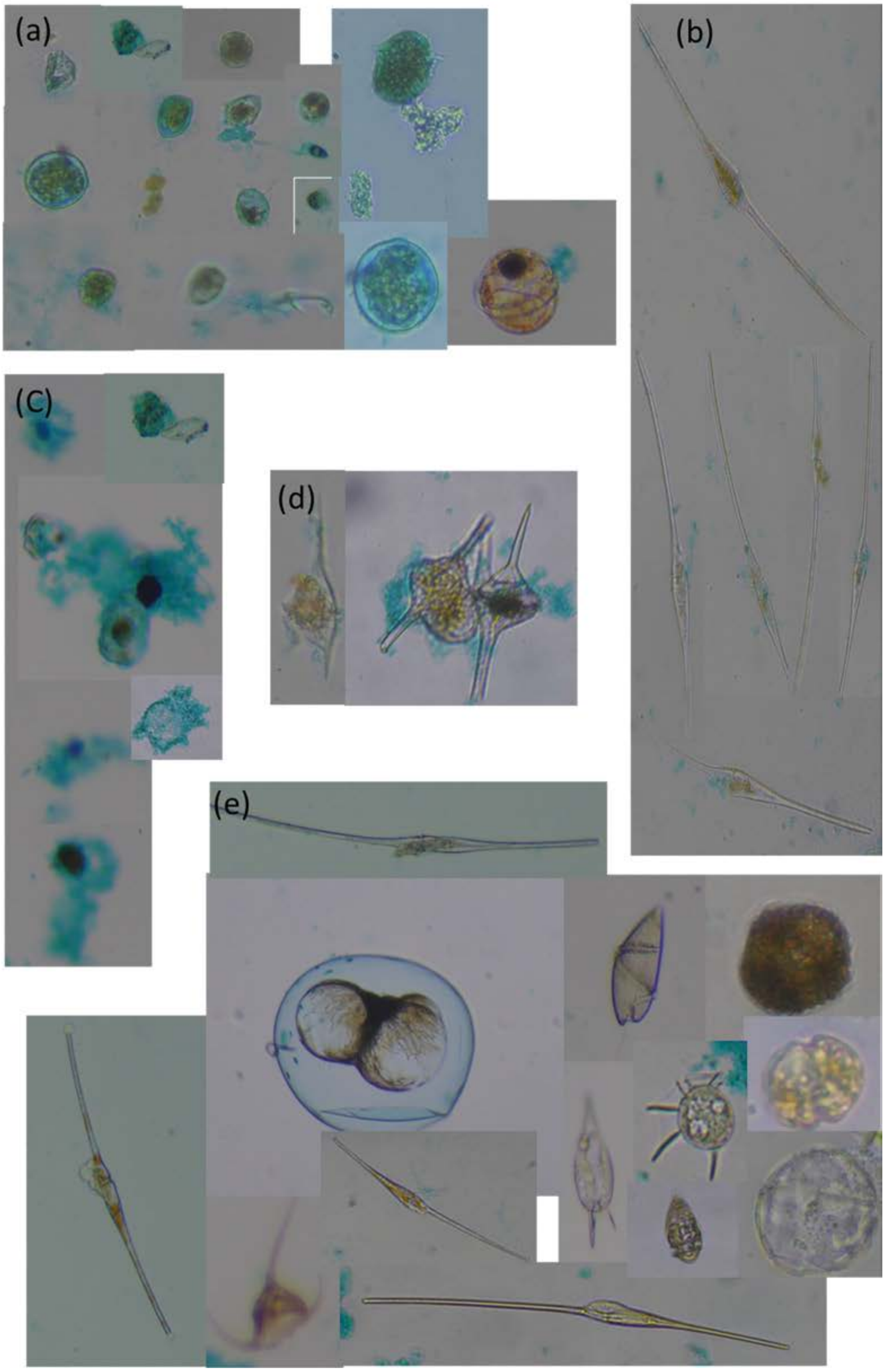


Figure 2. Optical microscope photographs of Alcian Blue stained TEP of Dinoflagellates and small unknown flagellates; (a) unknown small cells, (b) *Ceratium fusus*, (c) small dinoflagellate cysts, (d) other *Ceratium* species. All images are TEP unstained cells (e).

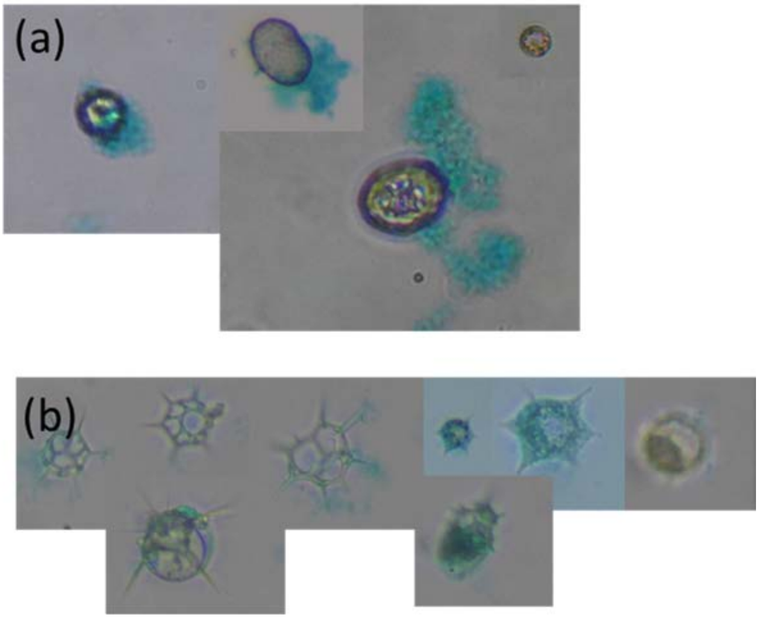


Figure 3. Optical microscope photographs of Alcian Blue stained TEP of (a) coccolithophores, and (b) silicoflagellates.

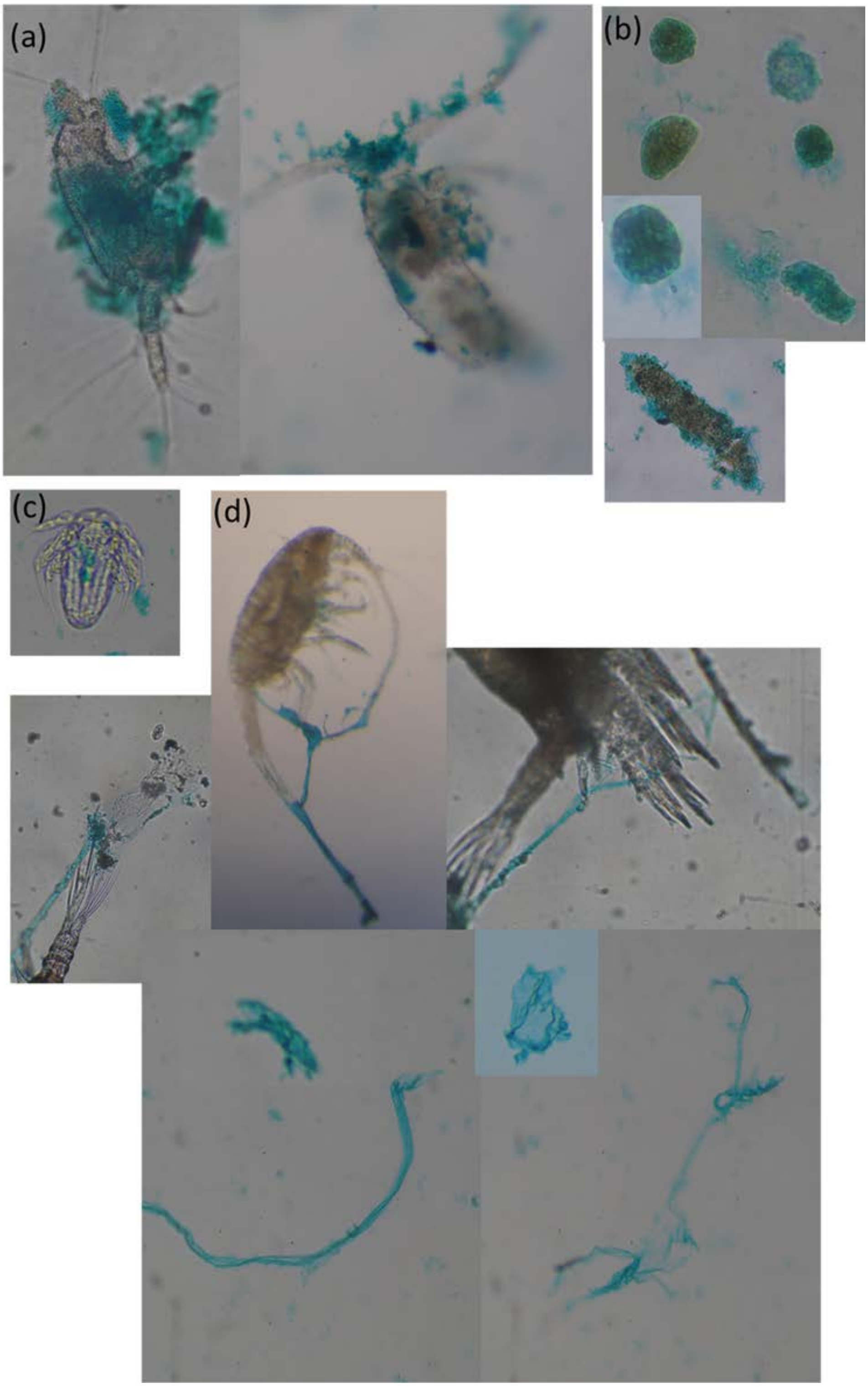


Figure 4. Optical microscope photographs of Alcian Blue stained TEP of (a) copepods, (b) fecal pellets, (c) a nauplius, and (d) copepods legs that attached and or detached TEPs.

