Final Report
of
The R/V HAKUHO MARU Cruise
KH-17-3 (KH-17-Obata)
--- Camelopardalis Expedition ---

June 23 to August 9, 2017

Biogeochemistry of Trace Elements and Their Isotopes in the subarctic North Pacific Ocean and the Gulf of Alaska (GEOTRACES GP-02 line included)

Atmosphere and Ocean Research Institute
The University of Tokyo
2017

by
The Scientific Members of the Expedition
Edited by
Hajime OBATA

Contents

1. Introduction

The R/V HAKUHO MARU KH-17-3 cruise, consisted of the following two legs, were conducted from 23 June to 9 August 2017 (48 days in total) in the northern North (subarctic) Pacific Ocean and the Gulf of Alaska. We nickname this cruise "Camelopardalis (CL) Expedition".

Leg-1: Tokyo, Japan (23 June 2017) to Kodiak, USA (15 July 2017)

Leg-2: Kodiak, USA (18 August 2017) to Vancouver, Canada (09 August 2017)

This cruise has been internationally authorized as the GEOTRACES section study in the subarctic Pacific Ocean (GP02). GEOTRACES is a cutting edge of global marine geochemical studies, started in 2006 as one of the large-scale international programs sponsored by SCOR (Scientific Committee on Oceanic Research). GEOTRACES means an international study of the marine biogeochemical cycles of trace elements and their isotopes (TEIs) with a global point of view. Scientists from approximately 35 nations have been involved in the programme, which is designed to study all major ocean basins.

Recently, we have realized that the information on TEIs in the ocean is useful to deepen our understandings on physical, chemical and biological processes in marine environments. To predict future environmental changes caused by human activities, we also need to investigate the global distributions of biologically available chemical species of TEIs in the ocean and their exchange fluxes at the air-sea and sediment-water interfaces. This is particularly important in the case of micronutrients such as Fe, Zn and Cu whose oceanic distributions seem to be a crucial link to climatic processes. Together with other biologically required TEIs, perturbations of their cycles may have fundamental consequences for the global carbon cycle, which is firmly associated with global climate. However, accumulated high-quality data are not large enough to draw a global picture of marine biogeochemical cycles of TEIs. Recent advances on precise analytical instruments and clean sampling techniques have just enabled us to get more information on TEIs in the ocean. These progresses are the powerful background to pursue a new international program, GEOTRACES.

This cruise aimed at establishing the 2-dimensional profiles of GEOTRACES TEIs in the subarctic Pacific, in order to advance ocean sciences on TEIs as mentioned above. The northern North Pacific is known as a typical High Nutrient, Low Chlorophyll (HNLC) zone. Some radioisotopes were partially released to this oceanic area with the accident at Fukushima nuclear power plant on March 11, 2011. In this important area, we had conducted a similar cruise by R/V HAKUHO MARU (KH-12-4) in 2012 for the zonal line along 47°N (GP02), and finished the line observations in the western and central subarctic Pacific. Unfortunately, however, we could not finish the zonal line in eastern subarctic Pacific because of stormy weather condition. During this cruise, we completed the zonal line observations along 47°N (GP02), especially in the eastern subarctic Pacific. Since we revisited the several stations in the western subarctic Pacific stations overlapping the previous stations during KH-12-4 cruise, it may be interesting to compare the data obtained this time with those in the past, revealing temporal changes in various physical, chemical and biological parameters in the western Pacific. One more important target of the cruise is to study the present and past status of TEIs in seawaters of the Gulf of Alaska, which is also a typical HNLC area. We set 2-dimensional section observations along 145°W to investigate TEIs in seawaters and sediments of Gulf of Alaska. It will be interesting to compare biogeochemical cycles of TEIs in the western subarctic Pacific with those in the Gulf of Alaska.

In order to pursue these purposes, we have taken air, seawater, and sediment samples for chemical analyses. Water samples were collected from surface to near the bottom by using a clean CTD Carousel Multi Sampling system (24 Niskin-X (12L) bottles) attached at the end of a Vectran-armored cable. The system was also equipped with various chemical sensors for *in situ* measurements. For the precise measurements of trace radioactive nuclides in seawater, large-volume water samplers with a volume of 250 L were also used for seawater sampling. Bottom sediment was taken with a multiple corer and a piston corer. Suspended particles were taken using an *in situ* filtering system. Chemical analyses on board the ship as well as those on shore-based laboratories were and will be carried out in clean conditions for trace elements such as Fe, Cu, Zn, Mn, Cd, Co, Pt, rare earth elements together with natural and anthropogenic radionuclides. In addition, we occupied two stations (47°N, 152°W) and (50°N, 145°W) for inter-comparison with the data obtained by the US GEOTRACES cruise and Canadian time-series observations.

Forty-two scientists, technicians, and students were on board to pursue international collaborative studies on GEOTRACES. We hope that the obtained data by this cruise will play an important role in the GEOTRACES program as zonal line data in the subarctic Pacific Ocean.

This cruise passed through the Exclusively Economic Zones (EEZs) of USA. We are thankful to the kind permission from the Governments of USA, which is indispensable to conduct the cruise successfully.

It is our great pleasure to thank Captain Kazuhiko Kasuga, the officers and crew of R/V HAKUHO MARU for their invaluable collaboration in the successful conduct of all shipboard works. Sincere thanks are also due to Office for Cruise Coordination of Atmosphere and Ocean Research Institute, the University of Tokyo, and Department of Ship Operation of Japan Agency for Marine-Earth Science and Technology (JAMSTEC) for their great efforts to support the cruise. This cruise was partly supported by the Grant-in-Aid for Scientific Research (A) (No. 16H02701) and Grants-in-Aid for Scientific Research in Innovative Areas “Ocean Mixing Processes” (No. JPH05820) from Monkasho (Ministry of Education, Culture, Sports, Science and Technology: MEXT).

Hajime Obata (Chief Scientist)
and the Shipboard Scientific Party

2. Caution about the cruise data

2.1. General rules

Data in this preliminary report should be treated as carefully as possible, in order to protect the priority of the participants of the KH-17-3 cruise.

Confidential and publication policies are as follows, mainly according to the data policy provided by the Steering Committee on Cooperative Studies using research vessels R/V HAKUHO MARU and R/V SHINSEI MARU:

(1) No one other than the cruise participants can submit papers or give oral presentations using any data in this report within two years after the end of the cruise.

(2) Although all data included in this report is common to the cruise participants, primary investigators of each study item have higher priority to use them.

(3) Any information on the release of the cruise data (oral presentations, publications of papers, etc.) by the cruise participants should be sent to the chief scientists and the Office for Cruise Coordination of Atmosphere and Ocean Research Institute, the University of Tokyo.

(4) Any questions or problems on the publication policy should be forwarded to the chief scientists.

There may be some misprints or mistakes to be corrected later in this report. If any misprint or mistake is found, kindly inform the chief scientists, who are responsible for distributing the correct data to the cruise participating GEOTRACERS.

2.2. GEOTRACES Data Policy (from http://www.bodc.ac.uk/geotraces/data/policy/)

GEOTRACES seeks, on the one hand, protection of the intellectual effort and time of originating investigators (those who plan an experiment, collect, calibrate, and process a data set to answer some questions about the ocean), and on the other hand, the need to compare various data sets and data types to check their consistency, to better understand the ocean processes involved, and to see how well the numerical models describe the real ocean. We stress that data will not be released within the proprietary period (see below) without the permission of the originator.

Data/Metadata Submission (timeline):

- As soon as a cruise is organised: Precruise metadata to be submitted to GEOTRACES IPO and GDAC.
- Within one week of cruise completion:

  Submit Postcruise metadata forms from chief scientist

Submit electronic versions (scanned or original) of event log and log sheets

Submit copy of ROSCOP/CSR form where one is required by ship operator

- Within 6 months of end of cruise:

  Chief scientist submits cruise report, where one is required by ship operator.

  Data and metadata for shared ancillary parameters (e.g., nutrients) submitted to DAC*.

  Submit CTD and underway data (both raw and processed files; sensor information and calibration) to national DAC (e.g., BCO-DMO) and BODC.

- As soon as possible, after the proprietary period (see below):

  Submit all data sets and accompanying metadata to DAC*

(*DAC: In most cases, data will be submitted initially to a national data centre (DAC). Where no national DAC is available, information should be submitted directly to the GDAC at BODC. In case of Japan, JODC plays a role as DAC.)

Data Access (timeline):

- Precruise metadata will be publicly accessible (GDAC web site) as soon as it is available
- Any metadata and data produced during the cruise/process study should be made available to participating scientists immediately in preliminary form during the cruise/process study.
- Any data generated from a cruise and submitted to the DAC will be password protected and available only to registered users (data originators and their designated collaborators) until the public release date.

Prior to public release, all data will be considered preliminary. Data should be shared with other cruise/process study participants as soon as they become available during or after a cruise or process study, to enable data synthesis to proceed rapidly, with the understanding that the data are the proprietary material of the originating scientist and may not be used without their permission. However, for non-participating scientists the data can be obtained only with the permission of the responsible participating scientist.

Proprietary period

Most nations have rules about data release that are imposed by funding agencies. GEOTRACES will adhere to these rules. In addition, we expect that all data will be released within two years of data generation, or at the time of publication (whichever is sooner). Exceptions are possible in the case of data forming a part of a student's thesis.

Adherence to this data policy is expected of all scientists participating in national and international GEOTRACES activities. Exceptions to this GEOTRACES policy may be allowed; e.g., where the policy is overridden by national constraints on data access.

3. Participant lists

3. 1. Scientist list

KH-17-3: List of on board scientists

	Family name	Given name	Affiliation	Leg-1	Leg-2
1	OBATA	Hajime	Univ. Tokyo	◎	◎
2	SEIKE	Koji	Univ. Tokyo		○
3	KIM	Taejin	Univ. Tokyo	○	○
4	HARA	Takuya	Univ. Tokyo	○	○
5	KOBAYASHI	Genki	Univ. Tokyo	○	
6	ESCOBAR	Teresa Lumantas	Univ. Tokyo	○	
7	LIAO	Wen-Hsuan	Univ. Tokyo	○	○
8	NAGASAWA	Maki	Univ. Tokyo	○	○
9	TODA	Ryoji	Univ. Tokyo	○	○
10	TAKEUCHI	Makoto	Univ. Tokyo	○	
11	NISHIOKA	Jun	Hokkaido Univ.	○	○
12	BAMBA	Rise	Hokkaido Univ.	○	○
13	MINAMI	Hideki	Tokai Univ.		○
14	NEJIGAKI	Katsuya	Tokai Univ.		○
15	TAZOE	Hirofumi	Hirosaki Univ.	○	○
16	NORISUYE	Kazuhiro	Niigata Univ.	○	○
17	MATSUBARA	Yuna	Niigata Univ.	○	○
18	MARUYAMA	Kai	Niigata Univ.	○	
19	HORIKAWA	Keiji	Univ. Toyama		○
20	KURISU	Minako	Univ. Tokyo	○	○
21	HORII	Sachiko	Univ. Tokyo	○	○
22	SHITASHIMA	Kiminori	Tokyo Univ. Mar. Sci. & Technol.		○
23	NAGAI	Hisao	Nihon Univ.	○	
24	YAMAGATA	Takeyasu	Nihon Univ.		○
25	GOUDO	Erika	Nihon Univ.	○	
26	DOI	Toshihiro	Meiji Univ.	○	○
27	MASHIO	Asami	Univ. Shizuoka	○	○
28	TAKANO	Shotaro	Kyoto Univ.		○
29	ZHENG	Linjie	Kyoto Univ.	○	
30	TSUJISAKA	Makoto	Kyoto Univ.	○	
31	TANAKA	Yuriko	Kyoto Univ.		○
32	FUKUDA	Yuki	Kinki Univ.	○	○
33	TSUJI	Naoki	Kinki Univ.	○	○
34	MURAYAMA	Masafumi	Kochi Univ.		○
35	KAWATA	Kosei	Kochi Univ.		○
36	KONDO	Yoshiko	Nagasaki Univ.	○	○
37	KUMAMOTO	Yuichiro	JAMSTEC	○	○
38	TAKEUCHI	Akinori	National Inst. Environmental Studies	○	○
39	SAKATA	Kohei	National Inst. Environmental Studies	○	○
40	MARUMOTO	Koji	National Inst. Minamata Disease	○	○
41	YOKOGAWA	Shinichiro	Marine Works Japan Ltd.	○	
42	ARII	Yasuhiro	Marine Works Japan Ltd.		○
43				31	33

◎Chief Scientist

3.2. Sharing of the shipboard works

Leg. 1

Groups for Sampling

1) CTD-CMS

1-1. Routine sampling: A. Takeuchi*, K. Marumoto, S. Horii, M.T.L. Escobar, W.H. Liao, Y. Fukuda, N. Tsuji, T. Doi, (A.S. Mashio)

1-2. Clean sampling:

A: Y. Kondo*, M. Tsujisaka, M. Kurisu, Y. Matsubara

B: K. Norisuye, T. Kim, L. Zheng, A.S. Mashio

C: J. Nishioka, K. Maruyama, R. Bamba

2) Large volume sampling: H. Nagai*, H. Tazoe, Y. Kumamoto, K. Sakata, T. Hara, E. Goudo

3) Muliple-Corer sampling: G. Kobayashi*, A. Takeuchi, K. Marumoto, H. Nagai, E. Goudo

4) In-situ Pumping: J. Nishioka*, R. Bamba

5) Clean Ti-wire hydrocast: J. Nishioka*, K. Norisuye, T. Kim, Y. Kondo, M. Tsujisaka, L. Zheng

6) Norpac Net: K. Marumoto*, S. Horii, A. Takeuchi

Groups for Routine Analyses

1) Salinity: H. Tazoe*, H. Nagai, A. Takeuchi, K. Marumoto, T. Doi

2) Dissolved Oxygen: Y. Kumamoto*, T. Kim, G. Kobayashi, M.T.L. Escobar, L. Zheng, M. Tsujisaka, E. Goudo

3) Nutrients: S. Yokogawa*, Y. Fukuda, N. Tsuji

4) Chlorophyll a.: Y. Kondo*, S. Horii, J. Nishioka, A.S. Mashio

5) pH & Alkalinity: K. Sakata*, T. Hara, M. Kurisu, W.H. Liao, R. Bamba, Y. Matsubara, K. Maruyama

6) SPM (Suspended Particulate Matter): K. Norisue*, K. Maruyama, Y. Matsubara, W.H. Liao, M. Kurisu, R. Bamba

*: Leader

Leg. 2

Groups for Sampling

1) CTD-CMS

1-1. Routine sampling: K. Shitashima*, A. Takeuchi, K. Marumoto, S. Horii, W.H. Liao, Y. Fukuda, N. Tsuji, T. Doi

1-2. Clean sampling:

A: Y. Kondo*, T. Kim, M. Kurisu, Y. Matsubara

B: K. Norisuye, S. Takano, Y. Tanaka

C: J. Nishioka, A.S. Mashio, R. Bamba

2) Large volume sampling: H. Tazoe*, Y. Kumamoto, T. Yamagata, K. Sakata, T. Hara, K. Nejigaki

3) Corer sampling: K. Horikawa*, M. Murayama, H. Minami, K. Seike, K. Nejigaki, K. Kawata

4) In-situ Pumping: J. Nishioka*, R. Bamba

5) Clean Ti-wire hydrocast: J. Nishioka*, K. Norisuye, T. Kim, Y. Kondo, S. Takano, Y. Tanaka

6) Norpac Net: K. Marumoto*, S. Horii, A. Takeuchi

Groups for Routine Analyses

1) Salinity: H. Tazoe*, A. Takeuchi, K. Marumoto, T. Doi, M. Murayama, T. Yamagata

2) Dissolved Oxygen: Y. Kumamoto*, T. Kim, K. Horikawa, K. Seike, S. Takano, K. Nejigaki, K. Kawata

3) Nutrients: Y. Arii*, Y. Fukuda, N. Tsuji

4) Chlorophyll a.: Y. Kondo*, S. Horii, J. Nishioka, A.S. Mashio

5) pH & Alkalinity: K. Sakata*, K. Shitashima, T. Hara, M. Kurisu, W.H. Liao, R. Bamba, Y. Matsubara, Y. Tanaka

6) SPM (Suspended Particulate Matter): K. Norisue*, Y. Matsubara, H. Minami, K. Nejigaki, W.H. Liao, M. Kurisu, R. Bamba

*: Leader

3.3. Crew list

No.	Family Name	Given Name	Ranking
1	KASUGA	Kazuhiko	Captain
2	SAKAI	Naoto	Chief Officer
3	KIYOMIYA	Tomonori	First Officer
4	NAKAMURA	Tetsuro	Second Officer
5	TAKATA	Saito	J. Second Officer
6	SHIBATA	Haruhiro	Third Officer
7	TAKASE	Shuhei	J. Third Officer
11	FUNATSU	Hironori	Chief Engineer
12	YAMANE	Tsukasa	First Engineer
13	MIKAMI	Ryuzo	Jr. First Engineer
14	SAKUMA	Yasuhiro	Second Engineer
15	SHIRAKATA	Kenichi	J. Second Engineer
16	SAKAMOTO	Shota	Third Engineer
21	YAMAMOTO	Yohei	Chief Electronics Officer
22	YAMAGUCHI	Takumi	Electronics Operator
24	URABE	Tsuyoshi	Boatswain
25	KAWANA	Yukio	Associate Boatswain
26	TERASAKA	Yukihiro	Associate Boatswain
27	YAMAZAKI	Myuta	Associate Boatswain
32	KATO	Naoki	Quarter Master
33	NAKATA	Hideaki	Quarter Master
33	ASAKUNI	Tomoki	Quarter Master
34	KIKUCHI	Kazuki	Sailor
35	ISHII	Yoshihiko	No.1 Oiler
36	YOSHIDA	Minoru	No.2 Oiler
38	YAMANAKA	Takahiro	No.3 Oiler
40	ABE	Yu	No.4 Oiler
41	TANIGUCHI	Keiya	No.5 Oiler
43	TAKAMIYA	Aoi	No.6 Oiler
44	KAI	Keishiro	No.7 Oiler
46	IIBOSHI	Shogo	Machineman
47	YAMADA	Yasutaka	Chief Steward
48	HAYASHI	Takumi	Associate Steward
50	OKAMURA	Shinya	Steward
51	SASAKI	Keigo	Steward
52	HIDAKA	Yoshie	Steward

4. Observation stations

4.1. List of KH-17-3 stations (Camelopardalis Expedition)

LEG	Station No.	Latitude*	Longitude*	Depth*	CTD-CMS	Separate Niskin	Large Volume	Multiple corer	Norpac Net	Piston corer	In situ	In-situ	Argo float	Free fall	EEZ*****	Remarks
				(m)	Clean winch	No.3 winch	No.1 winch	No.1 winch	No.3 winch	No.1 winch	Filtration	Light		Clean winch		
											No.3 winch	No.3 winch				
1	CL-1	41°00'N	150°00'E	5250	○		○	○	○			○				KH-12-4 BD-5
1	CL-2	47°03'N	160°00'E	5210	○		○	○	○		○	○				KH-12-4 BD-7, K2
1	CL-3	47°00'N	170°00'E	4960	○		○	○	○			○				KH-12-4 BD-9
1	CL-4	47°00'N	175°00'E	5768	○		○	○	○			○				
1	CL-5	47°00'N	170°00'W	5526	○		○	○	○			○				KH-12-4 BD-14
1	CL-6	47°00'N	165°00'W	5341	○		○	○	○			○	○**			
1	CL-7	47°00'N	160°00'W	5168	○		○	○	○			○	○***			
1	CL-8	47°00'N	155°00'W	5227	○		○	○	○			○	○****			
1	CL-9	47°00'N	152°00'W	5138	○	○	○	○	○			○				GEOTRACES Crossover Station
1	CL-10	47°00'N	150°00'W	5156	○		○	○	○			○		○		
2	CL-11	57°30'N	145°00'W	3846	○		○	○	○						USA	
2	CL-12	58°46.6'N	144°29.5'W	3679	○		○	○	○	○					USA	
2	CL-13	59°19'N	144°24'W	2400	○			○	○	○					USA	
2	CL-14	59°33.3'N	144°9.2'W	682	○		○	○	○	○					USA	
2	CL-15	55°00'N	145°00'W	4049	○		○	○	○			○				
2	CL-16	50°00'N	145°00'W	4270	○	○	○	○	○		○	○				Station Papa
2	CL-17	47°00'N	145°00'W	4700	○		○	○	○			○				
2	CL-18	44°00'N	145°00'W	4742	○		○	○	○			○				
2	CL-19	47°00'N	140°00'W	4323	○		○	○	○			○				
2	CL-20	47°00'N	135°00'W	3679	○		○	○	○			○				
2	CL-20P	47°00'N	134°52'W	3998				○		○						
2	CL-21	47°00'N	131°00'W	3100	○		○	○	○			○		○		

*These are approximate values. See chapters 5 and 7 for exact values.

**Released at 47°N, 161°W

***Released at 47°N, 158°W

****Deep Nnja was released.

*****EEZ: Exclusive Economic Zone


70°N
60°N
50°N
40°N
30°N
140°E
160°E
180°
160°W
140°W
120°W
Tokyo
Kodiak
Vancouver
CL-1
CL-2
CL-3
CL-4
CL-5
CL-6
CL-7
CL-8
CL-9
CL-10
CL-11
CL-12
CL-13
CL-14
CL-15
CL-16
CL-17
CL-18
CL-19
CL-20
CL-21


70°N
60°N
50°N
40°N
30°N
140°E
160°E
180°
160°W
140°W
120°W

5. Event log

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
23-Jun	Daiba																							
24-Jun																								
25-Jun											CL-1, CTD				LTD	LV			NET	CTD	NET	MULTI		
26-Jun	MULTI																							
27-Jun																		CL-2	CTD			LV		
28-Jun	CTD			In-situ filtration			NET	CTD		NET, LV				CTD		LV		CTD	LV				CTD	
29-Jun	MULTI			CTD																				
30-Jun										CL-3	LTD	CTD (Trouble)			NET	LV		CTD (Trouble)		LV		MULTI		
1-Jul	MULTI		CTD						CTD			CTD	CTD											
2-Jul				CL-4, CTD					LV			LTD, CTD			NET	LV				CTD		LV		
3-Jul	LV	CTD	LV			CTD			CTD	MULTI				CTD										
3-Jul	Date of July 3rd repeated				Passed date line																			
4-Jul								CL-5	CTD			LTD	LV		NET	CTD			LV				CTD	
5-Jul	LV		CTD		LV		CTD, MULTI				CTD	CTD												
6-Jul				CL-6, CTD				LV			LTD, CTD		NET	LV		CTD, MULTI				CTD				
7-Jul												CL-7, CTD				LTD, LV			NET	CTD				LV
8-Jul	LV			CTD	LV			CTD	LV		CTD	MULTI				CTD	CTD							
9-Jul									CL-8, CTD				LV			LTD, CTD		NET	LV		CTD, MULTI			
10-Jul	CTD									CL-9, CTD		LTD, LV			CTD	NET	Ti-wire		CTD		LV			
11-Jul	CTD			LV			CTD			LV		CTD			CTD	MULTI			CTD	CTD				
12-Jul			CL-10, MULTI				CTD			LV				CTD	NET	CTD		Free Fall						
13-Jul																								
14-Jul																								
15-Jul											Kodiak													

CTD	CTD-CMS
LV	Large Volume Sampling
MULTI	Multiple Corer
NET	Norpac Net
LTD	Compact LTD
Ti-wire	Niskin sampling with Ti-wire
PISTON	Piston Corer

5. Event log

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
18-Jul	Kodiak																							
19-Jul													CL-11 MULTI			LV	CTD			LV		CTD	NET	LV
20-Jul	LV													CL-14 LV					MULTI					CL-13 Survey
21-Jul	Survey	CL-14	CTD	LV			CTD	NET	MULTI		CTD	CL-13	MULTI		PISTON				CL-12 PISTON		CL-13	CTD		NET
22-Jul	CTD			CL-12	CTD			NET		CTD	PISTON						CL-13 PISTON							
23-Jul													CL-15	CTD						LV			NET	CTD
24-Jul	CTD	LV			CTD		LV	CTD	LV		CTD	LTD	MULTI		CTD									
25-Jul												CL-16	LTD CTD			LV			LTD	NET	CTD		In-situ filtration	
26-Jul	In-situ filtration Pump sampling	CTD	LV			CTD	LV			CTD	LV		Ti-wire		CTD	MULTI								
27-Jul								CL-17 MULTI				CTD			LTD LV			NET	CTD			LV		
28-Jul	LV CTD		LV		CTD	LV		CTD	CTD												CL-18	LTD CTD		
29-Jul	CTD	LV	CTD	NET	LV		CTD	MULTI																
30-Jul						CL-19 CTD			LV			LTD	CTD		LV			NET	CTD	LV		CTD	LV	CTD
31-Jul	CTD	MULTI																CL-20	Survey					
1-Aug	CTD		LV		NET	CTD	LV		LTD	CTD	MULTI				PISTON			MULTI						
2-Aug								CL-21	CTD		LTD	LV		CTD		LV		CTD	LV	NET	CTD	CTD	MULTI	
3-Aug	MULTI	Free Fall																						
4-Aug																								
5-Aug																								
6-Aug																								
7-Aug																Vancouver								

CTD	CTD-CMS
LV	Large Volume Sampling
MULTI	Multiple Corer
NET	Norpac Net
LTD	Compact LTD
Ti-wire	Niskin sampling with Ti-wire
PISTON	Piston Corer

6. Explanatory notes

6.1. Research Vessel HAKUHO-MARU

The RV HAKUHO-MARU (Japan Agency for Marine-Earth Science and Technology (JAMSTEC)) is equipped with the most up-to-date facilities for various researches in physical oceanography, chemical oceanography, marine biology, marine geology and geophysics, and fisheries, as well as the deck machinery for handling large observational tools and sampling gears. Main winches are housed under the working deck. The propulsion is dual with Diesel CPP and electric motor drives, which enables a cruising speed of ~15 knot and precise maneuvering with use of bow and stern thrusters. Particulars of the RV HAKUHO-MARU as of her completion were as follows:

Keel laid	8-May-84	Research equipment
Launching	27-Oct-84	7 Winches (swell compensator for Nos. 1 & 2 Winches)
Completion	30-Apr-85	No.1 Winch: 14f x15,000 m
Length (overall)	100.00 m	No.2 Winch: 8.15f x7,000 m (Armoured)
Length (p.p.)	90.00 m	No.3 Winch: 6.4f x12,000 m (Titanium)
Breadth (molded)	16.20 m	No.4, 5, 7, 8 Winches
Depth (molded)	8.90 m	10 Laboratories
Gross tonnage (JG)	3,987 T	No.1 & 3: Dry lab., No.2: RI lab., No.7: Wet lab.
Propulsion system	diesel/electric-motor driven	No.4: Clean room, No.5 & 6: Semi-dry lab.
Main engine	1,900 ps x 4 sets	No.10: Cold lab, etc.
Prop. Generator	1,085 kw x 2 sets	11 ton gantry
Twin propellers, twin rudders		11 ton bean crane & 3 ton deck crane
Main generator	715 KVA x 3 sets	Instruments
Bow thruster	4.2 T x 2 sets	Seabeam, Subbottom profiler,
Stern thruster	6.8T x 1 set	Oceanfloor imaging system,
Cruising speed	16.0 kn	Air gun compressor,
Endurance	12,000 n.m.	Marine meteorological observation system,
Complement	89 (include. sci. 35)	Acoustic biomass investigation system,
Builder		Meteorological satellite receiving system,
Shimonoseki Shipyard & Engine Works		CTD/DO, Precise gyrocompass,
Mitsubishi Heavy Industries, Ltd.		Data processing system, etc.

6.2. Sampling technologies
6.2.1. Water sampling
6.2.1.1. CTD Carousel multi sampling (CTD-CMS)

The CTD-CMS (CTD-Carousel Multi Sampling System) used during the KH-17-3 cruise usually consisted of the following instruments.

1) CTD fishes (Seabird Electronics, Model SBE-9-plus), with the basic sensors for temperature (Seabird Electronics, Model SBE-3), conductivity (Seabird Electronics, Model SBE-4) and pressure (Paroscientific, Digiquartz Transducer)
2) Six optional sensors:
   - DO sensor (Seabird, SBE-43)
   - Turbidity meter (SeaPoint, Turbiditymeter)
   - Fluorometer (Seapoint, Chlorophyll Fluorometer)
   - Carousel sampling system (Seabird, SBE-32)
   - Altimeter (Teledyne Benthos, Model PSA-916T)
   - Touch sensor (bottom contact switch (P/N 90149.1))
3) Twenty-four Niskin-X bottles (General Oceanics, 12-liter type)

The CTD-CMS system, attached at the end of the Vectran armored cable (14 mm o.d.) from the Clean winch was controlled on board the ship by a CTD deck unit (Seabird, Model 11plus) connected with a WINDOWS desktop computer. CTD data were processed using the software "SBE Sea save (ver. 7.23.2)" for on-line observation and "SBE Data Processing (ver. 7.23.2)" for off-line data calculation and analysis (Sea-bird Electronics, Inc.).

The Carousel array frame has a capability to hold 24 Niskin-X bottles with a volume of 12 liters. The altimeter was installed on the CTD-CMS system to monitor the distance above the sea bottom. The deepest sample was usually taken at a depth of ~10 meters above the bottom. Water samples were taken by triggering the Niskin-X bottles at appropriate depths while the system was coming up to the surface.

In order to reduce the contamination level as low as possible, Niskin-X bottles were cleaned before the cruise, by filling the bottles with 1 % Extran MA01 (1 day), 0.1M HCl (pH=1, 1day), and Milli-Q water (more than 2 days), successively. Teflon spigots were pre-washed by soaking in 1% of Extran MA02 (1 day) and 1M HCl(1 day), and cleaned by heating in conc.$HClO_4$:conc.H_2SO_4:conc.HNO_3=1:1:1 mixture (120ºC, 3 hrs), 6M HCl (120ºC, 3 hrs), and Milli-Q water (100ºC, 3 hrs), successively. Viton O-rings were pre-washed by soaking in 1% of Extran MA02 (1 day) and 0.1M HCl (1 day), and cleaned by heating in 0.1M HCl (at 60°C, 12hrs), and Milli-Q water (at 68°C, 12 hrs).

All the zinc anodes on the Carousel frame (except for those on the CTD housings) were replaced by aluminum anodes, in order to avoid Zn contamination.

Collected samples were separately distributed to sub-samples for routine analyses of salinity, dissolved oxygen, pH, alkalinity, nutrients (Si, PO_4, NO_2, and NO_3), and chlorophyll-a as explained in section 6.3. In addition to these routine measurements, various chemical components were or will be measured on board the ship or in shorebased laboratories in charge. Their brief reports on objectives and methods are shown in the following chapters.

