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KH-15-J01

(29 June – 13 July 2015)

Preliminary Cruise Report

August 2015

JAMSTEC

Note

This cruise report is a preliminary documentation published in approximately a month after the end of this cruise. It may not be corrected even if changes on contents are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the principal investigator and parsons in charge of respective observations for the latest information and permission before using. Users of data are requested to submit their results to JAMSTEC Data Management Group (DMG).

Acknowledgments

We are grateful to the captain and crew of the R/V ‘‘HAKUHO MARU’’ for their support during the cruise.

August 2015

Chief Scientist of KH-15-J01

Tetsuichi Fujiki
JAMSTEC

Cruise Report ERRATA of the Nutrients part

page	Error	Correction
61	potassium nitrate CAS No. 7757-91-1	potassium nitrate CAS No. 7757-79-1
58	1N H_2SO_4	1M H_2SO_4

Contents of KH-15-J01 Preliminary Cruise Report

1. Outline of KH-15-J01

1.1 Cruise information

Cruise ID: KH-15-J01

Research vessel: HAKUHO MARU

Cruise title: Response of marine ecosystem to the ocean acidification in the subarctic western North Pacific

Cruise period (port call): 29 June (Harumi Pier, Tokyo) – 13 July 2015 (Harumi Pier, Tokyo)

Research area: The subarctic western North Pacific, Station K2 (47°N, 160°E)

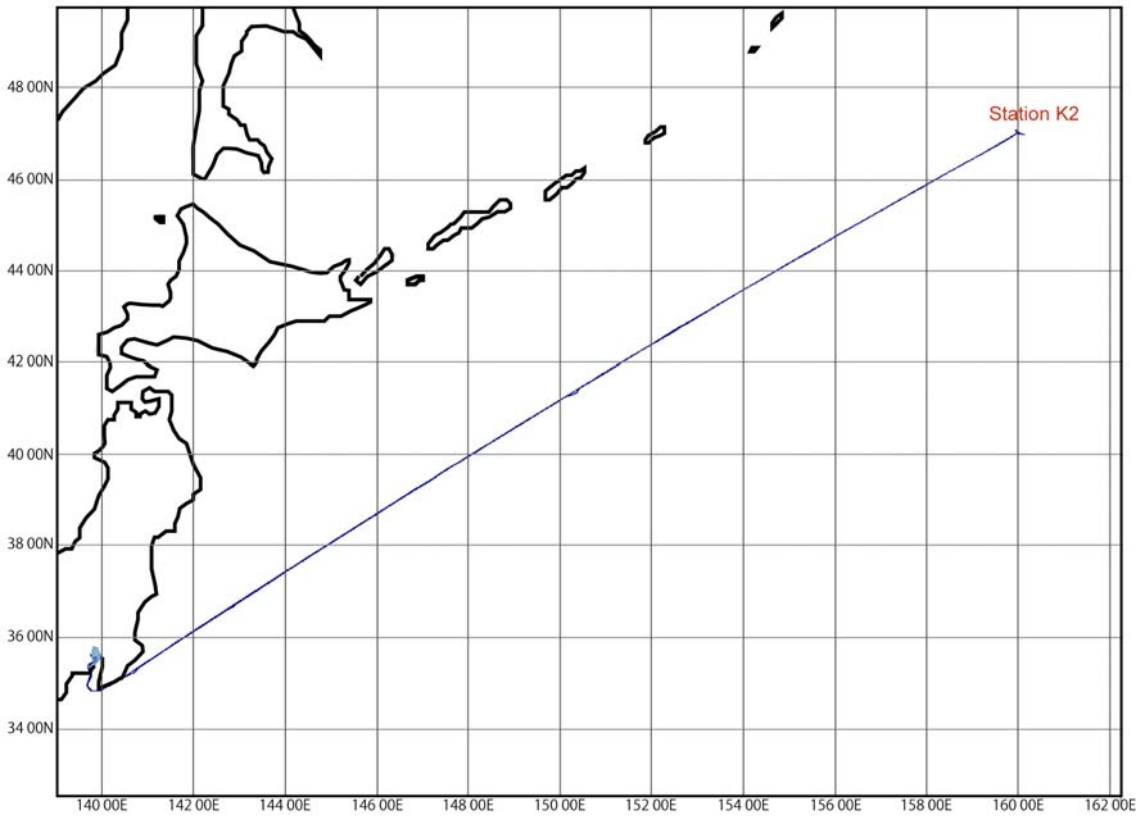
Chief Scientist: Tetsuichi Fujiki (RCGC/JAMSTEC)

Deputy Chief Scientist: Minoru Kitamura (RCGC/JAMSTEC)

Representative of the Science Party: Tetsuichi Fujiki (RCGC/JAMSTEC)

Proposal title: Response of marine ecosystem to the ocean acidification in the subarctic western North Pacific

Cruise truck:



Cruise log:

UTC		Position		Event logs
Date	Time	Latitude	Longtude	
150629	0400	35 38.793N	139 46.310E	DEPATURE FROM HARUMI PIER, TOKYO
150703	1047	46 59.948N	159 57.589E	ARRIVAL AT STATION K2
150703	1100	47 00.518N	159 58.204E	COMUNICATION TEST STARTED
150703	1445	47 00.737N	159 58.726E	COMUNICATION TEST FINISHED
150703	1706	47 00.350N	159 58.304E	NORPAC NET STARTED
150703	1714	47 00.356N	159 58.328E	NORPAC NET FINISHED
150703	1718	47 00.362N	159 58.321E	NORPAC NET STARTED
150703	1725	47 00.366N	159 58.313E	NORPAC NET FINISHED
150703	1729	47 00.364N	159 58.321E	NORPAC NET STARTED
150703	1737	47 00.374N	159 58.337E	NORPAC NET FINISHED
150703	1739	47 00.375N	159 58.339E	NORPAC NET STARTED
150703	1746	47 00.375N	159 58.362E	NORPAC NET FINISHED
150703	1749	47 00.371N	159 58.386E	NORPAC NET STARTED
150703	1756	47 00.369N	159 58.409E	NORPAC NET FINISHED
150703	1804	47 00.363N	159 58.432E	NORPAC NET STARTED
150703	1837	47 00.289N	159 58.511E	NORPAC NET FINISHED
150703	1847	47 00.286N	159 58.501E	NORPAC NET STARTED
150703	1855	47 00.284N	159 58.491E	NORPAC NET FINISHED
150703	1900	47 00.276N	159 58.482E	NORPAC NET STARTED
150703	1906	47 00.268N	159 58.478E	NORPAC NET FINISHED
150703	1921	47 00.263N	159 58.436E	NORPAC NET STARTED
150703	1958	47 00.258N	159 58.370E	NORPAC NET FINISHED
150703	2002	47 00.248N	159 58.351E	NORPAC NET STARTED
150703	2010	47 00.227N	159 58.318E	NORPAC NET FINISHED
150703	2101	47 00.407N	159 58.326E	FRRF STARTED
150703	2131	47 00.485N	159 58.217E	FRRF FINISHED
150703	2324	47 00.032N	159 59.973E	CTD-CMS STARTED
150704	0330	47 00.698N	159 59.667E	CTD-CMS FINISHED
150704	0606	47 01.039N	159 59.549E	CTD-CMS STARTED
150704	0929	47 01.633N	159 58.219E	CTD-CMS FINISHED
150704	1107	47 00.752N	159 59.831E	SETTING OF IN-SITU FILTRATION SYSTEM STARTED
150704	1151	47 00.718N	159 59.648E	SETTING OF IN-SITU FILTRATION SYSTEM FINISHED
150704	1500	47 00.884N	159 59.472E	RETRIEVING OF IN-SITU FILTRATION SYSTEM STARTED
150704	1521	47 00.915N	159 59.423E	RETRIEVING OF IN-SITU FILTRATION SYSTEM FINISHED
150704	2210	47 00.096N	159 58.691E	MOORING BUOY SYSTEM RELEASED
150704	2217	47 00.181N	159 58.674E	MOORING BUOY SYSTEM POPPED
150704	2334	47 00.476N	159 58.429E	RETRIEVING OF MOORING BUOY SYSTEM STARTED
150705	0117	47 01.005N	159 57.677E	RETRIEVING OF MOORING BUOY SYSTEM FINISHED
150705	0254	47 00.075N	160 00.090E	NORPAC NET STARTED
150705	0406	47 00.503N	159 59.969E	NORPAC NET FINISHED
150705	0408	47 00.515N	159 59.972E	NORPAC NET STARTED
150705	0416	47 00.565N	159 59.986E	NORPAC NET FINISHED
150705	0419	47 00.583N	159 59.974E	NORPAC NET STARTED
150705	0430	47 00.650N	159 59.986E	NORPAC NET STARTED
150705	0437	47 00.691N	159 59.999E	NORPAC NET FINISHED
150705	0441	47 00.716N	159 59.981E	NORPAC NET STARTED
150705	0544	47 01.140N	159 59.867E	NORPAC NET FINISHED
150705	0545	47 01.144N	159 59.860E	NORPAC NET STARTED
150705	0616	47 01.360N	159 59.794E	NORPAC NET FINISHED
150705	0620	47 01.391N	159 59.782E	NORPAC NET STARTED
150705	0626	47 01.438N	159 59.786E	NORPAC NET FINISHED
150705	0628	47 01.459N	159 59.794E	NORPAC NET STARTED
150705	0635	47 01.508N	159 59.776E	NORPAC NET FINISHED
150705	0638	47 01.524N	159 59.761E	NORPAC NET STARTED
150705	0651	47 01.313N	159 59.882E	NORPAC NET FINISHED
150705	0708	47 00.004N	159 59.996E	SETTING OF IN-SITU FILTRATION SYSTEM STARTED
150705	0830	47 00.104N	160 00.253E	SETTING OF IN-SITU FILTRATION SYSTEM FINISHED
150705	1246	47 00.311N	160 00.547E	RETRIEVING OF IN-SITU FILTRATION SYSTEM STARTED
150705	1355	47 00.332N	160 00.682E	RETRIEVING OF IN-SITU FILTRATION SYSTEM FINISHED
150705	1459	47 00.025N	159 59.986E	CTD-CMS STARTED
150705	1555	47 00.402N	159 59.762E	CTD-CMS FINISHED
150705	1604	47 00.429N	159 59.760E	FRRF STARTED
150705	1632	47 00.649N	159 59.603E	FRRF FINISHED

UTC		Position		Event logs
Date	Time	Latitude	Longtude	
150705	1657	47 00.752N	159 59.496E	VMPS NET STARTED
150705	1729	47 00.847N	159 59.271E	VMPS NET FINISHED
150705	1749	47 00.908N	159 59.177E	VMPS NET STARTED
150705	1759	47 00.954N	159 59.148E	VMPS NET FINISHED
150705	1810	47 01.008N	159 59.167E	VMPS NET STARTED
150705	1958	47 01.112N	159 58.805E	VMPS NET FINISHED
150705	2011	47 01.140N	159 58.832E	VMPS NET STARTED
150705	2052	47 01.187N	159 58.687E	VMPS NET FINISHED
150705	2059	47 01.206N	159 58.681E	VMPS NET STARTED
150705	2122	47 01.209N	159 58.612E	ORI NET STARTED
150705	2157	47 01.656N	160 00.330E	ORI NET FINISHED
150705	2216	47 01.526N	160 00.646E	ORI NET STARTED
150705	2235	47 01.738N	160 01.668E	ORI NET FINISHED
150705	2251	47 01.369N	160 01.410E	ORI NET STARTED
150705	2303	47 01.416N	160 02.042E	ORI NET FINISHED
150705	2359	47 00.114N	159 59.974E	CTD-CMS STARTED
150706	0056	47 00.439N	159 59.722E	CTD-CMS FINISHED
150706	0115	47 00.089N	160 00.104E	FRRF STARTED
150706	0145	47 00.314N	160 00.160E	FRRF FINISHED
150706	0156	47 00.416N	160 00.195E	VMPS NET STARTED
150706	0218	47 00.549N	160 00.133E	VMPS NET FINISHED
150706	0226	47 00.597N	160 00.104E	VMPS NET STARTED
150706	0238	47 00.691N	160 00.082E	VMPS NET FINISHED
150706	0254	47 00.784N	160 00.020E	NORPAC NET STARTED
150706	0446	47 01.443N	159 59.839E	NORPAC NET FINISHED
150706	0449	47 01.480N	159 59.851E	NORPAC NET STARTED
150706	0456	47 01.546N	159 59.858E	NORPAC NET FINISHED
150706	0459	47 01.579N	159 59.861E	NORPAC NET STARTED
150706	0509	47 01.676N	159 59.884E	NORPAC NET FINISHED
150706	0510	47 01.682N	159 59.886E	NORPAC NET STARTED
150706	0515	47 01.737N	159 59.910E	NORPAC NET FINISHED
150706	0519	47 01.775N	159 59.929E	NORPAC NET STARTED
150706	0525	47 01.832N	159 59.955E	NORPAC NET FINISHED
150706	0529	47 01.871N	159 59.973E	NORPAC NET STARTED
150706	0534	47 01.929N	160 00.003E	NORPAC NET FINISHED
150706	0536	47 01.943N	160 00.010E	NORPAC NET STARTED
150706	0542	47 02.004N	160 00.040E	NORPAC NET FINISHED
150706	0543	47 02.013N	160 00.044E	NORPAC NET STARTED
150706	0549	47 02.074N	160 00.071E	NORPAC NET FINISHED
150706	0701	46 59.865N	160 00.107E	CTD-CMS STARTED
150706	0748	46 59.962N	160 00.543E	CTD-CMS FINISHED
150706	0758	47 00.020N	160 00.616E	FRRF STARTED
150706	0826	47 00.093N	160 00.814E	FRRF FINISHED
150706	0842	46 59.994N	160 00.019E	VMPS NET STARTED
150706	0904	46 59.972N	160 00.145E	VMPS NET FINISHED
150706	0915	46 59.994N	160 00.207E	VMPS NET STARTED
150706	0929	47 00.020N	160 00.284E	VMPS NET FINISHED
150706	1056	47 00.103N	159 59.956E	CTD-CMS STARTED
150706	1144	47 00.106N	160 00.046E	CTD-CMS FINISHED
150706	1153	47 00.109N	160 00.032E	FRRF STARTED
150706	1222	47 00.177N	160 00.032E	FRRF FINISHED
150706	1233	47 00.203N	160 00.014E	VMPS NET STARTED
150706	1254	47 00.234N	159 59.959E	VMPS NET FINISHED
150706	1303	47 00.229N	159 59.963E	VMPS NET STARTED
150706	1315	47 00.216N	160 00.022E	VMPS NET FINISHED
150706	1856	47 00.018N	159 59.977E	NORPAC NET STARTED
150706	2008	47 00.010N	160 00.229E	NORPAC NET FINISHED
150706	2011	47 00.005N	160 00.229E	NORPAC NET STARTED
150706	2030	46 59.991N	160 00.249E	NORPAC NET FINISHED
150706	2031	46 59.990N	160 00.252E	NORPAC NET STARTED
150706	2037	46 59.988N	160 00.273E	NORPAC NET FINISHED
150706	2038	46 59.988N	160 00.275E	NORPAC NET STARTED
150706	2045	46 59.987N	160 00.313E	NORPAC NET FINISHED

UTC		Position		Event logs
Date	Time	Latitude	Longtude	
150706	2046	46 59.986N	160 00.317E	NORPAC NET STARTED
150706	2051	46 59.981N	160 00.352E	NORPAC NET FINISHED
150706	2053	46 59.978N	160 00.359E	NORPAC NET STARTED
150706	2105	46 59.941N	160 00.440E	NORPAC NET FINISHED
150706	2105	46 59.940N	160 00.442E	NORPAC NET STARTED
150706	2116	46 59.922N	160 00.501E	NORPAC NET FINISHED
150706	2117	46 59.924N	160 00.496E	NORPAC NET STARTED
150706	2121	46 59.930N	160 00.476E	NORPAC NET FINISHED
150706	2123	46 59.929N	160 00.476E	NORPAC NET STARTED
150706	2132	46 59.905N	160 00.509E	NORPAC NET FINISHED
150706	2133	46 59.901N	160 00.516E	NORPAC NET STARTED
150706	2138	46 59.881N	160 00.578E	NORPAC NET FINISHED
150706	2317	46 59.075N	160 08.438E	SETTING OF MOORING BUOY SYSTEM STARTED
150707	0413	47 00.403N	159 57.832E	SETTING OF MOORING BUOY SYSTEM FINISHED
150707	0959	46 59.987N	159 59.956E	SETTING OF IN-SITU FILTRATION SYSTEM STARTED
150707	1031	47 00.003N	160 00.054E	SETTING OF IN-SITU FILTRATION SYSTEM FINISHED
150707	1403	47 00.064N	160 00.030E	RETRIEVING OF IN-SITU FILTRATION SYSTEM STARTED
150707	1417	47 00.120N	159 59.934E	RETRIEVING OF IN-SITU FILTRATION SYSTEM FINISHED
150707	1458	46 59.944N	160 00.152E	CTD-CMS STARTED
150707	1552	46 59.700N	160 00.399E	CTD-CMS FINISHED
150707	1600	46 59.675N	160 00.419E	FRRF STARTED
150707	1627	46 59.534N	160 00.440E	FRRF FINISHED
150707	1635	46 59.478N	160 00.439E	VMPS NET STARTED
150707	1648	46 59.394N	160 00.522E	VMPS NET FINISHED
150707	1653	46 59.377N	160 00.544E	VMPS NET STARTED
150707	1710	46 59.287N	160 00.595E	VMPS NET FINISHED
150707	1719	46 59.244N	160 00.636E	VMPS NET STARTED
150707	1727	46 59.205N	160 00.689E	VMPS NET FINISHED
150707	1738	46 59.179N	160 00.772E	VMPS NET STARTED
150707	1930	46 58.857N	160 00.805E	VMPS NET FINISHED
150707	1932	46 58.852N	160 00.794E	VMPS NET STARTED
150707	1950	46 58.808N	160 00.665E	VMPS NET FINISHED
150707	1950	46 58.807N	160 00.664E	VMPS NET STARTED
150707	2029	46 58.635N	160 00.769E	VMPS NET FINISHED
150707	2041	46 58.550N	160 00.871E	VMPS NET STARTED
150707	2056	46 58.429N	160 00.974E	VMPS NET FINISHED
150707	2129	46 59.966N	159 59.974E	CTD-CMS STARTED
150708	0106	46 59.643N	160 00.978E	CTD-CMS FINISHED
150708	0149	47 00.459N	159 58.344E	COMMUNICATION TEST STARTED
150708	0215	47 00.650N	159 58.485E	COMMUNICATION TEST FINISHED
150708	0301	47 00.049N	160 00.139E	CTD-CMS STARTED
150708	0338	47 00.207N	160 00.239E	CTD-CMS FINISHED
150708	0347	47 00.263N	160 00.313E	NORPAC NET STARTED
150708	0447	47 00.785N	160 00.452E	NORPAC NET FINISHED
150708	0451	47 00.834N	160 00.475E	NORPAC NET STARTED
150708	0459	47 00.909N	160 00.522E	NORPAC NET FINISHED
150708	0459	47 00.916N	160 00.527E	NORPAC NET STARTED
150708	0505	47 00.969N	160 00.571E	NORPAC NET FINISHED
150708	0506	47 00.979N	160 00.579E	NORPAC NET STARTED
150708	0512	47 01.040N	160 00.627E	NORPAC NET FINISHED
150708	0512	47 01.046N	160 00.631E	NORPAC NET STARTED
150708	0519	47 01.112N	160 00.676E	NORPAC NET FINISHED
150708	0520	47 01.117N	160 00.680E	NORPAC NET STARTED
150708	0525	47 01.167N	160 00.731E	NORPAC NET FINISHED
150708	0526	47 01.178N	160 00.743E	NORPAC NET STARTED
150708	0532	47 01.221N	160 00.810E	NORPAC NET FINISHED
150708	0534	47 01.233N	160 00.829E	NORPAC NET STARTED
150708	0540	47 01.275N	160 00.914E	NORPAC NET FINISHED
150708	0540	47 01.276N	160 00.916E	NORPAC NET STARTED
150708	0548	47 01.326N	160 00.993E	NORPAC NET FINISHED
150708	0559	47 01.414N	160 01.113E	CHANGED ENGINE TO T/M
150708	0600	47 01.420N	160 01.120E	DEPATURE FROM STATION K2
150713	0100	35 34.588N	139 52.811E	ARRIVAL AT HARUMI PIER, TOKYO

1.2 Cruise participants

Chief Scientist: Tetsuichi Fujiki

Deputy Chief Scientist: Minoru Kitamura

Research and Development Center for Global Change (RCGC)

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

Chief Technician: Shungo Oshitani

Marine Works Japan Ltd. (MWJ)

Researchers:

Tetsuichi Fujiki, RCGC/JAMSTEC

Minoru Kitamura, RCGC/JAMSTEC

Katsunori Kimoto, RCGC/JAMSTEC

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Chiho Sukigara, Nagoya University

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(Not on board)

Naomi Harada, RCGC/JAMSTEC

Jonaotaro Onodera, RCGC/JAMSTEC

Koji Sugie, RCGC/JAMSTEC

Haruka Takagi, RCGC/JAMSTEC & Waseda University

Makio C. Honda, DEGCR/JAMSTEC

Hiroshi Uchida, RCGC/JAMSTEC

Akira Nagano, RCGC/JAMSTEC

Ryuichiro Inoue, RCGC/JAMSTEC

Tadahiro Hayasaka, Tohoku University

Technicians:

Shungo Oshitani, MWJ

Hiroshi Matsunaga, MWJ

Akira Watanabe, MWJ

Masaki Furuhata, MWJ

Masanori Enoki, MWJ

Keitaro Matsumoto, MWJ

1.3 Research brief

Purpose of research:

The main purpose of this research is to investigate the plankton community response to the progress of ocean acidification in the western subarctic North Pacific.

Content of research:

We conducted the following studies at time-series station K2 (47°N, 160°E) in the western subarctic North Pacific.