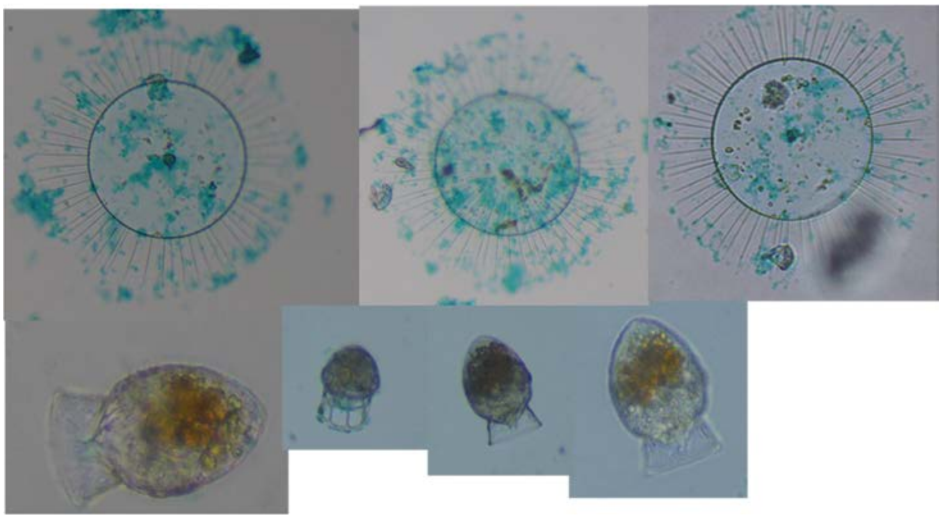


Figure 5. Optical microscope photographs of Alcian Blue stained TEP of other protozoans that include are unstained cells.

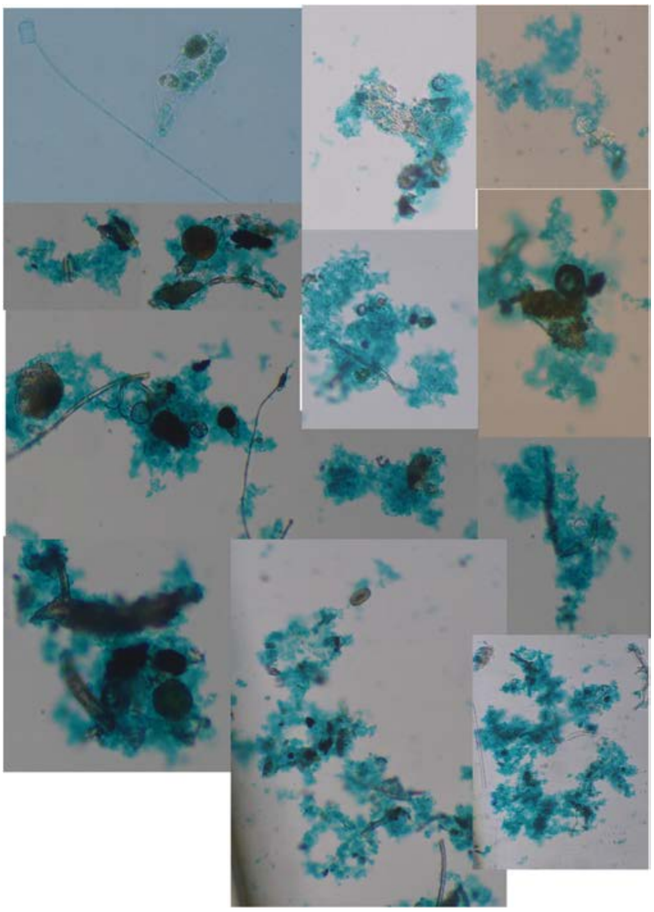


Figure 6. Optical microscope photographs of TEP attached many heterogeneous aggregations.

3.11. Other zooplankton studies
3.11.1. Species and genetic diversity of mesozooplankton

Kohei Matsuno (Hokkaido University)
Kanako Amei (Hokkaido University)
Kazuaki Tadokoro (Tohoku National Fisheries Research Institute)
Yuichiro Yamada (Kitazato University)
Satomi Komori (Kitazato University)
Ayako Oda (Kitazato University)
Rudi Stlickler (Univ. Wisconsin)

(1) Objective

1) To evaluate the spatial distribution of polychaetes and decapods larvae in Kuroshio region associated with gyre

2) To collect fresh zooplankton image and movie for analyzing zooplankton community structure and also for materials of education and outreach

(2) Sampling and on-board treatment

Zooplankton samples were collected by vertical haul of Twin NORPAC nets (mouth diameter: 45 cm, mesh sizes: 335 and 100 µm or 100 µm and 100 µm) at eight stations. The nets was towed between surface and 200 m depth except twice samplings (50 and 400 m) (Table 1).

Zooplankton samples collected by first cast were immediately fixed with 5% buffered formalin for zooplankton structure analysis. We picked up polychaetes and decapods larvae from fresh samples collected by second casts with 335 µm mesh on board. The sorted animals fixed with 70% ethanol. The remaining aliquot was fixed with 5% buffered formalin. Samples were collected by the second cast with 100 µm mesh were fixed with ethanol for DNA extraction. To take a movie of zooplankton activity, we collected fresh samples by third cast with slow towing speed (0.2 m $second^{-1}$).

Table 1. Data on plankton samples collected by vertical hauls with twin NORPAC net.

GG54: 335 μm mesh, XX13: 100 μm mesh. HU: Hokkaido University, TNFRI: Tohoku National Fisheries Research Institute, Kitasato University: KU

Station no.	Position Lat. (N)		Lon.			S.M.T. Date	Hour	Length of wire (m)	Angle of wire (°)	Depth estimated by wire angle (m)	Kind of cloth	Flowmeter No.	Reading	Remark
01(KEO)	32	21.248	144	25.24	E	21 July	17:58	200	4	200	GG54	3503	2161	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	2010	Formaline fixed, TNFRI(1/1)
							18:16	200	5	199	GG54	3503	2167	Ethanol fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	1984	Ethanol fixed, TNFRI(1/1)
							18:37	200	0	200	XX13	3139	1528	To take movie by TNFRI
											XX13	4156	1551	To take movie by Dr. Strickler
02(KEO2)	32	14.36	144	27.65	E	22 July	2:08	206	14	200	GG54	3503	2235	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	2173	Formaline fixed, TNFRI(1/1)
							2:27	200	4	200	GG54	3503	2221	Ethanol fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	1992	Ethanol fixed, TNFRI(1/1)
03(X4)	33	43.85	146	15.91	E	23 July	14:02	210	18	200	GG54	3503	2722	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	2350	Formaline fixed, TNFRI(1/1)
							14:32	426	20	400	GG54	3503	4760	Formalinel fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	2850	Ethanol fixed, TNFRI(1/1)
							15:01	205	13	200	XX13	3139	1984	To take movie by TNFRI
											XX13	4156	2042	To take movie by Dr. Strickler
04(Argo)	35	17.98	146	48.11	E	24 July	10:15	215	21	201	GG54	3503	3430	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	2742	Formaline fixed, TNFRI(1/1)
							10:33	233	31	200	GG54	3503	3840	Ethanol fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	3053	Ethanol fixed, TNFRI(1/1)
							10:52	231	30	200	XX13	3139	5072	To take movie by TNFRI
											XX13	4156	4718	To take movie by Dr. Strickler
05(X4)	33	45.36	146	14.79	E	26 July	21:00	203	10	200	GG54	3503	2456	Formalinel fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	1822	Formalinel fized, decapods (KU) and Polychaetes (HU) were sorted
06(Hotspot)	33	56.74	146	14.04	E	27 July	3:39	200	4	200	GG54	3503	2131	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	1470	Ethanol fixed, TNFRI(1/1)
							3:56	200	3	200	GG54	3503	2199	Formalinel fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	-	Formaline fixed, TNFRI(1/1)
							4:20	201	6	200	XX13	3139	1566	To take movie by TNFRI
											XX13	4156	1625	To take movie by Dr. Strickler
07(X4)	33	44.9	146	15.12	E	27 July	18:52	200	4	200	GG54	3503	2150	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	2089	Formaline fixed, TNFRI(1/1)
							19:09	203	10	200	GG54	3503	2259	Formalinel fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	1180	Ethanol fixed, TNFRI(1/1)
							19:29	200	4	200	XX13	3139	2037	To take movie by TNFRI
											XX13	4156	2071	To take movie by Dr. Strickler
08(X4)	33	44.93	146	14.93	E	28 July	19:15	212	19	200	GG54	3503	2550	Formaline fixed, HU(1/2), TNFRI(1/2)
											XX13	3182	1933	Formaline fixed, TNFRI(1/1)
							19:33	230	29	201	GG54	3503	2792	Formalinel fized, decapods (KU) and Polychaetes (HU) were sorted
											XX13	3182	2351	Ethanol fixed, TNFRI(1/1)
							19:51	110	25	100	GG54	3503	1629	Formaline fixed, JAMSTEC(1/1)
											XX13	3182	603	Formaline fixed, JAMSTEC(1/1)
							20:04	53	20	50	XX13	3139	1377	To take movie by TNFRI
											XX13	4156	1320	To take movie by Dr. Strickler

3.11.2. Field trials of the newly designed dual net system for collection of neuston and subsurface zooplankton

Minoru Kitamura (JAMSTEC)

To collect neuston and subsurface zooplankton separately but simultaneously, a dual net system was newly made and field trials of the system were carried out during the cruise. The system has two rectangular 60 x 60 cm SUS frames, and they are vertically connected each other. Plastic floats are attached to both sides of the upper frame and two weights are attached to lateral ends of the bottom leg in the lower frame. Specifications, a schematic diagram, and a photograph of this system are herein shown. Surface test tows were carried out two times from the starboard side of the vessel. There is still problem in balance between buoyancy of floats and weights. Collected neuston and zooplankton samples were not preserved in this cruise.

Specifications of the newly designed dual net system
- Size of the net mouth: 60 x 60 cm
- Mouth area: 0.36 m^2
- Length of net: 3 m
- Mesh size: 0.33 mm
- Mouth opening ratio: 6.1
- Weights: 1 kg x 2

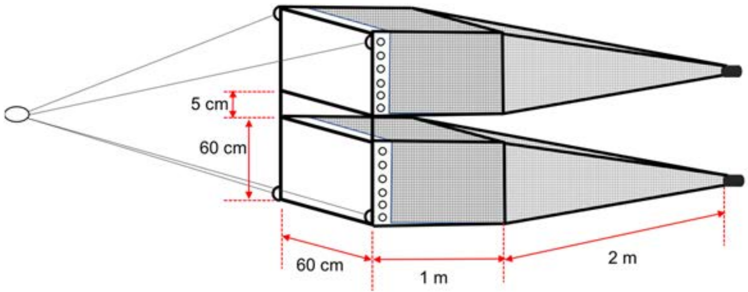


Fig. 3.11.2-1. A schematic diagram of the net system

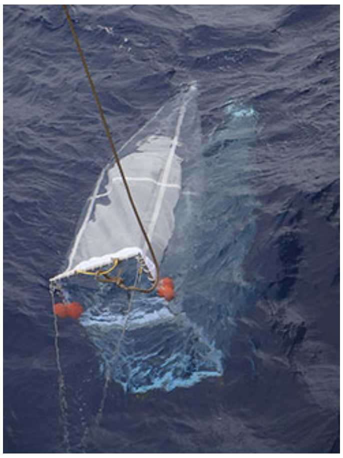


Fig. 3.11.2-2. Field trial of the net system at KEO.