According to a GEOTRACES recommendation, sub-sampling for trace element analyses was done inside a clean space, called "BUBBLE", in the 7^{th} laboratory on board R/V Hakuho Maru. This space has a volume of about 10 m^3 (2500 x 2000 x 2000), into which clean air is introduced from outside through two HEPA filter units. Up to eight Niskin-X bottles can be hold vertically on wooden frames in the BUBBLE. Compressed clean air was provided from the top air vent of each Niskin-X bottle, in order to take filtrated seawater samples inside the BUBBLE. Filtration was done using "polyethersulfone membrane filters" (Acropak Filter (pore size: 0.2 μm)).

6.2.1.2. Hydrocasts using titanium wire of the No.3 winch

We took clean seawater samples by fixing Niskin-X bottles separately at proper intervals to the titanium wire of the No.3 winch of R/V Hakuho Maru to compare sampling method with CTD-CMS system. We used Teflon-coated messengers made of stainless steel to trip the bottles. Eight Niskin-X samplers were attached separately at appropriate intervals to the No.3 winch wire. TD meters (MDS Mark 5, Alec Electronics, and ATD-HR, Alec electronics) were attached to the bottles at depths 400 m and 1,000 m to know the correct sampling depths and water temperatures.

The sampling station and layers were as follows:
Station CL-9: 25, 50, 100, 200, 400, 600, 800, 1000 m
Station CL-16: 25, 50, 100, 200, 400, 600, 800, 1000 m

After sampling, the Niskin-X bottles for clean sampling were brought into the “Bubble”, and the seawater samples were filtered in a clean condition in a similar way as the CTD-CMS clean samples.

6. 2. 2. Large volume water sampling system

There is an increasing need for the collection of large volume seawater samples from all depths for the determination of radiogenic (Nd ICs), and cosmogenic (^{7}Be, ^{10}Be) isotopes and artificial radio-nuclides (Cs-134, Cs-137, I-129, U-236, Pu). During the KH17-3 Camelopardalis Cruise, large volume water sampling was carried out as follows.

Large volume (300 L) surface seawater samples were obtained from the underway sampler of *R.V. Hakuho-Maru* at every station. About 250 L of seawater from a range of depths, from 10 m deep down to 6000m, were collected using a large-volume water sampler. The specially constructed large-volume water sampler （model N12-1000, Nichiyu-Giken-Kohgyo Co. Ltd., Japan; Table 6. 2. 2. 1, Fig. 6. 2. 2. 1） was first used on the KH-96-5 cruise and is equipped with the following units: (i) four rigid-PVC (poly(vinyl chloride)) sampling tubes, each of which has a 250 ℓ nominal capacity and bears a RBRduo-TD-Ti sensor (RBR Ltd., < 6000 m depth), (ii) a motor-driven trigger unit for stepwise closure of sampling tube, (iii) an acoustic unit which feeds electric power to the motor-driven trigger unit on receiving an acoustic command from the ship and sends an acoustic signal back to the ship immediately after each sampling and (iv) a battery unit (24 V and 12 V). On sending an acoustic command from the ship to the sampler at the sampling depth, the acoustic unit of the sampler feeds electric power to the motor-driven trigger unit. On triggering with the motor, hinged lids, fitted with strong rubber springs and rubber gaskets, are snapped into place at each end of a sampling tube and the thermometer frame rotates. By repeating the operational procedure, four 250 L seawater samples per cast can be obtained.

Table 6. 2. 2. 1. Specification of the large-volume water sampler used in the KH-12-4 cruise.

Maximum permissible operating depth	7000 m	
Construction materials	・Frame:	stainless steel (SUS304) aluminium alloy (A7075-T6) titanium alloy (TITA 1)
	・Sampling tube:	rigid polyvinyl chloride (PVC) (482 mm i.d.)
Outer dimensions	1650 mm (W) × 1650 mm (D) × 2571 mm (H)	
Weight	715 kgf (in air), 538 kgf (in water)	
Sampling capacity	1,000 L (250 L / tube × 4 tubes)	
Mode of control	controlled by acoustic transmission	
Trigger	motor-driven trigger	
Electric power supply	24 V and 12 V from 24 of 1.5 V dry cell	

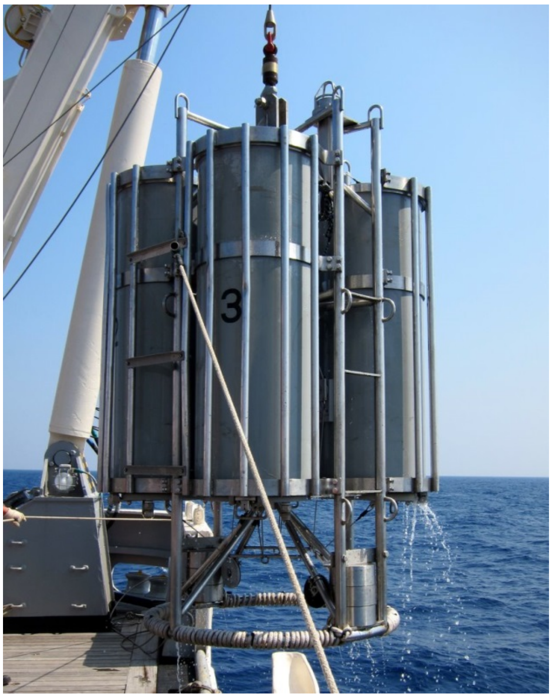

Fig. 6. 2. 2. 1. Photograph of the large-volume water sampler used in the KH-17-3 cruise.

Seawater samples were filtered with 0.5 μm-pore size wind-cartridge filter (Advantec, TCW-05N-PPS, 25 cm in length) on the ship deck and separated common samples (20L for deep water (>1000m depth) and 160 – 250L for shallow water) for analysis of Nd isotopic compositions ($^{143}Nd/^{144}Nd$), cosmogenic Be isotopes (^{7}Be and ^{10}Be) and specified samples for other artificial nuclides of $^{134, 137}Cs$ (40L), ^{129}I (1L), ^{236}U (5L), and Pu (20L). Samples for salinity (200 mL) and stable Be isotope, ^{9}Be (250 mL), and ^{238}U (50 mL) samples were also routinely collected.

Common samples for analysis of Nd ICs, and cosmogenic Be isotopes were transferred to 20L (S) or 200L (L, Fig. 6. 2. 2. 2) tanks by using a monoflex pump (Red and White). Flow rate ranged from 40 to 50 L/min. Dissolved Nd and Be isotopes were preconcentration by Fe-coprecipitation method on the deck. Filtered shallow water were acidified by 250 mL of conc. HCl (EL grade, Kanto chemicals) and added 2 mg of Be carrier and 3 g of Fe carrier. After isotope equilibrium (> 3 hr), 250 mL of conc. NH_4OH were added to pH>9. Settled Fe precipitates were collected and filtered out by the No. 2 qualitative filter paper (ϕ500 mm in diameter, Advantec) and dryness by IR-Rump in a clean bench.

Filtered deep water (expressed S or N in Table 6. 2. 2. 2) were acidified by 20 mL of conc. HCl (EL grade, Kanto chemicals) and added 0.5 mg of Be carrier and 0.5 g of Fe carrier. After isotope equilibrium (> 8 hr), 22 mL of conc. NH_4OH were added to pH > 9. Precipitates were collected to 1 L PP bottle using vacuum box system. After discard a supernatant, precipitates were transferred to 250 mL PP bottle. Then, samples were brought back to land based laboratory for further analysis.

Fig. 6. 2. 2. 2. Photograph of the large-volume (300 L) PVC tank

Table 6. 2. 2. 2. List of samples obtained by Large-Volumu sampling system

	Station No.																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Latitude	41.0	47.1	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	57.5	58.8	59.3	59.6	55.0	50.0	47.0	44.0	47.0	44.0	47.0
Longitude	150.1	160.0	170.0	175.0	190.0	195.0	200.0	205.0	208.0	210.0	215.0	215.5	215.7	215.9	215.0	215.0	215.0	215.0	220.0	225.0	229.0
Water depth/m	5253	5197	4969	5672	5514	5531	5163	5217	5138	5156	3846	3679	2400	682	4049	4270	4700	4742	4323	3679	3100
Sampling Depth /m																					
0*	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○
10		○	○	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○
20	○	○	○	○	○	○	○	○		○				○	○	○	○		○		○
40	○	○	○	○	○	○	○	○		○				○	○	○	○		○		○
60	○	○	○	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○
80	○	○	○	○	○	○	○	○		○					○	○	○		○		○
100	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○
150	○	○	○	○	○	○	○	○	○	○				○	○	○	○		○		○
200	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○
300	○	○	○	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○
400		○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○
500		○	○		○		○							○	○	○	○		○		○
600		○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○
800		○	○	○	○	○	○	○	○	○	○	○			○	○	○	○	○	○	○
1000		○	○	○	○	○	○	○	○	○	○	○			○	○	○	○	○	○	○
1250		○		○	○	○	○	○	○	○		○			○	○	○	○	○	○	○
1500		○	○	○	○	○	○	○	○	○	○	○			○	○	○	○	○	○	○
2000		○	○	○	○	○	○	○	○	○	○	○			○	○	○	○	○	○	○
2500		○		○	○		○		○						○	○	○		○		○
3000		○		○	○		○		○						○	○	○		○		○
3500		○		○	○		○		○						○	○	○		○		
4000		○		○	○		○		○						○	○	○		○		
4500		○		○	○		○		○								○				
5000		○		○	○		○		○												
5500				○																	
Bottom		○		○	○		○		○					○	○	○	○		○		○

*Seawater samples at depth of 0 m were obtained by underway sampler

6. 2. 3. Multiple and piston core sampling

Multiple-corer (AORI, 450 kg weight) was equipped with eight core tubes which are 60 cm long polycarbonate (9 cm diameter, see Fig. 6. 2. 3. 1). Core samples were preserved in Lab. 10 (4ºC) after recovery, and the sediment samples were sliced 0.5 cm or 1 cm thick throughout the core on board. The subsampled sediments were kept in Lab. 10 (4ºC) during the cruise. Some multiple cores were washed by a 200 µm mesh to collect benthos in the sediments, and one of multiple cores at each site will be cut into half to take a photograph and to conduct visual description of the sediments at Center for Advanced Marine Core Research, Kochi University.

The piston corer used in this cruise is composed of 900 kg weight and 10 m long aluminum pipes . After recovery of piston cores, we cut aluminum pipes into 1 m long on board, and stored them in Lab. 10 (about 4 °C) during the cruise. These samples will be transported to Center for Advanced Marine Core Research, Kochi University, and will be sampled for respective objectives (CT, MS, color, core scanner XRF etc). The coring sites at CL13PC and CL20PC were decided by surveying the sea floor topography using a 3.5 KHz sub-bottom profiler and a seabeam.

Fig. 6. 2. 3. 1. Photos of the mutiple-corer.

6. 3. Routine analysis

6. 3. 1. Salinity (Hirofumi Tazoe and Salinity group)

Salinity was measured with the Autosal (Model 8400B, Guildline Instruments Ltd., Canada) laboratory salinometer. Sampling bottles for salinity were prepared according to JGOFS protocols. The Autosal was standardized using the IAPSO standard seawater. To control air temperature, the measurement carried out in the 5th laboratory of Hakuho-Maru.

6. 3. 2. **Dissolved oxygen** (Yuichiro Kumamoto and DO-measurement Group)

Seawater samples for measurements of dissolved oxygen were collected in an oxygen bottle with volume of about 100 mL, avoiding contamination from air bubbles. Just after taking seawater sample, 1.0 mL of $MnCl_2$ solution and 1.0 mL of KI-NaOH solution were successively added into the bottle. This procedure fixes dissolved oxygen in seawater as $MnO(OH)_2$ precipitate. After standstill for several hours for settling down of the precipitate to the bottom of the bottle, 2 mL of 6N H_2SO_4 solution was added into the bottle to release I_2. Then I_2 was titrated by 0.02 mol/L sodium thiosulfate ($Na_2S_2O_3$) standard solution (WAKO Pure Chemical Industries, LTD., Cat. No. 191-05565, Lot PDG1535), employing an automatic titrator (DOT-15X; Kimoto Electric Co.). Sodium thiosulfate titrant was calibrated using 0.01 N potassium iodate (KIO_3) solution. Standard deviation of the measurement, which was derived from hundreds of replicate pair measurements, was calculated to be about 0.2 μmol/kg.

6. 3. 3. Nutrients (Sin-ichiro Yokogawa, Ysuhiro Arii and Nutrient Group)

Method

An aliquots of 10 cm^3 were used for analysis. Nutrient analysis was based on spectrophotometric determination.

Nitrate+nitrite (Nitrite): Nitrate is reduced quantitatively to nitrite by cadmium metal in the form of an open tubular cadmium reactor (OTCR). The sample system with its equivalent nitrite is treated with an acidic sulfanilamide reagent and the nitrite forms nitrous acid which reacts with the sulfanilamide to produce a diazonium ion. N-1-naphthylethylenediamine added to the sample system then couples with the diazonium ion to produce a red azo dye (absorbance maxima at 550 nm). With reduction of the nitrate to nitrite, both nitrate and nitrite react and are measured. Without reduction, only nitrite reacts. The nitrate concentration is calculated by subtracting the nitrite concentration from the summed nitrite and nitrate concentrations.

Phosphate: Phosphate reacts with molybdenum (VI) and antimony (III) in an acid medium to form a phosphoantimonylmolybdenum complex which is subsequently reduced by ascorbic acid to a heteropolyblue with an absorbance maximum at 880 nm.

Silicate: β-molybdosilicic acid is formed by the reaction of silicate with molybdeate at pH of 1 to 1.8. The β-molybdosilicic acid is reduced by tin(II) to form molybdenum blue with an absorbance maximum at 630 nm.

Apparatus

Nutirents are analyzed by an auto analyzer SWAAT (BLTEC Japan). All analytical data (nitrate, nitrite, phosphate and silicate) were corrected by using Certified Reference Material of nutrients in seawater (KANSO). KANSO CRMs (Lot: CE, CG, CF) were used to ensure the comparability and traceability of nutrient measurements during this cruise. These CRMs were stored at a room in the ship. The concentrations for CRM lots CE, CG, and CF are shown in Table 6.3.3.1

Table 6.3.3.1 Certified concentration and uncertainty (k=2) of CRMs.

Lot	Nitrate	Nitrite	Phosphate	Silicate
CE	0.01 ± 0.03	0.02 ± 0.01	0.012 ± 0.006	0.06 ± 0.09
CG	24.35 ± 0.21	0.06 ± 0.03	1.747 ± 0.021	57.95 ± 0.51

CF	44.60 ± 0.41	0.07 ± 0.02	3.145 ± 0.031	164.12 ± 1.03

unit: µmol L^{-1}

Quality control

Precision of nutrients analyses during this cruise was evaluated based on the 4 to 9 measurements, which are measured every 11 to 23 samples, during a run at the concentration of C-4 std. Summary of precisions are shown as Table 6.3.3.2.

Table 6.3.3.2 Summary of precision based on the replicate analyses

	Nitrate CV%	Nitrite CV%	Phosphate CV%	Silicate CV%
Median	0.08	0.11	0.17	0.12
Mean	0.09	0.11	0.17	0.12
Maximum	0.17	0.22	0.39	0.19
Minimum	0.00	0.00	0.06	0.06
N	14	14	14	14

Determination limit of nutrients analyses during this cruise was evaluated based on the 4 to 8 measurements, during a run at the low nutrients seawater. Summary of determination limit are shown as Table 6.3.3.3.

Table 6.3.3.3 Summary of determination limit based on the replicate analyses

	Nitrate	Nitrite	Phosphate	Silicate
Median	0.04	0.01	0.36	0.03
Mean	0.03	0.01	0.43	0.04
Maximum	0.07	0.03	0.87	0.12
Minimum	0.00	0.00	0.11	0.01
N	14	14	14	14

unit: µmol L^{-1}

6. 3. 4. pH and Total alkalinity (Kiminori Shitashima and pH & alkalinity group)

pH

Sub-samples for the pH measurement were aliquoted from 12L-Niskin X bottles, mounted on the CTD carousel, by transferring the collected seawaters into 100 mL dry plastic bottles after ~100% overflow of the samples with no air bubbles, in order to avoid any exchange of CO_2 with the atmosphere during the sub-sampling. The sample bottles were temporally stored in the 6th laboratory of R/V *Hakuho Maru* at room temperature. For the pH measurement, the sample was transferred to a specially designed glass cylindrical cell with overflow. The cell has a double structure, the inner ~20 mL space for sample seawater and a surrounding space where thermostated water (by using a constant temperature circulator THERMAX TN-1A (AS ONE Co. Ltd.)) is circulated to hold the temperature of the inner seawater sample at 25±0.1°C. Below the cell was a magnetic stirrer. The pH measurement was conducted using a PHM93 Reference pH Meter (Radiometer Copenhagen) within a day after sampling. A combined pH electrode (Radiometer, GK2401C) and a temperature sensor (Radiometer, T901) were tightly inserted into the inner space of the pH cell through two tapered joints. The pH measurement was therefore conducted in a completely closed environment with a constant temperature of 25±0.1°C.

Analysis time of each seawater sample is 10 minutes. Prior to analysis, the pH meter and the electrode were calibrated against two standards, pH=7.000 buffer solution (S11M004, Radiometer) and pH=4.005 buffer solution (S11M002, Radiometer) for IUPAC/NIST pH scale (NBS). Two buffer solutions: TRIS (Artificial Seawater (2-Amino-2-hydroxymethyl-1,3-propanediol), Lot. WDL9167, Wako pure chemical industries, 287-77321) and AMP (Artificial Seawater (2-Aminopyridine), Lot. WDL9168, Wako pure chemical industries, 284-77321) were used for calibration of seawater pH scale (SWS). In Wako pure chemical industries, the TRIS and AMP were prepared according to the manual (in SOP 6) described by Dickson and Goyet (1994). For the SWS, the e.m.f. values (mV) of the pH electrode were measured for the two buffers both at the beginning and the end of each series of measurements (usually 20 to 30 samples at each station). The e.m.f. values (mV) of the unknown seawater samples were converted to pH(X) values according to the equations in SOP 6 of the manual (Determination of the pH of sea water using a glass/reference electrode cell, August 30, 1996). The RSD of duplicate or triplicate analyses for surface seawater samples was less than 0.005.

Two pH values, NBS and SWS, are shown in the cruise report.

Total alkalinity (TA)

Sub-samples for the TA measurement were aliquoted from 12L-Niskin X bottles, mounted on the CTD carousel, by transferring the collected seawaters into 250 mL dry plastic bottles after ~100% overflow of the samples. The sample bottles were temporally stored in the 6th laboratory of R/V *Hakuho Maru* at room temperature. The volume-determined sample (50 mL) was transferred to a 100 mL glass beaker for open-cell titration. The beaker was putted in thermostated water bath (by using a constant temperature circulator THERMAX TN-1A (AS ONE Co. Ltd.)) to hold the temperature of the inner seawater sample at 25±0.1°C. Below the beaker was a magnetic stirrer. A Total Alkalinity titration analyzer ATT-05, Kimoto Electric Co. Ltd, was used for titration. A combined pH electrode (Radiometer, pHC3006-9), a temperature sensor (ATT-05) and a Teflon tube connected to a titrant were inserted in the beaker. The titrant was 0.1N HCl solution (Wako N/10 Hydrochloric Acid, 083-01115, Lot. WEL4206, Wako Pure Chemical Industries, Ltd.), and was also set in the thermostated water bath.

Analysis time of each seawater sample is about 10 minutes. The reference material (RM) for oceanic CO_2 measurements (Batch AP, bottled on Apr. 21, 2017) prepared by KANSO CO. Ltd. was used for calibration of samples. The TA value of the Batch AP was authorized using the international reference material for oceanic CO_2 measurements (Batch 160) prepared by Dr. A.G. Dickson of Scripps Institution of Oceanography. Bottom seawater collected at each station was used as the working standard, and five working standards were measured before each series of measurements for checking of the electrode stability. A duplicate RM was measured at the beginning and at the end of each sample measurement. The precision was estimated to be less than ±2 μmol/kg from replicate analyses of the working standard. The final TA values were corrected by using the authorized TA value of the reference material.

6. 3. 5. Chlorophyll *a* (Yoshiko Kondo and Chlorophyll-a group)

The fluorometric method was used for the quantitative analysis of chlorophyll *a*. Water samples (0–200 m depths) were collected from Niskin-X bottles into 280-ml amber polyethylene bottles. Samples (280 ml) were immediately filtered through 25 mm Whatman GF/F glass fiber filters maintaining vacuum levels of 0.02 MPa or less. Filters were placed in 13-mm glass cuvettes and extracted in 5.0 or 6.0 ml N, N-dimethylformamide. The samples are allowed to extract for over 24 hours in a freezer (-20ºC) under dark condition. Just before the anaysis, the samples were placed in dark room to put back to room temperature. Chlorophyll *a* concentration was measured by Turner Designs 10-AU field fluorometer with a chlorophyll optical kit for the non-acidification method (Welschmeyer, 1994, Limnology and Oceanography 39, 1985–1992). The concentrations of chlorophyll *a* in the sample ($\mu g\ l^{-1}$) were calculated from the reading using the calibration and scaling factors. The fluorometer was calibrated at the beginning of cruise with a commercially available chlorophyll *a* standard (from *Anacystis nidulans* algae, Sigma Chemical Co.). Serial dilutions were prepared and the linear calibration factors was calculated.

7. Sampling log

7. 1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL11**
Cast # : 1

Cast Type: CTD-CMS
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170719 19:17
Sampling End: 20170719 21:18

Watch: Kondo

CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrinets	Trace Metal	Archive	Speciation	15NO3	D-Fe	Nagasaki trace metal	Ligand	FDOM	SA-FeL	Fe IC	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	Se	Particle	Ba isotope	Total	Remark
						R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
											Meiji	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U	Toyama U		AORI	AORI	AORI	Toyama U	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U	Total	
											Noborio	Kumamoto (Uchida)	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Zhang	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kurisu	Norisuye/ Isshiki	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Fukuda	Daniel	Horikawa		
24	N	O2 min	12127	OK	CL1267	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
23	N	600	12080	OK	CL1266	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
22	N	800	12011	OK	CL1265	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
21	N	1000	12045	OK	CL1264	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
20	N	1250	12008	OK	CL1263	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
19	N	1500	12072	OK	CL1262	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
18	N	2000	12003	OK	CL1261	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
17	N	2500	12090	OK	CL1260	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
16	N	3000	12035	OK	CL1259	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
15	N	3500	12106	OK	CL1258	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
14	N	Bottom	12037	OK	CL1257	0.8	1.2	0.2	2.2			0.2		0.5	0.1		1.2	0.1																								6.5	
13	C	O2 min	12118	OK	CL1256														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3		3.0		11.8	
12	C	600	12159	OK	CL1255														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	11.0	
11	C	800	12156	OK	CL1254														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			10.6	
10	C	1000	12137	OK	CL1253														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	11.0	
9	C	1250	12128	OK	CL1252														0.2	0.7	0.7	0.7	0.3	0.2						0.2			1.2	1.2	0.3	0.3	0.3	0.3	0.4			7.0	
8	C	1500	12157	OK	CL1251														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			10.6	
7	C	1500	12114	OK	CL1250																																			3.0		3.0	
6	C	2000	12152	OK	CL1249														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	11.0	
5	C	2500	12105	OK	CL1248														0.2	0.7	0.7	0.7	0.3	0.2						0.2			1.2	1.2	0.3	0.3	0.3	0.3		3.0		9.6	
4	C	3000	12143	OK	CL1247														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.6	
3	C	3500	12151	OK	CL1246														0.2	0.7	0.7	0.7	0.3	0.2						0.2			1.2	1.2	0.3	0.3	0.3	0.3				6.6	
2	C	Bottom	12155	OK	CL1245														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			9.2	
1	C	Bottom	12149	OK	CL1244																																			3.0		3.0	

MEMO:
OK: no leak
L: leak
NC: not checked

7. 1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL11**
Cast # : **2**

Cast Type: CTD-CMS
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170719 22:27
Sampling End: 20170720 0:25

Watch: Kondo

						R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U	Toyama U		AORI	AORI	AORI	Toyama U	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U	Total	
											Noborio	Kumamoto (Uchida)	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Zhang	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kurisu	Norisuye/ Isshiki	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Fukuda	Daniel	Horikawa		
CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrinets	Trace Metal	Archive	Speciation	15NO3	D-Fe	Nagasaki trace metal	Ligand	FDOM	SA-FeL	Fe IC	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	Se	Particle	Ba isotope		Remark
		bucket			CL1292	0.8	1.2	0.2	1	0.6	0.8				0.1	3		0.1												0.15									0.4			8.4	
24	N	10	12127	OK	CL1291	0.8	1.2	0.2	1.0	0.6		0.2			0.1	3.0	1.2	0.1																								8.4	
23	N	25	12080	OK	CL1290	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																								4.2	
22	N	50	12011	OK	CL1289	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1	3.0		0.1																								8.0	
21	N	100	12045	OK	CL1288	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1	5.0		0.1																								10.0	
20	N	150	12008	OK	CL1287	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																								4.2	
19	N	200	12072	OK	CL1286	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1			0.1																								5.0	
18	N	200	12003	OK	CL1285											7.0																										7.0	
17	N	Chla max	12090	OK	CL1284	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																								4.2	
16	N	400	12035	OK	CL1283	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
15	C	10	12130	OK	CL1282														0.2	0.7	0.7	0.7	0.3	0.2					1.2	0.2	1.4	1.0	2.4		0.3	0.3	0.3	0.3	0.4		0.4	11.0	
14	C	10	12123	OK	CL1281																								12.0													12.0	
13	C	10	12118	OK	CL1280																																			3.0		3.0	
12	C	25	12159	OK	CL1279														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	12.0	
11	C	25	12156	NC	CL1278																																					0.0	
10	C	50	12137	OK	CL1277														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4			11.6	
9	C	100	12128	OK	CL1276														0.2	0.7	0.7	0.7	0.3	0.2									2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	9.6	
8	C	100	12157	OK	CL1275																									0.2	1.4	2.2								3.0		6.8	
7	C	150	12114	OK	CL1274														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4			11.6	
6	C	200	12152	OK	CL1273														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2									0.4	7.0	
5	C	200	12105	OK	CL1272																												2.4	2.4	0.3	0.3	0.3	0.3	0.4			6.4	
4	C	Chla max	12143	OK	CL1271														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2										5.2	
3	C	Chla max	12151	OK	CL1270																												2.4	2.4	0.3	0.3	0.3	0.3		3.0		9.0	
2	C	400	12155	OK	CL1269														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2							0.4			7.0	
1	C	400	12149	OK	CL1268																												2.4	2.4	0.3	0.3	0.3	0.3		3.0	0.4	9.4	

MEMO: OK: no leak
L: leak
NC: not checked

7.1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL12**
Cast # : **1**

Cast Type: CTD-CMS
Watch: Kondo
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170722 6:45
Sampling End: 20170722 8:28

CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrinets	Trace Metal	Archive	Speciation	15NO3	D-Fe	Nagasaki trace metal	Ligand	FDOM	SA-FeL	Fe IC	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	Se	Particle	Ba isotope	Total	Remark
						R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U	Toyama U		AORI	AORI	AORI	Toyama U	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U	Total	
											Noborio	Kumamoto (Uchida)	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Zhang	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kurisu	Norisuye/ Isshiki	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Fukuda	Daniel	Horikawa		
24	N	O2 min	12127	OK	CL1316	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
23	N	600	12080	OK	CL1315	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
22	N	800	12011	OK	CL1314	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
21	N	1000	12045	OK	CL1313	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
20	N	1250	12008	OK	CL1312	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
19	N	1500	12072	OK	CL1311	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
18	N	2000	12003	OK	CL1310	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
17	N	2500	12090	OK	CL1309	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
16	N	3000	12035	OK	CL1308	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
15	N	3500	12106	OK	CL1307	0.8	1.2	0.2	1.0			0.2			0.1			0.1																								3.6	
14	N	Bottom	12037	OK	CL1306	0.8	1.2	0.2	2.2			0.2		0.5	0.1		1.2	0.1																								6.5	
13	C	O2 min	12118	OK	CL1305														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3		3.0		11.8	
12	C	600	12159	OK	CL1304														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	11.0	
11	C	800	12156	OK	CL1303														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			10.6	
10	C	1000	12137	OK	CL1302														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	11.0	
9	C	1250	12128	OK	CL1301														0.2	0.7	0.7	0.7	0.3	0.2						0.2			1.2	1.2	0.3	0.3	0.3	0.3	0.4			7.0	
8	C	1500	12157	OK	CL1300														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			10.6	
7	C	1500	12114	OK	CL1299																																			3.0		3.0	
6	C	2000	12152	OK	CL1298														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	11.0	
5	C	2500	12105	OK	CL1297														0.2	0.7	0.7	0.7	0.3	0.2						0.2			1.2	1.2	0.3	0.3	0.3	0.3		3.0		9.6	
4	C	3000	12143	OK	CL1296														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.6	
3	C	3500	12151	OK	CL1295														0.2	0.7	0.7	0.7	0.3	0.2						0.2			1.2	1.2	0.3	0.3	0.3	0.3				6.6	
2	C	Bottom	12155	OK	CL1294														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.6	
1	C	Bottom	12149	OK	CL1293																																			3.0		3.0	

MEMO:
Bottle 10 and 11 attached jellyfish

OK: no leak
L: leak
NC: not checked

7.1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL12**
Cast # : **2**

Cast Type: CTD-CMS
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170722 10:12
Sampling End: 20170722 12:05