(a) Physical factors related to the progress of ocean acidification

(b) Impact assessment of ocean acidification on marine organisms based on dissolved chemical constituents

(c) Relationship between phytoplankton community and ocean acidification

(d) Relationship between zooplankton community and ocean acidification

(e) Measurements of carbonate shell density of planktic foraminifers and pteropods by the Micro-focus X-ray CT

(f) Performance evaluation test of the Hybrid CO_2-pH sensor

Observations and operations:

(1) Recovery of BGC mooring and deployment of hybrid profiling buoy system

(2) CTD cast and water sampling/biochemical analysis

(3) Plankton sampling by using the VMPS, ORI and NORPAC nets

(4) Particle collection by using in situ filtration system

(5) Assessment of phytoplankton photosynthesis by fast repetition rate fluorometry

(6) On-deck incubation experiments

(7) Measurements of shortwave and longwave radiation

(8) Upper ocean current measurements by shipboard ADCP

(9) Sea surface water sampling

(10) Performance evaluation test of the Hybrid CO_2-pH sensor

2. Buoy observations

2.1 BGC mooring

Tetsuichi Fujiki (JAMSTEC)
Minoru Kitamura (JAMSTEC)
Katsunori Kimoto (JAMSTEC)
Akira Watanabe (MWJ)
Masaki Furuhata (MWJ)
Hiroshi Matsunaga (MWJ)

2.1.1 Recovery

The BGC mooring system was designed for biogeochemistry at Station K2 in the Western Subarctic Gyre. We recovered BGC mooring at Station K2 which was deployed at KH-14-2. Recovery operation took approximately 3 hours. The position of the mooring is follow:

Station and type:	K2 BGC
Mooring Number:	K2BGC140530
Deployed date:	30 May. 2014
Recovered date:	05 Jul. 2015
Exact location:	47°00.36N, 159°58.35E
Depth:	5,206m

The recovery BGC mooring consists of a top float with 77lbs(35 kg) buoyancy, instruments, wire and ropes, glass floats (Benthos 17” glass ball), dual releasers (Edgetech) and 4,660 lbs (2,116 kg) sinker. An ARGOS compact mooring locators and a submersible recovery strobe was mounted on the top float. This mooring system was planned to keep the following time-series observational instruments are mounted approximately 890 m below sea surface. It is 10 m longer than real depth because recovered depth sensor which was installed on the Sediment trap shows 10 m deeper than our expected by mooring tilt. The recovery BGC mooring consists of two Sediment Traps installed on the 1,000m and 4,800m. Also Extra instrument are mounted. Details for each instrument are described below (section 2.1.2). Serial number of instruments are as follows:

Table 2.1.1-1 Serial number of instruments

Station and type	K2 BGC
Mooring Number	K2BGC140530

Top Buoy(890m)	-
ARGOS	18842
Strobe	B02-016
Sediment Trap Mark7-21(1,000m)	10236-02
RINKO	051
Optode	05
Sediment Trap Mark7-21 (4,800m)	10558-01
Releaser	27868, 27825
SBE-37	2731

Table 2.1.1-2 Recovery record of BGC Mooring

Mooring Number K2BGC140530

Project	Time-Series		Depth	5,206.2	m
Area	North Pacific		Planned Depth	5,216.2	m
Station	K2		Length	4,327.0	m
Target Position	**47° 00.350 N**		Depth of Buoy	890	m
	159° 58.326 E		Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	27868		27825		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**335534**		**344176**		
Enable C.	322710		356736		
Disable C.	322756		356770		
Battery	2 years		2 years		
Release Test	OK		OK		
RECOVERY					
Recorder	Akira Watanabe		Work Distance	0.7	Nmile
Ship	HAKUHO-MARU		Send Enable C.	2015/7/3	
Cruise No.	KH-15-J01		Slant Renge	-	msec
Date	2015/7/4-5		Send Release C.	22:05	
Weather	r		Discovery Buoy	22:17	
Wave Hight	0.5	m	Pos. of Top Buoy	47° 00.10	N
Seabeam Depth	5,206	m		159° 58.69	E
Ship Heading	<319>		Pos. of Start	47° 00.48	N
Ship Ave.Speed	-	knot		159° 58.43	E
Wind	<107> 3.7	m/s	Pos. of Finish	47° 01.01	N
Current	0	cm/s		159° 57.68	E

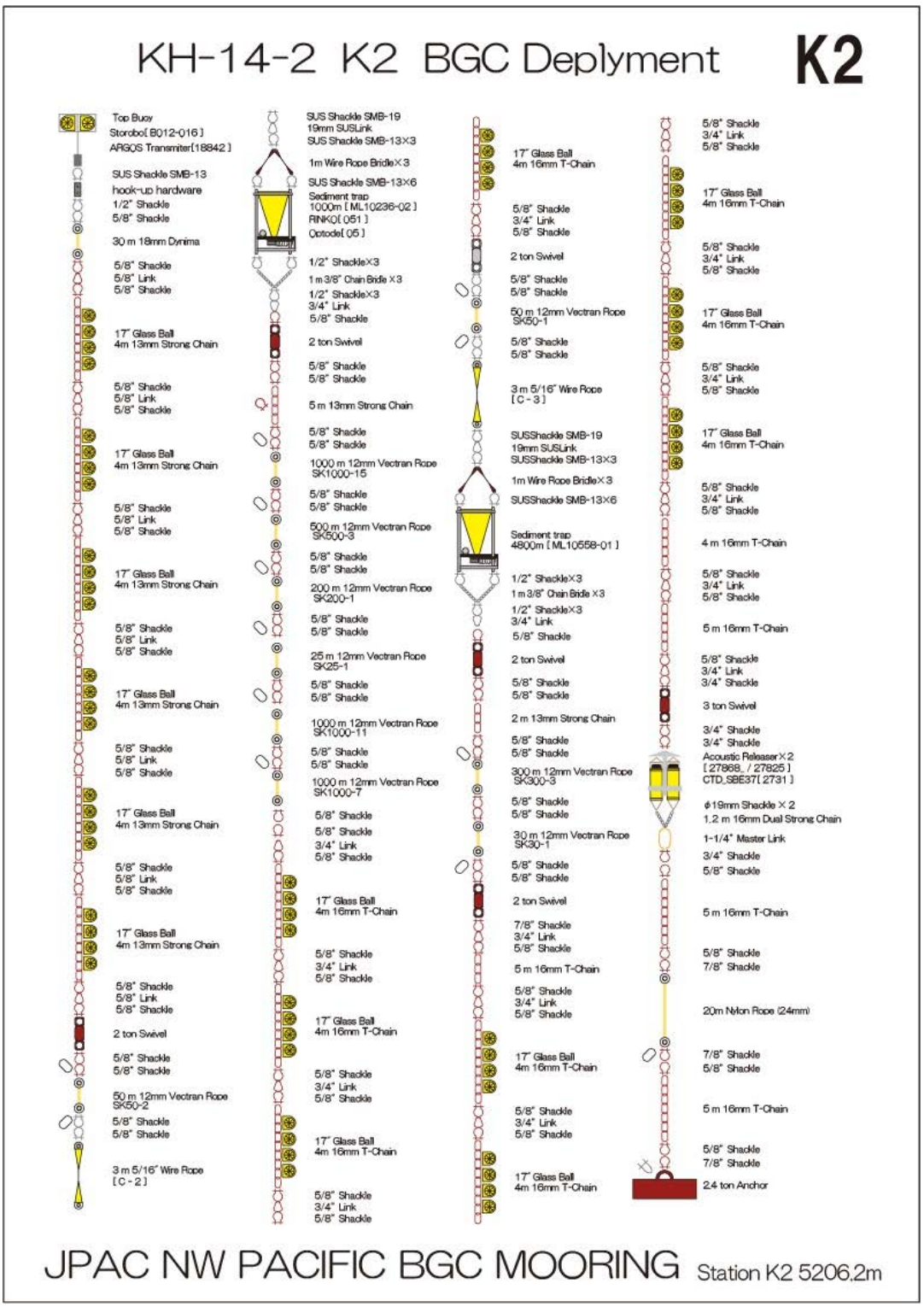

Fig. 2.1.1-1 Recovery BGC Mooring Figure

2.1.2 Instruments

On mooring systems, the following instruments are installed.

(1) ARGOS CML (Compact Mooring Locator)

The Compact Mooring Locator is a subsurface mooring locator based on SEIMAC's Smart Cat ARGOS PTT (Platform Terminal Transmitter) technology. Using CML, we can know when our mooring has come to the surface and its position. The CML employs a pressure sensor at the bottom. When the CML is turned ON, the transmission is started immediately every 90 seconds and then when the pressure sensor works ON by approximately 10 dbar, the transmission is stopped. When the top buoy with the CML comes to the surface, the pressure sensor will work OFF and the transmission will be started. Smart Cat transmissions will be initiated at this time, allowing us to locate our mooring. Depending on how long the CML has been moored, it will transmit for up to 120 days on a 90 second repetition period. Battery life, however, is affected by how long the CML has been moored prior to activation. A longer pre-activation mooring will mean less activation life.

Principle specification is as follows:

(Specification)

Transmitter:	Smart Cat PTT
Operating Temp.:	+35 [deg] to –5 [deg]
Standby Current:	80 microamps
Smart Cat Freq.:	401.650 MHz
Battery Supply:	7-Cell alkaline D-Cells
Ratings:	+10.5VDC nom., 10 Amp Hr
Hull:	6061-T6 Aluminum
Max Depth:	1,000 m
Length:	22 inches
Diameter:	3.4 inches
Upper flange:	5.60 inches
Dome:	Acrylic
Buoyancy:	-2.5 (negative) approx.
Weight	12 pounds approx.

(2) Submersible Recovery Strobe

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

(Specification)

Repetition Rate:	Adjustable from 2 bursts per second to 1 burst every 3 seconds.
Burst Length:	Adjustable from 1 to 5 flashes per burst. 100 ms between flashes nominal.
Battery Type:	C-cell alkaline batteries.
Life:	Dependent on repetition rate and burst length. 150 hours with a one flash burst every 2 seconds.
Construction:	Awl-grip painted, Hard coat anodized 6061 T-6 aluminum housing.
Max. Depth:	7,300m
Daylight-off:	User selected, standard
Pressure Switch:	On at surface, auto off when submerged below 10m.
Weight in Air:	4 pounds
Weight in Water:	2 poundsOutside
Diameter:	1.7 inches nominal
Length:	21-1/2 inches nominal

(3) CTD SBE-37

The SBE 37-SM MicroCAT is a high-accuracy conductivity and temperature (pressure optional) recorder with internal battery and memory. Designed for moorings or other long duration, fixed-site deployments, the MicroCAT includes a standard serial interface and nonvolatile FLASH memory. Constructed of titanium and other non-corroding materials to ensure long life with minimum maintenance, the MicroCAT's depth capability is 7000 meters; it is also available with an optional 250-meter plastic *ShallowCAT* housing. Data is sampled at 1-hour intervals from MR13-04 Cruise.

(Specification)

Measurement Range

Conductivity: 0 - 7 S/m (0 - 70 mS/cm)

Temperature: -5 to 35 °C

Optional Pressure: 7000 (meters of deployment depth capability)

Initial Accuracy

Conductivity: 0.0003 S/m (0.003 mS/cm)

Temperature: 0.002 °C

Optional Pressure: 0.1% of full scale range

Typical Stability (per month)

Conductivity: 0.0003 S/m (0.003 mS/cm)

Temperature: 0.0002 °C

Optional Pressure: 0.004% of full scale range

Resolution

Conductivity: 0.00001 S/m (0.0001 mS/cm)

Temperature: 0.0001 °C

Optional Pressure: 0.002% of full scale range

Time Resolution 1 second

Clock Accuracy 13 seconds/month

Quiescent Current * 10 microamps

Optional External Input Power 0.5 Amps at 9-24 VDC

Housing, Depth Rating, and Weight (without pressure sensor)

Standard Titanium, 7000 m (23,000 ft)

Weight in air: 3.8 kg (8.3 lbs)

Weight in water: 2.3 kg (5.1 lbs)

(4) JFE Advantech optical dissolved oxygen sensor, RINKO

JFE Advantech optical dissolved oxygen sensor, RINKO, is based on the oxygen luminescence quenching. The RINKO used has a datalogger with an internal battery and memory in a titanium housing designed for mooring observation. Data is sampled at 1-hour intervals.

(Manufacturer's specification)

Model:	RINKO I (ARO-USB)
Sensor Type:	Luminescence quenching
Operating Range:	0 ~ 200%
Resolution:	0.01 ~ 0.04%
Precision:	±2%FS (linearity)
Memory:	1GB mini SD card
Sampling interval:	0.1 ~ 600 seconds
Burst time:	1 ~ 1,440 minutes
Sample number:	1 ~ 18,000
Battery:	CR-V3 lithium battery, 3.3Ah (maximum 2 batteries)
Housing material:	Titanium
Size:	ϕ54 mm × 232 mm
Weight:	0.9 kg in air, 0.6 kg in water
Depth rating:	7000 m

(5) JFE Advantech miniature temperature sensor

ALEC DO (Compact Optode) sensor is digital memory type and designed for mounting on the plankton net and instrument for mooring and so on. It is small and right weight for easy handling. Sampling interval is chosen between 1 and 30 seconds. The data is converted to personal computer using exclusive cable (serial port)

(Specification)

Model:COMPACT-Optode

Sensor Type:Fluorescence quenching

Operating Range:0 ~ 120%

Precision: 0.4%

Accuracy: within 5%

Memory: 2Mbyte flash memory

Battery: lithium battery 7Ah

Battery Life: 172800 data

Sample interval: 1,2,5,10,15,20 and 30 seconds

Diameter:54mm

Length:272mm

Main Material:titanium

Weight in water:0.6kg

Broken Pressure:60MPa

2.1.3 Preliminary results

Sequential samplings of the sinking particle were conducted as scheduled. Because sediment traps were recovered during 20th sampling period (5th July, 2015), samples in #20 collecting cup moored at 1000 m were probably contaminated by suspended particles upper 1000 m. The sediment trap moored at 4800 m was recovered upside down, sample in the #20 collecting cup was lost. Onboard, heights of the sinking particle in collecting cups were measured with scale in order to know general view of seasonal change. Using base area of collecting cup (18.1 cm^2), we estimated total mass flux in volume for each collecting period (20 days). After back to land laboratory, pH of seawater in collecting cups were measured. Sampling date, mass flux (TMF, $cm^3/m^2/day$), and pH for each sample were summarized in the table 2.1.3-1.

Table 2.1.3-1. The sinking particle samplings using sediment traps morred at the station K2.
K2BGC140530

1000m Trap

Bottle No.	Open	Close	Mass Flux (cm3/m2/day)	pH
1	06/01/2014	06/21/2014	3.8	8.60
2	06/21/2014	07/11/2014	4.8	8.57
3	07/11/2014	07/31/2014	4.8	8.53
4	07/31/2014	08/20/2014	4.9	8.50
5	08/20/2014	09/09/2014	5.5	8.41
6	09/09/2014	09/29/2014	7.5	8.12
7	09/29/2014	10/19/2014	6.7	8.13
8	10/19/2014	11/08/2014	5.2	8.26
9	11/08/2014	11/28/2014	3.4	8.47
10	11/28/2014	12/18/2014	2.1	8.53
11	12/18/2014	01/07/2015	1.4	8.58
12	01/07/2015	01/27/2015	0.8	8.59
13	01/27/2015	02/16/2015	1.3	8.65
14	02/16/2015	03/08/2015	1.0	8.65
15	03/08/2015	03/28/2015	4.2	8.17
16	03/28/2015	04/17/2015	8.4	8.44
17	04/17/2015	05/07/2015	6.4	8.49
18	05/07/2015	05/27/2015	3.6	8.57
19	05/27/2015	06/16/2015	2.1	8.69
20	06/16/2015		2.7	8.23
21				

4800m Trap

Bottle No.	Open	Close	Mass Flux (cm3/m2/day)	pH
1	06/01/2014	06/21/2014	4.2	8.60
2	06/21/2014	07/11/2014	3.1	8.65
3	07/11/2014	07/31/2014	2.1	8.67
4	07/31/2014	08/20/2014	2.4	8.68
5	08/20/2014	09/09/2014	2.3	8.67
6	09/09/2014	09/29/2014	2.8	8.64
7	09/29/2014	10/19/2014	3.8	8.56
8	10/19/2014	11/08/2014	3.4	8.58
9	11/08/2014	11/28/2014	2.2	8.65
10	11/28/2014	12/18/2014	1.7	8.70
11	12/18/2014	01/07/2015	1.3	8.73
12	01/07/2015	01/27/2015	0.8	8.71
13	01/27/2015	02/16/2015	1.0	8.73
14	02/16/2015	03/08/2015	0.8	8.76
15	03/08/2015	03/28/2015	0.6	8.76
16	03/28/2015	04/17/2015	1.7	8.76
17	04/17/2015	05/07/2015	3.6	8.72
18	05/07/2015	05/27/2015	4.0	8.72
19	05/27/2015	06/16/2015	1.5	8.73
20	06/16/2015		no sample	
21				

Seasonal changes of mass fluxes at 1000 and 4800 m were shown in the figure 2.1.3-1. At 1000 m, two peaks in TMF were observed during September (#6) and April (#16), while low TMF were observed between mid December (#11) and early March (#14). Presence of two peaks in TMF during spring and autumn were also observed in the previous sediment trap experiment at K2 (see MR13-04 preliminary cruise report). At 4800 m, three peaks in TMF were detected during June (#1), October (#7), and May (#18). The second and third peaks followed the peaks in the TMF at 1000 m, while time lag between 1000 m and 4800 m peaks was shorter in the second peak than that in the third one. Based on our previous researches, primary productivities are high during early summer (June/July) at K2. However, TMF in early summer was not so high. Annual averages of TMF at 1000 and 4800 m were 4.0 and 2.3 $cm^3/m^2/day$, respectively.

All samples are stored in JAMSTEC/Yokosuka. Each sample will be divided into ten aliquots, and

these subsamples will be used for analysis which is summarized in Table 2.1.3-2.

Table 2.1.3-2. Summary of future analysis

Purpose	Investigator	
Organic carbon, Inorganic carbon, Si, Ca, Fe, Ti	M. Honda	JAMSTEC
Alkenones	N. Harada	JAMSTEC
Stable isotopes of carbon and nitrogen	Y. Mino	Nagoya Univ.
Stable isotopes of nitrogen	C. Yoshikawa	JAMSTEC
Stable isotopes of iron	K. Nagashima	JAMSTEC
Plankton with $CaCO_3$ test	K. Kimoto	JAMSTEC
Plankton with siliceous (SiO_2+nH_2O) test	T. Ikenoue	MERI
Phytoplankton	J. Onodera	JAMSTEC
Phytoplankton	T. Fujiki	JAMSTEC
DNA	F. Ito	Tsukuba Univ.

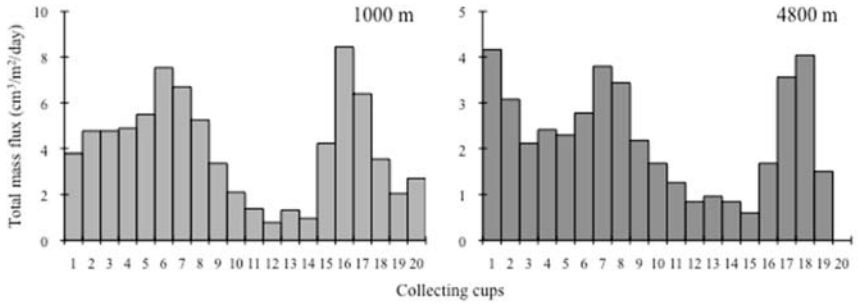

Fig. 2.1.3-1. Seasonal changes of total mass fluxes (cm3/m2/day) at 1000 m (left panel) and 4800 m (right panel) in the station K2. Collecting periods were summarized in the Table 2.1.3-1.

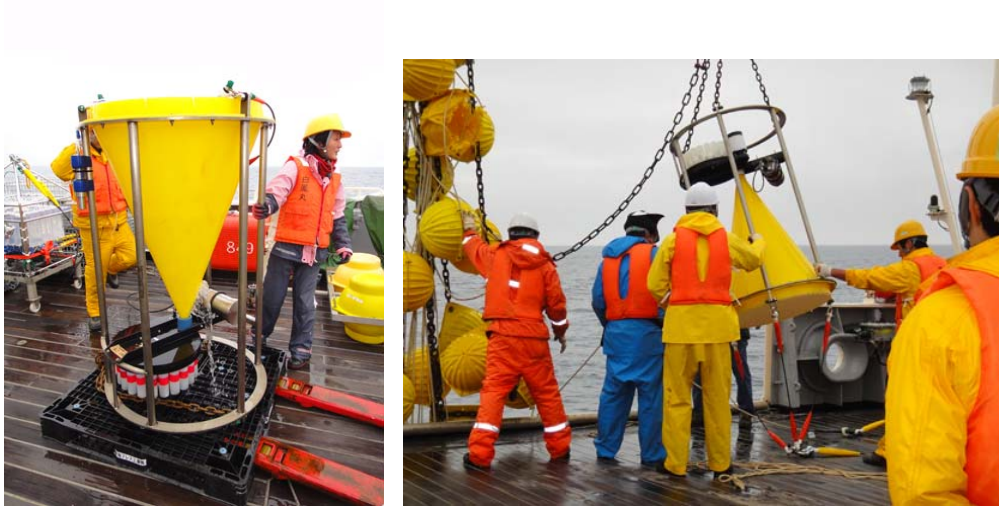

Fig.2.1.3-2. Recovered sediment trap moored at 1000 m (left) and that at 4800 m (right).

2.2 Hybrid profiling buoy system

Tetsuichi Fujiki (JAMSTEC RCGC)
Minoru Kitamura (JAMSTEC RCGC)
Masahide Wakita (JAMSTEC MIO)
Yoshiyuki Nakano (JAMSTEC MARITEC)
Hiroshi Uchida (JAMSTEC RCGC)
Akira Watanabe (MWJ)
Masaki Furuhata (MWJ)
Hiroshi Matsunaga (MWJ)

To better understand the plankton community response to environmental changes including ocean acidification, we developed a hybrid profiling buoy system that consists mainly of an underwater profiling buoy system (POPPS), a remote automatic water sampler (RAS), a hybrid pH sensor (HpHS), an acoustic Doppler current profiler (ADCP) and a sediment trap.

2.2.1 Deployment

Hybrid profiling buoy is combined two moorings, BGC mooring(biogeochemistry) and POPPS mooring (ocean productivity profiling system). We deployed Hybrid profiling buoy at Station K2. Deployment operation took approximately 5 hours. After sinker was dropped, we positioned the mooring systems by measuring the slant ranges between research vessel and the acoustic releaser(see 2.3 Location tracking of moorings). The position of the mooring is finally determined as follow:

Station and type:	K2 Hybrid profiling buoy
Mooring Number:	K2H150707
Deployed date:	07 Jul. 2015
Exact location:	47°00.43N, 159°58.30E
Depth:	5,208m

The deployment Hybrid profiling buoy consists of a top buoy with 24lbs(11kg) buoyancy, underwater winch, instruments, wire and ropes, recovery buoy with 496lbs(225kg) buoyancy, glass floats (Benthos 17” glass ball), dual releasers (Edgetech) and 4,911lbs (2,228kg) sinker. An ARGOS compact mooring locator and a submersible recovery strobe mounted on the top buoy. This mooring system was planned to keep the following time-series observational instruments are mounted approximately 120 m below

sea surface. It is 10 m longer than real depth because recovered depth sensor which was installed on the Sediment trap shows 10 m deeper than our expected by mooring tilt. On the Hybrid profiling buoy, two Sediment Traps are installed on the 500 m and 4,800 m. Two auto sampling systems(RAS) are installed on the 200m and 300m. Extra CTD (SBE-37) and Do Sensor (RINKO and Optode) are mounted on the dual acoustic releaser and inline wire rope, Sediment Trap, RAS. Details for each instrument are described below (section 2.2.2, 2.2.3, 2.2.4, 2.2.5, 2.2.6, 2.2.7, 2.2.8). Serial number of instruments are as follows:

Table 2.2.1-1 Serial number of instruments

Station and type	K2 Hybrid profiling buoy
Mooring Number	K2H150707
Top Buoy(120m)	AES-3-001
ARGOS	A11-061
Strobe	001
Iridium antenna	0215
FRRF	M813-3
PAR	20251
CTD(NXIC)	1708
CTD(JFE)	0109
Optode	002
RINKO	052
Underwater winch	AES-3-001
SBE37	1893
RINKO	0080
Wire(175m)	
SBE37	1892
RINKO	0087
RAS 3-48-500(200m)	11241-09
SBE-37	2239
RINKO	0088
HpHS	505061003
Wire(250m)	
SBE37	2756

RINKO	0092
RAS 3-48-500(300m)	11241-07
SBE-37	2289
RINKO	051
Optode	08
WH ADCP(400m)	1434
Sediment Trap Nichiyu(500m)	26S001
SBE37	10737
Sediment Trap Mark7-21(500m)	ML11241-22
Releaser	28533/28509
SBE-37	2731

Table 2.2.1-2 Deployment record of Hybrid profiling buoy

Mooring Number K2H150707

Project	Time-Series		Depth	5,206.2	m
Area	North Pacific		Planned Depth	5,216.2	m
Station	K2		Length	5,097.0	m
Target Position	**47° 00.350 N**		Depth of Buoy	120	m
	159° 58.320 E		Period	1	year
ACOUCTIC RELEASERS					
Type	Edgetech		Edgetech		
Serial Number	28533		28509		
Receive F.	11.0	kHz	11.0	kHz	
Transmit F.	14.0	kHz	14.0	kHz	
RELEASE C.	**223307**		**335704**		
Enable C.	201054		377142		
Disable C.	201077		377161		
Battery	2 years		2 years		
Release Test	OK		OK		
DEPLOYMENT					
Recorder	Akira Watanabe		Start	7.4	Nmile
Ship	HAKUHO-MARU		Overrun	600	m
Cruise No.	KH-15-J01		Let go Top Buoy	23:18	
Date	2015/7/6-7		Let go Anchor	4:13	
Weather	C		Sink Top Buoy	4:55	
Wave Hight	0.5	m	Pos. of Start	46° 59.08	N
PDR Depth	5,208	m		160° 08.44	E
Ship Heading	<280>		Pos. of Drop. Anc.	47° 00.40	N
Ship Ave.Speed	-	knot		159° 57.83	E
Wind	<296> 9.0	m/s	Pos. of Mooring	47° 00.43	N
Current	<299> 0.1	cm/s		159° 58.30	E