3.12. Radiocesium (^{134}Cs and ^{137}Cs)

Yuichiro Kumamoto (onboard)*
Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 2-15 Natushima-cho, Yokosuka, Kanagawa 237-0061, Japan

**Correspondence and requests for materials should be addressed to Y. K.*
(email:).

To investigate the water circulation in the western subtropical area of the North Pacific Ocean, seawaters for measurements of radiocesium (^{134}Cs and ^{137}Cs) were collected by the hydrocasts from the surface to near 800 m depth. We collected seawater samples from the Niskin sampler at two stations (KEO and X4) during this cruise. Seawater for radiocesium was collected at six layers: 50, 100, 200, 400, 600, and 800 m nominal depth. Surface water was also collected from underway pumping-up seawater from about 4 m depth. The sample seawater was stored into two 20 L plastic containers (40 L). In our laboratory onshore, radiocesium in the seawater sample will be concentrated using ammonium phosphomolybdate (AMP), which forms an insoluble compound with cesium. Radiocesium concentrated on the AMP will be measured using Ge γ-ray spectrometers in our laboratory.

3.13. KEO Sediment trap experiments

Makio HONDA (JAMSTEC RIGC)
Hiroki USHIROMURA (MWJ)
Masaki FURUHATA (MWJ) (not onboard)
Kai FUKUDA (MWJ) (not onboard)

(1) Purpose

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 biological activity 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). 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. Last year KEO sediment trap mooring system was turn around in July during R/V Mirai MR18-06 cruise.

(2) Recovery

On 21 July 2019, thanks to great efforts by marine technicians from Marine Works Japan ltd. and ship crews, sediment trap mooring system was successfully recovered. Although several grass floats were broken, time-series sediment trap sample since July 2018 was successfully collected.

(3) Preliminary result: total mass flux

Onboard, heights of collected samples (settling particles) in collecting cups were measured roughly with scale. Characteristic of variability of total mass flux of sediment trap samples are as follows:

(i) 2018 – 2019

After deployment, between July and November 2018, total mass fluxes (TMFs) were relatively constant (Fig. 1 upper). In winter season 18/19, TMFs were lower. In April 2019, total mass flux began to increase and peaked in May. Thereafter TMFs decreased and, but increased again in July.

(ii) History of TMF

Observed seasonal variability during the last deployment was compared with previous data (Fig. 1 lower). TMF and its seasonal variability in 2018/2019 were comparable to these in other previous years except 2015 and 2018: both years had large spring TMF peaks.

(4) Future analysis

Above preliminary result is qualitative one. 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.

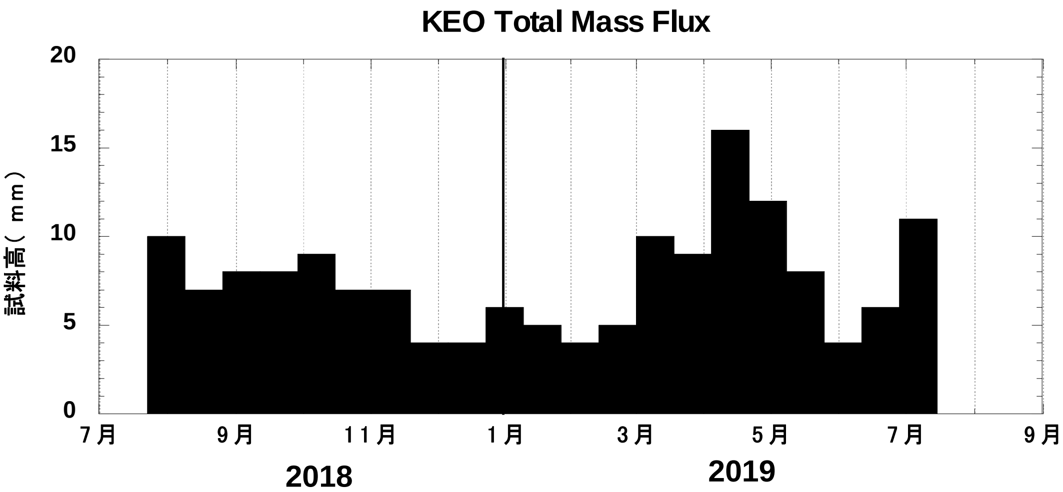
(4) Data archive

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

(5) References

Honda MC, Matsumoto K, Fujiki T, Siswanto E, Sasaoka K, Kawakami H, Wakita M, Mino Y, Sukigara C, Kitamura M, Sasai Y, Smith SL, Hashioka T, Yoshikawa C, Kimoto K, Watanabe S, Kobari T, Nagata T, Hamasaki K, Kaneko R, Uchimiya M, Fukuda H, Abe O, Saino T (2017) Comparison of carbon cycle between the western Pacific subarctic and subtropical time-series stations: highlights of the K2S1 project. *J Oceanogr* 73:647-667. doi:10.1007/s10872-017-0423-3.

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



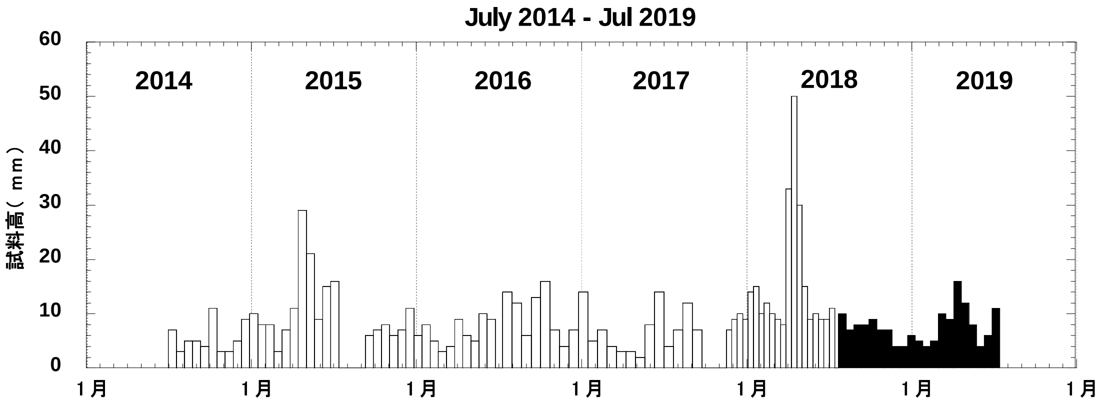


Figure 1. Seasonal variability in quantitative total mass flux (height day^{-1}) during July 2018 and July 2019 (upper) and since July 2014 (lower)

(6) Redeployment

After retrieving sample / data, replacement of new battery and initialization of schedule (Table 1), sediment trap mooring system was deployed on 26 July 2019. This time, in addition to 4800 m sediment trap, shallower sediment trap at about 1800 m was deployed. On 1800 m sediment trap, underwater video camera was installed in order to observe marine particles optically (photo 1). Designs of mooring system are shown in Fig. 2. Based on "positioning" with SSBL, determined anchor position is

32°21.4473'N
144°25.3753'E
Water depth 5763 m

It is planned that this mooring system will be recovered in summer 2020.

Table 1 Schedule (opening day of each cup for 1800 m and 4800 m sediment trap)

Int (days)	18
1	2019/7/27 0:00
2	2019/8/14 0:00
3	2019/9/1 0:00
4	2019/9/19 0:00
5	2019/10/7 0:00
6	2019/10/25 0:00
7	2019/11/12 0:00
8	2019/11/30 0:00
9	2019/12/18 0:00
10	2020/1/5 0:00
11	2020/1/23 0:00
12	2020/2/10 0:00
13	2020/2/28 0:00
14	2020/3/17 0:00
15	2020/4/4 0:00
16	2020/4/22 0:00
17	2020/5/10 0:00
18	2020/5/28 0:00
19	2020/6/15 0:00
20	2020/7/3 0:00
21	2020/7/21 0:00
22	2020/8/8 0:00