Watch: Kondo

						R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U	Toyama U		AORI	AORI	AORI	Toyama U	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U	Total	
											Noborio	Kumamoto (Uchida)	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Zhang	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kurisu	Norisuye/ Isshiki	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Fukuda	Daniel	Horikawa		
CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrinets	Trace Metal	Archive	Speciation	15NO3	D-Fe	Nagasaki trace metal	Ligand	FDOM	SA-FeL	Fe IC	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	Se	Particle	Ba isotope		Remark
		bucket			CL1341	0.8	1.2	0.2	1	0.6	0.8				0.1	3		0.1												0.15									0.4			8.4	
24	N	10	12127	OK	CL1340	0.8	1.2	0.2	1.0	0.6		0.2			0.1	3.0	1.2	0.1																								8.4	
23	N	25	12080	OK	CL1339	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																								4.2	
22	N	50	12011	OK	CL1338	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1	3.0		0.1																								8.0	
21	N	100	12045	OK	CL1337	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1	5.0		0.1																								10.0	
20	N	150	12008	OK	CL1336	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																								4.2	
19	N	200	12072	OK	CL1335	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1			0.1																								5.0	
18	N	200	12003	OK	CL1334											7.0																										7.0	
17	N	Chla max	12090	OK	CL1333	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																								4.2	
16	N	400	12035	OK	CL1332	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																								4.4	
15	C	10	12130	OK	CL1331														0.2	0.7	0.7	0.7	0.3	0.2						0.2	1.4	1.0	2.4		0.3	0.3	0.3	0.3	0.4		0.4	9.8	
14	C	10	12123	OK	CL1330																																			3.0		3.0	
13	C	25	12118	OK	CL1329														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	12.0	
12	C	25	12159	NC	CL1328																																					0.0	
11	C	50	12156	OK	CL1327														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4			11.6	
10	C	50	12137	NC	CL1326																																					0.0	
9	C	100	12128	OK	CL1325														0.2	0.7	0.7	0.7	0.3	0.2									2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	9.6	
8	C	100	12157	OK	CL1324																									0.2	1.4	2.2								3.0		6.8	
7	C	150	12114	OK	CL1323														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4			11.6	
6	C	200	12152	OK	CL1322															0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2										6.4	
5	C	200	12105	OK	CL1321														0.2														2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	7.0	
4	C	Chla max	12143	OK	CL1320														0.2	0.7	0.7	0.7	0.3	0.2						0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3				11.2	
3	C	Chla max	12151	OK	CL1319																																			3.0		3.0	
2	C	400	12155	OK	CL1318															0.7	0.7	0.7	0.3	0.2						0.2	1.4	2.2							0.4			6.8	
1	C	400	12149	OK	CL1317														0.2														2.4	2.4	0.3	0.3	0.3	0.3		3.0	0.4	9.6	

MEMO: OK: no leak
L: leak
NC: not checked

7.1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL13**
Cast # : **1**

Cast Type: CTD-CMS
Watch: Kondo
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170721 23:07
Sampling End: 20170722 0:27

						R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U.	Toyama U.		AORI	AORI	AORI	Toyama U	AORI	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U	Total	
											Noborio	Kumamoto (Uchida)	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Zhang	Obata	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kurisu	Norisuye/ Isshiki	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Fukuda	Daniel	Horikawa		
CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrinets	Trace Metal	Archive	Speciation	15NO3	Si isotopes	D-Fe	Nagasaki trace metal	Ligand	FDOM	SA-FeL	Fe IC	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	Se	Particle	Ba isotope		Remark
24	N	O2 min	12127	OK	CL1365	0.8	1.2	0.2	1.0			0.2			0.1			0.1																									3.6	
23	N	600	12080	OK	CL1364	0.8	1.2	0.2	1.0			0.2			0.1			0.1																									3.6	
22	N	800	12011	OK	CL1363	0.8	1.2	0.2	1.0			0.2			0.1			0.1																									3.6	
21	N	1000	12045	OK	CL1362	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																									4.4	
20	N	1250	12008	OK	CL1361	0.8	1.2	0.2	1.0			0.2			0.1			0.1																									3.6	
19	N	1500	12072	OK	CL1360	0.8	1.2	0.2	1.0			0.2			0.1			0.1																									3.6	
18	N	2000	12003	OK	CL1359	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																									4.4	
17	N	Bottom	12090	NC	CL1358																																						0.0	
16	N	Bottom	12035	NC	CL1357																																						0.0	
15	N	Bottom	12106	NC	CL1356																																						0.0	
14	N	Bottom	12037	OK	CL1355	0.8	1.2	0.2	1.0			0.2		0.5	0.1		1.2	0.1																									5.3	
13	C	O2 min	12118	OK	CL1354														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3		3.0		11.6	
12	C	O2 min	12159	NC	CL1353																																						0.0	
11	C	600	12156	OK	CL1352														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.4	
10	C	800	12137	OK	CL1351														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			9.0	
9	C	1000	12128	OK	CL1350														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.4	
8	C	1000	12157	NC	CL1349																																						0.0	
7	C	1250	12114	OK	CL1348														0.2	0.7	0.7	0.7	0.3	0.2										1.2	1.2	0.3	0.3	0.3	0.3	0.4			6.8	
6	C	1500	12152	OK	CL1347														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.4	
5	C	1500	12105	OK	CL1346																																				3.0		3.0	
4	C	2000	12143	OK	CL1345														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4		0.4	9.4	
3	C	2000	12151	NC	CL1344																																						0.0	
2	C	Bottom	12155	OK	CL1343														0.2	0.7	0.7	0.7	0.3	0.2									2.2	1.2	1.2	0.3	0.3	0.3	0.3	0.4			9.0	
1	C	Bottom	12149	OK	CL1342																																				3.0		3.0	

MEMO:
OK: no leak
L: leak
NC: not checked

7. 1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL13**
Cast # : **2**

Cast Type: CTD-CMS
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170722 1:34
Sampling End: 20170722 3:03

Watch: Kondo

CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrinets	Trace Metal	Archive	Speciation	15NO3	Si isotopes	D-Fe	Nagasaki trace metal	Ligand	FDOM	SA-FeL	Fe IC	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	Se	Particle	Ba isotope	Total	Remark
						R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		C		
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U.	Toyama U.		AORI	AORI	AORI	Toyama U	AORI	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U		
											Noborio	Kumamoto (Uchida)	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Zhang	Obata	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kurisu	Norisuye/ Isshiki	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Fukuda	Daniel	Horikawa		
		bucket			CL1390	0.8	1.2	0.2	1	0.6	0.8				0.1	3		0.1																						0.4			8.2	
24	N	10	12127	OK	CL1389	0.8	1.2	0.2	1.0	0.6		0.2			0.1	3.0	1.2	0.1																									8.4	
23	N	25	12080	OK	CL1388	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																									4.2	
22	N	50	12011	OK	CL1387	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1	3.0		0.1																									8.0	
21	N	100	12045	OK	CL1386	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1	5.0		0.1																									10.0	
20	N	150	12008	OK	CL1385	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																									4.2	
19	N	200	12072	OK	CL1384	0.8	1.2	0.2	1.0	0.6	0.8	0.2			0.1			0.1																									5.0	
18	N	200	12003	OK	CL1383											7.0																											7.0	
17	N	Chla max	12090	OK	CL1382	0.8	1.2	0.2	1.0	0.6		0.2			0.1			0.1																									4.2	
16	N	400	12035	OK	CL1381	0.8	1.2	0.2	1.0		0.8	0.2			0.1			0.1																									4.4	
15	C	10	12130	OK	CL1380														0.2	0.7	0.7	0.7	0.3	0.2									1.0	2.4		0.3	0.3	0.3	0.3	0.4		0.4	8.2	
14	C	10	12123	OK	CL1379																																				3.0		3.0	
13	C	25	12118	OK	CL1378														0.2	0.7	0.7	0.7	0.3	0.2									2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	11.8	
12	C	25	12159	NC	CL1377																																						0.0	
11	C	50	12156	OK	CL1376														0.2	0.7	0.7	0.7	0.3	0.2									2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4			11.4	
10	C	50	12137	NC	CL1375																																						0.0	
9	C	100	12128	OK	CL1374														0.2	0.7	0.7	0.7	0.3	0.2									2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	11.8	
8	C	100	12157	OK	CL1373																																				3.0		3.0	
7	C	150	12114	OK	CL1372														0.2	0.7	0.7	0.7	0.3	0.2									2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4			11.4	
6	C	200	12152	OK	CL1371														0.2	0.7	0.7	0.7	0.3										2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	11.6	
5	C	200	12105	NC	CL1370																																						0.0	
4	C	Chla max	12143	OK	CL1369														0.2	0.7	0.7	0.7	0.3	0.2									2.2	2.4	2.4	0.3	0.3	0.3	0.3				11.0	
3	C	Chla max	12151	OK	CL1368																																				3.0		3.0	
2	C	400	12155	OK	CL1367														0.2	0.7	0.7	0.7	0.3	0.2									2.2	2.4	2.4	0.3	0.3	0.3	0.3	0.4		0.4	11.8	
1	C	400	12149	OK	CL1366																																				3.0		3.0	

MEMO:
OK: no leak
L: leak
NC: not checked

7. 1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL14**
Cast # : **1**

Cast Type: CTD-CMS
Watch: Kondo
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170721 3:17
Sampling End: 20170721 4:47

						R	R	R	R	R	R	R	R	R	R	R	R	R	R	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U.	Toyama U.		AORI	AORI	AORI	Shizuoka	JAEA	Toyama	HU	HU	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo	NIIGATA Univ.	NIIGATA Univ.	NIIGATA Univ.	NIIGATA Univ.	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U	Total	
											Noborio	Kumamoto	Kumamoto	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa		Obata	Obata	Kim	Mashio	Okubo (Kim)	Zhang	Nishioka	Nishioka	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kondo	Kondo	Takeda/Kondo	Kurisu	Norisuye	Norisuye	Norisuye	Norisuye	Norisuye	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Tsujisaka	Fukuda	Daniel	Horikawa		
CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Tritium	Density	TCO2	14C	18O	POM	eDNA	18O	Nutrients	Trace Metal	Archive	Speciation	Pt	Th&Pa	15NO3	D-Fe	T-Fe	CDOM	Nagasaki trace metal	Ligand	FDOM	OnBoard FeL	SA-FeL	TAC-FeL	Filtered SW for Analysis	Fe IC	Unfilt: SS	Unfilt: SPM	Bi	Pb isotopes	Cr	REE (Tazoe, Hara)	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	W	Se	SPM	Ba isotope		Remark
24	N	400	12127	OK	CL1414	0.8	1.2	0.2	1.0		0.8		0.2			0.1		1.2	0.1																																				5.6	
23	N	600	12080	OK	CL1413	0.8	1.2	0.2	1.0				0.2			0.1			0.1																																				3.6	
22	N	O2 min	12011	OK	CL1412	0.8	1.2	0.2	1.0				0.2			0.1			0.1																																				3.6	
21	N	Bottom	12045	OK	CL1411	0.8	1.2	0.2	1.0				0.2		0.5	0.1		1.2	0.1																																				5.3	
20	C	O2 min	12094	OK	CL1410																																	1.2	11.0																12.2	
19	C	400	12153	OK	CL1409																0.7	0.7	0.7	3.5		0.3	0.2		0.1					0.7									1.4											0.4	8.7	
18	C	400	12142	OK	CL1408																																	1.2	11.0																12.2	
17	C	400	12113	OK	CL1407															0.2																				0.3	2.5	0.2		2.2	1.2	2.4	0.3	0.3	0.3	0.3		0.4			10.6	
16	C	600	12150	OK	CL1406																0.7	0.7	0.7	3.5		0.3	0.2		0.1	0.3				0.7																					7.2	
15	C	600	12130	OK	CL1405																																	1.2	11.0																12.2	
14	C	600	12123	OK	CL1404															0.2																				0.3	2.5	0.2	1.4	2.2	1.2	1.2	0.3	0.3	0.3	0.3		0.4		0.4	11.2	
13	C	O2 min	12118	OK	CL1403																0.7	0.7	0.7	3.5		0.3	0.2		0.1					0.7																					6.9	
12	C	O2 min	12159	OK	CL1402															0.2																				0.3	2.5	0.2		2.2	1.2	1.2	0.3	0.3	0.3	0.3					9.0	
11	C	O2 min	12156	OK	CL1401																																																12.0		12.0	
10	C	O2 min	12137	OK	CL1400																																																12.0		12.0	
9	C	O2 min	12128	OK	CL1399																																																12.0		12.0	
8	C	Bottom	12157	OK	CL1398																0.7	0.7	0.7	3.5		0.3	0.2		0.1					0.7																					6.9	
7	C	Bottom	12114	OK	CL1397																				10.0																														10.0	
6	C	Bottom	12152	OK	CL1396																																	1.2	11.0																12.2	
5	C	Bottom	12105	OK	CL1395																																			0.3	2.5	0.2	1.4	2.2										0.4	7.0	
4	C	Bottom	12143	OK	CL1394															0.2																									1.2	1.2	0.3	0.3	0.3	0.3		0.4			4.2	
3	C	Bottom	12151	OK	CL1393																																																12.0		12.0	
2	C	Bottom	12155	OK	CL1392																																																12.0		12.0	
1	C	Bottom	12149	OK	CL1391																																																12.0		12.0	

MEMO:
OK: no leak
L: leak
NC: not checked

7. 1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL14**
Cast # : **2**

Cast Type: CTD-CMS
Watch: Kondo
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170721 7:08
Sampling End: 20170721 9:25

CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	Salinity	DO	Nutrients	pH/Alkalinity	Chl.a	Dissolved CO2&CH4	Tritium	Density	TCO2	14C	18O	POM	eDNA	18O
						R	R	R	R	R	R	R	R	R	R	R	R	R	
						Routine	Routine	Routine	Routine	Routine	Meiji	JAMSTEC	JAMSTEC	Tokyo Kaiyo U.	Kochi U.	Kochi U.	U. Tokyo Agri.	Toyama U.	Toyama U.
											Noborio	Kumamoto	Kumamoto	Shitashima	Murayama	Murayama	Horii	Horikawa	Horikawa
		bucket			CL1439	0.8	1.2	0.2	1	0.6	0.8					0.1	3		
24	N	10	12127	OK	CL1438	0.8	1.2	0.2	1.0	0.6			0.2			0.1	3.0	1.2	0.1
23	N	25	12080	OK	CL1437	0.8	1.2	0.2	1.0	0.6			0.2			0.1			0.1
22	N	50	12011	OK	CL1436	0.8	1.2	0.2	1.0	0.6	0.8		0.2			0.1	3.0		0.1
21	N	100	12045	OK	CL1435	0.8	1.2	0.2	1.0	0.6	0.8		0.2			0.1	5.0	1.2	0.1
20	N	150	12008	OK	CL1434	0.8	1.2	0.2	1.0	0.6			0.2			0.1			0.1
19	N	200	12072	OK	CL1433	0.8	1.2	0.2	1.0	0.6	0.8		0.2			0.1		1.2	0.1
18	N	200	12003	OK	CL1432												7.0		
17	N	Chla max	12090	OK	CL1431	0.8	1.2	0.2	1.0	0.6			0.2			0.1			0.1
16	C	10	12150	OK	CL1430														
15	C	10	12130	OK	CL1429														
14	C	10	12123	OK	CL1428														
13	C	25	12118	OK	CL1427														
12	C	25	12159	OK	CL1426														
11	C	50	12156	OK	CL1425													1.2	
10	C	50	12137	OK	CL1424														
9	C	100	12128	OK	CL1423														
8	C	100	12157	OK	CL1422														
7	C	100	12114	OK	CL1421														
6	C	150	12152	OK	CL1420														
5	C	150	12105	OK	CL1419														
4	C	150	12143	OK	CL1418														
3	C	200	12151	OK	CL1417														
2	C	200	12155	OK	CL1416														
1	C	Chla max	12149	OK	CL1415														

CMS No.	Sample No.	Nutrients	Trace Metal	Archive	Speciation	Pt	Th&Pa	15NO3	D-Fe	T-Fe	CDOM	Nagasaki trace metal	Ligand	FDOM	OnBoard FeL	SA-FeL	TAC-FeL	Filtered SW for Analysis	Fe IC
		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
			AORI	AORI	AORI	Shizuoka	JAEA	Toyama	HU	HU	HU	Nagasaki	Nagasaki	Nagasaki	Nagasaki	Nagasaki	Nagasaki	Nagasaki	U-Tokyo
			Obata	Obata	Kim	Mashio	Okubo (Kim)	Zhang	Nishioka	Nishioka	Nishioka	Takeda/ Kondo	Takeda/ Kondo	Takeda/ Kondo	Kondo	Kondo	Kondo	Takeda/Kondo	Kurisu
	CL1439																		
24	CL1438																		
23	CL1437																		
22	CL1436																		
21	CL1435																		
20	CL1434																		
19	CL1433																		
18	CL1432																		
17	CL1431																		
16	CL1430		0.7	0.7	0.7	3.5		0.3	0.2		0.1	0.3	1.4	0.1		0.7			
15	CL1429																		
14	CL1428	0.2																	
13	CL1427		0.7	0.7	0.7			0.3	0.2		0.1								
12	CL1426	0.2																	
11	CL1425		0.7	0.7	0.7	3.5		0.3	0.2		0.1					0.7			
10	CL1424	0.2																	
9	CL1423		0.7	0.7	0.7	3.5		0.3	0.2		0.1					0.7			
8	CL1422																		
7	CL1421	0.2																	
6	CL1420		0.7	0.7	0.7			0.3	0.2		0.1								
5	CL1419																		
4	CL1418	0.2																	
3	CL1417		0.7	0.7	0.7			0.3	0.2		0.1	0.3				0.7			
2	CL1416	0.2																	
1	CL1415	0.2	0.7	0.7	0.7			0.3	0.2		0.1					0.7			

CMS No.	Sample No.	Unfilt: SS	Unfilt: SPM	Bi	Pb isotopes	Cr	REE	Trace Metal	NiCuZn	FeCd	Filtered BTM	Un-filt BTM	Filtered Zr	Un-filt Zr	W	Se	Particle	Ba isotope	Total	Remark
		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
		NIIGATA Univ.	NIIGATA Univ.	NIIGATA Univ.	NIIGATA Univ.	Kochi Ken U	Hirosaki, AORI	NIES/NIMD	Kyoto	South	Kyoto	Kyoto	Kyoto	Kyoto	Kyoto	Kindai	Taiwan	Toyama U		
		Norisuye	Norisuye	Norisuye	Norisuye	Norisuye	Tazoe/ Hara	Take/Maru	Takano	Conway	Tei	Tei	Tanaka	Tanaka	Tsujisaka	Fukuda	Daniel	Horikawa		
	CL1439	1.2				0.15										0.4			9.5	
24	CL1438																		8.4	
23	CL1437																		4.2	
22	CL1436																		8.0	
21	CL1435																		11.2	
20	CL1434																		4.2	
19	CL1433																		6.2	
18	CL1432																		7.0	
17	CL1431																		4.2	
16	CL1430																		8.7	
15	CL1429			0.3	2.5	0.2	1.4	1.0								0.4		0.4	6.2	
14	CL1428								2.4		0.3	0.3	0.3	0.3					3.8	
13	CL1427			0.3	2.5	0.2		2.2										0.4	8.3	
12	CL1426								2.4	2.4	0.3	0.3	0.3	0.3		0.4			6.6	
11	CL1425						1.4									0.4		0.4	10.3	
10	CL1424			0.3	2.5	0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3					11.4	
9	CL1423																		6.9	
8	CL1422			0.3	2.5	0.2	1.4	2.2								0.4		0.4	7.4	
7	CL1421								2.4	2.4	0.3	0.3	0.3	0.3					6.2	
6	CL1420			0.3	2.5	0.2	1.4	2.2										0.4	9.7	
5	CL1419	1.2	11.0																12.2	
4	CL1418								2.4	2.4	0.3	0.3	0.3	0.3		0.4			6.6	
3	CL1417			0.3	2.5	0.2													6.7	
2	CL1416						1.4	2.2	2.4	2.4	0.3	0.3	0.3	0.3		0.4		0.4	10.6	
1	CL1415					0.2		2.2	2.4	2.4	0.3	0.3	0.3	0.3					12.0	

MEMO:
OK: no leak
L: leak
NC: not checked

7. 1. KH-17-3 Water Sampling Log Sheet

Station ID: **CL14**
Cast # : **3**

Cast Type: CTD-CMS
Watch: Kondo
Bottle closure method: Immediately after stopping winding the wire.
Sampling Start: 20170721 10:40
Sampling End: 20170721 11:07

CMS No.	bottle type	Pressure (db)	Bottle No.	Leak check	Sample No.	C JAEA Okubo (Kim) Th&Pa	C U-Tokyo Kurisu Fe IC	C NIIGATA Univ. Norisuye Unfilt: SS	C NIIGATA Univ. Norisuye Unfilt: SPM	C Taiwan Daniel Particle	Total	Bottole Bottle No.	Remark
24	C	10	12158	OK	CL1463	10.0					10.0	24	
23	C	10	12028	OK	CL1462		6.0				6.0	23	
22	C	10	12098	NC	CL1461						0.0	22	
21	C	10	12145	OK	CL1460					12.0	12.0	21	
20	C	10	12094	OK	CL1459					12.0	12.0	20	
19	C	10	12153	OK	CL1458					12.0	12.0	19	
18	C	10	12148	OK	CL1457			1.2	11.0		12.2	18	
17	C	25	12113	OK	CL1456			1.2	11.0		12.2	17	
16	C	50	12150	OK	CL1455			1.2	11.0		12.2	16	
15	C	100	12130	OK	CL1454			1.2	11.0		12.2	15	
14	C	100	12123	OK	CL1453	10.0					10.0	14	
13	C	100	12018	OK	CL1452					12.0	12.0	13	
12	C	100	12159	OK	CL1451					12.0	12.0	12	
11	C	100	12156	OK	CL1450					12.0	12.0	11	
10	C	200	12137	OK	CL1449	10.0					10.0	10	
9	C	Chla max	12128	OK	CL1448					12.0	12.0	9	
8	C	Chla max	12154	OK	CL1447					12.0	12.0	8	
7	C	Chla max	12114	OK	CL1446					12.0	12.0	7	
6	C	400	12152	OK	CL1445					12.0	12.0	6	
5	C	400	12105	OK	CL1444					12.0	12.0	5	
4	C	400	12143	OK	CL1443					12.0	12.0	4	
3	C	400	12151	OK	CL1442	10.0					10.0	3	
2	C	400	12155	NC	CL1441						0.0	2	
1	C	600	12149	OK	CL1440	10.0					10.0	1	

MEMO:
OK: no leak
L: leak
NC: not checked

7.2. CTD data table

KH-17-3	CL-11-1		Depth	3968m	
Date:	2017/7/20		Lat.	57	30.09N
Time:	00:32		Long.	145	00.09W
CTD data (LAY)	Pres.	Temp.	Sal	DO	Flu.
	db	℃	(psu)	ml/l	ug/l
	Sur.	12.4	***	***	***
	20	12.142	32.527	6.2797	1.1600
	30	9.492	32.583	6.8375	1.3400
	40	6.983	32.671	7.0258	1.5300
	50	5.718	32.720	7.0134	1.2000
	75	4.844	32.759	6.8283	0.6080
	100	4.485	32.901	6.2419	0.2730
	125	4.550	33.211	5.0618	0.1470
	150	4.594	33.601	3.6421	0.1020
	175	4.570	33.768	2.9142	0.0927
	200	4.417	33.798	2.4469	0.0781
	250	4.077	33.835	1.7990	0.0791
	300	3.952	33.891	1.2964	0.0801
	400	3.867	33.998	0.8891	0.0797
	500	3.727	34.098	0.5922	0.0801
	600	3.589	34.188	0.4086	0.0806
	700	3.409	34.247	0.3784	0.0801
	800	3.255	34.302	0.3318	0.0804
	900	3.108	34.328	0.3587	0.0799
	1000	3.003	34.367	0.2989	0.0787
	1200	2.691	34.429	0.3438	0.0799
	1500	2.383	34.492	0.5281	0.0762
	2000	1.990	34.576	1.0769	0.0733
	2500	1.765	34.623	1.6567	0.0713
	3000	1.615	34.654	2.1832	0.0682
	3500	1.521	34.674	2.6777	0.0667
	3969	1.454	34.688	3.1149	0.0670

CTD data (BTL)						
BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	3895	3968.1	1.454	34.688	3.1125	0.0657
2	3895	3968.3	1.454	34.688	3.1166	0.0670
3	3439	3499.9	1.520	34.674	2.6990	0.0669
4	2951	2999.7	1.618	34.653	2.1965	0.0686
5	2464	2501.8	1.758	34.624	1.6792	0.0710
6	1973	2000.9	1.999	34.575	1.0808	0.0732
7	1481	1499.8	2.409	34.488	0.5130	0.0765
8	1481	1500.2	2.410	34.487	0.5206	0.0764
9	1236	1251.0	2.637	34.440	0.3790	0.0777
10	990	1001.8	3.008	34.365	0.3096	0.0792
11	792	800.4	3.258	34.299	0.3481	0.0807
12	594	600.3	3.587	34.189	0.4087	0.0824
13	1050	1062.3	2.925	34.384	0.3038	0.0783
14	3895	3968.0	1.454	34.689	3.1102	0.0659
15	3440	3500.6	1.521	34.674	2.6923	0.0674
16	2952	3000.6	1.620	34.653	2.1847	0.0686
17	2463	2501.2	1.758	34.624	1.6891	0.0703
18	1973	2000.8	1.999	34.575	1.0732	0.0730
19	1481	1500.5	2.407	34.488	0.5160	0.0765
20	1235	1250.1	2.637	34.440	0.3757	0.0776
21	990	1001.4	3.011	34.364	0.3061	0.0800
22	791	799.7	3.256	34.299	0.3452	0.0812
23	594	600.5	3.590	34.187	0.4121	0.0813
24	1050	1062.4	2.917	34.385	0.3048	0.0799

KH-17-3	CL-11-2		Depth	3970m	
Date:	2017/7/20		Lat.	57	30.14N
Time:	05:40		Long.	145	00.05W
CTD data (LAY)	Pres.	Temp.	Sal	DO	Flu.
	db	℃	(psu)	ml/l	ug/l
	Sur.	12.1	***	***	***
	20	9.613	32.567	6.7407	1.7691
	30	6.481	32.667	7.0174	1.3969
	40	5.613	32.708	7.0162	1.1282
	50	5.386	32.752	6.9490	0.9486
	75	4.775	32.817	6.7262	0.4356
	100	4.508	33.068	5.6085	0.2002
	125	4.596	33.608	3.6244	0.0915
	150	4.578	33.767	2.9468	0.0858
	175	4.339	33.788	2.4235	0.0806
	200	4.205	33.818	2.0733	0.0778
	250	4.090	33.860	1.6832	0.0813
	300	3.956	33.908	1.2402	0.0811
	400	3.858	34.018	0.8689	0.0799
	401	3.857	34.020	0.8613	0.0735

CTD data (BTL)						
BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	396	400.3	3.858	34.018	0.8664	0.0796
2	396	399.6	3.858	34.017	0.8679	0.0803
3	11	11.1	11.957	32.517	6.3944	2.1900
4	11	11.1	11.957	32.517	6.3975	2.1900
5	199	200.5	4.208	33.812	2.0946	0.0790
6	198	200.1	4.205	33.811	2.0956	0.0794
7	149	150.8	4.593	33.760	2.9825	0.0875
8	100	100.5	4.509	33.077	5.4844	0.1720
9	100	100.9	4.500	33.043	5.6127	0.1870
10	50	50.4	5.363	32.755	6.8970	0.9670
11	25	25.6	7.499	32.642	6.8952	1.5200
12	25	25.5	7.938	32.627	6.8690	1.5300
13	11	10.7	11.955	32.518	6.3911	2.2600
14	11	11.1	11.950	32.519	6.3954	2.2500
15	11	10.6	11.955	32.519	6.3919	2.3700
16	396	400.2	3.858	34.018	0.8656	0.0798
17	11	10.8	11.950	32.519	6.3951	2.2200
18	199	200.8	4.210	33.812	2.0957	0.0789
19	198	200.3	4.207	33.811	2.0956	0.0794
20	149	150.6	4.594	33.760	2.9768	0.0859
21	99	100.0	4.502	33.050	5.6626	0.1660
22	49	49.8	5.302	32.756	6.8784	0.8190
23	25	25.3	8.189	32.619	6.8400	1.8000
24	11	11.4	11.955	32.519	6.3905	2.1600

7.2. CTD data table

KH-17-3	CL-12-1	Depth	3702m
Date:	2017/7/22	Lat.	58 46.50N
Time:	11:58	Long.	144 29.82W

CTD data (LAY)

Pres.	Temp.	Sal	DO	Flu.
db	℃	(psu)	ml/l	ug/l
Sur.	13.5	***	***	***
5	13.582	32.500	6.1307	0.9900
10	13.559	32.501	6.1598	0.9460
20	13.394	32.506	6.2139	1.4400
30	10.165	32.556	6.9605	2.1200
40	8.091	32.580	6.7717	2.2800
50	7.436	32.651	6.7775	1.4500
75	5.942	32.752	6.3809	0.4530
100	5.680	32.933	5.7648	0.1550
125	6.091	33.353	4.1716	0.0946
150	6.177	33.672	2.8645	0.0834
175	5.762	33.763	2.7925	0.0826
200	5.469	33.799	2.8684	0.0801
250	4.733	33.832	2.2628	0.0800
300	4.404	33.884	1.6654	0.0801
400	4.243	33.972	1.0157	0.0795
500	3.998	34.062	0.6224	0.0801
600	3.805	34.162	0.4051	0.0798
700	3.580	34.218	0.3601	0.0797
800	3.406	34.266	0.3331	0.0788
900	3.221	34.307	0.3187	0.0786
1000	3.068	34.347	0.3191	0.0782
1200	2.781	34.413	0.3220	0.0777
1500	2.430	34.484	0.4726	0.0754
2000	1.963	34.581	1.1211	0.0738
2500	1.706	34.632	1.7956	0.0709
3000	1.551	34.663	2.3951	0.0685
3500	1.452	34.682	2.9299	0.0661
3720	1.424	34.688	3.1274	0.0661

CTD data (BTL)

BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	3653	3719.5	1.424	34.688	3.1269	0.0663
2	3653	3719.9	1.424	34.688	3.1318	0.0655
3	3440	3501.4	1.452	34.682	2.9492	0.0660
4	2951	2999.9	1.552	34.663	2.3925	0.0682
5	2462	2500.0	1.705	34.633	1.8090	0.0698
6	1973	2001.1	1.956	34.582	1.1529	0.0730
7	1480	1499.6	2.442	34.482	0.4760	0.0758
8	1481	1500.3	2.446	34.481	0.4701	0.0756
9	1235	1250.2	2.753	34.419	0.3347	0.0774
10	989	1000.3	3.096	34.350	0.2943	0.0792
11	791	799.6	3.433	34.263	0.3335	0.0805
12	594	600.1	3.772	34.165	0.4061	0.0809
13	948	959.6	3.136	34.331	0.3240	0.0788
14	3653	3719.6	1.424	34.688	3.1253	0.0662
15	3440	3501.6	1.452	34.682	2.9294	0.0658
16	2951	2999.5	1.554	34.663	2.3938	0.0685
17	2462	2499.6	1.704	34.633	1.8008	0.0698
18	1973	2001.3	1.956	34.582	1.1491	0.0727
19	1481	1500.3	2.447	34.481	0.4746	0.0761
20	1234	1249.4	2.757	34.418	0.3243	0.0784
21	989	1000.4	3.100	34.348	0.2936	0.0798
22	791	800.2	3.434	34.263	0.3330	0.0804
23	594	600.7	3.772	34.164	0.4085	0.0808
24	949	959.8	3.139	34.329	0.3279	0.0810