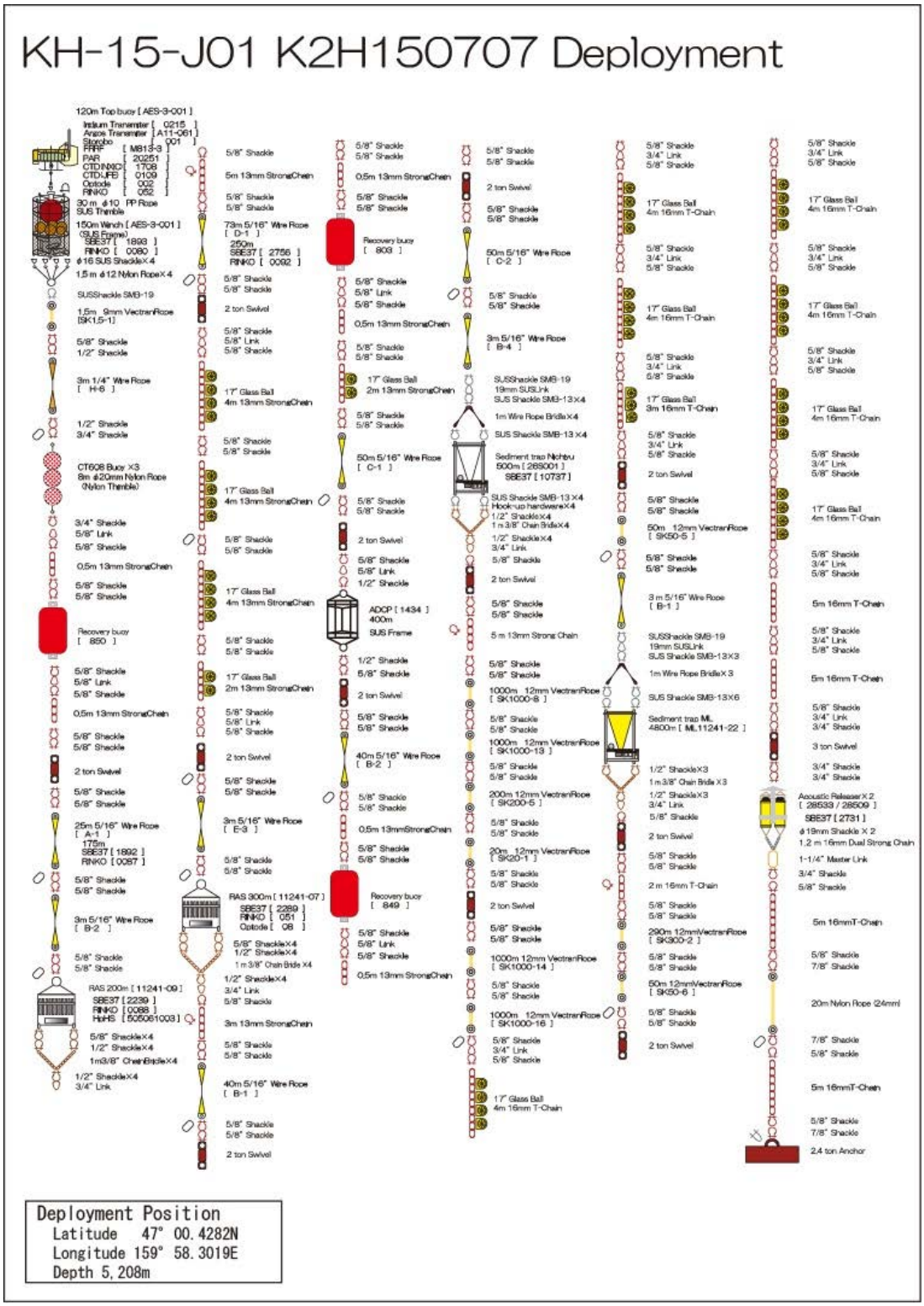

Fig. 2.2.1-1 Deployment Hybrid profiling buoy Figure

2.2.2 Instruments

On mooring systems, the following instruments are installed.

(1) ARGOS CML (Compact Mooring Locator)

The Compact Mooring Locator is a subsurface mooring locator based on NOVATECH's AS-900 ARGOS PTT (Platform Terminal Transmitter) technology. Using CML, we can know when our mooring has come to the surface and its position. The CML employs a pressure sensor at the bottom. When the CML is turned ON, the transmission is started immediately every 90 seconds and then when the pressure sensor works ON by approximately 10 dbar, the transmission is stopped. When the top buoy with the CML comes to the surface, the pressure sensor will work OFF and the transmission will be started. Smart Cat transmissions will be initiated at this time, allowing us to locate our mooring. Depending on how long the CML has been moored, it will transmit for up to 30 days on a 90 second repetition period. Battery life, however, is affected by how long the CML has been moored prior to activation. A longer pre-activation mooring will mean less activation life.

Principle specification is as follows:

(Specification)

Transmitter Output:	1 watt
Harmonics:	-40 db minimum
Batteries:	4 alkaline C-cells
BatteryLife:	30days
Operating Temp:	-40 °C to +60°C
Pressure Switch:	On at surface, auto off when submerged below 10m.
Transmit Freq:	401.6300 MHz - 401.6800 MHz
Antenna:	Field replaceable 1/4 wave whip
Max Depth:	7,300 m
Weight:	air 3.6lbs(1.6kg) , water 2.1lbs(0.95kg)
Dimensions:	18.5"long(470mm),1.7"diameter(430mm)

(2) Submersible Recovery Strobe

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

(Specification)

Repetition Rate:	Adjustable from 2 bursts per second to 1 burst every 3 seconds.
Burst Length:	Adjustable from 1 to 5 flashes per burst. 100 ms between flashes nominal.

Battery Type:	C-cell alkaline batteries.
Life:	Dependent on repetition rate and burst length. 150 hours with a one flash burst every 2 seconds.
Construction:	Awl-grip painted, Hard coat anodized 6061 T-6 aluminum housing.
Max. Depth:	7,300m
Daylight-off:	User selected, standard
Pressure Switch:	On at surface, auto off when submerged below 10m.
Weight in Air:	4 pounds
Weight in Water:	2 poundsOutside
Diameter:	1.7 inches nominal
Length:	21-1/2 inches nominal

(3) CTD SBE-37

The SBE 37-SM MicroCAT is a high-accuracy conductivity and temperature (pressure optional) recorder with internal battery and memory. Designed for moorings or other long duration, fixed-site deployments, the MicroCAT includes a standard serial interface and nonvolatile FLASH memory. Constructed of titanium and other non-corroding materials to ensure long life with minimum maintenance, the MicroCAT's depth capability is 7000 meters; it is also available with an optional 250-meter plastic *ShallowCAT* housing. Data is sampled at 1-hour intervals from MR13-04 Cruise.

(Specification)

Measurement Range

Conductivity: 0 - 7 S/m (0 - 70 mS/cm)

Temperature: -5 to 35 °C

Optional Pressure: 7000 (meters of deployment depth capability)

Initial Accuracy

Conductivity: 0.0003 S/m (0.003 mS/cm)

Temperature: 0.002 °C

Optional Pressure: 0.1% of full scale range

Typical Stability (per month)

Conductivity: 0.0003 S/m (0.003 mS/cm)

Temperature: 0.0002 °C

Optional Pressure: 0.004% of full scale range

Resolution

Conductivity: 0.00001 S/m (0.0001 mS/cm)

Temperature: 0.0001 °C

Optional Pressure: 0.002% of full scale range

Time Resolution 1 second

Clock Accuracy 13 seconds/month

Quiescent Current * 10 microamps

Optional External Input Power 0.5 Amps at 9-24 VDC

Housing, Depth Rating, and Weight (without pressure sensor)

Standard Titanium, 7000 m (23,000 ft)

Weight in air: 3.8 kg (8.3 lbs)

Weight in water: 2.3 kg (5.1 lbs)

(4) JFE Advantech optical dissolved oxygen sensor, RINKO

JFE Advantech optical dissolved oxygen sensor, RINKO, is based on the oxygen luminescence quenching. The RINKO used has a datalogger with an internal battery and memory in a titanium housing designed for mooring observation. Data is sampled at 1-hour intervals.

(Manufacturer's specification)

Model:	RINKO I (ARO-USB)
Sensor Type:	Luminescence quenching
Operating Range:	0 ~ 200%
Resolution:	0.01 ~ 0.04%
Precision:	±2%FS (linearity)
Memory:	1GB mini SD card
Sampling interval:	0.1 ~ 600 seconds
Burst time:	1 ~ 1,440 minutes
Sample number:	1 ~ 18,000
Battery:	CR-V3 lithium battery, 3.3Ah (maximum 2 batteries)
Housing material:	Titanium
Size:	ϕ54 mm × 232 mm
Weight:	0.9 kg in air, 0.6 kg in water
Depth rating:	7000 m

(5) JFE Advantech miniature temperature sensor

ALEC DO (Compact Optode) sensor is digital memory type and designed for mounting on the plankton net and instrument for mooring and so on. It is small and right weight for easy handling. Sampling interval is chosen between 1 and 30 seconds. The data is converted to personal computer using

exclusive cable (serial port)

(Specification)

Model:COMPACT-Optode

Sensor Type:Fluorescence quenching

Operating Range:0 ~ 120%

Precision: 0.4%

Accuracy: within 5%

Memory: 2Mbyte flash memory

Battery: lithium battery 7Ah

Battery Life: 172800 data

Sample interval: 1,2,5,10,15,20 and 30 seconds

Diameter:54mm

Length:272mm

Main Material:titanium

Weight in water:0.6kg

Broken Pressure:60MPa

2.2.3 Underwater profiling buoy system (POPPS)

Tetsuichi FUJIKI (JAMSTEC RCGC)

(1) Objective

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

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

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

(2) Methods

a) Primary productivity profiler

The POPPS (original design by Nichiyu Giken Kogyo) consisted mainly of an observation buoy equipped with a submersible FRR fluorometer (Diving Flash, Kimoto Electric), a scalar irradiance sensor (QSP-2200, Biospherical Instruments), a CTD sensor (MCTD, Falmouth Scientific) and a

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

b) Measurement principle of FRR fluorometer

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

Measurement schedule at station K2 (UTC)

1. 15/07/07 16:00	2. 15/07/08 01:00	3. 15/07/12 16:00	4. 15/07/13 01:00
5. 15/07/17 16:00	6. 15/07/18 01:00	7. 15/07/22 16:00	8. 15/07/23 01:00
9. 15/07/27 16:00	10. 15/07/28 01:00	11. 15/08/01 16:00	12. 15/08/02 01:00
13. 15/08/06 16:00	14. 15/08/07 01:00	15. 15/08/11 16:00	16. 15/08/12 01:00
17. 15/08/16 16:00	18. 15/08/17 01:00	19. 15/08/21 16:00	20. 15/08/22 01:00
21. 15/08/26 16:00	22. 15/08/27 01:00	23. 15/08/31 16:00	24. 15/09/01 01:00
25. 15/09/05 16:00	26. 15/09/06 01:00	27. 15/09/10 16:00	28. 15/09/11 01:00
29. 15/09/15 16:00	30. 15/09/16 01:00	31. 15/09/20 16:00	32. 15/09/21 01:00
33. 15/09/25 16:00	34. 15/09/26 01:00	35. 15/09/30 16:00	36. 15/10/01 01:00
37. 15/10/05 16:00	38. 15/10/06 01:00	39. 15/10/10 16:00	40. 15/10/11 01:00
41. 15/10/15 16:00	42. 15/10/16 01:00	43. 15/10/20 16:00	44. 15/10/21 01:00

45. 15/10/25 16:00 46. 15/10/26 01:00 47. 15/10/30 16:00 48. 15/10/31 01:00
49. 15/11/04 16:00 50. 15/11/05 01:00 51. 15/11/09 16:00 52. 15/11/10 01:00
53. 15/11/14 16:00 54. 15/11/15 01:00 55. 15/11/19 16:00 56. 15/11/20 01:00
57. 15/11/24 16:00 58. 15/11/25 01:00 59. 15/11/29 16:00 60. 15/11/30 01:00
61. 15/12/04 16:00 62. 15/12/05 01:00 63. 15/12/09 16:00 64. 15/12/10 01:00
65. 15/12/14 16:00 66. 15/12/15 01:00 67. 15/12/19 16:00 68. 15/12/20 01:00
69. 15/12/24 16:00 70. 15/12/25 01:00 71. 15/12/29 16:00 72. 15/12/30 01:00
73. 16/01/03 16:00 74. 16/01/04 01:00 75. 16/01/08 16:00 76. 16/01/09 01:00
77. 16/01/13 16:00 78. 16/01/14 01:00 79. 16/01/18 16:00 80. 16/01/19 01:00
81. 16/01/23 16:00 82. 16/01/24 01:00 83. 16/01/28 16:00 84. 16/01/29 01:00
85. 16/02/02 16:00 86. 16/02/03 01:00 87. 16/02/07 16:00 88. 16/02/08 01:00
89. 16/02/12 16:00 90. 16/02/13 01:00 91. 16/02/17 16:00 92. 16/02/18 01:00
93. 16/02/22 16:00 94. 16/02/23 01:00 95. 16/02/27 16:00 96. 16/02/28 01:00
97. 16/03/03 16:00 98. 16/03/04 01:00 99. 16/03/08 16:00 100. 16/03/09 01:00
101. 16/03/13 16:00 102. 16/03/14 01:00 103. 16/03/18 16:00 104. 16/03/19 01:00
105. 16/03/23 16:00 106. 16/03/24 01:00 107. 16/03/28 16:00 108. 16/03/29 01:00
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129. 16/05/22 16:00 130. 16/05/23 01:00 131. 16/05/27 16:00 132. 16/05/28 01:00
133. 16/06/01 16:00 134. 16/06/02 01:00 135. 16/06/06 16:00 136. 16/06/07 01:00
137. 16/06/11 16:00 138. 16/06/12 01:00 139. 16/06/16 16:00 140. 16/06/17 01:00
141. 16/06/21 16:00 142. 16/06/22 01:00 143. 16/06/26 16:00 144. 16/06/27 01:00
145. 16/07/01 16:00 146. 16/07/02 01:00 147. 16/07/06 16:00 148. 16/07/07 01:00
149. 16/07/11 16:00 150. 16/07/12 01:00 151. 16/07/16 16:00 152. 16/07/17 01:00
153. 16/07/21 16:00 154. 16/07/22 01:00 155. 16/07/26 16:00 156. 16/07/27 01:00
157. 16/07/31 16:00 158. 16/08/01 01:00 159. 16/08/05 16:00 160. 16/08/06 01:00
161. 16/08/10 16:00 162. 16/08/11 01:00 163. 16/08/15 16:00 164. 16/08/16 01:00
165. 16/08/20 16:00 166. 16/08/21 01:00 167. 16/08/25 16:00 168. 16/08/26 01:00
169. 16/08/30 16:00 170. 16/08/31 01:00 171. 16/09/04 16:00 172. 16/09/05 01:00
173. 16/09/09 16:00 174. 16/09/10 01:00 175. 16/09/14 16:00 176. 16/09/15 01:00
177. 16/09/19 16:00 178. 16/09/20 01:00 179. 16/09/24 16:00 180. 16/09/25 01:00
181. 16/09/29 16:00 182. 16/09/30 01:00 183. 16/10/04 16:00 184. 16/10/05 01:00

185. 16/10/09 16:00	186. 16/10/10 01:00	187. 16/10/14 16:00	188. 16/10/15 01:00
189. 16/10/19 16:00	190. 16/10/20 01:00	191. 16/10/24 16:00	192. 16/10/25 01:00
193. 16/10/29 16:00	194. 16/10/30 01:00	195. 16/11/03 16:00	196. 16/11/04 01:00
197. 16/11/08 16:00	198. 16/11/09 01:00	199. 16/11/13 16:00	200. 16/11/14 01:00

(3) References

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

2.2.4 CTDO and Remote Automatic water Sampler (RAS)

Masahide WAKITA (JAMSTEC MIO)
Hiroshi UCHIDA (JAMSTEC RCGC)

(1) Pressure, temperature, salinity and oxygen

In order to investigate the seasonal variation of hydrography in the upper layer at K2, Pressure, temperature and salinity (CTD) by SBE-37 SM (Sea-birds) and dissolved oxygen (DO) by ARO-USB (JFE Advantech) were observed every hour attached on POPPS winch (150m), RAS (200m and 300m), wire (175m and 250m) and sediment trap (500m) on Hybrid mooring system. In addition, CTD by COMPACT CTD lite and DO by AOP-CMP (JFE Advantech) also was attached on POPPS buoy for backup.

(2) RAS sample

In order to investigate the seasonal variation of pH in the upper layer, and the vertical gradients which affects vertical diffusion flux across the boundary with the thermocline, RAS on 200m and 300m will work following schedule (Table 1) and l obtain samples of dissolved inorganic carbon (DIC), CH_4, N_2O, total alkalinity (TA), nutrients (Phosphate, Nitrate + Nitrite, Silicate), $^{15}NO_3^-$ and salinity. CH_4, N_2O, and $^{15}NO_3^-$ will be measured by JAMSTEC or Tokai University. These properties were obtained from 10 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System for calibration on RAS samples at K2 in this cruise.

Salinity of RAS seawater samples will be measured by salinometer (Model 8400B "AUTOSAL" Guildline Instruments). Salinity of RAS samples should be lower than ambient seawater, because RAS samples were diluted with saturated $HgCl_2$ solution. Salinity measured by salinometer will be slightly lower than that observed by SBE-37 sensor (CTD). RAS samples (~500ml) were diluted with 0.5 ml of saturated $HgCl_2$ solution for preservative. For chemical properties, the dilutions of RAS samples by $HgCl_2$ must be corrected by a ratio of salinity by SBE-37 to that by salinometer

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

RAS No.	RAS 200m		RAS 300m		Memo	
	Interval 10 days		Interval 10 days			
#	mm/dd/yyyy	Time(UTC)	mm/dd/yyyy	Time(UTC)		
-	07/04/2015	3:30:00	07/04/2015	3:30:00	Deep cast (Routine)	CTD sampling KH-15-J01
-	07/04/2015	9:30:00	07/04/2015	9:30:00	Deep cast (3000m)	
-	07/05/2015	15:54:00	07/05/2015	15:54:00	Shallow cast (PP)	
-	07/07/2015	15:51:00	07/07/2015	15:51:00	Shallow cast (PP)	
-	07/08/2015	1:00:00	07/08/2015	1:00:00	Deep cast (3000m)	
1	07/08/2015	1:00:00	07/08/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	Interval 40 minutes
2	07/08/2015	1:40:00	07/08/2015	1:40:00	Saturated $HgCl_2$ 0.5ml	for duplicate sampling
3	07/18/2015	1:00:00	07/18/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
4	07/28/2015	1:00:00	07/28/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	Interval 40 minutes
5	07/28/2015	1:40:00	07/28/2015	1:40:00	Saturated $HgCl_2$ 0.5ml	for isotope
6	08/07/2015	1:00:00	08/07/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
7	08/17/2015	1:00:00	08/17/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
8	08/27/2015	1:00:00	08/27/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
9	09/06/2015	1:00:00	09/06/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
10	09/16/2015	1:00:00	09/16/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
11	09/26/2015	1:00:00	09/26/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
12	10/06/2015	1:00:00	10/06/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
13	10/16/2015	1:00:00	10/16/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
14	10/26/2015	1:00:00	10/26/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
15	11/05/2015	1:00:00	11/05/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	Interval 40 minutes
16	11/05/2015	1:40:00	11/05/2015	1:40:00	Saturated $HgCl_2$ 0.5ml	for isotope
17	11/15/2015	1:00:00	11/15/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
18	11/25/2015	1:00:00	11/25/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
19	12/05/2015	1:00:00	12/05/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
20	12/15/2015	1:00:00	12/15/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
21	12/25/2015	1:00:00	12/25/2015	1:00:00	Saturated $HgCl_2$ 0.5ml	
22	01/04/2016	1:00:00	01/04/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
23	01/14/2016	1:00:00	01/14/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
24	01/24/2016	1:00:00	01/24/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
25	02/03/2016	1:00:00	02/03/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
26	02/13/2016	1:00:00	02/13/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	Interval 40 minutes
27	02/13/2016	1:40:00	02/13/2016	1:40:00	Saturated $HgCl_2$ 0.5ml	for isotope
28	02/23/2016	1:00:00	02/23/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
29	03/04/2016	1:00:00	03/04/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
30	03/14/2016	1:00:00	03/14/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
31	03/24/2016	1:00:00	03/24/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
32	04/03/2016	1:00:00	04/03/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
33	04/13/2016	1:00:00	04/13/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
34	04/23/2016	1:00:00	04/23/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
35	05/03/2016	1:00:00	05/03/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	Interval 40 minutes
36	05/03/2016	1:40:00	05/03/2016	1:40:00	Saturated $HgCl_2$ 0.5ml	for isotope
37			05/13/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
38	05/23/2016	1:40:00	05/23/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
39			06/02/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
40	06/12/2016	1:00:00	06/12/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
41			06/22/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
42	07/02/2016	1:00:00	07/02/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
43			07/12/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
44	07/22/2016	1:00:00	07/22/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
45			08/01/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
46	08/11/2016	1:00:00	08/11/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
47			08/21/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	
48	08/31/2016	1:00:00	08/31/2016	1:00:00	Saturated $HgCl_2$ 0.5ml	

2.2.5. pH sensor

Yoshiyuki NAKANO (JAMSTEC MARITEC)

(1) Objective

We have been developing newly stable and accurate *in situ* system for pH measurement using hybrid technique (potentiometric and spectrophotometric). In this cruise, we aim at testing the new Hybrid pH sensor (HpHS) in the open sea. The HpHS was attached with RAS (200m) and start mooring for about one year.

(2) Method

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

(3) Preliminary results

We succeeded in deploying the HpHS with mooring. We will obtain long term (about one year) pH data every four hours.

(4) Data Archive

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

Reference

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

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

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

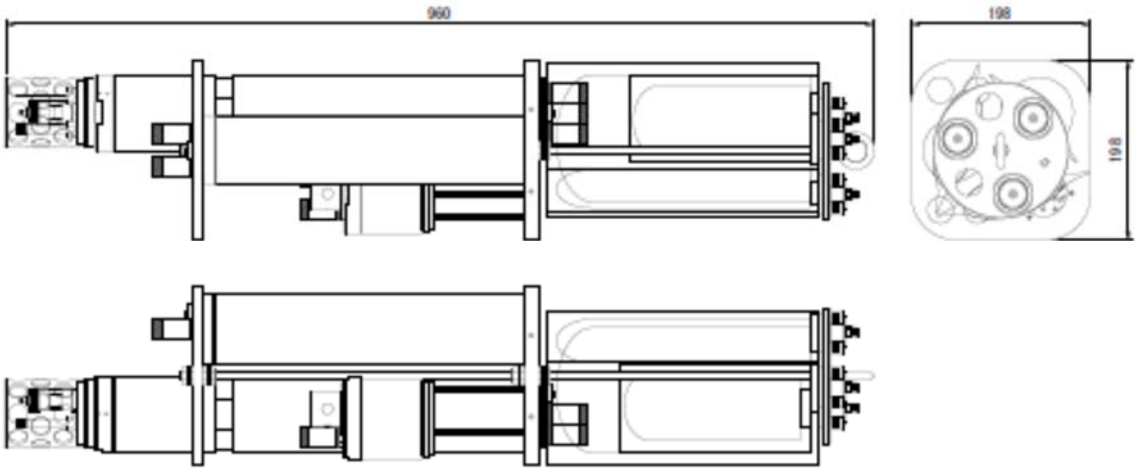

Fig. 2.2.5-1 Side view of HpHS.

2.2.6 ADCP

An Acoustic Doppler Current Profiler (ADCP) was installed at a depth of 400 m on the hybrid profiling buoy system which deployed at K2. Purposes of data samplings (and investigators) are as follows;

(1) to observe seasonal current structure fluctuation (A. Nagano and M. Wakita, JAMSTEC),

(2) to understand zooplankton dynamics (M. Kitamura, JAMSTEC)

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

Specifications

Model: Workhorse LongRanger (Teledyne RD Instruments, Poway, CA, USA)

S/N: 1434

Frequency: 75 kHz

Max. depth: 1500m

Dimensions: see Fig. 2.2.6-1

Weights:

ADCP; 86 kg in air, 55 kg in water

Frame;

Beam angle/width: 20°/4°

DC input: 20-60VDC, four internal alkaline battery packs

Voltage: 42V DC (new), 28V DC (depleted)

Velocity resolution: 1mm/s

Setting parameters for data sampling

Depth cell size: 8 m

Number of depth cells: 60

Ping per ensemble: 30

Intervals: 60 min.