Photo 1. Underwater video camera on 1800 m sediment trap

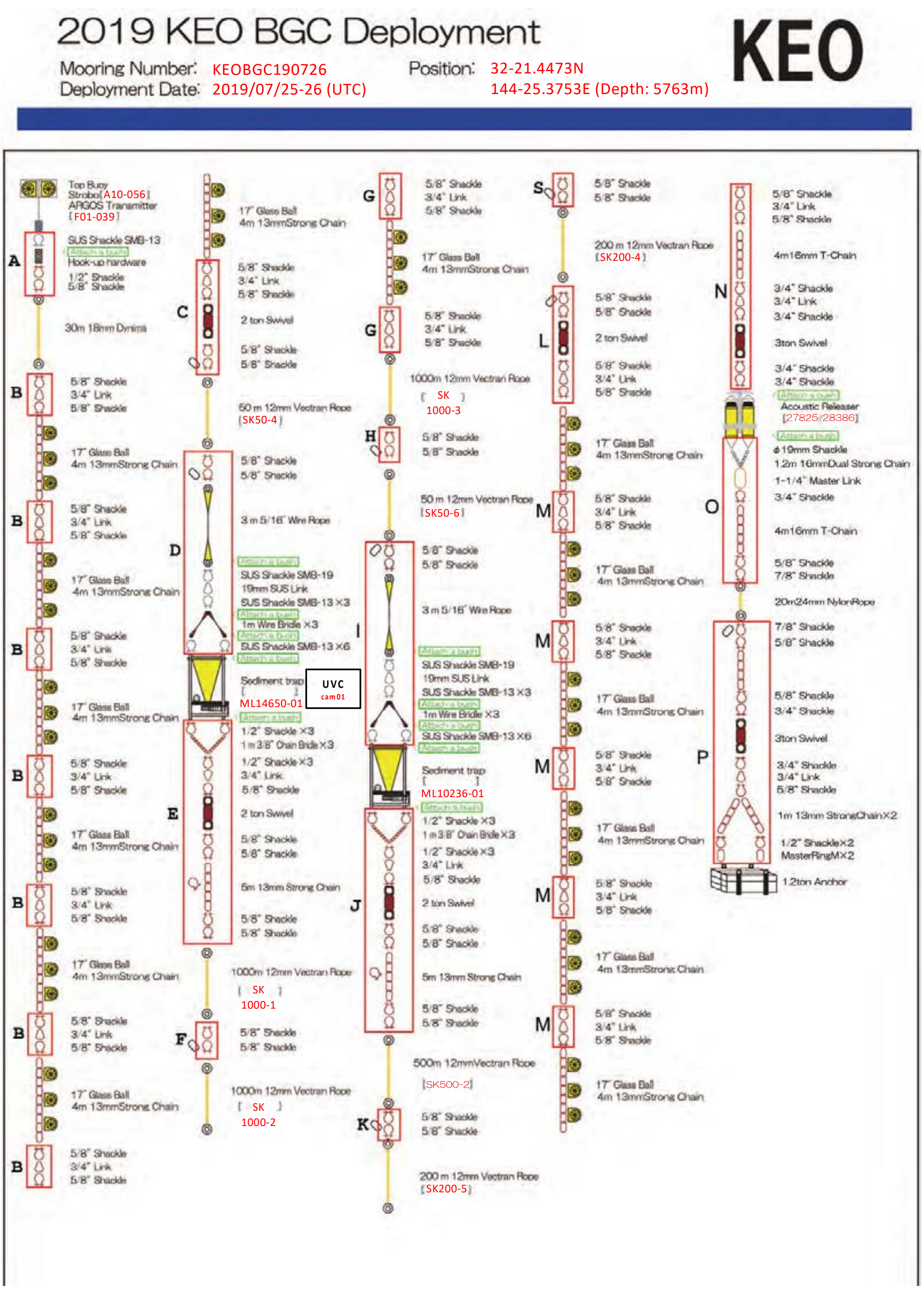


Figure 2. Design of 2018 KEO sediment trap mooring system

4. Event Log and cruise truck

S.M.T.		U.T.C.		Lat.	Long.	Station	Event
Date	Time	Date	Time				
190720	925	190720	25	35 19.122N	139 38.993E		Departure from JAMSTEC, Yokosuka
190721	815	190720	2315	32 21.453N	144 25.255E	KEO	Arraival at KEO
190721	817	190720	2317	32 21.371N	144 25.309E	KEO	SEDIMENT TRAP RELEASED
190721	927	190721	27	32 20.819N	144 25.822E	KEO	SEDIMENT TRAP POPPED
190721	1005	190721	105	32 21.226N	144 25.139E	KEO	RETRIEVING OF SEDIMENT TRAP STARTED
190721	1045	190721	145	32 20.495N	144 24.908E	KEO	RETRIEVING OF SEDIMENT TRAP FINISHED
190721	1216	190721	316	32 21.826N	144 24.969E	KEO	CTD-CMS STARTED (KH1904_1, Cesium, 800m)
190721	1308	190721	408	32 21.253N	144 24.971E	KEO	CTD-CMS FINISHED
190721	1341	190721	441	32 21.959N	144 24.975E	KEO	CTD-CMS STARTED (KH1904_2, KEO routine, 2000m)
190721	1520	190721	620	32 21.209N	144 25.256E	KEO	CTD-CMS FINISHED
190721	1536	190721	636	32 20.953N	144 25.456E	KEO	NEUSTON NET_1 STARTED
190721	1556	190721	656	32 21.268N	144 25.687E	KEO	NEUSTON NET FINISHED
190721	1613	190721	713	32 21.573N	144 25.789E	KEO	NEUSTON NET_2 STARTED
190721	1632	190721	732	32 21.855N	144 25.736E	KEO	NEUSTON NET FINISHED
190721	1702	190721	802	32 21.650N	144 25.392E	KEO	IONESS (Flow-meter calibration cast) STARTED
190721	1729	190721	829	32 21.286N	144 25.360E	KEO	IONESS FINISHED
190721	1755	190721	855	32 21.322N	144 25.159E	KEO	NORPAC NET STARTED
190721	1813	190721	913	32 21.057N	144 25.258E	KEO	NORPAC NET FINISHED
190721	1816	190721	916	32 21.010N	144 25.276E	KEO	NORPAC NET STARTED
190721	1830	190721	930	32 20.831N	144 25.350E	KEO	NORPAC NET FINISHED
190721	1837	190721	937	32 20.723N	144 25.410E	KEO	NORPAC NET STARTED
190721	1902	190721	1002	32 20.398N	144 25.548E	KEO	NORPAC NET FINISHED
190721	1938	190721	1038	32 21.783N	144 24.935E	KEO	CTD-CMS STARTED (KH1904_3, RINKO Calibration & SCM, 300m)
190721	2029	190721	1129	32 20.960N	144 24.786E	KEO	CTD-CMS FINISHED
190721	2044	190721	1144	32 20.687N	144 24.808E	KEO	FRRF STARTED
190721	2121	190721	1221	32 19.981N	144 24.875E	KEO	FRRF FINISHED
190721	2138	190721	1238	32 19.684N	144 24.817E	KEO	LISST STARTED
190721	2148	190721	1248	32 19.492N	144 24.795E	KEO	LISST DEEPEST
190721	2159	190721	1259	32 19.262N	144 24.882E	KEO	LISST DEEPEST
190721	2203	190721	1303	32 19.186N	144 24.917E	KEO	LISST FINISHED
190721	2207	190721	1307	32 19.108N	144 24.923E	KEO	TURBO MAP STARTED
190721	2220	190721	1320	32 18.880N	144 24.970E	KEO	TURBO MAP FINISHED
190721	2223	190721	1323	32 18.819N	144 24.998E	KEO	LISST STARTED
190721	2233	190721	1333	32 18.617N	144 25.104E	KEO	LISST DEEPEST
190721	2244	190721	1344	32 18.397N	144 25.239E	KEO	LISST DEEPEST
190721	2248	190721	1348	32 18.302N	144 25.304E	KEO	LISST FINISHED
190721	2251	190721	1351	32 18.252N	144 25.340E	KEO	TURBO MAP STARTED
190721	2302	190721	1402	32 18.027N	144 25.481E	KEO	TURBO MAP FINISHED
190721	2307	190721	1407	32 17.923N	144 25.536E	KEO	LISST STARTED
190721	2318	190721	1418	32 17.695N	144 25.658E	KEO	LISST DEEPEST
190721	2329	190721	1429	32 17.458N	144 25.794E	KEO	LISST DEEPEST
190721	2333	190721	1433	32 17.379N	144 25.838E	KEO	LISST FINISHED
190721	2338	190721	1438	32 17.278N	144 25.906E	KEO	TURBO MAP STARTED
190721	2348	190721	1448	32 17.056N	144 26.083E	KEO	TURBO MAP FINISHED
190722	18	190721	1518	32 16.449N	144 26.542E	KEO	VPR (vertical haul) STARTED
190722	56	190721	1556	32 15.554N	144 26.968E	KEO	VPR FINISHED
190722	104	190721	1604	32 15.379N	144 27.080E	KEO	AZFP STARTED
190722	137	190721	1637	32 14.601N	144 27.505E	KEO	AZFP FINISHED
190722	146	190721	1646	32 14.392N	144 27.635E	KEO	NORPAC NET STARTED
190722	202	190721	1702	32 14.004N	144 27.802E	KEO	NORPAC NET FINISHED
190722	205	190721	1705	32 13.924N	144 27.839E	KEO	NORPAC NET STARTED
190722	223	190721	1723	32 13.555N	144 27.999E	KEO	NORPAC NET FINISHED
190722	226	190721	1726	32 13.484N	144 28.031E	KEO	NORPAC NET STARTED
190722	241	190721	1741	32 13.186N	144 28.163E	KEO	NORPAC NET FINISHED
190722	611	190721	2111	32 21.986N	144 24.928E	KEO	SETTING OF IN-SITU FILTRATION SYSTEM STARTED
190722	754	190721	2254	32 21.180N	144 24.628E	KEO	SETTING OF IN-SITU FILTRATION SYSTEM FINISHED
190722	1141	190722	241	32 21.207N	144 24.596E	KEO	RETRIEVING OF IN-SITU FILTRATION SYSTEM STARTED
190722	1246	190722	346	32 21.353N	144 24.701E	KEO	RETRIEVING OF IN-SITU FILTRATION SYSTEM FINISHED
190722	1303	190722	403	32 21.236N	144 24.724E	KEO	CTD-CMS STARTED (KH1904_4, S-POM, 2000m)
190722	1441	190722	541	32 20.370N	144 24.862E	KEO	CTD-CMS FINISHED
190722	1445	190722	545	32 20.304N	144 24.885E	KEO	Departure from KEO
190722	2125	190722	1225	33 14.633N	145 44.625E		Arrival at mesoscale eddy area
190722	2127	190722	1227	33 15.021N	145 45.019E	X1	LET GO XBT