KH-17-3	CL-12-2	Depth	3700m
Date:	2017/7/22	Lat.	58 46.47N
Time:	16:54	Long.	144 29.98W

CTD data (LAY)

Pres.	Temp.	Sal	DO	Flu.
db	℃	(psu)	ml/l	ug/l
Sur.	14	***	***	***
5	13.682	32.483	6.1312	0.3390
10	13.667	32.483	6.1368	0.5760
20	10.926	32.529	6.9442	1.2700
30	9.395	32.563	6.9087	2.4000
40	7.817	32.586	6.6613	2.2500
50	7.060	32.638	6.5345	0.7970
75	5.934	32.762	6.5596	0.5730
100	5.734	32.934	5.7071	0.2000
125	6.366	33.284	4.0952	0.1000
150	6.262	33.660	2.9019	0.0794
175	5.679	33.763	2.7699	0.0791
200	5.338	33.801	2.8163	0.1260
250	4.655	33.825	2.2991	0.0781
300	4.368	33.884	1.6632	0.0799
400	4.248	33.991	0.9421	0.0790
500	3.965	34.062	0.6191	0.0789
600	3.857	34.142	0.4373	0.0796
700	3.662	34.202	0.3677	0.0795
800	3.435	34.262	0.3280	0.0797
900	3.238	34.304	0.3174	0.0802
1000	3.074	34.348	0.3097	0.0788
1060	2.979	34.368	0.3195	0.0795

CTD data (BTL)

BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	396	400.5	4.221	33.973	0.9784	0.0796
2	397	401.0	4.223	33.974	0.9812	0.0790
3	36	36.0	8.626	32.578	6.8572	2.7800
4	36	35.9	8.626	32.577	6.8692	2.7800
5	199	200.8	5.432	33.800	2.8448	0.0795
6	199	200.7	5.432	33.800	2.8398	0.0819
7	149	150.0	6.361	33.619	2.9786	0.0822
8	100	101.4	5.833	32.965	5.7161	0.1970
9	100	101.0	5.817	32.961	5.7177	0.1720
10	50	50.4	6.903	32.639	6.4544	0.6980
11	50	50.1	6.963	32.639	6.4651	0.6430
12	25	25.2	10.377	32.576	6.8609	2.1000
13	25	25.1	10.309	32.584	6.8788	1.7500
14	10	10.5	13.697	32.475	6.1240	0.5730
15	10	10.2	13.670	32.478	6.1221	0.5440
16	397	401.0	4.227	33.974	0.9810	0.0797
17	35	35.7	8.632	32.576	6.8681	2.7800
18	199	200.7	5.428	33.798	2.8208	0.0798
19	198	200.2	5.423	33.800	2.8328	0.0807
20	149	150.3	6.365	33.618	2.9920	0.0817
21	99	100.4	5.761	32.942	5.6051	0.1770
22	50	50.7	6.968	32.640	6.4679	0.7800
23	25	25.3	10.376	32.581	6.8774	1.7600
24	10	10.5	13.699	32.473	6.1082	0.5490

7.2. CTD data table

KH-17-3	CL-13-1			Depth	2315m	
Date:	2017/7/22			Lat.	59	18.77N
Time:	05:17			Long.	144	23.97W
CTD data (LAY)		Pres.	Temp.	Sal	DO	Flu.
		db	℃	(psu)	ml/l	ug/l
		Sur.	13.7	***	***	***
		10	13.537	32.053	6.3140	0.7440
		20	10.713	32.170	7.2632	2.3000
		30	8.640	32.237	6.4143	1.6800
		40	7.954	32.275	6.0650	0.7280
		50	7.489	32.316	6.0625	0.3660
		75	6.312	32.420	5.9687	0.0939
		100	6.294	32.556	5.9821	0.0857
		125	6.175	32.766	5.5825	0.0790
		150	6.104	33.046	4.8577	0.0813
		175	6.278	33.559	3.2294	0.0834
		200	5.738	33.701	3.2093	0.0818
		250	5.146	33.829	2.2833	0.0772
		300	4.568	33.857	1.8218	0.0765
		400	4.166	33.973	0.9758	0.0784
		500	4.054	34.056	0.6561	0.0792
		600	3.945	34.130	0.4548	0.0792
		700	3.748	34.194	0.3537	0.0792
		800	3.554	34.244	0.3117	0.0793
		900	3.353	34.288	0.3071	0.0792
		1000	3.241	34.321	0.2784	0.0784
		1200	2.913	34.393	0.2672	0.0768
		1500	2.353	34.501	0.5313	0.0752
		2000	1.857	34.600	1.3394	0.0731
		2331	1.743	34.624	1.6728	0.0705
CTD data (BTL)						
BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	2294	2328.6	1.759	34.621	1.6442	0.0715
2	2295	2329.1	1.745	34.624	1.6513	0.0709
3	1972	2000.2	1.855	34.600	1.3445	0.0727
4	1972	1999.9	1.855	34.600	1.3425	0.0726
5	1480	1499.6	2.348	34.502	0.5436	0.0761
6	1480	1499.8	2.350	34.501	0.5414	0.0748
7	1236	1251.0	2.837	34.408	0.2891	0.0776
8	989	1000.4	3.242	34.321	0.2743	0.0795
9	989	1000.5	3.246	34.320	0.2762	0.0798
10	792	801.0	3.552	34.248	0.3021	0.0802
11	594	600.0	3.929	34.133	0.4341	0.0800
12	1064	1077.2	3.116	34.351	0.2652	0.0794
13	1065	1077.4	3.120	34.351	0.2629	0.0778
14	2295	2329.2	1.745	34.623	1.6646	0.0704
15	2294	2328.7	1.751	34.622	1.6593	0.0709
16	2295	2329.7	1.747	34.623	1.6461	0.0715
17	2295	2329.3	1.750	34.623	1.6570	0.0709
18	1972	2000.1	1.854	34.600	1.3511	0.0730
19	1481	1500.8	2.351	34.501	0.5465	0.0765
20	1235	1250.5	2.835	34.408	0.2889	0.0783
21	989	1001.1	3.248	34.320	0.2771	0.0798
22	790	799.3	3.548	34.249	0.3020	0.0803
23	593	599.8	3.937	34.131	0.4432	0.0806
24	1064	1076.5	3.119	34.351	0.2635	0.0789

KH-17-3	CL-13-2			Depth	2292m	
Date:	2017/7/22			Lat.	59	18.67N
Time:	08:48			Long.	144	23.88W
CTD data (LAY)		Pres.	Temp.	Sal	DO	Flu.
		db	℃	(psu)	ml/l	ug/l
		Sur.	13.9	***	***	***
		5	13.533	32.273	6.3350	1.4600
		10	13.531	32.283	6.3455	1.6500
		20	11.331	32.293	7.0614	3.1900
		30	10.054	32.431	6.8384	3.0900
		40	8.913	32.424	6.6164	3.1000
		50	8.413	32.453	6.5342	2.0500
		75	7.299	32.541	6.3451	0.5060
		100	6.677	32.649	6.4122	0.2620
		125	5.992	32.766	6.1418	0.2030
		150	6.189	33.249	4.1578	0.0805
		175	6.146	33.668	3.0134	0.0790
		200	5.895	33.796	2.5848	0.0783
		250	5.098	33.847	2.1445	0.0777
		300	4.394	33.863	1.6971	0.0765
		400	4.195	33.964	1.0203	0.0787
		403	4.195	33.964	1.0084	0.0816
CTD data (BTL)						
BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	397	400.8	4.194	33.963	1.0172	0.0797
2	397	401.2	4.194	33.963	1.0185	0.0789
3	27	27.2	10.626	32.427	6.9786	3.6100
4	27	27.2	10.561	32.426	7.0021	3.8400
5	198	199.6	5.908	33.795	2.5728	0.0815
6	198	200.0	5.917	33.793	2.5578	0.0789
7	150	151.0	6.159	33.170	4.3877	0.0802
8	99	99.8	6.430	32.667	6.3867	0.2620
9	99	100.1	6.464	32.665	6.3829	0.2970
10	50	50.6	8.283	32.452	6.4558	1.4600
11	49	49.7	8.133	32.465	6.4706	1.3200
12	25	25.1	10.851	32.374	7.0611	3.9400
13	25	25.2	10.840	32.365	7.0701	4.0000
14	10	10.2	13.410	32.290	6.3843	2.0300
15	10	9.9	13.424	32.290	6.3627	2.1600
16	398	401.9	4.194	33.963	1.0210	0.0792
17	27	27.1	10.628	32.411	7.0276	3.7200
18	198	200.0	5.893	33.797	2.5641	0.0782
19	198	199.8	5.908	33.795	2.5683	0.0778
20	150	151.3	6.163	33.179	4.3927	0.0789
21	99	100.1	6.433	32.665	6.3580	0.2710
22	50	50.0	8.195	32.462	6.4779	1.5100
23	25	25.2	10.836	32.344	7.0816	4.2700
24	10	10.0	13.241	32.316	6.4449	2.3800

7.2. CTD data table

KH-17-3	CL-14-1	Depth	695m
Date:	2017/7/21	Lat.	59 33.19N
Time:	10:20	Long.	144 09.32W

CTD data (LAY)	Pres.	Temp.	Sal	DO	Flu.
	db	℃	(psu)	ml/l	ug/l
	Sur.	13.7	***	***	***
	10	13.210	31.870	6.3304	0.8448
	20	11.151	32.182	6.9210	2.4591
	30	9.522	32.288	6.5087	2.4420
	40	8.455	32.310	6.2898	1.1252
	50	7.735	32.312	6.0587	0.5133
	75	6.885	32.423	6.0689	0.2277
	100	6.340	32.505	6.0005	0.0885
	125	6.129	32.748	5.7400	0.0873
	150	6.088	33.022	4.8640	0.0814
	175	6.204	33.237	4.1169	0.0778
	200	6.238	33.549	3.2309	0.0786
	250	5.523	33.774	2.9930	0.0807
	300	4.623	33.834	2.2236	0.0776
	400	4.246	33.948	1.1343	0.0796
	500	4.076	34.037	0.7203	0.0801
	600	3.903	34.124	0.4483	0.0794
	678	3.766	34.182	0.3609	0.0800

CTD data (BTL)

BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	670	677.6	3.769	34.181	0.3574	0.0799
2	670	677.5	3.768	34.182	0.3603	0.0804
3	669	676.2	3.781	34.177	0.3576	0.0796
4	669	676.6	3.776	34.179	0.3645	0.0801
5	670	677.1	3.774	34.179	0.3628	0.0798
6	670	677.0	3.773	34.180	0.3628	0.0798
7	669	676.8	3.771	34.181	0.3584	0.0804
8	669	676.6	3.770	34.181	0.3574	0.0804
9	164	166.1	6.208	33.217	4.1542	0.0786
10	165	166.5	6.212	33.210	4.1830	0.0829
11	165	166.3	6.206	33.215	4.1313	0.0783
12	165	166.8	6.214	33.208	4.1724	0.0786
13	165	166.4	6.213	33.208	4.1872	0.0794
14	593	599.7	3.902	34.124	0.4481	0.0801
15	594	600.6	3.903	34.123	0.4491	0.0804
16	595	601.2	3.903	34.123	0.4461	0.0804
17	396	400.4	4.245	33.942	1.1761	0.0792
18	397	400.9	4.250	33.937	1.1888	0.0795
19	396	400.4	4.247	33.939	1.2016	0.0792
20	165	166.2	6.212	33.209	4.1736	0.0795
21	669	676.7	3.768	34.182	0.3571	0.0800
22	165	166.4	6.215	33.209	4.1807	0.0814
23	594	600.3	3.903	34.123	0.4467	0.0811
24	397	401.4	4.250	33.937	1.2078	0.0798

KH-17-3	CL-14-2	Depth	689m
Date:	2017/7/21	Lat.	59 33.27N
Time:	14:29	Long.	144 09.37W

CTD data (LAY)	Pres.	Temp.	Sal	DO	Flu.
	db	℃	(psu)	ml/l	ug/l
	Sur.	13.6	***	***	***
	20	11.773	32.325	7.1477	2.5000
	30	9.257	32.282	6.5157	3.9000
	40	8.040	32.334	6.1656	0.8650
	50	7.015	32.338	5.9832	0.3200
	75	6.169	32.451	5.9459	0.0787
	100	6.170	32.643	5.7822	0.0780
	125	6.066	32.863	5.3856	0.0857
	150	6.178	33.117	4.5583	0.0793
	175	6.247	33.326	3.8078	0.0756
	200	6.281	33.503	3.3875	0.0771
	201	6.254	33.515	3.3771	0.0768

CTD data (BTL)

BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	27	27.2	10.752	32.404	6.8568	3.9600
2	198	199.6	6.293	33.499	3.3888	0.0811
3	198	200.2	6.273	33.507	3.3957	0.0849
4	148	149.9	6.169	33.120	4.5151	0.0804
5	149	150.2	6.166	33.119	4.5254	0.0787
6	148	149.9	6.165	33.117	4.5282	0.0811
7	99	100.4	6.179	32.671	5.7862	0.0786
8	99	100.4	6.179	32.670	5.7815	0.0831
9	99	100.1	6.178	32.664	5.7842	0.0777
10	49	49.8	7.088	32.338	5.9827	0.3040
11	50	50.5	7.119	32.338	5.9862	0.3240
12	25	25.6	11.099	32.397	6.9728	4.8300
13	26	25.8	11.082	32.397	6.9917	4.9300
14	10	10.1	13.533	32.058	6.1251	0.9240
15	10	10.2	13.528	32.063	6.1222	0.8180
16	11	10.8	13.558	32.060	6.1282	0.7920
17	27	27.6	10.646	32.398	6.8555	3.7900
18	198	200.2	6.273	33.507	3.3924	0.0775
19	198	200.4	6.266	33.511	3.3809	0.0796
20	149	150.4	6.160	33.115	4.5386	0.0799
21	99	100.3	6.177	32.660	5.7789	0.0780
22	50	50.4	7.118	32.339	5.9886	0.3060
23	26	25.9	11.033	32.398	6.9760	5.1600
24	10	9.9	13.552	32.061	6.1020	0.7870

KH-17-3	CL-14-3	Depth	694m
Date:	2017/7/21	Lat.	59 33.36N
Time:	17:49	Long.	144 09.27W

CTD data (LAY)	Pres.	Temp.	Sal	DO	Flu.
	db	℃	(psu)	ml/l	ug/l
	Sur.	13.7	***	***	***
	5	13.484	32.367	6.3263	1.1200
	10	13.471	32.366	6.3263	1.3300
	20	13.440	32.367	6.3194	2.0400
	30	10.562	32.339	6.9683	3.4500
	40	8.619	32.301	6.2777	1.9000
	50	7.943	32.333	6.1449	0.9900
	75	6.596	32.444	6.1527	0.2700
	100	6.288	32.578	5.9657	0.0869
	125	6.157	32.812	5.4422	0.0793
	150	6.071	33.029	4.8674	0.0808
	175	6.276	33.343	3.8146	0.0760
	200	6.301	33.562	3.2083	0.0775
	250	4.925	33.798	2.7523	0.0821
	300	4.593	33.867	1.8555	0.0778
	400	4.252	33.938	1.2257	0.0803
	500	4.088	34.035	0.7304	0.0795
	600	3.931	34.107	0.4938	0.0796
	602	3.927	34.113	0.4827	0.0796

CTD data (BTL)

BTL	Depth	Pres.	Temp.	Sal	DO	Flu.
No.	m	db	℃	(psu)	ml/l	ug/l
1	595	601.2	3.928	34.112	0.4807	0.0800
2	396	400.4	4.240	33.960	1.0422	0.0798
3	396	399.9	4.238	33.960	1.0549	0.0792
4	396	400.2	4.238	33.959	1.0562	0.0798
5	396	400.2	4.239	33.955	1.0508	0.0784
6	396	400.3	4.243	33.950	1.1244	0.0790
7	31	31.3	8.717	32.340	6.4733	1.8900
8	32	31.9	8.769	32.345	6.5044	1.9400
9	32	31.9	8.766	32.346	6.5046	2.0100
10	199	200.7	6.284	33.564	3.1666	0.0778
11	99	100.3	6.318	32.597	5.9608	0.0987
12	100	100.6	6.341	32.592	5.9718	0.1090
13	100	101.0	6.338	32.591	5.9832	0.1060
14	100	100.6	6.342	32.591	5.9800	0.1100
15	100	100.5	6.345	32.592	5.9787	0.1170
16	51	51.1	7.539	32.375	6.1262	0.5570
17	25	25.1	10.300	32.352	6.9198	3.4800
18	10	9.9	13.431	32.363	6.3260	1.5700
19	10	10.2	13.442	32.364	6.3227	1.3300
20	10	10.1	13.451	32.365	6.3301	1.2700
21	10	10.4	13.450	32.365	6.3370	1.1900
22	10	10.2	13.450	32.365	6.3297	1.2100
23	11	10.7	13.449	32.365	6.3347	1.2000
24	10	10.2	13.451	32.365	6.3383	1.1600

7. 3. LV Sampling log

Station	Sample No.	Latitude			Longitude			WaterDepth [m]	Lag	Cast Start(SST)	Cast End(SST)	Depth [m]	Cast#	Sampler	Position	Tank	Closed (SST)	Wire out [m]	Acoustic [m]	Acoustic [m]	Depth (TD) [m]	Salinity	Nd IC/Be7/Be10 [L]	Nd IC/Be10 (kg)	Be9 [L]	Cs134,137 [L]	I129 [L]	U236 [L]	U238 [L]	I129(UT) [L]	
CL11		57	30	N	145	0.021	E	3978	-8	2017/7/19 23.34	0:17	100	2	LV	4		0:10	100	105			32.995		23.8	0.25						
CL11									-8			200	2	LV	3		0:05	200	202			33.802		24.7	0.25						
CL11									-8			400	2	LV	2		23:59	400	402			34.026		23.3	0.25						
CL11									-8			600	2	LV	1		23:54	600	592			34.169		24.4	0.25						
CL11									-8			800	1	LV	4			800				34.290		23.2	0.25						
CL11									-8			1000	1	LV	3			1000				34.358		23.3	0.25						
CL11									-8			1500	1	LV	2			1500				34.492		21.8	0.25						5
CL11									-8			2000	1	LV	1			2000				34.566		22.9	0.25						21
CL12		58	46.5	N	144	29.45	E	3703	-8	2017/7/20 17:02	17:28	10	3	LV	4		17:23	10	186			32.509		22.8	0.25	60	1				
CL12									-8			60	3	LV	3		17:20	60	65			32.680		22.3	0.25	60	1				
CL12									-8			100	3	LV	2		17:15	100	104			32.809		21.9	0.25	60	1				
CL12									-8			200	3	LV	1		17:10	200	205			33.810		21.3	0.25	60	1				
CL12		58	46.6	N	144	29.59	E	3703	-8	2017/7/20 15:42	16:31	300	2	LV	4		16:21	300	297			33.930		20.5	0.25	60	1				
CL12									-8			400	2	LV	3		16:16	400	400			34.009		21.5	0.25	60	1				
CL12									-8			600	2	LV	2		16:10	600	601			34.102		20.2	0.25	60	1				
CL12									-8			800	2	LV	1		16:04	800	810			34.262		23.2	0.25	60	1				
CL12		58	46.5	N	144	29.7	E	3703	-8	2017/7/20	15:13	1000	1	LV	4		14:25	1000	1116			34.349		22.7	0.25						
CL12									-8			1250	1	LV	3		14:37	1250	1321			34.410		22.0	0.25						
CL12									-8			1500	1	LV	2		14:44	1500	1516			34.486		24.0	0.25						
CL12									-8			2000	1	LV	1		14:51	2000	2141			34.574		22.0	0.25						
CL14		59	33.3	N	144	9.254	E	694	-8	2017/7/21 5:56	6:11	10	3	LV	4	H	6:07	10				32.033	208		0.25	40	1				
CL14									-8			20	3	LV	3	D	6:05	20				32.423	264		0.25						
CL14									-8			40	3	LV	2	G	6:02	40				32.333	248		0.25						
CL14									-8			60	3	LV	1	C	5:59	60				32.381	198		0.25	40	1	5	0.1		
CL14		59	33.3	N	144	9.235	E	694	-8	2017/7/21 4:55	5:23	100	2	LV	4	F	5:17	100	102			32.606	208		0.25	40	1				
CL14									-8			150	2	LV	3	C9	5:13	150	153			33.126	201		0.25			5	0.1		
CL14									-8			200	2	LV	2	B	5:10	200	202			33.609	207		0.25	40	1				
CL14									-8			300	2	LV	1	C3	5:05	300	301			33.834	198		0.25	40	1	5	0.1		
CL14		59	33.3	N	144	9.296	E	694	-8	2017/7/21 3:33	4:24	400	1	LV	4	C8	4:11	400	404			33.957	200		0.25	40	1				
CL14									-8			500	1	LV	3	C2	4:06	500	503			34.037	200		0.25			5	0.1		
CL14									-8			600	1	LV	2	C7	4:02	600	600			34.119	200		0.25						
CL14									-8			Bottom	1	LV	1	C1	3:57	673	678			34.178	200		0.25	40	1	5	0.1		

7. 3. LV Sampling log

Station	Sample No.	Latitude			Longitude			WaterDepth [m]	Lag	Cast Start(SST)	Cast End(SST)	Depth [m]	Cast#	Sampler	Position	
CL11		57	30	N	145	0.021	E	3978	-8	2017/7/19 23.34	0:17	100	2	LV	4	
CL11									-8			200	2	LV	3	
CL11									-8			400	2	LV	2	
CL11									-8			600	2	LV	1	
CL11									-8			800	1	LV	4	
CL11									-8			1000	1	LV	3	
CL11									-8			1500	1	LV	2	CTD-CMS, CL10-3 5-20
CL11									-8			2000	1	LV	1	CTD-CMS, CL10-3 21-24
CL12		58	46.5	N	144	29.45	E	3703	-8	2017/7/20 17:02	17:28	10	3	LV	4	
CL12									-8			60	3	LV	3	
CL12									-8			100	3	LV	2	
CL12									-8			200	3	LV	1	
CL12		58	46.6	N	144	29.59	E	3703	-8	2017/7/20 15:42	16:31	300	2	LV	4	
CL12									-8			400	2	LV	3	
CL12									-8			600	2	LV	2	
CL12									-8			800	2	LV	1	
CL12		58	46.5	N	144	29.7	E	3703	-8	2017/7/20	15:13	1000	1	LV	4	
CL12									-8			1250	1	LV	3	
CL12									-8			1500	1	LV	2	
CL12									-8			2000	1	LV	1	
CL14		59	33.3	N	144	9.254	E	694	-8	2017/7/21 5:56	6:11	10	3	LV	4	
CL14									-8			20	3	LV	3	
CL14									-8			40	3	LV	2	
CL14									-8			60	3	LV	1	
CL14		59	33.3	N	144	9.235	E	694	-8	2017/7/21 4:55	5:23	100	2	LV	4	
CL14									-8			150	2	LV	3	
CL14									-8			200	2	LV	2	
CL14									-8			300	2	LV	1	
CL14		59	33.3	N	144	9.296	E	694	-8	2017/7/21 3:33	4:24	400	1	LV	4	
CL14									-8			500	1	LV	3	
CL14									-8			600	1	LV	2	
CL14									-8			Bottom	1	LV	1	

7. 4. Sediment core samples

During KH17-3 *R/V* Hakuho-maru cruise (Camelopardalis Expedition), we obtained multiple-core sediments at 21 stations and piston core sediments at 4 stations in the subarctic North Pacific and in the Gulf of Alaska. Detailed information on multiple and piston cores and the localities of the core sites can be seen in Table 7. 4. 1. The multiple core sediments were distributed to Keiji Horikawa, Masafumi Murayama, Hideki Minami, Koji Seike, Genki Kobayashi, Hisao Nagai, and Akinori Takeuchi. Piston cores will be subsampled at Kochi Core Center, and KH has the responsibility for these piston cores.

Table 7. 4. 1. Sediment cores obtained during KH17-3 Cruise

Core ID		Date (UTC) yy-month-day	Lat	Long	Water depth (m)	Recovery (cm)	Note
KH17-3 CL11	MC	170719	57 29.767N	145 00.617W	3933	27	Clay, foraminifera might be included but not much
KH17-3 CL12	MC	170720	58 46.293N	144 29.313W	3684	30	Clay, foraminifera might be included but not much
	PC	170722	58 46.633N	144 29.504W	3682	~850	
KH17-3 CL13	MC	170721	59 18.909N	144 23.704W	2329	30	Clay, foraminifera might be included but not much
	PC	170721	59 18.907N	144 23.752W	2342	~20	Failed: Triger of piston corer did not work
	PC	170722	59 19.098N	144 23.864W	2383	~850	
KH17-3 CL14	MC	170721	59 33.334N	144 09.262W	692	40	Clay, foraminifera might be included but not much
	PC	170721	59 33.350N	144 09.344W	695	~850	

7. 5. Routine Data

Lat. 57 30.09 N Lon 145 0.09 W

Station CL11 (57°30.09'N, 145°00.09'W; Depth=3968 m); July 20, 2017, 0:32 ~ July 20, 2017, 6:12, Bottom altitude: 9.4 m)

depth	Cast No.	Sample No.	Niskin No.	Depth (m)	Pressure (decibar)	Temp. (°C) (CTD)	Pot.Temp	Sigma-th	Salinity (CTD)	Salinity (Routine)	QF	Oxygen (μmol/L)	Oxygen (μmol/kg)	QF	Chlorophyll a (μg/L)	QF	NO3+NO2 (μmol/L)	NO3+NO2 (μmol/kg)	QF	NO2 (μmol/L)	QF	SiO2 (μmol/L)	SiO2 (μmol/kg)	QF	PO4 (μmol/L)	PO4 (μmol/kg)	QF	pH (NBS)	QF	pH (SWS)	QF	Alkalinity	QF	
Bottom	1	CL1247	14	3895	3968.0	1.4535	1.139	27.786	34.689	34.681	1	149.9	145.8	1			36.85	35.85	1	0.00	1	170.35	165.74	1	2.51	2.44	1	7.724	1	7.589	1	2416.01	1	Bottom
3500	1	CL1248	15	3440	3500.6	1.5206	1.254	27.766	34.674	34.668	1	129.2	125.7	1			38.28	37.25	1	0.00	1	176.95	172.17	1	2.61	2.54	1	7.691	1	7.555	1	2418.54	1	3500
3000	1	CL1249	16	2952	3000.6	1.6201	1.400	27.739	34.653	34.647	1	105.4	102.6	1			39.98	38.90	1	0.00	1	180.71	175.83	1	2.72	2.65	1	7.650	1	7.514	1	2419.62	1	3000
2500	1	CL1250	17	2463	2501.2	1.7575	1.581	27.702	34.624	34.619	1	81.8	79.6	1			41.47	40.35	1	0.00	1	178.58	173.77	1	2.83	2.75	1	7.599	1	7.468	1	2409.39	1	2500
2000	1	CL1251	18	1973	2000.8	1.9992	1.863	27.642	34.575	34.572	1	52.8	51.4	1			43.18	42.02	1	0.00	1	175.78	171.05	1	2.96	2.88	1	7.543	1	7.413	1	2400.80	1	2000
1500	1	CL1252	19	1481	1500.5	2.4066	2.306	27.537	34.488	34.481	1	26.3	25.6	1			44.73	43.53	1	0.00	1	166.29	161.83	1	3.08	3.00	1	7.484	1	7.354	1	2387.72	1	1500
1250	1	CL1253	20	1235	1250.1	2.6369	2.553	27.478	34.440	34.437	1	20.7	20.1	1			44.90	43.70	1	0.00	1	159.27	155.01	1	3.10	3.02	1	7.467	1	7.337	1	2380.56	1	1250
1000	1	CL1254	21	990	1001.4	3.0113	2.943	27.383	34.364	34.359	1	16.9	16.4	1			44.97	43.77	1	0.00	1	147.19	143.27	1	3.12	3.04	1	7.458	1	7.329	1	2366.62	1	1000
800	1	CL1255	22	791	799.7	3.2558	3.201	27.307	34.299	34.298	1	18.8	18.3	1			44.64	43.45	1	0.00	1	138.41	134.73	1	3.10	3.02	1	7.456	1	7.327	1	2350.80	1	800
600	1	CL1256	23	594	600.5	3.5896	3.548	27.185	34.187	34.184	1	22.4	21.8	1			44.42	43.24	1	0.00	1	123.87	120.59	1	3.07	2.99	1	7.441	1	7.312	1	2336.73	1	600
O2 min	1	CL1257	24	1050	1062.4	2.9173	2.845	27.408	34.385	34.383	1	16.5	16.1	1			44.95	43.75	1	0.00	1	150.66	146.64	1	3.12	3.04	1	7.458	1	7.329	1	2374.96	1	O2 min
400	2	CL1273	16	396	400.2	3.8575	3.830	27.023	34.018	34.015	1	43.3	42.2	1			43.39	42.25	1	0.00	1	104.06	101.32	1	2.99	2.91	1	7.444	1	7.315	1	2305.56	1	400
Chla max	2	CL1274	17	11	10.8	11.95	11.949	24.673	32.519	32.520	1	297.4	290.2	1	0.59	1	10.25	10.00	1	0.16	1	20.24	19.75	1	1.08	1.05	1	8.013	1	7.864	1	2198.02	1	Chla max
200	2	CL1276	19	198	200.3	4.207	4.193	26.821	33.811	33.808	1	99.4	96.8	1	0.01	1	38.61	37.60	1	0.00	1	77.13	75.12	1	2.67	2.60	1	7.503	1	7.371	1	2278.95	1	200
150	2	CL1277	20	149	150.6	4.5935	4.583	26.738	33.760	33.764	1	136.4	132.8	1	0.02	1	34.39	33.49	1	0.00	1	66.06	64.34	1	2.41	2.35	1	7.574	1	7.441	1	2264.92	1	150
100	2	CL1278	21	99	100.0	4.5015	4.494	26.184	33.050	33.065	1	261.5	254.8	1	0.09	1	22.70	22.12	1	0.02	1	38.40	37.42	1	1.80	1.75	1	7.765	1	7.626	1	2221.52	1	100
50	2	CL1279	22	49	49.8	5.3023	5.299	25.863	32.756	32.756	1	318.2	310.2	1	0.33	1	15.05	14.67	1	0.37	1	24.61	23.99	1	1.40	1.36	1	7.883	1	7.738	1	2198.60	1	50
25	2	CL1280	23	25	25.3	8.1889	8.186	25.377	32.619	32.635	1	319.4	311.5	1	0.47	1	13.07	12.75	1	0.15	1	24.00	23.41	1	1.31	1.28	1	7.937	1	7.791	1	2193.85	1	25
10	2	CL1281	24	11	11.4	11.9554	11.954	24.672	32.519	32.519	1	297.2	290.0	1	0.64	1	10.33	10.08	1	0.16	1	20.30	19.81	1	1.08	1.05	1	8.012	1	7.864	1	2189.02	1	10
bucket	2	CL1282				12.1				32.519	1	295.2		1	0.63	1	10.31		1	0.16	1	20.26		1	1.08		1	8.012	1	7.863	1	2191.14	1	bucket

Notes:

QF(Good=1, Questionable=4)

Time is expressed as UTC.