Mode: Broadband mode

Time setting/Start time: UTC/0:00 25th June, 2015

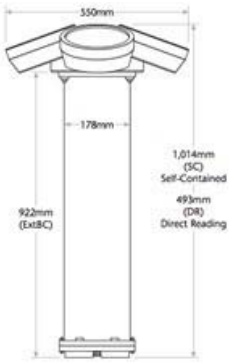

Fig. 2.2.6-1. Schematic drawing of ADCP.

2.2.7 Sediment trap

To collect the sinking particles, two sediment traps were installed on the hybrid profiling buoy system which deployed at K2. Two kinds of sediment traps were used in this experiment, SMD26S-6000 (NiGK Corporation, Tokyo, Japan) and MARK78H-21 (McLane Research Laboratories, INC., MA, USA). The former trap, which had 26 collecting cups, was deployed at a depth of 500 m. Shorter interval of sampling (10 days) were scheduled during the season of high primary productivity while samplings will be conducted every 20 days in other seasons. On the other hand, the latter model of sediment trap was moored at 4800 m in depth, and a sampling interval was every 20 days through the experiment. Specifications of the two traps are as follows:

Table 2.2.7-1 Specifications of two sediment traps

	SMD26S-6000 (NiGK Corporation)	MARK78H-21 (McLane Research Lab.)
S/N	26S001	ML11241-22
Max. depth (m)	6000	7000
Dimensions (diameter × height, cm)	104 × 160	91 ×164
Mouth area (m^2)	0.5	0.5
Weights (kg)	86 in air, 46 in water	72 in air, 39 in water
No. of sampling bottles	26	21
Volume of sampling bottles (ml)	270	250
Battery	Alkaline/Lithium pack	14 Alkaline battery
Communication cables	RMG4-USB	RMG3-Serial port
Software	N-SMD	Crosscut
OS	Win XP, Win 7	Win XP

To collect environmental properties (temperature, salinity, and depth), a CTD (SBE37, Sea-Bird Electronics, WA, USA) was attached at frame of the NiGK sediment trap. Data samplings will be conducted every 60 min.

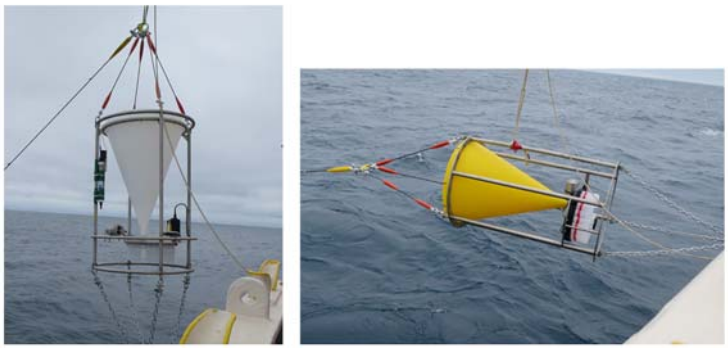

Fig. 2.2.7-1. NiGK sediment trap (left) and McLane trap (right)

Sampling schedules of the deployed sediment traps during KH-15-J01 cruise were summarized in Table 2.2.7-2. Internal clock of each sediment trap was set in UTC. These mooring systems will be recovered during cruise held in 2016.

Table 2.2.7-2. Sampling schedules of sediment trap experiments

Date of deployment: 2015/7/7

Local Time UTC+11h
JST UTC+9h

NGK Sediment Trap 500m

Bottle No.	Sampling (UTC)		Sampling (Local time)		Sampling (JST)		Interval (days)
	Start	End	Start	End	Start	End	
No.1	2015.07.07 13:00	2015.07.27 13:00	2015.07.08 0:00	2015.07.28 0:00	2015.07.07 22:00	2015.07.27 22:00	20
No.2	2015.07.27 13:00	2015.08.16 13:00	2015.07.28 0:00	2015.08.17 0:00	2015.07.27 22:00	2015.08.16 22:00	20
No.3	2015.08.16 13:00	2015.09.05 13:00	2015.08.17 0:00	2015.09.06 0:00	2015.08.16 22:00	2015.09.05 22:00	20
No.4	2015.09.05 13:00	2015.09.25 13:00	2015.09.06 0:00	2015.09.26 0:00	2015.09.05 22:00	2015.09.25 22:00	20
No.5	2015.09.25 13:00	2015.10.15 13:00	2015.09.26 0:00	2015.10.16 0:00	2015.09.25 22:00	2015.10.15 22:00	20
No.6	2015.10.15 13:00	2015.11.04 13:00	2015.10.16 0:00	2015.11.05 0:00	2015.10.15 22:00	2015.11.04 22:00	20
No.7	2015.11.04 13:00	2015.11.24 13:00	2015.11.05 0:00	2015.11.25 0:00	2015.11.04 22:00	2015.11.24 22:00	20
No.8	2015.11.24 13:00	2015.12.14 13:00	2015.11.25 0:00	2015.12.15 0:00	2015.11.24 22:00	2015.12.14 22:00	20
No.9	2015.12.14 13:00	2016.01.03 13:00	2015.12.15 0:00	2016.01.04 0:00	2015.12.14 22:00	2016.01.03 22:00	20
No.10	2016.01.03 13:00	2016.01.23 13:00	2016.01.04 0:00	2016.01.24 0:00	2016.01.03 22:00	2016.01.23 22:00	20
No.11	2016.01.23 13:00	2016.02.12 13:00	2016.01.24 0:00	2016.02.13 0:00	2016.01.23 22:00	2016.02.12 22:00	20
No.12	2016.02.12 13:00	2016.03.03 13:00	2016.02.13 0:00	2016.03.04 0:00	2016.02.12 22:00	2016.03.03 22:00	20
No.13	2016.03.03 13:00	2016.03.23 13:00	2016.03.04 0:00	2016.03.24 0:00	2016.03.03 22:00	2016.03.23 22:00	20
No.14	2016.03.23 13:00	2016.04.12 13:00	2016.03.24 0:00	2016.04.13 0:00	2016.03.23 22:00	2016.04.12 22:00	20
No.15	2016.04.12 13:00	2016.05.02 13:00	2016.04.13 0:00	2016.05.03 0:00	2016.04.12 22:00	2016.05.02 22:00	20
No.16	2016.05.02 13:00	2016.05.12 13:00	2016.05.03 0:00	2016.05.13 0:00	2016.05.02 22:00	2016.05.12 22:00	10
No.17	2016.05.12 13:00	2016.05.22 13:00	2016.05.13 0:00	2016.05.23 0:00	2016.05.12 22:00	2016.05.22 22:00	10
No.18	2016.05.22 13:00	2016.06.01 13:00	2016.05.23 0:00	2016.06.02 0:00	2016.05.22 22:00	2016.06.01 22:00	10
No.19	2016.06.01 13:00	2016.06.11 13:00	2016.06.02 0:00	2016.06.12 0:00	2016.06.01 22:00	2016.06.11 22:00	10
No.20	2016.06.11 13:00	2016.06.21 13:00	2016.06.12 0:00	2016.06.22 0:00	2016.06.11 22:00	2016.06.21 22:00	10
No.21	2016.06.21 13:00	2016.07.01 13:00	2016.06.22 0:00	2016.07.02 0:00	2016.06.21 22:00	2016.07.01 22:00	10
No.22	2016.07.01 13:00	2016.07.11 13:00	2016.07.02 0:00	2016.07.12 0:00	2016.07.01 22:00	2016.07.11 22:00	10
No.23	2016.07.11 13:00	2016.07.21 13:00	2016.07.12 0:00	2016.07.22 0:00	2016.07.11 22:00	2016.07.21 22:00	10
No.24	2016.07.21 13:00	2016.07.31 13:00	2016.07.22 0:00	2016.08.01 0:00	2016.07.21 22:00	2016.07.31 22:00	10
No.25	2016.07.31 13:00	2016.08.10 13:00	2016.08.01 0:00	2016.08.11 0:00	2016.07.31 22:00	2016.08.10 22:00	10
No.26	2016.08.10 13:00	2016.08.30 13:00	2016.08.11 0:00	2016.08.31 0:00	2016.08.10 22:00	2016.08.30 22:00	20

McLane Sediment Trap

Bottle No.	Sampling (UTC)		Sampling (Local time)		Sampling (JST)		Interval (days)
	Start	End	Start	End	Start	End	
No.1	2015.07.07 13:00	2015.07.27 13:00	2015.07.08 0:00	2015.07.28 0:00	2015.07.07 22:00	2015.07.27 22:00	20
No.2	2015.07.27 13:00	2015.08.16 13:00	2015.07.28 0:00	2015.08.17 0:00	2015.07.27 22:00	2015.08.16 22:00	20
No.3	2015.08.16 13:00	2015.09.05 13:00	2015.08.17 0:00	2015.09.06 0:00	2015.08.16 22:00	2015.09.05 22:00	20
No.4	2015.09.05 13:00	2015.09.25 13:00	2015.09.06 0:00	2015.09.26 0:00	2015.09.05 22:00	2015.09.25 22:00	20
No.5	2015.09.25 13:00	2015.10.15 13:00	2015.09.26 0:00	2015.10.16 0:00	2015.09.25 22:00	2015.10.15 22:00	20
No.6	2015.10.15 13:00	2015.11.04 13:00	2015.10.16 0:00	2015.11.05 0:00	2015.10.15 22:00	2015.11.04 22:00	20
No.7	2015.11.04 13:00	2015.11.24 13:00	2015.11.05 0:00	2015.11.25 0:00	2015.11.04 22:00	2015.11.24 22:00	20
No.8	2015.11.24 13:00	2015.12.14 13:00	2015.11.25 0:00	2015.12.15 0:00	2015.11.24 22:00	2015.12.14 22:00	20
No.9	2015.12.14 13:00	2016.01.03 13:00	2015.12.15 0:00	2016.01.04 0:00	2015.12.14 22:00	2016.01.03 22:00	20
No.10	2016.01.03 13:00	2016.01.23 13:00	2016.01.04 0:00	2016.01.24 0:00	2016.01.03 22:00	2016.01.23 22:00	20
No.11	2016.01.23 13:00	2016.02.12 13:00	2016.01.24 0:00	2016.02.13 0:00	2016.01.23 22:00	2016.02.12 22:00	20
No.12	2016.02.12 13:00	2016.03.03 13:00	2016.02.13 0:00	2016.03.04 0:00	2016.02.12 22:00	2016.03.03 22:00	20
No.13	2016.03.03 13:00	2016.03.23 13:00	2016.03.04 0:00	2016.03.24 0:00	2016.03.03 22:00	2016.03.23 22:00	20
No.14	2016.03.23 13:00	2016.04.12 13:00	2016.03.24 0:00	2016.04.13 0:00	2016.03.23 22:00	2016.04.12 22:00	20
No.15	2016.04.12 13:00	2016.05.02 13:00	2016.04.13 0:00	2016.05.03 0:00	2016.04.12 22:00	2016.05.02 22:00	20
No.16	2016.05.02 13:00	2016.05.22 13:00	2016.05.03 0:00	2016.05.23 0:00	2016.05.02 22:00	2016.05.22 22:00	20
No.17	2016.05.22 13:00	2016.06.11 13:00	2016.05.23 0:00	2016.06.12 0:00	2016.05.22 22:00	2016.06.11 22:00	20
No.18	2016.06.11 13:00	2016.07.01 13:00	2016.06.12 0:00	2016.07.02 0:00	2016.06.11 22:00	2016.07.01 22:00	20
No.19	2016.07.01 13:00	2016.07.21 13:00	2016.07.02 0:00	2016.07.22 0:00	2016.07.01 22:00	2016.07.21 22:00	20
No.20	2016.07.21 13:00	2016.08.10 13:00	2016.07.22 0:00	2016.08.11 0:00	2016.07.21 22:00	2016.08.10 22:00	20
No.21	2016.08.10 13:00	2016.08.30 13:00	2016.08.11 0:00	2016.08.31 0:00	2016.08.10 22:00	2016.08.30 22:00	20

2.2.8 Temporal changes in water properties of abyssal water in the western North Pacific

Hiroshi UCHIDA (JAMSTEC RCGC) (Principal Investigator)
Masahide WAKITA (JAMSTEC MIO)

(1) Objective

The objective of this study is to clarify temporal changes in water properties of abyssal water in the western North Pacific by means of moored CTD/O_2 observations. The time series data will be used to evaluate sampling error caused by short-term temperature fluctuation for the estimation of bottom water warming in recent decades derived from land-to-land repeat hydrographic data, and to monitor long-term fluctuation of water properties of the abyssal water.

(2) Materials and methods

CTDs used in the mooring observations were SBE-37 SM (Sea-Bird Electronics, Inc., Bellevue, Washington, USA). The SBE-37s had no pump, but included an optional pressure sensor with a range of 7000 m (Paine Electronics, LLC, East Wenatchee, Washington, USA). The CTD was attached to the acoustic releaser of the BGC mooring system (Table 1). Depth of the acoustic releasers was 34 m above the sea floor. The data were obtained at a sampling interval of 1 hour.

(3) Quality control of the CTD data

The data processing sequence for quality control of the CTD data was as follows:

1) The exponential time drift of the pressure sensor was corrected. The time drift was estimated by fitting an exponential-linear curve, $P = c_0 \exp[c_1 t] + c_2 t + c_3$, where t is time. Then the exponential time drift ($c_0 \exp[c_1 t]$) was subtracted from the pressure data.
2) Offset of the pressure sensor and linear time drift of the temperature sensor were estimated from the results of the in situ comparison with shipboard CTD data obtained during the cruises MR10-01 and MR12-02. Data obtained during the bottle firing stops for depths deeper than 5000 dbar were averaged and used to estimate offset and linear time drift relative to January 1, 2008.

   Pressure offset: 12.6 dbar for S/N 2731

   Temperature offset: –0.0018 ºC for S/N 2731

   Temperature time drift: $5.40917e^{-7}$ ºC/day for S/N 2731
3) Salinity measured by the moored CTD is very noisy. Therefore, salinity was estimated from the temperature–salinity relation obtained from the shipboard CTD data. Linear relations for the data deeper than 4500 dbar of the CTD profiles obtained during the cruises MR10-01, MR11-02, MR11-03, MR11-05, MR12-02, and MR13-04 were calculated. Salinity were measured referred to the

IAPSO Standard Seawater P152 for MR10-01, MR11-02, MR11-03 and MR11-05, and P154 for MR12-02 and MR13-04. The IAPSO Standard Seawater batch offset correction (+0.0005) was applied for the salinity data from MR12-02 and MR13-04. Firstly, salinity was preliminarily estimated by using temperature of the moored CTD and the in situ temperature–salinity relation. Secondly, potential temperature was calculated pressure and temperature of the moored CTD and the estimated salinity. Finally, salinity was estimated by using the potential temperature and the potential temperature–salinity relation. The temperature–salinity relations are as follows.

Salinity = 34.6324 + 0.0377726×(in situ temperature) for station K2

Salinity = 34.8123 – 0.113345×(potential temperature) for station K2

(4) Preliminary result

Time series of CTD/O_2 data obtained by the mooring observations was shown in Fig. 1.

(5) Data archive

The moored CTD/O2 dataset is obtained from www.jamstec.go.jp/iorgc/ocorp/data/bgc_ar/. These data files will be submitted to JAMSTEC Data Management Group (DMG).

Table 1. Summary of mooring observations of abyssal water.

Cruise	Mooring	K2
KH14-2	Deployment	2014/05/30 03:53 (K2 BGC) 47-00.37 N, 159-58.35 E, 5209 m SBE37 S/N 2731 (5175 m)
KH15-J01	Recovery	2015/07/05 01:17
	Deployment	2015/07/07 04:13 47-00.43 N, 159-58.30 E, 5208 m SBE 37 S/N 2731 (5174 m)

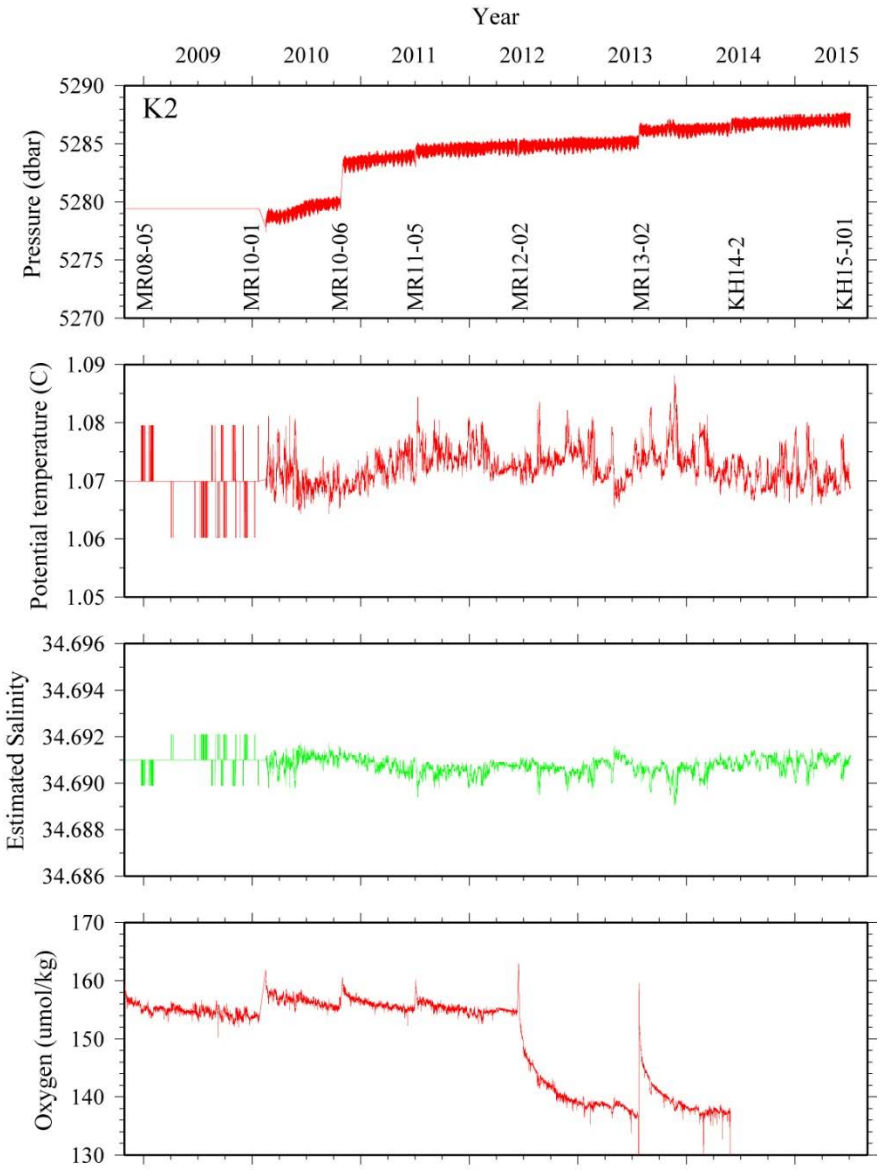

Fig. 1. Time series of pressure, potential temperature, estimated salinity and oxygen at 34 m above the sea floor for K2 station.

2.3 Location tracking of moorings

During the recovery and deployment of the mooring system, tracking and calibration (location identification) of the EdgeTech releaser were conducted using the acoustic navigation system (ANS) of R/V Hakuho-maru. The ANS was operated using a software named “Acoustrolabe”. The target (releaser) information were registered to the Acoustrolabe as followings;

Sending signal	Response signal	Turn around time: 15 msec.
Signal type; PCW	Signal type; PCW	Target type: Transponder
Frequency; 11.000 kHz	Frequency; 14.000 kHz	
Frequency; 8.5 msec.	Frequency; 8.5 msec.	

Fig. 2.3-1. Registration of target.

(1) Recovery

At the first, enable signal was sent to the releaser from the deck unit via hydrophone. After that, calibration of the releaser position was conducted using ANS. R/V Hakuho-maru cruised at 1~3 knot on a circumference with the 500 m radius from the mooring position where was estimated in the KH-14-02, and distances between the ship and releaser were continuously measured. Because the calibration was done just after the arrival to K2, sound speed in the seawater was not corrected. It took about one hour for the calibration. Calibrated position of the mooring “K2BGC140531” was 47°00.3736’N, 159°58.3372’E.

Two days after the calibration (5th July, 2015), the mooring “K2BGC140531” was recovered. After sending the release signal from a deck unit to the underwater releaser via hydrophone, tracking of the releaser using ANS was started. Top buoy was discovered just after the sending of release signal, but

tracking was continued until floating up of releaser into about 50 m. Operation windows of the Acoustrolabe during the calibration and tracking were shown in Figs. 2.3-2 and 2.3-3, respectively.

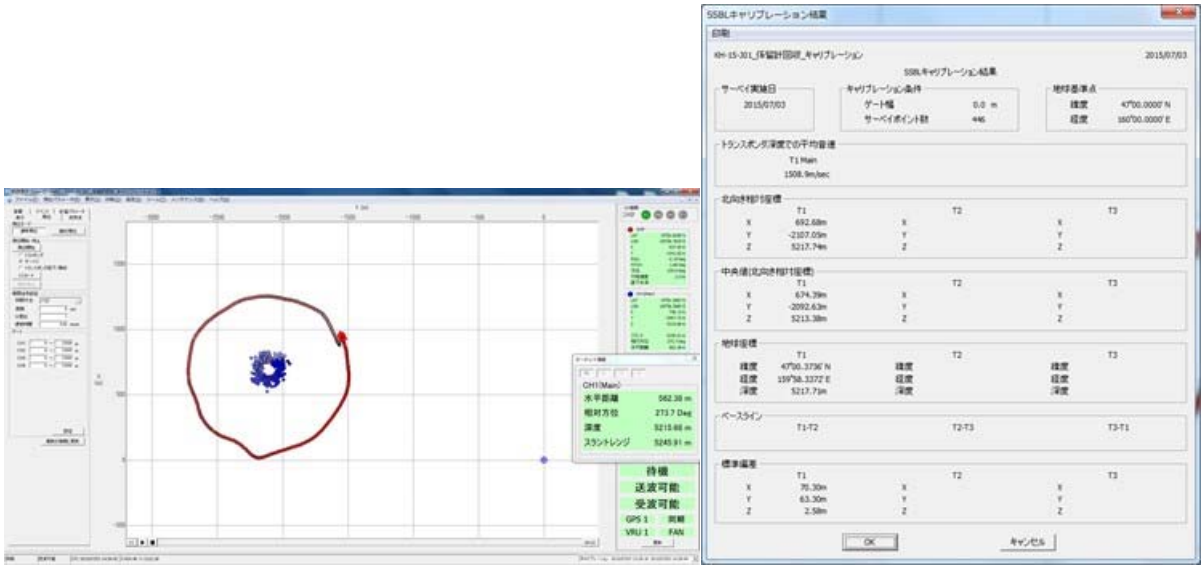

Fig. 2.3-2. Calibration of the moored releaser.

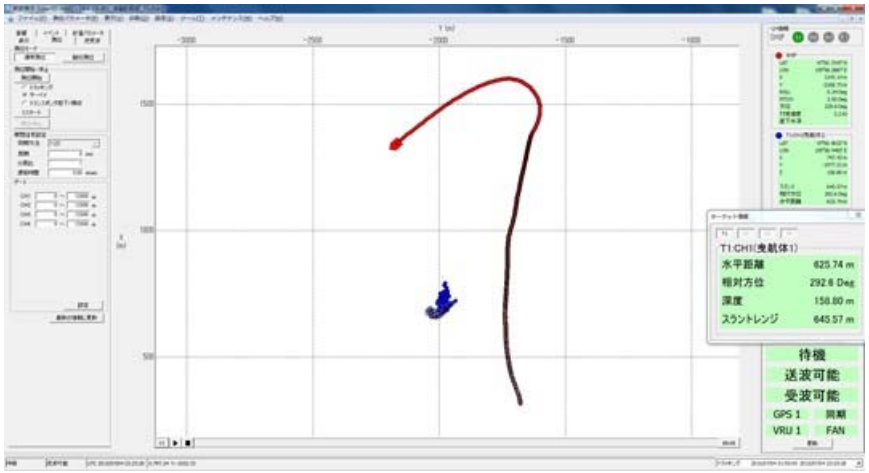

Fig. 2.3-3. Tracking of the floating releaser.