S.M.T.		U.T.C.		Lat.	Long.	Station	Event
Date	Time	Date	Time				
190722	2202	190722	1302	33 21.179N	145 51.154E	XBT1	LET GO XBT
190722	2238	190722	1338	33 27.348N	145 57.267E	XBT2	LET GO XBT
190722	2314	190722	1414	33 33.486N	146 03.367E	XBT3	LET GO XBT
190722	2351	190722	1451	33 39.611N	146 09.486E	XBT4	LET GO XBT
190723	28	190722	1528	33 45.785N	146 15.652E	XBT5	LET GO XBT
190723	107	190722	1607	33 51.937N	146 21.803E	XBT6	LET GO XBT
190723	145	190722	1645	33 57.766N	146 27.642E	XBT7	Canceled
190723	226	190722	1726	34 04.463N	146 34.345E	XBT8	LET GO XBT
190723	303	190722	1803	34 10.384N	146 40.250E	XBT9	LET GO XBT
190723	342	190722	1842	34 16.550N	146 46.461E	XBT10	LET GO XBT
190723	419	190722	1919	34 22.663N	146 52.656E	XBT11	LET GO XBT
190723	503	190722	2003	34 30.083N	147 00.138E	X2	LET GO XBT
190723	525	190722	2025	34 29.016N	146 58.894E	X2	UNDERWAY-CTD_1 STARTED
190723	547	190722	2047	34 26.743N	146 56.532E	Leg 0	UNDERWAY-CTD_2 STARTED
190723	608	190722	2108	34 24.643N	146 54.564E	Leg 0	UNDERWAY-CTD_3 STARTED
190723	628	190722	2128	34 22.641N	146 52.595E	Leg 0	UNDERWAY-CTD_4 STARTED
190723	647	190722	2147	34 20.633N	146 50.650E	Leg 0	UNDERWAY-CTD_5 STARTED
190723	707	190722	2207	34 18.745N	146 48.596E	Leg 0	UNDERWAY-CTD_6 STARTED
190723	727	190722	2227	34 16.733N	146 46.666E	Leg 0	UNDERWAY-CTD_7 STARTED
190723	745	190722	2245	34 14.795N	146 44.707E	Leg 0	UNDERWAY-CTD_8 STARTED
190723	805	190722	2305	34 12.768N	146 42.651E	Leg 0	UNDERWAY-CTD_9 STARTED
190723	824	190722	2324	34 10.866N	146 40.745E	Leg 0	UNDERWAY-CTD_10 STARTED
190723	844	190722	2344	34 08.950N	146 38.835E	Leg 0	UNDERWAY-CTD_11 STARTED
190723	903	190723	3	34 07.995N	146 36.872E	Leg 0	UNDERWAY-CTD_12 STARTED
190723	925	190723	25	34 04.762N	146 34.671E	Leg 0	UNDERWAY-CTD_13 STARTED
190723	948	190723	48	34 02.621N	146 32.465E	Leg 0	UNDERWAY-CTD_14 STARTED
190723	1011	190723	111	34 00.295N	146 30.240E	Leg 0	UNDERWAY-CTD_15 STARTED
190723	1026	190723	126	33 58.779N	146 28.759E	X3	UNDERWAY-CTD FINISHED, Shift to X4
190723	1200	190723	300	33 44.909N	146 15.000E	X4	Arrival at X4 (center of the mesoscale eddy)
190723	1206	190723	306			X4	CTD-CMS STARTED (KH1904_5, X4 routine, 2000m)
190723	1348	190723	448	33 44.017N	146 15.832E	X4	CTD-CMS FINISHED
190723	1359	190723	459	33 43.897N	146 15.881E	X4	NORPAC NET STARTED
190723	1417	190723	517	33 43.698N	146 16.096E	X4	NORPAC NET FINISHED
190723	1428	190723	528	33 43.602N	146 16.214E	X4	NORPAC NET STARTED
190723	1456	190723	556	33 43.431N	146 16.436E	X4	NORPAC NET FINISHED
190723	1502	190723	602	33 43.378N	146 16.483E	X4	NORPAC NET STARTED
190723	1529	190723	629	33 43.306N	146 16.708E	X4	NORPAC NET FINISHED
190723	1537	190723	637	33 43.213N	146 16.686E	X4	CTD-CMS STARTED (KH1904_6, Cesium, 800m)
190723	1628	190723	728	33 43.090N	146 16.718E	X4	CTD-CMS FINISHED
190723	1648	190723	748	33 42.939N	146 16.457E	X4	LISST STARTED
190723	1656	190723	756	33 42.930N	146 16.403E	X4	LISST DEEPEST
190723	1751	190723	851	33 43.152N	146 16.349E	X4	LISST FINISHED
190723	1948	190723	1048	33 45.584N	146 15.247E	X4	UVMP_1 STARTED
190723	2004	190723	1104	33 46.121N	146 15.831E	Leg 1	URINKO_1 STARTED
190723	2013	190723	1113	33 46.472N	146 16.213E	Leg 1	UVMP_2 Started
190723	2030	190723	1130	33 47.178N	146 16.915E	Leg 1	URINKO_2 Started
190723	2040	190723	1140	33 47.624N	146 17.345E	Leg 1	UVMP_3 Started
190723	2058	190723	1158	33 48.488N	146 18.228E	Leg 1	URINKO_3 Started
190723	2107	190723	1207	33 48.880N	146 18.572E	Leg 1	UVMP_4 Started
190723	2125	190723	1225	33 49.674N	146 19.363E	Leg 1	URINKO_4 Started
190723	2135	190723	1235	33 50.126N	146 19.852E	Leg 1	UVMP_5 Started
190723	2153	190723	1253	33 50.970N	146 20.724E	Leg 1	URINKO_5 Started
190723	2203	190723	1303	33 51.405N	146 21.234E	Leg 1	UVMP_6 Started
190723	2220	190723	1320	33 52.140N	146 21.998E	Leg 1	URINKO_6 Started
190723	2231	190723	1331	33 52.677N	146 22.534E	Leg 1	UVMP_7 Started
190723	2248	190723	1348	33 53.425N	146 23.253E	Leg 1	URINKO_7 Started
190723	2258	190723	1358	33 53.879N	146 23.684E	Leg 1	UVMP_8 Started
190723	2325	190723	1425	33 54.918N	146 24.67E	Leg 1	UVMP_9 Started
190723	2342	190723	1442	33 55.601N	146 25.354E	Leg 1	URINKO_9 Started
190723	2323	190723	1423	33 56.011N	146 25.742E	Leg 1	UVMP_10 Started
190724	9	190723	1509	33 56.808N	146 26.253E	Leg 1	URINKO_10 Started
190724	19	190723	1519	33 57.367N	146 26.499E	Leg 1	UVMP_11 Started
190724	35	190723	1535	33 58.240N	146 26.934E	Leg 1	URINKO_11 Started
190724	45	190723	1545	33 58.716N	146 27.141E	Leg 1	UVMP_12 Started
190724	101	190723	1601	33 59.631N	146 27.549E	Leg 1	URINKO_12 Started
190724	111	190723	1611	34 00.169N	146 27.322E	Leg 1	UVMP_13 Started
190724	127	190723	1627	34 01.049N	146 28.205E	Leg 1	URINKO_13 Started
190724	138	190723	1638	34 01.594N	146 28.424E	Leg 1	UVMP_14 Started