Position and depth are those when the deepest sample was taken.

Temp (°C) at Pressure zero was that of seawater obtained by bucket sampling.

Data marked by blue color are calculated values.

7. 5. Routine Data

Lat. 58 46.50 N Lon 144 29.82 W

Station CL12 (58°46.50'N, 144°29.82'W; Depth=3702 m); July 22, 2017, 11:58 ~ July 22, 2017, 18:01, Bottom altitude: 9.4 m)

depth	Cast No.	Sample No.	Niskin No.	Depth (m)	Pressure (decibar)	Temp. (°C) (CTD)	Pot.Temp	Sigma-th	Salinity (CTD)	Salinity (Routine)	QF	Oxygen (μmol/L)	Oxygen (μmol/kg)	QF	Chlorophyll a (μg/L)	QF
Bottom	1	CL1296	14	3653	3719.6	1.4239	1.137	27.786	34.688	34.688	1	150.0	145.9	1		
3500	1	CL1297	15	3440	3501.6	1.4522	1.187	27.777	34.682	34.680	1	140.9	137.1	1		
3000	1	CL1298	16	2951	2999.5	1.5535	1.335	27.751	34.663	34.666	1	116.0	112.9	1		
2500	1	CL1299	17	2462	2499.6	1.7044	1.529	27.713	34.633	34.631	1	87.9	85.5	1		
2000	1	CL1300	18	1973	2001.3	1.9559	1.820	27.651	34.582	34.580	1	56.4	54.9	1		
1500	1	CL1301	19	1481	1500.3	2.4468	2.345	27.528	34.481	34.481	1	24.7	24.0	1		
1250	1	CL1302	20	1234	1249.4	2.7572	2.672	27.450	34.418	34.416	1	17.8	17.3	1		
1000	1	CL1303	21	989	1000.4	3.1004	3.032	27.362	34.348	34.346	1	16.3	15.9	1		
800	1	CL1304	22	791	800.2	3.4339	3.378	27.262	34.263	34.261	1	19.1	18.6	1		
600	1	CL1305	23	594	600.7	3.772	3.730	27.148	34.164	34.165	1	22.2	21.6	1		
O2 min	1	CL1306	24	949	959.8	3.139	3.073	27.343	34.329	34.327	1	17.5	17.0	1		
400	2	CL1322	16	397	401.0	4.2271	4.198	26.949	33.974	33.973	1	48.1	46.8	1		
Chla max	2	CL1323	17	35	35.7	8.6315	8.628	25.278	32.576	32.589	1	317.7	309.9	1	1.01	1
200	2	CL1325	19	198	200.2	5.4226	5.407	26.677	33.800	33.801	1	133.8	130.3	1	0.01	1
150	2	CL1326	20	149	150.3	6.3653	6.352	26.416	33.618	33.637	1	138.2	134.6	1	0.02	1
100	2	CL1327	21	99	100.4	5.7611	5.753	25.957	32.942	33.008	1	246.0	239.8	1	0.07	1
50	2	CL1328	22	50	50.7	6.9675	6.963	25.565	32.640	32.644	1	300.5	293.0	1	0.43	1
25	2	CL1329	23	25	25.3	10.3762	10.373	25.001	32.581	32.586	1	319.0	311.2	1	0.83	1
10	2	CL1330	24	10	10.5	13.6988	13.697	24.297	32.473	32.531	1	300.1	293.0	1	0.52	1
bucket	2	CL1331				14.0				32.487	1	283.2		1	0.43	1

depth	NO3+NO2 (μmol/L)	NO3+NO2 (μmol/kg)	QF	NO2 (μmol/L)	QF	SiO2 (μmol/L)	SiO2 (μmol/kg)	QF	PO4 (μmol/L)	PO4 (μmol/kg)	QF	pH (NBS)	QF	pH (SWS)	QF	Alkalinity	QF
Bottom	37.32	36.31	1	0.00	1	170.16	165.56	1	2.55	2.48	1	7.716	1	7.594	1	2406.60	1
3500	37.96	36.93	1	0.00	1	174.33	169.62	1	2.59	2.52	1	7.697	1	7.575	1	2407.17	1
3000	39.74	38.67	1	0.00	1	181.91	177.00	1	2.71	2.64	1	7.654	1	7.534	1	2409.30	1
2500	41.48	40.36	1	0.00	1	182.08	177.17	1	2.85	2.77	1	7.602	1	7.486	1	2403.62	1
2000	43.51	42.34	1	0.00	1	177.55	172.77	1	2.98	2.90	1	7.549	1	7.433	1	2396.62	1
1500	45.26	44.05	1	0.00	1	166.20	161.75	1	3.12	3.04	1	7.469	1	7.353	1	2383.41	1
1250	45.37	44.16	1	0.00	1	156.61	152.43	1	3.15	3.07	1	7.456	1	7.341	1	2368.09	1
1000	45.33	44.12	1	0.00	1	144.95	141.09	1	3.15	3.07	1	7.441	1	7.325	1	2353.03	1
800	45.03	43.83	1	0.00	1	132.79	129.27	1	3.14	3.06	1	7.434	1	7.318	1	2336.93	1
600	44.82	43.64	1	0.00	1	118.46	115.33	1	3.09	3.01	1	7.426	1	7.310	1	2321.64	1
O2 min	45.25	44.05	1	0.00	1	143.41	139.59	1	3.17	3.09	1	7.448	1	7.332	1	2349.93	1
400	43.00	41.87	1	0.00	1	93.74	91.28	1	2.96	2.88	1	7.442	1	7.326	1	2274.10	1
Chla max	8.01	7.81	1	0.15	1	15.38	15.00	1	0.93	0.91	1	7.959	1	7.824	1	2163.98	1
200	33.52	32.65	1	0.01	1	59.36	57.82	1	2.35	2.29	1	7.584	1	7.464	1	2244.22	1
150	30.42	29.64	1	0.01	1	50.70	49.40	1	2.19	2.13	1	7.609	1	7.487	1	2240.71	1
100	19.69	19.19	1	0.02	1	30.19	29.43	1	1.62	1.58	1	7.769	1	7.642	1	2198.99	1
50	11.59	11.30	1	0.25	1	17.69	17.25	1	1.14	1.11	1	7.887	1	7.755	1	2172.72	1
25	7.17	7.00	1	0.11	1	14.90	14.54	1	0.88	0.86	1	7.985	1	7.851	1	2169.53	1
10	4.15	4.05	1	0.07	1	10.96	10.70	1	0.66	0.64	1	8.035	1	7.899	1	2165.65	1
bucket	2.36		1	0.05	1	8.54		1	0.52		1	8.056	1	7.919	1	2166.63	1

Notes:
- QF(Good=1, Questionable=4)
- Time is expressed as UTC.
- Position and depth are those when the deepest sample was taken.
- Temp (°C) at Pressure zero was that of seawater obtained by bucket sampling.
- Data marked by blue color are calculated values.

7. 5. Routine Data

Lat. 59 18.77 N Lon 144 23.97 W

Station CL13 (59°18.77'N, 144°23.97'W; Depth=2315 m); July 22, 2017, 5:17 ~ July 22, 2017, 9:21, Bottom altitude: 12.1 m)

depth	Cast No.	Sample No.	Niskin No.	Depth (m)	Pressure (decibar)	Temp. (°C) (CTD)	Pot.Temp	Sigma-th	Salinity (CTD)	Salinity (Routine)	QF	Oxygen (µmol/L)	Oxygen (µmol/kg)	QF	Chlorophyll a (µg/L)	QF	NO3+NO2 (µmol/L)	NO3+NO2 (µmol/kg)	QF	NO2 (µmol/L)	QF	SiO2 (µmol/L)	SiO2 (µmol/kg)	QF	PO4 (µmol/L)	PO4 (µmol/kg)	QF	pH (NBS)	QF	pH (SWS)	QF	Alkalinity	QF
Bottom	1	CL1345	14	2295	2329.2	1.7448	1.584	27.702	34.623	34.616	1	79.4	77.3	1			42.11	40.97	1	0.00	1	181.05	176.17	1	2.89	2.81	1	7.580	1	7.454	1	2413.48	1
2000	1	CL1349	18	1972	2000.1	1.8538	1.719	27.673	34.600	34.598	1	67.0	65.2	1			42.92	41.76	1	0.00	1	179.21	174.38	1	2.94	2.86	1	7.562	1	7.437	1	2408.72	1
1500	1	CL1350	19	1481	1500.8	2.3506	2.250	27.552	34.501	34.498	1	27.7	27.0	1			45.03	43.82	1	0.00	1	168.52	164.00	1	3.10	3.02	1	7.476	1	7.352	1	2391.64	1
1250	1	CL1351	20	1235	1250.5	2.8354	2.750	27.435	34.408	34.405	1	16.4	16.0	1			45.45	44.24	1	0.00	1	154.74	150.61	1	3.16	3.08	1	7.443	1	7.319	1	2270.66	1
1000	1	CL1352	21	989	1001.1	3.2483	3.179	27.326	34.320	34.317	1	16.9	16.5	4			45.28	44.08	4	0.00	4	140.32	136.59	4	3.16	3.08	4	7.438	1	7.314	1	2346.82	1
800	1	CL1353	22	790	799.3	3.5477	3.491	27.240	34.249	34.247	1	16.8	16.4	1			44.92	43.73	1	0.00	1	129.03	125.61	1	3.14	3.06	1	7.433	1	7.310	1	2345.99	1
600	1	CL1354	23	593	599.8	3.9372	3.894	27.106	34.131	34.129	1	23.7	23.1	1			44.51	43.34	1	0.00	1	112.65	109.68	1	3.09	3.01	1	7.414	1	7.290	1	2314.13	1
O2 min	1	CL1355	24	1064	1076.5	3.1189	3.044	27.363	34.351	34.347	1	14.9	14.5	1			45.39	44.18	1	0.00	1	145.14	141.27	1	3.16	3.08	1	7.436	1	7.312	1	2369.02	1
400	2	CL1371	16	398	401.9	4.1943	4.165	26.944	33.963	33.960	1	50.0	48.7	1			42.93	41.80	1	0.00	1	93.19	90.74	1	2.96	2.88	1	7.421	1	7.298	1	2295.53	1
Chla max	2	CL1372	17	27	27.1	10.628	10.625	24.826	32.411	32.427	1	314.7	307.1	1	1.43	1	4.56	4.45	1	0.11	1	11.75	11.47	1	0.72	0.70	1	7.989	1	7.852	1	2169.54	1
200	2	CL1374	19	198	199.8	5.9079	5.891	26.614	33.795	33.801	1	120.5	117.4	1	0.01	1	33.58	32.71	1	0.02	1	58.31	56.80	1	2.37	2.31	1	7.563	1	7.436	1	2259.92	1
150	2	CL1375	20	150	151.3	6.1629	6.150	26.096	33.179	34.394	1	197.2	192.2	1	0.02	1	23.97	23.36	1	0.02	1	39.23	38.23	1	1.87	1.82	1	7.690	1	7.562	1	2218.70	1
100	2	CL1376	21	99	100.1	6.4334	6.425	25.655	32.665	32.671	1	293.2	285.9	1	0.16	1	13.13	12.80	1	0.07	1	19.54	19.05	1	1.24	1.21	1	7.857	1	7.723	1	2181.70	1
50	2	CL1377	22	50	50.0	8.1948	8.190	25.254	32.462	32.458	1	300.9	293.5	1	1.00	1	8.52	8.31	1	0.32	1	14.53	14.17	1	0.96	0.94	1	7.924	1	7.788	1	2171.99	1
25	2	CL1378	23	25	25.2	10.8363	10.833	24.738	32.344	32.364	1	327.4	319.5	1	1.54	1	1.92	1.87	1	0.05	1	9.88	9.64	1	0.55	0.54	1	8.041	1	7.902	1	2167.13	1
10	2	CL1379	24	10	10.0	13.2414	13.240	24.268	32.316	32.297	1	300.2	293.1	1	0.83	1	0.11	0.11	1	0.01	1	7.95	7.76	1	0.38	0.37	1	8.067	1	7.932	1	2166.62	1
bucket	2	CL1380				13.9				31.689	1	286.0		1	0.38	1	0.00		1	0.00	1	7.71		1	0.33		1	8.078	1	7.936	1	2163.90	1

Notes:

QF(Good=1, Questionable=4)
Time is expressed as UTC.
Position and depth are those when the deepest sample was taken.
Temp (°C) at Pressure zero was that of seawater obtained by bucket sampling.
Data marked by blue color are calculated values.

7. 5. Routine Data

Lat. 59 33.19 N Lon 144 9.32 W

Station CL14 (59°33.19'N, 144°09.32'W; Depth=695 m); July 21, 2017, 10:20 ~ July 21, 2017, 14:55, Bottom altitude: 10.8 m)

depth

Cast No.	Sample No.	Niskin No.	Depth (m)	Pressure (decibar)	Temp. (°C) (CTD)	Pot.Temp	Sigma-th	Salinity (CTD)	Salinity (Routine)	QF	Oxygen (µmol/L)	Oxygen (µmol/kg)	QF	Chlorophyll a (µg/L)	QF
1	CL1401	21	669	676.7	3.7676	3.720	27.164	34.182	34.179	1	20.1	19.6	1		
1	CL1402	22	165	166.4	6.2146	6.201	26.113	33.209	33.202	1	196.6	191.6	1		
1	CL1403	23	594	600.3	3.903	3.860	27.103	34.123	33.534	4	23.6	23.0	1		
1	CL1404	24	397	401.4	4.2503	4.221	26.918	33.937	33.934	1	58.1	56.6	1		
2	CL1421	17	27	27.6	10.6464	10.643	24.812	32.398	32.357	1	307.5	300.1	1	1.80	1
2	CL1423	19	198	200.4	6.2658	6.249	26.345	33.511	33.497	1	158.7	154.6	1	0.02	1
2	CL1424	20	149	150.4	6.1604	6.148	26.045	33.115	33.120	1	211.0	205.6	1	0.03	1
2	CL1425	21	99	100.3	6.1768	6.168	25.683	32.660	32.660	1	268.4	261.7	1	0.03	1
2	CL1426	22	50	50.4	7.1179	7.113	25.308	32.339	32.341	1	278.0	271.1	1	0.24	1
2	CL1427	23	26	25.9	11.033	11.030	24.745	32.398	32.387	1	322.0	314.2	1	1.84	1
2	CL1428	24	10	9.9	13.5522	13.551	24.009	32.061	32.077	1	287.8	281.1	1	0.48	1
2	CL1429				13.6				32.632	1	282.2		1	0.50	1

Sample No.	NO3+NO2 (µmol/L)	NO3+NO2 (µmol/kg)	QF	NO2 (µmol/L)	QF	SiO2 (µmol/L)	SiO2 (µmol/kg)	QF	PO4 (µmol/L)	PO4 (µmol/kg)	QF	pH (NBS)	QF	pH (SWS)	QF	Alkalinity	QF
CL1401	44.20	43.03	1	0.00	1	119.83	116.66	1	3.08	3.00	1	7.425	1	7.302	1	2330.37	1
CL1402	23.33	22.74	1	0.02	1	39.06	38.07	1	1.84	1.79	1	7.698	1	7.564	1	2218.00	1
CL1403	43.79	42.63	1	0.00	1	112.45	109.48	1	3.06	2.98	1	7.420	1	7.292	1	2319.00	1
CL1404	41.52	40.43	1	0.00	1	89.35	87.01	1	2.87	2.79	1	7.448	1	7.324	1	2292.74	1
CL1421	4.86	4.74	1	0.16	1	11.98	11.69	1	0.74	0.72	1	7.988	1	7.851	1	2162.16	1
CL1423	27.93	27.21	1	0.03	1	46.31	45.12	1	2.05	2.00	1	7.638	1	7.507	1	2242.38	1
CL1424	21.94	21.38	1	0.02	1	36.23	35.31	1	1.76	1.72	1	7.716	1	7.583	1	2211.03	1
CL1425	15.07	14.69	1	0.01	1	24.44	23.83	1	1.36	1.33	1	7.809	1	7.675	1	2178.88	1
CL1426	12.77	12.45	1	0.03	1	20.09	19.59	1	1.22	1.19	1	7.851	1	7.713	1	2155.49	1
CL1427	2.53	2.47	1	0.07	1	10.53	10.28	1	0.57	0.56	1	8.036	1	7.897	1	2164.56	1
CL1428	0.01	0.01	1	0.00	1	7.38	7.21	1	0.34	0.33	1	8.085	1	7.945	1	2154.67	1
CL1429	0.00		1	0.00	1	7.26		1	0.34		1	8.087	1	7.949	1	2149.56	1

Notes:

QF(Good=1, Questionable=4)
Time is expressed as UTC.
Position and depth are those when the deepest sample was taken.
Temp (°C) at Pressure zero was that of seawater obtained by bucket sampling.
Data marked by blue color are calculated values.

8. Report of individual scientific subjects

8. 1. Seawaters

8. 1. 1. Distributions and their speciation of trace metals in the subarctic Pacific and the Gulf of Alaska during GEOTRACES section study

Taejin Kim, and Hajime Obata
Marine Inorganic Chemistry Division, Atmosphere and Ocean Research Institute, The University of Tokyo
Correspondence: obata@aori.u-tokyo.ac.jp

Distributions of trace metals in the South Pacific and Southern Ocean

Objective

Trace metals, such as Fe, Mn, Zn, Cu and Co are now thought to be essential for phytoplankton growth in the open oceans. However, large-scale distributions of trace metals have not been investigated yet in the subarctic North Pacific. To understand the controlling factors of trace metal concentrations, we need to investigate the detailed distributions of trace metals in the world ocean. In this study, we will study the distributions of dissolved trace metals (Fe, Mn, Zn, Cu, Co etc.) in the subarctic Pacific and the Gulf of Alaska, as the international GEOTRACES project.

Samples

Seawater samples for vertical profiles were collected using Teflon-coated X-type Niskin bottles mounted on a CTD/Carousel array. Filtered samples were obtained through a cleaned 0.2 μm filter cartridge (Acropak, Pall) connected to sampler directly with pressured air. Filtered samples (500mL of PE bottle) are acidified to pH<1.8 with ultra pure HCl (Tamapure AA-100) and stored. Another set of samples is also stored in 500mL of PE bottles as archive samples.

CTD sampling

Station : CL- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

Depth (m): 10, 25, 50, 100, 150, 200, 400, 600, 800, 1000, 1250, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000, 5500, Bottom

1-3) Analytical methods

Iron will be determined by a flow analytical system by using chelating resin preconcentration and ICP mass spectrometry, or cathodic stripping voltammetry (CSV) in the land-based laboratory. Manganese concentrations will be determined by a flow analytical system by using column preconcentration and chemiluminescence (CL) detection (Doi et al., 2004). Zinc will be determined by cathodic stripping voltammetry (Kim et al., 2015) in the land-based laboratory. Other trace metals will be determined by using chelating resin preconcentration and ICP mass spectrometry.

Trace metal speciation in the subarctic Pacific and Gulf of Alaska

Introduction

Trace metals, such as Fe, Cu, Zn and Co are essential micronutrients for phytoplankton in the ocean. At low concentration levels, trace metals can limit the growth of marine phytoplankton in culture. Additionally, speciation is also considered to be an important factor of the biological availability of trace metals. However, little is known about the organic complexation of trace metals in open-ocean waters. In this study, we will investigate trace metal speciation in the subarctic Pacific and the Gulf of Alaska using cathodic stripping voltammetry (CSV).

Sample

Seawater samples were collected using Teflon-coated X-type Niskin bottles mounted on a CTD/Carousel array. Filtered samples were obtained through a cleaned 0.2 μm filter cartridge (Acropak, Pall) connected to sampler directly with pressured air. Filtered samples (500mL of PE bottle) are frozen at -18°C and stored.

CTD sampling

Station :CL- 2, 4, 5, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21

Depth (m): 10, 25, 50, 100, 150, 200, 400, 600, 800, 1000, 1250, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000, 5500, Bottom

Methods

On the land-based laboratory, ligand concentrations and conditional stability constants for Zn, Cu, Fe and Co will be obtained from a titration using CSV (Ellwood et al., 2000; van den Berg, 2006; Laglera and van den Berg, 2009; Kim et al., 2015).

8. 1. 2. Thorium-230 and Protoactinium-231 in the eastern subarctic North Pacific and Gulf of Alaska

Hajime Obata, Taejin Kim, Toshitaka Gamo
Marine Inorganic Chemistry Division, Atmosphere and Ocean Research Institute, The University of Tokyo
Correspondence: obata@aori.u-tokyo.ac.jp

Introduction

Th-230 and Pa-231 are produced in seawater at a constant rate from the decay of dissolved uranium isotopes. Both are rapidly scavenged from the water column into the underlying sediments, resulting in large ^{230}Th and ^{231}Pa deficits in the water column and large excesses in the sediments. ^{230}Th is more particle-reactive with very short residence times in the water column (ranging from <1 yr in surface water to a few decades in deep water) than ^{231}Pa, which limits redistribution by horizontal transport. In contrast, ^{231}Pa, with a larger residence time in water column (up to 200 yr in deep water), is more effectively transported and scavenged in the regions with high productivity and particle flux. In this study, we will obtain the vertical profiles of ^{230}Th and ^{231}Pa, and reveal the horizontal transport process and scavenging intensity of both nuclides in the eastern subarctic Pacific and Gulf of Alaska.

Methods

Seawater samples were collected by X-Niskin samplers installed on the CTD-CMS system and filtered through 0.2 μm cartridge filter (Acropak, Pall) in a "bubble". The filtered samples were transferred into 10L polyethylene bottles and acidified with 68% HNO_3 (Tamapure AA-100, Tama chemicals). The water samples will be spiked by ^{229}Th(~50 pg), ^{233}Pa(~500fg) and will be extracted to Th and Pa fractions, respectively. These samples will be measured by Inductively Coupled Plasma-Mass Spectrometer.

Station : CL-2, 4, 5, 7, 14, 15, 16, 17, 19, 21

Depth (m): 10, 100, 200, 400, 600, 1000, 1500, 2000, 3000, 4000, 5000, Bottom

References

A.L. Thomas ea al., Earth and Planetary Science Letters 241(2006) 493-504

8. 1. 3. Iron distribution in the subarctic North Pacific -Onboard measurement for vertical section observation in the GEOTRACES program-

Jun Nishioka[1], Hajime Obata[2], Rise Bamba[3]
1. Institute of low temperature sciences, Hokkaido University,
2. Atmosphere and Ocean Research Institute, University of Tokyo
3. Graduate School of Environmental science, Hokkaido University
Correspondence: nishioka@lowtem.hokudai.ac.jp

Determining the distribution of Fe in the global ocean including the processes involved in oceanic cycles is important for understanding the biological production of ocean and its impact on the biogeochemical cycle and climate. Various Fe sources occur in the ocean such as atmospheric dust, river input, re-suspension of sediment on the shelf, glacial/sea ice melt, hydrothermal activity. To grasp all of the factors affecting the Fe distribution, sources and cycles in the Ocean Basin, extensive transect observations of the dissolved Fe were planned under the international GEOTRACES program (SCOR Working Group, 2006), and the Japanese GEOTRACES cruise in the North Pacific Ocean was carried out. Full depth water sampling for the longitudinal section profile along 47° N were conducted through the western subarctic gyre and Alaskan gyre.

Samples for dissolved iron analysis were collected from CL-1, CL-2, CL-3, CL-4, CL-5, CL-6, CL-7, CL-8, CL-9, CL-10, CL-11, CL-12, CL-14, CL-15, CL-16, CL-17, CL-18, CL-19, CL-20, CL-21 by using acid-cleaned Teflon-coated 12-liter Niskin-X bottles. The Niskin-X bottles were placed in a clean-air booth and the sample seawater was filtered through an AcroPak 200 Capsule filter unit having 0.8/0.2 micro-meter pore-size Supor Membrane (Pall) attached directly to the spigot with silicon tubing under a pressure of 1 atm by compressed clean air. Filtered seawater was collected in 125-ml LDPE bottles after rinsing 3 times. Ultrafiltration for measuring soluble Fe in the dissolved phase (soluble < 1000 kDa) (Nishioka et al., 2001) were also conducted at three stations, CL-2, CL-9, CL-16, to reveal the physical Fe form in seawater. Sample for measuring Fe(III) solubility were collected from CL-2, CL-9, CL-16. Sample for total dissolvable Fe were collected only from CL-2, CL-4, CL-16. To discuss interaction between Fe and dissolved organic matter C-DOM samples were collected from CL-2, CL-3, CL-4, CL-5 CL-6, CL-7, CL-9, CL-14, CL-15, CL-16, CL-17, CL-19.

All filtrates collected in 125-ml polyethylene bottle were then added distilled HCl and stored more than 24h. Then the samples were added 10 M formic acid-2.4 M ammonium formate buffer solution and ammonium solution to adjust pH 3.2. Concentrations of Fe (III) in the buffered samples were determined with an automatic Fe (III) analyzer (Kimoto Electric Co. Ltd.) using chelating resin (MAF-8HQ) concentration and chemiluminescence detection (Obata et al., 1993). Samples for total dissolvable Fe and C-DOM will be determined at onshore laboratory.

Our dissolved Fe measurement method and reference seawater were quality controlled by SAFe and GEOTRACES international standard seawater (S, D2, D1 and GS).

References

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Obata, H., Karatani, H., Nakayama, E., 1993. Automated determination of iron in seawater by chelating resin concentration and chemiluminescence detection. Analytical Chemistry 65, 1524–1528

8. 1. 4. Distributions of organic Fe-binding ligands and trace metals and influence of organic ligands on Fe bioavailability for natural phytoplankton communities in the subarctic Pacific Ocean

Yoshiko Kondo (onboard), Shigenobu Takeda (on land)
Graduate School of Fisheries and Environmental Sciences, Nagasaki University
Correspondence: yoshikondo@nagasaki-u.ac.jp

Introduction

Iron (Fe) bioavailability can be a significant constraint on phytoplankton growth in surface seawater. Because nearly all dissolved Fe appears to be strongly complexed with natural organic ligands, it is likely that phytoplankton have evolved various strategies to acquire Fe. At present, siderophores, porphyrin compounds, exogenous ligands, and humic substances are thought to act as marine organic ligands. However, the influence of organic ligands on phytoplankton growth is not clear.— The subarctic North Pacific is well known as a high-nitrate and low-chlorophyll (HNLC) region; Fe is thought to be an important limiting factor on phytoplankton growth in this area. During R/V HAKUHO MARU KH-17-3 cruise, distributions of organic Fe-binding ligands and trace metals (Fe, Mn, Co, Cu, Zn and Cd) are investigated to elucidate biogeochemical dynamics of Fe in the subarctic North Pacific. Furthermore, onboard bottle incubation experiments were conducted to clarify the influence of model organic ligands on natural phytoplankton growth in HNLC waters.

Methods & Future works

Distributions of dissolved trace metals and Fe speciation

Seawater samples were collected using acid-cleaned Teflon-coated 12-liter Niskin-X bottles on a CTD-Carousel system. As for organic Fe-binding ligands analyses, seawater samples were obtained from 10, 50, 100, 200, 400, 600, 1000, 2000, 3000, 4000 m depths and chlorophyll maximum, bottom and oxygen minimum layers at large stations (CL2, CL4, CL5, CL7, CL9, CL14, CL16, CL17, CL19 and CL21); at small stations (CL1, CL3, CL6, CL8, CL18 and CL20), the seawater samples were obtained from 10, 100, 200, 400 and 1000 m depths. As for trace metals analyses, the seawater samples were obtained from 10, 100, 200, 400, 600, 1000, and 3000 m depths and chlorophyll maximum and oxygen minimum layers at large stations (CL2, CL4, CL5, CL7, CL9, CL14, CL16, CL17, CL19 and CL21); at small stations (CL1, CL3, CL6, CL8, CL18 and CL20), the seawater samples were obtained from 10, 200 and 1000 m depths. After the recovery of Niskin-X bottles, these bottles were placed in a clean-air booth and the sample seawater was filtered through an AcroPak 200 Capsule filter unit having 0.2 μm pore-size Supor Membrane (Pall) attached directly to the spigot with silicon tubing under a pressure by compressed clean air. Filtered seawater collected in acid-cleaned 500-ml FLPE bottles were stored frozen under –20ºC for analysis of iron-complexing organic ligands in the onshore laboratory. Filtered water samples for analyses of dissolved trace-metals (Mn, Fe, Co, Ni, Cu Zn and Al) were collected in acid-cleaned 125-ml LDPE bottles and acidified to pH <1.7 with 20% quartz-distilled HCl (TAMAPURE AA-100). Filtered seawater samples were also collected into 30-ml amber-glass vials and stored frozen under –20ºC for the 3-D fluorometrical analysis of F-DOM.

The acidified water samples will be stored for more than three months, and then analysis of trace-metals (Mn, Fe, Co, Ni, Cu and Zn) concentration will be done by an automated, on-line extraction, flow-injection ICP-MS method (Lagerström *et al*. 2013). Concentrations of natural Fe-complexing organic ligands will be measured by competitive ligand exchange-cathodic stripping voltammetry using the salicylaldoxime (SA) (Abualhaija and van den Berg, 2015) and/or 2-(2-thiazolylazo)-*p*-cresol (Croot and Johansson, 2000) as the competitive ligands. Speciation of Fe (III) will be estimated from measured concentrations of total dissolved Fe and Fe-binding organic ligands, and these conditional stability constants.