(2) Deployment

Before the deployment of the mooring system, sound speeds in seawater were calculated according to the method of Chen & Millero (1977). Temperatures, salinities, and pressures for the calculation were collected during a deep hydrocast of CTD. Data file of CTD formatted "****.asc" which includes sound speed can be uploaded into "Acoustrolabe". After letting anchor go into the water, tracking of the releaser was started. The releaser moved toward northeast during the sinking (Fig. 2.3-4), and reached the bottom at 13:57 (JST). Location identification of the mooring system (releaser) was

conducted in two ways, distance measurements using hydrophone between the releaser and ship at three different points and calibration using ANS. The latter one was done during cruising at about 4 knot from a point to a next point. Although we could not measure the distances at one of three points using the former method, 269 data of distance were collected from the latter one (Fig. 2.3-5). Calibrated location of the mooring system was 47°00.4282'N, 159°58.3019'E where was 149 m north from the target point (Fig. 2.3-6). Before the departure from K2, bottom depth at the mooring position was measured using PDR and Seabeam, the depth was 5208 m.

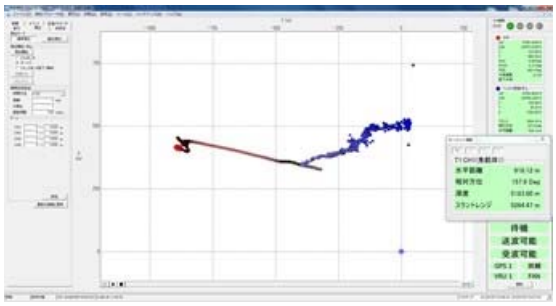

Fig. 2.3-4. Tracking of releaser.

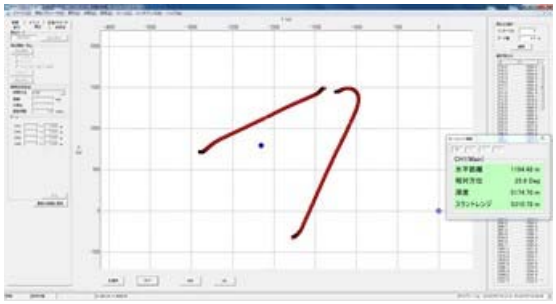

Fig. 2.3-5. Calibration of mooring position.

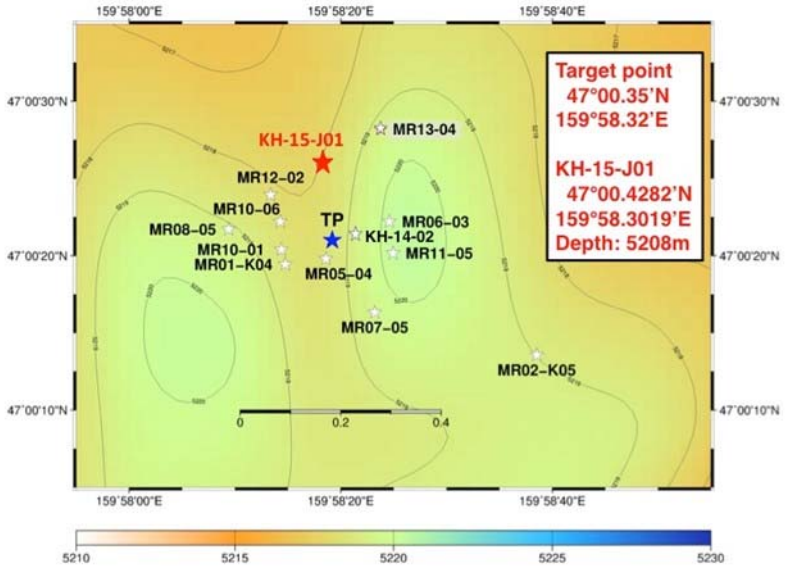

Fig. 2.3-6. History of K2 mooring position.

3. Ship observations and measurements

3.1 CTD cast and water sampling

Masahide WAKITA (JAMSTEC MIO): Principal investigator
Hiroshi UCHIDA (JAMSTEC RCGC)
Shungo OSHITANI (MWJ): Operation leader
Hiroshi MATSUNAGA (MWJ)

(1) Objective

Investigation of oceanic structure and water sampling.

(2) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen
Dissolved Oxygen voltage
Transmission % and beam attenuation coefficient and voltage
Fluorescence
Photosynthetically Active Radiation
Altimeter

(3) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 24-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles, which were washed by alkaline detergent and HCl, were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, dissolved oxygen, RINKO-III (dissolved oxygen sensor), transmission, fluorescence, PAR, altimeter and deep ocean standards thermometer. The Practical Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was

sampled during the up cast by sending fire commands from the personal computer. We stayed for 1 minute at above 500 m layers before fire command to stabilize CTD. At deeper layer, we stayed for 30 seconds. 9 casts of CTD measurements were conducted (Table 3.1-1).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.23.2) and SEASOFT were as follows:

(The process in order)

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

RINKOCOR (original module): Corrected of the hysteresis of RINK-III voltage.

RINKOCORROS (original module): Corrected of the hysteresis of RINKO-III voltage bottle data.

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

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 3 seconds advancing dissolved oxygen sensor (SBE43) output (dissolved oxygen voltage) relative to the temperature data. RINKO-III voltage (User polyminal 0 – 2) were advanced 1second, transmission data and transmission voltage were advanced 2 seconds

WILDEDIT: Mark extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 1000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to pressure, depth, temperature, conductivity and dissolved oxygen voltage (SBE43).

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

FILTER: Perform a low pass filter on pressure with a time constant of 0.15 second. In order to produce zero phase lag (no time shift) the filter runs forward first then backward

WFILTER: Perform a median filter to remove spikes in the fluorescence data, transmission data and voltage data. A median value was determined by 49 scans of the window.

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

LOOPEDIT: Mark scans where the CTD was moving less than the minimum velocity of 0.0 m/s (traveling backwards due to ship roll).

DESPIKE (original module): Remove spikes of the data. A median and mean absolute deviation was calculated in 1-dbar pressure bins for both down and up cast, excluding the flagged values. Values greater than 4 mean absolute deviations from the median were marked bad for each bin. This process was performed 2 times for temperature, conductivity, dissolved oxygen voltage (SBE43), RINKO-III voltage.

DERIVE: Compute dissolved oxygen (SBE43).

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

DERIVE: Compute the Practical Salinity, sigma-theta and potential temperature.

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

Configuration file: KH15j01a.xmlcon

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus (S/N 09P54451-0951, Sea-Bird Electronics, Inc.)

Pressure sensor: Digiquartz pressure sensor (S/N 114746)

Calibrated Date: 09 Apr 2014

Temperature sensors:

Primary: SBE03 (S/N 03P5507, Sea-Bird Electronics, Inc.)

Calibrated Date: 07 Apr. 2015

Secondary: SBE03 (S/N 03P4378, Sea-Bird Electronics, Inc.)

Calibrated Date: 18 Mar. 2014

Conductivity sensors:

Primary: SBE04 (S/N 042496, Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Apr. 2015

Secondary: SBE04 (S/N 042978, Sea-Bird Electronics, Inc.)

Calibrated Date: 13 May. 2014

Dissolved Oxygen sensor:

SBE43 (S/N 432528, Sea-Bird Electronics, Inc.)

Calibrated Date: 18 Mar. 2015

RINK-III (S/N 0037 (1204), Alec Electronics Co. Ltd.)

Calibrated Date: 21 May 2015

Transmissonmeter:

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

Calibrated Date: 02 Feb. 2013

Fluorescence:

Chlorophyll Fluorometer (S/N 3592, Seapoint Sensors, Inc.)

Photosynthetically Active Radiation:

PAR sensor (S/N 0049, Satlantic Inc.)

Calibrated Date: 22 Jan. 2009

Altimeter:

Benthos PSA-916T (S/N 1238, Teledyne Benthos, Inc.)

Deep Ocean Standards Thermometer:

SBE35 (S/N 0053, Sea-Bird Electronics, Inc.)

Calibrated Date: 02 Mary 2014

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

Carousel water sampler:

SBE32 (S/N 3253585-0704, Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P12217-0704, Sea-Bird Electronics, Inc.)

(4) Preliminary Results

During this cruise, 9 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 3.1-1.

(5) Data archive

All raw and processed data files will be submitted to the Data Management Office (DMO), JAMSTEC.

Table 3.1-1 KH-15-J01 CTD cast table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remark
		(mmddyy)	Start	End	Latitude	Longitude							
K02	1	070315	23:31	03:28	47-00.12N	159-58.58E	5176.0	5174.0	9.1	5165.6	5273.0	K02M001	Routine
K02	2	070415	06:09	09:27	47-01.23N	159-59.42E	5179.0	3008.0	-	3002.0	3049.0	K02M002	HCS
K02	3	070515	15:03	15:52	47-00.11N	160-00.00E	5178.0	300.0	-	301.3	304.0	K02M003	P.P
K02	4	070615	00:06	00:54	47-00.17N	159-59.88E	5177.0	199.0	-	200.2	202.0	K02M004	Daily variation
K02	5	070615	07:05	07:46	46-59.86N	160-00.23E	5183.0	200.0	-	201.2	203.0	K02M005	POM
K02	6	070615	11:00	11:42	47-00.09N	159-59.96E	5178.0	200.0	-	201.2	203.0	K02M006	Daily variation
K02	7	070615	15:02	15:51	46-59.87N	160-00.18E	5184.0	302.0	-	302.2	305.0	K02M007	P.P
K02	8	070715	21:34	01:05	46-59.72N	160-00.48E	5179.0	3019.0	-	3003.0	3050.0	K02M008	HCS
K02	9	070815	03:04	03:36	47-00.08N	160-00.16E	5181.0	200.0	-	202.2	204.0	K02M009	POM

Routine: Routine sampling

P.P.: Primary Production

HCS: Hybrid CO_2/pH Sensor

POM: Particulate Organic Matter

3.2 Salinity measurement

Masahide Wakita (JAMSTEC)

(1) Objective

To measure bottle salinity obtained by CTD casts, bucket sampling.

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(2) Methods

a. Salinity Sample Collection

Seawater samples were collected with 10 liter Niskin bottles and bucket. The salinity sample bottles of the 250ml brown grass bottles with screw caps were used for collecting the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. The salinity sample bottles were sealed with plastic inner caps and screw caps because we took into consideration the possibility of storage for about a month. These caps were rinsed three times with the sample water before use. The bottle was stored for more than 1 month on the laboratory before the salinity measurement. The number of samples is total of ~100 for CTD and Bucket

b. Instruments and Method

The salinity analysis on the laboratory was carried out using the salinometer (Model 8400B "AUTOSAL"; Guildline Instruments Ltd.: S/N 6286) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). Digital thermometers (Model D617; Tateyama Kagaku Ind. : S/N 03489) were used. The thermometer monitored the ambient temperature and the bath temperature of the salinometer.

The measurement system was almost the same as Aoyama et al. (2002). The salinometer was operated in the air-conditioned laboratory at a bath temperature of 24 deg C. The measurement for each sample was done with the double conductivity ratio and defined as the median of 60 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 15 seconds to collect 60 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing five times. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured a ninth filling of the cell and calculated the bottle salinity.

(3) Preliminary result

The distributions of Salinity will be determined as soon as possible after this cruise.

(4) Reference

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

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

3.3 Dissolved oxygen

Masahide WAKITA (JAMSTEC MIO)
Yoshiyuki NAKANO (JAMSTEC MARITEC)

(1) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(2) Instruments and Methods

Following procedure is based on an analytical method, entitled by "Determination of dissolved oxygen in sea water by Winkler titration", in the WHP Operations and Methods (Dickson, 1996).

a. Instruments

Burette for sodium thiosulfate and potassium iodate;
continuous E manufactured by VITLAB CO. Ltd. / 10 cm3 of titration vessel
Detector;
Automatic photometric titrator (DOT-05) manufactured by Kimoto Electronic Co. Ltd.

b. Reagents

Pickling Reagent I: Manganese chloride solution (3 mol dm^{-3})
Pickling Reagent II:
Sodium hydroxide (8 mol dm^{-3}) / sodium iodide solution (4 mol dm^{-3})
Sulfuric acid solution (5 mol dm^{-3})
Sodium thiosulfate (0.025 mol dm^{-3})
Potassium iodide (0.001667 mol dm^{-3})
CSK standard of potassium iodide:
Lot DCE2131, Wako Pure Chemical Industries Ltd., 0.0100N

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD-system and surface bucket sampler. Seawater for oxygen measurement was transferred from sampler to a volume calibrated flask (ca. 100 cm3). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I and II) of 1.0 cm3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate

finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. 1 cm3 sulfuric acid solution and a magnetic stirrer bar were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose morality was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise, we measured dissolved oxygen concentration using 1 set of the titration apparatus. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the CTD sensor, and titrated volume of sodium thiosulfate solution without the blank.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130°C. 1.7835 g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 mol dm^{-3}). 10 cm^3 of the standard potassium iodate solution was added to a flask using a volume-calibrated dispenser. Then 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 1.0 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (1.0 cm3) and II (1.0 cm3) was assumed to be 0.0017 ml (Murray et al., 1968). The blank due to other than oxygen was determined as follows. 1 cm^3 of the standard potassium iodate solution were added to flask using a calibrated dispenser. Then 100 cm3 of deionized water, 1 cm^3 of sulfuric acid solution, and 1 cm^3 of pickling reagent solution II and I each were added into the flask in order. The blank was determined by difference between the first (1 cm^3 of KIO3) titrated volume of the sodium thiosulfate and the second (1 cm^3 of KIO3) one. The results of 3 times blank determinations were averaged.

f. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 11. The standard deviation of the replicate measurement was 0.16 μmol kg^{-1} that was calculated by a procedure in Guide to best practices for ocean CO_2 measurements Chapter4 SOP23

Ver.3.0 (2007).

(3) Preliminary result

The distributions of dissolved oxygen will be determined as soon as possible after this cruise.

(4) References

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3.4 Nutrients

(1) Personnel

Masahide WAKITA	(JAMSTEC): Principal investigator
Masanori ENOKI	(MWJ): Operation leader

(2) Objectives

The objectives of nutrients analyses during the R/V Hakuho-maru KH-15-J01 cruise in the Western North Pacific Ocean is as follows:

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

(3) Parameters

The determinants are nitrate, nitrite, silicate and phosphate in the East Indian Ocean.

(4) Summary of nutrients analysis

We made 4 QuAAtro runs for the water columns sample at 8 casts during KH-15-J01. The total amount of layers of the seawater sample reached up to 127. We made basically duplicate measurement. The station locations for nutrients measurement is shown in Figure 3.4.1.

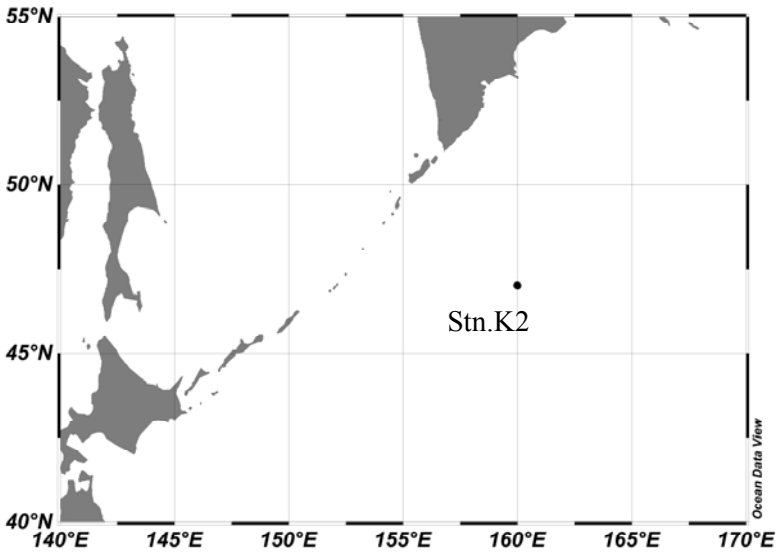

Figure 3.4.1. Sampling positions of nutrients sample.

(5) Instrument and Method

(5.1) Analytical detail using QuAAtro 2-HR systems (BL-Tech)

Nitrate + nitrite and nitrite were analyzed according to the modification method of Grasshoff (1970).

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

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

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

The ammonia in seawater is mixed with an alkaline containing EDTA, ammonia as gas state is formed from seawater. The ammonia (gas) is absorbed in sulfuric acid by way of 0.5 μm pore size membrane filter (ADVANTEC PTFE) at the dialyzer attached to analytical system. The ammonia absorbed in sulfuric acid is determined by coupling with phenol and hypochlorite to form indophenols blue. Wavelength using ammonia analysis is 630 nm, which is absorbance of indophenols blue.

The details of modification of analytical methods used in this cruise are also compatible with the methods described in nutrients section in GO-SHIP repeat hydrography manual (Hydes et al., 2010). The flow diagrams and reagents for each parameter are shown in Figures 3.4.2. to 3.4.5.

(5.2) Nitrate + Nitrite Reagents

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

Dissolve 4 g imidazole, $C_3H_4N_2$, in ca. 1000 ml DIW; add 2 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added.

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

Dissolve 10 g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 %f w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2$•2HCl, in 1000 ml of DIW and add 10 ml concentrated

HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

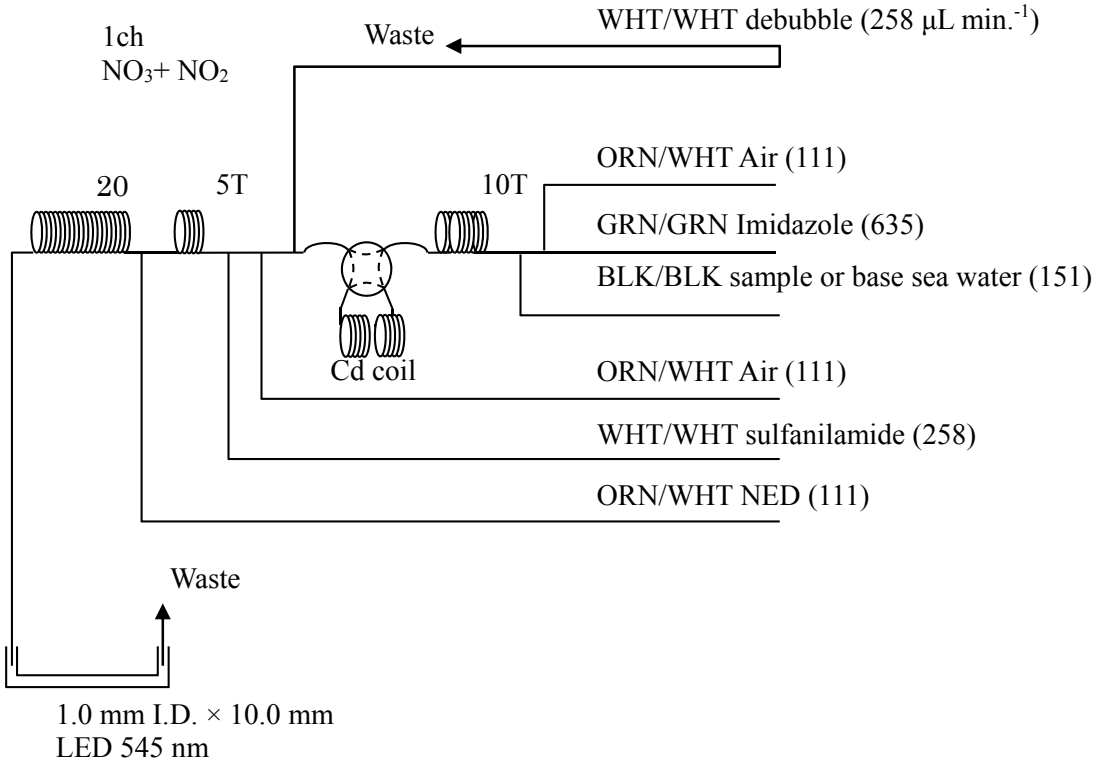

Figure 3.4.2.NO_3 + NO_2 (1ch.) Flow diagram.

(5.3) Nitrite Reagents

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

Dissolve 10g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 % w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

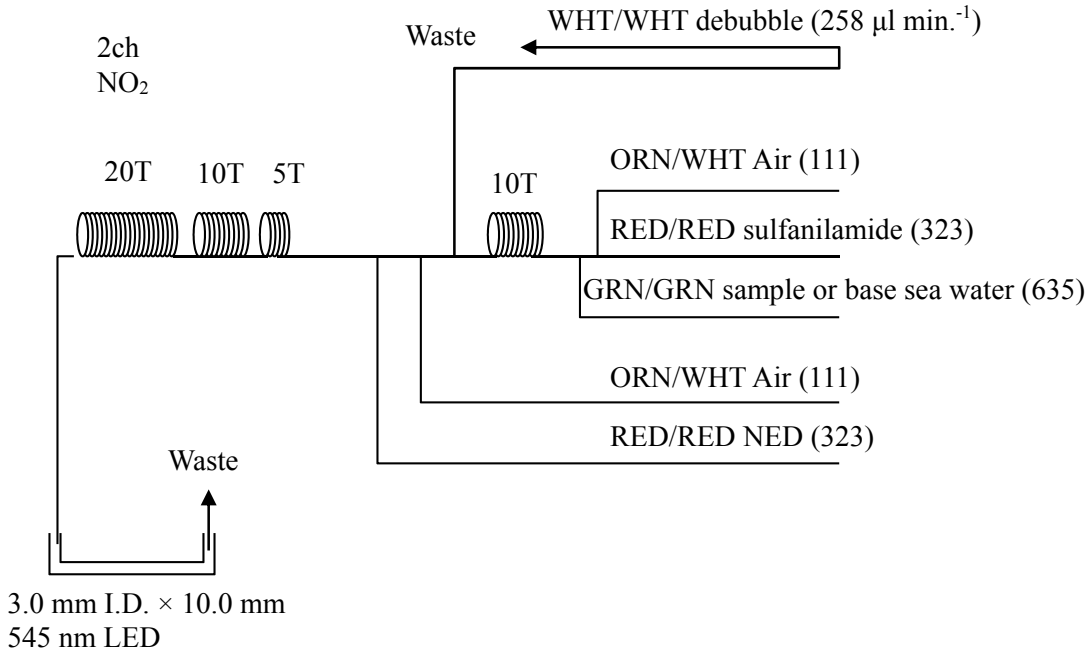

Figure3.4.3. NO_2 (2ch.) Flow diagram.

(5.4) Silicate Reagents

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

Dissolve 15 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \bullet 2H_2O$, in 980 ml DIW, add 8 ml concentrated H_2SO_4. After mixing, 20 ml sodium dodecyl sulphate (15 % solution in water) is added.

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

Dissolve 50 g oxalic acid anhydrous, HOOC: COOH, in 950 ml of DIW.

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

Dissolve 2.5g L (+)-ascorbic acid, $C_6H_8O_6$, in 100 ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

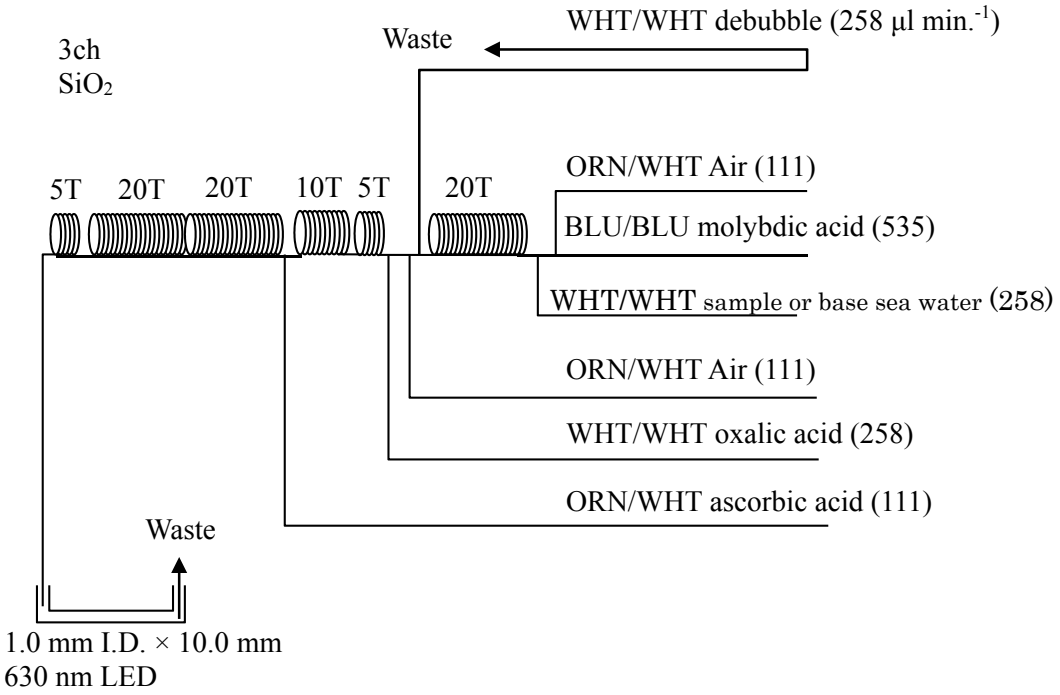

Figure3.4.4. SiO_2 (3ch.) Flow diagram.