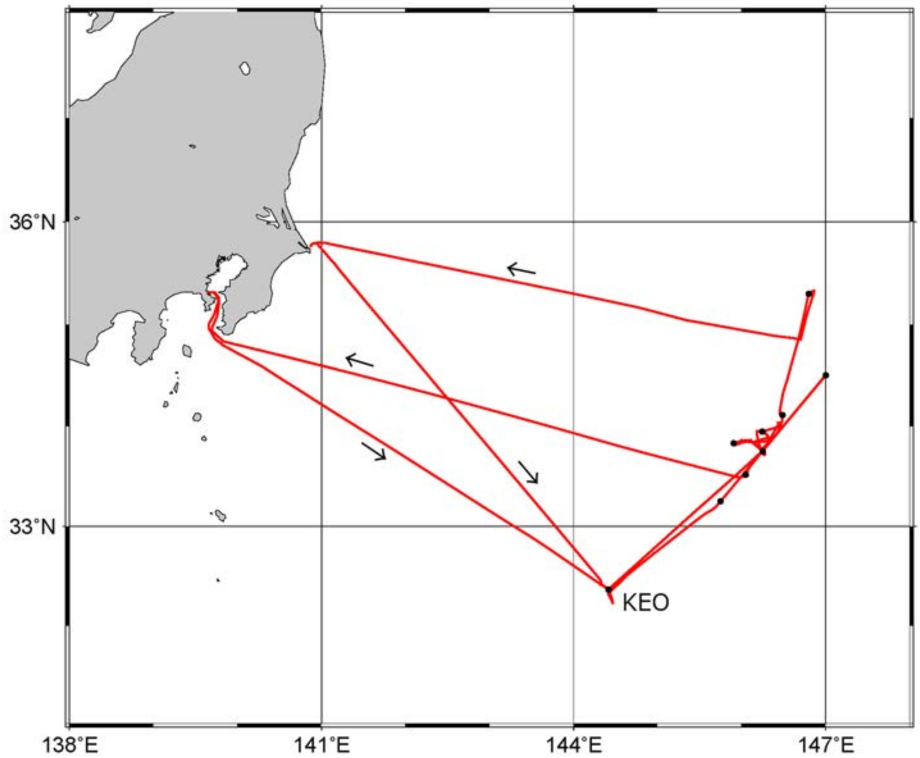
S.M.T.		U.T.C.		Lat.	Long.	Station	Event
Date	Time	Date	Time				
190724	154	190723	1654	34 02.523N	146 28.706E	Leg 1	URINKO_14 Started
190724	204	190723	1704	34 03.137N	146 28.424E	Leg 1	UVMP_15 Started
190724	220	190723	1720	34 02.523N	146 28.706E	Leg 1	URINKO_15 Started
190724	231	190723	1731	34 04.665N	146 29.129E	Leg 1	UVMP_16 Started
190724	248	190723	1748	34 04.085N	146 29.008E	Leg 1	URINKO_16 Started
190724	258	190723	1758	34 06.211N	146 29.535E	X5	U-RINKO PROFILER FINISHED
190724	314	190723	1814	34 06.492N	146 29.148E	X5	CTD-CMS STARTED (KH1904_7, X5 Rutine, 1000m)
190724	416	190723	1916	34 07.323N	146 27.724E	X5	CTD-CMS FINISHED
190724	420	190723	1920	34 07.371N	146 27.592E	X5	Departure from X5
190724	1000	190724	100	35 17.932N	146 47.997E		Arraival to Agro site
190724	1001	190724	101	35 17.955N	146 48.044E	Argo site	CTD-CMS STARTED (KH1904_8, Argo calibration & S-POM, 2000m)
190724	1013	190724	113	35 18.129N	146 48.387E	Argo site	NORPAC NET STARTED
190724	1031	190724	131	35 18.395N	146 48.803E	Argo site	NORPAC NET FINISHED
190724	1035	190724	135	35 18.449N	146 48.881E	Argo site	NORPAC NET STARTED
190724	1050	190724	150	35 18.669N	146 49.212E	Argo site	NORPAC NET FINISHED
190724	1051	190724	151	35 18.689N	146 49.246E	Argo site	NORPAC NET STARTED
190724	1129	190724	229	35 19.250N	146 50.290E	Argo site	NORPAC NET FINISHED
190724	1145	190724	245	35 19.553N	146 50.941E	Argo site	CTD-CMS FINISHED
190724	1150	190724	250	35 19.652N	146 51.149E		Departure from Argo site
190724	1420	190724	520	34 51.334N	146 40.792E		Cenge of course
190725	1145	190725	245	35 46.020N	140 52.334E		Arrival at off Choshi
190725	1221	190725	321	35 46.751N	140 52.942E		Departure from off Choshi
190726	545	190725	2045	32 24.846N	144 19.427E	KEO	Arrival at KEO
190726	625	190725	2125	32 25.173N	144 19.733E	KEO	DEPLOYMENT OF SEDIMENT TRAP STARTED
190726	908	190726	8	32 21.248N	144 25.458E	KEO	DEPLOYMENT OF SEDIMENT TRAP FINISHED
190726	1036	190726	136	32 21.318N	144 25.504E	KEO	Departure from KEO
190726	1952	190726	1052	33 44.922N	146 14.799E	X4	Arraival at X4
190726	1959	190726	1059	33 45.023N	146 14.832E	X4	CTD STARTED (KH1904_9, Center of eddy, 1000m)
190726	2046	190726	1146	33 45.637N	146 14.811E	X4	CTD FINISHED
190726	2053	190726	1153	33 45.723N	146 14.808E	X4	NORPAC NET STARTED
190726	2116	190726	1216	33 46.218N	146 14.642E	X4	NORPAC NET FINISHED
190726	2126	190726	1226	33 46.506N	146 14.562E		Departure from X4
190726	2200	190726	1300	33 50.926N	146 20.710E	Hot Spot #1	Arraival at Hots pot #1
190726	2208	190726	1308	33 51.154N	146 20.623E	Hot Spot #1	CTD-CMS STARTED (KH1904_10, F-POM, 200m)
190726	2237	190726	1337	33 52.196N	146 20.029E	Hot Spot #1	CTD-CMS FINISHED
190726	2244	190726	1344	33 52.436N	146 19.863E	Hot Spot #1	LISST STARTED
190726	2254	190726	1354	33 52.720N	146 19.669E	Hot Spot #1	LISST DEEPEST
190726	2350	190726	1450	33 54.175N	146 18.616E	Hot Spot #1	LISST FINISHED
190727	5	190726	1505	33 54.626N	146 18.240E	Hot Spot #1	TURBO MAP STARTED
190727	12	190726	1512	33 54.802N	146 18.055E	Hot Spot #1	TURBO MAP FINISHED
190727	12	190726	1512	33 54.808N	146 18.049E	Hot Spot #1	TURBO MAP STARTED
190727	16	190726	1516	33 54.913N	146 17.940E	Hot Spot #1	TURBO MAP FINISHED
190727	16	190726	1516	33 54.918N	146 17.935E	Hot Spot #1	TURBO MAP STARTED
190727	20	190726	1520	33 55.027N	146 17.807E	Hot Spot #1	TURBO MAP FINISHED
190727	20	190726	1520	33 55.032N	146 17.800E	Hot Spot #1	TURBO MAP STARTED
190727	24	190726	1524	33 55.134N	146 17.690E	Hot Spot #1	TURBO MAP FINISHED
190727	24	190726	1524	33 55.137N	146 17.687E	Hot Spot #1	TURBO MAP STARTED
190727	30	190726	1530	33 55.262N	146 17.525E	Hot Spot #1	TURBO MAP FINISHED
190727	31	190726	1531	33 55.305N	146 17.471E	Hot Spot #1	TURBO MAP STARTED
190727	40	190726	1540	33 55.507N	146 17.199E	Hot Spot #1	TURBO MAP FINISHED
190727	41	190726	1541	33 55.511N	146 17.195E	Hot Spot #1	TURBO MAP STARTED
190727	49	190726	1549	33 55.676N	146 16.954E	Hot Spot #1	TURBO MAP FINISHED
190727	51	190726	1551	33 55.730N	146 16.885E	Hot Spot #1	TURBO MAP STARTED
190727	101	190726	1601	33 55.915N	146 16.597E	Hot Spot #1	TURBO MAP FINISHED
190727	119	190726	1619	33 55.891N	146 16.562E	Hot Spot #1	AZFP STARTED
190727	152	190726	1652	33 56.211N	146 16.012E	Hot Spot #1	AZFP FINISHED
190727	158	190726	1658	33 56.216N	146 15.977E	Hot Spot #1	NORPAC NET STARTED
190727	214	190726	1714	33 56.352N	146 15.638E	Hot Spot #1	NORPAC NET FINISHED
190727	219	190726	1719	33 56.365N	146 15.581E	Hot Spot #1	FRRF STARTED
190727	247	190726	1747	33 56.584N	146 14.898E	Hot Spot #1	FRRF FINISHED
190727	254	190726	1754	33 56.621N	146 14.739E	Hot Spot #1	CTD-CMS STARTED (KH1904_11, SCM & Calibration, 300m)
190727	330	190726	1830	33 56.749N	146 13.842E	Hot Spot #1	CTD-CMS FINISHED
190727	338	190726	1838	33 56.745N	146 13.661E	Hot Spot #1	NORPAC NET STARTED
190727	357	190726	1857	33 56.832N	146 13.046E	Hot Spot #1	NORPAC NET STARTED
190727	411	190726	1911	33 56.840N	146 12.627E	Hot Spot #1	NORPAC NET FINISHED
190727	421	190726	1921	33 56.892N	146 12.274E	Hot Spot #1	NORPAC NET STARTED
190727	446	190726	1946	33 56.925N	146 11.428E	Hot Spot #1	NORPAC NET FINISHED

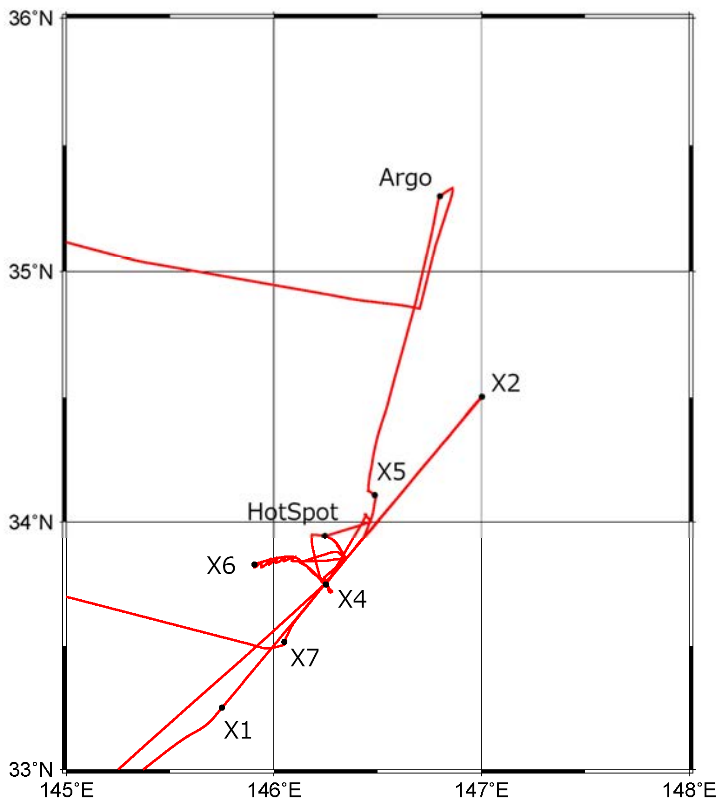
S.M.T.		U.T.C.		Lat.	Long.	Station	Event
Date	Time	Date	Time				
190727	456	190726	1956	33 56.959N	146 11.024E		Departure from Hot Spot #1
190727	608	190726	2108	33 44.961N	146 14.993E	X4	Arraival at X4
190727	735	190726	2235	33 46.343N	146 16.161E	X4	VPR TOW_1 STARTED (from X4, along Leg.1)
190727	758	190726	2258	33 46.990N	146 16.780E	Leg 1	VPR_2 started
190727	825	190726	2325	33 47.885N	146 17.687E	Leg 1	VPR_3 started
190727	841	190726	2341	33 48.404N	146 18.227E	Leg 1	VPR_4 started
190727	858	190726	2358	33 48.912N	146 18.727E	Leg 1	VPR_5 started
190727	909	190727	9	33 49.293N	146 19.088E	Leg 1	VPR_6 started
190727	921	190727	21	33 49.691N	146 19.446E	Leg 1	VPR_7 started
190727	938	190727	38	33 50.201N	146 19.729E	Leg 1	VPR FINISHED
190727	940	190727	40	33 50.246N	146 19.721E		Shift to Hot Spot #1
190727	1010	190727	110	33 51.117N	146 20.727E	Hot Spot #1	Arraival at Hot Spot #1
190727	1010	190727	110	33 51.120N	146 20.725E	Hot Spot #1	CTD-CMS STARTED (KH1904_12, PE1, 300m)
190727	1049	190727	149	33 52.247N	146 19.756E	Hot Spot #1	CTD-CMS FINISHED
190727	1056	190727	156	33 52.495N	146 19.592E	Hot Spot #1	AZFP STARTED
190727	1132	190727	232	33 53.476N	146 18.923E	Hot Spot #1	AZFP FINISHED
190727	1136	190727	236	33 53.586N	146 18.833E	Hot Spot #1	NORPAC NET STARTED
190727	1154	190727	254	33 54.063N	146 18.439E	Hot Spot #1	NORPAC NET FINISHED
190727	1208	190727	308	33 54.135N	146 18.325E	Hot Spot #1	TURBO MAP STARTED
190727	1218	190727	318	33 54.436N	146 18.172E	Hot Spot #1	TURBO MAP FINISHED
190727	1218	190727	318	33 54.439N	146 18.171E	Hot Spot #1	TURBO MAP STARTED
190727	1226	190727	326	33 54.690N	146 18.055E	Hot Spot #1	TURBO MAP FINISHED
190727	1226	190727	326	33 54.695N	146 18.052E	Hot Spot #1	TURBO MAP STARTED
190727	1236	190727	336	33 54.976N	146 17.888E	Hot Spot #1	TURBO MAP FINISHED
190727	1251	190727	351	33 55.071N	146 17.600E	Hot Spot #1	LISST STARTED
190727	1302	190727	402	33 55.244N	146 17.437E	Hot Spot #1	LISST DEEPEST
190727	1356	190727	456	33 55.957N	146 16.272E	Hot Spot #1	LISST FINISHED
190727	1409	190727	509	33 56.080N	146 15.936E	Hot Spot #1	CTD-CMS STARTED (KH1904_13, F-POM, 200m)
190727	1439	190727	539	33 56.326N	146 15.244E	Hot Spot #1	CTD-CMS FINISHED
190727	1451	190727	551	33 56.416N	146 14.844E		Departure from Hot Spot #1
190727	1558	190727	658	34 00.119N	146 28.022E	X8	Arraival at X8
190727	1604	190727	704	34 00.282N	146 27.930E	X8	AZFP STARTED
190727	1633	190727	733	34 00.981N	146 27.181E	X8	AZFP FINISHED
190727	1640	190727	740	34 01.176N	146 27.005E	X8	NORPAC NET STARTED
190727	1653	190727	753	34 01.497N	146 26.681E	X8	NORPAC NET FINISHED
190727	1704	190727	804	34 01.790N	146 26.417E		Departure from X8
190727	1846	190727	946	33 44.913N	146 15.183E	X4	Arraival at X4
190727	1854	190727	954	33 44.963N	146 15.004E	X4	NORPAC NET STARTED
190727	1907	190727	1007	33 45.107N	146 14.826E	X4	NORPAC NET FINISHED
190727	1910	190727	1010	33 45.145N	146 14.786E	X4	NORPAC NET STARTED
190727	1925	190727	1025	33 45.309N	146 14.616E	X4	NORPAC NET FINISHED
190727	1930	190727	1030	33 45.361N	146 14.557E	X4	NORPAC NET STARTED
190727	1958	190727	1058	33 45.699N	146 14.151E	X4	NORPAC NET FINISHED
190727	2003	190727	1103	33 45.781N	146 14.063E	X4	FRRF STARTED
190727	2030	190727	1130	33 46.156N	146 13.705E	X4	FRRF FINISHED
190727	2103	190727	1203	33 45.190N	146 14.782E	Leg 2	UVMP_1 Started
190727	2122	190727	1222	33 45.967N	146 13.737E	Leg 2	URINKO_1 Started
190727	2132	190727	1232	33 46.391N	146 13.172E	Leg 2	UVMP_2 Started
190727	2147	190727	1247	33 47.037N	146 12.367E	Leg 2	URINKO_2 Started
190727	2157	190727	1257	33 47.424N	146 11.925E	Leg 2	UVMP_3 Started
190727	2212	190727	1312	33 47.989N	146 11.202E	Leg 2	URINKO_3 Started
190727	2221	190727	1321	33 48.332N	146 10.755E	Leg 2	UVMP_4 Started
190727	2236	190727	1336	33 48.899N	146 10.015E	Leg 2	URINKO_4 Started
190727	2245	190727	1345	33 49.170N	146 09.632E	Leg 2	UVMP_5 Started
190727	2300	190727	1400	33 49.583N	146 08.917E	Leg 2	URINKO_5 Started
190727	2308	190727	1408	33 49.838N	146 08.526E	Leg 2	UVMP_6 Started
190727	2324	190727	1424	33 50.333N	146 07.881E	Leg 2	URINKO_6 Started
190727	2333	190727	1433	33 50.595N	146 07.544E	Leg 2	UVMP_7 Started
190727	2348	190727	1448	33 50.999N	146 06.941E	Leg 2	URINKO_7 Started
190727		190727		33 51.187N	146 06.540E	Leg 2	UVMP_8 Started (time of 23:37 in the Field Note was probably an eror)
190728	12	190727	1512	33 51.432N	146 05.836E	Leg 2	URINKO_8 Started
190728	20	190727	1520	33 51.517N	146 05.476E	Leg 2	UVMP_9 Started
190728	34	190727	1534	33 51.548N	146 04.635E	Leg 2	URINKO_9 Started
190728	44	190727	1544	33 51.515N	146 04.055E	Leg 2	UVMP_10 Started
190728	59	190727	1559	33 51.461N	146 03.040E	Leg 2	URINKO_10 Started
190728	108	190727	1608	33 51.401N	146 02.516E	Leg 2	UVMP_11 Started
190728	124	190727	1624	33 51.285N	146 01.624E	Leg 2	URINKO_11 Started
190728	132	190727	1632	33 51.200N	146 01.100E	Leg 2	UVMP_12 Started
190728	149	190727	1649	33 51.025N	146 00.165E	Leg 2	URINKO_12 Started