Influence of model Fe-binding ligands on natural phytoplankton communities

Bottle incubation experiments were conducted at stations CL2 and CL16. Unfiltered seawater was collected in two 20-L polycarbonate containers (Nalgene) from the 10-m depth at which the light intensity was ~50 % of the incident light at the sea surface. These containers were covered with black plastic bags and gently shaken to homogenize the seawater inside. The seawater was then poured into 250-mL polycarbonate bottles through 250-µm Teflon mesh to remove mesozooplankton and other large particles. All polycarbonate containers and Teflon meshes were acid-cleaned before the experiment. Iron or Fe-binding model ligand was then immediately added to the 250-mL polycarbonate bottles as described in Table 8. 1. 4. 1. We used desferrioxamine B, hemin, gallocatechin, glucuronic acid and Suwanee River fluvic acid standard (IHSS) as models for siderophores, tetrapyrrole-type cell breakdown ligands, catechol-type ligands, saccharides and humic substances, respectively, to compare their effects with those of inorganic Fe on the natural phytoplankton communities. The incubation bottles were placed in an onboard tank and covered with mesh screens so as to reduce the incident light irradiance to 50 % of its value at the surface water. Each treatment was performed in triplicate. Samples for the analyses of size-fractionated chlorophyll *a* concentrations (>10 µm, ≤10 µm), nutrient concentrations (nitrate+ nitrite, phosphate and silicic acid), and cell densities of pico- and nanophytoplankton were obtained from the incubation bottles at the beginning of the experiment and 1, 3, 5, and 7 days later. Seawater samples for microscope observation were also collected from the incubation bottles at the beginning and end of the experiment. An acidic Lugol's iodine solution was added to the samples (5%) and kept in a cold store.

For the analysis of size-fractionated chlorophyll *a*, water samples were filtered through 10-µm filters (Millipore) and GF/F glass fiber filters (pore size: 0.7 µm, Whatman). The filters were put into 6-mL N,N-dimethylfolmamide and kept in the dark over 24 h at -20^{o}C for extraction. Chlorophyll *a* concentrations were determined by a Turner Designs Model 10-AU fluorometer with the non-acidification method (Welshmeyer 1994). Seawater samples for the determination of nutrient concentrations (nitrate+nitrite and phosphate, silicic acid) were frozen at -20^{o}C immediately after sampling. These samples will be analyzed by an auto analyzer. The seawater samples for cell density of pico- and nanophytoplankton will be analyzed by flow cytometer. The quantitative phytoplankton analysis using a microscope will be performed following Uermohl method (Edler and Elbrachter, 2010).

Table 8. 1. 4. 1. List of incubation treatments.

Treatment	Fe	Model ligand
Control		
Inorganic Fe	2 nM	
Desferrioxamine B – Fe complex	2 nM	20 nM
(-)-Gallocatechin – Fe complex	2 nM	20 nM
Glucuronic acid – Fe complex	2 nM	20 nM
Hemin		2 nM
Suwanee River fuluvic acid – Fe mixture	2 nM	0.2 mg/L

Wet deposition of macro- and micro-nutrients

Wet deposition samples were collected using a collector with a 30 cm i.d. acid-cleaned plastic funnel into acid-cleaned 250 ml FLPE bottles. The collector was set up at the front of the compass deck and the funnel was opened only under the against wind condition during the cruise. Collected samples were frozen under –20ºC for onshore analysis of nutrients (inorganic/organic N), major ions and total Fe.

Water-soluble nutrients in wet deposition samples will be determined using a continuous flow analyzing system (AACS IV, BLTEC). Water-soluble total nitrogen will be analyzed by a $NO/NO_2/NO_x$ analyzer (Yanaco ECL-880US) attached to a total organic carbon analyzer (Simadzu, $TOC\text{-}V_{CSH}$), and amounts of organic nitrogen will be estimated from the differences between total and inorganic nitrogen concentrations. Major anions and cations in the samples will be analyzed by an ion chromatography.

8. 1. 5. Distribution of suspended solids and suspended particulate matter in the subarctic North Pacific

Kai Maruyama[1], Yuna Matsubara[1], Kazuhiro Norisuye[2], Hideki Minami[3], Toshitaka Gamo[4], Hajime Obata[4]
[1] Graduate School of Environmental Science and Technology, Niigata University
[2] Department of Environmental Science, Niigata University
[3] School of Biological Sciences, Tokai University
[4] Atmosphere and Ocean Research Institute, The University of Tokyo
Correspondence: knorisue@env.sc.niigata-u.ac.jp

Objective In the ocean, various kinds of particles exist, for example, mineral particles transported from the atmosphere, rivers and sediments, anthropogenic particles and particles produced in seawater through biological activities and chemical reactions. Thus the chemical compositions and size of suspended particles in seawater depend on their origins. By studying the chemical composition of suspended particles in seawater, we may understand the origin and the feature of suspended particles and water masses containing them. Also, suspended particles are thought to play important roles in oceanic biogeochemical cycles, e.g., biological pump for carbon and trace elements. During this cruise, we have collected water samples and filtered them to obtain particulate samples, which will be used for investigation of the chemical compositions of suspended particles in the subarctic Pacific and the Gulf of Alaska.

Sampling and Filtration Seawater samples were collected using Niskin-X samplers mounted on the CTD-CMS at most of stations. Upon retrieve, the samplers were shaken gently several times in order to homogenize particle distribution inside the sampler (according to the recent GEORACES protocol) and then collected to acid-cleaned duplicate 4-L low density polyethylene bottles for suspended particulate matter (SPM) and 5-L polyethylene cubic bags or 1-L polyethylene bottles depending on the sample size for total suspended solids (SS). The samples were filtered as followings:

(1) Total suspended solids (SS) for microscopic analyses

Water samples (100–6000 mL) were filtered through 25 mm diameter 0.4 µm porosity Nuclepore filters by aspiration at pressure values of 0.07~0.08 MPa. The filters were rinsed with ultra-high purity water (Milli-Q water), packed in a petri-slide and stored at low temperature laboratory (No. 10 Lab).

(2) Suspended particulate matter (SPM) for trace elements analyses

Seawater samples (8 L) were filtered through 47mm diameter 0.2 µm porosity Supor filters set on a Sartorius filter assembly system constructed in clean space where HEPA filtered air was supplied. Pressure values of 0.07~0.08 MPa were adopted for the filtration. The filter samples were misted with small volume of ultra-high purity water in order to remove sea-salt. The Supor filters were packed in a Petri-slide and stored at –20˚C (sample store of No. 7 Lab).

Analyses The shape and size of particles will be observed with the Scanning Electron Microscope (SEM) and the chemical composition of particles will be analyzed with Energy Dispersive Spectroscopy (EDS) or Electron Probe X-ray Micro Analyzer (EPMA) in the land-based laboratory. The Supor filter samples will be acid-digested in a Teflon vessel and trace metals in the solution will be determined with ICP-MS.

8. 1. 6. Sectional distribution of lead and lead isotopic ratios in the subarctic North Pacific

Yuna Matsubara[1], Kai Maruyama[1], Kazuhiro Norisuye[2], Toshitaka Gamo[3], Hajime Obata[3]
[1] Graduate School of Environmental Science and Technology, Niigata University
[2] Department of Environmental Science, Niigata University
[3] Atmosphere and Ocean Research Institute, the University of Tokyo
Correspondence: knorisue@env.sc.niigata-u.ac.jp

Objective Lead isotopes have been introduced to the oceans from various anthropogenic sources, such as industry and by combustion of leaded fuels for more than a century. These sources have characteristic isotopic ratios (e.g., $^{206}Pb/^{207}Pb$, $^{208}Pb/^{207}Pb$) and the changes in Pb isotopic ratios through time are available from coral record. Therefore, variations in Pb isotopic ratios in the oceans can be characterized and will provide knowledge about contributions from various anthropogenic sources and pathways to the oceans. They will provide valuable constraints on a range of ocean processes and will also be useful for prediction of the response of the oceans to changes in environments. During this cruise, we have collected water samples to reveal the sectional distribution of Pb isotopes (concentrations and isotopic ratios) in the subarctic North Pacific.

Sampling and Analyses Seawater samples were collected at most of stations. Water samples were filtered through an AcroPak cartridge filter (Pall Life Sciences) by the pressure of compressed air and transferred from Niskin-X bottles to 2-L rectangular polyethylene bottles (HDPE, Nalge) in a clean area, constructed in the No.7 Lab. All the filtered samples were acidified with 20% HCl (Tamapure AA-100, Tama chemicals) in the same space. On land, Pb isotopes will be purified by chelating resin column and measured by multiple collector ICP-MS.

8. 1. 7. Sectional distribution of dissolved bismuth in the subarctic North Pacific

Kazuhiro Norisuye[1], Tsubasa Arai[2], Kai Maruyama[2], Yuna Matsubara[2], Toshitaka Gamo[3], Hajime Obata[3]
[1] Department of Environmental Science, Niigata University
[2] Graduate School of Environmental Science and Technology, Niigata University
[3] Atmosphere and Ocean Research Institute, the University of Tokyo
Correspondence: knorisue@env.sc.niigata-u.ac.jp

Objective Volcanic aerosols, and snow and ice samples suggest that bismuth (Bi) is introduced to the global atmosphere and oceans predominantly from human and/or volcanic activities. These sources together with a very short oceanic residence time of Bi indicate that this element is a unique tracer for the input of volcanogenic and/or anthropogenic materials to the surface oceans and also for water masses in upper layer. However, the number of data in the open ocean is scarce and little is known about the global geochemical cycle of this element. During this cruise, we have collected water samples to reveal the sectional distribution of Bi in the subarctic North Pacific.

Sampling and Analyses Seawater samples were collected at most of stations. Water samples were filtered through an AcroPak cartridge filter (Pall Life Sciences) by the pressure of compressed air and transferred from Niskin-X bottles to 250-mL low density polyethylene bottles (LDPE, Nalge) in a clean area, constructed in the No.7 Lab. All the filtered samples were acidified with 20% HCl (Tamapure AA-100, Tama chemicals) in the same space. On land, Bi will be purified by chelating resin column and measured by sector-field ICP-MS.

8. 1. 8. Determination of platinum group elements (PGEs) in seawater in the Pacific Ocean

Asami Mashio
University of Shizuoka
Correspondence: a-mashio@u-shizuoka-ken.ac.jp

Objective

Anthropogenic platinum group elements are increasingly emitted and spread into the environments according to recent industrial uses for example automobile catalysis and anticancer drugs. However, only few data have been reported on platinum group elements in the oceanic environments. In this study, we will investigate dissolved Pt and Pd concentrations in seawater of the Pacific Ocean.

Method

Onboard

Seawater samples for vertical profiles were collected using X-type Niskin bottles mounted on a CTD/Carousel array. Seawater from Niskin bottle was passed through the 0.2 µm-pore size capsule filters, Acro Pak200 (Pall), with compressed air in the Bubble. They are acidified to pH<1.8 with ultra pure HCl in the Bubble and carried to the laboratory for analysis.

The seawater samples for PGEs determination were collected at Large Stations.

Depth (m): 10, 50, 100, 400, 600, 800, O_2 minimum, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000, Bottom

After the cruise

Using isotope dilution ICP-mass spectrometry (ID-ICPMS), platinum in seawater will be determined (Suzuki et al., 2014). After adding ^{192}Pt spike and ^{105}Pd spike, Pt and Pd will be preconcentrated with anion-exchange resins. Concentrated samples will be measured using a quadrapole inductivity coupled plasma mass spectrometer. The concentrations of these elements are calculated by the measured isotopic ratios using the equation for isotope dilution method.

8. 1. 9. Distribution of trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb, Zr, Hf, Nb, Ta, Mo, and W) and their isotopes (Ni, Cu, Zn, and W) in seawater

Shotaro Takano, Zheng Linjie, Makoto Tsujisaka, Yuriko Tanaka, Tomoharu Minami, Yoshiki Sohrin
Institute for Chemical Research, Kyoto University
Correspondence: shotaro@inter3.kuicr.kyoto-u.ac.jp

Introduction and Objectives Trace metals in seawater play important roles as micronutrients and geochemical tracers. In order to understand the biogeochemical cycles of trace metals, it is important to reveal their distribution. Furthermore, their isotopic data will add new insights. We have developed multi-elemental determination of trace metals in seawater based on preconcentration by solid phase extraction with chelating resins and detection by inductively coupled plasma mass spectrometry (ICP-MS; Firdaus et al., 2007; Sohrin et al., 2008; Minami et al., 2015; Takano et al., 2017). In this cruise, we will reveal the distribution of bioactive trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb) and incompatible trace metals (Zr, Nb, Mo, Hf, Ta, and W), and isotopic distribution of Ni, Cu, Zn, and W in the subarctic North Pacific Ocean.

Methods Seawater samples were collected using the clean CTD sampling system with Niskin-X bottles. Filtered samples were passed through an AcroPak cartridge filter (Pall Life Sciences) by the pressure of compressed air and transferred to 250 mL LDPE bottles (Nalge) for bioactive trace metals and incompatible trace metals, 1 L LDPE bottles for Ni, Cu, and Zn isotopes, 5 L cubic containers (Asone) for W isotopes. Unfiltered samples for bioactive trace metals and incompatible trace metals were transferred from the Niskin-X bottles to 250 mL LDPE bottles using a silicon tube with a bell. The bottles were carried into a clean booth constructed in the No.7 Lab. The samples were acidified with HCl (Optima grade, Thermo Scientific) for bioactive trace metals, with a mixture of HF-HCl (Tamapure AA-10 and AA-100) for the incompatible trace metals, or with HCl (Ultrapur 100, Kanto chemicals) for Ni, Cu, Zn, and W isotopes.

The target metals are going to be preconcentrated by solid phase extraction using chelating resins. The concentration of trace metals will be determined by ICP-MS. The isotopic composition will be measured by multi-collector ICP-MS.

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8. 1. 10. Development of sea surface salinity proxy: Seawater Ba concentration and its isotopes and oxygen isotopes in the Gulf of Alaska

Keiji Horikawa
Graduate School of Science and Engineering for Research, University of Toyama
Correspondence: horikawa@sci.u-toyama.ac.jp

Introduction and objectives

Salinity is the principal oceanographic information as well as seawater temperature. In the Gulf of Alaska, salinity is strongly related to the glacial-melt water input from the Alaskan mountain ranges, and therefore salinity changes in this region are believed to be sensitive to mountain glacier evolution related to climate changes.

Today, the Gulf of Alaska receives a large amount of glacial-melt water from the Alaskan mountain ranges, leading to high productivity (including fishes) due to high nutrient input to the coastal region although high freshwater supply (i.e., stratification) and high sediment load are considered to suppress marine productivity. A question is whether productivity response in the Gulf of Alaska is linearly controlled by salinity changes or not. If there is not any relationship between salinity and productivity, what is determinant factors for marine productivity in the Gulf of Alaska?

To answer this question, we will reconstruct salinity, temperature, productivity (bacteria, phytoplankton, environmental DNA), sediment load (flux), and sediment provenance based on microbiological and geochemical analyses of sediments. Using seawater samples, we are trying to develop Ba-based paleo-sea surface salinity proxy. Previous studies have pointed out that the seawater Ba concentration in estuaries and coastal waters shows an inverse correlation with salinity due to higher supplies of riverine-derived Ba to the coastal waters. Further, Ba isotopes are also thought to be related to salinity changes. Therefore, in this study we address development of these two salinity proxies in the Gulf of Alaska. By applying this SSS-proxy to the sediment cores obtained at CL12 and CL14, I will reconstruct sea surface salinity changes in the past (for the last 15 kyr) and conduct other geochemical and microbiological analyses to argue that what is determinant factors for marine productivity in the Gulf of Alaska.

Inventory information for the sampling

The seawater samples for Ba isotopes were collected at 10, 50, 100, 200, 400, 600, 1000, 2000, 3000, 4000, bottom by clean Niskin bottles. The $\delta^{18}O$ samples were taken at surface, 10, 25, 50, 100 m, in addition from 150, 200, chl-a max, 400, O_2 min, 600, 800, 1000, 1250, 1500, 200, 2500, 3000, 3500, and bottom at some stations by normal Niskin bottles. Seawater samples for environmental DNA were collected at 10 m and bottom layers, and at CL14 we got additional samples from 50, 100, 200, and 400 m. For sediment core samples, the sample list can be seen in the chapter *Sediment core samples*.

Analysis and method

The Ba concentration will be measured by isotope dilution method by using a ICP-MS (HP4500). Ba isotopes will be measured by using a TIMS at Kochi Core Center after chemical separation of Ba.

Anticipated results and work plan

We have worked on development of Ba/Ca-Salinity relationship in the ECS for the paleo-salinity reconstruction from planktonic foraminifera. Based on the data obtained by KH13-4 (July), KS15-6 (July), KH15-3 cruises, we already confirm that planktonic foraminiferal Ba/Ca ratios in the proximal areas of the Changjiang Diluted Water represent relatively higher Ba/Ca ratios, suggesting that Ba/Ca ratio in sedimentary foraminifera test in the ECS will provide information on past salinity in the ECS (Horikawa et al., 2015 PEPS). We will reinforce usefulness of Ba-based salinity proxy in other oceanic regions. We hope Ba isotopes can be also used as a salinity proxy in the Gulf of Alaska.

Data Archive

All of the raw and processed data from the KH-17-3 cruise will follow the General rules of

Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

8. 1. 11. Chemical speciation of selenium in the north Pacific Ocean

Yuki Fukuda[1] , Naoki Tsuji[1] and Yuzuru Nakaguchi[1,2]
1. Graduate School of Science and Engineering Research, Kindai University
2. Department of Chemistry, School of Science and Engineering, Kindai University
Correspondence: nakaguch@chem.kindai.ac.jp

Purpose

Selenium exists as three chemical forms such as selenite, selenate and organic selenium. Selenium speciation studies have been examined in estuaries, coastal waters and open seas. The speciation of and recycling of selenium in the North Pacific Ocean are still not well known. The purpose of this research cruise is making of the cross-sectional distribution of three selenium species in the north Pacific Ocean.

Sampling and Method

Seawater samples were collected by 12 L Teflon-coated Lever-action Niskin Bottles mounted on a 24-position Sea-Bird's 911 plus CTD-rosette, hung from a titanium-armored cable. The Niskin bottles were pre-cleaned successively with distilled HCl and deionized water. After collection, the water samples for selenium speciation were filtered.

Determination of selenite: A 30-ml sample of filtered water was placed into a 100-ml glass beaker, and 5 ml of 0.1% 2,3-diaminonaphthalene (DAN, Nacalai Tesque Co. Ltd.) -0.1M hydrochloric acid solution and 0.5 ml of 0.1 M ethylenediaminetetraacetic acid-sodium fluoride (EDTA-NaF, Kishida Kagaku Co. Ltd.) solution were added to ask any interfering metal ions. The sample solution was adjusted to pH 1 with 6 M hydrochloric acid, and was warmed at 50°C for 20 min. After cooling, the solution was transferred to a separating funnel and was mechanically shaken with 5 ml of cyclohexane for 10 min. The piaselenol in the cyclohexane was determined by HPLC (high performance liquid chromatography) with a fluorescence detector at Ex. 375nm / Em. 520nm. The detection limit (S/N=2) of the DAN-HPLC method was 1 pM. Determination of selenate: The selenate amount was calculated by subtracting the selenite amount from the summed selenite and selenate amount, which was obtained by the following reduction procedure. A 20-ml filtered water sample was placed into a 100 ml Erlenmeyer flask, and the acidity of the sample solution was adjusted to 1.2 M hydrochloric acid solution. After 2.0 g of potassium bromide was added, the flask was placed in a water bath and the solution was warmed at 85~90°C for 25 min. After cooling, the amount of reduced selenate and selenite in the solution was determined by HPLC. Determination of organic selenide: The amount of organic selenide was estimated by subtracting both the selenite and selenate from the total amount of selenium, which was determined after wet-ashing decomposition with conc. nitric and 60% perchloric acid (analytical grade), followed by HPLC

8. 1. 12. Mercury (Hg) distribution and air-sea exchange of Hg in a subarctic region of North Pacific Ocean and Gulf of Alaska

Kohji Marumoto[1], Akinori Takeuchi[2]
1. National Institute for Minamata Disease
2. National Institute for Environmental Studies, Japan
Correspondence: marumoto@nimd.go.jp

Introduction and objectives

In recent years, there have been increased concerns about environmental risks in relation to mercury (Hg) in the environment. Humans are mainly exposed to methylmercury (MeHg) because of consumption of fish and fish products. It is well known that MeHg is produced by the in situ methylation of inorganic Hg in aquatic environments and biomagnified in fish through the food web. However, MeHg production in seawater and bio-magnification processes of MeHg are still unclear. In particular, the data on intake of total Hg and MeHg into planktons that is the first stage of the food web in aquatic environments are currently very limited. In addition, East and Southeast Asia contributes approximately 50% of the global total anthropogenic mercury emissions and the Asian atmospheric Hg are easily transported to North Pacific region by a prevailing temperate westerly wind. With regard to the Hg pollution, present-day concentrations of Hg in North Pacific Ocean must be determined. Thus, seawater, planktons, and sediments were sampled at all stations in this cruise, and atmospheric Hg was also continuously monitored.

Sampling and Analysis

Seawater

Approximately 2.0 L of the seawater at assigned depths were sampled at all stations and were filtered using 0.20 μm of an Acro-Pack filter just after their samplings. Sampling containers are all acid-cleaned Teflon bottles. The sample bottles and other materials were prepared based upon US EPA Method 1630 and 1631. Approximately 400 pre-washed Teflon bottles by nitric and hydrochloric acid were prepared. Approximately 200 pre-baked Hg gold traps were on-board.

The filtered seawater samples were divided into two or three aliquots. Approximately 800 mL of the samples were collected for MeHg analysis and 4 mL of high purity H_2SO_4 was added to each sample. Approximately 80 mL of the filtered samples were preserved for total Hg analysis and 0.125 mL of high purity concentrated H_2SO_4 was added to each bottle. They were stored in a cool room. In addition, 500 mL of the samples were transferred into a custom-made Teflon bubbler and dissolved gaseous Hg (DGM) in the seawaters were trapped on a gold coated Hg collection tube by N_2 purging and were measured on shipboard using a dual amalgamation-CVAFS system (RA-FG+; Nippon Instruments Corporation). Unfiltered surface seawater samples were also collected by a custom-made Teflon sampler for analyzing total Hg, MeHg and DGM. All of the collected samples will be analyzed based upon a modified US EPA method 1631 for total Hg concentration and a hybrid method with EPA method1630 and Mercury Analysis Manual by the Ministry of the Environment, Japan for MeHg concentration.

Atmospheric gaseous Hg and Hg emission/deposition flux

Atmospheric Hg were continuously monitored using two-type of continuous Hg monitors at the upper deck (AM-4 and AM-5; Nippon Instruments Corporation). The AM-4 is atmospheric Hg monitor with a cold vapor atomic absorption spectrometry (CVAAS) detection, whereas AM-5 is also atmospheric Hg monitor with CVAFS detection. We checked their performance by comparison with their monitoring data because there is a possibility that swing and vibration of research vessels during their cruise affects the Hg monitor with CVAAS detection. To obtain the data of Hg emission/deposition flux across air-sea surface, atmospheric Hg at the middle deck and DGM in surface seawaters were also measured during the cruise. The gaseous Hg in air were sampled in gold traps at 0.5 L/min for 20 minutes.

Planktons

Plankton samples were collected by vertical tows of a net with a mesh size of 100 μm from less than 200 m in depth. Concentrations of total Hg and MeHg will be determined.

Sediments

Sediment cores were collected by a multiple core sampler. Length of the collected cores range from 20 to 30 cm. Each core was sliced by a plastic slicer and mold with 1 cm in thickness in the first 5 cm and sliced with 2 cm in thickness. Each sample was put in a plastic bag and kept in frozen.

Anticipated results and work plan

This will be the first Hg data in a subarctic region of North Pacific Ocean. In this cruise, we have already found that DGM concentrations were higher in deep and intermediate waters than in surface water. According to the number of studies about Hg concentrations in the other oceanic environment, it is expected that MeHg concentrations are also higher in deep and intermediate seawaters. Total Hg and MeHg in all samples including seawaters, planktons and sediments will be measured in our laboratory.

Data Archive:

All of the raw and processed data from the KH-17-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

8. 1. 13. Application of actinides and ^{129}I as a multi oceanographic tracer isotope in the North Pacific Ocean

Sakata Kohei[1, 2], Keita Sekiguchi[3], Karin Hain[4], Sakaguchi Aya[2]
1. National Institute for Environmental Studies
2. The University of Tokyo
3. University of Tsukuba
4. University of Vienna
Correspondence: ayaskgc@ied.tsukuba.ac.jp

Introduction

Anthropogenic radioisotopes have been spread over the world as a result of the human nuclear activity such as nuclear testing, nuclear power and medical treatments. These anthropogenic nuclides in the environment have different chemical/physical characters and isotopic compositions depending on their origins. Thus, the effective usage of the anthropogenic nuclides can give information on environmental dynamics spatially and temporally.

Due to recent improvements in instrumentation and chemical pretreatments, ultra-trace long-lived radionuclides are becoming to be measured easily using Accelerator Mass Spectrometry (AMS) (Steier et al., 2008). Actually, ultra-trace long-lived exotic radionuclides, which could be measured with AMS, have been used for the field of oceanography, and gives the new understanding on the water circulations for the study area.

The research done in the frame of this cruise mainly focuses on establishing/using the ultralow level of anthropogenic isotope ^{237}Np as a new oceanographic tracer, that help in explaining water circulation processes in the North Pacific Ocean, together with the usage of previously established tracers: ^{236}U, ^{239}Pu and ^{129}I.

Methods and sampling

Water samples: Seawater samples were taken at the sampling stations (CL-2, CL-5, CL-7, CL-9, CL-14, CL-15, CL-16, CL-17, CL19, and CL-21) by using large volume (LV) water sampling system. The sampling volumes for actinides were 5 L for water from shallow (0-1500 m) depths and 20 L for deeper layers at the stations (CL-12. CL-5, CL-7, CL-9, and CL19). As for stations (CL-14, CL-15, CL-16, CL-17, CL-21) 5 L of seawater samples were collected from all depths. Additionally, 50 mL of seawater were sampled for analysing the ^{238}U concentration in seawater at each depth.

In LV sampling, the seawater samples were filtrated with a cartridge-filtration system. 20 L samples taken from the CL-7 and CL-9 were treated directly on the ship by making fresh MnO_2 for co-precipitation of actinides. This precipitate was collected into 250 mL bottles for the following treatment in the laboratory. The chemicals used in this procedure were of EL grade.

Five litres and 20 L of seawater samples obtained from all sampling points, except CL-7 and CL-9, were taken to the laboratory without special treatments in order to leave the possibility of using a new method in the sample preparation.

At the CL-2, CL-5, and 19, 0.5L of seawater samples from all depths were collected for ^{129}I measurements.

Treatment and measurement (laboratory)

Actinides

The large volume seawater samples (5 and 10 L) are treated by adding Fe carrier and adjusting pH to pH=2 with concentrated HCl. Then, the samples are heated to 80°C during 3 hours and ammonia solution was added to form $Fe(OH)_3$ precipitate in which actinides are co-precipitated. This precipitate was collected by centrifugation. Some kinds of resins, such as UTEVA and TRU, are used to purify uranium, neptunium and plutonium from the $Fe(OH)_3$ precipitates. Purified uranium, neptunium and plutonium are prepared as Fe oxide cathode target for the measurements with AMS. The ^{238}U concentration is measured directly with the acidified seawater samples using an ICP-MS in high-matrix mode.

Iodine isotopes

As for ^{129}I in seawater samples, the $^{129}I/^{127}I$ ratio can be tremendously low ($<10^{-12}$). We will attempt to construct the carrier free method for seawater samples with AMS measurement. Then the appropriate method will be applied to the sampled seawater, and $^{129}I/^{127}I$ ratios in seawater samples will be determined. The ^{127}I concentration is measured directly from seawater samples using an ICP-MS in high-matrix mode.

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8. 1. 14. Size-fractionated particulate trace metal composition and Zn isotopic composition in the subarctic North Pacific Ocean

Wen-Hsuan (Daniel) Liao
Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan
Earth System Science Program, Taiwan International Graduate Program, Academia Sinica, Taipei, Taiwan
Correspondence: wsliao@earth.sinica.edu.tw, swl766@gmail.com

Introduction and objective:

Particles play fundamental roles on regulating material cycling in the ocean through many coupling processes, including adsorption and desorption, aggregation and disaggregation, dissolution and precipitation, suspension and sinking, and biological assimilation and microbial remineralization. It is thus necessary to study particle dynamics to comprehensively understand the mechanisms of material cycling in the ocean. Compared with the quickly increasing datasets of dissolved trace metal distribution globally, the knowledge of particulate trace metal distribution we have learned is still limited, particularly in the Pacific Ocean. In this cruise across subarctic North Pacific Ocean (SNPO), our study on trace metal composition of size-fractionated particles shall provide critical and essential understanding for the role of particles on trace metal cycling in the ocean.

The recent study of Nishioka and Obata (2017) on Fe has provided useful background information to study trace metal cycling in the SNPO. In addition, the studies in the North Atlantic Ocean and the eastern tropical South Pacific Ocean have shown measurements of trace metal isotopes become promising tools to identify the sources and to trace the regulating mechanisms across the oceanic basins (Conway and John 2014a, 2014b; John et al. 2017). In this study, I will measure not only size-fractionated particulate concentration but also Zn isotopic composition to study trace metal cycling processes and to identify their sources across the whole SNPO. Collaborating with Dr. Shotaro Takano in Kyoto University, dissolved Zn isotopic composition will also be measured at the same sampling stations.

Coupling dissolved and particulate trace metal distributions, elemental and isotopic compositions, I anticipate that a comprehensive view of trace metal cycling processes will be well obtained across the whole SNPO. Furthermore, the whole Zn cycling processes and Zn sources across the whole SNPO would be well constrained.

Materials and Methods:

Large volume sampling:

I collected three size-fractionated particulate fractions (0.2~10, 10~60, >60 μm) in this cruise. The filtration apparatus used here is a gravitational gentle filtration device. This trace metal clean filtration device equipped with 60 and 10 μm aperture changeable Nitex nets in sequence to gently collect the suspended particle samples with diverse sizes (Liao et al. 2017). The sampling procedures and the filtration device are described in details in my recent paper (Liao et al. 2017). Thirty-six to forty-eight liters of seawater were used to pass through the filtration device depending on the sampling arrangement. Subsequently, roughly five to ten liters of seawater filtered through the 10 μm net was also collected for collecting the 0.2-10 μm fraction. The 10 μm polycarbonate membrane (Millipore) was used for collecting the 10~60 and >60 μm fractions; the 0.2 μm polyethersulfone membrane (Sterlitech) was used for collecting the 0.2~10 μm fraction. After filtration, all the membranes with particles were quickly rinsed and misted with Milli-Q water three times to remove seawater residue to decrease the interference of sea salts on trace metal analysis. Then all the membranes were immediately sealed in 7mL Teflon vials, bringing back to the laboratory. The detail sampling information is shown in Table 8. 1. 14. 1.