(5.5) Phosphate Reagents

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

Dissolve 8 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \cdot 2H_2O$, and 0.17 g antimony potassium tartrate, $C_8H_4K_2O_{12}Sb_2 \cdot 3H_2O$, in 950 ml of DIW and add 50 ml concentrated H_2SO_4.

Mixed Reagent

Dissolve 1.2 g L (+)-ascorbic acid, $C_6H_8O_6$, in 150 ml of stock molybdate solution. After mixing, 3 ml sodium dodecyl sulphate (15 % solution in water) is added. Stored in a dark bottle and freshly prepared before every measurement.

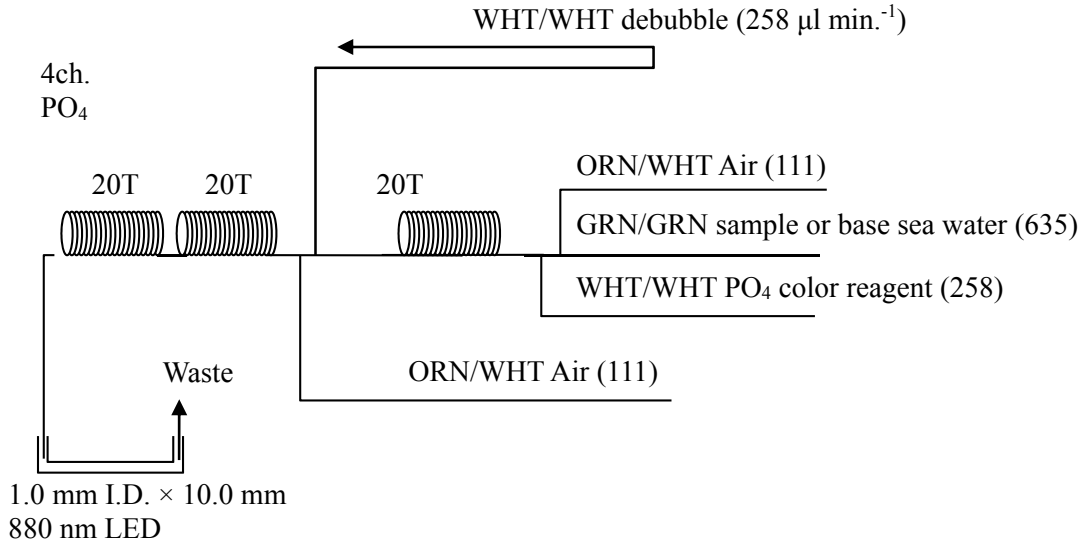

Figure3.4.5. PO_4 (4ch.) Flow diagram.

(5.6) Ammonia Reagents

EDTA

Dissolve 41 g EDTA (ethylenediaminetetraacetatic acid tetrasodium salt), $C_{10}H_{12}N_2O_8Na_4 \bullet 4H_2O$, and 2 g boric acid, H_3BO_3, in 200 ml of DIW. After mixing, 1 ml Triton®X-100 (30 % solution in DIW) is added. This reagent is prepared at a week about.

NaOH

Dissolve 5 g sodium hydroxide, NaOH, and 16 g EDTA in 100 ml of DIW. This reagent is prepared at a week about.

Stock Nitroprusside

Dissolved 0.25 g sodium pentacyanonitrosylferrate(II), $Na_2[Fe(CN)_5NO]$, in 100 ml of DIW and add 0.2 ml 1N H_2SO_4. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

Mixed 4 ml stock nitroprusside and 5 ml 1N H_2SO_4 in 500 ml of DIW. After mixing, 2ml Triton®X-100 (30 % solution in DIW) is added. This reagent is stored in a dark bottle and prepared at every 2 or 3 days.

Alkaline phenol

Dissolved 10 g phenol, C_6H_5OH, 5 g sodium hydroxide and citric acid, $C_6H_8O_7$, in 200 ml DIW.

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

NaClO solution

Mixed 3 ml sodium hypochlorite solution, NaClO, in 47 ml DIW. Stored in a dark bottle and fleshly prepared before every measurement. This reagent is prepared 0.3% available chlorine.

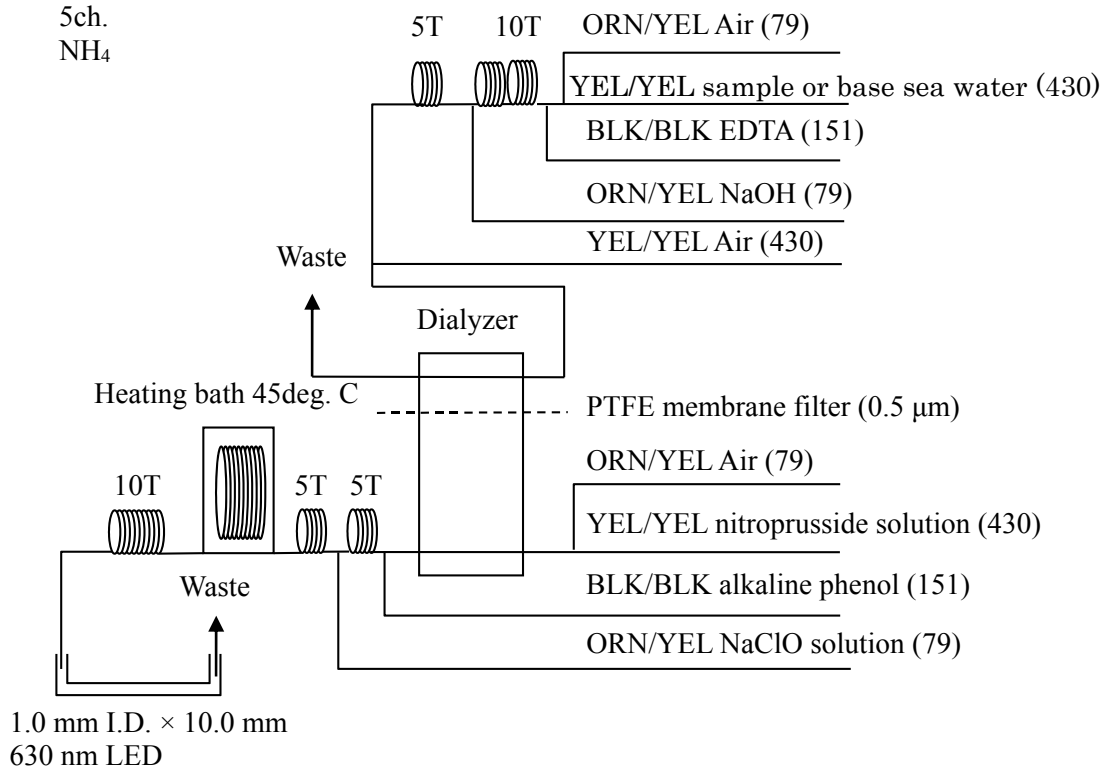

Figure 4.2.6 NH_4 (5ch.) Flow diagram.

(5.7) Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into a virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials ware kept to ambient temperature, 20.0 ± 1.0 deg. C, in about 60 minutes before use to stabilize the temperature of samples.

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

(5.8) Data processing

Raw data from QuAAtro were treated as follows:

- Check baseline shift.
- Check the shape of each peak and positions of peak values taken, and then change the positions of peak values taken if necessary.
- Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.
- Baseline correction and sensitivity correction were done basically using liner regression.
- Calibration curves to get nutrients concentration were assumed second order equations.

(6) Nutrients standards

(6.1) Volumetric laboratory ware of in-house standards

All volumetric glass ware and polymethylpentene (PMP) ware used were gravimetrically calibrated. Plastic volumetric flasks were gravimetrically calibrated at the temperature of use within 0 to 4 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05 % or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicate from the glass. PMP volumetric flasks were gravimetrically calibrated and used only within 0 to 4 K of the calibration temperature.

The computation of volume contained by glass flasks at various temperatures other than the calibration temperatures were done by using the coefficient of linear expansion of borosilicate crown glass.

Because of their larger temperature coefficients of cubical expansion and lack of tables constructed for these materials, the plastic volumetric flasks were gravimetrically calibrated over the temperature range of intended use and used at the temperature of calibration within 0 to 4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes have nominal calibration tolerances of 0.1 % or better. These were gravimetrically calibrated in order to verify and improve upon this nominal tolerance.

(6.2) Reagents, general considerations

Specifications

For nitrate standard, “potassium nitrate 99.995 suprapur®” provided by Merck, Lot. B0771365211,

CAS No.: 7757-91-1, was used.

For nitrite standard, “sodium nitrate” provided by Wako, HLK7454,CAS No.: 7632-00-0, was used. And assay of nitrite was determined according JIS K8019 and assays of nitrite salts were 98.53 %. We use that value to adjust the weights taken.

For the silicate standard, we use “Silicon standard solution SiO_2 in NaOH 0.5 mol/l CertiPUR®” provided by Merck, CAS No.: 1310-73-2, of which lot number is HC41358736 are used. We use this factor throughout KH-15-J01 to keep comparability for silicate concentration.

For phosphate standard, “potassium dihydrogen phosphate anhydrous 99.995 suprapur®” provided by Merck, Lot. B0691108204, CAS No.: 7778-77-0, was used.

For ammonia standard, “ammonium sulfate” provided by Wako, CAS No.: 7783-20-2, was used.

Ultra pure water

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

Low-nutrients seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.20μm pore size membrane filter. This water is stored in 20 liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in Oct 2014.

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

Concentrations of nutrients for A, B and C standards are set as shown in Table 3.4.1. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric laboratory wares.

The calibration curves for each run were obtained using 5 levels, C-1, C-2, C-3, C-4 and C-5.

Table 3.4.1. Nominal concentrations of nutrients for A, B and C.

	A	B	C-1	C-2	C-3	C-4	C-5
NO_3 (μM)	22600	900	0	9	18	36	54
NO_2 (μM)	4000	20	0	0.2	0.4	0.8	1.2
SiO_2 (μM)	35000	2760	0.8	28	56	111	166
PO_4 (μM)	3000	60	0.1	0.7	1.3	2.5	3.7
NH_4(μM)	4000	120	0	-	1.2	2.4	3.6

Table 3.4.2. Working calibration standard recipes.

C Std.	B-1 Std.	B-2 Std.	B-3 Std.	DIW
C-1	0 ml	0 ml	0 ml	75 ml
C-2	5 ml	5 ml	-	65 ml
C-3	10 ml	10 ml	5 ml	55 ml
C-4	20 ml	20 ml	10 ml	25 ml
C-5	30 ml	30 ml	15 ml	0 ml

B-1 Std.: Mixture of nitrate, silicate and phosphate

B-2 Std.: Nitrite

B-3 Std.: Ammonia

(6.4) Renewal of in-house standard solutions

In-house standard solutions as stated in paragraph c were renewed as shown in Table 3.4.3.

Table 3.4.3. Timing of renewal of in-house standards.

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

Table 4.2.3(b) Timing of renewal of working calibration standards.

C Std.	Renewal
C Std. (mixture of B-1 , B-2 and B-3 Std.)	every 24 hours

Table 4.2.3(c) Timing of renewal of in-house standards for reduction estimation.

Reduction estimation	Renewal
D-1 Std. (3600 μM NO_3)	maximum 8 days
43 μM NO_3	when C Std. renewed
47 μM NO_2	when C Std. renewed

(7) Reference material of nutrients in seawater

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., 2006, 2007, 2008, 2009). In the previous worldwide expeditions, such as WOCE cruises, the higher reproducibility and precision of nutrients measurements were required (Joyce and Corry, 1994). Since no standards were available for the measurement of nutrients in seawater at that time, the requirements were described in term of reproducibility. The required reproducibility was 1 %, 1 to 2 %, 1 to 3 % for nitrate, phosphate and silicate, respectively. Although nutrient data from the WOCE one-time survey was of unprecedented quality and coverage due to much care in sampling and measurements, the differences of nutrients concentration at crossover points are still found among the expeditions (Aoyama and Joyce, 1996, Mordy et al., 2000, Gouretski and Jancke, 2001). For instance, the mean offset of nitrate concentration at deep waters was 0.5 μmol kg^{-1} for 345 crossovers at world oceans, though the maximum was 1.7 μmol kg^{-1} (Gouretski and Jancke, 2001). At the 31 crossover points in the Pacific WHP one-time lines, the WOCE standard of reproducibility for nitrate of 1 % was fulfilled at about half of the crossover points and the maximum difference was 7 % at deeper layers below 1.6 deg. C in potential temperature (Aoyama and Joyce, 1996).

(7.1) RMNS for this cruise

RMNS lots BY, BU, CA, BW, BZ and BV, which cover full range of nutrients concentrations in the West Pacific ocean are prepared. 4 sets of BY, BU, CA, BW, BZ and BV are prepared.

(7.2) Certified concentration for RMNSs

The nutrients concentration of RMNS shown in Table 3.4.4. was certified by The General Environmental Technos Co.,Ltd.

Table 3.4.4 Certified concentration of RMNSs.

unit: μmol kg^{-1}

	Nitrate (uncertainty)	Nitrite (uncertainty)	Silicate (uncertainty)	Phosphate (uncertainty)	Certified year
BY	0.024 (0.019)	0.019 (0.0085)	1.763 (0.063)	0.039 (0.010)	2015
BU	3.937 (0.051)	0.072 (0.0059)	20.92 (0.49)	0.345 (0.0085)	2015
CA	19.66 (0.15)	0.063 (0.010)	36.58 (0.22)	1.407 (0.014)	2015
BW	24.59 (0.20)	0.067 (0.010)	60.01 (0.42)	1.541 (0.014)	2015
BV	35.36 (0.35)	0.047 (0.0073)	102.2 (1.1)	2.498 (0.023)	2015
BZ	43.35 (0.33)	0.215 (0.011)	161.0 (0.93)	3.056 (0.033)	2015

(8) Quality control

(8.1) Precision of nutrients analyses during the cruise

Precision of nutrients analyses during this cruise was evaluated based on the 4 measurements, which are measured every 8 to 14 samples, during a run at the concentration of C-5 std. Summary of precisions are shown as shown in Table 3.4.5.

Analytical precisions previously evaluated were 0.08 % for nitrate, 0.07 % for silicate and 0.10 % for phosphate in CLIVAR P21 revisited cruise of MR09-01 cruise in 2009, respectively. In this cruise, analytical precisions were 0.13% for nitrate, 0.15% for nitrite, 0.16% for silicate and 0.10% for phosphate, 0.32% for ammonia in terms of median of precision, respectively. Then we can conclude that the analytical precisions for nitrate, nitrite, silicate and phosphate were maintained throughout this cruise.

Table 3.4.5 Summary of precision based on the replicate analyses.

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %	Ammonia CV %
Median	0.13	0.15	0.16	0.10	0.32
Mean	0.13	0.15	0.13	0.10	0.29
Maximum	0.14	0.18	0.17	0.13	0.33
Minimum	0.11	0.12	0.07	0.07	0.22

N	4	4	4	4	4

(8.2) Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are small enough within acceptable levels as shown in Table 3.4.6.

Table 3.4.6. Summary of carry over throughout KH-15-J01

	Nitrate %	Nitrite %	Silicate %	Phosphate %	Ammonia %
Median	0.12	0.06	0.18	0.22	0.83
Mean	0.13	0.09	0.19	0.22	0.87
Maximum	0.15	0.22	0.25	0.27	1.18
Minimum	0.11	0.00	0.15	0.16	0.59
N	4	4	4	4	4

(9) Data archive

These data obtained in this cruise will be submitted to JAMSTEC.

(10) References

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3.5. pH and CO_2

Yoshiyuki NAKANO (JAMSTEC MARITEC)

(1) Objective

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

(2) Method

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

(3) Preliminary results

Concentrations of CO_2 (pCO_2) profile from 3,000m to 0m is shown in Fig. 3.5-1.

(4) Data Archive

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

Reference

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

Nakano, Y., H. Kimoto, S. Watanabe, K. Harada and Y. W. Watanabe (2006): Simultaneous Vertical Measurements of In situ pH and CO_2 in the Sea Using Spectrophotometric Profilers. J. Oceanogr., 62, 71-81.

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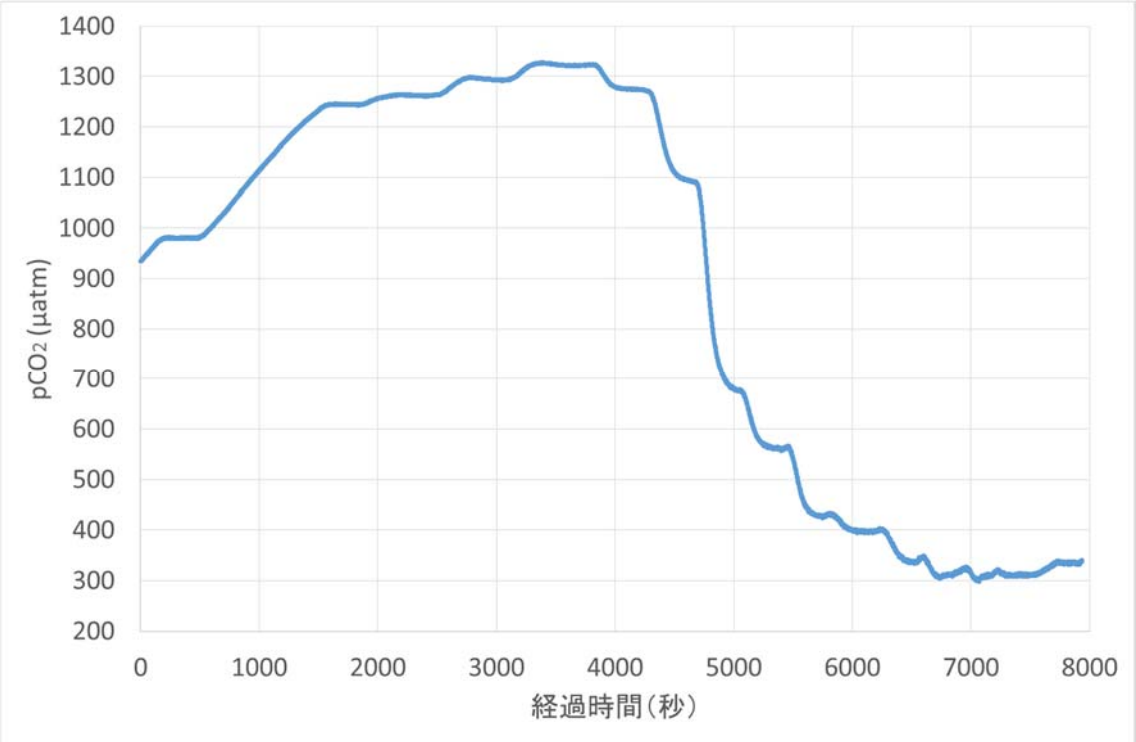

Fig. 3.5-1 Temporal changes of concentrations of CO_2 (pCO_2) profile from 0m to 3000m profile from 3,000m to 0m.

3.6 Dissolved inorganic carbon and Total alkalinity

Masahide WAKITA (JAMSTEC MIO)

(1) Purpose of the study

Concentration of CO_2 in the atmosphere is now increasing owing to human activities such as burning of fossil fuels, deforestation, and cement production. The ocean plays an important role in buffering the increase of atmospheric CO_2. Anthropogenic CO_2 emitted into the atmosphere as a result of human activities was globally taken up by oceans at a rate of 2.2 ± 0.4 Pg C y–1 during the 1990s [IPCC, 2007]. Ocean acidification is a direct consequence of the ocean absorbing large amounts of the anthropogenic CO_2. The CO_2 uptake by the oceans has led to lowering both pH and $CaCO_3$ saturation states with regard to the mineral phases due to increasing hydrogen ions (H^+) and declining carbonate ion (CO_3^{2-}), respectively. Because oceanic biological activity has an important role concerned to Carbon cycle in the ocean through its photosynthesis and respiration, the chemical changes associated with ocean acidification have the potential to affect ocean biogeochemistry and ecosystems in a myriad of ways. Therefore, it is important to clarify the mechanism of the oceanic CO_2 absorption and ocean acidification and to estimate CO_2 absorption capacity and decrease of pH and $CaCO_3$ saturation states in recent years. When CO_2 dissolves in 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, but calculated from two of four parameters: total dissolved inorganic carbon (DIC), total alkalinity (TA), pH and pCO_2. This study presents the distribution of DIC and TA in the North Pacific Ocean.

(2) Sampling

Seawater samples of DIC and TA were collected by 10 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at K2 station and brought the total to ~100. Seawaters were sampled in a 150 ml glass bottle for DIC and a 100 ml glass bottle for TA. These bottles were previously soaked in 1M HCl solution at least 6 hours and was cleaned by fresh water for 7 times and Milli-Q deionized water for 3 times. A sampling silicone rubber tube with PFA tip was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds. After collecting the samples on the deck, the glass bottles were carried to the laboratory. Within one hour after the sampling, 1 % by the bottle volume (1 ml) was removed from the glass bottle and poisoned with 0.05% by volume (0.05 ml) of over saturated solution of mercury chloride. Then, the samples were sealed by rubber and aluminum caps. All samples preserved at ~ 5°C cold until analysis.

(3) Analysis

DIC and TA samples were measured by using coulometric and potentiometric techniques, respectively, according to Dickson et al., 2007. The DIC and TA values will be determined with calibration against certified reference material provided by Prof. A. G. Dickson (Scripps Institution of Oceanography) and KANSO.

(4) Preliminary result

The distributions of DIC and TA will be determined as soon as possible after this cruise.

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

Masahide WAKITA (JAMSTEC MIO)

(1) Purpose of the study

Variabilities in the concentration of dissolved organic carbon (DOC) in seawater have a potentially great impact on the carbon cycle in the marine system, because DOC is a major global carbon reservoir. A change by < 10% in the size of the oceanic DOC pool, estimated to be ~ 700 GtC (IPCC, 2007), would be comparable to the annual primary productivity in the whole ocean. In fact, it was generally concluded that the bulk DOC in oceanic water, especially in the deep ocean, is quite inert based upon ^{14}C-age measurements. Nevertheless, it is widely observed that in the ocean DOC accumulates in surface waters at levels above the more constant concentration in deep water, suggesting the presence of DOC associated with biological production in the surface ocean. This study presents the distribution of DOC at K2 in the North Pacific.

(2) Sampling

Seawater samples of DOC and TDN were collected by 10 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at K2 stations and brought the total to ~200. Seawater from each Niskin bottle was transferred into 60 ml High Density Polyethylene bottle (HDPE) rinsed with same water three times. Water taken from the surface to bottom is filtered using precombusted (450°C) GF/F inline filters as they are being collected from the Niskin bottle. After collection, samples are frozen upright and preserved at ~ -20 °C cold until analysis in our land laboratory. Before use, all glassware was muffled at 550 °C for 5 hrs.

(3) Analysis

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

(4) Preliminary result

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

3.8 Particle organic matters

Yoshihisa MINO (Nagoya University)
Chiho SUKIGARA (Nagoya University)

(1) Objective

Carbon and nitrogen stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) of particulate organic matters in the ocean can provide insights into biogeochemical processes, formation and microbial transformation of particles since a mass-dependent isotopic fractionation occurs in each pathway. In this study we examined the vertical distribution of $\delta^{13}C$ and $\delta^{15}N$ of suspended particles to elucidate particle dynamics in the upper ocean of the station K2 in summer.