S.M.T.		U.T.C.		Lat.	Long.	Station	Event
Date	Time	Date	Time				
190728	158	190727	1658	33 50.926N	145 59.639E	Leg 2	UVMP_13 Started
190728	215	190727	1715	33 50.753N	145 58.713E	Leg 2	URINKO_13 Started
190728	225	190727	1725	33 50.611N	145 58.133E	Leg 2	UVMP_14 Started
190728	240	190727	1740	33 50.399N	145 57.254E	Leg 2	URINKO_14 Started
190728	250	190727	1750	33 50.270N	145 56.688E	Leg 2	UVMP_15 Started
190728	306	190727	1806	33 50.067N	145 55.775E	Leg 2	URINKO_15 Started
190728	315	190727	1815	33 49.959N	145 55.293E	Leg 2	UVMP_16 Started
190728	330	190727	1830	33 49.760N	145 54.472E	X6	UNDERWAY-VMP FINISHED
190728	335	190727	1835	33 49.620N	145 54.397E	X6	CTD STARTED (KH1904_14, leg.2 revisit, 200m)
190728	356	190727	1856	33 49.004N	145 54.269E	X6	CTD FINISHED
190728	432	190727	1932	33 50.124N	145 56.470E	L2a	CTD STARTED (KH1904_15, leg.2 revisit, 200m)
190728	454	190727	1954	33 49.267N	145 56.313E	L2a	CTD FINISHED
190728	539	190727	2039	33 50.727N	145 58.868E	L2b	CTD STARTED (KH1904_16, leg.2 revisit, 200m)
190728	557	190727	2057	33 49.989N	145 58.634E	L2b	CTD FINISHED
190728	641	190727	2141	33 51.037N	146 00.944E	L2c	CTD STARTED (KH1904_17, leg.2 revisit, 200m)
190728	701	190727	2201	33 50.370N	146 00.522E	L2c	CTD FINISHED
190728	747	190727	2247	33 51.304N	146 03.352E	L2d	CTD STARTED (KH1904_18, leg.2 revisit, 200m)
190728	807	190727	2307	33 50.578N	146 02.880E	L2d	CTD FINISHED
190728	853	190727	2353	33 51.343N	146 05.823E	L2e	CTD STARTED (KH1904_19, leg.2 revisit, 200m)
190728	912	190728	12	33 50.877N	146 05.345E	L2e	CTD FINISHED
190728	1036	190728	136	33 51.014N	146 20.609E		Arrival at Hot Spot #1
190728	1043	190728	143	33 51.250N	146 20.467E	Hot Spot #1	CTD-CMS STARTED (KH1904_20, PE2, 300m)
190728	1122	190728	222	33 52.219N	146 19.035E	Hot Spot #1	CTD-CMS FINISHED
190728	1133	190728	233	33 52.519N	146 18.662E	Hot Spot #1	Departure from Hot Spot #1
190728	1221	190728	321	33 50.318N	146 07.962E	L2f	CTD STARTED (KH1904_21, leg.2 revisit, 200m)
190728	1242	190728	342	33 50.100N	146 07.525E	L2f	CTD FINISHED
190728	1305	190728	405	33 48.981N	146 09.878E	L2g	CTD STARTED (KH1904_22, leg.1 revisit, 200m)
190728	1326	190728	426	33 48.862N	146 09.687E	L2g	CTD FINISHED
190728	1349	190728	449	33 48.981N	146 09.878E	L2h	CTD STARTED (KH1904_23, leg.2 revisit, 200m)
190728	1410	190728	510	33 47.657N	146 11.482E	L2h	CTD FINISHED
190728	1431	190728	531	33 46.350N	146 13.265E	L2i	CTD STARTED (KH1904_24, leg.2 revisit, 200m)
190728	1452	190728	552	33 46.252N	146 13.099E	L2i	CTD FINISHED
190728	1514	190728	614	33 44.996N	146 15.019E	X4	CTD STARTED (KH1904_25, leg.2 revisit, 200m)
190728	1535	190728	635	33 44.983N	146 14.907E	X4	CTD FINISHED
190728	1551	190728	651	33 45.078N	146 14.846E	Leg 2	VPR TOW_1 STARTED (from X4, along Leg.2)
190728	1608	190728	708	33 45.348N	146 14.487E	Leg 2	VPR_2 started
190728	1624	190728	724	33 45.880N	146 13.785E	Leg 2	VPR_3 started
190728	1642	190728	742	33 46.380N	146 13.179E	Leg 2	VPR_4 started
190728	1700	190728	800	33 46.799N	146 12.650E	Leg 2	VPR_5 started
190728	1718	190728	818	33 47.322N	146 11.994E	Leg 2	VPR_6 started
190728	1735	190728	835	33 47.788N	146 11.438E	Leg 2	VPR_7 started
190728	1754	190728	854	33 48.217N	146 10.856E	Leg 2	VPR TOW FINISHED
190728	1755	190728	855	33 48.222N	146 10.840E	Leg 2	Shift to X4
190728	1855	190728	955	33 44.991N	146 15.093E	X4	Arraival to X4
190728	1857	190728	957	33 44.930N	146 15.039E	X4	CTD-CMS STARTED (KH1904_26, S-POM, 2000m)
190728	1914	190728	1014	33 45.000N	146 14.813E	X4	NORPAC NET STARTED
190728	1931	190728	1031	33 45.167N	146 14.560E	X4	NORPAC NET FINISHED
190728	1936	190728	1036	33 45.221N	146 14.496E	X4	NORPAC NET STARTED
190728	1948	190728	1048	33 45.339N	146 14.366E	X4	NORPAC NET FINISHED
190728	2007	190728	1107	33 45.560N	146 14.140E	X4	NORPAC NET STARTED
190728	2025	190728	1125	33 45.829N	146 13.875E	X4	NORPAC NET FINISHED
190728	2125	190728	1225	33 46.684N	146 13.272E	X4	CTD-CMS FINISHED
190728	2200	190728	1300	33 45.013N	146 14.793E	X4	URINKO_1 Started
190728	2210	190728	1310	33 44.707N	146 14.530E	Leg 3	UVMP_1 Started
190728	2225	190728	1325	33 44.244N	146 14.057E	Leg 3	VPR_1 Started
190728	2247	190728	1347	33 43.555N	146 13.386E	Leg 3	URINKO_2 Started
190728	2256	190728	1356	33 44.286N	146 13.117E	Leg 3	UVMP_2 Started (this position was probably an error; ref, 33-43.352N, 146-13.184E @22:55)
190728	2310	190728	1410	33 42.764N	146 12.660E	Leg 3	VPR_2 Started
190728	2332	190728	1432	33 42.011N	146 11.932E	Leg 3	URINKO_3 Started
190728	2339	190728	14	33 41.878N	146 11.812E	Leg 3	UVMP_3 Started
190728	2355	190728	1455	33 41.379N	146 11.324E	Leg 3	VPR_3 Started
190729	15	190728	1515	33 40.770N	146 10.755E	Leg 3	URINKO_4 Started
190729	23	190728	1523	33 40.461N	146 10.489E	Leg 3	UVMP_4 Started
190729	36	190728	1536	33 39.884N	146 09.912E	Leg 3	VPR_4 Started
190729	58	190728	1558	33 39.291N	146 09.335E	Leg 3	URINKO_5 Started
190729	106	190728	1606	33 38.959N	146 09.008E	Leg 3	UVMP_5 Started
190729	123	190728	1623	33 38.360N	146 08.415E	Leg 3	VPR_5 Started
190729	142	190728	1642	33 37.764N	146 07.863E	Leg 3	URINKO_6 Started
190729	151	190728	1651	33 37.406N	146 07.503E	Leg 3	UVMP_6 Started
190729	207	190728	1707	33 36.740N	146 06.835E	Leg 3	VPR_6 Started