Analytical methods:

Back to the trace metal clean laboratory, the membranes with the particles will be leached/digested with 5 mL 8 N HNO_3 and 2.9 N HF mixture in the Teflon vials at 120°C on a hot plate for 12 hrs. After digestion, I will use Milli-Q water to rinse the membrane to remove the residue liquid. All of the elements will be analyzed by a sector field ICP-MS Element XR (Thermo Fisher Scientific), which is executed with a SC-Fast autosampler (Elemental Scientific). Dry plasma mode will be used to reduce oxide and hydride interferences through an Apex HF-Spiro membrane desolvation device (Elemental Scientific). More details for testing the precision, accuracy, and detection limit of the method for marine particles analysis were described by Liao et al. (2017). After digestion and concentration measurement, I will use anion exchange resin, AG-MP1, to purify Zn. The anion-exchange procedure is modified from the previous study (Takano et al. 2017), I will only collect Zn in this study. Double spike technique (^{64}Zn-^{67}Zn) will be used in this study to obtain Zn isotopic composition. Isotopic analysis of Zn will be performed on a Thermo Finnigan Neptune plus MC-ICPMS at medium mass resolution. More details for isotopic analysis were modified from and described by Takano et al. (2017). Over half a year period, on a Neptune plus in Institute of Earth Sciences, Academia Sinica, the δ^{66}Zn of IRMM-3702 standard gave +0.28±0.04 ‰ relative to JMC Lyon (2SE, n=124).

Anticipated results and work plan:

Working with Japanese colleagues, the first size-fractionated particulate trace metal distribution and Zn isotopic composition will be determined first. By the end of this year, I plan to finish the measurement of trace metal concentration for all the particulate samples collected. I except to finish the measurement of isotopic composition of the samples in 2018.

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Table 8. 1. 14. 1. The sample list of KH17-3 Leg. 2

	Leg 2	
Station	CL11	CL14
Depth (m)	10	10
	18	31
	100	100
	400	166
	1030	400
	1500	682
	2500	
	3846	

8. 1. 15. Distributions of Nd isotopic composition and REE concentrations in the North Pacific Oceans

Hirofumi Tazoe[1], Takuji Hara[2], and Hajime Obata[2]
[1] Institute of Radiation Emergency Medicine, Hirosaki University
[2] Atmosphere and Ocean Research Institute, University of Tokyo
Correspondence: tazoe@hirosaki-u.ac.jp

Introduction

Nd isotopic composition ($^{143}Nd/^{144}Nd$), one of the useful isotopic tracers in geochemistry, is frequently utilized in the field of marine chemistry, because water masses show characteristic values reflecting the geology of Nd source area. Since the mean residence time of Nd is relatively shorter than deep water circulation, the less homogenized isotopic composition of Nd ($^{143}Nd/^{144}Nd$) is expected to be a strong tracer for water masses, as well as relative abundance of REE concentration (normalized REE pattern). In this cruise, we will determine the vertical distribution for Nd ICs and REE concentrations in the South Pacific and Antarctic Ocean.

Methods

Vertical profiles of Nd isotopic composition

Seawater samples for vertical profiles of Nd IC were collected using a large volume water sampler (LV) and X-type Niskin samplers attached to CTD-CMS (3000m to Bottom at CL-03, CL-06, CL-10,CL-11, CL-18 and CL-20). Large volume samples were filtered with 0.5 μm-pore size wind-cartridge filter (Advantec) and transferred to PVC bottles settled on the ship deck. Seawater from Niskin bottle was passed through the 0.2 μm-pore size capsule filters, Acro Pak200 (Pall) using Peristaltic pump. Then HCl and Fe carrier (including Be carrier) were added. Nd was precipitated by NH_4OH with $Fe(OH)_3$. The precipitates were filtered out by the No.2 qualitative filter paper (500 mm in diameter, Advantec) and dryness for LV samples. Deeper water samples (>500 m) were also precipitated with Fe (500 mg). After 2 days, supernatant were cut down by decantation. Then, Then, precipitates were transferred to 250 mL PP bottles. Samples were brought back to land based laboratory for further analysis.

About 100 l of surface waters obtained from underway sampler were passed through the cartridge packed Mn-oxide impregnated fiber (MnO_2 fiber) and dissolved Nd isotopes in seawater were collected onto a Mn-oxide at every station.

REE concentrations

Seawater samples for vertical profiles were collected using X-type Niskin bottles mounted on a CTD/Carousel array. Seawater from Niskin bottle was passed through the 0.2 μm-pore size capsule filters, Acro Pak200 (Pall), with compressed air in the clean area. They are acidified to pH<1.8 with ultra pure

HCl in the clean area and carried to the AORI for analysis using Fe-coprecipitation and isotope dilution ICP-MS.

8. 1. 16. Distributions of cosmogenic ^{7}Be, ^{10}Be in the Atmosphere and Ocean

Hisao Nagai[1], Takeyasu Yamagata[1], Erika Godo[2], Hirofumi Tazoe[3]
1. College of Humanities and Sciences, Nihon University
2. Graduate school of Integrated Basic Sciences, Nihon University
3. Institute of Radiation Emergency Medicine, Hirosaki University
Correspondence: hnagai@chs.nihon-u.ac.jp

Purpose

Beryllium-7 (53.3d) and -10(1.36x10^{6}y) are produced in the atmosphere by cosmic rays. The production rates are dependent on latitude, altitude and time, because the intensity of the cosmic rays is not homogeneous. These nuclides are transported by aerosols, and move from the stratosphere to the surface soil and surface ocean via the troposphere. The distribution of production rates and precipitation rates of these nuclides were calculated by Masarik and J. Beer [1], but their calculation has not been confirmed experimentally. The purpose of this study is to obtain information on the concentration and transportation of Be isotopes in the atmosphere and ocean. This study consists of four parts:

1) Latitudinal distribution of cosmogenic ^{7}Be and ^{10}Be in the atmosphere,
2) Precipitation rates of ^{7}Be and ^{10}Be, from the atmosphere to the ocean surface,
3) Transportation of Be isotopes in the ocean surface layer,
4) Depth profiles of ^{7}Be and ^{10}Be, from the surface to the bottom of the water column.

Methods

Air

Atmospheric Be isotopes attached to aerosols were continuously collected on a filter paper (Whatman 41, 25 x 10 cm) using a high volume air sampler (Kimoto Electric Co. LTD., AS-1400), which was installed on the upper deck. Typical sampling time was 2-3 days, and flow rate was 1 m^{3}/min.

Seawater

To recover Be isotopes from large volume (250 L) seawater samples above 200m depth, 2 mg of Be carrier, 3 g of Fe carrier and 250 mL of conc. HCl were added. After 3 hours or more later, 250 mL of conc. NH_4OH were added to the solution to co-precipitate $Be(OH)_2$ and $Fe(OH)_3$. After discarding most of the supernatant, the precipitate was filtered onto a filter paper (Advantec No.2, ϕ 60 cm). Precipitates of $Be(OH)_2$ and $Fe(OH)_3$ were stripped from the dried filter paper samples, and then adjusted to 8M HCl solutions by adding conc. HCl for isopropyl ether extraction.

Extraction procedure was repeated 3 times to remove Fe. Finally, 4 mg of Fe(III) was added to the solution, and reprecipitated by conc. NH_4OH to obtain a small amount of $Be(OH)_2$ and $Fe(OH)_3$, which was dissolved by conc. HCl and transferred into a polypropylene tube for ^{7}Be γ-ray measurement. The purification for ^{10}Be AMS measurement will be made using a cation exchange column. For 20 L seawater samples below 300m depth, 0.5 mg of Be carrier, 0.5 g of Fe carrier and 25 mL of conc. HCl were added. Procedure for recovery and purification of Be isotopes were almost same as large volume sample. For ^{9}Be measurements, 250 mL of filtered seawater samples were separately stored in polypropylene bottles at seawater sampling.

Measurements of Be isotopes

Measurements of Be-7, 9 and 10 will be made with a well type HP Ge γ-ray detector, ICP- MS and AMS at MALT, Univ. of Tokyo, respectively.

[1] J. Masarik and J. Beer, J. Geophys. Res., 104, D10 (1999) 12099-12111

8. 1. 17. Carbon isotope ratios in dissolved inorganic carbon in the subarctic North Pacific Ocean

Yuichiro Kumamoto[1] (onboard) and Pavel Povinec[2]
1. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan
2. Department of Nuclear Physics and Biophysics, Faculty of Mathematics, Physics and Informatics, Comenius University, Slovakia
Correspondence: kumamoto@jamstec.go.jp

In order to investigate the water circulation and carbon cycle in the subarctic North Pacific Ocean, seawaters for measurements of carbon-14 (radiocarbon) and carbon-13 (stable carbon) of total dissolved inorganic carbon were collected by the hydrocasts from surface to near bottom.

Sampling method

We collected seawater samples from the CTD-CMS system with 12-liter Niskin-X bottles at the CL-2, 5, 9, and 20. The seawater sample was siphoned into a 250 mL glass bottle with enough seawater to fill the glass bottle 2 times. After sampling, 10 mL of seawater was removed from the bottle and poisoned by 0.1 mL of saturated $HgCl_2$ solution. Then the bottle was sealed by a glass stopper with Apiezon grease M and stored in a cool and dark space on board.

Analytical method

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

8. 1. 18. Evaluation of the algorithm to estimate Absolute Salinity in the International Thermodynamic Equation of Seawater 2010 (TEOS-10)

Hiroshi Uchida and Yuichiro Kumamoto (onboard)
Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan
Correspondence : huchida@jamstec.go.jp

The objective of this study is to collect Absolute Salinity (also called "density salinity") data in the subarctic region of the North Pacific whose Absolute Salinity anomaly is the largest in the open ocean, and to evaluate the algorithm to estimate absolute salinity provided along with TEOS-10 (the International Thermodynamic Equation of Seawater 2010) (IOC et al., 2010).

Sampling method

We collected seawater samples from the CTD-CMS system with 12-liter Niskin-X bottles at the CL-2 and CL-10~21. The seawater sample was siphoned into a 100 mL aluminum bottle with a screw cap. The bottles were stored at room temperature (~23 ºC) upside down until measurement after the cruise. Sound velocity profile was measured at every bottom cast in all the stations in this cruise.

Analytical method

Seawater densities will be measured with an oscillation-type density meter (DMA 5000M, Anton-Paar GmbH, Graz, Austria) with a sample changer (Xsample 122, Anton-Paar GmbH). The sample changer was used to load samples automatically from up to ninety-six 12-mL glass vials. Densities of the samples will be measured at 20 ºC by the density meter two times for each bottle and averaged to estimate the density and density salinity can be back calculated from measured density and temperature (20 ºC) with TEOS-10 (Uchida et al., 2011).

Sound velocity profiles were measured at the CTD casts by using a velocimeter (MiniSVP, serial no. 49618, Valeport Ltd., Devon, United Kingdom). The sound velocity sensing elements are a ceramic transducer (signal sound pulse of 2.5 MHz frequency), a signal reflector, and spacer rods to control the sound path length (10 cm), providing a measurement at depths up to 6000 m. The velocimeter was attached to the CTD frame and level of the sound path of the velocimeter was same as that of the CTD temperature sensor, just next to the primary temperature sensor. Although temperature and pressure data were also measured by the velocimeter, only sound velocity data measured at a sampling rate of 8 Hz will be combined with the CTD temperature and pressure data measured at a sampling rate of 24 Hz to estimate Absolute Salinity.

Although Absolute Salinity can be back calculated from measured pressure, temperature and sound velocity with TEOS-10, the calculated Absolute Salinity have large error since the algorithm to calculate sound velocity from pressure, temperature and Absolute Salinity, and the velocimeter itself have errors. Therefore, the calculated Absolute Salinity profiles will be calibrated in situ by referring to the density salinity measured by the density meter for the discrete water samples.

References

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8. 1. 19. Radiocesium (^{134}Cs and ^{137}Cs) and ^{129}I in the subarctic North Pacific Ocean

Hisao Nagai[1] (onboard), Takeyasu Yamagata[1] (onboard), Yuichiro Kumamoto[2] (onboard)
1. Department of Chemistry, College of Humanities and Sciences, Nihon University, Japan.
2. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan
Correspondence: hnagai@chs.nihon-u.ac.jp and kumamoto@jamstec.go.jp

In order to investigate the water circulation in the subarctic North Pacific Ocean, seawaters for measurements of radiocesium (^{134}Cs and ^{137}Cs) and ^{129}I were collected by the large-volume hydrocasts from surface to near 800 m depth.

Sampling method

We collected seawater samples from the large-volume water sampler which has four polyvinyl chloride 250-L tanks at all the stations except CL-11 and 13 (total 19 stations). Seawater for radiocesium was collected at eight layers: 10, 60, 100, 200, 300, 400, 600, and 800 m nominal depth. For ^{129}I, surface water was also collected from underway pumping-up seawater. The sample seawater was filtered with 0.5 µm-pore size wind-cartridge filter (Advantec, TCW-05N-PPS, 25 cm in length) on the ship deck using a pump and stored into 1 L polyethylene bottle and two 20 L plastic containers (40 L) for ^{129}I and radiocesium, respectively.

Analytical method

In our laboratory on shore, ^{129}I in the seawater sample is extracted by the solvent extraction technique. Extracted iodine is then precipitated as silver iodide by the addition of the silver nitrate. Iodine isotopic ratios ($^{129}I/^{127}I$) of the silver iodide are measured by the Accelerator Mass Spectrometry (AMS). To evaluate the ^{129}I concentration in the seawater samples, iodine concentration (^{127}I) will be measured by the inductively coupled plasma mass spectrometry (ICP-MS) and/or the voltammetry.

Radiocesium in the seawater sample was concentrated on KNiFC-PAN resin (Eichrom, NC-B200-M, 100-600 µm) on board. A volume of the resin was about 5 ml and a flow rate of seawater passing was about 50 ml/min. For seawater samples from stations CL-20 and 21, radiocesium will be concentrated using ammonium phosphomolybdate (AMP), which forms insoluble compound with cesium, in our laboratory on shore. Radiocesium concentrated on the resin or AMP will be measured using Ge γ-ray spectrometer.

8. 1. 20. Dissolved inorganic carbon and total alkalinity in the subarctic North Pacific Ocean

Masahide Wakita[1] and Yuichiro Kumamoto[2] (onboard)
1. Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology, Japan
2. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan
Correspondence: mwakita@jamstec.go.jp

In order to investigate the ocean acidification and carbon cycle in the subarctic North Pacific Ocean, seawaters for measurements of total dissolved inorganic carbon (DIC) and total alkalinity (TA) were collected by the hydrocasts from surface to near bottom.

Sampling method

We collected seawater samples from the CTD-CMS system with 12-liter Niskin-X bottles at the CL-2, 5, 9, and 20. The seawater sample was siphoned into a 250 mL glass bottle with enough seawater to fill the glass bottle 2 times. After sampling, 1 mL of seawater was removed from the bottle and poisoned by 0.1 mL of saturated $HgCl_2$ solution. Then the bottle was sealed by a rubber and aluminum caps and stored in a cool and dark space on board.

Analytical method

In our laboratory, DIC and TA samples are measured by using coulometric and potentiometric techniques, respectively, according to methods shown in Wakita et al. (2010). 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.

References

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8. 1. 21. Tritium in the subarctic North Pacific Ocean

Pavel Povinec[1] and Yuichiro Kumamoto[2] (onboard)
1. Department of Nuclear Physics and Biophysics, Faculty of Mathematics, Physics and Informatics, Comenius University, Slovakia
2. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan
Correspondence: povinec@fmph.uniba.sk

In order to investigate the water circulation in the subarctic North Pacific Ocean, seawaters for measurements of tritium (^{3}H) were collected by the hydrocasts from surface to near bottom.

Sampling method

We collected seawater samples from the CTD-CMS system with 12-liter Niskin-X bottles at the CL-2 and 9. The seawater sample was siphoned into a 300 mL glass bottle with enough seawater to fill the glass bottle 2 times. Then the bottle was sealed by a screw cap and stored in a cool and dark space on board.

Analytical method

Pre-screening of ^{3}H levels in seawater samples (to avoid possible contamination) is carried out by direct ^{3}H counting (after triple distillation) in water-liquid scintillator cocktails using Packard Liquid Scintillation Spectrometer. Tritium in seawater samples is then precisely analyzed using the ^{3}He in-growth method, which consists of three major steps: (i) The water sample is put in a stainless steel vessel and the dissolved gases including helium are then removed from the water by vacuum pumping. (ii) The clean samples are then stored in stainless steel vessels for several months so that ^{3}He atoms could be produced by tritium decay. (iii) The helium fraction containing ^{3}He is then admitted to a dual collector noble gas mass spectrometer, where the abundance of the tritiogenic ^{3}He is measured. Tritium activity concentration (or the $^{3}H/H$ atom ratio) is then calculated from the measured ^{3}He concentrations in the water samples. The sensitivity of the ^{3}He mass spectrometry method is about 0.01 TU (1 TU represents the $^{3}H/H$ ratio of 10^{-18}, equal to 118 mBq/L of water).

8. 1. 22. Oxygen and hydrogen isotope compositions of seawater in the east northern Pacific

Masafumi Murayama[1, 2, 3]
1. Science Department, Natural Science Cluster, Kochi University
2. Faculty of Agriculture and Marine Science, Kochi University
3. Center for Advanced Marine Core Research, Kochi University
Correspondence: murayama@kochi-u.ac.jp

Combined measurements of salinity and the oxygen-hydrogen stable isotope compositions of seawater can obtain information on the origin and mixing of water masses, such as freshwater mixing, evaporation, precipitation and sea-ice formation. Stable isotopes data with high spatial and temporal resolution are necessary for a detailed understanding of mixed water bodies with multiple inputs. Combined with salinity record andδ^{18}O-δD values provides additional discriminating insights for assessing water mass formation processes and histories through the east northern Pacific. During the Leg.2 cruise, double bottles of 25 cc seawater were collected from various depths at 11 sampling sites (CL11 to CL21). The δ^{18}O and δD values in seawater will be measured by mass spectrometry with high accuracy and precision in Kochi University.

8. 1. 23. Longitudinal variation in stable isotopes of nitrogen and carbon in epipelagic ecosystems in the subarctic North Pacific Ocean

Sachiko Horii and Kazutaka Takahashi
Graduate School of Agricultural and Life Sciences, The University of Tokyo
Correspondence: horii-sachiko@g.ecc.u-tokyo.ac.jp

Introduction

Distribution of nitrogen and carbon stable isotopes in biotic components have been gaining attention because they reflect regional variation of some important aspects in ecosystem structures such as nitrogen and carbon sources, trophic relationships between organisms and physiological status and properties of primary producers. However little studies were conducted for the epipelagic ecosystem in the Pacific open ocean. In this study, we aimed to clarify the distribution of N and C stable isotopes in plankton and nekton samples in the subarctic North Pacific Ocean, and to estimate which environmental parameters were indicated by these distributional patterns, nutrimental conditions, primary productivity and construction of plankton community, for example.

Sampling of plankton and nekton samples for N and C stable isotopic analysis

To collect suspended particles seawater was obtained at the surface and at 4 to 7 different depths including 10, 50, 100 and 200 m depths and 10%, 1% and 0.1% light depths using a bucket or Niskin-X bottles at every station. 2 to 8 L of water samples were pre-filtered by a 0.2 mm nylon mesh to remove larger particles, and particles in the filtrates were collected on pre-combusted GF/F filters by gentle vacuum filtration. In addition, 24 L of water samples collected at the surface, 10 m and 1% light depths at stations 2, 3, 4, 5, 6, 7, 8, 9, 15, 16, 17, 18, 19, 20 and 21 were size-fractionated in 200 – 50, 50 – 20, 20 – 5 and 5 – 0.6 μm using nylon mesh and were collected onto GF/F filters by gentle vacuum filtration for detailed analysis of isotopic compositions in suspended particles. Mesozooplankton were collected at every station using a Norpac XX double net towed vertically from 0 to 200 m depth and then immediately size-fractionated (>2.0, 2.0 –1.0, 1.0 – 0.5, 0.5 – 0.2 mm). Nekton samples including *Oncorhynchus gorbuscha*, *Brama japonica*, *Onychoteuthis* sp. *Gonatopsis* sp. were collected at stations 7, 8, 9, 15, 16 and 17 by fishing. Muscles and gut contents of them were preserved frozen at -20 °C after standard length or mantle length were measured. Zooplankton larger than 0.2 mm and particles smaller than 0.2 mm were also occasionally collected using seawater pumped from the bottom of the ship during this cruise. All samples were frozen at -80 or -20 °C for later analysis on land.

Sampling for nitrogen stable isotopic analysis in nitrate and DON

Nitrate supplied from below euphotic layer is believed as most important nitrogen source for primary production in the open ocean. DON is also gaining attention as an important nitrogen source. For analyses of abundances of natural ^{15}N in nitrate and DON, 50 mL of seawater samples were obtained from 0, 50, 100, 200, 300 and 500 m or 10 m depth using Niskin-X bottles at stations 2, 3, 4, 5, 7, 9 and 17. These samples were frozen at -20 °C.

Relationship between primary productivity and natural abundance of ^{13}C in primary produces

Variation in stable isotopic composition of carbon in organic particles is generally large in the subarctic and the arctic epipelagic ecosystems. This variation is often interpreted as differences of primary productivity because growth rate is an important factor controlling abundance of ^{13}C in phytoplankton, however, no study has shown their relationship in the field. To determine whether isotopic composition of carbon in suspended particles can indicate the primary productivity in the field, following experiment was conducted.

Light intensity was observed between 0 and 105 m depth using COMPACT-LTD during daytime before samplings of seawater to determine light depth. Water samples for measurement of primary production were collected using Niskin-X bottles at stations 2, 3, 4, 5, 6, 7, 8, 9, 15, 16, 17, 18, 20 and 21 from 0 and 10 m depths and 10%, 1% and 0.1% light depths with pre-filtration at 200 µm to remove mesozooplankton. ^{13}C-sodium bicarbonate tracer was added and the bottles were placed into on-deck water bath cooled by flowing surface seawater for 24 h. Light levels were adjusted using neutral-density screens. The incubation was terminated by gentle vacuum filtration of the seawater samples through a precombusted GF/F filter. The filters were then frozen at -80 or -20 °C for later analysis on land. Concentration of chl *a* at the fraction between 0.6 and 200 µm were also analyzed before and after incubation to determine growth rate of phytoplankton.

Construction of phytoplankton and zooplankton community

Seawater was obtained from the depths using a bucket or Niskin-X bottle at the depths where suspended particles for stable isotopic analysis were collected at stations 2, 3, 4, 5, 6, 7, 8, 9, 15, 16, 17, 18, 19, 20 and 21. Approximately 4 mL aliquots of the samples were fixed in glutal aldehyde-seawater solution and kept at -80°C for later flow cytometric observation of pico and nanoplankton. About 500 mL aliquots of the water samples were fixed in 1 or 2% Lugol-seawater solution and kept at 5°C for later microscopic observation of microplankton on land. Mesozooplankton for micoroscopic observation was collected using Norpac XX double net as written above at every station and were preserved in 10% neutral buffered formalin solution.

8. 1. 24. Abundance and variation of mixotrophic ciliate on longitudinal transect in the subarctic North Pacific Ocean

Sachiko Horii, Emiko Takano and Kazutaka Takahashi
Graduate School of Agricultural and Life Sciences, The University of Tokyo
Correspondence: akazutak@mail.ecc.u-tokyo.ac.jp

Introduction

Ciliates play critical role to link microbial loop to secondary production in the epipelagic ecosystem in the open ocean. Although they are traditionally considered as heterotrophs, recent studies are getting to show their potential importance as primary producer through mixotrophy. To estimate the abundance of mixotrophic ciliates in the subarctic North Pacific Ocean, we performed samplings described below.

Method

For fluorescent microscopic observation seawater was obtained from the depths using a bucket or Niskin-X bottle at 0, 10 and 50 m depths at stations 2, 3, 4, 5, 6, 7, 8, 9, 15, 16, 17, 18, 19, 20 and 21. 300 mL aliquots of the samples were filtrated onto 0.2 µm membrane filter after prefiltration at 10 µm to determine chl *a* concentration of phytoplankton, which is potential diet of ciliate. 1 L aliquots of the samples were concentrated by back-filtration using 10 µm nylon mesh and were fixed by glutal aldehyde. Fixed water samples were dyed by DAPI, filtrated onto 8 µm membrane filter and were preserved frozen with immersion oil on slide glass.

8. 1. 25. Total dissolved inorganic carbon (TCO_2)

Kiminori Shitashima
Tokyo University of Marine Science and Technology
Correspondence: kshita0@kaiyodai.ac.jp

The TCO_2 concentration in seawater samples was determined by using the NDIR detector (LI-COR Inc.). Samples for TCO_2 analysis were drawn from the Niskin sampler into 125 mL glass vial bottles after an overflow of about 100 mL of the seawater. The samples were immediately poisoned with 50 µl of 50% saturated $HgCl_2$ in order to restrict biological alteration prior to sealing the bottles. Seawater was introduced manually into the thermostated (25ºC±0.1ºC) measuring pipette with a volume of ~30 mL by a pressurized headspace CO_2-free air that had been passed through the soda-lime scrubber. The measured volume was then transferred to the extraction vessel. The seawater sample in the extraction vessel was acidified with 1.0 mL of 3.8% phosphoric acid and the CO_2 was extracted from the sample by bubbling with the CO_2-free air. After passing through the Ag_2SO_4 scrubber, polywool and $Mg(ClO_4)_2$ scrubber to remove sea salts and water vapor, the evolved CO_2 gas was continuously induced to the NDIR detector. The precision of the TCO_2 measurement was tested by analyzing CRMs (batch AP, KANSO CO. Ltd) at the beginning of the measurement of samples every day.

8. 1. 26. In-situ pH/pCO_2/ORP sensor, multi sensor and in-situ radon sensor

Kiminori Shitashima
Tokyo University of Marine Science and Technology
Correspondence: kshita0@kaiyodai.ac.jp

Objective

The measurement of pH in the marine system is important because the pH of seawater reflects the oceanic carbon cycles and the exchange of CO_2 between the atmosphere and the ocean. Furthermore, pH relates to and the biological and chemical processes occurring in the sea. Concerning the global warming, change of pH and pCO_2 in seawater should preferably be observed continually in a long term and a wide area (vertically and horizontally) to monitor air-sea CO_2 exchange and oceanic carbon cycle. In-situ measurement with a sensor is the most suitable for such observations.

Underwater in-situ radon measurement is important scientific priority for oceanography, especially for survey and monitoring of submarine groundwater discharge (SDG), hydrothermal systems and terrestrial input from seasurface. The high sensitivity and lightweight underwater in-situ radon sensor using NaI(Tl) doped plastic scintillator was developed for oceanographic applications. A NaI(Tl) doped plastic scintillator can expect high sensitivity in comparison with a NaI(Tl) crystal sealed in a container because the plastic scintillator contacts seawater directly.

The objective of this study is to develop high performance chemical sensor for in situ measurement in the deep sea and apply it to chemical oceanography.

Methods

- **In-situ pH/pCO_2/ORP sensor**

The in-situ pH sensor employs an Ion Sensitive Field Effect Transistor (ISFET) as a pH electrode, and the Chloride ion selective electrode (Cl-ISE) as a reference electrode. The ISFET is a semiconductor made of p-type Si coated with SiO_2 and Si_3N_4 that can measure H^+ ion concentration in aqueous phase. New ISFET-pH electrode specialized for oceanographic use was developed. The Cl-ISE is a pellet made of several chlorides having a response to the chloride ion, a major element in seawater. The electric potential of the Cl-ISE is stable in the seawater, since it has no inner electrolyte solution. Therefore, The in-situ pH sensor has a quick response (less than a second), high accuracy (±0.003pH) and pressure-resistant performance. The pCO_2 sensor was devised to incorporate the above-mentioned newly developed in-situ pH sensor to measure the in-situ pCO_2 in seawater. The principle of pCO_2 measurement is as follows. Both the ISFET-pH electrode and the Cl-ISE of the pH sensor are sealed in a unit with a gas permeable membrane whose inside is filled with inner electrolyte solution with 1.5 % of NaCl. The pH sensor can detect pCO_2 change as inner solution pH change caused by permeation of carbon dioxide gas species through the membrane. An amorphous Teflon membrane (Teflon AF™) manufactured by DuPont was used as the gas permeable membrane. The in-situ (3,000m, 1.8ºC) response time of the pCO_2 sensor was less than 60 seconds. The diode on ISFET can measure the temperature of seawater simultaneously. ISFET and Cl-ISE are connected to pH converter circuit in the pressure housing through the underwater cable connector. The pressure housing includes pH converter circuit, A/D converter, data logger RS-232C interface and Li ion battery.

The ORP (Oxidation-Reduction Potential) sensor employs platinum wire as a working electrode and the Cl-ISE as a reference electrode, and measures potential difference between both electrodes.

Before and after the observation, the pH sensor was calibrated using two different standard buffer solutions, 2-aminopyridine (AMP; pH 6.7866) and 2-amino-2-hydroxymethil-1,3-propanediol (TRIS; pH 8.0893) described by Dickson and Goyet, for the correction of electrical drift of pH data. The measured pH and temperature data are stored in the data logger. After finish of the pH measurement, these data are transferred from the data logger into a personal computer (PC) connected with RS-232C cable, and the in-situ pH is calculated using calibration data of AMP and TRIS in a PC. Since the calibration of in-situ pCO_2 measurements was not conducted in this cruise, only raw data (arbitrary unit) from the pCO_2 sensor output were obtained. Raw data showing small digit readings indicates pH depression of the inner solution, which reflects an increase in partial pressure of CO_2 in seawater.

The in-situ pH/pCO_2/ORP sensors were installed to the CTD-CMS, and in-situ data of pH, pCO_2 and ORP ware measured every 2 seconds during descent and ascent of the CTD-CMS.

- **Multi sensor**

The multi sensor is equipped with nine sensors (pH, pCO_2, ORP, conductivity, temperature, depth, dissolved oxygen, turbidity and fluorescent). The sensors of pH, pCO_2 and ORP are the above-mentioned sensor. The conductivity and temperature sensors, the depth and dissolved oxygen sensors and the turbidity and fluorescent sensors are provided from Neil Brown Ocean Sensors Inc., Aanderaa Instruments Inc.

and Seapoint Sensors Inc., respectively.

The multi sensor was installed to the CTD-CMS, and in-situ data of these sensors were measured every 2 seconds during descent and ascent of the CTD-CMS.

- **In-situ radon (gamma rays) sensor**

A plastic scintillator is made from polystyrene that doped scintillator such as NaI(Tl) and it absorbs radon like as liquid or crystal scintillator. Because NaI(Tl) doped plastic scintillator contacts seawater directly, the plastic scintillator can expect high sensitivity in comparison with NaI(Tl) crystal sealed in a container. In order to improve condensation efficiency of scintillation, the plastic scintillator was processed in funnel form. In the general scintillation measurement, a dark chamber is necessary to detect photon derived from only radon. However, in-situ scintillation measurement and downsizing of measurement unit are difficult because a dark chamber takes a lot of space. Therefore, the plastic scintilator was coated with a light-resistant paint instead of using a dark chamber. The radon sensor was installed to the CTD-CMS and in-situ data of radon was measured every 1 second during descent and ascent of the CTD-CMS.