(2) Sampling

About 20 to 80 liters of seawater were collected by CTD-RMS and a bucket at the depths from surface to 200 m depths, and filtered through pre-combusted GF/F filters (Whatman) and the filters were kept frozen until analysis on shore.

(3) Analysis

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

(4) Preliminary result

The distributions of $\delta^{13}C$ and $\delta^{15}N$ as well as POC and PN concentrations of suspended particles will be determined as soon as possible after this cruise.

(5) Data archive

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

3.9 Phytoplankton

3.9.1 Chlorophyll *a* measurements by fluorometric determination

Tetsuichi FUJIKI (JAMSTEC) : Principal Investigator
Keitaro MATSUMOTO (MWJ) : Operation Leader

1. Objective

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

2. Sampling

Samplings of total chl-*a* were conducted from 10-13 depths between the surface and 225 m at all observational stations. At the cast for primary production, water samples were collected at 13 depths between the surface and 200 m at the station of K2.

3. Instruments and Methods

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

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma-Aldrich Co.). We applied two kind of fluorometric determination for the samples of total chl-*a*: "Non-acidification method" (Welschmeyer, 1994). Size-fractionated samples were applied only "Non-acidification method". Analytical conditions of each method were listed in table 3.10.1-1.

4. Preliminary Results

The results of total chl-*a* at station K2 were shown in Figure 3.9.1-1. The results of size fractionated chl-*a* were shown in Figure3.9.1-2.

5. Data archives

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

6. Reference

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

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

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

Table 3.9.1-1. Analytical conditions of "Non-acidification method" for chlorophyll *a* with Turner Designs fluorometer (10-AU-005).

Excitation filter	436 nm
Emission filter	680 nm
Lamp	Blue Mercury Vapor

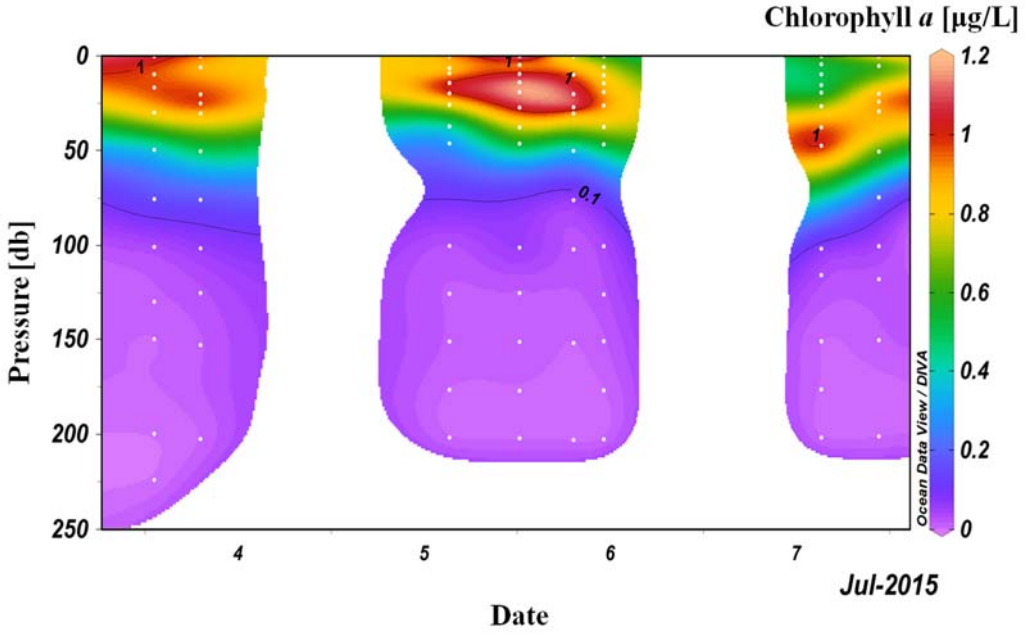

Figure 3.9.1-1 Time series of chlorophyll *a* vertical distribution during Stn.K2

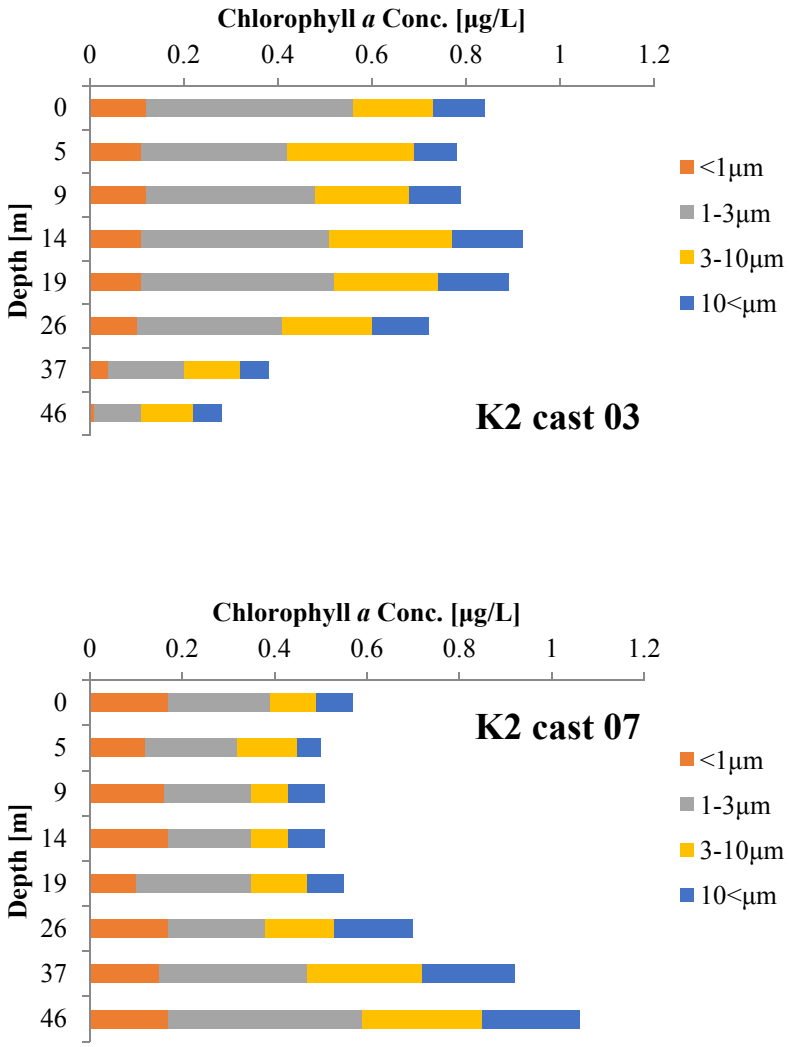

Figure 3.9.1-2 Vertical distribution of size-fractionated chlorophyll *a*

3.9.2 HPLC measurements of marine phytoplankton pigments

Tetsuichi FUJIKI (JAMSTEC) : Principal Investigator
Keitaro MATSUMOTO (MWJ) : Operation Leader

(1) Objective

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

(2) Methods, Apparatus and Performance

Seawater samples were collected from eight depths in the euphotic layer at the cast for the primary production. Seawater samples were collected using Niskin bottles, except for the surface water, which was taken by a bucket. Seawater samples (2L) were filtered (<0.02 MPa) through the 47-mm diameter Whatman GF/F filter. The sample filters are stored in a deep-freezer (-80 °C) until onshore HPLC analysis. Phytoplankton pigments are extracted with *N,N*-dimethylformamide for at least 24 h at –20 °C in the dark and then will be analyzed with an HPLC modular system (Agilent Technologies) on land.

(3) Data archives

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

3.9.3 Primary production

Tetsuichi FUJIKI (JAMSTEC) : Principal Investigator
Keitaro MATSUMOTO (MWJ) : Operation Leader

(1) Objective

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

(2) Methods

1) Sampling, incubation bottle and filter

Sampling was conducted at predawn immediately before the incubation experiment. Seawater samples were collected using Teflon-coated and acid-cleaned Niskin bottles, except for the surface water, which was taken by a bucket. Samplings were conducted at eight depths in the euphotic layer in response to the light levels of the incubation containers adjusted with the blue acrylic plate. The light levels of the incubation containers in the bath were shown in Table 3.9.3-1. The light depths relative to the surface had been estimated by the underwater optical sensor on the previous day of the sampling. Seawater samples were placed into acid-cleaned clear polycarbonate bottles in duplicate for PP, and in a single for the dark and the time-zero samples. The time-zero sample was filtered immediately after the addition of ^{13}C solution. Filtration of seawater sample was conducted with pre-combusted glass fiber filters (Whatman GF/F 25 mm) with temperature of 450 degree C for at least 4 hours.

2) Incubation

Each bottle was spiked with sufficient $NaH^{13}CO_3$ just before incubation so that ^{13}C enrichment was about 10% of ambient dissolved inorganic carbon as final concentration of 200 μmol dm^{-3} (Table 3.9.3-2). Incubation was begun at predawn and continued for 24 h. The simulated *in situ* method was conducted in the on-deck bath cooled by running surface seawater or by immersion cooler.

3) Measurement

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

(3) Data archives

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

Table 3.9.3-1 Light levels of the incubation containers

Number	Light Level
#1	100%
#2	50%
#3	25%
#4	10%
#5	5%
#6	2.5%
#7	1%
#8	0.5%

Table 3.9.3-2 Sampling cast table and spike ^{13}C concentration

Incubation type	CTD cast	$NaH^{13}CO_3$ ($\mu mol\ dm^{-3}$)
simulated *in situ*	K02M03	200
simulated *in situ*	K02M07	200

3.10 Zooplankton

Katsunori Kimoto (RCGC, JAMSTEC)
Minoru Kitamura (RCGC, JAMSTEC)
Takahito Ikenoue (Marine Ecology Research Institute)
Keisuke Shimizu (GeoBios JAMSTEC)
Minamo Hirahara (Soka University)

Ocean acidification is one of the most concerning issues of global climate changes. Oceanic pH decreasing and related carbonate chemistry changes could severally give biotic impact to most phyto-zooplankton, particularly creatures building external hard skeletons. In order to know such vulnerability and sensitivity of marine plankton to ocean acidification in the North Pacific, we focused on some typical faunas (Thecosomata (shelled pteropods), copepods, planktic foraminifers, and radiolarians) in station K2, and performed several biological analysis for each faunas.

For the purpose of collection of each zooplankton, we used some different plankton-net apparatus: Single Norpac, Twin Norpac and VMPS-3K. Single Norpac and Twin Norpac were performed from 150-0m and 1000-0m water depths for collection of mesozooplankton, respectively. VMPS-3K was performed for more deeper depths from 2000-0m for shell-beard microzooplankton. Details of each observation were described below.

3.10.1 Seasonal dynamics of zooplankton estimated using acoustical methods and vertical distribution of zooplankton during summer

Minoru KITAMURA (JAMSTEC, RCGC)

(1) Objective

Although seasonality of mesozooplankton biomasses at K2 was studied during from 2010 to 2012, it was not corresponded to seasonal change of the primary productivities. That is to say, the maximum mesozooplankton biomass was observed during April 2011 when the chl. *a* and primary productivity were still low. We suggested horizontal advection of the coastal mesozooplankton population into K2 as a potential reason for the high biomass during April, but biological data to discuss influences of advection on zooplankton dynamics at K2 are still limited. So, further observations on seasonal dynamics of zooplankton biomasses are needed, and it should be based on the samplings at more dense intervals. Mooring observations using acoustical devices are probably effective for them; thus, an ADCP (LongRanger, Teledyne RD Instruments, see 2.2.6) was installed on the hybrid profiling buoy system which was deployed at K2 during the present cruise. After recovery of the system during the 2016 cruise, we will analyze mesozooplankton dynamics using the backscatter intensities obtained by a moored ADCP. In the KH-15-J01 cruise, mesozooplankton were also collected using the ORI net to estimate biomass which will be used for calibration of acoustically estimated biomasses.

To understand/discuss influences of ocean acidification on plankton community are one of the themes for the KH-15-J01 cruise. Accurate understanding on seasonal dynamics of zooplankton, which is discussed above, is important as one of the basic information when we will detect biological responses against such kind of environmental changes. In addition, recent researches suggested that ocean acidification may influence not only maintaining of $CaCO_3$ test but also larval development of crustacean zooplankton. However, ecological studies of larvae for crustacean zooplankton are still limited. In this study, vertical distributions for copepods in early life stages are investigated.

(2) Methods

The ORI net (1.6 m in diameter, 8 m long, and 0.33 mm in mesh) was obliquely towed at an average ship speed of 2 knots. Target layers of the zooplankton samplings were 0-100, 0-200, and 0-400 m. Filtering volume of water was estimated using a flow meter (S/N: 2370) mounted in the net mouth. Maximum sampling depth of each trawl was recorded using a depth sensor (DEFI-D50, JFE-Advantec Co. Ltd; S/N 081N005) attached in the net frame, which were summarized in Table 3.10-1. All zooplankton samples were fixed and preserved in 5% buffered formalin seawater. Although

mesozooplankton samplings during both the day and night were planned before the cruise, nighttime sampling was canceled due to tight ship time.

For studies about larval staged copepods, a VMPS (0.25 m^2 in mouth area, 64 μm in mesh) was vertically hauled at wire reeling speed of 0.5 m/sec and at discrete depth intervals from 0 to 150 m (0-10, 10-30, 30-50, 50-100, 100-150 m). Although collection of total eight sample series (at 2:00, 11:00, 18:00, 22:00 × 2 days) was planned before the cruise, only five series were collected. To compare between diel changes of environments (T, S, Chl. *a*, underwater light conditions, photosynthesis activities of phytoplankton) and vertical distribution of zooplankton, these net samplings followed the shallow hydrocasts of CTD and FRRF. Each zooplankton sample was divided onboard using a sample splitter. 1/2 subsample was fixed and preserved in 5% buffered formalin seawater to analyze community structure. Another aliquot was filtered using a pre-weighed 0.1 mm meshes, and was frozen in −20°C to estimate bulk biomass of zooplankton.

Sampling information of zooplankton were summarized in Table 3.11-1.

(3) Sample archive

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

Table 3.10-1. Zooplankton samplings using ORI net

Sampling gear: ORI net (2 m^2 in mouth area, 0.33 mm in mesh).
VMPS (0.25 m^2 in mouth area, 64 μm in mesh).

Sample ID.	Date & Time (local time)		Wire out (m)	Sampling layer (m)	F-meter read	Filtering vol. (m^3)	Filter ID for frozen subsamples
ORI net samples							
ORI-1	2015.7.6	6:26-7:10	800	0~442	18,910	3,091.8	-
ORI-2	2015.7.6	7:19-7:43	400	0~217	9,935	1,624.4	-
ORI-3	2015.7.6	7:53-8:09	200	0~106	5,732	937.2	-
VMPS samples							
V150mA-2	2015.7.6	2:20-2:22		149~99	63	9.3	Ar4
V150mA-3		2:22-2:24		99~49	51	7.5	Ar5
V150mA-4		2:24-2:26		49~2	45	6.6	Ar6
V50mA-2		2:55-2:56		51~31	25	3.7	Ar1
V50mA-3		2:56-2:57		31~10	25	3.7	Ar2
V50mA-4		2:57-2:58		10~0	7	1.0	Ar3
V150mB-2	2015.7.6	11:09-11:11		150~100	50	7.4	Ar7
V150mB-3		11:11-11:13		100~49	43	6.3	Ar8
V150mB-4		11:13-11:15		49~1	40	5.9	Ar9
V50mB-2		11:32-11:33		51~30	31	4.6	Ar10
V50mB-3		11:33-11:34		30~9	20	2.9	Ar11
V50mB-4		11:34-11:34		9~1	8	1.2	Ar12
V150mC-2	2015.7.6	17:55-17:57		151~100	44	6.5	Ar13
V150mC-3		17:57-17:59		100~50	43	6.3	Ar14
V150mC-4		17:59-18:00		50~1	42	6.2	Ar15
V50mC-2		18:23-18:24		50~30	23	3.4	Ar16
V50mC-3		18:24-18:24		30~9	14	2.1	Ar17
V50mC-4		18:24-18:24		9~0	7	1.0	Ar18
V150mD-2	2015.7.6	21:45-21:47		151~100	46	6.8	Ar19
V150mD-3		21:47-21:49		100~49	40	5.9	Ar20
V150mD-4		21:49-21:50		49~2	39	5.7	Ar21
V50mD-2		22:09-22:10		50~30	22	3.2	Ar22
V50mD-3		22:10-22:11		30~10	18	2.6	Ar23
V50mD-4		22:11-22:11		10~0	10	1.5	Ar24
V150mE-2	2015.7.8	2:02-2:04		151~99	53	7.8	Ar25
V150mE-3		2:04-2:06		99~38	65	9.6	Ar26
V150mE-4		2:06-2:07		38~0	45	6.6	Ar27
V50mE-2		2:23-2:24		50~30	20	2.9	Ar28
V50mE-3		2:24-2:25		30~10	19	2.8	Ar29
V50mE-4		2:25-2:25		10~1	9	1.3	Ar30

3.10.2 Effect of fatty acids on egg hatching success of *Neocalanus* copepods

Minamo HIRAHARA (Soka University)

(1)Objective

Neocalanus cristatus, *N. plumchrus* and *N. flemingeri* are dominant species of copepods in the subarctic Pacific that have the unique life strategy. They do not feed during the adult stage and produce eggs by using stored lipids accumulated at the surface. Therefore, their egg production is dependent on stored lipids built up in the surface layer.

Their egg hatching success is fluctuated from 0 to 100% (Yoshiki et al., 2011). Previous studies have reported that the egg hatching success of *Calanus finmarchicus* and *Temora longicornis* is significantly affected by fatty acids composition of *in situ* food (Jónasdóttir et al., 2008; Evjemo et al., 2008). In terms of three species of *Neocalanus*, as the energy source for their egg production is not *in situ* food, but stored lipids adult females have, it is assumed that their egg hatching success is affected by the fatty acids composition of adult females. Moreover, the fatty acids composition supplied from adult females to eggs is also considered to be largely influential to their egg hatching success. In this cruise, I aimed to understand the effect of fatty acids compositions of adult females and eggs on the egg hatching success of copepod *Neocalanus cristatus*, *N. plumchrus* and *N. flemingeri*.

(2)Methods

Sampling was conducted by vertical hauls of a ring net (40 cm diameter) with 330 μm mesh fitted with a 1 l cod end. Hauls were from depths of 50, 500, 1000, 1500, and 2000 m to the surface. The contents of the cod end were diluted with surface seawater, and female *Neocalanus* copepods were sorted from the sample by using a chinese spoon and then transferred into 1 l bottles filled with seawater filtered through 0.7 μm glass-fiber filters (GF/F; Whatman®). Bottles were kept at approximately 4°C in either a cold room or an incubator. After the samples were returned to the laboratory, females were taxonomically classified under a dissecting microscope. *Neocalanus plumchrus* and *N. flemingeri* were individually transferred into 250 ml bottles filled with filtered seawater, whereas *N. cristatus* was individually transferred into 2 l bottles. The bottles containing copepod females were kept at 4°C in the dark and were checked daily for spawning.

When eggs were produced, copepod females were transferred to beakers and eggs were counted under a dissecting microscope. The half of eggs were then transferred to 12-well Nunc® multi-well dishes containing about 5 ml of filtered seawater (<0.7 μm) for counting egg hatching success within 72 h. The other half of eggs were harvested on 0.7 μm glass-fiber filters (GF/F; Whatman®) and stored at -80 ^{0}C for analyzing of fatty acids.

(3)Preliminary results

In this cruise, *N. cristatus* and *N. flemingeri* were most dominant species in the three target species. The egg production rate of *N. cristatus* and *N. flemingeri* was under 50 and 100 eggs clutch^{-1} at any clutches, respectively. Compared to the previous study of egg production rate of these two species, this result corresponded to the low egg production rate in a later period of egg-laying (Saito and Tsuda, 2000). The egg hatching success of both species was from <5 to 100%. There was no significant correlation between the egg production rate and the egg hatching success.

(4)Data archive

Samples of zooplankton and its eggs are stored at Soka University. Incubation experiments and fatty acids analysis will be conducted.

3.10.3 Planktic foraminifers and Pteropods (Thecosomata)

Katsunori Kimoto (RCGC, JAMSTEC)
Keisuke Shimizu (JAMSTEC)

1) Objectives

The anthropogenic CO_2 released to the atmosphere by the consumption of fossil fuel and by deforestation continues to raise the atmospheric CO_2 concentration. The ocean has already absorbed about 30% of the total anthropogenic CO_2 since the industrial revolution (approximately 155 GtC) (IPCC AR5, 2013). This helps to reduce atmospheric CO_2 levels and plays an important role in in the global climate system to mitigate global warming. At the same time, however, acidification of the ocean is increasing, and this will affect marine environments and ecosystems.

Pteropods (Thecosomata, shelled sea butterfly) and planktic foraminifera have calcium carbonate shells and they are fundamental components of oceanic material cycles and foodwebs. In this study, we collected pteropods and planktic foraminifer samples used the Vertical Multi-depth Plankton Sampler (VMPS-3K, Tsurumi Seiki co., Ltd) from the water column at station K2, and try to make general aspects of their biotic responses to carbonate saturation status.

2) Collection and shipboard treatment

VMPS-3K is integrated sampling apparatus for plankton collection from different water depths. VMPS-3K equipped 4 plankton nets, fluorometer (Wet Lab) and CTD sensors (Sea-bird Electrics) and can be deployed up to 3,000 m water depth. Closing of the each nets are electrically controlled from the lab on the ship. In this observation, we used 63 μm mesh sized plankton net (NXX25) for each plankton net. In addition, we did not use the first (No.1) net to avoid contamination of zooplankton/suspending matters during descent of VMPS. Basic information of sampling is shown in Table 3.10.3.

Samples were split by Motoda-type sample splitter for the purpose of analysis of carbonate and silicate-shelled plankton. Division of carbonate shelled plankton (for Peropods and planktic foraminifers) were fixed by the ethanol (99.5 %) immediately in the laboratory on the ship. Fixed samples were bottled in the plastic jars and stored in the refrigerator under 4°C.

3) Onshore study in the future

Pteropod and planktic foraminiferal shells will be analyzed by the Micro-focus X-ray CT (MXCT) equipped in JAMSTEC HQ in order to elucidate relationships between oceanic carbonate chemistry and individual shell density.

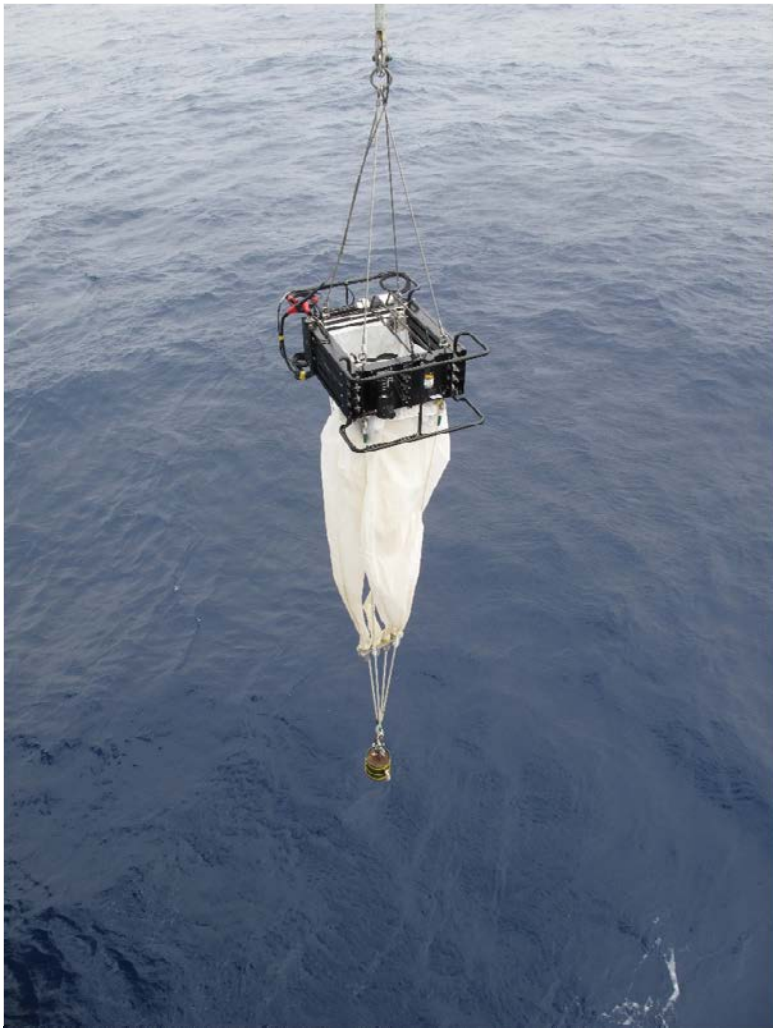

Fig. 3.10.3 Overview of VMPS-3K.