S.M.T.		U.T.C.		Lat.	Long.	Station	Event
Date	Time	Date	Time				
190729	226	190728	1726	33 36.116N	146 06.278E	Leg 3	URINKO_7 Started
190729	235	190728	1735	33 35.820N	146 06.007E	Leg 3	UVMP_7 Started
190729	252	190728	1752	33 35.112N	146 05.416E	Leg 3	URINKO_8 Started
190729	301	190728	1801	33 34.696N	146 05.144E	Leg 3	UVMP_8 Started
190729	317	190728	1817	33 33.909N	146 04.628E	Leg 3	VPR_7 Started
190729	336	190728	1836	33 33.080N	146 04.198E	Leg 3	URINKO_9 Started
190729	345	190728	1845	33 32.662N	146 03.945E	Leg 3	UVMP_9 Started
190729	403	190728	1903	33 31.706N	146 03.376E	Leg 3	VPR_8 Started
190729	419	190728	1919	33 30.974N	146 03.020E	Leg 3	VPR FINISHED
190729	425	190728	1925	33 30.753N	146 03.014E		Departure from research area
190730	607	190729	2107	35 12.685N	139 46.965E		ENTERED URAGA SUIDO TRAFFIC ROUTE
190730	643	190729	2143	35 18.694N	139 43.103E		CLEARED OUT URAGA SUIDO TRAFFIC ROUTE
190730	847	190729	2347	35 19.117N	139 38.995E		Arrival at JAMSTEC, Yokosuka

Time difference of SMT from UTC: +9:00
No time adjustment during the cruise

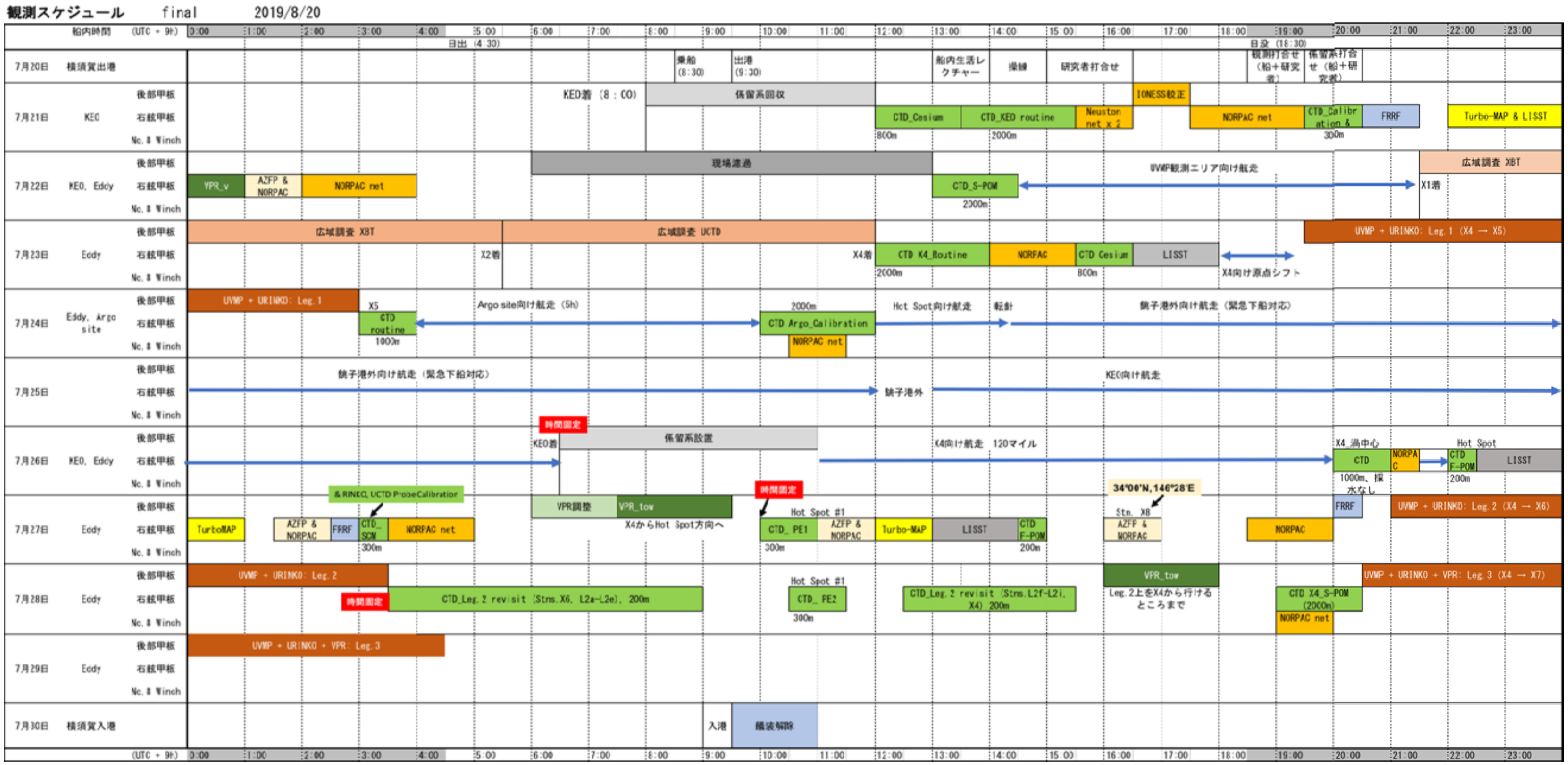

36°N
33°N
KEO
138°E
141°E
144°E
147°E


36°N
35°N
34°N
33°N
Argo
X2
X5
HotSpot
X6
X4
X7
X1
145°E
146°E
147°E
148°E

5. Notice on Using

This cruise report is a preliminary documentation as of the end of cruise. This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status. Users of information on this report are requested to submit Publication Report to Cooperative Research System Office.

E-mail: kyodoriyo@aori.u-tokyo.ac.jp



観測スケジュール final 2019/8/20
船内時間 (UTC + 9h)
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
日出 (4:30)
日没 (18:30)
後部甲板
右舷甲板
No.8 Winch
7月20日 横須賀出港
乗船 (8:30)
出港 (9:30)
船内生活レクチャー
操練
研究者打合せ
観測打合せ（船+研究者）
係留系打合せ（船+研究者）
7月21日 KEO
KEO着 (8:00)
係留系回収
CTD_Cesium
CTD_KEO routine
Neuston net x 2
IONESS較正
NORPAC net
CTD_Calibration &
FRRF
Turbo-MAP & LISST
800m
2000m
300m
7月22日 KEO, Eddy
VPR_v
AZFP & NORPAC
NORPAC net
現場通過
CTD_S-POM
2000m
UVMP観測エリア向け航走
広域調査 XBT
X1着
7月23日 Eddy
広域調査 XBT
X2着
広域調査 UCTD
X4着
CTD X4_Routine
NORPAC
CTD Cesium
LISST
2000m
800m
X4向け原点シフト
UVMP + URINKO: Leg.1 (X4 → X5)
7月24日 Eddy, Argo site
UVMP + URINKO: Leg.1
X5
CTD routine
1000m
Argo site向け航走 (5h)
2000m
CTD Argo_Calibration
NORPAC net
Hot Spot向け航走
転針
銚子港外向け航走（緊急下船対応）
7月25日
銚子港外向け航走（緊急下船対応）
銚子港外
KEO向け航走
7月26日 KEO, Eddy
時間固定
KEO着
係留系設置
X4向け航走 120マイル
X4 渦中心
CTD
NORPAC
1000m、採水なし
Hot Spot
CTD F-POM
200m
LISST
7月27日 Eddy
& RINKO, UCTD ProbeCalibration
TurboMAP
AZFP & NORPAC
FRRF
CTD_SCM
300m
NORPAC net
VPR調整
VPR_tow
X4からHot Spot方向へ
時間固定
Hot Spot #1
CTD_PE1
300m
AZFP & NORPAC
Turbo-MAP
LISST
CTD F-POM
200m
34°00'N, 146°28'E
Stn. X8
AZFP & NORPAC
NORPAC
FRRF
UVMP + URINKO: Leg.2 (X4 → X6)
7月28日 Eddy
UVMP + URINKO: Leg.2
時間固定
CTD_Leg.2 revisit (Stns.X6, L2a-L2e), 200m
Hot Spot #1
CTD_PE2
300m
CTD_Leg.2 revisit (Stns.L2f-L2i, X4) 200m
VPR_tow
Leg.2上をX4から行けるところまで
CTD X4_S-POM (2000m)
NORPAC net
UVMP + URINKO + VPR: Leg.3 (X4 → X7)
7月29日 Eddy
UVMP + URINKO + VPR: Leg.3
7月30日 横須賀入港
入港
艤装解除
(UTC + 9h)