8. 2. Sediments

8. 2. 1. Infaunal ecology of the abyssal plain in the North Pacific

Koji Seike and Genki Kobayashi
AORI, The University of Tokyo, Japan
Correspondence: seike@aori.u-tokyo.ac.jp

Introduction

Burrowing organisms are particularly important in seafloor environments, because they mix sediments, disrupt microstratigraphy, influence the biogeochemistry of seafloor sediment, and produce burrows that harbor other organisms and microbes. The deep sea is the largest single marine ecosystem on Earth and contains abundant benthic fauna living on and in the seafloor sediment: understanding their subsurface ecology is therefore important. The aim of our research group is to obtain fundamental information on 1) biogenic sedimentary structures (burrows) in the seafloor sediments, and 2) biogeographical distribution of annelid worms in this region.

Sample collection

Sediment core sampling

Sediment cores were collected during cruise KH-17-3 of the R/V HAKUHO MARU. A multiple corer, equipped with eight core tubes with internal diameters of 82 mm, was used to collect the sediment cores. This method enabled us to obtain seafloor sediments with virtually no disturbance. We obtained two sediment cores from the all sampling stations (CL 1–21). One of the cores for each station was preserved for later CT analysis.

Annelid worm sampling

One of the cores were sieved using 0.3 mm mesh screen to retrieve annelid worm specimens. Collected worms were preserved in 70% ethanol, and will be housed in Genki Kobayashi's worm collection.

Future analyses of the collected samples

X-ray observation of the cores

Physical and biogenic sedimentary structures are often obscured on the surface of sediment core sections. This lack of visibility can be overcome using X-ray radiography and computed tomography (CT) scanning, which can reveal many details that would otherwise not be seen in such samples. The sedimentary structures of the entire core taken during the cruise will be observed with CT installed at the Center for Advanced Marine Core Research (CMCR), Kochi University. The CT data will be analyzed with OsiriX imaging software, version 4.1.2, and/or with Amira imaging software version 6.1, to observe biogenic sedimentary structures of the cores.

Molecular analysis of the annelid worms

We will identify the collected worms and perform a molecular phylogenetic analysis using the COI gene to reveal biogeographical distributions of the worms in the abyssal plain of the North Pacific.

8. 2. 2. Remobilization of biophile and metal elements in the North Pacific seafloor.

Hideki Mimami[1], Katsuya Nejigaki[1], Yuzuru Nakaguchi[2] and Hajime Obata[3]
1. School of Biological Sciences, Tokai University
2. School of Science and Engineering, Kinki University
3. Atmosphere and Ocean Research Institute, The University of Tokyo
Correspondence: south@tsc.u-tokai.ac.jp

・*Purpose*

Marine sediment, which consists of solid sediment and pore water, is a major interface between the seawater and seafloor, and also accumulates continuously products formed within the sea as a record of environmental changes. High productivity in the North Pacific enhances the accumulation of biogenic materials on the seafloor. The mineralization and remobilization of such materials in sediments significantly influence the benthic fluxes of elements through pore waters and across the sediment-seawater interface. Since the North Pacific must play an important role in the carbon cycle in the ocean, it is a major concern to understand the benthic fluxes of dissolved carbon dioxide, nutrient, trace metal and other elements during early diagenesis. During this cruise, we study the remobilization of biophile and metal elemets in the North Pacific, and clarify the benthic fluxes of these elements in this oceanic region seafloor.

・*Sampling*

Surface sediments were collected by using a muti-corer (CL01, CL02, CL03, CL04, CL05, CL06, CL07, CL08, CL09, CL10, CL11, CL12, CL13, CL14, CL15, CL16, CL17, CL18, CL19, CL20 CL20P and CL21). One core was cut immediately after recovery at 0.5 cm intervals in the top 2 cm and 1.0 cm intervals in the rest of the core. Pore waters were squeezed from the sectioned sediment samples under N_2 gases conditions at 4 ^oC in a refrigerator by pressure filtration through a 0.45μm Millipore filter, using a hydraulic pressure type squeezer.

・*Analysis*

Nutrients in pore water were determined by an auto analyzer SWAAT (BLTEC Japan). All analytical data (nitrate, nitrite, phosphate and silicate) were corrected by using seawater reference material of nutrients (KANSO). Sediment samples will be freeze-dry powder in the laboratory ashore. The powdered sample will be digested in a

HNO_3-HCl-$HClO_4$-HF acid mixture in a Teflon bomb, and trace metals will be determined with ICP-MS, ICP-AES and AAS.

8. 2. 3. High-resolution depositional history and environmental changes in the east northern Pacific

Masafumi Murayama[1, 2, 3] and Kosei Kawata[4]

1. Science Department, Natural Science Cluster, Kochi University
2. Faculty of Agriculture and Marine Science, Kochi University
3. Center for Advanced Marine Core Research, Kochi University
4. Faculty of Science, Kochi University

Correspondence: Correspondence: murayama@kochi-u.ac.jp

Marine sediment cores contain the fundamental data for information on sea floor formation character, depositional history and environmental changes. They provide crucial data for a wide range of research including studies of global climate change, paleoceanography, sedimentology and marine resources. Such kind of records allow us to understand the past and predict the future earth.

Twelve surface cores using by multiple corer were collected at 8 sites along 145°00’ W longitude line and at 4 sites along 47°00’ N latitude line in the east northern Pacific. To extract high-resolution depositional history and environmental change in this region, non-destructive core logging and imaging techniques can be used at Center for Advanced Marine Core Research, Kochi University.

X-ray computed tomography (X-ray CT), multi-sensor core logger (MSCL) and XRF core scanner provide to understand the geological and geochemical processes in detail, such as sediment deposition, post-formational geochemical and geophysical alteration, bioturbation, dewatering and consolidation, erosion, migration, and many other phenomena.

Fig. 8. 2. 3. 1. A manganese nodule (ϕ 8 cm) at CL18.

Fig.8. 2. 3. 2 A lot of manganese nodules on sea

8. 3. Atmospheric samples

8. 3. 1. Iron Isotope Ratio in Size-Fractionated Marine Aerosols and Surface Seawater: Evaluation of Contribution of Anthropogenic and Natural Fe to Surface Seawater

Minako Kurisu[1], Kohei Sakata[1,2], Yoshio Takahashi[1]
[1]Department of Earth and Planetary Science, the University of Tokyo
[2]Center for Global Environmental Research Global Atmospheric Chemistry Section, National Institute for Environmental Studies
Correspondence: minako-kurisu@eps.s.u-tokyo.ac.jp, ytakaha@eps.s.u-tokyo.ac.jp

Objective

Iron is an important micronutrient for microorganisms in surface seawater (Jickells et al., 2005). Activation of primary production of microorganisms in surface seawater possibly control marine climate and change carbon and sulfur cycles (Chalrson et al., 1987; Martin and Fitzwater, 1988; Turner et al., 1996). Atmospheric deposition of Fe is one of the important sources of dissolved Fe in surface seawater, but their solubility behavior in aerosol particles have not been clear. Anthropogenic Fe have higher solubility than that of crustal Fe (Takahashi et al., 2013), which have low stable Fe isotope ratio ($\delta^{56}Fe = (^{56}Fe/^{54}Fe)_{sample} / (^{56}Fe/^{54}Fe)_{IRMM-014} - 1$, Kurisu et al., 2016). However, there is almost no data of Fe isotope ratio in marine aerosol particles. In this study, Fe isotope ratio analysis in size-fractionated marine aerosol particles are conducted with ultra-clean sampling technique for trace metals (Sakata et al., in prep.). In addition, Fe isotope ratio in surface seawater are also measured in order to estimate contribution of anthropogenic Fe in marine aerosol particles.

Sampling method

Size-fractionated marine aerosol particles are collected by high volume air sampler (MODEL-120SL, Kimoto, Japan) with cascade impactor (TE-235, Tisch Environmental Inc., USA). Total suspended particulates are also collected by high volume air sampler (MODEL-120SL, Kimoto, Japan). During all sampling periods, wind speed and direction are monitored to prevent from contamination of ship exhaust.

Analytical Methods

Fe concentrations

Total and (sea)water extractive BTMs concentrations are measured by inductively coupled plasma mass spectrometry (ICP-MS, Agilent 7700). Acid digestion for total BTMs concentration measurements are conducted by mixed-acid digestions (HNO_3, HCl and HF) with heating at 120 °C. BTMs in marine aerosol particles are extracted by ultra-pure water, artificial seawater and surface seawater. All procedures are conducted in Class-100 Clean-booth and acid-washed materials.

Fe isotope ratio

Iron isotope ratio are measured by multiple-collector ICP-MS (MC-ICP-MS, NEPTUNE Plus, Thermo, Germany). In this study, both total and water extractive Fe isotope ratio in marine aerosol particles are measured. Fe isotope ratio of surface seawater are also measured by MC-ICP-MS after desalination and purification of Fe.

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Sample List

Size-fractionated aerosol sampling

[Leg. 2]

No. 11: 57° 42N, 150° 40W (2017/7/19 2:34) – CL-11 (2017/7/19 15:17); CL-11 (2017/7/20 16:04) – CL-12 (2017/7/20 20:57); CL-12 (2017/7/21 5:30) – CL-13 (2017/7/21 8:45) Total: 1372.7 m^3

No. 12: CL-13 (2017/7/23 2:59) – CL-15 (2017/7/23 20:12) Total: 1157.6 m^3

Total suspended particle (TSP)

[Leg. 2]

No. 11: 57° 42N, 150° 40W (2017/7/19 2:34) – CL-11 (2017/7/19 15:17); CL-11 (2017/7/20 16:04) – CL-12 (2017/7/20 20:57); CL-12 (2017/7/21 5:30) – CL-13 (2017/7/21 8:45) Total: 1381.0 m^3

No. 12: CL-13 (2017/7/23 2:59) – CL-15 (2017/7/23 20:12) Total: 1162.5 m^3

Seawater

CL-1 (10 m), CL-2 (10 m, Chl. a max, O_2 min., 1000 m, 2000 m), CL-3 (10 m), CL-5 (10 m), CL-7 (10 m), CL-9 (10 m), CL-11 (10 m), CL-14 (10 m), CL-16 (10 m, Chl. a max, O_2 min., 1000 m, 2000 m), CL-17 (10 m), CL-20 (10 m)

8. 3. 2. Spatial and size distribution of bioactive trace metals in aerosol particles and their chemical reaction with organic ligand in submicron sea spray aerosol

Kohei Sakata[1, 2], Minako Kurisu[2], Aya Sakaguchi[3], Yoshio Takahashi[2]
[1]Center for Global Environmental Research Global Atmospheric Chemistry Section, National Institute for Environmental Studies
[2]Department of Earth and Planetary Science, the University of Tokyo
[3]Facluty of Pure and Applied Science, University of Tsukuba
Correspondence: sakata.kohei@nies.go.jp, minako-kurisu@eps.s.u-tokyo.ac.jp

Objective

Atmospheric deposition is one of the important sources of dissolved bioactive trace metals (BTMs) in surface seawater (Jickells et al., 2005). Solubility of bioactive trace metals in aerosol particles are depending on emission sources, chemical species, and atmospheric chemical reaction processes, which are different between coarse and fine aerosol particles (Takahashi et al., 2013; Sakata et al., 2014; Kurisu et al., 2016). However, size-distributions of BTMs concentrations, BTM species and their chemical reaction processes in marine aerosol particles are unclear. One of the reasons for insufficiency of these data is high filter blank of BTMs, although BTMs concentration in marine aerosol particles were not high. We developed ultra-clean size-fractionated aerosol particles for multiple component analysis (e.g., BTMs, major ions, and organic compounds; Sakata et al., in prep.) in order to understand solubility behavior of BTMs. In this study, organic complexes of BTMs in marine aerosol particles are focused, which have potential to increase solubility of BTMs in seawater. Especially, mixing of submicron anthropogenic particles and sea spray aerosol particles are expected to play an important role to control solubility behavior of BTMs, which are concentrated BTMs and organic compound from anthropogenic emissions and seawater, respectively (Prather et al., 2013; Quinn et al., 2014). Aims of this study is understanding of size and spatial distributions of BTMs concentrations and chemical reaction processes of organic complexes of BTMs in submicron aerosol particles.

Sampling method

Size-fractionated marine aerosol particles are collected by high volume air sampler (MODEL-123SL, Kimoto, Japan) with cascade impactor (TE-236, Tisch Environmental Inc., USA). Sampling filters were exchange each sampling station. During all sampling periods, wind speed and direction to prevent from contamination of ship exhaust.

Contributions of contamination from ship exhaust are evaluated by comparison of Ni/V ratio in marine aerosol particles and fly ashes of combustion.

Analytical Methods.

BTMs concentrations

Total and (sea)water extractive BTMs (Fe, Ni, Cu, Zn, Cd) and Pb concentrations are measured by inductively coupled plasma mass spectrometry (ICP-MS, Agilent 7700). Acid digestion for total BTMs concentration measurements are conducted by mixed-acid digestions (HNO_3, HCl and HF). BTMs in marine aerosol particles are extracted by ultra-pure water, artificial seawater and surface seawater. All procedures are conducted in Class-100 Clean-booth and acid-washed materials.

Chemical speciation

BTMs species (Fe, Cu, Zn, Pb) and organic ligand in marine aerosol particles were determined by X-ray absorption fine structure (XAFS) spectroscopy using micro-meter order X-ray and scanning transmission X-ray microscope, respectively, without any sample treatments. Chemical reaction processes are estimated by aquatic equilibrium reaction model, Geochemist WorkBench, based on concentration data of major ions and BTMs concentration (Sakata et al., 2017).

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Sample List

7 size fractionated aerosol sampling list

[Leg. 2]

No. 13: 57° 42N, 150° 40W (2017/7/19 2:34) – CL-11 (2017/7/19 15:17) Total: 439.5 m^3

No. 14: CL-11 (2017/7/20 16:04) – CL-12 (2017/7/20 20:57); CL-12 (2017/7/21 5:30) – CL-13 (2017/7/21 8:45) Total: 265.4 m^3

No. 15: CL-13 (2017/7/23 2:59) – CL-15 (2017/7/23 20:12) Total: 593.0 m^3

8. 3. 3. Micrometeorological Measurement of CH_4 and CO_2 Flux in the subarctic North Pacific

Toshihiro Doi[1], Shujiro Komiya[2], Fumiyoshi Kondo[3], and Kosuke Noborio[4]
[1]Graduate School of Agriculture, Meiji University
[2]Max Planck Institute for Biogeochemistry, Jena, Germany
[3]Japan Coast Guard Academy
[4]School of Agriculture, Meiji University
Correspondence: tdoi@meiji.ac.jp

Purpose

The exchange of methane (CH_4) and carbon dioxide (CO_2) at the air-sea interface is a major contributor to the global carbon cycle. Previous studies have theoretically estimated their exchange rates by the bulk method, i.e. a gas concentration gradient between in the air and in the seawater multiplied by a gas transfer coefficient usually as a function of wind speed. Recent advancement in computers and microelectronics enabled devices to measure CO_2 concentration and three-dimensional wind speed with the time scan rate of >10 Hz. Using those instruments a standard micrometeorological procedure, e.g., eddy covariance (EC), was established to directly measure CO_2 flux in a real time manner on the ground or above the tree canopy. Kondo and Tsukamoto (2007) applied the EC procedure to directly measure CO_2 flux at the air-sea interface with the aid of a 3-axis inclinometer and accelerometer boarding on a ship. They reported that the CO_2 flux measured with the micrometeorological method was as large as 20 times that estimated with the conventional bulk method. Not much research has been reported on the direct measurement of CH_4 flux at the air-sea interface because of few high-speed instruments available for measuring CH_4 concentration until a few years back. Our research group has developed another micrometeorological procedure, e.g., relaxed eddy accumulation (REA), and successfully applied to agricultural fields. Although the REA does not require a high-speed instrument to measure gas concentration, results are comparable to those with the EC. We're interested to apply our REA to the air-sea interface. The objectives of our research were to map CH_4 and CO_2 flux at the air-sea interface along the subarctic North Pacific Ocean.

Materials and Methods

Air was separately collected into 10 L aluminum bags or smart bags according to upward and downward wind measured with a 3-dimensional ultrasonic anemometer installed on the compass deck of R/V HAKUHO MARU approximately 20 m above the sea surface. A 3-axis inclinometer and accelerometer (MotionPak II, Bei Technologies

In., Concord, CA) and a net radiometer (hand-made in our lab.) were installed at the same compass deck as well. The concentration of CH_4 and CO_2 and $\delta^{13}C$ of CH_4 and CO_2 in the air separately collected in 10 L aluminum bags were alternatively measured every 15 min with a $CO_2/CH_4/\delta^{13}C$ laser gas analyzer (G2201-i, Picarro Inc., Santa Clara, CA) installed in Lab. 1. Gas flux at the air-sea interface was evaluated as (McInnes and Heilman, 2005):

$$J = B\sigma_w\left(\overline{C_u} - \overline{C_d}\right)\times 3600 \qquad [1]$$

where J is the flux of a specific gas (mg/m^2/h), B is an empirical constant, σ_w is the standard deviation of vertical wind speed (m/s), C_u and C_d are 15 min average gas concentrations in aluminum bags for upward and downward winds, respectively (g/m^3).

Dissolved concentration of CH_4 and CO_2 and their $\delta^{13}C$ values were measured with the laser gas analyzer (G2201-i, Picarro Inc., Santa Clara, CA). Equilibrated air in a silicon gas sampler with seawater, submerged in a box connected to a seawater faucet located just outside of Lab. 3, was circulated through the laser gas analyzer in Lab. 1.

At every observation point, 0.5L of seawater from the surface, 50, 100, 200, 400, 1000, 2000, 3000, 4000, and 5000 m deep were collected into a bottle. The 0.06L of seawater from the bottle was collected into a syringe. After, 0.06L of N_2 gas was inject into the syringe. The syringe was manually shaken for 2 minutes, followed by a 2 minutes standing period.CO_2 and CH_4 concentrations in a head space of a syringe were measured with the laser gas analyzer (G2201-i, Picarro Inc., Santa Clara, CA). The measurement was triplicated for each water sample.

Expected Outcomes

Fluctuations in CH_4 and CO_2 and their $\delta^{13}C$ values along the meridian are expected as were in the subarctic North Pacific. Flux of CH_4 and CO_2 may mostly be negative, meaning those gases are absorbed by the sea. A major concern may be the magnitude of fluxes because the application of REA is quite new on a severely moving boat.

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8. 3. 4. Determination of bioactive trace elements in the atmospheric aerosol

Naoki Tsuji[1] , Yuki Fukuda[1] and Yuzuru Nakaguchi[2]
1. Graduate School of Science and Engineering Research, Kindai University
2. Department of Chemistry, School of Science and Engineering, Kindai University, Japan
Correspondence: nakaguch@chem.kindai.ac.jp

Introduction and objectives

Trace elements such as Al, Mn, Fe, Co, Ni, Cu, Zn, Cd , Pb and Se are called "bioactive trace element". Most of the particulate matter falling from the surface water is produced initially by photosynthetic phytoplankton in the photic zone. The most of bioactive trace metals are taken up by marine organisms such as phytoplankton and bacteria. Consumption and decomposition of particulate matter sinking from surface water return the bioactive trace metals to solution. On the other hand, some suspended particulate matters come from terrestrial sources transported to the ocean by rivers and by winds in particulate forms. The bulk composition of suspended particulate matter in the various ocean is well known, whereas, the speciation of elements in suspended particle still remains poorly known. Individual particulate analysis can provide detailed information about the source, formation, transport and reactions of suspended particulate matter.

In this study, atmospheric aerosols are collected on the R/V HAKUHO MARU during KH-17-3 cruise. The chemical composition and the origin of atmospheric aerosols are investigated by individual particle analysis with SEM-EDX, ICP-MS and HPLC

Inventory information for the sampling

Aerosol samples were collected on the R/V HAKUHO MARU using by AS-9 aerosol sampler (Kimoto Electric Co.Ltd).

Analysis and method

Aerosol samples collected on the filters were preserved at 4 degree centigrade in a refrigerator. The shape and size of particles will be observed by individual particle analysis with the Scanning Electron Microscope (SEM) and Energy Dispersive X-ray spectroscopy (EDX) in the laboratory. The filter with the aerosol samples were removed to the Teflon beaker, and then it was decomposed by nitric and perchloric acid solution.

After the decomposition, bioactive trace metals were determined by ICP-MS.

Data Archive

All of the raw and processed data from the KH-17-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

8. 3. 5. Ocean-Atmosphere Interaction of Dissolved Organic Sulfur in Surface Seawater

Kohei Sakata[1, 2], Yuko Oomori[3], Satoshi Inomata[1], Yoshio Takahashi[2], Aya Sakaguchi[3], Hiroshi Tanimoto[1]
[1]National Institute for Environmental Studies
[2]The University of Tokyo
[3]University of Tsukuba
Correspondence: sakata.kohei@nies.go.jp, tanimoto@nies.go.jp

Objective

Volatile organic compounds (VOCs) in seawater, especially dimethyl sulfide (DMS) have potential to control marine climate and to change carbon and sulfur cycles (Charlson et al., 1987; Turner et al., 1996). Recent study indicated that a large amount of dissolved organic sulfur (DOS) were detected from seawater (Ksionzek et al., 2016). They also reported that inventory of known DOS and its related compounds (DMSP, DMS, DMSO, COS, CS, and MeSH), was only 5% into that of DOS. Therefore, DOS in seawater is potential sources of organic sulfur in marine atmosphere. However, volatility of DOS in seawater have not been clear. In addition, formation of submicron sea spray aerosol is the most important sources of organic compounds in marine atmosphere (Prather et al., 2013; Quinn et al., 2014), but almost no studies on chemical analysis of organic sulfur, except for methane sulfonate, in submicron aerosols. Therefore, knowledge of ocean-atmosphere interaction of DOS is quite unclear. In this study, high mass resolution analysis (up to m/z 500) of volatile organic sulfur in surface seawater is conducted by equilibrium inlet proton transfer reaction time-of-flight mass spectrometry (EI-PTR-ToF-MS). In addition, semi-volatile and refractory organic sulfur analysis are conducted by thermal desorption PTR-ToF-MS (TD-PTR-ToF-MS) and X-ray absorption fine structure (XAFS) spectroscopy, respectively. Aims of this study is understand of ocean-atmosphere interaction of DOS in surface seawater.

Analytical Methods.

Volatile organic sulfur in surface seawater

The EI-PTR-ToF-MS system comprised a PTR-MS instrument (PTR-1000, IONICON Analytik, Innsbruck, Austria) and a bubbling-type equilibrator for equilibration between the liquid and gas phases. The equilibrator consisted of brown (to prevent photolysis) vertical glass tubes (water volume: 10 L). For this observation, perfluoroalkoxy tubing and Tygon tubing® (Saint-Gobain, Courbevoie, France) were used for gas and water samples, respectively.

Surface seawater was pumped from a seawater intake on the bottom of the ship (5-m depth), and supplied to the laboratory. The surface seawater was continuously supplied to the equilibrator at a flow rate of >1 L min^{-1}. Ultrapure air flowed as the carrier gas from bottom of the equilibrator at a flow rate of 120 mL min^{-1}. Dissolved VOCs were extracted into the gas phase, and a portion of the gas was continuously directed to the PTR-ToF-MS instrument at ambient pressure.

AMEMBO continuous observation

Continuous recording of environmental parameters and phytoplankton abundance was done with an AMEMBO (Water Strider- AutoMated Environmental Monitor for Biological Oceanography). The AMEMBO consisted of a bubble trap, Chlorophyll WET Star, MBARI-In Situ Ultraviolet Spectrophotometer used as nitrate analyzer (calibrated in Jun 2012) and a Seabird SBE 19 (calibrated in Jul 1999). Seawater was pumped up to bottom of the ship (about 5 m depth) and continuously supplied to the AMEMBO.

Organic S in marine aerosol

Size-fractionated marine aerosol particles are collected by high volume air sampler (MODEL-123SL, Kimoto, Japan) with cascade impactor (TE-236, Tisch Environmental Inc., USA). Semi-volatile organic sulfur analysis is conducted by TD-PTR-ToF-MS with filter heating system at 120°C. Total organic sulfur, dissolved organic sulfur, and insoluble organic sulfur in marine aerosol particles are measured by inductively coupled plasma with triple quadrupole (ICP-QQQ-MS, Agilent, Japan) in University of Tsukuba, after appropriate treatments.

Organic sulfur speciation in marine aerosol particles are conducted by XAFS spectroscopy at BL27SU in SPring-8 and BL-9A and BL-15A in KEK. In addition, S speciation with C, N, O, Na, and some trace metals were conducted by micro-XAFS at BL37XU in SPring-8 and scanning transmission X-ray microscope (STXM) at BL-13A in KEK.

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Turner, S.M. et al. (1996), Increased dimethyl sulfide concentrations in sea water from in situ iron enrichment, Nature, 383, 513-517.

Sample List

7 size fractionated aerosol sampling list

[Leg. 2]

No. 13: 57° 42N, 150° 40W (2017/7/19 2:34) – CL-11 (2017/7/19 15:17) Total: 439.5 m^3

No. 14: CL-11 (2017/7/20 16:04) – CL-12 (2017/7/20 20:57); CL-12 (2017/7/21 5:30) – CL-13 (2017/7/21 8:45) Total: 265.4 m^3

No. 15: CL-13 (2017/7/23 2:59) – CL-15 (2017/7/23 20:12) Total: 593.0 m^3

8. 4. Plankton sampling

Kohji Marumoto[1], Sachiko Horii[2] and Akinori Takeuchi[3]
1. National Institute for Minamata Disease
2. Graduate School of Agricultural and Life Sciences, The University of Tokyo
3. National Institute for Environmental Studies
Correspondence: marumoto@nimd.go.jp

Plankton sampling using a NORPAC-net (North pacific standard net, Motoda, 1957) were conducted at all 21 stations in a subarctic region of North Pacific Ocean and the Gulf of Alaska from 25 June to 3 August (Table 8. 4. 1). A twin net with 153 µm of mesh size was used in this cruise. Flow meters were equipped with the mouth of each net. The net was towed from 200 m depth in twice at each station. Samples obtained by the first cast with a retrieval speed of 0.5 m/s were frozen for stable isotopic analysis and preserved in a saturated neutral formalin solution for microscopic analysis, whereas samples obtained by the second cast with a retrieval speed of 0.7 m/s were stored in a freezer with -18 ºC for Hg analysis.

Specifications of plankton nets Model: Home-made
Mouth diameter: 0.5 m
Mesh size: 153 µm
Length: 2 m

Table 8. 4. 1. Records for plankton sampling

Station	Cast	Date	Time (Shipboard time)	Wire speed (m/s)	Depth (m)	Angle	Flow (#3182)	Flow (#3912)
1	1	2017/6/25	18:38 – 18:46 – 18:53	0.5	0–200	10° (+3 m)	1740	2133
	2		20:35	0.7	0–200	—	2264	2023
2	1	2017/6/28	6:15 – 6:33	0.7	0–200	7° (+1 m)	1802	2133
	2		6:39 – 6:59	0.7	0–200	—	1717	2068
3	1	2017/6/30	14:12 – 14:20 – 14:30	0.5	0–200	6° (+1 m)	1472	1709
	2		14:35 – 14:48	0.7	0–200	—	1491	1788
4	1	2017/7/2	13:39 – 13:56 – 14:05	0.5	0–200	(+0 m)	1591	1884
	2		14:08 – 14:19	0.7	0–200	—	1588	1898
5	1	2017/7/4	14:36 – 14:52	0.5	0–200	4° (+0 m)	1270	1404
	2		14:57 – 15:03	0.7	0–200	—	1444	1639
6	1	2017/7/6	12:09 – 12:19 – 12:30	0.5	0–200	1° (+0 m)	1816	1948
	2		12:40 – 12:49 –	0.7	0–200	—	1859	2080
7	1	2017/7/7	18:35 – 18:52	0.5	0–200	6° (+1 m)	1726	2098
	2		18:59	0.7	0–200	—	1545	1868
8	1	2017/7/9	17:02 – 17:10 –	0.5	0–200	4° (+0 m)	1267	1416
	2		17:22 – 17:30 –	0.7	0–200	—	1320	1570
9	1	2017/7/10	15:18 – 15:25 – 15:35	0.5	0–200	4° (+0 m)	1452	1632
	2		15:40	0.7	0–200	—	1577	1772
10	1	2017/7/12	14:10 – 14:17 – 14:25	0.5	0–200	?	1199	1342
	2		14:31 – 14:44	0.7	0–200	—	1403	1562
11	1	2017/7/19	22:28 – 22:46	0.5	0–200	7° (+1 m)	1692	1826
	2		22:51 – 23:05	0.7	0–200	—	1910	2095
14	1	2017/7/20	7:07 – 7:25	0.5	0–200	0° (+0 m)	1577	1655
	2		7:34	0.7	0–200	—	1665	1871
13	1	2017/7/21	23:15 – 23:27	0.5	0–200	2° (+0 m)	1571	1683
	2		23:35 – 23:47	0.7	0–200	—	1748	1897
12	1	2017/7/22	6:58 – 7:11	0.5	0–200	1° (+0 m)	1465	1362
	2		7:21 – 7:33	0.7	0–200	—	1360	1520
15	1	2017/7/23	9:40 – 9:49 –	0.5	0–200	6° (+1 m)	1428	1738
	2		10:03 – 10:15	0.7	0–200	—	1443	1755
16	1	2017/7/25	19:00 – 19:12	0.5	0–200	0° (+0 m)	1523	1760
	2		19:18 – 19:27 – 19:33	0.7	0–200	—	1448	1694
17	1	2017/7/27	17:20 – 17:27 –	0.5	0–200	0° (+0 m)	1320	1461
	2		17:40 – 17:52	0.7	0–200	—	1375	1629
18	1	2017/7/29	3:33 – 3:41 –	0.5	0–200	0° (+0 m)	1248	1273
	2		3:54 – 4:02	0.7	0–200	—	1410	1549
19	1	2017/7/30	16:20 – 16:36	0.5	0–200	2° (+0 m)	1303	1419
	2		16:41 – 16:56	0.7	0–200	—	1335	1430
20	1	2017/8/1	4:23	0.5	0–200	0° (+0 m)	1293	1352
	2		4:44	0.7	0–200	—	1516	1782
21	1	2017/8/2	19:38	0.5	0–200	0° (+0 m)	1368	1430
	2		19:59 – 20:13	0.7	0–200	—	1530	1707