Table 3.10.3 Sampling information of VMPS observations for shell-beard zooplankton.

Date	Cast	Start Time (JST)	End Time (JST)	Depth (start)	depth (end)	VMPS Net No.	Flow meter
2015.7.6	Cast1	3:54	4:13	2000	1500	2	430
Station K2		4:13	4:27	1500	1000	3	410
		4:27	4:44	1000	500	4	445
	Cast2	5:31	5:41	500	200	2	279
		5:41	5:43	200	150	3	47
		5:43	5:44	150	100	4	46
	Cast3	6:00	6:09	100	50	2	53
		6:09	6:12	50	30	3	17
		6:12	6:13	30	0	4	25
2015.7.8	Cast1	3:26	3:43	2000	1500	2	429
Station K2		3:43	3:58	1500	1000	3	398
		3:58	4:15	1000	500	4	433
	Cast2	5:09	5:19	500	200	2	291
		5:19	5:21	200	150	3	43
		5:21	5:23	150	100	4	42
	Cast3	5:48	5:50	100	50	2	54
		5:50	5:51	50	30	3	25
		5:51	5:52	30	0	4	31

Calibration from the flow counts to filtered water volumes is calculated following factor:
0.147 m^3/count (calibrations were performed by K. Kimoto in July, 2014)

3.10.4 Radiolarians

Takahito Ikenoue (MERI)

(1) Objective

Radiolarians are one of the most common marine microzooplankton groups. They secrete siliceous skeletons, and that contribute to the material cycles of the ocean. Their species-specific abundance in a region is related to temperature, salinity, and nutrient availability. In this cruise, we collected radiolarians in each water depths to clarify their species abundance and vertical distributions in the western subarctic gyre.

(2) Methods

Plankton tow samples were collected using a vertical multiple plankton sampler (VMPS). The instrument (mesh size: 63 μm; open mouth area: 0.25 m^2 was towed from nine layers (30-0, 50-30, 100-50, 150-100, 200-150, 500-200, 1000-500, 1500-1000, and 2000-1500 m) at Station K2 in western subarctic gyre in 6 July 2015 and 8 July 2015. The volume of seawater filtered through the net was estimated using a flow meter mounted in the mouth of the VMPS. The samples collected by VMPS were split with a Motoda box splitter. The split samples were sieved through a stainless steel screen with 45 μm mesh size and were fixed with 99.5% ethanol for radiolarian studies.

(3) Data archive

Radiolarian samples are stored at MERI. Vertical distribution and standing stocks of radiolarian species will be examined.

3.10.5 Pteropod study in the western Pacific

Keisuke SHIMIZU (JAMSTEC)

(1) Objective

Ocean acidification (OA) is one of the serious marine environmental issue. Mollusca has one or more hard exoskeletons made of calcium carbonates and OA affects their mineralized shell formation. The main themes of this study is to investigate the phenotypic and genetic response against different pCO_2 condition in planktonic Mollusca Pteropods. In addition, in order to understand their population structure, I seek to compare their mtDNA sequences (COI region) between the populations of North Pacific ocean (station K2) and Arctic ocean.

(2) Methods

Pteropods samples were collected at station K2 by vertical towing of a NORPAC net (100 μm opening). The net was towed 35 times under 50 m from sea surface. The living Pteropods were removed culturing bottle (15 L) immediately from NORPAC net samples every time. Then, these samples were cultured in different pCO_2 concentration condition at 5 ºC. In order to understand their phenotypic and genetic response against acidic environment, the cultured Limacina were fixed by three different solutions, 99.5 % EtOH, 4 % PFA in MOPS and RNAlater (Life technologies) after 24 h and 72 h . 99.5 % EtOH-fixation samples were stored at -20 ºC, and RNAlater samples were stored at -80 ºC. 4 % PFA-fixation samples were stored at 4 ºC overnight, and after washing with PBS buffer, they were stored in 70 % EtOH at -20 ºC.

(3) Preliminary result

In order to identify the pteropods species, I performed DNA extraction by Gene releaser (BioVentures) from EtOH-fixed samples, and PCR amplification was performed using the standard Folmer primes (LCO1490 and HCO2198; Folmer et al. 1994). Sequencing results showed that all pteropods samples were collected at station K2 were *Limacina helicina* and their nucleotide sequences of COI region closed to the same of Arctic *L. helicina*. These results suggested that *L. helicina* is major pteropod species at station K2 (the western North Pacific ocean), and gene flow might exist between station K2 and Arctic oceans in this species.

(4) Data archive

The collected samples are stored at JAMSTEC. Gene expression analysis and morphological observations will be conducted.

3.11 Shipboard ADCP

Minoru KITAMURA (JAMSTEC, RCGC)

(1) Objective

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

(2) Methods

Upper ocean current measurements were made in KH-15-J01 cruise, using the Ocean Surveyor system (vessel-mount ADCP; Teledyne RD Instruments, CA, USA). The Ocean Surveyor has a phased-array transducer with single ceramic assembly and creates four acoustic beams electronically.

Specifications

Frequency: 38 kHz
Beam angle: 30°
Dimension of transducer: 914.4 mm in diameter
Max. altitude of bottom track: 1700 m
Max. range of water profiling: 1000 m (at high precision mode and 16 m of bin size)
Velocity accuracy: ±1.0% or 0.5 cm/sec.
Velocity range: −5 to 9 m/sec.
Number of depth cells: 1-128
Software: VMDAS for data acquisition, WinADCP for data display and export

Setup parameters for data collection

Mode of sampling: High Precision Mode (Broadband Mode)
Bottom-tracking/water-tracking: Bottom-tracking Mode
Vertical resolution cell size (bin size): 16 m
Number of bin: 80

(3) Data archives

All data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via JAMSTEC homepage.

3.12 Radiation measurement

Tetsuichi FUJIKI (JAMSTEC RCGC)
Yoshimi KAWAI (JAMSTEC RCGC)
Tadahiro HAYASAKA (Tohoku University)

(1) Objective

The subarctic region of Northwestern Pacific Ocean is covered with low-level clouds very frequently in summer. The low-level clouds greatly affect incoming radiation and the energy budget of the upper ocean. Shortwave radiation into the ocean is also very important for phytoplankton. However, in situ observations of radiation at the sea surface are quite lacking. Hence, we observed shortwave and longwave radiation on the vessel throughout the cruise.

(2) Description of instruments deployed

The instruments we used are as follows:

Shortwave radiation: CM-21 (Kipp&Zonen)

Longwave radiation: CG-4 (Kipp&Zonen)

These radiometers were installed in gimbals to keep them horizontal. The gimbals were attached on the forward part of the compass deck (Figure 3.12.1). A data logger was placed in the laboratory #1. Data were recorded every one minute.

(3) Preliminary result

Observed downward shortwave and longwave radiation are shown in Figure 3.12.2.

(4) Data archive

The data file was submitted to JAMSTEC Data Management Group (DMG). The data are written in ASCII format every one minute.

Figure 3.12.1. Instruments attached on the compass deck.

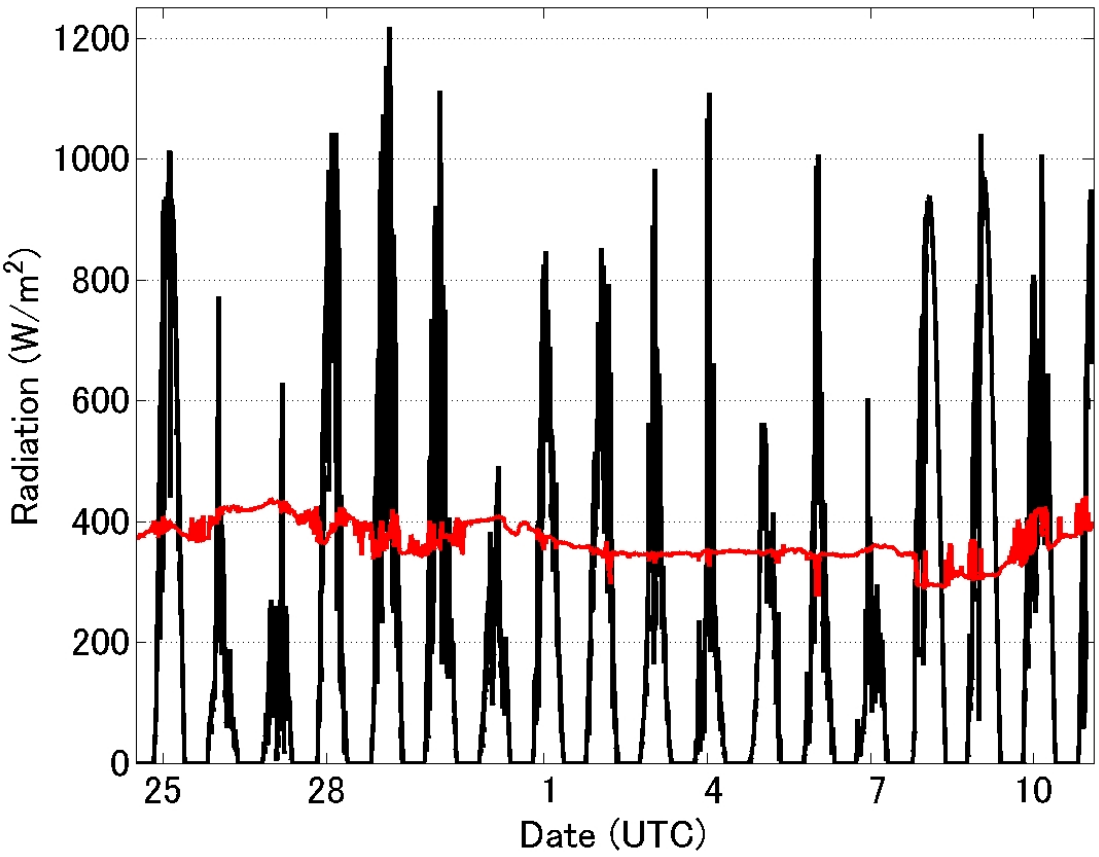

Figure 3.12.2. Time series of downward shortwave (black) and longwave (red) radiation observed in the cruise period.

3.13 N_2O and CH_4 with stable isotopes

Chisato YOSHIKAWA (JAMSTEC BGC)

(1) Introduction

Nitrous Oxide (N_2O) is recognized as significant anthropogenic greenhouse gas and a stratospheric ozone destroyer. The estimation of global N_2O flux from ocean to the atmosphere is 3.8 $TgNyr^{-1}$ and the estimation varies greatly, from 1.8 to 5.8 $TgNyr^{-1}$ (IPCC, 2013). This is because marine N_2O production processes are poorly understood quantitatively and so previous models had estimated N_2O concentration from oxygen concentration indirectly. Marine N_2O production processes are very complicated; hydroxylamine oxidation during nitrification, nitrite reduction during nitrifier denitrification and nitrite reduction during denitrification produce N_2O and N_2O reduction during denitrification consumes N_2O (Dore et al., 1998; Knowles et al., 1981; Rysgaard et al., 1993; Svensson, 1998; Ueda et al., 1993). N_2O isotopomers (oxygen isotope ratio ($\delta^{18}O$), difference in abundance of $^{14}N^{15}N^{16}O$ and $^{15}N^{14}N^{16}O$ (SP), and average nitrogen isotope ratio ($\delta^{15}N$)) are useful tracers to distinguish these processes and had revealed N_2O production processes in various ocean environments (e.g., Yoshida and Toyoda, 2000). Recently we had newly developed a marine N_2O box model including isotopomers at K2 (Yoshikawa et al., 2015). In this cruise we collected samples for the observed isotope values of N_2O and N_2O related materials, and are planning to expand the model to a one dimensional model by using the isotope data set.

Methane (CH_4) is a terminal product during decomposition of organic matter and acts as a potential greenhouse gas. The vast quantity of methane (about 500-600 Tg) is annually emitted to atmosphere, in which contribution of methane from ocean accounts for 3% (Conrad, 2009). In surface seawater, concentration of methane is oversaturated respect to the atmosphere, where dissolved oxygen concentration is maxima (Scranton et al., 1977). However, the mechanism of the methane production is still ambiguous, which has been termed the ocean methane paradox. As a traditional hypothesis, methane is produced in micro-anaerobic environments such as in guts of zooplankton and sinking particles of organic matter. A recent study suggested bacterial production as byproduct during decomposition of phosphonate (Karl et al., 2008). In this cruise we collected samples for the isotope values of CH_4 and a biomarker of methanogens F430 (see section 3.14 in detail), and are planning to clarify quantitative distribution of methanogens and their methanogenic pathway, which should provide important information about methane origin in the surface seawater.

(2) Materials and methods

Seawater samples are taken by CTD-CAROUSEL system attached Niskin samplers of 12 L at

24 layers and surface layer taken by plastic bucket at hydrographic stations as shown in Table 1.

Table 1. Parameters and hydrographic cast numbers for this study.

Parameters	Hydrographic cast numbers
1. $\delta^{15}N$ and $\delta^{18}O$ of NO_3^-	1, 2, 8
2. $\delta^{15}N$, SP and $\delta^{18}O$ of dissolved N_2O	1
3. $\delta^{15}N$ and $\delta^{18}O$ of NO_2^-	2, 8
4. $\delta^{15}N$ of NH_4^+, DON	2, 8
5. $\delta^{13}C$ of DIC	2, 8
6. $\delta^{13}C$ of CH_4	1

Samples for N_2O isotopomer analysis was transferred to two of 160 ml glass vials. After an approximately two-fold volume overflow, 100μL of saturated $HgCl_2$ solution were added. The vials were sealed with butyl rubbers and aluminum caps and stored in dark at 4°C until analysis. The $\delta^{15}N$, $\delta^{18}O$ and SP values and concentrations of N_2O in seawater will be determined by slightly modified version of GC-IRMS (PreCon/HP6890 GC/ MAT 252) at TIT described in detail in Yamagishi et al. (2007).

Samples for NO_3^-, NO_2^-, NH_4^+ and DON isotope analysis were collected through GF/F filter. The samples for NO_3^- were removed NO_2^- with sulfamic acid using the method of Granger and Sigman (2009) and preserved at -23°C until chemical analysis. The $\delta^{15}N$ and $\delta^{18}O$ values of NO_3^- will be measured using the "bacterial" method of Sigman et al., (2001) in which N_2O converted from nitrate is analyzed using GasBench/ PreCon/IRMS. The samples for NO_2^- were frozen until analysis. The $\delta^{15}N$ and $\delta^{18}O$ values of NO_2^- will be measured after conversion to N_2O using the azide method of McIlvin and Altabet (2005) by GC-IRMS. A PTFE pack, which contained a Whatman GF/D filter with 10 μL of 1M H_2SO_4 solution, and 0.3 g of MgO were added to the samples for NH_4^+. The bottles were shaken by hands at least once a day for 7 days. After ammonium was trapped to the acid, the pack was removed and rinsed with MilliQ water, then stored in a glass bottle with silica gels until analysis. The $\delta^{15}N$ values of ammonium will be measured by EA-IRMS. The samples for DON were frozen until analysis. The $\delta^{15}N$ values of DON will be measured after conversion to N_2O using wet oxidation and "denitrifier" method of Knapp et al. (2005) by GC-IRMS.

Samples for $\delta^{13}C$-CH_4 analysis were transferred to 160 mL glass vials from the Niskin sampler without head space. After the vials were sealed with butyl rubber and aluminum caps, 100 μL of saturated $HgCl_2$ solution was added. The water samples were stored until analysis on land. The $\delta^{13}C$ value of Methane will be measured using a method of Tsunogai et al. (1998 and 2000) by IRMS.

Samples for $\delta^{13}C$-DIC analysis were transferred to 30 mL glass vials from the Niskin sampler

without head space. After the vials were sealed with butyl rubber and aluminum caps, 20 μL of saturated $HgCl_2$ solution was added. The water samples were stored until analysis on land. The $\delta^{13}C$ value of DIC will be measured by IRMS.

(3) Expected result

In the surface layer, N_2O concentration of water affects the sea-air flux directly (Dore et al., 1998). However the pathway of N_2O production in surface layer is still unresolved. In the surface layer, N_2O is predominantly produced by nitrification, but also by nitrifer-denitrification and denitrification if oxygen concentration is low in the water mass or particles (Maribeb and Laura, 2004). The observed concentrations and isotopomer ratios of N_2O together with those values of substrates for N_2O (NO_3^-, NO_2^-, NH_4^+, and DON) will reveal the pathway of N_2O production in the surface layer and will expand and improve the marine N_2O isotopomer model.

The $\delta^{13}C$ value of methane reflects carbon source and methaogenic pathway (Whiticar, 1999). If the profile correlate with other chemical profiles including $\delta^{13}C$ value of DIC, concentrations of methane, chlorophyll and dissolved oxygen, it can be a strong evidence of that methanogens are source organisms for methane in the surface seawater. The $\delta^{13}C$ value of methane will support presence of methanogen and provide further constraints on methaongenic pathway, In addition with this, F430 and other chemicals will provide insight into environmental factors controlling distribution of methanogens.

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3.14 In situ filtration system

Chisato YOSHIKAWA (JAMSTEC BGC)
Tetsuichi FUJIKI (JAMSTEC RCGC)
Katsunori KIMOTO (JAMSTEC RCGC)
Yoshihisa MINO (Nagoya University)

(1) Introduction

The filtration is widely used to measure chemical and biological compositions, eg., elemental and compound compositions, chlorophyll pigment concentrations, isotope ratios, DNA, spices composition of virus, bacteria, phytoplankton and zooplankton, in suspended materials. The combiation of water sampling and suction filtration is a general method. However, this method is unsuitable for the microanalysis requiring a few hundred liter of seawater. In this cruise we conducted in situ filtration and collected suspended materials for $\delta^{15}N$ and $\delta^{13}C$ analysis for suspended materials, chlorophyll pigments, and species-specific phytoplankton, for HPLC analysis, for DNA analysis, for carbonate particle analysis, and for a biomarker of methanogens F430.

(2) Materials and methods

In situ filtration took place three times by using McLane WTS-LV samplers at 8 layers as shown in Table 1.

Table 1. Setting for in situ filtration.

Date	Depth (m)	Filtration rate (L)	Types of filter	Measurement items	Contact person
2015/07/04	5	303	GF/F, 300μm	Chlorophyll isotope	Yoshikawa
	27	397	GF/F, 300μm	Chlorophyll isotope	Yoshikawa
	26	242	GF/F, 300μm	Chlorophyll isotope	Yoshikawa
	25	280	GF/F, 300μm	F430	Yoshikawa
	50	4	GF/F, 53μm	Carbonate particle	Kimoto
	100	401	GF/F, 53μm	Carbonate particle	Kimoto
	150	484	GF/F, 53μm	Carbonate particle	Kimoto
	300	450	GF/F, 53μm	Carbonate particle	Kimoto
2015/07/05	25	674	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
	50	708	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
	100	636	GF/F, 300μm	HPLC, isotope, DNA	Fujiki

	200	647	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
	500	783	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
	1000	704	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
	2000	855	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
	3000	787	GF/F, 300μm	HPLC, isotope, DNA	Fujiki
2015/07/07	6	4	0.2μm, 5μm	Chlorophyll isotope	Yoshikawa
	5	0	0.2μm, 20μm	PHY isotope	Yoshikawa
	26	91	0.2μm, 5μm	Chlorophyll isotope	Yoshikawa
	25	79	0.2μm, 20μm	PHY isotope	Yoshikawa
	51	431	GF/F, 53μm, 250μm	isotope	Mino
	50	469	GF/F, 53μm, 250μm	isotope	Mino
	101	248	GF/F, 53μm, 250μm	isotope	Mino
	100	587	GF/F, 53μm, 250μm	isotope	Mino

Samples for chlorophyll isotope analysis were filtered with pre-combusted GF/F filters and acid-washed 0.2 and 5μm plankton nets. The filters were double up and wrapped in aluminum foil and stored at -20ºC until analysis. Chlorophyll pigments will be extracted and split into each pigments by HPLC. The $\delta^{15}N$ and $\delta^{13}C$ values of Chlorophyll pigments will be measured by using EA-IRMS at JAMSTEC.

Samples for phytoplankton isotope analysis were filtered with acid-washed 0.2 and 20μm plankton nets. The filters were rinsed in 40ml of filtrate seawater. Half of the seawater including particles were frozen by program freezer and the other half were fixed with PFA and then stored at -80 ºC until analysis. The particles will be sorted according to phytoplankton spices by a cell sorter at NIES. The $\delta^{15}N$ and $\delta^{13}C$ values of phytoplankton will be measured by using EA-IRMS at JAMSTEC.

Samples for F430 analysis were filtered with pre-combusted GF/F filter. The filter samples were wrapped with aluminum foil and stored at −20°C prior to analysis on land. Extraction and analysis of F430 will be conducted at JAMSTEC using a method of Kaneko et al. (2014).

Particulate samples for isotope analysis were size-separated by the filtration with acid-washed 53 and 250 μm nylon nets as well as pre-combusted GF/F filter. The particles on nylon nets were re-filtrated through GF/F filter. The filters were stored frozen until analysis. The $\delta^{13}C$ and $\delta^{15}N$ values of particulate organic matter in the samples are measured by using EA-IRMS at Nagoya University.

Particulate matter larger than 53 μm was rinsed by fresh water and fixed by the ethanol (99.5 %). Carbonate shelled planktic foraminifera was picked up by the brush under the stereomicroscope and dried on the assemblage slide at room temperature. Planktic foraminifer shells will be performed shell density measurement by Micro-focus X-ray CT (MXCT, ScanXmate-

DF160TS105, Comscan Tecno, Co.Ltd) installed in JAMSTEC HQ.

Samples for phytoplankton pigments are extracted with *N,N*-dimethylformamide for at least 24 h at –20 °C in the dark and then will be analyzed with an HPLC modular system (Agilent Technologies) on land.

For DNA analysis, sample filter was put in the 2ml plastic screw vial including 1ml of DNA-degradation inhibitor (0.25M EDTA, 20% DMSO, and saturated NaCl liquid). The samples will be analyzed at Tsukuba University.

(3) Expected result

The observed $\delta^{15}N$ and $\delta^{13}C$ values of chlorophyll pigments and species-specific phytoplankton and the values of nutrient sources obtained in this cruise (eg., $\delta^{15}N\text{-}NO_3^-$, $\delta^{15}N\text{-}NH_4^+$, $\delta^{15}N\text{-}NO_2^-$, $\delta^{15}N$-DON, $\delta^{13}C$-DIC) will reveal the source of nitrogenous and carbonaceous nutrients for phytoplankton. In addition with this, the nitrogen isotope ratios of phytoplankton will validate a model process of nutrient uptake by phytoplankton in a N_2O isotopomer model (Yoshikawa et al., 2015).

The observed F430 and other materials obtained in this cruise (eg., $\delta^{13}C$-DIC and $\delta^{13}C\text{-}CH_4$) will provide insight into environmental factors controlling distribution of methanogens.

The $\delta^{13}C$ and $\delta^{15}N$ values of particles with different sizes can provide insights into biogeochemical processes in particle dynamics in the upper ocean.

It is reported that some marine calcifiers are affected by oceanic pH decreasing and/or other physicochemical multistressor (e.g. Gazeau et al., 2013; Kleypas et al., 2013) Planktic foraminifera recovered from four different water depths could be influenced by such environmental parameters of surrounding seawater. In this study, we will measure density of individual carbonate shells by using MXCT and elucidate whether carbonate chemistry including pH decreasing is the most influenced environmental factors to determine shell density of planktic foraminifera.

The vertical profiles of phytoplankton pigments and DNA may provide information on the phytoplankton group responsible for the particle export from the euphotic zone intos the deep sea.

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